TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 11
American Eel Survey

Study Report

In support of Federal Energy Regulatory Commission Relicensing of:

Wilder Hydroelectric Project (FERC Project No. 1892-026)
Bellows Falls Hydroelectric Project (FERC Project No. 1855-045)
Vernon Hydroelectric Project (FERC Project No. 1904-073)

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March 1, 2016

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EXECUTIVE SUMMARY

The goal of this study was to provide baseline data relative to the presence of American Eel in the Wilder, Bellows Falls and Vernon project-affected areas. Study objectives included characterizing the distribution and abundance of American Eel in the project impoundments, riverine sections, and the project-influenced portions of tributaries.

The study surveyed a subset of the project-affected area for the presence of American Eels. This approximately 120-mile reach of the Connecticut River was divided into six mainstem geographic reaches delineated based on a combination of general river morphology and project structures. Surveys for the presence and abundance of American Eel were also specified to occur in tributary habitat within the limits of the project-influenced tributary reach.

Surveys were conducted from late July through August 2015 at 102 mainstem river sampling sites by boat or portable (pram/backpack) electrofish sampling as well as an overnight set of baited eel traps. In addition, twenty-four tributary sampling sites were surveyed by boat or portable electrofish sampling dependent on water depths present within the tributaries at the time of sampling. As with mainstem reaches, an overnight eel pot set was conducted at each location in addition to electrofish sampling. Environmental parameters including water quality, river velocity and dominant substrate were recorded at each sampling site in a location representative of the river conditions at that site. Biological data collection for captured eels included length, weight, an assessment of sexual maturity (status as a silver eel) and a reach unique fin clip to identify potential recaptures.

The sampling effort resulted in a total of three American Eels captured at two sites, both in the Bellows Falls impoundment. Results indicate that eels are present, however in low abundance, within the project-affected areas from the upper extent of Wilder impoundment downstream to the Vernon tailrace.

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List of Abbreviations

AOQL	Average Outgoing Quality Limit
CRWC	Connecticut River Watershed Council
°C	degrees Celsius
DO	dissolved oxygen
FERC	Federal Energy Regulatory Commission
FWS	U.S. Department of the Interior – Fish and Wildlife Service
fps	feet per second
ft	feet or foot
ILP	Integrated Licensing Process
hr	hour
m	meter
mg/L	milligrams per liter
µS/cm	micro-siemens per centimeter
NHDES	New Hampshire Department of Environmental Services
NHFGD	New Hampshire Fish and Game Department
NTU	Nephelometric Turbidity Units
RM	river mile
RSP	Revised Study Plan
SSR	Site Selection Report
su	standard units
TransCanada	TransCanada Hydro Northeast Inc.
TU	Trout Unlimited
USR	Updated Study Report
VANR	Vermont Agency of Natural Resources
VDEC	Vermont Department of Environmental Conservation

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1.0 INTRODUCTION

This study report presents the findings of the 2015 American Eel Survey (ILP Study 11) conducted in support of Federal Energy Regulatory Commission (FERC) relicensing efforts by TransCanada Hydro Northeast Inc. (TransCanada) for the Wilder Hydroelectric Project (FERC Project No. 1892), Bellows Falls Hydroelectric Project (FERC No. 1855) and the Vernon Hydroelectric Project (FERC No. 1904).

Evidence exists that American Eels (*Anguilla rostrata*) are moving upstream of the Vernon, Bellows Falls, and Wilder dams; however, the distribution and relative abundance of American Eels in the mainstem habitat upstream and in the project areas remains unknown. As described in the Pre-Application Documents (PADs) for the projects, a limited number of American Eels were collected during sampling for the Fish Assemblage and Habitat Assessment of the Upper Connecticut River study (Yoder et al., 2009). No eels were observed during sampling conducted within the Bellows Falls impoundment or upstream of Wilder dam. Twenty-seven eels have been captured during Entergy's annual sampling in the vicinity of Vermont Yankee from 1991-2014 (Normandeau, 2014).

In their study requests, US Fish & Wildlife Service (FWS), New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish & Game Department (NHFGD), Vermont Agency of Natural Resources (VANR), Connecticut River Watershed Council (CRWC), and Trout Unlimited (TU) identified potential issues related to Wilder, Bellows Falls, and Vernon Project operations on the distribution and relative abundance of American Eels in mainstem habitat upstream of the project dams and requested a baseline survey to determine the presence of American Eel within the project-affected areas.

Revised Study Plan (RSP) 11, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of the project-affected area would be studied for the presence of American Eel. An initial site selection report was posted on TransCanada's relicensing website on December 5, 2014 and comments were received during an aquatics working group meeting held on December 17, 2014. The final sampling locations were randomly selected and presented in the Revised Site Selection Report ((SSR) Normandeau, 2015a) which included modifications that addressed all working group discussion and comments. The Revised SSR was filed with FERC on September 14, 2015 as Volume II.C of TransCanada's Updated Study Report (USR), with corresponding geodata of final study site locations filed as Volume II.I of the USR.

This report provides results from data collected at the selected study locations during 2015, and reports on eel observations from other studies including Study 10 – Fish Assemblage Study, Study 17 – Upstream Passage of Riverine Fish Species, and Study 18 – American Eel Upstream Passage Assessment.

2.0 STUDY GOALS AND OBJECTIVES

As stated in the RSP, the goal of this study was to provide baseline data relative to the presence of American Eels in the project-affected areas. The specific objectives of this study were to:

- characterize the distribution of American Eel in the project impoundments, riverine sections, and the project-influenced portions of tributaries upstream of Wilder, Bellows Falls, and Vernon dams; and
- characterize the relative abundance of American Eel in the project impoundments, riverine sections, and the project-influenced portions of tributaries within the project-affected reaches.

3.0 STUDY AREA

Sampling was conducted to characterize the baseline American Eel assemblage within project-affected areas from the upper extent of Wilder impoundment downstream to Vernon dam (Study 18 – Upstream Passage of American Eel evaluated eel presence in project tailrace areas and the Bellows Falls bypassed reach). This approximately 120-mile reach of the Connecticut River was divided into six mainstem geographic reaches delineated based on a combination of general river morphology and project structures, as follows:

- Wilder impoundment (RM 262.4 - 217.4);
- Wilder downstream riverine reach (RM 217.4 – 199.7);
- Bellows Falls impoundment (RM 199.7 – 173.7);
- Bellows Falls downstream riverine reach (RM 173.7 – 167.9);
- Vernon impoundment (RM 167.9 – 141.9); and
- Vernon riverine reach (RM 140.4 – 141.9).

3.1 Study Sites

Study sites were selected in accordance with the process described in the Revised SSR and with concurrence from the aquatics working group, and summarized below.

The selection of mainstem sampling locations was based on a stratified random sampling design. Prior to the selection of study locations, each geographic reach (or stratum) was delineated into 500-meter map-unit segments using ArcGIS. As stated in the RSP, the number of map-units in each mainstem stratum was proportional to the contribution of the total length of that stratum to the entire study reach. This approach resulted in a total of 102 selected mainstem map-unit segments: 37 in the Wilder impoundment, 15 in the riverine section downstream of Wilder, 22 in the Bellows Falls impoundment, 5 in the riverine section downstream of Bellows Falls, 22 in the Vernon impoundment, and 1 in the riverine reach

downstream of Vernon. Within each selected map-unit, a river bank (east or west) was randomly selected for sampling.

Surveys were also specified to occur in tributary habitats within the limits of the project-influenced areas upstream of each dam. As part of the geographic assessment associated with Study 13 - Tributary and Backwater Fish Access, conducted in 2014 (Normandeau, 2015b), a total of 146 tributaries were identified entering the study area from the upper extent of Wilder impoundment downstream to Vernon dam. Since eels prefer larger, slow moving streams (Scarola, 1987; Langdon et al., 2006), the selection process for tributaries focused on tributaries classified as major (stream order 3 or higher). The total length of the project-affected area up into each selected tributary was estimated in ArcGIS. As specified in the RSP, 24 tributaries were selected: 7 upstream of Wilder, 9 upstream of Bellows Falls, and 8 upstream of Vernon.

