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Commonwealth of Massachusetts

Division of Fisheries & Wildlife

MassWildlife

Wayne F. MacCallum, *Director*

February 28, 2013

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E., Room 1A
Washington, DC 20426

Turners Falls Project, FERC No. 1889
Northfield Mountain Project, FERC No. 2485
Comments of the Massachusetts Division of Fisheries and Wildlife
Scoping Document 1
Preliminary Application Document
Study Requests

Dear Secretary Bose:

The Massachusetts Division of Fisheries and Wildlife (Division) is the agency responsible for the protection and management of the fish and wildlife resources of the Commonwealth. The Division is also responsible for the regulatory protection of imperiled species and their habitats as codified under the Massachusetts Endangered Species Act (M.G.L. c.131A). The Massachusetts Endangered Species Act (MESA) was enacted in December 1990. Implementing regulations (321 CMR 10.00) were promulgated in 1992 and recently revised and implemented as of November 2010. The MESA provides a framework for review of projects or activities that occur within mapped areas of the state, called *Priority Habitat*, and published in the Natural Heritage Atlas. As such, we monitor operations at hydroelectric projects within the Commonwealth, as well as comment on proposed hydroelectric facilities. The Division has received your letter dated October 30, 2012, requesting review of the Preliminary Application Document (PAD) for, the Turners Falls Project(FERC No. 1889) and the Northfield Mountain Project (FERC No. 2485), and offers the following comments on the PAD and the Scoping Document 1 (SD1).

PROJECT DESCRIPTION

The Turners Falls Project and Northfield Mountain Pumped Storage Project are located on the Connecticut River within Franklin County, Massachusetts, Windham County, Vermont, and Cheshire County, New Hampshire. The greater portion of the Turners Falls Project and Northfield Mountain Project, including developed facilities and most of the lands within the project boundary, are located in Franklin County, Massachusetts; specifically, in the towns of Erving, Gill, Greenfield, Montague, and Northfield. The northern reaches of the Turners Falls Project and Northfield Mountain Project boundary extend to the base of the Vernon dam in the towns of Hinsdale, New Hampshire, and Vernon, Vermont. The Turners Falls Project has an installed capacity of 67.709 MW and an annual generation of 320,140 MWh. The Northfield Mountain Pumped Storage Project has an installed capacity of 1,119.2 MW and an annual generation of 1,143,038 MWh.

The Turners Falls Project's dam is located at approximately RM 122 on the Connecticut River in the towns of Gill and Montague, Massachusetts. The tailrace of the Northfield Mountain Project is located approximately 5.2 miles upstream of Turners Falls Project's dam, in the town of Northfield, Massachusetts. The upper reservoir of the Northfield Mountain Project is located atop Northfield Mountain in Erving, Massachusetts. The Turners Falls impoundment serves as the lower reservoir for the Northfield Mountain Project.

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The Turners Falls dam is located on the Connecticut River at approximately RM 122 in the towns of Gill and Montague, Massachusetts. The dam consists of two individual concrete gravity dams, referred to as the Gill dam and Montague dam, which are connected by a natural rock island known as Great Island. The Montague dam is approximately 35 feet high and 630 feet long, is founded on bedrock and connects Great Island to the west bank of the Connecticut River. The Gill dam is approximately 55 feet high and 493 feet long extending from the Gill shoreline (east bank) to Great Island. The Turners Falls impoundment (which also serves as the lower reservoir for the Northfield Mountain Project), is approximately 20 miles long, extending upstream through the Connecticut River valley to the base of Vernon dam. The impoundment has a surface area of approximately 2,110 acres and a gross storage capacity of 21,500 acre-feet at elevation 185.0 feet msl (as measured at Turners Falls dam) and also serves as the lower reservoir for the Northfield Mountain Pumped Storage Project. Most of the Turners Falls impoundment lies in Massachusetts; however, approximately 5.7 miles of the northern portion of the impoundment are located in New Hampshire and Vermont. At Turners Falls dam, the total drainage area is approximately 7,163 mi^2, or about 64% of the Connecticut River Basin drainage area (11,250 mi^2). The project includes two powerhouses, Station No. 1 and Cabot Station, which together have an authorized installed capacity of 67.709 MW which generated an average of 320,140 MWh annually from 2000-2009. Station No. 1 contains seven turbine/generators of which five are currently operational. Station No. 1 generating units consist of single runner vertical Francis turbines. The approximate turbine and hydraulic capacities of each unit are as follows: 2,100hp/560 cfs for Unit 1; 590hp/140 cfs for Unit 2; 1,900hp/500 cfs for Unit 3; Unit 4 is non-operational; 1,635hp/490 cfs for Unit 5; Unit 6 is non-operational; and 1,955hp/520 cfs for Unit 7. Cabot Station generating units consist of six vertical single runner Francis turbines. The approximate turbine and hydraulic capacities of each of the Cabot unit are 13,867hp/2,288 cfs.

The tailrace of the Northfield Mountain Project is located approximately 5.2 miles upstream of Turners Falls dam, in the town of Northfield, Massachusetts, and in the Turners Falls impoundment. The upper reservoir of the Northfield Mountain Project is located atop Northfield Mountain in Erving, Massachusetts and consists of a main dam, rockfill dikes and a concrete gravity dam. The upper reservoir typically operates between elevations 1,000.5 feet msl and 938 msl which provides a 62.5 foot drawdown. Within this range of fluctuation, the upper reservoir has a surface area of 134 and 286 acres at elevations 938 and 1,000 feet msl, respectively, and approximately 12,318 acre-feet of usable storage. The underground powerhouse contains four reversible pump/turbines that operate at gross heads ranging from 753 to 824.5 msl. The project has an authorized installed capacity of 1,119.2 MW (Unit 1: 267.9 MW, Unit 2: 291.7 MW, Unit 3: 291.7 MW and Unit 4: 267.9 MW). The approximate station hydraulic capacity is 15,200 cfs (3,800 cfs per/pump) in pumping mode and 20,000 cfs (5,000 cfs per/turbine) in a generation mode.

PROPOSAL

The current FERC licenses for the Turners Falls Project and Northfield Mountain Project expire on April 30, 2018. The owner of these projects, FirstLight Hydro Generating Company (FirstLight), a subsidiary of IPR-GDF SUEZ North America, Inc., is applying to relicense the projects. FirstLight is proposing to evaluate potential modifications to the Turners Falls Project and Northfield Mountain Project at this time. The potential modifications that FirstLight is evaluating include the following:

- Upgrading Station No. 1 with new or rehabilitated turbines.
- Closing Station No. 1 and adding a turbine generator at Cabot of similar hydraulic capacity to Station No. 1's.
- Utilizing the full hydraulic capacity of the Cabot turbines including currently unused capacity.
- Utilizing more storage in the Northfield Mountain Project's upper reservoir.
- Increasing the unit and station capacity at the Northfield Mountain Project.

COMMENTS

Scoping Document 1

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2.1 2.1
Purposes of Scoping
"Scoping is the process used to identify issues, concerns, and opportunities for enhancement or mitigation associated with a proposed action." This is a difficult mandate given that we have no idea which (if any) of the potential project modifications listed in the SD1 and PAD the project owner will propose.

3.4.2.4
Water Resources
Reservoir Drawdown. How will the proposed changes to project operations affect the current practice of limiting reservoir drawdown to 3.7 feet rather than the 9 feet allowed by the current license?

Aquatic Resources
Fishways: The Division believes that the project's fishways do not provide adequate fish passage particularly for American Shad. Studies conducted over the last few years as well as studies that the Division is now proposing should allow the FERC to determine what will be required to remedy this situation. Upstream and downstream passage for American eel must also be addressed.

Minimum Flow: The Division believes that the current minimum flow provided to the project's bypass reach is insufficient to protect aquatic life in that reach. The project owner is proposing a study to help determine a more appropriate flow. The Division has been consulting on the design of this study and believes that the FERC should allow this study to commence this summer (2013).

3.4.2.5
Aquatic Resources
The Division is concerned about the magnitude and potential effects of entrainment of fish, particularly juvenile American shad by the Northfield Mt project and has proposed studies to address this concern.

Terrestrial Resources
Bennett Meadow Wildlife Management Area
Approximately 200 acres, mostly alluvial floodplain, of Northfield Mountain project land which is presently leased to local farmers for agricultural use. The area is open to the public and managed by the Division as a wildlife management area. Hunting and fishing is permitted. Crop production plus existing wetlands, forest cover and river frontage provide excellent wildlife habitat. Bennett Brook feeds an extensive beaver flowage and a slough which create excellent habitat for waterfowl. The Division presently stocks pheasants on the Bennett Meadow property and has considered stocking fish in Bennett Brook.

Bennett Meadows was to be transferred to Massachusetts Division of Fisheries and Wildlife ownership as part of the original FERC licensing of the Northfield Mountain Project. The very similar 161 acre Pauchaug Brook Wildlife Management Area was transferred from the project owner to the Division at that time. The Division has been actively involved with the management of the Bennett Meadow Wildlife Management Area throughout the term of the current license and is still very interested in obtaining ownership of this land. The Division asks that the Project owner and the FERC consider this.

4.0
Cumulative effects
Because the five Connecticut River Projects are located contiguously on the main stem Connecticut River between RM 262 and RM 122 the Division believes that many of the project effects should be considered cumulative. In addition to those already identified by FERC staff the Division believes the following issues need to be addressed.

4.3.3
Aquatic Resources
Because delays to migration at one project may lead to a diminished chance to pass subsequent projects the Division believes that effects of project facilities and operations, (including reservoir fluctuations, and generation releases) on fish migration through and within project fishways, reservoirs, and the downstream riverine corridor should be studies cumulatively.

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5.0 and 6.0 Proposed Studies and Requests for Studies

In addition to the list of studies proposed by the project owner, the Division has proposed specific studies which are attached to this letter.

Requested studies

1. In-stream Flow Habitat Assessment of the Turners Falls Bypassed Reach
2. In-stream Flow Habitat Assessment Downstream of Cabot Station
3. Telemetry Study of Upstream and Downstream Migrating Adult American Shad to Assess Passage Routes, Effectiveness, Delays, and Survival
4. Impact of Project Operations on Shad Spawning, Spawning Habitat, and Egg Deposition in the Project Area.
5. Shad Population Model for the Connecticut River
6. Impact of Project Operations on Downstream Migration of Juvenile American Shad
7. Upstream American Eel Passage Assessment at Turners Falls
8. Downstream American Eel Passage Assessment at Turners Falls and Northfield Mountain
9. Evaluation of Timing of Downstream Migratory Movements of American Eels on the Mainstem Connecticut River
10. Three-dimensional Computational Fluid Dynamics (CFD) Modeling in the Vicinity of Fishway Entrances and Powerhouse Forebays
11. Model flows in the Northfield Mountain Pumped Storage Project discharge tailrace using two-dimensional Computational Fluid Dynamics (CFD) model techniques
12. Entrainment of Migratory and Riverine Fish from the Connecticut River into the Northfield Mountain Pump Storage Project
13. Model River Flows and Water Levels Upstream and Downstream from the Turners Falls Project Dam Generating Stations and Integration of Project Modeling with Upstream and Downstream Project Operations
14. Impacts of the Turners Falls and Northfield Mountain Pumped Storage Project Operations on Tributary and Backwater Area Access and Habitats
15. Impacts of the Turners Falls and Northfield Mountain Pumped Storage Projects on Littoral Zone Fish Habitat and Spawning
16. Impacts of Turners Falls Canal Drawdown on Fish Migration and Aquatic Organism Populations
17. Climate Change as it Relates to Continued Operation of the Northfield Mountain Pumped Storage, and Turners Falls Projects
18. Climate Change as it Relates to Continued Operation of the Northfield Mountain Pumped Storage, and Turners Falls Projects
19. Integrate Modeled River Flows and Water Levels with Habitat Assessment for State-listed Riparian Invertebrate Species
20. Habitat Assessment, Surveys, and Modeling of Suitable Habitat for State-listed Mussel Species in the Connecticut River
21. Fish Assemblage Assessment and Glochidia Surveys in the Connecticut River
22. Assessing Operational Impacts on Emergence of State-listed Odonates in the Connecticut River and Northfield Mountain Upper Reservoir
23. Assessing Operational Impacts on State-listed Rare Plants in the Connecticut River

9.0 Comprehensive Plans

In 2006, the Massachusetts Division of Fisheries and Wildlife received approval for its State Wildlife Conservation Strategy, most often referred to as the State Wildlife Action Plan (SWAP). The SWAP is a comprehensive document that will help guide wildlife conservation decision making for Massachusetts' wildlife for many years. The Massachusetts Action Plan represents an important effort by the Division to engage the public in a dialogue about the future of our wildlife resources. During development of the Massachusetts Plan, we sought public input and comment through presentations of a draft to the Fisheries and Wildlife Board, the Natural Heritage and Endangered Species Advisory Committee, and the Massachusetts Teaming With Wildlife Coalition. In addition, the Fisheries and Wildlife Board held a public informational hearing. A draft copy of the Plan was posted prominently on the agency website for public comment. At least 4300 entities were directly notified of this website posting through the Division's newsletter, including media outlets, conservation organizations, sportsmen and other private citizens. As a

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result, we received over 600 website visits to the Plan. The final Plan incorporated public comments and was reposted on the website for further public review prior to formal submission to the US Fish and Wildlife Division.

The Plan includes:

- A brief history of the Division and past successful efforts to conserve the biodiversity of the Commonwealth.
- A review of the landscape changes which have affected wildlife populations and sets the stage for problems we see facing these species today.
- An explanation of the process used to identify the habitats and species in the greatest need of conservation. Identifies the primary strategies needed to conserve these species and their habitats
- An recognition of the need to monitor these efforts as strategies are implemented both to ensure that time and money are providing the expected results and to determine if changing conditions require a change in strategy.

Massachusetts' Plan is organized around 22 habitat types and 257 wildlife species in greatest need of conservation. The habitat types range from large-scale habitats such as Upland Forests; to medium-scale habitats like Grasslands, to small-scale habitats such as Vernal Pools. Information for each habitat type includes

- habitat description;
- the suite of species in associated with that habitat;
- the problems and threats faced by them;
- a map showing the distribution of the habitat type across the state, when available;
- a listing of the conservation strategies needed to conserve the habitat; and
- monitoring requirements that will ensure the success of the conservation strategies.

There is also information about the 257 wildlife species in greatest need of conservation occurring in one or more of the above 22 habitat types including:

- Conservation status ranking and habitat association
- Species Life History
- State distribution and abundance
- Habitat requirement
- Conservation threats

The Division has requested that FERC add the MA SWAP to the list of Comprehensive Plans in a separate filing on February 13, 2013.

Preliminary Application Document

General
The PAD is very thorough and provides a higher level of detail than we see in most applications.

Specific
Section 4.14: Tributary Streams. The Fall River which enters the project bypass reach just below the Turners falls Dam is not listed.

Figure 4.1-2: Connecticut River Subbasins, Tributaries, and Dams. Several Hydroelectric dams are not depicted in this figure. The Crescent Street Dam on the Millers River is located between the two projects that are depicted. There are three hydroelectric projects on the Westfield River in Russell- the figure depicts only one project in this location. The figure does not depict the two large USACE flood control dams on the Westfield River, Knightville on the East Branch and Littleville on the Middle Branch. There are a number of hydroelectric dams on the Chicopee that are not depicted. Starting at the Connecticut River they are: Dwight, Chicopee Falls, Indian Orchard, Putts Bridge, Collins, and Red Bridge.

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4.4.5.2: American Shad. Timing of outmigration of YOY is cited as September. New studies have shown that YOY shad in the CT River move all summer long[1].

4.4.5.2: Blueback Herring. Blueback Herring were known to spawn in the Fall River- a tributary to the Turners Falls project bypass reach.

Figure 4.4.5-2: Annual Number of Blueback Herring Passed into the Holyoke Impoundment below the Turners Falls Project, 1980-2012. Perhaps the use of a log scale would be better suited to the wide range of data depicted.

Section 5.4 Relevant Qualifying Resource Management Plans

In 2006, the Massachusetts Division of Fisheries and Wildlife received approval for its State Wildlife Conservation Strategy, most often referred to as the State Wildlife Action Plan (SWAP). The SWAP is a comprehensive document that will help guide wildlife conservation decision making for Massachusetts' wildlife for many years. The Massachusetts Action Plan represents an important effort by the Division to engage the public in a dialogue about the future of our wildlife resources. During development of the Massachusetts Plan, we sought public input and comment through presentations of a draft to the Fisheries and Wildlife Board, the Natural Heritage and Endangered Species Advisory Committee, and the Massachusetts Teaming With Wildlife Coalition. In addition, the Fisheries and Wildlife Board held a public informational hearing. A draft copy of the Plan was posted prominently on the agency website for public comment. At least 4300 entities were directly notified of this website posting through the Division's newsletter, including media outlets, conservation organizations, sportsmen and other private citizens. As a result, we received over 600 website visits to the Plan. The final Plan incorporated public comments and was reposted on the website for further public review prior to formal submission to the US Fish and Wildlife Division.

The Plan includes:

- A brief history of the Division and past successful efforts to conserve the biodiversity of the Commonwealth.
- A review of the landscape changes which have affected wildlife populations and sets the stage for problems we see facing these species today.
- An explanation of the process used to identify the habitats and species in the greatest need of conservation. Identifies the primary strategies needed to conserve these species and their habitats
- An recognition of the need to monitor these efforts as strategies are implemented both to ensure that time and money are providing the expected results and to determine if changing conditions require a change in strategy.

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- habitat description;
- the suite of species in associated with that habitat;
- the problems and threats faced by them;
- a map showing the distribution of the habitat type across the state, when available;
- a listing of the conservation strategies needed to conserve the habitat; and
- monitoring requirements that will ensure the success of the conservation strategies.

There is also information about the 257 wildlife species in greatest need of conservation occurring in one or more of the above 22 habitat types including:

- Conservation status ranking and habitat association
- Species Life History
- State distribution and abundance
- Habitat requirement

[1] O'Donnell, M.J. and B.H. Letcher. 2008. Size and age distributions of juvenile Connecticut River American shad above Hadley Falls: influence on outmigration representation and timing. River Research and Applications 24:929-940

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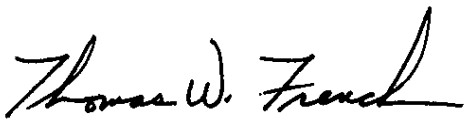
- Conservation threats

The Division has requested that FERC add the MA SWAP to the list of Relevant Qualifying Resource Management Plans for these projects in a separate filing on February 11, 2013. The plan is available online at (http://www.mass.gov/dfwele/dfw/habitat/cwcs/pdf/mass_cwcs_final.pdf).

Thank you for this opportunity to comment.

Sincerely,  Caleb Slater, Ph.D. Anadromous Fish Project Leader	Sincerely,  Thomas W. French, Ph.D. Assistant Director for the Natural Heritage & Endangered Species Program

cc: Melissa Grader, USFWS
Robert Kubit, MA DEP

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Requested Study No. 1.
In-stream Flow Habitat Assessment of the Turners Falls Bypassed Reach

Goals and Objectives

The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources in the bypassed reach between Turners Falls Dam and the Cabot Station discharge. Specifically, the objective of the study is to conduct an instream flow habitat study to assess the impacts of the range of the proposed project discharges on the wetted area and optimal habitat for key species.

Target fish species include: State listed (endangered) Shortnose sturgeon, American shad, fallfish, white sucker, freshwater mussels and benthic macroinvertebrates.

Relevant Resource Management Goals

The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to aquatic resources within the Turners Falls bypassed reach, the Division's goals are:

- Protect, enhance, or restore, diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
- Provide a flow regime in the bypassed reach that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels), state listed species, and diadromous fishes.
- Minimize the current negative effects of project operations on shortnose sturgeon spawning and rearing within known spawning areas of the bypassed natural river reach (i.e., the Rock Dam).
- Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest

The requestor is a resource agency.

Background and Existing Information

The Turners Falls Project bypasses a 2.7 mile-long section of the Connecticut River. Presently the only required spill releases from the Turners Falls dam to the bypassed reach are 400 cfs from May 1 through July 15 and 120 cfs from July 16 until the river temperature reaches 7°C.

In addition to these flows provided at the Turners Falls Dam, the bypassed reach receives flow from one small tributary (the Fall River, drainage area of 34.2 square miles), which enters the mainstem approximately 0.16 miles below the dam. The bypassed reach also receives the discharge from Station 1, when it is generating (typically when there is flow in excess of Cabot Station's needs). This discharge enters the bypassed reach approximately 0.9 miles below the dam.

Available information in the PAD does not indicate how project operations have altered downstream hydrology, habitat quantity and quality, and water quality, which may affect resident and migratory fish, macroinvertebrates, listed species, aquatic plants and other biota and natural processes in the Connecticut River from below the Turners

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Falls Dam downstream to the Cabot Station discharge. The PAD also provides no detailed description of the physical or biological characteristics of the bypassed reach.

Limited information exists on the adequacy of the existing bypass flow regime to protect water quality and aquatic life. However, there is existing information (not included in the PAD) relative to minimum flows necessary for shortnose sturgeon spawning and rearing at the Rock Dam spawning site (Kynard et al. 2012). Spawning success was observed at Rock Dam when discharge was between 2,500 cfs and 22,000 cfs during the spawning period of April 27 through May 22 (Kynard et al. 2012, chapter 3). In 1995 at the Cabot spawning area, the greatest level of spawning and spawning success occurred (i.e., 21 late stage females present, 342 early life stage captured, and the longest spawning period of 17 days) even though no spawning was detected at Rock Dam (Kynard et al. 2012, chapter 3). Discharges in 1995 at Rock dam had dropped below 2,500 cfs by March 26th (Kynard et al. 2012, chapter 3), which may indicate the need to have mitigated flow well in advance of spawning. Flow reductions at the Rock Dam site that occurred during spawning caused females to leave the spawning site and not return even if flow later increased to acceptable levels. Researchers observed that the rubble substrates remained dominant during fluctuating flows and cessation of spawning is likely due to velocities falling outside the range preferred by females. Given the current flow dynamics at Rock Dam, spawning does not occur most years (Kynard et al. 2012, chapter 3). These data represent the best available scientific information and does not support current minimum flow thresholds at the project.

An empirical study is needed to provide information on the relationship between flow and habitat in the bypassed reach for the Division to use in determining a flow recommendation.

Nexus to Project
The Project includes a 2.7 mile-long bypassed reach. The Turners Falls Project is currently operated with a seasonally-varying minimum bypass flow (200 cfs starting on May 1, increasing to 400 cfs when fish passage starts through to July 15, then reduced down to 120 cfs until river temperature drops below 7°C). The 400 cfs release is primarily to facilitate upstream movement of anadromous migrants to the spillway fish ladder at Turners Falls Dam and the 120 cfs was intended to provide protection to shortnose sturgeon by maintaining a wetted habitat 1.5 times the maximum adult body depth through connections between pools within the bypassed reach. Neither of the currently required flows were based on quantitative, rigorous scientific studies.

This section of the Connecticut River contains habitat that supports native riverine species, including important spawning and rearing habitat for the state endangered shortnose sturgeon. While the existing license does require seasonally-varying flow releases from the Turners Falls dam, we do not believe these flows sufficiently protect the aquatic resources, including endangered species, inhabiting the bypassed reach.

Results of the flow study will be used by the Division to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources in the bypassed reach for the duration of any new license issued by the Commission.

Proposed methodology
The Division requests a bypass flow study be conducted at the Project. Bypass flow habitat assessments are commonly employed in developing flow release protocols that will reduce impacts or enhance habitat conditions in reaches of river bypassed by hydroelectric projects.
Given the size of the bypassed reach (2.7 miles long) and the important resources known to inhabit the reach (i.e., state endangered shortnose sturgeon and diadromous fishes), we believe a study methodology that utilizes an IFIM approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[2]and has been accepted by the Commission in other licensing proceedings[3].

At a minimum, the study design should involve collecting wetted perimeter, depth, velocity, and substrate data within a range of discharge levels along transects located in the reach of river between the dam and the Cabot Station discharge. The measurements should be taken over a range of test flows up to 6,300 cfs or over a sufficient

[2] Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.
[3] Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pages 7-8, October 2007.

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range of flows to model flows up to 6,300 cfs. This information then should be synthesized to quantify habitat suitability (using mutually agreed upon HSI curves) of each test flow for target species/life stages identified by the fisheries agencies. Habitat modeling using standard PHABSIM 1 dimensional modeling is acceptable for the bypassed reach from the area downstream of the spillway where the river channel constricts to Rawsons Island upstream from the Rock Dam. The area from Rawson Island to the Cabot station discharge should be modeled using 2 dimensional (2D) modeling to better characterize flows and velocities in this complex channel area. Likewise, we recommend 2D modeling in the spillway area and mouth of the Falls River to the point where the channel constricts given this complex area with numerous potential flow discharge locations.

The flow study should incorporate the identified minimum flow and temporal parameters for shortnose sturgeon discussed in the Background and Existing Information section of this request.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Field work for flow studies can be reasonably extensive but will depend on consultation with the applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-fieldwork data analysis would be a moderate cost and effort. Field work associated with this study could be done in conjunction with the below-project instream flow study request. We anticipate that the level of effort and costs will be comparable to that experienced on similar FERC relicensing projects (e.g., the Glendale Project, FERC No. 2801).

