Boott Hydropower, LLC
Subsidiary of Central Rivers Power US, LLC
670 N. Commercial Street, Suite 204
Manchester, NH 03101

Via eFiling November 15, 2021

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: **Lowell Hydroelectric Project (FERC No. 2790-072)**
Response to Schedule A – Requests for Additional Information

Dear Secretary Bose:

Boott Hydropower, LLC (Boott or Licensee) is the Licensee, owner, and operator of the 20.2-megawatt Lowell Hydroelectric Project (Project or Lowell Project) (FERC No. 2790). Boott operates the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Project's existing license expires on April 30, 2023. Boott is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (C.F.R.) Part 5. In accordance with the applicable regulations at 18 C.F.R. § 5.17(a), Boott filed a final application for a new license (Final License Application or FLA) with the Commission on April 30, 2021.

On May 27, 2021, Commission staff issued a letter requesting Boott to resolve deficiencies to the license application. In response, Boott filed information to correct the deficiencies on August 25, 2021. Commission staff issued a Schedule A – Requests for Additional Information (AIR) on October 14, 2021. This filing, including the attachments, provides the requested information as noted in the Commission's letter. Information requested by FERC staff is listed below in italics, followed by Boott's response.

Current Project Operation

1. *Section E.5.8.4.1 of the revised Exhibit E of the license application indicates that during periods of high flow, when the hydraulic capacity of the E.L. Field Powerhouse units is reached (6,600 cubic feet per second (cfs)), up to 2,000 cfs is routed through the downtown canal system to the fifteen turbine-generator units located in Lowell, Massachusetts.*

   Please provide a detailed description of Boott's current operation of the downtown canal system, including: (a) a description of flow releases to the canal system during normal operating conditions, including the location and purpose of the release; (b) a description of how and when flow is released from the canal system to the Merrimack and Concord Rivers; and (c) daily or weekly canal water levels and flow records from 2016 to present.

Boott response:

(a) As stated in the FLA, there is no established flow requirement for the canal system. Instead, water levels are maintained in coordination with the National Park Service (NPS) to allow boat tour operations to navigate the canal system during May 15 to October 15. This is in accordance with the Revised Report on Recreational Resources, which was filed on April 16, 1984 pursuant to Article 38 of the existing license and approved by FERC on September 12, 1984. A copy of this report is included in Attachment A, along with consultation letters from the NPS, Massachusetts Historical Commission (MHC), and Massachusetts Department of Conservation and Recreation (MADCR) on the Revised Report on Recreational Resources. Boott is currently discussing with NPS, MADCR, the City of Lowell, and others, options to revisit and update this water elevation agreement.

As described in the *Operations Analysis of the Lowell Canal Study,* the E.L. Field turbine-generator units are more efficient and operate at a higher head than the older canal units and are, therefore, the priority first-on, last-off units in the Project operations scheme. When river flows exceed the hydraulic capacity of the E.L. Field units (approximately 3,300 cubic feet-per-second [cfs] per unit or 6,600 cfs for both units), excess flows up to approximately 2,000 cfs can be routed via the Guard Lock and Gates Facility ("Guard Locks") through the downtown canal system and to the canal units. As noted in the study, the Project's canal units were operated on 34 percent of days during the period of January 1, 1998 – December 31, 2007.

When the canal units were operated, the gates at the Guard Lock and Gates Facility would be opened to provide flow to the canal units. This is the sole source of water to the downtown canal system.

(b) The Hamilton units would generally be the first units to be dispatched, discharging to the Lower Pawtucket Canal and the Bridge Street (Section 8) units and the John Street units along the Eastern Canal. These lower canal units would then typically be sequenced to match the operating Hamilton Canal units. Since the total flow capacity of the lower canal units at John Street and Section 8 (3,050 cfs) is greater than the total hydraulic capacity of the Hamilton units (1,638 cfs), additional flow could be routed to the lower canal units via the Swamp Locks gates and/or the Hamilton Wasteway. The Section 8 units discharge to the Concord River, whereas the John Street units discharge to the Merrimack River upstream of its confluence with the Concord River. Excess flow would be released from the canal system through wasteways and gates discharging to the Merrimack River (e.g. Lawrence Wasteway, Boott Dam) or to the Concord River via the exit gates at Lower Locks. As reported in the study, during the period of record from 1998-2007, the Project's canal units were operated on average 25 percent of days during May – October. If generating at the canal units, Boott maintained water levels during the boating season in accordance with agreements with the NPS by releasing any extra flows as noted above.

During the other 66 percent of days during the period of record (1998-2007), the canal units were not operated. This is expected and normal for the Project. The canal units have experienced repeated maintenance issues, and under current conditions are deemed unsafe to operate. Several of the canal system units have experienced prolonged outages in recent years, and the canal system as a whole has not been operated for purposes of generation for more than a year. When canal units are not operated, flows are not deliberately released from the canal system through powerhouses or exit gates/wasteways. Certain gates or control structures may be opened to divert flow between canals as appropriate, but generally water is not being released from the system except as normal leakage. To make up for this leakage to maintain water levels in accordance with existing agreements, Boott normally releases to the downtown canal system via Guard Locks an estimated continuous flow of 200 to 300 cfs.

(c) Boott does not maintain records of canal water elevations or flows , other than generation records. Water levels in the lower canal system are not automatically recorded but rather are monitored at multiple staff gages throughout the canal system, including a staff gage near the Hamilton Wasteway and two staff gages on the Eastern Canal, located at the Section 8 (Bridge Street) powerhouse intake and at the John Street Unit 6 intake, respectively. Both of these gages refer to Proprietors of Locks & Canals (PL&C) datum, which is 5.2 feet higher than the National Geodetic Vertical Datum of 1929 (NGVD29), i.e., PL&C + 5.2 = NGVD29. The target water levels for the canals are:

- Upper canal system (including Upper Pawtucket Canal between Guard Locks and Swamp Locks, Hamilton Canal, Merrimack Canal, Western Canal, and Northern Canal between Hydro Locks and Western Canal): staff gage reading 81.5 ft PL&C = 86.7 ft NGVD29;

- Lower canal system (including Lower Pawtucket Canal and Eastern Canal): staff gage reading 66.6 ft PL&C = 71.8 ft NGVD29.

Water levels in the upper system are also monitored at a staff gage near the terminus of the Hamilton Canal, adjacent to the Hamilton Waste Gates.

Additionally, given Boott's canal elevation agreement with the NPS, Boott regularly coordinates on water elevations with the NPS and other stakeholders. Based on ongoing conversations with the NPS, City of Lowell, MADCR, and other stakeholders, Boott and NPS performed a site visit in October 2021 to review the target water levels in the upper and lower canal systems and to compare the staff gages separately maintained by NPS and Boott. The NPS' gages are located on the Swamp Locks Gatehouse left abutment and Lower Locks Gatehouse left abutment. These gages are monitored daily by the NPS during the tour boat season. Appended to this report as Attachment B are the target water elevations at NPS gages converted to NGVD29. Boott and NPS are working together to replace and relocate the canal gages to locations that are more readily accessible to all, all of which will reference the NGVD29 datum.

Proposed Project Operation

2. *Attachment A of Boott's August 25, 2021 filing provides a list of each project facility that Boott is proposing to remove from the project. For each of the canals, dams, gatehouses, and lock structures listed in Attachment A, Boott identifies a specific "action," including: (1) "maintain water levels and canal walls in line with existing rights, responsibilities and existing or new agreements;" (2) "no change from present;" or (3) "continue to operate the gates for canal water level management."*

   The actions listed in Attachment A lack specificity, such that it is unclear if Boott is proposing to continue operating and maintaining certain facilities in the downtown canal system as it does under the current license. Section 4.41(h)(2) of the Commission's regulations requires that a project boundary enclose all facilities necessary for operation and maintenance of the project and for other project purposes, such as recreation, shoreline control, or protection of environmental resources.

   To the extent Boott is proposing to continue operating and maintaining any facilities listed in Attachment A, please describe: (a) the specific measure(s) for operating and maintaining each facility; (b) the purpose of each measure; and (c) whether the facility is needed for any project purpose(s), including the purpose(s) associated with each specified measure.

   In addition, the Lawrence Wasteway is currently licensed as a project facility. According to the proposed Exhibit G filed with the license application, Boott is proposing to remove the wasteway from the project boundary. However, the wasteway is not Schedule A A-2 Project No. 2790-074 included in Attachment A of Boott's August 25, 2021 filing. Please revise Attachment A to include this facility and any additional facilities that may have been inadvertently omitted, as needed, to provide a complete list of facilities that Boott is proposing to decommission and/or remove from the project boundary.

   Boott Response: Attachment A of Boott's August 25, 2021 filing has been updated with this information and is appended to this letter as Attachment C. However, Boott notes this is subject to change. Given the physical extent and complexity of the canal system, together with the complex array of ownership and rights as documented in Boott's *Resources, Ownership, Boundaries, and Land Rights Study Report* it is clear that development of a comprehensive plan for the future management of the Lowell canal system will take substantial time, effort and coordination among Boott and the affected stakeholders. To that end, Boott convened nine meetings with the stakeholders to engage in discussions regarding the future management of the canal system outside of FERC's jurisdiction. The stakeholders in these meetings included NPS, MADCR, the City of Lowell and UMass Lowell. These meetings will continue as regular, facilitated discussions among Boott and the stakeholders, with the goal of developing an agreement for the future management of the canals and associated infrastructure. Once executed, the agreement will be submitted to the FERC in support of Boott's license application and its decommissioning proposal.

3. *In its August 25, 2021 response to Commission staff's May 27, 2021 deficiency letter, Boott lists target water levels that it currently maintains in the canal system, and states that it is proposing to continue to maintain these water levels in the canal system by releasing flow from the proposed project's Guard Lock and Gates Facility. Boott states that it would continue to maintain three gages to monitor water levels in the canal system.*

   However, it appears that these gages would be located in the Eastern Canal and Hamilton Canal, outside of the proposed project boundary. Boott estimates that it would need to release 200 to 300 cfs to the canal system from the Guard Lock and Gates Facility to make up for leakage and other water losses and maintain current water levels in the canal system. Boott states that it would "make any adjustments in flow necessary to manage canal levels."

   Please describe: (a) the specific locations, quantity, and duration of all proposed flow releases to the canal system needed to maintain the proposed water levels in the canal system on an annual basis; (b) specific proposed measures that Boott would take to "make any adjustments in flow necessary to manage canal levels;" (c) the location of the gages that Boott would use to monitor water levels in the canal system, including whether any gages would be outside of the proposed project boundary and, if so, how Boott would monitor and maintain those gages; and (d) any proposed measures for releasing flow from the canal system to the Merrimack and Concord Rivers to maintain the proposed water levels in the canal system.

   Please also provide an estimate of any lost generation and capital, operation, or maintenance costs associated with maintaining water levels and flow releases to the canal system.

   Boott Response:

   (a) In order to maintain the proposed water levels in the canals, Boott currently continuously releases approximately 200-300 cfs into the downtown canal system via Guard Locks. This is the general quantity understood to be sufficient to maintain water levels, however, the actual amount released depends on daily variability. Boott does not release a specific quantity at Guard Locks but rather releases a certain amount as needed to maintain the water elevations.

   There is no lost generation, capital, operation or maintenance costs associated with maintaining water levels and flow releases to the canal system, other than minor labor costs.

   (b) To make any adjustments in flow necessary to manage canal levels, Boott releases flows from Guard Locks into the Pawtucket Canal, and directs the flows as necessary through the canal system by opening or closing certain gates. From the Guard Locks, water flows for approximately 4,500 feet to a point where the Pawtucket Canal diverges into the Western Canal, Merrimack Canal, Lower Pawtucket Canal, and the Hamilton Canal. Gates and other control mechanisms control the flow of waters into the various canals as-needed. The Western Canal carries flows from the Pawtucket Canal to the Tremont Gatehouse, which controls flows into the Tremont Wasteway and Lawrence Wasteway, before emptying into the Merrimack River. Flow to the Merrimack Canal from the Pawtucket Canal is controlled by the Merrimack Gates, and either exits the Merrimack Wasteway or continues into the Eastern Canal. The Moody Street Feeder Gatehouse controls flows from the Moody Street Feeder to the Merrimack Canal. Hamilton Gates control flows into the Hamilton Canal, and Swamp Locks controls flows into the Lower Pawtucket Canal.

(c) Water levels in the lower system outside of the proposed Project boundary are monitored at two staff gages on the Eastern Canal, located at the Section 8 (Bridge Street) powerhouse intake and at the John Street Unit 6 intake, respectively. Both of these gages refer to Proprietors of Locks & Canals (PL&C) datum, which is 5.2 feet higher than the NGVD29, i.e., PL&C + 5.2 = NGVD29. The target water levels for the canals are:

- Upper canal system (including Upper Pawtucket Canal between Guard Locks and Swamp Locks, Hamilton Canal, Merrimack Canal, Western Canal, and Northern Canal between Hydro Locks and Western Canal): staff gage reading 81.5 ft PL&C = 86.7 ft NGVD29;

- Lower canal system (including Lower Pawtucket Canal and Eastern Canal): staff gage reading 66.6 ft PL&C = 71.8 ft NGVD29.

Water levels in the upper system are monitored at a staff gage adjacent to the Hamilton Waste Gates, near the terminus of the Hamilton Canal, and also outside of the proposed Project boundary. Within the proposed Project boundary, water levels are monitored in the Pawtucket Canal upstream of Guard Locks: 92.2 ft NGVD29, i.e., the same level as the normal pond level in Project impoundment. Boott typically monitors these gages on a weekly basis and adjusts the gates as necessary to maintain the canals at their target levels. As a part of this relicensing, Boott proposes to maintain all three gages in accordance with a gage plan to be submitted to FERC which will include, among other things, a plan to upgrade the two Eastern Canal gages to NGVD29 gages and a schedule to check the gages weekly.

As noted above, based on ongoing conversations with the NPS, City of Lowell, MADCR, and other stakeholders, Boott and NPS performed a site visit in October 2021 to review the target water levels in the upper and lower canal systems and to compare the staff gages separately maintained by NPS and Boott. The NPS' gages are located on the Swamp Locks Gatehouse left abutment and Lower Locks Gatehouse left abutment. These gages are monitored daily by the NPS during the tour boat season. Appended to this report as Attachment B are the target water elevations at NPS gages converted to NGVD29. Boott and NPS are working together to replace and relocate the canal gages to locations that are more readily accessible to all, all of which will reference the NGVD29 datum.

Exhibit E

4. *Section E.5.8.5 of the revised Exhibit E of the license application states that Boott is proposing to replace the existing fish lift at the E.L. Field Powerhouse with a fish ladder in the tailrace of the E.L. Field Powerhouse that would pass migratory fish from the tailrace to the bypassed reach. Boott states that it will consult with the Merrimack River Technical Committee (MRTC) to determine the design and installation schedule for the proposed fish ladder. In addition, section E.8 of the revised Exhibit E states that the capital cost of the proposed fish ladder would be $2,600,000. Section 4.51(f)(3)(v)(A) of the Commission's regulations states that the license application should include functional design drawings of any fish passage and collection facilities.*

   Section 4.51(f)(3)(v)(C) states that the license application should include an implementation or construction schedule for any proposed measures or facilities. Please provide the following information in accordance with the Commission's regulations: (1) functional design drawings of the proposed fish ladder that conform to the specifications of section 4.39 of the Commission's regulations; (2) whether the cost of any excavation in the bypassed reach associated with the proposed fish ladder is included in the $2,600,000 capital cost of the ladder; and (3) a timeline for the installation of the fish ladder.

   Boott Response:

   (1) Boott has developed conceptual design drawings for the proposed fish ladder and has provided these as Attachment D. Boott is designing the fishway in consultation with the MRTC[1], and as such functional design drawings of the proposed tailrace fish ladder cannot be provided in the timeframe required by this response. The conceptual design is subject to change based on ongoing consultation with the MRTC, however Boott anticipates the functional design drawings can be provided by August 2022.

   (2) Excavation in the bypassed reach associated with the proposed fish ladder was included in the $2,600,000 capital cost estimate.

   (3) After consultation with the MRTC, Boott proposes to construct the entrance to the fish ladder in the E.L. Field powerhouse tailrace within two years of license issuance, and to construct the remainder of the fish ladder in the bypass within three years of license issuance. This construction sequence is designed to take advantage of the extended E.L. Field powerhouse outage which will be required to construct the proposed new trashrack structure in the forebay. That is, the proposed new trashrack structure and tailrace portion of the new fish ladder would be constructed during an extended outage at the E.L. Field powerhouse, with the forebay dewatered and all inflow passed via the bypassed reach. Construction of the upstream exit portion of the new ladder within the

[1] The Merrimack River Technical Committee is comprised of the following state and federal agencies: New Hampshire Department of Fish and Game (NHDFG), Massachusetts Division of Fisheries and Wildlife (MADFW), Massachusetts Division of Marine Fisheries (MADMF), United States Fish and Wildlife Service (USFWS), United States Forest Service (USFS), and National Marine Fisheries Service (NMFS).

bypass reach would take place three years after license issuance, with the E.L. Field powerhouse on-line and with controlled bypass reach flows.

5. *Section E.6.2 of the revised Exhibit E of the license application states that Boott is proposing to consult with the MRTC to identify any necessary modifications to the existing upstream fish ladder located at the Pawtucket Dam and/or the existing weirs in the bypassed reach. Section 4.51(f)(3)(iii) of the Commission's regulations states that Exhibit E should include a statement of any measures or facilities proposed by the applicant for the mitigation of impacts on fish resources. Consultation is not a specific measure, and Boott does not provide any additional details about the potential modifications to the Pawtucket Dam fish ladder or bypassed reach weirs, or a timeline for implementing those measures.*

   Please provide the following information: (1) specific measures for any proposed modifications to the Pawtucket Dam fish ladder and/or bypassed reach weirs; and (2) a timeline for the implementation of any such measures.

   Boott Response:

   (1) In consultation with the MRTC, Boott has proposed to make modifications to the Pawtucket Dam fish ladder including installing an automatic flap gate at the entrance; changes to the configuration of the baffle plates; modifications to the 180° turn pool to reduce turbulence and eddies; and a screening system upstream from the auxiliary water supply (diffuser) gate.

   Potential modifications to the bypassed reach include the removal of bedrock barriers or the construction of additional weirs. However, these potential modifications are currently being evaluated in consultation with the MRTC, following the filing of the final *Instream Flow Assessment and Zone of Passage Study in the Bypassed Reach* on November 1, 2021. Boott anticipates providing these modifications to the Commission in the coming months as they are finalized in consultation with the MRTC.

   (2) As decided in consultation with the MRTC, Boott will make these modifications to the to the Pawtucket Dam fish ladder and bypassed reach within one year of license issuance.

6. *Section A.2.7 of the revised Exhibit A of the license application states that the Pawtucket Dam fish ladder operates at 200 cfs, including attraction flow, with an additional 300 cfs of supplemental attraction flow released from a slide gate adjacent to the passage facility. However, additional information filed by Boott on February 25, 2021 for Study 3, Upstream and Downstream Adult Alosine Passage Assessment, states that: (1) attraction water to the ladder consists of approximately 30 cfs of ladder flow and approximately 60 cfs through a floor diffuser; (2) the total far-field attraction flow is up to 500 cfs, including supplemental attraction flow from the adjacent sluice gate; (3) additional attraction flow, up to approximately 400 cfs depending on the two flow sources discussed above, is supplied from the south and largest gate on the headworks; and (4) flows from the two sluice gates can be*

adjusted to optimum flow and other passage conditions when the normal headpond level is not occurring.

So that staff can evaluate the effects of operating the Pawtucket Dam fish ladder on migratory fish species, please clarify the following information: (1) the amount of inladder flow; (2) the amount of flow discharged from the floor diffuser; (3) the amount of flow released from the "adjacent sluice gate;" (4) the amount of flow released from the "south" sluice gate; and (5) a description of conditions requiring additional flow to be released from the "south" sluice gate versus the "adjacent sluice gate."

Boott Response:

(1) In August 2021, Boott performed field measurements of the in-ladder flow, in consultation with the MRTC. The in-ladder flow was measured at 47 cfs.
(2) The amount of flow released from the floor diffuser via the auxiliary water supply gate is approximately 60 cfs.
(3) The "adjacent sluice gate" and "south sluice gate" refer to the same structure, a 10-foot wide slide gate which provides supplemental attraction flow adjacent to the fish ladder entrance. It is the located to the south (river right) of the three fish ladder gates, adjacent to the diffuser control gate, and releases approximately 360 cfs.
(4) The "south" sluice gate is the same structure as the "adjacent sluice gate" discussed in 6(3) above.
(5) The "south" sluice gate is the same structure as the "adjacent sluice gate" discussed in 6(3) above.

7. *Section E.7.4.1.4 of the revised Exhibit E of the license application provides information on wetland habitats located within the project boundary. However, the license application does not include an acreage estimate for each wetland type present. Please revise Table E.7-27 to estimate the acreage of each wetland type, and to clarify whether the wetland is within the project boundary.*

   Boott Response: Exhibit E has been revised and is appended to this letter as Attachment E. For convenience, the changes have been highlighted.

8. *Section E.7.4.2.2 of the revised Exhibit E of the license application states that Boott's routine vegetation management practices include mechanical vegetation removal around project facilities. So that staff can evaluate the effects of project maintenance activities on the monarch butterfly, please describe the frequency in which mechanical vegetation removal occurs, the type of vegetation that is being removed, and the total acreage of project land affected.*

   Boott Response: As part of the *Recreation and Aesthetics Study*, Boott performed a Visual Survey for Vegetation Growth, which included mapping vegetation growth within the downtown canal system. Boott determined that around 4.78 acres of Project land within the canal system contains vegetation that may need mechanical removal. This includes all vegetation types including herbaceous layers, scrub-shrub, and trees. Boott does not generally maintain any vegetation upstream along the Merrimack River (e.g. outside of the canal system). During this review vegetation was mapped using Geographic Information Systems (GIS), species were identified if possible, and photographs were taken and compiled into a photographic log. This information can be found as appendices G, H, I, and J of the *Recreation and Aesthetics Study* filed on February 25, 2021. According to the USFWS Species Status Assessment Report[2] for the monarch butterfly, the decline in availability, distribution, and quality of milkweed species is the primary reason for the long-term declines in the population abundance. No milkweed species were identified along the canal system during the Visual Survey for Vegetation Growth conducted for the *Recreation and Aesthetics Study*, and milkweed is not a target plant for removal by Boott.

Through the current license term, FERC and Boott have corresponded on vegetation growth at facilities within the Project boundary. Boott typically identifies canal structures in need of vegetation removal and control in its Dam Safety Surveillance and Monitoring Reports annually submitted to the FERC's New York Regional Office. Vegetation removal is performed as necessary, two to three times a year. Species most affected by vegetation removal include the invasive species Garlic mustard (*Alliaria petiolata*), Asiatic bittersweet (*Celastrus orbiculatus*), Tree of Heaven (*Ailanthus altissima*), and Japanese knotweed (*Fallopia japonica*).

As noted above, given the physical extent and complexity of the canal system, it is clear that development of a comprehensive plan for the future management of the Lowell canal system will take substantial time, effort and coordination among Boott and the affected stakeholders. These meetings continue with the goal of developing an agreement for the future management of the canals and associated infrastructure, which is likely to include understandings around management of vegetation growth in the canal system. Once executed, the agreement will be submitted to the FERC in support of Boott's license application and its decommissioning proposal.

Exhibit E has been revised and is appended to this letter as Attachment E. For convenience, the changes have been highlighted.

9. Section E.7.7.2.1 of the revised Exhibit E of the license application provides information on debris removal in the Project boundary, including Boott's current maintenance practice of removing trash and debris in the waterway at the Northern Canal Gatehouse and the upstream side of the Guard Lock and Gates Facility. The license application states that Boott is proposing to continue debris removal during the term of any new license. However, the license application does not describe how/whether trash and debris are currently removed from the downtown canal system (e.g., manually or through flushing flows through the downtown canal system to the Concord and Merrimack Rivers). Please describe

[2] https://www.fws.gov/savethemonarch/pdfs/Monarch-SSA-report.pdf

how/whether trash and debris are currently removed from the downtown canal system, and whether Boott is proposing to remove trash and debris from the downtown canal system during the term of any new license. In addition, please describe any potential effects of Boott's proposal to reduce flow releases to the downtown canal system (200 to 300 cfs) on trash and debris accumulation in the downtown canal system.

Boott Response:

Boott mechanically removes via clamshell bucket (or similar machinery) accumulated river-borne debris from the upstream side of the Northern Canal Gatehouse under a MADCR permit. This effort is performed as necessary, typically two to three times annually. Boott also occasionally lowers the crest gate located adjacent to the Northern Canal Gatehouse to release accumulated debris into the bypassed reach.

Boott also removes debris that accumulates from the upstream side of the Guard Lock and Gates Facility in the Pawtucket Canal on an as necessary basis, both for aesthetics and to ensure that debris does not interfere with the proper functioning of the Guard Gates. Recently, Boott has agreed with the City of Lowell to conduct canal debris removal at recognized accumulation points, many of which are noted in this study.

As noted above, given the physical extent and complexity of the canal system, it is clear that development of a comprehensive plan for the future management of the Lowell canal system will take substantial time, effort and coordination among Boott and the affected stakeholders. These meetings continue with the goal of developing an agreement for the future management of the canals and associated infrastructure, which is likely to include understandings around management of trash and debris accumulation in the canal system. Once executed, the agreement will be submitted to the FERC in support of Boott's license application and its decommissioning proposal.

Exhibit E has been revised and is appended to this letter as Attachment E. For convenience, the changes have been highlighted.

10. *Please provide any maps of the Area of Potential Effects (APE) that were used during National Historic Preservation Act section 106 consultation with the New Hampshire State Historic Preservation Office (SHPO), Massachusetts SHPO, the National Park Service (NPS), and Indian tribes, and any records of consultation with the New Hampshire SHPO, Massachusetts SHPO, NPS, and Indian tribes on the APE.*

Boott Response:

Appended to this letter as Attachment F are the letters of consultation with New Hampshire SHPO, Massachusetts SHPO, NPS, and Indian tribes, and any records of consultation with the New Hampshire SHPO, Massachusetts SHPO, NPS, and Indian tribes on the APE.

By letter dated April 26, 2017, FERC invited the Mashpee Wampanoag Tribe, Narragansett Indian Tribe, Stockbridge Munsee Tribe of Mohican Indians, and Wampanoag Tribe of Gay Head (Aquinnah) to participate in the relicensing process for the Project. The Mashpee Wampanoag Tribe stated they do not have concerns with relicensing unless new construction is proposed that has the potential to disturb cultural resources. By notice dated June 15, 2018, FERC designated Boott its nonfederal representative for purposes of conducting informal consultation pursuant to Section 106. A discussion of historical properties within the Project's APE and the consultation under Section 106 conducted to date for the relicensing of the Project was discussed in Exhibit E of the FLA.

Specifically, in March 2018, New Hampshire SHPO, Massachusetts SHPO, NPS, Bureau of Indian Affairs (BIA), and identified Indian Tribes were provided the Pre-Application Document (PAD) Questionnaire by email and hardcopy mailing. The PAD Questionnaire included a map identifying the Area of Interest for consultation. The PAD Questionnaire, associated map, and responses from NPS and BIA are included in Attachment F.

NPS, New Hampshire SHPO, Massachusetts SHPO, and Indian tribes are included on the Project's contact distribution list, and thus were informed of all major filings including the PAD, the Initial Study Report (ISR), the Revised ISR, the Draft License Application (DLA), and FLA. In the DLA and subsequent FLA, the APE for the Lowell Hydroelectric Project was defined as "lands within the defined FERC Project boundary" and a map of the Project Boundary was noted for reference.

On March 02, 2021, NPS filed comments with FERC on the DLA (Accession Number 20210302-5054). On March 15, 2021 Massachusetts Historical Commission filed comments with FERC on the DLA (Accession Number 20210315-0034). On May 27, 2021, FERC notified Boott to correct their Deficiency of License by providing the necessary information by August 25, 2021. On August 17, 2021 NPS and Massachusetts Historical Commission were included on efforts to consult on Boott's August 25, 2021 *Deficiency of License* response letter to FERC, notably to provide comments on the draft Decommissioning Plan. Included in this filing was an updated Exhibit E of the FLA, which as noted above included the definition and description of the APE. A hard copy of this consultation package was sent to the Massachusetts Historical Commission for comment as per their requirements. On August 20, 2021 the Department of the Interior (on NPS' behalf) responded to the Decommissioning Plan consultation package. On September 30, 2021, NPS filed comments with FERC on the August 25, 2021 *Deficiency of License* response (Accession Number 20210930-5102). Copies of correspondence are included in Attachment F.

11. *In Commission staff's February 2, 2021 study modification determination letter, staff recommended that Boott provide additional information for Study 3, Upstream and Downstream Adult Alosine Passage Assessment, including the average daily flow data for the bypassed reach and E.L. Field Powerhouse to evaluate the effects of project operation on upstream shad passage from 2017 through 2020. Boott's February 25, 2021 response letter provided operation data for the 2020 upstream passage season, including inflow data*

and discharge data for the Pawtucket Dam and fish ladder, downstream fish bypass, E.L. Field Powerhouse, and the downtown canal system. Boott did not provide inflow and discharge data for the Pawtucket Dam and fish ladder, and E.L. Field Powerhouse for 2017 through 2019, as requested.

So that staff can evaluate the effects of project operation on upstream shad passage, please provide a spreadsheet that includes the following information for the 2017 to 2020 upstream shad passage seasons (i.e., May 1 through July 15): (1) daily average discharge from the Pawtucket Dam, the fish ladder, the E.L. Field Powerhouse, the downstream fish bypass, and the downtown canal system; and (2) daily average elevations for the impoundment; fish ladder entrance and/or bypassed reach immediately downstream of the Pawtucket Dam; and the E.L. Field Powerhouse forebay and tailrace.

Boott Response:

Appended to this letter as Attachment G is a spreadsheet containing the requested information, if available. Given the required 30-day turn around for this information, Boott was not able to find all the requested information in that time. Included in Attachment G is Project operations data (e.g. forebay elevation, tailrace level, fish passage flow) from May through July 2020, historical headpond elevation, forebay elevation, and tailwater elevation from 1995-2010. Boott anticipates providing this information to FERC by December 15, 2021.

Please do not hesitate to contact me at (978) 935-6039 or kwebb@centralriverspower.com if you have any questions concerning this submittal.

Sincerely,

Boott Hydropower, LLC

Kevin M. Webb
Licensing Manager

cc: M. Stanley, CRP
C. Mooney, CRP
Distribution List

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Federal and State Agencies

John Eddins, PhD
Archaeologist/Program Analyst
Advisory Council on Historic Preservation
401 F Street NW
Suite 308
Washington, DC 20001-2637

Kimberly Bose
Secretary
Federal Energy Regulatory Commission
888 1st Street NE
Washington, DC 20426

John Spain
New York Regional Office
Federal Energy Regulatory Commission
Office of Energy Projects
Division of Dam Safety and Inspections

Steve Carlin
Park Supervisor
Massachusetts Department of Conservation and Recreation
Lowell Heritage State Park
160 Pawtucket Blvd
Lowell, MA 01854

Rodney Elliott
Massachusetts Department of Conservation and Recreation
25 Sahttuck St.
Lowell, MA 02115

Tom Walsh
Massachusetts Department of Conservation and Recreation
25 Sahttuck St.
Lowell, MA 02115

Office of Dam Safety
Massachusetts Department of Conservation and Recreation
John Augustas Hall
180 Beaman Street
West Boylston, MA 01583-1109

Michael Judge
Renewable Energy Division Director
Massachusetts Department of Energy Resources
100 Cambridge Street
Suite 1020
Boston, MA 02114-2533

Rachel Freed
Northeast Region Section Chief
Massachusetts Department of Environmental Protection
205 Lowell Street
Wilmington, MA 01887

Arthur Johnson
DWM Environmental Monitoring Program
Massachusetts Department of Environmental Protection
8 Bond Street
Worcester, MA 01606

Thomas Gruszkos
Bureau of Water Resources
Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108

Massachusetts Department of Fish and Game
251 Causeway Street
Suite 400
Boston, MA 02114

Massachusetts Department of Public Utilities
One South Station
Boston, MA 02110

Matthew Ayer
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Joseph Larson
Chairman
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Steve Mattocks
Fisheries Operations Biologist
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Rebecca Quinones
Stream Biologist Project Leader
1 Rabbit Hill Road
Westborough, MA 01581

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Ben Gahagan
Diadromous Fisheries Biologist
Massachusetts Division of Marine Fisheries
251 Causeway Street
Suite 400
Boston, MA 02114

Bob Durand
Massachusetts Executive Office of Energy & Environmental Affairs
100 Cambridge Street
Suite 900
Boston, MA 02114

Jonathan Patton
Preservation Planner
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Brona Simon
State Historic Preservation Officer
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Secretary of the Commonwealth
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Bill Saloma
Massachusetts Office of Dam Safety
180 Beaman Street
West Boylston, MA 01583

Massachusetts Office of the Attorney General
1 Ashburton Place
Boston, MA 02108-1518

Bjorn Lake
National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office
55 Great Republic Drive
Gloucester, MA 01930

Benjamin German
Marine Habitat Resource Specialist
National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office
55 Great Republic Drive
Gloucester, MA 01930

Bill McDavitt
Environmental Specialist
National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office
55 Great Republic Drive
Gloucester, MA 01930

Chris Boelke
Chief, New England Branch
National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office
55 Great Republic Drive
Gloucester, MA 01930

Juliet Galonska
Lowell National Historical Park
National Park Service
67 Kirk Street
Lowell, MA 01852

Duncan Hay
Northeast Region
National Park Service
15 State Street
Boston, MA 02109

Kevin Mendik
Hydro Program Manager
National Park Service
15 State Street
Boston, MA 02109

Misty Anne Marold
Senior Review Biologist
Natural Heritage Endangered Species Program
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Owen David
Water Quality Certification Program
New Hampshire Department of Environmental Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Jim Gallagher
Dam Bureau Administrator
New Hampshire Department of Environmental Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Brad Simpkins
Director
New Hampshire Division of Forests and Lands
172 Pembroke Road
Concord, NH 03301

Benjamin Wilson
SHPO & Director
New Hampshire Division of Historical Resources
19 Pillsbury Street, 2nd Floor
Concord, NH 03301-3570

Matt Carpenter
Fisheries Biologist
New Hampshire Fish and Game Department
11 Hazen Drive
Concord, NH 03301

George Rose
Deputy Director
Office of Emergency Management
The City of Lowell Fire Department
JFK Civic Center, 99 Moody Street
Lowell, MA 01852

Harold Peterson
Bureau of Indian Affairs
US Department of the Interior
545 Marriott Drive
Suite 700
Nashville, TN 37214

Office of the Solicitor, Northeast Region
US Department of the Interior
15 State Street
8th Floor
Boston, MA 02109-3502

Ed Reiner
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OEP06-3
Boston, MA 02109-3912

David Turin
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OES04-3
Boston, MA 02109-3912

Tom Chapman
Supervisor, New England Field Office
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301-5094

Ken Hogan
Fish and Wildlife Biologist
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301

Douglas Smithwood
Fish Biologist
US Fish and Wildlife Service
Central New England Fish and Wildlife Conservation Office
151 Broad Street
Nashua, NH 03063

Bryan Sojkowski
Civil Engineer
US Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035

Keith Nislow
Northern Research Station
US Forest Service
11 Campus Boulevard
Suite 200
Newton Square, PA 19073

Mark Prout
Region 9 - Eastern Region (Midwest and Northeast)
US Forest Service
626 East Wisconsin Avenue
Milwaukee, WI 53202

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Indian Tribes

Cedric Cromwell
Chairman
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

Ramona Peters
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

John Brown
Narragansett Indian Tribal Historic Preservation Office
Narragansett Indian Tribe
P.O. Box 268
Charlestown, RI 02813

Bonney Hartley
Tribal Historic Preservation Manager
Stockbridge Munsee Community
86 Spring Street
Williamstown, MA 01267

Shannon Holsey
Tribal President
Stockbridge Munsee Community, Wisconsin
N8476 MoHeConNuck Road
Bowler, WI 54416

Cheryl Andrew-Maltais
Chairwoman
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Bettina Washington
Tribal Historic Preservation Officer
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Municipalities

James Fiorentini
Mayor
City of Haverhill, MA
4 Summer Street
Haverhill, MA 01830

Kendrya Vasquez
Mayor
City of Lawrence, MA
200 Common Street
3rd Floor Room 309
Lawrence, MA 01840

Christine Clancy
City of Lowell Engineer
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 61
Lowell, MA 01852

John Leahy
Mayor
City of Lowell, MA
375 Merrimack Street
2nd Floor
Lowell, MA 01852

Christine O'Connor
City Solicitor
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 64
Lowell, MA 01852

Joyce Craig
Mayor
City of Manchester, NH
One City Hall Plaza
Manchester, NH 03101

James Jajuga
Mayor
City of Methuen, MA
41 Pleasant Street
Methuen, MA 01844

Jim Donchess
City of Nashua, NH
229 Main Street
Nashua, NH 03060

Scott Galvin
Mayor
City of Woburn, MA
10 Common Street
Woburn, MA 01801

Paul Bergeron
District #2
Hillsborough County, NH

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

329 Mast Road
Suite 120
Goffstown, NH 03045

Toni Pappas
District #1
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Robert Rowe
District #3
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

John Mangiaratti
Town Manager
Town of Acton, MA
472 Main Street
Acton, MA 01720

Andrew Flanagan
Town Manager
Town of Andover, MA
36 Bartlet Street
Andover, MA 01810

David Cressman
Town Administrator
Town of Atkinson, NH
19 Academy Avenue
Atkinson, NH 03811

Robert Pontbriand
Town Administrator
Town of Ayer, MA
1 Main Street
Ayer, MA 01432

Sarah Stanton
Town Manager
Town of Bedford, MA
10 Mudge Way
Bedford, MA 01730

John Curran
Town Manager
Town of Billerica, MA
365 Boston Road
Billerica, MA 01821

Alan Benson
Town Administrator
Town of Boxford, MA
7A Spofford Road
Boxford, MA 01921

Paul Sagarino
Town Administrator
Town of Burlington, MA
29 Center Street
Burlington, MA 01803

Jon Kurland
Town Moderator
Town of Chelmsford, MA
50 Billerica Road
Chelmsford, MA 01824

Stephen Crane
Town Manager
Town of Concord, MA
P.O. Box 535
Concord, MA 01742

David Caron
Town Administrator
Town of Derry, NH
14 Manning Street
Derry, NH 03038

Ann Vandal
Town Manager
Town of Dracut, MA
62 Arlington Street
Dracut, MA 01826

Robert Pontibriand
Town Manager
Town of Groton, MA
173 Main Street
Groton, MA 01450

Timothy Bragan
Town Administrator
Town of Harvard, MA
13 Ayer Road
Harvard, MA 01451

Lori Radke
Town Administrator
Town of Hollis, NH
7 Monument Square
Hollis, NH 03049

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Steve Malizia
Administrator
Town of Hudson, NH
12 School Street
Hudson, NH 03051

James Malloy
Town Manager
Town of Lexington, MA
1625 Massachusetts Avenue
2nd Floor, Town Office Building
Lexington, MA 02420

Timothy Higgins
Town Administrator
Town of Lincoln, MA
16 Lincoln Road
Lincoln, MA 01773

Troy Brown
Town Administrator
Town of Litchfield, NH
2 Liberty Way
Suite 2
Litchfield, NH 03052

Anthony Ansaldi
Town Administrator
Town of Littleton, MA
37 Shattuck Street
3rd Floor, Room 306
Littleton, MA 01460

Kevin Smith
Chairman
Town of Londonderry, NH
268B Mammoth Road
Londonderry, NH 03053

Robert Dolan
Town Administrator
Town of Lynnfield, MA
55 Summer Street
Lynnfield, MA 01940

Eileen Cabanel
Town Manager
Town of Merrimack, NH
6 Baboosic Lake Road
Merrimack, NH 03054

Andrew Sheehan
Town Administrator
Town of Middleton, MA
48 South Main Street
Middleton, MA 01949

Melissa Rodrigues
Town Manager
Town of North Andover, MA
120 Main Street
North Andover, MA 01845

Michael Gilleberto
Town Administrator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

John Murphy
Town Moderator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

Brian McCarthy
Town Administrator
Town of Pelham, NH
6 Village Green
Pelham, NH 03076

Andrew MacLean
Town Administrator
Town of Pepperell, MA
One Main Street
Pepperell, MA 01463

John Arena
Chair, Board of Selectmen
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Robert LeLacheur
Town Manager
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Christopher Dillon
Chairman
Town of Salem, NH
33 Geremonty Drive
Salem, NH 03079

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Michael McGovern
Town Administrator
Town of Shirley, MA
7 Keady Way
Shirley, MA 01464

Dennis Sheeham
Town of Stoneham, MA
35 Central Street
2nd Floor
Stoneham, MA 02180

Richard Montuori
Town Manager
Town of Tewksbury, MA
1009 Main Street
2nd Floor
Tewksbury, MA 01876

Matt Hanson
Town Administrator
Town of Tyngsborough, MA
25 Bryant Lane
Tyngsborough, MA 01879

Richard Reault
Chair, Board of Selectmen
Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

Jodi Ross
Town Manager
Town of Westford, MA
55 Main Street
Westford, MA 01886

Jeffrey Hull
Town Manager
Town of Wilmington, MA
121 Glen Road
Room 11
Wilmington, MA 01887

David Sullivan
Town Administrator
Town of Windham, NH
3 North Lowell Street
Windham, NH 03087

Additional Parties

Robert Nasdor
NE Stewardship Director
American Whitewater
65 Blueberry Hill Lane
Sudbury, MA 01776

Norman Sims
Appalachian Mountain Club
77 Back Ashuelot Road
Winchester, NH 03470

Kevin Webb
Licensing Manager
Central Rivers Power
670 N Commercial Street
Suite 204
Manchester, NH 03102

Kevin Hollenbeck
Metrowest District Manager
DCR Great Brook Farm State Park
984 Lowell Street
Carlisle, MA 01741

Robert Bersak
780 North Commercial Street
Eversource Energy
P.O. Box 330
Manchester, NH 03015

Jay Mason
President
Friends of Tyler Park
77 Tyler Park
Lowell, MA 01851

David Meeker
Hull Street Energy, LLC
4920 Elm Street
Suite 205
Bethesda, MD 20814

Jeffrey J. Winward
Fire Chief
Lowell Fire Department
99 Moody Street
Lowell, MA 01852

Dinell Clark
Lowell Flood Owner's Group
197 Wellman Avenue
North Chelmsford, MA 01863

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Bob Gagnon
Lowell Flood Owner's Group
136 Townsend Avenue
Lowell, MA 01854

Lynda Ignacio
Lowell Flood Owner's Group
66 Shirley Avenue
Lowell, MA 01854

Steve Masse
Lowell Flood Owner's Group
186 Humphrey Street
Lowell, MA 01850

John Nappi
Lowell Flood Owner's Group
279 Pawtucket Boulevard
Tyngsborough, MA 01879

Gene Porter
Lower Merrimack River Local Advisory
77 Concord Street
Nashua, NH 03064

Thomas Golden, Jr.
Massachusetts House of Representatives
24 Beacon Street
Room 473B
Boston, MA 02133

Vanna Howard
Massachusetts House of Representatives
24 Beacon Street
Boston, MA 02133

Rady Mom
Massachusetts House of Representatives
24 Beacon Street
Room 43
Boston, MA 02133

Edward Kennedy
Massachusetts Senate
24 Beacon Street
Room 405
Boston, MA 02133

Matthew Thorne
Executive Director
Merrimack River Watershed Council
60 Island Street
Suite 211-E
Lawrence, MA 01840

Chris Countie
Water Supply Manager
Pennichuck Water Works
P.O. Box 1947
25 Manchester Street
Merrimack, NH 03054

Peter Severance
Research/Program Director
River Merrimack

Fred Jennings
President, Nor'East Chapter
Trout Unlimited
P.O. Box 946
Ipswich, MA 01938

Arthur Faneros
Universal Apartment Rental
114 University Avenue
Lowell, MA 01854

Michele Tremblay
Upper Merrimack River Local Advisory Committee
P.O. Box 3019
Penacook, NH 03303

Ann Kuster
US House of Representatives
137 Cannon House Office Building
2nd District
Washington, DC 20515

Seth Moulton
6th District
US House of Representatives
21 Front Street
Salem, MA 01970

Chris Pappas
US House of Representatives
889 Elm Street
Manchester, NH 03101

Lori Trahan
3rd District
US House of Representatives
126 John Street
Suite 12
Lowell, MA 01852

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Margaret Hassan
US Senate
330 Hart Senate Office Building
Washington, DC 20510

Edward Markey
US Senate
218 Russell Senate Office Building
Washington, DC 20510

Jeanne Shaheen
US Senate
506 Hart Senate Office Building
Washington, DC 20510

Elizabeth Warren
US Senate
317 Hart Senate Office Building
Washington, DC 20510

Dinell Clark
President
Williamsburg Condominium I
197 Wellman Avenue
North Chelmsford, MA 01863

Richard Howe
Register of Deeds - Middlesex County North
360 Gorham Street
Lowell, MA 01852

ATTACHMENT A

2277
BT 401.2.5
Art 38

REVISED REPORT ON RECREATIONAL RESOURCES
FOR THE
LOWELL HYDROELECTRIC PROJECT

FERC PROJECT NO. 2790

INTRODUCTION

This revised report on recreational resources for the Lowell Hydroelectric Project, FERC Project No. 2790, is submitted in conformance with Article 38 of the Order issuing license (Major) dated April 13, 1983. It modifies and supplements Section E-5 of Exhibit E (Report on Recreational Resources) to the Application for License (Major Project - Existing Dam) dated May 20, 1980. Except as modified or supplemented herein, Section E-5 is hereby incorporated in and made a part of this revised recreational resources report by reference.

Article 38 requires that this revised report provide additional information in the following areas:

- o The navigation lock in the proposed control structure.
- o The Northern Canal walkway.
- o The Northern Canal gates.
- o The visitor facility at the proposed powerhouse.
- o The canal system water elevation maintenance plan.

These items are addressed in the remainder of this revised report.

As a preliminary matter, Boott notes that it had not reached agreement with the Massachusetts Department of Environmental Management (DEM) concerning acquisition of certain canal properties and water rights for the Lowell Heritage State Park at the time Boott filed its license application the with Commission. As a result of on-going negotiations during the past year, however, the DEM and Boott have reached an agreement in this regard. Counsel for the DEM, the firm of Murphy, Crowley, Spencer and Dray, are presently completing the necessary appraisals to finalize the so-called "Orders of Taking." These orders will enable the Commonwealth of Massachusetts to take the necessary land and water rights by condemnation rather than conveyance and establish what is considered clear title for all time for the State. This process has been agreed to by both the DEM and Boott and both parties anticipate executing a final agreement by May 15, 1984.

NAVIGATION LOCK

The navigation lock and control structure are shown in plan and section in drawing 3844D-CC-001, which is attached. This functional drawing has been developed in consultation with the National Park Service (NPS). Initially, a gabion and rock-fill control structure was planned with a reinforced concrete lock structure. Recently, two alternative designs were considered and a decision was made to use a concrete control structure and lock. The design details shown on the functional drawing are intended to be fully responsive to the requirements and suggestions of the NPS.

Construction of the control structure and lock is scheduled to begin in mid-May 1984 and be completed by the end of August 1984. A cofferdam was constructed across the Northern Canal and the section of the Canal from the Northern Gatehouse to the cofferdam dewatered in November 1983. Total direct construction costs of the navigation lock, exclusive of interest expense during construction and financing fees, is $175,000.

NORTHERN CANAL WALKWAY

The Northern Canal walkway begins at the Pawtucket Bridge where it is accessed through an iron gate and down several granite steps. It runs about 2200 feet along the Canal to its termination at the site of the new powerhouse. The continuity of the walkway has been interrupted for many years because of the deteriorated condition of a cantilevered section around the waste gatehouse approximately 200 feet from the project site. This section could only be transited by walking through the waste gatehouse, a structure normally kept locked. Thus, the entire walkway has not been open to the public in the past, except for special tours conducted by NPS guides.

Access to the walkway has now been further interrupted by the excavation of the forebay serving the new powerhouse and will so remain until the powerhouse intake structure is completed. Continuity of the walkway will then by reestablished across the powerhouse intake, ultimately providing good pedestrian access. This access will be barrier-free and utilizes design concepts set out in "Accommodation of Handicapped Visitors at Historic Sites," U.S. Department of the Interior, National Park Service. Throughout construction, however, virtually the entire length of the walkway remains accessible from the entrance gate at the Pawtucket Bridge to the waste gatehouse.

Drawings 2601-08-02 and 03 show the route of the walkway from the Great River Wall thru the waste gatehouse across the powerhouse intake at station 3+96.00 to the access road and Pawtucket Street. The walkway is not explicitly labeled in these drawings as their primary focus is the general layout of the new powerhouse and tailrace.

The construction of the powerhouse and integral intake structure will commence in April 1984 and be completed in November 1984. The cost of the work associated with the walkway is not readily ascertainable, as it is an integral part of the powerhouse. However, these costs have been included in Boott's determination of total project costs.

NORTHERN CANAL GATES

A total of ten sluice gates control the flow of water into the Northern Canal. Each of these is approximately

8 feet wide and 15 feet high with a depth of 12 inches. All gates currently remain intact and are in place.

The gates are considered to be in good condition except for the lifting mechanisms. Wear and tear on the gates over the years has reduced the thickness of the wood at the top of most gates from 12 inches to as little as 4 inches. This has caused many of the yokes to become loosened or unattached. The gate lifting mechanism is attached to the yoke thereby enabling the gates to be opened or closed.

Repair of the gates will consist of removing the yokes, rebuilding the worn top section of the gates to their original thickness of 12 inches, and refastening the yokes. Broken or missing pieces of the lifting mechanisms will be replaced in kind, or as approved by the NPS. It is anticipated that all remedial work can be accomplished while the gates remain in place. The work is scheduled to begin in May 1984 and completed by October 1984 at a total cost of $80,000. License Application Exhibit F-16, attached, provides the details of the Northern Canal Gatehouse. There are no functional drawings applicable to the repair of the gate.

<u>VISITOR FACILITY</u>

The visitor facility will be contructed concurrently with the powerhouse, of which it is an integral part. It consis of two separate rooms within the powerhouse: A small reception room complete with restroom facilities on top of the intake structure adjacent the walkway, and a visitor's gallery overlooking the turbine-generator via observation windows provided for this purpose. Drawings 2601-08-12 and 14, which are attached, show these rooms. The details of the exhibits and interpretive materials to be placed in these rooms, as discussed in the Report on Recreational Resources, have not as yet been finalized. These details will be worked out with the NPS throughout the construction period, cointinuing after commencement of commercial operations. They will be finalized prior to the 1986 tourist season.

Substantial progress has been made regarding the use of the powerhouse and the visitor facility by the University of Lowell. The lease agreement between Boott and the University calls for the following:

- The preservation of all models made by Boott or its contractor during design and construction for study and experimentation by students and instructors.

- The provision of at least 1000 square feet adequate fo non-exclusion, periodic use as a classroom.

- The provision of a 12-inch diameter conduit embedded in the powerhouse to enable hydraulic experiments to be conducted by students and instructors.

- The preservation of instrumentation used in the startup and testing of the plant.

- The provision of reasonable access to the plant for the purpose of making a videotape or film record of the construction of the project.
- The provision of access to data associated with the operation of fish passage facilities.

These details are discussed in Article 4 of the Lease Agreement between the University of Lowell and Boott, which is appended to this report.

As mentioned previously, the powerhouse construction will begin in April 1984 and be completed in November 1984. The finishing and outfitting of the powerhouse, including the visitor facility is scheduled to begin in April 1985 and be completed in late September 1985. The final outfitting of the visitor facility with exhibits, interpretive materials, models, etc. is scheduled for April of 1986. The cost of the visitor facility is difficult to ascertain, as it is an integral part of the powerhouse. However, Boott has included such cost in its determination of total project costs.

CANAL SYSTEM WATER ELEVATION MAINTENANCE

The canal system water surface elevations have been the subject of discussions with the NPS on various occasions extending back to March 1980. The principal concern is the clearance required by tour boats under the low bridges that span the canals. After considerable study of the canal system, the tour boat plans of the NPS, and the clearance constraints, Boott has agreed to lower the water surface elevation of the lower canal system by 3 to 6 inches during navigation periods. This is believed by all parties to satisfy the requirements for tour boat passage from the Concord River through the lower and upper Canal Systems to the reservoir impounded by the Pawtucket Dam.

SKADDEN, ARPS, SLATE, MEAGHER & FLOM
919 EIGHTEENTH STREET, N.W.
WASHINGTON, D.C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3931

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
(212) 371-6000

ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002

ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

VIA FEDERAL EXPRESS

Carol Cunningham, P.E.
International Engineering
Company, Inc.
777 Post Road
Darien, Connecticut 06820

Re: Lowell Hydroelctric Project
Artice 20 and Article 38

Dear Carol:

As I mentioned in our conversation last Friday, I received a telephone call from Mr. John Young, Chief of the Recreation and Land Use Section of the Division of Hydropower Licensing at the FERC regarding the Article 20 and Article 38 filing which we submitted on April 16, 1984.

The purpose of Mr. Young's phone call was to informally notify us (rather than sending out a deficiency letter at this time) that he would not begin processing our Article 38 Revised Recreational Report until we forward the letters of comment from the Massachusetts State Historic Preservation Officer, the National Park Service and the Massachusetts Department of Environmental Management. He requested our follow-up filing discuss any issues raised in the comment letters of these agencies and either explain how we have resolved the issues raised or, if necessary, explain why we are unable to respond to their comments. In particular, with regard to SHPO, he requested we obtain a finding that the Revised Recreational Report for the Project would have "no adverse effect" on the Lowell Historic District. Mr. Young also stated that he presently had no problem with our position that an Article 20 reservoir clearing plan is unnecessary.

As you requested, I have enclosed copies of the cover letters we sent out to the three agencies and a copy of the Revised Report which has been red-lined to show the minor technical changes that we made.

Sincerely,

June

June P. Broadstone

Enclosures

cc: Mr. Melvin G. Lezberg

SKADDEN, ARPS, SLATE, MEAGHER & FLOM
919 EIGHTEENTH STREET, N.W.
WASHINGTON, D.C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3951

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
(212) 371-6000

ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002

ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

Mr. S. Christopher Scott
Commonwealth of Massachusetts
Department of Environmental Management
100 Cambridge Street
Boston, Massachusetts 02108

Re: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Mr. Scott:

On April 12, 1984, Boott Hydropower, Inc. ("Boott") submitted for your review and comment the Revised Report on Recreational Resources (the "Revised Report") for the Lowell Hydroelectric Project, which was prepared in accordance with Article 38 of the Federal Energy Regulatory Commission (the "FERC") project license. On April 16, 1984, a copy of the Revised Report was filed with the FERC.

The Revised Report filed with the FERC contained certain minor changes. For your information and convenience, I have enclosed a redlined copy of the report as filed with the FERC on April 16, 1984. These changes were technical and did not affect the substance of the report. No changes were made to any of the attachments to the report.

We continue to look forward to your early response to the Revised Report.

Very truly yours,

June Broadstone

June P. Broadstone
Attorney for Boott
Hydropower, Inc.

Enclosure

SKADDEN, ARPS, SLATE, MEAGHER & FLOM
919 EIGHTEENTH STREET, N W
WASHINGTON, D.C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3931

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
(212) 371-6000

ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002

ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

Mr. John Burchill
U.S. Department of the Interior
National Park Service
Lowell National Historic Park
171 Merrimack Street
Lowell, Massachusetts 01853

Re: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Mr. Burchill:

On April 12, 1984, Boott Hydropower, Inc. ("Boott") submitted for your review and comment the Revised Report on Recreational Resources (the "Revised Report") for the Lowell Hydroelectric Project, which was prepared in accordance with Article 38 of the Federal Energy Regulatory Commission (the "FERC") project license. On April 16, 1984, a copy of the Revised Report was filed with the FERC.

The Revised Report filed with the FERC contained certain minor changes. For your information and convenience, I have enclosed a redlined copy of the report as filed with the FERC on April 16, 1984. These changes were technical and did not affect the substance of the report. No changes were made to any of the attachments to the report.

We continue to look forward to your early response to the Revised Report.

Very truly yours,

June Broadstone

June P. Broadstone
Attorney for Boott
Hydropower, Inc.

Enclosure

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(302) 429-9200
515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

Ms. Patricia Weslowski
State Historic Preservation Officer
Massachusetts Historic Commission
294 Washington Street
Boston, Massachusetts 02018

Re: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Ms. Weslowski:

On April 12, 1984, Boott Hydropower, Inc. ("Boott") submitted for your review and comment the Revised Report on Recreational Resources (the "Revised Report") for the Lowell Hydroelectric Project, which was prepared in accordance with Article 38 of the Federal Energy Regulatory Commission (the "FERC") project license. On April 16, 1984, a copy of the Revised Report was filed with the FERC.

The Revised Report filed with the FERC contained certain minor changes. For your information and convenience, I have enclosed a redlined copy of the report as filed with the FERC on April 16, 1984. These changes were technical and did not affect the substance of the report. No changes were made to any of the attachments to the report.

We continue to look forward to your early response to the Revised Report.

Very truly yours,

June Broadstone

June P. Broadstone
Attorney for Boott
Hydropower, Inc.

Enclosure

401.2.5 Art 38
JUN 11 1984

SKADDEN, ARPS, SLATE, MEAGHER & FLOM

919 EIGHTEENTH STREET, N.W.
WASHINGTON, D.C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3931

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BOSTON, MASSACHUSETTS 02108
(617) 523-0002

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WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

June 5, 1984

HAND DELIVERED

Honorable Kenneth F. Plumb
Secretary, Federal Energy Regulatory
Commission
825 N. Capitol Street, NE
Washington, DC 20426

Re: Lowell Hydroelectric Project
Project No. 2720

Dear Mr. Plumb:

Boott Hydropower, Inc., ("Boott"), joint licensee for Project No. 2790, hereby submits the comments that it has received from the Massachusetts State Historic Preservation Officer (the "SHPO") and the National Park Service (the "NPS") approving the Revised Report on Recreational Resources (the "Revised Report"), which was filed by Boott pursuant to Article 38 of the License on April 16, 1984.

As indicated by the comments of NPS, Boott has been and will continue to work closely with NPS regarding the development of the navigation lock in the proposed control structure, the restoration of the Northern Canal gates and the reconstruction of the Canal walls. In addition, within the next six months Boott will be developing plans for improvements to the Northern Canal walkway. Consistent with the manner in which Boott has conducted agency consultations in the past, the plans will be submitted to NPS and SHPO for their review and comment.

While comments have been solicited on the Revised Report from the Massachusetts Department of Environmental Management (the "DEM"), a response has not yet been received. Boott has renewed its request to DEM for comments (see enclosed letter) and will promptly forward the comments when they are available.

Respectfully submitted,

June P. Broadstone

June P. Broadstone
Attorney for Boott Hydropower, Inc.

Enclosures

CERTIFICATE OF SERVICE

I hereby certify that I have this 5th day of June, 1984, served a copy of the foregoing "Letter to the Honorable Kenneth F. Plumb" by first class mail, postage prepaid upon all persons on the attached Service List in accordance with the requirements of Rule 2010 of the Commission's Rules of Practice and Procedure.

June P. Broadstone

June P. Broadstone
Attorney for Boott Hydropower, Inc.

<u>SERVICE LIST</u>

Atlantic Associates
576 Lawrence Street
Lowell, Massachusetts 01582

Mr. G. E. Boutin
General Manager, Lawrence
Hydroelectric Associates
6 Essex Street
Lawrence, Massachusetts 01852

Commonwealth of Massachusetts
Bureau of Wildlife Research
and Management
Division of Fisheries and
Wildlife
Field Headquarters
Westboro, Massachusetts 01581
Attention: Carl Prescott,
Superintendent

Joseph P. Donahue, Jr.
Donahue & Donahue
21 George Street
Lowell, Massachusetts 01582

Frances E. Francis, Esquire
Spiegel & McDiarmid
2600 Virginia Avenue, NW.
Washington, D.C. 20037

Joel L. Greene, Esquire
Chapman, Duff & Paul
1730 Pennsylvania Avenue, N.W.
Washington, D. C. 20006

National Marine Fisheries
Service
Habitat Protection Branch
7 Pleasant Street
Gloucester, Massachusetts 01930
Attention: Douglas W. Black

Mr. Richard A. Norman
New Hampshire Hydro Associates
110 Tremont Street
Boston, Massachusetts 02116

U.S. Department of the Interior
Fish and Wildlife Services
P.O. Box 1518
Concord, New Hampshire 03301
Attention: Gordon E. Beckett,
Supervisor

U.S. Department of the Interior
National Park Service
Lowell National Historic
171 Merrimack Street
Lowell, Massachusetts 01853

David B. Ward, Esq.
Farmer, McGuinn, Flood,
Bechtel & Ward
1000 Potomac Street, NW
Suite 402
Washington, DC 20007

Ms. Patricia Weslowski
State Historic Preservation
Officer
Massachusetts Historic Commission
294 Washington Street
Boston, Massachusetts 02018

MASSACHUSETTS
HISTORICAL
COMMISSION

COMMONWEALTH OF MASSACHUSETTS
Office of the Secretary of State
294 Washington Street
Boston, Massachusetts
02108
617-727-8470

MICHAEL JOSEPH CONNOLLY
Secretary of State

April 19, 1984

Ms. Carol Cunningham
Principal Civil Engineer
International Engineering Company, Inc.
777 Post Road
Darien, CT 06820

RE: Revised Report on Recreational Resources, Lowell Hydroelectric Project

Dear Ms. Cunningham:

Thank you for providing this office with the Revised Report on Recreational Resources for the Lowell Hydroelectric Project.

I see no conflicts in the proposed Recreational Resources with the National Historic Landmark District. This office however should review design plans for the development of the Northern Canal walkway.

If you should have any questions please contact Joseph Orfant of the Commission staff.

Sincerely,

Valerie Talmage

Valerie A. Talmage
Executive Director
Massachusetts Historical Commission

VAT/vh

IECO			
Eastern District			
APR 23 '84			
To	A		
4/23 CHC			X

X June Broadstone

United States Department of the Interior

NATIONAL PARK SERVICE

Lowell National Historical Park
169 Merrimack Street
Lowell, Massachusetts 01852

IN REPLY REFER TO:

I E C O
Eastern District

MAY 31 '84

C–		I	O
To	A	I	R
5/31 CHC			1

cc June Broadstone

May 25, 1984

D-18

Ms. Carol Cunningham, P.E.
Principal Civil Engineer
International Engineering Company
50 Washington - 9th floor
Norwalk, Connecticut 06854

Dear Carol:

Reference: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Lowell National Historical Park has reviewed the Revised Report on Recreational Resources for the Lowell Hydroelectric Project, FERC Project 2790, and we do not wish to raise any major concerns at this time.

The Park will continue to provide review and technical assistance for the project in the following areas:

-- The navigation lock in the proposed control structure

-- The Northern Canal walkway

-- The Northern Canal gates restoration

-- Canal walls reconstruction

As the project proceeds with this input, the goals of preserving the canal system and making it available for recreational use, are being achieved.

The National Park Service is pleased to have the opportunity to assist in this project, and we look forward to its completion and availability to the Park visitor.

Sincerely,

John Burchill

John J. Burchill
Superintendent

CONSULTING
ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY

EASTERN DISTRICT OFFICE
50 WASHINGTON ST 9TH FLOOR
NORWALK CONN 06854
TELEPHONE (203) 838-3300

2601-410-A
0358c
47700

June 1, 1984

Mr. S. Christopher Scott
Commonwealth of Massachusetts
Department of Environmental Management
100 Cambridge Street
Boston, Massachusetts 02108

Subject: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Chris:

On April 12, 1984 I sent you a Revised Report on Recreational Resources for your review and comment. This report was subsequently filed with FERC on April 16, 1984 with minor technical changes. You were sent a copy of the report as it was filed with FERC by June Broadstone on June 23, 1984.

I have been unable to contact you by telephone to discuss any comments you may have on the revised report. May I please have your written comments as soon as possible so I may file them with FERC pursuant to Article 38 of our FERC license?

If you have any questions or wish to discuss any aspect of this report, please feel free to give me a call.

Very truly yours,

Carol H. Cunningham, P.E.
Principal Civil Engineer

CHC:nba

P.S. Please note our change of address.

cc: June Broadstone, Skadden-Arps

ATTACHMENT B

Canal elevations review, on-site at Lowell project canals
Review occurred by NPS and Boott/CRP, OCT 4 2021

Assumptions

1) All elevations moving forward should be on NGVD '29 datum (87.2' Pawtucket dam crest, 92.2' NWL impoundment, etc.)
2) "Upper" canal system would have a single, target elevation throughout
3) The single canal "target" or desired elevation is **always the higher value** of the max-min range established at any location

Conditions

1) The "Upper" canal system was lower than normal near Tremont/Wannalancit due to operation of the Western canal gates and Y
2) The Lower Pawtucket and Eastern canals were lower than normal due to site evaluation at Merrimack College; by CRP

Locations

Swamp Locks, Lower Locks, Tremont/Western canal and Hydrolocks were visited
Francis Gate Complex and Boott Mills not visited

Gage changes

Hamilton Wasteway gage--(discontinue) identical info to existing Swamp Locks gage
Section 8 (Bridge St) intake gage--(discontinue) replaced by existing and planned Lower Locks and Boott Mills gages
Swamp Locks--no change, existing staff gage on upstream left abutment
Tremont Gatehouse--add new gage, to note lower Northern Canal level
Boott Mills gage at Unit #6 intake, from catwalk--relocate to inside nearby Boott Gatehouse, provide NPS access (location on catwa
*"historic" gages with PL&C datum can remain, but will not be used for monitoring target canal elevations

Ranges

1) Acceptable range over target elevation is 0.25' (3"), after which action should be taken to achieve target elevation
2) Acceptable range under target elevation is 0.5' (6"), after which action should be taken to restore target elevation

Monitoring

Boott will establish flows/levels to targets, then monitor & document canal target elevations weekly (physical, visual staff gages)
NPS already monitors canal elevations daily, and more frequently as necessary during tour vessel operating periods
Boott still plans to accommodate atypical, stakeholder-requested canal draws as necessary for maintenance, debris removal, etc.

"Upper Swamp" gage
located on Gatehouse left abutment, near boating access ramp
monitored daily by NPS

		TARGET	
	Elevation 10/4/21 (ft. NGVD 1929)	Max desired (ft. NGVD 1929)	Min desired (ft. NGVD 1929)
NPS gage	86.25	**86.7**	**84.5**
PL&C		81.5	

Tremont Gatehouse
no gage available

*Elevation targets are the same as Swamp Locks, since both locations are on the Upper canal system

		TARGET	
	Elevation 10/4/21 (ft. NGVD 1929) MEASURED	Max desired (ft. NGVD 1929)	Min desired (ft. NGVD 1929)
NPS gage	84.27	**86.7**	**84.5**
PL&C		81.5	

The water level @ Tremont would rise 2.43' (from OCT 4 inspection) if the Upper system was operated at

Lower Locks gage
located on Gatehouse right abutment, near personnel access ramp
monitored daily by NPS

	Elevation 10/4/21 (NPS datum)	**TARGET** Max desired (ft. NGVD 1929)	Min desired (ft. NGVD 1929)
NPS gage	-0.5'	**71.8**	**70.2**
PL&C		66.6	65.0

ATTACHMENT C

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
CANALS					
Pawtucket Canal	Upper Pawtucket Canal (Downstream from Guard Locks and Gates Complex)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal[a] • Boott Water and Flowage Rights[b] • MADCR Recreation Rights and Exclusive Easement Rights[c]	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and urban aesthetics). • Maintain safety features in accordance with the existing Public Safety Plan (PSP)(for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Lower Pawtucket Canal	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and urban aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Hamilton Canal	–	Boott Hydropower LLC (Boott)	• MADCR Recreation Rights and Exclusive Easement Rights	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and urban aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain these structures as the owner, including maintaining water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Hamilton Wasteway	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and urban aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain these structures as the owner, including maintaining water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of a 400-foot stretch of the Western Canal. • Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of a 400-foot stretch of the Western Canal.
	Tremont Wasteway	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain these structures as the owner, including maintaining water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Lawrence Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain these structures as the owner, including maintaining water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Lawrence Wasteway	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain these structures as the owner, including maintaining water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Merrimack Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of a 400-foot stretch of the Western Canal. • Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of a 1,000-foot stretch of the Merrimack Canal (Downstream from Moody Street Feeder Gatehouse).
Eastern Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of a 400-foot stretch of the Western Canal. • Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of most of the Eastern Canal.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
	Merrimack (Massachusetts) Wasteway	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain these structures as the owner, including maintaining water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Northern Canal - Hydro Locks to Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of a 400-foot stretch of the Western Canal. • Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of the Northern Canal (from Hydro Locks to Western Canal).

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
DAMS, GATEHOUSES, AND LOCK STRUCTURES					
Swamp Locks Complex	Swamp Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures[d]	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Swamp Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures		
	Swamp Locks Dam (North and South)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	• Continue to operate as present (for water level management). • Maintain as needed (for water level management).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	• Continue to operate as present (for water level management). • Maintain as needed (for water level management).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Lower Locks Complex	Lower Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Lower Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures		

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
	Lower Locks Dam	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights[e]	• Continue to operate as present (for water level management). • Maintain as needed (for water level management).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Lower Locks Pier and Fill Valve	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Moody Street Feeder	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of a 400-foot stretch of the Western Canal. • Maintain canal walls as appropriate (for public safety and water level management). • Waterborne trash and vegetation management as appropriate (for structural stability and aesthetics). • Maintain safety features in accordance with the existing PSP (for public safety).	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable along the bottom of the Moody Street Feeder.
Moody Street Feeder Gatehouse and Gates	–	National Park Service	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	• Continue to operate as present (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Lawrence Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Hall Street Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Hamilton Canal Guard Gates	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Hamilton Gatehouse and Gate (Superstructure)	–	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Hamilton Gatehouse and Gate (Substructure)	–	Boott	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights		
Tremont Gatehouse (Superstructure)	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	• Continue to operate as present (for water level management). • Maintain as needed (for water level management).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Tremont Gatehouse (Substructure)	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Maintain safety features in accordance with the existing PSP (for public safety).	line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Merrimack Gate	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Massachusetts Wasteway Gatehouse (Superstructure)		MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Massachusetts Wasteway Gatehouse (Substructure)		Boott	• MADCR Recreation Rights and Exclusive Easement Rights		
Rolling Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Rolling Dam Gatehouse (North and South)	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Boott Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Boott Dam Gatehouse (Superstructure)	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Boott Dam Gatehouse (Substructure)	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights		

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Merrimack Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
Boott Penstock	-	MADCR	• Boott Water and Flowage Rights	• Continue to operate as present (for water level management). • Maintain as needed (for water level management). • Maintain safety features in accordance with the existing PSP (for public safety).	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements, and to continue with standard safety practices.
DOWNTOWN POWERHOUSES					
Assets	Intakes	Proprietors of Locks & Canals	–	Install concrete plug-in penstock opening at canal wall.	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Penstocks	Proprietors of Locks & Canals[f]	• Boott Easement to Penstocks and Tailraces[g]	Infill or brace as necessary based on results of an engineering assessment.	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers[h]	Remove transformer from the substation	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Turbines	Boott	–	Remain in place	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Generators	Boott	–	Disconnect the generators and switch gear	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Switchgear	Boott	–	Disconnect the generators and switch gear	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
Hamilton	Intakes	Boott	–	Install concrete plug-in penstock opening at canal wall.	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Turbines	Boott	–	Remain in place	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Generators	Boott	–	Disconnect the generators and switch gear	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Switchgear	Boott	–	Disconnect the generators and switch gear	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
John Street	Intakes	Boott	–	Install concrete plug-in penstock opening at canal wall.	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Turbines	Boott	–	Remain in place	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety practices.
	Generators	Boott	–	Disconnect the generators and switch gear	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
	Switchgear	Boott	–	Disconnect the generators and switch gear	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety practices.
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety practices.
Bridge Street (Section 8)	Intakes	Boott		• Install concrete plug-in penstock opening at canal wall. • Retain a 5' corridor for submarine interconnection cable.	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable through the intake.
	Penstocks	Boott	• Boott Easement to Penstocks and Tailraces	• Infill or brace as necessary based on results of an engineering assessment. • Retain a 5' corridor for submarine interconnection cable.	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable through the penstock.
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes
	Turbines	Boott	–	Remain in place	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Generators	Boott	–	Disconnect the generators and switch gear	• These measures and their purposes will not serve any Project purposes; as the owner, it is Boott's intent to continue with standard safety and decommissioning practices.
	Switchgear	Boott		• Disconnect the generators and switch gear • Retain any equipment necessary for interconnection purposes.	• For Project purposes, Boott will retain as needed for interconnection purposes.
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	• Remain in place • Retain a 5' corridor for submarine interconnection cable	• For Project purposes, Boott will repair, maintain, replace as needed the 5' corridor for submarine interconnection cable through the tailrace.

Structure	Subcomponents	Ownership	Other Rights	Specific Measures (and Purposes)	Specific Measures Needed for Proposed Project Purposes

[a] Easement to the Pawtucket Canal, Lower Pawtucket Canal, the Swamp Locks Dam and Lower Locks Dam for the uninterrupted flowage of water to the canals, together with the right to install conduits, pipes and wiring, and the right to maintain, repair, and replace canal walls and fences, and to maintain and operate Swamp Locks Dam and Lower Locks Dam. See pg. 4-5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[b] Any and all water rights which may exist regardless of how acquired, including, without limitation, any and all water rights by way of riparian rights. See pg. 4-7 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete description of said rights.

[c] All air rights over the canals, including the canal walls and any dams thereon. The exclusive right to use water in the entire canal system and the Merrimack River for recreational, educational, and navigational purposes. For a complete legal description of these rights, see Order of Taking pg. 27 – 28, filed as Appendix C of the Resources, Ownership, Boundaries, and Land Rights Study Report, filed with the Commission on February 25, 2021.

[d] Exclusive right of operating and controlling the gatehouses and locating, keeping in place, maintaining, replacing, operating, controlling and disposing of the control machinery and equipment, gauge equipment and other mechanisms located therein and for access and repair of the gatehouses and access to and maintenance, repair, and installation of the control machinery and equipment, gauge equipment and such other mechanisms located therein that may need to be repaired, reconstructed, or replaced See pg. 5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

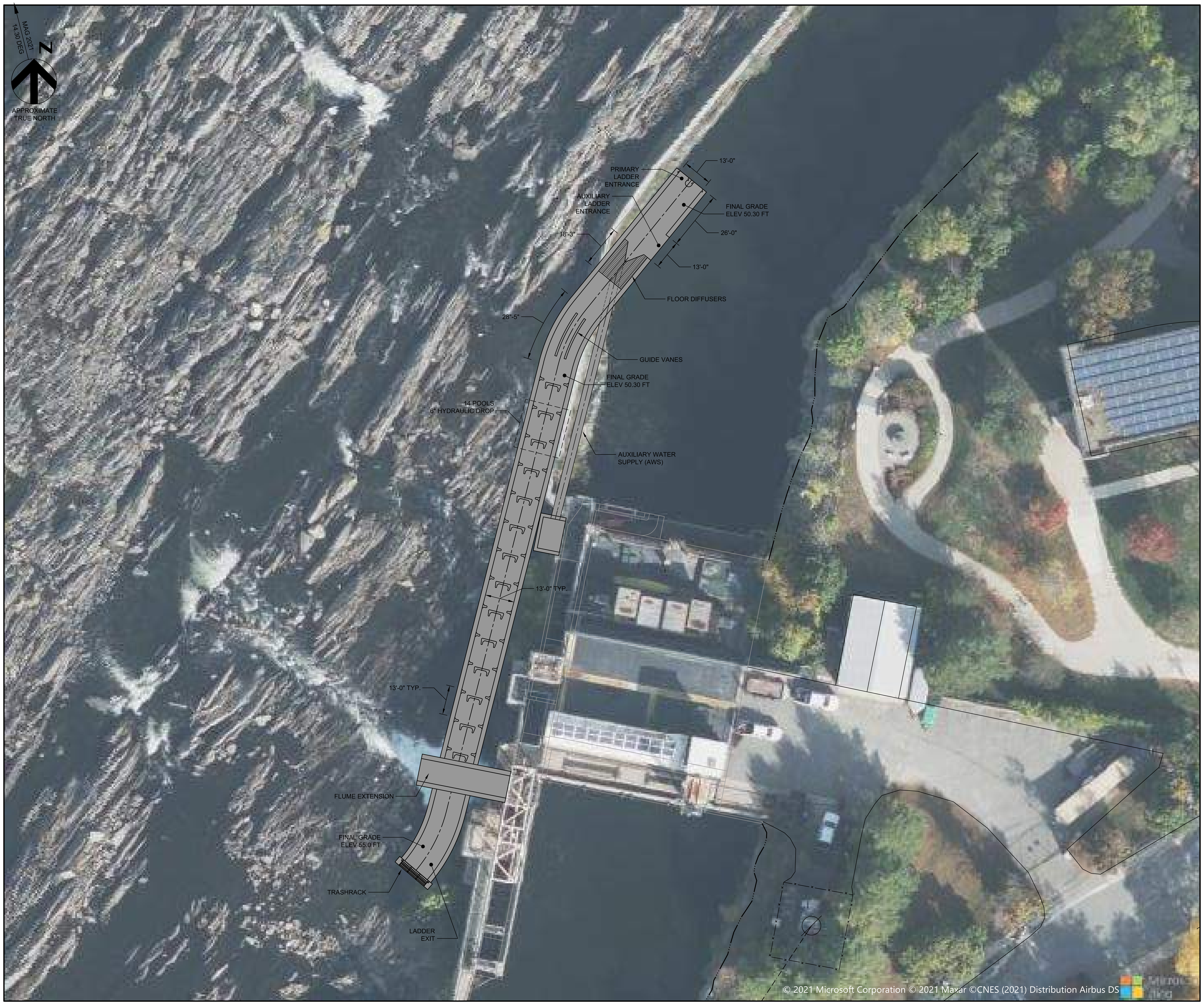
[e] Right to conduct land and canal tours, run interpretive programs and maintenance, improvement and restoration of Gatehouses and support structures, Dams, and Lock Chambers. See pg. 3 of the Grant of Easement (filed as Appendix D to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[f] Presumed ownership, to be confirmed.

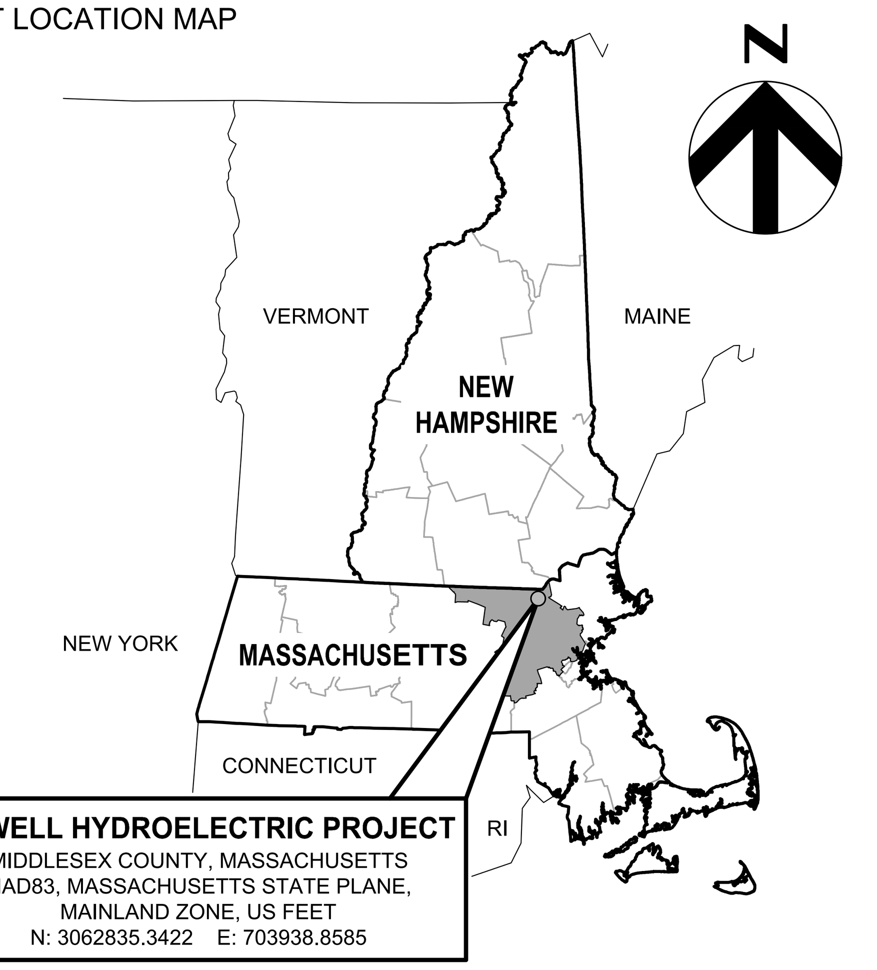
[g] Boott holds an easement to operate, maintain, repair, and replace penstocks leading from the Merrimack Canal, Eastern Canal or Hamilton Canal. Boott holds an easement to operate, maintain, repair, and replace tailraces leading to the Pawtucket Canal, the Concord River, or the Merrimack River. See pg. 8 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[h] An easement to keep in place, locate, operate, maintain, repair, remove and replace the transformers and an easement for unrestricted access thereto for such purposes. See pg. 9 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

ATTACHMENT D



PROJECT LOCATION MAP



APPROXIMATE SCALE: 1"=50 MILES

LEGEND

(hatched)	FLOOR DIFFUSERS
(shaded)	CONCRETE
(line)	STRUCTURE
(dash-dot line)	STRUCTURE CENTERLINE
(line)	AWS PIPE
(dash line)	AWS PIPE CENTERLINE

REFERENCE COORDINATE METADATA

PROJECTION - MASSACHUSETTS STATE PLANE
DATUM - NAD83, MAINLAND ZONE; NAVD88 VERTICAL
UNITS - U.S. SURVEY FEET

NOTES

1. CONCEPT PROVISIONAL AND SUBJECT TO CHANCE IN FUTURE DESIGN ITERATIONS.
2. ASSUMED DESIGN TAILWATER:
   a) HIGH TOTAL RIVER FLOW 26,000 CFS, WSELEV 60.1 FT (NAVD88)
   b) LOW TOTAL RIVER FLOW 1,750 CFS, WSELEV 54.3 FT (NAVD88)
3. ASSUMED DESIGN HEADWATER:
   a) HIGH TOTAL RIVER FLOW 26,000 CFS, WSELEV 66.7 FT (NAVD88)
   b) LOW TOTAL RIVER FLOW 1,750 CFS, WSELEV 59.0 FT (NAVD88)
4. MAXIMUM HYDRAULIC DROP PER POOL AT LOW OR HIGH HEAD = 0.5 FT
5. MINIMUM DEPTH AT ENTRANCE AND EXIT = 4.0 FT
6. MINIMUM DEPTH IN LADDER IS 3.0 FT BASED UPON LADDER CAPACITY FOR ANTICIPATED PEAK DAILY FISH ABUNDANCE
7. TOTAL ATTRACTION FLOW (COMBINATION OF LADDER FLOW AND AUXILIARY WATER SUPPLY [AWS]) CONFIGURATION FOR 330 CFS MAX FLOW APPROXIMATE BASED UPON INFORMATION AVAILABLE TO DATE. THIS FLOW REPRESENTS 5% OF THE MAXIMUM HYDRAULIC CAPACITY OF THE PROJECT'S TWO TURBINES. MAY BE INCORPORATED INTO DOWNSTREAM FISH PASSAGE SYSTEM AS DESIGN DETAILS ARE COMPLETED.

CONCEPT FISH PASSAGE SHEET 1 OF 1

LOWELL HYDROELECTRIC PROJECT
BOOTT MILLS
CONCEPT FISH LADDER PLAN

20 10 0 20 40 60 80

BOOTT HYDROPOWER, LLC FERC No. 2790

NOVEMBER 12, 2021	SCALE: 1"=20'	APPROVED: PENDING

PRELIMINARY - NOT FOR CONSTRUCTION

FERC NO. P-2790-XXXX

ATTACHMENT E

Final License Application Volume II of III

Part 1 - Exhibit E

Lowell Hydroelectric Project

(FERC No. 2790)

April 30, 2021
Revised November 15, 2021

Prepared by:

HDR

Prepared for:

Boott Hydropower, LLC
Manchester, New Hampshire

Central Rivers Power

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List of Acronyms

μS/cm	microsiemens per centimeter
ACHP	Advisory Council on Historic Preservation
ADA	Americans with Disabilities Act
APE	area of potential effects
ASRSC	Atlantic Sea Run Salmon Commission
AW	American Whitewater
BMI	Benthic macroinvertebrates
Boott	Boott Hydropower, LLC (or Licensee, or Applicant)
CEII	Critical Energy Infrastructure Information
CFPP	Comprehensive Fish Passage Plan
C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
Chapter 91	M.G.L. Chapter 91 of the Waterways Act
CMR	Codes of Massachusetts Regulations
CSO	Combined Sewer Overflow
CSPA	Comprehensive Shoreland Protection Act
CWA	Clean Water Act
DDT	Dichlorodiphenyltrichloroethane
DLA	Draft License Application
DMMSPs	Dam Safety Surveillance and Monitoring Plan
DO	dissolved oxygen
EA	Environmental Assessment
EAP	Emergency Action Plan
E.L. Field	Eldred L. Field
EPT	Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission (or Commission)
FGMP	Final General Management Plan
FHA	Federal Highway Administration
FLA	Final License Application

FPA	Federal Power Act
GECC	General Electric Credit Corporation
GIS	Geographic Information System
GPS	Global Positioning System
HAER	Historic American Engineering Record
ILP	Integrated Licensing Process
Integrated List	Integrated List of Waters
IPaC System	Information, Planning and Consultation System
IPANE	Invasive Plant Atlas of New England
ISR	Initial Study Report
kV	kilovolt
LHCDC	Lowell Historic Canal District Commission
LIHI	Low Impact Hydropower Institute
LMRLAC	Lower Merrimack River Local Advisory Committee
LNHP	Lowell National Historical Park
LRWU	Lowell Regional Water Utility
M	magnitude
MADCR	Massachusetts Department of Conservation and Recreation
MADEM	Massachusetts Department of Emergency Management
MADEP	Massachusetts Department of Environmental Protection
MADFW	Massachusetts Division of Fish and Wildlife
MADMF	Massachusetts Division of Marine Fisheries
Massachusetts NHESP	Massachusetts Natural Heritage Endangered Species Program
MassGIS	Massachusetts Bureau of Geographic Information
MDMR	Maine Department of Marine Resources
MDPW	Massachusetts Department of Public Works
MEOEEA	Massachusetts Executive Office of Energy and Environmental Affairs
MESA	Massachusetts Endangered Species Act
M.G.L.	Massachusetts General Law
mg/L	milligrams per liter
MHC	Massachusetts Historical Commission
MIPAG	Massachusetts Invasive Plant Advisory Group

MOU	Memorandum of Understanding
MRI	Merrimack River Initiative
MRTC	Merrimack River Technical Committee
MRWC	Merrimack River Watershed Council
MW	megawatt
MWh	megawatt hours
NAI	Normandeau Associates, Inc.
NEFMC	New England Fishery Management Council
New Hampshire NHB	New Hampshire Natural Heritage Bureau
NGOs	non-governmental organizations
NGVD 29	National Geodetic Vertical Datum 1929
NHDES	New Hampshire Department of Environmental Services
NHDFG	New Hampshire Department of Fish and Game
NHDHR	New Hampshire Division of Historical Resources
NHDNCR	New Hampshire Department of Natural and Cultural Resources
NHFGD	New Hampshire Fish and Game Department
NHL	National Historic Landmark
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRHP	National Register of Historic Places
NRPC	Nashua Regional Planning Commission
NTU	Nephelometric Turbidity Unit
NWI	Nation Wetland Inventory
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
PAD	Pre-Application Document
PM&E	protection, mitigation, and enhancement measures
Project	Lowell Hydroelectric Project

Proprietors	Proprietors of the Locks and Canals on the Merrimack River
PSP	Proposed Study Plan
Revised PPS	Revised Process Plan and Schedule and Determination on Requests for Study Modifications for the Lowell Hydroelectric Project
RM	river mile
RMC	RMC Environmental Services
ROR	run-of-river
RSA	Revised Statutes Annotated
RSP	Revised Study Plan
RTE	rare, threatened, and endangered
SAV	submerged aquatic vegetation
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SDR	Supporting Design Report
SD1	Scoping Document 1
SD2	Scoping Document 2
Section 106	Section 106 of the NHPA
SPD	Study Plan Determination
SHPO	State Historic Preservation Officer
stakeholders	resource agencies, federally recognized Indian tribes, non-governmental organizations (NGOs), and other interested parties
SWQS	surface water quality standards
Merrimack River Technical Committee	Representatives from NHDFG, MADFW, USFWS, USFS, NMFS
THPO	Tribal Historic Preservation Officers
TMDL	total maximum daily loads
TBSA	turbine blade strike analysis
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

VP	vegetation points
WPA	Wetlands Protection Act
WQC	Water Quality Certification
WUA	Weighted Useable Area
YOY	Young-of-year

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Exhibit E Environmental Report (18 C.F.R. § 5.18)

E.1 Introduction

Boott Hydropower, LLC (Boott or Licensee) is the Licensee, owner, and operator of the 20.16-megawatt (MW) Lowell Hydroelectric Project (Project or Lowell Project) (FERC No. 2790). Boott operates and maintains the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Commission, under the authority of the Federal Power Act (FPA), 16 United States Code (USC) §791(a), et seq., may issue a license for up to 50 years for the construction, operation, and maintenance of non-federal hydroelectric developments. The existing license was issued by FERC on April 13, 1983 and expires on April 30, 2023. Boott is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (C.F.R.) Part 5.

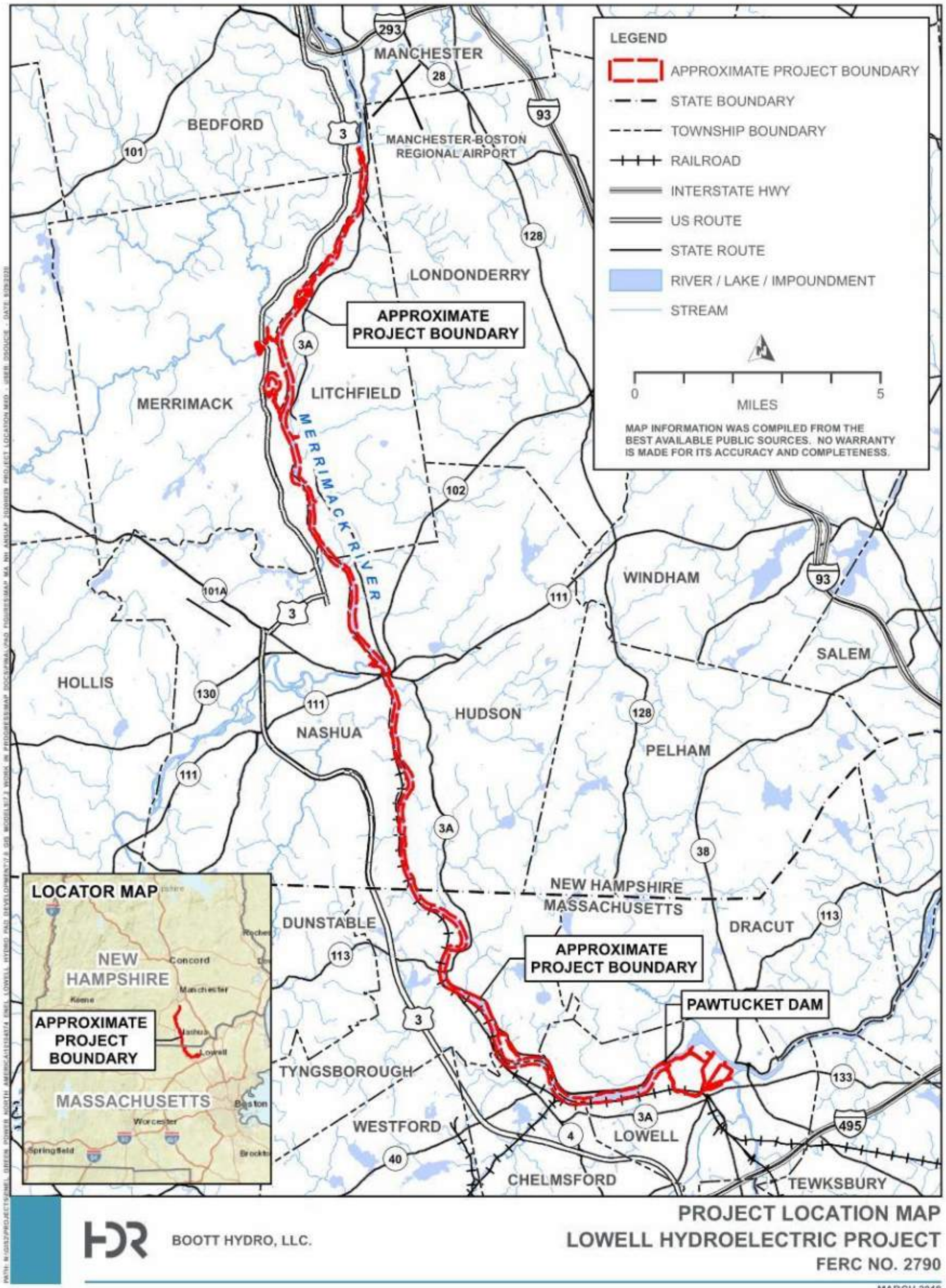
In accordance with the ILP and applicable regulations at 18 C.F.R. § 16.9(b), Boott must file its final application for a new license (Final License Application or FLA) with the Commission no later than April 30, 2021.

The Lowell Project is located at river mile (RM) 41 on the Merrimack River in the City of Lowell in Middlesex County, Massachusetts, with the current impoundment extending approximately 23 miles upstream into Hillsborough County, New Hampshire (Figure E.1-1).

The existing Lowell Project consists of:

1) A 1,093-foot-long, 15-foot-high masonry gravity dam (Pawtucket Dam) that includes a 982.5-foot-long spillway with a crest elevation of 87.2 feet National Geodetic Vertical Datum 1929 (NGVD 29) topped by 5-foot-high pneumatically-operated crest gates deployed in five independently-operable zones;
2) A 720-acre impoundment with a normal maximum water surface elevation of 92.2 feet NGVD 29;
3) A 5.5-mile-long canal system which includes several small dams and gatehouses;
4) A powerhouse (Eldred L. Field) which uses water from the Northern Canal and contains two turbine-generator units with a total installed capacity of 15.0 megawatts (MW);
5) A 440-foot-long tailrace channel;
6) Four powerhouses (Assets, Bridge Street, Hamilton, and John Street) housed in 19th century mill buildings along the Northern and Pawtucket Canal systems containing 15 turbine-generator units with a total installed capacity of approximately 5.1 MW;
7) A 4.5 mile-long, 13.8-kilovolt transmission line connecting the powerhouses to the regional distribution grid;
8) Upstream and downstream fish passage facilities including a fish elevator and downstream fish bypass at the Eldred. L. Field (E.L. Field) powerhouse, and a vertical-slot fish ladder at the Pawtucket Dam; and
9) Appurtenant facilities.

Figure E.1-1. Lowell Project Location and Existing Boundary Map



Boott proposes to eliminate the four mill powerhouses and associated canals from the new FERC license. The project features proposed to be retained in the new license include: the Pawtucket Dam; the E.L. Field powerhouse; the section of the Northern Canal and associated structures leading from the Pawtucket Dam to the E.L. Field powerhouse; the Hydro Locks; all fish passage facilities; and the Guard Lock and Gates facility. Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the National Park Service (NPS) and other stakeholders.

At the normal pond elevation of 92.2 feet NGVD 29 (crest of the pneumatic flashboards), the surface area of the impoundment encompasses an area of approximately 720[1] acres. The gross storage capacity between the normal surface elevation of 92.2 feet NGVD 29 and the minimum pond level of 87.2 feet NGVD 29 (spillway crest) is approximately 3,600[2] acre-feet. The Project operates in a run of river (ROR) mode using automatic pond level control of the E.L. Field units and has no usable storage capacity.

The Project's primary features are located along the Merrimack River in the City of Lowell, Massachusetts. The City of Lowell was founded in the early 1820s by Boston merchant capitalists and became one of the most significant planned industrial cities in America (Hay 1991). Lowell's factory system, which used the waterpower of the Merrimack River, incorporated new technologies to provide for the mass production of cotton cloth in mills throughout the city (NPS 1981). Lowell established the pattern for large-scale waterpower development for the next 50 years (Hay 1991).

Several Project facilities are located within overlapping locally, state, and nationally designated parks and historic properties and preservation districts. The Project's Pawtucket Dam and E.L. Field Powerhouse are located along the mainstem of the Merrimack River. The Project's existing two-tiered network of man-made canals extends throughout downtown Lowell. The 5.5-mile-long canal system provides flow to the Project's existing Hamilton, Assets, Bridge Street, and John Street developments. The Hamilton, Assets, Bridge Street, and John Street power stations and turbines are housed in large former mill buildings. The mill buildings are not included in the existing Project; the Project Boundary includes only the turbines and associated waterways and equipment at these downtown mill sites. In addition to the Pawtucket Dam and hydroelectric developments, the existing Project also includes miscellaneous civil works in the City of Lowell, including the Guard Lock and Gates, Moody Street Feeder Gatehouse, Lawrence Dam, Hall Street Dam, Tremont Wasteway, Lower Locks and Dam, Swamp Locks and Dam, Merrimack Dam and Merrimack Gate, Rolling Dam, and the Boott Dam.

The canal system, the downtown mill sites, and many of the Project's existing civil works, are contributing resources to Lowell Locks and Canals National Historic Landmark (NHL) District. The canal system and many Project facilities are also located within the Lowell

[1] During the initial licensing, the Project impoundment surface area was estimated at 720 acres. As a part of this relicensing, Boott updated Exhibit G and generated a new surface area estimate of 1,236 acres. See Exhibit G.

[2] The Project impoundment has an estimated gross storage capacity of 6,180 acre-feet.

National Historical Park (LNHP) managed by the NPS and the larger Lowell Historic

Preservation District. The LNHP was established by Congress in 1978 to "preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts, for the benefit and inspiration of present and future generations." The park is by design a partnership park in which federal, state, and local governments as well as the private sector and local community carry out the legislative intent of the park unit. The Lowell National Historical Park is also listed on the National Register of Historic Places (NRHP), and certain properties within the park overlap with properties in the NHL District.

The Lowell Heritage State Park, established in 1974 as a precursor to the LNHP, is also located within the City of Lowell and is comprised of linear greenways along the Merrimack River and canal system and a collection of historic buildings and structures related to the industrial development of the city. These buildings and structures include Project features and properties located within the NHL District. The Lowell Heritage State Park is operated by the Massachusetts Department of Conservation and Recreation (MADCR) and features exhibits created in partnership with the NPS (MADCR 2018). With the exception of the Rynne Bathhouse, all of the built resources within the Lowell Heritage State Park fall within the Lowell Historic District, designated by the City of Lowell to "…ensure that development activities within the district are consistent with the preservation of its 19th century setting" (MADCR 2014). Portions of the Lowell Heritage State Park also overlap with the Lowell Locks and Canals NHL District and the LNHP.

In accordance with 18 C.F.R. § 5.16(a), Boott filed the Draft License Application (DLA) with the Commission on December 2, 2020. FERC and stakeholders had 90 days to provide comments on the DLA (i.e., until March 2, 2021). Comments on the DLA were filed by the following participants: AW, Lowell Plan, Inc., City of Lowell, Massachusetts Department of Conservation and Recreation (MADCR), Lowell Parks & Conservation, Greater Lowell Community Foundation, NPS, United States Fish and Wildlife Service (USFWS), Massachusetts Senator Edward Kennedy, Lowell Historic Board, Massachusetts Historical Commission, and the University of Massachusetts. Boott has reviewed and considered all comments received, as evidenced through further development of the Licensee's measures proposed in this Final License Application.

The purpose of the Exhibit E, as defined in 18 CFR §5.18, is to describe: (1) the existing and proposed Project facilities, including Project lands and waters; (2) the existing and proposed Project operation and maintenance, to include measures for protection, mitigation, and enhancement (PM&E) with respect to each resource affected by the Project proposal; and (3) the continuing impacts of existing Project operations and maintenance on resources, including direct, indirect, and cumulative impacts based on information generated during the relicensing studies. Exhibit E of this license application was prepared consistent with 18 C.F.R. § 5.18(b) and is intended to support FERC's required analysis under the National Environmental Policy Act of 1969 (NEPA)[3], as amended. The analysis of potential effects is based on the information presented in Boott's April 30, 2018 Pre-Application Document (PAD), consultation with stakeholders, the results of eleven completed studies and two on-going studies, pursuant to the C

[3] 42 U.S.C. § 4321, et seq.

ommission's Study Plan Determination (SPD), and other information obtained by the Licensee. Table E.1-1 summarizes the studies conducted or to be completed by Boott.

Table E.1-1. Lowell Hydroelectric Project Study Reports

Study Report	Filing Type	Filing Date
Downstream American Eel Passage Assessment (Updated Study Report [USR])	Public	February 25, 2021
Juvenile Alosine Downstream Passage Assessment (USR)	Public	February 25, 2021
Upstream and Downstream Adult Alosine Passage Assessment (USR)	Public	February 25, 2021
Fish Passage Survival Study (Initial Study Report [ISR])	Public	February 25, 2021
Three-Dimensional Computational Fluid Dynamics (CFD) Modeling	Public	May 2021 (Anticipated)
Instream Flow Habitat Assessment and Zone of Passage Study in the Bypassed Reach (ISR)	Public	February 25, 2021
Fish Assemblage Study (USR)	Public	February 25, 2021
Recreation and Aesthetics Study (USR)	Public	February 25, 2021
Resources, Ownership, Boundaries, and Land Rights Study (ISR)	Public	February 25, 2021
Water Level and Flow Effects on Historic Resources Study (ISR)	Public/Privileged	March 5, 2021
Operation Analysis of the Lowell Canal Study (ISR)	Public	February 25, 2021
Historically Significant Waterpower Equipment Study (ISR)	Public	February 25, 2021
Whitewater Boating and Access Study	Public	June 2021 (Anticipated)

On February 25, 2021, Boott filed the ISR studies and USR studies noted above. Boott held a Revised ISR Meeting to discuss the results of these studies on March 11, 2021. Pursuant to the ILP, Boott filed a Revised ISR Meeting Summary with the Commission on March 26, 2021. Stakeholders were provided a 30-day period (ending on April 25, 2021) to provide comments on the Revised ISR Meeting Summary, recommend study modifications, or propose new studies. By letters to the Commission, National Marine Fisheries Service (NMFS), Massachusetts Division of Fisheries and Wildlife (MADFW), USFWS provided comments on the February 2021 Revised ISR and Revised ISR Summary.

The following sections summarize the existing environmental setting of the Project and the baseline conditions under which this environmental assessment is being undertaken.

E.2 General Description of the River Basin (18 C.F.R. § 5.18 (b)(1))

E.2.1 Drainage Area and Length of River

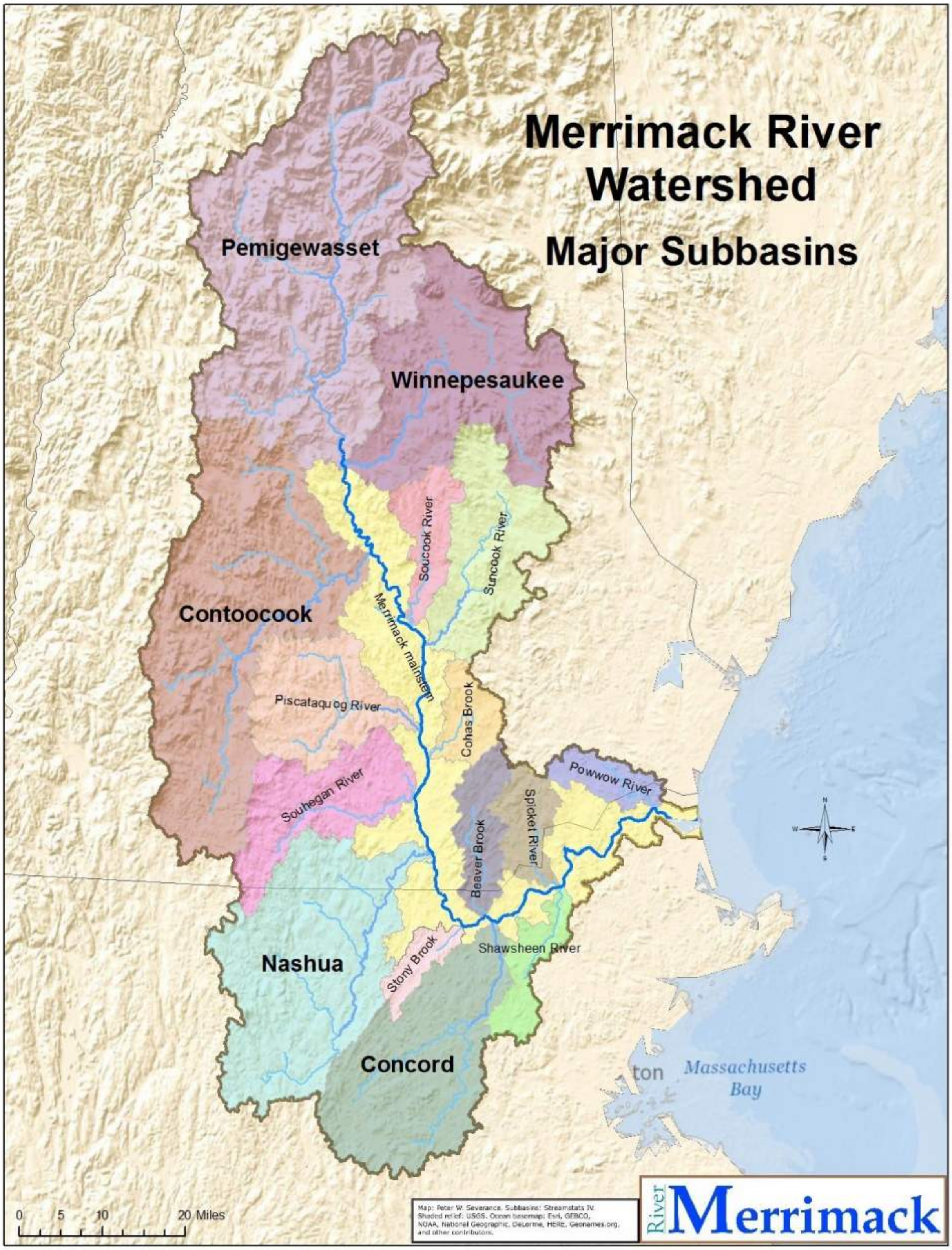
The 116-mile-long Merrimack River originates near Franklin, New Hampshire at the confluence of the Pemigewasset and Winnipesaukee Rivers (USACE 2003). The river flows southward for approximately 78 miles in New Hampshire, turns abruptly at the New Hampshire-Massachusetts boarder, and flows in a northeasterly direction for approximately 40 miles before draining into the Atlantic Ocean near Newburyport, Massachusetts. The final 22 miles of the river, downstream of Haverhill, Massachusetts, are tidally influenced (USACE 2003; NHDES 2019a).

The Merrimack River watershed has a total drainage area of approximately 5,010 square miles within the states of New Hampshire and Massachusetts, where about 3,800 square miles lie in New Hampshire and 1,200 square miles lie in Massachusetts (MEOEEA 2002). Lakes and ponds comprise 200 square miles, or four percent of the total area (Boott 1980). The Lowell Hydroelectric Project is located on the Merrimack River in Lowell, Massachusetts. The drainage area of the Lowell Project is approximately 3,979 square miles.

E.2.2 Tributary Rivers and Streams

The Merrimack River Basin (Basin) is the fourth largest river basin in New England (MEOEEA 2001). The Basin extends from the White Mountain region of northern New Hampshire to southeastern Massachusetts and spans the major cities of Laconia, Concord, Manchester, Nashua, in New Hampshire and Lowell, Lawrence, Haverhill, in Massachusetts. The Pemigewasset River flows for 64 miles, and the Winnipesaukee River stretches for ten miles. In addition to the Pemigewasset and Winnipesaukee River Basins, four principal tributaries contribute to the Merrimack River flow: the Contoocook, Piscataquog, Nashua, and Concord Rivers (USACE 2003; MEOEEA 2001). The Merrimack River Watershed and Major Subbasins are shown below in Figure E.2-1. The Lowell Project is located at RM 41 on the Merrimack River in the City of Lowell, Massachusetts. Several other smaller streams are contributory to the Merrimack or Concord Rivers within the City of Lowell and complete the major drainage pattern.

Figure E.2-1. Merrimack River Watershed and Major Subbasins



E.2.3 Topography

The Basin encompasses a variety of terrain as it ranges from steep, rugged conditions of the Northern New Hampshire White Mountain region to the estuarine coastal basin of northeastern Massachusetts (USACE 2003). The Basin is a part of the Eastern New England Upland physiographic unit containing three major sections -- the White Mountains, the New England Uplands, and the Seaboard Lowlands. The majority of the Basin is located in the New England Uplands, characterized by narrow floodplains and rolling hills ranging in elevation from below 1,000 feet to above 2,000 feet (USACE 2003). The Merrimack River itself drops 269 vertical feet over its long track to the Atlantic Ocean, with a more than 30-foot drop at the Project. The topography of the City of Lowell (13.4 square miles) is a combination of floodplain and, predominantly, gently undulating upland. The Merrimack corridor surface waters, in conjunction with the river's large watershed, form an extensive system of rivers, streams, lakes, ponds, wetlands and groundwater as well as densely forested lands consisting of evergreen or mixed evergreen-deciduous forests (NRPC 2008).

E.2.4 Dams and Diversion Structures within the Basin

There is a total of five[4] hydroelectric developments on the Merrimack River, comprising three separate Projects licensed by the Commission. Table E.2-1 presents information on the five FERC-regulated hydroelectric developments on the Merrimack River. All of the hydroelectric facilities on the Merrimack River operate in ROR mode.

In New Hampshire, there are four U.S. Army Corps of Engineers (USACE) flood storage dams within the Merrimack River basin. Boott and other licensees in the Merrimack River basin help to support the operational costs of these flood storage projects through Headwater Benefits payments assessed by FERC.

The USACE flood storage system in the Merrimack River basin consists of the following:

- Franklin Falls Dam is located in Franklin, New Hampshire, on the Pemigewasset River. The dam is three miles upstream of the confluence of the Pemigewasset and Winnipesaukee rivers where the Merrimack River originates. The dam is the key unit in the flood risk management for the Merrimack River basin. It provides flood protection for principal industrial and residential centers along the entire length of the Merrimack River. The construction of Franklin Falls Dam was completed in 1943, and it can store up to 50.2 billion gallons of water for flood control purposes (USACE 2016a).
- The Hopkinton-Everett Lakes Flood Risk Management Project consists of two dams, the dam at Hopkinton Lake, located on the Contoocook River in Hopkinton, New Hampshire, and the dam at Everett Lake, located on the Piscataquog River in Weare, New Hampshire. The two dams are connected by a two-mile-long canal and

[4] The five hydroelectric developments on the Merrimack River do not include the four downtown mill power stations Boott is proposing to remove from the FERC license.

in moderate to severe flooding are operated as a single flood risk management project. Construction of the project was completed in 1963. Together, the flood storage areas behind both dams can hold 52.6 billion gallons of water, which would cover approximately 8,000 acres (12.5 square miles). This is equivalent to 6.8 inches of water covering its drainage area of 446 square miles (USACE 2016b).

- The Blackwater Dam is located on the Blackwater River in Webster, New Hampshire. There is no lake at Blackwater Dam. The flood storage area of the project covers approximately 3,280 acres and extends upstream about seven miles through Salisbury, having a maximum width of one mile. Blackwater Dam can store up to 15 billion gallons of water for flood control purposes (USACE 2016c).

Table E.2-1. FERC-regulated Developments on the Merrimack River

Facility	FERC Project #	Licensee	River Mile	Generation Capacity (MW)
Garvins Falls (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	87	12.3
Hooksett (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	81	1.6
Amoskeag (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	73	16
Lowell	2790	Boott Hydropower, LLC	40	20.2 (current) 15 (proposed)
Lawrence	2800	Essex Company, LLC	29	16.8

E.2.5 Wetland and Vegetative Cover

Wetlands and vegetative cover with the Project area appear to be consistent with these areas of New Hampshire and Massachusetts. Wetlands along the Merrimack River primarily consist of low-lying areas near and adjacent to the river, with other isolated wetlands farther away from the river proper. The wetlands directly surrounding the Lowell Project are largely considered riverine wetlands with an unconsolidated bottom. Riverine wetlands include all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 parts per thousand (or greater (Cowardin et al. 1979). The majority of the wetlands near or adjacent to the Project area are palustrine wetlands. Palustrine wetlands, often called fens, swamps, marshes, or bogs, are nontidal wetlands. These wetlands are dominated by trees, shrubs, and/or persistent plants/mosses. These wetlands may also be composed of shallow, open-water ponds (Cowardin et al. 1979). According to the USACE (2002), freshwater wetland habitats play an integral role in the ecology of the Merrimack River corridor. The combination of high nutrient levels and primary productivity found in these habitats is ideal for the development of organisms that form the base of the food web.

Natural forest cover encompasses 75 percent of the Basin and consists of a mix of deciduous and evergreen forest. Natural vegetation in the region consists of mesic to dry Appalachian oak-pine forests with various combinations of red oak (*Quercus rubra*), white oak (*Q. alba*), and black oaks (*Q. velutina*), some scarlet (*Q. coccinea*) or chestnut oaks (*Q. prinus*) to the south, white pine (*Pinus strobus*), sugar maple (*Acer saccharum*), red maple (*A. rubrum*), hickories (*Carya spp*.), and other central or northern hardwoods. Floodplain forests are typically dominated with silver maple (*A. saccharinum*), American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*) (Griffith et al. 2009).

E.2.6 Climate

The Project is within a climate region typical of north central New England and inland New Hampshire, as it is characterized by moderately warm summers, cold winters, and adequate precipitation. The climatic conditions of the Basin vary significantly from its headwaters in the White Mountains to its discharge along the Atlantic Ocean (USACE 2003). The Basin is located partially with the Northern and Coastal Climatic divisions, but the majority of the watershed falls within the Central Climatic division. The Central division is generally more moderate than the Northern section due to its lower elevation and latitude; this division experiences some climate modification due to maritime influences (USACE 2003; National Oceanic and Atmospheric Administration [NOAA] 2020a). Precipitation in the watershed is evenly distributed throughout the year and weather systems throughout the Basin operate primarily from prevailing westerly winds and the confluence of many continental weather patterns in North America. The Basin's climate is humid continental climate (Dfa/Dfb) according to the Köppen-Geiger climate classification.

NOAA data from 1897 to 2020 for the Boston, Massachusetts weather station indicates an average temperature of 52.1°F, with an average maximum temperature of 96°F and average minimum temperature of 2.0°F. The warmest temperatures occur in July and coolest temperatures occur in January. NOAA 1897 to 2020 data for Boston, Massachusetts shows an average annual precipitation of 41.45 inches with relatively even monthly averages. (NOAA 2020b).

Three predominant storm patterns occur in the Merrimack River Basin: continental, coastal, and local summer thunderstorms. Continental storms are associated with the usual easterly or northeasterly air flows that bring western or central storm disturbances to the Northeast. These continental storms are experienced in all months of the year. Coastal storms originate in the Gulf or southeast coastal states and bring moist, generally warmer air into the region (Boott 1980).

E.2.7 Major Land and Water Uses

E.2.7.1 Major Land Uses

Historically, the Merrimack River Basin played a large role in the development of the region's economy and land use patterns. The Industrial Revolution in the mid-1800s encouraged many families towards more promising work in urban settings. Many of the larger towns adjacent to the Merrimack River mainstem began as factory or mill towns due to the need for hydromechanical and later hydroelectric power to power the emerging industries. This economic shift from farming to urban settings resulted in the reclamation of previously predominantly agricultural lands by forest and woodland (USACE 2003; Boott 1980).

Although the Merrimack River watershed is heavily forested (75 percent of the land area is covered with forest), it also supports all or parts of approximately 200 communities with a total population of 2.6 million people (U.S Environmental Protection Agency [USEPA] 2020; USACE 2006). The population density in the Basin tends to increase from north to south as the lower region is characterized by five major urban cities along the Merrimack River: Manchester and Nashua in New Hampshire, and Lowell, Lawrence, and Haverhill in Massachusetts (USACE 2003). Basin population density ranges from fewer than 100 people per square mile in the northeastern and northwestern portions of New Hampshire, to greater than 800 people per square mile in Manchester and Nashua, New Hampshire, and northeastern Massachusetts. A majority (74 percent) of the Basin's urban area is residential while the remaining areas consist of commercial, transportation, industrial, and other urban use. In addition to the 75 percent forested land, the Basin generally consists of 13.3 percent urban land, four to five percent surface water, and 5.5 percent agriculture. Recreation and timber harvesting for lumber are the primary economic activities occurring in forested lands, while agricultural lands are dominated by hay and livestock farming (Flanagan 1999). Land use is discussed in further detail in Section E.7.6 of this application.

E.2.7.2 Major Water Uses

Consumptive users of the Merrimack River water are primarily municipal and industrial, with specific uses including domestic, thermoelectric, commercial, mining, livestock, and irrigation uses. Many of the municipalities bordering the Merrimack River, or within its watershed, use the river as a potable water source as well as a wastewater discharge point. The Merrimack River is the only major New England River used as a drinking water supply and is used as such by the communities of Lowell, Lawrence, Tewksbury, Methuen, and Andover in Massachusetts and Nashua, New Hampshire. Two more cities in New Hampshire, Manchester and Concord, plan to use the river for drinking water supply in the near future (MRWC 2018b).

E.2.8 Economic Activities

The Lowell Project is located in Middlesex County, Massachusetts and Hillsborough County, New Hampshire. According to the U.S. Census Bureau, the median household income from 2014-2018 (in 2018 dollars) is estimated to be $97,012 in Middlesex County, $78,655 in Hillsborough County, and $51,987 for the City of Lowell (U.S. Census Bureau undated). The main employment sectors in the region include professional, scientific, and tech services, educational services, healthcare and social assistance, manufacturing, and retail trade (Data USA undated).

E.3 Cumulative Effects (18 C.F.R. § 5.18(b)(2))

According to the Council on Environmental Quality's regulations for implementing NEPA (40 C.F.R. §1508.7), a cumulative effect is the impact on the environment which results from the incremental impact of a Proposed Action when added to other past, present, and reasonably foreseeable future actions, regardless of agency (federal or non-federal) or person undertaking such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower project operations and other land and water development activities.

E.3.1 Resources That Could Be Cumulatively Affected

Through scoping, agency consultation, review of the PAD, and Commission staff's preliminary analyses, the Commission noted in its Scoping Document 2 (SD2) that migratory fisheries in the Merrimack River have the potential to be cumulatively affected by the proposed continued operation and maintenance of the Project, in combination with other hydroelectric projects and other activities in the Merrimack River Basin.

E.3.2 Geographic Scope

The geographic scope of the cumulative effects analysis defines the physical limits or boundaries of the proposed action's effect on the resources. The geographic scope of analysis for cumulatively affected resources is defined by the physical limits or boundaries of: (1) the proposed action's effect on the resources, and (2) contributing effects from other dams within the Merrimack River Basin. In SD2, FERC identified the geographic scope for migratory fisheries to include Pemigewasset River from the Eastman Falls Dam and the Winnipesaukee River from the Lakeport Dam, to the confluence of the Winnipesaukee and Pemigewasset Rivers (which form the Merrimack River), and the Merrimack River downstream to the Atlantic Ocean. The Eastman Falls Dam (at river mile 1 of the Pemigewasset River) and the Lakeport Dam (at river mile 17 of the Winnipesaukee River and 4 miles downstream from the outlet of Lake Winnipesaukee) are migration barriers that represent the upstream limits to which river herring and American eel are managed within the river basin.

E.3.3 Temporal Scope

The temporal scope of the cumulative effect's analysis in this exhibit addresses past, present, and reasonably foreseeable future actions and their effects on each resource that may be cumulatively affected. Based on the potential terms of the new license, the Commission's SD2 defined the temporal scope of this analysis to address reasonably foreseeable actions 30-50 years into the future. Historical discussion would by necessity, be limited by the amount of available information for each resource. As noted in SD2, the quality and quantity of information are diminished as resources that are further away in time from the present are analyzed.

E.4 Compliance with Applicable Laws (18 C.F.R. § 5.18 (b)(3))

E.4.1 Section 401 of the Clean Water Act

Under Section 401 of the Clean Water Act (CWA), any federal license or permit to conduct any activity that may result in a discharge into navigable waters requires a certification from the state in which the discharge originates, that such discharge will comply with the applicable provisions of the CWA, unless such certification is waived. Therefore, a state Water Quality Certification (WQC) or waiver is a prerequisite for obtaining a license from FERC. The MADEP is the state agency designated to carry out the certification requirements as prescribed in Section 401 of the CWA for waters of the Commonwealth of Massachusetts. Pursuant to 18 C.F.R. § 5.23(b), Boott will file an application for a WQC with the MADEP within 60 days of FERC's Notice of Acceptance and Ready for Environmental Analysis. The MADEP must act on the request for a WQC within the one-year time frame allowed under the CWA.

E.4.2 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) (19 U.S.C. § 1536(c)), as amended, requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or result in the destruction or adverse modification of the critical habitat of such species. Under the ESA, the United States Fish and Wildlife Service (USFWS) is responsible for freshwater and terrestrial species; and the National Marine Fisheries Service (NMFS; NOAA Fisheries) is responsible for marine and anadromous species.

In the Notice of the Licensee's Intent to File a License Application, Filing of the PAD, Commencement of the Pre-filing Process, and Scoping Document 1 issued on June 15, 2018, the Commission designated Boott as the Commission's non-federal representative for carrying out informal consultation, pursuant to section 7 of the ESA. Boott was granted designation as FERC's non-federal representative for Section 7 consultation on June 18, 2018. Information from the USFWS and the Massachusetts Division of Fisheries and Wildlife (MADFW) has been used by the Licensee to identify rare, threatened, and/or endangered (RTE) species in the Project area. A discussion of the RTE species relevant to this Project is contained in Section E.7.5 of this Exhibit.

E.4.3 Magnuson-Stevens Fishery Conservation Management Act

The 1996 amendments to the Magnuson-Stevens Act authorized the NMFS, in coordination with regional fisheries management councils, to delineate essential fish habitat (EFH) for the protection of habitat of marine, estuarine, and anadromous finfish, mollusks, and crustaceans. EFH includes “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.”

Based on a review of the NMFS online database, the Lowell Project reach of the Merrimack River is designated EFH under the Magnuson-Stevens Fishery Conservation and Management Act for Atlantic salmon (NOAA undated). This EFH was defined as “all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut” (New England Fishery Management Council [NEFMC] 1998).

E.4.4 Coastal Zone Management Act

Section 307(c)(3) of the Coastal Zone Management Act (CZMA) requires that activities conducted or supported by a federal agency that affect the coastal zone be consistent with the enforceable policies of the federally approved state coastal management plan to the maximum extent practicable. Section 307(c)(3) of the CZMA requires that all federally licensed activities that affect a state’s coastal zone be consistent with the enforceable policies of the state’s federally approved coastal management plan.

The Massachusetts Office of Coastal Zone Management (MOCZM) is the lead policy and planning agency on coastal and ocean issues within the Massachusetts Executive Office of Energy and Environmental Affairs (MEOEEA). In the preparation of the PAD, Boott initiated consultation with MOCZM, but has not received a response. By review of available coastal zone maps from the MOCZM, the activities associated with this project would fall outside the geographical boundaries of the Massachusetts Coastal Zone as delineated (MEOEEA 2014).

The New Hampshire Coastal Program (NHCP) is the lead policy and planning agency on coastal and ocean issues within the New Hampshire Department of Environmental Services (NHDES). In the preparation of the PAD, Boott initiated consultation with NHCP, but has not received a response. By review of available coastal zone maps from the NHDES, the activities associated with this project would fall outside the geographical boundaries of the Hew Hampshire Coastal Zone as delineated (NHDES undated).

As the Project is not subject to coastal zone management program review, no consistency certification is needed for FERC’s relicensing of the Project.

E.4.5 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (Section 106)8 requires federal agencies to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on such actions. Historic properties include significant sites, buildings, structures, districts, and individual objects that are listed in, or eligible for listing in the NRHP. FERC’s issuance of a new license for the Project is considered an undertaking subject to the regulations and requirements of Section 106 and its implementing regulations at 36 C.F.R. Part 800. In accordance with 36 C.F.R. §

800.14(b), FERC typically fulfills its responsibilities pursuant to Section 106 by entering into a Programmatic Agreement with the appropriate State and/or Tribal Historic Preservation Officer(s) (SHPO/THPO), and in some cases the ACHP.

FERC initiated consultation under Section 106 with federally recognized Indian tribes by letter dated April 26, 2017. By notice dated June 15, 2018, FERC designated Boott its nonfederal representative for purposes of conducting informal consultation pursuant to Section 106.

A discussion of historical properties within the Project's Area of Potential Effects (APE) and the consultation under Section 106 conducted to date for the relicensing of the Project is contained in E.7.8 of this Exhibit.

Early in the relicensing process, Boott contacted prospective stakeholders to determine their interest in this relicensing proceeding. As part of this outreach, Boott corresponded with representatives of the Massachusetts SHPO and federally recognized Indian tribes with a potential interest in the effects of this relicensing on historic properties. The Project does not occupy tribal reservation lands and the U.S. Bureau of Indian Affairs (BIA), via consultation, documented the following tribes as having historical interest in the Project area:

- Mashpee Wampanoag Tribe
- Wampanoag Tribe of Gay Head
- Penobscot Nation

By letter dated April 26, 2017, FERC invited the Mashpee Wampanoag Tribe, Narragansett Indian Tribe, Stockbridge Munsee Tribe of Mohican Indians, and Wampanoag Tribe of Gay Head (Aquinnah) to participate in the relicensing process for the Project. The Mashpee Wampanoag Tribe stated they do not have concerns with relicensing unless new construction is proposed that has the potential to disturb cultural resources.

E.4.6 Wild and Scenic Rivers and Wilderness Act

There are no rivers designated under the Wild and Scenic Rivers Act within or adjacent to the Project boundary; therefore, this act is not applicable to the relicensing of the Project. No Project facilities are located within any designated wilderness areas.

E.5 Project Facilities and Operation (18 C.F.R. § 5.18(b)(4))

E.5.1 Maps of Project Facilities within Project Boundaries (18 C.F.R. § 5.18(b)(4)(i))

The Lowell Hydroelectric Project boundary is shown in detail in Exhibit G of this license application. The physical composition, dimensions, and generation configuration of the facilities that comprise the Project are described in the following subsections.

E.5.2 Project Location and Facilities Overview (18 C.F.R. § 5.18(b)(4)(ii))

This section provides a summary of the existing facilities at the Project; additional, detailed descriptions of Project facilities are presented in Exhibit A of this license application.

The Project is located at the Pawtucket Dam on the Merrimack River in the City of Lowell in Middlesex County, Massachusetts. The Project is located approximately 11 miles upstream of the Lawrence Project (FERC No. 2800) and approximately 30 miles downstream of the Amoskeag Dam (a development of the Merrimack River Project, FERC No. 1893) in New Hampshire. The 116-mile-long Merrimack River begins at the confluence of the Winnipesaukee and Pemigewasset Rivers in Franklin, New Hampshire; flows southward into Massachusetts; and then travels northeast until it discharges into the Atlantic Ocean. The existing Project includes the 15.0 MW E.L. Field powerhouse constructed in 1985-1986 during Project redevelopment, and four smaller generating stations located within mill buildings along the downtown canal system. The current total installed capacity of the project is 20,164 kW. A Project location map is presented above as Figure E.1-1.

The E.L. Field powerhouse utilizes the existing Pawtucket Dam and the first 2,200 feet of the Northern Canal. The powerhouse is located close to the canal, downstream of the University Avenue Bridge (also called the Moody Street Bridge), with an intake structure drawing water from the canal. A 440-foot tailrace channel, surge gate and fish passage facilities comprise other major E.L. Field powerhouse features.

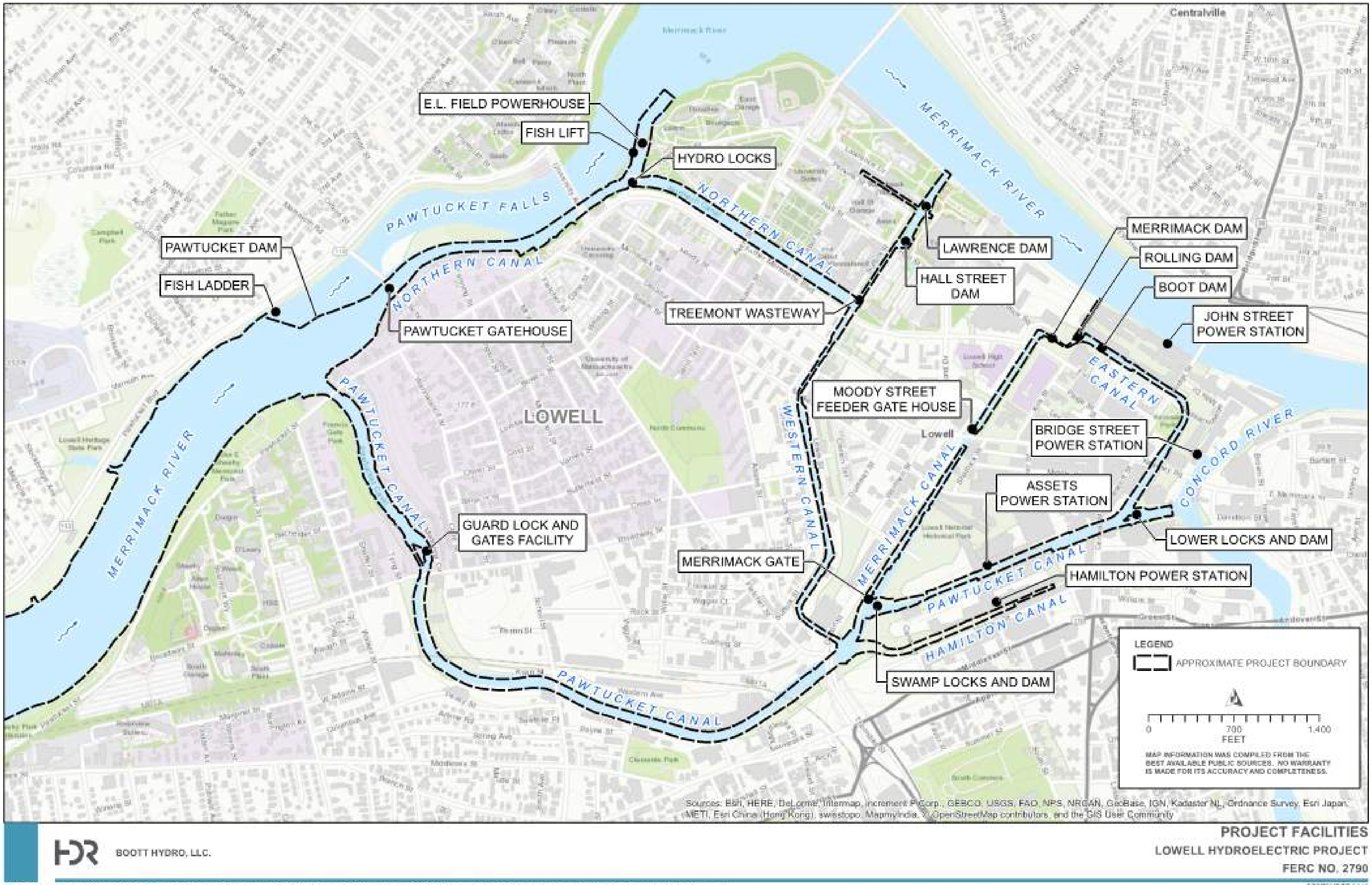
The current FERC license includes the Assets, Bridge Street, John Street, and Hamilton Power Stations which are housed within large nineteenth-century mill buildings sited along the 5.5-mile canal system (Figure E.5-1). Boott proposes to remove all four of these power stations from the new license. The current hydroelectric Project boundary includes only the turbines and associated equipment at these downtown mill sites. The Hamilton Power Station draws water from the Hamilton Canal and discharges into the Lower Pawtucket Canal. The Assets Power Station draws water through an intake structure at the Merrimack Canal and discharges into the Lower Pawtucket Canal. The Bridge Street Power Station (also known as “Section 8”) draws water from the Eastern

Cana

I and discharges into the Concord River. The John Street Power Station also draws water from the Eastern Canal and discharges into the Merrimack River.

As detailed in the Operations Analysis of the Lowell Canal Study (HDR 2021d), Boott notes that it is no longer economically feasible to operate these downtown power station units, and they have not been operated regularly in many years due to maintenance issues and other factors.

Figure E.5-1. Lowell Hydroelectric Project Canal System Map – Existing Facilities



E.5.3 Existing Structures Created Before Project Redevelopment

The site of the Lowell Project was historically used for hydromechanical and hydroelectric power for various mill operations. Much of the Project's current civil works were constructed during the 19th and early 20th centuries, and existed prior to Project licensing and redevelopment in the 1980's. These structures are described below.

E.5.3.1 The Pawtucket Dam

The Pawtucket Dam is of dressed masonry gravity construction with a length of 1,093 feet, a spillway crest length of 982.5 feet, a crest elevation of 87.2 feet NGVD 29, and an average height of 15 feet. Original drawings show the masonry was ashlar, laid dry with a mortared masonry upstream face at a 1:1 slope, a two-foot-thick capstone, and the bed course laid in mortar. It was built in two sections in 1847 and 1875, the latter being grouted during construction. The dam foundation rests on bedrock, except for a short section on hardpan. A fishway is located at the left dam abutment, and the Pawtucket Gatehouse to the Northern Canal is at the right abutment.

E.5.3.2 The Northern Canal

The Northern Canal is about 4,300 feet in length, with masonry or bedrock lining its complete length. The width of the Northern Canal varies along its length. At the head of the canal it is approximately 95 feet wide, at the location of the University Bridge overpass it is its most narrow at approximately 78 feet wide. About 2,200 feet downstream of the Pawtucket Gatehouse the canal widens to approximately 80 feet as it flows into the E.L. Field Powerhouse forebay. It then turns southeasterly at Pawtucket Street and Hydro Locks, widening to 105 feet between Pawtucket Street and the Tremont Gatehouse. In the new FERC license, Boott proposes to retain only the first ± 2,200-foot-long section of the Northern Canal extending from the Pawtucket Gatehouse to the E.L. Field forebay and Hydro Locks.

The Great River Wall is the left retaining wall of the Northern Canal. It runs from the Pawtucket Gatehouse to a natural rock outcrop upstream of the E.L. Field Powerhouse. The wall is a masonry structure that is 2,485 feet long and 32 feet in height. The first 1,000 feet combines masonry walls and an earth dike (with masonry core) as the river wall. The second length is a dressed masonry gravity structure to the site of the E.L. Field powerhouse. The crest of the Great River Wall is approximately 103.0 feet in elevation adjacent to the Pawtucket Gatehouse and varies in elevation along its length. The lowest point of the wall is approximately 93.3 feet at the University Bridge overpass. The width of the wall varies from 8 feet upstream at the Pawtucket Gatehouse to 10 feet at the downstream end. Boott proposes to retain the Great River Wall in the new FERC license.

E.5.3.3 Pawtucket Gatehouse

The Pawtucket Gatehouse (also known as the “Northern Canal Gatehouse”) is located at the southern abutment of the Pawtucket Dam and controls flow into the Northern Canal. The Pawtucket Gatehouse is 125 feet long by approximately 55 feet high from the base of the foundation to the roof peak, and contains the guard sluice gates, the brick gatehouse, and a navigation lock. All these structures were a part of the Northern Canal construction project of 1846-47. The gatehouse is principally constructed of dressed masonry with concrete over lintels and contains ten 8-foot-wide by 15-foot-high, motor-operated, timber sliding gates which feed the Northern Canal. Another small intake opening feeds a historic Francis-designed turbine, which formerly powered the gate mechanisms through a line shaft. The structure's water passages are nearly 80 feet in length. Most of the original equipment, including the Francis turbine, is intact. Alterations include a watertight enclosing wooden cover in the turbine pit in 1872 to prevent flooding of the turbine chamber in high water.

The small navigation lock constructed of dressed masonry with two sets of wooden miter gates (upstream and downstream) is located at the southern end of the Pawtucket Gatehouse (Boott 2017). The navigation lock is approximately 12 feet wide and 97.8 feet long.

E.5.3.4 The Pawtucket Canal

The Pawtucket Canal branches off the Merrimack River about 950 feet upstream of the Pawtucket Gatehouse and feeds water into the downtown canal system. From its starting point, the 9,000-foot canal curves south and then east to meet the Concord River near its junction with the Merrimack River. The width of the Pawtucket varies from 80 to 100 feet and the average depth is about 8 feet. The walls are of granite, ledge, or concrete. The canal beds are of ledge, concrete, or wood-planked virgin soil. Boott proposes to retain within the project boundary only the first approximately 1,600-foot-long section of the Pawtucket Canal, between the impoundment and the Guard Lock and Gates Facility.

E.5.3.5 Additional Canals

The Licensee’s existing four downtown power stations (Hamilton, Assets, Bridge Street, and John Street Power Stations) are fed by sections of the 5.5-mile canal system in Lowell. The principal canals in the system are the Pawtucket Canal and the Northern Canal, as described above. Smaller canals lead off these two major canals. The walls are of granite, ledge, or concrete. The canal beds are of ledge, concrete, or wood-planked virgin soil.

This Merrimack Canal branches off the Pawtucket Canal. In some areas the section is rectangular, but most of the Merrimack Canal has simply been gouged out of the native rock. The Merrimack Canal is 10 feet deep, 2,580 feet in length, and 40 to 50 feet wide. The Hamilton Canal begins at the Swamp Locks and is rectangular in section. The Hamilton Canal is 1,936 feet in length, 10 feet deep, 35 to 100 feet wide.

The Eastern Canal begins just above the Lower Locks of the Pawtucket Canal. The Eastern Canal runs for 2,037 feet and is rectangular in section. The Eastern Canal averages 8 feet in depth and 65 feet in width. The Western Canal was a two-level waterpower system, however the locks structures were removed and filled in 1840. The total length of the Western Canal is 4,964 feet. Its width varies from 35 to 55 feet, and its average depth is 9 feet.

As noted above, Boott proposes to remove all of these canals from the project boundary of the new FERC license, retaining only those portions of the Northern and Pawtucket Canal as described above. Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the NPS and other stakeholders.

E.5.3.6 Miscellaneous Canal Structures

E.5.3.6.1 Guard Lock and Gates Facility

The Guard Lock and Gates facility consists of a five-bay gate house located on the Pawtucket Canal and a series of three gate structures located within a boat lock. The substructure of the gate house on the Pawtucket Canal is of dressed masonry, and the superstructure is of brick masonry and wood frame. Adjacent to this structure is a boat lock consisting of the upper locking gate, Great Guard Gate (or Francis Gate), and lower locking gate. The gates span the lock chamber which is 24 feet wide with masonry walls. The upper locking gate and Great Guard Gate are housed in frame buildings. Boott proposes to retain the Guard Lock and Gates facility within the new FERC license.

The Great Guard Gate is a large portcullis gate located within the lock chamber between the upstream and downstream lock gates. This 25' wide by 25' high wooden gate is designed to be lowered into the lock chamber during extreme flood conditions on the Merrimack River, to prevent flooding of downtown Lowell via the Pawtucket Canal. A wood frame structure, the Francis Gatehouse, houses the Great Gate. When needed, the Great Gate can be dropped under its own weight to the bottom of the lock chamber, thereby closing off any flow through the boat lock channel at the Guard Locks, preventing flooding in downtown Lowell via the Pawtucket Canal. The original Great Gate has been used only twice during its history, the year following its construction in 1852 and again in 1936.

Due to the historic nature, public safety concerns and questionable functionality of the historic Great Guard Gate, in 2005 Boott designed and implemented a replacement gate in consultation with the FERC and NPS. The replacement gate is a segmented structural steel stoplog gate and frame which is stored on-site. The steel stoplog gate was designed and implemented to functionally replace the historic Great Guard Gate, which remains in place within the Francis Gate House. The steel stoplog gate fits immediately upstream of the Francis Gate House within existing stoplog slots in the granite masonry. When required, installation of the steel stoplog gate can be accomplished within a few hours by a local crane operator. The Project’s Emergency Action Plan (EAP) provides that the stoplogs should be installed when the water level at the Pawtucket Dam rises above 98.0 ft NGVD 29. To date, the steel stoplogs have been installed twice, during flooding events in May 2006 and April 2007.

E.5.3.6.2 Moody Street Feeder and Gate House

The Moody Street Feeder is a 1,400-foot-long underground conduit which allows flow to be passed from the Northern Canal to the Merrimack Canal. It terminates at the Moody Street Feeder Gate House which is located on the Merrimack Canal at the intersection of Dutton Street and Merrimack Street. Three 10-foot-wide gates allow closure of the three separate arched water passages. The gates are housed in a brick building measuring 62.5 feet long by 22.5 feet wide. Boott proposes to remove the Moody Street Feeder and Gate House from the new FERC license.

E.5.3.6.3 Lawrence Dam

The Lawrence Dam consists of a rock-filled timber-crib substructure with a three-tiered apron. The upper apron is of timbers overlaying rubble masonry. The second and third aprons consist of massive masonry. The superstructure is made of cast iron frames, fitted with wood bay boards. The structure is 100 feet long by 12 feet high and is located at the head of the Lawrence Wasteway, which leads to the Merrimack River. Boott proposes to remove the Lawrence Dam from the new FERC license.

E.5.3.6.4 Hall Street Dam

The Hall Street Dam consists of a rubble masonry structure with an upper protective timber deck and stepped massive ashlar masonry apron. The length of the structure is 115 feet with a maximum height of 15 feet. The dam is fitted with 1.5-foot flashboards. Boott proposes to remove the Hall Street Dam from the new FERC license.

E.5.3.6.5 Tremont Wasteway

The Tremont Wasteway is 30 feet wide by 600 feet long and is adjacent to Suffolk Street. The wasteway forms the water passageway between the Northern Canal and the Hall Street Dam. At the head of the wasteway is the Tremont Gate House. Two 9-foot-wide gates control the flow of water into the wasteway and are housed in a gate house building consisting of brick superstructure with masonry substructure. Boott proposes to remove the Tremont Wasteway from the new FERC license.

E.5.3.6.6 Lower Locks and Dam

The Lower Locks and Dam are on the Lower Pawtucket Canal and empty into the Concord River. The dam, with a maximum height of 12 feet, consists of a rubble masonry structure with a sloping timber apron. Energy dissipation is accomplished by large rubble masonry located downstream of the dam. The superstructure is constructed of cast iron frames, fitted with wood bay boards. A gated sluiceway is also provided. The lock structure contains two chambers 30.5 feet wide by 85 feet long. The width at the gate passageway is 12.5 feet. The lock walls are of hand laid masonry. Boott proposes to remove the Lower Locks and Dam from the new FERC license.

E.5.3.6.7 Swamp Locks and Dam

The Swamp Locks and Dam are at the head of the Lower Pawtucket Canal. The dam consists of a concrete apron overlaying a rubble masonry structure. The superstructure is made of cast iron frames, fitted with wood bay boards. The maximum height of the dam is 15 feet. A sluiceway, similar to the Lower Locks and Dam is also provided. A two-chamber lock, with narrowest width of 12.5 feet allows passage by the Swamp Locks and Dam. The lock is constructed of rubble masonry. Boott proposes to remove the Swamp Locks and Dam from the new FERC license.

E.5.3.6.8 Rolling Dam

The Rolling Dam consists of a masonry structure with curved apron protected by wood planks. The maximum height of the dam is 19 feet. The masonry construction is carried downstream of the dam to provide scour protection. The Rolling Dam is located downstream of the Merrimack Dam. Boott proposes to remove the Rolling Dam from the new FERC license.

E.5.3.6.9 Merrimack Dam, Merrimack Gate and Boott Dam

The Merrimack Dam consists of a sloping apron rubble masonry structure. The apron is protected with timber planks. The maximum height of the dam is 8 feet, and it acts as a submerged weir, no longer used to control water elevations.

The Merrimack Gate consists of a concrete dam structure with sloping upstream face and vertical downstream face. The center portion of the structure is fitted with a 10-foot-wide by 6-foot-high timber gate. The maximum height of the dam is 9 feet.

The Boott Dam is located 80 feet southeast of the Merrimack Wasteway adjacent to Boott Mills. It consists of a masonry structure 40 feet long with a maximum height of 7 feet and a gated sluiceway.

Boott proposes to remove the Merrimack Dam, the Merrimack Gate, and the Boott Dam from the new FERC license.

E.5.3.7 Mill Buildings

The Hamilton, Assets, Bridge Street, and John Street power stations and turbines are housed in large old mill buildings. The buildings, not included in the Project, are exceptionally sturdy structures used principally as space for small industrial manufacturers, storage space or apartment/condominium units. The existing hydroelectric Project boundary includes only the turbines and associated equipment at these downtown mill sites. Boott proposes to remove these turbines and associated water passages from the new FERC license.

E.5.4 Structures Constructed During Project Redevelopment

The principal civil works constructed during project redevelopment in 1985-1986 include the E.L. Field powerhouse, associated intake and tailrace channels, a canal control structure with navigation lock, fish passage facilities and a substation. Boott proposes to retain all of these structures within the new FERC license.

E.5.4.1 Eldred L. Field Powerhouse

The E.L. Field powerhouse is a reinforced concrete structure. The powerhouse is approximately 109 feet long by 96 feet wide and houses two generating units with a total authorized generation of 15.0 MW. The powerhouse incorporates a separate conventional intake structure for each of the station's two identical units. Each intake is equipped with trashracks; intake and draft tube gate slots with permanent or bulkhead style gates for emergency shutdown and dewatering purposes are also provided. The powerhouse is equipped with a traversing trash rake to remove debris at the intake. Both mobile and on-site cranes are used for heavy equipment movement at the facility. The E.L. Field powerhouse forebay is an excavated rock channel approximately 200 feet long, 50 feet deep, and 80 feet wide. The left (northern) side of the forebay is a reinforced concrete wall, and includes the exit channel of the existing fish lift system.

E.5.4.2 Tailrace Channel

A 440-foot-long tailrace channel was excavated out of bedrock in the river. The channel excavation is approximately 60 feet wide by an average of 20 feet deep. The tailrace is protected from high river flows by a 10 to 16 -foot-high concrete training wall, which directs bypassed river flows away from the tailrace.

E.5.4.3 Crest Gate System

A pneumatically operated crest gate system is mounted on the spillway crest to maintain the headpond at its normal maximum water surface elevation of 92.2 feet NGVD 29. The pneumatic crest gate system consists of five-foot-high, 20-foot-long hinged steel panels supported on their downstream side by tubular rubber air bladders. The crest gate system is installed in five independently controllable zones. Air compressors, which supply system inflation and deflation pressure, and the crest gate control system are housed in a building located near the fish ladder and the left (northerly) abutment of the dam.

E.5.4.4 Control Structures

During the construction of the E.L. Field powerhouse in the 1980's a concrete control structure known as "Hydro Locks" was constructed at the bend in the Northern Canal upstream of the E.L. Field intake and underneath the Pawtucket Street Bridge. The control structure was constructed to maintain effective net head at the E.L. Field Powerhouse by isolating the powerhouse forebay from the remainder of the Lowell canal system. It includes a navigation lock at its western end to allow passage of NPS tour boats. The control structure runs 100 feet long parallel to and slightly underneath the Pawtucket Street Bridge and is 26 feet high by 22.25 feet wide. The lock structure is approximately 88 feet long located on the canal side along Father Morissette Boulevard, with sets of butterfly wicket lock gates approximately 15 feet high and 56 feet apart on either end of the lock. The lock structure is also equipped with stop log slots and rubber fenders.

Located along the Great River Wall is the canal surge gate, located just upstream of the E.L. Field Powerhouse. The steel gate is pneumatically operated and is 15-feet-high by 78 feet wide set on a masonry weir with a crest elevation of 77.0 feet. This system is designed to attenuate the surge wave in the canal that occurs when there is a sudden plant shutdown. When flow is less than 3,500 cubic feet per second (cfs), the surge suppressor gate is manually disabled. Should the flow increase to over 3,500 cfs, the gate is returned to the automatic operating condition. A safety boom has been installed in the canal above the gate.

E.5.4.5 Fish Passage Facilities

Upstream and downstream fish passage facilities at the Project include a fish elevator[5] and downstream fish bypass at the E.L. Field powerhouse, and a vertical-slot fish ladder at the Pawtucket Dam. All fish passage facilities were designed in consultation with the U.S. Fish and Wildlife Service. Passage operations are supervised by the state and federal fishery agencies.

The reinforced concrete fish ladder at the Pawtucket Dam is designed to allow for controlled fish passage at river flows up to 25,000 cfs The fishway operates at 200 cfs, including attraction flow, with an additional 300 cfs of supplemental attraction flow released from a slide gate adjacent to the passage facility. The fish ladder is a vertical slot design with 13-foot-wide by 10-foot-long pools. A counting station and fish trap area is provided. The Pawtucket Dam has been modified by removing ashlar masonry to allow the exit channel to penetrate the dam.

The upstream fishway at the powerhouse is a fish elevator. The design discharge capacity is 200 cfs. A fish collection gallery with two openings spans the downstream wall of the powerhouse to collect fish migrating through the tailrace channel, however only the westerly “river side” entrance has been used since the 1990’s, by agreement with the fishery agencies. The fish are attracted into the 30-foot crowding pool, trapped, and crowded. From the crowding pool, they enter the elevator and are lifted in a hopper to the exit channel. From the elevator area, the fish enter a holding pool 10 feet wide by 50 feet long. Fish next enter the fish trap area where they can be counted. A 10-foot by 12-foot fish counting station is provided. Passage of fish through the trap area allows fish to enter the exit channel, passing into the Northern Canal and then upriver.

The downstream fishway at the powerhouse consists of an adjustable-flow sluiceway and bypass adjacent to the intake headwall. Downstream migrants entering the bypass are quickly sluiced into an enlarged and deepened plunge pool located in the bypassed river reach next to the powerhouse. Natural channel braids in the riverbed allow

[5] The terms “fish elevator” and “fish lift” are used interchangeably in this document to describe the existing upstream fish passage facility at the E.L. field Powerhouse.

emigrants to move downstream to the mainstem river, at the confluence of the river reach and tailrace.

E.5.4.6 Impoundment Characteristics (18 C.F.R. §5.18 (b)(4)(iii)

The Project operates in a ROR mode and has no usable storage capacity. The existing Project boundary extends approximately 23 miles upstream to Moore's Falls in Litchfield and Merrimack, New Hampshire.

Boott is proposing to remove 7.4 miles from the upstream extent of the current Project boundary, as shown in Exhibit G. At the normal pool elevation of 92.2 ft NGVD 29, the surface area of the proposed impoundment is reported to encompass an area of about 1,236 acres. The gross storage capacity between the normal surface elevation of 92.2 feet NGVD 29 and the minimum pond level of 87.2 feet NGVD 29 is approximately 6,180 acre-feet.

E.5.4.7 Generating Equipment (18 C.F.R. §5.18(b)(4)(iv)

Turbine and generator data for each of the five existing power stations (including the E.L. Powerhouse) are provided below in Table E.5-1. Boott proposes to remove all of the mill powerhouse units from the new FERC license, leaving only the two units at the E.L. Field Powerhouse. The proposed project capacity is 15,012 kW.

Table E.5-1. Lowell Hydroelectric Existing Project Turbine, Generator, and Unit Capacity Data

				TURBINES								GENERATORS				
			Size	Speed	Head	Flow	Power	Power			Power	Power	Voltage	Speed		Unit
Powerhouse	**Unit #**	**Type**	**Inches**	**RPM**	**Feet**	**cfs**	**HP**	**kW**	**Type**	**kVA**	**Factor**	**kW**	**Volts**	**RPM**		**Capacity**
E. L. Field	1	Fuji Horizontal Full Kaplan	152.4	120	39	3,300	11,540	8,655	Fuji Electric	8,340	0.9	7,506	4,160	120		7,506
E. L. Field	2	Fuji Horizontal Full Kaplan	152.4	120	39	3,300	11,540	8,655	Fuji Electric	8,340	0.9	7,506	4,160	120		7,506
Assets	1	Hercules Double Runner Styles C & D	33 / 31	150	13	376	444	333	General Electric Type ATB 48-332-150	330	0.8	264	600	150		264
Assets	2	Hercules Double Runner Styles C & D	33 / 31	150	13	376	444	333	General Electric Type ATB 48-332-150	330	0.8	264	600	150		264
Assets	3	Hercules Double Runner Styles C & D	33 / 31	150	13	376	444	333	General Electric Type ATB 48-332-150	330	0.8	264	600	150		264
Bridge Street	4	Hercules Type D Single Runner	42	138.5	22	333	655	491	General Electric Co. Type ATB	450	0.8	360	600	138.5		360
Bridge Street	5	Hercules Type D Single Runner	42	138.5	22	333	655	491	General Electric Co. Type ATB	450	0.8	360	600	138.5		360
Bridge Street	6	Hercules Type D Single Runner	42	138.5	22	333	655	491	General Electric Co. Type ATB	450	0.8	360	600	138.5		360
Hamilton	1	Leffel Type Z Single Runner	45	120	13	374	459	344	Westinghouse Electric Co.	350	0.8	280	600	120		280
Hamilton	2	Leffel Type Z Single Runner	39	133	13	279	341	256	Electric Machinery Co.	225	0.8	180	600	133		180
Hamilton	3	Leffel Type Z Single Runner	36	150	13	237	287	215	Electric Machinery Co.	200	0.8	160	600	150		160
Hamilton	4	Leffel Type Z Single Runner	45	120	13	374	459	344	Electric Machinery Co.	350	0.8	280	600	120		280
Hamilton	5	Leffel Type Z Single Runner	45	120	13	374	459	344	Electric Machinery Co.	350	0.8	280	600	120		280
John Street	3	Leffel Single Runner	33	200	21	250	482	362	General Electric Co. Type ATI	375	0.8	300	600	200		300
John Street	4	Leffel Single Runner	33	200	21	250	482	362	General Electric Co. Type ATI	375	0.8	300	600	200		300
John Street	5	Leffel Single Runner	33	200	21	250	482	362	General Electric Co. Type ATI	375	0.8	300	600	200		300
John Street	6	Allis Chalmers Single Runner	72	100	21	1,000	1,925	1,444	Allis-Chalmers Type AV	1,500	0.8	1,200	600	100		1,200
											TOTAL EXISTING PROJECT CAPACITY:					**20,164**

E.5.5 Estimated Average Annual Energy Production (18 C.F.R. §5.18(b)(4)(v)

The average annual energy generation of the Lowell Hydroelectric Project for the period of 2008 through 2017 was 84,501 megawatt-hours (MWh). The Project operates in a ROR mode and, therefore, experiences seasonal and annual variations in generation based on natural hydrologic conditions in the Merrimack River Watershed. Table E.5-2 provides a summary of monthly Project generation for a 10-year period from 2008 through 2017 in MWh.

Table E.5-2. Lowell Hydroelectric Project Monthly and Annual Generation (MWh)

Month	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
January	10,610	2,574	6,403	7,163	10,272	8,064	10,422	6,624	9,258	9,325
February	10,955	3,851	6,672	5,228	8,928	8,304	5,232	3,216	9,312	6,335
March	11,727	5,088	8,555	10,176	12,432	12,784	10,536	5,820	10,042	9,395
April	10,876	7,341	8,061	11,088	7,872	13,392	10,959	10,128	8,427	8,387
May	7,690	10,147	8,094	11,472	11,712	9,600	9,264	5,219	7,244	8,181
June	4,512	10,464	4,752	8,304	9,792	11,551	3,075	6,563	2,577	9,716
July	5,615	11,252	2,963	3,552	3,216	11,520	4,608	6,432	1,010	6,635
August	4,810	8,026	2,072	4,416	4,560	6,144	5,472	2,412	1,044	2,959
September	4,962	4,012	1,677	10,128	3,696	6,214	4,428	1,898	498	3,462
October	5,287	5,703	8,457	11,136	7,344	3,894	4,314	5,297	1,059	3,332
November	4,726	4,404	10,216	10,272	6,384	5,376	6,880	6,367	3,649	7,380
December	4,656	4,747	9,687	10,272	8,880	7,772	10,700	8,395	9,025	7,946
Annual	86,425	77,609	77,608	103,207	95,088	104,614	85,890	68,371	63,146	83,053

E.5.6 Estimated Dependable Capacity (18 C.F.R. §5.18(b)(4)(v)

Dependable capacity is generally defined as the amount of load a hydroelectric plant can carry under adverse hydrologic conditions during a period of peak demand, for example, during the hot, dry conditions typical of August in the Project area. The estimated dependable capacity is also determined by the minimum flow requirements included in the existing license. Under the current license, the Project's estimated dependable capacity is approximately 4.9 MW, based on the August median flow of 1,940 cfs at the Project site. The estimated dependable capacity is not expected to change with removal of the four power stations along the downtown canal system given they were only operated during flow conditions over 6,600 cfs.

E.5.7 Current and Proposed Project Operations (18 C.F.R. §5.18(b)(4)(vi)

The Project is operated using the automatic pond level control capability of the E.L. Field Powerhouse. Boott is proposing to continue to operate the Project in the same manner as it is currently operated (automatic).

E.5.7.1 General Operations

The Project is operated in a ROR mode. Under the current project configuration, Boott normally operates the Project to maximize flow through the available units at the E.L. Field Powerhouse, then routes any additional flows through the Pawtucket Canal system. The E.L. Field turbine-generator units are more efficient and operate at a higher head than the older canal units, and are, therefore, the priority first-on, last-off units in the Project operations scheme. When river flows exceed the hydraulic capacity of the E.L. Field units (nameplate hydraulic capacity = 3,300 cfs per unit or 6,600 cfs for both units), excess flows up to approximately 2,000 cfs may be routed through the downtown canal system and to the canal units. Any flows in excess of approximately 8,600 cfs (6,600 cfs at E.L. Field plus 2,000 cfs via canals) are passed over the Pawtucket Dam spillway. Pursuant to Article 37, the Project maintains a minimum flow of 1,990 cfs or inflow, whichever is less, as measured immediately downstream from the Project, which is met or exceeded by operating the project in ROR mode (Boott 2017).

Project operations will not change significantly with the proposed removal of the 15 mill units and associated canal infrastructure from the new license. The Project will continue to operate in ROR mode using automatic pond level control of the E.L. Field powerhouse units, passing all excess flow over the spillway of the Pawtucket Dam. Boott will continue to manage flow passed through the Guard Locks on an as-needed basis for water level and flow management purposes within the downtown canal system.

E.5.8 Pneumatic Crest Gate Operations

On April 18, 2013, FERC authorized Boott to replace the existing wooden flashboard system on the Project's Pawtucket Dam with a pneumatic crest gate system. FERC approved the amended crest gate system operation plan on March 30, 2015. The plan describes the operation of the pneumatic crest gate system under normal and high-water operations.

The pneumatic crest gate system works in conjunction with the automatic pond level control system at the E.L. Field Powerhouse to maintain consistent headpond level conditions.

Below (Table E.5-3) is a tabular description of the operating curve currently used for operations.

Table E.5-3. Pneumatic Crest Gate System Current Operational Scheme

Approximate Spillway Flow (cfs) †	Crest Gate Status	Target Pond Level (ft NGVD 1929)	Unit Operation
0	Full elevation	92.2 ft (Normal pond)	Pond level control maintained at E.L. Field Powerhouse; additional flow passed through downtown canal system as necessary.
0 – 3,250	Full elevation	Rising to ± 93.2 ft	Full available output
3,250 - ± 23,000 (est.)	Automatic pond level control	± 93.2 ft	Full available output
± 23,000 (est.) – 35,000††	Automatic pond level control if High Water Operations Protocol is not triggered.	± 93.2 ft	Full available output
	Fully lowered if High Water Operations Protocol is triggered	Pond level follows spillway rating curve based on spillway flow.	Full available output
>35,000	Fully lowered	Rises above 93.2 ft as spillway discharge increases.	Fully available output

Source: FERC 2015.
† Flow over the spillway is the inflow to the headpond minus any flow through the turbines at the E.L. Field Powerhouse, through the downtown canal system or through the fish ladder. The maximum combined hydraulic capacity of E.L. Field Powerhouse and the canal system is approximately 9,000 cfs, but may be restricted by unit availability, debris accumulation at the Northern Canal Gatehouse, high tailwater conditions, and other factors.
†† The potential range of spillway flows over which the crest gate may be fully lowered per the High-Water Operations Protocol. The estimated flow over the spillway is the flow at the Merrimack River (U.S. Geological Survey [USGS] gage No. 01100000) minus the flow at the Concord River (USGS gage No. 01099500) and minus any flow released through Boott's turbines and the downtown canal system.

E.5.8.1.1 Normal Operation

Under normal operations, the crest gate will be maintained at full elevation, and the E.L. Field Powerhouse control system will adjust the main units' output to match inflow and maintain the impoundment water level at the normal, authorized pond elevation.

E.5.8.2 Operations During Low Water and Adverse Conditions

During low inflow conditions, Boott operates the Project to maintain the impoundment level of 92.2 feet NGVD 29 and provides the required minimum downstream releases and flows necessary for operation of the fish passage structures in accordance with Articles 36 and 37 of the Project's license.

Boott also proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam during the period outside of the fish passage season. The minimum flow would be provided as spillage over one or more of the crest gate zones.

E.5.8.3 Operations During High Water and Adverse Conditions

Under past and current operations, when river flows exceed the hydraulic capacity of the E.L. Field Powerhouse units (approximately 3,300 cfs per unit or 6,600 cfs for both units), excess flows up to approximately 2,000 cfs can be routed through the downtown canal system and to the canal units (as described below). Any flows in excess of these flows are passed over the Pawtucket Dam spillway.

During these high-water conditions, the crest gate control system will automatically adjust the gates to maintain the impoundment elevation no higher than 93.2 feet NGVD 29, or one foot above the normal pond elevation. When under automatic control, the crest gates would all be fully lowered at spillway flows of approximately 35,000 cfs. In addition, the approved crest gate operations plan requires Boott to fully lower the crest gate panels in anticipation of potential flood events. This minimizes the upstream backwater effect of the Pawtucket Dam to the extent possible. (FERC 2015).

Under very high flow conditions when the water level at the Pawtucket Dam reaches 98.0 feet NDVD 29, Boott initiates the installation of the steel stoplogs upstream of the Great Guard Gate, per the provisions of the EAP, as discussed in detail under Section E.5.6.3.1. These stoplogs are designed to functionally replace the historic Great Guard Gate, to prevent the potentially flooding of downtown Lowell via the Pawtucket Canal.

E.5.8.4 Canal System Operations

The existing Lowell Hydroelectric Project includes a two-tiered network of man-made canals, totaling 5.5 miles in length. Flow enters the canal system upstream of the Pawtucket Dam via the Pawtucket Canal and is controlled by the Guard Lock and Gates Facility.

The Lowell Hydroelectric Project presently includes four power stations located within mill buildings along the downtown canal system. The Hamilton Power Station contains five units and draws water from the Hamilton Canal in the upper canal system and discharges into the Lower Pawtucket Canal in the lower canal system at a head of approximately 13 feet. The Assets Power Station contains three units and draws water from the Merrimack Canal in the upper canal system and discharges into the Lower Pawtucket Canal in the lower canal system at a head of approximately 13 feet. In the lower canal system, the Bridge Street and John Street Power Stations each draw from the Eastern Canal and discharge to the Merrimack River or the Concord River, at a head of approximately 21 feet. The John Street Power Station contains four units and discharges into the Merrimack River. The Bridge Street Power Station has three units known as “Section 8” discharging into the Concord River.

As stated elsewhere in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage the canal structures, water levels and flows in line with current agreements with the NPS and other stakeholders.

E.5.8.4.1 Minimum Flow Management

Although there is no formal flow requirement for the canal system, Boott maintains an operating agreement with the NPS to allow tour boat operations to navigate the canal system. Boott maintains canal water levels within appropriate limits during the May 15 to October 15 tour boat operating season. Operations are maintained through a series of locks and gatehouses along the canal system (Cleantech Analytics 2017).

E.5.8.4.2 Normal Operation

The nominal flow capacity of the downtown canal system via the Pawtucket Canal and the Guard Lock and Gates Facility is approximately 2,000 cfs. Future normal operations will consist of providing sufficient flow through the Guard Gates structure necessary to maintain and manage water levels in the downtown canal system, consistent with current practices and agreements.

E.5.8.4.3 Operation During High Water

As discussed in Section E.5.7.1, when river flows exceed the hydraulic capacity of the E.L. Field Powerhouse units (6,600 cfs for both units), excess flows up to approximately 2,000 cfs can be routed through the downtown canal system and to the canal units. Any flows in excess of these capacities are passed over the Pawtucket Dam spillway. Under proposed future operations Boott does not anticipate any need to pass excess flow through the canal system, since the Pawtucket Dam spillway has ample capacity and the crest gates would be fully lowered during high flow events.

The Guard Lock and Gates facility includes the Great Guard Gate, a large portcullis gate constructed in 1851 to prevent flooding in downtown Lowell via the Pawtucket Canal. In 2005 Boott designed and implemented a replacement for the historic Great Guard Gate. The replacement gate is a segmented structural steel stoplog gate and frame which is stored on-site and was designed and implemented in consultation with the FERC and NPS. When required, installation of the steel stoplog gate can be accomplished within a few hours by a local crane operator. The Project’s Emergency Action Plan (EAP) provides that the stoplogs should be installed when the water level at the Pawtucket Dam rises above 98.0 ft NGVD 29. Boott proposes to retain the Great Guard Lock and Gates facility in the Project license, and to continue implementation of the existing EAP associated with the facility.

E.5.8.5 Fish Passage Operations

The Comprehensive Fish Passage Plan (CFPP), approved by FERC on November 28, 2000, required operation of a fish ladder at the Pawtucket Dam. The fish ladder has a total operating flow of 500 cfs including attraction flow. The 500 cfs is the primary source of flow in the bypass reach, other than spillage over the Pawtucket Dam spillway. The fish lift system at E.L Field Powerhouse has a total flow capacity of 180 cfs; however, it presently operates at 100-120 cfs. Boott is required to operate both the fish ladder and the fish lift daily during spring of each year when a cumulative total of 50 American shad (*Alosa sapidissima*) or 200 River herring (*A. pseudoharengus*) are passed at the downstream Lawrence Hydroelectric Project. Additionally, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech Analytics 2017). All fish passage facilities were designed in consultation with the USFWS. Since 2013, Boott has worked cooperatively with the USFWS and other fishery agencies as part of the Merrimack River Technical Committee (MRTC) to assess and provide passage for eels moving upstream in the mainstem Merrimack. The efforts have occurred primarily at the fish ladder at the Pawtucket Dam, from mid-July through September, annually. Fish passage operations are coordinated with the MRTC.

Under the new Project license, Boott proposes to replace the existing fish lift with a short fish ladder to pass migratory fish from the tailrace to the bypass reach, such that all fish would be passed upstream of the Project via the existing fish ladder at the Pawtucket Dam. The Licensee will work with the MRTC member agencies to determine the design and installation schedule for the proposed ladder.

E.5.9 Proposed Project Operations (18 C.F.R. §5.18(b)(4)(vi))

The Project is operated in a ROR mode with no useable storage capacity, and a minimum flow of 1,990 cfs (or inflow, whichever is less) is provided immediately downstream from the Project for the purpose of protection of fish and wildlife resources. Boott also adheres to the CFPP (approved by FERC on November 28, 2000) and the Crest Gate Operation Plan (approved March 30, 2015).

Boott also proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam during the period outside of the fish passage season. The minimum flow would be provided as spillage over one or more of the crest gate zones. During the fish passage season, which generally runs from late April through mid-July, the Licensee proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the fishery agencies, consistent with current practice.

E.6 Proposed Action and Action Alternatives

E.6.1 Summary of Existing Measures

Boott currently implements the following PM&E measures for the protection of aquatic, water quality, geologic/soil, recreation, and cultural resources pursuant to the existing license for the Project.

Article 33 (amended April 18, 2013 and approved May 18, 2016): Requires the Licensee, prior to the commencement of any construction activities, to cooperate with the Massachusetts State Historic Preservation Officer (SHPO) and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historical Park (The license was amended to replace wooden flashboards on Pawtucket Dam with pneumatic crest gate system and mitigation measures were required).

Article 34 (approved September 24, 1984): Requires the Licensee to design and construct upstream and downstream fish passage facilities at the Project, in consultation with the fishery agencies. Accordingly, in the late 1980s the Licensee constructed a fish lift and downstream fish passage facility at the E.L. Field powerhouse and a fish ladder at the Pawtucket Dam. These facilities are operated and managed under the CFPP, as discussed below.

Article 35 (approved November 28, 2000): Requires the Licensee to conduct an operational study to determine the effectiveness of the fish passage facilities required under Article 34, in consultation with the fishery agencies. During the term of the license The Licensee has conducted numerous fish passage studies and has implemented operational and facility improvements based on the results of those studies. These studies and improvements have been carried out pursuant to the CFPP, as discussed below.

Article 36 (approved November 27, 1984; November 28, 2000; July 11, 2001): Required the Licensee develop (1) an instream flow study plan to determine the relationship between Project discharges and downstream aquatic habitat, and (2) a fishery study plan to determine Project discharges necessary to provide for the migration of anadromous fish.

Pursuant to Article 35 and 36, Boott adheres to the Comprehensive Fish Passage Plan, approved by FERC on November 28, 2000.The CFPP requires operations of a fish ladder at the Pawtucket Dam. The fish ladder has a total operating flow of 500 cfs including attraction flow. The 500 cfs is the primary source of flow in the bypass reach, other than spillage over the Pawtucket Dam spillway. The fish lift system at E.L Field Powerhouse has a total flow capacity of 180 cfs; however, it presently operates at 100-120 cfs. Boott is required to operate both the fish ladder and the fish lift daily during spring of each year when a cumulative total of 50 American Shad or 200 River Herring are passed at the downstream Lawrence Hydroelectric Project. Additionally, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech Analytics 2017).

Since 2013, Boott has worked cooperatively with USFWS and other fishery agencies to assess and provide passage for eels moving upstream in the mainstem Merrimack. The efforts have occurred primarily at the fish ladder at the Pawtucket Dam, from mid-July through September, annually.

Article 37 (ordered November 27, 1984): Requires the Licensee to discharge an interim continuous minimum flow of 1,990 cfs or inflow, whichever is less, for the purpose of protection of fish and wildlife resources, as measured immediately downstream from the Project.

Article 38 (ordered September 12, 1984): Requires the Licensee to file a revised Report on Recreational Resources to include: (1) functional plans for certain repairs and improvements to the Northern Canal and a visitor facility at the E.L. Field Powerhouse; (2) a canal system water level agreement with the NPS.

Boott is also required to adhere to the following operations-related plan:

Crest Gate Operation Plan (approved March 30, 2015): Requires the Licensee to adhere to the detailed plan for operation of the pneumatic crest gate system filed on July 16, 2013 and revised on July 30, 2014. The plan describes the operation of the pneumatic crest gate system under normal and high-water operations. Table E.5-3 above provides a tabular description of the operating curve used for operations.

The pneumatic crest gate system works in conjunction with the automatic pond level control system at the E.L. Field Powerhouse to maintain consistent headpond level conditions. Under normal operations, the crest gate will be maintained at full elevation, and the E.L. Field control system will adjust the main units' output to match inflow and maintain the impoundment water level at the normal, authorized pond elevation (92.2 feet). When inflows begin to exceed the capacity of the available units, the crest gate control system will automatically adjust the gates to maintain the impoundment elevation no higher than 93.2 feet, or one foot above the normal pond elevation. When under automatic control, the crest gates would all be fully lowered at spillway flows of approximately 35,000 cfs and above (FERC 2015a). Under high-water operations, Boott will fully lower the crest gate system in anticipation of potential flood events in order to minimize the upstream backwater effect of the Pawtucket Dam to the extent possible.

E.6.2 Summary of Proposed Measures

Based on the studies conducted in support of this relicensing and consultation with stakeholders to date, Boott proposes the following measures to be included in the new Project license:

<u>Project Facilities and Operations</u>

- Boott proposes to operate the Project in a ROR mode using automatic pond level control of the E.L. Field powerhouse units, to protect fish and wildlife resources downstream from the Project. ROR operation may be temporarily modified for short periods to allow flow management for other project and non-project needs, e.g., downtown canal water level management, raising the crest gates following a high-water event, or for recreational purposes.

- During the upstream fish passage season, which generally runs from late April through mid-July, Boott proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the Merrimack River Technical Committee,[6] consistent with current practice. At all other times, Boott proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam, for the protection of aquatic habitat within the bypass reach.
- Boott proposes continued adherence to the requirements of the Project's existing Crest Gate Operation Plan (approved by FERC on March 30, 2015).
- Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage its canal structures and facilities, water levels and flows through the downtown canal system in line with the current agreements with NPS and other stakeholders.

  In general, Boott is proposing to install a concrete plug in each penstock opening at the canal wall, and disconnecting turbines, generators, and other electrical equipment at the Assets, Hamilton, John Street, and Bridge Street (Section 8) powerhouses. The potential need for infilling or bracing of dewatered penstocks would be handled on a case-by-case basis, based on the results of an engineering assessment to be performed during the preparation of the Decommissioning Plan to be developed for each power station. As detailed in Section E.7.6 of this exhibit, Boott, the NPS, MADCR, and Proprietors have different ownership of, easements to, and rights associated with the canals, powerhouses, lock structures, control structures, and water conveyance structures as described in the Memorandum of Understanding (MOU), the 1984 Great Deed between Proprietors and Boott (Proprietors 1984), the 1986 Order of Taking (Commonwealth of Massachusetts 1986), and the 1995 Grant of Easement from the Commonwealth of Massachusetts to the LNHP (Commonwealth 1995). Boott is proposing to continue to operate and maintain these structures consistent with the existing ownership, rights, and easements, as well as any existing or new agreements developed among the concerned stakeholders. The proposed disposition of the downtown facilities is summarized in Table E.6-1.

[6] The Merrimack River Technical Committee is comprised of the following state and federal agencies: New Hampshire Department of Fish and Game (NHDFG), Massachusetts Division of Fisheries and Wildlife (MADFW), Massachusetts Division of Marine Fisheries (MADMF), United States Fish and Wildlife Service (USFWS), United States Forest Service (USFS), and National Marine Fisheries Service (NMFS).

Table E.6-1. Proposed Disposition of Project Facilities Following Decommissioning

Structure	Subcomponents	Ownership	Other Rights	Action	Other
CANALS					
Upper Pawtucket Canal	–	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal[a] • Boott Water and Flowage Rights[b] • MADCR Recreation Rights and Exclusive Easement Rights[c]	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Lower Pawtucket Canal	–	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Hamilton Canal	–	Boott Hydropower LLC (Boott)	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Lawrence Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Merrimack Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
Eastern Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
Northern Canal - Hydro Locks to Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
DAMS, GATEHOUSES, AND LOCK STRUCTURES					
Swamp Locks Complex	Swamp Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures[d]	No change from present	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Swamp Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
	Swamp Locks Dam (North and South)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	No change from present	–
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	No change from present; Boott will continue to operate the gates for canal water level management.	–
Lower Locks Complex	Lower Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
	Lower Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Lower Locks Dam	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights[e]	No change from present	–
	Lower Locks Pier and Fill Valve	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Moody Street Feeder	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	Retain a 5' corridor for submarine interconnection cable

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Moody Street Feeder Gatehouse	–	National Park Service	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	No change from present	–
Lawrence Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Hall Street Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Hamilton Wasteway	-	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Hamilton Gatehouse and Gate (Superstructure)	–	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
Hamilton Gatehouse and Gate (Substructure)	–	Boott	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–
Tremont Wasteway	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Tremont Gatehouse (Superstructure)	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	No change from present	–
Tremont Gatehouse (Substructure)	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Merrimack Dam and Gate	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Massachusetts Wasteway Gatehouse (Superstructure)		MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	No change from present	–
Massachusetts Wasteway Gatehouse (Substructure)		Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Rolling Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Rolling Dam Gatehouse (North and South)	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	No change from present	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Boott Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Boott Dam Gatehouse (Superstructure)	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights • Boott Easement for Access to Structures	No change from present	–
Boott Dam Gatehouse (Substructure)	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
DOWNTOWN POWERHOUSES					
Assets	Intakes	Proprietors of Locks & Canals	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals[f]	• Boott Easement to Penstocks and Tailraces[g]	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers[h]	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
Hamilton	Intakes	Boott	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
John Street	Intakes	Boott	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
Bridge Street (Section 8)	Intakes	Boott		Install concrete plug-in penstock opening at canal wall.	Retain a 5' corridor for submarine interconnection cable
	Penstocks	Boott	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	Retain a 5' corridor for submarine interconnection cable
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott		Disconnect the generators and switch gear	Retain any equipment necessary for interconnection purposes.
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	Retain a 5' corridor for submarine interconnection cable

[a] Easement to the Pawtucket Canal, Lower Pawtucket Canal, the Swamp Locks Dam and Lower Locks Dam for the uninterrupted flowage of water to the canals, together with the right to install conduits, pipes and wiring, and the right to maintain, repair, and replace canal walls and fences, and to maintain and operate Swamp Locks Dam and Lower Locks Dam. See pg. 4-5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[b] Any and all water rights which may exist regardless of how acquired, including, without limitation, any and all water rights by way of riparian rights. See pg. 4-7 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete description of said rights.

[c] All air rights over the canals, including the canal walls and any dams thereon. The exclusive right to use water in the entire canal system and the Merrimack River for recreational, educational, and navigational purposes. For a complete legal description of these rights, see Order of Taking pg. 27 – 28, filed as Appendix C of the Resources, Ownership, Boundaries, and Land Rights Study Report, filed with the Commission on February 25, 2021.

[d] Exclusive right of operating and controlling the gatehouses and locating, keeping in place, maintaining, replacing, operating, controlling and disposing of the control machinery and equipment, gauge equipment and other mechanisms located therein and for access and repair of the gatehouses and access to and maintenance, repair, and installation of the control machinery and equipment, gauge equipment and such other mechanisms located therein that may need to be repaired, reconstructed, or replaced See pg. 5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[e] Right to conduct land and canal tours, run interpretive programs and maintenance, improvement and restoration of Gatehouses and support structures, Dams, and Lock Chambers. See pg. 3 of the Grant of Easement (filed as Appendix D to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[f] Presumed ownership, to be confirmed.

[g] Boott holds an easement to operate, maintain, repair, and replace penstocks leading from the Merrimack Canal, Eastern Canal or Hamilton Canal. Boott holds an easement to operate, maintain, repair, and replace tailraces leading to the Pawtucket Canal, the Concord River, or the Merrimack River. See pg. 8 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[h] An easement to keep in place, locate, operate, maintain, repair, remove and replace the transformers and an easement for unrestricted access thereto for such purposes. See pg. 9 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

- Boott proposes to maintain and monitor target water elevations in the canal system in accordance with current practice. Presently, the target water level in the upper canal system is 81.5 ft as read on a staff gage adjacent to the Hamilton Wasteway, which equals 86.7 ft NGVD29.[7] The target water level for the lower canal system is 66.6 ft as read on staff gauges on the Eastern Canal, located at the Section 8 (Bridge Street) powerhouse intake and at the John Street Unit 6 intake, respectively, which equals 71.8 ft NGVD29.
- Boott will continue to operate the gates at the Guard Lock and Gates Facility ("Guard Locks") to manage water levels in the non-project downtown canal system. Boott anticipates that absent the flow demand of the existing mill turbine units, flows normally released to the downtown canal system will largely consist of those necessary to maintain and manage canal water levels. Presently, Boott estimates that a flow of 200 to 300 cfs must be released from the Guard Locks to make up for leakage and other water losses within the 5.5 mile long canal system. Boott will continue to respond to any requests for canal level or flow modifications from the NPS, MA DCR, the City of Lowell and other stakeholders in the downtown Lowell area, on a case-by-case basis.
- Boott understands that removal of the fifteen turbine-generator units and canal system from its license will require a decommissioning plan to define the final disposition of the canal system, turbine-generator units, water conveyance structures, and mechanical and electrical components. A decommissioning plan is also necessary to protect the public from any safety, dam safety, or environmental concerns. Boott will develop a decommissioning plan for each of the four downtown power stations and the canal system. In developing the decommissioning plan, Boott will consult with the NPS, MADCR, City of Lowell, and the Massachusetts Historical Commission (MHC). Boott will file a decommissioning plan for the Commission's approval within 18 months of issuance of a new license.

<u>Fish Passage</u>

- Boott proposes to replace the existing fish lift with a short fish ladder to pass migratory fish from the E.L. Field powerhouse tailrace to the bypass reach, such that all fish would be passed upstream of the Project via the existing fish ladder at the Pawtucket Dam. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed ladder.
- Following installation and operation of the fish ladder at the tailrace, Boott proposes to cease operations of the upstream fish elevator at the tailrace. The timing of cessation of operation of the upstream fish elevator will be determined based on consultation with the MRTC.

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[7] The staff gages in the Lowell canal system refer to Proprietors of Locks & Canals (PL&C) datum, which is 5.2 feet higher than the National Geodetic Vertical Datum of 1929 (NGVD29), i.e., PL&C + 5.2 = NGVD29.

- Boott proposes to continue to work with the MRTC to identify any necessary minor modifications to the existing upstream fish ladder located at the Pawtucket Dam, and/or to the existing weirs in the bypass reach to improve passage.
- Boott proposes the installation of new trashracks or other fish exclusion facility at the E.L. Field Powerhouse which will be consistent with current USFWS passage guidelines, to prevent entrainment of fish through the turbines. Downstream passage of fish will continue to be provided via the existing sluice gate in the left forebay wall of the E.L. Field Powerhouse. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed fish exclusion system. Boott reserves the right to seasonally deploy the new trashracks or other exclusion facility only during the downstream fish passage season (mid-May – November), and to use the existing trashracks outside of the fish migration season.
- Boott proposes to develop a Fishways Operation and Management Plan in consultation with the MRTC. The proposed plan would effectively replace the Project's existing Comprehensive Fish Passage Plan.

Historic Properties

- Within one year of license issuance, Boott will develop a Historic Properties Management Plan (HPMP) for the Project that will describe appropriate management measures to avoid, minimize, or mitigate Project-related adverse effects on historic and archaeological resources over the term of the new license issued for the Project. The measures provided in the HPMP will direct the Licensee's management of NRHP-listed or eligible historic properties within the proposed Project boundary. Boott will develop the HPMP in consultation with the NPS, MHC, New Hampshire Division of Historic Resources (NHDHR), and Indian tribes.
- Boott proposes to continue to adhere to existing license Article 33, which requires that prior to the commencement of any construction activities inside the Project boundary, Boott will cooperate with the Massachusetts SHPO and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historical Park.

Recreation

- Within one year of license issuance, Boott will develop a Recreation Access and Facilities Management Plan in consultation with the stakeholders to: a) evaluate opportunities for increasing pedestrian access to the Northern Canal Walkway under certain conditions; b) define flow management practices needed to enhance recreational opportunity in the project vicinity; and c) continue to manage the Project's recreation facility, the E.L. Field Powerhouse Visitor Center.

License Term

- In view of the substantial capital investment in new or improved fish passage facilities that Boott is committing to within this license application, Boott requests that the Commission issue the new license for a term of 50 years. This request is consistent with the Commission's 2017 Policy Statement on Establishing License Terms for

Hydroelectric Projects,[8] which recognizes "significant measures expected to be r

[8] PL17-3-000, October 19, 2017

equired under the new license” when considering extension of a license term beyond the 40-year default period.

Boott notes that certain studies required by the Commission are ongoing (the Three-Dimensional CFD Modeling Study and the Whitewater Boating and Access Study). Boott will consult with stakeholders regarding the results and recommendations of these studies and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7 Environmental Analysis by Resource Area

Pursuant to 18 C.F.R. § 5.18(b), this section discusses the existing Project related resources in more detail and analyzes the effects of the proposed action on these Project area resources. This section incorporates by reference all relevant prior relicensing materials including the resource study reports. The most important and relevant information from the reports and prior documentation are summarized herein as part of the analysis of the effects.

This section is divided into the following major resource areas:

- Geological and Soil Resources
- Water Quantity and Quality
- Fish and Aquatic Resources
- Terrestrial Resources
- Rare, Threatened, and Endangered (RTE) Species
- Recreation and Land Use
- Aesthetic and Socioeconomic Resources, and
- Cultural Resources

Each of the above resource areas is further divided into the following major subsections:

- Affected Environment - This subsection presents information on the affected environment using the information filed in the Licensee's PAD, information developed through the Licensee's FERC-approved study plans, and other information otherwise developed or obtained by the Licensee.
- Environmental Analysis - This subsection describes the beneficial and potential adverse effects of continued operation of the Project as proposed. Where appropriate, this subsection addresses both site-specific and cumulative Project effects, as required by Scoping Document 2 (SD2). The environmental analysis for each resource area is based on information presented in the PAD, the results of studies conducted in support of the license application, professional expertise, and other information obtained by the Licensee. This subsection also describes the Licensee's proposed environmental measures designed to address potential Project effects, and how the Licensee's proposed measures would protect or enhance the existing environment. The measures are listed above and described in greater detail in these subsections, as appropriate.
- Proposed environmental measures - This subsection describes any proposed new environmental measures, including, but not limited to, changes in the project design or operations, to address the environmental effects identified above and its basis for proposing the measures.
- Unavoidable Adverse Effects - This subsection describes any adverse impacts that would occur despite the Licensee's proposed environmental measures.

E.7.1 Geology and Soil Resources

The subsections below describe geology and soil resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on geological and soil resources.

E.7.1.1 Affected Environment

E.7.1.1.1 Geology

Physiography and Topography

The Lowell Project is located in the New England Physiographic Province. This broad physiographic section is characterized as a mountainous area of significant relief. The area is made up of highly deformed Precambrian and Paleozoic metamorphic rocks, including gneiss, schist, slate, quartzite, and marble. The province was glaciated during the Pleistocene and shows both depositional and erosional effects of glacial ice. The Taconic, Green, and White Mountain ranges are distinct features of the New England Physiographic Province. The Taconic Mountains are a north-south trending mountain range along the western edge of the province and are thought to be formed by erosion of an upper block of a large thrust fault. Also, trending north south, the Green Mountains exist primarily in Vermont and are made of Precambrian gneisses. The White Mountains are an exhumed mass of Paleozoic granite and include Mount Washington in New Hampshire, the tallest mountain in the region at 6,288 feet. The province is valued for its mineral resources, both industrial and as building materials. Marble, granite, and slate are all widely distributed and quarried within the province (NPS undated *a*).

The Merrimack River watershed traverses each of the three major sections of the New England Physiographic Province: the White Mountains, New England Uplands, and Seaboard Lowlands (Flanagan et al. 1999 as cited in USACE 2003). The majority of the basin falls within the New England Uplands region, which is characterized by rolling hills and has a local relief ranging from a few hundred feet to 1,000 feet in more mountainous regions. The watershed elevation ranges from a high of 5,249 feet on Mount Lafayette in the White Mountain region to mean sea level along the northeastern Massachusetts coast (USACE 2003).

The Lowell Project is located in the Seaboard Lowlands Section of the New England Physiographic Province. The Seaboard Lowlands Section is lower in elevation and less hilly than the New England Upland Section. The boundary between these two sections is between 400 and 500 feet in elevation in most places. According to Flanagan et al. (1999), topographic relief in the Seaboard Lowlands Section is limited to less than approximately 200 feet in most places. In the vicinity of the Project, the Merrimack River flows through a region of rapid population growth and development that is heavily influenced by the Lowell metropolitan area. The local relief in the Merrimack River Valley in the Project vicinity is generally characterized as low, open hills. A topographic map of the Project and vicinity is presented in Figure E.7-1 through Figure E.7-5.

Figure E.7-1. Lowell Project Topographic Map Showing Proposed Project Boundary

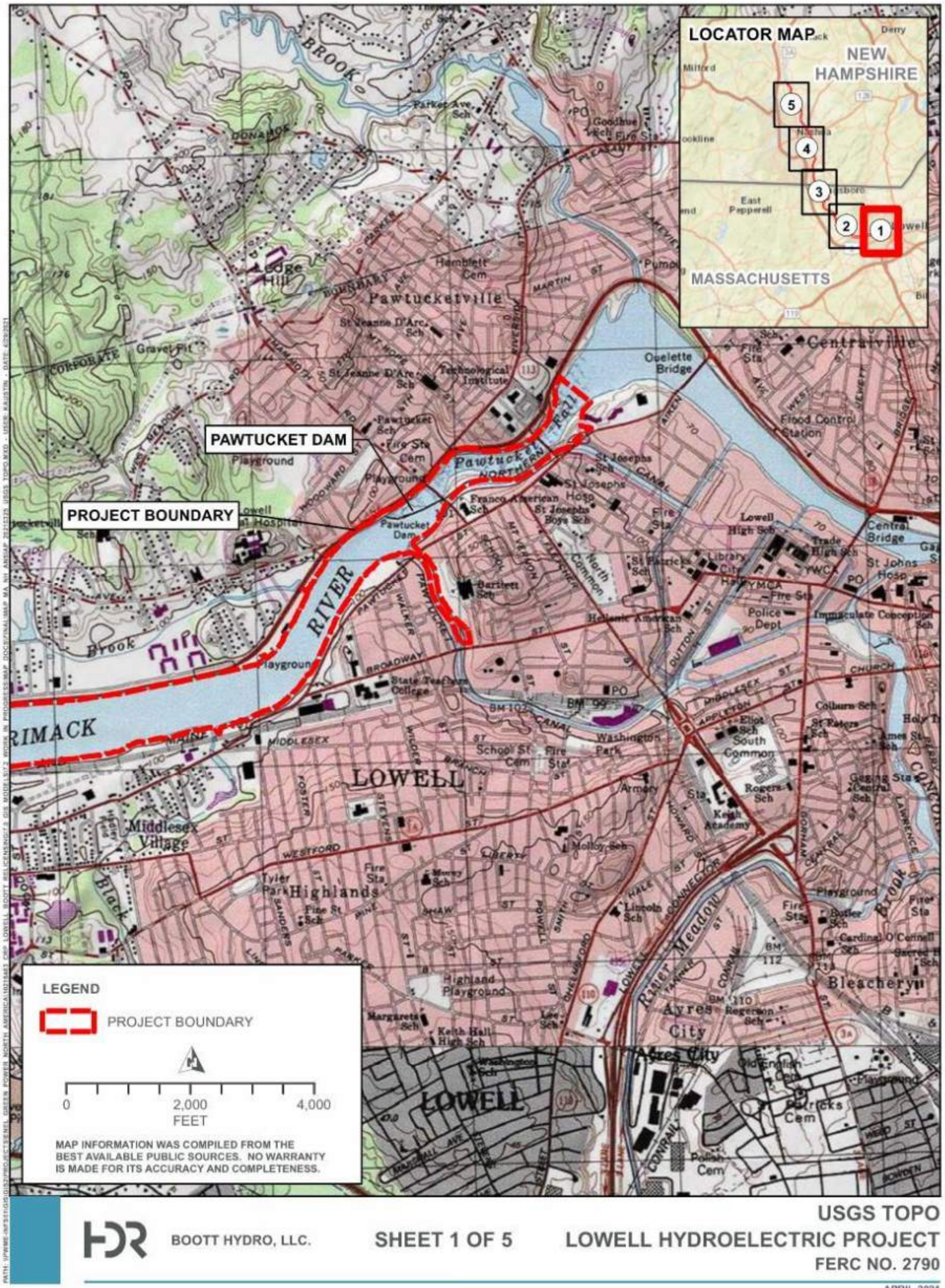


Figure E.7-2. Lowell Project Topographic Map Showing Proposed Project Boundary

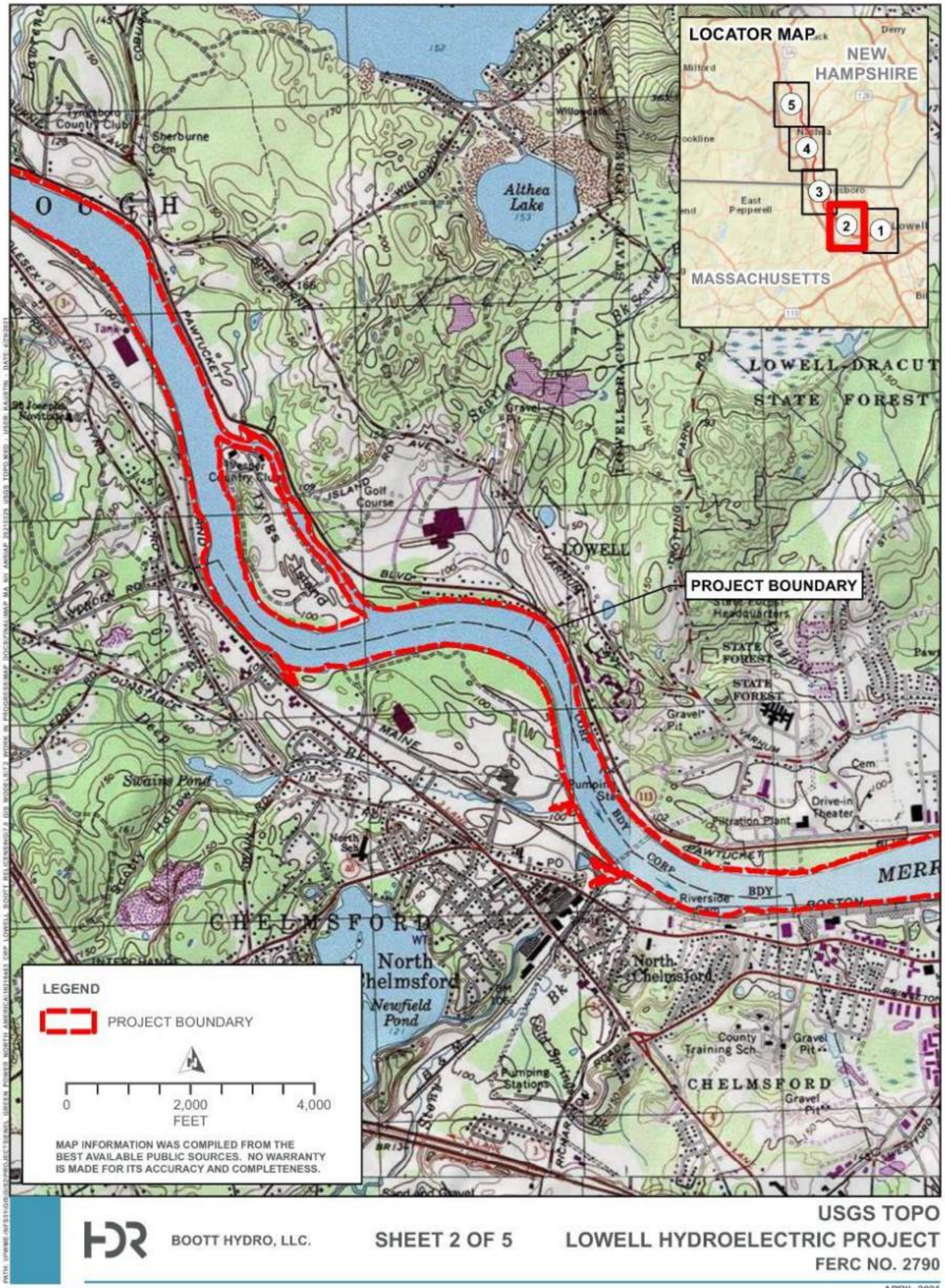


Figure E.7-3. Lowell Project Topographic Map Showing Proposed Project Boundary

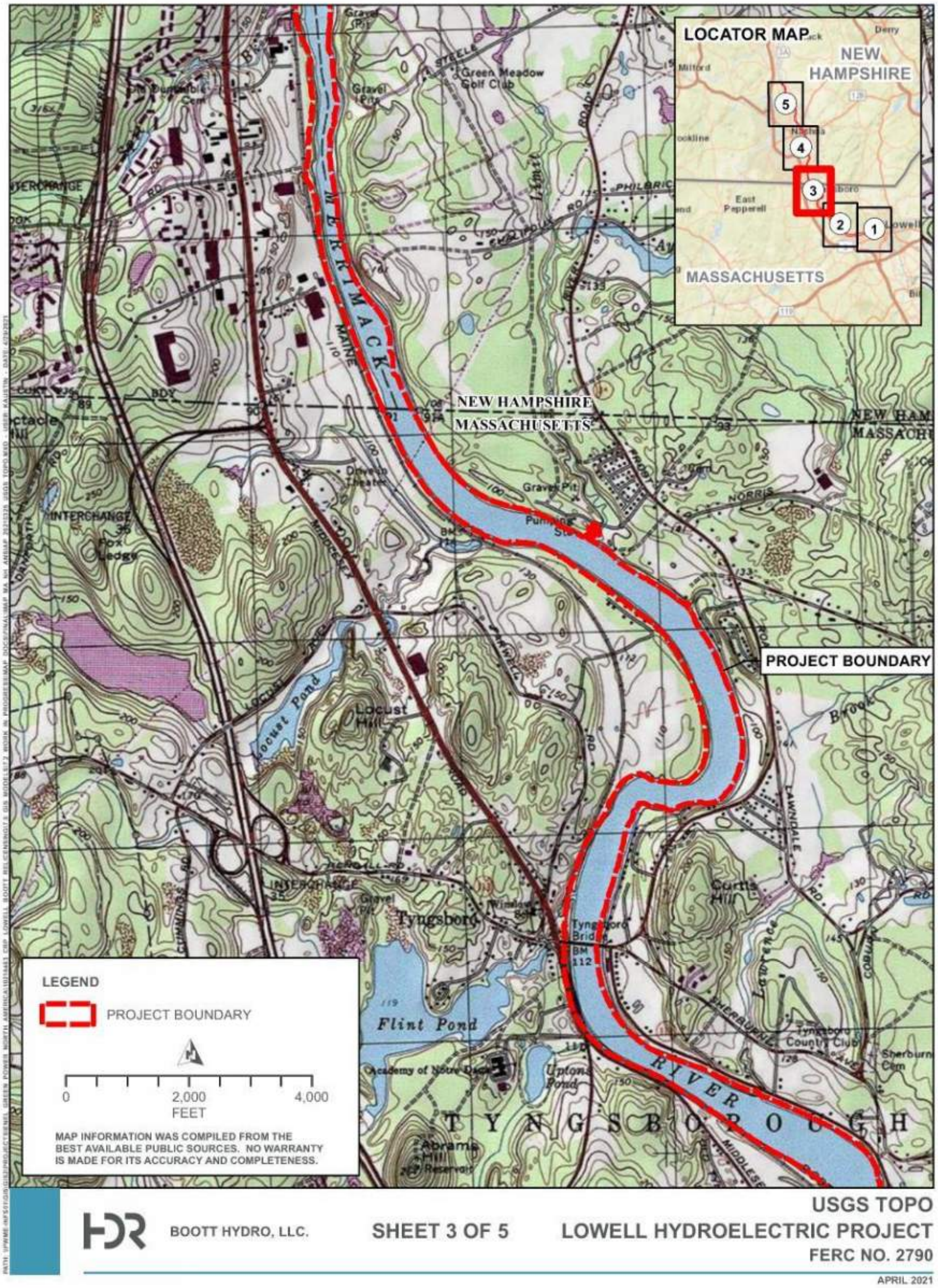


Figure E.7-4. Lowell Project Topographic Map Showing Proposed Project Boundary

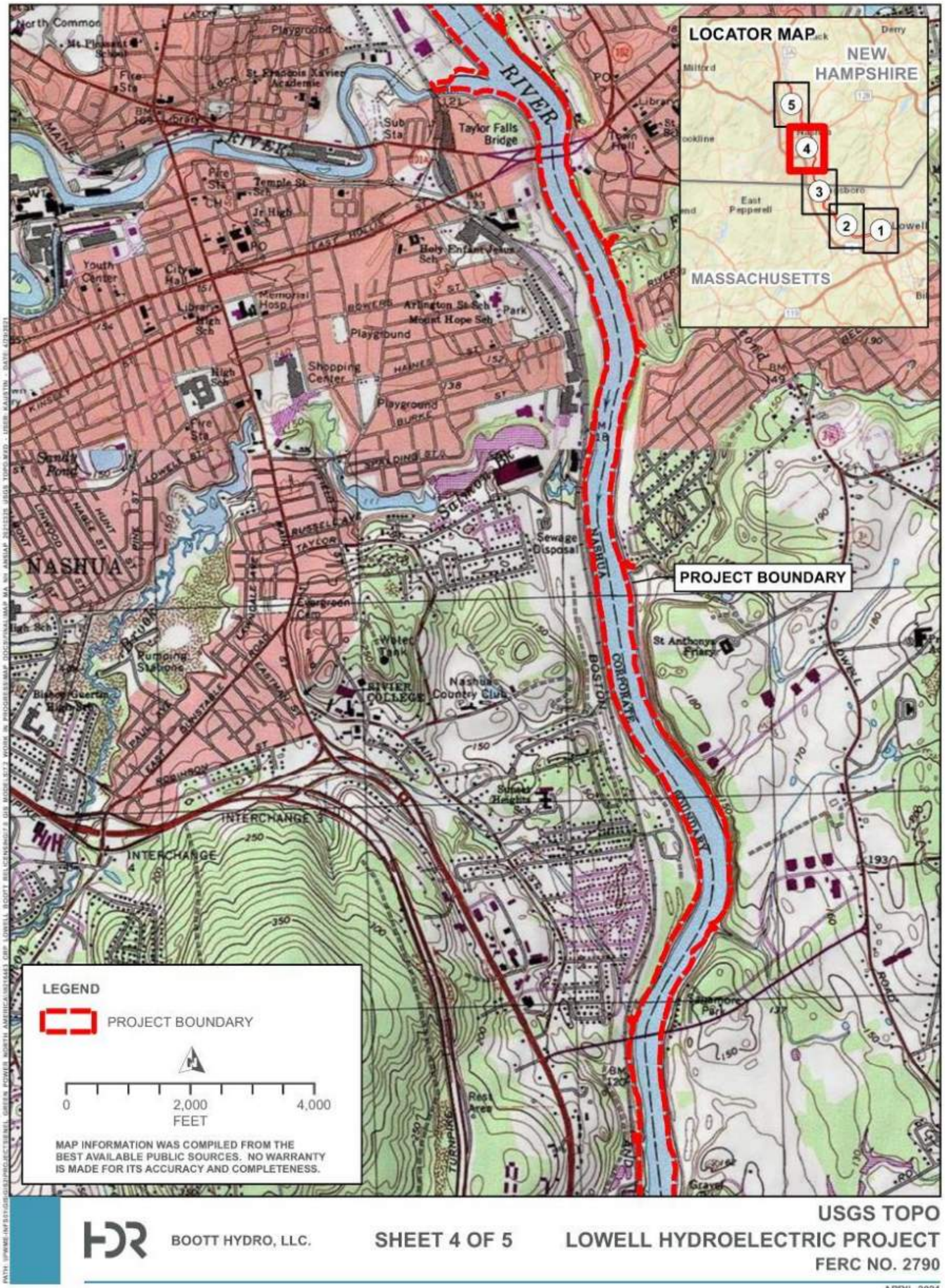
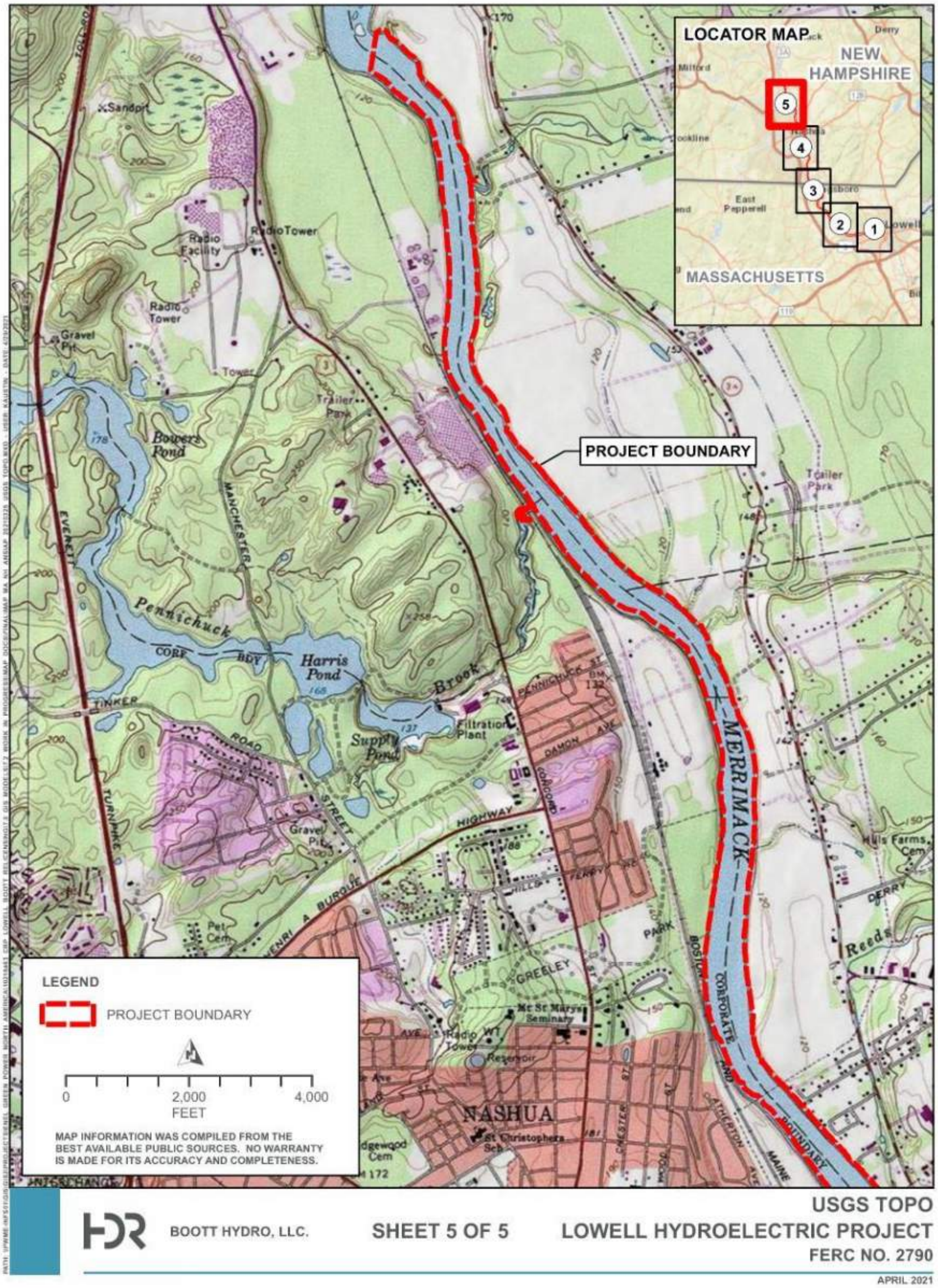


Figure E.7-5. Lowell Project Topographic Map Showing Proposed Project Boundary



Bedrock Geology

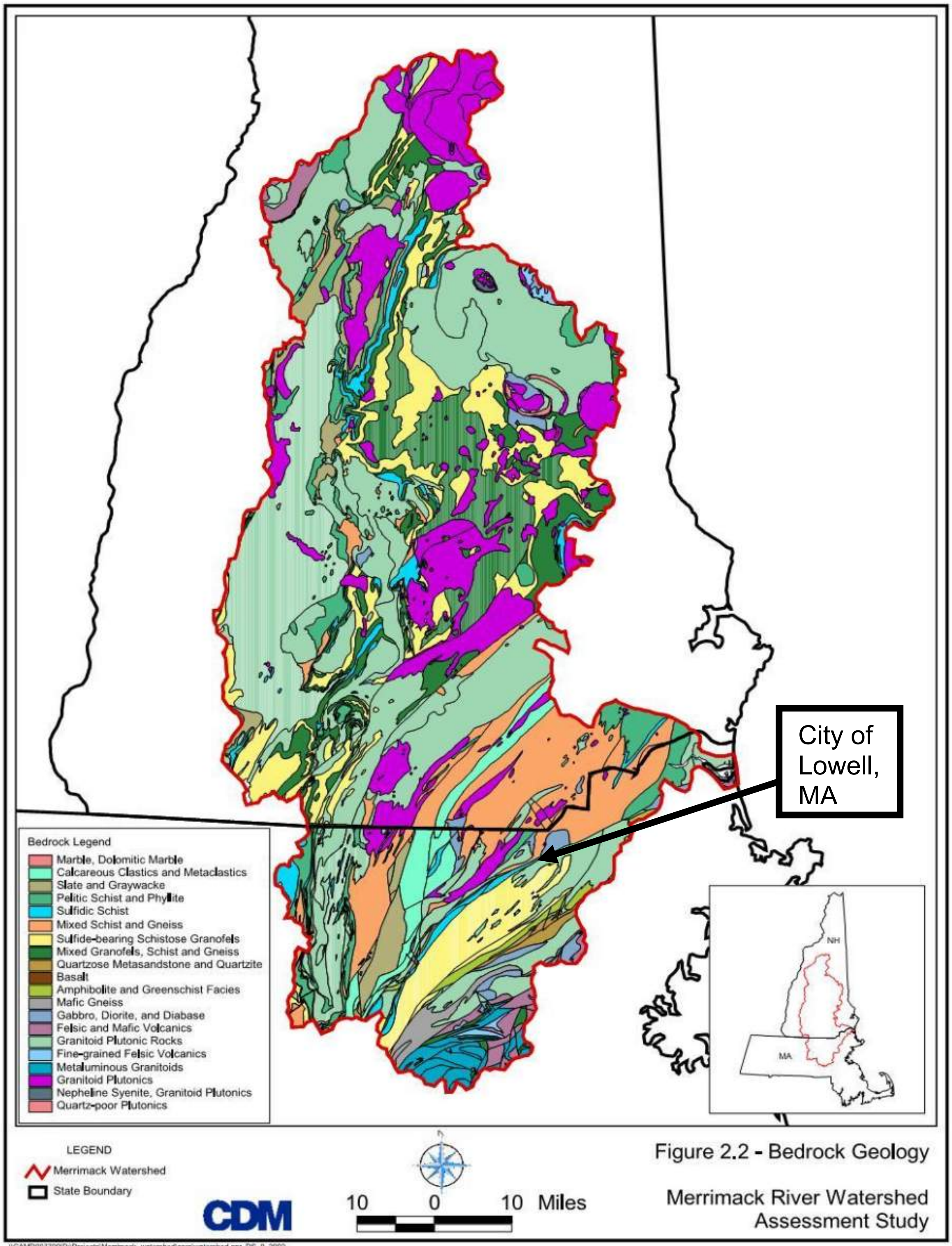
Bedrock in the Merrimack River watershed is generally of similar age and genesis. Intrusive igneous rocks, primarily Granitoid Plutonic rocks, dominate the northeastern portion of the river basin. Large deposits of metamorphic mixed and sulfide-bearing granofels cover the north-central and northwestern portion of the basin. A strip of metamorphic grade rocks, including mixed schist and gneiss deposits, cuts across the Massachusetts-New Hampshire border in a northeasterly direction (USACE 2003). The bedrock is generally layered and complexly deformed. Structures and contacts generally trend northeast to southwest, perpendicular to the direction of collision during the Acadian Orogeny. The mineralogy of the bedrock units is highly varied, from pure quartz in quartzite formations to thin layers of calc-silicate rocks, large bodies of schist with various mineral assemblages (often with high iron and manganese concentrations), and metavolcanics with high base-cation concentrations (Flanagan et al. 1999).

