

Relicensing Study 3.3.4

EVALUATE UPSTREAM PASSAGE OF AMERICAN EEL AT THE TURNERS FALLS PROJECT

Study Report

**Northfield Mountain Pumped Storage Project (No. 2485)
and Turners Falls Hydroelectric Project (No. 1889)**

Prepared for:



Prepared by:



FEBRUARY 2016

EXECUTIVE SUMMARY

FirstLight Hydro Generating Company (FirstLight) is the current licensee of the Northfield Mountain Pumped Storage Project (Northfield Mountain Project, FERC No. 2485) and the Turners Falls Hydroelectric Project (Turners Falls Project, FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the Northfield Mountain and Turners Falls Projects using the FERC's Integrated Licensing Process (ILP). The current licenses for the Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both set to expire on April 30, 2018. This report documents the results of Study No. 3.3.4 *Evaluate Upstream Passage of American Eel at the Turners Falls Project*.

The Holyoke Hydroelectric Project (FERC No. 2004) is the first barrier to upstream American eel migration on the Connecticut River. Between 2003 and 2014, the Holyoke Project passed approximately 100 to over 50,000 juvenile eels each year ([Normandeau, 2015](#)). The 35 river mile reach between the Holyoke and Turners Falls Projects contains eel rearing habitat. American eels are currently able to pass the Turners Falls Dam complex and are known to ascend the Turners Falls fishways. However, the total number of eels attempting to migrate past the Turners Falls Dam and the amount that successfully pass the Turners Falls Project is unknown.

FirstLight conducted a presence/absence study during the 2014 upstream eel migration season to identify and assess the potential locations for upstream eel passage at the Turners Falls Project. The study objectives were to identify areas where eel congregated or attempted to ascend wetted structures, to assess whether eel could be passed in substantial numbers, and to determine whether there are suitable sites for permanent eel passage structures. Eleven nighttime surveys were performed between June 11 and October 9, 2014. Several areas within the Project (including the Cabot Station discharge area and Cabot Fishway, Station No. 1 discharge area, various canal discharge areas, the Turners Falls Dam and Turners Falls Spillway Fishway) were monitored. The approximate number of eels, the date and time, eel behavior, and environmental conditions (i.e., weather, leakage, discharge) were recorded. About 94% of the 6,263 total eels observed during the study period occurred at the Turners Falls Spillway Fishway.

In 2015, FirstLight erected temporary eel ramp traps at the Spillway and Cabot Fishways and at the Cabot Emergency Spill Gate No. 10, and deployed Medusa traps in the No. 1 Station tailrace to investigate passage potential and eel abundance at those locations. The locations were selected in consultation with stakeholders during an onsite meeting at the Turners Falls Project on May 7, 2015. The ramp traps were operated continuously between July 9 and November 2, 2015, except during the annual canal drawdown. The Medusa traps were installed on July 22, 2016. Eel collected at the Spillway Fishway Trap accounted for 87.7% (n=5,235) of the total collected at the four sites (n=5,972). The Cabot Emergency Spillway Trap and Cabot Ladder Trap, accounted for 7.1% (n=424) and 5.2% (n=319) of the total, respectively. No eels were collected at the Medusa traps. The most viable and appropriate location for permanent upstream eel passage is at the Spillway Fishway.

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LIST OF ABBREVIATIONS

cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
ILP	Integrated Licensing Process
Northfield Mountain Project	Northfield Mountain Pumped Storage Project
PAD	Pre-Application Document
PSP	Proposed Study Plan
RSP	Revised Study Plan
SD1	Scoping Document 1
SD2	Scoping Document 2
SPDL	Study Plan Determination Letter
TFI	Turners Falls Impoundment
Turners Falls Project or Project	Turners Falls Hydroelectric Project
USGS	United States Geological Survey
VY	Vermont Yankee Nuclear Power Plant

1 INTRODUCTION

FirstLight Hydro Generating Company (FirstLight) is the current licensee of the Northfield Mountain Pumped Storage Project (Northfield Mountain Project, FERC No. 2485) and the Turners Falls Hydroelectric Project (Turners Falls Project, Project, FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the Northfield Mountain and Turners Falls Projects using the FERC's Integrated Licensing Process (ILP). The current licenses for the Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both set to expire on April 30, 2018.

As part of the ILP, FERC conducted a public scoping process during which various resource issues were identified. On October 31, 2012, FirstLight filed its Pre-Application Document (PAD) and Notice of Intent with the FERC. The PAD included FirstLight's preliminary list of proposed studies. On December 21, 2012, FERC issued Scoping Document 1 (SD1) and preliminarily identified resource issues and concerns. On January 30 and 31, 2013, FERC held scoping meetings for the two Projects. FERC issued Scoping Document 2 (SD2) on April 15, 2013.

FirstLight filed its Proposed Study Plan (PSP) on April 15, 2013 and, per the Commission regulations, held a PSP meeting at the Northfield Visitors Center on May 14, 2013. Thereafter, FirstLight held ten resource-specific study plan meetings to allow for more detailed discussions on each PSP and on studies not being proposed. On June 28, 2013, FirstLight filed with the Commission an Updated PSP to reflect further changes to the PSP based on comments received at the meetings. On or before July 15, 2013, stakeholders filed written comments on the Updated PSP. FirstLight filed a Revised Study Plan (RSP) on August 14, 2013 with FERC addressing stakeholder comments.

On August 27, 2013 Entergy Corp. announced that the Vermont Yankee Nuclear Power Plant (VY), located on the downstream end of the Vernon Impoundment on the Connecticut River and upstream of the two Projects, will be closing no later than December 29, 2014. With the closure of VY, certain environmental baseline conditions will change during the relicensing study period. On September 13, 2013, FERC issued its first Study Plan Determination Letter (SPDL) in which many of the studies were approved or approved with FERC modification. However, due to the impending closure of VY, FERC did not act on 19 proposed or requested studies pertaining to aquatic resources. The SPDL for these 19 studies was deferred until after FERC held a technical meeting with stakeholders on November 25, 2013 regarding any necessary adjustments to the proposed and requested study designs and/or schedules due to the impending VY closure. FERC issued its second SPDL on the remaining 19 studies on February 21, 2014. FERC approved the RSP for Study No. 3.3.4 *Evaluate Upstream Passage of American Eel* without modification.

1.1 Existing Information

The Holyoke Hydroelectric Project (FERC No. 2004) is the first barrier to upstream American eel (*Anguilla rostrata*) migration on the Connecticut River. Between 2003 and 2014, the Holyoke Project passed approximately 100 to over 50,000 juvenile eels each year ([Normandeau, 2015](#)). There is eel rearing habitat in the 35 river mile reach between the Holyoke and Turners Falls Project (Project). American eel are currently able to pass the Turners Falls Dam complex and are known to ascend the Turners Falls fishways. However, the total number of eels attempting to migrate past the dam and the amount that successfully pass the Turners Falls Project are unknown.

In 2014, FirstLight conducted a presence/absence study during the upstream eel migration season to identify and assess the potential locations for upstream eel passage at the Project. The study objectives were to identify areas where eels congregated or attempted to ascend wetted structures, to assess whether eels could be passed in substantial numbers, and to determine whether there are suitable sites for permanent eel passage structures. FirstLight identified a primary location where eels congregated: the Turners Falls

EVALUATE UPSTREAM PASSAGE OF AMERICAN EEL AT THE TURNERS FALLS PROJECT

Spillway Fishway. This location accounted for 94% of the 6,263 total eel observed during the study period. Eels were also observed at the Cabot Emergency Spillway in the vicinity of spill gate No. 10 (n= 332), at the Cabot lower level gate (n=33), within the Cabot fishway (n=18), at the Spillway attraction water stilling basin, and within No. 1 Station tailrace (n=3).

1.2 Study Goals and Objectives

The goals of the study were to identify and assess potential locations for upstream American eel passage, determine the most suitable locations for permanent eel passage and evaluate passage abundance.

The study has two specific objectives:

- Identify concentrations of eels staging in pools or attempting to ascend wetted structures (2014 objective); and
- Assess whether eels can be passed and whether sites are viable for permanent passage structures (2015 objectives).

2 STUDY AREA AND TRAP SITE SELECTION

In 2015, the study area included the Spillway and Cabot Fishways, Emergency Spillway Gate No. 10 and Station No. 1 tailrace ([Figures 2.0-1](#), [2.0-2](#) and [2.0-3](#)). These sites were selected based on the results of the systematic survey conducted during the 2014 upstream migration season (RSP Task 1), which revealed that the majority of eel observed recruited to the Spillway Fishway (94%) and Emergency Spill Gates No. 10 (5.2%); and also at the request of stakeholders (Station No. 1 tailrace and Cabot Fishway) during a conference call held on April 22, 2015 and an onsite meeting on May 7, 2015.



Legend

- Temporary Eel Trap Locations



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0 50 100 200
Feet

Figure 2.0-1: Location of
Temporary Eel Trap Near
Turners Falls Dam

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Legend

- Temporary Eel Trap Locations



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0 50 100 200 Feet

**Figure 2.0-2: Locations of
Temporary Eel Traps Near
Cabot Station**

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0 50 100 200

Feet

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**Figure 2.0-3:
Locations of Temporary Eel
Traps near Station No. 1**

3 METHODS

FirstLight installed temporary ramp and Medusa eel traps to assess if migrating eels could be collected and passed upstream of the Turners Falls Dam. The ramp trap configuration was designed in consultation with Alex Haro of the United States Geological Survey (USGS) Conte Anadromous Fish Research Center. Haro visited the traps on July 13, 2015 to inspect them and offer recommendations, as necessary. The design, construction and installation of the traps is described below.

