II. Suggested Format for the HYDRO General Permit Notice of Intent (NOI):

Request for General Permit Authorization to Discharge Wastewater Notice of Intent (NOI) to be covered by Hydroelectric Generating Facilities General Permit (HYDROGP) No. MAG360000 or NHG360000

Indicate Applicable General Permit for Discharge(s): ☑MAG360000 ☐ NHG360000

A. Facility Information

1.	Facility Location	Name: LOWELL HYDROELECTRIC PROJECT	
		Street: 145 PAWTUCKET STREET	
		City: LOWELL	State: MA
		Zip: 01854	SIC Code: 4911
		Latitude: N 42° 39’ 09”	Longitude: W 71° 19’ 21”
		Type of Business: ELECTRIC POWER GENERATION	
2.	Facility Mailing Address (if different from Location)	Street: 4747 BETHESDA AVE., SUITE 1220	
		City: BETHESDA	State: MD
		Zip: 20814	
3.	Facility Owner	Name: HULL STREET ENERGY	Email: sblair@hullstreetenergy.com
		Street: 4747 BETHESDA AVE., SUITE 1220	Telephone: (410) 685-7950

		City: BETHESDA	State: MD
		Contact Person: SCOTT BLAIR	Zip: 20814
4.	Facility Operator (if different from above)	Name:	Email:
		Street:	Telephone:
		City:	State:
		Zip:	
5.	Current Permit Status	Has prior HYDROGP coverage been granted for the discharge(s) listed in the NOI?	☑ Yes ☐ No
		Permit number (if yes): MAG360024	
		Is the facility covered under an Individual Permit?	☐ Yes ☑ No
		Is there a pending NPDES application of file with EPA for the discharge(s)?	☐ Yes ☑ No
		Date of Submittal (if yes): Click or tap to enter a date.	Permit Number (if known):
		Attach a topographic map indicating the locations of the facility and outfall(s) to the receiving water	☑ Map Attached
		Number of turbines: 2	
		Combined turbine discharge (installed capacity) at:	Maximum capacity? 6400 cfs Minimum capacity? 900 cfs
		Is this facility operated as a pump storage project?	☐ Yes ☑ No

B. Discharge Information

1.	Name of Receiving Water(s): MERRIMACK RIVER	☑ Freshwater ☐ Marine
2.	Waterbody classification: ☐ Class A ☑ Class B ☐ Class SA ☐ Class SB	
3.	Is the receiving water is listed in the State's Integrated List of Waters (i.e., CWA Section 303(d))?	☑ Yes ☐ No
4.	If the applicant answered yes to B.2, has the applicant identified the designated uses that are impaired, any pollutants indicated, and whether a final TMDL is available for any of the indicated pollutants in a separate attachment to the NOI?	☑ Yes ☐ No
5.	Attach a line drawing or flow schematic showing water flow through the facility including location of intake(s), operations contributing to effluent flow, treatment units, outfalls, and receiving water(s).	☑ Line Drawing Attached

6. List each outfall (numbered sequentially) discharging effluent from the following categories and provide an estimate of the average monthly flow (in gallons per day) for each discharge type. See Parts 1.1 through 1.5 (for MA) or Parts 2.1 through 2.5 (for NH) for descriptions and permit conditions for each discharge type.

Equipment-related cooling water	Outfalls: 002	114,048 gpd
Equipment and floor drain water	Outfalls: 002	388,800 gpd
Maintenance-related water	Outfalls: 001, 003	250 gpd
Facility maintenance-related water during flood/high water events	Outfalls:	gpd
Equipment-related backwash strainer water	Outfalls:	gpd

7. For each outfall listed above, provide the following information (attach additional sheets if necessary). Outfalls may be eligible for alternative pH effluent limits. See Parts 1.7.l. and 2.7.l of the permit for additional information. Contact MassDEP or NHDES to determine the required information and protocol to request alternative pH effluent limits.		
Outfall No. 001	Latitude: N 42° 39’ 15”	Longitude: W 71° 19’ 36”
	Discharge is: ☑ Continuous ☐ Intermittent ☐ Seasonal	
	Maximum Daily Flow 0.605 MGD	Average Monthly Flow 0.303 MGD
	Maximum Daily Temperature °F Varies	Average Monthly Temperature °F Varies
	Maximum Daily Oil & Grease 15 mg/L	Average Monthly Oil & Grease>0 mg/L <15
	Maximum Monthly pH 8.3s.u.	Minimum Monthly pH 6.5s.u.
	Alternative pH limits requested? ☐Yes ☑ No	State approval attached? ☐ Yes ☑No
Outfall No. 002	Latitude: N 42° 39’ 16”	Longitude: W 71° 19’ 36”
	Discharge is: ☑ Continuous ☐ Intermittent ☐ Seasonal	
	Maximum Daily Flow 0.389 MGD	Average Monthly Flow 0.195 MGD
	Maximum Daily Temperature °F Varies	Average Monthly Temperature °F Varies
	Maximum Daily Oil & Grease mg/L 15	Average Monthly Oil & Grease mg/L >0 <15
	Maximum Monthly pH s.u. 8.3	Minimum Monthly pH s.u. 6.5
	Alternative pH limits requested? ☐Yes ☑ No	State approval attached? ☐ Yes ☑No

Outfall No. 003	Latitude: N 42° 39’ 16”	Longitude: W 71° 19’ 36”
	Discharge is: ☑ Continuous ☐ Intermittent ☐ Seasonal	
	Maximum Daily Flow 0.00025 MGD	Average Monthly Flow 0.000125 MGD
	Maximum Daily Temperature °F Varies	Average Monthly Temperature °F Varies
	Maximum Daily Oil & Grease 15 mg/L	Average Monthly Oil & Grease >0 <15mg/L
	Maximum Monthly pH 8.3 s.u.	Minimum Monthly pH 6.5 s.u.
	Alternative pH limits requested? ☐ Yes ☑ No	State approval attached? ☐ Yes ☑ No

C. Best Technology Available for Cooling Water Intake Structures

Facilities that checked “equipment-related cooling” as one of the discharges in Part B. of this NOI are subject to the following requirements.	
1. Does the facility intake water for cooling purposes subject to the BTA Requirements at Part 4 of the HYDROGP?	☑ Yes ☐ No If no, skip to Part D of this NOI.
2. If yes, indicate which technology employed to comply with the general BTA requirements at Part 4.2.b of the HYDROGP:	
☑ An existing technology (e.g., a physical or behavioral barrier, spillway, or guidance device) that directs fish towards a downstream passage that minimizes exposure to the CWIS. Has the applicant attached a narrative description of the barrier to demonstrate that the downstream fish passage effectively transports live fish in a manner that minimizes the likelihood of becoming impinged or entrained at the cooling water intake? ☑ Yes ☐ No	
☐ An effective intake velocity at the point of cooling water withdrawal, or alternatively, at the point where cooling water enters the penstock (for intakes located within the penstock), not to exceed 0.5 fps. Has the applicant attached a demonstration of compliance with this intake velocity through observation of live fish in the intake or calculation based on the maximum intake volume and minimum bypass flow? ☐ Yes ☐ No ☑ NA	

☐ For cooling water withdrawn directly from the source waterbody (*i.e.*, not from within the penstock), a physical screen or other barrier technology with a mesh size no greater than ½-inch) that minimizes the potential for adult and juvenile fish to become entrapped in the CWIS. Has the applicant attached a description of the technology? ☐ Yes ☐ No ☑ NA If the mesh size of the screen is greater than ½-inch has the applicant demonstrated that the calculated intake velocity is less than 0.5 fps based on the screen dimensions, maximum intake volume, and source water 7Q10 low flow?
3. If the answer to question C.1 is yes, in addition to complying with one of the criteria above, the applicant must submit the following information:
Maximum daily volume of cooling water withdrawn during previous five (5) years: 114,048 gpd
Maximum monthly average volume of cooling water withdrawn during the previous five (5) years: 114,048 gpd
Maximum daily and average monthly volume of water used exclusively for cooling: Max: 114,048 gpd Avg: 114,048 gpd Maximum daily and average monthly volume of water used for another process before or after being used for cooling: Max: 0 gpd Avg: 0 gpd Has the applicant attached a narrative description explaining how cooling water is reused? ☐ Yes ☑ No
Volume of total intake water withdrawn and used in facility as a percentage of: Installed turbine capacity 0.0028 % Average daily flow through penstock 0.0055% Minimum flow through penstock 0.0196%
Source water annual mean flow (*e.g.*, available from USGS, MassDEP, or NHDES): 7,950 cfs
Source water 7-day mean low flow with 10-year recurrence interval (7Q10): 930 cfs

Volume of total intake water withdrawn and used in facility as a percentage of:	
Source water mean annual flow	0.002%
Source water 7Q10 flow	0.019%

D. Chemical Additives

1.	Does the facility use or plan to use non-toxic chemicals for pH adjustment?	☐ Yes ☑ No
2.	Does the facility use or plan to use chemicals for anti-freeze purposes?	☐ Yes ☑ No
3.	If the answer to D.2 is yes, provide the following for **EACH** chemical additive used for anti-freeze:	
Chemical Name and Manufacturer:		
Maximum Dosage Concentration Used:		Average Dosage Concentration Used:
Maximum Concentration in Discharge: mg/L		Average Concentration in Discharge: mg/L
Material Safety Data Sheet (MSDS) or other toxicity documentation for each chemical attached? ☐ Yes ☐ No ☑ NA		

E. Endangered Species Act Certification

Appendix 2 to the HYDROGP explains the certification requirements related to threatened and endangered species and designated critical habitat. Indicate under which criteria the discharge is eligible for coverage under the HYDROGP:	
1. ESA eligibility for species under jurisdiction of USFWS	**Criterion A**: No endangered or threatened species or critical habitat are in proximity to the discharges or related activities or come in contact with the "action area." See Appendix 2, Part B for documentation requirements. Documentation attached? ☐ Yes ☐ No
	☑ **Criterion B**: Formal or informal consultation with the USFWS under Section 7 of the ESA resulted in either a no jeopardy opinion (formal consultation) or a written concurrence by USFWS on a finding that the discharges and related activities are "not likely to adversely affect" listed species or critical habitat. Has the operator completed consultation with USFWS and attached documentation? ☑ Yes ☐ No If no, is consultation underway? ☐ Yes ☐ No

		☐ **Criterion C**: Using the best scientific and commercial data available, the effect of the discharges and related activities on listed species and designated critical habitat have been evaluated. Based on those evaluations, a determination is made by EPA, or by the operator and affirmed by EPA, that the discharges and related activities will have "no effect" on any federally threatened or endangered species or designated critical habitat under the jurisdiction of the USFWS. Has the applicant attached documentation of the "no effect" finding? ☐ Yes ☐ No
2.	ESA eligibility for species under jurisdiction of NMFS	Is the facility located on: the Connecticut River between the Massachusetts/Connecticut state line and Turners Falls, MA; the Taunton River; the Merrimack River between Lawrence, MA and the Atlantic Ocean; the Piscataqua River including the Salmon Falls and Cocheco Rivers; or a marine water? ☐ Yes ☑No
		If yes, was the applicant authorized to discharge from the facility under the 2009 HYDROGP? ☐ Yes ☐ No
		If the discharge is to one of the named rivers above or to a marine water *and* the facility was not previously covered under the 2009 HYDROGP, has there been any previous formal or informal consultation with NMFS? ☐ Yes ☐ No Documentation of consultation attached? ☐ Yes ☐ No

F. National Historic Properties Act Eligibility

1.	Indicate under which criterion the discharge(s) is eligible for covered under the HYDROGP:
☐	**Criterion A**: No historic properties are present.
☑	**Criterion B**: Historic properties are present. The discharges and related activities do not have the potential to impact historic properties.
☐	**Criterion C**: Historic properties are present. The discharges and related activities have the potential to impact or adversely impact historic properties.

2.	Has the applicant attached supporting documentation for NHPA eligibility described in Appendix 3, Part C of the HYDROGP? ☐ Yes ☑ No
3.	Does supporting documentation include a written agreement from the State Historic Preservation Officer, Tribal Historic Preservation Officer, or other tribal representative that outlines measures the operation will carry out to mitigate or prevent any adverse effects on historic properties? ☐ Yes ☑ No

G. Supplemental Information

Please provide any supplemental information, including antidegradation review information applicable to new or increased discharges. Attach any certifications required by the HYDROGP. Supplemental information attached? ☑ Yes ☐ No

H. Signature Requirements

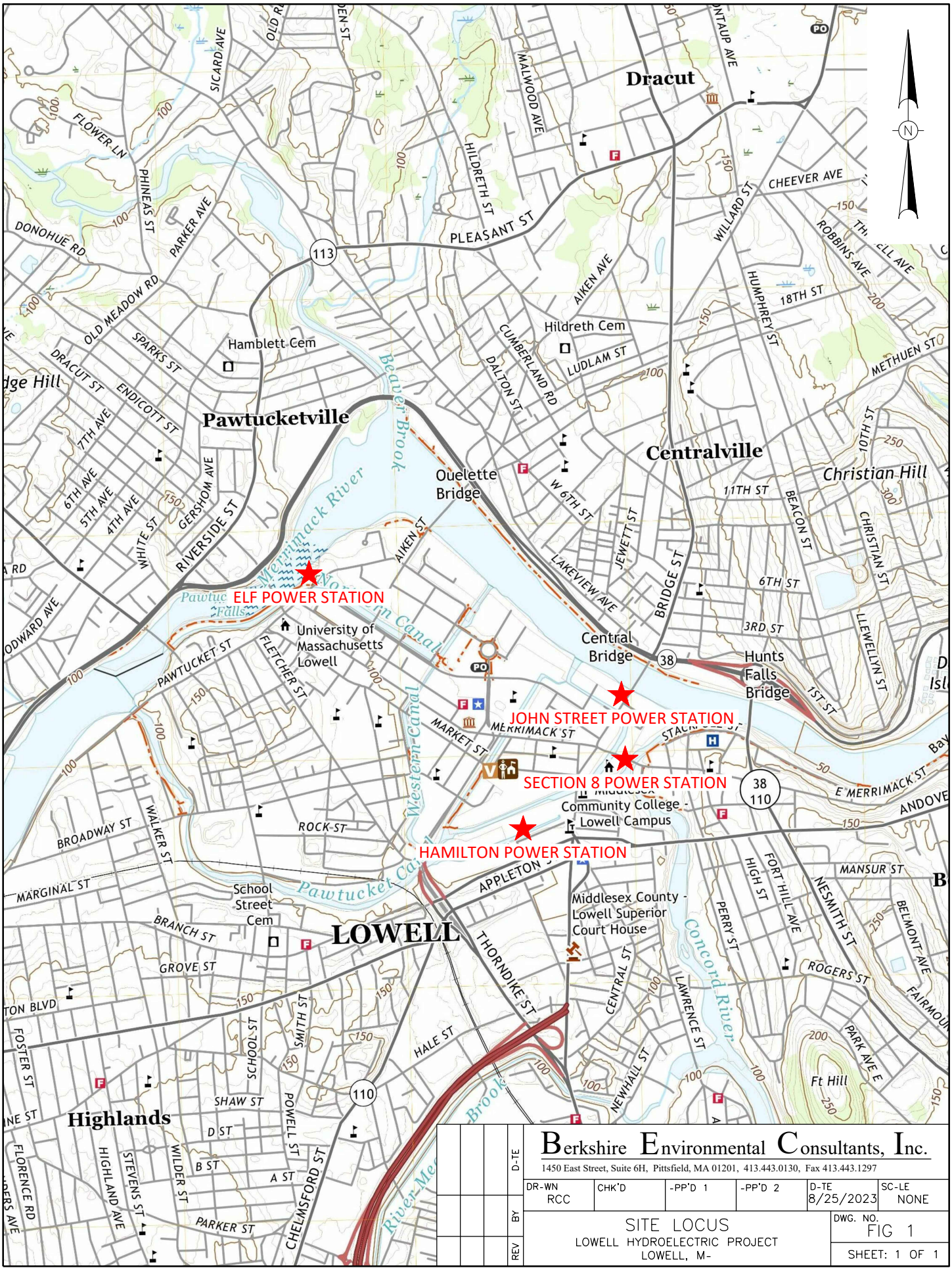
1. The NOI must be signed by the operator in accordance with the signatory requirements of 40 C.F.R. § 122.22, including the following certification:

I certify under penalty of law that no chemical additives are used in the discharges to be authorized under this General Permit except for those used for pH adjustment or anti-freeze purposes and that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, I certify that the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I certify that I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

2. Notification provided to the appropriate State, including a copy of this NOI, if required?	☑ Yes ☐ No
Signature: Scott M Blair	Date: 10/4/2023
Print Name and Title: SCOTT BLAIR, ASSET MANAGER	

ATTACHMENT A

TOPOGRAPHIC MAP OF FACILITY



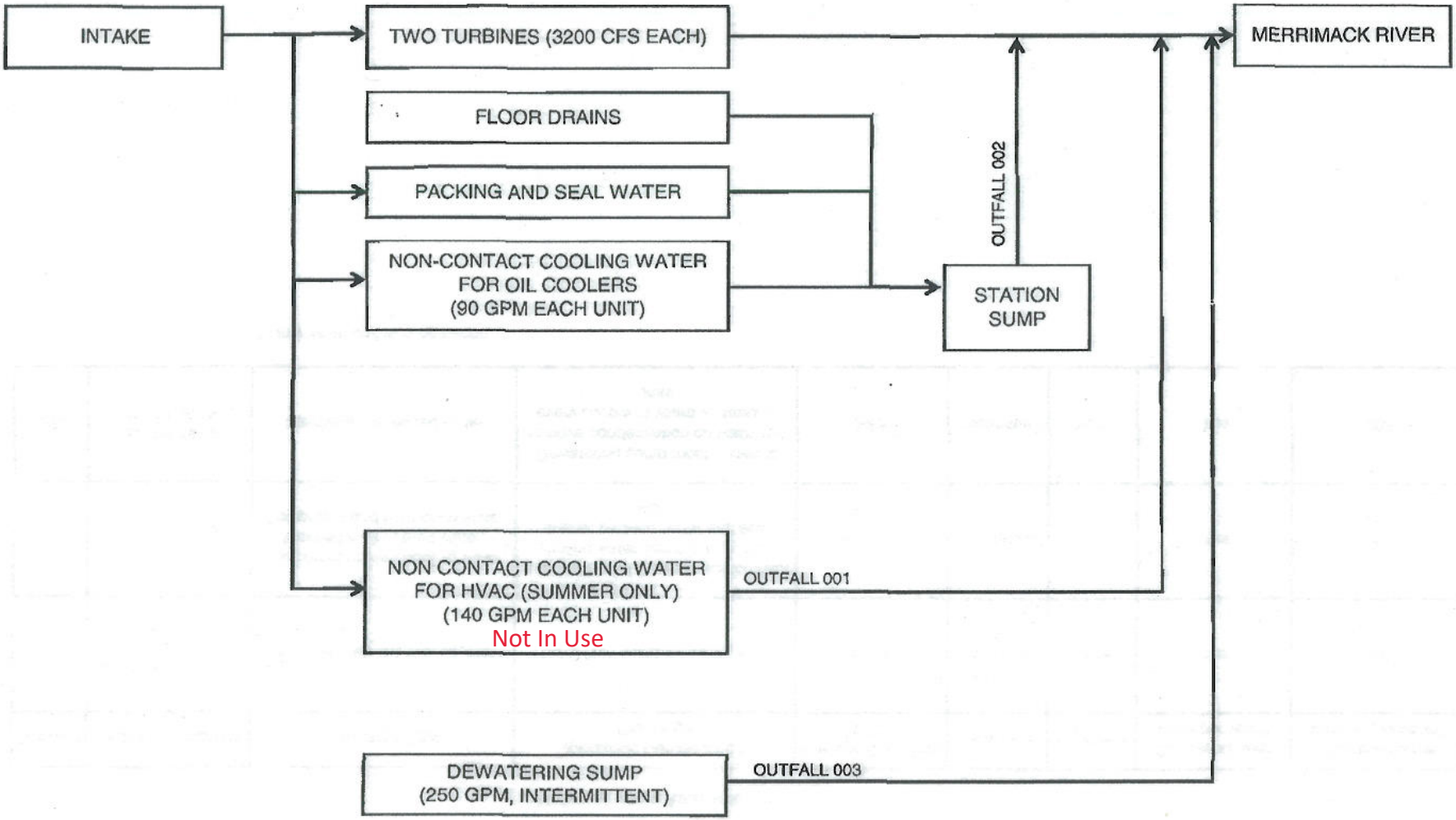
				D-TE	Berkshire Environmental Consultants, Inc.			
					1450 East Street, Suite 6H, Pittsfield, MA 01201, 413.443.0130, Fax 413.443.1297			
					DR-WN: RCC	CHK'D	-PP'D 1	-PP'D 2	D-TE: 8/25/2023	SC-LE: NONE
				BY	SITE LOCUS LOWELL HYDROELECTRIC PROJECT LOWELL, M-				DWG. NO. FIG 1	
				REV					SHEET: 1 OF 1	