Literature Cited

Kieffer, M. and B. Kynard. 2012. Spawning and non-spawning migrations, spawning, and effects of river regulation on spawning success of Connecticut River shortnose sturgeon. In Life history and behavior of Connecticut Rver shortnose sturgeon and other sturgeons. B. Kynard, P. Bronzi, and H. Rosenthal Editors. World Sturgeon Conservation Society: Special Publication #4. Norderstedt, Germany.

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Requested Study No. 2.
In-stream Flow Habitat Assessment Downstream of Cabot Station

Conduct an instream flow habitat study to assess the impacts of the range of the proposed project discharges on the wetted area and optimal habitat for key species. The study should include non-steady flow approaches to assess effects of within-day flow fluctuations due to peaking power operations on target fish species and benthic invertebrate communities. Target fish species include: state listed (endangered) shortnose sturgeon, American shad, fallfish, and white sucker.

Goals and Objectives
The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources from the Cabot tailrace of the Turners Falls Project downstream to the Rt. 116 bridge in Sunderland, MA. Specifically, the objective of the study is to conduct an instream flow habitat study to assess the impacts of a range if flows on the wetted area and optimal habitat for key species, including the impacts of hydropeaking flow fluctuations on the quantity and location of aquatic habitat.

The study should include non-steady flow approaches to assess effects of within-day flow fluctuations due to peaking power operations on target fish species and benthic invertebrate communities. Target fish species include: state endangered shortnose sturgeon, American shad, fallfish, white sucker and walleye.

For shortnose sturgeon, the flow study will need to evaluate bottom velocities in shortnose sturgeon spawning and rearing areas during discharge conditions normally observed from April 15th to June 22nd. Protection of shortnose sturgeon spawning will necessitate establishment of discharges that create bottom velocities suitable for shortnose sturgeon spawning and rearing over a sustained period of time and avoid dramatically fluctuating flows. To protect shortnose sturgeon rearing, adequate discharge without dramatic flow fluctuations are needed to ensure the rearing shoals are wetted and velocities are sufficiently protective for early life stage (ELS) rearing.

Field verification will be necessary to confirm the flow modeling results that identify the flows needed to provide sustained bottom velocities for spawning also maintain flows, depths, and water release regime adequate for spawning and rearing. Velocity and depth data should be collected under each potential operation scenarios such that actual velocity, depth, and flow conditions occurring across the entire spawning and rearing areas including wetted shoals.

Resource Management Goals
The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to aquatic resources, the Division's goals are:

- Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
- Provide an instream flow regime that meets the life history requirements of resident and migratory fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
- Minimize current and potential negative project operation effects on water quality and aquatic habitat.
- Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing at the Cabot Station spawning and rearing site.

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Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requestor is a resource agency.

Existing Information
Presently FirstLight is required to release 1,433 cfs below the Project. Information included in the PAD does not provide a detailed description of how this minimum flow was established and the Division is not aware of any previously conducted studies that evaluated the adequacy of this minimum flow in protecting aquatic resources in the 10+ miles of riverine habitat below the Cabot Station. Therefore, in order to fill this important information gap, an empirical study is needed to provide information on the relationship between flow and habitat in the Connecticut River downstream of the Cabot tailrace. Results will be used by the Division to determine an appropriate flow recommendation.

Kynard et al. (2012, chapter 3) examined the effects of water manipulation at the Turners Falls project on shortnose sturgeon spawning over the course of 17 years. This body of data represents the best available scientific information which does not support 1,433 cfs as an adequate minimum flow to support successful shortnose sturgeon spawning at Cabot Station. Peaking operations at Cabot Station cause discharge fluctuations to rapidly change bottom velocities from 0.4 m/s to 1/3 m/s over 30 minutes (Kynard et al. 2012, chapter 3). Shortnose sturgeon have not evolved to adapt to such artificial rapid changes in velocities and therefore continue to spawn during fluctuations even though conditions may be unsuitable and likely result in high egg mortality. During the 10 years when spawning succeeded at Cabot Station, discharge flow decreased to less than 35, 460 cfs by April 29th. The lowest discharge level observed while females remained on the spawning site was 4,700 cfs. Spawning behavior was not monitored during Cabot Station discharges at or below 3,500 cfs, so it is unclear what the minimum flow threshold is for spawning at Cabot Station. When peaking generation discharges cease during naturally low flow years, the tailrace shoals, likely used by shortnose ELS for rearing, were exposed (observed during years ’95, ’98-99, ’04) and may have resulted in larvae mortality due to stranding and exposure (Kynard et al 2012, chapter 3). Researchers observed that shoal exposure began when river flow below Cabot Station dropped below 7,062 cfs (Kieffer and Kynard 2007). Thus, total flow at Cabot, which may include flow from the Turners Falls Dam or Station 1, must be at least 7,062 cfs to both support adequate bottom velocities and prevent shoal exposure.

Furthermore, the emergency water control gates at Cabot Station that are used to sluice trash from the canal and balance canal flows spill large amounts of water. These large spill events create a plume of turbid turbulent flow, which caused some females to leave the area. These spill events scour bottom sediments which are then carried downstream over the spawning and rearing shoals where an entire year class of early life stages may be destroyed (Kynard et al. 2012, chapter 3). Information included in the PAD does not address adequate flows for shortnose sturgeon spawning and rearing. Results of the requested modeling will be used by the Divisions to determine an appropriate flow recommendation.

Researchers have also looked at suitable depth and velocity habitat for spawning (Kieffer and Kynard 1996, Kynard et al. 2012, chapter 3). Spawning sites are characterized by moderate river flows with average bottom velocities between 0.4 and 0.8 m/s (Hall et al. 1991, Kieffer and Kynard 1996, NMFS 1998). Water depth at the spawning site appears to be a less important habitat feature than substrate type and flow. A recent study by Kynard et al. (2012, chapter 6) demonstrated that females in an artificial stream will readily accept a shallow water depth of 0.6 m, with a rubble bottom, and 0.3–1.2 m/s bottom velocity. In addition, although eggs and embryos can likely tolerate very low depths, researchers measuring water depths between Turners Falls Dam and Cabot Station in order to recommend minimum flows suitable for an escape route for shortnose sturgeon trapped in the Turners Falls Dam Plunge Pool used a minimum depth of 1.5 x adult body depth. Because adults spawning in an artificial spawning channel frequently positioned themselves on top of one another (Kynard et al. 2012 Chapter 6), a minimum depth to facilitate spawning within the known Cabot Station spawning area is 3.0 body depths, or 19.2 inches.

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Nexus to Project

The Project is currently operated with a minimum flow release that was not based on biological criteria or field study. Further, the project generates power in a peaking mode resulting in significant with-in day flow fluctuations between the minimum and project capacity on hourly or daily basis. The large and rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota downstream of the project (Cushman 1985, Blinn 1995, Freeman *et al*. 2001). There are more than ten miles of lotic habitat below the project's discharge that are impacted by peaking operations at Cabot Station. This section of the Connecticut River contains habitat that supports native riverine species, including important spawning and rearing habitat for migratory fish such as American shad and state endangered shortnose sturgeon. Shortnose sturgeon larval migrants initially become bottom dwellers and transition from living off of yolk sacs to orally feeding, which is a critical stage in their life history. While the existing license does require a continuous flow of 1,433 cfs below the project (0.20 cubic feet per second flow per square mile of drainage area - cfsm), that is equal to only 40% of the Aquatic Base Flow[4] this flow does not sufficiently protect the aquatic resources, including endangered species, in this substantial reach of river, especially in the context of the magnitude, frequency, and duration of changes in habitat that likely occur between minimum and generation flows.

Results of the flow study will be used by the Division to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources below the Project.

Methodology Consistent with Accepted Practice

In-stream flow habitat assessments are commonly employed in developing plant operational regimes that will reduce impacts or enhance habitat conditions downstream of hydroelectric projects.

The Division requests a flow study be conducted at the Project. Given the length of the river reach (10+ miles) impacted by project operations, we believe a study methodology that utilizes an IFIM approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[5]and has been accepted by the Commission in other licensing proceedings[6].

At a minimum, the study design should involve collecting wetted perimeter, depth, velocity, and substrate data along transects located in the reach of river below Cabot Station. The measurements should be taken over a range of test flows. This information then should be synthesized to quantify habitat suitability (using mutually agreed upon HSI curves) of each test flow for target species identified by the fisheries agencies. Habitat modeling using standard PHABSIM 1 dimensional modeling is acceptable for the river channel downstream from the railroad bridge below the mouth of the Deerfield River. The area from the Cabot Station discharge to the railroad bridge should be modeled using 2 dimensional (2D) modeling to better characterize flows and velocities in this complex channel area.

The types of data collected with this study should be sufficient to perform a dual-flow analysis and habitat time series or similar approaches that will permit assessment of how quality and location of habitat for target species changes over a range of flows between existing minimum flow and maximum project generation flows.

Level of Effort/Cost, and Why Alternative Studies will not suffice

Field work for instream flow studies can be reasonably extensive but will depend on consultation with the applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-fieldwork data analysis would be a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to that experienced on similar FERC relicensing projects of this size (e.g., the Conowingo Project, FERC No. 405).

[4] The Aquatic Base Flow equates to the August Median Flow as determined using unregulated hydrography or on drainage area at the project site (0.5 cfs per square mile of drainage area) if unregulated hydrography is unavailable.
[5] Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.
[6] Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pages 7-8, October 2007.

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Requested Study No. 3.
Telemetry Study of Upstream and Downstream Migrating Adult American Shad to Assess Passage Routes, Effectiveness, Delays, and Survival

Goals and Objectives

Assess behavior, approach routes, passage success, survival, and delay by adult American shad as they encounter the projects during both upstream and downstream migrations, under permitted project operations conditions, proposed operational conditions, and study treatment operational conditions. There are multiple fishways and issues related to both upstream and downstream passage success at the projects.

Telemetry Study - This requested study requires use of telemetry using both radio and Passive Integrated Transponder (PIT) tag types to provide information to address multiple upstream and downstream fish passage issues. The following objectives shall be addressed in these studies:

- Assessment of any migration delays resulting from the presence of the dam and peaking flow operations of the Turners Falls Project;
- Determine route selection and behavior of upstream migrating shad at the Turners Falls Project under various spill flow levels (e.g., movement to the dam, attraction to Cabot Station, attraction to Station 1 discharge, movement between locations, delay, timing, etc.). A plan and schedule for dam spill flow releases will need to be developed that provides sufficient periods of spill flow conditions, and various generating levels from Turners #1 Station coupled with Cabot Station generation flows (e.g., treatments will require multiple days of consistent discharge). Evaluated spill flows should include flows between 2,500 – 6,300 cfs, which relate to bypass flows identified as providing spawning opportunities for shortnose sturgeon in the lower bypass reach at the Rock Dam. (Kieffer and Kynard 2012). Sturgeon spawning and upstream shad passage occur concurrently;
- Assess near field attraction to, and entrance efficiency of the Spillway Ladder by shad reaching the dam spillway, under a range of spill conditions;
- Evaluate the internal efficiency of the Turners Falls Spillway Ladder;
- Continue data collection of Cabot Station Ladder and Gatehouse Ladder efficiency, to include rates of approach to fishway entrances, entry into fishways, and passage through them, under different operational conditions that occur in these areas;
- Evaluate modifications to the Cabot and/or Spillway fishways recommended by the Division if they are implemented;
- Assess upstream migration from Turners Falls to the Vernon Dam in relation to Northfield Mountain's pumping and generating operations and Vernon Project peaking generation operations. Typical existing and proposed project operation alterations should be evaluated;
- Assess impacts of Northfield Mountain operations on up- and downstream adult shad migration, including delays, entrainment, and behavioral changes and migration direction shifts under existing and proposed project operations;
- Determine downstream passage route selection, timing/delay, and survival under varied project operational flows into the power canal and spill flows at Turners Falls Dam;
- Determine downstream passage route selection, timing/delay in the canal, Cabot Station fish bypass facility effectiveness, and survival of Cabot-bypassed adult shad that enter the Turners Falls Canal system;
- Compare rates and or measures of delay, movement and survival etc., among project areas or routes utilized (e.g., spill at dam vs. power canal) under the range of permitted and proposed conditions; and
- Utilize available data sets and further analyze raw data (e.g., 2003- 2012 Conte Lab Studies) where possible to address these questions and inform power analyses and experimental design.

Information to address all of these questions would rely on the tagging of upstream migrating adult shad at Holyoke Dam and releasing them to migrate naturally from Holyoke through the Turners Falls and Vernon projects and back downstream after spawning. Additional tagged individuals would likely need to be released farther upstream (Turners Falls Canal, upstream of Turners Falls Dam), to ensure that enough tagged individuals encounter project dams on both upstream and downstream migrations, that these individuals are exposed to a sufficient range of turbine and operational conditions to test for project effects, and to provide adequate samples sizes for statistically

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valid data analyses to address the many objectives listed. This study will require two years of field data collection to attempt to account for inter-annual variability in river discharge and water temperatures.

Evaluation of Past Study Data- In addition to collection and analysis of new telemetry data, substantial data has already been collected at Turners Falls from multiple years of passage assessments conducted for First Light by U.S. Geological Survey's Conte Anadromous Fish Research Center (Conte Lab) researchers and there are also data from the 2011 and 2012 full river study conducted by the Conte Lab that address Turners Falls, Northfield Mountain and Vernon project migration and passage questions that have not yet been analyzed. These data include several million records each year from more than 30 radio telemetry receivers deployed between Middletown, CT and Vernon Dam. This data will provide substantial information free from the field data collection costs and therefore should be analyzed as part of this study. This data analysis should be completed in 2013 to help inform the design of subsequent field studies.

Evaluation of Methods to Get Shad Past Cabot Station for Spillway Passage at the Turners Falls Dam – The poor passage efficiency of the Cabot Ladder, the first and most used fishway encountered by shad arriving at the Turners Falls Project, and at the entrance to the Gatehouse Ladder, which all Cabot fishway-passed fish must use, has resulted in very poor overall shad passage efficiency at the project. An alternative to passing fish at the Cabot Station is to install a fish lift at the dam that would put fish directly into the Turners Falls pool, thereby eliminating problems with the Cabot Fishway, and the Gatehouse Fishway entrance and the variable passage efficiency of the Gatehouse Fishway. For this to be effective, attraction of shad to the Cabot Station discharge and associated delays would need to be overcome. It is possible that spillway flow releases coupled with behavioral measures at Cabot Station that dissuade shad from that tailrace could achieve this end. In order to assess the possibilities, we recommend the following study:

- A literature search and desk-top assessment of the possible behavioral measures that could be effective in getting shad to pass Cabot Station tailrace and continue upstream to the dam.
- Based on results of the desk-top assessment, possible evaluation of behavioral measures that are likely to be effective.
- Field evaluation of the effect of different levels of spill at the dam that would induce fish to move past the Cabot Station into the bypass reach and up to the dam (as noted in objectives).

Besides passage success and delays at passage facilities, these studies would assess the impacts of project operations on migration passage delay, route, timing, injury, mortality, and passage structure attraction, retention, and success. Of particular interest will be fish behavior during periods when flow releases from the project increase from the required minimum flows to peak generation flows and when flows subside from peak generation flows to minimum flows and the operation of NMPS in pumping and generation modes.

Resource Management Goals

The Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following

- Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
- Achieve annual passage of 40% to 60% of the spawning run (based on a 5-year running average) at each successive upstream barrier on the Connecticut River mainstem.
- Maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010 includes the following objective:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes and recommendations:
- Upstream Passage –

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  - American shad must be able to locate, enter, and pass the passage facility with little effort and without stress.
  - Where appropriate, improve upstream fish passage effectiveness through operational or structural modifications at impediments to migration.
  - Fish that have ascended the passage facility should be guided/routed to an appropriate area so that they can continue upstream migration, and avoid being swept back downstream below the obstruction.
- Downstream Passage –
  - To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines,, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the least delay and best survival rate.

Based on the CRASC plan, the Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad movement and migration, the Division's goals are:

- Minimize current and potential negative project operation effects such as migration delays, false attraction, turbine entrainment, survival of project passage routes, and trashrack impingement that could hinder management goals and objectives.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest

The requestor is a fish and wildlife resource agency.

Background and Existing Information

Passage of adult shad at the Turners Falls fishway complex has been the subject of intense study by the Conte Lab since before 1999. These studies have clearly demonstrated that passage through the existing fishways at Cabot and Spillway is poor (<10% in many years). Passage through the Gatehouse fishway is better, but still rarely exceeds 80%, despite the short length of this ladder. In addition to poor passage for fish entering the ladders, shad that ascend the Cabot Fishway experience extensive delays before entry into the Gatehouse Fishway. Shad that ascend Spillway frequently fall back into the canal and are also subject to these upstream delays. A new entrance to the Gatehouse Fishway installed in 2007 led to dramatic improvements in passage out of the canal (from 5% to over 50% in 2011), but passage still falls well short of management goals. In addition, shad spend considerable time (up to several weeks) attempting to pass. These delays likely influence spawning success and survival. Adult shad, unable to pass Gatehouse, experience similar delays in downstream passage, even after they have stopped trying to pass Gatehouse. Without spill, all outmigrating shad that have passed Gatehouse must enter the canal at the Gatehouse and may be subject to delays exiting the canal.

During the course of these studies a very large dataset has been compiled that could yield useful information for further improving passage of shad out of the canal in both the upstream and downstream directions. A unique feature of these data is a 2-dimensional array covering the canal just downstream of Gatehouse, documenting fine scale movements and occupancy of this zone. These data should be combined with computational fluid dynamics (CFD) and real-time hydraulic data to determine how canal hydraulics influence the ability of shad to locate and enter the fishway, and to identify modifications that are likely to lead to improvements in approach and entry rates. A separate

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CFD modeling study is requested that includes modeling of the Gatehouse Fishway entrance are at the head of the power canal.

In addition, whole-river shad telemetry studies performed in 2011 and 2012 will likely provide useful information and should be analyzed. These data should allow quantification of delay below Turners Falls, and could help guide studies requested above. Preliminary analyses of data through 2011 have been made available to FirstLight and the resource agencies (Castro-Santos and Haro 2005; Castro-Santos and Haro 2010).

The whole-river studies have also shown that, at least in 2011, most shad that pass Turners Falls rapidly progress upstream to Vernon Dam where extensive delays also occur. Data from the 2012 study were not available at this time, but Dr. Castro-Santos stated similar patterns were noted in the data between the years on the topic of upstream delay (personal communication, Dr. Theodore Castro-Santos). Similarly, concerns relative to the downstream passage of spent shad also remain relative to delays, with existing unpublished USGS telemetry data sets suggesting this is an issue within the Turners Falls canal.

Since the first year of operation of the Turners Falls upstream fishways (1980), the percent passage of American shad annually passed upstream of Turners Falls Dam compared to the number passed at the Holyoke Fish Lift has averaged 3.6% (1980-2012 data). The highest values for this metric has not exceed 11% and are well below the noted CRASC Management Plan target range for this objective noted earlier as 40-60% on a five year running average.

Since the first year of operation of the Vernon Dam upstream fish ladder (1981), the percent passage of American shad annually passed at Vernon compared to the number passed upstream of Turners Falls Dam (Gatehouse counts) has averaged 39.4%, ranging from 0.42% to 116.4% (> 100% due to counting error at one or both facilities, unknown).

Nexus to Project

Existing project operations (peaking power generation) and limited bypass flows have a direct impact on instream flow and zones of passage (migration corridors). Project flow releases affect passage route selection, entry into fishways, and create delays to upstream migration. Inefficient downstream bypasses can result in migration delays and increased turbine passage. Mortality of adult shad passing through these turbines is expected to be high (Bell and Kynard 1985), additional stresses associated with passage and delay may cause mortality as shad are unable to return to salt water in a timely manner. The project's upstream and downstream passage facilities need to be designed and operated to provide timely and effective upstream and downstream fish passage to meet restoration goals of passage to upstream habitat and maximize post-spawn survival. These factors are all critically important to the success of restoration efforts.

Methodology Consistent with Accepted Practice

Use of radio including passive-integrated transponder (PIT) telemetry is widely accepted as the best method to assess fish migratory behavior and passage success and has been used extensively to assess migration and passage issues at Turners Falls as well as other Connecticut River projects. These studies include one conducted in 2011 and 2012 by the U.S. Fish and Wildlife Service and U.S. Geological Survey's Conte Anadromous Fish Research Center, which has provided substantial information related to some of the issues identified here. The requested study will build and expand on the information collected over the past two years.

The study design must specify sample sizes, tag configurations and receiver configurations, to ensure that rates of entry and exit to the tailraces, fishways, downstream bypasses, and the bypassed reach can be calculated with sufficient precision to determine effectiveness of flow. For project assessments at Turners Falls (e.g., Cabot, Spillway and Gatehouse ladder attraction and entry, route selection, operational effects), double tagged (radio and PIT) shad will be required for release from Holyoke Dam. Additional shad must be released directly into the Turners Falls Canal to support assessment of the various operational and structural conditions in effect, to be modified in this period, and proposed conditions within the Turners Falls power canal relative to entrances to the Gatehouse fishway. A related request on CFD modeling in the Cabot Station tailrace, the upper power canal near Gatehouse, and in the area around the entrance of the Spillway Ladder will address related project operational

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effects that will also address identified objectives in this telemetry request. Shad captured at Holyoke and tagged and release upstream of Turners Falls Dam, or tagged out of Gatehouse Ladder, would help to ensure an adequate sample size for evaluations in the vicinity of NMPS and to the Vernon Dam and the ability to address identified study objectives in those project areas. Additional tagged shad are expected to be required for release upstream of the Vernon Dam, which should ensure adequate sample for a separate study request, where shad spawn upstream of Vernon Dam as well as ensuring there is an adequate number of outmigrating spent adults to address related study objectives for adult outmigrants. The required number of tagged fish to address study objectives may be adjusted accordingly from area to area depending on target numbers (i.e., best information on resultant viable tagged fish and power analyses to detect effects) to account for typical passage rates, survival rates, and handling effects as examples.

Existing information on captured, handled, tagged fish performance (e.g., percent that drop back, unsuitable for tracking) and factors such as timing of tagging and potentially transport, must all be carefully considered to ensure an adequate sample size of healthy (e.g., viable to characterize behavior, survival, etc.) tagged fish is available to address the many questions identified in this request (as supported by a statistical power analysis). Additionally, ensuring adequate downstream adult fish sample sizes (to address project effect questions above) requires close consideration as expected losses of healthy tagged fish during upstream passage, natural mortality rates, and tagging related effects, are expected to reduce sample sizes on downstream passage objectives/questions as the season progresses. The use of single PIT tagged fish can help improve sample sizes, but will be of limited use to answer some of the passage questions we have identified.

Due to environmental variability, two years of study work will be necessary. A large array of stationary monitoring stations (radio and PIT) will be needed to address the issues identified among the project areas. A sufficient level of radio receiver and PIT reader coverage will be required, to provide an appropriate level of resolution, for data analyses, to answer these questions on project operational effects. The study will provide information on a variety of structural and operational aspects of fish migration, relative to route selection, timing, survival, and up and downstream passage attraction, retention, delay, efficiency, survival as some examples at three projects (Turners Falls, NMPS, and Vernon). The use of video monitoring may also be utilized for specific study areas such as the Spillway Ladder, to provide additional information on shad entrance activity, with the understanding of some data limitations associated with this approach (fish identification, water visibility).

In addition to the tagging studies, use of video monitoring of the Spillway Fishway would provide additional overall data on Spillway Fishway efficiency as all shad attempting to pass could be monitored versus just those shad that have been tagged.

Level of Effort/Cost, and Why Alternative Studies will not suffice

The requested study is extensive and will require a substantial effort and cost to capture, PIT tag, and radio tag a sufficient number of shad at Holyoke to release at upstream locations. We are not aware of any other study technique that would provide project specific fish behavior and migration information to adequately assess existing project operations and provide insight in possible alternative operations and measures needed to address observed negative impacts to fish migration success. Cost for the entire multi-project tagging, tracking and data analysis are expected to range from $400,000 to $500,000 based on past Turners Falls' studies and the 2011 and 2012 shad telemetry studies. Video monitoring of the Spillway fishway would add a modest cost to this study.

Due to the fact tagged shad will move throughout the larger five project area, to varying degrees, there will be expected cost savings (e.g., radio tags) to both owner/operators, provided cooperation in study planning and implementation occurs.

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Requested Study No. 4.
Impact of Project Operations on Shad Spawning, Spawning Habitat, and Egg Deposition in the Project Area.

Conduct a field study of spawning by American shad in the Connecticut River mainstem downstream of Turners Falls Dam and in the Turners Falls Dam impoundment to determine if project operations (including operations of the Northfield Mountain Pump Storage) negatively impact shad spawning behavior, spawning habitat use, areal extent and quality of those spawning areas, and spawning activity in terms of egg deposition in those areas.

Goals and Objectives

Determine if project operations (under the permitted and proposed operational ranges) affect American shad spawning site use and availability, spawning habitat quantity and quality, and spawning activity in the river reaches downstream from Cabot Station and in the project bypass reach of Turners Falls Dam and in the Turners Falls Dam impoundment and in relation to Northfield Mountain Pump Storage operations. The following objectives will address this request:

- Determine areas utilized by American shad for spawning by conducting night-time visual observation of spawning activity, identify and define areas geospatially, and obtain data on physical habitat conditions effected by project operations (e.g., water depth, velocity, discharge, substrate, exposure and inundation of habitats);
- Determine project operation effects on observed spawning activity, under a range of permitted or proposed project operation conditions;
- Quantify effects (e.g., water velocity, depths, inundation, exposure of habitats) of project operation on identified spawning areas for a range of conditions, over the complete period of spawning activity;
- Quantify spawning activity as measured by night-time spawning/splash surveys and egg collection in areas of spawning activity, and downstream of these areas, to further determine project operation effects (location extent of exposure from changing water levels and flows and on associated habitats from project operations).