- The **Spillway Fishway Eel Trap** was located within the second turn pool of the Spillway Fishway ([Figure 2.0-1](#)). It consisted of a ramp, collection tank and attraction/conveyance flow system ([Figure 3.0-1](#)). A single wooden ramp overlain with was employed. The covered ramp was 19 feet long by 1.5 feet wide with 6 inch high side walls. The ramp was constructed at a 38° incline; at the top it transitioned to an aluminum plate with a 90 degree bend to guide eel into a collection tank ([Figures 3.0-1](#) and [3.0-2](#)). The ramp entrance was located immediately downstream from an orifice (one of two) in the fishway weir upstream of the turn pool. The orifices are located at the bottom of the weir, and under typical fishway operation, the orifices provides a path to the next pool. One orifice was partially blocked to pool water for attraction/conveyance flow. The other orifice was completely blocked using plywood. The partial block was constructed with a 90° bend at the top to prevent eel from climbing over the block. Leakage through the shutdown gate at the upper end of the fishway provided flow into the turn pool sufficient to supply flow to the ramp. . Attraction/conveyance flow was pumped from the turn pool using a ¼ horsepower electric sump pump. The pump conveyed water continuously to the top of the ramp, where it passed through two adjustable spray nozzles. The nozzles were oriented such that flow was both conveyed down the ramp and into the collection tank ([Figure 3.0-2](#)). The covered collection tank was 3 feet high, 2 feet deep and 2.5 feet wide. Additional flow was pumped to the tank to maintain good water quality. An overflow pipe was used to maintain the water level within the tank. Drain water was conveyed back to the ramp such that the scent of trapped eels would be propagated into the attraction flow. A net bag (1/8 inch knotless mesh) was deployed within the tank to aid in collection of trapped eels. The Spillway Fishway was not in operation but 125 cfs was discharged from the fishway entrance via the fishway attraction water throughout this study, except on July 11 and 12, 2015 during necessary maintenance. The flow control gate was set at 1.86 feet, which corresponds to a water level differential of 1 foot at the entrance when there is no spill at the dam.
- The **Cabot Fishway Eel Trap** was located in the third turn pool (turn pool C) of the Cabot Fishway ([Figure 2.0 -2](#)). The trap arrangement was similar to that of the Spillway Fishway trap, except that the ramp was longer, approximately 21.5 feet with an incline of 40° ([Figure 3.0-3](#)). The Cabot Fishway was not operational during the study, but attraction flow was discharged throughout the study period, set to maintain a 1-foot differential at the Fishway entrance. The flow rate associated with the 1-ft differential varies and depends on water surface elevation in the Cabot tailrace. It is generally less than 350 cfs. Entrance conditions were similar to conditions maintained at the spillway fishway entrance for the spillway eel trap.
- The **Cabot Emergency Spillway Eel Trap** was located at Emergency Spill Gate No. 10, on the northern side of the spillway ([Figure 2.0-2](#)). The holding tank and plumbing were identical to the Spillway and Cabot Fish Ladder traps. The Emergency Spillway Eel Trap employed a dual level ramp with a landing ([Figure 3.0-4](#)). The upper and lower ramps were overlain with 1 inch Milieu substrate and inclined at 34° and 43°, respectively. The two ramp sections were joined by a landing. The landing was flat, approximately 2 feet by 2 feet and was overlain by Akwadrain substrate. The lower ramp was approximately 24 feet long and positioned such that the ramp entrance was located approximately 1 foot downstream of gate No. 10. The upper ramp was approximately 4 feet long.

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Attraction/conveyance flow came from the power canal and was provided by a ¼ hp electric sump pump and gate leakage.

- The **Station No. 1 Medusa Traps (2)** were located on either side of the tailrace ([Figure 2.0-3](#)). A Medusa trap consisted of a 5 gallon bucket and lid with a mop head and ballast rock. Approximately 25 holes (¾ inch diameter) were drilled into each bucket to allow access by eel. The Medusa traps provided a place for migrating eel to hide during daylight hours. For the purposes of this study, eels found within the Medusa traps would indicate recruitment to the Station 1 tailrace area.

The ramp traps were operational on July 9, 2016; the Medusa traps were operational on July 22, 2016. The traps were operated continuously throughout the study period ending on November 2, 2015, except during the annual canal outage, which began at 2100 hours on October 4, and ended at 1020 hours on October 11, 2015. The traps were checked for eels every few days throughout the study period. All eels were collected from the holding tanks, transported upstream to the Turners Falls Impoundment (TFI) and released from the northern river bank in the vicinity of the old suspension bridge foundation at the end of River View Drive in Gill, MA ([Figure 3.0-5](#)). Data recorder initials, collection location, time of day, date of collection, number of eels trapped and environmental conditions (precipitation, air and water temperatures, and cloud cover) were recorded. Lengths (<10 cm, 10-20 cm and >20 cm) were recorded from a subsample of 50 eel per collection event. The data sheets were reviewed for quality assurance and archived.

Water temperature was recorded using a HOBO U20 Water Level Data Logger equipped with temperature sensor. The Logger was located in the bypass reach upstream of the Station No. 1 tailrace. Water temperature data were collected continuously at 15 minute intervals between July 9, and November 2, 2015. These data were used to calculate an average daily water temperature.

Hydrologic data (river flow) were obtained from the USGS gage 01170500 Connecticut River at Montague City, MA (Provisional Data, downloaded on January 11, 2016). The USGS gage is located approximately 1000 ft downstream of the confluence of the Connecticut and Deerfield Rivers. Operation data, including generation at Cabot and No.1 Stations and spill at the dam, was obtained at 15 minute intervals during the study period. Correlations between precipitation events and collection rate; and average daily flow and collection rate, were investigated through the use of a Pearson Correlation Coefficient test.

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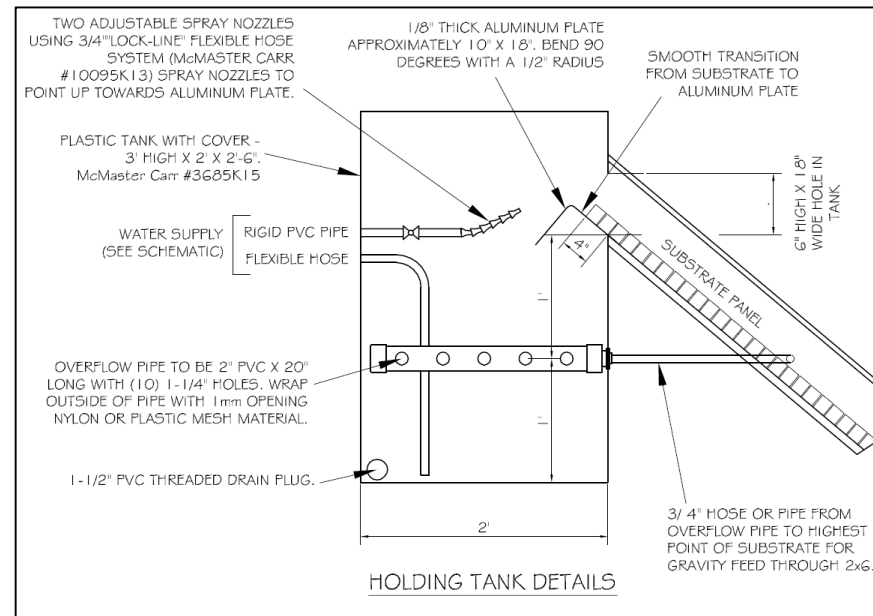
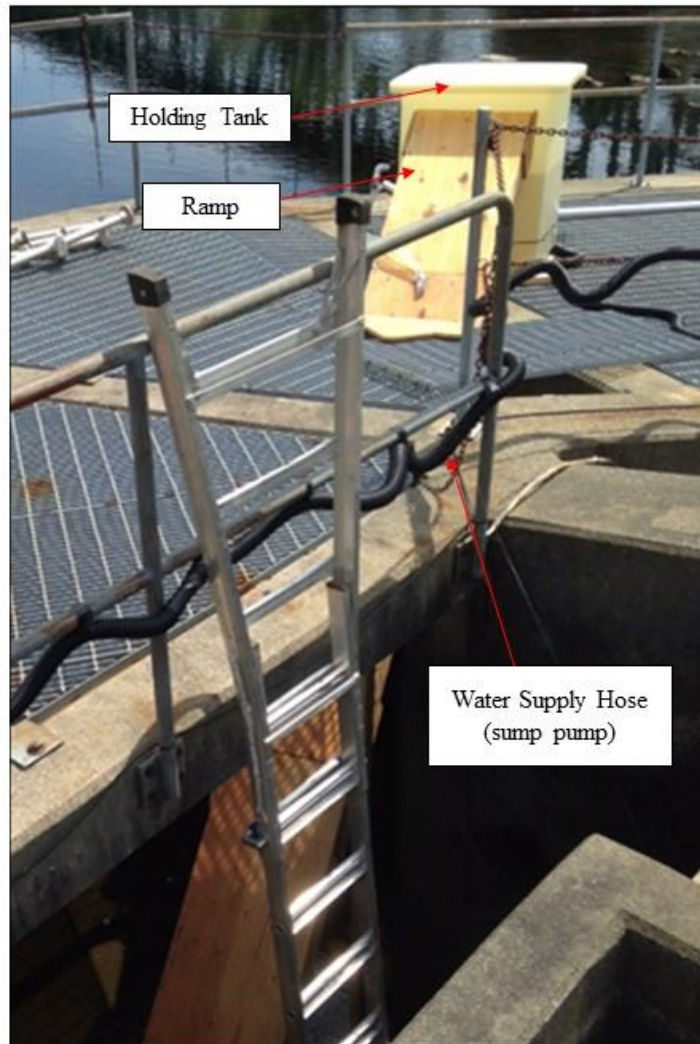