The Merrimack Quartzite is the principal bedrock unit underlying the Project. Although the rock is cut by abundant fractures, it is hard and relatively unweathered. The low-grade metasedimentary rock is of Silurian or Devonian age, approximately 400 million years old. Lithologically, the rock is a fine-grained, impure, bedded quartzite with minor schist. In places, quartzite consists of alternating coarse-grained sandy beds with silty beds (Boott 2015).

The Project is also nearby the mapped contact between the Merrimack Quartzite and the Ayer Granite. The Ayer Granite is a late Paleozoic intrusion. It is a complex igneous rock with an average composition of granodiorite. It is a light- to medium-gray, medium- to coarse-grained rock, commonly porphyritic, gneissic or migmatitic (Boott 2015).

A bedrock geology map of the Merrimack River watershed is presented in Figure E.7-6.

Figure E.7-6. Merrimack River Watershed Bedrock Geology



Source: USACE 2002

Surficial Geology

Glaciation has shaped the landscape of eastern North America during several major glacial periods. As glaciers flowed across the landscape, they scraped and sculpted the land surface. As glaciers retreated from the landscape during deglaciation, they created lakes and altered the course of rivers. Debris scraped off the land surface was carried by the ice and deposited as sand, gravel, and other unconsolidated sediments across the landscape. Some of the sediments were deposited by the ice directly, and the rest were carried by meltwater streams and deposited in the sea or elsewhere on land. Most of the surficial sediments found across New England are a result of glaciation (Flanagan et al. 1999).

The Merrimack River basin is generally covered by a sheet of glacial till, with areas of large fine- and large-grained, glacial-lake deposits along the river mainstem and major tributaries (Flanagan et al. 1999 as cited in USACE 2003). Till, known locally as "hardpan," is composed of boulders, gravel, sand, silt, and clay mixed in various proportions, and is usually compact, stony, and difficult to dig. Lodgement (or basal) till, deposited directly beneath active ice, is generally more compact than ablation till (Flanagan et al. 1999).

According to the USACE (1977), the till cover within the Merrimack River basin is composed of variable, unstratified, silty, gravelly, sand and clays. The cover is generally thin on the hilltops and in the deep valleys, with exposed bedrock typically visible in the hilly upland regions. Large glacial melt-water lakes formed throughout the basin during glacial retreat (USACE 2003).

Mineral Resources

As mentioned above, the New England Physiographic Province is valued for its mineral resources, both industrial and as building materials. Marble, granite, and slate are all widely distributed and quarried within the province (NPS undated *a*). There are no mapped oil, gas, or mineral resources in the Lowell Project boundary. According to the USGS (USGS Undated *a*), there are three active mines in the Project vicinity, including the Westford Quarry located approximately 4.5 miles southwest of Pawtucket Dam, the Chelmsford Quarry located approximately 4.4 miles southwest of Pawtucket Dam, and a Sand and Gravel Operation located approximately 5.4 miles northeast of Pawtucket Dam in Essex County, MA.

E.7.1.1.2 Soils

Soil types in the vicinity of the Lowell Project are variable and reflect the diversity of parent materials, the local topography, and the physiographic position of landforms. The Project vicinity is composed of soil series formed primarily in glacial and glaciofluvial deposits, sandy outwash or eolian deposits, and recent alluvium. According to USACE (2003), soil types occurring in the vicinity of the Project include silt loam, unweathered bedrock, loamy sand, and areas mapped as mucky peat. Additionally, a large portion of the soils mapped in the Project vicinity are classified as Udorthents. There are many types of Udorthent soils, but in general they include areas of human altered soil and non-soil areas that are mapped based on their surface texture, type of alteration, depth to water table, and geologic setting. Some human-altered map units include sand, gravel, till, quarry pits, areas of excavated (cut and fill) geologic material, and areas used for the disposal of refuse.

Mapped soils in the vicinity of the Project are presented in Figure E.7-7 through Figure E.7-8. A 100-foot buffer has been applied to the Project boundary to develop this figure. Map unit delineation on a soil map represents an area that is dominated by one or more major kinds of soil or miscellaneous area. Each map unit is identified, and names are in accordance with the taxonomic classification of the dominant soils. The U.S. Department of Agriculture's (USDA) Official Soil Series Descriptions for mapped soil series Figure E.7-7 through Figure E.7-8 are presented in Appendix A of this FLA (USDA undated).

E.7.1.1.3 Impoundment Shoreline and Stream Banks

The shoreline surrounding the Merrimack River within the Project area typically consists of low-to-moderate slopes dominated by urban, commercial, industrial, and residential development. Some areas along the shoreline within the Project vicinity consist of agricultural areas and some areas consist of forest canopy vegetation underlain by established shrub and herbaceous layers. Large boulders, cobbles, or exposed bedrock are uncommon along the shoreline of the Merrimack River within the Project area. A portion of the shoreline is bordered by walking trails which are used by the public, and the majority of the southern shoreline is bordered by a railroad.

A summary description of the streambanks for the Merrimack River within the Project area in the vicinity of the Project is provided below based on the results of the Recreation and Aesthetics Study performed by Boott in 2020 (HDR 2021a).

A wide variety of vegetation types, occurrences, and distribution, ranging from herbaceous, non-woody plants to forested areas of trees and underbrush, and shoreline/canal types, ranging from earthen embankments to placed, uniformly sized blocks were observed during the study. Mapped vegetation was greatest in the Pawtucket Canal, followed by the Eastern Canal, Western Canal, and Northern Canal. Common vegetation species observed along the canals and within the Project area along the Merrimack River include tree of heaven (*Ailanthus altissima*), American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), red maple (*A. rubrum*), Siberian elm (*Ulmus pumila*), various goldenrod (*Solidago*) species, and some weedy and invasive species including purple loosestrife (*Lythrum salicaria*), poison ivy (*Toxicodendron radicans*), Boston ivy (*Parthenocissus tricuspidata*), mullein (*Verbascum thapsus*), and common ragweed (*Ambrosia artemisiifolia*).

There is no evidence of erosion, slumping, or slope instability around the shoreline of the Project.

E.7.1.1.4 Seismicity

The northeast United States lies within the relatively tectonically stable and geologically old North American plate, where a great deal of the tectonic action took place over 200 million years ago when the Atlantic basin began to form due to the separation of Africa from North America. However, based on instrumental seismic records, earth scientists believe that the tectonic activity in the northeast is still ongoing (Ebel 1987).

The Project is located in Seismic Zone 2 and is subject to earthquakes of moderate intensity. The Clinton-Newbury fault zone forms an important regional crustal plate boundary and is located roughly 1.5 miles southeast of the Project area. No recent largescale earth movements are known along the Clinton-Newbury fault and it is considered inactive (Boott 2015).

Regarding historic seismicity, the USGS National Earthquake Information Center Database was searched regarding earthquakes within the Project region from 1970 to present day. The most significant (largest and closest) events were indicated by the USGS to be a magnitude (M) of 3.7 on October 2, 1994, 54 miles from the Project, and a M of 3.1 on January 10, 1999, 22.3 miles from the Project (USGS undated *b*).

E.7.1.2 Environmental Analysis

No potential issues related to geological or soil resources were identified during the scoping process. There are currently no adverse Project effects on geology or soils, and Boott is not proposing major operational changes to the Project. Continued operation of the Project is not expected to have a material adverse effect on geologic resources, soils, or the geomorphology of the Project impoundment.

E.7.1.2.1 Effects of Decommissioning

As described in Section E.6.2 of this exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Removal of these facilities and decommissioning the powerhouses is not expected to have any adverse effects on geology and soils.

E.7.1.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain PM&E consistent with the measures required by the Project's existing license.

Decommissioning the downtown powerhouses may require minor ground disturbance in areas primarily characterized by urban fill. Boott has proposed to develop a plan for decommissioning the powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

E.7.1.4 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those effects that may still occur after implementation of PM&E measures. Continued Project operations as proposed by the Licensee are not expected to have any unavoidable adverse impacts on geological or soils resources.

Figure E.7-7. Lowell Project Soils Map Showing Proposed Project Boundary

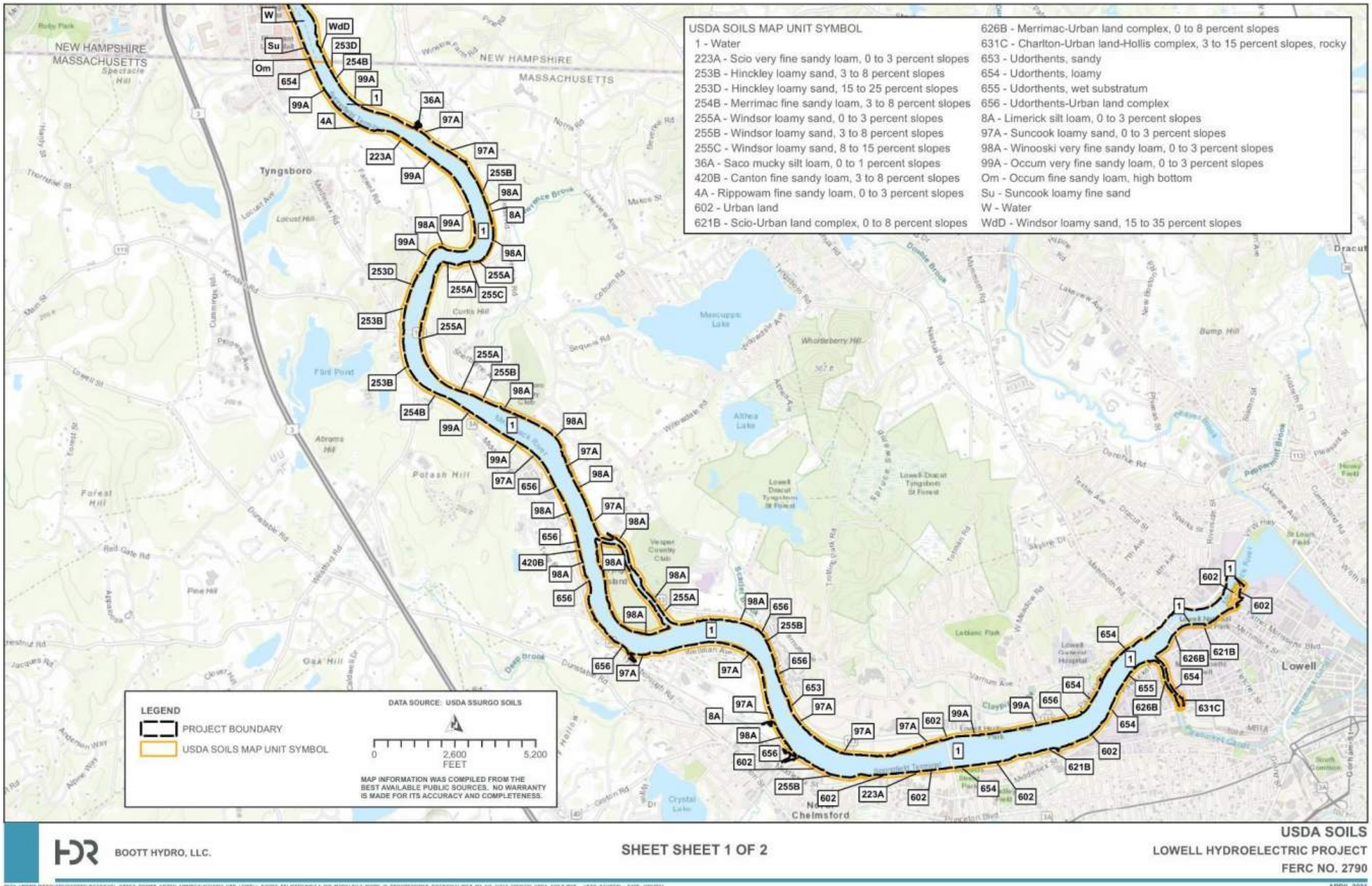
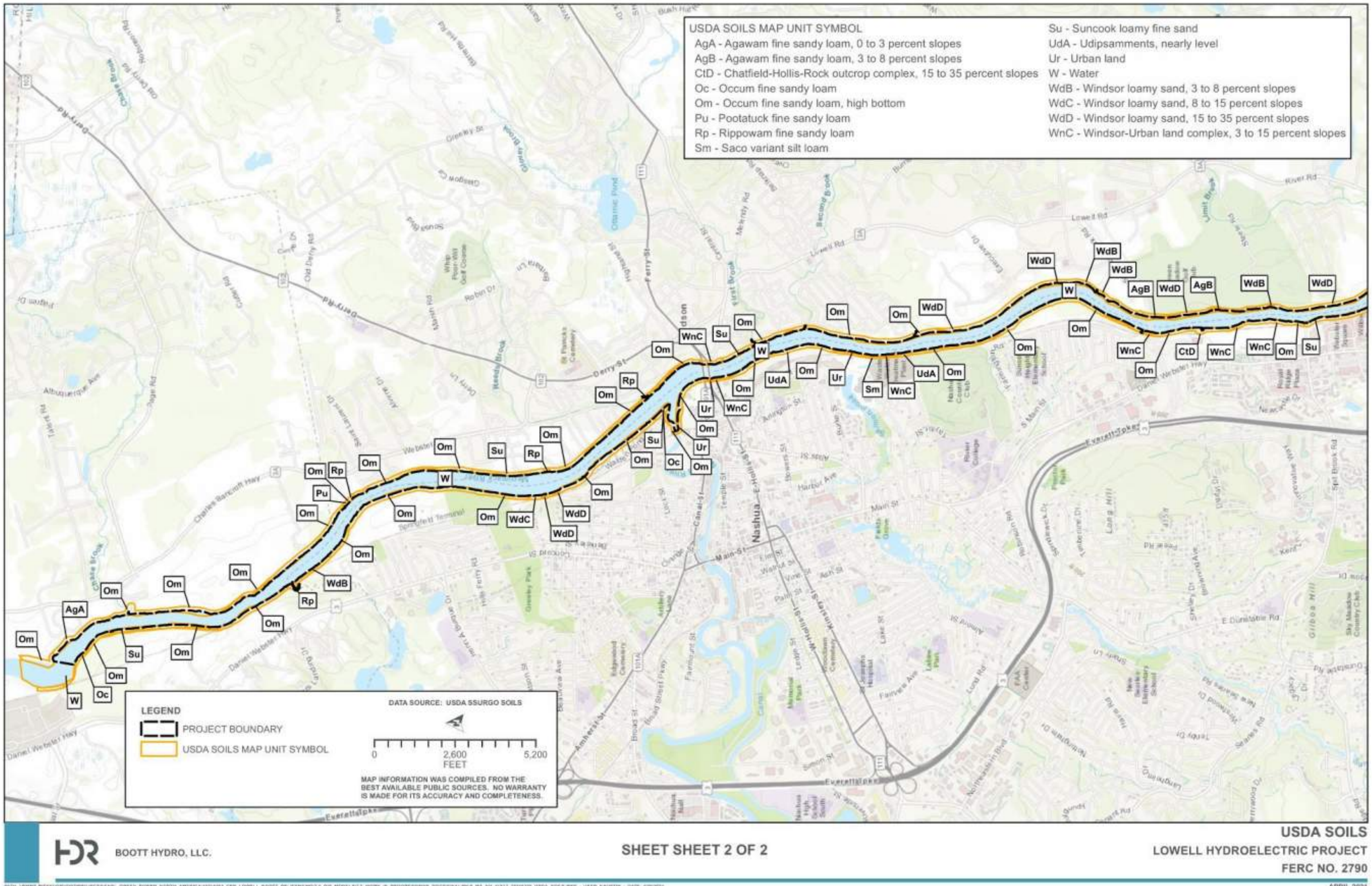


Figure E.7-8. Lowell Project Soils Map Showing Proposed Project Boundary



E.7.2 Water Quantity and Quality

The subsections below describe water resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on water quantity and quality. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD and water resources data collected from:

- Downstream American Eel Passage Assessment (Normandeau Associates, Inc [NAI] 2021a)
- Fish Assemblage Study (NAI 2021d)

These reports are included in Appendix B of this exhibit.

E.7.2.1 Affected Environment

E.7.2.1.1 Water Quantity

The Merrimack River watershed has a total drainage area of approximately 5,010 square miles within the states of New Hampshire and Massachusetts (Massachusetts Executive Office of Energy and Environmental Affairs [MEOEEA] 2002). The Lowell Project is located at river mile (RM) 41 on the Merrimack River in Massachusetts with an existing impoundment extending upstream approximately 16miles to Cromwell's Falls in Merrimack and Litchfield, New Hampshire.[9] The drainage area of the Project is approximately 3,979 square miles.

E.7.2.1.2 Project Hydrology

The Project operates in a run of river (ROR) mode, and therefore, experiences seasonal and annual variations in flows based on natural hydrologic conditions in the Merrimack River Watershed. Table E.7-1 provides Project hydrologic data from 1987-2016.

Table E.7-1. Lowell Project Hydrologic Data (1987-2016)

Month	Minimum (cfs)	90% Exceedance (cfs)	Average (cfs)	10% Exceedance (cfs)	Maximum (cfs)
January	916	3,462	7,651	12,834	39,710
February	1,478	3,272	6,813	11,415	39,180
March	1,914	4,508	11,484	21,355	50,220

[9] The preparation of Exhibit G boundary maps provided Boott the opportunity to make corrections and modifications consistent with the Project's operations. Boott is proposing to remove about 7.4 miles from the upper limit of the current Project boundary, making the proposed Project impoundment about 16 miles in length. This removal more accurately follows the 92.2 NGVD 29 contour of the Project impoundment. See Exhibit G.

Month	Minimum (cfs)	90% Exceedance (cfs)	Average (cfs)	10% Exceedance (cfs)	Maximum (cfs)
April	2,765	6,558	17,901	31,178	78,890
May	2,034	4,112	10,749	18,657	88,410
June	874	2,279	6,768	13,286	44,660
July	670	1,325	4,207	9,270	29,820
August	569	1,121	3,526	6,852	30,030
September	460	1,008	3,162	6,025	32,264
October	787	1,676	5,938	12,706	50,150
November	1,345	2,888	7,978	14,747	30,990
December	1,839	3,472	9,141	17,243	34,810
Annual	460	1,723	7,941	17,059	88,410

Note: Project hydrology determined by subtracting flows from USGS Gage No. 01099500 (*Concord River Below Meadow Brook, at Lowell, MA*) from USGS Gage No. 01100000 (*Merrimack River Below Concord River at Lowell, MA*).

Existing Instream Flow Uses

Existing instream flow uses of the Merrimack River include hydropower generation and industrial uses with recreation (e.g., fishing and boating). There are five FERC-regulated hydroelectric projects on the Merrimack River, and another two located on the main stem Pemigewasset River. The Project is located approximately 11 miles upstream of the Lawrence Hydroelectric Project (FERC No. 2800) and approximately 30 miles downstream of the Amoskeag Dam (one of the three developments of the Merrimack River Project, FERC No. 1893) in New Hampshire. There are also four U.S. Army Corps of Engineers (USACE) flood storage dams within the Merrimack River basin.

Existing and Proposed Uses of Project Waters

In Massachusetts, the Massachusetts Department of Environmental Protection (MADEP) regulates the quantity of water withdrawn from both surface and groundwater supplies to ensure adequate water supplies for current and future water needs pursuant the Massachusetts Water Management Act (MADEP 2018a). Available registrations and permits were reviewed. Two regulated water withdrawals were identified in Lowell. These withdrawal users were identified as Lowell Water Treatment Facility (Permit #9P231316003) and Western Avenue Dyers (Permit #9P131316001). Based on the 2016-2019 Annual Water Quality Reports by the Lowell Regional Water Utility (LRWU), the utility withdrew 3.9 to 4.2 billion gallons of water from the Merrimack River annually to provide drinking water for Lowell and the surrounding communities (LRWU 2016, 2017, 2018, 2019).

In New Hampshire, Pennichuck Water Works supplies water for the City of Nashua and 10 surrounding New Hampshire municipalities located in southern New Hampshire, using both surface water and groundwater sources. The Nashua Core water system derives its water supply from the Pennichuck Brook and the Merrimack River watersheds (Pennichuck Water Works 2018). The city of Manchester currently does not utilize the Merrimack River as a drinking water source, but it is anticipated to by year 2022 (Manchester Water Works 2019).

In New Hampshire, the New Hampshire Department of Environmental Services (NHDES) regulates large groundwater withdrawals under the state's Groundwater Protection Act to ensure that no adverse impacts to water users or natural resources occur as a result of withdrawals (NHDES 2018). The only two groundwater withdrawal permits within the Project vicinity were issued to the Merrimack Village District Water Works in New Hampshire (Permittee Number LGWP-2017-0001) for 432,000 gallons per day and to Manchester Water Works (Permittee Number LGWP-2020-0001) for 7.2 million gallons per day. However, neither permit holder has started withdrawing from the permitted source (NHDES 2020).

The U.S. Environmental Protection Agency (USEPA) is the permitting authority in Massachusetts and New Hampshire for issuing National Pollutant Discharge Elimination System (NPDES) permits, which are required whenever a municipality, industry, or other entity wishes to discharge pollutants to a surface water of the United States. In Massachusetts, NPDES permits are typically co-issued by the USEPA and MADEP (MADEP 2018b). Available NPDES permits were reviewed for the Project vicinity in Massachusetts (Commonwealth of Massachusetts 2020a, USEPA 2018). The only permit located within the Project area was issued to the City of Lowell for Combined Sewer Overflow (CSO) outfalls at 9 locations, 7 of which are discharged into the main stem of the Merrimack River, and one of these outfalls is located just upstream of the Pawtucket Dam. The other two outfalls discharge in Beaver Brook and the Concord River, which are both tributaries to the Merrimack River just downstream from the Pawtucket Dam (USEPA 2019a).

Three NPDES permits were identified within the Project vicinity in New Hampshire, which were issued for wastewater treatment facilities and combined sewer overflows to the city of Manchester (Permit Number NH0100447), the town of Merrimack (Permit Number NH0100161) and the city of Nashua (Permit Number NH0100170) (USEPA 2020a). Another permit was issued to Nylon Corporation of America in Manchester for two separate outfalls (USEPA 2019b).

The Lowell Project has four NPDES permits issued under the Massachusetts General Permit no. MAG360000. These are: Permit No. MAG360024 for the Eldred L. Field Powerhouse; No. MAG360026 for the Hamilton powerhouse; No. MAG360025 for the John St. powerhouse; and No. MAG360027 for the Section 8 powerhouse.

E.7.2.1.3 Water Quality

Massachusetts Water Quality Standards

Water quality standards for the Commonwealth are contained in the Code of Massachusetts Regulations (CMR) at 314 CMR 4.00: Massachusetts Surface Water Quality Standards (SWQS). Inland surface waters of the Commonwealth are classified by appropriate use Class (A, B, or C) as defined in 314 CMR 4.05. Qualifiers applied to these classifications indicate special considerations and uses applicable to a waterbody segment that may affect the application of criteria or antidegradation provisions. The classification of surface water in Massachusetts is provided in 314 CMR 4.06.

The MADEP's Division of Water Pollution Control has classified waters within the Project vicinity as Class B with specific qualifiers (Table E.7-2). As defined in 314 CMR 4.05(3)(b), Class B waters are designated as:

> *[A] habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth, and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06, Class B waters shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.*

A summary of the standards applicable to Class B waters with the Warm Water qualifier is provided in Table E.7-3.

Table E.7-2. Water Quality Classification Applicable to the Lowell Project in Massachusetts

Boundary	Mile Points	Class	Qualifiers
State line to Pawtucket Dam	49.8 – 40.6	B	Warm Water[1] Treated Water Supply[2] CSO[3]
Pawtucket Dam to Essex Dam, Lawrence	40.6 – 29.0	B	Warm Water[1] Treated Water Supply[2] CSO[3]

Source: 314 CMR 4.06.

[1] In these waters, dissolved oxygen and temperature criteria for warm water fisheries apply.

[2] Denotes those Class B waters that are used as a source of public water supply after appropriate treatment. These waters may be subject to more stringent site-specific criteria established by the Department as appropriate to protect and maintain the use. See, also, 310 CMR 22.00.

[3] These waters are identified as impacted by the discharge of combined sewer overflows (CSO); however, a long-term control plan has not been approved or fully implemented for CSO discharges.

Table E.7-3. Water Quality Standards for Class B Waters with the Warm Water Qualifier in Massachusetts

Parameter	Class B Warm Water Standards
Dissolved Oxygen (DO)	Shall not be less than 5.0 milligrams per liter (mg/L) in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

Parameter	Class B Warm Water Standards
Temperature	Shall not exceed 83 degrees Fahrenheit (°F) (28.3 degrees Celsius [°C]) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month). Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions, or growth of aquatic organisms.
pH	Shall be in the range of 6.5 through 8.3 standard units and not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.
Color and Turbidity	These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class.

Source: 314 CMR 4.05.

New Hampshire Water Quality Standards

Water quality standards in New Hampshire are contained in New Hampshire's Revised Statutes Annotated (RSA) 485A:8, Standards for Classification of Surface Waters of the State, and in Env-Wq 1700, the Surface Water Quality Standards. RSA 485A:8 establishes that all New Hampshire surface waters must be classified as either Class A or Class B waters and establishes certain minimum surface water quality criteria for each classification (NHDES 2019b). The Merrimack River is designated as a Class B in New Hampshire, which pursuant to RSA 485A:8 shall be considered acceptable for fishing, swimming, and other recreational purposes and, after adequate treatment, for use as water supplies. A summary of the applicable standards to Class B is provided in Table E.7-4.

Table E.7-4. Water Quality Standards for Class B Waters in New Hampshire

Parameter	Class B Warm Water Standards
DO	Except as naturally occurs, waters shall have a DO concentration of at least 75% of saturation based on a daily average and an instantaneous minimum DO concentration of at least 5 mg/L.
Temperature	Any stream temperature increase associated with the discharge of treated sewage, waste or cooling water, water diversions, or releases shall not be such as to appreciably interfere with the uses assigned to this class.
pH	Shall be 6.5 to 8.0 unless due to natural causes.
Turbidity	Shall not exceed naturally occurring conditions by more than 10 Nephelometric Turbidity Units (NTUs).

Parameter	Class B Warm Water Standards
Color	Shall contain no color in such concentrations that would impair any existing or designated uses, unless naturally occurring.

E.7.2.1.4 Existing Water Quality Data

Water quality data have been collected throughout the Project area including: (1) in the Project's impoundment and bypassed reach in support of recent relicensing activities, (2) at a USGS gage just downstream from the Pawtucket Dam, (3) at three NHDES monitoring sites in the Project impoundment, and (4) at numerous sites from RM 29.6 to 55.9 by a volunteer monitoring program established by the Merrimack River Watershed Council.

Relicensing Study Data

In support of relicensing the Project, water quality data were collected in the Project's impoundment and bypassed reach during the Fish Assemblage Study (NAI 2021d) in the spring, summer, and fall of 2019. Water temperature, dissolved oxygen, conductivity, and pH data were collected at 12 locations throughout the impoundment and at three locations[10] throughout the bypassed reach. Turbidity data was also collected at the impoundment site locations, which trended towards shallower at the upper end of the reach upstream of the Pawtucket Dam in areas classified as pool and run, and deeper at the lower end in areas classified as impoundment. Sampling in the impoundment was conducted at a depth of approximately one meter. Sampling in the Project's bypass reach was conducted during low flows. All data collected in the impoundment and bypassed reach met state water quality standards.

In the impoundment, the average water temperature was 21.5°C (20.6-22.1°C) during the spring sampling, 25.6°C (25.2-26.0°C) during the summer sampling, and 10.8°C (10.3-11.5°C) during the fall sampling (Table E.7-5). The average dissolved oxygen concentration was 8.7 mg/L (8.4-9.0 mg/L) during the spring sampling, 8.4 mg/L (8.1-8.8 mg/L) during the summer sampling, and 10.6 mg/L (9.8-11.1 mg/L) during the fall sampling. Conductivity averaged 114 microsiemens per centimeter (µs/cm) (97-139 µs/cm) during the spring sampling, 181 µs/cm (166-199 µs/cm) during the summer sampling, and 117 µs/cm (91-152 µs/cm) during the fall sampling. The pH ranged from 6.5-7.5 units and turbidity ranged from 0.8-3.7 NTUs.

In the bypassed reach, data were only obtained at one location in the spring where the water temperature averaged 22.9°C, dissolved oxygen concentration was 9.5 mg/L, conductivity was 148 µS/cm, and the pH was 6.5 units (Table E.7-5). The average water temperature was 23.8°C (23.4-24.1°C) in the summer and 13.1°C (13.0-13.2°C) in the fall. The average dissolved oxygen concentration was 9.4 mg/L (9.1-9.6 mg/L) in the summer and 9.8 mg/L (8.9-10.6 mg/L) in the fall. Conductivity averaged 194 µS/cm (191-197 µS/cm) in the summer and 100 µS/cm (95-104 µS/cm) in the fall. The pH ranged

[10] Water quality data were only obtained from one location in the spring.

from

6.3-8.1 units, with the average river pH in the bypassed reach being higher during the summer (7.8 units) than was observed during the spring (6.5) or fall (6.6.).

Continuous water temperature data was also collected at the Project's intake canal from October 9, 2019 until November 31, 2019 during the Downstream American Eel Passage Assessment (NAI 2021a). Water temperatures ranged from 2°C to 16°C and were below the state of Massachusetts's maximum temperature criterion.

USGS Gage Data

The USGS periodically collected water quality data approximately 1.6 RM downstream from the Project powerhouse at gage 01100000 (Merrimack River BL Concord River at Lowell, MA) between 1953 and 2004 (USGS 2018), Figure E.7-9. The most recent data are presented in figures below, which consists of water temperature, DO, pH, and specific conductance data collected between 1998-2004 (Figure E.7-10 through Figure E.7-14). Data were collected at numerous times during the summer, often when temperatures are the highest and DO concentrations are the lowest, except in 1998. Water temperatures were seasonal and were below the state of Massachusetts's maximum temperature criterion. DO concentrations were well above the state minimum criterion of 5.0 mg/L and were near saturation, except on one occasion in August 1999. The pH met state standards, except on a single sampling event in December 2003 when it was 6.3 units. Specific conductance ranged from 83 to 328 µS/cm (USGS 2018).

Merrimack River Watershed Council Data

A volunteer monitoring program established by the Merrimack River Watershed Council (MRWC) collected water quality data at 41 monitoring stations located along the mainstem of the Merrimack River in 2009 (MRWC 2010). Results were grouped into one of the five river segments identified during the study. Results from three sections, including from the Essex Dam to the Pawtucket Dam in Lowell (Section 3), from the Pawtucket Dam to the Massachusetts/New Hampshire state border (Section 4), and from the state border to Greeley Park in Nashua (Section 5), are presented in Table E.7-6 through Table E.7-8. Nine sites were sampled in Section 3, eight sites were sampled in Section 4, and seven sites were sampled in Section 5. Monitoring occurred periodically between May and October in 2009, which included sampling during the summer months. Water temperatures ranged from 8.1 to 25.7°C and were below the maximum temperature criterion in Massachusetts of 28.3°C. DO concentrations ranged from 7.2 mg/L to 12.1 mg/L and were well above the Massachusetts and New Hampshire minimum state criterion of 5.0 mg/L. The pH was frequently below the acceptable minimum Massachusetts and New Hampshire criterion of 6.5 units and ranged from 3.3 to 6.8 units. However, according to the MRWC (2010) these data could be erroneous and could not be confirmed by the USEPA. Specific conductance ranged from 99 to 211 µS/cm.

The study also conducted continuous water quality monitoring over two weeks in 2009 off of the Lowell Motor Boat Club dock located on the right descending bank immediately upstream of the Pawtucket and Northern Canals in the Project's impoundment. Water temperature, dissolved oxygen, conductivity, and pH were recorded in 10-minute intervals from September 22 to October 5 at a depth of one meter. According to the

Project's Low Impact Hydropower Institute (LIHI) certification, results indicate that data met state quantitative water quality standards for parameters with numeric limits except episodic low pH readings (LIHI 2018).

NHDES Data

A search was conducted using the USEPA's STORET database for water quality data within the Project vicinity in Massachusetts and New Hampshire. Water temperature, DO, pH, and specific conductance data were available for the following three sites in New Hampshire, which were sampled by the NHDES (Figure E.7-9):

1. Bridge Connecting RTE 3 & 3A (Station ID 11113300-02-MER)
2. RTE 111 BRIDGE, EAST HOLLIS ST (Station ID 11113300-03-MER)
3. RR BRIDGE D.S. OF MANCHESTER WWTF (Station ID 11113300-08-MER)

Data collected over the past 20 years (1998-2015) are presented in Figure E.7-10 through Figure E.7-14. Water temperatures ranged up to 28°C. DO concentrations ranged from 6.6 to 10.8 mg/L, which were well above the minimum criterion in New Hampshire of 5.0 mg/L, and waters were 82.1 to 121.0 percent saturated. The pH ranged from 5.7 to 7.5 units and levels were frequently below the minimum criterion of 6.5 units. Specific conductance ranged from 64 to 180 µS/cm.

Merrimack River Watershed Assessment Study

DO concentrations were also monitored during the Merrimack River Watershed Assessment Study, which was a joint effort between federal, state, and local communities to develop a comprehensive watershed management plan for the Merrimack River (USACE 2018). During the study, water quality sampling was conducted along the mainstem of the Merrimack River from Concord, New Hampshire, to its estuary in Newburyport, Massachusetts. From 2003 to 2005, three dry-weather surveys and four wet-weather surveys were conducted. Additionally, a continuous survey of DO and temperature was conducted at two locations for a one-month period during low-flow conditions in August and September 2003. These data were not available, but the study summary indicated DO along the mainstem of the Merrimack River from Manchester, New Hampshire, to the Atlantic Ocean were well above the minimum criterion of 5 mg/L.

Figure E.7-9. USGS and STORET Water Quality Sample Locations and Proposed Project Boundary

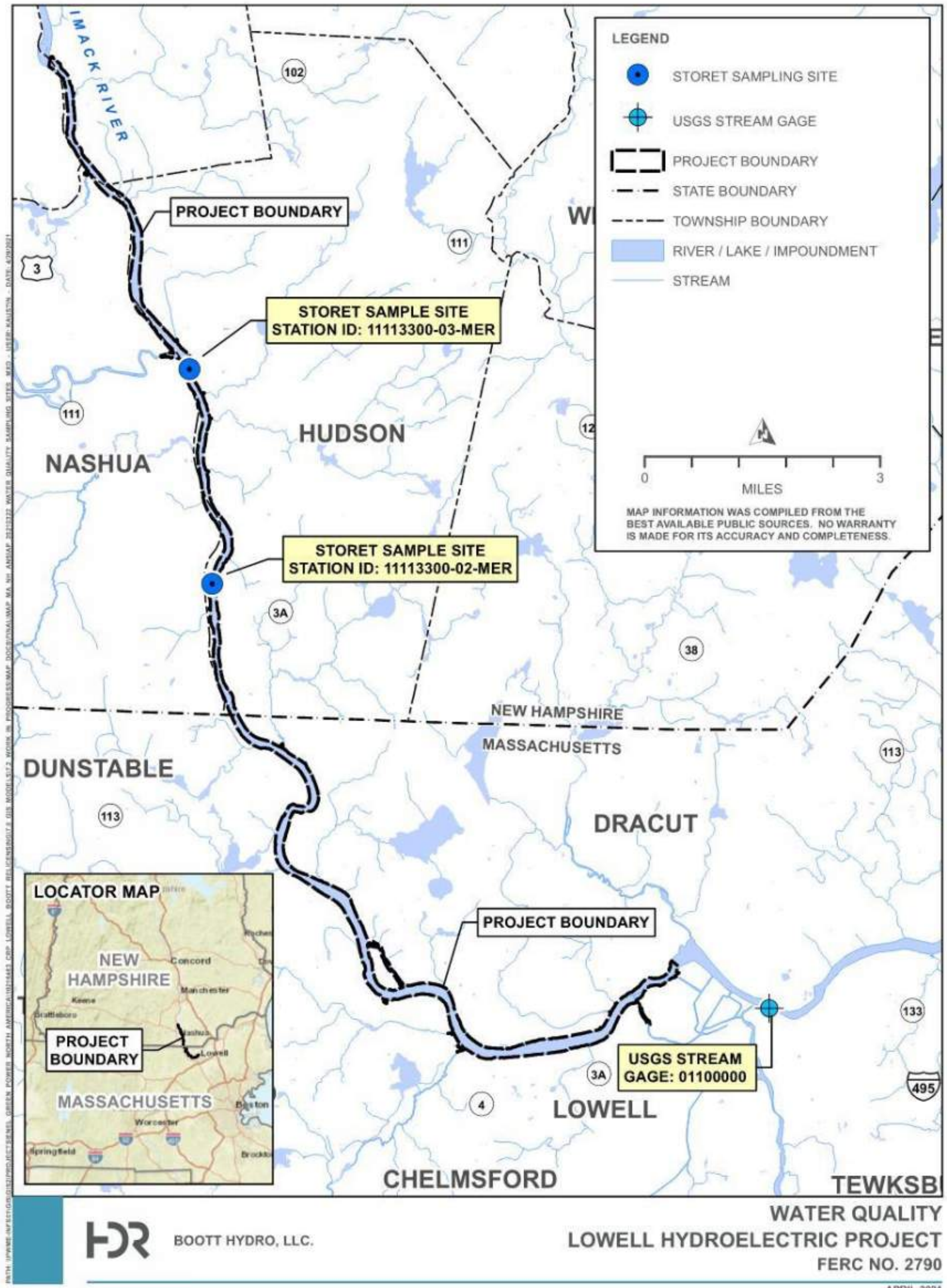


Table E.7-5. Summary of Water Quality Data Obtained in the Project's Impoundment and Bypassed Reach by NAI in 2019.

Location	Season	Water Temperature (°C)			Dissolved Oxygen (mg/L)			Conductivity (µS/cm)			pH (units)			Turbidity (NTU)		
		Average (Avg)	Minimum (Min)	Maximum (Max)	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Impoundment	Spring	21.5	20.6	22.1	8.7	8.4	9.0	114.0	97.0	139.0	-	6.5	7.4	2.6	1.6	3.7
	Summer	25.6	25.2	26.0	8.4	8.1	8.8	181.0	166.0	199.0	-	6.7	7.5	1.8	1.5	1.9
	Fall	10.8	10.3	11.5	10.6	9.8	11.1	117.0	91.0	152.0	-	6.5	7.4	1.6	0.8	2.2
Bypassed Reach	Spring	-	22.9	22.9	-	9.5	9.5	-	148.0	148.0	-	6.5	6.5	-	-	-
	Summer	23.8	23.4	24.1	9.4	9.1	9.6	194.3	191.0	197.0	-	7.4	8.1	-	-	-
	Fall	13.1	13.0	13.2	9.8	8.9	10.6	100.3	95.0	104.0	-	6.3	6.8	-	-	-

Figure E.7-10. Water Temperature Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

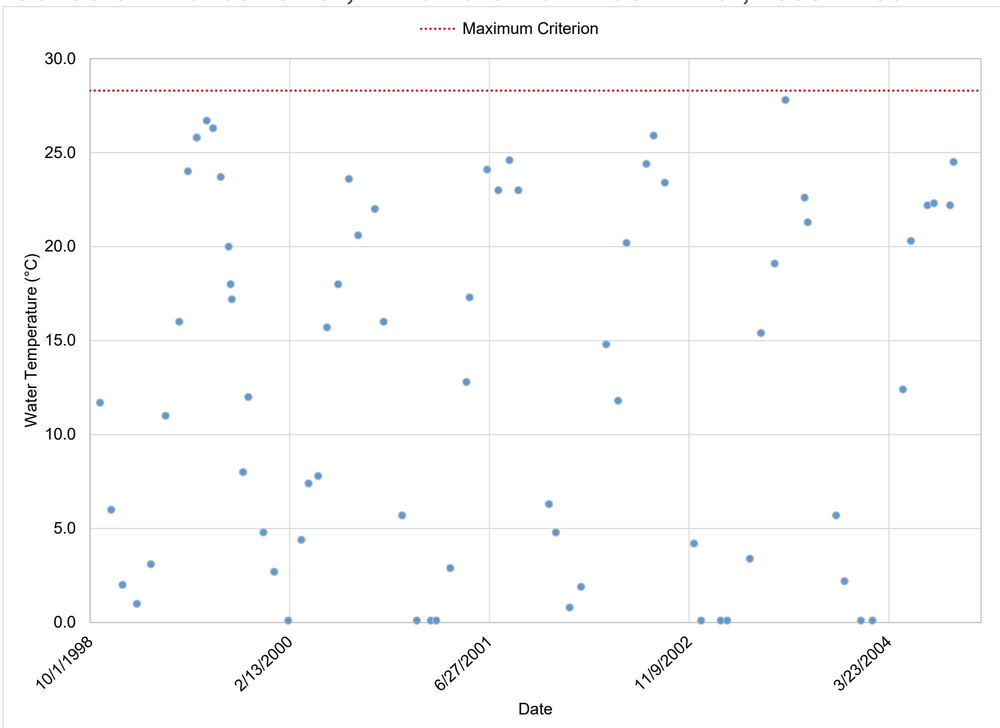


Figure E.7-11. Dissolved Oxygen Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

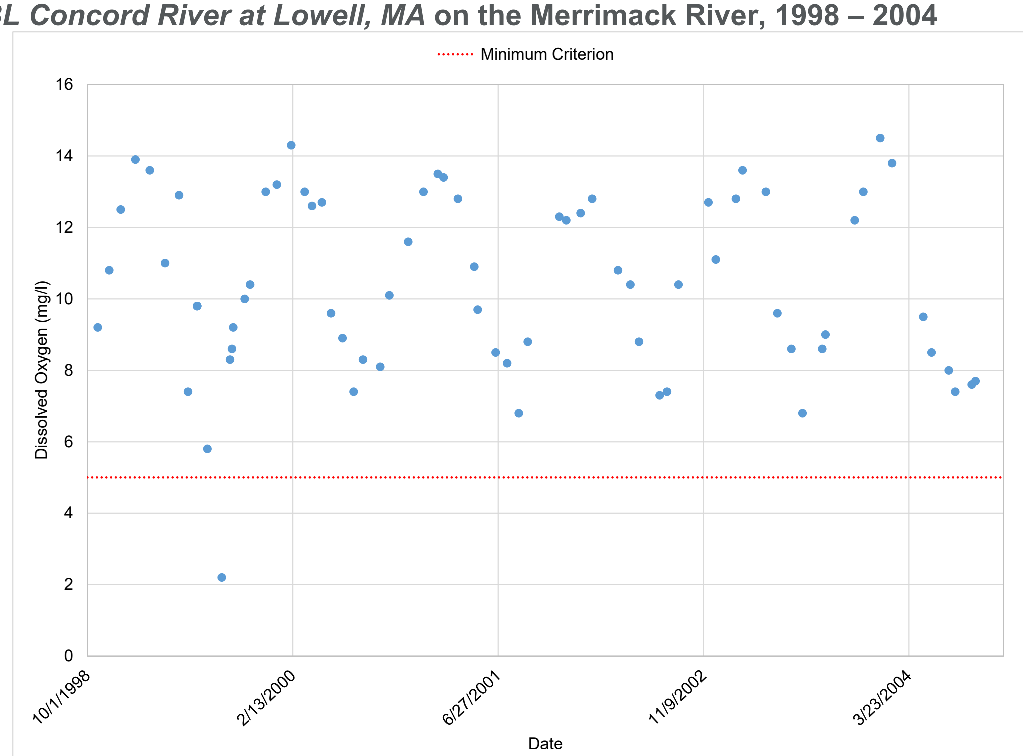


Figure E.7-12. Dissolved Oxygen Percent Saturation Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

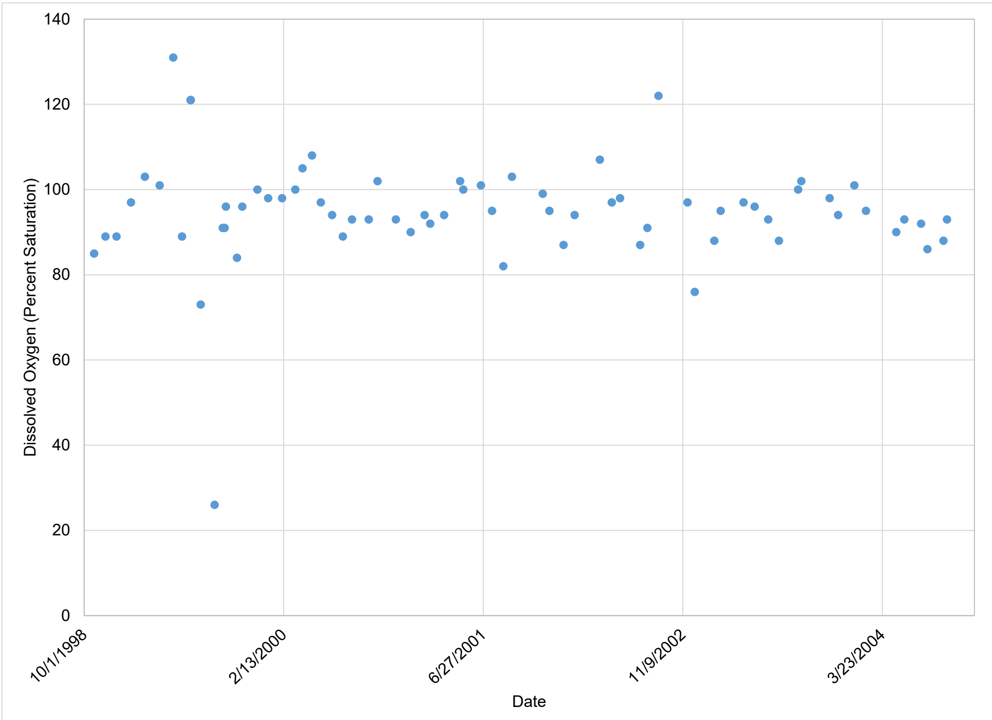


Figure E.7-13. pH Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

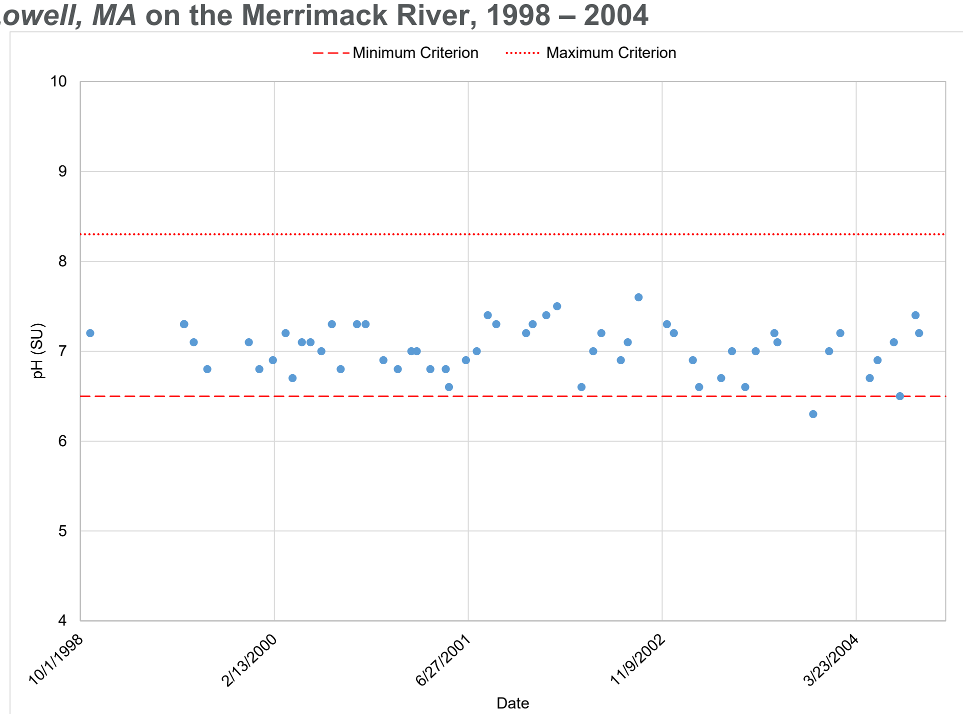


Figure E.7-14. Specific Conductance Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

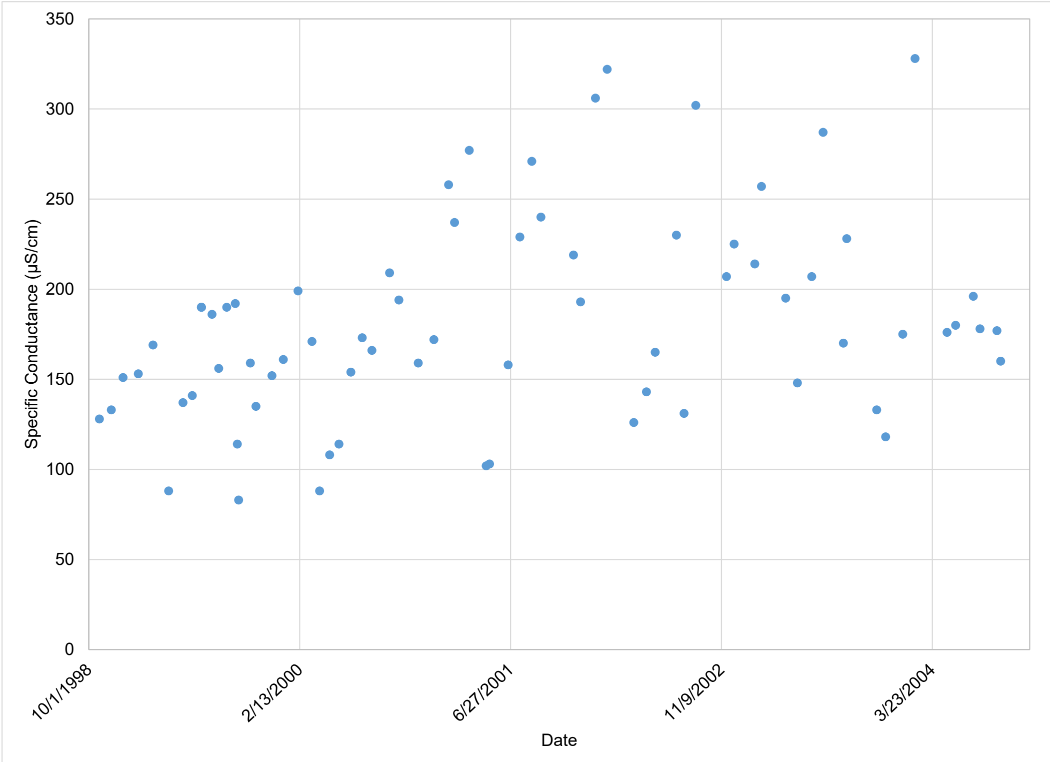


Table E.7-6. Water quality data collected by a volunteer monitoring program established by the MRWC at 9 sites along the Merrimack River from Essex Dam to the Pawtucket Dam in Lowell, 2009

River Mile	Description	Water Temperature (°C)						DO (mg/L)						pH (SU)						Specific Conductance (µS/cm)					
		14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug
29.6	Above Essex Dam	15.6	16.6	19.2	22.5	23.3	23.4	11.1	10.5	8.5	7.9	9.9	8.0	6.5	4.8	6.6	6.3	4.2	-	117	169	189	178	109	160
31.4	Methuen Water Intake	15.4	16.6	19.4	22.3	23.3	23.2	11.2	8.5	8.5	7.6	10.0	7.8	6.4	6.0	6.7	6.4	5.6	-	119	159	190	169	106	147
32.2	Bartlett Brook	15.4	16.5	19.3	22.4	23.3	23.1	11.6	8.2	8.5	7.6	10.0	7.8	6.4	6.1	6.6	6.4	4.6	-	118	157	194	169	103	144
33.4	Fish Brook	15.6	16.5	19.2	22.4	23.2	23.2	12.1	7.8	8.3	7.5	10.0	7.7	6.5	4.1	6.6	6.4	5.5	-	124	161	195	187	119	170
35.1	Gravel Pit	15.6	16.7	19.1	22.4	23.1	23	11.7	7.7	8.1	7.5	10.1	8.0	6.5	4.6	6.5	6.4	6.0	-	122	152	176	155	104	142
36.3	Trull Brook	15.4	16.9	19.2	22.5	23.0	23.2	11.6	7.8	8.7	7.9	10.2	7.9	6.4	4.3	6.7	6.4	6.0	-	111	170	211	177	99	166
37.9	Duck Island	15.4	16.8	19.2	22.4	-	23.1	11.7	7.6	8.6	7.7	-	7.9	6.2	5.8	6.6	6.3	-	6.5	106	135	176	151	-	133
38.9	Concord River	-	-	-	-	-	23.3	-	-	-	-	-	7.2	-	-	-	-	-	6.6	-	-	-	-	-	196
40.0	Oulette Bridge	-	-	-	-	-	23.2	-	-	-	-	-	7.7	-	-	-	-	-	6.5	-	-	-	-	-	122
	Minimum	15.4	16.5	19.1	22.3	23	23	11.1	7.6	8.1	7.5	9.9	7.2	6.2	4.1	6.5	6.3	4.2	6.5	106	135	176	151	99	122
	Maximum	15.6	16.9	19.4	22.5	23.3	23.4	12.1	10.5	8.7	7.9	10.2	8.0	6.5	6.1	6.7	6.4	6.0	6.6	124	170	211	187	119	196

Note: dash (-) indicates no data collected.

Table E.7-7. Water quality data collected by a volunteer monitoring program established by the MRWC at 8 sites along the Merrimack River from Pawtucket Dam to the Massachusetts/New Hampshire border, 2009

River Mile	Description	Water Temperature (°C)								DO (mg/L)								pH (SU)								Specific Conductance (µS/cm)							
		12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct
41.1	Pawtucket Dam	15.7	19.9	18.3	21.3	22.3	25.7	20.8	8.4	9.6	9.4	8.8	8.8	8.4	7.9	8.0	-	6.1	6.4	6.0	6.0	6.6	3.3	6.3	6.0	108	143	102	119	121	130	132	128
42.4	Rourke Bridge	15.6	19.8	-	21.4	22.3	-	20.5	8.1	9.4	8.4	-	8.8	8.4	-	8.0	-	6.2	6.4	-	6.1	6.7	-	6.3	5.9	104	145	-	118	120	-	132	121
43.4	Stony Brook	15.6	19.7	-	21.4	22.4	-	20.4	8.1	9.4	8.2	-	8.8	8.5	-	8.0	-	6.2	6.4	-	6.1	6.7	-	6.3	5.8	103	143	-	114	118	-	129	118
44.6	Vesper Country Club	15.5	19.7	-	21.4	22.4	-	20.2	8.2	9.3	8.0	-	8.8	8.3	-	8.0	-	6.2	6.5	-	6.2	6.6	-	6.3	5.9	103	141	-	114	119	-	127	120
46.4	Lawrence Brook	15.4	19.7	-	21.2	22.4	-	20.4	8.3	9.3	7.8	-	8.8	8.4	-	8.2	-	6.2	6.4	-	6.2	6.7	-	6.4	6.0	102	145	-	113	116	-	135	138
47.3	Tyngsborough (Rte. 113) bridge	15.3	19.6	-	21.2	22.4	-	20.5	8.3	9.3	7.8	-	8.8	8.3	-	8.2	11.9	6.2	6.4	-	6.2	6.7	-	6.4	5.9	100	144	-	113	116	-	133	131
48.9	Limit Brook	15.3	19.3	-	21.1	22.5	-	20.5	8.3	9.3	7.7	-	8.7	8.5	-	8.3	11.6	6.2	6.4	-	6.1	6.7	-	6.3	5.9	102	144	-	112	111	-	128	123
49.6	MA/NH border	15.3	19.2	18.2	21.1	22.4	-	20.4	8.3	9.4	7.7	9.8	8.8	8.3	-	8.0	11.6	6.3	6.4	6.0	6.0	6.8	-	6.3	5.9	99	142	99	114	114	-	129	129
	Minimum	15.3	19.2	18.2	21.1	22.3	25.7	20.2	8.1	9.3	7.7	8.8	8.7	8.3	7.9	8.0	11.6	6.1	6.4	6.0	6.0	6.6	3.3	6.3	5.8	99	141	99	112	111	130	127	118
	Maximum	15.7	19.9	18.3	21.4	22.5	25.7	20.8	8.4	9.6	9.4	9.8	8.8	8.5	7.9	8.3	11.9	6.3	6.5	6.0	6.2	6.8	3.3	6.4	6.0	108	145	102	119	121	130	135	138

Note: dash (-) indicates no data collected.

Table E.7-8. Water quality data collected by a volunteer monitoring program established by the MRWC at 7 sites along the Merrimack River from Massachusetts/New Hampshire border to Greeley Park in Nashua, 2009

River Mile	Description	Water temperature (°C)					DO (mg/L)					pH (SU)					Specific conductance (µS/cm)				
		12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct
49.9	Pheasant Lane Mall	-	21.0	22.4	20.3	8.3	-	8.3	8.4	8.0	11.3	-	6.3	6.7	6.4	5.9	-	117	121	132	127
50.9	Spit Brook	15.5	21.1	22.4	20.3	8.3	9.3	8.4	8.3	8.2	11.3	6.3	6.3	6.8	6.4	5.9	103	128	116	133	126
51.8	Unnamed stream	-	20.9	-	-	-	-	8.7	-	-	-	-	6.0	-	-	-	-	97	-	-	-
52.5	Nashua Country Club	-	20.9	-	-	-	-	8.6	-	-	-	-	6.3	-	-	-	-	139	-	-	-
53.1	Nashua WWTP	-	20.9	-	-	-	-	8.6	-	-	-	-	6.5	-	-	-	-	199	-	-	-
54.4	Nashua River	-	20.8	-	-	-	-	8.6	-	-	-	-	6.2	-	-	-	-	164	-	-	-
55.9	Greeley Park	-	21.2	-	-	-	-	8.9	-	-	-	-	6.2	-	-	-	-	96	-	-	-
	Minimum	15.5	20.8	22.4	20.3	8.3	9.3	8.3	8.3	8.0	11.3	6.3	6.0	6.7	6.4	5.9	103	96	116	132	126
	Maximum	15.5	21.2	22.4	20.3	8.3	9.3	8.9	8.4	8.2	11.3	6.3	6.5	6.8	6.4	5.9	103	199	121	133	127

Note: dash (-) indicates no data collected.

Figure E.7-15. Water Temperature STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

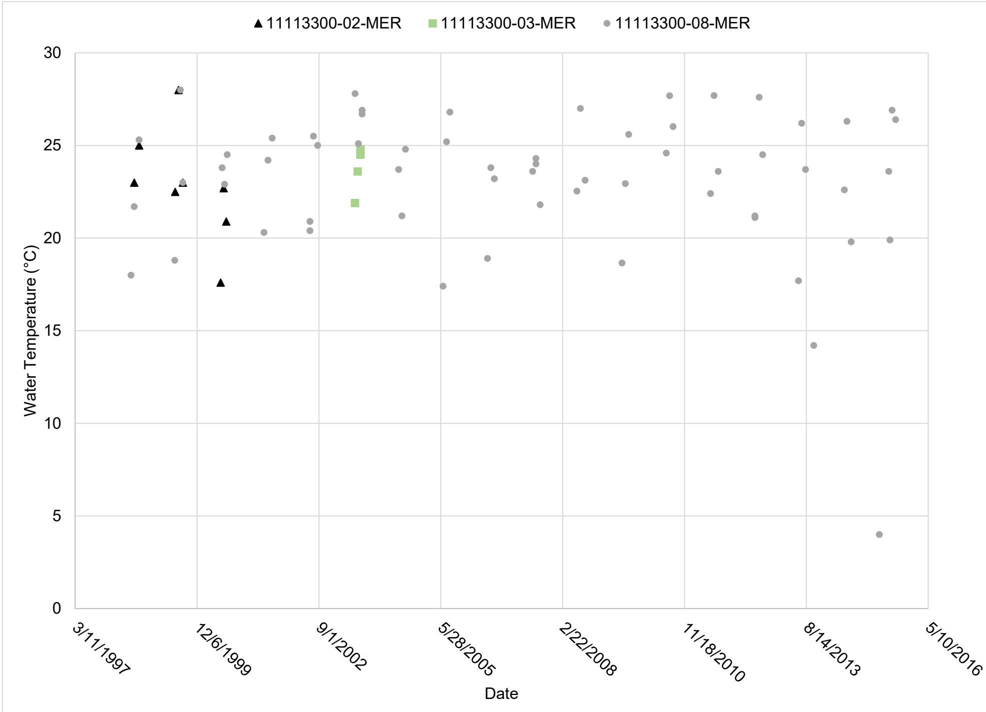


Figure E.7-16. Dissolved Oxygen STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

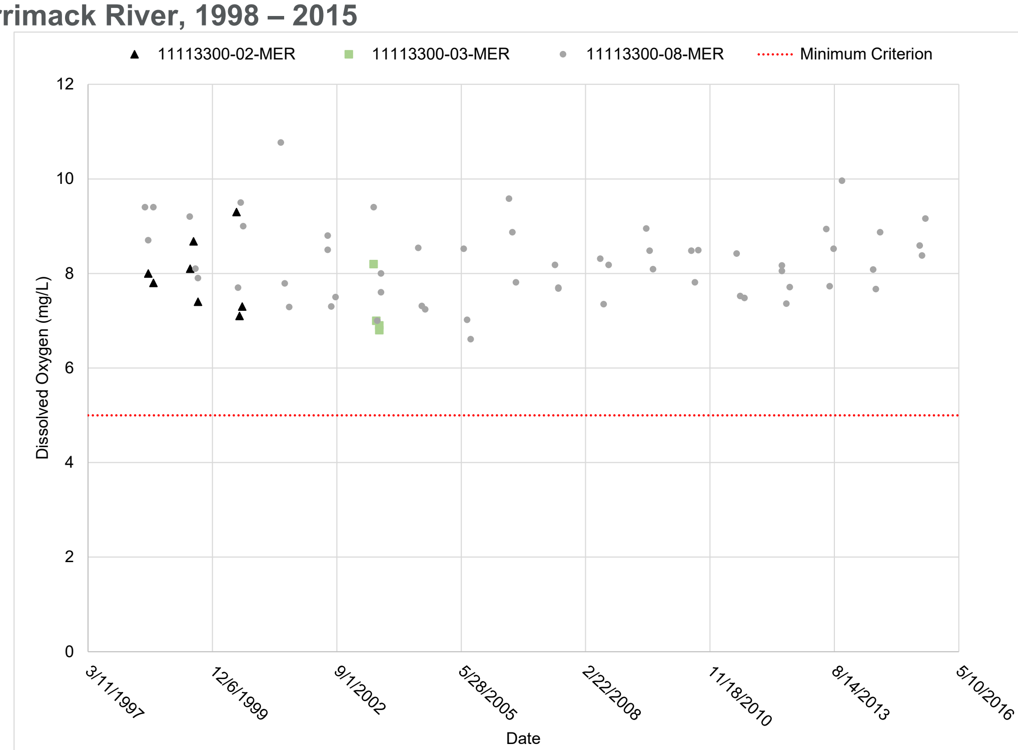


Figure E.7-17. Dissolved Oxygen Percent Saturation STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

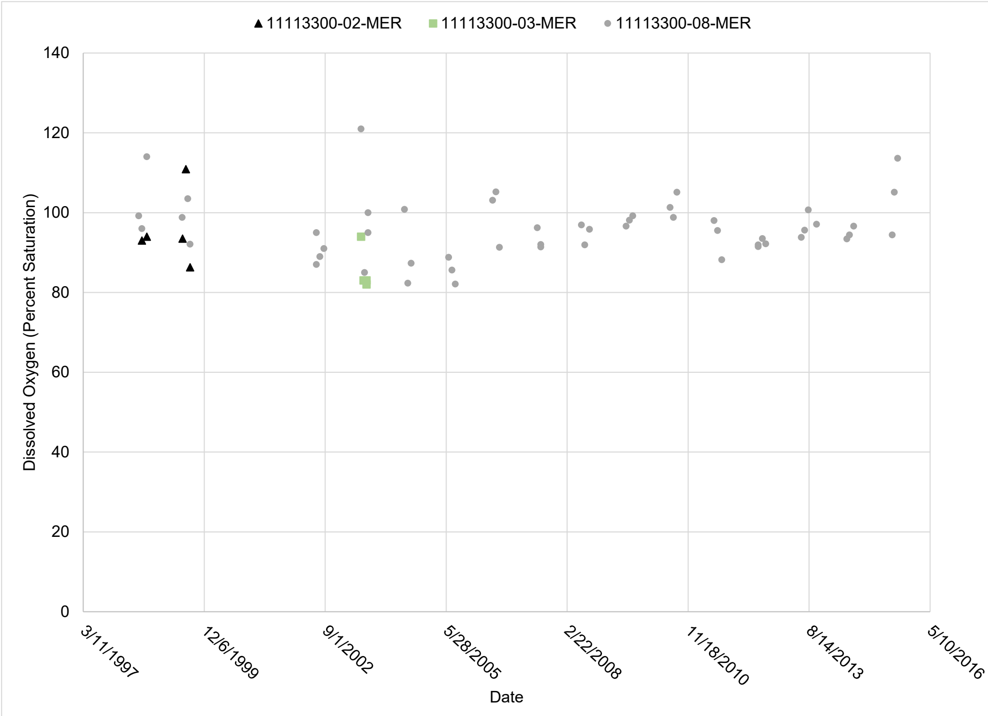


Figure E.7-18. pH STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

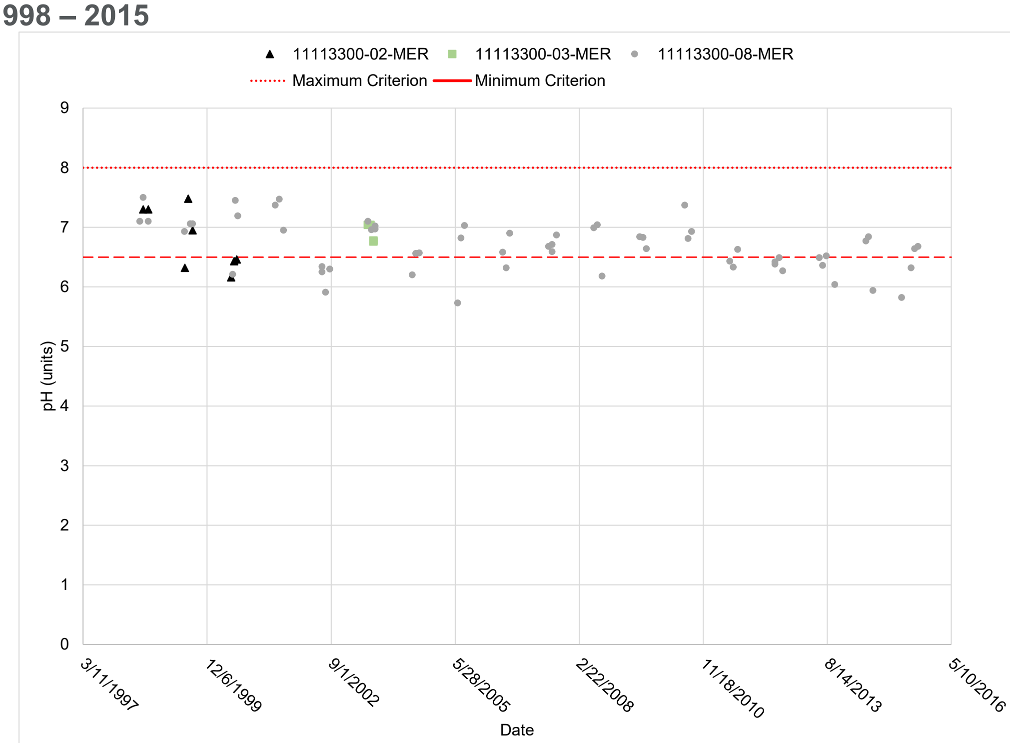
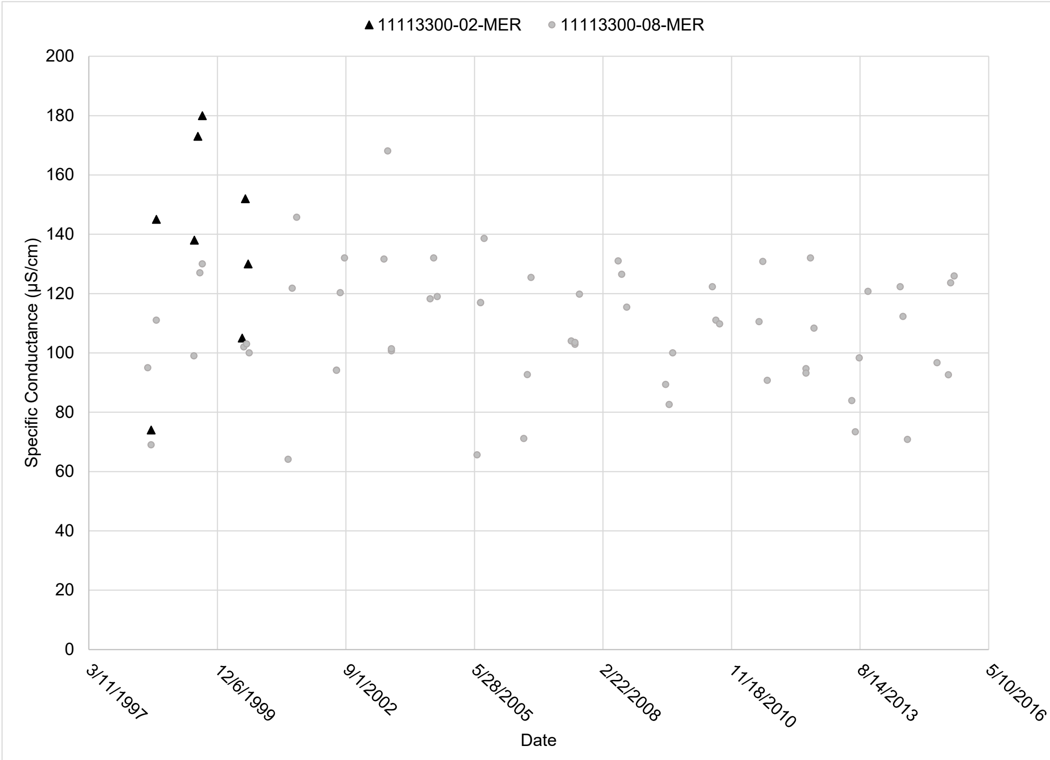


Figure E.7-19. Specific Conductance STORET Data Collected at two sites by the NHDES in the Merrimack River, 1998 – 2015



E.7.2.1.5 Use Impairment

An Integrated List of Waters (Integrated List) for Massachusetts and New Hampshire is submitted to the USEPA in fulfillment of reporting requirements under the Clean Water Act (CWA). Section 303(d) of the CWA requires states to identify those water bodies that are not expected to meet surface water quality standards after the implementation of technology-based controls and to prioritize and schedule them for the derivation of total maximum daily loads (TMDLs).

E.7.2.1.6 Massachusetts

The Integrated List in Massachusetts assigns waterbody segments to one of five categories, depending upon their status with respect to designated use support (Table E.7-9). The Merrimack River is listed as Category 5 impaired waters in Massachusetts, which includes portions within the Project vicinity (Table E.7-10) (MADEP 2016). Probable sources contributing to impairment included atmospheric deposition, CSOs from municipal discharges, impacts from hydrological flow regulation/modification, wet weather discharges from municipal discharges/sewage, municipal point source discharges of municipal discharges/sewage, and urban-related runoff/stormwater. The canal system at the Project is also listed as Category 5 waters (MADEP 2016).

A draft Pathogen TMDL has been drafted for the Merrimack River Watershed (MADEP et al. undated). No other TMDLs were located for the Merrimack River Watershed (Commonwealth of Massachusetts 2020b).

Table E.7-9. Description of Integrated Report Categories in Massachusetts (MADEP 2016)

Category	Description
1	Unimpaired and not threatened for all designated uses
2	Unimpaired for some uses and not assessed for others
3	Insufficient information to make assessments for any uses
4	Impaired or threatened for one or more uses, but not requiring the calculation of a TMDL
5	Impaired or threatened for one or more uses requiring a TMDL

Table E.7-10. Impaired Water Segments within the Lowell Project vicinity (MADEP 2016)

Name	Segment ID	Description	Length (miles)	Impairment
Project Impoundment	MA84A-01	State line at Hudson, NH/Tyngsborough, MA to Pawtucket Dam, Lowell	9	*Escherichia Coli* (*E. Coli*) Fecal coliform Mercury in fish tissue
Project Canal System	MA84A-29	Canal System near Pawtucket Falls, Lowell	4.90	DDT in fish tissue Lead Mercury in fish tissue PCBs in fish tissue
Bypassed/ Downstream Reach	MA84A-02	Pawtucket Dam, Lowell to Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell	3.2	Dewatering* *E. Coli* Mercury in fish tissue Total phosphorus
Downstream Reach	MA84A-03	Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell to Essex Dam, Lawrence	8.80	*E. Coli* Mercury in fish tissue PCBs in fish tissue
Reach Downstream of Essex Dam	MA84A-04	Essex Dam, Lawrence to confluence with Little River, Haverhill	10.00	*E.Coli* PCBs in fish tissue Total phosphorus

*TMDL not required (non-pollutant).

E.7.2.1.7 New Hampshire

The Section 305(b) and 303(d) consolidated list in New Hampshire assigns waterbody segments to various categories (Table E.7-11). Portions of the Merrimack River in New Hampshire are identified as Category 5 waters and are included in the 2018 303(d) list (Table E.7-12) (NHDES 2019b). Sources of impairment in these sections are unknown.

Table E.7-11. Description of Integrated Report Categories in New Hampshire

Category	Description
1	Attaining all designated uses and no use is threatened.
2	Attaining some of the designated uses; no use is threatened; and insufficient or no data and information is available to determine if the remaining uses are attained or threated (i.e., more data is needed to assess some of the uses).
3	Insufficient or no data and information are available to determine if any designated use is attained, impaired, or threatened (i.e., more monitoring is needed to assess any use).
4	Impaired or threatened for one or more designated uses but does not require development of a TMDL because:
4A	A TMDL has been completed, or
4B	Other pollution control requirements are reasonably expected to result in attainment of the water quality standard in the near future, or
4C	The impairment is not caused by a pollutant.
5	Impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL, which is the 303(d) list.

Table E.7-12. Impaired Water Segments within Project vicinity in New Hampshire (NHDES 2019b)

Assessment Unit ID	Water Name	Primary Town	Water Size (miles)	Use Description	Impairment Name	DES Category	TMDL Priority
NHRIV700061206-24	Merrimack River	Nashua	5.2	Aquatic Life	Aluminum	5-M	Low
					pH	5-M	Low
				Primary Contact Recreation	Chlorophyll-a	5-M	Low
NHRIV700061002-14	Merrimack River	Nashua	3.7	Aquatic Life	pH	5-M	Low
				Primary Contact Recreation	Creosote	5-M	Low

E.7.2.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on streamflow and water quality in the impoundment, canal system, bypassed reach, and Merrimack River.

- Effects of continued project operation on flooding along the shoreline of the project impoundment and surrounding areas.
- Effects of continued project operation on streamflow in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of continued project operation on water quality in the impoundment, canal system, bypassed reach, and Merrimack River.

The Project operates in a ROR mode and has no useable storage capacity. Therefore, seasonal and annual variations in flows within the Project area are based on natural hydrologic conditions in the Merrimack River Watershed. In 2011, the MADEP specified that it had waived Water Quality Certification related to a Project license amendment (i.e., replacement of the flashboard system with the crest gate system) (LIHI 2018), which suggests there were not water quality concerns at that time and there have been no substantial changes to Project operations since.

In 2019, the licensee completed the construction of a pneumatically operated crest gate on the spillway crest to maintain the headpond at its normal level of 92.2 feet NGVD 1929. The system was installed to prevent flooding in the impoundment zone, after backwater analysis and technical evaluation found the system would enhance project operational control and generation, and would provide significant advantages for other resources that are dependent on water levels, including flood control, recreation, and fish passage. The Commission's Environmental Assessment completed prior to the crest gate installation noted up to 46 miles of shoreline aquatic habitat could benefit from installing the crest gate, and the system would normally provide slightly lower water level elevations during flood events of less than 75,000 cfs. The Pawtucket Dam spillway becomes submerged at flows greater than 75,000 cfs, which causes the water level upstream to be influenced by the river channel structure within the bypassed reach downstream of the dam. The proposal was strongly endorsed by the Massachusetts Division of Fish and Wildlife (MADFW) and NMFS, who both noted the project's beneficial effect on fish habitat and movement within the project area (FERC 2011).

Some hydroelectric facilities can influence instream flows, and those that have large deep impoundments impact to water quality. The Project is operated as a ROR hydroelectric project. Therefore, the Project's ability to influence flow and thus water quality is minimal due to its limited storage and hydraulic capacity. At the normal pond elevation of 92.2 feet NGVD 29 (crest of the pneumatic flashboards), the surface area of the impoundment encompasses an area of approximately 1,236 acres. The gross storage capacity between the normal surface elevation of 92.2 feet and the minimum pond level of 87.2 feet (at spillway crest) is approximately 6,180 acre-feet.

Under current operations, when river flows exceed the hydraulic capacity of the E.L. Field Powerhouse units (3,300 cfs per unit or 6,600 cfs for both units), excess flows up to approximately 2,000 cfs are routed through the downtown canal system and to the canal units. Any flows in excess of approximately 8,600 cfs (6,600 cfs at E.L. Field plus 2,000 cfs via canals) are passed over the Pawtucket Dam spillway. Pursuant to Article 37, operating the Project in ROR mode meets and exceeds the present Project minimum flow requirement of 1,990 cfs or inflow, whichever is less, as measured immediately downstream from the Project (Boott 2017). As a result of the Project's ROR operations, there is a constant flow downstream of the Project during summer low flow conditions, which prevents impacts to downstream water quality.

In support of relicensing the Project, water quality data were collected in the Project's impoundment and bypass reach during the Fish Assemblage Study in the spring, summer, and fall of 2019. Water temperature, dissolved oxygen, conductivity, and pH data were collected at 12 locations throughout the impoundment and at three locations throughout the bypass reach. Turbidity data was also collected at the impoundment site locations. All data collected in the impoundment and bypassed reach met state water quality standards. Additionally, as stated above, waters in the Project impoundment, bypassed reach, and downstream reaches have historically met state water quality standards. This suggests that the Project operation has little to no effect on the overall water quality in the Merrimack River, which is consistent with a ROR hydroelectric project. Water quality data indicates that water quality in the Project area is consistent with the water quality of the lower Merrimack River and is likely driven by natural environmental and biological factors as well as anthropogenic disturbance within the larger context of this regional portion of the river basin. Since the Project operates in a ROR mode, seasonal and annual variations in flows within the Project area are based on natural hydrologic conditions in the Merrimack River Watershed. Continued operation of the Project is not expected to have negative effects on water quality, and therefore the fish and aquatic resources in the Merrimack River.

Water quality data have been collected throughout the general Project area including throughout the 16-mile impoundment, the bypassed reach, and downstream from the Project in the Merrimack River. Much of these data were collected during the summer months and data were collected in the bypassed reach during minimum flows. Often these are when water temperatures are highest and dissolved oxygen levels are lowest. Regardless, water quality met state standards.

The man-made canal system utilizes flows upstream of the Pawtucket dam and discharges at multiple locations just upstream of the USGS gage 1.6 RM downstream of the Project. The data obtained from this gage met state water quality standards and there is no indication that the canal system is impacting water quality in the Merrimack River. The waters of the canal system are listed as impaired by the state of Massachusetts; however, the impairments (i.e., Dichlorodiphenyltrichloroethane [DDT] in fish tissue, lead, and mercury/PCBs in fish tissue) are not related to the Project or Project operations and are likely a result of atmospheric deposition and historical contamination from the mills and industrial facilities that line the canal system (LIHI 2018).

E.7.2.2.1 Effects of Decommissioning

As summarized in Section E.6.2 of this exhibit, Boott is proposing to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage its canal structures and facilities, water levels, and flows in line with existing rights, responsibilities, and existing or new agreements among the concerned stakeholders. With respect to water levels in the downtown canal system, Boott is proposing to maintain the water levels as described above in Section E.6.2.

When the downtown units were in operation under the current license, additional flows in excess of leakage make-up water were generally passed into the canal system only when Merrimack River flows exceeded the 6,600 cfs hydraulic capacity of the E. L. Field Powerhouse turbines. This occurred approximately 40% of the time annually, primarily during the spring and fall when water temperatures are cooler. Conversely, based on flow duration additional generation flows would have been routed to the downtown units only about 10% of the time during the warmer summer months of July, August and September, when water quality would be of greater concern. Thus, reducing flows passed through the Guard Locks to 200 to 300 cfs leakage make-up flow should not result in any substantive change from current conditions with respect to water quality conditions within the downtown canals.

E.7.2.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain PM&E measures consistent with the measures required by the Project's existing license. Boott believes that the continued operation of the Project, as proposed, will limit effects on water quality and quantity. Boott proposes to operate the Project in a ROR mode using automatic pond level control of the E.L. Field powerhouse units. ROR operation may be temporarily modified for short periods to allow flow management for other project and non-project needs, e.g., downtown canal water level management, raising the crest gates following a high-water event, or for recreational purposes.

Boott also proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam during the period outside of the fish passage season. During the fish passage season, which generally runs from late April through mid-July, the Licensee proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the MRTC, consistent with current practice.

Boott has proposed to maintain the water levels described above in Section E.6.2, typically providing approximately 300 cfs of leakage make-up flow into the canal system via the Guard Lock and Gates Facility. Decommissioning the downtown powerhouses may require minor ground disturbance in areas primarily characterized by urban fill. Boott has proposed to develop a plan for decommissioning the powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

Boott proposes to continue to adhere to the Crest Gate Operation Plan approved by FERC on March 30, 2015, and operate fish passage facilities as determined in consultation with the MRTC.

E.7.2.4 Unavoidable Adverse Impacts

Continued Project operations as proposed by the Licensee are not expected to have any unavoidable adverse impacts on water quality or quantity. However, Boott notes that certain studies required by the Commission are ongoing, including the Three-Dimensional CFD Modeling Study. Boott will consult with stakeholders regarding the results and recommendations of this study and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.3 Fish and Aquatic Resources

The subsections below describe fish and aquatic resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, and the:

- Downstream American Eel Passage Assessment Study Report (NAI 2021a)
- Juvenile Alosine Downstream Passage Assessment Study Report (NAI 2021b)
- Upstream and Downstream Adult Alosine Passage Assessment Study Report (NAI 2021c)
- Fish Assemblage Study Report (NAI 2021d)
- Instream Flow Habitat Assessment and Zone of Passage Study (NAI 2021e)
- Fish Passage Survival Study (NAI 2021f)

These reports are included in Appendix B of this exhibit. However, Boott notes that certain studies required by the Commission are ongoing, including the Three-Dimensional CFD Modeling Study. Boott will consult with stakeholders regarding the results and recommendations of this study and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.3.1 Affected Environment

E.7.3.1.1 Overview

Historically, the Merrimack River served as a major resource for fisheries. However, the increase in industrial and urban pollution and construction of numerous dams along its length during the past two hundred years resulted in lowering the value of the river as an important aquatic habitat. The most affected fish populations have been the sensitive migrating species: anadromous fish that live in salt water and spawn in fresh water, and catadromous species that inhabit the river and spawn in the ocean. The changes in water quality of the Merrimack River combined with impoundments created by dams has increased the warm water fisheries habitat and resulted in the demise or severe reductions of migratory fish species (Massachusetts Department of Transportation

Federal Highway Administration [FHA] and The Commonwealth of Massachusetts Department of Public Works [MDPW] 1985).

In more recent years, the quality of the Merrimack River has improved, and today there is a concerted effort on the part of state and federal fish and wildlife agencies to restore anadromous fish populations in the Merrimack River. These restoration efforts have included stocking the headwaters of the river with adult American shad (*Alosa sapidissima*) and juvenile Atlantic salmon (*Salmo salar*) and building fish ladders at dams to allow fish access to the upper reaches of the Merrimack River. Other anadromous fish that are returning to the Merrimack River include the alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and sea lamprey (*Petromyzon marinus*). According to the FHA and MDPW (1985), the only catadromous species in the Lowell portion of the Merrimack River is the American eel (*Anguilla rostrata*).

In 1969 the State of New Hampshire, the Commonwealth of Massachusetts, USFWS, United States Forest Service (USFS), and the NMFS combined their efforts and formed Policy and Technical Committees for the Anadromous Fishery Management of the Merrimack River. Largely through the efforts of these committees, much progress has recently been made (Boott Mills 1980).

The MRTC was formed to address the restoration of anadromous fish in the Merrimack River watershed and includes representatives from the following government organizations: New Hampshire Department of Fish and Game (NHDFG), MADFW, Massachusetts Division of Marine Fisheries (MADMF), USFWS, USFS, and NMFS (Technical Committee 2010). The MRTC coordinates restoration activities such as installation, evaluation, operation, and maintenance of fish passage and capture facilities at hydroelectric facilities along the Merrimack River. Boott collaborates with the MRTC under an adaptive management framework regarding all activities related to managing the fishery resources impacted by the Lowell Project.

The MRTC oversees the management of the Lowell Project fisheries as directed by the Project’s CFPP which was filed pursuant to articles 35 and 36 of the Project’s existing license and approved by FERC in November 2000. The CFPP and fish passage at the Project is described in more detail in Section E.7.3.1.4.

E.7.3.1.2 Aquatic Habitat

Aquatic habitat found in the Project vicinity consists of habitat types typical of most northeastern large rivers, which support a variety of cool and warm water species. Shallow water, littoral, and riparian habitat types exist along the shoreline of the Project’s impoundment, as well as along the several islands scattered in the Project’s impoundment. At low river flows, the habitat in the Project’s bypass reach is generally broad, relatively shallow, and rocky with numerous areas of exposed bedrock, with a large pool occupying the middle portion of the bypass reach.

During the 2019 Fish Assemblage Study (NAI 2021d), habitat was visually evaluated and characterized in the impoundment and bypass reach. The dominant substrate, proportion of transect with submerged aquatic vegetation, and the proportion of transect with overhanging vegetative cover was recorded. Water depth and velocity was measured within each sampling transect. Water quality data (i.e., water temperature, dissolved oxygen, conductivity, pH, and turbidity data) was also collected during spring, summer, and fall at each transect at a depth of one meter.

Impoundment

Within the impoundment, habitat was identified primarily as impoundment (78%), with less amounts of run (7%) and pool (15%) habitat. Dominant substrate, presence of submerged aquatic vegetation (SAV), and presence of general cover were consistent among all sample units regardless of mesohabitat classification (i.e., pool, run or impoundment). Sampled areas upstream of Pawtucket Dam were characterized by sand-silt-clay sediments, presence of SAV over 0-25% of the sample area and the presence of general cover over 0-25% of the sample area. Mean water depth (as sampled at quarter points of the river channel at the upper, middle, and lower points of each transect) trended towards shallower at the upper end of the reach upstream of Pawtucket Dam in areas classified as pool and run, and deeper at the lower end in areas classified as impoundment (NAI 2021d).

Water temperature in the impoundment was relatively consistent among sample units with a ± 1-2°C range in values within each season. The average Merrimack River water temperature was 21.5°C during the spring sampling, 25.6°C during the summer sampling, and 10.8°C during the fall sampling. Dissolved oxygen was measured at 8.1 mg/L or greater at all stations upstream of Pawtucket Dam regardless of season. Conductivity averaged 114 µs/cm during the spring sampling, 181 µs/cm during the summer sampling, and 117 µs/cm during the fall sampling. In general, conductivity increased with proximity to the Pawtucket Dam. River pH was consistent across seasons ranging from 6.5-7.5. The average turbidity reading was higher during the spring sampling (2.6 Nephelometric Turbidity Units [NTUs]) than was observed during the summer or fall periods (1.8 and 1.6 NTUs, respectively) (NAI 2021d).

Bypass Reach

Within the bypass reach, habitat was identified primarily as pooled sections (75%) with ledge channels (25%). A range of substrate types was sampled during each of the three seasons, ranging from areas of boulders to sand-silt-clay habitat. Sampled areas within the bypass reach were characterized by the presence of SAV over 0-25% of the sample area and the presence of general cover over 0-25% of the sample area. Mean water depth was consistent among sample areas and season, ranging from 1.5-2.4 feet (NAI 2021d).

Water temperature was relatively consistent among sample units within each season and averaged 22.9°C during the spring sampling, 23.8°C during the summer sampling, and 13.1°C during the fall sampling. Dissolved oxygen was measured at 8.9 mg/L or greater at all bypass reach stations downstream of Pawtucket Dam regardless of season. Conductivity averaged 148 µs/cm during the spring sampling, 194 µs/cm during the summer sampling, and 100 µs/cm during the fall sampling. The average river pH in the bypass reach was higher during the summer sampling event (7.8) than was observed during the spring (6.5) or fall (6.6) (NAI 2021d).

During the Instream Flow Habitat Assessment and Zone of Passage Study (NAI 2021e), an aquatic habitat model was developed for 9 species and associated life stages in the Bypass Reach through the bedrock rapids to the tailrace confluence at flows from 250 cfs to 14,000 cfs. An index of suitable habitat at each modeled flow, expressed as weighted usable area (WUA) in m^2, is presented below in Table E.7-13. Figure E.7-20 illustrates the flow:habitat relationships for each species and life stage.

Table E.7-13. Weighted Usable Area (WUA) in m2 in the Bypass Reach according to flow, species, and life stage

Flow	American Shad		River Herring	Sea Lamprey	Fallfish	
cfs	Juvenile	Spawning	Spawning	Spawning	Juvenile	Adult
250	11,923	6,738	3,110	576	2,764	15,133
482	14,468	9,368	2,951	1,012	3,134	17,586
1,000	15,864	12,859	2,421	1,599	2,873	18,363
2,000	14,946	15,664	1,711	1,908	1,726	14,308
4,345	9,948	15,755	1,011	1,282	893	8,219
6,000	7,558	13,396	820	858	895	6,782
7,011	6,517	11,852	723	724	894	6,201
8,000	5,710	10,313	675	611	819	5,724
10,000	4,644	7,864	568	489	688	4,979
12,000	4,025	6,418	523	415	511	4,573
14,000	3,641	5,718	490	355	371	4,277
Flow	**Smallmouth Bass**				**Longnose Dace**	
cfs	**Fry**	**Juvenile**	**Adult**	**Spawning**	**Juvenile**	**Adult**
250	10,617	10,141	5,834	879	838	1,970
482	10,491	12,772	7,155	727	1,086	2,414
1,000	7,768	13,820	8,021	508	735	1,657
2,000	5,507	11,407	6,350	324	385	848
4,345	3,340	6,793	4,014	215	283	537
6,000	2,817	5,412	3,366	201	296	580
7,011	2,454	4,882	3,087	173	265	599
8,000	2,270	4,394	2,818	161	212	508
10,000	1,899	3,665	2,402	143	116	303
12,000	1,660	3,249	2,153	104	69	160
14,000	1,526	2,983	2,016	98	44	109

Flow	White Sucker			Freshwater Mussels	Benthic Macro-invertebrates	
cfs	Fry	Juvenile	Adult	Rearing	Rearing	
250	25,085	10,724	159	8,217	7,213	
482	22,449	12,398	95	9,686	12,031	
1,000	16,881	10,462	61	10,937	18,958	
2,000	11,986	6,989	21	11,066	24,062	
4,345	7,219	4,352	69	8,528	21,698	
6,000	6,041	3,758	123	6,679	17,847	
7,011	5,233	3,361	95	5,802	15,777	
8,000	4,787	3,165	66	5,039	13,819	
10,000	4,065	2,706	34	3,913	10,948	
12,000	3,657	2,481	12	3,244	8,867	
14,000	3,488	2,354	9	2,866	7,250	

Figure E.7-20. Relationship between WUA (m^2) and flow (cfs) in Bypass Reach according to species and life stage

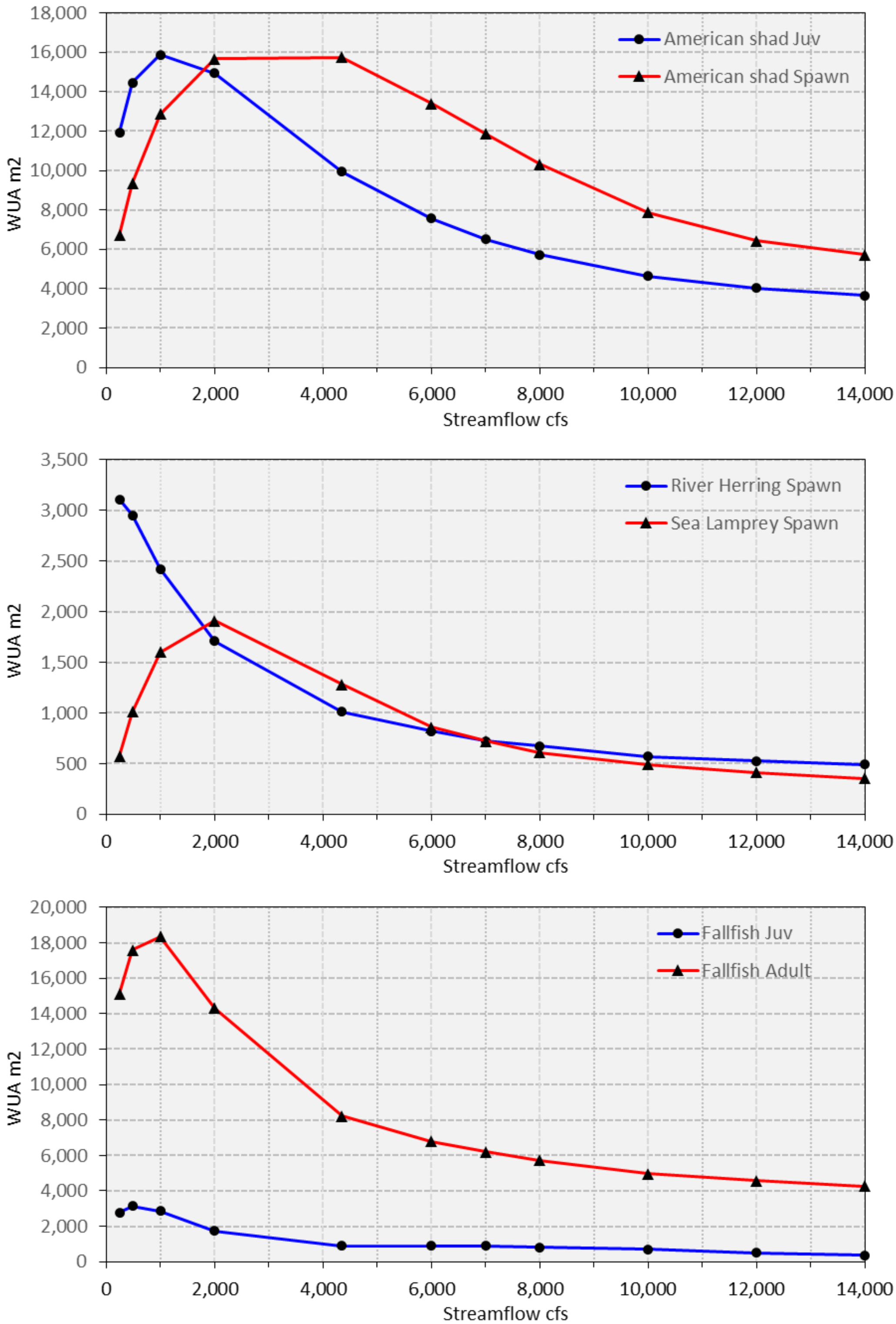


Figure E.7-20 (Continued)

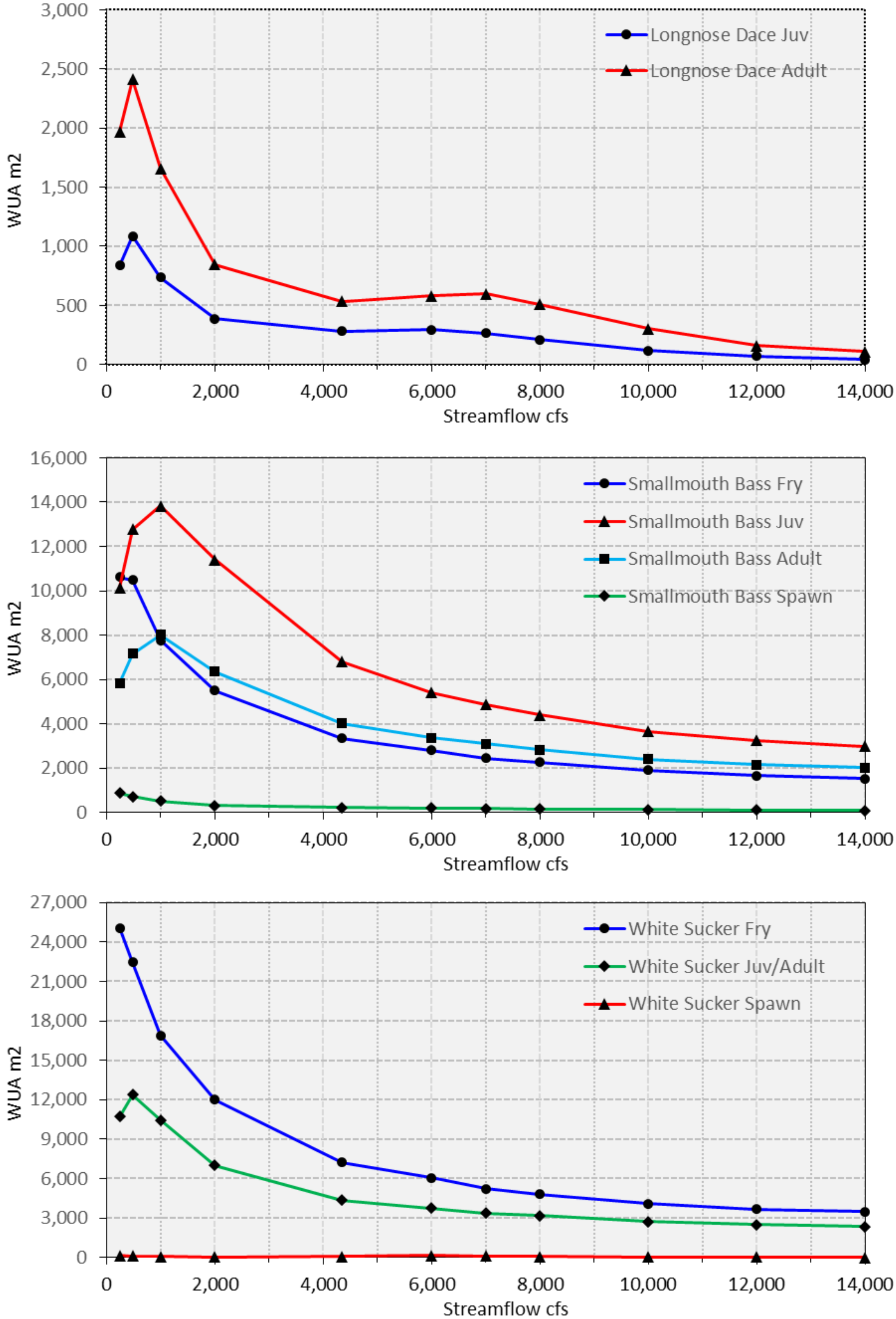
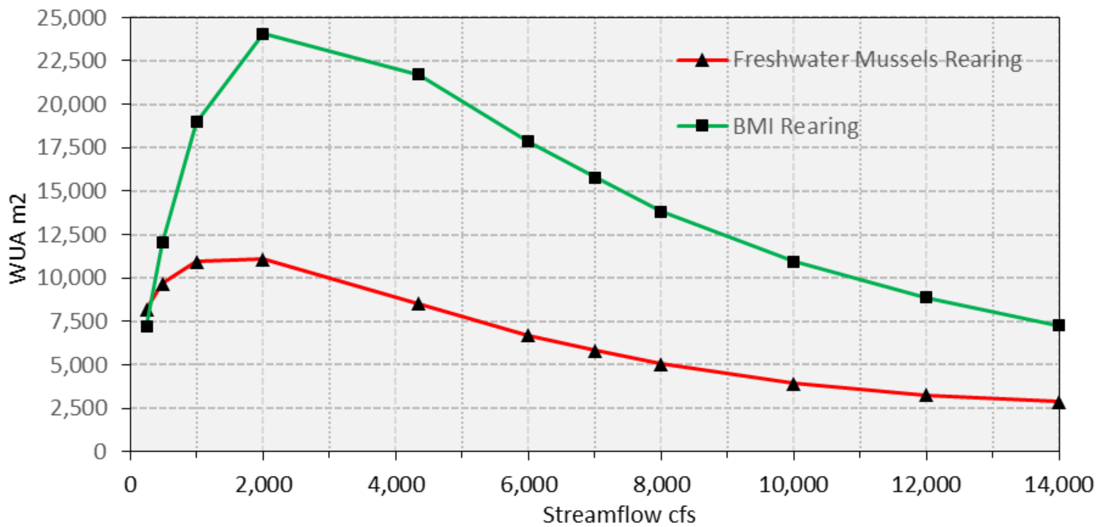


Figure E.7-20 (Continued)



The index of suitable habitat for American shad juveniles remained relatively high (>10,000 m^2) at flows between 250 cfs and 2,000 cfs, with declining suitability to a minimum (3,641 m^2) at the maximum modeled flow of 14,000 cfs. The suitability index for shad spawning stayed high (>10,000 m^2) over a wider range of flows (1,000-8,000 cfs), with minimum (~6,700 to ~5,700 m^2) at the lowest and the highest modeled flows, respectively. Most suitable habitat for both life stages occurred in the upper half of the modeled reach.

The habitat index for spawning by river herring was highest at 3,110 m^2 at the lowest modeled flow (250 cfs), then progressively declined to 490 m^2 as flows increased to 14,000 cfs. Virtually all of the estimated habitat was of low suitability, due to the low suitability (0.1) for all rocky substrates.

As shown above, benthic macroinvertebrates showed the highest estimates of WUA of all species groups, with a maximum of 24,062 m^2 at 2,000 cfs, and maintained high habitat values (>10,000 m^2) from 500 cfs to 10,000 cfs.

In most cases the habitat indexes for each species and life stage showed maximum suitable habitat at relatively low flows through the Bypass Reach. Thirteen of the 17 assessments produced maximum WUA at flows of 1,000 cfs or less, with 3 other species/life stages (lamprey spawning, freshwater mussels, and BMI rearing) reaching maximum WUA at 2,000 cfs, and one species/life stage (shad spawning) showing maximum habitat at a higher flow (4,345 cfs). This result is primarily due to the steep, bedrock dominated habitat that characterizes the Bypass Reach.

Canal System

The principal canals in the system are the Pawtucket Canal and the Northern Canal. Smaller canals lead off these two major canals. The canals vary in width from 40 to 120 feet. The walls are of granite, ledge, or concrete. The canal beds consist of ledge, concrete, or wood-planked virgin soil (Boott 2017).

Flow enters the canal system upstream of the Pawtucket Dam via the Pawtucket Canal and is controlled by the Guard Lock and Gates Facility. The nominal flow capacity of the downtown canal system via the Pawtucket Canal and the Guard Lock and Gates Facility is approximately 2,000 cfs.

The Northern Canal is approximately 2,200 feet long, with masonry or bedrock lining its complete length. The first 1,000 feet combines masonry walls and an earth dike (with masonry core) as the river wall. The second length is a dressed masonry gravity structure to the site of the E.L. Field Powerhouse. This structure is approximately 30 feet in height (Boott 2017).

E.7.3.1.3 Fish Assemblage

The Merrimack River is home to a diverse assemblage of fish species, including both cold water and warm water species. During the last 150 years, over 15 non-indigenous species such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), walleye (*Sander vitreus*), common carp (*Cyprinus carpio*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), various catfish species (*Ictalurus* spp.) and goldfish (*Carassius auratus*) have successfully established themselves through human introduction within the Merrimack River. The Merrimack River basin is home to approximately 50 species of fish; nine of which are anadromous (Stolte 1982 as cited in Technical Committee for Anadromous Fishery Management of the Merrimack River Basin [Technical Committee] 1997). The slower-moving, ponded reaches within the basin contain the majority of the warm water species, while those areas having steeper gradients contain the majority of the cold-water species (Technical Committee 1997).

Common freshwater game species currently found in the Lower Merrimack River include yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), northern pike (*E. lucius*), brown bullhead (*Ameiurus nebulosus*), smallmouth and largemouth bass, walleye, common carp and Centrarchid sunfishes (Lower Merrimack River Local Advisory Committee [LMRLAC] 2008).

2019 Fish Assemblage Study

In 2019, a Fish Assemblage Study was conducted at the Project to characterize the fish assemblage in the Project's impoundment and bypass reach (NAI 2021d). Sampling locations in the impoundment and bypass reach were randomly selected and weighted proportional to mesohabitat type frequency.

Fish community data in the impoundment were collected from twelve 500-meter sample units during spring (June 24-26), summer (August 19-21), and fall (October 28-30) nights of 2019 (total of 36). At each sample unit, boat electrofishing[11] was conducted over a 500-meter reach of shoreline at depths less than 10 feet, an experimental gill net[12] was set in areas with adequate water depths (>8ft) and flow conditions for 4 hours, and two

[11] Boat electrofishing used 4.0 amps of pulsed DC current.

[12] Gillnets were eight feet deep and constructed of four 25-ft panels of increasing mesh size (1.0, 2.0, 3.0, and 4.0-inch stretch mesh).

mi[13]

[13] Traps were 2.5 feet long galvanized wire mesh (0.25 square inch) cylinders with two entry fykes.

nnow traps were set to sample deeper habitats (>10ft deep) for 4 hours simultaneously with the gill nets (NAI 2021d).

Fish community data in the bypass reach was collected from three 50-meter sample units during the spring (June 28), summer (August 27), and fall (October 21) of 2019 (total of 12). Due to safety and gear limitations, sampling was not conducted in: (1) the reach from the Pawtucket Dam downstream to the School Street Bridge (also known as Mammoth Road); and (2) the lowermost section of the bypass channel downstream of the Northern Canal surge gate. At each sample unit daytime backpack electrofishing[14] was conducted during minimum flows.

Fish collected from the impoundment and bypass reach were identified to the lowest possible taxonomic classification, enumerated, measured to total length (to the nearest millimeter), and weighed (to the nearest gram). If large numbers of small fish (i.e., young-of-year [YOY] or small cyprinid species) were captured, length and weight information was collected from the first 25 individuals within the sample and the remaining individuals were grouped, enumerated, and batch weighed (NAI 2021d).

In the impoundment, a total of 1,847 individuals and 22 fish species were collected during the sampling efforts in the impoundment. Spottail shiner (*Notropis hudsonius*) (23.0%), redbreast sunfish (*Lepomis auratus*) (20.5%) and smallmouth bass (12.3%) were the three most numerically abundant species within the impoundment. Spottail shiners were the most abundant species in the spring (27.6% of seasonal catch) and fall (33.9% of seasonal catch) sampling, whereas redbreast sunfish were the most abundant species in the summer sampling (27.1% of seasonal catch).

Through the impoundment sampling, centrarchid species were the most abundant within impoundment habitat with redbreast sunfish (24.2%), pumpkinseed (*Lepomis gibbosus*) (14.2%), and smallmouth bass (12.5%) representing the three most abundantly collected species. Spottail shiner were the most abundantly sampled fish species in the pool (28.4%) and run (46.3%) habitat areas.

The majority of catch in the impoundment were obtained via boat electrofishing, where a total of 1,792 fish and 20 species were collected. Spottail shiner, redbreast sunfish, and smallmouth bass were the most frequently collected species during boat electrofishing efforts. Total boat electrofish catch was fairly consistent across seasons. A total of 55 fish and 15 species were collected using gill nets. Yellow bullhead (*Ameiurus natalis*) were the most collected species and the majority of catch was recorded during the summer season. No fish were collected with minnow traps.

In the bypass reach, a total of 526 fish and fourteen fish species were collected. Fallfish (*Semotilus corporalis*) (39.9%), smallmouth bass (20.3%) and spottail shiner (16.7%)

[14] Halltech Aquatic Research Model HT2000B/MK5, battery-powered backpack electrofishers with ring probes and rattail cathodes were used for sampling. The backpack units were set at 550 volts at 100 Hertz (Hz). A fine mesh seine was anchored at the downstream end of the 50-m sample unit. A pair of backpack electrofishing units and four technicians moved in a downstream direction towards the seine while actively netting stunned fish and kicking the substrate to drive additional stunned fish towards the collection net.

were the three most numerically abundant species. Spottail shiner were most abundant during the spring (48.8%) and fallfish during the summer (55.0%) and fall (39.9%).

In the bypass reach, fallfish were the most abundant fish collected within the pooled habitat, which represented 47% of the total catch. Smallmouth bass were the most abundant fish species collected in the ledge habitat in the bypass reach, which represented 60.6% of the total catch from that habitat. Close to 14 percent of the total catch in ledge habitat were American eels (*Anguilla rostrata*).

Table E.7-14 provides a comparison of the percent composition of all species collected during the 2019 Fish Assemblage Study. In comparison to the historical fish community in the vicinity of the Project, one new species was collected during the 2019 sampling effort, the channel catfish (*Ictalurus punctatus*). An additional 19 fish species have been observed historically in the Project vicinity, which are presented in Table E.7-15.

Table E.7-14. Fish Assemblage Observed During the 2019 Sampling of the Impoundment and Bypass Reach

Common Name	Scientific Name	Percent Composition	
		Impoundment	Bypass Reach
Alewife	*Alosa pseudoharengus*	6.1	-
American Eel	*Anguilla rostrata*	0.9	6.3
Black Crappie	*Pomoxis nigromaculatus*	0.3	-
Bluegill	*Lepomis macrochirus*	6.6	0.6
Brown Trout	*Salmo trutta*	-	0.2
Channel Catfish	*Ictalurus punctatus*	0.1	-
Common Carp	*Cyprinus carpio*	0.3	-
Fallfish	*Semotilus corporalis*	7.7	39.9
Golden Shiner	*Notemigonus crysoleucas*	0.7	-
Largemouth Bass	*Micropteris salmoides*	2.2	0.4
Sunfish, species unidentified	*Lepomis* spp.	0.2	0.2
Longnose Dace	*Rhinichthys cataractae*	-	0.4
Margined Madtom	*Notorus insignis*	0.5	3.2
Pumpkinseed	*Lepomis gibbosus*	8.4	-
Redbreast Sunfish	*Lepomis auritus*	20.5	2.5
Rock Bass	*Ambloplites rupestris*	0.4	-
Sea Lamprey	*Petromyzon marinus*	1.1	0.2
Smallmouth Bass	*Micropterus dolomieu*	12.3	20.3
Spottail Shiner	*Notropis hudsonius*	23	16.7

Common Name	Scientific Name	Percent Composition	
		Impoundment	Bypass Reach
Tessellated Darter	*Etheostoma olmstedi*	1.7	1.9
Walleye	*Sander vitreus*	0.1	-
White Perch	*Morone americana*	0.1	-
White Sucker	*Catostomus commersoni*	3	6.3
Yellow Bullhead	*Ameiurus natalis*	2.9	1
Yellow Perch	*Perca flavescens*	1.1	-

Source: NAI 2021d

Table E.7-15. Additional Fish Species Observed Historically at the Project

Common Name	Scientific Name
American shad	*Alosa sapidissima*
Atlantic salmon	*Salmo salar*
Banded killifish	*Fundulus diaphanus*
Banded sunfish	*Enneacanthus obesus*
Blacknose dace	*Rhinichthys atratulus*
Blueback herring	*Alosa* aestivalis
Bridle shiner	*Notropis bifrenatus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ameiurus nebulosus*
Chain pickerel	*Esox niger*
Common shiner	*Luxilus cornutus*
Creek chubsucker	*Erimyson oblongus*
Gizzard shad	*Dorosoma cepedianum*
Goldfish	*Carassius auratus*
Northern pike	*Esox lucius*
Redfin pickerel	*Esox americanus*
Slimy sculpin	*Cottus cognatus*
Striped bass	*Morone saxatilis*

Common Name	Scientific Name
Swamp darter	*Etheostoma fusiforme*
White catfish	*Ameiurus catus*

Sources: Hartel et al. 2002; Merrimack River Technical Committee 1997.

E.7.3.1.4 Migratory Species and Fish Passage

Overview

Fish passage at the Lowell Hydroelectric Project is managed in accordance with the CFPP. The CFPP includes details of operational measures undertaken by Boott to protect upstream and downstream migrating anadromous fish. Upstream and downstream fish passage facilities at the Project include a fish lift and downstream fish bypass at the E.L. Field Powerhouse and a vertical-slot fish ladder at the Pawtucket Dam. The fish passage facilities at the Project were designed in consultation with the USFWS and current fish passage operations are supervised by both state and federal fishery agencies per the CFPP.

In accordance with the CFPP, Boott is required to begin operating the fish passage facilities at the Lowell Project when a cumulative total of 50 American shad (*Alosa sapidissima*) or 200 river herring (*A. pseudoharengus*) are passed at the downstream Lawrence Hydroelectric Project (FERC No. 2800). Termination of upstream fish passage operations at the end of the upstream passage season is determined each year in consultation with the MRTC, and typically occurs in early to mid-July. Additionally, in accordance with the CFPP, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech Analytics 2017). Under the CFPP, Boott provides annual post-season updates to the MRTC. Fish are capable of bypassing the Project's entire canal system via the Merrimack River and use the existing upstream and downstream fish passage facilities at the Pawtucket Dam and E.L. Field Powerhouse. There are no exclusionary measures at the entrance of the Project's canal system. However, in the CFPP, Boott included an operational protocol to pass additional flows through the canal system in the rare instance where the Northern Canal needs to be dewatered to conduct repairs or maintenance on the main powerhouse during downstream fish passage season (Cleantech Analytics 2017). This provision has been implemented only once during the term of the license, to facilitate repairs to the Northern Canal wall in 1996.

As currently provided in the CFPP, the fish lift has historically been the primary route of upstream passage at the project, whereas the ladder has typically been operated only during periods of higher flow when spillage at the dam may attract upstream migrants toward the bypass reach. In recent years, Boott and the MRTC have tested the success of passage through the ladder under normal, non-spill conditions with very favorable results. Beginning in 2018 Boott has agreed to operate both the lift and the ladder throughout the fish passage season, in exchange for agency support of LIHI certification of the Project.

As a component of the CFPP, Boott collects information regarding the abundance of diadromous fishes using the upstream fishways annually. This activity is a joint monitoring effort to inform the MRTC that manages these fishery resources. MADFW and Boott staff work cooperatively to record diadromous fish counts at the E. L. Field Powerhouse fish lift throughout the upstream migration season. Beginning in 2017, fish count records also were kept at the Pawtucket Dam fish ladder. Boott provides a summary of these counts as part of its annual fishway operations report to the MRTC (Table E.7-16).

The CFPP is based on several fisheries studies conducted at the Project and experience gained at the Project since the installation of the Project's fish lift and fish bypass facilities. The CFPP was developed in consultation with the resource agencies, and many of the agencies' recommendations have been incorporated into the CFPP. Currently, Boott is coordinating with the USFWS and University of Massachusetts, Amherst, in upstream and downstream American eel passage studies at the Project. Since 2013 Boott has actively worked with USFWS to assess and improve upstream eel passage at the Pawtucket Dam.

In 2016, Boott purchased new radio telemetry equipment to assist the USFWS monitoring at three sites to assess the downstream movement of radio tagged adult eels released at the Merrimack River Project upstream (Cleantech Analytics 2017). In 2017 Boott deployed telemetry equipment at six locations at the Lowell Project and two locations at the Lawrence Project to again track the movement of radio-tagged eels released at the Merrimack River Project through the Lowell Project facilities. As discussed in more detail below, each of the fourteen radio-tagged eels determined to have successfully passed downstream of the Lowell Project, with the majority of individuals passing via the turbines and the remainder passing by spill.

The priority species for management at the Lowell Project are the catadromous American eel and three anadromous Alosidae species, American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), and alewife (*Alosa pseudoharengus*). Juvenile and adult American eel upstream and downstream migration periods overlap. Juveniles ascend beginning in May and continue through October. The adult outmigration period begins in late summer and lasts through November. The peak outmigration period is October through mid-November (Boott 2018).

Adult American shad and river herring ascend the Merrimack River from May through early July. The peak period is highly dependent on water temperature and total river discharge. The juvenile outmigration period is in the fall (September through November) and is also highly dependent on ambient water temperature and river discharge conditions (Boott 2018).

Outmigrating fish encountering the Pawtucket Dam can: (1) pass through the Pawtucket Gatehouse and enter the power canal; (2) pass downstream over Pawtucket Dam via spill; or (3) enter the Pawtucket Canal and navigate downstream via the downtown canal system. Individuals which enter the Northern Canal can pass downstream via one of the two turbine units at the E.L. Field Powerhouse, utilize the downstream bypass, or pass via the surge gate (operated only in the event of a station trip).

Table E.7-16. Lowell and Lawrence Diadromous Fish Passage Counts Since 1983

Year	River Herring (Lawrence)	River Herring (Lowell)	American Shad (Lawrence)	American Shad (Lowell)	Atlantic Salmon (Lawrence)	American Eel (Lowell)	American Eel (Lawrence)
1983	4,794		5,629		114		
1984	1,769		5,497		115		
1985	23,112		12,793		213		
1986	16,265		18,173	1,630	103		
1987	77,209		16,909	3,926	139		
1988	361,012	56,739	12,359	1,289	65		
1989	387,973	137,296	7,875	940	84		
1990	254,242	9,888	6,013	443	248		
1991	379,588	6,920	16,098	428	332		
1992	102,166	32,501	20,796	6,491	199		
1993	14,027	4,315	8,599	1,679	61		
1994	88,913	33,735	4,349	383	21		
1995	33,425	11,848	13,861	5,255	34		
1996	51	51	11,322	400	76		
1997	403	403	22,661	4,446	71		
1998	1,362	13	27,891	4,159	123		
1999	7,898	2,930	56,461	16,347	185		
2000	19,405	673	72,800	12,716	82		
2001	1,550	58	76,717	7,740	83		
2002	526		54,586	5,283	56		
2003	10,866	194	55,620	6,580	147		
2004	15,051	7,448	36,593	11,028	129		
2005	99	201	6,382	716	34		
2006	1,257	27	1,205		91		
2007	1,169		15,876	1,653	74		
2008	108		25,116	4,050	119		
2009	1,456	139	23,199	2,267	81		
2010	518	43	10,442	490	85		
2011	740	228	13,835	831	402		
2012	8,992	1,809	21,396	1,728	137		6,969
2013	17,359	13,490	37,149	9,756	22		915
2014	57,213	23,610	38,107	3,357	75	166	1,788
2015	128,692	31,323	89,467	20,937	13	2,647	8,124

Year	River Herring (Lawrence)	River Herring (Lowell)	American Shad (Lawrence)	American Shad (Lowell)	Atlantic Salmon (Lawrence)	American Eel (Lowell)	American Eel (Lawrence)
2016	417,240	287,343	67,528	11,439	6	328	1,981
2017	91,616	5,656	62,846	5,086	5	1,981	17,738
2018	276,449	311,867	25,081	14,046	10	*	267,353
2019	43,108	43,871	19,450	2,201	15	*	81,179
2020	87,150	181,979	52,239	8,449	1	974	93,058
TOTAL	**2,934,773**	**1,357,876**	**1,072,920**	**178,169**	**3,850**	**6,096**	**479,105**

*continuously ran fish ladder in 2018 and 2019 was primary upstream passage for eels, accurate quantity was unavailable without trapping.
Source: Boott 2018; K. Webb, Boott Hydropower, personal communication, March 19, 2018

Historical Studies

Multiple studies have been conducted at the Lowell Project to assess the movement behavior, passage route use, and survival of migratory fish species during the past three decades. Use and efficiency studies of the E.L. Field Powerhouse fish lift by American shad were conducted in 1999 and 2000 by Boott and by Alden Research Laboratory in 2011. The earlier studies led to significant modifications and upgrades of those facilities that improved the passage efficiencies of American shad. In addition, a 1988 acoustic telemetry study performed by RMC Environmental Services (RMC) of adult American shad movement through the Northern Canal demonstrated delayed movement through the Pawtucket Gatehouse, as well as incidental information regarding downstream passage routes for post-spawning individuals (RMC 1988). In a follow-up study in 1991 by NAI found similar findings as the 1988 adult American shad telemetry study (NAI 1991a).

Downstream bypass effectiveness studies in 1991 and subsequent studies in 1994 and 1995 by NAI yielded information regarding the use of the Project's bypass reach. This information led to phased modifications of the bypass which increased its use and efficiency at passing juvenile Alosids downstream. Similar studies were performed for Atlantic salmon smolts in 1996 and 2003 by NAI. A 2005 USFWS radio telemetry study provided information regarding American shad movement behavior between the downstream hydroelectric station, Lawrence, and the Lowell facilities. The upstream passage of American shad was also assessed at the Lowell Project in 2011 by Alden Research Laboratory, Inc, with additional analyses performed in 2013. Most recently, a study performed in 2017 by NAI yielded information regarding the downstream migratory behaviors of American eel in the Lowell Project.

During 2019, three additional fish passage studies were conducted at the Lowell Hydroelectric Project as outlined in the RSP, which are described further below along with more specific details on the historical studies.

American Eel Passage

The downstream passage for silver-phase American eels was evaluated by NAI in 2017. As part of that evaluation, fourteen radio-tagged eels passing downstream of the Amoskeag Project (the next hydroelectric facility upstream of Lowell in New Hampshire) were detected at Pawtucket Dam and thirteen of the fourteen study eels arriving at Lowell were subsequently detected downstream at Lawrence. The transit times between Amoskeag and Pawtucket Dam ranged from 10 – 244 hours. Eel passage events occurred primarily between sunset and sunrise via the turbines (eight) and over Pawtucket Dam (five); one individual was not detected at the passage detection fields at Lowell but was detected at the Lawrence Project. In addition, the E.L. Field Powerhouse bypass was not used as a downstream passage route.

More recently, a radio-telemetry assessment of the downstream passage success for adult silver-phase American eels was performed during the fall of 2019, pursuant to the SPD (NAI 2021a). Monitoring of outmigrating adult American eels focused on the evaluation of movement through the Project impoundment, residence time immediately upstream of the Pawtucket Dam and prior to passage, passage route utilization and estimation of downstream passage survival at the Project.

Following the release of 102 radio-tagged individuals[15] into the Merrimack River 11 miles upstream of the Lowell impoundment, their movements were monitored using a series of stationary radio-telemetry receivers in place at the Project[16] to inform on general movements, distribution among available passage routes and Project passage success (NAI 2021a).

Radio-tagged eels moved through the existing 23-mile-long Project impoundment in a median duration of 2.1 days. Upon initial detection at the Pawtucket Dam, the median duration of time spent immediately upstream of the dam structure was 0.4 hours with 94% passing downstream within the first 24 hours of their initial detection. Closer examination of the total residence time for radio-tagged eels indicated that the 95% of individuals passing through the Pawtucket Gatehouse did so in 30 minutes or less and upon entry into the Northern Canal the median residence duration prior to downstream passage was 0.2 hours (NAI 2021a).

During the 2019 evaluation there was no detected use of the downtown canal system by outmigrating radio-tagged eels. The majority of radio-tagged individuals passed through the Pawtucket Gatehouse and approached the E.L. Field powerhouse with 92.5% eventually passing downstream via the turbine units (Table E.7-17). Use of the existing downstream bypass system was limited to only two individuals. Downstream passage at the Project peaked during late October with all passage events completed by October

[15] Normandeau Associates simultaneously conducted an additional downstream adult eel passage study at the Merrimack River Project (FERC No. 1893) during fall 2019. A total of 60 eels were radio-tagged during that assessment and were also monitored for passage at Lowell. Results from that group of eels at Lowell and points downriver have been incorporated into this report.

[16] 12 monitoring stations total.

31. The majority of downstream passage events occurred during the evening and overnight hours (NAI 2021a).

The high number of radio-tagged individuals that passed downstream via the turbine units likely resulted from drier than normal conditions in the region. Only two major spill events, associated with increases in river flows, occurred during the monitoring period. The first major spill event occurred from approximately October 29 to November 5 and the second occurred towards the end of the passage season (~November 25) (NAI 2021a). The timing of the spill events occurred primarily after the peak of downstream passage at the Project. Under normal conditions, the frequency of spill events would be greater due to more frequent increases in river flows, thereby increasing the downstream passage of individuals over the dam and decreasing individuals passing downstream via the turbine units.

Downstream passage survival was estimated for all radio-tagged eels from the point of initial detection upstream of the Pawtucket Dam downstream to Lawrence. This resulted in an estimated downstream passage survival for silver-phase American eel at Lowell of 75.5% (75% Confidence Interval [CI] = 71.4%-79.6%). This estimate of downstream passage survival for adult eels at the Project includes any background (i.e., natural) or tagging-related mortality for the species in the reach from approach to the Pawtucket Dam to Lawrence. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult eels at the Project. Due to the limited distribution of downstream passage route selection, route-specific estimates of passage were developed for only individuals using turbine units at the E.L. Field powerhouse (n = 136; 75.0% survival; 75% CI = 70.6%-79.4%). The limited number of radio-tagged eels passing the Project via spill or the downstream bypass system were all determined to have successfully approached the Lawrence Project following downstream passage at Lowell (NAI 2021a).

Table E.7-17. Downstream passage route selection for radio-tagged eels released upstream of the Lowell project boundary and upstream of Garvins Falls Dam during the fall 2019 downstream passage assessment.

Release Location	Release Date	Lowell Downstream Passage Route					
		Did not Detect	Did Not Pass	Unknown	Turbine	Spill	Bypass
Garvins Falls	9-Oct	7	0	1	11	1	0
Garvins Falls	11-Oct	2	1	0	15	1	1
Garvins Falls	15-Oct	6	0	0	13	1	0
Garvins Falls	All	15	1	1	39	3	1
Lowell	9-Oct	0	0	1	19	0	0
Lowell	11-Oct	0	0	0	19	0	1

Release Location	Release Date	Lowell Downstream Passage Route					
		Did not Detect	Did Not Pass	Unknown	Turbine	Spill	Bypass
Lowell	16-Oct	0	0	1	18	1	0
Lowell	18-Oct	0	0	0	20	0	0
Lowell	23-Oct	0	0	1	21	0	0
Lowell	All	0	0	3	97	1	1
All		15	1	4	136	4	2
Percent Utilization			0.7%	2.7%	92.5%	2.7%	1.4%

Source: NAI 2021a.

The Fish Passage Survival Study (NAI 2021f) addressed the qualitative classification of impingement, entrainment, and the probability of turbine passage survival at the Project using a review of relevant biological criteria and physical Project characteristics for American eel. The study used a turbine blade strike analysis (TBSA) model, which relied on recent USFWS guidance on the use of a varied correlation coefficient for American eel, to calculate survival estimates through the E.L. Field Kaplan units. The estimated range of survival for eels passing downstream through the E.L. Field turbines ranged from 71-39 percent, with the predicted rate of survival for adult eels decreasing as body size/length increased (Table E.7-18). In the case of adult eels, the TBSA model tended to underestimate turbine survival when compared to empirical results from the Downstream American Eel Passage Assessment.

Table E.7-18. TBSA predicted survival estimates for adult American eels at the E.L. Field powerhouse.

Species/Life Stage	Size potentially encountered the region (in)	Body Length (inches)						
		21	24	28	32	36	40	45
American eel (Adult)	25-41	71.20%	67.30%	61.80%	56.50%	51.70%	46.00%	39.10%

Juvenile Alosine Downstream Passage

The downstream passage of juvenile alosines has been studied at the Lowell Project a number of times since 1990. After conducting a mark and recapture study in the fall of 1990 to determine the relative efficiency of its fish bypass system at passing juvenile clupeids, it was determined that because water depth in the vicinity of the E.L. Field Powerhouse's bypass is greater than 30 feet, the 91-centimeter-deep bypass opening at the facility may be too shallow for the majority of fish to locate it (NAI 1991b). During this study, a total of 7,882 juvenile clupeids were captured in the bypass net between September 25 and October 23. Alewives comprised 95% of the catch, shad 4.5%, and blueback herring less than 0.5%. Modifications to the fish bypass at the E.L Field

Powerhouse were subsequently completed, and downstream juvenile alosine passage was again examined during the fall of 1993 and 1994 to assess efficiency of the modified bypass opening. Both studies concluded that the modified bypass opening greatly improved passage efficiency, by approximately 30 percent (NAI 1994 and NAI 1995).

An evaluation of the potential impacts on the outmigration of juvenile alosines was conducted in the fall 2019 migration season using radio-telemetry as outlined in the RSP (NAI 2021b). Monitoring of outmigrating juvenile alosines focused on the evaluation of the residence time immediately upstream of the Pawtucket Dam and prior to passage as well as passage route utilization at the Project.

A total of 145 juvenile alosines[17] were tagged and released at mid-river locations approximately one mile upstream of the Pawtucket Gatehouse. Their subsequent downstream arrival and passage at the Project was monitored via a series of fixed-location telemetry receivers within the Lowell Project area.

Upon initial detection at the Pawtucket Dam, the median duration of time spent immediately upstream of the dam structure was 1.3 days with 42% passing downstream within the first 24 hours of their initial detection. Closer examination of the total residence time for radio-tagged juvenile alosines indicated that all individuals determined to have entered the Northern Canal passed through the Pawtucket Gatehouse in less than 30 minutes. Upon entry into the Northern Canal, the median residence duration prior to downstream passage was longer (22.0 hours; range = 0.2 hours to 4.7 days). Nearly 70% of all downstream passage events for radio-tagged juvenile alosines occurred within 48 hours of initial detection in the E.L. Field forebay. A statistically significant interaction was suggested between mid and high generation conditions in relation to passage failure from the E.L. Field forebay. The presence of higher generation flows increased the probability that a radio-tagged individual would approach downstream passage options in the power canal (i.e., turbines or downstream bypass) and decreased the passage attempt relative to lower generation flows.

During the 2019 evaluation, the majority of radio-tagged individuals passed through the Pawtucket Gatehouse and approached the E.L. Field Powerhouse (Table E.7-19). Of the individuals which approached the E.L. Field Powerhouse and had a known downstream passage route, 83% eventually passed downstream via the turbine units. Use of the existing downstream bypass system was estimated at 17%.

Table E.7-19. Downstream passage route selection and percent utilization of route options after detection at Station 21 for radio-tagged juvenile alosines released upstream of Pawtucket Dam during the fall 2019 downstream passage assessment.

Release Date	Lowell Downstream Passage Route						
	Did not Detect	Did Not Pass	Downtown Canal System	Spill	Bypass	Turbine	Unknown

[17] The FERC-approved RSP indicated that a total of 150 radio-tagged juvenile alosines shall be used for the study. Five of the transmitters purchased for this study could not be activated. As a result, a total of 145 radio-tagged juvenile alosines were released and assessed for downstream passage at the Project. There were no additional variances from the FERC-approved study plan.

Release Date	Lowell Downstream Passage Route						
	Did not Detect	Did Not Pass	Downtown Canal System	Spill	Bypass	Turbine	Unknown
9-Oct	0	2	1	1	5	6	0
11-Oct	0	2	1	0	4	8	0
13-Oct	1	3	0	1	4	4	1
14-Oct	1	1	1	0	1	10	1
15-Oct	0	2	0	2	2	8	1
16-Oct	0	0	0	6	0	7	2
17-Oct	0	2	0	2	0	9	3
18-Oct	0	2	0	0	0	13	0
23-Oct	1	3	0	0	1	11	1
24-Oct	0	4	0	1	0	6	0
All	3	18	3	13	17	82	9
Percent Utilization		12.7%	2.1%	9.2%	12.0%	57.7%	6.3%

Source: NAI 2021b.

During the Revised ISR Meeting on October 15, 2020, FERC and NAI discussed the models at the gatehouses and the correlations between flow and temperature. NAI stated they could likely make changes to the model to further explore those variables.

The Fish Passage Survival Study (NAI 2021f) used the TBSA desktop tool to estimate total project survival for juvenile alosines at the Project. Estimates of turbine passage were inversely related to body length for each species/life stage considered with highest survival estimated for small juvenile shad or herring at 2 inches of length (~99%) (Table E.7-20).

Table E.7-20. TBSA predicted survival estimates for juvenile American shad and river herring at the E.L. Field powerhouse.

Species/Life Stage	Size potentially encountered the region (in)	Body Length (inches)		
		2	4	6
American shad (Juv)	2-6	98.6%	97.2%	95.9%
River herring (Juv)	1.5-6	98.6%	97.2%	95.9%

An empirical estimate of juvenile alosine survival was not derived during the 2019 Juvenile Alosine Downstream Passage Assessment at Lowell. The model required input of available downstream passage routes and an estimate of their proportional usage. Those rates were obtained from the 2019 study which estimated route usage for individuals passing the project via known mainstem routes as 11.6% via spill, 15.1% via the downstream bypass, and 73.2% via the E.L. Field turbine units. These observed route selection probabilities were imported into a multi-route TBSA model to evaluate the predicted whole-station survival for a normally distributed population of 1,000 3.5 inch (S.D. ±1.0 inches) fish. For non-turbine routes (e.g., downstream bypass or spill), an estimate of passage mortality was required and was based on the empirical estimates obtained for adult alosines at the Project (12% at the downstream bypass and 11% via spill). Using this methodology, total project survival at Lowell for juvenile alosine-sized fish is estimated at 94.8%. Passage failures were attributed to fish passing downstream via the turbines (2.1% of total losses) and the downstream bypass facility/spill (3.1% of total losses).

Upstream and Downstream Adult Alosine Passage

Upstream and downstream passage of alosines at the Lowell Project has been evaluated several times since 1990. Downstream passage routes of radio-tagged American shad were evaluated in 1990. Approximately half of the shad tagged during their upstream migration returned to the Project site and 53% proceeded to pass through the E.L. Field Powerhouse, 22% passed using the fish bypass, 9% entered the Pawtucket Canal, and 13% spilled over the Pawtucket Dam. The study also indicated that the losses of adult shad upriver from the Lowell Project was consistent with shad runs in other rivers (NAI 1991a).

The internal efficiency of the Lowell Project fish lift at passing adult American shad upstream to spawn was evaluated in 1996 using underwater cameras. Study results indicated that internal fish lift efficiency for shad at the Project was low for both flows evaluated (50 cfs and 90 cfs), probably due to the low flow velocities inside the fish lift entrance channel, especially upstream of the crowder gates. With higher flows and velocities inside the fish lift entrance channel, fewer shad dropped out of the system and internal lift efficiency improved. However, even with the increased flow, most of the shad observed approaching the crowder gates did not pass through them. A similar study was performed in the spring of 1999, in which the upstream passage season was exceptionally successful at passing the highest number of shad since the fish lift was commissioned. Four hundred percent more individual shad were lifted in the spring 1999 season compared to both 1997 and 1998. The average internal lift efficiency (42%) achieved at the Lowell Project during the 1999 fish lifting season represented a substantial improvement over the previous results, increasing over seventeen-fold compared to results achieved in 1996. Additional upstream fish lift internal efficiency studies were performed in 2000 and 2001. Both studies concluded that the crowder gate opening has a significant effect on internal fish lift efficiency. Brail camera results, which are most comparable to previous studies at Lowell and Lawrence, clearly show that internal efficiency at Lowell had substantially improved due to the fish lift modifications and was comparable to efficiencies experienced at Lawrence.

The upstream passage of American shad was also assessed at the Lowell Project in 2011 by Alden Research Laboratory, Inc. Adult shad passage success or impediments and overall fish migration patterns from the Lawrence Hydroelectric Project into the Lowell tailrace and into the Lowell project's fish lift hopper was evaluated during this study. The acoustic telemetry results indicated that 57% of shad that pass the Lawrence Hydroelectric Project reach the Lowell tailrace. Only three individual fish were detected as entering the riverside fish lift entrance. Additional analysis in 2013 by Blue Leaf Environmental concluded that shad did not spend long periods of time holding in a specific position within the tailrace or reside in areas outside of the established pattern of movement. Shad were also determined to move in a clockwise and counter-clockwise direction along both walls in the tailrace, contrary to the 2011 study which suggested shad move in a "U" shaped swimming pattern following the edges of the tailrace and the wall of the powerhouse.

An evaluation of the upstream and downstream passage effectiveness for adult alewives and American shad was conducted during the spring 2020 passage season (May through June) (NAI 2021c). Merrimack River conditions were considered normal or low for the majority of May, and low for most of the month of June. The E.L. Field fish passage facilities (i.e., upstream fish lift and downstream fish bypass) were operated throughout the study period and those turbine units were in operation for the duration of the study period. Two major spill events, associated with increases in river flows, occurred during the early portion of the monitoring period (May 7 and May 18). Flows to the downstream canal system were limited during both months as Boott suspended operation of the generating units in that system prior to the onset of the study due to overriding safety concerns.

Following the release of radio-tagged individuals[18] into the Merrimack River both upstream and downstream of the Lowell facility, their movements were monitored using a series of stationary radio-telemetry receivers in place at the Project as well as at several additional stationary monitoring receivers installed at bank-side locations upstream and downstream of the Project to inform on general movements, distribution among available passage routes and Project passage success.

Of the dual-tagged[19] adult alewives released downstream of the Project (150 individuals were dual-tagged and 204 were PIT-tagged), 85% were determined to have approached Lowell and were available to assess passage effectiveness of either the E.L. Field Powerhouse fish lift or the Pawtucket Dam fish ladder. The duration of time for fish to move upstream from the release location at Lawrence to Lowell was around one day for most dual-tagged adult alewives (median = 19.6 hours; 75th percentile = 28.6 hours). Following arrival downstream of the Project, 95% of dual-tagged adult alewives made at least one foray upstream towards either the fish lift or ladder. When examined by structure, 64% of dual-tagged alewives made at least one foray in the direction of the fish lift, 67% in the direction of the fish ladder, and 39% in the direction of the fish lift and fish

[18] A total of 150 adult alewives and 150 adult American shad were radio-tagged and released upstream of the Pawtucket Dam for the purposes of evaluating downstream passage. A total of 354 adult alewives and 384 adult American shad were radio-tagged and released for the purposes of evaluating upstream passage.

[19] Dual- and PIT-tagged individual fish were analyzed separately due to poor conditions at Monitoring Station 20, which precluded effected monitoring of PIT-tagged individuals.

ladder. The overall effectiveness of the E.L. Field fish lift for adult alewife passage during 2

020 was estimated at 43.9% (75% CI = 39.3-51.4%). The overall effectiveness of the Pawtucket Dam fish ladder for adult alewife passage during 2020 was estimated at 75.6% (75% CI = 69.2-82.2%).

Of the 150 radio-tagged adult alewives released upstream of Lowell, 83% approached the Pawtucket Dam and were available to evaluate downstream passage at the Project. The median upstream residence time prior to downstream passage was 2.0 days with 77% of individuals passing downstream in less than 96 hours after their arrival. The majority of individuals passed downstream of Lowell via the E.L. Field turbine units (52% of radio-tagged alewives) or utilized the downstream bypass (45% of radio-tagged alewives). Downstream passage survival was calculated as the joint probability of the three reach-specific survival estimates which encompasses the full section of the Merrimack River from Lowell downstream to Lawrence and resulted in an estimated downstream passage survival for adult alewives at Lowell of 76.5% (75% CI = 71.5%-80.5%). This estimate of downstream passage survival for adult alewives at Lowell included background mortality (i.e., natural mortality) for the species in the downstream reach, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult alewives at the Project.

Of the 180 dual-tagged[9] adult American shad released downstream of the Project, 40% were determined to have approached Lowell and were available to assess passage effectiveness of either E.L. Field Powerhouse fish lift or the Pawtucket Dam fish ladder. An additional 47% of the dual-tagged shad exhibited upstream movement following tagging and release at Lawrence but did not move the full length of the Merrimack River reach between the two Projects. The median duration of time for shad to move upstream from the release location at Lawrence to Lowell was 64.5 hours (2.7 days). The vast majority those shad made one or more forays in the direction of the fish lift. Only a single dual-tagged shad was determined to have initiated an upstream ascent into the bypassed reach and in the direction of the fish ladder and two additional PIT-tagged shad entered the fish ladder. The overall effectiveness of the E.L. Field fish lift for adult American shad passage during 2020 was estimated at 30.4% (75% CI = 22.1-39.5%).

Of the 150 radio-tagged adult shad released upstream of Lowell, 79% approached the Pawtucket Dam and were available to evaluate downstream passage at the Project. The median upstream residence time prior to downstream passage was 3.9 days with 51% of individuals passing downstream in less than 96 hours after their arrival. The majority of individuals passed downstream of Lowell via the E.L. Field turbine units (26%), the downstream bypass (28%) or utilized the bypassed reach (38%). Downstream passage survival was calculated as the joint probability of the three reach-specific survival estimates which encompasses the full section of the Merrimack River from Lowell downstream to Lawrence and resulted in an estimated downstream passage survival for adult shad at Lowell of 70.0% (75% CI = 64.5%-74.6%). This estimate of downstream passage survival for adult shad at Lowell included background mortality (i.e., natural mortality) for the species in the downstream reach, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult American shad at the Project.

The Fish Passage Survival Study (NAI 2021f) used the TBSA tool to estimate survival for American shad and river herring. The TBSA produced a range of survival estimates for American shad and river herring turbine survival through the Project's E.L. Field powerhouse Kaplan units. Within that range of estimates, the probability of mortality due to blade strike increased as body size increased. In the case of adult alosines, the TBSA model tended to overestimate turbine survival when compared to the 2019 empirical results from the Upstream and Downstream Adult Alosine Passage Assessment (NAI 2021c).

Table E.7-21. TBSA predicted survival estimates for juvenile American shad and river herring at the E.L. Field powerhouse.

Species/Life Stage	Size potentially encountered the region (in)	Body Length (inches)				
		8	12	16	20	25
American shad (adult)	15-23			89.0%	86.4%	83.1%
River herring (adult)	9-13	94.8%	91.8%	89.0%		

The Instream Flow Habitat Assessment and Zone of Passage Study (NAI 2021e) used River 2D (a two-dimensional hydraulic model) to assess the relationship between bypass flow and upstream passage through the bypassed reach. The zone of passage model was developed for three adult migratory species: American shad, blueback herring, and alewife. The 2.5 ft depth criteria for American shad showed that near full connectivity did not occur throughout the bypass reach until flows exceeded 4,000 cfs. This modeled lack of passage zones at low flows was largely due to the deep passage criteria for shad. Because the deep depth criteria may not be realistic for shad swimming through natural channels (as opposed to jumping weirs or ascending ladders), this analysis was re-run using 1.0 ft depth criteria, which is the depth criteria for river herring. Decreasing the depth criteria from 2.5 ft to 1.0 ft for shad resulted in almost continuous passage opportunities at just under 500 cfs, with multiple continuous pathways becoming available at flows of 1,000 cfs and above. Depth suitability for shad passage continued to increase at higher flows and velocities largely remain suitable for shad until flows exceed 6,000 cfs.

Passage conditions for river herring (blueback herring and alewife), using 1.0 ft minimum depth criteria show almost continuous passage opportunities at 482 cfs with multiple continuous pathways becoming available at flows over 1,000 cfs. Because the herring velocity criteria is somewhat slower than for American shad, the model predicted more impassable area within the bedrock channels due to rapid currents. However, it appears likely that herring could ascend the channels along the bottom or along the margins at 482 cfs. Velocities within the bedrock habitat increase with increasing flows, with excessive velocities through the bedrock at flows over 4,000 cfs.

Atlantic Salmon Passage

Efforts to restore Atlantic salmon (*Salmo salar*) to the Merrimack River were abandoned in 2013 after consistently low return numbers were observed, but the species may still occasionally be present in the Project area. Efforts since 2013 have shifted towards the restoration of the remaining migratory fish species, notably river herring and shad (Cleantech Analytics 2017). Atlantic salmon counts are available for the Lawrence Project downstream (Table E.7-16).

In 1996, a radio telemetry study was performed to determine the extent to which the Lowell and Lawrence downstream fish bypass systems are used by radio-tagged Atlantic salmon smolts. The fish bypass systems at both the Lowell and Lawrence Hydroelectric Projects were not found to be effective at passing radio-tagged Atlantic salmon smolts, and at both sites, most of the downstream passage was through the turbines. At the Lowell Project, 13% of the radio-tagged salmon used the bypass, a significant increase compared to the 4% bypass usage by radio-tagged salmon in 1990. Only four (15%) of the radio-tagged salmon that passed the Lowell Project made it downstream to the Lawrence Project's headpond and of these, none were recorded passing the Lawrence site. Predation appears to have been a factor in the disappearance of some radio-tagged salmon released upstream of both hydroelectric sites (NAI 1996).

The effectiveness of the Lowell Project at safely passing downstream migrating Atlantic salmon smolts, as well as passage routing and turbine survival was evaluated in 2001. Using twenty radio-tagged salmon smolts to test three bypass flows, fish bypass efficiency at the Lowell Project averaged 32% and ranged from 15% passage with a bypass flow of approximately 2% of turbine flow to 42% passage with approximately 4% bypass flow. No turbine-passed fish appeared to be injured as a result of turbine passage. Similar to the 1996 study, predation in the tailrace and downstream of the Project seem to have a substantial impact on the survival rates of salmon smolts emigrating past the Lowell Project (Boott 2001).

E.7.3.1.5 Essential Fish Habitat

Based on a review of the NMFS online database, the Lowell Project reach of the Merrimack River is designated essential fish habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act for Atlantic salmon (National Oceanic and Atmospheric Administration [NOAA] undated). Essential fish habitat was defined as “all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut” (New England Fishery Management Council [NEFMC] 1998).

E.7.3.1.6 Benthic Macroinvertebrates

Benthic macroinvertebrates (BMI) are small aquatic animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. They lack a backbone, are visible without the aid of a microscope, and are found in and around water bodies during some period of their lives. Benthic macroinvertebrates are often found attached to rocks, vegetation, logs and sticks or burrowed into the bottom sand and sediments (USEPA undated). These organisms provide a link between a system's primary productivity and its aquatic consumers through the conversion of plant biomass to consumable energy. Benthic macroinvertebrates can be useful indicators of water quality because many species have a wide range of tolerances to pollution.

Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) species are highly sensitive to pollution. Furthermore, EPT species are high-quality forage for a variety of freshwater fish species.

In recent years, the MADEP, NHDES, the Merrimack River Initiative (MRI), and numerous smaller watershed committees have begun conducting macroinvertebrate biomonitoring studies in the Merrimack River basin (USACE 2003). According to the USACE (2003), benthic macroinvertebrate sampling was conducted at 44 locations throughout the Merrimack River Basin (10 mainstem and 34 tributary). Artificial substrates were deployed in August 1994 and collected seven weeks later after a colonization period. The results of the MRI study were published in November 1996 in a two-part study report titled Merrimack River Bi-State Water Quality Report, Part One and the Merrimack River Bi-State Biomonitoring Report, Part Two.

As shown above in Table E.7-13, the Instream Flow Habitat Assessment and Zone of Passage Study identified that benthic macroinvertebrates showed the highest estimates of WUA of all species groups, with a maximum of 24,062 m^2 at 2,000 cfs, and maintained high habitat values (>10,000 m^2) from 500 cfs to 10,000 cfs. The 2D model predicted suitable habitat for BMI throughout the Bypass Reach, although the highest quality habitat occurred in the upper end of the reach and near the bottom of the reach.

Three macroinvertebrate species of management concern that are entirely or semi-aquatic potentially reside in the Lowell Project vicinity of the Merrimack River. These species include the eastern pondmussel (*Ligumia nasuta*), the cobra clubtail (*Gomphus vastus*) and the umber shadowdragon (*Neurocordulia obsoleta*). These species were identified as species of special concern in Massachusetts (Commonwealth of Massachusetts 2018 *a*).

E.7.3.1.7 Aquatic Invasive Species

Invasive species are defined as non-indigenous plant or animal species that aggressively compete with native species. These species often out-compete local native species, impacting biodiversity, recreation, and human health. The Merrimack River supports a relatively large number of invasive species. The Invasive Plant Atlas of New England (IPANE), NHDES, and the MRWC identifies the species listed in Table E.7-22 as potentially occurring in the general vicinity of the Project. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-22. Aquatic Invasive Species Likely to Occur in the Project Vicinity

Common Name	Scientific Name
Common reed*	*Phragmites australis*
Curly-leaved pondweed	*Potamogeton crispus*
Eurasian water milfoil	*Myriophyllum spicatum*
Carolina fanwort	*Cabomba caroliniana*
Purple loosestrife*	*Lythrum salicaria*

Common Name	Scientific Name
Twoleaf milfoil	*Myriophyllum heterophyllum*
European water chestnut	*Trapa natans*
Yellow Iris	*Iris pseudacorus*
European water-clover	*Marsilea quadrifolia*
Watercress	*Nasturtium officinale*
Reed canarygrass	*Phalaris arundinacea*
Yellow iris	*Iris pseudacorus*
Flowering rush	*Butomus umbellatus*
Yellow floating heart	*Nymphoides peltata*
Asian clam	*Corbicula fluminea*

Sources: MRWC 2015; IPANE 2018

E.7.3.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on fish and aquatic resources as potential resource issues. Specifically, SD2 identified the following needed to be analyzed for site-specific effects:

- Effects of continued project operation on resident and migratory fisheries resources in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of continued project operation on the aquatic macroinvertebrate community in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of continued project operation on fish passage for migratory species, including American shad, river herring, and American eel.

The following potential resource issues related to fish and aquatic resources were identified to be analyzed for both cumulative and site-specific effects:

- Effects of continued project operation on migratory fisheries resources in the impoundment, canal system, bypassed reach, and Merrimack River.

E.7.3.2.1 Site-Specific Effects

Effects of Continued Project Operation on Fish Passage for Resident and Migratory Species

The Merrimack River is home to a diverse assemblage of fishes. Stolte (1982; as cited in the Merrimack River Technical Committee for Anadromous Fishery Management of the Merrimack River Basin, 1997) noted that during the last 150 years, over 15 non-indigenous species such as largemouth bass, smallmouth bass, walleye, common carp, rainbow trout, brown trout, various catfish species and goldfish have established through human introductions within the Merrimack River. At that time, the Merrimack River was identified as home to approximately 50 species of fish, nine of which were anadromous. The slower moving, ponded reaches of the Merrimack contain a higher predominance of warm-water species whereas those areas with higher gradient contain the majority of cold-water species. Hartel et al. (2002) identified a total of 57 reproducing fish species within the drainage; 21 primary species (i.e., those living full life cycle in freshwater), 8 secondary species (i.e., those with physiological capacity to move between fresh and salt water), 18 introduced species, and 10 diadromous species.

Fish assemblage sampling within the Lowell impoundment and bypass reach during the spring, summer and fall of 2019 resulted in the identification of 24 fish species. Of those species, 21 are considered freshwater and 3 are considered diadromous. The species collected during the 2019 sampling resulted in a similar and expected fish assemblage in the Project vicinity compared to existing information on the Merrimack River fish community (Hartel et al. 2002). Based on the results of the 2019 Fish Assemblage Study, approximately 75% of the composition of fish species in the impoundment and bypassed reach was comprised of five or less species in all sampling seasons (NAI 2021d). As expected, there is a slight seasonal shift in the fish community in both the impoundment and bypass reach. Table E.7-23 presents the most abundant fish species in the impoundment for each season and Table E.7-24 presents the most abundant fish species in the bypass reach for each season. Additionally, fish assemblage was found to differ based on habitat, as described in Section E.7.3.1.

Table E.7-23. Top five most abundant fish species each season in the impoundment from the 2019 Fish Assemblage Study.

Spring		Summer		Fall	
Species	**Percent Composition**	**Species**	**Percent Composition**	**Species**	**Percent Composition**
Redbreast Sunfish	23.7	Redbreasted Sunfish	27.1	Spottail Shiner	33.9
Smallmouth Bass	21.9	Pumpkinseed	17.5	Alewife	16.8
Spottail Shiner	27.6	Spottail Shiner	10.9	Fallfish	13.7
Fallfish	5.9	Bluegill	10.7	Smallmouth Bass	9.2
Bluegill and White Sucker[1]	8.2	Smallmouth Bass	6.9	Redbreasted Sunfish	8.2
Total	**87.3%**	**Total**	**73.1%**	**Total**	**81.8%**

Note: 1 Bluegill and white sucker had the same percent composition (4.1%).

Table E.7-24. Most abundant fish species each season in the bypass reach from the 2019 Fish Assemblage Study.

Spring		Summer		Fall	
Species	Percent Composition	Species	Percent Composition	Species	Percent Composition
Spottail Shiner	48.8	Fallfish	55	Smallmouth Bass	64.2
Fallfish	27.5	Spottail Shiner	14.4	Margined Madtom	13.2
American Eel	12.5	Smallmouth Bass	10.9	Redbreast Sunfish	6.6
Bluegill	2.5	White Sucker	8.8	Tessellated Darter	3.8
Smallmouth Bass	2.5	American Eel	5.3	White Sucker	2.8
Total	**93.8%**	**Total**	**94.4%**	**Total**	**90.6%**

Overview of Migratory Species and Fish Passage

Existing information for the Project, along with the results of the studies completed by the Licensee in 2019 and 2020, demonstrate that existing operations under the terms of the current license and the Project's CFPP are maintaining and supporting resident game and non-game fish species, as well as migrating anadromous fish, and habitat for aquatic species in the Merrimack River upstream and downstream of the dam.

The CFPP includes details of operational measures undertaken by Boott to protect upstream and downstream migrating anadromous fish. The CFPP is based on several fisheries studies conducted at the Project and experience gained at the Project since the installation of the Project's fish lift and fish bypass facilities. The priority species for management at the Lowell Project are the catadromous American eel and three anadromous Alosidae species (American shad, blueback herring, and alewife). Atlantic salmon restoration is no longer a management focus for the Merrimack River. Because of minimal fluctuation of the impoundment and adherence to a strict minimum flow regime, the operation of the Project has little effect on overall river flow in the lower Merrimack River.

The licensee has consulted with the USFWS, New Hampshire Fish and Game Department (NHFGD), MADFW, and NMFS extensively regarding fish passage at the Project. Boott provides a post-season update on the fish passage at the Lawrence and Lowell Hydroelectric Projects annually and the agencies have the opportunity to recommend improvements to the fish passage facilities. The fish passage facilities at both Projects are continually monitored and modified to increase effectiveness at the agencies' requests and recommendations (Cleantech Analytics 2017).

The recent construction of the pneumatic crest gate was strongly endorsed by the Federal and state (both New Hampshire and Massachusetts) fishery agencies due to its anticipated benefits to migratory species. The USFWS, NMFS, MADFW, and NHFGD submitted letters of support to the Commission for the pneumatic crest gate system. The system allows rapid re-inflation following periods of high flow, which prevents delay in upstream fish passage which occurs with lost or damaged wooden flashboards. The pneumatic crest gate system is expected to maintain consistent water levels, reduce leakage from the dam, and minimize the need for impoundment drawdowns, which all provide improved fish passage and spawning habitat. The reduction in leakage is expected to improve upstream passage efficiency by decreasing false attraction flow at the dam (FERC 2011).

American Eel Passage

The impoundment and river segment in the vicinity of the Project would be suitable for foraging, growth, and development of American eel prior to their downstream spawning migrations. American eels are adaptable and can utilize a wide range of riverine, lake, or reservoir habitat (McCleave 2001, Greene et al. 2009). The passage of American eel upstream of hydropower dams can expose the eventual out-migrating silver eels to migratory delay at each dam and mortality when passing through turbines or over spillways.

A radio-telemetry assessment of the downstream passage success for adult silver-phase American eels was performed during the fall of 2019 (NAI 2021a). Monitoring of outmigrating adult American eels focused on the evaluation of movement through the Project impoundment, residence time immediately upstream of the Pawtucket Dam and prior to passage, passage route utilization and estimation of downstream passage survival at the Project. During the 2019 American Eel Passage Assessment, the majority of American eels (92.5%) passed downstream of Lowell via the E.L. Field turbine units, while two eels used the downstream bypass and four eels used the bypassed reach (NAI 2021a). The limited use of the downstream bypass system at E.L. Field is similar to the results of the 2018 downstream eel passage evaluation.

Downstream passage survival was estimated for all radio-tagged eels from the point of initial detection upstream of the Pawtucket Dam downstream to Lawrence. This resulted in an estimated downstream passage survival for silver-phase American eel at Lowell of 75.5% (75% CI = 71.4%-79.6%). This estimate of downstream passage survival for adult eels at the Project includes any background (i.e., natural) or tagging-related mortality for the species in the reach from approach to the Pawtucket Dam to Lawrence. As a result, this estimate should be viewed as a minimum estimate of total Project survival (i.e., due solely to Project effects) for adult eels at the Project. Due to the limited distribution of downstream passage route selection, route-specific estimates of passage were developed for only individuals using turbine units at the E.L. Field Powerhouse (n = 136; 75.0% survival; 75% CI = 70.6%-79.4%). The limited number of radio-tagged eels passing the Project via spill or the downstream bypass system were all determined to have successfully approached the Lawrence Project following downstream passage at Lowell (NAI 2021a).

A TBSA model was conducted as part of the Fish Passage Survival Study (NAI 2021f) for American eel. The estimated range of survival for eels passing downstream through the E.L. Field turbines ranged from 71-39%, with the predicted rate of survival for adult eels decreasing as body size/length increased. In the case of adult eels, the TBSA model tended to underestimate turbine survival when compared to the empirical results from the Downstream American Eel Passage Assessment.

American shad and river herring passage

The presence of herring in the Merrimack River appears to be strong in recent years. In 2016, record numbers of herring (since the establishment of the restoration efforts,) were observed at the Amoskeag Dam, upstream of the Lowell project. The returns have been so successful that the large number of herring ascending the fish ladder at the Amoskeag Dam overwhelmed the trap and truck operation in 2016 (Cleantech Analytics 2017). In 2018, the Lawrence facility passed river herring upstream in the highest number (418,689) since the project was built over 30 years ago, and the Lowell project passed about 58% of those fish upstream, through its fish lift (62,421) and fish ladder (182,268) (Enel 2018). In 2016, 70% of the herring that passed at Lawrence also passed at Lowell (Enel 2016). Also, in 2018, while only 26,347 American shad were passed upstream at Lawrence, 56% of those were passed through the Lowell project, through its lift (4,630) and ladder (10,171). The high ratio of passage success for shad from Lawrence through Lowell is the highest ever observed in over 30 years of passage comparison (Enel 2018).

During the 2019 Juvenile Alosine Downstream Passage Assessment, 83% of juvenile alosines eventually passed downstream via the turbine units. Use of the existing downstream bypass system was estimated at 17% (NAI 2021b). During the 2019 Adult Alosine Downstream Passage Assessment, the majority of adult alewives passed downstream of Lowell via the E.L. Field turbine units (52% of radio-tagged alewives) or utilized the downstream bypass (45% of radio-tagged alewives). During 2020, the overall effectiveness of the E.L. Field fish lift for adult alewife passage was estimated at 43.9%, while the overall effectiveness of the Pawtucket Dam fish ladder for adult alewife passage was estimated at 75.6%. Also, during 2020, the overall effectiveness of the E.L. Field fish lift for adult American shad passage during 2020 was estimated at 30.4%, while only two tagged shad utilized the fish ladder (NAI 2021c).

The Fish Passage Survival Study (NAI 2021f) used the TBSA desktop tool to estimate total project survival for juvenile alosines at the Project. Estimates of turbine passage were inversely related to body length for each species/life stage considered with highest survival estimated for small juvenile shad or herring at two inches of length (~99%), and total project survival at Lowell for juvenile alosine-sized fish is estimated at 94.8%. Passage failures were attributed to fish passing downstream via the turbines (2.1% of total losses) and the downstream bypass facility/spill (3.1% of total losses).

The TBSA analysis conducted for adult alosines as part of the Fish Passage Survival Study produced a range of survival estimates for turbine survival through the Project's E.L. Field powerhouse Kaplan units. Within that range of estimates, the probability of mortality due to blade strike increased as body size increased. In the case of adult alosines, the TBSA model tended to overestimate turbine survival.

Effects of continued project operation on the aquatic macroinvertebrate community in the impoundment, canal system, bypassed reach, and Merrimack River

There is limited information available regarding aquatic macroinvertebrates at the Lowell Project. The pneumatic crest gate minimizes impoundment fluctuations and therefore helps to protect benthic macroinvertebrate communities and fish habitat within the littoral zone of the Project impoundment. Boott proposes to continue to operate the Project in ROR mode, for the purpose of protection of fish, aquatic habitat, and wildlife resources.

Hydroelectric projects have been shown to influence benthic macroinvertebrate communities by altering flow conditions and thereby habitat, water quality, and instream transport processes. The severity of impact on aquatic resources is largely influenced by the extent of flow regulation. The Project operates as a ROR facility, which uses the natural flow of the water to produce electricity. As such, flow regulation is minimal at ROR projects, which are often considered low impact facilities compared to peaking and storage hydroelectric projects. Although hydropower operations may affect the macroinvertebrate communities to some degree, the Licensee anticipates that the continued ROR operation of the Project will not affect macroinvertebrate communities.

Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

The primary downstream and upstream fish passage routes are in the mainstem of the Merrimack River, where flows historically have been substantially higher than the flows into the canal system. Under the current license, fish may have entered the canal system when flows were routed to the downtown powerhouses. Once fish entered the canal system, they would have needed to navigate several dams, water conveyance structures, locks, and the downtown mill powerhouses to return to the mainstem of the Merrimack River. None of the features in the canal system are equipped with fish passage structures. However, fish passage studies conducted in support of this license application detected only limited use of the canals by outmigrating diadromous species under elevated canal flow conditions. NAI did not detect any use of the downtown canal system by outmigrating radio-tagged eels in 2019. Furthermore, only two percent of all radio-tagged outmigrating juvenile alosines were determined to have entered the canal system, and there were no radio-tagged outmigrating adult shad determined to have utilized the downtown canal system. Limiting canal flows to an estimated 200 to 300 cfs of leakage make-up flow will further limit or eliminate the likelihood that outmigrating species would be drawn into the canal system.

There is limited information regarding fish species in the Project's canal system, and the Fish Assemblage Study did not include any fish sampling in the canals. The canals do not offer significant habitat for aquatic species. The canal beds consist of ledge, concrete, or wood-planked virgin soil, and there is little cover or structure to attract fish (Boott 2017).

Boott's proposal to decommission the downtown canal units is likely to have a net benefit to fish and aquatic resources. Because flows of up to 2,000 cfs will no longer be periodically routed to the downtown canal system, there is less likelihood that outmigrating diadromous fish will enter the canals. The primary means for fish to enter the canal system will be via the 200 to 300 cfs leakage make-up flow, or via lockages associated with the NPS's canal boat tours, which require a relatively small volume of water passed during a brief period. Even if fish do enter the canal system, Boott is proposing to discontinue generating with the powerhouses' turbines and to seal the penstock intakes. These actions will eliminate the possibility of fish becoming impinged at or entrained by the downtown powerhouses. Accordingly, decommissioning of the Project's downtown powerhouses is expected to have a net benefit on fish and other aquatic resources, particularly for diadromous species.

E.7.3.2.2 Cumulative Effects

In SD2, the Commission identified that migratory fish resources could be cumulatively affected by the continued operation of the Project in combination with other hydroelectric Projects on the river. The geographic scope for the cumulative effects analysis on migratory fish is the Pemigewasset River from the Eastman Falls Dam and the Winnipesaukee River from the Lakeport Dam, to the confluence of the Winnipesaukee and Pemigewasset Rivers (which form the Merrimack River), and the Merrimack River downstream to the Atlantic Ocean.

Boott believes that the continued operation of the Project, as proposed, will limit cumulative effects on the aquatic habitat, and resident and migratory fisheries resources in the impoundment, canal system, bypass reach, and Merrimack River based on the proposed minimum flow, operating the Project to maintain water quality standards, operating the pneumatic crest gate per the operation plan approved by FERC on March 30, 2015, operating fish passage facilities consistent with the CFPP approved by FERC on November 28, 2000.

The current operation of the Project has been designed to consider and support ongoing efforts to maintain resident and migratory fisheries to the Merrimack River Basin. The Project is operated in a ROR mode, consistent with minimum flow requirements, in order to comprehensively address river flows and related hydroelectric project operations to best support aquatic life downstream of the Project, including migratory fish species. Boott has undertaken substantial enhancements in the form of upstream and downstream passage measures at the Project, which should continue to minimize any cumulative effects to fisheries resources in the Merrimack River resulting from operation of the Project.

Similarly, Boott has undertaken a number of studies relative to fish restoration efforts at the Project that are designed to assess not only direct Project effects on fishery resources, but also to examine the potential cumulative effects of the Project on the overall migratory fish restoration efforts.

Operation of the Project may cumulatively affect migratory fish species including American eel, American shad, river herring (alewife and blueback herring). Upstream and downstream fish passage facilities including a fish elevator and downstream fish bypass at the E.L. Field Powerhouse, and a vertical-slot fish ladder at the Pawtucket dam are currently in place at the Project. To date, there has been no significant mortality observed or documented at the Project. Any mortality that may occur from entrainment or impingement of fish species at the Project would contribute to the cumulative effect of the fisheries in the Merrimack River.

Notably, in its 2007 finding on the petition to list the American eel, the USFWS found that:

- The species is highly resilient.
- The reproductive contribution of eels from coastal and estuarine habitat is substantial, and habitat in the lower reaches of a watershed produces more eels than habitat higher in the watershed.
- Loss of habitat resulting from dams does not threaten the long-term persistence of the American eel.
- American eel are able to navigate many barriers.
- Turbines can affect the regional abundance of eel, but no evidence indicates that turbines are affecting the species at the population level (USFWS 2007).

Removing the four mill powerhouses from the Project will result in much lower flows being routed through the downtown canal system, largely eliminating the possibility that outmigrating diadromous fish would be attracted into the canal system, and fully eliminating the possibility of entrainment in the downtown units.

E.7.3.2.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Boott believes that the continued operation of the Project, as proposed, will limit effects on fish and aquatic resources. Specifically:

- Boott proposes to operate the Project in a ROR mode using automatic pond level control of the E.L. Field powerhouse units, to protect fish and wildlife resources downstream from the Project. ROR operation may be temporarily modified for short periods to allow flow management for other project and non-project needs, e.g., downtown canal water level management, raising the crest gates following a high-water event, or for recreational purposes.

- During the upstream fish passage season, which generally runs from late April through mid-July, Boott proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the MRTC, consistent with current practice. At all other times, Boott proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam, for the protection of aquatic habitat within the bypass reach.

- Boott proposes continued adherence to the requirements of the Project's existing Crest Gate Operation Plan (approved by FERC on March 30, 2015). Maintaining stable water upstream levels will protect and enhance fish and wildlife habitat in the Project impoundment.
- Boott proposes to replace the existing fish lift with a short fish ladder to pass migratory fish from the E.L. Field powerhouse tailrace to the bypass reach, such that all fish would be passed upstream of the Project via the existing fish ladder at the Pawtucket Dam. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed ladder.
- Following installation and operation of the fish ladder at the tailrace, Boott proposes to cease operations of the upstream fish elevator at the tailrace. The timing of cessation of the upstream fish elevator will be determined based on consultation with the MRTC.
- Boott proposes to continue to work with the MRTC to identify any necessary minor modifications to the existing upstream fish ladder located at the Pawtucket Dam, and/or to the existing weirs in the bypass reach to improve passage.
- Boott proposes the installation of new trashracks or other fish exclusion facility at the E.L. Field Powerhouse which will be consistent with current USFWS passage guidelines , to prevent entrainment of fish through the turbines. Downstream passage of fish will continue to be provided via the existing sluice gate in the left forebay wall of the E.L. Field Powerhouse. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed fish exclusion system. Boott reserves the right to seasonally deploy the new trashracks or other exclusion facility only during the downstream fish passage season (mid-May – November), and to use the existing trashracks outside of the fish migration season.
- Boott proposes to develop a Fishways Operation and Management Plan in consultation with the MRTC. The proposed plan would effectively replace the Project's existing Comprehensive Fish Passage Plan.
- Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Ceasing the operation of the mill power station units will eliminate the possibility of outmigrating diadromous fish being entrained through those units.

Boott notes that certain studies required by the Commission are ongoing, including the Three-Dimensional CFD Modeling Study. Boott will consult with stakeholders regarding the results and recommendations of these studies and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.3.3 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those effects that may still occur after implementation of PM&E measures. Operation of the Project may continue to result in the delay or entrainment of American eels, American shad, river herring, Atlantic salmon, striped bass, sea lamprey, and other resident species, but these effects are expected to be limited in scope and will not have an effect at the population level.

E.7.4 Terrestrial Resources

The subsections below describe terrestrial resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, other existing information, and from the results of the Recreation and Aesthetics Study performed by Boott (HDR 2021a), included in Appendix B of this exhibit.

E.7.4.1 Affected Environment

The Merrimack River watershed encompasses approximately 5,010 square miles within the states of New Hampshire and Massachusetts. It is the fourth largest watershed in New England. Although the Merrimack River watershed is heavily forested (75 percent of the land area is covered with forest), it also supports all or parts of approximately 200 communities with a total population of 2.6 million people (USEPA 2020b; USACE 2006).

Ecoregions are used to provide general understandings of vegetation, wetland, and terrestrial habitat in an area (USEPA 1997). The Merrimack River watershed is located in both the Northeastern Highlands ecoregion and the Northeastern Coastal Zone. The north and westerly portions of the watershed, located in the Northeastern Highlands, are characterized by low mountains and mostly ungrazed forest and woodland. The southern portion of the watershed is located in the Northeastern Coastal Zone, which is characterized primarily as modified woodland and forest. However, the states of New Hampshire and Massachusetts report that undeveloped open space along the Merrimack River watershed generally decreases further downstream as riverfront communities are more industrialized (MEOEEA 2001; NHDNCR 2018).

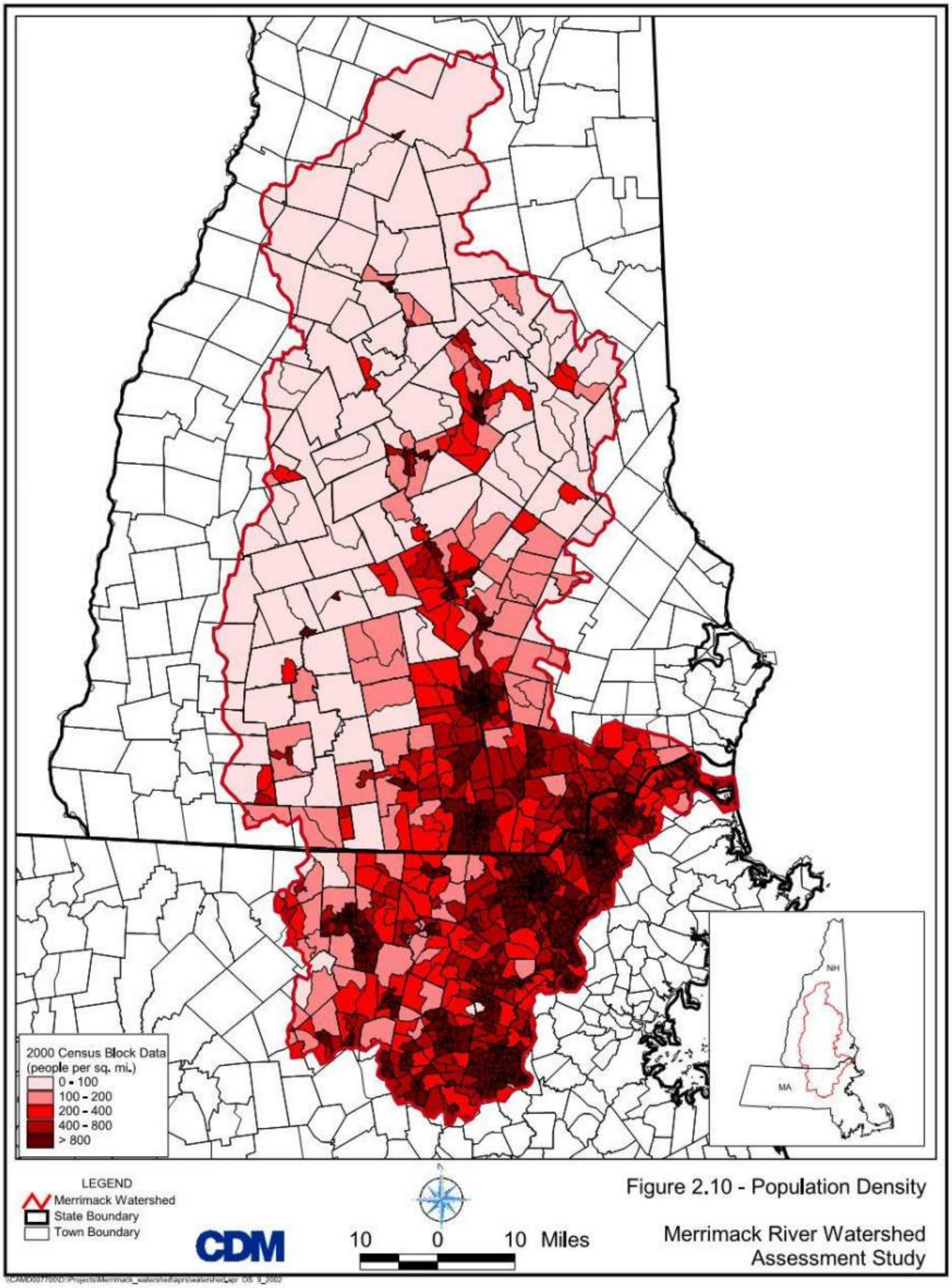
Along the upper northern boundary of the Merrimack River watershed, the relatively undeveloped White Mountain National Forest in New Hampshire provides almost 800,000 acres of protected land; this region also provides over one million acres of private forest and agricultural land (NHDNCR 2018). The Project dam is located at RM 41 on the Merrimack River, and the impoundment extends upstream approximately 23 miles almost to the City of Manchester in New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. In the vicinity of the Project in Lowell, Massachusetts, the Merrimack River flows through a region of rapid population growth and development stemming from the 1800s that is still heavily influenced by the growing Boston urban metropolitan area (Figure E.7-21).

The area near the Project's dam and E. L. Field powerhouse is urban in nature and the vegetation found within the project area is typical of an urbanized setting in this region. The project area has sparsely vegetated shorelines and a narrow riparian corridor consisting of grasses, weeds, and scattered wild shrubs. Early successional/young forest/shrub lands cover types occur in scattered patches along the shoreline of the river intermixed with small stands of mature forest and disturbed sites (fill slopes and millwork areas adjacent to developed sites) (FERC 2011). The developed lands nearby include the University of Massachusetts - Lowell, a variety of housing and residential subdivisions and an extensive network of roads and highways. The area south of these primary power-generating facilities includes several industrial sites, and the bisecting 5.5-mile downtown canal system.

The Merrimack River watershed’s land use composition, from the relatively undeveloped White Mountain National Forest in northern New Hampshire to highly urbanized areas along the mainstem of the Merrimack River, is reflected in the basin’s general land use and terrestrial resources (Figure E.7-22).

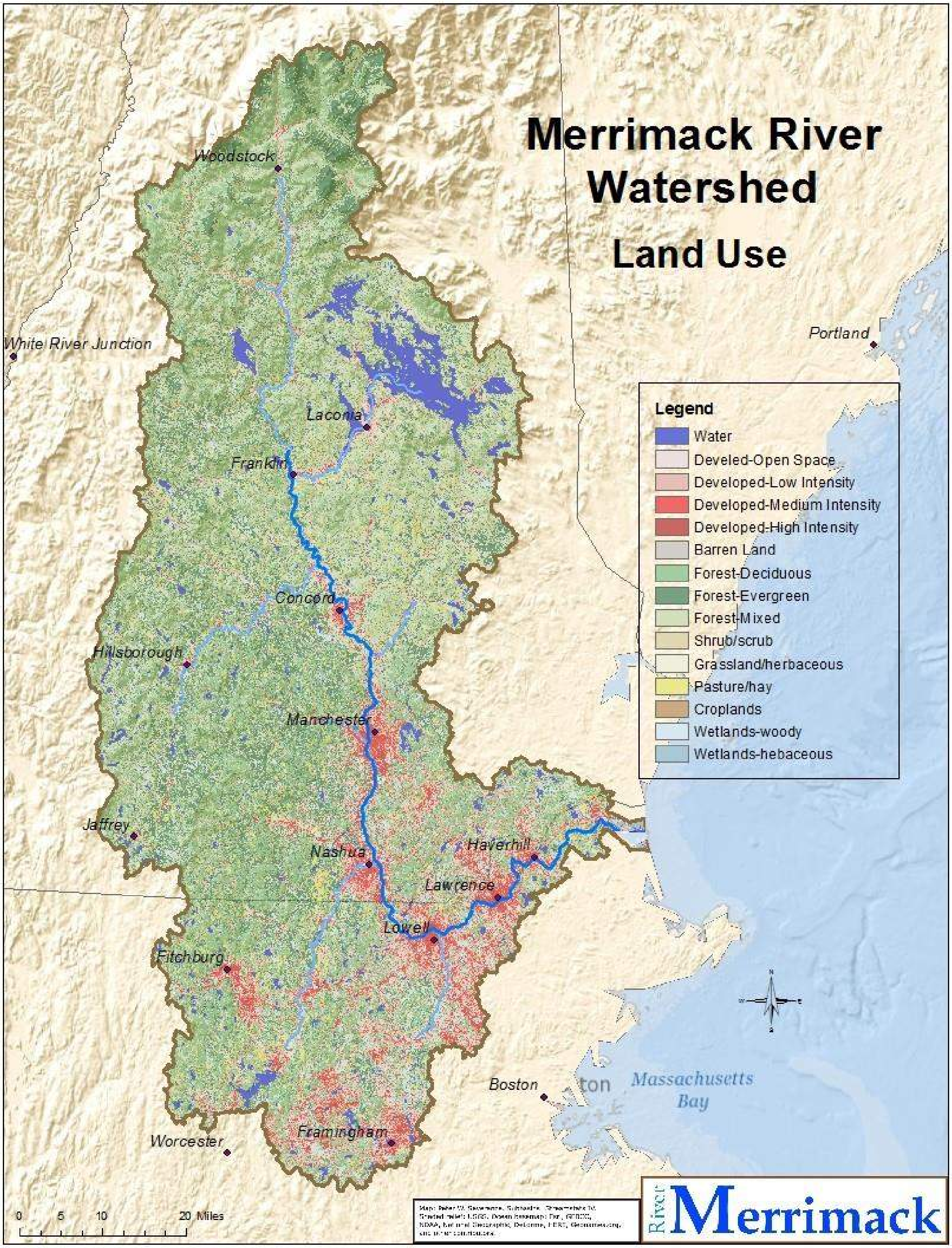
For purposes of describing the existing condition of terrestrial wildlife and botanical resources, this discussion has been divided into the following subsections: (1) botanical resources, (2) wetland, riparian, and littoral habitat, and (3) wildlife. As appropriate, these subsections describe other germane studies conducted by Boott relative to their resource areas.

Figure E.7-21. Population Density in the Merrimack River Basin



Source: USACE 2002

Figure E.7-22. Land Use in the Merrimack River Basin



Source: Merrimack River Watershed 2018.

E.7.4.1.1 Recreation and Aesthetics Study

In accordance with the Commission's SPD, Boott conducted a Recreation and Aesthetics Study to determine the adequacy and capacity of existing recreational facilities, assess potential effects of water levels and flow rates on existing recreational facilities, other forms of recreational assessments, and identify areas within the canal system where vegetation growth on historic canal walls are a concern. Methods and results of the Recreation and Aesthetics Study are described in detail in Boott's Recreation and Aesthetics Study report (HDR 2021a) which was filed with the Commission on February 25, 2021. A portion of the results of this study were used to help form the baseline characterization of terrestrial habitat and wildlife within the Project area; as such the study methods are summarized in this section, with the relevant results discussed in the subsections below.

Boott conducted a Recreation and Aesthetics Study, in part, to identify areas within the canal system where vegetation growth on historic canal walls are a concern, including background literature reviews, desktop analyses, and field investigations.

The visual survey for vegetation growth was conducted between September 25 and 27, 2019. The survey was conducted to identify vegetation growth along the canal walls within the study area. Technicians identified the relative quantity and spatial distribution of each vegetation type using aerial photography and observations of habitat and specific plant species occurrences. Terrestrial vegetation types occurring in the study area were described based on a review of existing information, an inspection of aerial photography, a review of the USGS 7.5-minute quadrangles, and observations of habitat and specific vegetation type occurrences during the field surveys.

For the purposes of examining vegetation type distribution, the study area was divided into the six canals associated with the Lowell Project canal system including: 1) Pawtucket Canal, 2) Northern Canal, 3) Western Canal, 4) Merrimack Canal, 5) Eastern Canal, and 6) Hamilton Canal.

Visual qualitative surveys were conducted in the study area by foot along the shorelines of the canals, or via an NPS boat for the surveys conducted in the Pawtucket Canal from the Swamp Locks and Dam to the Merrimack River. Vegetation was characterized by dominant type (i.e., Herbaceous, Scrub-Shrub, Trees, Forested, or Mixed). The vegetation type assessments were based on overall dominant vegetation characteristics at the time of the survey that may have variations within small areas. In addition, the shoreline/canal was characterized by dominant features (i.e., Block Wall, Concrete, Earthen/Terrestrial Cultural, Stone Wall, Block Wall/Concrete/Stone Wall Mix).

Mapped Vegetation Polygons and Vegetation Points (VPs)[20] were located using an EOS Positioning Systems Arrow 100™ GNSS receiver linked to an iPad™ Air 2 or Android device operating Collector for ArcGIS™ hand-held Global Positioning System (GPS) unit (equipped with a data dictionary aiding in feature attribution). The presence and extent of

[20] Vegetation points were used to identify areas along canal walls where a single vegetation type point was recorded. Vegetation points generally identify where a single species (e.g., shrub, tree) was located.

cover of the vegetation on/along the canal walls observed at the time of the field survey w as evaluated based on photographs and field observations. Geospatial vegetation data were transferred to a Geographic Information System (GIS) format and used to develop both visual maps depicting vegetation presence boundaries and VPs along the canal walls as well as tabular information quantifying the abundance and distribution of dominant vegetation types in the study area. Vegetation polygons were then analyzed to calculate the percentage represented by each vegetation category within each canal; VPs were not included in vegetation category percentage calculations because they represent a single point on the canal wall.

Relevant study results are discussed in the subsections below. As noted above, these subsections also describe other germane studies conducted by Boott relative to their resource areas.

E.7.4.1.2 Botanical Resources[21]

As presented in Section E.7.1, the Project is located in both the Northeastern Highlands ecoregion and the Northeastern Coastal Zone. The north and westerly portions of the watershed, located in the Northeastern Highlands, are characterized by low mountains and mostly ungrazed forest and woodland. The southern portion of the watershed is located in the Northeastern Coastal Zone, which is characterized primarily as modified woodland and forest. The Project is also located in the New England Physiographic Province. The Taconic, Green, and White Mountain ranges are distinct features of the New England Physiographic Province. The Taconic Mountains are a north-south trending mountain range along the western edge of the province and are thought to be formed by erosion of an upper block of a large thrust fault. Also, north-south trending, the Green Mountains exist primarily in Vermont and are made of Precambrian gneisses. The White Mountains are an exhumed mass of Paleozoic granite and include Mt Washington in New Hampshire, the tallest mountain in the region at 6,288 feet (NPS undated *a*).

The Lowell Project is located in the Seaboard Lowlands Section of the New England Physiographic Province. The Seaboard Lowlands Section is lower in elevation and less hilly than the adjacent New England Upland Section. Fenneman considered the Seaboard Lowlands Section as the sloping margin of the uplands, although it also roughly coincides with the area inundated by the ocean and areas of large proglacial lakes during the last glacial retreat (Stone and Borns 1986 as cited in Flanagan et al. 1999). In the vicinity of the Project, the Merrimack River flows through a region of rapid population growth and development that is heavily influenced by the Lowell metropolitan area. The local relief in the Merrimack River Valley in the Project vicinity is generally characterized as low, open hills.

Botanical resources in the Merrimack River corridor vary between urban areas and nonurban areas. In the vicinity of the Lowell Project, botanical resources are dominated by hemlock-hardwood-pine, Appalachian oak-pine, and grasslands (NHDFG 2015). These habitat types are discussed below in further detail.

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[21] State-listed RTE plant species are discussed in Section E.7.5 of this Exhibit.

Hemlock-Hardwood-Pine Forest

Hemlock-hardwood-pine forest is a wide-spread habitat in the lower Merrimack River corridor. It is a transitional forest between Appalachian oak-pine and northern hardwood found at elevations less than 400 feet and greater than 1,500 feet, respectively. White pine (*Pinus strobus*) and eastern hemlock (*Tsuga canadensis*) are the dominant trees, but American beech (*Fagus grandifolia*) and patches of sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), and red oak (*Quercus rubra*) contribute to a variable species mix of this forest type. The understory contains small trees and shrubs such as witch hazel (*Hamamelis virginiana*), maple-leaved viburnum (*Viburnum acerifolium*), black birch (*Betula nigra*), black cherry (*Prunus serotina*), and ironwood (*Ostrya virginiana*). Typical plants found on the forest floor include starflower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadensis*), and wild sarsaparilla (*Aralia nudicaulis*).

Most white pine stands that have grown up from abandoned pastures are examples of this type of hemlock-hardwood pine forest habitat. On fertile soils, white pine is replaced by hemlock or hardwoods over time. Older forests that have succeeded to later stages contain patches of larger diameter trees (>18 inches) hemlock or beech in the canopy, layers of young trees and shrubs in the understory, many standing dead trees, and abundant decaying wood on the forest floor. Large-sized cavity trees, pockets of wetlands, patches of acorn-rich oaks, seeps, and tall pine trees make some patches of this forest type especially rich for wildlife (NHDFG 2015; Swain 2020).

Appalachian Oak-Pine Forest

Appalachian oak-pine forests, with their abundance of nut-bearing oaks such as red oak, white oak (*Quercus alba*), and black oak (*Q. velutina*), and hickories such as shagbark (*Carya ovata*), pignut (*C. glabra*), and sweet pignut (*C. ovalis*), provide a rich food source for wildlife such as ruffed grouse (*Bonasa umbellus*), turkey (*Meleagris gallopavo*), gray squirrels (*Sciurus carolinensis*), and eastern chipmunks (*Tamias striatus*). Common understory shrubs and smaller trees of this forest type include black birch (*Betula lenta*), bigtooth aspen (*Populus grandidentata*), sassafras (*Sassafras albidum*), and yellow birch (*Betula alleghaniensis*). Blueberries (*Vaccinium angustifolium* and *V. pallidum*), black huckleberry (*Gaylussacia baccata*), sheep laurel (*Kalmia angustifolia*), and Pennsylvania sedge (*Carex pennsylvanica*), are typical understory plants. Raptors such as northern goshawk (*Accipiter gentilis*) feed on small mammals and find nesting and perching sites in white pines in the tree canopy. White pines adjacent to the Merrimack River provide key nest and perch sites for bald eagles (*Haliaeetus leucocephalus*), great blue herons (*Ardea herodias*), and osprey (*Pandion haliaetus*) (NHDFG 2015).

Many stands of Appalachian oak-pine forest are of the same age, approximately 80-100 years. They grew after farms were abandoned throughout the last century. Many wildlife species found in this forest type are attracted to patches of old or young trees within the larger forested landscape. Historically, the dry soils and warm temperatures in this region allowed occasional low-intensity fires to burn in these forests. Without fire, these forests have a higher proportion of white pine, hemlock, sugar maple and birch species (*Betula* spp.), than nut-bearing trees. Mature Appalachian oak-pine forests may also be denser due to a lack of low ground fires to maintain an open understory (NHDFG 2015).

Grasslands

The most common grassland habitats in the lower Merrimack River corridor are agricultural fields such as hayfields, pastures, and fallow fields. Grassland vegetation is a mixture of grass species, or a combination of grasses, sedges, and wildflowers. Most plants found in grasslands are non-native grasses, introduced for agricultural use. These include timothy (*Phleum pretense*), Kentucky bluegrass (*Poa pratensis*), orchard grass (*Dactylis glomerata*), and perennial ryegrass (*Lolium perenne*). Common native plants include big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), and a variety of species of the wildflower genera including goldenrod species (*Solidago* spp.) and various Aster. Vegetation growing in grassland habitat ranges from less than 6 inches to over four feet in height. Vegetation height plays an important role in determining which wildlife species will use it. Few, if any, trees or shrubs are found in grasslands. Unless maintained, most grasslands will return to forest habitat (NHDFG 2015).

Major-River Floodplain Forest

The immediate shoreline of the Merrimack River and some portions of the canals within the Project area (e.g., the Pawtucket Canal near the confluence of the Merrimack River) include areas of floodplain forest and some of these areas have characteristics of Major-river Floodplain Forest as described by Swain (2020). Major-river floodplain forests are deciduous forested wetland communities, which develop next to rivers and streams and receive annual (or semi-annual) overbank flooding and alluvial silt deposition. Soils are predominantly sandy loams without soil mottles and without a surface organic layer. Flooding at these sites occurs annually and can be severe. An island variant of Major-river Floodplain Forests occurs on elevated sections of riverine islands and riverbanks of major rivers, where there are high levels of both natural and human disturbance. All floodplain forest communities in Massachusetts have silver maple (*Acer saccharinum*) as the defining tree, but associated plant species vary depending on the intensity and duration of the flooding and on geographic location. Common plant species occurring with silver maple include cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), and/or slippery elm (*U. rubra*) in the subcanopy and shrubs are generally lacking. The herbaceous layer is usually dominated by a 3-6 ft. (1-2 m) tall, dense cover of wood-nettles (*Laportea canadensis*) and ostrich fern (*Matteuccia struthiopteris*) is sometimes abundant (Swain 2020). Other species growing along the upland margins include tree of heaven (*Ailanthus altissima*), staghorn sumac (*Rhus typhina*), the non-native bittersweet (*Celastrus orbiculatus*), riverbank grape (*Vitis riparia*), Virginia creeper (*Parthenocissus quinquefolia*), scattered Siberian elm (*Ulmus pumila*), purple loosestrife (*Lythrum salicaria*), poison ivy (*Toxicodendron radicans*), Boston ivy (*Parthenocissus tricuspidata*), mullein (*Verbascum thapsus*), and common ragweed (*Ambrosia artemisiifolia*) (HDR 2021a).

Ruderal Herbaceous/Scrub-Shrub/Forested

Ruderal Herbaceous/Scrub-Shrub/Forested areas in the Project vicinity are largely anthropogenic communities of herbaceous or mixed scrub-shrub and forested vegetation resulting from succession following complete or partial removal of native woody cover.

These communities are found in areas where the native forest vegetation has been cleared or partially cleared, in old fields, hedgerows, pedestrian walkways, along Project canals, roadways, etc. Characteristic species can include red maple, American elm, Siberian elm, bush honeysuckles (*Lonicera* spp.), tree of heaven, Boston ivy, poison ivy, goldenrods (*Solidago* spp.), and various grass species (HDR 2021a).

2019 Visual Survey for Vegetation Growth

In September 2019, a visual survey was conducted to identify vegetation growth along the canal walls within the Project area. A wide variety of vegetation types, occurrences, and distribution, ranging from herbaceous, non-woody plants to forested areas of trees and underbrush, and shoreline/canal types, ranging from earthen embankments to placed, uniformly sized blocks were observed during the study. In total, 96 Vegetation Polygons (representing 80% of the total survey data collected in the study area) and 24 VPs (representing 20% of the total survey data collected in the study area) were mapped between September 25 and September 27, 2019. As shown in Table E.7-25, the total study area encompassed approximately 44 acres and mapped vegetation on/along canal walls accounted for approximately 5 acres (11%) of the study area[22]. The Pawtucket Canal (19.63 acres; 44% of the total study area), Northern Canal (11.67 acres; 26% of the total study area), and Western Canal (5.51 acres; 13% of the total study area) represent more than 80 percent of the total study area (Table E.7-25).

At the time of the study, most mapped VPs within the total study area had a dominant vegetation type of Scrub-Shrub (46% of the total VP count), followed closely by Trees (38% of the total VP count). The majority of mapped Vegetation Polygons within the total study area had a dominant vegetation type of Mixed (41% of the total mapped vegetation area) at the time of the study. Mapped vegetation polygons with a dominant vegetation type of Forested were only recorded within the Western Canal (53% of the Western Canal study area), and the Northern Canal (28% of the Northern Canal study area) at the time of the study (HDR 2021a).

Maps showing the results of the vegetation assessment and mapping within the study area are illustrated in a 21-sheet, 11 by 17-inch vegetation type map set with numbered polygons (e.g., 1, 2) and VPs (e.g., VP1, VP2) for each vegetation polygon and/or VP, respectively in Appendix G of the Recreation and Aesthetics Study Report (HDR 2021a). Additionally, results from the canal wall vegetation mapping are compiled in Appendix H and field reconnaissance data is summarized in Appendix I of the Recreation and Aesthetics Study Report.

[22] VPs are not included in mapped vegetation acreage calculations because they represent a single point(s) on a canal wall.

Table E.7-25. Percent total acreage and mapped vegetation acreage of the six major canals associated with the Lowell Project Canal system

Canal	Area (acres)	Percentage (%) of Total Study Area	Mapped Vegetation Area (acres)	Percentage (%) of Total Study Area with Mapped Vegetation
Eastern Canal	4.03	9%	0.93	2%
Hamilton Canal	2.01	5%	0.35	1%
Merrimack Canal	1.40	3%	0.38	1%
Northern Canal	11.67	26%	0.89	2%
Pawtucket Canal	19.63	44%	1.33	3%
Western Canal	5.51	13%	0.90	2%
Total	**44.25**	**100%**	**4.78**	**11%**

Source: HDR 2021a

E.7.4.1.3 Invasive Plant Species

Invasive species are defined as non-indigenous plant or animal species that aggressively compete with native species. These species often out-compete local native species, impacting biodiversity, recreation, and human health. Invasive plants tend to appear on disturbed ground, and the most aggressive have the ability to invade existing ecosystems.

Non-native invasive species and noxious weeds are typically prolific pioneering species that have the ability to quickly outcompete native vegetation. These species grow rapidly, mature early, and effectively spread seeds that can survive for significant periods in the soil until site conditions are favorable for growth. Invasive plant species are prevalent throughout the Merrimack River Valley, as indicated by the IPANE (IPANE Undated), and have been observed along the banks of the Merrimack River, the Project's canals, and in some vegetation communities within the Project area. Of the 2,263 plant species in Massachusetts that have been documented as native or naturalized, about 725 (32%) are naturalized. Of these, the Massachusetts Invasive Plant Advisory Group (MIPAG) recognized 69 species as "Invasive," "Likely Invasive," or "Potentially Invasive" (Commonwealth of Massachusetts 2020). In accordance with the Invasive Species Act, HB 1258-FN, the New Hampshire Department of Agriculture, Markets & Food, Division of Plant Industry is the lead state agency responsible for the evaluation, publication and development of rules on invasive plant species for the purpose of protecting the health of native species, the environment, commercial agriculture, forest crop production, or human health in New Hampshire. New Hampshire's Prohibited Invasive Plant Species List identifies 35 species. These invasive species are provided in Table E.7-26 and include non-native species that have spread into native or minimally managed plant systems and can cause economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems.

Table E.7-26. Invasive Plant Species in Massachusetts and Prohibited Invasive Plant Species in New Hampshire

Common Name	Scientific Name	Common Name	Scientific Name
Norway maple	*Acer platanoides*	Creeping jenny	*Lysimachia nummularia*
Sycamore maple	*Acer pseudoplatanus*	Purple loosestrife	*Lythrum salicaria*
Bishop's goutweed	*Aegopodium podagraria*	Variable water-milfoil	*Myriophyllum heterophyllum*
Tree of heaven	*Ailanthus altissima*	European water-milfoil	*Myriophyllum spicatum*
Garlic mustard	*Alliaria petiolata*	Reed canary-grass	*Phalaris arundinacea*
Japanese barberry	*Berberis thunbergii*	Common reed	*Phragmites australis*
Carolina fanwort	*Cabomba caroliniana*	Japanese knotweed	*Polygonum cuspidatum*
Oriental bittersweet	*Celastrus orbiculatus*	Crisped pondweed	*Potamogeton crispus*
Black swallow-wort	*Cynanchum louiseae*	Lesser celandine	*Ranunculus ficaria*
Autumn olive	*Elaeagnus umbellata*	Common buckthorn	*Rhamnus cathartica*
Winged euonymus	*Euonymus alatus*	Black locust	*Robinia pseudoacacia*
Leafy spurge	*Euphorbia esula*	Multiflora rose	*Rosa multiflora*
European buckthorn	*Frangula alnus*	Water-chestnut	*Trapa natans*
Sea or horned poppy	*Glaucium flavum*	European black alder	*Alnus glutinosa*
Dame's rocket	*Hesperis matronalis*	European barberry	*Berberis vulgaris*
Yellow iris	*Iris pseudacorus*	Spotted knapweed	*Centaurea stoebe ssp. micranthos*
Broad-leaved pepperweed	*Lepidium latifolium*	Pale swallow-wort	*Cynanchum rossicum*
Japanese honeysuckle	*Lonicera japonica*	Giant hogweed	*Heracleum mantegazzianum*
Morrow's honeysuckle	*Lonicera morrowii*	Ornamental jewelweed	*Impatiens glandulifera*
Bell's honeysuckle	*Lonicera x bella*	Japanese stilt grass	*Microstegium vimineum*
Amur honeysuckle	*Lonicera maackii*	Blunt-leaved privet	*Ligustrum obtusifolium*
Tartarian honeysuckle	*Lonicera tatarica*	Common privet	*Ligustrum vulgare*
Mile-a-minute weed	*Persicaria perfoliata*	Bohemia knotweed	*Reynoutria x bohemica*
Kudzu	*Pueraria montana*	Reed sweet grass	*Glyceria maxima*
Giant knotweed	*Reynoutria sachalinensis*	--	--

Sources: Commonwealth of Massachusetts 2020; New Hampshire Department of Agriculture, Markets & Food, Division of Plant Industry 2017; IPANE Undated

As part of the 2019 and 2020 relicensing studies, ten plant species, which are designated as invasive or prohibited species (Commonwealth of Massachusetts 2020; New Hampshire Department of Agriculture, Markets & Food, Division of Plant Industry 2017), were incidentally observed in the Project's vicinity:

- Tree of heaven
- Japanese barberry
- Japanese knotweed
- Oriental bittersweet
- Autumn olive
- Winged euonymus
- Japanese honeysuckle
- Purple loosestrife
- Common buckthorn, and
- Black locust

E.7.4.1.4 Wetland, Riparian, and Littoral Habitats

Wetlands are generally defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Most formal wetland definitions emphasize three primary components that define wetlands: the presence of water, unique soils, and hydrophytic vegetation. The USFWS (Cowardin et al. 1979) defines wetlands as follows:

> *…lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have been one or more of the following three attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some point during the growing season of the year.*

Riparian habitats are areas that support vegetation found along waterways such as lakes, reservoirs, rivers, and streams. The boundary of the riparian area and the adjoining uplands is gradual and not always well defined. However, riparian areas differ from the uplands because of their high levels of soil moisture, frequency of flooding, and unique assemblage of plant and animal communities (Virginia State University 2000). These habitats can range from mature forests to areas covered by emergent vegetation and shrubs. Riparian habitats are unique because of their linear form and because they process large fluxes of energy and materials from upstream systems (Mitsch and Gosselink 1993). Riparian areas and the associated vegetation provide important habitat for wildlife and often contain a higher number of species, both plant and animal, than surrounding upland areas due to the proximity to water. These areas are also important avian habitats for resident and migratory birds. Riparian habitats typically function as travel corridors for migratory wildlife species. The riparian zone serves as the primary interface between riverine and upland habitats, influencing both the primary productivity and food resources within a river. Primary wildlife resources associated with riparian habitats include early spring plant growth in lowland riparian habitats, which provide food sources for migrating birds, white-tailed deer, and other wildlife species.

The USFWS, MADEP, and the NHDES have jurisdiction over wetlands within the Project area. The MADEP's and NHDES's wetland definition is consistent with the USFWS' wetland definition.

Terrestrial habitat conditions in the Project area and upstream along the Merrimack River are largely a result of land use, especially of urban and suburban development (Boott Mills 1980). Based on USFWS National Wetland Inventory (NWI) mapping, wetlands along the Merrimack River primarily consist of low-lying areas near and adjacent to the river, with other isolated wetlands farther away from the river proper. The USEPA has designated the Merrimack River from Franklin, New Hampshire, to Lowell, Massachusetts, as a Priority Waterbody/Wetland due to its importance to waterfowl and fish populations (Carley 2001 as cited in USACE 2003).

There are MADEP and NHDES wetlands and NWI wetlands encompassed within, adjacent to, or in close proximity to the Project boundary. Most of the MADEP, NHDES, and NWI mapped wetland boundaries overlay each other[23]. Within the current Project boundary there are approximately 739.2 acres of MADEP wetland, approximately 6.4 acres of NHDES wetland, and approximately 1,659 acres of NWI wetlands. The 745.6 acres of MADEP and NHDES wetlands are mostly encompassed within the 1,659 acres of NWI wetlands (MassGIS 2018; NH GRANIT undated).

Wetlands currently mapped by the USFWS NWI within the proposed Project boundary are presented in Figure E.7-23 through Figure E.7-24 and are summarized in Table E.7-27. Table E.7-27 provides acreages mapping code descriptions for the NWI codes found on the wetland base maps within proposed Project boundary (USFWS 2020a). The wetlands directly surrounding the Lowell Project are largely considered riverine wetlands with an unconsolidated bottom (Figure E.7-23 through Figure E.7-24). Riverine wetlands include all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 parts per thousand (or greater (Cowardin et al. 1979).

According to a review of GIS data (Massachusetts Bureau of Geographic Information [MassGIS]), there are no Massachusetts Natural Heritage and Endangered Species Program certified vernal pools within the Project boundary. Potential vernal pools were also identified using GIS data. According to MassGIS (2018), two potential vernal pools are located within 100 feet of the Project boundary, but not within the Project boundary.

No formal survey data on wetlands at or near the Project is available. However, based on observations made during the Recreation and Aesthetics Study, as well as during other relicensing studies, riparian vegetation within the Project area appears to be consistent with these areas of New Hampshire and Massachusetts. Where steep banks present themselves, the riparian corridor is narrow with wetland vegetation only occurring immediately adjacent to the river/land interface. Where the shoreline is more gradual and

[23] The NHDES wetland data GIS layer only included data for the Palustrine System within the Project boundary.

the Merrimack River floodplain extends away from the current river course, palustrine wetlands cover areas of former oxbows, floodplain, and low-lying areas.

Massachusetts floodplain communities are typically dominated by river birch (*Betula nigra*) associations (USACE 2003). Development activity is contributing to the decline of these riparian communities in Massachusetts (Carley 2001 as cited in USACE 2003). The palustrine forested wetland habitats located within and adjacent to the Project boundary are primarily dominated by broad-leaved deciduous subclasses located along forested floodplains. These areas are characterized by their flood regime; lower areas are annually flooded in spring, whereas higher areas are flooded irregularly. Common trees include silver maple, red maple, green ash (*Fraxinus pennsylvanica*), and American elm. The shrub layer may include silky dogwood (*Cornus amomum*) and buttonbush (*Cephalanthus occidentalis*). Common herbaceous species may include sensitive fern (*Onoclea sensibilis*), false nettle (*Boehmeria cylindrica*), water hemlock (*Cicuta maculata*), swamp candles (*Lysimachia terrestris*), and water parsnip (*Sium suave*) (Swain 2020).

Figure E.7-23. Wetlands in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary

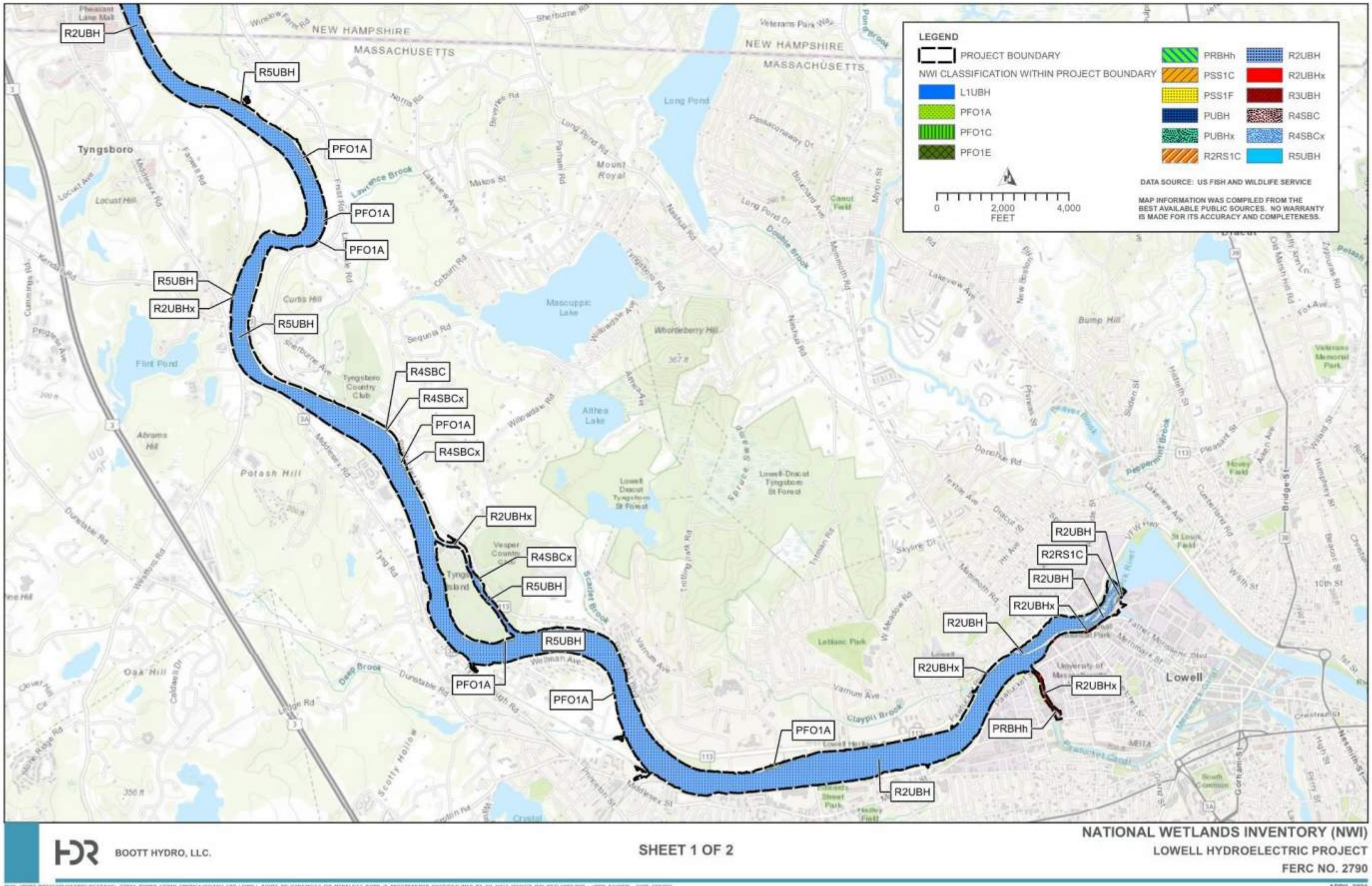

Figure E.7-24. Wetlands in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary

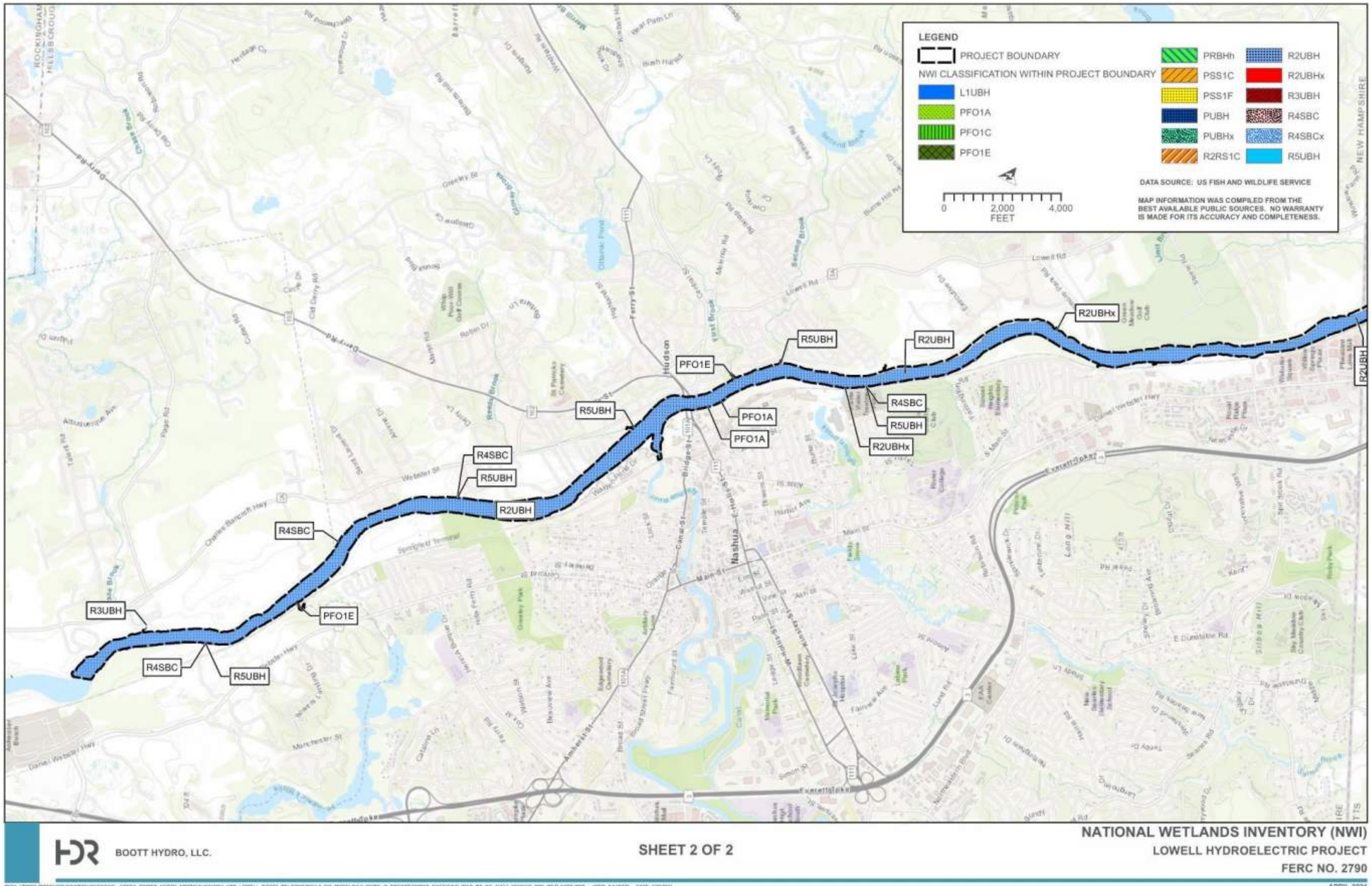

Table E.7-27. NWI Wetlands Within the Proposed Project Boundary

Wetlands Code	System	Subsystem	Class	Subclass	Water Regime	Qualifier	Acres
R2UBH	Riverine	Lower Perennial	Unconsolidated Bottom	--	Permanently Flooded	--	1147.42
R2UBHx	Riverine	Lower Perennial	Unconsolidated Bottom	--	Permanently Flooded	Excavated	5.59
R3UBH	Riverine	Upper Perennial	Unconsolidated Bottom	--	Permanently Flooded	--	0.01
R2RS1C	Riverine	Lower Perennial	Rocky Shore	Bedrock	Seasonally Flooded	--	5.60
R4SBC	Riverine	Intermittent	Streambed	--	Seasonally Flooded	--	0.02
R4SBCx	Riverine	Intermittent	Streambed	--	Seasonally Flooded	Excavated	0.10
R5UBH	Riverine	Unknown Perennial	Unconsolidated Bottom	--	Permanently Flooded	--	0.56
PFO1A	Palustrine	--	Forested	Broad-leaved Deciduous	Temporarily Flooded	--	2.61
PFO1E	Palustrine	--	Forested	Broad-leaved Deciduous	Seasonally Flooded/ Saturated	--	0.38
PRBHh	Palustrine	--	Rock Bottom	--	Permanently Flooded	Diked/ Impounded	0.12

Source: USFWS 2020a.