If it is determined that the Project operations are adversely affecting the spawning activity of American shad and impacting spawning area habitat, identify operational regimes that will reduce and minimize impacts spawning habitat and spawning success, within the project area. This study will require two years of field data to capture inter-annual variability to river discharge and water temperatures and to allow for evaluation of alternative flow regimes if year one studies determine that the present peaking regime negatively affects spawning.

Resource Management Goals

The Connecticut River Atlantic Salmon Commission developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:

- Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
- Achieve annual passage of 40% to 60% of the spawning run (based on a 5-year running average) at each successive upstream barrier on the Connecticut River mainstem.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010 includes the following objective:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes

and recommendations:

- To mitigate hydrological changes from dams, consider operational changes such as turbine venting, aerating reservoirs upstream of hydroelectric plants, aerating flows downstream, and adjusting in-stream flows.
- Natural river discharge should be taken into account when instream flow alterations are being made to a river (flow regulation) because river flow plays an important role in the migration of diadromous fish.

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- Ensure that decisions on river flow allocation (e.g., irrigation, evaporative loss, out of basin water transport, hydroelectric operations) take into account instream flow needs for American shad migration, spawning, and nursery use, and minimize deviation from natural flow regimes.
- When considering options for restoring alosine habitat, include study of impacts and possible alteration of dam-related operations to enhance river habitat.

The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad, the Division's goals are:

- Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest

The requestor is a resource agency.

Existing Information

Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764 and the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad population, and numbers of shad passing Turners Falls and Vernon Dam have not met CRASC management plan objectives. Population number and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers over the last 10 years of 211,850. Since historically approximately half of the returning population of shad to the river passed upstream of Holyoke, recent returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management goals for the Connecticut River.

American shad broadcast spawn in congregations over shallow flats and rocky or sandy substrates (Davis et al, 1970, Mansuetti and Kolb 1953), at depths less than 10 feet and often far shallower with spawning fish swimming vigorously near the surface in a closely packed circle (Marcy 1972, Mackenzie et al 1985). Fertilized eggs drift downstream until hatching (Mackenzie et al 1985).

American shad are known to spawn downstream from the Turners Falls Project. Layzer (1974) identified 6 spawning sites from an area below the mouth of the Deerfield River (river mile 191.9) to river mile 161.7 below the Mill River in Hatfield, MA. Kuzmeskus (1977) verified 16 different spawning sites ranging from downstream of the Cabot tailrace to just upstream of the Holyoke dam (river mile 87.1). The only parameter that all spawning sites had in common was current (Kuzmeskus 1977). The Division is not aware of any more recent studies that document whether these 16 sites are still viable spawning locations for shad.

First Light Power conducted studies in the late spring and summer of 2012, examined habitat conditions downstream of the Turners Falls Dam. The study documented that in low flow conditions, Cabot Station project operations produced fluctuations in water level elevations that can range over 4 feet in magnitude (daily operation) at the USGS Montague Gage Station, to lower values of 2 to 3 feet at the Route 116 Bridge, Sunderland, MA (PAD). Similar

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short-term, limited monitoring in the upper Turners Falls Dam impoundment identified water level changes due to project operations that d cyclically varied several feet on a sub-daily frequency.

Nexus to Project

American shad are known to spawn at five locations downstream from the Turners Falls Project from an area below the mouth of the Deerfield River (river mile 191.9) and ten other locations downstream to river mile 161.7 below the Mill River in Hatfield (Layzer 1974, Kuzmeskus 1977).

Shad spawning is likely influenced by river flow, which fluctuates greatly due to the project's peaking mode of operation. These fluctuations may impact shad spawning activity by altering current velocities and water depth at the spawning sites. Effects on spawning behavior could include suspension of spawning activity, poor fertilization, flushing of eggs into unsuitable habitat due to higher peaking discharges, eggs dropping out into unsuitable substrate and being covered by sediment deposition and/or eggs becoming stranded on dewatered shoal areas as peak flows subside.

While a number of shad spawning and egg deposition studies were conducted in the 1970s, that research was aimed at assessing the potential impact of developing a nuclear power station in the Montague Plains section of the Connecticut River. The Division is not aware of any studies being conducted specifically designed to determine if a relationship between spawning behavior, habitat use, and egg deposition and project operations effects of the Turners Falls, Northfield Mountain Pump Storage.

The Division is concerned that peaking operations may be altering spawning behavior and contributing to the failure of the Connecticut River shad population to meet management targets.

Methodology Consistent with Accepted Practice

The first year of study should examine known spawning areas downstream of the Turners Falls Dam project, to determine operation effects on shad spawning behavior, activity, and success. In areas upstream of Turners Falls Dam to the Bellow Falls Dam tailrace, the study should identify areas utilized for spawning by American shad. In the second year, should results from year one determine project operations affected spawning activity, access to habitat, or success, downstream of Turners Falls Dam, then an identical more detailed assessment (identified objectives) should be conducted in spawning areas upstream of Turners Falls Dam to the Bellows Falls Dam tailwater. Measures to reduce or eliminate any documented project operation impacts should be explored and evaluated in year two, downstream of Turners Falls Dam.

The impacts to spawning behavior would best be studied by night-time observations of actual in-river spawning behavior (Ross et al. 1993). Project discharge increases or decreases during actual observed spawning activity will provide empirical evidence of change in behaviors. The observational methodology should follow the protocol specified in Layzer (1974) and/or as described in Ross et al. (1993). The analysis should utilize the observational field data in conjunction with operational data from the projects (station generation and spill on a sub-hourly basis). To assess the impacts of changes in generation flows, the study should include scheduled changes in project operation to ensure that routine generation changes that occur during the nighttime spawning period affect downstream spawning habitats selected for study while shad are spawning. Stier and Crance (1985) provide optimal water velocities during spawning to range between 1 to 3 ft/sec.

In areas used for spawning, the characteristics of those areas (e.g., location, depth, flow, substrate) should be recorded. The effect of project operations (discharge, water velocity, inundation and exposure) should be assessed. Drift nets will be used to collect eggs to quantify egg production before and after flow changes at the spawning site.

In the reaches above the Turners Falls dam, night time observations of splashing associated with shad spawning should be done in each reach as sufficient numbers of shad are passed above each dam. Observations should be done regularly until the end of the spawning season. The use of radio-tagged adult shad from a separate Study Request will aid in this effort. An estimate of the total area used for spawning and an index of spawning activity should be recorded for each site.

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Level of Effort/Cost, and Why Alternative Studies will not suffice

First Light has not proposed any studies to meet this need. Estimated cost for the study is expected to be moderate (up to $40,000), with the majority of costs associated with fieldwork labor.

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Atlantic States Marine Fisheries Commission. 2010. Amendment #3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management). Washington, D.C.

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Ross, R. R., T. W. H. Backman, R. M. Bennett. 1993. Evaluation of habitat suitability index models for riverine life stages of American shad, with proposed models for premigratory juveniles. Biological Report #14. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Stier, D. J. and J. H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U. S. Fish and Wildlife Service Biological Report No. 82(10.88), Washington, D.C.

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Requested Study No. 5.
Shad Population Model for the Connecticut River

Develop an American shad annual step, mathematical simulation population model for the Connecticut River to quantify how project operations and potential restoration/mitigation measures impact the population of shad in the Connecticut River.

Goals and Objectives
The goal of the model is to assess impacts of both upstream and downstream passage at each of the Connecticut River projects and potential management options for increasing returns to the river.

Specific objectives include:
- Annual projections of returns to the Connecticut River;
- A deterministic and stochastic option for model runs
- Life history inputs of Connecticut River shad
- Understanding the effect of upstream and downstream passage delay at projects
- Calibration of the model with existing data
- Analysis of the sensitivity of model inputs
- Analysis of sensitivity to different levels of up- and downstream passage efficiencies at all projects
- Multiple output formats including a spreadsheet with yearly outputs for each input and output parameter

Resource Management Goals
The Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:
- Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
- Achieve annual passage of 40 to 60% of the spawning run (based on a 5-year running average) at each successive upstream barrier on the Connecticut River mainstem.
- Maximize outmigrant survival for juvenile and spent adult shad.

The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:
- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad, the Division's goals are:
- Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requestor is a resource agency.

Existing Information
Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764 and

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the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad populations, and numbers of shad passing Holyoke, Turners Falls and Vernon Dam have not met CRASC management goals.

Population and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers since 2000 of 229,876. Whole river population estimates have shown that approximately half of the returning population of shad pass upstream of Holyoke. Recent returns to Holyoke are far below management goals. Average passage efficiency of shad at Turners Falls (Gatehouse counts) and Vernon since 2000 has been 3.1 and 20.4 % respectively. These too are well below the CRASC management goals.

Safe, timely and effective up- and downstream passage along with successful spawning and juvenile production are necessary to help achieve shad management goals for the Connecticut River.

Nexus to Project

Existing project operations and fish ladder efficiencies have a direct effect on shad populations in the Connecticut River. Poor upstream passage efficiencies and delays restrict river access to returning shad. Fish unable to reach upriver spawning grounds may not spawn or have reduced fitness or survival of young. Poor downstream passage survival and downstream passage delays affect outmigration and consequently repeat spawning, an important ecological aspect of the iteroparous Connecticut River shad population (Limberg et al. 2003).

The Division is concerned that poor passage efficiencies and delays at projects may be limiting access to upstream reaches of the river, altering spawning behavior, decreasing outmigration survival and contributing to the failure of the Connecticut River shad population to meet management targets (Castro-Santos and Letcher 2010).

Development of a population model will allow an assessment of individual project impacts on the population as well as the cumulative impacts of multiple projects. The model will allow managers to direct their efforts in the most efficient manner toward remedying the conditions that most impact the shad population.

Methodology Consistent with Accepted Practice

Population models are commonly used to assess anthropomorphic and natural impacts and are consistent with accepted practice. A model similar to this request was constructed for the Susquehanna River by Exelon (FERC #405, RSP 3.4). The model is constructed in Microsoft Access

Specific parameters that would be included in the model:

- Upstream passage efficiency at Holyoke, Turners Falls (Cabot, Gatehouse and Spillway Ladders), Vernon fishways, and any impacts associated with Northfield Mountain.
- Distribution of shad approaching the Turners Falls project between the Cabot Ladder and the spillway at the dam
- Downstream passage efficiencies at Vernon, Northfield Mountain, Turners Falls, and Holyoke projects for juveniles and adults
- Entrainment at Mount Tom and Vermont Yankee
- Sex ratio of returning adults
- The proportion of virgin female adults returning at 4, 5, 6, and 7 years
- The proportion of repeat spawning females at 5, 6 and 7 years
- Spawning success of females in each reach
- Fecundity
- Percent egg deposition
- Fertilization success
- Larval and juvenile in-river survival
- Calibration factor to account for unknown parameters such as at sea survival
- Options for fry stocking and trucking as enhancement measures
- Start year and model run years
- Start population
- Rates of movement to and between barriers

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- Temperature, river discharge, and other variable of influence to migration and other life history events

The model should be adaptable to allow the input of new data and other inputs.

Level of Effort/Cost, and Why Alternative Studies will not suffice
Neither First Light nor TransCanada have proposed any study to meet this need. Estimated cost for the study is expected to be low to moderate. As the model describes the impacts of multiple projects and two owners, both project owners would share the cost of model development.

Literature cited:

CRASC (Connecticut River Atlantic Salmon Commission). 1992. A management plan for American shad in the Connecticut River basin. Sunderland, MA

Castro-Santos, T and B. H. Letcher. 2010. Modeling migratory bioenergetics of Connecticut River American shad (*Alosa sapidissima*): implications for the conservation of an iteroparous anadromous fish. Can.J.Fish.Aquat.Sci. 67: 806-830

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Requested Study No. 6.
Impact of Project Operations on Downstream Migration of Juvenile American Shad

Conduct a field study of juvenile American shad outmigration in the Turners Falls impoundment and the power canal and at Turners Falls Dam, Station #1, and Cabot Station to determine if project operations negatively impact juvenile American shad survival and production.

Goals and Objectives
Determine if project operations affect juvenile American shad outmigration survival, recruitment, and production. The following objectives will address this request:

- Assess project operations effects of NMPS and Turners Falls Dam on the timing, orientation, routes, migration rates, and survival of juvenile shad;
- Determine the proportion of juvenile shad that select the Gatehouse into the power canal versus the dam spill gates as a downstream passage route, under varied operational conditions, including a range of spill conditions up to full spill;
- Determine if there are any delays with downstream movement related to either spill via dam gates or through the Gatehouse and within the impoundment due to operations (i.e., NMPS pumping and generation);
- Determine survival rates for juvenile spilled over/through dam gates, under varied operation conditions, including up to full spill during the annual fall power canal outage period;
- Determine the juvenile downstream passage timing and route selection in the power canal to: Station 1; Cabot Station; and the Cabot Station log sluice bypass, and assess delays associated with each of these locations and with project operations (e.g., stockpiling in the canal);
- Based upon year 1 study results on route selection, determine the survival rate for juvenile shad entrained into Station 1; and
- Determine the survival rates for juvenile shad entrained into Cabot Station units;

If it is determined that the Project operations are adversely affecting juvenile shad survival, migration timing, or other deleterious population effects , identify operational solutions or other passage measures that will reduce and minimize these impacts within the project area. This study will require two years of field data to capture inter-annual variability of river discharge, water temperatures, and variability in the timing and abundance of juvenile production and their outmigration timing, which may relate to spring, summer, and fall conditions. This study will compliment the NMPS Fish Entrainment Study Request which includes assessment of impacts to juvenile shad.

Resource Management Goals
The Connecticut River Atlantic Salmon Commission developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:

- Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
- Maximize outmigrant survival for juvenile and spent adult shad.
-

The Atlantic States Marine Fisheries Commission *Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management*), approved in 2010 includes the following objective:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes.

and Recommendation:

- To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.

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- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad, the Division's goals are:

- Minimize current and potential negative project operation effects on juvenile American shad survival, production, and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest

The requestor is a resource agency.

Existing Information

Since the construction of the Turners Falls Dam upstream fishways in 1980, American shad have had access to spawning and rearing habitat upstream of Turners Dam. A number of modifications to the Turners Falls fishways have occurred since that time, with the numbers of adult shad passed at Gatehouse Ladder (into Turners Falls Dam impoundment) reaching as much 60,089 in 1992 when a record 721,764 shad passed upstream of Holyoke Dam. However, since 1980 an average of only 3.6 % of the adult shad passed upstream of Holyoke Dam subsequently have passed upstream of Turners Falls Dam, and this value has never exceeded 11%. This value is well below the CRASC 1992 Shad Plan objective of 40-60% passage from the previous dam. In addition, population number and passage numbers past Holyoke have declined substantially, with the average Holyoke passage number over the last 10 years being 211,850. Because historic data suggests that approximately half the returning adult shad to the Connecticut River pass the Holyoke Dam, recent adult returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management restoration goals for the Connecticut River, which extends to the Bellows Falls Dam. In 1990, FirstLight's predecessor, Northeast Utilities, CRASC and its member agencies, signed an MOA on downstream fish passage to address both juvenile and adults at the Turners Falls Project and Northfield Mountain Pumped Storage Project.

American shad broadcast spawn with the highest spawning activity occurring in runs and lowest activity in pools and riffle/pools (Ross et al. 1993). Field research by Ross et al. (1993) in the Delaware River further noted that a combination of physical characteristics that seems to be avoided by spawning adults is slow current and greater depth. American shad year-class strength has been shown to depend on parent stock size and environmental conditions during the larval life stages (Creeco and Savoy 1984). Delays in juvenile American shad outmigration may affect survival rates in the transition to the marine environment (Zydlewski et al. 2003). One published study on the Connecticut River, identified that juvenile shad outmigration began when declining autumn temperatures reached 19C and peaked at 16C (O'Leary and Kynard 1986).

Juvenile American shad production has been monitored upstream of the Vernon Dam and immediately downstream of that dam by Vermont Yankee Nuclear as part of an annual monitoring program using both boat electrofishing (since 1991) and beach seining (since 2000). Sampling of juvenile shad was also conducted by a contractor hired by Northeast Utilities in the Turners Falls impoundment in 1992. O'Donnell and Letcher (2008) examined juvenile shad early life history and migration upstream and downstream of Turners Falls Dam. Their study results led to the decision by the agencies to require earlier operation of downstream fishways to protect early season juvenile shad out-migrants (1 September prior to 2010, 15 August in 2010, and since 2011, 1 August).

Downstream juvenile clupeid passage studies at Turners Falls were conducted in the fall of 1991 which included the objectives of determining the percentage of juvenile shad and herring that pass via the bypass log sluice or that were entrained in the Cabot Station turbines and related data (e.g., catch rates) were compared. The 1991 Downstream Clupeid Study did not assess survival rates for juveniles for either of these passage routes. The 1991 study report documented a higher rate of entrainment into the project turbines (23.0 fish per minute) versus through the bypass

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sluice (11.6 fish per minute). It was concluded that only an estimated 54% (average bypass rate, weighted by estimated number bypassed) of the juvenile American shad approaching Cabot Station were bypassed via the log sluice. The range of the percent bypassed varied widely by date, between nearly 0 and 83%, with "no clear explanation as to why." The report did not identify the percentage entrained into the turbines but it can be reasoned to be substantial based on the data presented in the report or assumed as the remaining balance (46%) as there were no spill events reported during this study, and therefore nowhere else for them to pass. It was further noted that entrainment rates for juveniles were consistently greatest for units 1 and 6 (ends), not uniform across all units. Although no concurrent bypass sampling occurred during the first entrainment sampling events, it was noted that "entrainment rates were relatively high during the end of September." Additional modifications have occurred over time without quantitative evaluation to improve downstream passage attraction and use to the bypass sluice, including lighting systems.

The 1994 Downstream Juvenile Shad Study report assessed juvenile shad survival from passage via the log sluice, reported to be 98%, based on tagged and recaptured fish (held for up to 48 hours). Scale loss (<20%) (22 of treatment fish) compared with scale loss of >20% (5 of treatment fish) was examined and determined to occur in an overall total of 10% of study fish (adjusted by control fish data).

Nexus to Project

Adult American shad passed upstream of Turners Falls Dam utilize upstream spawning habitat. Juvenile American shad production occurs in these habitats upstream of Turners Falls Dam on an annual basis. Juvenile American shad require safe and timely downstream passage measures to have the opportunity to contribute to the fishery agencies' target restoration population size.

The Division is not aware of any studies being conducted specifically designed to determine:

- When spill gates are open at the Turners Falls Dam?;
- What proportion of juvenile outmigrant shad take that route of passage?;
- What is the rate of survival under a range of spill and gate configurations?
- What is the timing, duration, and magnitude of juvenile shad outmigrants in summer and fall to the Turners Falls Dam and Gatehouse?
- Are there delays in migration/movement at the dam, Gatehouse, Cabot Station, or Station 1?
- For juveniles that enter the power canal, what proportion subsequently enter the Station 1 power canal?
- As there is no downstream passage facilities at Station #1, and trash rack spacing is 2.6 inches, what is the survival rate of juvenile shad entrained at Station #1?
- What is the rate of movement through the Turners Power Canal, relative to r delay to outmigrant juvenile shad and the potential accumulation of juveniles (e.g., prior to the canal drawdown in September)?
- What proportion of juvenile shad use the downstream sluice bypass versus the Cabot Station turbines under varied operational conditions given that project operations may change (PAD notes possible increase in turbine capacity at Cabot)?
- Based upon earlier facility studies (1991 Downstream Clupeid) a large proportion and number of juvenile shad are entrained into Cabot Station turbines. What are the associated impacts in terms of short-term and longer term survival and injury (i.e., scale loss)?

The Division is concerned that project operations may impact juvenile shad outmigration survival and be contributing to the failure of the Connecticut River shad population to meet management targets. In the PAD, proposed modification include; Station 1 may be upgraded with new turbines, Station 1 may be closed, and/or the turbine capacity at Cabot may be increased. It is unclear how these scenarios will affect the questions identified in this request.

Methodology Consistent with Accepted Practice

The impact to juvenile shad outmigrants by project operations would be best studied by a combination of approaches including hydroacoustic, radio telemetry, and turbine balloon tags. Project discharge over a full range of existing and, to the extent possible, potential future operational conditions at Station 1 and Cabot, at the dam (likely increased bypass reach flows in new license) and in relation to the Gatehouse, should be examined relative to timing, duration, and magnitude of juvenile shad migration to and through these areas, with hydroacoustic

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equipment for natural/wild fish evaluation. In addition, study fish should be collected and tagged (PIT, radio, other mark, and balloon) to also empirically determine rates of survival for fish passed over or through the dam's gates, under varied operations, including up to full spill condition that occurs annually in fall with canal outage period. The understanding of the timing, magnitude, duration of the wild fish outmigration will help inform the design, data/results, and assessment of tagged study fish. The release of tagged or marked fish (radio, PIT) upstream of the Gatehouse induction into the power canal, will provide data on concerns of delay and route selection to Station 1, Cabot Station downstream bypass, Cabot Station spill gates, and Cabot Station turbines. Additional hydroacoustic assessment at Cabot Station forebay will provide information on wild/natural juvenile fish timing, magnitude, and duration to and through this area. Based upon Year 1 study findings relative to the frequency, magnitude, timing of juvenile American shad that end up in the forebay of Station 1, the determination of whether an entrainment survival study at that site is necessary will be made. Release sites for tagged fish will be determined based upon further consultation among the parties.

Radio tagged juvenile shad will be released in areas upstream of the NMPS facility at multiple release locations, to determine operation effects on migration rates, route, orientation, entrainment, and survival, over a full range of permitted and operational conditions.

Level of Effort/Cost, and Why Alternative Studies will not suffice
First Light does not propose any studies to meet this need. Estimated cost for the study is expected to be high, between $200,000 and $300,000, with the majority of costs associated with equipment (hydroacoustic gear, radio tags, radio receivers, and PIT readers) and related fieldwork labor.

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Requested Study No. 7.
Upstream American Eel Passage Assessment at Turners Falls

Goals and Objectives

This study has two objectives:

- Conduct systematic surveys of eel presence/abundance at Cabot Station discharge, Station #1 discharge, canal discharges, and Turners Falls Dam to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures that would potentially establish the most effective locations to place upstream eel passage facilities.
- Collect eels with temporary trap/pass devices from areas identified from surveys as potential locations of eel concentration to assess whether eels can be collected/passed in substantial numbers, and whether locations are viable sites for permanent eel trap/pass structures.

Resource Management Goals

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

- Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
- Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Eel (Anguilla rostrata) in the Connecticut River Basin* in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

- Protect and enhance eel populations where they currently exist;
- Where practical, restore populations to waters where they had historical abundance;
- Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
- Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to upstream passage of American eel, the Division's goals are:

- Minimize current and potential negative project operation effects that could hinder management goals and objectives.
- Minimize project-related sources of upstream passage delay, injury, and stress in order to facilitate access to historical rearing habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest

The requester is a resource agency.

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Existing Information

The PAD contains no information relative to areas where eels seeking to move upstream concentrate downstream of the dam, or annual numbers of eels attempting to ascend past Turners Falls Dam. While eels have been known to ascend the Cabot Station ladder (A. Haro, U.S. Geological Survey, pers. comm.), its efficiency is unknown, and it is only operated during the American shad passage season (from April 1 through July 15). Eels are currently able to pass the Turners Falls Dam complex (as evidenced by documented presence of eels upstream), but the total number of eels attempting to pass Turners Falls and the proportion successfully passing the project is unknown (but suspected to be low). The downstream Holyoke Project has operated upstream eel passage facilities since 2004. Last year these facilities passed over 40,000 juvenile eels. While there is rearing habitat in between the Holyoke and Turners Falls dams, some eels will attempt to continue upstream, and passage needs to be provided so these fish can access historical habitat.

These information gaps need to be filled so resource agencies can determine the best locations to site upstream eel passage facilities and assess whether operating the existing anadromous ladders would be an effective mechanism to move juvenile eels upstream past the project.

We also note that within the past seven years, the U.S. Fish and Wildlife Service (Service) has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005 the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011 the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Nexus to Project

The project generates hydropower on the head created by the Turners Falls dam. This dam creates a barrier to upstream migrating eels. While some eels are able to pass dams, some are not, and the passability of a given dam depends on factors such as its height, hydraulics, presence of climbable surfaces, presence of predators, risk of exposure to heat or drying while climbing a dam, etc. The Turners Falls dam is high (35 feet above bedrock), and the majority of the dam face is dry during most of the upstream eel passage season. Design of the dam is not currently amenable to passage of eels by climbing. While flow is released to the bypass reach via a bascule gate (typically the one closest to the gatehouse), this would not facilitate eel passage, as bascule gates open outward and downward (i.e., requiring the eels to essentially swim nearly upside down to get over the gate). As mentioned earlier, the existing anadromous passage facilities are not designed to pass eels, and even if some eels are able to ascend the ladders, they may incur delays (in attraction or passage rates), be size-selective (e.g. velocity barrier for small eels presented by ~8 ft/sec flow through weirs and orifices), present a potential predation risk (predators in or near the fishways), and are not operated throughout the upstream eel passage season.

