Technical Memorandum

To: Randy Dorman, Brookfield

From: Greg Allen and Steve Amaral, Alden

Date: October 7, 2021; Revised May 5, 2022

Re: **Review of Maine Department of Marine Resources' Nature-like Fishway Concepts for the Shawmut Hydroelectric Project (FERC Project No. 2322)**

This memorandum summarizes Alden Research Laboratory Inc.'s (Alden) review of the nature-like fishway (NLF) concepts proposed by the Maine Department of Marine Resources (MDMR) which was filed in their comments to the draft Environmental Assessment (EA) prepared for the Shawmut Hydropower Project (Shawmut, P-2322). MDMR has proposed to replace or supplement Brookfield's current proposed fishways with the NLF concepts. Alden focused the review on the technical merits regarding fish passage performance. A thorough review of other issues (e.g., property ownership, substation interferences, powerhouse access, etc.) is not included but needs be evaluated to ultimately determine feasibility.

A brief description of Brookfield's proposed fishways and relevant design parameters are included for context, as well as discussion of the NLF proposed to replace or supplement fish passage.

This memo was originally submitted to Brookfield on October 7, 2021. A subsequent revision incorporating new information from field evaluations of Atlantic Salmon upstream passage through NLFs was completed on May 5, 2022.

Background – Brookfield Proposed Fishways

Alden developed designs for upstream fish passage facilities for the Shawmut project in consultation with resource agencies. A technical design review team was consulted throughout the process consisting of representatives from State and Federal resource agencies[1]. A brief timeline of the design process is provided in Table 1.

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[1] Resource agencies include US Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), Maine Department of Marine Resources (MDMR), Maine Department Inland Fisheries and Wildlife (MIFW) and Maine Department of Environmental Protection (MDEP)

Table 1. Design Timeline

Year	Description
2016	Fish telemetry study Computational Fluid Dynamic (CFD) model study Conceptual design
2017	Preliminary design 30% Design submittal 60% Design submittal Alden design memo
2018	Agency CFD model study request CFD study and design optimization of Unit 7&8 fishway 90% Design submittal Alden design memo
2019	Completion of Issued for Bid Design Documents Completion of Issued for Construction Documents

The fish telemetry study and CFD modeling completed in 2016 aided in the siting of the fishways. The telemetry study (Normandeau 2016) showed that alewife spent the majority of time in the vicinity of the Unit 1-6 powerhouse. Fish were also attracted to the Unit 7&8 powerhouse, but spent much less time there. These results were supported by the CFD modeling (BHH 2016), which showed good far field attraction from flow discharges at the project (i.e., discharge from the two powerhouses). Hence, a fish lift was sited between the spillway and Unit 1-6 powerhouse and a short vertical slot fishway channel was sited in the Unit 7&8 tailrace to allow fish to cross over to the Unit 1-6 powerhouse tailrace and fish lift location.

A fish lift proposed between the spillway and powerhouse was selected due to the space limitations of this area and the track record of success for fish lifts installed at other projects. The fish lift design was developed in accordance with USFWS guidelines (USFWS 2019) and in consultation with the resource agencies. The recently installed fish lift at Milford on the Penobscot River was often referred to by resource agencies as the design to emulate and improve upon during the design consultations for Shawmut.

Relevant fish passage design parameters for the project are provided below.

Project Fish Passage Design Parameters

Target Species and Bypass Reach Fishway Design Populations
(MDMR as cited in NMFS 2016)

Atlantic salmon: 12,000
American shad: 177,000

Alewives:	134,000
Blueback herring:	1,535,000

River flow for fish passage operation

Design high:	20,270 cfs (5% exceedance)
Design Low:	2,540 cfs (95% exceedance)

Powerhouse capacity 6700 cfs

Head pond Elevations

Max:	122 ft (100 yr)
Normal:	112 ft
Design low:	108 ft

Dam crest El.:	108 ft
Flashboard El.:	112 ft

Tailwater Elevation

<u>Unit 1 – 6 Powerhouse</u>

Design high:	91.5 ft
Normal:	89.1 ft
Design low:	88.6 ft

<u>Unit 7&8 Powerhouse</u>

Design high:	90.0 ft
Normal:	87.6 ft
Design low:	87.1 ft

Gross head: 20.5 to 23.4 ft

Proposed Fish Passage Facilities

Fish Lift

Location – North of Unit 1 – 6 powerhouse and adjacent to the spillway
Entrance width – 8 ft
Entrance invert El. – 79.6 ft
Entrance gate – hinged flap gate controlled to provide an entrance differential of 6 to 12 inches with at least a 3 ft water depth.
Hopper volume – 490 ft^3