Study site map-unit locations are illustrated in Figures 3.1-1 through 3.1-5 and Tables 3.1-1 and 3.1-2 provide study site details.

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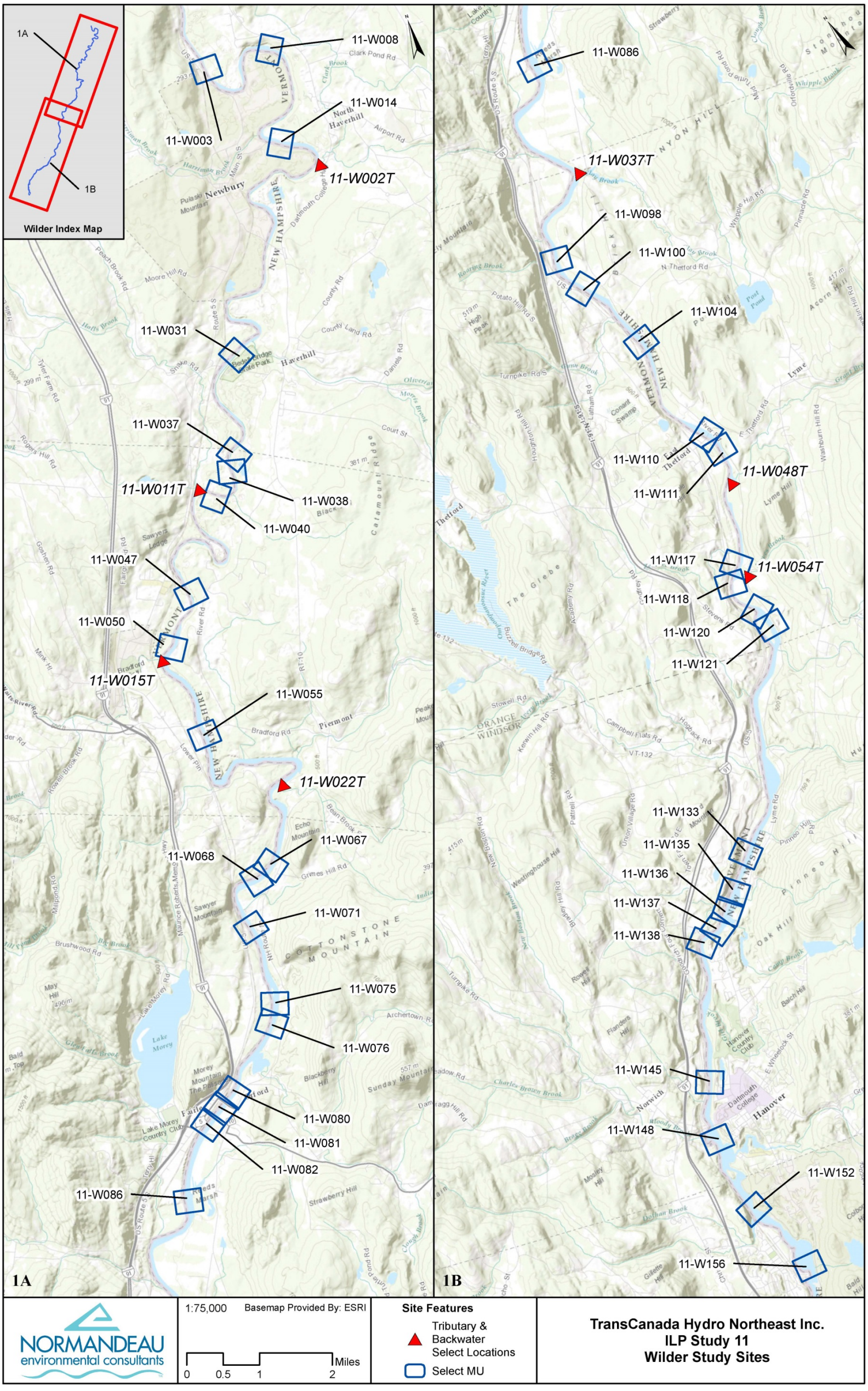

Figure 3.1-1. Map-units sampled within the Wilder impoundment, 2015.

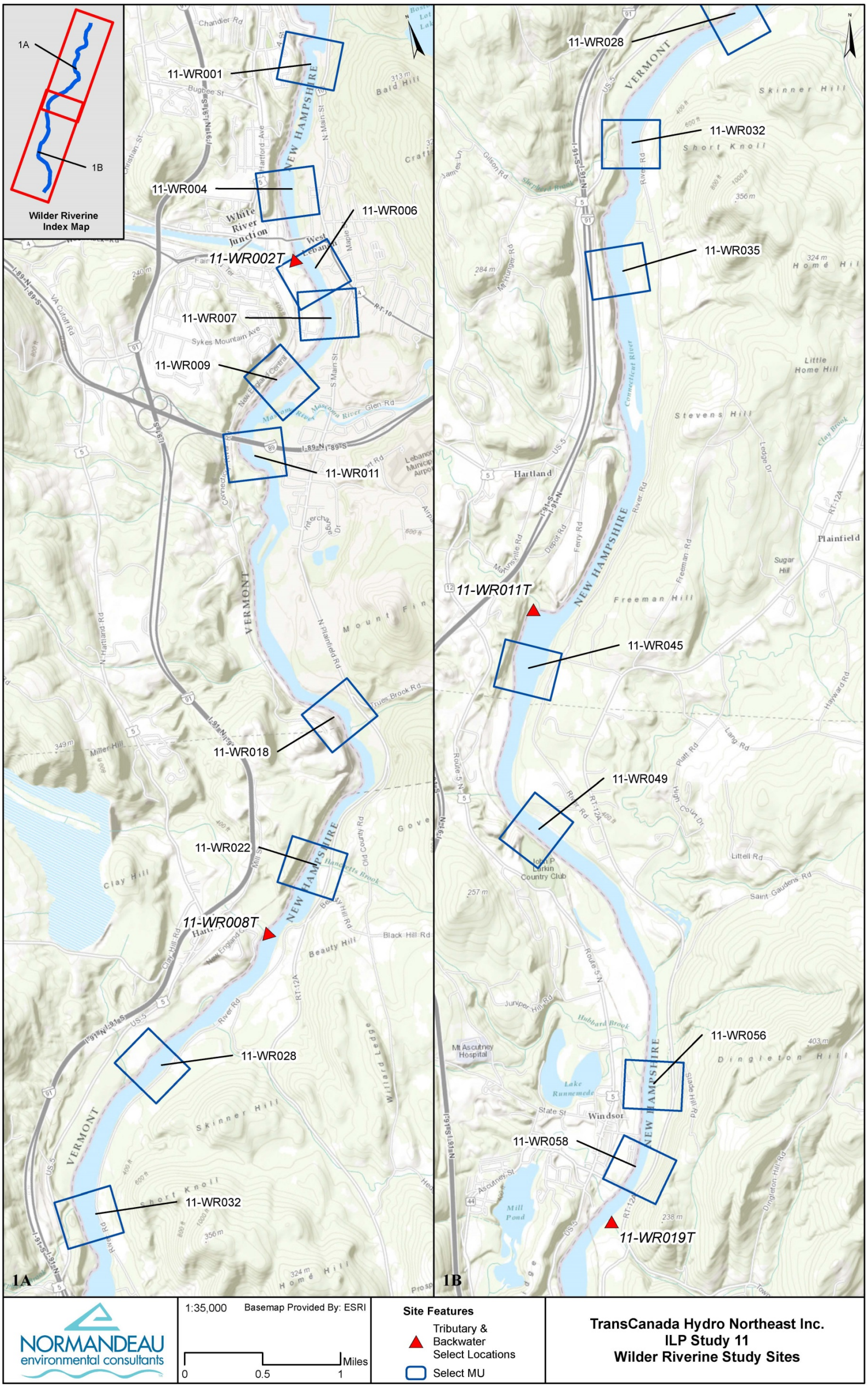

Figure 3.1-2. Map-units sampled within the Wilder Riverine Reach, 2015.