Methodology Consistent with Accepted Practice

- Objective 1: Systematic Surveys
  Surveys of eel presence and relative abundance should be conducted at regular intervals throughout the eel upstream migratory season (~1 May to ~15 October, or when river temperatures exceed 10 C). Surveys should consist of visual inspection and trapping in likely areas where eels may concentrate as they attempt to climb structures wetted by significant spill or leakage flow in the Turners Falls dam complex area. These locations include: Cabot Station downstream bypass outfall, Cabot Station spillway (including attraction water stilling basin), Cabot Fishway (dewatered state), USGS Conte Lab flume outfall, Number One Station outfall, various small turbine and process water outfalls from the Cabot Canal, Spillway Fishway attraction water stilling basin, and leakage points along the downstream face of Turners Falls Dam (bascule and taintor gates). Methods should include visual surveys (on foot, from a boat, or snorkeling) and trapping using small mesh (< 1/8" clear opening) baited eel pots. Visual surveys should be performed

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once per week, at night, preferentially during precipitation events. Trap sets should be performed once per week, with an overnight soak time. Recorded data should include location, observation of eels (presence, absence, relative numbers, relative sizes, behaviors, time/date of observation), and survey method.

- Objective 2: Trap/Pass Collections
  Areas identified from Systematic Surveys as having significant number of eels present should be targeted as potential areas for permanent eel trap/passes, and should be initially assessed using temporary/portable trap passes. At a minimum (regardless of survey results), temporary trap passes should be installed at the following locations: Cabot Fishway attraction flow stilling basin (during dewatered fishway period), Number One Station outfall, and Spillway Fishway attraction flow stilling basin (during watered and dewatered fishway period), as these locations may be supplemented with additional attraction flow and have high potential for being concentration points for upstream migrant eels. Temporary trap/passes should be purpose-designed and built for each location, and operated throughout the eel upstream migratory season (~1May to 15 October, or when river temperatures exceed 10 C). Ramp-type traps with supplementary attraction flow are preferred temporary trap/pass designs. Traps should operate daily, with catches quantified every 2-3 days. Recorded data should include location, trapping interval, absolute numbers of eels trapped, relative eel sizes, and hydraulic and environmental conditions during the trapping period.

All collected eels from surveys should be released at their point of capture; those eels collected from trap/pass collections should be transported to and released above the dam in the Turners Falls Pool.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies will not suffice

The level of cost and effort for the survey component of the study would be low; a minimal number of personnel may be able to conduct the weekly surveys. The trap/pass component would require low to moderate cost (estimated at $40,000) and effort.

In the PAD, the applicant has identified the need to assess issues related to upstream passage for American eels at the project, but indicates that it intends to rely on information from previously conducted studies and ongoing studies. The Division is not aware of any previously conducted or ongoing studies related to upstream eel passage.

Literature Cited:

Atlantic States Marine Fisheries Commission. 2008. Addendum II to the Fishery Management Plan for American Eel. Approved October 23, 2008.

Atlantic States Marine Fisheries Commission. 2000. Interstate Fishery Management Plan for American Eel. Fishery Management Report No. 36 of the ASMFC. April 2000.

CRASC (Connecticut River Atlantic Salmon Commission). 2005. A management plan for American eel in the Connecticut River basin. Sunderland, MA.

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Requested Study No. 8.
Downstream American Eel Passage Assessment at Turners Falls and Northfield Mountain

Goals and Objectives

The goal of this study is to determine the impact of two hydroelectric projects on the outmigration of silver eels in the Connecticut River. Entrainment of eels at the Northfield Mountain Pumped Storage Station (NFMPS) removes eels from the river, effectively removing them from the population. Entrainment into the turbines at Station 1 and Cabot Station of the Turners Falls Project may result in mortality or injury. It is important to understand the passage routes at each project and the potential for mortality to assess alternative management options to increase survival.

The objectives of this study are:

- Quantify the movement rates (including delays) and relative proportion of eels passing via various routes at the projects; i.e. for NFMPS, the proportion entrained into the intake; for Turners Falls Dam, the proportion entrained into the power canal and spilled via bascule and taintor gates; for the Cabot Canal, proportion of fish passing via spillways, turbines, and the downstream bypass.
- Evaluate instantaneous and latent mortality and injury of eels passed via the Turners Falls Dam routes, including bascule and taintor gates, spillways, turbines, and the downstream bypass.

Resource Management Goals

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

- Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
- Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watershed where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the FERC relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Eel (Anguilla rostrata) in the Connecticut River Basin* in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

- Protect and enhance eel populations where they currently exist;
- Where practical, restore populations to waters where they had historical abundance;
- Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
- Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to downstream passage of American eel, the Division's goals are:

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- Minimize current and potential negative project operation effects that could hinder management goals and objectives.
- Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest

The requester is a resource agency.

Existing Information

The PAD contains information on the biology, life history, and regulatory status of American eel. It also discusses 2-D and 3-D telemetry studies that were conducted at Cabot Station in 1996, 1997, 2002 and 2003. Results of those studies indicate that a significant proportion of eels entering the Cabot forebay become entrained (90% in 2002, 100% in 2003; Brown 2005, Brown *et al*. 2009). The PAD notes that the study done in 2003 determined that 15 of the 29 test eels were detected at the Hadley Falls Station. However, that study was not designed to assess turbine mortality.

To date, no directed studies of eel mortality at Cabot Station or eel entrainment or mortality at either Station 1 or the NFMPS facility have been conducted. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations on outmigrating eels and develop adequate passage and protection measures to meet management goals and objectives.

We also note that within the past seven years, the U.S. Fish and Wildlife Service (Service) has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005 the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011 the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made prior to any new licenses are issued for the projects.

Nexus to Project

The Turners Falls Project operates as a peaking facility, except during periods when inflow exceeds the hydraulic capacity of Cabot Station and Station 1. Silver eels outmigrate during the mid- summer through late fall, a time of year when flows are generally near the maximum operating capacity of the stations. Therefore, the project would be expected to spill infrequently during the silver eel outmigration beyond the nominal amount required in the bypass reach.

Racks at Cabot Station, Station 1, and NFMPS facility are not designed to protect eels from entrainment. At Cabot, the racks have one-inch clear spacing on the top 11-feet, with five-inch clear spacing on the bottom 20 feet of racks. The approach velocity at the racks is approximately 2.0 feet per second at maximum hydraulic capacity. At Station 1, the racks have 2.6-inch clear spacing and an approach velocity of 1.2 feet per second. Eels can readily pass through a 2.6-inch clear space. NFMPS has 48-foot-deep trashracks with six-inch clear spacing over the intake and an approach velocity of 3.5 feet per second at full pumping capacity (15,000 cfs).

As mentioned above, previous studies conducted at Cabot Station documented eel entrainment. Cabot Station has existing downstream passage facilities designed for anadromous species, but studies have documented few eels

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utilizing the surface bypass (likely because Cabot has a relatively deep, wide intake area). Station 1 has no passage and protection facilities. NFMPS has a seasonally-deployed barrier net to minimize entrainment of Atlantic salmon smolts, but it is only operated from April through June 15 annually. While no studies have been conducted at Station 1 or NFMPS facility, the rack spacing is wide enough to allow for entrainment.

Methodology Consistent with Accepted Practice

In order to understand the movements of outmigrating silver eels as they relate to operations at the Northfield Mountain Pump Storage Facility, Station 1, and Cabot Station, radio telemetry technology should be utilized. Radio telemetry is an accepted technology that has been used for a number of studies associated with hydropower projects, including at the Muddy Run Project (FERC No. 2355).

Studies should be designed to investigate route selection (i.e., entrainment vs. spill) independently from estimation of mortality/injury, because these metrics require different telemetric methodologies. Studies also will likely benefit from data from several seasons (especially route selection studies, which may be more significantly affected by environmental conditions during a given season that mortality/injury studies). It is also envisioned that results from route selection studies can guide design of turbine mortality studies. Therefore, it is proposed, at a minimum, that route selection studies be conducted in multiple years, but mortality/injury studies may be conducted after the first year of route selection studies have been completed.

- Objective 1: Route Selection

  This study will involve systematic releases of radio-tagged silver phase eels at strategic points above areas of interest, to assess general routes of passage (i.e., via spill, bypass, or turbines). Active downstream migrants should be collected within-basin if possible (i.e., Cabot or Holyoke bypass samplers), but fish sourced from out of basin may be acceptable to meet sample size demands. Experimental fish must meet morphometric (e.g. eye diameter relative to body size) criteria to ensure they are migrant silver phase. Collections should be made within the migratory season (late Aug to mid Oct), and eels should be tagged and released within 7 days of collection.

  - NFMPS Route Selection Study:
    A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Eels will be released at least 5 km upstream of the NFMPS project; releases should be timed so that there is a significant probability that migrating eels will encounter NFMPS during the pumping stage. Radio telemetry antennas will be strategically placed to determine times eels are present within the river reach in the vicinity of the NFMPS intakes, within the intakes themselves, and whether they are entrained into the upper reservoir.

  - Turners Falls Dam Route Selection Study:
    A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during spill and non-spill periods if possible. Tagged eels will be released at least 3 km upstream of the Turners Falls dam but several km below the intake to NFMPS. Telemetry receivers and antennas will be located above and below the dam to assess passage via the following potential routes: entrainment into power canal; passage via spill over the bascule gates; passage via spill through the taintor gates.

    Eels from the NFMPS route study not entrained into the NFMPS intake and migrating to the Turners Falls Dam may be used to supplement (but not serve in lieu of) these release groups.

  - Turners Falls Project – Canal Route Selection Study:
    A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during periods of low, moderate, and high generation conditions if possible. Eels will be released in the upper canal (ideally just downstream of the Gatehouse), and allowed to volitionally descend through the canal. Telemetry receivers and antennas will be located within the canal, bypass, channel, and mainstem below Cabot Station to assess passage via the following potential routes: Spillway Fishway attraction water intake

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(if operational); Station 1 turbines; Cabot Station spillway; Cabot Station bypass; Cabot Station turbines

Eels from the NFMPS and Turners Falls Dam Route Studies not entrained into the NFMPS intake and migrating into the Turners Falls Canal may be used to supplement (but not serve in lieu of) these release groups.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals during and after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

Movement rates (time between release and passage) of eels passing the projects by various routes will also be quantified.

The route selection portion of this study should occur in both study years.

- Objective 2: Spill, Bypass, and Turbine Mortality/Injury Studies

  Spill, bypass, and turbine mortality will be assessed using a radio-telemetric balloon tag method. A minimum number of 50 tagged eels (e.g., 5 separate groups of approximately 10 eels each) will be required at each location (dam bascule gate, dam taintor gate, Cabot Station spillway, Cabot Station bypass, Station 1 and Cabot Station) to maximize the data return. Turbine mortality studies are not required at NFMPS because it is assumed that all entrained fish (including eels) are lost to the Connecticut River system.

  For spill mortality sites (dam bascule gate, dam taintor gate, Cabot spillway, Cabot Station bypass), tagged eels will be injected or released into spill flow at points where water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming upstream into the headpond or canal. Passed balloon-tagged eels will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

  For turbine mortality sites (Station 1 and Cabot Station), tagged eels will be injected into intakes of units operating at or near full generation at points where intake water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming back upstream through the intakes. Passed balloon-tagged eels will be recovered in the tailrace and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

  Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

  The turbine mortality component of the study should occur in Study Year 2.

Data analyses of route selection and turbine mortality (instantaneous and latent) will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies will not suffice

The level of cost and effort for the downstream eel passage study would be moderate to high; silver eels would need to be collected, tagged, and released in several locations over the course of the migration season. Antennas and receivers would need to be installed at the intakes to all stations as well as at the Turners Falls dam spillway and Cabot Station bypass, and monitored regularly. Data would need to be retrieved periodically, then analyzed. A multi-site route selection study conducted by the USGS Conte Lab on the Shetucket River in Connecticut cost

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approximately $75,000 for the first year of study. Cost are estimated at $100,000 per year for the Route Selection studies and $75,000 per year for the Spill, Bypass, and Turbine Mortality/Injury Studies.

In the PAD, the applicant has identified the need to assess issues related to downstream passage for American eels at the project, but indicates that it intends to rely on information from previously conducted studies and ongoing studies. The Division is not aware of any previously conducted or ongoing studies related to downstream eel passage.

Literature Cited

Atlantic States Marine Fisheries Commission. 2008. Addendum II to the Fishery Management Plan for American Eel. Approved October 23, 2008.

Atlantic States Marine Fisheries Commission. 2000. Interstate Fishery Management Plan for American Eel. Fishery Management Report No. 36 of the ASMFC. April 2000.

Brown, L.S. 2005. Characterizing the downstream passage behavior of silver phase American eels at a small hydroelectric facility. M.Sc. Thesis, Department of Natural Resource Conservation, University of Massachusetts, Amherst, Massachusetts. 110 pp.

Brown, L., A. Haro, and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

CRASC (Connecticut River Atlantic Salmon Commission). 2005. A management plan for American eel in the Connecticut River basin. Sunderland, MA.

EPRI (Electric Power Research Institute). 2001. Review and documentation of research and technologies on passage and protection of downstream migrating catadromous eels at hydroelectric facilities. EPRI Technical Report No. 1000730, Palo Alto, California 270 pp.

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Requested Study No. 9.
Evaluation of Timing of Downstream Migratory Movements of American Eels on the Mainstem Connecticut River

Goals and Objectives

The goal of this study is to better understand migration timing of adult, silver-phase American eels as it relates to environmental factors and operations of mainstem hydropower projects on the Connecticut River.

The objectives of this study are:

- Quantify and characterize the general migratory timing and presence of adult, silver-phase American eels in the Connecticut River relative to environmental factors and operations of mainstem river hydroelectric projects

Resource Management Goals

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

- Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
- Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watershed where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the FERC relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Eel (Anguilla rostrata) in the Connecticut River Basin* in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

- Protect and enhance eel populations where they currently exist;
- Where practical, restore populations to waters where they had historical abundance;
- Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
- Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to downstream passage of American eel, the Division's goals are:

- Minimize current and potential negative project operation effects that could hinder management goals and objectives.
- Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

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Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requester is a resource agency.

Existing Information
Data on timing of downstream migratory movements and rates of American eels in the mainstem Connecticut River are sparse and relatively incomplete. Preliminary data on presence of "eel-sized" acoustic targets have been collected (Haro et al. 1998) within the Turners Falls Project's Cabot Station forebay that were somewhat confirmed by video monitoring at the Cabot Station downstream fish bypass; however, these were short-term studies, with acoustic monitoring only performed from 17 September to 5 October and video monitoring only conducted between 18 September to 22 October.

Some daily monitoring of the downstream bypass at the Holyoke Dam (canal louver array) was performed in 2004 and 2005 (Kleinschmidt, Inc. 2005, 2006, Normandeau Associates 2007); these studies also were of relatively short duration (spanning from October 5 to November 10 in 2004 and September 9 to November 11 in 2005) and the sampler was only operated at night.

To date, no other directed studies of eel migratory movements have been conducted at any location on the Connecticut River mainstem. This information gap needs to be filled, as it relates directly to when downstream passage and protection measures need to be operated.

We also note that within the past seven years, the U.S. Fish and Wildlife Service (Service) has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005 the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability. On September 29, 2011 the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Nexus to Project
The timing of downstream migration of adult eels is poorly defined for the Connecticut River; therefore the general effects of hydroelectric project operations on eel survival to the ocean are unknown. Although separate study requests have been submitted to address project-specific downstream passage route selection, delays, and mortality of eels, general characteristics of river flow and environmental conditions may have significant relationships with project operation and eel migratory success and survival. For example, eels may tend to move immediately before or during periods of significant precipitation (or consequently river flow); times at which projects may be generating at maximum capacity or spilling, which may (or may not) present a higher passage risk to eels. Conversely, periods of low flow may be associated with a significant proportion of total river flow passing through turbine units, which present additional (or different) passage risk to eels. If discrete conditions which promote eel downstream migration are known, it may be possible to take actions with respect to project operations which reduce or minimize passage risk; i.e., operation of a bypass, reduction of intake approach velocities, directed spillage through a "safe" route, etc. These studies should provide baseline information on river-specific downstream migration to predict when silver-phase eels are expected to be migrating in the mainstem Connecticut River, from which project operations could be modified to minimize passage risks.

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The studies are proposed for a single or multiple sites; the results will be relevant to all sites on the Connecticut River mainstem.

Methodology Consistent with Accepted Practice

Quantification of downstream movements of American eels in river systems requires systematic sampling of migrants throughout the migratory season. This can be accomplished with traditional active trapping methods; i.e., fyke or stow net sampling, weirs, or eel racks, but these methods are technically challenging on larger mainstem rivers, due to the scale of flows that need to be sampled, difficulties in operation throughout all flow conditions, and high debris loading during fall flows. Passive monitoring of migrant eels using hydroacoustic methods offers an alternative to active trapping. However, passive monitoring requires verification of potential acoustic targets with some level of active (collection) or visual (traditional optical or acoustic video) sampling.

Two potential locations offer opportunities to conduct simultaneous passive and active sampling: the Cabot Station (Turners Falls project) canal/forebay and the Holyoke Dam forebay and canal louver/bypass system. Each location possesses a route of downstream passage which conducts a significant proportion of river flow (Cabot canal and Holyoke forebay or canal), and each has a proximal bypass equipped with a sampler so that fish can be concentrated/collected from the passage route and identified to species. Project operations do influence the relative proportion of flow (and thus numbers of downstream migrant eels) in each passage route, so numbers of eels sampled in each route represent only a proportion of the total number of eels migrating downstream within the entire river. Because the absolute proportion of eels using a specific route at any one time is unknown, numbers of eels quantified within a route must serve as a relative index of the degree of migratory movement.

This study shall quantify eel movements in either one, or preferably both, locations for two consecutive years (since environmental conditions strongly influence migratory timing of eels, which can vary significantly from year to year; Haro 2003). Eels will be quantified using methods similar to Haro et al. (1999), by continuously monitoring a fixed location at the projects with hydroacoustics. Because eels tend to concentrate in areas of dominant flow (Brown et al. 2009, EPRI 2001), the zone to be monitored should pass a dominant proportion of project flow throughout most periods of operation (i.e., forebay intake area). Hydroacoustic monitoring shall encompass the entire potential migratory season, beginning in mid-August and ending in mid-December, and shall operate 24 hours per day. Data will be recorded for later processing and archiving.

Systematic active quantification of eels at downstream bypass samplers shall be performed simultaneously with passive hydroacoustic monitoring, to verify presence of eels and relative abundance of eel-sized hydroacoustic targets from the hydroacoustic data. Although daily operation of the bypass sampler could be performed, a more comprehensive technique is to monitor eels entering the bypass with an acoustic camera (i.e. DIDSON, BlueView, etc.). The acoustic camera will afford positive visual identification of eels as they enter the bypass, which is a concentration point for migrating eels. Acoustic camera monitoring will also allow monitoring to be performed 24 hours a day, and will be relatively unaffected by water turbidity (which influences effectiveness of traditional optical video monitoring). The acoustic camera system will be operated during the same time period as acoustic monitoring, and images will be recorded for later processing and archiving.

Data analyses of hydroacoustic, acoustic camera, bypass sampling, and environmental/ operational data will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies will not suffice

The level of cost and effort for the downstream migrant eel migratory timing study would be moderate, given the level of cost for instrumentation, deployment, and data review/analysis. Cost is estimated at $50,000 per year for the study.

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The applicant did not propose any studies to meet this need in the PAD.

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Requested Study No. 10.
Three-dimensional Computational Fluid Dynamics (CFD) Modeling in the Vicinity of Fishway Entrances and Powerhouse Forebays

Goals and Objectives
The goal of this study is to determine the flow field conditions that exist in and around the fishway entrances, and upstream of both Turners Falls powerhouses (Station 1 and Cabot). The information from this request is meant to be coupled with data from telemetry studies such that a comprehensive understanding of fish behavior is developed.

The objective of this study is to develop a series color contour maps of velocity magnitude and direction at discharges that have been agreed upon by the resource agencies and the licensee. With respect to upstream passage, the results will show approach velocities and orientation within the approach zone of the fish that may create a response in fish. This information can be coupled with telemetry data (from the requested telemetry studies) and passage counts to understand which conditions are optimal for guiding migrating fish to the fishway entrances and for stimulating fishway entry.

With respect to downstream migration, the results will show velocities and orientations in front of each powerhouse. At Cabot Station, the results will indicate to what degree, if any, flow directs downstream migrating fish towards the surface bypass weir. At Station 1, we will have an improved understanding of the magnitude of velocity in front of the turbine intakes.

Resource Management Goals
The management goals of this study request are to obtain information that will help assist in designing effective upstream fishways for upstream migrating trust species and to reduce impingement, entrainment and delay for downstream migrating fish. CFD models are a relatively cost effective way to analyze existing and future conditions. As such, changes in the amount of attraction water, changes in which turbines are operating, and which spillway gates are releasing water can all be examined. As stated, the results from this study are meant to be used along with the data generated from the telemetry study. The combined analysis from these two data sources can help assess which flow conditions are most advantageous for migrating trust species to enter the fishway under current and proposed conditions.

As for downstream migration of adult and juvenile shad, and adult eel, the results from the models will reveal flow magnitude and direction in front of each powerhouse. Given the limited information that currently exists on survival through Cabot and Station 1, our management goal is to direct as many downstream migrating fish as possible towards the uniform acceleration weir and downstream bypass. With respect to upstream passage, we want to maximize the number of fish that find and enter the fishway entrances

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requester is a resource agency.

Existing Information and the Need for Additional Information
To date, no CFD modeled data exist in front of either fish ladder, nor do they exist in front of either powerhouse. Some preliminary modeling has been done downstream of the gatehouse, but changes to the gatehouse entrances would require updated modeling. It is our understanding that the licensee has worked with the firm Alden Research Laboratory, Inc., to develop a CFD model of the upper end of the power canal and that elevation survey data from the power canal also are available. Detailed two-dimensional movement data on shad are available from observations made between 2003 to 2005 and 2010 to 2012. By coupling and analyzing these two data sets, flow and fish movement, we believe this will have substantial benefits to our management efforts.

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Nexus to Project
The Turners Fall Project has direct impacts to upstream and downstream migrating shad and eel.
When designing upstream passage structures, a site assessment is critical. The development of these models will give resource agencies valuable information into the hydraulic cues which may elicit a response from upstream migrants. For downstream passage, the U.S. Fish and Wildlife Service has approach velocity guidelines; the output from these models would inform the resource agencies under what conditions appropriate approach velocities are being met and when they are being exceeded

With respect to upstream migration, the auxiliary water system (AWS) plays a critical role in determining whether or not fish are attracted to the entrance. The results from this study would allow us to assess how well the AWS is performing and under what conditions it attracts the most fish.

With respect to downstream migration, the development of a CFD model under existing conditions also informs the design of future modifications and improves the survivability of downstream migrating shad and eel.

The CFD models for the spillway fishway and gatehouse fishway should be developed as part of year one studies and it would be preferable to have them completed prior to year one field studies in spring 2014. It would be useful to have the gatehouse area CFD modeling completed as soon as possible to begin comparing hydraulic conditions to the two-dimensional shad location data from prior studies. This analysis may provide information on adjustments to canal operations or structures that can subsequently be analyzed.

Understanding the entrance conditions of the spillway fishway under a range of spill conditions would be informative as we evaluate the spillway fishway entrances. If developed prior to the year one upstream shad telemetry studies, it would provide information on spill gate settings that would likely best achieve entrance and ultimately passage. Further work with the model after year one studies could evaluate changes in ladder entrance or spill conditions that could improve passage and be tested with year two telemetry, video and/or count data.

CFD modeling of the flows leading to the canal via the gatehouse and the Cabot Station and Number 1 Station forebays would have value in interpretation of year one downstream passage telemetry results, but would not need to be completed prior to the year one telemetry, downstream juvenile shad and downstream eel passage studies, as those studies will provide the context for how and where shad and eels are passing the project and how successful passage is. The CFD modeling could then be focused on the locations indicated as important based on the field studies and could assess changes to structures or operations that could be evaluated in the model. Promising alternatives could then be tested in year two studies.

Methodology Consistent with Accepted Practice
A three-dimensional CFD model has become an increasing common standard of analysis at hydro-electric projects around the nation. Within the northeast region, we have seen these types of models developed at the Holyoke (P-2004), Brunswick (P-2284), Shawmut (P-2322), Milford (P-2534) and Orono (P-2710) projects. We would expect to engage with the licensee in terms of determining the appropriate area and flows to be modeled. We expect that the spatial extent of the model at each study site will vary. Given the large number of ways that output from these models can be presented and the near infinite number of flows that could potentially be modeled, we would expect to consult with the licensee to reach agreed upon modeling efforts and scenarios to be examined.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice
The cost of developing, running and testing a CFD model can vary tremendously; one large variable in determining the cost is based on the amount of existing bathymetric data to which the Applicant currently has access. We roughly estimate that the cost of each CFD model could run as high as $50,000, assuming no bathymetric data currently exist. Proactive communication with resource agencies will reduce the cost and iterative effort. Given the level of effort that has occurred at other projects that have proposed to amend their license, we see the level of effort requested here as reasonable, given that the Applicant is seeking a renewal of its license.

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Requested Study No. 11.
Computational Fluid Dynamics (CFD) modeling of the Northfield Mountain Pumped Storage Project Intake/Tailrace Channel and Connecticut River Upstream and Downstream of the Intake/Tailrace.