ATTACHMENT B

FACILITY WATER FLOW SCHEMATIC

Eldred L. Field Powerhouse
Lowell, MA

Notice of Intent Attachment 1



ATTACHMENT C

USGS MERRIMACK RIVER STREAM STATS

WATER INTAKE STRUCTURE CALCULATIONS

StreamStats Data-Collection Station Report

Gage Information

Name	Value
USGS Station Number	**01100000 (https://waterdata.usgs.gov/monitoring-location/01100000)**
Station Name	MERRIMACK RIVER BL CONCORD RIVER AT LOWELL, MA
Station Type	Gaging Station, continuous record
Latitude	42.6459247
Longitude	-71.2983936
NWIS Latitude	42.64592464
NWIS Longitude	-71.2983937
Is regulated?	true
Agency	United States Geological Survey
NWIS Discharge Period of Record	05/31/1923 - 08/28/2023

Physical Characteristics

Filter By Statistic Group: Select Filter By Citation: Select

Basin Dimensional Characteristics

Characteristic Name	Value	Units	Citation
Drainage Area	4635	square miles	**193**

Streamflow Statistics Filter By Statistic Group: Select Filter By Citation: Select Show Only Preferred

Low-Flow Statistics

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
7 Day 2 Year Low Flow	1340	cubic feet per second	✓			**30**	
7 Day 10 Year Low Flow	930	cubic feet per second	✓			**30**	

Flow-Duration Statistics

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
1 Percent Duration	36200	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
2 Percent Duration	31200	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
3 Percent Duration	27800	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
5 Percent Duration	23400	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
10 Percent Duration	17700	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
15 Percent Duration	14300	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
20 Percent Duration	12100	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
25 Percent Duration	10300	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
30 Percent Duration	8860	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
35 Percent Duration	7770	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
40 Percent Duration	6870	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
45 Percent Duration	6130	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
50 Percent Duration	5440	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
55 Percent Duration	4820	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
60 Percent Duration	4270	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
65 Percent Duration	3770	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
70 Percent Duration	3280	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
75 Percent Duration	2840	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
80 Percent Duration	2430	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
85 Percent Duration	2040	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
90 Percent Duration	1690	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
95 Percent Duration	1280	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
97 Percent Duration	1040	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
98 Percent Duration	872	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
99 Percent Duration	585	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

Annual Flow Statistics

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
Mean Annual Flow	7950	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Stand Dev of Mean Annual Flow	2040	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Maximum Annual Mean Flow	14600	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Minimum Annual Mean Flow	3070	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

General Flow Statistics

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
Minimum daily flow	214	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Maximum daily flow	161000	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Std Dev of daily flows	7780	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Average daily s treamflow	7651.607	cubic feet per second	✓	81		**86**	
Harmonic Mean Streamflow	3560	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Mean_of_Logs_ of_Daily_Value s	3.73118	Log base 10	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Std_Dev_of_Lo gs_of_Daily_Val ues	0.39229	Log base 10	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
Skew_of_Logs_of_Daily_Values	-0.097981	Log base 10	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015
Non_Zero_Adjusted_Harmonic_Mean_Flow	3560	cubic feet per second	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

Base Flow Statistics

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
Number of years to compute BFI	80	years	✓	81		**87**	
Average BFI value	0.59	dimensionless	✓	81		**87**	
Std dev of annual BFI values	0.066	dimensionless	✓	81		**87**	

Probability Statistics

Statistic Name	Value	Units	Preferred?	Years of Record	Standard Error, percent	Citation	Comments
Probability zero flow durations	0	dimensionless	✓	92		**52**	Statistic Date Range 10/1/1923 - 9/30/2015

Citations

ID	Citation
193	Imported from NWIS file (http://waterdata.usgs.gov/nwis/si)
30	Wandle, S.W., Jr., and Fontaine, R.A., 1984, Gazetteer of Hydrologic Characteristics of Streams in Masssachusetts--Merrimack River Basin: U.S. Geolological Survey Water-Resources Investigations Report 84-4284 (http://pubs.er.usgs.gov/usgspubs/wri/wri844284)
52	Granato G.E., Ries, K.G., III, and Steeves, P.A., 2017, Compilation of streamflow statistics calculated from daily mean streamflow data collected during water years 1901–2015 for selected U.S. Geological Survey streamgages: U.S. Geological Survey Open-File Report 2017-1108, 17 p. (https://pubs.er.usgs.gov/publication/ofr20171108)
86	Wolock, D.M., 2003, Flow characteristics at U.S. Geological Survey streamgages in the conterminous United States: U.S. Geological Survey Open-File Report 03-146, digital data set (http://water.usgs.gov/GIS/metadata/usgswrd/XML/qsitesdd.xml)
87	Wolock, D.M., 2003, Base-flow index grid for the conterminous United States: U.S. Geological Survey Open-File Report 03-263, digital data set (https://water.usgs.gov/GIS/metadata/usgswrd/XML/bfi48grd.xml)

Eldred L. Field Powerhouse
Hydro General Permit Notice of Intent (NOI)
Best Technology Available for Cooling Water Intake Structures

Purpose: The ELF Powerhouse Facility utilizes a water intake structure to supply water to the associated oil cooling system connected to each of the two generator units. Because of this intake structure, the facility is required to submit additional data in the NOI related to waterflow and percent of flow used for cooling.

Volume of cooling water withdrawn during previous five (5) years:

Maximum daily:	0.176	cfs
	79.2	gpm
	114,048	gpd
Maximum monthly average:	0.176	cfs
	79.2	gpm
	114,048	gpd

Note: During operations, the water cooling structures operate at full capacity therefore the assumption was made that the maximum daily and maximum monthly average are estimated to be the same.

Maximum daily and average monthly volume of water used exclusively for cooling:

Maximum daily:	114,048	gpd
Monthly average:	114,048	gpd

Note: During operations, the water cooling structures operate at full capacity therefore the assumption was made that the maximum daily and maximum monthly average and monthly average are estimated to be the same.

Volume of water used for another process before or after being used for cooling:

Maximum daily:	0	gpd
Monthly average:	0	gpd

Volume of total intake water withdrawn and used in facility as a percentage of the following:

Installed turbine capacity:	6,400	cfs
	0.0028	%
Average daily flow through penstock:	3,200	cfs
	0.0055	%
Minimum flow through penstock:	900	cfs
	0.0196	%

Note: *The average daily flow through the penstock was estimated to be 50% of the total turbine capacity. This assumption was made after reviewing historical generation data for the entire set of four facilities associated with Lowell Hydroelectric Project from 2013 to 2017. This review showed that the Lowell Hydroelectric Project operated approximately 37% percent of time during those years, and because the ELF Powerhouse has the largest generation capacity of the four stations.*

Source water annual mean flow (e.g., available from USGS, MassDEP, or NHDES):

Source Water 7-day mean flow: 7,950 cfs

Source water 7-day mean low flow with 10-year recurrence interval (7Q10):

Source Water 7-day low flow: 930 cfs

Volume of total intake water withdrawn and used in facility as a percentage of the following:

Source water mean annual flow: 0.0022 %

Source water 7Q10 flow: 0.0190 %

ATTACHMENT D

ENDANGERED SPECIES ACT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
Phone: (603) 223-2541 Fax: (603) 223-0104

In Reply Refer To: August 25, 2023
Project Code: 2023-0121593
Project Name: Lowell Hydroelectric Project - ELF Station

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

Updated 4/12/2023 - Please review this letter each time you request an Official Species List, we will continue to update it with additional information and links to websites may change.

About Official Species Lists

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Federal and non-Federal project proponents have responsibilities under the Act to consider effects on listed species.

The enclosed species list identifies threatened, endangered, proposed, and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested by returning to an existing project's page in IPaC.

Endangered Species Act Project Review

Please visit the "**New England Field Office Endangered Species Project Review and Consultation**" website for step-by-step instructions on how to consider effects on listed

species and prepare and submit a project review package if necessary:

https://www.fws.gov/office/new-england-ecological-services/endangered-species-project-review

NOTE Please do not use the **Consultation Package Builder** tool in IPaC except in specific situations following coordination with our office. Please follow the project review guidance on our website instead and reference your **Project Code** in all correspondence.

Northern Long-eared Bat - (**Updated 4/12/2023**) The Service published a final rule to reclassify the northern long-eared bat (NLEB) as endangered on November 30, 2022. The final rule went into effect on March 31, 2023. You may utilize the **Northern Long-eared Bat Rangewide Determination Key** available in IPaC. More information about this Determination Key and the Interim Consultation Framework are available on the northern long-eared bat species page:

https://www.fws.gov/species/northern-long-eared-bat-myotis-septentrionalis

For projects that previously utilized the 4(d) Determination Key, the change in the species' status may trigger the need to re-initiate consultation for any actions that are not completed and for which the Federal action agency retains discretion once the new listing determination becomes effective. If your project was not completed by March 31, 2023, and may result in incidental take of NLEB, please reach out to our office at newengland@fws.gov to see if reinitiation is necessary.

Additional Info About Section 7 of the Act
Under section 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to determine whether projects may affect threatened and endangered species and/or designated critical habitat. If a Federal agency, or its non-Federal representative, determines that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Federal agency also may need to consider proposed species and proposed critical habitat in the consultation. 50 CFR 402.14(c)(1) specifies the information required for consultation under the Act regardless of the format of the evaluation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/service/section-7-consultations

In addition to consultation requirements under Section 7(a)(2) of the ESA, please note that under sections 7(a)(1) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species. Please contact NEFO if you would like more information.

Candidate species that appear on the enclosed species list have no current protections under the ESA. The species' occurrence on an official species list does not convey a requirement to

consider impacts to this species as you would a proposed, threatened, or endangered species. The ESA does not provide for interagency consultations on candidate species under section 7, however, the Service recommends that all project proponents incorporate measures into projects to benefit candidate species and their habitats wherever possible.

Migratory Birds

In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see:

https://www.fws.gov/program/migratory-bird-permit

https://www.fws.gov/library/collections/bald-and-golden-eagle-management

Please feel free to contact us at **newengland@fws.gov** with your **Project Code** in the subject line if you need more information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat.

Attachment(s): Official Species List

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
(603) 223-2541

PROJECT SUMMARY

Project Code: 2023-0121593
Project Name: Lowell Hydroelectric Project - ELF Station
Project Type: Wastewater Discharge
Project Description: EPA Hydro GP NOI Supporting Documentation
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@42.6532464,-71.31365342650304,14z

Counties: Middlesex County, Massachusetts

ENDANGERED SPECIES ACT SPECIES

There is a total of 2 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Endangered

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

IPAC USER CONTACT INFORMATION

Agency: Berkshire Environmental Consultants, Inc.
Name: Ryan Capasse
Address: 1450 East St Suite 6-H
City: Pittsfield
State: MA
Zip: 01201
Email rcapasse@berkshireenvironmental.com
Phone: 5857488544

ATTACHMENT E

FISHWAYS OPERATION AND MAINTENANCE PLAN 2019

Fishways Operation and Maintenance Plan

Lowell Hydroelectric Project (FERC No. 2790-MA)

Prepared For
Boott Hydropower, LLC
100 Brickstone Square, Suite 300
Andover, Massachusetts 01810

Prepared By
Normandeau Associates, Inc.
25 Nashua Road
Bedford, NH 03110
www.normandeau.com

October 17, 2019

RECORD OF CHANGES

Revision ID	Date of Issue	Modifications
Revision 1	Jan. 31, 2019	Initial draft
Revision 2	May 16, 2019	Incorporates responses to initial USFWS comments provided to Enel on March 11, 2019
Revision 3	May 30, 2019	Incorporates additional information from Enel based on USFWS comments
Revision 4	October 17, 2019	Provides post-season and updated content revision from agency review, on-site post-season inspection

Table of Contents

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1 Introduction

This Fishways Operations and Management Plan (FOMP, Plan) details the operations, maintenance, and record keeping required to operate the fish passage facilities at the Lowell Project (FERC No. 2790) owned by Boott Hydropower, LLC (Boott; a subsidiary of ENEL Green Power North America, Inc.). The Plan describes the existing upstream and downstream fish passage facilities as well as upstream eel passage facilities located at the Lowell Project (Project), the period in which the facilities will be operated, pre and post-season checks and maintenance, annual start-up and shut-down procedures, operating procedures and guidelines, and established maintenance/safety guidelines. In addition to the above described procedures and guidelines, pertinent contact information will also be included. This FOMP has been developed as a "living document" and will be updated on an as needed basis to reflect modifications to fishway operations that may be implemented following future consultations with the resource agencies comprising the Merrimack River Technical Committee (Technical Committee)[1].

2 Project Facilities and Structures

The Project is located at river mile (RM) 41 on the Merrimack River in the city of Lowell, Middlesex County, Massachusetts. The impounded reach of the Merrimack River extends into the towns of Merrimack and Litchfield, Hillsborough County, NH. The Project operates in a run of river (ROR) mode and has no usable storage capacity. The existing Lowell Project consists of: (1) a 1,093-foot-long, 15-foot-high masonry gravity dam (Pawtucket dam) that includes a 980.5-foot-long spillway with a crest elevation of 92.2 feet National Geodetic Vertical Datum 1929 (NGVD 29) and five zones of 5-foot-high pneumatically-operated crest gates; (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 (Northern and Pawtucket Canal System) that includes several small dams and a gatehouse; (4) two intake facilities; (5) a powerhouse (E.L. Field) that uses water from the Northern Canal and contains two Fuji Horizontal Full Kaplan units with a total hydraulic capacity of 6,600 cubic feet per second (cfs); (6) a 1,000-foot-long tailrace channel; (7) four powerhouses (Assets, Bridge Street, Hamilton, and John Street) housed in nineteenth century mill buildings along the Northern and Pawtucket Canal System containing fifteen turbine-generator units with a total hydraulic capacity of approximately 5,500 cfs (Table 2-1)[2]; (8) a 4.5-mile long, 13.8-kilovolt transmission line connecting the powerhouses to the regional distribution grid; (9) 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

[1] The Merrimack River Technical Committee is comprised of representatives from the U.S. Fish and Wildlife Service, Massachusetts Division of Fish and Wildlife, Massachusetts Division of Marine Fisheries, New Hampshire Fish and Game Department, and the National Marine Fisheries Service.

[2] The description reflects the Commission's Order Amending License By Deleting Four Generating Units from the Bridge Street Station and Revising Annual Charges, 164 FERC ¶ 62,035, July 19, 2018

Pawtucket dam; and (10) appurtenant facilities. Figure 2-1 identifies the major Project features located within the city of Lowell.

2.1 Fish Passage Facilities

The Lowell Project fish passage facilities include a fish lift and a downstream bypass at the E.L. Field Powerhouse, a vertical slot fish ladder at the North end of Pawtucket Dam, and an upstream eel passage measures recently located at the fish ladder or adjacent gate bays at Pawtucket Dam (Figure 2-2).

2.1.1 E.L. Field Powerhouse Fish Lift

At the E.L. Field Powerhouse, the upstream facility is an elevator type lift with a designed total operational flow of 200 cfs (both entrances) with 50 cfs supplied through the fishway channel and the remaining 150 cfs supplied through floor diffusers in the lower fishway attraction channel (Appendix A-1 through A-5). The collection gallery has an entrance on each side of the tailrace although only the northern (river-side) entrance has been used since the mid-1990's (Normandeau 1997). A late-1990's dividing wall was installed in the lower fishway at the cutover gallery of the streetside entrance to prevent fish access to the cross-powerhouse gallery. The street side entrance to the upstream fish lift system was simultaneously closed, with Tech Committee concurrence. Fish are presently attracted into the riverside entrance channel and then trapped via pneumatic gates that crowd the fish into the elevator bay where they are then lifted by the hopper and released into the upper fishway channel. Fish are then counted as they pass through the 10-foot by 12-foot fish trap and counting station. From the fish trap/counting station, fish are able to volitionally exit the facility and enter the Northern Canal. The Northern Canal Gatehouse is located at the southern abutment of the Pawtucket Dam and controls flow into the Northern Canal (Figure 2.1, Appendix A-6). It 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 presently unused wheel, which formerly powered the gate mechanisms through a line shaft. The structure's water passages are nearly 80 feet in length. A small navigation lock located at the southerly end of the Northern Canal Gatehouse is used by National Park Service (NPS) tour boats. Under direction of the NPS, the boat lock is not presently opened or operated during the fish passage season. Following exit from the Northern Canal through its Gatehouse, fish have access to upper reaches of the Merrimack River. At present, monitoring of fish passage is conducted at a counting window in the upper exit flume by video recording (i.e. SalmonSoft – FishTick counting software). Visual counts at the hopper and count window were made from the mid-1980's until 2015, and visual estimates of species and abundance in each lift are made by the lift operator.

2.1.2 E.L. Field Downstream Bypass

The downstream fishway at the powerhouse consists of an adjustable-flow sluiceway and bypass adjacent to the intake headwall. Downstream emigrants 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 emigrants to move downstream to the mainstem river at the confluence of the river reach and tailrace. Target flows for the

downstream bypass are 2% of station flow; provided in a flume structural configuration developed with the Technical Committee in the 1990's. As configured, the downstream bypass and upstream passage system can not operate simultaneously. During the spring upstream passage period, upstream passage is afforded by the lift system from 0800-1600 daily, after which the system is converted to downstream passage, after 1600 and before 0600 daily. Extended lifting hours are accommodated when necessary during high upstream passage periods.

2.1.3 Pawtucket Dam Vertical Slot Fish Ladder

On the northern abutment of Pawtucket Dam is a vertical slot fish ladder. Flow through the fish ladder is controlled by a pair of 18", full-depth openings between each pool (Appendix A-7, A-8). The ladder is constructed of reinforced concrete and designed to allow for controlled passage at river flows of up to 25,000 cfs although at the upper limits, the fishway becomes inundated. The ladder consists of two sections (upper and lower) with two turn pools, at the entrance and mid-point. The lower section measures 93 feet in length and contains seven vertical slot weir structures. The upper leg measures 104 feet in length and contains 9 vertical slot weir structures, and is equipped with a coarse trash rack and dewatering gate (fully open when ladder is operating). Each pool measures 13 feet by 10 feet. Total operational flow, including both through-ladder and attraction water, is 500 cfs. Ladder flow is self-regulated by the fixed concrete weir(s), subject to impoundment level, and operates at ~30 cfs. Within each ladder weir, slots for adjustable metal baffles exist. Present configuration of baffles is: 2 stacked plates on each inside weir slot; 1 plate on each outside slot. Supplemental ladder attraction flow is supplied by an adjacent gate, and enter the lower ladder through a floor diffusion chamber upstream of the entrance supplying an additional 60 cfs (determined seasonally to minimize turbulence and air entrainment). Additional attraction flows are supplied by the adjacent gate C (Figure 2.2). Monitoring of fish passage is conducted at a counting window by video recording (SalmonSoft), with a fish trapping facility located near the exit of the ladder.

Fish approaching the Pawtucket Dam fish ladder from points downstream must ascend the 0.7 mile long bypassed reach which extends from the top of Pawtucket Dam to the E.L. Field Powerhouse tailrace. To facilitate upstream fish passage through ledge habitat within the upper portion of the bypassed reach, Boott constructed six concrete flow control weirs (with adjustable stop-log sections) at the request of the U.S. Fish & Wildlife Service and in response to Article 36, section (2) of the Project's FERC license (Figure 2-3).

2.1.4 Pawtucket Dam Upstream Eel Passage

At the present time, upstream passage of American Eels at the Pawtucket Dam will be performed via use of the vertical slot fish ladder. At the end of the upstream diadromous fish passage season (~ July 15) two weighted strands of mussel spat will be layered across the bottom of the ladder to the entrance turn pool to provide ascent substrate and refuge during any dewatered assessments. A description of the existing vertical slot fish ladder is provided in Section 2.1.3.