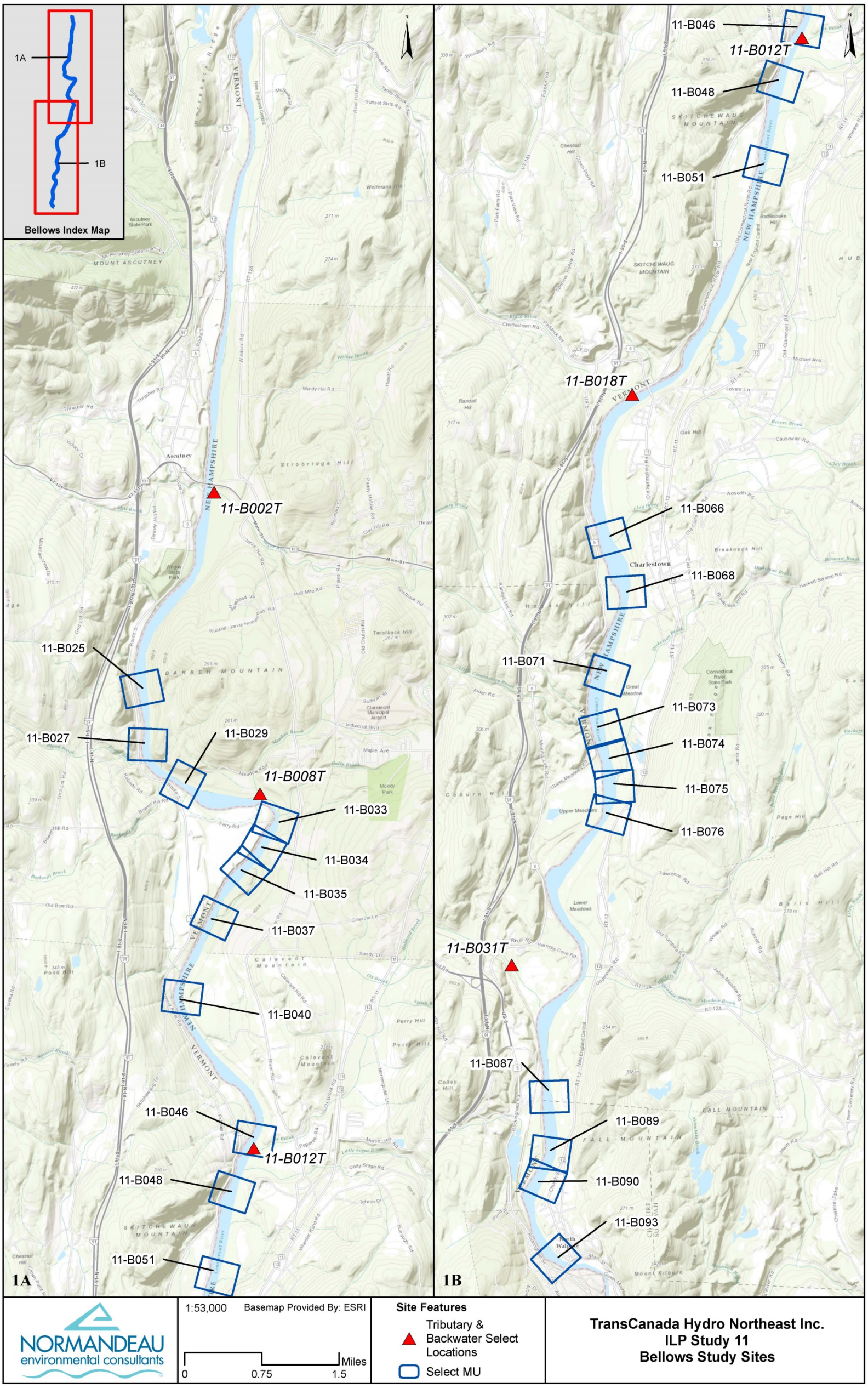

Figure 3.1-3. Map-units sampled within the Bellows Falls impoundment, 2015.

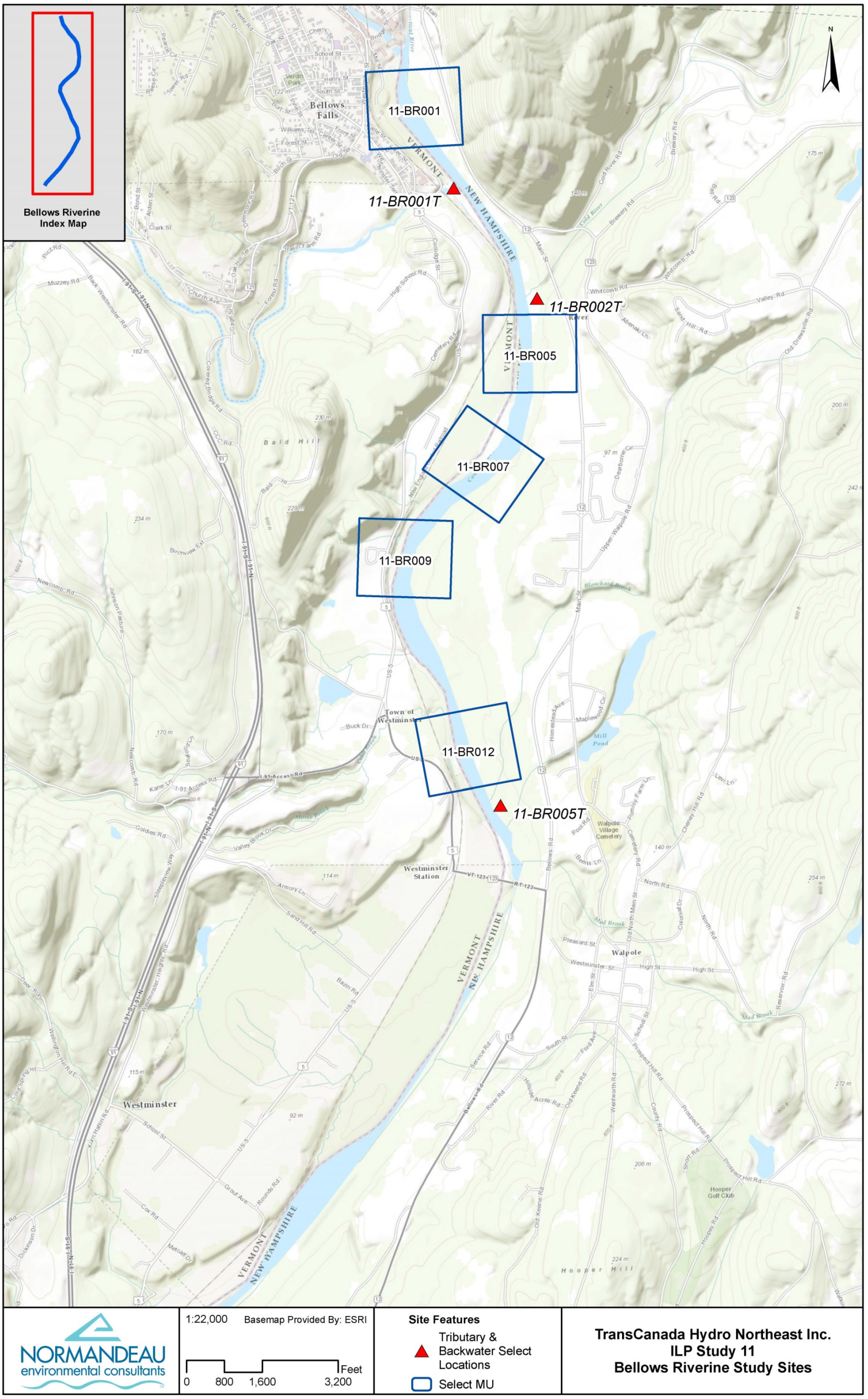

Figure 3.1-4. Map-units sampled within the Bellows Falls riverine reach, 2015.