Goals and Objectives
The goal of this study is to determine the potential impacts of the Northfield Mountain Pump Storage Project (NMPS) operations (pumping and generating) on: (1) the zone of passage for migratory fish near the turbine discharge/pump intake; (2) natural flow regimes in the area of the Connecticut River immediately upstream and downstream of the project; and (3) the potential for fish entrainment during pumping operations.

Specific objectives of the study include:

- Develop a CFD model of the NMPS intake and tailrace channel, along with the full width of the Connecticut River upstream and downstream of the discharge.
- Model flow characteristics upstream and downstream of the project under existing project operations (pumping and generating) and at several representative river flow levels, as well as proposed operations such as those proposed in section 3.4.4 of the PAD, and any other modifications under consideration, to assess potential impacts to fish and wildlife resources
- Assess velocities and flow fields at and in proximity to the NMPS intake/discharge structure when pumping or generating and their potential to interfere with fish migration, create undesirable attraction flows and result in fish entrainment.
- Assess the potential for velocity barriers in the mainstem river resulting from pumping and generation flows at the project, alone or in combination with generation flows from the upstream Vernon Project and operations at the Turners Falls Project.
- Assess the potential of a mainstem instream local flow reversal associated with pumping operations to impact migrating fish.
- Model and then evaluate flow characteristics under alternative project operations with potential measures to avoid, minimize, or mitigate impacts to fish and wildlife resources.

Resource Management Goals
The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to aquatic resources, the Division's goals are:

- Protect, enhance, or restore, diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
- Provide an instream flow regime that meets the life history requirements of resident and migratory fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
- Minimize current and potential negative project operation effects on water quality and aquatic habitat.
- Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing at the Cabot Station spawning and rearing site.

Instream flow is an important riverine habitat characteristic that can have a great impact on aquatic habitat for fish, wildlife, and plants. Flow is an important directional guidance cue for instream navigation and attraction to fishway entrances for migratory fish.

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Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requester is a resource agency.

Existing Information
No project specific information exists that will allow for a comprehensive assessment of existing project operations (pumping and generating flows) on Connecticut River flows and on fish and aquatic organisms in the project area upstream and downstream of the project in the Connecticut River. Preliminary results from an ongoing study of radio-tagged American shad by the USFWS and USGS Silvio O. Conte Anadromous Fish Research Center indicate that shad are exposed to the intakes and some individuals spend substantial amounts of time in the vicinity of the intakes. The PAD does not contain any information or tool that will allow for predictions of impacts of alternative project operations, or potential mitigation measures to protect or enhance aquatic fish and wildlife resources.

Nexus to Project Operations and Effects
Existing project operations have a direct impact on instream flow and aquatic habitat in the pump/discharge area of the Connecticut River. The PAD in section 3.2.2 says that the discharge at the trash racks when operating at full capacity is 20,000 cfs and maximum pumping conditions are 15,200 cfs. Annual flow duration curves shown for below the Vernon Dam submitted in the PAD section 4.3.1.2 (for years 1944-1973; recent and near project flows are not available; see p. 459) indicate that river flows are ≤ 20,000 cfs more than 85% of the time. Flows released from the project must therefore influence flow patterns and velocities in the Connecticut River, particularly at flows below some unknown threshold level.

Recreational users of the Connecticut River in the Turners Falls impoundment have anecdotally described flow reversals in the mainstem river. Discharges from the project could potentially be larger than river flows or at least act like a major tributary to the Connecticut River. Project flows may influence the availability and extent of upstream and downstream migration zones, or may confuse fish and delay migration.

Methodology Consistent with Accepted Practice
CFD modeling is consistent with generally accepted practice, and has been used to assess proposed modifications to the Holyoke Project (FERC No. 2004) fish passage facilities, upstream of the intakes and downstream of the dam, as well as at hydroelectric projects on the Susquehanna River to assess existing and proposed project operations, and develop mitigation measures for fish and wildlife resources.

A study plan that describes the specific modeling tools to be used, the amount of bathymetric data to be gathered, the geographic scope of the assessment and the flow conditions to be modeled will need to be developed in consultation with the Division and other parties.

Level of Effort/Cost, and Why Alternative Studies will not suffice
This study will require a detailed elevation map of the study area upstream and downstream of the NMPS intake structure. Some information already exists in historic construction files for the project and past hydraulic analyses. Additional bathymetric data likely will need to be collected in the field using standard survey techniques. The CFD computer program will need to simulate existing project operations as well as accommodate all potential variations of pumping and generating, and static operation.

No project-specific instream flow analysis tool has been developed for the NMPS that will allow for assessment of existing operations and alternative operational impacts on instream flow and aquatic habitat for fish and wildlife resources. The computer model, once built, can be used to simulate flow conditions in the vicinity of the project during migratory fish passage and can be used together with behavior studies (i.e., telemetry studies and entrainment studies requested herein) to assess the impacts of varying project operations or potential mitigation operations and measures on fish migration and aquatic habitat. We know of no other tool that will provide for these types of assessments. Cost is expected to be moderate to high.

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Requested Study No. 12.
Entrainment of Migratory and Riverine Fish from the Connecticut River into the Northfield Mountain Pump Storage Project.

Goals and Objectives

The goal of the study is to determine the impact of Northfield Mountain Pump Storage Project (NFMPS) during the pumping cycle on entrainment of juvenile American shad, adult shad, adult American eel, and riverine fish, including early life stages.

The objective of the study is to quantify the number of resident and migratory fishes entrained at the NFMPS intake on an annual basis in order to evaluate potential impacts to riverine fish populations in the Turners Falls pool and diadormous fish migrants moving through the project area. This will be accomplished through a combination of hydroacoustic monitoring and netting using various gear types to quantify and identify species of different life stages.

Resource Management Goals

The Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following

- Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually. (Table 1)
- Achieve annual passage of 40 to 60% of the spawning run (based on a 5-year running average) at each successive upstream barrier on the Connecticut River mainstem.
- Maximize outmigrant survival for juvenile and spent adult shad.

Based on the CRASC plan, the Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

- Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
- Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watershed where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the FERC relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Eel (Anguilla rostrata) in the Connecticut River Basin* in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

- Protect and enhance eel populations where they currently exist;
- Where practical, restore populations to waters where they had historical abundance;

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- Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
- Comply with all requirements of the Fishery Management Plan of the ASMFC.

Specific to resident riverine and migratory fish entrainment, the Division's goals are:

- Minimize current and potential negative project operation effects such as turbine entrainment that could hinder management goals and objectives.
- Minimize project-related sources of mortality to resident and migratory fishes in order to restore natural food web interactions and ecosystem functions and values.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requestor is a fish and wildlife resource agency.

Existing Information
Limited project-specific information exists regarding entrainment of fish and aquatic organisms at the NFMPS. As part of a Memorandum of Agreement between then-owner Northeast Utilities Service Company (NUSCO) and regulatory agencies (including the Division), NUSCO conducted studies to determine the impact of NFMPS on anadromous fishes, including Atlantic salmon, American shad, and blueback herring. Results of a pilot study conducted in the fall of 1990 indicated that trap netting at the intake was ineffective at collecting fish. Gill netting and boat-shocking did result in collection of some juvenile shad, but further refinement in both methods was recommended to improve effectiveness. A total of 78 fish were collected at the intake (77 of which were American shad) by gill netting and 11 shad were collected by boat electrofishing. Hydoacoustic monitoring was deemed an effective method for monitoring entrained fish during pumpback operation. Hydroacoustic sampling over a two-week period (September 12-27, 1990) produced hourly entrainment estimates that cumulatively equaled 14,816 fish. Based on the results of the pilot study, NUSCO developed a two-year plan to quantitatively determine the number of shad and salmon entrained at NFMPS station. In 1992, an entrainment study targeting juvenile American shad life stages was conducted in the lower (mainstem river) and upper reservoirs of NMPS. The study used several gear types to quantify egg through juvenile shad densities in different areas. Entrained juveniles were sampled using an upper reservoir net. Pumping operations were modified to only run three (77% of sample time) and sometimes two (23% of sample time) of the station's four units during the study and effort was limited to a total of 80 hours over a period spanning 9 August through 27 October (80 days). An estimated total of 1,175,900 shad eggs, 2,744,000 yolk-sac larvae, 10,525,600 post yolk-sac larvae, and 37,260 juveniles were reported entrained.

There are no reliable data on the timing, magnitude and duration of entrainment of larval riverine fishes in the NFMPS area. Unlike anadromous shad and river herring, riverine species occurrence and susceptibility relative to space and time exposure windows to NFMPS pumping are undocumented. The complete lack of any long-term fish population monitoring data for riverine species in the Turners Falls impoundment leaves questions unanswered on the types and extent of impacts to these populations that may be linked to the near daily cycling of river water up and down through the NFMPS operations system. As a starting point, it is necessary to obtain baseline data on project operation impacts for all species potentially impacted by NFMPS. An additional study request seeks to obtain a more accurate documentation of all fish species inhabiting or utilizing the Turners Falls impoundment.

Nexus to Project Operations and Effects
Entrainment of fish and aquatic organisms associated with water withdrawal and hydroelectric operations has been documented to result in injury or death of entrained organisms. Migratory and resident fish pass through the project area directly in front of the pump intakes. These organisms may be entrained and thus exposed to passage though the project pumps and reservoir supply tubes. How far from the intake these species and life stages may be drawn into the intake on a pumping cycle or how susceptible they are to the repeated daily cycles of pumping and discharge, and how these factors vary in relation to habitat and river conditions are unknown. Survival of fish

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subjected to entrainment on the pumping cycle is unknown, but regardless of whether fish survive the pumping process, they are lost to the Connecticut River system. Depending on the species, life stages, and numbers entrained, this loss could impact the ecosystem productivity of the Turners Falls pool and may hinder restoration goals for diadromous fishes.

Previous entrainment studies have been conducted at the project. Those studies, which were done 20 years ago, documented entrainment of American shad and Atlantic salmon at the project, including over 13 million yolk sac and post-yolk sac larvae of American shad. This level of entrainment is cause for concern, not only due to the resultant loss of potential adult returns, but for the important role early life history phases and juveniles play in their ecological contributions to the river system (e.g., trophic interactions).

No entrainment studies for other species of fish have been conducted at the project. The unknown extent of other riverine species ichthyoplankton entrained by the NFMPS requires evaluation. Studies conducted in 1969 and 1970 at the Muddy Run Pumped Storage Station documented significant entrainment of eggs and larval fish. In June and July of 1970, 5.3 million eggs and 56.6 million larvae were entrained (Snyder 1975). Muddy Run and NFMPS are of a similar size and both use a river as the lower reservoir. It is anticipated that a considerable number of eggs and larvae will be entrained by the NFMPS.

Since the previous studies were conducted, operations at the NFMPS facility have changed (e.g., the project increased the efficiency of its turbines, and raised the pumping capacity from 12,000 cfs up to 15,000 cfs), as have river conditions (e.g., Vermont Yankee has increased its thermal discharge and the Vernon Project has increased its station capacity). Further, the PAD indicates that FirstLight will evaluate the feasibility of utilizing an additional 3,009 acre-feet of storage capacity to generate an additional 1,990 MWhs (this represents a 23% increase over existing storage and stored generation levels). While not specified in the PAD, increasing storage and generation would mean longer periods of both pumping and generation at NFMPS. In addition, anticipated improvements in fish passage at the Turners Falls Project will result in increased juvenile production above the NFMPS. These factors, individually or cumulatively, could increase the potential for entrainment at NFMPS station.

Methodology Consistent with Accepted Practice

Previous studies used varying methodologies for determining entrainment. The 1990 study concluded that hydroacoustic monitoring at the intake was a viable method for determining entrainment of later life stages, but does not allow for identification of the species being entrained. While trap netting was ineffective at collecting fish near the intake, gill netting and boat shocking did capture some fish. Both may prove to be viable sampling methods; however it is likely that additional testing and gear refinement will be necessary.

The 1992 study used nets at the pump discharge location into the upper reservoir to collect entrained fish. Testing showed that this method was only 10% efficient. Plankton netting in the nearfield area of intake was used to estimate entrainment of ichthyofauna. It is likely that a combination of methods would provide the most reliable results (e.g., hydroacoustic monitoring at the racks during pumpback operations, variable gear sampling in the vicinity of the intake immediately prior to initiation of pumpback operations to determine species composition, and plankton netting in the nearfield area of the intake to obtain information on entrainment of ichthyofauna). As these methodologies have previously been utilized at the site, they are consistent with accepted practice.

Although a previous entrainment study was conducted, the Division believes it should be repeated, using a modified study design. The 1992 study only collected a total of 330 juvenile shad over a three-month period (resulting in an overall estimate of 37,260 juveniles entrained, after accounting for poor net efficiency); whereas the hydroacoustic study conducted in 1990 estimated nearly 15,000 fish in 15 days (while these fish were not identified, 77 of the 78 fish collected at the intake during the study were juvenile shad). It also should be noted that in the 1992 study, juvenile shad were collected on the first day of sampling, indicating that the sampling did not begin early enough, which would mean the results are an underestimate of the number of juvenile shad that were actually entrained. In 1990, 27,908 adult shad passed the Turners Falls gatehouse, while in 1992 over 60,000 shad passed gatehouse. The fact that the numbers entrained were so variable between study years argues for repeating the study, using a combination of previously-used methodologies.

The study will require deployment of at least five hydroacoustic transducers (one per rack face and one offshore). These transducers would be operated during every pumping cycle from April 15 through May 14 to assess riverine

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fish entrainment, from May 15 through July 15 for spent adult shad, and from July 16 through November 30 for entrainment of adult silver eels, juvenile American shad, and riverine fishes. Concurrent field sub-sampling at the intake to determine species composition would need to occur.

Sampling for planktonic fish larvae should capture early spring spawning species (white suckers) through later season centrarchid species (bass and sunfish). Active plankton trawl surveys should utilize a sampling design that adequately captures temporal and spatial changes in water pumping cycle (i.e., early start-up is local water, later cycle pumping is drawn in from both upstream and downstream habitat areas).

Level of Effort/Cost, and Why Alternative Studies will not suffice

We know of no other tool that will provide for this type of assessments for all fish species and organisms that may pass through the project. Cost and effort are expected to be high.
The applicant did not propose any studies to meet this need in the PAD.

Literature Cited

CRASC. 1992. A Management Plan for American Shad in the Connecticut River.

Harza Engineering Company. 1991. Draft Northfield Mountain Pumped Storage Project 1990 Field Sampling Program. February 1991. Northeast Utilities Service Company, Berlin, CT.

Lawler, Matusky and Skelly Engineers (LMS). 1993. Northfield Mountain Pumped-Storage Facility – 1992 American Shad Studies. February 1993. Northeast Utilities Service Company, Berlin, CT.

Memorandum of Agreement NUSCO. July 1990.

Snyder, D.E. 1975. Passage of fish eggs and young through a pumped storage generation station. J. Fish Res. Board Canada. 32: 1259-1266.

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Requested Study No. 13.
Model River Flows and Water Levels Upstream and Downstream from the Turners Falls Project Dam Generating Stations and Integration of Project Modeling with Upstream and Downstream Project Operations

Goals and Objectives

Develop a river flow model(s) that are designed to evaluate the hydrologic changes to the river caused by the physical presence and operation of the Turners Falls Hydroelectric Project and the interrelationships between the operation of all five hydroelectric projects up for relicensing (i.e., P-1889 Turners Falls Hydroelectric Project, P-2485 Northfield Mountain Pumped Storage, P-1904 Vernon Hydroelectric Project, P-1855 Bellows Hydroelectric Project, P-1892 Wilder Hydroelectric Project) and river inflows. The flow studies should assess the following topics:

- Conduct quantitative hydrologic modeling of the hydrologic influences and interactions that exist between the water surface elevations of the Turners Falls Project impoundment and discharges from the Turners Falls Dam and generating facilities and the upstream and downstream hydroelectric projects. Data inputs to and outputs from the model(s) should include:
  - Withdrawals from the Turners Falls impoundment by the Northfield Mountain Pumped Storage Project, FERC No. 2485,
  - Discharges to the Turners Falls impoundment by the Northfield Mountain Pumped Storage Project,
  - Discharges into the Turners Falls impoundment from the Vernon Project, FERC No. 1904 and other sources.
  - Existing and potential discharges from the Turners Falls Project generating facilities and spill flows.
  - Existing and potential water level fluctuation restrictions (maximum and minimum pond levels) of the Turners Falls impoundment and downstream flows from the project
  - Existing and potential required minimum flows and/or other operation requirements at each of the four upstream projects.
  - Minimum discharge flows ranging between 2,500 and 6,300 cfs in the bypass reach from April 15th through June 22nd to support spawning, rearing, and outmigration of shortnose sturgeon at Rock Dam.

- Document how the existing and potential outflow characteristics from the four upstream projects affect the operation of the Turners Falls Project including downstream flow releases and Turners Falls impoundment levels.

- Assess how the operation of the existing Turners Falls Project and upstream projects affect Holyoke Project (P-2004) operations including:
  - How Turners Falls Project flow fluctuations affect Holyoke impoundment water levels, with emphasis on the influence on the water levels on listed Puritan tiger beetle habitat at Rainbow Beach in Northampton, MA and assess what changes would be needed in Turners Falls operations to stabilize water levels at Rainbow Beach.
  - How Turners Falls Project operations affect Holyoke Project discharges and what changes in Turners Falls operations would be needed to reduce fluctuations in the discharges from the Holyoke Project.

A. To the extent predictable and practical, incorporate the potential effects of climate change on project operations over the course of the license.

Determine the extent of alteration of river hydrology caused by operation of the project and the interactions between upstream project operations, Turners Falls operations and downstream operations at the Holyoke Project. The models will provide necessary information on what changes can be made to each of the five project's flow releases and/or water levels restrictions, and how those changes affect downstream resources.

Specifically, for the Turners Falls Project continuous minimum discharge flows in the Turners Falls bypass reach need to be no less than 2,500 cfs during shortnose sturgeon spawning, rearing, and outmigration (April 15th – June

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22nd). Incorporating these parameters into the model will inform what changes, if any, need to be made to operations of upstream projects to accommodate such flows.

As other specific modifications of the operations of each of the projects are identified based on results of other requested studies, these desired conditions will need to be input into the models to assess how each change affects that project and other project operations and the implications of those changes on other resources and/or the ability to achieve desired operational changes at other projects.

Resource Management Goals

The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.
- Assist FERC to ensure that the continued operation of the facility is not likely to jeopardize the continued existence of shortnose sturgeon.

Specific to aquatic resources, the Division's goals are:

- Protect, enhance, or restore, diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
- Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
- Minimize current and potential negative project operation effects on water quality and aquatic habitat.
- Ensure that project operations are not likely to jeopardize the continued existence of shortnose sturgeon.
- Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing within the Montague spawning area (i.e. Rock Dam and Cabot Station spawning sites and associated early life stage rearing areas).

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest

The requestor is resource agency.

Existing Information

Available information in the PAD does not indicate how project operations have altered downstream hydrology, which may affect resident and migratory fish, macroinvertebrates, rare, threatened, and endangered species, aquatic plants and other biota and natural processes in the Connecticut River from below the Vernon Dam downstream to the Holyoke Dam.

Information in the PAD also does not reflect data analyzed in Kynard et al. 2012, which identifies minimum discharge thresholds for shortnose sturgeon spawning and rearing at the Rock Dam spawning site. Spawning success was observed at Rock Dam when discharge was between 2,500 cfs and 22,000 cfs during the spawning period (April 27–May 22nd) (Kynard et al. 2012, chapter 3). In 1995 at the Cabot spawning area, the greatest level of spawning and spawning success occurred (i.e., 21 late stage females present, 342 early life stage captured, spawning period was 17 days) even though no spawning was detected at Rock Dam (Kynard et al. 2012, chapter 3). Discharges in 1995 at Rock Dam had dropped below 2,500 cfs by March 26th (Kynard et al. 2012, chapter 3), showing that even though 1995 saw the largest number of pre-spawning adults, none spawned at Rock Dam. This may indicate the need to have adequate flow well in advanced of spawning. Discharge reductions at the Rock Dam site that occurred during spawning caused females to leave the spawning cite and not return even if flow increased to acceptable levels later during the spawning period. Researchers observed that substrate did not change during

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fluctuating flows and thus cessation of spawning is likely due to velocities falling below the range preferred by females. Given the current flow dynamics at Rock Dam, spawning does not occur most years (Kynard et al. 2012, chapter 3). These data represent the best available scientific information and indicates that the current minimum flow thresholds at the project are not adequate for the protection of endangered shortnose sturgeon. All modeling efforts described above must incorporate the identified minimum flow and temporal parameters.

Nexus to Project

The Turners Falls Project is currently operated with a seasonally-varying minimum bypass flow (400 cfs from 5/1 through 7/15, then 120 cfs through the winter until river temperature rises to ≥ 7°C) and year-round minimum flow below the projects of 1,433 cfs. The project operates as a daily peaking project, often with large, rapid, daily flow fluctuations between the minimum and project capacity (15,928 cfs) and fluctuations in headpond elevation (175' to 186' MSL). These changes affect biotic habitat and biota upstream and downstream of the project. Project operations and potential changes to operations to mitigate impacts are influenced by inflows and operations of upstream peaking projects and the Northfield Mountain Pumped Storage Project operations and potential changes in operations of each project could affect the ability to achieve desired operational changes at other projects. Results of river flow analyses will be used to develop flow-related license requirements and/or other mitigation measures.

Methodology Consistent with Accepted Practice

River hydrology statistics and modeling are commonly employed at hydroelectric projects to assess implications of project operations on the river environment.

Level of Effort/Cost, and Why Alternative Studies will not suffice

Level of effort and cost of model development are expected to be moderate but to be valuable in developing license conditions, the model(s) will need to be run under various scenarios throughout the relicensing process to assess the implications of changes to the operations of each project on other projects and other resources. Therefore, ongoing consultation and re-running of the model(s) are likely to be needed throughout the relicensing process. The modeling exercise will also require coordination and cooperation between First Light and the upstream licensee to assure that the model inputs and outputs can be accurately related.

We would anticipate that the expected level of effort and anticipated costs will be comparable to that experienced on similar FERC relicensing projects of this size (e.g., Conowingo, FERC No. 405).

Literature Cited

Kynard, B., P. Bronzi, and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

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Requested Study No. 14.
Impacts of the Turners Falls and Northfield Mountain Pumped Storage Project Operations on Tributary and Backwater Area Access and Habitats

Goals and Objectives
One goal of this study is to determine if water level fluctuations from the Turners Falls and Northfield Mountain Pumped Storage projects result in a barrier(s) to fish movement in and out of tributaries and backwaters to the impoundments and riverine reaches below dams.

A second goal is to determine if water level fluctuations in the Turners Falls and Northfield Mountain Pumped Storage project impoundments impact water levels, available fish habitat and water quality in tributaries and backwaters to the impoundments and riverine reaches below dams, and if impacts are found, to ascertain how spatially far reaching they are and develop mitigation measures.

Results of this study may also be used to help determine the adequacy of existing downstream minimum flow requirements.

Specific objectives include:

- Conduct a field study of tributaries and backwaters, including water velocity and habitat data where appropriate, to evaluate potential impacts of impoundment fluctuation on fish access to tributaries and backwater areas. The study should also evaluate if changes in impoundment fluctuation range would mitigate for any identified impacts and if other mitigative measures would improve access.

- Conduct a field study to examine potential impacts of impoundment fluctuations on water levels, available habitat and water quality in tributaries and backwaters. The evaluation should also evaluate if changes in impoundment fluctuation range would mitigate for identified impacts and if other mitigative measures would lessen these impacts.

Resource Management Goals
This requested study will help promote tributary and backwater access and protect valuable fish habitat and maintain appropriate water quality conditions for diadromous and riverine fish species in project-affected areas. Maintaining connectivity between the mainstem of the Connecticut River and tributaries and backwaters is vital to the fish populations in these systems, as many fish species utilize these areas for spawning, rearing, refuge, and feeding.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requestor is resource agency.

Existing Information
To our knowledge, limited information exists related to this requested study.

Nexus to Project
Project operations have the potential to impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, water level changes due to project operations could create conditions that could impede free movement of fish between tributaries/backwaters and the mainstem of the Connecticut River, thus limiting access to spawning habitat and/or growth opportunities. Additionally, water level changes could also alter tributary and backwater fish habitat quality, quantity, and also water quality, thus decreasing productivity and available habitat.

Methodology Consistent with Accepted Practice

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Common tools to evaluate water level impacts would be used including: bathymetric mapping, substrate, depth and velocity measurements, and water quality information (dissolved oxygen, temperature, turbidity, and pH). Studies should be conducted throughout the year.

The study area for tributary and backwater fish sampling should cover all tributaries and backwaters within the project-affected areas of the Turners Falls and Northfield Mountain Pumped Storage projects. A second year of study may be required if first year data collection is limited due to environmental or other conditions, or if river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort/Cost, and Why Alternative Studies will not suffice
First Light does not propose any studies to meet this need. Estimated cost for the study is moderate.

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Requested Study No. 15.
Impacts of the Turners Falls and Northfield Mountain Pumped Storage Projects on Littoral Zone Fish Habitat and Spawning

Goals and Objectives
The goal of this study is to determine if project operations and water level fluctuations in the Turners Falls Project impoundment negatively impact anadromous and resident fish. This study complements a separate study request specific to American shad spawning and also on habitats affected by water level manipulations.