2.2 Operational Period

2.2.1 E.L. Field Powerhouse Fish Lift

Operation of the E.L. Field fish lift is initiated when either (1) a cumulative total of 50 American Shad or 200 river herring are passed at the downstream Lawrence Project or (2) one week after fish have begun to pass the Lawrence Project (FERC No. 2800). Daily fish lift operations are initiated by engaging the attraction water system at 0600 with the first lift at 0800. The final daily lift on a given operational day is regularly conducted at 1600. However, if high numbers of diadromous fish species are observed during the late afternoon lifts, additional lifts will be implemented, as determined by site personnel in regular contact with Lawrence project passage staff (Enel and agency representatives). The fish lift will remain operational seven days a week (including holidays) until the completion of the fish passage season (typically mid-July). The lift is operational up to Merrimack River flows of 25,000 cfs (based on USGS gage 01100000 Merrimack River below Concord River at Lowell, MA).

2.2.2 E.L. Field Downstream Bypass

Based on the CFPP (2001) the downstream bypass facility is operated from April 1 through July 15 during hours when the fish lift is not operating. The fish bypass is re-opened and operated on a 24-hour basis from September 1 through November 15 annually. In several recent years and per Technical Committee request, Boott has operated the downstream bypass earlier than September 1 to accommodate recognized timing of downstream alosid migrations.

2.2.3 Pawtucket Dam Vertical Slot Fish Ladder

The operational period for the vertical slot fish ladder mirrors the fish lift at E.L. Field, starting when either a cumulative total of 50 American Shad/200 river herring are passed at the downstream Lawrence Project or one week after fish have begun to pass the Lawrence Project (FERC No. 2800). The Pawtucket Dam fish ladder is run continuously. The fish ladder is operational up to Merrimack River flows of 25,000 cfs (based on USGS gage 01100000 Merrimack River below Concord River at Lowell, MA).

2.2.4 Pawtucket Dam Upstream Eel Passage

Operation of the Pawtucket Dam fish ladder continues through the end of September for the upstream passage of juvenile American Eels. Ladder operation for juvenile eel passage is discontinued by October 1 annually, typically coincident with cessation of the annual upstream eel migration period.

2.3 Attraction Flow

2.3.1 E.L. Field Powerhouse Fish Lift

The upstream facility is an elevator type lift with a designed total operational flow of ~200 cfs (both entrances). Approximately 50 cfs is supplied through the fishway channel and the remaining 150 cfs is designed to be supplied through floor diffusers in the lower fishway

attraction channel, resulting in ~120 cfs river-side and ~80 cfs street-side entrance allocations. Because the street-side entrance is not used, attraction flow currently ranges between 80-120 cfs, adjusted regularly according to USFWS-provided guidelines to achieve the best combination of flow, differential, etc. for passage. Attraction water to the E.L. Field fishway is supplied to the entrance via two intakes, both of which are located in the floor of the exit channel. The smaller intake is 24 inches in diameter and is designed to draw 50 cfs through the intake grating that is located at the most downstream end of the upper exit channel. The 50 cfs supply is operated daily at full capacity from 0600 until the final lift of the day. A slide gate at the entrance of the pipe can be used to regulate the flow if necessary for maintenance, or to optimize turbulence, differential, total flow, etc. This circulation flow is discharged to a diffusion chamber located just upstream of the hopper pit and then flows through the crowder channel to the entrance gate. The larger attraction water supply conveyance is 3 feet in diameter and expands to 4 feet prior to discharging to the floor diffusion chamber. This system is designed to draw 150 cfs through the intake grating that is located just upstream of the counting window. One manually operated 36-inch butterfly valve is used to regulate the flow. Downstream of this valve, the attraction water pipe supplies the flow to the chamber located below the floor elevation on the lower fishway, where it then flows up through several floor diffusers comprised of dimensional lumber before exiting a 20-foot-long by 10-foot-wide floor diffuser grating to the entrance channel. The 150 cfs attraction water is operated for the duration of the upstream fish passage season. Actual daily attraction water flow settings are adjusted per USFWS-supplied 'operating guidelines' and consider tailwater elevation and fishway differential, overall fishway flow, turbulence, etc. to establish best passage conditions (USFWS 2017).

2.3.2 E.L. Field Downstream Bypass

The downstream bypass at E.L. Field is 7.7 foot-wide by 9.0 foot deep with flows adjusted by a weir gate to approximately 2% of turbine flow. As noted above (section 2.1.2), the actual flume opening is configured to provide best downstream passage conditions.

2.3.3 Pawtucket Dam Vertical Slot Fish Ladder

Upstream migrating fish enter the upper bypassed reach area where they are attracted to the vertical slot fish ladder entrance along the northern embankment of the Pawtucket Dam. Attraction water to the channel entrance weirs consists of approximately 30 cfs ladder flow and ~ 60 cfs flow through a floor diffuser. The total far-field attraction flow is up to 500 cfs when including supplemental attraction flow from the adjacent sluice gate (i.e. Gate #3; Figure 2-2).

2.3.4 Pawtucket Dam Upstream Eel Passage

As of 2019, the current plan is to use the vertical slot fish ladder for eel passage. Attraction flow requirements are described in Section 2.3.3.

2.4 Unit Prioritization

At present, Boott operates the E.L. Field Powerhouse in a balanced load across both units during the upstream fish passage season. For various mechanical or electrical reasons, it is

sometimes necessary to operate or prioritize a single unit. Currently there is no official priority given to unit sequencing associated with upstream fish passage.

Table 2–1. Lowell Hydroelectric Project Turbine Data[2], Lowell MA.

Powerhouse	Unit Number	Unit Type	Capacity (cfs)
Assets	1	Hercules Double Runner Styles C&D	376
Assets	2	Hercules Double Runner Styles C&D	376
Assets	3	Hercules Double Runner Styles C&D	376
Bridge Street	4	Hercules Type D Single Runner	333
Bridge Street	5	Hercules Type D Single Runner	333
Bridge Street	6	Hercules Type D Single Runner	333
Hamilton	1	Leffel Type Z Single Runner	374
Hamilton	2	Leffel Type Z Single Runner	279
Hamilton	3	Leffel Type Z Single Runner	237
Hamilton	4	Leffel Type Z Single Runner	374
Hamilton	5	Leffel Type Z Single Runner	374
John Street	3	Leffel Single Runner	250
John Street	4	Leffel Single Runner	250
John Street	5	Leffel Single Runner	250
John Street	6	Allis Chalmers Single Runner	1,000

2 Data reproduced from Table 4.3-1 in PAD

Figure 2–1. Major features of the Lowell Hydroelectric Project.

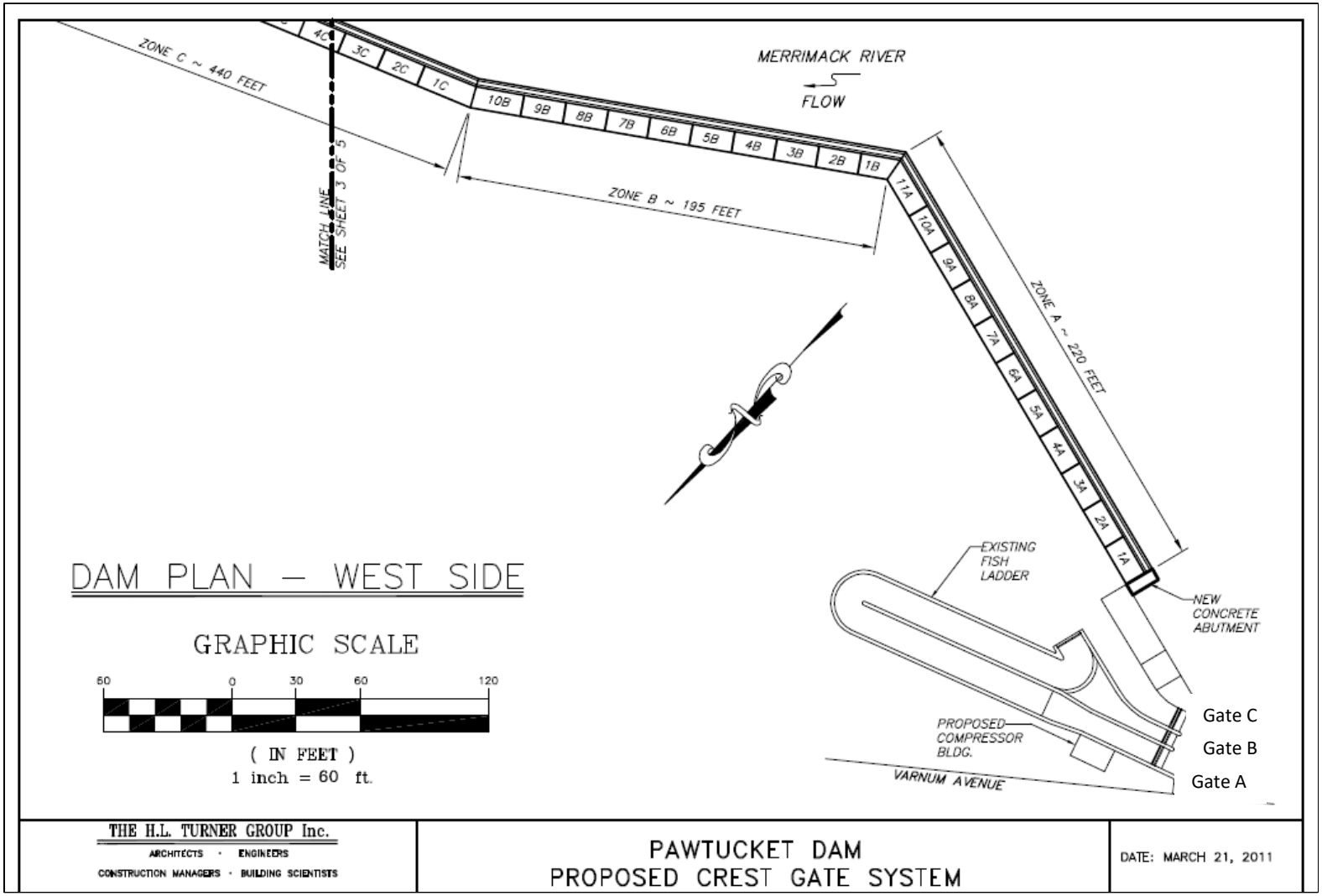


Figure 2–2. Pawtucket Dam fish ladder, through-water supply (gate A), supplemental attraction water gates (gates B and C), and zones A-C of crest gate system.

Figure 2–3. Photo of the six concrete flow control weirs located within the Project bypassed reach and downstream of the entrance to the Pawtucket Dam vertical slot fishway.

3 Fish Passage Training and Safety

3.1 Staffing

Staffing for the E.L. Field Powerhouse fish lift and ladder is provided by Boott. Seasonal employees under the supervision of the permanent Boott operations staff are hired and retained at Lowell for the duration of the fish passage season. Operations and maintenance of the Pawtucket Dam vertical slot fish ladder is performed by Boott operations staff.

3.2 Training

Each seasonal staff member hired by Boott receives the same general safety and operations training consistent with that provided to permanently hired Boott employees. In addition they receive site-specific training necessary to safely perform the duties required to operate the E.L. Field fish lift. Additional training, offered by USFWS, is available annually for Boott's seasonal staff provided the seasonal staff is under contract and are available to attend at the scheduled date and time.

3.3 Safety

Safety training for temporary staff is the responsibility of Boott. The following guidelines refer specifically to staff working on site and agency or other visitors at all Lowell fishways and should be used in conjunction with the training and rules applicable to all Enel sites.

3.3.1 On-site Safety and Personal Protective Equipment

- Hardhats: A Type I Class E is to be worn at all times on site by personnel (excluding in the counting room).
- Safety Glasses: Safety glasses meeting ANSI Z87.1 standard (or approved prescription glasses with side shields) will be worn at all times on site
- Clothing:
    - Long pants and long/short sleeve shirts are required, short pants and tank tops are not acceptable
    - ASTM F 2413 (or ANSI Z41) rated, I/C protective-toe, EH designated boots with a minimum 6-inch ankle height must be worn on site
- Hoists: All hoist operation is to be conducted by Boott operations staff only.
- All incidents are to be reported to Boott host immediately.
- Agency personnel are permitted in established work areas only and are required to have the appropriate clothing and PPE to be on-site.
- Initial site safety review to counting personnel will be provided, including work area review, site protocols and access, unusual conditions, personal protective equipment,

etc. Notify Boott host if any new personnel are to be brought onsite that have not received site safety review.

- A daily Job Hazard Analysis form discussing the daily work to be conducted and the potential hazards/safety measures that will be present is to be read and discussed by staff prior to initiating daily work.

3.3.2 Fish Rescue and Restricted Areas Access

- Restricted areas are considered to be any area other than working deck, counting room, hopper dump area, or control room. Restricted areas include, but are not limited to:
  - The dam toe
  - Retaining walls
  - Interior of fish ladder
  - Tailrace walls
- Access is limited to agency personnel pre-approved by Boott Project staff. Approval from on-site Project staff must be obtained for each access event.
- Personnel must be equipped with appropriate safety gear in addition to standard PPE if required for specific tasks or accessing certain areas. Additional safety items may include:
  - Life vest
  - Safety harness
- Spotters are required for all fish rescue and restricted area access as well as during the backing up of tank trucks on site.
- Established exclusion barriers will be clearly identified and must be respected at all times.

3.3.3 Scheduling and Communication

- Lift timing and duration requests beyond the 0800-1600 hour time frame are to be conveyed clearly to staff as soon as determined.
- Any items or plan modifications must be noted to Project staff as appropriate.

3.3.4 Volunteers or Visitors

- No photos or video footage without prior authorization from Boott.
- All visitors must be approved by Boott.
- Boott 'Release and Waiver' executed by ALL non-agency personnel prior to entering the property for any site activities.
- Boott 'Release and Waiver' execution rests entirely with volunteer/visitor
- Site access log (sign in/out) to be completed by all personnel.

- Visitor badge may be required of all visitors, obtained when completing the site access log and must be worn in a visible location at all times on-site.
- Failure to comply with indemnification, access log and badge requirements will result in ejection from the site, at the Project's discretion.
- All volunteers and other visitors may be subject to background checks.

3.3.5 Agency Personnel

- Verifiable agency ID may be requested of agency personnel.
- Responsibility for 'Release and Waiver' execution rests entirely with agency personnel.
- Site access log (sign in/out) to be completed by all agency personnel.
- Visitor badge may be required of all agency personnel, obtained when completing the site access log and must be worn at all times on-site.

4 Off-Season Maintenance

4.1 E.L. Field Powerhouse Fish Lift

4.1.1 Off-Season Maintenance

The off-season maintenance procedures for the fish lift at Lowell are designed to ensure that the fishway is operable and that equipment and fixtures in need of repair or replacement are completed prior to the fish passage season, preventing downtime of the passage system or inefficient/ineffective passage. Upstream fish passage maintenance procedures at the E.L Field fish lift described in this section have been developed based on methods used by Boott operations staff. Additional input incorporated from Agency inspections (USFWS annual inspections) and the documents 'Analysis of Fish Passage Facilities and Operation' (Gomez and Sullivan 2016) and 'Fish Passage Engineering Design Criteria' (USFWS 2017) have been used to modify and improve the efficiency and effectiveness of fish passage at the Project.

Generally, the fish lift is dewatered and visually inspected for damage and necessary repairs following each season's operation. Debris is removed and all critical components are serviced as necessary (e.g. grease/lube/clean/ inspect/test). At all locations where grating or brails are present, sections are visually inspected to ensure good condition and that all fasteners are intact and secure.

Common deficiencies to be inspected include, but are not limited to, concrete cracking and deterioration, surface defects, rust, displacement, deformation, leakage and seepage, erosion, insufficient drainage, overgrown vegetation, debris, sedimentation, and vandalism.

4.1.2 Off-Season Maintenance Procedures

Pre-season maintenance and preparation is also necessary to ensure the fish lift system's reliability. Inspection and maintenance prior to the fish passage season are recorded on an

inspection checklist (Appendix B) with notes added for areas requiring additional servicing or to confirm maintenance (e.g. part replacement). In addition to annual maintenance tasks listed here, Boott should address all items listed on any Agency provided inspection lists prior to the season. Listed deficiencies or items able to be completed post-season (typically fall) should be identified and addressed; as this timeframe is typically better than the immediate spring pre-season period for major work.

- Address all items listed on agency-provided inspection list
- Grease all gears and gearboxes (including hoist boxes).
- Test run all motors for entrance gates, crowder, fish hopper, separation gate, upper weir gate, repair as necessary.
- Have all hoists inspected by MA Crane and Hoist (or other reputable company). Follow any recommendations.
- De-water fish lift exit channel (upper fishway):
    - Remove debris from upper fishway.
    - 50 cfs slide gate: clean, lubricate, and check operational status.
    - 50 cfs intake grating: inspect grating to verify it is intact, fish cannot pass through any openings and that grating is firmly attached.
    - 150 cfs attraction water valve and valve chamber: Dewater and ensure sump pump is present/available for dewatering. Clean, operate and assess working condition of the 150 cfs valve and piping for use during fish passage season. Check that wooden diffusers are in place.
    - 150 cfs attraction water intake grating: inspect grating to verify it is intact, fish cannot pass through any openings and that grating is firmly attached.
    - Trapping station: install diversion grating as necessary to divert fish to window and prevent debris into hopper and lower fishway, ensure grating is properly secured for fish passage season and fish cannot pass through any gaps.
    - Exit gate: check gearing and lubrication, note equipment condition, test functionality.
    - Viewing window: clean both sides, note damage, and provide access to long handled cleaning brush.
    - Clean or replace viewing grid panel opposite counting room window.
    - Clean off fish trap brails opposite counting window.
    - Test the 3/4" drill (auxiliary for opening the exit, entrance and bypass gates), repair as necessary.
    - Counting room: clean and prep for fish passage season.

- Install surface trash boom at fish way exit and suspended grating to reduce fishway debris (SPRING ONLY).
- Check and clean supplemental water pump and piping, verify operation.
- Check condition and operation of flow meter

- De-water fish lift entrance channel (lower fishway; should occur AFTER work on upper channel):
  - Ensure dewatering pump is available and functioning, clear debris from lower fishway.
  - Inspect crowder rubber flaps for any tears, etc. and repair or replace as necessary. Ensure gaps between crowder and concrete wall do not exist
  - 50 cfs discharge grating: inspect grating to verify it is intact, fish cannot pass through any openings and that grating is firmly attached. Remove enough grating at exit of 50 cfs tube to allow for visual inspection or to remove any trapped debris.
  - 150 cfs discharge grating: Check fishway grating to ensure it is in good condition and securely fastened with hardware in good condition, check and secure blinding plates, check and secure diffuser grating.
  - Provide annual photographic documentation of attraction water chamber after cleaning and condition of flow diffusers for MTC review.
  - Inspect structural steel and fasteners, repair or replace as required.
  - Evaluate condition, clean, lubricate and run the fishway to ensure it operates properly prior to fish passage season. Assess and repair/replace crowder air lines. Correct any drag or binding of the crowder doors.
  - Inspect entrance gate seals. Tighten bolts as required.
  - Clean any debris in hopper shaft. Run hopper to full lowered position. Check that top of elevator is below concrete that crowder runs on.
  - Inspect plates, grating, and all other fixtures above diffusion chamber. Tighten or replace fasteners as necessary.
  - Lower separation gate to lower limit, check that gate is flush with concrete floor, adjust limit switch as necessary. Lubricate and ensure working.
  - Inspect mesh screening on separation gate (full depth). Repair or replace mesh screen as necessary to avoid gap sizes capable of gilling passing fish.
  - Place crowder in lifting position, adjust limit if clearance to the separation gate is greater than 8 inches (target clearance of $\leq$ 8 inches).
  - Inspect mesh screening on crowder (full depth). Repair or replace mesh screen as necessary to avoid gap sizes capable of gilling passing fish.

  - Inspect aluminum hopper rail, tighten or replace fasteners as needed. Inspect downstream passage stoplogs, replace as needed.
  - Ensure limit switches are working properly for downstream bypass gate such that leakage does not occur
  - Inspect fish hopper door seal in actual operation, repair or replace seal if necessary. Clean and paint fish hopper, check /replace door wheels and pins, test hoist, check compressor, lines, routing and attachment for hopper.
  - Check lower fishway flashboards: check integrity, anchoring and condition.

- Test the monorail and hoists used to raise/lower the stoplogs. Repair as necessary.
- Remove and store 4" x 6" stoplogs located just downstream of exit gate (SPRING ONLY).
- Differential gauging system: calibrate gauge and supply permanent electric power to box.
- Install and test video recording system at counting window (SPRING ONLY).
- Clear debris from upstream of gatehouse on Northern Canal.

4.1.3 Spare Parts List

Mechanical:

- Spare drive flange and keys for gate drives,
- 2 cam followers for crowder arms,
- Air hose,
- Grating,
- Mesh screening (3/4 inch, #9 expanded metal) for separation gate and crowder,
- Expanded metal and sheet rubber for crowder/hopper repairs,
- Hoist for converting upstream/downstream passage.

