STATE OF MAINE
DEPARTMENT OF MARINE RESOURCES
21 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0021

JANET T. MILLS
GOVERNOR

CARL J. WILSON
COMMISSIONER

June 21, 2025

Laura Paye, Hydropower Coordinator
Maine Department of Environmental Protection
17 State House Station
Augusta, Maine 04333-0017

Subject: MDMR Comments on 401 Water Quality Certification Applications for the Lockwood (P-2574), Hydro-Kennebec (P-2611), Shawmut (P-2322), and Weston (P-2325) Hydroelectric Projects

Dear Ms. Paye:

On May 12, 2025, the Maine Department of Environmental Protection (MDEP) published their Notification of Project Review for Water Quality Certifications pursuant to Section 401 of the Clean Water Act, 33 U.S.C. §§ 1251 *et. seq*. for the federal relicensing and continued operation of the Shawmut Hydroelectric Project (P-2322) and license amendment requests for the Lockwood (P-2574), Hydro-Kennebec (P-2611) and Weston (P-2325) hydroelectric projects. The applications were filed by Brookfield White Pine Hydro LLC (BWPH), Merimil Limited Partnership, and Hydro Kennebec LLC, which are subsidiaries of Brookfield Renewable (Brookfield or Applicant). The Maine Department of Marine Resources (MDMR) is an active participant in federal licensing and relicensing activities through the Federal Energy Regulatory Commission (FERC) for these projects. We provide the following comments and recommendations to assist MDEP in their review of the Water Quality Certification applications for the projects.

Please contact Casey Clark (casey.clark@maine.gov; 207-350-9791) or Lars Hammer (lars.hammer@maine.gov; 207-557-1564) if you have any questions.

Sincerely,

Sean Ledwin

Sean Ledwin
Director
Bureau of Sea-Run Fisheries and Habitat

Executive Summary

Restoration of Atlantic salmon, American Shad, Blueback Herring, Alewife, American eel, and Sea Lamprey has lagged on the mainstem Kennebec River, primarily because of the lack of upstream fish passage. Diadromous fish species require safe, timely, and effective access to high quality habitats at different life stages in order to successfully survive and reproduce. The Lockwood, Hydro-Kennebec, Shawmut, and Weston Project waters currently are used as spawning and rearing habitat and/or a migratory corridor for five indigenous fish species (Atlantic salmon, American Shad, Blueback Herring, Alewife, and American Eel). Upstream fish passage has been provided for juvenile American Eel at the lower four mainstem dams, but adult Atlantic salmon, American Shad, Blueback Herring, and Alewife have been captured at the Lockwood Project fish lift and transported upstream for 19 years (2006-2025). A sixth indigenous species, Sea Lamprey, also will use the project waters as spawning/rearing habitat and as a migration corridor when new upstream passage is implemented at the Lockwood, Hydro-Kennebec, Shawmut, and Weston projects. These aquatic habitats are extremely important for diadromous fish and have been designated as Critical Habitat for Atlantic salmon under the Endangered Species Act (ESA) and Essential Fish Habitat (EFH) under the Magnuson Stevens Act (MSA) for a number of species based on the location and characteristics of habitats required to support healthy fish populations. Almost 100% of high-quality Atlantic salmon spawning and rearing habitat, over 50% of spawning and rearing habitat for American Shad and Blueback Herring, and significant areas for the other native anadromous species in the Kennebec River watershed is upstream of these projects.

The applicant's proposal for fish passage measures described in the Water Quality Certification application and FERC's Final Environmental Impact Statement (FEIS) will not provide effective fish passage to all indigenous diadromous fish species and life stages without additional measures. The proposal will continue to have significant adverse impacts on these indigenous fish species and their habitat. These adverse impacts include, but are not limited to, anticipated low passage efficiency rates at upstream and downstream fishways, mortality and injury to upstream and downstream migrating diadromous fish, impaired in-stream habitat, significant delays in passage, and cumulative effects of multiple proposed fish passages at other projects in the watershed. When taken cumulatively, the lack of effective upstream and downstream passage measures could prevent meaningful restoration of any diadromous fish species above the projects and could prevent the achievement of MDMR's management goals for the Kennebec River.

For upstream passage, the applicant's proposal includes a single fishway approach for three of the dams that may not address fish attraction issues. This approach may not achieve adequate passage success for meaningful restoration, as has been shown in other rivers throughout the east coast[1]. In addition, downstream passage measures included in the applicant's proposal will not provide adequate protection for all diadromous species and life stages, and MDMR continues to support the installation of 0.75-inch angled racks at each powerhouse as intake velocities permit. Angled racks are a comprehensive, long-term measure to exclude or guide the majority of species and life stages away from the turbines and to effective dedicated downstream passage facilities. Given our concerns with upstream and downstream passage, MDMR believes that the current proposal is highly unlikely to achieve the passage performance standards included in the proposal for Atlantic salmon (96% US, 97% DS) at all four dams and alosines (70% US, 95% DS) at the Shawmut dam only, without additional measures and accountable adaptive

[1] Brown, J.J., Limburg, K.E., Waldman, J.R., Stephenson, K., Glenn, E.P., Juanes, F. and Jordaan, A., 2013. Fish and hydropower on the US Atlantic coast: failed fisheries policies from half-way technologies. *Conservation letters*, *6*(4), pp.280-286.

management. Furthermore, recent modeling conducted by MDMR suggests that upstream passage must be higher than 70% for American shad (85%), blueback herring (90%), and alewife (96%) at every dam in order to achieve management goals in the Kennebec River. Population modeling of the cumulative impacts of upstream and downstream passage of Atlantic salmon, American Shad, Blueback Herring, and Alewife has shown that efficient downstream and upstream fish passage with minimal delays are critical to support these fish species' life history needs. Unless fish passage facilities meet MDMR's proposed performance standards based on this modeling and also provide effective passage for eels and Sea Lamprey, the project waters will likely be of insufficient quality to support self-sustaining runs of these important indigenous species. To determine achievement of passage performance standards, each facility must be tested using robust and scientifically supported passage studies for each species and life stage. If, based on appropriate testing, performance standards are not achieved, there must be a robust adaptive management plan with clear measures and timelines in place for curing passage deficiencies. Below we provide a series of additional recommendations to DEP related to specific Water Quality Certification conditions that would provide meaningful restoration for indigenous sea-run fish species. In addition, we have provided a list of relevant documents on the FERC record (Appendix 1).

Table of Contents

Minimum Species Goals for the Kennebec River....4

Recommendations for All Projects....5

Recommendations for Specific Projects....16

- Lockwood....16
- Hydro- Kennebec....23
- Shawmut....29
- Weston....35

Supplemental Information....41

Minimum Species Goals for the Kennebec River

The Department's goal is to restore diadromous fish populations in Maine to their historic habitat. Diadromous fish species require safe, timely, and effective access to high quality habitats at different life stages in order to successfully survive and reproduce. Hydroelectric projects often prevent or delay migrations or cause injury or mortality that contribute to population declines. These adverse impacts can be mitigated by properly designed fishways, however many fishways fail to perform as intended, including fishways developed and operated utilizing USFWS Fish Passage Design Criteria (USFWS 2019). When there are a series of fishways within a migration corridor for diadromous species, such as in the Kennebec River, the risks increase that one or more underperforming fishways will result in significant cumulative negative impacts to these fish populations. This potential for cumulative impacts creates the need for highly effective fish passage at each of the dams that meet agency design and performance standards. MDMR has developed "minimum goals" that are achievable if suitable habitat of sufficient quality is available to support fish and other aquatic life. Building fish runs to meet these minimum demographic goals is a benchmark for having resilient self-sustaining populations, which require safe, timely, and effective passage and supportive aquatic habitats. The minimum goals and concerns about how the proposed project will not likely achieve those goals without our recommended measures and discussion of additional impacts to fish and aquatic habitat are outlined below. More detail on the modeling and background can be found in the in FERC comments on the record.

The minimum goal for **Atlantic Salmon** is to provide safe, timely, and effective upstream and downstream passage in order to achieve a minimum annual return of 500 naturally-reared adults to historic spawning/rearing habitat in the Kennebec River for Endangered Species Act (ESA) downlisting and a minimum annual return of 2,000 naturally-reared adults to historic spawning/rearing habitat in the Kennebec River for reclassification based on the NOAA and USFWS Recovery Plan (2019)[2]. To reach spawning/rearing habitat in the Sandy River, Carrabassett River, and mainstem Kennebec River, all returning adults must annually pass upstream at the Lockwood, Hydro Kennebec, Shawmut, and Weston project dams.

The minimum goal for **American Shad** is to provide safe, timely, and effective upstream and downstream passage in order to achieve a minimum annual return of 1,018,000[3] wild adults to the mouth of the Kennebec River; a minimum annual return of 509,000 adults above Augusta; a minimum of 303,500 adults annually passing upstream at the Lockwood and Hydro Kennebec Project dams; a minimum of 260,500 adults annually passing upstream at the Shawmut Project dam; and a minimum of 156,600 adults annually passing upstream at the Weston Project dam.

The minimum goal for **Blueback Herring** is to provide safe, timely, and effective upstream and downstream passage in order to achieve a minimum annual return of 6,000,000[4] wild adults to the mouth of the Kennebec River; a minimum annual return of 3,000,000 adults above Augusta; a minimum of 1,788,000 adults annually passing upstream at the Lockwood and Hydro Kennebec Project dams; a

[2] USFWS and NMFS (U.S. Fish and Wildlife Service and National Marine Fisheries Service. 2019. Recovery plan for the Gulf of Maine Distinct Population Segment of Atlantic salmon (Salmo salar). 74 pp.

[3]Maine State Planning Office. 1993. Kennebec River Resource Management Plan. Augusta, Maine. February 1993. At page 53-62. Based on 5,015 hectares of spawning/rearing habitat and a minimum return of 203 adults per hectare.

[4]Accession Number: 20200828-5199. Based on 5,015 hectares of spawning/rearing habitat and a minimum return of 1,196 adults/hectare.

minimum of 1,535,000 adults annually passing upstream at the Shawmut Project dam; and a minimum of 922,400 adults passing upstream at the Weston Project dam.

The minimum goal for **Alewife** is to provide safe, timely, and effective upstream and downstream passage in order to achieve a minimum annual return of 5,785,000[5] adults above Augusta; a minimum of 608,200 adults annually passing at the Lockwood, Hydro Kennebec, and Shawmut project dams; and a minimum of 473,500 adults annually passing upstream at the Weston Project dam.

The minimum goal for **Sea Lamprey and American Eel** is to provide safe, timely, and effective upstream and downstream passage throughout the historically accessible habitat of these two species.[6]

Recommendations for All Projects

Recommendation 1: Achieve an upstream performance standard of at least 96% within 48 hours for adult Atlantic salmon and downstream performance standard of at least 97% within 24 hours for Atlantic salmon smolts at each project and conduct three years of effectiveness testing to document that standards have been met (3 total testing events). Provide a provision to be able to update and increase future performance standard based on a river specific dam impact model that could be developed to assess performance for achievement of ESA Recovery Based on the Recovery Plan criteria.

Justification: Foster and Atkins (1868)[7] and Atkins (1887)[8] reported that within the Kennebec River Atlantic salmon ascended many miles in the Carrabassett River and the Sandy River, and these two rivers probably were the principal spawning grounds; however, the upstream limit of Atlantic salmon in the Kennebec River may have been about 12 miles upstream of the confluence with the Dead River, and at Grand Falls on the Dead River. The Kennebec River has the most habitat units[9] in the Merrymeeting Bay SHRU with 93,369 of those habitat units upstream of Lockwood Dam.[10] Nearly all the high-quality habitat in the Merrymeeting Bay SHRU is in the Kennebec River, specifically in the Sandy River, Carrabassett River, and upper Kennebec River. To reach this habitat Atlantic salmon will need to successfully ascend four dams in a timely way to reach the Sandy River. Rapid passage is becoming even more important as climate change is causing Atlantic salmon rivers to warm and increasing variability in the hydrograph, both of which increase the need for salmon to reach cold water refuges before the onset of heat waves (Gillis et al. 2023)[11]. Ensuring that salmon can reach the climatically resilient habitat present in the Sandy River and other cold water reaches of the Kennebec will be

[5] Maine State Planning Office. 1993. Kennebec River Resource Management Plan. Augusta, Maine. February 1993. At page 53-62. Based on 9,946 hectares of spawning/rearing habitat and a minimum of 581.5 adults/hectare; the Maine State average is 988.4 adults/hectare.
[6] Accession Number: 20200828-5199.
[7] Atkins CG, Foster N (1868) First Report of the Commissioners of Fisheries of the State of Maine, 1867. Owen and Nash, Printers to the State, Augusta, ME.
[8] Atkins CG (1887) The river fisheries of Maine. In: Goode BG (ed) The fisheries and fishery industries of the United States, Section V, vol. 1, pp 673–728
[9] One habitat unit equals 100 square meters.
[10] National Marine Fisheries Service). 2009. *Biological valuation of Atlantic salmon habitat with the Gulf of Maine Distinct Population Segment* . Gloucester, MA: National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office.
[11] Gillis, C.A., Ouellet, V., Breau, C., Frechette, D. and Bergeron, N., 2023. Assessing climate change impacts on North American freshwater habitat of wild Atlantic salmon-urgent needs for collaborative research. *Canadian Water Resources Journal/Revue canadienne des ressources hydriques*, *48*(2), pp.222-246.

essential for meeting the recovery goals laid out in the recovery plan (USFWS and NMFS 2019)[12]. In order to meet those recovery goals and restore this indigenous species to its habitat, MDMR is recommending performance standards for Atlantic salmon, which are mandatory conditions of each project's license by FERC and NOAA. More information and justification for those standards can be found in NOAA's Biological Opinion.[13] A population viability analysis (Dam Impacts Analysis model[14]) could be used in the future specifically for the development of performance standards for Atlantic salmon passage that consider the effects of dams on the survival and recovery of Atlantic salmon in the Kennebec River. If a river specific standard that is focused on meeting ESA delisting criteria is developed and standards are set higher, performance standards could be updated accordingly.

It is feasible to achieve high performance for Atlantic Salmon. For example, Keefer et al. (2021) [15] found that the passage efficiency for Pacific salmonids at eight dams on the Columbia River were regularly among the highest recorded for any migratory species, averaging 96.6%, which the study attributed to a "sustained adaptive management approach to fishway design, maintenance, and improvement" where many of the dams have more than one fishway. DMR expects a 96% upstream passage standard could be achievable, particularly with a robust adaptive management plan in place, potential for two fishways at each project, and appropriate water management (i.e., at minimum 5% of station capacity used as attraction for each fishway and directing spill near fishway entrances to be used as additional attraction). MDMR has serious concerns about meeting delay standards but believes with robust measures and continued improvements, it may be possible.

Recommendation 2: Achieve an upstream passage performance standard of 85% within 72 hours for American shad and downstream performance standard of at least 95% within 24 hours for American shad at each project and conduct three years of effectiveness testing to document that standards have been met (3 total testing events).