Fish lift cycle time – 15 min
Total attraction flow – 340 cfs

Unit 7 & 8 Fishway

Location – South of Unit 1 – 6 powerhouse and adjacent to Unit 7 & 8 powerhouse
Channel – 10.5 ft wide by 77 ft long connecting tailraces
Single 42 inch slot baffle
Total head – 1.5 ft
Entrance width – 8 ft
Entrance gate – hinged flap gate controlled to provide an entrance differential of 6 to 12 inches with at least a 3 ft water depth.
Flow – 100 to 140 cfs

Expected Passage Efficiency

Fish lifts have been installed at hydropower dams in Connecticut, Massachusetts, and Maine for passing American Shad, river herring, and Atlantic Salmon upstream. In general, most of these fish lifts are considered effective in passing the target species, with a couple of exceptions (e.g., the Lowell fish lift at the second dam on the Merrimack River in Massachusetts). However, studies have not been conducted at most of these projects to estimate passage efficiency. Issues with attraction and passage through entrance systems have been determined at several sites and efforts are ongoing to improve these conditions for greater passage efficiency (primarily for shad and herring, given restoration of Atlantic Salmon has been abandoned in all New England states other than Maine).

An evaluation of upstream passage of Atlantic Salmon at the Milford Project on the Penobscot River was conducted following its installation in 2014 (Izzo et al. 2016). During the two years of study, passage efficiency of salmon was determined to be 95 and 100%. However, despite study fish locating the fish lift entrance within five hours of arrival at the project, passage delays of a week or more were noted for a large proportion of fish. The results of the Milford study demonstrate that high passage efficiencies can be achieved for Atlantic Salmon using fish lifts, but delays in passage may occur. The occurrence and extent of delays is likely site specific and probably related to entrance design and hydraulic conditions, among other factors (e.g., light/shadows, noise, and magnitude and location of any competing flows).

Passage effectiveness studies have also been conducted with river herring at Milford in 2015, 2019, and 2021. The results of the 2015 study were inconclusive due to most of the radio-tagged fish falling back downstream after release and not returning upstream. The 2019 study produced an overall passage efficiency of 65%, but this was a proof-of-concept evaluation for improved tagging techniques and does not account for any test-related bias, tag loss, or natural mortality. The results for the 2021 study are not yet available. Upstream movement of shad in the lower Penobscot has been investigated by University of Maine researchers, but very few tagged study fish have been detected approaching or passing Milford.

Based on high passage numbers of shad and herring at fish lifts installed at several dams on other large rivers on the east coast (including very high passage numbers for river herring at several projects in Maine), it is expected that a fish lift at Shawmut could also pass high numbers of these species and would likely have passage efficiencies similar to or greater than other fishway designs. The ability of lifts to effectively pass a wide range of species of varying sizes and swimming abilities, including those targeted for passage at Shawmut, often make this technology the preferred approach for passing fish upstream at hydropower dams.

Nature-like Fishway Review

The NLF concepts presented by MDMR are described in a memo dated July 20, 2021, from Interfluve titled Nature-like Fishway Conceptual Analysis, Shawmut Dam, Kennebec River, Maine (Interfluve 2021). Two conceptual layouts were presented both with an entrance downstream of the Unit 7&8 tailrace approximately 650 ft downstream of the spillway. The alignment extends upstream from the entrance west of the project structures between the existing substation and railroad with an exit approximately 360 ft upstream of the existing head gate structure. The total length of the alignment is approximately 1250 ft and the two concepts are similar but with different widths, 100 and 80 ft. Relevant features reported from the designs are provided below.

NLF Features

Length:	1250 ft (full length)
	1150 ft (to hydraulic control structure)
Wetted width:	100 ft and 80 ft (max and reduced width concepts)
Max top width:	170 ft
Entrance invert elevation:	85 ft
Exit invert elevation:	107 ft
Channel bed slope:	1.7%

The design water levels for the head pond and tailwater should be similar to the design parameters for the fish lift. Control of the head pond is maintained at elevation 112 ft with the use of the flashboards, rubber dams, log sluice and unit flows over the range of fish passage design river flows (95% exceedance to 5% exceedance). The dam crest is at elevation 108 ft which represents a low flow condition if the hinged flashboards are down. The location of the NLF entrance is downstream of the Unit 7&8 tailrace and based on previous CFD modeling, we estimate an approximately 0.5 ft lower water surface elevation than the elevations at the Unit 7&8 powerhouse. The following design conditions for the NLF were determined based on current project information.