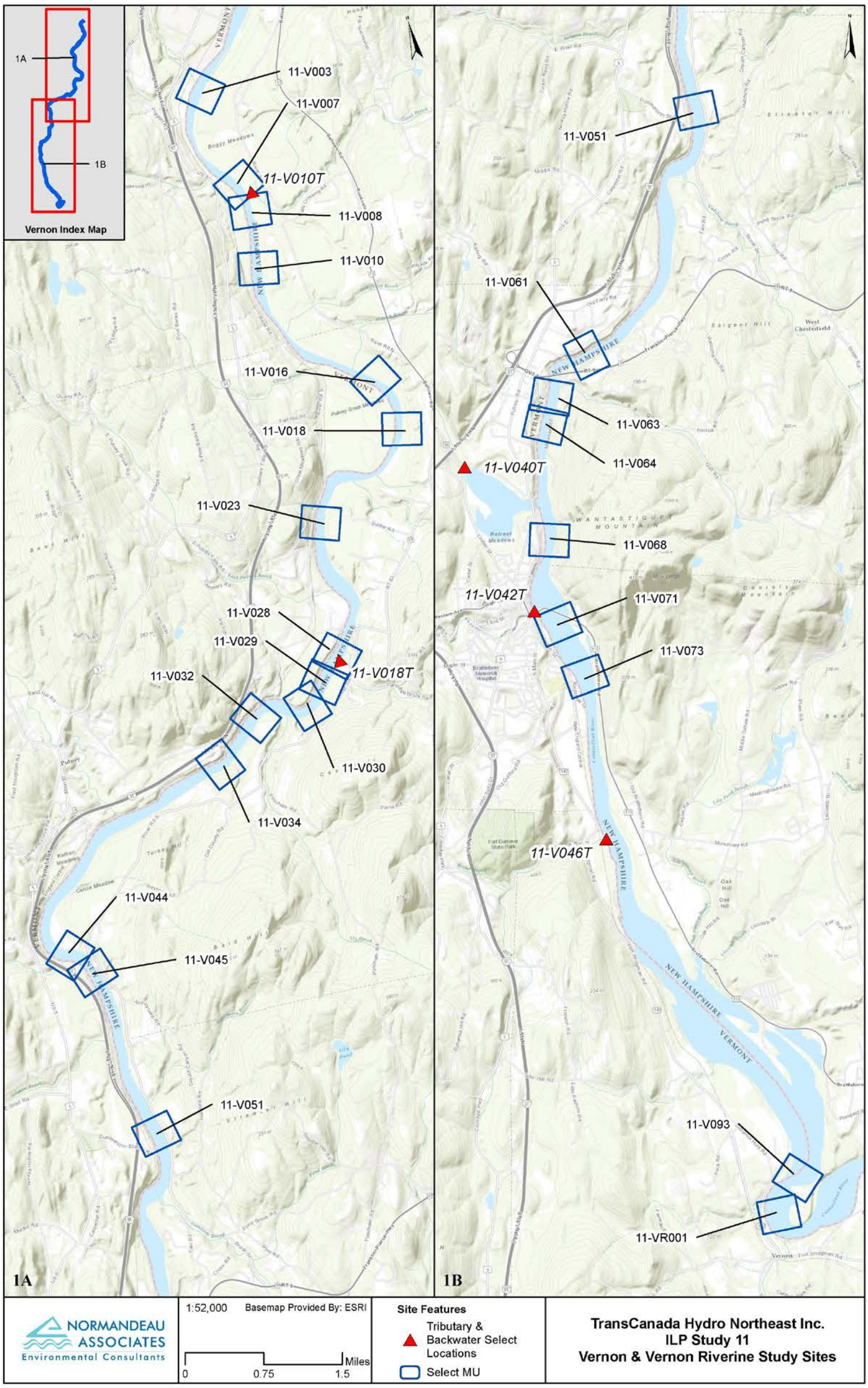

Figure 3.1-5. Map-units sampled within the Vernon impoundment and Vernon riverine reach, 2015.

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Table 3.1-1. Randomly selected mainstem map-units.

Map-Unit	Sample Bank	Downstream Coordinate (DD NAD83 UTM Z18N)	
		X	Y
Wilder Impoundment			
11 - W003	West	-72.052502	44.100648
11 - W008	East	-72.030980	44.101548
11 - W014	West	-72.036978	44.082584
11 - W031	West	-72.072831	44.046419
11 - W037	West	-72.082072	44.027498
11 - W038	East	-72.080222	44.023015
11 - W040	West	-72.089844	44.023806
11 - W047	East	-72.102327	44.002890
11 - W050	East	-72.114761	43.994463
11 - W055	West	-72.112886	43.975376
11 - W067	West	-72.109467	43.948122
11 - W068	West	-72.114636	43.947475
11 - W071	East	-72.115560	43.936420
11 - W075	East	-72.117981	43.920348
11 - W076	East	-72.121659	43.917040
11 - W080	East	-72.138638	43.906908
11 - W081	West	-72.144212	43.905656
11 - W082	West	-72.148838	43.903372
11 - W086	West	-72.159507	43.889003
11 - W098	West	-72.188101	43.856207
11 - W100	West	-72.184838	43.848049
11 - W104	West	-72.182846	43.832548
11 - W110	East	-72.181489	43.810385
11 - W111	East	-72.182506	43.806104
11 - W117	West	-72.202111	43.787693
11 - W118	East	-72.204415	43.783802
11 - W120	West	-72.202460	43.776022
11 - W121	East	-72.201405	43.772266
11 - W133	East	-72.247599	43.739466
11 - W135	West	-72.258414	43.737020
11 - W136	West	-72.263013	43.734784
11 - W137	West	-72.268446	43.734533
11 - W138	West	-72.273026	43.732192
11 - W145	West	-72.294940	43.709206
11 - W148	West	-72.302425	43.698767
11 - W152	East	-72.302328	43.683265
11 - W156	East	-72.302037	43.667387
Wilder Riverine Reach			
11 – WR001	East	-72.305491	43.663394
11 - WR004	East	-72.313128	43.652533
11 - WR006	East	-72.312177	43.644865
11 - WR007	East	-72.313696	43.640758
11 - WR009	West	-72.324827	43.637899
11 - WR011	West	-72.327508	43.630489
11 - WR018	East	-72.326946	43.605430

