TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 7
Aquatic Habitat Mapping

Final 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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1.0 INTRODUCTION

This report presents the final results of the 2013 Aquatic Habitat Mapping Study (ILP Study 7) 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). TransCanada has initiated the Integrated Licensing Process (ILP) for these projects in order to extend the term of their operating licenses beyond the current expiration date of April 30, 2018 for each project.

Operation of TransCanada's Wilder, Bellows Falls, and Vernon hydroelectric projects may have potential effects on fish and aquatic resources in the associated impoundments, tailwaters, and downstream riverine sections of the Connecticut River. Specifically, water level fluctuations and flow conditions at certain times may affect the ability of fish and other aquatic species to use aquatic habitats. Minimal information existed pertaining to characteristics, types, and proportions of aquatic habitat within the project impoundments, tailwaters, and riverine reaches. Specific aquatic habitat data within all project reaches was lacking and this study served to fill those data gaps.

FERC issued a February 21, 2014 Study Plan Determination (SPD) for aquatic studies as a result of the announced closure of Entergy's Vermont Yankee Nuclear Power Plant (VY). In that determination, the final study report for Study 7 is required to be filed by March 1, 2015. The initial study report was filed on September 15, 2014 as Volume II of TransCanada's larger Initial Study Report (ISR) filing. No comments on the Study 7 initial study report were received; however, US Fish and Wildlife Services (FWS), in their November 14, 2014 ISR comment letter, requested that TransCanada upload additional geo database files and data layer. Most of the requested data was provided to stakeholders via the online geo database at the time of the ISR filing. Simultaneously with this filing, water level logger data from Study 7 is being filed with FERC in Microsoft Excel format. This data will be uploaded to the TransCanada website as well.

This final report also:

- Makes minor corrections to water level logger information in Section 8.3 where it was discovered that one additional level logger malfunctioned;
- Updates Table 8-4; and
- Updates Section 9.3.

2.0 STUDY OBJECTIVES AND STATUS

2.1 Study Objectives

The goal of this study was to survey, identify, and map aquatic habitat in the Wilder, Bellows Falls and Vernon project-affected impoundments, tailwaters, and downstream riverine reaches; and provide baseline information that can contribute to the assessment of potential effects under current licensed operations. The objective was to survey and map the aquatic habitat types distributed within the project impoundments, tailwaters, and downstream riverine reaches from the Wilder dam downstream to the upper extent of the Turners Falls Project impoundment, including the Bellows Falls bypassed reach.

Methodologies and results presented in this report for the identification and mapping of aquatic habitat in the study area is broken down into four categories: 1) Impoundment Bathymetry in Section 5 of this report), 2) Impoundment Aquatic Habitat Mapping in Section 6, 3) Riverine Aquatic Mesohabitat Mapping in Section 7, and 4) Water Surface Elevation Monitoring in Section 8.

2.2 Study Status

The Revised Study Plan for this study was approved without modification in FERC's February 21, 2014 Study Plan Determination; however, the deadline for filing of the Final Study Report was extended to March 1, 2015 in that determination.

The study had been largely completed in late 2013 with concurrence of the aquatics working group, and data consolidation occurred in early 2014. The Initial Study Report was prepared in draft form and provided for working group review. Results and data from the study were summarized at a May 23, 2014 working group meeting. Impoundment bathymetry and habitat mapping data were provided to meeting attendees in Arc GIS format on CDs. The Initial Study Report and mapping data were included as Volumes II and VII of TransCanada's September 15, 2014 Initial Study Report filing.

Nine water level loggers were left in the Connecticut River over the winter of 2013/2014 and remain in place at this time; however, there are some data gaps due to some level loggers found to be missing in either July or October 2014 (see Section 8.3). Data that was successfully retrieved in 2014 from these level loggers are included in Excel format as Attachment D to this Final Study Report. Data from the nine level loggers being overwintered from 2014 to 2015 will be provided when data is retrieved in 2015.

3.0 PROJECT OVERVIEW

3.1 Wilder Hydroelectric Project

The Wilder Project's dam and powerhouse are located on the Connecticut River at river mile (RM) 217.4. Required minimum flow is 675 cubic feet per second (cfs) or inflow, whichever is less. A generated minimum flow of 700 cfs is supplied by the

No. 3 turbine generator. The remaining two turbine units have operating capacities of 6,000 cfs. The riverine segment extends approximately 17 miles downstream to the upper extent of the Bellows Falls impoundment.

3.2 Bellows Falls Hydroelectric Project

The Bellows Falls Project consists of a dam located at RM 173.7 on the Connecticut River and a canal and powerhouse located approximately 1,700 feet downstream of the dam. Minimum flow of 1,083 cfs or inflow, whichever is less is required, with a generated minimum flow of 1,300 cfs. The impoundment extends upstream approximately 26 miles to Chase Island near the town of Windsor, Vermont, approximately 17.7 miles downstream of Wilder dam. The powerhouse consists of three turbines with a generating capacity 3,670 cfs each. The riverine segment extends approximately 6 miles downstream of the tailrace.

The Bellows Falls bypassed reach is approximately 3,500 ft in length and generally flow through the reach is due to dam leakage. Spill occurs into the reach when project capacity is exceeded. A fish barrier was constructed in 1996 in the lower portion of the reach to prevent fish from gaining access to the upper portion of the reach and possibly becoming stranded.

3.3 Vernon Hydroelectric Project

The Vernon dam and powerhouse are located on the Connecticut River at RM 141.9. The impoundment extends upstream about 26 miles to the Walpole Bridge (Route 123) at Westminster Station, Vermont, approximately 6 miles downstream of the Bellows Falls Project. The powerhouse consists of 10 generating units ranging in capacity from 1,465 cfs to 2,035 cfs. The segment from Vernon dam downstream approximately 1.5 miles may at times exhibit riverine characteristics, depending on operational scenarios at the Vernon project relative to those at the downstream Turners Falls Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485).

4.0 STUDY AREA

The study area includes all impounded and riverine segments of the Connecticut River from Wilder dam to just downstream of Vernon dam (Figure 4-1). There is a 45-mile impoundment associated with Wilder dam and 26-mile impoundments associated with each of the Bellows Falls and Vernon dams. Riverine segments consist of an approximate 17-mile segment downstream of Wilder dam, a 6-mile segment downstream of Bellows Falls dam, the approximately 3,500-foot long Bellows Falls bypassed reach, and an approximate 1.5-mile segment downstream of Vernon dam.

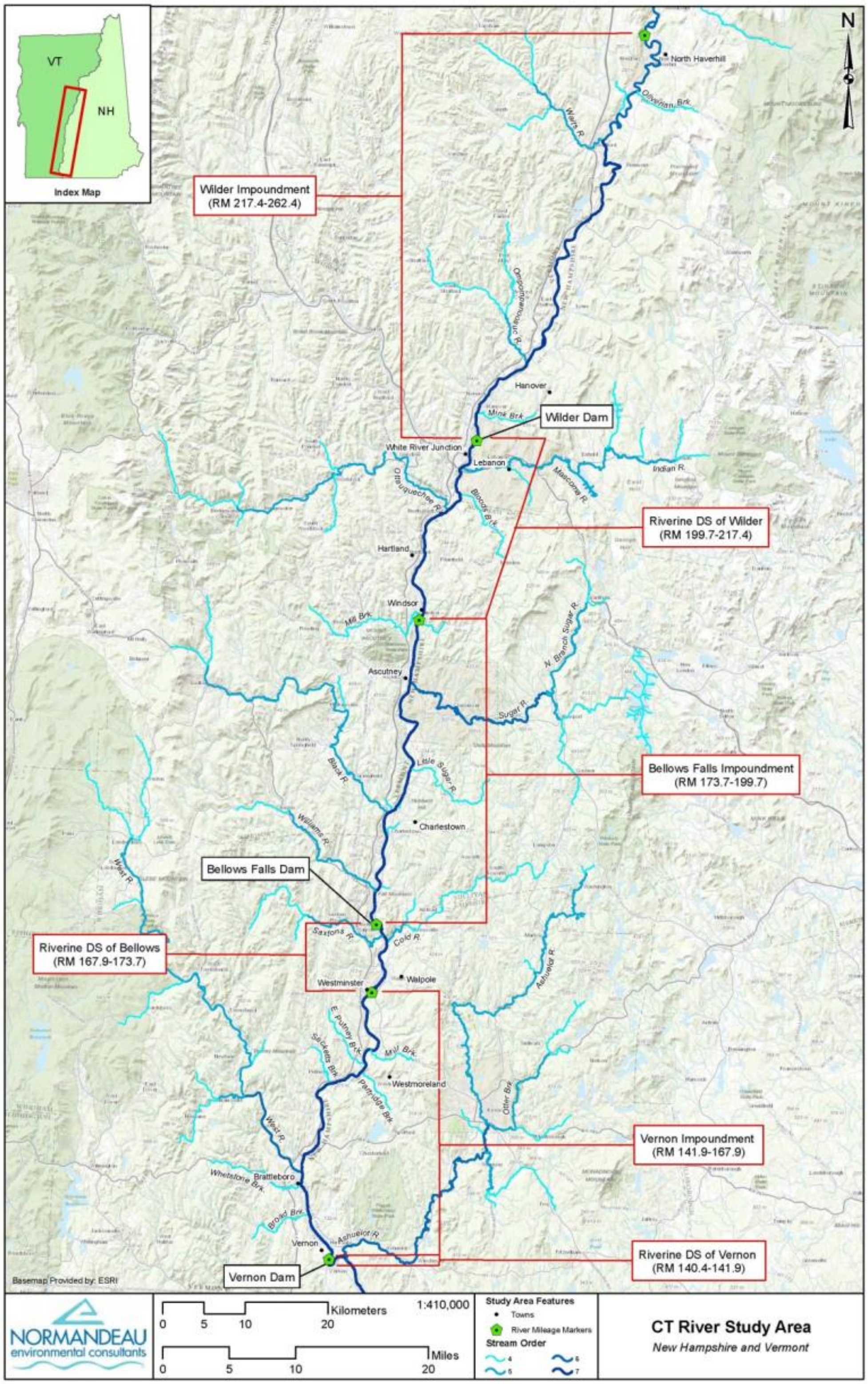


Figure 4-1. TransCanada Wilder, Bellows Falls, and Vernon hydroelectric projects study area.

5.0 IMPOUNDMENT BATHYMETRY

5.1 Field Methodology

Impoundment bathymetry mapping was collected using a 200-kHz Odom® Hydrotrac single-beam echosounder (<0.03-foot (~0.01-meter) vertical accuracy). Hypack hydrographic survey software was used for navigation and integration of the depth sounding and positional data collected using a Leica Viva GS14 Real Time Kinematic (RTK) unit. The RTK unit had a horizontal positioning accuracy of less than 0.03-inch (0.01-meter) and provided vertical water surface positional information at an accuracy of less than 0.1-foot (0.02-0.03 meter) to compensate for fluctuations in water levels as well as differentials in water surface elevations within each impoundment. This allowed the bathymetry survey to output river bed surface elevations by calculating the difference of the elevation of the survey vessel and the water depth while the survey was in progress.

Horizontal positioning was collected in NH state plane (NAD83, feet) coordinate system. The ping rate for the Odom Hydrotrac echosounder automatically adjusted based on sound speed and depth, but generally provided multiple soundings per second (<1m distance between soundings at a survey speed of three knots). Bathymetric data was collected along pre-determined survey lines and at a point density allowing for the determination of 1-ft contours throughout the study area.

5.2 Data Analysis and Processing

Bathymetric contours were constructed for the Wilder, Bellows Falls and Vernon impoundments using a combination of: 1) geo-referenced elevation data collected from wetted, boatable areas using a single-beam echosounder, 2) geo-referenced elevation data collected by RTK from wetted, wadeable areas, and 3) geo-referenced elevation data collected by aerial LiDAR sampling. LiDAR data was provided to Normandeau by U.S. Imaging. In addition to the LiDAR data set, U.S. Imaging supplied Normandeau with a geo-referenced “waterline” for each of the three impoundment areas. This “waterline” was created by U.S. Imaging based on the wetted area during their aerial photography of the project impoundments during early-May 2013.

Raw depth soundings were processed using HYPACK software to generate smoothed gridded XYZ coordinates in ASCII format. LiDAR data was subset to contain only points classified by U.S. Imaging as “ground” within a 300-ft buffer of the waterline. Sonar and LiDAR data were imported into Arc GIS software and an interpolation process based on the inherent spatial correlation structure of the data was used to generate 1-ft contours throughout the three project impoundments. Normandeau utilized ESRI’s Advanced Arc GIS license, as well as their 3D and Spatial Analyst extensions to combine, process, and extrapolate the Sonar and LiDAR data. Data was converted to points and then a raster for each impoundment. From there, bathymetric contours were extracted from the rasters. All data was created in UTM Zone 18N, WGS84 Meters since the data from U.S. Imaging came in that coordinate system. However, all contour data elevations are in feet. The full pond polygons for each impoundment were a merge of the “waterline”, which was created from the LiDAR interpolation by U.S. Imaging, and a contour polygon at the full pond elevation for each pond derived from LiDAR point data and Sonar point data by Normandeau. The final Wilder elevation was 385 feet, Bellows Falls elevation was 291.6 feet, and Vernon was 220 feet.

5.3 Results and Discussion

Bathymetry survey data was collected by boat between the dates of July 8 –July 25, 2013 in Vernon impoundment, July 26 – August 2, 2013 in Bellows Falls impoundment and August 7 – September 5, 2013 in Wilder impoundment. Additional bathymetric data was collected on foot from shallow water tributary and backwater confluence areas during September 2013 within all three project impoundments. Figures 5-1 through 5-3 present the bathymetry for Wilder, Bellows Falls and Vernon impoundments in raster format, which provides a color-coded view of each project impoundment broken down into 20-ft elevations. Bathymetric data is presented from an elevation of 385 feet in Wilder, 291.6 feet in Bellows Falls and 220 feet in Vernon down to the lowest elevation mapped in each impoundment (289’ in Wilder, 206’ in Bellows Falls, and 159’ in Vernon). More detailed bathymetric data is provided electronically in association with this report.

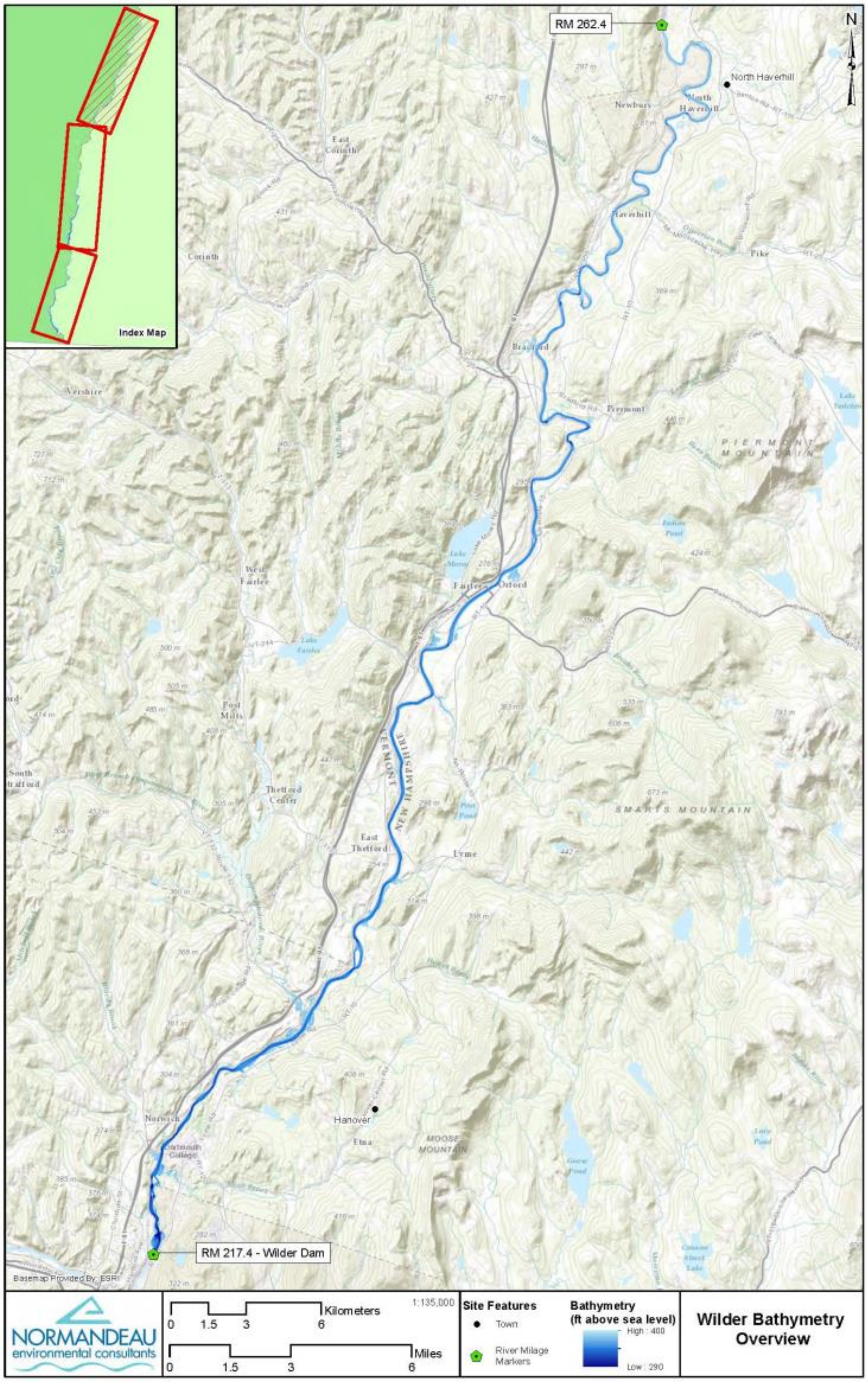


Figure 5-1. Wilder impoundment bathymetry depicted in 20-ft raster intervals.