Design Conditions

Head pond water levels

Max:	122 ft (100 yr)
High:	112 ft
Normal:	112 ft (top of flashboards)
Design low:	108 ft (dam crest)

Tailwater levels

Estimated at NLF entrance location assumed to be 0.5 ft less than Unit 7&8 powerhouse levels.

Design high:	89.5 ft
Normal:	87.1 ft
Design low:	86.6 ft

Gross head: 22.5 to 25.4 ft

NLF Hydraulic Slope

High river flow:	1.8 %, 2.0 % (w/ hydraulic control)
Normal:	2.0 %, 2.2 % (w/ hydraulic control)
Low river flow:	2.0 % 2.2 % (w/ hydraulic control)

Reported hydraulic capacity

Maximized width option	1600 – 2400 cfs (wetted width approximately 100 ft)
Reduced width option	1500 – 2000 cfs (wetted width approximately 80 ft)

Comments

NLF as a Fish Passage Technology

Nature-like fishway channels are a relatively new technology for fish passage and there have been very few evaluations of fish passage effectiveness. USFWS fish passage guidelines (USFWS 2019) recommend slopes less than 3% for roughened channels, which is the type of NLF channel proposed for Shawmut. Alden's hydraulic modeling experience evaluating a roughened channel suggests shallower slopes are needed to provide acceptable velocity conditions for shad and river herring. Alden recommends a slope less than 2%, but ideally 1.5 % to provide acceptable velocity conditions over a range of flow conditions. Without hydraulic modeling as part of the design process, Alden cannot confirm appropriate hydraulic conditions throughout the fishway for the targeted species.

The total head of 25 ft is greater than any other NLF installed and results in a length of 1250 ft. The design is unprecedented in scale and presents significant risk without extensive performance data from installed projects for any of the Shawmut target species. While the Howland bypass channel is cited as an analog for the proposed design, limited passage data for Atlantic salmon attempting to pass upstream at this site has only recently become available. The study that produced this data evaluated upstream migration of tagged adult salmon in the Penobscot River and reported passage efficiencies ranging from 35 to 82% for salmon that approached the Howland bypass during four migration seasons (Peterson 2022).[2] These efficiencies were lower than those reported for technical fishways at Milford (fish lift; 82-100%) and West Enfield (vertical slot fish ladder; 65-100%) as part of the same study (Peterson 2022).[3] A major conclusion of this study was that migratory delays were common for Atlantic Salmon in the Penobscot River primarily due to the different types of passage structures and smolt stocking practices (mainly releasing hatchery smolts downstream of Milford, thereby reducing homing instincts to prime spawning habitat in upstream reaches and tributaries). It should be noted that the proposed NLF design for Shawmut deviates significantly from several key parameters of the Howland bypass channel, which has a slope of 1.5%, a total head of 16 ft, a length of about 1000 ft, and an entrance location adjacent to the powerhouse and spillway.

The only other site where a similar sized NLF was installed and evaluated was at the Herting Dam in Sweden (about 15 ft of head, a length of 1,500 ft, and a slope on the order of 1%). Atlantic Salmon passage efficiency was estimated to be 97% at this site (Nyqvist et al. 2017). However, the NLF at Herting is actually a rehabilitated bypass reach (i.e., main river channel below the spillway) and not a new channel constructed adjacent to the project. The

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[2] This study was not specifically designed as a passage effectiveness assessment of the Howland Bypass, but rather an evaluation of system-wide upstream migration of tagged fish in the Penobscot River with respect to the effects dams and fishways. As such, data specific to external and internal passage efficiency at Howland were not collected. Consequently, the reported passage efficiencies represent the percentage of fish that were detected within a specified distance of the bypass entrance (classified as approaches to the fishway) that were later detected upstream of the bypass (i.e., successful passage event).