Justification: American shad historically were able to access 2,508 hectares of riverine spawning and rearing habitat above the head-of-tide in Augusta. Adults ascended the mainstream Kennebec River as far upstream as Norridgewock Falls, current location of the Abenaki and Anson projects, migrated into lower parts of the Sandy River, and ascended to the confluence of the East and West Branch of the Sebasticook River.[16] Most of the habitat (59.6%) lies above the Lockwood Dam. There are 1,495 hectares of spawning/rearing habitat in the Kennebec River above the Lockwood Dam is not freely accessible and MDMR annually transports American shad. Impedance of migration at the dams has the potential to restrict access to habitat, decrease the efficacy of spawners, and reduce the probability of post-spawn survival.[17]

---

[12] National Oceanographic and Atmospheric Administration and United States Fish and Wildlife 661 Service. (2019). Recovery plan for the Gulf of Maine distinct population segment of 662 Atlantic salmon (Salmo salar): Final plan for the 2009 ESA listing.
[13] Accession Number: 20230320-5179.
[14] Nieland JL, Sheehan TF, Saunders R, Murphy JS, Trinko Lake TR, Stevens JR. 2013. Dam Impact Analysis Model for Atlantic Salmon in the Penobscot River, Maine. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13-09; 524 p.
[15] Keefer, M. L., Jepson, M. A., Clabough, T. S., & Caudill, C. C. (2021). Technical fishway passage structures provide high passage efficiency and effective passage for adult Pacific salmonids at eight large dams. PLoS One, 16(9), e0256805.
[16] Atkins CG (1887) The river fisheries of Maine. In: Goode BG (ed) The fisheries and fishery industries of the United States, Section V, vol. 1, pp 673–728.
[17] Stich, D.S., Sheehan, T.F. and Zydlewski, J.D., 2019. A dam passage performance standard model for American shad. *Canadian Journal of Fisheries and Aquatic Sciences*, *76*(5), pp.762-779.

MDMR has utilized a life-history model (*anadrofish*[18]) to develop performance standards for American shad at the four hydroelectric projects on the Kennebec River. This tool uses the best available scientific information to model population responses to a range of upstream and downstream passage performance at dams within a river system. These modeling efforts determined that upstream passage needed to meet or exceed 85% (combined with at least 95% downstream passage) to meet the department's management goal for American shad in the river. Migration delay is considered an additional limitation for population growth and therefore necessary to meet population goals[19]. For more information related to the *anadrofish* model, please see Appendix 1of our comments on the Shawmut DEIS.[20] A peer-reviewed manuscript detailing the utility of this model for Maine Rivers is in prep and is supported by MDMR, NOAA, and SUNY Oneonta.

It is feasible to achieve high performance for American Shad. For example, the average effectiveness of upstream passage at the Safe Harbor Project on the Susquehanna River is 76% from 1997-2019 with a single fishway, with many years exceeding 85% passage efficiency[21]. Large numbers of American Shad also pass the Columbia River dams each year, suggesting that those fishways may provide efficient Shad passage. MDMR expects a 85% upstream passage standard could be achievable, particularly with a robust adaptive management plan in place, potential for two fishways at each project, and appropriate water management (i.e., at minimum 5% of station capacity used as attraction for each fishway and directing spill near fishway entrances to be used as additional attraction).

Recommendation 3: Achieve an upstream passage performance standard of 96% within 72 hours for alewives and downstream performance standard of at least 95% within 24 hours for alewives at each project and conduct three years of effectiveness testing to document that standards have been met (3 total testing events).

Justification: Adult Alewife historically ascended the mainstem Kennebec River as far upstream as Norridgewock Falls, current location of the Abenaki and Anson projects, migrated into the lower part of the Sandy River, and ascended to the confluence of the East Branch and West Branch of the Sebasticook River.[22,23] Above the Shawmut and Weston dams in the Kennebec River there are 1,047 hectares[24] of historic spawning and rearing habitat for alewives. Alewives require timely access to lakes or slow moving river habitat to spawn, which may necessitate migration of hundreds of kilometers in the Kennebec. Migration delays impact their reproductive success through expenditure of energy and mismatch of environmental conditions as seen with American shad.[25] Similarly, their iteroparous life history requires safe downstream routes at dams for adults after spawning to allow for repeated

[18] Available at https://github.com/danStich/anadrofish
[19] Castro-Santos, T. and Letcher, B.H., 2010. Modeling migratory energetics of Connecticut River American shad (Alosa sapidissima): implications for the conservation of an iteroparous anadromous fish. *Canadian Journal of Fisheries and Aquatic Sciences*, *67*(5), pp.806-830.
[20] Accession Number: 20240604-5145.
[21] https://www.fws.gov/project/susquehanna-river-fish-passage#:~:text
[22] Atkins CG, Foster N (1868) First Report of the Commissioners of Fisheries of the State of Maine, 1867. Owen and Nash, Printers to the State, Augusta, ME.
[23] Atkins CG (1887) The river fisheries of Maine. In: Goode BG (ed) The fisheries and fishery industries of the United States, Section V, vol. 1, pp 673–728
[24] 1,047 hectares equals 2,587 acres.
[25] Stich, D.S., Sheehan, T.F. and Zydlewski, J.D., 2019. A dam passage performance standard model for American shad. *Canadian Journal of Fisheries and Aquatic Sciences*, *76*(5), pp.762-779.

spawning migrations in following years. MDMR modified an existing alewife population model[26] to develop performance standards for alewife at the four hydroelectric projects on the Kennebec River. The model uses the best available scientific information to compare theoretical spawner abundance between scenarios with dam passage rates. MDMR's modifications added stochasticity in the model through the recruits per acre parameter, given the uncertainty of true carrying capacity estimates for alewife in the Kennebec River. MDMR's modeling efforts determined that upstream passage needed to meet or exceed 96% (combined with 95% downstream passage) to meet the department's management goal for alewife in the river. This management goal also meets the limited conservation targets for fisheries management under the Atlantic States Marine Fisheries Commission (235 alewives/acre of habitat). For more information related to MDMR's modifications to the model and model results, please see Appendix 1of our comments on the Shawmut DEIS.[27]

A 2021 radio telemetry study[28] at the Milford fish lift documented 86.1% passage effectiveness for river herring. Given the lessons learned at Milford since commencement of operations, and increased understanding in the field of fish passage engineering since ~2012, MDMR expects a 96% upstream passage standard could be achievable, particularly with a robust adaptive management plan in place, potential for two fishways at each project, and appropriate water management (i.e., at minimum 5% of station capacity used as attraction for each fishway and directing spill near fishway entrances to be used as additional attraction). Achievement of this standard has been made in other systems for other species (Keefer et al. (2021) [29].

Recommendation 4: Achieve an upstream passage performance standard of 90% within 72 hours for blueback herring and downstream performance standard of at least 95% within 24 hours for blueback herring and conduct three years of effectiveness testing to document that standards have been met (3 total testing events).

Justification: Blueback herring likely accessed the same areas as Alewife and American Shad considering their comparable swimming abilities and spawning habitat requirements. Adult Blueback Herring likely historically ascended the mainstem Kennebec River to Norridgewock Falls, current location of the Abenaki and Anson projects, migrated into lower part of the Sandy River, and ascended to the confluence of the East Branch and West Branch of the Sebasticook River and were able to access 2,508 hectares of spawning and rearing habitat above Augusta. Most of the habitat (59.6%) lies above the Lockwood Dam. There are 1,495 hectares of spawning/rearing habitat in the Kennebec River above the Lockwood Dam is not freely accessible and MDMR annually transports blueback herring. Blueback Herring require timely access to riverine habitat to spawn, which may necessitate migration of hundreds of kilometers in the Kennebec. Migration delays impact their reproductive success through expenditure of energy and mismatch of environmental conditions as seen with American shad[30] Similarly, their iteroparous life history require safe downstream routes at dams for adults after spawning to allow for

[26] Barber BL, AJ Gibson, AJ O'Malley, and J Zydlewski. 2018. Does what goes up also come down? Using a recruitment model to balance Alewife nutrient import and export. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 10:236-254.
[27] Accession Number: 20240604-5145.
[28] Accession Number. 20220118-5295
[29] Keefer, M. L., Jepson, M. A., Clabough, T. S., & Caudill, C. C. (2021). Technical fishway passage structures provide high passage efficiency and effective passage for adult Pacific salmonids at eight large dams. PLoS One, 16(9), e0256805.
[30] Stich, D.S., Sheehan, T.F. and Zydlewski, J.D., 2019. A dam passage performance standard model for American shad. *Canadian Journal of Fisheries and Aquatic Sciences*, *76*(5), pp.762-779.

repeated spawning migrations in following years. Dr. Dan Stich developed a stochastic, life-history based, simulation model for blueback herring for the Mohawk and Kennebec River. These models are conceptually similar to the *shadia* model developed for American shad[31] and were used in the benchmark stock assessment for blueback herring. Dr. Stich ran 48 scenarios to explore the effects of downstream passage survival (1.00, 0.95, and 0.9) in combination with varying upstream passage efficiency (0.7-1.00) and time-to-pass (1, 3, 7, and 20 days per dam) on blueback herring distribution and abundance. On the basis of these models, MDMR has determined that at least 90% of adult blueback herring need to pass upstream to each of these dams within 72 hours to achieve its management goals for Blueback Herring in the Kennebec River. For more information related to MDMR's modifications to the model, please see Appendix 1 of our comments on the Shawmut DEIS.[32]

A 2021 radio telemetry study[33] at the Milford fish lift documented 86.1% passage effectiveness for river herring. Given the lessons learned at Milford since commencement of operations, and increased understanding in the field of fish passage engineering since ~2012, MDMR expects a 90% upstream passage standard could be achievable, particularly with a robust adaptive management plan in place, potential for two fishways at each project, and appropriate water management (i.e., at minimum 5% of station capacity used as attraction for each fishway and directing spill near fishway entrances to be used as additional attraction).

Recommendation 5: Achieve an upstream passage performance standard of 80% for sea lamprey and conduct three years of effectiveness testing to document that standard has been met (3 total testing events).

Justification: Sea lamprey are recognized as an important indigenous species in Maine and serve a uniquely important role in community structure and community function in freshwater habitats in the Kennebec River and its tributaries. More specifically, Sea lamprey function as ecosystem engineers by reconditioning habitat during their spawning process and sea lamprey also serve as a vital source of marine derived nutrients for freshwater streams. Sea lamprey have similar upstream migration behavior and spawning habitat to that of Atlantic salmon[34,35], and therefore it is assumed that sea lamprey had a similar historic extent to that of Atlantic salmon in all Maine rivers. Thus, MDMR assumes a historic range that includes the mainstem Kennebec to its confluence with the Dead River as well as the Carrabassett and Sandy Rivers.

Sea lamprey are capable of reaching small, high-gradient, headwater streams. They spawn in gravel-cobble substrate, and the spawning process results in streambed modification and sediment transport. A life history-based modeling framework does not exist to assist in development of performance standards for sea lamprey. However, information from tagging studies of modern fishways can serve as a proxy for how new fishways on the Kennebec River may perform for sea lamprey. A University of Maine study[36]

---

[31] Stich DS, TF Sheehan, and JD Zydlewski. 2019. A dam passage performance standards model for American shad. Canadian Journal of Fisheries and Aquatic Sciences 76(5): 762-779.
[32] Accession Number: 20240604-5145.
[33] Accession Number. 20220118-5295
[34] Kircheis F.W. (2004) Sea Lamprey. F.W. Kircheis L.L.C, Carmel, ME.
[35] Nislow,K.H. and Kynard,B.E. 2009. The role of anadromous sea lamprey in nutrient and material transport between marine and freshwater environments. Am.Fish.Soc.Symp. 69: 485-494.
[36] Peterson E, R Thors, D Frechette, and JD Zydlewski. 2023. Adult sea lamprey approach and passage at the Milford dam fishway, Penobscot River, Maine, United States. North American Journal of Fisheries Management 43(4): 1052-1065.

conducted at the Milford fishway, a modern fish lift on the Penobscot River, is the best approximation of conditions for passage at Kennebec River dams. During the first year of the study, 41 of 50 (82%) of tagged sea lamprey that approached the project were successfully passed. Given that each of the four Kennebec River projects is anticipated to have a fish passage that will operate 24 hours per day during the sea lamprey passage season, MDMR expects that each facility will be able to achieve 80% upstream passage effectiveness. FERC calculated that it is possible to achieve 82.2% cumulative sea lamprey at these four projects, indicating the reasonableness of this standard.[37] More information or new modeling frameworks may be available in the future, but for now, MDMR relies upon available tagging data as the basis for this passage standard. For more information, please see Appendix 1 of MDMR's comments on the Shawmut DEIS[38]

Recommendation 6: After construction of new project infrastructure or changes in project operations that result in changes in project discharge (amount or location), Brookfield will reevaluate the location of eelway(s) to determine if eels continue to congregate near, and are able to enter, the existing eelway(s). This evaluation will consist of one or more years of siting studies[39] dependent on study results and environmental conditions. Study plans and timelines for siting studies must be submitted to DEP and approved by DEP. Brookfield must implement new eelways if necessary based on study results with approval from Maine DEP in consultation with MDMR. Allow for future process for eel performance standards to be developed and incorporated into the WQC.

A. No later than 6 months after the initiation of siting studies, Brookfield shall distribute a draft study results report to MDMR and DEP.
B. If the study finds that eels are not congregating near existing eelway(s) or eels are congregating in areas where eelway(s) are not present, Brookfield will develop a plan and, after approval from DEP, construct new eelway(s) that are expected to remedy the issues identified in the report. Unless another timeline is approved by DEP, the new eelway(s) will be constructed within 1 year of the initiation of siting studies.
C. If the study finds that eels are not able to enter the existing eelway(s), Brookfield will develop a plan and, after approval from DEP, make modifications to the existing eelway, develop new eelways, or modify associated nearby infrastructure that are expected to remedy the issues identified in the report. Unless another timeline is approved by DEP, the modifications will be completed within 1 year of the initiation of siting studies.
D. Brookfield may request to modify the study or implementation process above by providing DEP with revised plan and a rational that justifies the modification. If DEP approves of the request and plan, Brookfield can implement the proposed plan.

Justification: New or existing and untested eelways need to be tested to ensure that they are constructed, operating, and functioning as intended. There are multiple large-scale changes in discharge (amount and location) that are being proposed by Brookfield and MDMR at each project. Many of these changes are likely to result in large amounts of water (100s of cfs) being discharged in different locations and

---

[37] Accession Number: 20250228-3002.
[38] Accession Number: 20240604-5145.
[39] Siting Studies is defined here as nighttime visual observations below project spillways and other project works throughout the upstream eel season.

amounts than they are currently or have already changed due to the spill program and shutdowns. The USFWS minimum attraction water guidance for eel ramps is a mere 50 gallons per minute (~0.11 cfs), thus even miniscule changes in discharge can render previously constructed eelways ineffective. Further, the recommended studies are needed to confirm that the eelway is indeed passing representative size classes of eels compared to those present below the dam. In addition, an independent tag-recapture or PIT study is necessary to determine the proportion of tagged eels that can successfully find (i.e., approach) and pass the eelway to ensure that it is providing safe, timely, and effective passage. Eel performance standards could be developed in the future, which assist in quantifying impact and measuring performance.

Recommendation 7: Brookfield will design, construct, operate, and maintain a 0.75 inch or less, full depth, angled or inclined rack structure in the forebay within four years of license amendment approval at each project. The structures should be designed to meet USFWS guidelines (2019 or current version) including that normal velocities do not exceed two feet per second as measured at an upstream location where velocities are not influenced by the local acceleration around guidance structures. The structure shall include low level entrances to a downstream bypass system and provide guidance to a surface bypass location or locations.