E.7.4.1.5 Wildlife

The Merrimack River corridor provides habitat for a diversity of wildlife species. Diverse habitats such as wetlands, forests, fields, as well as the river and associated tributaries support a variety of species. The quality and types of habitat that the Merrimack River corridor provides is what dictates which wildlife species occupy and use it. The Merrimack River mainstem is categorized as a large/great river habitat (Olivero and Anderson 2008). Large river habitats such as the Merrimack River support a diverse wildlife community which includes many of the mammalian, reptilian, and amphibian species found in northeastern North America.

Mammals

Mammals present in the vicinity of the Lowell Project are those commonly found throughout the region that are adapted to living near humans and urban areas. Some large mammal species that require extensive habitat areas, or species that require solitude, such as moose (*Alces alces*) and black bear (*Ursus americanus*), typically prefer less developed environments that are scarce in the lower Merrimack River corridor and the Lowell Project. White-tailed deer (*Odocoileus virginianus*) is the most common big game species in the Project vicinity, occurring in a wide variety of habitats ranging from forests to agricultural land. This species is most prevalent along forest edges characterized by brushy and woody vegetation, swamp borders, and areas interspersed with fields and woodland openings (DeGraaf and Yamasaki 2001; Doutt et al. 1977). Raccoon (*Procyon lotor*) are also common, especially along the riparian corridor associated with the Merrimack River within the Project vicinity. Other mammals present in the Project vicinity include furbearers, small game species, rodents, and bats. These wildlife species reside in many different habitat types such as woodland, scrub-shrub or early successional areas, and grassland areas; use of these areas may shift during different life stages and/or times or year (DeGraaf and Yamasaki 2001; Doutt et al. 1977).

Mammals typically found in woodland and riparian areas include northern raccoon, long-tailed weasel (*Mustela frenata*), eastern gray squirrel (*Sciurus carolinensis*), American mink (*Mustela vison*), and marten (*Martes martes*). Bat species may include the red bat (*Lasiurus borealis*), silver haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), and little brown bat (*Myotis lucifugus*). These mammals are normally found in woodland/riparian areas due to food requirements, predator/prey relationships, and a preference by several species for trees as den or nest sites (DeGraaf and Yamasaki 2001; Doutt et al. 1977).

Mammals typically found in grassland areas include the meadow vole (*Microtus pennsylvanicus*), house mouse (*Mus musculus*), and the deer mouse (*Peromyscus maniculatus*). Several species of bats also are likely to use these areas or manmade structures within these areas of the Project vicinity. Additionally, several species typical of grassland mammals can be found in multiple habitat types due to their generalized requirements. Coyotes, for example, use woodlands, wetlands, and grasslands in addition to scrub-shrub areas for foraging, dens, and travel corridors (DeGraaf and Yamasaki 2001; Doutt et al. 1977). Table E.7-28 lists the mammalian species potentially occurring in the vicinity of the Lowell Project. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-28. Mammalian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Beaver	*Castor canadensis*
Big brown bat	*Eptesicus fuscus*
Black bear	*Ursus americanus*
Black rat	*Rattus rattus*
Bobcat	*Lynx rufus*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Eastern chipmunk*	*Tamias striatus*

Common Name	Scientific Name
Eastern red bat	*Lasiurus borealis*
Ermine	*Mustela ermina*
Fisher	*Pekania pennanti*
Gray fox	*Urcyon cinereoargenteus*
Gray squirrel*	*Sciurus carolinensis*
Hairy-tailed mole	*Parascalops breweri*
Hoary bat	*Lasiurus cinereus*
House mouse*	*Mus musculus*
Little brown bat	*Myotis lucifugus*
Long-tail weasel	*Mustela frenata*
Long-tailed shrew	*Sorex dispar*
Masked shrew	*Sorex cinereus*
Meadow jumping mouse	*Zapus hudsonicus*
Meadow vole	*Microtus pennsylvanicus*
Mink	*Mustela vison*
Moose*~	*Alces alces*
Muskrat	*Ondatra zibethicus*
Northern flying squirrel	*Glaucomys sabrinus*
Northern short-tailed shrew	*Blarina brevicauda*
Norway rat	*Rattus norvegicus*
Porcupine	*Erethizon dorsatum*
Pygmy shrew	*Sorex hoyi*
Raccoon*	*Procyon lotor*
Red fox	*Vulpes vulpes*
Red squirrel*	*Tamiasciurus hudsonicus*
River otter	*Lontra canadensis*
Silver-haired bat	*Lasionycteris noctivagans*

Common Name	Scientific Name
Small-footed bat	*Myotis leibii*
Smoky shrew	*Sorex fumeus*
Snowshoe hare	*Lepus americanus*
Southern bog lemming	*Synaptomys cooperi*
Southern flying squirrel	*Glaucamys volans*
Southern red-backed vole	*Clethrionomys gapperi*
Star-nosed mole	*Condylura cristata*
Striped skunk	*Mephitis mephitis*
Tricolored bat	*Perimyotis subflavus*
Virginia opossum	*Didelphis virginiana*
Water Shrew	*Sorex palustris*
White-footed mouse	*Peronyscus leucopus*
White-tailed deer	*Odocoileus virginianus*
Woodchuck*	*Marmota monax*
Woodland jumping mouse	*Napaeozapus insignis*
Woodland vole	*Microtus pinetorum*

Sources: NHDFG 2015; DeGraaf and Yamasaki 2001.
Note: ~ A moose was tranquilized and relocated by Massachusetts Environmental Police officers from the Northern Canal on June 11, 2020 (CBS Boston News Undated).

Avifauna

The diversity of habitats in the Lowell Project and lower Merrimack River corridor provide breeding, migratory stopover, and wintering habitat for a high diversity of avifauna including neotropical songbirds, resident species, waterbirds, and waterfowl. Species such as the black capped chickadee (*Poecile atricapillus*), blue jay (*Cyanocitta cristata*), and northern flicker (*Colaptes auratus*), and an assortment of woodpeckers occur within the wooded areas of the Project vicinity. Birds that inhabit non-forested areas within the Project's area include American robin (*Turdus migratorius*) and mourning dove (*Zenaida macroura*). The Merrimack River corridor, including the Project's impoundment and adjacent wetlands, attracts a variety of waterfowl. Four species of waterfowl were observed throughout the area while conducting various relicensing studies associated with the Project: Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), black duck (*Anas rubripes*), and double-crested cormorant (*Phalacrocorax auritus*). Double-crested cormorants were observed on several occasions within the bypass reach as well as in the vicinity of the Pawtucket Dam. Mallards were also seen along the Project canals as well at the confluence of the Pawtucket Canal and Merrimack River.

The ruderal herbaceous/scrub-shrub/forested areas in the Project vicinity are typically utilized by common species that are adapted to a variety of habitat types and are tolerant of human disturbance (i.e., generalist species). Common species of these habitats include rock pigeon (*Columba livia*), mourning dove, blue jay, common crow (*Corvus brachyrhynchos*), black-capped chickadee, northern cardinal (*Cardinalis cardinalis*), chipping sparrow (*Spizella passerina*), tree sparrow (*S. arborea*), mockingbird (*Mimus polyglottos*), starling (*Sturnus vulgaris*), and house finch (*Carpodacus mexicanus*) (DeGraaf and Yamasaki 2001). Incidental species observations, documented by environmental scientists during site visits conducted during 2019 and 2020 relicensing studies, supports this.

Great egret (*Ardea alba*) and great blue heron (*Ardea herodias*) observations were noted while conducting various relicensing studies associated with the Project. These species were usually noted feeding in the bypass reach or flying in the general vicinity of the E.L. Field Powerhouse. Table E.7-29 lists bird species potentially occurring in the vicinity of the Lowell Project. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-29. Avian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Alder flycatcher	*Empidonax alnorum*
American bittern	*Botaurus lentiginosus*
American black duck*	*Anas rubripes*
American coot	*Fulica americana*
American crow*	*Corvus brachyrhynchos*
American goldfinch*	*Carduelis tristis*
American kestrel	*Falco sparverius*
American redstart	*Setophaga ruticilla*
American robin*	*Turdus migratorius*
American woodcock	*Scolopax minor*
Bald eagle	*Haliaeetus leucocephalus*
Baltimore oriole	*Icterus galbula*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Megaceryle alcyon*
Black-billed cuckoo	*Coccyzus erythropthalmus*

Common Name	Scientific Name
Blackburnian Warbler	*Dendroica fusca*
Black-capped chickadee*	*Poecile atricapillus*
Black-throated Blue Warbler	*Dendroica caerulescens*
Black-crowned night heron	*Nycticorax nycticorax*
Black-throated Green Warbler	*Dendroica virens*
Blue jay*	*Cyanocitta cristata*
Blue-gray gnatcatcher	*Polioptila caerulea*
Blue-headed Vireo	*Vireo solitarius*
Bobolink	*Dolichonyx oryzivorus*
Broad-winged hawk	*Buteo platypterus*
Brown creeper	*Certhia americana*
Brown-headed cowbird	*Molothrus ater*
Brown thrasher	*Toxostoma rufum*
Bufflehead	*Bucephala albeola*
Canada goose*	*Branta canadensis*
Canvasback	*Aythya valisineria*
Carolina Wren	*Thryothorus ludovicianus*
Cedar waxwing	*Bombycilla cedrorum*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Chimney Swift	*Chaetura pelagica*
Chipping Sparrow*	*Spizella passerina*
Common goldeneye	*Bucephala clangula*
Common grackle	*Quiscalus quiscula*
Common Merganser	*Mergus merganser*
Common nighthawk	*Chordeiles minor*
Common raven	*Corvus corax*
Common redpoll	*Acanthis flammea*
Common Yellowthroat	*Geothlypis trichas*

Common Name	Scientific Name
Cooper's hawk	*Accipiter cooperii*
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant*	*Phalacrocorax auritus*
Downy Woodpecker	*Picoides pubescens*
Eastern Bluebird	*Sialia sialis*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern phoebe	*Sayornis phoebe*
Eastern screech owl	*Megascops asio*
Eastern Wood-Pewee	*Contopus virens*
European Starling*	*Sturnus vulgaris*
Evening grosbeak	*Coccothraustes vespertinus*
Field sparrow	*Spizella pusilla*
Gadwall	*Mareca strepera*
Golden-crowned kinglet	*Regulus satrapa*
Golden eagle	*Aquila chrysaetos*
Gray catbird	*Dumetella carolinensis*
Great blue heron*	*Ardea herodias*
Greater scaup	*Aythya marila*
Great crested flycatcher	*Myiarchus crinitus*
Great horned owl	*Bubo virginianus*
Great egret*	*Ardea alba*
Green heron	*Butorides virescens*
Hairy Woodpecker	*Picoides villosus*
Hermit thrush	*Catharus guttatus*
Herring gull	*Larus argentatus*
Horned grebe	*Podiceps auritus*
House finch*	*Carpodacus mexicanus*
House sparrow*	*Passer domesticus*

Common Name	Scientific Name
House Wren	*Troglodytes aedon*
Indigo Bunting	*Passerina cyanea*
Killdeer	*Charadrius vociferus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Long-eared owl	*Asio otus*
Louisiana Waterthrush	*Seiurus motacilla*
Magnolia Warbler	*Dendroica magnolia*
Mallard*	*Anas platyrhynchos*
Mockingbird*	*Mimus polyglottos*
Mourning dove*	*Zenaida macroura*
Mourning warbler	*Oporornis philadelphia*
Northern cardinal*	*Cardinalis cardinalis*
Northern flicker*	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Northern parula	*Setophaga americana*
Northern saw-whet owl	*Aegolius acadicus*
Northern shrike	*Lanius borealis*
Northern shoveler	*Spatula clypeata*
Northern waterthrush	*Seiurus noveboracensis*
Olive-sided flycatcher	*Contopus cooperi*
Orchard oriole	*Icterus spurius*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapilla*
Pied-billed grebe	*Pied-billed grebe*
Pileated woodpecker	*Dryocopus pileatus*
Pine siskin	*Spinus pinus*
Purple finch	*Carpodacus purpureus*

Common Name	Scientific Name
Red-bellied woodpecker	*Melanerpes carolinus*
Red-breasted nuthatch	*Sitta canadensis*
Red crossbill	*Loxia curvirostra*
Red-eyed vireo	*Vireo olivaceus*
Redhead	*Aythya americana*
Red-shouldered hawk	*Buteo lineatus*
Red-tailed hawk*	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Ring-necked duck	*Aythya collaris*
Rock pigeon*	*Columba livia*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Ruby-crowned kinglet	*Regulus calendula*
Ruby-throated hummingbird	*Archilochus colubris*
Ruddy duck	*Oxyura jamaicensis*
Ruffed grouse	*Bonasa umbellus*
Sandhill crane	*Antigone canadensis*
Savannah sparrow	*Passerculus sandwichensis*
Scarlet tanager	*Piranga olivacea*
Sharp-shinned hawk	*Accipiter striatus*
Short-eared owl	*Asio flammeus*
Snow bunting	*Plectrophenax nivalis*
Snow goose	*Anser caerulescens*
Snowy owl	*Bubo scandiacus*
Song sparrow	*Melospiza melodia*
Sora	*Porzana carolina*
Spotted sandpiper	*Actitis macularius*
Swainson's thrush	*Catharus ustulatus*

Common Name	Scientific Name
Swamp sparrow	*Melospiza georgiana*
Tree sparrow*	*Spizella arborea*
Tree swallow	*Tachycineta bicolor*
Tufted titmouse	*Baeolophus bicolor*
Turkey vulture	*Cathartes aura*
Veery	*Catharus fuscescens*
Virginia rail	*Rallus limicola*
Warbling vireo	*Vireo gilvus*
White-breasted nuthatch*	*Sitta carolinensis*
White-winged crossbill	*Loxia leucoptera*
Wild turkey	*Meleagris gallopavo*
Wilson's warbler	*Cardellina pusilla*
Willow flycatcher	*Empidonax traillii*
Wood duck	*Aix sponsa*
Wood thrush	*Hylocichla mustelina*
Yellow warbler	*Dendroica petechia*
Yellow-bellied flycatcher	*Empidonaz flaviventris*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-rumped warbler	*Dendroica coronata*
Yellow-throated vireo	*Vireo flavifrons*

Sources: NHDFG 2015; DeGraaf and Yamasaki 2001.
* Species observed during field studies performed at the Project.

Amphibians and Reptiles

Amphibians and reptiles are common and well represented in the Project vicinity. However, only three amphibian species were observed throughout the area while conducting various relicensing studies associated with the Project (Table E.7-30). Species typically found in wetland and open water areas include green frog (*Lithobates clamitans*), bullfrog (*L. catesbeianus*), northern spring peeper (*Pseudacris crucifer*), and the northern water snake (*Nerodia sipedon sipedon*) (DeGraaf and Rudis 1983; Tyning

1990

; Hunter et al. 1999). These amphibians and reptiles are normally found in wetland and open water areas due to food and reproductive requirements.

Species typically found in woodland areas include: spotted salamander (*Ambystoma maculatum*), eastern newt (*Notophthalmus viridescens*), American toad (*Anaxyrus americanus*), gray treefrog (*Hyla versicolor*), wood frog (*Lithobates sylvaticus*), and the northern two-lined salamander (*Eurycea bislineata*) (DeGraaf and Rudis 1983; Tyning 1990; Hunter et al. 1999). These amphibians are normally found in woodland areas due to food and reproductive requirements. A list of herptile species observed, that may occur, or may utilize habitat in the vicinity of the Project is included in Table E.7-30. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-30. List of Herptile Species Observed or Anticipated to Occur in the Project Vicinity

Common Name	Scientific Name
Amphibians	
American toad*	*Anaxyrus americana*
Blue-spotted salamander	*Ambystoma laterale*
Bullfrog*	*Lithobates catesbeiana*
Dusky salamander	*Desmognathus fuscus*
Eastern spadefoot	*Scaphiopus holbrookii*
Four-toed salamander	*Hemidactylium scutatum*
Fowler's toad	*Anaxyrus fowleri*
Gray treefrog	*Hyla versicolor*
Green frog*	*Lithobates clamitans melanota*
Marbled salamander	*Ambystoma opacum*
Northern leopard frog	*Lithobates pipiens*
Northern spring salamander	*Gyrinophilus porphyriticus*
Pickerel frog	*Lithobates palustris*
Redback salamander	*Plethodon cinereus*
Red-spotted newt	*Notophthalmus viridescens*
Spotted salamander	*Ambystoma maculatum*
Spring peeper	*Pseudacris crucifer*
Two-lined salamander	*Eurycea bislineata*

Common Name	Scientific Name
Wood frog	*Lithobates sylvatica*
Reptiles	
Black racer	*Coluber constrictor*
Bog turtle	*Glyptemys muhlenbergii*
Blanding's turtle	*Emydoidea blandingii*
Brown snake	*Storeria dekayi*
Common garter snake	*Thamnophis sirtalis*
Common musk turtle	*Sternotherus odoratus*
Eastern box turtle	*Terrapene carolina*
Eastern gartersnake	*Thamnophis sirtalis*
Eastern hognose snake	*Heterodon platirhinos*
Eastern ratsnake	*Pantherophis alleghaniensis*
Milk snake	*Lampropeltis triangulum*
Northern water snake	*Nerodia sipedon*
Painted turtle	*Chrysemys picta*
Red-bellied snake	*Storeria occipitomaculata*
Ribbon snake	*Thamnophis sauritus*
Ringneck snake	*Diadophis punctatus*
Smooth green snake	*Liochlorophis vernalis*
Snapping turtle	*Chelydra serpentina*
Spotted turtle	*Clemmys guttata*
Wood turtle	*Glyptemys insculpta*

Source: NHDFG 2015; DeGraaf and Rudis 1983; Jackson et al. 2010.
* Species observed during field studies performed at the Project.

E.7.4.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on terrestrial resources as potential resource issues. Specifically, SD2 identified the following potential resource issues related to terrestrial resources to be analyzed for site-specific effects:

- Effects of continued project operation on riparian, littoral, and wetland habitat and associated wildlife.
- Effects of continued project operation, including maintenance activities (e.g., vegetation management) on wildlife habitat and associated wildlife.
- Effects of continued project operation and maintenance on the introduction and persistence of invasive plants within the Project boundary.

E.7.4.2.1 Effects of Continued Project Operation on Riparian, Littoral, and Wetland Habitat and Associated Wildlife

The types of wetlands bordering the Project generally reflect the expectations for the natural community in this area. The Project operates in ROR mode, and experiences seasonal and annual variations in flows based on natural hydrologic conditions in the Merrimack River Basin. Boott also proposes to continue to adhere to the requirements of the Project's existing Crest Gate Operation Plan, which provides for a stable impoundment level maintained over a wide range of flows. Therefore, the proposed operation of the Project will have negligible effects on the flow regime and wetland and riparian habitats in the Merrimack River.

Additionally, the occurrence and distribution of wildlife resources in the Project area is generally unrelated to Project operations, and Project operations have little potential to impact wildlife resources within and bordering the Project. Since the Licensee is not proposing changes to the existing baseline conditions or changes to the operation of the Project, continued operation of the Project as proposed by the Licensee is not expected to have any adverse effects on wetland, riparian, or littoral habitat or associated wildlife.

E.7.4.2.2 Effects of Continued Project Operation on Wildlife Habitat, Associated Wildlife, and the Introduction and Persistence of Invasive Plants

The operation of the Project has very little, if any, effect on the wildlife habitat or resources within and bordering the Project boundary, and the occurrence and distribution of wildlife resources in the Project area is generally unrelated to Project operations. Boott does however, conduct routine Project maintenance activities. Project maintenance activities are generally localized and minor in nature.

Many types of land uses contribute to the invasion and spread of non-native invasive species, including ground-disturbing activities and activities that promote the dispersal of weed seed. Roads, rivers, streams, agriculture, farming/ranching, recreation, residential, and commercial developments all contribute to the spread of invasive species.

Continued Project operations are not expected to contribute to the spread of invasive species. As noted above, the botanical resources located within the Project boundary have developed under the current operating regime and are generally stable, mature, and well established. Boott's routine vegetation management practices typically involve mechanical vegetation removal around Project facilities and the clearing of hazard trees as necessary. Boott is not proposing to conduct additional ground-disturbing activities such as road construction or land-clearing that would facilitate the spread of invasive botanical species within the Project boundary. The continued operation and maintenance of the Project as proposed by the Licensee is not expected to have any adverse effects on the wildlife habitat and associated wildlife, or the introduction and persistence of invasive plants within the Project boundary.

E.7.4.2.3 Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

Boott does not anticipate that the proposed decommissioning of the downtown powerhouses will have any effect on terrestrial resources. The downtown powerhouses are generally located in an urban area that does not provide significant habitat for terrestrial plant or wildlife species. Boott is proposing to decommission the existing powerhouses without demolishing the structures or undertaking land-clearing activities. Accordingly, Boott's proposal will not require any modifications to existing terrestrial habitat in the Project's vicinity.

E.7.4.3 Proposed Environmental Measures

Boott proposes to continue operations of the Project with certain PM&E as outlined above in Section E.6.2. Boott has proposed to develop a plan for decommissioning the downtown powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

E.7.4.4 Unavoidable Adverse Impacts

Continued operation of the Project as proposed by the Licensee will not result in any unavoidable adverse effects on terrestrial botanical or wildlife resources.

E.7.5 Rare, Threatened and Endangered Species

The subsections below describe RTE species in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, and the:

- Fish Assemblage Study (NAI 2021d)
- Downstream American Eel Passage Assessment (NAI 2021a)

These reports are included in Appendix B of this exhibit.

E.7.5.1 Affected Environment

E.7.5.1.1 Federal-listed Species

As part of the environmental evaluation conducted for the Project, the USFWS Information, Planning, and Consultation System (IPaC System) identified a list of species under the USFWS's jurisdiction that are known or expected to be on or near the Project area. Based on a search of the USFWS IPaC system for ESA-listed species, northern long-eared bat (*Myotis septentrionalis*) is ESA-listed as threatened and may occur in the Project area; the habitat requirements and distribution of the species are described below. No ESA-listed aquatic species are identified in the USFWS database as being known or believed to occur in the Project area (USFWS 2020b). In addition to this species, the bald eagle (*Haliaeetus leucocephalus*) is known to occur as a transient in the Project vicinity; this species is protected under the Federal Bald and Golden Eagle Protection Act[24] (and is separately listed by the Commonwealth of Massachusetts and New Hampshire; see below).

Northern long-eared bat

The northern long-eared bat is found across much of eastern and north-central United States, and all Canadian provinces from the Atlantic Ocean west to the southern Yukon Territory and British Columbia (USFWS 2013). It is a medium-sized bat, measuring 3 – 3.7 inches, with a wingspan of 9 or 10 inches. Its fur color can be medium to dark brown on the back and tawny to pale brown on the underside (USFWS 2013). The bat is distinguished by its long ears relative to other bats in the genus Myotis (USFWS 2013). The northern long-eared bat spends winters hibernating in caves and mines, preferring hibernacula with very high humidity. During the summer months, the northern long-eared bat prefers to roost singly or in colonies underneath bark, in cavities, or in the crevices of live or dead trees (USFWS 2013). Breeding begins in late summer or early fall when males swarm near hibernacula. After a delayed fertilization, pregnant females migrate to summer colonies where they roost and give birth to a single pup. Young bats start flying 18 – 21 days after birth, and adult northern long-eared bats can live up to 19 years (USFWS 2013).

Northern long-eared bats emerge at dusk and fly through the understory of forested hillsides feeding on moths, flies, leafhoppers, caddisflies, and beetles. They also feed by gleaning motionless insects from vegetation and water (USFWS 2013).

The most severe and immediate threat to the northern long-eared bat is white-nose syndrome. As a result of this disease, numbers have declined by 99 percent in the northeast. Other significant sources of mortality include impacts to hibernacula from human disturbance. Loss or degradation of summer habitat as a result of highway or commercial development, timber management, surface mining, and wind facility construction and operation can also contribute to mortality (USFWS 2015).

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[24] 16 U.S.C. 668, *et seq.*

No Biological Opinions have been developed by the USFWS for the northern long-eared bat in the Project area. In addition, no status reports or recovery plans were located for this species in the vicinity of the Project.

The USFWS has not designated critical habitat for the northern long-eared bat in the vicinity of the Project.

E.7.5.1.2 State-listed Species

Listings of the applicable state-listed threatened, endangered, and candidate species, as well as species of special concern, candidate species, and communities (RTE species) were obtained by request from map and database information provided by the Massachusetts Natural Heritage and Endangered Species Program (Massachusetts NHESP) and the New Hampshire Natural Heritage Bureau (New Hampshire NHB). In addition, habitat information was provided by the New Hampshire NHB, Massachusetts NHESP, as derived from the New Hampshire NHB's and Massachusetts NHESP's fact sheets, and flora manuals (e.g., Magee and Ahles 1999). Specific to the Project area, the potential presence of RTE species was determined by consulting with the Massachusetts NHESP and the New Hampshire NHB during development of the PAD. Table E.7-31 lists the state-listed species and communities that the Commonwealth of Massachusetts and the State of New Hampshire list as potentially occurring within the Project area and provides habitat requirements information.

Table E.7-31. State-listed threatened, endangered, species of special concern, candidate species, and communities potentially occurring within the Project vicinity.

Scientific Name	Common Name	Status[a,b]	Habitat/Notes
Massachusetts			
Haliaeetus leucocephalus	Bald Eagle	T	Large lakes, rivers; large riparian trees for nesting, roosting (DeGraaf and Yamasaki 2001).
Stylurus amnicola	Riverine Clubtail	E	Riverine clubtails inhabit primarily medium to large rivers. Although most species of *Stylurus* fly late in the season, riverine clubtails are on the wing from late June through mid-August (Massachusetts NHESP 2015).
New Hampshire			
Alasmidonta varicosa	Brook Floater	E	Sections of stream with low to moderate flow and stable substrates (Nedeau et al. 2000).
Anguilla rostrata	American Eel	SC	American eels are opportunistic carnivores, selecting a range of prey items from small aquatic insects and crustaceans to larger macroinvertebrates and fish (Ross et al. 2001). Yellow eels associate with pools or backwater habitats and often have relatively small home ranges (Gunning and Shoop 1962).

Scientific Name	Common Name	Status[a,b]	Habitat/Notes
Haliaeetus leucocephalus	Bald Eagle	SC	Large lakes, rivers; large riparian trees for nesting, roosting (DeGraaf and Yamasaki 2001).
Emydoidea blandingii	Blanding's Turtle	E	Permanent, shallow, dark waters with abundant vegetation; marshes, bogs, ditches, ponds, swamps, also in slow moving rivers and protected coves (DeGraaf and Yamasaki 2001).
Heterodon platirhinos	Eastern Hognose Snake	E	Where sandy soils predominate, such as beaches, open fields, dry, open pine or deciduous woods (DeGraaf and Yamasaki 2001).
Sturnella magna	Eastern Meadowlark	T	Large grassy fields of intermediate height and density but also uses grassy meadows, hay fields, tall-grass prairies, agricultural fields and open weedy orchards (DeGraaf and Yamasaki 2001).
Ammodramus savannarum	Grasshopper Sparrow	T	Generally prefers moderately open grasslands with patchy bare ground: dry hayfields, especially those with alfalfa and red clover, weedy fallow fields, prairies, and coastal dunes in Massachusetts (DeGraaf and Yamasaki 2001).
Sylvilagus transitionalis	New England Cottontail	E	Brushy areas, open woodlands, swamps, mountains, beaches, and open lands (DeGraaf and Yamasaki 2001).
Lithobates pipiens	Northern Leopard Frog	SC	Wet open meadows and fields and wet woods during summer months, including river floodplains (DeGraaf and Yamasaki 2001).
Petromyzon marinus	Sea Lamprey	SC	In fresh water, sea lampreys use river reaches with gravel substrate for spawning. Spawning habitat is similar to that used by salmon, occurring at the upstream end of riffles and the tail end of pools (NHDFG undated *a*).
Porzana carolina	Sora	SC	Prefers freshwater marshes with shallow to intermediate water depths and dominated by emergent vegetation (DeGraaf and Yamasaki 2001).
Pooecetes gramineus	Vesper Sparrow	SC	Sparsley vegetated dry uplands such as short-grass meadows, grazed pastures, hayfields, grain fields, dry open uplands, and burned and cutover areas (DeGraaf and Yamasaki 2001).
Viola pedata var. pedata	Bird-foot Violet	T	This species occurs in sandplains, disturbed openings, dry forests, and thin woods. Threats would include direct destruction of the plants or major alterations in their habitat (Magee and Ahles 1999; New Hampshire NHB 2018).

Scientific Name	Common Name	Status[a,b]	Habitat/Notes
*Cenchrus longispinus**	Long-spined Sandbur	E	This species grows in dry, sandy soil of fields, roadsides, waste areas, beaches, river flats, sandplains, and disturbed openings, and is sensitive to disturbances that eliminate its habitat (Magee and Ahles 1999; New Hampshire NHB 2018).
Betula nigra	River Birch	T	This species grows along rivers and streambanks and the population could be deleteriously affected by any project activities that alter the hydrology of its habitat, by increased sedimentation, and by increased nutrients/pollutants in stormwater runoff (Magee and Ahles 1999; New Hampshire NHB 2018).
Lupinus perennis ssp. perennis	Wild Lupine	T	This wildflower grows in extremely dry, sandy openings. It is tolerant of surrounding disturbance and depends upon periodic mowing (or, historically, wildfire) to eliminate trees that would otherwise shade it out (New Hampshire NHB 2018).
Eleocharis diandra	Wright's Spikesedge	E	Wright's spikesedge is found along gently sloping freshwater shorelines and marshes. It commonly occurs in disturbed, saturated soils of river edges, often in small depressions. It is typically found in the zone along the water’s edge that undergoes spring flooding and is exposed in the summer. The species is primarily vulnerable to changes to the hydrology of its wetland habitat, especially alterations that change water levels. It may also be susceptible to increased pollutants and nutrients carried in stormwater runoff (Magee and Ahles 1999; New Hampshire NHB 2018; Massachusetts NHESP 2012).
N/A	Hemlock Forest*	--	Hemlock forests typically occur on rocky, coarse, and/or thin soils poor in nutrients, including ravines, gorges, river and kame terraces, and other microsites below 2000 feet in elevation. Soils typically have welldeveloped E horizons (classic Spodosols), are very acidic, high in exchangeable aluminum, and low in available nitrogen and other nutrients. Threats include logging, introduction of invasive species, and direct destruction due to development (Sperduto and Nichols 2004; New Hampshire NHB 2018).
N/A	Highgradient Rocky Riverbank System	--	Threats are primarily changes to the hydrology of the river, land conversion and fragmentation, introduction of invasive species, and increased input of nutrients and pollutants (New Hampshire NHB 2018).

Sources: New Hampshire NHB 2018; Massachusetts NHESP 2018; MEOEEA 2018.

a: "E" = Endangered, "T" = Threatened, “SC” = Special Concern, "--" = an exemplary natural community, or a rare species tracked by New Hampshire NHB that has not yet been added to the official state list. An asterisk (*) indicates that the most recent report for that occurrence was more than 20 years ago.
b: The request to New Hampshire NHB included lands within the FERC Project boundary but did not specify a maximum linear distance from the Project boundary in which potential RTE species would be identified. Therefore, for the purposes of this Exhibit, the RTE project area in New Hampshire has been defined as all lands within the FERC Project boundary and lands within approximately 500 feet of the Project boundary.

Massachusetts NHESP Priority and Estimated Habitats

The Massachusetts NHESP identifies Priority Habitat based on the known geographical extent of habitat for all state-listed rare species, both plants and animals, and is codified under the Massachusetts Endangered Species Act (MESA). Habitat alteration within Priority Habitat may result in a take of a state-listed species and is subject to regulatory review by the Massachusetts NHESP. Currently, a portion of the Project boundary, and adjacent terrestrial habitats outside the Project boundary, are listed as Massachusetts NHESP Priority Habitat (Priority Habitat 1987). This area extends from approximately 1.03 miles south of the New Hampshire border on the northern end to just south of the Greater Lowell Technical High School on the southern end along the Merrimack River.

The Massachusetts NHESP also identifies Estimated Habitats, which are a sub-set of the Priority Habitats, and are based on the geographical extent of habitat of state-listed rare wetlands wildlife and is codified under the Wetlands Protection Act (WPA), which does not protect plants. State-listed wetland wildlife species are protected under the MESA as well as the WPA. Currently, a portion of the Project boundary, and adjacent terrestrial habitats outside the Project boundary, are listed as Massachusetts NHESP Estimated Habitat (Estimated Habitat 1320). This area extends from approximately 1.03 miles south of the New Hampshire border on the northern end to just south of the Greater Lowell Technical High School on the southern end along the Merrimack River.

E.7.5.1.3 Identified Federal- and State-listed Species in the Project Area

Fish Species

State-listed fish species were identified through two primary studies, the Fish Assemblage Study and the Downstream American Eel Passage Assessment Study. The methods and results of these studies are presented in the Technical Report for the Fish Assemblage Study (NAI 2021d) and the Technical Report for the Downstream American Eel Passage Assessment (NAI 2021a), respectively, which were filed with the Commission on February 25, 2021.

In accordance with the approved study plan, Boott conducted a Fish Assemblage Study in 2019 to characterize the fish assemblage in areas affected by the Lowell Project, specifically the impoundment and bypassed reach. The study area for this fish community survey included the mainstem Merrimack River from the Pawtucket Dam to the upper extent of the Project’s impoundment located approximately 23 river miles upstream, and the Project’s 0.7-mile-long bypassed reach (NAI 2021d). Two State-listed species of special concern, the American eel and the sea lamprey, were identified. Boott captured 17 American eel upstream of the Pawtucket Dam by boat electrofishing and experimental gill net and also captured 33 American eel within the bypassed reach downstream of Pawtucket Dam by backpack electrofishing during the spring, summer and fall sampling in 2019. American eel represented 13.8% of the total electrofishing catch from the ledge channel habitat located in the lower portion of the Lowell bypassed reach. Additionally, Boott captured 21 sea lampreys upstream of Pawtucket Dam by boat electrofishing and experimental gill net during the spring, summer and fall sampling in 2019 (NAI 2021d).

Wildlife Species

No ESA-listed wildlife species (i.e., northern long-eared bat) were observed during field studies conducted in 2019 or 2020; although no specific surveys were conducted for this species.

E.7.5.1.4 Designated Critical Habitat

When a species is proposed for listing as endangered or threatened under the ESA, the USFWS must consider whether there are areas of habitat believed to be essential to the species' conservation. Those areas may be proposed for designation as Critical Habitat. Critical Habitat is a specific geographic area that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection. No Critical Habitat has been designated under the ESA for terrestrial species in the Project vicinity (USFWS 2020b).

E.7.5.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on threatened and endangered species as potential resource issues. Specifically, SD2 identified the following potential resource issues related to threatened and endangered species to be analyzed for site-specific effects:

- Effects of continued project operation and maintenance on the federally threatened northern long-eared bat.

One federally threatened mammal species, the northern long-eared bat, may occur within the Project area. This aerial insectivore may forage adjacent to Project waters in forested habitats in the summer but is not expected to be adversely affected as a result of Project operation. This bat species roosts in upland areas (live or snag trees, caves, etc.), outside of the range of potential Project operational affects. This bat species spends winters months in hibernacula and is not expected to be adversely affected by Project operations. There are no known hibernacula or roost trees for northern long-eared bat in the immediate vicinity of the Project's facilities. Additionally, the occurrence and distribution of terrestrial wildlife resources in the Project area is generally unrelated to operation of the Project. The operation of the Project as proposed is not expected to have any adverse effects on northern long-eared bat; however, in the event Boott performs maintenance activities at the Projects that could affect bat habitat, Boott will perform the required consultation and protection measures pursuant to applicable federal and state laws and regulations, including the Endangered Species Act.

Bald eagles are known to use the Merrimack River watershed for winter perching, roosting, and feeding activities and have been documented along the Merrimack River mainstem from Franklin to Nashua, New Hampshire, and throughout the Massachusetts portion of the basin (USACE 2003). Continued Project operations as proposed by the Licensee have a very low potential to impact bald eagles or roost trees. The occurrence and distribution of terrestrial wildlife resources in the study area is generally unrelated to Project operations. Boott conducts routine Project maintenance activities and manages formal Project recreation facilities at the Project. Project maintenance activities are generally localized and minor in nature.

Some State wildlife Species of Special Concern may potentially occur within the Project. These include several bird species and one amphibian species (northern leopard frog). All of the wildlife Species of Special Concern that have potential to occur within the Project area are highly mobile and are most likely to occur in the Project area for foraging (and, in some cases, breeding) during temperate months. The Licensee is proposing no fundamental changes in operation. As a result, and given that no RTE species have been documented within the Project boundary, continued operation of the Project is not expected to adversely affect RTE species.

E.7.5.2.1 Environmental Analysis

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

Boott does not anticipate that the proposed decommissioning of the downtown powerhouses will have any effect on rare, threatened, or endangered species. The downtown powerhouses are generally located in an urban area that does not provide significant habitat for federal- or state-listed terrestrial plant or wildlife species. Boott is proposing to decommission the existing powerhouses without demolishing the structures or undertaking land-clearing activities. Accordingly, Boott's proposal will not require any modifications to existing terrestrial habitat in the Project's vicinity.

With respect to federal- or state-listed aquatic species, Boott notes that there is no evidence that these species are utilizing the downtown canal system. Boott's proposal to decommission the downtown canal units is likely to have a net benefit to fish and aquatic resources. Because flows of up to 2,000 cfs will no longer be periodically routed to the downtown canal system, there is less likelihood that outmigrating diadromous fish will enter the canals. The primary means for fish to enter the canal system will be lockages associated with the NPS's canal boat tours, which require a relatively small volume of water passed during a brief period. Even if fish do enter the canal system through lockages or via the 200 to 300 cfs leakage make-up flow, Boott is proposing to discontinue generating with the powerhouses' turbines and to seal the penstock intakes.

These actions will eliminate the possibility of fish becoming impinged at or entrained by the downtown powerhouses. Accordingly, decommissioning of the Project's downtown powerhouses is not expected to have an adverse effect on federal- or state-listed fish or other aquatic resources.

E.7.5.3 Proposed Environmental Measures

Boott proposes continued operations of the Project with environmental PM&E measures which will protect rare, threatened and endangered species and their habitats. These measures include:

- Continue to operate the Project in ROR mode;
- Maintain a bypass reach minimum flow of 500 cfs via the Pawtucket Dam fish ladder during the fish passage season (typically May 1 – July 15), and 100 cfs outside of the fish passage season;
- Continued adherence to the requirements of the Project's existing Crest Gate Operation Plan;
- Install new trashracks or other fish exclusion facility at the E.L. Field Powerhouse, which will prevent the entrainment of outmigrating adult American eel.
- Boott has proposed to develop a plan for decommissioning the downtown powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

E.7.5.4 Unavoidable Adverse Impacts

The occurrence and distribution of terrestrial wildlife and RTE resources in the study area is generally unrelated to Project operations. The continued operation of the Project as proposed by the Licensee is not expected to have any adverse effects on the northern long-eared bat. Routine Project maintenance activities that could affect bat habitat are generally localized. Bat foraging may take place over the impoundment and along the shoreline; however, the ROR operation of the Project will not affect the ability of bats to access foraging habitat or limit potential prey species (e.g., invertebrates).

E.7.6 Recreation and Land Use

The subsections below describe recreation and land use in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, and the:

- Recreation and Aesthetics Study Report (HDR 2021a)

- Water Level and Flow Effects on Historic Resources Study Report (HDR 2021b)
- Resources, Ownership, Boundaries and Land Rights Study Report

However, Boott also notes that the Whitewater Boating and Access Study required by the Commission is on-going. Subsequent to completion of the study activities, Boott anticipates additional consultation with stakeholders.

E.7.6.1 Affected Environment

E.7.6.1.1 Project Recreation Facilities

Pursuant to existing License Article 38 and the FERC-approved Recreation Plan, Boott maintains one formal recreation area at the Project:

E.L. Field Powerhouse Visitor Center (Visitor Center)

The Visitor Center, located along the mainstem of the Merrimack River, offers a secured view of the interior of the turbine gallery and an interpretive display that provides information regarding the development, history, and operation of the Project, and nearby historic, natural, cultural, recreational resources, and other items of interest.

E.7.6.1.2 Recreation in the Project Area

The Project's primary features are located along the Merrimack River in the City of Lowell, Massachusetts. The Merrimack River watershed supports all or parts of approximately 200 communities with a total population of 2.6 million people (USEPA 2020b; USACE 2006). The Merrimack River provides numerous recreational opportunities to the residents of the communities along its banks but is also utilized by residents of major cities in the region, particularly residents from Boston (Nashua Regional Planning Commission [NRPC] 2008; NHDES 2019a; USACE 2006).

The Project dam is located at RM 41 on the Merrimack River, and the impoundment extends upstream approximately 16 miles to Cromwell's Falls in Litchfield and Merrimack, New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. The Merrimack River provides extensive recreational opportunities, including boating, canoeing, kayaking, rowing, fishing, and swimming. Several parks and conservation areas in the vicinity of the Project afford additional recreation opportunities that include hiking, cross country skiing, picnicking, and bird watching. Recreational opportunities differ closer to the larger, more populated cities along the river.

Several project facilities are located within overlapping locally, state, and nationally designated parks and historic properties/preservation districts. Non-Project related recreational facilities and opportunities in the Project's vicinity include:

- Depot Street Boat Ramp
- Greely Park and Boat Ramp
- Lowell National Historic Park (LHNP)
- Lowell Heritage State Park

- Lowell-Dracut Tyngsborough State Forest
- Flints Pond Access
- Merrill Park
- Twin Bridge Park
- Moore's Falls Conservation Area
- John Bryant River Access
- Thornton's Ferry Boat Launch
- Litchfield State Forest
- Horse Hill Nature Preserve
- Leslie Bockes Memorial Forest
- New Hampshire Heritage Trail
- Chelmsford Boat Access
- Great Brook Farm State Park
- Warren H. Manning State Forest
- Billerica State Forest
- Carlisle State Forest
- Governor Thomas Dudley State Park
- Merrimack River Boat Access.

These and other non-Project related facilities are not owned or operated by Boott but are popular Merrimack River recreational areas. In addition, there are numerous informal access areas on Lowell Hydroelectric Project lands that are used by the public for access to the Merrimack River. Figure E.7-25 through Figure E.7-26 depict the wide range of recreational opportunities in the vicinity of the Project, which are described in more detail below.

Figure E.7-25. Recreation Opportunities in the Vicinity of the Lowell Hydroelectric Project

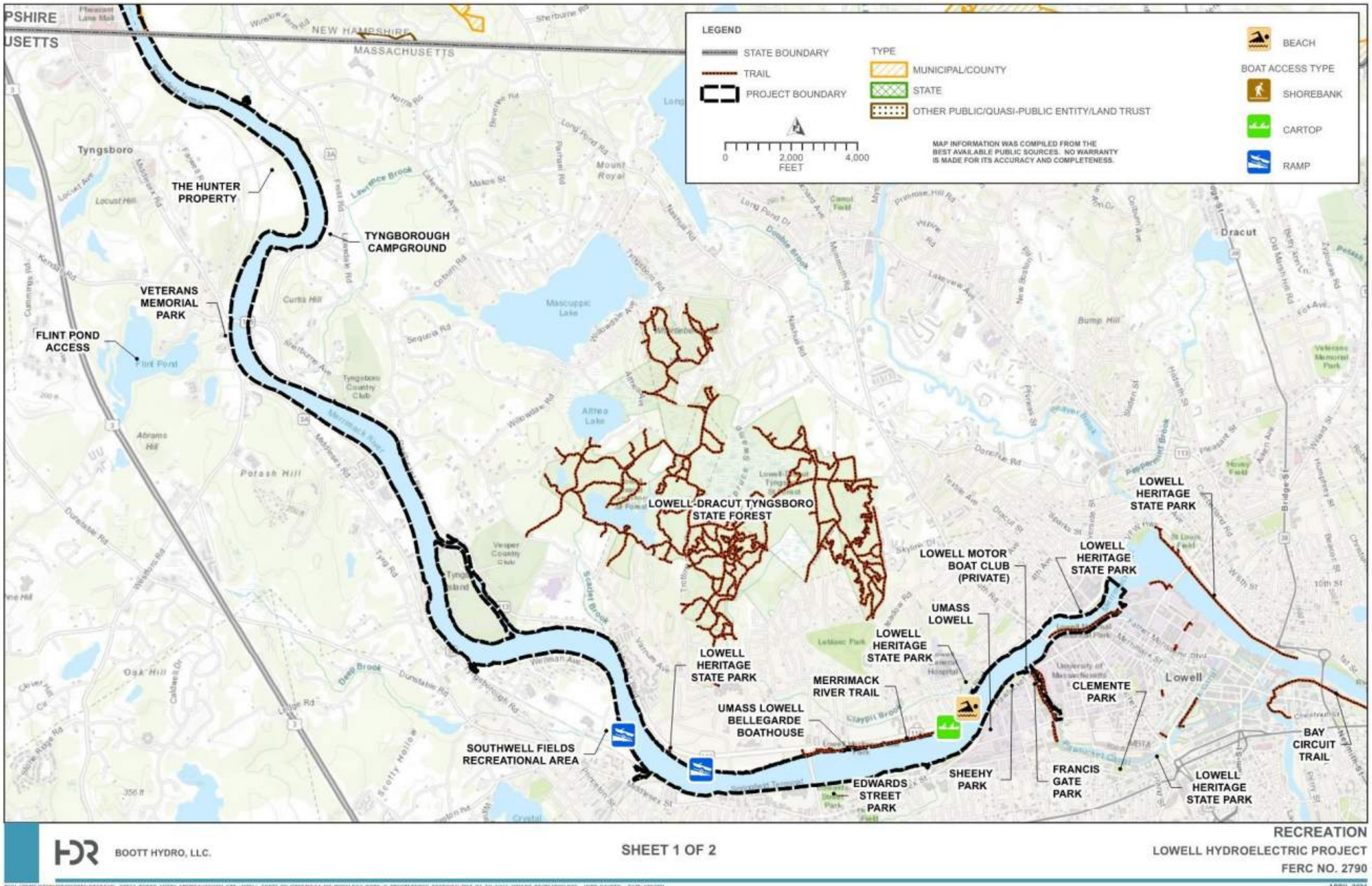
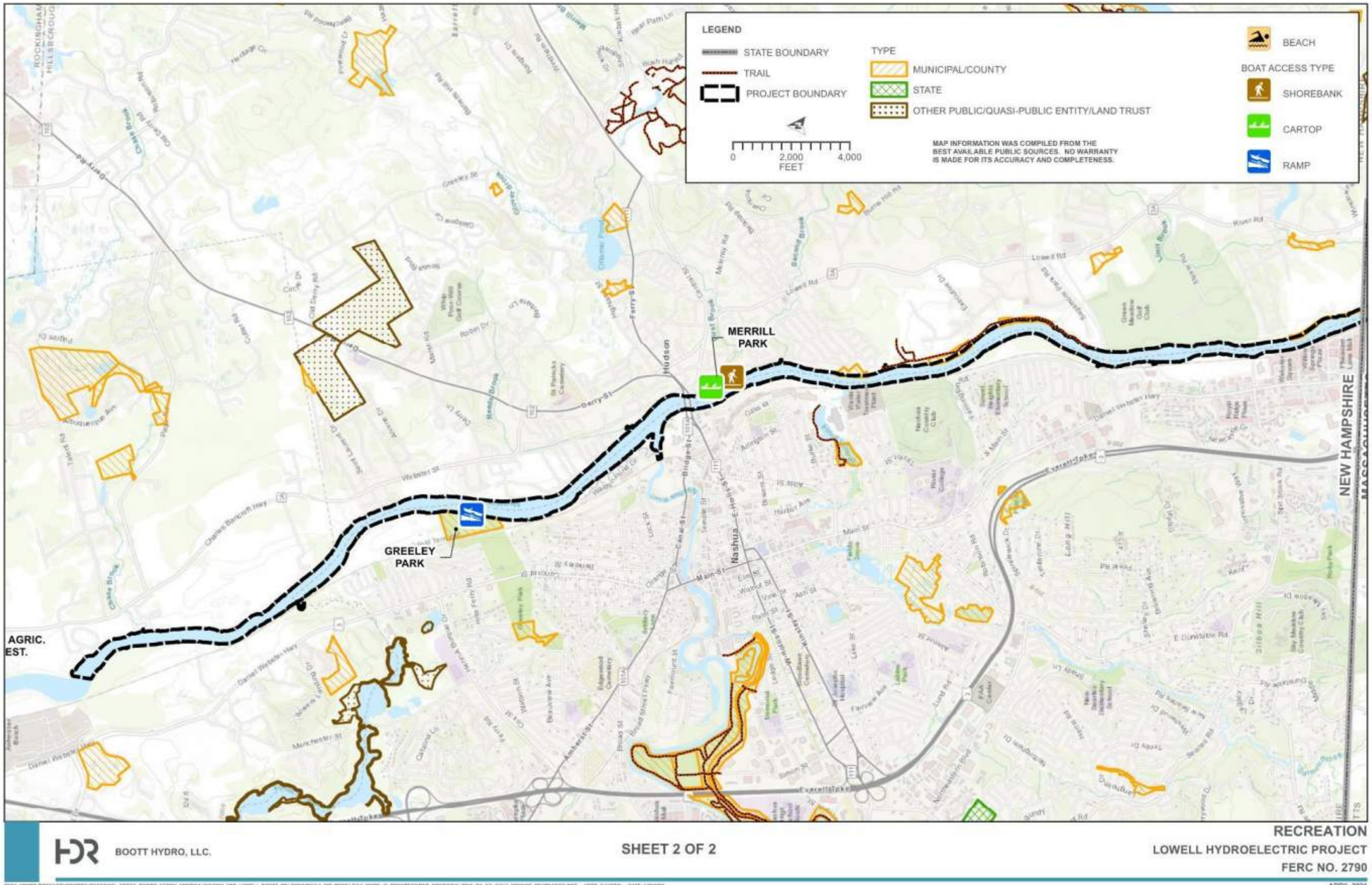


Figure E.7-26. Recreation Opportunities in the Vicinity of the Lowell Hydroelectric Project



E.7.6.1.3 Recreation Opportunities in New Hampshire

The State of New Hampshire reports many recreational uses of the Project impoundment, including fishing, canoeing, kayaking, rowing, and motor boating. Much of the Project impoundment is in Hillsborough County, New Hampshire, which has approximately 54,480 acres of recreation lands and 116 public access sites to the water (New Hampshire Department of Natural and Cultural Resources [NHDNCR] 2018). Most of the shore lands along the Merrimack River in New Hampshire are privately owned; therefore, recreation activities take place immediately on the Merrimack River (NRPC 2008). There are six known boat access facilities in New Hampshire with direct access to the Project impoundment. These facilities range in design from concrete ramps to shoreline access and are described below:

Moore's Falls Conservation Area: Moore's Falls Conservation Area offers shoreline fishing and car-top boating access to Moore's Falls upstream of the Project impoundment. Moore's Falls are a length of rapids on the Merrimack River which drop 6 feet in elevation over 650 feet in distance, which define the upstream extent of the Project impoundment. There are also walking trails through the woods, an old trolley track trail, multiple access points to the Merrimack River for fishing, educational information regarding environmental conservation, and birdhouses. Running along the east bank of the river are the remains of a historic lock structure constructed in the early 1800s. NHDES recommends this conservation area for angler fishing, as small and large mouth bass are often caught, as well as rainbow and brook trout, both of which are stocked by the NHFGD in the Lower Merrimack River (Middlesex Canal Association 2009; NHDES 2019a).

Depot Street Boat Ramp: The Depot Street Boat Ramp offers a carry-in boat ramp and fishing access to the Merrimack River and is managed by the Town of Merrimack. The trail to the river runs under railroad tracks. This access is suitable for motorboats, as the river slows from the rocky rapids upstream (NHDES 2019a; Merrimack Parks and Recreation 2020). There is also a scenic picnic area.

John Bryant River Access: The John Bryant River Access is a canoe/kayak car top facility managed by the Litchfield Recreation Commission. It provides fishing access, scenic views of the river, and birdwatching. It is available only to Town of Litchfield, New Hampshire residents (Litchfield Recreation Commission 2020).

Thornton's Ferry Boat Launch: Thornton's Ferry Boat Launch is owned by the Town of Merrimack and offers cartop carry-in boating and fishing access to the Merrimack River (NHFGD undated).

Greeley Park & Boat Ramp: Greeley Park is a 125-acre city park located in Nashua, New Hampshire. Greely Park offers many recreation amenities/facilities including baseball/softball fields, historical sites, picnic areas, playgrounds, restrooms, tennis courts, trails, and wading pools (NHFGD undated; City of Nashua 2020). In 2019, the City of Nashua issued an invitation to bid for reconstruction of the Greeley Park Boat Ramp, as well as construction of a gravel parking lot, placement of new signs, and three biological retention ponds. The work was scheduled for completion in July 2020 (NHFGD undated; City of Nashua 2019). A paved ramp at the north end of Greeley Park in

Nashua also allows access to the river for boaters. NHDES recommends this conservation area for angler fishing (NHDES 2019a).

Merrill Park: Merrill Park is a 9.3-acre city park located in Hudson, New Hampshire. It is adjacent to the east riverbank and Project boundary. The park is mostly forested with a few walking paths and picnic benches. It has a path which leads down to the Merrimack River, allowing hand-carry access for canoes or kayaks, or fishing (Town of Hudson undated).

In addition to the facilities mentioned above, the following facilities are within a 30-minute drive from the Project boundary and provide outdoor activities that include wildlife observation, driving for pleasure, sightseeing, day hiking, and jogging/running/walking:

Litchfield State Forest: The Litchfield State Forest is a 450-acre forest in Litchfield managed by the State of New Hampshire. It is located about 1.5 miles east of the Project boundary. The 1.3-mile Litchfield State Forest Trail provides comfortable walking and biking trails. Off trails provide an additional four miles of hiking, wildlife observation, and scenic opportunities. The trails are often used for cross country skiing in the winter (Litchfield Recreation Commission 2020; ExploreYourSpaces 2020).

Flints Pond Access: Flints pond is a 50-acre, warm water pond located in the Town of Hollis in New Hampshire. The pond is open to the public for fishing, kayaking, and canoeing in the summer. In the winter, ice fishing, snowshoeing, and snowmobiling are also popular. A boat ramp is available at the north end of the pond (Flints Pond Improvement Association 2015). Flints Pond Access is approximately 0.2 miles west of the Project boundary.

Horse Hill Nature Preserve: Horse Hill Nature Preserve is a 560-acre property owned by the town of Merrimack, located about three miles west of the Project Boundary. It is primarily a mixed hardwood forest, with a series of streams, ponds, swamps, and numerous wetlands. Old logging roads form the basis of what is today a trail network used by hikers, bikers, cross country skiing, snowshoeing, hunters, snowmobilers, and horseback riders. This trail network covers most of the property, however, there are still large areas without defined access.

Leslie Bockes Memorial Forest: Forest Society owns and manages this approximately 226-acre forest located in Londonderry, New Hampshire (five miles east of the Project boundary). Nearly four miles of old logging roads provide hiking, skiing, and snowshoeing with numerous access points. The trails are on well-maintained woods roads that enable easy walking and generally good footing. The tract is a known spot for bird and nature-watching (Forest Society 2020).

Twin Bridge Park: Twin Bridge Park is in Merrimack, New Hampshire, and features a baseball field, playground, picnic area, and extensive hiking trails through 27 acres of woods along Baboosic Brook (Town of Merrimack undated). Twin Bridge Park is approximately 0.2 miles west of the Project boundary.

New Hampshire Heritage Trail: The completed trail system will connect trail segments along the Lower Merrimack River and ultimately extend south into Massachusetts, and north along the Merrimack, Pemigewasset, and Connecticut Rivers to the Canadian border. Several trail sections have been completed along this part of the river and northward, with existing segments in Nashua, Hooksett and Manchester, New Hampshire (NHDES 2019a).

E.7.6.1.4 Recreation Opportunities in Massachusetts

The state of Massachusetts reports that recreation along the Project impoundment changes as open space generally decreases further downstream and riverfront communities are more industrialized (MEOEEA 2001). Water-based recreation (boating, fishing, canoeing, and swimming), is provided on the downstream portion of the Project impoundment by multiple boat ramps and waterfront parks. There are many additional recreational opportunities in and surrounding Lowell, including networks of trails, thousands of acres of nearby state forest, and urban passive parks for walking, jogging, dog-walking, and picnicking (City of Lowell 2018; MADCR 2014; Lowell National Historical Park [LNHP] 2017).

As part of the LNHP or Lowell Heritage State Park, different sites in and around the city of Lowell are related to the historical era of textile manufacturing and offer museum exhibits, walking tours, and interpretive/interactive displays (LNHP 2017; MADCR 2014). Boat tours led by NPS guides also provide access to the historic canal system and the Project impoundment. The canal boat tours highlight some of the Lowell Hydroelectric Project facilities by travelling through the historic navigation locks (NPS undated c). Although portions of the LHNP are within the Project boundary, it is not a FERC-approved recreation facility. Additional recreational opportunities provided by NPS at the LNHP include trolley rides available for touring the city.

The downstream portion of the Project impoundment is accessible for water-based recreation by the following recreational facilities:

Lowell National Historical Park: The LNHP was established in 1978 and is operated by the NPS. This National Historic Park is made up of a group of different sites in and around the city of Lowell, Massachusetts, related to the era of textile manufacturing that relied on hydroelectric power to operate during the Industrial Revolution of the early 1800s. It is a primary recreation attraction for the City of Lowell and the Lowell Hydroelectric Project. While the majority of the Project facilities, canals, gatehouses, dams, locks, and powerhouses, are necessary components of its operations, they serve a dual purpose as a NPS attraction for which it is maintained and preserved as a historic property (NPS undated c). As noted above, LHNP is not a FERC-approved recreation facility despite the canal system and many of the Project's facilities being located within the Project boundary.

Lowell Heritage State Park: The 83-acre Lowell Heritage State Park occupies a 2-mile long stretch along the north bank of the Project impoundment, upstream of the Pawtucket Dam. The park features historical exhibits that were created in partnership with the NPS to educate the public regarding the network of canals and mills constructed in the 19th century to power Lowell's then bustling textile industry. Activities available include biking, boating (non-motorized and motorized), canoeing and kayaking, swimming, fishing, hiking, and educational programs. Facilities include a paved bike path and walking esplanade, picnic area, a beach, restrooms, scenic viewing area, an outdoor concert stage, and visitors center (Commonwealth of Massachusetts 2018a). Also located within the park boundary is the University of Massachusetts Lowell Bellegarde Boathouse, which also houses the Merrimack River Rowing Association, a non-profit rowing club.

Rourke Brothers Boat Ramp (part of the Lowell Heritage State Park): The park provides a trailered boat launch, located on the north bank of the impoundment about 2 miles upstream of the Pawtucket Dam. Adjacent to the boat launch is an access dock for boating and fishing.

Chelmsford Boat Access: The park provides a trailered boat launch, shoreline fishing access, picnic areas, athletic fields, and trails.

In addition to the facilities mentioned above, these facilities are located within a 30-minute drive from the Project boundary:

Lowell-Dracut Tyngsborough State Forest: The Lowell-Dracut Tyngsborough State Forest is approximately one mile north of the Project boundary. The Lowell-Dracut Tyngsborough State Forest spreads across three towns and features over 1,140 acres of protected land, including 180 acres of open water or wetlands and 457 acres of land in the city of Lowell. Popular activities include hiking, fishing, hunting, cycling, birding, picnicking, nature walking, mountain biking, and playing various field sports. In the winter, people sled, ice skate, and cross-country ski (Commonwealth of Massachusetts 2018c).

Great Brook Farm State Park: Located seven miles south of the Project, this park is a working dairy farm connected to miles of trails that can be used for a variety of recreational activities. The park also includes historic buildings and resources, interpretive programming, and a cross-country ski concession.

Warren H. Manning State Forest: Located five miles south of the Project, this state forest is a largely wooded property with a small recreation area, complete with a spray deck, picnic area, water playground, and fitness trail.

Billerica State Forest: Located six miles south of the Project, this state forest offers rustic, multi-use trails and wooded areas for walking and wildlife viewing.

Carlisle State Forest: Located ten miles south of the Project, this state forest provides over a mile of trails through wooded property protected from forestry activities at the turn of the 20th century. The forest includes an older stand of exceptionally large eastern white pines.

Governor Thomas Dudley State Park: Located ten miles south of the Project, this 11-acre park is a small wooded parcel that provides access to the Concord River and links to other protected open spaces.

E.7.6.1.5 Existing Shoreline Management Plans

There is no formal Shoreline Management Plan or permitting policy for the shoreline of the Lowell Hydroelectric Project.

E.7.6.1.6 Existing Shoreline Buffer Zones

At normal pool elevation of 92.2 feet NGVD, there are approximately 32 shoreline miles bordering the current impoundment of the Pawtucket Dam. Both New Hampshire and Massachusetts have established shoreline buffer zones. Per New Hampshire's Comprehensive Shoreland Protection Act (CSPA), which contains minimum standards to protect public surface waters and their immediate environs, any disturbance activity greater than 50,000 $feet^2$ occurring within 250 feet of the Merrimack River requires an Alteration-of-Terrain permit (LMRLAC 2008). In Massachusetts, the Wetlands Protection Act (Massachusetts General Laws Chapter 131, Section 40) protects important water-related lands and other areas from destruction or alteration. Generally implemented by the local Conservation Commission in each municipality, the Act establishes a 100-foot buffer zone around all coastal banks, inland banks, freshwater wetlands, coastal wetlands, tidal flats, beaches, dunes, marshes, and swamps, and a riverfront area within 200 feet of rivers and streams (or 25 feet of some urban rivers) that flow year round. The canals in Lowell are specifically defined as not having a riverfront area [310 CMR 10.58 (2)1.g] (MACC undated).

E.7.6.1.7 National Wild and Scenic River System, National Trail System, and Wilderness Areas

The Merrimack River is not designated as a National Wild and Scenic River or under study for inclusion in the National Wild and Scenic River System. The Lowell Hydroelectric Project is not located within or adjacent to lands included in, or under study for inclusion in, the National Trails System or designated as, or under study for inclusion as, a Wilderness Area.

E.7.6.1.8 Nationwide Rivers Inventory

The upper portion of the impoundment was listed under the National Rivers Inventory in 1995. The full classified reach is 16 miles long from Amoskeag Dam in Manchester to the confluence with Pennichuck Brook in Merrimack. The reach is considered notable due to fish, historic, recreational, and wildlife values (NPS undated *b).*

E.7.6.1.9 State-protected Rivers

The lower reach of the Merrimack River, which includes the upstream impoundment of the Project in New Hampshire, is designated as a "Community River" under the New Hampshire Rivers Management and Protection Program (NHDES 2017). Community rivers are defined as "those rivers or river segments which flow through populated areas of the state and which possess actual or potential resource values. Such rivers have some residential or other building development near their shorelines, are readily accessible by road or railroad, and may include some impoundments or diversion." (NHDES 1990). The LMRLAC provides an advisory role on matters pertaining to the management of the river, and comments on development plans which might affect the river's resource values. The LMRLAC also maintains a river corridor management plan pursuant to NH RSA 483:10 (NHDES 2008).

E.7.6.1.10 Regionally or Nationally Significant Recreation Areas

The Lowell Hydroelectric Project is located within the LNHP, a regionally and nationally significant recreation area.

E.7.6.1.11 Recreation Use and Need

Pursuant to the approved study plan, Boott conducted a Recreation and Aesthetics Study to identify existing recreation use as well as recreation resources and activities that may be affected by the continued operation of the Project. The methods and results of the Recreation and Aesthetics Study are described in detail in Boott's Recreation and Aesthetics Study Report (HDR 2021a) filed with the Commission on February 25, 2021.

Field Inventory

Boott inventoried non-Project recreation facilities within the Project's vicinity in the fall of 2019, including the Chelmsford Boat Access, Depot Street Boat Ramp, Greeley Boat Ramp, Lowell Heritage State Park, LNHP, Merrill Park, Merrimack Trail System, Moore's Falls Conservation Area, NPS Canal Walkway, Pawtucket Falls Overlook, and Rourke Brothers Boat Ramp. The Visitor Center (the only-FERC approved recreation facility), was closed on the days of inventory, but the external features (e.g. parking lot) were also inventoried. Pursuant to the RSP, Boott collected information regarding each facility including the type and location of existing recreation facilities, the type of recreation provided (e.g., boat access, angler access, picnicking, etc.), existing amenities and sanitation, the type of vehicular access and parking (if any), the suitability of facilities to provide recreational opportunities and access for persons with disabilities (i.e., compliance with current Americans with Disabilities Act [ADA] standards for accessible design), GPS location data, and representative photographic documentation of recreation facilities. The results of the field inventory are presented in Appendix B to the Recreation and Aesthetics Study Report. A map of inventoried facilities is presented as Figure E.7-27.

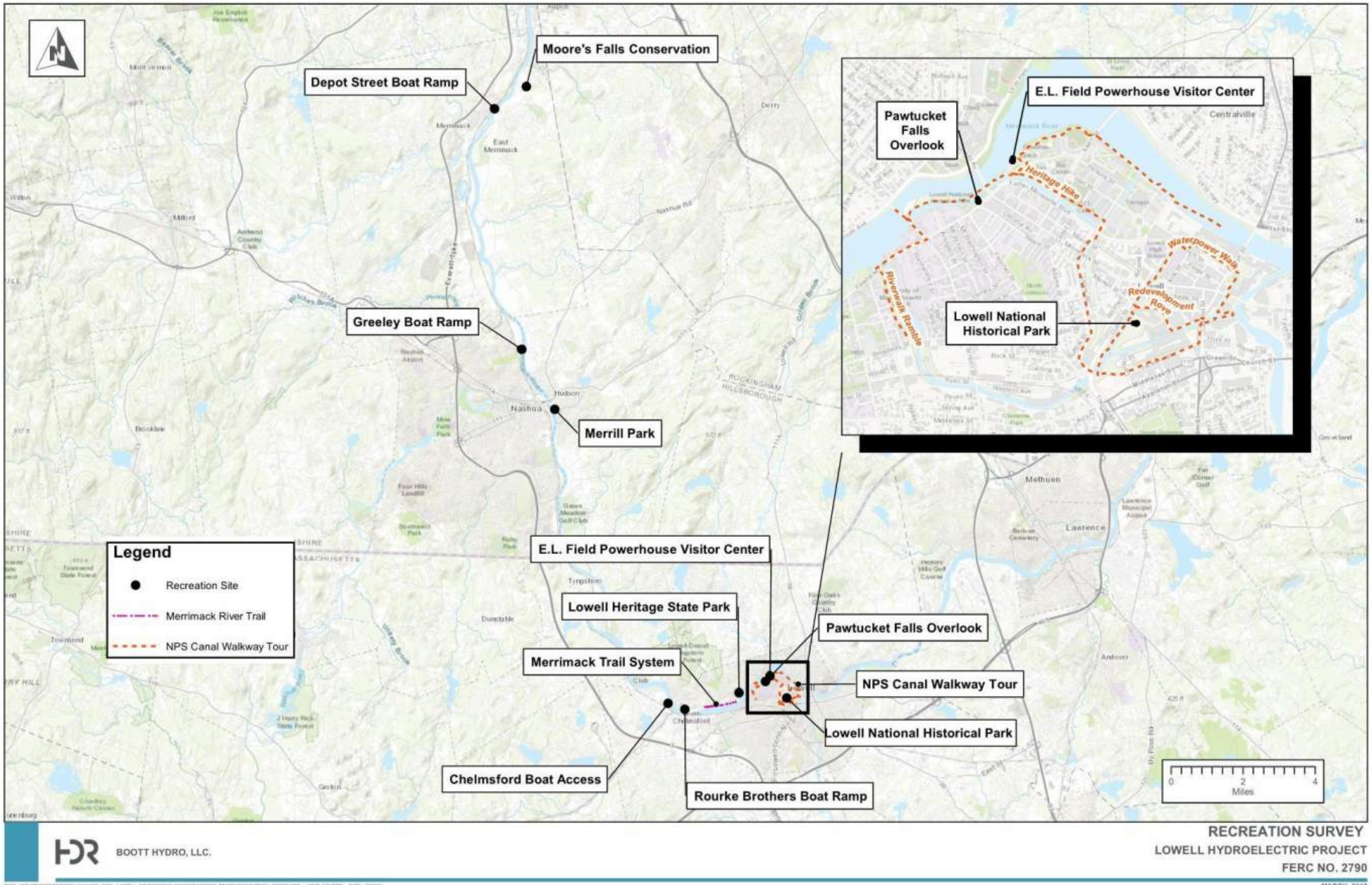
Visitor Use Data and Field Reconnaissance

As provided in the approved study plan, Boott conducted personal interviews (visitor intercept surveys) and field reconnaissance activities at recreation facilities in the Project's vicinity between May and October 2019. Boott developed survey questions based on general concepts and guidance from the U.S. Forest Service's (USFS) National Visitor Use Monitoring Handbook (USFS 2007) and questions that were asked during recreation studies for other relevant hydropower relicensings. The survey questions that were asked during the personal interviews are included in Appendix A of the Recreation and Aesthetics Study Report. Boott consulted with the NPS, MADCR, and American Whitewater (AW) to identify specific recreation survey locations.

In May 2019, Boott began conducting personal interviews at the Lowell Heritage State Park, Merrimack Trail System, Pawtucket Falls Overlook, NPS Canal Walkways, LNHP Visitor Center, Chelmsford Boat Access, Rourke Brothers Boat Ramp, Merrill Park, and Whitewater takeout location. The surveys were conducted on random weekdays and weekend days throughout the months of May, June, July, August, September, and

October of 2019. Personal interviews and field reconnaissance were conducted on four days of each month on both weekdays, weekend days, and holidays. A team of two technicians traveled between each of the aforementioned recreation sites and spent approximately one hour at each site conducting the personal interviews and collecting field reconnaissance data including (a) the various types of recreation activities, (b) an estimation of the number of vehicles, and (c) the approximate numbers of recreationists observed at each site. Field reconnaissance data is summarized in Appendix D of the Recreation and Aesthetics Study Report.

Figure E.7-27. Recreation Facilities Inventoried During Recreation and Aesthetics Study



For the personal interviews, individual recreationists and groups were interviewed, including visitors using boat launches and LNHP-managed facilities. Respondents answered questions verbally while a technician recorded their responses using the Qualtrics® offline survey platform to record and submit answers.[25] The personal interview questions included topics such as: general user information; age group, resident/visitor; purpose and duration of visit; distance traveled; history of visiting the site or area; types of recreational activities respondents participated in or planned to participate in during their visit; other recreational sites that respondents visited or intended to visit during their trip; general satisfaction with recreational opportunities, flow conditions, facilities, and the respondents overall visit and/or areas that need improvement; accessibility of facilities or areas; economic aspects, including dollars spent during their trip; and day use/overnight lodging during their visit. Before rotating to the next site, technicians also recorded the date, time, and weather conditions observed.

A total of 53 individuals participated in the interviews. Personal interviewees travelled an average of 7.3 miles to the recreation area, with a range of 0.1 miles to 3,000 miles. The majority (77 percent) of personal interview respondents rated their overall experience of recreational activities at the Project as “totally acceptable” or “acceptable.” Results from the personal interviews are compiled in Appendix C of the Recreation and Aesthetics Study Report.

Online Survey

In addition to the personal interviews and visitor use data collection, Boott developed a version of the interview questions to allow respondents to provide survey responses online. In accordance with the approved study plan, the survey was made available for one year, from June 2019 to June 2020, on the Project’s relicensing website (www.lowellprojectrelicensing.com). The online survey was developed using the Qualtrics® survey platform. Boott posted a brief description of the purpose and intent of the survey and the website address at popular recreation access areas at the Project. During personal interviews and field reconnaissance, Boott provided handouts to recreationists with the relevant information on how to access the online survey. Boott notified the Commission and stakeholders of the availability of the online survey in the Second Quarterly Study Progress Report filed with the Commission on October 1, 2019. The survey questions developed for the online survey are also included in Appendix A of the Recreation and Aesthetics Study Report.

A total of 96 respondents completed the online survey. Online respondents stated they travelled on average around 11 miles to the Project area. The majority (92 percent) of online respondents rated their overall experience of recreational activities at the Project as “totally acceptable” or “acceptable.” Results from the online surveys are compiled in Appendix E of the Recreation and Aesthetics Study Report.

[25] While the survey questions in the approved study plan were utilized for these interviews, the numbering and specific wording was adapted during the interview to better facilitate the interview and to accommodate the Qualtrics® survey platform.

E.7.6.1.12 Evaluation of Water Levels and Flows on Recreational Access

In accordance with the SPD, Boott initiated data collection to better understand effects of the crest gate and water levels and flows on (1) NPS boat tours and (2) access to the Northern Canal Walkway. These methods and results are described in detail in Boott's final Recreation and Aesthetics Study Report filed with the Commission on February 25, 2021.

NPS Boat Tours

Under the amended Crest Gate System Operations Plan, when flows in the river are below 8,600 cfs [the combined hydraulic capacity of the E.L. Field Powerhouse (6,600 cfs) and downtown canal system (2,000 cfs)], the reservoir elevation is maintained at the normal pond elevation of 92.2 ft NGVD 29. When Merrimack River flows exceed 8,600 cfs, the Crest Gate System Operations Plan allows for a gradual rise in elevation to ± 93.2 ft NGVD 29 as flows reach approximately 11,850 cfs. With this 1-foot elevation rise of the Project impoundment, NPS states their boats would be unable to pass under the Pawtucket Street Bridge.

The Project maintains a normal pond elevation of 92.2 ft NGVD 29 when flows in the Merrimack River are up to 8,600 cfs. According to USGS gage data presented in Table E.7-1, average flows during the operating season (May 15 through October 15) for NPS boat tours generally do not exceed 8,600 cfs. May is the only month with an average Merrimack River flow above 8,600 cfs.

As described above, when Merrimack River flows exceed 8,600 cfs, the crest elevation gradually rises to 93.2 ft NGVD 29 until flows reach 11,850 cfs. Ultimately, only between Merrimack River flows of 11,850 cfs and 12,500 cfs (NPS' self-reported threshold), are NPS boats supposedly unable to pass under Pawtucket Street Bridge. This is a relatively narrow window, especially since the average flow for the entire operating season never reaches 11,850 cfs, and a 10% chance of exceedance of 11,850 cfs only occurs in May, June, and October.

Additionally, while Boott is permitted by the Crest Gate Operations Plan to raise the impoundment level to 93.2 ft, it is not Boott's standard practice to do so every time flows reach 11,850 cfs. As detailed in the Water Level and Flow Effects on Historic Resources Study, Boott collected impoundment elevation data from March 10 – September 29, 2020, and the results are shown below in Figure E.7-39. As shown, there were only slight exceedances above the normal pond elevation during the months of March and April, despite the highest monthly average flows occurring during the months of March (11,484 cfs) and April (17, 901 cfs).

The majority of flows through the Lowell Project are a direct result of the annual hydrologic cycle, much of which is unpredictable and inconsistent. The effect of the crest gate system on NPS boat tours appears to be minimal. Merrimack River flows high enough to raise the pond elevation 1-foot are seemingly just as likely to rise above NPS' self-reported threshold of 12,500 cfs.

Northern Canal Walkway

The Northern Canal Walkway opens seasonally (May 15 through October 15) when flow rates in the Merrimack River and Northern Canal are lower than 3,500 cfs. This threshold was determined in a study demonstrating that a surge wave above 3,500 cfs in the Northern Canal poses a risk of overtopping the Great River Wall. In 1999, the Licensee completed construction of the Surge Gate, designed to attenuate the surge wave in the canal that occurs during sudden plant shutdown. A test of the Surge Gate revealed that the gate did attenuate the resulting transient wave. However, as reported to FERC, the test indicated when fully opened, the significant volume of discharge through the Surge Gate is hazardous to any persons in the riverbed below or near the gate. FERC directed Boott to design a Public Safety Plan to warn the public of this hazard, which included warning signs, sirens and beacons installed at various locations along and in the Merrimack River (FERC 2000). Accordingly, to be conservative and assure public safety, the 3,500 cfs threshold to open the Northern Canal Walkway remained despite the installation of the Surge Gate.

Within one year of license issuance, Boott will develop a Recreation Access and Facilities Management Plan in consultation with the stakeholders to: a) evaluate opportunities for increasing pedestrian access to the Northern Canal Walkway under certain conditions; b) define flow management practices needed to enhance recreational opportunity in the project vicinity; and c) continue to manage the Project’s recreation facility, the E.L. Field Powerhouse Visitor Center.

E.7.6.1.13 Land Use

Land use in the immediate vicinity of the Project is shown in Figure E.7-28 through Figure E.7-29. There are limited Project lands within the Project Boundary and only facilities needed for operation of the Project are included within the Project Boundary. Land use at the Project facilities is primarily Developed, High Intensity.

Land use along the impoundment of the Lowell Hydroelectric Project varies. The land use at the southern reach of the impoundment, in the Nashua area, and near Manchester is predominantly Developed, High Intensity. Elsewhere along the impoundment, where there are suburban and rural areas, land use is predominantly Developed, Low Intensity, except at the northern reach of the impoundment where other significant land uses include forest, hay/pasture, and crops.

Figure E.7-28. Land Use in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary

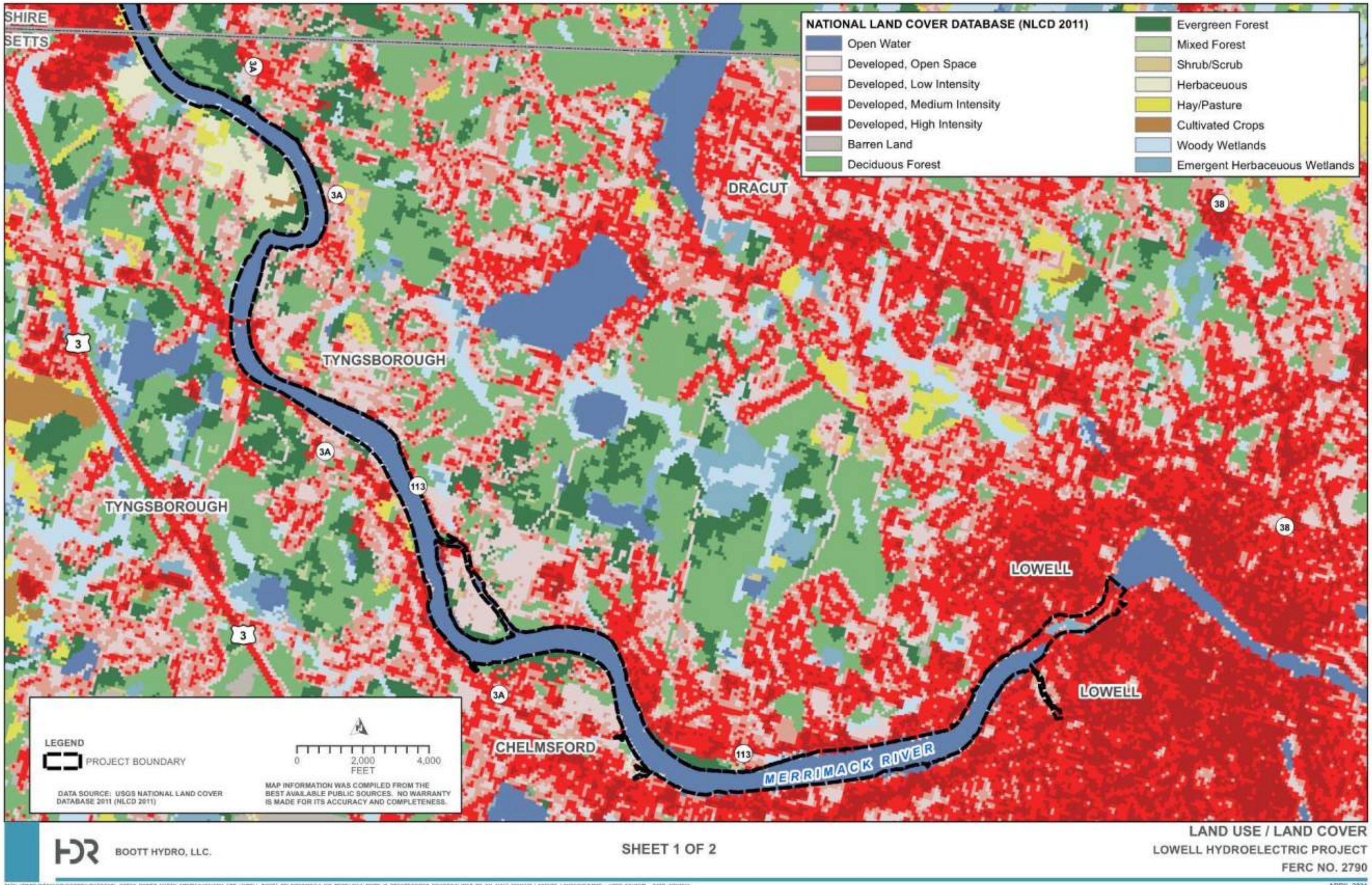
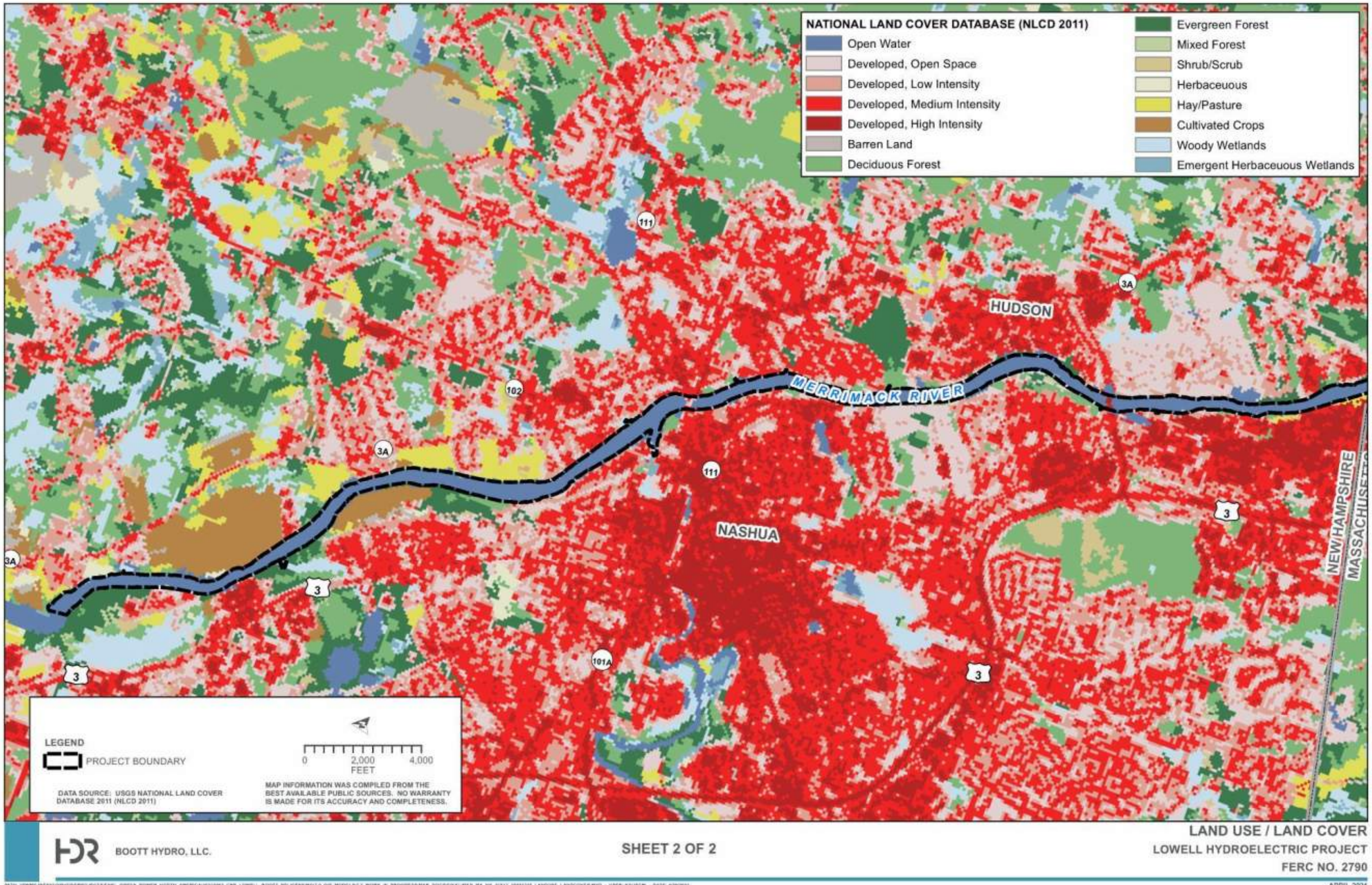


Figure E.7-29. Land Use in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary



E.7.6.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on recreation and land use as potential resource issues. Specifically, SD2 identified the following potential resource issues related to recreational use and land use to be analyzed for site-specific effects:

- Effects of continued project operation on recreational use in the Project area, including the adequacy of existing recreational access, and the adequacy and capacity of existing recreational facilities.
- Effects of continued project operation on land use in the project area.

E.7.6.2.1 Recreational Resources

As described in the Recreation and Aesthetics Report (HDR 2021a), more than 145 recreationists participated in interview or online surveys to share their opinions of and experiences with existing non-Project recreation facilities within the Project's vicinity. Most sites inventoried were reported in good condition, with parking lots, ample signage, and educational exhibits. Respondents both in-person and online overwhelmingly rated their overall experience as "totally acceptable" or "acceptable". Overall, the visitor use data indicates that non-Project recreation facilities within the Project's vicinity provide an "acceptable" or "totally acceptable" recreation experience for visitors.

While walking was the most common primary recreation activity, other trail-related activities (dog-walking, hiking, running, or jogging), bank and/or boat fishing, and kayaking all ranked high among activities that respondents participated in while visiting Project recreation facilities. The most frequently visited recreational facilities in the Project area were Lowell Heritage State Park, the Rourke Brothers Boat Ramp, Chelmsford Boat Access, Merrimack Trail System, and LNHP-facilities. Potential issues with the recreation facilities included crowding and safety; however, in general, respondents did not experience much crowding at the recreational facilities, parking issues, or lack of accessibility to the specific recreational facilities.

As part of the Recreation and Aesthetics Study, Boott conducted an evaluation of expanded recreational access in the Project canals. Boott's primary concerns were the recreational rights to the canal system and understanding public safety issues associated with providing recreational access in the Project's canal system. Boott reviewed many sources to understand the recreational rights to the Lowell canal system, including the Memorandum of Understanding (MOU), the 1984 Great Deed between Proprietors and Boott (Proprietors 1984), the 1986 Order of Taking (Commonwealth of Massachusetts 1986), and the 1995 Grant of Easement from the Commonwealth of Massachusetts to the LNHP (Commonwealth 1995).

By letter dated May 14, 1980, MADCR stated that they were currently in the process of negotiating purchase rights to the Lowell canal system which would allow for recreational boating in the canals, stating further that use of the canals and implementation of the boating program were key elements of the Lowell Heritage State Park (Massachusetts Department of Emergency Management [MADEM] 1980). Through the 1986 Order of Taking, MADCR purchased all air rights over the canals, including over the canal walls and dams, and the exclusive right to use water in the entire canal system for recreational, educational, and navigational purposes, unless said purposes interfere with Boott's hydroelectric generation (Commonwealth 1986). Included in the 1986 Order of Taking is a permanent and exclusive easement to MADCR for all canal walls, beds, or bottoms throughout the canal system for purposes consistent with the use of the canal system as a recreational park. These purposes specifically include placement and attachment of docks, wharves, walls, and boat ramps of a temporary or permanent nature (Commonwealth 1986). The 1995 Grant of Easement from MADCR to LNHP did not convey these exclusive recreation rights to LNHP (Commonwealth 1995).

Based on the review of the MOU, the 1984 Great Deed between Proprietors and Boott, the 1986 Order of Taking, and the 1995 Grant of Easement from the Commonwealth of Massachusetts to the LNHP, Boott currently does not have any right to expand recreational opportunities throughout the Lowell canal system. MADCR purchased all recreational rights over all the canals and canal walls (even canals owned by Boott), including exclusive navigational rights such as boating or canoeing. MADCR maintains an exclusive and permanent easement throughout the entire canal system to install access points such as boat ramps, wharves, and docks. Boott and other stakeholders are not permitted to use the canals as recreational resources, as those rights are exclusively held by MADCR.

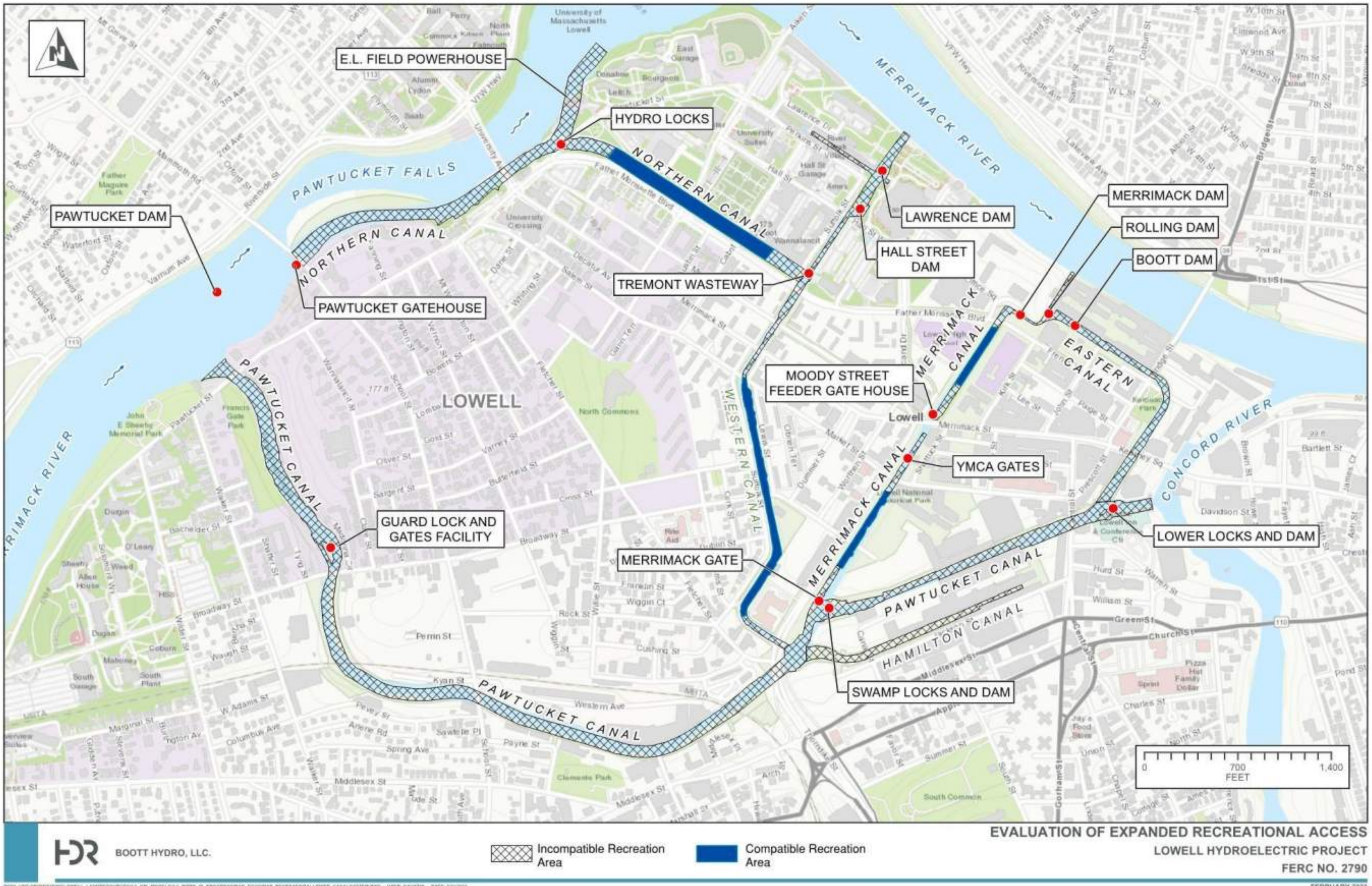
Additionally, while Boott does not have recreational or navigational rights to the canal system, Boott believes that providing access for the general public to the Northern Canal between the Pawtucket Gatehouse and the E.L. Field powerhouse would present a number of significant safety concerns. The current velocities in the Northern Canal are too high for safe navigation by non-powered boats when the E.L. Field powerhouse is operating, and the steep canal walls restrict the ability of public safety officials to respond to any emergency situations. Allowing recreationists access to or near to these Project facilities poses significant and unacceptable safety and security risks. That said, Boott is willing to work with local stakeholders to manage canal flows and water levels to facilitate safe public access to certain areas of the non-Project canal system identified below in Figure E.7-30, should that be desired.

As reported in the Recreation and Aesthetics Study Report, Boott conducted an analysis of any effects of the crest gate and water levels and flows on NPS bout tours and access to the Northern Canal Walkway. The effect of the crest gate system on NPS boat tours appears to be minimal, as flows in the Merrimack River are generally not that high (8,600 cfs) during the boat tour season, and even under those flow conditions Boott does not always raise the crest gates.

Boott's surge gate operations have the potential to affect access to the Northern Canal Walkway. Due to safety reasons with the surge gate, the Northern Canal Walkway opens seasonally (May 15 through October 15) when flow rates in the Merrimack River and Northern Canal are lower than 3,500 cfs.

Continued Project operations as proposed by the Licensee are not expected to result in any changes to the adequacy, availability, and accessibility of the non-Project related recreational facilities within the Project's vicinity.

Figure E.7-30. Identified Recreation Areas Potentially Compatible with Project Operations



E.7.6.2.2 Land Use

The facilities of the Lowell Hydroelectric Project are situated in an intensely developed urban landscape. The historic use of the Merrimack River in the vicinity of the Project for navigation, transportation, and industrial applications remain as the primary feature guiding its current use as a tourism attraction, municipal and industrial infrastructure element, and recreational asset. The City of Lowell was built by hydropower during the Industrial Revolution and hydropower is consistent with the current land use as an urban, industrial city. Continued Project operations as proposed by the Licensee are not expected to result in any changes to land use.

E.7.6.2.3 Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

Boott does not anticipate that removal of the canal facilities from the Project's license and decommissioning of the downtown powerhouses will have any adverse effects on recreation or land use within the Project's vicinity. Recreational boating is not permitted on the canal system, and the MADCR retains exclusive rights with respect to recreation on the canals. As noted above, MADCR also holds an exclusive and permanent easement throughout the entire canal system to install access points such as boat ramps, wharves, and docks. Boott and other stakeholders are not permitted to use the canals as recreational resources, as those rights are exclusively held by MADCR. The MADCR will continue to maintain those rights after the canal system is removed from the FERC license and the downtown powerhouses are decommissioned. Boott is not proposing to remove or otherwise modify the features of the canal system, and Boott will maintain facilities associated with the downtown canals in accordance with existing rights, responsibilities and existing or new agreements developed among the concerned stakeholders. Boott's proposal to maintain the canal water levels consistent with current practices will continue to support the NPS's seasonal canal boat tours.

Boott is not proposing any modifications to existing land use at the Project. While the downtown powerhouses will be decommissioned, Boott is not proposing any demolition or land-clearing activities associated with decommissioning that would affect the existing land use. For these reasons, the proposed removal of the canal system and the decommissioning of the downtown powerhouses is not expected to adversely affect recreation or land use.

E.7.6.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain measures consistent with those required by the Project's existing license.

Within one year of license issuance, Boott will develop a Recreation Access and Facilities Management Plan in consultation with the stakeholders to: a) evaluate opportunities for increasing pedestrian access to the Northern Canal Walkway under certain conditions; b) define flow management practices needed to enhance recreational opportunity in the project vicinity; and c) continue to manage the Project's recreation facility, the E.L. Field Powerhouse Visitor Center.

E.7.6.4 Unavoidable Adverse Impacts

Continued Project operations as proposed by the Licensee are not expected to result in any changes to recreation or land use. Considering that the Whitewater Boating and Access Study is on-going, Boott anticipates continuing to consult with AW and other relevant stakeholders on appropriate PM&E measures, if any, based on the results of that study. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.7 Aesthetics and Socioeconomic Resources

The subsections below describe aesthetic and socioeconomic resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, other existing information, and from the results of the Recreation and Aesthetics Study performed by Boott in 2020.

E.7.7.1 Affected Environment

E.7.7.1.1 Aesthetic Resources

The Lowell Project is located within the Seaboard Lowlands Section of the New England Physiographic Province. The Taconic, Green, and White Mountain ranges are distinct features of the New England Physiographic Province. The Seaboard Lowlands Section is lower in elevation and less hilly than the adjoining New England Upland Section (Flanagan et al. 1999). The local relief in the Merrimack River Valley in the Project vicinity is generally characterized as low, open hills. The Merrimack River watershed encompasses approximately 5,010 square miles within the states of New Hampshire and Massachusetts. It is the fourth largest watershed in New England. Although the Merrimack River watershed is heavily forested (75 percent of the land area is covered with forest), it also supports all or parts of approximately 200 communities with a total population of 2.6 million people (USEPA 2020b; USACE 2006).

Along the upper northern boundary of the Merrimack River watershed, the relatively undeveloped White Mountain National Forest in New Hampshire provides almost 800,000 acres of protected land; this region also provides over one million acres of private forest and agricultural land (NHDNCR 2018). The Project dam is located at RM 41 on the Merrimack River, and the impoundment extends upstream approximately 23 miles almost to the City of Manchester in New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. In the vicinity of the Project in Lowell, Massachusetts, the Merrimack River flows through a region of rapid population growth and development stemming from the 1800s that is still heavily influenced by the growing Boston urban metropolitan area (Figure E.7-28 through Figure E.7-29).

The Project facilities are generally bordered to the north by Route 113 and VFW Highway, and to the south by Pawtucket Street in the heavily populated City of Lowell, MA. The Project's impoundment is largely visible from Route 113 to the north and east and from Route 3A (Tyngsboro Road) to the south and west. One of the best views of the dam is from the Pawtucket Gatehouse which is located at the southern abutment of the Pawtucket Dam that controls flow into the Northern Canal. The Project's facilities can also be seen from the pedestrian trail located along the Northern Canal, from the University Avenue Bridge crossing, and from VFW Highway. The Project's bypass reach, located north of Mammoth Road and extending down below the Project's powerhouse, offers scenes of jumbles of rocks near the Pawtucket Dam, bedrock outcroppings, and ledges at low water periods, and contains strips of forest vegetation along the streambanks typical of the region. Scenic intrusions and topographical alterations resulting from original Project construction have long since disappeared, and the Project area has become integrated with the environmental and visual setting of the surrounding area.

The aesthetic resources of the Lowell Project largely reside in the historic infrastructure that the Project is a part of. The multiple historic textile mills, gatehouses, locks, canals, and walkways that are part of the Lowell National Historical Park are the primary aesthetic attraction of the Lowell Project (Figure E.7-31 through Figure E.7-35). Tourists are drawn to the city of Lowell to witness the historic site of the Industrial Revolution in the United States. Lowell is essentially a living exhibit of the process and the consequences of the American Industrial Revolution. In addition, the Project's immediate shoreline, associated canals, and river corridor offer a scenic backdrop in an intensely urbanized setting (Figure E.7-33 and Figure E.7-34).

Figure E.7-31. Pedestrian Walk with View of the Northern Canal (left) and Bypass Reach (right).

Figure E.7-32. Guard Lock and Gates Facility.

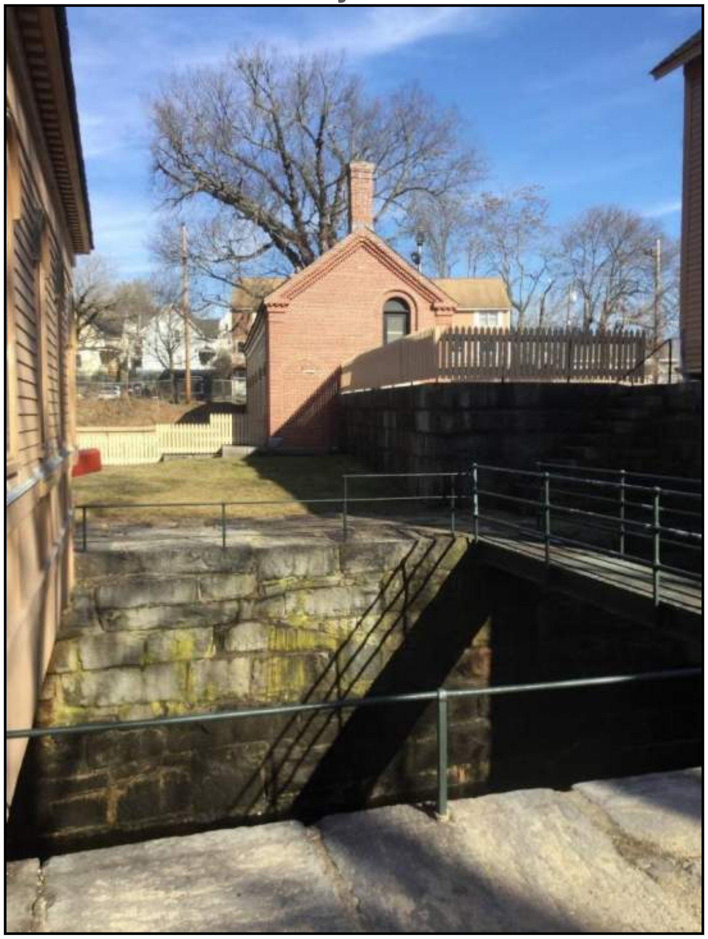
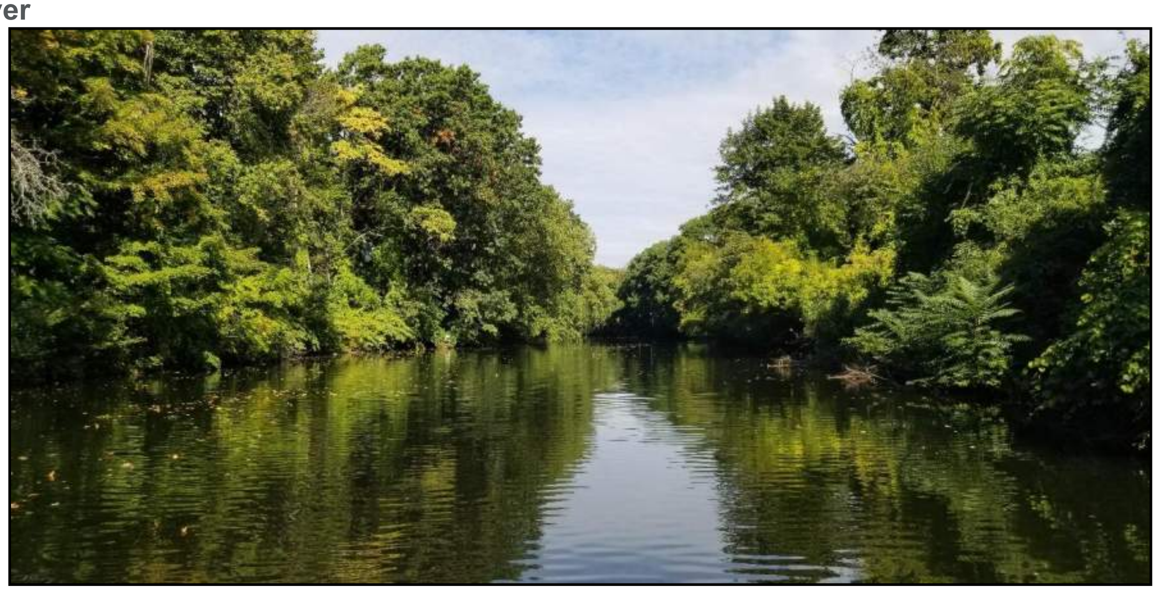


Figure E.7-33. Upstream View of Bypass Reach Near University Avenue

Figure E.7-34. Westerly View of Pawtucket Canal Near the Confluence with the Merrimack River



During the original licensing of the Project, NPS and other stakeholders stated that the powerhouse architecture should not mimic the nineteenth-century structures nearby. It was stated by officials that the modern nature of the new facility would be apparent and that it would harmonize well with the Northern Canal, the local neighborhood, and the river. The Licensee agreed to coordinate final exterior building design with the NPS and other interested agencies to help achieve this aim. Landscaping of the powerhouse area was also discussed in the prior application and the following proposals were made (Boott Mills 1980):

- Riverbank vegetation near the site to be protected to the extent feasible.
- Steep, riverside areas disturbed during construction are to be planted with native plant material.
- Street-level areas to compliment state and federal park design.
- Transmission lines from station to adjacent highway bridge to be inconspicuous.

Figure E.7-35 and Figure E.7-36 depict the Pawtucket Dam and E.L. Field Powerhouse, respectively. The E.L. Field Powerhouse is located in the vicinity of more modern architecture such as the University of Massachusetts Lowell dormitories.

Figure E.7-35. Westerly View of Pawtucket Dam from the Pawtucket Gatehouse

Figure E.7-36. E.L. Field Powerhouse with University of Massachusetts Lowell in the Background

E.7.7.1.2 Recreation and Aesthetics Study

Pursuant to the RSP, on April 9, 2020, Boott mapped areas within the canal system owned or under the control of Boott where waterborne trash may be a potential concern. The amount and type of waterborne trash that accumulates within the Project boundary can vary according to several factors including the season, Project operations, and the magnitude and duration of the flow events (HDR 2021a).

The surveys for waterborne trash have shown that waterborne trash accumulates within the Project's canal system, and these accumulations are somewhat dependent on the level of the water within the canals as well as the required operation of some of the NPS gates within the study area. For example, NPS gates that are operated on a routine basis had minimal signs of waterborne trash associated with them, while others that are largely in the closed position tended to have accumulations of waterborne trash behind them at varying densities (HDR 2021a).

Accumulated waterborne trash includes material floating on the impoundment surface and/or found on the surface of the canal system. Most of the waterborne trash accumulation within the Lowell Canal system appears to be derived from upstream inputs (the Merrimack River) as well as direct canal inputs (accidental and intentional littering) and from runoff events (also likely from accidental and intentional littering) (HDR 2021a).

In total, eight (8) areas of waterborne trash totaling 0.21 acres were mapped on April 9, 2020 as well as three additional areas of accumulated trash on the canal bed and a single area with a waterborne sheen. The total study area encompassed approximately 44 acres and the mapped areas within the canals were 3.531 acres or approximately 154,000 square feet (HDR 2021a).

Waterborne trash consisted of common materials such as foam board pieces, plastic cups, foam plates, foam bait containers, shoes, plastic bottles, organic debris, etc. (see Figure E.7-37 and Figure E.7-38).

Figure E.7-37. Waterborne trash on the Pawtucket Canal at Guard Lock and Gates Facility.

Figure E.7-38. Waterborne trash on the Merrimack River upstream of the Northern Canal Gatehouse

E.7.7.1.3 Socioeconomic Resources

The Lowell Project is located in Middlesex County, Massachusetts and Hillsborough County, New Hampshire. The population of Middlesex County, based on the vintage year[26] V2019 census data, was 1,611,699 resulting in a 7.2 percent increase in population from April 1, 2010 to July 1, 2019 (U.S. Census Bureau undated). The population of Hillsborough County, based on the vintage year V2019 census data, was 417,025 resulting in a 4.1 percent increase in population from April 1, 2010 to July 1, 2019 (U.S. Census Bureau undated).

According to the U.S. Census Bureau, the median household income in Middlesex County (in 2018 dollars) from 2014-2018 is estimated to be $97,012. There is an estimated 7.3 percent[27] living below the poverty line in Middlesex County (U.S. Census Bureau undated). The most common employment sectors for Middlesex County are healthcare and social assistance; professional, scientific, and tech services; and educational services (Data USA undated).

According to the U.S. Census Bureau, the median household income in Hillsborough County (in 2018 dollars) from 2014-2018 is estimated to be $78,655. There is an estimated 7.4 percent[2] living below the poverty line in Hillsborough County (U.S. Census Bureau undated). The most common employment sectors for Hillsborough County are healthcare and social assistance, manufacturing, and retail trade (Data USA undated).

The Lowell Project is located within the Greater Boston metropolitan area, which is primarily composed of urban and suburban towns and cities. The city of Lowell's estimated population in 2019 was 110,997 - making it the fourth largest city in Massachusetts. The population of Lowell grew an estimated 4.2 percent since the previous 2010 census. The median household income in Middlesex County (in 2018 dollars) from 2014-2018 is estimated to be $97,012, while the Lowell household annual income (in 2018 dollars) from 2014-2018 was $51,987. An estimated 20.7[2] percent of families were below the poverty line in 2018 (U.S. Census Bureau undated).

The economy of Lowell employs approximately 50,000 people. Lowell's economy is specialized in manufacturing, administration, waste management services, and healthcare and social assistance. The largest industries in Lowell are healthcare, manufacturing, and retail trade. Educational, scientific, and technical services are also notable contributing industries to the Lowell economy.

The City of Lowell's Healthy and Sustainable Local Economy 2025 Master Plan targets multiple facets of the local economy and the well-being of its citizens. One facet is to continue to support the urban revitalization plan of the Hamilton Canal District which includes properties adjacent to Lowell Project facilities. A second facet of the City of Lowell's plan is to attract and maintain environmentally sustainable businesses,

[26] The vintage year (e.g., V2019) refers to the final year of the series (2010 thru 2019). Different vintage years of estimates are not comparable.

[27] Estimates are not comparable to other geographic levels due to methodology differences that may exist between different data sources.

institutions, and industry. Hydropower is a suitable industrial energy supplier that satisfies this local economic development goal (City of Lowell 2013).

E.7.7.2 Environmental Analysis

FERC's SD2 identified the following potential resource issue related to aesthetics and socioeconomic effects:

- Effects of continued project operation on aesthetic resources in the project area, including the historic industrial context of the project structures and features.

E.7.7.2.1 Aesthetic Resources

A described above, the facilities of the Lowell Hydroelectric Project are situated in an intensely developed urban landscape. The Project dam is located at river mile 41 on the Merrimack River, and the impoundment extends upstream approximately 23 miles almost to the City of Manchester in New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. In the vicinity of the Project in Lowell, Massachusetts, the Merrimack River flows through a region of rapid population growth and development stemming from the 1800s that is still heavily influenced by the growing Boston urban metropolitan area.

The aesthetic resources of the Lowell Project largely reside in the historic infrastructure of the Project. The multiple historic textile mills, gatehouses, locks, canals, and walkways that are part of the Lowell National Historical Park are the primary aesthetic attraction of the City of Lowell, portions of which are included in the Lowell Project (Figure E.7-31 through Figure E.7-35).

Pursuant to the approved study plan for the Recreation and Aesthetics Study, Boott reviewed several sources to summarize historical and current practices for maintaining aesthetics (vegetation and waterborne trash management) in the Project Area. Following establishment of the LNHP in 1978, MADCR[28], NPS, and Proprietors, entered into an agreement in 1979 regarding management of the Lowell canal system and other historic structures. This agreement establishes MADCR as the lead party responsible for the maintenance of canal structural components, including canal banks and walls. As the lead party, MADCR was responsible for "landscaping and damage repair" to canal banks and walls, with assistance provided by NPS if needed. NPS was charged with the operation of the canal-related exhibits and services, and Proprietors were responsible for the operation and maintenance of the hydroelectric and hydromechanical parts of the Lowell canal system (NPS 1981). NPS developed and issued a Final General Management Plan (FGMP) in August 1981 to provide a basis for visitor use, resource management, and general development within the LNHP. The FGMP states that management of the Lowell canal system will be accomplished through cooperative agreements between private and public entities, but MADCR is the lead agency r

[28] The signatory of the 1979 agreement was the Massachusetts Department of Environmental Management, the predecessor agency to MADCR.

esponsible for maintaining, developing, and renovating the major elements of the canal system (NPS 1981).

In 1991, MADCR, the NPS, and Boott executed a MOU for the purpose of maintaining and operating the Lowell Canal System.[29] The MOU assigned specific responsibilities to each party and was filed with the Commission[30] on April 25, 1991 (MOU 1991). Article IV of the MOU directed NPS to assist MADCR in the removal and control of vegetation along the canal system, ("particularly that growing on and in the canal walls") and to assist MADCR in performing ground maintenance. Article IV also directed NPS to assist MADCR in the removal of litter and other waterborne trash from the Lowell Canal System, and states NPS is solely responsible for maintaining and cleaning, ("including removal of trash") all existing trash booms and safety lines/booms on the Lowell Canal System (MOU 1991).

Responsibilities assigned to MADCR under Article V of the MOU include serving as the lead agency for all grounds maintenance, keeping all grass, trees, and shrubs neatly trimmed and in a healthy condition, removing dead or diseased plants, fertilizing, pruning, and thinning of plants (as required), and approving ground maintenance or improvement plans as proposed by NPS. Article V also directs MADCR to assist NPS in the removal and control of destructive vegetation along the canal system, and to cooperate with the NPS on developing a litter removal program for waterborne litter and trash on the canals. (MOU 1991). This article also directed MADCR to reimburse NPS for time and materials for work done on the canal system.

Article VI of the MOU directed NPS and MADCR to hold a joint annual meeting to develop an annual destructive vegetation clearing program and canal surface water cleanup program. The annual programs were to be developed in accordance with each agency's budget and seasonal staffing level. Under Article VI, MADCR was also directed to consult with NPS to develop a long-term capital improvement program for the canal system. The minutes of this annual meeting between MADCR and NPS were to be provided to Boott and the Proprietors each year (MOU 1991).

Article IX stated that the MOU would expire five years from the date of signing, with an option for renewal. Efforts to renew the MOU apparently stalled around 1996, as MADCR issued a Grant of Easement[31] to the NPS in late 1995 (FERC 2001; Boott 2001; Lowell Sun 2006). This Grant of Easement provided NPS rights to implement construction and maintenance improvements at forty-two MADCR-owned parcels around the canal system. Such rights include landscaping, decking, and lighting. The Grant of Easement did not exclusively limit NPS's rights, only stating that construction and maintenance improvements must be consistent with the use of the area as a park. The Grant of

[29] Proprietors of the Locks and Canals on the Merrimack River was included as a party in the MOU but did not execute the agreement.

[30] The 1991 Memorandum of Understanding is available on FERC's eLibrary (https://elibrary.ferc.gov/eLibrary/search) under docket number p-2790.

[31] The 1995 Grant of Easement is also generally referred to as LNHP Deed No. 40.

Easement did not relinquish MADCR's waterborne trash and vegetation management responsibilities provided by the FGMP or MOU, as described above.

In the Resource Management Plan (RMP) for the Lowell/Great Brook Planning Unit, MADCR elaborates the agency was directed by the Commonwealth in 1993 to "concentrate on maximizing the riverfront component and minimizing, but not eliminating, [its] position in the downtown." Under a lower annual budget, MADCR states it has since focused its resources on the riverfront portion of the Lowell Heritage State Park system and less on the downtown canal system (MADCR 2014).

Boott annually removes accumulated river-borne debris from the upstream side of the Northern Canal Gatehouse under an MADCR permit. This effort is performed as necessary, typically two to three times annually. Boott also removes debris that accumulates from the upstream side of the Guard Locks and Gatehouse in the Pawtucket Canal on an as necessary basis, both for aesthetics and to ensure that debris does not interfere with the proper functioning of the Guard Gates. Boott will continue these practices under the new FERC license.

The combination of past and present land use activities in and around the Project area have contributed and will likely continue to contribute to the accumulation of waterborne trash within the Project's canal system that occur in the study area today (e.g., industrialization, commercial development, residential areas in close proximity to canals, etc.). However, the complexity and diversity of historical and current land use activities in the study area create a problem for tracing and identifying the sources of waterborne trash and its movement and distribution within the study area. Waterborne trash consisted of common materials such as foam board pieces, plastic cups, foam plates, foam bait containers, shoes, plastic bottles, and organic debris. It is well known that many types of land uses contribute to the accumulations of waterborne trash including stormwater drainage systems, upstream sources, inappropriately discarded trash, natural events (woody debris), densely populated areas, etc. Roads, construction, recreation, residential developments, and commercial and industrial developments all can contribute to the problem. Ongoing Project operation and maintenance has very little potential to cause and/or significantly contribute to the waterborne trash accumulation areas observed during the study.

Existing Project facilities are an integral part of the river's ecologic and aesthetic character. The Licensee is not proposing to modify Project operations. Current Project operations do not involve activities that directly affect aesthetics. Continued operation of the Project will help maintain the aesthetic quality of the Merrimack River by providing a continuous flow in the Project's bypassed reach and downstream areas. No impacts on aesthetic resources are expected as a result of continued Project operations.

E.7.7.2.2 Socioeconomic Resources

As previously described in this application, the Project is located within the historic infrastructure of the LNHP. Tourists are drawn to the city of Lowell to witness the historic site of the Industrial Revolution of the United States. Boott is not proposing to modify Project operations in manner that would affect regional tourism. As such, the continued operation of the Project as proposed by the Licensee is not expected to have any adverse effects on socioeconomic resources.

E.7.7.2.3 Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

The proposed removal of the canal system from the FERC license and decommissioning of the downtown powerhouses is not expected to adversely affect aesthetic or socioeconomic resources. Boott is proposing to maintain flows in the canal system equivalent to what is currently provided to maintain the aesthetics of the canals that attract tourists and visitors to the City of Lowell. Boott is also proposing to continue to maintain canal facilities consistent with existing rights, responsibilities, and existing or new agreements developed among the concerned stakeholders. Boott intends to decommission the downtown powerhouses and is not proposing demolition or land-clearing activities in association with decommissioning that would affect the aesthetic character of the powerhouses.

The proposed maintenance of canal water levels consistent with current practices will continue to support the NPS's canal boat operations that attract visitors to the LNHP. Boott does not anticipate that the proposed decommissioning of the downtown powerhouses will have any adverse effects on aesthetic or socioeconomic resources.

Given the physical extent and complexity of the canal system, together with the complex array of ownership and rights as documented in Boott's *Resources, Ownership, Boundaries, and Land Rights Study Report* it is clear that development of a comprehensive plan for the future management of the Lowell canal system will take substantial time, effort and coordination among Boott and the affected stakeholders. To that end, Boott convened nine meetings with the stakeholders to engage in discussions regarding the future management of the canal system outside of FERC's jurisdiction. The stakeholders in these meetings included NPS, MADCR, the City of Lowell and UMass Lowell. These meetings will continue as regular, facilitated discussions among Boott and the stakeholders, with the goal of developing an agreement for the future management of the canals and associated infrastructure, which may include measures for trash and/or vegetation management. Once executed, the agreement will be submitted to the FERC in support of Boott's license application and its decommissioning proposal.

E.7.7.3 Proposed Environmental Measures

Boott proposes to continue operations of the Project with certain PM&E as outlined above in Section E.6.2.

E.7.7.4 Unavoidable Adverse Impacts

The continued operation of the Project as proposed by the Licensee is not expected to have any unavoidable adverse effects on aesthetic or socioeconomic resources.

E.7.8 Cultural Resources

The subsections below describe cultural resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources.

In considering a new license for the Project, the Commission has the lead responsibility for compliance with applicable Federal laws, regulations, and policies pertaining to historic properties, including the National Historic Preservation Act of 1966, as amended (NHPA)[32]. Section 106 of the NHPA (Section 106)[33] requires Federal agencies to consider the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment.

The term “historic property” is defined in the implementing[34] regulations as any precontact or historic period district, site, building, structure, or individual object included in or eligible for inclusion in the National Register of Historic Places (NRHP), including any artifacts, records, and remains that are related to and located within historic properties, and properties of traditional religious and cultural significance that meet the NRHP criteria. The criteria for evaluating properties for inclusion in the National Register (36 C.F.R. Part 60) has been established by the Secretary of the Interior. In accordance with the criteria, properties are eligible if they are significant in American history, architecture, archaeology, engineering, or culture. The quality of significance is present in historic properties that possess integrity of location, design, setting, materials, workmanship, feeling, association, and:

1. That are associated with events that have made a significant contribution to the broad patterns of our history;
2. That are associated with the lives of persons significant in our past;
3. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant or distinguishable entity whose components may lack individual distinction; and/or
4. That have yielded or may be likely to yield information important in prehistory or history.

The regulations implementing Section 106 are intended to accommodate historic preservation concerns with the needs of federal undertakings through a process of

[32] 54 U.S.C. §300101 et seq.

[33] 54 U.S.C. §306108

[34] 36 C.F.R. Part 800 – The Protection of Historic Properties

consultation among agency officials, Federally recognized Native American tribes, SHPO, Tribal Historic Preservation Officers (THPO), and other parties, including the public, as appropriate. By letter dated April 26, 2017, the Commission initiated consultation under Section 106 with Federally recognized Native American tribes, including the Mashpee Wampanoag Tribe, Narragansett Indian Tribe, Stockbridge Munsee Tribe of Mohican Indians, and Wampanoag Tribe of Gay Head (Aquinnah).

The Commission designated Boott as its non-federal representative for purposes of conducting informal consultation pursuant to Section 106 via the June 15, 2018 NOI to file a License Application for a New License and Commencing Pre-filing Process.

E.7.8.1 Affected Environment

E.7.8.1.1 Area of Potential Effects

The area of potential effects (APE) for any undertaking is defined in 36 C.F.R. §800.16(d) as the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. The APE is influenced by the scale and nature of an undertaking. Although the Project's potential effects are limited by the nature of this undertaking (the relicensing and continued operation and maintenance of existing hydroelectric facilities), the Project has the potential to affect historic properties directly or indirectly (should any such properties exist). As described in the PAD, Project-related effects on historic properties may potentially result from (1) the Project's operations, (2) potential enhancement measures at the Project, and (3) routine maintenance activities. Potential enhancement measures at the Project (e.g., development of new recreation access areas) could result in ground disturbance which has the potential to disturb intact archaeological deposits, should any be present. Routine maintenance activities at the Project could result in ground disturbance and could also affect the integrity of historic buildings and structures.

Consistent with the scope of potential effects on historic properties, Boott proposed to define the APE for relicensing the Project as the following:

> *The APE for the Lowell Hydroelectric Project is the lands within the defined FERC Project boundary.*

Since the Project boundary encompass all lands that are necessary for the Project's purposes, the definition of the APE is consistent with the 36 C.F.R. §800.16(d) and the manner in which the Commission has defined the APE for similar hydroelectric projects. The existing Project boundary is presented in Figure E.1-1.

As stated elsewhere in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license and associated Project boundary.

E.7.8.1.2 Cultural Context

Precontact Period

For several thousand years, the Pawtucket Falls was a thriving center of Native American economic and cultural activity. The annual run of anadromous fish drew Pennacook Native Americans from a wide area of northern New England, and two subtribes, the Pawtuckets and Wamesits, established villages on the flats near the bend of the Merrimack below the falls. Salmon, sturgeon, shad, and alewives were harvested with nets, spears, and barbed arrows. The fish provided not only a large portion of the Native Americans' yearly protein intake, but also served as fertilizer for the nearby agricultural fields. The site retains its Native American name today, for "Pawtucket" means rapids or falls in the Algonquin dialect of its early settlers (Boott Mills 1980).

There are three pre-Contact archaeological sites recorded in the area of Lowell Park, however, many more exist along the Merrimack River both upstream and downstream of the Project. Many Archaic Period village sites, camp sites, and fishing grounds are documented in the vicinity of the Project (MADCR 2014). Boott distributed PAD questionnaires to the MHC and the NHDHR; however, no responses were received.

According to the MHC's survey map of prehistoric sites in Lowell, a major Native American archeological site is on the flood plain beyond the bluff. Much of this area, site of Native American campgrounds and cultural activities associated with fishing, has been disturbed by a series of construction projects for roads and buildings. The likely locations of artifactual remains lie northeast of the path followed by the intake channel (Boott Mills 1980).

E.7.8.1.3 Historical Context

This section provides an historical context of the Project Area from early Anglo-European settlement through the Industrial Revolution.

Anglo-European settlers gradually acquired Native American homelands, and private ownership divided the once common land into scattered farms. Proprietors of riverbank properties even acquired legal title to the fishing rights on sections of the rapids. Although remnants of former Native American bands made annual trips to fish at the Pawtucket Falls as late as the 1840s, they were considered a quaint curiosity in the growing industrial community (Boott Mills 1980).

Background of Industrial Lowell

A number of circumstances are responsible for Lowell becoming America's first industrial city, particularly, the existence of the great waterpower potential at the Pawtucket Falls. Although a transportation canal around the rapids at Lowell was completed in 1796, the manufacturing potential of the site was not fully appreciated until 1821. The Boston Associates chose the site of the Pawtucket Falls for their new textile manufacturing community (Boott Mills 1980). The Boston investors acquired control of Proprietors of the Locks and Canals on Merrimack River, the company that had built the Pawtucket navigation canal and that, due to the success of the competing Middlesex Canal (direct route to Boston), was not doing well financially. The Boston investors and other industrialists formed a series of textile corporations in Lowell. The old canal company was set up to build canals, sell mill sites, manufacture machinery, and lease waterpower to the textile manufacturers (Boott Mills 1980). The Pawtucket Canal became the feeder for a complex system of power canals beginning in 1822. By 1826, two canals branched from the Pawtucket and four additional canals were already envisioned. Ten years later, the expanded system was complete. Water drove the machinery of mills located on two distinct levels, with the tailraces of mills on the upper level emptying into canals leading to lower level mills. By 1846, when a second major expansion of the canal system began, ten textile mill complexes and a machine shop received their power from Proprietors of the Locks and Canals on Merrimack River (Boott Mills 1980).

General History of the Northern Canal Area

Since 1826, engineers had been able to increase the flow into the Lowell Canal system by constructing dams at Pawtucket Falls. The first was a crude wooden structure; but by 1830, a masonry dam seated on heavy wooden cribbing was helping to maintain a “pond” behind the falls. Three years later, workmen added two more courses of granite headers and raised wooden flashboards. This raised the level of the upper river and diminished its current for over 18 miles upstream. However, the dam did not meet the water needs of the growing industrial city for long as the demand for waterpower continued to increase yearly as the textile corporations expanded their manufacturing operations. Power was continually scarce in the dry summer months; and by the 1840s, shortages were common throughout the year. One problem was the severe friction losses in the canals created by greater flow rates. When mills needed more water, the current had to increase to supply this demand. Increased current produced friction, which actually dropped the level of water in the canals and reduced the head, or potential to generate power. Thus, the mills could only get a greater flow of water by giving up some of the head that they also needed. In times of freshets, river water entering the tailraces of mills impeded their wheels. Such backwater conditions placed excessive demands on the canal system (Boott Mills 1980).

James B. Francis, the British-born chief engineer of Proprietors, proposed the construction of a second feeder canal. This huge waterway would bring additional water into the system and allow a reduction of current in most of the canals. To make such a plan effective, however, two conditions had to be met. First, Locks and Canals would have to prohibit the use of water for manufacturing at night, so that the river’s flow could be ponded until the morning. Second, the power company would have to control the outlets of the major lakes that fed the Merrimack River. Using the lakes as reservoirs, Lowell would then have a source of extra water in dry seasons (Boott Mills 1980).

With booming economic conditions in American textile manufacturing in the 1840s, the Essex Company of Lawrence and the Locks and Canals acquired control of over 100 square miles of lake surface in New Hampshire. James. B. Francis selected a new route for a second feeder canal. The route ran parallel to the river for over 2,000 feet, then turned inland to join the Western Canal. The route required Francis to build a “Great River Wall” to hold his canal above the Merrimack rapids and also required him to (1) rebuild a large part of the Pawtucket Dam, (2) construct sophisticated gate controls, and (3) modify the existing canal system to integrate it with the new canal (Boott Mills 1980).

The construction of the Northern Canal, under the supervision of James B. Francis in 1846-1847, was one of the most impressive achievements in the history of American engineering. The vast undertaking was the culmination of efforts to harness the flow of the Merrimack River at Pawtucket Falls to drive the textile machinery of the Boston investors. When completed, the project set new standards in civil and hydraulic engineering and introduced the famous “Francis” turbine to the world (Boott Mills 1980). The Northern Canal brought water into the system with a higher head than had been previously possible, and it reversed the current in the Western Canal from the junction to the Swamp Locks Basin. Water from the Northern Canal supplied the demands of the Tremont, Suffolk, and Lawrence Mills. Once Francis had completed the Moody Street Feeder in 1848, the Northern Canal also fed the Merrimack Canal through three brick vaulted tunnels. A smaller underground passage, known as the Boott Penstock, transferred some of this flow from the Merrimack Canal to the end of the Eastern Canal, where an adequate water level had always been hard to maintain (Boott Mills 1980). After testing the results of his physical improvements to the system, Francis arranged for redistribution of power and an increase in the number of “mill powers” leased to each company. Because of the limitations of the old Pawtucket Canal as the sole feeder, only 91 mill powers had been leased up to that time. The Northern Canal enabled the chief engineer to lease 139 mill powers, a gain of more than 50 percent. These were "permanent mill powers” to be supplied in all seasons; for most of the year, the corporations could also purchase “surplus" mill powers at an inexpensive rate. The mill complexes were assured of almost 12,000 gross horsepower, even in summer (Boott Mills 1980).

Francis, acting as "The Chief of Police of Water,” tried to prevent waste in the system and developed techniques to monitor the water use by individual corporations. When the flow in the river was low, he even closed the gates of the Northern Canal during the noon break. His 1846 tests of Uriah Boyden's outward-flow turbines in the Appleton Mills led to the development of the first “Francis” turbine, which was used to raise and lower the headgates within the Pawtucket Gatehouse. The original Francis turbine and drive belts remain in the Pawtucket Gatehouse, but are no longer used. This work convinced Francis that the corporations should switch from breastwheels to more efficient hydraulic turbines. In this way, they could produce more net horsepower from each “mill power" delivered to their sites. Also, turbines, which ran well underwater, could generate during the "backwater" conditions that ruined the efficiency of breastwheels. The widespread conversion to turbines in Lowell took place during and immediately following the construction of the Northern Canal. Francis' Northern Canal and its associated structures remain one of the most important historic engineering resources in the Northeast (Boott Mills 1980).

Historic Resources

In 1976 the Locks and Canals Historic District was listed on the National Register of Historic Places. The Locks and Canals Historic District includes the City of Lowell’s canal system, surviving millyards, and other industrial-related resources. In 1977, the Locks and Canals Historic District was designated a National Historic Landmark (NHL), the nation’s highest level of historic significance and recognition. In 1978, Congress passed the Lowell Act, which recognized the historical value of this industrial area and established the Lowell Park and Lowell Historic Preservation District, stating:

> *"…certain sites and structures in Lowell, Massachusetts, historically and culturally the most significant planned industrial city in the United States, symbolize in physical form the Industrial Revolution…"*

The Lowell Historic Preservation District surrounds Lowell Park as a buffer zone and enables federal assistance in the preservation and revitalization of the City of Lowell, while Lowell Park consists of the areas indeed for intensive visitor use in the interpretation of the City of Lowell and its canal system. The intention of the establishment of the Lowell Park and Lowell Historic Preservation District is to preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts.

A Cultural Resources Inventory of the Lowell National Historical Park and Preservation District was prepared for the NPS in 1980. This inventory was completed in response to the 1978 legislation establishing the Lowell National Historical Park and the Lowell Historic Preservation District. This legislation was two-fold in that it created a park as well as a historic preservation district. The legislation outlined broad policies and goals of the federal commitment and required careful planning. To address this need for planning, the cultural resources inventory was conducted to assess the resources and aid in future planning. The defining features of the Locks and Canals Historic District and Lowell National Historic District are discussed in further detail below.

Locks and Canals Historic District

The Locks and Canals Historic District was listed on the National Register in 1976 and became a National Historic Landmark in 1977. The Locks and Canals Historic District encompasses all the canals in Lowell (built between 1793 and 1848), their associated locks, and the mills that were powered by the canals. This district contains features of the Lowell Project. There are approximately five miles of canals, and the associated mill yards increase the acreage of the district to approximately 100 acres. The canals are contiguous and meander throughout the city. The mill buildings and yards are all associated directly with a canal, and three boarding houses, not contiguous to the canals but built by mill owners for their workers, are also included in the district. The main components of the Locks and Canals Historic District are:

- Lock House
- Francis Gate and House
- Sluice Gate House
- Northern Canal Gatehouse
- Locks and Canals Blacksmith Shop
- Gate Keeper's Cottage
- Northern Canal
- Northern Canal Walk and Great River Wall
- Suffolk Millyard
- Tremont Gatehouse
- Tremont Yard

- Lawrence Yard
- Moody Street Feeder
- Moody Street Feeder Gatehouse
- Boott Mills
- Massachusetts Mills
- Boot Mills Boarding House
- Massachusetts Mills Boarding House
- Lower Locks, Pawtucket Canal
- Bigelow Yard
- Hamilton Yard
- Eastern canal
- Lower Pawtucket Canal
- Appleton Mills
- Hamilton Canal
- Swamp Locks
- Merrimack Canal
- Lowell Machine Shop
- Proprietors of Locks and Canals Yard
- Western Canal
- Upper Pawtucket Canal
- Pawtucket Dam
- Suffolk Manufacturing Company Boarding Houses

The Locks and Canals Historic District is significant for its contributions to the development of Lowell as the first great industrial city in the United States.

Lowell National Historical Park

The LNHP and Preservation District was listed on the National Register in 1978. The LNHP Preservation District includes within its boundaries an approximate 5-mile power canal system, a portion of the central business district, and three major mill complexes. The area within the park boundaries totals 134 acres, but with only NPS ownership of a handful of buildings with other property privately owned. The Lowell Historic Preservation District includes the mills or mill sites of most of the rest major textile corporations, the remainder of the historic central business district, and areas along the Concord River where smaller factories flourished outside the main waterpower system. There are 895 properties within Lowell Park and the Lowell Historic Preservation District and are classified as follows:

- 307 residential buildings
  - 147 single family
  - 62 duplexes
  - 99 multiple family
- 210 commercial buildings
- 130 buildings within textile mill complexes
- 27 other industrial structures
- 16 schools

- 9 churches
- 24 government buildings
- 92 vacant lots
- 33 components of the canal system
- 11 bridges
- 37 miscellaneous structures (theaters, parking garages, playgrounds, etc.)

In terms of the condition, the properties (excluding the canals) are classified according to 1979 data as follows: 56 in excellent condition, 412 in good condition, 244 need minor repair, 70 need major repair, and 8 are derelict. In terms of period, the structures range in period from pre-1820 to post-1950 with the greatest number of structures dated in the 1890s and from 1900-1925.

Lowell Park and the LHPD's most important historical resources are the canal system, the remaining major mill complexes, and the central business district's nineteenth century commercial buildings. The District also includes elements of other historic industrial enterprises, particularly along the Concord River. Residential properties within the District represent most of the range of styles, forms, and periods of Lowell's architectural history, but these houses generally fall short of Lowell's historic houses outside the Lowell Historic Preservation District's in quantity, quality, and concentration.

Lowell Canal System

The Lowell Canal System has also been recognized for its significance within the field of engineering. The American Society of Civil Engineers designated the "Lowell Waterpower System" as a Historic Civil Engineering Landmark in 1984, and the American Society of Mechanical Engineers designated the "Lowell Power Canal System and Pawtucket Gatehouse" as a Historic Mechanical Engineering Landmark in 1985 (MADCR 2014).

E.7.8.1.4 Cultural and Historical Resource Studies

Pursuant to the approved RSP and SPD, Boott filed with the Commission the following studies relating to historical and cultural resources:

- Water Level and Flow Effects on Historic Resources Study (HDR 2021b),
- Historically Significant Waterpower Equipment Study (Gray & Pape 2021), and
- Resources, Ownership, Boundaries and Land Rights Study (HDR 2021c).

Significant prior research and studies have been conducted to document historic buildings and structures within the City of Lowell, including Project facilities. In 1976, the Historic American Engineering Record (HAER) documented the history of the canal system in Lowell. The HAER study included detailed narratives, photographs, drawings, and maps of the historic canal system. The Lowell National Historical Park and Historic Preservation District Cultural Resources Inventory (Shepley, 1981) provides a comprehensive and detailed inventory of historic buildings and structures within the park unit and surrounding preservation area. Later studies, including the 1984 HAER documentation of the Boott Cotton Mills Complex, documented specific resources within the park unit. While these studies have documented historically significant buildings, structures, and some of the hydroelectric equipment associated with the Project, no systematic survey of historically significant waterpower equipment associated with the Project has been conducted until now.

Ownership, boundaries, and land/access rights within the FERC Project Boundary in downtown Lowell are complex. The licensee owns some, but by no means all, of the existing Project works. The Project is situated within several different and overlapping parks, and preservation/conservation districts. The canal system, the downtown mill sites, and many of the Project's civil works, are contributing resources to Lowell Locks and Canals NHL District. The canal system and many Project facilities are also located within the LNHP and larger Lowell Historic Preservation District. The park is by design a partnership park in which federal, state, and local governments as well as the private sector and local community carry out the legislative intent of the park unit. The Project's Hamilton, Assets, Bridge Street, and John Street power stations and turbines are housed in large old mill buildings within the Lowell National Historical Park and Lowell Historic Preservation District. As stated elsewhere in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the NPS and other stakeholders.

Water Level and Flow Effects on Historic Resources Study

In accordance with the Commission's SPD, Boott conducted a Water Level and Flow Effects on Historic Resources Study. The objective of this study was to analyze the potential effects of water level fluctuations from Project operations in the headpond, Northern Canal, and the Upper Pawtucket Canal (extending upstream from the Guard Lock Gate Complex to the mainstem of the Merrimack River) on historic structures with a focus on the Pawtucket Gatehouse, the Northern Canal Waste Gatehouse, the Guard Lock and Gatehouse Complex, and the Great Wall. Methods and results are described in detail in Boott's study report (HDR 2021b) which was filed with the Commission on March 5, 2021.

The results indicated the magnitude of fluctuation in the Project's headpond and the Pawtucket Canal has been significantly reduced by the implementation of the pneumatic crest gates, as shown by post crest gates operations presented in Figure E. 7-39 and pre crest gate operations shown in Figure E. 7-40 below. Water levels in the Pawtucket Canal upstream of the Guard Locks complex are essentially the same as the Project impoundment and remained below the normal headpond level of 92.2 ft NGVD29 throughout the 2020 study period except for one occasion. The elevation of the Guard Locks complex walkway (92.45 ft), the clapboard siding (92.45 ft), and the bottom of the mid-level windows (94.08 ft) are all above the normal water level of the Upper Pawtucket Canal. Only river flows in excess of 35,000 cfs could cause the Upper Pawtucket Canal to inundate the wooden structural elements of the Guard Locks complex; however, these conditions are outside of the ability of the Project to control the impoundment water level and therefore not attributable to Project operations.

The operation of the Northern Canal has caused periodic inundation of the sill at the Northern Canal Waste Gatehouse (Figure E.7-41). This inundation may be one factor in the continued deterioration of the gatehouse's southern sill. Spray from the canal spillway may also be contributing to deterioration along the eastern end of the northern sill.

Figure E.7-39. Project Headpond Water Surface Elevation During 2020 Monitoring Period

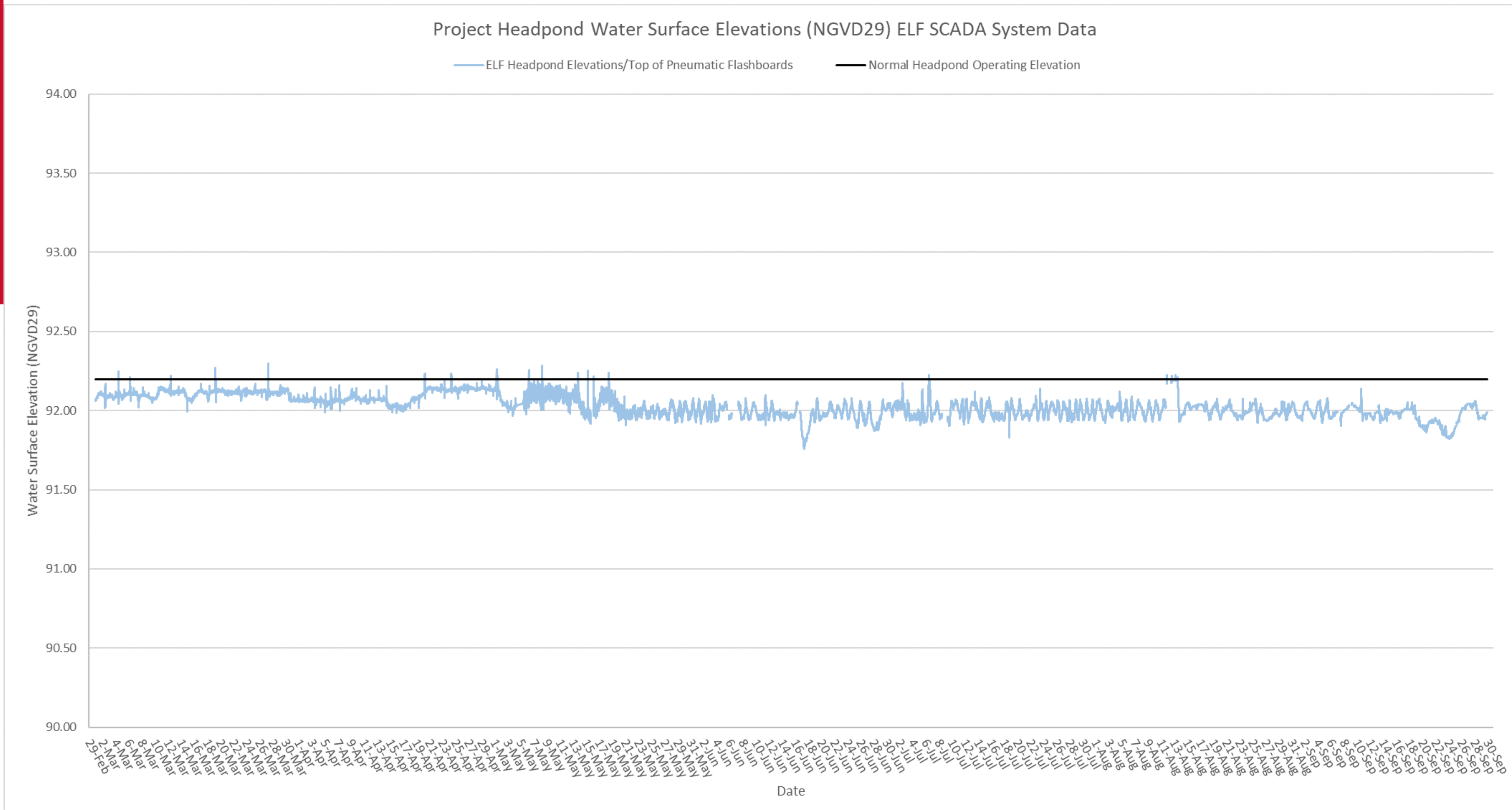


Figure E.7-40. Merrimack River – Pawtucket Dam Headpond Elevations for Period of Record (1995-2010)

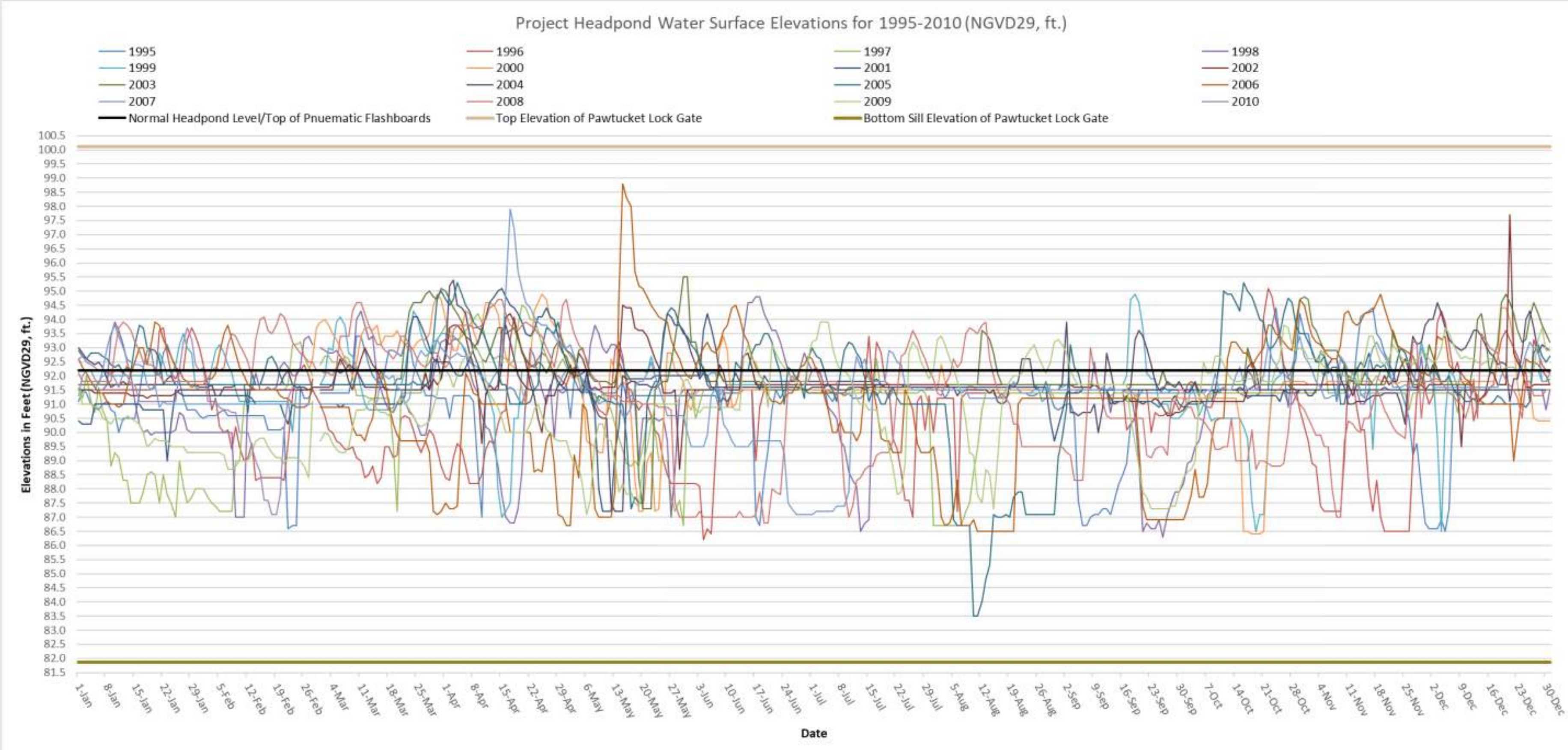
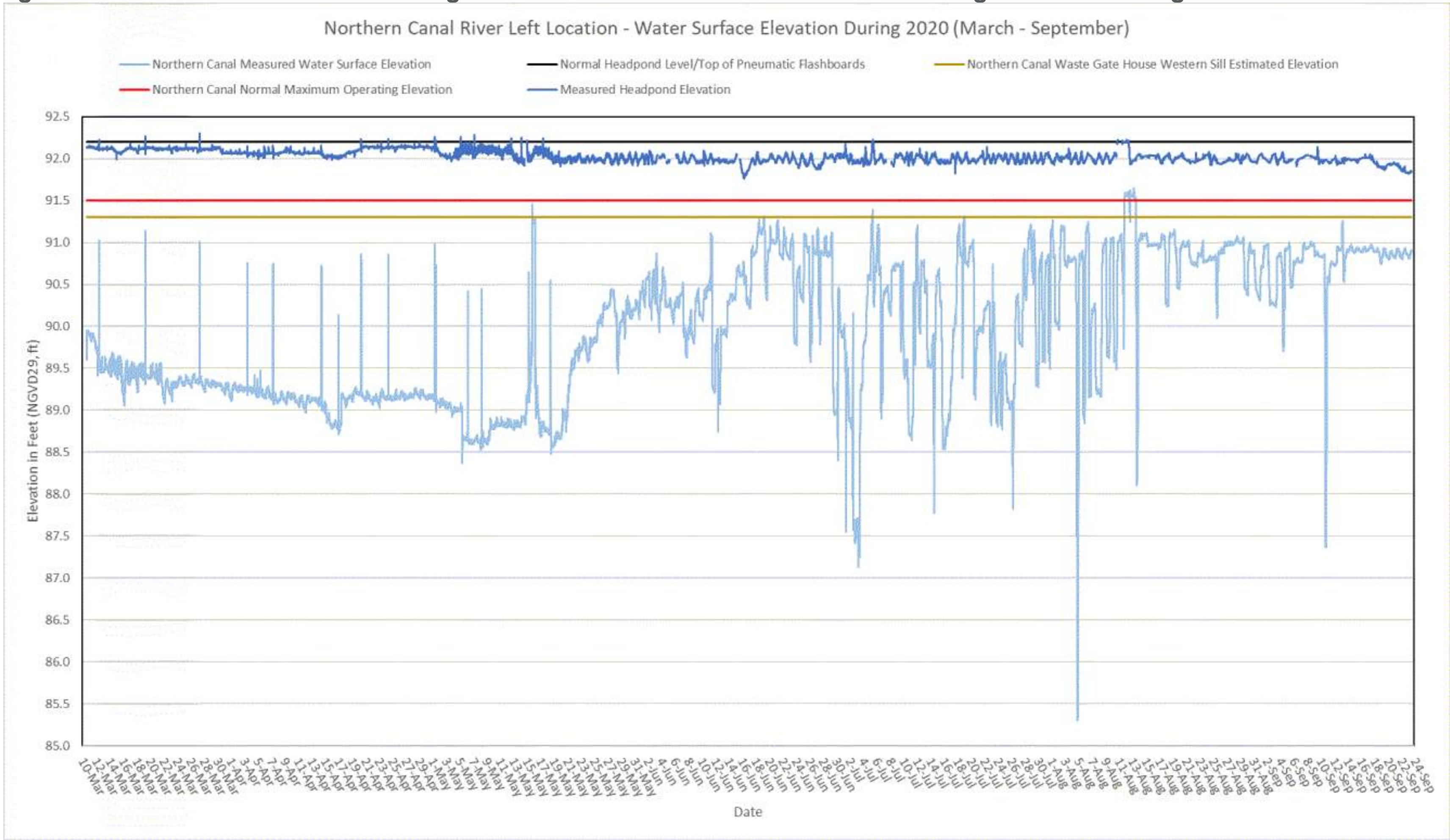


Figure E.7-41. Northern Canal River Right Location - Water Surface Elevation During 2020 Monitoring Period



The results of the study indicate the wooden structural elements of the historic resources located along the Upper Pawtucket and Northern Canals appear most susceptible to damage from submergence, periodic inundation, and waterborne trash. While the magnitude of fluctuation in the Project's headpond and the Pawtucket Canal has been significantly reduced by the implementation of the pneumatic crest gates, the Merrimack River is subject to routine seasonal high flow events. High flow events can also mobilize waterborne trash and debris that have the potential to damage wooden structural elements; however, neither high flow events nor the presence of waterborne trash and debris in the Merrimack River are attributable to Project operations.

While normal Project operations do not appear to be adversely affecting the Pawtucket Gatehouse Lock Structure beyond normal wear, at least one incident appears to have contributed to recorded damage to the upstream miter gate (Figure E.7-42). The canal surge event that occurred in 2018 was caused by the malfunction of a water level transducer. The effect of the resulting surge was exacerbated by the practice of chaining the gates closed. This anomalous incident does not represent normal Project operations, and Boott is repairing the damage to the gate.

Figure E.7-42. Damage to the Northern Canal Lock Timber Gate

Historically Significant Waterpower Equipment Study

In accordance with the Commission's SPD, Boott conducted a Historically Significant Waterpower Equipment Study to identify historically significant waterpower equipment for potential future interpretation, exhibition, or as scrap equipment to maintain and operate other historic machinery. Methods and results are described in detail in Boott's study report (Gray and Pape 2021) which was filed with the Commission on February 25, 2021.

The results indicated that it is the totality of the system of waterpower and water-control machinery at Lowell that is historically significant. Removal and replacement of individual pieces of equipment was nearly continual, from the day the system first became operational. Removal or alteration of existing equipment would constitute an adverse effect upon the qualities that make the existing system historically significant if they prevented or precluded the system from operating. Several pieces of equipment appear to be historically significant, distinct from their role as a part of the larger system. These pieces of equipment include the surviving 1870 hydraulic gate hoist system at the Pawtucket Canal Guard Locks, and the Francis turbine powered belt-and-line shafting gate operating system at the Pawtucket Gatehouse. The extant gate operating system at the Moody Street Feeder Gatehouse is likely also historically significant.

Resources, Ownership, Boundaries, and Land Rights Study

Pursuant to the approved study plan, Boott conducted a Resources, Ownership, Boundaries, and Land Rights Study to determine current ownership of resources within the canal system and existing Project Boundary, and document maintenance responsibilities, access rights, and FERC jurisdiction. The methods and results of the Resources, Ownership, Boundaries, and Land Rights Study filed with the Commission on February 25, 2021.

Ownership, easement rights, and use of the canal system in Lowell are complex, with intersecting roles between public agencies and private entities at the local, State, and Federal level. Boott conducted desktop research and a literature review to compile and review available ownership and rights documentation to obtain a better understanding of the rights and responsibilities related to resources within the Project Boundary. As appropriate and relevant, public guidance and conceptual planning and/or management documentation was reviewed by Boott including the 1977 Report of the LHCDC, the 1980 Details of the Preservation Plan, the 1981 FGMP, and the 1990 Preservation Plan Amendment. Additionally, Boott reviewed and analyzed the three legal documents that establish most of the ownership, responsibilities, and land rights to the Lowell canal system. The 1984 Deed, Bill of Sale and Grant of Easements, also known as the "Great Deed" details the sale of portions of the Project from the Proprietors of the Locks and Canals on the Merrimack River (Proprietors) to Boott, as well as associated access and repair easements. The 1986 Order of Taking details the take of properties, rights, and responsibilities from Boott and Proprietors to the Commonwealth, operating through MADCR. The 1995 Grant of Easement describes the easement rights provided to the NPS from MADCR for specific properties and parcels around the canal system.

The conceptual framework for the rights and responsibilities for management of the Lowell canal system remain consistent within the 1977 Report of the LHCDC, the 1980

Details of the Preservation Plan, the 1981 FGMP, and the 1990 Preservation Plan Amendment. MADCR and NPS are presented as the main parties responsible for developing, renovating, and maintaining the major elements of the canal system. In the 1977 Report of the LHCDC, agency responsibilities were characterized and are shown below in Table E.7-32.

Table E.7-32. Agency Responsibilities Identified in 1977 Report of the LHCDC

Agency	Responsibilities
NPS	interpretation, park wide downtown "cross-section" of 19th Century Lowell (including preservation, building and open space improvements, transportation, and visitor services)
MADCR	canals, riverbanks, and related recreational areas gatehouses, locks and dams barge system

Ownership of the Lowell canal system is largely determined by the 1984 Great Deed and 1986 Order of Taking. Components of the canal system are owned by Proprietors, Boott, and MADCR. Proprietors owns most of the Pawtucket Canal and Lower Pawtucket Canal, as well as all or portions of associated structures in those canals (e.g. Swamp Locks Dam, Lower Locks Dam, and the Guard Locks and Francis Gate). Boott is not known to own any structures of or within the Pawtucket or Lower Pawtucket Canal.

Boott owns the Northern Canal, Western Canal, Merrimack Canal, Eastern Canal, and Hamilton Canal. Boott owns specific dams, lock structures, and hydroelectric equipment within the canals they own. The specific structures fully owned by Boott within these canals include Hall Street Dam, Lawrence Dam, Boott Dam, Rolling Dam, Merrimack Dam, Merrimack Gates, YMCA Gates, and the Moody Street Feeder. Boott owns hydroelectric equipment located inside most gatehouses, such as the Boott Dam Gatehouse and Tremont Gatehouse, but Boott does not own the gatehouse buildings.

MADCR owns most of the gatehouses throughout the canal system (e.g. Pawtucket Gatehouse, Lower Locks Gatehouse, and Swamp Locks Gatehouse, Rolling Dam Gatehouse, Hamilton Gatehouse, and Massachusetts Wasteway Gatehouse) and this is largely determined based on elevation.

Easement rights to structures of the Lowell canal system are held by Proprietors, Boott, MADCR, and NPS. In the 1984 Great Deed, Boott obtained easement rights, in common with Proprietors, to the Pawtucket Canal and structures of the Pawtucket Canal. These easement rights allow Boott to access, operate, maintain, repair, and replace the Pawtucket Canal and structures of the Pawtucket Canal. In the 1986 Order of Taking, MADCR obtained a permanent and exclusive easement to structures of the canal system, including canal walls, beds, and bottoms, for purposes including conservation, preservation, maintenance, and other uses consistent with the use of the system as a park. NPS obtained similar easement rights through the 1995 Grant of Easement from MADCR, including the right to maintain, repair, conduct grounds maintenance, and operate boat tours.

An exclusive easement allows the easement holder to control and implement specific purposes as if they are the owner. MADCR has a permanent and exclusive easement over most of the canal system for the following purposes, which include the following enhancements and upgrades:

a) Support of all fixtures or structures of the Commonwealth now or hereafter attached;
b) Preservation and conservation;
c) Supplemental maintenance in addition to that performed by the Condemnees (the prior or current owner) and their successors and assigns;
d) Landscaping and erection of exhibits and structures;
e) Placement of barriers and fences;
f) Placement and attachment of docks, wharves, walls, and boat ramps of a temporary or permanent nature;
g) Placement of lighting and other utilities;
h) Operation and maintenance of boat locking chambers, if any, for any and all purposes; and
i) Any and all other uses consistent with the operation of the canal system as a park.

Given that MADCR's exclusive easement is throughout most of the canal system, it overlaps significantly with Boott and Proprietors' owned property. It is understood that Boott, Proprietors, and MADCR have a duty and right to maintain properties under their ownership to achieve a standard of reasonable care. Owners do not have an obligation or duty to upgrade or enhance their property. However, MADCR's exclusive easement throughout most of the Lowell canal system gives them the right to implement any of the purposes noted above, which include enhancements and upgrades, as if they were the owner.

The Resources, Ownership, Boundaries, and Land Rights Study also determined different resource rights. The results indicated that recreational resource rights are exclusively owned by MADCR. In early conceptual planning documents, MADCR was presented as the party that would own, implement, and manage any recreational resources. MADCR obtained such rights in the 1986 Order of Taking, including the exclusive right to use water for recreational, educational, or navigational purposes, and permanent and exclusive rights to build wharves, docks, and boat ramps. The two other identified resources are air resource rights, and water and flowage rights. Air resource rights have been owned by MADCR since issuance of the 1986 Order of Taking. Water and flowage rights are owned by Boott and Proprietors, as established in the 1984 Great Deed.

E.7.8.2 Environmental Analysis

The NHPA establishes the statutory responsibility of federal agencies to consider historic properties under their jurisdiction. Section 106 requires federal agencies to consider the effects of their undertakings on historic properties listed in or eligible for inclusion in the NRHP. The Commission's issuance of a new license for the Project is defined as an undertaking under the NHPA and is, therefore, subject to the provisions of Section 106 and its implementing regulations at 36 C.F.R. Part 800.

FERC's SD2 identified effects of continued Project operations on cultural and historical resources as potential resource issues. Specifically, SD2 identified the following potential resource issues related to cultural and historical resources to be analyzed for site-specific effects:

- Effects of continued project operation and maintenance on historic resources, archeological resources, and traditional cultural properties that are included or may be eligible for inclusion in the National Register of Historic Places.
- Effects of continued project operation and maintenance on properties of traditional religious and cultural importance to an Indian tribe.

During the previous relicensing, Boott consulted extensively with the Massachusetts SHPO and NPS to avoid destroying historic Waste Gates on the Northern Canal and to fund repairs to the Northern Canal Gates to restore them to their original condition. The proposed powerhouse was relocated, and fish passage facilities were modified to avoid any impacts to the Northern Canal Gatehouse. In addition, the Owner constructed a new set of locks in the Northern Canal to provide boat passage, to avoid any loss of historic use of the canal system. Furthermore, additional mitigative measures were undertaken by the Licensee to minimize impacts of new structures introduced into the historic district (Cleantech Analytics 2017).

Current Project operations may be a contributing factor to the continued deterioration of the Northern Canal Waste Gatehouse's southern and northern sills. The Northern Canal periodically inundates the southern sill, and spray from the Northern Canal spillway may be contributing to the deterioration of the northern sill. Repeated inundation and drying of timber sills has the potential adversely affect the integrity of the Northern Canal Waste Gatehouse; however, other factors unrelated to Project operations have also likely contributed to the ongoing deterioration of the sills, including the age of the wooden timbers, general maintenance, weathering, and atmospheric conditions.

Boott has not identified any other historic properties that are being adversely affected by the ongoing operation and maintenance of the Project. As noted above, Boott determined at least one incident that appears to have contributed to recorded damage to the upstream miter gate at the Pawtucket Gatehouse. This anomalous incident does not represent normal Project operations, and Boott is repairing the damage to the gate.

Boott is not currently proposing modifications to the Project's operations or any land-clearing or land-disturbing development activities within the APE that would result in an impact to any archaeological sites, historic architectural resources, or areas that have been identified as having moderate to high potential for containing archaeological sites.

In addition, only one out of the nine tribes, the Mashpee Wampanoag Tribe, responded to FERC's initial tribal consultation letter dated April 26, 2017 and did not identify any concerns related to the Project pertaining to cultural resources.

E.7.8.2.1 Effects of Decommissioning

While Boott is not proposing modifications to the Project's operations that have the potential to adversely affect historic properties, Boott is proposing to remove the four mill power stations and associated canal infrastructure from the Project boundary and the new FERC license. Pursuant to 36 C.F.R § 800.5(a)(2)(vii), the removal of the downtown canal system from FERC's federal jurisdiction could result in an adverse effect if removal is done "without adequate and legally enforceable restrictions or conditions to ensure long-term preservation of the property's historic significance." As noted above, the downtown canals are located within the LNHP, the Locks and Canals Historic District (a National Historic Landmark) and the Lowell National Historical Park and Preservation District, which are listed in the National Register of Historic Places. Accordingly, Boott expects that potential effects will be limited as the downtown canal system and associated structures will still remain under the federal and state oversight provided by the NPS and MADCR.

As reported in the Resources, Ownership, Boundaries, and Land Rights Study Report (HDR 2021c), Boott owns all the canals except the Pawtucket Canal and Lower Pawtucket Canal, but MADCR and NPS have various easement rights to the downtown canal system for purposes of preservation, conservation, and other uses consistent with that of a park. MADCR has a permanent and exclusive easement to the entire canal system for all uses consistent with the operation of the canal system as a park, which gives MADCR the right to implement preservation and conservation measures as if they were the owner of the structures. Boott does not own most of the historic gatehouses, dams, and locks that will be removed from the Project boundary with the canals; these are mostly owned by MADCR and Proprietors. Boott does have certain easement rights to these structures they do not own, but those easement rights are mostly limited to hydropower maintenance and operation. While the removal of the downtown canal system may result in an adverse effect, the system will remain protected by federal and state oversight, and Boott will still be obligated to and limited by its legal agreements with MADCR and NPS. Further, and as discussed below, Boott is proposing to develop a decommissioning plan to address, *inter alia*, the final disposition of the canal system, turbine-generator units, water conveyance structures, and mechanical and electrical components.

Boott is not proposing demolition or land-clearing activities in association with decommissioning the downtown powerhouses. Decommissioning the powerhouses will not adversely affect the integrity of the LNHP, Locks and Canals Historic District, or the Lowell National Historical Park and Preservation District. Boott will continue to provide flows into the canal system and maintain water levels consistent with current practices. Boott will also maintain canal facilities consistent with existing rights, responsibilities, and existing or new agreements developed among the concerned stakeholders. For these reasons, Boott does not anticipate that the proposed removal of the canal facilities from the FERC license and the decommissioning of the downtown powerhouses will have an adverse effect on historic or archaeological resources.

E.7.8.3 Proposed Environmental Measures

- Boott proposes to continue operations of the Project with certain PM&E measures required by the existing license. This includes continued adherence to Article 33, which requires that prior to the commencement of any construction activities inside the Project boundary, Boott will cooperate with the Massachusetts SHPO and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historical Park.
- Boott understands that removal of the fifteen turbine-generator units and canal system from its license will require a decommissioning plan to define the final disposition of the canal system, turbine-generator units, water conveyance structures, and mechanical and electrical components. A decommissioning plan is also necessary to protect the public from any safety, dam safety, or environmental concerns. Boott will develop a decommissioning plan for each of the four downtown power stations and the canal system. In developing the decommissioning plan, Boott will consult with the NPS, MADCR, City of Lowell, and the MHC. Boott will file a decommissioning plan for the Commission's approval within 18 months of issuance of a new license.

  Within one year of license issuance, Boott will develop an HPMP for the Project that will describe appropriate management measures to avoid, minimize, or mitigate adverse effects on historic and archaeological resources over the term of the new license issued for the Project. The measures provided in the HPMP will direct the Licensee's management of NRHP-listed or eligible historic properties within the Project's APE, which is preliminary defined as the proposed Project boundary. Boott will develop the HPMP in consultation with the NPS, MHC, NHDHR, and Indian tribes.

  Through this consultation, the Licensee will develop historic properties management measures to be incorporated into the HPMP. Boott has outlined the following two goals for managing historic resources within the Project's APE:

  - Support continued normal operation of the Project while maintaining and preserving the integrity of historic properties; and
  - To the fullest extent possible, avoid, minimize, or mitigate adverse effects on historic properties within the APE.

  To address these goals, the Licensee will develop an HPMP for the Project in accordance with the *Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects* promulgated by FERC and the ACHP on May 20, 2002. The HPMP will describe measures for the management of and protection of historic properties within the Project's APE through the term of the new license. As such, continued operation of the Project as proposed by the Licensee is not expected to adversely affect historic or archaeological resources.

E.7.8.4 Unavoidable Adverse Impacts

The continued operation of the Project as proposed by the Licensee is not expected to have any unavoidable adverse effects on historic or archaeological resources.

E.8 Economic Analysis

This section identifies estimated costs specific to proposed PM&E measures. Overall Project cost and value information is provided in Exhibit D of the license application.

Table E.8-1. Incremental O&M/Annual Costs of Proposed PM&E Measures

Proposed PM&E Measure	One Time Implementation/ Construction Costs (2021 Dollars)	Incremental Operations and Maintenance (O&M) Costs or Annual Costs (2021 Dollars)
ROR operation	$0 – (currently implemented)	$0
Modifications to upstream fish ladder and bypass weirs	$100,000	$5,000
Provide 100 cfs bypass flow approximately . July 16 – April 30	$0	± 1,100 MWh / year lost generation
Upstream fish ladder	$2,600,000	$10,000
Cessation of fish elevator operations	$75,000	$0
Downstream rack structure	$5,200,000	$10,000
Develop and implement a Decommissioning Plan for each of the four downtown power stations and file for FERC approval.	$4,000,000	$0
Develop a Historic Properties Management Plan and file for FERC approval.	$75,000	$5,000
Develop a Recreation Access and Facilities Management Plan and file for FERC approval.	$50,000	$10,000

E.9 Consistency with Comprehensive Plans

Section 10(a)(2) of the FPA, 16 U.S.C. section 803(a)(2)(A), requires the Commission to consider the extent to which a project is consistent with federal and state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by a project. Under 18 CFR §5.18(b)(5)(ii)(F) each license application must identify relevant comprehensive plans and explain how and why the proposed project would, would not, or should not comply with such plans. In addition, the license application must include a description of any relevant resource agency or Native American Tribe determination regarding the consistency of the project with any such comprehensive plan.

The Commission's SD2 identified twenty-eight comprehensive plans for New Hampshire and Massachusetts that are potentially relevant to the Lowell Hydroelectric Project. On December 19, 2018, the NPS filed five additional comprehensive plans, and by letter dated March 20, 2019, the Commission accepted four of the five plans. Boott has reviewed the Commission's list of the available comprehensive plans. Listed below are the comprehensive plans applicable to the Project. For the reasons noted in this application, Boott has determined that the proposed operation of the Project, as proposed in this Final License Application, is consistent with these plans.

E.9.1 Federal Plans

Atlantic States Marine Fisheries Commission. 1998. Amendment 1 to the Interstate Fishery Management Plan for Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*). (Report No. 31). July 1998.

Atlantic States Marine Fisheries Commission. 1999. Amendment 1 to the Interstate Fishery Management Plan for shad and river herring. (Report No. 35). April 1999.

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E.9.2 Massachusetts Comprehensive Plans

Massachusetts Department of Environmental Management. n.d. Commonwealth connections: A greenway vision for Massachusetts. Boston, Massachusetts.

Massachusetts Department of Fish and Game. 2006. Comprehensive wildlife conservation strategy. West Boylston, Massachusetts. September 2006.

Massachusetts Executive Office of Energy and Environmental Affairs. Statewide Comprehensive Outdoor Recreation Plan (SCORP): Massachusetts Outdoor 2006. Boston, Massachusetts.

E.9.3 New Hampshire Comprehensive Plans

Merrimack River Policy and Technical Committees. 1990. Strategic plan for the restoration of Atlantic salmon to the Merrimack River, 1990 through 2004. Concord, New Hampshire. April 1990.

New Hampshire Office of Energy and Planning. 2007. New Hampshire Statewide Comprehensive Outdoor Recreation Plan (SCORP): 2008-2013. Concord, New Hampshire. December 2007.

New Hampshire Office of State Planning. 1977. Wild, scenic, & recreational rivers for New Hampshire. Concord, New Hampshire. June 1977.

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E.10 Consultation Documentation

In accordance with 18 C.F.R § 5.18(b)(5)(G), a list of containing the name, and address of every Federal, state, and interstate resource agency, Indian tribe, and member of the public with which the Licensee consulted in preparation of Exhibit E is presented in Volume I. In addition, Boott is providing a consultation log of relevant correspondence with the contacts of the distribution list and copes of relevant documentation, presented in Appendix C.

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ATTACHMENT F

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Boott Hydropower, LLC (Boott), a subsidiary of Enel Green Power North America, Inc. (Enel), is the Licensee and operator of the Lowell Hydroelectric Project (FERC No. 2790) (Project), with principal Project facilities located along the Merrimack River in Middlesex County, Massachusetts and a reservoir extending upstream to Hillsborough County, New Hampshire (see attached map). Boott, with assistance from HDR, Inc. (HDR), is beginning the Federal Energy Regulatory Commission (FERC) relicensing process for the existing Project. Accordingly, Boott is preparing a Pre-Application Document (PAD) that will provide FERC and other entities with existing, relevant, and reasonably available information pertaining to the Project that will be used to prepare documents related to analyzing the relicensing application to be prepared by Boott. To prepare the PAD, Boott will use information in its possession and information obtained from additional sources. This PAD Information Questionnaire will be used by Boott to help identify sources of existing, relevant, and reasonably available information that are not currently in Boott's possession.

1. Information about person completing the questionnaire:

Name & Title	
Organization	
Address	
Phone	
Email Address	

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

   ___ Yes (*If yes, please complete 2a through 2c*)   __ No (*If no, go to 3*)

   a. If yes, please circle the specific resource area(s) that the information relates to:

- Geology and soils
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened & endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socio-economic resources
- Tribal resources
- Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

___ Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	
Address	
Phone	
Email Address	

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

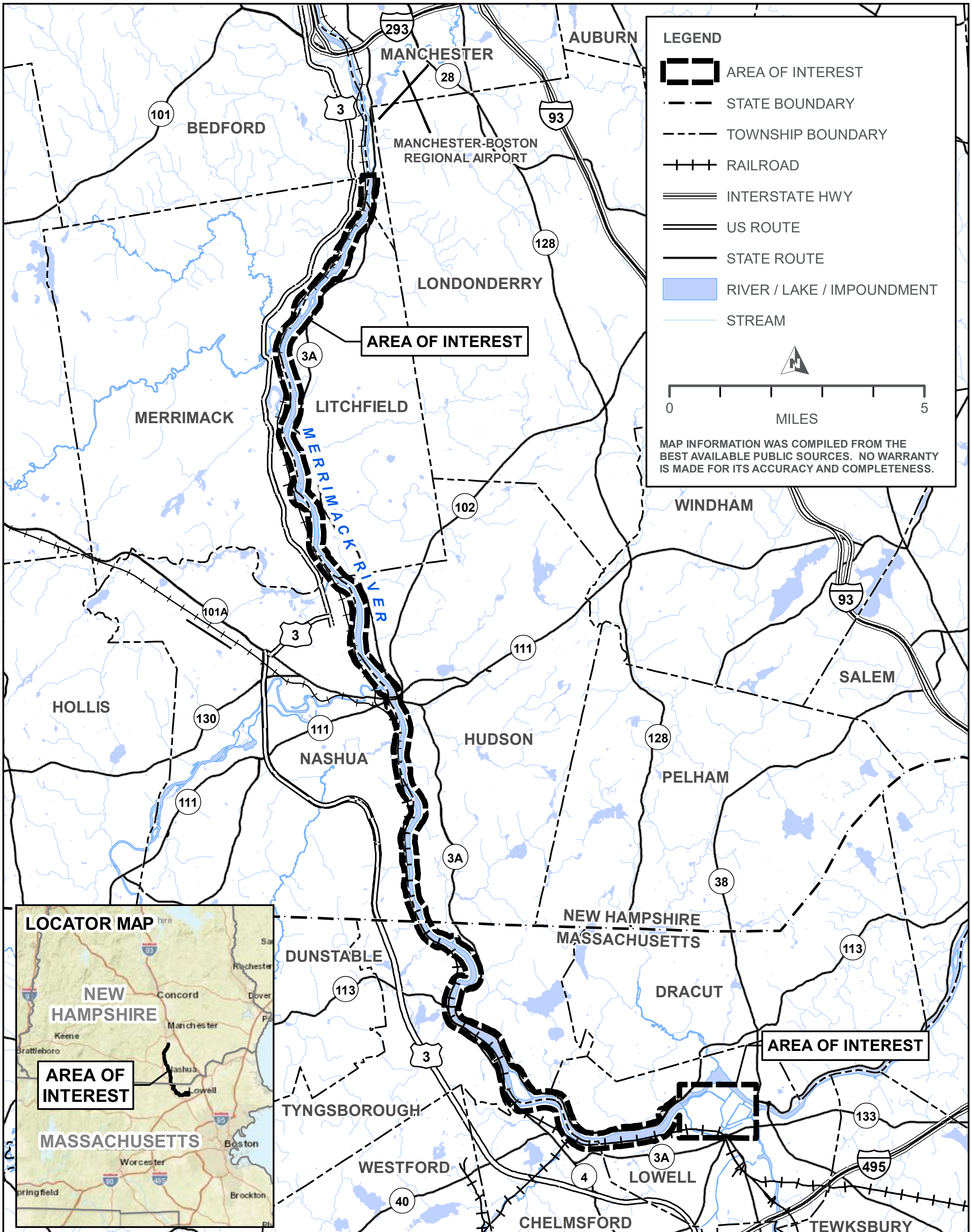
Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.



LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790
BOOTT HYDRO, LLC.

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Federal and State Agencies

Charlene Dwin Vaughn
Assistant Director
Advisory Council on Historic Preservation
401 F Street NW
Suite 308
Washington, DC 20001-2637

John Eddins
Program Analyst
Advisory Council on Historic Preservation
401 F Street NW
Suite 308
Washington, DC 20001-2637

John Fowler
Executive Director
Advisory Council on Historic Preservation
401 F Street NW
Suite 308
Washington, DC 20001-2637

Office of Dam Safety
Massachusetts Department of Conservation and Recreation
John Augustas Hall
180 Beaman Street
West Boylston, MA 01583-1109

Michael Judge
Renewable Energy Division Director
Massachusetts Department of Energy Resources
100 Cambridge Street
Suite 1020
Boston, MA 02114-2533

Rachel Freed
Northeast Region Section Chief
Massachusetts Department of Environmental Protection
205 Lowell Street
Wilmington, MA 01887

Arthur Johnson
DWM Environmental Monitoring Program
Massachusetts Department of Environmental Protection
8 Bond Street
Worcester, MA 01606

Massachusetts Department of Fish and Game
251 Causeway Street
Suite 400
Boston, MA 02114

Massachusetts Department of Public Utilities
One South Station
Boston, MA 02110

Matthew Ayer
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Joseph Larson
Chairman
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Caleb Slater
Anadromous Fish Project Leader
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Ben Gahagan
Diadromous Fisheries Biologist
Massachusetts Division of Marine Fisheries
251 Causeway Street
Suite 400
Boston, MA 02114

Bob Durand
Massachusetts Executive Office of Energy & Environmental Affairs
100 Cambridge Street
Suite 900
Boston, MA 02114

Jonathan Patton
Preservation Planner
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Brona Simon
State Historic Preservation Officer
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Secretary of the Commonwealth
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Massachusetts Office of the Attorney General
1 Ashburton Place
Boston, MA 02108-1518

Bjorn Lake
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Sue Tuxbury
Fisheries Biologist
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Misty Anne Marold
Senior Review Biologist
Natural Heritage Endangered Species Program
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Owen David
Water Quality Certification Program
New Hampshire Department of Environmental Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Jim Gallagher
Dam Bureau Administrator
New Hampshire Department of Environmental Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Brad Simpkins
Director
New Hampshire Division of Forests and Lands
172 Pembroke Road
Concord, NH 03301

Elizabeth Muzzey
Director and State Historic Preservation Officer
New Hampshire Division of Historical Resources
19 Pillsbury Street
Concord, NH 03301

Matt Carpenter
Fisheries Biologist
New Hampshire Fish and Game Department
11 Hazen Drive
Concord, NH 03301

Bill McDavitt
Environmental Specialist
NOAA Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Sean McDermott
Marine Habitat Resource Specialist, Hydropower Coordinator
NOAA Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Harold Peterson
Bureau of Indian Affairs
US Department of the Interior
545 Marriott Drive
Suite 700
Nashville, TN 37214

Andrew Tittler
Attorney-Advisor
US Department of the Interior
One Gateway Center
Suite 612
Newton, MA 02458

Ed Reiner
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OEP06-3
Boston, MA 02109-3912

David Turin
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OES04-3
Boston, MA 02109-3912

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Michael Bailey
Assistant Project Leader
US Fish and Wildlife Service
151 Broad Street
Nashua, NH 03603

Tom Chapman
Supervisor, New England Field Office
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301-5094

Julianne Rosset
Fish and Wildlife Biologist
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301

Bryan Sojkowski
Civil Engineer
US Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035

John Warner
Assistant Supervisor Federal Activities
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301

Keith Nislow
Northern Research Station
US Forest Service
11 Campus Boulevard
Suite 200
Newton Square, PA 19073

Mark Prout
Region 9 - Eastern Region (Midwest and Northeast)
US Forest Service
626 East Wisconsin Avenue
Milwaukee, WI 53202

Celeste Bernardo
Lowell National Historic Park
US National Park Service
67 Kirk Street
Lowell, MA 01852

Kevin Mendik
Hydro Program Manager
US National Park Service
15 State Street
Boston, MA 02109

Indian Tribes

Cedric Cromwell
Chairman
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

Ramona Peters
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

John Brown
Narragansett Indian Tribal Historic Preservation Office
Narragansett Indian Tribe
P.O. Box 268
Charlestown, RI 02813

Bonney Hartley
Tribal Historic Preservation Officer
Stockbridge Munsee Community, Wisconsin
65 1st Street
Troy, NY 12180

Shannon Holsey
Tribal President
Stockbridge Munsee Community, Wisconsin
N8476 MoHeConNuck Road
Bowler, WI 54416

Cheryl Andrew-Maltais
Chairwoman
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Bettina Washington
Tribal Historic Preservation Officer
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Municipalities

James Fiorentini
Mayor
City of Haverhill, MA
4 Summer Street
Haverhill, MA 01830

Daniel Rivera
Mayor
City of Lawrence, MA
200 Common Street
3rd Floor Room 309
Lawrence, MA 01840

Nicolas Bosonetto
Interim City Engineer
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 61
Lowell, MA 01852

Edward Kennedy
Mayor
City of Lowell, MA
375 Merrimack Street
2nd Floor, Room 50
Lowell, MA 01852

Christine O'Connor
City Solicitor
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 64
Lowell, MA 01852

Joyce Craig
Mayor
City of Manchester, NH
One City Hall Plaza
Manchester, NH 03101

James Jajuga
Mayor
City of Methuen, MA
41 Pleasant Street
Methuen, MA 01844

Jim Donchess
City of Nashua, NH
229 Main Street
Nashua, NH 03060

Scott Galvin
Mayor
City of Woburn, MA
10 Common Street
Woburn, MA 01801

Paul Bergeron
District #2
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Toni Pappas
District #1
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Robert Rowe
District #3
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Steven Ledoux
Town Manager
Town of Acton, MA
472 Main Street
Acton, MA 01720

Andrew Flanagan
Town Manager
Town of Andover, MA
36 Bartlet Street
Andover, MA 01810

Jason Grosky
Chairman
Town of Atkinson, NH
21 Academy Avenue
Atkinson, NH 03811

Robert Pontbriand
Town Administrator
Town of Ayer, MA
1 Main Street
Ayer, MA 01432

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Richard Reed
Town Manager
Town of Bedford, MA
10 Mudge Way
Bedford, MA 01730

John Curran
Town Manager
Town of Billerica, MA
365 Boston Road
Billerica, MA 01821

Alan Benson
Town Administrator
Town of Boxford, MA
7A Spofford Road
Boxford, MA 01921

Amy Warfield
Town Clerk
Town of Burlington, MA
29 Center Street
Burlington, MA 01803

Jon Kurland
Town Moderator
Town of Chelmsford, MA
50 Billerica Road
Chelmsford, MA 01824

Jane Hotchkiss
Chair, Select Board
Town of Concord, MA
P.O. Box 535
Concord, MA 01742

James Morgan
Councilor
Town of Derry, NH
14 Manning Street
Derry, NH 03038

Alison Hughes
Chairman
Town of Dracut, MA
62 Arlington Street
Dracut, MA 01826

Town Manager
Town of Groton, MA
173 Main Street
Groton, MA 01450

Timothy Bragan
Town Administrator
Town of Harvard, MA
13 Ayer Road
Harvard, MA 01451

Kim Galipeau
Town Administrator
Town of Hollis, NH
7 Monument Square
Hollis, NH 03049

Thaddeus Luszey
Chairman
Town of Hudson, NH
12 School Street
Hudson, NH 03051

Suzanne Barry
Chairman
Town of Lexington, MA
1625 Massachusetts Avenue
2nd Floor, Town Office Building
Lexington, MA 02420

Timothy Higgins
Town Administrator
Town of Lincoln, MA
16 Lincoln Road
Lincoln, MA 01773

Troy Brown
Town Administrator
Town of Litchfield, NH
2 Liberty Way
Suite 2
Litchfield, NH 03052

Keith Bergman
Town Administrator
Town of Littleton, MA
37 Shattuck Street
3rd Floor, Room 306
Littleton, MA 01460

Tom Dolan
Chairman
Town of Londonderry, NH
268B Mammoth Road
Londonderry, NH 03053

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Robert Dolan
Town Administrator
Town of Lynnfield, MA
55 Summer Street
Lynnfield, MA 01940

Eileen Cabanel
Town Manager
Town of Merrimack, NH
6 Baboosic Lake Road
Merrimack, NH 03054

Andrew Sheehan
Town Administrator
Town of Middleton, MA
48 South Main Street
Middleton, MA 01949

Andrew Maylor
Town Manager
Town of North Andover, MA
120 Main Street
North Andover, MA 01845

John Murphy
Town Moderator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

Douglas Viger
Chairman
Town of Pelham, NH
6 Village Green
Pelham, NH 03076

Mark Andrews
Town Administrator
Town of Pepperell, MA
One Main Street
Pepperell, MA 01463

John Arena
Chair, Board of Selectmen
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Michael Lyons
Chairman
Town of Salem, NH
33 Geremonty Drive
Salem, NH 03079

Town Administrator
Town of Shirley, MA
7 Keady Way
Shirley, MA 01464

George Seibold
Chairman
Town of Stoneham, MA
35 Central Street
2nd Floor
Stoneham, MA 02180

Richard Montuori
Town Manager
Town of Tewksbury, MA
1009 Main Street
2nd Floor
Tewksbury, MA 01876

Robert Jackson
Chair, Board of Selectmen
Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

Board of Selectmen
Town of Westford, MA
55 Main Street
Westford, MA 01886

Jeffrey Hull
Town Manager
Town of Wilmington, MA
121 Glen Road
Room 11
Wilmington, MA 01887

Ross Mcleod
Chairman
Town of Windham, NH
3 North Lowell Street
Windham, NH 03087

Additional Parties

Robert Nasdor
NE Stewardship Director
American Whitewater
65 Blueberry Hill Lane
Sudbury, MA 01776

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Norman Sims
Appalachian Mountain Club
77 Back Ashuelot Road
Winchester, NH 03470

Ross Holland
Enel Green Power North America, Inc.
One Tech Drive
Andover, MA 01810

Kevin Webb
Hydro Licensing Manager
Enel Green Power North America, Inc.
One Tech Drive
Andover, MA 01810

Robert Bersak
780 North Commercial Street
Eversource Energy
P.O. Box 330
Manchester, NH 03015

Jay Mason
President
Friends of Tyler Park
77 Tyler Park
Lowell, MA 01851

David Meeker
4920 Elm Street
Hull Street Energy, LLC
Suite 205
Bethesda, MD 20814

Dinell Clark
Lowell Flood Owner's Group
197 Wellman Avenue
North Chelmsford, MA 01863

Bob Gagnon
Lowell Flood Owner's Group
136 Townsend Avenue
Lowell, MA 01854

Lynda Ignacio
Lowell Flood Owner's Group
66 Shirley Avenue
Lowell, MA 01854

Steve Masse
Lowell Flood Owner's Group
186 Humphrey Street
Lowell, MA 01850

John Nappi
Lowell Flood Owner's Group
279 Pawtucket Boulevard
Tyngsborough, MA 01879

Gene Porter
Lower Merrimack River Local Advisory
77 Concord Street
Nashua, NH 03064

Thomas Golden, Jr.
Massachusetts House of Representatives
24 Beacon Street
Room 473B
Boston, MA 02133

Rady Mom
Massachusetts House of Representatives
24 Beacon Street
Room 43
Boston, MA 02133

David Nangle
Massachusetts House of Representatives
24 Beacon Street
Room 479
Boston, MA 02133

Eileen Donoghue
Massachusetts Senate
24 Beacon Street
Room 405
Boston, MA 02133

Kim Goddu
Merrimack River Watershed Council
60 Island Street
Suite 211-E
Lawrence, MA 01840

Rusty Russell
Executive Director
Merrimack River Watershed Council
60 Island Street
Suite 211-E
Lawrence, MA 01840

Fred Britton
Associate President
Thoreau's Landing Condominium Association
32 Walden Pond Drive
Nashua, NH 03064

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Fred Jennings
President, Nor'East Chapter
Trout Unlimited
P.O. Box 946
Ipswich, MA 01938

Arthur Faneros
Universal Apartment Rental
114 University Avenue
Lowell, MA 01854

Michele Tremblay
Upper Merrimack River Local Advisory Committee
P.O. Box 3019
Penacook, NH 03303

Ann Kuster
US House of Representatives
137 Cannon House Office Building
2nd District
Washington, DC 20515

Seth Moulton
6th District
US House of Representatives
21 Front Street
Salem, MA 01970

Carol Shea-Porter
US House of Representatives
1530 Longworth House Office Building
1st District
Washington, DC 20515

Niki Tsongas
3rd District
US House of Representatives
126 John Street
Suite 12
Lowell, MA 01852

Margaret Hassan
US Senate
330 hart Senate Office Building
Washington, DC 20510

Edward Markey
US Senate
218 Russell Senate Office Building
Washington, DC 20510

Jeanne Shaheen
US Senate
506 Hart Senate Office Building
Washington, DC 20510

Elizabeth Warren
US Senate
317 Hart Senate Office Building
Washington, DC 20510

Dinell Clark
President
Williamsburg Condominium I
197 Wellman Avenue
North Chelmsford, MA 01863

Richard Howe
Register of Deeds - Middlesex County North
360 Gorham Street
Lowell, MA 01852

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Boott Hydropower, LLC (Boott), a subsidiary of Enel Green Power North America, Inc. (Enel), is the Licensee and operator of the Lowell Hydroelectric Project (FERC No. 2790) (Project), with principal Project facilities located along the Merrimack River in Middlesex County, Massachusetts and a reservoir extending upstream to Hillsborough County, New Hampshire (see attached map). Boott, with assistance from HDR, Inc. (HDR), is beginning the Federal Energy Regulatory Commission (FERC) relicensing process for the existing Project. Accordingly, Boott is preparing a Pre-Application Document (PAD) that will provide FERC and other entities with existing, relevant, and reasonably available information pertaining to the Project that will be used to prepare documents related to analyzing the relicensing application to be prepared by Boott. To prepare the PAD, Boott will use information in its possession and information obtained from additional sources. This PAD Information Questionnaire will be used by Boott to help identify sources of existing, relevant, and reasonably available information that are not currently in Boott's possession.

1. Information about person completing the questionnaire:

Name & Title	PETER AUCELLA, ASSISTANT SUPERINTENDENT
Organization	LOWELL NATIONAL HISTORICAL PARK
Address	67 KIRK ST., LOWELL, MA. 01852
Phone	978-275-1722
Email Address	PETER_AUCELLA@NPS.GOV

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

   ✓ Yes (*If yes, please complete 2a through 2c*) __ No (*If no, go to 3*)

   a. If yes, please circle the specific resource area(s) that the information relates to:

- Geology and soils
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened & endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socio-economic resources
- Tribal resources
- Other resource information

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	CELESTE BERNARDO, SUPERINTENDENT
Address	LOWELL NHP, 67 KIRK ST, LOWELL, MA. 01852
Phone	978-275-1700
Email Address	CELESTE_BERNARDO@NPS.GOV

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.

Scida, Rebecca

From: MacVane, Kelly
Sent: Wednesday, April 04, 2018 5:26 PM
To: Scida, Rebecca
Subject: FW: Lowell Hydroelectric Project (FERC 2790) Relicensing Pre-Application Questionnaire - Lowell National Park Response
Attachments: Slingshot.txt

Follow Up Flag: Follow up
Flag Status: Flagged

HDR Employees:
Use the "Download Attachments" button after opening this message in Outlook to download attached files.

Non-HDR Recipients:
If you are not an HDR employee and this is your first time using Slingshot click here and follow the prompts to set your password.

Returning users click here to Download (files: Lowell NHP Response to Lowell Hydro Project Questionnaire.pdf; National Register Nomination Lowell 8-13-76.pdf; Lowell NHP P.L.95-290 as amended.pdf; DCR lowell-gbfm-rmp.pdf; Boundary Map 1978 LOWE_475_80008A_[id3686].pdf;)

Notice: The link in this email will only work for up to 30 days (as set by the sender). If you need access to these files for longer, please download and save a copy locally. Recipients of forwarded emails WILL NOT have access to the files using this link.

D 315.414.2202 **M** 315.415.2729
jim.gibson@hdrinc.com

hdrinc.com/follow-us

From: Aucella, Peter [mailto:peter_aucella@nps.gov]
Sent: Wednesday, April 4, 2018 5:08 PM
To: Kevin Webb <kevin.webb@enel.com>; Gibson, Jim <Jim.Gibson@hdrinc.com>; Quiggle, Robert <Robert.Quiggle@hdrinc.com>
Subject: Lowell Hydroelectric Project (FERC 2790) Relicensing Pre-Application Questionnaire - Lowell National Park Response

Hello:

On behalf of Lowell National Historical Park, this is to reply to your survey seeking document related to the Lowell Project relicensing.

I have attached the questionnaire responses plus the following documents:

1) Lowell National Historical Park Authorizing Legislation with reference to Lowell Canal System.
2) Lowell National Historical Park Boundary Map referenced in authorizing law.
3) National Register Nomination for the Locks & Canals Historic District (1976).
4) The Lowell Heritage State Park Resource Management Report referencing the Lowell Canal System.

Please let me know if you have any questions.

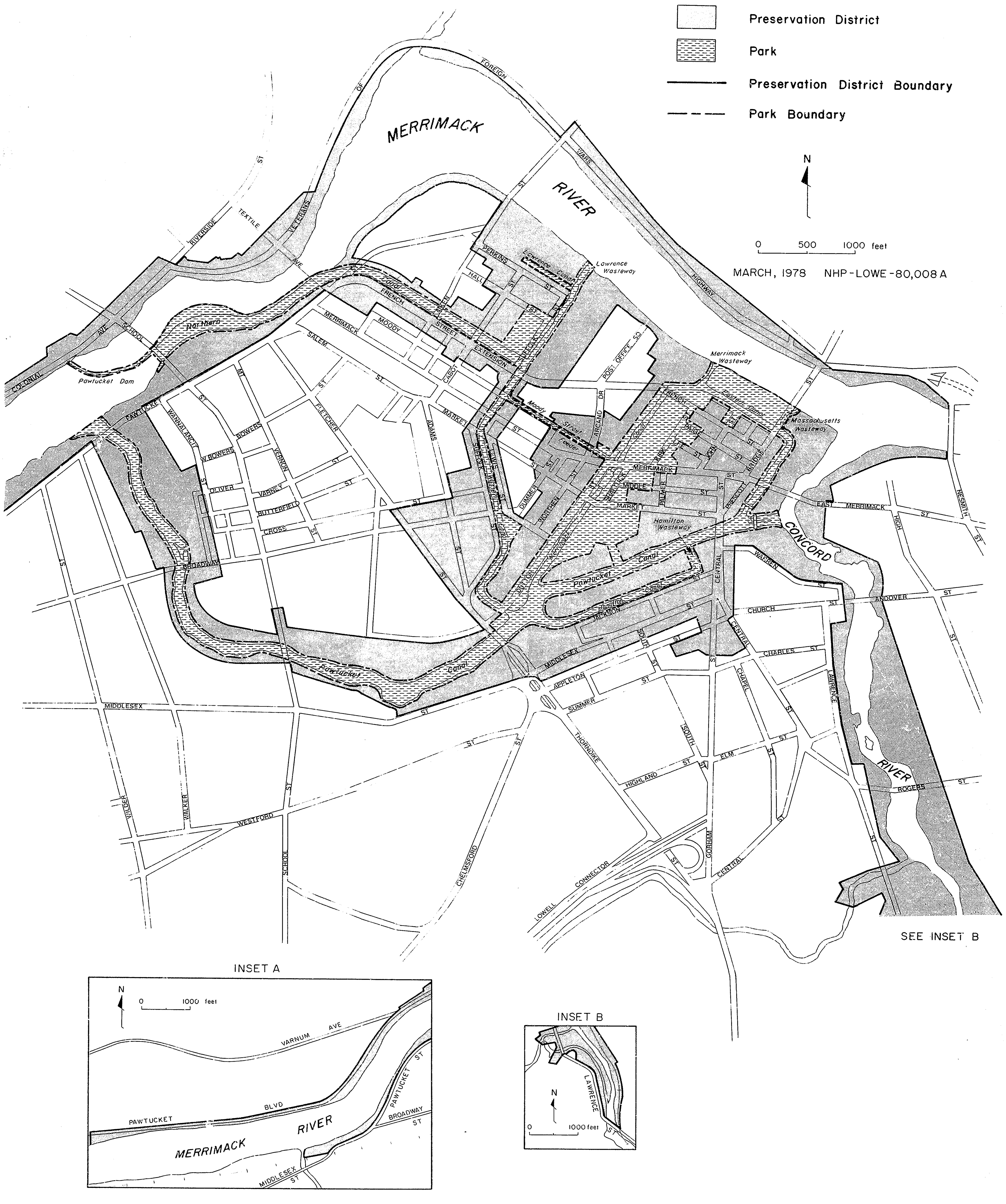
Thanks,

Peter Aucella
Assistant Superintendent
Lowell National Historical Park
67 Kirk Street
Lowell, MA 01852
978-275-1722

LOWELL NATIONAL HISTORICAL PARK

BOUNDARY MAP

LOWELL, MASSACHUSETTS



Massachusetts Department of Conservation and Recreation
Bureau of Planning and Resource Protection
Resource Management Planning Program

RESOURCE MANAGEMENT PLAN

Lowell/Great Brook Planning Unit

Including Lowell-Dracut-Tyngsborough State Forest, Lowell Heritage State Park, Great Brook Farm State Park, Carlisle State Forest, Warren H. Manning State Forest, Billerica State Forest, and Governor Thomas Dudley State Park

July 2014 – Public Review Draft

Lowell/Great Brook Planning Unit

Including Lowell-Dracut-Tyngsborough State Forest, Lowell Heritage State Park, Great Brook Farm State Park, Carlisle State Forest, Warren H. Manning State Forest, Billerica State Forest, and Governor Thomas Dudley State Park

RESOURCE MANAGEMENT PLAN

2014

Deval L. Patrick, Governor
Maeve Vallely Bartlett, Secretary
John P. Murray, Commissioner
Kevin J. Whalen, Deputy Commissioner for Park Operations

Resource Management Plans provide guidance for managing properties under the stewardship of the Department of Conservation and Recreation (DCR). They are intended to be working documents for setting priorities, enabling the DCR to adapt to changing fiscal, social, and environmental conditions. The planning process provides a forum for communication and cooperation with park visitors and the surrounding communities to ensure transparency in the DCR's stewardship efforts.

The Lowell/Great Brook Planning Unit is as diverse as the DCR's park system as a whole. From the collection of highly significant cultural resources and urban green spaces that make up Lowell Heritage State Park, to the historic working agricultural landscape of Great Brook Farm State Park, to the roughly 1,500 acres that encompass five other heavily wooded properties in the planning unit, visitors can enjoy a range of urban, rural, and backwoods experiences all within a seven mile radius. It is really pretty remarkable.

There are also many educational and recreational opportunities available within the planning unit, from learning about the 19th century textile industry and the inner workings of a dairy farm, to hiking, biking, and cross-country skiing by moonlight, the properties provide a little bit of everything for everyone. In several cases, the DCR has partnered with private and public entities to further enhance these opportunities, and ensure that the planning unit is able to be enjoyed today, and for years to come.

This Resource Management Plan provides recommendations that protect the natural and cultural resources of each property, while providing for compatible recreation, so that they are available for future generations.

John P. Murray
Commissioner

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EXECUTIVE SUMMARY

INTRODUCTION

The Department of Conservation and Recreation is directed by a legislative mandate (M.G.L. Chapter 21, Section 2F) to prepare management plans for every reservation, park and forest, to provide guidelines for the management and stewardship of natural and cultural resources and ensure consistency between recreation, resource protection and sustainable forest management. The legislative mandate also requires the incorporation of public review and input into the development of management plans, and review and adoption by the DCR Stewardship Council.

Resource Management Plans (RMPs) consider the past, present and future of a reservation, park or forest. Through an assessment of resources and their existing conditions, clear management goals and objectives are developed, and short and long-term implementation action plans are identified for the management of properties under the stewardship of the DCR. RMPs are written to meet the information needs of a diverse audience: from the decision-makers directly involved in the operation and management of a property, to a variety of outside stakeholders. RMPs are intended to be working documents for setting priorities, budgeting and resource allocation, and establishing guidelines for balancing sustainable recreation with the stewardship of natural and cultural resources. Finally, RMPs are of value to users that are interested in learning more about specific properties, the challenges the DCR faces and how decisions affecting the properties are made.

This plan covers the Lowell/Great Brook Planning Unit in the municipalities of Lowell, Dracut, Tyngsborough, Carlisle, Chelmsford, and Billerica, Massachusetts.

THE LOWELL/GREAT BROOK PLANNING UNIT

The Lowell/Great Brook Planning Unit is very diverse and can be viewed as a microcosmic representation of the DCR state park system as a whole. From the collection of highly significant cultural resources and urban greenspaces that make up Lowell Heritage State Park, to the historic working agricultural landscape of Great Brook Farm State Park, to the roughly 1,500 acres encompassing the five other heavily wooded properties in this planning unit, and a range of recreational uses in between, there are few characteristics that can be applied to the planning unit as a whole. In addition, there are several complex partnerships and co-management relationships to balance at many of these facilities. The defining characteristics for the individual properties are as follows:

Lowell-Dracut-Tyngsborough State Forest

A large swath of protected open space that is predominantly wooded, with many low wet areas and little park infrastructure, Lowell-Dracut-Tyngsborough provides miles of trails and recreational access for the nearby urban population, along with habitat protection that is regionally important. There are also three Conservation Restrictions associated with the forest, totaling approximately 73 acres.

Lowell Heritage State Park

An urban park encompassing a variety of parcels within the City of Lowell and operated through multiple and complex shared management systems, this property was established to help showcase the history of the city. The DCR owns numerous historic and a few more recently constructed buildings, including four gatehouses that are a part of canal operations and the Mack building; greenspaces ranging from a small Victorian garden to the one-mile-long Vandenberg esplanade along the river; and some unusual resources, including air rights over many of the city's canals. Lowell Heritage State Park provides both interpretive opportunities and recreational access in a dense urban environment.

Great Brook Farm State Park

A working dairy farm connected to miles of trails that are used for a variety of recreational activities, Great Brook Farm includes historic buildings and resources alongside a new "smart" barn with a robotic milking system, interpretive programming and a cross-country ski concession.

Carlisle State Forest

A small wooded property protected from forestry activities at the turn of the 20th century to conserve an older stand of exceptionally large white pines. Undeveloped and used primarily by local residents, this small gem provides recreational access and habitat protection.

Warren H. Manning State Forest

A largely wooded property with a small recreation area, complete with a spray deck, picnic area and fitness trail. Named for the preeminent landscape architect that advocated (and donated land for) the establishment of a town forest, this property provides recreational opportunities and habitat protection in a suburban environment.

Billerica State Forest

An undeveloped and largely wooded property bordering Route 3, this property provides recreational access and habitat protection.

Governor Thomas Dudley State Park

The smallest facility within the planning unit, this 11-acre park is a small wooded parcel that provides access to the Concord River and links to other protected open space.

Management Principle and Goals

Through the Resource Management Planning process, a principle for managing the Lowell/Great Brook Planning Unit was established and four associated goals developed.

Management Principle

Protect the natural and cultural resources of the planning unit and provide enhanced recreational and educational opportunities for visitors through the creative use of state resources and partnerships.

Management Goals

The following four management goals have been developed to achieve the management principle. These goals are of equal importance, and are not presented in order of priority.

Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.

Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.

Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.

Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.

Priority Recommendations

Recommendations are characterized on the basis of priority (i.e., High, Medium, or Low) and resource availability. High priority recommendations are those that address regulatory compliance or public health and safety; prevent immediate damage to, or loss of, resources; or repair or replace damaged equipment or systems critical to park operations. They are typically time sensitive. Medium priority recommendations maintain existing resources and visitor experiences. Low priority recommendations enhance resources or visitor experiences; they are not time sensitive.

Resource availability considers both funding and labor. A resource availability of one indicates that funding and/or labor are available to implement the recommendation. A resource availability of two indicates that funding and/or labor are not currently available, but may become so in the near future (i.e., the next five years). A resource availability of three indicates that funding and/or labor are not anticipated in the next five years. Resources to implement these recommendations may, or may not, become available after five years.

This RMP identifies 150 management recommendations; 69 are classified as high priorities. Resources are currently available to implement 46 of these high priority recommendations. It is anticipated that resources will be available within the next five years to implement 19 additional high priority recommendations. These recommendations, and the lead DCR unit responsible for their implementation, are identified in the Action Plan that accompanies this Executive Summary.

Table ES.1. Summary of management recommendations.

Priority		Resource Availability 1	2	3	*Total*
High		41	24	4	*69*
Medium		14	30	7	*51*
Low		7	12	11	*30*
	Total	*62*	*66*	*22*	

Public Participation in Developing this RMP

Notice of a public meeting and the DCR's intent to prepare a Resource Management Plan for the Lowell/Great Brook Planning Unit appeared in the July 11, 2012 issue of the Environmental Monitor. Additional announcements were posted on the DCR website and press releases were provided to the local media. Announcements were also distributed to individuals, statewide, regional and local stakeholder organizations and local officials. An initial public meeting occurred on July 23, 2012 in the Hart Barn at Great Brook Farm State Park in Carlisle. Approximately 20 people attended this initial meeting. Public input was received at the meeting and through e-mail received during a 30-day public comment period after the meeting.

A public meeting to present an overview of the draft RMP held on July 21, 2014 in Alumni Hall at the University of Massachusetts Lowell; it was attended by [#] people. Notice of the meeting was published in the July 9, 2014 issue of the Environmental Monitor and posted on the DCR website. Press releases were provided to local media and notices were sent directly to individuals, stakeholder organizations and local officials. The draft RMP was made available on the DCR website, at the Powell Memorial Library in Lowell, Gleason Public Library in Carlisle, Billerica Public Library, Parker Memorial Library in Dracut, and Tyngsborough Public Library, as well as at the Great Brook Farm State Park headquarters on [DATE].

The public comment period on the draft RMP ran from July 22, 2014 to August 29, 2014. [#] sets of comments were received and incorporated into the final RMP (see Appendix B). This Resource Management Plan was submitted to the DCR's Stewardship Council on [DATE] and was adopted by the Council on [DATE].