[3] Although upstream passage efficiency was estimated to be relatively low for Atlantic Salmon adults approaching the Howland Bypass (Peterson et al. 2022), an evaluation of smolt downstream migration in the Piscataquis River estimated very high survival (99%) of tagged fish passing downstream at the Howland Dam after the project was decommissioned and the NLF bypass was installed and operational (Molina-Moctezuma et al. 2021). That noted, at Howland Dam the primary route of downstream passage is a dedicated gate at the former powerhouse location with the NLF available as a secondary route. The Howland Dam layout is typical of NLF designs, which primarily provide upstream passage. As with Howland, a typical NLF exits into the headpond sufficiently upstream from the dam so that upstream moving fish do not emerge in front of turbine intakes or an open gate, which could make them susceptible to being swept back downstream. Because of this arrangement, there is potential for downstream migrating fish to miss a typical NLF and instead end up downstream at the dam.

rehabilitation included splitting the spillway into two angled structures through which the modified bypass reach extended (i.e., fish pass upstream into the impoundment between the two new spillway structures). This allows flow to also enter the NLF over the two new weirs when there is spill. With this new design, it is not surprising that passage efficiency of salmon is very high at Herting. It also prevents the results of this study from being considered as representative of alternative designs that include the construction of NLF channels that run separate and adjacent to the main river channel (i.e., the Howland Bypass and the proposed Shawmut design). Given the unprecedented scale and lack of data from similar sites (particularly for shad and herring), the proposed NLF should be considered an experimental technology with respect to its potential application at Shawmut.

Expected Performance

Nature-like fishways designed specifically for salmonids and/or shad and herring have had fewer installations compared to more technical fish passage designs (e.g., vertical slot, pool and weir). However, recent research on the swimming capabilities and behavior of upstream migrating shad and herring has increased the interest in the use of nature-like fishways for these species and, subsequently, guidelines for their design have been developed (Turek et al. 2016). Assuming appropriate slopes, depths, and velocities throughout an NLF designed for Shawmut, internal passage efficiencies likely would be relatively high for American Shad (> 70%), river herring (> 80%), and Atlantic Salmon (> 90%). However, the location of the NLF entrance in the conceptual designs for Shawmut is about 650 ft downstream of the dam on the right bank. Depending on flow conditions (i.e., presence of flow from powerhouse and/or spillway), many upstream migrants could be attracted to the turbine discharge or spill. Also, the length and slope of the NLF conceptual designs for Shawmut may exceed what is required for acceptable levels of passage efficiency of shad and herring. Depending on the passage efficiency of an NLF, it is possible that having an NLF and a fish lift at Shawmut could be less efficient at passing fish upstream than having only a fish lift with respect to total passage numbers and the potential for migration delay.

Few studies have evaluated passage efficiency of NLF designs for American Shad, river herring, and Atlantic Salmon. Studies that have evaluated NLF designs in the lab and field with shad and herring have reported a wide range of efficiencies (0-94%; Table 2). These studies have only been conducted for NLF channels with slopes between 3.5 to 6.7% and passage efficiencies at these slopes typically were 65% or less. NLF designs with relatively short lengths (110 ft and less) had the highest efficiencies. The longest length for which passage efficiency was evaluated with shad and river herring was 300 ft (with slopes of 3.5 to 5.0%); efficiency for shad at this site was reported to be 53 to 65%.

The only NLF that is similar in design and with a length close to the alternative designs developed for Shawmut is the Howland Bypass on the Penobscot River, which is 1,050 ft in length and has a slope of 1.5%. This length is about 25% shorter than what has been proposed for Shawmut. Given the relatively low passage efficiencies reported for shad and herring at higher slopes (3% and greater) and shorter channel lengths, slopes greater than 1.5% probably should not be considered for Shawmut and thus, any NLF meeting the necessary slope for expected passage of shad would need to be in excess of 1,650 ft long, approximately 100 ft longer than MDMR's proposed design.

With respect to Atlantic Salmon, observations from recent upstream migration studies in the Penobscot River indicate relatively low passage efficiencies for the Howland Bypass (35-82%; Peterson 2022). The entrance to the Howland bypass is adjacent to the existing powerhouse and spillway structures so there is no possibility of upstream migrants swimming past it due to competing flows further upstream, as would be the case for the proposed Shawmut NLF design. However, it is possible for upstream migrants to be attracted to the Howland dam during periods of spill, but the NLF entrance should be easy for fish to locate when there is little or no spill over the dam. Without a better understanding of what factors contributed to the poor passage efficiencies of salmon at the Howland Bypass, it would not be prudent to install an even longer NLF channel at Shawmut with an entrance location about 650 ft downstream from the spillway. Based on the passage efficiencies reported for the Howland Bypass, passage efficiencies of the proposed Shawmut NLF for salmon could consistently be less than 50%.