Justification: Brookfield has proposed or is required to construct or maintain fish guidance boom systems and overlays that are intended to preclude downstream migrating fish from entrainment. However, many anadromous species may pass downstream at depth. A 1990 paper reported that adult American Shad were captured in the lower half of the water column 83% of the time when migrating upstream and downstream, and a 1987 and 1990 paper reported that adult Blueback Herring migrated at mid-water depth.[40,41] In addition, a 1982 paper that compared surface and bottom trawls for juvenile alosines found that the majority of alewife (98.5%) and American Shad (76.8%) and a large portion of Blueback herring (33%) were captured in bottom trawls.[42] In addition, downstream passage studies performed at West Enfield with Atlantic salmon smolts, adult river herring, adult American shad, and juvenile river herring demonstrate that these fish either approach the project at depth or sound down more than 15 feet to reach the submerged entrance of the entrance rack, which starts at 15 feet below normal headpond. The results of these studies are as follows:

- 2016: 49.4% of smolts were entrained
- 2017: 57% of smolts were entrained
- 2018: 26% percent of smolts, 16% of adult river herring, and 13% of adult American shad were entrained[43]
- 2019: 99% of juvenile river herring were entrained

Data provided by Brookfield in the (SPP, Table 5-1) demonstrates that the guidance booms used at the Lockwood, Hydro-Kennebec, and Weston Projects do not guide 14.3-30.6% of the migrating smolts away from the turbines. Data provided by Brookfield (FLA, Table 4-22) shows that 32.7% of the downstream migrating smolts were entrained into the turbines at the Shawmut Project and the

---

[40] Witherall, D. B. and B. Kynard. 1990. Vertical distribution of adult American shad in the Connecticut River. Transactions of the American Fisheries Society. 119: 151-155.

[41] Witherall, D. B. 1987. Vertical distributions of adult American shad and blueback herring during riverine movement. Master's thesis. University of Massachusetts, Amherst.

[42] Loesch, J. G., W, H. Kriete, Jr., and E. J. Foell. 1982. Effects of light intensity on the catchability of juvenile anadromous Alosa species. Transactions of the American Fisheries Society 111:41-77.

[43] These entrainment values would have likely been higher but flashboard damage during the study period caused spill conditions that don’t normally occur.

instantaneous survival was 7% lower when fish went through the turbines compared to spill routes at Shawmut. This grossly underestimates the sublethal effects, including injury and disorientation, that would result in higher mortality in the estuary (latent mortality). Furthermore, this analysis does not account for all causes of mortality through a hydroelectric project, including mechanical damage, pressure-induced damage, shearing action damage, and cavitation damage[44]. Studies at the Ellsworth dam on the Union River assessing injury to salmon showed that 22-30% of fish that went through the turbines had injuries compared to 3.8% that went through spill routes, demonstrating that impact quantitatively. The 2015 Evaluation of Downstream Passage for Adult and Juvenile River Herring demonstrated that 53 percent of the study fish went through the Lockwood turbines, rather than being guided by the boom to the downstream bypass, and survival was lowest for those fish passing Lockwood via the units (i.e., 77.4-81.7% survival).[45] In their comments on the proposed downstream alternatives for the West Enfield project (P-2600), USFWS summarized effectiveness of guidance booms on the Kennebec River, at the Lockwood and Weston projects (both project had the bypass operating at greater than 5% of station capacity and the panels of the booms are rigid and extend 10 feet below the water surface), and concluded “the boom does not provide safe, timely, and effective passage for the Service’s trust species and does not comport with our most up to date design criteria.”[46] They noted that inefficiencies associated with guidance booms may be due to downward velocities that are produced by the panels themselves, as presented by Mulligan et al. 2017 [47].

The anticipated guidance structures at the project are unlikely to prevent or significantly reduce entrainment of adult river herring, juvenile alosines, and juvenile sea lamprey. Adult river herring are more likely to migrate downstream past the Lower Kennebec Projects during the summer months (July-September) when average flows are not likely to result in spill at the project. During this time the majority of river flow would be going through the turbines in a typical year. Adult river herring would typically migrate downstream in proportion to the ratio of flow provided at each passage route. With an ineffective boom system (see previous paragraph) and large spaced trash rack overlays that do not provide further guidance, these fish will fit right through the trash racks and pass through the turbines resulting in significant injury and mortality. This issue is even more pronounced for smaller juvenile alosines, which have decreased swimming abilities and are even more likely to follow proportional flow paths at the project. Thus, under the current proposal, there is minimal to no protection for these fish to prevent them from being entrained in the project turbines, which have been documented as the passage route with the highest mortality. Even fish that cannot pass through the trash rack overlays (i.e., adult American shad) may experience severe impingement due to relatively high intake velocities and no guidance additional guidance to downstream passage routes once they have passed downstream of the guidance boom. A 2020 study found that Juvenile American shad were more susceptible to both fluid shear and rapid decompression associated with passage through hydropower turbines than Chinook salmon with injuries such as scale loss, damage to the eyes and operculum, and damage or rupture of the

[44] Pflugrath BD, RK Saylor, K Engbrecht, RP Mueller, JR Stephenson, M Bevelhimer, BM Pracheil, and AH Colotelo. 2020. Biological Response Models: Predicting injury and mortality of fish during downstream passage through hydropower facilities. PNNL-30893.
[45] Accession Number. 20160331-5144
[46] Accession Number: 20211217-5213.
[47] Kevin Brian Mulligan, Brett Towler, Alex Haro, David P. Ahlfeld, A computational fluid dynamics modeling study of guide walls for downstream fish passage, Ecological Engineering, Volume 99, 2017, Pages 324-332, ISSN 0925-8574, https://doi.org/10.1016/j.ecoleng.2016.11.025.

swim bladder.[48] And the authors go on to say, "When compared to other fish species, American shad are highly susceptible to fluid shear and rapid decompression."

The current proposal would also be ineffective for American eel. American eels typically approach hydroelectric projects in the lower portion of the water column and therefore would not be effectively guided by floating booms. The USFWS Fish Passage Design Criteria provides very specific guidance around floating booms:

> "A floating guidance system for downstream fish passage is constructed as a series of partial depth panels or screens anchored across a river channel, reservoir, or power canal. These structures are designed for pelagic fish which commonly approach the guidance system near the upper levels of the water column. While full-depth guidance systems are strongly preferred, partial-depth guidance systems may be acceptable at some sites (e.g., for protection of salmonids, but not eels)."[49]

American eels are also highly likely to fit through the currently proposed trash rack overlays. In addition to these issues, the current proposal does not provide any new low-level bypasses, which will result in increased delay (i.e., time spent searching for downstream passage) and increase the likelihood of entrainment. Providing effective low-level bypass facilities would reduce delay and promote passage effectiveness for this bottom-oriented species. Downstream passage facilities such as weirs (surface or bottom opening) and flumes have been incorporated at many dams to mitigate the effects of turbine mortality.[50] A 2003 paper found that eels presented with surface and bottom opening bypass weirs preferred the bottom bypass (94%).[51] A study in 2008 of silver eel passage at a hydroelectric project on the Magaguadavic River in New Brunswick found only 21% of tagged eels used a new surface bypass weir, 11 percent passed safely by other routes and the remaining silver eels entered the turbines soon after encountering this route and died, as evidenced by cessation of movement.[52]

Broadly, the current proposal will result in adverse impacts to these species and will not be conducive to producing self-sustaining runs above these projects if further measures are not required. USFWS has summarized passage data on guidance booms in a filing.[53] The data in their summary demonstrates that guidance booms do not meet current USFWS design criteria, nor do they provide safe, timely, and effective passage for many species. The FERC FEIS analysis and assumptions demonstrate that turbine passage would be significantly higher with the current action compared to MDMR's recommendation of full depth 0.75-inch angled racks and appropriate bypass facilities (including low-level bypasses for eels) at each project. FERC's analysis estimated that 0.75-inch full depth screening would eliminate turbine entrainment for Atlantic salmon kelts, adult river herring, and American eels and significantly reduce entrainment for Atlantic salmon smolts and juvenile alosines compared to the proposed action. While

---

[48] Pflugrath, B. D., Harnish, R. A., Rhode, B., Engbrecht, K., Beirao, B., Mueller, R. P., ... & Colotelo, A. H. (2020). The susceptibility of Juvenile American shad to rapid decompression and fluid shear exposure associated with simulated hydroturbine passage. *Water*, *12*(2), 586.

[49] USFWS (U.S. Fish and Wildlife Service). 2019. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.

[50] Shepard, S.L. 2015. American eel biological species report. Supplement to: Endangered and Threatened Wildlife and Plants; 12-Month Petition Finding for the American Eel (Anguilla rostrata) Docket Number FWS-HQ-ES-2015-0143. U.S. Fish and Wildlife Service, Hadley, Massachusetts. xii +120 pages.

[51] Durif, C., P. Elie, C. Gosset, J. Rives, and F. Travade. 2003. Behavioral study of downstream migrating eels by radio-telemetry at a small hydroelectric power plant. Pages 343–356 in D.A. Dixon, editor. Biology, management, and protection of catadromous eels. American Fisheries Society Symposium 33. Page 350.

[52] Carr, J. W., and F. G. Whoriskey. 2008. Migration of silver American eels past a hydroelectric dam and through a coastal zone. Fisheries Management and Ecology 15(5– 6):393–400. Page 396–398.

[53] Accession Number: 2021217-5213

trash rack overlays with 1-inch clear spacing or less have been installed at some projects, testing has shown that those measures do not adequately reduce entrainment. For example, 1-inch clear spaced racks were installed at the Mattaceunk Project on the Penobscot River in 2023 and tested in 2024. Testing found the majority of eels used the roll gate to pass the project during the daily shutdown times, however all eels that passed outside of the daily shutdown times passed via the turbines and were therefore not deterred by 1" racks.[54]

Thus, MDMR continues to recommend that all project passage measures comport with the USFWS Fish Passage Design Criteria (2019 or current version) and based on those criteria, we recommend screening all operating turbines with angled, full-depth bar racks with a clear space less than or equal to 0.75-inches.

Recommendation 8: Develop and implement a plan to install, maintain, and report on counts of each species of fish that enter and pass each project each year. The plan shall detail the approach for counting fish at each project, the resolution of data for counts, details on other data that will be provided (E.g. operations data), and shall be submitted to DEP prior to commencement of construction of passage measures. The plan must be approved by DEP and counts must be carried out in the first passage season in which new passage measures are operated at a given project.

Justification: Fish counts are crucial to monitor fish populations throughout the license term, particularly when the applicant is not conducting passage studies. Anomalously low counts could be indicative of changes to operational or structural conditions that have negatively impacted fish passage in a specific year. Any detrimental changes in project conditions may go unnoticed without the information provided by counts.

Recommendation 9: Brookfield shall develop a Fishway Operation and Maintenance Plan (FOMP) for each of the four projects, the Lockwood, Hydro Kennebec, Shawmut, and Weston projects. Within 12 months of FERC's issuance of a subsequent license or license amendment for each Project, Brookfield shall submit a FOMP to DEP for approval in consultation from MDMR and in coordination with FERC requirements. Brookfield shall keep the FOMP updated on an annual basis to reflect any changes in fish passage operations and maintenance planned for the year. The annual FOMP shall include general schedules and procedures for:

A. Operation and maintenance of existing or anticipated new fishways, including the method and calculations for provision of any required flows;
B. Inspection and monitoring of the fishway facilities, including regular observation of facilities and periodic trash rack inspections;
    i. Standards for temporary suspension or other changes to fishway operations due unplanned (e.g., unusual weather events such as ice conditions) or planned (e.g., maintenance) circumstances upon approval by DEP;
    ii. Replacement of flashboards and limiting leakage within 3 days after river flow is within the hydraulic control of the powerhouse, or within such longer period as is necessary to account for worker safety concerns;
    iii. Brookfield shall conduct an annual inspection of the trash racks to ensure proper spacing and to check for damage and functionality;
    iv. A schedule for routine fishway maintenance to ensure the fishways are ready for

[54] Accession Number: 20250331-5471.

operation at the start of the migration season;

v. Procedures for seasonal upstream and downstream fishway operations;

vi. Procedures for monitoring and reporting on the operation and maintenance of the facilities as they affect fish passage;

vii. If DEP, at its discretion, or in consultation with MDMR, request a modification of the FOMP, Brookfield shall amend the FOMP within 30 days of the request and send a copy of the revised FOMP to the DEP, MDMR, and the Commission. Further, any modifications to the FOMP by Brookfield require the approval of DEP, in consultation with the MDMR, prior to implementation and prior to submitting the revised FOMP to the Commission for its approval; and

viii. Brookfield shall provide information on fish passage operations and project generating operations that may affect fish passage, upon written request to DEP or MDMR. Such information shall be provided within 10 calendar days of the request, or upon a mutually agreed upon schedule.

Brookfield shall prepare a Fishway Operation and Maintenance Report (FOMR) and submit it to the DEP and MDMR by January 31 each year following the completion of fishway construction. The FOMR shall be in letter report format and shall include a summary of the current state of the fishways (structures, flows, etc.), a yearly fishway operation and maintenance report (deviations, issues, timing of installation, etc.), and summary data on the flows (e.g., high flow events) and generation experienced (e.g., non-operational periods) at the Project throughout the year. Additionally, FOMR should include information regarding Brookfield's annual inspection of the trash racks.

Justification: Annual documentation of the operation and maintenance at new or existing fishways is needed to ensure they are constructed, operating, and functioning as intended. There are multiple large-scale changes that are being proposed by Brookfield and MDMR at each project. Many of these changes will alter each project's operation and maintenance schedules and therefore passage efficacy and fish survival rates. The recommended annual FOMP and FOMR will help Brookfield reach performance standards and identify issues at each Project.

<u>Recommendation 10</u>: Brookfield, following approval from DEP in consultation with MDMR, shall implement the following process for the design of all new fish passage measures at the four projects, which include Lockwood, Hydro Kennebec, Shawmut, and Weston projects. Brookfield shall develop, design, and submit plans to DEP for review and approval, in consultation with MDMR at 30%, 60%, 90% design stages, and final designs (if fish design is already in progress, the latest design stage for review). DEP and MDMR shall have 30 days to review and comment on any submitted design drawings. Designs shall be consistent with the Service's Engineering Criteria (USFWS 2019) or other updated versions or guidance, as determined by DEP. Brookfield shall submit final design plans, approved by the DEP in consultation with MDMR, to the Commission for approval prior to the commencement of fishway construction activities. Once the fish passage measures are installed, final as-built drawings that accurately reflect the Project as constructed shall be filed with DEP and MDMR, and the Commission.

Justification:
Design coordination and approval from DEP is critical through the licensing term to ensure all new fish passage measures will result in safe, timely, and effective fish passage at the Projects. The staged review

allows for multiple opportunities for Brookfield, DEP, and MDMR to develop designs to meet Project performance standards and follow USFWS Fish Passage Design Criteria (2019 or current version).