Electrical:

- Spare brake for elevator hoist motor,
- Control transformer for attraction gates,
- Two ¾ inch drills to operate gates,
- Limit switches,
- Control panel fuses,
- Contactors.

4.1.4 In-Season Operations & Maintenance

The following section describes the daily operational steps that are to occur at the E.L. Field Powerhouse fish lift. The General, Debris Management, and Fish Count sections are a daily occurrence while other steps (Crest Gate/Spill Protocol, Outage Protocols) are conducted as necessary (e.g. lift system or component outage, river flow exceeding station capacity).

4.1.5 Operational Procedures

Prior to the first fish lift of the day, the following items must be addressed:

- At 0600, the attraction water (50 cfs) is turned on, downstream fish bypass turned off.
- Confirm exit debris exclusion grating is in the water and functioning.
- Check tailwater elevation, 150 cfs flow should be on for the duration of the fish passage season.
- Adjust differential between tailrace and fishway water level at entrance to between 0.5 and 1.2 feet.
- Check (and adjust if necessary) 150 cfs attraction flow to achieve 4-6 fps velocity at entrance (should occur if AWS and differential are correct; Section 4.1.8).
- Check for and clear any debris that has accumulated overnight from all areas essential to fish passage (e.g. gates, grating, hopper etc.)

Unless otherwise arranged, the first lift of the day is scheduled for 0800. Lift operations will typically be performed hourly up until 1600. During the peak of the fish passage season, lift events may extend beyond 1600 up until conditions are no longer safe to do so (i.e., darkness). Daily duration and frequency of fish lifts at Lowell will be determined by the fishery agencies personnel responsible for counting fish and collecting data at Lawrence. Seasonal employees or Boott operations staff should collect the data necessary to complete the Lowell Fish Lift Daily Inspection Form (Appendix C-1) immediately prior to each lift.

Fish hopper cycling will occur using the following steps:

- Collect and record operational/environmental data onto Lowell Fish Lift Daily Inspection Form (Appendix C-1)
- Turn on hopper supplemental water pump
- Close crowder doors
- Drive crowder upstream
- Lower separation gate
- Begin hopper lift/return crowder to downstream position simultaneously
- Open crowder doors as soon as it is returned to downstream position

- Lift staff to estimate the number of fish (by species if possible) in lift
- When hopper reaches upper level of lift, disengage piston to dump hopper contents into upper fishway canal
- Shutdown make-up water pump and lower hopper to fishing position
- Engage piston to shut door
- Raise separation gate

Prior to the final lift of the day, all pertinent data should be collected, per date collection protocol. Following the last lift Boott will ensure:

- The 50 cfs attraction water valve is shut.
- Ensure exit channel is clear of fish
- The two wooden exit channel gates should be closed and the two downstream bypass gates opened (to allow for downstream passage during night hours).
- At present, the 150 cfs attraction flow remains on 24-hours a day. In the event that the 150 valve is replaced during future improvements, it may be possible to reduce flow during non-operational hours.
- Populate Lowell Log of Daily Inspection Form Data (Appendix C-2) using data collected throughout the day.

4.1.6 Debris Management

In addition to debris removal from the lift conducted prior to the start of the passage season, debris should be removed from the upper and lower lift structures and screens, the hopper, and any entrance or exit areas at the onset of each day and prior to the first lift. Any debris attached to grating (near the counting window, attraction water, etc.) should be removed before lifts are initiated.

Maintenance of the following structures will help prevent debris accrual within the lift:

- Ensure suspended grating upstream of exit gate is maintained at a proper height (extending above the water surface).

4.1.7 Fish Counts

In addition to count estimates recorded based on visual estimates from the hopper for each fish lift event, seasonal fish counts at the E.L. Field fish lift are recorded by SalmonSoft video software. Prior to the onset of the fish passage season, system components will be inspected to ensure working condition, installed and tested. Equipment and supplies necessary for installation of fish monitoring equipment include:

- Computer with enough processing power to continuously run Salmonsoft fish counting software for multiple months,

- Tripod or similar device for mounting camera,
- Digital video camera preferably with built-in infrared light,
- Dazzle Video Capture USB v1.0 digital video converter,
- External hard drive or USB flash drive with 64+ GB of space,
- Extension cords,
- Zip Ties,
- Electrical tape.

Installation of the video recording hardware will occur in the following order:

- Plug in UPS and ensure that the backup battery is charged or charging.
- Plug in (to UPS) and power on computer (pre-loaded with SalmonSoft software).
- Plug Dazzle digital video converter into USB port on computer.
    - Confirm that the blue light on the video converter illuminates.
- Plug in external memory device to a USB port on the computer.
- Open SalmonSoft "FishCap".
    - Click "Change Parameters".
    - Select "Dazzle" from "Capture Driver" drop down menu.
- Mount camera to desired mounting device and plug camera's power adapter into UPS.
- Plug camera's video cable into Dazzle video converter.
- If camera and video converter are plugged in and powered on properly, you should now see the live video feed in the open Salmonsoft window on the computer.
- Use the video feed as reference to adjust the camera so that the fish ladder window is adequately framed.
- Use zip ties and/or electrical tape to solidify pieces of the installation to prevent equipment from becoming unplugged or moved between system checks.
- Navigate through the parameters menu to input the prescribed settings for the project, and to select the desired saving location.

Prior to the start of each lift day, the counting system will be maintained by:

- Cleaning the waterside window to ensure optimal viewing of fish as they pass counting room.
- Check angle and view of camera on screen to ensure it is optimally covering the viewing window and has not be moved or altered to a non-optimal position.
- Check and verify that the video system (SalmonSoft) is actively working, recording and has enough drive space available to continue operating throughout the passage day.

Detailed instruction on how to check and verify that the video counting system is on and working are presented in Appendix D.

4.1.8 Attraction Flow and Entrance Differential Adjustment Procedures

Attraction flow for the E.L. Field fish lift consists of 50 cfs and 150 cfs flow. The smaller 50 cfs flow control is a stem driven gate whereas the 150 cfs flow control is a butterfly valve. As the mechanisms are opened, attraction water is conveyed via piping into the lower fishway, over its

entrance weir gate and into the tailrace. Target settings for the attraction water system and entrance gate were developed in consultation with the Technical Committee to achieve and entrance jet velocity of 4 to 6 fps resulting from a water surface differential across the entrance of 0.5 to 1.2 ft (Table 4-1).

Normandeau (2016) collected depth and velocity information to calculate the attraction water discharge under a range of entrance weir crest and valve settings for the 50 and 150 cfs flows. Measured discharge values in addition to calculated values based on use of the sharp-crested weir formula are provided in Appendix E. The following section describes the steps necessary to adjust the attraction flow and entrance differential located at the E.L. Field Fish Lift.

50 cfs Attraction Flow

The 50 cfs attraction flow originates at the downstream end of the exit trough and is operated by a slide gate at the entrance of the 24-inch diameter pipe. This circulation water is discharged to a diffusion chamber located just upstream of the hopper pit and flows through the crowder channel to the entrance gate. During typical lift operations, this gate is opened 2 hours prior to the first daily lift and remains open until after the final lift of the day.

- Controls for the 50 cfs gate are located along the walkway near where the hopper empties into the upper fishway.
- Facing the controls, turn Slide Gate hand wheel clockwise
- Set the Gate Stem to maximum open setting
- Stop turning Slide Gate hand wheel

150 cfs Attraction Flow

The 150 cfs attraction flow draws water from intake grating located immediately upstream of the counting room. The attraction water pipe is 3-feet in diameter, expanding to 4-feet prior to discharge into the floor diffuser chamber.

- The valve operating the 150 cfs attraction flow is located below the counting room at the E.L. Field fish lift.
- Turning the valve to the left increases the amount of water allowed through the pipe while turning it to the right decreases the amount.
- As shown in Appendix E, discharge can be estimated based on the valve setting (% open), although values are valid only for similar tailwater levels, which can vary by several feet through the season.
- Currently, this valve is opened at the beginning of the fish passage season and remains on until lifting is discontinued in mid-July.

Weir Gate Adjustment

An adjustable weir gate is located at the entrance of the fish lift and is designed to provide a differential of 0.5-1.2 feet between the fish lift entrance and the tail water.

Controls for adjusting the weir gate are located at the back corner of the downstream side of the powerhouse on the landing above the fishway entrance gate.

- Pushbuttons are utilized to raise and lower the gate to maintain the correct differential at the fishway entrance, based on USFWS operational protocol.
- After attraction water (50 cfs) is turned on and flow has stabilized adjust weir to between 0.5 and 1.2 feet.

4.2 E.L. Field Powerhouse Downstream Bypass

4.2.1 Off-Season Maintenance

Off-season maintenance and preparation is also necessary to ensure the downstream bypass is operable and reliable during the entire passage period. Inspection and maintenance prior to the fish passage season of the fish lift and bypass are recorded on an inspection checklist (Appendix B) with notes added for areas requiring additional servicing or to confirm maintenance (e.g. part replacement). In addition to annual maintenance tasks listed here, Boott should address all items listed on any Agency provided inspection lists prior to the season. Listed deficiencies or items able to be completed post-season (typically fall) should be identified and addressed; as this timeframe is typically better than the immediate spring pre-season period for major work. The following bullet points are specific to off season maintenance for the downstream bypass.

- Address all items listed on agency-provided inspection list
- Grease all gears and gearboxes (including hoist boxes).
- Test run all motors, repair as necessary.
- Have all hoists inspected by MA Crane and Hoist (or other reputable company). Follow any recommendations.
- Inspect downstream passage stop logs, replace as necessary.
- Clear downstream bypass plunge pool and exit channel of debris.
- Test, adjust and repair all limit switches

4.2.2 In-Season Operations & Maintenance

4.2.3 Operational Procedures

As described in Section 2.2.2, the downstream bypass facility is operated from April 1 through July 15 during hours when the fish lift is not operating. The fish bypass is operated on a 24-hour basis from September 1 through November 15. Steps to operate the downstream bypass are as follows:

- After the final lift of the day, Boott staff will ensure exit channel is clear of fish
- The two wooden exit channel gates are closed and the two downstream bypass gates opened (to allow for downstream passage during night hours).
- At 0600, the attraction water (50 cfs) is turned on and the downstream fish bypass turned off (i.e., close the two downstream bypass gates and open the two wooden exit channel gates.

The downstream bypass is controlled by a mechanized weir gate and has a target flow of 2% station flow. Boott operations staff are the only qualified personnel to operate/adjust the downstream passage weir gate.

- The controls for the weir gate are located on the motor that operates the gate.
- After identifying station flow, the weir gate is adjusted according to a chart developed by the MTC and Enel.
- Referencing the chart (with calculations to set gate positon)
- Operate the toggle switch (on front of motor) to operate the motor to move the gate
- If the chart refers to the gate to be in a higher position, move gate to new position
- If the chart refers to the gate to be in a lower position, lower the gate to the new position.

4.2.4 Debris Management

See Section 4.1.6.

4.3 Pawtucket Dam Vertical Slot Fish Ladder

4.3.1 Off-Season Maintenance

The off-season maintenance procedures for the vertical slot ladder (including downstream weirs) at Lowell are designed to ensure that it is operable and that equipment and fixtures in need of repair or replacement are completed prior to the fish passage season, preventing downtime of the passage system or inefficient/ineffective passage. Upstream fish passage maintenance procedures at the Pawtucket Dam vertical slot fish ladder described in this section

have been developed based on methods used by Boott operations staff. Additional input incorporated from Agency inspections (USFWS annual inspections) and the documents 'Analysis of Fish Passage Facilities and Operation' (Gomez and Sullivan 2016) and 'Fish Passage Engineering Design Criteria' (USFWS 2017) have been used to modify and improve the efficiency and effectiveness of fish passage at the Project.

Generally, the ladder is dewatered and visually inspected for damage and necessary repairs following each season's operation. Debris is removed and all critical components are serviced as necessary (e.g. grease/lube/clean/ inspect/test). At all locations within Project fishways where grating or brails are present, sections should be visually inspected to ensure good condition and that all fasteners are intact and secure.

Common deficiencies to be inspected include, but are not limited to, concrete cracking and deterioration, surface defects, rust, displacement, deformation, leakage and seepage, erosion, insufficient drainage, overgrown vegetation, debris, sedimentation, and vandalism.

4.3.2 Off-Season Maintenance Procedures

Any items able to be completed post-season (typically fall) should be identified and addressed; as this timeframe is typically better than the immediate spring pre-season period for major work. Pre-season maintenance and preparation is also necessary to ensure lift and ladder system's reliability. Inspection and maintenance prior to the fish passage season are recorded on an inspection checklist (Appendix B) with notes added for areas requiring additional servicing or to confirm maintenance (e.g. part replacement). In addition to annual maintenance tasks listed here, Boott should address all items listed on any Agency provided inspection lists prior to the season.

The following off-season procedures are necessary to maintain the Pawtucket Dam vertical slot fish ladder in working condition.

- Address all items listed on agency-provided inspection list.
    - Boott will configure ladder baffles (removable slot plates) prior to the passage season as specified in consultation with the Merrimack River Technical Committee.
- Dewater ladder: check, adjust and replace baffles as necessary, remove debris from ladder, assess state, and store ladder entrance stoplogs on site (enough for 2 entrance bays, 6' dewater capability).
- Dewater diffusion chamber: Remove all debris, check/ensure diffuser baffles are in good condition, check and secure diffuser screen grating with appropriate hardware.
- Provide Tech Committee with photographic evidence of completed maintenance (e.g. ladder, diffusion chambers, baffles, gages, weir repairs and condition, etc.)
- Remove all debris from the ladder floor.

- Grease all gears and gear boxes. Visually inspect drive chains for wear, replace as necessary.
- Replace any missing or damaged baffles and install.
- Remove any debris from ladder floor; check and rake debris screens.
- Pump out counting station if necessary.
- Clean and prepare counting room and clean counting house window. Remove grate to clean outside, then re-install to prevent vandalism.
- Clean or replace reflector panel.
- Check flow diffusers at ladder entrance, replace any that are missing.
- Check fasteners on log boom and replace as necessary.
- Clean off crowder brailles opposite counting window.
- Clean, repair, and/or replace the staff gages at the fish ladder entrance channel, tailwater and exit channel.
- Inspect diffusion chamber between dam and the entrance turning pool and clean out debris as necessary.
- Clear debris below fishway.
- Gate drill: Ensure availability and function of drill, provide cords, flange and key.
- Check upstream gates: Assess condition, lubricate, and operate to ensure function.
- Trapping station (opposite window): Check, clean grating and ensure it is fastened with hardware in good condition.
- Inspect downstream weirs for missing stoplogs. Inspect for loose or missing fasteners, configure per USFWS specifications (Appendix F).

4.3.3 Spare Parts List

Spare Parts to be held on hand for the fish ladder during fish passage season include:

- 4x4 timbers for differential management
- ¾ inch drill for gate control
- Pick poles/rakes for debris removal
- Long handled brush for window cleaning
- Rope
- Extension cords and GFCI (where necessary)
- Life jacket kept in compressor building
- Baffle (weir slot) plates

The checklist attached in Appendix B is to be used as an annual reference and confirmation of inspection/maintenance completion for Boott operators at both the Lowell fish lift and ladder.

4.3.4 In-Season Operations & Maintenance

4.3.5 Operational Procedures

The vertical slot fish ladder runs for the entirety of the fish passage season and does not require all of the daily maintenance and start up associated with the fish lift. However, it does require daily checks and maintenance from Boott operations staff. The checklist form in Appendix C-3 is used as a reference for daily inspection of the fish ladder during the upstream passage season at Lowell. The following list of items should be performed on a daily basis at the ladder:

- Record crest gate settings, river flow, ladder differentials, and gate settings.
- Confirm differentials and gate settings are appropriate (see Section 4.3.8).
- Remove debris from trash rack gate, log boom, and in ladder.
- Clean viewing window and clear any debris on grating at counting station
- Complete visual inspection of the entrance channel, directly above the floor diffuser, for excessive turbulence and entrained air; adjust Gate B flow as necessary
- Implement any additional repairs, configurations, or adjustments as indicated by annual fishway inspection by Technical Committee.

4.3.6 Debris Management

In addition to debris removal from the ladder conducted prior to the start of the passage season, debris should be removed from the ladder pools, from any grating inside the ladder, the log debris exclusion boom and the trash rack gate on a daily basis.

Maintenance of the following structures will help prevent debris accrual within the ladder:

- Ensure trash rack system upstream of exit gate is maintained at a proper height (extending above the water surface).
- Ensure log boom is in place, and is effectively preventing debris from entering by a surface boom and subsurface skirt combination.

4.3.7 Fish Counts

Seasonal fish counts at the Pawtucket Dam vertical slot fish ladder are also recorded by SalmonSoft video software. Prior to the onset of the fish passage season, system components will be inspected to ensure working condition, installed and tested. Equipment and supplies necessary for installation of fish monitoring equipment include:

- Computer with enough processing power to continuously run Salmonsoft fish counting software for multiple months,

- Tripod or similar device for mounting camera,
- Digital video camera preferably with built-in infrared light,
- Dazzle Video Capture USB v1.0 digital video converter,
- External hard drive or USB flash drive with 64+ GB of space,
- Extension cords,
- Zip Ties,
- Electrical tape.

Installation of the video recording hardware will occur in the following order:

- Plug in UPS and ensure that the backup battery is charged or charging.
- Plug in (to UPS) and power on computer (pre-loaded with SalmonSoft software).
- Plug Dazzle digital video converter into USB port on computer.
    - Confirm that the blue light on the video converter illuminates.
- Plug in external memory device to a USB port on the computer.
- Open SalmonSoft "FishCap".
    - Click "Change Parameters".
    - Select "Dazzle" from "Capture Driver" drop down menu.
- Mount camera to desired mounting device and plug camera's power adapter into UPS.
- Plug camera's video cable into Dazzle video converter.
- If camera and video converter are plugged in and powered on properly, you should now see the live video feed in the open Salmonsoft window on the computer.
- Use the video feed as reference to adjust the camera so that the fish ladder window is adequately framed.
- Use zip ties and/or electrical tape to solidify pieces of the installation to prevent equipment from becoming unplugged or moved between system checks.
- Navigate through the parameters menu to input the prescribed settings for the project, and to select the desired saving location.

Prior to the start of each lift day, the counting system will be maintained by:

- Cleaning the window and board to ensure optimal viewing of fish as they passing counting room.
- Check angle and view of camera on screen to ensure it is optimally covering the viewing window and has not be moved or altered to a non-optimal position.
- Check and verify that the video system (SalmonSoft) is actively working, recording and has enough drive space available to continue operating throughout the passage day.

Detailed instruction on how to check and verify that the video counting system is on and working are presented in Appendix D.

4.3.8 Attraction Flow and Entrance Differential Adjustment Procedures

Fish ladder and attraction flow are provided through the three gates as shown in Figure 2-2. Attraction water to the channel entrance weirs consists of approximately 30 cfs from the ladder operating flow (Gate A in Figure 2-2) and additional flow through a floor diffuser (Gate B in

Figure 2-2). Currently, flow through the floor diffuser is adjusted to ~ 60 cfs. The total flow associated with the vertical slot fish ladder is up to 500 cfs when including supplemental attraction flow from the adjacent sluice gate (i.e. Gate C; Figure 2-2).

Current operational policy of the ladder entrance gate (A) is to open it fully, supplying ~30 cfs for fish passage. Operations for Gate B and C are dependent on headpond and tailwater elevations as well as debris loading. The means of providing the desired flows through these gates are achieved through the use of the submerged gate opening formula:

$Q=C*A\sqrt{2*g*H}$

Where:

Q = flow (cfs)

C = contraction coefficient (0.6-0.7)

A = Area of the opening or hole (sq. ft)

g = acceleration due to gravity (32.2 ft/s^2)

H =
head, H (in feet) is measured from the headpond water surface to the center of the opening

Based on this formula, table 4-2 shows calculated flows, compared with design flow, through the B and C gates when open 2 feet for headpond elevations ranging from 91.5-93.2 ft. Current operation of Gate B since approximately 2016, per USFWS recommendation, is to open the gate 6-8 inches to provide the 60 cfs of attraction water through the floor diffuser.

4.4 Pawtucket Dam Upstream Eel Passage

4.4.1 Off-Season Maintenance

Described above in Section 4.3.1, 4.3.2.