Action Plan 2014-2019

Priority Action	DCR Lead Unit(s)
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.	
Remove the debris at the former headquarters site that poses a threat to significant resources (i.e., the pump house cellar hole) and public safety (i.e., glass bottles). [LDT SF]	Mass Parks
Address the culverts within the forest that are blocked and/or collapsing. [LDT SF]	MassParks, Planning and Engineering
Remove the graffiti from Sheep Rock and work with the Environmental Police to curb the illegal activities that take place at the site. [LDT SF]	MassParks and Planning
Assess the condition of the interior and exterior of the Rynne bathhouse and make repairs, where necessary. [Lowell Heritage SP]	MassParks, Planning and Engineering
Meet with the National Park Service to develop and implement a preservation plan for the Hamilton Wasteway Gatehouse. [Lowell Heritage SP]	MassParks, Planning and Engineering
Revisit the draft Comprehensive Interpretive Plan; revise and update as necessary and finalize. [Great Brook Farm SP]	MassParks
Develop interpretive programs, opportunities, and products as identified in the Comprehensive Interpretive Plan, working to expand interpretive offerings beyond the smart barn tours. [Great Brook Farm SP]	MassParks
Clear the debris currently built up around the beaver deceivers to maintain water flow and keep them operational. [Great Brook Farm SP]	MassParks
Routinely monitor "The City," particularly the Garrison House site, for stability and potential disturbances. [Great Brook Farm SP]	MassParks and Planning
Remove the broken sign at the Garrison House site. [Great Brook Farm SP]	MassParks
North Schoolhouse: Carefully remove the English ivy from the walls, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	MassParks and Planning
Main Farm House: Install an appropriate gutter, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	Planning
Main Farm House: Complete minor repairs to the siding and the front door sill, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	Planning
Tie Stall Barn: Assess the stability of the foundation in areas where it has visibly been compromised, and repair as necessary, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	Planning and Engineering
Litchfield House: Complete repairs to the barn. [Great Brook Farm SP]	Planning
Update the inventory of the large eastern white pine trees, last done in 1980. [Carlisle SF]	Forestry
After completion of tree inventory update, revisit the Land Stewardship Zoning to determine if any changes are applicable. [Carlisle SF]	Planning and Forestry
Monitor for invasive pests, especially hemlock wooly adelgid. Propose biological or chemical controls if warranted on the specimen trees. [Carlisle SF]	Forestry
Clean up the dumping debris located off of Rangeway Road, and continue to monitor the area for illegal dumping. [Manning SF]	MassParks
Dismantle the fire ring located at the top of Gilson Hill, to discourage use. [Billerica SF]	MassParks
Clean up the dumping debris located adjacent to Winning Street, and continue to monitor the area for illegal dumping. [Billerica SF]	MassParks

Continued on next page.

Action Plan 2014-2019 (Continued)

Priority Action	DCR Lead Unit(s)
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.	
Review and update or create, where appropriate, a trail map for each of the properties in the planning unit, and make the maps available through multiple outlets. [Planning Unit]	MassParks and External Affairs
Work with the Environmental Police to curb the illegal recreation activities (e.g., off-highway vehicle use and paintball games) taking place at the forest. [LDT SF]	MassParks
Post signs that clearly indicate the boundary of the forest's "No Hunting Areas." [LDT SF]	MassParks and Forestry
Improve the trail signage within the forest, adding trail names and intersection numbers where appropriate. [LDT SF]	MassParks and Forestry
Post fish consumption advisory signs in multiple, locally spoken languages at popular fishing spots along the Merrimack River and Lowell Canal System. [Lowell Heritage SP]	MassParks and External Affairs
Ensure that all of the violations noted in the most recent inspection of the Lord pool are addressed in the upcoming modernization project. [Lowell Heritage SP]	Engineering
Develop a trails plan, assessing existing density and incorporating critical information developed through the hydrological study to better address areas that have trail washout problems. [Great Brook Farm SP]	Planning
Securely cover the open well located southeast of the Litchfield House. [Great Brook Farm SP]	MassParks
Reassess all boardwalk crossings to identify older ones in need of replacement, including those on the Acorn Trail. [Great Brook Farm SP]	MassParks
Establish designated handicapped accessible parking spaces in the parking lot, total number to be determined in consultation with DCR's Universal Access Program. [Manning SF]	Engineering
Goal 3. Address vacant infrastructure to improve visitor experiences and DCR operational responsibilities.	
Former Regional HQ site: remove former sign holder and pavement to let the site return to a natural state. [Great Brook Farm SP]	MassParks and Engineering
Tie Stall Barn: Address the outstanding permit issues for the event space and renew discussions about future use. [Great Brook Farm SP]	MassParks and Engineering
Farnham Smith's Cabin: Undertake a structural assessment and reuse feasibility study to determine if reuse is possible and develop some potential options. [Great Brook Farm SP]	Planning, MassParks and Engineering
Cabin Shed: Access and clean out the interior of the shed, so that it does not become a potential nuisance. [Great Brook Farm SP]	MassParks
Boat House: Complete and submit MHC Inventory form. [Great Brook Farm SP]	Planning
Boat House: Undertake demolition. [Great Brook Farm SP]	Engineering
South House/District 6 Fire Control: Assess for any reuse possibilities by the park and/or the region, such as accommodating the storage needs currently being met by the Hadley House and the Anderson Barn. [Great Brook Farm SP]	Planning, MassParks and Forestry
Hadley House: Investigate alternative uses of the property and possibly making it available to be moved. If not possible, identify a funding source for demolition before it becomes an attractive nuisance. [Great Brook Farm SP]	Planning, MassParks and Engineering
West Farm/Manseau House: Assess for inclusion in the Historic Curatorship Program. If not a good candidate, identify a funding source for demolition, before it becomes an attractive nuisance. [Great Brook Farm SP]	Planning, MassParks and Engineering
North Farm House and Barn: Make sure the buildings are secure, and routinely monitor to ensure they aren't damaged or broken into. [Great Brook Farm SP]	MassParks

Continued on next page.

Action Plan 2014-2019 (Continued)

Priority Action	DCR Lead Unit(s)
Goal 3. Address vacant infrastructure to improve visitor experiences and DCR operational responsibilities.	
North Farm House and Barn: Work with current long term leaseholders of other facilities within the park to identify any potential complementary reuses for this property, and explore putting out a Request for Proposals. [Great Brook Farm SP]	Planning, MassParks and External Affairs
Anderson Barn: Explore any potential interest in, and options for, permitting use of the barn by others, and relocate current storage closer to the Park HQ. [Great Brook Farm SP]	MassParks and Planning
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.	
Establish webpages on the DCR website for the properties in the planning unit that currently do not have a webpage. [Planning Unit]	MassParks and External Affairs
Renew the agreement with the Greater Lowell Indian Cultural Association (GLICA). [LDT SF]	MassParks and Legal
Arrange a meeting between the Dracut Water Supply District and appropriate DCR staff to discuss their need to replace the reservoir at the forest. [LDT SF]	MassParks and Legal
Work with the Merrimack Valley Chapter of the New England Mountain Bike Association to review and approve, where appropriate, the existing technical features in the forest. [LDT SF]	Planning, MassParks and Legal
Develop a formal agreement with the Merrimack Valley Chapter of the New England Mountain Bike Association regarding the review and approval of their trail maintenance, repair and construction projects within the forest. [LDT SF]	Planning, MassParks and Legal
Determine the owner of the Hadley House and establish an agreement that guides the management and use of the building. [Lowell Heritage SP]	Planning, MassParks and Legal
Install DCR signs at the parking areas along the Vandenberg esplanade, next to the Lord pool and on Broadway Street. [Lowell Heritage SP]	MassParks
Renew the agreements with the City of Lowell related to their management of the regatta field and Rynne beach, as well as their use of the Rynne bathhouse. [Lowell Heritage SP]	MassParks and Legal
Renew the agreement with the stakeholders in the Lowell Canal System. [Lowell Heritage SP]	MassParks and Legal
Renew the agreement with the New England Electric Railway Historical Society / Seashore Trolley Museum. [Lowell Heritage SP]	MassParks and Legal
Establish an agreement with the Boston & Maine Railroad Historical Society regarding their maintenance of the B&M 410. [Lowell Heritage SP]	MassParks and Legal
Finalize the transfer of the Bellegarde boathouse, obtaining a copy of the items listed in Section 4.4. and executing the care, custody, management and control agreement. [Lowell Heritage SP]	Legal
Conduct annual meetings with lease holders and annual property inspections of leased property as specified in lease agreements and permits. [Great Brook Farm SP]	MassParks and Legal
Woods House: Update and renew the expired lease agreement for the Woods House with the old North Bridge Hounds. [Great Brook Farm SP]	Legal
Clear the vegetation from around the former DEM sign stanchion, and hang a new DCR entrance sign from the existing sign stanchion. [Carlisle SF]	MassParks
Work with the Town of Billerica to get a Special Use Permit in place, to formalize their operation of the recreational area. [Manning SF]	MassParks and Legal
Hold bi-annual meetings with the Town of Billerica Recreation Department to discuss programs, events, and maintenance and operation of the recreational area. [Manning SF]	MassParks and External Affairs
Provide DCR information on the informational kiosk. [Manning SF]	External Affairs
Install a DCR entrance sign for the forest. [Billerica SF]	MassParks

Continued on next page.

Action Plan 2014-2019 (Continued)

Priority Action	DCR Lead Unit(s)
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.	
Hold an annual meeting with the MA Department of Fish & Game and the Town of Billerica Conservation Commission to discuss any issues, plans or projects. [Dudley SP]	MassParks
With the MA Department of Fish & Game and the Town of Billerica Conservation Commission, conduct the stipulated 5 year review of the Management Agreement. [Dudley SP]	MassParks and Legal
Working with the Town of Billerica and the MA Department of Fish & Game, identify an appropriate location for an entrance sign that recognizes the partners. [Dudley SP]	MassParks

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Great Brook Farm State Park (Peter E. Lee; CC BY-NC 2.0; cropped from original)

SECTION 1. INTRODUCTION

1.1. Mission of the Department of Conservation and Recreation

The Department of Conservation and Recreation (DCR) is responsible for the stewardship of approximately 450,000 acres of Massachusetts' forests, parks, reservations, greenways, historic sites and landscapes, seashores, lakes, ponds, reservoirs and watersheds. The mission of the DCR is:

"To protect, promote and enhance our common wealth of natural, cultural and recreational resources for the well-being of all."

In meeting today's responsibilities and planning for tomorrow, the DCR's focus is on:

- Improving outdoor recreational opportunities and natural resource conservation;
- Restoring and improving our facilities;
- Expanding public involvement in carrying out our mission; and
- Establishing first-rate management systems and practices.

The DCR was created pursuant to state legislation that in 2003 merged the former Metropolitan District Commission and the former Department of Environmental Management. The DCR manages over 300,000 acres of the state's forests, parks, beaches, mountains, ponds, rivers and trails. The Department has broad management responsibilities for the preservation, maintenance and enhancement of the natural, scenic, historic and aesthetic qualities within these areas.

The health and happiness of people across Massachusetts depend on the accessibility and quality of our green spaces, natural and cultural resources, recreation facilities and great historic landscapes. The DCR continues to improve this vital connection between people and their environment.

1.2. Introduction to Resource Management Plans

The Department of Conservation and Recreation is directed by a legislative mandate (M.G.L. Chapter 21, Section 2F) to prepare management plans for every reservation, park and forest, to provide guidelines for the management and stewardship of natural and cultural resources and ensure consistency between recreation, resource protection and sustainable forest management. The legislative mandate also requires the incorporation of public review and input into the development of management plans, and review and adoption by the DCR Stewardship Council.

Resource Management Plans (RMPs) consider the past, present and future of a reservation, park or forest. Through an assessment of resources and their existing conditions, clear management goals and objectives are developed, and short and long-term implementation action plans are identified for the management of properties under the stewardship of the DCR. RMPs are written to meet the information needs of a diverse audience: from the decision-makers directly involved in the operation and management of a property, to a variety of outside stakeholders. RMPs are intended to be working documents for setting priorities, budgeting and resource allocation, and establishing guidelines for balancing sustainable recreation with the stewardship of natural and cultural resources. Finally, RMPs are of value to users that are interested in learning more about specific properties, the challenges the DCR faces and how decisions affecting the properties are made.

DCR staff undertook a statewide survey in 2008–2009 to assess the level of existing resource and planning data available, and correlate that with operations and management considerations. This assessment was used to identify groupings of properties that should be included together in a single RMP, i.e. planning units. The statewide survey was also used to develop a tiered sequence for preparing RMPs. The Lowell/Great Brook Planning Unit is ranked 6th out of the 80 planning units identified statewide.

1.3. The Planning Process

Resource Management Plans are developed by the DCR's Resource Management Planning Program through an iterative process of data gathering and analyses, public input, review and revision. Administrative, cultural, ecological, recreation, social and spatial information is gathered. Sources of information include interviews with DCR staff, site visits, administrative files and reports, legal documents, map data and municipal and regional plans. An initial public meeting is convened to provide an opportunity to discuss the properties included in the RMP and to solicit public input for the plan. The public meeting is announced in the Environmental Monitor and advertised electronically and through local media outlets.

An inventory of available information on natural, cultural, recreation and operational resources and an assessment of their existing conditions is the foundation of an RMP, from which recommendations for stewardship can be made. The draft is distributed within the DCR for internal review, and is repeatedly reviewed and revised to produce a draft RMP for public review and comment.

A second public meeting is convened to present an overview of the draft RMP's findings and recommendations and solicit input. Once again, the public meeting is announced in the Environmental Monitor and advertised electronically and through local media outlets. After the second public meeting, the draft RMP is made available to the public via the DCR website and local libraries. The meeting is followed by a 30-day public comment period. Comments made during the meeting and written comments received during the public comment period are taken into consideration and used to further develop the RMP.

Once revised, a final draft RMP is submitted to the DCR Stewardship Council for review and adoption. The Stewardship Council is a 13-member citizen advisory board (appointed by the Governor) that works with the Department to provide a safe, accessible, well-maintained and well-managed system of open spaces and recreation facilities that are managed and maintained on behalf of the public.

Once adopted, the Commissioner of the Department of Conservation and Recreation files copies with the Secretary of State and the Joint Committee on Environment, Natural Resources and Agriculture of the Massachusetts General Court and posts the adopted RMP on the DCR website for use. The adopted RMP provides structure and guidance for the operation and management of properties included in the plan.

1.4. Public Participation

Notice of a public meeting and the DCR's intent to prepare a Resource Management Plan for the Lowell/Great Brook Planning Unit appeared in the July 11, 2012 issue of the Environmental Monitor. Additional announcements were posted on the DCR website and press releases were provided to the local media. Announcements were also directly distributed to individuals, statewide, regional and local stakeholder organizations and local officials. An initial public meeting occurred on July 23, 2012 in the Hart Barn at Great Brook Farm State Park in Carlisle. Approximately 20 people attended this initial meeting. Public input was received at the meeting and through e-mail received during a 30-day public comment period after the meeting.

To promote greater citizen participation and obtain additional information about visitor use, an online survey was created using Survey Monkey. Announcements of this survey were distributed electronically to stakeholders and signs were posted at individual properties. Surveys were created and made available in English and Spanish, in an effort to reach out to a broad constituency. One hundred and sixty one (161) surveys were submitted, nearly all of which were related to Great Brook Farm State Park and Lowell-Dracut-Tyngsborough State Forest.

A public meeting to present an overview of the draft RMP held on July 21, 2014 in Alumni Hall at the University of Massachusetts Lowell; it was attended by [#] people. Notice of the meeting was published in the July 9, 2014 issue of the Environmental Monitor and posted on the DCR website. Press releases were provided to local media and notices were sent directly to individuals, stakeholder organizations and local officials. The draft RMP was made available on the DCR website, at the Powell Memorial Library in Lowell, Gleason Public Library in Carlisle, Billerica Public Library, Parker Memorial Library in Dracut, and Tyngsborough Public Library, as well as at the Great Brook Farm State Park headquarters on [DATE].

The public comment period on the draft RMP ran from July 22, 2014 to August 29, 2014. [#] sets of comments were received and incorporated into the final RMP (see Appendix B). This Resource Management Plan was submitted to the DCR's Stewardship Council on [DATE] and was adopted by the Council on [DATE].

1.5. Properties Included in this RMP

This plan covers the Lowell/Great Brook Planning Unit, which includes:

- Lowell-Dracut-Tyngsborough State Forest
- Three Conservation Restrictions abutting Lowell-Dracut-Tyngsborough State Forest
- Lowell Heritage State Park
- Great Brook Farm State Park
- Carlisle State Forest
- Warren H. Manning State Forest
- Billerica State Forest
- Governor Thomas Dudley State Park

A Conservation Restriction is a legal document that limits the uses of a property to protect specific open space values of that land. Locations of these properties are indicated on Figure 1. Although these properties are not owned in fee by the DCR, they are included in the plan because of their physical proximity to Lowell-Dracut-Tyngsborough State Forest and the DCR's responsibility for overseeing the stipulations of the restrictions.

1.6. Defining Characteristics

The Lowell/Great Brook Planning Unit is very diverse and can be viewed as a microcosmic representation of the DCR state park system as a whole. From the collection of highly significant cultural resources and urban greenspaces that make up Lowell Heritage State Park, to the historic working agricultural landscape of Great Brook Farm State Park, to the roughly 1,500 acres encompassing the five other heavily wooded properties in this planning unit, and a range of recreational uses in between, there are few characteristics that can be applied to the planning unit as a whole. In addition, there are several complex partnerships and co-management relationships to balance at many of these facilities. The defining characteristics for the individual properties are as follows:

Lowell-Dracut-Tyngsborough State Forest

A large swath of protected open space that is predominantly wooded, with many low wet areas and little park infrastructure, Lowell-Dracut-Tyngsborough provides miles of trails and recreational access for the nearby urban population, along with habitat protection that is regionally important. There are also three Conservation Restrictions associated with the forest, totaling approximately 73 acres.

Placeholder for Figure 1.

Lowell Heritage State Park

An urban park encompassing a variety of parcels within the City of Lowell and operated through multiple and complex shared management systems, this property was established to help showcase the history of the city. The DCR owns numerous historic and a few more recently constructed buildings, including four gatehouses that are a part of canal operations and the Mack building; greenspaces ranging from a small Victorian garden to the one-mile-long Vandenberg esplanade along the river; and some unusual resources, including air rights over many of the city's canals. Lowell Heritage State Park provides both interpretive opportunities and recreational access in a dense urban environment.

Great Brook Farm State Park

A working dairy farm connected to miles of trails that are used for a variety of recreational activities, Great Brook Farm includes historic buildings and resources alongside a new "smart" barn with a robotic milking system, interpretive programming and a cross-country ski concession.

Carlisle State Forest

A small wooded property protected from forestry activities at the turn of the 20th century to conserve an older stand of exceptionally large white pines. Undeveloped and used primarily by local residents, this small gem provides recreational access and habitat protection.

Warren H. Manning State Forest

A largely wooded property with a small recreation area, complete with a spray deck, picnic area and fitness trail. Named for the preeminent landscape architect that advocated (and donated land for) the protection of public woodlands in the Town of Billerica, this property provides recreational opportunities and habitat protection in a suburban environment.

Billerica State Forest

An undeveloped and largely wooded property bordering Route 3, this property provides recreational access and habitat protection.

Governor Thomas Dudley State Park

The smallest facility within the planning unit, this 11-acre park is a small wooded parcel that provides access to the Concord River and links to other protected open space.

1.7. Management Principle and Goals

Through the Resource Management Planning process, a principle for managing the Lowell/Great Brook Planning Unit was established and four associated goals developed.

Management Principle

Protect the natural and cultural resources of the planning unit and provide enhanced recreational and educational opportunities for visitors through the creative use of state resources and partnerships.

Management Goals

The following four management goals have been developed to achieve the management principle. These goals are of equal importance, and are not presented in order of priority.

Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.

Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.

Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.

Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.

1.8. Regional Context

The Lowell/Great Brook Planning Unit is located within Middlesex County; the towns of Billerica, Chelmsford, Dracut and Tyngsborough and the City of Lowell are all in the northern section of Middlesex County, while the Town of Carlisle is in the southern portion of the county. Lowell is the urban focus for this region, while Carlisle provides a rural respite. The towns of Billerica, Chelmsford, Dracut and Tyngsborough are all suburban in character.

Rivers have indelibly influenced the settlement, land use and development of the communities in this region from pre-historic times through today. The City of Lowell is located at the confluence of the Merrimack River and the Concord River. The mighty Merrimack River, flowing from Franklin, New Hampshire to the Atlantic Ocean is the engine that drove the industrial development of the City of Lowell. Flowing through Tyngsborough and Lowell, the river also serves as the southern boundary of Dracut. The smaller Concord River, a tributary of the Merrimack, flows through Lowell and Billerica, and is the southeast boundary for Carlisle.

The pre-contact Native American population in this region utilized these rivers for travel and subsistence, with major anadramous fish runs on the Concord and Merrimack. The region's landscape provided additional resources for subsistence through freshwater ponds and fertile soils ideal for agricultural use, particularly along the rivers. Traditional hunting and gathering likely occurred in the upland areas, and supported other subsistence activities.

Pawtucket Falls on the Merrimack River served as a regional focus of settlement (MHC 1980*a*). The falls became a regionally important fishing ground and the Merrimack River served as a trade corridor. The area appears to have been extensively settled by native peoples and may have served as a population core area.

The Merrimack River was first visited by the French explorer Samuel de Champlain in 1605 as he explored the New England coast. A Praying Indian town, Wamesit, was established by John Eliot by the 1640s in what is now Lowell in an effort to Christianize native peoples. European settlement in this region started in earnest in the mid 17th century. Settlement through the second half of 17th century was dispersed, with small clusters of colonists in frontier communities relying primarily on subsistence farming, fishing and small mills set up on the rivers and streams in the region.

Population in the region began to uptick in the early to mid 18th century, as villages began to take shape in town centers and near mills, and transportation improvements made in the region helped facilitate travel and trade. By the turn of the 19th century, small scale granite quarrying and early manufacturing started to develop. Construction began on the Middlesex Canal in 1794, connecting Lowell and the Merrimack Valley to Boston, opening for use in 1804. Twenty-seven miles in length, running through several communities including Billerica, Chelmsford, Tyngsborough and current day Lowell, the Middlesex Canal provided a transportation connection to haul goods and passengers from Boston to New Hampshire (Middlesex Canal Association 1993).

A range of small industries began to develop and take advantage of both the local water power and the proximity to the Middlesex Canal, and the textile industry in Lowell began in the 1820s with the establishment of the first major textile mill, the Merrimack Manufacturing Company. Others quickly followed over the course of the next dozen years, building off the early success and the application of the innovative system of manufacturing utilized here and the development of a system of power canals to run large mills. Additional industrial development also began in Chelmsford and to a smaller degree in Dracut.

The City of Lowell was established in 1826, from parts of Chelmsford, Dracut, and Tewksbury (MHC 1980*a*). Rapid growth ensued in Lowell, with the manufacturing base downtown and a series of suburban outlying neighborhoods. Railroads were introduced to the region, providing a more effective (and non-seasonal) form of transportation, and the Middlesex Canal was closed in 1853 (Middlesex Canal Commission n.d.).

Many nearby communities also experienced population growth and new immigrant populations headed to the region to work in manufacturing in Lowell (facilitated by streetcar lines providing access) and nearby towns. Carlisle however remained very rural throughout the 19th century, with agriculture remaining as the dominant focus of the local economy.

The Great Depression impacted the textile industry and the region saw a big decline in manufacturing. New highways provided enhanced regional access and with the exception of a population decline in Lowell, the nearby communities continued to grow. Post WWII suburban expansion impacted much of the region, however the City of Lowell struggled and the Town of Carlisle maintained its rural economy and character. The 1970s saw the establishment of Lowell Heritage State Park and brought the National Park Service to Lowell, as well as renovated mills, new immigrant communities and a growing interest in urban areas, which brought revitalization to downtown Lowell.

Table 1.1. Physical, Ecological and Political Settings of the Lowell/Great Brook Planning Unit

Planning Unit: Lowell/Great Brook

Location:

City of Lowell	Middlesex County
Town of Dracut	Middlesex County
Town of Tyngsborough	Middlesex County
Town of Carlisle	Middlesex County
Town of Chelmsford	Middlesex County
Town of Billerica	Middlesex County

DCR Management Structure: Walden Complex
Metro West District
North Region

Properties:	***Landscape Designation***	***City/Town***	***Area (acres)[a]***	***Perimeter (miles)[a]***
Lowell-Dracut-Tyngsborough State Forest	Parkland	Lowell	320	15
		Dracut	554	
		Tyngsborough	236	
Lowell Heritage State Park	Parkland	Lowell	87	18
Great Brook Farm State Park	Parkland	Carlisle	907	16
		Chelmsford	23	
Carlisle State Forest	Parkland	Carlisle	25	1
Warren H. Manning State Forest	Parkland	Billerica	183	5
Billerica State Forest	Parkland	Billerica	141	3
Governor Thomas Dudley State Park	Parkland	Billerica	11	1

Ecoregion: Southern New England Coastal Plains and Hills

Watersheds: Sudbury-Assabet-Concord (SuAsCo)
Merrimack River

Legislative Districts:

Senate District	First Middlesex	*House District*	Second Middlesex
	Second Essex and Middlesex		Fourteenth Middlesex
	Third Middlesex		Sixteenth Middlesex
	Fourth Middlesex		Seventeenth Middlesex
			Eighteenth Middlesex
			Twenty-second Middlesex
			Thirty-sixth Middlesex

Conservation Restrictions:	***Property***	***City/Town***	***Area (acres)[a]***	***Fee Interest***
	Lowell-Dracut-Tyngsborough State Forest	Lowell	17	Northeast Radio, Inc.
	Lowell-Dracut-Tyngsborough State Forest	Dracut	9	Boisvert Family
	Lowell-Dracut-Tyngsborough State Forest	Tyngsborough	47	Town of Tyngsborough

Designations:	**Property**	**Designations**
	Lowell-Dracut-Tyngsborough State Forest	Priority Habitat
		BioMap2 Core Habitat
		BioMap2 Critical Natural Landscape

Continued on next page.

Table 1.1. Physical, Ecological and Political Settings of the Lowell/Great Brook Planning Unit (Continued)

Designations:	Property	Designations
	Lowell Heritage State Park	Priority Habitat BioMap2 Core Habitat BioMap2 Critical Natural Landscape Downtown Lowell Local Historic District City Hall District Locks and Canals National Register Historic District Locks and Canals National Historic Landmark Lowell National Historical Park and Preservation District Historic Civil Engineering Landmark Historic Mechanical Engineering Landmark Environmental Justice Population
	Great Brook Farm State Park	Priority Habitat BioMap2 Core Habitat
	Carlisle State Forest	National Wild & Scenic River
	Warren H. Manning State Forest	Priority Habitat BioMap2 Core Habitat
	Billerica State Forest	Priority Habitat BioMap2 Core Habitat
	Governor Thomas Dudley State Park	BioMap2 Core Habitat BioMap2 Critical Natural Landscape

a. These values were calculated in GIS and rounded to the nearest whole number.

1.9. VISITATION

Visitation information for the planning unit is negligible, due in part to reduced DCR staffing and established management agreements with other entities, as well as physical constraints that make it difficult to capture the information (e.g., little or no infrastructure at a property, multiple entry points for a property, etc.).

The online survey that was undertaken as part of this RMP (see Section 1.4. Public Participation) did not provide a lot of information that could objectively be drawn from in order to get a sense of the complete visitor profile and experience for individual properties, or the planning unit as a whole. While there was a high response rate for both Lowell-Dracut-Tyngsborough State Forest and Great Brook Farm State Park, 78 responses for each, the remaining properties had minimal response rates, ranging from zero to three. This is due to the fact that the survey was very well publicized within the mountain biking community, and many members of that community responded to the survey for the two properties in the planning unit that are utilized the most for mountain biking. Despite promoting the survey to a wide variety of stakeholders, without active park friends groups for these properties to help promote the survey within other user communities, responses from outside the mountain biking community were low.

Lowell-Dracut-Tyngsborough State Forest

The state forest is not staffed and, as a result, there are no visitor estimates; however, the property is well-known as a popular mountain biking destination. Respondents to the online survey, most of whom were part of the mountain biking community, identified the state forest's convenient location and trail network as characteristics of the property that they liked the best. Among the ways that the state forest could be improved, respondents indicated enforcing regulations related to off-highway vehicle (OHV) use, adding more parking and trail signage, naming more trails and updating the trail map.

Lowell Heritage State Park

Although Lowell Heritage State Park is staffed, as an urban property with individual parcels spread across the city, visitor data is especially difficult to capture. Fortunately, the National Park Service (NPS), a partner in Lowell through their Lowell National Historical Park, collects and publicizes annual visitation data based on the number of visitors that enter their visitor center and exhibits, and attend special events on park property. While these estimates do not provide any insight into the level of visitorship on the DCR's Vandenberg esplanade, they do highlight the number of people who view, and in some cases tour, DCR property in downtown Lowell (see Section 4 for more information).

Since 1982, annual visitation rates at Lowell National Historical Park have exceeded 400,000 (NPS 2014*a*). In 2013, over 500,000 visitors enjoyed the park (NPS 2014*a*). Half of those individuals visited the park in July and August, with July being the most popular month (174,530 visitors; NPS 2014*a*). The majority of July visitors were "Special Event Visitors," and likely participated in the Lowell Folk Festival, a very popular event held in downtown Lowell each year (NPS 2014*a*). Peak visitation for the DCR's Francis Gate Park and Pawtucket Gatehouse were in August (2,022 visitors) and September (1,292 visitors), respectively (NPS 2014*a*).

Great Brook Farm State Park

Visitation increased ten-fold at Great Brook Farm State Park between the establishment of the park (1974) and mid-1990s, but it is now on a downward slope. In the early 1980s, the annual visitation rate was approximately 20,000 – 25,000, while in 1996 car counters recorded approximately 205,000 visitors enjoying the park. In the late 1990s staffing and programming began to decrease and in the early 2000s a parking fee was established, collectively leading to a decline in visitation. By 2010, annual visitation decreased to roughly 120,000. Although the completion of the Smart Barn in 2011 seems to have generated a small spike in visitation, recent estimates are steadily decreasing, and are now at approximately 100,000 visitors per year.

Due to the wide range of activities available, unlike some of the other properties in this planning unit, Great Brook Farm State Park has high year-round visitation. The online survey indicated little seasonal variation in park use by regular visitors. Mid-week visitation includes a fair amount of older visitors, primarily active retirees who like to walk the trails. Through the online survey, park users provided high praise for the variety and quality of trails, as well as the appeal of the active farm and ice cream stand for visiting with children.

Carlisle State Forest

In the absence of a formal parking lot and on site staff, visitation estimates are not available for Carlisle State Forest. Visitation is believed to be quite low, and primarily by local residents.

Warren H. Manning State Forest

The DCR does not have estimates on visitation for this property. The spray deck area is very popular with young families during the summer, and the Town of Billerica, who manages the spray deck area, reports that on hot days, the parking lot often reaches capacity (Hannon-Rizza 2013).

Billerica State Forest

Without a formal parking lot and the presence of on site staff, visitation estimates are not available for Billerica State Forest.

Governor Thomas Dudley State Park

As a facility that is managed by the Town of Billerica and not staffed, the DCR does not have estimates of visitation levels at Governor Thomas Dudley State Park.

In a survey conducted during the preparation of the 2008 update to the Billerica Open Space and Recreation Plan, only three of the 68 respondents included Dudley Park, as it is locally known, as one of the open space or recreation properties that their family utilized in town (Northern Middlesex Council of Governments 2008).

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Park Serve Day at Lowell-Dracut-Tyngsborough State Forest (DCR)

SECTION 2. MANAGEMENT RESOURCES AND PRACTICES

2.1. INTRODUCTION

The Lowell/Great Brook Planning Unit contains a diverse set of natural, cultural and recreation resources. Managing these resources can be challenging, due to the competing demands of resource protection and providing public access to recreational opportunities. Effective management of this two-pronged goal requires an understanding of various laws, regulations, policies and legal agreements, while working with limited operational resources.

This section describes the resources available to the planning unit, as well as relevant management practices, regulations, policies and legal considerations. Variations to these resources and practices, which occur at the property-level, are addressed in Section 3 through Section 9.

2.2. NATURAL RESOURCES

Research Permits are required for all ecological research on DCR property. Additional state (e.g., Scientific Collecting) and federal (e.g., Bird Banding and Marking) permits may be required, depending on the nature of research. Research within wetland and river jurisdictional areas may also require regulatory review and approval from the local conservation commission.

Water Resources

Storm Water Management

Activities on DCR properties that affect the quantity or quality of storm water are regulated by a National Pollutant Discharge Elimination System (NPDES) storm water management plan (DCR 2007*a*). The plan describes control measures that the DCR uses to satisfy NPDES Phase II permit requirements for transportation and non-traditional Municipal Separate Storm Sewer Systems (MS4s). Best Management Practices (BMPs) are also identified in the plan, some of which are implemented at the agency-level (e.g., the detection and elimination of illicit discharges, catch basin cleaning), while others are implemented at the facility-level (e.g., the stenciling of catch basins).

Wetlands Protection

Activities within a wetland resource area or buffer are regulated by the Massachusetts Wetland Protection Act. (See Appendix F for additional information.)

Rare Species

The Massachusetts Endangered Species Act (MESA) protects rare species and their habitats by prohibiting the "take" of any plant or animal listed as Endangered, Threatened or Special Concern. Projects within Priority Habitat of Rare Species must undergo review by the Natural Heritage & Endangered Species Program (NHESP), unless otherwise exempted under the law.

The term "project" refers not only to the construction of buildings and infrastructure, but also to activities that involve grading or the destruction of plant life. (See 321 CMR 10.00 for the full definition of "project.") Many staff and volunteer activities that take place within the planning unit (e.g., invasive species removal, trail construction and maintenance, and habitat improvement activities) meet the definition of "project" and must go through regulatory review, if they occur in Priority Habitat.

State agencies, such as the DCR, have special obligations under MESA. First, agencies are directed to use their authorities in furtherance of the purposes of MESA and "use all practicable means and measures to avoid or minimize damage." Next, they are required to submit draft management plans, such as RMPs, to the NHESP for review. Finally, state-owned lands "that provide habitat for state-listed species shall be managed for the benefit of such listed species;" agencies "shall give management priority to the protection, conservation, and restoration of" state-listed species on state-owned lands. All "practicable means and measures shall be taken to resolve conflicts between the protection, conservation, and restoration of state-listed species…and other uses of such lands in favor of the listed species."

Additional information on MESA and its implementing regulations is available on the NHESP's website: http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/regulatory-review/mass-endangered-species-act-mesa.

Vegetation

There is no single management plan for the planning unit's vegetation. The *de facto* management policy is to permit populations of most species of plants to increase or decrease without human intervention. Exceptions include the maintenance of lawns and other turf areas, removal of hazardous trees and vegetation cutting associated with the management of plant or wildlife habitat.

Continuous Forest Inventory (CFI) monitoring plots are located throughout the planning unit. The number of these one-fifth acre, circular plots varies by property. A series of forestry related metrics, including the number of trees five or more inches in diameter, tree regeneration, amount of coarse woody debris and presence of invasive plants and tree diseases, are collected at each plot. On average, each plot is visited, and data collected, once every ten years.

Wildlife

There is no single wildlife management plan for the planning unit. The *de facto* management policy is to permit most wildlife populations to increase or decrease without human intervention. Exceptions to this include the hunting of game species and fishing at select properties. Hunting, trapping, and fishing are managed through a variety of regulations (see Section 2.4, below).

2.3. Cultural Resources

The DCR's Office of Cultural Resources (OCR) provides technical assistance on issues relating to archaeology and the preservation of landscapes, buildings, structures and objects. It also conducts a coordinated program of basic and applied research to support planning for, and management of, cultural resources on DCR properties through project management and resource management planning. The OCR also nominates properties for inclusion on the State and National Registers. A copy of the DCR Cultural Resources Policy has been included as Appendix D.

The OCR is also responsible for overseeing the historic preservation regulatory compliance responsibilities of the agency. It assesses regulatory needs and, when applicable, notifies the Massachusetts Historical Commission (MHC) through the filing of a Project Notification Form or Environmental Notification Form for any proposed projects undertaken, funded, permitted or licensed, in whole or in part, by the agency. This is done so that the MHC may make a Determination of Effect of the project on historic and archaeological resources. Finally, the OCR coordinates all archaeological survey, testing and excavation with the State Archaeologist at the MHC through an archaeological permit.

Buildings, structures, landscapes, sites and objects that are a minimum of 50 years old, retain historic integrity and are of significance on the local, statewide or national level may be listed on the National Register of Historic Places. Repairs, rehabilitation and other preservation activities on listed and eligible resources follow guidelines in the *Secretary of the Interior's Standards for the Treatment of Historic Properties* (Weeks and Grimmer 1995).

Massachusetts law requires the review of all subsurface disturbances on state property. The DCR's Archaeologist holds an archaeological permit from the MHC that allows them to provide initial review of activities that result in subsurface disturbance. They are the primary reviewer of such projects and activities in the Lowell/Great Brook Planning Unit.

The inspection, investigation or removal of underwater archaeological resources is also regulated under Massachusetts law (M.G.L. 6:179–180). No person may remove, displace, damage or destroy any underwater archaeological resource, except in conformity with permits issued by the Massachusetts Board of Underwater Archaeological Resources. This applies to both inland and coastal waters. All archaeological resources in the waters of the planning unit are subject to this law.

Two of the properties within this planning unit are part of the OCR's Historic Curatorship Program, a program in which curators are selected through a competitive process to rehabilitate and maintain historic buildings in exchange for long term leases. The Historic Curatorship Program Manager is responsible for ensuring compliance with work and maintenance plans; maintaining investment accounting totals from curator reports; ensuring up to date insurance coverage; scheduling annual or bi-annual inspections; coordinating public benefit activities; and enforcing compliance with other lease terms and responsibilities.

2.4. Recreation Resources

Regulations guiding the recreational use of forests and parks may be found in 304 CMR 12.00. (See Appendix F for a summary of these regulations.) In general, all public use of DCR property must take place from dawn through dusk.

Permits

Special Use Permits are required for "any commercial or special activity or event upon the lands or waters" of all DCR properties (304 CMR 12.17; Appendix F). Non-commercial activities requiring a Special Use Permit include, but are not limited to: concerts, charity walks, road races, cultural festivals, community service projects, small weddings and gatherings with amplified sound. Research on recreation and recreationists requires a Research Permit. Commercial filming, photography, and videography are regulated through Filming and Photography Permits. Additional information on these permits, and how they may be obtained, is available on the DCR's website: http://www.mass.gov/eea/agencies/dcr/massparks/permits-rentals/dcr-permits.html.

Camping

Camping on DCR property is restricted to designated campsites or cabins; there are no permanent camping areas in the planning unit.

Geocaching

There is no Massachusetts regulation or agency policy on the placement of geocaches on DCR property. In their absence, geocaches may be placed at any location not identified as closed to the public.

Hunting and Fishing

Hunting and freshwater fishing are addressed in Massachusetts regulations 304 CMR 12.00, 321 CMR 3.00 and 321 CMR 4.00, and the official Massachusetts hunting, freshwater fishing and trapping regulations that are published annually. In general, all DCR properties are open to hunting, fishing and trapping unless otherwise specified in the Forests and Park Rules (304 CMR 12.00). Summaries of these and other applicable regulations are presented in Appendix F.

Officers from the Executive Office of Energy and Environmental Affairs' Office of Law Enforcement (i.e., Massachusetts Environmental Police officers) enforce hunting, fishing and off-highway vehicle (OHV) use.

Trail Use

Dogs may accompany trail users provided the animals are kept under control and do not interfere with any other visitor's enjoyment of DCR property (304 CMR 12.00; Appendix F).

With the exception of DCR, public safety and utility company vehicles, motor vehicles are generally not permitted on the trails in the planning unit.

A March 15, 2011 Department of Justice ruling allows individuals with mobility disabilities to use "other power-driven mobility devices" on trails. Such devices include any device powered by batteries, fuel or other engines that are used by individuals with mobility disabilities for the purpose of locomotion. Use of such devices may be restricted on trails due to factors such as: the type, size, weight and speed of the device; the volume of pedestrian traffic; the design and operational characteristics of the device; whether or not the device may be operated safely; and the potential for substantial risk of serious harm to the environment or natural and cultural resources. None of the trails within the planning unit have been assessed for their compatibility with these devices.

2.5. INFRASTRUCTURE

Property Boundary

The Management Forester or Assistant Management Forester attempts to locate and mark property boundaries in association with forest inventory activities. They also mark the boundaries of new properties as they are acquired. Boundary marking typically involves locating and painting cement bounds or pipes, and posting boundary signs.

Buildings and Structures

The management of DCR-owned buildings is performed by DCR employees or contractors. Minor maintenance and repair is performed by on-site staff. More technical repairs (e.g., plumbing and electrical) are performed by DCR in-house trades staff or by trade or engineering contractors (e.g., well repair) whose activities are coordinated through the agency's Parks Support Operation Program. Major repairs are performed solely by licensed contractors.

Roads

The DCR maintains and repairs forest and park roads, and parkways. Management of traffic and related systems is supervised by the Parkways Section of the DCR's Division of Engineering and guided by American Association of State Highway and Transportation Officials standards, the *Manual on Uniform Traffic Control Devices* (FHA 2012) and the *Historic Parkway Preservation Treatment Guidelines* (DCR 2007*b*), if applicable. Public roads adjacent to DCR properties are maintained and repaired by either local municipalities or the Massachusetts Department of Transportation (MassDOT).

Snow removal is performed by the DCR, MassDOT and local municipalities. In general, the municipalities or MassDOT plow the public roads adjacent to forests and parks, and the DCR is responsible for plowing internal roads.

Parking

The DCR is responsible for maintaining and repairing its parking areas. Most snow removal is performed by the DCR.

Trails

A variety of regulations and policies guide the management of trails. The design, management and marking of trails are guided by the DCR *Trails Guidelines and Best Practices Manual* (DCR 2012*a*). Additional regulations, such as the Massachusetts Endangered Species Act and Wetlands Protection Act, and the DCR Cultural Resources Policy may also apply, depending on location. These regulations and policies apply to DCR employee, partner and volunteer activities.

In accordance with DCR practices, trail maintenance and construction activities should be implemented in the following order, in accordance with the regulations, policies and guidance identified above:

1. Maintain appropriate existing trails and fire roads.
2. Close or improve existing trails with known public safety hazards.
3. Close or relocate existing trails that adversely impact documented state-listed species, in consultation with the DCR's Bureau of

Planning, Design and Resource Protection and NHESP staff.

4. Close, relocate or improve existing trails that impact vernal pools.
5. Close, relocate or improve wetland crossings on existing trails that impact wetlands, streams or ponds.
6. Close redundant, dead end and unauthorized trails.
7. Close, relocate or improve existing eroded and poor condition trail segments.
8. Construct new trail connections to enhance desired, authorized recreational experiences; create additional loop opportunities; and form new connections between access points and important features.

Signs and Kiosks

The format and placement of regulatory and informational signs are governed by the *Manual of Uniform Traffic Control Devices* (FHA 2012) and guided by the DCR *Graphics Standards Manual* (DCR n.d.). The design and construction of kiosks are solely governed by the graphics manual.

Informational kiosks are managed by park staff as new information becomes available; they also perform kiosk installation and repair.

Memorials and Markers

The placement of markers or plaques is not explicitly addressed in the Forests and Park Rules (see 304 CMR 12.00; Appendix F).

2.6. Interpretive Services

Regional interpretive staff provides programming in the planning unit. There is no Comprehensive Interpretive Plan (CIP) for the entire planning unit, nor are there programs offered at every property in the planning unit.

2.7. Operational Resources

DCR Staffing

The DCR manages its forests, parks and reservations through the Division of State Parks and Recreation, otherwise known as the MassParks Division. Resources within the MassParks Division, including finances, staffing and physical equipment, are organized by regions, districts and complexes. Under this organizational structure, the Lowell/Great Brook Planning Unit is within the North Region, Metro West District and Walden Complex.

North Region

The North Region is comprised of three districts: Metro West, Middlesex Essex and Coastal. Specialized staffing resources assigned to the North Region are available on an as needed basis to the planning unit. This includes services related to interpretation, public outreach and safety, and engineering. The region is headed by a North Region Director who reports to the Deputy Director of MassParks.

Metro West District

The Metro West District is comprised of two complexes: Walden and Hopkinton. The district includes a functionally and geographically varied set of properties in the DCR system. Management is provided by a Metro West District Manager who reports to the North Region Director.

Walden Complex

The Walden Complex includes Walden Pond State Reservation in Concord and Lincoln; Carlisle State Forest and Great Brook Farm State Park in Carlisle; Billerica State Forest, Warren H. Manning State Forest and Governor Thomas Dudley State Park in Billerica; Lowell Heritage State Park, the John J. Janas Skating Rink and Raymond J. Lord Memorial Swimming Pool in Lowell; and Lowell-Dracut-Tyngsborough State Forest.

The Forest and Park Supervisor at Walden Pond State Reservation also serves as the Walden Complex Field Operation Team (FOT) Leader. The team leader is responsible for coordinating the operational needs for each facility in the Walden Complex, through the use of Field Operation Teams. The Walden Complex FOT Leader reports to the Metro West District Manager.

Table 2.1. DCR Staffing Resources in the Walden Complex, by Reporting Location[a]

Job Title[b]	Type[c]	Reporting Location
Walden Pond State Reservation		
Walden Complex FOT Leader	Y	Concord
Forest and Parks Supervisor II	Y	Concord
Clerk I	Y	Concord
Visitor Services Supervisor I	Y	Concord
Park Interpreter (2)	S	Concord
Forest and Parks Supervisor I (3)	S	Concord
Summer Worker (4)	S	Concord
Laborer I (8)	S	Concord
Recreation Facility Supervisor I	S	Concord
Park Ranger	S	Concord
Lifeguard II	S	Concord
Lifeguard I (12)	S	Concord
Great Brook Farm State Park		
Forest and Parks Supervisor III	Y	Carlisle
Laborer II	Y	Carlisle
Laborer I (3)	S	Carlisle
Park Interpreter	S	Carlisle
Park Ranger	S	Carlisle
Lowell Heritage State Park		
Forest and Parks Supervisor I	Y	Lowell
Laborer I (2)	S	Lowell
Raymond J. Lord Memorial Swimming Pool		
Recreation Facility Supervisor III	S	Lowell
Recreation Facility Supervisor I	S	Lowell
Lifeguard II	S	Lowell
Lifeguard I (10)	S	Lowell
Summer Worker (2)	S	Lowell

a. Includes staff from the Division of State Parks and Recreation who worked exclusively within the Walden Complex in 2013.
b. The number of multiple employees with the same job title are indicated in parentheses.
c. Type: Y = Year-round; S = Seasonal.

Park staff are responsible for a number of management activities in order to keep the properties clean and accessible for use year round. Duties include cleaning bathrooms, picking up litter and emptying trash barrels. Due to current limited staffing levels, these activities are not always able to be performed on a daily basis. Mowing and trimming is performed on an as needed basis, typically weekly, during the warmer months of the year.

Bureau of Forestry and Fire Control

The Bureau manages a variety of programs, including management forestry, forest fire control, forest health and urban/community forestry, that provide technical assistance and services on forestry related issues to DCR forests, parks and reservations. Bureau staff and assets are organized into districts that generally follow county boundaries.

Middlesex County is divided into two fire districts; the Lowell/Great Brook Planning Unit falls within Fire District 6, which is based out of Great Brook Farm State Park. Beyond fighting fires and managing prescribed burns, the fire staff does a lot of fire road maintenance.

Bureau of Ranger Services

The Bureau of Ranger Services includes field ranger staff who provide outreach related to Massachusetts regulations and public safety services. While other DCR districts have an assigned District Ranger, the Metro West District does not.

Division of Engineering

The Division of Engineering is responsible for the engineering and construction of parkways, dams, buildings and recreation facilities. It also provides a Regional Engineer to oversee day-to-day repair and construction projects, and to maintain a working relationship with the Regional Director in identifying capital improvement priorities. The Division also provides catch basin cleaning at Lowell Heritage State Park in support of park operations.

Bureau of Planning, Design and Resource Protection

This Bureau prepares RMPs and Trail System Plans; develops and updates GIS data; provides technical assistance with the management of archaeological and historic resources; identifies and acquires properties to be added to the DCR system; maintains an archive of park documents; provides technical support on ecological resources and the monitoring of CRs; and designs and manages projects to enhance DCR properties.

Office of External Affairs and Partnerships

The Office of External Affairs and Partnerships works to enhance DCR's constituency of supporters and users by: working in partnership with park users and supporters to develop and sustain community-based stakeholder groups; facilitating external financial assistance for the planning, design and construction of capital projects; managing the DCR partnerships Matching Funds Program, which leverages private contributions to improve DCR-owned and managed facilities; and serving as a dedicated point of contact for individuals and nonprofit, institutional and community-based organizations.

Supplemental Staffing

Volunteers

Volunteers can provide a variety of human and intellectual resources to support the management and maintenance of the properties in the Lowell/Great Brook Planning Unit. Volunteer services include clean-ups, trail maintenance, monitoring, botanical surveys, grant writing, interpretive programming and others. Volunteers may be individuals or members of groups, businesses or organizations, and may be organized by DCR staff or partner organizations.

All volunteer activities must be conducted with prior approval and supervision of the DCR, and in accordance with DCR standards and volunteer policies, including documentation through a Volunteer/Stewardship Agreement Form, Volunteer Release Form and Volunteer Service Log (DCR 2013).

Law Enforcement and Public Safety

The Massachusetts State Police has primary law enforcement authority on state-owned lands. Local police provide additional law enforcement in the planning unit, within their respective jurisdictions. The Executive Office of Energy and Environmental Affairs' Office of Law Enforcement (i.e., the Massachusetts Environmental Police) provides primary enforcement of hunting, fishing, boating, OHV and snowmobile regulations.

DCR Rangers are not law enforcement officers, but have the authority to enforce DCR regulations and issue citations (i.e., parking tickets and dogs off leash) on DCR property. They also coordinate search and rescue activities in forests, parks and reservations.

Municipalities provide emergency fire and medical response to incidents on state lands. DCR Forest Fire Control District 6 provides assistance to Municipalities in the detection, suppression and prevention of wildfires. DCR Rangers may provide first aid.

General Budgetary Info

Operating Budget

The annual operating budget supports daily operations and maintenance, including utilities, supplies, equipment leases, administration, and the maintenance and minor repair of facilities, vehicles and equipment. In Fiscal Year 2013, the Lowell/Great Brook Planning Unit operating budget, excluding personnel costs, was $16,725. Funds are also available from the region for specific projects or activities within the planning unit.

Capital Budget

The capital budget supports projects (e.g., construction and repair) and items (i.e., equipment) with a per-unit cost of at least $5,000 and an expected lifespan of at least seven years.

Capital projects are identified and funded through a five-year capital plan. These plans identify proposed capital projects, their costs and the year in which they are to be funded. In fiscal years 2012 through 2014, improvements to the Mack building and Rynne bathhouse were completed at Lowell Heritage State Park. These projects cost $134,471. At Great Brook Farm State Park, the Fiscal Year 2012 projects were related to the design of the dairy barn and construction of a modular storage building, which cost $110,096. An additional project in Fiscal Year 2013 involved masonry work at the Hart Barn and cost $9,320.

Capital plans are extensively reviewed within the DCR, approved by the Commissioner and included in the DCR's annual budget. This budget is then reviewed by the Executive Office of Energy and Environmental Affairs, the Executive Office of Administration and Finance, and the Governor. Additional capital initiatives may be identified and added to the budget by the Commissioner, Secretary or the Governor during this review process.

Deferred Maintenance

These funds are used for infrastructure repair that exceed typical maintenance, but do not rise to the level of a capital project. They may also be used to address emergency capital projects for which funds have not been allocated. Each region is allotted deferred maintenance funds on an annual basis; the Regional Director determines how these funds are to be used. Recent deferred maintenance projects within the planning unit include $4,500 to bring the fire security system in buildings along the Vandenberg esplanade up to compliance; $1,000 to fix the communication and video system at the Mack building; and approximately $3,000 to repair trails and build boardwalks at Great Brook Farm State Park.

Supplemental Funding

Grants

Federal and private funds, in the form of grants, are periodically awarded on a competitive basis to the DCR for park maintenance and operation activities (e.g., recreational trails grants). There have been no recent grants awarded to the planning unit.

Earmarks

Earmarks are funds directed to specific projects by the Massachusetts General Court via the annual state budget. There have been no recent earmarks for the planning unit.

Conservation Trust Fund

This trust fund uses donations to support special initiatives that go above and beyond basic property maintenance. It is funded through charitable contributions to the DCR, including those donations placed into the "iron rangers" (i.e., a secure metal donation box) located at Lowell Heritage State Park (1) and Great Brook Farm State Park (2). In 2013, Lowell Heritage State Park received over $1,000 in charitable contributions, while Great Brook Farm State Park received over $225. As of February 11, 2014, there is approximately $2,915 in the Conservation Trust Fund for Lowell Heritage State Park and $5,550 in the fund for Great Brook Farm State Park.

Heritage Parks Fund

In Fiscal Year 2014, 20 benches within the Mack plaza at Lowell Heritage State Park were replaced using approximately $45,000 from this fund.

Dedicated Funds

Dedicated property funds may come from a variety of sources (e.g., telecommunication tower fees), and are limited to use at the property on which they are derived. There are no sources of dedicated funds for any property within the planning unit.

Retained Revenues

The state operating budget specifies the maximum amount of park revenue from fees, licenses and rents charged by DCR that may be retained by the agency in a given FY (the amount changes yearly). Revenue is deposited in the state's general fund. DCR may then use (or retain) up to 80% of this revenue statewide for its operating expenses and improvements to DCR facilities statewide.

Great Brook Farm State Park is the only property in this planning unit that currently generates any retained revenue. Revenue is collected from a number of different sources, including parking, annual pass sales, rental fees and event permits. In calendar year 2013, Great Brook Farm State Park collected $33,580 in parking fees, $12,240 in annual pass sales, $1,126 in event fees, and $16,680 in rental income (from lease holders), for a total of $63,626. This total does not include revenue or in-kind investments from the farm lease or the ski concession.

In-kind Contributions

In-kind contributions are the donation of goods or services, rather than funds. The Student Conservation Association (SCA) has provided work crews to assist with trail maintenance activities at Great Brook Farm State Park, contributing their time and labor. The New England Mountain Bike Association (NEMBA) also holds annual trail days at both Great Brook Farm State Park and Lowell-Dracut-Tyngsborough State Forest. NEMBA members assist with the maintenance of trails used for mountain biking purposes, providing labor and materials.

Spruce Swamp (DCR)

SECTION 3. LOWELL-DRACUT-TYNGSBOROUGH STATE FOREST

3.1. Introduction

Lowell-Dracut-Tyngsborough State Forest (1,109 acres) is a natural treasure of the Merrimack Valley. Its location between the urban centers of Lowell, MA and Nashua, NH make it unique and valuable, in terms of the recreational and educational opportunities available. The forest's network of trails provides access to largely undisturbed woodlands and wetlands, as well as several noteworthy cultural sites, for hikers, horseback riders and mountain bikers alike. It is an ideal location to discover the rich history of the region, from the influence of retreating glaciers to the course of human settlement over the last nine thousand years.

3.2. History of Property

The history of Lowell-Dracut-Tyngsborough State Forest dates back thousands of years to Native American settlements along the Merrimack River. The principal tribe of the Merrimack Valley was the Pennacook, who were led by Passaconaway, and later by his son Wonalancet, two of the most renowned chiefs in New England. Both men were known for their mild dispositions, "preferring the ease and comforts of peace to the hardships and deprivations of war," and were respected by all of the smaller tribes in the region (Piotrowski 2002, 17).

At the start of King Philip's War in 1675, the Pennacook fled the Merrimack Valley to avoid having to take a side in the conflict. When Wonalancet returned to the area 10 years later, he sold all of his tribe's homelands to Jonathan Tyng and his partners, reserving only the right to fish and hunt. Soon after this "million-acre" sale, Wonalancet joined a tribe in Quebec, Canada and did not return to the area until 1692 (Crowley 1904; Piotrowski 2002, 18). It was at the request of a few hardy colonists, who were comforted by his presence, that Wonalancet moved back to Tyngsborough, where he lived with Jonathan Tyng in the Tyng Mansion until his death in 1696.

The area surrounding the state forest was slow to develop through the early decades of the 18th century, primarily due to unstable frontier conditions. After 1730, increased settlement took place throughout the area, especially along the riverine lowlands of the Merrimack. By 1800, Chelmsford (part of which would become Lowell), Dracut and Tyngsborough were flourishing. Farms, quarries, mills and other small-scale manufacturing industries supported the regional economy. A series of transportation improvements throughout the 19th century, including roads and bridges, river ferries, canals and railroad corridors, maintained the vitality of the Merrimack Valley.

During the 19th century, the character of Dracut and Tyngsborough began to shift as Lowell established itself as the industrial powerhouse in the region. Both towns became popular vacation communities with established waterfront parks and resorts attracting seasonal visitors from Boston and New York. Lakeview Park (Dracut), Willowdale and Mount Rock (Tyngsborough) were just a few of the more popular destinations in the area, all of which were situated around Lake Mascuppic.

Land for Lowell-Dracut-Tyngsborough State Forest was first acquired by the Commonwealth between 1933 and 1936. During that time, federal Works Progress Administration projects were carried out in the forest, including the reconstruction of Trotting Park Road (Lowell and Tyngsborough); creation of scenic vistas from Whortleberry Hill; improvement of timber stands on Gage Hill; and construction of a tool shed and blacksmith shop. An old spring water bottling building, remnants of a company once located on the land, was repurposed as a forest headquarters (Stone & Webster Environmental Technology & Services 1998). In 1937, a 16- by 30-foot single-story woodshed and public comfort station was built at the headquarters site, which was located on the east side of Trotting Park Road (Lowell), south of the current main entrance to the state forest (Stone & Webster Environmental Technology & Services 1998).

By the early 1950s, there was considerable interest in developing the state forest into a major facility (see Appendix H). However, early efforts to act on this interest, such as the small recreation area and ski trail established near Whortleberry Hill, never became popular with visitors (Lambert 1972). For the next 20 years, the forest remained largely undeveloped; hiking and "some" snowmobiling were the principal recreation uses (DNR 1970, 2).

In 1970, the Department of Natural Resources (DNR) wrote a plan for the state forest to "help meet the increasing need for a variety of recreation and natural experiences in the rapidly suburbanizing Lowell region" (DNR 1970, 2). According to the plan, much of the forest was "to be left in its natural state, protected and enhanced as resource management areas" (DNR 1970, 2). However, specific recommendations were made for an organized interpretive trail system, an environmental education or visitor's center, a day use area for swimming and picnicking, and a group camping area. The plan also recommended acquiring an additional 300 acres of land to provide a larger buffer between the proposed development and more natural areas of the forest.

Several years after the DNR plan was written, but before any of its recommendations were implemented, Lowell-Dracut-Tyngsborough State Forest fell into a state of disrepair. The buildings at the headquarters site were boarded-up and the forest was "ravaged by vandalism" (Sylvester 1977). "Stripping and torching" cars was one of the more notorious activities that took place within the forest; in 1976, 85 burnt cars were found in the Dracut portion alone (Sylvester 1977). The lack of supervision over the forest's Cut-A-Cord Program led to further abuse, with permit holders reportedly taking three or four times their share of wood from the forest and reselling it at a much higher price (Sylvester 1977).

One bright spot in the forest's history during this time period was the partnership and agreement between the Department of Environmental Management and Greater Lowell Indian Cultural Association (GLICA). In 1978, an initial three-year Memorandum of Understanding was signed, which granted the GLICA access to 150 acres of the state forest where the group erected temporary wigwams and teepees, laid out a ceremonial circle and held cultural festivals (Anonymous 1981). The GLICA's presence enhanced the state forest's natural and cultural resources and helped curb some of the vandalism taking place there (Anonymous 1981).

In 1996, all of the buildings associated with the headquarters site were removed and forest operation and maintenance responsibilities shifted to eight year-round and seasonal staff based out of Lowell Heritage State Park (Stone & Webster Environmental Technology & Services 1998). Today, the state forest remains largely undeveloped and staff are based out of both Great Brook Farm State Park and Lowell Heritage State Park.

3.3. EXISTING CONDITIONS

Natural Resources

Physical Features

Topography. The state forest is shaped roughly like a bowl, with a large wetland near its center and several drumlins, or elongated hills, situated around its perimeter. The highest points within the forest are atop Whortleberry Hill (364 feet) and Gage or Huckleberry Hill (324 feet), both of which are located in the northernmost portion of the forest (see Figure 2).

Geology. The bedrock in the area of Lowell-Dracut-Tyngsborough State Forest is largely comprised of calcareous sandstones, siltstones and shale, with Ayer granite and Dracut diorite intruding near the Town of Dracut (Skehan 2001). The best examples of these formations fall outside of the forest, underlying the Merrimack River, near the University Avenue Bridge in Lowell (calcareous sandstones, siltstones and shale) and at Nickel Mine Hill, north of Methuen Street in Dracut (Dracut diorite; Skehan 2001).

Within the state forest itself, several large glacial erratics, or boulders, are recognized as significant natural and cultural resources (e.g., Horsehead Rock, Sheep Rock and Indian Head Rock). There is also evidence of multiple stone quarries within the forest, where granite and gneiss were collected as building material for Lowell's canal system and textile mills (Ali and Hudon n.d.).

Soils. Soils within the forest vary based on the topography. Poorly and very poorly drained sandy loams and Freetown or Swansea mucks are associated with the low-lying wetlands. These soils are considered severely limited for picnic areas, paths and trails (Peragallo 2009). Well to excessively drained sandy loams and exposed stones or boulders dominate the rolling to moderately steep hills. These soils range from being severely to slightly limited for picnic areas, paths and trails (Peragallo 2009). The severe limitations are strictly related to picnic areas and the soils being too sandy, too rocky or too steep.

Table 3.1. Soils of Lowell-Dracut-Tyngsborough State Forest

Soil Series	% of Forest	Drainage Class
Canton fine sandy loam	18.4	Well drained
Montauk fine sandy loam	14.0	Well drained
Freetown muck	13.8	Very poorly drained
Charlton-Hollis-Rock outcrop complex	7.0	Well to somewhat excessively drained
Hollis-Rock outcrop-Charlton complex	6.6	Well to somewhat excessively drained
Deerfield loamy sand	6.0	Moderately well drained
Narragansett silt loam	5.3	Well drained
Birdsall mucky silt loam	4.4	Very poorly drained
Scituate fine sandy loam	4.4	Moderately well drained
Scarboro mucky fine sandy loam	2.9	Very poorly drained
Merrimac fine sandy loam	2.8	Somewhat excessively drained
Swansea muck	2.8	Very poorly drained
Water	2.6	N/A
Ridgebury fine sandy loam	2.4	Poorly drained
Whitman fine sandy loam	1.6	Very poorly drained
Wareham loamy fine sand	1.4	Poorly drained
Windsor loamy sand	1.1	Excessively drained
Paxton fine sandy loam	1.0	Well drained
Tisbury silt loam	0.8	Moderately well drained
Sudbury fine sandy loam	0.5	Moderately well drained
Hinckley loamy sand	0.2	Excessively drained
Woodbridge fine sandy loam	0.2	Moderately well drained
Merrimac-Urban land complex	0.0	Somewhat excessively drained

Water Resources

Ponds. There is only one named pond in Lowell-Dracut-Tyngsborough State Forest; it serves as a portion of the property's northeastern boundary (see Figure 2). Althea Lake is a relatively small, 43-acre pond with a maximum depth of 15 feet (MassWildlife 1993*a* and MassGIS 2009). The DCR owns approximately 1,735 feet of the shoreline; the remaining portion is lightly developed. Emergent

Placeholder for Figure 2.

aquatic vegetation has historically been very heavy at Althea Lake, making it difficult to fish (MassWildlife 1993*a*).

There are approximately 33 acres of other smaller, unnamed pools and ponds within the forest.

A second named pond abuts the DCR's Conservation Restriction in Tyngsborough (see Figure 2). Long Pond is a 158-acre interstate pond with a maximum depth of 25 feet (MassWildlife 1993*b* and MassGIS 2009). The DCR has an interest in approximately 1,200 feet of the shoreline; the remaining portion is heavily developed. Long Pond is an infertile body of water; it contains very little aquatic vegetation or sizeable fish (MassWildlife 1993*b*).

Wetlands. Wetlands account for nearly one-quarter of the forest's acreage (approximately 244 acres or 22%). Spruce Swamp is the largest wetland within the forest (approximately 107 acres; see Figure 2). It contains areas of deep marsh, shrub swamp and wooded swamp, as well as acidic shrub fen, a rare Priority Natural Community. Before the construction of Carney Road (Dracut and Lowell), which dammed a small stream, Spruce Swamp was known as Indian Head Lake.

Vernal Pools. There are 31 certified and 15 potential vernal pools within the state forest, several of which are Civilian Conservation Corps (CCC) water holes (see Cultural Resources, below, for more information).

Streams. There are three named streams within the forest, all of which flow into the Merrimack River (see Figure 2). Scarlet Brook flows out of a wetland southeast of Althea Lake, towards Sherburne Avenue in Lowell, and enters the Merrimack River near Greater Lowell Technical High School. Claypit Brook originates from a wetland south of Spruce Swamp. The stream flows south towards Varnum Avenue in Lowell, where it turns east and enters the Merrimack River near Pawtucket Falls. Flagg Meadow Brook is located in the easternmost portion of the forest and flows south towards Lowell General Hospital before entering the Merrimack River downstream of Claypit Brook.

Groundwater. There are no aquifers beneath the state forest.

Flood Zones. The 100-year flood zone overlaps with the wetland immediately east of Althea Lake (18 acres), the western edge of Spruce Swamp (22 acres) and portions of Scarlet Brook (29 acres). The 500-year flood zone overlaps with the northern edge of Spruce Swamp, near Forest Park Road in Dracut (six acres).

Rare Species

Lowell-Dracut-Tyngsborough State Forest is home to three state-listed species. One of these species is susceptible to collection and is not identified in this plan.

Table 3.2. State-listed Species of Lowell-Dracut-Tyngsborough State Forest, as identified by the Natural Heritage & Endangered Species Program (NHESP)

Species	Type	MESA[a]
Blanding's turtle	Reptile	T
Blue-spotted salamander[b]	Amphibian	SC
Data sensitive species[c]	Insect	T

Source: Harper 2013

a. Status of species listed under the Massachusetts Endangered Species Act (MESA): SC = Special Concern and T = Threatened.

b. Blue-spotted salamander has not been re-observed at the state forest since 1989 and will be considered to be historic at this location at the end of 2014.

c. This species is not identified in accordance with the NHESP's policy of withholding, in site-specific documents, the name or location of rare species susceptible to collection.

Blanding's turtles use a variety of habitats, including vernal pools, marshes, scrub-shrub wetlands and open uplands, during their life cycle (NHESP 2007*a*). Blue-spotted salamanders, on the other hand, rely solely on moist, moderately shaded habitats and vernal pools, in particular, for breeding (NHESP 2007*b*). The data sensitive species can be found in the forest's wetlands and nearby wooded areas.

Nearly 90% of the forest (995 acres) has been designated as Priority Habitat under the Massachusetts Endangered Species Act (321 CMR 10.00; see Appendix F). Approximately 79% of the lands on which the DCR holds a Conservation Restriction are also designated as Priority Habitat (56 acres). These same areas have been identified as Core Habitat in the MassWildlife and The Nature Conservancy publication "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010).

BioMap2 highlights two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010).

Within Lowell-Dracut-Tyngsborough State Forest, there are also 260 acres (23%) of Critical Natural Landscape, which encompass Spruce Swamp and adjacent wetlands to the north and west.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified nine forest sub-types within Lowell-Dracut-Tyngsborough State Forest.

Table 3.3. Forest Sub-types of Lowell-Dracut-Tyngsborough State Forest

Forest Sub-type	Acres	% of Forest
Mixed oak	299.2	27.0
Eastern white pine-oak	274.9	24.8
Eastern white pine	72.1	6.5
Oak-hardwoods	64.3	5.8
Eastern white pine-hardwoods	36	3.2
Red maple-swamp hardwoods	33.9	3.1
Red pine plantation	30.8	2.8
Grey birch-red maple	10.8	1.0
Eastern hemlock-hardwoods	6.8	0.6
Total	*828.8*[a]	*74.8*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

More recently (2010-2011), specific areas within the forest were visited by DCR Management Foresters as part of the Massachusetts Continuous Forestry Inventory (CFI). The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for sivicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There are seven CFI plots within Lowell-Dracut-Tyngsborough State Forest. They range in age from approximately 70 to 100 years and are comprised of mostly white or red pine, pitch pine, oak or swamp hardwoods. As part of the CFI process, DCR Management Foresters also look for signs of disturbances that affect the development of vegetation in the vicinity of each CFI plot. Since 2010, four disturbance agents have been observed in the forest's CFI plots. These agents, in decreasing order of occurrence, are: fire, clearing for pasture, insects and beavers.

Priority Natural Communities. One Priority Natural Community, acidic shrub fen, has been identified within Lowell-Dracut-Tyngsborough State Forest. Acidic shrub fens are typically found along wet pond margins in the eastern half of Massachusetts and consist primarily of low-growing, interwoven shrubs, with patches of Sphagnum moss growing at the shrub bases (Swain and Kearsley 2001). Acidic shrub fens have a state ranking of S3, which means that they are neither rare (S1) nor common (S5), however their conservation is encouraged. The biggest threats to this natural community are hydrological alterations that affect either water quality or quantity (Swain and Kearsley 2001).

Invasive Species. Since 2010, five invasive species have been observed by DCR Management Foresters in the forest's CFI plots. These invasive species are: common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Frangula alnus*), garlic mustard (*Alliaria petiolata*), oriental bittersweet (*Celastrus orbiculatus*) and black locust (*Robinia pseudoacacia*). Japanese knotweed (*Fallopia japonica*) was also observed in the former headquarters site while conducting fieldwork for this plan.

Pests and Disease. Since 2010, DCR Management Foresters have observed, as part of the CFI process, several biological agents responsible for tree loss. These agents are: heart rot, black knot of cherry (*Apiosporina morbosa*), white pine weevil (*Pissodes strobe*), borers, gypsy moth (*Lymantria dispar*) and other unknown insects and biological agents.

It is also worth noting that Emerald Ash Borer, an invasive wood boring insect that was first identified in Massachusetts in 2012 and adversely affects all genera of ash trees, has recently been discovered in the neighboring town of Methuen (Church 2014).

Wildlife

Birds. Approximately 150 species of birds have been recorded on, or over, the state forest in recent years (see Appendix G). Of these species, 23 are classified as Species in Greatest Need of Conservation (MassWildlife 2006).

Mammals. There is little current information on the forest's mammals. Sixteen species confirmed to occur within the forest and an additional 26 species that may possibly occur within the forest are identified in Appendix G.

Reptiles. There is little current information on the forest's reptiles. Seven species confirmed to occur within the forest, three of which are classified as Species in Greatest Need of Conservation, and an additional nine species that may possibly occur within the forest are identified in Appendix G (MassWildlife 2006).

Amphibians. There is little current information on the forest's amphibians. Eight species confirmed to occur within the forest, one of which is classified as a Species in Greatest Need of Conservation, and an additional 10 species that may possibly occur within the forest are identified in Appendix G (MassWildlife 2006).

Fish. There is no current information on the forest's fish. Surveys conducted by MassWildlife in 1978 at Althea Lake identified the following seven species: largemouth bass (*Micropterus salmoides*), chain pickerel (*Esox niger*), yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), yellow bullhead (*Ameiurus natalis*) and brown bullhead (*Ameiurus nebulosus*; MassWildlife 1993*a*). A separate MassWildlife survey at Long Pond in 1981 found these same seven species, plus white sucker (*Catostomus commersonii*) and golden shiner (*Notemigonus crysoleucas*; MassWildlife 1993*b*).

Cultural Resources

Pre-Contact Archaeological Sites

Two pre-Contact sites are documented within the state forest. During an archaeological survey, a camp site was uncovered on an upland terrace in Dracut dating to the Early Archaic Period (10,000-7,500 B.P.; Before Present). Many stone tools were recorded, as well as a unique feature unlike any other documented in the northeast. A small pit containing 1,200 fragments of calcined (burned) deer bone was located on a steep slope making this site potentially eligible for listing on the National Register of Historic Places. In another area of the forest (Lowell), a Late Archaic Period (5,000-3,000 B.P.) camp site was recorded. No archaeological sites have been recorded in the Tyngsborough section of the forest, however it has not been systematically surveyed. The physical characteristics, regional setting and known pre-Contact occupation in the area all confer a high archaeological potential for the state forest.

Historic Archaeological Resources

Timothy Coburn reportedly operated one of the earliest mills in Lowell (Richardson 1978). The remnants of this mill site may fall within the southern portion of the forest, along Claypit Brook. The remnants of a dam (see Structures, below) suggest that there was also some small scale industrial activity located along the brook. However, more research is needed to determine the nature and extent of the site, to identify any additional features, and to confirm its association with one of the six men named Timothy Coburn who resided in the area in the 18th and 19th centuries (Richardson 1978).

A spring water bottling company was established at the former headquarters site in the late 19th century, operating until c1920. When the state forest was established in the 1930s, at least one building from the former bottling plant, a pump house, was renovated for forest use. The site was utilized as the forest headquarters until the 1970s, and then left vacant until the buildings were removed in 1996. A concrete pad, the foundation from the former headquarters building and a depression with stones that is likely the cellar hole of the former pump house, are still present on site. The pump house cellar hole is currently filled with branch debris. A trash pile that contains glass bottle debris, as well as a terra cotta pipe sticking out of the ground (possibly a part of the former bottling works), was also located nearby.

Earlier research on the history of the state forest indicates that there are at least two additional cellar holes that are expected to exist on the property (Richardson 1978). These resources were sought during the fieldwork for this plan, but could not be confidently located; additional research is needed.

Historic Resources

Buildings. There are no historic buildings within the state forest.

Structures. There are five Civilian Conservation Corps (CCC) water holes within the state forest. These water holes, typically small, stone lined ponds, were developed by the CCC in larger state forests and used as a source of water for forest fire control purposes. Two of the water holes within Lowell-Dracut-Tyngsborough State Forest are adjacent to Trotting Park Road (Lowell): one is near the former headquarters site and the other is on the edge of Spruce Swamp. A third water hole is just north of Trotting Park Road (Tyngsborough), adjacent to an unnamed administrative road and Spruce Swamp. The fourth is adjacent to Totman Road (Dracut) and is notable for being encircled by a pathway, providing more access to the resource than is typical. The fifth water hole is located north of Totman Road (Dracut) and is notable for being rectangular in shape, where the others within the forest are round. In general, the water holes are all in fair to poor condition, with some of the side walls settling and vegetation creeping in from the edges. All have drainage issues.

CCC Water Hole (DCR)

There are three stone slab bridges of unknown age located in the forest. This simple bridge type utilizes a single large, relatively flat stone, supported on either side by earth or stone abutments, to cross a small stream or brook. Two of the bridges are located in the southern portion of the forest, not far from the former headquarters site, and serve as part of the current trail system. One bridge is small, while the other is larger and covered by earth that has been held in place by wooden side rails, making the slab construction only visible from the side view. Both are in good condition. The third stone slab bridge is located off-rail, near intersection D3 on Carney Road (Dracut). This bridge is in fair condition and has some vegetative growth on it.

Stone Slab Bridge (DCR)

Four stone culverts were located during the fieldwork for this plan. One is located beneath Trotting Park Road (Lowell), adjacent to Spruce Swamp; another is located beneath the unnamed administrative road in Tyngsborough; a third culvert is located on Carney Road (Dracut), near intersection D3; and the fourth culvert is located on the former headquarter site's entrance loop road, adjacent to the CCC water hole. These culverts, which facilitate the flow of water beneath a roadway, were constructed utilizing small stones. The culvert beneath the former entrance loop road is also lined with a metal pipe, while the others are all stone. They may have been constructed as part of the Works Progress Administration improvements to the forest. All of the culverts are in poor condition, with some blockage and/or minor collapse impeding full flow.

The remnants of a dam, constructed of stone, can be found in the southern portion of the property, along

Claypit Brook. This dam may be associated with the Timothy Coburn mill site. See Historic Archaeological Resources, above, for more information on this resource.

Objects. There are four stone markers located within the state forest, identifying property and/or town boundaries.

- Located near an entrance to the forest on Trotting Park Road in Tyngsborough, this stone is leaning significantly and has some paint remnants on the top. The stone is inscribed with:

  T
ARD
1822

- A small property boundary marker inscribed with a "C," located in the southern portion of the forest.
- A town boundary marker with a "T" inscribed on one side and an "L" inscribed on the other. This stone is located at intersection of all three towns; it is leaning and covered in lichen.
- A town boundary marker with an "L" inscribed on one side and a "D" inscribed on the other. This stone is located just off of Trotting Park Road, near the boundary of all three towns. Despite some remnants of paint, it is in the best condition of any boundary marker in the forest.

Stone Boundary Marker (DCR)

Sheep Rock is located in the southern portion of the forest, not far from the former headquarters site. It is a large glacial erratic, approximately 10 feet long, 6 feet wide and 12 feet tall. A large split cuts through the rock and lichen is growing on some of the surface. The north face of Sheep Rock has been vandalized by graffiti and the south face contains the following inscription, in block letters:

SHEEP ROCK
IN MEMORY OF GEORGE J. CARNEY
BORN JUNE 13, 1835
DIED APRIL 24, 1906

Local legend states that Sheep Rock saved a flock of sheep owned by William Parham, a local farmer. During a blizzard, the flock found shelter under an overhang of the boulder. There, they were able to survive for several days until being rescued. The land where Sheep Rock lies was formerly owned by George Carney.


Sheep Rock (DCR)

Stone walls can be found throughout the state forest; they are remnants of the historic land use and ownership in the area, and also reflect the geology of the region. The walls are all dry laid, rubble walls that are generally in fair to poor condition. The walls were not mapped as part of this plan.

Several of the roads in the forest pre-date the establishment of the state forest itself, including Trotting Park Road (Lowell and Tyngsborough) and Totman Road (Dracut). Totman Road, in particular, has been identified as being an older road that may have been laid out along an established Native American pathway. Today it is a typical wide, unpaved forest road that is enjoyed by hikers and mountain bikers.

Landscapes. Remnants of quarrying activity dot the forested landscape, where early settlers took advantage of both the underlying geology of the area and the large collection of glacial erratics. It is a fascinating collection that ties the natural and cultural history of the forest together, and provides a connection to the industrial heritage of Lowell, as stone from the forest was reportedly utilized as building material for Lowell's canal system and textile mills (Ali and Hudon n.d.).

Most of the quarrying activity that was located during the fieldwork for this plan appears to be very small scale; five areas were identified where one or two stones retain visual evidence, in the form of drill scars, of past use for quarrying. Three of these sites are located in the northern portion of the forest, near Trotting Park Road (Tyngsborough) and an unnamed administrative road (Dracut), while the other two are located in the southern portion of the forest, not far from the former headquarters site.

Two other areas were identified where larger scale quarrying took place. One of these quarries is located on the eastern edge of the forest, not far from Gumpus Road in Dracut, and is the only area where a quarry pit, now filled with water, was observed. The other area has evidence of quarrying from exposed ledge. This area, near Sheep Rock, includes a collection of ledge rock and boulders that display drill scars and drill holes.

A boulder that has been worked for quarrying stone. (DCR)

There is undoubtedly evidence of other quarrying activity elsewhere in the forest that was not captured during the fieldwork for this plan. Richardson (1978) noted that he located 73 individual quarry works, the extent of which is unclear, between the former headquarters site and Carney Road (Dracut and Lowell), an area that is popular for mountain biking. However, only one quarry site is recorded on an MHC Inventory form (MHC #LOW.30).

The former entrance loop road that leads to the old headquarters site is a U-shaped drive located in the southern portion of the forest. It is defined by the placement of medium-sized rocks set on either side of the roadbed, approximately five feet apart. It is not known if these rocks were placed during the development of a spring water company in the late 19th century or during the transformation of the area into the state forest headquarters by the Works Progress Administration in 1936-1937.

Recreation Resources

Lowell-Dracut-Tyngsborough State Forest is primarily accessed via motor vehicle. Individuals who live nearby may also choose to walk or ride their bicycle to any one of the trailheads. The Lowell Regional Transit Authority offers an additional, likely underutilized, means of accessing the forest. There are two bus routes, 7 and 10, that run along Varnum Avenue (Lowell) and Tyngsboro Road (Dracut), respectively, and serve downtown Lowell, local high schools and universities, and suburban shopping centers. However, there are no bus stops adjacent to the forest on either bus route.

Recreation at the state forest includes trail-based activities such as hiking and running, horseback riding, mountain biking, snowmobiling and cross-country skiing. Geocaching also occurs throughout the forest, with participants both on and off trails. As of May 2013, there were 13 known geocaches at Lowell-Dracut-Tyngsborough State Forest and two geocaches on the DCR's Tyngsborough Conservation Restriction. Evidence of off-highway vehicle (OHV) use, paintball games, alcohol consumption and campfires, which are in violation of DCR regulations, have also been found along the forest's trails.

Hunting is permitted at the state forest; however there are two designated "No Hunting Areas" (see Figure 2). The first area (approximately 173 acres) is located in the western half of the forest, south of Althea Lake, and overlaps with the portion of the forest that was formerly under agreement with the Greater Lowell Indian Cultural Association (see Section 3.4. Management Resources and Practices). The second area (approximately 36 acres) is located east of Totman Road (Dracut) and south of the

Dracut town line. Neither area is clearly marked in the field.

The Greater Lowell Indian Cultural Association (GLICA) holds several annual recreation events at the state forest each year. The events range from seasonal cleanups to traditional ceremonies that are educational in nature. Each event is open to the public and held within a designated area of the forest, south of Althea Lake in Tyngsborough. Portable sanitary facilities are routinely rented by the GLICA for these events and, in the past, were permitted through a Memorandum of Understanding (MOU) with the DCR; that MOU has expired. Open fires, cooking and camping occasionally take place at GLICA-sponsored events; these activities were also permitted per the expired MOU with the DCR. For more information on the expired MOU, see Section 3.4. Management Resources and Practices.

The Merrimack Valley Chapter of the New England Mountain Bike Association (MV-NEMBA) devotes most of its resources to trail construction and maintenance in the Greater Lowell area. The primary focus of the MV-NEMBA is Lowell-Dracut-Tyngsborough State Forest, but the group is also active at other properties within the Lowell/Great Brook Planning Unit. In addition to their trail work, the MV-NEMBA organizes several group riding and cleanup events within the state forest each year. The majority of the group's activities are approved and permitted, via a Recreational Use Permit, by the Forest and Parks Supervisor.

Infrastructure

Property Boundary

Fee Interest Land. The 1,109-acre state forest is situated northeast of the Merrimack River, between Route 113 in Lowell and Mammoth Road in Dracut, where the City of Lowell and towns of Dracut and Tyngsborough meet. The forest can be reached by car in less than 15 minutes from Lowell, MA and less than 30 minutes from Nashua, NH.

Conservation Restrictions. There are three Conservation Restrictions (CRs) associated with the forest; one each in the towns of Tyngsborough and Dracut, and one in the City of Lowell (see Figure 2).

A 47-acre CR is located off of Autumn and Alden streets in the Town of Tyngsborough. The fee interest is held by the town and its Conservation Commission is responsible for the care and control of the property. The purpose of the CR is "…to retain the premises predominantly in its natural, scenic and open condition; to protect and promote the conservation of forests, wetlands, soils, natural watercourses, ponds, water supplies and wildlife thereon; to allow public access to Long Pond (a Great Pond) for fresh-water recreation and to the premises for the enjoyment of wildlife, natural resources, and passive recreation." Activities that are detrimental to the property's water and soil resources, including the use of motorized vehicles, are prohibited. The construction of two public parking areas, one on Alden Street for not more than 10 cars and one on Autumn Street for not more than five cars, is permitted.

A nine-acre CR is located off of Lakeview Terrace in the Town of Dracut. The fee interest is held by the Boisvert family. The purpose of the CR is "to retain the premises predominantly in its natural, scenic and open condition; to protect and promote the conservation of forests, wetlands, soils, natural watercourses, ponds, water supplies and wildlife thereon; to protect the horticultural resources of the premises; to protect and enhance the value of the abutting conservation areas; and to allow public access for enjoyment of wildlife and open space resources of the premises as specifically provided for herein." Activities that are detrimental to the property's water and soil resources, including the use of motorized vehicles, are prohibited.

A 17-acre CR is located off of Totman Road in the City of Lowell. The fee interest is held by Northeast Radio, Inc. There are existing structures, including four towers for radio transmission, on the property. The purpose of the CR is to allow the DCR to inspect the property on foot; to selectively cut and/or prune trees and erect signs interpreting or regulating access to the land; and to enter and pass through on foot to access the state forest. The property is not open to the public. In addition, activities that are detrimental to the property's water and soil resources are prohibited.

Buildings and Structures

On November 29, 1935, the Town of Dracut granted the Dracut Water Supply District (DWSD), an independent entity, the right to construct and maintain water supply infrastructure on its land. According to the deed, the exact location of the infrastructure was to be determined by the Commissioners of the DWSD at the time of construction (Middlesex County Registry of Deeds, Northern District, Book 872, Page 85). However, the next day, November 30, 1935, the town conveyed approximately 335 acres to the Commonwealth, reserving the "…rights of the Dracut Water Supply District to construct and maintain a reservoir or standpipe on parcel four (4)…together with all rights necessary and incidental thereto" (Middlesex County Registry of Deeds, Northern District, Book 876, Page 228).

Parcel four includes most of Whortleberry Hill; the reservoir and related infrastructure described below are located on the eastern side of Gage Hill (or parcel five, as described in the deed; see Figure 2). To date, neither the DWSD nor the DCR have found any correspondence regarding the construction of a reservoir, or related infrastructure, on parcel five instead of parcel four. There is also no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides access to and maintenance of the infrastructure on parcel five.

Reservoir. The one million gallon water supply reservoir, constructed in 1939, is located on the eastern side of Gage Hill, near the summit (Riopelle 2013*a*). It is covered by a 93-foot square concrete slab and surrounded by a six-foot tall chain-link fence topped with barbed wire. The fence features two gates that are secured with padlocks and one sign that reads: "Public Water Supply No Trespassing." The DCR is currently reviewing a proposal by the DWSD to replace the reservoir, due to the fact that it is undersized and nearly 75 years old.

Pump House. Down slope of the reservoir is a 15- by 24-foot windowless, single-story, masonry block building with a wood framed roof and asphalt shingles. The building, which was constructed within the last 10 years, serves as a pump house; it has electricity and is serviced by propane gas and fuel oil providers (Riopelle 2013*b*). A single, double-wide, locking metal door secures the building. Next to the entrance, and affixed to the exterior of the building, is a secure propane tank storage area.

At the rear of the building are one of two fire hydrants on site and a raised, circular concrete slab, approximately six feet in diameter. On top of the concrete slab is a secure access panel. Before the pump house was built, this structure was used to access and maintain critical water supply infrastructure. In the future, this structure will be removed and the area resurfaced to match the material and grade of the surrounding access road (Riopelle 2013*b*).

On the north side of the pump house are the second fire hydrant and a four- by five-foot secure, metal electrical transformer box, which is owned by National Grid. The transformer box sits on a five- by six-foot concrete slab and is surrounded by three, four-foot tall concrete bollards for safety and security purposes.

Dam. An illegal dam is located on the northeast side of Trotting Park Road (Tyngsborough), approximately 200 feet southeast of a DCR gate that separates the public and private portions of the road. The dam limits the flow of water from a wetland into Scarlet Brook through a culvert under Trotting Park Road (Tyngsborough). The dam primarily consists of logs greater than 12 inches in diameter and over 10 feet in length. It is not known when the dam was constructed or by whom.

Over time, water and sediment have collected behind the dam, creating a pond-like environment and promoting the growth of leafy vegetation on the dam itself. Water frequently overflows the dam, which floods and erodes portions of Trotting Park Road (Tyngsborough). At times, the erosion is significant enough to prevent DCR staff and emergency vehicles from entering the forest through the nearby DCR gate.

Trash Dumpsters. In the southern portion of the forest, within the former headquarters site, there are four large trash dumpsters that are in fair to poor condition. The dumpsters are primarily used by DCR staff to dispose of trash and larger debris collected at the state forest and nearby Lowell Heritage State Park.

Roads

Althea Avenue (Tyngsborough) is the only public road that runs through Lowell-Dracut-Tyngsborough State Forest; approximately 0.3 miles of the dead end, residential street are located within the northern section of the forest.

Trotting Park Road is the forest's primary administrative road (0.8 miles; see Figure 2). It is oriented in a north-south direction and connects the public portions of Trotting Park Road in Lowell and Tyngsborough. The paved portion of this road (0.6 miles) runs from the main entrance (Trotting Park Road, Lowell) to the northwest corner of Spruce Swamp. From Spruce Swamp to Trotting Park Road in Tyngsborough, the road surface is bank run gravel (0.2 miles).

The paved portion of Trotting Park Road continues north from Spruce Swamp to Dexter Avenue (Dracut) as an unnamed administrative road (0.5 miles; see Figure 2). An additional unnamed administrative road, located off of Tyngsboro Road (Dracut), provides access to the Dracut Water Supply District reservoir and related infrastructure (paved 0.2 miles; processed gravel 0.1 miles).

Parking

The forest has two small parking areas (see Figure 2). The first is located at the main entrance on Trotting Park Road in Lowell. It is a paved lot with a shared entrance and exit, and can accommodate approximately six vehicles. Individual spaces are not marked and there are no designated accessible spaces.

This parking area is the most popular with visitors. Vehicles are routinely parked on either end of the paved portion of the lot when there are no other spaces available. Further south on Trotting Park Road (Lowell), approximately 40 feet from the designated parking area, an "overflow" lot has been created. This unofficial parking area can accommodate three or four vehicles.

The second parking area, as indicated on the current state forest trail map, is located at the end of Trotting Park Road in Tyngsborough. It is unclear where to park when visiting this area of the forest. The most obvious location is in front of a forest gate on the west side of the road; however, this prevents DCR staff and first responders from being able to enter the forest in the event of an emergency.

Trails

There are approximately 27 miles of trails within the state forest, nearly all of which are official. An assessment of trail condition, conducted in 2009, indicated that 95% of the official trails were in good or fair condition and only 1.3 miles (5%) were in poor condition. Several official trails include technical features (e.g., banked or bermed corners, jumps and ramps), which are constructed to increase the technical challenge for mountain bike riders. It is unclear whether these features were subject to all applicable regulatory reviews and approved by the reviewing authorities and the DCR.


A mountain bike jump constructed in the forest. (DCR)

There is one, 1.5-mile long Healthy Heart Trail within the forest; it is located between the main entrance in Lowell and Spruce Swamp. Healthy Heart Trails are pathways used for hiking or walking that are easy to moderate in activity level and promoted by the DCR as a way to improve health through routine use.

The current version of the state forest trail map indicates four other named trails within the state forest (Thompson Lane, Totman Road, Carney Road and Gumpus Road), as well as "Public Safety Markers," or trail intersection numbers, that correspond to the town in which they are located (e.g., "L1" in Lowell, "D1" in Dracut, "T1" in Tyngsborough, etc.). Signs for these features are largely missing from the trail network. There are also more trails in the network than indicated on the current version of the state forest trail map.

Signs and Kiosks

There is one Main Identification Sign for the state forest. It is set back from, and parallel to, the north side of Varnum Avenue (Lowell), near the intersection of Trotting Park Road (Lowell). The orientation, material and design of this sign do not meet DCR signage standards (DCR n.d.). There are no Road Marker Signs that lead visitors to the state forest from the surrounding communities.

There are six kiosks located within the state forest; each is constructed of wood framing and has an asphalt shingle roof. Two kiosks are near the forest's parking areas and do not meet DCR signage standards for Welcome Wayside Signs (DCR n.d.). Only one kiosk, at the main entrance on Trotting Park Road in Lowell, features the current state forest trail map. Four of the six kiosks feature information on hunting (e.g., seasons, rules and regulations). The two kiosks closest to the parking area on Trotting Park Road in Tyngsborough are completely blank.

All six kiosks are in fair to good condition. Moss is growing on the roof of the kiosk at the main entrance on Trotting Park Road in Lowell. The two kiosks on Totman Road in Dracut have been vandalized with permanent marker and paint.

Memorials and Markers

Sheep Rock is the only known memorial within the state forest. (See Section 3.3. Existing Conditions, Cultural Resources, for additional information.)

3.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

The Dracut Water Supply District (DWSD) maintains the vegetation along the access road leading to the summit of Gage Hill, as well as around the water supply infrastructure there. (See Section 3.3. Existing Conditions, Buildings and Structures, for additional information.) The DWSD also maintains an approximately 20-foot-wide vegetated corridor that runs from the pump house north to Tyngsboro Road (Dracut). The purpose of this corridor is to prevent woody or deep-rooted vegetation from disturbing the underground pipelines in the area (Riopelle 2013*c*). There is no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides this maintenance activity.

Wildlife

For the most part, the DCR does not actively manage wildlife at the state forest. However, when beaver activity becomes a problem (e.g., it threatens public health or safety), a wildlife specialist is called upon to install one or more beaver deceivers, or to trap the animal(s). In addition, the hunting of game species is permitted outside of the forest's "No Hunting Areas" (see Section 3.3. Existing Conditions, Recreation Resources).

Cultural Resources

There are no cultural resource management activities that are unique to the state forest.

Recreation Resources

Greater Lowell Indian Cultural Association (GLICA) Memorandum of Understanding (MOU)

The purpose of the expired MOU between the DCR and the GLICA was to "authorize the GLICA to use approximately two hundred and fifty-two (252) acres of the Lowell-Dracut-Tyngsboro [sic] State Forest…for temporary American Indian cultural activities and special events…to promote understanding of American Indian people and customs." The document largely outlined the GLICA's responsibilities related to the use and maintenance of the agreed upon area. Permissible activities, public access to events and circumstances requiring advanced or immediate notification to the DCR were addressed, among other topics.

On April 13, 2012, the GLICA notified the DCR, in writing, of their interest in renewing the MOU that was scheduled to expire on July 1, 2012. The DCR sent a new five-year MOU (valid through July 1, 2017) to the GLICA for their signature on July 6, 2012, but that document was never signed and returned to the DCR.

Camping

There are no permanent campsites or cabins at Lowell-Dracut-Tyngsborough State Forest; however, temporary campsites have been designated in the past, by the Forest and Parks Supervisor, for events sponsored by the Greater Lowell Indian Cultural Association.

Hunting and Fishing

Hunting is not permitted in two separate areas of Lowell-Dracut-Tyngsborough State Forest (see Section 3.3. Existing Conditions, Recreation Resources). The Greater Lowell Indian Cultural Association was responsible for posting and maintaining DCR approved “No Hunting” signs within the portion of the forest that was under agreement.

Trail Use

Snowmobiles may be used on any unplowed forest road or way at Lowell-Dracut-Tyngsborough State Forest, provided that: the vehicle is registered; sub-surface soil is “solidly frozen and completely covered with a minimum of four inches of hard packed snow or ice;” and the vehicle is carrying a spare spark plug, flashlight, drive belt and “sufficient tools to effect minor repairs.” Snow vehicles may operate on frozen waters when there are five or more inches of frozen ice and in “fields, gravel banks or similar open areas where such use is permitted by appropriate signage.” (See 304 CMR 12.29; Appendix F.)

Infrastructure

Buildings and Structures

The Dracut Water Supply District (DWSD) manages the majority of the infrastructure near the summit of Gage Hill; National Grid is responsible for the maintenance of the electrical transformer box (see Section 3.3. Existing Conditions, Buildings and Structures). There is no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides this management activity.

DCR staff maintain the culvert and leafy vegetation associated with the illegal dam on Trotting Park Road in Tyngsborough (see Infrastructure, above, for more information). Staff have also added a layer of course gravel to the surface of the road, however flooding remains an issue.

The four large trash dumpsters located within the former headquarters site are routinely serviced by a disposal company that is under contract with the DCR.

Roads

The DCR’s Forest Fire Control District 6 provides forest road maintenance (e.g., roadside mowing, tree removal and road repairs) on an annual basis.

The Dracut Water Supply District (DWSD) plows the access road leading to the summit of Gage Hill. (See Section 3.3. Existing Conditions, Roads, for additional information.) There is no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides this maintenance activity.

Trails

The Merrimack Valley Chapter of the New England Mountain Bike Association performs volunteer trail work, including trail maintenance, repair and construction, and bridge building for trails, within the state forest. In the past, this work has primarily been done in consultation with the Forest and Parks Supervisor; a more formal agreement for this work is needed to ensure compliance with any required regulatory reviews. All trail work, whether performed by DCR employees or others, must be performed in accordance with general regulations and policies identified in Section 2.

Interpretive Services

Interpretive service programming is not offered at the state forest, nor is any other interpretive information provided.

Operational Resources

DCR Staffing

The state forest is operated as a satellite of Lowell Heritage State Park and does not have any dedicated on site staff.

Supplemental Staffing

Members of the Greater Lowell Indian Cultural Association and Merrimack Valley Chapter of the New England Mountain Bike Association routinely volunteer their time at the state forest for various general cleanup and trail maintenance activities. The potential exists for members of the Friends of the Forest, a group that has been inactive for several years, and students at the Greater Lowell Regional Technical High School to become more involved in organized activities at the state forest.

Public Safety

Local emergency response and law enforcement support within the state forest is complicated by the fact that the forest occurs in three municipalities. Recent efforts to improve communication between the DCR, local responders and visitors include: adopting a town-specific trail intersection numbering system (see Section 3.3. Existing Conditions, Trails) and distributing a "safety map" of the forest to pertinent DCR staff and local officials. The safety map includes information on the forest's trails, fire roads, major trail intersections and access gates, as well as neighboring access roads and municipal boundaries.

DCR Rangers issue citations for violations of various forest and park rules. A summary of incident reports recorded in the state forest during 2013 is provided below.

Table 3.4. Lowell-Dracut-Tyngsborough State Forest Incident Reports, January 1 through December 31, 2013

Incident	Number
Illegal dumping	1
Property damage	1
Violation of DCR regulations[a]	2
Total	*4*

a. These violations were related to off-highway vehicle (OHV) use and a campsite/fire within the state forest.


Vandenberg Esplanade (Peter E. Lee; CC BY-NC 2.0; cropped from original)

SECTION 4. LOWELL HERITAGE STATE PARK

4.1. Introduction

Forty years ago, the Department of Natural Resources proposed the Commonwealth's first heritage state park in Lowell. The purpose of the park was twofold: to preserve the cultural heritage of the city and surrounding region, and to increase public appreciation and enjoyment of the area's natural and cultural resources. Through an ambitious plan of acquisition, conservation and development, the agency and its partners were able to bring their vision of urban recreation and a revitalized industrial city to life.

Lowell Heritage State Park (87 acres) is comprised of linear greenways along the Merrimack River and Lowell Canal System, and a collection of historic buildings and structures related to the industrial development of the city. The park provides much needed open space in the city's downtown; showcases the city's history, with a focus on the canal system and associated mills; and serves as an important venue for a variety of civic and social functions.

4.2. History of Property

The story of Lowell Heritage State Park is closely tied to that of the Merrimack River. The river originates in Franklin, New Hampshire and runs southward for 116 miles, reaching the Atlantic Ocean in Newburyport, Massachusetts. Although the Merrimack descends "a modest average of 2.6 feet per mile," there are several waterfalls where the river drops more rapidly in elevation (Steinberg 1991, 50). Prior to the construction of dams, a total of 14 waterfalls existed along the course of the Merrimack. Both Native Americans and European colonists established settlements near many of these falls.

Native Americans were drawn to Lowell because of its natural resources and strategic location. Pawtucket Falls slowed the progress of migrating Atlantic salmon, American shad, lamprey and alewife, allowing them to be caught in large numbers (Stolte 1981). This abundant and predictable seasonal food supply, along with easy access to coastal and forest resources, attracted the Pennacook Tribe, who established a populous settlement downstream of the falls. In 1653, the Massachusetts General Court authorized John Elliot to establish Wamesit, a praying village for the Pennacook, at the confluence of the Merrimack and Concord rivers (Hudon 2004). Twenty-three years later, however, the Pennacook abandoned Wamesit due to King Phillip's War.

As European settlements expanded, colonists sought ways to move timber and crops to coastal cities, and imported goods inland. However, Pawtucket Falls impeded the flow of river traffic, requiring goods to be shipped over land around the falls. In 1792, a group of wealthy Newburyport businessmen, known as the Proprietors of Locks and Canals on the Merrimack River (the Proprietors), constructed the Pawtucket Canal to solve this problem. The canal, which ran from upstream of the falls to the confluence of the Merrimack and Concord rivers, bypassed both the falls and a near 90-degree bend in the Merrimack. In 1801, five years after the Pawtucket Canal opened, work began on a competing canal. Beginning in 1803, the Middlesex Canal, which connected Chelmsford to Charlestown, moved raw materials and goods to the port of Boston. Although the Middlesex Canal outcompeted the Pawtucket Canal, its success was short-lived due to the arrival of the railroad in the 1830s.

The industrial development of Lowell began in 1821 when a second group of businessmen visited Pawtucket Falls to assess its potential for industrial water power (Hudon 2004). Within a month they had purchased over 350 acres of land between the bend in the river and the Pawtucket Canal, in what was then East Chelmsford. In 1822, they purchased water power rights from the Proprietors, the company that constructed the Pawtucket Canal 30 years earlier. This established the Proprietors as the developer and power broker of the city, selling land and leasing mill power to textile manufacturers for years to come (Hudon 2004).

In 1825, the Merrimack Canal, the city's first power canal, was completed. Four additional power canals were constructed between 1826 and 1835; by 1840 these canals were distributing power to 32 mills (Hudon 2004). One additional canal and an underground connector between canals were built in the late 1840s. A permanent dam across the Merrimack, constructed in 1830 and increased in height in 1833, created an 18-mile stretch of river as a water holding area to ensure an adequate supply of water for the mills. In 1845, the Proprietors bought outlets to several bays and lakes in New Hampshire to further ensure sufficient water to power the mills.

As the mills grew, so too did the city. In 1826, the site of the mills in East Chelmsford became the town of Lowell. Ten years later, Lowell was given a city charter and in three short years, it was the third largest city in Massachusetts. This rapid population growth was driven by the arrival of mill workers. Initially, most mill workers were single, young females from the Merrimack Valley who lived in boarding houses owned by the mills. However, immigration soon changed the demographics of mill workers.

A massive influx of immigrants, from Ireland and other parts of Europe, took place in the 1840s. By 1850, the population of Lowell was 33,000. According to the 1915 state census, one-third of Merrimack Valley residents were foreign born (Hudon 2004). These immigrants remained the major source of labor until the 1920s (Forrant and Strobel 2011). Fewer immigrants made their way to Lowell between the mid-1920s and mid-1960s due to changes in immigration laws and the closing of mills. It was at the end of this period of decline, amid a 13% unemployment rate and a surplus of abandoned, deteriorating infrastructure, that an interest in revitalizing the city first took hold.

In 1974, the Department of Natural Resources (DNR) developed a nine million dollar proposal for Lowell Heritage State Park, the first of its kind in the state system. The following year, the Department of Environmental Management (DEM), a successor to the DNR, announced the completion of a Memorandum of Understanding with the City of Lowell and an accelerated development schedule for two "nodes" within the park: Francis Gate and Pawtucket Boulevard. A few years later, in 1978, President Carter signed legislation dedicating $40 million to the creation of Lowell National Historical Park, which spurred a unique preservation partnership between local, state and federal governments, and later, the private sector.

By the mid-1980s, the DEM had exceeded its original acquisition, conservation and development goals for the park. It also created an ambitious and successful year-round interpretive program, including a living history component, which was fully integrated with the efforts of the National Park Service. At its peak in 1987, Lowell Heritage State

Park employed 16 full-time and 17 seasonal staff, and had an annual operating budget of $480,000.

Over the next five years, the DEM's budget was greatly reduced and the agency was forced to cut personnel and park budgets. Lowell Heritage State Park presented a particular challenge, since it served as the model for the heritage park concept, and was the largest and most complex heritage park in the state system. At the request of then Commissioner Peter Webber, an intradivisional task force was convened to review the status of the park and develop recommendations for its future. The task force's report concluded that the DEM should "concentrate on maximizing the riverfront component and minimizing, but not eliminating, [its] position in the downtown" (DEM 1993, ES).

Today, the Department of Conservation and Recreation (DCR), successor to the DEM, retains an ownership interest in most of the land that once comprised Lowell Heritage State Park. However, under even greater budget constraints, the DCR continues to focus its resources on the riverfront portion of the park and uses legal agreements with its original partners, the City of Lowell and National Park Service, to operate and maintain facilities park-wide.

4.3. Existing Conditions

In this section and the following, 4.4. Management Resources and Practices, the park's resources are presented in order, from west to east. In other words, under each heading (e.g., Natural Resources), resources related to the Vandenberg esplanade are presented first, followed by resources related to the downtown portion of the park. The descriptions of the downtown resources are further organized by the flow of water. In general, resources related to the Pawtucket and Northern canals are present first, followed by resources related to the remaining canals, in the same order as the water flows through the system today.

Natural Resources

Physical Features

Topography. The Merrimack and Concord rivers are the defining features of Lowell Heritage State Park (see Figure 3). The Merrimack River flows easterly through the northern portion of Lowell, dropping approximately 60 feet in its eight-mile course through the city. The Concord River flows northerly through the eastern half of the city and enters the Merrimack near Bridge Street. In general, the Concord River is fairly level and its floodplain is mostly broad. However, within the city, the Concord River drops rapidly, due to three sets of falls, and has a relatively narrow floodplain.

Geology. The City of Lowell is located within the northern portion of the Nashoba terrane, a rock formation that consists of interlayered gneisses and schists. The Clinton-Newbury fault zone forms the northern boundary of the Nashoba terrane and is believed to have played a role in changing the course of the Merrimack River at the western limits of the city. The river originally flowed southeast through Woburn and into Boston Harbor. The buried bedrock valley from this original course provides valuable resources for the region. For example, wells that supply Lowell, Winchester and Woburn with abundant groundwater are situated along the former course of the river. In addition, glacial outwash deposits within the buried valley are mined for concrete aggregate and other building purposes.

Soils. Soils within Lowell Heritage State Park vary based on the topography and level of development near the Merrimack River. Very poorly to excessively drained silt and sandy loams are associated with the wide floodplain and limited development between the river and Varnum Avenue. These soils are considered severely limited for playgrounds and moderately limited for picnic areas, paths and trails (Peragallo 2009). Well to excessively drained glacial deposits, most of which have been disturbed by heavy development, dominate the remaining portion of the park. These soils range from being moderately to slightly limited for picnic areas, playgrounds, paths and trails (Peragallo 2009).

Table 4.1. Soils of Lowell Heritage State Park[a]

Soil Series	% of Park	Drainage Class
Udorthents	17.1	N/A
Urban land	16.1	N/A
Suncook loamy sand	12.8	Excessively drained
Merrimac-Urban land complex	10.8	Somewhat excessively drained
Occum very fine sandy loam	9.9	Well drained
Limerick silt loam	8.5	Poorly drained
Water	7.0	N/A
Winooski very fine sandy loam	7.8	Moderately well drained
Scio very fine sandy loam	3.6	Moderately well drained
Birdsall mucky silt loam	3.5	Very poorly drained
Windsor loamy sand	1.7	Excessively drained
Scio-Urban land complex	0.8	Moderately well drained
Canton-Charlton-Urban land complex	0.3	Well drained

a. Excluding the Lord swimming pool and Janas skating rink.

Water Resources

Ponds. There are no ponds within the park.

Wetlands. There are approximately 11 acres of wetlands along the Vandenberg esplanade, immediately upstream of the Rourke Bridge and north of regatta field. In addition, there is a small (0.5 acres) wetland in between the Janas skating rink and Douglas Road. (See Figure 3.)

Vernal Pools. There are no certified or potential vernal pools within the park.

Streams. There are three named streams or rivers within Lowell Heritage State Park (see Figure 3). Claypit Brook, the smallest of the water bodies, originates in Lowell-Dracut-Tyngsborough State Forest. The stream flows south from the forest towards Varnum Avenue in Lowell, where it turns east and runs near regatta field before entering the Merrimack River.

The next water body is the heart of the park and the city. Once considered one of the most polluted rivers in the country, the Merrimack River's water quality has improved greatly in the last 40 years. However, it is still considered "impaired" by the United States Environmental Protection Agency (EPA), due to a variety of chemical and biological contaminants that are routinely detected in present day water quality assessments.

Table 4.2. Causes of Impairment for Select Segments of the Merrimack River, Reporting Year 2012

Segment Location	Cause of Impairment
NH/MA State Line to Pawtucket Dam, Lowell	Fecal coliform, mercury in fish tissue
Pawtucket Dam, Lowell to Duck Island, Lowell	E. Coli, mercury in fish tissue, total phosphorus
Duck Island, Lowell to Essex Dam, Lawrence	E. Coli, mercury and PCBs in fish tissue, total phosphorus

Source: EPA 2014

The remaining water body, located on the easternmost side of the park, is the Concord River. It originates at the confluence of the Sudbury and Assabet rivers and flows north, approximately 16 miles, through Concord, Carlisle, Bedford and Billerica before entering the Merrimack River in Lowell. The EPA also considers a portion of the Concord River in Lowell, from the Rogers Street Bridge to the Merrimack River, to be "impaired." The causes of impairment are: excess algal growth, fecal coliform, mercury in fish tissue and total phosphorus (EPA 2014).

Groundwater. A portion of two medium-yield aquifers and one high-yield aquifer occur beneath two sections of the park (see Figure 3). Near the Rourke brothers boat ramp, approximately 16 acres of the park overlap with both a high- and medium-yield aquifer that follows Stony Brook and Black Brook south, past Route 3 in Chelmsford. Further east, at the bend in the Merrimack River, between Pawtucket Falls and Aiken Street, a medium-yield aquifer extends south from Pleasant Street, along Beaver Brook, to the northern shoreline of the river. Approximately two acres of the park overlap with this aquifer.

Flood Zones. The 100-year flood zone covers 64 acres (73%) of the park; its boundary approximately parallels the Merrimack River and each of the canals, where the DCR has an ownership interest. All of the developed areas along the Vandenberg esplanade are included in the 100-year flood zone. In addition, many of the historic buildings within downtown Lowell are included in the 100-year flood zone. However, it should be noted that water levels

Placeholder for Figure 3 (front).

Placeholder for Figure 3 (back).

within the canal system are regulated to reduce the likelihood of flooding in this portion of the park.

The 500-year flood zone covers an additional nine acres (10%) of the park, including the majority of the Rynne bathhouse and its parking area. In downtown Lowell, the Gatekeeper's Barn is the only historic building included in the 500-year flood zone. Further east, the 500-year flood zone also extends across the Janas skating rink parcel, impacting approximately 22% of the property (one acre), but not the skating rink itself.

Rare Species

Lowell Heritage State Park is home to three state-listed species.

Table 4.3. State-listed Species of Lowell Heritage State Park, as identified by the Natural Heritage & Endangered Species Program (NHESP)

Species	Type	MESA[a]
Bald eagle	Bird	T
Cobra clubtail	Insect	SC
Umber shadowdragon	Insect	SC

Source: Harper 2013

a. Status of species listed under the Massachusetts Endangered Species Act (MESA): SC = Special Concern and T = Threatened.

While occasionally spotted over the park, bald eagles are more common near the mouth of the Merrimack River, where there is more suitable nesting and wintering habitat (NHESP 2012). The cobra clubtail and umber shadowdragon can also be found in the park, on occasion, primarily along the Merrimack River. Both species of dragonflies prefer large, unvegetated rivers and lakes for breeding, and the surrounding upland borders for feeding, resting and maturing (NHESP 2008*a* and NHESP 2008*b*).

Nearly half of Lowell Heritage State Park (42 riverfront acres) has been designated as Priority Habitat under the Massachusetts Endangered Species Act (321 CMR 10.00; see Appendix F). Most of this same area (39 riverfront acres) has also been identified as Core Habitat in the MassWildlife and The Nature Conservancy publication "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010).

BioMap2 highlights two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010).

Within the park, there are also 35 acres (40%) of Critical Natural Landscape adjacent to the Merrimack River.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified three forest sub-types along the Vandenberg esplanade.

Table 4.4. Forest Sub-types of Lowell Heritage State Park[a]

Forest Sub-type	Acres	% of Park
Oak-hardwoods	3.3	3.8
Mixed oak	3.2	3.7
Scots pine plantation	2.7	3.1
Total	*9.2*[b]	*10.6*

a. Excluding the Lord swimming pool and Janas skating rink.

b. Only the park's riverfront acres were included in the analysis. Of those acres, wetlands, areas of open water and day use and administrative areas were removed from the total.

There is also one Continuous Forest Inventory (CFI) plot within the park. The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for sivicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

Unfortunately, the plot within Lowell Heritage State Park is located within a grassy area of the Vandenberg esplanade, so it does not provide any additional information about the health of the park's limited forest.

Priority Natural Communities. There are no Priority Natural Communities within the park.

Invasive Species. Japanese knotweed (*Fallopia japonica*) was observed along the western half of the Vandenberg esplanade, between the river and the retaining wall, while conducting fieldwork for this plan.

Pests and Disease. None has been identified at the park.

Wildlife

Birds. There is little current information on the park's birds. Five species confirmed to occur within the park are identified in Appendix G. Of these species, one is classified as a Species in Greatest Need of Conservation (MassWildlife 2006).

Mammals. There is little current information on the park's mammals. Fourteen species that may possibly occur within the park are identified in Appendix G.

Reptiles. There is little current information on the park's reptiles. One species confirmed to occur within the park and an additional four species that may possibly occur within the park are identified in Appendix G.

Amphibians. There is little current information on the park's amphibians. Five species confirmed to occur within the park and an additional three species that may possibly occur within the park are identified in Appendix G.

Fish. The Massachusetts Office of Fishing & Boating Access lists largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), northern pike (*Esox lucius*), white perch (*Morone americana*), chain pickerel (*Esox niger*), black crappie (*Pomoxis nigromaculatus*) and walleye (*Sander vitreus*) as fish species that are typically caught in the Merrimack River (OFBA 2014).

In addition, the Department of Public Health lists American eel (*Anguilla rostrata*) and white sucker (*Catostomus commersonii*) as part of the public health fish consumption advisories for the Merrimack River and canal system (DPH 2014). (See Recreation Resources, below, for more information about the advisories.)

Finally, the United States Fish & Wildlife Service, through its Central New England Fishery Resources Office, monitors migratory fish populations in the Merrimack River. Fish passage data for the Pawtucket Dam indicate American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*) and sea lamprey (*Petromyzon marinus*) also occur in the park (USFWS 2014).

Cultural Resources

Pre-Contact Archaeological Site

Although only three pre-Contact sites are recorded in the park, many more exist along the Merrimack River both downstream and up. Many Archaic Period village sites, camp sites and fishing grounds are documented nearby along the banks of the river. Archaeological testing along the river clearly revealed it has been reconfigured and straightened. Above Pawtucket Dam, which was constructed at the naturally occurring Pawtucket Falls, the shoreline had to be raised and straightened and Pawtucket Boulevard was constructed on the fill afterwards. Despite land modification and filling, there is a moderate potential for the complex.

Historic Archaeological Resources

The Tremont Mills powerhouse, formerly located in Tremont Yard, on the Western Canal where it meets Father Morissette Boulevard, was partially demolished when it became a part of Lowell Heritage State Park. The single-story ruin was in a state of serious deterioration when it was completely demolished in 2008, as part of a lease for redevelopment (see Infrastructure, below, for more information). The stipulations for redevelopment included preserving the historically significant below grade features, such as the original turbine pits dating from 1847-1854. It was within this powerhouse that James B. Francis, chief engineer for the Proprietors of Locks and Canals on the Merrimack River, conducted experiments that allowed for the development of a more powerful and efficient turbine technology. The original turbine pits are viewable within the office building that is now located on the site and interpretive information is provided.

Historic Resources

This section provides information on Lowell Heritage State Park's historic buildings, structures, objects and landscapes (see Figure 3). See Infrastructure, below, for information on the park's non-historic buildings and structures.

Designations

With the exception of the Rynne bathhouse, all of the resources within Lowell Heritage State Park fall within the Downtown Lowell Local Historic District. This district, initially established on December 13, 1983, and later expanded in 1986 and 2004, "…seeks to ensure that development activities within the district are consistent with the preservation of its 19th century setting" (City of Lowell 2014). More protective than a National Register of Historic Places designation, the local historic district requires review of alterations to any exterior feature by the Lowell Historic Board for compliance with the design review standards and policies that have been established for this district. The DCR has a seat on the Lowell Historic Board.

There are also three National Register Districts, with some overlaps, and a National Historic Landmark designation that apply to the DCR properties within Lowell Heritage State Park:

- The City Hall District, of which only the Mack building is a part, was listed on the National Register on April 21, 1975.
- The Locks and Canals Historic District was listed on the National Register on August 13, 1976 and became a National Historic Landmark on December 22, 1977. With the exception of the Rynne bathhouse, all of Lowell Heritage State Park falls within this district.
- The Lowell National Historical Park and Preservation District was listed on the National Register on June 5, 1978. This much larger district includes all of Lowell Heritage State Park.

The Lowell Canal System has also been recognized for its significance within the field of engineering. The American Society of Civil Engineers designated the "Lowell Waterpower System" as a Historic Civil Engineering Landmark in 1984, and the American Society of Mechanical Engineers (ASME) designated the "Lowell Power Canal System and Pawtucket Gatehouse" as a Historic Mechanical Engineering Landmark in 1985 (Reese 2014; ASME 2014).

Buildings

The ***Michael Rynne Bathhouse*** is the lone historic building on the Vandenberg esplanade. Located at 160 Pawtucket Boulevard, the building was constructed sometime between 1906 and 1924. It is named for Mike Rynne, a former Lowell police officer and highly regarded athlete that excelled in swimming. The bathhouse is a brick building with a flat roofed, square central core, flanked by two gable roofed wings, each three bays in length. Architectural details include brick piers on the wings, round headed door and window openings in the central core and a small, low parapet on the center of the street façade of the building. The wings of the building have wood trim, an asphalt shingle roof and the upper portion of the gable ends are sheathed in unpainted clapboard. Some of the former openings have been filled in with brick and some of the wood trim is exhibiting signs of deterioration or missing. Water damage to the roof framing is also evident on the interior of the building.

The bathhouse is open year-round. The central core contains public restrooms and each wing is used for office and storage space. DCR staff use one wing and the City of Lowell uses the other for their seasonal lifeguards and waterfront equipment (see Recreation Resources, below, for more information). The building has electricity, a phone line, domestic water and waste water disposal; it is in fair condition.

Rynne Bathhouse (DCR)

The majority of the park's historic buildings are located in downtown Lowell and associated with the city's canal system (see Figure 3). The National Park Service maintains these resources as part of an expired Memorandum of Understanding with the Department of Environmental Management, Boott Hydropower, Inc. and the Proprietors of Locks and Canals on the Merrimack River (see Section 4.4. Management Resources and Practices for more information). The Gatekeeper's House and barn are excluded from this arrangement, as the buildings are part of the DCR's Historic Curatorship Program. The Mack building is also excluded because it is not directly associated with the canal system.

The ***Pawtucket Gatehouse***, located at the eastern edge of the Pawtucket Dam and the head of the Northern Canal, was constructed in 1847. The gatehouse contains the machinery designed by James B. Francis to operate 10 sluice gates via a turbine and hoisting screws. Constructed of brick, on top of the granite dam, and extending 11 bays long, the Italianate style gatehouse has a gabled slate roof. Architectural details include denticulated cornices, pediment returns, round headed door openings and recessed, round headed, six-over-six double-hung sash windows. Twin end interior chimneys complete the picture. One corner of the building is rounded, a detail that is seemingly part of the original design, but the purpose is unclear. A navigational lock, not used since 1871, is located next to the gates. One end wall of the gatehouse has experienced some cracking, but it is otherwise in good condition. The building has electricity.

Pawtucket Gatehouse (DCR)

Next to the Pawtucket Gatehouse, at 23 School Street, is the ***Gatekeeper's House***, historically home to the operator of the Pawtucket Gate. The Gatekeeper's House is a two-story, side gabled, wood frame house built in 1847, in the Italianate style. It is three bays wide by two bays deep, with a hipped roof section at the rear and a one-story kitchen ell. The projecting center entrance with enclosed pediment is an addition made sometime before 1890, and the front façade windows have round arched trim. The house is clad in wooden clapboards, has a stone foundation, asphalt shingled roof, two interior brick chimneys and wood cornerboards with a boxed cornice. The building has electricity, a phone line, domestic water and waste water disposal; it is in good condition.

Gatekeeper's House (DCR)

Behind, and perpendicular to, the Gatekeeper's House is the ***Gatekeeper's Barn***. Constructed in three separate phases (dates unknown), the barn has two gable roofed sections with a smaller, shed roofed component. Clad in a combination of clapboards and vertical board sheathing, the barn has an asphalt shingle roof and is in good condition. The building also has electricity. The oldest section of the barn, located in the center, is set up as a one car garage. Due to the slope of the surrounding land, the rear façade of the building is a full story higher than the front, which provides storage space below the garage.

Gatekeeper's Barn (DCR)

The gatekeeper's property was acquired by the DCR in 1977 and housed a staff interpreter until 1986. After being vacant for 15 years, it was included in the DCR's Historic Curatorship Program and leased by curators from 2001 through 2011. The house and barn are once again vacant and available for curatorship; proposals are currently being solicited.

Located beyond the Gatekeeper's Barn is the ***Blacksmith Shop***. Primarily utilized by the Proprietors of Locks and Canals on the Merrimack River as a boathouse and blacksmith shop, to fix and maintain flashboard hardware, this building was brought or built on site in 1884. Clad in vertical board sheathing and clapboards, the Blacksmith Shop has a hipped roof covered with asphalt shingles and a brick chimney that pierces the roof line. A large exterior sliding door provides access. The building has electricity and is in excellent condition.

Blacksmith Shop (DCR)

Francis Gate Park is located on the Pawtucket Canal near Broadway Street and includes a series of resources associated with the Guard Locks. The first navigational lock was built in 1796-1798, with the development of the canal. This lock was subsequently rebuilt and several other features were added to the site over the course of the 19th century, including a dam, power canal, second navigational lock and flood gate. A manmade island separates the dam and sluice gates from the navigational locks and flood gate.

The oldest extant resource within Francis Gate Park is the ***Great Gate***, also known as the Francis Gate or Francis' Folly. Constructed in 1848-1850, this Portcullis gate was designed by James B. Francis for flood control purposes. The gate itself is made of wood, constructed of 17-inch-wide southern pine timbers that are held together with vertical iron rods; it is in excellent condition. The gate protected the city from serious flood damage in 1852, and again in 1936. The Great Gate is sheltered by the ***Guard Locks Great Gate Gatehouse***; a tall, narrow, wood frame building sheathed in clapboard with a cedar shingle roof. Buttresses support the building, tying it to the granite abutments. The gatehouse has electrical service, and is also in excellent condition.

Great Gate and Gatehouse (DCR)

The ***Guard Locks Gatehouse*** contains the hydraulic machinery for operating the sluice gates located at the dam, in the easternmost section of Francis Gate Park. Constructed in 1870, predominantly of brick with a single wood frame wall, this one-story building has a full height basement level on the upstream side of the dam. The gatehouse is sheathed in brick and clapboard, and has a slate roof. Italianate details include denticulated cornices; pediment returns; round headed, recessed, four-over-four, double-hung sash windows; and round headed door openings. Twin end interior chimneys complete the picture. The gatehouse has electricity, and it is in excellent condition.

Guard Locks Gatehouse (DCR)

The ***Guard Locks Lock House*** is located just north of the Guard Locks Great Gate Gatehouse, where it shelters the equipment that mechanically assists with opening the gates of the lock. Constructed in 1881, this single-story, seven-bay-long building is sheathed in clapboard and has a two stage hipped roof sheathed with slate; it is in excellent condition. Italianate architectural details include round headed, four-over-four, double-hung sash windows; round headed door openings; projecting wooden lintels; and paneled trim along the lower portion of the building, where some of the projecting lock mechanisms are accommodated. The lock house also has electricity.

Guard Locks Gatehouse, left, and Guard Locks Lock House, right (DCR)

The ***Hadley House***, located at 719 Broadway Street, was originally located in Middlesex Village. In 1990, the Federal style home was moved from 1708 Middlesex Street by the Jaycees of Lowell in an effort to save it from demolition and restore it, possibly for housing. The building has been vacant since the move and is presumably owned by the Jaycees, who may now be incorporated as the Lowell Jaycees Housing Corporation, Jaycee-Lowell Limited Partnership, or Jaycee-Lowell, LLC. There is no Memorandum of Agreement, or similar document, between the Jaycees and the DCR that describe the terms under which the Hadley House was moved to, and remains at, Francis Gate Park.

Hadley House (DCR)

The ***Northern Canal Wasteway Gatehouse*** was constructed in 1872, when the waste gates that are part of the Northern Canal Great Wall dam were modified to be mechanically operated by a turbine. It is the only gatehouse without electricity. Accessed by a walkway, the building sits on top of the Great River Wall and was built to shelter the mechanical equipment. The gatehouse is a rectangular, two-story timber frame building with a very low pitched shed roof. Four window bays are located on the river side of the building. The gatehouse is sheathed in clapboard and has a membrane roof; it is in excellent condition.

Northern Canal Wasteway Gatehouse (DCR)

The ***Tremont Gatehouse*** is located at the intersection of the Northern and Western canals; it controls the flow of water from the Northern Canal into the lower Western Canal by a pair of offset sluice gates. These gates are operated electrically, but the manual operation equipment is still located in the building. Constructed c1855, this gatehouse is in excellent condition, reflecting maintenance work that was done to remove the extensive ivy growth that covered the building in the 1970s.

This single story, gable roofed gatehouse has a granite foundation, walls constructed of brick and a slate roof. Italianate details include denticulated cornices; pediment returns; round headed, recessed, six-over-four, double-hung sash windows; and round headed doors. Twin end interior chimneys complete the picture. One corner of the building has an unusual taper, where the corner itself has been removed in what appears to be a modification of the original design.

Tremont Gatehouse (DCR)

The ***Swamp Locks Gatehouse*** was first constructed on the crest of the Swamp Locks dam and south sluice gate in 1859, to provide some shelter and protection for the dam. The gatehouse, a wood framed, single-story, interlocking gable roofed structure, has walls sheathed in a combination of clapboard and vertical boards, and an asphalt shingle roof. The wood windows are six-over-six, double-hung sash. The gatehouse has electricity.

Four different sections currently connect across the length of the dam. The longest section, located above the flashboard crest of the dam, is present in a historic photo from 1922, but was removed years later, as it is not present in DCR file photos from 1979. This section was reconstructed sometime after 1994, as it was not present when the National Park Service documented the site in the List of Classified Structures at that time. The gatehouse is in excellent condition.

Swamp Locks Gatehouse (DCR)

The ***Hamilton Wasteway Gatehouse***, located at the head of the Hamilton Wasteway, was constructed in 1872 when the wasteway itself was rebuilt, replacing an earlier gatehouse and wasteway dating from 1850. The purpose of the wasteway was to remove ice from the Hamilton Canal and divert it into the Pawtucket Canal. The gatehouse was manually operated until an electric motor drive was installed in the early 20th century. The small, single-story hipped roof building has rolled asphalt roofing and is clad with metal panels that have been pressed to resemble brick. The three windows that overlook the visible portion of the wasteway have four-over-four, double-hung sash windows; the remaining openings are boarded up. Vegetation is encroaching on the building, some of the cladding has been peeled away and a few pieces of the simple wood trim are missing. Unlike the other gatehouses in the park, this building is in very poor condition and lacks interpretive information.

Hamilton Wasteway Gatehouse (DCR)

Two buildings have been in place at the Lower Locks Dam since the mid-19th century; they provide shelter for the dam and house some of its mechanical components. The ***Lower Locks Gatehouse***, a one-by-one-bay building clad in clapboards with a cedar shingle roof, is located at the edge of the dam, at the upstream entry to the lock. An enclosed pediment on the gable end and a diamond pane, double-hung, sash window adorn the building.

A larger, single-story, wood framed, gabled roof building is located on top of the dam. A cross gabled component of this building, known as the ***Watch House***, shields the deep gate control housing. A gabled cupola sits atop the Watch House. The walls of this building are clad with vertical board siding, the windows are fixed 12-light windows and the roof is sheathed with cedar shingles.

Both of these buildings have electricity and are in excellent condition.

Lower Locks Gatehouse and Watch House (DCR)

The ***Massachusetts Wasteway Gatehouse*** is located at the turn in the Eastern Canal and sits slightly below Bridge Street. Built in 1862, in conjunction with the wasteway, the gatehouse protects the flashboard controls that direct water through the wasteway. The wasteway connects the Eastern Canal to the Merrimack River and assisted with ice removal in the canal.

The gatehouse is a single-story, five-by-one-bay building with a gabled roof and an inaccessible center entrance that faces the canal. Clad in clapboards, the roof is sheathed with cedar shingles and the windows are four-over-four, double-hung sash with hood moldings. The roof of the building has changed over time. Photographs from 1979 show a flat roof with a slight pitch, possibly a modification of an original gabled roof that was then rebuilt sometime between 1979 and 1994 to reflect its presumably historic appearance. The gatehouse has electricity and is in excellent condition.

Massachusetts Wasteway Gatehouse (DCR)

The ***Boott Dam Gatehouse***, built above the Boott Dam in 1892 as part of a rebuilding effort, provides shelter for the dam and houses hydraulic equipment to lift the sluice gate, which controls the level of water in the Eastern Canal. The gatehouse, which has electricity, is composed of two single-story, gable roofed sections that are situated at a slight angle to each other, probably to accommodate the infrastructure below. One section, attached to the sidewall of the Boott Mills, is slightly wider and taller than the other section. The building is clad in corrugated metal sheathing and it has a rolled asphalt roof. The only architectural detailing includes a plain vergeboard made of corrugated metal. A set of seven, six-over-six, vinyl windows stretch across the side of the building facing the canal. A brick chimney extends from the center of the building. Boston ivy has started to drape itself over part of the roof of the smaller section. The building is otherwise in good condition.

Boott Dam Gatehouse (DCR)

The ***W.A. Mack & Company Building***, located at 25 Shattuck Street, is the current home of the National Streetcar Museum (first and second floors) and DCR's North Region Headquarters (third and fourth floors). The museum utilizes space within the building through an expired Memorandum of Understanding with the DCR (see Section 4.4. Management Resources and Practices for more information).

The Mack building was constructed in 1886 by Sewall Mack for the W. A. Mack & Company on land they originally leased, and later purchased, from the Proprietors of Locks and Canals on the Merrimack River. The Queen Anne style brick building, with a cast iron storefront, served as the retail arm for their ironworks. Originally a three-story building, with decorative panel brick details on the second and third floors, a fourth story was added sometime between 1890 and 1905. Four-over-two, double-hung sash windows are located in the upper stories of the façade; all 38 of the building's double-hung windows are scheduled to be replaced in the fall of 2014 (see Section 2 for more information).

A full height brick and glass, stair and elevator tower was added to the north side of the building in 1979, when it was being renovated to serve as the visitor center for Lowell Heritage State Park. The building has electricity, telephone and internet service, domestic water and waste water disposal; it is in good condition.

The Mack building, prior to the window replacement project. (DCR)

Structures

The ***Lowell Canal System*** evolved steadily from 1821, when the old Pawtucket transportation canal was purchased and, a few years later, used to channel water into a series of new power canals. These virtually unaltered waterways, together with the remaining mills and their machinery, form what is "the most historically significant extant aggregation of early 19th century industrial structures and artifacts in the United States" (NPS 2014*b*).

Table 4.5. Power Canals within Lowell Heritage State Park[a]

Name	Date(s) of Construction
Merrimack Canal	1821-1823
Hamilton Canal	1825-1826
Lowell Canal[b]	1828
Western Canal	1831-1832
Lawrence Canal[c]	1831-1832
Eastern Canal	1835
Northern Canal	1846-1847

a. See Infrastructure, below, for more information on the DCR's ownership interest in the power canals.
b. The Lowell Canal was covered in 1880 (NPS 2014*b*).
c. Most of the Lawrence Canal is covered; sections of the canal have also been filled in (Herlihy 2014).

Each canal is unique, from the Pawtucket Canal, which follows the features of the surrounding landscape, to the Northern Canal, which is the deepest and widest canal, and perfectly straight. The canals are generally eight to 20 feet deep and 30 to 100 feet wide (NPS 2014*b*). The canal walls are constructed of natural materials, ranging from earth to granite, and the canal bottoms are mostly wood (Lowell Canalwaters Cleaners 2014). The canals are generally in good condition, however some vegetative growth and localized deterioration was observed in the canal walls while conducting fieldwork for this plan.

Table 4.6. Dams within Lowell Heritage State Park, by the DCR's Ownership Interest[a]

Dam	Class[b]	Last Inspection[c]	Condition	DCR Interest
Northern Canal Great Wall	S	6/18/2012	Satisfactory	Fee and Ease
Guard Locks	S	6/18/2012	Satisfactory	Ease
Swamp Locks	S	6/18/2012	Fair	Ease
Lower Locks	L	6/1/2006	Satisfactory	Ease
Boott[d]	N/A	N/A	N/A	Ease
Rolling[d]	N/A	N/A	N/A	Ease

a. See Infrastructure, below, for more information on the DCR's ownership interest in the dams. In this table, ownership is summarized as: Fee = fee interest; Ease = easement interest.
b. Hazard Class: Low (L) = the dam is located where failure may cause minimal property damage to others and the loss of life is not expected; Significant (S) = the dam is located where a failure may cause the loss of life and damage to homes, industrial or commercial facilities, secondary highways or railroads, or cause interruption of use or service of relatively important facilities (MassGIS 2012).
c. Low hazard potential dams are inspected every 10 years; significant hazard potential dams are inspected every 5 years.
d. The DCR's Office of Dam Safety defines the Boott and Rolling dams as canal gates, which are not classified or inspected.

Northern Canal Great Wall Dam. The Northern Canal Great Wall Dam (MA-00833), also known as the Great River Wall, is an approximately 2,000-foot-long earthen island and stone wall that runs along the south side of the Merrimack River, near Pawtucket Falls. The DCR holds a fee interest in approximately 1,000 feet of the upstream portion of the dam, which consists of a naturally deposited earthen and bedrock island, as well as some man placed earth. Downstream of the island, the dam transitions into a cut granite stone wall for a length of about 1,000 feet; the DCR holds an easement interest in this portion of the structure.

The dam was constructed in 1846-1847 to provide additional water power to downstream mills and the canal system in Lowell. Today, it continues to supply water to the canals, as well as a hydroelectric power plant owned by Boott Hydropower, Inc. Sudden gate closures at the power plant can cause the water in the Northern Canal to rise rapidly and overtop the Great River Wall. Due to this threat, the walkway along the wall and island is generally closed to the public; however the National Park Service does offer periodic guided tours along the walkway.

The most recent inspection of the dam determined that the structure was in good condition, identifying excessive vegetation on the great wall and island, and voids in between the cut granite stones along the crest of the great wall. An estimated $204,000 in additional analysis, maintenance and repairs is needed to correct these issues (Haley & Aldrich, Inc. 2012*a*).

Guard Locks Dam. The Guard Locks Dam (MA-00834) includes a lock, earthen embankment, gatehouse and spillway with hydroelectric power mechanisms. The dam and lock system was constructed in 1848 to regulate water levels in the Pawtucket Canal for mills in the center of Lowell. Today, the locks are used by the National Park Service for tourism and the dam is used to regulate water levels in the canal for hydroelectric power and flood control purposes.

While the dam is in good condition, the following issues were identified during a recent inspection of the structure: vegetation in the walls and downstream earthen embankment, debris in the spillway area, and voids in between the granite stones. The total estimated repair cost for the Guard Locks dam is $120,000 (Haley & Aldrich, Inc. 2012*b*).

Swamp Locks Dam. The Swamp Locks Dam (MA-00836) was originally constructed as part of the development of the Pawtucket Canal in the 1790s. The 1822-1823 reconstruction of the Pawtucket Canal reworked the lock system from a navigational system to a power system, creating a two-tiered power canal network and placing the Swamp Locks Dam centrally within this system. This configuration was retained through several subsequent rebuilding efforts. Many of the existing components of the dam (e.g. the lock, gates, spillway and weirs) date back to those reconstruction periods in 1839-1841, 1859, 1892, 1928, 1942 and 1946. The original purpose of the dam was to regulate the flow of water as a power source for downstream mills. Today the structure is used to impound water for boat tours of the canal system and flood control purposes.

The most recent inspection of the dam identified areas of broken and missing concrete, vegetation in the stone block walls, leakage and wear on the broad crested weir and gatehouse structure. An estimated $665,000 in additional analysis, maintenance and repairs is needed to correct these issues (Haley & Aldrich, Inc. 2012*c*).

Lower Locks Dam. The Lower Locks Dam (MA-00835) was constructed in the late 18th century as part of the Pawtucket transportation canal, which allowed boat access around Pawtucket Falls. It was rebuilt in 1822-1823 and consists of two gatehouses, a primary spillway, low level outlet (deep gate), two-bay lock chamber, canal drain pipe and valve, and a culvert system that drains excess flow from the adjacent Eastern Canal into the discharge channel downstream of the dam. Today, the dam is primarily used for flood control purposes.

During a 2006 inspection of the dam, vegetation and debris were identified as minor deficiencies. The canal drain valve control platform upstream of the dam was also noted as being potentially unstable. An estimated $27,000 to $42,000 in additional analysis, maintenance and repairs was needed to correct these deficiencies (Weston & Sampson 2006).

Since the inspection, the vegetation on the spillway has been removed and the canal drain valve control platform has been stabilized with guy wires; it is unclear whether this is a temporary or permanent solution.

Objects

Boston & Maine (B&M) Railroad No. 410, a steam locomotive built in 1911 by the American Locomotive Company's Manchester, NH works, is on permanent display at the corner of Merrimack and Dutton streets in downtown Lowell. Engines like No. 410 were used by the B&M Railroad to move freight cars around train yards throughout New England; in Lowell, the engine shuttled cars between textile mills for nearly 40 years.

In 1950, No. 410 was sold to H.E. Fletcher Company, where it was used in a quarry for approximately 30 years before being retired. In 1993, the engine was moved to its current location and is part of the interpretive components of the park. No. 410 is in excellent condition due to over 20 years of restorative work and routine annual maintenance by volunteers (see Section 4.4. Management Resources and Practices for more information). A restored 1907 Pullman Coach, owned by the National Park Service, is on display with No. 410.

Landscapes

The Lowell Canal System and its associated buildings and structures, while discussed individually in this section for inventory and management documentation purposes, collectively form a historic landscape that needs to be considered as a whole. These resources shaped the historic development and growth of the city, and continue to do so today. The canal system defines the character of downtown Lowell, and together with the remaining mills, provides a physical connection to the city's illustrious industrial past.

The parcel known as Tremont Yard, located on the Western Canal between Hall Street and Father Morissette Boulevard, is the site of the former Tremont Mills. Now predominantly paved over for parking, with remnants of the tailraces below it, the only above ground feature remaining is a one-story segment of brick wall with a concrete cap that runs along the north and east edges of the property. This wall, containing arched window openings that have been bricked in, serves as an important landscape feature and a reminder of what was once located on the site. By the late 1990s, the northern section of the wall, adjacent to Hall Street, had become a serious safety hazard, so it was dismantled by hand and partially rebuilt with the salvaged brick. The eastern section of the wall has a significant amount of vegetation growth.

The eastern section of the wall in Tremont Yard. (DCR)

Recreation Resources

Visitors to Lowell Heritage State Park can drive, bike or walk to the various facilities and points of interest within the park. In addition, the Lowell Regional Transit Authority operates buses that circulate through downtown. However, there are only three bus routes (1, 7 and 8) that cross the Merrimack River and provide indirect access to the Vandenberg esplanade. The closest bus stop to the concentration of recreation resources on the western half of the esplanade is located in front of Lowell General Hospital on Varnum Avenue.

There are a variety of active and passive recreational opportunities within Lowell Heritage State Park, including:

- Bicycling
- Boating, motorized and non-motorized
- Events (e.g., concerts, movies)
- Field sports (e.g., soccer, flag football)
- Fishing
- Geocaching
- Interpretive displays and programs
- Nature study
- Pet walking
- Photography
- Picnicking
- Swimming
- Walking/jogging/running

Boating takes place in the Merrimack and Concord rivers and, to a limited extent, in the canal system (see Figure 3). Motorized and non-motorized boats are launched into the Merrimack River from the Rourke brothers boat ramp; there are no fees charged at this facility. Non-motorized boats are also launched into the Merrimack at the Bellegarde boathouse. The Merrimac River Rowing Association (MRRA) and University of Massachusetts Lowell offer a variety of kayaking and rowing programs to the public at the boathouse; some of these programs are free of charge, while others require a fee. On a much larger scale, the MRRA also hosts two regattas, the Festival Regatta and the Textile River Regatta, at the boathouse each year.

Motorized and non-motorized boats can also be found on the Concord River. Every spring, the Lowell Parks & Conservation Trust, in partnership with Zoar Outdoor, offers a unique whitewater rafting opportunity on the Concord River, for a fee. Each trip concludes with passing through the Lower Locks Lock Chambers. Finally, the National Park Service offers motorized boat tours of the entire canal system for a nominal fee. The canal system is not open to the public for boating, aside from these two opportunities.

Fishing takes place in the rivers and canal system too. The Department of Public Health alerts the general public to the possible dangers of eating fish caught in Massachusetts waters through a public health fish consumption advisory. There are several advisories for the Merrimack River and canal system; there are no advisories for the Concord River in Lowell.

Table 4.7. Fish Consumption Advisories for the Merrimack River and Lowell Canals

Water Body	Hazard	Advisory[a]	Fish Species
Merrimack River	Mercury	P1, P3	Largemouth bass, white sucker
Canals[b]	Mercury, lead, PCBs, DDT	P1	All fish
Canals[b]	Mercury, lead, PCBs, DDT	P2, P4	American eel

Source: DPH 2014

a. P1 = Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not consume the affected fish species; P2 = The general public should not consume the affected fish species; P3 = The general public should limit consumption of the affected fish species to two meals per month; P4 = The general public should limit consumption of non-affected fish species to two meals per month (DPH 2014).

b. For the canals, the general public is advised to consume only the fillet of non-affected fish species (DPH 2014).

Special events, such as carnivals, and athletic events take place at the Anne Dean Welcome Regatta Field (see Figure 3). The City of Lowell sells permits for the use of the field through an expired Memorandum of Understanding with the DCR (see Section 4.4. Management Resources and Practices for more information). In 2013, the city issued 46 permits; the months of May and September were the most popular for events (Faticanti 2014).

Walks for charity, large cultural events, like the Southeast Asian Water Festival, and DCR-sponsored programming also take place along the Vandenberg esplanade. In a typical year, there is a special event on the esplanade every weekend from April through October. Many of these events are coordinated from the Sampas pavilion; there are fees to use the lawn in front of the stage and the stage itself. Permits for the esplanade are issued by the Forest and Parks Supervisor or the DCR's Office of Special Events, for a fee.

Guarded, freshwater swimming is available at the Rynne beach in July and August, every year, free of charge. The City of Lowell manages the beach through an expired Special Use Permit that was issued by the Department of Environmental Management (see Section 4.4. Management Resources and Practices for more information). During the swimming season, water quality is tested weekly; if poor water quality becomes a problem, tests are conducted daily until the results indicate improved water quality (Faticanti 2014).

Table 4.8. Water Quality Results for the Rynne Beach, May 2013-August 2013

Sample Date	*E. coli* per 100ml[a]	Days Since Last Rainfall	Amount of Last Rainfall (inches)
5/31/13	30	1	0.6
6/6/13	0	2	0.4
6/12/13	60	1	1.0
6/20/13	50	3	0.3
6/25/13	10	8	0.3
7/2/13	210	1	0.9
7/4/13	150	3	0.9
7/9/13	80	1	0.3
7/15/13	30	6	0.1
7/22/13	110	11	0.1
7/29/13	30	8	0.5
8/6/13	50	5	0.5
8/12/13	100	2	1.0
8/19/13	60	6	0.1

a. Limit = 235 *E. coli* per 100 ml.

The Merrimack River Watershed Council (MRWC) also monitors the river's water quality through its Safe Beaches Project. The closest sampling location to the Rynne beach is upstream, at the Bellegarde boathouse. The MRWC did not sample in 2013, due to a lack of volunteers (O'Mara 2013).

The Lord pool is another location within the park for visitors to enjoy guarded swimming (see Figure 3). The pool is open from June through August, every year; there are no fees charged at the facility. DCR staff are responsible for managing the pool and testing its water quality during the swimming season. In addition, the Department of Public Health (DPH) inspects the pool once each year as part of a Memorandum of Agreement with the DCR (see Section 4.4. Management Resources and Practices for more information). The DPH provides a brief report on the water quality, health and safety, and general sanitation conditions of the pool to DCR staff after the inspection.

Table 4.9. DPH Water Quality Results for the Lord Pool, August 8, 2013

Test	Allowable Result[a]	Test Result[a]
pH	7.2-7.8	7.6
Alkalinity	50-150	70
Calcium Hardness	150-1,000	210
Free Chlorine	1.0-3.0	4.2[b]
Combined Chlorine	0.0-0.2	0.0
Secchi Disk	Clearly visible	Clearly visible

a. Results are reported in parts per million (ppm), except for the pH and Secchi disk tests.
b. Additional testing was conducted 45 minutes later, after corrective actions were taken. The second test result, 3.8ppm, exceeded the allowable range, and the pool was closed until the free chlorine reading was brought into compliance.

The following health and safety, and general sanitation violations were also noted as part of the 2013 DPH inspection:

- The water depth is not marked at or above the water surface on the pool wall.
- A gap in the outside fence of greater than three inches.
- A broken step on the ladder in the deep end.
- An insufficient emergency communication system in the first aid room.
- The log book indicated the pool was not closed with free chlorine reading of 13.8ppm.
- The paint on the pool floor is peeling.
- A portion of the cement deck is raised, creating a tripping hazard.

Many of these violations, such as the broken step ladder, were addressed during the 2013 season and the remaining items, such the raised cement deck, will be addressed as part of the fall 2014 modernization project (see Infrastructure, below for more information).

Visitors to the Lord pool enjoy biking to the property; however there are no bike racks available for storing and securing their bikes. Social gatherings are also popular on the lawn and at the picnic tables that surround the pool. Two mature trees, near the corner of Cross and Fletcher streets, are the only source of shade in this open space.

The National Park Service (NPS) provides most of the interpretive programming within the downtown portion of the park. Visitors can participate in a free ranger-guided walking or trolley tour of the historic sites. A variety of indoor exhibits are open to the public too, including the NPS's visitor center at Market Mills, the Boott Cotton Mills Museum (fees apply), the Patrick J. Morgan Cultural Center and the Wannalancit Mill. The NPS also co-sponsors one of the largest, free folk festivals in the world; the Lowell Folk Festival is held each summer and over 100,000 people come to Lowell and the park to celebrate traditional music, ethnic foods and crafts (NPS 2014*c*).

Geocaching also occurs in the park. As of March 2014, there were three known geocaches along the Vandenberg esplanade and two known geocaches in the downtown portion of the park.

Infrastructure

Property Boundary

Fee Interest. Lowell Heritage State Park (87 acres) is situated in the northern half of Lowell, adjacent to the Merrimack River and the city's historic power canals. The majority of the parcels that comprise the park are linear in nature, and most were acquired between 1976 and 1986.

By 1980, the Department of Environmental Management (DEM) purchased a fee interest in a portion of the Vandenberg esplanade, from the Rourke Bridge to the intersection of Pawtucket Boulevard and Varnum Avenue; a portion of Francis Gate Park, north of Broadway Street; the gatekeeper's property; Tremont Yard; and the Mack building. Over the next five years, the agency added a few more parcels to the Vandenberg esplanade, near the intersection of Pawtucket Boulevard and Varnum Avenue, and Francis Gate Park, south of Broadway Street.

In 1986, the DEM obtained a fee interest in the park's remaining parcels through a complicated and lengthy Order of Taking, recorded in the Middlesex County Registry of Deeds, Northern District, Book 3830, Page 70. This legal action completed the Vandenberg esplanade, from the intersection of Pawtucket Boulevard and Varnum Avenue to Pawtucket Falls, and further east, along VFW Highway. It also created a network of protected land, in combination with property owned by the National Park Service and City of Lowell, along each of the city's canals. Finally, it established the DEM's ownership interest in 13 buildings associated with the canal system (see below). Only one of these buildings, the Rolling Dam Gatehouse, has been demolished.

1. Pawtucket Gatehouse
2. Blacksmith Shop
3. Guard Locks Great Gate Gatehouse
4. Guard Locks Gatehouse
5. Guard Locks Lock House
6. Northern Canal Wasteway Gatehouse
7. Tremont Gatehouse
8. Swamp Locks Gatehouse
9. Hamilton Wasteway Gatehouse
10. Lower Locks Gatehouse
11. Massachusetts Wasteway Gatehouse
12. Boott Dam Gatehouse
13. Rolling Dam Gatehouse (demolished)

The Janas rink and Lord pool parcels were acquired before the 10-year effort to establish Lowell Heritage State Park. In 1972, the Department of Natural Resources (DNR) purchased the two-acre Lord pool parcel from the City of Lowell; the deed is recorded in the Middlesex County Registry of Deeds, Northern District, Book 2211, Page 558. The following year, the city sold the Janas rink parcel (4.5 acres) to the DNR; the deed is recorded in the Middlesex County Registry of Deeds, Northern District, Book 2091, Page 58.

Other Legal Interests. The DEM also obtained a number of other legal interests through its 1986 Order of Taking (see Middlesex County Registry of Deeds, Northern District, Book 3830, Page 70). These easements and other rights are the most complicated, and confusing, parts of the taking.

With respect to the 13 canal system buildings, the DCR holds a permanent easement in the canal walls and beds or bottoms that support each building, and the associated structures and fixtures. The Proprietors of Locks and Canals on the Merrimack River (the Proprietors), and their successors and assigns, retain the right to access the buildings in order to maintain and operate the gates and canals for hydroelectric power production. In addition, the Proprietors, their successors and assigns reserve an easement for access and the right to use the Blacksmith Shop for maintaining and operating the Pawtucket Dam for hydroelectric power production.

The DCR also holds a permanent easement in the following structures, which are specifically named in the taking:

- Pawtucket Gatehouse Wall and Lock Chamber;
- Guard Locks Lock Chambers;
- Northern Canal Walkway;
- Swamp Locks Dam;
- Swamp Locks Chamber;
- Lower Locks Dam;
- Lower Locks Lock Chambers;
- Boott Dam;
- Rolling Dam; and
- YMCA Gates.

The permanent easement is for the following purposes, provided that the Proprietors, their successors and assigns are able to use, maintain and operate the structures and surrounding property for hydroelectric power production without interference.

- Support of all fixtures or structures of the Commonwealth;
- Preservation and conservation;
- Supplemental maintenance in addition to that performed by the Proprietors, their successors and assigns;
- Landscaping and erection of exhibits and structures;
- Placement of barriers and fences;
- Placement and attachment of docks, wharves, walls and boat ramps of a temporary or permanent nature;
- Placement of lighting and other utilities;
- Operation and maintenance of boat locking chambers, if any, for any and all purposes; and
- Any and all other uses consistent with the operation of the canal system as a park.

In addition to the permanent easements described above, the DCR has an interest in the following:

1. An overarching "…permanent and exclusive easement in all canal walls and beds or bottoms and in all dams and boat lock chambers located in said canals and not otherwise referred to in [the taking]…" (Book 3830, Page 102). This permanent easement is for the same purposes as described immediately above.
2. "All air rights over the canals, including the canal walls and any dams thereon, to the extent not already lawfully obstructed or occupied, for so long as such lawful obstruction or occupation continues uninterrupted in its present form" (Book 3830, Page 103).
3. "The exclusive right to use the water in the entire canal system and the Merrimack River for recreational, educational and navigational purposes, which use shall be nonconsumptive with respect to hydroelectric power generation, except for reasonable amounts to operate locking gates" (Book 3830, Page 103).

In 2001, the Highway Department (MassHighway) granted the DEM possession, care, custody and control of Anne Dean Welcome Regatta Field through a license agreement (see Section 4.4. Management Resources and Practices for more information). The DCR's use of the property is restricted to passive recreation. MassHighway reserved the right to utilize the property, in whole or in part, for highway purposes.

Pocket Parks

The two smaller "pocket parks" within the downtown portion of Lowell Heritage State Park, the Mack plaza and Victorian garden, were designed by Carr, Lynch Associates, Inc. in 1982. The firm received multiple awards for their work, including a:

- Citation for Excellence in Urban Design from the American Institute of Architects (1990);
- Mayoral Proclamation for the Preservation of Lowell's Historic Architecture (1990);
- Citation from the American Society of Landscape Architects (1987); and
- Massachusetts Governor's Design Award (1986).

Mack Plaza. The Mack plaza is located next to the Mack building, on the corner of Shattuck and Market streets. Nineteen linden trees and 20 new benches enhance the brick plaza as a relaxing oasis in an otherwise busy section of the city. (See Section 2 for more information on the bench replacement project.) The fountain component of "The Worker" sculpture, when functioning, adds to the ambiance of the space (see Buildings and Structures, below, for more information).

An approximately three-foot-tall steel rail and granite post fence encloses the plaza along Market Street. For several decades, the condition of the granite posts has been deteriorating. Today, 11 of the 13 posts are badly cracked; several posts are being held in place by a temporary wooden support structure. In 2007, a close inspection of the fence identified the pin mounting system and temperature changes in the steel as the likely causes of cracking (DCR 2007*c*).

A cracked granite post and temporary wooden support structure in the Mack plaza. (DCR)

Mary J. Bacigalupo Victorian Garden. The Victorian garden is also located next to the Mack building, at the intersection of Shattuck and Middle streets. Raised beds dominate the space and support a variety of mature evergreen and deciduous trees, as well as smaller, shade-tolerant perennial and annual plantings. Seven benches situated along the garden's brick pathways offer a welcoming respite from city life. An approximately seven-foot-tall fence, identical to the one in the Mack plaza, surrounds the entire garden. There are 25 granite posts in this fence and 22 are badly cracked. One post that supported the garden's western gates was recently removed for public safety reasons (DCR 2007*c*).

In 2005, the garden was dedicated to Mary Bacigalupo, a Lowell citizen who was instrumental in the beautification of the City of Lowell (see Appendix H). A large granite marker bearing Mary's name is located within the garden (see Memorials and Markers, below, for more information).

Victorian Garden (DCR)

Buildings and Structures

This section provides information on Lowell Heritage State Park's non-historic buildings and structures. See Cultural Resources, above, for information on the park's historic infrastructure.

Rourke Brothers Memorial Boat Ramp. The Rourke brothers boat ramp is located at the western end of the Vandenberg esplanade, upstream of the Rourke Bridge (see Figure 3). The concrete ramp, which is approximately 45 feet wide, leads from an access road and parking area off of Pawtucket Boulevard into the Merrimack River. The ramp was constructed by the Office of Fishing and Boating Access (OFBA) in 2002 and is in good condition (Sheppard 2013). Extensive regulations govern the use of OFBA sites; see Section 4.4. Management Resources and Practices for more information.

Edmund A. Bellegarde Boathouse. The Bellegarde boathouse, situated on a parcel of land between Pawtucket Boulevard and the Merrimack River, was once the headquarters for Lowell Heritage State Park between 1993 and 2002, but is now under the care and control of the University of Massachusetts Lowell (see Section 4.4. Management Resources and Practices for more information).

Charles G. Sampas Pavilion. The Sampas pavilion is located on the Vandenberg esplanade, near the intersection of Pawtucket Boulevard and Delaware Avenue (see Figure 3). The 30- by 50-foot open-air, poured concrete and steel frame structure has functioned as the park's performing arts stage for 37 years. The stage is equipped with electricity and limited performance lighting; it is in good condition.

Merrimack River Retaining Wall. A riprap and poured concrete retaining wall is located along the Vandenberg esplanade, from the Rourke Bridge to the Sampas pavilion. It is not known when the wall was constructed. Woody vegetation, some of which is an invasive species, is growing in the riprap portion of the wall. Many sections of the poured concrete wall are also misaligned. Overall, the retaining wall is in fair condition.

Raymond J. Lord Memorial Swimming Pool. The Lord swimming pool, located at 81 Cross Street, is a complex of one pool, one spray deck (formerly a wading pool), one bathhouse and one outbuilding, constructed in 1972 (see Figure 3). The pool has a maximum depth of 12 feet; a set of stairs provides access to the shallow end of the pool. In 2010, the wading pool was converted into a spray deck with one centrally located spray feature. Both the pool and the spray deck are in good condition. Pending approval and funding, plans are in place to modernize the structures in the fall of 2014 by reducing the maximum depth of the pool to five feet; replacing the stairs in the shallow end of the pool with a "zero entry" ramp; adding more spray features to the spray deck; and constructing a shade shelter.

The bathhouse, approximately 3,300 square feet, is a single-story, masonry block building with a wood framed gabled roof clad with asphalt shingles. The 983-square-foot outbuilding, which houses pool equipment (e.g., pumps, filters and chemicals), a first aid station and staff restroom, is constructed of similar materials; however it has a flat, tar and gravel roof. Both the bathhouse and outbuilding received new roofs in 2009, and new epoxy floors and fresh interior and exterior paint in 2012. The pool's filtration system was also replaced 2012. Both buildings have electricity, domestic water and waste water disposal. In addition, the outbuilding has a phone line. Both buildings are in good condition.

Tremont Yard. For many years, the predominant feature on the Tremont Yard parcel, located at 257 Father Morissette Boulevard, was the one-story ruin of a brick powerhouse with below grade water power features (see Cultural Resources, above, for more information). In 2003, the Legislature authorized the DCR to lease the property (see Appendix H) and two years later, a Request for Proposals (RFP) was issued. In 2008, a 25-year lease was signed by Tremont Yard, LLC (see Section 4.4. Management Resources and Practices for more information). That same year, construction began on a modern, five-story office building; the ruin was demolished as part of that process, but the historic power system features were preserved. Today, the site is the headquarters for the Jeanne D'Arc Credit Union, which includes a first-floor interpretive display (see Figure 3). Although this preservation effort is open to the public, there is little promotion of the space.

Trolley Tracks. The National Park Service (NPS) operates a free trolley service for visitors to Lowell National Historical Park. The trolleys run on approximately one-mile of track that is laid out in a "T" shape within downtown Lowell. The western terminus of the track is located on the DCR's Tremont Yard parcel. The Department of Environmental Management granted the United States of America, through the Lowell Historic Preservation Commission, an easement for the construction of the tracks and associated fixtures. The easement is recorded in the Middlesex County Registry of Deeds, Northern District, Book 6249, Page 209.

Lowell Public Art Collection. From 1984 to 1995, former U.S. Senator and Lowell resident Paul Tsongas, along with staff from the Lowell Historic Preservation Commission, led the development of the Lowell Public Art Collection (Marion 2014). During that time, a series of permanent sculptures were placed throughout the downtown area, but generally within sight of the National Park Service's canalway walking path. Each work of art addresses a theme of the federal and state park systems: the industrial city, labor, machines, power and capital.

While a few of the sculptures are located on DCR property, e.g., "The Worker" in the Mack plaza, the collection is owned by the City of Lowell, through its Cultural Affairs and Special Events Department, and the National Park Service, both of whom are responsible for its ongoing maintenance. However, oversight of the collection is limited, due to a lack of resources at the municipal and federal levels (Marion 2014).

John J. Janas Memorial Skating Rink. The Janas skating rink, located at 382 Douglas Road, is managed and operated by the North Shore Rink

Management Associates, Inc. through a 25-year lease (see Section 4.4. Management Resources and Practices for more information).

Roads

Public roads, which are owned and maintained either by the City of Lowell or Department of Transportation, surround the park. Pawtucket Boulevard, or Route 113, and VFW Highway border, and provide primary access to, the riverfront portion of the park. In downtown Lowell, Broadway Street and Fletcher Street provide access to the DCR's westernmost historic resources and Lord pool, respectively. Dutton Street and Father Morissette Boulevard are the highest-capacity roads that lead to the concentration of the DCR's historic resources.

Parking

Along the Vandenberg esplanade, there are five DCR-owned parking areas (see Figure 3). The first is a paved lot, with a shared entrance and exit, located next to the Rourke brothers boat ramp. It can accommodate 64 vehicles; 44 spaces are reserved for vehicles with trailers, while the remaining 20 spaces are reserved for vehicles with car-top boats. All of the spaces are well marked, including the lot's four accessible spaces. The parking area is signed as being DCR property and gated.

The second parking area is located next to the Bellegarde boathouse; it is not under the care and control of the University of Massachusetts Lowell (see Section 4.4. Management Resources and Practices for more information). Forty-one vehicles can park in this paved lot, which has a separate entrance and exit. All of the spaces are well marked, including the four accessible spaces. The parking area is not signed as being DCR property or gated.

A third, unpaved parking area is located next to the regatta field. This unlined lot, with a shared entrance and exit, is heavily used during events and is showing serious signs of wear and tear. Vehicles, up to 40 at one time, are sometimes forced to park haphazardly due to deep ruts that fill with rain water and small patches of shrub-like vegetation. While the regatta field itself is signed as being DCR property, the parking area is not signed. The lot is also not gated.

The remaining two parking areas are located near the Sampas pavilion. Both lots are paved and marked, and utilize shared entrances and exits. The lot upstream of the pavilion has 22 spaces, including two accessible spaces. The lot downstream of the pavilion has 14 spaces, two of which are designated as accessible. Neither lot is signed or gated.

Visitors to the downtown portion of Lowell Heritage State Park most likely utilize the National Park Service's (NPS) visitor center parking lot, located near the intersection of Broadway and Dutton streets, or municipal parking options throughout the city (see Figure 3). The NPS's visitor center parking lot was formerly owned by the Department of Environmental Management (DEM). Upon selling a portion of the property to the NPS, the DEM established a Memorandum of Understanding (MOU) with the NPS regarding the use of the parking lot (see Section 4.4. Management Resources and Practices for more information). The remaining portion of the property was sold to the City of Lowell; there is no record of an MOU, or similar document, between the city and the DEM.

The DCR leases one parking area within Tremont Yard to the University of Massachusetts Lowell (see Section 4.4. Management Resources and Practices for more information). The other three DCR-owned parking areas within downtown Lowell are located outside of the concentration of historic resources (see Figure 3).

The first of these parking areas is located on Cross Street, next to the Lord pool. It is a paved lot, with a shared entrance and exit, and can accommodate approximately 40 vehicles. The majority of the individual spaces are not marked, however there are two accessible spaces that are well marked. The parking area is not signed as being DCR property or gated and, as a result, it is heavily used by residents and visitors in the immediate area.

The second downtown parking area is located on Broadway Street, near the Pawtucket Canal. Approximately 15 vehicles can park in this gravel lot, which has a separate entrance and exit. Individual spaces are not marked and there are no designated accessible spaces. Like the parking area at the Lord pool, this lot is not signed or gated and is routinely used by students, residents and visitors in the immediate area.

The final parking area is associated with the Janas skating rink, which is under the care and control of the North Shore Rink Management Associates, Inc. as part of a 25-year lease (see Section 4.4. Management Resources and Practices for more information). This lot is paved and can accommodate 80 to 90 vehicles. Individual spaces are well marked, including two designated accessible spaces. The lot's shared entrance and exit features a large DCR sign, as well as a gate.

Trails

There is one trail within Lowell Heritage State Park; it is a 10-foot-wide paved path located along the northern shoreline of the Merrimack River. The first section of the path, designated as the Scott Finneral Memorial Riverwalk, is approximately one mile long (see Appendix H). It runs from the Rourke Bridge to the Sampas pavilion on the Vandenberg esplanade. Portions of this path have been damaged by tree roots lifting and cracking the pavement. Sinkholes also appear along the path on occasion, due to water undermining the Merrimack River retaining wall (see Buildings and Structures, above, for more information).

The second, unnamed section of the path is approximately two miles long. It runs from Beaver Brook to near the Duck Island Wastewater Treatment Facility. Only the upstream portion, ending near the Hunts Falls Bridge, is on DCR property (approximately one mile of path). Small sections of this path can become overgrown, due to the dense vegetation that grows on both sides. Currently, the only connection between this section of the path and the Scott Finneral Memorial Riverwalk is the public sidewalk along VFW Highway.

Signs and Kiosks

There are very few DCR signs within Lowell Heritage State Park and there are no kiosks. Five separate Site/Facility Identification Signs exist for the Rourke brothers boat ramp, regatta field, Vandenberg esplanade, Francis Gate Park and Lord pool.

- The sign for the boat ramp, located at the ramp's main entrance, does not meet DCR signage standards (DCR n.d.).
- The regatta field sign, located on the north side of Pawtucket Boulevard near the sidewalk, within the larger of the two playing fields, meets all DCR signage standards (DCR n.d.).
- The sign for the Vandenberg esplanade, which is located on the south side of Pawtucket Boulevard near the intersection of Varnum Avenue, should be double-sided in order to meet DCR signage standards (DCR n.d.).
- The Francis Gate Park sign, located near the Guard Locks Lock House, does not meet DCR signage standards (DCR n.d.).
- The sign for the Lord pool meets all DCR signage standards (DCR n.d.).

A standard Rink Identification Sign is located at the main entrance of the Janas rink (DCR n.d.).

There is one Road Marker Sign that leads visitors to Lowell Heritage State Park from the Lowell Connector. The sign reads: "Lowell National and State Parks Exit 5B;" it does not meet DCR signage standards.

A small identification sign is attached to each of the DCR-owned buildings that the National Park Service maintains (see Section 4.4. Management Resources and Practices for more information). Although these signs do not meet DCR signage standards, they are consistent in appearance and placement, and thus easily recognizable as a component of Lowell National Historical Park.

National Park Service Identification Sign (DCR)

Within the last 10 years, Lowell General Hospital constructed a three-sided directional sign on DCR property located on the corner of Pawtucket

Boulevard and Varnum Avenue. There is no record of a legal document (e.g., permit, Memorandum of Understanding, etc.) being issued or a bill being passed that authorized the construction of this sign.

Memorials and Markers

There are five known memorials within Lowell Heritage State Park. The first, a large granite marker, is located at the entrance to the Rourke brothers boat ramp. It is inscribed with the names of three Rourke brothers, Steve, Cliff and Bud, all of whom served in World War II.

The second memorial is dedicated to Charles G. Sampas, a former columnist for the Lowell Sun. An approximately four-foot-tall, one-foot-square granite post, topped with a bronze plaque, is located near the Sampas pavilion. The plaque includes the names of the state and national parks.

Another bronze plaque, the third memorial, is mounted directly to the front of the Rynne bathhouse. It pays tribute to Michael Rynne, a former Lowell policeman and athlete, and also includes the names of the state and national parks.

The fourth memorial, located at the eastern end of the Vandenberg esplanade, is dedicated to George Scott Finneral, who was killed in action during the Persian Gulf War. It, too, is a bronze plaque mounted atop an approximately four-foot-tall, one-foot-square granite post. However, the plaque does not match the design of the other memorials.

The fifth and final memorial is small granite marker located within the Victorian garden. It is inscribed with Mary J. Bacigalupo's name and reads, in part: IN RECOGNITION FOR HER LEADERSHIP AND DEDICATION TO THE PEOPLE AND CITY OF LOWELL.

There are at least nine other bronze plaque markers, either mounted on a granite post or directly to a building, placed throughout the park. These markers provide information about the nearby buildings and objects. Each marker includes the name of the state and national parks. The plaque for the brick vault, located near the Victorian garden, was stolen and has not been replaced.

Bronze Plaque and Granite Post Marker (DCR)

Surprisingly, there is no marker for Hoyt S. Vandenberg (1899-1954), the presumed namesake of the esplanade and Lowell's highest ranking general.

4.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation management within the park consists primarily of mowing and trimming. DCR staff maintain the lawn and landscaping at the Rourke brothers boat ramp and along the Vandenberg esplanade. The city maintains regatta field (see Recreation Resources, below for more information).

Within downtown Lowell, the National Park Service maintains the grounds around the canal system resources (see Cultural Resources, below). The maintenance of the lawn and landscaping within the Gatekeeper's property falls to the curator or DCR staff, when a curator is not present. DCR staff also maintain the grounds at the Lord pool and the plantings at the Victorian garden. The lawn and landscaping at Tremont Yard and the Janas rink are maintained by Tremont Yard, LLC and North Shore

Rink Management Associates, Inc., respectively (see Infrastructure, below).

Cultural Resources

Buildings and Structures

Michael Rynne Bathhouse. In 1996, the Department of Environmental Management (DEM) issued the City of Lowell a three-year Special Use Permit "to use and occupy the [beach] adjacent to the Rynne [bathhouse] on the Merrimack River for the purpose of providing a safe, clean and accessible swimming area for the general public."

As part of this permit, the city was given one room in the bathhouse, "as designated by the Park Supervisor, for the purpose of a First Aid and storage area." In addition, the DEM agreed, "subject to appropriation and available personnel, to make major repairs to the [bathhouse] such as, roof replacement, exterior painting, heating system replacement, etc." The shared use of the bathhouse has continued, under agreeable terms, for the last 15 years without a Memorandum of Agreement or similar document in place.

Buildings and Structures Associated with the Canal System. In 1991, the four major stakeholders in downtown Lowell's historic properties – the Department of Environmental Management (DEM), Boott Hydropower, Inc. (Boott), the Proprietors of Locks and Canals on the Merrimack River (Proprietors) and the National Park Service (NPS) – signed a five-year Memorandum of Understanding (MOU) for the purpose of "maintaining and operating the Lowell Canal System for the benefit and enjoyment of the general public and for the private production of hydroelectricity and for other private uses of its waters." The agreement divided the critical tasks related to maintaining and operating the canal system, including the associated buildings and structures, among the four major stakeholders with the understanding that each held a slightly different ownership, and general, interest in the various components of the system.

In general, maintenance of the canal walls and bottoms, dams and control apparatuses fell to Boott and the Proprietors. Boott was also responsible for maintaining, and providing access to, the Eldred L. Field Power Station for interpretive tours, as well as managing the water levels and flow rates in the canal system. The cost of utilities for the associated buildings was split between the DEM and Boott, while the DEM and NPS worked together to maintain and secure the buildings and grounds. The DEM and NPS also agreed to meet each year in order to develop building maintenance, destructive vegetation clearing, canal water surface cleanup, and long term capital improvement programs.

Despite evidence that one or more of the stakeholders attempted to renew this MOU after it expired in 1996, the maintenance and operation of the canal system continues today, under somewhat agreeable, if not confusing, terms, in the absence of any legally binding document.

W.A. Mack & Company Building. In 2007, the DCR and New England Electric Railway Historical Society / Seashore Trolley Museum signed a five-year Memorandum of Understanding (MOU), which authorized the group to utilize space on the first and second floors, including the window displays, of the Mack building for the purpose of operating the National Streetcar Museum. As part of this MOU, the group is responsible for:

- Any and all utility services and costs;
- Notifying the DCR's Regional Director of any fees under consideration or charged for using and/or accessing the museum;
- Scheduling and attending an annual in-person meeting with the Regional Director;
- Receiving the approval of the Regional Director prior to making any changes or improvements to the building; and
- Notifying the Regional Director of any injuries, closures, property damage or related incidents associated with the use of the building.

Even though this MOU expired on June 30, 2012, the museum has continued to utilize the Mack building, under agreeable terms, for the last two years.

Objects

Boston & Maine (B&M) Railroad No. 410. The historic steam locomotive is maintained and cleaned, at least twice a year, by the Boston & Maine Railroad Historical Society (B&MRRHS), a non-profit historical and educational organization comprised of volunteers who share a common interest in the history and operations of the B&M

Railroad. There is no Memorandum of Agreement, or similar document, between the B&MRRHS and DCR that guides this management activity.

Recreation Resources

Anne Dean Welcome Regatta Field. In 2007, the DCR and City of Lowell signed a five-year Memorandum of Understanding (MOU), which authorized the city to "…manage, maintain, and schedule events and programs consistent with the recreational missions of both parties at the [field]…." As part of this agreement, the city:

- Retains the funds it generates through permitting fees;
- Schedules an annual meeting with the DCR's Regional Director to discuss the previous year's programs and compliance with the MOU;
- Receives approval from the Regional Director before making any changes or improvements to the property;
- Does not cut, remove or interfere in any manner with any natural vegetation or store equipment or property without approval from the Regional Director; and
- Notifies the Regional Director of any injuries, closures, property damage or related incidents associated with the use of the property.

Despite the fact that this MOU has expired, the management and maintenance of the field, as well as communications between the city and park staff, have seamlessly continued for the last two years.

Rynne Beach. In 1996, the Department of Environmental Management (DEM) issued the City of Lowell a three-year Special Use Permit "to use and occupy the [beach] adjacent to the Rynne [bathhouse] on the Merrimack River for the purpose of providing a safe, clean and accessible swimming area for the general public." As part of this permit, the city agreed, at its own expense, to:

- Assume complete management responsibility of the waterfront area, including daily maintenance of the public restrooms;
- Provide qualified personnel to staff and manage the beach from June 1st through Labor Day of each year;
- Notify the DEM of incidents, such as vandalism, accidents, serious injuries, etc.; and
- Provide the park supervisor with a weekly report that includes a summary of incidents and attendance figures.

The management and maintenance of the beach, as well as communications between the city and park staff, have seamlessly continued for the last 15 years without a Memorandum of Agreement or similar document in place. Today, the beach is generally open from July 1st through mid- to late-August; a schedule that is dependent on the availability of students to fill the lifeguard positions and the timing of the Southeast Asian Water Festival, a popular event that is held on the Vandenberg esplanade each summer (Faticanti 2014).

The lack of a small, motorized boat presents the biggest management challenge for the city (Faticanti 2014). Every year, staff must borrow a boat to place and remove moorings, or swimming area markers, in and from the river. In addition, the city borrows a boat, or more, if available, to guard the non-motorized, dragon boat races that are an integral part of the Southeast Asian Water Festival. Finally, staff are routinely called upon to assist individuals who are swimming outside of the designated area, sometimes up to a mile away.

Raymond J. Lord Memorial Swimming Pool. In 2011, the DCR and Department of Public Health (DPH) signed a Memorandum of Agreement in order facilitate compliance with the State Sanitary Code (105 CMR 435.00, see Appendix F). As part of this agreement, the two agencies meet a minimum of twice per year to discuss pool inspections and compliance issues; share seasonal information regarding the operation of each pool; and jointly inspect each pool at least once per season. The agreement is in effect until terminated by either agency, upon 60 days written notice.

Infrastructure

Property Boundary

Anne Dean Welcome Regatta Field. Under the terms of the license agreement, signed by the Department of Environmental Management (DEM) and Highway Department (MassHighway) in 2001, the DEM must obtain written approval from MassHighway before altering the property and before transferring or assigning the license, in part or in whole. In addition, the DEM is responsible for maintaining the property, as well as any existing or additional utilities needed to utilize the property. This license is in effect until terminated by MassHighway or the DEM, now DCR.

Buildings and Structures

Rourke Brothers Memorial Boat Ramp. Extensive regulations govern the use of the Office of Fishing and Boating Access (OFBA) sites, such as the Rourke brothers boat ramp (320 CMR 2.00; Appendix F). Use of these sites is restricted to the launching of watercraft and the parking of associated vehicles. No other parking or recreational uses are allowed. Special Use Permits are required for events (e.g., fishing tournaments) at OFBA sites. Permits are issued by the OFBA, following DCR review.

Edmund A. Bellegarde Boathouse. Chapter 238 of the Acts of 2006 authorized the transfer of the boathouse from the DCR to the University of Massachusetts Lowell (UMass). Sections seven through nine of the Act describe the terms and conditions of the transfer, including the requirements for public access and consequences regarding a change in use. The following additional items were also agreed upon, in order to execute and deliver a "care, custody, management and control" agreement between the DCR and UMass:

- Any document transferring the property shall include a reversionary clause, stating that care, custody, management and control reverts back to the DCR if the property ceases to be used as a public boathouse and park land.
- The Division of Capital Asset Management (DCAM), in consultation with the DCR, shall survey and provide a legal description of the property to be transferred.
- UMass shall prepare and submit, at its own expense, an Environmental Notification Form (ENF) regarding a land transfer of Article 97 protected lands.
- The transfer shall not be completed until the Secretary issues a certificate stating that no Environmental Impact Report (EIR) is needed, or that the EIR is adequate until the expiration of the legal challenge period.
- UMass shall comply with all requirements of the National Park Service and shall seek and obtain any required approvals.

The boathouse was officially transferred by the DCAM in 2006 (a signed Transfer Request 1, or TR1, form was located during this planning process); however the care, custody, management and control agreement has yet to be finalized. Several items from the list above, including the property survey and ENF, could not be located during this planning process.

The area including the parking lot to the west of the boathouse and the boathouse itself was estimated to be 1.15 acres, which exceeds the agreed upon land transfer estimate of one-third of an acre. Based on the estimate of 1.15 acres, it is presumed that the parking lot was not included in the land transfer.

Tremont Yard. The 25-year lease signed by Tremont Yard, LLC is a lengthy and detailed document that guides the management and operation of the DCR's property located at 257 Father Morissette Boulevard, excluding the parking area (see Parking, below). Permitted uses, rent, insurance, maintenance and subletting, among other topics, are addressed in the agreement. The DCR's Long-term Permit and Lease Program staff, within the Office of the General Counsel, ensure that the terms of the lease are being met. This lease is scheduled to expire on May 21, 2033, however it may also be extended for seven additional 10-year periods.

On October 31, 2008, Tremont Yard, LLC entered into a 15-year sublease with Jeanne D'Arc Credit Union. The sublease only covers the building that was constructed at 257 Father Morissette Boulevard. The credit union has options to extend the term of the lease, expand the leased premises and to purchase the property from Tremont Yard, LLC. For this sublease, Tremont Yard, LLC is the landlord and responsible for ensuring that the terms of the sublease are being met.

John J. Janas Memorial Skating Rink. The 25-year lease signed by the North Shore Rink Management Associates, Inc. is a lengthy and detailed document that guides the management and operation of the DCR's property located at 382 Douglas Road. Permitted uses, rent, insurance, maintenance and subletting, among other topics, are addressed in the agreement. The DCR's Long-term Permit and Lease Program staff, within the Office of the General Counsel, ensure that the terms of the lease are being met. This lease is scheduled to expire on June 20, 2027.

Parking

National Park Service's Visitor Center Parking Lot. In 1982, the Department of Environmental Management (DEM) and National Park Service (NPS) signed a Memorandum of Understanding (MOU) regarding the use of the parking lot located near the intersection of Broadway and Dutton streets in downtown Lowell. As part of this MOU, the two entities agreed:

- The NPS would be solely responsible for the operation and maintenance of the property, including staffing, daily operation, trash and snow removal, and repairs;
- The DEM would maintain a continuing role in the development of management policy relative to property;
- The obligations assumed by the NPS would not be transferred, assigned or modified without written approval by the DEM;
- The NPS would maintain a sign at the entrance of property, indicating that it may be used by visitors of both state and federal parks; and
- That a reasonable number of official spaces would be reserved for use by state or federal vehicles.

The MOU acknowledged that the DEM was authorized and intended to convey a portion of the property to the NPS and to that end, stated, "This agreement shall remain in full force and effect and shall not be defeated by the execution and delivery of a deed from [the] DEM to [the] NPS in connection therewith."

Tremont Yard. On January 10, 1985 the Trustees of Wannalancit Office and Technology Center Trust (Trustees) signed a 99-year lease with the Department of Environmental Management for the parking area located in the rear of 257 Father Morissette Boulevard. On September 27, 1996, the Trustees assigned the lease to the University of Massachusetts Lowell (UMass), who remains the tenant today. UMass is responsible for maintaining and, when it deems necessary, improving the parking area. Any construction on the property must be approved by the DCR. This lease is set to expire in 2084.

Interpretive Services

The National Park Service provides all of the interpretive programming related to the historic resources in downtown Lowell, due to the lack of DCR interpretive staff assigned to Lowell Heritage State Park and the overlap between the state and federal parks.

Lowell Heritage State Park is a participant in the Park Passport Program; the passport box is located next to the Rynne bathhouse.

Operational Resources

Supplemental Staffing

The supplemental staff at Lowell Heritage State Park are truly invaluable. Without the help of the City of Lowell and National Park Service, many of the DCR's most significant resources would certainly be in a state of disrepair, inaccessible to the public, or safety hazards requiring demolition. Other important partners include the Office of Fishing and Boating Access, University of Massachusetts Lowell, Merrimac River Rowing Association and Merrimack River Watershed Council, all of whom play a role in providing quality, safe access to the Merrimack River. Finally, the many volunteers in downtown Lowell – from the Lowell Canalwaters Cleaners, to the Boston & Maine Railroad Historical Society, to Park Serve Day attendees – help preserve and enhance the park's individual resources, as well as the visitor experience overall.

Public Safety

DCR Rangers issue citations for violations of various forest and park rules. A summary of incident reports recorded in the park during 2013 is provided below.

Table 4.10. Lowell Heritage State Park Incident Reports, January 1 through December 31, 2013

Incident	Number
Vandalism	1
Violation of DCR regulations[a]	1
Total	*2*

a. This violation was related to alcohol consumption on state property and, in turn, a suspected drunk driver. The incident was relayed to the Lowell Police Department, as the individual drove their vehicle onto a city-owned road after leaving the park.

Dairy cows at Great Brook Farm State Park. (DCR)

SECTION 5. GREAT BROOK FARM STATE PARK

5.1. Introduction

Great Brook Farm State Park is a large property – 929 acres – located in the northern section of the rural community of Carlisle, with a few acres falling over the town border to the north, in Chelmsford. Main access points to the property are located off of Curve Street, North Road and Lowell Street. This is a diverse property with a variety of resources, uses and issues, including an active dairy farm; multiple historic buildings; acres of wetlands, forests and agricultural fields; miles of trails popular with walkers, equestrians and mountain bikers; and home to a cross-country ski concession.

Great Brook Farm is the largest active farm remaining in Carlisle, and is touted as the only active dairy farm within a state park in the country. The farm complex boasts a robotic milking system, the first one to be installed in Massachusetts.

5.2. History of Property

The Concord River Valley area has a long history of human occupation, with a Native American presence that stems back thousands of years. Known archaeological sites within Great Brook Farm State Park confirm pre-contact use of this property.

European settlement of the Carlisle area took place in the mid 17th century, with the establishment of three separate small settlements, one of which, Chelmsford South End, began sometime after 1655 and was located in the area of the present day park (MHC 1980*d*). River Meadow Brook provided serviceable waterpower, and mills and dwellings began appearing along its banks in the 17th century, including the area known as "The City," a small milling community with multiple homes and even a possible garrison (Markey 2002). A fulling mill was established in 1691 by John Barrett. Saw, grist and hoop mills were also located along River Meadow Brook, operated by the Adams and Robbins families through the early 18th century. A blacksmith shop was located in the area, and small scale quarrying also took place on land that is now within the park. A hoop mill continued to operate into the late 19th century.

By the early 18th century, the Spaulding and Adams families settled in the area and established small farms. The first North District schoolhouse was authorized in 1788, and the brick school building, the second one on this site, was constructed by Benjamin Barret in 1828. Small scale agriculture continued into the early to mid 20th century.

In 1939, Farnham Smith purchased eight acres off of North Road and built himself a cabin on a small pond as a summer retreat. Attracted to the area, he began purchasing additional property – the Adams farm in 1943, the home at 886 Lowell St in 1953, and the purchase of the Hart property, including the barn and the schoolhouse shortly thereafter (Miller 1998). He ultimately purchased 29 individual parcels, owning more than 900 acres, eight houses, the former schoolhouse, and five barns (Markey 2002). Smith began dairy farming and some breeding, and in 1948 he hired a farm manager, embarking fully into the breeding of Holsteins. Great Brook Farm became one of the largest dairy farm operations in New England and a highly respected breeder of Holsteins.

In September 1974, Smith sold Great Brook Farm to the Commonwealth of Massachusetts for $4.3 million, for the establishment of a state park. Smith retained the rights to: operate the farm for an additional three years, use and lease the North Farm house for an additional five years, use the log cabin and the East Farm house for an additional eight years, and life tenancy use of the schoolhouse. Smith decided to cease farm operations just one year later, selling off equipment and animals in 1975.

Legislation was passed in 1982 for the establishment of an interpretive farm. The cross-country ski concession has been operating since the 1983-1984 ski season (weather permitting). Applicants were sought to operate the farm in 1986, and Mark and Tamma Duffy have been operating the dairy farm component of the park under lease agreements since 1987. The ice cream stand opened in 1988.

5.3. Existing Conditions

Natural Resources

Physical Features

Topography. The topography within Great Brook Farm State Park is composed of lowlands in the south and gently rolling hills in the north. Elevation ranges from 170 to 300 feet above sea level.

Geology. Located within the Nashoba terrane, Great Brook Farm State Park lies primarily within the Nashoba formation. This formation is composed of metamorphosed volcanic rocks and includes schist, gneiss and biotite gneiss as well as an abundance of mica and sillimanite (Skehan 2001). Glacial eskers and erratics can be seen throughout the park.

Soils. The soils at Great Brook Farm State Park include large areas that are well suited to agricultural and pasture use, although there are some issues with droughtiness that limits crop production and pasture usage (Peragallo 2009). The wetlands present on the property are reflected in the high percentage of acres characterized as muck type soils. There are slight to moderate limitations on path and trail development in dry areas, depending on slope, and some limitations on picnic and playground development, based on slope and the stoniness of the soils (Peragallo 2009).

Table 5.1. Soils of Great Brook Farm State Park

Soil Series	% of Park	Drainage Class
Canton fine sandy loam	20.7	Well drained
Freetown muck	14.4	Very poorly drained
Hinckley loamy sand	10.5	Excessively drained
Charlton-Hollis-Rock outcrop complex	7.6	Well drained to somewhat excessively drained
Merrimac fine sandy loam	5.7	Somewhat excessively drained
Swansea muck	5.2	Very poorly drained
Woodbridge fine sandy loam	4.6	Moderately well drained
Scarboro mucky fine sandy loam	4.4	Very poorly drained
Saco mucky silt loam	2.7	Very poorly drained
Freetown muck, ponded	2.3	Very poorly drained
Carver loamy coarse sand	2.3	Excessively drained
Windsor loamy sand	2.2	Excessively drained
Scituate fine sandy loam	2.2	Moderately well drained
Haven silt loam	2.1	Well drained
Hollis-Rock outcrop-Charlton complex	2.1	Somewhat excessively drained to well drained
Deerfield loamy sand	2.0	Moderately well drained
Raypol silt loam	1.7	Poorly drained
Narragansett silt loam	1.7	Well drained
Water	1.2	N/A
Wareham loamy fine sand	1.1	Poorly drained
Raynham silt loam	0.8	Poorly drained
Rock outcrop-Hollis complex	0.6	Somewhat excessively drained
Udorthents	0.5	Variable
Whitman fine sandy loam	0.3	Very poorly drained
Tisbury silt loam	0.2	Moderately well drained

Water Resources

Great Brook Farm State Park is rich in water resources – almost a quarter of the park's total acreage is made up of either ponds or wetlands.

Ponds. Meadow Pond, centrally located in the park, is the largest body of water in Great Brook Farm State Park (see Figure 4). Meadow Pond has an abundant amount of water chestnut (*Trapa natans*) that is impacting the chemistry and habitat of this body of water. Beaver activity, weather, and water releases from nearby cranberry bogs impact the water level, and have led to flooding on nearby trails.

There are two smaller ponds on the property. One is the farm pond located adjacent to the farm complex and the second is located north of North Road, in the eastern portion of the park, near the site of Farnham Smith's cabin retreat (see Figure 4). There are almost 12 acres of water that are encompassed by these three ponds.

Wetlands. The southern portion of the park is dominated by Tophet Swamp, a 76 acre wooded wetland area consisting primarily of mixed trees (see Figure 4), along with two blocks of coniferous wooded swamp. A smaller (28 acre) coniferous wooded swamp can be found in the northern section of the park. Shrub swamps (approximately 33 acres) and deciduous wooded swamps (57 acres) can be found spread throughout the property. All combined, swamp areas cover almost 21% of the park.

Some shallow marsh meadow lands encompassing 10 acres are found north of Meadow Pond, in the area known as "The Meadows". Small pockets of deep marsh can be found scattered nearby, totaling almost nine acres. The largest of these deep marshes is located directly northeast of Meadow Pond.

A small bog area, just over one acre in size, is located within the southern section of Tophet Swamp.

Vernal Pools. There are seven certified vernal pools and 12 potential vernal pools located in the park.

Streams. River Meadow Brook, also locally known as Great Brook, is situated roughly west-east through the park, starting in a cranberry bog west of the park and running just south of Curve Street and North Road until it enters Meadow Pond (see Figure 4). Exiting the north end of Meadow Pond, River Meadow Brook heads northward out of the park into a series of mill ponds in Chelmsford and into the Concord River in Lowell.

Two small, unnamed streams flow into River Meadow Brook from the north, on either side of Lowell Road, while a third stream swings through a small portion of the southern border of the park, ultimately connecting to Pages Brook south of the park.

Groundwater. A small portion of a medium-yield aquifer lies beneath nine acres in the northern part of the park, extending from Meadow Pond north to the park boundary.

There are two drinking water wells located at Great Brook Farm State Park. One well (#3051017-01G) is located just east of the Main Farm house, and serves the farm and the ice cream stand. The second well (#3051017-02G) is located north of the Nature Center Pavilion, in the field just southeast of the North Farm House Barn, along the Litchfield Loop trail, and serves the Nature Center Pavilion. Both are categorized as Transient Non-Community Groundwater Sources by the Department of Environmental Protection.

Flood Zones. The 100-year flood zone covers 84 acres that fall within Great Brook Farm State Park. This zone roughly corresponds to lands adjacent to River Meadow Brook and Meadow Pond, and extends north from Meadow Pond into The Meadows. The 500-year flood zone incorporates 162 acres of land, concentrated in the Tophet Swamp area in the southern half of the park.

Rare Species

A very small component of Great Brook Farm State Park, just 33 acres, has been designated as Priority Habitat under the Massachusetts Endangered Species Act (321 CMR 10.00). Located in the westernmost parcel of the park, the Priority Habitat is located on a non-contiguous piece of land located south of Curve Street and west of Old Morse Road, and extends into nearby municipal conservation land and private lands.

Placeholder for Figure 4.

Two rare species, both reptiles, can be found in this Priority Habitat: Blanding's turtle and eastern box turtle (NHESP 2007*a*; NHESP 2007*c*). These two species are similar in appearance and have similar nesting habitats, and thus are often confused with each other.

Table 5.2. State-listed Species of Great Brook Farm State Park, as identified by the Natural Heritage & Endangered Species Program (NHESP)

Species	Type	MESA[a]
Blanding's turtle	Reptile	T
Eastern box turtle	Reptile	SC

Source: Harper 2013

a. Status of species listed under the Massachusetts Endangered Species Act (MESA): SC = Special Concern and T = Threatened.

Blanding's turtles use a variety of habitats, including vernal pools, marshes, scrub-shrub wetlands and open uplands, during their life cycle, and travel long distances during their active season (NHESP 2007*a*). Eastern box turtles are more of a terrestrial turtle and inhabit a variety of habitat types (NHESP 2007*c*).

In 2010, MassWildlife and The Nature Conservancy (TNC) issued "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience, and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010). At Great Brook Farm State Park, 490 acres (54% of the park) has been designated Core Habitat, a much larger area than the MESA designated Priority Habitat, but no Critical Natural Landscape areas have been designated.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified seven forest sub-types within Great Brook Farm State Park (Table 5.3).

Table 5.3. Forest Sub-types of Great Brook Farm State Park

Forest Sub-type	Acres	% of Park
Eastern white pine - oak	209.3	22.5
Eastern white pine	123.8	13.3
Eastern white pine - hardwoods	83.2	9.0
Mixed oak	76.6	8.2
Oak – hardwoods	33.9	3.6
Eastern white pine - eastern hemlock	8.8	0.9
Red maple - swamp hardwood	3.6	0.4
Total	*539.2*[a]	*57.9*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the park's boundaries since 2003.

More recently (2010-2011), specific areas within the forest were visited by DCR Management Foresters as part of the Massachusetts Continuous Forestry Inventory (CFI). The CFI is a network of permanent, one-fifth-acre plots on state park and forest lands that are routinely monitored for sivicultural purposes, and help to gage forest health. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There are seven CFI plots at Great Brook Farm State Park. These even aged stands range in age from 70 to 100 years and are comprised mostly of white or red pine, red maple, and white, black or scarlet oak.

Some disturbance agents have been noted in these stands, including pasturing (1900 to the present); insects (1981) and wind (1985). Harvesting also occurred in these stands in 1960.

Priority Natural Communities. There are no Priority Natural Communities within the park.

Invasive Species. A number of invasive species have been observed and identified by foresters and visitors to Great Brook Farm State Park. These species include:

- Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub that threatens wetlands, where it can suppress other species, and field edges.

- Garlic mustard (*Alliaria petiolata*), a biennial herb that can spread rapidly, displacing native vegetation and in turn altering habitat. Garlic mustard is very difficult to eradicate.
- Bittersweet, a deciduous woody vine that has the capacity to grow over 60 feet long, girdles trees and smothers other plants. Bittersweet has been observed by the ice cream stand, along the Acorn Trail, and at the small parking area at the intersection of Lowell Street and North Road.
- Purple loosestrife (*Lythrum salicaria*), an herbaceous perennial, can suppress native populations, alter wetland structure and function, and impede water flow. Dense stands can form that are unsuitable for use by wetland habitat animals. Purple loosestrife has been found in wetland areas and along the brook.
- Water chestnut (*Trapa natans*), a fast growing aquatic plant, can crowd out native species and choke waterways. Water chestnut damages habitat and can impede recreational access. This is particularly present at Meadow Pond, and has been one of the contributing factors to the decrease in recreational boating in this pond.
- Multiflora rose (*Rosa multiflora*), is a densely spreading shrub that forms thickets that crowd out native species.
- Japanese knotweed (*Polygonum cuspidatum*), a shrub-like herbaceous plant that forms dense thickets that crowd out native species and reduce wildlife habitat, posing significant threats in riparian areas in particular.
- Catalpa (*Catalpa bignonioides* or *Catalpa speciosa)*, a fast growing tree that can reach a height of 50 feet and crowd out native trees in the process.
- Winged burning bush (*Euonymus alatus*), also known as winged euonymus or burning bush, is a deciduous shrub that forms dense thickets that crowd out native species.
- Japanese barberry (*Berberis thunbergii*), a spiny shrub that forms dense stands that can displace native plants and reduce wildlife habitat and forage. Barberry also harbors deer ticks that have the potential to carry the Lyme disease bacteria, functioning as a nursery of sorts for juvenile ticks (Benson 2011).
- Privet, a rapidly maturing semi-evergreen shrub that forms dense thickets that crowd out native species.

Pests and Disease. White pine weevil (*Pissodes strobe*) has been identified in Great Brook Farm State Park. While tree mortality from this pest is low, damage does impact tree health and reduce wood quality. Leaf feeders have also been identified here as well, although to a much lesser degree than the weevils. Leaf feeders encompass a broad category of insects that are all defoliators, impacting trees and other plants.

Wildlife

Birds. Great Brook Farm State Park is popular with birders, and over 150 wild species have been recorded in or over the park in recent years (see Appendix G). Of these species, 22 are classified as Species in Greatest Need of Conservation (MassWildlife 2006). As part of the farming operation, the farmers also maintain a flock of domesticated chickens.

Mammals. There is little current information on the park's mammals. Nine species confirmed to occur within the park and an additional 34 species that may possibly occur within the park are identified in Appendix G. Of the confirmed species, one of them, the Eastern red bat, is classified as a Species in Greatest Need of Conservation (MassWildlife 2006).

As part of the farming operation, the farmers also maintain a herd of dairy cows for milk production, as well as some goats, sheep, pigs, rabbits and a horse. Some are family pets, while others are kept for visitor enjoyment and farm income.

Reptiles. There is little current information on the park's reptiles. Seven species confirmed to occur within the park and an additional nine species that may possibly occur within the park are identified in Appendix G. Of the confirmed species, two are classified as Species in Greatest Need of Conservation (MassWildlife 2006). These are the Blanding's turtle and the Eastern box turtle.

Amphibians. There is little current information on the park's amphibians. Ten species confirmed to occur within the park and an additional eight species that may possibly occur within the park are identified in Appendix G.

Fish. There is no current information on the park's fish. A survey of River Meadow Brook in 1979 yielded an American eel (*Anguilla rostrata*), a brown bullhead (*Ameiurus nebulosus*), 12 bluegill (*Lepomis macrochirus*), four pumkinseed (*Lepomis gibbosus*), and four largemouth bass (*Micropterus salmoides*) (Wineman 1980).

Cultural Resources

There is a wide range of cultural resources within Great Brook Farm State Park. Some are associated with Farnham Smith's use of the property, while others predate his acquisition of these lands. Many of the cultural resources have been documented on Massachusetts Historical Commission (MHC) inventory forms. The park was evaluated by the MHC in the late 1990s and determined at that time to be eligible for listing in the National Register of Historic Places.

Pre-Contact Archaeological Sites

Four pre-Contact sites have been recorded in the park. One site is a stone tool making workshop that dates to the Middle Archaic Period (7,500-5,000 B.P.). The remaining sites are identified as "find spots" with little more than locational information provided. Despite the low number of sites, the physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the area, all confer a high archaeological potential for this park.

Historic Archaeological Resources

Remnants of the 18th – 19th century mill site operated by the Adams family are located on River Meadow Brook, adjacent to Farnham Smith's cabin. (See MHC inventory form # CAR.902.) The Adams mill site includes a dam, two sluiceways, an impoundment, and the foundation of a mill. The dam and the sluiceways were originally constructed of dry laid stone, which helped to control water and create the impoundment area. The dam, also known as Cabin Pond Dam in agency records (MA02506), has an earthen core and sluiceways with concrete reinforcing. This dam is considered non-jurisdictional, meaning it is not under the regulation or jurisdiction of the DCR Office of Dam Safety and has not been assigned a hazard code. This dam was last inspected in 2007. A gate mechanism was added in the 20th century, probably to manage the water levels in the impoundment area. The mill foundation is located just north of the dam. According to research, this building once functioned as a grist, hoop, and saw mill (Dwyer 1995).

Not far from the Adams mill site, off of the Garrison Loop Trail, is the area locally known as "The City," also known as Chelmsford South End. This area, a collection of cellar holes likely dating from the 18th century, was potentially affiliated with the nearby mill, possibly as an area of mill worker housing. An archaeological survey of the area in 1995 identified five visible cellar holes in this area (Dwyer 1995); only two definite cellar holes and a possible third cellar hole were located during the RMP fieldwork. Archaeological work revealed a low density of artifacts, suggesting the area was not inhabited for a sustained period of time.

One of the cellar holes that is still visible is locally known as the Garrison House site. Although archival research points to a garrison located in the Great Brook area in the 17th century, the archaeological investigation yielded domestic artifacts, and cannot confirm its use as a garrison (Dwyer 1995).

Another cellar hole is located next to three pieces of quarried stone. A third, possible cellar hole is located north of these other two, near the northern intersection of Garrison Loop with the Woodchuck Trail. Lots of leaf and brush debris were noted in the cellar holes during the RMP fieldwork.

Other cellar holes that may or may not be affiliated with the settlement of "The City" can be found within the park. One of these, located across the street from the Litchfield House, consists of a dry laid stone foundation in an I-shape, with a large chimney base. This was also researched and tested during the 1995 archaeological survey of the park, at which time it was determined to have been the site of a mid to late 18th century residential structure (Dwyer 1995). This particular cellar hole is currently filled with brush.

Another cellar hole is located northeast of "The City," alongside the Woodchuck Trail. This one is small and square, with a smaller cellar hole next to it, suggesting an outbuilding. Of note are some stone walls that make some unusual turns in the immediate vicinity of this cellar hole.

The stonework remnants of John Barrett's Mill, located on River Meadow Brook near the intersection of Lowell Street and North Road, on the west side of Lowell Street, are still somewhat visible. Local historians suggest that this was established in 1691 as one of the first fulling mill sites in the U.S., and later used as a hoop mill until the late 19th century (Lapham 1970). A stone dam that may have been affiliated with this mill site is located near this same intersection, on the east side of Lowell Street, and is known as the Lowell Road dam (MA02508). This dam is considered non-jurisdictional, meaning it is not under the regulation or jurisdiction of the DCR Office of Dam Safety and has not been assigned a hazard code. This dam was last inspected in 2006.

Two historic wells were located in the park during the RMP fieldwork. One of them, located south of North Road, once serviced the Main Farm House. A small well house covered this well until relatively recently, when it was removed for safety reasons and replaced by wooden decking. The other well, which is located southeast of the Litchfield House, is an open well located just off the trail.

Historic Resources

Buildings. In the process of acquiring the acreage for his large farm, Farnham Smith acquired several nearby farms – and their buildings – over the course of about 20 years. Since the establishment of the park, some were able to be put to use for park purposes or through long-term lease agreements. However, several of them no longer function for park purposes, or are residences that in the recent past have housed DCR staff, but with the disbandment of the staff housing program are no longer utilized. The buildings are presented here in three groupings: those that are currently in active use by park staff, long-term leaseholders, or curators; those that are used solely for storage purposes by the park and/or the region; and those that are currently vacant and no longer in active use (see Figure 4).

Buildings in Active Use

North Schoolhouse, located at 984 Lowell Street, is also known as the Park Headquarters building. See MHC Inventory form #CAR.7. Constructed in 1828, this single-story, side gabled, three-by-four bay brick building has a granite block foundation and a slate roof. A single-story rear ell, perpendicular to the main block, has another ell added onto the first one, oriented parallel to the main block. Both are clad in clapboard. The building has two interior brick chimneys; one is located in the main block and the other in the rear ell.

Utilized as a grade school until 1906, the former schoolhouse was adapted in the early 20th century for vegetable storage. Farnham Smith purchased the property in 1955, and renovated the schoolhouse into his farm offices in 1959, which may have been when the side entrance was modified to the present-day central recessed entrance under the elliptical arch. The rear ells, clad in clapboard, were added in 1959 and 1969 respectively.

English ivy is growing on the end walls of the main block, and the brick chimney in the rear ell is experiencing major spalling. The building is in satisfactory condition.

The North Schoolhouse has been in use as the Park Headquarters since establishment of the park.

North Schoolhouse/Park HQ (DCR)

Hart Barn, located at 1018 Lowell Street. This one-and-one-half story, gambrel roofed barn was once a dairy barn, constructed in the first quarter of the 20th century. With a poured concrete foundation, a concrete block first floor, a clapboard second story, and an asphalt shingle roof, this barn also has an attached milk room and metal stave silo. Aluminum framed fixed sash windows and a metal vent in the roof completes the picture.

Recent mortar repairs efforts between the concrete blocks is evident, and it appears that multiple materials were used in the process. This was done in anticipation of a repainting project scheduled for later in 2014. Asbestos abatement of the window glazing was completed in 2014. The development of a plan for the remaining lead and asbestos inside the building is also anticipated. While the southern side of the roof was replaced in the recent past, the northern side has not been in some time, and lichen growth is evident. While work has slowly been occurring here to address major issues, the building is still in unsatisfactory condition.

The Hart Barn has been in use as the Great Brook Ski Touring Center since the l983-1984 ski season.


Hart Barn (DCR)

The ***Main Farm House***, historically known as the Adams House, is located at 247 North Road. See MHC inventory form #CAR.8. The Main Farm House is a two-story, side-gabled, three-by-two bay, central chimney, Georgian style home with a single-story rear ell. A shed roof provides a covered patio area on the rear façade, between the main block and the ell. The main house has a granite block foundation, and the ell has a concrete block foundation. The entire house is clad in clapboards and has an asphalt shingle roof. Windows are primarily six-over-nine double hung sash, with exterior storms. Architectural details include cornice returns on the gable ends, wide and flat window trim with a small projecting cornice, and top lights above the main entrance. Documentation on the MHC inventory form prepared in 1993 notes interior details including original paneling, wide pine flooring, and exposed gunstock posts in one second floor bedroom, however park staff could not confirm if these features still exist.

The house was constructed in the second half of the 18th century. Local historians differ about the date of construction - Timothy Adams, who purchased the property in 1793, may have constructed a new home on the site or may have remodeled an earlier c1760 home. The main farm complex was acquired by Smith in 1943 and a rear ell was added c1949.

While there is a gutter on the ell, there is no gutter on the main block of the house. This has led to the presence of lichen on the front and rear façades of the house due to splash back, and the doorsill at the main entrance appears to have some moisture damage. Some minor woodpecker damage can be seen on a front corner board. This building is in satisfactory condition.

The Main Farm House is now in use as the residence of the farmers that operate Great Brook Farm under a long-term lease.


Main Farm House (DCR)

Garage/Apartment. Located within the core of the farm complex is a two-story, side gabled structure. This building was built for equipment storage and farm staff housing, and is still utilized for these same purposes. Constructed during Smith's ownership of the property, this concrete block and clapboard building has five vehicle bays on the first floor and a two bedroom apartment on the second floor. Park staff has use of two of these vehicle bays for storage purposes. This building is in satisfactory condition.


Garage/Apartment (DCR)

Tie Stall Barn. Constructed in phases, this long building consists of a single-story gable roofed tie stall barn constructed c1910-1920 on the eastern end; connected to a two-and-one-half-story gambrel roofed barn built in the 1950s; connected to a single-story gable roofed open ended building on the western end. Gabled dormers punctuate the gambrel roofed section, and small single-story additions punctuate the eastern section, one of which links the barn to a wood stave silo that is no longer in use. The foundation is fieldstone on the eastern end and concrete block on the western end. The building is clad in drop board siding and roofed with asphalt shingles. Vinyl replacement windows dot the structure. Exposed rafter tails provide the only adornment on this building.

Some small sections of siding are in need of repair, due to cracking or pieces missing. There are serious sill and foundation issues in need of attention. The north facing roof has some lichen growth and staining, and may need replacement. The building is in satisfactory condition.

The Tie Stall Barn used to house the dairy herd. A seasonal ice cream stand that is operated by the farmers April through October is now located at the eastern end of the structure. An interior dining and event space was developed by the farmers just behind the pre-existing ice cream stand section, however it was done without prior consultation with the DCR (as stipulated in the farm lease agreement) and without the benefit of a building permit. Authorization of future use of this space for this purpose is still pending, and will not occur until all applicable permits are obtained. The remainder of the barn is currently utilized primarily for storage of hay and sawdust.

Tie Stall Barn (DCR)

Bull Barn. This one-and-one-half-story front gabled building, located just to the east of the Tie Stall Barn, is composed of concrete block on the first floor and clad in drop board above, and has an asphalt shingle roof. Windows are aluminum framed sliding sash, some of which may no longer function. The main entrance is located on the side of the front façade and three more doors are located on the south elevation. A door sized opening is located in the gable end of the upper floor, presumably to access the area for storage. Like the Tie Stall Barn, the only adornment here is exposed rafter tails.

Constructed during Smith's ownership of the property, severe cracking has since occurred in the foundation through the front wall. Due to this issue, the building is in unsatisfactory condition.

This building is currently used for storage. The sign on the building, "Non-Hazardous Industrial Wastewater," reflects the nearby presence of underground piping associated with the tight tank for the Smart Barn (see the Infrastructure section for more information).

Bull Barn (DCR)

The ***Litchfield House***, historically known as the East Farm, is located at 437 North Road. See MHC inventory form #CAR.6. This c1860 one-and-one-half-story front gabled Greek Revival house is composed of a three-by-three bay main block with a one-story rear ell. The ell connects to a side gabled barn and two car garage through a small shed roofed addition, forming an L-shaped plan. The home has a granite block foundation, clapboard sheathing, and an asphalt roof. Architectural details include a deep eave overhang, sidelights flanking the main entrance, and six-over-six double hung sash windows that have been fitted with exterior storms. The New England style banked barn has large at grade openings on both the front and lower rear facades. Lichen is present on the north side of the roof and some can be seen creeping up the walls. The house has two interior brick chimneys, both of which could use some minor repair work. Extensive gardens surround the house. This property was purchased by Farnham Smith in the 1940s and served as the home for his head farmer, Lowell Litchfield.

This home is currently in use as a residence under a long-term lease as a part of the DCR's Historic Curatorship Program. This building is in satisfactory condition. The curators are currently working on the rear wall of the barn, which is in poor condition.

Litchfield House (DCR)

The ***Hounds House***, historically known as the Woods House, is located at 659 North Road. The Hounds House is a two-story, flat roofed modern home, constructed in c1950 of concrete block, with vertical board wood sheathing on the second floor. With metal casement windows and a deep raking eave with exposed rafters, this home reflects the modernism movement that had a large presence in nearby communities. This building is in satisfactory condition. A small one-story, front gabled wood frame horse barn is located to the rear of the home.

This home is currently used as a residential and commercial facility. It has been operating under a long-term lease to Old North Bridge Hounds, a business that kennels hound dogs and organizes local equestrian hunts.

Hounds House (DCR)

Buildings Used for Storage Purposes

Hadley House and Garage. Located at 1003 Lowell Street, this small mid-19th century residential building is a one-and-one-half-story, side gabled, two-by-one bay main block with a full width one-story shed roofed component on the rear. The foundation is largely fieldstone, with some concrete block on the southwest corner. The sheathing is clapboard and the roof is asphalt shingle.

The windows are primarily two-over-two double hung sash, and the main entrance is located on the side of the building, on the south facing façade. A centrally located brick chimney pierces the roofline. A wide fascia board and gable returns are the only adornments on this building.

A lilac bush, along with some bittersweet, can be found in the back yard.

The building has no gutters, the paint is failing, and a hose coming from the basement suggests a water problem.

Most recently, the Hadley House had been in use as staff housing. Vacated about seven years ago, the house is now used for storage by the region, is in non-functioning condition and is on the agency demolition list. As the timing of demolition is unknown, park staff plans on repainting the building in 2014 to make it less of a potentially attractive nuisance.

Hadley House (DCR)

A well maintained, detached two car garage in satisfactory condition is located just south of the Hadley House. Built c 1960, the side gabled garage has a concrete slab foundation, clapboard walls and an asphalt shingle roof. A gutter is located on the front wall, but not the rear wall of the garage.

Park staff currently use this garage for snowmobile storage, and do not plan to demolish the building.

Anderson Barn. Located at 360 Curve Street, this one-and-one-half-story, side gabled 19th century barn has a fieldstone foundation, clapboard walls and an asphalt shingle roof. The primary façade has a pair of adjoining entrances, located slightly off center. One is composed of a set of double doors that swing inward; directly next to it is a small entrance that has an intact sliding door that is affixed to the exterior. Built into a bank, an on grade entrance to the basement level is visible on the west side façade, but not accessible due to vegetative overgrowth. Six-over-six, double-hung sash windows are present on the side and rear walls of the building. This barn has several architectural details not always present in such a utilitarian structure, including: corner boards, a full cornice that wraps the building, an overhanging eave, decorative gable end treatments, and wide and flat trim around the windows that includes a small projecting cornice.

The building is in unsatisfactory condition. Paint is failing on the wall, and some small holes have been addressed by stapling mesh wire over them to prevent access by rodents. Interior evidence suggests some recent insect damage. Lichen is starting to grow on the roof and vegetation is encroaching on the side and rear façades of the building.