Figure 3.0-1: The Eel Trap Employed at the Spillway Fishway at the Project, Turners Falls, MA

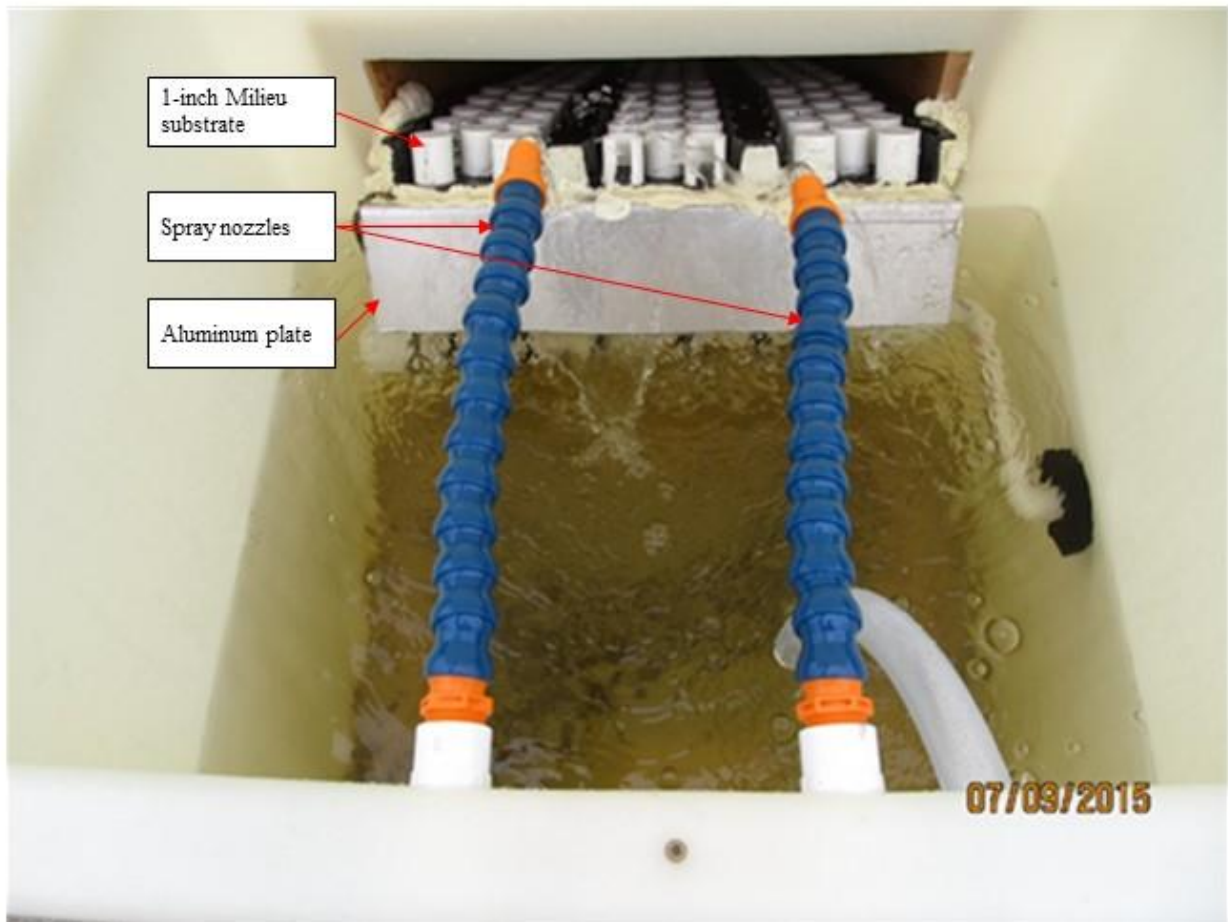


Figure 3.0-2: The Transition between the Ramp Substrate to the Aluminum Plate¹ and spray nozzles

¹ Note that the spray nozzles were adjusted to provide flow down the ramp as well as down the aluminum plate to entice eel to drop down into the collection tank. Also, the gap between the Milieu substrate and the aluminum plate was filled with silicon caulk for a smooth transition.

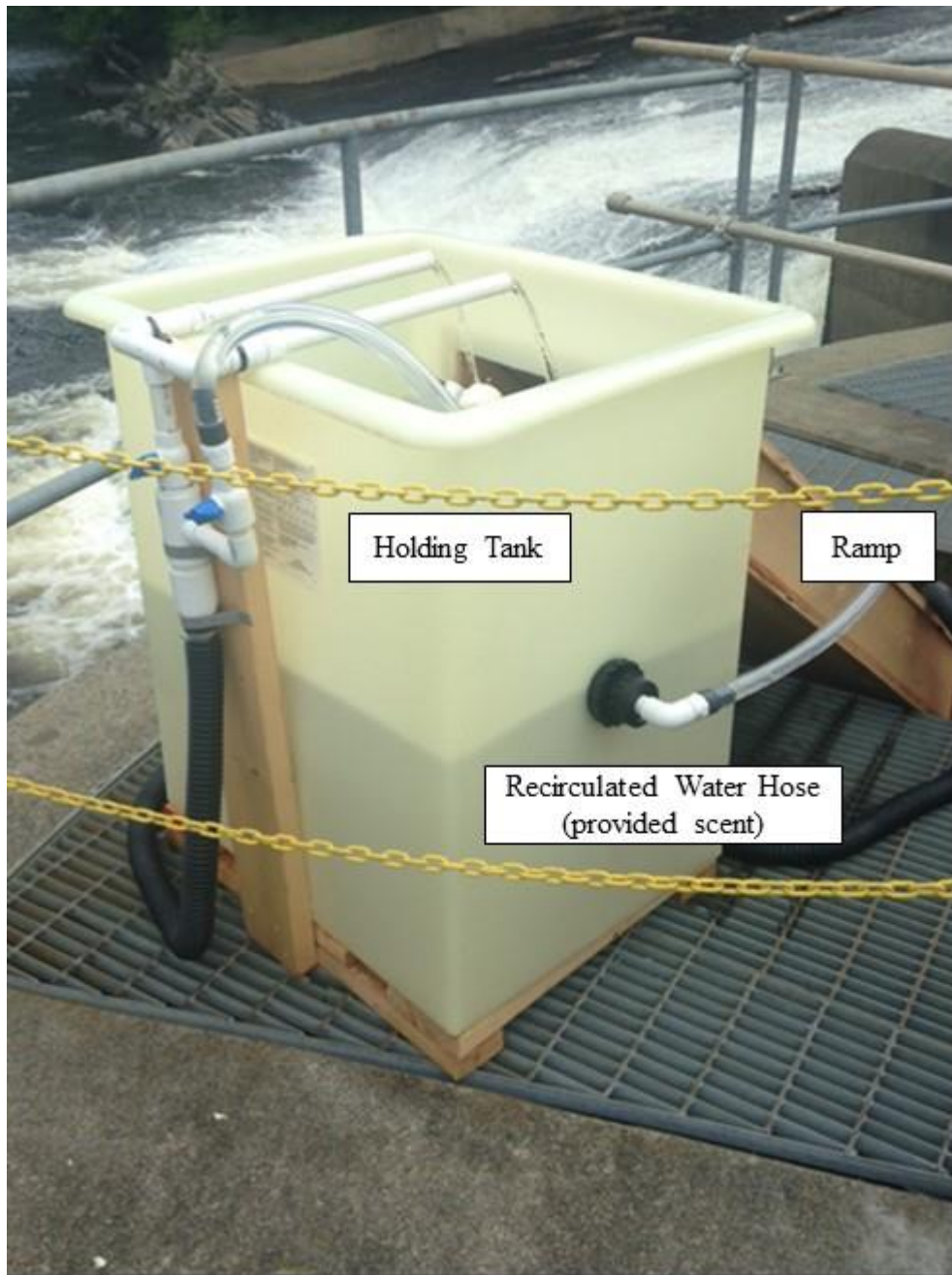


Figure 3.0-3. The Cabot Fishway Eel Trap, Turners Falls, MA²

² The photo was taken prior to the installation of the adjustable spray nozzles, which were installed on July 9, 2015.



Figure 3.0-4: The Temporary Eel Trap Located at Gate No. 10 of the Cabot Emergency Spillway at the Project, Turners Falls, MA



Legend

● Eel Release Site



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0 125 250 500
Feet

Figure 3.0-5: Location of
Eel Release Site

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4 RESULTS

4.1 Eel Monitoring

Forty (40) eel collection events occurred at the ramp traps between July 9 and November 2, 2015; and 35 occurred at the Medusa traps between July 24 and November 2, 2015. [Table 4.1-1](#) summarizes the number of eel collected at each location during the study. A total of 5,972 eels were collected; the majority, 87.7% (n=5,235) were collected at the Spillway Fishway Trap, followed by the Cabot Emergency Spillway Trap and Cabot Fishway Trap, which collected 7.1% (n=424) and 5.2% (n=319), respectively ([Figure 4.1-1](#)). No eels were collected at the Medusa Traps.