Specific objectives include:

- delineate, quantitatively describe (e.g., substrate composition, vegetation type and abundance), and map shallow water aquatic habitat types subject to inundation and exposure due to project operations, noting and describing additional areas where water depths at lowest operational range are wetted to a depth less than one foot (flats, near shore areas, gravel bars, etc. with very slight bathymetric change);
- conduct analyses of the impacts of normal operations and the maximum permitted reservoir fluctuation range on the suitability of littoral zone habitats for all life stages of target species likely to inhabit these areas;
- conduct field studies to assess timing and location of fish spawning;
- conduct field studies to evaluate potential impacts of impoundment fluctuations on nest abandonment, spawning fish displacement, and egg dewatering; and
- evaluate potential impoundment fluctuation ranges and how implementation of such changes would mitigate for identified impacts.

Resource Management Goals
The mission of the Massachusetts Division of Fisheries and Wildlife is to protect and conserve fish and their habitats. Resident fish species are an important component of the river's ecology and in some cases are the basis for a sport fishery. This requested study will help protect and conserve resident fish species by ensuring project operations do not negatively impact their spawning success and spawning habitats.

Public Interest
The requestor is a resource agency.

Existing Information
To our knowledge, no information exists related to this requested study. The Massachusetts Integrated List of Waters shows the project area from the Vermont/New Hampshire state line to the Turners Falls Dam impaired due to "other flow regime alterations."

Nexus to Project
Project operations have the potential to impact fish species by influencing spawning success and spawning habitat quality and quantity. For example, water level changes due to project operations could create conditions where fish eggs are exposed to air, where spawning habitat is dewatered, and/or where fish abandon nests containing eggs.

Methodology Consistent with Accepted Practice
Common tools to evaluate water level impacts would be used, including bathymetric mapping and measurement of physical habitat characteristics such as substrate, depth and velocity. Studies should be conducted throughout the spawning season (e.g., April through August).

Common tools to evaluate fish spawning would be used, including visual observations of habitats and sampled fish (i.e., in spawning condition, coloration, gonads mature, and other external features that become developed with spawning) collected by gears such as electrofishing, seining and other net gears during defined environmental and/or time windows for spawning activity. Project operation-impacted areas should be quantified to identify and define areas subject to dewatering and mapped relative to observations of fish nests, spawning fish, and egg deposits. During identified spawning periods for the target species, suitable spawning habitats subjected to daily project operational fluctuations will be surveyed to document the type and extent of project effects on nests or spawning

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habitat (e.g., nests of fallfish, lamprey, bass and sunfish) and observable eggs or larvae, relative to water level and other environmental conditions, including water temperature and water velocity in noted areas.

At least one year of data collection is necessary. A second year of study may be required should environmental (e.g., river discharge, air/water temperature) or operational conditions in the first year prove to be atypical during the study period (end of March through August).

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice
FirstLight Power does not propose any studies to meet this need. Estimated cost for the study is moderate.

Literature Cited

Massachusetts Year 2012 Integrated List of Waters, *Proposed Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act,* Massachusetts Division of Watershed Management, Watershed Planning Program, Worcester, Massachusetts, January, 2012.

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Requested Study No. 16.
Evaluate the frequency and impact of:
1) Emergency water control gate discharge events and:
2) Bypass flume spill events, on shortnose sturgeon spawning and rearing habitat in the tailrace and downstream from Cabot Station

Goals and Objectives

This evaluation should directly address the impact of sediment disturbance and excessive velocities on habitat in Cabot Station tailrace and downstream resulting from emergency water control gate discharge events and bypass spill events and effects of spill from the downstream fish bypass sluice on shortnose sturgeon spawning and incubation.

The goal of this study is to determine appropriate scenarios for operation of the emergency water control gates and bypass flume that will be sufficiently protective of shortnose spawning and rearing below Cabot Station from excessive water velocities and exposure to abrasive sediments dislodged and transported across spawning and rearing areas. Furthermore, avoidance or minimization of rapid fluctuations in flow is also a goal of this study applicable to the operations of the emergency water control gates and bypass flume.

The objective of the study will be to determine how often the emergency water control gates are operated to discharge large quantities of water and evaluate the impact of these events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat below Cabot Station. Another objective is to understand the operation of the bypass flume that result in bypass flume spill events and evaluate the impacts of these spill events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat below Cabot station. Even when bottom velocities fall within the range optimum for shortnose sturgeon spawning, rapid fluctuations may result in sediment transport having a harmful impact on developing eggs and embryos.

Specific Objectives include:

- Emergency water control gate discharge events
    - Field verification during operation of the emergency water control gates during a range of spill and discharge conditions is necessary during years 2014 and 2015 if emergency water control gates will continue to be operated during shortnose sturgeon spawning and rearing (April 15th – June 22nd).
        - Collection of sedimentation and bottom velocity data during 2014 and 2015 is necessary to verify proposed alternative operation scenarios for the emergency water control gates that will avoid or minimize negative impacts to spawning and rearing habitat.

- Bypass flume spill events
    - Field verification during bypass flume spill events under a range of spill and discharge conditions is necessary during years 2014 and 2015 if bypass flume spill events continue to be a part of future project operations and will occur during shortnose sturgeon spawning and rearing (April 15th and June 22nd).
        - Collection of sedimentation and bottom velocity data during 2014 and 2015 is necessary to verify proposed alternative operation scenarios for the bypass flume that will avoid or minimize negative impacts to spawning and rearing habitat.

Resource Management Goals

The Division seeks to understand current emergency water control gate bypass flume operations and associated impacts to determine potential operation scenarios that avoid or minimize negative effects on shortnose sturgeon spawning a rearing.

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Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requestor is resource agency.

Existing Information
The emergency water control gates are used to spill large amounts of water and Cabot Station also spills water from the bypass flume (Kynard et al. 2012, chapter 3, Kieffer and Kynard 2007). These large spill events created a plume of turbid turbulent flow, which caused some females to leave the area (Kynard et al. 2012, chapter 3, Kieffer and Kynard 2007). Additional spill events create a scour effect on the bottom and the scoured sediments are then pushed downstream over, or deposited on spawning and rearing shoals where an entire years class of Shortnone sturgeon eggs early life stages may be destroyed (Kynard et al. 2012, chapter 3, Kieffer and Kynard 2007). Information included in the PAD does not address operation of the emergency water control gates or bypass flume and impacts on shortnose sturgeon spawning and rearing.

Nexus to Project
The large and rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota downstream of the project (Cushman 1985, Blinn 1995, Freeman *et al*. 2001). One of the two critical shortnose sturgeon spawning and rearing areas in the Connecticut River is located within the Cabot Station tailrace and impacted by the project's discharges, including spill from the emergency water control gates and bypass flume. This section of the Connecticut River also contains habitat that supports important spawning and rearing areas for migratory fish such as American shad and American eel. Current operations of the emergency water control gates and bypass flume create flow dynamics that are not sufficiently protective of shortnose sturgeon spawning and rearing. Results of this study will be used by the Division to determine recommendations for operation of the emergency water control gates and bypass flume that will avoid or minimize sedimentation and improve bottom velocities that are sufficiently protective of shortnose sturgeon spawning and rearing.

Methodology Consistent with Accepted Practice
River hydrology modeling is commonly employed at hydroelectric projects to assess implications of project operations on the river environment. It is assumed that the planned hydrologic modeling can incorporate emergency water control gate operations and associated impacts. Thus, an additional model would not be required for this request.

Field assessment will be needed to collect sedimentation and bottom velocity data at the emergency water control gates and fish bypass sluice discharge areas to determine what operational scenarios of those structures avoid or minimize impacts to shortnose sturgeon spawning and rearing. Velocity gauges will be employed to collect data on bottom velocities associated with project operations at Cabot Station. Coordination of gauge placement for this request with the field measurements for the instream flow study should help minimize the number of necessary gauges. Field assessment of sedimentation may be collected using a variety of techniques. One potential method of collection of sedimentation data would be to set fine-mesh nets similar to shortnose sturgeon larval collection nets; these nets may show changes in the amount of dislodged substrate material that travels along the spawning site as a result of powerful releases at both the Cabot spillway and bypass flume.

Level of Effort/Cost, and Why Alternative Studies will not suffice
Field verification for this study request will likely be coordinated with other field work for related study requests. It is not expected that the required field work for this request will result in significant additional cost and effort beyond what is expected for field work related to the instream flow study request. Post-fieldwork data analysis would be a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to that experienced on similar FERC relicensing projects of this size (e.g., the Conowingo Project, FERC No. 405).

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Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5: 330–339.

Freeman, M.C, Z.H. Bowen, K.D. Bovee, and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11: 179–190.

Kieffer, M. and B. Kynard. 2007. Effect of Water Manipulation by the Turners Falls Dam Hydroelectric Complex on Rearing Conditions for Connecticut River Shortnose Sturgeon Early Life Stages. S.O. Conte Anadromous Fish Research Center, Turners Falls, MA.

Kynard, B., P. Bronzi, and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

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Requested Study No. 16.
Impacts of Turners Falls Canal Drawdown on Fish Migration and Aquatic Organism Populations

Goals and Objectives
Quantitatively assess the effects of the Turners Falls Canal drawdown on diadromous fishes and other aquatic organisms known to be present in the canal during the annual drawdown.
Objectives of this study request include:

- Determine whether juvenile shad and American eel abundance in the canal increases leading up to the time of its closure, due to delays in downstream passage (e.g., is fish accumulation occurring?)
- Determine level of mortality for juvenile sea lamprey from exposure of burrow habitats;
- Conduct surveys to determine aquatic organisms (fishes, freshwater mussels, and mudpuppies) present in the canal during the drawdown, their densities, status (stranded, dead, alive), and locations (mapping to document habitat, substrate type, wetted , at complete drawdown);
- Evaluate measures to minimize aquatic organism population impacts of the canal drawdown.

Resource Management Goals
The Connecticut River Atlantic Salmon Commission developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:

- Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
- Maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, has the stated goal of "*Protect, enhance, and restore Atlantic coast migratory stocks and critical habitat of American shad in order to achieve levels of spawning stock biomass that are sustainable, can produce a harvestable surplus, and are robust enough to withstand unforeseen threats,"* and includes the following objective:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes.

and recommendation:

- To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to diadromous fishes, the Division's goals are:

- Minimize current and potential negative project operation effects on diadromous fishes, including juvenile shad, adult silver eels, and sea lamprey ammocetes.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures

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pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), and the Clean Water Act (33 U.S.C. §1251 *et seq*.).

Public Interest
The requestor is a resource agency.

Existing Information
Existing information in the PAD does not provide data on the population size or survival rates of juvenile American shad, American eels, or juvenile sea lamprey located in the power canal during the de-watering process. The power canal is dewatered in early September of each year for over a one week period to perform facility maintenance, inspections, and repairs including substantial silt removal and bank repairs. Historically, the canal drawdown occurred in July, but approximately five years ago it was moved to September, where it has occurred annually since then, with the exception of 2010. The agencies were informed in a letter by FLP that the shift to September was at the request of the Independent System Operator –New England (ISO-NE) to avoid peak load months of June through August. Studies conducted by the previous operator, Northeast Utilities Service Company (NUSCO), to assess downstream clupeid survival and use (1991 and 1994 studies at Cabot Station) support the contention that juvenile shad out-migration is occurring within the current drawdown time frame. There are no data to suggest that out-migration would occur earlier than 1 August, but likely does begin in the month of August (O'Donnell and Letcher 2008). Based on these data, CRASC altered its Fish Passage Notification Letter for Downstream Passage Operations for juvenile shad and herring to require the Cabot Station downstream bypass to begin operating on 15 August in 2010 and then moved the date to 1 August in 2011

It is unknown, whether the power canal may, through potential mechanism(s) of delay due to its configuration or operation, cause out-migrating juvenile shad to accumulate in the canal. This information gap leads to concerns that migrant numbers may be elevated beyond simple extrapolations of surface area comparison in the canal to main stem habitat. In the PAD, FLP indicates that the Cabot Station forebay in the vicinity of the intake has a maximum depth of 60 feet, while the existing near-surface downstream bypass structure at the Cabot Station is designed to operate only within a depth of six feet of the surface. As a result, the downstream bypass only operates effectively for a short period during the drawdown period (timing of this is unknown). The only points of egress, once the bypass becomes unavailable, are through the turbines at Cabot as well as at Station 1, and eventually at the Keith Street gate located well upstream from the Cabot Station intakes. It is unknown what the survival rates are for these passage routes, what proportion of fish are using each route, what number may become stranded and their survival rates, and how many fish are subjected to this situation. The related Study Requests on downstream juvenile shad outmigration and American eel outmigration outline objectives that would address some of these information gaps.

There is also a paucity of information relative to the disposition of fish moving downstream in the impoundment during the canal drawdown. Once the Turners Falls Gatehouse closes its gates, all inflow passes over the dam; a situation unique to this brief one week annual time period. Survival rates for outmigrating juvenile American shad and adult American eel moving past the project during the period of spill are not known.

Lastly, there exists an information gap regarding the fate of juvenile sea-lamprey (known as ammocetes) that reside in the soft substrate materials located in much of the lower or downstream end of the canal (personal communication, Boyd Kynard). In previous drawdowns, thousands to tens of thousands of dessicated ammocetes have been observed (Matt O'Donnell, personal communication, USGS Conte Lab). However, the distribution and abundance of ammocetes in the canal as well as mortality rates for ammocetes during the drawdown period has not been quantitatively determined.

Nexus to Project
Previous studies at Cabot Station have documented that juvenile American shad and American eel migrate through the project area during the canal drawdown period. During normal operations (where canal water level elevations are stable), downstream migrants are able to utilize the Cabot bypass facility; however, as the canal water level is drawn down, the bypass is no longer available, and the only routes of egress are through the turbines at Cabot Station and Station 1, unless the Cabot Station spill gates are utilized (the spill gates have a canal depth limitation of approximately 16 feet). Turbine entrainment at hydropower projects has been shown to cause injury and mortality to fishes.

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The annual canal drawdown was formerly conducted in July. In response to ISO-NE's request that FL conduct the drawdown outside of the June through August period, FL moved the drawdown to a period of time when diadromous fishes are known to be moving through the project area.

Once the canal has been drawn down, isolated shallow pools are left standing until the canal is refilled. During this period, fish (including lamprey ammocetes), amphibians, and benthic invertebrates are prone to dessication, predation or other sources of mortality or impact.

Methodology Consistent with Accepted Practice
The methods presented here are consistent with the study requests addressing downstream juvenile American shad passage and downstream American eel passage, with an emphasis on addressing survival and movement immediately prior to and during the canal draw down. Hydroacoustic monitoring immediately upstream of the Turners Falls Gatehouse, as well as upstream of opened dam gates for spill, will provide data on the timing, frequency and magnitude of natural wild juvenile shad movement into these areas, particularly the power canal. The abundance of juvenile shad moving into the canal can be derived and compared with similar data obtained with hydroacoustic equipment monitoring upstream of the Cabot Station intake and bypass, for comparisons. Juvenile shad will be PIT tagged, released, and monitored in the canal, for movements, timing and location including Station 1 canal and forebay. PIT tagged fish will be detected at the Cabot Bypass Sluice sampler. Juvenile fish should be specifically targeted for release immediately prior to drawdown to assess survival and movement in and through the canal. Surveys of sea lamprey ammocetes should be conducted by a stratified sampling design based upon substrate.

Lamprey density surveys, immediately after drawdown and in a subsequent later survey, may derive rates of change in observed densities and their status (live, moribund, dead); appropriate methods would need to be discussed. Surveys of remaining ponded water should be conducted immediately following drawdown and at later intervals (mid- week and end of week) to compare species occurrence and densities (relative abundance) which will be used to develop catch-curve analyses that can inform rates of mortality to the observed populations.

Assessments of freshwater mussels should also be conducted to quantify drawdown impacts. As with lamprey, the assessment can be based on sampling identified habitats in a stratified, random design, over the three time periods noted (initial drawdown, mid week, and end of week), tracking changes in densities and status of observed individuals among areas. Sub-sampling, with sufficient repeated measures to determine variability and acceptable level of precision of data will inform the required sampling intensity that will be needed. This sampling intensity will be determined as the study occurs and may vary among identified species. Comparisons among the three time periods for measures of density and status will inform the evaluation of project effects for juvenile shad, sea lamprey ammocetes, freshwater mussels and mudpuppies

The canal drawdown mitigation assessment involves evaluating alternative drawdown protocols to minimize impacts to resident and migratory fish, mussels and amphibians inhabiting the canal. Alternatives should include: (1) moving the drawdown to a time of year outside of migration seasons; (2) keeping or moving the timing of the drawdown, but utilize technologies to keep the majority of the canal wetted during the drawdown (e.g., portadams in the forebay immediately upstream of the trashracks and at other canal intakes in need of maintenance); and (3) in combination with alternative #2, assess whether other existing infrastructure within the forebay could be used to pass fish safely out of the canal (e.g., low level outlets, deep gates, side spillway boards, etc.). The assessment should compare the merits and drawbacks of each alternative and provide an order of magnitude cost estimate for implementation.

Level of Effort/Cost, and Why Alternative Studies will not suffice
This Study Request has many elements that overlap directly with a larger scale downstream juvenile American shad passage and downstream American eel passage study requests. With equipment costs principally covered in those requests, many components of what has already been proposed will be used in this study. However this request does include some specific elements not specified in the other two larger requests. The study cost and effort are expected to be low to moderate. Some additional radio tags and balloon tags with additive days of field work to accurately assess impacts specific to the drawdown period will be required. Surveys for identified aquatic organisms will take several days during the drawdown period as well.

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The canal drawdown mitigation assessment should require a low to moderate level of effort and cost. One staff person would evaluate alternative drawdown protocols. This should take less than one week to complete.

The applicant did not propose any studies to meet this need in the PAD.

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Requested Study No. 18.
Climate Change as it Relates to Continued Operation of the Northfield Mountain Pumped Storage, and Turners Falls Projects

Goals and Objectives

This study should relate to the cumulative impacts of the five Connecticut River projects being relicensed at this time. The goal of this study is to determine how climate change relates to the continued operation of the Vernon, Bellows Falls, Wilder, Northfield Mountain Pumped Storage, and Turners Falls projects.

The objectives of this study are:

1. Quantify the amount of thermal loading contributed by each respective impoundment (including the NMPS upper reservoir).
2. Using climate change prediction models, calculate how much warmer the project impoundments are projected to get in the next 30-50 years.
3. Model the effect of various project modifications on river temperature under current conditions and climate change predictions (e.g., converting to run-of-river, deep-water releases, dam removal, large-scale riparian revegetation, etc.).
4. Using climate change prediction models, determine if the projects actually provide an environmental benefit with respect to mitigating against climate change impacts (vis a vis warming of air and water temperatures) by producing low greenhouse gas emitting energy. The Northfield Mountain Pump Storage assessment must be based on net energy production (i.e., NMPS generates1,143,038 MWh annually, but consumes 1,567,506 in its pumping operations; for a net consumption of 424,468 MWh annually).
5. Determine how climate change predictions will impact management of high flow events at the three projects and evaluate if changes to dam structures would mitigate adverse impacts of the existing flood management protocols.

Resource Management Goals

The Division seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
- Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to climate change, the Division's goals are:

- Minimize current and potential negative project operation effects that could hinder management goals and objectives.
- Minimize deep headpond drawdowns associated with the loss of stanchion logs during high flow events, which are predicted to increase due to climate change.
- Minimize project-related sources of thermal increases to Connecticut River waters to mitigate against predicted climate change impacts.

In September 2011 The MA Executive Office of Energy and Environmental Affairs published the *Massachusetts Climate Change Adaptation Report*. Strategies identified in this report include measures that preserve, protect, and restore natural habitats and the hydrology of watersheds. These strategies strive to integrate the protection of rivers, streams, lakes, riparian areas, floodplains, and wetlands with comprehensive land-use, watershed, and floodplain/buffer management, and targeted land acquisition. Strategies include:

- Land Protection
- Develop streamflow criteria and regulations to encourage re-establishment of natural flow regimes in rivers and streams.
- Identify vulnerable river reaches, establish and protect belt-width-based river corridors, restore floodplains, and increase use of bioengineering techniques for bank stabilization.
- Seek to reconnect high quality habitats by removing in-stream barriers and re-establishing in-stream flows.

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- Identify and implement strategies for early detection, rapid response, and prevention of invasive exotic plants and animals that out-compete native species and gradually reduce the diversity of species composition.
- Through geomorphic assessment, identify vulnerable river reaches and monitor rivers for disconnection from floodplains.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a resource agency.

Existing Information

The PADs contains no information relative to climate change and how climate change predictions may impact future operation of the hydroelectric plants, nor of how the projects either mitigate for or exacerbate predicted climate change impacts to freshwater ecosystems.

TransCanada's PADs provide a summary of water quality data collected in 2012. Table 1 below is a synthesis of the temperature data collected by TransCanada. It should be noted that the upper and mid-impoundment stations at each project represent the average of temperature readings taken over the entire water column, while the continuous loggers (Lower Cont. and TR) were located near the water surface. These data indicate that from the upstream end of the Wilder headpond to the Vernon tailrace, water temperature increased approximately 6°C.

Table 1. Median water temperature at monitoring stations located within the impoundments and tailraces of the three hydropower projects.

	Median Water Temperature °C			
Project	Upper Imp.	Mid-Imp.	Lower Cont.	TR
Wilder	20.86	21.83	24.08	23.59
BF	22.43	23.67	24.86	24.38
Vernon	23.81	24.49	26.73	26.35

Relative to existing flood management protocols at each station, TransCanada's PADs identify that all three dams utilize stanchion bays (two at Vernon, three at Bellows Falls, and four at Wilder). When inflows to each dam reach certain levels, the stanchion bays are removed, and cannot be replaced until inflows subside. The depth of these bays and the flows they are removed at are outlined in Table 2, below.

Table 2. Summary of pertinent stanchion bay Information for the Vernon, Bellows Falls, and Wilder projects.

Project	Stanchion Height (feet)	Flow Triggering Complete Stanchion Removal
Wilder	17	145,000 cfs
BF	13	50,000 cfs
Vernon	10	105,000 cfs

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The PADs provide no information on the history of stanchion removal at any of the projects (frequency, duration, timing), nor a discussion of how predicted climate change might alter management of the stanchion bays in the future (with respect to the frequency and seasonality of occurrence). There also is no discussion of potential impacts to headpond resources that occurs as a result of stanchion bay removal. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations with respect to the Division's management goals and objectives, including those identified in the Massachusetts Climate Change Adaptation Report.

Data provided by the National Oceanic and Atmospheric Administration, Climate Data Center, illustrates long-term increasing air temperatures in the Northeast (Figure 1). Long-term, monthly mean water temperature data for the Vernon Dam impoundment, monitored by Vermont Yankee, has shown significant differences over time (ANOVA analyses, $P < 0.05$) that when plotted and further analyzed by linear regression, show a significant increasing trend for the period 1974 – 2011 for the months of January, September, and October (Figure 2). These analyses were performed with data from Vermont Yankee, analyzed by the Massachusetts Department of Environmental Protection.

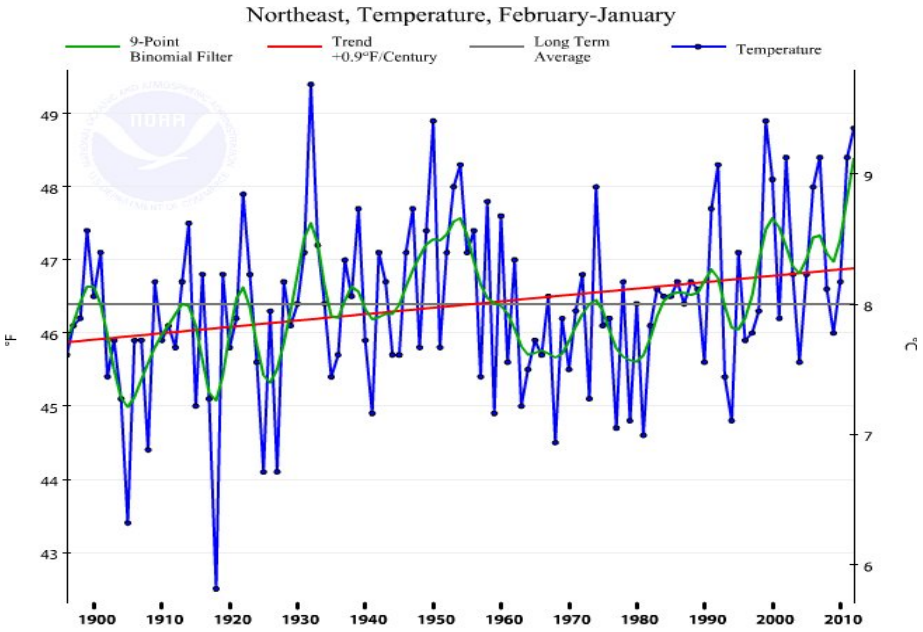

Figure 1. NOAA National Climate Data Center, Northeast 12-month average temperature for the period 1896 through 2012 (October).