4.4.2 In-Season Operations & Maintenance

The existing fish ladder at the north end of the Pawtucket Dam is a dual vertical slot fishway used for anadromous fish passage from May 1 through July 15 annually. The ladder operates with a through-flow of ~30 cfs and is positioned adjacent to two attraction water supply gates, both typically closed after July 15th or the end of the upstream fish passage season.

4.4.3 Operational Procedures

Described above in Section 4.3.5.

4.4.4 Debris Management

Described above in Section 4.3.6.

4.4.5 Attraction Flow and Entrance Differential Adjustment Procedures

Described above in Section 4.3.8.

Table 4–1. Recommended weir gate setting (ft) and target attraction flow setting (cfs) values at ELF lift, recommended by USFWS to achieve a target differential of 0.5-1.2 ft and entrance velocity of 4-6 fps based on tailwater elevation (ft).

TARGET AWS (cfs)	Tailwater Elevation (ft)	Recommended Gate Setting (ft above entrance invert)	Estimated Differential (ft)	Estimated Entrance Velocity (fps)
80	52	1	0.7	5.9
80	52.25	1.3	0.8	5.9
90	52.5	1.3	0.8	6.0
90	52.75	1.5	0.8	5.9
100	53	1.5	0.8	6.0
100	53.25	1.7	0.8	5.9
110	53.5	1.7	0.8	6.0
110	53.75	1.9	0.8	5.9
120	54	1.9	0.8	6.0
120	54.25	2	0.8	6.0
130	54.5	2	0.8	6.0
130	54.75	2.2	0.8	6.0
130	55	2.2	0.7	5.8
140	55.25	2.4	0.8	6.0
140	55.5	2.4	0.7	5.8
150	55.75	2.6	0.8	6.0

Table 4–2. Calculated flow (cfs) through the Pawtucket Dam attraction water gates (B and C) based on the submerged gate opening formula.

Gate B

Headpond Elevation (ft)	Gate Open Height (ft)	Open Height at Center (ft)	Gate Width (ft)	Calculated Flow (cfs)	Design Flow (cfs)
93.2	2	8.2	6	193	170
92.2	2	7.2	6	180	170
92.2	0.5	7.95	6	47	60
91.5	2	6.5	6	171	170

Gate C

Headpond Elevation (ft)	Gate Open Height (ft)	Open Height at Center (ft)	Gate Width (ft)	Calculated Flow (cfs)	Design Flow (cfs)
93.2	2	8.2	10	321	300
92.2	2	7.2	10	301	300
91.5	2	6.5	10	286	300

5 Outage Protocols

In the event that environmental conditions (e.g. flows in excess of 25,000 cfs) or mechanical factors (e.g. broken hoist) result in a complete or partial passage outage at either the fish ladder or the fish lift, the following protocols will be initiated:

- The E.L. Field Lowell Project supervisor(s) will be alerted as to the outage and provided with the time of shut down.
    - Lowell Site Supervisor
    - Regional Manager
    - Enel passage compliance specialist
- Boott operations staff or, if necessary, third party contractors will be contacted to assess the problem and establish the safest and most efficient way to repair and return the damaged lift/ladder to operation.
- The Merrimack River Technical Committee will be alerted about the outage (date/time), the problem (if known), and the proposed means of repair and estimate of time until returning to operations (if possible).
    - Massachusetts Division of Fisheries & Wildlife representative;
    - USFWS-designated representative
- While it is understood that Boott will maintain a standing stock of materials necessary to perform basic repairs and part replacements, it may be necessary to order some parts.
- Off-season inspections of the ladder and lift are intended to prevent any major equipment malfunctions from occurring during the fish passage season.

6 Crest Gate Operations

A pneumatic crest gate system is installed on the Pawtucket Dam in five independently-controllable zones (numbered sequentially from 1 (closest to fish ladder) to 5 (closest to headgates). The crest gate system is designed for one foot of overtopping in the raised position, and can be operated in both a fully raised and a partially raised position for extended periods of overtopping without experiencing significant oscillation, adverse flow conditions, or wear. The crest gate control 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 is maintained at full elevation and the E.L. Field control system adjusts the main units' output to match inflow and maintain the impoundment water level at the normal, authorized pond elevation (92.2 ft NGVD) at the crest gate crest. When inflows begin to exceed the capacity of the available units, the crest gate control system automatically adjusts the gates to maintain the impoundment elevation no higher than El. 93.2 ft NGVD, or one foot above the normal pond elevation. When under automatic control the crest gates are fully lowered at spillway flows of approximately 47,500 cfs and above, and the headpond level will rise above El. 93.2 ft following the spillway rating curve. The five crest gate zones are

independently controllable, allowing zones to be prioritized in the pond level control scheme. Specific zones could be prioritized in the control system to deflate first when Merrimack River flows are less than ±23,000 cfs (est), in order to provide supplemental attraction flow toward the fish ladder entrance (Table 6-1). In December 2018, Boott personnel and members of the Technical Committee observed flows passed through each one of the five crest gate sections to identify a preferred operating method for use during the fish passage season. The demonstration flows indicated that having excess spill flow routed through zone 5 (i.e., the section of crest gate closest to the headgates) resulted in the least amount of additional flow over the ladder approach weirs in the upper bypassed reach. Therefore, spill through zone 5 should occur preferentially during upstream passage season, so that the weirs' hydraulic capacity is not overwhelmed.

If additional spill release is necessary, the December 2018 test showed that crest gate zones 4-3-2-1 should be lowered in sequence to least affect upstream ladder passage.

Table 6–1. The crest gate status, target headpond level (ft NGVD), and unit operation at approximate spillway flows at Pawtucket Dam, Lowell MA.

Approximate Spillway Flow (cfs)[2]	Crest Gate Status	Target Pond Level (ft NGVD)	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 output available
3,250 - ± 23,000 (est.)	Automatic pond level control	± 93.2 ft	Full output available
± 23,000 (est.) – 35,000[3]	Automatic pond level control if High Water Operations Protocol is not triggered	± 93.2 ft	Full output available
	Fully lowered if High Water Operations Protocol is triggered	Pond level follows spillway rating curve based on spillway flow	Full output available
>35,000	Fully Lowered	Rises above 93.2 ft as spillway discharge increases.	Full output available

1 - Table reproduced from letter to FERC 'Lowell Hydroelectric Project (FERC No. 2790-060); Amended Crest Gate System Operation Plan. July 30, 2014'.

2 - Flow over the spillway is the inflow to the headpond less 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 and the canal system is approximately 10,000 cfs, but may be restricted by unit availability, debris accumulation at the Northern Canal Gatehouse, high tailwater conditions, and other factors.

3 - 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 USGS gage # 0100000 minus the flow at the Concord River (USGS # 01099500) and less any flow released through Boott turbines and the downtown canal system.

7 Reporting Requirements

7.1 Fish Passage Reporting

Boott will provide a weekly summary of fish counts and fishway conditions to the Merrimack River Technical Committee. Weekly counts will be based on the visual estimates of passage numbers made at the E.L. Field Powerhouse fish lift and incorporated into a spreadsheet developed in consultation with USFWS. Seasonal SalmonSoft counts for passage at the lift and fish ladder will be provided by Boott after the completion of the passage season.

Boott will host a minimum of two annual meetings with the Merrimack River Technical Committee:

- Fall Season: review recently completed fish passage activities and develop scope of monitoring and evaluations for next season.
- Spring Season: review details and expectations for the upcoming passage season.

In addition, Boott will accommodate the annual fishway inspections conducted by the Merrimack River Technical Committee and consider recommendations made as part of that process.

7.2 Eel Passage Reporting

Boott will provide a weekly summary of eel counts, size class distribution, and eel ladder conditions to the Merrimack River Technical Committee. Weekly counts will be based on the visual estimates of passage numbers made and recorded by Boott staff. Seasonal passage counts at each ladder will be provided by Boott after the completion of the passage season.

Boott will host a minimum of two annual meetings with the Merrimack River Technical Committee:

- Fall Season: review recently completed fish passage/eel passage activities and develop scope of monitoring and evaluations for next season.
- Spring Season: review details and expectations for the upcoming fish and eel passage season.

In addition, Boott will accommodate the annual fishway inspections conducted by the Merrimack River Technical Committee and consider recommendations made as part of that process.

8 Literature Cited

Gomez and Sullivan 2016. Analysis of upstream fish passage facilities and operation; Boott Hydroelectric Project (FERC # P-2790-MA). Prepared for ENEL Green Power, North America. Prepared by Gomez and Sullivan Engineers, D.P.C. March, 2016.

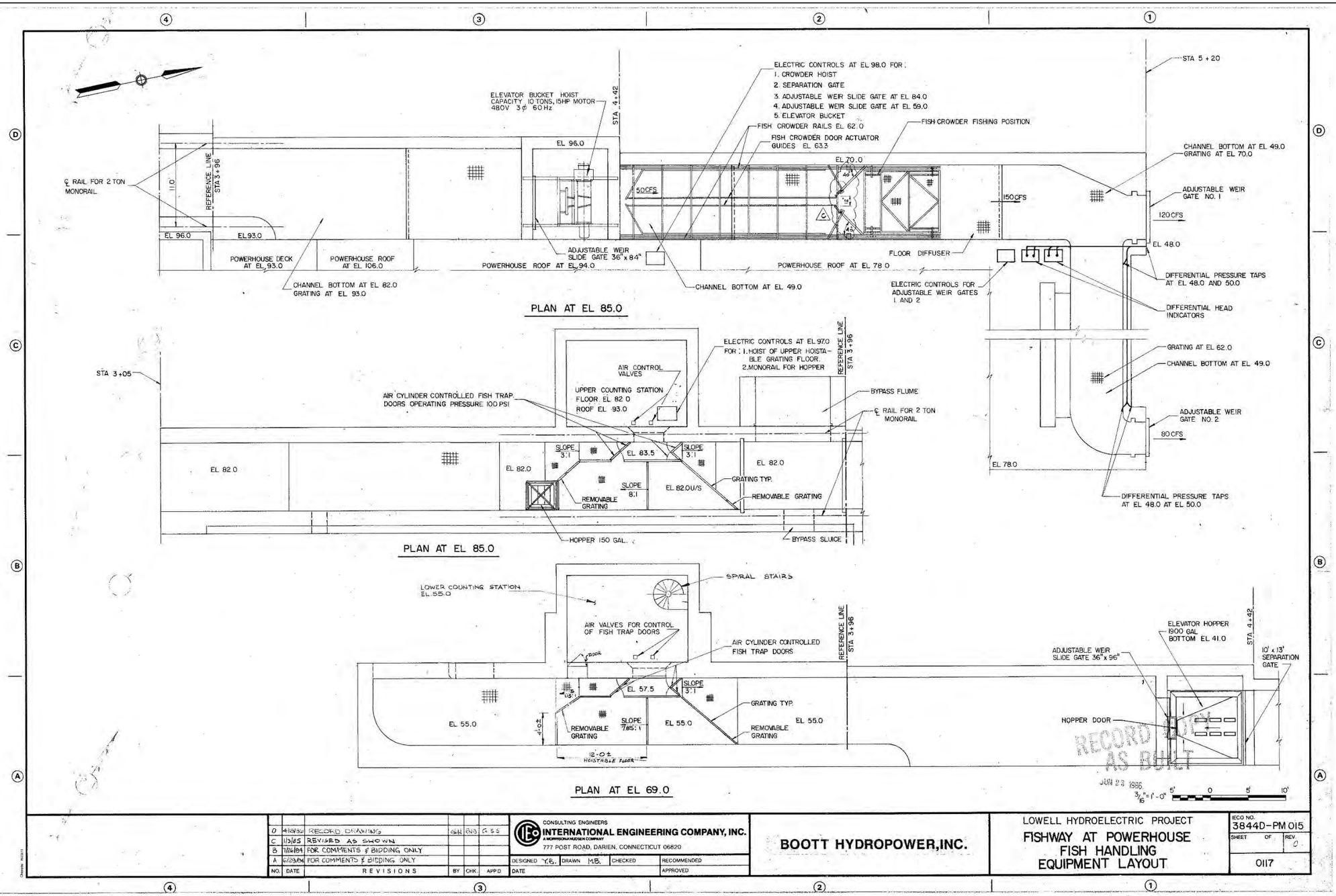
Normandeau (Normandeau Associates, Inc.) 1997. Lowell Hydroelectric Project Internal Fish Lift Efficiency Monitoring Program, Spring 1996. Report prepared for Consolidated Hydro Inc.

USFWS (U.S. Fish and Wildlife Service). 2017. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.

9 Appendices

Appendix A

A-1



NO.	DATE	REVISIONS	BY	CHK	APPD
0	4/16/86	RECORD DRAWING	GH	GNS	G.S.S.
C	1/13/85	REVISED AS SHOWN			
B	11/26/84	FOR COMMENTS & BIDDING ONLY			
A	6/29/84	FOR COMMENTS & BIDDING ONLY			

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
777 POST ROAD, DARIEN, CONNECTICUT 06820

DESIGNED Y.B. DRAWN M.B. CHECKED RECOMMENDED
DATE APPROVED

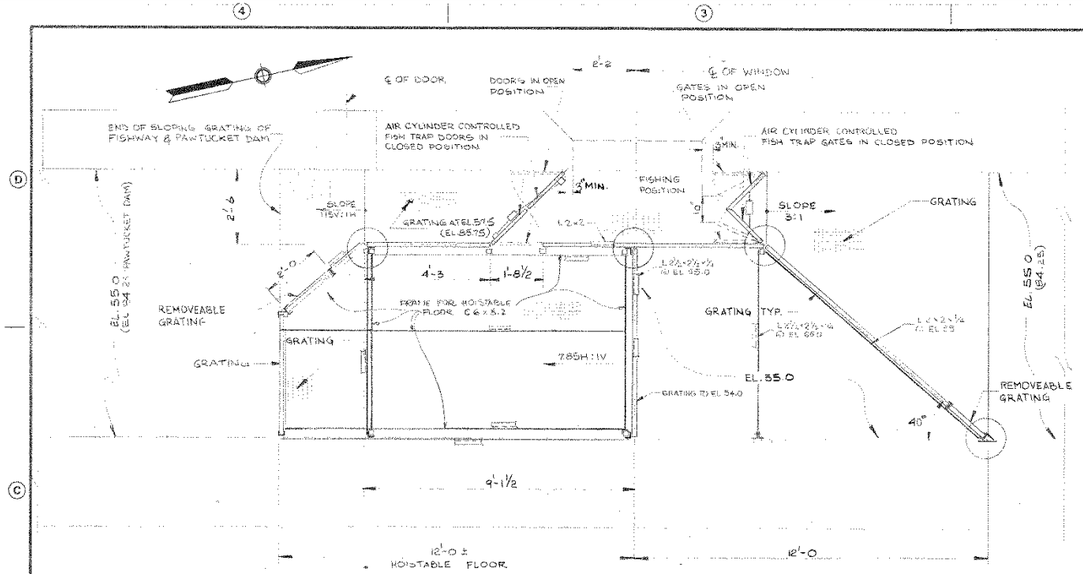
BOOTT HYDROPOWER, INC.

LOWELL HYDROELECTRIC PROJECT
FISHWAY AT POWERHOUSE
FISH HANDLING
EQUIPMENT LAYOUT

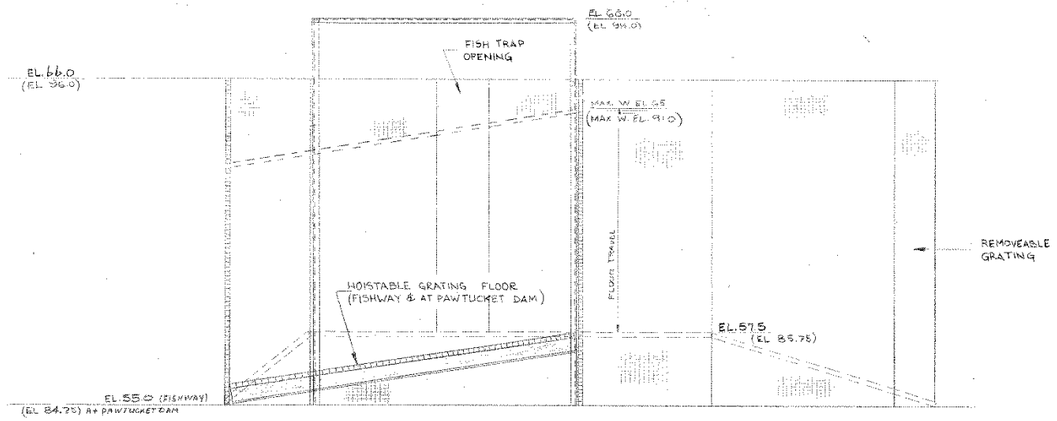
IECO NO. 3844D-PM 015
SHEET 0117 OF REV. 0

2212

A-2



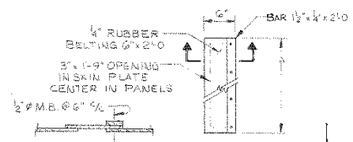
LOWER LEVEL FISH TRAP
PLAN
½" = 1'-0
(FISH TRAP AT PAWTUCKET DAM)



PROFILE
½" = 1'-0

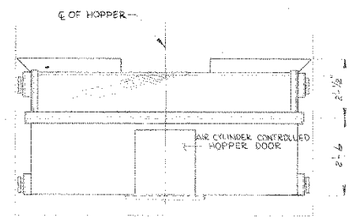
NOTES:

1. FOR DETAILS OF FISH TRAP CONNECTIONS, SUPPORTS, AND MEMBER SIZES, SEE DRAWING NO. 3844D-PM016.
2. FISH TRAP AT FISH LADDER NEAR THE PAWTUCKET DAM IS SIMILAR TO LOWER LEVEL FISH TRAP.
3. ELEVATIONS IN BRACKETS REFER TO FISH TRAP AT DAM.