During the study period, the upstream eel migration occurred between July 10 and October 14, 2015. Peak migration, during the study period, occurred in July, with the peak events on July 15, 2015 at the Spillway Fishway Trap (n=702); July 22, 2015 at the Cabot Fishway Trap (n=51) and on July 29, 2015 at the Cabot Emergency Spillway Trap (n=102). Very few eels were trapped after August ([Table 4.1-1](#) and [Figure 4.1-1](#)).

A subsample of collected eels was sorted into one (1) of three (3) size categories during each collection event: less than 10cm; between 10cm and 20cm; and greater than 20cm. A total of 2,526 eel were sorted into the three size categories. The majority (97.1%) were between 10cm and 20cm in length, with only 0.04% less than 10cm and 2.85% greater than 20cm ([Figure 4.1-2](#)).

Survival in the traps was very high with only 3 mortalities (99.95% survival); the remaining 5,969 eel were released alive in the TFI.

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Table 4.1-1: Eels collected during the 2015 Upstream Eel Passage Study

Date of Collection	Number of Eels Trapped			
	Spillway Ladder Trap	Cabot Emergency Spillway Trap	Cabot Ladder Trap	Medusa Traps at No.1 Station
7/10/2015	2	0	0	-
7/13/2015	117	10	15	-
7/15/2015	702	6	23	-
7/17/2015	182	11	17	-
7/20/2015	280	1	29	-
7/22/2015	602	88	51	-
7/24/2015	520	59	13	0
7/27/2015	135	3	7	0
7/29/2015	119	102	10	0
7/31/2015	308	8	24	0
8/3/2015	264	7	29	0
8/5/2015	89	17	19	0
8/7/2015	148	6	1	0
8/10/2015	187	7	1	0
8/12/2015	130	4	0	0
8/14/2015	162	10	0	0
8/17/2015	135	7	14	0
8/19/2015	7	12	10	0
8/21/2015	10	11	15	0
8/24/2015	155	5	0	0
8/26/2015	116	7	0	0
8/28/2015	137	12	2	0
8/31/2015	173	6	0	0
9/2/2015	178	2	4	0
9/4/2015	35	4	2	0
9/8/2015	197	12	15	0
9/10/2015	38	2	2	0
9/14/2015	14	2	3	0
9/16/2015	6	0	1	0
9/18/2015	9	0	0	0
9/21/2015	6	0	1	0
9/25/2015	11	0	0	0
9/28/2015	1	1	0	0
9/30/2015	5	0	0	0
10/1/2015	45	2	4	0

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Date of Collection	Number of Eels Trapped			
	Spillway Ladder Trap	Cabot Emergency Spillway Trap	Cabot Ladder Trap	Medusa Traps at No.1 Station
10/4/2015	10	0	1	0
10/14/2015	0	0	0	0
10/19/2015	0	0	0	0
10/26/2015	0	0	0	0
11/2/2015	0	0	0	0
Total	5,235	424	313	0