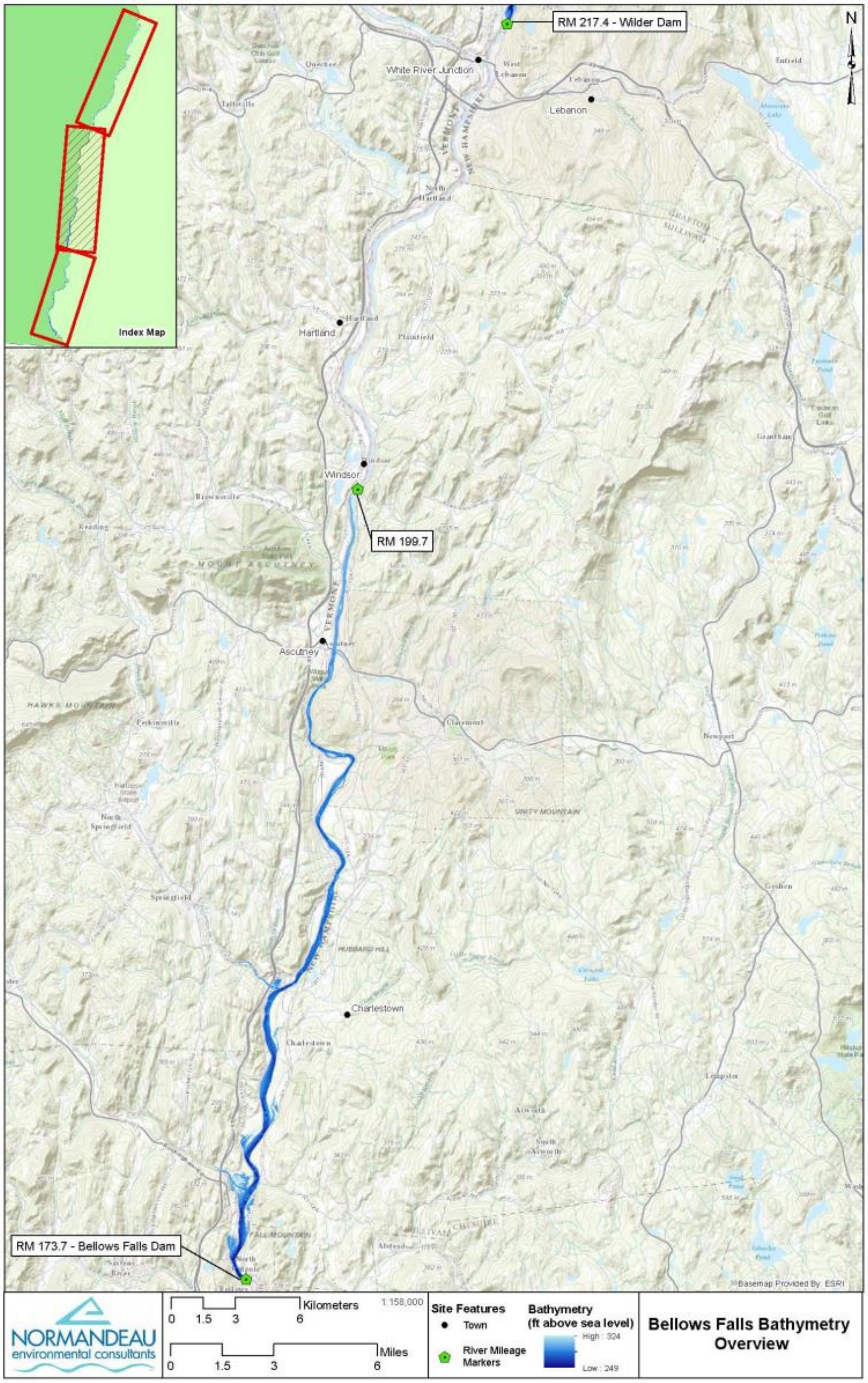


Figure 5-2. Bellows Falls impoundment bathymetry depicted in 20-ft raster intervals.

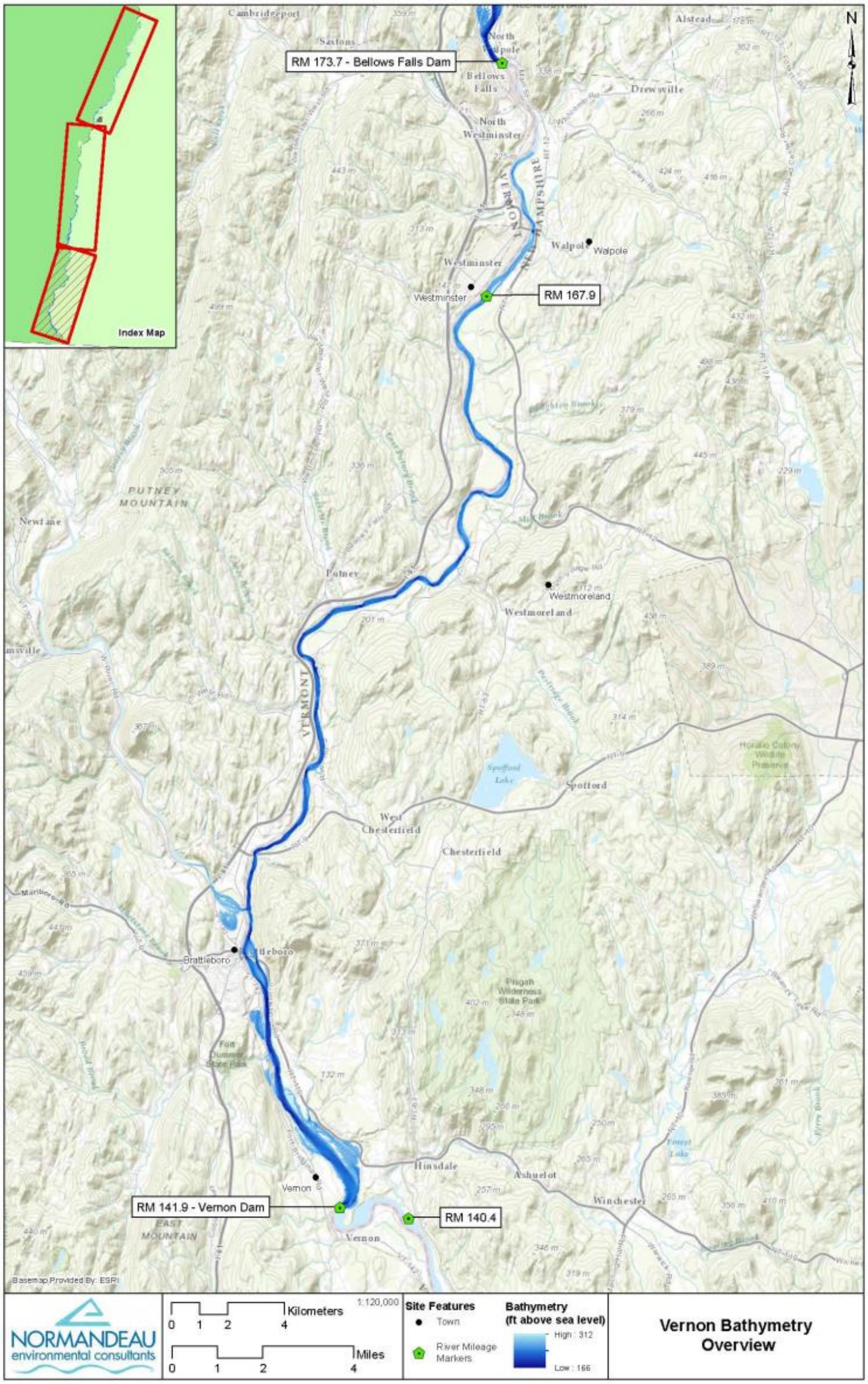


Figure 5-3. Vernon impoundment bathymetry depicted in 20-ft raster intervals.

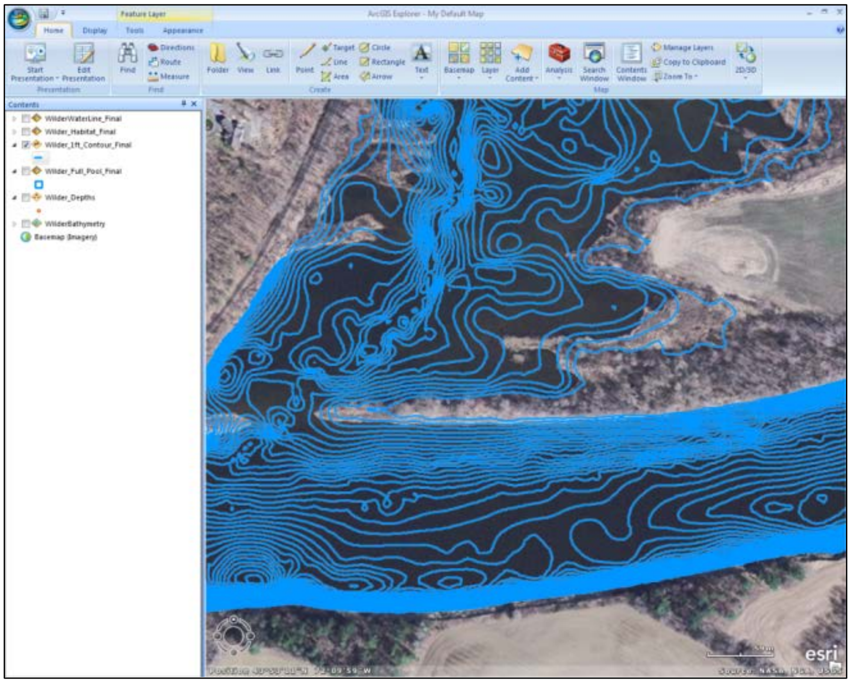


Figure 5-4. Example screen shot depicting content of the "1-ft-countour" layer contained within the geodatabase file for Wilder, Bellows Falls and Vernon impoundments.

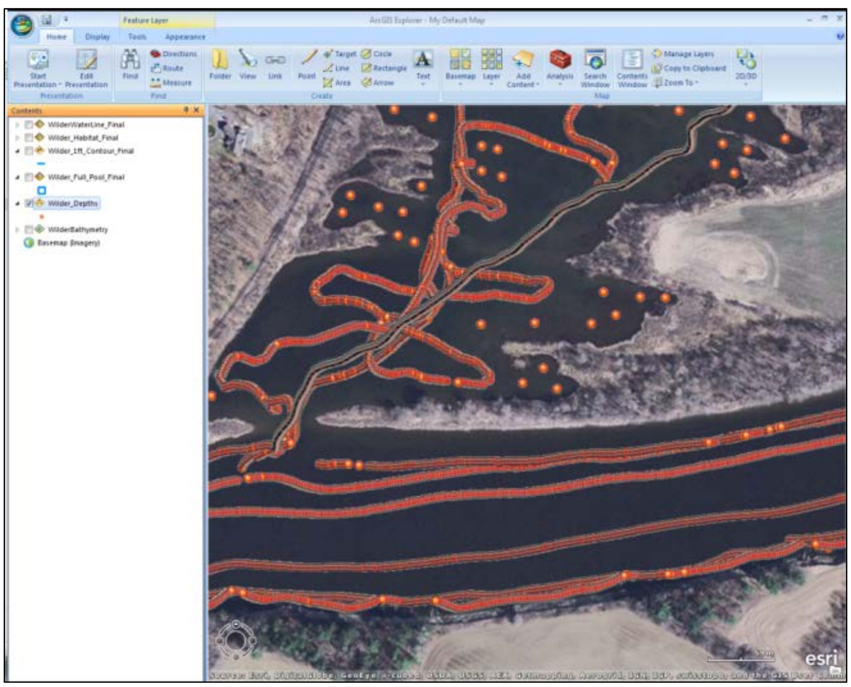


Figure 5-5. Example screen shot depicting content of the "depths" layer contained within the geodatabase file for Wilder, Bellows Falls and Vernon impoundments.

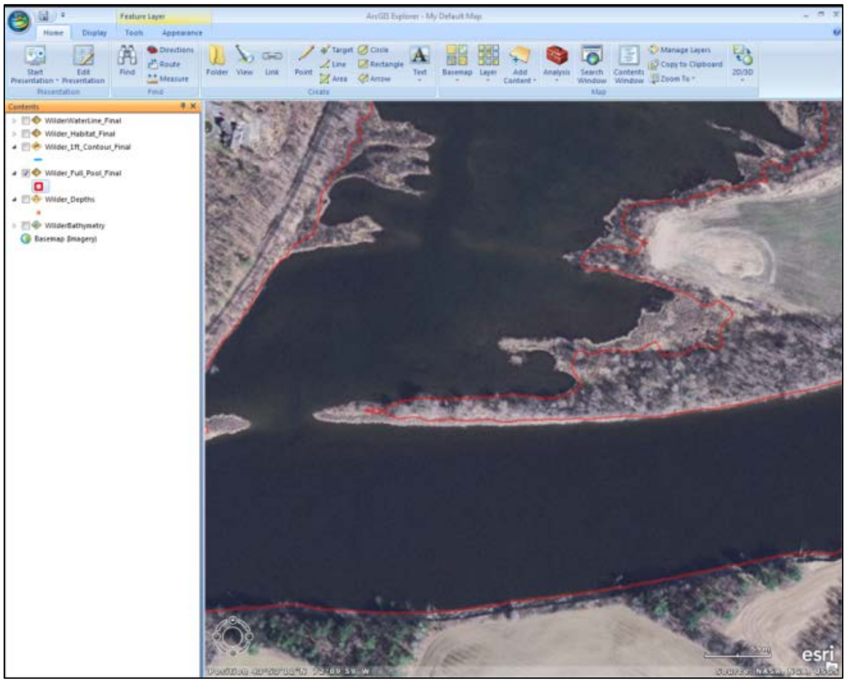


Figure 5-6. Example screen shot depicting content of the “Full Pool” layer contained within the geodatabase file for Wilder, Bellows Falls and Vernon impoundments.

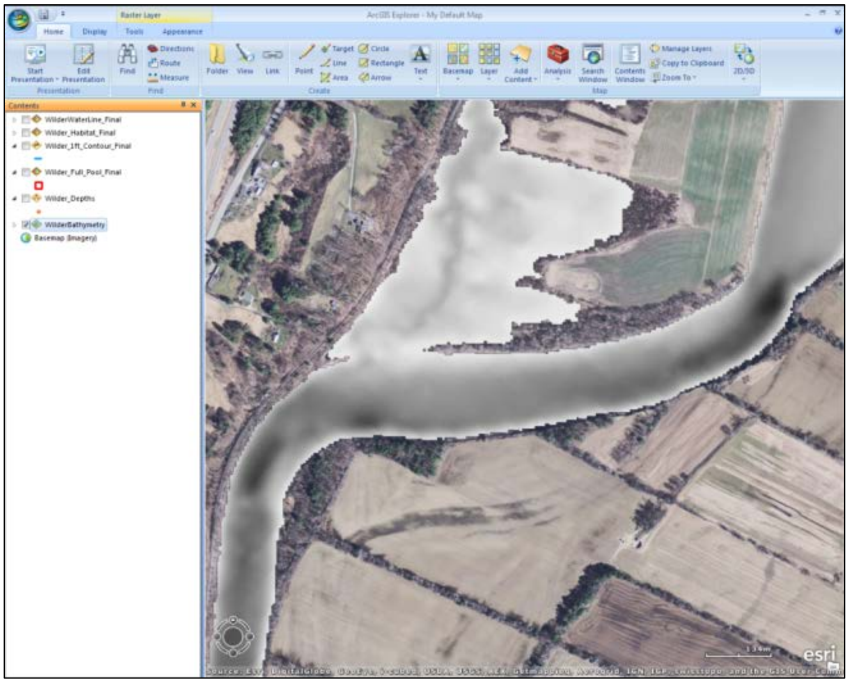


Figure 5-7. Example screen shot depicting content of the “Bathymetry” layer contained within the geodatabase file for Wilder, Bellows Falls and Vernon impoundments.

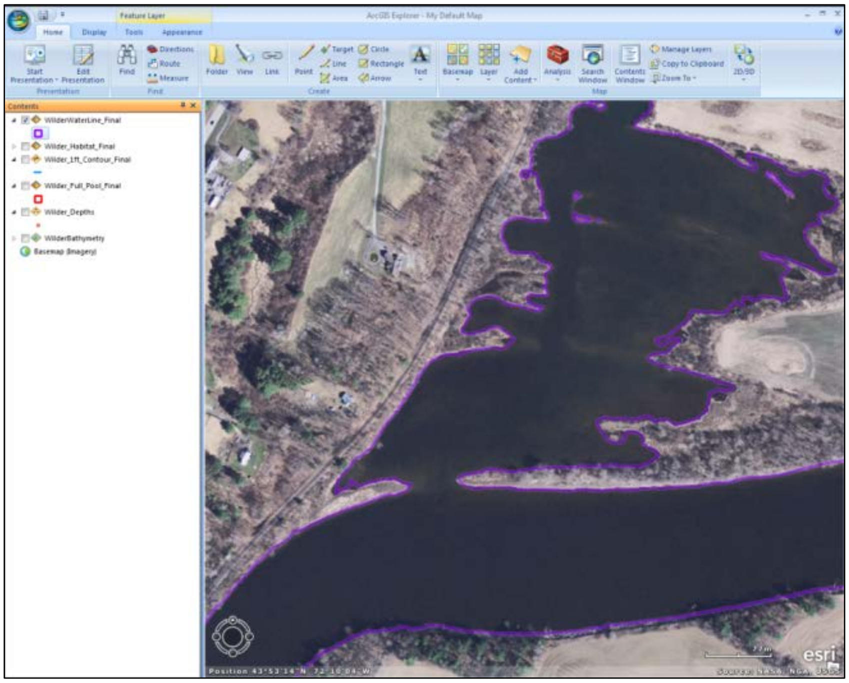


Figure 5-8. Example screen shot depicting content of the “Water Line” layer contained within the geodatabase file for Wilder, Bellows Falls and Vernon impoundments.

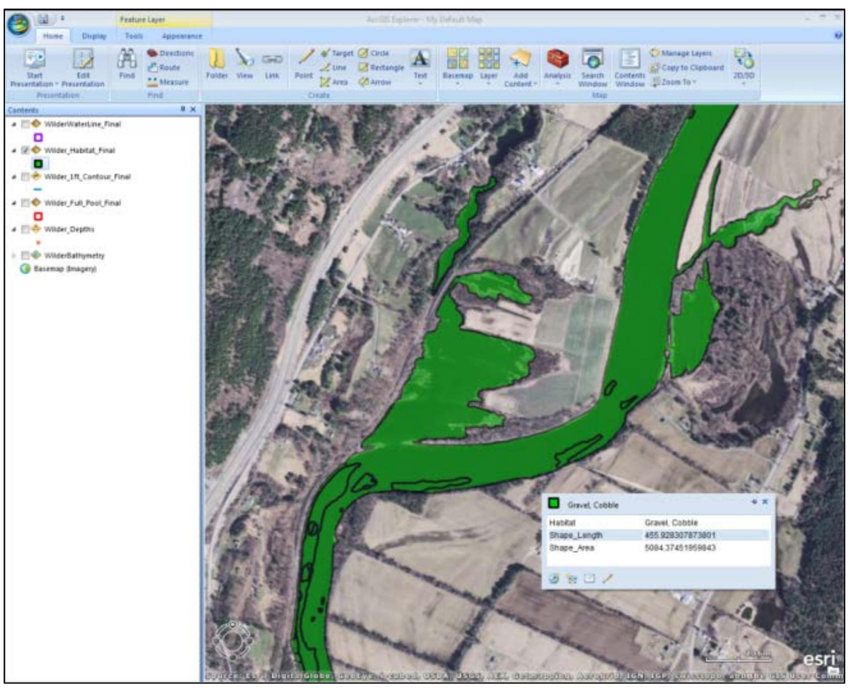


Figure 5-9. Example screen shot depicting content of the “Habitat” layer contained within the geodatabase file for Wilder, Bellows Falls and Vernon impoundments.