Map-Unit	Sample Bank	Downstream Coordinate (DD NAD83 UTM Z18N)	
		X	Y
11 - WR022	West	-72.340962	43.593646
11 - WR028	East	-72.367599	43.580303
11 - WR032	West	-72.380303	43.568515
11 - WR035	East	-72.379811	43.556885
11 - WR045	East	-72.394118	43.519826
11 - WR049	East	-72.391110	43.506467
11 - WR056	East	-72.379397	43.481037
11 - WR058	East	-72.383251	43.473392
Bellows Falls Impoundment			
11 - B025	East	-72.412955	43.372575
11 - B027	West	-72.414631	43.364527
11 - B029	West	-72.405442	43.359096
11 - B033	East	-72.390549	43.353052
11 - B034	East	-72.393104	43.349397
11 - B035	East	-72.396808	43.346143
11 - B037	West	-72.404516	43.340438
11 - B040	East	-72.407391	43.328662
11 - B046	West	-72.398322	43.308865
11 - B048	East	-72.399531	43.300884
11 - B051	East	-72.403316	43.289324
11 - B066	West	-72.437577	43.237601
11 - B068	West	-72.434704	43.230155
11 - B071	East	-72.436056	43.218103
11 - B073	East	-72.436530	43.211314
11 - B074	East	-72.434889	43.207188
11 - B075	West	-72.438873	43.202854
11 - B076	West	-72.440582	43.199534
11 - B087	West	-72.452465	43.159590
11 - B089	West	-72.453235	43.151847
11 - B090	West	-72.457619	43.149278
11 - B093	West	-72.448667	43.137311
Bellows Falls Riverine Reach			
11 – BR001	East	-72.437171	43.127345
11 - BR005	West	-72.432934	43.112911
11 - BR007	West	-72.438569	43.107571
11 - BR009	East	-72.441853	43.101253
11 - BR012	East	-72.435714	43.090281
Vernon Impoundment			
11 - V003	East	-72.463788	43.054903
11 - V007	West	-72.460655	43.040752
11 - V008	West	-72.460988	43.037280
11 - V010	East	-72.460663	43.029111
11 - V016	West	-72.444227	43.010222
11 - V018	East	-72.442991	43.002415
11 - V023	West	-72.464761	42.993445
11 - V028	West	-72.469667	42.976049
11 - V029	East	-72.471455	42.971829
11 - V030	West	-72.478117	42.972826

Map-Unit	Sample Bank	Downstream Coordinate (DD NAD83 UTM Z18N)	
		X	Y
11 - V032	East	-72.486203	42.969760
11 - V034	West	-72.496489	42.967053
11 - V044	East	-72.526732	42.946202
11 - V045	East	-72.525044	42.942047
11 - V051	West	-72.524275	42.917824
11 - V061	West	-72.548545	42.886566
11 - V063	West	-72.553643	42.879225
11 - V064	East	-72.553345	42.875072
11 - V068	East	-72.552985	42.859224
11 - V071	West	-72.553622	42.846987
11 - V073	East	-72.545523	42.840635
11 - V093	West	-72.514698	42.771953
Vernon Riverine Reach			
11 – VR001	East	-72.455665	43.060274

Table 3.1-2. Randomly selected tributary map-units.

Site ID	Stream Name	Stream Order	Location (DD NAD83 UTM Z18N)	
			X	Y
Wilder Impoundment				
11 - W002T	Clark Brook	3	-72.030968	44.077717
11 - W011T	Halls Brook	4	-72.091649	44.024377
11 - W015T	Waits River	5	-72.116406	43.994523
11 - W022T	Indian Pond Brook	3	-72.096067	43.963445
11 - W037T	Clay Brook	3	-72.16642	43.869146
11 - W048T	Grant Brook	3	-72.186158	43.801778
11 - W054T	Hewes Brook	3	-72.198335	43.78525
Wilder Riverine Reach				
11 - WR002T	White River	6	-72.31521	43.648842
11 - WR008T	Ottauquechee River	5	-72.346058	43.590471
11 - WR011T	Lulls Brook	3	-72.393608	43.527828
11 - WR019T	Mill Brook NH	4	-72.386094	43.470803
Bellows Falls Impoundment				
11 - B002T	Sugar River	6	-72.399662	43.401959
11 - B008T	Meadow Brook	3	-72.392633	43.359371
11 - B012T	Ox Brook	3	-72.395968	43.309573
11 - B018T	Black River	5	-72.430747	43.260163
11 - B031T	Williams River	5	-72.45725	43.180528
Bellows Falls Riverine Reach				
11 - BR001T	Saxtons River	5	-72.437392	43.124848

Site ID	Stream Name	Stream Order	Location (DD NAD83 UTM Z18N)	
			X	Y
11 - BR002T	Cold River	5	-72.431083	43.118314
11 - BR005T	Blanchard Brook	3	-72.435189	43.089057
Vernon Impoundment				
11 - V010T	Great Brook	3	-72.458572	43.041899
11 - V018T	Partridge Brook	4	-72.466342	42.976335
11 - V040T	West River	6	-72.568873	42.871931
11 - V042T	Whetstone Brook	4	-72.556527	42.851768
11 - V046T	Broad Brook	4	-72.544266	42.820078

4.0 METHODOLOGY

Each of the 102 mainstem river 500-meter sampling reaches selected was sampled by boat or portable (pram/backpack) electrofish equipment as well as by an overnight set of baited eel traps. Tributary sampling reaches (n=24) were sampled within the project-influenced area upstream of each dam. Sampling techniques within the project-influenced portions of the tributary were identical to those at the mainstem locations and included boat/portable electrofish sampling as well as overnight sets of baited eel pots.

Environmental parameters including water quality, river velocity and dominant substrate were recorded at each sampling site in a location representative of the river conditions at that site. Biological data collection for American Eel captured included length, weight, an assessment of sexual maturity (i.e., status as a silver eel) and a reach unique fin clip to identify recaptures.

4.1.1 Electrofish Sampling

Boat Electrofish Sampling

At sites where the conditions allowed for boat electrofish sampling the following protocols were followed to ensure sampling consistency, crew safety and to maximize the chance of capturing and releasing American Eel alive back into the Connecticut River or tributary. Boat electrofish sampling was conducted during evening and night hours, defined as the period two hours before sunset and sunrise, when eels are most active. Prior to the start of sampling, settings on the Smith-Root electrofish unit were adjusted by a trained crew member to ensure approximately 4.0 amps of pulsed DC current was being generated. The initiation of sampling began with the recording of the start time at the downstream coordinates on the predetermined bank of the river or tributary and consisted of a single shoreline pass proceeding upstream. Efforts were made by the boat driver to follow the shoreline contour and probe into habitat areas (overhanging vegetation,

submerged and emergent aquatic vegetation, woody debris, etc.). A scap netter on the bow of the sampling vessel netted and placed all stunned eels into an onboard livewell for processing. Once the sample reach was completed, the stop time, duration (the number of seconds the electrofishing gear was active as recorded by the Smith Root counter) and average water depth (ft) were recorded.

Portable Electrofish Sampling

Portable electrofish sampling (i.e., pram or backpack) was used in most (15 of 24) tributary sites as well as at 21 of the 102 mainstem locations where boat electrofishing was not possible due to field conditions (water depth, water velocity, etc.). In variance to the RSP (and inadvertently not included in the USR or discussed with the working group during the course of field work) it was determined that portable electrofish sampling needed to be conducted during daytime hours rather than at night. This decision was made due to safety concerns about field crews attempting to cross flowing water over slippery and unstable substrates at night while electrofishing. Prior to sampling, the settings on the electrofish unit (Smith Root backpack electrofisher or Georator pram unit) were adjusted to ensure approximately 4.0 amps of pulsed DC current were being generated and a fine mesh seine net was placed at the downstream end of the sample reach. A sampling start time was recorded and then field crew members moved downstream from the upper end of the reach actively netting any stunned individuals and disturbing the substrates to drive additional stunned individuals toward the collection nets. Efforts were made to follow the shoreline contour and probe into habitat areas. Stunned eels were placed in a bucket of ambient river water and held for processing. Once the sample reach was completed, the stop time, duration (the number of seconds the electrofishing gear was active as recorded by an electronic counter) and average water depth (ft) were recorded.

4.1.2 Eel Traps

Eel trap sampling was conducted at each of the mainstem and tributary stations. Deployment of eel traps did not necessarily coincide with the electrofish sampling. The exact location for the eel traps was determined by the field crew leader at the time of sampling. Eel traps were standard double entry wire mesh cylinders (31 inch long by 9 inch diameter, ¼-inch galvanized mesh) equipped with a weight for anchoring the trap on station, float line and a marker buoy. Traps were baited with canned mackerel, canned anchovies, or cat food. Once the sample station was determined, the coordinates were recorded along with set time. After a period of approximately 24 hours, the sample was retrieved and the pull time recorded. Any eels captured were held in a live well for processing. Each eel trap sample consisted of a single 24-hour set.