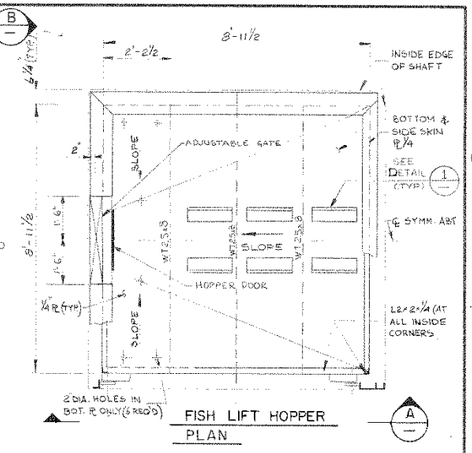


SECTION PLAN

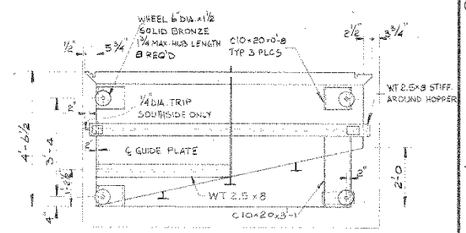
DETAIL 1 (TYP)



ELEVATION B

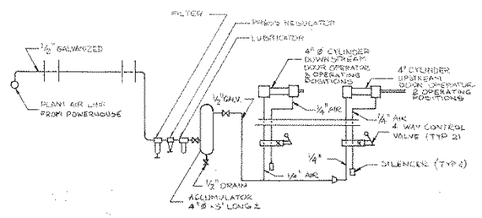


FISH LIFT HOPPER
PLAN



ELEVATION A

FISH LIFT HOPPER
N.T.S



PNEUMATIC FLOW DIAGRAM
FISH TRAP DOOR OPERATOR
(TYP)

NOTE:
SEE KENNEY/HOWE SHOP DRAWINGS FOR CORRECT DETAILS

NO.	DATE	REVISIONS	BY	CHK	APP'D
D	5/1/86	RECORD DRAWING	RNB	RNB	GEG
C	10/25/84	AS SHOWN			
B	7/26/84	FOR COMMENTS AND BIDDING ONLY			
A	6/29/84	FOR COMMENTS AND BIDDING ONLY			

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
777 POST ROAD, DARIEN, CONNECTICUT 06820

DESIGNED | DRAWN M.J.Foran | CHECKED | RECOMMENDED
DATE | APPROVED

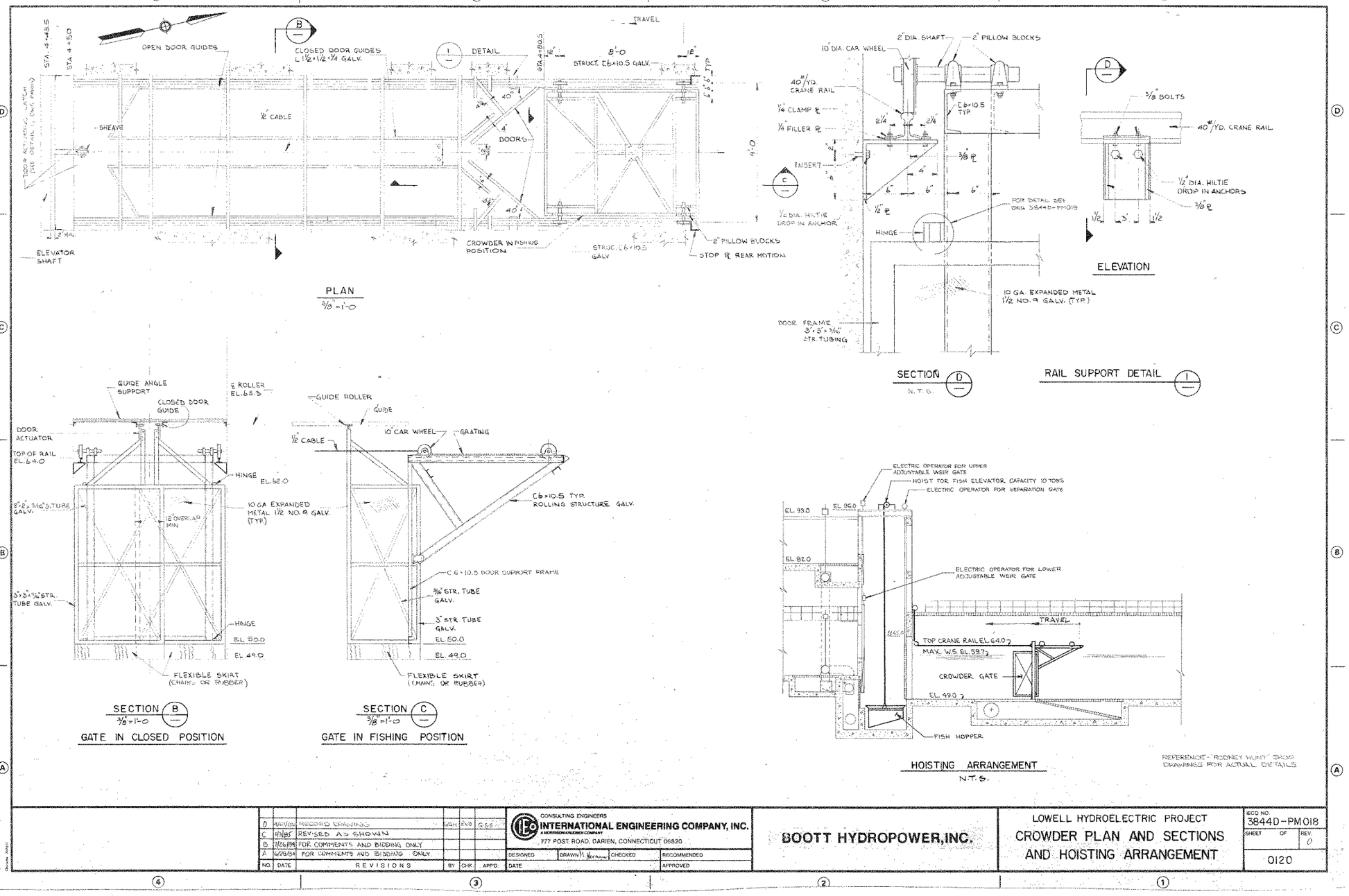
BOOTT HYDROPOWER, INC.

LOWELL HYDROELECTRIC PROJECT
FISHWAY AT POWERHOUSE
LOWER FLUME TRAPPING AREA
AND FISH LIFT HOPPER

ECO NO. 3844D-PM017
SHEETS OF | REV. 0
0119

1825

A-3



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C	11/1/85	REVISED AS SHOWN			
B	7/26/84	FOR COMMENTS AND BIDDING ONLY			
A	6/29/84	FOR COMMENTS AND BIDDING ONLY			

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
777 POST ROAD, DARIEN, CONNECTICUT 06820

DESIGNED	DRAWN	CHECKED	RECOMMENDED
DATE			APPROVED

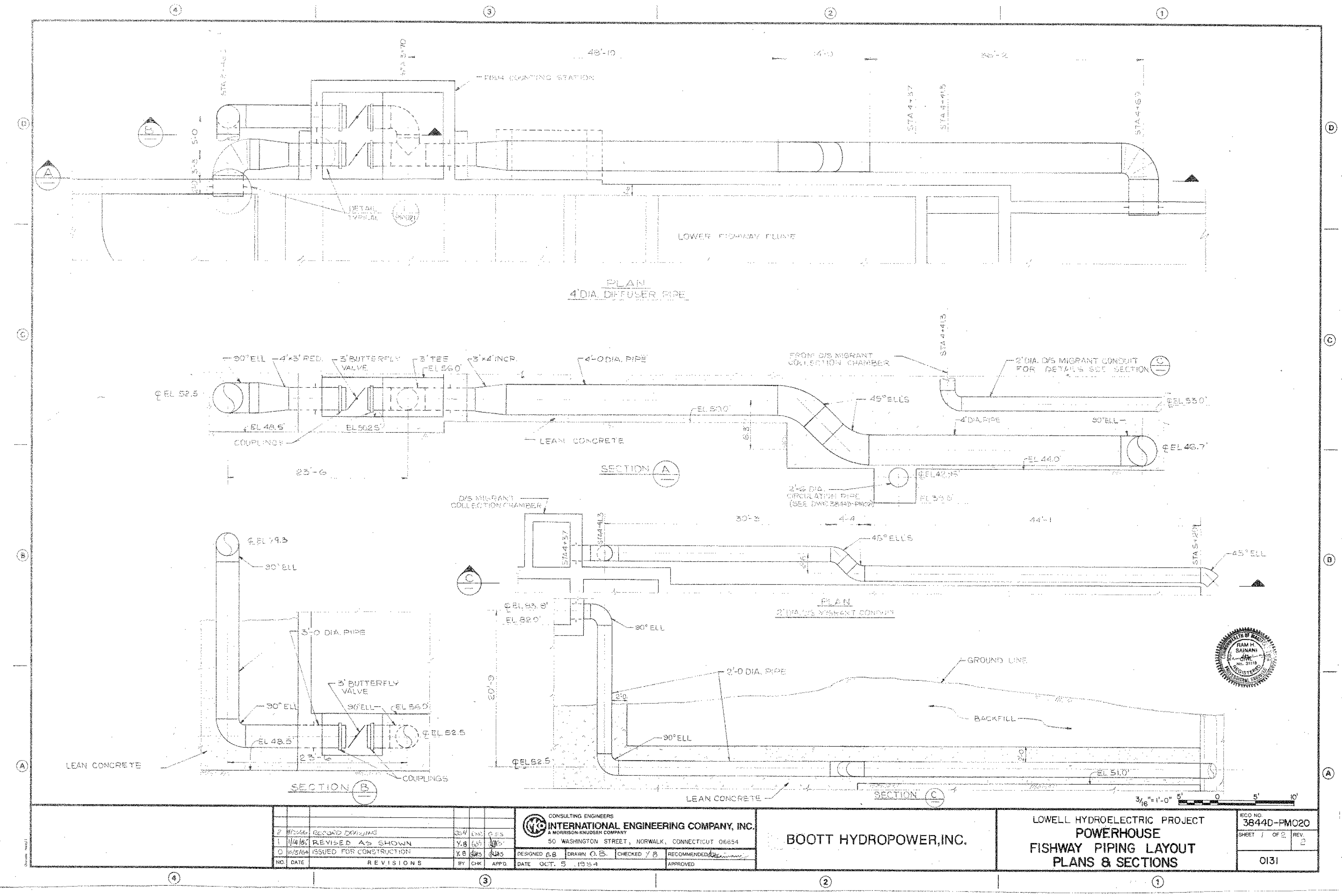
BOOTT HYDROPOWER, INC.

LOWELL HYDROELECTRIC PROJECT
CROWDER PLAN AND SECTIONS AND HOISTING ARRANGEMENT

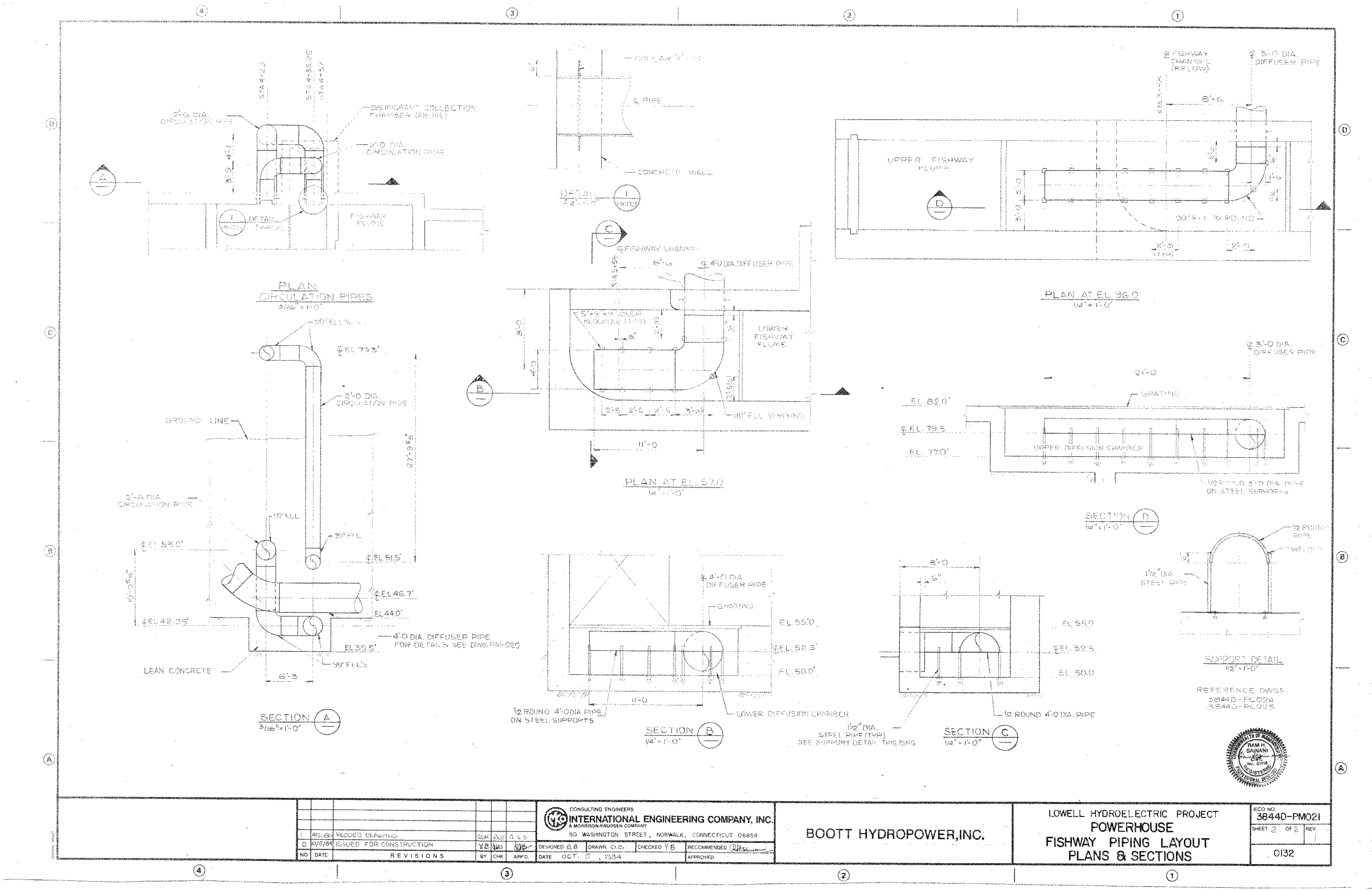
IECO NO. 3844D-PM018
SHEET 0120 OF REV. 0

1826

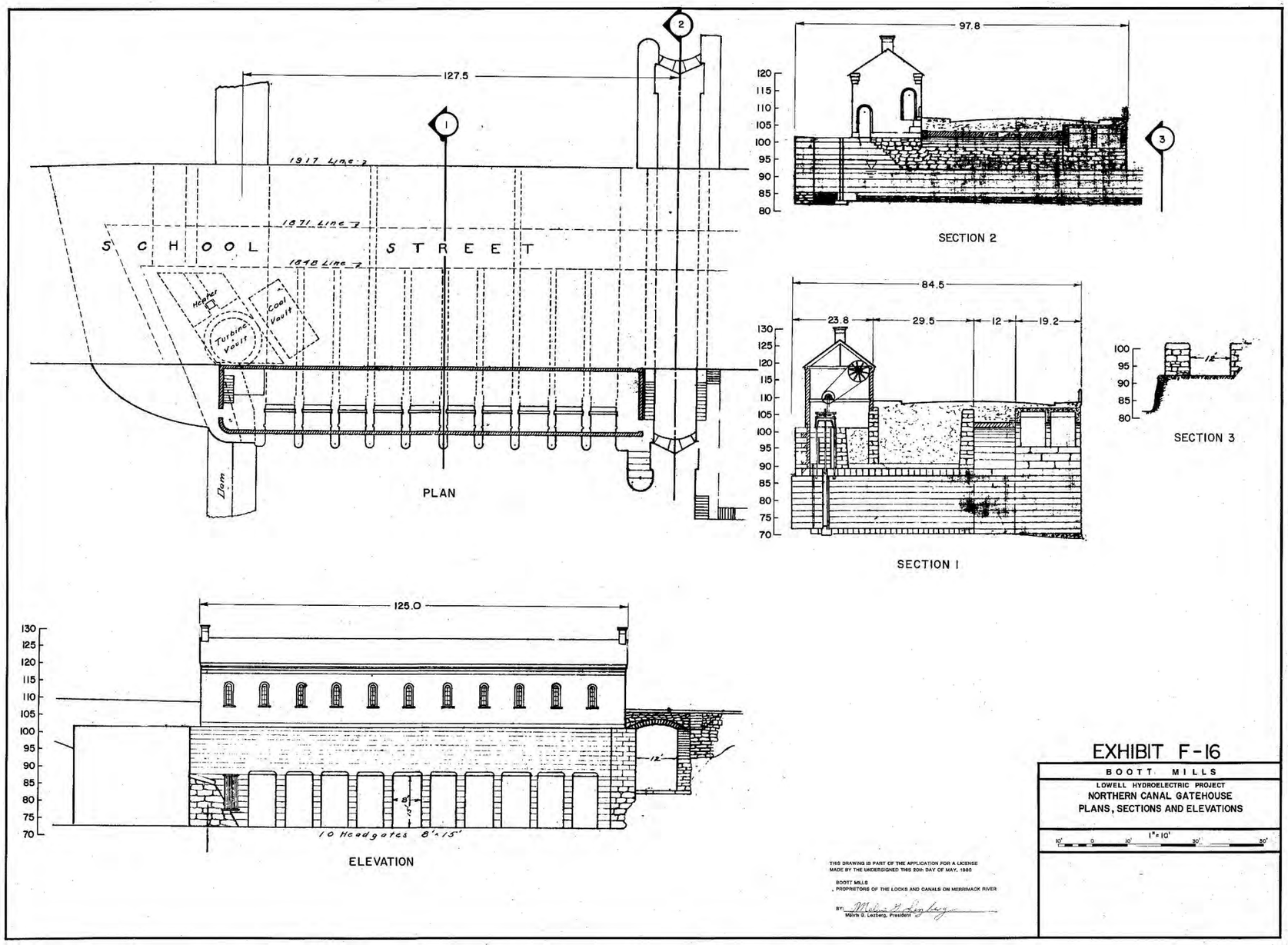
A-4


PLAN
4' DIA. DIFFUSER PIPE
FISH COUNTING STATION
LOWER FISHWAY FLUME
SECTION A
SECTION B
SECTION C
PLAN
2' DIA. D/S MIGRANT CONDUIT
LEAN CONCRETE
GROUND LINE
BACKFILL
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
50 WASHINGTON STREET, NORWALK, CONNECTICUT 06854
BOOTT HYDROPOWER,INC.
LOWELL HYDROELECTRIC PROJECT
POWERHOUSE
FISHWAY PIPING LAYOUT
PLANS & SECTIONS
3844D-PM020
0131
DATE OCT. 5, 1984

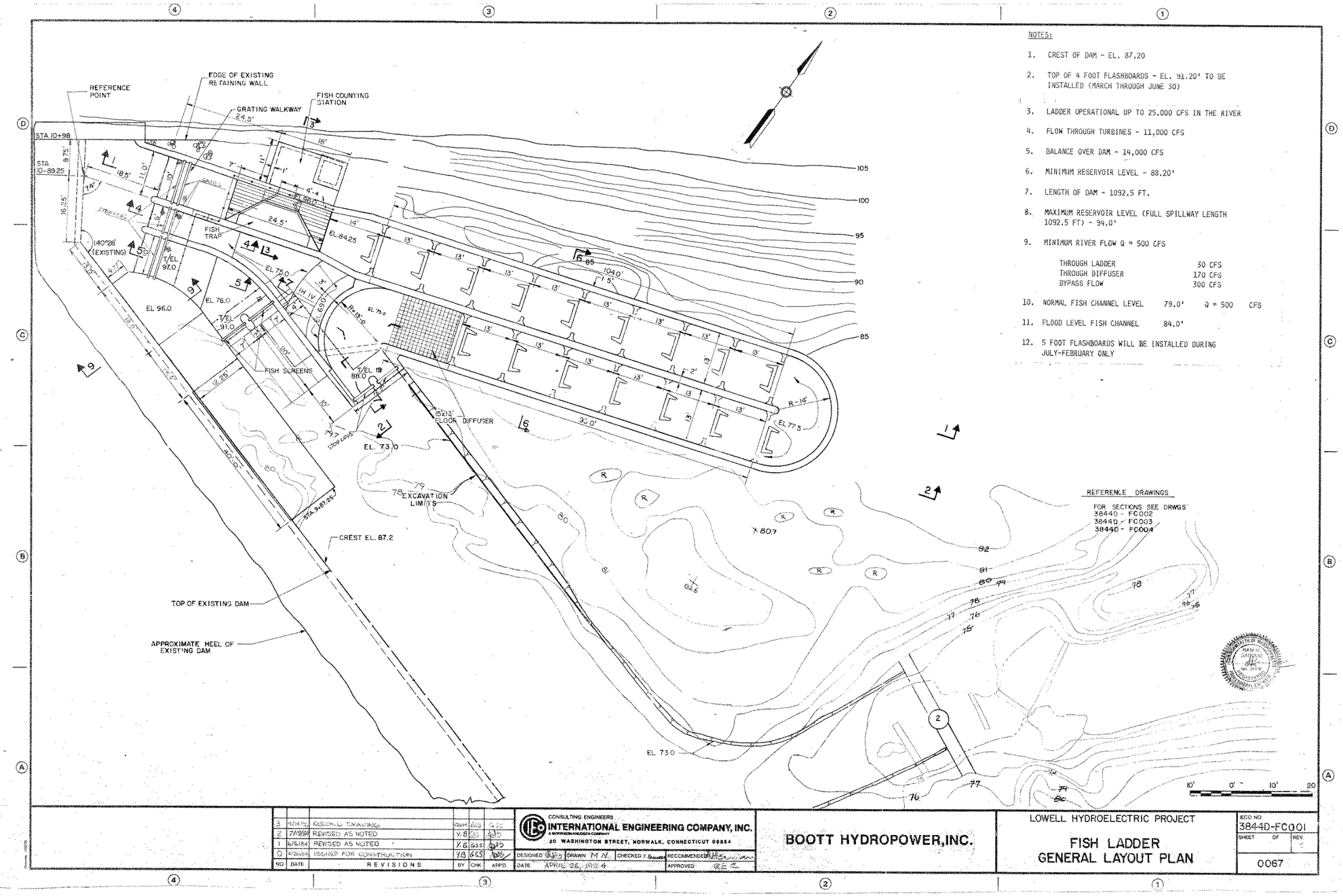
A-5


PLAN
CIRCULATION PIPES
PLAN AT EL. 57.0
PLAN AT EL. 96.0
SECTION A
SECTION B
SECTION C
SECTION D
SUPPORT DETAIL
REFERENCE DWGS.
38440-PC024
38440-PC025
INTERNATIONAL ENGINEERING COMPANY, INC.
50 WASHINGTON STREET, NORWALK, CONNECTICUT 06854
BOOTT HYDROPOWER,INC.
LOWELL HYDROELECTRIC PROJECT
POWERHOUSE
FISHWAY PIPING LAYOUT
PLANS & SECTIONS
38440-PM021
0132

A-6


127.5
1917 Line
1931 Line
1948 Line
SCHOOL STREET
Heater
Turbine Vault
Cool Vault
Dam
PLAN
97.8
120
115
110
105
100
95
90
85
80
SECTION 2
84.5
23.8
29.5
12
19.2
130
125
120
115
110
105
100
95
90
85
80
75
70
SECTION 1
100
95
90
85
80
12'
SECTION 3
125.0
130
125
120
115
110
105
100
95
90
85
80
75
70
12'
8'
10 Headgates 8'x15'
ELEVATION
THIS DRAWING IS PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 30th DAY OF MAY, 1980
BOOTT MILLS
, PROPRIETORS OF THE LOCKS AND CANALS ON MERRIMACK RIVER
BY: Melvin D. Lazberg
Melvin D. Lazberg, President
EXHIBIT F-16
BOOTT MILLS
LOWELL HYDROELECTRIC PROJECT
NORTHERN CANAL GATEHOUSE
PLANS, SECTIONS AND ELEVATIONS
1"=10'
9077

A-7



NOTES:

1. CREST OF DAM - EL. 87.20
2. TOP OF 4 FOOT FLASHBOARDS - EL. 91.20' TO BE INSTALLED (MARCH THROUGH JUNE 30)
3. LADDER OPERATIONAL UP TO 25,000 CFS IN THE RIVER
4. FLOW THROUGH TURBINES - 11,000 CFS
5. BALANCE OVER DAM - 14,000 CFS
6. MINIMUM RESERVOIR LEVEL - 88.20'
7. LENGTH OF DAM - 1092.5 FT.
8. MAXIMUM RESERVOIR LEVEL (FULL SPILLWAY LENGTH 1092.5 FT) - 94.0'
9. MINIMUM RIVER FLOW Q = 500 CFS

THROUGH LADDER	30 CFS
THROUGH DIFFUSER	170 CFS
BYPASS FLOW	300 CFS

10. NORMAL FISH CHANNEL LEVEL 79.0' Q = 500 CFS
11. FLOOD LEVEL FISH CHANNEL 84.0'
12. 5 FOOT FLASHBOARDS WILL BE INSTALLED DURING JULY-FEBRUARY ONLY

NO.	DATE	REVISIONS	BY	CHK	APPD.
3	11/4/12	REVISED DRAWINGS	GSH	EAB	GJS
2	7/19/84	REVISED AS NOTED	Y.B.	EAB	GJS
1	6/6/84	REVISED AS NOTED	Y.B.	EAB	GJS
0	4/26/84	ISSUED FOR CONSTRUCTION	Y.B.	EAB	GJS

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
30 WASHINGTON STREET, NORWALK, CONNECTICUT 06854

DESIGNED | DRAWN M.N. | CHECKED | RECOMMENDED
DATE APRIL 26, 1984 | APPROVED

BOOTT HYDROPOWER, INC.