6.0 IMPOUNDMENT AQUATIC HABITAT MAPPING

6.1 Field Methodology

Sonar data was collected from the Wilder, Bellows Falls and Vernon impoundments using a Humminbird™ 1197c, side imaging unit. The Humminbird unit was used in conjunction with a Leica Viva GS14 Real Time Kinematic (RTK) unit to provide the precise coordinate information (horizontal positional accuracy of less than 0.03-inch (0.01-meter) necessary for geo-referencing captured images in the horizontal plane. The Humminbird transducer was positioned at the bow of a flat-bottom work-boat and was secured to a rigid mount. The operating frequency for the unit was set at 455 kHz for all surveys. Prior to data collection, survey lines within each impoundment were established in ArcGIS and were laid out in a manner which would provide full coverage of the bottom substrate within each impoundment during data collection. The number of survey lines needed for a particular reach of river was based on a combination of river width and the transducer's effective range. Data collection along shoreline areas for each impoundment was conducted by using a single side beam set at a range of 90 to 100 feet and along survey lines within the central portions of the three impoundments with the side beam range set at 100 to 140 feet per side. Collected data images were allowed to overlap to ensure full coverage of the bottom habitat. Boat speed was maintained at 2.5 to 4.5 knots during all data collection.

Portions of the Wilder, Bellows Falls and Vernon impoundments could not be mapped using side scan sonar due to shallow water depths or dense beds of aquatic vegetation. These areas included the majority of backwater and tributary confluence areas over the entire project reach. In cases where habitat could not be mapped by boat-mounted sonar, habitat was mapped manually. Geo-referenced substrate classifications were recorded using a method appropriate to the site-specific conditions (e.g., view tube, ponar sample, wading and visual determination).

6.2 Data Analysis and Processing

Sonar image data was processed by placing each individual sonar image into its geo-spatially correct map location, interpreting their content and finally, creating polygons representing each unique habitat area. Sonar images were geo-rectified using a combination of ArcGIS, IrfanView graphic editor and scripted software tools developed at the Georgia Department of Natural Resources (Kaeser and Litts, 2010).

Sonar images were processed by cropping to remove display information, and then cropped again based on overlap with the adjacent images along the boat's path. Accurate waypoint and track data were imported into ArcGIS and were cropped to reflect the areas where valid data was obtained. The positional information was used to accurately reference the sonar imagery to its proper place along the river bottom. The positional information and the distance from the center of the boat was entered into one of the scripted sidescan processing tools to create a network of points for each image. This resulted in a text file for each habitat survey image containing points used to rectify each image to their corresponding location on the ground. The text files and images were then merged into mosaic groups of 10-15 images. The SPLINE transformation solution (Powell, 1995) was applied to these mosaics so that they fit with the points assigned to the images along the curve of the tracks. Each group of georectified images became a 2-4 inch resolution GIS layer file in JPEG format with an associated word file that contains information used to project the image onto a map. The resulting layer files were subjected to visual quality control inspection for positional accuracy and image quality.

Lines were drawn as borders between the habitat types as observed from scales ranging from 1:300 to 1:427 (Figure 6-1). Borders were interpreted by observing changes in surface texture, signal amplitude, and habitat indicator patterns (e.g. sand waves). Slant range correction was not performed on sonar imagery to correct distortion. The dark area in the center of the side scan image represents the water column and the total dark area has a direct relationship with the depth. Distortion occurs near the beams interface with the bottom as the image is compressed to represent the area near the boat path and the water column in the same space. Therefore, in deeper areas (>10 feet) it became necessary to interpret substrates that appear just outside the water column as if they extended under the boat's position. Border lines were converted into polygons and habitat types were assigned to each created polygon unit. A total of six substrate types were identified based on dominant habitat types: 1) sand/silt/clay, 2) gravel/cobble, 3) boulder, 4) rip-rap, 5) ledge, and 6) woody debris. Figures 6-2 through 6-7 provide examples for the six habitat types classified from the sonar imagery. The habitat types were delimited with a predetermined precision of ±100 square feet (0.0023 acres). However, in most cases habitats smaller than this area or habitat borders were discernable at a greater resolution and were mapped at a higher precision.

The final product produced from this process was a GIS layer containing the aquatic habitat types for each of the three impoundments. Figure 6-8 provides an example screenshot of the polygon creation process and the corresponding GIS habitat layer. The total area (acres) for the six habitat types found in each of the three surveyed impoundments was quantified. When the aquatic habitat shapefile is combined with the bathymetric data collected in the Wilder, Bellows Falls and Vernon impoundments (Section 5.0), total square area (by habitat type) watered or dewatered can be determined for elevations at one-ft increments.

6.3 Results and Discussion

Sonar habitat data was collected by boat between the dates of July 8 –July 25, 2013 in Vernon impoundment, July 26 – August 2, 2013 in Bellows Falls impoundment and August 7 – September 5, 2013 in Wilder impoundment. Additional habitat data was collected on foot from shallow water tributary and backwater confluence areas during September 2013 within all three project impoundments. Figures 6-9 through 6-17 present the mapped habitat within the

Wilder, Bellows Falls and Vernon impoundments. More detailed data is provided electronically in association with this report.

Within the Wilder impoundment, a total of 3,028 acres of total aquatic habitat was delineated during the 2013 survey (Table 6-1, Figures 6-9 through 6-11). The majority (76.2%) of the mapped area consisted of the sand/silt/clay habitat type. Gravel-cobble (14.9% of total aquatic habitat area), boulder (3.3% of total aquatic habitat area), and woody debris (3.0% of total aquatic habitat area) were present in lesser amounts. Artificially created rip-rap habitat comprised a total of 52 acres (1.7% of total aquatic habitat area) within the Wilder impoundment.

Within the Bellow Falls impoundment, a total of 2,921 acres of total aquatic habitat was delineated during the 2013 survey (Table 6-2, Figures 6-12 through 6-14). The majority (83.9%) of the mapped area consisted of the sand/silt/clay habitat type. Gravel-cobble (11.9% of total aquatic habitat area), boulder (1.7% of total aquatic habitat area), and woody debris (1.5% of total aquatic habitat area) were present in lesser amounts. Artificially created rip-rap habitat comprised a total of 25 acres (0.9% of total aquatic habitat area) within the Bellows Falls impoundment.

Within the Vernon impoundment, a total of 3,137 acres of total aquatic habitat was delineated during the 2013 survey (Table 6-3, Figures 6-15 through 6-17). The majority (72.5%) of the mapped area consisted of the sand/silt/clay habitat type. Gravel-cobble (20.8% of total aquatic habitat area), woody debris (2.7% of total aquatic habitat area), and boulder (1.7% of total aquatic habitat area), were present in lesser amounts. Artificially created rip-rap habitat comprised a total of 44 acres (1.4% of total aquatic habitat area) within the Vernon impoundment.

Table 6-1. Total area (acres) and percent of total area for six aquatic habitat types mapped using sonar imagery within the Wilder impoundment.

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,308.9	76.2%
gravel/cobble	450.1	14.9%
boulder	100.0	3.3%
rip rap	52.6	1.7%
ledge	26.1	0.9%
woody debris	90.7	3.0%
TOTAL	3,028.5	100.0%

Table 6-2. Total area (acres) and percent of total area for six aquatic habitat types mapped using sonar imagery within the Bellows Falls impoundment.

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,450.9	83.9%
gravel/cobble	348.7	11.9%
boulder	49.9	1.7%
rip rap	25.4	0.9%
ledge	3.8	0.1%
woody debris	43.0	1.5%
TOTAL	2,921.8	100.0%

Table 6-3. Total area (acres) and percent of total area for six aquatic habitat types mapped using sonar imagery within the Vernon impoundment.

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,273.1	72.5%
gravel/cobble	653.6	20.8%
boulder	53.8	1.7%
rip rap	44.3	1.4%
ledge	27.2	0.9%
woody debris	85.2	2.7%
TOTAL	3,137.2	100.0%

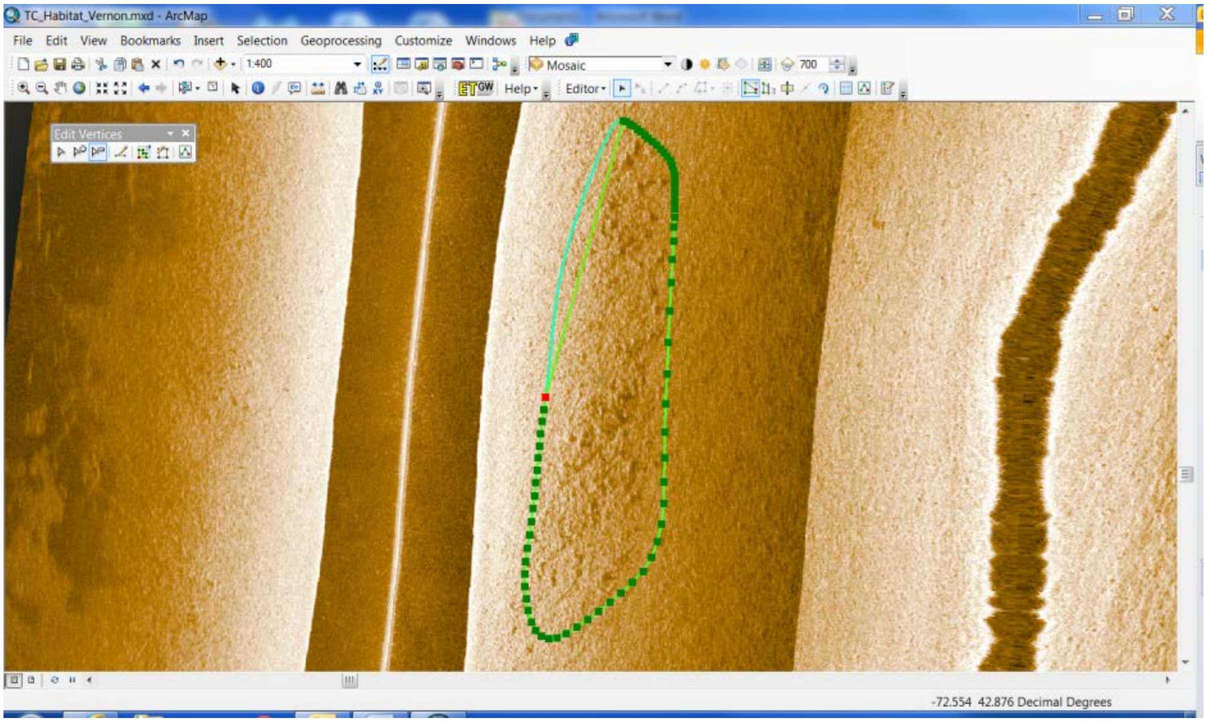


Figure 6-1. Example screen shot showing the creation of polygon units as borders around unique habitat types. Example showing boulder outcrop within gravel-cobble habitat.

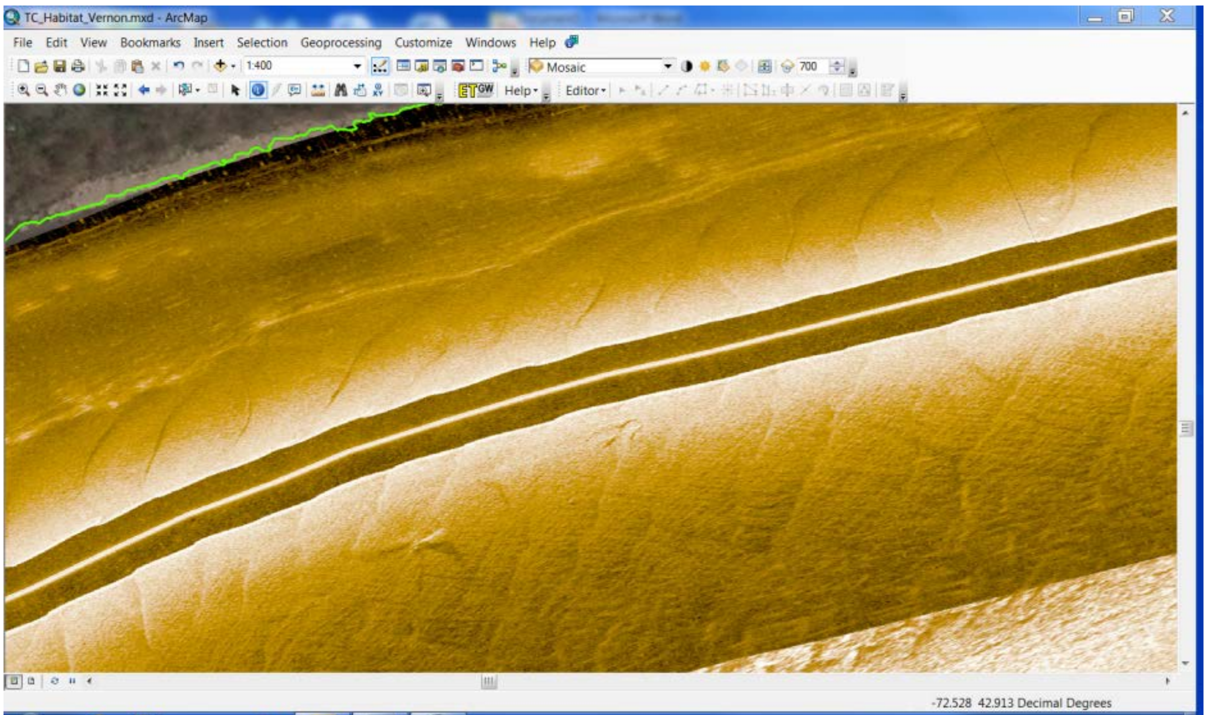


Figure 6-2. Example of sand/silt/clay as classified from sonar imagery for the Wilder, Bellows Falls and Vernon habitat surveys.

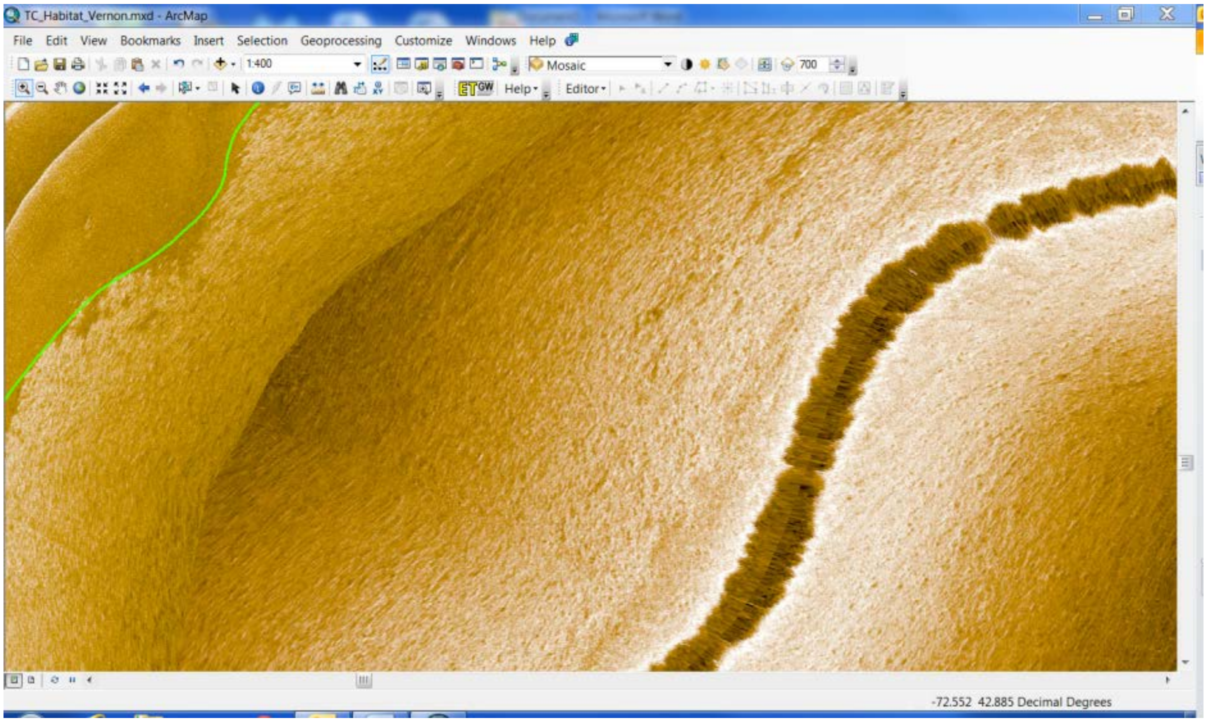


Figure 6-3. Example of gravel/cobble as classified from sonar imagery for the Wilder, Bellows Falls and Vernon habitat surveys.