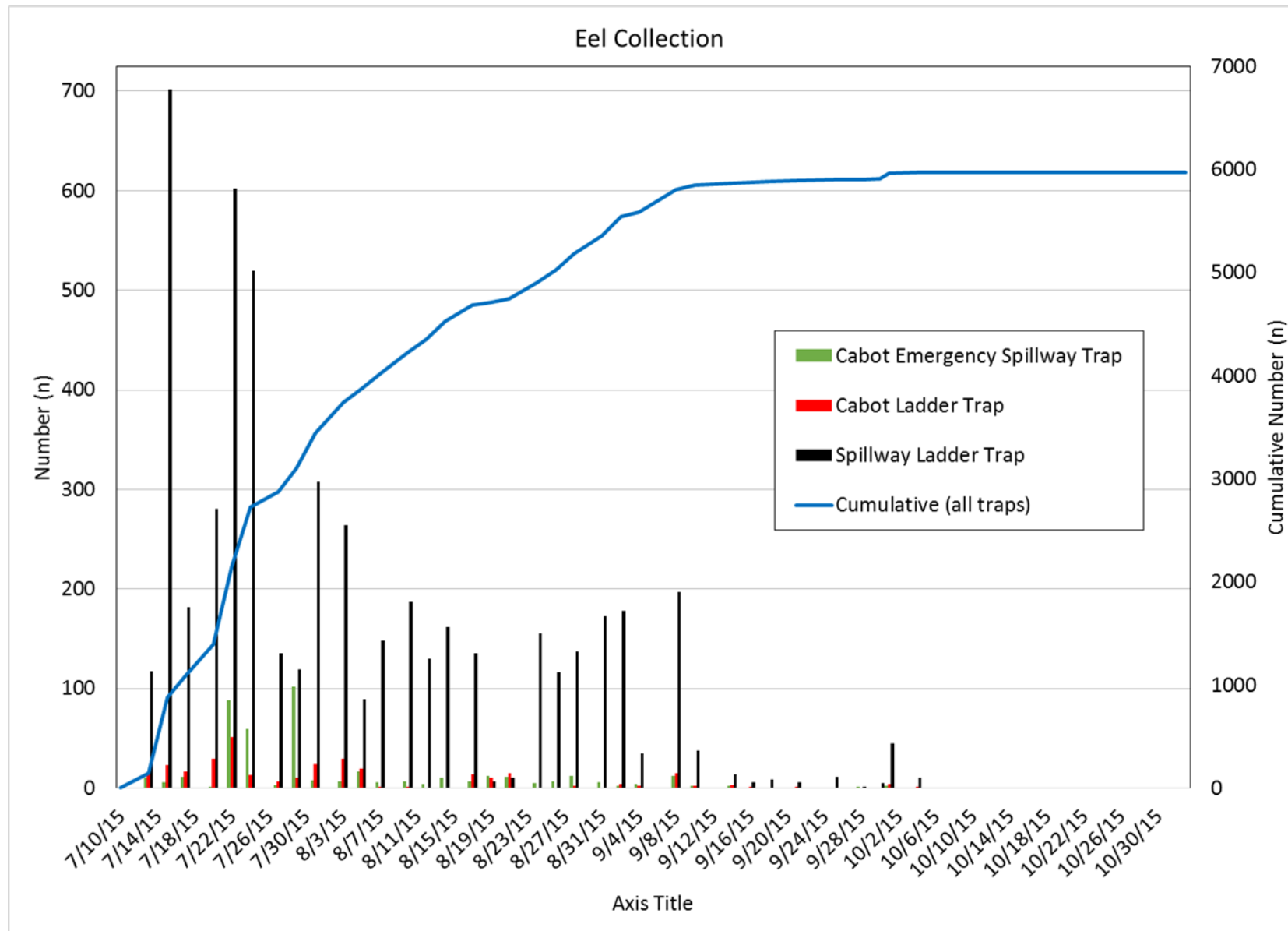


Figure 4.1-1: Eel Collections at the Project, Turners Falls, MA

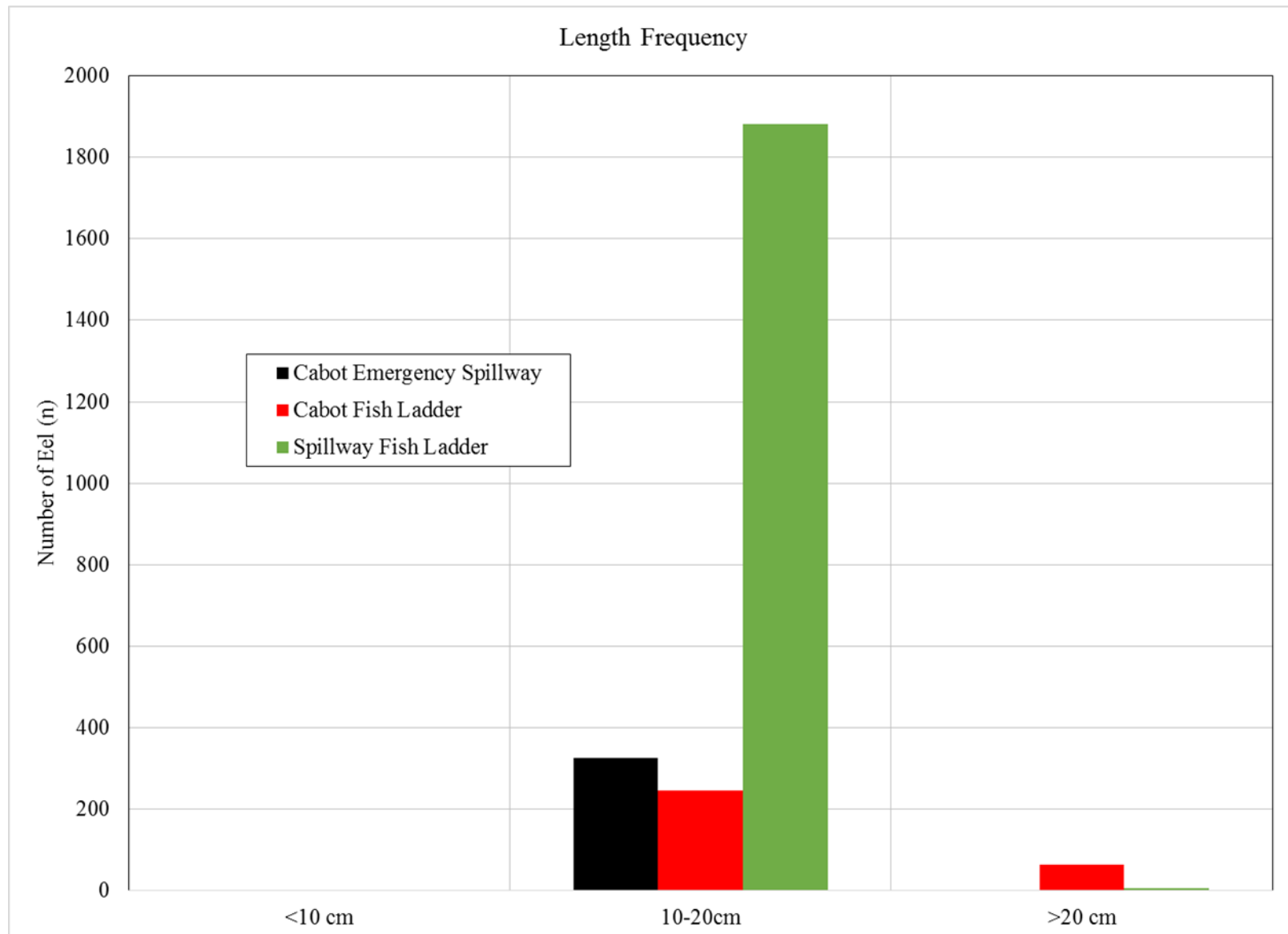


Figure 4.1-2: Length Frequency of a Sub-Sample (n=2,526) of the Eels Collected at the Turners Falls Project, Turners Falls, MA

4.2 Environmental and Operational Conditions

[Table 4.2-1](#) summarizes the environmental conditions at the time of each eel collection. Thirty eight (38) rain events occurred during the study period ranging from trace amounts (≤ 0.01 inches) on July 27, August 16, September 17 and on October 16, 21 and 23, 2015 to 3.77 inches on September 30, 2015 ([Figure 4.2-1](#) and [Table 4.2-1](#)) (Weather Underground). The months of July, August and September were wet, whereas October was dry as shown in [Table 4.2-2](#).

Table 4.2.2: Comparison of July-October 2015 Rainfall Totals versus Long Term

(Source: Weather Underground)

Month	2015 Rainfall Total (inches)	Long Term Average Rainfall Total (inches)	2015 Rainfall – Long Term Average Rainfall (inches)
July	3.33	2.86	+0.47
August	2.45	2.17	+0.28
*September	6.36	3.17	+3.19
October	2.24	3.15	-0.91

*Of the 6.36 inches of rain that fell in September, nearly 4 inches fell on September 30, 2015

Based on the Pearson Correlation Coefficient test, there was no significant correlation ($r = -0.1962$) between precipitation and eel collection rate at the Project ([Figure 4.2-2](#)).

River flow within the study area is influenced by operations at the Turners Falls Project, among other factors. The Project discharges to the Connecticut River via Cabot Station and Station No. 1, through the fishways (during fish passage seasons, April through mid-July) and the Cabot log sluice (during downstream fish passage season, April through mid-November, and periodically for intake rack cleaning), over the dam through bascule gates 1-4 and taintor gates 1-3, discharges from the mills, from the emergency spill gates at Cabot, and from the spillway fishway attraction water supply for shortnose sturgeon protection. The Turners Falls power canal has a hydraulic capacity of approximately 18,000 cfs, inflow in excess of the canal capacity is discharged to the bypass reach. During the study period, the Connecticut River discharge, as measured at the Montague City USGS Gage, ranged from a low of 1,950 cfs on August 23, to a high of 38,000 cfs on October 1, 2015 ([Figure 4.2-3](#)). [Table 4.2-1](#) summarizes average daily discharge as calculated from data collected at a 15 minute interval at the Montague City USGS gage. There was no significant correlation between average daily river flow and collection rate at the Project (Pearson Correlation Coefficient = 0.0429³).

Air and water temperature, predominant weather conditions and cloud cover data were collected throughout the study period and are summarized in [Table 4.2-1](#). Air temperature ranged from a low of 1.3°C on October 19, to a high of 25.6°C on September 8, 2015. Water temperature ranged from a low of 9.4°C on November 2, to a high of 26.1°C on August 19, 2015. Eel collection occurred from the onset of collection on July 10, 2015 at a water temperature of 21.7°C through October 4, 2015 when the water temperature fell to 14.9°C ([Figure 4.2-4](#)).

At least one hydroelectric unit operated throughout the study period at Cabot Station or No. 1 Station or both, except during maintenance conducted on July 11 and 12, 2015, during a 1.25 hour period on the night of August 15, 2015 and during the canal drawdown ([Figure 4.2-5](#)). Generally, Cabot Station and No. 1 Station were operated concurrently when canal inflow exceeded the hydraulic capacity of Cabot. When inflow was less than Cabot's capacity but sufficient to run one unit at Cabot, flow was routed through Cabot Station; under low flow scenarios, generally less than approximately 2,000 cfs, flow was routed through

³ Pearson Correlation factor- values near or 1 suggest high correlation between variables; values near 0 suggest low correlation between variables.

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No. 1 Station. Cabot Station generated, up to a maximum output of 62.96 MW (October 12, 2015), during most of the study period. Station No. 1 operated less frequently, but operated continuously during a low flow period from August 23 through September 24, 2015.

Spill at the Turners Falls Dam occurred during the study period ([Figure 4.2-6](#)), but was infrequent until 3.77 inches of rain fell on September 30, 2015. Following the rain event, flow in the Connecticut River, as measured at the Montague USGS Gage, spiked to over 37,700 cfs. Flow in excess of Project capacity (approximately 18,000 cfs) was diverted into the bypass reach via the bascule gates. The high flow event coincided with peak discharge into the bypass reach of nearly 18,000 cfs. A brief period of spill (peak of 8,343 cfs on 7/11/15) into the bypass reach occurred between July 9 and 13, 2015 after a rainfall of 1.17 inches on July 9 and 10, 2015. During the annual canal outage all flow was routed into the bypass reach (October 4-11, 2015). Spill occurring after October 14, 2015 was generally associated with survival testing of juvenile American shad, Study No. 3.3.3 (*Evaluate Downstream Passage of Juvenile American Shad*). Data suggests that spill at the Turners Falls Dam does not affect collection rate at the traps.

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Table 4.2-1: Summary of Environmental Conditions During the 2015 Upstream Eel Passage Study, Turners Falls, MA

Collection Date	Average Daily Discharge (cfs)¹	Average Daily Water Temperature (°C)³	Average Daily Air Temperature (°C)²	Predominant Weather Conditions	Precipitation (in.)²	Cloud Cover (%)⁴
7/10/2015	11,776	21.7	21.8	Thunder Storms	0.61	50
7/13/2015	11,570	23.4	23.0	Thunder Storms	0.1	60
7/15/2015	7,599	23.5	22.1	Rain	0	82
7/17/2015	6,474	23.3	18.7	Clear	0	39
7/20/2015	13,622	24.3	25.1	Fog	0	70
7/22/2015	13,072	25.2	21.3	Partly Cloudy	0	28
7/24/2015	11,359	24.0	19.2	Thunder Storms	0	75
7/27/2015	5,439	24.2	21.3	Thunder Storms	0.01	69
7/29/2015	8,335	24.8	24.4	Fog	0	23
7/31/2015	6,250	25.2	22.6	Fog	0	14
8/3/2015	6,648	25.4	24.3	Clear	0	65
8/5/2015	3,495	25.3	20.3	Fog	0	25
8/7/2015	6,175	25.0	19.6	Scattered Clouds	0	24
8/10/2015	5,318	25.2	21.4	Partly Cloudy	0	50
8/12/2015	9,699	22.7	21.3	Fog	0	64
8/14/2015	6,400	24.1	20.8	Scattered Clouds	0.07	12
8/17/2015	7,049	25.5	21.9	Fog	0	20
8/19/2015	5,954	26.1	25.0	Partly Cloudy	0	-
8/21/2015	4,674	26.0	21.4	Rain	0.3	78
8/24/2015	5,492	25.8	23.4	Rain	0	40
8/26/2015	8,188	23.1	19.8	Fog	0	43
8/28/2015	3,294	23.5	17.9	Fog	0	10
8/31/2015	5,471	24.2	22.6	Fog	0	46
9/2/2015	3,439	24.6	21.4	Fog	0	5
9/4/2015	4,993	24.8	20.7	Partly Cloudy	0	85
9/8/2015	3,806	25.4	25.6	Clear	0	60
9/10/2015	3,004	25.0	20.4	Rain	0.52	100
9/14/2015	13,161	20.8	15.0	Partly Cloudy	0	-
9/16/2015	8,078	21.7	18.8	Fog	0	11
9/18/2015	3,741	22.2	19.7	Fog	0	-
9/21/2015	3,560	21.4	13.1	Clear	0	25
9/25/2015	5,572	20.3	14.3	Clear	0	60
9/28/2015	2,921	19.7	15.8	Partly Cloudy	0	40
9/30/2015	21,174	20.0	19.3	Rain	3.77	100
10/1/2015	34,583	18.3	12.2	Partly Cloudy	0	60
10/4/2015	14,914	14.9	10.4	Scattered Clouds	0	20

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Collection Date	Average Daily Discharge (cfs) ¹	Average Daily Water Temperature (°C) ³	Average Daily Air Temperature (°C) ²	Predominant Weather Conditions	Precipitation (in.) ²	Cloud Cover (%) ⁴
10/14/2015	6,965	14.7	13.1	Scattered Clouds	0	-
10/19/2015	4,982	11.6	1.3	Scattered Clouds	0	-
10/26/2015	6,238	10.8	6.6	Clear	0	-
11/2/2015	8,230	9.4	11.3	Clear	0	-

¹Calculated using data acquired from USGS gage 01170500 Connecticut River at Montague City, MA (Provisional Data, downloaded on January 11, 2016)

²Obtained from Weather Underground Montague City, MA (<http://www.wunderground.com>, cited 12/17/15).