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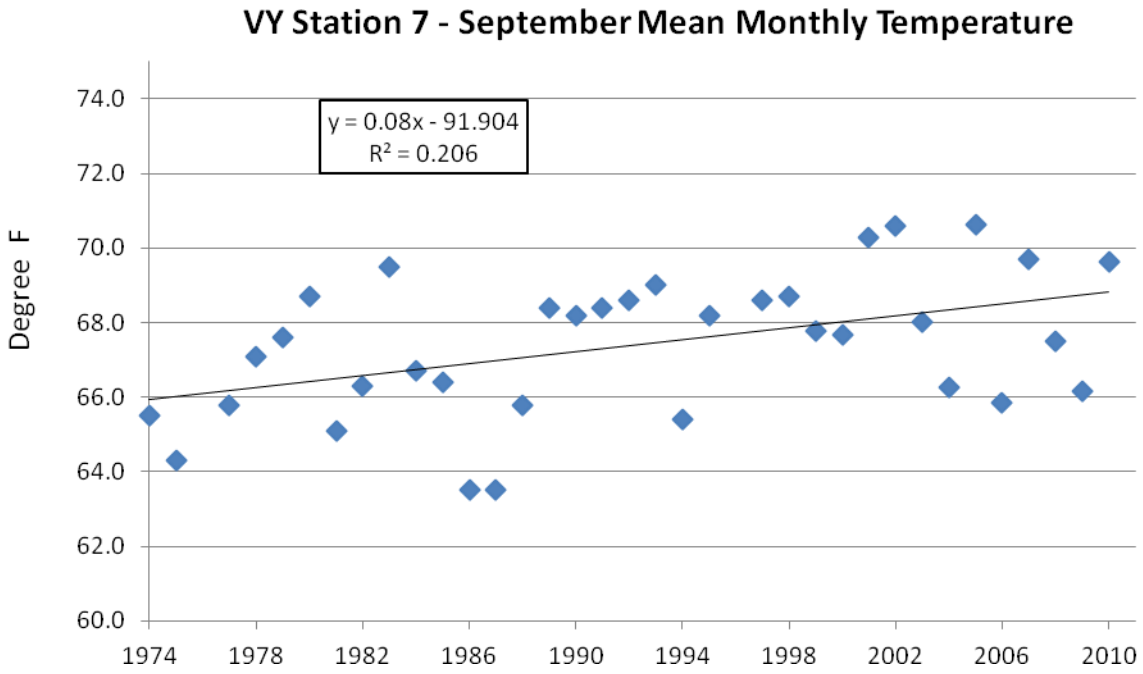

Figure 2. A plot of September's mean temperatures for Vermont Yankees' Station 7 (excludes outlier 1996 data point) for the period 1974 through 2011.

The PAD for Turners Falls and Northfield Mountain Pump Storage projects provides a summary of existing water quality data compiled by FirstLight, including water temperature data obtained from the U.S. Fish and Wildlife Service. The PAD also notes a 1991 study by the former licensee that modeled thermal effects of pumping to the upper reservoir. That model reported a maximum temperature difference attributable to NMPS operation of 0.21°C in the Turners Falls reach of the Connecticut River in low flow (4,000 CFS) simulation.

Nexus to Project

The four mainstem projects have very long impoundments capable of storing large volumes of water (Table 3, below). These impoundments effectively have converted large portions of the Connecticut River into a series of in-river "lakes." Because water velocities slow in these impounded sections of river, it allows for increased thermal loading and resultant higher water surface temperatures than in free-flowing sections of river.

Table 3. Relevant characteristics of the reservoirs behind the Wilder, Bellows Falls, Vernon, Turners Falls dams and NMPS.

Project	Headpond Length (miles)	Gross Storage Volume (acre-ft.)	Average Depth (ft.)	Surface Area (acres)	Flushing Rate (days)
Wilder	45	34,350	11	3,100	3
BF	26	26,900	10	2,804	<2
Vernon	26	40,000	16	2,550	2
Turners	20	21,500		2,110	
NMPS	n.a.	17,,050		246	n.a.

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Depending on where the hydropower intakes withdraw water, these warmer surface waters may be discharged downstream, raising the temperature of those waters as well (the data in Table 1 above suggest that the projects do draw water from the upper levels of the reservoirs). This effect may be felt for miles downstream. If there are a series of impoundments (like on the Connecticut River), the cumulative impact is an overall warming of the river. Even small run-of-river dams have been shown to elevate downstream water temperature (Lessard and Hayes 2003; Saila et al. 2005). The most recent climate change prediction models specific to the northeast forecast warmer air temperatures, more frequent high precipitation events, more heat waves, and an increase in the incidence of short term droughts (Karl et al. 2009).

Resource concerns related to this project effect include the potential impacts to populations (reductions in abundance, structure, condition) or loss of species not tolerant of increases in temperature and other effects related to physiology such as energetic costs with warmer temperatures (Leggett 2004). As one example, American shad restoration target numbers for fish passage at mainstem dams into upstream historic habitat could be negatively impacted from artificially increased water temperatures. Water temperature has been identified as a factor in the timing (i.e., duration) of this species migration, as well as its role in gonad development and spawning (Glebe and Leggett 1981; Leggett 2004). These factors can be logical reasoned to potentially result in accelerated rates of energy reserve use and a reduced migration window, possibly reducing the ability of fish to reach up-river habitats and further reducing the ability to survive downstream outmigration.

With respect to project operations during high flow events, all TransCanada projects have stanchion bays that are used to manage water during high flow events. Each time these stanchion bays are removed, the headponds are lowered substantially (from 10 to 17 feet, depending on the project) and must remain lowered until inflows subside. Depending on the timing and duration of these deep drawdowns, headpond resources could be negatively impacted.

All of the dams also contain other mechanisms for managing flows, such as tainter gates, sluice gates, roller gates, skimmer gates and hydraulic flood gates. All of these gates have an advantage over stanchion bays in that they do not require flows to subside significantly before they can be closed to return impoundment levels back to normal. One climate change prediction for the northeast is that we will see more frequent high precipitation events which will result in high flow conditions on rivers. Therefore, it is likely that the stanchion bay removal protocol will have to be employed more frequently in the future.

Methodology Consistent with Accepted Practice

- In order to quantify the amount of thermal loading contributed by each respective impoundment, detailed bathymetry will need to be collected. This bathymetry, combined with storage volume, tributary hydrology, and project operations, should be used to calculate the thermal loading of each headpond. The individual and cumulative increase in surface water temperature due to the impoundments should then be used to predict future warming based on climate change models.
- Analyze different mitigation strategies to understand which have the greatest benefit in terms of building resilience against the impacts of climate change on water temperature. Potential scenarios to analyze include converting the projects to run-of-river, implementing deep-water releases, removing one or more dams, conducting large-scale riparian revegetation, etc.).
- Input to climate change models the amount of GHG emissions that would be generated if fossil fuel plants were producing the equivalent amount of net energy as the five hydropower projects to determine the impact on air and surface water temperatures.
- Climate change prediction model output should be assessed to determine if the frequency and timing of high flow events is likely to change in the future. If high flow events that necessitate initiating the stanchion bay removal protocol are predicted to increase in frequency and/or shift in timing, the applicant should evaluate structural and/or operational alternatives that would mitigate adverse impacts of the existing flood management protocols.

Level of Effort/Cost, and Why Alternative Studies will not suffice

The level of cost and effort for the thermal loading analysis would be low to moderate. Collecting bathymetry in the three TransCanada headponds would take two staff less than one week to collect (it took the Kansas Biological Survey two days to collect bathymetry at a 3,500 acre lake; Jakubauskas et al. 2011). Bathymetry for the Turners

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Falls pool and NMPS upper reservoir already exist. The remaining work would be desk-based; loading relevant information into an appropriate thermal loading model to compute the estimated thermal loading of each headpond and then comparing this information to surface water data from climate change prediction models.

The high flow flood protocol study is a desktop analysis that should require low cost and effort. Climate change models already exist and that output would be downloaded and analyzed. The remaining analysis requires a review of alternative means of managing flows without the use of stanchion bays.

The applicants did not propose any studies to meet this need in the PAD.

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Climate Change Adaptation Report for Massachusetts, Executive Office of Energy and Environmental Affairs and the Climate Change Adaptation Advisory Committee, Boston, MA, September 2011.

Jakubauskas, M., J. deNoyelles, E. A. Martinko. 2011. Bathymetric and Sediment Survey of Elk City Reservoir, Montgomery County, Kansas. Applied Science and Technology for Reservoir Assessment (ASTRA) Program, Lawrence, KS. Report No. 2010-01

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Stier, D. J. and J. H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U. S. Fish and Wildlife Service Biological Report No. 82 (10.88), Washington D.C.

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Requested Study No. 19.
Integrate Modeled River Flows and Water Levels with Habitat Assessment for State-listed Riparian Invertebrate Species

Goals and Objectives

The goal of this study is to develop a river flow model(s) that evaluates hydrologic changes in the Connecticut River caused by the physical presence and operation of the Turners Falls Dam (TFD) Hydroelectric Project, the Northfield Mountain Pumped Storage Project, the Vernon Hydroelectric Project (P-1855), the Holyoke Dam, and river flows. The model should specifically assess the influence of existing and proposed Project operations on water levels at both known populations and potential habitats for state-listed invertebrate species - including the Cobblestone Tiger Beetle (*Cicindela marginipennis)*, state-listed as "Endangered," and the Puritan Tiger Beetle (*Cicindela puritana*), state-listed as "Endangered" and federally-listed as "Threatened" – and assess how Project operations may be modified to conserve and enhance existing populations and potential habitats.

The specific objectives of this study are to:

A. Conduct quantitative modeling of the hydrologic influences and interactions that exist between water surface elevations within the TFD Impoundment, discharges from the TFD (and its associated generating facilities), and both up- and downstream hydroelectric projects. Data inputs to and outputs from the model(s) should include:

    a. Withdrawals from and discharges to the TFD Impoundment from the Northfield Mountain Pumped Storage Project.
    b. Discharges into the TFD Impoundment from the Vernon Hydroelectric Project and other sources.
    c. Existing and potential water level fluctuation restrictions (maximum and minimum pond levels) of the TFD Impoundment and downstream flows.
    d. Existing and potential discharges from the TFD and its associated generating facilities and spill flows.

B. Assess how water level fluctuations within the TFD Impoundment affect potential habitat for state-listed invertebrate species, and assess what changes would be needed to Project operations to stabilize water levels and maintain/enhance said habitats.

C. Assess how Project operations affect potential habitat for state-listed invertebrate species downstream from the TFD - with an emphasis on the influence of water levels on known habitat for the state-listed Cobblestone Tiger Beetle - and assess what changes would be needed to Project operations to stabilize water levels and maintain/enhance said habitats.

D. Assess how Project operations affect water levels within the Holyoke Dam Impoundment - with emphasis on the influence of water levels on known habitat for the state- and federally-listed Puritan Tiger Beetle - and assess what changes would be needed to Project operations to stabilize water levels at Rainbow Beach.

Relevant Resource Management Goals

The conservation and protection of species state-listed as Endangered, Threatened, or of Special Concern under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) is an important objective of the Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife. State-listed species and their habitats are protected pursuant to the MESA and its implementing regulations (321 CMR 10.00), as well as the rare wildlife species provisions of the Massachusetts Wetlands Protection Act (WPA) (310 CMR 10.59). The Division seeks to accomplish the resource goals and regulatory requirements of the MESA in order to:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and meet MESA requirements for the Project.
- Conserve, protect, and enhance the habitats for state-listed species that will be affected by Project operations

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Our study requests are intended to facilitate the collection of information necessary to conduct impact analyses and develop reasonable conservation, protection, mitigation and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Clean Water Act (33 U.S.C. §1251 *et seq*.), the MESA, and the WPA.

Public Interest
The requestor is a fish and wildlife resource agency, with regulatory authority under the MESA and the WPA.

Background and Existing Information
The PAD does not indicate how Project operations have or will alter hydrology in the Connecticut River from below the Vernon Hydroelectric Project downstream to the Holyoke Dam, or how operations have or may affect known populations and potential habitats for state-listed invertebrate species, including the Puritan and Cobblestone Tiger Beetles. However, the daily peaking mode of current Project operations are widely believed to negatively affect known populations; it is also likely that Project operations reduce the extent and quality of potential habitat for these species within the Connecticut River more broadly. However, the Division is not currently aware of any studies that have evaluated the relationship between Project operations, river hydrology, known populations, and potentially suitable habitat.

Puritan Tiger Beetle is among the most imperiled species in the United States, and populations of both the Puritan and Cobblestone Tiger Beetles are severely limited in Massachusetts. The only known population of each species is found along the Connecticut River, with Puritan Tiger Beetle known from a single site in Northampton, MA and Cobblestone Tiger Beetle known from a single site in Montague, MA, first observed in 2000. Annual reports from the monitoring of Puritan Tiger Beetle adults and larvae have documented the negative effects of flooding on the known Massachusetts population (Davis 2002-2012, unpublished).

Nexus to Project
The TFD is currently operated with a seasonally-varying minimum bypass flow (400 cfs from 5/1 through 7/15, then 120 cfs through the winter until river temperature rises to ≥ 7°C) and year-round minimum flows below the TFD of 1,433 cfs. The Project operates on a daily peaking mode, often with large, rapid, downstream daily flow fluctuations between this minimum and Project capacity (15,928 cfs) as well as fluctuations in headpond elevation (175' to 186' MSL). Large, rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota both up- and downstream of such facilities. Further, existing and potential Project operations are influenced by operations at upstream peaking projects, including (primarily) the Vernon Hydroelectric Project and the Northfield Mountain Pumped Storage Project. Indeed, potential changes to the operations of any project could affect the ability to achieve desired operational changes of other projects. Results of river flow analyses should be combined with field assessments of potentially suitable habitats to determine appropriate flow recommendations that will protect and/or enhance known populations as well as potential habitats for state-listed invertebrate species.

Proposed Methodology
River hydrology statistics and modeling are commonly employed at hydroelectric projects to assess the effects of project operations on the river environment. Field assessments are also common in developing operational regimes that will reduce impacts or enhance habitat conditions up- and downstream of hydroelectric projects. Field assessments should involve collecting flood depth, timing, duration, as well as frequency and changes to substrate characteristics along the mainstem of the Connecticut River sufficient to permit assessment of how the quality, extent, and location of existing and potentially suitable habitat changes over a range of flows. The measurements should be taken over a range of test flows, between the existing minimum flow and maximum project generation flows. This information should be synthesized to quantify habitat suitability for each species under each test flow.

Level of Effort and Cost
Level of effort and cost of model development are expected to be moderate, but in order to be valuable in developing revised license conditions, the model(s) should be run under a suite of various scenarios throughout the relicensing process to assess the implications of changes to the operations of any project on other projects and target natural resources. The modeling exercise will also require coordination and cooperation between FirstLight and the upstream licensee to assure that model inputs and outputs can be accurately related. Field work for habitat

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assessment studies can be reasonably extensive, but will depend on further consultation with the Division regarding study methodology and on-site decisions for the locations and the number of data replicates. Post-fieldwork data analysis would be of moderate cost and effort.

We would anticipate that the expected level of effort and anticipated costs will be comparable to that experienced on similar FERC relicensing projects of this size (e.g., Conowingo, FERC No. 405).

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Requested Study No. 20.
Habitat Assessment, Surveys, and Modeling of Suitable Habitat for State-listed Mussel Species in the Connecticut River

Goals and Objectives

The goal of this study is to conduct an instream flow habitat study and field surveys to assess the impacts of existing and proposed discharges from the Turners Falls Dam (TFD) Hydroelectric Project on suitable habitat and existing populations of state-listed mussel species downstream of the TFD, if any, of the Yellow Lampmussel (*Lampsilis cariosa),* state-listed as "Endangered," and the Eastern Pondmussel, state-listed as "Special Concern." In addition, the results of the study can be used to assess how Project operations may be modified to conserve and enhance these populations/habitats.

The specific objectives of this study are to:

A. Delineate, through field survey, populations of state-listed mussels downstream of Cabot Station and determine their distribution, abundance, and age-distribution within and between populations.
B. Delineate, through field survey, parameters of habitat suitability for each state-listed mussel species.
C. Evaluate the effects of existing and potential flow regimes on suitable habitats for the state-listed Yellow Lampmussel and Eastern Pondmussel, and determine an appropriate flow regime that will protect and enhance existing populations and suitable habitats in the Connecticut River.

Relevant Resource Management Goals

The conservation and protection of species state-listed as Endangered, Threatened, or of Special Concern under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) is an important objective of the Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife. State-listed species and their habitats are protected pursuant to the MESA and its implementing regulations (321 CMR 10.00), as well as the rare wildlife species provisions of the Massachusetts Wetlands Protection Act (WPA) (310 CMR 10.59). The Division seeks to accomplish the resource goals and regulatory requirements of the MESA in order to:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and meet MESA requirements for the Project.
- Conserve, protect, and enhance the habitats for state-listed species that will be affected by Project operations

Our study requests are intended to facilitate the collection of information necessary to conduct impact analyses and develop reasonable conservation, protection, mitigation and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Clean Water Act (33 U.S.C. §1251 *et seq*.), the MESA, and the WPA. Specific to state-listed mussels, the Divisions goals are to:

- Protect, enhance, or restore diverse high quality aquatic habitats for state-listed mussel species in the Connecticut River watershed and mitigate for any loss or degradation of these habitats.
- Minimize current and potentially negative effects of Project operations on state-listed mussels and their habitats.

Public Interest

The requestor is a fish and wildlife resource agency, with regulatory authority under the MESA and the WPA.

Background and Existing Information

It has been well documented that the damming of rivers can have detrimental impacts on mussel communities inhabiting areas both upstream and downstream of dams (Watters 1999, Layzer et. al. 1993, Moog 1993). The PAD provides a list of plant and wildlife species whose native ranges overlap with the Project area. In 2011, FirstLight facilitated surveys for state- and federally-listed mussel species within the 19.5-mile TFD Impoundment, the 3.5-

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mile long bypass reach of the TFD, and the facility's 2.2-mile long power canal by Biodrawversity, LLC. No state- or federally-listed mussel species were found by these surveys. This survey was semi-quantitative, the main goal being to assess the distribution, abundance, demographics, and habitat of state- and federally-listed mussels in the 2011 study area. However, the study did not assess all suitable habitats and flow conditions or perform mussel surveys in the free-flowing reaches of the Connecticut River downstream of Cabot Station, in which populations of Yellow Lampmussel and Eastern Pondmussel have been documented and which are potentially impacted by existing and proposed Project operations. Studies to date have also not assessed how existing and proposed Project flows affect glochidial settlement of state-listed freshwater mussel species.

The range of the Yellow Lampmussel in New England is limited to four major watersheds, three of which occur in Maine and the fourth in the Connecticut River (Massachusetts and Connecticut) (Nedeau et al. 2000, Nedeau 2008). In Massachusetts, extant populations are limited to the mainstem of the Connecticut River south of the TFD, although historic records exist from reaches in Northfield (Nedeau 2008). Populations of the Eastern Pondmussel are known from the mainstem of the Connecticut River and some low-gradient tributaries.

FirstLight is required to release a minimum of 1,433 cfs into the Connecticut River below the TFD; however, the Project currently generates power in a peaking mode, resulting in significant within-day flow fluctuations between the minimum release and project capacity on an hourly or daily basis. These large and rapid changes in water elevations and flow dynamics, out of synch with expected seasonal variation, may cause adverse effects to state-listed mussels, their habitats, and their long-term viability in the Connecticut River. The Division is not aware of any studies that have evaluated these effects. Finally, information included in the PAD does not provide a detailed description of how the selected minimum flow was established, or how minimum flow relates to flows necessary for the conservation and protection of rare species.

Nexus to Project

The Project currently operates with minimum flow releases and flow regimes that do not appear to have been based on biological criteria or field study and do not mimic natural fluctuations. The timing, rate, and magnitude of releases from the TFD may have direct, adverse effects on rare mussel populations and their habitats, although the degree and character of these effects is unknown. However, before an evaluation of effects can be made a better understanding of the distribution and abundance of state-listed mussel species and their habitats is required. Therefore, in order to fill this important information gap, field surveys to establish baseline population information and suitable monitoring sites is needed. Additionally, an empirical study is needed to provide information on the relationship between the proposed mode(s) of operation and rare mussel species and their habitats in the Connecticut River downstream of Cabot Station. Results will be used to assess proposed flow regimes on existing populations (if any) and potentially suitable state-listed mussel habitat, and to determine appropriate recommendations that will protect and/or enhance state-listed mussels and their habitats.

Proposed Methodology

A. *Habitat assessments* should be conducted during suitable water visibility and depths to afford a clear view of the river bottom between 1 June and 25 September (similar to those outlined within Biodrawversity and LBG 2012). This field work and analysis was performed on the mussel community inhabiting the lower Osage River in Missouri as part of the relicensing process of the Osage Hydroelectric Project (FERC No. 459) (ESI 2003). Surveys should provide systematic and sufficient coverage of potential habitats downstream of Cabot Station to detect occupied and unoccupied patches of suitable habitat.

   Habitat should be classified regarding occupancy by state-listed mussels. Methods for the habitat assessment portion of the study should include the use of snorkel, view bucket, and scuba, as necessary, based on water depth and clarity; shoreline-based surveys are not suitable alternatives. Occupied habitat patches will be utilized as a minimum habitat condition benchmark and data collection will include macro-scale (e.g., stream gradient, distance from Cabot Station, reach habitat mapping) and micro-scale features (e.g., depth profile, velocity profile, stability of patch, substrate, temperature, aquatic vegetation and other key features). Using these measured parameters, the habitat assessment should then locate and map patches of suitable but currently unoccupied habitat, if present. The requested habitat assessment will provide habitat descriptions and mapping to adequately describe the relative amount, distribution, and quality of suitable habitat for the Yellow Lampmussel and Eastern Pondmussel in Project-affected portions of the

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Connecticut River that were not surveyed as part of the 2011 study referenced above . The Division will work with FirstLight to develop and refine a habitat assessment protocol.

B. *Mussel Surveys. S*imultaneous with the habitat assessment, state-listed mussels will be surveyed and population parameters measured and quantified. Surveys, in conformance with Massachusetts protocols for state-listed mussel species, include:

1) Use SCUBA in depths over 3 feet and snorkeling in depths less than 3 feet. Mucket buckets and hand surveys may be used in very shallow or turbid waters.
2) Conduct subsurface exploration in ten percent (10%) of the survey area if state-listed mussels are encountered, and/or in areas where juveniles are encountered or juvenile habitat exists (e.g., depositional areas behind rocks, along streambanks, sandbars, etc.) (Yeager et al. 1994). Substrate sediments shall be excavated using $0.25m^2$ quadrats to a depth of 10cm and sieved through a mesh screen with openings of 4-6mm to detect juvenile mussels.
3) Count and identify all state-listed mussels to species.
4) Collect all standard morphometeric (e.g., species, size, shell injury/erosion etc.) and site data (location, extent, elevation, and age class structure). Length (millimeters) of the first 100 state-listed mussel individuals per species should be recorded to help assess recruitment length of all state-listed specimens less than 40mm. The first 50 specimens of all common species should be counted and identified; overall common species abundance (e.g., abundant, scattered, infrequent) should be estimated.
5) Use the Catch per Unit Effort (CPUE) method to qualitatively assess mussel species abundance. Estimate density at each site using number of mussels found per species per square meter of survey area.
6) Collect photographs of representatives for each state-listed species per site to document and confirm identity; photos should show a lateral view. If underwater cameras are available, photos of mussels while siphoning can help confirm identification.
7) Collect a representative sample of spent shells (for each species) that shall be forwarded to the Division for documentation and identification purposes.
8) Return any mussels removed from the substrate to the same area and carefully re-bed into the sediment in their original orientation; anteriorly into the substrate, posterior end up.

The Division will work with FirstLight to develop and refine the survey protocols outlined above. The Division must pre-approve the candidate mussel biologist who can demonstrate adequate field experience. The ability to locate and identify state-listed freshwater mussel species and their habitat(s) is required for an adequate freshwater mussel habitat assessment, and the Division may reject assessments that are not conducted by qualified individuals. The mussel biologist is required to obtain a Scientific Collection Permit from the Division, pursuant to 321 CMR 10.04, to handle dead or live state-listed mussels. If federally-listed mussel species are present, the mussel biologist may also need a permit from the USFWS (e.g., to collect vouchers).

C. An *instream flow habitat study* should be conducted in order to collect wetted perimeter, point-velocities, and substrate data along transects located in reaches of the Connecticut River downstream of Cabot Station. The data collected by the habitat assessment portion of the study will allow for application of the instream flow habitat model to the assessment of both occupied and unoccupied patches of suitable habitat. Flow measurements should be taken in each transect and at a subset of occupied and unoccupied habitat patches over a range of test flows. Additionally, flow conditions should be evaluated to determine potential effects of current and proposed Project operations on glochidial settlement into suitable patches, using an assumed range of sizes for larval mussels. At a subset of occupied patches, an assessment of flow-effects on mussel behavior should also be conducted. The requested *instream flow habitat study* will provide habitat descriptions and mapping to adequately describe the flow conditions, relative amount, distribution, and quality of suitable habitat for the Yellow Lampmussel and Eastern Pondmussel within suitable habitat at each test flow. The types of data collected should be sufficient to permit assessment of how quality, quantity, and location of habitat changes over a range of flows between existing minimum flow, peak

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flows, and maximum project generation flows. Similar methods are being employed to evaluate persistence of Dwarf Wedgemussel habitat on the Delaware (Maloney et. al. 2012) and Susquehanna (T. Moburg, The Nature Conservancy, personal communication) rivers, although these studies did not include the requested patch-level velocity analysis.

Level of Effort and Cost

Field work for instream flow studies may be reasonably extensive, but will depend on consultation between the applicant and the Division on study methodology and on-site decisions regarding locations for data collection and the number of collection locations. Additionally, there may be potential to combine assessment of habitat with broader in-stream flow habitat assessments requested for other target species, which would reduce costs associated with the habitat assessment component of the study. Post-fieldwork data analysis would be a moderate cost and effort. The methods proposed by the Division are widely accepted methods to assess habitat and conduct mussel surveys, and surveys of this nature are comparable to other FERC projects where state-listed mussels have been investigated.