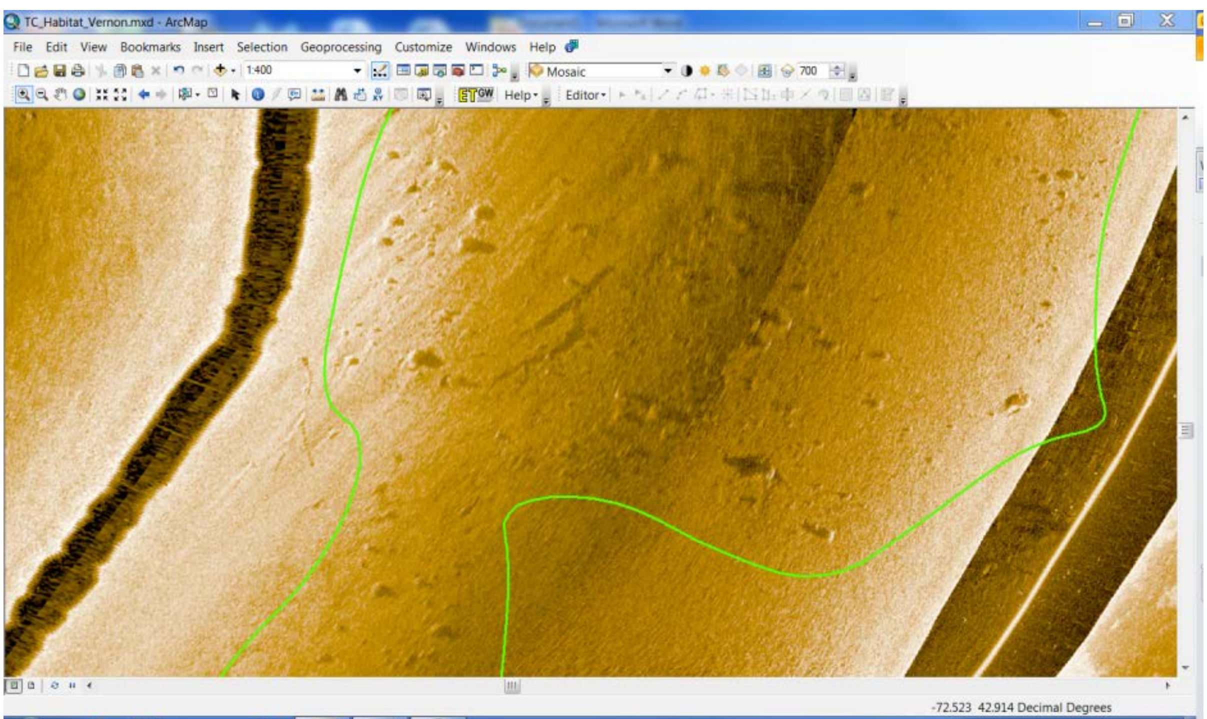


Figure 6-4. Example of boulder as classified from sonar imagery for the Wilder, Bellows Falls and Vernon habitat surveys.

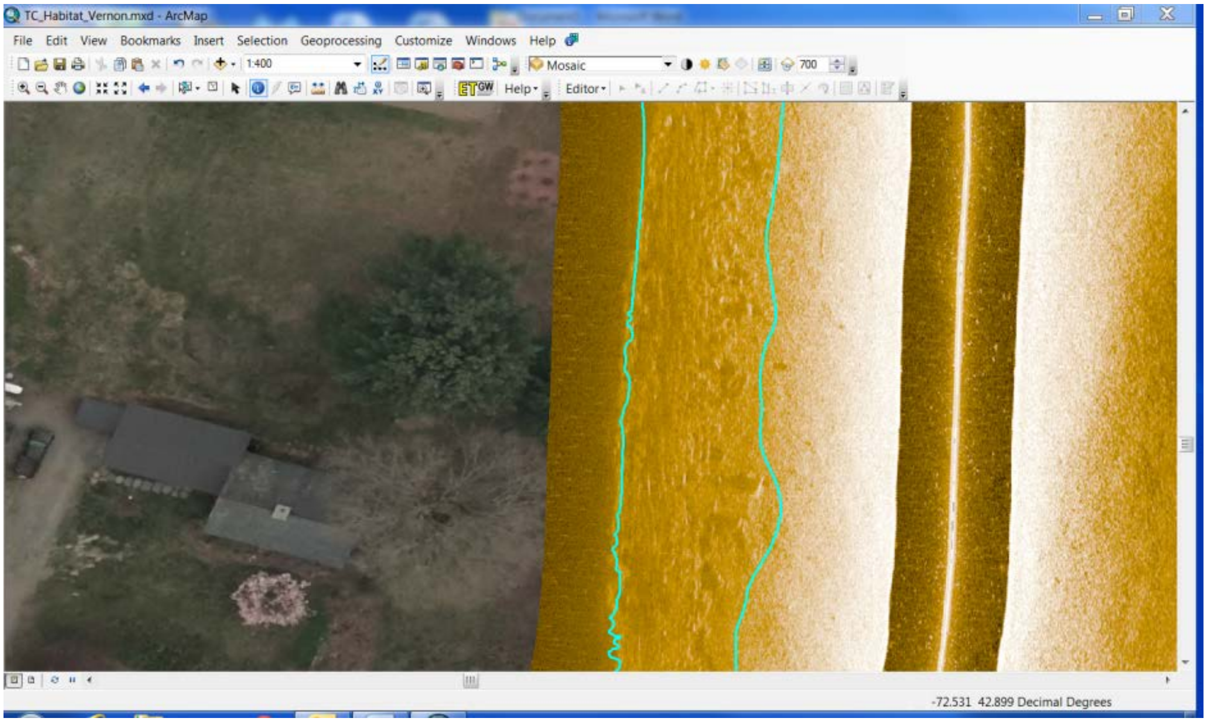


Figure 6-5. Example of rip-rap as classified from sonar imagery for the Wilder, Bellows Falls and Vernon habitat surveys.

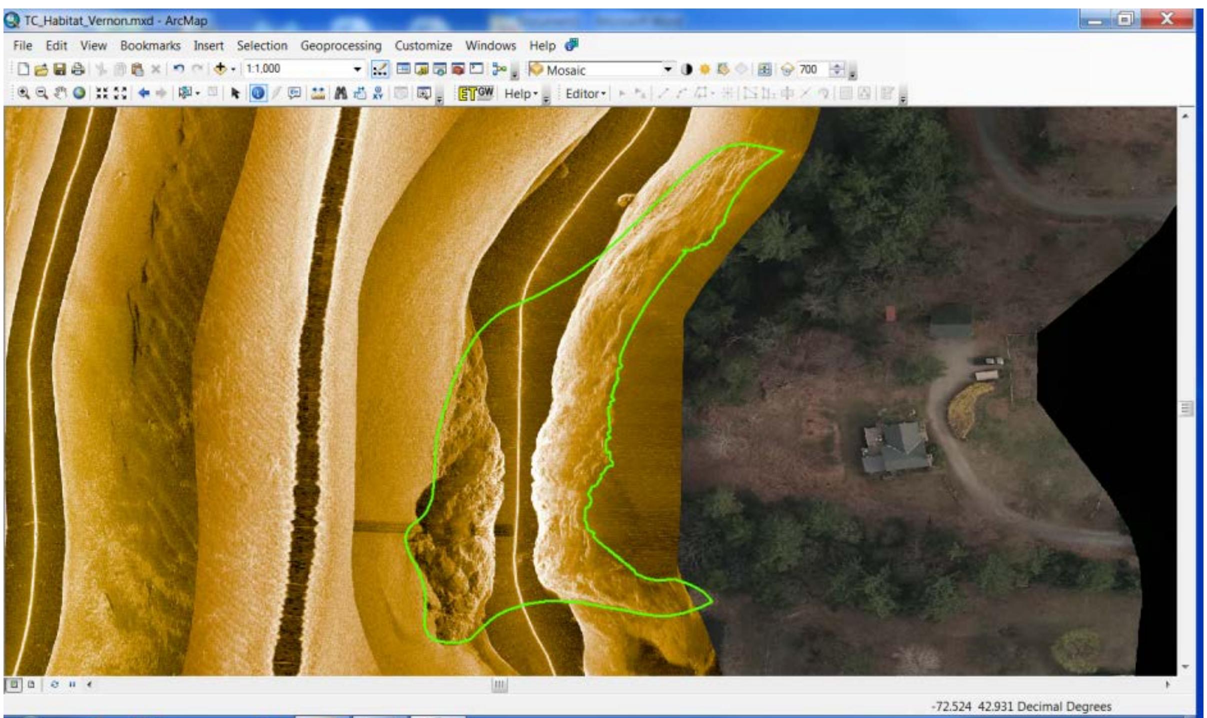


Figure 6-6. Example of ledge as classified from sonar imagery for the Wilder, Bellows Falls and Vernon habitat surveys.

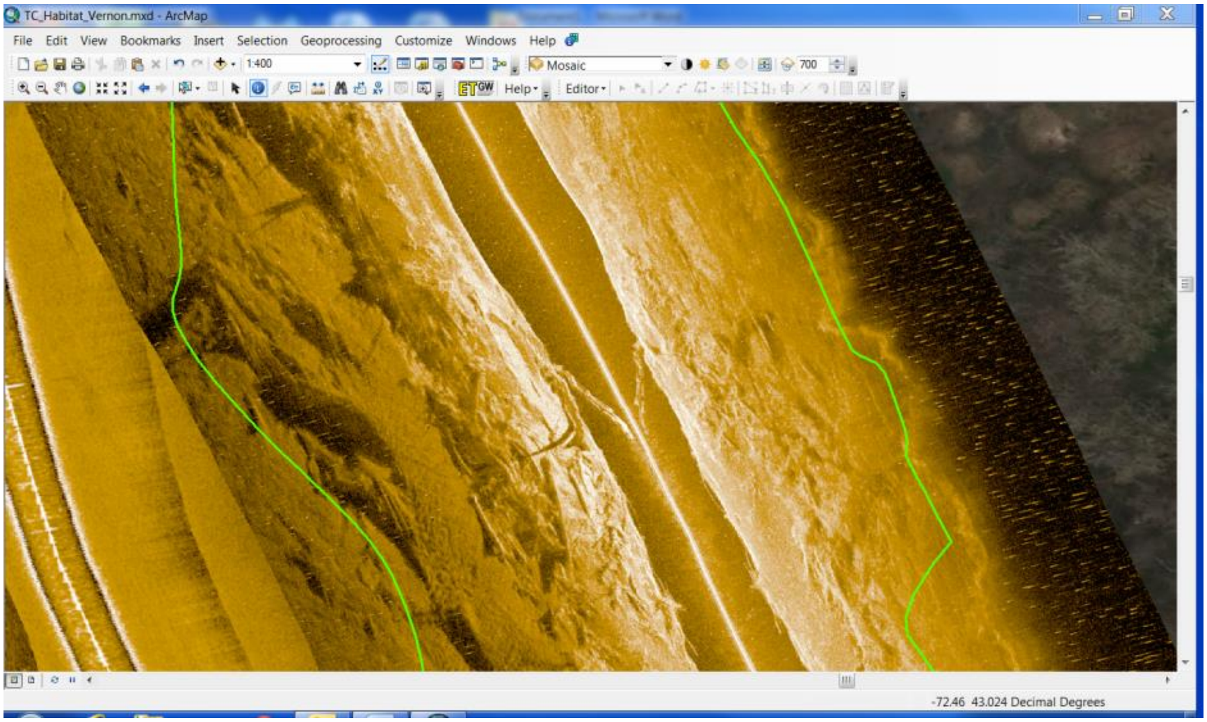


Figure 6-7. Example of woody debris as classified from sonar imagery for the Wilder, Bellows Falls and Vernon habitat surveys.

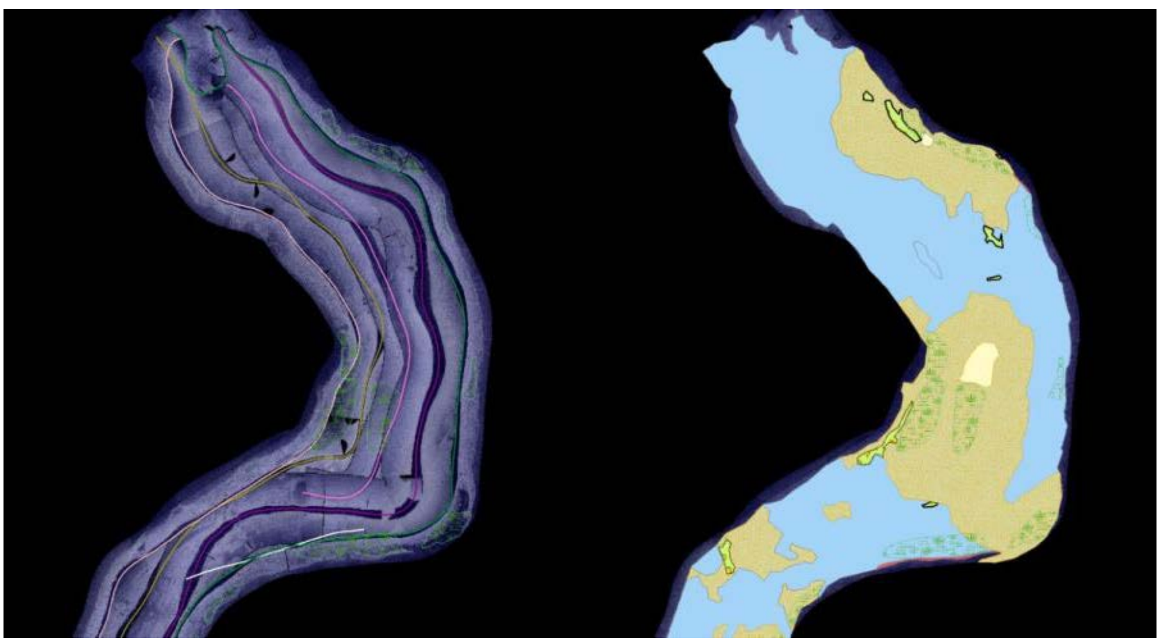


Figure 6-8. Screen shots showing polygon creation overlaying stitched sonar data files (left image) and resulting GIS habitat product (right image) created from sonar imagery for the Wilder, Bellows Falls and Vernon habitat surveys.

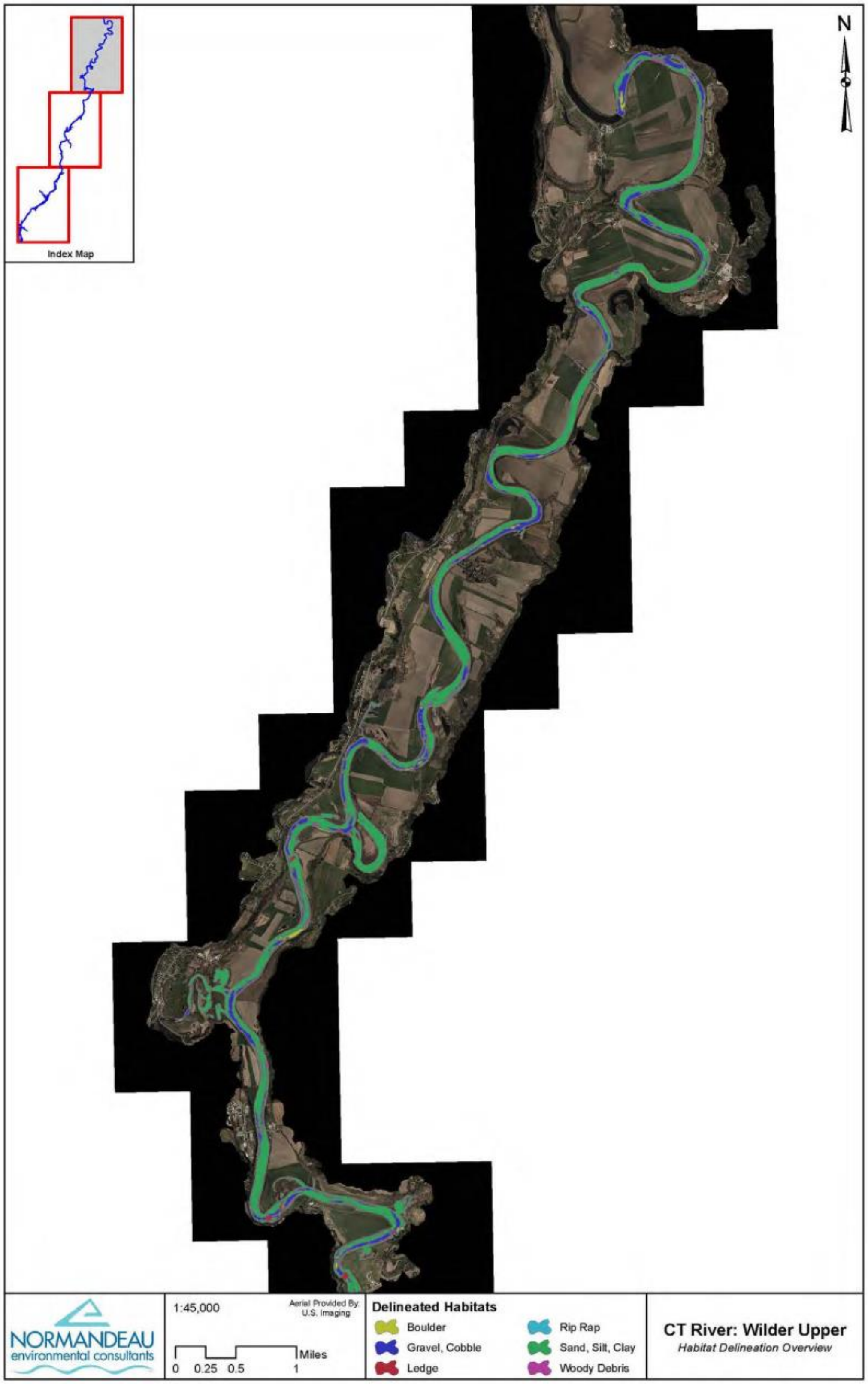


Figure 6-9. Overview of upper Wilder impoundment aquatic habitat.