This building has electrical service, and is currently utilized for storage by the regional office (including IT equipment and former exhibit materials), as well as the regional Foresters and district Fire Control. It abuts private property and is across the street from another private property that maintains horses on site.


Anderson Barn (DCR)

Vacant Buildings

Duck Coop. Located just to the east of the Main Farm House, the Duck Coop is a small shed roofed outbuilding built into a bank, with the lower level providing access to a low, poorly drained area that used to function as a seasonal pond. The building has a concrete foundation, clapboard walls and an asphalt shingle roof.

Moss and lichen are present on the roof, and the foundation has been compromised by the roots of the directly abutting trees. Due to the foundation damage, this building is in unsatisfactory condition.


Duck Coop (DCR)

Farnham Smith's Cabin. This cross-gabled, L-shaped, single-story cabin was built by Farnham Smith in 1939 as a summer retreat, prior to his establishment of Great Brook Farm. Located adjacent to the Adams Mill site, the cabin provided him with a private spot on a small pond.

Built partially on stone and concrete piers and partially on a fieldstone foundation, the building has a shed roofed front porch and a centrally located rubblestone chimney. Although at first glance it appears to be a log cabin, the building is actually a wood frame building with half round logs that have been applied as exterior sheathing. Since they are not structural, the log ends are mitered at the corners. Exposed rafter tails complete the rustic look. The building was wired for electrical and phone service, and was also outfitted with a security system by Smith (none of these services are currently live).

The cedar shake roofing has deteriorated to the point where there are a several holes in the roof, coupled with minor vegetation growth. At least one interim repair effort involving tar paper occurred, possibly covering an earlier hole. The porch steps are deteriorating as well. The building is in unsatisfactory condition.

In the sale of the property, Farnham Smith negotiated use of the log cabin for an additional eight years. After use reverted to the DCR, the cabin was periodically rented out for day use, primarily for corporate retreats. It was then briefly utilized as staff housing in the early 1990s. The windows are now boarded over, the door is locked, and the building is posted with "No Trespassing" signs.

Farnham Smith's Cabin (DCR)

Farnham Smith's Cabin Shed. A small, one-by-one bay front gabled shed is located adjacent to Farnham Smith's Cabin. Sheathed in cedar shingles, the shed is built on piers, has a tar paper roof, and is in satisfactory condition. A small open lean-to, probably used for protecting firewood, is located directly in front of this shed. Park staff does not have a key and do not use the space. Materials stored within the shed appear to date to use of the property by the former resident.

Cabin Shed and Lean-to (DCR)

Boat House. A small, one-story, three-by-one bay front gabled building located on the southwest end of Meadow Pond, the Boat House has a full-width front porch and rear addition. Built on a concrete block foundation, the building has drop board siding and an asphalt shingle roof.

The Boat House, unused since the early 1970s, is currently in extremely poor condition and considered to be in a state of critical failure. It has been posted with "No Trespassing" signs and is marked off with snow fencing to discourage people from exploring the site. Chunks of siding are missing, portions of the roof are caving in, and a section of sill appears to no longer exist.

The building is slated for demolition. As per a Memorandum of Agreement with Massachusetts Historical Commission, documentation on an MHC inventory form is underway.

Boat House (DCR)

The ***District 6 Fire Control Office***, historically known as the South House, is located at 841 Lowell Street. This c1950 traditional Cape Cod style former residence is a one-and-one-half story, side gabled, three-by-two bay building. The house has a concrete block foundation, a clapboard exterior, and an asphalt shingle roof. The front slope of the roof was replaced in the recent past with architectural style shingles; the rear slope has standard three-tab style shingles.

Two front gabled dormers punctuate the roof line and a single story breezeway connects the main block to a two car garage. Windows are six-over-six and eight-over-twelve double hung wooden sash. A brick chimney pierces the front slope of the roof, slightly off-center.

The exterior siding has some holes, and other minor deterioration, and the paint job is failing. There may be some foundation sill issues and several window sills are deteriorating. The building no longer has gutters and as one result, the front fascia board is deteriorating. The basement has water issues, as evidenced by the pipe leading out from a basement window.

This building was utilized as the District 6 Fire Control Office and also housed some regional staff until 2010, when those operations relocated to the new, large garage and office built on site to the rear of this building. (See the Infrastructure section for more information.) At that time, the septic system for this building was retrofitted and re-permitted for use by the new building. This house is in unsatisfactory condition, and is on the agency demolition list.

District 6 Fire Control Office (DCR)

The ***Manseau House***, historically known as the West Farm, is located at 1112 Lowell Street. This three-by-two bay, two-story, central entrance home with a hipped roof, reflects a plan that was popular in the first quarter of the 20thc. A hipped roof entry porch with some scrollwork adorns the façade, and a small single story shed roofed addition has been added to the rear entrance. The home has a fieldstone foundation, late stage aluminum siding, and an asphalt shingle roof. There are no gutters.

Two brick chimneys are present: an exterior one on the south façade and an internal one that pierces the north slope of the roof. Windows are primarily two-over-two double hung sash. Historic photos show a central hipped roof dormer, removed sometime after 1973.

The house is in poor shape. English ivy, growing up the south side and rear walls, appears to have infiltrated the interior of the home. The internal chimney is leaning and the rear entry porch is collapsing.

Most recently, the Manseau House had been in use by regional fire control as storage until about 2008, and prior to that as staff housing. Vacated by the last residents approximately 10 years ago, the house is in non-functioning condition and is on the agency demolition list.

Manseau House (DCR)

A well maintained, detatched, two car garage in excellent condition is located behind the Manseau House. Built c1960, the hipped roof garage has a concrete slab foundation, clapboard walls that have recently been repainted, and an asphalt shingle roof.

The District Fire Control staff currently uses this garage for vehicle and other storage, and there are no plans to demolish this building.

North Farm House and Barn. Located at 107 Old North Road, this well maintained, one-and-one-half-story, cross gabled, five-by-three bay home has a fieldstone foundation, clapboard sheathing and an asphalt shingle roof. The house has two brick chimneys – an exterior one on the south façade and an interior one in the north end of the building. Windows are six-over-six double hung sash. The building is situated on a small rise with nice views of the fields to the south and the barn to the east. Extensively renovated and added onto in 1961, it appears this was originally a Cape Cod style home that had the front gable added to the north half of the front façade.

This home was utilized for staff housing until March, 2014, vacated as part of the discontinuance of the staff housing program. There are no current plans for its future use, but park staff would like the house to be reused in some capacity, especially since it is located on the edge of the park property. Neighbors have already expressed concerns to park staff, and are worried about vandalism.

North Farm House (DCR)

The North Farm House Barn, just east of the house, is a one-and-one-half-story barn with a gambrel roof. Built into a small bank, the foundation is poured concrete, the sheathing is dropboard and the roof is covered with asphalt shingles. The windows appear to be fixed wooden sash and exposed rafter tails provide the only adornment. The barn has also been well maintained.

The lower level of the barn has been used for park storage for many years, while the tenant utilized the upper level of the barn. Park staff has expressed an interest in using the upper level for additional storage, ideally for equipment that cannot stay in the Hart Barn during the winter, but no decisions have been made.

Structures. There are a number of different historic structures located within the park.

Bridges and Culverts

Along the Woodchuck Trail is a small ***bridge*** that is graced on one corner by a short cobblestone pillar with a concrete cap. The pillar appears to have had electrical service to it at some point, possibly to light the bridge. This bridge, constructed of non-historic wooden decking that rests on historic stone and concrete abutments, spans a small stream bed. The abutments appear to have been originally stone, but partially rebuilt through the addition of concrete. A concrete gate is located about 20 feet upstream from the bridge, probably utilized to create a small impoundment and control water flow.

Small bridge on Woodchuck Trail (DCR)

A ***stone arch bridge*** is located on the Pine Point Loop Trail, just north of the Boat House. This at grade crossing consists of a triple arch stone bridge, composed of dressed granite blocks, with low stone curbing for sidewalls, and an earthen pathway. Round holes are visible in the granite curbing, although their original purpose is unclear. While this spans the outlet of Meadow Pond, water seems to be creating problems at either end of the bridge. Debris is visible on the upstream side of the bridge and little headspace is visible through the arched culverts, suggesting that either the water level of the pond has risen over time, or that the openings may be partially blocked and impeding water flow beneath the bridge at the rate needed.

Stone bridge on Pine Point Loop Trail (DCR)

A small stone and earthen ***causeway***, outfitted with a stone culvert, is located just west of the stone bridge. The culvert is composed of rough dry laid fieldstone.

Farm Structures

Pole Barn. This partially enclosed, side gabled barn is actually a post and beam structure with a corrugated metal roof. Where exterior walls exist, they have board and batten siding. Vegetation is encroaching upon the rear (northern) façade of the building.

Pole Barn (DCR)

Bunk Feeder. The Bunk Feeder, an open air pavilion, provides shade for the farmers' cows and is a space used for feeding. This wood frame building has a corrugated metal roof that appears to have some minor damage, including small spots of corrosion.

Bunk Feeder (DCR)

Both the Pole Barn and the Bunk Feeder were constructed during Smith's ownership of the property, and are currently used for Heifers of breeding age. Both structures are in satisfactory condition.

Metal Stave Silo. This silo, one of two on the property, is located between the Pole Barn and the Bunk Feeder. It appears to be in satisfactory condition, but it is no longer used for silage.

Metal Stave Silo (DCR)

A few additional small farm structures of indeterminate age are located in the core farm area, most notably a chicken coop and a pig shed.

Other Structures

Segments of ***stone walls*** can be seen in many areas throughout the park, both within the woods as well as alongside some of the roadways. These walls, predominantly dry laid loose rubble, vary in condition from failing to being in good condition. These walls show how this land was used and divided over the past three centuries.

A section of ***concrete retaining wall***, poured in stages, is located on the south side of North Road, across the street from the Main Farm House. The function of this retaining wall is not entirely clear. It is almost entirely covered in moss.

A free standing ***stone and brick hearth***, designed for outdoor grilling, is located just south of the Adams Mill remnants, not far from Farnham Smith's Cabin. Designed with two levels for cooking, it has a full chimney to direct smoke away from the cook. The hearth likely dates to Smith's development of this piece of property as his cabin retreat.

Outdoor Stone and Brick Hearth (DCR)

Located outside of Great Brook Farm, proper, is a fire tower, ***Massachusetts State Tower #21***, also known as the Hollis Wilkins Memorial Tower. Situated on a small (.06 acre) parcel at the peak of Robbin Hill, the property at 30 Summit Avenue in Chelmsford was purchased by the Commonwealth for 50 cents in 1918. First used as a site for fire monitoring purposes in 1911, the 60-foot-tall steel tower is the fourth one on the site, dating from 1939. The current cab dates from 1970.

The tower has also served as a host to a number of pieces of telecommunication equipment since 1978, from ham radio antennae to microwave dish antenna and repeaters for state police to commercial users. The following entities currently have equipment on this tower: Nextel, Massachusetts Department of Transportation, Greater Boston Police Council (GBPC), Massachusetts Port Authority, and the Massachusetts State Police.

A structural analysis of the tower undertaken in July, 2009 indicated the tower is in conformance with the requirements of the TIA/EIA-222-F standard (Structural Steel Standard for Steel Antenna Towers and Supporting Structures) for the current and antenna loading. An analysis completed in April, 2013 using the TIA-222-G-2 standard (Structural Standard for Antenna Supporting Structures and Antennas*)*, a more critical standard, found the tower to be overloaded with the existing and proposed antenna load by the GBPC. However, the GBPC chose not to add the proposed antenna systems due to a lack of funding. When and if they obtain the necessary grant funding to proceed with the project, the GBPC will have to reinforce the tower to meet the TIA-222-G-2 standard and their proposed antenna load.

Objects. There are no historic objects within the park.

Landscapes. There are a range of historic landscapes within Great Brook Farm State Park that showcase the history of Carlisle.

The core of ***Great Brook Farm*** and its adjacent fields to the east and northeast collectively form an historic landscape that conveys the agricultural history of the property, and is documented on MHC inventory form #CAR.A. It is through this collection of historic buildings and structures, the farmyard, the adjacent manmade farm pond, and the immediate surrounding fields that visitors can get a sense of what this place is, and see how dairy farming has evolved through the 20th century and into the 21st. The layout of these buildings and structures, as well as the fenced enclosures, provides pathways for visitors and safe spaces for animals and also help visitors understand how the farmyard functions. While the buildings and structures are described separately, the complex as a whole needs to be considered collectively.

Two other historic landscapes, the ***Adams mill site*** and ***"The City,"*** are discussed above, in the Historic Archaeological Resources section. The individual resources within these areas collectively make up larger historic landscapes, and each individual resource within these two sites needs to be considered within the full context of their larger landscape.

Finally, what appears to be a small unmarked family ***cemetery*** can be found off of the Woodchuck Trail, in the part of the park known as "The City." A series of 11 or 12 small stones are lined up, possibly head and foot stones. While there are no inscriptions, and the stones are not formally shaped, their rectilinear layout suggests they were lined up for this purpose, and may have served the mill village community. Additional research is needed.

During the last few decades, stone features and other landscape elements in the park have been the subject of differing research perspectives. Some of the stone features in the park are interpreted as symbolic and having astronomical alignments, or anthropomorphic details, and some have been designated "prayer seats". The public, independent researchers, historians, and archaeologists have all contributed to literature on the interpretation of the stone features within the park. The interpreted origins range from Precolumbian European exploration, Native Americans, and farmers. Because of the differing backgrounds, beliefs and agendas, a consensus on the debate has not been reached.


Cemetery (DCR)

Recreation Resources

Great Brook Farm State Park is primarily accessed via motor vehicle, although some local residents and regional cyclists do visit by bicycle. There are no public transit options to reach this park.

The primary recreational activities at Great Brook Farm State Park revolve around its extensive network of trails. This network, encompassing over 26 miles of trails, provides a variety of trail experiences that help make this park a popular destination. From wooded areas, to the edges of open fields, to rocky areas with some hills, to low lying areas along wetlands, visitors are not apt to get bored with the scenery.

The trails are routinely used by walkers and hikers, often accompanied by a dog, and according to park staff, the occasional goat. Despite signs at trailheads informing users of on-leash restrictions, many dogs are off-leash.

This park is a popular destination for mountain biking, in part because the trail system provides a range of experiences that can accommodate riders of all skill levels; mountain bikers range from beginners to experienced riders, and biking occurs throughout the park. When surveying park users about their use of the park for this RMP, the majority of survey respondents (65%) indicated that they have biked here in the past year. Technically challenging sections are concentrated in the Stone Row and Indian Hill areas. Riders explore the park individually, as well as through organized club rides and events, including an annual event organized by the New England Mountain Bike Association (NEMBA) as a part of the Kona Bicycles MTB Adventure Series. Park staff reports that some mountain bikers ride some of these trails after dark, despite the park officially closing at dusk.

The park's trails are also utilized by individuals and clubs for orienteering activities. The New England Orienteering Club has held events at Great Brook Farm State Park for several years, developing courses that are on- and off-trails. Other trail user groups include the Carlisle Trails Committee, the Cambridge Sports Union, and the local school system, which holds high school cross-country races as well as a local history search for third graders within the park.

The cross-country ski concession is very popular during the winter months, and serves as a major draw of visitors to the park. Over 8 miles of machine groomed loop trails are open, when there is enough snow to ski. The ski trails are restricted for use by skiers during the winter. An active effort made in 2010 to keep hikers off of the ski trails seems to be effective in maintaining the trails in good condition for skiers. The Lantern Loop, lit for nighttime skiing on Tuesday and Thursday evenings, provides visitors with a unique and interesting way to experience the park.

The ice cream stand at the main farm is also a big draw for visitors. Located at the eastern end of the Tie Stall Barn, ice cream is available on a seasonal basis. Approximately 10 picnic tables are located here for sitting and dining and checking out the farm animals. The farmers maintain a number of small farm animals in addition to the dairy cows, including goats, pigs, chickens and rabbits, for viewing in enclosures located adjacent to the Tie Stall Barn.

Equestrian use of the trails is also popular at the park. Complimenting the trail use, a series of cross-country horse jumps are located just off-trail in the section of the park south of North Road, most notably in the open fields to the west of Meadow Pond. These jumps, wooden fencing often flanked by overgrown cedars, are in fair condition. Some visitors complain to park staff (and also evident in the user survey for this RMP) about the frequent presence of horse droppings on the trails.

A canoe launch used to be located at the northern end of Meadow Pond, providing access to this body of water for canoeing and kayaking. This launch was removed in 2009 when a new large bridge was constructed nearby; some park users were unhappy about this outcome. While there has been some discussion of designing and installing a new canoe launch area nearby, this has not yet happened. The abundance of water chestnut growth in the pond also poses an impediment to canoeing and kayaking. As a result, the use of the pond by boaters has decreased significantly in recent years.

Infrastructure

Property Boundary

Great Brook Farm State Park is located in the northern part of the Town of Carlisle, roughly in the middle of the triangle formed by state routes 4, 225 and 27. Easily accessible by car from interstates 495 and 95/128 and state routes 3 and 2, Great Brook Farm State Park is a popular destination park within the greater metro Boston region.

Buildings and Structures

In addition to the historic buildings and structures discussed in the Cultural Resources section, there are a few more recent ones that have been constructed since establishment of the park, the two most prominent being the Nature Center Pavilion and the Smart Barn (see Figure 4).

The Nature Center Pavilion, constructed in 2002, provides a sheltered area under which interpretive programs can be held and visitors can relax at the six picnic tables. This pavilion also includes an enclosed portion that contains restrooms and an office for the seasonal interpreter.

Nature Center Pavilion (DCR)

Designed to reflect the agricultural history of the park, the cross gabled building features a standing seam metal roof, a bank of clerestory windows in the pavilion to help bring natural light into the sheltered portion, and a gable end detail intended to appear as a haymow.

The Smart Barn, constructed in 2010-2011 and located within the farm complex, is equipped with a DeLaval robotic milking system to support the dairy farm operations. This robotic system is touted as the first one to be installed in Massachusetts. The barn, a cross gabled building with a standing seam metal roof, vertical board siding and a clerestory, evokes the history of the farm and blends nicely with the nearby historic barns.

Smart Barn (DCR)

Also in line with evolving agricultural practices, the silage for the cows is no longer kept in the tall vertical silos, still found on the property. Rather it is stored in a large trench silo, an open trench with large concrete block retaining walls on three sides and a central divider, to facilitate loading and unloading by heavy equipment.

The District 6 Fire Control Office and Garage is located at 841 Lowell Street. It does not have a very visible presence, as it is set back from the road, behind the vacant Cape Cod house, and is not open to the general public. A non-descript, tall, front gabled building with corrugated metal siding and a standing seam metal roof was constructed in 2010 to house vehicles and equipment utilized for regional fire control purposes.

There are several non-historic bridges in the park, facilitating trail connections over wet areas and streams. (For a review of historic bridges, see the Cultural Resources section.) The northernmost bridge, noted on the park's trail map, is located near the intersection of Woodchuck Trail and East Farm Trail and crosses River Meadow Brook. This is a wide bridge, to accommodate park vehicles if needed, constructed of preformed concrete abutments and wooden decking.

Two wooden pedestrian bridges are located over the sluiceways at the Adams mill site, located near Farnham Smith's Cabin.

The largest bridge is located next to the parking area at the Pine Point Trail Loop. It is a wide bridge with a metal truss and wooden decking, sturdy enough to accommodate vehicular traffic. Installed in 2009, this bridge provides a connection to the other end of the loop so that trail users can avoid walking on North Road. As a part of the network of groomed ski trails, this safe connection is also important to skiers.

Non-historic culverts can also be found within the park, in an effort to control water flow. Near the northern intersection of the Woodchuck Trail and Garrison Loop is a concrete culvert, bridged by wooden decking on the trail. This culvert, equipped with a small gate controlled by wood boards to control water flow, has been outfitted with a beaver deceiver. A lot of brush debris has collected around the deceiver and the wetland itself has a lot of vegetation.

A culvert at the intersection of Woodchuck Trail and Garrison Loop. (DCR)

Two other smaller pipe culverts can be found along the Woodchuck Trail.

The last category of non-historic structures is a collection of three rock shelters located in the northern portion of the park, off of the Stone Row trail. These three shelters, one with a functioning chimney, are composed of dry laid fieldstone constructed around an existing glacial outcrop, with makeshift roofing composed of branches.

Rock Shelter (DCR)

Due to local lore suggesting that these may have past and present Native American associations, one of these rock shelters was investigated during the 1995 archaeological survey of the park (Dwyer 1995). After a walk over of the site with local Native American representatives, as well as subsurface testing within one of the shelters, it was determined at that time that these are not affiliated with past or present Native American use of this land.

Park staff indicates that these shelters have been created since the development of the property as the state park. The structures reportedly began as the work of a local park user, a mason that was interested in modern druid culture, and have since been altered, rebuilt, or new ones created by others. According to long time park staff, these have only been in place for approximately the last 25 years.

Roads

Curve Street, Lowell Street and North Road are all town-owned, locally designated scenic roads (see Figure 4). These roads provide access to Great Brook Farm State Park. While these roads are not owned by the park, impacts to any stone walls or trees on DCR land that fall in the right of way of these roads must be first seek the written consent of the Carlisle Planning Board.

Parking

The main parking area for the park, located off of North Road, provides easy access to the Nature Center Pavilion, the farm and the ice cream stand (see Figure 4). This paved lot accommodates over 80 vehicles, and has two spots allocated for handicapped parking. A parking fee of $2.00 is charged seasonally (April 1st – December 1st) via a pay and display machine located on site. This parking lot contains over 20 signs, 12 of which concern parking and the use of the pay and display machine. Some of these signs are official looking, while others are laminated paper.

Adjacent to this parking lot is a low impact rain garden that the DCR installed in 2010. The garden is planted with native flowers and shrubs, and it catches and filters the water run off from the parking lot and the Nature Center Pavillion.

A paved parking lot is also located at the North School House that now serves as the park headquarters (see Figure 4). This parking area, which primarily serves park staff, is also available for public use. The lot can accommodate approximately seven vehicles and it has one spot that is demarcated for handicapped parking.

A small parking area is located off of North Road at the trail head for Pine Point Loop, adjacent to the former canoe launch location (see Figure 4). This unpaved lot holds four to six vehicles. This location also has a lot of signage and includes four separate signs that address parking and are clustered in one area. None of these signs utilize the actual name of the park.

Signage at the Pine Point Loop parking area. (DCR)

Another small, unpaved lot is located at the intersection of Lowell Street and North Road, and can accommodate parking for approximately four vehicles (see Figure 4). This area is needed for large vehicle turnaround purposes rather than parking, but it is not signed as such.

Parking is also available in the former field directly adjacent to the Hart Barn, and serves the cross-country ski concession (see Figure 4). This unpaved lot can accommodate approximately 120 vehicles. A parking fee of $2.00 is charged seasonally (April 1st – December 1st) via a pay and display machine located on site.

Trails

Great Brook Farm State Park has an extensive and well utilized trail network spread over its 929 acres. This network includes a little over 24 miles of official trails (see Figure 4) and almost two miles worth of additional, unofficial trails.

Of the network of official trails, 0.5 miles are administrative roads, including the entrance to the District 6 Fire Control Office and Garage, as well as the roads within the farm complex. Unpaved forest roads make up 11.5 miles of the network and the remaining 12 miles are trails.

A survey of the trail network within Great Brook Farm State Park was undertaken in 2010. At that time, 19.4 miles were deemed to be in good condition, 4.6 miles were in fair condition, and only 0.3 miles were in poor condition, a fairly low percentage (1.5%) than is typical in other DCR properties, possibly reflecting the presence of the cross-country concession and their use of the trails and the strong volunteer participation in trail construction and maintenance by the mountain biking community. This survey does not reflect the condition of those trails that were subjected to extensive flooding while conducting fieldwork for this RMP. Some of the trails around Meadow Pond in particular were impassable due to flooding, interrupting the trail network in this area.

A series of short boardwalks are placed throughout the trail system, where necessary, for erosion control or wetland and stream crossings. Some of these structures are in good condition, while others are aging.

Great Brook Farm State Park is unique within the DCR system, as it separates trail users during the winter season. During the winter, 8.3 miles of trails in the eastern section of the park are set aside for the exclusive use of cross-country skiers. These trails are groomed to facilitate use by skiers and all other users are encouraged to use the remaining trails that are open to multi-purpose use, most of which are located on the western side of the park. Some trails in the eastern section of the park are closed to all uses during the winter season, if they connect to the groomed trails, but are not groomed for use by skiers. This practice has helped to reduce user conflicts and maintain a high quality network of groomed trails for use by skiers.

Two trail maps have been developed for Great Brook Farm State Park; one is for summer use, while the other shows the separation of trail uses during the winter. These trail maps are available on the park's webpage, on the DCR's website, as well as at the Hart Barn (during the winter) and in the park headquarters at the North Schoolhouse.

Signs and Kiosks

There is one Road Marker Sign that leads visitors to the state park, located in the center of Carlisle. There is one Main Identification Sign for the state park, located at the intersection of North and Lowell roads. The orientation, material and design of this sign does meet DCR signage standards (DCR n.d.).The sign is surrounded by ornamental plantings that are starting to get tall enough to obscure the bottom of the sign.

There are two informational kiosks located at the park; one is located at the eastern end of Hart Barn parking area, and the other is located within the farm complex.

Informational signage is also located within the Nature Center Pavilion, where a glass enclosed bulletin board is located on one wall, next to a wildlife sighting white board for use by visitors.

Additional interpretive signage is also located within the Smart Barn, informing visitors about the robotic milking system.

A routed wooden sign, now partially broken, marks the site of the Garrison House.

In the user survey undertaken for this RMP, several individuals suggested that better trail signage is needed.

Memorials and Markers

There is one memorial within the park, dedicated to Prospera, a prized cow of Farnham Smith's. Prospera was a champion Holstein heifer, who routinely won prizes from the Holstein-Friesien Association for her level of milk production. She is buried at the entrance to the farm, just off of North Road, and the spot is marked by a stone with a brass plaque that has raised lettering:

PROSPERA
1949 – 1969

5.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Water Resources

Drinking Water. The Transient Non-community Ground Water Sources (TNCs) within the park are tested under contract by WhiteWater Environmental Inc., a Massachusetts certified operator. These systems are operated in accordance with applicable regulations (310 CMR 22; Appendix F).

Massachusetts' regulations require a circular protective area around public water supply wells, including TNCs. The radius of this protective area, known as a Zone I, is based on the well's pumping rate. The DEP requires that activities within Zone I be limited to those directly related to the provision of water. Best Management Practices (BMPs) for protecting Zone I areas include the following (DEP 2001):

- Keep out non-water supply activities.
- Do not establish parking areas.
- Do not store or use lawn chemicals, road salt/deicers, motor oil, gasoline or paints.
- Remove or relocate underground storage tanks, hazardous materials, and septic systems, if possible.
- Use propane or natural gas powered pumps.
- Seal floor drains.
- Properly label, store, and dispose of hazardous substances.
- Restrict access to the well and post water supply protection signs.

These are recommendations, and not requirements.

Vegetation

As part of the long-term lease agreement with the farmers, there are 16 separate fields, totaling 74 acres that are actively managed for agricultural purposes.

Wildlife

A population of beavers has been present in Great Brook Farm State Park for several years, and their dam building and culvert blocking activities effect water levels, impacting the surrounding trail system. The current approach to beaver management includes the installation of beaver deceivers at some of the culverts where there has been a lot of beaver activity, along with beaver trapping by a wildlife contractor through the DCR's Lake and Ponds Program. The wildlife contractor is used at least annually, and makes the final assessment on which approach will be most effective to address the problems on hand.

Great Brook Farm State Park has been included in a statewide Cerceris wasp monitoring project that started in 2010. The Cerecreis wasp is a non-stinging wasp that makes nests in sandy soils and prey on Buprestid beetles, a family of beetles that includes the Emerald Ash Borer (EAB). Monitors examine what kinds of beetles the wasps are bringing back to their nests as one method of potential early detection of EAB. The data is currently very limited, but EAB has not been detected in the nests of the population here.

Cultural Resources

The Litchfield House is under lease with the DCR and is being rehabilitated, occupied and maintained as a single family residence by Darrold and Janet Fritz-Endres through the DCR's Historic Curatorship Program. Through the program, outside partners are selected through an open and competitive proposal process to help the DCR preserve some of its vacant and dilapidated historic properties in exchange for a long-term lease. The current tenants signed a twenty-five year lease in 1996, have rehabilitated the house and grounds, and are in the final stages of restoring the historic barn. The curator's responsibilities for the property include the complete rehabilitation of the house and its systems, management of its reuse (including all utility and insurance costs), and all maintenance responsibilities for the house and surrounding 1.08 acres.

The Hounds House has been under lease to Old North Bridge Hounds since 1994. This lease was established by legislation (Chapter 424, S-1234, 1993), and there have been two subsequent lease clarifications between the Department and the lessees, in 2002 and 2007. As part of the 2007 clarification, the lessee agreed to pay the DCR $550.00 per month and to perform capital repairs on the buildings and grounds at 649 North Road. This lease expired on December 31, 2013; the business owners would like a new lease. While this issue is pending resolution, the lessees are continuing to pay their monthly rental fees to the agency.

Great Brook Farm itself has been leased to Mark and Tammy Duffy since 1987. The original lease, ten years in length, was extended first in 1997, and again in 2007, and next expires on April 30, 2017. The lease was amended in July, 2011 to include language covering the Smart Barn, and establish ownership and maintenance responsibilities, as well as to bring some other language up to date, including insurance provisions. Their lease area consists of 90 acres, including the farm complex, farm buildings several fields and the cranberry bog. As part of the lease agreement, the farmers pay two percent of their gross retail on a quarterly basis to the DCR. Stipulations include the provision of some public access in selected areas of the farm during park hours, and maintaining building interiors and equipment.

Recreation Resources

The Hart Barn has been in use as the Great Brook Ski Touring Center, operating under a series of permit agreements with the same operators since the l983-1984 ski season. The operators groom the designated ski trails and provide lighting on some of the trails during the ski season for nighttime skiing. The current permit for this operation runs through the 2017-2018 ski season.

For the equestrian features within the park, the DCR mows the fields where the equestrian jumps are located; the local equestrian group maintains the jumps.

Infrastructure

Multiple buildings and structures are managed by outside lease holders (see Cultural Resources, above, for more information). Management responsibilities for these resources are stipulated in their lease agreements. Since these resources are predominantly historic, they must also coordinate their efforts in consultation with the DCR's Office of Cultural Resources.

Interpretive Services

A Comprehensive Interpretive Plan was drafted in 2011 for Great Brook Farm State Park by the DCR's Interpretive Services staff. Due to staff workload issues, this plan has not yet been finalized.

The Nature Center Pavilion serves as the home base area for interpretive services. Tours revolve primarily around the farm complex, and currently emphasize the workings of the dairy farm and the technological aspects of the Smart Barn. Tours run on weekends from Memorial Day through Columbus Day.

A Seasonal Interpreter is on site from mid-April through mid-October, providing guided tours of the farm complex, conducting junior ranger and nature programs, guiding school groups, and assisting with the planning and implementation of two major events, Picnic on the Farm, held the first Sunday in June, and Down on the Farm, held the last Sunday of September.

Great Brook Farm State Park is a participant in the Park Passport Program; the passport box is located within the Nature Center Pavilion.

Operational Resources

Supplemental Staffing

Mark and Tamma Duffy operate and staff the agricultural business at the park as part of the terms of their long-term lease agreement. The farm is a key attraction of the park, and the farmers maintain their lease areas so that the public can access much of it.

The park occasionally gets the assistance of a crew of volunteers from the Student Conservation Association (SCA) for specific trail-related projects. In the summer of 2013, the group did work on the Acorn Trail that will be continued in the summer of 2014.

Members of the Merrimack Valley Chapter of the New England Mountain Bike Association (MV-NEMBA) also volunteer at the park, and have been involved with trail construction within the park, as well as the purchase, construction and installation of boardwalks.

Given the wide range of opportunities this park presents to visitors, the many active user groups and the network of local and regional conservation organizations, the potential exists for the reformation of a Friends of Great Brook Farm State Park and their involvement in activities at the park.

Public Safety

DCR Rangers issue citations for violations of various forest and park rules. A summary of incident reports recorded in the state park during 2013 is provided below.

Table 5.4. Great Brook Farm State Park Incident Reports, January 1 through December 31, 2013

Incident	Number
Violation of DCR regulations[a]	3
Suspicious activity	1
Total	*4*

a. These violations were related to after hours use of the park and dogs not under control.

A large eastern white pine tree at Carlisle State Forest. (DCR)

SECTION 6. CARLISLE STATE FOREST

6.1. Introduction

Carlisle State Forest is the second smallest facility in the Lowell/Great Brook Planning Unit. Covering 25 acres, this property is tucked behind some relatively recent residential development (a subdivision known as Tall Pines), west of Hutchins Road. Access to the property is provided by Forest Park Drive on the south and Barnes Place on the north. Town owned conservation land and property owned by the Carlisle Conservation Foundation, a local land trust, abuts the property to the west.

6.2. History of Property

In November of 1901, prominent landscape architect Warren Manning learned that a collection of about 100 very large eastern white pine were about to be harvested for lumber. Concerned about preserving this collection, he obtained a stay of proceedings and secured an option on the property, and convinced his fellow members of the executive committee of the Massachusetts Forestry Association to raise the funds to purchase the property.

Working in partnership with the Appalachian Mountain Club (AMC), $1,600 was raised through subscriptions by early 1902 to purchase approximately nine acres, with some excess funds collected going towards the AMC, which had agreed to serve as the property owner (Massachusetts Forestry Association, 1902*a* and 1902*b*).

Warren Manning at the Carlisle Pines. (Iowa State University Library Special Collections)

The AMC laid out trails and posted markers, and also selectively thinned some hardwoods on the property in order to showcase the large pines, improve growing conditions, and control gypsy moths (Goodall 1970; Shepard 1913). In 1912, the AMC expanded the reservation through the purchase of approximately 10 additional acres, and increasing the collection of very large eastern white pine to approximately 150.

In 1934, the AMC sold the Commonwealth the Carlisle Pines and two other AMC reservations in Billerica and Warwick, with the stipulation that if these properties are no longer to be used as state forests, ownership would revert back to the AMC. Following transfer of the property to the Commonwealth, some small red pine plantations, as well as some additional white pine and Norway spruce were planted. The Hurricane of 1938 caused significant damage, knocking down all but 28 of the large eastern white pines, and after the Hurricane of 1954, further pines were lost. By 1980, there were only 14 of the large eastern white pines still standing (Stoddard 1980).

6.3. Existing Conditions

Natural Resources

Physical Features

Topography. Carlisle State Forest is located between two ridges, and has relatively level to gently rolling terrain.

Geology. Carlisle State Forest falls within the Nashoba Terrane, formed of plutonic and metamorphic rocks including metamorphosed volcanic rock rich in biotite and hornblende. Surficial glacial deposits are found in the forest (Skehan 2001).

Soils. The soil of Carlisle State Forest consists primarily of Charlton-Hollis-Rock outcrop complex, which is a combination of soils and exposed bedrock encompassing about 50% Charlton soils, 25% Hollis soils, 15% rock outcrop and 10% other soils (Peragallo 2009). Found in upland areas, the Charlton soils can be found on toe slopes, while the Hollis soils are on hilltops and ridges. There are only slight limitations when it comes to potential trail and path development, with moderate limitations in areas where slope exceeds 15%. The Hollis soils are shallow and raise the risk of blown down trees, which could impact the forest. The Deerfield loamy sand, a very deep soil type, can be found on glacial stream terraces and deltas. These soils present moderate limitations to trail and path development due to its sandy composition (Peragallo 2009).

Table 6.1. Soils of Carlisle State Forest

Soil Series	% of Forest	Drainage Class
Charlton-Hollis-Rock outcrop complex	74.0	Well drained to somewhat excessively drained
Deerfield loamy sand	18.9	Moderately well drained
Swansea muck	5.6	Very poorly drained
Whitman fine sandy loam	1.3	Very poorly drained
Scarboro mucky fine sandy loam	0.2	Very poorly drained

Water Resources

Ponds. There are no ponds within the forest.

Wetlands. There are two small wooded swamp areas in Carlisle State Forest (see Figure 5). On the western edge of the property is a 0.4 acre wooded swamp composed of deciduous trees. On the southern edge of the property is a 0.6 acre wooded swamp composed of mixed trees.

Vernal Pools. There are no vernal pools within the forest.

Streams. There are no streams within the forest.

Groundwater. There are no aquifers beneath the forest.

Flood Zones. A very small sliver of the western most corner of the forest, 0.05 acres of property, falls within the 500-year flood zone.

Rare Species

There have been no rare species recorded in the forest.

Vegetation

Forest Types. Carlisle State Forest exists today due to an effort led by Warren Manning to protect an impressive stand of 200+ year old, very large eastern white pine from being logged in 1901. At the time, there were approximately 150 large, mature growth white pine; the hurricanes of both 1938 and 1954 took a serious toll on this stand and by 1980 only 14 remained (Stoddard 1980). DCR Forestry staff recently noted that more have since come down. Known historically (and locally) as the Carlisle Pines, Carlisle State Forest includes a stand of white

Placeholder for Figure 5.

Pine, some hemlock, and a small, centrally located plantation of red pine.

In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified four forest sub-types within Carlisle State Forest (Table 6.2). Some large eastern hemlock that appear to be old was also identified here during the RMP fieldwork, some of which appear to have been impacted by Hemlock Woody Adelgid.

There are no Continuous Forest Inventory (CFI) plots within Carlisle State Forest.

Table 6.2. Forest Sub-types of Carlisle State Forest

Forest Sub-type	Acres	% of Forest
Eastern white pine	10.0	40.0
Mixed oak	7.3	29.2
Eastern white pine – oak	3.0	12.0
Red pine plantation	0.6	2.4
Total	*20.9*[a]	*83.6*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

Priority Natural Communities. There are no Priority Natural Communities within the forest.

Invasive Species. Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub, threatens wetlands and field edges, where it can suppress other species. It has been observed in the southern portion of this forest in the past. Common buckthorn is often spread by seed dispersal through birds.

Pests and Disease. Hemlock woolly adelgid is present in the Eastern hemlock trees on this site. No other information has been located to date on pests and disease at Carlisle State Forest.

Wildlife

Birds. There is little current information on the forest's birds. Over 175 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.1.

Mammals. There is little current information on the forest's mammals. Over 45 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.2.

Reptiles. There is little current information on the forest's reptiles. Over 15 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.3.

Amphibians. There is little current information on the forest's amphibians. Over 15 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.4.

Fish. There is no current information on the forest's fish.

Cultural Resources

Pre-Contact Archaeological Sites

There are no recorded pre-Contact sites in the Carlisle State Forest, and the forest has not been subject to an archaeological survey. The physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the region all confer a high archaeological potential for the forest.

Historic Archaeological Resources

There are no recorded historic archaeological sites in the Carlisle State Forest, and the forest has not been subject to an archaeological survey.

Historic Resources

Buildings. There are no historic buildings within the forest.

Structures. A dry laid stone wall lines much of the eastern boundary of Carlisle State Forest. A segment of another dry laid stone wall is centrally located on the west side of the property, and runs east to west. Constructed of glacial till, these walls are in fair to poor condition.

A stone wall in Carlisle State Forest, with a granite boundary marker in the foreground. (DCR)

Objects. A small granite boundary marker was identified next to the stone wall that lines the eastern boundary, near the Forest Park Drive entrance.

Landscapes. The stand of very old and large eastern white pines that are located in the northwest section of the property inspired the protection of this land, and the creation of the state forest. These natural resources have not only catalyzed the protection of this land, but are the primary draw for visitors to this small parcel and have become a part of its history.

Recreation Resources

Carlisle State Forest is primarily accessed via motor vehicle or on foot by local residents. Individuals who live nearby may walk or ride their bicycle to one of the two trailheads. There are no public transit options to reach this forest.

Recreation resources are limited to a network of 0.7 miles of trails through Carlisle State Forest. These trails are used primarily for hiking, as well as some dog walking, mountain biking, horseback riding, snowshoeing and cross-country skiing.

There is one known geocache located here as of October 2013.

Infrastructure

Property Boundary

Carlisle State Forest is a 25 acre undeveloped property in the northwest section of Carlisle, located west of Curve Street and north of Westford Road /Route 225. Town owned conservation land and property owned by the Carlisle Conservation Foundation, a local land trust, abuts the property to the west. Much of the eastern boundary is marked by a stone wall.

Buildings and Structures

There are no buildings or structures in the forest.

Roads

There are no roads in the forest.

Parking

There is no parking at Carlisle State Forest. At the end of Barnes Place, there is one unpaved parking space; it appears to be located on the abutting Town of Carlisle conservation land. Neighbors do express occasional frustration with the lack of parking in the area.

Trails

There are approximately 0.7 miles of well maintained trails in Carlisle State Forest. This network was mapped and assessed in 2009, and determined to be in good condition.

A trail map has not been created for Carlisle State Forest, and there is no information on the DCR website for the forest or its network of trails.

Signs and Kiosks

There are no Lead-in or Main Identification signs for Carlisle State Forest. The remnants of a wooden sign stanchion are located just off trail at the Forest Park Drive entrance. The only indications that this is state property are some boundary markers, found mostly at the southern edge of the property.

The former entrance sign stanchion. (DCR)

There are no informational kiosks at Carlisle State Forest.

Memorials and Markers

There are no memorials or markers in the forest.

6.4. MANAGEMENT RESOURCES AND PRACTICES

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

The DCR's forestry staff has periodically undertaken inventory of the remaining large eastern white pines, recording measurements. However, the most recent inventory was completed in 1980 (Stoddard 1980).

Wildlife

The DCR does not actively manage wildlife at Carlisle State Forest.

Cultural Resources

There are no cultural resource management activities that are unique to this state forest.

Recreation Resources

With the exception of keeping the small network of trails clear and usable, there are no other recreational resources in need of active management at this forest.

Infrastructure

With the exception of the small network of trails, there is no other infrastructure at this park to manage.

Interpretive Services

Interpretive service programs are not offered at Carlisle State Forest, nor is any other interpretive information provided.

Operational Resources

DCR Staffing

Carlisle State Forest does not have any full or part-time DCR staff on site.

Supplemental Staffing

The Carlisle Trails Committee has, in the recent past, completed volunteer trail clean ups on the trails at Carlisle State Forest, in conjunction with their work at the abutting town conservation lands.

A fitness trail through a white pine plantation at Warren Manning State Forest. (DCR)

SECTION 7. WARREN H. MANNING STATE FOREST

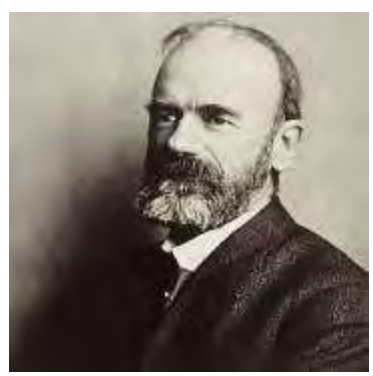
7.1. Introduction

Warren H. Manning State Forest, named for influential landscape architect Warren H. Manning (1860 – 1938), is a 183-acre property located in the northwest part of Billerica. The forest is located predominantly on the east side of Route 3, and is bisected by Chelmsford Road/Route 129 into two distinctly separate sections: a developed northern section and an undeveloped southern section (see Figure 6).

The forest includes a system of trails throughout the property, utilized mostly by local residents, as well as a picnic area, fitness trail and a small spray deck in the developed, northern section of the forest. The Billerica Recreation Department staffs the spray deck and manages the parking lot and bathhouse.

7.2. History of Property

The area that is now Warren H. Manning State Forest is located in a part of Billerica that was not heavily settled through the 17^{th}, 18^{th} and most of the 19^{th} centuries (MHC 1980*e*). One of the few settlers in this area was Samuel Manning, who built the Manning Manse, located at 56 Chelmsford Road/Route 129, in 1696. The ancestral home of Warren H. Manning, the Manning Manse was empty and in need of preservation when Manning moved to Billerica in 1895. A landscape architect who began working in his family's nursery business in Reading, MA, amassing an extensive horticultural background, Manning then honed his design skills in the Olmsted firm until branching out on his own in 1896. Manning was a founding member of the American Society of Landscape Architects in 1899, and pioneered a system of resource-based planning.



Warren Manning (The Cultural Landscape Foundation)

Placeholder for Figure 6.

After 1900, Manning began to acquire land in close proximity to the Manning Manse. In 1915, Manning moved his practice to Billerica, ultimately operating out of an octagonally-shaped office that was constructed in 1917 on the north side of Chelmsford Road (no longer extant). In 1923, Manning moved his practice to Cambridge when access to Boston and Lowell from Billerica became impossible via public transit.

Manning was very active in Billerica town affairs, and his efforts included promoting the creation of public woodlands in town, with a particular focus on developing a town forest system in Billerica. Manning developed the Billerica Town Forest Plan in the mid-1920s and it was accepted by the town in 1926. In 1934, Manning sold approximately 140 acres of his property surrounding the Manse to the Commonwealth, for the purpose of establishing a state forest, at a rate of $5.00 per acre (Manning n.d.). This property included Manning's former office, which was later removed by the Commonwealth sometime after his death in 1938 (Rockwell 2002). In 1935 and 1939, additional acreage in the area was purchased, increasing the size of the facility. In 1953, even more land was acquired through takings as the Old Middlesex Turnpike was realigned, and the new Middlesex Turnpike, Route 3, cut through a portion of the property. This project left a small portion of the forest on the western side of Route 3, impacting the trail system and making this parcel inaccessible to staff and visitors.

Around 1955, a recreation area was developed in the portion of the property north of Chelmsford Road/Route 129, in what is now known locally as Manning Park. The 1950s improvements included a wading pool, equipment cabin and picnic area.

In 1961, an Act of the Legislature led to the disposition of two parcels of land west of Route 3 to the Town of Billerica for industrial purposes. (See Appendix H for more information.) A lumber yard and self storage business are located here today.

A master plan completed for the forest in the early 1970s proposed an expansion of the picnic area and the installation of a full-sized swimming pool in the northern section of the property, and development of a camping area south of Chelmsford Road; none of these proposals came to fruition.

The Town of Billerica has been managing the recreation area in the northern section of the forest since 1990. A series of Special Use Permits from 1990 through December 2004 formalized this management arrangement. A renewed permit that was to run from 2005 through 2010 was never finalized, due to disagreements between the DCR and the Town over parking revenue. As a result, the Town of Billerica has been managing this area without any formalized agreement or permit in place for almost a decade.

In 2002, the recreation area was updated and the wading pool was replaced by a spray deck. An adult fitness trail is also located on this portion of the property, installed by the Town of Billerica in 2012.

7.3. Existing Conditions

Natural Resources

Physical Features

Topography. Warren H. Manning State Forest is fairly level in the southern section, with some low rolling uplands in the northern portions of the forest.

Geology. Warren H. Manning State Forest lies within the Nashoba Terrane, and the bedrock of the area includes gneiss, schists and Andover granite, a pink to buff colored granite that has a granular texture (Skehan 2001). The gneiss and schists are metamorphic rocks that may have originated as volcanic rocks. Some glacial erratics are scattered throughout the property.

Soils. Warren H. Manning State Forest is comprised of a wide range of soil types, from loamy sands in the uplands to muck, reflecting the presence of wetlands. The deep Hinckley loamy sands can be found on glacial outwash plains and terraces, while the Canton fine sandy loam and the Scituate fine sandy loam soils are located on the side slopes and toe slopes of uplands (Peragallo 2009). Slight to moderate limitations on path and trail development exist in the upland areas, the limitations increasing with slope and the sandiness of the soil. Severe limitations are present in the wetter areas where the muck based soils are found. Limitations on playground and picnic area development range from slight to severe, based upon slope and the stoniness of the soils present (Peragallo 2009).

Table 7.1. Soils of Warren H. Manning State Forest

Soil Series	% of Forest	Drainage Class
Hinckley loamy sand	27.4	Excessively drained
Canton fine sandy loam	18.5	Well drained
Scituate fine sandy loam	14.2	Moderately well drained
Saco mucky silt loam	9.8	Very poorly drained
Freetown muck	9.3	Very poorly drained
Montauk fine sandy loam	6.7	Well drained
Windsor loamy sand	6.6	Excessively drained
Deerfield loamy sand	2.6	Moderately well drained
Urban land	2.4	N/A
Ridgebury fine sandy loam	1.8	Poorly drained
Charlton-Hollis-Rock outcrop complex	0.7	Well drained to somewhat excessively drained
Udorthents	0.1	Variable

Water Resources

Ponds. There are no ponds within the forest.

Wetlands. Wooded swamp areas containing deciduous trees can be found throughout the forest, totaling 14 acres; an additional 10 acres of wooded swamp area, centrally located within the forest, contains a mix of trees. Two smaller areas of shrub swamp, one in the center of the forest and one in the northern portion of the forest, have a combined total of just over seven acres in size. A small bog (0.9 acres), locally known as Spruce Pond, is located within the centrally located shrub swamp. See Figure 6.

Vernal Pools. There is one certified vernal pool located in Warren H. Manning State Forest. In addition, there are five potential vernal pools located within this facility.

Streams. Black Brook enters Warren H. Manning State Forest on the northern boundary and heads south, flowing under Route 129/Chelmsford Road and ends in the bog located in the western portion of the forest (see Figure 6).

Flood Zones. On the northern edge of the property, there are two small areas, totaling 0.09 acres of land, that abut wetlands on neighboring properties that fall within the 100-year flood zone. These same areas expand to cover nearly four acres within the 500-year flood zone.

Rare Species

Priority Habitat has been designated on 72 acres of Warren H. Manning State Forest, encompassing roughly two-thirds of the land between Route 3 and Route 129/Chelmsford Road.

The only rare species recorded here, the blue-spotted salamander, is an amphibian that utilizes wetland habitat for reproduction and upland forest habitat for foraging, both of which are present in this part of the forest (Natural Heritage and Endangered Species Program 2007*b*). This species has a MESA status of Species of Special Concern.

In 2010, MassWildlife and The Nature Conservancy (TNC) issued “BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World” (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is “important to conserve the full suite of biodiversity” in Massachusetts (MassWildlife and TNC 2010).

In Warren H. Manning State Forest, there are 72 acres of Core Habitat, covering the same area that has been designated Priority Habitat. Critical Natural Landscape has not been identified at Warren H. Manning State Forest.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified four forest sub-types within Warren H. Manning State Forest (Table 7.2).

Table 7.2. Forest Sub-types of Warren H. Manning State Forest

Forest Sub-type	Acres	% of Forest
Mixed oak	74.1	40.5
Eastern white pine - oak	54.5	29.8
Eastern white pine	25.2	13.8
Red maple - swamp hardwood	1.9	1.0
Total	*155.7*[a]	*85.1*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

Hardwood species – including oak – are uncommon in the town of Billerica. Most of the hardwood stands in town are located on DCR lands.

As part of the Massachusetts Continuous Forestry Inventory (CFI), a specific area within the forest was visited by DCR Management Foresters in 2000. The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for sivicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There is one CFI plot within Warren H. Manning State Forest. This even-aged, two storied stand is 55 to 60 years old and comprised of primarily of red maple, along with some white pine and swamp hardwoods, including American elm and gray birch.

As part of the CFI process, DCR Management Foresters also look for signs of disturbances that affect the development of vegetation in the vicinity of each CFI plot. One disturbance agent, snow and ice, was recorded here in 1996.

Priority Natural Communities. There are no Priority Natural Communities within the forest.

Invasive Species. A few invasive species have been observed within the forest by DCR staff however none of these species have been identified in the CFI plot. The invasive species observed here include:

- Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub, has been observed by DCR Foresters. Common buckthorn threatens wetlands, where it can suppress other species, and field edges. It is often spread by seed dispersal through birds.
- Multiflora rose (*Rosa multiflora*) has also been observed here. It is a densely spreading shrub that forms thickets that crowd out native species.
- Japanese knotweed (*Fallopia japonica*) is a shrub-like herbaceous plant that forms dense thickets that crowd out native species and reduce wildlife habitat, posing significant threats in riparian areas in particular. This was observed along the edge of Black Brook during RMP fieldwork.

Pests and Disease. White pine weevil (*Pissodes strobe*) has been identified in Warren H. Manning State Forest. While tree mortality from this pest is low, damage does impact tree health and reduce wood quality. To a lesser extent, gypsy moths (*Lymantria dispar*) and Dutch elm disease have also been observed here.

Wildlife

Birds. There is little current information on the forest's birds. Over 175 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.1.

Mammals. There is little current information on the forest's mammals. Over 45 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.2.

Reptiles. There is little current information on the forest's reptiles. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.3.

Amphibians. There is little current information on the forest's amphibians. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.4. Only one of these, the blue-spotted salamander, has been recorded at this forest.

Fish. There is no current information on the forest's fish.

Cultural Resources

Pre-contact Archaeological Sites

There are no recorded pre-Contact sites recorded in the forest, and no archaeological surveys have been conducted. The physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the region all contribute to a high archaeological potential for the forest.

Historic Archaeological Resources

The remnant of a concrete foundation (MHC Inventory Form #BIL-HA-46) from Manning's office complex is located just north of the Warren H. Manning Office Memorial Stone. A concrete curb covered by vegetation, it appears to have been approximately 12 feet square. Some of the ground cover in the area may be remnant plant material from when the office was in use. From c1911 – c1919, Manning built a series of buildings used by his practice, many of which were ultimately interconnected as spokes to a hub. All but two of the buildings were burned down or demolished after 1938.

The foundation of an outbuilding is located adjacent to Spruce Pond, just south of the Manning Manse property. This foundation of poured concrete has been built into a slope and is open on grade on the low sloped side, with a rustic stone retaining wall extending off the rear corner. In the corner formed by the retaining wall there is an overgrown tree that might date to Manning's involvement with the property.

Outbuilding Foundation (DCR)

Historic Resources

Buildings. There are no historic buildings within the forest.

Structures. Stone wall remnants are located in the southern portion of the property, extending north from Old Rangeway Road. These are dry laid, loose stone walls that are in fair to poor condition.

A concrete pad foundation is located just south of Route 129, near the intersection with Rangeway Road. This foundation, roughly 20 feet by 12 feet, is becoming covered in leafy vegetation and moss. A utility pole that once served this structure is located directly adjacent to the pad and still has some severed wires dangling from it. The structure once located on this site housed a forest fire control building.

A concrete pad is located adjacent to the spray deck, and appears to be the foundation of the former bathhouse that was installed in the 1950s as part of the recreational development. The building was removed in the 2002 improvements to the area.

A former bridge abutment was once located at the end of Old Rangeway Road (MHC Inventory From #BIL-HA-44), however that seems to have been removed in a recent culvert replacement project.

Objects. The Warren H. Manning Office Memorial Stone (MHC Inventory Form #BIL.937) is located east of the entrance, adjacent to the picnic area. This memorial stone marks the location of where Warren Manning's office once stood, when his landscape architecture practice operated seasonally out of Billerica from 1915–1923.

Warren H. Manning Office Memorial Stone(DCR)

The memorial stone marking the location of the office, installed sometime between 1938 and 1950, is inscribed as follows:

HERE STOOD THE OFFICE OF
WARREN H. MANNING
LANDSCAPE DESIGNER
A STUDENT AND LOVER OF NATURE
AND MAN. A PIONEER AND LEADER
IN THE FINE ART OF PLANNING THE
WISE USE OF THE LAND FOR THE
PLEASURE AND BENEFIT OF MANKIND.
1860 – 1938

Some lichen growth is present on the memorial stone.

A concrete marker, approximately 8 inches tall and 3 inches square, is located north of the spray deck area. Possibly a former property boundary marker, the letter "C" is inscribed on one side.

Concrete Marker (DCR)

Landscapes. The forest contains a collection of two miles of woods roads that were used in the 19th century for access to woodlots, and in the 20th century as forest roads for recreational purposes and some administrative access. These unpaved roads, approximately eight feet wide in predominantly good to fair condition, vary in terms of level vegetative growth in the road pathway and make up the bulk of the network of trails in use today.

Recreation Resources

Warren H. Manning State Forest is primarily accessed via motor vehicle. Individuals who live nearby may also choose to walk or ride their bicycle to any one of the trailheads, although the area is not particularly pedestrian friendly. The Lowell Regional Transit Authority offers an additional, though likely underutilized, means of accessing the forest. The nearest stop is about a one mile walk to the main entrance.

Recreation at the state forest includes trail-based activities such as hiking and running, dog walking and cross-country skiing. Geocaching also occurs throughout the forest, with participants both on and off trails. As of November 2013, there were three known geocaches at the state forest.

Hunting is currently allowed in Warren H. Manning State Forest. This activity is not allowed near the spray deck area, but it is still not popular with local residents. During the development of this RMP, some concerns were expressed that hunters may be coming too close to abutting properties.

Some bikers and snowmobilers use the forest as well.

The primary recreational feature at Warren H. Manning State Forest is the spray deck area (see Figure 6). A wading pool was constructed here in the 1950s and was in use until it was replaced in 2002 with the new spray deck equipment. The spray deck, which is managed by the Billerica Recreation Department, is operational from May through the end of September. This area is very popular with young families, and on hot days often reaches capacity (Hannon-Rizza 2013).

Complementing the spray deck area is an adjacent picnic area, located between the spray deck and the parking lot. This picnic area includes 18 picnic tables, three of which are accessible, as well as nine grills for use by visitors. Four of these grills are of the metal variety on a low post, while five are concrete bases on the ground. These grills get occasional use by visitors, more so in the off-season than during the summer months. Twice a year, the Billerica Recreation Department offers an outdoor cooking program here that is very popular with families (Hannon-Rizza 2013).

The Billerica Recreation Department has created a "Story Book Trail," a short trail that loops around a portion of the picnic area and includes a series of 10 wooden and plexiglass wayside panels. These panels have laminated pages of a children's book within each of them, so that it is possible to walk the trail and read a story. These panels are periodically updated with a new book so that visitors can read new stories. This trail was recently marked by local girl scouts with green trail markers affixed to trees via screws.

The Billerica Recreation Department installed an adult fitness trail in 2012. Complete with fitness equipment composed primarily of powder coated metal piping, the fitness trail has five exercise stations with 19 total pieces of equipment and 11 signs providing instruction for safe use.

Fitness Trail (DCR)

The Billerica Recreation Department offers a pre-school program at the park in the summer. The scheduling of this program is coordinated with an adult fitness program that utilizes the fitness trail equipment, providing a unique recreational opportunity for the parents of these pre-schoolers (Hannon-Rizza 2013).

Infrastructure

Property Boundary

Warren H. Manning State Forest is a 183 acre property that is divided into three blocks of land: a developed area located north of Chelmsford Road/Route 129; an undeveloped area south of Chelmsford Road/Route 129 and bordered on the west by Route 3; and 40 acres (22% of the forest), located west of Route 3 and cut off from the remainder of the forest by the highway. This latter piece is inaccessible to DCR staff and visitors.

Billerica State Forest is located just to the south of Warren H. Manning State Forest, and those portions of Warren H. Manning State Forest that lie south of Chelmsford Road/Route 129 are often considered by the public to be a part of Billerica State Forest. Locals refer to the northern section of the forest that contains the spray deck as Manning Park.

A utility easement cuts through the park, as a part of an underground pipeline that is owned and managed by Tennesse Gas. A trail composed of loose stone is located on the northern segment of this corridor. One access stanchion pole was located during fieldwork, located on the north side of Route 129.

Buildings and Structures

There is one contact station, located at the main entrance and parking area. A small front gabled wooden structure with an asphalt roof, this station is portable, in good condition, and does not have electrical service. It is managed by the Billerica Recreation Department.

Contact Station (DCR)

There is one bathhouse at Warren H. Manning State Forest (see Figure 6). Located adjacent to the parking lot, the bathhouse is open when the park is staffed, and is also managed by the Billerica Recreation Department. It is a side gabled, concrete block structure with a metal roof that has plumbing (on town sewer system) and electrical service. It is in good condition.

Bathhouse (DCR)

The Town of Billerica has expressed interest in developing the recreation area further.

Roads

The access road into the parking lot is the only administrative, paved road within Warren H. Manning State Forest.

There are two miles of unpaved forest roads that pre-date the establishment of the forest and continue to be used for hiking and administrative purposes.

Parking

The only parking lot for the forest is at the main entrance, located off the north side of Chelmsford Road/Route 129 (see Figure 6). This paved lot holds 36 vehicles. There are no designated handicapped parking spaces. West of the main entrance on Chelmsford Road/Route 129, there is room for two or three cars to pull over on the north side of the road in front of a trail head.

Trails

There are approximately 3.4 miles of trails at Warren H. Manning State Forest (see Figure 6). All of the trails are located in the eastern portion of the property. Prior to the construction of Route 3 in 1953, some trails went through the northwestern portion of the forest, however the installation of Route 3 effectively cut off this western segment of the property, and any trails that were located here have since grown in.

Of these trails, two miles are comprised of unpaved forest roads, with an additional 1.4 miles of narrow trails that are in good to fair condition.

A trail map has not been created by the DCR for Warren H. Manning State Forest and there is no information on the DCR website for the forest or its network of trails. The Town has developed a map that covers the northern section of the park only. This map is available on the Town's website.

Signs and Kiosks

There are no Lead-in signs for this property.

The forest's Main Identification sign is located at the main entrance to the park on Chelmsford Road/Route 129. While the orientation, material and design of this sign does meet DCR signage standards (DCR n.d.), the information regarding management is not entirely accurate as this only applies to the northern section of the forest.

Main Identification Sign (DCR)

One kiosk, maintained by the Billerica Recreation Department, is located at the northern edge of the parking lot. A small mailbox for map distribution is attached to the kiosk, as is a pet waste bag dispenser.


Informational Kiosk (DCR)

The Billerica Recreation Department has created a "Story Book Trail," a short trail that loops around a portion of the picnic area. Ten panels located alongside the trail include the pages of a popular children's book, so that one reads a story from start to finish while walking along this trail.

Memorials and Markers

There is one memorial in Warren H. Manning State Forest, the Warren H. Manning Office Memorial Stone. For information on this memorial, please refer to the Cultural Resources section.

Other

Residents along the southeast side of Rangeway Road have installed their mailboxes across the street on the forest property, possibly within the road right-of-way.

Illegal Activities

At the southern end of the forest, just off the southernmost trail head off of Rangeway Road, tire dumping has been occurring. This appears to be relatively recent dumping, but may have occurred multiple times.

Dumping Area (DCR)

7.4. MANAGEMENT RESOURCES AND PRACTICES

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

In the past, the DCR used to allow Home Fuelwood harvests to occur at this state forest. However, since this property has been designated as a Parkland through the Landscape Designation process, this activity is no longer allowed at this facility.

The vegetation in the gas pipeline corridor is managed by Tennessee Gas.

Wildlife

The DCR does not actively manage wildlife at Billerica State Forest; however the hunting of game species is permitted.

Cultural Resources

The DCR's Office of Cultural Resources hired a team of cultural resource management professionals to undertake a survey of cultural resources at Warren Manning State Forest in 2002. The aforementioned MHC Inventory Forms are a result of that effort.

Recreation Resources

The Town of Billerica, through its Recreation Department, has been operating the recreation area in the northern section of the forest since 1990. A series of Special Use Permits formalizing this arrangement were in place from 1990 through December 2004. Attempts were made to get a new permit in place for the 2005 recreation season, but appear to have stalled due to questions regarding the collection and retention of revenue by the Town through the parking fees they collected. The conversation began again in 2006, but appears to have gone nowhere since then. Despite this, the Town continues to operate the area and has since invested in the property with the installation of the fitness equipment. This installation was done in consultation with the DCR Operations staff, however the town typically does not consult with the agency on smaller projects, volunteer requests and programming.

Hunting is currently allowed in Warren Manning State Forest.

Infrastructure

The parking lot, spray deck, bathhouse and "Story Book Trail" are all managed by the Billerica Recreation Department, as part of the Town's management of the northern section of the forest. The Town charges a parking fee of \$3.00, and a season pass is available for \$35.00. This revenue goes to the Town to help offset their operational costs.

Interpretive Services

There are no formal interpretive service programs provided here by DCR or by the Town of Billerica.

Operational Resources

DCR Staffing

DCR does not maintain a staff presence on site. DCR staff does periodically drive through the property in the off season, when the town does not actively manage the recreation area.

Supplemental Staffing

The Billerica Recreation Department provides seasonal staffing for the northern portion of the forest. There is staff at the facility seven days a week, from 8:30am to 6pm, from May through the end of September. There is one person on duty at a time, and they are responsible for collecting parking fees, maintaining the restrooms and the trash, and doing periodic walk-throughs of the facility (Hannon-Rizza 2013). Billerica Recreation Department staff manages the Town programming at the site.

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A forest road in Billerica State Forest. (DCR)

SECTION 8. BILLERICA STATE FOREST

8.1. Introduction

Billerica State Forest is a 141-acre undeveloped property located in the northwest part of the town. Utilized primarily by local residents, due to a lack of parking, the network of trails and forest roads provide hikers with an opportunity to access nature in an otherwise dense suburban setting.

8.2. History of Property

Billerica State Forest is located in an area that was not heavily settled through the 17th, 18th and 19th centuries (MHC 1980*e*). Gilson Hill is named for an early settler of Billerica, Samuel Gilson. The name first began appearing on maps in 1853. Maps from the 19th century show this area as being wooded and undeveloped; it was utilized for logging, with wood lots in active use until the turn of the 20th century.

In 1908, Warren H. Manning and John E. Rowell gifted about 25 acres of land that included Gilson Hill to the Appalachian Mountain Club (AMC), who in turn entered into a maintenance agreement with the Billerica Improvement Association (Rockwell 2002; Shepard 1913). Several other landowners soon followed their lead, encouraged by Manning and his efforts to promote and create public woodlands in town, with a particular focus on developing a town forest system in Billerica. Manning developed the Billerica Town Forest Plan in the mid-1920s, and it was accepted by the Town in 1926. He suggested in this plan that Gilson Hill be named Start Forest, in honor of Edwin F. Start, the first Commissioner of the Massachusetts Forest Commission. Manning also suggested names for the trails through this property, many of them for friends and family members, however none of his naming suggestions were ever implemented (Rockwell 2002).

The property was sold by the AMC to the Commonwealth in 1934, along with two other AMC properties (one in Carlisle and one in Warwick), at which time it was renamed Billerica State Forest. In 1953, the Old Middlesex Turnpike was realigned, and the new Middlesex Turnpike (Route 3) cut through a portion of the property, leaving a small portion of the forest on the western side of Route 3, impacting the trail system and leaving this parcel inaccessible.

In the late 1960s and early 1970s, local interest in developing Gilson Hill into a downhill ski facility led to legislation in 1971 authorizing a transfer of this property to the Town of Billerica for this purpose. However, shortly after the town started planning for the ski area, it was determined that the transfer was not possible due to a stipulation in the original conveyance. The deed stated that if the land were ever discontinued as a state forest it would revert to the AMC. Local pressure on the Commonwealth to develop this for ski purposes followed, but the Department of Natural Resources (DNR), a predecessor to the Department of Conservation and Recreation, staff did not feel this was possible without considerable earth moving, and did not pursue this plan (DNR 1975).

Billerica State Forest was also considered as a potential location for a regional headquarters in 1973-1974, but that plan did not move forward either (Cook 1973; Maisner 1974).

8.3. Existing Conditions

Natural Resources

Physical Features

Topography. The primary topographic feature of Billerica State Forest is Gilson Hill (see Figure 7). At 310 feet above sea level, Gilson Hill is the second highest point in Billerica. Large glacial erratics dot the slopes of the hill, and rolling uplands surround the base of the hill.

Geology. Billerica State Forest lies within the Nashoba terrane, and the bedrock of the area includes gneiss, schists and Andover granite, a pink to buff colored granite that has a granular texture (Skehan 2001). The gneiss and schists are metamorphic rocks that may have originated as volcanic rocks. Gilson Hill, like the other low lying hills in Billerica, is a glacial drumlin covered in glacial till (Northern Middlesex Council of Governments 2008).

Soils. Over half of the state forest is covered in Paxton fine sandy loam soils, found on the convex side slopes of glaciated hills. This soil is often found alongside Montauk, Charlton and Woodbridge soils in upland areas, which are also located here. Between the stoniness of these soils and septic tank limitations due to slow percolation rates, land composed of these soils are often woodland (Peragallo 2009). Scituate fine sandy loam, found on the slopes of uplands, is also found here. All of these soils have moderate to high potential productivity for forestry. These soil types generally present slight to moderate limitations with regards to path and trail development, as well as to picnic area and playground development (Peragallo 2009).

Table 8.1. Soils of Billerica State Forest

Soil Series	% of Forest	Drainage Class
Paxton fine sandy loam	46.8	Well drained
Woodbridge fine sandy loam	12.4	Moderately well drained
Charlton fine sandy loam	9.0	Well drained
Charlton-Hollis-Rock outcrop complex	8.8	Well drained to somewhat excessively drained
Montauk fine sandy loam	8.2	Well drained
Scituate fine sandy loam	6.5	Moderately well drained
Hinckley loamy sand	2.8	Excessively drained
Windsor loamy sand	2.8	Excessively drained
Swansea muck	1.4	Very poorly drained
Deerfield loamy sand	0.7	Moderately well drained
Whitman fine sandy loam	0.6	Very poorly drained

Water Resources

Billerica State Forest is largely upland, with little in the way of water resources within this facility.

Ponds. There are no ponds within the forest.

Wetlands. There are three small wetland areas within Billerica State Forest (see Figure 7). The largest one is a 0.8-acre wooded swamp, composed of deciduous trees. There is also a 0.46-acre shallow marsh meadow or fen, and a 0.08-acre shrub swamp.

Vernal Pools. There is one potential vernal pool at Billerica State Forest.

Streams. There are no streams within the forest.

Groundwater. There are no aquifers beneath Billerica State Forest.

Flood Zones. There are no flood zones within the forest.

Placeholder for Figure 7.

Rare Species

Priority Habitat has been designated on 26 acres of Billerica State Forest, encompassing a semi-circular shaped area on the northern boundary of the forest, extending northwest from the intersection of Treble Cove Road and Winning Street.

The only rare species recorded here, the blue-spotted salamander, is an amphibian that utilizes upland forest habitat for foraging (NHESP 2007*b)*. This species has a MESA status of Species of Special Concern.

In 2010, MassWildlife and The Nature Conservancy (TNC) issued "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010).

In Billerica State Forest, there are 26 acres of Core Habitat, the same area that has been designated as Priority Habitat. Critical Natural Landscape has not been identified at Billerica State Forest.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified four forest sub-types within Billerica State Forest (Table 8.2).

Table 8.2. Forest Sub-types of Billerica State Forest

Forest Sub-type	Acres	% of Forest
Mixed oak	124.7	88.4
Eastern white pine – oak	10.2	7.2
Eastern white pine	1.4	1.0
Norway spruce - white spruce	1.3	0.9
Total	*137.6*[a]	*97.5*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

Hardwood species, including oak and maple, are uncommon in Billerica. Most of the hardwood stands in town can be found within Billerica and Warren H. Manning state forests. The stand of Norway spruce – white spruce is a small plantation stand that may date to Warren Manning's involvement with the property. Images of Norway Spruce appear in his slide collection, and his autobiography notes that some planting was done on the land he owned in Billerica with his staff as part of their training (Manning n.d.). There is a stand of some very large eastern white pine trees along the northern border of the property, adjacent to Winning Street, which is still a town road and may in fact fall within the road right of way.

As part of the Massachusetts Continuous Forestry Inventory (CFI), a specific area within this forest was visited by DCR Management Foresters in 2000. The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for silvicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There is one CFI plot within Billerica State Forest. The trees in this CFI plot range in age from approximately 75 to 100 years and the stand is comprised mostly of mixed oak with maple and birch associated with this sub-type. This stand has an even-aged, two-storied structure.

As part of the CFI process, DCR Management Foresters also look for signs of disturbances that affect the development of vegetation in the vicinity of each CFI plot. One disturbance agent, likely gypsy moth, was recorded here in 1981.

Priority Natural Communities. There are no Priority Natural Communities within Billerica State Forest.

Invasive Species. A number of invasive species have been observed at Billerica State Forest by DCR Management Foresters. Surprisingly however, none of these invasive species have been identified in the CFI plot. The invasive species observed here include:

- Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub that threatens wetlands and field edges, where it can suppress other species. It is often spread by seed dispersal through birds.
- Garlic mustard (*Alliaria petiolata*), a biennial herb that can spread rapidly, displacing native vegetation and in turn altering habitat. Garlic mustard is very difficult to eradicate.
- Multiflora rose (*Rosa Multiflora*), a densely spreading shrub that forms thickets that crowd out native species.
- Japanese knotweed (*Fallopia japonica*) is a shrub-like herbaceous plant that forms dense thickets that crowd out native species and reduce wildlife habitat, posing significant threats in riparian areas in particular.
- Winged burning bush (*Euonymus alatus*), also known as winged euonymus or burning bush, is a deciduous shrub that forms dense thickets that crowd out native species.
- Japanese barberry (*Berberis thunbergii*), a spiny shrub that forms dense stands that can displace native plants and reduce wildlife habitat and forage. Barberry also harbors deer ticks that have the potential to carry the Lyme disease bacteria, functioning as a nursery of sorts for juvenile ticks (Benson 2011).
- Privet, a rapidly maturing semi-evergreen shrub that forms dense thickets that crowd out native species.

Pests and Disease. Billerica State Forest has experienced issues with gypsy moths, defoliators that commonly feed on oak, which is prevalent here. White pine weevil and bark beetles have also been observed here, although to a lesser extent.

Wildlife

Birds. There is little current information on the forest's birds. Over 175 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.1.

Mammals. There is little current information on the forest's mammals. Over 45 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.2.

Reptiles. There is little current information on the forest's reptiles. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.3.

Amphibians. There is little current information on the forest's amphibians. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are identified in Appendix G, Table G.4. Only two of these, the blue-spotted salamander and American toad, have been recorded at this forest.

An American toad observed during fieldwork. (DCR)

Fish. There is no current information on the forest's fish.

Cultural Resources

Pre-contact Archaeological Sites

One pre-Contact site is recorded in the forest, but no data is available on it. There are many sites recorded adjacent to the forest including Woodland (1650 - 450 B.P.) and Late Archaic Period (5000-3000 B.P.) campsites, a village site, and burials. The physical characteristics, regional setting, and the confirmed nearby pre-Contact occupation of the area, all confer a high archaeological potential for the forest.

Historic Archaeological Resources

Remnants of a 19th century sawmill are reportedly located off of Rangeway Road. This site was recorded in 2002 on a Massachusetts Historical Commission (MHC) Inventory Form (in MHC Area form #BIL.S), but the site could not be located during the fieldwork for this RMP.

Evidence of quarrying activity has been located in the northwestern portion of the forest, along the northern border of Gilson Hill. Waste stone with drill scars are visible. An MHC Inventory Form completed in 2002 (#BIL.S) noted two depressions that were likely the site of the quarrying, but these were not specifically located during the RMP fieldwork.

Historic Resources

Buildings. There are no historic buildings within the forest.

Structures. Remnants of stone walls can be found in Billerica State Forest, along the southwest and northern edges of the forest where the slope is low. These are dry laid walls, constructed using the large glacial till located on site. These remnants are in fair to poor condition, and are starting to fall apart.

Objects. The Rowell Memorial Stone (MHC Inventory Form #BIL.938) is located near the top of Gilson Hill. A glacial erratic that is approximately six feet wide, by 10 feet long, by three feet high, this stone contains the following inscription, in all block letters, on the north side of the boulder:

JOHN EDWIN ROWELL
MEMORIAL

John Rowell, a Billerica resident who was active in conservation, along with Warren Manning donated the land at Gilson Hill to establish the AMC Reservation here in 1908. It is suspected that the memorial inscription was completed shortly after Rowell's death in 1927.

Inscription on Rowell Memorial Stone (DCR)

This same stone was historically called Indian Rock, due to the three large holes on the top of the boulder that are thought to have been evidence of use for grinding, a remnant of pre-contact Native American use of the area.

Grinding holes located on top of the Rowell Memorial Stone. (DCR)

Lichen growth is impacting the resource, and the inscription is becoming difficult to read, resulting in a condition assessment of unsatisfactory.

Landscapes. The core of Billerica State Forest, Gilson Hill, includes a system of nearly one-and-a-half miles of connected wood roads that were used in the 19th century for access to woodlots, and in the 20th century as forest roads for recreational purposes and administrative access. These unpaved roads, approximately 8 to 10 feet wide, vary in terms of level vegetative growth in the road pathway, and are a part of the network of trails in use today. These roads were a part of the appeal of the property to Warren Manning when he set out to protect this land for public enjoyment.

Slide from a lecture Warren Manning gave to the Billerica Improvement Association. Source: Iowa State Library – Warren H. Manning Digital Collection

Recreation Resources

Billerica State Forest is primarily accessed via motor vehicle or on foot by local residents. Individuals who live nearby may walk or ride their bicycle to any one of the trailheads, although the area is not particularly pedestrian friendly. There are no public transit options to reach this forest.

Recreation resources are limited to a network of nearly three miles of trails on the eastern portion of the forest. These trails are used primarily for hiking, as well as some dog walking, mountain biking, snowshoeing and cross-country skiing. The construction of Route 3 in 1953, which cut off a small segment of the northwest portion of the forest, disrupted trail access to this area. This segment of the forest is now inaccessible for use.

Hunting is currently allowed in Billerica State Forest.

There is one known geocache located here as of August 2013.

There are no camping facilities at Billerica State Forest, and back country camping is not allowed here. However, a makeshift lean-to using tree branches and other camping materials (e.g., tarps and other debris) was observed just west of the peak of Gilson Hill. The landscape adjacent to this area also showed evidence of minor fire damage in the past, although it is unclear if this came about through unauthorized camping or a natural cause, such as lightning.

A stone fire ring (not recently used) was also found along one of the forest roads at the top of Gilson Hill, along with evidence of its use as a party spot.

Infrastructure

Property Boundary

Billerica State Forest is a 141-acre undeveloped property located in the northwest part of Billerica, south of Rangeway Road and Winning Street (a town road that is partially gated off from use), lying primarily in between Treble Cove Road and Route 3. A small and inaccessible portion of the forest – 12 acres (8.5%) – is located just west of Route 3 (see Figure 7).

Warren H. Manning State Forest is located just to the north of this property, and the southern portion of that property is often considered by the public to be a part of Billerica State Forest.

Buildings and Structures

There are no buildings and structures within Billerica State Forest.

Roads

There are no paved roads within Billerica State Forest.

There are 1.4 miles of unpaved forest roads that pre-date the establishment of the park and continue to be used for hiking and administrative purposes.

Parking

There are no designated parking areas for Billerica State Forest. There is a place to pull off and park one vehicle in front of the northernmost gate along Treble Cove Road. This lack of access not only discourages use, but also prevents DCR staff and first responders from being able to enter the forest at that gate in the event of an emergency.

Parking also occurs informally at the gated end of Winning Street, which is not a part of the forest, but is a town road.

Trails

There are approximately 2.8 miles of trails at Billerica State Forest, 2.6 miles of which are legal trails. All of the trails are located in the eastern portion of the property. Prior to the construction of Route 3, some trails went through the northwestern portion of the forest. However the installation of Route 3 effectively cut off this western segment of the property, and the trails that were located here have since been lost to vegetation.

Forest roads make up just about half of the trail system, with almost 1.5 miles of unpaved forest roads that pre-date the establishment of the forest. These historic pathways were mapped and evaluated in 2008, at which time it was determined that approximately 70% were in fair condition, while the remaining 30% were in poor condition.

The remainder of the trail network consists of approximately 1.2 miles of trails, 80% of which were deemed to be in fair condition; the remaining 20% of trails were categorized as poor.

It is worth noting that the percentage of trails rated as poor is higher than normal, and none of the trails at Billerica State Forest were determined to be in good condition. This is likely due, in part, to low visitation rates. Without regular use, vegetative growth impacts both the base and the width of the trail system.

A trail map has not been created for Billerica State Forest, and there is no information on the DCR website for the forest or its network of trails.

Winning Street, which is gated a short way in from Treble Cove Road, continues heading northwest and serves as the functional northern boundary for Billerica State Forest (see Figure 7). This town road is unpaved beyond the gate and is currently not in active use. It is not counted in the total trail mileage as it is not owned by the DCR and not a part of the forest. However, it does serve as a link for several trails from the forest and is used by visitors for recreational purposes.

Signs and Kiosks

There are no Lead-in or Forest Entrance signs for Billerica State Forest.

There are no informational kiosks at Billerica State Forest.

Memorials and Markers

There is one memorial in Billerica State Forest, the Rowell Memorial Stone. For information on this memorial, please refer to the Cultural Resources section.

Other

There are a set of fire hydrants along Treble Cove Road. These hydrants are located within the road right of way, are owned by the town, and maintained by the Billerica Water Department (Conway 2013).

Illegal Activities

Debris has been collecting near the eastern edge of the property, adjacent to Winning Street, reflecting some illegal dumping activity. The top of Gilson Hill also appears to be used as a party spot, with debris and a makeshift fire ring found in the area during fieldwork.

8.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

Vegetation around fire hydrants is maintained by the Billerica Water Department.

Wildlife

The DCR does not actively manage wildlife at Billerica State Forest; however the hunting of game species is permitted.

Cultural Resources

The DCR's Office of Cultural Resources hired a team of Cultural Resource Management professionals to undertake a survey of cultural resources at Billerica State Forest in 2002, resulting in the completion of the MHC Inventory Form for the Rowell Memorial Stone.

Recreation Resources

There are no unique recreation resource management practices at this property, beyond the trail maintenance practices described under Infrastructure.

Infrastructure

Buildings and Structures

The Town of Billerica owns the fire hydrants located alongside Treble Cove Road, within the road right-of-way; these hydrants are maintained by the Billerica Water Department. There is no Memorandum of Agreement (MOA), or similar document, between the DCR and the town that guides this management activity.

Roads

The DCR's Forest Fire Control District 6 provides forest road maintenance on an annual basis.

Trails

Trail maintenance is performed on a limited basis by DCR staff, and is typically at the request of the DCR's Forest Fire Control District 6 to meet their access needs.

Interpretive Services

Interpretive service programming is not offered at Billerica State Forest, nor is any other interpretive information provided.

Operational Resources

Billerica State Forest does not have any full or part-time DCR staff on site.

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The Concord River, as viewed from Governor Thomas Dudley State Park. (DCR)

SECTION 9. GOVERNOR THOMAS DUDLEY STATE PARK

9.1. Introduction

Governor Thomas Dudley State Park is the smallest facility in the Lowell/Great Brook Planning Unit, just under 11 acres in size. The park is located off of Dudley Road in Billerica, a locally designated scenic road, providing access to the Concord River (see Figure 8). Access to the property is through an adjacent parcel of Town of Billerica conservation land, as there is no frontage on Dudley Road. Other abutting properties include a parcel owned by the Department of Fish and Game (DFG) and a parcel that is part of the Great Meadows National Wildlife Refuge. This park is approximately one quarter of a mile from the town line with Bedford.

The three properties now owned by the DCR, DFG and Town of Billerica was once a single 21 acre parcel that was split and acquired by these three entities for conservation purposes. A management agreement between these organizations exists, and the Town of Billerica is the primary management and enforcement authority for all three parcels.

This park is located within the Two Brothers Rocks-Dudley Road National Register Historic District, which is located in both Billerica and Bedford.

This property was identified in the Massachusetts Scenic Landscape Inventory of 1982.

This section of the Concord River is also within the Sudbury, Assabet and Concord National Wild and Scenic Rivers designation and the Sudbury/Concord River Valley State Important Bird Area, as recognized by the National Audubon Society (National Park Service 2008; National Audubon Society 2008).

9.2. History of Property

Part of a 1637 Massachusetts General Court land grant of 1,000 acres to then Deputy Governor Thomas Dudley, this area was known at the time as Dudley Farm. Sold in 1652 in several parcels, the farm became an early focus of settlement in Billerica (Broomer 2010). The land along this section of Dudley Road became a part of the Stearns family farm holdings in the late 17th century, and stayed in the family until 1850 when Moses Greenwood purchased the property. The western edge of the Greenwood property along the Concord River was known as Greenwood Grove as early as 1891, and likely functioned as a picnic grove. By 1910, the Greenwood family owned 10 cottages on the property, probably providing a source of income in

Placeholder for Figure 8.

the form of summer rentals. The cottage community grew to 17 by 1930, but was back down to 10 by 1939, and by 1950 only six remained (Broomer 2010). No cottages survive.

Parcels of Greenwood Grove began to be subdivided and sold off in the late 1970s. In 1985, 24 acres of the former Greenwood property were sold for the development of a subdivision known as Heatherwood Estates, with 17 individual homesites planned. In January 1988, three adjoining parcels in Billerica were jointly acquired from the developer for open space protection by the Town of Billerica, the Department of Environmental Management (the DCR's predecessor agency), and the Department of Fisheries, Wildlife and Environmental Law Enforcement (the DFG's predecessor), totaling approximately 21 acres. Acquisition of this land occurred in part to contribute to the Massachusetts Bay Circuit Trail land protection efforts. A cooperative management agreement among these three entities details how the entities agreed to manage the land. Lands adjacent to these three properties are also protected as part of the Great Meadows National Wildlife Refuge property, which is owned by the US Fish and Wildlife Service (USFWS).

9.3. Existing Conditions

Natural Resources

A portion of the Great Meadows National Wildlife Refuge abuts Governor Thomas Dudley State Park along the park's western border. The Final Comprehensive Conservation Plan for the wildlife refuge identifies a wide range of natural resources within the property (USFWS 2005). It is worth noting that some of the resources identified within the refuge, particularly flora and fauna, may also exist within the state park.

Physical Features

Topography. The topography is rolling uplands, with a high point of approximately 150 feet above sea level roughly in the middle of the property, and decreasing elevations to the eastern side and on the western side, by the Concord River.

Geology. Falling within the Nashoba terrane, the bedrock of the area surrounding Governor Thomas Dudley State Park is largely Andover granite, commonly pink granite with a granular texture. (Skehan 2001).

Soils. Soils for this property are primarily Merrimac fine sandy loam, with some concentrations of Hinckley loamy sand. The Merrimac fine sandy loam is a very deep, somewhat excessively drained soil. The Hinckley loamy sand deposits in the Concord River Valley are three to four feet thick, and are underlain by glacial till (Northern Middlesex Council of Governments 2005). These soil types are formed in glaciofluvial deposits. Both types have primarily slight limitations for path and trail development, with some moderate to severe limitations in areas where the slope is above 15% (Peragallo 2009).

Table 9.1. Soil Types of Governor Thomas Dudley State Park

Soil Type	% of Park	Drainage Class
Merrimac fine sandy loam	66.3	Somewhat excessively drained
Hinckley loamy sand	22.3	Excessively drained
Deerfield loamy sand	9.3	Moderately well drained
Rippowam fine sandy loam	1.5	Poorly drained
Saco mucky silt loam	0.3	Very poorly drained
Windsor loamy sand	0.03	Excessively drained

Water Resources

Ponds. There are no ponds within the park.

Wetlands. There is a small shrub swamp, less than a half acre in size, located in this park.

Vernal Pools. There are no vernal pools within the park.

Streams. Governor Thomas Dudley State Park lies on the eastern shore of the Concord River, a 16 mile long river that drains an area of 27 miles. The Concord River has slow moving characteristics and little change in elevation along its length (USFWS 2005). A portion of the Concord River, including the section that abuts the park, has been designated as a Wild and Scenic River. The Town of Billerica utilizes the Concord River as its sole source of drinking water (Northern Middlesex Council of Governments 2005).

Groundwater. There are no aquifers beneath the park.

Flood Zones. A small half-acre section of the western most edge of the park, alongside the Concord River, falls within the 100-year flood zone.

Rare Species

No part of Governor Thomas Dudley State Park falls within land that has been designated as Priority Habitat. A very large swath of land just south of the park, extending into the western edge of Bedford and encompassing much of the northern half of Concord is currently designated as Priority Habitat.

In 2010, MassWildlife and The Nature Conservancy issued "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience, and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010). The entire park has been designated Core Habitat, and three-and-a-half of these acres (33%) have also been designated as Critical Natural Landscape.

Despite the lack of Priority Habitat designation within this facility, two rare species have been identified by the Natural Heritage and Endangered Species Program (NHESP) here: Blanding's turtle and river bulrush.

Blanding's turtles are reptiles that use both wetland and upland habitats and travel long distances during their active season (NHESP 2007a). This species has a MESA status of Threatened.

River bulrush, a plant, was formerly protected under MESA but has been delisted, and is now on the NHESP Plant Watch list, which is a non-regulatory tool. It is robust perennial sedge that can be found on river shores and in floodplains.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified two forest sub-types within Governor Thomas Dudley State Park (Table 9.2).

Table 9.2. Forest Sub-types of Governor Thomas Dudley State Park

Forest Sub-type	Acres	% of Park
Eastern white pine - hardwoods	8.1	73.6
Eastern white pine	1.7	15.5
Total	*9.8*	*89.1*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the park's boundaries since 2003.

The 2008 Billerica Open Space and Recreation Plan Update identified the predominant species in town as red oak and white pine, noting that white pine thrives in this area (Northern Middlesex Council of Governments 2008).

There are no Continuous Forest Inventory (CFI) plots within Governor Thomas Dudley State Park providing additional site specific data for any part of this property.

Priority Natural Communities. There are no Priority Natural Communities within Governor Thomas Dudley State Park.

Invasive Species. No information has been located to date on invasive species within Governor Thomas Dudley State Park.

Pests and Disease. No information has been located to date on pests and disease within Governor Thomas Dudley State Park.

Wildlife

Birds. There is little current information on the park's birds. Over 175 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.1. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Mammals. There is little current information on the park's mammals. Over 45 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.2. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Reptiles. There is little current information on the park's reptiles. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.3. Only one of these, Blanding's turtle, has been recorded at this park. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Amphibians. There is little current information on the park's amphibians. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.4. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Fish. A small portion of the boundary of this property is at the edge of the Concord River. The Final Comprehensive Conservation Plan for the wildlife refuge identifies 19 different species of fish, including several common varieties of pike, perch and trout (USFWS 2005). The plan also notes an alewife recovery program that was underway while the plan was being written (USFWS 2005). Many of these species may be present in the waters off of Governor Thomas Dudley State Park.

Cultural Resources

Pre-contact Archaeological Sites

Governor Thomas Dudley State Park has not been systematically surveyed and contains no recorded pre-Contact sites. The physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the region all confer a high archaeological potential for the park.

Historic Archaeological Resources

Governor Thomas Dudley State Park has not been systematically surveyed and contains no recorded historic archaeological sites.

Historic Resources

Buildings. There are no historic buildings within the park.

Structures. A small stretch of dry laid stone wall can be found on this property, and more of the historic system of walls can also be seen on adjacent properties. This wall is in fair to poor condition.

Objects. There are no historic objects within the park.

Landscapes. The primary entrance trail into the property is a former cart path that passes through the Town of Billerica conservation land, and has an aging allee of white pine trees. The majority of this allee is on the town owned land, but the western end of it does fall on DCR property. This historic allee may be a remnant from Greenwood Grove.

White Pine Allee (DCR)

Recreation Resources

Governor Thomas Dudley State Park is primarily accessed via motor vehicle. There are no public transit options to reach this park.

Recreation resources within Governor Thomas Dudley State Park consist of a small network of trails for passive walking and hiking use. These trails connect the DCR parcel to the adjacent town, DFG and USFWS lands. There is no boat access to the river.

One picnic table is located alongside the entrance trail, providing a place to rest about halfway between the entrance and the western edge of the property.

There is one known geocache located here as of November 2013.

Infrastructure

Property Boundary

Governor Thomas Dudley State Park is an 11 acre undeveloped property located in the southwest corner of Billerica, very close to the town line with Bedford (see Figure 8). The park is located west of Route 4, and east of the Concord River. A small portion of the western property line abuts the river itself. Directly to the north is property owned by the DFG, and to the east is property owned by the Town of Billerica. These parcels are collectively managed by the town. Much of the western boundary abuts a portion of the Great Meadows Wildlife Refuge, which is managed by the USFWS, and to the south is private property.

No boundary markers were noted during fieldwork, and only one trail marker was located.

Buildings and Structures

There are no buildings or structures at Governor Thomas Dudley State Park.

Roads

There are no roads in Governor Thomas Dudley State Park. The main entrance trail on the property, a former cart path, is wide enough at the entry to be gated, but it quickly narrows.

Parking

There is no parking on the DCR portion of Governor Thomas Dudley State Park. This parcel does not have frontage access on nearby Dudley Road.

One small unpaved parking area is located off of Dudley Road on the adjacent parcel owned by the Town of Billerica. This lot can fit approximately six vehicles.

Trails

There are 0.4 miles of trails in good to fair condition within Governor Thomas Dudley State Park (see Figure 8). With the exception of the main entrance trail, a former cart path, the trails are narrow in nature and do not appear to be extensively utilized. Primary use of these trails is for walking and hiking. These trails connect to a similar system of trails that fall on the DFG land, with some leading further north, into the Great Meadows Wildlife Refuge.

Signs and Kiosks

There is currently no signage at this facility of any kind, and as a result, visitors and local residents are not entirely familiar with the ownership or management of the property. There are no kiosks providing any information. The management agreement between the Town, DCR and DFG stipulated that the three agencies would provide identification and informational signage, as well as a trail map for the property, but it does not appear as if this occurred.

Memorials and Markers

There are no memorials and markers in Governor Thomas Dudley State Park.

9.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

The facility is managed by the Billerica Conservation Commission as per the management agreement between the Commonwealth and the Town. This agreement is supposed to be reviewed every five years; however DCR staff indicates that this does not currently occur.

Despite the lack of management responsibilities here, DCR Operations staff does periodically walk through the facility.

Natural Resources

The DCR does not actively manage the natural resources at this park.

Cultural Resources

The DCR does not actively manage the cultural resources at this park.

Recreation Resources

The DCR does not actively manage the recreational resources at this park. As per the management agreement, trails are to be managed by the Town of Billerica.

Hunting is not allowed at Governor Thomas Dudley State Park.

Infrastructure

With the exception of the small network of trails, there is no other infrastructure at this park to manage.

A trail map has not been created for Governor Thomas Dudley State Park, and there is no information on the DCR website for the park or its network of trails.

Interpretive Services

There are no interpretive services provided at Governor Thomas Dudley State Park, either by DCR, DFG or the Town of Billerica.

Operational Resources

DCR Staffing

Governor Thomas Dudley State Park does not have any full or part-time DCR staff on site.

Supplemental Staffing

The facility is managed by the Billerica Conservation Commission as per the management agreement between the Commonwealth and the Town. This management agreement is supposed to be reviewed by all parties every five years.

Public Safety

As per the management agreement between the DCR, DFG and Town of Billerica, the Town is responsible for policing the property and enforcing use restrictions.

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Pawtucket Falls and Gatehouse (Peter E. Lee; CC BY-NC 2.0; cropped from original)

SECTION 10. RECOMMENDATIONS

10.1. Introduction

The DCR has a broad and dynamic mission that encompasses resource protection, providing public access to recreational opportunities, and active forest management. This multi-faceted mission often results in complex management challenges. These responsibilities are central to the agency's mission and statutory charge.

To help meet this broad mission, the DCR has developed a two-tier system for guiding the management of all state forest and park properties under its care. The two systems, known as Landscape Designations and Land Stewardship Zoning, work in an integrated fashion to accommodate primary ecosystem services while recognizing and providing site-specific resource protection.

The application of Landscape Designations and Land Stewardship Zoning to properties within the Lowell/Great Brook Planning Unit is summarized below. For a more detailed description of Landscape Designations and Land Stewardship Zoning, please see Appendix I.

10.2. Landscape Designations

Applied statewide at the property level to assess and guide management activities throughout the DCR system, Landscape Designations are based on primary ecosystem services and guide management decisions based upon these services. The designations also communicate the agency's landscape-level management objectives to the public.

As a result of a robust public process called Forest Futures Visioning, the DCR established the following designations for properties under its jurisdiction:

Reserves. Properties designated as reserves provide backcountry recreational experiences and protect the least fragmented forested areas and diverse ecological settings. Successional processes are allowed to progress unimpeded by human disturbance, and are monitored to assess and inform long-term forest stewardship.

Woodlands. Woodlands demonstrate exemplary forest management practices for landowners and the general public, while supporting the range of ecosystem services that sustainably-managed forests offer, including a diversity of native species and age classes, and compatible recreational opportunities.

Parklands. Areas designated as parklands focus on providing public recreational opportunities while protecting resources of ecological and cultural significance.

Selection criteria and management guidelines for all three landscape designations are described in *Landscape Designations for DCR Parks & Forests: Selection Criteria and Management Guidelines* (DCR 2012*b*).

Applied Landscape Designations

All properties within the Lowell/Great Brook Planning Unit have been designated as Parklands.

10.3. LAND STEWARDSHIP ZONING

Land Stewardship Zoning, and the resource management planning process of which it is a part, addresses the agency's statutory responsibilities in M.G.L. Chapter 21: Section 2F. The legislation requires the DCR to prepare management plans that encompass all reservations, forests and parks; provide for the protection and stewardship of natural, cultural and recreation resources under the agency's management; and ensure consistency between recreation, resource protection and sustainable forest management.

Land Stewardship Zoning Guidelines

The Land Stewardship Zoning Guidelines define three types of zones to ensure resource protection based upon site-specific field data and provide guidance for current and future management based upon resource sensitivities. The inventory and assessment of resources during the preparation of an RMP is factored into land use management and decision-making, and provides guidance for stewardship of these resources. The process results in zoning of areas and specific sites within DCR properties based on their sensitivity to recreational and management activities that are appropriate for each facility as recognized during the RMP process. In this way, the Land Stewardship Zoning system helps to ensure that recreational and management activities do not degrade various resources and values.

The three land stewardship zones provide a general continuum to categorize resources (relative to potential degradation from human activities) from undisturbed sites with highly sensitive resources, through stable/hardy resources, to sites that have been developed and are consistently used for intensive recreation or park administration purposes. The Land Stewardship Zoning system also includes Significant Feature Overlays that may be applied to highlight resource features that have been assessed and documented by professional resource specialists.

Below is a description on the various zones used for Land Stewardship Zoning.

Zone 1

Management Objective. Protection of sensitive resources from management, or other human activities, that may adversely impact the resources.

General Description. This zone encompasses areas with highly sensitive ecological and cultural resources that require additional management approaches and practices to protect and preserve the special features and values identified in the RMP. Zone 1 areas are not suitable for future intensive development.

Examples. Examples identified as being highly sensitive to human activities include rare species habitat or natural communities, areas with concentrations of sensitive aquatic habitats, excessively steep slopes with erodible soils, and archaeological sites or fragile cultural sites, where stewardship of these resources must be the primary consideration when assessing management and recreational activities in these areas.

Zone 2

Management Objective. Provide for a balance between the stewardship of natural and cultural resources and recreational opportunities that can be appropriately sustained.

General Description. This zone encompasses stable yet important natural and cultural resources. Zone 2 is a very important component to the DCR's management responsibilities, because the protected landscape within this zone provides a buffer for sensitive resources, recharge for surface and groundwater, and large areas where existing types of public recreational activities can be managed at sustainable levels.

Examples. Examples include areas of non-intensive use that contain diverse ecosystems, rare species habitat that is compatible with dispersed recreation and sustainable management practices, and cultural resources that are not highly sensitive to human activities.

Zone 3

Management Objective. Provide public access to safe and accessible recreational opportunities, as well as administrative and maintenance facilities that meet the needs of DCR visitors and staff.

General Description. This zone includes altered landscapes in active use and areas suitable for future administrative, maintenance and recreation purposes. The resources in this zone can accommodate concentrated use and require regular maintenance by DCR staff.

Examples. Examples of areas of concentrated use include park headquarters and maintenance areas, parking lots, swimming pools and skating rinks, paved bikeways, swimming beaches, campgrounds, playgrounds and athletic fields, parkways, golf courses, picnic areas and pavilions, and concessions. Examples of future use areas include disturbed sites with no significant ecological or cultural values that are not suitable for restoration, identified through the RMP or in a Master Plan as being suitable for intensive recreation or park administration sites. Note that development would be preceded by detailed site assessments to ensure protection of natural and cultural resources.

Significant Feature Overlays

Management Objective. Provide precise management guidance in order to maintain or preserve recognized resource features, regardless of the zone in which they occur.

General Description. The three land stewardship zones may be supplemented with Significant Feature Overlays that identify formally designated or recognized resources. These resource features have been recognized through research and assessment by professional resource specialists. Information on the significant features is brought into the RMP process via review of previous research projects and associated designations.

Examples. A natural or cultural resource, recognized through professional inventory or research, which cuts across more than one land stewardship zone, or which is located in an area characterized by intensive visitor use. In the latter case, the Significant Feature Overlay is used to highlight the potential conflict between resource stewardship and ongoing visitor use, and provide mitigation strategies. Examples include:

- National Register Historic District.
- Areas subject to public drinking water regulations.
- Priority Habitat for species that are not sensitive to human activities.
- BioMap 2 Core Habitat.
- Designated Areas of Critical Environmental Concern.
- A NHESP Priority Natural Community associated with a summit that is also a popular destination for hikers.
- A barrier beach that provides habitat for rare shorebirds and is subject to CZM barrier beach management guidelines and coastal wetlands regulations, but also supports thousands of visitors during the summer season.
- A significant cultural site such as Plymouth Rock that is subject to ongoing, intensive visitation.
- A natural or cultural resource, recognized through professional inventory or research, which is located in an area characterized by intensive visitor use.

Applied Land Stewardship Zoning

The following Land Stewardship Zoning is recommended for properties in the Lowell/Great Brook Planning Unit. A figure (i.e., Figure 9, 10 and 11) accompanies each property with more than one type of zoning. The remaining properties, which only have one type of zoning, do not have a corresponding figure.

Lowell-Dracut-Tyngsborough State Forest

Zone 1. Spruce Swamp, home to several rare species and a rare Priority Natural Community, is designated a Zone 1 (see Figure 9).

Zone 2. The remainder of the forest is designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. The main parking area for the forest, located at the end of Trotting Park Road, and the former headquarters site are designated a Zone 3 (see Figure 9).

Significant Feature Overlay. There are no significant feature overlays.

Lowell Heritage State Park

Zone 1. No sections of the park have been designated a Zone 1.

Zone 2. No sections of the park have been designated a Zone 2.

Zone 3. The entire park has been designated a Zone 3. While it is historically significant, it is also an integral part of a heavily developed urban landscape.

Significant Feature Overlay. There are no significant feature overlays.

Great Brook Farm State Park

Zone 1. Due to the sensitivity of the area around "The City," it is designated a Zone 1 (see Figure 10).

Zone 2. The remainder of the park is designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. The portion of the park that includes the active farm complex, the Hart Barn, the North Schoolhouse (home of the park headquarters), and the two largest parking areas in the park, are all designated a Zone 3 (see Figure 10).

Significant Feature Overlay. There are no significant feature overlays.

Carlisle State Forest

Zone 1. No sections of the forest have been designated a Zone 1.

Zone 2. The entire forest has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. No sections of the forest have been designated a Zone 3.

Significant Feature Overlay. There are no significant feature overlays.

The Land Stewardship Zoning for Carlisle State Forest should be reviewed following the recommendation to update the large tree inventory, in order to determine if there should be a Zone 1 designation or a Significant Feature Overlay to encompass these resources.

Warren H. Manning State Forest

Zone 1. No sections of the forest have been designated a Zone 1.

Zone 2. The remainder of the forest outside of the active recreation area has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. The active recreation area, including the parking lot, spray deck and picnic area, has been designated a Zone 3 (see Figure 11).

Significant Feature Overlay. There are no significant feature overlays.

Billerica State Forest

Zone 1. No sections of the forest have been designated a Zone 1.

Zone 2. The entire forest has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. No sections of the forest have been designated a Zone 3.

Significant Feature Overlay. There are no significant feature overlays.

Governor Thomas Dudley State Park

Zone 1. No sections of the park have been designated a Zone 1.

Zone 2. The entire park has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. No sections of the park have been designated a Zone 3.

Significant Feature Overlay. There are no significant feature overlays.

Placeholder for Figure 9.

Placeholder for Figure 10.

Placeholder for Figure 11.

10.4. MANAGEMENT RECOMMENDATIONS

Management Principle

The resource management planning process for the Lowell/Great Brook Planning Unit resulted in the following management principle:

Protect the natural and cultural resources of the planning unit and provide enhanced recreational and educational opportunities for visitors through the creative use of state resources and partnerships.

Management Goals

The following management goals have been identified to achieve the management principle. These goals are of equal importance, and are not presented in order of priority.

Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.

Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.

Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.

Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.

Recommendations

These management recommendations have been organized first by the planning unit in its entirety, for those that apply to all or most of the properties, and then by individual property. Each set of recommendations is presented by the management goals identified for the planning unit.

Recommendations are also characterized on the basis of priority (i.e., high, medium or low) and resource availability. High priority recommendations are those that address regulatory compliance or public health and safety; prevent immediate damage to, or loss of, resources; or repair or replace damaged equipment or systems critical to operations. They are typically time sensitive. Medium priority recommendations maintain existing resources and visitor experiences. Low priority recommendations enhance resources or visitor experiences; they are not time sensitive.

Resource availability considers both funding and labor. A resource availability of one (1) indicates that funding and/or labor are available to implement the recommendation. A resource availability of two (2) indicates that funding and/or labor are not currently available, but may become so in the near future (i.e., the next five years). A resource availability of three (3) indicates that funding and/or labor are not anticipated in the next five years. Resources to implement these recommendations may, or may not, become available after five years.

Table 10.1. Recommendations for the Lowell/Great Brook Planning Unit[a]

Recommendation	Priority[b]	Resources[c]	Implementation[d]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Complete the certification process for the potential vernal pools within the planning unit.	M	2	P, M, V
Develop a Vegetation Management Plan to address the invasive species observed within the planning unit.	M	2	P, C, F
Undertake a mapping effort to document the stone walls located on these properties and record their condition.	L	3	P, F
Review and apply the Best Management Practices developed by the Office of Cultural Resources for stone wall protection.	M	1	P, M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Review and update or create, where appropriate, a trail map for each of the properties in the planning unit, and make the maps available through multiple outlets.	H	1	M, X
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
There are no recommendations associated with this goal.	-	-	-
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Fill the Metro West District Ranger position.	H	3	M
Establish webpages on the DCR website for the properties in the planning unit that currently do not have a webpage.	H	1	M, X

a. These recommendations apply to all, or most, properties in the planning unit.
b. Priorities are High (H), Medium (M), or Low (L).
c. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
d. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.2. Recommendations for Lowell-Dracut-Tyngsborough State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Work with the Natural Heritage & Endangered Species Program to conduct a survey for the blue-spotted salamander.	M	2	P, M, O, V
Investigate the nature and extent of the Coburn mill site.	L	2	P, M
Acquire additional land in the southern part of the forest, if necessary, in order to protect the Coburn mill site.	L	2	P, L
Remove the debris at the former headquarters site that poses a threat to significant resources (i.e., the pump house cellar hole) and public safety (i.e., glass bottles).	H	1	M, V
Undertake further research on the cellar holes that were not located during the fieldwork for this plan.	L	3	P, M
Stabilize the walls and remove the vegetation from the forest's CCC water holes.	M	2	P, M
Address the culverts within the forest that are blocked and/or collapsing.	H	2	P, M, E
Reposition and clean, where applicable, the stone markers within the forest.	L	2	P, M
Remove the graffiti from Sheep Rock and work with the Environmental Police to curb the illegal activities that take place at the site.	H	2	P, M, O
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Work with the Environmental Police to curb the illegal recreation activities (e.g., off-highway vehicle use and paintball games) taking place at the forest.	H	1	M, O
Post signs that clearly indicate the boundary of the forest's "No Hunting Areas."	H	1	M, F, V
Formalize the main parking area at the forest's main entrance on Trotting Park Road in Lowell; consider signing, paving and expanding the area, lining the spaces and designating at least one accessible space.	M	3	P, M, C
Investigate the options for establishing a more suitable parking area on Trotting Park Road in Tyngsborough.	L	1	P, M
Improve the trail signage within the forest, adding trail names and intersection numbers where appropriate.	H	2	M, F, V
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Investigate the options for removing the illegal dam on Trotting Park Road in Tyngsborough.	M	1	E

Continued on next page.

Table 10.2. Recommendations for Lowell-Dracut-Tyngsborough State Forest (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Renew the agreement with the Greater Lowell Indian Cultural Association (GLICA).	H	2	M, L
Work with the Dracut Water Supply District to address and resolve the issues surrounding the current location of their water supply infrastructure.	M	2	M, L
Establish a formal agreement with the Dracut Water Supply District regarding their access to and maintenance of the water supply infrastructure located on Gage Hill.	M	2	M, L
Arrange a meeting between the Dracut Water Supply District and appropriate DCR staff to discuss their need to replace the reservoir at the forest.	H	1	M, L
Work with the Merrimack Valley Chapter of the New England Mountain Bike Association to review and approve, where appropriate, the existing technical features in the forest.	H	1	P, M, L
Develop a formal agreement with the Merrimack Valley Chapter of the New England Mountain Bike Association regarding the review and approval of their trail maintenance, repair and construction projects within the forest.	H	1	P, M, L
Install a new Main Identification and several Road Marker signs at the forest.	M	1	M, O

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.3. Recommendations for Lowell Heritage State Park

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Assess the condition of the interior and exterior of the Rynne bathhouse and make repairs, where necessary.	H	2	P, E, M
Work with the National Park Service to repair the cracked end wall of the Pawtucket Gatehouse.	M	2	P, E, M, V
Meet with the National Park Service to develop and implement a preservation plan for the Hamilton Wasteway Gatehouse.	H	1	P, E, M, V
Work with the National Park Service to remove the Boston ivy from the Boott Dam Gatehouse.	M	2	P, E, M, V
Work with Boott Hydropower, Inc. to assess the condition of the Lowell Canal System and make repairs, where necessary.	L	3	P, E, M, V
Work with Boott Hydropower, Inc. to implement the recommendations featured in the DCR's Office of Dam Safety dam inspection reports for the Northern Canal Great Wall, Guard Locks, Swamp Locks and Lower Locks dams.	L	3	P, E, M, V
Repair the steel rail and granite post fences at the Mack plaza and Victorian garden.	H	3	P, E, M, C
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Post fish consumption advisory signs in multiple, locally spoken languages at popular fishing spots along the Merrimack River and Lowell Canal System.	H	1	M, X, V
Ensure that all of the violations noted in the most recent inspection of the Lord pool are addressed in the upcoming modernization project.	H	1	E, C
Install a bike rack at the Lord pool.	M	2	P, M, C, V
Plant additional trees or construct a shade structure(s) in the lawn surrounding the Lord pool.	L	3	P, M, C, V
Work with the Department of Transportation and City of Lowell to improve the parking area at regatta field.	M	2	M, O, C
Assess and repair, where necessary, the condition of the Scott Finneral Memorial Riverwalk.	M	2	P, M, C
Consider adding a formal, off-road connection between the Scott Finneral Memorial Riverwalk and the eastern end of the Vandenberg esplanade.	L	3	P, M
Consider options, such as the DCR's Matching Funds Program, for acquiring a small, motorized boat for public safety purposes at Rynne beach.	M	3	P, M, X
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Complete an assessment of the Merrimack River retaining wall and make repairs, where needed.	M	2	M, E
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Determine the owner of the Hadley House and establish an agreement that guides the management and use of the building.	H	1	P, M, L
Meet with the University of Massachusetts Lowell to develop and implement a preservation plan for the eastern section of the wall in the Tremont Yard parking area.	M	2	P, M, L
Meet with Tremont Yard, LLC to discuss ways in which the preserved, below grade water power features within the Jeanne D'Arc Credit Union can be promoted.	L	2	M, L
Install DCR signs at the parking areas along the Vandenberg esplanade, next to the Lord pool and on Broadway Street.	H	2	M, O
Install gates at the parking areas next to the Lord pool and on Broadway Street.	H	3	M, C
Install a new Main Identification Sign at Francis Gate Park.	M	2	M, O

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Table 10.3. Recommendations for Lowell Heritage State Park (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Establish an agreement with Lowell General Hospital regarding the placement and maintenance of their three-sided directional sign.	M	2	M, L
Replace the bronze plaque for the brick vault.	L	3	P, M
Confirm that the namesake of the Vandenberg esplanade is Hoyt S. Vandenberg and update DCR signage to reflect the full and proper name of the esplanade, where needed.	L	3	P, L, O
Renew the agreements with the City of Lowell related to their management of the regatta field and Rynne beach, as well as their use of the Rynne bathhouse.	H	1	M, L
Renew the agreement with the stakeholders in the Lowell Canal System.	H	1	M, L
Renew the agreement with the New England Electric Railway Historical Society / Seashore Trolley Museum.	H	1	M, L
Establish an agreement with the Boston & Maine Railroad Historical Society regarding their maintenance of the B&M 410.	H	2	M, L
Finalize the transfer of the Bellegarde boathouse, obtaining a copy of the items listed in Section 4.4. and executing the care, custody, management and control agreement.	H	1	L
Work with the National Park Service to establish signage at the visitor center lot that indicates the parking area is open to state park visitors.	M	2	M, V

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.4. Recommendations for Great Brook Farm State Park

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1 Preserve natural and cultural resources through appropriate stewardship strategies.			
Work with the DCR Lakes and Ponds program to assess the water chestnut growth in Meadow Pond and make a plan for eradication.	M	1	P, O, M
Undertake a hydrological study to gain a complete understanding of water flow through the park, assessment of existing culvert capacity and impacts to trails, and make recommendations for improvements.	H	3	P, C
Revisit the draft Comprehensive Interpretive Plan; revise and update as necessary and finalize.	H	1	M
Develop interpretive programs, opportunities, and products as identified in the Comprehensive Interpretive Plan, working to expand interpretive offerings beyond the smart barn tours.	H	2	M
Clear the debris currently built up around the beaver deceivers to maintain water flow and keep them operational.	H	1	M, C
Make sure park and regional staff are aware of local scenic road designations and local review requirements.	L	1	P, M
Remove leaf and brush debris from all cellar holes and routinely monitor these sites for other disturbances.	M	2	M
Routinely monitor the Adam's Mill dam site for stability and potential disturbances.	M	2	M
Routinely monitor "The City," particularly the Garrison House site, for stability and potential disturbances.	H	1	M, P
Remove the broken sign at the Garrison House site.	H	1	M
North Schoolhouse: Carefully remove the English ivy from the walls, with guidance from DCR's Office of Cultural Resources.	H	2	M, P
North Schoolhouse: Assess the condition of the chimney, and identify and address the moisture issue that is causing the spalling.	M	2	P, E
Main Farm Area: Request a reevaluation of the Main Farm Area for National Register eligibility by the Massachusetts Historical Commission, and complete a nomination if still deemed eligible.	L	3	P
Hart Barn: Replace the roofing shingles on the north side of the barn.	M	2	E, C
Hart Barn: Assess the effectiveness and stability of the recent mortar repairs.	M	2	E
Main Farm House: Install an appropriate gutter, with guidance from DCR's Office of Cultural Resources.	H	2	P, V, C
Main Farm House: Clean the lichen growth that has appeared on the walls of the house.	M	2	V
Main Farm House: Complete minor repairs to the siding and the front door sill, with guidance from DCR's Office of Cultural Resources.	H	2	P, V, C
Tie Stall Barn: Undertake selective siding repair, with guidance from DCR's Office of Cultural Resources.	M	3	P, V, C
Tie Stall Barn: Replace the roofing shingles on the north side of the barn.	M	2	E, V, C
Tie Stall Barn: Assess the stability of the foundation in areas where it has visibly been compromised, and repair as necessary, with guidance from DCR's Office of Cultural Resources.	H	1	P, E, V, C
Pole Barn: Carefully remove vegetation from the rear façade.	L	3	V
Duck Coop: Assess the stability of the foundation.	L	3	E
Duck Coop: Work with the farmer to determine if any new uses are possible for this building.	L	2	P, E, V, M
Silos: Assess structural stability of each and explore possible interpretive opportunities with farmer, park, and interpretive staff.	M	2	E, M, V

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Table 10.4. Recommendations for Great Brook Farm State Park (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1 Preserve natural and cultural resources through appropriate stewardship strategies.			
Silos: Assess structural stability of each and explore possible interpretive opportunities with farmer, park, and interpretive staff.	M	2	E, M, V
Litchfield House: Complete repairs to the barn.	H	2	V, P
Litchfield House: Clean the lichen growth that has appeared on the walls of the house.	M	2	V
Litchfield House: Identify the cause of the lichen growth on the roof and address.	M	2	V, P
Litchfield House: Assess the chimneys to determine if any repairs are necessary.	M	3	V, P
Cemetery: Apply the BMP developed by the office of Cultural Resources.	L	1	M, P
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Working with the Lakes and Ponds program, determine if a new canoe launch should be designed and installed to reopen Meadow Pond for recreational boating.	M	1	M, O
Develop a trails plan, assessing existing density and incorporating critical information developed through the hydrological study to better address areas that have trail washout problems.	H	2	P
Work with the local equestrian community to formalize the maintenance of the horse jumps, and prune the vegetation growth around them.	M	1	M, X, V
Securely cover the open well located southeast of the Litchfield House.	H	1	M
Reassess all boardwalk crossings to identify older ones in need of replacement, including those on the Acorn Trail.	H	1	M
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Routinely monitor the area around the rock shelters for possible illicit activities.	M	1	M
Former Regional HQ site: remove former sign holder and pavement to let the site return to a natural state.	H	2	M, E
Tie Stall Barn: Address the outstanding permit issues for the event space and renew discussions about future use.	H	2	V, E, M
Farnham Smith's Cabin: Undertake a structural assessment and reuse feasibility study to determine if reuse is possible and develop some potential options.	H	2	P, E, M
Cabin Shed: Access and clean out the interior of the shed, so that it does not become a potential nuisance.	H	1	M
Boat House: Complete and submit MHC Inventory form.	H	1	P
Boat House: Undertake demolition.	H	2	E, C
South House/District 6 Fire Control: Assess for any reuse possibilities by the park and/or the region, such as accommodating the storage needs currently being met by the Hadley House and the Anderson Barn.	H	2	F, M, P
Hadley House: Investigate alternative uses of the property and possibly making it available to be moved. If not possible, identify a funding source for demolition before it becomes an attractive nuisance.	H	2	P, M, E
West Farm/Manseau House: Assess for inclusion in the Historic Curatorship Program. If not a good candidate, identify a funding source for demolition, before it becomes an attractive nuisance.	H	2	P, M, E

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Table 10.4. Recommendations for Great Brook Farm State Park (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
North Farm House and Barn: Make sure the buildings are secure, and routinely monitor to ensure they aren't damaged or broken into.	H	1	M
North Farm House and Barn: Work with current long term leaseholders of other facilities within the park to identify any potential complementary reuses for this property, and explore putting out a Request for Proposals.	H	1	P, X, M
Anderson Barn: Explore any potential interest in, and options for, permitting use of the barn by others, and relocate current storage closer to the Park HQ.	H	2	P, M
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Conduct annual meetings with lease holders and annual property inspections of leased property as specified in lease agreements and permits.	H	1	M, L
Twice a year, hold a joint meeting of park staff and all leaseholders, to maintain the lines of communication among all parties and make sure that everyone is aware of activities, events, or other projects that have the potential to impact each other.	M	1	M, X
Encourage and support the re-establishment of a Friends of Great Brook Farm State Park.	L	1	M, X
Pine Point Loop Parking Area: Streamline the signage as to not visually overwhelm visitors, but still inform them.	M	1	M, X
Main Parking Area: Streamline the signage as to not visually overwhelm visitors, but still inform them.	M	1	M, X
Litchfield House: Identify joint interpretive and public programming opportunities with the Curators that enhance interpretive activities while promoting DCR's Historic Curatorship Program.	L	1	P, M, V, X
Woods House: Update and renew the expired lease agreement for the Woods House with the old North Bridge Hounds.	H	1	L

a. Priorities are High (H), Medium (M), or Low (L).

b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.

c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.5. Recommendations for Carlisle State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Update the inventory of the large eastern white pine trees, last done in 1980.	H	1	F
After completion of tree inventory update, revisit the Land Stewardship Zoning to determine if any changes are applicable.	H	1	P, F
Establish a Continuous Forest Inventory (CFI) plot within the forest.	L	2	F
Develop an interpretive program around the natural and cultural history of the Carlisle Pines.	L	1	M, P
Monitor and assess red pine stands within the forest; manage if necessary for public safety or ecological need.	M	1	F
Monitor for invasive pests, especially hemlock wooly adelgid. Propose biological or chemical controls if warranted on the specimen trees.	H	1	F
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Develop and install an informational kiosk that includes interpretive information, for installation within the interior of the property.	M	2	M
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
There are no recommendations associated with this goal.	-	-	-
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Clear the vegetation from around the former DEM sign stanchion, and hang a new DCR entrance sign from the existing sign stanchion.	H	1	M
Continue to partner with the Carlisle Trails Committee for assistance with trail work.	M	1	M, P, X,

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.6. Recommendations for Warren H. Manning State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Undertake further research on the outbuilding foundation located near Spruce Pond to determine if it has any connection to Warren Manning.	L	2	P
Clean up the dumping debris located off of Rangeway Road, and continue to monitor the area for illegal dumping.	H	2	M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Establish designated handicapped accessible parking spaces in the parking lot, total number to be determined in consultation with DCR's Universal Access Program.	H	1	E, U
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Assess the accessibility and potential uses of the portion of the state forest west of Route 3, and evaluate options to better utilize this space and/or establishing connections to other nearby open space.	L	2	P, M, V, X
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Work with the Town of Billerica to get a Special Use Permit in place, to formalize their operation of the recreational area.	H	1	L, M
Hold bi-annual meetings with the Town of Billerica Recreation Department to discuss programs, events, and maintenance and operation of the recreational area.	H	1	M, X
Provide DCR information on the informational kiosk.	H	1	X

a. Priorities are High (H), Medium (M), or Low (L).

b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.

c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.7. Recommendations for Billerica State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Carefully clean the lichen from the Rowell Memorial Stone.	L	1	P, M
Document the network of historic forest roads on a MHC inventory form.	L	2	P
Clean up illegal camping debris located near the top of Gilson Hill.	M	1	M
Dismantle the fire ring located at the top of Gilson Hill, to discourage use.	H	1	M
Clean up the dumping debris located adjacent to Winning Street, and continue to monitor the area for illegal dumping.	H	2	M
Develop interpretive materials to tell the story of this land and the establishment of the forest – it is an interesting piece of Billerica history.	L	2	M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Establish a system of routine trail maintenance to address the high percentage of trails in poor condition, possibly partnering with other organizations such as the Student Conservation Association or other local organizations for assistance with specific projects.	M	3	M, P
Evaluate potential locations and establish a small formal parking area (possibly adjacent to an existing gate) to facilitate safe access to the forest.	M	3	M, E, C
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Assess the accessibility and potential uses of the portion of the state forest west of Route 3, and evaluate options to better utilize this space and/or establishing connections to other nearby open space.	L	2	P, M, V, X
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Monitor the area for future illegal camping activities, engaging local residents and police for additional assistance.	M	1	M
Install a DCR entrance sign for the forest.	H	1	M

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.8. Recommendations for Governor Thomas Dudley State Park

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Conduct further research on the historic drive and allee of trees to determine if it is a remnant of Greenwood Grove.	L	2	P
Develop interpretive materials to tell the story of this property and the connection to Governor Dudley.	M	2	M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
In coordination with abutting property owners, establish a system of routine trail maintenance for the park, possibly partnering with other organizations such as the Student Conservation Association for assistance with specific projects.	M	3	M, X, V
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
There are no recommendations associated with this goal.	-	-	-
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Hold an annual meeting with the MA Department of Fish & Game and the Town of Billerica Conservation Commission to discuss any issues, plans or projects.	H	1	M
With the MA Department of Fish & Game and the Town of Billerica Conservation Commission, conduct the stipulated 5 year review of the Management Agreement.	H	1	M, L
Establish and maintain an active relationship with the Sudbury, Assabet and Concord Wild & Scenic River Stewardship Council.	M	2	M
Establish and maintain active communication with US Fish & Wildlife about the resources in this general area and potential collaborative efforts.	M	2	M, P
Working with the Town of Billerica and the MA Department of Fish & Game, identify an appropriate location for an entrance sign that recognizes the partners.	H	2	M

a. Priorities are High (H), Medium (M), or Low (L).

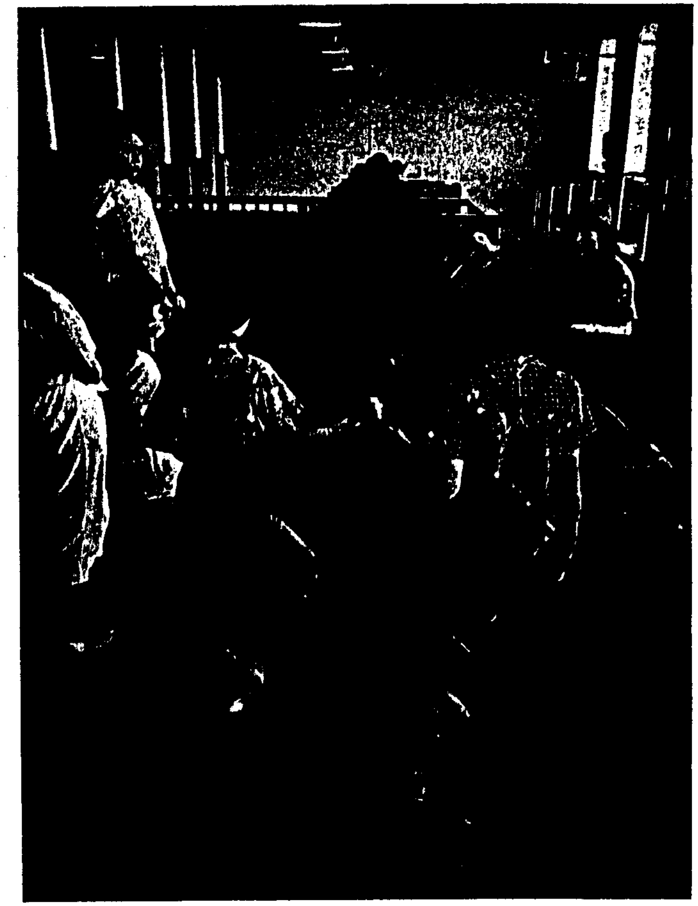
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.

c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Appendix E

Legislation

16 USC 410cc.



LOWELL NATIONAL HISTORICAL PARK

PART A—ESTABLISHMENT OF PARK AND PRESERVATION DISTRICT

§ 410cc. Congressional statement of findings and purpose

(a) The Congress finds that—

(1) certain sites and structures in Lowell, Massachusetts, historically and culturally the most significant planned industrial city in the United States, symbolize in physical form the Industrial Revolution;

(2) the cultural heritage of many of the ethnic groups that immigrated to the United States during the late nineteenth and early twentieth centuries is still preserved in Lowell's neighborhoods;

(3) a very large proportion of the buildings, other structures, and districts in Lowell date to the period of the Industrial Revolution and are nationally significant historical resources, including the five-and-six-tenths-mile power canal system, seven original mill complexes, and significant examples of early

housing, commercial structures, transportation facilities, and buildings associated with labor and social institutions; and

(4) despite the expenditure of substantial amounts of money by the city of Lowell and the Commonwealth of Massachusetts for historical and cultural preservation and interpretation in Lowell, the early buildings and other structures in Lowell may be lost without the assistance of the Federal Government.

(b) It is the purpose of sections 410cc to 410cc-37 of this title to preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts, for the benefit and inspiration of present and future generations by implementing to the extent practicable the recommendations in the report of the Lowell Historic Canal District Commission.

(Pub.L. 95-290, § 1, June 5, 1978, 92 Stat. 290.)

§ 410cc-1. Definitions

For purposes of sections 410cc to 410cc-37 of this title—

(1) the term "park" means the Lowell National Historical Park, established by section 410cc-11(a)(1) of this title;

(2) the term "preservation district" means the Lowell Historic Preservation District, established by section 410cc-11(a)(1) of this title;

(3) the term "Commission" means the Lowell Historic Preservation Commission established by section 410cc-31(a) of this title;

(4) the term "Secretary" means the Secretary of the Interior; and

(5) the term "report of the Lowell Historic Canal District Commission" means the report submitted to the Congress by the Lowell Historic Canal District Commission pursuant to an Act entitled "An Act to provide for a plan for the preservation, interpretation, development and use of the historic, cultural, and architectural resources of the Lowell Historic Canal District in Lowell, Massachusetts, and for other purposes", approved January 4, 1975 (88 Stat. 2330).

(Pub.L. 95-290, § 2, June 5, 1978, 92 Stat. 290.)

References in Text. An Act entitled "An Act to provide for a plan for the preservation, interpretation development and use of the historic, cultural, and architectural resources of the Lowell Historic Canal District in Lowell, Massachusetts, and for other purposes", approved January 4, 1975 (88 Stat. 2330), referred to in par. (5), is Pub.L. 93-645, Jan. 4, 1975, 88 Stat. 2330, and is set out as a note under section 461 of this title.

§ 410cc-11. Establishment of Lowell National Historical Park; establishment and administration of Lowell Historic Preservation District; establishment, publication, and revision of boundaries

(a)(1) To carry out the purpose of sections 410cc to 410cc-37 of this title, there is established as a unit of the National Park System in the city of Lowell, Massachusetts, the Lowell National Historical Park. There is further established in an area adjacent to the park the Lowell Historic Preservation District, which will be administered by the Secretary and by the Commission in accordance with sections 410cc to 410cc-37 of this title. The boundaries of the park and preservation district shall be the boundaries depicted on the map entitled "Lowell National Historical Park, Massachusetts", dated March 1978, and numbered "Lowe—80,008A". Such map shall be on file and available for inspection in the office of the National Park Service, Department of the Interior, and in the office of the city clerk, city of Lowell.

(2) The Secretary shall publish in the Federal Register, as soon as practicable after June 5, 1978, a detailed description and map of the boundaries established under paragraph (1) of this subsection.

(b) The Secretary may make minor revisions of the park and preservation district boundaries established under subsection (a)(1) of this section, after consulting with the Commission and the city manager of Lowell, by publication of a revised drawing or other boundary description in the Federal Register; but no waters, lands, or other property outside of the park or preservation district boundaries established under such subsection may be added to the park or preservation district without the consent of the city manager of Lowell and the city council of Lowell. A boundary revision made under this subsection shall be effective only after timely notice in writing is given to the Congress.

(Pub.L. 95-290, Title I, § 101, June 5, 1978, 92 Stat. 291.)

§ 410cc-12. Consultations, cooperation, and conduct of activities by Federal entities; issuance of licenses or permits by Federal entities

(a) Any Federal entity conducting or supporting activities directly affecting the park or preservation district shall—

(1) consult with, cooperate with, and to the maximum extent practicable, coordinate its activities with the Secretary and with the Commission; and

(2) conduct or support such activities in a manner which (A) to the maximum extent practicable is consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title, and (B) will not have an adverse effect on the resources of the park or preservation district.

(b) No Federal entity may issue any license or permit to any person to conduct an activity within the park or preservation district unless such entity determines that the proposed activity will be conducted in a manner consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title and will not have an adverse effect on the resources of the park or preservation district.

(Pub.L. 95-290, Title I, § 102, June 5, 1978, 92 Stat. 291.)

§ 410cc-13. Authorization of appropriations

(a) General authority; maximum amounts

There are authorized to be appropriated such sums as may be necessary to carry out sections 410cc to 410cc-37 of this title, except that—

(1) the total of the amounts authorized to be appropriated for the purpose of acquisition and development under the park management plan established pursuant to section 410cc-21(b) of this title and emergency assistance under section 410cc-25(a)(1) of this title shall not exceed $18,500,000; and

(2) the total of the amounts authorized to be appropriated for the purpose of carrying out section 410cc-32(b)(2) of this title, for the payment of grants and loans under section 410cc-33 of this title, for the acquisition of property under section 410cc-34 of this title, and for carrying out any transportation program and any educational and cultural program described in section 410cc-32(c) of this title shall not exceed $21,500,000.

(b) Commencement date

No funds shall be authorized pursuant to this section prior to October 1, 1978.

(c) Availability of appropriations

Funds appropriated under subsection (a) of this section shall remain available until expended.

(d) Aggregate amount of money expended; certifying statement to Congress as limiting availability of appropriated amounts

(1) Within 60 days after June 5, 1978, and on each subsequent October 1 and March 1, the Secretary shall submit to the Congress a statement certifying the aggregate amount of money expended by the Commonwealth of Massachusetts, the city of Lowell, and by any nonprofit entity for activities in the city of Lowell consistent with the purpose of sections 410cc to 410cc-37 of this title during the period beginning on January 1, 1974, and ending on the date such statement is submitted.

(2) The aggregate amount of funds made available by the Secretary to the Commission from funds appropriated under subsection (a)(2) of this section may not exceed the amount certified by the Secretary in the most recent statement submitted to the Congress under paragraph (1) of this subsection.

(Pub.L. 95-290, Title I, § 103, June 5, 1978, 92 Stat. 292.)

§ 410cc-14. Funding limitations

Notwithstanding any other provision of sections 410cc to 410cc-36 of this title, no authority to enter into agreements or to make payments under sections 410cc to 410cc-37 of this title shall be effective except to the extent, or in such amounts, as may be provided in advance in appropriation Acts.

(Pub.L. 95-290, Title I, § 104, June 5, 1978, 92 Stat. 292.)

PART B—POWERS AND DUTIES OF SECRETARY

§ 410cc-21. Park management plan; submission date and contents of preparatory statement to Congress; establishment, submission date, contents, etc., of plan

(a) The Secretary shall submit a statement to the Congress, within two years after the date on which funds are made available to carry out sections 410cc to 410cc-37 of this title, which—

(1) reports on the progress that the Secretary has made in acquiring the properties identified under section 410cc-22 of this title, and describes the way the Secretary intends to use these properties;

(2) identifies the properties within the park and preservation district respecting which the Secretary has entered into or intends to enter into agreements relating to interpretive exhibits or programs under section 410cc-23(a) of this title;

(3)(A) reports on the progress of the Secretary in leasing a portion of the Lowell Manufacturing Company, located on Market Street, for the purpose of establishing a visitors' center in close proximity to parking and other transportation facilities, and (B) identifies any other property within the park which the Secretary has leased or intends to lease for purposes of the park;

(4) reports any other activities which the Secretary has taken or intends to take to carry out the purpose of sections 410cc to 410cc-37 of this title; and

(5) contains a tentative budget for the park and preservation district for the subsequent five fiscal years.

(b)(1) Not later than three years after the date on which funds are made available to carry out sections 410cc to 410cc-37 of this title, the Secretary shall establish and submit to the Congress a park management plan containing the information described in subsection (a) of this section. Such plan shall, upon request, be available to the public.

(2) After consulting with the Commission, the city manager of Lowell, and the Commonwealth of Massachusetts, the Secretary may make revisions in the park management plan established pursuant to paragraph (1) of this subsection by publication of such revisions in the Federal Register. A revision made under this paragraph shall be effective 90 days after written notice of the revision is submitted to the Congress.

(Pub.L. 95-290, Title II, § 201, June 5, 1978, 92 Stat. 292.)

§ 410cc-22. Acquisition of property

(a) Specified property; manner of acquisition

(The Secretary is authorized to acquire the properties designated in paragraph (2) of this subsection, or any interest therein, by donation, purchase with donated or appropriated funds, condemnation, or otherwise. Any property or interest therein owned by the Commonwealth of Massachusetts or any political subdivision thereof may be acquired only by donation. The Secretary may initiate condemnation proceedings under this paragraph only after making every reasonable effort to acquire property through negotiations and purchase, and consulting with the Commission (if established) and the city council of Lowell.

(2) The properties referred to in paragraph (1) of this subsection are the following:

(A) The Linus Childs House, 63 Kirk Street.

(B) The H and H Paper Company (commonly referred to as Boott Mill Boarding House), 42 French Street.

(C) Old City Hall, 226 Merrimack Street.

(d) Merrimack Gatehouse, 269 Merrimack Street.

(E) The Wnnnalancit Textile Company, 562 Suffolk Street.

(F) The structures containing the Jade Pagoda and Solomon's Yard Goods, 210 and 200 Merrimack Street.

(b) Other property within park or preservation district; criteria for acquisition; manner of acquisition

Until the date on which the Commission conducts its first meeting, the Secretary may acquire any property within the park or preservation district not designated in subsection (a)(2) of this section, or any interest therein, if such property—

(1) is identified in the report of the Lowell Historical Canal District Commission as a property which should be preserved, restored, managed, developed, or maintained in a manner consistent with the purpose of sections 410cc to 410cc-37 of this title;

(2) is listed in the National Register of Historic Places, as maintained by the Secretary pursuant to section 470a(a) of this title, and section 462(b) of this title; or

(3) is determined by the Secretary to be of national significance;

and would be subject to demolition or major alteration in a manner inconsistent with the purposes of sections 410cc to 410cc-37 of this title unless acquired by the Secretary. Such property may be acquired only as provided in subsection (a)(1) of this section.

(c) Easements; manner of acquisition

The Secretary may acquire easements within the park for the purpose of carrying out sections 410cc to 410cc-37 of this title. Such easements may be acquired only as provided in subsection (a)(1) of this section.

(Pub.L. 95-290, Title II, § 202, June 5, 1978, 92 Stat. 293.)

§ 410cc-23. Agreements and technical assistance

(a) The Secretary may enter into agreements with any owner of property with national historic or cultural significance within the park to provide for interpretive exhibits or programs. Such agreements shall provide, whenever appropriate, that—

(1) the public may have access to such property at specified, reasonable times for purposes of viewing such property or the exhibits or attending the programs established by the Secretary under this subsection; and

(2) the Secretary may make such minor improvements to such property as the Secretary deems necessary to enhance the public use and enjoyment of such property, exhibits, and programs.

(b)(1) The Secretary shall provide, upon request, technical assistance to—

(A) the city of Lowell to assist the city in establishing regulations or laws consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title; and

(B) the Commission to assist the Commission in establishing the index and the standards and criteria required by section 410cc-32 of this title.

(2) The Secretary may provide to any owner of property within the park or preservation district, the Commission, the Commnnwealth of Massachusetts, the city of Lowell, and any other Federal entity or any institution such technical assistance as the Secretary considers appropriate to carry out the purpose of sections 410cc to 410cc-37 of this title.

(Pub.L. 95-290, Title II, § 203, June 5, 1978, 92 Stat. 294.)

§ 410cc-24. Withholding of funds; criteria

The Secretary may refuse to obligate or expend any money appropriated for the purposes described in section 410cc-13(a)(1) or section 410cc-13(a)(2) of this title if the Secretary determines that—

(a) the city of Lowell has failed to establish regulations or laws consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title within one year after the date such standards and criteria have been established, except that the Secretary may extend such one-year period for not more than six months if the Secretary determines that the city has made a good faith effort to establish such regulations or laws;

(b) the city of Lowell has failed to notify the Commission of (1) applications for building permits or zoning variances respecting any property which is included in the index established pursuant to section 410cc-32(d) of this title, or (2) any proposals of the city of Lowell to change the regulations or laws described in paragraph (c)(1) of this subsection;

(c)(1) during the period before the city of Lowell has established regulations or laws consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title, the city of Lowell has granted any building permit or zoning variance or has taken any other action respecting any property within the park or preservation district, which either the Secretary or the Commission consider to be inconsistent with such standards and criteria;

(2) after the city of Lowell has established the regulations or laws described in subparagraph (1) of this paragraph, the city of Lowell has granted any building permit or zoning variance or has taken any other action respecting any property within the park or preservation district, which either the Secretary or the Commission consider to be inconsistent with such regulations or laws; or

(d) the Commission has not made good faith efforts to (1) provide for the preservation, restoration, management, development, or maintenance of property within the park and preservation district or (2) carry out the park preservation plan approved under section 410cc-32 of this title.

(Pub.L. 95-290, Title II, § 204, June 5, 1978, 92 Stat. 294.)

§ 410cc-25. Administrative functions

(a) Implementation of park management plan; emergency assistance for protection of property owners; availability of funds for Commission

(1) The Secretary, acting through the National Park Service, shall take appropriate actions to implement to the extent practicable the park management plan established pursuant to section 410cc-21(b) of this title. In carrying out such plan, the Secretary shall administer the park in accordance with laws, rules, and regulations applicable to the national park system. Before the date on which the Commission conducts its first meeting, the Secretary may take any other action the Secretary deems necessary to provide owners of property with national historic or cultural significance within the park or preservation district with emergency assistance for the purpose of preserving and protecting their property in a manner consistent with the purpose of sections 410cc to 410cc-37 of this title.

(2) Subject to sections 410cc-24 and 410cc-32(b) of this title, the Secretary shall make available to the Commission any funds appropriated under section 410cc-13(a)(2) of this title for the purpose of carrying out sections 410cc-31 to 410cc-36 of this title.

(b) Acceptance of donations of funds, property, or services for implementation of park management plan

Notwithstanding any other provisions of law, the Secretary may accept donations of funds, property, or services from individuals, foundations, corporations, and other private entities, and from public entities, for the purpose of implementing the park management plan.

(c) Sponsorship or coordination of educational or cultural programs

The Secretary may sponsor or coordinate within the park and preservation district such educational or cultural programs as the Secretary considers appropriate to encourage appreciation of the resources of the park and preservation district.

(d) Acquisition of leases respecting property within park

The Secretary may acquire such leases respecting property within the park as may be necessary to carry out the purpose of sections 410cc to 410cc-37 of this title.

(Pub.L. 95-290, Title II, § 205, June 5, 1978, 92 Stat. 295.)

Part C—Powers and Duties of Preservation Commission

§ 410cc-31. Lowell Historic Preservation Commission

(a) Establishment and administrative role; composition of membership

There is established within the Department of the Interior a commission to be known as the Lowell Historic Preservation Commission which shall administer the preservation district and provide certain services within the park in accordance with this part. The Commission shall consist of fifteen members appointed by the Secretary as follows:

(1) Three members who are members of the city council of Lowell, appointed from recommendations made by the mayor of Lowell.

(2) Three members appointed from recommendations made by the city manager of Lowell of persons who are representative of organized labor, the business community, local neighborhoods, and cultural institutions, and who are not elected officials.

(3) One member appointed from recommendations made by the president of the University of Lowell.

(4) Three members appointed from recommendations made by the Governor of the Commonwealth of Massachusetts.

(5) One member appointed from recommendations made by the Secretary of Commerce and who shall be an employee of the Department of Commerce.

(6) One member appointed from recommendations made by the Secretary of Transportation and who shall be an employee of the Department of Transportation.

(7) One member appointed from recommendations made by the Secretary of Housing and Urban Development and who shall be an employee of the Department of Housing and Urban Development.

(8) Two members who are qualified to serve on the Commission because of their familiarity with programs of the Department of the Interior involving national parks and historic preservation and who shall be an employee of the Department of the Interior.

(b) Continuation of status as appointed member for member leaving government office or becoming elected official of government; duration

If any member of the Commission who was appointed to the Commission under paragraph (1) or (4) of subsection (a) of this section as a member of the city council of Lowell or any other government leaves that office, or if any member of the Commission who was appointed from persons who are not elected officials of any government becomes an elected official of a government, such person may continue as a member of the Commission for not longer than the thirty-day period beginning on the date such person leaves that office or becomes such an elected official, as the case may be.

(c) Terms of office and reappointment of members

(1) Except as provided in paragraph (2) of this subsection, members shall be appointed for terms of two years. A member may be reappointed only three times unless such member was originally appointed to fill a vacancy pursuant to subsection (e)(1) of this section, in which case such member may be reappointed four times.

(2) Of the members first appointed pursuant to subsection (a) of this section, the following shall be appointed for terms of three years:

(A) The members appointed pursuant to paragraphs (2), (3), and (8) of such subsection.

(B) One of the members appointed pursuant to paragraph (4) of such subsection, as designated by the Secretary at the time of appointment upon recommendation of the Governor.

(d) Chairman; election by members; term of office

The chairman of the Commission shall be elected by the members of the Commission. The term of the chairman shall be two years.

(e) Vacancies; appointment and term of office; service by member after expiration of term

(1) Any vacancy in the Commission shall be filled in the same manner in which the original appointment was made.

(2) Any member appointed to fill a vacancy shall serve for the remainder of the term for which his predecessor was appointed. Any member may serve after the expiration of his term for a period not longer than thirty days.

(f) Quorum and holding of hearings

Eight members of the Commission shall constitute a quorum, but a lesser number may hold hearings.

(g) Meetings

The Commission shall meet at least once each month, at the call of the chairman or a majority of its members.

(h) Compensation; travel expenses and per diem

(1) Except as provided in paragraph (2) of this subsection, members of the Commission shall each be entitled to receive $100 for each day (including travel time) during which they are engaged in the performance of the duties of the Commission.

(2) Members of the Commission who are full-time officers or employees of the United States, the city of Lowell, or the Commonwealth of Massachusetts shall receive no additional pay on account of their service on the Commission.

(3) While away from their homes or regular places of business in the performance of services for the Commission, members of the Commission shall be allowed travel expenses, including per diem in lieu of subsistence, in the same manner as persons employed intermittently in the Government service are allowed expenses under section 5703 of Title 5.

(i) Termination

The Commission established pursuant to sections 410cc to 410cc–37 of this title, shall cease to exist ten years from June 5, 1978.

(Pub L. 95-290, Title III, § 301, June 5, 1978, 92 Stat. 295.)

§ 410cc–32. Park preservation plan and index

(a) Submission by Commission and approval or disapproval by Secretary of draft and final plans; procedures applicable; revisions in approved plan

(1) Within one year after the date on which the Commission conducts its first meeting, the Commission shall submit to the Secretary a draft park preservation plan meeting the requirements of subsection (c) of this section. The Secretary shall review the draft park preservation plan and, within ninety days after the date on which such plan is submitted to the Secretary, suggest appropriate changes in such plan to the Commission.

(2) Within eighteen months after the date on which the Commission conducts its first meeting, the Commission shall submit to the Secretary a park preservation plan which meets the requirements of subsection (c) of this section. The Secretary shall, within ninety days after the date on which such plan is submitted to the Secretary, approve or disapprove such plan. The Secretary may not approve such plan unless the Secretary determines that such plan would adequately carry out the purpose of sections 410cc to 410cc–37 of this title.

(3) If the Secretary disapproves a park preservation plan, the Secretary shall advise the Commission of the reasons for such disapproval together with the recommendations of the Secretary for revision of such plan. Within such period as the Secretary may designate, the Commission shall submit a revised park preservation plan to the Secretary. The Secretary shall approve or disapprove any revised park preservation plan in the same manner as required in paragraph (2) of this subsection for the approval or disapproval of the original park preservation plan.

(4) If the Secretary approves a park preservation plan, the Secretary shall publish notice of such approval in the Federal Register and shall forward copies of the approved plan to the Congress.

(5) Any park preservation plan or draft plan submitted to the Secretary under this subsection shall, upon request, be available to the public.

(6) No changes other than minor revisions may be made in the approved park preservation plan without the approval of the Secretary. The Secretary shall approve or disapprove any proposed change in the approved park preservation plan, except minor revisions in the same manner as required in paragraph (2) of this subsection for the approval or disapproval of the original park preservation plan.

(b) Funding availability and requirements for plan implementation, activities, etc.

(1) Except as provided in paragraph (2) of this subsection, the Secretary shall not make any funds available to the Commission to carry out section 410cc–33 or 410cc–34 of this title until a park preservation plan has been approved under subsection (a) of this section.

(2) Before a park preservation plan is approved under subsection (a) of this section, the Secretary may make available to the Commission such funds as the Commission may request to carry out any activity specified in paragraph (3) of this section. However, no funds shall be made available under this paragraph unless a proposal describing such activity is reviewed and approved by the Secretary.

(3) The Commission may request funds from the Secretary to—

(A) carry out activities to preserve, restore, manage, develop, or maintain any property identified in subsection (c)(1) of this section;

(B) take any action the Commission considers necessary to provide owners of property with national historical or cultural significance within the park or preservation district with emergency assistance for the purpose of preserving and protecting their property in a manner consistent with the purpose of sections 410cc to 410cc–37 of this title; or

(C) acquire in accordance with section 410cc–34 of this title, any property within the park which—

(i) is identified in the report of the Lowell Historic Canal District Commission as a property which should be preserved, restored, managed, developed, or maintained in a manner consistent with the purpose of sections 410cc to 410cc–37 of this title;

(ii) is listed in the National Register of Historic Places, as maintained by the Secretary pursuant to section 470a(a) of this title, and section 462(b) of this title; or

(iii) is determined by the Secretary to be of national significance;

and would be subject to demolition or major alteration in a manner inconsistent with the purpose of sections 410cc to 410cc–37 of this title unless acquired by the Commission.

(c) Requirements for plan

Any plan submitted to the Secretary under subsection (a) of this section shall—

(1) describe the manner in which the Commission, to the extent practicable in accordance with the recommendations in the report of the Lowell Historic Canal District Commission, proposes to provide for the preservation, restoration, management, development, or maintenance of—

(A) the Welles Block, 169 Merrimack Street;

(B) the Jordan Marsh Company Building, 153 Merrimack Street and 15 Kirk Street;

(C) the Yorick Club, 91 Dutton Street;

(D) the Lowell Gas Light Company, 22 Shattuck Street;

(E) St. Anne's Church and Rectory, 237 Merrimack Street;

(F) Lowell Institution for Savings, 18 Shattuck Street;

(G) the Ahepa Building, 31 Kirk Street;

(H) Boott Mill, Foot of John Street;

(I) Lowell Manufacturing Company on Market Street; and

(J) the structure commonly referred to as the Early Residence, 45, 47, and 49 Kirk Street;

(2) identify the properties included in the index established pursuant to subsection (d) of this section;

(3) identify the properties which the Commission intends to acquire under section 410cc-34 of this title and specify how such properties shall be used;

(4) include the standards and criteria established pursuant to subsection (e) of this section;

(5) provide a detailed description of the manner in which the Commission intends to implement the grant and loan programs under section 410cc-33 of this title, including information relating to the estimated amount of such grants and the manner in which such grants shall be awarded by the Commission;

(6) provide for a transportation program by which the Commission shall provide, directly or by agreement with any person or any public or private entity, transportation services and facilities for park and preservation district visitors, including barge equipment, docking facilities, and local rail facilities;

(7) provide for educational and cultural programs to encourage appreciation of the resources of the park and preservation district; and

(8) include a tentative budget for the subsequent five fiscal years.

(d) Establishment and contents of index; modification of index

The Commission shall establish, within one year after the date on which the Commission conducts its first meeting, an index which includes—

(1) any property in the park or preservation district (except for any property identified in section 410cc-21(a)(2) of this title) which should be preserved, restored, managed, developed, maintained, or acquired by the Commission because of its national historic or cultural significance; and

(2) any property which should be preserved, restored, managed, developed, or maintained in a manner compatible with the purpose of sections 410cc to 410cc-37 of this title because of its proximity to (A) any property referred to in paragraph (1) of this subsection, or (B) any property designated in section 410cc-21(a)(2) of this title.

The index may be modified only by a majority vote of the members of the Commission, taken when a quorum is present.

(e) Standards and criteria for construction, preservation, etc., of properties within preservation district and park; authorization; establishment; revisions; publication in Federal Register

(1) The Commission shall establish standards and criteria applicable to the construction, preservation, restoration, alteration, and use of all properties within the preservation district with the advice of the Commonwealth of Massachusetts and of the Secretary, and the consent of the city manager of Lowell.

(2) The Commission shall establish the standards and criteria described in paragraph (1) of this subsection for any property within the park with the advice of the Commonwealth of Massachusetts and the city manager of Lowell and subject to the review and approval of the Secretary.

(3) The Commission shall establish standards and criteria under paragraphs (1) and (2) of this subsection within one year after the date on which the Commission conducts its first meeting. Such standnrds and criteria may be revised in the same manner in which they were originally established.

(4) The Secretary shall publish the standards and criteria established under paragraphs (1) and (2) of this subsection, and any revisions thereof, in the Federal Register.

(Pub.L. 95-290, Title III, § 302, June 5, 1978, 92 Stat. 297.)

§ 410cc-33. Financial and technical assistance

(a) Loans to Lowell Development and Financial Corporation for loans for preservation, etc., of property; terms of loan agreement with corporation; determination of compliance by corporation with requirements for loans; repayment by corporation

The Commission may make loans to the Lowell Development and Financial Corporation (established under chapter 844 of the Massachusetts General Laws and hereinafter referred to as the "corporation") to enable the corporation to provide low interest loans for the preservation, restoration, or development of any property described in section 410cc-32(d)(1) of this title. The Commission may make any such loan to the corporation only after entering into a loan agreement with the corporation which includes the following terms:

(1) The loan to the corporation shall have a maturity of thirty-five years. At the end of such period, the corporation shall repay to the Secretary of the Treasury (in a lump sum) for deposit in the general fund of the Treasury the full amount of the loan and any additional amounts accruing to the corporation pursuant to this subsection excepting those amounts expended by the corporation for reasonable administrative expenses.

(2) The money received from the Commission, and any interest earned on such money, may be obligated by the corporation only for low interest loans made under paragraphs (6) and (7) of this subsection, except that the corporation may use such money to the extent the Commission considers reasonable to satisfy the costs of the corporation in administering the loan or procuring loan guarantees or insurance.

(3) Within five years after receiving the loan from the Commission, the corporation shall make loans under paragraphs (6) and (7) of this subsection which, in the aggregate, obligate the full amount of money received from the Commission (minus any amount required to satisfy the costs described in paragraph (2) of this subsection).

(4) As loans made under paragraphs (6) and (7) of this subsection are repaid, the corporation shall make additional loans under such paragraphs with the money made available for obligation by such repayments.

(5) The corporation shall make available to the Commission and to the Secretary, upon request, all accounts, financial records, and other information related to loans made under paragraphs (6) and (7) of this subsection.

(6) Before the corporation approves any application for a low interest loan for which money has been made available to the corporation by the Commission, the corporation shall require the prospective borrower to furnish the corporation with a statement from the Commission stating that the Commission has reviewed the application and has determined that any loan received by the prospective borrower will be spent in a manner consistent with—

(A) the standards and criteria established pursuant to section 410cc-32(e) of this title, and

(B) the goals of the park preservation plan approved under section 410cc-32(a) of this title.

(7) The corporation may approve any application for a low interest loan which meets the terms and conditions prescribed by the corporation with the approval of the Commission and for which money has been made available to the corporation by the Commission if—

(A) the prospective borrower furnishes the corporation with the statement described in paragraph (6) of this subsection;

(B) the corporation determines that such borrower has sufficient financial resources to repay the loan; and

(C) such borrower satisfies any other applicable credit criteria established by the corporation.

In order to determine whether the corporation has complied with this subsection, the Commission, or such other appropriate person or entity as the Commission may designate, shall conduct an audit at least once every two years of all accounts, financial records, and other information related to loans made under paragraphs (6) and (7) of this subsection. If the Commission determines, after conducting a hearing on the record, that the corporation has substantially failed to comply with this subsection, the outstanding balance of any loan made to the corporation under this subsection shall become payable in full upon the demand of the Commission.

(b) Grants to property owners for preservation, etc., of property; grants to persons or public or private entities for educational and cultural programs or for necessary services; terms of grant agreements; recovery of amounts for inconsistent uses

(1) The Commission may make grants to owners of property described in section 410cc-32(d)(1) of this title for the preservation, restoration, management, development, or maintenance of such property in a manner consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title.

(2) The Commission, with the approval of the Secretary, may make grants to any person or any public or private entity to provide for (i) educational and cultural programs which encourage appreciation of the resources of the park and preservation district, or (ii) any planning, transportation, maintenance, or other services the Commission considers necessary to carry out the purposes of sections 410cc to 410cc-37 of this title.

(3) Grants under this subsection shall be made under agreements which specify the amount of the grant, the installments (if any) by which the grant shall be paid to the grant recipient, the purpose for which the grant may be used, and any other condition the Commission considers appropriate. The Commission shall be entitled, under the terms of any grant agreement, to recover from the recipient any funds used in a manner inconsistent with such grant agreement.

(c) Technical assistance to property owners, etc.

The Commission with the advice of the Secretary may provide technical assistance to—

(1) owners of property within the park or preservation district to assist such owners in (A) making repairs to or improvements in any property included in the index established pursuant to section 410cc-32(d) of this title, or (B) applying for loans under subsection (a) of this section; and

(2) any other person or public or private entity to assist such person or entity in taking actions consistent with the purpose of sections 410cc to 410cc-37 of this title.

(d) Availability to Secretary of all accounts, financial records, and other information relating to loans and grants

The Commission shall make available to the Secretary, upon request, all accounts, financial records, and other information of the Commission relating to grants and loans made under this section.

(e) Annual report to Congress; contents

The Secretary shall make an annual report to the Congress describing the loans, grants, and technical assistance provided under this section and under section 410cc-23 of this title. Such report shall specify the amount, recipient, and purpose of any loan, grant or technical assistance so provided and contain such additional information as the Secretary considers appropriate.

(Pub.L. 95-290, Title III, § 303, June 5, 1978, 92 Stat. 300.)

§ 410cc-34. Acquisition and disposition of property

(a) Acquisition of specified property; manner of acquisition

(1) The Commission may acquire any property designated in paragraph (3) of this subsection, any property described in section 410cc-32(d)(1) of this title, or any interest therein, by donation, by purchase with donated or appropriated funds, or by condemnation in accordance with paragraph (2) of this subsection.

(2) Only properties within the park or property designated in paragraph (3) of this subsection may be acquired by the Commission by condemnation. The Commission may initiate condemnation proceedings only after making every reasonable effort to acquire any such property through negotiations and purchase and consulting with the city council of Lowell. No lands or interests therein may be acquired by the Commission by condemnation without the approval of the Secretary.

(3) The Commission may acquire in accordance with paragraph (1) of this subsection the following properties, or any interest therein:

(A) World Furniture Building, 125 Central Street; and

(B) The Martin Building, 102-122 Central Street.

(b) Sale or lease of specified property; conditions

The Commission, with the approval of the Secretary, may sell or lease any property which it acquires under subsection (a) of this section subject to such deed restrictions or other conditions as the Commission deems appropriate to carry out the purpose of sections 410cc to 410cc-37 of this title.

(c) Agreement for disposal of specified property in Commonwealth of Massachusetts; purposes of transfers

Pursuant to a written agreement between the Commission and the Commonwealth of Massachusetts, the Commission, with the approval of the Secretary, may sell, donate, lease, or in any other manner the Commission and the Secretary deem appropriate make available to the Commonwealth any property which the Commission has acquired under subsection (a) of this section in order to provide for the administration or maintennnce of such property by the Commonwealth in a manner consistent with the purpose of sections 410cc to 410cc-37 of this title.

(Pub.L. 95-290, Title III, § 304, June 5, 1978, 92 Stat. 302.)

§ 410cc-35. Powers of Commission

(a) Conduct of hearings, etc.

The Commission may for the purpose of carrying out sections 410cc to 410cc-37 of this title hold such hearings, sit and act at such times and places, take such testimony, and receive such evidence, as the Commission may deem advisable. The Commission may administer oaths or affirmations to witnesses appearing before it.

(b) Authorization of action by member or agent

When so authorized by the Commission, any member or agent of the Commission may take any action which the Commission is authorized to take by this section.

(c) Receipt of necessary information from other Federal departments or agencies; information furnished upon request by Chairman

Subject to section 552a of Title 5, the Commission may secure directly from any department or agency of the United States information necessary to enable it to carry out sections 410cc to 410cc-37 of this title. Upon request of the chairman of the Commission, the head of such department or agency shall furnish such information to the Commission.

(d) Authorization to seek and accept donations of funds, property, or services

Notwithstanding any other provision of law, the Commission may seek and accept donations of funds, property, or services from individuals, foundations, corporations, and other private entities, and from public entities, for the purpose of carrying out its duties.

(e) Use of funds for obtaining additional moneys

The Commission may use its funds to obtain money from any source under any program or law requiring the recipient of such money to make a contribution in order to receive such money.

(f) Use of mails

The Commission may use the United States mails in the same manner and upon the same conditions as other departments and agencies of the United States.

(g) Purchase, rental, donation, etc., of property, facilities, and services; manner of acquisition; transfers to Department of Interior upon termination of Commission

The Commission may obtain by purchase, rental, donation, or otherwise, such property, facilities, and services as may be needed to carry out its duties. Any acquisition of property by the Commission shall be in accordance with section 410cc-34 of this title: *Provided, however,* That the Commission may not acquire lan . or interests therein pursuant to this subsection by condemnation. Upon the termination of the Commission, all property, personnl and real, and unexpended funds shall be transferred to the Department of the Interior.

(Pub.L. 95-290, Title III, § 305, June 5, 1978, 92 Stat. 302.)

§ 410cc-36. Staff of Commission

(a) Appointment and compensation of Director

The Commission shall have a Director who shall be appointed by the Commission and who shall be paid at a rate not to exceed the rate of pay payable for grade GS-15 of the General Schedule.

(b) Appointment and compensation of additional personnel

The Commission may appoint and fix the pay of such additional personnel as the Commission deems desirable.

(c) Applicability of civil service provisions to appointment and compensation of Director and staff

The Director and staff of the Commission may be appointed without regard to the provisions of Title 5 governing appointments in the competitive service, and may be paid without regard to the provisions of chapter 51, and subchapter III of chapter 53 of such title relating to classification and General Schedule pay rates, except that no individual so appointed may receive pay in excess of the annual rate of basic pay payable for grade GS-15 of the General Schedule.

(d) Temporary or intermittent services; procurement and compensation

Subject to such rules as may be adopted by the Commission, the Commission may procure temporary and intermittent services to the same extent as is authorized by section 3109(b) of Title 5, but at rates determined by the Commission to be reasonable.

(e) Detail of personnel from other Federal agencies represented by members on Commission; reimbursement by Commission; administrative support services by Administrator of General Services Administration; reimbursement by Commission

(1) Upon request of the Commission, the head of any Federal agency represented by members on the Commission may detail, on a reimbursable basis, any of the personnel of such agency to the Commission to assist it in carrying out its duties under sections 410cc to 410cc-37 of this title.

(2) The Administrator of the General Services Administration shall provide to the Commission on a reimbursable basis such administrative support services as the Commission may request.

(Pub.L. 95-290, Title III, § 306, June 5, 1978, 92 Stat. 303.)

§ 410cc-37. Use of funds; maintenance of financial records; audits

(a) Any revenues or other assets acquired by the Commission by donation, the lease or sale of property or fees for services shall be available to the Commission, without fiscal year limitation, to be used for any function of the Commission authorized under sections 410cc to 410cc-37 of this title. The Commission shall keep financial records fully disclosing the amount and source of revenues and other assets acquired by the Commission, and shall keep such other financial records as the Secretary may prescribe.

(b) The Secretary shall require audits of the financial records of the Commission to be conducted not less frequently than once each year in order to ensure that revenues and other assets of the Commission are being used in a manner authorized under sections 410cc to 410cc-37 of this title.

(Pub.L. 95-290, Title III, § 307, as added Pub.L. 96-344, § 10, Sept. 8, 1980, 94 Stat. 1136.)

An Act

Oct. 16, 1987
[H.R. 2035]

To amend the Act establishing Lowell National Historical Park, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. AMENDMENTS.

The Act entitled "An Act to provide for the establishment of the Lowell National Historical Park in the Commonwealth of Massachusetts, and for other purposes", approved June 5, 1978 (92 Stat. 290; 16 U.S.C. 410cc et seq.), is amended—

16 USC 410cc-13.
(1) in section 103(a)—

(A) by striking "$18,500,000" and inserting "$19,900,000" in paragraph (1); and

(B) by striking "$21,500,000" and inserting "$33,600,000" in paragraph (2);

16 USC 410cc-31.
(2) in section 301(e)(2) by striking "for a period not longer than thirty days" and inserting "until his successor is appointed"; and

(3) in section 301(i) by striking "ten" and inserting "seventeen".

16 USC 410cc-13 note.
SEC. 2. EFFECTIVE DATES.

(a) IN GENERAL.—Except as provided in subsection (b), the amendments made by section 1 shall take effect on the date of the enactment of this Act.

(b) EFFECTIVE DATE OF AUTHORIZATION OF APPROPRIATION.—The amendments mode by section 1(1) shall take effect on October 1, 1987.

Approved October 16, 1987.

Form No. 10-300 (Rev. 10-74)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

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NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

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SEE INSTRUCTIONS IN *HOW TO COMPLETE NATIONAL REGISTER FORMS*
TYPE ALL ENTRIES -- COMPLETE APPLICABLE SECTIONS

1 NAME

HISTORIC
Locks and Canals Historic District

AND/OR COMMON
same

2 LOCATION

STREET & NUMBER
multiple

__NOT FOR PUBLICATION

CITY, TOWN
Lowell

__ VICINITY OF

CONGRESSIONAL DISTRICT
5

STATE
Massachusetts

CODE
025

COUNTY
Middlesex

CODE
017

3 CLASSIFICATION

CATEGORY	OWNERSHIP	STATUS	PRESENT USE	
X_DISTRICT	__PUBLIC	X_OCCUPIED	__AGRICULTURE	__MUSEUM
__BUILDING(S)	__PRIVATE	__UNOCCUPIED	X_COMMERCIAL	X_PARK
__STRUCTURE	X_BOTH	X_WORK IN PROGRESS	__EDUCATIONAL	__PRIVATE RESIDENCE
__SITE	**PUBLIC ACQUISITION**	**ACCESSIBLE**	__ENTERTAINMENT	__RELIGIOUS
__OBJECT	X_IN PROCESS	__YES: RESTRICTED	__GOVERNMENT	__SCIENTIFIC
	__BEING CONSIDERED	X_YES: UNRESTRICTED	X_INDUSTRIAL	__TRANSPORTATION
		__NO	__MILITARY	__OTHER:

4 OWNER OF PROPERTY

NAME
multiple ownership

STREET & NUMBER

CITY, TOWN
Lowell

__ VICINITY OF

STATE
Massachusetts

5 LOCATION OF LEGAL DESCRIPTION

COURTHOUSE, REGISTRY OF DEEDS, ETC.
Northern Middlesex District Registry of Deeds

STREET & NUMBER
Goreham Street

CITY, TOWN
Lowell

STATE
Massachusetts

6 REPRESENTATION IN EXISTING SURVEYS

TITLE
Inventory of the Historic Assets of the Commonwealth/ HAER

DATE
1976

X_FEDERAL X_STATE __COUNTY __LOCAL

DEPOSITORY FOR SURVEY RECORDS
Massachusetts Historical Commission/ Library of Congress

CITY, TOWN
Boston/ Washington D.C.

STATE
Massachusetts

7 DESCRIPTION

CONDITION		CHECK ONE	CHECK ONE
__EXCELLENT	__DETERIORATED	__UNALTERED	X ORIGINAL SITE
X GOOD	__RUINS	X ALTERED	__MOVED DATE______
__FAIR	__UNEXPOSED		

DESCRIBE THE PRESENT AND ORIGINAL (IF KNOWN) PHYSICAL APPEARANCE

'he Locks and Canals Historic District encompasses all of the canals in Lowell, (built between 1793 and 1848), their associated locks, and the mills that were powered by the canals. There are about five miles of canals, and the associated mill yards increase the creage of the nominated district to approximately 100 acres. The canals are all contiguous hough they meander throughout the city. The mill buildings and yards are all associated irectly with a canal, and three boarding houses, not contiguous to the canals but built y mill owners for their workers, are also included in the district.

'he Pawtucket Canal, the first canal to be built in Lowell, leaves the Merrimack River a ew hundred yards upstream from the Pawtucket Dam. The site of the guard locks, about ,000 feet from the head of the canal, has been in continuous use since the canal was pened to navigation in 1796, and the present structures and facilities include the Francis ate, a lock house and a sluice gate house. The Francis Gate (#2) also known locally as rancis' Folly, is a proticullis flood gate, built in 1848-1850. The lock house (#1), uilt in 1881 over the upstream gate of the locking chamber, replaced an earlier 1852 tructure. It is a wooden frame building with round arched windows and a slate hipped oof. The sluice gate house (#3) built in 1870, is a brick Romanesque structure with ound arched windows and a slate ridge roof, containing machinery for five gates. Maonry work around the Guard Locks includes the lower part of the dam (1832), the upper dam ortion (1848), the walls of the upstream island and lock chamber (1801) and downstream ock chamber (1877) and the downstream wall of the power canal chamber, built in 1867 nd 1900.

ne Northern Canal (#7), the last canal to be built, was constructed in 1846-48. It was uilt as a feeder canal to supplement the Pawtucket Canal and to raise the water level t the lower end of the canal system. Its construction provided for almost perfect conrol of the water level in the canal system and greatly increased its complexity by reersing flows and transforming some canals from power to feeder uses.

ne Great River Wall surmounted by the Northern Canal Walk (#8) was created by the conruction of the Northern Canal. The Great Wall is a 2,200 foot section of the canal all that separates the Northern Canal from the river. The Northern Canal Gatehouse, ne blacksmith shop and the Gate Keeper's Cottage are all located at the head of the orthern Canal. The Gatehouse (#4), constructed in 1847, is a one-story brick Romansque Revival structure with round arched windows and a slate ridge roof; the interior conains ten guard sluice gates and the Francis turbine. Opposite the building is a navjation lock. The Locks and Canals Blacksmith Shop (#5) is a simple wood shed built next the river, and is used to repair the lock machinery after spring flooding. Next to the ate House is the Gate Keeper's Cottage (#6), a one and one-half story Victorian wood rame cottage built c. 1850 to serve as living quarters for the gate keeper.

e Suffolk Millyard (#9) adjacent to the Northern Canal, covers approximately five acres. e of the earliest corporations, the yard was built in 1831, but the major courtyard was built in 1863. The buildings are primarily Romanesque Revival although much of the rly Federal styling remains. Structures of particular interest are the Counting House d an 1831 boarding house converted for industrial use. The Suffolk Manufacturing Comny Boarding Houses (#3) across French Street from the Suffolk Yard, were constructed 1845. Five units at the northern end of this fine example of workers' row housing re removed in the 1960's to allow construction of the French Street extension, a part of e Northern Canal Urban Renewal Project, but the remaining block has been re-habed.

continued

SIGNIFICANCE

PERIOD

- __PREHISTORIC
- __1400-1499
- __1500-1599
- __1600-1699
- X 1700-1799
- X 1800-1899
- __1900-

AREAS OF SIGNIFICANCE -- CHECK AND JUSTIFY BELOW

- __ARCHEOLOGY-PREHISTORIC
- __ARCHEOLOGY-HISTORIC
- __AGRICULTURE
- __ARCHITECTURE
- __ART
- X COMMERCE
- __COMMUNICATIONS
- __COMMUNITY PLANNING
- __CONSERVATION
- __ECONOMICS
- __EDUCATION
- X ENGINEERING
- __EXPLORATION/SETTLEMENT
- X INDUSTRY
- __INVENTION
- __LANDSCAPE ARCHITECTURE
- __LAW
- __LITERATURE
- __MILITARY
- __MUSIC
- __PHILOSOPHY
- __POLITICS/GOVERNMENT
- __RELIGION
- __SCIENCE
- __SCULPTURE
- __SOCIAL/HUMANITARIAN
- __THEATER
- X TRANSPORTATION
- __OTHER (SPECIFY)

SPECIFIC DATES 1790-1870 BUILDER/ARCHITECT

STATEMENT OF SIGNIFICANCE

The Locks and Canals Historic District in Lowell is significant for its contributions to the development of Lowell as the first great industrial city in the United States. The industrial revolution in North America was first initiated on a large scale in Lowell, and our industrial economy and present levels of technology are a reflection of Lowell's manufacturing experiments.

In 1792 Governor John Hancock signed a charter incorporating the Proprietors of the Locks and Canals on the Merrimack River. The charter gave to this group of Newburyport merchants riparian rights on the Merrimack River from the Massachusetts border to the Atlantic Ocean, and more specifically, the right to build locks and a canal to circumvent the Pawtucket Falls. This canal, opened in 1796, formed an island between itself and the Merrimack River, where the City of Lowell later developed. The canal was used to transport lumber, foodstuffs and people around the Pawtucket Falls on their journey from New Hampshire to Newburyport. In 1803 the Middlesex Canal opened, funnelling off to Boston the traffic which had been going to Newburyport, and caused the Pawtucket Canal to fail financially.

In 1822 the Merrimack Manufacturing Company, founded by Patrick Tracy Jackson and Nathan Appleton, bought up the holdings of the Proprietors and all of the land between the Merri- ack River and the Pawtucket Canal. Both Jackson and Appleton had been partners of Francis abot Lowell in his successful mill at Waltham, Massachusetts where, for the first time, otton was processed into cloth within a single building. At the Waltham mill Francis owell had developed the system of boarding houses and strict social regulation, which rought New England farm girls into the mills and had such an impact on the early days f the American industrial revolution. Expansion of the mill at Waltham was not possible ecause the Charles River was too slow moving to provide sufficient power, so after Lowell's eath in 1816, his partners, searching for a new site, chose the area that is now the city f Lowell.

n 1825 the Merrimack Manufacturing Company had widened the Pawtucket Canal and constructed he Merrimack Canal. They built the first large mill (no longer extant) to be established n Lowell between the Merrimack River and Merrimack Canal and paved the way for future ill development. The first mill used only a fraction of the available water power, so he Merrimack Company, determined to keep out of the development business, sold its water ower rights and unused land back to the Proprietors of the Locks and Canals, who were re- rganized to develop the area by selling land and water power, building additional canals d supplying textile mechinery to the mills. The Locks and Canals Company built the milton Canal in 1826, the Lowell Canal in 1828, the Western Canal in 1831-32, the Eastern nal in 1835, and finally the Northern Canal in 1847. Each of the new canals supplied wer to new mill companies, built on the best sites to obtain power. The first priority . the development of the town was to bring water power to these mills; corporate housing, ivate businesses, and homes were built only where they did not interfere with the

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#7:

The Tremont Gatehouse (#10), a one-story ridge roof Romanesque Revival building, five bays wide, was constructed in 1855 as a component of the Northern Canal Project. Its purpose was to direct the flow of water from the Northern Canal through the upper level of the Western Canal to the Lawrence Yard, should the flow from the Suffolk and Tremont tailraces prove insufficient. The Tremont Yard (#11), next to the Western Canal, incorporates a site of about five acres and was the location of the Tremont Corporation, formed in 1830. The structures were razed in the 1930's and only fragments of the buildings remain.

The Lawrence Yard (#12), bounded by the Western Canal and the Merrimack River, covers approximately nine acres and contains structures ranging in date from 1826 to 1909. The weaving and spinning mills are principally Federal in style, four to six stories in height with Romanesque Revival additions and ornamentation. The Counting House is a particularly notable two-story High Victorian Gothic structure distinguished by the polychromatic banding of its slate roof. The Lawrence Canal, about 500 feet long, was constructed in 1831 and runs westerly from the Western Canal to provide water power for the Lawrence Yards.

Completed in 1848, the Moody Street Feeder (#13) was also built as part of the Northern Canal project, to increase the supply of water flowing into the Merrimack and Eastern Canals via the Boott Penstock. The Feeder extends from the Western Canal to the Merrimack Canal and consists of three brick vaulted tunnels. The Merrimack Canal Gate House (#14), built over the Moody Street Feeder and completed in 1848, is a Romanesque Revival building, two bays wide and six bays long. The building is distinguished by its fine dentiled cornice. The Gate House contains three service gates, each manually operated with counterweighted rock and pinion equipment over the waterway. The gate operating equipment is original to the feeder construction except for the counterweight system which was added in 1853. The building is already listed in the National Register as part of the City Hall Historic District.

The Eastern Canal (#22) runs northerly from the Pawtucket Canal just above the lower locks and, bending 90°, runs parallel to the Merrimack River but flows in the opposite direction. The Canal is 1,913 feet long and provided power to the Prescott, Massachusetts and Boott Mills. The Boott Mills (#15), bounded by the Merrimack River and the Eastern Canal, were founded in 1839. The cores of the majority of the buildings date from this period, but the yard was extensively rebuilt in the 1860's. The Romanesque Revival style of this completely intact millyard is enhanced by a graceful octagonal cupola and bell tower. The site comprises about six acres and is completely enclosed by buildings which form two interior courtyards.

The Massachusetts Mills Boarding House (#18), constructed in the 1840's by the Massachusetts Mills, is a three and one-half story Greek Revival building. The first floor has been altered for commercial use. The Boott Mills Boarding House (#17), across French Street from the Massachusetts Mills Boarding House, was also constructed in the 1840's. In the 1890's a Queen Anne facade was applied to the Bridge Street elevation and a wing was attached at the southwest corner, facing French Street.

continued

#7:

The Pawtucket Canal, both upper (#31) and lower (#23) portions, was originally constructed between 1792-96 with four sets of locks, for use as a navigation canal around the Pawtucket Falls on the Merrimack River. Falling into disuse after the opening of the Middlesex Canal in 1805, it was extensively rebuilt between 1821-25 to provide both transportation and water power to the Lowell mills. The canal is 9,188 feet long and is the backbone of the locks and canals system. The Lower Locks (#19) on the Lower Pawtucket Canal were originally built in 1822, and rebuilt in 1841. The locks consist of a dam and two navigation locks, covered by a frame structure. The Merrimack Canal (#27) was built in 1822-23 to provide water power to the Merrimack Manufacturing Co., Lowell's first mill yard, no longer extant. It runs in a northerly direction 2,586 feet from the Pawtucket Canal at the Swamp Locks and eventually discharges into the Merrimack River. It includes a dam and a connector to the Eastern Canal, the Boott Penstock. The Bigelow Yard (#20), originally founded in 1828, is located between the Merrimack and Lower Pawtucket Canals. The only extant structures include a four-story Romanesque Revival structure from the 1870's and three other buildings from the 1890's. The Lowell Canal, now covered, was built in 1828 to supply water to this yard. It is 500 feet long, has a drop of thirteen feet, and runs between the Merrimack and Lower Pawtucket Canals.

The Hamilton Canal (#25), 1,771 feet long, runs parallel to the Pawtucket Canal from the Swamp Locks and discharges into the Pawtucket Canal by raceways through the Hamilton and Appleton Yards. It was constructed in 1826 to power the aforementioned mills, and has a fall of 13 feet. The Hamilton Yard (#21) was the site of Lowell's second oldest manufacturing company, the Hamilton Mills, incorporated in 1825. The structure now standing along the Pawtucket Canal is early Greek Revival distinguished by triangular granite pediments over the windows, and granite lintels on square brackets. The fifth and sixth floors and the other structures in the yard are Romanesque Revival dating from the rebuilding of the 1860's and 70's. The Appleton Mills (#24) east of the Hamilton Yard, were founded in 1828. The structures on the island between the Hamilton and Pawtucket Canals nearly all date from the c. 1905 rebuilding; the structures on the south side of Jackson Street were built in 1873 and are Romanesque Revival. The Swamp Locks (#26) similar to the Lower Locks, were built in 1822-23 and rebuilt in 1839-41.

The Lowell Machine Shop (#28), razed in the 1930's, stood in the island formed by the Lowell, Merrimack and Pawtucket Canals. The only remaining portions of the shop are on Dutton Street; a mill, constructed c. 1890 and c. 1910, and a reinforced concrete plant built in 1911 now cover the site of the Machine Shop boarding houses. The Proprietors of the Locks and Canals Yard, containing one and one-half and two-story buildings now used as offices and shops, are frame Italianate structures built in the 1850's to serve as the administrative headquarters for the canal system.

The Western Canal (#30), a mile long, originally ran northwesterly from the Pawtucket Canal to provide water power to the Tremont, Suffolk and Lawrence Mills. The construction of the Northern Canal changed its direction so that it now flows south from the Northern Canal to the Swamp Locks, but continues to flow north from the Tremont Gate House to power

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the Tremont, Suffolk and Lawrence Mills.

The Pawtucket Dam (#32), built between 1826-1830 at the Pawtucket Falls, created a "mill pond" on the Merrimack River eighteen miles long. The dam has been continually modified throughout the nineteenth century.

#8:

routing of water power and the production of textiles. The population of Lowell mushroomed during this period, from 200 people in 1822 to over 33,000 in 1850.

The engineering involved in the construction of the canals was extremely complex, and each new canal was built in an attempt to solve the problem of keeping all the mills supplied with a sufficient supply of power. The construction of the Northern Canal, the most complex of all because it reversed the flow of the Western Canal, finally increased the average flow of water to each mill sufficiently to solve the distribution problem. The hydro-engineering breakthroughs of the canal engineers, including James Francis and George Whistler, received international acclaim and recognition, and their techniques were used world-wide. The sociological pattern of corporate paternalism in Lowell, manifested by the mill-owned boarding houses and strictly run social functions, also received international recognition and served as a model for Utopian industrial communities in the United States and Europe.

Unfortunately, Lowell's position as a leader in the field of science and as an ideal industrial society was lost in the last quarter of the nineteenth century. The latter nineteenth century mill owners were more concerned about making a profit than in their workers' welfare and the waves of immigrants who poured into Lowell completed the destruction of the boarding house system; speculative tenement flats became the norm. In this century, when many of the major textile companies left the north to move south to cheaper power and labor sources, Lowell was left with huge empty mill buildings, a large canal system and a high level of unemployment. The entire city has been affected by this economic depression and most of the commercial, industrial and residential buildings in the district have deteriorated.

Prospects for Lowell are now looking brighter. The State of Massachusetts, through the Department of Environmental Management, is in the process of acquiring all of the locks and canals and turning them into a state heritage park. The Federal government is considering the creation of an urban cultural park in Lowell, and Federal funds, through the Department of Housing and Urban Development and funds appropriated especially for Lowell are being expended to upgrade housing and to rehab existing mill buildings. New uses are being sought for the abundant mill space in the district, both in order to save the buildings and to provide jobs.

9 MAJOR BIBLIOGRAPHICAL REFERENCES

Historic American Engineering Record Survey Inventory; Spec Struc:Hydra (81.2), 1975
Coolidge, John, Mill and Mansion, Russell & Russell, New York 1967
Malone, Patrick, The Power Canals of Lowell, Massachusetts; Human Services Corporation Lowell, 1973

10 GEOGRAPHICAL DATA

ACREAGE OF NOMINATED PROPERTY approximately 100 acres

UTM REFERENCES

	ZONE	EASTING	NORTHING		ZONE	EASTING	NORTHING
A	1 9	3 0 9 9 6 0	4 7 2 4 9 0 0	B	1 9	3 1 1 2 9 0	4 7 2 3 8 4 0
C	1 9	3 0 9 3 6 0	4 7 2 2 6 8 0	D	1 9	3 0 8 5 4 0	4 7 2 4 1 6 0

VERBAL BOUNDARY DESCRIPTION

see district sketch map

LIST ALL STATES AND COUNTIES FOR PROPERTIES OVERLAPPING STATE OR COUNTY BOUNDARIES

STATE	CODE	COUNTY	CODE
STATE	CODE	COUNTY	CODE

11 FORM PREPARED BY

NAME / TITLE
Christine Boulding, Preservation Planner, and Joe Orfant

ORGANIZATION
Massachusetts Historical Commission

DATE
March 1976

STREET & NUMBER
294 Washington Street

TELEPHONE
617-727-8470

CITY OR TOWN
Boston

STATE
Massachusetts 02108

12 STATE HISTORIC PRESERVATION OFFICER CERTIFICATION

THE EVALUATED SIGNIFICANCE OF THIS PROPERTY WITHIN THE STATE IS:

NATIONAL X STATE X LOCAL ___

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

STATE HISTORIC PRESERVATION OFFICER SIGNATURE Elizabeth Reed Amadon

TITLE Executive Director, Massachusetts Historical Commission DATE 3/30/76

OR NPS USE ONLY

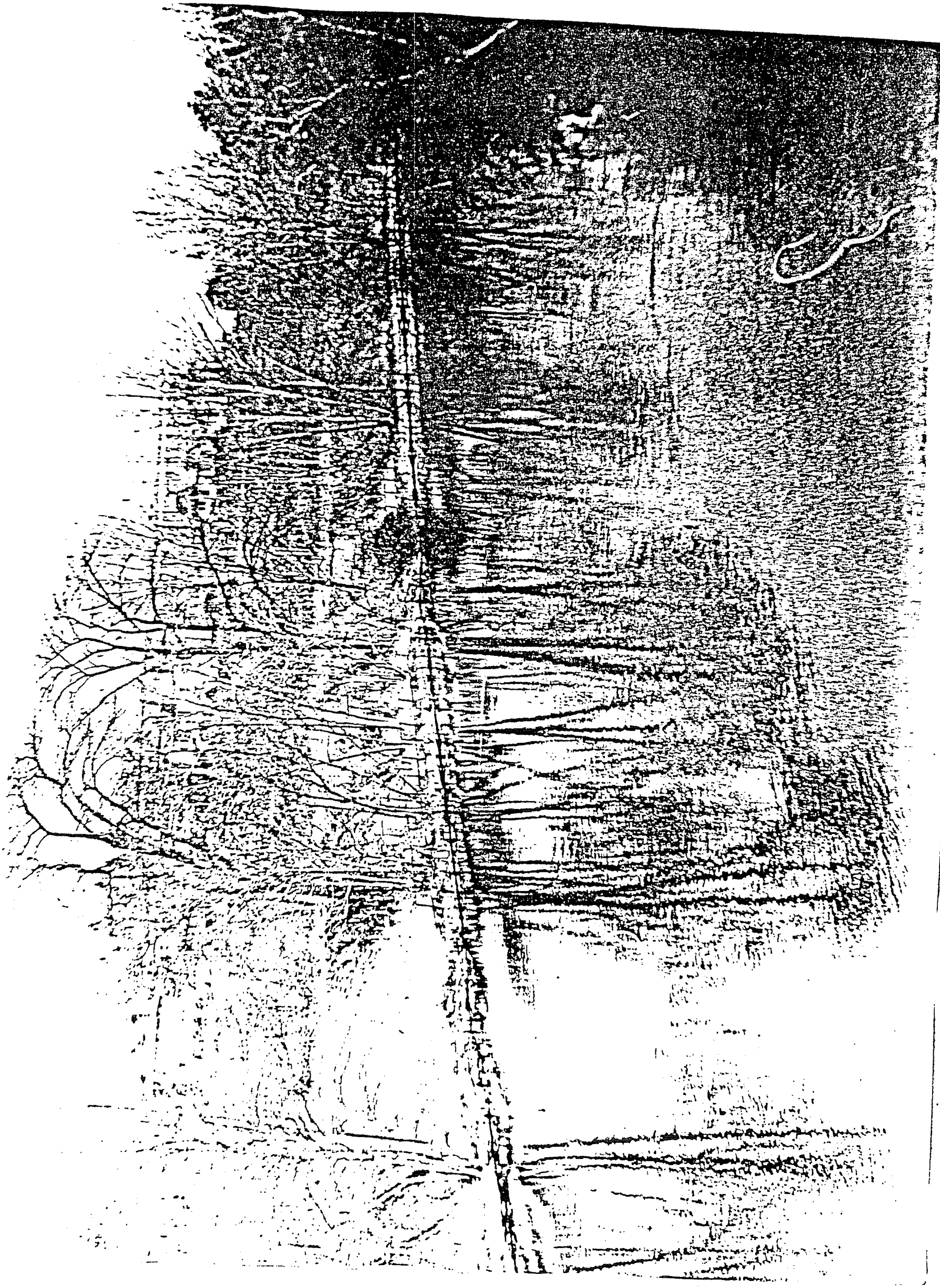
I HEREBY CERTIFY THAT THIS PROPERTY IS INCLUDED IN THE NATIONAL REGISTER

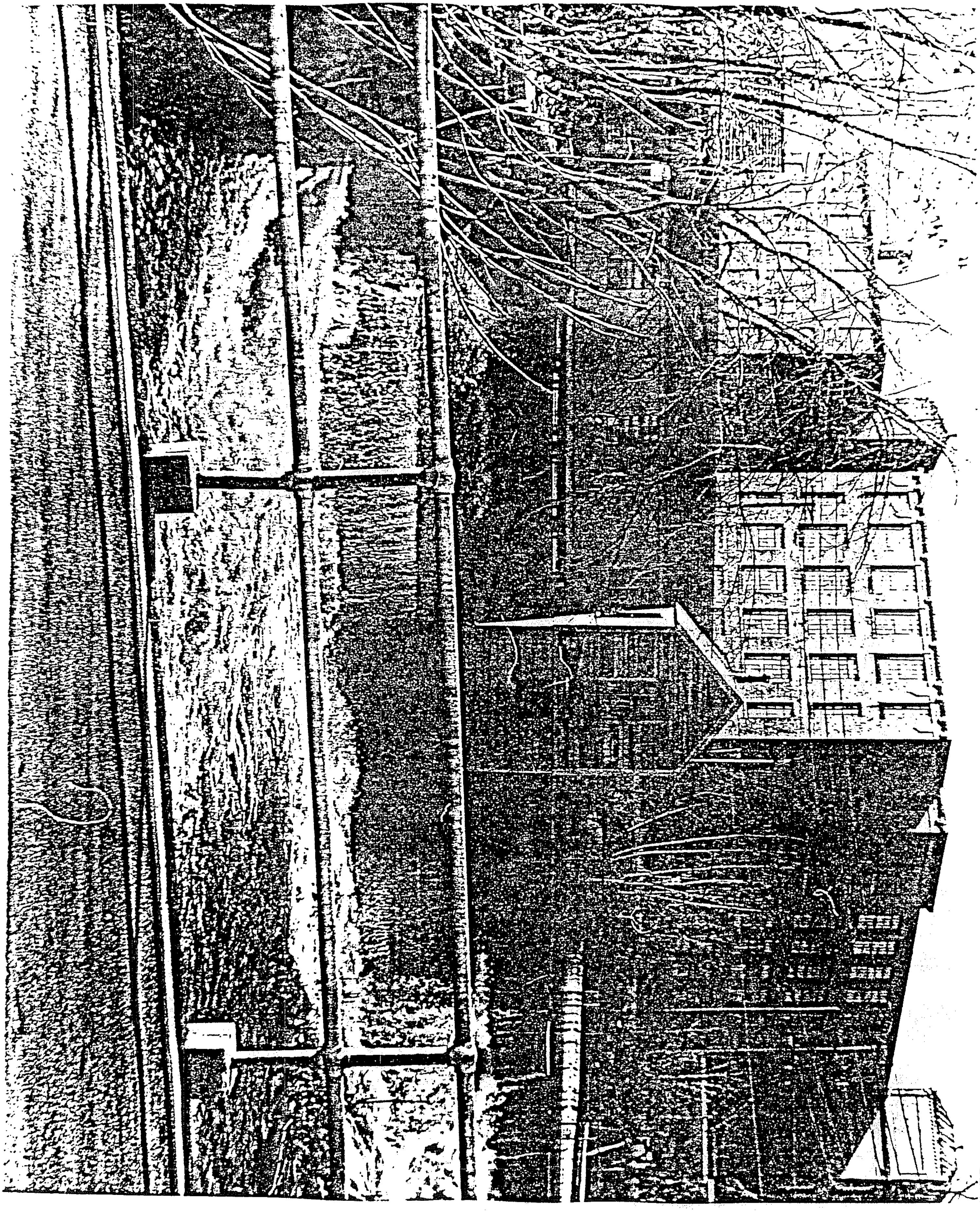
DATE

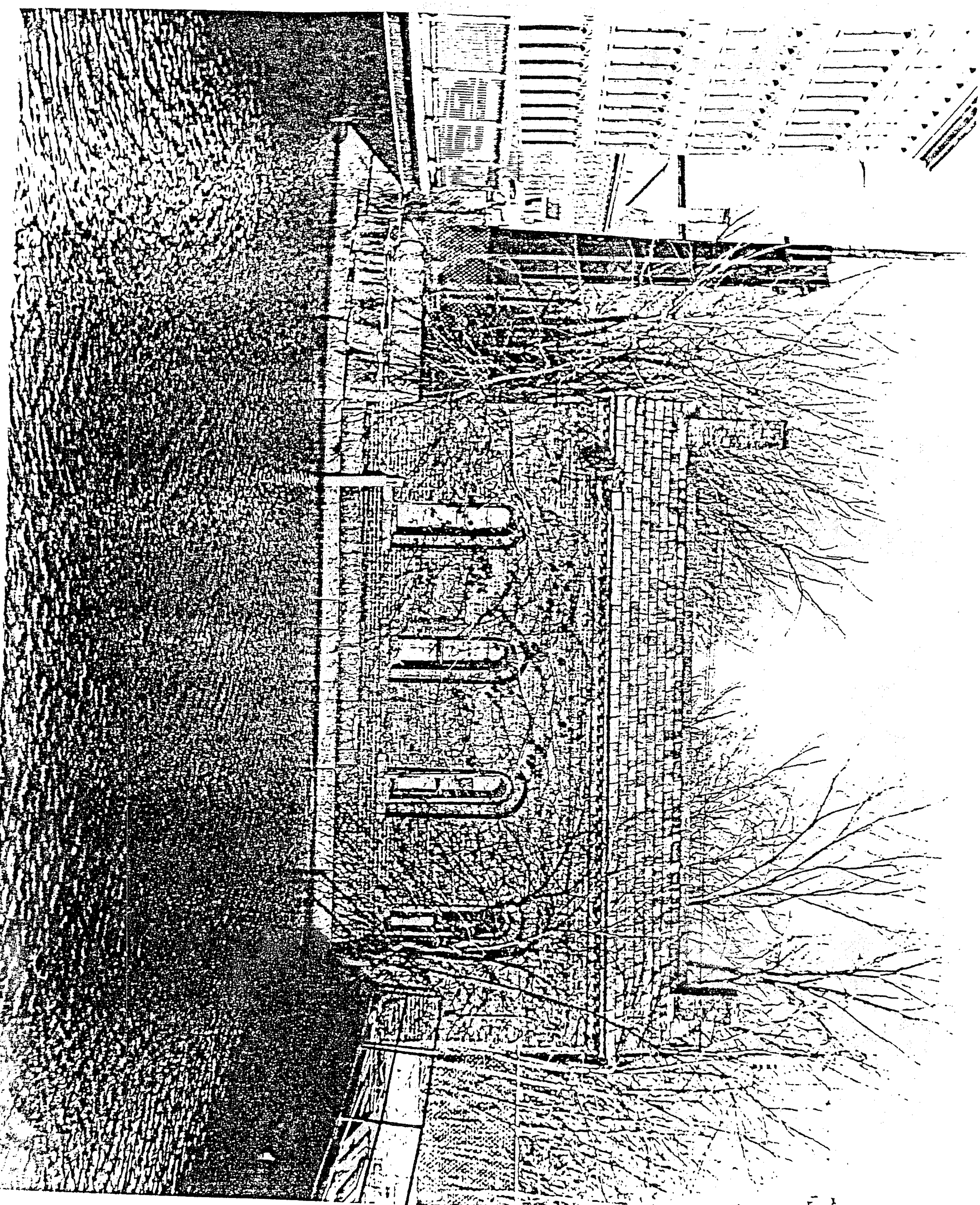
DIRECTOR, OFFICE OF ARCHEOLOGY AND HISTORIC PRESERVATION

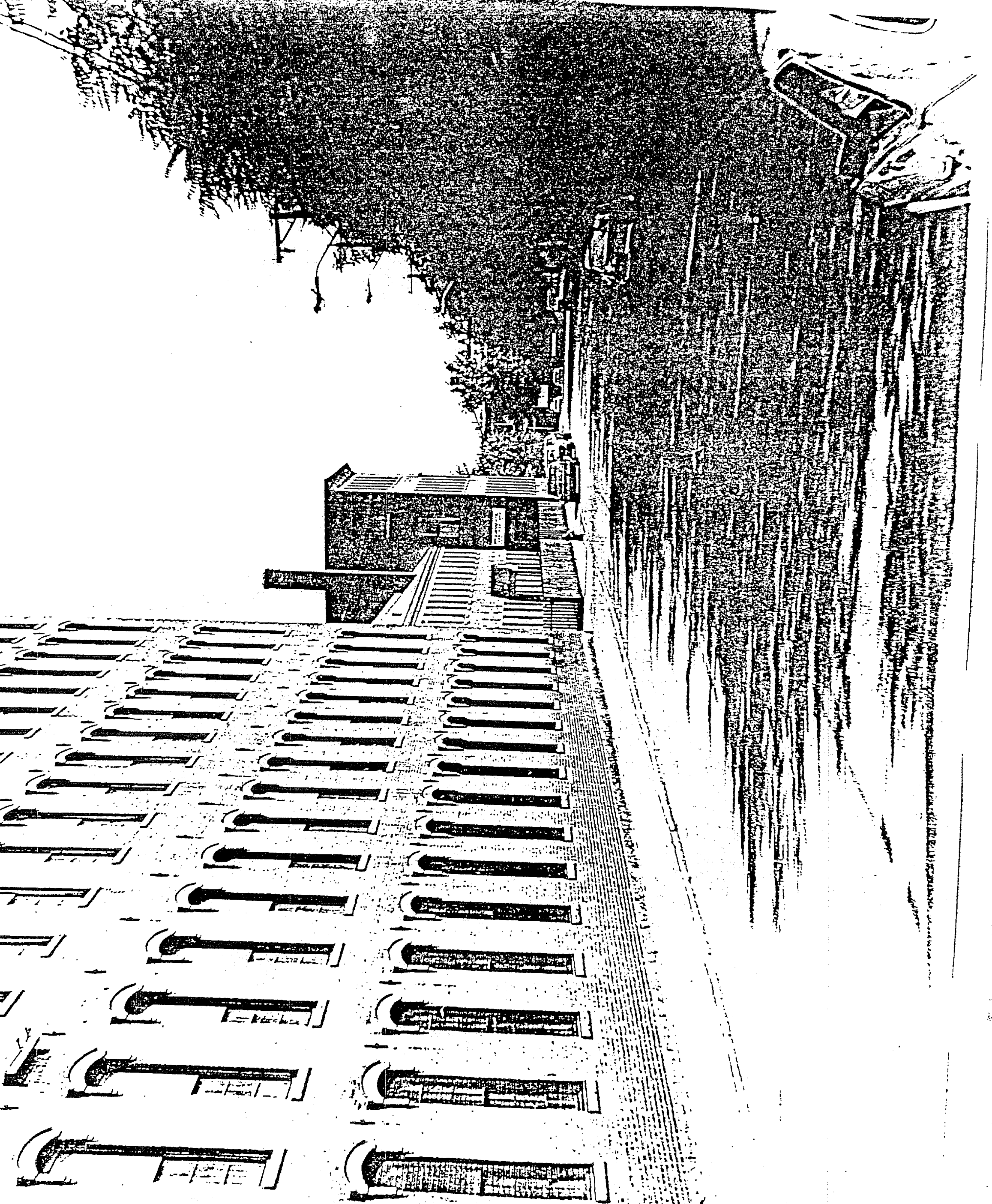
TTEST: DATE

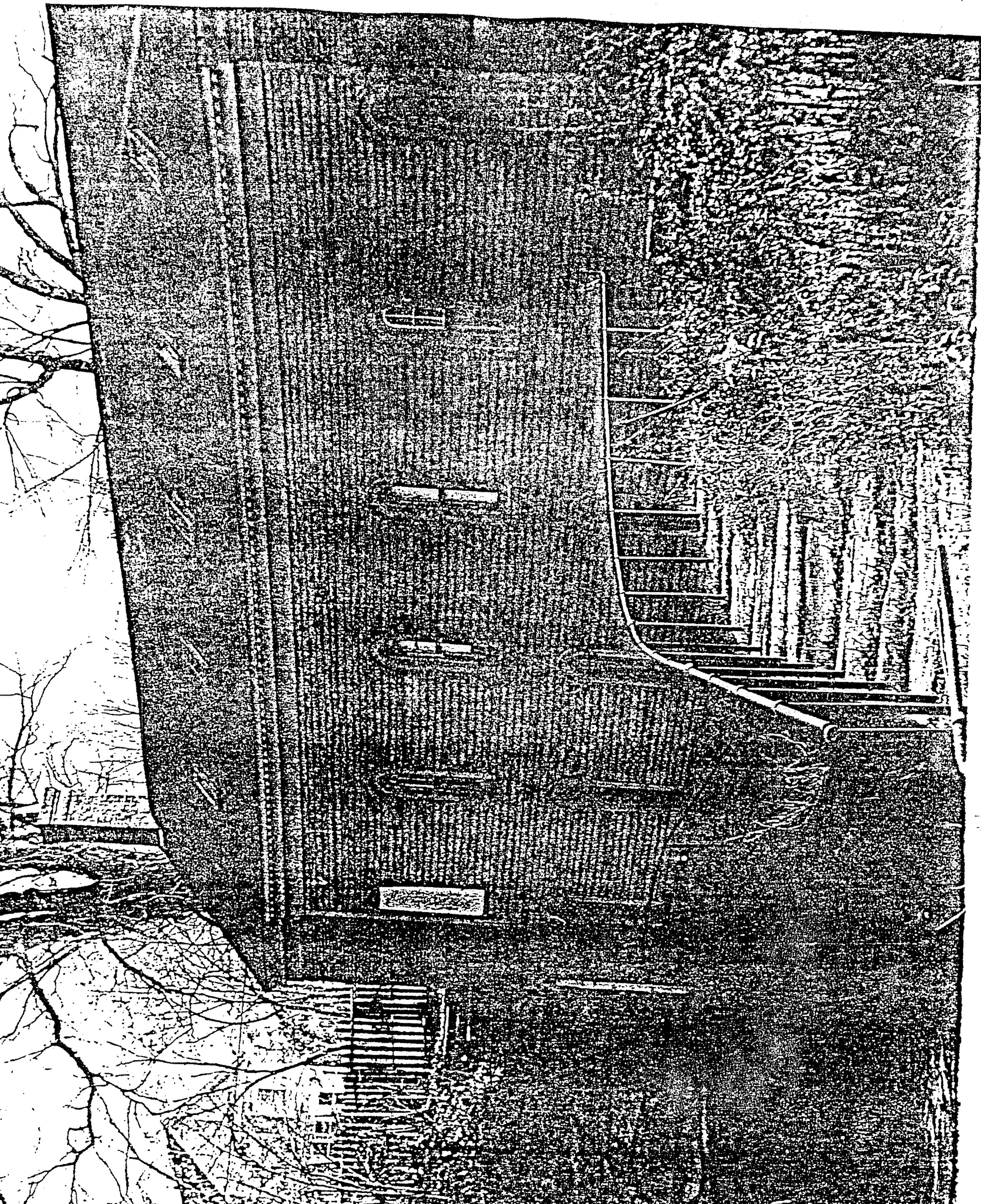
KEEPER OF THE NATIONAL REGISTER

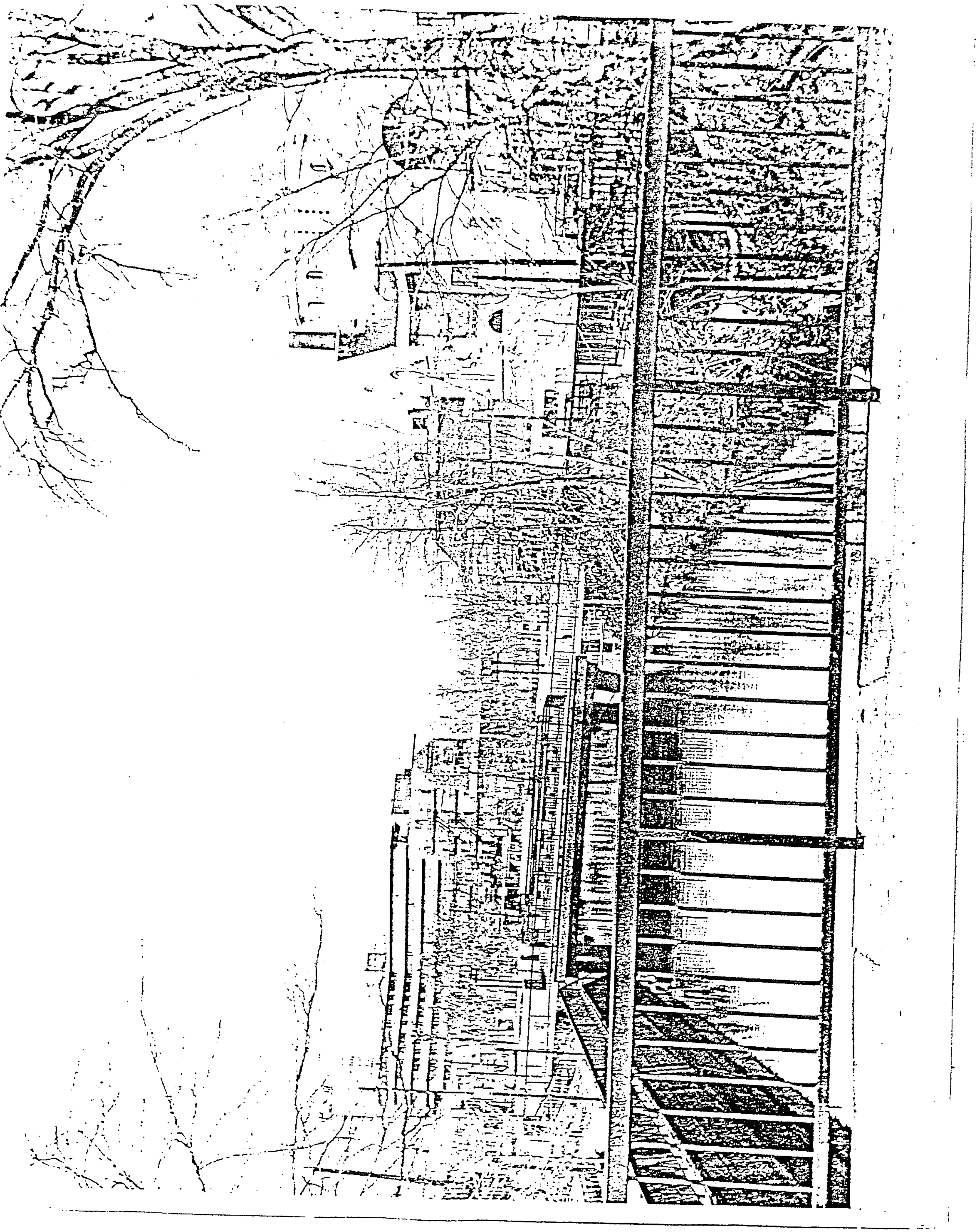












ocks and Canals Historic District, Lowell, MA
oe Orfant, 1975
ty Development Authority, Lowell, MA
oking northeasterly from the O'Donnell Bridge
at the Northern Canal and the Canal Walk
oto #1

ocks and Canals Historic District, Lowell, MA
oe Orfant, 1975
DA, 50 Arcand Drive, Lowell
ooking southwest at the Swamp Locks Dam and
Sluicway, in the Background is the 1890
plant of the Lowell Machine Shop
oto #2

and Canals Historic District, Lowell, MA
fant, 1975
0 Arcand Drive, Lowell
g north from French Street Extension to
Tremont Gatehouse and the Suffolk Yard
he left
3

and Canals Historic District, Lowell, MA
fant, 1975
0 Arcand Drive, Lowell
g north on Suffolk Street to the Suffolk
on the left, the Lawren ce County House :
he background, and the Tremont Yard on
right

#4

Locks and Canals Historic District, Lowe
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking south at the sluiceways gatehouse
the Francis Gate site
photo #5

Locks and Canals Historic District, Lowe
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking northwest from Broadway at the
Western Canal
photo #6

10-300a
74)

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NATIONAL PARK SERVICE

TIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

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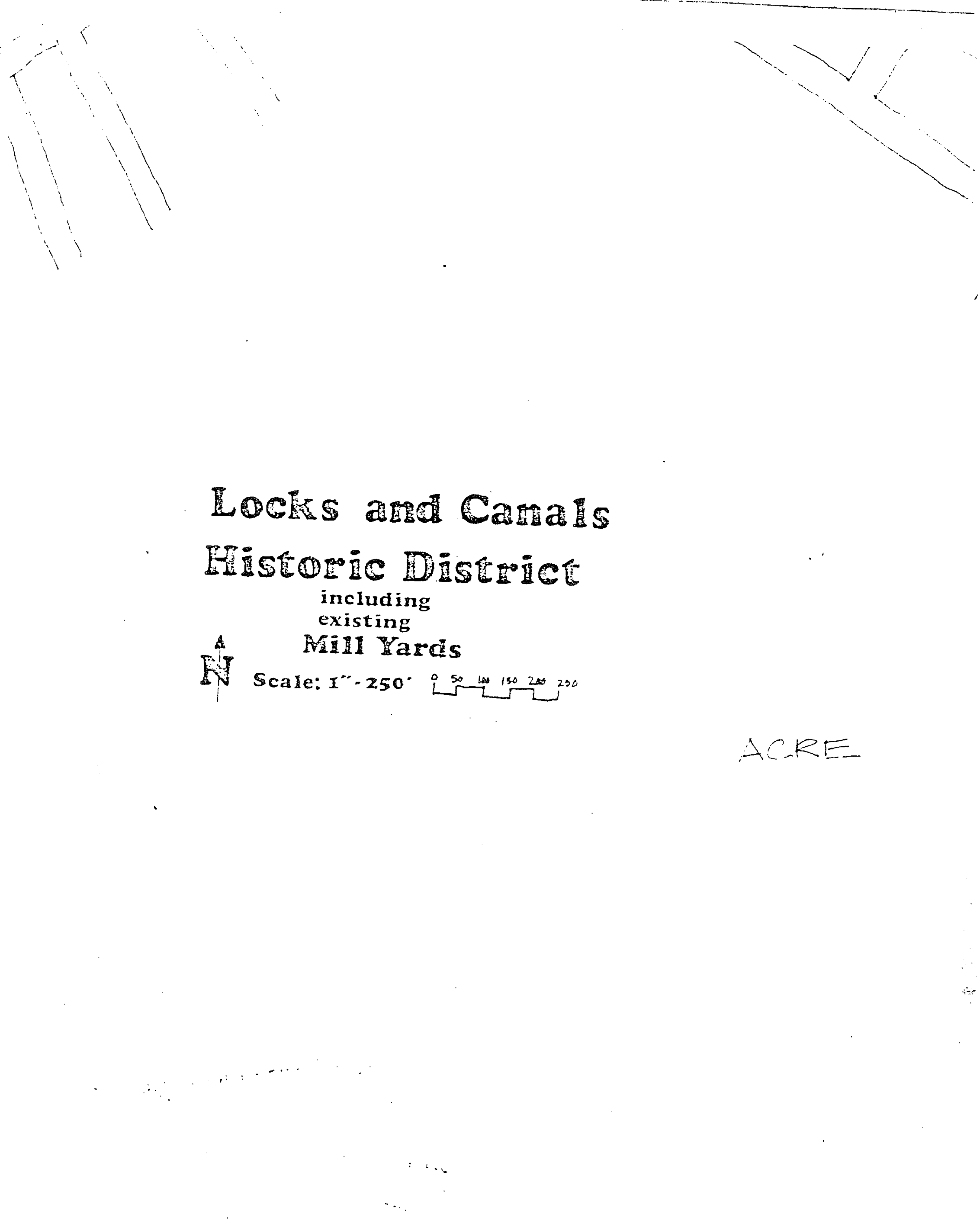
CONTINUATION SHEET ITEM NUMBER PAGE 4

Lowell

Key to sketch Map

Number	Property name
1 - 1144	B Lock House - Broadway
2 - 1145	B Francis Gate and House - Broadway
3 - 1146	B Sluice gate house . Broadway
4	Northern Canal Gatehouse
5 - 1147	B Locks and Canals Blacksmith Shop School St
6 - 1148	B Gate Keeper's Cottage - School St
7 - 1149	S Northern Canal - Northern Canal
8 - 1150	S Northern Canal Walk and Great River Wall - Northern Canal
9	Suffolk Millyard
10	Tremont Gatehouse
11 - 1151	B Tremont Yard - Hall St
12	Lawrence Yard
13 - 1152	S Moody Street Feeder Moody St
14 - 1153	B Moody Street Feeder Gatehouse Dutton St
15	Boott Mills
16	Massachusetts Mills
17 - 1154	B Boott Mills Boarding House French St
18	Massachusetts Mills Boarding House
19 - 1155	S Lower Locks, ~~Pawtucket Canal~~ Lower Pawtucket Canal
20 - 1156	B Bigelow Yard - Market St
21	Hamilton Yard
22 - 1157	S Eastern Canal Eastern Canal
23 - 1158	S Lower Pawtucket Canal Lower Pawtucket Canal
24	Appleton Mills
25 - 1159	S Hamilton Canal Hamilton Canal
26 - 1160	S Swamp Locks - Lower Pawtucket Canal
27 - 1161	S Merrimack Canal - Merrimack Canal
28 - 1162	B Lowell Machine Shop - Dutton St
29 - 1163	B Proprietors of Locks and Canals Yard - Broadway
30 - 1164	S Western Canal - Western Canal
31 - 1165	S Upper Pawtucket Canal - Upper Pawtucket Canal
32 - 1166	S Pawtucket Dam - Pawtucket Canal
33	Suffolk Manufacturing Company Boarding Houses


Locks and Canals
Historic District
including
existing
Mill Yards
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Scale: 1" - 250'
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AUG 7 1980

MASS. HIST. COMM.