Recommendations for Specific Projects

Lockwood

Lockwood Recommendation 1: Brookfield shall implement the following measures, including the development of a comprehensive adaptive management plan with DEP approval that outlines clear steps and timelines for implementation and testing of passage measures at the Lockwood Project. Should the Lockwood Project facilities fail to achieve any of MDMR's performance standards, the plan will include a timeline for the implementation of additional measures. For the Lockwood project this will include the following measures and milestones:

a. Brookfield will construct, operate, and maintain a volitional fishway with an auxiliary water supply spillway in the bypass within 3 years of license amendment approval.
b. Brookfield will construct, operate, and maintain crest gates in the bypass reach adjacent to the volitional fishway capable of conveying spill flows during nighttime shutdowns required under NOAA's Biological Opinion[55] or a minimum of 20% of station capacity, whichever is greater, within 3 years of license amendment approval.
c. Brookfield will construct a flume to connect the existing fish lift to the headpond within 4 years of license amendment approval.
d. Brookfield will design, construct, operate, and maintain a 0.75-inch or less, full depth, angled or inclined rack structure in the forebay within 4 years of license amendment approval. The structure should be designed such that normal velocities do not exceed two feet per second as measured at an upstream location where velocities are not influenced by the local acceleration around guidance structures. The structure shall include low level entrances to a downstream bypass system and provide guidance to the existing forebay surface sluice or a new surface bypass location. MDMR supports Brookfield's proposal to install a uniform acceleration weir in the surface sluice.
e. Effectiveness testing to assess survival, injury, and delay in upstream and downstream passage shall be implemented by Brookfield in the first downstream fish passage season and the second upstream fish passage season following installation of Lockwood Recommendation measures a, b, c, and d. Atlantic salmon testing will be coordinated with federal agencies. Brookfield will prepare study plans for effectiveness testing for Atlantic salmon, shad, alewife, blueback herring, American eel, and sea lamprey and distribute draft plans to MDMR and DEP for review and for approval by DEP no later one year prior to the start of the passage season in which the study will be conducted. The study plans will include appropriate measures for testing to determine if the project meets the applicable performance standards.
    a. These initial studies may be limited to specific species and life stages, with approval from DEP, to prevent delay of potential modifications. However, the facilities will need to be tested for all species and life stages on a timeline approved by DEP.
    b. No later than 8 months after the initiation of effectiveness testing, Brookfield shall distribute a draft study results report to MDMR and DEP. If performance standards have not been achieved, Brookfield will consult with MDMR and DEP within 30 days of

[55] Accession Number: 20230320-5179.

distribution of the effectiveness testing report to review study results and identify areas of deficiency.

f. If performance standards have not been achieved, but the results are close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield can implement minor operational or structural modifications to address the deficiency as approved by DEP and retest the facility as described in measure e or as determined by DEP. .
g. If upstream and/or downstream performance standards have not been achieved, and the results are not close (not within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield shall construct additional measures no later than 3 years after the distribution of the effectiveness testing report. The specific measures shall be selected by DEP from Table 1 for the Lockwood Project in consultation with MDMR and Federal Resource Agencies to address areas of deficiency at the project. If the area(s) of deficiency are uncertain (E.g. due to lack of resolution of data from testing), an adequate number of measures will be selected by DEP and constructed by Brookfield to address all potential areas of deficiency on a timeline defined by DEP.
h. Brookfield may propose alternative adaptive measures. If DEP determines that any alternative proposed measure or combination of alternative proposed measures from Brookfield is likely to achieve the performance standard and approves the timeline of implementation of the measure, Brookfield can implement that/those proposed measure(s).
i. Once Brookfield has implemented DEP's required measures, Brookfield will repeat steps e-i of this adaptive management plan until deficiencies have been addressed. This includes the potential design and development of new or replacement fishways that could achieve these standards.

Table 1: Adaptive Management Measures for Lockwood Project

Target Area	Adaptive Management Measure
Upstream passage- Fishway entrance	• Construction, modification, and/or addition of entrance(s) to either the fish lift or volitional fishway
Upstream passage- Internal fishway	• Operational or structural modifications of fishway(s) (e.g., lift frequency, baffle modifications, and entrance gate positions), which may include associated structural modifications. • Adjust flow within the fishway to address hydraulic concern and/or seasonal species-specific passage needs • Addition or modification of fallback prevention devices (e.g., weirs, baffles, trap gates, etc.). • Reconstruction, replacement, or modification of attraction water system to either the fish lift or the volitional fishway to include building an alternative system (E.g. palisade, wall diffuser, etc.) • Redesign and replace one of the upstream fishways determined to be deficient.

Upstream passage- Nearfield attraction	• Construction of additional crest or other spillway gates. • Construction or modification of the tailwater area downstream of the crest gates and river right of the volitional fishway. • Modification to fishway entrance location(s).
Downstream passage-	• Construction of a new downstream fish bypass facility. • Construction of additional crest gates or other spillway gates and/or other modifications to the spillway. • Modifications to the downstream existing bypass facility. • Installation of a uniform acceleration weir in entrance to downstream bypass. • Increase the downstream attraction flow of downstream bypasses up to 20% of hydraulic capacity.

Justification:

Upstream Fish Passage: As the lowermost dam on the river, safe, timely, and effective volitional upstream fish passage at the Lockwood Project is essential. MDMR agrees with FERC's findings related to continued operation of the fish lift and need for 24 hour operations. Summer low flows at the Lockwood project will continue to result in most of the water moving through the turbines and drawing fish to the fish lift and away from the new volitional fishway. Under these lower flow conditions, fish are more likely to attempt passage at the fish lift. During June and July, when river temperatures do not allow handling of salmon, it will be especially important to have the ability to capture salmon in the fish lift and allow them to volitionally swim upstream. This would also reduce handling stress on river herring and American shad. Based on fish passage timing and flow duration curves, river flow exceeds the maximum powerhouse capacity of 6,236 cfs approximately 65% of the time in May, 48% of the time in June, and 20% of the time in July. Due to this shift if flows, the attraction to the fish lift increases as the migration season progresses. Given the expected increase in fish numbers due to new upstream passage and varying attraction flows, the Lockwood fish lift will become a bottleneck for river herring if not converted to a swim-through facility. Currently and into the future, not all fish can be moved at the current fish lift as it is not connected to the headpond and cannot be operated at night when trap and truck operations cannot be carried out safely.[56] Additionally, the fish lift cannot currently operate 24

[56] There are several limitations, drawbacks, and impacts to fish that are inherent to a trap and haul passage approach. For these reasons, MDMR believes trap and haul should be precluded from being considered as a permanent solution.

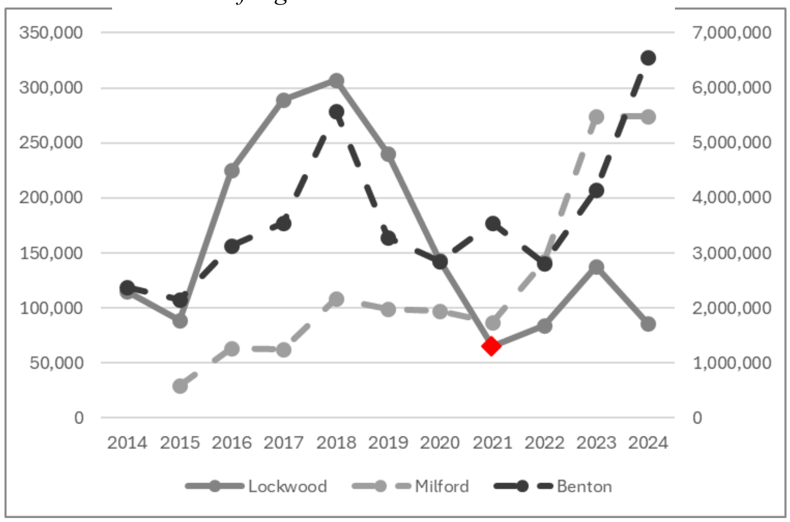
hours a day given trucking constraints for sea lamprey[57] and other nocturnal migrants[58]. The FERC Final EIS staff alternative requires Brookfield to operate all upstream anadromous fishways 24 hours per day from May 1 to June 30 for sea lamprey passage (instead of 12 hours as proposed). This would necessitate the inclusion of the flume connection to the headpond to ensure this requirement can be achieved given the above safety and logistical constraints of reliance on trap and haul for 24 hours. Additionally, Brookfield has proposed to operate the secondary fishway (Denil) at Milford Dam on the Penobscot River 24-hours a day through the fish passage season to reduce migratory delay for Atlantic salmon (pers. comm. Dan Tierney, NMFS), demonstrating that it is a reasonable measure to achieve performance to have two fishways operating 24 hours.

There is a fish capacity issue at the fish lift that necessitates completion of the flume. The holding capacity of the fishway is limited to three tanks and fish passage is reliant on staff to transport fish upstream. When the tanks are full and staff are not able to transport fish from Lockwood, fish are sluiced back downstream of the project.[59] This limited capacity increases delay and mortality because fish are forced to attempt to pass the Lockwood project even if they were already successful in finding the fish lift. This can be particularly impactful at high water temperatures. Fishway effectiveness is also reduced if fish cannot pass. Without swim-through passage, this bottleneck would need to be alleviated through an extensive, long-term trap and transport program, which is not supported by MDMR nor conducive to FERC requirements to operate the fishway for 24 hours per day. Brookfield has already developed a design for the flume connection as stated in their 2016 ISPP Annual Report[60]. It is reasonable and prudent to construct this flume as currently designed. It is not prudent to continue to operate a terminal fishway indefinitely.

Due to the complicated nature of the Lockwood Project the new upstream passage facilities will be impacted by the current nighttime shut down measures (typically beginning the last week of April and lasting 38-35 days) to protect out-migrating smolts. The nighttime shutdown measures overlap with the peak of the river herring upstream migration and has resulted in decreased passage efficiency of river herring. The potential extension of these nighttime shutdowns to up to 54 days, would further impact river herring and American shad upstream passage. These impacts are documented through counts at the Lockwood Project for river herring and American shad, which have both decreased when compared to previous years at Lockwood and to other projects in Maine (Figure 1). To ensure safe, timely, and effective passage of both river herring and smolts, Brookfield will need to utilize new crest gates and attraction water channel for the volitional fishway to manage spill flows in a way that will promote attraction to the fishway during the nighttime shutdowns and high flows.[61] By raising flashboards prior to the upstream migration season and utilizing the crest gates to direct flow to pass adjacent to the new volitional fishway in the bypass, Brookfield can improve far- and near-field attraction during the night time shutdowns and high flows during the upstream migration season.

[57] Peterson E, R Thors, D Frechette, and JD Zydlewski. 2023. Adult sea lamprey approach and passage at the Milford dam fishway, Penobscot River, Maine, United States. North American Journal of Fisheries Management 43(4): 1052-1065.
[58] Grote, A. B. , M. M. Bailey, J. D. Zydlewski, and J. E. Hightower. 2014. Multibeam sonar (DIDSON) assessment of American Shad (Alosa sapidissima) approaching a hydroelectric dam. Canadian Journal of Fisheries and Aquatic Sciences. 71: 545-558.
[59] Fish are also sluiced back downstream on weekends and holidays if staff are not available.
[60] Accession Number: 20170331-5212
[61] Accession Number: 20230320-5179.

Figure 1:River Herring captured at Lockwood Dam (primary axis) and Milford and Benton Dams (secondary axis). Red diamond indicates the start of nighttime shutdowns at Lockwood.



Downstream Fish Passage: To ensure safe, timely, and effective downstream passage, Brookfield has initiated nighttime turbine shutdowns to reduce the likelihood of entrainment of out-migrating smolts. While these shutdowns may achieve the intended 97% of smolt out-migration, it fails to provide similar protection for river herring, American shad, American eels, and sea lamprey due to their migration timing (Supplemental Table 1). For example, the annual timing of these shutdowns relies on either 1) trapping of wild smolts in the watershed or 2) a smolt timing model that relies on air temperature in upstream rearing habitat for the first 90 days of a given year as a predictor of smolt migration timing. The proposed downstream passage measures fail to include actions that will reduce entrainment and other impacts during downstream passage for most diadromous species.[62]

In an additional effort to guide downstream migrants away from the turbines, Brookfield is operating a floating guidance boom. However, the *2015 Evaluation of Downstream Passage for Adult and Juvenile River Herring* demonstrated that 53% of the study fish went through the Lockwood turbines, rather than being guided by the boom to the downstream bypass, and survival was lowest for those fish passing Lockwood via the units (i.e., 77-4-81.7% survival).[63] This would indicate that performance standards would not likely be met with the current guidance boom.

As alosines migrate downstream when river flows are below station hydraulic capacity, FERC's survival estimate for alosines assumed they would only be able to pass the project through the surface bypass or through the powerhouse. FERC assumed that the guidance boom would be as effective for alosines as it is at guiding smolts (i.e. 59%) and that alosines would pass through each of the turbines at the same proportion as smolts did during the 2012–2014 study. However, FERC's assumption that the guidance boom would have the same efficacy for river herring as smolts is not based on any known information. On the contrary, the 2015 adult river herring study at Lockwood documented that 32% of study fish were guided by the boom, while the remaining fish swam under the boom. In their comments on the proposed downstream alternatives for the West Enfield project (P-2600), USFWS summarized effectiveness of guidance booms on the Kennebec River, at the Lockwood and Weston projects (both project had the bypass operating at greater than 5% of station capacity and the panels of the booms are rigid and extend 10 feet below the water surface), and concluded "the boom does not provide safe, timely, and effective passage for the Service's trust species and does not comport with our most up to date design criteria."[64] They noted that inefficiencies associated with guidance booms may be due to downward velocities that are produced by the panels themselves, as presented by Mulligan et al. 2017 [65]

[62] Accession Number: 20230320-5179 p.193-196.
[63] Accession Number. 20160331-5144
[64] Accession Number: 20211217-5213.
[65] Kevin Brian Mulligan, Brett Towler, Alex Haro, David P. Ahlfeld, A computational fluid dynamics modeling study of guide walls for downstream fish passage, Ecological Engineering, Volume 99, 2017, Pages 324-332, ISSN 0925-8574, https://doi.org/10.1016/j.ecoleng.2016.11.025.

Similarly, to improve downstream passage survival Brookfield has proposed installing 2-inch trash rack overlays to protect out-migrating salmon kelts. The overlays are perpendicular to the flow and therefore provide no guidance to safe passage routes. The proposed screening approach will physically prevent some larger fish from entrainment but will not exclude the majority of fish (all juvenile and some adult alosines, American eels, and Atlantic salmon smolts) from turbine passage.[66] In the FEIS FERC makes the assumption that any species that has the swimming ability to overcome the approach velocity in front of the trash racks will do so and would therefore not become entrained. The information we presented in the preceding paragraphs shows that this assumption is incorrect and as noted by FERC "there is no data on any potential behavioral deterrence for alosines that may be provided by the 2-inch narrower bar spacing."[67] Therefore the proposed measure provides no guidance to a downstream bypass and there is no information that the measure provides any behavioral deterrence. These deficiencies coupled with relatively high velocities, 2.95 cfs upstream of the intake structure, and the majority of station flow passing through this route has a very high likelihood of causing high rates of entrainment and impingement.

FERC's proposal in the FEIS does include continuing to operate the "deep canal drain gate (herein referred to as the "forebay deep gate") next to Unit 1 at an opening of 1.5 feet, to pass approximately 300 cfs, from August 15 to October 31 for 8 hours per night for eel passage." However, this downstream measure is limited, I.e. 8 hours per night, in comparison to the potential downstream migration period for American eel, which also is known to vary depending on the timing of increasing river discharge and decreasing water temperatures which vary greatly year to year.[68]. The Applicant does not propose any measure(s) to document annual downstream migration timing for American eels or to adjust the timing of the proposed measure to ensure it covers the American eel downstream outmigration, as they have proposed for the smolt spill measure. Finally, the proposed measure, opening the forebay deep gate to convey 300 cfs or 5% of station unit flow, does not include any guidance to the forebay deep gate. As we have seen from other projects, providing a dedicated downstream facility is one part of effective downstream passage and the second part is providing guidance to that downstream passage facility. Without guidance, the best-case scenario is that the proportion of downstream migrants that find the downstream bypass facility is equal to the proportion of flows, E.g. 5% of migrants would find the facility if 5% of flow is provided and the remaining 95% of migrants would migrate via the turbines.[69] However, some studies have shown the American eels follow the bulk of flow during their downstream migration and in this scenario, again with no guidance proposed, most if not all downstream migrating adult American eels would pass via the turbines as the location with the overwhelming bulk of flow.