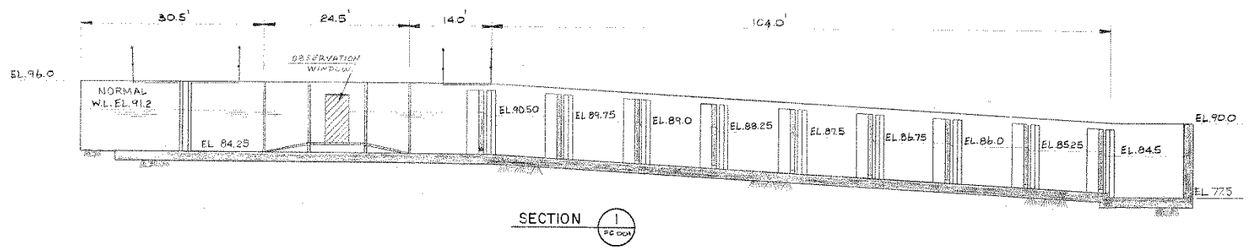
LOWELL HYDROELECTRIC PROJECT

FISH LADDER
GENERAL LAYOUT PLAN

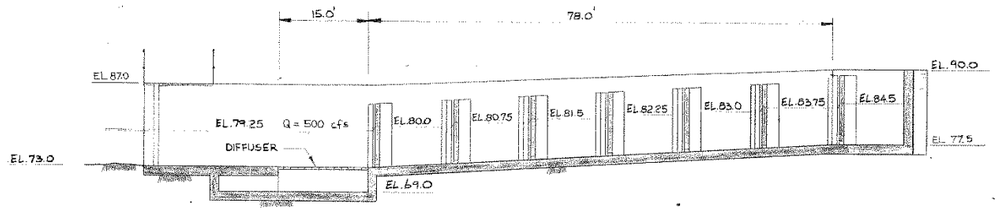
IECO NO. 3844D-FC001
SHEET 0067 OF REV.

1762

A-8

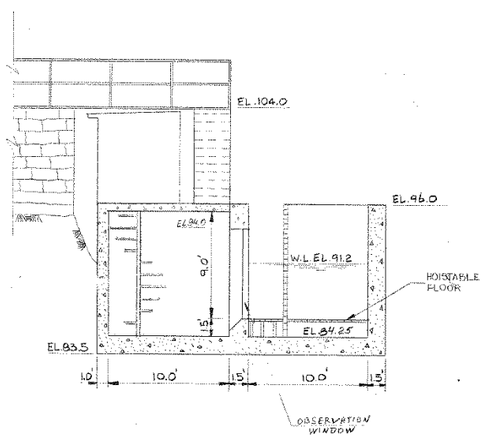


SECTION 1 FC001

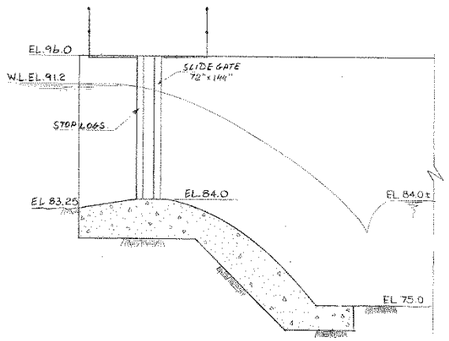


SECTION 2 FC001

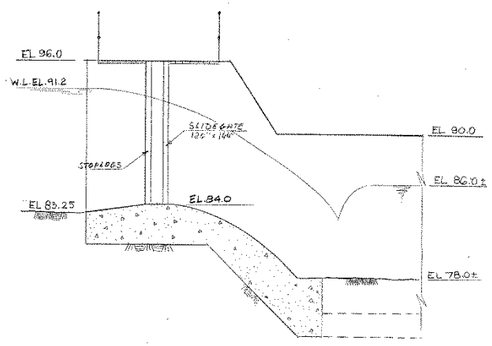
10' 5' 0 10' 20'



SECTION 3 FC001



SECTION 4 FC001



SECTION 5 FC001

COMMONWEALTH OF MASSACHUSETTS — RAM H. SAINANI — CIVIL — No. 31198 — REGISTERED PROFESSIONAL ENGINEER

5' 0 5' 10'

NO.	DATE	REVISIONS	BY	CHK.	APP'D.
1	4/14/84	RECORD DRAWINGS	CBH	RHS	CJS
0	4/26/84	ISSUED FOR CONSTRUCTION	YB	GGS	RHS

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON KNUDSEN COMPANY
50 WASHINGTON STREET, NORWALK, CONNECTICUT 06854

DESIGNED Y B | DRAWN N. Norman | CHECKED [illegible] | RECOMMENDED [illegible]
DATE APRIL 26 1984 | APPROVED

BOOTT HYDROPOWER, INC.

LOWELL HYDROELECTRIC PROJECT

FISH LADDER SECTIONS

IECO NO. 3844D-FC002
SHEET OF REV. 1
0068

1763

Appendix B

LOWELL PRE-SEASON CHECKLIST

Inspectors/Owners Representative:

_____

Weather/Site Conditions:

_____

Headpond Level (ft): _____ Tailwater Level (ft): _____

River Flow (cfs): _____ Powerhouse Flow (cfs): _____

Checklist Instructions Dewater the fishway and visually inspect and maintain (e.g., grease/lube/clean) each of the critical components of the fishway below. After inspecting and maintaining a checklist item, water the fishway and operate each component. Place a √ or *X* next to that components name once confirmed to operate as designed. Add notes in the areas provided as necessary for each component. Note location and dimensions of deficiencies with a sketch or photo. Additional observations may be added to the *Other* item located at the end of the checklist.

Common deficiencies to be inspected include but are not limited to concrete cracking and deterioration, surface defects, rust, displacement, deformation, leakage and seepage, erosion, insufficient drainage, overgrown vegetation, debris, sedimentation, and vandalism.

Fish Lift

___ Entrance Gate

- Physical Condition:
- Operator:
- Staff Gauges:

___ Holding Pool

- Physical Condition:
- Sedimentation:

___ Crowder

- Grating Condition:
- Guide Wheels:
- Hoist:
- Actuator:

___ Closure Gate

- Grating Condition:
- Hoist:

___ Hopper

- Paint:
- Guide Wheels:
- Cable:
- Hoist:
- Discharge Gate:
- Fill Ports:

___ Exit Flume

- Physical Condition:
- Crowder Grating:
- Viewing Window:
- Viewing Backboard:
- Counting Room:

___ Exit Gate

- Physical Condition:
- Actuator:
- Trash Racks/Boom:

___ Auxiliary Water Supply

- Intake gratings:
- Intake Chambers:

- Auxiliary Water Pump:
- Valves:
- Diffusion Chambers:
- Flow Baffles:
- Diffusion Grating:

___ Other

- Item 1:
- Item 2:
- Changes from Prior Inspections:

Downstream Fishway

___ Bypass Forebay Gate

- Physical Condition:
- Operator and Motor:

___ Bypass Aluminum Gate

- Physical Condition:
- Operator:

___ Wooden Gates

- Physical Condition:
- Operator:

___ Other

- Item 1:
- Item 2:

Fish Ladder

___ Entrance Gates

- Physical Condition:
- Operators:
- Staff Gauges:

___ Ladder

- Condition of Baffles:
- Condition of Pools:

___ Exit Flume

- Physical Condition:
- Crowder Grating:
- Viewing Window:
- Viewing Backboard:
- Counting Room:

___ Exit Gate

- Physical Condition:
- Actuator:
- Trash Racks:

___ Auxiliary Water Supply

- Trash Racks:
- Intake gate condition:
- Intake Chambers:
- Diffusion Chambers:
- Flow Baffles:
- Diffusion Grating:

___ Other

- Item 1:
- Item 2:

Additional Notes:

Appendix C

C-1

LOWELL FISH LIFT DAILY INSPECTION FORM	
GENERAL	
DATE	
TIME	
INSPECTOR	

RIVER CONDITIONS	
HEADPOND EL, ft	
TAILWATER EL, ft	
RIVER FLOW, cfs	
RIVER TEMP, ^{O}C	

FLOW ALLOCATION	
50 CFS VALVE SETTING, in	
150 CFS VALVE SETTING, %	
AWS (METER), CFS	
BYPASS FLOW ESTIMATE, cfs	

UNIT CONDITIONS	
UNIT 1, CFS	
UNIT 2, CFS	

FISHWAY CONDITIONS	
ENTRANCE GATE SETTING, ft	
ENTRANCE DROP, ft	
V-TRAP OPENING, in	

FISH COUNTS	
AMERICAN SHAD	
RIVER HERRING	
ATLANTIC SALMON	
SEA LAMPREY	
AMERICAN EEL	

GENERAL COMMENTS

*Please fill out this inspection form once/lift and enter all data into the data collection program once/day to provide to agencies. Contact Bryan Sojkowski with any questions (413-253-8645).

C-2

LOWELL LOG OF DAILY INSPECTION FORM DATA												
GENERAL			RIVER CONDITIONS				FLOW ALLOCATION					
Date	Time	Inspector	HP, ft	TW, ft	River Flow, cfs	River Temp, °C	50 Valve, in	150 Valve, %	AWS (curve), cfs	AWS (meter), cfs	% Hydraulic Discharge	Amount of Spill, cfs

Continued.									
UNIT CONDITIONS		FISHWAY CONDITIONS			FISH COUNTS				
Unit 1 Flow, cfs	Unit 2 Flow, cfs	ENT Gate Setting, ft	ENT Drop, ft	v-trap opening, in	American shad	Atlantic Salmon	River Herring	Sea Lamprey	American Eel

Continued.				
"No Fish Data" Reason	Comments	Conditions Outside of Range?	Comment	Recommendation

C-3

Daily Fish Ladder Checklist
Exit gate out of the water?
Glass clean?
Grating free of debris?
Staff gauge visible?
Camera equipment working?
Check entrance gate differential
Is crest gate properly inflated?
Trash rack clear?

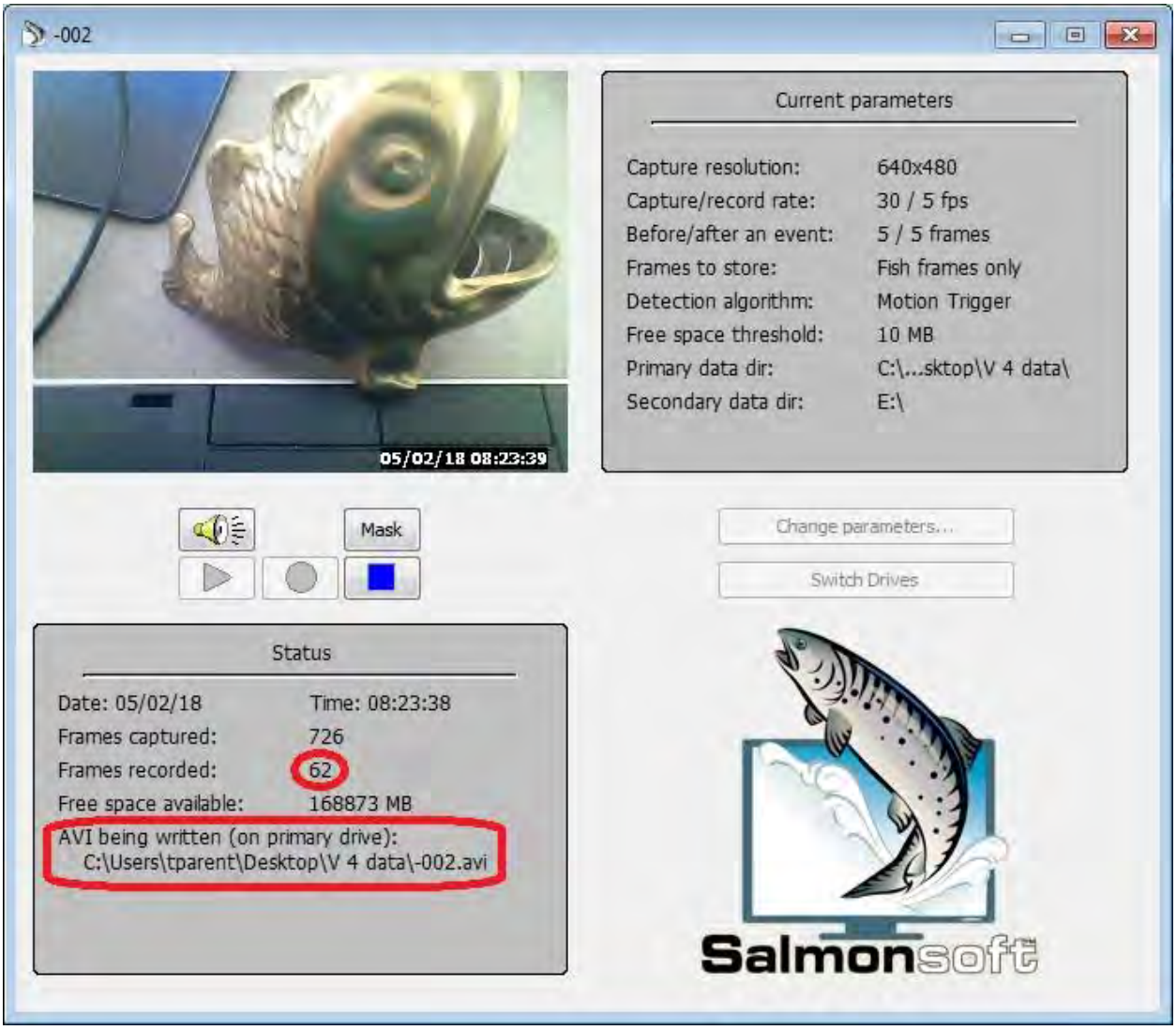
Appendix D

Upon arriving at the video capture computer, the screen will likely be off but after moving the mouse just a little, the screen should illuminate to reveal that a program called, “FishCap” is already open. To confirm that the system is filming as it should there are a couple of onscreen cues to check.

-Wave your hand in front of the camera and confirm that you can see your hand on the viewing window in the top left of the program.

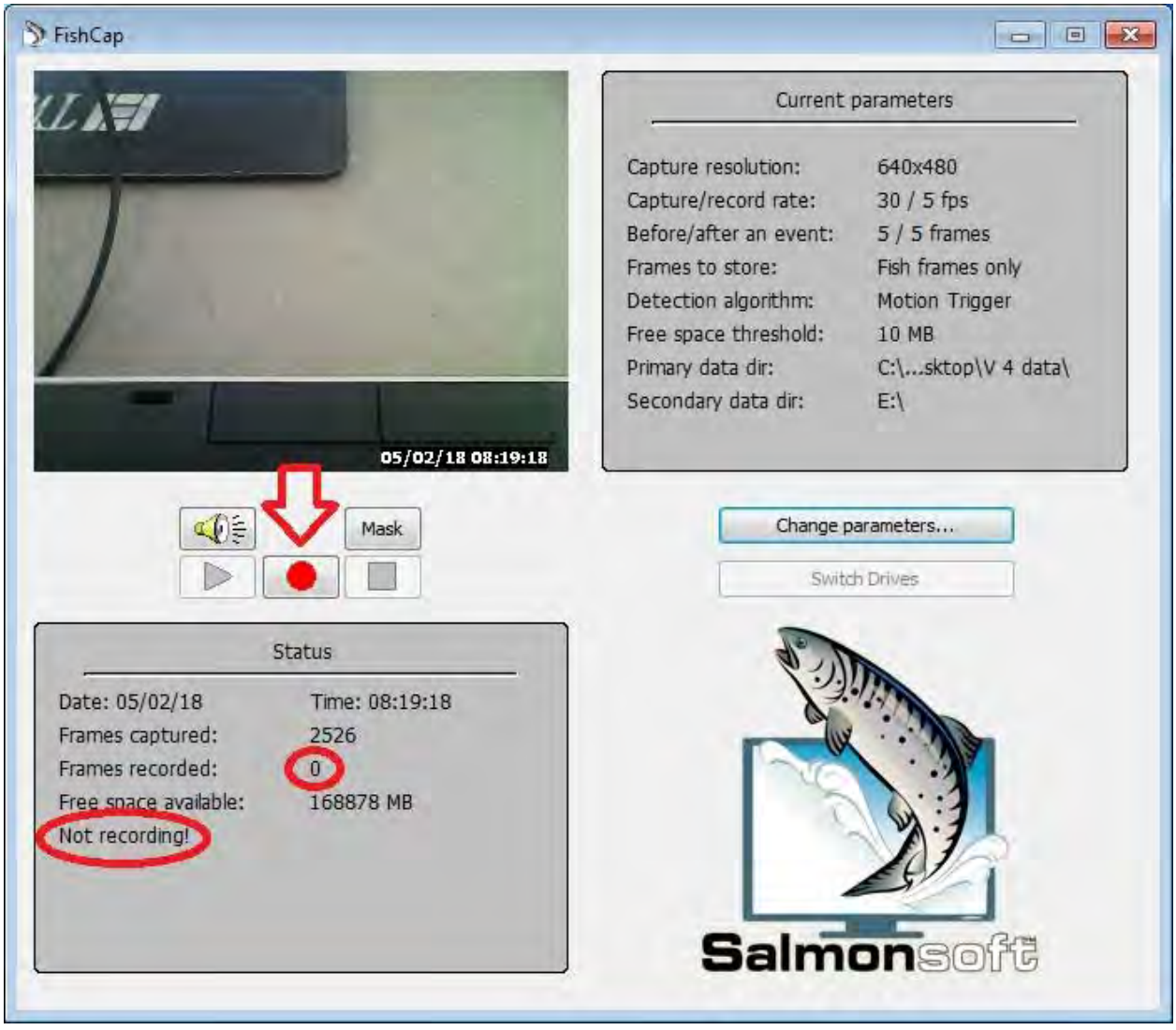
-Next confirm that the number of frames recorded (62 in the screenshot below) is getting larger when you wave your hand in front of the camera. Note: Frames captured should always be growing, even if there is no motion in front of the camera.