4.1.3 Biological Data Collection

Following the completion of each unique sample, biological data was collected from any captured eels. Each eel was assigned a length class (0 to 6 inches, 6 to 12 inches, 12 to 18 inches, >18 inches). All individuals captured within each length class were individually measured for total length (mm) and wet weight (g). In

addition to length and weight, eye diameter (mm) measurements were recorded for all individual eels in the >18-inch length class. To facilitate collection of length and weight data as well as prevent unnecessary injuries to the eels, it was necessary to anesthetize individuals. An anesthesia solution of clove oil and 95% ethanol, in a dissolve ratio of 1:9, was used in a concentration of 40 mg/L mixed with river water to create an anesthesia bath. The ethanol was used to ensure uniformity of the anesthesia in the bath.

To account for any recaptures, all unmarked eels (> 1 g wet weight) were marked with a specific fin clip using a standard hole punch as follows:

- Wilder impoundment = paired circle punch in dorsal fin
- Wilder riverine/Bellows Falls impoundment = paired circle punch in anal fin
- Bellows Falls riverine/Vernon impoundment = single circle punch in dorsal and single circle punch in anal fin
- Vernon riverine = single circle punch in dorsal and paired circle punch in anal fin

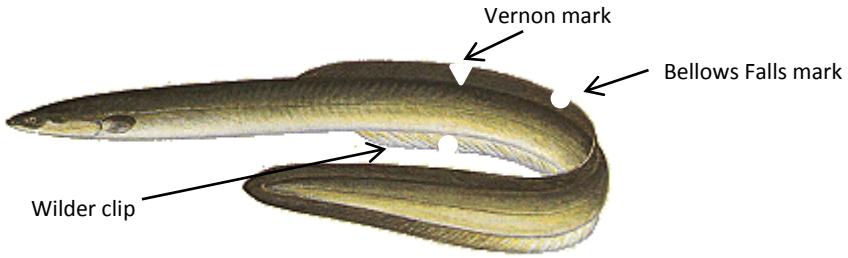

Figure 4.1-1. Fin marking of captured eels.

Following processing, and after full recovery from anesthesia, if used, all eels were returned to the river.

4.1.4 Environmental Parameters

The following water quality environmental parameters were measured and recorded during American Eel sampling: water temperature (°C), dissolved oxygen (mg/L), conductivity (µs/cm), pH, and turbidity (NTU). Water quality measurements were taken at 1-m of depth at a location representative of river conditions for the sampling location. In addition, velocity (ft/s) was recorded for each sample and the dominant substrate was determined based on previous survey data collected in Study 7 – Aquatic Habitat Mapping Study (Normandeau, 2015c).

Water quality samples were collected using a YSI 6920 multi probe sonde coupled to a YSI 650 MDS display. Prior to the collection of field data, both the 6920 and 650 unit were initialized to ensure that the correct parameters were being measured and displayed. Additionally, YSI probes for dissolved oxygen, pH, and

turbidity were calibrated on a daily basis whereas the probe for conductivity was calibrated on a weekly basis.

Mean column, water velocity was measured with Marsh-McBirney flowmeters on top-setting wading rods at each sampling location. The calibration of velocity meters was verified prior to field use. Velocity measurements were taken at a location considered by the field crew leader to be representative of sample site conditions and velocity was recorded for a minimum of 40 seconds and at standard depth settings. For depths less than 2.5 ft, mean column velocity was estimated by a single measurement at 0.6 of the total depth. For depths of 2.5-4.0 ft, measurements were taken at 0.2 and 0.8 of the total depths and averaged to estimate mean column velocity. Water velocity at locations over 4 ft deep was measured at 0.2, 0.6, and 0.8 of the total depth, with mean velocity calculated as (0.2v+0.8v+2*0.6v)/4. Multiple depth velocity measurements were recorded on the field data sheet. Final values of mean column water velocity for each location were calculated during data processing. Weather at the time of sampling was recorded as an additional environmental parameter.

4.2 Data Processing

4.2.1 QC Process

Data sheets containing all field recorded parameters (e.g., sampling effort, catch, water quality, etc.) were collected; data was keypunched and then subjected to a QC inspection to assure a 1% Average Outgoing Quality Limit (AOQL) according to a lot sampling plan (ASQL, 1993). This procedure ensures that ≥99% of the observations in a data file agree with the original data sheets. The number of observations to be checked, and the number of those that must be within tolerance are presented in Table 4.2-1. If more than the acceptable number of failures is found the data set must be inspected 100%.

Table 4.2-1. Lot sampling plan for QC inspection at less than 1% AOQL.

Lot Size* (range of observations recorded)	Sample Size (number of observations QC'd)	Number of Failures	
		Accept if ≤	Reject if ≥
1-32	ALL	0	1
33-500	32	0	1
501-3,200	125	1	2
3,201-10,000	200	2	3
10,001-35,000	315	3	4
35,001-150,000	500	5	6
150,001-500,000	800	7	8
500,001 and over	1,250	10	11

* Lot size represents the total number of observations for the category being evaluated

4.2.2 Abundance

Relative abundance, the number of fish captured with known sampling effort and indexed as catch per unit of effort (CPUE), was calculated on a species and gear-specific basis. Values were calculated in units appropriate to the method (i.e., per hour for electroshocking, per 24-hour for eel trap set). All zero catch samples (i.e., those with no fish catch of any species) were included in the matrix. CPUE values are presented in Section 5.0 for each river reach and sampling gear.

4.2.3 Silver Eels

The designation of an individual eel as "silver" was determined for all eels captured greater than 18 inches. The total length (mm), vertical eye diameter (mm) and horizontal eye diameter (mm) were recorded. A previously described correlation between eye size, body length and gonad development for the closely related European Eel (*Anguilla anguilla*) was used to determine whether individuals were mature and likely to be out-migrating from the system (Pankhurst, 1982). This relationship was described using the formula:

$$I = [(A+B)^2\pi/L]*100$$

where:
I = index value,
A = horizontal eye diameter,
B = vertical eye diameter,
L = total body length.

During the previously reported study (Pankhurst, 1982), eels with an index value of ≤6.5 were classified as sexually immature and eels with an index value of >6.5 were classified as sexually mature. The same determining criteria used during that study was used in this study, designating eels with an index value of >6.5 as silver eels.

5.0 RESULTS AND DISCUSSION

5.1 Sampling Effort and Catch Data

The Revised SSR identified six geographic reaches within the approximately 120-mile section of project-affected waters in the Connecticut River. A total of 102 sampling locations in the mainstem river and 24 in the project-affected portions of tributaries were randomly selected and sampled between July 29, 2015 and August 31, 2015. Each site selected was sampled using electrofish equipment and eel traps, and environmental data were collected.

The summary of the sampling effort is presented in Table 5.1-1. A listing of the effort associated with individual sites is located in Appendix A for electrofish

sampling and Appendix B for eel traps (appendices filed separately in Excel format). Boat electrofish sampling equipment was used to collect 90 of the 126 electrofish samples whereas portable electrofish equipment (including backpack, pram, and any boat/pram/backpack combinations) accounted for the remaining 36 samples. These sampling methods were used in areas where boat accessibility was limited.

In addition to electrofish sampling sites, a 24-hour baited eel trap set was conducted at each of the 126 sites selected. Three types of bait were tried during sets including canned mackerel, canned anchovies, and commercially available canned cat food. Mackerel was initially used and accounted for approximately 50% of the 24-hour sets. Due to a lack of catch using mackerel, both anchovies (30%) and canned cat food (20%) were tried in an effort to improve catch rates.

Table 5.1-1. Number of sample locations (by river reach) and number of completed samples by gear type.