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Requested Study No. 21.
Fish Assemblage Assessment and Glochidia Surveys in the Connecticut River

Goals and Objectives

The goal of this study is to determine the occurrence, distribution, and relative abundance of fish species in the Connecticut River up- and downstream of the Turners Falls Dam (TFD) Hydroelectric Project, including state-listed fish species as well as host fish species of the Dwarf Wedgemussel (*Alasmidonta heterodon*), federally- and state-listed as "Endangered," the Yellow Lampmussel (*Lampsilis cariosa)*, state-listed as "Endangered," and the Eastern Pondmussel (*Ligumia nasuta*), state-listed as "Special Concern." The study should also assess the occurrence and abundance of mussel larvae on resident host fish.

The specific objectives of this study are to:

A. Document fish species occurrence, distribution and abundance within the Project-affected area along spatial and temporal gradients.
B. Compare study results to historical records of fish species occurrence in the Project-affected.
C. Assess the occurrence and abundance of state-listed freshwater mussel larvae (glochidia) on host fish species.

Relevant Resource Management Goals

The conservation and protection of species state-listed as Endangered, Threatened, or of Special Concern under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) is an important objective of the Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife. State-listed species and their habitats are protected pursuant to the MESA and its implementing regulations (321 CMR 10.00), as well as the rare wildlife species provisions of the Massachusetts Wetlands Protection Act (WPA) (310 CMR 10.59). The Division seeks to accomplish the resource goals and regulatory requirements of the MESA in order to:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and meet MESA requirements for the Project.
- Conserve, protect, and enhance the habitats for state-listed species that will be affected by Project operations

Our study requests are intended to facilitate the collection of information necessary to conduct impact analyses and develop reasonable conservation, protection, mitigation and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Clean Water Act (33 U.S.C. §1251 *et seq*.), the MESA, and the WPA. Specific to state-listed fish and mussel species, the Divisions goals are to:

- Protect, enhance, or restore diverse high quality aquatic habitats in the Connecticut River watershed and mitigate for the loss or degradation of these habitats.
- Minimize current and potentially negative effects of Project operations on state-listed species and their habitats.

Determining species occurrence, distribution, and abundance of fish species more generally will better clarify what species occur in the project area both spatially and temporally relative to habitats which may be affected by Project operations. This information will better inform results from other study requests that will be examining the effects of Project operation on various aquatic habitats, water quality and other related concerns. This information will be used to make recommendations and enable full consideration for all species, including those that might not otherwise be known to occur in the Project-affected area and impacts that may affect their population status through direct or indirect effects of Project operations.

Public Interest

The requestor is a fish and wildlife resource agency, with regulatory authority under the MESA and the WPA.

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Background and Existing Information

The PAD identifies a total of twenty-two fish species in the Project area, but omits any reference to the presence or absence of the tessellated darter. The PAD does note that resident fish surveys were conducted by the Commonwealth of Massachusetts in the early- to mid-1970s, and the Division is aware of a limited sampling effort by Midwest Biodiversity Institute (contracted by the U.S. Environmental Protection Agency) conducted in 2008 (Yoder et al., 2009), which represents the most relevant and recent study related to Project-affected areas. While some sampling was conducted in the Project areas during the course of the 2008 survey, it did not have the same goals and objectives as those outlined above. Although species presence was documented by this study, it did not assess the structure, distribution and abundance of species within the Project-affected areas nor estimate change in these parameters over time. The design of the study, limitations in geographic/habitat type coverage both spatially and temporally, and the use of a single gear type limits the use of this study, which may not fully represent species occurrence in Project-affected areas. It follows that since information is limited regarding the composition of fish communities and their use of habitats in the Project-affected areas, the impacts of current and proposed Project operations on fish species are also unknown. Because FirstLight has not proposed any studies specifically addressing the goals and objectives outlined above, we request a thorough and comprehensive assessment of fish assemblages in the Project areas.

As referenced in the PAD, two state-listed fish species are known to occur in the Connecticut River, including the Eastern Silvery Minnow (*Hybognathus regius*) and Burbot (*Lota lota*), both of which are state-listed as "Special Concern." Currently, there are only two known populations of the Eastern Silvery Minnow in Massachusetts, both located in the Connecticut River. Eastern Silvery Minnow use aquatic vegetation as habitat, and therefore, are sensitive to flow alterations, erosion, sedimentation, and other factors that may reduce the quality and quantity of their habitat. Burbot are also rare in Massachusetts, with only a few individuals having been collected in the Connecticut River watershed, and, historically (records >25 years old), in the Housatonic River watershed. However, like many small bodied fishes, neither of these species are effectively sampled through boat-based electroshocking. Therefore, a fish assemblage study should be designed to ensure that small bodied fishes are adequately sampled.

Further, seven percent of unionid species are listed as possibly extinct in North America (Strayer et al. 2004, Williams et al. 1993). Watters (1996) found that 30-60% of all native mussels were negatively impacted by damming of rives from shore erosion and siltation, which suffocates mussels and impairs their reproductive cycle through the loss of (Bogan 1993) or access to host species through impediments to fish passage. Documenting the resident and transient fish assemblages in the Project-affected areas is critical to understanding potential impacts to freshwater mussel populations, including state- and federally-listed freshwater mussel species such as the Dwarf Wedgemussel, Yellow Lampmussel, and Eastern Pondmussel. The larvae of freshwater mussels must attach to the gills or fins of a suitable fish host in order to develop into juveniles. The suitability of the host fish is a complex relationship between mussels and fish, and research has found that even closely related fish species do not enable adequate survival of mussel glochidia.

Freshwater Mussel	Glochidial Host Fish
Dwarf Wedgemussel	Tesselated darter, Johnny darter*, mottled sculpin*, slimy sculpin, (Michaelson & Neves 1995); juvenile and parr Atlantic salmon (B. Wicklow, Saint Anselm College, unpublished data)
Yellow Lampmussel	White perch, yellow perch; recent studies have suggested that banded killifish, chain pickerel, white sucker, smallmouth bass, and largemouth bass may serve as potential hosts (Kneeland and Rhymer 2008)
Eastern Pondmussel	Unknown; reported to parasitize centrarchids (sunfishes and bass) as well as banded killifish

*Fish species not found in Massachusetts

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As adult mussels are largely sessile, and some amount of glochidia drift in the currents (Schwalb et al. 2010), the transportation of the glochidia via the host fish is believed to be a critical element of ensuring genetic flux between populations and colonization/re-colonization.

The tessellated darter is one of only three fish species in the Upper Connecticut River that serve as hosts for the glochidia of Dwarf Wedgemussel, the others being the slimy sculpin (*Cottus cognatus*) and the Atlantic salmon (*Salmo salar*) (Nedeau 2008). Tessellated darters are a relatively sedentary benthic insectivorous fish with small home ranges and short, fast bursts of speed. Tessellated darters may become the most important hosts for the Dwarf Wedgemussel in the Upper Connecticut, as both USFWS and the Division have or are in the process of ending their programs of stocking hatchery-reared salmon in the River. The Atlantic salmon was extremely rare in the Upper Connecticut River prior to stocking; in the future, even fewer juveniles and parr will be available as hosts.

Nexus to Project

Project operations have the potential to directly impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, headpond and tailwater water level fluctuations could dewater important spawning areas, limiting productivity of fish species by direct impacts to their spawning success and indirectly limiting the spawning success of forage fish species. Accordingly, a thorough understanding of the current fish assemblage structure and associated metrics are needed in order to examine potential Project impacts. Determining species distribution and abundance will better clarify what species occur in the Project area, spatially and temporally, relative to habitats that may be affected by Project operations.

In addition to direct impacts to state-listed fish species, both current and proposed Project operations have the potential to indirectly affect state-listed mussel populations by affecting the abundance, distribution, and movements of their glochidial fish hosts. This is especially true given that the TFD and its associated operations may act as a barrier to the dispersal of resident fish species; indeed, studies have consistently demonstrated that passage through the Cabot and Spillway fishway structures is poor (Kenneth Sprankle, USFWS, personal communication). The tessellated darter, in particular, does not typically disperse great distances, which suggests that the TFD may significantly impact the ability of Dwarf Wedgemussel to recolonize and sustain populations in otherwise suitable riverine habitats. It is likely that the maintenance and recovery of rare mussel populations in the Upper Connecticut River more broadly may depend on facilitating effective passage of host fish species.

The information requested through this study will help assess how the Project has and will affect the structure, distribution and abundance of state-listed fish and freshwater mussel species, and help the Division develop recommendations that will protect and/or enhance populations of each species.

Proposed Methodology

An accepted and robust field sampling design (e.g., as described in Pollock et al. 2002 or MacKenzie et al. 2006) and accepted methods for collecting fish species likely to be present in the Project-affected areas (Bonar et al. 2009) should be used to conduct field surveys. Randomly sampling multiple habitat types using a multi-gear approach will be required to ensure that all fish species present are sampled. The spatial scope of the study will be from the headwaters of the Turners Falls Impoundment downstream to Sunderland, Massachusetts, but may omit the Upper Reservoir of Northfield Mountain Pump Storage Project. Sampling should occur at each selected site across multiple seasons (spring, summer, and fall). Digital photographs should be taken to avoid misidentification of certain species, such as Cyprinids. This will be a one year study provided river discharge conditions fall within 25th to 75th percentile for weekly averages. Based upon this study's results, and the additional information obtained on requests to survey aquatic habitats and littoral zone fish spawning, an additional study may be required if evidence of project operation affects on population status or habitat for identified species.

The sampling design should include replicate samples for estimation of species detection probability. Sample replicates may be gathered temporally, using different methods, by independent observers, or by randomly sampled spatial replicates (MacKenzie et al. 2006). For each replicate sample, data that may be important for describing variation in species occurrence and presence/absence should be collected and recorded, such as gear type, mesohabitat type, depth, velocity, flow, water temperature, substrate, time of day, day of year, presence of cover, proportion of vegetation cover, size of individuals collected (juveniles may select different habitat), and/or other factors as determined by a qualified biologist. Species detection, occurrence, and/or abundance and related habitat

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measures on these parameters should be estimated using methods as described by Kery et al. (2005), MacKenzie et al. (2006), Wenger and Freeman (2008), or Zipkin et al. (2010).

Sampling to assess the occurrence and abundance of encysted larvae of state-listed mussel species on known and potential host fishes will require collection and analyzing gill samples. Sampling across multiple seasons is necessary in order to capture the variable timing of glochidial release, which differs seasonally between target mussel species. Collection may occur in conjunction with fish assemblage field surveys, as described above, from both above and below the TFD. Identification of mussel larvae to species level would require additional lab analysis of fish gill samples, and can utilize techniques based on morphological analysis (Kennedy & Haag, 2005; Zieritz and Aldridge 2009; Zieritz et al. 2010; Zieritz and Aldridge 2011), or molecular analysis, such as DNA barcoding or identification keys based on restriction fragment length polymorphisms (RFLP) (Zieritz et al. 2012). Field-samples of glochidia should be field-collected from gravid females of each target species to serve as references for identification, which can be collected concurrent with the requested mussel survey (see Study Request No. 20).

Level of Effort and Cost

The cost of the fish assemblage study will be moderate to high as seasonal sampling with several types of gear will be required. However, cost will also be partially dependent on the number of sites sampled, the number of sample replicates, and the extent of the covariate data that are measured, all which may be flexible. Based on first year study results, a second year of sampling or specific studies examining impacts of project operations on specific fish species may be needed and requested. Provided the collected data are of high quality, analysis and synthesis should take approximately 10-20 days.

The cost of the glochidia assessment will likely be moderate. Portions of this study (collection of fish samples) can be performed in conjunction with the broader fish assemblage study, which may reduce overall cost. Assessment and identification of mussel glochidia will depend on the number of sample replicates, which may be flexible, and technique selected for identification. Studies should be developed in consultation with the Division.

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Requested Study No. 22.
Assessing Operational Impacts on Emergence of State-listed Odonates in the Connecticut River and Northfield Mountain Upper Reservoir

Goals and Objectives

The goal of this study is to quantify the impacts of water level fluctuation on emerging teneral odonates in the Northfield Mountain Pumped Storage Project's Upper Reservoir, the Turners Falls Dam (TFD) Impoundment, and the 13+ miles of riverine habitat below the TFD (to the Rt. 116 Bridge in Sunderland). Study should include both field surveys as well as a river flow model(s) that evaluate the relationship between Project operations and water surface elevations. The specific objectives of this study are:

A. To obtain baseline information on which state-listed odonates inhabit and are emerging within the Northfield Mountain's Upper Reservoir, the TFD Impoundment, and the 13+ miles of riverine habitat below the TFD.

B. To determine if current water level fluctuations permitted under the TFD and Northfield Mountain Project licenses affect the abundance, composition, and distribution of state-listed rare odonate populations, and whether these populations can be protected and/or enhanced through modifications to Project operations or other mitigation measures.

Relevant Resource Management Goals

The conservation and protection of odonate species state-listed as Endangered, Threatened, or of Special Concern under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) is an important objective of the Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife. State-listed species and their habitats are protected pursuant to the MESA and its implementing regulations (321 CMR 10.00), as well as the rare wildlife species provisions of the Massachusetts Wetlands Protection Act (WPA) (310 CMR 10.59). The Division seeks to accomplish the resource goals and regulatory requirements of the MESA in order to:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and meet MESA requirements for the Project.
- Conserve, protect, and enhance the habitats for state-listed species that will be affected by Project operations

Our study requests are intended to facilitate the collection of information necessary to conduct impact analyses and develop reasonable conservation, protection, mitigation and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Clean Water Act (33 U.S.C. §1251 *et seq*.), the MESA, and the WPA.

Public Interest

The requestor is a fish and wildlife resource agency, with regulatory authority under the MESA and the WPA.

Background and Existing Information

The Project generates power in a peaking mode resulting in significant within-day flow fluctuations between minimum release and project capacity on an hourly and daily basis. The current license also permits up to a nine (9) foot change in pool elevation within the TFD Impoundment. The PAD notes that FirstLight would like to expand its Upper Reservoir capacity (by up to 24%), but it is not known how this may affect the magnitude and rate of water level fluctuations. The PAD also notes that water is typically pumped to the Upper Reservoir in the evening and then is directed back to the Connecticut River once or twice daily (during the day), based upon power needs and value. Provided that set thresholds for minimum flow and TFD Impoundment elevations are met, Northfield Mountain Power Station may operate with no restrictions on the timing, frequency, or magnitude of pumping, generation, or pool elevation within the Upper Reservoir.

Previous surveys on the Connecticut River in Northfield and adjacent towns in Massachusetts have established that rapid water level changes resulting from motorboat wakes and other factors can wash away or damage emerging odonate tenerals. There is limited data available regarding the details of emergence, including how high above the

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water emergence takes place, how long the process takes, what substrates are typically used, and how these factors differ by species or family groups. It is known, however, that emergence from larval wetlands is considered one of the most perilous stages of the odonate life cycle. Therefore, it is likely that large, rapid changes in water elevation and/or flow dynamics – where the magnitude and rate of water level increase exceeds the capacity of tenerals to successfully complete the emergence process - may cause adverse effects to the life cycle of state-listed odonates, and particularly, the emergence of tenerals. This, in turn, may impact the abundance, composition, and distribution of state-listed odonate populations in the central Connecticut River.

It is generally known which state-listed odonate species inhabit the Connecticut River in the vicinity of the TFD as larvae. However, it is not known exactly which species inhabit stretches of the River as differentiated by depth, substrate, speed, and other factors, such as the deep, ponded stretch immediately above the TFD in Barton's Cove or the fast, rocky, relatively shallow stretches below the TFD. Nothing is currently known about which odonate species, whether rare or common, inhabit the Upper Reservoir as either larvae or adults.

Nexus to Project
The Project is currently operated with minimum flow releases and head pond fluctuations that were not based on biological criteria or field study. The timing, rate, and magnitude of releases from the TFD, including water level fluctuations within the TFD Impoundment and the Northfield Mountain's Upper Reservoir, may have direct, adverse effects on emerging odonate tenerals. In order to fill this important information gap, an empirical study is needed to provide information on the relationship between the proposed mode(s) of operation and the effects of water level changes on emerging odonate tenerals. Results will be used by the Division to determine appropriate recommendations to protect and/or enhance state-listed odonates and their habitats.

Proposed Methodology
Surveys of larval odonates via exuviae collection, dredging, and visual surveys are standard methodologies for studying odonate populations. In the Upper Reservoir, the Impoundment, and downstream of the TFD on the river, these surveys will concentrate on exuviae collection and dredging for nymphs. In the Upper Reservoir, surveys will also include visual searches for recently emerged odonates, especially damselflies, near the water's edge.

Surveying for exuviae involves methodical visual searches of appropriate substrates near (typically, within 10 feet) the river's edge. Appropriate substrates vary by species, and because there is some degree of within-species variability, these may include sand, silt, rocks, trees, coarse woody debris, undercut banks, tree / plant roots, and anthropogenic structures such as bridge abutments or walls. Visual surveys should be carried out every day, starting at dawn. Most odonates emerge at night, and wind, rain or water level changes can remove exuviae quickly if they're not located in protected sites. Surveying for nymphs via dredging also depends on the species. Sand/silt/cobble dwellers can be adequately sampled for presence/absence by kick-netting. Species that cling to coarse woody debris or to rocks/concrete need to be sampled by visual inspection (which might involve diving). Surveying for recently emerged adults would involve visual surveys by a qualified biologist along the water's edge.

Qualified biologists will need to survey for odonates at a suite of sites up- and downstream of the TFD at several times during the field season to catch the emergence peaks of state-listed odonate species. Because odonate species may differentially emerge within different habitat types, surveys should assess emergence across a range of depths, substrates, water velocities, and other factors. Finally, to make the connection (if any exists) between Project operations and odonate emergence, the study will need to determine the elevation of nymphs relative to the water surface when they initiate emergence, how long emergence takes, and both the magnitude and rate of water level fluctuations.

The height of water levels will need to be cataloged during the field season, but the magnitude and rate of water level change will likely need to be addressed through the development of river hydrology statistics and modeling, which are commonly employed at hydroelectric projects to assess the effects of project operations on the river environment. Field survey results, as described above, should be combined with the results of a river flow model(s) that evaluate hydrologic changes in the Connecticut River due to existing and proposed Project operations, as requested in related studies by the Division. Modeling should enable the quantitative assessment of how water surface elevations within the Northfield Mountain's Upper Reservoir, the TFD Impoundment, and the reaches downstream of the TFD are affected by discharges from the TFD, pumping into the Upper Reservoir, and their

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associated generating facilities. Field assessments may be required to collect flood depth, timing, duration, frequency and changes to substrate to inform the model. Such measurements should be taken over a range of test flows, between existing minimum flows and maximum project generation flows, and should be synthesized to quantify how water surface elevations change.

Level of Effort and Cost

The field assessment portions of this study will be moderately time- and cost-intensive; the cost is entirely dependent on the number of sites, number of sample replicates, and the extent of the covariate data that are measured, all of which may be flexible and determined through consultation with the Division.

Level of effort and cost for model development are expected to be moderate, and running of various scenarios through the model(s) may be needed throughout the relicensing process to assess the implications of changes to Project operations. However, because similar models have been requested as part of other study requests, the modeling portion of this study may not represent a significant increase in effort.

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Requested Study No. 23.
Assessing Operational Impacts on State-listed Rare Plants in the Connecticut River

Goals and Objectives

Conduct a study to quantify the impacts of water level fluctuations on state-listed rare plant species in the Turners Falls Dam (TFD) Impoundment, as well as current and proposed flow regimes in the 13+ miles of riverine habitat below the TFD (to the Rt. 116 Bridge in Sunderland)..

The specific objectives of this study are to:

A. Obtain baseline information, through field surveys, on the locations and population parameters of Massachusetts state-listed rare plant species in the TFD Impoundment and the 13+ miles of riverine habitat below the TFD (to the Rt. 116 Bridge in Sunderland).

B. Assess how current and proposed Project operations affect existing habitat for, and the growth, survival, and reproduction of state-listed plant species inhabiting mud flats, sand bars, and high energy shore and cobble island habitat types, including (but not limited to) the following:

1. Mountain Alder (*Alnus viridis ssp. crispa*) – "Threatened"
2. Tufted Hairgrass (*Deschampsia cespitosa ssp. glauca*) – "Endangered"
3. Wright's Spike-rush (*Eleocharis diandra*) – "Endangered"
4. Intermediate Spike-sedge (*Eleocharis intermedia*) – "Threatened"
5. Ovate Spike-sedge (*Eleocharis ovate*) – "Endangered"
6. Frank's Lovegrass (*Eragrostis frankii*) – "Special Concern"
7. Upland White Aster (*Oligoneuron album*) – "Endangered"
8. Sandbar Cherry (*Prunus pumila var. depressa*) – "Threatened"
9. Sandbar Willow (*Salix exigua ssp. interior*) – "Threatened"
10. Tradescant's Aster (*Symphyotrichum tradescantii*) – "Threatened"

C. Assess how current and proposed Project operations affect potential habitats for state-listed plant species exhibiting meta-population dynamics, as further described below, including Wright's Spike-rush, Intermediate Spike-sedge, Ovate Spike-sedge, Frank's Lovegrass, and Tufted Hairgrass.

Relevant Resource Management Goals

The conservation and protection of populations and habitats for the 256 species of plants state-listed as Endangered, Threatened, or of Special Concern under the Massachusetts Endangered Species Act is an important objective of the Natural Heritage & Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife. State-listed species and their habitats are protected pursuant to the MESA and its implementing regulations (321 CMR 10.00), and the Division seeks to accomplish the resource goals and regulatory requirements of the MESA in order to:

- Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and meet MESA requirements for the Project.
- Conserve, protect, and enhance the habitats for state-listed species that will be affected by Project operations.

Our study requests are intended to facilitate the collection of information necessary to conduct impact analyses and develop reasonable conservation, protection, and mitigation measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Clean Water Act (33 U.S.C. §1251 *et seq*.), and the MESA.

Public Interest

The requester is a state natural resource agency, with regulatory authority under the MESA.

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Background and Existing Information

It is generally known which state-listed plant species inhabit the Connecticut River in the vicinity of the TFD. The PAD provides a list of plant and wildlife species whose native ranges overlap with the Project-affected area, but it does not provide baseline information on known occurrences of state-listed plant species. Several surveys along this stretch of the River by professional and volunteer botanists have shown that many of these species are dynamic; local populations often display meta-population dynamics, changing in size and location from year to year. This is particularly true of plants species inhabiting sand bars and high energy shore and cobble islands, including (but not limited to) the state-listed Wright's Spike-rush, Intermediate Spike-sedge, Ovate Spike-sedge, Frank's Lovegrass, and Tufted Hairgrass.

Large and/or rapid changes in water elevation and/or flow dynamics may cause adverse effects to existing and potential habitat for state-listed plants. More broadly, Project operations may also adversely affect the life cycle of state-listed plants, and in particular, the germination, growth, and dispersal of species inhabiting mudflats, sand bars and cobble islands. However, these effects are poorly understood and the Division is not aware of any studies that have evaluated these effects.

Nexus to Project

The Project is currently operated with minimum flow releases and head pond fluctuations that are not based on biological criteria or field study. Large, rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota downstream of such facilities. The timing, rate, and magnitude of releases from the TFD, and the water level fluctuations in the TFD Impoundment, may have direct, adverse effects on rare plant populations and their habitats. In order to fill this important information gap, an empirical study is needed to provide information on the relationship between the proposed mode(s) of Project operations and the quantity and quality of state-listed plant habitat in the Connecticut River. Results will be used by the Division to determine appropriate operational recommendations to protect and/or enhance state-listed plants and their habitats.

Proposed Methodology

Field surveys, within appropriate habitat types, should involve visual surveys during appropriate phenological windows via transects, meander survey, or fixed plots. In addition, the rate and height of water level changes resulting from Project operations during the field season will need to be cataloged. Surveys should collect information regarding location, elevation, and population size, extent and condition, and should occur monthly in order to assess the effects of seasonal flow dynamics on documented individuals and populations. To make the connection (if any exists) between Project operations and the life-cycle of rare plant populations, biologists will need to determine when rare plants start growth and assess how long it takes for maturation and seed dispersal to occur.

River hydrology statistics and modeling are commonly employed at hydroelectric projects to assess the effects of project operations on the river environment. Habitat assessments are also a common tool in developing operational regimes that will reduce impacts or enhance habitat conditions up- and down-stream of hydroelectric projects. Field assessments should involve collecting flood depth, timing, duration, frequency and changes to substrate characteristics along the mainstem of the Connecticut River. Data collected should be sufficient to permit assessment of how the quality, extent, and location of existing and potentially suitable habitat for known populations – and for species exhibiting meta-population dynamics, as described above - changes over a range of flows. The measurements should be taken over a range of test flows, between existing minimum flow and maximum project generation flows, and synthesized to quantify habitat suitability under each test flow.

Level of Effort and Cost

In the PAD, FirstLight identified impacts of the Project operations on wetlands, riparian and littoral zone habitat as a potential issue to be addressed in relicensing. However, additional analyses are needed to understand the impacts of the Project on rare plants and their habitats more broadly. The study proposed here will be moderately time- and cost-intensive. However, the cost is entirely dependent on the number of sample replicates that will be surveyed and measured, all of which should be determined in consultation with the Division.

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