Memorandum

Monday, November 01, 2021

TO: Kevin Webb, Licensing Manager, Central Rivers Power

FROM: Drew Trested, Fisheries Scientist, Normandeau Associates, Inc.

SUBJECT: Response to June 23, 2021 FERC Staff Recommendations on Requested Modifications to Approved Studies – Fish Passage Survival

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Background

Boott Hydropower, LLC (Boott), a subsidiary of Central Rivers Power US, LLC, is the Licensee, owner, and operator of the 20-megawatt Lowell Hydroelectric Project (Project) (FERC No. 2790). Boott operates and maintains the Project under 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). Pursuant to the ILP process, Boott submitted a Revised Initial Study Report (ISR) to FERC on February 25, 2021. Comments on the February 25, 2021 Revised ISR, including requests for study modifications, were filed by the Massachusetts Division of Fisheries and Wildlife (MDFW), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (FWS). Boott filed responses to resource agency comments on May 28, 2021.

On June 23, 2021, the Commission issued a Determination on Requests for Study Modifications for the Lowell Hydroelectric Project. The letter contained the determination on requests for modifications to the approved study plan for the ongoing relicensing of the Lowell Project. Among the resource studies identified in the June 23 FERC determination letter was the Fish Passage Survival Study. Specific to the Fish Passage Survival Study, FERC indicated Boott should "*rerun the model for adult eels, adult alosines, and juvenile alosines for low, medium, and high flow conditions (i.e., 75, 50, and 25 percent exceedance flows), using the calibrated lambda values discussed above, with the assumption that fish routing will occur in proportion to flows*".

This technical memo provides a summary of the methodology and findings related to the FERC request for additional analysis for the Fish Passage Survival Study.

Methodology

To address the FERC request above, the following information was required:

- Mean body length and associated standard deviation for anticipated outmigrating populations of adult river herring, adult American shad, juvenile alosines, and adult American eels;
- Lowell inflow for the downstream passage season for spring (i.e., May to June) and fall (i.e., October to November) migrants for the 75%, 50%, and 25% exceedance conditions;
- Set of physical parameter values and estimates for characterizing the two Kaplan turbine units housed in the E.L. Field powerhouse;
- Calibrated values of lambda for use in the new downstream passage models for adult alosines and adult eels (calibration to be informed using estimated turbine survival rates obtained during 2019-2020 field studies for adult eels and alosines);
- Proportional distribution among available downstream passage routes; and
- Non-turbine route-specific survival estimates.

All estimates of fish passage survival were calculated using the USFWS Turbine Blade Strike Analysis (TBSA) Tool. The TBSA estimates the fraction of a population of fish that are lost during downstream passage at a hydroelectric project. TBSA simulates passage of a normally distributed population of fish described by a user-defined mean length and associated standard deviation of length. The TBSA then routes the theoretical population through potential downstream passage routes at the project (e.g., turbine unit, downstream bypass or spill) using a user-defined set of proportions. The TBSA Tool provides an estimate of total passage survival for the subset of fish determined to pass the project via each user-input route. The TBSA uses turbine specific parameters to estimate blade strike for fish passing through the powerhouse units and incorporates user-defined survival rates for non-turbine routes.

Fish Size Information:
Body size information for the four target fish species used in this analysis is presented in Table 1. Species-specific length ranges are those originally presented in the Fish Passage Survival Study. For modeling purposes a normal distribution was assumed and the mid-point of the species-specific range was adopted as the mean value. An associated standard deviation was calculated as 1/3 the value between the mean and upper or lower bound of the range. This ensured that approximately 99% of the overall expected size range for each species would be considered.

Table 1. Size range (i.e., minimum – maximum), average, and associated standard deviation for target diadromous fish species.

Species	Minimum (inches)	Maximum (inches)	Average (inches)	Std. Dev.
River herring (Adult)	9	13	11	0. 7
American shad (Adult)	15	23	19	1.3
Juvenile Alosine	2	6	4	0.7
American Eel	25	41	33	2. 7

Lowell Inflow Conditions:

FERC requested modeled passage survival under low, medium and high flow conditions. Flow duration curves for the spring (i.e., May-June) and fall (i.e., October-November) were reviewed (Figure 1). Values for the 25%, 50%, and 75% exceedance conditions were considered as part of this analysis and are presented in Table 2.

Table 2. Merrimack River inflow at Lowell for the 25%, 50%, and 75% exceedance condition during the spring (May-June) and fall (September-October) seasons.