³Water temperature was measured in the Connecticut River just upstream of the Station No. 1 tailrace.

⁴Observations by study team during eel collection events.

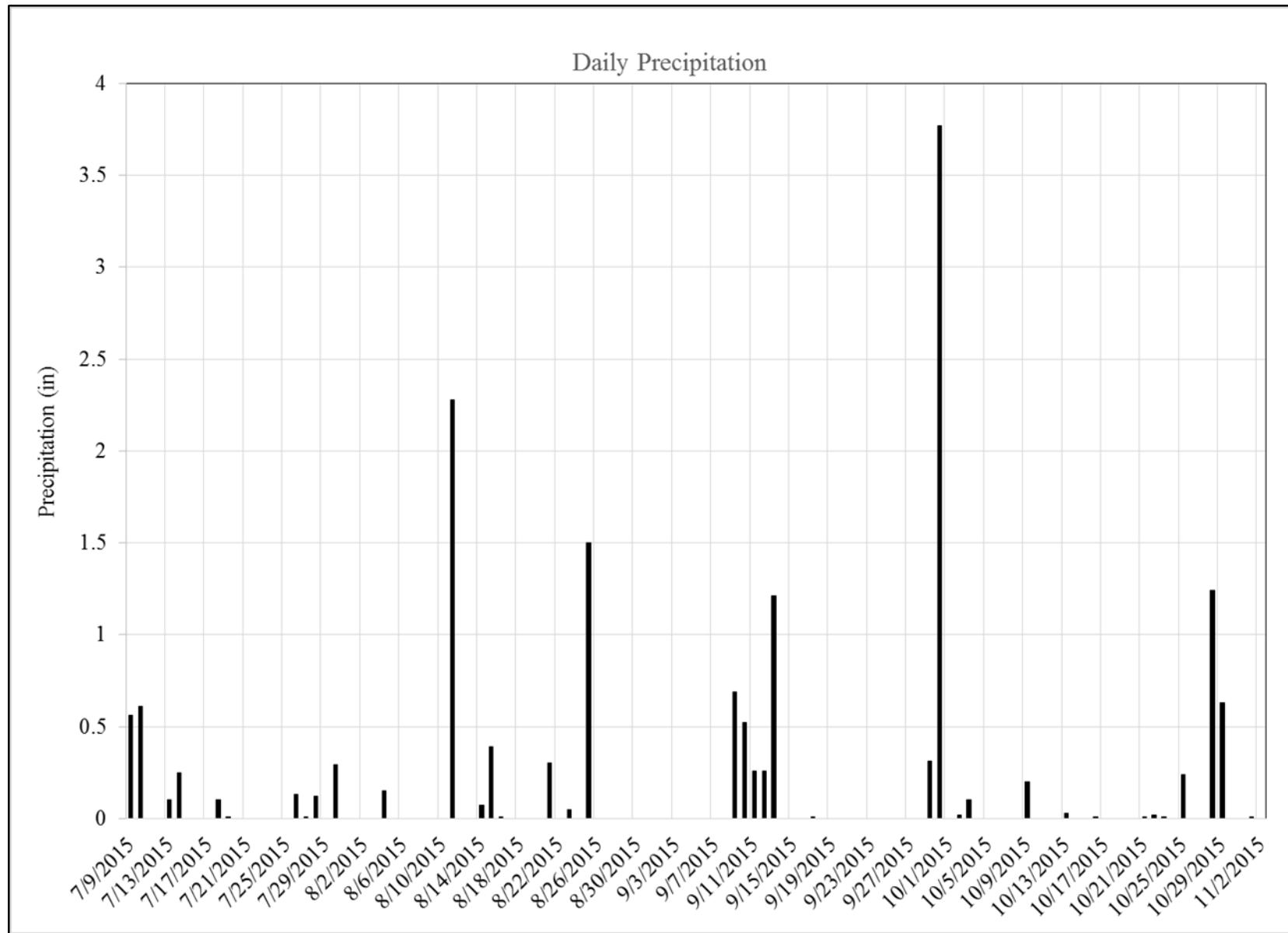


Figure 4.2-1: Daily Precipitation at the Turners Falls Project, Turners Falls, MA

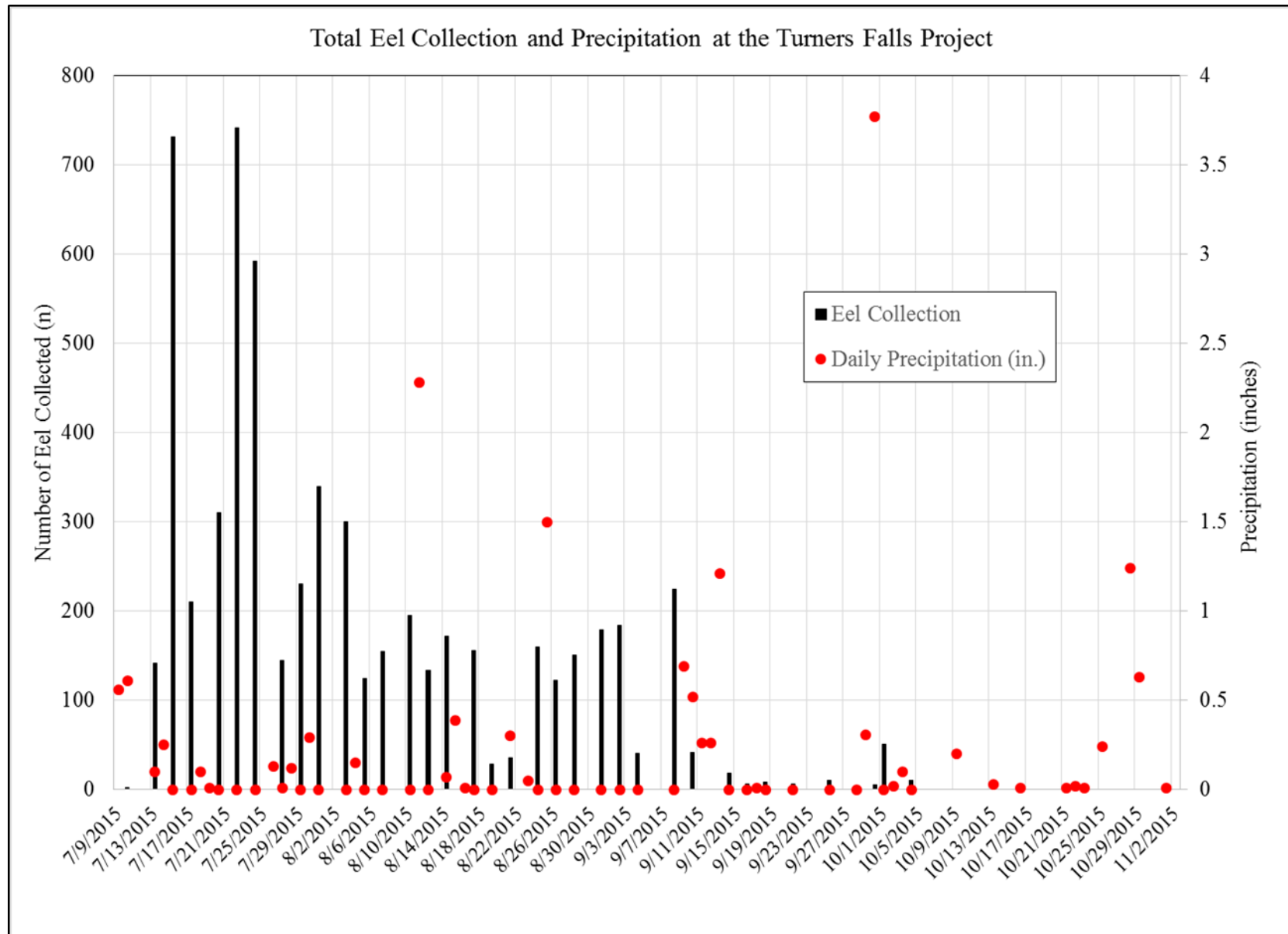


Figure 4.2-2: Daily Precipitation and Total Eel Collections (All Three Traps) at the Turners Falls Project, Turners Falls, MA