32-NAR(PC)

Memorandum

To: Assistant Manager, Cultural Resources Management Division, Washington (560)

From: Regional Director, North Atlantic Region

Subject: National Register Data for Lowell National Historical Park

Enclosed are continuation sheets for the five properties which will eventually come under federal ownership. All of the structures are already listed on the National Register, but because they are included as parts of large historic districts, the existing forms contain little specific information. This amplification of sections seven and eight will provide a greater understanding of those sites for all who are involved in the management and compliance processes. Please forward them on to the National Register at your earliest convenience.

(SGD.) RICHARD L. STANTON

Richard L. Stanton

cc: LOWE, Supt.
/Mass. SHPO

project file

DPitcaithley:id 7/31/80

Merrimack Gate House

Situated over the eastern terminus of the Moody Street Feeder, this rectangular one-and-one-half-story brick gate house was built in 1848[1]. The Merrimack Gate House extends approximately 60' along Dutton Street and the Merrimack Canal. Its southern facade faces Merrimack Street. The waters of the Moody Street Feeder flow through the three granite arches on which this structure rests. Its exterior walls are red brick laid in Flemish bond. The pitched roof is covered in slate shingles. Chimneys are situated at the ridge near the north and south end walls.

Stylistically, the Merrimack Gate House is a hybrid of the Italianate and Romanesque Revival styles. Its windows are inserted and round arched. The cornice features brick dentils. The date "1848" appears incised on its eastern foundation and in raised brick on the gable of its southern facade.

There are three gates for the Moody Street Feeder housed within the Merrimack Gate House. The gates are original with the exception of the woodbox counterweights which were added in 1853[2].

Structurally, the Merrimack Gate House is in good condition. Exterior and interior alterations date, with a few exceptions, from the early 1970s[3]. A doorway has replaced a window on the Merrimack Street facade. Other alterations include the addition of interior platforms, stairs, restrooms and a heating system. At some point in the late nineteenth or early-twentieth century the two original stoves disappeared and a vent was added to the center of the roof.

[1] Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District Cultural Resources Inventory, 1979, n.p.

[2] Merrimack Valley Textile Museum and H.A.E.R., The Lower Merrimack River Valley, An Inventory of Historic Engineering and Industrial Sites. p. 80, 1976.

[3] Roberts, Shelley K., Historic Structures Report-Merrimack Gate House, 1979 p.36.

Francis Gate Complex

The structures located at the head of the Pawtucket Canal, presently referred to as the Francis Gate Complex, include a Guard Dam Gate House, Guard Locks Lock House, and the Great Gate. An island, formed in 1822[1], is situated between the canal and boat lock. The Guard Dam Gate House and Great Gate stand atop the dam. The Guard Locks Lock House which shelters the headgates is upstream of the dam at a lower level.

The Guard Dam Gate House, built in 1870[2], contains the controls to the sluice gates. The upstream side of the Guard Dam Gate House shelters five sluice gates, some of which retain their original lifting machinery. Although most of the openings in the brick portion of the building have been bricked in, much of the original fabric is intact and is in good condition.

The present guard dam may contain elements of the earlier dam (1832) which served the same purpose on this site. 3 This rectangular structure is built of wood frame and is two stories tall. The rest of the building is brick and a single story in height. Both portions display round headed openings and a plain freize and dentils at the cornice. A brownstone plaque set into the east end of the Gate House near the gable is inscribed:

Guard Dam built A.D. 1832
Raised A.D. 1848
Sluice Gates reconstructed A.D. 1970

This Italianate/Romanesque structure culminates in chimneys situated at either end of the ridge roof. The slope of the roof features five small square skylights.

The Pawtucket Canal Guard Locks Lock House was built in 1881. This Lock House structure stands over the upstream pair of gates for the navigational lock. 4 The single-story Lock House is constructed of wood and is of an "T" shaped plan. It has a granite foundation and exterior walls faced with painted clapboards approximately four inches wide. The hipped roof is covered with slate shingles. A hybrid of the Italianate and Romanesque Revival in style, the exterior walls of the Lock House are pierced by narrow round-arched openings.

The chain and windlass equipment which assists in opening the navigational lock date from 1881. 5 The head lock gates are badly deteriorated. The Guard Locks Lock House has been severely vandalized in recent years, threatening the structural integrity of the southern end of the building. That end was built with long horizontal slots through the walls to accommodate the ends of the gate-lever beams. These beams have been broken and burned away.

The navigation lock below the Lock House extends beneath the Francis Gate, ending at a downstream pair of gates which appear to be in good condition. 6

The Great or Francis Gate was built 1848-50 for the purpose of flood control. This portcullis gate is sheltered by a rectangular wood frame structure. The Great Gate consists of 26 timbers, each 27' long and 17" wide, assembled in two separate sections held together by vertical iron rods. The wooden gate is suspended over the boat lock by an iron strap. 7 Both the Great Gate and its shelter are in good condition.

1 Robbins, John, Historic Structure Report, Architectural Data, Pawtucket Canal Guard Gates, Locks and Great Gate and Northern Canal Guard Gates and Lock (NPS: February, 1980), pg. 54.

Form No. 10 300a
(Rev. 10-74)

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CONTINUATION SHEET Locks and Canals Historic District ITEM NUMBER 7 PAGE 3

2 Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District Cultural Resource Inventory, Lowell Canal System, (1979)

3 Ibid.

4 Ibid.

5 Ibid.

6 Ibid.

7 Ibid., pg. 16

Tremont Gate House/Tremont Yard

1. The Tremont Gate House is located at the point where the northern and western canals meet. It was built in 1855 to replace a temporary installation that had performed the same function since 1847[1]. The gate house shelters sluice gates which control the flow of water into the lower level of the Western Canal which in turn feeds the Lawrence Canal.

   This diminutive one-story building is of a rectangular plan. It rests on a granite ashlar foundation. The gate house's exterior walls are constructed of red brick laid in common bond. The pitched roof is covered with slate shingles. Chimneys are at the ridge near the east and west ends. Access to the guard house's interior is gained via the narrow round-arched doorway on the western facad

   Stylistically, the Tremont Gate House is a hybrid of the Italianate and Romanesque Revival styles. Its windows are insetted and round arched. The cornice features brick dentils.

   Structurally, the Tremont Gate House is in good condition. The northern facade's wide round-arched doorways are boarded over. The slate shingles of the roof's southern slope are in need of replacement.

2. Tremont Yard is the site of the Tremont Mill complex which existed from 1831 until its demolition during the 1930s[2]. The western boundary of this rectangular parcel is Suffolk Street. To the east is Tremont Street. The southern boundary is adjacent to the Tremont Gate House and railroad tracks.

   Foundations of buildings which pre- and post-date the 1862[3] reconstruction of the Tremont Mill complex are still evident as are traces of three tail races which date from the late 1860s[4], the remains of a cloth shute, and the locations of hydrants from the mills' fire-fighting system.

   The Tremont Yard is presently framed on the east, north and west by the exterior walls of Mills No. 1, 9, 4 and 3 which have been reduced to a height of 5 to 6'.

   Mill No. 2 at the south end of the yard is also in ruins. Beneath the floor of Mill No. 2 are four Morgan-Smith 46" turbines for electric power which date from 1919-1924[5].

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[1] Peter M. Molloy, editor. The Lower Merrimack River Valley. An Inventory of Historic Engineering and Industrial Sites sponsored by Merrimack Valley Textile Museum, North Andover, Mass. and Historic American Engineering Record. National Park Service, Washington, D. C. 1976. p. 76.

[2] Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District, Cultural Resource Inventory, prepared for Division of Cultural Resources, North Atlantic Regional Office, National Park Service. see volume entitled "Industrial: Merrimack Manufacturing Company Site through Whipple's Mills and Wamesit Canal. Research Report: Suffolk Manufacturing Co." pp. 2 and 28.

[3] ibid. p. 14

[4] ibid. p. 24

[5] ibid. p. 28.

Wannalancit Textile Company (Suffolk Manufacturing Company)

Mill buildings formerly owned by the Suffolk Manufacturing Company occupy a large squa[re] parcel within Lowell's northwestern industrial district. The Suffolk site is bounded by Hall Street to the north, Suffolk Street to the east, the Northern Canal to the south and Cabot Street to the west.

With the exception of the William J. Graham Company building (Suffolk Machine Shop) the eastern half of the Suffolk complex is owned by the Wannalancit Textile Company. This company leases the first floor of Mills No. 8 and 6 to the Lowell Museum.

To the west of Wannalancit property are Suffolk buildings which are presently controll[ed] by Stoney Brook Properties and Tewksbury Wood Products Company. These buildings include Mill No. 10 and its annex, Boiler House No. 2, and Building No. 12.

The Wannalancit buildings are grouped around a large rectangular open yard which is parallel to Suffolk Street. Entrance and egress to the Suffolk Yard is provided by a passage defined by the southern wall of the Counting House and Mill No. 8's northern wall. Mill No. 8 and Mill No. 6 frame the southeastern corner of the yard. Mill No. is parallel to the Northern Canal. The central portion of Mill No. 6's northern wall is abutted by Mill No. 5. Running from Mill No. 6 to Hall Street, Mill No. 5 forms the yard's western boundary. The former Suffolk Machine Shop and the Repair Shop portion of the Counting House enclose the yard's northeastern corner.

The mills surrounding the Suffolk Yard display a uniformity of plan, materials, and height. These rectangular red brick buildings rise to a height of five stories. Mill roofs are either flat or slightly pitched. Most of the Suffolk building stock dates from 1862-1900[1]. The two-story Counting House, however, was built prior to 1850[2]. Its flat, simply detailed facades show the influence of the Federal Style. The majority of Suffolk buildings exhibit a surface plasticity characteristic of the

Italianate style. Projecting from factory facades are brick segmental lintels and corbelled cornices. Particularly picturesque are the octagonal stair towers situated at the southeastern and northeastern corners of Mill No. 5. The towers' facades are ornamented with the curved forms of narrow round-arched openings and oculus windows insetted in recessed eliptical panels. Below the cornice of the eastern facade of Mill No. 5's central pavillion are three granite pl[illegible] Placed at regular intervals, these plaques proclaim in raised lettering, "[illegible] 31.... Suffolk Mills... Rebuilt 1862."

The Suffolk Complex has served as a manufacturing facility for almost one hundred and fifty years. The good condition of Suffolk Manufacturing Company buildings' exterior and interior fabric is probably attributable to the periodic maintenance which accompanies continuous occupancy.

[1]Shepley, Bulfinch, Richardson, and Abbott. Lowell National Historical Park and Preservation District Cultural Resource Inventory prepared for Division of Cultural Resources, North Atlantic Regional Office, Na[illegible] Park Service. See volume entitled Industrial: Merrimack Manufacturing Company [illegible] through Whipples Mills and Wameset Canal." Suffolk Mfg. Co. 1979 Research Report" pp. 14-29.

[2]Cornelia E. Wyma and Paul C. Cloyd, Historic Structures Report Wannalancit Textile Company, Lowell National Historical Park 1979. n.p. See Existing Conditions chapter-raises questions about traditional 1831 dates for the Counting House.

Dutton Street Parking Lot

The Dutton Street Parking Lot is a roughly trapezoidal parcel situated to the southeast of the Market and Dutton Streets intersection. The northern boundary of this asphalt-paved parking facility is in line with the southern wall of two brick additions which project from Bigelow Lowell Building #1. Its eastern and southern boundaries are demarcated by a chain link fence which separates the lot from Pandel Bradford and Pellon Corporation property. The eastern boundary is parallel to the Merrimack Canal. A ten-foot-wide strip of Locks and Canals land is situated between the Dutton Street Parking Lot and the Merrimack Canal

Entrance and egress to the lot is provided via a road which leads from Dutton Street into the southwestern portion of this site. To the immediate north of this entrance is a portion of the Lowell Machine Shop offices' western wall.

This parking lot site and adjacent areas were covered by Lowell Machine Shop and Lowell Manufacturing Company buildings, Canal Components, and railroad tracks. The lot was paved with asphalt sometime after the 1930s[1]. Accompanying this description are maps which show the locations of these earlier structures and features.

[1]Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District Cultural Resource Inventory. Industrial: Lowell Machine Shop Site through Massic Falls Industrial Site. Lowell Machine Shop Research Report pg. 6.

Merrimack Gate House

The Merrimack Gatehouse is a significant element of the district because it possesses a high degree of structural integrity. The exterior of the structure as well as the interior with its three original gates has changed only slightly since the mid-nineteen century.

Despite its rather diminutive scale, the Merrimack Gate House occupies a commanding position in the downtown streetscape. The effects of its canal-side site is maximized through considerable length compared to width and its crisp detailing (including locally unusual use of Flemish bond brickwork).

Francis Gate Complex

The Francis Gate Complex is a key component of the Lowell Power Canal System. Since the mid-nineteenth century it has functioned as a power, navigation and flood control facility on the Pawtucket Canal. It is significant that a high percentage of its original structural and mechanical fabric dating from 1849-1881 is still extant.[1]

The Francis Gate Complex has important historical associations with James B. Francis. Francis was chief engineer and agent of the Proprietors of the Locks and Canals from 1834-1885. He designed the Francis Gate Complex's most famous feature, the Francis or Great Gate. Initially dubbed Francis' Folly upon its completion in 1850, the Great Gate saved the heart of the city from the great floods of 1852 and 1936[2].

Francis gained international recognition for his improvement of water turbine design and the publication of Lowell Hydraulic Experiments (1855)[3]. He might well be called "the Father of American Hydraulic Engineering."

The Francis Gate Complex was the last major hydraulic engineering project completed in Lowell during the Ante-bellum era.

[1]Merrimack Valley Textile Museum and Historic American Engineering Record. The Lower Merrimack River Valley, an Inventory of Historic Engineering and Industrial Sites. p. 1976.

[2]Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resources Inventory. prepared for Division of Cultural Resources North Atlantic Regional Office, National Park Service. Industrial Lowell Canal System Volume . n.p. Pawtucket Canal North of Broadway.

[3]Arthur L. Eno, Jr. ed. Cotton was King, a History of Lowell, Massachusetts. p. 219 New Hampshire Publishing Company 1976.

Tremont Gate House/Tremont Yard

1. The Tremont Gate House, built in 1855[1], is significant as a Lowell Power Canal System component which retains most of its mid-nineteenth century structural and mechanical fabric. The sluice gates' original manually operated rack and pinion equipment is sheltered within the gate house[1].

   Despite its diminutive scale, the Tremont Gate House occupies a commanding position on the southern perimeter of Lowell's northwestern industrial district. Its ivy-covered red brick southern wall, pierced by narrow round-arched openings, picturesquely presides over the Western Canal's northern terminus.

2. Construction of the Tremont Mill buildings was begun in 1832[3]. During the 1860s, however, this complex was dismantled and the Tremont Mills were rebuilt[4]. The final phase of building on the Tremont site occurred in the 1890s[5]. The Tremont Millyard was demolished between 1929 and 1933[6]. The significance of this site is its potential for yielding significant information. It could be developed as an interpreted industrial archeological site.

   The razed Tremont Yard is a perfect foil for the largely intact Suffolk Yard as its original configuration was essentially the mirror image of the adjacent Suffolk Complex. The Tremont site affords the opportunity to view features of a hydropower system (e.g. turbines and tail races) which were originally located under ground. A similarly disposed and equipped hydropower system exists beneath the Suffolk millyard.

[1]Peter M. Molloy, editor. The Lower Merrimack River Valley, an Inventory of Historic Engineering and Industrial Sites. sponsored by the Merrimack Valley Textile Museum and Historic American Engineering Record. 1976. p. 77.

[2]ibid. p. 77

[3]Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resources Inventory. prepared for Division of Cultural Resources North Atlantic Regional Office, National Park Service. see volume-Industrial Merrimack Manufacturing Co. Site through Whipple Mill and Wamesit Canal. Research Report: Suffolk Manufacturing Co. p. 5.

[4]ibid. p. 16.

[5]ibid. p. 27.

[6]ibid. p. 28.

Wannalancit Textile Co. (Suffolk Mfg. Co.)

From 1831 until 1926[1] the buildings currently occupied by the Wannalancit Textile Company were known as the Suffolk Mills. The Suffolk Manufacturing Company was incorporated in 1831[2]. Mill building construction began in the spring of 1832[3]. During the 1860s[4] the Suffolk and Tremont Yards were the scene of an ambitious rebuild campaign. The modernized mills merged in 1872[5]. Sold to the Nashua Manufacturing Company in 1926, the Suffolk Complex survived the 1930s essentially intact[6]. Edward A. Lartner, Jr., owner and president of the Wannalancit Mills has controlled most of the Suffolk Millyard since 1950[7].

The Suffolk Complex is an important survivor of the initial phase of the American Industrial Revolution. It is the only Lowell mill still engaged in the manufacturing of textiles. Virtually every stage of the Suffolk Millyard's development is presently represented by buildings dating from 1831-1915[8]. The Suffolk Mills have significant historical associations with prominent nineteenth-century Boston and Lowell business leaders. Its founders included "Proper Bostonians" such as Amos and Abbott Lawrence, Samuel and William Appleton, Henry Cabot and George W. Lyman.[9] Local patent medicine tycoon James C. Ayer directed the Suffolk and Tremont's merger in 1872[10].

[1]Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resource Inventory. prepared for Division of Cultural Resources, North Atlantic Regional Office, National Park Service. see volume entitled Industrial: Merrimack Manufacturing Company Site through Whipples Mills and Wamesit Canal. Suffolk Mfg. Co. Research Report pgs. 2-28.

[2]ibid. pg. 2.

[3]ibid. pg. 2.

[4]ibid. pg. 14-25.

[5]ibid. pg. 25

[6]ibid. pp. 28-31

[7]ibid. p. 29

[8]ibid. pp. 2, 28.

[9]ibid. p.2.

[10]ibid. p. 25.

The Dutton Street Parking Lot

The Dutton Street Parking Lot has a high potential for yielding subsurface archeological remains. From the 1820s until the 1930s[1], Lowell Machine Shop and Lowell Manufacturing Company buildings covered portions of this site. Presumably the foundations of machine shops, storehouses, and offices exist below ground. An understanding of 19th and early 20th century onsite activities would be fostered by the recovery of mechanical apparatus, tools and other artifact deposits associated with social and industrial activities.

This asphalt-paved parcel overlies, as well, components of the Lowell Power Canal System. No longer visible are the Lowell Canal, three penstocks and a rectangular "basin." The Lowell Canal, laid out in 1828[2], is covered for its entire 500' length. It was filled in during the 1930s[3]. Three penstocks lie beneath the central and southern portion of this lot.

Immediately to the southeast of the junction of the Merrimack and Lowell Canals was a rectangular body of water labeled "basin" on an 1828 Lowell Manufacturing Company plan[4]. A raceway lead from the basin to a sawmill. The sawmill was situated to the east of the present lot. The basin is of particular interest because it was aligned with a semicircular basin to the west of Dutton Street which was apparently designed for purely decorative purposes[5]. All of these canal features are significant remnants of the important Lowell industrial power system which was one of the most elaborate and sophisticated ever developed. In addition to being the physical remains of this historically important sytem, their configuration and characteristics probably contain important information about the construction, modification and maintenance of the canal system.

[1] Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resource Inventory. Inventory Forms and Research Reports. Industrial: Lowell Machine Shop site through Massic Falls Industrial site. Lowell Machine Shop research report pp. 1-8. Lowell Manufacturing Co. research report pp. 1-19.

[2] ibid, Industrial: Lowell Canal Systeml Lowell Canal System Research Report. p. 6.

[3] ibid, p. 7.

[4] ibid. Industrial: Lowell Machine Shop site through Massic Falls Industrial site. Lowell Manufacturing Company Research Report Fig. 2.

[5] ibid. Lowell Machine Shop Research Report Figure 3A.

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Lowell Hydroelectric Project (FERC Project No. 2790) Relicensing Pre-Application Document Information Questionnaire

Boott Hydropower, LLC (Boott), a subsidiary of Enel Green Power North America, Inc. (Enel), is the Licensee and operator of the Lowell Hydroelectric Project (FERC No. 2790) (Project), with principal Project facilities located along the Merrimack River in Middlesex County, Massachusetts and a reservoir extending upstream to Hillsborough County, New Hampshire (see attached map). Boott, with assistance from HDR, Inc. (HDR), is beginning the Federal Energy Regulatory Commission (FERC) relicensing process for the existing Project. Accordingly, Boott is preparing a Pre-Application Document (PAD) that will provide FERC and other entities with existing, relevant, and reasonably available information pertaining to the Project that will be used to prepare documents related to analyzing the relicensing application to be prepared by Boott. To prepare the PAD, Boott will use information in its possession and information obtained from additional sources. This PAD Information Questionnaire will be used by Boott to help identify sources of existing, relevant, and reasonably available information that are not currently in Boott's possession.

1. Information about person completing the questionnaire:

Name & Title	Harold Peterson, Natural Resources Officer
Organization	U.S. Bureau of Indian Affairs - Eastern Region
Address	545 Marriott Dr Ste 700 Nashville, TN 37214
Phone	615-564-6838
Email Address	harold.peterson@bia.gov

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

X Yes (*If yes, please complete 2a through 2c*) __ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- Geology and soils
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened & endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socio-economic resources
- Tribal resources
- Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

The following Tribes have historic interests in the area and should be consulted:
Mashpee Wampanoag Tribe
Wampanoag Tribe of Gay Head
Penobscot Nation

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

tribal leaders directory or www.bia.gov

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

X Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Harold Peterson
Address	Same
Phone	
Email Address	

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.

HDR
1304 Buckley Rd Ste 202
Syracuse, NY 13212

Scott, Kelsey

From:	Scott, Kelsey
Sent:	Thursday, December 3, 2020 9:22 AM
To:	Andrew MacLean - Town of Pepperell; Andrew Sheehan - Town of Middleton; Andrew Titler - USDOI; Arthur Johnson - MADES; Ben Gahagan - MADMF; Benjamin Wilson - NHDHR; Bill McDavitt - NOAA; Bjorn Lake - NMFS; bob@americanwhitewater.org; Bryan Sojkowski - USFWS (bryan_sojkowski@fws.gov); Bub Durand - MAOEEA; Celeste Bernardo - Lowell NHP; Christine Bruins - NPS; dam.safety@state.ma.us; Daniel Rivera - City of Lawrence, MA; David Meeker - Hull Street Energy LLC; David Turin - USEPA; Derek Standish - MADEP BWR; Dinell Clark - Lowell Flood Owners Group and Williamsburg Condominium I; Duncan Hay - NPS; Ed Reiner - USEPA; Fred Jennings - TU; Gene Porter - LMRLAC; Harold Peterson; jack.buckley@state.ma.us; Jim Donchess - City of Nashua, NH; John Eddins - ACHP; John Leahy - Mayor City of Lowell; John Nappi - Lowell Flood Owners Group; John Spain - FERC NYRO; Jon Kurland - Town of Chelmsford, MA; Keith Nislow - USFS; Ken Hogan - USFWS; Kevin Hollenbeck - DCR Great Brook Farm State Park; Kevin Mendik - NPS; Kevin Smith - Town of Londonderry; Kevin Webb - CRP; Lori Radke - Town of Hollis; Mark Prout - USFS; Matt Carpenter - NHFGD; Matthew Thorne - Merrimack Rvier Watershed Council; Melissa Rodriques - Town of N Andover; Michael Bailey - USFWS; michael.judge@state.ma.us; Misty Anne Marold; Norman Sims - AMC 2; Owen David - NHDES; Peter Severance - River Merrimack; Rachel Freed - MADEP; Richard Reault - Town of Tyngsborough; Robert Bersak - Eversource Energy; Scott Galvin - City of Woburn, MA; Sean McDermott - NOAA; Steve Carlin - MADCR; Steve Mattocks - MADFW FOB; Timothy Higgins - Town of Lincoln, MA; Tom Chapman - USFWS; Troy Brown - USFWS
Cc:	Quiggle, Robert; Richard Malloy
Subject:	Lowell Hydroelectric Project Draft License Application Submission
Attachments:	Cover Letter Lowell DLA 20201202.pdf

Dear Stakeholders:

Boott Hydropower, LLC (Boott) is pursuing a new license from the Federal Energy Regulatory Commission for the Lowell Hydroelectric Project using the Commission's Integrated Licensing Process, as defined in 18 Code of Federal Regulations (C.F.R.) Part 5. In accordance with 18 C.F.R. § 5.16(a), on December 2, 2020, Boott filed the Draft License Application (DLA) for the Project. The attached cover letter provides a description of the DLA and instructions for how to download an electronic copy. As detailed in the cover letter, interested parties may file comments regarding the DLA within 90 days.

Should you have any questions regarding the recent filing, please contact Kevin Webb, Licensing Manager with Boott, at (978) 935-6039 or kwebb@centralriverspower.com.

Kelsey Scott, MS
HDR
1304 Buckley Road, Suite 202
Syracuse, NY 13212
D 315.414.2206 **M** 315.706.5176
kelsey.scott@hdrinc.com
hdrinc.com/follow-us

Central Rivers Power

Boott Hydropower, LLC
Subsidiary of Central Rivers Power US, LLC
670 N. Commercial Street, Suite 204
Manchester, NH 03101

<u>Via eFiling</u> December 2, 2020

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: **Lowell Hydroelectric Project (FERC No. 2790-072)**
Draft License Application

Dear Secretary Bose:

Boott Hydropower, LLC (Boott or Licensee) is the Licensee, owner, and operator of the 20 megawatt Lowell Hydroelectric Project (Project or Lowell Project) (FERC No. 2790). Boott operates the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Project's existing license expires on April 30, 2023. Boott is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (C.F.R.) Part 5. In accordance with 18 C.F.R. § 5.16(a), Boott is filing herewith the Draft License Application (DLA) for the Project.

The DLA is composed of two volumes, as described below. Exhibit E – Environmental Report contains Licensee's analysis of the effects of the Proposed Action, relicensing the continued operation and maintenance of the Project. Based upon the analysis of the effects of the Proposed Action on developmental and non-developmental resources, the Licensee is proposing certain environmental measures consistent with the Project's current license as discussed in detail in Exhibit E. As stated in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Nevertheless, Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the National Park Service and other stakeholders.

The DLA consists of the following:

VOLUME I OF II

Volume I contains Public information and exhibits as follows:

- Table of Contents
- Executive Summary
- Initial Statement and Additional Information Required by 18 C.F.R. § 5.18(a)
- Exhibit A – Project Description
- Exhibit B – Project Operation and Resource Utilization
- Exhibit C – Construction History and Proposed Construction Schedule
- Exhibit D – Cost and Financing
- Exhibit F – General Design Drawings
- Exhibit G – Project Maps
- Exhibit H – Description of Project Management and Need for Project Power

VOLUME II OF II

- Part 1 – Exhibit E – Environmental Exhibit
- Part 2 – Exhibit E – Appendices

Please note that Boott is not submitting the portions of the application which would constitute Critical Energy Infrastructure (CEII) at this time. These would include the Exhibit F drawings, Supporting Design Report, and the Single Line Diagram referenced in Exhibit A. Certain information within the DLA is still under development or more appropriately filed with the Final License Application (FLA) in April 2021. Additionally, proposals presented in the DLA are preliminary.

Boott is making the DLA available to resource agencies, Indian tribes, local governments, nongovernmental organizations, and members of the public who are on the Project distribution list. An electronic copy of the DLA can be downloaded from FERC's eLibrary system (https://www.ferc.gov/docs-filing/elibrary.asp) by searching under docket number P-2790 (sub docket 072). The DLA will also be available at the Project's public relicensing website at www.lowellprojectrelicensing.com.

In accordance with 18 CFR § 5.16(e), interested parties may file comments regarding the DLA within 90 days of the date of this letter (i.e., by March 2, 2021). All comments must be eFiled with FERC or sent to FERC at the following address:

Hon. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street. NE
Washington, D.C. 20426

Please do not hesitate to contact me at (978) 935-6039 or kwebb@centralriverspower.com if you have any questions concerning this submittal.

Sincerely,
Boott Hydropower, LLC

Kevin M. Webb
Licensing Manager

cc: M. Stanley, CRP
C. Mooney, CRP

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Federal and State Agencies

John Eddins, PhD
Archaeologist/Program Analyst
Advisory Council on Historic Preservation
401 F Street NW
Suite 308
Washington, DC 20001-2637

Kimberly Bose
Secretary
Federal Energy Regulatory Commission
888 1st Street NE
Washington, DC 20426

John Spain
New York Regional Office
Federal Energy Regulatory Commission
Office of Energy Projects
Division of Dam Safety and Inspections

Steve Carlin
Park Supervisor
Massachusetts Department of Conservation and Recreation
Lowell Heritage State Park
160 Pawtucket Blvd
Lowell, MA 01854

Office of Dam Safety
Massachusetts Department of Conservation and Recreation
John Augustas Hall
180 Beaman Street
West Boylston, MA 01583-1109

Michael Judge
Renewable Energy Division Director
Massachusetts Department of Energy Resources
100 Cambridge Street
Suite 1020
Boston, MA 02114-2533

Rachel Freed
Northeast Region Section Chief
Massachusetts Department of Environmental Protection
205 Lowell Street
Wilmington, MA 01887

Arthur Johnson
DWM Environmental Monitoring Program
Massachusetts Department of Environmental Protection
8 Bond Street
Worcester, MA 01606

Derek Standish
Bureau of Water Resources
Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108

Massachusetts Department of Fish and Game
251 Causeway Street
Suite 400
Boston, MA 02114

Massachusetts Department of Public Utilities
One South Station
Boston, MA 02110

Matthew Ayer
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Joseph Larson
Chairman
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Steve Mattocks
Fisheries Operations Biologist
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Ben Gahagan
Diadromous Fisheries Biologist
Massachusetts Division of Marine Fisheries
251 Causeway Street
Suite 400
Boston, MA 02114

Bob Durand
Massachusetts Executive Office of Energy & Environmental Affairs
100 Cambridge Street
Suite 900
Boston, MA 02114

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Jonathan Patton
Preservation Planner
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Brona Simon
State Historic Preservation Officer
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Secretary of the Commonwealth
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Massachusetts Office of the Attorney General
1 Ashburton Place
Boston, MA 02108-1518

Bjorn Lake
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Celeste Bernardo
Lowell National Historical Park
National Park Service
67 Kirk Street
Lowell, MA 01852

Christine Bruins
Lowell National Historical Park
National Park Service
67 Kirk Street
Lowell, MA 01852

Duncan Hay
Northeast Region
National Park Service
15 State Street
Boston, MA 02109

Kevin Mendik
Hydro Program Manager
National Park Service
15 State Street
Boston, MA 02109

Misty Anne Marold
Senior Review Biologist
Natural Heritage Endangered Species
Program
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Owen David
Water Quality Certification Program
New Hampshire Department of Environmental
Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Jim Gallagher
Dam Bureau Administrator
New Hampshire Department of Environmental
Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Brad Simpkins
Director
New Hampshire Division of Forests and Lands
172 Pembroke Road
Concord, NH 03301

Benjamin Wilson
SHPO & Director
New Hampshire Division of Historical
Resources
19 Pillsbury Street
2nd Floor
Concord, NH 03301-3570

Matt Carpenter
Fisheries Biologist
New Hampshire Fish and Game Department
11 Hazen Drive
Concord, NH 03301

Bill McDavitt
Environmental Specialist
NOAA Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Sean McDermott
Marine Habitat Resource Specialist,
Hydropower Coordinator
NOAA Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

George Rose
Deputy Director
Office of Emergency Management
The City of Lowell Fire Department
JFK Civic Center, 99 Moody Street
Lowell, MA 01852

Harold Peterson
Bureau of Indian Affairs
US Department of the Interior
545 Marriott Drive
Suite 700
Nashville, TN 37214

Andrew Tittler
Attorney-Advisor
US Department of the Interior
15 State Street
8th Floor
Boston, MA 02109-3502

Ed Reiner
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OEP06-3
Boston, MA 02109-3912

David Turin
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OES04-3
Boston, MA 02109-3912

Michael Bailey
National Aquatic Habitat Coordinator
US Fish and Wildlife Service
151 Broad Street
Nashua, NH 03603

Tom Chapman
Supervisor, New England Field Office
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301-5094

Ken Hogan
Fish and Wildlife Biologist
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301

Bryan Sojkowski
Civil Engineer
US Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035

Keith Nislow
Northern Research Station
US Forest Service
11 Campus Boulevard
Suite 200
Newton Square, PA 19073

Mark Prout
Region 9 - Eastern Region (Midwest and Northeast)
US Forest Service
626 East Wisconsin Avenue
Milwaukee, WI 53202

Indian Tribes

Cedric Cromwell
Chairman
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

Ramona Peters
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

John Brown
Narragansett Indian Tribal Historic Preservation Office
Narragansett Indian Tribe
P.O. Box 268
Charlestown, RI 02813

Bonney Hartley
Tribal Historic Preservation Officer
Stockbridge Munsee Community, Wisconsin
65 1st Street
Troy, NY 12180

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Shannon Holsey
Tribal President
Stockbridge Munsee Community, Wisconsin
N8476 MoHeConNuck Road
Bowler, WI 54416

Cheryl Andrew-Maltais
Chairwoman
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Bettina Washington
Tribal Historic Preservation Officer
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Municipalities

James Fiorentini
Mayor
City of Haverhill, MA
4 Summer Street
Haverhill, MA 01830

Daniel Rivera
Mayor
City of Lawrence, MA
200 Common Street
3rd Floor Room 309
Lawrence, MA 01840

Christine Clancy
City of Lowell Engineer
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 61
Lowell, MA 01852

John Leahy
Mayor
City of Lowell, MA
375 Merrimack Street
2nd Floor
Lowell, MA 01852

Christine O'Connor
City Solicitor
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 64
Lowell, MA 01852

Joyce Craig
Mayor
City of Manchester, NH
One City Hall Plaza
Manchester, NH 03101

James Jajuga
Mayor
City of Methuen, MA
41 Pleasant Street
Methuen, MA 01844

Jim Donchess
City of Nashua, NH
229 Main Street
Nashua, NH 03060

Scott Galvin
Mayor
City of Woburn, MA
10 Common Street
Woburn, MA 01801

Paul Bergeron
District #2
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Toni Pappas
District #1
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Robert Rowe
District #3
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

John Mangiaratti
Town Manager
Town of Acton, MA
472 Main Street
Acton, MA 01720

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Andrew Flanagan
Town Manager
Town of Andover, MA
36 Bartlet Street
Andover, MA 01810

David Cressmand
Town Administrator
Town of Atkinson, NH
19 Academy Avenue
Atkinson, NH 03811

Robert Pontbriand
Town Administrator
Town of Ayer, MA
1 Main Street
Ayer, MA 01432

Sarah Stanton
Town Manager
Town of Bedford, MA
10 Mudge Way
Bedford, MA 01730

John Curran
Town Manager
Town of Billerica, MA
365 Boston Road
Billerica, MA 01821

Alan Benson
Town Administrator
Town of Boxford, MA
7A Spofford Road
Boxford, MA 01921

Paul Sagarino
Town Administrator
Town of Burlington, MA
29 Center Street
Burlington, MA 01803

Jon Kurland
Town Moderator
Town of Chelmsford, MA
50 Billerica Road
Chelmsford, MA 01824

Stephen Crane
Town Manager
Town of Concord, MA
P.O. Box 535
Concord, MA 01742

David Caron
Town Administrator
Town of Derry, NH
14 Manning Street
Derry, NH 03038

Ann Vandal
Town Manager
Town of Dracut, MA
62 Arlington Street
Dracut, MA 01826

Robert Pontibriand
Town Manager
Town of Groton, MA
173 Main Street
Groton, MA 01450

Timothy Bragan
Town Administrator
Town of Harvard, MA
13 Ayer Road
Harvard, MA 01451

Lori Radke
Town Administrator
Town of Hollis, NH
7 Monument Square
Hollis, NH 03049

Steve Malizia
Administrator
Town of Hudson, NH
12 School Street
Hudson, NH 03051

James Malloy
Town Manager
Town of Lexington, MA
1625 Massachusetts Avenue
2nd Floor, Town Office Building
Lexington, MA 02420

Timothy Higgins
Town Administrator
Town of Lincoln, MA
16 Lincoln Road
Lincoln, MA 01773

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Troy Brown
Town Administrator
Town of Litchfield, NH
2 Liberty Way
Suite 2
Litchfield, NH 03052

Joseph Laydon
Town Administrator
Town of Littleton, MA
37 Shattuck Street
3rd Floor, Room 306
Littleton, MA 01460

Kevin Smith
Chairman
Town of Londonderry, NH
268B Mammoth Road
Londonderry, NH 03053

Robert Dolan
Town Administrator
Town of Lynnfield, MA
55 Summer Street
Lynnfield, MA 01940

Eileen Cabanel
Town Manager
Town of Merrimack, NH
6 Baboosic Lake Road
Merrimack, NH 03054

Andrew Sheehan
Town Administrator
Town of Middleton, MA
48 South Main Street
Middleton, MA 01949

Melissa Rodrigues
Town Manager
Town of North Andover, MA
120 Main Street
North Andover, MA 01845

3. Municipalities
Michael Gilleberto
Town Administrator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

John Murphy
Town Moderator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

Brian McCarthy
Town Administrator
Town of Pelham, NH
6 Village Green
Pelham, NH 03076

Andrew MacLean
Town Administrator
Town of Pepperell, MA
One Main Street
Pepperell, MA 01463

John Arena
Chair, Board of Selectmen
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Robert LeLacheur
Town Manager
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Christopher Dillon
Chairman
Town of Salem, NH
33 Geremonty Drive
Salem, NH 03079

Michael McGovern
Town Administrator
Town of Shirley, MA
7 Keady Way
Shirley, MA 01464

Dennis Sheeham
Town of Stoneham, MA
35 Central Street
2nd Floor
Stoneham, MA 02180

Richard Montuori
Town Manager
Town of Tewksbury, MA
1009 Main Street
2nd Floor
Tewksbury, MA 01876

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Matt Hanson
Town Administrator
Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

Richard Reault
Chair, Board of Selectmen
Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

Jodi Ross
Town Manager
Town of Westford, MA
55 Main Street
Westford, MA 01886

Jeffrey Hull
Town Manager
Town of Wilmington, MA
121 Glen Road
Room 11
Wilmington, MA 01887

David Sullivan
Town Administrator
Town of Windham, NH
3 North Lowell Street
Windham, NH 03087

<u>Additional Parties</u>

Robert Nasdor
NE Stewardship Director
American Whitewater
65 Blueberry Hill Lane
Sudbury, MA 01776

Norman Sims
Appalachian Mountain Club
77 Back Ashuelot Road
Winchester, NH 03470

Kevin Webb
Licensing Manager
Central Rivers Power
670 N Commercial Street
Suite 204
Manchester, NH 03102

Kevin Hollenbeck
Metrowest District Manager
DCR Great Brook Farm State Park
984 Lowell Street
Carlisle, MA 01741

Robert Bersak
780 North Commercial Street
Eversource Energy
P.O. Box 330
Manchester, NH 03015

Jay Mason
President
Friends of Tyler Park
77 Tyler Park
Lowell, MA 01851

David Meeker
Hull Street Energy, LLC
4920 Elm Street
Suite 205
Bethesda, MD 20814

Jeffrey J. Winward
Fire Chief
Lowell Fire Department
99 Moody Street
Lowell, MA 01852

Dinell Clark
Lowell Flood Owner's Group
197 Wellman Avenue
North Chelmsford, MA 01863

Bob Gagnon
Lowell Flood Owner's Group
136 Townsend Avenue
Lowell, MA 01854

Lynda Ignacio
Lowell Flood Owner's Group
66 Shirley Avenue
Lowell, MA 01854

Steve Masse
Lowell Flood Owner's Group
186 Humphrey Street
Lowell, MA 01850

John Nappi
Lowell Flood Owner's Group
279 Pawtucket Boulevard
Tyngsborough, MA 01879

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Gene Porter
Lower Merrimack River Local Advisory
77 Concord Street
Nashua, NH 03064

Thomas Golden, Jr.
Massachusetts House of Representatives
24 Beacon Street
Room 473B
Boston, MA 02133

Rady Mom
Massachusetts House of Representatives
24 Beacon Street
Room 43
Boston, MA 02133

David Nangle
Massachusetts House of Representatives
24 Beacon Street
Room 479
Boston, MA 02133

Edward Kennedy
Massachusetts Senate
24 Beacon Street
Room 405
Boston, MA 02133

Matthew Thorne
Executive Director
Merrimack River Watershed Council
60 Island Street
Suite 211-E
Lawrence, MA 01840

Chris Countie
Water Supply Manager
Pennichuck Water Works
P.O. Box 1947
25 Manchester Street
Merrimack, NH 03054

Peter Severance
Research/Program Director
River Merrimack

Fred Jennings
President, Nor'East Chapter
Trout Unlimited
P.O. Box 946
Ipswich, MA 01938

Arthur Faneros
Universal Apartment Rental
114 University Avenue
Lowell, MA 01854

Michele Tremblay
Upper Merrimack River Local Advisory
Committee
P.O. Box 3019
Penacook, NH 03303

Ann Kuster
US House of Representatives
137 Cannon House Office Building
2nd District
Washington, DC 20515

Seth Moulton
6th District
US House of Representatives
21 Front Street
Salem, MA 01970

Chris Pappas
US House of Representatives
889 Elm Street
Manchester, NH 03101

Lori Trahan
3rd District
US House of Representatives
126 John Street
Suite 12
Lowell, MA 01852

Margaret Hassan
US Senate
330 Hart Senate Office Building
Washington, DC 20510

Edward Markey
US Senate
218 Russell Senate Office Building
Washington, DC 20510

Jeanne Shaheen
US Senate
506 Hart Senate Office Building
Washington, DC 20510

Elizabeth Warren
US Senate
317 Hart Senate Office Building
Washington, DC 20510

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Dinell Clark
President
Williamsburg Condominium I
197 Wellman Avenue
North Chelmsford, MA 01863

Richard Howe
Register of Deeds - Middlesex County North
360 Gorham Street
Lowell, MA 01852

Scott, Kelsey

From:	Scott, Kelsey
Sent:	Tuesday, May 4, 2021 2:40 PM
To:	Andrew MacLean - Town of Pepperell; Andrew Sheehan - Town of Middleton; Arthur Johnson - MADES; Ben Gahagan - MADMF; Benjamin Wilson - NHDHR; Bill McDavitt - NOAA; Bjorn Lake - NMFS; Bob Durand - MAOEEA; bob@americanwhitewater.org; Bonney Hartley - Stockbridge Munsee; Bryan Sojkowski - USFWS (bryan_sojkowski@fws.gov); Celeste Bernardo - Lowell NHP; Christine Bruins - NPS; dam.safety@state.ma.us; David Meeker - Hull Street Energy LLC; David Turin - USEPA; Derek Standish - MADEP BWR; Dinell Clark - Lowell Flood Owners Group and Williamsburg Condominium I; Doug Smithwood - USFWS; Duncan Hay - NPS; Ed Reiner - USEPA; Fred Jennings - TU; Gene Porter - LMRLAC; Harold Peterson; jack.buckley@state.ma.us; Jim Donchess - City of Nashua, NH; John Eddins - ACHP; John Leahy - Mayor City of Lowell; John Nappi - Lowell Flood Owners Group; John Spain - FERC NYRO; Jon Kurland - Town of Chelmsford, MA; Keith Nislow - USFS; Ken Hogan - USFWS; Kendrys Vasquez; Kevin Hollenbeck - DCR Great Brook Farm State Park; Kevin Mendik - NPS; Kevin Smith - Town of Londonderry; Kevin Webb - CRP; Lori Radke - Town of Hollis; MA Rep - Vanna Howard; Mark Prout - USFS; Matt Carpenter - NHFGD; Matthew Thorne - Merrimack Rvier Watershed Council; Melissa Rodriques - Town of N Andover; Michael Bailey - USFWS; michael.judge@state.ma.us; Misty Anne Marold; Norman Sims - AMC 2; Owen David - NHDES; Peter Severance - River Merrimack; Rachel Freed - MADEP; Rebecca Quinones ; Richard Reault - Town of Tyngsborough; Robert Bersak - Eversource Energy; Rodney Elliott - MADCR; Scott Galvin - City of Woburn, MA; Steve Carlin - MADCR; Steve Mattocks - MADFW FOB; Timothy Higgins - Town of Lincoln, MA; Tom Chapman - USFWS; Tom Walsh - MADCR; Troy Brown - USFWS; USDOI Office of the Solicitor NE Region; christopher.boelke
Cc:	Richard Malloy; Quiggle, Robert
Subject:	Lowell Project Final License Application - April 30 2021 - ILP Filing
Attachments:	20210430 Lowell License Application_cvletter.pdf

Lowell Hydroelectric Project Stakeholders:

Boott Hydropower, LLC (Boott) is pursuing a new license from the Federal Energy Regulatory Commission (FERC or Commission) for the Lowell Hydroelectric Project using the Integrated Licensing Process (ILP), as defined in 18 Code of Federal Regulations (C.F.R.) Part 5. The Project's existing license expires on April 30, 2023. In accordance with the applicable regulations at 18 C.F.R. § 5.17(a), Boott filed their application for a new license (Final License Application or FLA) with the Commission on April 30, 2021. As detailed in the attached cover letter, Boott is making public portions of the FLA available to resource agencies, local governments, non-governmental organizations, and members of the public. An electronic copy of the application can be found via FERC's online eLibrary at https://elibrary.ferc.gov/eLibrary/search, by searching FERC Project No. P-2790 (sub-docket 072).

Should you have any questions regarding the attached filing, please contact Kevin Webb, Licensing Manager with Boott, at (978) 935-6039 or kwebb@centralriverspower.com.

Kelsey Scott, MS
Regulatory Specialist

HDR
1304 Buckley Road, Suite 202
Syracuse, NY 13212

D 315.414.2206 **M** 315.706.5176
kelsey.scott@hdrinc.com
hdrinc.com/follow-us

Boott Hydropower, LLC
Subsidiary of Central Rivers Power US, LLC
670 N. Commercial Street, Suite 204
Manchester, NH 03101

Via eFiling April 30, 2021

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: **Lowell Hydroelectric Project (FERC No. 2790-072)**
Final License Application

Dear Secretary Bose:

Boott Hydropower, LLC (Boott or Licensee) is the Licensee, owner, and operator of the 20 megawatt Lowell Hydroelectric Project (Project or Lowell Project) (FERC No. 2790). Boott operates the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Project's existing license expires on April 30, 2023. Boott is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (C.F.R.) Part 5. In accordance with the applicable regulations at 18 C.F.R. § 5.17(a), Boott is hereby filing this final application for a new license (Final License Application or FLA) with the Commission. In conjunction with the electronic filing of the FLA, Boott is providing the Commission with the two enclosed courtesy copies of the FLA, as well as a compact disk that contains the associated Exhibit G drawings and data, which will follow in a separate transmittal to the Commission.

Concurrent with this filing, Boott is making public portions of the FLA available to resource agencies, Indian tribes, local governments, non-governmental organizations, and members of the public on the Project's distribution list. Electronic copies of the applications will be available on the Project's public relicensing website at http://www.lowellprojectrelicensing.com/ or via FERC's online eLibrary at https://elibrary.ferc.gov/eLibrary/search, by searching FERC Project No. P-2790 (sub-docket 072). The FLA can also be reviewed during normal business hours at the Pollard Memorial Library, 276 Broadway Street, Lowell, MA 01854, or at the Nashua Public Library, 2 Court Street, Nashua, NH 03060. In addition, paper copies of the application can be reproduced at the cost of production and postage by contacting the undersigned at 670 N. Commercial Street, Suite 204 Manchester, NH 03101 or at (978) 935-6039.

In accordance with 18 C.F.R. § 5.17(d)(2), Boott will publish public notice of the filing of the FLA twice (each) in The Lowell Sun, a daily newspaper in circulation in Middlesex County, Massachusetts, and The Union Leader, a daily newspaper in circulation in Hillsborough County, New Hampshire.

The Applicant is not proposing the development of any new hydroelectric facilities or increased generation capacity but provides protection, mitigation, and enhancement (PM&E) measures related to fish passage, water quality, historic properties, and recreation associated with the Project. Proposals presented by in the FLA reflect careful consideration of available information, the results of studies conducted, and issues specific to the Project. Boott believes that the proposed PM&E measures as described in the FLA adequately take into consideration the important power and non-power values of the Project. As stated in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the National Park Service and other stakeholders.

The FLA is composed of three volumes, as described below. Exhibit E – Environmental Report contains Licensee's analysis of the effects of the Proposed Action, relicensing the continued operation and maintenance of the Project.

The FLA consists of the following:

VOLUME I OF III

- Table of Contents
- Executive Summary
- Initial Statement and Additional Information Required by 18 C.F.R. § 5.18(a)
- Exhibit A – Project Description
- Exhibit B – Project Operation and Resource Utilization
- Exhibit C – Construction History and Proposed Construction Schedule
- Exhibit D – Cost and Financing
- Exhibit F – General Design Drawings
- Exhibit G – Project Maps
- Exhibit H – Description of Project Management and Need for Project Power

VOLUME II OF III

- Part 1 – Exhibit E – Environmental Exhibit
- Part 2 – Exhibit E – Appendices

VOLUME III OF III Critical Energy Infrastructure Information (CEII)

- Exhibit F – General Design Drawings
- Exhibit H – Single-line Electrical Diagram

Please do not hesitate to contact me at (978) 935-6039 or kwebb@centralriverspower.com if you have any questions concerning this submittal.

Sincerely,
Boott Hydropower, LLC

Kevin M. Webb
Licensing Manager

cc: M. Stanley, CRP
C. Mooney, CRP
Distribution List

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Federal and State Agencies

John Eddins, PhD
Archaeologist/Program Analyst
Advisory Council on Historic Preservation
401 F Street NW
Suite 308
Washington, DC 20001-2637

Kimberly Bose
Secretary
Federal Energy Regulatory Commission
888 1st Street NE
Washington, DC 20426

John Spain
New York Regional Office
Federal Energy Regulatory Commission
Office of Energy Projects
Division of Dam Safety and Inspections

Steve Carlin
Park Supervisor
Massachusetts Department of Conservation and Recreation
Lowell Heritage State Park
160 Pawtucket Blvd
Lowell, MA 01854

Rodney Elliott
Massachusetts Department of Conservation and Recreation
25 Sahttuck St.
Lowell, MA 02115

Tom Walsh
Massachusetts Department of Conservation and Recreation
25 Sahttuck St.
Lowell, MA 02115

Office of Dam Safety
Massachusetts Department of Conservation and Recreation
John Augustas Hall
180 Beaman Street
West Boylston, MA 01583-1109

Michael Judge
Renewable Energy Division Director
Massachusetts Department of Energy Resources
100 Cambridge Street
Suite 1020
Boston, MA 02114-2533

Rachel Freed
Northeast Region Section Chief
Massachusetts Department of Environmental Protection
205 Lowell Street
Wilmington, MA 01887

Arthur Johnson
DWM Environmental Monitoring Program
Massachusetts Department of Environmental Protection
8 Bond Street
Worcester, MA 01606

Derek Standish
Bureau of Water Resources
Massachusetts Department of Environmental Protection
One Winter Street
Boston, MA 02108

Massachusetts Department of Fish and Game
251 Causeway Street
Suite 400
Boston, MA 02114

Massachusetts Department of Public Utilities
One South Station
Boston, MA 02110

Matthew Ayer
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Joseph Larson
Chairman
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Steve Mattocks
Fisheries Operations Biologist
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Rebecca Quinones
Stream Biologist Project Leader
1 Rabbit Hill Road
Westborough, MA 01581

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Ben Gahagan
Diadromous Fisheries Biologist
Massachusetts Division of Marine Fisheries
251 Causeway Street
Suite 400
Boston, MA 02114

Bob Durand
Massachusetts Executive Office of Energy & Environmental Affairs
100 Cambridge Street
Suite 900
Boston, MA 02114

Jonathan Patton
Preservation Planner
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Brona Simon
State Historic Preservation Officer
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Secretary of the Commonwealth
Massachusetts Historical Commission
220 Morissey Boulevard
Boston, MA 02125-3314

Bill Saloma
Massachusetts Office of Dam Safety
180 Beaman Street
West Boylston, MA 01583

Massachusetts Office of the Attorney General
1 Ashburton Place
Boston, MA 02108-1518

Bjorn Lake
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Celeste Bernardo
Lowell National Historical Park
National Park Service
67 Kirk Street
Lowell, MA 01852

Christine Bruins
Lowell National Historical Park
National Park Service
67 Kirk Street
Lowell, MA 01852

Duncan Hay
Northeast Region
National Park Service
15 State Street
Boston, MA 02109

Kevin Mendik
Hydro Program Manager
National Park Service
15 State Street
Boston, MA 02109

Misty Anne Marold
Senior Review Biologist
Natural Heritage Endangered Species Program
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Owen David
Water Quality Certification Program
New Hampshire Department of Environmental Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Jim Gallagher
Dam Bureau Administrator
New Hampshire Department of Environmental Services
29 Hazen Drive
P.O. Box 95
Concord, NH 03302

Brad Simpkins
Director
New Hampshire Division of Forests and Lands
172 Pembroke Road
Concord, NH 03301

Benjamin Wilson
SHPO & Director
New Hampshire Division of Historical Resources
19 Pillsbury Street, 2nd Floor
Concord, NH 03301-3570

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Matt Carpenter
Fisheries Biologist
New Hampshire Fish and Game Department
11 Hazen Drive
Concord, NH 03301

Bill McDavitt
Environmental Specialist
NOAA Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

Chris Boelke
Chief, New England Branch
NOAA Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930

George Rose
Deputy Director
Office of Emergency Management
The City of Lowell Fire Department
JFK Civic Center, 99 Moody Street
Lowell, MA 01852

Harold Peterson
Bureau of Indian Affairs
US Department of the Interior
545 Marriott Drive
Suite 700
Nashville, TN 37214

Office of the Solicitor, Northeast Region
US Department of the Interior
15 State Street
8th Floor
Boston, MA 02109-3502

Ed Reiner
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OEP06-3
Boston, MA 02109-3912

David Turin
Region 1 - New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: OES04-3
Boston, MA 02109-3912

Tom Chapman
Supervisor, New England Field Office
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301-5094

Ken Hogan
Fish and Wildlife Biologist
US Fish and Wildlife Service
70 Commercial Street
Suite 300
Concord, NH 03301

Douglas Smithwood
Fish Biologist
US Fish and Wildlife Service
Central New England Fish and Wildlife
Conservation Office
151 Broad Street
Nashua, NH 03063

Bryan Sojkowski
Civil Engineer
US Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035

Keith Nislow
Northern Research Station
US Forest Service
11 Campus Boulevard
Suite 200
Newton Square, PA 19073

Mark Prout
Region 9 - Eastern Region (Midwest and
Northeast)
US Forest Service
626 East Wisconsin Avenue
Milwaukee, WI 53202

Indian Tribes

Cedric Cromwell
Chairman
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Ramona Peters
Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

John Brown
Narragansett Indian Tribal Historic Preservation Office
Narragansett Indian Tribe
P.O. Box 268
Charlestown, RI 02813

Bonney Hartley
Tribal Historic Preservation Manager
Stockbridge Munsee Community
86 Spring Street
Williamstown, MA 01267

Shannon Holsey
Tribal President
Stockbridge Munsee Community, Wisconsin
N8476 MoHeConNuck Road
Bowler, WI 54416

Cheryl Andrew-Maltais
Chairwoman
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Bettina Washington
Tribal Historic Preservation Officer
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Municipalities

James Fiorentini
Mayor
City of Haverhill, MA
4 Summer Street
Haverhill, MA 01830

Kendrya Vasquez
Mayor
City of Lawrence, MA
200 Common Street
3rd Floor Room 309
Lawrence, MA 01840

Christine Clancy
City of Lowell Engineer
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 61
Lowell, MA 01852

John Leahy
Mayor
City of Lowell, MA
375 Merrimack Street
2nd Floor
Lowell, MA 01852

Christine O'Connor
City Solicitor
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 64
Lowell, MA 01852

Joyce Craig
Mayor
City of Manchester, NH
One City Hall Plaza
Manchester, NH 03101

James Jajuga
Mayor
City of Methuen, MA
41 Pleasant Street
Methuen, MA 01844

Jim Donchess
City of Nashua, NH
229 Main Street
Nashua, NH 03060

Scott Galvin
Mayor
City of Woburn, MA
10 Common Street
Woburn, MA 01801

Paul Bergeron
District #2
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Toni Pappas
District #1
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

Robert Rowe
District #3
Hillsborough County, NH
329 Mast Road
Suite 120
Goffstown, NH 03045

John Mangiaratti
Town Manager
Town of Acton, MA
472 Main Street
Acton, MA 01720

Andrew Flanagan
Town Manager
Town of Andover, MA
36 Bartlet Street
Andover, MA 01810

David Cressman
Town Administrator
Town of Atkinson, NH
19 Academy Avenue
Atkinson, NH 03811

Robert Pontbriand
Town Administrator
Town of Ayer, MA
1 Main Street
Ayer, MA 01432

Sarah Stanton
Town Manager
Town of Bedford, MA
10 Mudge Way
Bedford, MA 01730

John Curran
Town Manager
Town of Billerica, MA
365 Boston Road
Billerica, MA 01821

Alan Benson
Town Administrator
Town of Boxford, MA
7A Spofford Road
Boxford, MA 01921

Paul Sagarino
Town Administrator
Town of Burlington, MA
29 Center Street
Burlington, MA 01803

Jon Kurland
Town Moderator
Town of Chelmsford, MA
50 Billerica Road
Chelmsford, MA 01824

Stephen Crane
Town Manager
Town of Concord, MA
P.O. Box 535
Concord, MA 01742

David Caron
Town Administrator
Town of Derry, NH
14 Manning Street
Derry, NH 03038

Ann Vandal
Town Manager
Town of Dracut, MA
62 Arlington Street
Dracut, MA 01826

Robert Pontibriand
Town Manager
Town of Groton, MA
173 Main Street
Groton, MA 01450

Timothy Bragan
Town Administrator
Town of Harvard, MA
13 Ayer Road
Harvard, MA 01451

Lori Radke
Town Administrator
Town of Hollis, NH
7 Monument Square
Hollis, NH 03049

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Steve Malizia
Administrator
Town of Hudson, NH
12 School Street
Hudson, NH 03051

James Malloy
Town Manager
Town of Lexington, MA
1625 Massachusetts Avenue
2nd Floor, Town Office Building
Lexington, MA 02420

Timothy Higgins
Town Administrator
Town of Lincoln, MA
16 Lincoln Road
Lincoln, MA 01773

Troy Brown
Town Administrator
Town of Litchfield, NH
2 Liberty Way
Suite 2
Litchfield, NH 03052

Anthony Ansaldi
Town Administrator
Town of Littleton, MA
37 Shattuck Street
3rd Floor, Room 306
Littleton, MA 01460

Kevin Smith
Chairman
Town of Londonderry, NH
268B Mammoth Road
Londonderry, NH 03053

Robert Dolan
Town Administrator
Town of Lynnfield, MA
55 Summer Street
Lynnfield, MA 01940

Eileen Cabanel
Town Manager
Town of Merrimack, NH
6 Baboosic Lake Road
Merrimack, NH 03054

Andrew Sheehan
Town Administrator
Town of Middleton, MA
48 South Main Street
Middleton, MA 01949

Melissa Rodrigues
Town Manager
Town of North Andover, MA
120 Main Street
North Andover, MA 01845

Michael Gilleberto
Town Administrator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

John Murphy
Town Moderator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

Brian McCarthy
Town Administrator
Town of Pelham, NH
6 Village Green
Pelham, NH 03076

Andrew MacLean
Town Administrator
Town of Pepperell, MA
One Main Street
Pepperell, MA 01463

John Arena
Chair, Board of Selectmen
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Robert LeLacheur
Town Manager
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Christopher Dillon
Chairman
Town of Salem, NH
33 Geremonty Drive
Salem, NH 03079

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Michael McGovern
Town Administrator
Town of Shirley, MA
7 Keady Way
Shirley, MA 01464

Dennis Sheeham
Town of Stoneham, MA
35 Central Street
2nd Floor
Stoneham, MA 02180

Richard Montuori
Town Manager
Town of Tewksbury, MA
1009 Main Street
2nd Floor
Tewksbury, MA 01876

Matt Hanson
Town Administrator
Town of Tyngsborough, MA
25 Bryant Lane
Tyngsborough, MA 01879

Richard Reault
Chair, Board of Selectmen
Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

Jodi Ross
Town Manager
Town of Westford, MA
55 Main Street
Westford, MA 01886

Jeffrey Hull
Town Manager
Town of Wilmington, MA
121 Glen Road
Room 11
Wilmington, MA 01887

David Sullivan
Town Administrator
Town of Windham, NH
3 North Lowell Street
Windham, NH 03087

<u>Additional Parties</u>

Robert Nasdor
NE Stewardship Director
American Whitewater
65 Blueberry Hill Lane
Sudbury, MA 01776

Norman Sims
Appalachian Mountain Club
77 Back Ashuelot Road
Winchester, NH 03470

Kevin Webb
Licensing Manager
Central Rivers Power
670 N Commercial Street
Suite 204
Manchester, NH 03102

Kevin Hollenbeck
Metrowest District Manager
DCR Great Brook Farm State Park
984 Lowell Street
Carlisle, MA 01741

Robert Bersak
780 North Commercial Street
Eversource Energy
P.O. Box 330
Manchester, NH 03015

Jay Mason
President
Friends of Tyler Park
77 Tyler Park
Lowell, MA 01851

David Meeker
Hull Street Energy, LLC
4920 Elm Street
Suite 205
Bethesda, MD 20814

Jeffrey J. Winward
Fire Chief
Lowell Fire Department
99 Moody Street
Lowell, MA 01852

Dinell Clark
Lowell Flood Owner's Group
197 Wellman Avenue
North Chelmsford, MA 01863

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Bob Gagnon
Lowell Flood Owner's Group
136 Townsend Avenue
Lowell, MA 01854

Lynda Ignacio
Lowell Flood Owner's Group
66 Shirley Avenue
Lowell, MA 01854

Steve Masse
Lowell Flood Owner's Group
186 Humphrey Street
Lowell, MA 01850

John Nappi
Lowell Flood Owner's Group
279 Pawtucket Boulevard
Tyngsborough, MA 01879

Gene Porter
Lower Merrimack River Local Advisory
77 Concord Street
Nashua, NH 03064

Thomas Golden, Jr.
Massachusetts House of Representatives
24 Beacon Street
Room 473B
Boston, MA 02133

Vanna Howard
Massachusetts House of Representatives
24 Beacon Street
Boston, MA 02133

Rady Mom
Massachusetts House of Representatives
24 Beacon Street
Room 43
Boston, MA 02133

Edward Kennedy
Massachusetts Senate
24 Beacon Street
Room 405
Boston, MA 02133

Matthew Thorne
Executive Director
Merrimack River Watershed Council
60 Island Street
Suite 211-E
Lawrence, MA 01840

Chris Countie
Water Supply Manager
Pennichuck Water Works
P.O. Box 1947
25 Manchester Street
Merrimack, NH 03054

Peter Severance
Research/Program Director
River Merrimack

Fred Jennings
President, Nor'East Chapter
Trout Unlimited
P.O. Box 946
Ipswich, MA 01938

Arthur Faneros
Universal Apartment Rental
114 University Avenue
Lowell, MA 01854

Michele Tremblay
Upper Merrimack River Local Advisory Committee
P.O. Box 3019
Penacook, NH 03303

Ann Kuster
US House of Representatives
137 Cannon House Office Building
2nd District
Washington, DC 20515

Seth Moulton
6th District
US House of Representatives
21 Front Street
Salem, MA 01970

Chris Pappas
US House of Representatives
889 Elm Street
Manchester, NH 03101

Lori Trahan
3rd District
US House of Representatives
126 John Street
Suite 12
Lowell, MA 01852

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Margaret Hassan
US Senate
330 Hart Senate Office Building
Washington, DC 20510

Edward Markey
US Senate
218 Russell Senate Office Building
Washington, DC 20510

Jeanne Shaheen
US Senate
506 Hart Senate Office Building
Washington, DC 20510

Elizabeth Warren
US Senate
317 Hart Senate Office Building
Washington, DC 20510

Dinell Clark
President
Williamsburg Condominium I
197 Wellman Avenue
North Chelmsford, MA 01863

Richard Howe
Register of Deeds - Middlesex County North
360 Gorham Street
Lowell, MA 01852

Scott, Kelsey

From:	Scott, Kelsey
Sent:	Tuesday, August 17, 2021 3:06 PM
To:	Bernardo, Celeste; duncan_hay@nps.gov; kevin_mendik@nps.gov; Baacke, Adam C; cmccall@lowellma.gov; william.salomaa@mass.gov; robert.lowell@mass.gov; 'Fedele, Mark D. (DOT)'; Lonsway, Peter; Cassidy, Lisa A; rodney.elliott@mass.gov; Elliott, Rodney (DCR; Keefe Mullin, Kara; JGleason@lowellma.gov; Chang, Ting; patrice.kish@state.ma.us; Clancy, Christine; 'thomas.m.walsh@state.ma.us; marmel23 @myfairpoint.net; mhc@sec.state.ma.us; Bjorn Lake; Hogan, Kenneth J; Sojkowski, Bryan; Smithwood, Doug; Mattocks, Steven (FWE); Gahagan, Ben (FWE); Carpenter, Matthew; Slater, Caleb (FWE); christopher.boelke; Quinones, Rebecca (FWE); Benjamin German - NOAA Federal
Cc:	Kevin Webb; Richard Malloy; Quiggle, Robert
Subject:	Lowell Hydroelectric Project - Response to Deficiency of License Application
Attachments:	20210817 Lowell Deficiency Response for Consultation.pdf

Dear Stakeholders,

Boott Hydropower, LLC (Boott) is pursuing a new license from the Federal Energy Regulatory Commission (FERC) for the Lowell Hydroelectric Project. In accordance with the applicable regulations at 18 C.F.R. § 5.17(a), Boott filed a final application for a new license (Final License Application or FLA) with the Commission on April 30, 2021. On May 27, 2021, the Commission issued correspondence identifying deficiencies in the FLA and directed Boott to file additional information to correct the deficiencies on or before August 25, 2021.

As noted in the Commission's letter, and detailed in the attached package, FERC is requesting Boott consult with state and federal agencies regarding the decommissioning proposed action. Therefore, Boott is requesting a response to the attached package on or before August 24, 2021.

Should you have any questions regarding the enclosed letter and associated attachments, please contact Kevin Webb, Licensing Manager with Boott, at (978) 935-6039 or kwebb@centralriverspower.com.

Kelsey Scott, MS
Regulatory Specialist

HDR
1304 Buckley Road, Suite 202
Syracuse, NY 13212
D 315.414.2206 M 315.706.5176
kelsey.scott@hdrinc.com
hdrinc.com/follow-us

Boott Hydropower, LLC
Subsidiary of Central Rivers Power US, LLC
670 N. Commercial Street, Suite 204
Manchester, NH 03101

Via eFiling August 17, 2021

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: **Lowell Hydroelectric Project (FERC No. 2790-074)**
Response to Deficiency of License Application - Proposed Action

Dear Secretary Bose:

Boott Hydropower, LLC (Boott or Licensee) is the Licensee, owner, and operator of the 20.2-megawatt Lowell Hydroelectric Project (Project or Lowell Project) (FERC No. 2790). Boott operates the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Project's existing license expires on April 30, 2023. Boott is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (C.F.R.) Part 5. In accordance with the applicable regulations at 18 C.F.R. § 5.17(a), Boott filed a final application for a new license (Final License Application or FLA) with the Commission on April 30, 2021.

On May 27, 2021, the Commission issued correspondence identifying deficiencies in the FLA and directed Boott to file additional information to correct the deficiencies on or before August 25, 2021. This consultation package, including the attachments, provides the requested information to resolve certain deficiencies regarding proposed actions. Information requested by FERC staff is listed below in italics, followed by Boott's response.

As noted in the Commission's letter, deficiency item 1(g) in FERC's letter, Boott is required to provide letters of consultation to FERC. Due to the deadline provided by the Commission, Boott is requesting responses to this consultation package by August 24, 2021.

Proposed Action

1. *Section 5.18(b)(4) of the Commission's regulations requires an applicant to provide a description of the proposed facilities and operation of the project. Section 5.18(b)(5) of the Commission's regulations requires that the license application include an environmental document that explains the effects of the applicant's proposal on resources, proposed environmental measures, and an implementation schedule for proposed measures and facilities.*

   In the FLA, Boott proposes to decommission fifteen turbine-generator units that are included in the current license and to remove the canal system located in downtown Lowell, *Massachusetts from the current project boundary. In Exhibit E of the application (e.g., page E-40), Boott proposes to develop a decommissioning plan within 18 months of issuance of a new license to define the final disposition of the turbine-generators, canal system, and appurtenant facilities, and to address public safety, dam safety, and environmental concerns associated with its decommissioning proposal.*

The FLA does not include the information required by sections 5.18(b)(4) or (5) in relation to Boott's decommissioning proposal, including: how the project will operate after the facilities are decommissioned (e.g., the frequency and duration of flow releases to the historic canal system); the proposed project's effects on environmental resources (e.g., fisheries, recreation, and cultural resources); the proposed project's effects on dam safety and public safety; specific environmental measures; or a schedule for decommissioning the facilities. Addressing these issues cannot be put off until after a decision is issued on the project's relicensing.

To correct these deficiencies, Boott must revise the FLA to include the following information:

(a) a full list of every project facility that Boott is proposing to decommission and remove from the project, and a description of how Boott will decommission each facility (e.g., disconnecting mechanical and electrical components, installing cofferdams, removing facilities, sealing points of discharge, etc.);

Boott response: In this response, Boott is using the term "decommission" in its strict sense, i.e., to remove from service or to render inactive. Boott proposes to decommission only the existing four downtown mill power stations and associated infrastructure. All other canal infrastructure will remain in operable condition. Boott will continue to manage canal levels and flows and to maintain facilities in line with existing rights, responsibilities, and existing or new agreements developed among the concerned stakeholders. In Attachment A of this response Boott has provided a list of each Project facility proposed to be removed from the Lowell Project's FERC license, the ownership and associated rights of each facility to the extent known at this time, and a description of how Boott will decommission or manage each facility.

(b) a description of how the project will operate after the facilities are decommissioned, including: (i) target water elevations within the canal system; (ii) a schedule and volume of flow releases to the canal system, as described on a seasonal and/or annual basis; (iii) a description of how flows will be monitored and released to the canal system; and (iv) copies of all current agreements with the National Park Service, Massachusetts Department of Conservation and Recreation, City of Lowell, Massachusetts Historical Commission, and other stakeholders related to water levels and flows in the downtown canal system;

Boott response:

(i) As stated in the FLA, Boott will continue to maintain and monitor canal water levels consistent with current practices. Water levels in the upper system are monitored at a staff gauge near the terminus of the Hamilton Canal, adjacent to the Hamilton Waste Gates. Water levels in the lower system are monitored at two staff gauges on the Eastern Canal, located at the Section 8 (Bridge Street) powerhouse intake and at the John Street Unit 6 intake, respectively. All three of these gages refer to Proprietors of Locks & Canals (PL&C) datum, which is 5.2 feet higher than the National Geodetic Vertical Datum of 1929 (NGVD29), i.e., PL&C + 5.2 = NGVD29. The target water levels for the canals are:

- Pawtucket Canal upstream of Guard Locks: 92.2 ft NGVD29, i.e., the same level as the normal pond level in Project impoundment;
- Upper canal system (including Upper Pawtucket Canal between Guard Locks and Swamp Locks, Hamilton Canal, Merrimack Canal, Western Canal, and Northern Canal between Hydro Locks and Western Canal): staff gage reading 81.5 ft PL&C = 86.7 ft NGVD29;
- Lower canal system (including Lower Pawtucket Canal and Eastern Canal): staff gage reading 66.6 ft PL&C = 71.8 ft NGVD29.

Canal levels may vary from these target levels, e.g., during canal drawdowns to facilitate maintenance and repair of infrastructure adjacent to the canals.

(ii) Boott anticipates that absent the flow demand of the existing mill turbine units, flows normally released to the downtown canal system via the Guard Lock and Gates Facility ("Guard Locks") will largely consist of those necessary to maintain and manage canal water levels. Presently, Boott estimates that a flow of 200 to 300 cfs must be released from the Guard Locks to make up for leakage and other water losses within the 5.5-mile-long canal system.

Boott will continue to respond to any requests for canal level or flow modifications from the NPS, MADCR, the City of Lowell and other stakeholders in the downtown Lowell area, on a case-by-case basis. Prior to performing any such canal level modifications Boott issues a notice to all concerned stakeholders. As these canal level modifications are and will continue to be scheduled and performed on an as-needed basis, Boott is not able to provide a seasonal and/or annual schedule of flow releases to the canal system.

(iii) Boott will continue to maintain and monitor the staff gauges in both the upper and lower canal systems as described above and will make any adjustments in flow necessary to manage canal levels. Water levels in the upper system are monitored at a staff gauge adjacent to the Hamilton Waste Gates, near the terminus of the Hamilton Canal. Boott typically monitors these gages on a weekly basis and adjusts the gates as necessary to maintain the canals at their target levels.

(iv) Boott consulted with the stakeholders to determine whether there are any documents or agreements which specify canal water levels or flows. The only such document that has been identified is Boott's Revised Report on Recreational Resources, which was filed on April 16, 1984 pursuant to Article 38 of the existing license and approved by FERC on September 12, 1984.[1] A copy of this report is included in Attachment B. The Revised Report includes a section entitled Canal System Water Elevation Maintenance, which states "Boott has agreed to lower the water surface elevation of the lower canal system by 3 to 6 inches during navigation periods" to provide adequate clearance under bridge crossings for NPS tour boats. The statement does not reference a normal water level from which the canal levels would be lowered. However, archival data from the Proprietors of Locks and Canals indicate that the normal water level in the upper canal system was 82.50 feet PL&C at Swamp Locks and in the Hamilton Canal, whereas the water level in the lower canal system is variously shown between 67.50- and 68.50-feet PL&C. Comparing these levels to the current target levels provided in item (i) above, it appears that Boott presently operates the canals approximately one foot lower than historic levels, and about 6 inches lower than provided in the Revised Report on Recreational Resources. Boott operates the canals at these levels year-round and does not normally modify canal levels during navigation vs. non-navigation periods.

(c) an environmental report that describes environmental effects that are expected to occur during and after decommissioning and any proposed measures for mitigating those effects. At a minimum, this information should explain the effects of the proposal for each resource area (i.e., Geology and Soils; Water Quantity and Quality; Fish and Aquatic Resources; Terrestrial Resources; Rare, Threatened and Endangered Species; Recreation and Land Use; Aesthetics and Socioeconomic Resources; and Cultural Resources) and include: (i) a description of the affected environment, (ii) a detailed analysis of the effects of the proposal, (iii) a description of any unavoidable adverse impacts, and (iv) proposed measures to mitigate effects of the licensing proposal;

Boott response: Boott has revised Exhibit E of the FLA to include a description of environmental effects that are expected to occur during and after decommissioning and any proposed measures for mitigating those effects. The revised Exhibit E is included as Attachment C. For convenience, revisions to the exhibit have been highlighted.

[1] 28 FERC ¶ 62,357, September 12, 1984.

(d) *a description of proposed measures to address public safety and dam safety concerns associated with the decommissioning proposal;*

Boott response: Attachment A includes a description of measures that Boott proposes to undertake to address public safety and dam safety concerns associated with the decommissioning process. In general, these measures include removing intakes, infilling penstocks with a concrete plug, and disconnecting turbines, generators, and other electrical equipment.

Boott currently maintains safety signage and a Public Safety Plan[2], which includes signage throughout the canal system, as a requirement under its current FERC license. Boott proposes to continue to maintain the signage and Plan for the downtown canal infrastructure outside of the new FERC license.

(e) *a schedule/timeline for decommissioning each project facility and implementing any proposed measures (see also 4.51(d));*

Boott response: Boott proposes the following prospective schedule for decommissioning the four mill power stations:

- File Decommissioning Plan for Assets Power Station within one year of license issuance and decommission within two years of license issuance.
- File Decommissioning Plan for John Street Power Station within two years of license issuance and decommission within three years of license issuance.
- File Decommissioning Plan for Bridge Street Power Station ("Section 8") within three years of license issuance and decommission within four years of license issuance.
- File Decommissioning Plan for Hamilton Power Station within four years of license issuance and decommission within five years of license issuance.

(f) *a description of any direct and indirect costs associated with decommissioning each project facility, such as disconnecting mechanical and electrical components, installing cofferdams, removing facilities, sealing points of discharge, etc. (see also 4.51(e));*

[2] Accession Number 20200320-5120

Boott response:

Boott anticipates a cost of $x,xxx,xxx (*Boott is currently calculating anticipated costs*) to decommission all four power stations. This estimate includes all direct and indirect costs associated with decommissioning facilities.

Please do not hesitate to contact me at (978) 935-6039 or kwebb@centralriverspower.com if you have any questions concerning this submittal.

Sincerely,

Boott Hydropower, LLC

Kevin M. Webb
Licensing Manager

ATTACHMENT A

Structure	Subcomponents	Ownership	Other Rights	Action	Other
CANALS					
Upper Pawtucket Canal	–	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal[a] • Boott Water and Flowage Rights[b] • MADCR Recreation Rights and Exclusive Easement Rights[c]	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Lower Pawtucket Canal	–	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Hamilton Canal	–	Boott Hydropower LLC (Boott)	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Merrimack Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
Eastern Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
Northern Canal - Hydro Locks to Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
DAMS AND LOCK STRUCTURES					
Swamp Locks Complex	Swamp Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures[d]	No change from present	–
	Swamp Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Swamp Locks Dam (North and South)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	No change from present	–
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	No change from present; Boott will continue to operate the gates for canal water level management.	–
Lower Locks Complex	Lower Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
	Lower Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
	Lower Locks Dam	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights[e]	No change from present	–
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Moody Street Feeder	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	Retain a 5' corridor for submarine interconnection cable
Lawrence Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Hall Street Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Hamilton Wasteway	-	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Hamilton Gatehouse and Gate (Superstructure)	–	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
Hamilton Gatehouse and Gate (Substructure)	–	Boott	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–
Tremont Wasteway	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Tremont Gatehouse	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Merrimack Dam and Gate	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Rolling Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Boott Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
DOWNTOWN POWERHOUSES					
Assets	Intakes	Proprietors of Locks & Canals	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals[f]	• Boott Easement to Penstocks and Tailraces[g]	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers[h]	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
Hamilton	Intakes	Boott	–	Install concrete plug in penstock opening at canal wall.	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
John Street	Intakes	Boott	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
Bridge Street (Section 8)	Intakes	Boott		Install concrete plug-in penstock opening at canal wall.	Retain a 5' corridor for submarine interconnection cable
	Penstocks	Boott	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	Retain a 5' corridor for submarine interconnection cable
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott		Disconnect the generators and switch gear	Retain any equipment necessary for interconnection purposes.

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	Retain a 5' corridor for submarine interconnection cable

[a] Easement to the Pawtucket Canal, Lower Pawtucket Canal, the Swamp Locks Dam and Lower Locks Dam for the uninterrupted flowage of water to the canals, together with the right to install conduits, pipes and wiring, and the right to maintain, repair, and replace canal walls and fences, and to maintain and operate Swamp Locks Dam and Lower Locks Dam. See pg. 4-5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[b] Any and all water rights which may exist regardless of how acquired, including, without limitation, any and all water rights by way of riparian rights. See pg. 4-7 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete description of said rights.

[c] All air rights over the canals, including the canal walls and any dams thereon. The exclusive right to use water in the entire canal system and the Merrimack River for recreational, educational, and navigational purposes. For a complete legal description of these rights, see Order of Taking pg. 27 – 28, filed as Appendix C of the Resources, Ownership, Boundaries, and Land Rights Study Report, filed with the Commission on February 25, 2021.

[d] Exclusive right of operating and controlling the gatehouses and locating, keeping in place, maintaining, replacing, operating, controlling and disposing of the control machinery and equipment, gauge equipment and other mechanisms located therein and for access and repair of the gatehouses and access to and maintenance, repair, and installation of the control machinery and equipment, gauge equipment and such other mechanisms located therein that may need to be repaired, reconstructed, or replaced See pg. 5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[e] Right to conduct land and canal tours, run interpretive programs and maintenance, improvement and restoration of Gatehouses and support structures, Dams, and Lock Chambers. See pg. 3 of the Grant of Easement (filed as Appendix D to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[f] Presumed ownership, to be confirmed.

[g] Boott holds an easement to operate, maintain, repair, and replace penstocks leading from the Merrimack Canal, Eastern Canal or Hamilton Canal. Boott holds an easement to operate, maintain, repair, and replace tailraces leading to the Pawtucket Canal, the Concord River, or the Merrimack River. See pg. 8 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[h] An easement to keep in place, locate, operate, maintain, repair, remove and replace the transformers and an easement for unrestricted access thereto for such purposes. See pg. 9 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

ATTACHMENT B

2277
BT 401.2.5
Art 38

REVISED REPORT ON RECREATIONAL RESOURCES
FOR THE
LOWELL HYDROELECTRIC PROJECT

FERC PROJECT NO. 2790

INTRODUCTION

This revised report on recreational resources for the Lowell Hydroelectric Project, FERC Project No. 2790, is submitted in conformance with Article 38 of the Order issuing license (Major) dated April 13, 1983. It modifies and supplements Section E-5 of Exhibit E (Report on Recreational Resources) to the Application for License (Major Project - Existing Dam) dated May 20, 1980. Except as modified or supplemented herein, Section E-5 is hereby incorporated in and made a part of this revised recreational resources report by reference.

Article 38 requires that this revised report provide additional information in the following areas:

- The navigation lock in the proposed control structure.
- The Northern Canal walkway.
- The Northern Canal gates.
- The visitor facility at the proposed powerhouse.
- The canal system water elevation maintenance plan.

These items are addressed in the remainder of this revised report.

As a preliminary matter, Boott notes that it had not reached agreement with the Massachusetts Department of Environmental Management (DEM) concerning acquisition of certain canal properties and water rights for the Lowell Heritage State Park at the time Boott filed its license application the with Commission. As a result of on-going negotiations during the past year, however, the DEM and Boott have reached an agreement in this regard. Counsel for the DEM, the firm of Murphy, Crowley, Spencer and Dray, are presently completing the necessary appraisals to finalize the so-called "Orders of Taking." These orders will enable the Commonwealth of Massachusetts to take the necessary land and water rights by condemnation rather than conveyance and establish what is considered clear title for all time for the State. This process has been agreed to by both the DEM and Boott and both parties anticipate executing a final agreement by May 15, 1984.

NAVIGATION LOCK

The navigation lock and control structure are shown in plan and section in drawing 3844D-CC-001, which is attached. This functional drawing has been developed in consultation with the National Park Service (NPS). Initially, a gabion and rock-fill control structure was planned with a reinforced concrete lock structure. Recently, two alternative designs were considered and a decision was made to use a concrete control structure and lock. The design details shown on the functional drawing are intended to be fully responsive to the requirements and suggestions of the NPS.

Construction of the control structure and lock is scheduled to begin in mid-May 1984 and be completed by the end of August 1984. A cofferdam was constructed across the Northern Canal and the section of the Canal from the Northern Gatehouse to the cofferdam dewatered in November 1983. Total direct construction costs of the navigation lock, exclusive of interest expense during construction and financing fees, is $175,000.

NORTHERN CANAL WALKWAY

The Northern Canal walkway begins at the Pawtucket Bridge where it is accessed through an iron gate and down several granite steps. It runs about 2200 feet along the Canal to its termination at the site of the new powerhouse. The continuity of the walkway has been interrupted for many years because of the deteriorated condition of a cantilevered section around the waste gatehouse approximately 200 feet from the project site. This section could only be transited by walking through the waste gatehouse, a structure normally kept locked. Thus, the entire walkway has not been open to the public in the past, except for special tours conducted by NPS guides.

Access to the walkway has now been further interrupted by the excavation of the forebay serving the new powerhouse and will so remain until the powerhouse intake structure is completed. Continuity of the walkway will then by reestablished across the powerhouse intake, ultimately providing good pedestrian access. This access will be barrier-free and utilizes design concepts set out in "Accommodation of Handicapped Visitors at Historic Sites," U.S. Department of the Interior, National Park Service. Throughout construction, however, virtually the entire length of the walkway remains accessible from the entrance gate at the Pawtucket Bridge to the waste gatehouse.

Drawings 2601-08-02 and 03 show the route of the walkway from the Great River Wall thru the waste gatehouse across the powerhouse intake at station 3+96.00 to the access road and Pawtucket Street. The walkway is not explicitly labeled in these drawings as their primary focus is the general layout of the new powerhouse and tailrace.

The construction of the powerhouse and integral intake structure will commence in April 1984 and be completed in November 1984. The cost of the work associated with the walkway is not readily ascertainable, as it is an integral part of the powerhouse. However, these costs have been included in Boott's determination of total project costs.

NORTHERN CANAL GATES

A total of ten sluice gates control the flow of water into the Northern Canal. Each of these is approximately

8 feet wide and 15 feet high with a depth of 12 inches. All gates currently remain intact and are in place.

The gates are considered to be in good condition except for the lifting mechanisms. Wear and tear on the gates over the years has reduced the thickness of the wood at the top of most gates from 12 inches to as little as 4 inches. This has caused many of the yokes to become loosened or unattached. The gate lifting mechanism is attached to the yoke thereby enabling the gates to be opened or closed.

Repair of the gates will consist of removing the yokes, rebuilding the worn top section of the gates to their original thickness of 12 inches, and refastening the yokes. Broken or missing pieces of the lifting mechanisms will be replaced in kind, or as approved by the NPS. It is anticipated that all remedial work can be accomplished while the gates remain in place. The work is scheduled to begin in May 1984 and completed by October 1984 at a total cost of $80,000. License Application Exhibit F-16, attached, provides the details of the Northern Canal Gatehouse. There are no functional drawings applicable to the repair of the gate.

VISITOR FACILITY

The visitor facility will be contructed concurrently with the powerhouse, of which it is an integral part. It consis of two separate rooms within the powerhouse: A small reception room complete with restroom facilities on top of the intake structure adjacent the walkway, and a visitor's gallery overlooking the turbine-generator via observation windows provided for this purpose. Drawings 2601-08-12 and 14, which are attached, show these rooms. The details of the exhibits and interpretive materials to be placed in these rooms, as discussed in the Report on Recreational Resources, have not as yet been finalized. These details will be worked out with the NPS throughout the construction period, cointinuing after commencement of commercial operations. They will be finalized prior to the 1986 tourist season.

Substantial progress has been made regarding the use of the powerhouse and the visitor facility by the University of Lowell. The lease agreement between Boott and the University calls for the following:

- o The preservation of all models made by Boott or its contractor during design and construction for study and experimentation by students and instructors.

- o The provision of at least 1000 square feet adequate fo non-exclusion, periodic use as a classroom.

- o The provision of a 12-inch diameter conduit embedded in the powerhouse to enable hydraulic experiments to be conducted by students and instructors.

- o The preservation of instrumentation used in the startup and testing of the plant.

- The provision of reasonable access to the plant for the purpose of making a videotape or film record of the construction of the project.

- The provision of access to data associated with the operation of fish passage facilities.

These details are discussed in Article 4 of the Lease Agreement between the University of Lowell and Boott, which is appended to this report.

As mentioned previously, the powerhouse construction will begin in April 1984 and be completed in November 1984. The finishing and outfitting of the powerhouse, including the visitor facility is scheduled to begin in April 1985 and be completed in late September 1985. The final outfitting of the visitor facility with exhibits, interpretive materials, models, etc. is scheduled for April of 1986. The cost of the visitor facility is difficult to ascertain, as it is an integral part of the powerhouse. However, Boott has included such cost in its determination of total project costs.

CANAL SYSTEM WATER ELEVATION MAINTENANCE

The canal system water surface elevations have been the subject of discussions with the NPS on various occasions extending back to March 1980. The principal concern is the clearance required by tour boats under the low bridges that span the canals. After considerable study of the canal system, the tour boat plans of the NPS, and the clearance constraints, Boott has agreed to lower the water surface elevation of the lower canal system by 3 to 6 inches during navigation periods. This is believed by all parties to satisfy the requirements for tour boat passage from the Concord River through the lower and upper Canal Systems to the reservoir impounded by the Pawtucket Dam.

SKADDEN, ARPS, SLATE, MEAGHER & FLOM
919 EIGHTEENTH STREET, N.W.
WASHINGTON, D.C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3931

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
(212) 371 6000

ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002

ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

VIA FEDERAL EXPRESS

Carol Cunningham, P.E.
International Engineering
Company, Inc.
777 Post Road
Darien, Connecticut 06820

Re: Lowell Hydroelctric Project
Artice 20 and Article 38

Dear Carol:

As I mentioned in our conversation last Friday, I received a telephone call from Mr. John Young, Chief of the Recreation and Land Use Section of the Division of Hydropower Licensing at the FERC regarding the Article 20 and Article 38 filing which we submitted on April 16, 1984.

The purpose of Mr. Young's phone call was to informally notify us (rather than sending out a deficiency letter at this time) that he would not begin processing our Article 38 Revised Recreational Report until we forward the letters of comment from the Massachusetts State Historic Preservation Officer, the National Park Service and the Massachusetts Department of Environmental Management. He requested our follow-up filing discuss any issues raised in the comment letters of these agencies and either explain how we have resolved the issues raised or, if necessary, explain why we are unable to respond to their comments. In particular, with regard to SHPO, he requested we obtain a finding that the Revised Recreational Report for the Project would have "no adverse effect" on the Lowell Historic District. Mr. Young also stated that he presently had no problem with our position that an Article 20 reservoir clearing plan is unnecessary.

As you requested, I have enclosed copies of the cover letters we sent out to the three agencies and a copy of the Revised Report which has been red-lined to show the minor technical changes that we made.

Sincerely,

June

June P. Broadstone

Enclosures

cc: Mr. Melvin G. Lezberg

SKADDEN, ARPS, SLATE, MEAGHER & FLOM
919 EIGHTEENTH STREET, N. W.
WASHINGTON, D. C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3951

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
(212) 371-6000

ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002

ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

Mr. S. Christopher Scott
Commonwealth of Massachusetts
Department of Environmental Management
100 Cambridge Street
Boston, Massachusetts 02108

Re: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Mr. Scott:

On April 12, 1984, Boott Hydropower, Inc. ("Boott") submitted for your review and comment the Revised Report on Recreational Resources (the "Revised Report") for the Lowell Hydroelectric Project, which was prepared in accordance with Article 38 of the Federal Energy Regulatory Commission (the "FERC") project license. On April 16, 1984, a copy of the Revised Report was filed with the FERC.

The Revised Report filed with the FERC contained certain minor changes. For your information and convenience, I have enclosed a redlined copy of the report as filed with the FERC on April 16, 1984. These changes were technical and did not affect the substance of the report. No changes were made to any of the attachments to the report.

We continue to look forward to your early response to the Revised Report.

Very truly yours,

June Broadstone

June P. Broadstone
Attorney for Boott
Hydropower, Inc.

Enclosure

SKADDEN, ARPS, SLATE, MEAGHER & FLOM
919 EIGHTEENTH STREET, N. W.
WASHINGTON, D. C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3931

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
(212) 371-6000

ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002

ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

Mr. John Burchill
U.S. Department of the Interior
National Park Service
Lowell National Historic Park
171 Merrimack Street
Lowell, Massachusetts 01853

Re: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Mr. Burchill:

On April 12, 1984, Boott Hydropower, Inc. ("Boott") submitted for your review and comment the Revised Report on Recreational Resources (the "Revised Report") for the Lowell Hydroelectric Project, which was prepared in accordance with Article 38 of the Federal Energy Regulatory Commission (the "FERC") project license. On April 16, 1984, a copy of the Revised Report was filed with the FERC.

The Revised Report filed with the FERC contained certain minor changes. For your information and convenience, I have enclosed a redlined copy of the report as filed with the FERC on April 16, 1984. These changes were technical and did not affect the substance of the report. No changes were made to any of the attachments to the report.

We continue to look forward to your early response to the Revised Report.

Very truly yours,

June Broadstone

June P. Broadstone
Attorney for Boott
Hydropower, Inc.

Enclosure

SKADDEN, ARPS, SLATE, MEAGHER & FLOM
919 EIGHTEENTH STREET, N.W.
WASHINGTON, D.C. 20006
(202) 463-8700

TELECOPIER
(202) 293-3931

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
212 371 6000
ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002
ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200
515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4600

April 23, 1984

Ms. Patricia Weslowski
State Historic Preservation Officer
Massachusetts Historic Commission
294 Washington Street
Boston, Massachusetts 02018

Re: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Ms. Weslowski:

On April 12, 1984, Boott Hydropower, Inc. ("Boott") submitted for your review and comment the Revised Report on Recreational Resources (the "Revised Report") for the Lowell Hydroelectric Project, which was prepared in accordance with Article 38 of the Federal Energy Regulatory Commission (the "FERC") project license. On April 16, 1984, a copy of the Revised Report was filed with the FERC.

The Revised Report filed with the FERC contained certain minor changes. For your information and convenience, I have enclosed a redlined copy of the report as filed with the FERC on April 16, 1984. These changes were technical and did not affect the substance of the report. No changes were made to any of the attachments to the report.

We continue to look forward to your early response to the Revised Report.

Very truly yours,

June Broadstone

June P. Broadstone
Attorney for Boott
Hydropower, Inc.

Enclosure

401.2.5 Art 38
JUN 11 1984

SKADDEN, ARPS, SLATE, MEAGHER & FLOM

919 EIGHTEENTH STREET, N.W.
WASHINGTON, D.C. 20006

(202) 463-8700

TELECOPIER
(202) 293-3931

919 THIRD AVENUE
NEW YORK, NEW YORK 10022
(212) 371-8000

ONE BEACON STREET
BOSTON, MASSACHUSETTS 02108
(617) 523-0002

ONE RODNEY SQUARE
WILMINGTON, DELAWARE 19801
(302) 429-9200

515 SOUTH FIGUEROA STREET
LOS ANGELES, CALIFORNIA 90071
(213) 486-4800

June 5, 1984

HAND DELIVERED

Honorable Kenneth F. Plumb
Secretary, Federal Energy Regulatory
Commission
825 N. Capitol Street, NE
Washington, DC 20426

Re: Lowell Hydroelectric Project
Project No. 2720

Dear Mr. Plumb:

Boott Hydropower, Inc., ("Boott"), joint licensee for Project No. 2790, hereby submits the comments that it has received from the Massachusetts State Historic Preservation Officer (the "SHPO") and the National Park Service (the "NPS") approving the Revised Report on Recreational Resources (the "Revised Report"), which was filed by Boott pursuant to Article 38 of the License on April 16, 1984.

As indicated by the comments of NPS, Boott has been and will continue to work closely with NPS regarding the development of the navigation lock in the proposed control structure, the restoration of the Northern Canal gates and the reconstruction of the Canal walls. In addition, within the next six months Boott will be developing plans for improvements to the Northern Canal walkway. Consistent with the manner in which Boott has conducted agency consultations in the past, the plans will be submitted to NPS and SHPO for their review and comment.

While comments have been solicited on the Revised Report from the Massachusetts Department of Environmental Management (the "DEM"), a response has not yet been received. Boott has renewed its request to DEM for comments (see enclosed letter) and will promptly forward the comments when they are available.

Respectfully submitted,

June P. Broadstone

June P. Broadstone
Attorney for Boott Hydropower, Inc.

Enclosures

CERTIFICATE OF SERVICE

I hereby certify that I have this 5th day of June, 1984, served a copy of the foregoing "Letter to the Honorable Kenneth F. Plumb" by first class mail, postage prepaid upon all persons on the attached Service List in accordance with the requirements of Rule 2010 of the Commission's Rules of Practice and Procedure.

June P. Broadstone

June P. Broadstone
Attorney for Boott Hydropower, Inc.

SERVICE LIST

Atlantic Associates
576 Lawrence Street
Lowell, Massachusetts 01582

Mr. G. E. Boutin
General Manager, Lawrence
Hydroelectric Associates
6 Essex Street
Lawrence, Massachusetts 01852

Commonwealth of Massachusetts
Bureau of Wildlife Research
and Management
Division of Fisheries and
Wildlife
Field Headquarters
Westboro, Massachusetts 01581
Attention: Carl Prescott,
Superintendent

Joseph P. Donahue, Jr.
Donahue & Donahue
21 George Street
Lowell, Massachusetts 01582

Frances E. Francis, Esquire
Spiegel & McDiarmid
2600 Virginia Avenue, NW.
Washington, D.C. 20037

Joel L. Greene, Esquire
Chapman, Duff & Paul
1730 Pennsylvania Avenue, N.W.
Washington, D. C. 20006

National Marine Fisheries
Service
Habitat Protection Branch
7 Pleasant Street
Gloucester, Massachusetts 01930
Attention: Douglas W. Black

Mr. Richard A. Norman
New Hampshire Hydro Associates
110 Tremont Street
Boston, Massachusetts 02116

U.S. Department of the Interior
Fish and Wildlife Services
P.O. Box 1518
Concord, New Hampshire 03301
Attention: Gordon E. Beckett,
Supervisor

U.S. Department of the Interior
National Park Service
Lowell National Historic
171 Merrimack Street
Lowell, Massachusetts 01853

David B. Ward, Esq.
Farmer, McGuinn, Flood,
Bechtel & Ward
1000 Potomac Street, NW
Suite 402
Washington, DC 20007

Ms. Patricia Weslowski
State Historic Preservation
Officer
Massachusetts Historic Commission
294 Washington Street
Boston, Massachusetts 02018

MASSACHUSETTS HISTORICAL COMMISSION

COMMONWEALTH OF MASSACHUSETTS
Office of the Secretary of State
294 Washington Street
Boston, Massachusetts
02108
617-727-8470

MICHAEL JOSEPH CONNOLLY
Secretary of State

April 19, 1984

Ms. Carol Cunningham
Principal Civil Engineer
International Engineering Company, Inc.
777 Post Road
Darien, CT 06820

RE: Revised Report on Recreational Resources, Lowell Hydroelectric Project

Dear Ms. Cunningham:

Thank you for providing this office with the Revised Report on Recreational Resources for the Lowell Hydroelectric Project.

I see no conflicts in the proposed Recreational Resources with the National Historic Landmark District. This office however should review design plans for the development of the Northern Canal walkway.

If you should have any questions please contact Joseph Orfant of the Commission staff.

Sincerely,

Valerie Talmage

Valerie A. Talmage
Executive Director
Massachusetts Historical Commission

VAT/vh

IECO
Eastern District
APR 23

To	A		
4/23 CHC			

June Broadstone

United States Department of the Interior

NATIONAL PARK SERVICE

Lowell National Historical Park
169 Merrimack Street
Lowell, Massachusetts 01852

IN REPLY REFER TO:

IECO
Eastern District
MAY 31 '84

C–		I	O
To	A	I	R
CHC			/

5/31

cc June Broadstone

May 25, 1984

D-18

Ms. Carol Cunningham, P.E.
Principal Civil Engineer
International Engineering Company
50 Washington - 9th floor
Norwalk, Connecticut 06854

Dear Carol:

Reference: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Lowell National Historical Park has reviewed the Revised Report on Recreational Resources for the Lowell Hydroelectric Project, FERC Project 2790, and we do not wish to raise any major concerns at this time.

The Park will continue to provide review and technical assistance for the project in the following areas:

-- The navigation lock in the proposed control structure

-- The Northern Canal walkway

-- The Northern Canal gates restoration

-- Canal walls reconstruction

As the project proceeds with this input, the goals of preserving the canal system and making it available for recreational use, are being achieved.

The National Park Service is pleased to have the opportunity to assist in this project, and we look forward to its completion and availability to the Park visitor.

Sincerely,

John Burchill

John J. Burchill
Superintendent

CONSULTING
ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY

EASTERN DISTRICT OFFICE
50 WASHINGTON ST 9TH FLOOR
NORWALK CONN 06854
TELEPHONE (203) 838-3300

2601-410-A
0358c
47700

June 1, 1984

Mr. S. Christopher Scott
Commonwealth of Massachusetts
Department of Environmental Management
100 Cambridge Street
Boston, Massachusetts 02108

Subject: Revised Report on Recreational Resources
Lowell Hydroelectric Project
FERC Project No. 2790

Dear Chris:

On April 12, 1984 I sent you a Revised Report on Recreational Resources for your review and comment. This report was subsequently filed with FERC on April 16, 1984 with minor technical changes. You were sent a copy of the report as it was filed with FERC by June Broadstone on June 23, 1984.

I have been unable to contact you by telephone to discuss any comments you may have on the revised report. May I please have your written comments as soon as possible so I may file them with FERC pursuant to Article 38 of our FERC license?

If you have any questions or wish to discuss any aspect of this report, please feel free to give me a call.

Very truly yours,

Carol H. Cunningham, P.E.
Principal Civil Engineer

CHC:nba

P.S. Please note our change of address.

cc: June Broadstone, Skadden-Arps

ATTACHMENT C

Final License Application Volume II of III

Part 1 - Exhibit E

Lowell Hydroelectric Project

(FERC No. 2790)

April 30, 2021
Revised August 25, 2021

Prepared by:

HDR

Prepared for:

Boott Hydropower, LLC
Manchester, New Hampshire

Central Rivers Power

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Table of Contents

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List of Acronyms

µS/cm	microsiemens per centimeter
ACHP	Advisory Council on Historic Preservation
ADA	Americans with Disabilities Act
APE	area of potential effects
ASRSC	Atlantic Sea Run Salmon Commission
AW	American Whitewater
BMI	Benthic macroinvertebrates
Boott	Boott Hydropower, LLC (or Licensee, or Applicant)
CEII	Critical Energy Infrastructure Information
CFPP	Comprehensive Fish Passage Plan
C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
Chapter 91	M.G.L. Chapter 91 of the Waterways Act
CMR	Codes of Massachusetts Regulations
CSO	Combined Sewer Overflow
CSPA	Comprehensive Shoreland Protection Act
CWA	Clean Water Act
DDT	Dichlorodiphenyltrichloroethane
DLA	Draft License Application
DMMSPs	Dam Safety Surveillance and Monitoring Plan
DO	dissolved oxygen
EA	Environmental Assessment
EAP	Emergency Action Plan
E.L. Field	Eldred L. Field
EPT	Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission (or Commission)
FGMP	Final General Management Plan
FHA	Federal Highway Administration
FLA	Final License Application

FPA	Federal Power Act
GECC	General Electric Credit Corporation
GIS	Geographic Information System
GPS	Global Positioning System
HAER	Historic American Engineering Record
ILP	Integrated Licensing Process
Integrated List	Integrated List of Waters
IPaC System	Information, Planning and Consultation System
IPANE	Invasive Plant Atlas of New England
ISR	Initial Study Report
kV	kilovolt
LHCDC	Lowell Historic Canal District Commission
LIHI	Low Impact Hydropower Institute
LMRLAC	Lower Merrimack River Local Advisory Committee
LNHP	Lowell National Historical Park
LRWU	Lowell Regional Water Utility
M	magnitude
MADCR	Massachusetts Department of Conservation and Recreation
MADEM	Massachusetts Department of Emergency Management
MADEP	Massachusetts Department of Environmental Protection
MADFW	Massachusetts Division of Fish and Wildlife
MADMF	Massachusetts Division of Marine Fisheries
Massachusetts NHESP	Massachusetts Natural Heritage Endangered Species Program
MassGIS	Massachusetts Bureau of Geographic Information
MDMR	Maine Department of Marine Resources
MDPW	Massachusetts Department of Public Works
MEOEEA	Massachusetts Executive Office of Energy and Environmental Affairs
MESA	Massachusetts Endangered Species Act
M.G.L.	Massachusetts General Law
mg/L	milligrams per liter
MHC	Massachusetts Historical Commission
MIPAG	Massachusetts Invasive Plant Advisory Group

MOU	Memorandum of Understanding
MRI	Merrimack River Initiative
MRTC	Merrimack River Technical Committee
MRWC	Merrimack River Watershed Council
MW	megawatt
MWh	megawatt hours
NAI	Normandeau Associates, Inc.
NEFMC	New England Fishery Management Council
New Hampshire NHB	New Hampshire Natural Heritage Bureau
NGOs	non-governmental organizations
NGVD 29	National Geodetic Vertical Datum 1929
NHDES	New Hampshire Department of Environmental Services
NHDFG	New Hampshire Department of Fish and Game
NHDHR	New Hampshire Division of Historical Resources
NHDNCR	New Hampshire Department of Natural and Cultural Resources
NHFGD	New Hampshire Fish and Game Department
NHL	National Historic Landmark
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRHP	National Register of Historic Places
NRPC	Nashua Regional Planning Commission
NTU	Nephelometric Turbidity Unit
NWI	Nation Wetland Inventory
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
PAD	Pre-Application Document
PM&E	protection, mitigation, and enhancement measures
Project	Lowell Hydroelectric Project

Proprietors	Proprietors of the Locks and Canals on the Merrimack River
PSP	Proposed Study Plan
Revised PPS	Revised Process Plan and Schedule and Determination on Requests for Study Modifications for the Lowell Hydroelectric Project
RM	river mile
RMC	RMC Environmental Services
ROR	run-of-river
RSA	Revised Statutes Annotated
RSP	Revised Study Plan
RTE	rare, threatened, and endangered
SAV	submerged aquatic vegetation
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SDR	Supporting Design Report
SD1	Scoping Document 1
SD2	Scoping Document 2
Section 106	Section 106 of the NHPA
SPD	Study Plan Determination
SHPO	State Historic Preservation Officer
stakeholders	resource agencies, federally recognized Indian tribes, non-governmental organizations (NGOs), and other interested parties
SWQS	surface water quality standards
Merrimack River Technical Committee	Representatives from NHDFG, MADFW, USFWS, USFS, NMFS
THPO	Tribal Historic Preservation Officers
TMDL	total maximum daily loads
TBSA	turbine blade strike analysis
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

VP	vegetation points
WPA	Wetlands Protection Act
WQC	Water Quality Certification
WUA	Weighted Useable Area
YOY	Young-of-year

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Exhibit E Environmental Report (18 C.F.R. § 5.18)

E.1 Introduction

Boott Hydropower, LLC (Boott or Licensee) is the Licensee, owner, and operator of the 20.16-megawatt (MW) Lowell Hydroelectric Project (Project or Lowell Project) (FERC No. 2790). Boott operates and maintains the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Commission, under the authority of the Federal Power Act (FPA), 16 United States Code (USC) §791(a), et seq., may issue a license for up to 50 years for the construction, operation, and maintenance of non-federal hydroelectric developments. The existing license was issued by FERC on April 13, 1983 and expires on April 30, 2023. Boott is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (C.F.R.) Part 5.

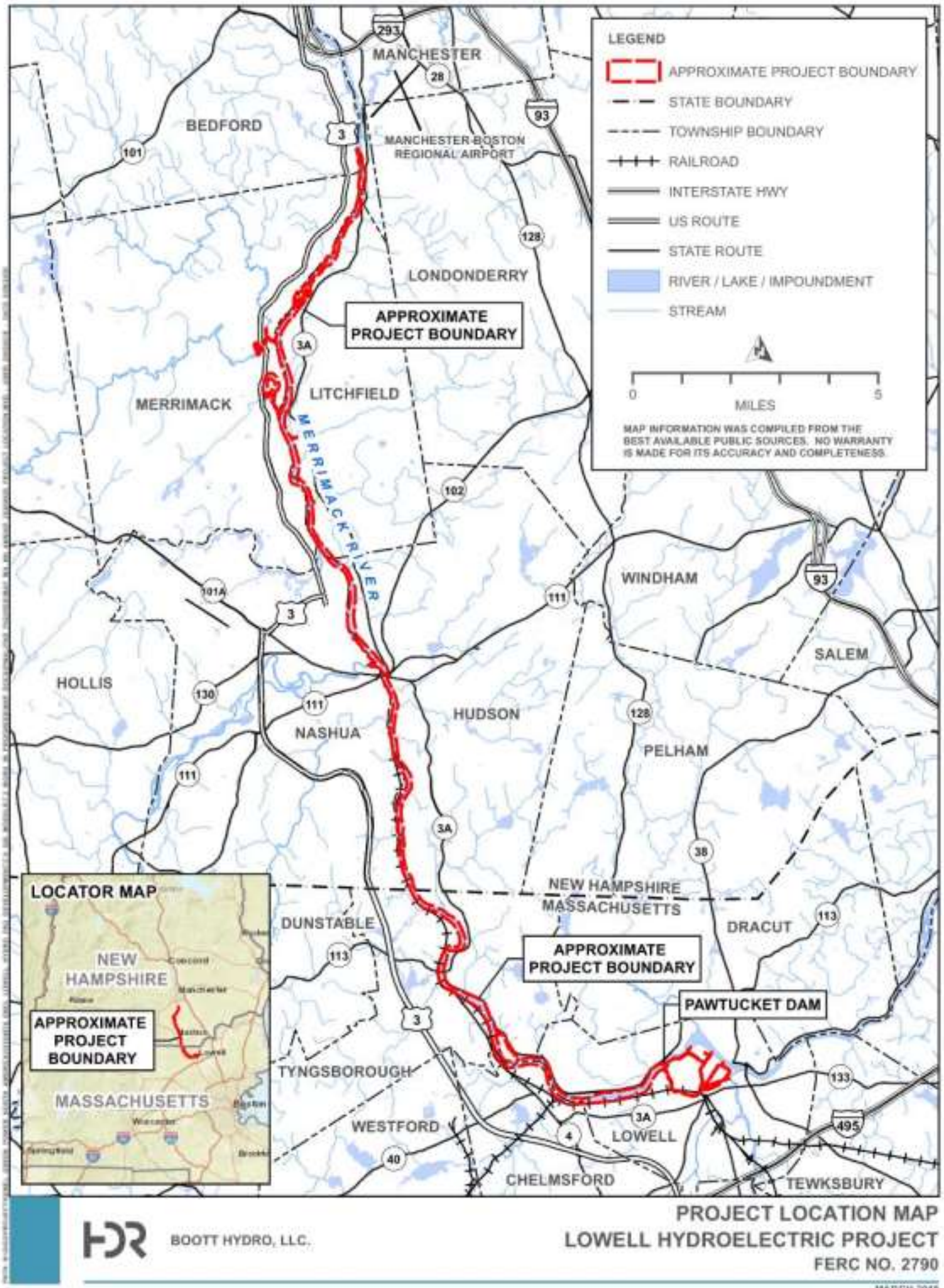
In accordance with the ILP and applicable regulations at 18 C.F.R. § 16.9(b), Boott must file its final application for a new license (Final License Application or FLA) with the Commission no later than April 30, 2021.

The Lowell Project is located at river mile (RM) 41 on the Merrimack River in the City of Lowell in Middlesex County, Massachusetts, with the current impoundment extending approximately 23 miles upstream into Hillsborough County, New Hampshire (Figure E.1-1).

The existing Lowell Project consists of:

1) A 1,093-foot-long, 15-foot-high masonry gravity dam (Pawtucket Dam) that includes a 982.5-foot-long spillway with a crest elevation of 87.2 feet National Geodetic Vertical Datum 1929 (NGVD 29) topped by 5-foot-high pneumatically-operated crest gates deployed in five independently-operable zones;
2) A 720-acre impoundment with a normal maximum water surface elevation of 92.2 feet NGVD 29;
3) A 5.5-mile-long canal system which includes several small dams and gatehouses;
4) A powerhouse (Eldred L. Field) which uses water from the Northern Canal and contains two turbine-generator units with a total installed capacity of 15.0 megawatts (MW);
5) A 440-foot-long tailrace channel;
6) Four powerhouses (Assets, Bridge Street, Hamilton, and John Street) housed in 19th century mill buildings along the Northern and Pawtucket Canal systems containing 15 turbine-generator units with a total installed capacity of approximately 5.1 MW;
7) A 4.5 mile-long, 13.8-kilovolt transmission line connecting the powerhouses to the regional distribution grid;
8) Upstream and downstream fish passage facilities including a fish elevator and downstream fish bypass at the Eldred. L. Field (E.L. Field) powerhouse, and a vertical-slot fish ladder at the Pawtucket Dam; and
9) Appurtenant facilities.

Figure E.1-1. Lowell Project Location and Existing Boundary Map



Boott proposes to eliminate the four mill powerhouses and associated canals from the new FERC license. The project features proposed to be retained in the new license include: the Pawtucket Dam; the E.L. Field powerhouse; the section of the Northern Canal and associated structures leading from the Pawtucket Dam to the E.L. Field powerhouse; the Hydro Locks; all fish passage facilities; and the Guard Lock and Gates facility. Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the National Park Service (NPS) and other stakeholders.

At the normal pond elevation of 92.2 feet NGVD 29 (crest of the pneumatic flashboards), the surface area of the impoundment encompasses an area of approximately 720[1] acres. The gross storage capacity between the normal surface elevation of 92.2 feet NGVD 29 and the minimum pond level of 87.2 feet NGVD 29 (spillway crest) is approximately 3,600[2] acre-feet. The Project operates in a run of river (ROR) mode using automatic pond level control of the E.L. Field units and has no usable storage capacity.

The Project's primary features are located along the Merrimack River in the City of Lowell, Massachusetts. The City of Lowell was founded in the early 1820s by Boston merchant capitalists and became one of the most significant planned industrial cities in America (Hay 1991). Lowell's factory system, which used the waterpower of the Merrimack River, incorporated new technologies to provide for the mass production of cotton cloth in mills throughout the city (NPS 1981). Lowell established the pattern for large-scale waterpower development for the next 50 years (Hay 1991).

Several Project facilities are located within overlapping locally, state, and nationally designated parks and historic properties and preservation districts. The Project's Pawtucket Dam and E.L. Field Powerhouse are located along the mainstem of the Merrimack River. The Project's existing two-tiered network of man-made canals extends throughout downtown Lowell. The 5.5-mile-long canal system provides flow to the Project's existing Hamilton, Assets, Bridge Street, and John Street developments. The Hamilton, Assets, Bridge Street, and John Street power stations and turbines are housed in large former mill buildings. The mill buildings are not included in the existing Project; the Project Boundary includes only the turbines and associated waterways and equipment at these downtown mill sites. In addition to the Pawtucket Dam and hydroelectric developments, the existing Project also includes miscellaneous civil works in the City of Lowell, including the Guard Lock and Gates, Moody Street Feeder Gatehouse, Lawrence Dam, Hall Street Dam, Tremont Wasteway, Lower Locks and Dam, Swamp Locks and Dam, Merrimack Dam and Merrimack Gate, Rolling Dam, and the Boott Dam.

The canal system, the downtown mill sites, and many of the Project's existing civil works, are contributing resources to Lowell Locks and Canals National Historic Landmark (NHL) District. The canal system and many Project facilities are also located within the Lowell National Historical Park (LNHP) managed by the NPS and the larger Lowell Historic

[1] During the initial licensing, the Project impoundment surface area was estimated at 720 acres. As a part of this relicensing, Boott updated Exhibit G and generated a new surface area estimate of 1,236 acres. See Exhibit G.

[2] The Project impoundment has an estimated gross storage capacity of 6,180 acre-feet.

Preservation District. The LNHP was established by Congress in 1978 to "preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts, for the benefit and inspiration of present and future generations." The park is by design a partnership park in which federal, state, and local governments as well as the private sector and local community carry out the legislative intent of the park unit. The Lowell National Historical Park is also listed on the National Register of Historic Places (NRHP), and certain properties within the park overlap with properties in the NHL District.

The Lowell Heritage State Park, established in 1974 as a precursor to the LNHP, is also located within the City of Lowell and is comprised of linear greenways along the Merrimack River and canal system and a collection of historic buildings and structures related to the industrial development of the city. These buildings and structures include Project features and properties located within the NHL District. The Lowell Heritage State Park is operated by the Massachusetts Department of Conservation and Recreation (MADCR) and features exhibits created in partnership with the NPS (MADCR 2018). With the exception of the Rynne Bathhouse, all of the built resources within the Lowell Heritage State Park fall within the Lowell Historic District, designated by the City of Lowell to "…ensure that development activities within the district are consistent with the preservation of its 19th century setting" (MADCR 2014). Portions of the Lowell Heritage State Park also overlap with the Lowell Locks and Canals NHL District and the LNHP.

In accordance with 18 C.F.R. § 5.16(a), Boott filed the Draft License Application (DLA) with the Commission on December 2, 2020. FERC and stakeholders had 90 days to provide comments on the DLA (i.e., until March 2, 2021). Comments on the DLA were filed by the following participants: AW, Lowell Plan, Inc., City of Lowell, Massachusetts Department of Conservation and Recreation (MADCR), Lowell Parks & Conservation, Greater Lowell Community Foundation, NPS, United States Fish and Wildlife Service (USFWS), Massachusetts Senator Edward Kennedy, Lowell Historic Board, Massachusetts Historical Commission, and the University of Massachusetts. Boott has reviewed and considered all comments received, as evidenced through further development of the Licensee's measures proposed in this Final License Application.

The purpose of the Exhibit E, as defined in 18 CFR §5.18, is to describe: (1) the existing and proposed Project facilities, including Project lands and waters; (2) the existing and proposed Project operation and maintenance, to include measures for protection, mitigation, and enhancement (PM&E) with respect to each resource affected by the Project proposal; and (3) the continuing impacts of existing Project operations and maintenance on resources, including direct, indirect, and cumulative impacts based on information generated during the relicensing studies. Exhibit E of this license application was prepared consistent with 18 C.F.R. § 5.18(b) and is intended to support FERC's required analysis under the National Environmental Policy Act of 1969 (NEPA)[3], as amended. The analysis of potential effects is based on the information presented in Boott's April 30, 2018 Pre-Application Document (PAD), consultation with stakeholders, the results of eleven completed studies and two on-going studies, pursuant to the

[3] 42 U.S.C. § 4321, et seq.

Commission's Study Plan Determination (SPD), and other information obtained by the Licensee. Table E.1-1 summarizes the studies conducted or to be completed by Boott.

Table E.1-1. Lowell Hydroelectric Project Study Reports

Study Report	Filing Type	Filing Date
Downstream American Eel Passage Assessment (Updated Study Report [USR])	Public	February 25, 2021
Juvenile Alosine Downstream Passage Assessment (USR)	Public	February 25, 2021
Upstream and Downstream Adult Alosine Passage Assessment (USR)	Public	February 25, 2021
Fish Passage Survival Study (Initial Study Report [ISR])	Public	February 25, 2021
Three-Dimensional Computational Fluid Dynamics (CFD) Modeling	Public	May 2021 (Anticipated)
Instream Flow Habitat Assessment and Zone of Passage Study in the Bypassed Reach (ISR)	Public	February 25, 2021
Fish Assemblage Study (USR)	Public	February 25, 2021
Recreation and Aesthetics Study (USR)	Public	February 25, 2021
Resources, Ownership, Boundaries, and Land Rights Study (ISR)	Public	February 25, 2021
Water Level and Flow Effects on Historic Resources Study (ISR)	Public/Privileged	March 5, 2021
Operation Analysis of the Lowell Canal Study (ISR)	Public	February 25, 2021
Historically Significant Waterpower Equipment Study (ISR)	Public	February 25, 2021
Whitewater Boating and Access Study	Public	June 2021 (Anticipated)

On February 25, 2021, Boott filed the ISR studies and USR studies noted above. Boott held a Revised ISR Meeting to discuss the results of these studies on March 11, 2021. Pursuant to the ILP, Boott filed a Revised ISR Meeting Summary with the Commission on March 26, 2021. Stakeholders were provided a 30-day period (ending on April 25, 2021) to provide comments on the Revised ISR Meeting Summary, recommend study modifications, or propose new studies. By letters to the Commission, National Marine Fisheries Service (NMFS), Massachusetts Division of Fisheries and Wildlife (MADFW), USFWS provided comments on the February 2021 Revised ISR and Revised ISR Summary.

The following sections summarize the existing environmental setting of the Project and the baseline conditions under which this environmental assessment is being undertaken.

E.2 General Description of the River Basin (18 C.F.R. § 5.18 (b)(1))

E.2.1 Drainage Area and Length of River

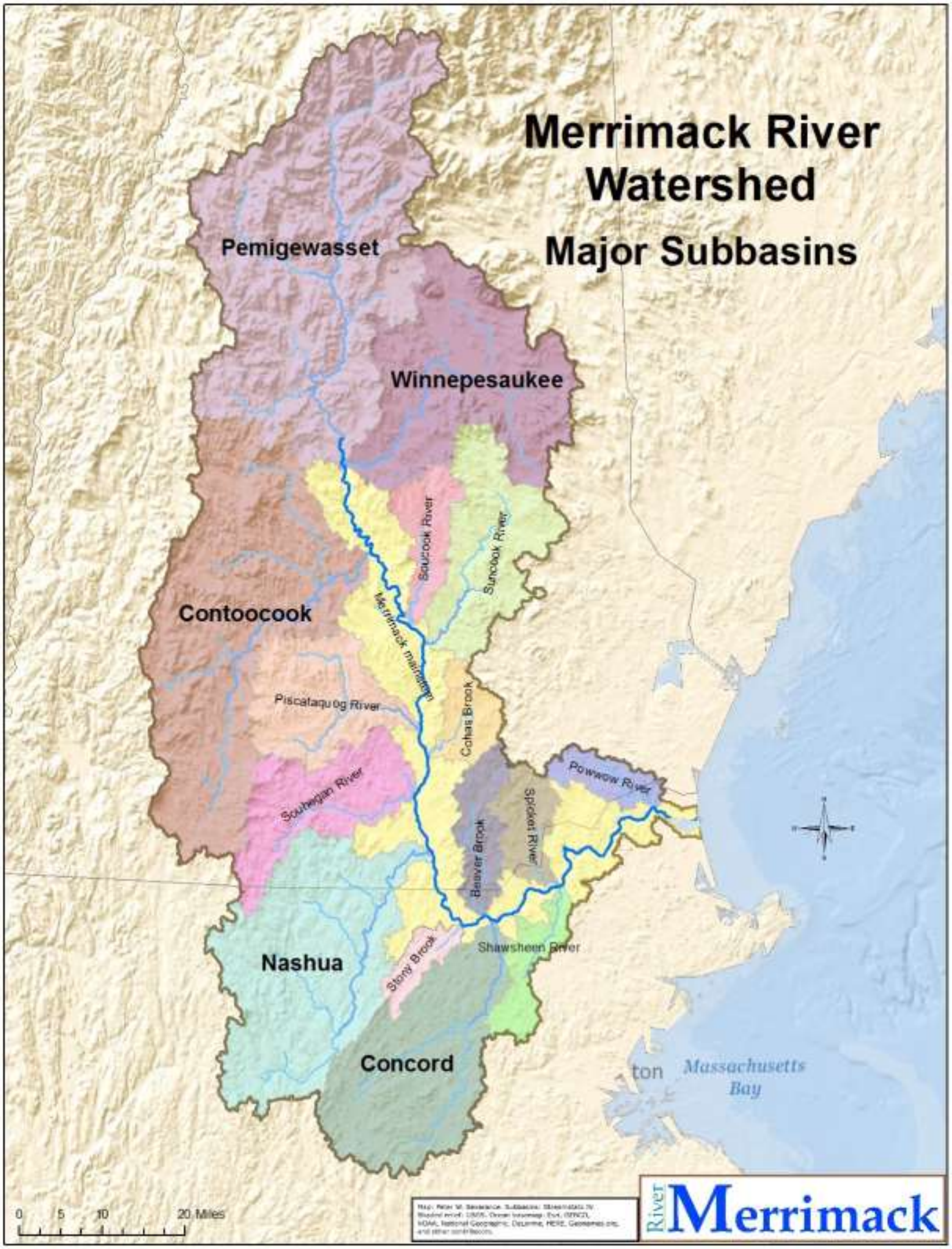
The 116-mile-long Merrimack River originates near Franklin, New Hampshire at the confluence of the Pemigewasset and Winnipesaukee Rivers (USACE 2003). The river flows southward for approximately 78 miles in New Hampshire, turns abruptly at the New Hampshire-Massachusetts boarder, and flows in a northeasterly direction for approximately 40 miles before draining into the Atlantic Ocean near Newburyport, Massachusetts. The final 22 miles of the river, downstream of Haverhill, Massachusetts, are tidally influenced (USACE 2003; NHDES 2019a).

The Merrimack River watershed has a total drainage area of approximately 5,010 square miles within the states of New Hampshire and Massachusetts, where about 3,800 square miles lie in New Hampshire and 1,200 square miles lie in Massachusetts (MEOEEA 2002). Lakes and ponds comprise 200 square miles, or four percent of the total area (Boott 1980). The Lowell Hydroelectric Project is located on the Merrimack River in Lowell, Massachusetts. The drainage area of the Lowell Project is approximately 3,979 square miles.

E.2.2 Tributary Rivers and Streams

The Merrimack River Basin (Basin) is the fourth largest river basin in New England (MEOEEA 2001). The Basin extends from the White Mountain region of northern New Hampshire to southeastern Massachusetts and spans the major cities of Laconia, Concord, Manchester, Nashua, in New Hampshire and Lowell, Lawrence, Haverhill, in Massachusetts. The Pemigewasset River flows for 64 miles, and the Winnipesaukee River stretches for ten miles. In addition to the Pemigewasset and Winnipesaukee River Basins, four principal tributaries contribute to the Merrimack River flow: the Contoocook, Piscataquog, Nashua, and Concord Rivers (USACE 2003; MEOEEA 2001). The Merrimack River Watershed and Major Subbasins are shown below in Figure E.2-1. The Lowell Project is located at RM 41 on the Merrimack River in the City of Lowell, Massachusetts. Several other smaller streams are contributory to the Merrimack or Concord Rivers within the City of Lowell and complete the major drainage pattern.

Figure E.2-1. Merrimack River Watershed and Major Subbasins



E.2.3 Topography

The Basin encompasses a variety of terrain as it ranges from steep, rugged conditions of the Northern New Hampshire White Mountain region to the estuarine coastal basin of northeastern Massachusetts (USACE 2003). The Basin is a part of the Eastern New England Upland physiographic unit containing three major sections -- the White Mountains, the New England Uplands, and the Seaboard Lowlands. The majority of the Basin is located in the New England Uplands, characterized by narrow floodplains and rolling hills ranging in elevation from below 1,000 feet to above 2,000 feet (USACE 2003). The Merrimack River itself drops 269 vertical feet over its long track to the Atlantic Ocean, with a more than 30-foot drop at the Project. The topography of the City of Lowell (13.4 square miles) is a combination of floodplain and, predominantly, gently undulating upland. The Merrimack corridor surface waters, in conjunction with the river's large watershed, form an extensive system of rivers, streams, lakes, ponds, wetlands and groundwater as well as densely forested lands consisting of evergreen or mixed evergreen-deciduous forests (NRPC 2008).

E.2.4 Dams and Diversion Structures within the Basin

There is a total of five[4] hydroelectric developments on the Merrimack River, comprising three separate Projects licensed by the Commission. Table E.2-1 presents information on the five FERC-regulated hydroelectric developments on the Merrimack River. All of the hydroelectric facilities on the Merrimack River operate in ROR mode.

In New Hampshire, there are four U.S. Army Corps of Engineers (USACE) flood storage dams within the Merrimack River basin. Boott and other licensees in the Merrimack River basin help to support the operational costs of these flood storage projects through Headwater Benefits payments assessed by FERC.

The USACE flood storage system in the Merrimack River basin consists of the following:

- Franklin Falls Dam is located in Franklin, New Hampshire, on the Pemigewasset River. The dam is three miles upstream of the confluence of the Pemigewasset and Winnipesaukee rivers where the Merrimack River originates. The dam is the key unit in the flood risk management for the Merrimack River basin. It provides flood protection for principal industrial and residential centers along the entire length of the Merrimack River. The construction of Franklin Falls Dam was completed in 1943, and it can store up to 50.2 billion gallons of water for flood control purposes (USACE 2016a).
- The Hopkinton-Everett Lakes Flood Risk Management Project consists of two dams, the dam at Hopkinton Lake, located on the Contoocook River in Hopkinton, New Hampshire, and the dam at Everett Lake, located on the Piscataquog River in Weare, New Hampshire. The two dams are connected by a two-mile-long canal and in moderate to severe flooding are operated as a single flood risk management

[4] The five hydroelectric developments on the Merrimack River do not include the four downtown mill power stations Boott is proposing to remove from the FERC license.

project. Construction of the project was completed in 1963. Together, the flood storage areas behind both dams can hold 52.6 billion gallons of water, which would cover approximately 8,000 acres (12.5 square miles). This is equivalent to 6.8 inches of water covering its drainage area of 446 square miles (USACE 2016b).

- The Blackwater Dam is located on the Blackwater River in Webster, New Hampshire. There is no lake at Blackwater Dam. The flood storage area of the project covers approximately 3,280 acres and extends upstream about seven miles through Salisbury, having a maximum width of one mile. Blackwater Dam can store up to 15 billion gallons of water for flood control purposes (USACE 2016c).

Table E.2-1. FERC-regulated Developments on the Merrimack River

Facility	FERC Project #	Licensee	River Mile	Generation Capacity (MW)
Garvins Falls (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	87	12.3
Hooksett (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	81	1.6
Amoskeag (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	73	16
Lowell	2790	Boott Hydropower, LLC	40	20.2 (current) 15 (proposed)
Lawrence	2800	Essex Company, LLC	29	16.8

E.2.5 Wetland and Vegetative Cover

Wetlands and vegetative cover with the Project area appear to be consistent with these areas of New Hampshire and Massachusetts. Wetlands along the Merrimack River primarily consist of low-lying areas near and adjacent to the river, with other isolated wetlands farther away from the river proper. The wetlands directly surrounding the Lowell Project are largely considered riverine wetlands with an unconsolidated bottom. Riverine wetlands include all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 parts per thousand (or greater (Cowardin et al. 1979). The majority of the wetlands near or adjacent to the Project area are palustrine wetlands. Palustrine wetlands, often called fens, swamps, marshes, or bogs, are nontidal wetlands. These wetlands are dominated by trees, shrubs, and/or persistent plants/mosses. These wetlands may also be composed of shallow, open-water ponds (Cowardin et al. 1979). According to the USACE (2002), freshwater wetland habitats play an integral role in the ecology of the Merrimack River corridor. The combination of high nutrient levels and primary productivity found in these habitats is ideal for the development of organisms that form the base of the food web.

Natural forest cover encompasses 75 percent of the Basin and consists of a mix of deciduous and evergreen forest. Natural vegetation in the region consists of mesic to dry Appalachian oak-pine forests with various combinations of red oak (*Quercus rubra*), white oak (*Q. alba*), and black oaks (*Q. velutina*), some scarlet (*Q. coccinea*) or chestnut oaks (*Q. prinus*) to the south, white pine (*Pinus strobus*), sugar maple (*Acer saccharum*), red maple (*A. rubrum*), hickories (*Carya spp*.), and other central or northern hardwoods. Floodplain forests are typically dominated with silver maple (*A. saccharinum*), American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*) (Griffith et al. 2009).

E.2.6 Climate

The Project is within a climate region typical of north central New England and inland New Hampshire, as it is characterized by moderately warm summers, cold winters, and adequate precipitation. The climatic conditions of the Basin vary significantly from its headwaters in the White Mountains to its discharge along the Atlantic Ocean (USACE 2003). The Basin is located partially with the Northern and Coastal Climatic divisions, but the majority of the watershed falls within the Central Climatic division. The Central division is generally more moderate than the Northern section due to its lower elevation and latitude; this division experiences some climate modification due to maritime influences (USACE 2003; National Oceanic and Atmospheric Administration [NOAA] 2020a). Precipitation in the watershed is evenly distributed throughout the year and weather systems throughout the Basin operate primarily from prevailing westerly winds and the confluence of many continental weather patterns in North America. The Basin's climate is humid continental climate (Dfa/Dfb) according to the Köppen-Geiger climate classification.

NOAA data from 1897 to 2020 for the Boston, Massachusetts weather station indicates an average temperature of 52.1°F, with an average maximum temperature of 96°F and average minimum temperature of 2.0°F. The warmest temperatures occur in July and coolest temperatures occur in January. NOAA 1897 to 2020 data for Boston, Massachusetts shows an average annual precipitation of 41.45 inches with relatively even monthly averages. (NOAA 2020b).

Three predominant storm patterns occur in the Merrimack River Basin: continental, coastal, and local summer thunderstorms. Continental storms are associated with the usual easterly or northeasterly air flows that bring western or central storm disturbances to the Northeast. These continental storms are experienced in all months of the year. Coastal storms originate in the Gulf or southeast coastal states and bring moist, generally warmer air into the region (Boott 1980).

E.2.7 Major Land and Water Uses

E.2.7.1 Major Land Uses

Historically, the Merrimack River Basin played a large role in the development of the region's economy and land use patterns. The Industrial Revolution in the mid-1800s encouraged many families towards more promising work in urban settings. Many of the larger towns adjacent to the Merrimack River mainstem began as factory or mill towns due to the need for hydromechanical and later hydroelectric power to power the emerging industries. This economic shift from farming to urban settings resulted in the reclamation of previously predominantly agricultural lands by forest and woodland (USACE 2003; Boott 1980).

Although the Merrimack River watershed is heavily forested (75 percent of the land area is covered with forest), it also supports all or parts of approximately 200 communities with a total population of 2.6 million people (U.S Environmental Protection Agency [USEPA] 2020; USACE 2006). The population density in the Basin tends to increase from north to south as the lower region is characterized by five major urban cities along the Merrimack River: Manchester and Nashua in New Hampshire, and Lowell, Lawrence, and Haverhill in Massachusetts (USACE 2003). Basin population density ranges from fewer than 100 people per square mile in the northeastern and northwestern portions of New Hampshire, to greater than 800 people per square mile in Manchester and Nashua, New Hampshire, and northeastern Massachusetts. A majority (74 percent) of the Basin's urban area is residential while the remaining areas consist of commercial, transportation, industrial, and other urban use. In addition to the 75 percent forested land, the Basin generally consists of 13.3 percent urban land, four to five percent surface water, and 5.5 percent agriculture. Recreation and timber harvesting for lumber are the primary economic activities occurring in forested lands, while agricultural lands are dominated by hay and livestock farming (Flanagan 1999). Land use is discussed in further detail in Section E.7.6 of this application.

E.2.7.2 Major Water Uses

Consumptive users of the Merrimack River water are primarily municipal and industrial, with specific uses including domestic, thermoelectric, commercial, mining, livestock, and irrigation uses. Many of the municipalities bordering the Merrimack River, or within its watershed, use the river as a potable water source as well as a wastewater discharge point. The Merrimack River is the only major New England River used as a drinking water supply and is used as such by the communities of Lowell, Lawrence, Tewksbury, Methuen, and Andover in Massachusetts and Nashua, New Hampshire. Two more cities in New Hampshire, Manchester and Concord, plan to use the river for drinking water supply in the near future (MRWC 2018b).

E.2.8 Economic Activities

The Lowell Project is located in Middlesex County, Massachusetts and Hillsborough County, New Hampshire. According to the U.S. Census Bureau, the median household income from 2014-2018 (in 2018 dollars) is estimated to be $97,012 in Middlesex County, $78,655 in Hillsborough County, and $51,987 for the City of Lowell (U.S. Census Bureau undated). The main employment sectors in the region include professional, scientific, and tech services, educational services, healthcare and social assistance, manufacturing, and retail trade (Data USA undated).

E.3 Cumulative Effects (18 C.F.R. § 5.18(b)(2))

According to the Council on Environmental Quality's regulations for implementing NEPA (40 C.F.R. §1508.7), a cumulative effect is the impact on the environment which results from the incremental impact of a Proposed Action when added to other past, present, and reasonably foreseeable future actions, regardless of agency (federal or non-federal) or person undertaking such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower project operations and other land and water development activities.

E.3.1 Resources That Could Be Cumulatively Affected

Through scoping, agency consultation, review of the PAD, and Commission staff's preliminary analyses, the Commission noted in its Scoping Document 2 (SD2) that migratory fisheries in the Merrimack River have the potential to be cumulatively affected by the proposed continued operation and maintenance of the Project, in combination with other hydroelectric projects and other activities in the Merrimack River Basin.

E.3.2 Geographic Scope

The geographic scope of the cumulative effects analysis defines the physical limits or boundaries of the proposed action's effect on the resources. The geographic scope of analysis for cumulatively affected resources is defined by the physical limits or boundaries of: (1) the proposed action's effect on the resources, and (2) contributing effects from other dams within the Merrimack River Basin. In SD2, FERC identified the geographic scope for migratory fisheries to include Pemigewasset River from the Eastman Falls Dam and the Winnipesaukee River from the Lakeport Dam, to the confluence of the Winnipesaukee and Pemigewasset Rivers (which form the Merrimack River), and the Merrimack River downstream to the Atlantic Ocean. The Eastman Falls Dam (at river mile 1 of the Pemigewasset River) and the Lakeport Dam (at river mile 17 of the Winnipesaukee River and 4 miles downstream from the outlet of Lake Winnipesaukee) are migration barriers that represent the upstream limits to which river herring and American eel are managed within the river basin.

E.3.3 Temporal Scope

The temporal scope of the cumulative effect's analysis in this exhibit addresses past, present, and reasonably foreseeable future actions and their effects on each resource that may be cumulatively affected. Based on the potential terms of the new license, the Commission's SD2 defined the temporal scope of this analysis to address reasonably foreseeable actions 30-50 years into the future. Historical discussion would by necessity, be limited by the amount of available information for each resource. As noted in SD2, the quality and quantity of information are diminished as resources that are further away in time from the present are analyzed.

E.4 Compliance with Applicable Laws (18 C.F.R. § 5.18 (b)(3))

E.4.1 Section 401 of the Clean Water Act

Under Section 401 of the Clean Water Act (CWA), any federal license or permit to conduct any activity that may result in a discharge into navigable waters requires a certification from the state in which the discharge originates, that such discharge will comply with the applicable provisions of the CWA, unless such certification is waived. Therefore, a state Water Quality Certification (WQC) or waiver is a prerequisite for obtaining a license from FERC. The MADEP is the state agency designated to carry out the certification requirements as prescribed in Section 401 of the CWA for waters of the Commonwealth of Massachusetts. Pursuant to 18 C.F.R. § 5.23(b), Boott will file an application for a WQC with the MADEP within 60 days of FERC's Notice of Acceptance and Ready for Environmental Analysis. The MADEP must act on the request for a WQC within the one-year time frame allowed under the CWA.

E.4.2 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) (19 U.S.C. § 1536(c)), as amended, requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or result in the destruction or adverse modification of the critical habitat of such species. Under the ESA, the United States Fish and Wildlife Service (USFWS) is responsible for freshwater and terrestrial species; and the National Marine Fisheries Service (NMFS; NOAA Fisheries) is responsible for marine and anadromous species.

In the Notice of the Licensee's Intent to File a License Application, Filing of the PAD, Commencement of the Pre-filing Process, and Scoping Document 1 issued on June 15, 2018, the Commission designated Boott as the Commission's non-federal representative for carrying out informal consultation, pursuant to section 7 of the ESA. Boott was granted designation as FERC's non-federal representative for Section 7 consultation on June 18, 2018. Information from the USFWS and the Massachusetts Division of Fisheries and Wildlife (MADFW) has been used by the Licensee to identify rare, threatened, and/or endangered (RTE) species in the Project area. A discussion of the RTE species relevant to this Project is contained in Section E.7.5 of this Exhibit.

E.4.3 Magnuson-Stevens Fishery Conservation Management Act

The 1996 amendments to the Magnuson-Stevens Act authorized the NMFS, in coordination with regional fisheries management councils, to delineate essential fish habitat (EFH) for the protection of habitat of marine, estuarine, and anadromous finfish, mollusks, and crustaceans. EFH includes “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.”

Based on a review of the NMFS online database, the Lowell Project reach of the Merrimack River is designated EFH under the Magnuson-Stevens Fishery Conservation and Management Act for Atlantic salmon (NOAA undated). This EFH was defined as “all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut” (New England Fishery Management Council [NEFMC] 1998).

E.4.4 Coastal Zone Management Act

Section 307(c)(3) of the Coastal Zone Management Act (CZMA) requires that activities conducted or supported by a federal agency that affect the coastal zone be consistent with the enforceable policies of the federally approved state coastal management plan to the maximum extent practicable. Section 307(c)(3) of the CZMA requires that all federally licensed activities that affect a state’s coastal zone be consistent with the enforceable policies of the state’s federally approved coastal management plan.

The Massachusetts Office of Coastal Zone Management (MOCZM) is the lead policy and planning agency on coastal and ocean issues within the Massachusetts Executive Office of Energy and Environmental Affairs (MEOEEA). In the preparation of the PAD, Boott initiated consultation with MOCZM, but has not received a response. By review of available coastal zone maps from the MOCZM, the activities associated with this project would fall outside the geographical boundaries of the Massachusetts Coastal Zone as delineated (MEOEEA 2014).

The New Hampshire Coastal Program (NHCP) is the lead policy and planning agency on coastal and ocean issues within the New Hampshire Department of Environmental Services (NHDES). In the preparation of the PAD, Boott initiated consultation with NHCP, but has not received a response. By review of available coastal zone maps from the NHDES, the activities associated with this project would fall outside the geographical boundaries of the Hew Hampshire Coastal Zone as delineated (NHDES undated).

As the Project is not subject to coastal zone management program review, no consistency certification is needed for FERC’s relicensing of the Project.

E.4.5 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (Section 106)8 requires federal agencies to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on such actions. Historic properties include significant sites, buildings, structures, districts, and individual objects that are listed in, or eligible for listing in the NRHP. FERC’s issuance of a new license for the Project is considered an undertaking subject to the regulations and requirements of Section 106 and its implementing regulations at 36 C.F.R. Part 800. In accordance with 36 C.F.R. §

800.14(b), FERC typically fulfills its responsibilities pursuant to Section 106 by entering into a Programmatic Agreement with the appropriate State and/or Tribal Historic Preservation Officer(s) (SHPO/THPO), and in some cases the ACHP.

FERC initiated consultation under Section 106 with federally recognized Indian tribes by letter dated April 26, 2017. By notice dated June 15, 2018, FERC designated Boott its nonfederal representative for purposes of conducting informal consultation pursuant to Section 106.

A discussion of historical properties within the Project's Area of Potential Effects (APE) and the consultation under Section 106 conducted to date for the relicensing of the Project is contained in E.7.8 of this Exhibit.

Early in the relicensing process, Boott contacted prospective stakeholders to determine their interest in this relicensing proceeding. As part of this outreach, Boott corresponded with representatives of the Massachusetts SHPO and federally recognized Indian tribes with a potential interest in the effects of this relicensing on historic properties. The Project does not occupy tribal reservation lands and the U.S. Bureau of Indian Affairs (BIA), via consultation, documented the following tribes as having historical interest in the Project area:

- Mashpee Wampanoag Tribe
- Wampanoag Tribe of Gay Head
- Penobscot Nation

By letter dated April 26, 2017, FERC invited the Mashpee Wampanoag Tribe, Narragansett Indian Tribe, Stockbridge Munsee Tribe of Mohican Indians, and Wampanoag Tribe of Gay Head (Aquinnah) to participate in the relicensing process for the Project. The Mashpee Wampanoag Tribe stated they do not have concerns with relicensing unless new construction is proposed that has the potential to disturb cultural resources.

E.4.6 Wild and Scenic Rivers and Wilderness Act

There are no rivers designated under the Wild and Scenic Rivers Act within or adjacent to the Project boundary; therefore, this act is not applicable to the relicensing of the Project. No Project facilities are located within any designated wilderness areas.

E.5 Project Facilities and Operation (18 C.F.R. § 5.18(b)(4))

E.5.1 Maps of Project Facilities within Project Boundaries (18 C.F.R. § 5.18(b)(4)(i))

The Lowell Hydroelectric Project boundary is shown in detail in Exhibit G of this license application. The physical composition, dimensions, and generation configuration of the facilities that comprise the Project are described in the following subsections.

E.5.2 Project Location and Facilities Overview (18 C.F.R. § 5.18(b)(4)(ii))

This section provides a summary of the existing facilities at the Project; additional, detailed descriptions of Project facilities are presented in Exhibit A of this license application.

The Project is located at the Pawtucket Dam on the Merrimack River in the City of Lowell in Middlesex County, Massachusetts. The Project is located approximately 11 miles upstream of the Lawrence Project (FERC No. 2800) and approximately 30 miles downstream of the Amoskeag Dam (a development of the Merrimack River Project, FERC No. 1893) in New Hampshire. The 116-mile-long Merrimack River begins at the confluence of the Winnipesaukee and Pemigewasset Rivers in Franklin, New Hampshire; flows southward into Massachusetts; and then travels northeast until it discharges into the Atlantic Ocean. The existing Project includes the 15.0 MW E.L. Field powerhouse constructed in 1985-1986 during Project redevelopment, and four smaller generating stations located within mill buildings along the downtown canal system. The current total installed capacity of the project is 20,164 kW. A Project location map is presented above as Figure E.1-1.

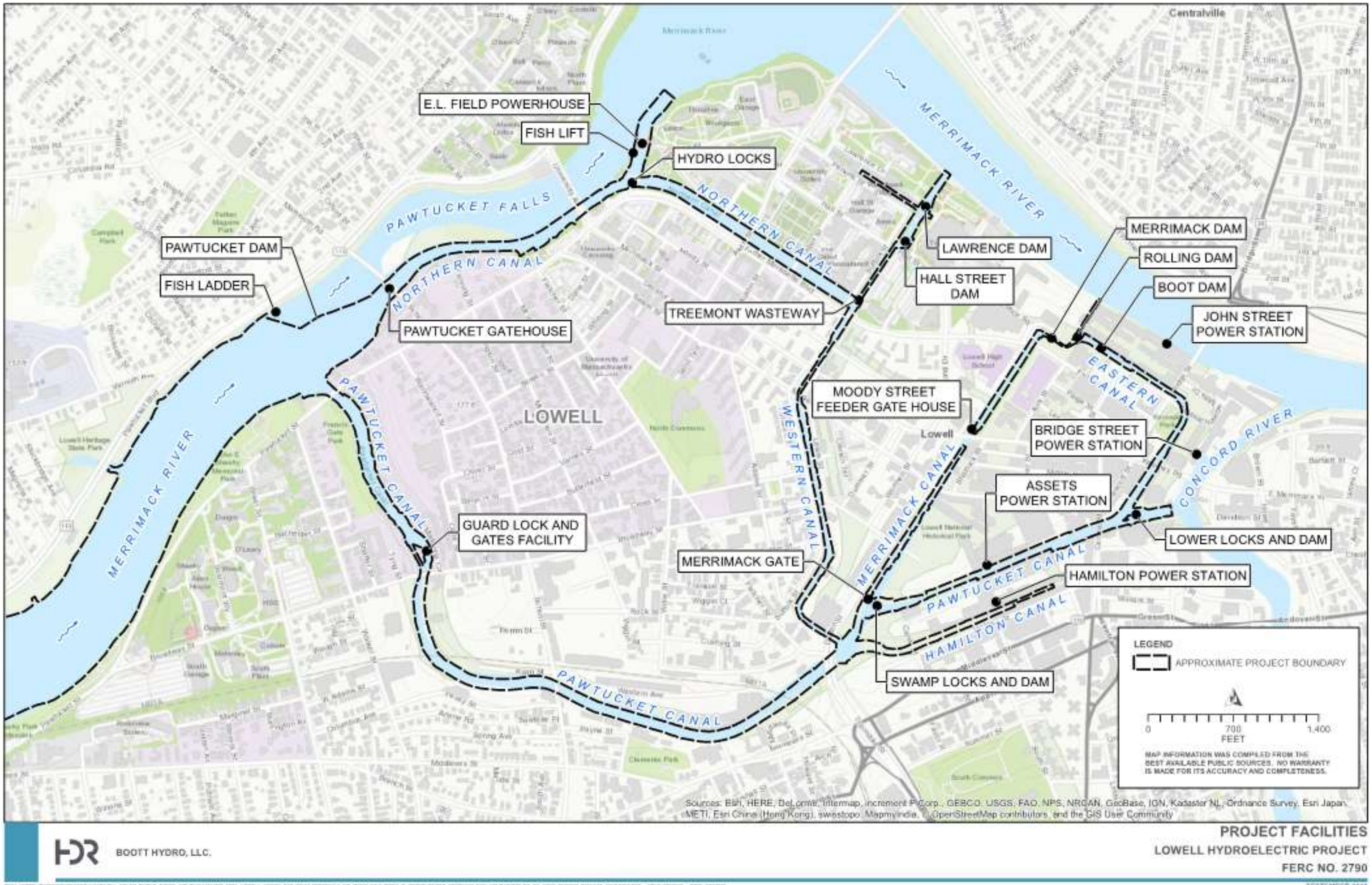
The E.L. Field powerhouse utilizes the existing Pawtucket Dam and the first 2,200 feet of the Northern Canal. The powerhouse is located close to the canal, downstream of the University Avenue Bridge (also called the Moody Street Bridge), with an intake structure drawing water from the canal. A 440-foot tailrace channel, surge gate and fish passage facilities comprise other major E.L. Field powerhouse features.

The current FERC license includes the Assets, Bridge Street, John Street, and Hamilton Power Stations which are housed within large nineteenth-century mill buildings sited along the 5.5-mile canal system (Figure E.5-1). Boott proposes to remove all four of these power stations from the new license. The current hydroelectric Project boundary includes only the turbines and associated equipment at these downtown mill sites. The Hamilton Power Station draws water from the Hamilton Canal and discharges into the Lower Pawtucket Canal. The Assets Power Station draws water through an intake structure at the Merrimack Canal and discharges into the Lower Pawtucket Canal. The Bridge Street Power Station (also known as “Section 8”) draws water from the Eastern

Canal and discharges into the Concord River. The John Street Power Station also draws water from the Eastern Canal and discharges into the Merrimack River.

As detailed in the Operations Analysis of the Lowell Canal Study (HDR 2021d), Boott notes that it is no longer economically feasible to operate these downtown power station units, and they have not been operated regularly in many years due to maintenance issues and other factors.

Figure E.5-1. Lowell Hydroelectric Project Canal System Map – Existing Facilities



E.5.3 Existing Structures Created Before Project Redevelopment

The site of the Lowell Project was historically used for hydromechanical and hydroelectric power for various mill operations. Much of the Project's current civil works were constructed during the 19th and early 20th centuries, and existed prior to Project licensing and redevelopment in the 1980's. These structures are described below.

E.5.3.1 The Pawtucket Dam

The Pawtucket Dam is of dressed masonry gravity construction with a length of 1,093 feet, a spillway crest length of 982.5 feet, a crest elevation of 87.2 feet NGVD 29, and an average height of 15 feet. Original drawings show the masonry was ashlar, laid dry with a mortared masonry upstream face at a 1:1 slope, a two-foot-thick capstone, and the bed course laid in mortar. It was built in two sections in 1847 and 1875, the latter being grouted during construction. The dam foundation rests on bedrock, except for a short section on hardpan. A fishway is located at the left dam abutment, and the Pawtucket Gatehouse to the Northern Canal is at the right abutment.

E.5.3.2 The Northern Canal

The Northern Canal is about 4,300 feet in length, with masonry or bedrock lining its complete length. The width of the Northern Canal varies along its length. At the head of the canal it is approximately 95 feet wide, at the location of the University Bridge overpass it is its most narrow at approximately 78 feet wide. About 2,200 feet downstream of the Pawtucket Gatehouse the canal widens to approximately 80 feet as it flows into the E.L. Field Powerhouse forebay. It then turns southeasterly at Pawtucket Street and Hydro Locks, widening to 105 feet between Pawtucket Street and the Tremont Gatehouse. In the new FERC license, Boott proposes to retain only the first ± 2,200-foot-long section of the Northern Canal extending from the Pawtucket Gatehouse to the E.L. Field forebay and Hydro Locks.

The Great River Wall is the left retaining wall of the Northern Canal. It runs from the Pawtucket Gatehouse to a natural rock outcrop upstream of the E.L. Field Powerhouse. The wall is a masonry structure that is 2,485 feet long and 32 feet in height. The first 1,000 feet combines masonry walls and an earth dike (with masonry core) as the river wall. The second length is a dressed masonry gravity structure to the site of the E.L. Field powerhouse. The crest of the Great River Wall is approximately 103.0 feet in elevation adjacent to the Pawtucket Gatehouse and varies in elevation along its length. The lowest point of the wall is approximately 93.3 feet at the University Bridge overpass. The width of the wall varies from 8 feet upstream at the Pawtucket Gatehouse to 10 feet at the downstream end. Boott proposes to retain the Great River Wall in the new FERC license.

E.5.3.3 Pawtucket Gatehouse

The Pawtucket Gatehouse (also known as the "Northern Canal Gatehouse") is located at the southern abutment of the Pawtucket Dam and controls flow into the Northern Canal. The Pawtucket Gatehouse is 125 feet long by approximately 55 feet high from the base of the foundation to the roof peak, and contains the guard sluice gates, the brick gatehouse, and a navigation lock. All these structures were a part of the Northern Canal construction project of 1846-47. The gatehouse is principally constructed of dressed masonry with concrete over lintels and contains ten 8-foot-wide by 15-foot-high, motor-operated, timber sliding gates which feed the Northern Canal. Another small intake opening feeds a historic Francis-designed turbine, which formerly powered the gate mechanisms through a line shaft. The structure's water passages are nearly 80 feet in length. Most of the original equipment, including the Francis turbine, is intact. Alterations include a watertight enclosing wooden cover in the turbine pit in 1872 to prevent flooding of the turbine chamber in high water.

The small navigation lock constructed of dressed masonry with two sets of wooden miter gates (upstream and downstream) is located at the southern end of the Pawtucket Gatehouse (Boott 2017). The navigation lock is approximately 12 feet wide and 97.8 feet long.

E.5.3.4 The Pawtucket Canal

The Pawtucket Canal branches off the Merrimack River about 950 feet upstream of the Pawtucket Gatehouse and feeds water into the downtown canal system. From its starting point, the 9,000-foot canal curves south and then east to meet the Concord River near its junction with the Merrimack River. The width of the Pawtucket varies from 80 to 100 feet and the average depth is about 8 feet. The walls are of granite, ledge, or concrete. The canal beds are of ledge, concrete, or wood-planked virgin soil. Boott proposes to retain within the project boundary only the first approximately 1,600-foot-long section of the Pawtucket Canal, between the impoundment and the Guard Lock and Gates Facility.

E.5.3.5 Additional Canals

The Licensee's existing four downtown power stations (Hamilton, Assets, Bridge Street, and John Street Power Stations) are fed by sections of the 5.5-mile canal system in Lowell. The principal canals in the system are the Pawtucket Canal and the Northern Canal, as described above. Smaller canals lead off these two major canals. The walls are of granite, ledge, or concrete. The canal beds are of ledge, concrete, or wood-planked virgin soil.

This Merrimack Canal branches off the Pawtucket Canal. In some areas the section is rectangular, but most of the Merrimack Canal has simply been gouged out of the native rock. The Merrimack Canal is 10 feet deep, 2,580 feet in length, and 40 to 50 feet wide. The Hamilton Canal begins at the Swamp Locks and is rectangular in section. The Hamilton Canal is 1,936 feet in length, 10 feet deep, 35 to 100 feet wide.

The Eastern Canal begins just above the Lower Locks of the Pawtucket Canal. The Eastern Canal runs for 2,037 feet and is rectangular in section. The Eastern Canal averages 8 feet in depth and 65 feet in width. The Western Canal was a two-level waterpower system, however the locks structures were removed and filled in 1840. The total length of the Western Canal is 4,964 feet. Its width varies from 35 to 55 feet, and its average depth is 9 feet.

As noted above, Boott proposes to remove all of these canals from the project boundary of the new FERC license, retaining only those portions of the Northern and Pawtucket Canal as described above. Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the NPS and other stakeholders.

E.5.3.6 Miscellaneous Canal Structures

E.5.3.6.1 Guard Lock and Gates Facility

The Guard Lock and Gates facility consists of a five-bay gate house located on the Pawtucket Canal and a series of three gate structures located within a boat lock. The substructure of the gate house on the Pawtucket Canal is of dressed masonry, and the superstructure is of brick masonry and wood frame. Adjacent to this structure is a boat lock consisting of the upper locking gate, Great Guard Gate (or Francis Gate), and lower locking gate. The gates span the lock chamber which is 24 feet wide with masonry walls. The upper locking gate and Great Guard Gate are housed in frame buildings. Boott proposes to retain the Guard Lock and Gates facility within the new FERC license.

The Great Guard Gate is a large portcullis gate located within the lock chamber between the upstream and downstream lock gates. This 25' wide by 25' high wooden gate is designed to be lowered into the lock chamber during extreme flood conditions on the Merrimack River, to prevent flooding of downtown Lowell via the Pawtucket Canal. A wood frame structure, the Francis Gatehouse, houses the Great Gate. When needed, the Great Gate can be dropped under its own weight to the bottom of the lock chamber, thereby closing off any flow through the boat lock channel at the Guard Locks, preventing flooding in downtown Lowell via the Pawtucket Canal. The original Great Gate has been used only twice during its history, the year following its construction in 1852 and again in 1936.

Due to the historic nature, public safety concerns and questionable functionality of the historic Great Guard Gate, in 2005 Boott designed and implemented a replacement gate in consultation with the FERC and NPS. The replacement gate is a segmented structural steel stoplog gate and frame which is stored on-site. The steel stoplog gate was designed and implemented to functionally replace the historic Great Guard Gate, which remains in place within the Francis Gate House. The steel stoplog gate fits immediately upstream of the Francis Gate House within existing stoplog slots in the granite masonry. When required, installation of the steel stoplog gate can be accomplished within a few hours by a local crane operator. The Project’s Emergency Action Plan (EAP) provides that the stoplogs should be installed when the water level at the Pawtucket Dam rises above 98.0 ft NGVD 29. To date, the steel stoplogs have been installed twice, during flooding events in May 2006 and April 2007.

E.5.3.6.2 Moody Street Feeder and Gate House

The Moody Street Feeder is a 1,400-foot-long underground conduit which allows flow to be passed from the Northern Canal to the Merrimack Canal. It terminates at the Moody Street Feeder Gate House which is located on the Merrimack Canal at the intersection of Dutton Street and Merrimack Street. Three 10-foot-wide gates allow closure of the three separate arched water passages. The gates are housed in a brick building measuring 62.5 feet long by 22.5 feet wide. Boott proposes to remove the Moody Street Feeder and Gate House from the new FERC license.

E.5.3.6.3 Lawrence Dam

The Lawrence Dam consists of a rock-filled timber-crib substructure with a three-tiered apron. The upper apron is of timbers overlaying rubble masonry. The second and third aprons consist of massive masonry. The superstructure is made of cast iron frames, fitted with wood bay boards. The structure is 100 feet long by 12 feet high and is located at the head of the Lawrence Wasteway, which leads to the Merrimack River. Boott proposes to remove the Lawrence Dam from the new FERC license.

E.5.3.6.4 Hall Street Dam

The Hall Street Dam consists of a rubble masonry structure with an upper protective timber deck and stepped massive ashlar masonry apron. The length of the structure is 115 feet with a maximum height of 15 feet. The dam is fitted with 1.5-foot flashboards. Boott proposes to remove the Hall Street Dam from the new FERC license.

E.5.3.6.5 Tremont Wasteway

The Tremont Wasteway is 30 feet wide by 600 feet long and is adjacent to Suffolk Street. The wasteway forms the water passageway between the Northern Canal and the Hall Street Dam. At the head of the wasteway is the Tremont Gate House. Two 9-foot-wide gates control the flow of water into the wasteway and are housed in a gate house building consisting of brick superstructure with masonry substructure. Boott proposes to remove the Tremont Wasteway from the new FERC license.

E.5.3.6.6 Lower Locks and Dam

The Lower Locks and Dam are on the Lower Pawtucket Canal and empty into the Concord River. The dam, with a maximum height of 12 feet, consists of a rubble masonry structure with a sloping timber apron. Energy dissipation is accomplished by large rubble masonry located downstream of the dam. The superstructure is constructed of cast iron frames, fitted with wood bay boards. A gated sluiceway is also provided. The lock structure contains two chambers 30.5 feet wide by 85 feet long. The width at the gate passageway is 12.5 feet. The lock walls are of hand laid masonry. Boott proposes to remove the Lower Locks and Dam from the new FERC license.

E.5.3.6.7 Swamp Locks and Dam

The Swamp Locks and Dam are at the head of the Lower Pawtucket Canal. The dam consists of a concrete apron overlaying a rubble masonry structure. The superstructure is made of cast iron frames, fitted with wood bay boards. The maximum height of the dam is 15 feet. A sluiceway, similar to the Lower Locks and Dam is also provided. A two-chamber lock, with narrowest width of 12.5 feet allows passage by the Swamp Locks and Dam. The lock is constructed of rubble masonry. Boott proposes to remove the Swamp Locks and Dam from the new FERC license.

E.5.3.6.8 Rolling Dam

The Rolling Dam consists of a masonry structure with curved apron protected by wood planks. The maximum height of the dam is 19 feet. The masonry construction is carried downstream of the dam to provide scour protection. The Rolling Dam is located downstream of the Merrimack Dam. Boott proposes to remove the Rolling Dam from the new FERC license.

E.5.3.6.9 Merrimack Dam, Merrimack Gate and Boott Dam

The Merrimack Dam consists of a sloping apron rubble masonry structure. The apron is protected with timber planks. The maximum height of the dam is 8 feet, and it acts as a submerged weir, no longer used to control water elevations.

The Merrimack Gate consists of a concrete dam structure with sloping upstream face and vertical downstream face. The center portion of the structure is fitted with a 10-foot-wide by 6-foot-high timber gate. The maximum height of the dam is 9 feet.

The Boott Dam is located 80 feet southeast of the Merrimack Wasteway adjacent to Boott Mills. It consists of a masonry structure 40 feet long with a maximum height of 7 feet and a gated sluiceway.

Boott proposes to remove the Merrimack Dam, the Merrimack Gate, and the Boott Dam from the new FERC license.

E.5.3.7 Mill Buildings

The Hamilton, Assets, Bridge Street, and John Street power stations and turbines are housed in large old mill buildings. The buildings, not included in the Project, are exceptionally sturdy structures used principally as space for small industrial manufacturers, storage space or apartment/condominium units. The existing hydroelectric Project boundary includes only the turbines and associated equipment at these downtown mill sites. Boott proposes to remove these turbines and associated water passages from the new FERC license.

E.5.4 Structures Constructed During Project Redevelopment

The principal civil works constructed during project redevelopment in 1985-1986 include the E.L. Field powerhouse, associated intake and tailrace channels, a canal control structure with navigation lock, fish passage facilities and a substation. Boott proposes to retain all of these structures within the new FERC license.

E.5.4.1 Eldred L. Field Powerhouse

The E.L. Field powerhouse is a reinforced concrete structure. The powerhouse is approximately 109 feet long by 96 feet wide and houses two generating units with a total authorized generation of 15.0 MW. The powerhouse incorporates a separate conventional intake structure for each of the station's two identical units. Each intake is equipped with trashracks; intake and draft tube gate slots with permanent or bulkhead style gates for emergency shutdown and dewatering purposes are also provided. The powerhouse is equipped with a traversing trash rake to remove debris at the intake. Both mobile and on-site cranes are used for heavy equipment movement at the facility. The E.L. Field powerhouse forebay is an excavated rock channel approximately 200 feet long, 50 feet deep, and 80 feet wide. The left (northern) side of the forebay is a reinforced concrete wall and includes the exit channel of the existing fish lift system.

E.5.4.2 Tailrace Channel

A 440-foot-long tailrace channel was excavated out of bedrock in the river. The channel excavation is approximately 60 feet wide by an average of 20 feet deep. The tailrace is protected from high river flows by a 10 to 16 -foot-high concrete training wall, which directs bypassed river flows away from the tailrace.

E.5.4.3 Crest Gate System

A pneumatically operated crest gate system is mounted on the spillway crest to maintain the headpond at its normal maximum water surface elevation of 92.2 feet NGVD 29. The pneumatic crest gate system consists of five-foot-high, 20-foot-long hinged steel panels supported on their downstream side by tubular rubber air bladders. The crest gate system is installed in five independently controllable zones. Air compressors, which supply system inflation and deflation pressure, and the crest gate control system are housed in a building located near the fish ladder and the left (northerly) abutment of the dam.

E.5.4.4 Control Structures

During the construction of the E.L. Field powerhouse in the 1980's a concrete control structure known as "Hydro Locks" was constructed at the bend in the Northern Canal upstream of the E.L. Field intake and underneath the Pawtucket Street Bridge. The control structure was constructed to maintain effective net head at the E.L. Field Powerhouse by isolating the powerhouse forebay from the remainder of the Lowell canal system. It includes a navigation lock at its western end to allow passage of NPS tour boats. The control structure runs 100 feet long parallel to and slightly underneath the Pawtucket Street Bridge and is 26 feet high by 22.25 feet wide. The lock structure is approximately 88 feet long located on the canal side along Father Morissette Boulevard, with sets of butterfly wicket lock gates approximately 15 feet high and 56 feet apart on either end of the lock. The lock structure is also equipped with stop log slots and rubber fenders.

Located along the Great River Wall is the canal surge gate, located just upstream of the E.L. Field Powerhouse. The steel gate is pneumatically operated and is 15-feet-high by 78 feet wide set on a masonry weir with a crest elevation of 77.0 feet. This system is designed to attenuate the surge wave in the canal that occurs when there is a sudden plant shutdown. When flow is less than 3,500 cubic feet per second (cfs), the surge suppressor gate is manually disabled. Should the flow increase to over 3,500 cfs, the gate is returned to the automatic operating condition. A safety boom has been installed in the canal above the gate.

E.5.4.5 Fish Passage Facilities

Upstream and downstream fish passage facilities at the Project include a fish elevator[5] and downstream fish bypass at the E.L. Field powerhouse, and a vertical-slot fish ladder at the Pawtucket Dam. All fish passage facilities were designed in consultation with the U.S. Fish and Wildlife Service. Passage operations are supervised by the state and federal fishery agencies.

The reinforced concrete fish ladder at the Pawtucket Dam is designed to allow for controlled fish passage at river flows up to 25,000 cfs The fishway operates at 200 cfs, including attraction flow, with an additional 300 cfs of supplemental attraction flow released from a slide gate adjacent to the passage facility. The fish ladder is a vertical slot design with 13-foot-wide by 10-foot-long pools. A counting station and fish trap area is provided. The Pawtucket Dam has been modified by removing ashlar masonry to allow the exit channel to penetrate the dam.

The upstream fishway at the powerhouse is a fish elevator. The design discharge capacity is 200 cfs. A fish collection gallery with two openings spans the downstream wall of the powerhouse to collect fish migrating through the tailrace channel, however only the westerly “river side” entrance has been used since the 1990’s, by agreement with the fishery agencies. The fish are attracted into the 30-foot crowding pool, trapped, and crowded. From the crowding pool, they enter the elevator and are lifted in a hopper to the exit channel. From the elevator area, the fish enter a holding pool 10 feet wide by 50 feet long. Fish next enter the fish trap area where they can be counted. A 10-foot by 12-foot fish counting station is provided. Passage of fish through the trap area allows fish to enter the exit channel, passing into the Northern Canal and then upriver.

The downstream fishway at the powerhouse consists of an adjustable-flow sluiceway and bypass adjacent to the intake headwall. Downstream migrants entering the bypass are quickly sluiced into an enlarged and deepened plunge pool located in the bypassed river reach next to the powerhouse. Natural channel braids in the riverbed allow

[5] The terms “fish elevator” and “fish lift” are used interchangeably in this document to describe the existing upstream fish passage facility at the E.L. field Powerhouse.

emigrants to move downstream to the mainstem river, at the confluence of the river reach and tailrace.

E.5.4.6 Impoundment Characteristics (18 C.F.R. §5.18 (b)(4)(iii)

The Project operates in a ROR mode and has no usable storage capacity. The existing Project boundary extends approximately 23 miles upstream to Moore's Falls in Litchfield and Merrimack, New Hampshire.

Boott is proposing to remove 7.4 miles from the upstream extent of the current Project boundary, as shown in Exhibit G. At the normal pool elevation of 92.2 ft NGVD 29, the surface area of the proposed impoundment is reported to encompass an area of about 1,236 acres. The gross storage capacity between the normal surface elevation of 92.2 feet NGVD 29 and the minimum pond level of 87.2 feet NGVD 29 is approximately 6,180 acre-feet.

E.5.4.7 Generating Equipment (18 C.F.R. §5.18(b)(4)(iv)

Turbine and generator data for each of the five existing power stations (including the E.L. Powerhouse) are provided below in Table E.5-1. Boott proposes to remove all of the mill powerhouse units from the new FERC license, leaving only the two units at the E.L. Field Powerhouse. The proposed project capacity is 15,012 kW.

Table E.5-1. Lowell Hydroelectric Existing Project Turbine, Generator, and Unit Capacity Data

		TURBINES							GENERATORS							
			Size	Speed	Head	Flow	Power	Power			Power	Power	Voltage	Speed		Unit
Powerhouse	Unit #	Type	Inches	RPM	Feet	cfs	HP	kW	Type	kVA	Factor	kW	Volts	RPM		Capacity
E. L. Field	1	Fuji Horizontal Full Kaplan	152.4	120	39	3,300	11,540	8,655	Fuji Electric	8,340	0.9	7,506	4,160	120		7,506
E. L. Field	2	Fuji Horizontal Full Kaplan	152.4	120	39	3,300	11,540	8,655	Fuji Electric	8,340	0.9	7,506	4,160	120		7,506
Assets	1	Hercules Double Runner Styles C & D	33 / 31	150	13	376	444	333	General Electric Type ATB 48-332-150	330	0.8	264	600	150		264
Assets	2	Hercules Double Runner Styles C & D	33 / 31	150	13	376	444	333	General Electric Type ATB 48-332-150	330	0.8	264	600	150		264
Assets	3	Hercules Double Runner Styles C & D	33 / 31	150	13	376	444	333	General Electric Type ATB 48-332-150	330	0.8	264	600	150		264
Bridge Street	4	Hercules Type D Single Runner	42	138.5	22	333	655	491	General Electric Co. Type ATB	450	0.8	360	600	138.5		360
Bridge Street	5	Hercules Type D Single Runner	42	138.5	22	333	655	491	General Electric Co. Type ATB	450	0.8	360	600	138.5		360
Bridge Street	6	Hercules Type D Single Runner	42	138.5	22	333	655	491	General Electric Co. Type ATB	450	0.8	360	600	138.5		360
Hamilton	1	Leffel Type Z Single Runner	45	120	13	374	459	344	Westinghouse Electric Co.	350	0.8	280	600	120		280
Hamilton	2	Leffel Type Z Single Runner	39	133	13	279	341	256	Electric Machinery Co.	225	0.8	180	600	133		180
Hamilton	3	Leffel Type Z Single Runner	36	150	13	237	287	215	Electric Machinery Co.	200	0.8	160	600	150		160
Hamilton	4	Leffel Type Z Single Runner	45	120	13	374	459	344	Electric Machinery Co.	350	0.8	280	600	120		280
Hamilton	5	Leffel Type Z Single Runner	45	120	13	374	459	344	Electric Machinery Co.	350	0.8	280	600	120		280
John Street	3	Leffel Single Runner	33	200	21	250	482	362	General Electric Co. Type ATI	375	0.8	300	600	200		300
John Street	4	Leffel Single Runner	33	200	21	250	482	362	General Electric Co. Type ATI	375	0.8	300	600	200		300
John Street	5	Leffel Single Runner	33	200	21	250	482	362	General Electric Co. Type ATI	375	0.8	300	600	200		300
John Street	6	Allis Chalmers Single Runner	72	100	21	1,000	1,925	1,444	Allis-Chalmers Type AV	1,500	0.8	1,200	600	100		1,200
											TOTAL EXISTING PROJECT CAPACITY:					**20,164**

E.5.5 Estimated Average Annual Energy Production (18 C.F.R. §5.18(b)(4)(v)

The average annual energy generation of the Lowell Hydroelectric Project for the period of 2008 through 2017 was 84,501 megawatt-hours (MWh). The Project operates in a ROR mode and, therefore, experiences seasonal and annual variations in generation based on natural hydrologic conditions in the Merrimack River Watershed. Table E.5-2 provides a summary of monthly Project generation for a 10-year period from 2008 through 2017 in MWh.

Table E.5-2. Lowell Hydroelectric Project Monthly and Annual Generation (MWh)

Month	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
January	10,610	2,574	6,403	7,163	10,272	8,064	10,422	6,624	9,258	9,325
February	10,955	3,851	6,672	5,228	8,928	8,304	5,232	3,216	9,312	6,335
March	11,727	5,088	8,555	10,176	12,432	12,784	10,536	5,820	10,042	9,395
April	10,876	7,341	8,061	11,088	7,872	13,392	10,959	10,128	8,427	8,387
May	7,690	10,147	8,094	11,472	11,712	9,600	9,264	5,219	7,244	8,181
June	4,512	10,464	4,752	8,304	9,792	11,551	3,075	6,563	2,577	9,716
July	5,615	11,252	2,963	3,552	3,216	11,520	4,608	6,432	1,010	6,635
August	4,810	8,026	2,072	4,416	4,560	6,144	5,472	2,412	1,044	2,959
September	4,962	4,012	1,677	10,128	3,696	6,214	4,428	1,898	498	3,462
October	5,287	5,703	8,457	11,136	7,344	3,894	4,314	5,297	1,059	3,332
November	4,726	4,404	10,216	10,272	6,384	5,376	6,880	6,367	3,649	7,380
December	4,656	4,747	9,687	10,272	8,880	7,772	10,700	8,395	9,025	7,946
Annual	86,425	77,609	77,608	103,207	95,088	104,614	85,890	68,371	63,146	83,053

E.5.6 Estimated Dependable Capacity (18 C.F.R. §5.18(b)(4)(v)

Dependable capacity is generally defined as the amount of load a hydroelectric plant can carry under adverse hydrologic conditions during a period of peak demand, for example, during the hot, dry conditions typical of August in the Project area. The estimated dependable capacity is also determined by the minimum flow requirements included in the existing license. Under the current license, the Project's estimated dependable capacity is approximately 4.9 MW, based on the August median flow of 1,940 cfs at the Project site. The estimated dependable capacity is not expected to change with removal of the four power stations along the downtown canal system given they were only operated during flow conditions over 6,600 cfs.

E.5.7 Current and Proposed Project Operations (18 C.F.R. §5.18(b)(4)(vi)

The Project is operated using the automatic pond level control capability of the E.L. Field Powerhouse. Boott is proposing to continue to operate the Project in the same manner as it is currently operated (automatic).

E.5.7.1 General Operations

The Project is operated in a ROR mode. Under the current project configuration, Boott normally operates the Project to maximize flow through the available units at the E.L. Field Powerhouse, then routes any additional flows through the Pawtucket Canal system. The E.L. Field turbine-generator units are more efficient and operate at a higher head than the older canal units, and are, therefore, the priority first-on, last-off units in the Project operations scheme. When river flows exceed the hydraulic capacity of the E.L. Field units (nameplate hydraulic capacity = 3,300 cfs per unit or 6,600 cfs for both units), excess flows up to approximately 2,000 cfs may be routed through the downtown canal system and to the canal units. Any flows in excess of approximately 8,600 cfs (6,600 cfs at E.L. Field plus 2,000 cfs via canals) are passed over the Pawtucket Dam spillway. Pursuant to Article 37, the Project maintains a minimum flow of 1,990 cfs or inflow, whichever is less, as measured immediately downstream from the Project, which is met or exceeded by operating the project in ROR mode (Boott 2017).

Project operations will not change significantly with the proposed removal of the 15 mill units and associated canal infrastructure from the new license. The Project will continue to operate in ROR mode using automatic pond level control of the E.L. Field powerhouse units, passing all excess flow over the spillway of the Pawtucket Dam. Boott will continue to manage flow passed through the Guard Locks on an as-needed basis for water level and flow management purposes within the downtown canal system.

E.5.8 Pneumatic Crest Gate Operations

On April 18, 2013, FERC authorized Boott to replace the existing wooden flashboard system on the Project's Pawtucket Dam with a pneumatic crest gate system. FERC approved the amended crest gate system operation plan on March 30, 2015. The plan describes the operation of the pneumatic crest gate system under normal and high-water operations.

The pneumatic crest gate system works in conjunction with the automatic pond level control system at the E.L. Field Powerhouse to maintain consistent headpond level conditions.

Below (Table E.5-3) is a tabular description of the operating curve currently used for operations.

Table E.5-3. Pneumatic Crest Gate System Current Operational Scheme

Approximate Spillway Flow (cfs) †	Crest Gate Status	Target Pond Level (ft NGVD 1929)	Unit Operation
0	Full elevation	92.2 ft (Normal pond)	Pond level control maintained at E.L. Field Powerhouse; additional flow passed through downtown canal system as necessary.
0 – 3,250	Full elevation	Rising to ± 93.2 ft	Full available output
3,250 - ± 23,000 (est.)	Automatic pond level control	± 93.2 ft	Full available output
± 23,000 (est.) – 35,000††	Automatic pond level control if High Water Operations Protocol is not triggered.	± 93.2 ft	Full available output
	Fully lowered if High Water Operations Protocol is triggered	Pond level follows spillway rating curve based on spillway flow.	Full available output
>35,000	Fully lowered	Rises above 93.2 ft as spillway discharge increases.	Fully available output

Source: FERC 2015.
† Flow over the spillway is the inflow to the headpond minus any flow through the turbines at the E.L. Field Powerhouse, through the downtown canal system or through the fish ladder. The maximum combined hydraulic capacity of E.L. Field Powerhouse and the canal system is approximately 9,000 cfs, but may be restricted by unit availability, debris accumulation at the Northern Canal Gatehouse, high tailwater conditions, and other factors.
†† The potential range of spillway flows over which the crest gate may be fully lowered per the High-Water Operations Protocol. The estimated flow over the spillway is the flow at the Merrimack River (U.S. Geological Survey [USGS] gage No. 01100000) minus the flow at the Concord River (USGS gage No. 01099500) and minus any flow released through Boott's turbines and the downtown canal system.

E.5.8.1.1 Normal Operation

Under normal operations, the crest gate will be maintained at full elevation, and the E.L. Field Powerhouse control system will adjust the main units’ output to match inflow and maintain the impoundment water level at the normal, authorized pond elevation.

E.5.8.2 Operations During Low Water and Adverse Conditions

During low inflow conditions, Boott operates the Project to maintain the impoundment level of 92.2 feet NGVD 29 and provides the required minimum downstream releases and flows necessary for operation of the fish passage structures in accordance with Articles 36 and 37 of the Project’s license.

Boott also proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam during the period outside of the fish passage season. The minimum flow would be provided as spillage over one or more of the crest gate zones.

E.5.8.3 Operations During High Water and Adverse Conditions

Under past and current operations, when river flows exceed the hydraulic capacity of the E.L. Field Powerhouse units (approximately 3,300 cfs per unit or 6,600 cfs for both units), excess flows up to approximately 2,000 cfs can be routed through the downtown canal system and to the canal units (as described below). Any flows in excess of these flows are passed over the Pawtucket Dam spillway.

During these high-water conditions, the crest gate control system will automatically adjust the gates to maintain the impoundment elevation no higher than 93.2 feet NGVD 29, or one foot above the normal pond elevation. When under automatic control, the crest gates would all be fully lowered at spillway flows of approximately 35,000 cfs. In addition, the approved crest gate operations plan requires Boott to fully lower the crest gate panels in anticipation of potential flood events. This minimizes the upstream backwater effect of the Pawtucket Dam to the extent possible. (FERC 2015).

Under very high flow conditions when the water level at the Pawtucket Dam reaches 98.0 feet NDVD 29, Boott initiates the installation of the steel stoplogs upstream of the Great Guard Gate, per the provisions of the EAP, as discussed in detail under Section E.5.6.3.1. These stoplogs are designed to functionally replace the historic Great Guard Gate, to prevent the potentially flooding of downtown Lowell via the Pawtucket Canal.

E.5.8.4 Canal System Operations

The existing Lowell Hydroelectric Project includes a two-tiered network of man-made canals, totaling 5.5 miles in length. Flow enters the canal system upstream of the Pawtucket Dam via the Pawtucket Canal and is controlled by the Guard Lock and Gates Facility.

The Lowell Hydroelectric Project presently includes four power stations located within mill buildings along the downtown canal system. The Hamilton Power Station contains five units and draws water from the Hamilton Canal in the upper canal system and discharges into the Lower Pawtucket Canal in the lower canal system at a head of approximately 13 feet. The Assets Power Station contains three units and draws water from the Merrimack Canal in the upper canal system and discharges into the Lower Pawtucket Canal in the lower canal system at a head of approximately 13 feet. In the lower canal system, the Bridge Street and John Street Power Stations each draw from the Eastern Canal and discharge to the Merrimack River or the Concord River, at a head of approximately 21 feet. The John Street Power Station contains four units and discharges into the Merrimack River. The Bridge Street Power Station has three units known as “Section 8” discharging into the Concord River.

As stated elsewhere in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage the canal structures, water levels and flows in line with current agreements with the NPS and other stakeholders.

E.5.8.4.1 Minimum Flow Management

Although there is no formal flow requirement for the canal system, Boott maintains an operating agreement with the NPS to allow tour boat operations to navigate the canal system. Boott maintains canal water levels within appropriate limits during the May 15 to October 15 tour boat operating season. Operations are maintained through a series of locks and gatehouses along the canal system (Cleantech Analytics 2017).

E.5.8.4.2 Normal Operation

The nominal flow capacity of the downtown canal system via the Pawtucket Canal and the Guard Lock and Gates Facility is approximately 2,000 cfs. Future normal operations will consist of providing sufficient flow through the Guard Gates structure necessary to maintain and manage water levels in the downtown canal system, consistent with current practices and agreements.

E.5.8.4.3 Operation During High Water

As discussed in Section E.5.7.1, when river flows exceed the hydraulic capacity of the E.L. Field Powerhouse units (6,600 cfs for both units), excess flows up to approximately 2,000 cfs can be routed through the downtown canal system and to the canal units. Any flows in excess of these capacities are passed over the Pawtucket Dam spillway. Under proposed future operations Boott does not anticipate any need to pass excess flow through the canal system, since the Pawtucket Dam spillway has ample capacity and the crest gates would be fully lowered during high flow events.

The Guard Lock and Gates facility includes the Great Guard Gate, a large portcullis gate constructed in 1851 to prevent flooding in downtown Lowell via the Pawtucket Canal. In 2005 Boott designed and implemented a replacement for the historic Great Guard Gate. The replacement gate is a segmented structural steel stoplog gate and frame which is stored on-site and was designed and implemented in consultation with the FERC and NPS. When required, installation of the steel stoplog gate can be accomplished within a few hours by a local crane operator. The Project’s Emergency Action Plan (EAP) provides that the stoplogs should be installed when the water level at the Pawtucket Dam rises above 98.0 ft NGVD 29. Boott proposes to retain the Great Guard Lock and Gates facility in the Project license, and to continue implementation of the existing EAP associated with the facility.

E.5.8.5 Fish Passage Operations

The Comprehensive Fish Passage Plan (CFPP), approved by FERC on November 28, 2000, required operation of a fish ladder at the Pawtucket Dam. The fish ladder has a total operating flow of 500 cfs including attraction flow. The 500 cfs is the primary source of flow in the bypass reach, other than spillage over the Pawtucket Dam spillway. The fish lift system at E.L Field Powerhouse has a total flow capacity of 180 cfs; however, it presently operates at 100-120 cfs. Boott is required to operate both the fish ladder and the fish lift daily during spring of each year when a cumulative total of 50 American shad (*Alosa sapidissima*) or 200 River herring (*A. pseudoharengus*) are passed at the downstream Lawrence Hydroelectric Project. Additionally, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech Analytics 2017). All fish passage facilities were designed in consultation with the USFWS. Since 2013, Boott has worked cooperatively with the USFWS and other fishery agencies as part of the Merrimack River Technical Committee (MRTC) to assess and provide passage for eels moving upstream in the mainstem Merrimack. The efforts have occurred primarily at the fish ladder at the Pawtucket Dam, from mid-July through September, annually. Fish passage operations are coordinated with the MRTC.

Under the new Project license, Boott proposes to replace the existing fish lift with a short fish ladder to pass migratory fish from the tailrace to the bypass reach, such that all fish would be passed upstream of the Project via the existing fish ladder at the Pawtucket Dam. The Licensee will work with the MRTC member agencies to determine the design and installation schedule for the proposed ladder.

E.5.9 Proposed Project Operations (18 C.F.R. §5.18(b)(4)(vi))

The Project is operated in a ROR mode with no useable storage capacity, and a minimum flow of 1,990 cfs (or inflow, whichever is less) is provided immediately downstream from the Project for the purpose of protection of fish and wildlife resources. Boott also adheres to the CFPP (approved by FERC on November 28, 2000) and the Crest Gate Operation Plan (approved March 30, 2015).

Boott also proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam during the period outside of the fish passage season. The minimum flow would be provided as spillage over one or more of the crest gate zones. During the fish passage season, which generally runs from late April through mid-July, the Licensee proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the fishery agencies, consistent with current practice.

E.6 Proposed Action and Action Alternatives

E.6.1 Summary of Existing Measures

Boott currently implements the following PM&E measures for the protection of aquatic, water quality, geologic/soil, recreation, and cultural resources pursuant to the existing license for the Project.

Article 33 (amended April 18, 2013 and approved May 18, 2016): Requires the Licensee, prior to the commencement of any construction activities, to cooperate with the Massachusetts State Historic Preservation Officer (SHPO) and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historical Park (The license was amended to replace wooden flashboards on Pawtucket Dam with pneumatic crest gate system and mitigation measures were required).

Article 34 (approved September 24, 1984): Requires the Licensee to design and construct upstream and downstream fish passage facilities at the Project, in consultation with the fishery agencies. Accordingly, in the late 1980s the Licensee constructed a fish lift and downstream fish passage facility at the E.L. Field powerhouse and a fish ladder at the Pawtucket Dam. These facilities are operated and managed under the CFPP, as discussed below.

Article 35 (approved November 28, 2000): Requires the Licensee to conduct an operational study to determine the effectiveness of the fish passage facilities required under Article 34, in consultation with the fishery agencies. During the term of the license The Licensee has conducted numerous fish passage studies and has implemented operational and facility improvements based on the results of those studies. These studies and improvements have been carried out pursuant to the CFPP, as discussed below.

Article 36 (approved November 27, 1984; November 28, 2000; July 11, 2001): Required the Licensee develop (1) an instream flow study plan to determine the relationship between Project discharges and downstream aquatic habitat, and (2) a fishery study plan to determine Project discharges necessary to provide for the migration of anadromous fish.

Pursuant to Article 35 and 36, Boott adheres to the Comprehensive Fish Passage Plan, approved by FERC on November 28, 2000.The CFPP requires operations of a fish ladder at the Pawtucket Dam. The fish ladder has a total operating flow of 500 cfs including attraction flow. The 500 cfs is the primary source of flow in the bypass reach, other than spillage over the Pawtucket Dam spillway. The fish lift system at E.L Field Powerhouse has a total flow capacity of 180 cfs; however, it presently operates at 100-120 cfs. Boott is required to operate both the fish ladder and the fish lift daily during spring of each year when a cumulative total of 50 American Shad or 200 River Herring are passed at the downstream Lawrence Hydroelectric Project. Additionally, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech Analytics 2017).

Since 2013, Boott has worked cooperatively with USFWS and other fishery agencies to assess and provide passage for eels moving upstream in the mainstem Merrimack. The efforts have occurred primarily at the fish ladder at the Pawtucket Dam, from mid-July through September, annually.

Article 37 (ordered November 27, 1984): Requires the Licensee to discharge an interim continuous minimum flow of 1,990 cfs or inflow, whichever is less, for the purpose of protection of fish and wildlife resources, as measured immediately downstream from the Project.

Article 38 (ordered September 12, 1984): Requires the Licensee to file a revised Report on Recreational Resources to include: (1) functional plans for certain repairs and improvements to the Northern Canal and a visitor facility at the E.L. Field Powerhouse; (2) a canal system water level agreement with the NPS.

Boott is also required to adhere to the following operations-related plan:

Crest Gate Operation Plan (approved March 30, 2015): Requires the Licensee to adhere to the detailed plan for operation of the pneumatic crest gate system filed on July 16, 2013 and revised on July 30, 2014. The plan describes the operation of the pneumatic crest gate system under normal and high-water operations. Table E.5-3 above provides a tabular description of the operating curve used for operations.

The pneumatic crest gate system works in conjunction with the automatic pond level control system at the E.L. Field Powerhouse to maintain consistent headpond level conditions. Under normal operations, the crest gate will be maintained at full elevation, and the E.L. Field control system will adjust the main units' output to match inflow and maintain the impoundment water level at the normal, authorized pond elevation (92.2 feet). When inflows begin to exceed the capacity of the available units, the crest gate control system will automatically adjust the gates to maintain the impoundment elevation no higher than 93.2 feet, or one foot above the normal pond elevation. When under automatic control, the crest gates would all be fully lowered at spillway flows of approximately 35,000 cfs and above (FERC 2015a). Under high-water operations, Boott will fully lower the crest gate system in anticipation of potential flood events in order to minimize the upstream backwater effect of the Pawtucket Dam to the extent possible.

E.6.2 Summary of Proposed Measures

Based on the studies conducted in support of this relicensing and consultation with stakeholders to date, Boott proposes the following measures to be included in the new Project license:

<u>Project Facilities and Operations</u>

- Boott proposes to operate the Project in a ROR mode using automatic pond level control of the E.L. Field powerhouse units, to protect fish and wildlife resources downstream from the Project. ROR operation may be temporarily modified for short periods to allow flow management for other project and non-project needs, e.g., downtown canal water level management, raising the crest gates following a high-water event, or for recreational purposes.

- During the upstream fish passage season, which generally runs from late April through mid-July, Boott proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the Merrimack River Technical Committee,[6] consistent with current practice. At all other times, Boott proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam, for the protection of aquatic habitat within the bypass reach.
- Boott proposes continued adherence to the requirements of the Project's existing Crest Gate Operation Plan (approved by FERC on March 30, 2015).
- Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage its canal structures and facilities, water levels and flows through the downtown canal system in line with the current agreements with NPS and other stakeholders.

  In general, Boott is proposing to install a concrete plug in each penstock opening at the canal wall, and disconnecting turbines, generators, and other electrical equipment at the Assets, Hamilton, John Street, and Bridge Street (Section 8) powerhouses. The potential need for infilling or bracing of dewatered penstocks would be handled on a case-by-case basis, based on the results of an engineering assessment to be performed during the preparation of the Decommissioning Plan to be developed for each power station. As detailed in Section E.7.6 of this exhibit, Boott, the NPS, MADCR, and Proprietors have different ownership of, easements to, and rights associated with the canals, powerhouses, lock structures, control structures, and water conveyance structures as described in the Memorandum of Understanding (MOU), the 1984 Great Deed between Proprietors and Boott (Proprietors 1984), the 1986 Order of Taking (Commonwealth of Massachusetts 1986), and the 1995 Grant of Easement from the Commonwealth of Massachusetts to the LNHP (Commonwealth 1995). Boott is proposing to continue to operate and maintain these structures consistent with the existing ownership, rights, and easements, as well as any existing or new agreements developed among the concerned stakeholders. The proposed disposition of the downtown facilities is summarized in Table E.6-1.

[6] The Merrimack River Technical Committee is comprised of the following state and federal agencies: New Hampshire Department of Fish and Game (NHDFG), Massachusetts Division of Fisheries and Wildlife (MADFW), Massachusetts Division of Marine Fisheries (MADMF), United States Fish and Wildlife Service (USFWS), United States Forest Service (USFS), and National Marine Fisheries Service (NMFS).

Table E.6-1. Proposed Disposition of Project Facilities Following Decommissioning

Structure	Subcomponents	Ownership	Other Rights	Action	Other
CANALS					
Upper Pawtucket Canal	–	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal[a] • Boott Water and Flowage Rights[b] • MADCR Recreation Rights and Exclusive Easement Rights[c]	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Lower Pawtucket Canal	–	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Hamilton Canal	–	Boott Hydropower LLC (Boott)	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	–
Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Merrimack Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
Eastern Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
Northern Canal - Hydro Locks to Western Canal	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	Maintain water levels and canal walls in line with existing rights, responsibilities, and existing or new agreements.	Retain a 5' corridor for submarine interconnection cable
DAMS AND LOCK STRUCTURES					
Swamp Locks Complex	Swamp Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures[d]	No change from present	–
	Swamp Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Swamp Locks Dam (North and South)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	No change from present	–
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal	No change from present; Boott will continue to operate the gates for canal water level management.	–
Lower Locks Complex	Lower Locks Gatehouse (Superstructure)	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
	Lower Locks Gatehouse (Substructure)	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
	Lower Locks Dam	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Lock Structures	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights[e]	No change from present	–
	Gates	Proprietors of Locks & Canals	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • MADCR Recreation Rights and Exclusive Easement Rights • NPS Easement VIII Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Moody Street Feeder	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	Retain a 5' corridor for submarine interconnection cable
Lawrence Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Hall Street Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Hamilton Wasteway	-	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Hamilton Gatehouse and Gate (Superstructure)	–	MADCR	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights • Boott Easement for Access to Structures	No change from present	–
Hamilton Gatehouse and Gate (Substructure)	–	Boott	• Boott Easement to Pawtucket Canal • Boott Water and Flowage Rights	No change from present	–
Tremont Wasteway	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Tremont Gatehouse	–	MADCR	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Merrimack Dam and Gate	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–
Rolling Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present	–
Boott Dam	–	Boott	• MADCR Recreation Rights and Exclusive Easement Rights	No change from present; Boott will continue to operate the gates for canal water level management.	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
DOWNTOWN POWERHOUSES					
Assets	Intakes	Proprietors of Locks & Canals	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals[f]	• Boott Easement to Penstocks and Tailraces[g]	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers[h]	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
			•		

Structure	Subcomponents	Ownership	Other Rights	Action	Other
Hamilton	Intakes	Boott	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
John Street	Intakes	Boott	–	Install concrete plug in penstock opening at canal wall.	–
	Penstocks	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	–
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott	–	Disconnect the generators and switch gear	–
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	–
Bridge Street (Section 8)	Intakes	Boott		Install concrete plug-in penstock opening at canal wall.	Retain a 5' corridor for submarine interconnection cable
	Penstocks	Boott	• Boott Easement to Penstocks and Tailraces	Infill or brace as necessary based on results of an engineering assessment.	Retain a 5' corridor for submarine interconnection cable
	Transformer	Proprietors of Locks & Canals[f]	• Boott Easement to Transformers	Remove transformer from the substation	–
	Turbines	Boott	–	Remain in place	–
	Generators	Boott	–	Disconnect the generators and switch gear	–
	Switchgear	Boott		Disconnect the generators and switch gear	Retain any equipment necessary for interconnection purposes.

Structure	Subcomponents	Ownership	Other Rights	Action	Other
	Tailraces	Proprietors of Locks & Canals	• Boott Easement to Penstocks and Tailraces	Remain in place	Retain a 5' corridor for submarine interconnection cable

[a] Easement to the Pawtucket Canal, Lower Pawtucket Canal, the Swamp Locks Dam and Lower Locks Dam for the uninterrupted flowage of water to the canals, together with the right to install conduits, pipes and wiring, and the right to maintain, repair, and replace canal walls and fences, and to maintain and operate Swamp Locks Dam and Lower Locks Dam. See pg. 4-5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[b] Any and all water rights which may exist regardless of how acquired, including, without limitation, any and all water rights by way of riparian rights. See pg. 4-7 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete description of said rights.

[c] All air rights over the canals, including the canal walls and any dams thereon. The exclusive right to use water in the entire canal system and the Merrimack River for recreational, educational, and navigational purposes. For a complete legal description of these rights, see Order of Taking pg. 27 – 28, filed as Appendix C of the Resources, Ownership, Boundaries, and Land Rights Study Report, filed with the Commission on February 25, 2021.

[d] Exclusive right of operating and controlling the gatehouses and locating, keeping in place, maintaining, replacing, operating, controlling and disposing of the control machinery and equipment, gauge equipment and other mechanisms located therein and for access and repair of the gatehouses and access to and maintenance, repair, and installation of the control machinery and equipment, gauge equipment and such other mechanisms located therein that may need to be repaired, reconstructed, or replaced See pg. 5 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[e] Right to conduct land and canal tours, run interpretive programs and maintenance, improvement and restoration of Gatehouses and support structures, Dams, and Lock Chambers. See pg. 3 of the Grant of Easement (filed as Appendix D to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[f] Presumed ownership, to be confirmed.

[g] Boott holds an easement to operate, maintain, repair, and replace penstocks leading from the Merrimack Canal, Eastern Canal or Hamilton Canal. Boott holds an easement to operate, maintain, repair, and replace tailraces leading to the Pawtucket Canal, the Concord River, or the Merrimack River. See pg. 8 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

[h] An easement to keep in place, locate, operate, maintain, repair, remove and replace the transformers and an easement for unrestricted access thereto for such purposes. See pg. 9 of Great Deed (filed as Appendix B to the February 25, 2021 Resources, Ownership, Boundaries, and Land Rights Study Report) for the complete legal description of said rights.

- Boott proposes to maintain and monitor target water elevations in the canal system in accordance with current practice. Presently, the target water level in the upper canal system is 81.5 ft as read on a staff gage adjacent to the Hamilton Wasteway, which equals 86.7 ft NGVD29.[7] The target water level for the lower canal system is 66.6 ft as read on staff gauges on the Eastern Canal, located at the Section 8 (Bridge Street) powerhouse intake and at the John Street Unit 6 intake, respectively, which equals 71.8 ft NGVD29.
- Boott will continue to operate the gates at the Guard Lock and Gates Facility ("Guard Locks") to manage water levels in the non-project downtown canal system. Boott anticipates that absent the flow demand of the existing mill turbine units, flows normally released to the downtown canal system will largely consist of those necessary to maintain and manage canal water levels. Presently, Boott estimates that a flow of 200 to 300 cfs must be released from the Guard Locks to make up for leakage and other water losses within the 5.5 mile long canal system. Boott will continue to respond to any requests for canal level or flow modifications from the NPS, MA DCR, the City of Lowell and other stakeholders in the downtown Lowell area, on a case-by-case basis.
- Boott understands that removal of the fifteen turbine-generator units and canal system from its license will require a decommissioning plan to define the final disposition of the canal system, turbine-generator units, water conveyance structures, and mechanical and electrical components. A decommissioning plan is also necessary to protect the public from any safety, dam safety, or environmental concerns. Boott will develop a decommissioning plan for each of the four downtown power stations and the canal system. In developing the decommissioning plan, Boott will consult with the NPS, MADCR, City of Lowell, and the Massachusetts Historical Commission (MHC). Boott will file a decommissioning plan for the Commission's approval within 18 months of issuance of a new license.

Fish Passage

- Boott proposes to replace the existing fish lift with a short fish ladder to pass migratory fish from the E.L. Field powerhouse tailrace to the bypass reach, such that all fish would be passed upstream of the Project via the existing fish ladder at the Pawtucket Dam. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed ladder.
- Following installation and operation of the fish ladder at the tailrace, Boott proposes to cease operations of the upstream fish elevator at the tailrace. The timing of cessation of operation of the upstream fish elevator will be determined based on consultation with the MRTC.
- Boott proposes to continue to work with the MRTC to identify any necessary minor modifications to the existing upstream fish ladder located at the Pawtucket Dam, and/or to the existing weirs in the bypass reach to improve passage.

[7] The staff gages in the Lowell canal system refer to Proprietors of Locks & Canals (PL&C) datum, which is 5.2 feet higher than the National Geodetic Vertical Datum of 1929 (NGVD29), i.e., PL&C + 5.2 = NGVD29.

- Boott proposes the installation of new trashracks or other fish exclusion facility at the E.L. Field Powerhouse which will be consistent with current USFWS passage guidelines, to prevent entrainment of fish through the turbines. Downstream passage of fish will continue to be provided via the existing sluice gate in the left forebay wall of the E.L. Field Powerhouse. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed fish exclusion system. Boott reserves the right to seasonally deploy the new trashracks or other exclusion facility only during the downstream fish passage season (mid-May – November), and to use the existing trashracks outside of the fish migration season.
- Boott proposes to develop a Fishways Operation and Management Plan in consultation with the MRTC. The proposed plan would effectively replace the Project's existing Comprehensive Fish Passage Plan.

Historic Properties

- Within one year of license issuance, Boott will develop a Historic Properties Management Plan (HPMP) for the Project that will describe appropriate management measures to avoid, minimize, or mitigate Project-related adverse effects on historic and archaeological resources over the term of the new license issued for the Project. The measures provided in the HPMP will direct the Licensee's management of NRHP-listed or eligible historic properties within the proposed Project boundary. Boott will develop the HPMP in consultation with the NPS, MHC, New Hampshire Division of Historic Resources (NHDHR), and Indian tribes.
- Boott proposes to continue to adhere to existing license Article 33, which requires that prior to the commencement of any construction activities inside the Project boundary, Boott will cooperate with the Massachusetts SHPO and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historical Park.

Recreation

- Within one year of license issuance, Boott will develop a Recreation Access and Facilities Management Plan in consultation with the stakeholders to: a) evaluate opportunities for increasing pedestrian access to the Northern Canal Walkway under certain conditions; b) define flow management practices needed to enhance recreational opportunity in the project vicinity; and c) continue to manage the Project's recreation facility, the E.L. Field Powerhouse Visitor Center.

License Term

- In view of the substantial capital investment in new or improved fish passage facilities that Boott is committing to within this license application, Boott requests that the Commission issue the new license for a term of 50 years. This request is consistent with the Commission's 2017 Policy Statement on Establishing License Terms for Hydroelectric Projects,[8] which recognizes "significant measures expected to be

[8] PL17-3-000, October 19, 2017

required under the new license" when considering extension of a license term beyond the 40-year default period.

Boott notes that certain studies required by the Commission are ongoing (the Three-Dimensional CFD Modeling Study and the Whitewater Boating and Access Study). Boott will consult with stakeholders regarding the results and recommendations of these studies and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7 Environmental Analysis by Resource Area

Pursuant to 18 C.F.R. § 5.18(b), this section discusses the existing Project related resources in more detail and analyzes the effects of the proposed action on these Project area resources. This section incorporates by reference all relevant prior relicensing materials including the resource study reports. The most important and relevant information from the reports and prior documentation are summarized herein as part of the analysis of the effects.

This section is divided into the following major resource areas:

- Geological and Soil Resources
- Water Quantity and Quality
- Fish and Aquatic Resources
- Terrestrial Resources
- Rare, Threatened, and Endangered (RTE) Species
- Recreation and Land Use
- Aesthetic and Socioeconomic Resources, and
- Cultural Resources

Each of the above resource areas is further divided into the following major subsections:

- Affected Environment - This subsection presents information on the affected environment using the information filed in the Licensee's PAD, information developed through the Licensee's FERC-approved study plans, and other information otherwise developed or obtained by the Licensee.

- Environmental Analysis - This subsection describes the beneficial and potential adverse effects of continued operation of the Project as proposed. Where appropriate, this subsection addresses both site-specific and cumulative Project effects, as required by Scoping Document 2 (SD2). The environmental analysis for each resource area is based on information presented in the PAD, the results of studies conducted in support of the license application, professional expertise, and other information obtained by the Licensee. This subsection also describes the Licensee's proposed environmental measures designed to address potential Project effects, and how the Licensee's proposed measures would protect or enhance the existing environment. The measures are listed above and described in greater detail in these subsections, as appropriate.

- Proposed environmental measures - This subsection describes any proposed new environmental measures, including, but not limited to, changes in the project design or operations, to address the environmental effects identified above and its basis for proposing the measures.

- Unavoidable Adverse Effects - This subsection describes any adverse impacts that would occur despite the Licensee's proposed environmental measures.

E.7.1 Geology and Soil Resources

The subsections below describe geology and soil resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on geological and soil resources.

E.7.1.1 Affected Environment

E.7.1.1.1 Geology

Physiography and Topography

The Lowell Project is located in the New England Physiographic Province. This broad physiographic section is characterized as a mountainous area of significant relief. The area is made up of highly deformed Precambrian and Paleozoic metamorphic rocks, including gneiss, schist, slate, quartzite, and marble. The province was glaciated during the Pleistocene and shows both depositional and erosional effects of glacial ice. The Taconic, Green, and White Mountain ranges are distinct features of the New England Physiographic Province. The Taconic Mountains are a north-south trending mountain range along the western edge of the province and are thought to be formed by erosion of an upper block of a large thrust fault. Also, trending north south, the Green Mountains exist primarily in Vermont and are made of Precambrian gneisses. The White Mountains are an exhumed mass of Paleozoic granite and include Mount Washington in New Hampshire, the tallest mountain in the region at 6,288 feet. The province is valued for its mineral resources, both industrial and as building materials. Marble, granite, and slate are all widely distributed and quarried within the province (NPS undated *a*).

The Merrimack River watershed traverses each of the three major sections of the New England Physiographic Province: the White Mountains, New England Uplands, and Seaboard Lowlands (Flanagan et al. 1999 as cited in USACE 2003). The majority of the basin falls within the New England Uplands region, which is characterized by rolling hills and has a local relief ranging from a few hundred feet to 1,000 feet in more mountainous regions. The watershed elevation ranges from a high of 5,249 feet on Mount Lafayette in the White Mountain region to mean sea level along the northeastern Massachusetts coast (USACE 2003).

The Lowell Project is located in the Seaboard Lowlands Section of the New England Physiographic Province. The Seaboard Lowlands Section is lower in elevation and less hilly than the New England Upland Section. The boundary between these two sections is between 400 and 500 feet in elevation in most places. According to Flanagan et al. (1999), topographic relief in the Seaboard Lowlands Section is limited to less than approximately 200 feet in most places. In the vicinity of the Project, the Merrimack River flows through a region of rapid population growth and development that is heavily influenced by the Lowell metropolitan area. The local relief in the Merrimack River Valley in the Project vicinity is generally characterized as low, open hills. A topographic map of the Project and vicinity is presented in Figure E.7-1 through Figure E.7-5.