River Reach	Number Sample Locations		Number of Collected Samples		
	Mainstem	Major Tributaries	Boat Efish	Portable Efish	Eel Trap
Wilder Impoundment	37	7	41	3	44
Wilder Riverine	15	4	0	19	19
Bellows Falls Impoundment	22	5	24	3	27
Bellows Falls Riverine	5	3	0	8	8
Vernon Impoundment	22	5	24	3	27
Vernon Riverine	1	0	1	0	1
Total	**102**	**24**	**90**	**36**	**126**

The total catch of eels during the study period is presented in Table 5.1-2 and Figure 5.1-1. The entire study sampling effort produced a total of 3 eels, all collected within the Bellows Falls impoundment. Two eels were captured at Site 11-B051 on August 19, the third was captured at Site 11-B035 also on August 19. The CPUE for American Eel at Station 11-B035 was 5.8 eels per hour while the CPUE at Station 11-B051 was 11.1 eels per hour. Given the small sample size and coincidence of capture timing, CPUE values have little meaning. No eels were captured at any other sites so all CPUE values for those sites are 0.0 eels. In addition, no eels were captured in any geographical reach during eel trap sets and as a result all CPUE values for this gear type are 0.0 eels per 24-hour set.

Table 5.1-2. Number of eels caught and catch per unit effort (eels per hour).

Site ID	Location	Date	Time	Number of eels caught	Distance surveyed (m)	CPUE (eels per hour)
11 - B035	Bellows Falls Impoundment	8/19/2015	21:35	1	500	5.8
11 - B051	Bellows Falls Impoundment	8/19/2015	18:31	2	500	11.1

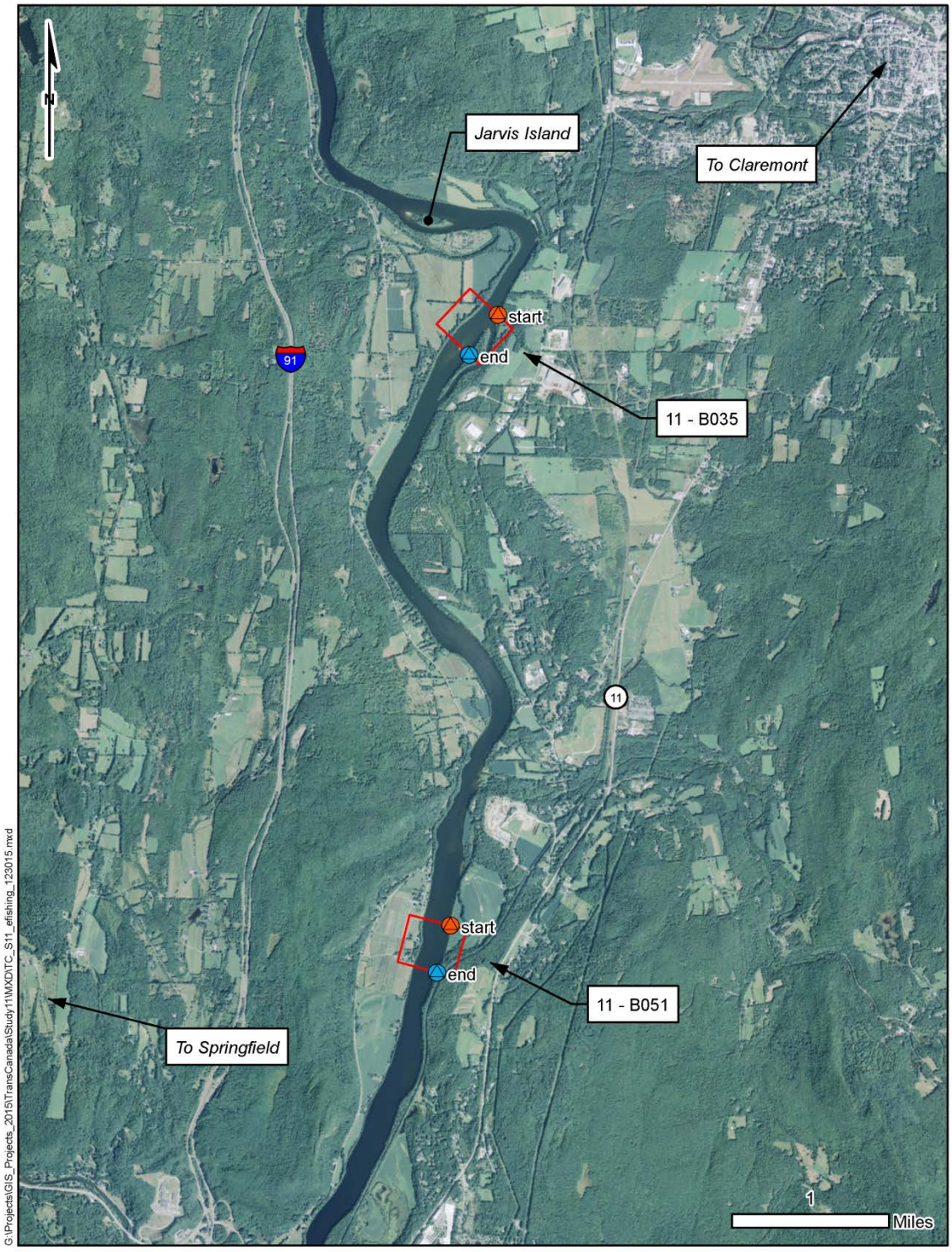

Figure 5.1-1. Locations of captured American Eels.

All three eels captured were greater than 18 inches in length and as a result, horizontal and vertical eye diameter measurements were recorded as a means of determining status as a silver eel through the formula described in Section 4.2.3. Results of that process are presented in Table 5.1-3. One of the two eels captured at Station 11-B051 had an index value of greater than 6.5, designating it as a silver eel. The other two eels did not meet the requirements as outlined and were designated as immature or 'yellow' eels.

Table 5.1-3. Eye measurements and silver eel status of captured eels.

Site Id	Horizontal Eye Meas. (mm)	Vertical Eye Meas. (mm)	T. Length (mm)	Index	Weight (g)
11-B035	6.73	6.1	615	5.3	465
11-B051	11.34	11.42	1156	8.8	3800
11-B051	6.97	6.67	747	4.9	900

Note: Index value of 6.5 or greater indicates sexual maturity.

5.2 Summary of Site Conditions

The sample depth (ft), weather, water velocity (fps) and dominant habitat for each sampling station are presented in Appendix C (filed separately in Excel format). Site conditions for the samples in which eels were captured by boat electrofishing are summarized in Table 5.2-1. Both Site 11-B035 and 11-B051 were located within the Bellows Falls impoundment and were sampled on the same night. Clear conditions and a dominant substrate of sand, silt, clay were recorded at both sites. At site 11-B035, typical sampling depth was 4 ft and mean water velocity was 0.15 fps while at 11-B051 typical sampling depth was 6 ft and no velocity was detectable during sampling. None of the conditions recorded for these sites stand out in comparison to other stations sampled. Sand, silt, clay was the most commonly encountered substrate at sites in the Bellows Falls impoundment as well as overall within the study area. Mean sampling depth for all samples collected in the Bellows Falls impoundment electrofishing was just over 4 ft with several samples collected in the 4-6 ft depth range (Appendix C). Additionally, many samples with no catch were collected during a similar diel period (18:00-21:30) and on the same day (8/19/15; Appendix A).

Table 5.2-1. Sampling date, time, depth, weather conditions, water velocity and dominant substrate recorded at the stations in which eels were captured.

Station ID	Sampling Date	Sampling Time	Sample depth (ft)	Weather	Water velocity (fps)	Dominant Habitat
11 - B035	08/19/15	21:05	4	Clear	0.15	Sand, Silt, Clay
11 - B051	08/19/15	18:31	6	Clear	0	Sand, Silt, Clay

5.3 Water Quality

Water quality parameters were collected at each study site and included temperature (°C), pH (standard units, su), conductivity (µS/cm), turbidity (NTU), dissolved oxygen (DO in mg/L), and % saturation. All measurements were taken with handheld field meters and data represent instantaneous readings. The study included collection and reporting of limited grab samples of water quality data from 1 or 2 visits to each of the study sites. As a result, the data should not be used to characterize general site conditions or trends. Study 6 (Water Quality Monitoring) data will provide the best data on overall water quality within the project-affected area.