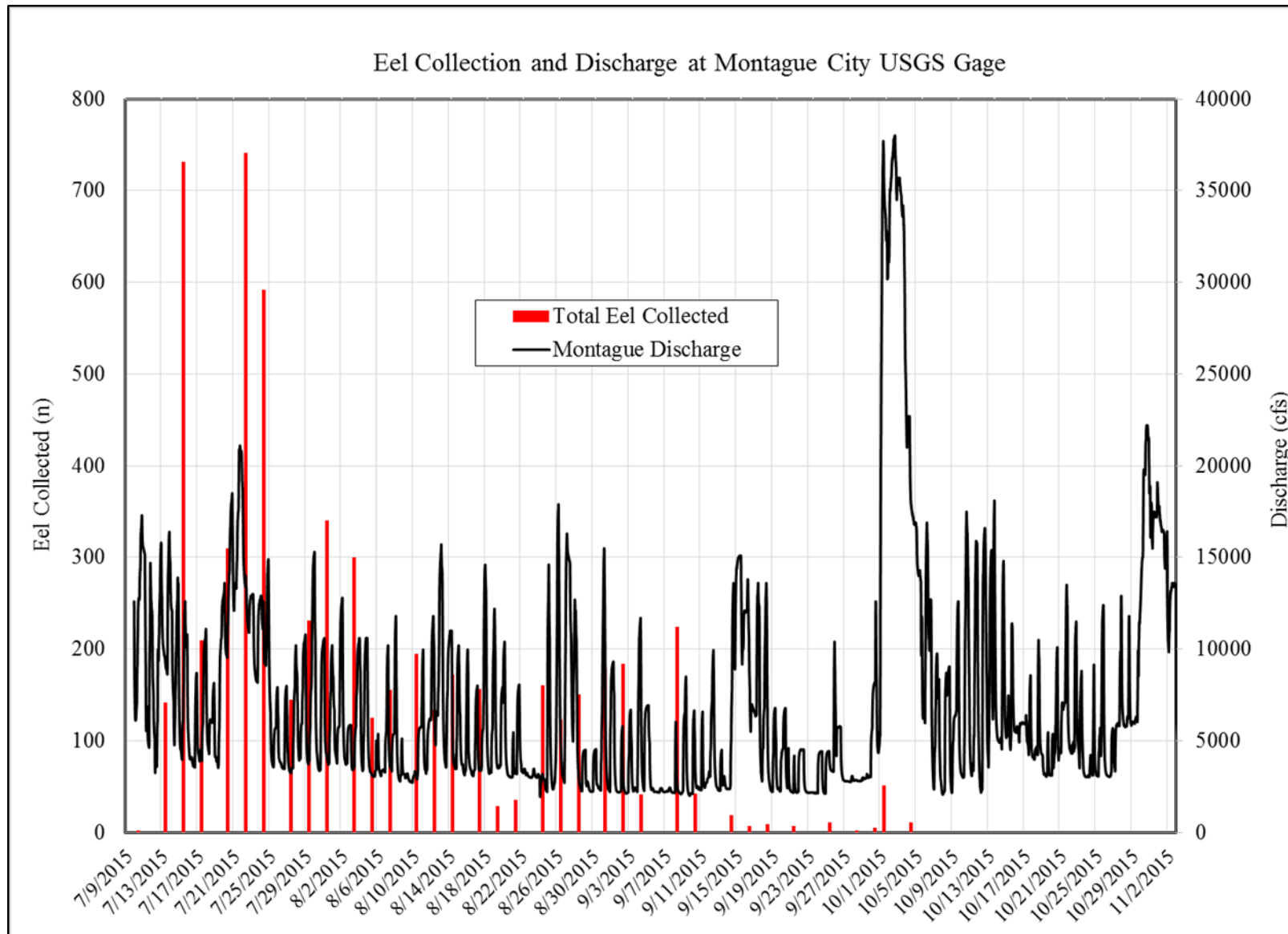


Figure 4.2-3: Connecticut River Discharge, Plotted on a 15 Minute Interval, at Montague City (USGS gage 01170500), Montague City, MA

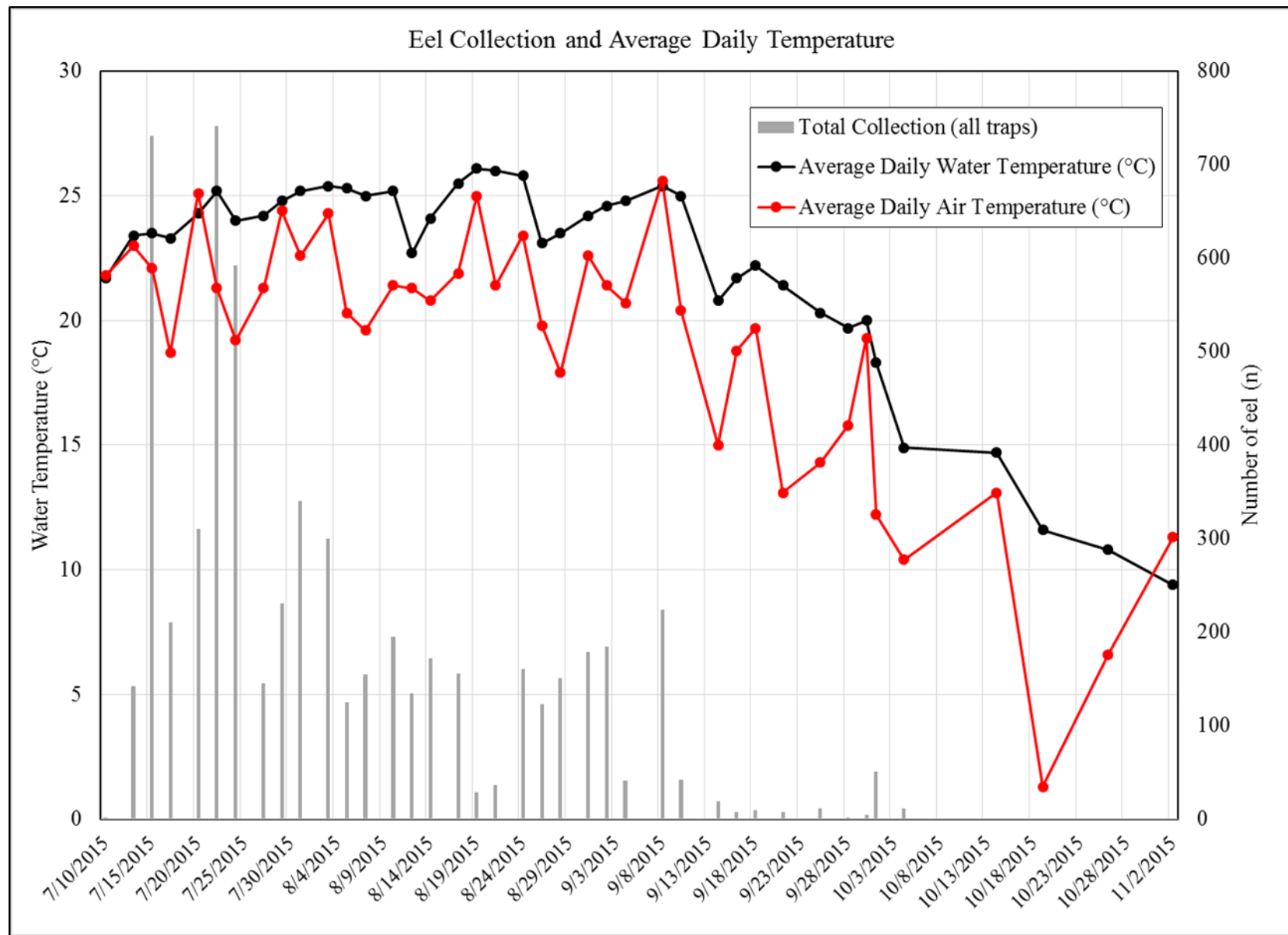


Figure 4.2-4: Average Daily Air and Water Temperature and number of American eel collected daily (all traps) at the Turners Falls Project, MA