Figure E.7-1. Lowell Project Topographic Map Showing Proposed Project Boundary

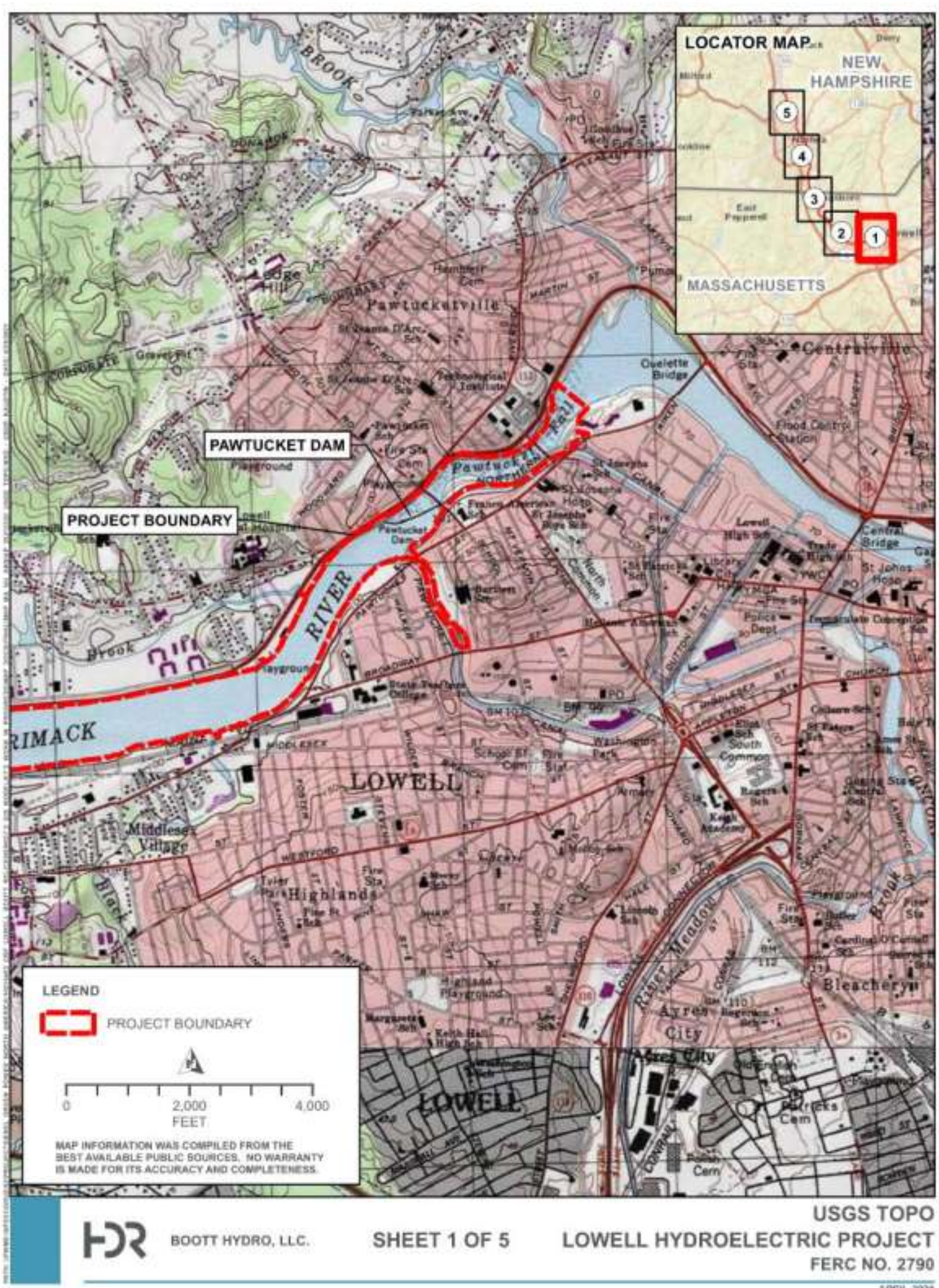


Figure E.7-2. Lowell Project Topographic Map Showing Proposed Project Boundary

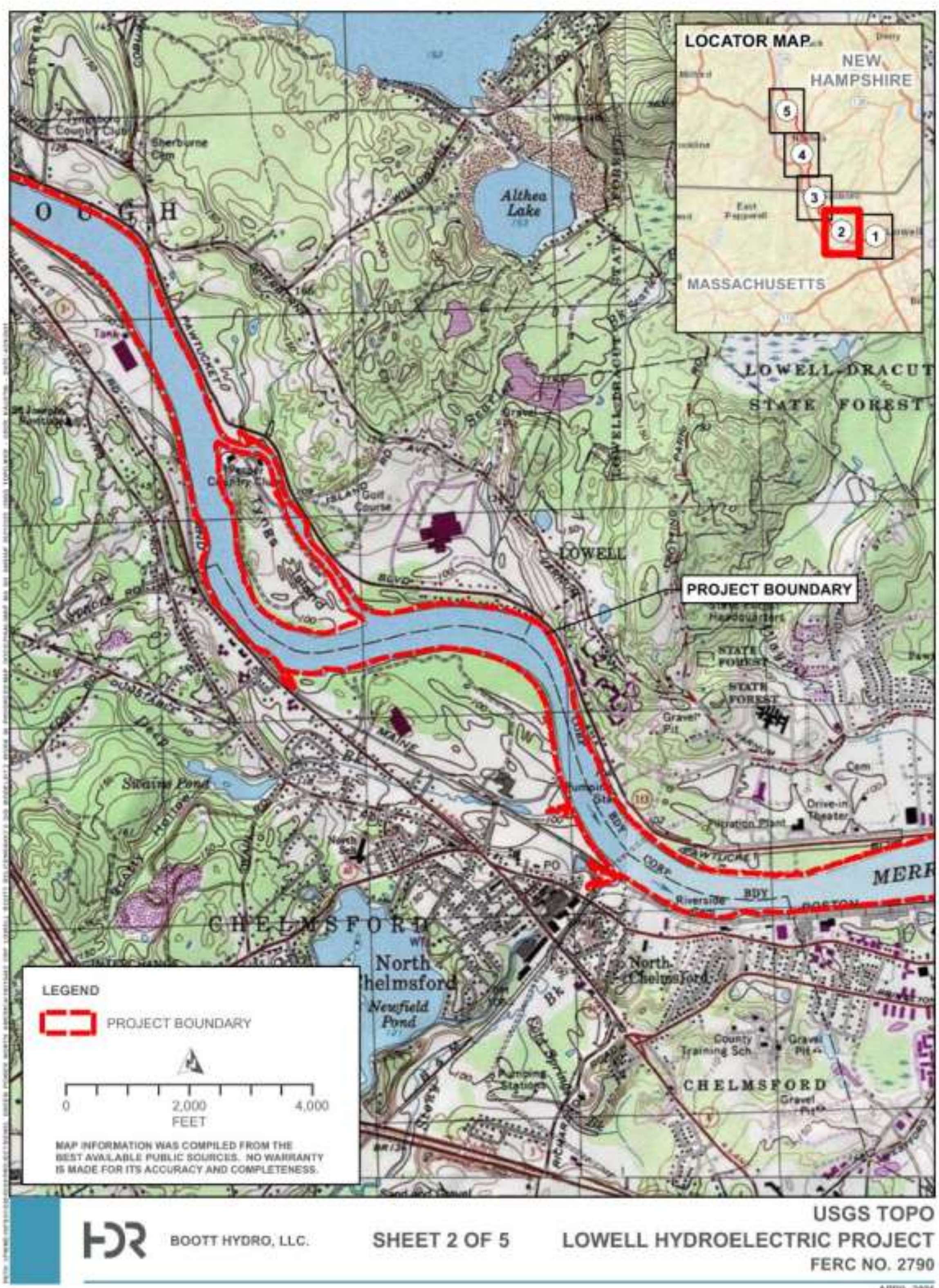


Figure E.7-3. Lowell Project Topographic Map Showing Proposed Project Boundary

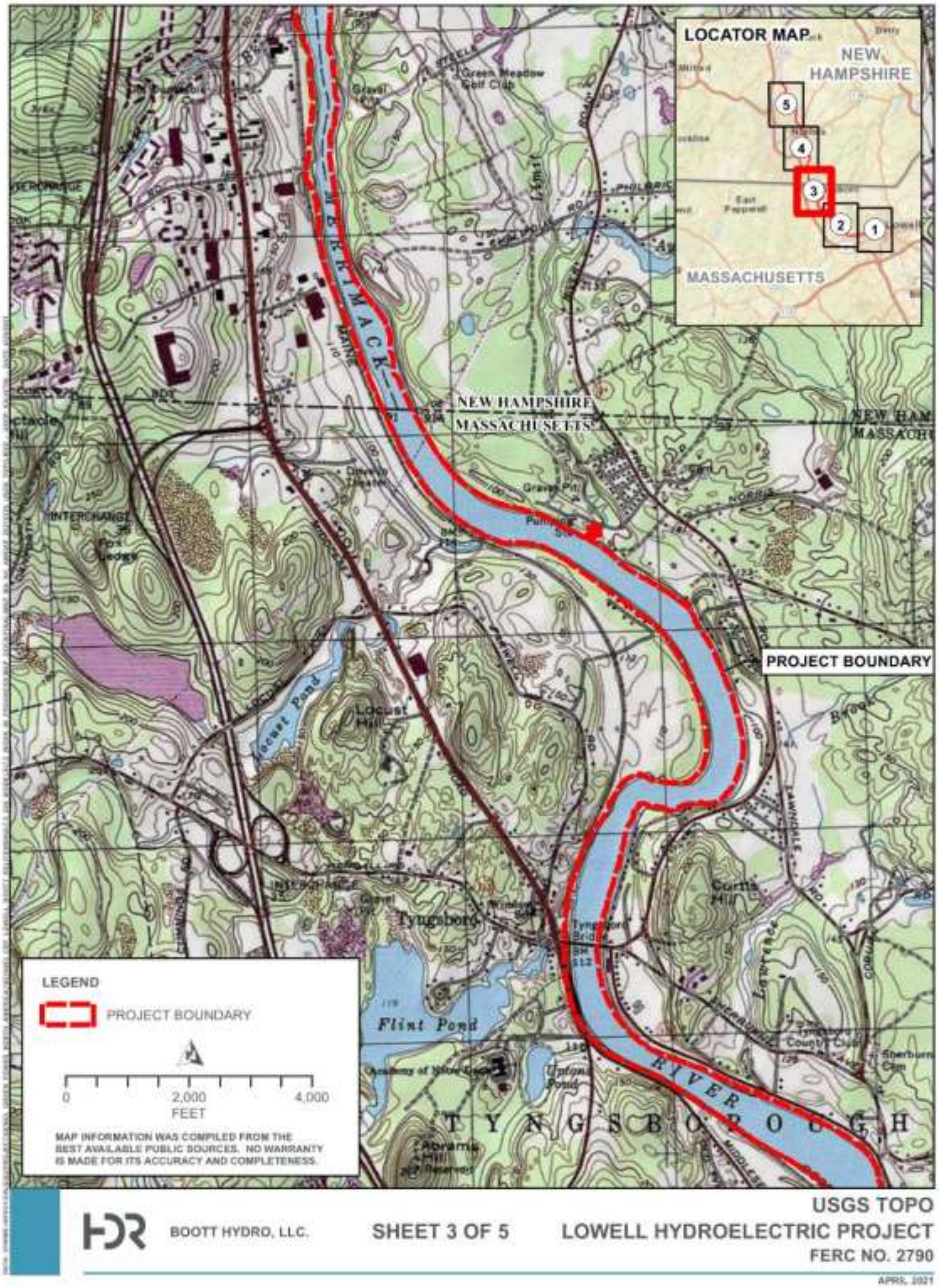


Figure E.7-4. Lowell Project Topographic Map Showing Proposed Project Boundary

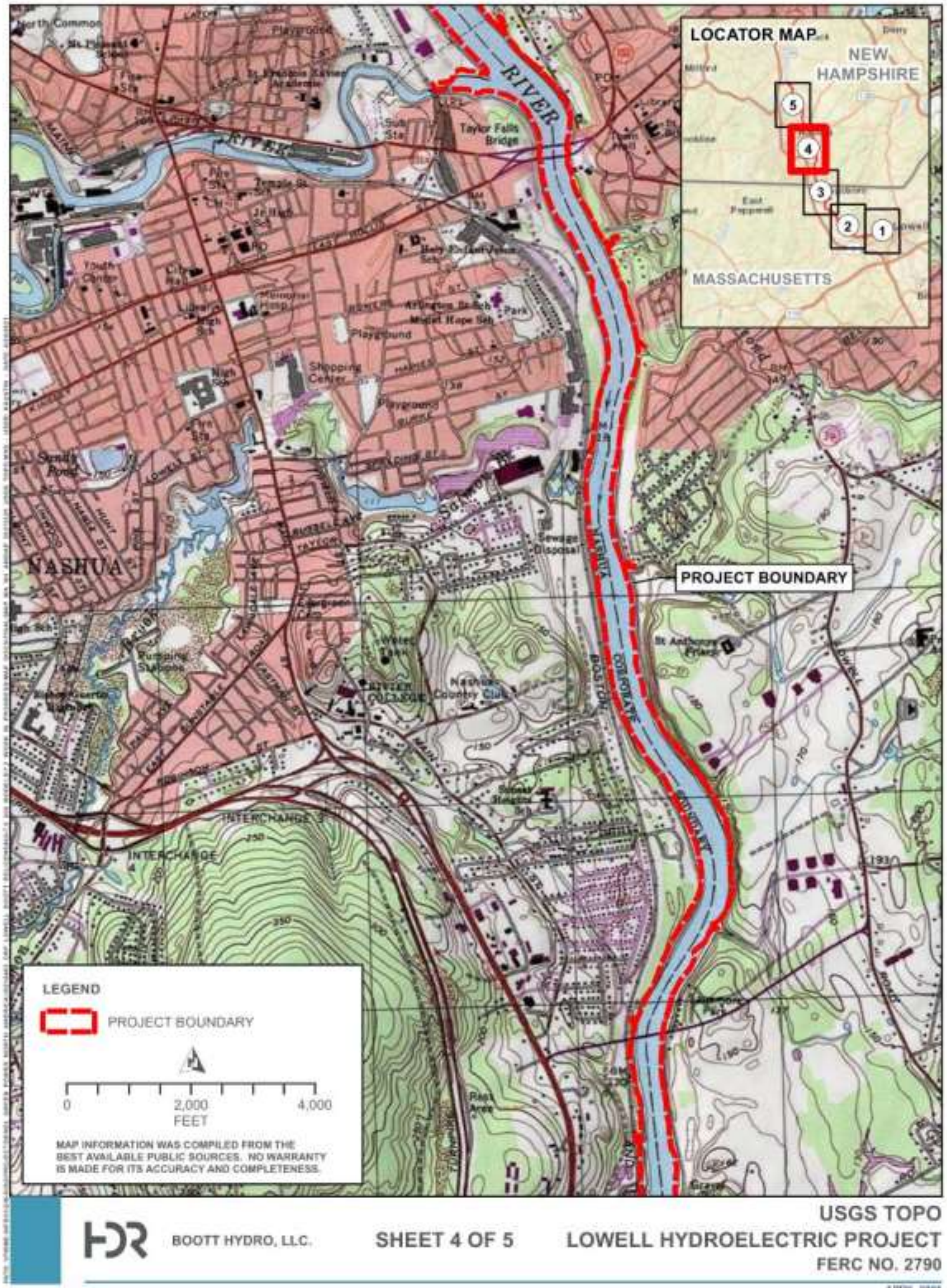
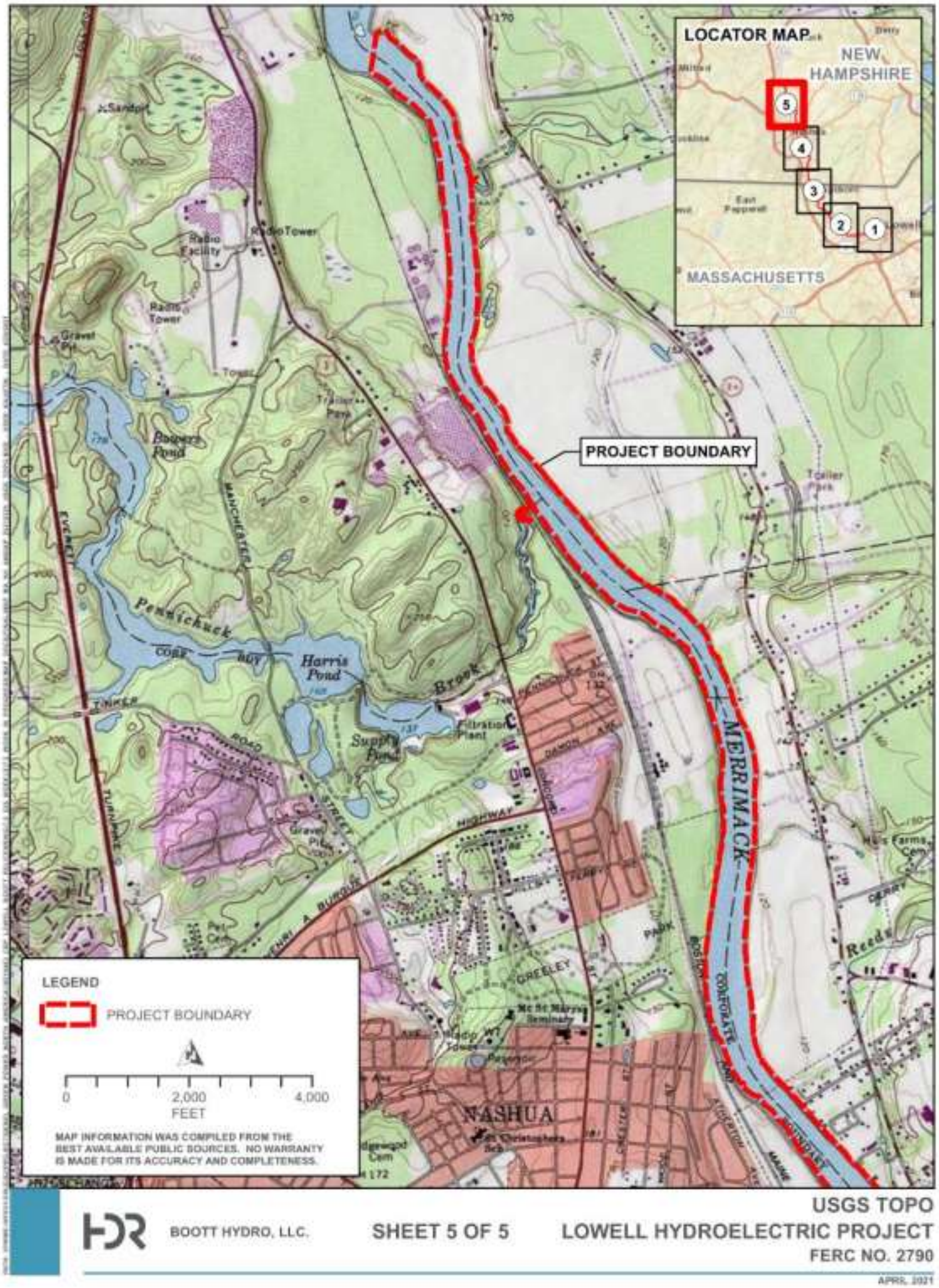


Figure E.7-5. Lowell Project Topographic Map Showing Proposed Project Boundary



Bedrock Geology

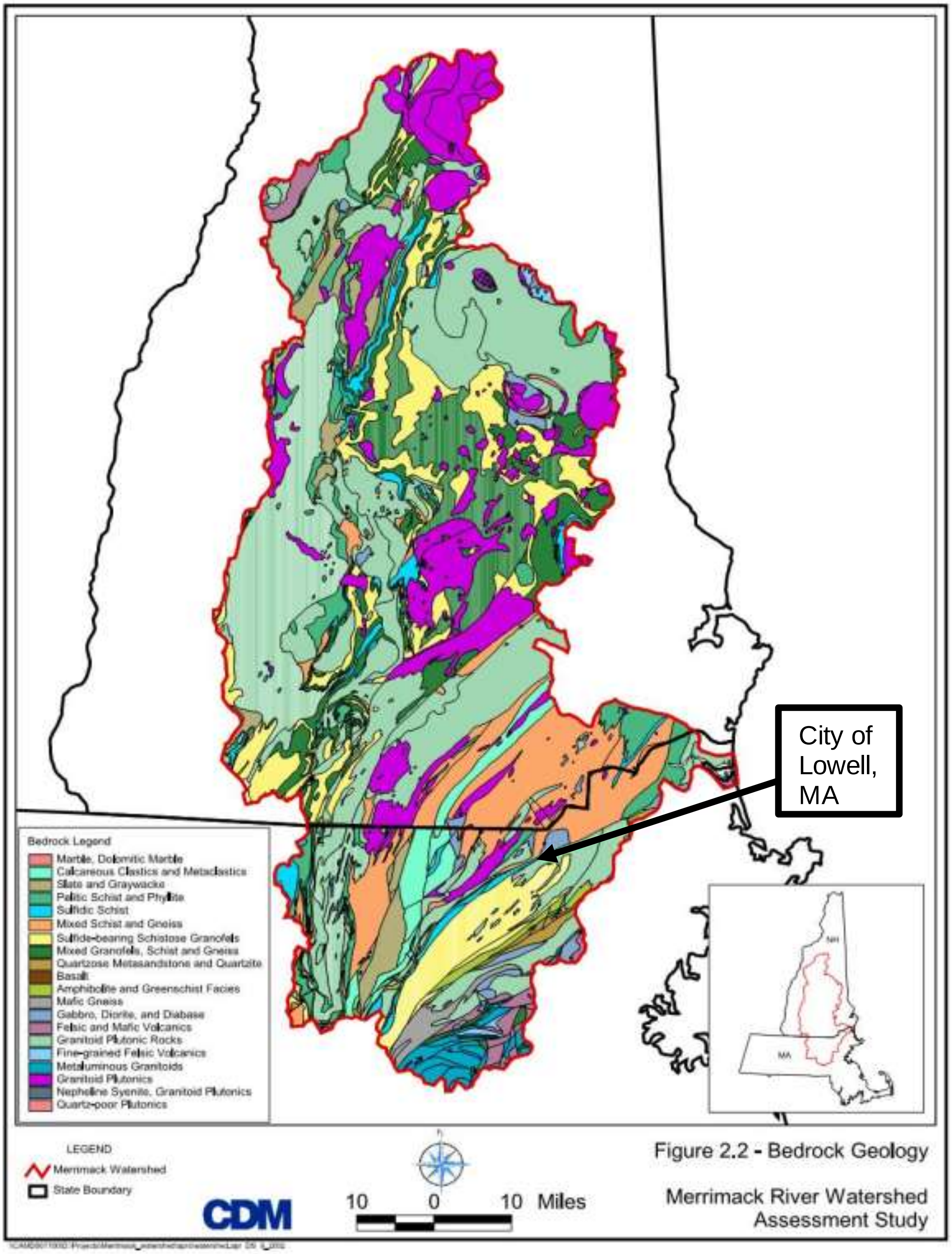
Bedrock in the Merrimack River watershed is generally of similar age and genesis. Intrusive igneous rocks, primarily Granitoid Plutonic rocks, dominate the northeastern portion of the river basin. Large deposits of metamorphic mixed and sulfide-bearing granofels cover the north-central and northwestern portion of the basin. A strip of metamorphic grade rocks, including mixed schist and gneiss deposits, cuts across the Massachusetts-New Hampshire border in a northeasterly direction (USACE 2003). The bedrock is generally layered and complexly deformed. Structures and contacts generally trend northeast to southwest, perpendicular to the direction of collision during the Acadian Orogeny. The mineralogy of the bedrock units is highly varied, from pure quartz in quartzite formations to thin layers of calc-silicate rocks, large bodies of schist with various mineral assemblages (often with high iron and manganese concentrations), and metavolcanics with high base-cation concentrations (Flanagan et al. 1999).

The Merrimack Quartzite is the principal bedrock unit underlying the Project. Although the rock is cut by abundant fractures, it is hard and relatively unweathered. The low-grade metasedimentary rock is of Silurian or Devonian age, approximately 400 million years old. Lithologically, the rock is a fine-grained, impure, bedded quartzite with minor schist. In places, quartzite consists of alternating coarse-grained sandy beds with silty beds (Boott 2015).

The Project is also nearby the mapped contact between the Merrimack Quartzite and the Ayer Granite. The Ayer Granite is a late Paleozoic intrusion. It is a complex igneous rock with an average composition of granodiorite. It is a light- to medium-gray, medium- to coarse-grained rock, commonly porphyritic, gneissic or migmatitic (Boott 2015).

A bedrock geology map of the Merrimack River watershed is presented in Figure E.7-6.

Figure E.7-6. Merrimack River Watershed Bedrock Geology



Source: USACE 2002

Surficial Geology

Glaciation has shaped the landscape of eastern North America during several major glacial periods. As glaciers flowed across the landscape, they scraped and sculpted the land surface. As glaciers retreated from the landscape during deglaciation, they created lakes and altered the course of rivers. Debris scraped off the land surface was carried by the ice and deposited as sand, gravel, and other unconsolidated sediments across the landscape. Some of the sediments were deposited by the ice directly, and the rest were carried by meltwater streams and deposited in the sea or elsewhere on land. Most of the surficial sediments found across New England are a result of glaciation (Flanagan et al. 1999).

The Merrimack River basin is generally covered by a sheet of glacial till, with areas of large fine- and large-grained, glacial-lake deposits along the river mainstem and major tributaries (Flanagan et al. 1999 as cited in USACE 2003). Till, known locally as "hardpan," is composed of boulders, gravel, sand, silt, and clay mixed in various proportions, and is usually compact, stony, and difficult to dig. Lodgement (or basal) till, deposited directly beneath active ice, is generally more compact than ablation till (Flanagan et al. 1999).

According to the USACE (1977), the till cover within the Merrimack River basin is composed of variable, unstratified, silty, gravelly, sand and clays. The cover is generally thin on the hilltops and in the deep valleys, with exposed bedrock typically visible in the hilly upland regions. Large glacial melt-water lakes formed throughout the basin during glacial retreat (USACE 2003).

Mineral Resources

As mentioned above, the New England Physiographic Province is valued for its mineral resources, both industrial and as building materials. Marble, granite, and slate are all widely distributed and quarried within the province (NPS undated *a*). There are no mapped oil, gas, or mineral resources in the Lowell Project boundary. According to the USGS (USGS Undated *a*), there are three active mines in the Project vicinity, including the Westford Quarry located approximately 4.5 miles southwest of Pawtucket Dam, the Chelmsford Quarry located approximately 4.4 miles southwest of Pawtucket Dam, and a Sand and Gravel Operation located approximately 5.4 miles northeast of Pawtucket Dam in Essex County, MA.

E.7.1.1.2 Soils

Soil types in the vicinity of the Lowell Project are variable and reflect the diversity of parent materials, the local topography, and the physiographic position of landforms. The Project vicinity is composed of soil series formed primarily in glacial and glaciofluvial deposits, sandy outwash or eolian deposits, and recent alluvium. According to USACE (2003), soil types occurring in the vicinity of the Project include silt loam, unweathered bedrock, loamy sand, and areas mapped as mucky peat. Additionally, a large portion of the soils mapped in the Project vicinity are classified as Udorthents. There are many types of Udorthent soils, but in general they include areas of human altered soil and non-soil areas that are mapped based on their surface texture, type of alteration, depth to water table, and geologic setting. Some human-altered map units include sand, gravel, till, quarry pits, areas of excavated (cut and fill) geologic material, and areas used for the disposal of refuse.

Mapped soils in the vicinity of the Project are presented in Figure E.7-7 through Figure E.7-8. A 100-foot buffer has been applied to the Project boundary to develop this figure. Map unit delineation on a soil map represents an area that is dominated by one or more major kinds of soil or miscellaneous area. Each map unit is identified, and names are in accordance with the taxonomic classification of the dominant soils. The U.S. Department of Agriculture's (USDA) Official Soil Series Descriptions for mapped soil series Figure E.7-7 through Figure E.7-8 are presented in Appendix A of this FLA (USDA undated).

E.7.1.1.3 Impoundment Shoreline and Stream Banks

The shoreline surrounding the Merrimack River within the Project area typically consists of low-to-moderate slopes dominated by urban, commercial, industrial, and residential development. Some areas along the shoreline within the Project vicinity consist of agricultural areas and some areas consist of forest canopy vegetation underlain by established shrub and herbaceous layers. Large boulders, cobbles, or exposed bedrock are uncommon along the shoreline of the Merrimack River within the Project area. A portion of the shoreline is bordered by walking trails which are used by the public, and the majority of the southern shoreline is bordered by a railroad.

A summary description of the streambanks for the Merrimack River within the Project area in the vicinity of the Project is provided below based on the results of the Recreation and Aesthetics Study performed by Boott in 2020 (HDR 2021a).

A wide variety of vegetation types, occurrences, and distribution, ranging from herbaceous, non-woody plants to forested areas of trees and underbrush, and shoreline/canal types, ranging from earthen embankments to placed, uniformly sized blocks were observed during the study. Mapped vegetation was greatest in the Pawtucket Canal, followed by the Eastern Canal, Western Canal, and Northern Canal. Common vegetation species observed along the canals and within the Project area along the Merrimack River include tree of heaven (*Ailanthus altissima*), American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), red maple (*A. rubrum*), Siberian elm (*Ulmus pumila*), various goldenrod (*Solidago*) species, and some weedy and invasive species including purple loosestrife (*Lythrum salicaria*), poison ivy (*Toxicodendron radicans*), Boston ivy (*Parthenocissus tricuspidata*), mullein (*Verbascum thapsus*), and common ragweed (*Ambrosia artemisiifolia*).

There is no evidence of erosion, slumping, or slope instability around the shoreline of the Project.

E.7.1.1.4 Seismicity

The northeast United States lies within the relatively tectonically stable and geologically old North American plate, where a great deal of the tectonic action took place over 200 million years ago when the Atlantic basin began to form due to the separation of Africa from North America. However, based on instrumental seismic records, earth scientists believe that the tectonic activity in the northeast is still ongoing (Ebel 1987).

The Project is located in Seismic Zone 2 and is subject to earthquakes of moderate intensity. The Clinton-Newbury fault zone forms an important regional crustal plate boundary and is located roughly 1.5 miles southeast of the Project area. No recent largescale earth movements are known along the Clinton-Newbury fault and it is considered inactive (Boott 2015).

Regarding historic seismicity, the USGS National Earthquake Information Center Database was searched regarding earthquakes within the Project region from 1970 to present day. The most significant (largest and closest) events were indicated by the USGS to be a magnitude (M) of 3.7 on October 2, 1994, 54 miles from the Project, and a M of 3.1 on January 10, 1999, 22.3 miles from the Project (USGS undated *b*).

E.7.1.2 Environmental Analysis

No potential issues related to geological or soil resources were identified during the scoping process. There are currently no adverse Project effects on geology or soils, and Boott is not proposing major operational changes to the Project. Continued operation of the Project is not expected to have a material adverse effect on geologic resources, soils, or the geomorphology of the Project impoundment.

E.7.1.2.1 Effects of Decommissioning

As described in Section E.6.2 of this exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Removal of these facilities and decommissioning the powerhouses is not expected to have any adverse effects on geology and soils.

E.7.1.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain PM&E consistent with the measures required by the Project's existing license.

Decommissioning the downtown powerhouses may require minor ground disturbance in areas primarily characterized by urban fill. Boott has proposed to develop a plan for decommissioning the powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

E.7.1.4 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those effects that may still occur after implementation of PM&E measures. Continued Project operations as proposed by the Licensee are not expected to have any unavoidable adverse impacts on geological or soils resources.

Figure E.7-7. Lowell Project Soils Map Showing Proposed Project Boundary

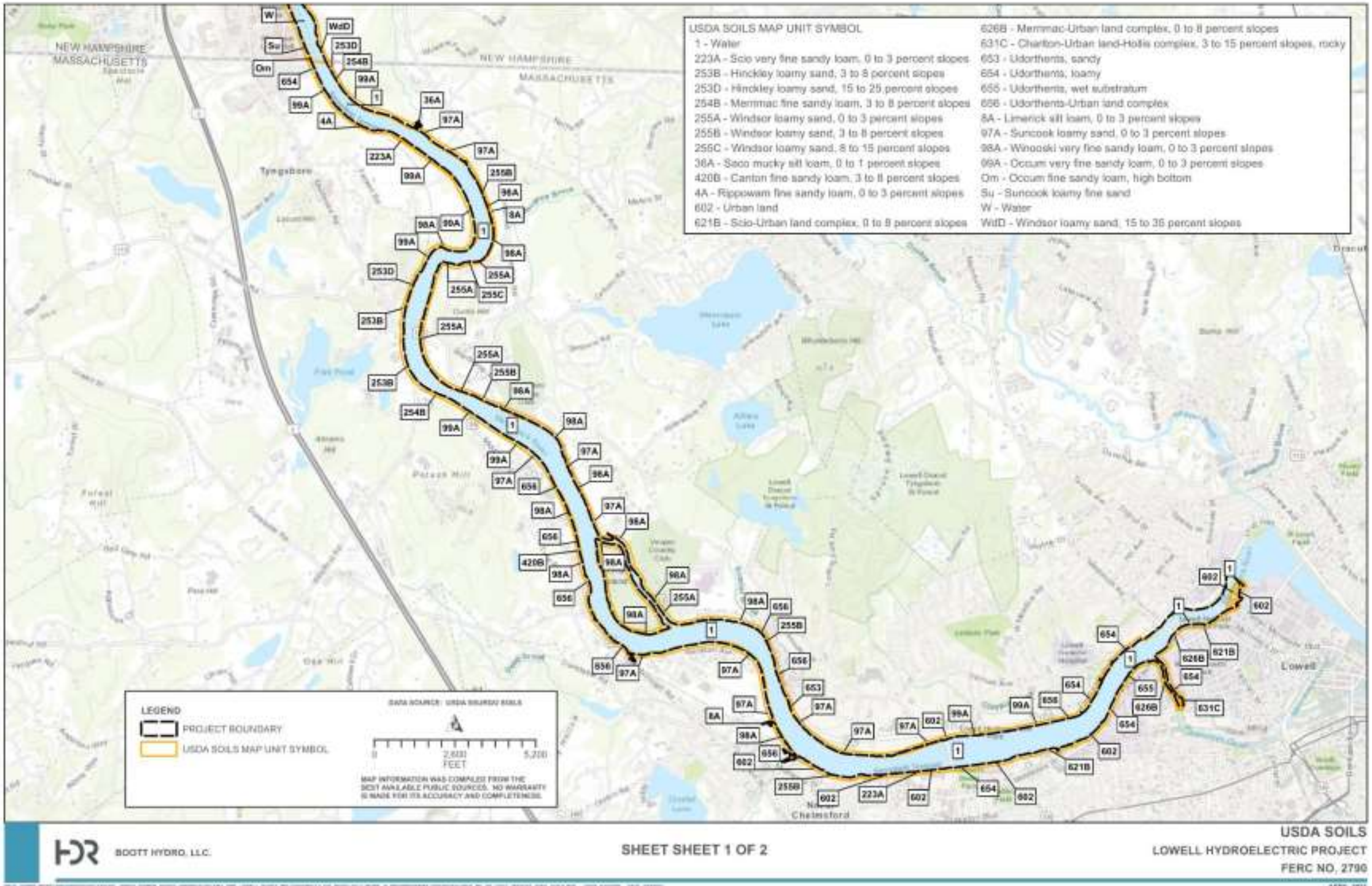
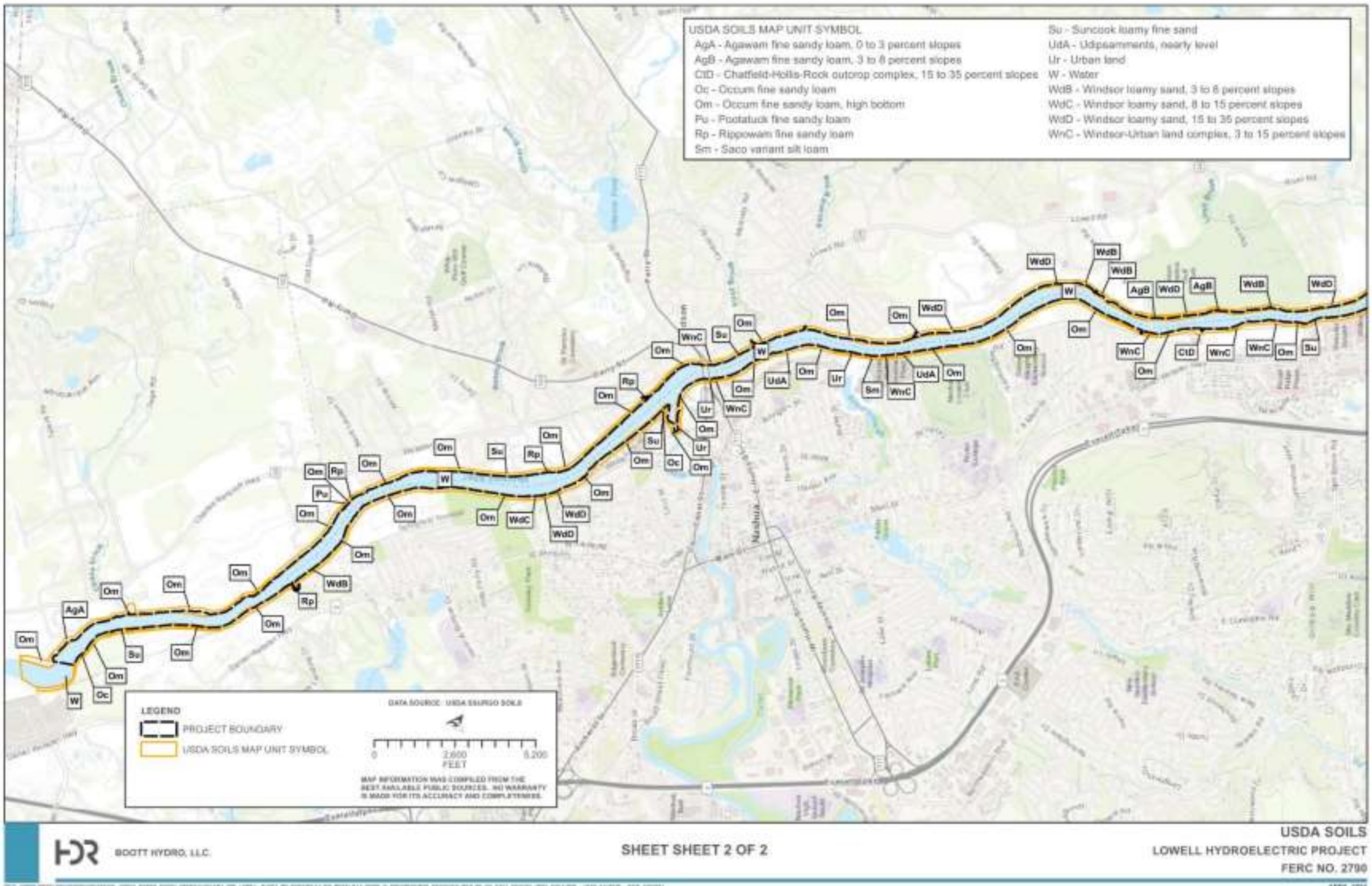


Figure E.7-8. Lowell Project Soils Map Showing Proposed Project Boundary



E.7.2 Water Quantity and Quality

The subsections below describe water resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on water quantity and quality. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD and water resources data collected from:

- Downstream American Eel Passage Assessment (Normandeau Associates, Inc [NAI] 2021a)
- Fish Assemblage Study (NAI 2021d)

These reports are included in Appendix B of this exhibit.

E.7.2.1 Affected Environment

E.7.2.1.1 Water Quantity

The Merrimack River watershed has a total drainage area of approximately 5,010 square miles within the states of New Hampshire and Massachusetts (Massachusetts Executive Office of Energy and Environmental Affairs [MEOEEA] 2002). The Lowell Project is located at river mile (RM) 41 on the Merrimack River in Massachusetts with an existing impoundment extending upstream approximately 16miles to Cromwell's Falls in Merrimack and Litchfield, New Hampshire.[9] The drainage area of the Project is approximately 3,979 square miles.

E.7.2.1.2 Project Hydrology

The Project operates in a run of river (ROR) mode, and therefore, experiences seasonal and annual variations in flows based on natural hydrologic conditions in the Merrimack River Watershed. Table E.7-1 provides Project hydrologic data from 1987-2016.

Table E.7-1. Lowell Project Hydrologic Data (1987-2016)

Month	Minimum (cfs)	90% Exceedance (cfs)	Average (cfs)	10% Exceedance (cfs)	Maximum (cfs)
January	916	3,462	7,651	12,834	39,710
February	1,478	3,272	6,813	11,415	39,180
March	1,914	4,508	11,484	21,355	50,220
April	2,765	6,558	17,901	31,178	78,890

[9] The preparation of Exhibit G boundary maps provided Boott the opportunity to make corrections and modifications consistent with the Project's operations. Boott is proposing to remove about 7.4 miles from the upper limit of the current Project boundary, making the proposed Project impoundment about 16 miles in length. This removal more accurately follows the 92.2 NGVD 29 contour of the Project impoundment. See Exhibit G.

Month	Minimum (cfs)	90% Exceedance (cfs)	Average (cfs)	10% Exceedance (cfs)	Maximum (cfs)
May	2,034	4,112	10,749	18,657	88,410
June	874	2,279	6,768	13,286	44,660
July	670	1,325	4,207	9,270	29,820
August	569	1,121	3,526	6,852	30,030
September	460	1,008	3,162	6,025	32,264
October	787	1,676	5,938	12,706	50,150
November	1,345	2,888	7,978	14,747	30,990
December	1,839	3,472	9,141	17,243	34,810
Annual	460	1,723	7,941	17,059	88,410

Note: Project hydrology determined by subtracting flows from USGS Gage No. 01099500 (*Concord River Below Meadow Brook, at Lowell, MA*) from USGS Gage No. 01100000 (*Merrimack River Below Concord River at Lowell, MA*).

Existing Instream Flow Uses

Existing instream flow uses of the Merrimack River include hydropower generation and industrial uses with recreation (e.g., fishing and boating). There are five FERC-regulated hydroelectric projects on the Merrimack River, and another two located on the main stem Pemigewasset River. The Project is located approximately 11 miles upstream of the Lawrence Hydroelectric Project (FERC No. 2800) and approximately 30 miles downstream of the Amoskeag Dam (one of the three developments of the Merrimack River Project, FERC No. 1893) in New Hampshire. There are also four U.S. Army Corps of Engineers (USACE) flood storage dams within the Merrimack River basin.

Existing and Proposed Uses of Project Waters

In Massachusetts, the Massachusetts Department of Environmental Protection (MADEP) regulates the quantity of water withdrawn from both surface and groundwater supplies to ensure adequate water supplies for current and future water needs pursuant the Massachusetts Water Management Act (MADEP 2018a). Available registrations and permits were reviewed. Two regulated water withdrawals were identified in Lowell. These withdrawal users were identified as Lowell Water Treatment Facility (Permit #9P231316003) and Western Avenue Dyers (Permit #9P131316001). Based on the 2016-2019 Annual Water Quality Reports by the Lowell Regional Water Utility (LRWU), the utility withdrew 3.9 to 4.2 billion gallons of water from the Merrimack River annually to provide drinking water for Lowell and the surrounding communities (LRWU 2016, 2017, 2018, 2019).

In New Hampshire, Pennichuck Water Works supplies water for the City of Nashua and 10 surrounding New Hampshire municipalities located in southern New Hampshire, using both surface water and groundwater sources. The Nashua Core water system derives its water supply from the Pennichuck Brook and the Merrimack River watersheds (Pennichuck Water Works 2018). The city of Manchester currently does not utilize the Merrimack River as a drinking water source, but it is anticipated to by year 2022 (Manchester Water Works 2019).

In New Hampshire, the New Hampshire Department of Environmental Services (NHDES) regulates large groundwater withdrawals under the state's Groundwater Protection Act to ensure that no adverse impacts to water users or natural resources occur as a result of withdrawals (NHDES 2018). The only two groundwater withdrawal permits within the Project vicinity were issued to the Merrimack Village District Water Works in New Hampshire (Permittee Number LGWP-2017-0001) for 432,000 gallons per day and to Manchester Water Works (Permittee Number LGWP-2020-0001) for 7.2 million gallons per day. However, neither permit holder has started withdrawing from the permitted source (NHDES 2020).

The U.S. Environmental Protection Agency (USEPA) is the permitting authority in Massachusetts and New Hampshire for issuing National Pollutant Discharge Elimination System (NPDES) permits, which are required whenever a municipality, industry, or other entity wishes to discharge pollutants to a surface water of the United States. In Massachusetts, NPDES permits are typically co-issued by the USEPA and MADEP (MADEP 2018b). Available NPDES permits were reviewed for the Project vicinity in Massachusetts (Commonwealth of Massachusetts 2020a, USEPA 2018). The only permit located within the Project area was issued to the City of Lowell for Combined Sewer Overflow (CSO) outfalls at 9 locations, 7 of which are discharged into the main stem of the Merrimack River, and one of these outfalls is located just upstream of the Pawtucket Dam. The other two outfalls discharge in Beaver Brook and the Concord River, which are both tributaries to the Merrimack River just downstream from the Pawtucket Dam (USEPA 2019a).

Three NPDES permits were identified within the Project vicinity in New Hampshire, which were issued for wastewater treatment facilities and combined sewer overflows to the city of Manchester (Permit Number NH0100447), the town of Merrimack (Permit Number NH0100161) and the city of Nashua (Permit Number NH0100170) (USEPA 2020a). Another permit was issued to Nylon Corporation of America in Manchester for two separate outfalls (USEPA 2019b).

The Lowell Project has four NPDES permits issued under the Massachusetts General Permit no. MAG360000. These are: Permit No. MAG360024 for the Eldred L. Field Powerhouse; No. MAG360026 for the Hamilton powerhouse; No. MAG360025 for the John St. powerhouse; and No. MAG360027 for the Section 8 powerhouse.

E.7.2.1.3 Water Quality

Massachusetts Water Quality Standards

Water quality standards for the Commonwealth are contained in the Code of Massachusetts Regulations (CMR) at 314 CMR 4.00: Massachusetts Surface Water Quality Standards (SWQS). Inland surface waters of the Commonwealth are classified by appropriate use Class (A, B, or C) as defined in 314 CMR 4.05. Qualifiers applied to these classifications indicate special considerations and uses applicable to a waterbody segment that may affect the application of criteria or antidegradation provisions. The classification of surface water in Massachusetts is provided in 314 CMR 4.06.

The MADEP's Division of Water Pollution Control has classified waters within the Project vicinity as Class B with specific qualifiers (Table E.7-2). As defined in 314 CMR 4.05(3)(b), Class B waters are designated as:

> *[A] habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth, and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06, Class B waters shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.*

A summary of the standards applicable to Class B waters with the Warm Water qualifier is provided in Table E.7-3.

Table E.7-2. Water Quality Classification Applicable to the Lowell Project in Massachusetts

Boundary	Mile Points	Class	Qualifiers
State line to Pawtucket Dam	49.8 – 40.6	B	Warm Water[1] Treated Water Supply[2] CSO[3]
Pawtucket Dam to Essex Dam, Lawrence	40.6 – 29.0	B	Warm Water[1] Treated Water Supply[2] CSO[3]

Source: 314 CMR 4.06.
[1] In these waters, dissolved oxygen and temperature criteria for warm water fisheries apply.
[2] Denotes those Class B waters that are used as a source of public water supply after appropriate treatment. These waters may be subject to more stringent site-specific criteria established by the Department as appropriate to protect and maintain the use. See, also, 310 CMR 22.00.
[3] These waters are identified as impacted by the discharge of combined sewer overflows (CSO); however, a long-term control plan has not been approved or fully implemented for CSO discharges.

Table E.7-3. Water Quality Standards for Class B Waters with the Warm Water Qualifier in Massachusetts

Parameter	Class B Warm Water Standards
Dissolved Oxygen (DO)	Shall not be less than 5.0 milligrams per liter (mg/L) in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

Parameter	Class B Warm Water Standards
Temperature	Shall not exceed 83 degrees Fahrenheit (°F) (28.3 degrees Celsius [°C]) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month). Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions, or growth of aquatic organisms.
pH	Shall be in the range of 6.5 through 8.3 standard units and not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.
Color and Turbidity	These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class.

Source: 314 CMR 4.05.

New Hampshire Water Quality Standards

Water quality standards in New Hampshire are contained in New Hampshire's Revised Statutes Annotated (RSA) 485A:8, Standards for Classification of Surface Waters of the State, and in Env-Wq 1700, the Surface Water Quality Standards. RSA 485A:8 establishes that all New Hampshire surface waters must be classified as either Class A or Class B waters and establishes certain minimum surface water quality criteria for each classification (NHDES 2019b). The Merrimack River is designated as a Class B in New Hampshire, which pursuant to RSA 485A:8 shall be considered acceptable for fishing, swimming, and other recreational purposes and, after adequate treatment, for use as water supplies. A summary of the applicable standards to Class B is provided in Table E.7-4.

Table E.7-4. Water Quality Standards for Class B Waters in New Hampshire

Parameter	Class B Warm Water Standards
DO	Except as naturally occurs, waters shall have a DO concentration of at least 75% of saturation based on a daily average and an instantaneous minimum DO concentration of at least 5 mg/L.
Temperature	Any stream temperature increase associated with the discharge of treated sewage, waste or cooling water, water diversions, or releases shall not be such as to appreciably interfere with the uses assigned to this class.
pH	Shall be 6.5 to 8.0 unless due to natural causes.
Turbidity	Shall not exceed naturally occurring conditions by more than 10 Nephelometric Turbidity Units (NTUs).

Parameter	Class B Warm Water Standards
Color	Shall contain no color in such concentrations that would impair any existing or designated uses, unless naturally occurring.

E.7.2.1.4 Existing Water Quality Data

Water quality data have been collected throughout the Project area including: (1) in the Project's impoundment and bypassed reach in support of recent relicensing activities, (2) at a USGS gage just downstream from the Pawtucket Dam, (3) at three NHDES monitoring sites in the Project impoundment, and (4) at numerous sites from RM 29.6 to 55.9 by a volunteer monitoring program established by the Merrimack River Watershed Council.

Relicensing Study Data

In support of relicensing the Project, water quality data were collected in the Project's impoundment and bypassed reach during the Fish Assemblage Study (NAI 2021d) in the spring, summer, and fall of 2019. Water temperature, dissolved oxygen, conductivity, and pH data were collected at 12 locations throughout the impoundment and at three locations[10] throughout the bypassed reach. Turbidity data was also collected at the impoundment site locations, which trended towards shallower at the upper end of the reach upstream of the Pawtucket Dam in areas classified as pool and run, and deeper at the lower end in areas classified as impoundment. Sampling in the impoundment was conducted at a depth of approximately one meter. Sampling in the Project's bypass reach was conducted during low flows. All data collected in the impoundment and bypassed reach met state water quality standards.

In the impoundment, the average water temperature was 21.5°C (20.6-22.1°C) during the spring sampling, 25.6°C (25.2-26.0°C) during the summer sampling, and 10.8°C (10.3-11.5°C) during the fall sampling (Table E.7-5). The average dissolved oxygen concentration was 8.7 mg/L (8.4-9.0 mg/L) during the spring sampling, 8.4 mg/L (8.1-8.8 mg/L) during the summer sampling, and 10.6 mg/L (9.8-11.1 mg/L) during the fall sampling. Conductivity averaged 114 microsiemens per centimeter (µs/cm) (97-139 µs/cm) during the spring sampling, 181 µs/cm (166-199 µs/cm) during the summer sampling, and 117 µs/cm (91-152 µs/cm) during the fall sampling. The pH ranged from 6.5-7.5 units and turbidity ranged from 0.8-3.7 NTUs.

In the bypassed reach, data were only obtained at one location in the spring where the water temperature averaged 22.9°C, dissolved oxygen concentration was 9.5 mg/L, conductivity was 148 µS/cm, and the pH was 6.5 units (Table E.7-5). The average water temperature was 23.8°C (23.4-24.1°C) in the summer and 13.1°C (13.0-13.2°C) in the fall. The average dissolved oxygen concentration was 9.4 mg/L (9.1-9.6 mg/L) in the summer and 9.8 mg/L (8.9-10.6 mg/L) in the fall. Conductivity averaged 194 µS/cm (191-197 µS/cm) in the summer and 100 µS/cm (95-104 µS/cm) in the fall. The pH ranged

[10] Water quality data were only obtained from one location in the spring.

from 6.3-8.1 units, with the average river pH in the bypassed reach being higher during the summer (7.8 units) than was observed during the spring (6.5) or fall (6.6.).

Continuous water temperature data was also collected at the Project's intake canal from October 9, 2019 until November 31, 2019 during the Downstream American Eel Passage Assessment (NAI 2021a). Water temperatures ranged from 2°C to 16°C and were below the state of Massachusetts's maximum temperature criterion.

USGS Gage Data

The USGS periodically collected water quality data approximately 1.6 RM downstream from the Project powerhouse at gage 01100000 (Merrimack River BL Concord River at Lowell, MA) between 1953 and 2004 (USGS 2018), Figure E.7-9. The most recent data are presented in figures below, which consists of water temperature, DO, pH, and specific conductance data collected between 1998-2004 (Figure E.7-10 through Figure E.7-14). Data were collected at numerous times during the summer, often when temperatures are the highest and DO concentrations are the lowest, except in 1998. Water temperatures were seasonal and were below the state of Massachusetts's maximum temperature criterion. DO concentrations were well above the state minimum criterion of 5.0 mg/L and were near saturation, except on one occasion in August 1999. The pH met state standards, except on a single sampling event in December 2003 when it was 6.3 units. Specific conductance ranged from 83 to 328 µS/cm (USGS 2018).

Merrimack River Watershed Council Data

A volunteer monitoring program established by the Merrimack River Watershed Council (MRWC) collected water quality data at 41 monitoring stations located along the mainstem of the Merrimack River in 2009 (MRWC 2010). Results were grouped into one of the five river segments identified during the study. Results from three sections, including from the Essex Dam to the Pawtucket Dam in Lowell (Section 3), from the Pawtucket Dam to the Massachusetts/New Hampshire state border (Section 4), and from the state border to Greeley Park in Nashua (Section 5), are presented in Table E.7-6 through Table E.7-8. Nine sites were sampled in Section 3, eight sites were sampled in Section 4, and seven sites were sampled in Section 5. Monitoring occurred periodically between May and October in 2009, which included sampling during the summer months. Water temperatures ranged from 8.1 to 25.7°C and were below the maximum temperature criterion in Massachusetts of 28.3°C. DO concentrations ranged from 7.2 mg/L to 12.1 mg/L and were well above the Massachusetts and New Hampshire minimum state criterion of 5.0 mg/L. The pH was frequently below the acceptable minimum Massachusetts and New Hampshire criterion of 6.5 units and ranged from 3.3 to 6.8 units. However, according to the MRWC (2010) these data could be erroneous and could not be confirmed by the USEPA. Specific conductance ranged from 99 to 211 µS/cm.

The study also conducted continuous water quality monitoring over two weeks in 2009 off of the Lowell Motor Boat Club dock located on the right descending bank immediately upstream of the Pawtucket and Northern Canals in the Project's impoundment. Water temperature, dissolved oxygen, conductivity, and pH were recorded in 10-minute intervals from September 22 to October 5 at a depth of one meter. According to the

Project's Low Impact Hydropower Institute (LIHI) certification, results indicate that data met state quantitative water quality standards for parameters with numeric limits except episodic low pH readings (LIHI 2018).

NHDES Data

A search was conducted using the USEPA's STORET database for water quality data within the Project vicinity in Massachusetts and New Hampshire. Water temperature, DO, pH, and specific conductance data were available for the following three sites in New Hampshire, which were sampled by the NHDES (Figure E.7-9):

1. Bridge Connecting RTE 3 & 3A (Station ID 11113300-02-MER)
2. RTE 111 BRIDGE, EAST HOLLIS ST (Station ID 11113300-03-MER)
3. RR BRIDGE D.S. OF MANCHESTER WWTF (Station ID 11113300-08-MER)

Data collected over the past 20 years (1998-2015) are presented in Figure E.7-10 through Figure E.7-14. Water temperatures ranged up to 28°C. DO concentrations ranged from 6.6 to 10.8 mg/L, which were well above the minimum criterion in New Hampshire of 5.0 mg/L, and waters were 82.1 to 121.0 percent saturated. The pH ranged from 5.7 to 7.5 units and levels were frequently below the minimum criterion of 6.5 units. Specific conductance ranged from 64 to 180 µS/cm.

Merrimack River Watershed Assessment Study

DO concentrations were also monitored during the Merrimack River Watershed Assessment Study, which was a joint effort between federal, state, and local communities to develop a comprehensive watershed management plan for the Merrimack River (USACE 2018). During the study, water quality sampling was conducted along the mainstem of the Merrimack River from Concord, New Hampshire, to its estuary in Newburyport, Massachusetts. From 2003 to 2005, three dry-weather surveys and four wet-weather surveys were conducted. Additionally, a continuous survey of DO and temperature was conducted at two locations for a one-month period during low-flow conditions in August and September 2003. These data were not available, but the study summary indicated DO along the mainstem of the Merrimack River from Manchester, New Hampshire, to the Atlantic Ocean were well above the minimum criterion of 5 mg/L.

Figure E.7-9. USGS and STORET Water Quality Sample Locations and Proposed Project Boundary

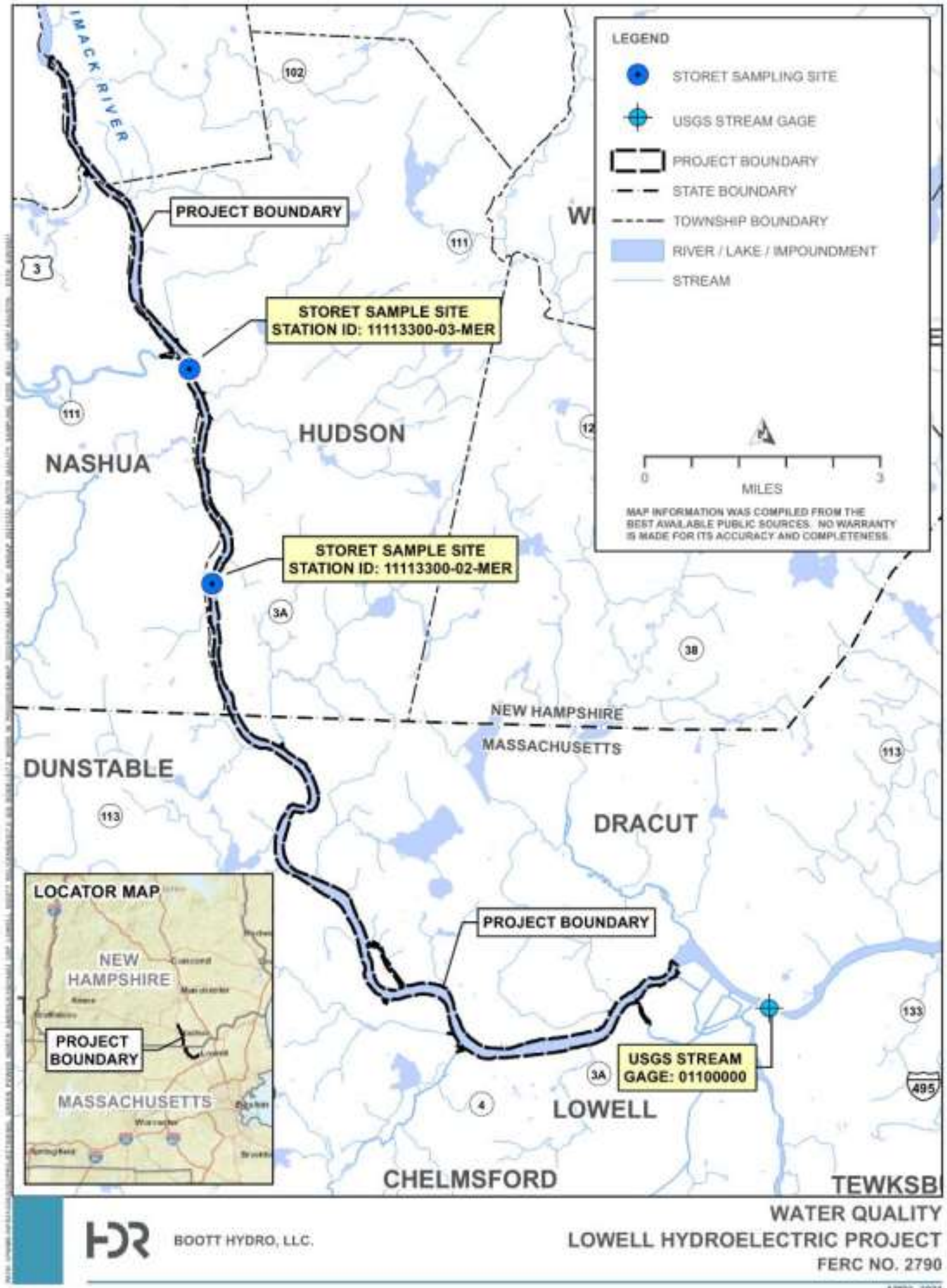


Table E.7-5. Summary of Water Quality Data Obtained in the Project's Impoundment and Bypassed Reach by NAI in 2019.

Location	Season	Water Temperature (°C)			Dissolved Oxygen (mg/L)			Conductivity (µS/cm)			pH (units)			Turbidity (NTU)		
		Average (Avg)	Minimum (Min)	Maximum (Max)	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Impoundment	Spring	21.5	20.6	22.1	8.7	8.4	9.0	114.0	97.0	139.0	-	6.5	7.4	2.6	1.6	3.7
	Summer	25.6	25.2	26.0	8.4	8.1	8.8	181.0	166.0	199.0	-	6.7	7.5	1.8	1.5	1.9
	Fall	10.8	10.3	11.5	10.6	9.8	11.1	117.0	91.0	152.0	-	6.5	7.4	1.6	0.8	2.2
Bypassed Reach	Spring	-	22.9	22.9	-	9.5	9.5	-	148.0	148.0	-	6.5	6.5	-	-	-
	Summer	23.8	23.4	24.1	9.4	9.1	9.6	194.3	191.0	197.0	-	7.4	8.1	-	-	-
	Fall	13.1	13.0	13.2	9.8	8.9	10.6	100.3	95.0	104.0	-	6.3	6.8	-	-	-

Figure E.7-10. Water Temperature Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

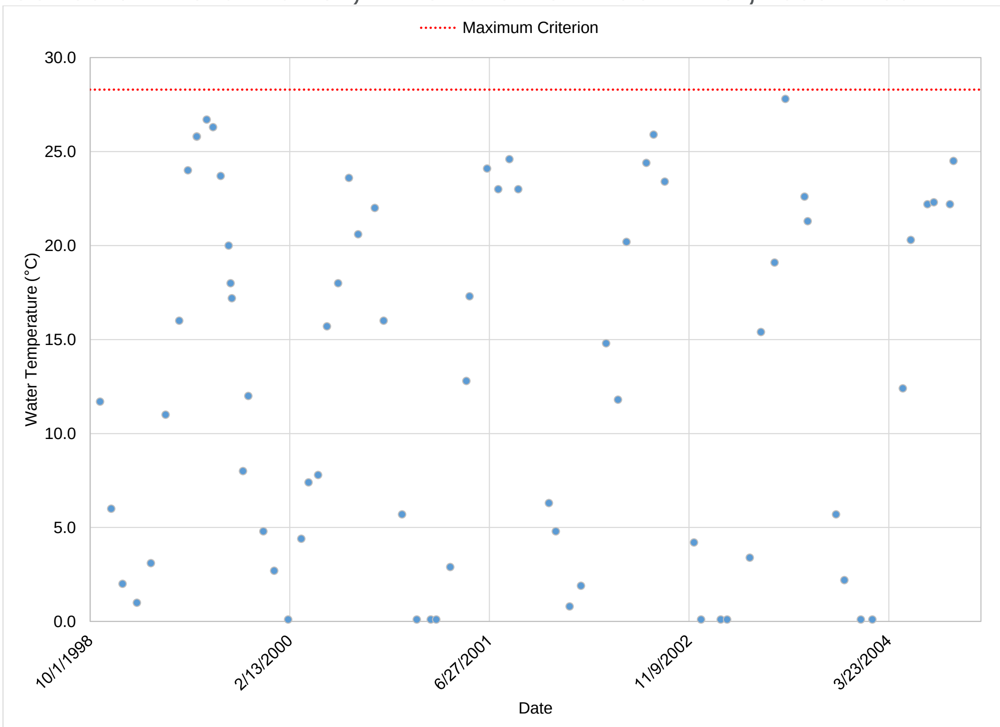


Figure E.7-11. Dissolved Oxygen Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

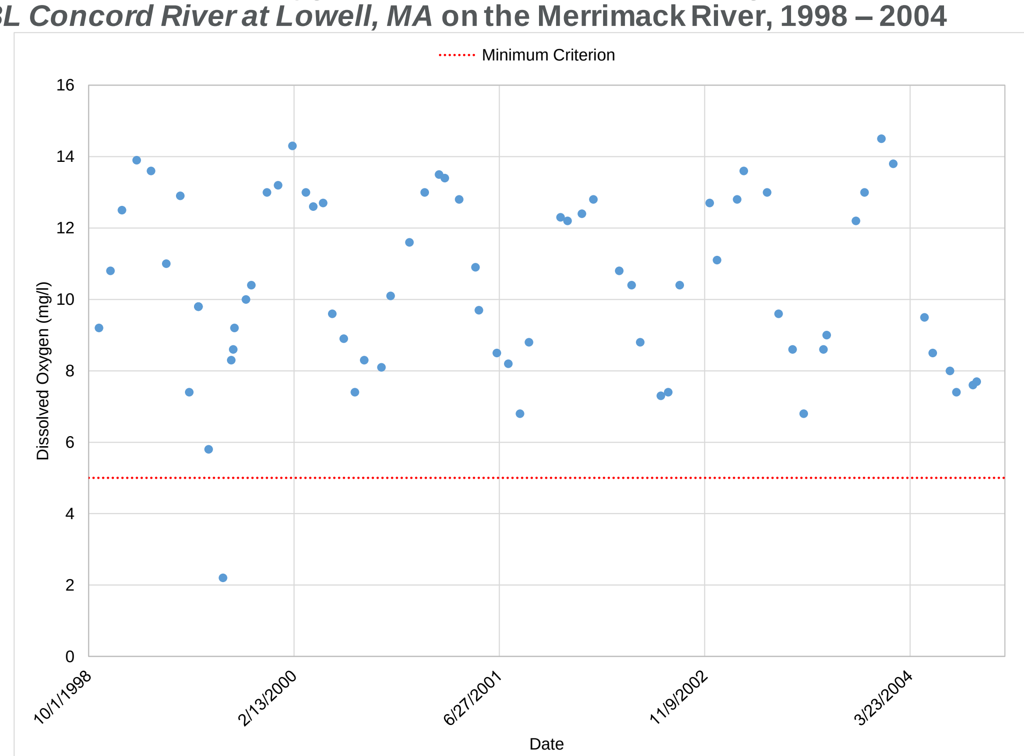


Figure E.7-12. Dissolved Oxygen Percent Saturation Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

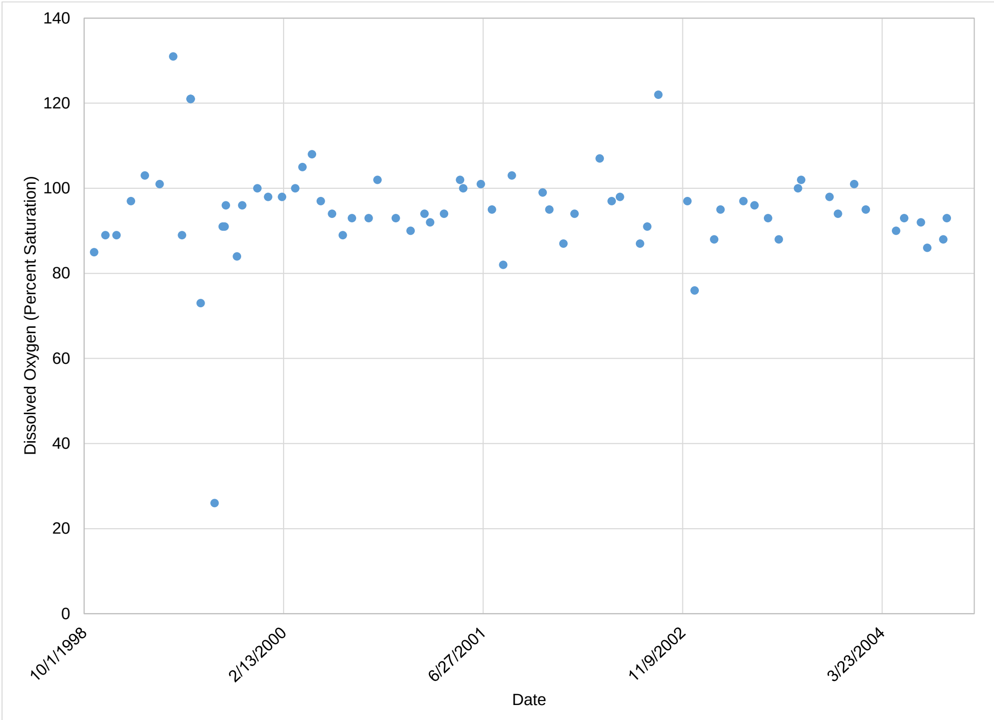


Figure E.7-13. pH Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

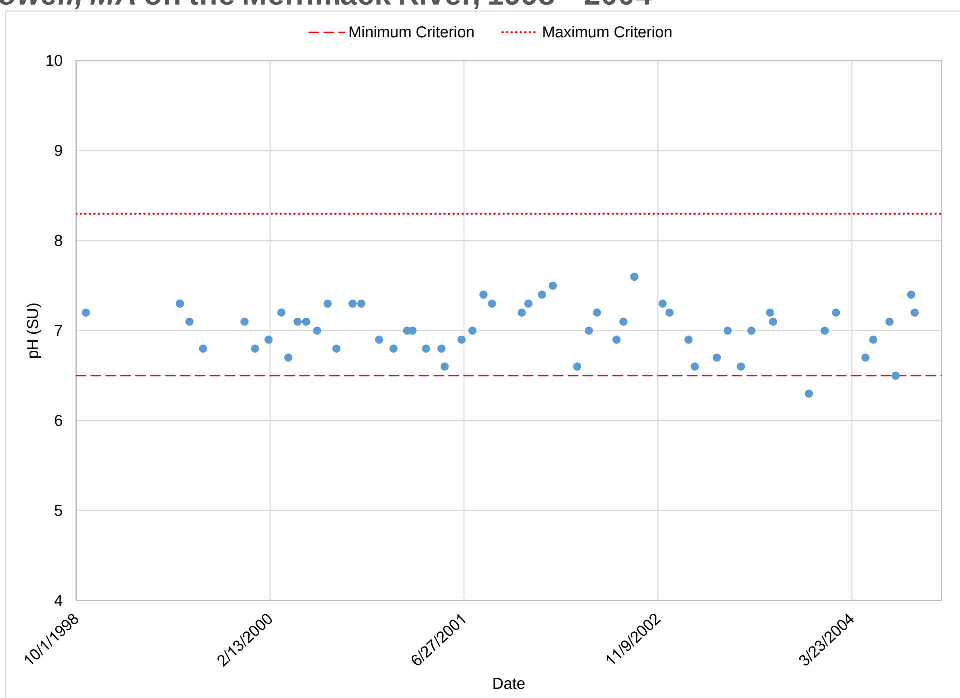


Figure E.7-14. Specific Conductance Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004

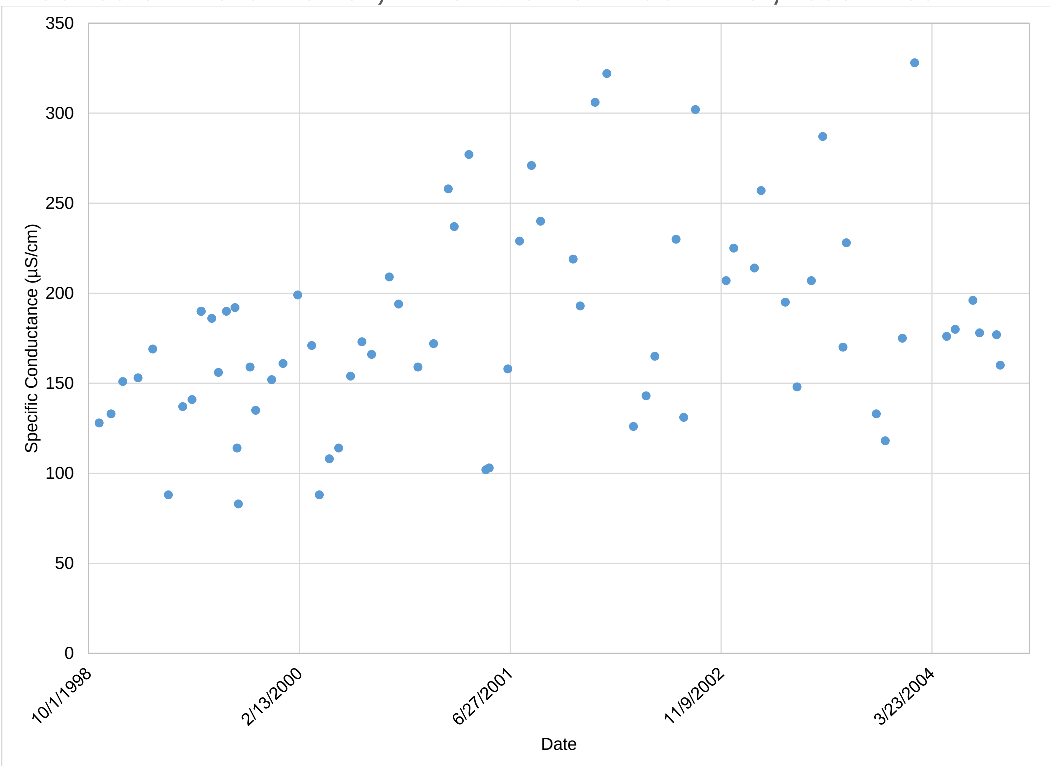


Table E.7-6. Water quality data collected by a volunteer monitoring program established by the MRWC at 9 sites along the Merrimack River from Essex Dam to the Pawtucket Dam in Lowell, 2009

River Mile	Description	Water Temperature (°C)						DO (mg/L)						pH (SU)						Specific Conductance (µS/cm)					
		14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug
29.6	Above Essex Dam	15.6	16.6	19.2	22.5	23.3	23.4	11.1	10.5	8.5	7.9	9.9	8.0	6.5	4.8	6.6	6.3	4.2	-	117	169	189	178	109	160
31.4	Methuen Water Intake	15.4	16.6	19.4	22.3	23.3	23.2	11.2	8.5	8.5	7.6	10.0	7.8	6.4	6.0	6.7	6.4	5.6	-	119	159	190	169	106	147
32.2	Bartlett Brook	15.4	16.5	19.3	22.4	23.3	23.1	11.6	8.2	8.5	7.6	10.0	7.8	6.4	6.1	6.6	6.4	4.6	-	118	157	194	169	103	144
33.4	Fish Brook	15.6	16.5	19.2	22.4	23.2	23.2	12.1	7.8	8.3	7.5	10.0	7.7	6.5	4.1	6.6	6.4	5.5	-	124	161	195	187	119	170
35.1	Gravel Pit	15.6	16.7	19.1	22.4	23.1	23	11.7	7.7	8.1	7.5	10.1	8.0	6.5	4.6	6.5	6.4	6.0	-	122	152	176	155	104	142
36.3	Trull Brook	15.4	16.9	19.2	22.5	23.0	23.2	11.6	7.8	8.7	7.9	10.2	7.9	6.4	4.3	6.7	6.4	6.0	-	111	170	211	177	99	166
37.9	Duck Island	15.4	16.8	19.2	22.4	-	23.1	11.7	7.6	8.6	7.7	-	7.9	6.2	5.8	6.6	6.3	-	6.5	106	135	176	151	-	133
38.9	Concord River	-	-	-	-	-	23.3	-	-	-	-	-	7.2	-	-	-	-	-	6.6	-	-	-	-	-	196
40.0	Oulette Bridge	-	-	-	-	-	23.2	-	-	-	-	-	7.7	-	-	-	-	-	6.5	-	-	-	-	-	122
	Minimum	15.4	16.5	19.1	22.3	23	23	11.1	7.6	8.1	7.5	9.9	7.2	6.2	4.1	6.5	6.3	4.2	6.5	106	135	176	151	99	122
	Maximum	15.6	16.9	19.4	22.5	23.3	23.4	12.1	10.5	8.7	7.9	10.2	8.0	6.5	6.1	6.7	6.4	6.0	6.6	124	170	211	187	119	196

Note: dash (-) indicates no data collected.

Table E.7-7. Water quality data collected by a volunteer monitoring program established by the MRWC at 8 sites along the Merrimack River from Pawtucket Dam to the Massachusetts/New Hampshire border, 2009

River Mile	Description	Water Temperature (°C)								DO (mg/L)								pH (SU)								Specific Conductance (µS/cm)							
		12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct
41.1	Pawtucket Dam	15.7	19.9	18.3	21.3	22.3	25.7	20.8	8.4	9.6	9.4	8.8	8.8	8.4	7.9	8.0	-	6.1	6.4	6.0	6.0	6.6	3.3	6.3	6.0	108	143	102	119	121	130	132	128
42.4	Rourke Bridge	15.6	19.8	-	21.4	22.3	-	20.5	8.1	9.4	8.4	-	8.8	8.4	-	8.0	-	6.2	6.4	-	6.1	6.7	-	6.3	5.9	104	145	-	118	120	-	132	121
43.4	Stony Brook	15.6	19.7	-	21.4	22.4	-	20.4	8.1	9.4	8.2	-	8.8	8.5	-	8.0	-	6.2	6.4	-	6.1	6.7	-	6.3	5.8	103	143	-	114	118	-	129	118
44.6	Vesper Country Club	15.5	19.7	-	21.4	22.4	-	20.2	8.2	9.3	8.0	-	8.8	8.3	-	8.0	-	6.2	6.5	-	6.2	6.6	-	6.3	5.9	103	141	-	114	119	-	127	120
46.4	Lawrence Brook	15.4	19.7	-	21.2	22.4	-	20.4	8.3	9.3	7.8	-	8.8	8.4	-	8.2	-	6.2	6.4	-	6.2	6.7	-	6.4	6.0	102	145	-	113	116	-	135	138
47.3	Tyngsborough (Rte. 113) bridge	15.3	19.6	-	21.2	22.4	-	20.5	8.3	9.3	7.8	-	8.8	8.3	-	8.2	11.9	6.2	6.4	-	6.2	6.7	-	6.4	5.9	100	144	-	113	116	-	133	131
48.9	Limit Brook	15.3	19.3	-	21.1	22.5	-	20.5	8.3	9.3	7.7	-	8.7	8.5	-	8.3	11.6	6.2	6.4	-	6.1	6.7	-	6.3	5.9	102	144	-	112	111	-	128	123
49.6	MA/NH border	15.3	19.2	18.2	21.1	22.4	-	20.4	8.3	9.4	7.7	9.8	8.8	8.3	-	8.0	11.6	6.3	6.4	6.0	6.0	6.8	-	6.3	5.9	99	142	99	114	114	-	129	129
	Minimum	15.3	19.2	18.2	21.1	22.3	25.7	20.2	8.1	9.3	7.7	8.8	8.7	8.3	7.9	8.0	11.6	6.1	6.4	6.0	6.0	6.6	3.3	6.3	5.8	99	141	99	112	111	130	127	118
	Maximum	15.7	19.9	18.3	21.4	22.5	25.7	20.8	8.4	9.6	9.4	9.8	8.8	8.5	7.9	8.3	11.9	6.3	6.5	6.0	6.2	6.8	3.3	6.4	6.0	108	145	102	119	121	130	135	138

Note: dash (-) indicates no data collected.

Table E.7-8. Water quality data collected by a volunteer monitoring program established by the MRWC at 7 sites along the Merrimack River from Massachusetts/New Hampshire border to Greeley Park in Nashua, 2009

River Mile	Description	Water temperature (°C)					DO (mg/L)					pH (SU)					Specific conductance (µS/cm)				
		12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct
49.9	Pheasant Lane Mall	-	21.0	22.4	20.3	8.3	-	8.3	8.4	8.0	11.3	-	6.3	6.7	6.4	5.9	-	117	121	132	127
50.9	Spit Brook	15.5	21.1	22.4	20.3	8.3	9.3	8.4	8.3	8.2	11.3	6.3	6.3	6.8	6.4	5.9	103	128	116	133	126
51.8	Unnamed stream	-	20.9	-	-	-	-	8.7	-	-	-	-	6.0	-	-	-	-	97	-	-	-
52.5	Nashua Country Club	-	20.9	-	-	-	-	8.6	-	-	-	-	6.3	-	-	-	-	139	-	-	-
53.1	Nashua WWTP	-	20.9	-	-	-	-	8.6	-	-	-	-	6.5	-	-	-	-	199	-	-	-
54.4	Nashua River	-	20.8	-	-	-	-	8.6	-	-	-	-	6.2	-	-	-	-	164	-	-	-
55.9	Greeley Park	-	21.2	-	-	-	-	8.9	-	-	-	-	6.2	-	-	-	-	96	-	-	-
	Minimum	15.5	20.8	22.4	20.3	8.3	9.3	8.3	8.3	8.0	11.3	6.3	6.0	6.7	6.4	5.9	103	96	116	132	126
	Maximum	15.5	21.2	22.4	20.3	8.3	9.3	8.9	8.4	8.2	11.3	6.3	6.5	6.8	6.4	5.9	103	199	121	133	127

Note: dash (-) indicates no data collected.

Figure E.7-15. Water Temperature STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

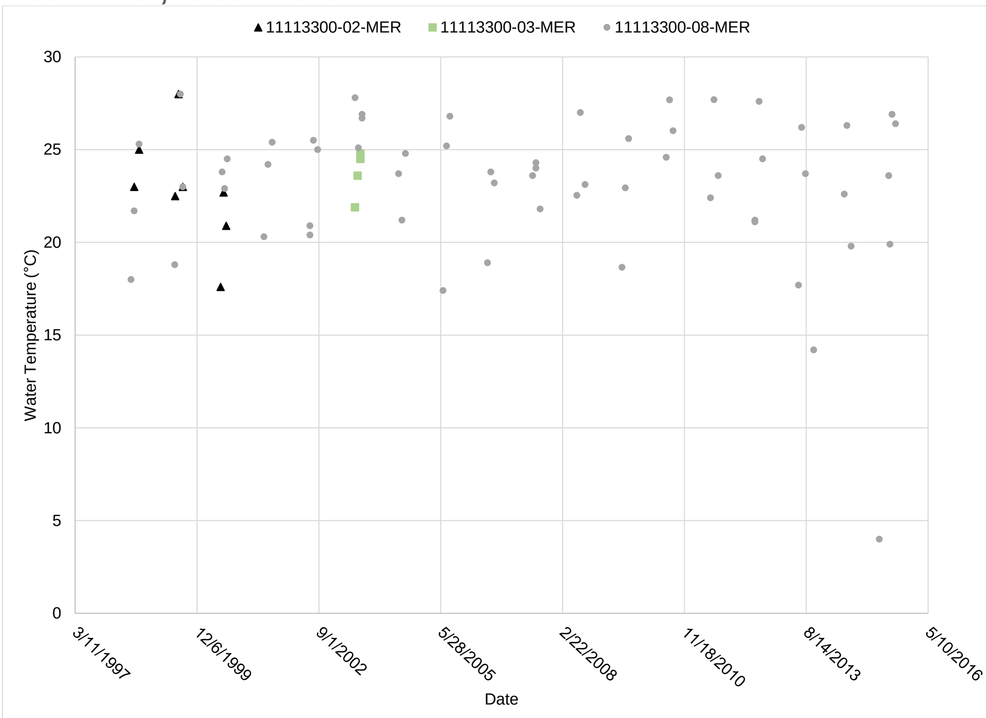


Figure E.7-16. Dissolved Oxygen STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

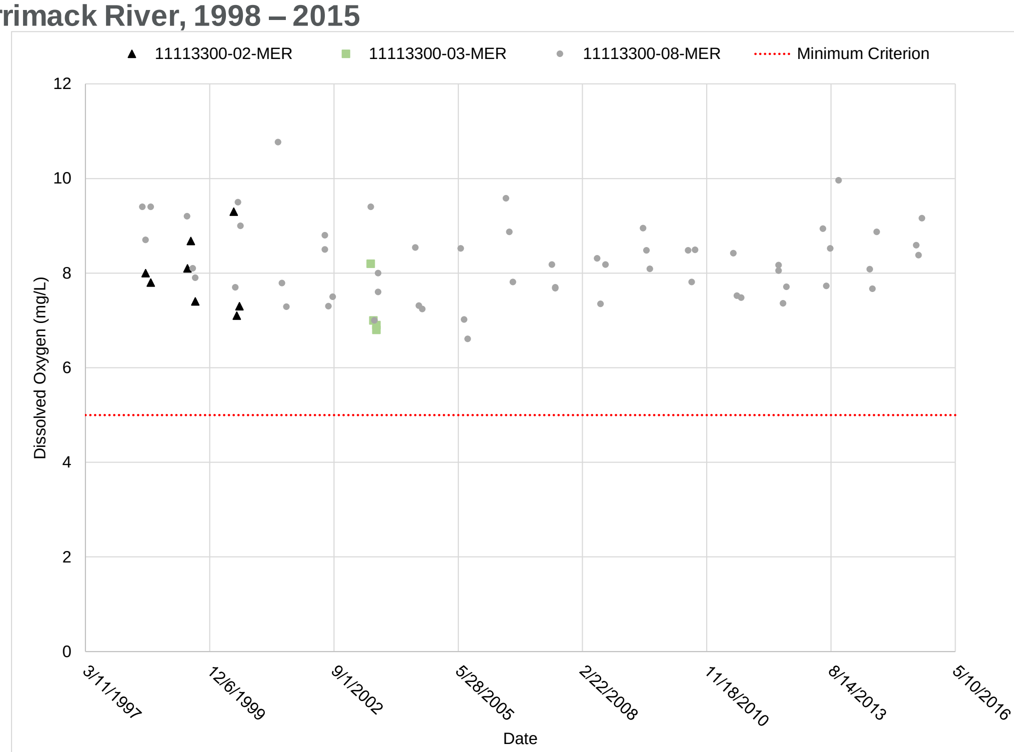


Figure E.7-17. Dissolved Oxygen Percent Saturation STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

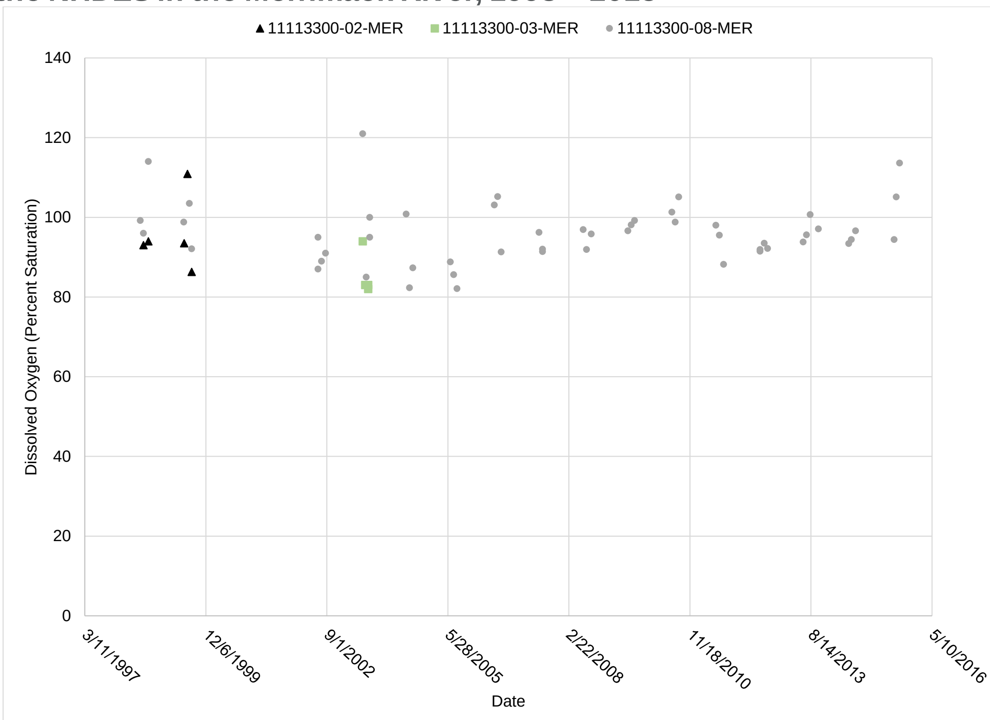


Figure E.7-18. pH STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015

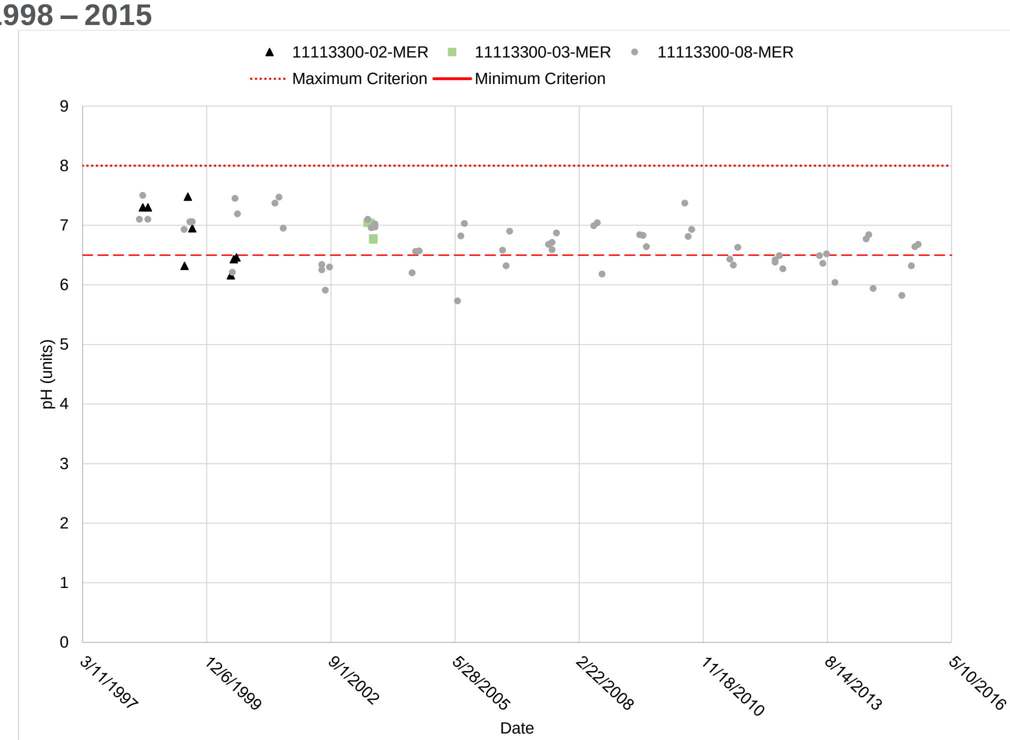
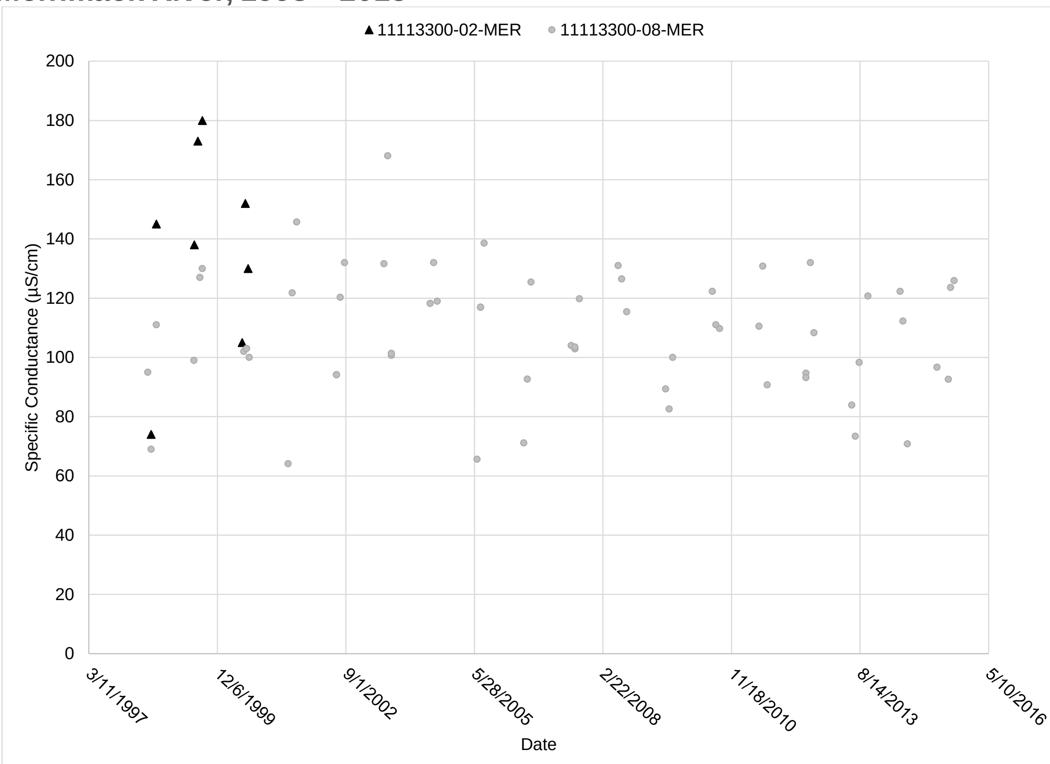


Figure E.7-19. Specific Conductance STORET Data Collected at two sites by the NHDES in the Merrimack River, 1998 – 2015



E.7.2.1.5 Use Impairment

An Integrated List of Waters (Integrated List) for Massachusetts and New Hampshire is submitted to the USEPA in fulfillment of reporting requirements under the Clean Water Act (CWA). Section 303(d) of the CWA requires states to identify those water bodies that are not expected to meet surface water quality standards after the implementation of technology-based controls and to prioritize and schedule them for the derivation of total maximum daily loads (TMDLs).

E.7.2.1.6 Massachusetts

The Integrated List in Massachusetts assigns waterbody segments to one of five categories, depending upon their status with respect to designated use support (Table E.7-9). The Merrimack River is listed as Category 5 impaired waters in Massachusetts, which includes portions within the Project vicinity (Table E.7-10) (MADEP 2016). Probable sources contributing to impairment included atmospheric deposition, CSOs from municipal discharges, impacts from hydrological flow regulation/modification, wet weather discharges from municipal discharges/sewage, municipal point source discharges of municipal discharges/sewage, and urban-related runoff/stormwater. The canal system at the Project is also listed as Category 5 waters (MADEP 2016).

A draft Pathogen TMDL has been drafted for the Merrimack River Watershed (MADEP et al. undated). No other TMDLs were located for the Merrimack River Watershed (Commonwealth of Massachusetts 2020b).

Table E.7-9. Description of Integrated Report Categories in Massachusetts (MADEP 2016)

Category	Description
1	Unimpaired and not threatened for all designated uses
2	Unimpaired for some uses and not assessed for others
3	Insufficient information to make assessments for any uses
4	Impaired or threatened for one or more uses, but not requiring the calculation of a TMDL
5	Impaired or threatened for one or more uses requiring a TMDL

Table E.7-10. Impaired Water Segments within the Lowell Project vicinity (MADEP 2016)

Name	Segment ID	Description	Length (miles)	Impairment
Project Impoundment	MA84A-01	State line at Hudson, NH/Tyngsborough, MA to Pawtucket Dam, Lowell	9	*Escherichia Coli* (*E. Coli*) Fecal coliform Mercury in fish tissue
Project Canal System	MA84A-29	Canal System near Pawtucket Falls, Lowell	4.90	DDT in fish tissue Lead Mercury in fish tissue PCBs in fish tissue
Bypassed/ Downstream Reach	MA84A-02	Pawtucket Dam, Lowell to Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell	3.2	Dewatering* *E. Coli* Mercury in fish tissue Total phosphorus
Downstream Reach	MA84A-03	Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell to Essex Dam, Lawrence	8.80	*E. Coli* Mercury in fish tissue PCBs in fish tissue
Reach Downstream of Essex Dam	MA84A-04	Essex Dam, Lawrence to confluence with Little River, Haverhill	10.00	*E.Coli* PCBs in fish tissue Total phosphorus

*TMDL not required (non-pollutant).

E.7.2.1.7 New Hampshire

The Section 305(b) and 303(d) consolidated list in New Hampshire assigns waterbody segments to various categories (Table E.7-11). Portions of the Merrimack River in New Hampshire are identified as Category 5 waters and are included in the 2018 303(d) list (Table E.7-12) (NHDES 2019b). Sources of impairment in these sections are unknown.

Table E.7-11. Description of Integrated Report Categories in New Hampshire

Category	Description
1	Attaining all designated uses and no use is threatened.
2	Attaining some of the designated uses; no use is threatened; and insufficient or no data and information is available to determine if the remaining uses are attained or threated (i.e., more data is needed to assess some of the uses).
3	Insufficient or no data and information are available to determine if any designated use is attained, impaired, or threatened (i.e., more monitoring is needed to assess any use).
4	Impaired or threatened for one or more designated uses but does not require development of a TMDL because:
4A	A TMDL has been completed, or
4B	Other pollution control requirements are reasonably expected to result in attainment of the water quality standard in the near future, or
4C	The impairment is not caused by a pollutant.
5	Impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL, which is the 303(d) list.

Table E.7-12. Impaired Water Segments within Project vicinity in New Hampshire (NHDES 2019b)

Assessment Unit ID	Water Name	Primary Town	Water Size (miles)	Use Description	Impairment Name	DES Category	TMDL Priority
NHRIV700061206-24	Merrimack River	Nashua	5.2	Aquatic Life	Aluminum	5-M	Low
					pH	5-M	Low
				Primary Contact Recreation	Chlorophyll-a	5-M	Low
NHRIV700061002-14	Merrimack River	Nashua	3.7	Aquatic Life	pH	5-M	Low
				Primary Contact Recreation	Creosote	5-M	Low

E.7.2.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on streamflow and water quality in the impoundment, canal system, bypassed reach, and Merrimack River.

- Effects of continued project operation on flooding along the shoreline of the project impoundment and surrounding areas.
- Effects of continued project operation on streamflow in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of continued project operation on water quality in the impoundment, canal system, bypassed reach, and Merrimack River.

The Project operates in a ROR mode and has no useable storage capacity. Therefore, seasonal and annual variations in flows within the Project area are based on natural hydrologic conditions in the Merrimack River Watershed. In 2011, the MADEP specified that it had waived Water Quality Certification related to a Project license amendment (i.e., replacement of the flashboard system with the crest gate system) (LIHI 2018), which suggests there were not water quality concerns at that time and there have been no substantial changes to Project operations since.

In 2019, the licensee completed the construction of a pneumatically operated crest gate on the spillway crest to maintain the headpond at its normal level of 92.2 feet NGVD 1929. The system was installed to prevent flooding in the impoundment zone, after backwater analysis and technical evaluation found the system would enhance project operational control and generation, and would provide significant advantages for other resources that are dependent on water levels, including flood control, recreation, and fish passage. The Commission's Environmental Assessment completed prior to the crest gate installation noted up to 46 miles of shoreline aquatic habitat could benefit from installing the crest gate, and the system would normally provide slightly lower water level elevations during flood events of less than 75,000 cfs. The Pawtucket Dam spillway becomes submerged at flows greater than 75,000 cfs, which causes the water level upstream to be influenced by the river channel structure within the bypassed reach downstream of the dam. The proposal was strongly endorsed by the Massachusetts Division of Fish and Wildlife (MADFW) and NMFS, who both noted the project's beneficial effect on fish habitat and movement within the project area (FERC 2011).

Some hydroelectric facilities can influence instream flows, and those that have large deep impoundments impact to water quality. The Project is operated as a ROR hydroelectric project. Therefore, the Project's ability to influence flow and thus water quality is minimal due to its limited storage and hydraulic capacity. At the normal pond elevation of 92.2 feet NGVD 29 (crest of the pneumatic flashboards), the surface area of the impoundment encompasses an area of approximately 1,236 acres. The gross storage capacity between the normal surface elevation of 92.2 feet and the minimum pond level of 87.2 feet (at spillway crest) is approximately 6,180 acre-feet.

Under current operations, when river flows exceed the hydraulic capacity of the E.L. Field Powerhouse units (3,300 cfs per unit or 6,600 cfs for both units), excess flows up to approximately 2,000 cfs are routed through the downtown canal system and to the canal units. Any flows in excess of approximately 8,600 cfs (6,600 cfs at E.L. Field plus 2,000 cfs via canals) are passed over the Pawtucket Dam spillway. Pursuant to Article 37, operating the Project in ROR mode meets and exceeds the present Project minimum flow requirement of 1,990 cfs or inflow, whichever is less, as measured immediately downstream from the Project (Boott 2017). As a result of the Project's ROR operations, there is a constant flow downstream of the Project during summer low flow conditions, which prevents impacts to downstream water quality.

In support of relicensing the Project, water quality data were collected in the Project's impoundment and bypass reach during the Fish Assemblage Study in the spring, summer, and fall of 2019. Water temperature, dissolved oxygen, conductivity, and pH data were collected at 12 locations throughout the impoundment and at three locations throughout the bypass reach. Turbidity data was also collected at the impoundment site locations. All data collected in the impoundment and bypassed reach met state water quality standards. Additionally, as stated above, waters in the Project impoundment, bypassed reach, and downstream reaches have historically met state water quality standards. This suggests that the Project operation has little to no effect on the overall water quality in the Merrimack River, which is consistent with a ROR hydroelectric project. Water quality data indicates that water quality in the Project area is consistent with the water quality of the lower Merrimack River and is likely driven by natural environmental and biological factors as well as anthropogenic disturbance within the larger context of this regional portion of the river basin. Since the Project operates in a ROR mode, seasonal and annual variations in flows within the Project area are based on natural hydrologic conditions in the Merrimack River Watershed. Continued operation of the Project is not expected to have negative effects on water quality, and therefore the fish and aquatic resources in the Merrimack River.

Water quality data have been collected throughout the general Project area including throughout the 16-mile impoundment, the bypassed reach, and downstream from the Project in the Merrimack River. Much of these data were collected during the summer months and data were collected in the bypassed reach during minimum flows. Often these are when water temperatures are highest and dissolved oxygen levels are lowest. Regardless, water quality met state standards.

The man-made canal system utilizes flows upstream of the Pawtucket dam and discharges at multiple locations just upstream of the USGS gage 1.6 RM downstream of the Project. The data obtained from this gage met state water quality standards and there is no indication that the canal system is impacting water quality in the Merrimack River. The waters of the canal system are listed as impaired by the state of Massachusetts; however, the impairments (i.e., Dichlorodiphenyltrichloroethane [DDT] in fish tissue, lead, and mercury/PCBs in fish tissue) are not related to the Project or Project operations and are likely a result of atmospheric deposition and historical contamination from the mills and industrial facilities that line the canal system (LIHI 2018).

E.7.2.2.1 Effects of Decommissioning

As summarized in Section E.6.2 of this exhibit, Boott is proposing to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage its canal structures and facilities, water levels, and flows in line with existing rights, responsibilities, and existing or new agreements among the concerned stakeholders. With respect to water levels in the downtown canal system, Boott is proposing to maintain the water levels as described above in Section E.6.2.

When the downtown units were in operation under the current license, additional flows in excess of leakage make-up water were generally passed into the canal system only when Merrimack River flows exceeded the 6,600 cfs hydraulic capacity of the E. L. Field Powerhouse turbines. This occurred approximately 40% of the time annually, primarily during the spring and fall when water temperatures are cooler. Conversely, based on flow duration additional generation flows would have been routed to the downtown units only about 10% of the time during the warmer summer months of July, August and September, when water quality would be of greater concern. Thus, reducing flows passed through the Guard Locks to 200 to 300 cfs leakage make-up flow should not result in any substantive change from current conditions with respect to water quality conditions within the downtown canals.

E.7.2.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain PM&E measures consistent with the measures required by the Project's existing license. Boott believes that the continued operation of the Project, as proposed, will limit effects on water quality and quantity. Boott proposes to operate the Project in a ROR mode using automatic pond level control of the E.L. Field powerhouse units. ROR operation may be temporarily modified for short periods to allow flow management for other project and non-project needs, e.g., downtown canal water level management, raising the crest gates following a high-water event, or for recreational purposes.

Boott also proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam during the period outside of the fish passage season. During the fish passage season, which generally runs from late April through mid-July, the Licensee proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the MRTC, consistent with current practice.

Boott has proposed to maintain the water levels described above in Section E.6.2, typically providing approximately 300 cfs of leakage make-up flow into the canal system via the Guard Lock and Gates Facility. Decommissioning the downtown powerhouses may require minor ground disturbance in areas primarily characterized by urban fill. Boott has proposed to develop a plan for decommissioning the powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

Boott proposes to continue to adhere to the Crest Gate Operation Plan approved by FERC on March 30, 2015, and operate fish passage facilities as determined in consultation with the MRTC.

E.7.2.4 Unavoidable Adverse Impacts

Continued Project operations as proposed by the Licensee are not expected to have any unavoidable adverse impacts on water quality or quantity. However, Boott notes that certain studies required by the Commission are ongoing, including the Three-Dimensional CFD Modeling Study. Boott will consult with stakeholders regarding the results and recommendations of this study and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.3 Fish and Aquatic Resources

The subsections below describe fish and aquatic resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, and the:

- Downstream American Eel Passage Assessment Study Report (NAI 2021a)
- Juvenile Alosine Downstream Passage Assessment Study Report (NAI 2021b)
- Upstream and Downstream Adult Alosine Passage Assessment Study Report (NAI 2021c)
- Fish Assemblage Study Report (NAI 2021d)
- Instream Flow Habitat Assessment and Zone of Passage Study (NAI 2021e)
- Fish Passage Survival Study (NAI 2021f)

These reports are included in Appendix B of this exhibit. However, Boott notes that certain studies required by the Commission are ongoing, including the Three-Dimensional CFD Modeling Study. Boott will consult with stakeholders regarding the results and recommendations of this study and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.3.1 Affected Environment

E.7.3.1.1 Overview

Historically, the Merrimack River served as a major resource for fisheries. However, the increase in industrial and urban pollution and construction of numerous dams along its length during the past two hundred years resulted in lowering the value of the river as an important aquatic habitat. The most affected fish populations have been the sensitive migrating species: anadromous fish that live in salt water and spawn in fresh water, and catadromous species that inhabit the river and spawn in the ocean. The changes in water quality of the Merrimack River combined with impoundments created by dams has increased the warm water fisheries habitat and resulted in the demise or severe reductions of migratory fish species (Massachusetts Department of Transportation

Federal Highway Administration [FHA] and The Commonwealth of Massachusetts Department of Public Works [MDPW] 1985).

In more recent years, the quality of the Merrimack River has improved, and today there is a concerted effort on the part of state and federal fish and wildlife agencies to restore anadromous fish populations in the Merrimack River. These restoration efforts have included stocking the headwaters of the river with adult American shad (*Alosa sapidissima*) and juvenile Atlantic salmon (*Salmo salar*) and building fish ladders at dams to allow fish access to the upper reaches of the Merrimack River. Other anadromous fish that are returning to the Merrimack River include the alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and sea lamprey (*Petromyzon marinus*). According to the FHA and MDPW (1985), the only catadromous species in the Lowell portion of the Merrimack River is the American eel (*Anguilla rostrata*).

In 1969 the State of New Hampshire, the Commonwealth of Massachusetts, USFWS, United States Forest Service (USFS), and the NMFS combined their efforts and formed Policy and Technical Committees for the Anadromous Fishery Management of the Merrimack River. Largely through the efforts of these committees, much progress has recently been made (Boott Mills 1980).

The MRTC was formed to address the restoration of anadromous fish in the Merrimack River watershed and includes representatives from the following government organizations: New Hampshire Department of Fish and Game (NHDFG), MADFW, Massachusetts Division of Marine Fisheries (MADMF), USFWS, USFS, and NMFS (Technical Committee 2010). The MRTC coordinates restoration activities such as installation, evaluation, operation, and maintenance of fish passage and capture facilities at hydroelectric facilities along the Merrimack River. Boott collaborates with the MRTC under an adaptive management framework regarding all activities related to managing the fishery resources impacted by the Lowell Project.

The MRTC oversees the management of the Lowell Project fisheries as directed by the Project's CFPP which was filed pursuant to articles 35 and 36 of the Project's existing license and approved by FERC in November 2000. The CFPP and fish passage at the Project is described in more detail in Section E.7.3.1.4.

E.7.3.1.2 Aquatic Habitat

Aquatic habitat found in the Project vicinity consists of habitat types typical of most northeastern large rivers, which support a variety of cool and warm water species. Shallow water, littoral, and riparian habitat types exist along the shoreline of the Project's impoundment, as well as along the several islands scattered in the Project's impoundment. At low river flows, the habitat in the Project's bypass reach is generally broad, relatively shallow, and rocky with numerous areas of exposed bedrock, with a large pool occupying the middle portion of the bypass reach.

During the 2019 Fish Assemblage Study (NAI 2021d), habitat was visually evaluated and characterized in the impoundment and bypass reach. The dominant substrate, proportion of transect with submerged aquatic vegetation, and the proportion of transect with overhanging vegetative cover was recorded. Water depth and velocity was measured within each sampling transect. Water quality data (i.e., water temperature, dissolved oxygen, conductivity, pH, and turbidity data) was also collected during spring, summer, and fall at each transect at a depth of one meter.

Impoundment

Within the impoundment, habitat was identified primarily as impoundment (78%), with less amounts of run (7%) and pool (15%) habitat. Dominant substrate, presence of submerged aquatic vegetation (SAV), and presence of general cover were consistent among all sample units regardless of mesohabitat classification (i.e., pool, run or impoundment). Sampled areas upstream of Pawtucket Dam were characterized by sand-silt-clay sediments, presence of SAV over 0-25% of the sample area and the presence of general cover over 0-25% of the sample area. Mean water depth (as sampled at quarter points of the river channel at the upper, middle, and lower points of each transect) trended towards shallower at the upper end of the reach upstream of Pawtucket Dam in areas classified as pool and run, and deeper at the lower end in areas classified as impoundment (NAI 2021d).

Water temperature in the impoundment was relatively consistent among sample units with a ± 1-2°C range in values within each season. The average Merrimack River water temperature was 21.5°C during the spring sampling, 25.6°C during the summer sampling, and 10.8°C during the fall sampling. Dissolved oxygen was measured at 8.1 mg/L or greater at all stations upstream of Pawtucket Dam regardless of season. Conductivity averaged 114 µs/cm during the spring sampling, 181 µs/cm during the summer sampling, and 117 µs/cm during the fall sampling. In general, conductivity increased with proximity to the Pawtucket Dam. River pH was consistent across seasons ranging from 6.5-7.5. The average turbidity reading was higher during the spring sampling (2.6 Nephelometric Turbidity Units [NTUs]) than was observed during the summer or fall periods (1.8 and 1.6 NTUs, respectively) (NAI 2021d).

Bypass Reach

Within the bypass reach, habitat was identified primarily as pooled sections (75%) with ledge channels (25%). A range of substrate types was sampled during each of the three seasons, ranging from areas of boulders to sand-silt-clay habitat. Sampled areas within the bypass reach were characterized by the presence of SAV over 0-25% of the sample area and the presence of general cover over 0-25% of the sample area. Mean water depth was consistent among sample areas and season, ranging from 1.5-2.4 feet (NAI 2021d).

Water temperature was relatively consistent among sample units within each season and averaged 22.9°C during the spring sampling, 23.8°C during the summer sampling, and 13.1°C during the fall sampling. Dissolved oxygen was measured at 8.9 mg/L or greater at all bypass reach stations downstream of Pawtucket Dam regardless of season. Conductivity averaged 148 µs/cm during the spring sampling, 194 µs/cm during the summer sampling, and 100 µs/cm during the fall sampling. The average river pH in the bypass reach was higher during the summer sampling event (7.8) than was observed during the spring (6.5) or fall (6.6) (NAI 2021d).

During the Instream Flow Habitat Assessment and Zone of Passage Study (NAI 2021e), an aquatic habitat model was developed for 9 species and associated life stages in the Bypass Reach through the bedrock rapids to the tailrace confluence at flows from 250 cfs to 14,000 cfs. An index of suitable habitat at each modeled flow, expressed as weighted usable area (WUA) in m^2, is presented below in Table E.7-13. Figure E.7-20 illustrates the flow:habitat relationships for each species and life stage.

Table E.7-13. Weighted Usable Area (WUA) in m2 in the Bypass Reach according to flow, species, and life stage

Flow	American Shad		River Herring	Sea Lamprey	Fallfish	
cfs	Juvenile	Spawning	Spawning	Spawning	Juvenile	Adult
250	11,923	6,738	3,110	576	2,764	15,133
482	14,468	9,368	2,951	1,012	3,134	17,586
1,000	15,864	12,859	2,421	1,599	2,873	18,363
2,000	14,946	15,664	1,711	1,908	1,726	14,308
4,345	9,948	15,755	1,011	1,282	893	8,219
6,000	7,558	13,396	820	858	895	6,782
7,011	6,517	11,852	723	724	894	6,201
8,000	5,710	10,313	675	611	819	5,724
10,000	4,644	7,864	568	489	688	4,979
12,000	4,025	6,418	523	415	511	4,573
14,000	3,641	5,718	490	355	371	4,277
Flow	**Smallmouth Bass**				**Longnose Dace**	
cfs	**Fry**	**Juvenile**	**Adult**	**Spawning**	**Juvenile**	**Adult**
250	10,617	10,141	5,834	879	838	1,970
482	10,491	12,772	7,155	727	1,086	2,414
1,000	7,768	13,820	8,021	508	735	1,657
2,000	5,507	11,407	6,350	324	385	848
4,345	3,340	6,793	4,014	215	283	537
6,000	2,817	5,412	3,366	201	296	580
7,011	2,454	4,882	3,087	173	265	599
8,000	2,270	4,394	2,818	161	212	508
10,000	1,899	3,665	2,402	143	116	303
12,000	1,660	3,249	2,153	104	69	160
14,000	1,526	2,983	2,016	98	44	109

Flow	White Sucker			Freshwater Mussels	Benthic Macro-invertebrates	
cfs	Fry	Juvenile	Adult	Rearing	Rearing	
250	25,085	10,724	159	8,217	7,213	
482	22,449	12,398	95	9,686	12,031	
1,000	16,881	10,462	61	10,937	18,958	
2,000	11,986	6,989	21	11,066	24,062	
4,345	7,219	4,352	69	8,528	21,698	
6,000	6,041	3,758	123	6,679	17,847	
7,011	5,233	3,361	95	5,802	15,777	
8,000	4,787	3,165	66	5,039	13,819	
10,000	4,065	2,706	34	3,913	10,948	
12,000	3,657	2,481	12	3,244	8,867	
14,000	3,488	2,354	9	2,866	7,250	

Figure E.7-20. Relationship between WUA (m^2) and flow (cfs) in Bypass Reach according to species and life stage

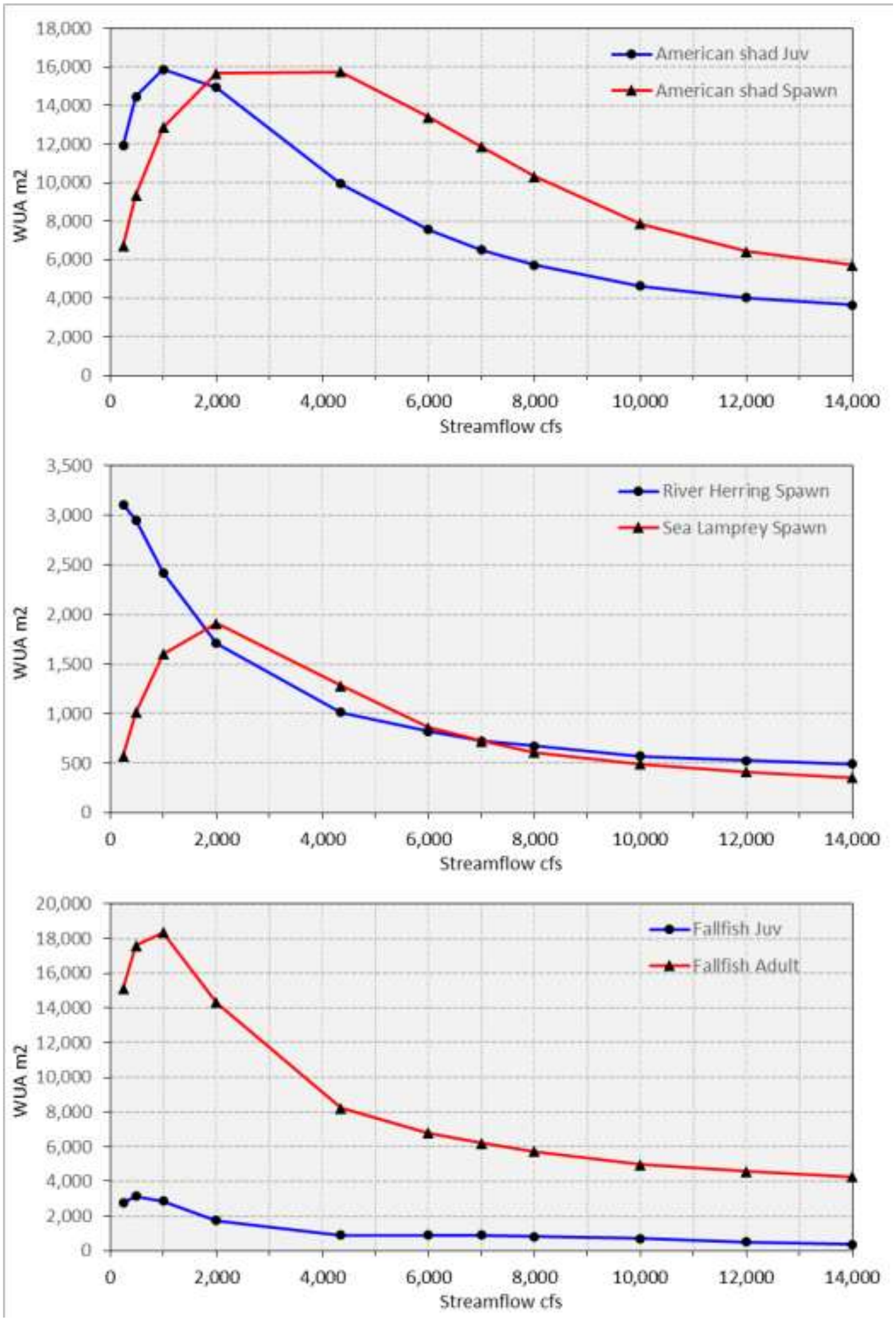


Figure E.7-20 (Continued)

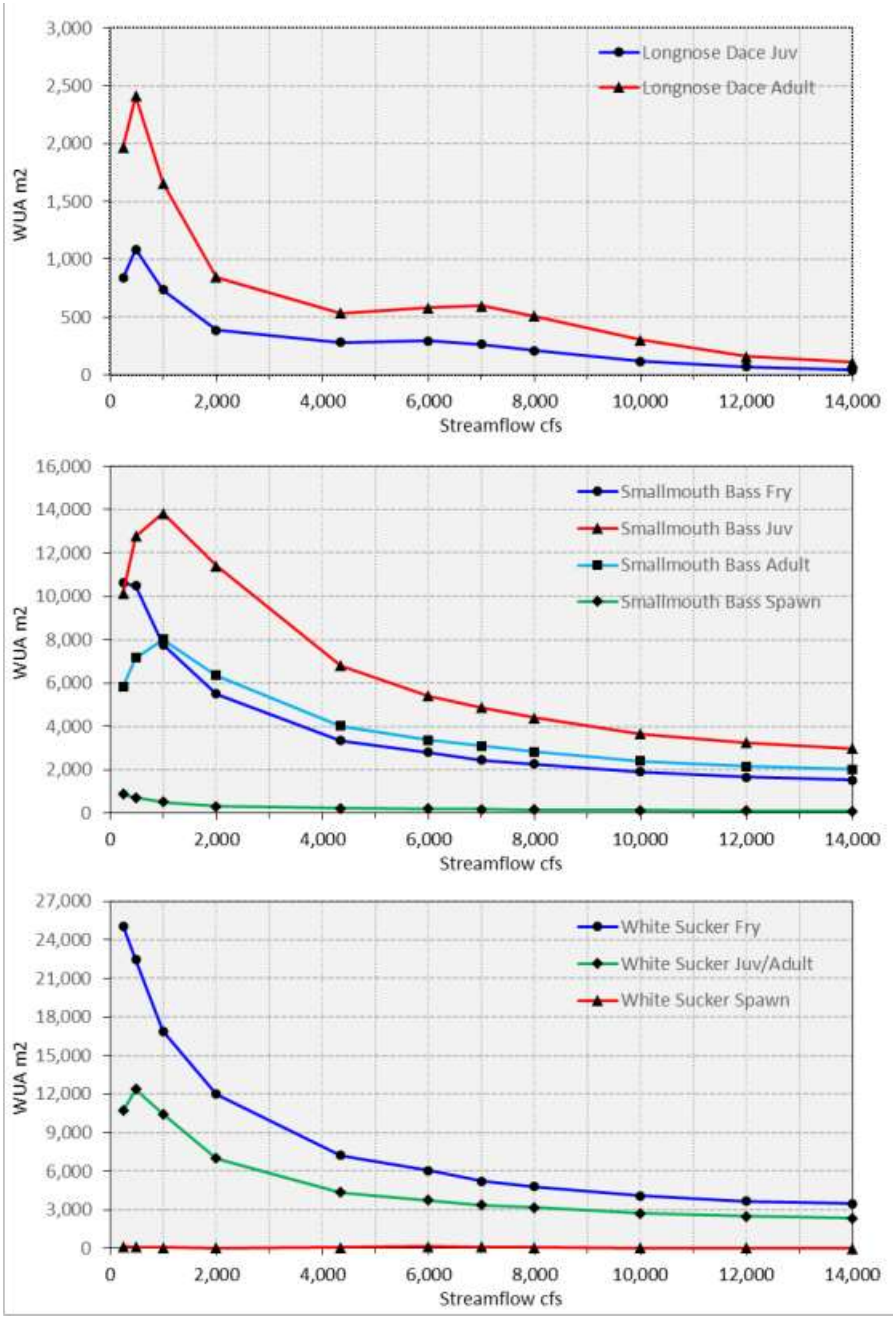
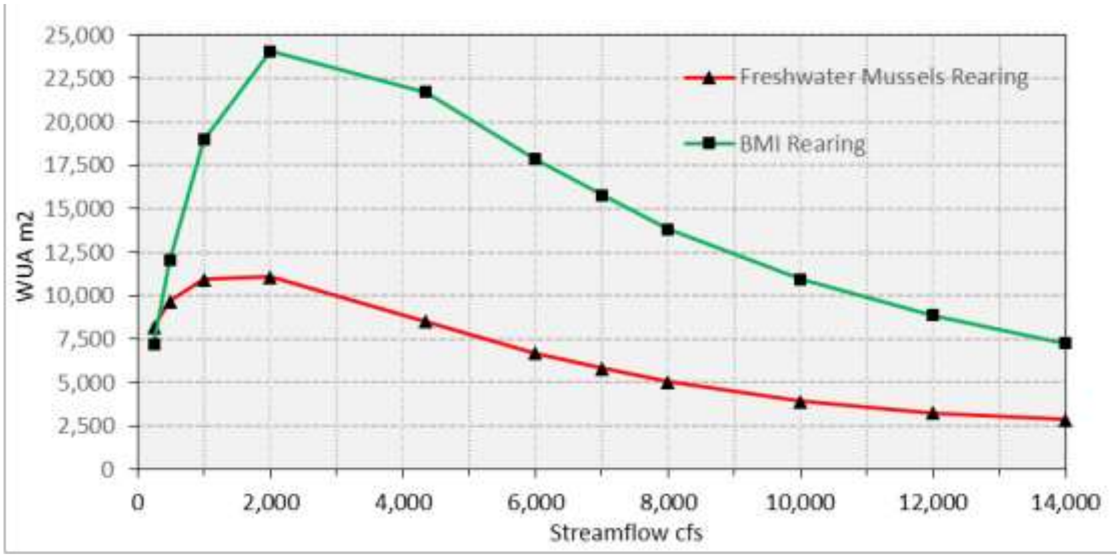


Figure E.7-20 (Continued)



The index of suitable habitat for American shad juveniles remained relatively high (>10,000 m^2) at flows between 250 cfs and 2,000 cfs, with declining suitability to a minimum (3,641 m^2) at the maximum modeled flow of 14,000 cfs. The suitability index for shad spawning stayed high (>10,000 m^2) over a wider range of flows (1,000-8,000 cfs), with minimum (~6,700 to ~5,700 m^2) at the lowest and the highest modeled flows, respectively. Most suitable habitat for both life stages occurred in the upper half of the modeled reach.

The habitat index for spawning by river herring was highest at 3,110 m^2 at the lowest modeled flow (250 cfs), then progressively declined to 490 m^2 as flows increased to 14,000 cfs. Virtually all of the estimated habitat was of low suitability, due to the low suitability (0.1) for all rocky substrates.

As shown above, benthic macroinvertebrates showed the highest estimates of WUA of all species groups, with a maximum of 24,062 m^2 at 2,000 cfs, and maintained high habitat values (>10,000 m^2) from 500 cfs to 10,000 cfs.

In most cases the habitat indexes for each species and life stage showed maximum suitable habitat at relatively low flows through the Bypass Reach. Thirteen of the 17 assessments produced maximum WUA at flows of 1,000 cfs or less, with 3 other species/life stages (lamprey spawning, freshwater mussels, and BMI rearing) reaching maximum WUA at 2,000 cfs, and one species/life stage (shad spawning) showing maximum habitat at a higher flow (4,345 cfs). This result is primarily due to the steep, bedrock dominated habitat that characterizes the Bypass Reach.

Canal System

The principal canals in the system are the Pawtucket Canal and the Northern Canal. Smaller canals lead off these two major canals. The canals vary in width from 40 to 120 feet. The walls are of granite, ledge, or concrete. The canal beds consist of ledge, concrete, or wood-planked virgin soil (Boott 2017).

Flow enters the canal system upstream of the Pawtucket Dam via the Pawtucket Canal and is controlled by the Guard Lock and Gates Facility. The nominal flow capacity of the downtown canal system via the Pawtucket Canal and the Guard Lock and Gates Facility is approximately 2,000 cfs.

The Northern Canal is approximately 2,200 feet long, with masonry or bedrock lining its complete length. The first 1,000 feet combines masonry walls and an earth dike (with masonry core) as the river wall. The second length is a dressed masonry gravity structure to the site of the E.L. Field Powerhouse. This structure is approximately 30 feet in height (Boott 2017).

E.7.3.1.3 Fish Assemblage

The Merrimack River is home to a diverse assemblage of fish species, including both cold water and warm water species. During the last 150 years, over 15 non-indigenous species such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), walleye (*Sander vitreus*), common carp (*Cyprinus carpio*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), various catfish species (*Ictalurus* spp.) and goldfish (*Carassius auratus*) have successfully established themselves through human introduction within the Merrimack River. The Merrimack River basin is home to approximately 50 species of fish; nine of which are anadromous (Stolte 1982 as cited in Technical Committee for Anadromous Fishery Management of the Merrimack River Basin [Technical Committee] 1997). The slower-moving, ponded reaches within the basin contain the majority of the warm water species, while those areas having steeper gradients contain the majority of the cold-water species (Technical Committee 1997).

Common freshwater game species currently found in the Lower Merrimack River include yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), northern pike (*E. lucius*), brown bullhead (*Ameiurus nebulosus*), smallmouth and largemouth bass, walleye, common carp and Centrarchid sunfishes (Lower Merrimack River Local Advisory Committee [LMRLAC] 2008).

2019 Fish Assemblage Study

In 2019, a Fish Assemblage Study was conducted at the Project to characterize the fish assemblage in the Project's impoundment and bypass reach (NAI 2021d). Sampling locations in the impoundment and bypass reach were randomly selected and weighted proportional to mesohabitat type frequency.

Fish community data in the impoundment were collected from twelve 500-meter sample units during spring (June 24-26), summer (August 19-21), and fall (October 28-30) nights of 2019 (total of 36). At each sample unit, boat electrofishing[11] was conducted over a 500-meter reach of shoreline at depths less than 10 feet, an experimental gill net[12] was set in areas with adequate water depths (>8ft) and flow conditions for 4 hours, and two

[11] Boat electrofishing used 4.0 amps of pulsed DC current.

[12] Gillnets were eight feet deep and constructed of four 25-ft panels of increasing mesh size (1.0, 2.0, 3.0, and 4.0-inch stretch mesh).

minnow traps[13] were set to sample deeper habitats (>10ft deep) for 4 hours simultaneously with the gill nets (NAI 2021d).

Fish community data in the bypass reach was collected from three 50-meter sample units during the spring (June 28), summer (August 27), and fall (October 21) of 2019 (total of 12). Due to safety and gear limitations, sampling was not conducted in: (1) the reach from the Pawtucket Dam downstream to the School Street Bridge (also known as Mammoth Road); and (2) the lowermost section of the bypass channel downstream of the Northern Canal surge gate. At each sample unit daytime backpack electrofishing[14] was conducted during minimum flows.

Fish collected from the impoundment and bypass reach were identified to the lowest possible taxonomic classification, enumerated, measured to total length (to the nearest millimeter), and weighed (to the nearest gram). If large numbers of small fish (i.e., young-of-year [YOY] or small cyprinid species) were captured, length and weight information was collected from the first 25 individuals within the sample and the remaining individuals were grouped, enumerated, and batch weighed (NAI 2021d).

In the impoundment, a total of 1,847 individuals and 22 fish species were collected during the sampling efforts in the impoundment. Spottail shiner (*Notropis hudsonius*) (23.0%), redbreast sunfish (*Lepomis auratus*) (20.5%) and smallmouth bass (12.3%) were the three most numerically abundant species within the impoundment. Spottail shiners were the most abundant species in the spring (27.6% of seasonal catch) and fall (33.9% of seasonal catch) sampling, whereas redbreast sunfish were the most abundant species in the summer sampling (27.1% of seasonal catch).

Through the impoundment sampling, centrarchid species were the most abundant within impoundment habitat with redbreast sunfish (24.2%), pumpkinseed (*Lepomis gibbosus*) (14.2%), and smallmouth bass (12.5%) representing the three most abundantly collected species. Spottail shiner were the most abundantly sampled fish species in the pool (28.4%) and run (46.3%) habitat areas.

The majority of catch in the impoundment were obtained via boat electrofishing, where a total of 1,792 fish and 20 species were collected. Spottail shiner, redbreast sunfish, and smallmouth bass were the most frequently collected species during boat electrofishing efforts. Total boat electrofish catch was fairly consistent across seasons. A total of 55 fish and 15 species were collected using gill nets. Yellow bullhead (*Ameiurus natalis*) were the most collected species and the majority of catch was recorded during the summer season. No fish were collected with minnow traps.

In the bypass reach, a total of 526 fish and fourteen fish species were collected. Fallfish (*Semotilus corporalis*) (39.9%), smallmouth bass (20.3%) and spottail shiner (16.7%)

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[13] Traps were 2.5 feet long galvanized wire mesh (0.25 square inch) cylinders with two entry fykes.

[14] Halltech Aquatic Research Model HT2000B/MK5, battery-powered backpack electrofishers with ring probes and rattail cathodes were used for sampling. The backpack units were set at 550 volts at 100 Hertz (Hz). A fine mesh seine was anchored at the downstream end of the 50-m sample unit. A pair of backpack electrofishing units and four technicians moved in a downstream direction towards the seine while actively netting stunned fish and kicking the substrate to drive additional stunned fish towards the collection net.

were the three most numerically abundant species. Spottail shiner were most abundant during the spring (48.8%) and fallfish during the summer (55.0%) and fall (39.9%).

In the bypass reach, fallfish were the most abundant fish collected within the pooled habitat, which represented 47% of the total catch. Smallmouth bass were the most abundant fish species collected in the ledge habitat in the bypass reach, which represented 60.6% of the total catch from that habitat. Close to 14 percent of the total catch in ledge habitat were American eels (*Anguilla rostrata*).

Table E.7-14 provides a comparison of the percent composition of all species collected during the 2019 Fish Assemblage Study. In comparison to the historical fish community in the vicinity of the Project, one new species was collected during the 2019 sampling effort, the channel catfish (*Ictalurus punctatus*). An additional 19 fish species have been observed historically in the Project vicinity, which are presented in Table E.7-15.

Table E.7-14. Fish Assemblage Observed During the 2019 Sampling of the Impoundment and Bypass Reach

Common Name	Scientific Name	Percent Composition	
		Impoundment	Bypass Reach
Alewife	*Alosa pseudoharengus*	6.1	-
American Eel	*Anguilla rostrata*	0.9	6.3
Black Crappie	*Pomoxis nigromaculatus*	0.3	-
Bluegill	*Lepomis macrochirus*	6.6	0.6
Brown Trout	*Salmo trutta*	-	0.2
Channel Catfish	*Ictalurus punctatus*	0.1	-
Common Carp	*Cyprinus carpio*	0.3	-
Fallfish	*Semotilus corporalis*	7.7	39.9
Golden Shiner	*Notemigonus crysoleucas*	0.7	-
Largemouth Bass	*Micropteris salmoides*	2.2	0.4
Sunfish, species unidentified	*Lepomis* spp.	0.2	0.2
Longnose Dace	*Rhinichthys cataractae*	-	0.4
Margined Madtom	*Notorus insignis*	0.5	3.2
Pumpkinseed	*Lepomis gibbosus*	8.4	-
Redbreast Sunfish	*Lepomis auritus*	20.5	2.5
Rock Bass	*Ambloplites rupestris*	0.4	-
Sea Lamprey	*Petromyzon marinus*	1.1	0.2
Smallmouth Bass	*Micropterus dolomieu*	12.3	20.3
Spottail Shiner	*Notropis hudsonius*	23	16.7

Common Name	Scientific Name	Percent Composition	
		Impoundment	Bypass Reach
Tessellated Darter	*Etheostoma olmstedi*	1.7	1.9
Walleye	*Sander vitreus*	0.1	-
White Perch	*Morone americana*	0.1	-
White Sucker	*Catostomus commersoni*	3	6.3
Yellow Bullhead	*Ameiurus natalis*	2.9	1
Yellow Perch	*Perca flavescens*	1.1	-

Source: NAI 2021d

Table E.7-15. Additional Fish Species Observed Historically at the Project

Common Name	Scientific Name
American shad	*Alosa sapidissima*
Atlantic salmon	*Salmo salar*
Banded killifish	*Fundulus diaphanus*
Banded sunfish	*Enneacanthus obesus*
Blacknose dace	*Rhinichthys atratulus*
Blueback herring	*Alosa* aestivalis
Bridle shiner	*Notropis bifrenatus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ameiurus nebulosus*
Chain pickerel	*Esox niger*
Common shiner	*Luxilus cornutus*
Creek chubsucker	*Erimyson oblongus*
Gizzard shad	*Dorosoma cepedianum*
Goldfish	*Carassius auratus*
Northern pike	*Esox lucius*
Redfin pickerel	*Esox americanus*
Slimy sculpin	*Cottus cognatus*
Striped bass	*Morone saxatilis*

Common Name	Scientific Name
Swamp darter	*Etheostoma fusiforme*
White catfish	*Ameiurus catus*

Sources: Hartel et al. 2002; Merrimack River Technical Committee 1997.

E.7.3.1.4 Migratory Species and Fish Passage

Overview

Fish passage at the Lowell Hydroelectric Project is managed in accordance with the CFPP. The CFPP includes details of operational measures undertaken by Boott to protect upstream and downstream migrating anadromous fish. Upstream and downstream fish passage facilities at the Project include a fish lift and downstream fish bypass at the E.L. Field Powerhouse and a vertical-slot fish ladder at the Pawtucket Dam. The fish passage facilities at the Project were designed in consultation with the USFWS and current fish passage operations are supervised by both state and federal fishery agencies per the CFPP.

In accordance with the CFPP, Boott is required to begin operating the fish passage facilities at the Lowell Project when a cumulative total of 50 American shad (*Alosa sapidissima*) or 200 river herring (*A. pseudoharengus*) are passed at the downstream Lawrence Hydroelectric Project (FERC No. 2800). Termination of upstream fish passage operations at the end of the upstream passage season is determined each year in consultation with the MRTC, and typically occurs in early to mid-July. Additionally, in accordance with the CFPP, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech Analytics 2017). Under the CFPP, Boott provides annual post-season updates to the MRTC. Fish are capable of bypassing the Project's entire canal system via the Merrimack River and use the existing upstream and downstream fish passage facilities at the Pawtucket Dam and E.L. Field Powerhouse. There are no exclusionary measures at the entrance of the Project's canal system. However, in the CFPP, Boott included an operational protocol to pass additional flows through the canal system in the rare instance where the Northern Canal needs to be dewatered to conduct repairs or maintenance on the main powerhouse during downstream fish passage season (Cleantech Analytics 2017). This provision has been implemented only once during the term of the license, to facilitate repairs to the Northern Canal wall in 1996.

As currently provided in the CFPP, the fish lift has historically been the primary route of upstream passage at the project, whereas the ladder has typically been operated only during periods of higher flow when spillage at the dam may attract upstream migrants toward the bypass reach. In recent years, Boott and the MRTC have tested the success of passage through the ladder under normal, non-spill conditions with very favorable results. Beginning in 2018 Boott has agreed to operate both the lift and the ladder throughout the fish passage season, in exchange for agency support of LIHI certification of the Project.

As a component of the CFPP, Boott collects information regarding the abundance of diadromous fishes using the upstream fishways annually. This activity is a joint monitoring effort to inform the MRTC that manages these fishery resources. MADFW and Boott staff work cooperatively to record diadromous fish counts at the E. L. Field Powerhouse fish lift throughout the upstream migration season. Beginning in 2017, fish count records also were kept at the Pawtucket Dam fish ladder. Boott provides a summary of these counts as part of its annual fishway operations report to the MRTC (Table E.7-16).

The CFPP is based on several fisheries studies conducted at the Project and experience gained at the Project since the installation of the Project's fish lift and fish bypass facilities. The CFPP was developed in consultation with the resource agencies, and many of the agencies' recommendations have been incorporated into the CFPP. Currently, Boott is coordinating with the USFWS and University of Massachusetts, Amherst, in upstream and downstream American eel passage studies at the Project. Since 2013 Boott has actively worked with USFWS to assess and improve upstream eel passage at the Pawtucket Dam.

In 2016, Boott purchased new radio telemetry equipment to assist the USFWS monitoring at three sites to assess the downstream movement of radio tagged adult eels released at the Merrimack River Project upstream (Cleantech Analytics 2017). In 2017 Boott deployed telemetry equipment at six locations at the Lowell Project and two locations at the Lawrence Project to again track the movement of radio-tagged eels released at the Merrimack River Project through the Lowell Project facilities. As discussed in more detail below, each of the fourteen radio-tagged eels determined to have successfully passed downstream of the Lowell Project, with the majority of individuals passing via the turbines and the remainder passing by spill.

The priority species for management at the Lowell Project are the catadromous American eel and three anadromous Alosidae species, American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), and alewife (*Alosa pseudoharengus*). Juvenile and adult American eel upstream and downstream migration periods overlap. Juveniles ascend beginning in May and continue through October. The adult outmigration period begins in late summer and lasts through November. The peak outmigration period is October through mid-November (Boott 2018).

Adult American shad and river herring ascend the Merrimack River from May through early July. The peak period is highly dependent on water temperature and total river discharge. The juvenile outmigration period is in the fall (September through November) and is also highly dependent on ambient water temperature and river discharge conditions (Boott 2018).

Outmigrating fish encountering the Pawtucket Dam can: (1) pass through the Pawtucket Gatehouse and enter the power canal; (2) pass downstream over Pawtucket Dam via spill; or (3) enter the Pawtucket Canal and navigate downstream via the downtown canal system. Individuals which enter the Northern Canal can pass downstream via one of the two turbine units at the E.L. Field Powerhouse, utilize the downstream bypass, or pass via the surge gate (operated only in the event of a station trip).

Table E.7-16. Lowell and Lawrence Diadromous Fish Passage Counts Since 1983

Year	River Herring (Lawrence)	River Herring (Lowell)	American Shad (Lawrence)	American Shad (Lowell)	Atlantic Salmon (Lawrence)	American Eel (Lowell)	American Eel (Lawrence)
1983	4,794		5,629		114		
1984	1,769		5,497		115		
1985	23,112		12,793		213		
1986	16,265		18,173	1,630	103		
1987	77,209		16,909	3,926	139		
1988	361,012	56,739	12,359	1,289	65		
1989	387,973	137,296	7,875	940	84		
1990	254,242	9,888	6,013	443	248		
1991	379,588	6,920	16,098	428	332		
1992	102,166	32,501	20,796	6,491	199		
1993	14,027	4,315	8,599	1,679	61		
1994	88,913	33,735	4,349	383	21		
1995	33,425	11,848	13,861	5,255	34		
1996	51	51	11,322	400	76		
1997	403	403	22,661	4,446	71		
1998	1,362	13	27,891	4,159	123		
1999	7,898	2,930	56,461	16,347	185		
2000	19,405	673	72,800	12,716	82		
2001	1,550	58	76,717	7,740	83		
2002	526		54,586	5,283	56		
2003	10,866	194	55,620	6,580	147		
2004	15,051	7,448	36,593	11,028	129		
2005	99	201	6,382	716	34		
2006	1,257	27	1,205		91		
2007	1,169		15,876	1,653	74		
2008	108		25,116	4,050	119		
2009	1,456	139	23,199	2,267	81		
2010	518	43	10,442	490	85		
2011	740	228	13,835	831	402		
2012	8,992	1,809	21,396	1,728	137		6,969
2013	17,359	13,490	37,149	9,756	22		915
2014	57,213	23,610	38,107	3,357	75	166	1,788
2015	128,692	31,323	89,467	20,937	13	2,647	8,124

Year	River Herring (Lawrence)	River Herring (Lowell)	American Shad (Lawrence)	American Shad (Lowell)	Atlantic Salmon (Lawrence)	American Eel (Lowell)	American Eel (Lawrence)
2016	417,240	287,343	67,528	11,439	6	328	1,981
2017	91,616	5,656	62,846	5,086	5	1,981	17,738
2018	276,449	311,867	25,081	14,046	10	*	267,353
2019	43,108	43,871	19,450	2,201	15	*	81,179
2020	87,150	181,979	52,239	8,449	1	974	93,058
TOTAL	**2,934,773**	**1,357,876**	**1,072,920**	**178,169**	**3,850**	**6,096**	**479,105**

*continuously ran fish ladder in 2018 and 2019 was primary upstream passage for eels, accurate quantity was unavailable without trapping.
Source: Boott 2018; K. Webb, Boott Hydropower, personal communication, March 19, 2018

Historical Studies

Multiple studies have been conducted at the Lowell Project to assess the movement behavior, passage route use, and survival of migratory fish species during the past three decades. Use and efficiency studies of the E.L. Field Powerhouse fish lift by American shad were conducted in 1999 and 2000 by Boott and by Alden Research Laboratory in 2011. The earlier studies led to significant modifications and upgrades of those facilities that improved the passage efficiencies of American shad. In addition, a 1988 acoustic telemetry study performed by RMC Environmental Services (RMC) of adult American shad movement through the Northern Canal demonstrated delayed movement through the Pawtucket Gatehouse, as well as incidental information regarding downstream passage routes for post-spawning individuals (RMC 1988). In a follow-up study in 1991 by NAI found similar findings as the 1988 adult American shad telemetry study (NAI 1991a).

Downstream bypass effectiveness studies in 1991 and subsequent studies in 1994 and 1995 by NAI yielded information regarding the use of the Project's bypass reach. This information led to phased modifications of the bypass which increased its use and efficiency at passing juvenile Alosids downstream. Similar studies were performed for Atlantic salmon smolts in 1996 and 2003 by NAI. A 2005 USFWS radio telemetry study provided information regarding American shad movement behavior between the downstream hydroelectric station, Lawrence, and the Lowell facilities. The upstream passage of American shad was also assessed at the Lowell Project in 2011 by Alden Research Laboratory, Inc, with additional analyses performed in 2013. Most recently, a study performed in 2017 by NAI yielded information regarding the downstream migratory behaviors of American eel in the Lowell Project.

During 2019, three additional fish passage studies were conducted at the Lowell Hydroelectric Project as outlined in the RSP, which are described further below along with more specific details on the historical studies.

American Eel Passage

The downstream passage for silver-phase American eels was evaluated by NAI in 2017. As part of that evaluation, fourteen radio-tagged eels passing downstream of the Amoskeag Project (the next hydroelectric facility upstream of Lowell in New Hampshire) were detected at Pawtucket Dam and thirteen of the fourteen study eels arriving at Lowell were subsequently detected downstream at Lawrence. The transit times between Amoskeag and Pawtucket Dam ranged from 10 – 244 hours. Eel passage events occurred primarily between sunset and sunrise via the turbines (eight) and over Pawtucket Dam (five); one individual was not detected at the passage detection fields at Lowell but was detected at the Lawrence Project. In addition, the E.L. Field Powerhouse bypass was not used as a downstream passage route.

More recently, a radio-telemetry assessment of the downstream passage success for adult silver-phase American eels was performed during the fall of 2019, pursuant to the SPD (NAI 2021a). Monitoring of outmigrating adult American eels focused on the evaluation of movement through the Project impoundment, residence time immediately upstream of the Pawtucket Dam and prior to passage, passage route utilization and estimation of downstream passage survival at the Project.

Following the release of 102 radio-tagged individuals[15] into the Merrimack River 11 miles upstream of the Lowell impoundment, their movements were monitored using a series of stationary radio-telemetry receivers in place at the Project[16] to inform on general movements, distribution among available passage routes and Project passage success (NAI 2021a).

Radio-tagged eels moved through the existing 23-mile-long Project impoundment in a median duration of 2.1 days. Upon initial detection at the Pawtucket Dam, the median duration of time spent immediately upstream of the dam structure was 0.4 hours with 94% passing downstream within the first 24 hours of their initial detection. Closer examination of the total residence time for radio-tagged eels indicated that the 95% of individuals passing through the Pawtucket Gatehouse did so in 30 minutes or less and upon entry into the Northern Canal the median residence duration prior to downstream passage was 0.2 hours (NAI 2021a).

During the 2019 evaluation there was no detected use of the downtown canal system by outmigrating radio-tagged eels. The majority of radio-tagged individuals passed through the Pawtucket Gatehouse and approached the E.L. Field powerhouse with 92.5% eventually passing downstream via the turbine units (Table E.7-17). Use of the existing downstream bypass system was limited to only two individuals. Downstream passage at the Project peaked during late October with all passage events completed by October 31. The majority of downstream passage events occurred during the evening and overnight hours (NAI 2021a).

[15] Normandeau Associates simultaneously conducted an additional downstream adult eel passage study at the Merrimack River Project (FERC No. 1893) during fall 2019. A total of 60 eels were radio-tagged during that assessment and were also monitored for passage at Lowell. Results from that group of eels at Lowell and points downriver have been incorporated into this report.

[16] 12 monitoring stations total.

The high number of radio-tagged individuals that passed downstream via the turbine units likely resulted from drier than normal conditions in the region. Only two major spill events, associated with increases in river flows, occurred during the monitoring period. The first major spill event occurred from approximately October 29 to November 5 and the second occurred towards the end of the passage season (~November 25) (NAI 2021a). The timing of the spill events occurred primarily after the peak of downstream passage at the Project. Under normal conditions, the frequency of spill events would be greater due to more frequent increases in river flows, thereby increasing the downstream passage of individuals over the dam and decreasing individuals passing downstream via the turbine units.

Downstream passage survival was estimated for all radio-tagged eels from the point of initial detection upstream of the Pawtucket Dam downstream to Lawrence. This resulted in an estimated downstream passage survival for silver-phase American eel at Lowell of 75.5% (75% Confidence Interval [CI] = 71.4%-79.6%). This estimate of downstream passage survival for adult eels at the Project includes any background (i.e., natural) or tagging-related mortality for the species in the reach from approach to the Pawtucket Dam to Lawrence. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult eels at the Project. Due to the limited distribution of downstream passage route selection, route-specific estimates of passage were developed for only individuals using turbine units at the E.L. Field powerhouse (n = 136; 75.0% survival; 75% CI = 70.6%-79.4%). The limited number of radio-tagged eels passing the Project via spill or the downstream bypass system were all determined to have successfully approached the Lawrence Project following downstream passage at Lowell (NAI 2021a).

Table E.7-17. Downstream passage route selection for radio-tagged eels released upstream of the Lowell project boundary and upstream of Garvins Falls Dam during the fall 2019 downstream passage assessment.

Release Location	Release Date	Lowell Downstream Passage Route					
		Did not Detect	Did Not Pass	Unknown	Turbine	Spill	Bypass
Garvins Falls	9-Oct	7	0	1	11	1	0
Garvins Falls	11-Oct	2	1	0	15	1	1
Garvins Falls	15-Oct	6	0	0	13	1	0
Garvins Falls	All	15	1	1	39	3	1
Lowell	9-Oct	0	0	1	19	0	0
Lowell	11-Oct	0	0	0	19	0	1
Lowell	16-Oct	0	0	1	18	1	0
Lowell	18-Oct	0	0	0	20	0	0

Release Location	Release Date	Lowell Downstream Passage Route					
		Did not Detect	Did Not Pass	Unknown	Turbine	Spill	Bypass
Lowell	23-Oct	0	0	1	21	0	0
Lowell	All	0	0	3	97	1	1
All		15	1	4	136	4	2
Percent Utilization			0.7%	2.7%	92.5%	2.7%	1.4%

Source: NAI 2021a.

The Fish Passage Survival Study (NAI 2021f) addressed the qualitative classification of impingement, entrainment, and the probability of turbine passage survival at the Project using a review of relevant biological criteria and physical Project characteristics for American eel. The study used a turbine blade strike analysis (TBSA) model, which relied on recent USFWS guidance on the use of a varied correlation coefficient for American eel, to calculate survival estimates through the E.L. Field Kaplan units. The estimated range of survival for eels passing downstream through the E.L. Field turbines ranged from 71-39 percent, with the predicted rate of survival for adult eels decreasing as body size/length increased (Table E.7-18). In the case of adult eels, the TBSA model tended to underestimate turbine survival when compared to empirical results from the Downstream American Eel Passage Assessment.

Table E.7-18. TBSA predicted survival estimates for adult American eels at the E.L. Field powerhouse.

Species/Life Stage	Size potentially encountered the region (in)	Body Length (inches)						
		21	24	28	32	36	40	45
American eel (Adult)	25-41	71.20%	67.30%	61.80%	56.50%	51.70%	46.00%	39.10%

Juvenile Alosine Downstream Passage

The downstream passage of juvenile alosines has been studied at the Lowell Project a number of times since 1990. After conducting a mark and recapture study in the fall of 1990 to determine the relative efficiency of its fish bypass system at passing juvenile clupeids, it was determined that because water depth in the vicinity of the E.L. Field Powerhouse's bypass is greater than 30 feet, the 91-centimeter-deep bypass opening at the facility may be too shallow for the majority of fish to locate it (NAI 1991b). During this study, a total of 7,882 juvenile clupeids were captured in the bypass net between September 25 and October 23. Alewives comprised 95% of the catch, shad 4.5%, and blueback herring less than 0.5%. Modifications to the fish bypass at the E.L Field Powerhouse were subsequently completed, and downstream juvenile alosine passage was again examined during the fall of 1993 and 1994 to assess efficiency of the modified bypass opening. Both studies concluded that the modified bypass opening greatly improved passage efficiency, by approximately 30 percent (NAI 1994 and NAI 1995).

An evaluation of the potential impacts on the outmigration of juvenile alosines was conducted in the fall 2019 migration season using radio-telemetry as outlined in the RSP (NAI 2021b). Monitoring of outmigrating juvenile alosines focused on the evaluation of the residence time immediately upstream of the Pawtucket Dam and prior to passage as well as passage route utilization at the Project.

A total of 145 juvenile alosines[17] were tagged and released at mid-river locations approximately one mile upstream of the Pawtucket Gatehouse. Their subsequent downstream arrival and passage at the Project was monitored via a series of fixed-location telemetry receivers within the Lowell Project area.

Upon initial detection at the Pawtucket Dam, the median duration of time spent immediately upstream of the dam structure was 1.3 days with 42% passing downstream within the first 24 hours of their initial detection. Closer examination of the total residence time for radio-tagged juvenile alosines indicated that all individuals determined to have entered the Northern Canal passed through the Pawtucket Gatehouse in less than 30 minutes. Upon entry into the Northern Canal, the median residence duration prior to downstream passage was longer (22.0 hours; range = 0.2 hours to 4.7 days). Nearly 70% of all downstream passage events for radio-tagged juvenile alosines occurred within 48 hours of initial detection in the E.L. Field forebay. A statistically significant interaction was suggested between mid and high generation conditions in relation to passage failure from the E.L. Field forebay. The presence of higher generation flows increased the probability that a radio-tagged individual would approach downstream passage options in the power canal (i.e., turbines or downstream bypass) and decreased the passage attempt relative to lower generation flows.

During the 2019 evaluation, the majority of radio-tagged individuals passed through the Pawtucket Gatehouse and approached the E.L. Field Powerhouse (Table E.7-19). Of the individuals which approached the E.L. Field Powerhouse and had a known downstream passage route, 83% eventually passed downstream via the turbine units. Use of the existing downstream bypass system was estimated at 17%.

[17] The FERC-approved RSP indicated that a total of 150 radio-tagged juvenile alosines shall be used for the study. Five of the transmitters purchased for this study could not be activated. As a result, a total of 145 radio-tagged juvenile alosines were released and assessed for downstream passage at the Project. There were no additional variances from the FERC-approved study plan.

Table E.7-19. Downstream passage route selection and percent utilization of route options after detection at Station 21 for radio-tagged juvenile alosines released upstream of Pawtucket Dam during the fall 2019 downstream passage assessment.

Release Date	Lowell Downstream Passage Route						
	Did not Detect	Did Not Pass	Downtown Canal System	Spill	Bypass	Turbine	Unknown
9-Oct	0	2	1	1	5	6	0
11-Oct	0	2	1	0	4	8	0
13-Oct	1	3	0	1	4	4	1
14-Oct	1	1	1	0	1	10	1
15-Oct	0	2	0	2	2	8	1
16-Oct	0	0	0	6	0	7	2
17-Oct	0	2	0	2	0	9	3
18-Oct	0	2	0	0	0	13	0
23-Oct	1	3	0	0	1	11	1
24-Oct	0	4	0	1	0	6	0
All	3	18	3	13	17	82	9
Percent Utilization		12.7%	2.1%	9.2%	12.0%	57.7%	6.3%

Source: NAI 2021b.

During the Revised ISR Meeting on October 15, 2020, FERC and NAI discussed the models at the gatehouses and the correlations between flow and temperature. NAI stated they could likely make changes to the model to further explore those variables.

The Fish Passage Survival Study (NAI 2021f) used the TBSA desktop tool to estimate total project survival for juvenile alosines at the Project. Estimates of turbine passage were inversely related to body length for each species/life stage considered with highest survival estimated for small juvenile shad or herring at 2 inches of length (~99%) (Table E.7-20).

Table E.7-20. TBSA predicted survival estimates for juvenile American shad and river herring at the E.L. Field powerhouse.

Species/Life Stage	Size potentially encountered the region (in)	Body Length (inches)		
		2	4	6
American shad (Juv)	2-6	98.6%	97.2%	95.9%
River herring (Juv)	1.5-6	98.6%	97.2%	95.9%

An empirical estimate of juvenile alosine survival was not derived during the 2019 Juvenile Alosine Downstream Passage Assessment at Lowell. The model required input of available downstream passage routes and an estimate of their proportional usage. Those rates were obtained from the 2019 study which estimated route usage for individuals passing the project via known mainstem routes as 11.6% via spill, 15.1% via the downstream bypass, and 73.2% via the E.L. Field turbine units. These observed route selection probabilities were imported into a multi-route TBSA model to evaluate the predicted whole-station survival for a normally distributed population of 1,000 3.5 inch (S.D. ±1.0 inches) fish. For non-turbine routes (e.g., downstream bypass or spill), an estimate of passage mortality was required and was based on the empirical estimates obtained for adult alosines at the Project (12% at the downstream bypass and 11% via spill). Using this methodology, total project survival at Lowell for juvenile alosine-sized fish is estimated at 94.8%. Passage failures were attributed to fish passing downstream via the turbines (2.1% of total losses) and the downstream bypass facility/spill (3.1% of total losses).

Upstream and Downstream Adult Alosine Passage

Upstream and downstream passage of alosines at the Lowell Project has been evaluated several times since 1990. Downstream passage routes of radio-tagged American shad were evaluated in 1990. Approximately half of the shad tagged during their upstream migration returned to the Project site and 53% proceeded to pass through the E.L. Field Powerhouse, 22% passed using the fish bypass, 9% entered the Pawtucket Canal, and 13% spilled over the Pawtucket Dam. The study also indicated that the losses of adult shad upriver from the Lowell Project was consistent with shad runs in other rivers (NAI 1991a).

The internal efficiency of the Lowell Project fish lift at passing adult American shad upstream to spawn was evaluated in 1996 using underwater cameras. Study results indicated that internal fish lift efficiency for shad at the Project was low for both flows evaluated (50 cfs and 90 cfs), probably due to the low flow velocities inside the fish lift entrance channel, especially upstream of the crowder gates. With higher flows and velocities inside the fish lift entrance channel, fewer shad dropped out of the system and internal lift efficiency improved. However, even with the increased flow, most of the shad observed approaching the crowder gates did not pass through them. A similar study was performed in the spring of 1999, in which the upstream passage season was exceptionally successful at passing the highest number of shad since the fish lift was commissioned. Four hundred percent more individual shad were lifted in the spring 1999 season compared to both 1997 and 1998. The average internal lift efficiency (42%) achieved at the Lowell Project during the 1999 fish lifting season represented a substantial improvement over the previous results, increasing over seventeen-fold compared to results achieved in 1996. Additional upstream fish lift internal efficiency studies were performed in 2000 and 2001. Both studies concluded that the crowder gate opening has a significant effect on internal fish lift efficiency. Brail camera results, which are most comparable to previous studies at Lowell and Lawrence, clearly show that internal efficiency at Lowell had substantially improved due to the fish lift modifications and was comparable to efficiencies experienced at Lawrence.

The upstream passage of American shad was also assessed at the Lowell Project in 2011 by Alden Research Laboratory, Inc. Adult shad passage success or impediments and overall fish migration patterns from the Lawrence Hydroelectric Project into the Lowell tailrace and into the Lowell project's fish lift hopper was evaluated during this study. The acoustic telemetry results indicated that 57% of shad that pass the Lawrence Hydroelectric Project reach the Lowell tailrace. Only three individual fish were detected as entering the riverside fish lift entrance. Additional analysis in 2013 by Blue Leaf Environmental concluded that shad did not spend long periods of time holding in a specific position within the tailrace or reside in areas outside of the established pattern of movement. Shad were also determined to move in a clockwise and counter-clockwise direction along both walls in the tailrace, contrary to the 2011 study which suggested shad move in a "U" shaped swimming pattern following the edges of the tailrace and the wall of the powerhouse.

An evaluation of the upstream and downstream passage effectiveness for adult alewives and American shad was conducted during the spring 2020 passage season (May through June) (NAI 2021c). Merrimack River conditions were considered normal or low for the majority of May, and low for most of the month of June. The E.L. Field fish passage facilities (i.e., upstream fish lift and downstream fish bypass) were operated throughout the study period and those turbine units were in operation for the duration of the study period. Two major spill events, associated with increases in river flows, occurred during the early portion of the monitoring period (May 7 and May 18). Flows to the downstream canal system were limited during both months as Boott suspended operation of the generating units in that system prior to the onset of the study due to overriding safety concerns.

Following the release of radio-tagged individuals[18] into the Merrimack River both upstream and downstream of the Lowell facility, their movements were monitored using a series of stationary radio-telemetry receivers in place at the Project as well as at several additional stationary monitoring receivers installed at bank-side locations upstream and downstream of the Project to inform on general movements, distribution among available passage routes and Project passage success.

Of the dual-tagged[19] adult alewives released downstream of the Project (150 individuals were dual-tagged and 204 were PIT-tagged), 85% were determined to have approached Lowell and were available to assess passage effectiveness of either the E.L. Field Powerhouse fish lift or the Pawtucket Dam fish ladder. The duration of time for fish to move upstream from the release location at Lawrence to Lowell was around one day for most dual-tagged adult alewives (median = 19.6 hours; 75th percentile = 28.6 hours). Following arrival downstream of the Project, 95% of dual-tagged adult alewives made at least one foray upstream towards either the fish lift or ladder. When examined by structure, 64% of dual-tagged alewives made at least one foray in the direction of the fish lift, 67% in the direction of the fish ladder, and 39% in the direction of the fish lift and fish ladder. The overall effectiveness of the E.L. Field fish lift for adult alewife passage during

[18] A total of 150 adult alewives and 150 adult American shad were radio-tagged and released upstream of the Pawtucket Dam for the purposes of evaluating downstream passage. A total of 354 adult alewives and 384 adult American shad were radio-tagged and released for the purposes of evaluating upstream passage.

[19] Dual- and PIT-tagged individual fish were analyzed separately due to poor conditions at Monitoring Station 20, which precluded effected monitoring of PIT-tagged individuals.

2020 was estimated at 43.9% (75% CI = 39.3-51.4%). The overall effectiveness of the Pawtucket Dam fish ladder for adult alewife passage during 2020 was estimated at 75.6% (75% CI = 69.2-82.2%).

Of the 150 radio-tagged adult alewives released upstream of Lowell, 83% approached the Pawtucket Dam and were available to evaluate downstream passage at the Project. The median upstream residence time prior to downstream passage was 2.0 days with 77% of individuals passing downstream in less than 96 hours after their arrival. The majority of individuals passed downstream of Lowell via the E.L. Field turbine units (52% of radio-tagged alewives) or utilized the downstream bypass (45% of radio-tagged alewives). Downstream passage survival was calculated as the joint probability of the three reach-specific survival estimates which encompasses the full section of the Merrimack River from Lowell downstream to Lawrence and resulted in an estimated downstream passage survival for adult alewives at Lowell of 76.5% (75% CI = 71.5%-80.5%). This estimate of downstream passage survival for adult alewives at Lowell included background mortality (i.e., natural mortality) for the species in the downstream reach, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult alewives at the Project.

Of the 180 dual-tagged[9] adult American shad released downstream of the Project, 40% were determined to have approached Lowell and were available to assess passage effectiveness of either E.L. Field Powerhouse fish lift or the Pawtucket Dam fish ladder. An additional 47% of the dual-tagged shad exhibited upstream movement following tagging and release at Lawrence but did not move the full length of the Merrimack River reach between the two Projects. The median duration of time for shad to move upstream from the release location at Lawrence to Lowell was 64.5 hours (2.7 days). The vast majority those shad made one or more forays in the direction of the fish lift. Only a single dual-tagged shad was determined to have initiated an upstream ascent into the bypassed reach and in the direction of the fish ladder and two additional PIT-tagged shad entered the fish ladder. The overall effectiveness of the E.L. Field fish lift for adult American shad passage during 2020 was estimated at 30.4% (75% CI = 22.1-39.5%).

Of the 150 radio-tagged adult shad released upstream of Lowell, 79% approached the Pawtucket Dam and were available to evaluate downstream passage at the Project. The median upstream residence time prior to downstream passage was 3.9 days with 51% of individuals passing downstream in less than 96 hours after their arrival. The majority of individuals passed downstream of Lowell via the E.L. Field turbine units (26%), the downstream bypass (28%) or utilized the bypassed reach (38%). Downstream passage survival was calculated as the joint probability of the three reach-specific survival estimates which encompasses the full section of the Merrimack River from Lowell downstream to Lawrence and resulted in an estimated downstream passage survival for adult shad at Lowell of 70.0% (75% CI = 64.5%-74.6%). This estimate of downstream passage survival for adult shad at Lowell included background mortality (i.e., natural mortality) for the species in the downstream reach, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult American shad at the Project.

The Fish Passage Survival Study (NAI 2021f) used the TBSA tool to estimate survival for American shad and river herring. The TBSA produced a range of survival estimates for American shad and river herring turbine survival through the Project's E.L. Field powerhouse Kaplan units. Within that range of estimates, the probability of mortality due to blade strike increased as body size increased. In the case of adult alosines, the TBSA model tended to overestimate turbine survival when compared to the 2019 empirical results from the Upstream and Downstream Adult Alosine Passage Assessment (NAI 2021c).

Table E.7-21. TBSA predicted survival estimates for juvenile American shad and river herring at the E.L. Field powerhouse.

Species/Life Stage	Size potentially encountered the region (in)	Body Length (inches)				
		8	12	16	20	25
American shad (adult)	15-23			89.0%	86.4%	83.1%
River herring (adult)	9-13	94.8%	91.8%	89.0%		

The Instream Flow Habitat Assessment and Zone of Passage Study (NAI 2021e) used River 2D (a two-dimensional hydraulic model) to assess the relationship between bypass flow and upstream passage through the bypassed reach. The zone of passage model was developed for three adult migratory species: American shad, blueback herring, and alewife. The 2.5 ft depth criteria for American shad showed that near full connectivity did not occur throughout the bypass reach until flows exceeded 4,000 cfs. This modeled lack of passage zones at low flows was largely due to the deep passage criteria for shad. Because the deep depth criteria may not be realistic for shad swimming through natural channels (as opposed to jumping weirs or ascending ladders), this analysis was re-run using 1.0 ft depth criteria, which is the depth criteria for river herring. Decreasing the depth criteria from 2.5 ft to 1.0 ft for shad resulted in almost continuous passage opportunities at just under 500 cfs, with multiple continuous pathways becoming available at flows of 1,000 cfs and above. Depth suitability for shad passage continued to increase at higher flows and velocities largely remain suitable for shad until flows exceed 6,000 cfs.

Passage conditions for river herring (blueback herring and alewife), using 1.0 ft minimum depth criteria show almost continuous passage opportunities at 482 cfs with multiple continuous pathways becoming available at flows over 1,000 cfs. Because the herring velocity criteria is somewhat slower than for American shad, the model predicted more impassable area within the bedrock channels due to rapid currents. However, it appears likely that herring could ascend the channels along the bottom or along the margins at 482 cfs. Velocities within the bedrock habitat increase with increasing flows, with excessive velocities through the bedrock at flows over 4,000 cfs.

Atlantic Salmon Passage

Efforts to restore Atlantic salmon (*Salmo salar*) to the Merrimack River were abandoned in 2013 after consistently low return numbers were observed, but the species may still occasionally be present in the Project area. Efforts since 2013 have shifted towards the restoration of the remaining migratory fish species, notably river herring and shad (Cleantech Analytics 2017). Atlantic salmon counts are available for the Lawrence Project downstream (Table E.7-16).

In 1996, a radio telemetry study was performed to determine the extent to which the Lowell and Lawrence downstream fish bypass systems are used by radio-tagged Atlantic salmon smolts. The fish bypass systems at both the Lowell and Lawrence Hydroelectric Projects were not found to be effective at passing radio-tagged Atlantic salmon smolts, and at both sites, most of the downstream passage was through the turbines. At the Lowell Project, 13% of the radio-tagged salmon used the bypass, a significant increase compared to the 4% bypass usage by radio-tagged salmon in 1990. Only four (15%) of the radio-tagged salmon that passed the Lowell Project made it downstream to the Lawrence Project's headpond and of these, none were recorded passing the Lawrence site. Predation appears to have been a factor in the disappearance of some radio-tagged salmon released upstream of both hydroelectric sites (NAI 1996).

The effectiveness of the Lowell Project at safely passing downstream migrating Atlantic salmon smolts, as well as passage routing and turbine survival was evaluated in 2001. Using twenty radio-tagged salmon smolts to test three bypass flows, fish bypass efficiency at the Lowell Project averaged 32% and ranged from 15% passage with a bypass flow of approximately 2% of turbine flow to 42% passage with approximately 4% bypass flow. No turbine-passed fish appeared to be injured as a result of turbine passage. Similar to the 1996 study, predation in the tailrace and downstream of the Project seem to have a substantial impact on the survival rates of salmon smolts emigrating past the Lowell Project (Boott 2001).

E.7.3.1.5 Essential Fish Habitat

Based on a review of the NMFS online database, the Lowell Project reach of the Merrimack River is designated essential fish habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act for Atlantic salmon (National Oceanic and Atmospheric Administration [NOAA] undated). Essential fish habitat was defined as "all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut" (New England Fishery Management Council [NEFMC] 1998).

E.7.3.1.6 Benthic Macroinvertebrates

Benthic macroinvertebrates (BMI) are small aquatic animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. They lack a backbone, are visible without the aid of a microscope, and are found in and around water bodies during some period of their lives. Benthic macroinvertebrates are often found attached to rocks, vegetation, logs and sticks or burrowed into the bottom sand and sediments (USEPA undated). These organisms provide a link between a system's primary productivity and its aquatic consumers through the conversion of plant biomass to consumable energy. Benthic macroinvertebrates can be useful indicators of water quality because many species have a wide range of tolerances to pollution.

Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) species are highly sensitive to pollution. Furthermore, EPT species are high-quality forage for a variety of freshwater fish species.

In recent years, the MADEP, NHDES, the Merrimack River Initiative (MRI), and numerous smaller watershed committees have begun conducting macroinvertebrate biomonitoring studies in the Merrimack River basin (USACE 2003). According to the USACE (2003), benthic macroinvertebrate sampling was conducted at 44 locations throughout the Merrimack River Basin (10 mainstem and 34 tributary). Artificial substrates were deployed in August 1994 and collected seven weeks later after a colonization period. The results of the MRI study were published in November 1996 in a two-part study report titled Merrimack River Bi-State Water Quality Report, Part One and the Merrimack River Bi-State Biomonitoring Report, Part Two.

As shown above in Table E.7-13, the Instream Flow Habitat Assessment and Zone of Passage Study identified that benthic macroinvertebrates showed the highest estimates of WUA of all species groups, with a maximum of 24,062 m^2 at 2,000 cfs, and maintained high habitat values (>10,000 m^2) from 500 cfs to 10,000 cfs. The 2D model predicted suitable habitat for BMI throughout the Bypass Reach, although the highest quality habitat occurred in the upper end of the reach and near the bottom of the reach.

Three macroinvertebrate species of management concern that are entirely or semi-aquatic potentially reside in the Lowell Project vicinity of the Merrimack River. These species include the eastern pondmussel (*Ligumia nasuta*), the cobra clubtail (*Gomphus vastus*) and the umber shadowdragon (*Neurocordulia obsoleta*). These species were identified as species of special concern in Massachusetts (Commonwealth of Massachusetts 2018 *a*).

E.7.3.1.7 Aquatic Invasive Species

Invasive species are defined as non-indigenous plant or animal species that aggressively compete with native species. These species often out-compete local native species, impacting biodiversity, recreation, and human health. The Merrimack River supports a relatively large number of invasive species. The Invasive Plant Atlas of New England (IPANE), NHDES, and the MRWC identifies the species listed in Table E.7-22 as potentially occurring in the general vicinity of the Project. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-22. Aquatic Invasive Species Likely to Occur in the Project Vicinity

Common Name	Scientific Name
Common reed*	*Phragmites australis*
Curly-leaved pondweed	*Potamogeton crispus*
Eurasian water milfoil	*Myriophyllum spicatum*
Carolina fanwort	*Cabomba caroliniana*
Purple loosestrife*	*Lythrum salicaria*

Common Name	Scientific Name
Twoleaf milfoil	*Myriophyllum heterophyllum*
European water chestnut	*Trapa natans*
Yellow Iris	*Iris pseudacorus*
European water-clover	*Marsilea quadrifolia*
Watercress	*Nasturtium officinale*
Reed canarygrass	*Phalaris arundinacea*
Yellow iris	*Iris pseudacorus*
Flowering rush	*Butomus umbellatus*
Yellow floating heart	*Nymphoides peltata*
Asian clam	*Corbicula fluminea*

Sources: MRWC 2015; IPANE 2018

E.7.3.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on fish and aquatic resources as potential resource issues. Specifically, SD2 identified the following needed to be analyzed for site-specific effects:

- Effects of continued project operation on resident and migratory fisheries resources in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of continued project operation on the aquatic macroinvertebrate community in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of continued project operation on fish passage for migratory species, including American shad, river herring, and American eel.

The following potential resource issues related to fish and aquatic resources were identified to be analyzed for both cumulative and site-specific effects:

- Effects of continued project operation on migratory fisheries resources in the impoundment, canal system, bypassed reach, and Merrimack River.

E.7.3.2.1 Site-Specific Effects

Effects of Continued Project Operation on Fish Passage for Resident and Migratory Species

The Merrimack River is home to a diverse assemblage of fishes. Stolte (1982; as cited in the Merrimack River Technical Committee for Anadromous Fishery Management of the Merrimack River Basin, 1997) noted that during the last 150 years, over 15 non-indigenous species such as largemouth bass, smallmouth bass, walleye, common carp, rainbow trout, brown trout, various catfish species and goldfish have established through human introductions within the Merrimack River. At that time, the Merrimack River was identified as home to approximately 50 species of fish, nine of which were anadromous. The slower moving, ponded reaches of the Merrimack contain a higher predominance of warm-water species whereas those areas with higher gradient contain the majority of cold-water species. Hartel et al. (2002) identified a total of 57 reproducing fish species within the drainage; 21 primary species (i.e., those living full life cycle in freshwater), 8 secondary species (i.e., those with physiological capacity to move between fresh and salt water), 18 introduced species, and 10 diadromous species.

Fish assemblage sampling within the Lowell impoundment and bypass reach during the spring, summer and fall of 2019 resulted in the identification of 24 fish species. Of those species, 21 are considered freshwater and 3 are considered diadromous. The species collected during the 2019 sampling resulted in a similar and expected fish assemblage in the Project vicinity compared to existing information on the Merrimack River fish community (Hartel et al. 2002). Based on the results of the 2019 Fish Assemblage Study, approximately 75% of the composition of fish species in the impoundment and bypassed reach was comprised of five or less species in all sampling seasons (NAI 2021d). As expected, there is a slight seasonal shift in the fish community in both the impoundment and bypass reach. Table E.7-23 presents the most abundant fish species in the impoundment for each season and Table E.7-24 presents the most abundant fish species in the bypass reach for each season. Additionally, fish assemblage was found to differ based on habitat, as described in Section E.7.3.1.

Table E.7-23. Top five most abundant fish species each season in the impoundment from the 2019 Fish Assemblage Study.

Spring		Summer		Fall	
Species	**Percent Composition**	**Species**	**Percent Composition**	**Species**	**Percent Composition**
Redbreast Sunfish	23.7	Redbreasted Sunfish	27.1	Spottail Shiner	33.9
Smallmouth Bass	21.9	Pumpkinseed	17.5	Alewife	16.8
Spottail Shiner	27.6	Spottail Shiner	10.9	Fallfish	13.7
Fallfish	5.9	Bluegill	10.7	Smallmouth Bass	9.2
Bluegill and White Sucker[1]	8.2	Smallmouth Bass	6.9	Redbreasted Sunfish	8.2
Total	**87.3%**	**Total**	**73.1%**	**Total**	**81.8%**

Note: 1 Bluegill and white sucker had the same percent composition (4.1%).

Table E.7-24. Most abundant fish species each season in the bypass reach from the 2019 Fish Assemblage Study.

Spring		Summer		Fall	
Species	Percent Composition	Species	Percent Composition	Species	Percent Composition
Spottail Shiner	48.8	Fallfish	55	Smallmouth Bass	64.2
Fallfish	27.5	Spottail Shiner	14.4	Margined Madtom	13.2
American Eel	12.5	Smallmouth Bass	10.9	Redbreast Sunfish	6.6
Bluegill	2.5	White Sucker	8.8	Tessellated Darter	3.8
Smallmouth Bass	2.5	American Eel	5.3	White Sucker	2.8
Total	**93.8%**	**Total**	**94.4%**	**Total**	**90.6%**

Overview of Migratory Species and Fish Passage

Existing information for the Project, along with the results of the studies completed by the Licensee in 2019 and 2020, demonstrate that existing operations under the terms of the current license and the Project's CFPP are maintaining and supporting resident game and non-game fish species, as well as migrating anadromous fish, and habitat for aquatic species in the Merrimack River upstream and downstream of the dam.

The CFPP includes details of operational measures undertaken by Boott to protect upstream and downstream migrating anadromous fish. The CFPP is based on several fisheries studies conducted at the Project and experience gained at the Project since the installation of the Project's fish lift and fish bypass facilities. The priority species for management at the Lowell Project are the catadromous American eel and three anadromous Alosidae species (American shad, blueback herring, and alewife). Atlantic salmon restoration is no longer a management focus for the Merrimack River. Because of minimal fluctuation of the impoundment and adherence to a strict minimum flow regime, the operation of the Project has little effect on overall river flow in the lower Merrimack River.

The licensee has consulted with the USFWS, New Hampshire Fish and Game Department (NHFGD), MADFW, and NMFS extensively regarding fish passage at the Project. Boott provides a post-season update on the fish passage at the Lawrence and Lowell Hydroelectric Projects annually and the agencies have the opportunity to recommend improvements to the fish passage facilities. The fish passage facilities at both Projects are continually monitored and modified to increase effectiveness at the agencies' requests and recommendations (Cleantech Analytics 2017).

The recent construction of the pneumatic crest gate was strongly endorsed by the Federal and state (both New Hampshire and Massachusetts) fishery agencies due to its anticipated benefits to migratory species. The USFWS, NMFS, MADFW, and NHFGD submitted letters of support to the Commission for the pneumatic crest gate system. The system allows rapid re-inflation following periods of high flow, which prevents delay in upstream fish passage which occurs with lost or damaged wooden flashboards. The pneumatic crest gate system is expected to maintain consistent water levels, reduce leakage from the dam, and minimize the need for impoundment drawdowns, which all provide improved fish passage and spawning habitat. The reduction in leakage is expected to improve upstream passage efficiency by decreasing false attraction flow at the dam (FERC 2011).

American Eel Passage

The impoundment and river segment in the vicinity of the Project would be suitable for foraging, growth, and development of American eel prior to their downstream spawning migrations. American eels are adaptable and can utilize a wide range of riverine, lake, or reservoir habitat (McCleave 2001, Greene et al. 2009). The passage of American eel upstream of hydropower dams can expose the eventual out-migrating silver eels to migratory delay at each dam and mortality when passing through turbines or over spillways.

A radio-telemetry assessment of the downstream passage success for adult silver-phase American eels was performed during the fall of 2019 (NAI 2021a). Monitoring of outmigrating adult American eels focused on the evaluation of movement through the Project impoundment, residence time immediately upstream of the Pawtucket Dam and prior to passage, passage route utilization and estimation of downstream passage survival at the Project. During the 2019 American Eel Passage Assessment, the majority of American eels (92.5%) passed downstream of Lowell via the E.L. Field turbine units, while two eels used the downstream bypass and four eels used the bypassed reach (NAI 2021a). The limited use of the downstream bypass system at E.L. Field is similar to the results of the 2018 downstream eel passage evaluation.

Downstream passage survival was estimated for all radio-tagged eels from the point of initial detection upstream of the Pawtucket Dam downstream to Lawrence. This resulted in an estimated downstream passage survival for silver-phase American eel at Lowell of 75.5% (75% CI = 71.4%-79.6%). This estimate of downstream passage survival for adult eels at the Project includes any background (i.e., natural) or tagging-related mortality for the species in the reach from approach to the Pawtucket Dam to Lawrence. As a result, this estimate should be viewed as a minimum estimate of total Project survival (i.e., due solely to Project effects) for adult eels at the Project. Due to the limited distribution of downstream passage route selection, route-specific estimates of passage were developed for only individuals using turbine units at the E.L. Field Powerhouse (n = 136; 75.0% survival; 75% CI = 70.6%-79.4%). The limited number of radio-tagged eels passing the Project via spill or the downstream bypass system were all determined to have successfully approached the Lawrence Project following downstream passage at Lowell (NAI 2021a).

A TBSA model was conducted as part of the Fish Passage Survival Study (NAI 2021f) for American eel. The estimated range of survival for eels passing downstream through the E.L. Field turbines ranged from 71-39%, with the predicted rate of survival for adult eels decreasing as body size/length increased. In the case of adult eels, the TBSA model tended to underestimate turbine survival when compared to the empirical results from the Downstream American Eel Passage Assessment.

American shad and river herring passage

The presence of herring in the Merrimack River appears to be strong in recent years. In 2016, record numbers of herring (since the establishment of the restoration efforts,) were observed at the Amoskeag Dam, upstream of the Lowell project. The returns have been so successful that the large number of herring ascending the fish ladder at the Amoskeag Dam overwhelmed the trap and truck operation in 2016 (Cleantech Analytics 2017). In 2018, the Lawrence facility passed river herring upstream in the highest number (418,689) since the project was built over 30 years ago, and the Lowell project passed about 58% of those fish upstream, through its fish lift (62,421) and fish ladder (182,268) (Enel 2018). In 2016, 70% of the herring that passed at Lawrence also passed at Lowell (Enel 2016). Also, in 2018, while only 26,347 American shad were passed upstream at Lawrence, 56% of those were passed through the Lowell project, through its lift (4,630) and ladder (10,171). The high ratio of passage success for shad from Lawrence through Lowell is the highest ever observed in over 30 years of passage comparison (Enel 2018).

During the 2019 Juvenile Alosine Downstream Passage Assessment, 83% of juvenile alosines eventually passed downstream via the turbine units. Use of the existing downstream bypass system was estimated at 17% (NAI 2021b). During the 2019 Adult Alosine Downstream Passage Assessment, the majority of adult alewives passed downstream of Lowell via the E.L. Field turbine units (52% of radio-tagged alewives) or utilized the downstream bypass (45% of radio-tagged alewives). During 2020, the overall effectiveness of the E.L. Field fish lift for adult alewife passage was estimated at 43.9%, while the overall effectiveness of the Pawtucket Dam fish ladder for adult alewife passage was estimated at 75.6%. Also, during 2020, the overall effectiveness of the E.L. Field fish lift for adult American shad passage during 2020 was estimated at 30.4%, while only two tagged shad utilized the fish ladder (NAI 2021c).

The Fish Passage Survival Study (NAI 2021f) used the TBSA desktop tool to estimate total project survival for juvenile alosines at the Project. Estimates of turbine passage were inversely related to body length for each species/life stage considered with highest survival estimated for small juvenile shad or herring at two inches of length (~99%), and total project survival at Lowell for juvenile alosine-sized fish is estimated at 94.8%. Passage failures were attributed to fish passing downstream via the turbines (2.1% of total losses) and the downstream bypass facility/spill (3.1% of total losses).

The TBSA analysis conducted for adult alosines as part of the Fish Passage Survival Study produced a range of survival estimates for turbine survival through the Project's E.L. Field powerhouse Kaplan units. Within that range of estimates, the probability of mortality due to blade strike increased as body size increased. In the case of adult alosines, the TBSA model tended to overestimate turbine survival.

Effects of continued project operation on the aquatic macroinvertebrate community in the impoundment, canal system, bypassed reach, and Merrimack River

There is limited information available regarding aquatic macroinvertebrates at the Lowell Project. The pneumatic crest gate minimizes impoundment fluctuations and therefore helps to protect benthic macroinvertebrate communities and fish habitat within the littoral zone of the Project impoundment. Boott proposes to continue to operate the Project in ROR mode, for the purpose of protection of fish, aquatic habitat, and wildlife resources.

Hydroelectric projects have been shown to influence benthic macroinvertebrate communities by altering flow conditions and thereby habitat, water quality, and instream transport processes. The severity of impact on aquatic resources is largely influenced by the extent of flow regulation. The Project operates as a ROR facility, which uses the natural flow of the water to produce electricity. As such, flow regulation is minimal at ROR projects, which are often considered low impact facilities compared to peaking and storage hydroelectric projects. Although hydropower operations may affect the macroinvertebrate communities to some degree, the Licensee anticipates that the continued ROR operation of the Project will not affect macroinvertebrate communities.

Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

The primary downstream and upstream fish passage routes are in the mainstem of the Merrimack River, where flows historically have been substantially higher than the flows into the canal system. Under the current license, fish may have entered the canal system when flows were routed to the downtown powerhouses. Once fish entered the canal system, they would have needed to navigate several dams, water conveyance structures, locks, and the downtown mill powerhouses to return to the mainstem of the Merrimack River. None of the features in the canal system are equipped with fish passage structures. However, fish passage studies conducted in support of this license application detected only limited use of the canals by outmigrating diadromous species under elevated canal flow conditions. NAI did not detect any use of the downtown canal system by outmigrating radio-tagged eels in 2019. Furthermore, only two percent of all radio-tagged outmigrating juvenile alosines were determined to have entered the canal system, and there were no radio-tagged outmigrating adult shad determined to have utilized the downtown canal system. Limiting canal flows to an estimated 200 to 300 cfs of leakage make-up flow will further limit or eliminate the likelihood that outmigrating species would be drawn into the canal system.

There is limited information regarding fish species in the Project's canal system, and the Fish Assemblage Study did not include any fish sampling in the canals. The canals do not offer significant habitat for aquatic species. The canal beds consist of ledge, concrete, or wood-planked virgin soil, and there is little cover or structure to attract fish (Boott 2017).

Boott's proposal to decommission the downtown canal units is likely to have a net benefit to fish and aquatic resources. Because flows of up to 2,000 cfs will no longer be periodically routed to the downtown canal system, there is less likelihood that outmigrating diadromous fish will enter the canals. The primary means for fish to enter the canal system will be via the 200 to 300 cfs leakage make-up flow, or via lockages associated with the NPS's canal boat tours, which require a relatively small volume of water passed during a brief period. Even if fish do enter the canal system, Boott is proposing to discontinue generating with the powerhouses' turbines and to seal the penstock intakes. These actions will eliminate the possibility of fish becoming impinged at or entrained by the downtown powerhouses. Accordingly, decommissioning of the Project's downtown powerhouses is expected to have a net benefit on fish and other aquatic resources, particularly for diadromous species.

E.7.3.2.2 Cumulative Effects

In SD2, the Commission identified that migratory fish resources could be cumulatively affected by the continued operation of the Project in combination with other hydroelectric Projects on the river. The geographic scope for the cumulative effects analysis on migratory fish is the Pemigewasset River from the Eastman Falls Dam and the Winnipesaukee River from the Lakeport Dam, to the confluence of the Winnipesaukee and Pemigewasset Rivers (which form the Merrimack River), and the Merrimack River downstream to the Atlantic Ocean.

Boott believes that the continued operation of the Project, as proposed, will limit cumulative effects on the aquatic habitat, and resident and migratory fisheries resources in the impoundment, canal system, bypass reach, and Merrimack River based on the proposed minimum flow, operating the Project to maintain water quality standards, operating the pneumatic crest gate per the operation plan approved by FERC on March 30, 2015, operating fish passage facilities consistent with the CFPP approved by FERC on November 28, 2000.

The current operation of the Project has been designed to consider and support ongoing efforts to maintain resident and migratory fisheries to the Merrimack River Basin. The Project is operated in a ROR mode, consistent with minimum flow requirements, in order to comprehensively address river flows and related hydroelectric project operations to best support aquatic life downstream of the Project, including migratory fish species. Boott has undertaken substantial enhancements in the form of upstream and downstream passage measures at the Project, which should continue to minimize any cumulative effects to fisheries resources in the Merrimack River resulting from operation of the Project.

Similarly, Boott has undertaken a number of studies relative to fish restoration efforts at the Project that are designed to assess not only direct Project effects on fishery resources, but also to examine the potential cumulative effects of the Project on the overall migratory fish restoration efforts.

Operation of the Project may cumulatively affect migratory fish species including American eel, American shad, river herring (alewife and blueback herring). Upstream and downstream fish passage facilities including a fish elevator and downstream fish bypass at the E.L. Field Powerhouse, and a vertical-slot fish ladder at the Pawtucket dam are currently in place at the Project. To date, there has been no significant mortality observed or documented at the Project. Any mortality that may occur from entrainment or impingement of fish species at the Project would contribute to the cumulative effect of the fisheries in the Merrimack River.

Notably, in its 2007 finding on the petition to list the American eel, the USFWS found that:

- The species is highly resilient.
- The reproductive contribution of eels from coastal and estuarine habitat is substantial, and habitat in the lower reaches of a watershed produces more eels than habitat higher in the watershed.
- Loss of habitat resulting from dams does not threaten the long-term persistence of the American eel.
- American eel are able to navigate many barriers.
- Turbines can affect the regional abundance of eel, but no evidence indicates that turbines are affecting the species at the population level (USFWS 2007).

Removing the four mill powerhouses from the Project will result in much lower flows being routed through the downtown canal system, largely eliminating the possibility that outmigrating diadromous fish would be attracted into the canal system, and fully eliminating the possibility of entrainment in the downtown units.

E.7.3.2.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Boott believes that the continued operation of the Project, as proposed, will limit effects on fish and aquatic resources. Specifically:

- Boott proposes to operate the Project in a ROR mode using automatic pond level control of the E.L. Field powerhouse units, to protect fish and wildlife resources downstream from the Project. ROR operation may be temporarily modified for short periods to allow flow management for other project and non-project needs, e.g., downtown canal water level management, raising the crest gates following a high-water event, or for recreational purposes.

- During the upstream fish passage season, which generally runs from late April through mid-July, Boott proposes to release a minimum flow of 500 cfs into the bypass reach via the existing fish ladder at the Pawtucket Dam. The operating period for the fish ladder will continue to be determined annually through consultation with the MRTC, consistent with current practice. At all other times, Boott proposes to release a minimum flow of 100 cfs or inflow, whichever is less, to the bypass reach downstream of the Pawtucket Dam, for the protection of aquatic habitat within the bypass reach.

- Boott proposes continued adherence to the requirements of the Project's existing Crest Gate Operation Plan (approved by FERC on March 30, 2015). Maintaining stable water upstream levels will protect and enhance fish and wildlife habitat in the Project impoundment.
- Boott proposes to replace the existing fish lift with a short fish ladder to pass migratory fish from the E.L. Field powerhouse tailrace to the bypass reach, such that all fish would be passed upstream of the Project via the existing fish ladder at the Pawtucket Dam. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed ladder.
- Following installation and operation of the fish ladder at the tailrace, Boott proposes to cease operations of the upstream fish elevator at the tailrace. The timing of cessation of the upstream fish elevator will be determined based on consultation with the MRTC.
- Boott proposes to continue to work with the MRTC to identify any necessary minor modifications to the existing upstream fish ladder located at the Pawtucket Dam, and/or to the existing weirs in the bypass reach to improve passage.
- Boott proposes the installation of new trashracks or other fish exclusion facility at the E.L. Field Powerhouse which will be consistent with current USFWS passage guidelines , to prevent entrainment of fish through the turbines. Downstream passage of fish will continue to be provided via the existing sluice gate in the left forebay wall of the E.L. Field Powerhouse. The Licensee will consult with the MRTC member agencies to determine the design and installation schedule for the proposed fish exclusion system. Boott reserves the right to seasonally deploy the new trashracks or other exclusion facility only during the downstream fish passage season (mid-May – November), and to use the existing trashracks outside of the fish migration season.
- Boott proposes to develop a Fishways Operation and Management Plan in consultation with the MRTC. The proposed plan would effectively replace the Project's existing Comprehensive Fish Passage Plan.
- Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Ceasing the operation of the mill power station units will eliminate the possibility of outmigrating diadromous fish being entrained through those units.

Boott notes that certain studies required by the Commission are ongoing, including the Three-Dimensional CFD Modeling Study. Boott will consult with stakeholders regarding the results and recommendations of these studies and potential PM&E measures. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.3.3 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those effects that may still occur after implementation of PM&E measures. Operation of the Project may continue to result in the delay or entrainment of American eels, American shad, river herring, Atlantic salmon, striped bass, sea lamprey, and other resident species, but these effects are expected to be limited in scope and will not have an effect at the population level.

E.7.4 Terrestrial Resources

The subsections below describe terrestrial resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, other existing information, and from the results of the Recreation and Aesthetics Study performed by Boott (HDR 2021a), included in Appendix B of this exhibit.

E.7.4.1 Affected Environment

The Merrimack River watershed encompasses approximately 5,010 square miles within the states of New Hampshire and Massachusetts. It is the fourth largest watershed in New England. Although the Merrimack River watershed is heavily forested (75 percent of the land area is covered with forest), it also supports all or parts of approximately 200 communities with a total population of 2.6 million people (USEPA 2020b; USACE 2006).

Ecoregions are used to provide general understandings of vegetation, wetland, and terrestrial habitat in an area (USEPA 1997). The Merrimack River watershed is located in both the Northeastern Highlands ecoregion and the Northeastern Coastal Zone. The north and westerly portions of the watershed, located in the Northeastern Highlands, are characterized by low mountains and mostly ungrazed forest and woodland. The southern portion of the watershed is located in the Northeastern Coastal Zone, which is characterized primarily as modified woodland and forest. However, the states of New Hampshire and Massachusetts report that undeveloped open space along the Merrimack River watershed generally decreases further downstream as riverfront communities are more industrialized (MEOEEA 2001; NHDNCR 2018).

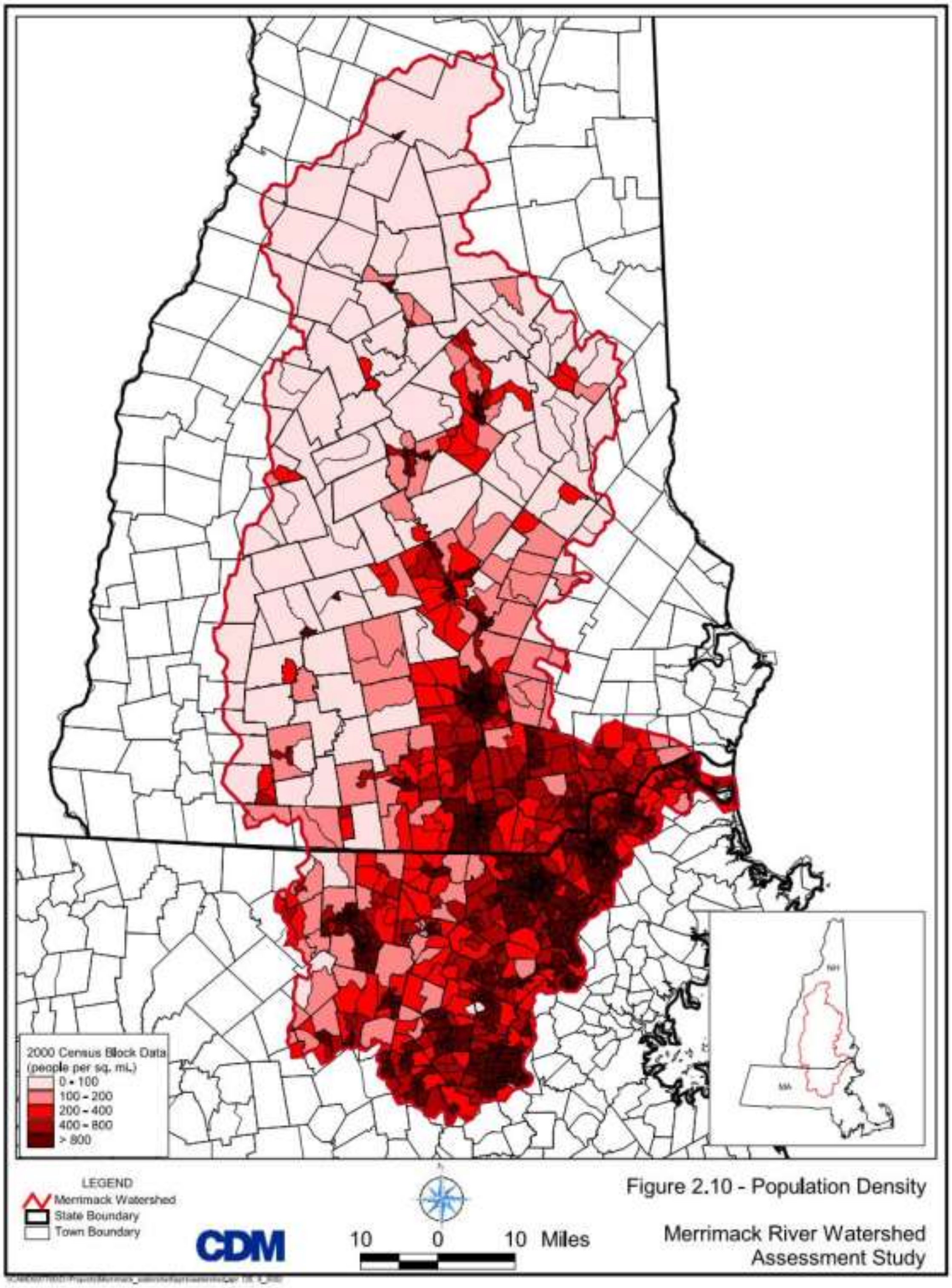
Along the upper northern boundary of the Merrimack River watershed, the relatively undeveloped White Mountain National Forest in New Hampshire provides almost 800,000 acres of protected land; this region also provides over one million acres of private forest and agricultural land (NHDNCR 2018). The Project dam is located at RM 41 on the Merrimack River, and the impoundment extends upstream approximately 23 miles almost to the City of Manchester in New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. In the vicinity of the Project in Lowell, Massachusetts, the Merrimack River flows through a region of rapid population growth and development stemming from the 1800s that is still heavily influenced by the growing Boston urban metropolitan area (Figure E.7-21).

The area near the Project's dam and E. L. Field powerhouse is urban in nature and the vegetation found within the project area is typical of an urbanized setting in this region. The project area has sparsely vegetated shorelines and a narrow riparian corridor consisting of grasses, weeds, and scattered wild shrubs. Early successional/young forest/shrub lands cover types occur in scattered patches along the shoreline of the river intermixed with small stands of mature forest and disturbed sites (fill slopes and millwork areas adjacent to developed sites) (FERC 2011). The developed lands nearby include the University of Massachusetts - Lowell, a variety of housing and residential subdivisions and an extensive network of roads and highways. The area south of these primary power-generating facilities includes several industrial sites, and the bisecting 5.5-mile downtown canal system.

The Merrimack River watershed's land use composition, from the relatively undeveloped White Mountain National Forest in northern New Hampshire to highly urbanized areas along the mainstem of the Merrimack River, is reflected in the basin's general land use and terrestrial resources (Figure E.7-22).

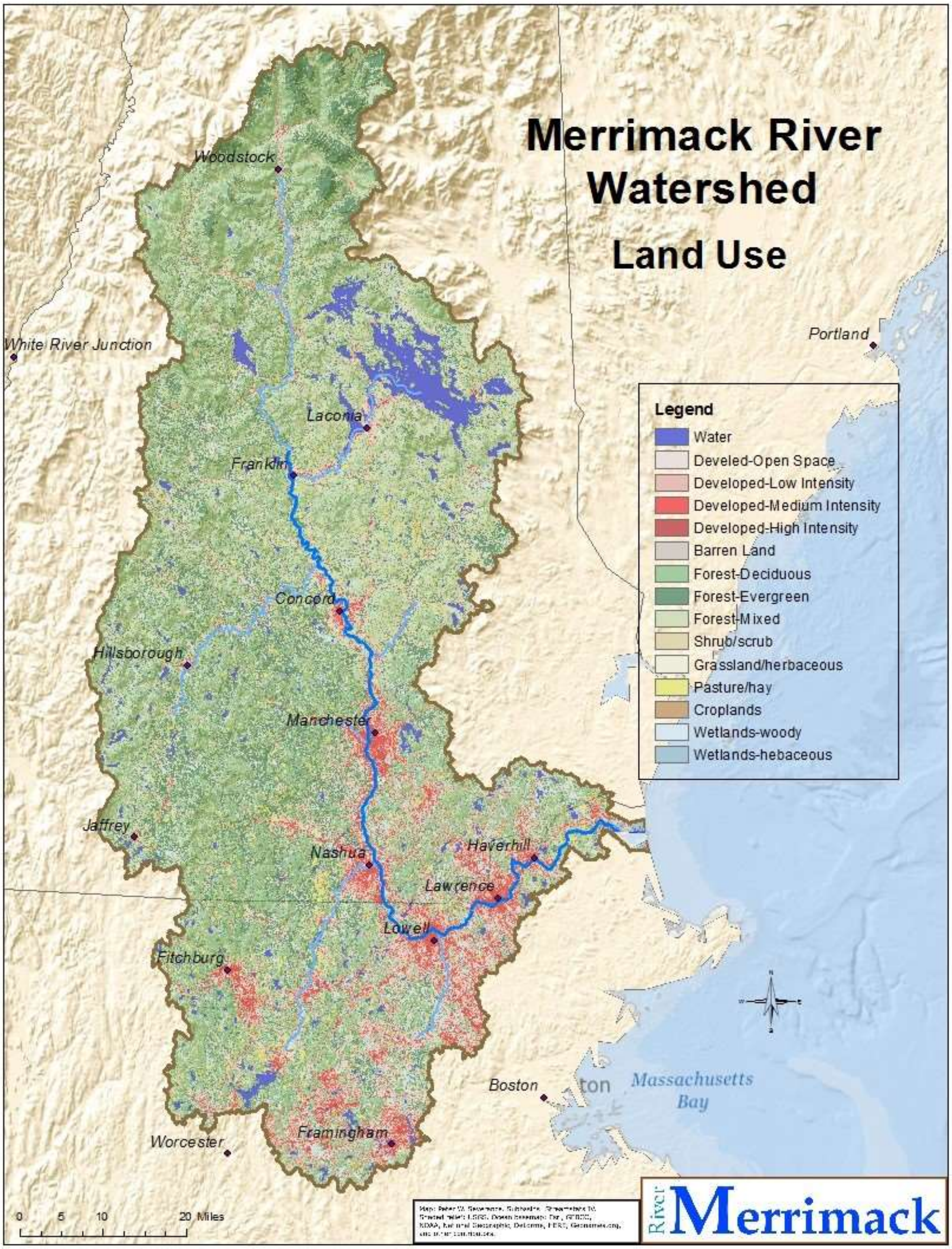
For purposes of describing the existing condition of terrestrial wildlife and botanical resources, this discussion has been divided into the following subsections: (1) botanical resources, (2) wetland, riparian, and littoral habitat, and (3) wildlife. As appropriate, these subsections describe other germane studies conducted by Boott relative to their resource areas.

Figure E.7-21. Population Density in the Merrimack River Basin



Source: USACE 2002

Figure E.7-22. Land Use in the Merrimack River Basin



Source: Merrimack River Watershed 2018.

E.7.4.1.1 Recreation and Aesthetics Study

In accordance with the Commission's SPD, Boott conducted a Recreation and Aesthetics Study to determine the adequacy and capacity of existing recreational facilities, assess potential effects of water levels and flow rates on existing recreational facilities, other forms of recreational assessments, and identify areas within the canal system where vegetation growth on historic canal walls are a concern. Methods and results of the Recreation and Aesthetics Study are described in detail in Boott's Recreation and Aesthetics Study report (HDR 2021a) which was filed with the Commission on February 25, 2021. A portion of the results of this study were used to help form the baseline characterization of terrestrial habitat and wildlife within the Project area; as such the study methods are summarized in this section, with the relevant results discussed in the subsections below.

Boott conducted a Recreation and Aesthetics Study, in part, to identify areas within the canal system where vegetation growth on historic canal walls are a concern, including background literature reviews, desktop analyses, and field investigations.

The visual survey for vegetation growth was conducted between September 25 and 27, 2019. The survey was conducted to identify vegetation growth along the canal walls within the study area. Technicians identified the relative quantity and spatial distribution of each vegetation type using aerial photography and observations of habitat and specific plant species occurrences. Terrestrial vegetation types occurring in the study area were described based on a review of existing information, an inspection of aerial photography, a review of the USGS 7.5-minute quadrangles, and observations of habitat and specific vegetation type occurrences during the field surveys.

For the purposes of examining vegetation type distribution, the study area was divided into the six canals associated with the Lowell Project canal system including: 1) Pawtucket Canal, 2) Northern Canal, 3) Western Canal, 4) Merrimack Canal, 5) Eastern Canal, and 6) Hamilton Canal.

Visual qualitative surveys were conducted in the study area by foot along the shorelines of the canals, or via an NPS boat for the surveys conducted in the Pawtucket Canal from the Swamp Locks and Dam to the Merrimack River. Vegetation was characterized by dominant type (i.e., Herbaceous, Scrub-Shrub, Trees, Forested, or Mixed). The vegetation type assessments were based on overall dominant vegetation characteristics at the time of the survey that may have variations within small areas. In addition, the shoreline/canal was characterized by dominant features (i.e., Block Wall, Concrete, Earthen/Terrestrial Cultural, Stone Wall, Block Wall/Concrete/Stone Wall Mix).

Mapped Vegetation Polygons and Vegetation Points (VPs)[20] were located using an EOS Positioning Systems Arrow 100™ GNSS receiver linked to an iPad™ Air 2 or Android device operating Collector for ArcGIS™ hand-held Global Positioning System (GPS) unit (equipped with a data dictionary aiding in feature attribution). The presence and extent of cover of the vegetation on/along the canal walls observed at the time of the field survey

[20] Vegetation points were used to identify areas along canal walls where a single vegetation type point was recorded. Vegetation points generally identify where a single species (e.g., shrub, tree) was located.

was evaluated based on photographs and field observations. Geospatial vegetation data were transferred to a Geographic Information System (GIS) format and used to develop both visual maps depicting vegetation presence boundaries and VPs along the canal walls as well as tabular information quantifying the abundance and distribution of dominant vegetation types in the study area. Vegetation polygons were then analyzed to calculate the percentage represented by each vegetation category within each canal; VPs were not included in vegetation category percentage calculations because they represent a single point on the canal wall.

Relevant study results are discussed in the subsections below. As noted above, these subsections also describe other germane studies conducted by Boott relative to their resource areas.

E.7.4.1.2 Botanical Resources[21]

As presented in Section E.7.1, the Project is located in both the Northeastern Highlands ecoregion and the Northeastern Coastal Zone. The north and westerly portions of the watershed, located in the Northeastern Highlands, are characterized by low mountains and mostly ungrazed forest and woodland. The southern portion of the watershed is located in the Northeastern Coastal Zone, which is characterized primarily as modified woodland and forest. The Project is also located in the New England Physiographic Province. The Taconic, Green, and White Mountain ranges are distinct features of the New England Physiographic Province. The Taconic Mountains are a north-south trending mountain range along the western edge of the province and are thought to be formed by erosion of an upper block of a large thrust fault. Also, north-south trending, the Green Mountains exist primarily in Vermont and are made of Precambrian gneisses. The White Mountains are an exhumed mass of Paleozoic granite and include Mt Washington in New Hampshire, the tallest mountain in the region at 6,288 feet (NPS undated *a*).

The Lowell Project is located in the Seaboard Lowlands Section of the New England Physiographic Province. The Seaboard Lowlands Section is lower in elevation and less hilly than the adjacent New England Upland Section. Fenneman considered the Seaboard Lowlands Section as the sloping margin of the uplands, although it also roughly coincides with the area inundated by the ocean and areas of large proglacial lakes during the last glacial retreat (Stone and Borns 1986 as cited in Flanagan et al. 1999). In the vicinity of the Project, the Merrimack River flows through a region of rapid population growth and development that is heavily influenced by the Lowell metropolitan area. The local relief in the Merrimack River Valley in the Project vicinity is generally characterized as low, open hills.

Botanical resources in the Merrimack River corridor vary between urban areas and nonurban areas. In the vicinity of the Lowell Project, botanical resources are dominated by hemlock-hardwood-pine, Appalachian oak-pine, and grasslands (NHDFG 2015). These habitat types are discussed below in further detail.

[21] State-listed RTE plant species are discussed in Section E.7.5 of this Exhibit.

Hemlock-Hardwood-Pine Forest

Hemlock-hardwood-pine forest is a wide-spread habitat in the lower Merrimack River corridor. It is a transitional forest between Appalachian oak-pine and northern hardwood found at elevations less than 400 feet and greater than 1,500 feet, respectively. White pine (*Pinus strobus*) and eastern hemlock (*Tsuga canadensis*) are the dominant trees, but American beech (*Fagus grandifolia*) and patches of sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), and red oak (*Quercus rubra*) contribute to a variable species mix of this forest type. The understory contains small trees and shrubs such as witch hazel (*Hamamelis virginiana*), maple-leaved viburnum (*Viburnum acerifolium*), black birch (*Betula nigra*), black cherry (*Prunus serotina*), and ironwood (*Ostrya virginiana*). Typical plants found on the forest floor include starflower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadensis*), and wild sarsaparilla (*Aralia nudicaulis*).

Most white pine stands that have grown up from abandoned pastures are examples of this type of hemlock-hardwood pine forest habitat. On fertile soils, white pine is replaced by hemlock or hardwoods over time. Older forests that have succeeded to later stages contain patches of larger diameter trees (>18 inches) hemlock or beech in the canopy, layers of young trees and shrubs in the understory, many standing dead trees, and abundant decaying wood on the forest floor. Large-sized cavity trees, pockets of wetlands, patches of acorn-rich oaks, seeps, and tall pine trees make some patches of this forest type especially rich for wildlife (NHDFG 2015; Swain 2020).

Appalachian Oak-Pine Forest

Appalachian oak-pine forests, with their abundance of nut-bearing oaks such as red oak, white oak (*Quercus alba*), and black oak (*Q. velutina*), and hickories such as shagbark (*Carya ovata*), pignut (*C. glabra*), and sweet pignut (*C. ovalis*), provide a rich food source for wildlife such as ruffed grouse (*Bonasa umbellus*), turkey (*Meleagris gallopavo*), gray squirrels (*Sciurus carolinensis*), and eastern chipmunks (*Tamias striatus*). Common understory shrubs and smaller trees of this forest type include black birch (*Betula lenta*), bigtooth aspen (*Populus grandidentata*), sassafras (*Sassafras albidum*), and yellow birch (*Betula alleghaniensis*). Blueberries (*Vaccinium angustifolium* and *V. pallidum*), black huckleberry (*Gaylussacia baccata*), sheep laurel (*Kalmia angustifolia*), and Pennsylvania sedge (*Carex pennsylvanica*), are typical understory plants. Raptors such as northern goshawk (*Accipiter gentilis*) feed on small mammals and find nesting and perching sites in white pines in the tree canopy. White pines adjacent to the Merrimack River provide key nest and perch sites for bald eagles (*Haliaeetus leucocephalus*), great blue herons (*Ardea herodias*), and osprey (*Pandion haliaetus*) (NHDFG 2015).

Many stands of Appalachian oak-pine forest are of the same age, approximately 80-100 years. They grew after farms were abandoned throughout the last century. Many wildlife species found in this forest type are attracted to patches of old or young trees within the larger forested landscape. Historically, the dry soils and warm temperatures in this region allowed occasional low-intensity fires to burn in these forests. Without fire, these forests have a higher proportion of white pine, hemlock, sugar maple and birch species (*Betula* spp.), than nut-bearing trees. Mature Appalachian oak-pine forests may also be denser due to a lack of low ground fires to maintain an open understory (NHDFG 2015).

Grasslands

The most common grassland habitats in the lower Merrimack River corridor are agricultural fields such as hayfields, pastures, and fallow fields. Grassland vegetation is a mixture of grass species, or a combination of grasses, sedges, and wildflowers. Most plants found in grasslands are non-native grasses, introduced for agricultural use. These include timothy (*Phleum pretense*), Kentucky bluegrass (*Poa pratensis*), orchard grass (*Dactylis glomerata*), and perennial ryegrass (*Lolium perenne*). Common native plants include big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), and a variety of species of the wildflower genera including goldenrod species (*Solidago* spp.) and various Aster. Vegetation growing in grassland habitat ranges from less than 6 inches to over four feet in height. Vegetation height plays an important role in determining which wildlife species will use it. Few, if any, trees or shrubs are found in grasslands. Unless maintained, most grasslands will return to forest habitat (NHDFG 2015).