Percent Exceedance	Spring (cfs)	Fall (cfs)
25	11,239	8,835
50	6,755	4,989
75	4,129	3,038

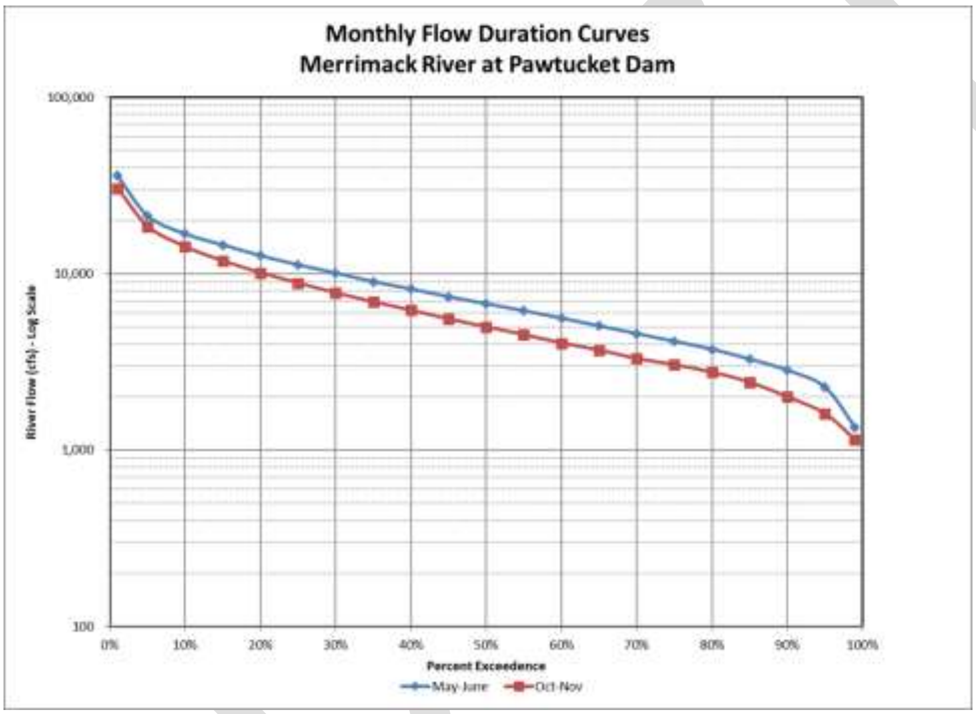

Figure 1. Flow duration curves for the two month periods of May-June and October-November at Lowell.

Lowell Turbine Parameters:

Table 3 provides a summary of the descriptive parameters for the two Kaplan turbines in operation at the E.L. Field powerhouse. These values were previously used during analyses presented in the Revised ISR.

Table 3. Characteristics of Kaplan turbines in operation at the Lowell Project E.L. Field Powerhouse.

Turbine Type	Kaplan
Runner Diameter (ft)	12.7
Number of Blades	5
Turbine Discharge (cfs)	3,300
Discharge at Optimum Efficiency (%)	81.3%
Net Head (ft)	39
Speed (rpm)	120
Turbine Efficiency (%)	92.8

<u>*Calibration of Lambda*</u>:
In addition to the turbine parameters described above, the strike mortality correlation factor, lambda (λ) is also required to run simulations of downstream fish passage survival using the USFWS TBSA Tool. The Fish Passage Survival Study provided by Boott as part of the Revised ISR, utilized recommended starting values of 0.2 for alosines and 0.4 for adult eels. As part of comments on the Revised ISR, the resource agencies requested the use of calibrated TBSA models to estimate total project survival. To accomplish this, multiple simulations were run which held the project-specific turbine parameters and fish population characteristics constant while allowing the correlation factor to vary. These simulations were run until a value of lambda was identified which produced a TBSA estimate of turbine passage survival equivalent to that observed during field studies conducted during 2019 and 2020. The resulting values for lambda used as part of this analysis are presented in Table 4.

Table 4. Correlation factor values (λ) used to calibrate turbine passage component of TBSA models to approximate field-derived turbine survival rates.

Fish Species (life stage)	Field-derived Turbine Survival Rate	Correlation Factor (λ)	Resulting TBSA Turbine Survival Rate
River herring (Adult)	73.9% (75% CI = 68.8%-79.1%)	0.7	73.9%
American shad (Adult)	35.5% (75% CI = 25.8%-45.2%)	1	34.6%
Juvenile Alosine	-	0.2*	-
American Eel	75.0% (75% CI = 70.6%-79.4%)	0.2	75.0%

*As no field-derived estimate of juvenile alosine survival was available, the standard USFWS value of λ =0.2 was used

<u>*Passage Route Distribution*</u>:
In their June 23, 2021 Determination on Requests for Study Modifications, FERC requested that additional downstream passage survival analyses assume that fish routing among available passage routes occur proportional to flow. Table 5 summarize the distribution of water at the Lowell Project under each of the seasonal inflow conditions presented in Table 2. In all cases it was assumed that the downstream bypass was in operation and passing 2% of station capacity. Inflow of up to 6,600 cfs was assumed to pass via the two turbine units. Any inflow in excess of

the downstream bypass and powerhouse was assumed to pass downstream via spill into the bypassed reach.