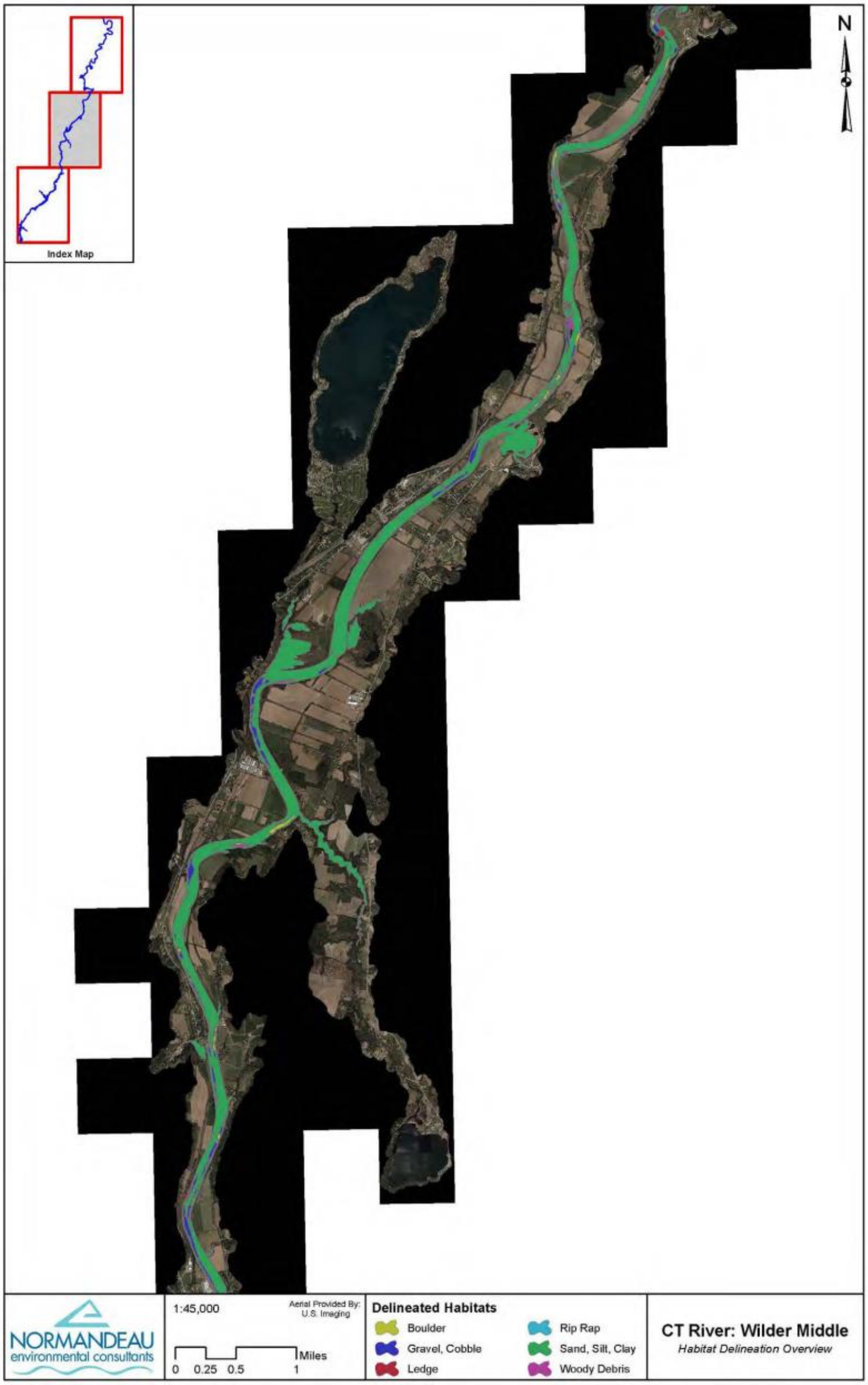


Figure 6-10. Overview of middle Wilder impoundment aquatic habitat.

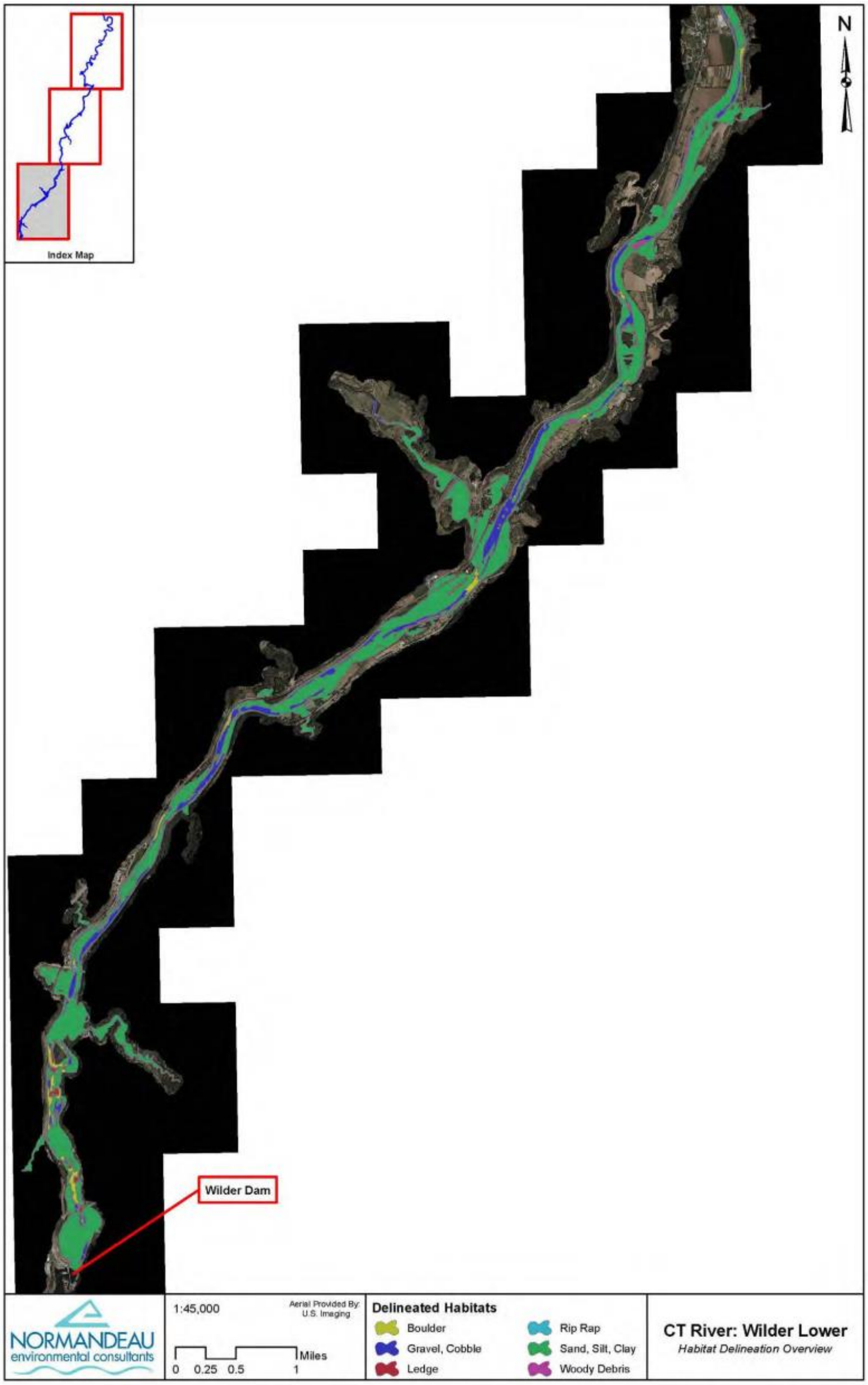


Figure 6-11. Overview of lower Wilder impoundment aquatic habitat.

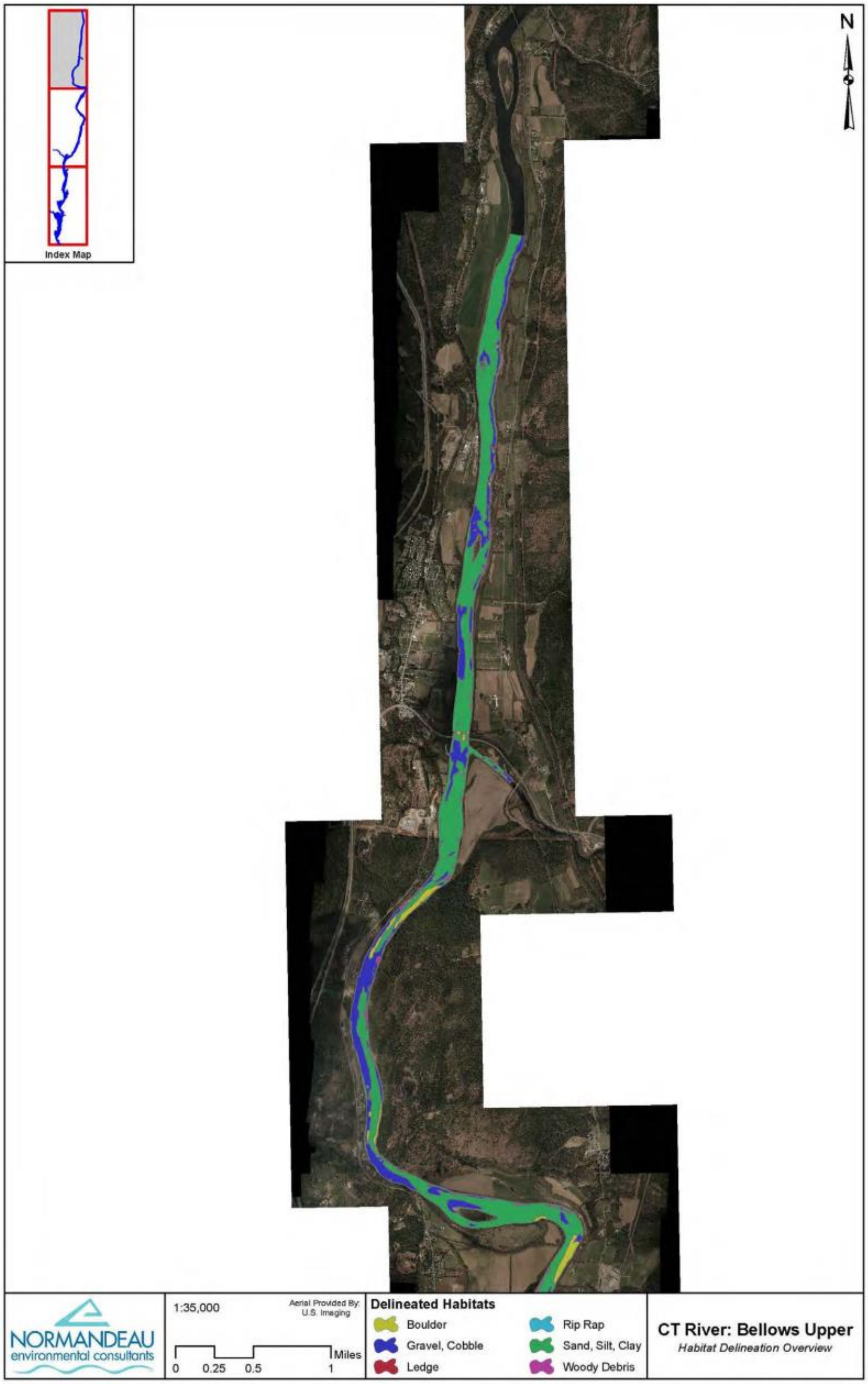


Figure 6-12. Overview of upper Bellows Falls impoundment aquatic habitat.

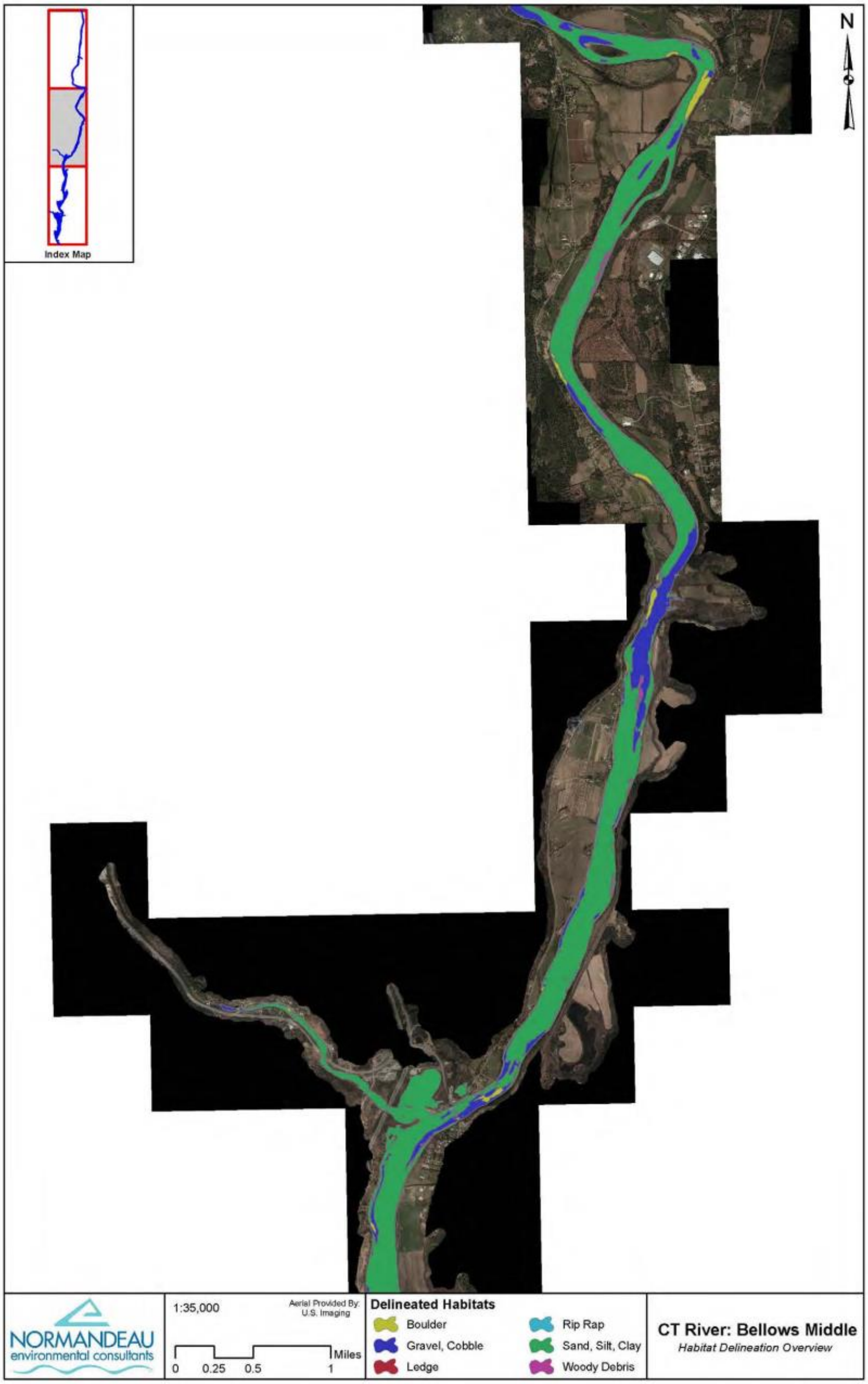


Figure 6-13. Overview of middle Bellows Falls impoundment aquatic habitat.

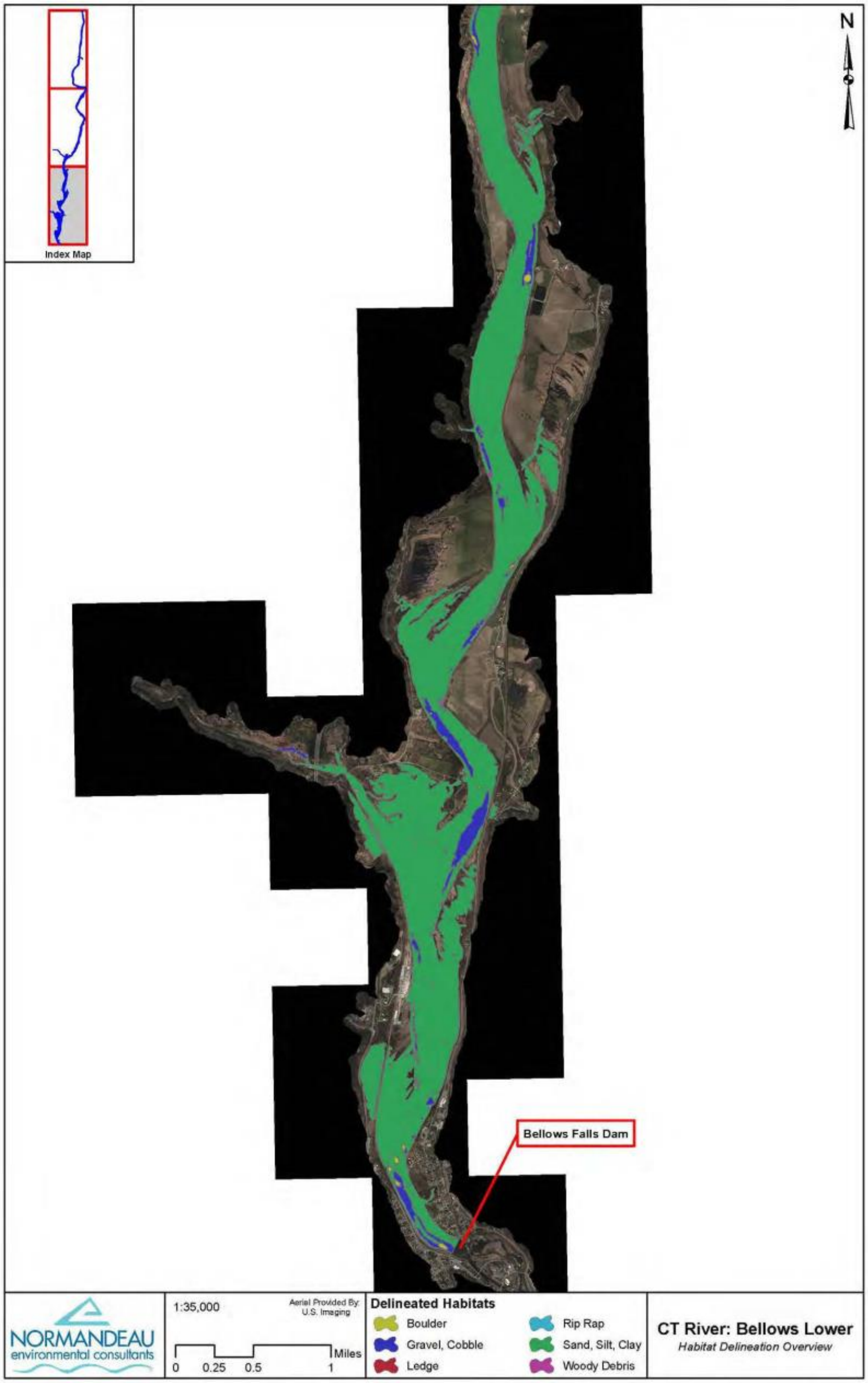


Figure 6-14. Overview of lower Bellows Falls impoundment aquatic habitat.

Figure 6-15. Overview of upper Vernon impoundment aquatic habitat.