Major-River Floodplain Forest

The immediate shoreline of the Merrimack River and some portions of the canals within the Project area (e.g., the Pawtucket Canal near the confluence of the Merrimack River) include areas of floodplain forest and some of these areas have characteristics of Major-river Floodplain Forest as described by Swain (2020). Major-river floodplain forests are deciduous forested wetland communities, which develop next to rivers and streams and receive annual (or semi-annual) overbank flooding and alluvial silt deposition. Soils are predominantly sandy loams without soil mottles and without a surface organic layer. Flooding at these sites occurs annually and can be severe. An island variant of Major-river Floodplain Forests occurs on elevated sections of riverine islands and riverbanks of major rivers, where there are high levels of both natural and human disturbance. All floodplain forest communities in Massachusetts have silver maple (*Acer saccharinum*) as the defining tree, but associated plant species vary depending on the intensity and duration of the flooding and on geographic location. Common plant species occurring with silver maple include cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), and/or slippery elm (*U. rubra*) in the subcanopy and shrubs are generally lacking. The herbaceous layer is usually dominated by a 3-6 ft. (1-2 m) tall, dense cover of wood-nettles (*Laportea canadensis*) and ostrich fern (*Matteuccia struthiopteris*) is sometimes abundant (Swain 2020). Other species growing along the upland margins include tree of heaven (*Ailanthus altissima*), staghorn sumac (*Rhus typhina*), the non-native bittersweet (*Celastrus orbiculatus*), riverbank grape (*Vitis riparia*), Virginia creeper (*Parthenocissus quinquefolia*), scattered Siberian elm (*Ulmus pumila*), purple loosestrife (*Lythrum salicaria*), poison ivy (*Toxicodendron radicans*), Boston ivy (*Parthenocissus tricuspidata*), mullein (*Verbascum thapsus*), and common ragweed (*Ambrosia artemisiifolia*) (HDR 2021a).

Ruderal Herbaceous/Scrub-Shrub/Forested

Ruderal Herbaceous/Scrub-Shrub/Forested areas in the Project vicinity are largely anthropogenic communities of herbaceous or mixed scrub-shrub and forested vegetation resulting from succession following complete or partial removal of native woody cover.

These communities are found in areas where the native forest vegetation has been cleared or partially cleared, in old fields, hedgerows, pedestrian walkways, along Project canals, roadways, etc. Characteristic species can include red maple, American elm, Siberian elm, bush honeysuckles (*Lonicera* spp.), tree of heaven, Boston ivy, poison ivy, goldenrods (*Solidago* spp.), and various grass species (HDR 2021a).

2019 Visual Survey for Vegetation Growth

In September 2019, a visual survey was conducted to identify vegetation growth along the canal walls within the Project area. A wide variety of vegetation types, occurrences, and distribution, ranging from herbaceous, non-woody plants to forested areas of trees and underbrush, and shoreline/canal types, ranging from earthen embankments to placed, uniformly sized blocks were observed during the study. In total, 96 Vegetation Polygons (representing 80% of the total survey data collected in the study area) and 24 VPs (representing 20% of the total survey data collected in the study area) were mapped between September 25 and September 27, 2019. As shown in Table E.7-25, the total study area encompassed approximately 44 acres and mapped vegetation on/along canal walls accounted for approximately 5 acres (11%) of the study area[22]. The Pawtucket Canal (19.63 acres; 44% of the total study area), Northern Canal (11.67 acres; 26% of the total study area), and Western Canal (5.51 acres; 13% of the total study area) represent more than 80 percent of the total study area (Table E.7-25).

At the time of the study, most mapped VPs within the total study area had a dominant vegetation type of Scrub-Shrub (46% of the total VP count), followed closely by Trees (38% of the total VP count). The majority of mapped Vegetation Polygons within the total study area had a dominant vegetation type of Mixed (41% of the total mapped vegetation area) at the time of the study. Mapped vegetation polygons with a dominant vegetation type of Forested were only recorded within the Western Canal (53% of the Western Canal study area), and the Northern Canal (28% of the Northern Canal study area) at the time of the study (HDR 2021a).

Maps showing the results of the vegetation assessment and mapping within the study area are illustrated in a 21-sheet, 11 by 17-inch vegetation type map set with numbered polygons (e.g., 1, 2) and VPs (e.g., VP1, VP2) for each vegetation polygon and/or VP, respectively in Appendix G of the Recreation and Aesthetics Study Report (HDR 2021a). Additionally, results from the canal wall vegetation mapping are compiled in Appendix H and field reconnaissance data is summarized in Appendix I of the Recreation and Aesthetics Study Report.

[22] VPs are not included in mapped vegetation acreage calculations because they represent a single point(s) on a canal wall.

Table E.7-25. Percent total acreage and mapped vegetation acreage of the six major canals associated with the Lowell Project Canal system

Canal	Area (acres)	Percentage (%) of Total Study Area	Mapped Vegetation Area (acres)	Percentage (%) of Total Study Area with Mapped Vegetation
Eastern Canal	4.03	9%	0.93	2%
Hamilton Canal	2.01	5%	0.35	1%
Merrimack Canal	1.40	3%	0.38	1%
Northern Canal	11.67	26%	0.89	2%
Pawtucket Canal	19.63	44%	1.33	3%
Western Canal	5.51	13%	0.90	2%
Total	**44.25**	**100%**	**4.78**	**11%**

Source: HDR 2021a

E.7.4.1.3 Invasive Plant Species

Invasive species are defined as non-indigenous plant or animal species that aggressively compete with native species. These species often out-compete local native species, impacting biodiversity, recreation, and human health. Invasive plants tend to appear on disturbed ground, and the most aggressive have the ability to invade existing ecosystems.

Non-native invasive species and noxious weeds are typically prolific pioneering species that have the ability to quickly outcompete native vegetation. These species grow rapidly, mature early, and effectively spread seeds that can survive for significant periods in the soil until site conditions are favorable for growth. Invasive plant species are prevalent throughout the Merrimack River Valley, as indicated by the IPANE (IPANE Undated), and have been observed along the banks of the Merrimack River, the Project's canals, and in some vegetation communities within the Project area. Of the 2,263 plant species in Massachusetts that have been documented as native or naturalized, about 725 (32%) are naturalized. Of these, the Massachusetts Invasive Plant Advisory Group (MIPAG) recognized 69 species as "Invasive," "Likely Invasive," or "Potentially Invasive" (Commonwealth of Massachusetts 2020). In accordance with the Invasive Species Act, HB 1258-FN, the New Hampshire Department of Agriculture, Markets & Food, Division of Plant Industry is the lead state agency responsible for the evaluation, publication and development of rules on invasive plant species for the purpose of protecting the health of native species, the environment, commercial agriculture, forest crop production, or human health in New Hampshire. New Hampshire's Prohibited Invasive Plant Species List identifies 35 species. These invasive species are provided in Table E.7-26 and include non-native species that have spread into native or minimally managed plant systems and can cause economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems.

Table E.7-26. Invasive Plant Species in Massachusetts and Prohibited Invasive Plant Species in New Hampshire

Common Name	Scientific Name	Common Name	Scientific Name
Norway maple	*Acer platanoides*	Creeping jenny	*Lysimachia nummularia*
Sycamore maple	*Acer pseudoplatanus*	Purple loosestrife	*Lythrum salicaria*
Bishop's goutweed	*Aegopodium podagraria*	Variable water-milfoil	*Myriophyllum heterophyllum*
Tree of heaven	*Ailanthus altissima*	European water-milfoil	*Myriophyllum spicatum*
Garlic mustard	*Alliaria petiolata*	Reed canary-grass	*Phalaris arundinacea*
Japanese barberry	*Berberis thunbergii*	Common reed	*Phragmites australis*
Carolina fanwort	*Cabomba caroliniana*	Japanese knotweed	*Polygonum cuspidatum*
Oriental bittersweet	*Celastrus orbiculatus*	Crisped pondweed	*Potamogeton crispus*
Black swallow-wort	*Cynanchum louiseae*	Lesser celandine	*Ranunculus ficaria*
Autumn olive	*Elaeagnus umbellata*	Common buckthorn	*Rhamnus cathartica*
Winged euonymus	*Euonymus alatus*	Black locust	*Robinia pseudoacacia*
Leafy spurge	*Euphorbia esula*	Multiflora rose	*Rosa multiflora*
European buckthorn	*Frangula alnus*	Water-chestnut	*Trapa natans*
Sea or horned poppy	*Glaucium flavum*	European black alder	*Alnus glutinosa*
Dame's rocket	*Hesperis matronalis*	European barberry	*Berberis vulgaris*
Yellow iris	*Iris pseudacorus*	Spotted knapweed	*Centaurea stoebe ssp. micranthos*
Broad-leaved pepperweed	*Lepidium latifolium*	Pale swallow-wort	*Cynanchum rossicum*
Japanese honeysuckle	*Lonicera japonica*	Giant hogweed	*Heracleum mantegazzianum*
Morrow's honeysuckle	*Lonicera morrowii*	Ornamental jewelweed	*Impatiens glandulifera*
Bell's honeysuckle	*Lonicera x bella*	Japanese stilt grass	*Microstegium vimineum*
Amur honeysuckle	*Lonicera maackii*	Blunt-leaved privet	*Ligustrum obtusifolium*
Tartarian honeysuckle	*Lonicera tatarica*	Common privet	*Ligustrum vulgare*
Mile-a-minute weed	*Persicaria perfoliata*	Bohemia knotweed	*Reynoutria x bohemica*
Kudzu	*Pueraria montana*	Reed sweet grass	*Glyceria maxima*
Giant knotweed	*Reynoutria sachalinensis*	--	--

Sources: Commonwealth of Massachusetts 2020; New Hampshire Department of Agriculture, Markets & Food, Division of Plant Industry 2017; IPANE Undated

As part of the 2019 and 2020 relicensing studies, ten plant species, which are designated as invasive or prohibited species (Commonwealth of Massachusetts 2020; New Hampshire Department of Agriculture, Markets & Food, Division of Plant Industry 2017), were incidentally observed in the Project's vicinity:

- Tree of heaven
- Japanese barberry
- Japanese knotweed
- Oriental bittersweet
- Autumn olive
- Winged euonymus
- Japanese honeysuckle
- Purple loosestrife
- Common buckthorn, and
- Black locust

E.7.4.1.4 Wetland, Riparian, and Littoral Habitats

Wetlands are generally defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Most formal wetland definitions emphasize three primary components that define wetlands: the presence of water, unique soils, and hydrophytic vegetation. The USFWS (Cowardin et al. 1979) defines wetlands as follows:

> *…lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have been one or more of the following three attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some point during the growing season of the year.*

Riparian habitats are areas that support vegetation found along waterways such as lakes, reservoirs, rivers, and streams. The boundary of the riparian area and the adjoining uplands is gradual and not always well defined. However, riparian areas differ from the uplands because of their high levels of soil moisture, frequency of flooding, and unique assemblage of plant and animal communities (Virginia State University 2000). These habitats can range from mature forests to areas covered by emergent vegetation and shrubs. Riparian habitats are unique because of their linear form and because they process large fluxes of energy and materials from upstream systems (Mitsch and Gosselink 1993). Riparian areas and the associated vegetation provide important habitat for wildlife and often contain a higher number of species, both plant and animal, than surrounding upland areas due to the proximity to water. These areas are also important avian habitats for resident and migratory birds. Riparian habitats typically function as travel corridors for migratory wildlife species. The riparian zone serves as the primary interface between riverine and upland habitats, influencing both the primary productivity and food resources within a river. Primary wildlife resources associated with riparian habitats include early spring plant growth in lowland riparian habitats, which provide food sources for migrating birds, white-tailed deer, and other wildlife species.

The USFWS, MADEP, and the NHDES have jurisdiction over wetlands within the Project area. The MADEP's and NHDES's wetland definition is consistent with the USFWS' wetland definition.

Terrestrial habitat conditions in the Project area and upstream along the Merrimack River are largely a result of land use, especially of urban and suburban development (Boott Mills 1980). Based on USFWS National Wetland Inventory (NWI) mapping, wetlands along the Merrimack River primarily consist of low-lying areas near and adjacent to the river, with other isolated wetlands farther away from the river proper. The USEPA has designated the Merrimack River from Franklin, New Hampshire, to Lowell, Massachusetts, as a Priority Waterbody/Wetland due to its importance to waterfowl and fish populations (Carley 2001 as cited in USACE 2003).

There are MADEP and NHDES wetlands and NWI wetlands encompassed within, adjacent to, or in close proximity to the Project boundary. Most of the MADEP, NHDES, and NWI mapped wetland boundaries overlay each other[23]. Within the current Project boundary there are approximately 739.2 acres of MADEP wetland, approximately 6.4 acres of NHDES wetland, and approximately 1,659 acres of NWI wetlands. The 745.6 acres of MADEP and NHDES wetlands are mostly encompassed within the 1,659 acres of NWI wetlands (MassGIS 2018; NH GRANIT undated).

Wetlands currently mapped by the USFWS NWI within the proposed Project boundary are presented in Figure E.7-23 through Figure E.7-24 and are summarized in Table E.7-27. Table E.7-27 provides mapping code descriptions for the NWI codes found on the wetland base maps (USFWS 2020a). The wetlands directly surrounding the Lowell Project are largely considered riverine wetlands with an unconsolidated bottom (Figure E.7-23 through Figure E.7-24). Riverine wetlands include all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 parts per thousand (or greater (Cowardin et al. 1979).

According to a review of GIS data (Massachusetts Bureau of Geographic Information [MassGIS]), there are no Massachusetts Natural Heritage and Endangered Species Program certified vernal pools within the Project boundary. Potential vernal pools were also identified using GIS data. According to MassGIS (2018), two potential vernal pools are located within 100 feet of the Project boundary, but not within the Project boundary.

No formal survey data on wetlands at or near the Project is available. However, based on observations made during the Recreation and Aesthetics Study, as well as during other relicensing studies, riparian vegetation within the Project area appears to be consistent with these areas of New Hampshire and Massachusetts. Where steep banks present themselves, the riparian corridor is narrow with wetland vegetation only occurring immediately adjacent to the river/land interface. Where the shoreline is more gradual and the Merrimack River floodplain extends away from the current river course, palustrine wetlands cover areas of former oxbows, floodplain, and low-lying areas.

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[23] The NHDES wetland data GIS layer only included data for the Palustrine System within the Project boundary.

Massachusetts floodplain communities are typically dominated by river birch (*Betula nigra*) associations (USACE 2003). Development activity is contributing to the decline of these riparian communities in Massachusetts (Carley 2001 as cited in USACE 2003). The palustrine forested wetland habitats located within and adjacent to the Project boundary are primarily dominated by broad-leaved deciduous subclasses located along forested floodplains. These areas are characterized by their flood regime; lower areas are annually flooded in spring, whereas higher areas are flooded irregularly. Common trees include silver maple, red maple, green ash (*Fraxinus pennsylvanica*), and American elm. The shrub layer may include silky dogwood (*Cornus amomum*) and buttonbush (*Cephalanthus occidentalis*). Common herbaceous species may include sensitive fern (*Onoclea sensibilis*), false nettle (*Boehmeria cylindrica*), water hemlock (*Cicuta maculata*), swamp candles (*Lysimachia terrestris*), and water parsnip (*Sium suave*) (Swain 2020).

Figure E.7-23. Wetlands in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary

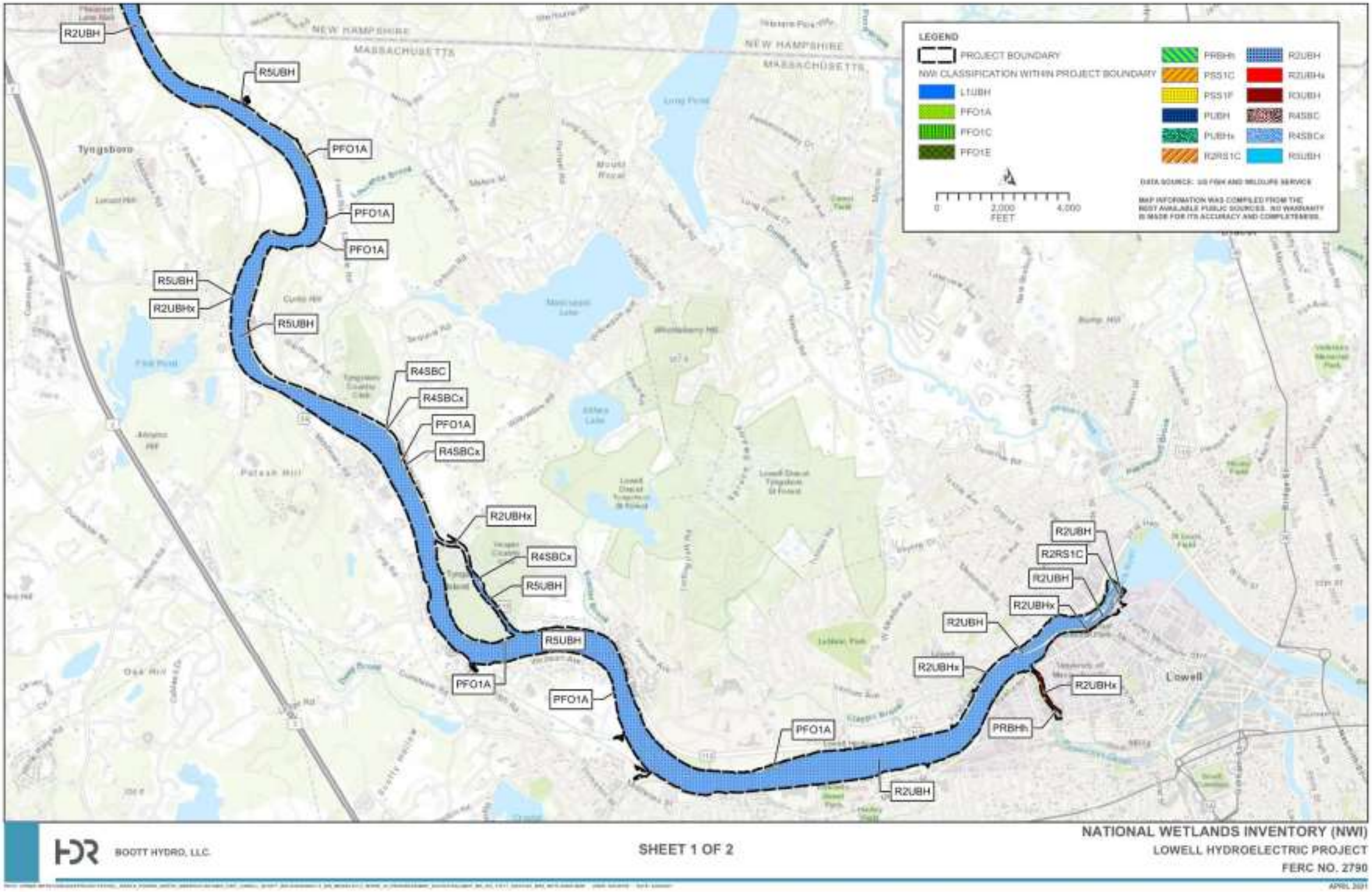


Figure E.7-24. Wetlands in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary

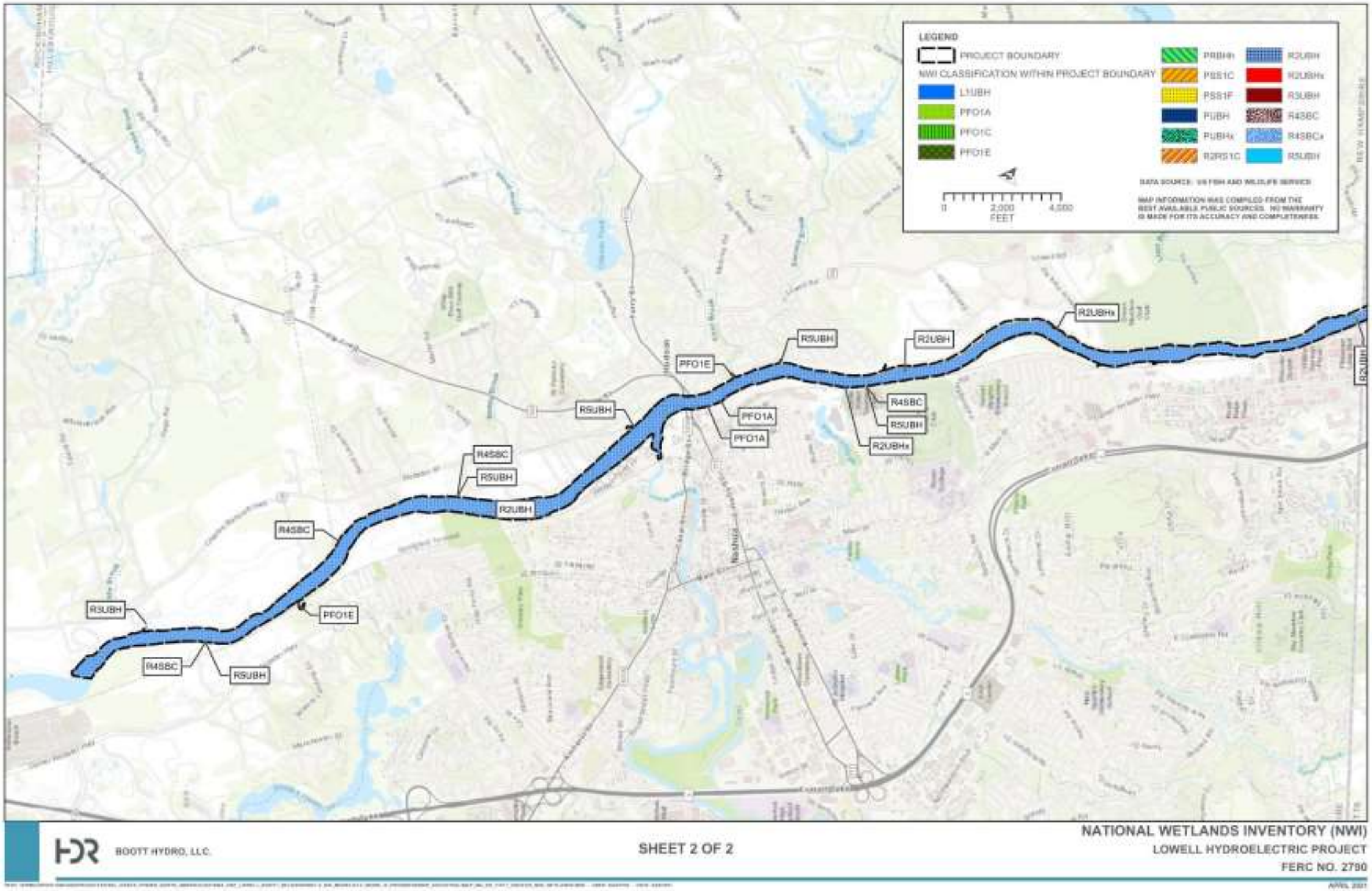


Table E.7-27. National Wetlands Inventory Classification System

Wetlands Code	System	Subsystem	Class	Subclass	Water Regime	Qualifier
R2UBH	Riverine	Lower Perennial	Unconsolidated Bottom	--	Permanently Flooded	--
R2UBHx	Riverine	Lower Perennial	Unconsolidated Bottom	--	Permanently Flooded	Excavated
R3UBH	Riverine	Upper Perennial	Unconsolidated Bottom	--	Permanently Flooded	--
R2RS1C	Riverine	Lower Perennial	Rocky Shore	Bedrock	Seasonally Flooded	--
R4SBC	Riverine	Intermittent	Streambed	--	Seasonally Flooded	--
R4SBCx	Riverine	Intermittent	Streambed	--	Seasonally Flooded	Excavated
R5UBH	Riverine	Unknown Perennial	Unconsolidated Bottom	--	Permanently Flooded	--
PUBH	Palustrine	--	Unconsolidated Bottom	--	Permanently Flooded	--
PUBHx	Palustrine	--	Unconsolidated Bottom	--	Permanently Flooded	Excavated
L1UBH	Lacustrine	Limnetic	Unconsolidated Bottom	--	Permanently Flooded	--
PFO1A	Palustrine	--	Forested	Broad-leaved Deciduous	Temporarily Flooded	--
PFO1C	Palustrine	--	Forested	Broad-leaved Deciduous	Seasonally Flooded	--
PFO1E	Palustrine	--	Forested	Broad-leaved Deciduous	Seasonally Flooded/ Saturated	--
PSS1F	Palustrine	--	Scrub-Shrub	Broad-leaved Deciduous	Semipermanently Flooded	--
PSS1C	Palustrine	--	Scrub-Shrub	Broad-leaved Deciduous	Seasonally Flooded	--
PRBHh	Palustrine	--	Rock Bottom	--	Permanently Flooded	Diked/ Impounded

Source: USFWS 2020a.

E.7.4.1.5 Wildlife

The Merrimack River corridor provides habitat for a diversity of wildlife species. Diverse habitats such as wetlands, forests, fields, as well as the river and associated tributaries support a variety of species. The quality and types of habitat that the Merrimack River corridor provides is what dictates which wildlife species occupy and use it. The

Merrimack River mainstem is categorized as a large/great river habitat (Olivero and Anderson 2008). Large river habitats such as the Merrimack River support a diverse wildlife community which includes many of the mammalian, reptilian, and amphibian species found in northeastern North America.

Mammals

Mammals present in the vicinity of the Lowell Project are those commonly found throughout the region that are adapted to living near humans and urban areas. Some large mammal species that require extensive habitat areas, or species that require solitude, such as moose (*Alces alces*) and black bear (*Ursus americanus*), typically prefer less developed environments that are scarce in the lower Merrimack River corridor and the Lowell Project. White-tailed deer (*Odocoileus virginianus*) is the most common big game species in the Project vicinity, occurring in a wide variety of habitats ranging from forests to agricultural land. This species is most prevalent along forest edges characterized by brushy and woody vegetation, swamp borders, and areas interspersed with fields and woodland openings (DeGraaf and Yamasaki 2001; Doutt et al. 1977). Raccoon (*Procyon lotor*) are also common, especially along the riparian corridor associated with the Merrimack River within the Project vicinity. Other mammals present in the Project vicinity include furbearers, small game species, rodents, and bats. These wildlife species reside in many different habitat types such as woodland, scrub-shrub or early successional areas, and grassland areas; use of these areas may shift during different life stages and/or times or year (DeGraaf and Yamasaki 2001; Doutt et al. 1977).

Mammals typically found in woodland and riparian areas include northern raccoon, long-tailed weasel (*Mustela frenata*), eastern gray squirrel (*Sciurus carolinensis*), American mink (*Mustela vison*), and marten (*Martes martes*). Bat species may include the red bat (*Lasiurus borealis*), silver haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), and little brown bat (*Myotis lucifugus*). These mammals are normally found in woodland/riparian areas due to food requirements, predator/prey relationships, and a preference by several species for trees as den or nest sites (DeGraaf and Yamasaki 2001; Doutt et al. 1977).

Mammals typically found in grassland areas include the meadow vole (*Microtus pennsylvanicus*), house mouse (*Mus musculus*), and the deer mouse (*Peromyscus maniculatus*). Several species of bats also are likely to use these areas or manmade structures within these areas of the Project vicinity. Additionally, several species typical of grassland mammals can be found in multiple habitat types due to their generalized requirements. Coyotes, for example, use woodlands, wetlands, and grasslands in addition to scrub-shrub areas for foraging, dens, and travel corridors (DeGraaf and Yamasaki 2001; Doutt et al. 1977). Table E.7-28 lists the mammalian species potentially occurring in the vicinity of the Lowell Project. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-28. Mammalian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Beaver	*Castor canadensis*
Big brown bat	*Eptesicus fuscus*
Black bear	*Ursus americanus*
Black rat	*Rattus rattus*
Bobcat	*Lynx rufus*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Eastern chipmunk*	*Tamias striatus*
Eastern red bat	*Lasiurus borealis*
Ermine	*Mustela ermina*
Fisher	*Pekania pennanti*
Gray fox	*Urcyon cinereoargenteus*
Gray squirrel*	*Sciurus carolinensis*
Hairy-tailed mole	*Parascalops breweri*
Hoary bat	*Lasiurus cinereus*
House mouse*	*Mus musculus*
Little brown bat	*Myotis lucifugus*
Long-tail weasel	*Mustela frenata*
Long-tailed shrew	*Sorex dispar*
Masked shrew	*Sorex cinereus*
Meadow jumping mouse	*Zapus hudsonicus*
Meadow vole	*Microtus pennsylvanicus*
Mink	*Mustela vison*
Moose*~	*Alces alces*
Muskrat	*Ondatra zibethicus*
Northern flying squirrel	*Glaucomys sabrinus*

Common Name	Scientific Name
Northern short-tailed shrew	*Blarina brevicauda*
Norway rat	*Rattus norvegicus*
Porcupine	*Erethizon dorsatum*
Pygmy shrew	*Sorex hoyi*
Raccoon*	*Procyon lotor*
Red fox	*Vulpes vulpes*
Red squirrel*	*Tamiasciurus hudsonicus*
River otter	*Lontra canadensis*
Silver-haired bat	*Lasionycteris noctivagans*
Small-footed bat	*Myotis leibii*
Smoky shrew	*Sorex fumeus*
Snowshoe hare	*Lepus americanus*
Southern bog lemming	*Synaptomys cooperi*
Southern flying squirrel	*Glaucamys volans*
Southern red-backed vole	*Clethrionomys gapperi*
Star-nosed mole	*Condylura cristata*
Striped skunk	*Mephitis mephitis*
Tricolored bat	*Perimyotis subflavus*
Virginia opossum	*Didelphis virginiana*
Water Shrew	*Sorex palustris*
White-footed mouse	*Peronyscus leucopus*
White-tailed deer	*Odocoileus virginianus*
Woodchuck*	*Marmota monax*
Woodland jumping mouse	*Napaeozapus insignis*
Woodland vole	*Microtus pinetorum*

Sources: NHDFG 2015; DeGraaf and Yamasaki 2001.
Note: ~ A moose was tranquilized and relocated by Massachusetts Environmental Police officers from the Northern Canal on June 11, 2020 (CBS Boston News Undated).

Avifauna

The diversity of habitats in the Lowell Project and lower Merrimack River corridor provide breeding, migratory stopover, and wintering habitat for a high diversity of avifauna including neotropical songbirds, resident species, waterbirds, and waterfowl. Species such as the black capped chickadee (*Poecile atricapillus*), blue jay (*Cyanocitta cristata*), and northern flicker (*Colaptes auratus*), and an assortment of woodpeckers occur within the wooded areas of the Project vicinity. Birds that inhabit non-forested areas within the Project's area include American robin (*Turdus migratorius*) and mourning dove (*Zenaida macroura*). The Merrimack River corridor, including the Project's impoundment and adjacent wetlands, attracts a variety of waterfowl. Four species of waterfowl were observed throughout the area while conducting various relicensing studies associated with the Project: Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), black duck (*Anas rubripes*), and double-crested cormorant (*Phalacrocorax auritus*). Double-crested cormorants were observed on several occasions within the bypass reach as well as in the vicinity of the Pawtucket Dam. Mallards were also seen along the Project canals as well at the confluence of the Pawtucket Canal and Merrimack River.

The ruderal herbaceous/scrub-shrub/forested areas in the Project vicinity are typically utilized by common species that are adapted to a variety of habitat types and are tolerant of human disturbance (i.e., generalist species). Common species of these habitats include rock pigeon (*Columba livia*), mourning dove, blue jay, common crow (*Corvus brachyrhynchos*), black-capped chickadee, northern cardinal (*Cardinalis cardinalis*), chipping sparrow (*Spizella passerina*), tree sparrow (*S. arborea*), mockingbird (*Mimus polyglottos*), starling (*Sturnus vulgaris*), and house finch (*Carpodacus mexicanus*) (DeGraaf and Yamasaki 2001). Incidental species observations, documented by environmental scientists during site visits conducted during 2019 and 2020 relicensing studies, supports this.

Great egret (*Ardea alba*) and great blue heron (*Ardea herodias*) observations were noted while conducting various relicensing studies associated with the Project. These species were usually noted feeding in the bypass reach or flying in the general vicinity of the E.L. Field Powerhouse. Table E.7-29 lists bird species potentially occurring in the vicinity of the Lowell Project. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-29. Avian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Alder flycatcher	*Empidonax alnorum*
American bittern	*Botaurus lentiginosus*
American black duck*	*Anas rubripes*
American coot	*Fulica americana*
American crow*	*Corvus brachyrhynchos*
American goldfinch*	*Carduelis tristis*

Common Name	Scientific Name
American kestrel	*Falco sparverius*
American redstart	*Setophaga ruticilla*
American robin*	*Turdus migratorius*
American woodcock	*Scolopax minor*
Bald eagle	*Haliaeetus leucocephalus*
Baltimore oriole	*Icterus galbula*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Megaceryle alcyon*
Black-billed cuckoo	*Coccyzus erythropthalmus*
Blackburnian Warbler	*Dendroica fusca*
Black-capped chickadee*	*Poecile atricapillus*
Black-throated Blue Warbler	*Dendroica caerulescens*
Black-crowned night heron	*Nycticorax nycticorax*
Black-throated Green Warbler	*Dendroica virens*
Blue jay*	*Cyanocitta cristata*
Blue-gray gnatcatcher	*Polioptila caerulea*
Blue-headed Vireo	*Vireo solitarius*
Bobolink	*Dolichonyx oryzivorus*
Broad-winged hawk	*Buteo platypterus*
Brown creeper	*Certhia americana*
Brown-headed cowbird	*Molothrus ater*
Brown thrasher	*Toxostoma rufum*
Bufflehead	*Bucephala albeola*
Canada goose*	*Branta canadensis*
Canvasback	*Aythya valisineria*
Carolina Wren	*Thryothorus ludovicianus*
Cedar waxwing	*Bombycilla cedrorum*
Chestnut-sided Warbler	*Dendroica pensylvanica*

Common Name	Scientific Name
Chimney Swift	*Chaetura pelagica*
Chipping Sparrow*	*Spizella passerina*
Common goldeneye	*Bucephala clangula*
Common grackle	*Quiscalus quiscula*
Common Merganser	*Mergus merganser*
Common nighthawk	*Chordeiles minor*
Common raven	*Corvus corax*
Common redpoll	*Acanthis flammea*
Common Yellowthroat	*Geothlypis trichas*
Cooper's hawk	*Accipiter cooperii*
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant*	*Phalacrocorax auritus*
Downy Woodpecker	*Picoides pubescens*
Eastern Bluebird	*Sialia sialis*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern phoebe	*Sayornis phoebe*
Eastern screech owl	*Megascops asio*
Eastern Wood-Pewee	*Contopus virens*
European Starling*	*Sturnus vulgaris*
Evening grosbeak	*Coccothraustes vespertinus*
Field sparrow	*Spizella pusilla*
Gadwall	*Mareca strepera*
Golden-crowned kinglet	*Regulus satrapa*
Golden eagle	*Aquila chrysaetos*
Gray catbird	*Dumetella carolinensis*
Great blue heron*	*Ardea herodias*
Greater scaup	*Aythya marila*
Great crested flycatcher	*Myiarchus crinitus*

Common Name	Scientific Name
Great horned owl	*Bubo virginianus*
Great egret*	*Ardea alba*
Green heron	*Butorides virescens*
Hairy Woodpecker	*Picoides villosus*
Hermit thrush	*Catharus guttatus*
Herring gull	*Larus argentatus*
Horned grebe	*Podiceps auritus*
House finch*	*Carpodacus mexicanus*
House sparrow*	*Passer domesticus*
House Wren	*Troglodytes aedon*
Indigo Bunting	*Passerina cyanea*
Killdeer	*Charadrius vociferus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Long-eared owl	*Asio otus*
Louisiana Waterthrush	*Seiurus motacilla*
Magnolia Warbler	*Dendroica magnolia*
Mallard*	*Anas platyrhynchos*
Mockingbird*	*Mimus polyglottos*
Mourning dove*	*Zenaida macroura*
Mourning warbler	*Oporornis philadelphia*
Northern cardinal*	*Cardinalis cardinalis*
Northern flicker*	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Northern parula	*Setophaga americana*
Northern saw-whet owl	*Aegolius acadicus*
Northern shrike	*Lanius borealis*
Northern shoveler	*Spatula clypeata*

Common Name	Scientific Name
Northern waterthrush	*Seiurus noveboracensis*
Olive-sided flycatcher	*Contopus cooperi*
Orchard oriole	*Icterus spurius*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapilla*
Pied-billed grebe	*Pied-billed grebe*
Pileated woodpecker	*Dryocopus pileatus*
Pine siskin	*Spinus pinus*
Purple finch	*Carpodacus purpureus*
Red-bellied woodpecker	*Melanerpes carolinus*
Red-breasted nuthatch	*Sitta canadensis*
Red crossbill	*Loxia curvirostra*
Red-eyed vireo	*Vireo olivaceus*
Redhead	*Aythya americana*
Red-shouldered hawk	*Buteo lineatus*
Red-tailed hawk*	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Ring-necked duck	*Aythya collaris*
Rock pigeon*	*Columba livia*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Ruby-crowned kinglet	*Regulus calendula*
Ruby-throated hummingbird	*Archilochus colubris*
Ruddy duck	*Oxyura jamaicensis*
Ruffed grouse	*Bonasa umbellus*
Sandhill crane	*Antigone canadensis*
Savannah sparrow	*Passerculus sandwichensis*
Scarlet tanager	*Piranga olivacea*

Common Name	Scientific Name
Sharp-shinned hawk	*Accipiter striatus*
Short-eared owl	*Asio flammeus*
Snow bunting	*Plectrophenax nivalis*
Snow goose	*Anser caerulescens*
Snowy owl	*Bubo scandiacus*
Song sparrow	*Melospiza melodia*
Sora	*Porzana carolina*
Spotted sandpiper	*Actitis macularius*
Swainson’s thrush	*Catharus ustulatus*
Swamp sparrow	*Melospiza georgiana*
Tree sparrow*	*Spizella arborea*
Tree swallow	*Tachycineta bicolor*
Tufted titmouse	*Baeolophus bicolor*
Turkey vulture	*Cathartes aura*
Veery	*Catharus fuscescens*
Virginia rail	*Rallus limicola*
Warbling vireo	*Vireo gilvus*
White-breasted nuthatch*	*Sitta carolinensis*
White-winged crossbill	*Loxia leucoptera*
Wild turkey	*Meleagris gallopavo*
Wilson’s warbler	*Cardellina pusilla*
Willow flycatcher	*Empidonax traillii*
Wood duck	*Aix sponsa*
Wood thrush	*Hylocichla mustelina*
Yellow warbler	*Dendroica petechia*
Yellow-bellied flycatcher	*Empidonaz flaviventris*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Yellow-billed cuckoo	*Coccyzus americanus*

Common Name	Scientific Name
Yellow-rumped warbler	*Dendroica coronata*
Yellow-throated vireo	*Vireo flavifrons*

Sources: NHDFG 2015; DeGraaf and Yamasaki 2001.
* Species observed during field studies performed at the Project.

Amphibians and Reptiles

Amphibians and reptiles are common and well represented in the Project vicinity. However, only three amphibian species were observed throughout the area while conducting various relicensing studies associated with the Project (Table E.7-30). Species typically found in wetland and open water areas include green frog (*Lithobates clamitans*), bullfrog (*L. catesbeianus*), northern spring peeper (*Pseudacris crucifer*), and the northern water snake (*Nerodia sipedon sipedon*) (DeGraaf and Rudis 1983; Tyning 1990; Hunter et al. 1999). These amphibians and reptiles are normally found in wetland and open water areas due to food and reproductive requirements.

Species typically found in woodland areas include: spotted salamander (*Ambystoma maculatum*), eastern newt (*Notophthalmus viridescens*), American toad (*Anaxyrus americanus*), gray treefrog (*Hyla versicolor*), wood frog (*Lithobates sylvaticus*), and the northern two-lined salamander (*Eurycea bislineata*) (DeGraaf and Rudis 1983; Tyning 1990; Hunter et al. 1999). These amphibians are normally found in woodland areas due to food and reproductive requirements. A list of herptile species observed, that may occur, or may utilize habitat in the vicinity of the Project is included in Table E.7-30. Those species that were observed during field studies performed at the Project are indicated with an asterisk (*).

Table E.7-30. List of Herptile Species Observed or Anticipated to Occur in the Project Vicinity

Common Name	Scientific Name
Amphibians	
American toad*	*Anaxyrus americana*
Blue-spotted salamander	*Ambystoma laterale*
Bullfrog*	*Lithobates catesbeiana*
Dusky salamander	*Desmognathus fuscus*
Eastern spadefoot	*Scaphiopus holbrookii*
Four-toed salamander	*Hemidactylium scutatum*
Fowler's toad	*Anaxyrus fowleri*
Gray treefrog	*Hyla versicolor*

Common Name	Scientific Name
Green frog*	*Lithobates clamitans melanota*
Marbled salamander	*Ambystoma opacum*
Northern leopard frog	*Lithobates pipiens*
Northern spring salamander	*Gyrinophilus porphyriticus*
Pickerel frog	*Lithobates palustris*
Redback salamander	*Plethodon cinereus*
Red-spotted newt	*Notophthalmus viridescens*
Spotted salamander	*Ambystoma maculatum*
Spring peeper	*Pseudacris crucifer*
Two-lined salamander	*Eurycea bislineata*
Wood frog	*Lithobates sylvatica*
Reptiles	
Black racer	*Coluber constrictor*
Bog turtle	*Glyptemys muhlenbergii*
Blanding's turtle	*Emydoidea blandingii*
Brown snake	*Storeria dekayi*
Common garter snake	*Thamnophis sirtalis*
Common musk turtle	*Sternotherus odoratus*
Eastern box turtle	*Terrapene carolina*
Eastern gartersnake	*Thamnophis sirtalis*
Eastern hognose snake	*Heterodon platirhinos*
Eastern ratsnake	*Pantherophis alleghaniensis*
Milk snake	*Lampropeltis triangulum*
Northern water snake	*Nerodia sipedon*
Painted turtle	*Chrysemys picta*
Red-bellied snake	*Storeria occipitomaculata*
Ribbon snake	*Thamnophis sauritus*
Ringneck snake	*Diadophis punctatus*

Common Name	Scientific Name
Smooth green snake	*Liochlorophis vernalis*
Snapping turtle	*Chelydra serpentina*
Spotted turtle	*Clemmys guttata*
Wood turtle	*Glyptemys insculpta*

Source: NHDFG 2015; DeGraaf and Rudis 1983; Jackson et al. 2010.
* Species observed during field studies performed at the Project.

E.7.4.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on terrestrial resources as potential resource issues. Specifically, SD2 identified the following potential resource issues related to terrestrial resources to be analyzed for site-specific effects:

- Effects of continued project operation on riparian, littoral, and wetland habitat and associated wildlife.
- Effects of continued project operation, including maintenance activities (e.g., vegetation management) on wildlife habitat and associated wildlife.
- Effects of continued project operation and maintenance on the introduction and persistence of invasive plants within the Project boundary.

E.7.4.2.1 Effects of Continued Project Operation on Riparian, Littoral, and Wetland Habitat and Associated Wildlife

The types of wetlands bordering the Project generally reflect the expectations for the natural community in this area. The Project operates in ROR mode, and experiences seasonal and annual variations in flows based on natural hydrologic conditions in the Merrimack River Basin. Boott also proposes to continue to adhere to the requirements of the Project's existing Crest Gate Operation Plan, which provides for a stable impoundment level maintained over a wide range of flows. Therefore, the proposed operation of the Project will have negligible effects on the flow regime and wetland and riparian habitats in the Merrimack River.

Additionally, the occurrence and distribution of wildlife resources in the Project area is generally unrelated to Project operations, and Project operations have little potential to impact wildlife resources within and bordering the Project. Since the Licensee is not proposing changes to the existing baseline conditions or changes to the operation of the Project, continued operation of the Project as proposed by the Licensee is not expected to have any adverse effects on wetland, riparian, or littoral habitat or associated wildlife.

E.7.4.2.2 Effects of Continued Project Operation on Wildlife Habitat, Associated Wildlife, and the Introduction and Persistence of Invasive Plants

The operation of the Project has very little, if any, effect on the wildlife habitat or resources within and bordering the Project boundary, and the occurrence and distribution of wildlife resources in the Project area is generally unrelated to Project operations. Boott does however, conduct routine Project maintenance activities. Project maintenance activities are generally localized and minor in nature.

Many types of land uses contribute to the invasion and spread of non-native invasive species, including ground-disturbing activities and activities that promote the dispersal of weed seed. Roads, rivers, streams, agriculture, farming/ranching, recreation, residential, and commercial developments all contribute to the spread of invasive species.

Continued Project operations are not expected to contribute to the spread of invasive species. As noted above, the botanical resources located within the Project boundary have developed under the current operating regime and are generally stable, mature, and well established. Boott's routine vegetation management practices typically involve mechanical vegetation removal around Project facilities and the clearing of hazard trees as necessary. Boott is not proposing to conduct additional ground-disturbing activities such as road construction or land-clearing that would facilitate the spread of invasive botanical species within the Project boundary. The continued operation and maintenance of the Project as proposed by the Licensee is not expected to have any adverse effects on the wildlife habitat and associated wildlife, or the introduction and persistence of invasive plants within the Project boundary.

E.7.4.2.3 Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

Boott does not anticipate that the proposed decommissioning of the downtown powerhouses will have any effect on terrestrial resources. The downtown powerhouses are generally located in an urban area that does not provide significant habitat for terrestrial plant or wildlife species. Boott is proposing to decommission the existing powerhouses without demolishing the structures or undertaking land-clearing activities. Accordingly, Boott's proposal will not require any modifications to existing terrestrial habitat in the Project's vicinity.

E.7.4.3 Proposed Environmental Measures

Boott proposes to continue operations of the Project with certain PM&E as outlined above in Section E.6.2. Boott has proposed to develop a plan for decommissioning the downtown powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

E.7.4.4 Unavoidable Adverse Impacts

Continued operation of the Project as proposed by the Licensee will not result in any unavoidable adverse effects on terrestrial botanical or wildlife resources.

E.7.5 Rare, Threatened and Endangered Species

The subsections below describe RTE species in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, and the:

- Fish Assemblage Study (NAI 2021d)
- Downstream American Eel Passage Assessment (NAI 2021a)

These reports are included in Appendix B of this exhibit.

E.7.5.1 Affected Environment

E.7.5.1.1 Federal-listed Species

As part of the environmental evaluation conducted for the Project, the USFWS Information, Planning, and Consultation System (IPaC System) identified a list of species under the USFWS's jurisdiction that are known or expected to be on or near the Project area. Based on a search of the USFWS IPaC system for ESA-listed species, northern long-eared bat (*Myotis septentrionalis*) is ESA-listed as threatened and may occur in the Project area; the habitat requirements and distribution of the species are described below. No ESA-listed aquatic species are identified in the USFWS database as being known or believed to occur in the Project area (USFWS 2020b). In addition to this species, the bald eagle (*Haliaeetus leucocephalus*) is known to occur as a transient in the Project vicinity; this species is protected under the Federal Bald and Golden Eagle Protection Act[24] (and is separately listed by the Commonwealth of Massachusetts and New Hampshire; see below).

Northern long-eared bat

The northern long-eared bat is found across much of eastern and north-central United States, and all Canadian provinces from the Atlantic Ocean west to the southern Yukon Territory and British Columbia (USFWS 2013). It is a medium-sized bat, measuring 3 – 3.7 inches, with a wingspan of 9 or 10 inches. Its fur color can be medium to dark brown on the back and tawny to pale brown on the underside (USFWS 2013). The bat is distinguished by its long ears relative to other bats in the genus Myotis (USFWS 2013).

[24] 16 U.S.C. 668, *et seq.*

The northern long-eared bat spends winters hibernating in caves and mines, preferring hibernacula with very high humidity. During the summer months, the northern long-eared bat prefers to roost singly or in colonies underneath bark, in cavities, or in the crevices of live or dead trees (USFWS 2013). Breeding begins in late summer or early fall when males swarm near hibernacula. After a delayed fertilization, pregnant females migrate to summer colonies where they roost and give birth to a single pup. Young bats start flying 18 – 21 days after birth, and adult northern long-eared bats can live up to 19 years (USFWS 2013).

Northern long-eared bats emerge at dusk and fly through the understory of forested hillsides feeding on moths, flies, leafhoppers, caddisflies, and beetles. They also feed by gleaning motionless insects from vegetation and water (USFWS 2013).

The most severe and immediate threat to the northern long-eared bat is white-nose syndrome. As a result of this disease, numbers have declined by 99 percent in the northeast. Other significant sources of mortality include impacts to hibernacula from human disturbance. Loss or degradation of summer habitat as a result of highway or commercial development, timber management, surface mining, and wind facility construction and operation can also contribute to mortality (USFWS 2015).

No Biological Opinions have been developed by the USFWS for the northern long-eared bat in the Project area. In addition, no status reports or recovery plans were located for this species in the vicinity of the Project.

The USFWS has not designated critical habitat for the northern long-eared bat in the vicinity of the Project.

E.7.5.1.2 State-listed Species

Listings of the applicable state-listed threatened, endangered, and candidate species, as well as species of special concern, candidate species, and communities (RTE species) were obtained by request from map and database information provided by the Massachusetts Natural Heritage and Endangered Species Program (Massachusetts NHESP) and the New Hampshire Natural Heritage Bureau (New Hampshire NHB). In addition, habitat information was provided by the New Hampshire NHB, Massachusetts NHESP, as derived from the New Hampshire NHB's and Massachusetts NHESP's fact sheets, and flora manuals (e.g., Magee and Ahles 1999). Specific to the Project area, the potential presence of RTE species was determined by consulting with the Massachusetts NHESP and the New Hampshire NHB during development of the PAD. Table E.7-31 lists the state-listed species and communities that the Commonwealth of Massachusetts and the State of New Hampshire list as potentially occurring within the Project area and provides habitat requirements information.

Table E.7-31. State-listed threatened, endangered, species of special concern, candidate species, and communities potentially occurring within the Project vicinity.

Scientific Name	Common Name	Status[a,b]	Habitat/Notes
Massachusetts			

Scientific Name	Common Name	Status[a,b]	Habitat/Notes
Haliaeetus leucocephalus	Bald Eagle	T	Large lakes, rivers; large riparian trees for nesting, roosting (DeGraaf and Yamasaki 2001).
Stylurus amnicola	Riverine Clubtail	E	Riverine clubtails inhabit primarily medium to large rivers. Although most species of *Stylurus* fly late in the season, riverine clubtails are on the wing from late June through mid-August (Massachusetts NHESP 2015).
New Hampshire			
Alasmidonta varicosa	Brook Floater	E	Sections of stream with low to moderate flow and stable substrates (Nedeau et al. 2000).
Anguilla rostrata	American Eel	SC	American eels are opportunistic carnivores, selecting a range of prey items from small aquatic insects and crustaceans to larger macroinvertebrates and fish (Ross et al. 2001). Yellow eels associate with pools or backwater habitats and often have relatively small home ranges (Gunning and Shoop 1962).
Haliaeetus leucocephalus	Bald Eagle	SC	Large lakes, rivers; large riparian trees for nesting, roosting (DeGraaf and Yamasaki 2001).
Emydoidea blandingii	Blanding's Turtle	E	Permanent, shallow, dark waters with abundant vegetation; marshes, bogs, ditches, ponds, swamps, also in slow moving rivers and protected coves (DeGraaf and Yamasaki 2001).
Heterodon platirhinos	Eastern Hognose Snake	E	Where sandy soils predominate, such as beaches, open fields, dry, open pine or deciduous woods (DeGraaf and Yamasaki 2001).
Sturnella magna	Eastern Meadowlark	T	Large grassy fields of intermediate height and density but also uses grassy meadows, hay fields, tall-grass prairies, agricultural fields and open weedy orchards (DeGraaf and Yamasaki 2001).
Ammodramus savannarum	Grasshopper Sparrow	T	Generally prefers moderately open grasslands with patchy bare ground: dry hayfields, especially those with alfalfa and red clover, weedy fallow fields, prairies, and coastal dunes in Massachusetts (DeGraaf and Yamasaki 2001).
Sylvilagus transitionalis	New England Cottontail	E	Brushy areas, open woodlands, swamps, mountains, beaches, and open lands (DeGraaf and Yamasaki 2001).
Lithobates pipiens	Northern Leopard Frog	SC	Wet open meadows and fields and wet woods during summer months, including river floodplains (DeGraaf and Yamasaki 2001).

Scientific Name	Common Name	Status[a,b]	Habitat/Notes
Petromyzon marinus	Sea Lamprey	SC	In fresh water, sea lampreys use river reaches with gravel substrate for spawning. Spawning habitat is similar to that used by salmon, occurring at the upstream end of riffles and the tail end of pools (NHDFG undated *a*).
Porzana carolina	Sora	SC	Prefers freshwater marshes with shallow to intermediate water depths and dominated by emergent vegetation (DeGraaf and Yamasaki 2001).
Pooecetes gramineus	Vesper Sparrow	SC	Sparsley vegetated dry uplands such as short-grass meadows, grazed pastures, hayfields, grain fields, dry open uplands, and burned and cutover areas (DeGraaf and Yamasaki 2001).
Viola pedata var. pedata	Bird-foot Violet	T	This species occurs in sandplains, disturbed openings, dry forests, and thin woods. Threats would include direct destruction of the plants or major alterations in their habitat (Magee and Ahles 1999; New Hampshire NHB 2018).
*Cenchrus longispinus**	Long-spined Sandbur	E	This species grows in dry, sandy soil of fields, roadsides, waste areas, beaches, river flats, sandplains, and disturbed openings, and is sensitive to disturbances that eliminate its habitat (Magee and Ahles 1999; New Hampshire NHB 2018).
Betula nigra	River Birch	T	This species grows along rivers and streambanks and the population could be deleteriously affected by any project activities that alter the hydrology of its habitat, by increased sedimentation, and by increased nutrients/pollutants in stormwater runoff (Magee and Ahles 1999; New Hampshire NHB 2018).
Lupinus perennis ssp. perennis	Wild Lupine	T	This wildflower grows in extremely dry, sandy openings. It is tolerant of surrounding disturbance and depends upon periodic mowing (or, historically, wildfire) to eliminate trees that would otherwise shade it out (New Hampshire NHB 2018).

Scientific Name	Common Name	Status[a,b]	Habitat/Notes
Eleocharis diandra	Wright's Spikesedge	E	Wright's spikesedge is found along gently sloping freshwater shorelines and marshes. It commonly occurs in disturbed, saturated soils of river edges, often in small depressions. It is typically found in the zone along the water's edge that undergoes spring flooding and is exposed in the summer. The species is primarily vulnerable to changes to the hydrology of its wetland habitat, especially alterations that change water levels. It may also be susceptible to increased pollutants and nutrients carried in stormwater runoff (Magee and Ahles 1999; New Hampshire NHB 2018; Massachusetts NHESP 2012).
N/A	Hemlock Forest*	--	Hemlock forests typically occur on rocky, coarse, and/or thin soils poor in nutrients, including ravines, gorges, river and kame terraces, and other microsites below 2000 feet in elevation. Soils typically have welldeveloped E horizons (classic Spodosols), are very acidic, high in exchangeable aluminum, and low in available nitrogen and other nutrients. Threats include logging, introduction of invasive species, and direct destruction due to development (Sperduto and Nichols 2004; New Hampshire NHB 2018).
N/A	Highgradient Rocky Riverbank System	--	Threats are primarily changes to the hydrology of the river, land conversion and fragmentation, introduction of invasive species, and increased input of nutrients and pollutants (New Hampshire NHB 2018).

Sources: New Hampshire NHB 2018; Massachusetts NHESP 2018; MEOEEA 2018.
a: "E" = Endangered, "T" = Threatened, "SC" = Special Concern, "--" = an exemplary natural community, or a rare species tracked by New Hampshire NHB that has not yet been added to the official state list. An asterisk (*) indicates that the most recent report for that occurrence was more than 20 years ago.
b: The request to New Hampshire NHB included lands within the FERC Project boundary but did not specify a maximum linear distance from the Project boundary in which potential RTE species would be identified. Therefore, for the purposes of this Exhibit, the RTE project area in New Hampshire has been defined as all lands within the FERC Project boundary and lands within approximately 500 feet of the Project boundary.

Massachusetts NHESP Priority and Estimated Habitats

The Massachusetts NHESP identifies Priority Habitat based on the known geographical extent of habitat for all state-listed rare species, both plants and animals, and is codified under the Massachusetts Endangered Species Act (MESA). Habitat alteration within Priority Habitat may result in a take of a state-listed species and is subject to regulatory review by the Massachusetts NHESP. Currently, a portion of the Project boundary, and adjacent terrestrial habitats outside the Project boundary, are listed as Massachusetts

NHESP Priority Habitat (Priority Habitat 1987). This area extends from approximately 1.03 miles south of the New Hampshire border on the northern end to just south of the Greater Lowell Technical High School on the southern end along the Merrimack River.

The Massachusetts NHESP also identifies Estimated Habitats, which are a sub-set of the Priority Habitats, and are based on the geographical extent of habitat of state-listed rare wetlands wildlife and is codified under the Wetlands Protection Act (WPA), which does not protect plants. State-listed wetland wildlife species are protected under the MESA as well as the WPA. Currently, a portion of the Project boundary, and adjacent terrestrial habitats outside the Project boundary, are listed as Massachusetts NHESP Estimated Habitat (Estimated Habitat 1320). This area extends from approximately 1.03 miles south of the New Hampshire border on the northern end to just south of the Greater Lowell Technical High School on the southern end along the Merrimack River.

E.7.5.1.3 Identified Federal- and State-listed Species in the Project Area

Fish Species

State-listed fish species were identified through two primary studies, the Fish Assemblage Study and the Downstream American Eel Passage Assessment Study. The methods and results of these studies are presented in the Technical Report for the Fish Assemblage Study (NAI 2021d) and the Technical Report for the Downstream American Eel Passage Assessment (NAI 2021a), respectively, which were filed with the Commission on February 25, 2021.

In accordance with the approved study plan, Boott conducted a Fish Assemblage Study in 2019 to characterize the fish assemblage in areas affected by the Lowell Project, specifically the impoundment and bypassed reach. The study area for this fish community survey included the mainstem Merrimack River from the Pawtucket Dam to the upper extent of the Project's impoundment located approximately 23 river miles upstream, and the Project's 0.7-mile-long bypassed reach (NAI 2021d). Two State-listed species of special concern, the American eel and the sea lamprey, were identified. Boott captured 17 American eel upstream of the Pawtucket Dam by boat electrofishing and experimental gill net and also captured 33 American eel within the bypassed reach downstream of Pawtucket Dam by backpack electrofishing during the spring, summer and fall sampling in 2019. American eel represented 13.8% of the total electrofishing catch from the ledge channel habitat located in the lower portion of the Lowell bypassed reach. Additionally, Boott captured 21 sea lampreys upstream of Pawtucket Dam by boat electrofishing and experimental gill net during the spring, summer and fall sampling in 2019 (NAI 2021d).

Wildlife Species

No ESA-listed wildlife species (i.e., northern long-eared bat) were observed during field studies conducted in 2019 or 2020; although no specific surveys were conducted for this species.

E.7.5.1.4 Designated Critical Habitat

When a species is proposed for listing as endangered or threatened under the ESA, the USFWS must consider whether there are areas of habitat believed to be essential to the species' conservation. Those areas may be proposed for designation as Critical Habitat. Critical Habitat is a specific geographic area that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection. No Critical Habitat has been designated under the ESA for terrestrial species in the Project vicinity (USFWS 2020b).

E.7.5.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on threatened and endangered species as potential resource issues. Specifically, SD2 identified the following potential resource issues related to threatened and endangered species to be analyzed for site-specific effects:

- Effects of continued project operation and maintenance on the federally threatened northern long-eared bat.

One federally threatened mammal species, the northern long-eared bat, may occur within the Project area. This aerial insectivore may forage adjacent to Project waters in forested habitats in the summer but is not expected to be adversely affected as a result of Project operation. This bat species roosts in upland areas (live or snag trees, caves, etc.), outside of the range of potential Project operational affects. This bat species spends winters months in hibernacula and is not expected to be adversely affected by Project operations. There are no known hibernacula or roost trees for northern long-eared bat in the immediate vicinity of the Project's facilities. Additionally, the occurrence and distribution of terrestrial wildlife resources in the Project area is generally unrelated to operation of the Project. The operation of the Project as proposed is not expected to have any adverse effects on northern long-eared bat; however, in the event Boott performs maintenance activities at the Projects that could affect bat habitat, Boott will perform the required consultation and protection measures pursuant to applicable federal and state laws and regulations, including the Endangered Species Act.

Bald eagles are known to use the Merrimack River watershed for winter perching, roosting, and feeding activities and have been documented along the Merrimack River mainstem from Franklin to Nashua, New Hampshire, and throughout the Massachusetts portion of the basin (USACE 2003). Continued Project operations as proposed by the Licensee have a very low potential to impact bald eagles or roost trees. The occurrence and distribution of terrestrial wildlife resources in the study area is generally unrelated to Project operations. Boott conducts routine Project maintenance activities and manages formal Project recreation facilities at the Project. Project maintenance activities are generally localized and minor in nature.

Some State wildlife Species of Special Concern may potentially occur within the Project. These include several bird species and one amphibian species (northern leopard frog). All of the wildlife Species of Special Concern that have potential to occur within the Project area are highly mobile and are most likely to occur in the Project area for foraging (and, in some cases, breeding) during temperate months. The Licensee is proposing no fundamental changes in operation. As a result, and given that no RTE species have been documented within the Project boundary, continued operation of the Project is not expected to adversely affect RTE species.

E.7.5.2.1 Environmental Analysis

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

Boott does not anticipate that the proposed decommissioning of the downtown powerhouses will have any effect on rare, threatened, or endangered species. The downtown powerhouses are generally located in an urban area that does not provide significant habitat for federal- or state-listed terrestrial plant or wildlife species. Boott is proposing to decommission the existing powerhouses without demolishing the structures or undertaking land-clearing activities. Accordingly, Boott's proposal will not require any modifications to existing terrestrial habitat in the Project's vicinity.

With respect to federal- or state-listed aquatic species, Boott notes that there is no evidence that these species are utilizing the downtown canal system. Boott's proposal to decommission the downtown canal units is likely to have a net benefit to fish and aquatic resources. Because flows of up to 2,000 cfs will no longer be periodically routed to the downtown canal system, there is less likelihood that outmigrating diadromous fish will enter the canals. The primary means for fish to enter the canal system will be lockages associated with the NPS's canal boat tours, which require a relatively small volume of water passed during a brief period. Even if fish do enter the canal system through lockages or via the 200 to 300 cfs leakage make-up flow, Boott is proposing to discontinue generating with the powerhouses' turbines and to seal the penstock intakes. These actions will eliminate the possibility of fish becoming impinged at or entrained by the downtown powerhouses. Accordingly, decommissioning of the Project's downtown powerhouses is not expected to have an adverse effect on federal- or state-listed fish or other aquatic resources.

E.7.5.3 Proposed Environmental Measures

Boott proposes continued operations of the Project with environmental PM&E measures which will protect rare, threatened and endangered species and their habitats. These measures include:

- Continue to operate the Project in ROR mode;
- Maintain a bypass reach minimum flow of 500 cfs via the Pawtucket Dam fish ladder during the fish passage season (typically May 1 – July 15), and 100 cfs outside of the fish passage season;

- Continued adherence to the requirements of the Project's existing Crest Gate Operation Plan;
- Install new trashracks or other fish exclusion facility at the E.L. Field Powerhouse, which will prevent the entrainment of outmigrating adult American eel.
- Boott has proposed to develop a plan for decommissioning the downtown powerhouses. As appropriate, the Decommissioning Plan will include best management practices and provisions for erosion and sediment control measures during decommissioning.

E.7.5.4 Unavoidable Adverse Impacts

The occurrence and distribution of terrestrial wildlife and RTE resources in the study area is generally unrelated to Project operations. The continued operation of the Project as proposed by the Licensee is not expected to have any adverse effects on the northern long-eared bat. Routine Project maintenance activities that could affect bat habitat are generally localized. Bat foraging may take place over the impoundment and along the shoreline; however, the ROR operation of the Project will not affect the ability of bats to access foraging habitat or limit potential prey species (e.g., invertebrates).

E.7.6 Recreation and Land Use

The subsections below describe recreation and land use in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, and the:

- Recreation and Aesthetics Study Report (HDR 2021a)
- Water Level and Flow Effects on Historic Resources Study Report (HDR 2021b)
- Resources, Ownership, Boundaries and Land Rights Study Report

However, Boott also notes that the Whitewater Boating and Access Study required by the Commission is on-going. Subsequent to completion of the study activities, Boott anticipates additional consultation with stakeholders.

E.7.6.1 Affected Environment

E.7.6.1.1 Project Recreation Facilities

Pursuant to existing License Article 38 and the FERC-approved Recreation Plan, Boott maintains one formal recreation area at the Project:

E.L. Field Powerhouse Visitor Center (Visitor Center)

The Visitor Center, located along the mainstem of the Merrimack River, offers a secured view of the interior of the turbine gallery and an interpretive display that provides information regarding the development, history, and operation of the Project, and nearby historic, natural, cultural, recreational resources, and other items of interest.

E.7.6.1.2 Recreation in the Project Area

The Project's primary features are located along the Merrimack River in the City of Lowell, Massachusetts. The Merrimack River watershed supports all or parts of approximately 200 communities with a total population of 2.6 million people (USEPA 2020b; USACE 2006). The Merrimack River provides numerous recreational opportunities to the residents of the communities along its banks but is also utilized by residents of major cities in the region, particularly residents from Boston (Nashua Regional Planning Commission [NRPC] 2008; NHDES 2019a; USACE 2006).

The Project dam is located at RM 41 on the Merrimack River, and the impoundment extends upstream approximately 16 miles to Cromwell's Falls in Litchfield and Merrimack, New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. The Merrimack River provides extensive recreational opportunities, including boating, canoeing, kayaking, rowing, fishing, and swimming. Several parks and conservation areas in the vicinity of the Project afford additional recreation opportunities that include hiking, cross country skiing, picnicking, and bird watching. Recreational opportunities differ closer to the larger, more populated cities along the river.

Several project facilities are located within overlapping locally, state, and nationally designated parks and historic properties/preservation districts. Non-Project related recreational facilities and opportunities in the Project's vicinity include:

- Depot Street Boat Ramp
- Greely Park and Boat Ramp
- Lowell National Historic Park (LHNP)
- Lowell Heritage State Park
- Lowell-Dracut Tyngsborough State Forest
- Flints Pond Access
- Merrill Park
- Twin Bridge Park
- Moore's Falls Conservation Area
- John Bryant River Access
- Thornton's Ferry Boat Launch
- Litchfield State Forest
- Horse Hill Nature Preserve
- Leslie Bockes Memorial Forest
- New Hampshire Heritage Trail
- Chelmsford Boat Access
- Great Brook Farm State Park

- Warren H. Manning State Forest
- Billerica State Forest
- Carlisle State Forest
- Governor Thomas Dudley State Park
- Merrimack River Boat Access.

These and other non-Project related facilities are not owned or operated by Boott but are popular Merrimack River recreational areas. In addition, there are numerous informal access areas on Lowell Hydroelectric Project lands that are used by the public for access to the Merrimack River. Figure E.7-25 through Figure E.7-26 depict the wide range of recreational opportunities in the vicinity of the Project, which are described in more detail below.

Figure E.7-25. Recreation Opportunities in the Vicinity of the Lowell Hydroelectric Project

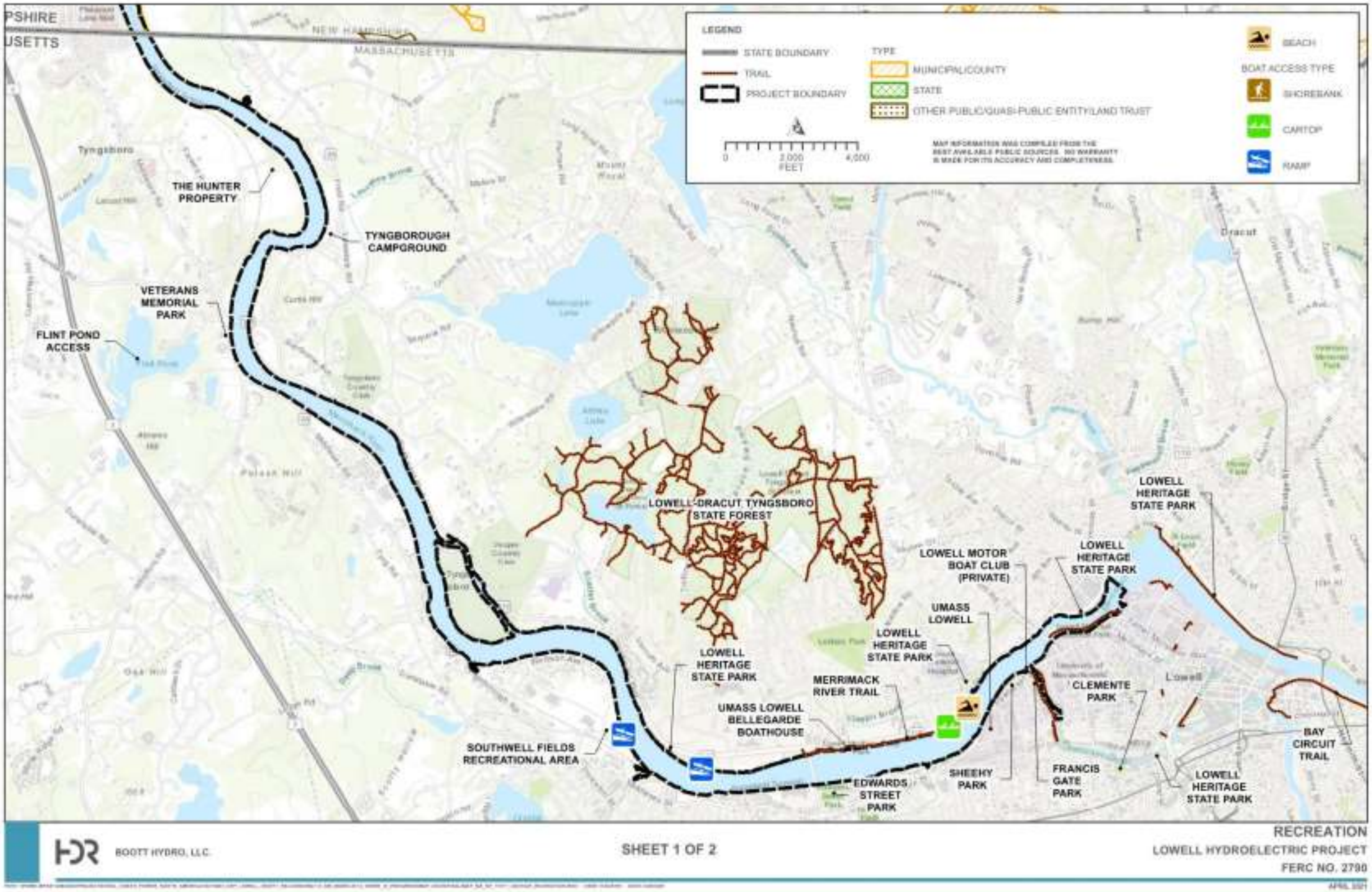
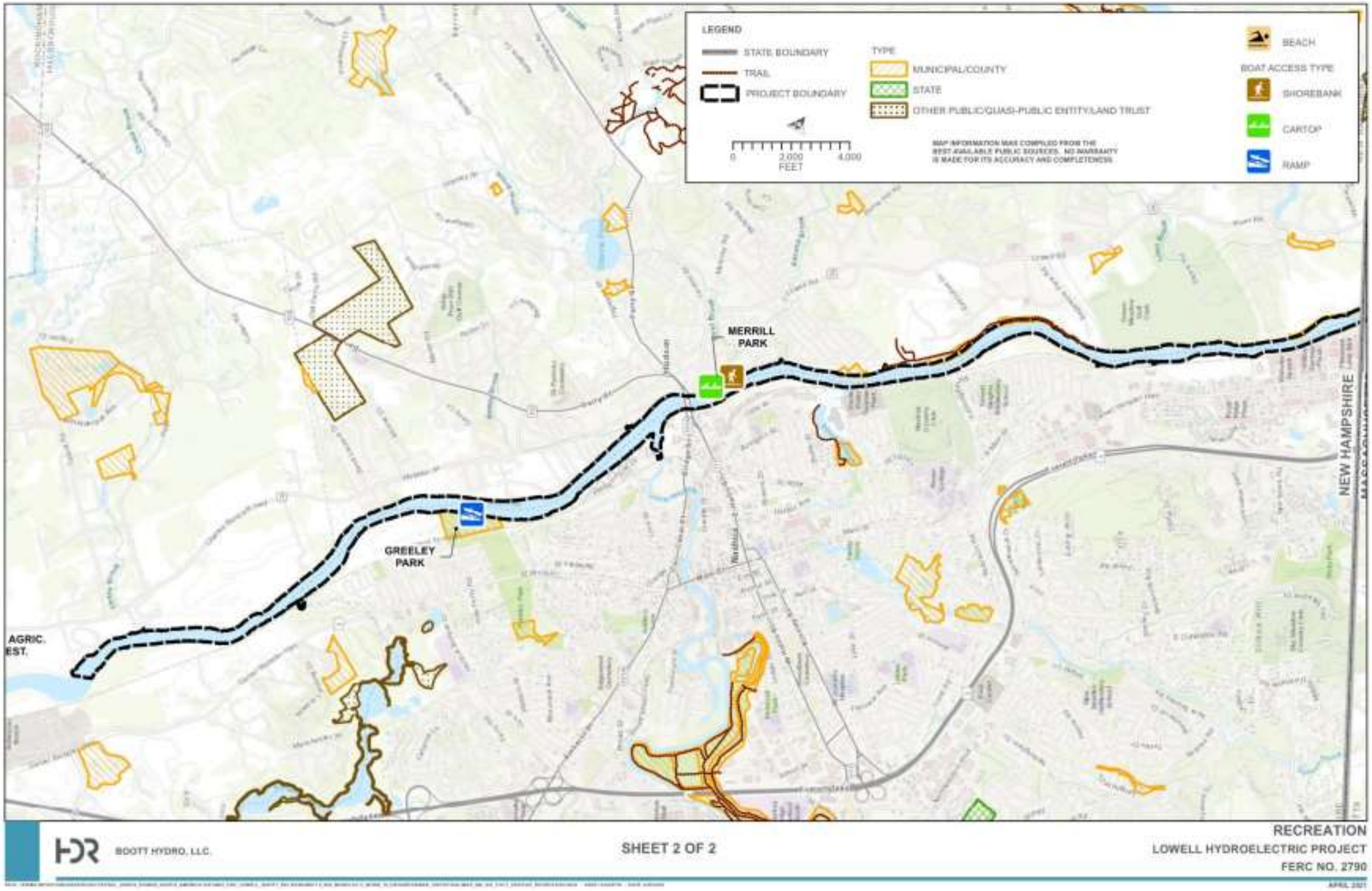


Figure E.7-26. Recreation Opportunities in the Vicinity of the Lowell Hydroelectric Project



E.7.6.1.3 Recreation Opportunities in New Hampshire

The State of New Hampshire reports many recreational uses of the Project impoundment, including fishing, canoeing, kayaking, rowing, and motor boating. Much of the Project impoundment is in Hillsborough County, New Hampshire, which has approximately 54,480 acres of recreation lands and 116 public access sites to the water (New Hampshire Department of Natural and Cultural Resources [NHDNCR] 2018). Most of the shore lands along the Merrimack River in New Hampshire are privately owned; therefore, recreation activities take place immediately on the Merrimack River (NRPC 2008). There are six known boat access facilities in New Hampshire with direct access to the Project impoundment. These facilities range in design from concrete ramps to shoreline access and are described below:

Moore's Falls Conservation Area: Moore's Falls Conservation Area offers shoreline fishing and car-top boating access to Moore's Falls upstream of the Project impoundment. Moore's Falls are a length of rapids on the Merrimack River which drop 6 feet in elevation over 650 feet in distance, which define the upstream extent of the Project impoundment. There are also walking trails through the woods, an old trolley track trail, multiple access points to the Merrimack River for fishing, educational information regarding environmental conservation, and birdhouses. Running along the east bank of the river are the remains of a historic lock structure constructed in the early 1800s. NHDES recommends this conservation area for angler fishing, as small and large mouth bass are often caught, as well as rainbow and brook trout, both of which are stocked by the NHFGD in the Lower Merrimack River (Middlesex Canal Association 2009; NHDES 2019a).

Depot Street Boat Ramp: The Depot Street Boat Ramp offers a carry-in boat ramp and fishing access to the Merrimack River and is managed by the Town of Merrimack. The trail to the river runs under railroad tracks. This access is suitable for motorboats, as the river slows from the rocky rapids upstream (NHDES 2019a; Merrimack Parks and Recreation 2020). There is also a scenic picnic area.

John Bryant River Access: The John Bryant River Access is a canoe/kayak car top facility managed by the Litchfield Recreation Commission. It provides fishing access, scenic views of the river, and birdwatching. It is available only to Town of Litchfield, New Hampshire residents (Litchfield Recreation Commission 2020).

Thornton's Ferry Boat Launch: Thornton's Ferry Boat Launch is owned by the Town of Merrimack and offers cartop carry-in boating and fishing access to the Merrimack River (NHFGD undated).

Greeley Park & Boat Ramp: Greeley Park is a 125-acre city park located in Nashua, New Hampshire. Greely Park offers many recreation amenities/facilities including baseball/softball fields, historical sites, picnic areas, playgrounds, restrooms, tennis courts, trails, and wading pools (NHFGD undated; City of Nashua 2020). In 2019, the City of Nashua issued an invitation to bid for reconstruction of the Greeley Park Boat Ramp, as well as construction of a gravel parking lot, placement of new signs, and three biological retention ponds. The work was scheduled for completion in July 2020 (NHFGD undated; City of Nashua 2019). A paved ramp at the north end of Greeley Park in

Nashua also allows access to the river for boaters. NHDES recommends this conservation area for angler fishing (NHDES 2019a).

Merrill Park: Merrill Park is a 9.3-acre city park located in Hudson, New Hampshire. It is adjacent to the east riverbank and Project boundary. The park is mostly forested with a few walking paths and picnic benches. It has a path which leads down to the Merrimack River, allowing hand-carry access for canoes or kayaks, or fishing (Town of Hudson undated).

In addition to the facilities mentioned above, the following facilities are within a 30-minute drive from the Project boundary and provide outdoor activities that include wildlife observation, driving for pleasure, sightseeing, day hiking, and jogging/running/walking:

Litchfield State Forest: The Litchfield State Forest is a 450-acre forest in Litchfield managed by the State of New Hampshire. It is located about 1.5 miles east of the Project boundary. The 1.3-mile Litchfield State Forest Trail provides comfortable walking and biking trails. Off trails provide an additional four miles of hiking, wildlife observation, and scenic opportunities. The trails are often used for cross country skiing in the winter (Litchfield Recreation Commission 2020; ExploreYourSpaces 2020).

Flints Pond Access: Flints pond is a 50-acre, warm water pond located in the Town of Hollis in New Hampshire. The pond is open to the public for fishing, kayaking, and canoeing in the summer. In the winter, ice fishing, snowshoeing, and snowmobiling are also popular. A boat ramp is available at the north end of the pond (Flints Pond Improvement Association 2015). Flints Pond Access is approximately 0.2 miles west of the Project boundary.

Horse Hill Nature Preserve: Horse Hill Nature Preserve is a 560-acre property owned by the town of Merrimack, located about three miles west of the Project Boundary. It is primarily a mixed hardwood forest, with a series of streams, ponds, swamps, and numerous wetlands. Old logging roads form the basis of what is today a trail network used by hikers, bikers, cross country skiing, snowshoeing, hunters, snowmobilers, and horseback riders. This trail network covers most of the property, however, there are still large areas without defined access.

Leslie Bockes Memorial Forest: Forest Society owns and manages this approximately 226-acre forest located in Londonderry, New Hampshire (five miles east of the Project boundary). Nearly four miles of old logging roads provide hiking, skiing, and snowshoeing with numerous access points. The trails are on well-maintained woods roads that enable easy walking and generally good footing. The tract is a known spot for bird and nature-watching (Forest Society 2020).

Twin Bridge Park: Twin Bridge Park is in Merrimack, New Hampshire, and features a baseball field, playground, picnic area, and extensive hiking trails through 27 acres of woods along Baboosic Brook (Town of Merrimack undated). Twin Bridge Park is approximately 0.2 miles west of the Project boundary.

New Hampshire Heritage Trail: The completed trail system will connect trail segments along the Lower Merrimack River and ultimately extend south into Massachusetts, and north along the Merrimack, Pemigewasset, and Connecticut Rivers to the Canadian border. Several trail sections have been completed along this part of the river and northward, with existing segments in Nashua, Hooksett and Manchester, New Hampshire (NHDES 2019a).

E.7.6.1.4 Recreation Opportunities in Massachusetts

The state of Massachusetts reports that recreation along the Project impoundment changes as open space generally decreases further downstream and riverfront communities are more industrialized (MEOEEA 2001). Water-based recreation (boating, fishing, canoeing, and swimming), is provided on the downstream portion of the Project impoundment by multiple boat ramps and waterfront parks. There are many additional recreational opportunities in and surrounding Lowell, including networks of trails, thousands of acres of nearby state forest, and urban passive parks for walking, jogging, dog-walking, and picnicking (City of Lowell 2018; MADCR 2014; Lowell National Historical Park [LNHP] 2017).

As part of the LNHP or Lowell Heritage State Park, different sites in and around the city of Lowell are related to the historical era of textile manufacturing and offer museum exhibits, walking tours, and interpretive/interactive displays (LNHP 2017; MADCR 2014). Boat tours led by NPS guides also provide access to the historic canal system and the Project impoundment. The canal boat tours highlight some of the Lowell Hydroelectric Project facilities by travelling through the historic navigation locks (NPS undated c). Although portions of the LHNP are within the Project boundary, it is not a FERC-approved recreation facility. Additional recreational opportunities provided by NPS at the LNHP include trolley rides available for touring the city.

The downstream portion of the Project impoundment is accessible for water-based recreation by the following recreational facilities:

Lowell National Historical Park: The LNHP was established in 1978 and is operated by the NPS. This National Historic Park is made up of a group of different sites in and around the city of Lowell, Massachusetts, related to the era of textile manufacturing that relied on hydroelectric power to operate during the Industrial Revolution of the early 1800s. It is a primary recreation attraction for the City of Lowell and the Lowell Hydroelectric Project. While the majority of the Project facilities, canals, gatehouses, dams, locks, and powerhouses, are necessary components of its operations, they serve a dual purpose as a NPS attraction for which it is maintained and preserved as a historic property (NPS undated c). As noted above, LHNP is not a FERC-approved recreation facility despite the canal system and many of the Project's facilities being located within the Project boundary.

Lowell Heritage State Park: The 83-acre Lowell Heritage State Park occupies a 2-mile long stretch along the north bank of the Project impoundment, upstream of the Pawtucket Dam. The park features historical exhibits that were created in partnership with the NPS to educate the public regarding the network of canals and mills constructed in the 19th century to power Lowell's then bustling textile industry. Activities available include biking, boating (non-motorized and motorized), canoeing and kayaking, swimming, fishing, hiking, and educational programs. Facilities include a paved bike path and walking esplanade, picnic area, a beach, restrooms, scenic viewing area, an outdoor concert stage, and visitors center (Commonwealth of Massachusetts 2018a). Also located within the park boundary is the University of Massachusetts Lowell Bellegarde Boathouse, which also houses the Merrimack River Rowing Association, a non-profit rowing club.

Rourke Brothers Boat Ramp (part of the Lowell Heritage State Park): The park provides a trailered boat launch, located on the north bank of the impoundment about 2 miles upstream of the Pawtucket Dam. Adjacent to the boat launch is an access dock for boating and fishing.

Chelmsford Boat Access: The park provides a trailered boat launch, shoreline fishing access, picnic areas, athletic fields, and trails.

In addition to the facilities mentioned above, these facilities are located within a 30-minute drive from the Project boundary:

Lowell-Dracut Tyngsborough State Forest: The Lowell-Dracut Tyngsborough State Forest is approximately one mile north of the Project boundary. The Lowell-Dracut Tyngsborough State Forest spreads across three towns and features over 1,140 acres of protected land, including 180 acres of open water or wetlands and 457 acres of land in the city of Lowell. Popular activities include hiking, fishing, hunting, cycling, birding, picnicking, nature walking, mountain biking, and playing various field sports. In the winter, people sled, ice skate, and cross-country ski (Commonwealth of Massachusetts 2018c).

Great Brook Farm State Park: Located seven miles south of the Project, this park is a working dairy farm connected to miles of trails that can be used for a variety of recreational activities. The park also includes historic buildings and resources, interpretive programming, and a cross-country ski concession.

Warren H. Manning State Forest: Located five miles south of the Project, this state forest is a largely wooded property with a small recreation area, complete with a spray deck, picnic area, water playground, and fitness trail.

Billerica State Forest: Located six miles south of the Project, this state forest offers rustic, multi-use trails and wooded areas for walking and wildlife viewing.

Carlisle State Forest: Located ten miles south of the Project, this state forest provides over a mile of trails through wooded property protected from forestry activities at the turn of the 20th century. The forest includes an older stand of exceptionally large eastern white pines.

Governor Thomas Dudley State Park: Located ten miles south of the Project, this 11-acre park is a small wooded parcel that provides access to the Concord River and links to other protected open spaces.

E.7.6.1.5 Existing Shoreline Management Plans

There is no formal Shoreline Management Plan or permitting policy for the shoreline of the Lowell Hydroelectric Project.

E.7.6.1.6 Existing Shoreline Buffer Zones

At normal pool elevation of 92.2 feet NGVD, there are approximately 32 shoreline miles bordering the current impoundment of the Pawtucket Dam. Both New Hampshire and Massachusetts have established shoreline buffer zones. Per New Hampshire's Comprehensive Shoreland Protection Act (CSPA), which contains minimum standards to protect public surface waters and their immediate environs, any disturbance activity greater than 50,000 feet^2 occurring within 250 feet of the Merrimack River requires an Alteration-of-Terrain permit (LMRLAC 2008). In Massachusetts, the Wetlands Protection Act (Massachusetts General Laws Chapter 131, Section 40) protects important water-related lands and other areas from destruction or alteration. Generally implemented by the local Conservation Commission in each municipality, the Act establishes a 100-foot buffer zone around all coastal banks, inland banks, freshwater wetlands, coastal wetlands, tidal flats, beaches, dunes, marshes, and swamps, and a riverfront area within 200 feet of rivers and streams (or 25 feet of some urban rivers) that flow year round. The canals in Lowell are specifically defined as not having a riverfront area [310 CMR 10.58 (2)1.g] (MACC undated).

E.7.6.1.7 National Wild and Scenic River System, National Trail System, and Wilderness Areas

The Merrimack River is not designated as a National Wild and Scenic River or under study for inclusion in the National Wild and Scenic River System. The Lowell Hydroelectric Project is not located within or adjacent to lands included in, or under study for inclusion in, the National Trails System or designated as, or under study for inclusion as, a Wilderness Area.

E.7.6.1.8 Nationwide Rivers Inventory

The upper portion of the impoundment was listed under the National Rivers Inventory in 1995. The full classified reach is 16 miles long from Amoskeag Dam in Manchester to the confluence with Pennichuck Brook in Merrimack. The reach is considered notable due to fish, historic, recreational, and wildlife values (NPS undated *b).*

E.7.6.1.9 State-protected Rivers

The lower reach of the Merrimack River, which includes the upstream impoundment of the Project in New Hampshire, is designated as a "Community River" under the New Hampshire Rivers Management and Protection Program (NHDES 2017). Community rivers are defined as "those rivers or river segments which flow through populated areas of the state and which possess actual or potential resource values. Such rivers have some residential or other building development near their shorelines, are readily accessible by road or railroad, and may include some impoundments or diversion." (NHDES 1990). The LMRLAC provides an advisory role on matters pertaining to the management of the river, and comments on development plans which might affect the river's resource values. The LMRLAC also maintains a river corridor management plan pursuant to NH RSA 483:10 (NHDES 2008).

E.7.6.1.10 Regionally or Nationally Significant Recreation Areas

The Lowell Hydroelectric Project is located within the LNHP, a regionally and nationally significant recreation area.

E.7.6.1.11 Recreation Use and Need

Pursuant to the approved study plan, Boott conducted a Recreation and Aesthetics Study to identify existing recreation use as well as recreation resources and activities that may be affected by the continued operation of the Project. The methods and results of the Recreation and Aesthetics Study are described in detail in Boott's Recreation and Aesthetics Study Report (HDR 2021a) filed with the Commission on February 25, 2021.

Field Inventory

Boott inventoried non-Project recreation facilities within the Project's vicinity in the fall of 2019, including the Chelmsford Boat Access, Depot Street Boat Ramp, Greeley Boat Ramp, Lowell Heritage State Park, LNHP, Merrill Park, Merrimack Trail System, Moore's Falls Conservation Area, NPS Canal Walkway, Pawtucket Falls Overlook, and Rourke Brothers Boat Ramp. The Visitor Center (the only-FERC approved recreation facility), was closed on the days of inventory, but the external features (e.g. parking lot) were also inventoried. Pursuant to the RSP, Boott collected information regarding each facility including the type and location of existing recreation facilities, the type of recreation provided (e.g., boat access, angler access, picnicking, etc.), existing amenities and sanitation, the type of vehicular access and parking (if any), the suitability of facilities to provide recreational opportunities and access for persons with disabilities (i.e., compliance with current Americans with Disabilities Act [ADA] standards for accessible design), GPS location data, and representative photographic documentation of recreation facilities. The results of the field inventory are presented in Appendix B to the Recreation and Aesthetics Study Report. A map of inventoried facilities is presented as Figure E.7-27.

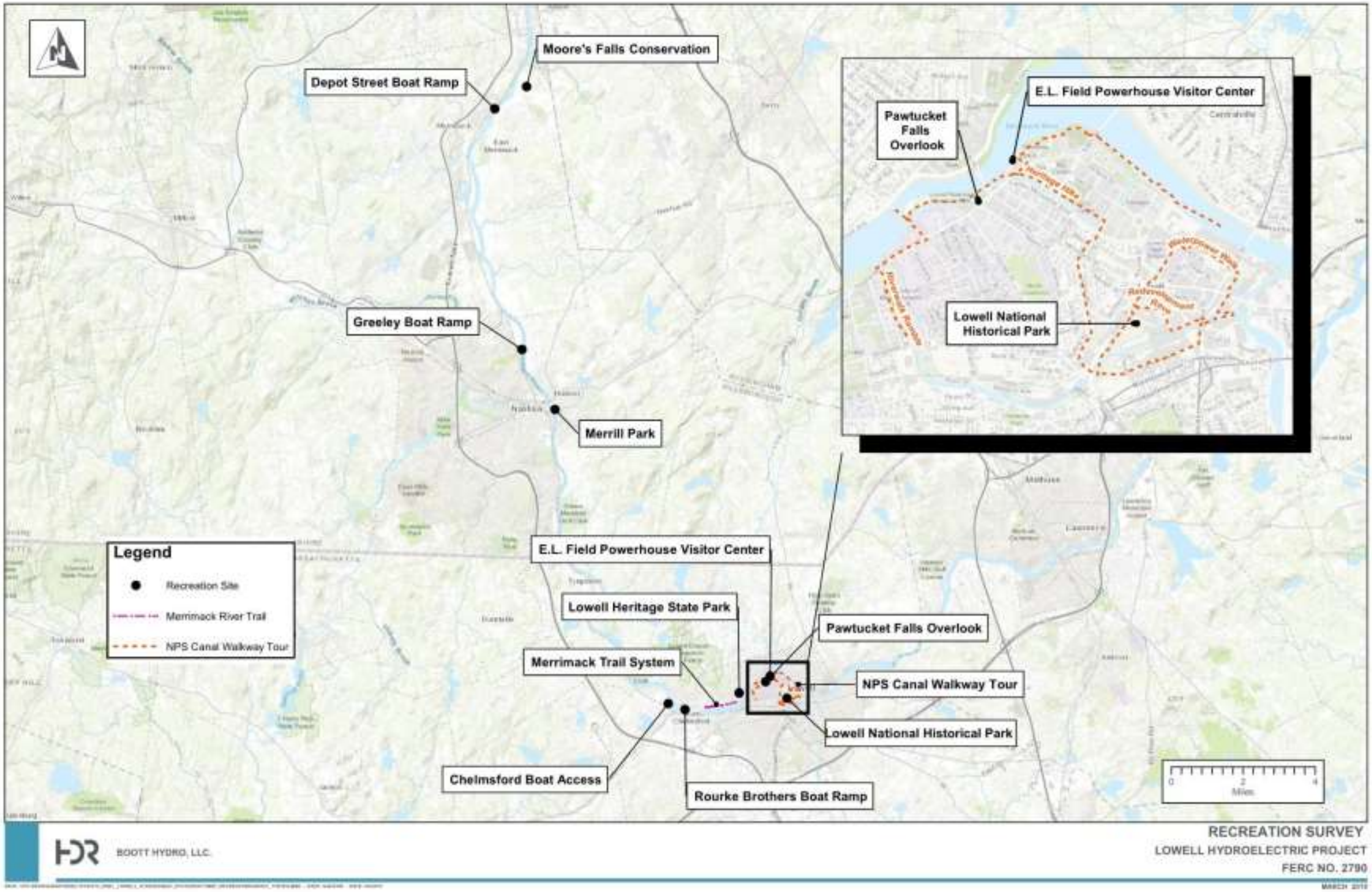
Visitor Use Data and Field Reconnaissance

As provided in the approved study plan, Boott conducted personal interviews (visitor intercept surveys) and field reconnaissance activities at recreation facilities in the Project's vicinity between May and October 2019. Boott developed survey questions based on general concepts and guidance from the U.S. Forest Service's (USFS) National Visitor Use Monitoring Handbook (USFS 2007) and questions that were asked during recreation studies for other relevant hydropower relicensings. The survey questions that were asked during the personal interviews are included in Appendix A of the Recreation and Aesthetics Study Report. Boott consulted with the NPS, MADCR, and American Whitewater (AW) to identify specific recreation survey locations.

In May 2019, Boott began conducting personal interviews at the Lowell Heritage State Park, Merrimack Trail System, Pawtucket Falls Overlook, NPS Canal Walkways, LNHP Visitor Center, Chelmsford Boat Access, Rourke Brothers Boat Ramp, Merrill Park, and Whitewater takeout location. The surveys were conducted on random weekdays and weekend days throughout the months of May, June, July, August, September, and

October of 2019. Personal interviews and field reconnaissance were conducted on four days of each month on both weekdays, weekend days, and holidays. A team of two technicians traveled between each of the aforementioned recreation sites and spent approximately one hour at each site conducting the personal interviews and collecting field reconnaissance data including (a) the various types of recreation activities, (b) an estimation of the number of vehicles, and (c) the approximate numbers of recreationists observed at each site. Field reconnaissance data is summarized in Appendix D of the Recreation and Aesthetics Study Report.

Figure E.7-27. Recreation Facilities Inventoried During Recreation and Aesthetics Study



For the personal interviews, individual recreationists and groups were interviewed, including visitors using boat launches and LNHP-managed facilities. Respondents answered questions verbally while a technician recorded their responses using the Qualtrics® offline survey platform to record and submit answers.[25] The personal interview questions included topics such as: general user information; age group, resident/visitor; purpose and duration of visit; distance traveled; history of visiting the site or area; types of recreational activities respondents participated in or planned to participate in during their visit; other recreational sites that respondents visited or intended to visit during their trip; general satisfaction with recreational opportunities, flow conditions, facilities, and the respondents overall visit and/or areas that need improvement; accessibility of facilities or areas; economic aspects, including dollars spent during their trip; and day use/overnight lodging during their visit. Before rotating to the next site, technicians also recorded the date, time, and weather conditions observed.

A total of 53 individuals participated in the interviews. Personal interviewees travelled an average of 7.3 miles to the recreation area, with a range of 0.1 miles to 3,000 miles. The majority (77 percent) of personal interview respondents rated their overall experience of recreational activities at the Project as “totally acceptable” or “acceptable.” Results from the personal interviews are compiled in Appendix C of the Recreation and Aesthetics Study Report.

Online Survey

In addition to the personal interviews and visitor use data collection, Boott developed a version of the interview questions to allow respondents to provide survey responses online. In accordance with the approved study plan, the survey was made available for one year, from June 2019 to June 2020, on the Project’s relicensing website (www.lowellprojectrelicensing.com). The online survey was developed using the Qualtrics® survey platform. Boott posted a brief description of the purpose and intent of the survey and the website address at popular recreation access areas at the Project. During personal interviews and field reconnaissance, Boott provided handouts to recreationists with the relevant information on how to access the online survey. Boott notified the Commission and stakeholders of the availability of the online survey in the Second Quarterly Study Progress Report filed with the Commission on October 1, 2019. The survey questions developed for the online survey are also included in Appendix A of the Recreation and Aesthetics Study Report.

A total of 96 respondents completed the online survey. Online respondents stated they travelled on average around 11 miles to the Project area. The majority (92 percent) of online respondents rated their overall experience of recreational activities at the Project as “totally acceptable” or “acceptable.” Results from the online surveys are compiled in Appendix E of the Recreation and Aesthetics Study Report.

[25] While the survey questions in the approved study plan were utilized for these interviews, the numbering and specific wording was adapted during the interview to better facilitate the interview and to accommodate the Qualtrics® survey platform.

E.7.6.1.12 Evaluation of Water Levels and Flows on Recreational Access

In accordance with the SPD, Boott initiated data collection to better understand effects of the crest gate and water levels and flows on (1) NPS boat tours and (2) access to the Northern Canal Walkway. These methods and results are described in detail in Boott's final Recreation and Aesthetics Study Report filed with the Commission on February 25, 2021.

NPS Boat Tours

Under the amended Crest Gate System Operations Plan, when flows in the river are below 8,600 cfs [the combined hydraulic capacity of the E.L. Field Powerhouse (6,600 cfs) and downtown canal system (2,000 cfs)], the reservoir elevation is maintained at the normal pond elevation of 92.2 ft NGVD 29. When Merrimack River flows exceed 8,600 cfs, the Crest Gate System Operations Plan allows for a gradual rise in elevation to ± 93.2 ft NGVD 29 as flows reach approximately 11,850 cfs. With this 1-foot elevation rise of the Project impoundment, NPS states their boats would be unable to pass under the Pawtucket Street Bridge.

The Project maintains a normal pond elevation of 92.2 ft NGVD 29 when flows in the Merrimack River are up to 8,600 cfs. According to USGS gage data presented in Table E.7-1, average flows during the operating season (May 15 through October 15) for NPS boat tours generally do not exceed 8,600 cfs. May is the only month with an average Merrimack River flow above 8,600 cfs.

As described above, when Merrimack River flows exceed 8,600 cfs, the crest elevation gradually rises to 93.2 ft NGVD 29 until flows reach 11,850 cfs. Ultimately, only between Merrimack River flows of 11,850 cfs and 12,500 cfs (NPS' self-reported threshold), are NPS boats supposedly unable to pass under Pawtucket Street Bridge. This is a relatively narrow window, especially since the average flow for the entire operating season never reaches 11,850 cfs, and a 10% chance of exceedance of 11,850 cfs only occurs in May, June, and October.

Additionally, while Boott is permitted by the Crest Gate Operations Plan to raise the impoundment level to 93.2 ft, it is not Boott's standard practice to do so every time flows reach 11,850 cfs. As detailed in the Water Level and Flow Effects on Historic Resources Study, Boott collected impoundment elevation data from March 10 – September 29, 2020, and the results are shown below in Figure E.7-39. As shown, there were only slight exceedances above the normal pond elevation during the months of March and April, despite the highest monthly average flows occurring during the months of March (11,484 cfs) and April (17, 901 cfs).

The majority of flows through the Lowell Project are a direct result of the annual hydrologic cycle, much of which is unpredictable and inconsistent. The effect of the crest gate system on NPS boat tours appears to be minimal. Merrimack River flows high enough to raise the pond elevation 1-foot are seemingly just as likely to rise above NPS' self-reported threshold of 12,500 cfs.

Northern Canal Walkway

The Northern Canal Walkway opens seasonally (May 15 through October 15) when flow rates in the Merrimack River and Northern Canal are lower than 3,500 cfs. This threshold was determined in a study demonstrating that a surge wave above 3,500 cfs in the Northern Canal poses a risk of overtopping the Great River Wall. In 1999, the Licensee completed construction of the Surge Gate, designed to attenuate the surge wave in the canal that occurs during sudden plant shutdown. A test of the Surge Gate revealed that the gate did attenuate the resulting transient wave. However, as reported to FERC, the test indicated when fully opened, the significant volume of discharge through the Surge Gate is hazardous to any persons in the riverbed below or near the gate. FERC directed Boott to design a Public Safety Plan to warn the public of this hazard, which included warning signs, sirens and beacons installed at various locations along and in the Merrimack River (FERC 2000). Accordingly, to be conservative and assure public safety, the 3,500 cfs threshold to open the Northern Canal Walkway remained despite the installation of the Surge Gate.

Within one year of license issuance, Boott will develop a Recreation Access and Facilities Management Plan in consultation with the stakeholders to: a) evaluate opportunities for increasing pedestrian access to the Northern Canal Walkway under certain conditions; b) define flow management practices needed to enhance recreational opportunity in the project vicinity; and c) continue to manage the Project's recreation facility, the E.L. Field Powerhouse Visitor Center.

E.7.6.1.13 Land Use

Land use in the immediate vicinity of the Project is shown in Figure E.7-28 through Figure E.7-29. There are limited Project lands within the Project Boundary and only facilities needed for operation of the Project are included within the Project Boundary. Land use at the Project facilities is primarily Developed, High Intensity.

Land use along the impoundment of the Lowell Hydroelectric Project varies. The land use at the southern reach of the impoundment, in the Nashua area, and near Manchester is predominantly Developed, High Intensity. Elsewhere along the impoundment, where there are suburban and rural areas, land use is predominantly Developed, Low Intensity, except at the northern reach of the impoundment where other significant land uses include forest, hay/pasture, and crops.

Figure E.7-28. Land Use in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary

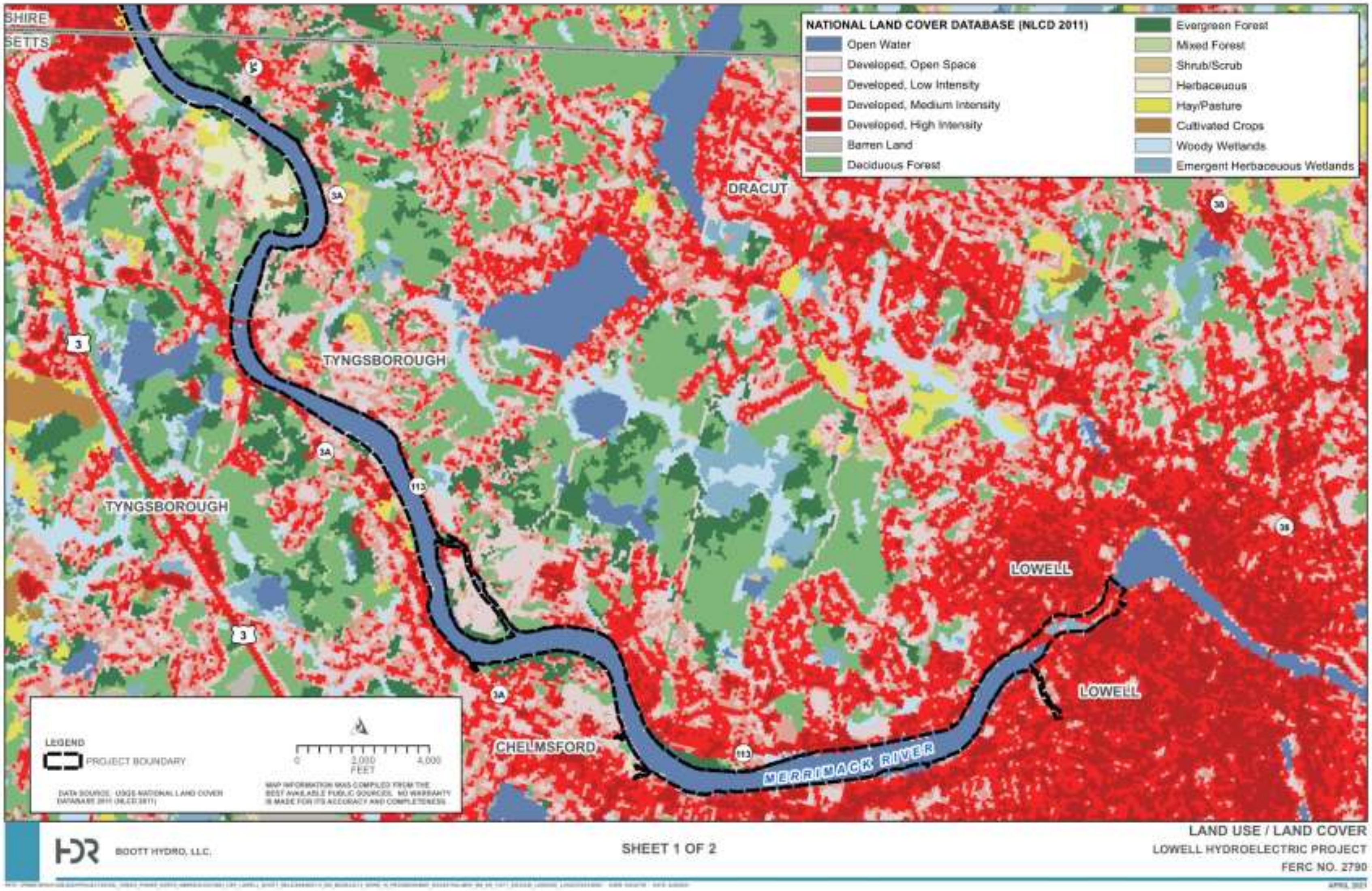
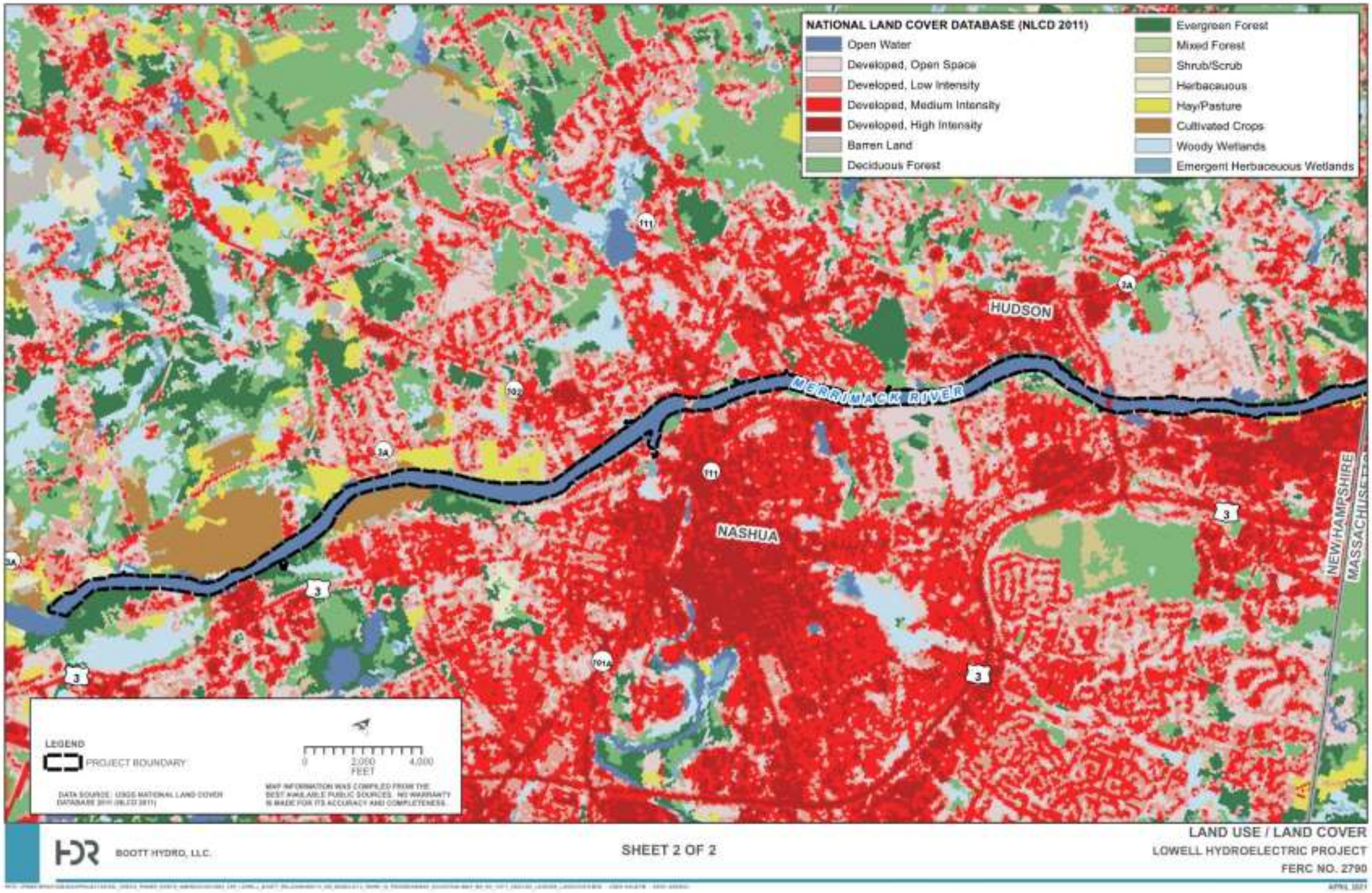


Figure E.7-29. Land Use in the Vicinity of the Lowell Hydroelectric Project and Proposed Project Boundary



E.7.6.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on recreation and land use as potential resource issues. Specifically, SD2 identified the following potential resource issues related to recreational use and land use to be analyzed for site-specific effects:

- Effects of continued project operation on recreational use in the Project area, including the adequacy of existing recreational access, and the adequacy and capacity of existing recreational facilities.
- Effects of continued project operation on land use in the project area.

E.7.6.2.1 Recreational Resources

As described in the Recreation and Aesthetics Report (HDR 2021a), more than 145 recreationists participated in interview or online surveys to share their opinions of and experiences with existing non-Project recreation facilities within the Project's vicinity. Most sites inventoried were reported in good condition, with parking lots, ample signage, and educational exhibits. Respondents both in-person and online overwhelmingly rated their overall experience as "totally acceptable" or "acceptable". Overall, the visitor use data indicates that non-Project recreation facilities within the Project's vicinity provide an "acceptable" or "totally acceptable" recreation experience for visitors.

While walking was the most common primary recreation activity, other trail-related activities (dog-walking, hiking, running, or jogging), bank and/or boat fishing, and kayaking all ranked high among activities that respondents participated in while visiting Project recreation facilities. The most frequently visited recreational facilities in the Project area were Lowell Heritage State Park, the Rourke Brothers Boat Ramp, Chelmsford Boat Access, Merrimack Trail System, and LNHP-facilities. Potential issues with the recreation facilities included crowding and safety; however, in general, respondents did not experience much crowding at the recreational facilities, parking issues, or lack of accessibility to the specific recreational facilities.

As part of the Recreation and Aesthetics Study, Boott conducted an evaluation of expanded recreational access in the Project canals. Boott's primary concerns were the recreational rights to the canal system and understanding public safety issues associated with providing recreational access in the Project's canal system. Boott reviewed many sources to understand the recreational rights to the Lowell canal system, including the Memorandum of Understanding (MOU), the 1984 Great Deed between Proprietors and Boott (Proprietors 1984), the 1986 Order of Taking (Commonwealth of Massachusetts 1986), and the 1995 Grant of Easement from the Commonwealth of Massachusetts to the LNHP (Commonwealth 1995).

By letter dated May 14, 1980, MADCR stated that they were currently in the process of negotiating purchase rights to the Lowell canal system which would allow for recreational boating in the canals, stating further that use of the canals and implementation of the boating program were key elements of the Lowell Heritage State Park (Massachusetts Department of Emergency Management [MADEM] 1980). Through the 1986 Order of Taking, MADCR purchased all air rights over the canals, including over the canal walls and dams, and the exclusive right to use water in the entire canal system for recreational, educational, and navigational purposes, unless said purposes interfere with Boott's hydroelectric generation (Commonwealth 1986). Included in the 1986 Order of Taking is a permanent and exclusive easement to MADCR for all canal walls, beds, or bottoms throughout the canal system for purposes consistent with the use of the canal system as a recreational park. These purposes specifically include placement and attachment of docks, wharves, walls, and boat ramps of a temporary or permanent nature (Commonwealth 1986). The 1995 Grant of Easement from MADCR to LNHP did not convey these exclusive recreation rights to LNHP (Commonwealth 1995).

Based on the review of the MOU, the 1984 Great Deed between Proprietors and Boott, the 1986 Order of Taking, and the 1995 Grant of Easement from the Commonwealth of Massachusetts to the LNHP, Boott currently does not have any right to expand recreational opportunities throughout the Lowell canal system. MADCR purchased all recreational rights over all the canals and canal walls (even canals owned by Boott), including exclusive navigational rights such as boating or canoeing. MADCR maintains an exclusive and permanent easement throughout the entire canal system to install access points such as boat ramps, wharves, and docks. Boott and other stakeholders are not permitted to use the canals as recreational resources, as those rights are exclusively held by MADCR.

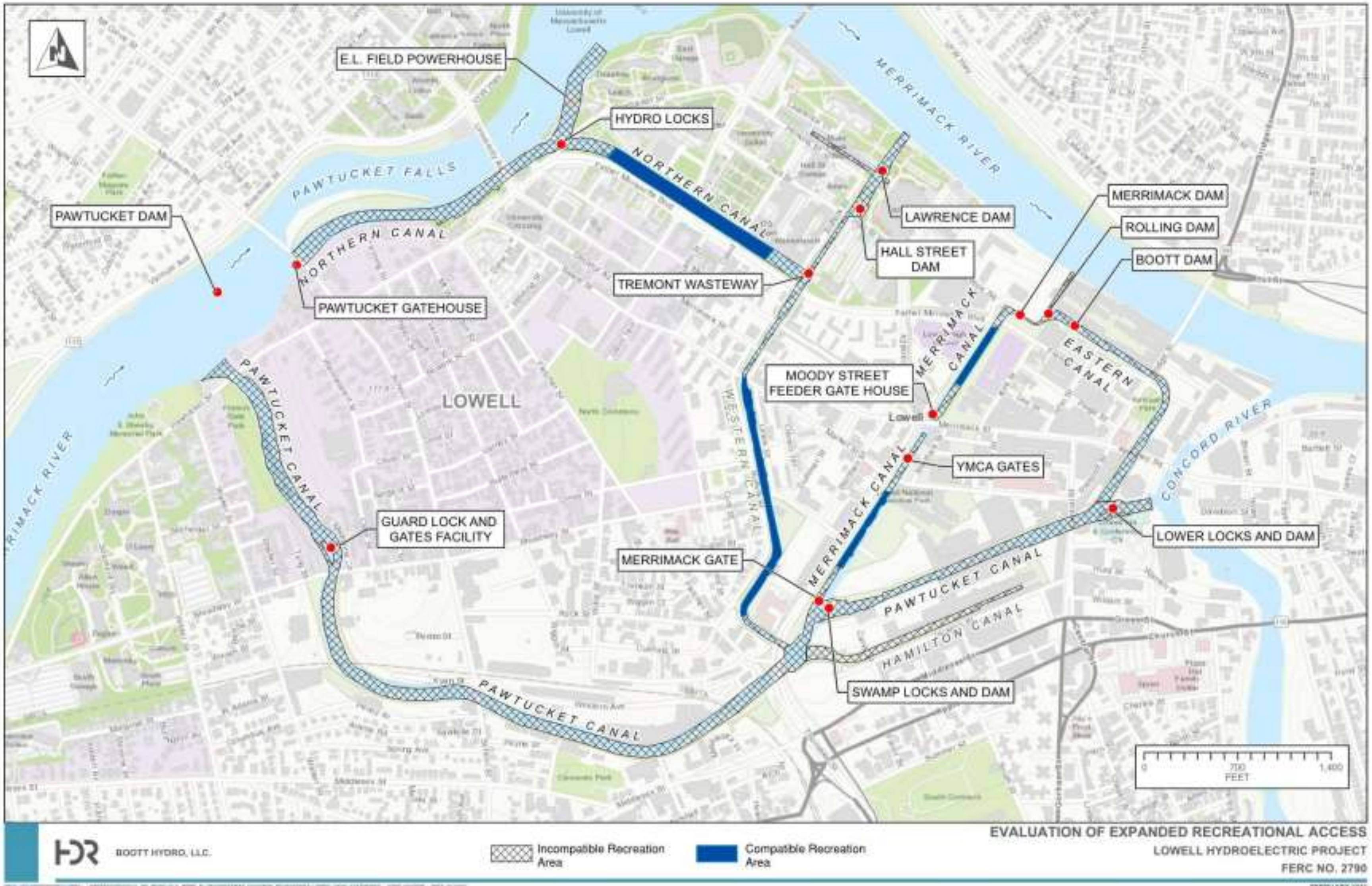
Additionally, while Boott does not have recreational or navigational rights to the canal system, Boott believes that providing access for the general public to the Northern Canal between the Pawtucket Gatehouse and the E.L. Field powerhouse would present a number of significant safety concerns. The current velocities in the Northern Canal are too high for safe navigation by non-powered boats when the E.L. Field powerhouse is operating, and the steep canal walls restrict the ability of public safety officials to respond to any emergency situations. Allowing recreationists access to or near to these Project facilities poses significant and unacceptable safety and security risks. That said, Boott is willing to work with local stakeholders to manage canal flows and water levels to facilitate safe public access to certain areas of the non-Project canal system identified below in Figure E.7-30, should that be desired.

As reported in the Recreation and Aesthetics Study Report, Boott conducted an analysis of any effects of the crest gate and water levels and flows on NPS bout tours and access to the Northern Canal Walkway. The effect of the crest gate system on NPS boat tours appears to be minimal, as flows in the Merrimack River are generally not that high (8,600 cfs) during the boat tour season, and even under those flow conditions Boott does not always raise the crest gates.

Boott's surge gate operations have the potential to affect access to the Northern Canal Walkway. Due to safety reasons with the surge gate, the Northern Canal Walkway opens seasonally (May 15 through October 15) when flow rates in the Merrimack River and Northern Canal are lower than 3,500 cfs.

Continued Project operations as proposed by the Licensee are not expected to result in any changes to the adequacy, availability, and accessibility of the non-Project related recreational facilities within the Project's vicinity.

Figure E.7-30. Identified Recreation Areas Potentially Compatible with Project Operations



E.7.6.2.2 Land Use

The facilities of the Lowell Hydroelectric Project are situated in an intensely developed urban landscape. The historic use of the Merrimack River in the vicinity of the Project for navigation, transportation, and industrial applications remain as the primary feature guiding its current use as a tourism attraction, municipal and industrial infrastructure element, and recreational asset. The City of Lowell was built by hydropower during the Industrial Revolution and hydropower is consistent with the current land use as an urban, industrial city. Continued Project operations as proposed by the Licensee are not expected to result in any changes to land use.

E.7.6.2.3 Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

Boott does not anticipate that removal of the canal facilities from the Project's license and decommissioning of the downtown powerhouses will have any adverse effects on recreation or land use within the Project's vicinity. Recreational boating is not permitted on the canal system, and the MADCR retains exclusive rights with respect to recreation on the canals. As noted above, MADCR also holds an exclusive and permanent easement throughout the entire canal system to install access points such as boat ramps, wharves, and docks. Boott and other stakeholders are not permitted to use the canals as recreational resources, as those rights are exclusively held by MADCR. The MADCR will continue to maintain those rights after the canal system is removed from the FERC license and the downtown powerhouses are decommissioned. Boott is not proposing to remove or otherwise modify the features of the canal system, and Boott will maintain facilities associated with the downtown canals in accordance with existing rights, responsibilities and existing or new agreements developed among the concerned stakeholders. Boott's proposal to maintain the canal water levels consistent with current practices will continue to support the NPS's seasonal canal boat tours.

Boott is not proposing any modifications to existing land use at the Project. While the downtown powerhouses will be decommissioned, Boott is not proposing any demolition or land-clearing activities associated with decommissioning that would affect the existing land use. For these reasons, the proposed removal of the canal system and the decommissioning of the downtown powerhouses is not expected to adversely affect recreation or land use.

E.7.6.3 Proposed Environmental Measures

Boott proposes continued operation of the Project with certain measures consistent with those required by the Project's existing license.

Within one year of license issuance, Boott will develop a Recreation Access and Facilities Management Plan in consultation with the stakeholders to: a) evaluate opportunities for increasing pedestrian access to the Northern Canal Walkway under certain conditions; b) define flow management practices needed to enhance recreational opportunity in the project vicinity; and c) continue to manage the Project's recreation facility, the E.L. Field Powerhouse Visitor Center.

E.7.6.4 Unavoidable Adverse Impacts

Continued Project operations as proposed by the Licensee are not expected to result in any changes to recreation or land use. Considering that the Whitewater Boating and Access Study is on-going, Boott anticipates continuing to consult with AW and other relevant stakeholders on appropriate PM&E measures, if any, based on the results of that study. As appropriate, Boott may propose additional PM&E measures in a supplement to this license application.

E.7.7 Aesthetics and Socioeconomic Resources

The subsections below describe aesthetic and socioeconomic resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, other existing information, and from the results of the Recreation and Aesthetics Study performed by Boott in 2020.

E.7.7.1 Affected Environment

E.7.7.1.1 Aesthetic Resources

The Lowell Project is located within the Seaboard Lowlands Section of the New England Physiographic Province. The Taconic, Green, and White Mountain ranges are distinct features of the New England Physiographic Province. The Seaboard Lowlands Section is lower in elevation and less hilly than the adjoining New England Upland Section (Flanagan et al. 1999). The local relief in the Merrimack River Valley in the Project vicinity is generally characterized as low, open hills. The Merrimack River watershed encompasses approximately 5,010 square miles within the states of New Hampshire and Massachusetts. It is the fourth largest watershed in New England. Although the Merrimack River watershed is heavily forested (75 percent of the land area is covered with forest), it also supports all or parts of approximately 200 communities with a total population of 2.6 million people (USEPA 2020b; USACE 2006).

Along the upper northern boundary of the Merrimack River watershed, the relatively undeveloped White Mountain National Forest in New Hampshire provides almost 800,000 acres of protected land; this region also provides over one million acres of private forest and agricultural land (NHDNCR 2018). The Project dam is located at RM 41 on the Merrimack River, and the impoundment extends upstream approximately 23 miles almost to the City of Manchester in New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. In the vicinity of the Project in Lowell, Massachusetts, the Merrimack River flows through a region of rapid population growth and development stemming from the 1800s that is still heavily influenced by the growing Boston urban metropolitan area (Figure E.7-28 through Figure E.7-29).

The Project facilities are generally bordered to the north by Route 113 and VFW Highway, and to the south by Pawtucket Street in the heavily populated City of Lowell, MA. The Project's impoundment is largely visible from Route 113 to the north and east and from Route 3A (Tyngsboro Road) to the south and west. One of the best views of the dam is from the Pawtucket Gatehouse which is located at the southern abutment of the Pawtucket Dam that controls flow into the Northern Canal. The Project's facilities can also be seen from the pedestrian trail located along the Northern Canal, from the University Avenue Bridge crossing, and from VFW Highway. The Project's bypass reach, located north of Mammoth Road and extending down below the Project's powerhouse, offers scenes of jumbles of rocks near the Pawtucket Dam, bedrock outcroppings, and ledges at low water periods, and contains strips of forest vegetation along the streambanks typical of the region. Scenic intrusions and topographical alterations resulting from original Project construction have long since disappeared, and the Project area has become integrated with the environmental and visual setting of the surrounding area.

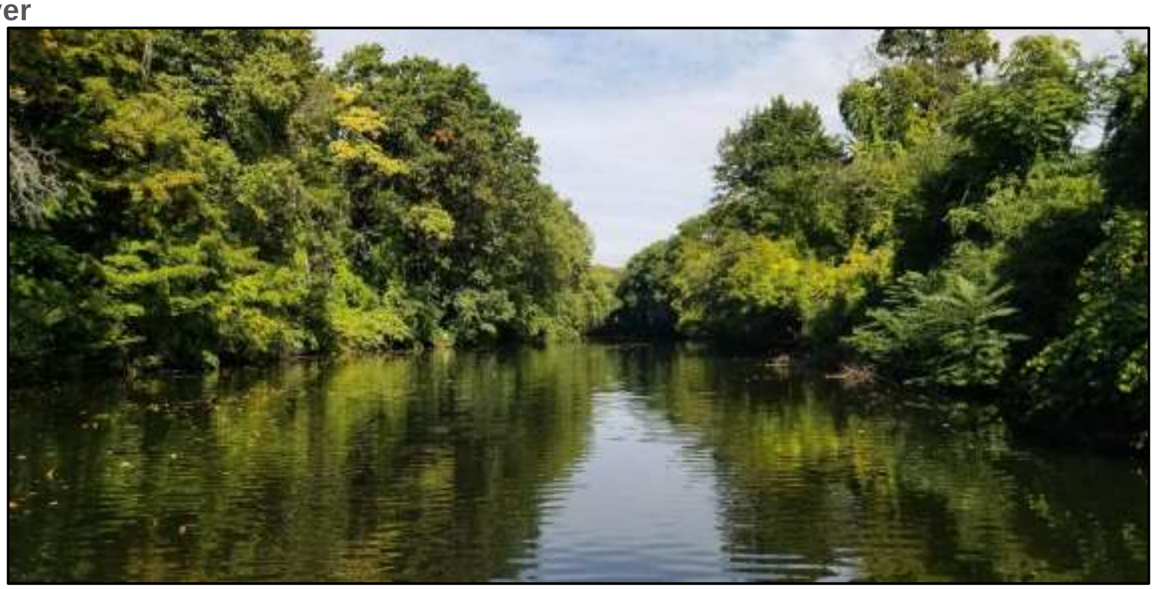
The aesthetic resources of the Lowell Project largely reside in the historic infrastructure that the Project is a part of. The multiple historic textile mills, gatehouses, locks, canals, and walkways that are part of the Lowell National Historical Park are the primary aesthetic attraction of the Lowell Project (Figure E.7-31 through Figure E.7-35). Tourists are drawn to the city of Lowell to witness the historic site of the Industrial Revolution in the United States. Lowell is essentially a living exhibit of the process and the consequences of the American Industrial Revolution. In addition, the Project's immediate shoreline, associated canals, and river corridor offer a scenic backdrop in an intensely urbanized setting (Figure E.7-33 and Figure E.7-34).

Figure E.7-31. Pedestrian Walk with View of the Northern Canal (left) and Bypass Reach (right).

Figure E.7-32. Guard Lock and Gates Facility.

Figure E.7-33. Upstream View of Bypass Reach Near University Avenue

Figure E.7-34. Westerly View of Pawtucket Canal Near the Confluence with the Merrimack River



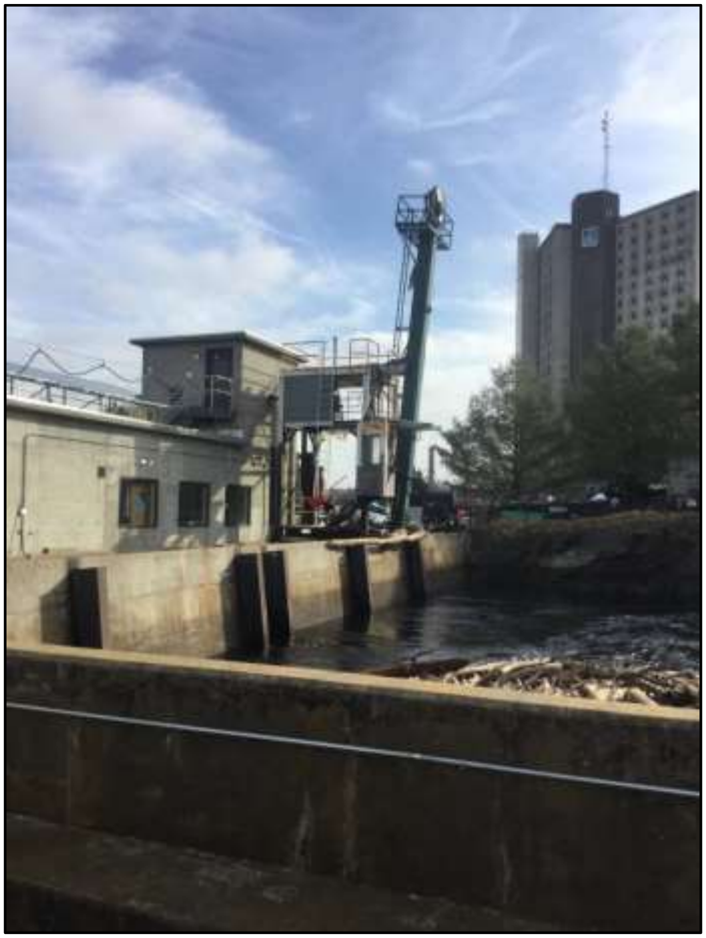
During the original licensing of the Project, NPS and other stakeholders stated that the powerhouse architecture should not mimic the nineteenth-century structures nearby. It was stated by officials that the modern nature of the new facility would be apparent and that it would harmonize well with the Northern Canal, the local neighborhood, and the river. The Licensee agreed to coordinate final exterior building design with the NPS and other interested agencies to help achieve this aim. Landscaping of the powerhouse area was also discussed in the prior application and the following proposals were made (Boott Mills 1980):

- Riverbank vegetation near the site to be protected to the extent feasible.
- Steep, riverside areas disturbed during construction are to be planted with native plant material.
- Street-level areas to compliment state and federal park design.
- Transmission lines from station to adjacent highway bridge to be inconspicuous.

Figure E.7-35 and Figure E.7-36 depict the Pawtucket Dam and E.L. Field Powerhouse, respectively. The E.L. Field Powerhouse is located in the vicinity of more modern architecture such as the University of Massachusetts Lowell dormitories.

Figure E.7-35. Westerly View of Pawtucket Dam from the Pawtucket Gatehouse

Figure E.7-36. E.L. Field Powerhouse with University of Massachusetts Lowell in the Background



E.7.7.1.2 Recreation and Aesthetics Study

Pursuant to the RSP, on April 9, 2020, Boott mapped areas within the canal system owned or under the control of Boott where waterborne trash may be a potential concern. The amount and type of waterborne trash that accumulates within the Project boundary can vary according to several factors including the season, Project operations, and the magnitude and duration of the flow events (HDR 2021a).

The surveys for waterborne trash have shown that waterborne trash accumulates within the Project's canal system, and these accumulations are somewhat dependent on the level of the water within the canals as well as the required operation of some of the NPS gates within the study area. For example, NPS gates that are operated on a routine basis had minimal signs of waterborne trash associated with them, while others that are largely in the closed position tended to have accumulations of waterborne trash behind them at varying densities (HDR 2021a).

Accumulated waterborne trash includes material floating on the impoundment surface and/or found on the surface of the canal system. Most of the waterborne trash accumulation within the Lowell Canal system appears to be derived from upstream inputs (the Merrimack River) as well as direct canal inputs (accidental and intentional littering) and from runoff events (also likely from accidental and intentional littering) (HDR 2021a).

In total, eight (8) areas of waterborne trash totaling 0.21 acres were mapped on April 9, 2020 as well as three additional areas of accumulated trash on the canal bed and a single area with a waterborne sheen. The total study area encompassed approximately 44 acres and the mapped areas within the canals were 3.531 acres or approximately 154,000 square feet (HDR 2021a).

Waterborne trash consisted of common materials such as foam board pieces, plastic cups, foam plates, foam bait containers, shoes, plastic bottles, organic debris, etc. (see Figure E.7-37 and Figure E.7-38).

Figure E.7-37. Waterborne trash on the Pawtucket Canal at Guard Lock and Gates Facility.

Figure E.7-38. Waterborne trash on the Merrimack River upstream of the Northern Canal Gatehouse

E.7.7.1.3 Socioeconomic Resources

The Lowell Project is located in Middlesex County, Massachusetts and Hillsborough County, New Hampshire. The population of Middlesex County, based on the vintage year[26] V2019 census data, was 1,611,699 resulting in a 7.2 percent increase in population from April 1, 2010 to July 1, 2019 (U.S. Census Bureau undated). The population of Hillsborough County, based on the vintage year V2019 census data, was 417,025 resulting in a 4.1 percent increase in population from April 1, 2010 to July 1, 2019 (U.S. Census Bureau undated).

According to the U.S. Census Bureau, the median household income in Middlesex County (in 2018 dollars) from 2014-2018 is estimated to be $97,012. There is an estimated 7.3 percent[27] living below the poverty line in Middlesex County (U.S. Census Bureau undated). The most common employment sectors for Middlesex County are healthcare and social assistance; professional, scientific, and tech services; and educational services (Data USA undated).

According to the U.S. Census Bureau, the median household income in Hillsborough County (in 2018 dollars) from 2014-2018 is estimated to be $78,655. There is an estimated 7.4 percent[2] living below the poverty line in Hillsborough County (U.S. Census Bureau undated). The most common employment sectors for Hillsborough County are healthcare and social assistance, manufacturing, and retail trade (Data USA undated).

The Lowell Project is located within the Greater Boston metropolitan area, which is primarily composed of urban and suburban towns and cities. The city of Lowell's estimated population in 2019 was 110,997 - making it the fourth largest city in Massachusetts. The population of Lowell grew an estimated 4.2 percent since the previous 2010 census. The median household income in Middlesex County (in 2018 dollars) from 2014-2018 is estimated to be $97,012, while the Lowell household annual income (in 2018 dollars) from 2014-2018 was $51,987. An estimated 20.7[2] percent of families were below the poverty line in 2018 (U.S. Census Bureau undated).

The economy of Lowell employs approximately 50,000 people. Lowell's economy is specialized in manufacturing, administration, waste management services, and healthcare and social assistance. The largest industries in Lowell are healthcare, manufacturing, and retail trade. Educational, scientific, and technical services are also notable contributing industries to the Lowell economy.

The City of Lowell's Healthy and Sustainable Local Economy 2025 Master Plan targets multiple facets of the local economy and the well-being of its citizens. One facet is to continue to support the urban revitalization plan of the Hamilton Canal District which includes properties adjacent to Lowell Project facilities. A second facet of the City of Lowell's plan is to attract and maintain environmentally sustainable businesses,

[26] The vintage year (e.g., V2019) refers to the final year of the series (2010 thru 2019). Different vintage years of estimates are not comparable.

[27] Estimates are not comparable to other geographic levels due to methodology differences that may exist between different data sources.

institutions, and industry. Hydropower is a suitable industrial energy supplier that satisfies this local economic development goal (City of Lowell 2013).

E.7.7.2 Environmental Analysis

FERC's SD2 identified the following potential resource issue related to aesthetics and socioeconomic effects:

- Effects of continued project operation on aesthetic resources in the project area, including the historic industrial context of the project structures and features.

E.7.7.2.1 Aesthetic Resources

A described above, the facilities of the Lowell Hydroelectric Project are situated in an intensely developed urban landscape. The Project dam is located at river mile 41 on the Merrimack River, and the impoundment extends upstream approximately 23 miles almost to the City of Manchester in New Hampshire. The Project impoundment is characterized by the urban/industrialized cities of Nashua, New Hampshire and Lowell, Massachusetts. In the vicinity of the Project in Lowell, Massachusetts, the Merrimack River flows through a region of rapid population growth and development stemming from the 1800s that is still heavily influenced by the growing Boston urban metropolitan area.

The aesthetic resources of the Lowell Project largely reside in the historic infrastructure of the Project. The multiple historic textile mills, gatehouses, locks, canals, and walkways that are part of the Lowell National Historical Park are the primary aesthetic attraction of the City of Lowell, portions of which are included in the Lowell Project (Figure E.7-31 through Figure E.7-35).

Pursuant to the approved study plan for the Recreation and Aesthetics Study, Boott reviewed several sources to summarize historical and current practices for maintaining aesthetics (vegetation and waterborne trash management) in the Project Area. Following establishment of the LNHP in 1978, MADCR[28], NPS, and Proprietors, entered into an agreement in 1979 regarding management of the Lowell canal system and other historic structures. This agreement establishes MADCR as the lead party responsible for the maintenance of canal structural components, including canal banks and walls. As the lead party, MADCR was responsible for "landscaping and damage repair" to canal banks and walls, with assistance provided by NPS if needed. NPS was charged with the operation of the canal-related exhibits and services, and Proprietors were responsible for the operation and maintenance of the hydroelectric and hydromechanical parts of the Lowell canal system (NPS 1981). NPS developed and issued a Final General Management Plan (FGMP) in August 1981 to provide a basis for visitor use, resource management, and general development within the LNHP. The FGMP states that management of the Lowell canal system will be accomplished through cooperative agreements between private and public entities, but MADCR is the lead agency

[28] The signatory of the 1979 agreement was the Massachusetts Department of Environmental Management, the predecessor agency to MADCR.

responsible for maintaining, developing, and renovating the major elements of the canal system (NPS 1981).

In 1991, MADCR, the NPS, and Boott executed a MOU for the purpose of maintaining and operating the Lowell Canal System.[29] The MOU assigned specific responsibilities to each party and was filed with the Commission[30] on April 25, 1991 (MOU 1991). Article IV of the MOU directed NPS to assist MADCR in the removal and control of vegetation along the canal system, ("particularly that growing on and in the canal walls") and to assist MADCR in performing ground maintenance. Article IV also directed NPS to assist MADCR in the removal of litter and other waterborne trash from the Lowell Canal System, and states NPS is solely responsible for maintaining and cleaning, ("including removal of trash") all existing trash booms and safety lines/booms on the Lowell Canal System (MOU 1991).

Responsibilities assigned to MADCR under Article V of the MOU include serving as the lead agency for all grounds maintenance, keeping all grass, trees, and shrubs neatly trimmed and in a healthy condition, removing dead or diseased plants, fertilizing, pruning, and thinning of plants (as required), and approving ground maintenance or improvement plans as proposed by NPS. Article V also directs MADCR to assist NPS in the removal and control of destructive vegetation along the canal system, and to cooperate with the NPS on developing a litter removal program for waterborne litter and trash on the canals. (MOU 1991). This article also directed MADCR to reimburse NPS for time and materials for work done on the canal system.

Article VI of the MOU directed NPS and MADCR to hold a joint annual meeting to develop an annual destructive vegetation clearing program and canal surface water cleanup program. The annual programs were to be developed in accordance with each agency's budget and seasonal staffing level. Under Article VI, MADCR was also directed to consult with NPS to develop a long-term capital improvement program for the canal system. The minutes of this annual meeting between MADCR and NPS were to be provided to Boott and the Proprietors each year (MOU 1991).

Article IX stated that the MOU would expire five years from the date of signing, with an option for renewal. Efforts to renew the MOU apparently stalled around 1996, as MADCR issued a Grant of Easement[31] to the NPS in late 1995 (FERC 2001; Boott 2001; Lowell Sun 2006). This Grant of Easement provided NPS rights to implement construction and maintenance improvements at forty-two MADCR-owned parcels around the canal system. Such rights include landscaping, decking, and lighting. The Grant of Easement did not exclusively limit NPS's rights, only stating that construction and maintenance improvements must be consistent with the use of the area as a park. The Grant of Easement did not relinquish MADCR's waterborne trash and vegetation management responsibilities provided by the FGMP or MOU, as described above.

[29] Proprietors of the Locks and Canals on the Merrimack River was included as a party in the MOU but did not execute the agreement.

[30] The 1991 Memorandum of Understanding is available on FERC's eLibrary (https://elibrary.ferc.gov/eLibrary/search) under docket number p-2790.

[31] The 1995 Grant of Easement is also generally referred to as LNHP Deed No. 40.

In the Resource Management Plan (RMP) for the Lowell/Great Brook Planning Unit, MADCR elaborates the agency was directed by the Commonwealth in 1993 to “concentrate on maximizing the riverfront component and minimizing, but not eliminating, [its] position in the downtown.” Under a lower annual budget, MADCR states it has since focused its resources on the riverfront portion of the Lowell Heritage State Park system and less on the downtown canal system (MADCR 2014).

Boott annually removes accumulated river-borne debris from the upstream side of the Northern Canal Gatehouse under an MADCR permit. This effort is performed as necessary, typically two to three times annually. Boott also removes debris that accumulates from the upstream side of the Guard Locks and Gatehouse in the Pawtucket Canal on an as necessary basis, both for aesthetics and to ensure that debris does not interfere with the proper functioning of the Guard Gates. Boott will continue these practices under the new FERC license.

The combination of past and present land use activities in and around the Project area have contributed and will likely continue to contribute to the accumulation of waterborne trash within the Project’s canal system that occur in the study area today (e.g., industrialization, commercial development, residential areas in close proximity to canals, etc.). However, the complexity and diversity of historical and current land use activities in the study area create a problem for tracing and identifying the sources of waterborne trash and its movement and distribution within the study area. Waterborne trash consisted of common materials such as foam board pieces, plastic cups, foam plates, foam bait containers, shoes, plastic bottles, and organic debris. It is well known that many types of land uses contribute to the accumulations of waterborne trash including stormwater drainage systems, upstream sources, inappropriately discarded trash, natural events (woody debris), densely populated areas, etc. Roads, construction, recreation, residential developments, and commercial and industrial developments all can contribute to the problem. Ongoing Project operation and maintenance has very little potential to cause and/or significantly contribute to the waterborne trash accumulation areas observed during the study.

Existing Project facilities are an integral part of the river’s ecologic and aesthetic character. The Licensee is not proposing to modify Project operations. Current Project operations do not involve activities that directly affect aesthetics. Continued operation of the Project will help maintain the aesthetic quality of the Merrimack River by providing a continuous flow in the Project’s bypassed reach and downstream areas. No impacts on aesthetic resources are expected as a result of continued Project operations.

E.7.7.2.2 Socioeconomic Resources

As previously described in this application, the Project is located within the historic infrastructure of the LNHP. Tourists are drawn to the city of Lowell to witness the historic site of the Industrial Revolution of the United States. Boott is not proposing to modify Project operations in manner that would affect regional tourism. As such, the continued operation of the Project as proposed by the Licensee is not expected to have any adverse effects on socioeconomic resources.

E.7.7.2.3 Effects of Decommissioning

As described in Section E.6.2 of this Exhibit, Boott is proposing to remove the downtown canal facilities from the Project's FERC license and to decommission the Assets, Hamilton, John Street, and Bridge Street powerhouses. Boott will maintain canal water levels consistent with current practices, and under normal operations will continue to release an estimated 200 to 300 cfs into the canal system via the Guard Locks and Gates Facility to balance leakage from the canal system.

The proposed removal of the canal system from the FERC license and decommissioning of the downtown powerhouses is not expected to adversely affect aesthetic or socioeconomic resources. Boott is proposing to maintain flows in the canal system equivalent to what is currently provided to maintain the aesthetics of the canals that attract tourists and visitors to the City of Lowell. Boott is also proposing to continue to maintain canal facilities consistent with existing rights, responsibilities, and existing or new agreements developed among the concerned stakeholders. Boott intends to decommission the downtown powerhouses and is not proposing demolition or land-clearing activities in association with decommissioning that would affect the aesthetic character of the powerhouses.

The proposed maintenance of canal water levels consistent with current practices will continue to support the NPS's canal boat operations that attract visitors to the LNHP. Boott does not anticipate that the proposed decommissioning of the downtown powerhouses will have any adverse effects on aesthetic or socioeconomic resources.

E.7.7.3 Proposed Environmental Measures

Boott proposes to continue operations of the Project with certain PM&E as outlined above in Section E.6.2.

E.7.7.4 Unavoidable Adverse Impacts

The continued operation of the Project as proposed by the Licensee is not expected to have any unavoidable adverse effects on aesthetic or socioeconomic resources.

E.7.8 Cultural Resources

The subsections below describe cultural resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources.

In considering a new license for the Project, the Commission has the lead responsibility for compliance with applicable Federal laws, regulations, and policies pertaining to historic properties, including the National Historic Preservation Act of 1966, as amended (NHPA)[32]. Section 106 of the NHPA (Section 106)[33] requires Federal agencies to

[32] 54 U.S.C. §300101 et seq.

[33] 54 U.S.C. §306108

consider the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment.

The term "historic property" is defined in the implementing[34] regulations as any precontact or historic period district, site, building, structure, or individual object included in or eligible for inclusion in the National Register of Historic Places (NRHP), including any artifacts, records, and remains that are related to and located within historic properties, and properties of traditional religious and cultural significance that meet the NRHP criteria. The criteria for evaluating properties for inclusion in the National Register (36 C.F.R. Part 60) has been established by the Secretary of the Interior. In accordance with the criteria, properties are eligible if they are significant in American history, architecture, archaeology, engineering, or culture. The quality of significance is present in historic properties that possess integrity of location, design, setting, materials, workmanship, feeling, association, and:

1. That are associated with events that have made a significant contribution to the broad patterns of our history;
2. That are associated with the lives of persons significant in our past;
3. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant or distinguishable entity whose components may lack individual distinction; and/or
4. That have yielded or may be likely to yield information important in prehistory or history.

The regulations implementing Section 106 are intended to accommodate historic preservation concerns with the needs of federal undertakings through a process of consultation among agency officials, Federally recognized Native American tribes, SHPO, Tribal Historic Preservation Officers (THPO), and other parties, including the public, as appropriate. By letter dated April 26, 2017, the Commission initiated consultation under Section 106 with Federally recognized Native American tribes, including the Mashpee Wampanoag Tribe, Narragansett Indian Tribe, Stockbridge Munsee Tribe of Mohican Indians, and Wampanoag Tribe of Gay Head (Aquinnah).

The Commission designated Boott as its non-federal representative for purposes of conducting informal consultation pursuant to Section 106 via the June 15, 2018 NOI to file a License Application for a New License and Commencing Pre-filing Process.

E.7.8.1 Affected Environment

E.7.8.1.1 Area of Potential Effects

The area of potential effects (APE) for any undertaking is defined in 36 C.F.R. §800.16(d) as the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such

[34] 36 C.F.R. Part 800 – The Protection of Historic Properties

properties exist. The APE is influenced by the scale and nature of an undertaking. Although the Project's potential effects are limited by the nature of this undertaking (the relicensing and continued operation and maintenance of existing hydroelectric facilities), the Project has the potential to affect historic properties directly or indirectly (should any such properties exist). As described in the PAD, Project-related effects on historic properties may potentially result from (1) the Project's operations, (2) potential enhancement measures at the Project, and (3) routine maintenance activities. Potential enhancement measures at the Project (e.g., development of new recreation access areas) could result in ground disturbance which has the potential to disturb intact archaeological deposits, should any be present. Routine maintenance activities at the Project could result in ground disturbance and could also affect the integrity of historic buildings and structures.

Consistent with the scope of potential effects on historic properties, Boott proposed to define the APE for relicensing the Project as the following:

> *The APE for the Lowell Hydroelectric Project is the lands within the defined FERC Project boundary.*

Since the Project boundary encompass all lands that are necessary for the Project's purposes, the definition of the APE is consistent with the 36 C.F.R. §800.16(d) and the manner in which the Commission has defined the APE for similar hydroelectric projects. The existing Project boundary is presented in Figure E.1-1.

As stated elsewhere in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license and associated Project boundary.

E.7.8.1.2 Cultural Context

Precontact Period

For several thousand years, the Pawtucket Falls was a thriving center of Native American economic and cultural activity. The annual run of anadromous fish drew Pennacook Native Americans from a wide area of northern New England, and two subtribes, the Pawtuckets and Wamesits, established villages on the flats near the bend of the Merrimack below the falls. Salmon, sturgeon, shad, and alewives were harvested with nets, spears, and barbed arrows. The fish provided not only a large portion of the Native Americans' yearly protein intake, but also served as fertilizer for the nearby agricultural fields. The site retains its Native American name today, for "Pawtucket" means rapids or falls in the Algonquin dialect of its early settlers (Boott Mills 1980).

There are three pre-Contact archaeological sites recorded in the area of Lowell Park, however, many more exist along the Merrimack River both upstream and downstream of the Project. Many Archaic Period village sites, camp sites, and fishing grounds are documented in the vicinity of the Project (MADCR 2014). Boott distributed PAD questionnaires to the MHC and the NHDHR; however, no responses were received.

According to the MHC's survey map of prehistoric sites in Lowell, a major Native American archeological site is on the flood plain beyond the bluff. Much of this area, site of Native American campgrounds and cultural activities associated with fishing, has been disturbed by a series of construction projects for roads and buildings. The likely locations of artifactual remains lie northeast of the path followed by the intake channel (Boott Mills 1980).

E.7.8.1.3 Historical Context

This section provides an historical context of the Project Area from early Anglo-European settlement through the Industrial Revolution.

Anglo-European settlers gradually acquired Native American homelands, and private ownership divided the once common land into scattered farms. Proprietors of riverbank properties even acquired legal title to the fishing rights on sections of the rapids. Although remnants of former Native American bands made annual trips to fish at the Pawtucket Falls as late as the 1840s, they were considered a quaint curiosity in the growing industrial community (Boott Mills 1980).

Background of Industrial Lowell

A number of circumstances are responsible for Lowell becoming America's first industrial city, particularly, the existence of the great waterpower potential at the Pawtucket Falls. Although a transportation canal around the rapids at Lowell was completed in 1796, the manufacturing potential of the site was not fully appreciated until 1821. The Boston Associates chose the site of the Pawtucket Falls for their new textile manufacturing community (Boott Mills 1980). The Boston investors acquired control of Proprietors of the Locks and Canals on Merrimack River, the company that had built the Pawtucket navigation canal and that, due to the success of the competing Middlesex Canal (direct route to Boston), was not doing well financially. The Boston investors and other industrialists formed a series of textile corporations in Lowell. The old canal company was set up to build canals, sell mill sites, manufacture machinery, and lease waterpower to the textile manufacturers (Boott Mills 1980). The Pawtucket Canal became the feeder for a complex system of power canals beginning in 1822. By 1826, two canals branched from the Pawtucket and four additional canals were already envisioned. Ten years later, the expanded system was complete. Water drove the machinery of mills located on two distinct levels, with the tailraces of mills on the upper level emptying into canals leading to lower level mills. By 1846, when a second major expansion of the canal system began, ten textile mill complexes and a machine shop received their power from Proprietors of the Locks and Canals on Merrimack River (Boott Mills 1980).

General History of the Northern Canal Area

Since 1826, engineers had been able to increase the flow into the Lowell Canal system by constructing dams at Pawtucket Falls. The first was a crude wooden structure; but by 1830, a masonry dam seated on heavy wooden cribbing was helping to maintain a "pond" behind the falls. Three years later, workmen added two more courses of granite headers and raised wooden flashboards. This raised the level of the upper river and diminished its current for over 18 miles upstream. However, the dam did not meet the water needs of the growing industrial city for long as the demand for waterpower continued to increase yearly as the textile corporations expanded their manufacturing operations. Power was continually scarce in the dry summer months; and by the 1840s, shortages were common throughout the year. One problem was the severe friction losses in the canals created by greater flow rates. When mills needed more water, the current had to increase to supply this demand. Increased current produced friction, which actually dropped the level of water in the canals and reduced the head, or potential to generate power. Thus, the mills could only get a greater flow of water by giving up some of the head that they also needed. In times of freshets, river water entering the tailraces of mills impeded their wheels. Such backwater conditions placed excessive demands on the canal system (Boott Mills 1980).

James B. Francis, the British-born chief engineer of Proprietors, proposed the construction of a second feeder canal. This huge waterway would bring additional water into the system and allow a reduction of current in most of the canals. To make such a plan effective, however, two conditions had to be met. First, Locks and Canals would have to prohibit the use of water for manufacturing at night, so that the river's flow could be ponded until the morning. Second, the power company would have to control the outlets of the major lakes that fed the Merrimack River. Using the lakes as reservoirs, Lowell would then have a source of extra water in dry seasons (Boott Mills 1980).

With booming economic conditions in American textile manufacturing in the 1840s, the Essex Company of Lawrence and the Locks and Canals acquired control of over 100 square miles of lake surface in New Hampshire. James. B. Francis selected a new route for a second feeder canal. The route ran parallel to the river for over 2,000 feet, then turned inland to join the Western Canal. The route required Francis to build a "Great River Wall" to hold his canal above the Merrimack rapids and also required him to (1) rebuild a large part of the Pawtucket Dam, (2) construct sophisticated gate controls, and (3) modify the existing canal system to integrate it with the new canal (Boott Mills 1980).

The construction of the Northern Canal, under the supervision of James B. Francis in 1846-1847, was one of the most impressive achievements in the history of American engineering. The vast undertaking was the culmination of efforts to harness the flow of the Merrimack River at Pawtucket Falls to drive the textile machinery of the Boston investors. When completed, the project set new standards in civil and hydraulic engineering and introduced the famous "Francis" turbine to the world (Boott Mills 1980). The Northern Canal brought water into the system with a higher head than had been previously possible, and it reversed the current in the Western Canal from the junction to the Swamp Locks Basin. Water from the Northern Canal supplied the demands of the Tremont, Suffolk, and Lawrence Mills. Once Francis had completed the Moody Street Feeder in 1848, the Northern Canal also fed the Merrimack Canal through three brick vaulted tunnels. A smaller underground passage, known as the Boott Penstock, transferred some of this flow from the Merrimack Canal to the end of the Eastern Canal, where an adequate water level had always been hard to maintain (Boott Mills 1980). After testing the results of his physical improvements to the system, Francis arranged for redistribution of power and an increase in the number of "mill powers" leased to each company. Because of the limitations of the old Pawtucket Canal as the sole feeder, only 91 mill powers had been leased up to that time. The Northern Canal enabled the chief engineer to lease 139 mill powers, a gain of more than 50 percent. These were "permanent mill powers" to be supplied in all seasons; for most of the year, the corporations could also purchase "surplus" mill powers at an inexpensive rate. The mill complexes were assured of almost 12,000 gross horsepower, even in summer (Boott Mills 1980).

Francis, acting as "The Chief of Police of Water," tried to prevent waste in the system and developed techniques to monitor the water use by individual corporations. When the flow in the river was low, he even closed the gates of the Northern Canal during the noon break. His 1846 tests of Uriah Boyden's outward-flow turbines in the Appleton Mills led to the development of the first "Francis" turbine, which was used to raise and lower the headgates within the Pawtucket Gatehouse. The original Francis turbine and drive belts remain in the Pawtucket Gatehouse, but are no longer used. This work convinced Francis that the corporations should switch from breastwheels to more efficient hydraulic turbines. In this way, they could produce more net horsepower from each "mill power" delivered to their sites. Also, turbines, which ran well underwater, could generate during the "backwater" conditions that ruined the efficiency of breastwheels. The widespread conversion to turbines in Lowell took place during and immediately following the construction of the Northern Canal. Francis' Northern Canal and its associated structures remain one of the most important historic engineering resources in the Northeast (Boott Mills 1980).

Historic Resources

In 1976 the Locks and Canals Historic District was listed on the National Register of Historic Places. The Locks and Canals Historic District includes the City of Lowell's canal system, surviving millyards, and other industrial-related resources. In 1977, the Locks and Canals Historic District was designated a National Historic Landmark (NHL), the nation's highest level of historic significance and recognition. In 1978, Congress passed the Lowell Act, which recognized the historical value of this industrial area and established the Lowell Park and Lowell Historic Preservation District, stating:

> *"…certain sites and structures in Lowell, Massachusetts, historically and culturally the most significant planned industrial city in the United States, symbolize in physical form the Industrial Revolution…"*

The Lowell Historic Preservation District surrounds Lowell Park as a buffer zone and enables federal assistance in the preservation and revitalization of the City of Lowell, while Lowell Park consists of the areas indeed for intensive visitor use in the interpretation of the City of Lowell and its canal system. The intention of the establishment of the Lowell Park and Lowell Historic Preservation District is to preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts.

A Cultural Resources Inventory of the Lowell National Historical Park and Preservation District was prepared for the NPS in 1980. This inventory was completed in response to the 1978 legislation establishing the Lowell National Historical Park and the Lowell Historic Preservation District. This legislation was two-fold in that it created a park as well as a historic preservation district. The legislation outlined broad policies and goals of the federal commitment and required careful planning. To address this need for planning, the cultural resources inventory was conducted to assess the resources and aid in future planning. The defining features of the Locks and Canals Historic District and Lowell National Historic District are discussed in further detail below.

Locks and Canals Historic District

The Locks and Canals Historic District was listed on the National Register in 1976 and became a National Historic Landmark in 1977. The Locks and Canals Historic District encompasses all the canals in Lowell (built between 1793 and 1848), their associated locks, and the mills that were powered by the canals. This district contains features of the Lowell Project. There are approximately five miles of canals, and the associated mill yards increase the acreage of the district to approximately 100 acres. The canals are contiguous and meander throughout the city. The mill buildings and yards are all associated directly with a canal, and three boarding houses, not contiguous to the canals but built by mill owners for their workers, are also included in the district. The main components of the Locks and Canals Historic District are:

- Lock House
- Francis Gate and House
- Sluice Gate House
- Northern Canal Gatehouse
- Locks and Canals Blacksmith Shop
- Gate Keeper's Cottage
- Northern Canal
- Northern Canal Walk and Great River Wall
- Suffolk Millyard
- Tremont Gatehouse
- Tremont Yard
- Lawrence Yard
- Moody Street Feeder
- Moody Street Feeder Gatehouse
- Boott Mills
- Massachusetts Mills
- Boot Mills Boarding House
- Massachusetts Mills Boarding House
- Lower Locks, Pawtucket Canal
- Bigelow Yard
- Hamilton Yard
- Eastern canal
- Lower Pawtucket Canal
- Appleton Mills
- Hamilton Canal
- Swamp Locks
- Merrimack Canal
- Lowell Machine Shop
- Proprietors of Locks and Canals Yard
- Western Canal

- Upper Pawtucket Canal
- Pawtucket Dam
- Suffolk Manufacturing Company Boarding Houses

The Locks and Canals Historic District is significant for its contributions to the development of Lowell as the first great industrial city in the United States.

Lowell National Historical Park

The LNHP and Preservation District was listed on the National Register in 1978. The LNHP Preservation District includes within its boundaries an approximate 5-mile power canal system, a portion of the central business district, and three major mill complexes. The area within the park boundaries totals 134 acres, but with only NPS ownership of a handful of buildings with other property privately owned. The Lowell Historic Preservation District includes the mills or mill sites of most of the rest major textile corporations, the remainder of the historic central business district, and areas along the Concord River where smaller factories flourished outside the main waterpower system. There are 895 properties within Lowell Park and the Lowell Historic Preservation District and are classified as follows:

- 307 residential buildings
  - 147 single family
  - 62 duplexes
  - 99 multiple family
- 210 commercial buildings
- 130 buildings within textile mill complexes
- 27 other industrial structures
- 16 schools
- 9 churches
- 24 government buildings
- 92 vacant lots
- 33 components of the canal system
- 11 bridges
- 37 miscellaneous structures (theaters, parking garages, playgrounds, etc.)

In terms of the condition, the properties (excluding the canals) are classified according to 1979 data as follows: 56 in excellent condition, 412 in good condition, 244 need minor repair, 70 need major repair, and 8 are derelict. In terms of period, the structures range in period from pre-1820 to post-1950 with the greatest number of structures dated in the 1890s and from 1900-1925.

Lowell Park and the LHPD’s most important historical resources are the canal system, the remaining major mill complexes, and the central business district’s nineteenth century commercial buildings. The District also includes elements of other historic industrial enterprises, particularly along the Concord River. Residential properties within the District represent most of the range of styles, forms, and periods of Lowell’s architectural history, but these houses generally fall short of Lowell’s historic houses outside the Lowell Historic Preservation District’s in quantity, quality, and concentration.

Lowell Canal System

The Lowell Canal System has also been recognized for its significance within the field of engineering. The American Society of Civil Engineers designated the "Lowell Waterpower System" as a Historic Civil Engineering Landmark in 1984, and the American Society of Mechanical Engineers designated the "Lowell Power Canal System and Pawtucket Gatehouse" as a Historic Mechanical Engineering Landmark in 1985 (MADCR 2014).

E.7.8.1.4 Cultural and Historical Resource Studies

Pursuant to the approved RSP and SPD, Boott filed with the Commission the following studies relating to historical and cultural resources:

- Water Level and Flow Effects on Historic Resources Study (HDR 2021b),
- Historically Significant Waterpower Equipment Study (Gray & Pape 2021), and
- Resources, Ownership, Boundaries and Land Rights Study (HDR 2021c).

Significant prior research and studies have been conducted to document historic buildings and structures within the City of Lowell, including Project facilities. In 1976, the Historic American Engineering Record (HAER) documented the history of the canal system in Lowell. The HAER study included detailed narratives, photographs, drawings, and maps of the historic canal system. The Lowell National Historical Park and Historic Preservation District Cultural Resources Inventory (Shepley, 1981) provides a comprehensive and detailed inventory of historic buildings and structures within the park unit and surrounding preservation area. Later studies, including the 1984 HAER documentation of the Boott Cotton Mills Complex, documented specific resources within the park unit. While these studies have documented historically significant buildings, structures, and some of the hydroelectric equipment associated with the Project, no systematic survey of historically significant waterpower equipment associated with the Project has been conducted until now.

Ownership, boundaries, and land/access rights within the FERC Project Boundary in downtown Lowell are complex. The licensee owns some, but by no means all, of the existing Project works. The Project is situated within several different and overlapping parks, and preservation/conservation districts. The canal system, the downtown mill sites, and many of the Project's civil works, are contributing resources to Lowell Locks and Canals NHL District. The canal system and many Project facilities are also located within the LNHP and larger Lowell Historic Preservation District. The park is by design a partnership park in which federal, state, and local governments as well as the private sector and local community carry out the legislative intent of the park unit. The Project's Hamilton, Assets, Bridge Street, and John Street power stations and turbines are housed in large old mill buildings within the Lowell National Historical Park and Lowell Historic Preservation District. As stated elsewhere in this application for license, Boott proposes to remove the four mill power stations and associated canal infrastructure from the new FERC license. Boott will continue to manage the canal structures, water levels and flows using best practices and consistent with current agreements with the NPS and other stakeholders.

Water Level and Flow Effects on Historic Resources Study

In accordance with the Commission's SPD, Boott conducted a Water Level and Flow Effects on Historic Resources Study. The objective of this study was to analyze the potential effects of water level fluctuations from Project operations in the headpond, Northern Canal, and the Upper Pawtucket Canal (extending upstream from the Guard Lock Gate Complex to the mainstem of the Merrimack River) on historic structures with a focus on the Pawtucket Gatehouse, the Northern Canal Waste Gatehouse, the Guard Lock and Gatehouse Complex, and the Great Wall. Methods and results are described in detail in Boott's study report (HDR 2021b) which was filed with the Commission on March 5, 2021.

The results indicated the magnitude of fluctuation in the Project's headpond and the Pawtucket Canal has been significantly reduced by the implementation of the pneumatic crest gates, as shown by post crest gates operations presented in Figure E. 7-39 and pre crest gate operations shown in Figure E. 7-40 below. Water levels in the Pawtucket Canal upstream of the Guard Locks complex are essentially the same as the Project impoundment and remained below the normal headpond level of 92.2 ft NGVD29 throughout the 2020 study period except for one occasion. The elevation of the Guard Locks complex walkway (92.45 ft), the clapboard siding (92.45 ft), and the bottom of the mid-level windows (94.08 ft) are all above the normal water level of the Upper Pawtucket Canal. Only river flows in excess of 35,000 cfs could cause the Upper Pawtucket Canal to inundate the wooden structural elements of the Guard Locks complex; however, these conditions are outside of the ability of the Project to control the impoundment water level and therefore not attributable to Project operations.

The operation of the Northern Canal has caused periodic inundation of the sill at the Northern Canal Waste Gatehouse (Figure E.7-41). This inundation may be one factor in the continued deterioration of the gatehouse's southern sill. Spray from the canal spillway may also be contributing to deterioration along the eastern end of the northern sill.

Figure E.7-39. Project Headpond Water Surface Elevation During 2020 Monitoring Period

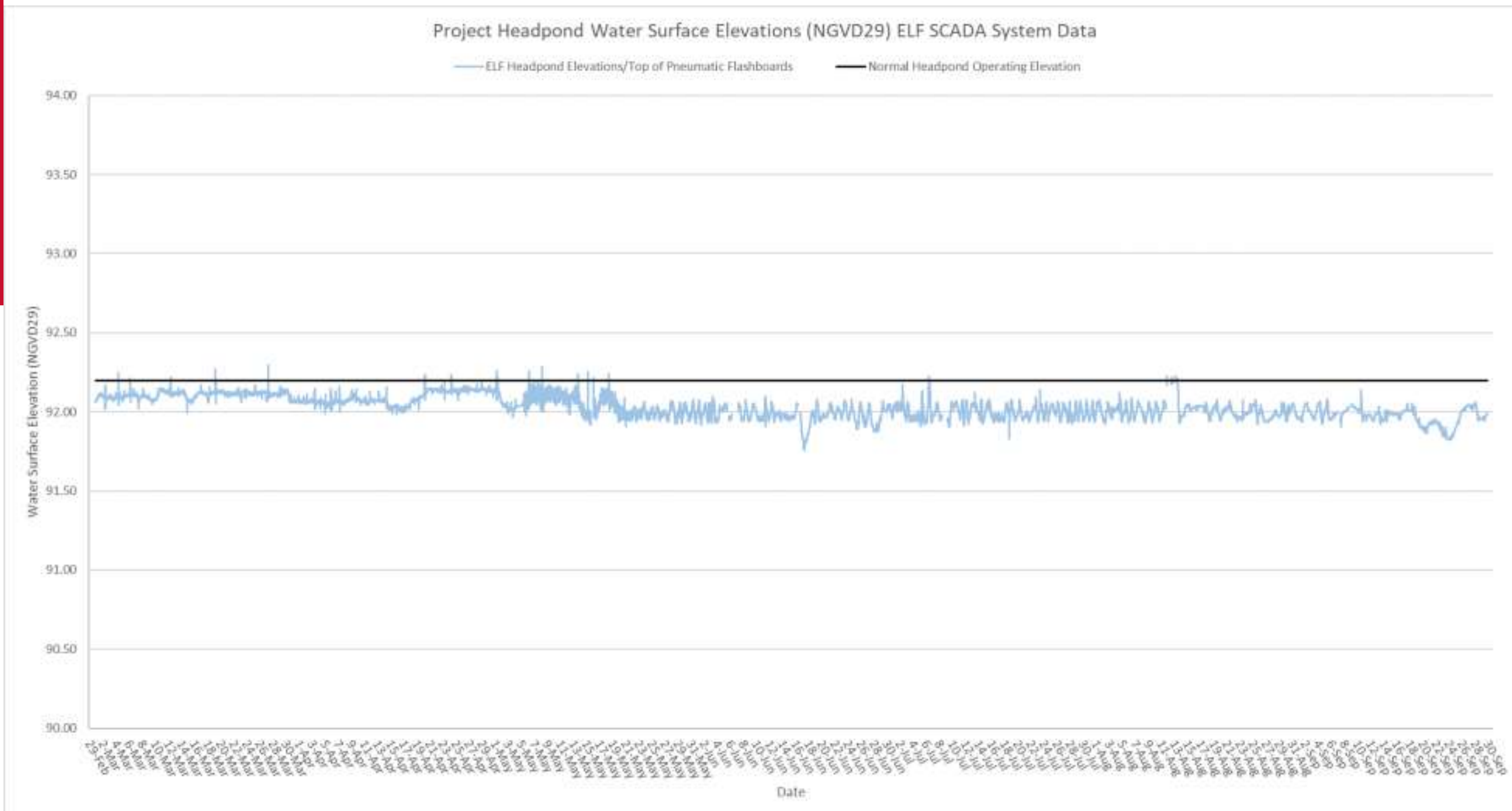


Figure E.7-40. Merrimack River – Pawtucket Dam Headpond Elevations for Period of Record (1995-2010)

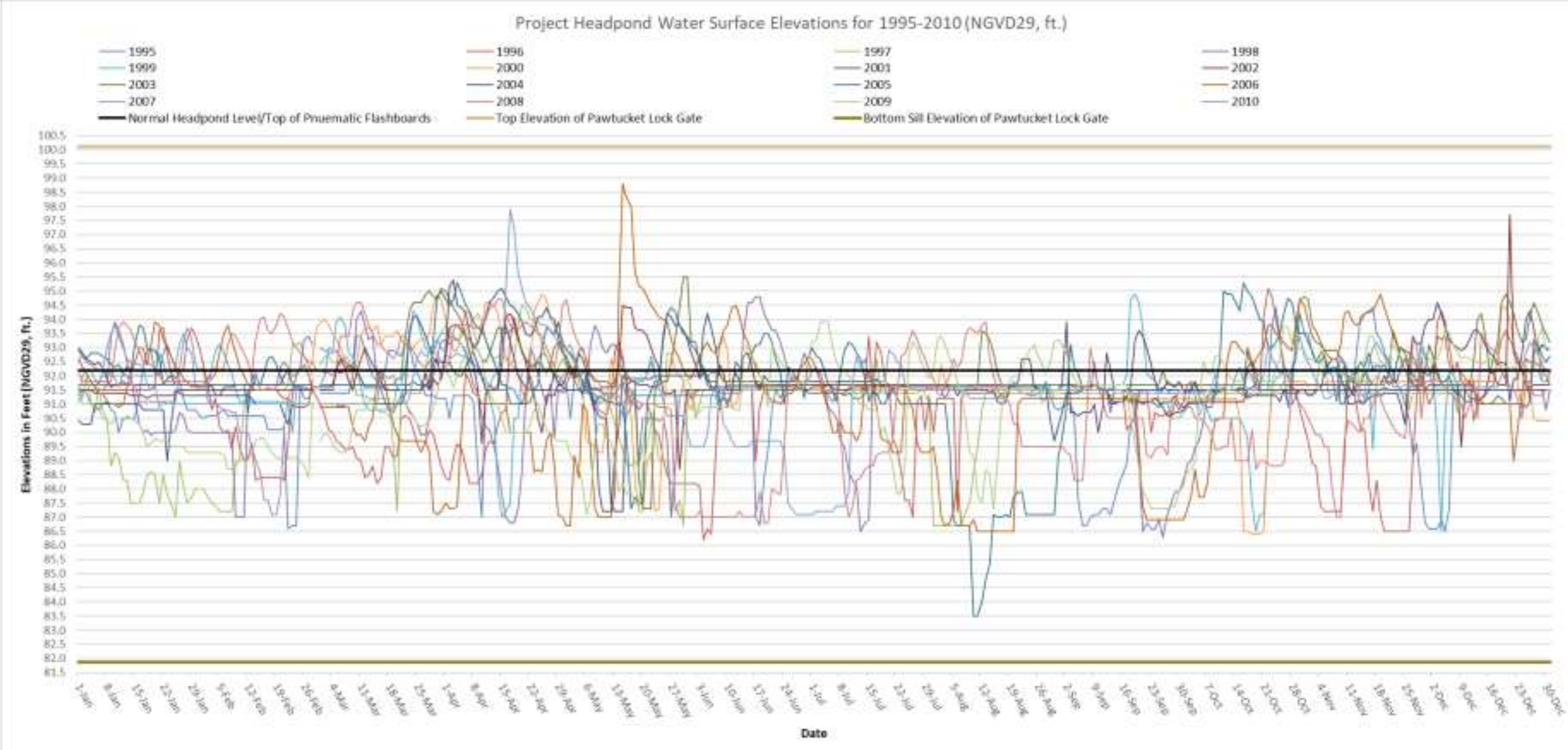
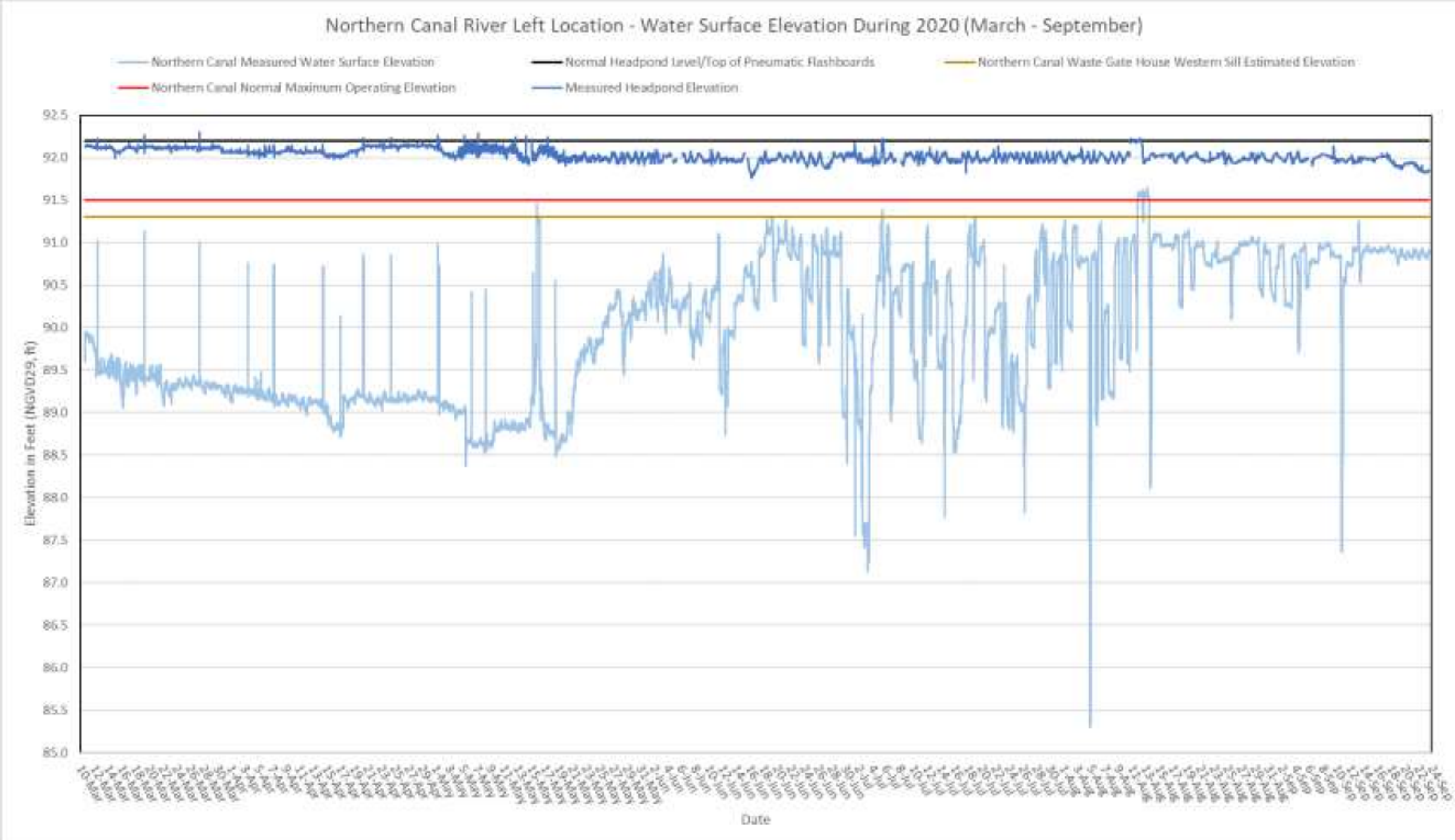


Figure E.7-41. Northern Canal River Right Location - Water Surface Elevation During 2020 Monitoring Period



The results of the study indicate the wooden structural elements of the historic resources located along the Upper Pawtucket and Northern Canals appear most susceptible to damage from submergence, periodic inundation, and waterborne trash. While the magnitude of fluctuation in the Project's headpond and the Pawtucket Canal has been significantly reduced by the implementation of the pneumatic crest gates, the Merrimack River is subject to routine seasonal high flow events. High flow events can also mobilize waterborne trash and debris that have the potential to damage wooden structural elements; however, neither high flow events nor the presence of waterborne trash and debris in the Merrimack River are attributable to Project operations.

While normal Project operations do not appear to be adversely affecting the Pawtucket Gatehouse Lock Structure beyond normal wear, at least one incident appears to have contributed to recorded damage to the upstream miter gate (Figure E.7-42). The canal surge event that occurred in 2018 was caused by the malfunction of a water level transducer. The effect of the resulting surge was exacerbated by the practice of chaining the gates closed. This anomalous incident does not represent normal Project operations, and Boott is repairing the damage to the gate.

Figure E.7-42. Damage to the Northern Canal Lock Timber Gate

Historically Significant Waterpower Equipment Study

In accordance with the Commission's SPD, Boott conducted a Historically Significant Waterpower Equipment Study to identify historically significant waterpower equipment for potential future interpretation, exhibition, or as scrap equipment to maintain and operate other historic machinery. Methods and results are described in detail in Boott's study report (Gray and Pape 2021) which was filed with the Commission on February 25, 2021.

The results indicated that it is the totality of the system of waterpower and water-control machinery at Lowell that is historically significant. Removal and replacement of individual pieces of equipment was nearly continual, from the day the system first became operational. Removal or alteration of existing equipment would constitute an adverse effect upon the qualities that make the existing system historically significant if they prevented or precluded the system from operating. Several pieces of equipment appear to be historically significant, distinct from their role as a part of the larger system. These pieces of equipment include the surviving 1870 hydraulic gate hoist system at the Pawtucket Canal Guard Locks, and the Francis turbine powered belt-and-line shafting gate operating system at the Pawtucket Gatehouse. The extant gate operating system at the Moody Street Feeder Gatehouse is likely also historically significant.

Resources, Ownership, Boundaries, and Land Rights Study

Pursuant to the approved study plan, Boott conducted a Resources, Ownership, Boundaries, and Land Rights Study to determine current ownership of resources within the canal system and existing Project Boundary, and document maintenance responsibilities, access rights, and FERC jurisdiction. The methods and results of the Resources, Ownership, Boundaries, and Land Rights Study filed with the Commission on February 25, 2021.

Ownership, easement rights, and use of the canal system in Lowell are complex, with intersecting roles between public agencies and private entities at the local, State, and Federal level. Boott conducted desktop research and a literature review to compile and review available ownership and rights documentation to obtain a better understanding of the rights and responsibilities related to resources within the Project Boundary. As appropriate and relevant, public guidance and conceptual planning and/or management documentation was reviewed by Boott including the 1977 Report of the LHCDC, the 1980 Details of the Preservation Plan, the 1981 FGMP, and the 1990 Preservation Plan Amendment. Additionally, Boott reviewed and analyzed the three legal documents that establish most of the ownership, responsibilities, and land rights to the Lowell canal system. The 1984 Deed, Bill of Sale and Grant of Easements, also known as the "Great Deed" details the sale of portions of the Project from the Proprietors of the Locks and Canals on the Merrimack River (Proprietors) to Boott, as well as associated access and repair easements. The 1986 Order of Taking details the take of properties, rights, and responsibilities from Boott and Proprietors to the Commonwealth, operating through MADCR. The 1995 Grant of Easement describes the easement rights provided to the NPS from MADCR for specific properties and parcels around the canal system.

The conceptual framework for the rights and responsibilities for management of the Lowell canal system remain consistent within the 1977 Report of the LHCDC, the 1980

Details of the Preservation Plan, the 1981 FGMP, and the 1990 Preservation Plan Amendment. MADCR and NPS are presented as the main parties responsible for developing, renovating, and maintaining the major elements of the canal system. In the 1977 Report of the LHCDC, agency responsibilities were characterized and are shown below in Table E.7-32.

Table E.7-32. Agency Responsibilities Identified in 1977 Report of the LHCDC

Agency	Responsibilities
NPS	interpretation, park wide downtown "cross-section" of 19th Century Lowell (including preservation, building and open space improvements, transportation, and visitor services)
MADCR	canals, riverbanks, and related recreational areas gatehouses, locks and dams barge system

Ownership of the Lowell canal system is largely determined by the 1984 Great Deed and 1986 Order of Taking. Components of the canal system are owned by Proprietors, Boott, and MADCR. Proprietors owns most of the Pawtucket Canal and Lower Pawtucket Canal, as well as all or portions of associated structures in those canals (e.g. Swamp Locks Dam, Lower Locks Dam, and the Guard Locks and Francis Gate). Boott is not known to own any structures of or within the Pawtucket or Lower Pawtucket Canal.

Boott owns the Northern Canal, Western Canal, Merrimack Canal, Eastern Canal, and Hamilton Canal. Boott owns specific dams, lock structures, and hydroelectric equipment within the canals they own. The specific structures fully owned by Boott within these canals include Hall Street Dam, Lawrence Dam, Boott Dam, Rolling Dam, Merrimack Dam, Merrimack Gates, YMCA Gates, and the Moody Street Feeder. Boott owns hydroelectric equipment located inside most gatehouses, such as the Boott Dam Gatehouse and Tremont Gatehouse, but Boott does not own the gatehouse buildings.

MADCR owns most of the gatehouses throughout the canal system (e.g. Pawtucket Gatehouse, Lower Locks Gatehouse, and Swamp Locks Gatehouse, Rolling Dam Gatehouse, Hamilton Gatehouse, and Massachusetts Wasteway Gatehouse) and this is largely determined based on elevation.

Easement rights to structures of the Lowell canal system are held by Proprietors, Boott, MADCR, and NPS. In the 1984 Great Deed, Boott obtained easement rights, in common with Proprietors, to the Pawtucket Canal and structures of the Pawtucket Canal. These easement rights allow Boott to access, operate, maintain, repair, and replace the Pawtucket Canal and structures of the Pawtucket Canal. In the 1986 Order of Taking, MADCR obtained a permanent and exclusive easement to structures of the canal system, including canal walls, beds, and bottoms, for purposes including conservation, preservation, maintenance, and other uses consistent with the use of the system as a park. NPS obtained similar easement rights through the 1995 Grant of Easement from MADCR, including the right to maintain, repair, conduct grounds maintenance, and operate boat tours.

An exclusive easement allows the easement holder to control and implement specific purposes as if they are the owner. MADCR has a permanent and exclusive easement over most of the canal system for the following purposes, which include the following enhancements and upgrades:

a) Support of all fixtures or structures of the Commonwealth now or hereafter attached;

b) Preservation and conservation;

c) Supplemental maintenance in addition to that performed by the Condemnees (the prior or current owner) and their successors and assigns;

d) Landscaping and erection of exhibits and structures;

e) Placement of barriers and fences;

f) Placement and attachment of docks, wharves, walls, and boat ramps of a temporary or permanent nature;

g) Placement of lighting and other utilities;

h) Operation and maintenance of boat locking chambers, if any, for any and all purposes; and

i) Any and all other uses consistent with the operation of the canal system as a park.

Given that MADCR's exclusive easement is throughout most of the canal system, it overlaps significantly with Boott and Proprietors' owned property. It is understood that Boott, Proprietors, and MADCR have a duty and right to maintain properties under their ownership to achieve a standard of reasonable care. Owners do not have an obligation or duty to upgrade or enhance their property. However, MADCR's exclusive easement throughout most of the Lowell canal system gives them the right to implement any of the purposes noted above, which include enhancements and upgrades, as if they were the owner.

The Resources, Ownership, Boundaries, and Land Rights Study also determined different resource rights. The results indicated that recreational resource rights are exclusively owned by MADCR. In early conceptual planning documents, MADCR was presented as the party that would own, implement, and manage any recreational resources. MADCR obtained such rights in the 1986 Order of Taking, including the exclusive right to use water for recreational, educational, or navigational purposes, and permanent and exclusive rights to build wharves, docks, and boat ramps. The two other identified resources are air resource rights, and water and flowage rights. Air resource rights have been owned by MADCR since issuance of the 1986 Order of Taking. Water and flowage rights are owned by Boott and Proprietors, as established in the 1984 Great Deed.

E.7.8.2 Environmental Analysis

The NHPA establishes the statutory responsibility of federal agencies to consider historic properties under their jurisdiction. Section 106 requires federal agencies to consider the effects of their undertakings on historic properties listed in or eligible for inclusion in the NRHP. The Commission's issuance of a new license for the Project is defined as an undertaking under the NHPA and is, therefore, subject to the provisions of Section 106 and its implementing regulations at 36 C.F.R. Part 800.

FERC's SD2 identified effects of continued Project operations on cultural and historical resources as potential resource issues. Specifically, SD2 identified the following potential resource issues related to cultural and historical resources to be analyzed for site-specific effects:

- Effects of continued project operation and maintenance on historic resources, archeological resources, and traditional cultural properties that are included or may be eligible for inclusion in the National Register of Historic Places.
- Effects of continued project operation and maintenance on properties of traditional religious and cultural importance to an Indian tribe.

During the previous relicensing, Boott consulted extensively with the Massachusetts SHPO and NPS to avoid destroying historic Waste Gates on the Northern Canal and to fund repairs to the Northern Canal Gates to restore them to their original condition. The proposed powerhouse was relocated, and fish passage facilities were modified to avoid any impacts to the Northern Canal Gatehouse. In addition, the Owner constructed a new set of locks in the Northern Canal to provide boat passage, to avoid any loss of historic use of the canal system. Furthermore, additional mitigative measures were undertaken by the Licensee to minimize impacts of new structures introduced into the historic district (Cleantech Analytics 2017).

Current Project operations may be a contributing factor to the continued deterioration of the Northern Canal Waste Gatehouse's southern and northern sills. The Northern Canal periodically inundates the southern sill, and spray from the Northern Canal spillway may be contributing to the deterioration of the northern sill. Repeated inundation and drying of timber sills has the potential adversely affect the integrity of the Northern Canal Waste Gatehouse; however, other factors unrelated to Project operations have also likely contributed to the ongoing deterioration of the sills, including the age of the wooden timbers, general maintenance, weathering, and atmospheric conditions.

Boott has not identified any other historic properties that are being adversely affected by the ongoing operation and maintenance of the Project. As noted above, Boott determined at least one incident that appears to have contributed to recorded damage to the upstream miter gate at the Pawtucket Gatehouse. This anomalous incident does not represent normal Project operations, and Boott is repairing the damage to the gate.

Boott is not currently proposing modifications to the Project's operations or any land-clearing or land-disturbing development activities within the APE that would result in an impact to any archaeological sites, historic architectural resources, or areas that have been identified as having moderate to high potential for containing archaeological sites.

In addition, only one out of the nine tribes, the Mashpee Wampanoag Tribe, responded to FERC's initial tribal consultation letter dated April 26, 2017 and did not identify any concerns related to the Project pertaining to cultural resources.

E.7.8.2.1 Effects of Decommissioning

While Boott is not proposing modifications to the Project's operations that have the potential to adversely affect historic properties, Boott is proposing to remove the four mill power stations and associated canal infrastructure from the Project boundary and the new FERC license. Pursuant to 36 C.F.R § 800.5(a)(2)(vii), the removal of the downtown canal system from FERC's federal jurisdiction could result in an adverse effect if removal is done "without adequate and legally enforceable restrictions or conditions to ensure long-term preservation of the property's historic significance." As noted above, the downtown canals are located within the LNHP, the Locks and Canals Historic District (a National Historic Landmark) and the Lowell National Historical Park and Preservation District, which are listed in the National Register of Historic Places. Accordingly, Boott expects that potential effects will be limited as the downtown canal system and associated structures will still remain under the federal and state oversight provided by the NPS and MADCR.

As reported in the Resources, Ownership, Boundaries, and Land Rights Study Report (HDR 2021c), Boott owns all the canals except the Pawtucket Canal and Lower Pawtucket Canal, but MADCR and NPS have various easement rights to the downtown canal system for purposes of preservation, conservation, and other uses consistent with that of a park. MADCR has a permanent and exclusive easement to the entire canal system for all uses consistent with the operation of the canal system as a park, which gives MADCR the right to implement preservation and conservation measures as if they were the owner of the structures. Boott does not own most of the historic gatehouses, dams, and locks that will be removed from the Project boundary with the canals; these are mostly owned by MADCR and Proprietors. Boott does have certain easement rights to these structures they do not own, but those easement rights are mostly limited to hydropower maintenance and operation. While the removal of the downtown canal system may result in an adverse effect, the system will remain protected by federal and state oversight, and Boott will still be obligated to and limited by its legal agreements with MADCR and NPS. Further, and as discussed below, Boott is proposing to develop a decommissioning plan to address, *inter alia*, the final disposition of the canal system, turbine-generator units, water conveyance structures, and mechanical and electrical components.

Boott is not proposing demolition or land-clearing activities in association with decommissioning the downtown powerhouses. Decommissioning the powerhouses will not adversely affect the integrity of the LNHP, Locks and Canals Historic District, or the Lowell National Historical Park and Preservation District. Boott will continue to provide flows into the canal system and maintain water levels consistent with current practices. Boott will also maintain canal facilities consistent with existing rights, responsibilities, and existing or new agreements developed among the concerned stakeholders. For these reasons, Boott does not anticipate that the proposed removal of the canal facilities from the FERC license and the decommissioning of the downtown powerhouses will have an adverse effect on historic or archaeological resources.

E.7.8.3 Proposed Environmental Measures

- Boott proposes to continue operations of the Project with certain PM&E measures required by the existing license. This includes continued adherence to Article 33, which requires that prior to the commencement of any construction activities inside the Project boundary, Boott will cooperate with the Massachusetts SHPO and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historical Park.
- Boott understands that removal of the fifteen turbine-generator units and canal system from its license will require a decommissioning plan to define the final disposition of the canal system, turbine-generator units, water conveyance structures, and mechanical and electrical components. A decommissioning plan is also necessary to protect the public from any safety, dam safety, or environmental concerns. Boott will develop a decommissioning plan for each of the four downtown power stations and the canal system. In developing the decommissioning plan, Boott will consult with the NPS, MADCR, City of Lowell, and the MHC. Boott will file a decommissioning plan for the Commission's approval within 18 months of issuance of a new license.

  Within one year of license issuance, Boott will develop an HPMP for the Project that will describe appropriate management measures to avoid, minimize, or mitigate adverse effects on historic and archaeological resources over the term of the new license issued for the Project. The measures provided in the HPMP will direct the Licensee's management of NRHP-listed or eligible historic properties within the Project's APE, which is preliminary defined as the proposed Project boundary. Boott will develop the HPMP in consultation with the NPS, MHC, NHDHR, and Indian tribes.

  Through this consultation, the Licensee will develop historic properties management measures to be incorporated into the HPMP. Boott has outlined the following two goals for managing historic resources within the Project's APE:

  - Support continued normal operation of the Project while maintaining and preserving the integrity of historic properties; and
  - To the fullest extent possible, avoid, minimize, or mitigate adverse effects on historic properties within the APE.

  To address these goals, the Licensee will develop an HPMP for the Project in accordance with the *Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects* promulgated by FERC and the ACHP on May 20, 2002. The HPMP will describe measures for the management of and protection of historic properties within the Project's APE through the term of the new license. As such, continued operation of the Project as proposed by the Licensee is not expected to adversely affect historic or archaeological resources.

E.7.8.4 Unavoidable Adverse Impacts

The continued operation of the Project as proposed by the Licensee is not expected to have any unavoidable adverse effects on historic or archaeological resources.

E.8 Economic Analysis

This section identifies estimated costs specific to proposed PM&E measures. Overall Project cost and value information is provided in Exhibit D of the license application.

Table E.8-1. Incremental O&M/Annual Costs of Proposed PM&E Measures

Proposed PM&E Measure	One Time Implementation/ Construction Costs (2021 Dollars)	Incremental Operations and Maintenance (O&M) Costs or Annual Costs (2021 Dollars)
ROR operation	$0 – (currently implemented)	$0
Modifications to upstream fish ladder and bypass weirs	$100,000	$5,000
Provide 100 cfs bypass flow approximately . July 16 – April 30	$0	± 1,100 MWh / year lost generation
Upstream fish ladder	$2,600,000	$10,000
Cessation of fish elevator operations	$75,000	$0
Downstream rack structure	$5,200,000	$10,000
Develop and implement a Decommissioning Plan for each of the four downtown power stations and file for FERC approval.	$x,xxx,xxx	$0
Develop a Historic Properties Management Plan and file for FERC approval.	$75,000	$5,000
Develop a Recreation Access and Facilities Management Plan and file for FERC approval.	$50,000	$10,000

E.9 Consistency with Comprehensive Plans

Section 10(a)(2) of the FPA, 16 U.S.C. section 803(a)(2)(A), requires the Commission to consider the extent to which a project is consistent with federal and state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by a project. Under 18 CFR §5.18(b)(5)(ii)(F) each license application must identify relevant comprehensive plans and explain how and why the proposed project would, would not, or should not comply with such plans. In addition, the license application must include a description of any relevant resource agency or Native American Tribe determination regarding the consistency of the project with any such comprehensive plan.

The Commission's SD2 identified twenty-eight comprehensive plans for New Hampshire and Massachusetts that are potentially relevant to the Lowell Hydroelectric Project. On December 19, 2018, the NPS filed five additional comprehensive plans, and by letter dated March 20, 2019, the Commission accepted four of the five plans. Boott has reviewed the Commission's list of the available comprehensive plans. Listed below are the comprehensive plans applicable to the Project. For the reasons noted in this application, Boott has determined that the proposed operation of the Project, as proposed in this Final License Application, is consistent with these plans.

E.9.1 Federal Plans

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E.9.2 Massachusetts Comprehensive Plans

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E.9.3 New Hampshire Comprehensive Plans

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E.10 Consultation Documentation

In accordance with 18 C.F.R § 5.18(b)(5)(G), a list of containing the name, and address of every Federal, state, and interstate resource agency, Indian tribe, and member of the public with which the Licensee consulted in preparation of Exhibit E is presented in Volume I. In addition, Boott is providing a consultation log of relevant correspondence with the contacts of the distribution list and copes of relevant documentation, presented in Appendix C.

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Scott, Kelsey

To:	Kevin Webb; Johnathan Robichaud; Curtis Mooney; Skip Medford; Richard Malloy; Gibson, Jim; Quiggle, Robert
Subject:	RE: Comments of National Park Service on deficiency response

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From: Tittler, Andrew <Andrew.Tittler@sol.doi.gov>
Sent: Friday, August 20, 2021 11:59 AM
To: Kevin Webb <kwebb@centralriverspower.com>; Bernardo, Celeste <Celeste_Bernardo@nps.gov>
Cc: Mendik, Kevin R <Kevin_Mendik@nps.gov>; Hay, Duncan E <Duncan_Hay@nps.gov>; Hogan, Kenneth J <kenneth_hogan@fws.gov>; Meade, Jonathan D <Jonathan_Meade@nps.gov>; Strack, Brian <Brian_Strack@nps.gov>
Subject: Comments of National Park Service on deficiency response

Dear Mr. Webb -
Attached, on behalf of the National Park Service, please find comments on your August 17, 2024 draft responses to FERC's May 27 deficiency notice in the relicensing process for the Boott Hydroelectric project.

Andrew Tittler
Field Solicitor, Boston Office

Office of the Solicitor
United States Department of the Interior
15 State St., 8th Floor
Boston, MA 02109-3502

phone: 617 223 5712
fax: 617 223 5792
andrew.tittler@sol.doi.gov

***** PLEASE NOTE Until further notice I will be unable to receive physical mail as our office is closed. Please send materials electronically. If you have something that must, by regulation, be sent by U.S. mail, whether regular, registered, or certified, this does not waive that requirement but please send an electronic copy as well******

UNITED STATES DEPARTMENT OF THE INTERIOR

OFFICE OF THE SOLICITOR
15 State Street - 8th Floor
Boston, MA 02109-3502

TEL: (617) 223-5700
FAX: (617) 223-5792

August 20, 2021

Kevin Webb
Licensing Manager
Central Rivers Power
670 N. Commercial St., Suite 204
Manchester, NH 03101

Re: Lowell Hydroelectric Project (FERC no. P-2790-074)

Via: e-mail at kwebb@centralriverspower.com

Dear Mr. Webb,

This letter is provided on behalf of the National Park Service (NPS) in response to your August 17, 2021 “response package,” circulated via e-mail to various stakeholders in the licensing process. On May 27, 2021, the Director of Hydropower Licensing issued Boott Hydropower, LLC, the Applicant, a letter identifying deficiencies in the license application before the Commission, related largely to the Applicant’s proposal to decommission fifteen turbine-generator units included in the present license and to remove the canal system located in downtown Lowell, Massachusetts from the project boundary. The Applicant was directed to provide:

> (a) a full list of every project facility that Boott is proposing to decommission and remove from the project, and a description of how Boott will decommission each facility (e.g., disconnecting mechanical and electrical components, installing cofferdams, removing facilities, sealing points of discharge, etc.);
>
> (b) a description of how the project will operate after the facilities are decommissioned, including: (i) target water elevations within the canal system; (ii) a schedule and volume of flow releases to the canal system, as described on a seasonal and/or annual basis; (iii) a description of how flows will be monitored and released to the canal system; and (iv) copies of all current agreements with the National Park Service, Massachusetts Department of Conservation and Recreation, City of Lowell, Massachusetts Historical Commission, and other stakeholders related to water levels and flows in the downtown canal system;
>
> (c) an environmental report that describes environmental effects that are expected to occur during and after decommissioning and any proposed measures

for mitigating those effects. At a minimum, this information should explain the effects of the proposal for each resource area (i.e., Geology and Soils; Water Quantity and Quality; Fish and Aquatic Resources; Terrestrial Resources; Rare, Threatened and Endangered Species; Recreation and Land Use; Aesthetics and Socioeconomic Resources; and Cultural Resources) and include: (i) a description of the affected environment, (ii) a detailed analysis of the effects of the proposal, (iii) a description of any unavoidable adverse impacts, and (iv) proposed measures to mitigate effects of the licensing proposal;

(d) a description of proposed measures to address public safety and dam safety concerns associated with the decommissioning proposal;

(e) a schedule/timeline for decommissioning each project facility and implementing any proposed measures (see also 4.51(d));

(f) a description of any direct and indirect costs associated with decommissioning each project facility, such as disconnecting mechanical and electrical components, installing cofferdams, removing facilities, sealing points of discharge, etc. (see also 4.51(e)); and

(g) documentation of consultation with federal and state agencies regarding the decommissioning proposal.

The Commission set a 90 day deadline for the Applicant's response. During a July 28th partner's meeting, Boott suggested that the City, DCR, UMASS Lowell representatives hold a final meeting with Boott to discuss the proposed decommissioning plan on August 24th,, the same date that you were requesting comments from the partners. When partners suggested that it would be better to move the meeting up, Boott agreed. It was therefore surprising to see the Applicant's August 17 letter requesting responses to the "consultation package" by August 24 without further discussion with the partners. The time allotted is scarcely sufficient to allow for a comprehensive response by NPS. Accordingly, NPS may have further comment to provide, which it will provide directly to the Commission in response to the filing of the response to the deficiency letter.

First, we note that the license applicant met three times with the indicated entities for consultation: once, electronically on June 16, 2016, and then on Jun 30, 2021 and July 28, 2021. This schedule was established despite NPS's suggestion to meet weekly. From NPS' point of view, these meetings advanced its understanding of the applicant's plans very little. If the point of consultation is to try to get buy-in from stakeholders with regard to the Applicant's plans, the process has not achieved that to date; we are no closer to understanding these plans than when the deficiency letter was sent, despite some promising progress in beginning a process of discussion. Put simply, it does not appear that the 90 days allotted was sufficient time for the applicant to fill the data gaps required. NPS believes that a significantly longer period of time, involving additional study and consultation, will be required to allow the license applicant to supply all of the answers the Commission will require before it can conduct an environmental analysis of the proposal and shape conditions governing what must be done before the Commission surrenders jurisdiction over the project works to be removed from the boundary.

Second, we are concerned with the narrow scope of Boott's proposed answers. It takes the position that it need only provide plans for the power stations themselves "and associated infrastructure." This is not consistent with Commission precedent or the Commission's responsibilities. The full canal system is currently "project works" within the Project boundary, as described in the 1983 License. *Boott Mills and Proprietors of the Locks and Canals on Merrimack River*, 23 F.E.R.C. ¶ 62,043 (April 13, 1983) (Ordering Paragraph B) and is proposed to be removed from the boundary and from Commission jurisdiction. In effect, the applicant is engaged in a license surrender process for those portions of the present Project.

As noted by the Commission, its regulations require, at a minimum, that the license be conditioned on orders for the disposition of project works to ensure public safety. A *See, e.g. Pacificorp*, 108 F.E.R.C. ¶ 61130, 61771 (August 4, 2004); *Niagara Mohawk Power Corporation* 85 F.E.R.C. ¶ 61420, 62591 (December 23, 1998) ("the Commission conditions surrenders to ensure public safety and to provide as appropriate for the restoration of project lands and the mothballing or removal of some or all of the project works"). The Commission usually requires an inspection of all project works prior to surrender, so that it may understand what safety and environmental issues exist, and issue orders remedying any immediate concerns before turning over jurisdiction to the State. *See City of Port Angeles*, 167 F.E.R.C. ¶ 61048 (April 18, 2019). While its concern may be primarily with dam safety, it makes a determination based on all the project works. *Id.* It applies a broad public interest standard. *Arizona Public Service Co.*, 109 F.E.R.C. ¶ 61036 (October 8, 2004). Environmental conditions on surrender applications, designed to protect the public interest in water quality, wildlife, and other interests, are not uncommon. *See, e.g. Madison Electric Works*, 115 F.E.R.C. ¶ 62113 (May 1, 2006). It is clear that the Commission will need, at a minimum, to issue an order addressing the safety of project works that are leaving its jurisdiction, and this requires, first, an analysis of the present condition of all project works, and second, proposed measures to address any concerns found. The applicant has not provided this information, beginning with a comprehensive condition assessment of project work, including the canal walls, gatehouses, retaining structures, and so on. While the applicant reiterates that it is not going away and will continue to maintain as it has, this is beside the point: the *Commission* is going away, and must ensure that it is not leaving unacceptable conditions behind, by way of safety and other topics. The response to deficiency notice fails, therefore, to address the Commission's concerns, which are shared largely by NPS.

With regard to specific requests by the Commission, the NPS is particularly concerned with deficiencies in particular responses, as follows:

Paragraph a. NPS believes the following areas should be added to the decommissioning plan: Lawrence Canal; Lower Locks Pier and Fill Valve in front of Lower Locks Gatehouse; Hamilton Gatehouse; Massachusetts Wasteway Gatehouse; Rolling Dam Gatehouse; Moody Street Feeder Gatehouse; Boott Dam Gatehouse; Transmission Lines throughout canal system.

Paragraph b. While NPS appreciates that Boott "anticipates" that a flow of 200-300 cfs will have to be released from the Guard Locks to maintain present water levels, there does not appear to be any analysis or record evidence to support that claim. To NPS' knowledge, the applicant has conducted no studies of the integrity of the system, or of what flow rates correspond to what water levels. With the generating units at the bottom of the system proposed to be plugged, it is not clear how much water will flow into the system, and how such flows will affect water levels. Stagnation of the system may lead to water quality concerns, siltation, and difficulty using it for recreational purposes, the latter of which DCR and NPS retain rights to. NPS anticipates asking the Commission to set a requirement for flow into the canal system, but that request is unknown since the historic canal system will change dramatically once the power stations are decommissioned. The Applicant plainly intends to provide some flow also. The record is barren of substantial evidence as to what that flow should be.

Paragraph d. As there has been no full assessment of the condition of the project works (including all canal system walls, gates, dams, penstocks, and so on) this paragraph does not seem to have been responded to. Attachment A contains a list of structures, most of which simply have "maintain water levels and canal walls in line with existing rights, responsibilities and existing or new agreements" or "no change from present" listed as actions. This provides no information about substantive measures to protect public safety, which is not surprising, as the applicant has not conducted any survey or analysis to determine whether such concerns exist. As to the units themselves, which have clearly received more thought and attention, there are still details and concerns to be worked out, once NPS has a more complete understanding of what is planned there.

Paragraph e. In response to the Commission's notice that the proposal to develop a decommissioning plan and file it within 18 months after license issuance is not sufficient, the applicant now proposes to file such plans anywhere from one to four years after license issuance. The Commission asked for a schedule/timeline for decommissioning, and the applicant is proposing only to file decommissioning plans later, and decommission within a certain number of years. Given the uncertainty about *how* many of these actions will be accomplished, and especially about what may be necessary on project works beyond the powerhouses themselves and their contents, NPS does not believe that this is responsive to the Commission's request.

We understand that the license applicant was likely given too short a time to fully answer all of the Commission's questions – as evidenced by the fact that as of the 17^{th}, the package still had a blank in place for costs. NPS believes that substantially more information is required about the condition of the canal system, anticipated flow rates, and the environmental consequences of cutting flows to those levels. Those gaps in the record are sufficiently wide that NPS believes that there is no way the Commission will have enough information after you file the package to declare the application complete, let alone "ready for environmental analysis." Depending on the Commission's reaction, NPS anticipates the need to request additional study. Although the time for requesting studies is formally past, the license applicant changed its plans to include removing the canal system from the project boundary too late for requests to study the consequences of that action, and if the Commission's request does not yield the necessary information, we anticipate making the request. This will, we believe, be in the interest of all parties, as it will provide both information to inform the discussions you have begun to have with stakeholders, and the time necessary to let those discussions bear fruit in the form of a shared plan and understanding of how to move forward through the surrender and decommissioning process and afterwards.

Very Truly Yours,

ANDREW TITTLER

Digitally signed by ANDREW TITTLER
Date: 2021.08.20 11:56:55 -04'00'

Cc: NPS, Celeste Bernardo (via email)
NPS, Brian Strack (via email)
NPS, Jonathan Meade (via email)
NPS, Kevin Mendik (via email)
NPS, Duncan Hay (via email)
USFWS, Kenneth Hogan (via email)
MHC/SHPO, Brona Simon (via mail)
MADCR, Jim Montgomery (via email)
City of Lowell, Eileen Donoghue (via email)
UMASS Lowell, Adam Baacke (via email)

Scott, Kelsey

From:	Bell, Ed (SEC) <ed.bell@state.ma.us>
Sent:	Wednesday, August 18, 2021 10:05 AM
To:	Scott, Kelsey
Cc:	Kevin Webb; Richard Malloy; Quiggle, Robert
Subject:	RE: Lowell Hydroelectric Project - Response to Deficiency of License Application

The Massachusetts Historical Commission (MHC), office of the SHPO, cannot accept electronic submissions for review of projects in compliance with state and/or federal historic preservation law.

Here are the FAQs. https://www.sec.state.ma.us/mhc/mhcrevcom/revcomidx.htm

Mail or deliver any information to the MHC's office. Any oversize materials such as plans should be sized no larger than 11" x 17".

Please address your submittal as follows:

Ms. Brona Simon
Executive Director/SHPO
Massachusetts Historical Commission
Mass. Archives Bldg.
220 Morrissey Blvd
Boston MA 02125

From: Scott, Kelsey <Kelsey.Scott@hdrinc.com>
Sent: Tuesday, August 17, 2021 3:06 PM
To: Bernardo, Celeste <Celeste_Bernardo@nps.gov>; duncan_hay@nps.gov; kevin_mendik@nps.gov; Baacke, Adam C <Adam_Baacke@uml.edu>; cmccall@lowellma.gov; william.salomaa@mass.gov; robert.lowell@mass.gov; 'Fedele, Mark D. (DOT)' <mark.fedele@dot.state.ma.us>; Lonsway, Peter <Peter_Lonsway@nps.gov>; Cassidy, Lisa A <Lisa_Cassidy@nps.gov>; rodney.elliott@mass.gov; Elliott, Rodney (DCR <rodney.elliott@mass.gov>; Keefe Mullin, Kara <KKeefeMullin@lowellma.gov>; JGleason@lowellma.gov; Chang, Ting <TChang@lowellma.gov>; patrice.kish@state.ma.us <patrice.kish@mass.gov>; Clancy, Christine <CClancy@lowellma.gov>; 'thomas.m.walsh@state.ma.us; marmel23@myfairpoint.net; SEC-DL-MHCWEB <SEC-DL-MHCWEB@sec.state.ma.us>; Bjorn Lake <Bjorn.lake@noaa.gov>; Hogan, Kenneth J <kenneth_hogan@fws.gov>; Sojkowski, Bryan <Bryan_Sojkowski@fws.gov>; Smithwood, Doug <doug_smithwood@fws.gov>; Mattocks, Steven (FWE) <steven.mattocks@mass.gov>; Gahagan, Ben (FWE) <ben.gahagan@mass.gov>; Carpenter, Matthew <Matthew.Carpenter@wildlife.nh.gov>; Slater, Caleb (FWE) <caleb.slater@mass.gov>; christopher.boelke <christopher.boelke@noaa.gov>; Quinones, Rebecca (FWE) <rebecca.quinones@mass.gov>; benjamin.german <benjamin.german@noaa.gov>
Cc: Kevin Webb <kwebb@centralriverspower.com>; Richard Malloy <RMalloy@centralriverspower.com>; Quiggle, Robert <robert.quiggle@hdrinc.com>
Subject: Lowell Hydroelectric Project - Response to Deficiency of License Application

Dear Stakeholders,

Boott Hydropower, LLC (Boott) is pursuing a new license from the Federal Energy Regulatory Commission (FERC) for the Lowell Hydroelectric Project. In accordance with the applicable regulations at 18 C.F.R. § 5.17(a), Boott filed a final application for a new license (Final License Application or FLA) with the Commission on April 30, 2021. On May 27, 2021, the Commission issued correspondence identifying deficiencies in the FLA and directed Boott to file additional information to correct the deficiencies on or before August 25, 2021.

As noted in the Commission's letter, and detailed in the attached package, FERC is requesting Boott consult with state and federal agencies regarding the decommissioning proposed action. Therefore, Boott is requesting a response to the attached package on or before August 24, 2021.

Should you have any questions regarding the enclosed letter and associated attachments, please contact Kevin Webb, Licensing Manager with Boott, at (978) 935-6039 or kwebb@centralriverspower.com.

Kelsey Scott, MS
Regulatory Specialist

HDR
1304 Buckley Road, Suite 202
Syracuse, NY 13212
D 315.414.2206 **M** 315.706.5176
kelsey.scott@hdrinc.com
hdrinc.com/follow-us