Table 5. Distribution of inflow at the Lowell Project under the 25%, 50%, and 75% exceedance conditions during the spring and fall fish migration periods.

Condition	Inflow (cfs)	Discharge (cfs)			Distribution (%)		
		Turbine	Bypass	Spill	Turbine	Bypass	Spill
Spring - 25% Exceedance	11,239	6,600	132	4,507	59%	1%	40%
Spring - 50% Exceedance	6,755	6,600	132	23	98%	2%	0%
Spring - 75% Exceedance	4,129	4,046	83	0	98%	2%	0%
Fall - 25% Exceedance	8,835	6,600	132	2,103	75%	1%	24%
Fall - 50% Exceedance	4,989	4,889	100	0	98%	2%	0%
Fall - 75% Exceedance	3,038	2,977	61	0	98%	2%	0%

Non-Turbine Mortality Rates:
Determination of whole-station survival for a theoretical fish population using the TBSA requires user-defined input to characterize survival of individuals passing downstream via any non-turbine passage routes. In this case the field-derived passage rates for alosines and eels observed during the 2019 and 2020 studies were utilized. These values are summarized in Table 6.

Table 6. Field-derived or assumed non-turbine route mortality rates for species/life stages at Lowell.

Fish Species (life stage)	Bypass	Spill	Notes
River herring (Adult)	12.2%	10.8%	Spill was limited to 1 individual; used rate for adult shad as a surrogate
American shad (Adult)	17.4%	10.8%	
Juvenile Alosine	12.0%	11.0%	Used adult alosine rates as a surrogate
American Eel	0.0%	0.0%	Spill based on 4 individuals; bypass assumed to be equivalent

Results

Species-specific body size information, turbine parameters, assumed passage route distribution information, and available non-turbine survival rates were combined using the TBSA Tool to generate estimates of passage survival for adult river herring, adult American shad, juvenile alosines and adult American eels. Estimates were generated for a high flow condition (i.e., 25% exceedance condition), mid flow condition (i.e., 50% exceedance condition) and a low flow condition (i.e., 75% exceedance condition). Results are presented in Tables 7 (adult river herring, 8 (adult American shad), 9 (juvenile alosines), and 10 (adult American eels). In general, whole station survival was greatest under the high flow condition. The high flow condition resulted in 40% (spring) and 24% (fall), respectively, of flow (and fish) passing via spill into the downstream bypass. Downstream passage during the mid and low flow condition was limited to use of the downstream bypass or via the turbine units. As evidenced in Tables 7-9, blade strike at the turbine units was the primary cause of mortality under most species-inflow condition combinations.

Table 7. TBSA estimated rates for turbine strike, bypass failure, and passage survival for adult river herring under a high, mid, and low flow condition at Lowell.

Condition	Turbine Strikes	Bypass Failures	Survival
Spring - 25% Exceedance	14.7%	6.5%	78.8%
Spring - 50% Exceedance	24.2%	0.0%	75.8%
Spring - 75% Exceedance	35.8%	0.0%	64.2%

Table 8. Estimates of rates for turbine strike, bypass failure, and passage success for adult American shad under a high, mid, and low flow condition at Lowell.

Condition	Turbine Strikes	Bypass Failures	Survival
Spring - 25% Exceedance	42.2%	2.7%	55.1%
Spring - 50% Exceedance	64.5%	0.6%	34.9%
Spring - 75% Exceedance	79.4%	0.3%	20.3%

Table 9. Estimates of rates for turbine strike, bypass failure, and passage success for juvenile alosines under a high, mid, and low flow condition at Lowell.

Condition	Turbine Strikes	Bypass Failures	Survival
Fall - 25% Exceedance	1.1%	2.8%	96.1%
Fall - 50% Exceedance	3.2%	0.7%	96.1%
Fall - 75% Exceedance	3.9%	0.2%	95.9%

Table 10. Estimates of rates for turbine strike, bypass failure, and passage success for adult American eel under a high, mid, and low flow condition at Lowell.

Condition	Turbine Strikes	Bypass Failures	Survival
Fall - 25% Exceedance	16.7%	0.0%	83.3%
Fall - 50% Exceedance	27.2%	0.0%	72.8%
Fall - 75% Exceedance	33.9%	0.0%	66.1%