Table 2. Summary of design information and effectiveness studies for NLF fishways

Site	River	State/ Country	Total Head (ft)	Slope (%)	Length (ft)	Species	Passage Efficiency (%)	Source
Shawmut Dam	Kennebec	ME	25.0	2.0	1,566	Atlantic Salmon, river herring, American Shad	--	Interfluve 2021
Howland Bypass	Piscataquis	ME	16.0	1.5	1,050	Atlantic Salmon, river herring, American Shad, American Eel, and Sea Lamprey	35-82 (salmon)	Peterson 2022
Town Brook	Town Brook	MA	12.0	5.0	105	Alewife	94	Haro et al. 2008; Franklin et al. 2012
East River	East River	CT	--	6.7	160	Alewife	40.6	Haro et al. 2008; Franklin et al. 2013
Conte Lab Study	Connecticut	MA	5.5	5.0	110	American Shad Blueback herring	40-90 0-40	Haro et al. 2008
Saccarappa East Channel Saccarappa West Channel	Presumpscot	ME	9.0 9.0	2.0 1.5	300 500	American Shad, river herring, and American eel	--	Alden design documents
Cape Fear River	Cape Fear	NC	13.0	3.5-5.0	200 - 300	American Shad	53-65	Raabe et al. 2019
Herting Dam	Altran	Sweden	15.3	--	1,476	Atlantic Salmon	97	Nyqvist et al. 2017
Springs Dam	Saco	ME	5.2	3.0	230	American Shad and river herring	--	--

NLF Conceptual Designs and Evaluated Scenarios

As mentioned previously, the NLF was designed as large as possible within the site space constraints using the Howland Bypass NLF as an example. The concepts were developed to maximize flow volume to enhance attraction to the fishway, particularly when the river flow exceeds the station capacity (6700 cfs). Comments are provided for the following scenarios:

Scenario A - NLF to supplement Brookfield's currently planned fishways

Scenario B - NLF to replace Brookfield's currently planned fishways

Scenario C - NLF installed with project decommissioning

Scenario A – Nature-like fishway to supplement currently proposed fish passage facilities

The Interfluve memo states the NLF could be considered to supplement or as an alternative to the proposed fish passage facilities. This scenario assumes the proposed fish lift between the old powerhouse and spillway would be installed and the fishway channel connecting the two powerhouse tailraces would be installed. This scenario would include the following fish passage flows:

- Fish lift: 340 cfs
- Tailrace fishway channel: 80 to 100 cfs
- NLF: 1500 to 2400 cfs

The fish lift is ideally located at the confluence of the spillway and old powerhouse. This is the most upstream location and the existing powerhouse provides far-field attraction as shown in the fish telemetry study (Normandeau 2016) and CFD study (BHH 2016). The addition of the NLF may or may not benefit upstream passage performance under this scenario, depending on project operation, river flow conditions, actual NLF performance, and potential delay due to NLF entrance location. The entrance to the NLF is approximately 650 ft downstream of the dam on the right bank. Fish approaching the project along the right side of the river will have an opportunity to find the NLF entrance. Fish that swim past the entrance due to attraction to the powerhouse flows will have the opportunity to find the fish lift entrance.

The Interfluve memo does not directly provide a recommendation for the operation of the project facilities and the NLF. If the NLF were to operate passively, as the memo states as the preference, without flow control, it would curtail generation at river flows less than 9440 cfs. This in turn would reduce the far field attraction to the fish lift, due to lower powerhouse flows and the NLF would represent a greater percentage of the overall river flow. This should increase attraction to the NLF and the overall performance of the NLF. However, this may not increase the overall performance of upstream passage at the project and could potentially decrease performance due to inferior internal fishway effectiveness of the NLF or due to delay of fish finding the NLF entrance. Given the lack of data to assess the internal effectiveness of the NLF, the uncertainty of the entrance location and the available performance data for the fish lift technology, we recommend operational preference to the fish lift.

If preference is given to the fish lift passage facilities the NLF would require a flow control structure to limit flows once the river flow falls below 9440 cfs. This would ensure continued attraction to the fish lift entrance. At river flows greater than the station capacity, the NLF flows would increase. The NLF would provide a benefit at higher river flows by providing a greater percentage of fish passage attraction which may decrease overall fish passage delay at the project.

Alden cannot recommend this scenario at this time due to a lack of information. The incremental benefit of the NLF is uncertain due to lack of performance data and uncertainty regarding attraction to the entrance. To reduce the uncertainty would require additional fish telemetry studies at greater river flows, CFD modeling of the NLF entrance conditions, and obtaining actual performance data for NLF projects such as the Howland Bypass.