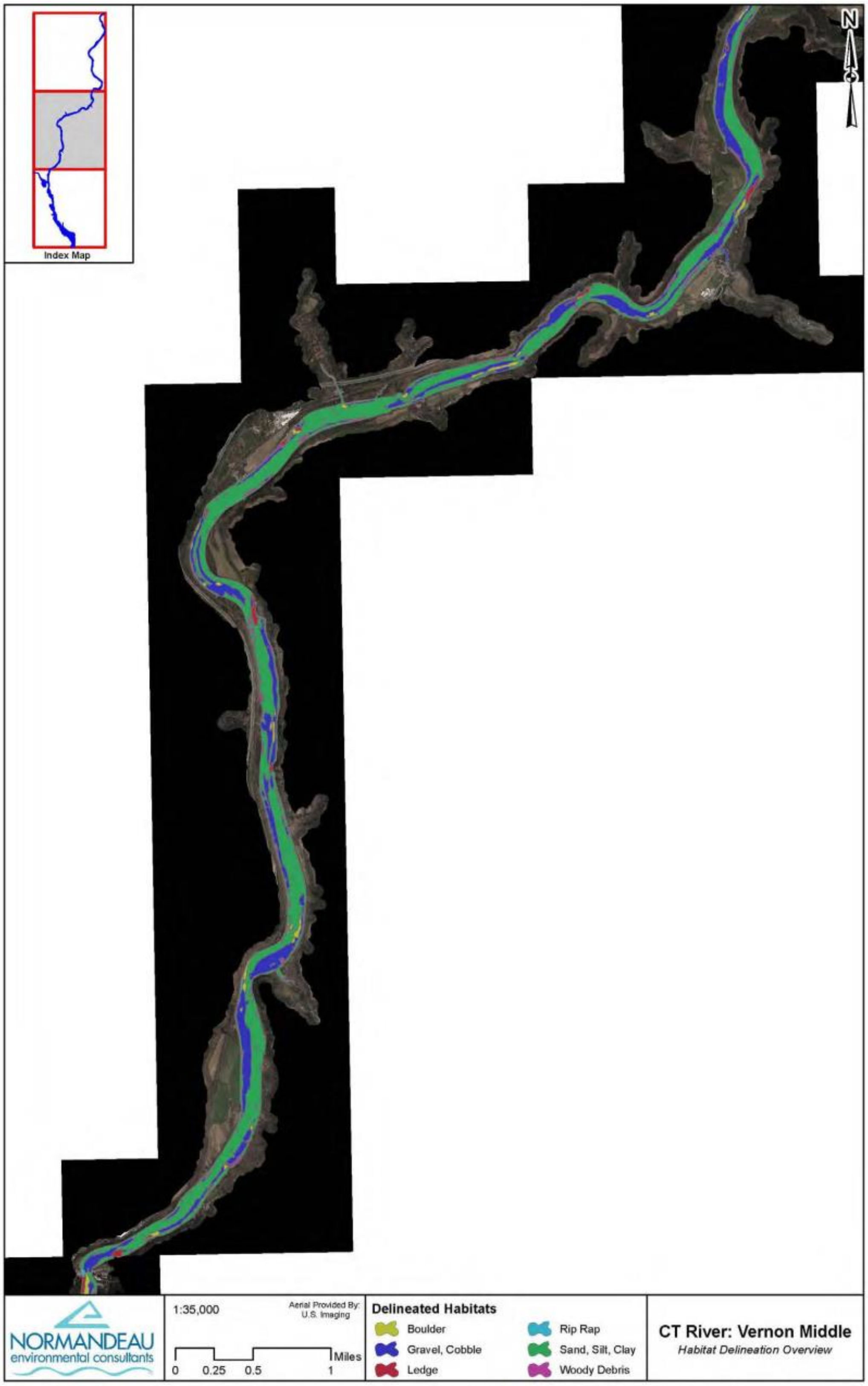


Figure 6-16. Overview of middle Vernon impoundment aquatic habitat.

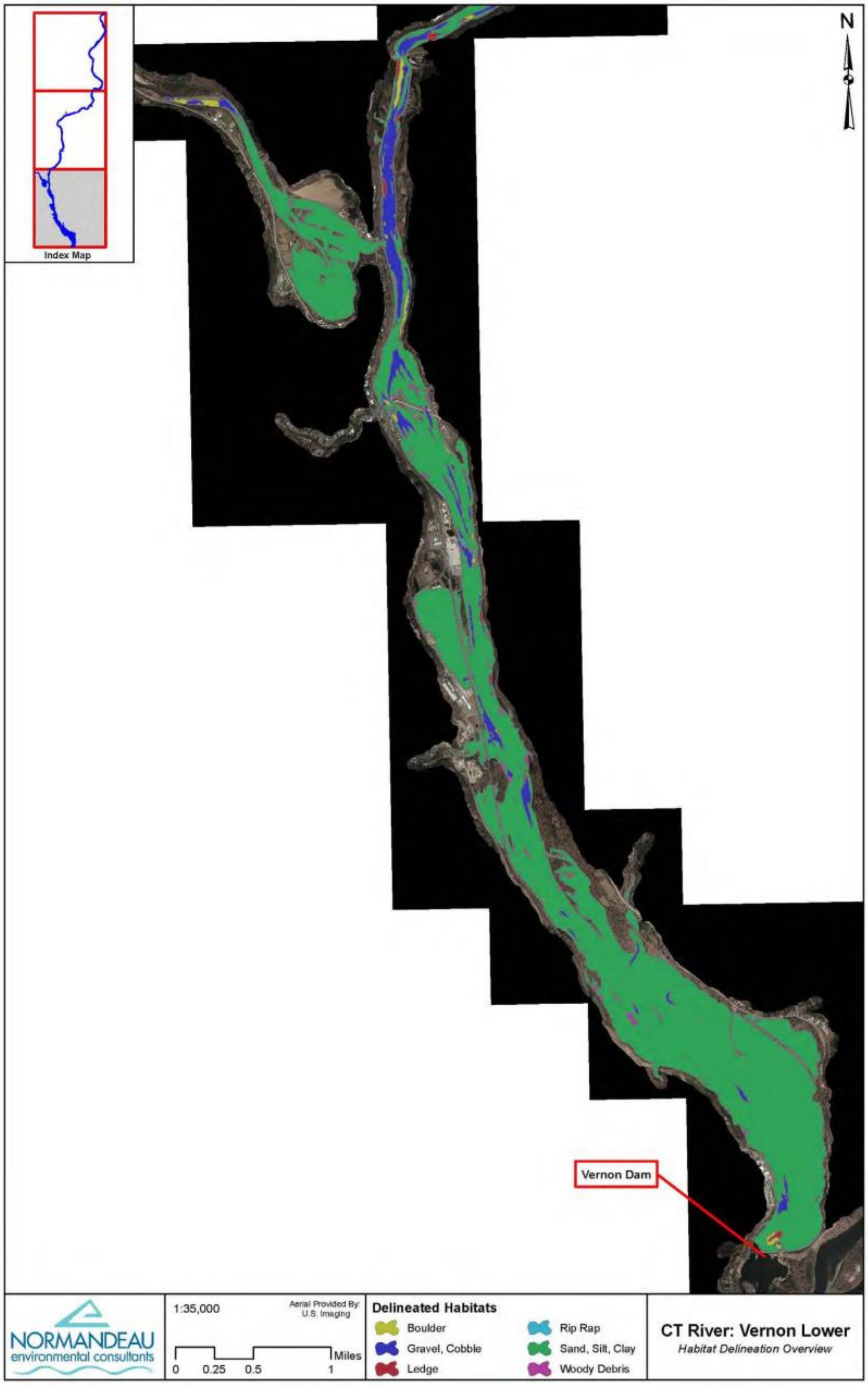


Figure 6-17. Overview of lower Vernon impoundment aquatic habitat.

7.0 RIVERINE AQUATIC MESOHABITAT MAPPING

7.1 Field Methodology

Riverine segments were mapped at flow levels within bounds of project operations at the time of the field effort, generally the lowest available flow. Visibility is normally improved at lower flows, allowing for easier classification of substrate. In addition, identification of shallow water mesohabitats (e.g. riffles), gravel bars and shoals is also enhanced, as many of these features could be inundated at higher operational flows and not recognizable.

Riverine habitat mapping was performed moving downstream in a 14-ft Porta-Bote equipped with a 6 hp outboard motor and oars. An Airmar 60 235 kHz digital depth transducer mounted to the side of the boat and a GPS unit connected to a Toughbook C-19 laptop computer were used to record depth and time-stamped GPS positions. Locations of habitat boundaries and other features such as top and bottom of islands, side channels and locations of exposed gravel bars were recorded on a hand-held Garmin GPS unit. Depths were recorded at 15-second intervals and logged as text files for importation into spreadsheets or a GIS database.

The survey generally followed a meandering path down the channel, detecting changes in depth and locating the thalweg (deepest part) of the channel. Tracking channel depth aids in identifying mesohabitat unit transitions from deep to shallow areas (pools to glides for example) or runs which typically have a well-defined thalweg. In instances of islands or split channels, both channels were mapped by boat unless flow or depth was limited, in which case mapping was conducted on foot. The Bellows Falls bypassed reach was mapped on foot since flows are typically low and boat access is difficult, particularly in the upper portion of the reach.

Riverine mesohabitat types were identified and delineated based on the following descriptions:

- **Pool** – deep, low velocity with a generally well-defined control and retains water at zero discharge.
- **Glide** – shallow with moderate velocity distributed across the channel, without a well-defined thalweg, sometimes referred to as shallow pool if velocities are low.
- **Run** – deep to moderately deep with fast velocity in a well-defined thalweg, surface may be turbulent, substrate variable.
- **Riffle** – shallow with gravel, cobble, or boulder substrate, fast water with turbulent flow or white-water, possible exposed substrate.
- **Rapid** – shallow bedrock, boulder with turbulent white-water flow and possible exposed substrate, may be brief and abrupt across the stream channel or extend for a greater distance.

- **Other** – may include backwaters or other mesohabitat types if primary types are believed to be insufficient for characterization. The mapping protocol allowed for additional types or sub-types to be added according to the best judgment of the field personnel.

In some instances mesohabitat units were classified as a combination of two types, run/riffle for example, if characteristics of both types were observed. Typically this occurred where certain features such as a cobble bar split the channel or extended into the channel from the bank. Subsequent descriptions and analysis include only the primary mesohabitat type.

Additional information collected for each mesohabitat unit included dominant and subdominant substrate and bank or instream cover type (ledges, boulders, woody debris, etc.), if any. Substrate was classified into (1) organics, (2) mud and clay, (3) silt, (4) sand, (5) gravel, (6) cobble, (7) boulder, and (8) bedrock (Table 7-1). Substrate composition was visually identified where depths and water visibility allowed. In deeper areas, a collapsible hollow fiberglass stadia rod was used to "feel" and "listen" to determine firmness and size of the substrate. Prior to field data collection crew members calibrated this technique by employing it in areas of known substrate composition. Soft indicated sand and silt while hard areas identified rocky substrates. Substrate size was determined by feeling the degree of bounce, the larger the substrate the more bounce. This technique was restricted to depths less than 15 feet due to physical limits and capabilities and consequently, substrate composition in deep pools may not always be accurate. Substrate was recorded for most habitat units unless lack of visibility and/or depth, primarily in pools, limited identification.

7.2 Data Analysis and Processing

Upon completion of the field data collection effort, data were entered into spreadsheets for review and summary. The final mapping results are presented in Appendix A (a complete database spreadsheet with additional notes and waypoints is available upon written request to TransCanada). Distances between mesohabitat unit boundaries were calculated from GPS coordinates. Minor adjustments were made to a few mesohabitat unit boundaries and subsequent lengths based on examination of changes in the depth profile, location of GPS coordinates relative to banks and bends in the channel, or from notes recorded during mapping. For example, it may have been noted that a waypoint was not recorded in the correct location based on depths acquired during mapping and should be moved upstream. Maximum depths were noted and average depths were calculated for most habitat units. Exceptions included some riffles which were too shallow to safely deploy the depth sounder and those habitat units that were mapped on foot. Depths were plotted and overlaid on orthographic photos using ArcGIS along with mesohabitat unit boundaries.

Maximum and average depth frequencies for pool and run habitat were evaluated to determine if it would be appropriate to further refine these mesohabitats into deep and shallow types. Only main channel and the larger of split channels around islands were used to calculate total length of reaches, number of units and percent composition. In most instances both channels around islands contained similar mesohabitat types so that final proportions were not affected to any degree by this process.

7.3 Results and Discussion

In the course of mapping, waypoints were taken at apparent habitat unit boundaries based on mesohabitat definitions, changes in depth, substrate composition or general change in channel character (e.g. velocity, slope). In some cases this resulted in a series of two or more consecutive units of the same mesohabitat type as shown in Table 7-2. As a result, the actual number of mesohabitat unit types, primarily pool and glide, is less than indicated. However, the relative mesohabitat proportions remain the same and noted variation in depth and substrate composition is maintained. Mesohabitat orthographic overlays for all reaches are presented in Appendix B. Photographs are presented in Appendix C. More detailed data is provided electronically in association with this report.

7.3.1 Wilder

The Wilder riverine segment was mapped between August 15 and August 18, 2013. Mapping from Wilder dam to Sumner Falls took place on August 15 between 0900 and 1500 hrs during which time project flows were increasing from about 900 cfs to 5,000 cfs (1,700 to 5,610 cfs recorded at the USGS West Lebanon gage, Figure 7-1). Peak flows at the gage occurred between 1300 and 1900 hours. The difference in water surface elevation between low flow and peak operation flows for the day was approximately 2.0 feet based on the USGS gage.

The segment from Sumner Falls downstream to the Cornish boat launch near Windsor, Vermont was mapped on August 17, 2013 at a flow of 1,470 cfs as measured at the USGS West Lebanon gage. Flows from Wilder dam began increasing at 1100 hours from 850 cfs to a peak of 5,000 cfs between 1500 and 1900 hours (1,470 to 5,490 cfs as measured at the USGS West Lebanon gage, Figure 7-1). However, due to water travel time of approximately 2 hours to Sumner Falls and 4 hours to Cornish, the higher operational flow wasn't perceptible during mapping. Similar to the Sumner Falls to Cornish segment, flow between Cornish and the upper end of the Bellows Falls impoundment at Chase Island was not affected by Wilder operations due to water travel time. This segment was mapped on August 18, 2013 at a flow of 1,420 cfs as recorded at the USGS West Lebanon gage.

An evaluation of pool depth frequency in the Wilder riverine segment between Wilder dam and Chase Island revealed that of the 46 pools with maximum depth readings, 29 were 15 feet or less in depth (Figure 7-2). Of the remaining 17 pools, 11 had maximum depths between 16 and 25 feet with 6 pools greater than 30 feet maximum depth. A review of run habitat types found that the overall range in maximum depths (3.5 to 10.9 feet with an average of 7.7 feet) was not broad enough to provide a sufficient level of separation. Based on pool depth frequency a decision was made to apply a depth of 15 feet or less to represent shallow pools and depths greater than 15 feet to represent deep pools.

Overall mesohabitat proportions for the Wilder segment from Wilder dam to Chase Island (17.6 miles) are presented in Table 7-3. Pools account for 55.5 percent of mesohabitats, with 25 percent of that attributed to deep pools. Glides accounted for 23.4 percent, followed by runs at 14.7 percent and riffles at 5.0 percent. General trends noted during mapping from Wilder dam to Chase Island included a transition in mesohabitat distribution from deep pools and runs to shallow pools and glides and a slight increase in riffle habitat. In addition, the dominant substrate trended from cobble to gravel moving downstream. With the exception of the occasional piece of large woody debris along the banks, instream cover was absent.

7.3.2 Wilder Reaches

Based primarily on hydrology and flow accretion from major tributaries and noted differences in mesohabitat distribution, the Wilder riverine segment was broken into three reaches:

- Reach 1 Wilder Dam to White River – 1.5 miles
- Reach 2 White River to Ottauquechee River – 5.2 miles
- Reach 3 Ottauquechee River to Chase Island – 11.0 miles

Reach 1 is short in length, 1.5 miles, and contains two major islands (Photo 1 and 2). Deep pool accounts for 59 percent of the reach with run making up 24 percent and glide 15 percent (Table 7-4). A single short riffle of 125 feet was noted at the transition from the pool immediately below the dam. This would likely be inundated at flows above those experienced during mapping.

Reach 2 from the White River to the Ottauquechee River contains a complex of multiple channels known as Johnston Island. Almost all riffle habitat identified in this reach is found within this island complex (Photo 3). A large cobble/gravel bar at the mouth of Bloods Brook persists under normal project operations (Photo 4 and 5). Overall pool is the dominant habitat type accounting for 63 percent of the reach, 36 percent of which was classified as deep pool (Table 7-5). Run accounts for 22 percent of the reach followed by glide at 11 percent and riffle at 4 percent.

Reach 3 from the Ottauquechee River to Chase Island includes a bedrock rapid known as Sumner Falls (Photos 6-10). The 2.5 mile stretch between the Ottauquechee River and Sumner Falls is composed of pool and glide habitat with little complexity, though two small side channels were noted in this section. Reach 3 is dominated by pools (52 percent) and glides (30 percent) with the majority of pool habitat classified as shallow (Table 7-6). Riffles make up almost 6 percent of the reach and are clustered around two locations - a large gravel bar area approximately 1.0 mile downstream of Sumner Falls (Photo 11) and near the lower end of Hart Island. The entrance to the right channel of Hart Island consists of a gravel bar which restricts flow into the channel under low flow conditions, such as that encountered during mapping (Photo 12). Mapping of the right channel of Hart Island was completed and potential habitat types identified, even though there was minimal flow (Photos 13 and 14). The small amount of flow observed in the channel at the time originated from Lulls Brook, a tributary near the top of the right channel. It was noted that the entire length of the channel would probably be classified as run at a two unit operation flow level. A hydrologic study conducted in 2012 indicated river discharge would need to exceed approximately 3,000 cfs before water would begin to flow down the channel (Normandeau, 2013).

7.3.3 Bellows Falls Segment

The Bellows Falls riverine segment was mapped on August 16, 2013. Mapping was initiated at the bottom of the Bellows Falls bypassed channel, approximately 600 feet downstream of the powerhouse. Discharge from the project was 2,070 cfs at the beginning of the day, increasing gradually to 3,500 cfs by 1030 hours at which point flow remained steady until 1300 hours (Figure 7-3). Discharge increased again beginning at 1300 hours to 6,800 cfs. However, mapping was completed under the lower flow conditions of 2,070 to 3,500 cfs prior to the arrival the higher flow in the lower end of the river segment.

The purported influence of the Vernon impoundment is near the Walpole Bridge, identified in the Preliminary Application Document as being approximately 6 miles downstream of the Bellows Falls Project. However, mapping results indicate the bridge is 4 miles downstream of the powerhouse. Mapping of the reach was continued downstream of Dunshee Island, approximately 6.3 miles from the powerhouse. The mapping summary is based on data collected to the downstream end of Dunshee Island, a distance of 5.6 miles. Below Dunshee Island the influence of the Vernon impoundment is apparent as this 3,700- ft segment was classified as pool with silt and sand substrate.