The FERC Final EIS analysis and assumptions demonstrate that the proportion of fish that pass the project through the turbines would be significantly higher with the current action compared to MDMR's recommendation of full depth 0.75-inch angled racks and appropriate bypass facilities (including low-level bypasses for eels). FERC's analysis estimated that 0.75-inch full depth screening would eliminate turbine entrainment for Atlantic salmon kelts, adult river herring, and American eels and significantly

---

[66] Accession Number: 20250228-3002; Table 0-2 Minimum sizes of diadromous fishes physically excluded from trash racks under six different spacing alternatives.

[67] Accession Number: 20250228-3002. Page 83.

[68] Weaver, D.M., Sigourney, D.B., Delucia, M.B. and Zydlewski, J.D., 2021. Characterizing downstream migration timing of American Eels using commercial catch data in the Penobscot and Delaware rivers. *Marine and Coastal Fisheries*, *13*(5), pp.534-547.

[69] Jansen, H. M., Winter, H. V., Bruijs, M. C., & Polman, H. J. (2007). Just go with the flow? Route selection and mortality during downstream migration of silver eels in relation to river discharge. ICES Journal of marine Science, 64(7), 1437-1443.

reduce entrainment for Atlantic salmon smolts and juvenile alosines compared to the proposed action. In the DEIS, FERC noted the advantages of an angled rack over the proposed measures. Specifically, they summarized data from studies at the Stillwater A and Orono A Projects that showed that 1-inch spaced trash racks coupled with a surface bypass operating at 5% of Station Unit Flow reduced the entrainment rate of smolts to 6.6% (Brookfield, 2022).[70]

The USFWS Fish Passage Engineering Design Criteria (2019) would recommend replacing the floating boom with a full depth guidance structure.[71] The cited USFWS Design Criteria is based on the best available scientific information on safe, timely, and effective passage diadromous species in Atlantic Coast rivers and streams. Without these modifications, achievement of performance standards and/or safe passage for American eels is unlikely to occur.

Adaptive Management: Effectiveness testing is critical to ensure that the proposed measures at Lockwood are consistent with the designated uses of the Kennebec River and MDMR's goals for diadromous species native to the watershed. If effectiveness testing shows that the proposed measures fail to meet passage standards, adaptive management will ensure improvements are made to upstream and/or downstream fish passage to meet watershed goals. The specific measures identified in Table 1 seek to provide a suite of solutions that have been effective on similar projects in the northeast. This approach and the measures identified closely align with the approach of NMFS, who, in their Biological Opinion, anticipated that performance standards may not be achieved immediately with the proposed construction, and additional operational and structural modifications (such as increasing attraction flow, installing additional entrances, or constructing new fishways) may be necessary. Brookfield's proposed adaptive management of its upstream fishways include the development and implementation, in consultation with NMFS, of "additional operational or infrastructure measures, as reasonable and practicable, that are likely to meet or exceed the upstream performance standard." As such, Brookfield's proposal does not appear to preclude any modifications necessary to achieve its proposed upstream passage standards. While the FERC FEIS did not require testing of all the species, it does require the development of an adaptive management and monitoring plan that includes: (1) procedures for fishway effectiveness testing, (2) a description of a hatchery salmon stocking program to use in effectiveness testing, and (3) a framework and schedule for identifying and selecting adaptive management measures if Brookfield fails to achieve salmon passage effectiveness standards at any of the projects.

To reduce the negative impacts of dam on downstream moving fish, well-performing downstream passage systems that consider not only current requirements regarding design, dimensioning and location, but also the site-specific conditions and fish species, must be tested and modified to provide optimal performance. The proposed measures are the best scientific and technical solutions common to species in the northeast and utilize USFWS (2019) passage criteria.

Therefore, given that the licenses will require that these standards be achieved and given the breadth of the adaptive management protocol, we expect that the proposed actions, combined with effective

[70] Accession Number: 20250228-3002. In the FEIS FERC assumed that new 0.75-inch trash racks would be at least as effective at guiding smolts as 1-inch-spaced trash racks were at these projects, and determined that new 0.75-inch trash racks would reduce powerhouse entrainment from 28.1% to 6.6% for Atlantic salmon smolts. With Brookfield's other proposed improvements to the bypass and FERC's assumed survival rates, FERC estimated that smolt survival with new 0.75 inch trash racks would be about 96.7% (table 3-56 of FEIS).

[71] USFWS (U.S. Fish and Wildlife Service). 2019. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.

adaptive management of the fishways will achieve high passage efficiencies and low passage delays consistent with the standards outlined in Brookfield's proposal and those recommended by MDMR.

Hydro- Kennebec

Hydro-Kennebec Recommendation 1: Brookfield shall implement the following measures, including the development of a comprehensive adaptive management plan with DEP approval that outlines clear steps and timelines for implementation and testing of passage measures at the Hydro-Kennebec Project. Should the Hydro-Kennebec Project facilities fail to achieve any of MDMR's performance standards, the plan will include a timeline for the implementation of additional measures. For the Hydro-Kennebec dam this will include the following measures and milestones:

a. Brookfield will design, construct, operate, and maintain a 0.75-inch or less, full depth, angled or inclined rack structure in the forebay within 4 years of license issuance. The structure should be designed such that normal velocities do not exceed two feet per second as measured at an upstream location where velocities are not influenced by the local acceleration around guidance structures. The structure shall include low level entrances to a downstream bypass system. MDMR supports Brookfield's proposal to relocate and modify the surface bypass gate to pass at least 5% of Station Unit Flow and include a new uniform acceleration weir. MDMR recommends that the new full-depth trash racks extend to the downstream edge of the relocated bypass gate to ensure adequate guidance for downstream migrants.
b. Effectiveness testing to assess survival, injury, and delay in upstream and downstream passage shall be implemented by Brookfield in the first downstream fish passage season and the second upstream fish passage season following installation of Hydro Kennebec recommend measure a. Atlantic salmon testing will be coordinated with federal agencies. Brookfield will prepare study plans for effectiveness testing for Atlantic salmon, shad, alewife, blueback herring, American eel, and sea lamprey and distribute draft plans to MDMR and DEP for review and for approval by DEP no later one year prior to the start of the passage season in which the study will be conducted. The study plans will include appropriate measures for testing to determine if the project meets the applicable performance standards.
    a. These initial studies may be limited to specific species and lifestages, with approval from DEP, to prevent delay of potential modifications. However, the facilities will need to be tested for all species and life stages on a timeline approved by DEP.
    b. No later than 8 months after the initiation of effectiveness testing, Brookfield shall distribute a draft study results report to MDMR and DEP. If performance standards have not been achieved, Brookfield will consult with MDMR and DEP within 30 days of distribution of the effectiveness testing report to review study results and identify areas of deficiency.
c. If performance standards have not been achieved, but the results are close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield can implement minor operational or structural modifications to address the deficiency as approved by DEP and retest the facility as described in measure c or as determined by DEP. .
d. If upstream performance standards have not been achieved, and the results are not close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield shall construct the following measures no later than 4 years after the distribution of the effectiveness testing report:

a. Design, construct, operate, and maintain a second fishway.
b. Construct, operate, and maintain attraction flow channel(s) that discharge in the vicinity of the fishway entrance(s) and are capable of conveying the amount of spill flows required under NOAA's Biological Opinion[72] or a minimum of 20% of station capacity, whichever is greater.
c. Modifications to the fish lift including the entrance gate, internal infrastructure and/or attraction water system.
d. Modifications to the spillway including: installation of new spillway gates or rubber dam type infrastructure to manage flow during the upstream passage season.

e. If downstream performance standards have not been achieved, and the results are not close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield shall construct the following measures no later than 3 years after the distribution of the effectiveness testing report:
    a. Construction of a new downstream fish bypass facility with low level entrances and surface entrance(s). The surface entrance(s) shall include uniform acceleration weir(s).
    b. Construction of additional crest gates or other spillway gates.
    c. Modifications to the downstream existing bypass facility.
f. Brookfield may propose alternative adaptive measures from the list below or as identified by Brookfield. If DEP determines that any alternative proposed measure or combination of alternative proposed measures from Brookfield is likely to achieve the performance standard and approves the timeline of implementation of the measure(s), Brookfield can implement that/those proposed measure(s).
    b. Additional Adaptive Upstream Measures could include:
        i. Construction of additional fishway entrance(s).
        ii. Modification to fishway entrance location(s).
        iii. Modification of spillway infrastructure.
    c. Additional Interim Adaptive Downstream Measures include:
        i. Construction of a new downstream fish bypass facility.
        ii. Modifications of spillway infrastructure.
g. Once Brookfield has implemented DEP's required measures, Brookfield will repeat steps b-g of this adaptive management plan until deficiencies have been addressed. This includes the design and development of new or replacement fishways that could achieve these standards.

Justification:

Downstream Passage: The existing downstream passage facility at the Hydro-Kennebec Project consists of a 10-foot-deep floating angled guidance boom that guides fish to a deep-gated surface bypass weir with a hydraulic capacity of 320 cfs (4% of station hydraulic capacity), which discharges into a plunge pool and then flows to the tailwater area. Under current operations, Brookfield operates the surface bypass by releasing 320 cfs from April 1 to December 31, as river and ice conditions allow, to provide downstream passage for salmon smolts and kelts, juvenile and adult alosines, and adult American eel.

The 10-foot-deep floating angled guidance boom has been shown to be ineffective at guiding downstream migrants towards the bypass and away from the Hydro-Kennebec turbines. The *2015 Evaluation of Downstream Passage for Adult and Juvenile River Herring* demonstrated that 53% of the

[72] Accession Number: 20230320-5179.

study fish went through the Lockwood turbines, rather than being guided by the floating boom to the downstream bypass, and survival was lowest for those fish passing Lockwood via the units (i.e., 77.4–81.7% survival).[73] Brookfield conducted a post-spawned adult river herring radio telemetry downstream passage study at the Hydro-Kennebec Project in the spring of 2016. This study found that guidance boom at Hydro-Kennebec failed to guide 15% of adult post spawn river herring from passing through the project turbines. Similarly, data provided by Brookfield in the (SPP, Table 5-1) demonstrates that the floating guidance booms used at the Lockwood, Hydro-Kennebec, and Weston Projects do not guide 14.3–30.6% of the migrating smolts away from the turbines. Studies at the Ellsworth dam on the Union River assessing injury to salmon showed that 22–30% of fish that went through the turbines had injuries compared to 3.8% that went through spill routes, demonstrating the impact of turbine quantitatively. This indicates that performance standards would not likely be met with the current guidance boom alone. In order to meet the Atlantic salmon smolt performance standard, FERC has required that Brookfield shut down both units at the project for 12 hours per night for up to 54 days to ensure shutdowns occur when at least 97% of the smolt run is migrating. However, this nighttime shutdown measure does not extend to the downstream migration season for Alewives, Blueback herring, American shad, American eels, Sea Lamprey, or early spring and all of the fall downstream migration of Atlantic salmon kelts.

As alosines migrate downstream when river flows are below station hydraulic capacity, FERC's survival estimate for alosines assumed they would only be able to pass the project through the surface bypass or through the powerhouse. FERC assumed that the guidance boom would be as effective for alosines as it is at guiding smolts (i.e. 59%) and that alosines would pass through each of the turbines at the same proportion as smolts did during the 2012–2014 study. Under baseline conditions FERC estimated 94.2% survival for juvenile alosines, 88.2% survival for adult river herring, and 84.2% survival for adult American shad. However, FERC's assumption that the guidance boom would have the same efficacy as smolts is not based on any known information. On the contrary, the 2015 adult river herring study at Lockwood documented that 32% of study fish were guided by the boom, while the remaining fish swam under the boom. In their comments on the proposed downstream alternatives for the West Enfield project (P-2600), USFWS summarized effectiveness of guidance booms on the Kennebec River, at the Lockwood and Weston projects (both project had the bypass operating at greater than 5% of station capacity and the panels of the booms are rigid and extend 10 feet below the water surface), and concluded "the boom does not provide safe, timely, and effective passage for the Service's trust species and does not comport with our most up to date design criteria."[74] They noted that inefficiencies associated with guidance booms may be due to downward velocities that are produced by the panels themselves, as presented by Mulligan et al. 2017 [75].

However, the effectiveness of guidance booms is also limited by their depth in relation to the depth of fish in the water column and thus can only provide guidance to surface oriented fish. Again, the USFWS Fish Passage Design Criteria (2019) provides a clear statement specific to the use of guidance booms.

> "A floating guidance system for downstream fish passage is constructed as a series of partial depth panels or screens anchored across a river channel, reservoir, or power canal. These structures are designed for pelagic fish which commonly approach the guidance system near the upper levels of the

[73] Accession Number: 20160331-5144

[74] Accession Number: 20211217-5213.

[75] Kevin Brian Mulligan, Brett Towler, Alex Haro, David P. Ahlfeld, A computational fluid dynamics modeling study of guide walls for downstream fish passage,Ecological Engineering, Volume 99, 2017, Pages 324-332, ISSN 0925-8574, https://doi.org/10.1016/j.ecoleng.2016.11.025.

water column. While full-depth guidance systems are strongly preferred, partial-depth guidance systems may be acceptable at some sites (e.g., for protection of salmonids, but not eels)."[76]

However, a 1990 paper reported that adult American Shad were captured in the lower half of the water column 83% of the time when migrating upstream and downstream, and a 1987 and 1990 paper reported that adult Blueback Herring migrated at mid-water depth.[77,78] In addition, a 1982 paper that compared surface and bottom trawls for juvenile alosines found that the majority of alewife (98.5%) and American Shad (76.8%) and a large portion of Blueback herring (33%) were captured in bottom trawls.[79] In addition, downstream passage studies performed at West Enfield with Atlantic salmon smolts, adult river herring, adult American shad, and juvenile river herring demonstrate that these fish either approach the project at depth or sound down more than 15 feet to reach the submerged entrance of the entrance rack, which starts at 15 feet below normal headpond. The results of these studies are as follows:

- 2016: 49.4% of smolts were entrained
- 2017: 57% of smolts were entrained
- 2018: 26% percent of smolts, 16%t of adult river herring, and 13% of adult American shad were entrained[80]
- 2019: 99% of juvenile river herring were entrained

Protection of downstream passing eels at hydropower facilities also requires effective exclusion from intakes and guidance to bypasses that is specific to the physiology and behavior of American eels, i.e. low-level entrances with appropriate hydraulic cues for attraction. Downstream passage facilities such as weirs (surface or bottom opening) and flumes have been incorporated at many dams to mitigate the effects of turbine mortality.[81] A 2003 paper found that eels presented with surface and bottom opening bypass weirs preferred the bottom bypass (94%).[82] A study in 2008 of silver eel passage at a hydroelectric project on the Magaguadavic River in New Brunswick found only 21% of tagged eels used a new surface bypass weir, 11 percent passed safely by other routes and the remaining silver eels entered the turbines soon after encountering this route and died, as evidenced by cessation of movement.[83]

In addition to incorrectly assuming the effectiveness of the boom, FERC also did not include reasonable causes of mortality during downstream passage. A 2000 paper listed the causes of mortality in fish passage through turbines as: mechanical damage, pressure-induced damage, shearing action damage, and

---

[76] USFWS (U.S. Fish and Wildlife Service). 2019. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.
[77] Witherall, D. B. and B. Kynard. 1990. Vertical distribution of adult American shad in the Connecticut River. Transactions of the American Fisheries Society. 119: 151-155.
[78] Witherall, D. B. 1987. Vertical distributions of adult American shad and blueback herring during riverine movement. Master's thesis. University of Massachusetts, Amherst.
[79] Loesch, J. G., W, H. Kriete, Jr., and E. J. Foell. 1982. Effects of light intensity on the catchability of juvenile anadromous Alosa species. Transactions of the American Fisheries Society 111:41-77.
[80] These entrainment values would have likely been higher but flashboard damage during the study period caused spill conditions that don't normally occur.
[81] Shepard, S.L. 2015. American eel biological species report. Supplement to: Endangered and Threatened Wildlife and Plants; 12-Month Petition Finding for the American Eel (Anguilla rostrata) Docket Number FWS-HQ-ES-2015-0143. U.S. Fish and Wildlife Service, Hadley, Massachusetts. xii +120 pages.
[82] Durif, C., P. Elie, C. Gosset, J. Rives, and F. Travade. 2003. Behavioral study of downstream migrating eels by radio-telemetry at a small hydroelectric power plant. Pages 343–356 in D.A. Dixon, editor. Biology, management, and protection of catadromous eels. American Fisheries Society Symposium 33. Page 350.
[83] Carr, J. W., and F. G. Whoriskey. 2008. Migration of silver American eels past a hydroelectric dam and through a coastal zone. Fisheries Management and Ecology 15(5– 6):393–400. Page 396–398.

cavitation damage.[84] The FEIS estimates of survival only include one type of mechanical damage (i.e., blade strikes). In addition, the FEIS estimated that the turbine survival of juvenile alosines (93%-94.4%) would be higher than that of smolts (85-88%). However, a 2020 study found that Juvenile American shad were more susceptible to both fluid shear and rapid decompression associated with passage through hydropower turbines than Chinook salmon with injuries such as scale loss, damage to the eyes and operculum, and damage or rupture of the swim bladder.[85] And the authors go on to say, "When compared to other fish species, American shad are highly susceptible to fluid shear and rapid decompression."