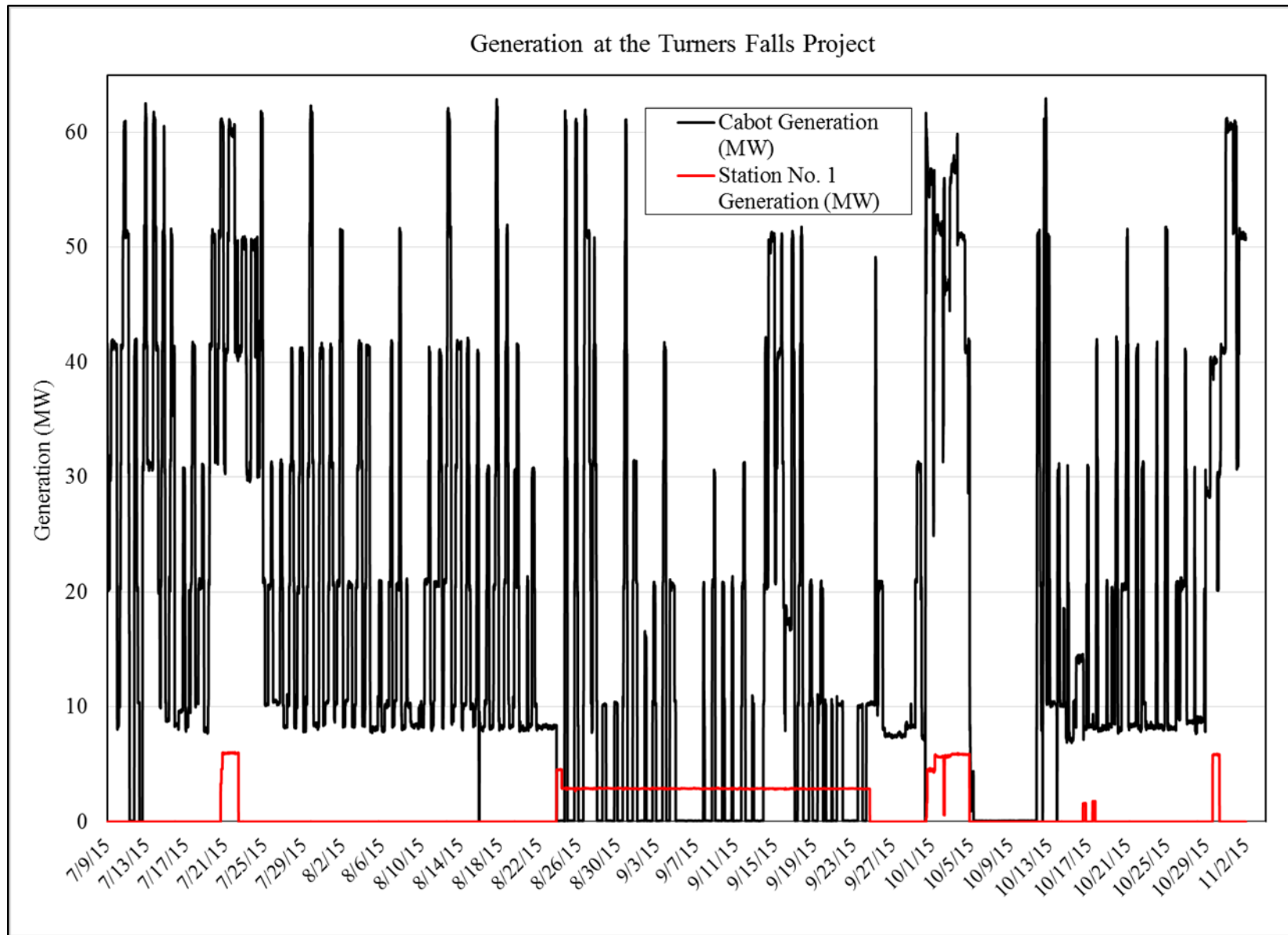


Figure 4.2-5: Operation at the Project, Turners Falls, MA

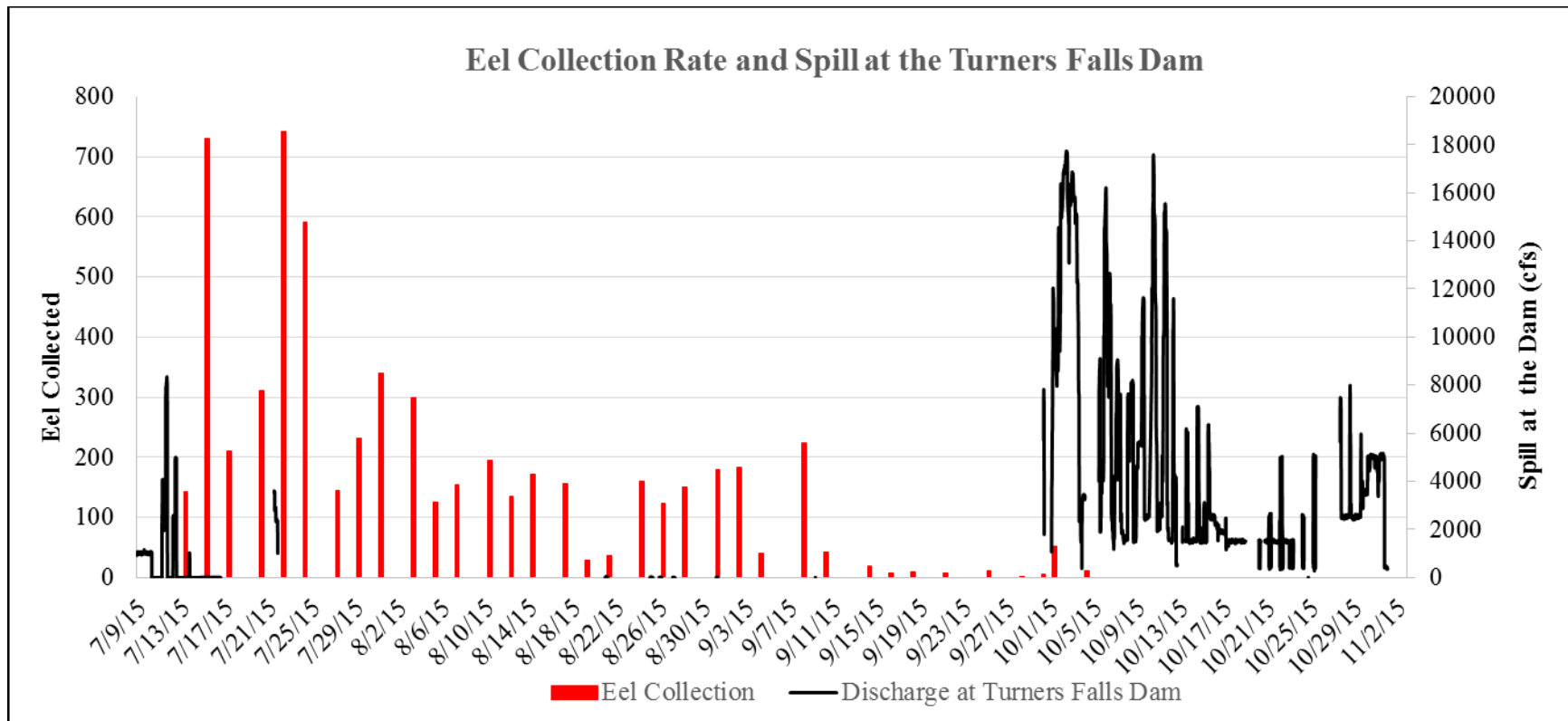


Figure 4.2-6. Spill at the Turners Falls Dam, Turners Falls, MA

5 DISCUSSION

Upstream American eel migration occurs annually in the Connecticut River drainage. In recent years, eel recruitment to the Turners Falls Project has presumably been on the rise since the installation of permanent passage facilities at the Holyoke Project, the first dam on the Connecticut River. Monitoring of upstream passage at Holyoke began in 2003 and an increasing number of eels have passed annually, culminating in the highest passage rate yet in 2014, when a total of 50,319 eels was recorded at Holyoke Dam ([Normandeau, 2015](#)). Rearing habitats exist in the 35 mile reach between the Holyoke Dam and the Turners Falls Dam but an unknown number of eel continue upstream migration, some passing the Project via existing upstream fish passage facilities. These fish passage facilities cease operations in mid-July, after which juvenile eels are still attempting upstream migration.

At Turners Falls Dam, upstream migration was observed as soon as the traps became operational on July 9, 2015, thus it is likely that the upstream migration commenced prior to the onset of sampling. Upstream eel passage monitoring at the Holyoke Project began on May 13, and the first observed eel passage occurred on May 17, 2015 (Steve Leach, Normandeau Associates, personal communication). Researchers have reported that migration is triggered when water temperatures increase to between 10 and 14°C ([Greene et al., 2009](#)). This observation corresponds well with the results of this study; where the end of eel collections, and thus migration, at the Project, occurred when the water temperature fell to 14.9°C on October 4, 2015. Data collected at the Project revealed that water temperature reached 10-14°C in early to mid-May. Given this, and observation at Holyoke, it is likely that migration began in mid-May at the Project. The peak period of migration during trap operation for this study at Turners Falls was mid-July. Monitoring at Holyoke revealed that peak migration occurred in July as well, with a secondary peak occurring in mid-September (Steve Leach, Normandeau Associates, personal communication).

In addition to temperature, other factors are thought to influence daily migration rates including lunar cycle, river flow and precipitation ([Greene et al., 2009](#)). River flow and precipitation events were plotted and compared to collection rate and no significant correlation was found.

The location of passage structures is critical for effective passage ([Haro, 2013](#)). The results of this study, as well as observations conducted during the 2014 study, indicate that the Spillway Fishway attracts the greatest number of migrating eel and probably has the most potential as a site for permanent passage facilities.

Eels were observed and trapped at other locations, most notably at the Emergency Spillway and within the Cabot Fishway. However, the number of eels collected at these locations was much lower than the number collected at the Spillway Fishway. Further, the Emergency Spillway is not an appropriate location for a permanent passage structure. Its operation is intended to rapidly draw down the power canal in the event of a Cabot Station load rejection or canal dike breach or to sluice ice and debris downstream. During such events, the gates open automatically and without warning, discharging excess water to the spillway. Should a passage structure be built at this location, discharge at the Emergency Spillway has the potential to damage the Emergency Spillway and passage structures. [Figure 5.0-1](#) is a photo that illustrates the flow conditions in the Emergency Spillway during a full load rejection.

No eel were collected at the No. 1 Station tailrace. During the 2014 study, a very small number of eel (n=3) were observed in the tailrace. The lack of collection may be a result of the low recruitment to this location but the trapping method was different than those employed at the other locations, which may have affected the catch rate. However, despite the difference in collection methods, it does not appear that No. 1 Station attracts eel.



Figure 5.0-1: Cabot Emergency Spillway, Turners Falls, MA

Illustrates the flow conditions within the Emergency spillway during a full load rejection at Cabot Station, Turners Falls, MA.

6 CONCLUSION

The results demonstrate that American eel are recruited to the Spillway Fishway in the thousands and can be effectively collected there in much greater numbers than at the other locations studied. During the study period, most fish attempt to pass during July and August and were typically 10cm to 20cm in length. While eel do recruit to other locations at the Project, they do so in much lower numbers. Of the three ramp trap locations, the Cabot Emergency Spillway Trap is the least suitable due to a low eel recruitment and collection rate, but also due to concerns of trap durability in the sometimes energetic environment of the Cabot Emergency Spillway when spill events occur.

7 LITERATURE CITED

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