Because the Bellows Falls river segment is relatively short, minor accretion sources only occur in the first mile downstream of the dam and there were no notable changes in channel character, it is considered a single reach. Splitting of deep and shallow pools is based on the maximum depth frequency analysis conducted for the Wilder riverine segment with shallow pools less than 15 feet in depth. Pools make up 59 percent of the Bellows Falls reach (shallow pool accounts for 36 percent of this total), followed by glide at 24 percent and run at 15 percent (Table 7-7).

The Bellows Falls reach contains two tributaries, Saxtons River and Cold River within the upper mile of the reach, both sources of large alluvial cobble/gravel bars that extend out into the channel (Photos 15 and 16). The single riffle identified in the reach is just downstream of Saxtons River and is likely a product of the downstream movement of sediment from the alluvial fan (Photo 17). The bar at Cold River constricts the channel into a deep run along the right bank at lower flows. However, it is likely that at higher operational flows than those experienced during mapping, this bar may become inundated and exhibit riffle characteristics over half the channel. A small side channel just upstream of the Walpole Bridge was dry at the flow levels encountered during mapping (Photo 18 and 19), but a side channel of the unnamed island downstream of the bridge retained flow (Photo 20).

7.3.4 Bellows Falls Bypassed Reach

The Bellows Falls bypassed reach was mapped on August 19, 2013. Flow in the reach was 400 cfs, higher than normal due to a gate being partially open due to debris. The upper part of the reach was accessed near the base of the dam (Photo 21). Immediately below the dam the channel is over 400 feet wide and consists of a large pool with some backwater areas (Photo 22). Downstream of this are a series of runs and riffles (Photo 23) which terminate at the top of a large pool immediately upstream of the fish barrier (Photo 24). Substrate in the upper part of the reach is primarily bedrock and boulder, though some large cobble exists in the riffle and run habitat units.

The lower part of the reach was mapped on foot beginning in a backwater pool formed by operations of the project. Flow from the project was approximately 6,000 cfs at the time. Access within the lower section of the reach under Villas Bridge and a railroad bridge is limited due to the sheer bedrock walls on both banks and steepness of the channel (Photo 25). The lower part of the reach is primarily pool all the way up to the base of a steep bedrock area just downstream of the fish barrier (Photos 26-28). Substrate in the lower part of the reach is composed of bedrock and large boulders.

Overall pool makes up 73 percent of the reach, run 16 percent and riffle 8.5 percent (Table 7-8). Due to safety concerns depths were not measured in this reach.

7.3.5 Vernon Reach

The Vernon reach was mapped on August 13, 2013. Project flows were 3,500 cfs prior to mapping, increasing to approximately 9,600 cfs during the time mapping occurred. This was the only reach mapped at a high flow level. Tailrace elevation at 9,600 cfs was 184.6 feet, the median elevation that can be experienced at this flow level depending on operations at Turners Falls (range of 183 to 186 feet). Mapping was initiated at the downstream end of the pool below Vernon dam, excluding the pool from the database (Photos 29 and 30). A small side channel at the top of the reach contained minimal flow at discharge of 3,500 cfs but was flowing at discharge of 9,600 cfs (Photos 31 and 32). Mapping was terminated at the downstream end of Stebbins Island, a distance of 1.3 miles.

Splitting of deep and shallow pools was based on the maximum depth frequency analysis conducted for the Wilder riverine segment with shallow pools less than 15 feet in depth. Overall pools account for 39.5 percent of the reach followed by run (34.9 percent) and glide at 25.6 percent (Table 7-9). No riffles were identified in the reach.

Table 7-1. Aquatic habitat mapping substrate codes, descriptions and particle size.

Code	Description	Particle Size (mm)	Particle Size (in)
OR	Detritus/Organic		
MUD	Mud/ Clay		
SI	Silt	<0.06	<0.002
SA	Sand	0.06 – 2.0	0.002 – 0.08
GR	Gravel	2.0 – 64.0	0.08 – 2.5
CB	Cobble	64.0 – 150.0	2.5 – 12.0
BD	Boulder	>250.0	12+
BR	Bedrock		

Source: Bovee 1982

Table 7-2. Example of consecutive mesohabitat units of the same type with boundaries based on depth (pool) and substrate (glide).

Waypoint	Habitat Type	Length (ft)	Maximum Depth (ft)	Average Depth (ft)	Substrate[a] Dom/Sub
101	Pool	2,291	11.8	6.8	SA/GR
102	Pool	1,858	16.4	8.6	??
103	Pool	654	39.6	22.0	??
104	Pool	705	26.4	13.3	??
190	Glide	646	3.2	2.3	CB/GR
191	Glide	374	3.1	2.1	GR/SA
192	Glide	1686	4.9	3.4	CB/GR
193	Glide	381	5.0	4.2	GR/CB

[a] Substrate codes from Table 5.1-1; Dom = Dominant, Sub= Sub-dominant

Table 7-3. Summary of mesohabitat types and percentages in the Wilder project riverine segment.

Wilder Segment (Wilder Dam to Chase Island)			
Habitat Type	**Number**	**Length (ft)**	**Percent**
Pools	43	51,642	55.5
Deep Pool (>15')	*16*	*23,382*	*25.1*
Shallow Pool	*27*	*28,260*	*30.4*
Glide	25	21,782	23.4
Run	20	13,681	14.7
Riffle	12	4,623	5.0
Rapid	1	1,284	1.4
Totals	100	93,012	100.0

Table 7-4. Summary of mesohabitat types and percentages in Reach 1 of the Wilder project riverine segment.

Wilder Reach 1: Wilder Dam to White River Reach			
Habitat Type	**Number**	**Length (ft)**	**Percent**
Pools	4	4,601	59.2
Deep Pool (>15')	*4*	*4,601*	*59.2*
Shallow Pool	*0*	*0*	*0*
Glide	2	1,196	15.4
Run	2	1,846	23.8
Riffle	1	125	1.6
Rapid	0	0	0
Totals	9	7,768	100.0

Table 7-5. Summary of mesohabitat types and percentages in Reach 2 of the Wilder project riverine segment.

Wilder Reach 2: White River to Ottauquechee River Reach			
Habitat Type	**Number**	**Length (ft)**	**Percent**
Pools	13	17,123	62.6
Deep Pool (>15')	*6*	*9,886*	*36.2*
Shallow Pool	*7*	*7,237*	*26.5*
Glide	3	2,939	10.7
Run	9	6,131	22.4
Riffle	3	1,149	4.2
Rapid	0	0	0
Totals	28	27,342	100.0

Table 7-6. Summary of mesohabitat types and percentages in Reach 3 of the Wilder project riverine segment.

Wilder Reach 3: Ottauquechee River to Chase Island Reach			
Habitat Type	**Number**	**Length (ft)**	**Percent**
Pools	26	29,918	51.7
Deep Pool (>15')	*6*	*8,896*	*15.4*
Shallow Pool	*20*	*21,022*	*36.3*
Glide	20	17,647	30.5
Run	8	5,703	9.8
Riffle	8	3,349	5.8
Rapid	1	1,284	2.2
Totals	63	57,902	100.0

Table 7-7. Summary of mesohabitat types and percentages in the Bellows Falls Reach from Bellows Falls powerhouse to Dunshee Island.

Bellows Falls Reach: Bellows Falls Dam to Dunshee Island			
Habitat Type	**Number**	**Length (ft)**	**Percent**
Pools	13	17,250	58.8
Deep Pool (>15')	*4*	*6,559*	*22.4*
Shallow Pool	*9*	*10,691*	*36.4*
Glide	9	7,134	24.3
Run	5	4,448	15.2
Riffle	1	509	1.7
Totals	28	29,341	100.0

Table 7-8. Summary of mesohabitat types and percentages in the Bellows Falls bypassed reach.

Bellows Falls Bypass Reach			
Habitat Type	**Number**	**Length (ft)**	**Percent**
Pools[a]	8	2,824	72.6
Deep Pool (>15')	----	----	----
Shallow Pool	----	----	----
Glide	0	0	0
Run	4	638	16.4
Riffle	3	332	8.5
Cascade	1	98	2.5
Totals	16	3,892	100.0

[a] No depths taken in Bellows Falls bypassed reach

Table 7-9. Summary of mesohabitat types and percentages in the Vernon reach.

Vernon Reach			
Habitat Type	**Number**	**Length (ft)**	**Percent**
Pools	3	2,631	39.5
Deep Pool (>15')	*2*	*1,653*	*24.8*
Shallow Pool	*1*	*978*	*14.7*
Glide	3	1,701	25.6
Run	4	2,325	34.9
Riffle	0	0	0
Totals	10	6,657	100.0

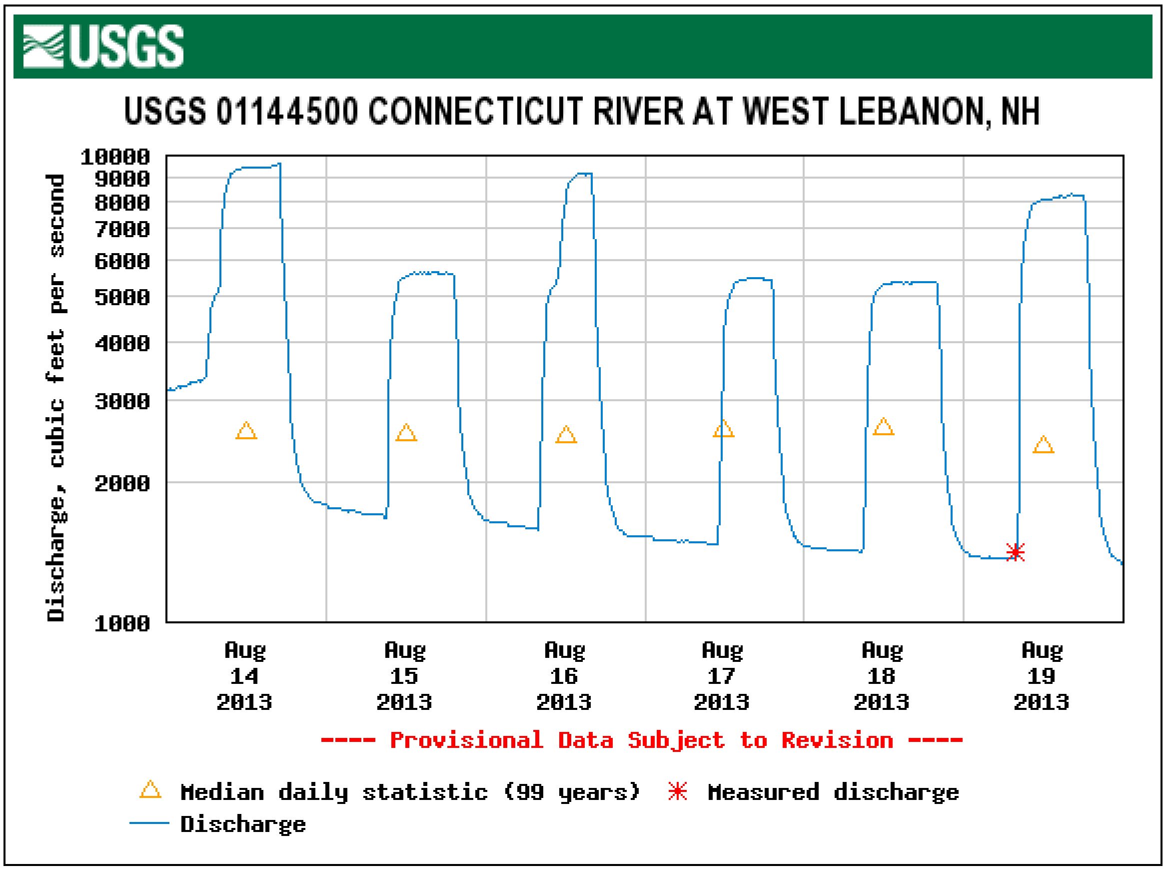


Figure 7-1. Discharge recorded at the USGS West Lebanon gage between August 14 and August 19, 2013.

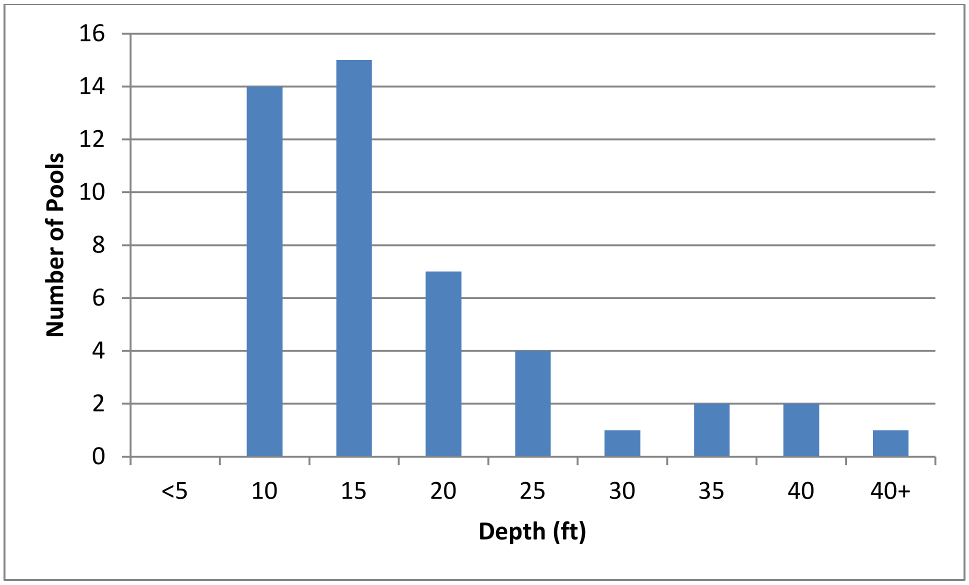


Figure 7-2. Pool maximum depth frequency in the Wilder project riverine segment from Wilder Dam to Chase Island.

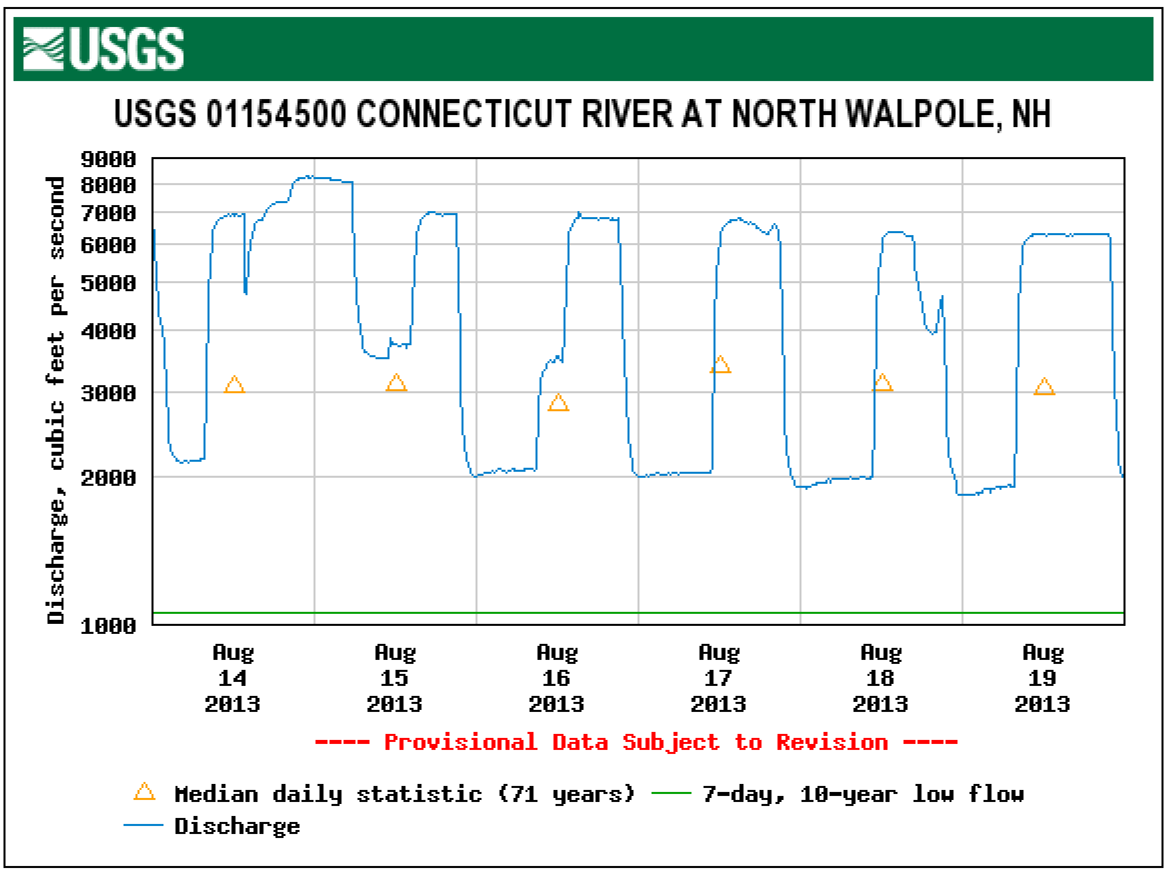


Figure 7-3. Discharge recorded at the USGS North Walpole gage between August 14 and August 19, 2013.

8.0 WATER SURFACE ELEVATION MONITORING

8.1 Field Methodology

Onset HOBO water-level data loggers (vertical accuracy of ± 0.1 inch) were installed at selected locations over the entire 120.5 mile study area in 2013 (Figures 8-1 through 8-3). Level loggers were installed during July 2013 within the confluence areas of some tributaries and backwater areas as well as throughout the mainstem Connecticut River (Table 8-1). Locations selected for monitoring during 2013 were provided to the resource agencies as part of Study Plan 7 and were intended to provide data for one or more of the following objectives:

- Hydraulic modeling simulating river flow through project impoundments and riverine reaches (Study 4);
- Assessment of project-related erosion (Studies 1, 2, and 3);
- Assessment of changes in water surface elevations associated with project operations on backwater habitat;
- Assessment of changes in water surface elevations associated with project operations on tributary confluence area habitat; and
- Data collection of air barometric pressure required for the processing and calculation of level logger water depths.