Finally, at Hydro-Kennebec Brookfield has proposed installing 2-inch trash racks overlays on the powerhouse intakes to protect kelts. The overlays are perpendicular to the flow and therefore provide no guidance to safe passage routes. The proposed screening approach will physically prevent some larger fish from entrainment but will not exclude the majority of fish (all juvenile and some adult alosines, American eels, and Atlantic salmon smolts) from turbine passage.[86] In the FEIS FERC makes the assumption that any species that has the swimming ability to overcome the approach velocity in front of the trash racks will do so and would therefore not become entrained. The information we presented in the preceding paragraphs shows that this assumption is incorrect and as noted by FERC "there is no data on any potential behavioral deterrence for alosines that may be provided by the 2-inch narrower bar spacing."[87] Therefore the proposed measure provides no guidance to a downstream bypass and there is no information that the measure provides any behavioral deterrence. These deficiencies coupled with relatively high velocities, 2.96 cfs upstream of the intake structure at Hydro-Kennebec, and the majority of station flow passing through this route has a very high likelihood of causing high rates of entrainment and impingement, which have been documented at other hydroelectric projects (see preceding paragraphs).

In order to effectively to protect downstream migrating Atlantic salmon, Alewives, American shad, Blueback Herring, American Eel, sea lamprey, Brookfield will need to provide effective guidance to the surface bypass gate and a low-level bypass. In the DEIS, FERC noted the advantages of an angled rack over the proposed measures. Specifically, they summarized data from studies at the Stillwater A and Orono A Projects that showed that 1-inch spaced trash racks coupled with a surface bypass operating at 5% of Station Unit Flow reduced the entrainment rate of smolts to 6.6% (Brookfield, 2022).[88] In addition, the only measure that meets the criteria for guidance in the USFWS Fish Passage Design Criteria (2019) for all of the species, including Atlantic salmon, alewife, Blueback Herring, American Shad, and American eel, is angled close-spaced racks. A 2005 paper on European eels, an acceptable surrogate for this purpose, found that a bar spacing of 20 mm (0.787 inches) is able to prevent 88% of

[84] Clay, C. H. (2000) Design of Fishways and Other Fish Passage Facilities. CRC press, second edition, Florida.
[85] Pflugrath, B. D., Harnish, R. A., Rhode, B., Engbrecht, K., Beirao, B., Mueller, R. P., ... & Colotelo, A. H. (2020). The susceptibility of Juvenile American shad to rapid decompression and fluid shear exposure associated with simulated hydroturbine passage. *Water*, *12*(2), 586.
[86] Accession Number: 20250228-3002; Table 0-2 Minimum sizes of diadromous fishes physically excluded from trash racks under six different spacing alternatives.
[87] Accession Number: 20250228-3002. Page 83.
[88] Accession Number: 20250228-3002. In the FEIS FERC assumed that new 0.75-inch trash racks would be at least as effective at guiding smolts as 1-inch-spaced trash racks were at these projects, and determined that new 0.75-inch trash racks would reduce powerhouse entrainment from 28.1% to 6.6% for Atlantic salmon smolts. With Brookfield's other proposed improvements to the bypass and FERC's assumed survival rates, FERC estimated that smolt survival with new 0.75 inch trash racks would be about 96.7% (table 3-56 of FEIS).

European eels from passing through trash racks.[89] They recommended that bar screen should be installed at no greater than 45 degrees to the flow field and spacing should be a maximum of 0.75 inches for adult American eels.[90] MDMR supports Brookfield's proposal to relocate and modify the surface bypass gate to pass at least 5% of Station Unit Flow and include a new uniform acceleration weir. MDMR recommends that the new full-depth trash racks extend to the downstream edge of the relocated bypass gate to ensure adequate guidance for downstream migrants.

Adaptive Management: Effectiveness testing is critical to ensure that the proposed measures at Hydro-Kennebec are consistent with the designated uses of the Kennebec River and MDMR's goals for diadromous species native to the watershed. If effectiveness testing shows that the proposed measures fail to meet passage standards, adaptive management will ensure improvements are made to upstream and/or downstream fish passage to meet watershed goals. The specific measures identified seek to provide a suite a solutions that have been effective on similar projects in the northeast. This approach and the measures identified closely align with the approach of NMFS, who, in their Biological Opinion, anticipated that performance standards may not be achieved immediately with the proposed construction, and additional operational and structural modifications (such as increasing attraction flow, installing additional entrances, or constructing new fishways) may be necessary. Brookfield's proposed adaptive management of its upstream fishways include the development and implementation, in consultation with NMFS, of "additional operational or infrastructure measures, as reasonable and practicable, that are likely to meet or exceed the upstream performance standard." As such, we conclude that Brookfield's proposal does not preclude any modifications necessary to achieve its proposed upstream passage standards, including additional fishways. While the FERC FEIS did not require testing of all the species, it does require the development of an adaptive management and monitoring plan that includes: (1) procedures for fishway effectiveness testing, (2) a description of a hatchery salmon stocking program to use in effectiveness testing, and (3) a framework and schedule for identifying and selecting adaptive management measures if Brookfield fails to achieve salmon passage effectiveness standards at any of the projects.

There is significant evidence that new measures, such as second fishways, will significantly improve performance for fish passage effectiveness and timing. FERC's analysis in the Final EIS stated that cumulative American Shad passage at the four projects would increase from 0.5% to 6.2% with the addition of secondary fishways in the "Second Fish Lift Alternative" compared to the proposed action. That would indicate an improvement of Shad passage of 1140% with multiple fishways at all the projects. For river herring, the cumulative upstream passage for river herring through the four projects under the Proposed Action based on FERC's analysis would equate to about 13.6% and 55.7% under the Second Fish Lift Alternative. This would indicate an improvement of river herring passage of 310% with multiple fishways at all projects. For sea lamprey, the cumulative upstream passage through the four projects under the Proposed Action based on FERC's analysis would equate to about 41.7% and 82.2% under the Second Fish Lift Alternative. This would indicate an improvement of passage of 97% with multiple fishways at all projects. For Atlantic salmon, the cumulative upstream passage through the four projects under the Proposed Action based on FERC's analysis would equate to about 93.5% and 99.6% under the Second Fish Lift Alternative. This would indicate an improvement of Atlantic salmon of

[89] Travade, F., Gosset, C., Larnier, M., Subra, S., Durif, C., Rives, J., & Elie, P. (2006). Evaluation of surface and bottom bypasses to protect eel migrating downstream at small hydroelectric facilities in France.
[90] Environment Agency UK. 2017. Screening at intakes and outfalls: measures to protect eel. Report GEHO0411BTQD-E-E, The Environment Agency, Bristol, England. 125 pp.

nearly 7% with multiple fishways at all projects. Keefer et al. (2021) [91]found that the passage efficiency for Pacific salmonids at eight dams on the Columbia River were regularly among the highest recorded for any migratory species, averaging 96.6%, which the study attributed to a "sustained adaptive management approach to fishway design, maintenance, and improvement" where many of the dams have more than one fishway. Notable large river projects with two fishways proposed or previously constructed in Maine include Lockwood Dam (Kennebec), Milford Dam (Penobscot), and Woodland Dam (St. Croix), demonstrating that it is a reasonable measure to improve performance.

Regarding fish passage timing criteria, fishways on the Columbia River, have consistently Pacific salmon in less than 48 hours.[92] Keefer et al. (2004) evaluated upstream migration rates of over 12,000 adult Chinook salmon and steelhead, and documented that most fish successfully passed the dams in the Columbia River in less than two days. Modeling on the Kennebec River indicates how much energy reserve loss can be caused by delays (Rubenstein et al. 2022)[93]. According to the author's modeling, with four dams in place, only 30.7% of salmon would be expected to reproduce if delays are prolonged. Many of the dams in Keefer's study have more than one fishway, which likely provides more opportunities for fish to pass and therefore leads to reduced passage delay. If multiple fishways are the reason for higher efficiencies, then it's probable that Brookfield could meet delay standards if a second fishway is built if performance is not met. Brookfield has proposed to operate the secondary fishway (Denil) at Milford Dam on the Penobscot River 24-hours a day through the fish passage season to reduce migratory delay (pers. comm. Dan Tierney, NMFS), demonstrating that it is a reasonable measure to achieve improved performance.

To reduce the negative impacts of dam on downstream moving fish, well-performing downstream passage systems that consider not only current requirements regarding design, dimensioning and location, but also the site-specific conditions and fish species, must be tested and modified to provide optimal performance. The proposed measures are the best scientific and technical solutions common to species in the northeast and utilize USFWS (2019) passage criteria.

Therefore, given that the licenses will require that these standards be achieved and given the breadth of the adaptive management protocol, we expect that the proposed actions, combined with effective adaptive management of the fishways will achieve high passage efficiencies and low passage delays consistent with the standards outlined in Brookfield's proposal and those recommended by MDMR.

Shawmut

MDMR believes that our additional measures outlined for every project as well as the measures detailed below for the Shawmut project are necessary to meet minimum fisheries management goals without impacting upstream developments such as the Sappi Fine Paper mill intake and outfall systems. MDMR does not support fish passage alternatives at this location that would negatively impact the Sappi mill.

---

[91] Keefer, M. L., Jepson, M. A., Clabough, T. S., & Caudill, C. C. (2021). Technical fishway passage structures provide high passage efficiency and effective passage for adult Pacific salmonids at eight large dams. PLoS One, 16(9), e0256805.
[92] "Stock-Specific Migration Timing of Adult Spring–Summer Chinook Salmon in the Columbia River Basin", Adult Salmon and Steelhead Migration Studies: 1996-2014, University of Idaho Library Digital Collections, https://www.lib.uidaho.edu/digital/ferl/items/ferl-keefer2004a.html
[93] Rubenstein, S.R., Peterson, E., Christman, P. and Zydlewski, J.D., 2022. Adult Atlantic salmon (Salmo salar) delayed below dams rapidly deplete energy stores. *Canadian Journal of Fisheries and Aquatic Sciences*, *80*(1), pp.170-182.

Shawmut Recommendation 1: Brookfield shall implement the following measures, including the development of a comprehensive adaptive management plan with DEP approval that outlines clear steps and timelines for implementation and testing of passage measures at the Shawmut Project. Should the Shawmut Project facilities fail to achieve any of MDMR's performance standards, the plan will include a timeline for the implementation of additional measures. For the Shawmut dam this will include the following measures and milestones:

a. Brookfield will construct, operate, and maintain a fish lift with an integrated attraction water supply spillway adjacent to the 1912 Powerhouse and a fish passage flume to provide volitional passage to the Shawmut Project's headpond within three years of license issuance.
b. Brookfield will design, construct, operate, and maintain a 0.75-inch or less, full depth, angled or inclined rack structure upstream of the forebay within 4 years of license issuance. The structure should be designed such that normal velocities do not exceed two feet per second as measured at an upstream location where velocities are not influenced by the local acceleration around guidance structures. The structure shall include low level entrances to a downstream bypass system and provide guidance to a surface bypass location or locations.
    a. In the interim, while Brookfield works to install full depth inclined or angled racks, Brookfield will open the Tainter gate to pass a minimum of 6% of station flow (approximately 425 cfs) from April 1 through December 31.
c. Effectiveness testing to assess survival, injury, and delay in upstream and downstream passage shall be implemented by Brookfield in the first downstream fish passage season and the second upstream fish passage season following installation of the fish lift, flume, and rack structure. Atlantic salmon testing will be coordinated with federal agencies. Brookfield will prepare study plans for effectiveness testing for Atlantic salmon, shad, alewife, blueback herring, American eel, and sea lamprey and distribute draft plans to MDMR and DEP for review and for approval by DEP no later one year prior to the start of the passage season in which the study will be conducted. The study plans will include appropriate measures for testing to determine if the project meets the applicable performance standards.
    a. These initial studies may be limited to specific species and life stages, with approval from DEP, to prevent delay of potential modifications. However, the facilities will need to be tested for all species and life stages on a timeline approved by DEP.
    b. No later than 8 months after the initiation of effectiveness testing, Brookfield shall distribute a draft study report to MDMR and DEP and schedule a meeting to review study results within 30 days of report distribution.
d. If performance standards have not been achieved, but the results are close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield can implement minor operational or structural modifications to address the deficiency as approved by DEP and retest the facility as described in measure c or as determined by DEP.
e. If upstream performance standards have not been achieved, and the results are not close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield shall construct the following measures no later than 4 years after the distribution of the effectiveness testing report:
    a. Design, construct, operate, and maintain a second fishway adjacent to the 1982 powerhouse.
    b. Construct, operate, and maintain attraction flow channel(s) that discharge in the vicinity of the fishway entrance(s) and are capable of conveying the amount of spill flows

required under NOAA's Biological Opinion[94] or a minimum of 20% of station capacity, whichever is greater.
    c. Modify the fish lift including the entrance gate, internal infrastructure and/or attraction water system.

f. If downstream performance standards have not been achieved, and the results are not close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield shall construct the following measures no later than 3 years after the distribution of the effectiveness testing report:
    a. construction of a new downstream fish bypass facility with low level and surface entrances,
    b. construction of additional crest gates or other spillway gates,
    c. modifications to the downstream existing bypass facility.
g. Brookfield may propose alternative adaptive measures. If DEP determines that any alternative proposed measure or combination of proposed measures from Brookfield is likely to achieve the performance standard and approves the timeline of implementation of the measure(s), Brookfield can implement that/those proposed measure(s).
    a. Additional adaptive measures could include, but are not limited to, those identified by Brookfield in Appendix 3 of the Shawmut WQC Application:
h. Once Brookfield has implemented DEP's required measures, Brookfield will repeat steps c-h of this adaptive management plan until deficiencies have been addressed. This includes the design and development of new or replacement fishways that could achieve these standards.