Scenario B – Nature-like fishway to replace proposed fish passage facilities

This NLF concept would replace the currently proposed fish passage facilities, yet maintain operation of generating facilities. The performance of the NLF would be critically dependent on the ability to attract fish to the entrance and successfully ascend the NLF. The large scale design, similar to the Howland Bypass, relies on flow volume to attract fish to the entrance. The USFWS recommends that the fishway entrance be located immediately downstream of the barrier or adjacent to the dominant source of far field attraction flow (e.g. powerhouse discharge, spillway) (USFWS 2019). The NLF entrance is 650 ft downstream of the dam and main powerhouse, not immediately downstream of the spillway. Fish that continue past the entrance and are attracted to the powerhouse flows may not find the entrance or could be significantly delayed. Unlike the fish lift proposal, which provides a supplemental vertical slot fishway to relocate fish attracted to the competing Unit 7&8 powerhouse flows, the NLF would make no accommodations for the fish attracted to the main powerhouse flows. The NLF would perform best, in terms of attraction, at lower river flows with no competing powerhouse flows.

Alden does not recommend this scenario, as it is likely to be inferior in performance compared to the currently proposed fish passage facilities. This scenario is expected to cause significant delay due to the entrance location and competing powerhouse flows.

Scenario C – Nature-like fishway and decommissioning of hydropower project

In this scenario the generating facilities would be decommissioned and the dam would remain. Active operation of project discharge at the dam would cease and flows would discharge passively over the spillway. The NLF would also operate passively and the head pond would fluctuate with river flows as there would be no active control of project discharge via use of gates. Similar to Scenario B, fish that swim past the NLF entrance attracted to the spillway may not find the NLF entrance or would be significantly delayed. This option has the disadvantage of distributing river flow across the entire length of the spillway rather than concentrating flows from a powerhouse, which in turn aides in far field attraction to a fishway.

Alden does not recommend this scenario, which is expected to be less effective than the currently proposed fish passage facilities. In addition, this scenario is expected to be less effective than either of the previous two scenarios in terms of fish attraction. This alternative is expected to cause significant delay due to the entrance location and lack of bulk attraction provided by gates and powerhouse flows. This scenario would perform best during low river flows when there is less competing flows from the spillway.

Summary of Alden's Comments and Recommendations for MDMR's proposed NLF for Shawmut

- The proposed NLF would be less effective than Brookfield's proposed fish passage facilities based on the entrance location, anticipated length given expected slope, and lack of available effectiveness studies. The proposed fish lift is a proven state-of-the-art technology designed with resource agency consultation using Milford as an example to emulate/ improve throughout the design process.
- More data on NLF effectiveness are needed to determine the ability to meet fish passage performance requirements at Shawmut. However, existing information and data indicate passage efficiencies of the proposed design for Shawmut could be low for American Shad, river herring, and Atlantic Salmon.
- NLF as a fish passage technology is experimental for the unprecedented scale proposed for Shawmut. The only NLF with a similar design is the shorter Howland Bypass, for which Atlantic Salmon passage efficiencies were recently reported to be 35 to 82%.
- Alden recommends a slope of less than 2% and ideally 1.5% to meet hydraulic requirements of the target species. The design process should include hydraulic modeling and comparison to swimming capabilities of the target species.
- Scenario A – NLF to complement proposed fish passage facilities (fish lift). In this scenario priority should be given to the fish lift and the Unit 1 - 6 powerhouse flows to attract fish to the lift. There is significant uncertainty with the performance of the NLF and curtailing powerhouse flows for the sake of the NLF operation may hinder overall fish passage performance at the site due to unknown internal effectiveness.
- Scenario B – NLF to replace proposed fish passage facilities. The entrance to the NLF is located a significant distance (650 ft) downstream of the dam. Fish are likely to experience significant delay with competing flows from the powerhouse and spillway which will attract fish a large distance away from the NLF entrance. This scenario is expected to be less effective than Scenario A and the current proposed fish passage

facilities due to entrance location, entrance attraction and unknown internal effectiveness.

- Scenario C – NLF installed with project decommissioning. This scenario is expected to be less effective than Scenario A, B and the current proposed fish passage facilities, due to lack of controlled project discharge, entrance location, and unknown internal effectiveness. River flow would be discharged passively over the entire length of the dam.

This memo focused solely on the merits of fish passage and did not include other potential issues that impact the overall feasibility of the NLF alternative, such as property ownership, setbacks from railroad and residence, utility interferences, site access, flood conditions, etc.

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