-Finally, Confirm that at the bottom of the gray window below the video feed, the program shows, “AVI being written…….” This will confirm that it is actively creating a new file.



Below is a screenshot of an open FishCap window that is not recording. You should never see the record button illuminated (Red circle). This means that the system is waiting for someone to push record. Additionally, you will notice that frames recorded = 0, and at the bottom of the gray area it says, “Not recording!”.

If this is what you find when checking the computer, simply press the record button (red circle) and confirm the steps from the previous page of checks to ensure that the system is now recording properly.



If FishCap is not running for some reason, open FishCap, (it is on the desktop) and then press record (red circle) to resume recording.

Appendix E

NORMANDEAU ASSOCIATES
Environmental Consultants

April 17, 2016

Mr. Skip Medford
Enel Green Power North America, Inc.
One Tech Drive, Suite 220
Andover, MA 01810

Re: Lowell Rating Curve Development

Dear Mr. Medford:

Normandeau Associates, Inc. (Normandeau) collected field measurements required for the preparation of a flow rating curve for the weir gate of the upstream fish passage facility at the Lowell Hydroelectric Project in Lowell, Massachusetts on April 6, 2016. Attraction water at the upstream passage facility is provided by two conduits with separate control points. The smaller "50" control is a stem driven gate whereas the larger "150" control is a butterfly valve. As the mechanisms are opened, attraction water is carried via piping into the lower fishway, over a weir gate and into the tailrace. Normandeau collected depth and velocity information to calculate the true attraction water discharge under a range of settings for both the "50" and "150" devices. The two were tested independently of one another. The collection technique and results for the April 6th field effort are provided in this letter. Field-derived discharge values are presented along with calculated values based on use of the sharp-crested weir formula.

During the evaluation of the "50" supply, the weir gate was set with a top elevation of 56.54' MSL. Enel staff opened the "50" gate through a series of seven settings ranging from 4 to 26.5 inches (Table 1). Following stabilization of flows at each valve setting, Normandeau obtained the forebay elevation, tailwater elevation and the lower fishway water elevation from the station's control system. Depth over the weir gate was calculated as the difference between the lower fishway elevation (as measured by the project sensor) and the pre-set top elevation of the entrance weir gate. A series of water velocities (ft/s) were collected at the quarter points of the weir gate using a Marsh McBierney Flowmate digital flow meter. Mean column velocities were estimated by a measurement taken at approximately 0.6 of the total depth determined to be passing over top of the weir. As fluid dynamics around the sensor electrodes of the flow meter can cause the readings to fluctuate, values were stabilized by setting the unit to use a 10 second fixed point averaging function. This essentially provided an average velocity value for multiple readings collected at one second increments during the 10 second time period. This process was repeated three times at each measurement location.

During the evaluation of the "150" supply, the weir gate was set with a top elevation of 55.55' MSL. Enel staff opened the "150" valve through a series of five settings ranging from 0 to 75% (Table 1).

30 International Drive, Suite 6, Pease International Tradeport • Portsmouth, NH 03801 • (603) 319-5300

Corporate Office: Normandeau Associates, Inc. • 25 Nashua Road • Bedford, NH 03110 • (603) 472-5191
www.normandeau.com

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Normandeau obtained the forebay elevation, tailwater elevation, lower fishway elevation, overflow depth and representative velocities in the same manner as described above for the "50" valve.

Field-Derived Discharge Determination, Velocity Measurement

Discharge estimates (Q) for the various settings of the "50" and "150" were calculated as the average cross-weir velocity multiplied by the area and using the formula:

$$Q = WDV$$

Where: Q = discharge (cfs)
W = width of weir gate channel (i.e., 6 ft)
D = depth of water over weir gate (i.e., (lower fishway elevation) – (weir crest elevation))
V = average velocity (ft/s)

Sharp-crested Weir Discharge Determination

Field derived discharge estimates were cross-checked using a crested-weir formula:

$$Q = CW(D^{3/2})$$

Where: Q = discharge (cfs)
C = weir coefficient (i.e., 3.3)
W = width of weir gate channel (i.e., 6 ft)
D = depth of water over weir gate (i.e., (lower fishway elevation) – (weir crest elevation))

The field-derived and weir-calculated discharge values for each setting examined for the "50" and "150" devices are presented in tabular format in Table 1 and graphical format in Figures 1 and 2.

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Table 1. Attraction flow settings and resulting depth and velocity values for the "50" and "150" conduits at the Lowell Hydroelectric Project, with corresponding discharge over the weir gate.

Valve	Valve Setting	Forebay Elevation (MSL)	Tailrace Elevation (MSL)	Fishway WS Elevation (MSL)	Water Depth over Weir (ft)	Mean Column Velocity (ft/s)	Discharge (cfs)	
							Field-Derived	Calculated
50	4"	89.59	53.59	57.67	1.13	3.23	21.9	23.8
	8"	89.63	53.8	58.27	1.73	4.16	43.2	45.1
	12"	89.65	53.77	58.74	2.2	4.82	63.7	64.6
	16"	89.63	53.8	58.99	2.45	4.87	71.9	75.9
	20"	89.62	53.8	59.25	2.71	5.16	83.9	88.3
	24"	89.61	53.79	59.26	2.72	5.49	89.5	88.8
	26.5"	89.62	53.84	59.26	2.72	5.65	92.3	88.8
150	0%	89.66	53.81	56.12	0.57	1.59	5.4	8.5
	25%	89.66	53.81	56.92	1.37	3.67	30.1	31.8
	35%	89.65	53.82	57.7	2.15	4.78	61.6	62.4
	50%	89.62	53.85	58.26	2.71	5.41	87.9	88.3
	75%	89.62	53.85	58.9	3.35	6.37	128.0	121.4

*(Forebay Elevation)-(Fishway WS Elevation) equals net head within fishway at each test setting
*(Forebay Elevation)-(Tailrace Elevation) equals approximate powerhouse head during test

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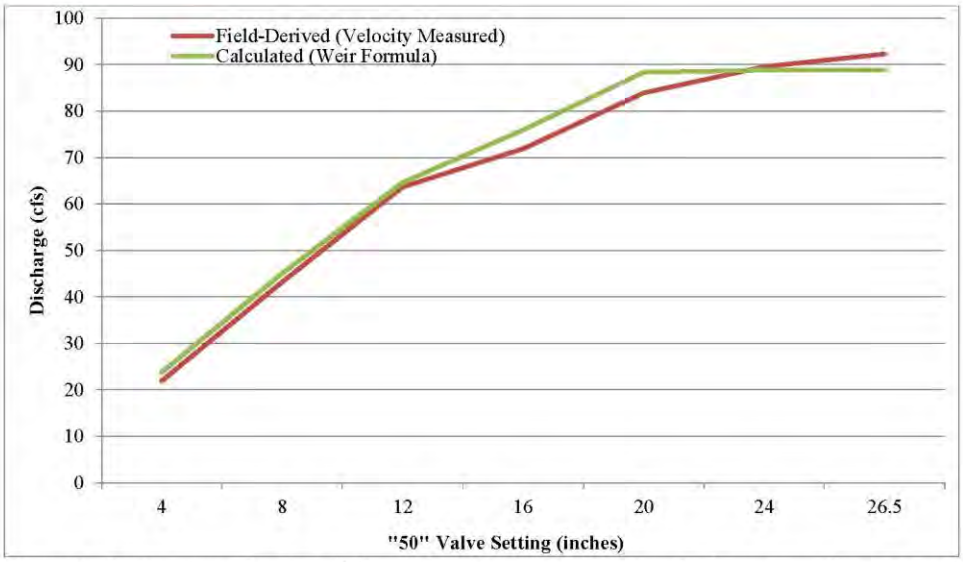

Figure 1. Rating curve showing "50" supply settings and resulting discharge over the entrance weir crest at the Lowell Hydroelectric Project.

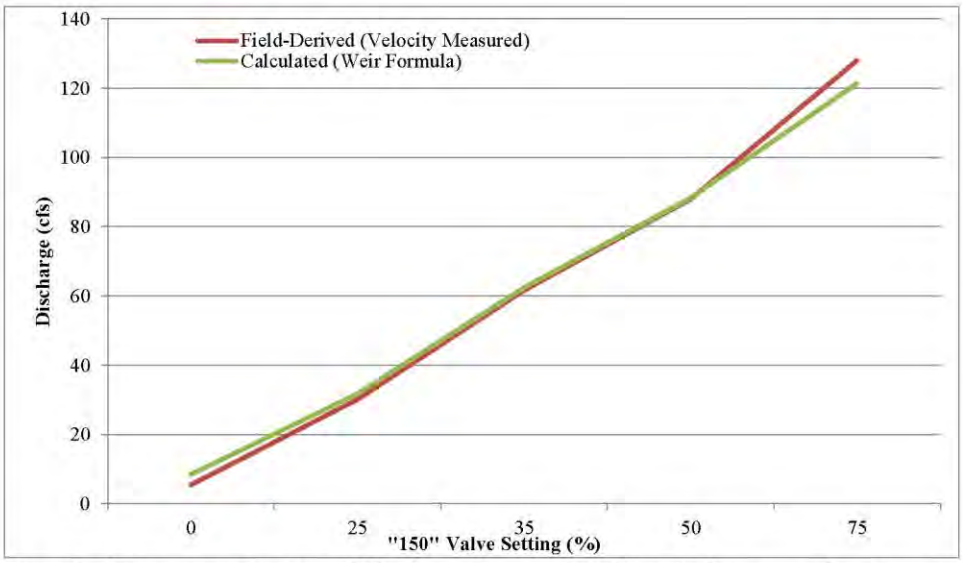

Figure 2. Rating curve showing "150" valve settings and resulting discharge over the entrance weir crest at the Lowell Hydroelectric Project.

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Measured discharges ranged between 23.8 cfs and 92.3 cfs for the "50" and between 5.4 cfs and 128 cfs for the "150" valve. For the most part, forebay and tailwater elevations remained very stable during testing, remaining within 0.1 ft.

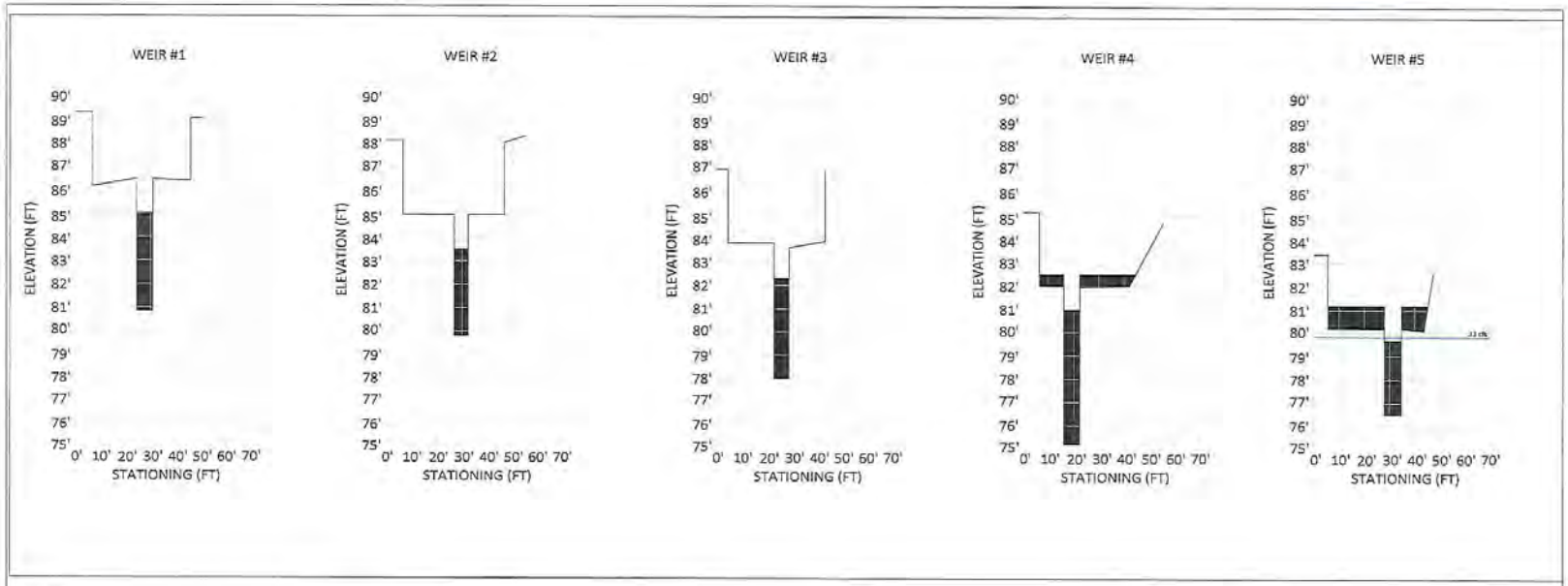
Should you have any further questions related to these measurements please do not hesitate to contact me (dtrested@normandeau.com).

Sincerely,

Drew Trested
Fisheries Biologist
Normandeau Associates, Inc.

Appendix F

P-2790
LOWELL WEIRS
2015



NOTES:

1. HATCHED AREAS ABOVE THE WEIR SILLS REPRESENT WOODEN BOARDS TO BE LOCATED ON THE DOWNSTREAM EDGE OF THE ASSOCIATED SILL. WEIR #4 WILL BE RAISED 6" ALONG THE ENTIRE LENGTH OF THE SILL. WEIR #5 WILL BE RAISED 1.0 ft ALONG THE ENTIRE LENGTH OF THE SILL.

2. HATCHED AREAS WITHIN THE LOW FLOW NOTCHES REPRESENT WOODEN STOP LOGS. THE USFWS RECOMMENDS THAT THE TOP OF THESE STOP LOGS REMAIN 1.5 ft BELOW THE EXISTING AND RECOMMENDED SILL ELEVATIONS.

3. THESE RECOMMENDATIONS VARY SLIGHTLY FROM BEN RIZZO'S ORIGINAL RECOMMENDATIONS NOTED WITHIN HIS MEMO TO CHI, DATED JULY 9, 1991. THE INTENT IS TO ENSURE THAT THE DROP IN WATER SURFACE ELEVATION FROM UPSTREAM TO DOWNSTREAM OF EACH WEIR IS APPROXIMATELY EQUAL.

4. NOTE THAT THE DIMENSIONS COULD CHANGE DURING IMPLEMENTATION AND SHOULD BE APPROVED BY THE USFWS POST CONSTRUCTION.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
DIVISION OF FISHERIES
FISH PASSAGE BRANCH

LOWELL LADDER RECOMMENDATIONS
DOWNSTREAM WEIRS

TO: SKIP MEDFORD, ENVIRONMENTAL SPECIALIST, ENEL
BY: BRYAN SOJKOWSKI, P.E., FISH PASSAGE ENG

SHEET 1 OF 1

Medford, Skip (EGP North America)

From: Sojkowski, Bryan <bryan_sojkowski@fws.gov>
Sent: Thursday, May 21, 2015 3:02 PM
To: Medford, Skip (EGP North America)
Cc: Bartlett, Randald (EGP North America); van Lingen, Hans (EGP North America); Joe McKeon; John Warner; Michael Bailey
Subject: Lowell Weir Recommendations
Attachments: Lowell Weir Recommendations_150521.pdf

Hi Skip,

Thanks again for spending some time with us on site this week. One of the items that seemed to be time sensitive was modifications to the weirs downstream of the Lowell ladder. Unfortunately I have not had the time to perform a thorough analysis but with the survey data we took last year and Ben's original recommendations I was able to come up with the following (see attached PDF):

The modifications consist of raising the sill elevations of weir #4 and weir #5 (see original survey document for numbering convention). Weir #4 will be raised 6" and weir #5 will be raised 1.0 ft. The entire length of the sill will need to be raised via wooden boards attached to the concrete on the **downstream** side of the weirs. Ben had also recommended that weir #2 be raised 2" but I have omitted unless I see an issue post alterations. Stop logs should be placed into the slots up to an elevation that is 1.5 ft from the top of the existing or modified sill. This dimension may change but will be the easiest to modify on site.

As I understand the weir modifications could occur this week or early next week. I unfortunately may not be able to be on site so will have to rely on Mike or others to take photos and measurements. Please look these over and provide any feedback.

Thanks, talk to you soon.

–
Bryan Sojkowski, P.E.
Hydraulic Engineer - Fish Passage
U.S. Fish and Wildlife Service
Region 5, Fisheries
300 Westgate Center Drive
Hadley, MA 01035
413-253-8645
413-253-8488 (fax)
bryan_sojkowski@fws.gov

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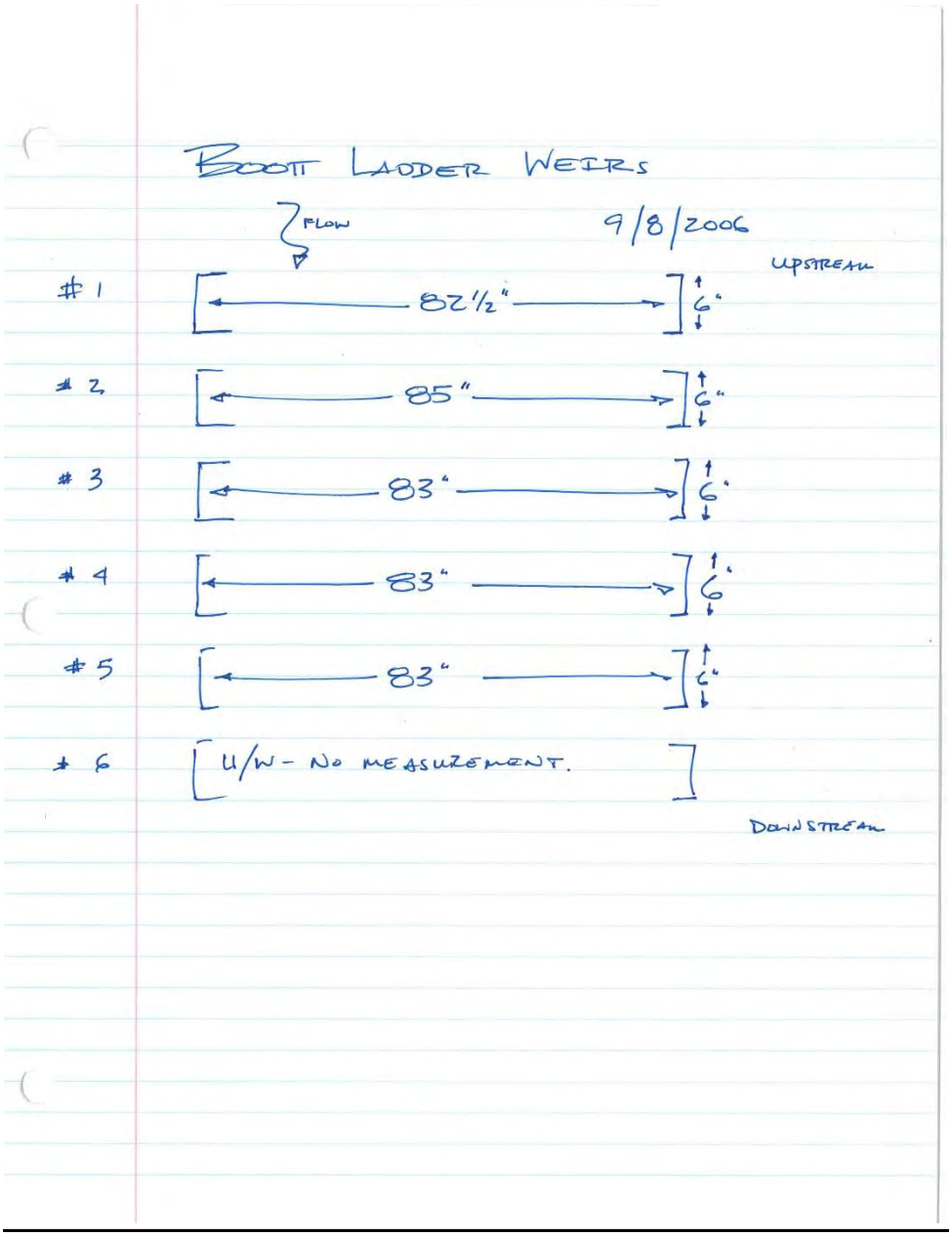
BOOTT LADDER WEIRS
FLOW
9/8/2006
UPSTREAM
#1
82½"
6"
#2
85"
6"
#3
83"
6"
#4
83"
6"
#5
83"
6"
#6
U/W - NO MEASUREMENT.
DOWNSTREAM