Justification:

Upstream Passage: The Shawmut Project has an existing temporary upstream American eel passage facility however the project does not have upstream passage facilities for other anadromous species. Safe, timely, and effective upstream fish passage at the Shawmut Project is essential due to the cumulative adverse impacts of the Lockwood, Hydro-Kennebec, and Weston projects. Brookfield has proposed to construct, operate, and maintain a new permanent upstream fish lift at the Shawmut project. With the construction of the new fish lift, the locations of the American eel fishways should be revaluated due to modified flow conditions. MDMR is concerned about the effectiveness of the proposed fishway in May, June, and July when the majority of anadromous species are migrating upstream. MDMR recommends Brookfield construct the fish lift, test effectiveness, and implement adaptive measures to achieve performance standards if needed.

Downstream Passage: In an effort to guide downstream migrants away from the turbines, Brookfield is operating a floating guidance boom. However, data provided by Brookfield in the (SPP, Table 5-1) demonstrates that the guidance booms used at the Lockwood, Hydro-Kennebec, and Weston Projects do not guide 14.3-30.6% of the migrating smolts away from the turbines. The *2015 Evaluation of Downstream Passage for Adult and Juvenile River Herring* demonstrated that 53% of the study fish went through the Lockwood turbines, rather than being guided by the boom to the downstream bypass, and survival was lowest for those fish passing Lockwood via the units (i.e., 77-4-81.7% survival).[95] Data provided by Brookfield (FLA, Table 4-22) shows that 32.7% of the downstream migrating smolts were entrained into the turbines at the Shawmut Project. The instantaneous survival was 7% lower when fish

[94] Accession Number: 20230320-5179.
[95] Accession Number. 20170329-5234

went through the turbines compared to spill routes at Shawmut and that grossly underestimates the sub lethal effects, including injury and disorientation, that would result in higher mortality in the estuary. Studies at the Ellsworth dam on the Union River assessing injury to salmon showed that 22-30% of fish that went through the turbines had injuries compared to 3.8% that went through spill routes, demonstrating that impact quantitatively. This would indicate that performance standards would not likely be met with the current guidance boom. The USFWS Fish Passage Engineering Design Criteria (2019) recommends replacing the floating boom with a full depth guidance structure.[96] The cited USFWS Design Criteria is based on the best available scientific information on safe, timely, and effective passage for 12 diadromous species using Atlantic Coast rivers and streams.

In another effort to improve downstream survival of migrants Brookfield has most recently proposed installing new trash racks or overlays with 2-inch clear spacing on the intakes of Unit 7 and 8 (pending the determination of approach velocities) and 1-inch clear spacing on the intakes for Unit 1 through Unit 6 (pending the determination of approach velocities). This screening approach is inadequate and does not take into account adult and juvenile river herring, juvenile shad, juvenile sea lamprey, or eels resulting in unsafe downstream passage of indigenous species. The proposed screening approach will physically prevent some larger fish from entrainment, but will not prevent the majority of fish from entering the turbines (juvenile alosines and adult American eels).[97] The relatively high velocities at Shawmut coupled with no guidance to downstream bypasses and the majority of station flow passing through the turbine route significantly increases risk of fish impingement and entrainment. FERC Staff has estimated mean turbine passage survival for juvenile alosines through unit 7-8 to be 95.4% and through units 1-6 to be 93.9% (Table 2). This is an overestimate of survival because the analysis only focuses on mechanical blade-strike. Nevertheless, under these assumptions passage via units 7-8 would just meet MDMR's performance standard of 95% survival and passage via units 1-6 would not meet performance standards. In order to protect downstream migrating Atlantic salmon, Alewives, juvenile American Shad, Blueback Herring, American Eel, and sea lamprey, Brookfield should install full-depth inclined or angled screening with 0.75-inch or less spacing and size the rack area so that the normal velocities should not exceed 2 feet per second measured at an upstream location where velocities are not influenced by the local acceleration around the guidance structures. In 2011, Brookfield consulted with the resource agencies, conducted CFD modeling, and developed conceptual plans for a 1-inch spaced trash rack structure extending from the west shoreline of the impoundment at an angle across and upstream of the forebay headworks to its terminus at a new bypass facility near the proposed fish lift. In the Final Environmental Impact Statement (FEIS), FERC staff incorrectly assessed the potential benefits of this structure. Namely FERC staff failed to include the benefit of sweeping flow that would provide guidance for all downstream migrating species, regardless of size, to the new bypass facility, in addition to the physical exclusion. MDMR provided the conceptual plans for the 1-inch spaced trash rack structure on the FERC record along with our comments scoping for the Environmental Impact Statement.[98] This design is recommended to be updated during the 60% and 90% design phases to meet USFWS guidelines and be implemented as refined during design review.

Table 2. Immediate turbine passage survival rates of fish based on turbine type and fish size. (Source Winchell et al., 2000; as modified by FERC staff).

---

[96] USFWS (U.S. Fish and Wildlife Service). 2019. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.

[97] Accession Number: 20250228-3002; Table 0-2 Minimum sizes of diadromous fishes physically excluded from trash racks under six different spacing alternatives.

[98] Accession Number: 20211223-5259.

Turbine Type	Runner Speed (*RPM*)	Hydraulic Capacity (*cfs*)	Fish Size (*in*)	% Survival		
				Min	Max	Mean
Axial-flow	< 300	636 – 1,203	< 4	94.1	98.0	95.4
Francis	< 250	440 – 1,600	< 4	85.9	100	93.9

The FERC Final EIS analysis and assumptions demonstrate that turbine passage would be significantly higher with the current action compared to MDMR's recommendation of full depth 0.75-inch angled racks and appropriate bypass facilities (including low-level bypasses for eels) at each project. FERC's analysis estimated that 0.75-inch full depth screening would eliminate turbine entrainment for Atlantic salmon kelts, adult river herring, and American eels and significantly reduce entrainment for Atlantic salmon smolts and juvenile alosines compared to the proposed action.

Adaptive Management: The applicant has proposed constructing a single upstream fish lift. Successful fishways must create hydraulic signals strong enough to attract fish to one or multiple entrances in the presence of competing flows (i.e., false attraction). The Shawmut dam is extremely long and has multiple discharge locations that will provide significant false attraction flows during the passage season. MDMR has serious concerns about the design, operation, and location of the fishway and believes the current proposal could result in significant delays and likely poor upstream passage efficiency for multiple species.

MDMR is very concerned about the effectiveness of the proposed fishway in May, June, and July when the majority of anadromous species are migrating upstream (Table 3). The maximum station hydraulic capacity of the Shawmut Project is 6,690 cfs, which is exceeded approximately 65% of the time in May, 35% of the time in June, and 20% of the time in July. Water in excess of station capacity is spilled at the sluice gate in the middle of the 1,435-foot long dam, the hinged flashboards on the west side of the dam, or the rubber crest(s) on the eastern half of the dam, providing multiple sources of false attraction. As a result, there will be false attraction at the project during the majority of the upstream migration season to multiple areas without a fishway to the headpond. A proposed cross channel egress from an identified false attraction zone would not provide passage to the headpond or directly to the lift.

Table 3. Upstream Run timing by month of Atlantic salmon, river herring (Alewife and Blueback Herring) and American Shad captured at the Lockwood Project (2006-2020) and Sea Lamprey captured at the Milford Project (2009-2020).

Month	Atlantic salmon	River herring	American Shad	Sea Lamprey
May	9%	72%	2%	56%
June	49%	28%	78%	44%
July	32%		19%	
August	2%			
September	3%			
October	4%			

The Lockwood fish lift was designed consistent with current standards for upstream passage of anadromous fish and yet the complicated setup at the dam has undermined the ability of the fishway to effectively pass fish. Similar results may be expected at the Shawmut project. Results at projects such as Lockwood show significantly less than minimum goals necessary to support Atlantic salmon populations and could fully preclude American shad or other species from accessing necessary habitats above the Shawmut project. MDMR believes that the current proposal may result in large percentages of fish not finding the fish lift and/or experiencing substantial delays.

Effectiveness testing is critical to ensure that the proposed measures at Shawmut are consistent with the designated uses of the Kennebec River and MDMR's goals for diadromous species native to the watershed. If effectiveness testing shows that the proposed measures fail to meet passage standards, adaptive management will ensure improvements are made to upstream and/or downstream fish passage to meet watershed goals. The specific measures identified seek to provide a suite a solutions that have been effective on similar projects in the northeast. This approach and the measures identified closely align with the approach of NMFS, who, in their Biological Opinion, anticipated that performance standards may not be achieved immediately with the proposed construction, and additional operational and structural modifications (such as increasing attraction flow, installing additional entrances, or constructing new fishways) may be necessary. Brookfield's proposed adaptive management of its upstream fishways include the development and implementation, in consultation with NMFS, of "additional operational or infrastructure measures, as reasonable and practicable, that are likely to meet or exceed the upstream performance standard." As such, we conclude that Brookfield's proposal does not preclude any modifications necessary to achieve its proposed upstream passage standards, including additional fishways– provided that information demonstrates necessity. While the FERC FEIS did not require testing of all the species, it does require the development of an adaptive management and monitoring plan that includes: (1) procedures for fishway effectiveness testing, (2) a description of a hatchery salmon stocking program to use in effectiveness testing, and (3) a framework and schedule for identifying and selecting adaptive management measures if Brookfield fails to achieve salmon passage effectiveness standards at any of the projects.

There is significant evidence that new measures, such as second fishways, will significantly improve performance for fish passage effectiveness and timing. FERC's analysis in the Final EIS stated that cumulative American Shad passage at the four projects would increase from 0.5% to 6.2% with the addition of secondary fishways in the "Second Fish Lift Alternative" compared to the proposed action. That would indicate an improvement of Shad passage of 1140% with multiple fishways at all the projects. For river herring, the cumulative upstream passage for river herring through the four projects under the Proposed Action based on FERC's analysis would equate to about 13.6% and 55.7% under the Second Fish Lift Alternative. This would indicate an improvement of river herring passage of 310% with multiple fishways at all projects. For sea lamprey, the cumulative upstream passage for through the four projects under the Proposed Action based on FERC's analysis would equate to about 41.7% and 82.2% under the Second Fish Lift Alternative. This would indicate an improvement of passage of 97% with multiple fishways at all projects. For Atlantic salmon, the cumulative upstream passage for through the four projects under the Proposed Action based on FERC's analysis would equate to about 93.5% and 99.6% under the Second Fish Lift Alternative. This would indicate an improvement of river Atlantic salmon of nearly 7% with multiple fishways at all projects. Keefer et al. (2021) [99]found that the passage efficiency for Pacific salmonids at eight dams on the Columbia River were regularly among the highest recorded for any migratory species, averaging 96.6%, which the study attributed to a "sustained adaptive management approach to fishway design, maintenance, and improvement" where many of the dams have more than one fishway. Notable large river projects with two fishways proposed or previously constructed in Maine include Lockwood Dam (Kennebec), Milford Dam (Penobscot), and Woodland

[99] Keefer, M. L., Jepson, M. A., Clabough, T. S., & Caudill, C. C. (2021). Technical fishway passage structures provide high passage efficiency and effective passage for adult Pacific salmonids at eight large dams. PLoS One, 16(9), e0256805.

Dam (St. Croix), demonstrating that it is a reasonable measure to improve performance. Multiple fishways may also reduce passage delay (a component of MDMR's performance standards), as may have occurred in Keefer et al. (2004) [100]and has been proposed by Brookfield at the Milford Dam to meet the delay standard (pers. Comm. Dan Tierney, NMFS). Thus, multiple fishways are reasonable to achieve improved performance.

To reduce the negative impacts of dam on downstream moving fish, well-performing downstream passage systems that consider not only current requirements regarding design, dimensioning and location, but also the site-specific conditions and fish species, must be tested and modified to provide optimal performance. The proposed measures are the best scientific and technical solutions common to species in the northeast and utilize USFWS (2019) passage criteria.

Therefore, given that the licenses will require that these standards be achieved and given the breadth of the adaptive management protocol, we expect that the proposed actions, combined with effective adaptive management of the fishways will achieve high passage efficiencies and low passage delays consistent with the standards outlined in Brookfield's proposal and those recommended by MDMR.

Weston

Weston Recommendation 1: Brookfield shall implement the following measures, including the development of a comprehensive adaptive management plan with DEP approval that outlines clear steps and timelines for implementation and testing of passage measures at the Weston Project. Should the Weston Project facilities fail to achieve any of MDMR's performance standards, the plan will include a timeline for the implementation of additional measures. For the Weston dam this will include the following measures and milestones:

a. Brookfield will construct, operate, and maintain a new upstream anadromous fish lift between the South Channel Dam log sluice and the powerhouse within three years after license amendment approval.
b. Brookfield will design, construction, operate, and maintain a 0.75-inch or less, full depth, angled or inclined rack structure in the forebay within 4 years of license amendment approval. The structure should be designed such that normal velocities do not exceed two feet per second as measured at an upstream location where velocities are not influenced by the local acceleration around guidance structures. The structure shall include low level entrances to a downstream bypass system and provide guidance to a surface bypass location or locations.
c. Effectiveness testing to assess survival, injury, and delay in upstream and downstream passage shall be implemented by Brookfield in the first downstream fish passage season and the second upstream fish passage season following installation of Weston Recommended measures a and b. Atlantic salmon testing will be coordinated with federal agencies. Brookfield will prepare study plans for effectiveness testing for Atlantic salmon, shad, alewife, blueback herring, American eel, and sea lamprey and distribute draft plans to MDMR and DEP for review and for approval by DEP no later one year prior to the start of the passage season in which the study will be

[100] "Stock-Specific Migration Timing of Adult Spring–Summer Chinook Salmon in the Columbia River Basin", Adult Salmon and Steelhead Migration Studies: 1996-2014, University of Idaho Library Digital Collections, https://www.lib.uidaho.edu/digital/ferl/items/ferl-keefer2004a.html

conducted. The study plans will include appropriate measures for testing to determine if the project meets the applicable performance standards.

   a. These initial studies may be limited to specific species and life stages, with approval from DEP, to prevent delay of potential modifications. However, the facilities will need to be tested for all species and life stages on a timeline approved by DEP.
   b. No later than 8 months after the initiation of effectiveness testing, Brookfield shall distribute a draft study results report to MDMR and DEP. If performance standards have not been achieved, Brookfield will consult with MDMR and DEP within 30 days of distribution of the effectiveness testing report to review study results and identify areas of deficiency.

d. If performance standards have not been achieved, but the results are close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield can implement minor operational or structural modifications to address the deficiency as approved by DEP and retest the facility as described in measure c or as determined by DEP.
e. If upstream performance standards have not been achieved, and the results are not close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield shall construct the following measures no later than 4 years after the distribution of the effectiveness testing report:
   a. Design, construct, operate, and maintain a second fishway in the north channel.
   b. Construct, operate, and maintain attraction flow channel(s) that discharge in the vicinity of the fishway entrance(s) and are capable of conveying the amount of spill flows required under NOAA's Biological Opinion[101] or a minimum of 20% of station capacity, whichever is greater.
   c. modifications to the fish lift including the entrance gate, internal infrastructure and/or attraction water system.
   d. Modifications to the spillway including: installation of new spillway gates or rubber dam type infrastructure to manage flow during the upstream passage season.
f. If downstream performance standards have not been achieved, and the results are not close (within 10% of performance standard criteria for passage efficiency or timing for the tested species), Brookfield shall construct the following measures no later than 3 years after the distribution of the effectiveness testing report:
   d. Construction of a new downstream fish bypass facility at the north channel dam with low level entrances and surface entrance(s). The surface entrance(s) shall include uniform acceleration weir(s).
   e. Construction of a new downstream bypass at the South Channel dam adjacent to log sluice, which is currently proposed as the downstream bypass. The new downstream bypass should have both surface and low level entrances and should be capable of passing a minimum of 5% of station hydraulic capacity.
   f. Construction of additional crest gates or other spillway gates,
   g. Modifications to the downstream existing bypass facility.
   h. Construct a plunge pool and/or prioritize spill to areas with sufficient depth and away from rock outcrops or concrete that meet USFWS criteria (2019 or current version)

[101] Accession Number: 20230320-5179.

g. Brookfield may propose alternative adaptive measures from the list below or as identified by Brookfield. If DEP determines that any alternative measure or combination of measures proposed from Brookfield is likely to achieve the performance standard and approves the timeline of implementation of the measure(s), Brookfield can implement that/those proposed measure(s).
    a. Additional Adaptive Upstream Measures could include:
        i. Construction of additional fishway entrance(s).
        ii. Modification to fishway entrance location(s).
        iii. Modification of spillway infrastructure.
    b. Additional Interim Adaptive Downstream Measures include:
        i. Construction of a new downstream fish bypass facility.
        ii. Modifications of spillway infrastructure.

h. Once Brookfield has implemented DEP's required measures, Brookfield will repeat steps c-h of this adaptive management plan until deficiencies have been addressed. This includes the design and development of new or replacement fishways that could achieve these standards.