Both New Hampshire and Vermont have numeric water quality standards for pH and DO, but only narrative criteria for the other parameters measured. Results for the two sites where eels were found are presented in Table 5.3-1 and results of water quality sampling at all sites are summarized below. Appendix D (filed separately in Excel format) presents the water quality sampling data collected at each site on each visit date. It should be noted that frequent problems with meter calibration for turbidity measurement resulted in negative turbidity values (identified as "bad data" in the data table). In rare instances, some water quality measurements were not recorded on field data sheets (identified as "no data" in the data table).

Table 5.3-1. Water quality data collected at eel capture locations.

Site Id	11-B035	11-B035	11-B051	11-B051
Date	7/30/2015	8/19/2015	8/3/2015	8/19/2015
Time	9:37	21:05	15:15	18:31
Sample Depth (ft)	3.3	3.3	3.3	3.3
Temp. (°C)	22.4	24.6	25.2	25.4
pH (su)	7.4	7.2	7.6	8.8
Conductivity (µS/cm)	115	132	152	139
Turbidity (NTU)	0.9	0	4	0
DO (mg/L) instan.	8.7	8.2	10.5	6.7
DO (% sat) instan.	100.2	99.6	97.9	106.8

As indicated in Table 5.3-1 at the two sites where eels were captured, one pH measurement was above the numerical water quality standards for Vermont (8.0 su) and New Hampshire (8.5 su). Dissolved oxygen was within standards for both states, and water temperature was typical of late summer conditions. Turbidity was low and conductivity was typical of large, developed rivers and consistent with all mainstem study sites.

Water temperature measured at all mainstem sites ranged from 18.5 to 26.1°C over the course of the study (late July to late August). Temperatures in all sampled

tributaries ranged from 15.7 to 26.5°C over the course of the study and are typical of late summer conditions. Measurements of pH ranged from 6.4 to 8.8 su at mainstem sites. One mainstem pH measurement (on August 8 at site 11-V-073 near Brattleboro) was lower than the New Hampshire and Vermont state standards of 6.5 (su) for Class B waters. The pH reading at the same site a few days earlier was within both state standards at 7.4 su. At tributary sites, pH ranged from 5.9 to 8.1 su. Three tributary pH readings were below state standards on one of the two visits (5.9 su at site 11-V010T Great Brook; 6.4 su at site 11-W054T Hewes Brook; and 6.4 su at site 11-B018T Black River). At two tributary sites, pH was above the New Hampshire standard of 8.0 su but within the Vermont standard of 8.5 su: 11-WR011T Lull's Brook (8.1 su) and 11-WR002T White River (8.4 su).

Conductivity measurements at all mainstem sites ranged from 86 to 219 µS/cm. Eight percent of conductivity measurements were less than 100 µS/cm; 91% were between 100 and 200 µS/cm; and 1% were greater than 200 µS/cm. Sites 11-WR032 and 11-WR009 had the highest conductivity readings (152 and 219 µS/cm, respectively). No sites had consistently higher readings than other sites and sites fluctuated up to 30 µS/cm between sampling events on different days. No other general trends were apparent. At tributary sites, conductivity ranged from 69 to 84 µS/cm. Seven percent of conductivity measurements were less than 100 µS/cm; 50% were between 100 and 200 µS/cm; and 43% were greater than 200 µS/cm. Site 11-BR005T (Blanchard Brook) had the two highest conductivity readings (373 and 384 µS/cm on two site visits). Other tributary sites experienced some fluctuation in conductivity over the two site visits with one higher reading taken in late August coupled with a lower reading taken earlier in the sampling season (July or early August), but no other general trends were apparent.

Valid turbidity measurements at all mainstem sites ranged from 0 to 5.5 NTU, with all mainstem readings less than 10 NTU. Turbidity measurements at tributary sites ranged from 0 to 26.2 NTU, with 95% less than 10 NTU. Two turbidity readings in late August were greater than 10 NTU (site 11-B008T Meadow Brook with 18.8 NTU and 11-W002T Clark Brook with 26.2 NTU), but turbidity at both sites during late July had lower measurements (1.3 and 3.1 NTU respectively). Elevated turbidity levels are generally related to precipitation events and associated sediment movement. Instream construction or logging activities can also lead to short-term increases in turbidity. None of the turbidity readings in this study exhibited elevated turbidity levels that would be indicative of these conditions.

Dissolved oxygen measured in mg/L remained within Class B water quality standards of at least 5.0 mg/L in New Hampshire and 6.0 mg/L in Vermont at all sites and in all sampling rounds. DO measured in % saturation in all cases was above the Vermont standard of 70% for cold water habitat. New Hampshire's 75% DO saturation standard is a daily average numerical standard, while the data collected in this study was instantaneous, so the New Hampshire DO % saturation standard is not applicable for this study.

6.0 STUDY CONCLUSIONS

American Eel are known to inhabit the Connecticut River as far north as the Connecticut Lakes (Scarola, 1987) including some streams and ponds of the Connecticut River drainage (Langdon et al., 2006). While presence provides an indication of range, it does not give a sense of relative abundance of the species nor the distribution within the available habitats throughout that range. Study 11 was intended to provide information regarding the relative abundance and distribution of American Eel within project-affected areas from the upper extent of Wilder impoundment downstream to the Vernon tailrace.

Overall catch rates for the sampling effort were very low, counting only three American Eels captured in two samples from a total of 126 sampling stations. While there are many possible variables that may have contributed to the low catch rates, they are comparable to previous sampling efforts conducted on the upper Connecticut River. Yoder et al. (2009) conducted a fish assemblage and habitat assessment of the Upper Connecticut River from Lake Francis (river mile (RM) 325.6) to Turners Falls (RM 122). Electrofish sampling over the 203.6 miles covered by Yoder included only two American Eels, one captured below Vermont Yankee and the other upstream of Turners Falls, outside of the Study 11 study area. Similarly, annual electrofishing at Vermont Yankee within the lower Vernon impoundment recorded 27 American Eels in 25 years of sampling (1991-2014; Normandeau, 2014).

Other American Eel studies conducted in 2015 included Study 10 – Fish Assemblage Study, Study 17 – Upstream Passage of Riverine Fish Species, and Study 18 – American Eel Upstream Passage Assessment. Study 10 also recorded only three eels within the project-affected impoundments and riverine sections of the Connecticut River (two in the Vernon riverine reach and one within the Wilder impoundment) despite a significant spatial and temporal (spring, summer and fall) sampling effort.

Greater numbers of eels were identified in Studies 17 and 18, although the focus of these studies was in areas where eels would be congregating in an attempt to migrate upstream. Study 18 identified 80 American Eels below Vernon dam, three at Bellows Falls dam and none at Wilder dam during a period of approximately 6 months. Similarly, passage of American Eel recorded at the fish ladders in Study 17 indicated greater numbers migrating upstream at Vernon (1,551) with substantially reduced numbers achieving passage at Bellows Falls (60) and Wilder (52). While these studies indicate a trend of decreasing numbers of American Eel with increasing latitude, they do not provide further evidence of distribution within the different reaches or any insight regarding how long eels are residing within the project-affected area.

The results of previous and current studies (Yoder et al., 2009; Normandeau, 2014; and Studies 10 and 11) suggest that American Eel are distributed in low abundance throughout the project-affected areas from the upper extent of Wilder impoundment to downstream of Vernon dam.

7.0 LITERATURE CITED

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Appendices filed separately as worksheets in a single workbook

Appendix A - Electrofish Sampling Effort

Appendix B - Eel Trap Sampling Effort

Appendix C - Site Condition Data

Appendix D - Water Quality Data