Justification:

Upstream Passage: The Weston Project has an existing temporary upstream American eel passage facility however the project does not have upstream passage facilities for other anadromous species. Safe, timely, and effective upstream fish passage at the Weston Project is essential due to the cumulative adverse impacts of the Lockwood, Hydro-Kennebec, and Weston projects. Brookfield has proposed to construct, operate, and maintain a new permanent upstream fish lift at the Weston project. With the construction of the new fish lift, the locations of the American eel fishways should be revaluated due to modified flow conditions. MDMR recommends Brookfield construct the fish lift, test effectiveness, and implement adaptive measures to achieve performance standards if needed.

Downstream Passage: The existing information from Atlantic salmon smolt survival studies at the project provides reasonable basis for the need to implement these downstream fish passage measures. The survival studies at the Weston Project have documented the log sluice surface bypass as the route of passage with the lowest estimated survival.[102] The log sluice surface bypass survival rate was 92.8%, spill way survival was 93.1%, and turbine survival was 98.3% (SPP, Table 6-4). MDMR recommended that Brookfield remove the guidance boom and existing surface bypass and installing a full-depth guidance facility that is design consistent USFWS Fish Passage Design Criteria (2019 or current version).[103] MDMR has concluded that floating guidance booms are inadequate to protect diadromous species in the Kennebec River. Data provided by Brookfield in the SPP, Table 5-1 demonstrates that the guidance booms used at the Lockwood, Hydro-Kennebec, and Weston Projects do not guide 14.3-30.6% of the migrating smolts away from the turbines. Data provided by Normandeau, (SPP Table 6-4) shows that 41.7% of the downstream migrating smolts were entrained into the turbines at the Weston Project. Studies at the Ellsworth dam on the Union river assessing injury to salmon showed that 22-30% of fish that went through the turbines had injuries compared to 3.8% that went through spill routes, demonstrating that impact quantitatively. The 2015 *Evaluation of Downstream Passage for Adult and Juvenile River Herring* demonstrated that 53 percent of the study fish went through the Lockwood

[102] Accession Number: 20160329-5151. 239-240.
[103] USFWS (U.S. Fish and Wildlife Service). 2019. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, Massachusetts.

turbines, rather than being guided by the boom to the downstream bypass, and survival was lowest for those fish passing Lockwood via the units (i.e., 77-4-81.7% survival).[104]

A 2012 eel passage study[105] found that 93% of eels passed the project through the turbines with the remaining 7% passing through the log sluice with a combined survival estimate of 89.4% at the Weston Project. However, safe passage means passage without mortality or injury to ensure eels can successfully migrate downstream. Therefore, this estimate is higher than actual successful passage at the site. In the FEIS FERC evaluate the MDMR's 0.75 inch angled rack and new bypass, and concluded that the measure would physically prevent most eels from entrainment and therefore most eels would pass the project via a bypass with an estimated survival rate of 100%.

Brookfield has proposed installing 2-inch trash racks overlays on the powerhouse intakes to protect kelts. The overlays are perpendicular to the flow and therefore provide no guidance to safe passage routes. The proposed screening approach will physically prevent some larger fish from entrainment but will not exclude the majority of fish (all juvenile and some adult alosines, American eels, and Atlantic salmon smolts) from turbine passage.[106] At Weston when modeling 2-inch and 0.75-inch racks for smolts downstream survival increased from 90.4% to 97.5%.[107] In the FEIS FERC makes the assumption that any species that has the swimming ability to overcome the approach velocity in front of the trash racks will do so and would therefore not become entrained. The information we presented in the preceding paragraphs shows that this assumption is incorrect and as noted by FERC "there is no data on any potential behavioral deterrence for alosines that may be provided by the 2-inch narrower bar spacing."[108] Therefore the proposed measure provides no guidance to a downstream bypass and there is no information that the measure provides any behavioral deterrence. These deficiencies coupled with the majority of station flow passing through this route indicate a very high likelihood of entrainment, which has been documented at other hydroelectric projects (see preceding project sections).

In order to effectively protect downstream migrating Atlantic salmon, Alewives, American shad, Blueback Herring, American Eel, sea lamprey, Brookfield will need to provide effective guidance to the surface bypass gate. In the DEIS, FERC noted the advantages of an angled rack over the proposed measures. Specifically, they summarized data from studies at the Stillwater A and Orono A Projects that showed that 1-inch spaced trash racks coupled with a surface bypass operating at 5% of Station Unit Flow reduced the entrainment rate of smolts to 6.6% (Brookfield, 2022).[109] In addition, the only measure that meets the criteria for guidance in the USFWS Fish Passage Design Criteria (2019) for all species including Atlantic salmon, alewife, Blueback Herring, American Shad, and American eel is angled close-spaced racks. A 2005 paper on European eels, an acceptable surrogate for this purpose, found that a bar spacing of 20 mm (0.787 inches) is able to prevent 88% of European eels from passing through

[104] Accession Number:. 20 l6033 l-5 l 44
[105] Accession Number:. 20130329-5231
[106] Accession Number: 20250228-3002; Table 0-2 Minimum sizes of diadromous fishes physically excluded from trash racks under six different spacing alternatives.
[107] Accession Number: 20250228-3002. Page 381
[108] Accession Number: 20250228-3002. Page 83.
[109] Accession Number: 20250228-3002. In the FEIS FERC assumed that new 0.75-inch trash racks would be at least as effective at guiding smolts as 1-inch-spaced trash racks were at these projects, and determined that new 0.75-inch trash racks would reduce powerhouse entrainment from 28.1% to 6.6% for Atlantic salmon smolts. With Brookfield's other proposed improvements to the bypass and FERC's assumed survival rates, FERC estimated that smolt survival with new 0.75 inch trash racks would be about 96.7% (table 3-56 of FEIS).

trash racks.[110] The author recommended that a bar screen should be installed at no greater than 45 degrees to the flow field and spacing should be a maximum of 0.75 inches for adult American eels.[111]

Adaptive Management: Effectiveness testing is critical to ensure that the proposed measures at Weston are consistent with the designated uses of the Kennebec River and MDMR's goals for diadromous species native to the watershed. If effectiveness testing shows that the proposed measures fail to meet passage standards, adaptive management will ensure improvements are made to upstream and/or downstream fish passage to meet watershed goals. The specific measures identified seek to provide a suite a solutions that have been effective on similar projects in the northeast. This approach and the measures identified closely align with the approach of NMFS, who, in their Biological Opinion, anticipated that performance standards may not be achieved immediately with the proposed construction, and additional operational and structural modifications (such as increasing attraction flow, installing additional entrances, or constructing new fishways) may be necessary. Brookfield's proposed adaptive management of its upstream fishways include the development and implementation, in consultation with NMFS, of "additional operational or infrastructure measures, as reasonable and practicable, that are likely to meet or exceed the upstream performance standard." As such, we conclude that Brookfield's proposal does not preclude any modifications necessary to achieve its proposed upstream passage standards, including additional fishways– provided that information demonstrates necessity. While the FERC FEIS did not require testing of all the species, it does require the development of an adaptive management and monitoring plan that includes: (1) procedures for fishway effectiveness testing, (2) a description of a hatchery salmon stocking program to use in effectiveness testing, and (3) a framework and schedule for identifying and selecting adaptive management measures if Brookfield fails to achieve salmon passage effectiveness standards at any of the projects.

There is significant evidence that new measures, such as second fishways, will significantly improve performance for fish passage effectiveness and timing. FERC's analysis in the Final EIS stated that cumulative American Shad passage at the four projects would increase from 0.5% to 6.2% with the addition of secondary fishways in the "Second Fish Lift Alternative" compared to the proposed action. That would indicate an improvement of Shad passage of 1140% with multiple fishways at all the projects. For river herring, the cumulative upstream passage for river herring through the four projects under the Proposed Action based on FERC's analysis would equate to about 13.6% and 55.7% under the Second Fish Lift Alternative. This would indicate an improvement of river herring passage of 310% with multiple fishways at all projects. For sea lamprey, the cumulative upstream passage for through the four projects under the Proposed Action based on FERC's analysis would equate to about 41.7% and 82.2% under the Second Fish Lift Alternative. This would indicate an improvement of passage of 97% with multiple fishways at all projects. For Atlantic salmon, the cumulative upstream passage for through the four projects under the Proposed Action based on FERC's analysis would equate to about 93.5% and 99.6% under the Second Fish Lift Alternative. This would indicate an improvement of Atlantic salmon of nearly 7% with multiple fishways at all projects. Keefer et al. (2021) [112]found that the passage efficiency for Pacific salmonids at eight dams on the Columbia River were regularly among the highest recorded for any migratory species, averaging 96.6%, which the study attributed to a "sustained adaptive management approach to fishway design, maintenance, and improvement" where many of the dams have

[110] Travade, F., Gosset, C., Larnier, M., Subra, S., Durif, C., Rives, J., & Elie, P. (2006). Evaluation of surface and bottom bypasses to protect eel migrating downstream at small hydroelectric facilities in France.
[111] Environment Agency UK. 2017. Screening at intakes and outfalls: measures to protect eel. Report GEHO0411BTQD-E-E, The Environment Agency, Bristol, England. 125 pp.
[112] Keefer, M. L., Jepson, M. A., Clabough, T. S., & Caudill, C. C. (2021). Technical fishway passage structures provide high passage efficiency and effective passage for adult Pacific salmonids at eight large dams. PLoS One, 16(9), e0256805.

more than one fishway. Notable large river projects with two fishways proposed or previously constructed in Maine include Lockwood Dam (Kennebec), Milford Dam (Penobscot), and Woodland Dam (St. Croix), demonstrating that it is a reasonable measure to improve performance.

Regarding fish passage timing criteria, fishways on the Columbia River, have consistently Pacific salmon in less than 48 hours.[113] Keefer et al. (2004)[114] evaluated upstream migration rates of over 12,000 adult Chinook salmon and steelhead, and documented that most fish successfully passed the dams in the Columbia River in less than two days. Modeling on the Kennebec River indicates how much energy reserve loss can be caused by delays[115]. According to the author's modeling, with four dams in place, only 30.7% of salmon would be expected to reproduce if delays are prolonged. We note that some of the dams in Keefer's study have more than one fishway, which likely provides more opportunities for fish to pass and therefore leads to reduced passage delay. If multiple fishways are the reason for higher efficiencies, then it's probable that Brookfield could meet delay standards if a second fishway is built if performance is not met. Brookfield has proposed to operate the secondary fishway (Denil) at Milford Dam on the Penobscot River 24-hours a day through the fish passage season to reduce migratory delay (pers. comm. Dan Tierney, NMFS), demonstrating that it is a reasonable measure to achieve improved performance.

Successful fishways must create hydraulic signals strong enough to attract fish to one or multiple entrances in the presence of competing flows (i.e., false attraction). The Weston Project comes with added complexity due to a second channel within the project footprint. MDMR believes that the current fishway proposal of a single fishway and timeline of four years could be inadequate due to false attraction of fish to the secondary channel.

MDMR believes constructing an additional fishway would enhance upstream fish passage and could be necessary to meet Brookfield and agency goals for all species based on reasonable expectations and experience from other projects. As described in MDMR's previous comments and in NOAA's Biological Opinion, these large river projects have multiple competing flows and associated areas of potential false attraction and "Fish that are attracted to a section of the dam that is distant from the new fishway entrance (such as the spillway on the other side of the river), for instance, are unlikely to be attracted to the fishway entrance within a reasonable amount of time if competing flows cannot be adequately managed."

To reduce the negative impacts of dam on downstream moving fish, well-performing downstream passage systems that consider not only current requirements regarding design, dimensioning and location, but also the site-specific conditions and fish species, must be tested and modified to provide optimal performance. The proposed measures are the best scientific and technical solutions common to species in the northeast and utilize USFWS (2019) passage criteria.

Therefore, given that the licenses will require that these standards be achieved and given the breadth of the adaptive management protocol, we expect that the proposed actions, combined with effective

[113] "Stock-Specific Migration Timing of Adult Spring–Summer Chinook Salmon in the Columbia River Basin", Adult Salmon and Steelhead Migration Studies: 1996-2014, University of Idaho Library Digital Collections, https://www.lib.uidaho.edu/digital/ferl/items/ferl-keefer2004a.html

[114] Keefer, M. L., Jepson, M. A., Clabough, T. S., & Caudill, C. C. (2021). Technical fishway passage structures provide high passage efficiency and effective passage for adult Pacific salmonids at eight large dams. PLoS One, 16(9), e0256805.

[115] Rubenstein, S.R., Peterson, E., Christman, P. and Zydlewski, J.D., 2022. Adult Atlantic salmon (Salmo salar) delayed below dams rapidly deplete energy stores. *Canadian Journal of Fisheries and Aquatic Sciences*, *80*(1), pp.170-182.

adaptive management of the fishways will achieve high passage efficiencies and low passage delays consistent with the standards outlined in Brookfield's proposal and those recommended by MDMR.

Supplemental Information

Appendix 1. List of relevant MDMR comments on the FERC record for the Lockwood, Hydro-Kennebec, Shawmut, and Weston Projects.

1. Accession Number. 20240604-5145: Comments of MDMR on the DEIS for the Shawmut project.
2. Accession Number. 20240820-5055 : MDMR Additional Information Related to Shawmut 10(j) meeting with FERC
3. Accession Number. 20240820-5089: MDMR Additional Information Related to Shawmut 10(j) meeting with FERC.
4. Accession Number. 20240820-5090: MDMR Submits Design Drawings for 1" Trash racks at Shawmut and Fishway Exit Flume at Lockwood.
5. Accession Number. 20230214-5044: MDMR Clarification on Supplemental Information Filing

Supplemental Table 1. Migration periods for diadromous species in the Kennebec River are adopted from the
Milford Project in the Penobscot River.

Species	Upstream Migration Period	Downstream Migration Period
Atlantic Salmon	May 1- November 10	April 1-June 15 smolts and kelts; October 15-December 31 kelts
Alewife and Blueback Herring	May 1-July 31	June 1-November 30 adults and juveniles
American Shad	May 15-July 31	June 1-July 31 adults; July 15-November 15 juveniles
American Eel	June 1-September 15	August 15-November 15
Sea Lamprey	May 1- July 30	