During installation, the exact position of each unit (latitude, longitude and elevation relative to the project structures) was recorded using a Leica GS-14 Real Time Kinematic (RTK) unit. Level loggers were maintained at their set elevations by being set inside a perforated well pipe structure which was affixed to a piece of ¾-inch rebar and set vertically into the bottom substrate (Figure 8-4). Each unit was programmed to record pressure at 15 minute intervals. A total of six barometric reference loggers were installed over the study reach for use in processing logger data collected at mainstem, tributary and backwater locations.

Following logger installation, each monitoring location was visited once monthly (August-November). During each visit, the logger was removed from the well pipe holding structure and data was downloaded using to a laptop computer loaded with HOBOware Pro Software. Following download, the level logger was returned to the well pipe. The “pull” and “set” times bracketing the period of time the logger was out of water were recorded.

8.2 Data Analysis and Processing

Downloaded data files were imported into HOBOware Pro Software and sensor depths at each 15-minute interval were determined based on the relationship between recorded pressure values at the in-water logger and in-air barometric reference location. Following determination of water depth values, each individual record was assigned a use code which defines its collection status and subsequent use in analytical tasks (Table 8-2).

8.3 Results and Discussion

The majority of level loggers (80 out of 81) were installed between July 22 and August 6, 2013. A single station (#77) was not installed until August 15, 2013. A total of 75 level loggers were installed in aquatic habitat and six in-air barometric data loggers or "reference loggers" were installed over the study reach. The reference loggers collected background barometric pressure readings at the same 15-minute intervals as programmed for the level loggers. The atmospheric pressure values were used by the Onset HOBOware Pro software to process pressure data collected by the level loggers and providing calculated water depth values.

Pressure data was successfully recorded for the duration of the July through November period at 72 of the 81 logger locations. No data or an incomplete data set was collected at six locations (Station 3 – Oliverian Brook, Wilder impoundment, Station 5 – mainstem, Wilder impoundment, Station 24 – mainstem, Wilder impoundment, Station 76 – mainstem, riverine reach downstream of Bellows Falls, Station 81 – mainstem, Vernon impoundment, and Station 84 – backwater, Vernon impoundment) due to malfunctions associated with the HOBO level logger units. Incomplete data sets were obtained at Station 39 (mainstem, Bellows Falls impoundment) and Station 40 (Mill Brook, Bellows Falls impoundment) due to vandalism issues and at Station 57 (Cobb Brook, riverine reach downstream of Bellows Falls) due to logger loss associated with repeated bank collapses within the confluence area.

Table 8-3 presents the minimum, maximum, median, and mean values of the daily change in water depth at each location having sufficient valid data. Daily change in water depth was calculated as the difference between the maximum and minimum calculated water depths at each logger station for all records within a single calendar date. When all mainstem loggers are considered, the average daily change in water depth was greater at logger stations established in the riverine sections downstream of Wilder and Bellows Falls than those established in the project impoundments (only one logger was located in the riverine reach downstream of Vernon).

Table 8-1. Summary of HOBO level logger locations within the Wilder, Bellows Falls, and Vernon study areas, July–November 2013.

River Reach	Description	Tributary	Backwater	Mainstem	Total
RM 217.4-262.4	Wilder Impoundment	6	9	12	27
RM 199.7-217.4	Riverine Downstream of Wilder Dam	4	0	3	8
RM 173.7-199.7	Bellows Falls Impoundment	4	5	5	14
RM 167.9-173.7	Riverine Downstream of Bellows Falls Dam	3	0	3	7
RM 141.9-167.9	Vernon Impoundment	7	4	5	16
RM 140.4-141.9	Riverine Downstream of Vernon Dam	0	0	3	3

River Reach	Description	Tributary	Backwater	Mainstem	Total
RM 141.9-262.4	Total	24	19	32	75

Table 8-2. Use code definitions assigned to individual depth readings determined for HOBO level logger data, 2013.

Use Code	Description
1	Valid for all analytical tasks
2	Logger out of water (act of downloading)
3	Logger out of water (not yet deployed)
4	Sensor potentially out of water (based on depth readings)
5	Sensor depth exceeds reported instrument range
6	Manually flagged during data review: bad pressure data due to malfunction
7	Manually flagged during data review: ice formation in sensor
8	Manually flagged during data review: ice formation in barometer
9	Manually flagged after time series review

Table 8-3. Minimum, maximum, median, and mean values of the daily change in water depth at each HOBO logger location within the Wilder, Bellows Falls, and Vernon study areas, July–November 2013.

Station ID	River Reach	Purpose	Daily Change in Water Depth (ft)			
			Min	Max	Mean	Median
1	Wilder	Mainstem	0.2	4.3	1.3	1.0
2	Wilder	Mainstem	0.3	3.4	1.0	0.9
3	Wilder	Tributary	0.1	3.1	0.9	0.7
4	Wilder	Mainstem	0.3	3.1	0.9	0.8
5	Wilder	Mainstem	0.5	1.9	0.9	0.8
6	Wilder	Backwater	0.3	2.8	0.9	0.9
7	Wilder	Backwater	0.2	2.5	1.0	0.9
9	Wilder	Backwater	0.2	2.4	1.0	1.0
10	Wilder	Tributary	0.2	2.3	1.0	1.0
11	Wilder	Mainstem	0.2	2.2	1.1	1.0
12	Wilder	Mainstem	0.5	2.4	1.1	1.0
13	Wilder	Backwater	0.2	2.2	1.1	1.1
14	Wilder	Mainstem	0.2	2.5	1.2	1.1
15	Wilder	Backwater	0.4	2.3	1.1	1.0
16	Wilder	Backwater	0.3	2.3	1.1	1.0

Station ID	River Reach	Purpose	Daily Change in Water Depth (ft)			
			Min	Max	Mean	Median
17	Wilder	Mainstem	0.3	2.3	1.0	1.0
18	Wilder	Mainstem	0.3	2.3	1.0	0.9
19	Wilder	Mainstem	0.2	2.3	1.0	1.0
20	Wilder	Backwater	0.2	2.3	1.0	0.9
21	Wilder	Tributary	0.2	2.4	1.0	0.9
23	Wilder	Tributary	0.2	3.2	1.0	0.9
74	Wilder	Backwater	0.2	2.3	1.0	0.9
25	Wilder	Backwater	0.2	2.5	1.1	0.9
26	Wilder	Mainstem	0.3	2.5	1.1	1.0
27	Wilder	Tributary	0.3	2.5	1.1	1.0
28	Wilder	Tributary	0.3	2.5	1.1	1.0
29	Wilder Riverine	Mainstem	0.0	7.0	3.2	3.4
30	Wilder Riverine	Tributary	0.0	4.0	0.9	0.7
32	Wilder Riverine	Mainstem	0.3	6.1	3.3	3.5
33	Wilder Riverine	Backwater	0.3	5.7	3.0	3.1
35	Wilder Riverine	Mainstem	0.3	5.5	2.9	3.0
36	Wilder Riverine	Tributary	0.3	4.5	2.2	2.3
37	Wilder Riverine	Tributary	0.2	4.2	2.1	2.2
38	Wilder Riverine	Tributary	0.0	2.7	0.6	0.4
39	Bellows	Mainstem	0.2	4.2	1.7	1.6
40	Bellows	Tributary	0.0	2.3	0.7	0.6
41	Bellows	Mainstem	0.2	3.6	1.2	1.1
78	Bellows	Mainstem	0.1	2.9	1.0	0.9
42	Bellows	Tributary	0.0	1.1	0.1	0.0
43	Bellows	Mainstem	0.2	1.8	1.0	1.0
45	Bellows	Tributary	0.2	1.7	0.9	1.0
46	Bellows	Tributary	0.2	2.2	1.1	1.1
48	Bellows	Backwater	0.2	2.3	1.2	1.1
49	Bellows	Mainstem	0.2	3.0	1.1	1.1
50	Bellows	Backwater	0.2	2.3	1.2	1.1
80	Bellows	Backwater	0.2	2.1	0.9	0.8
79	Bellows	Backwater	0.2	1.9	0.9	0.9
51	Bellows	Backwater	0.2	2.1	1.1	1.1
76	Bellows Riverine	Mainstem	1.1	4.4	2.6	2.6

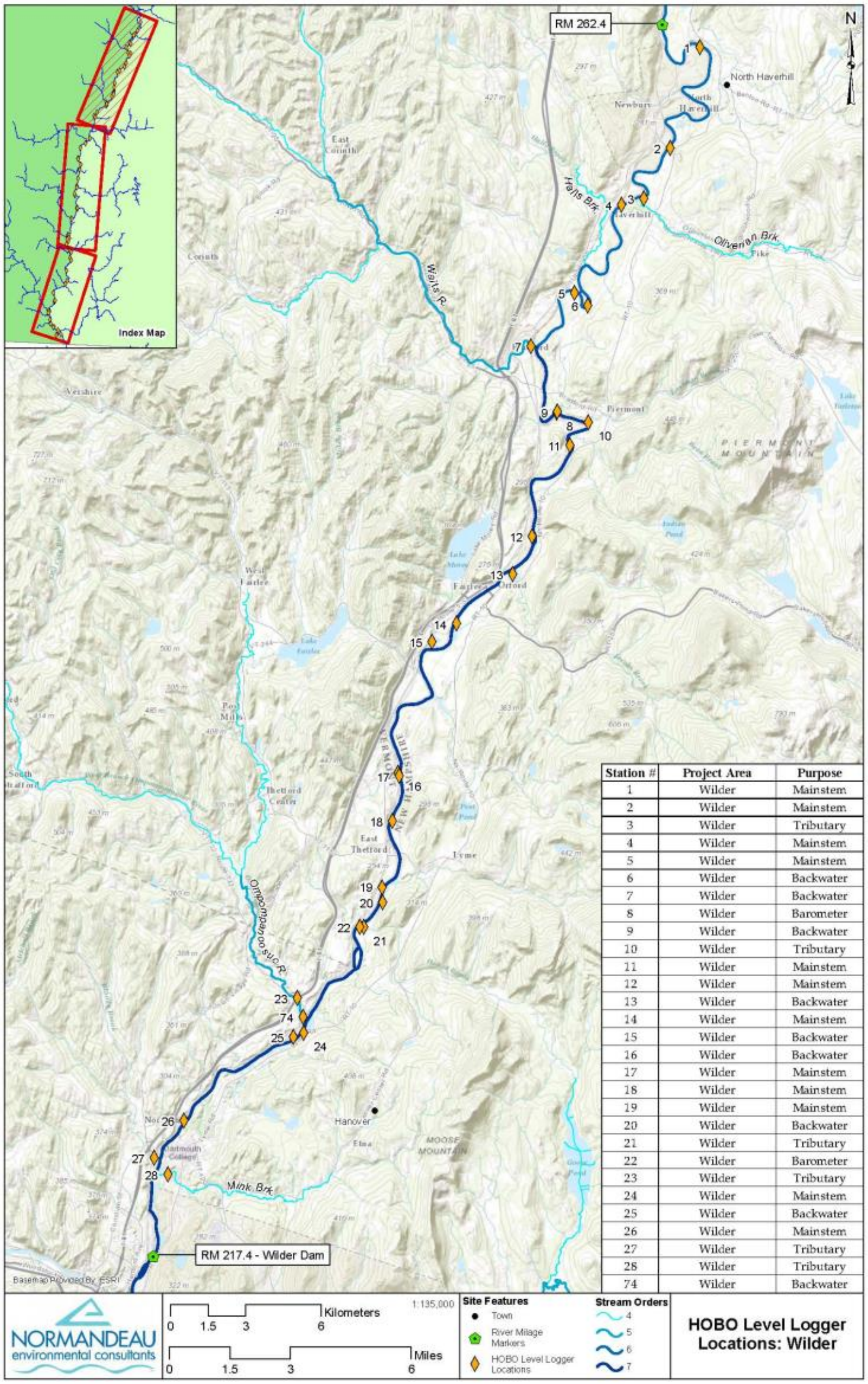
Station ID	River Reach	Purpose	Daily Change in Water Depth (ft)			
			Min	Max	Mean	Median
77	Bellows Riverine	Mainstem	0.3	5.2	2.8	2.9
52	Bellows Riverine	Tributary	0.1	4.0	2.0	1.8
53	Bellows Riverine	Mainstem	0.1	5.9	3.9	3.7
55	Bellows Riverine	Tributary	0.0	2.4	0.5	0.5
56	Bellows Riverine	Mainstem	0.2	4.8	2.7	2.5
57	Bellows Riverine	Tributary	0.0	4.5	1.6	1.4
58	Vernon	Tributary	0.0	2.2	0.6	0.6
59	Vernon	Tributary	0.0	2.2	0.2	0.1
60	Vernon	Mainstem	0.0	2.1	0.6	0.6
61	Vernon	Tributary	0.1	2.2	0.6	0.5
62	Vernon	Tributary	0.0	1.5	0.1	0.0
82	Vernon	Mainstem	0.1	1.5	0.7	0.7
63	Vernon	Tributary	0.1	1.7	0.8	0.7
65	Vernon	Mainstem	0.1	1.6	0.8	0.8
66	Vernon	Tributary	0.1	1.6	0.8	0.8
67	Vernon	Tributary	0.1	1.6	0.8	0.8
68	Vernon	Backwater	0.1	1.3	0.6	0.6
83	Vernon	Backwater	0.0	0.4	0.1	0.0
69	Vernon	Backwater	0.1	1.6	0.8	0.8
70	Vernon	Mainstem	0.1	1.7	0.8	0.8
72	Vernon Riverine	Backwater	0.4	6.4	3.0	3.0
73	Vernon Riverine	Mainstem	0.4	6.2	2.9	2.9
71	Vernon Riverine	Mainstem	0.6	6.0	2.6	2.5

Nine water level loggers were left in the Connecticut River over the winter of 2013/2014 and were searched for via SCUBA diving in early July 2014. Three were not found and presumed lost or submerged under bottom sediment or debris. High flows from a rain event forced the early termination of this effort resulting in one (#56) not being searched for; however, at that time it was presumed to be still in place. Five of the level loggers were successfully retrieved, downloaded, and reinstalled; and replacement level loggers were installed at the three sites where level loggers were missing.

All nine stations were revisited during October 2014. Three level loggers were not found and presumed lost or submerged in bottom sediment or debris (#56 was one of those and therefore had no data retrieved from fall of 2013 through October 2014). Replacement level loggers were installed at the three sites where level loggers were missing and the other six level loggers were successfully retrieved, downloaded, and reinstalled. The original logger at station #70 was found in October 2014 and data from 2013 to July 2014 was retrieved. The replacement logger installed in July 2014 was downloaded in October 2014 and found to contain invalid pressure data, and there invalid data for the period from July – October 2014. All nine will be searched for and downloaded (if present) in the spring of 2015.

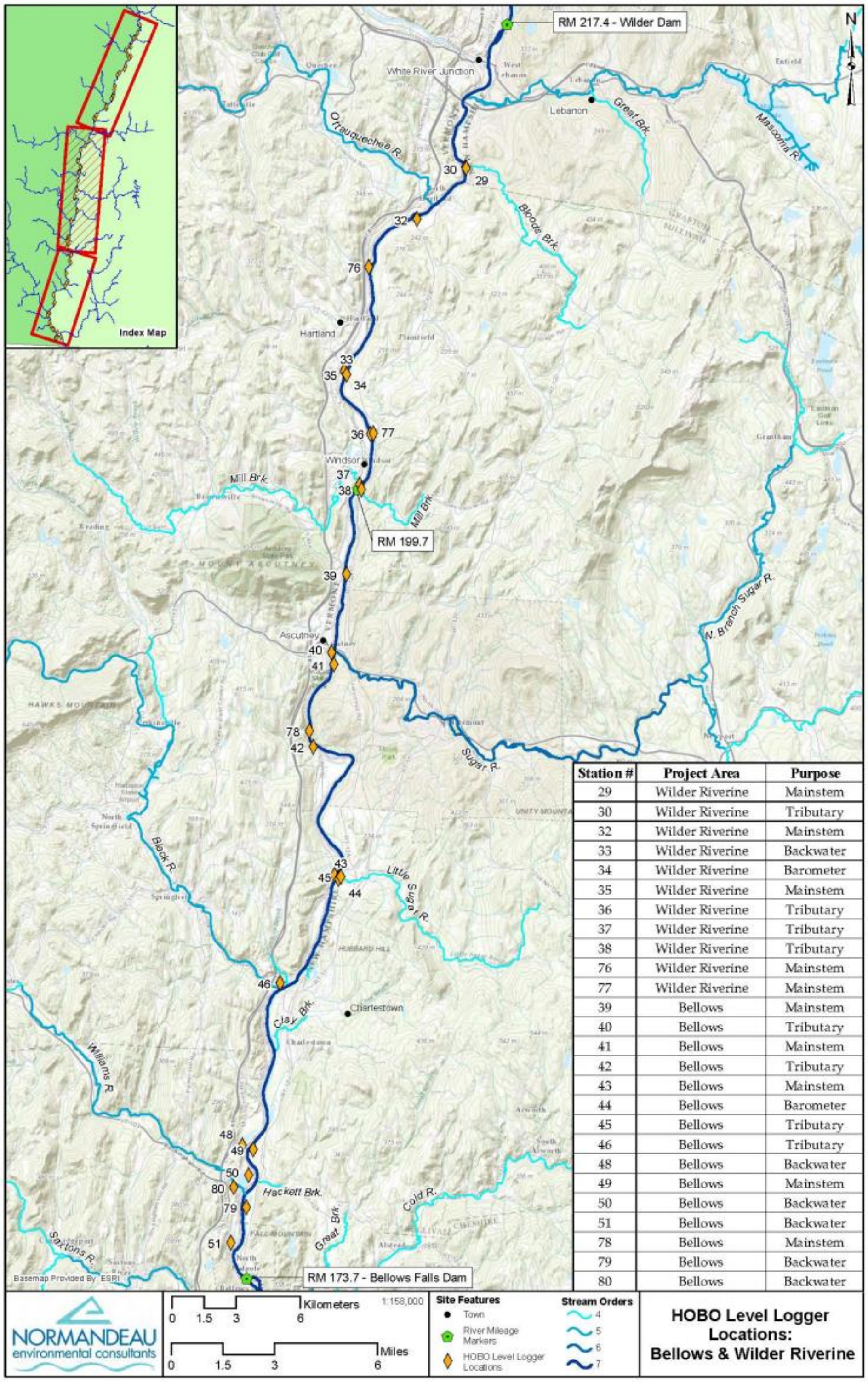
Table 8-4. Status of level loggers overwintered from 2013 to 2014.

Logger Station	Searched for July 2014	Found and Downloaded July 2014	Logger Installed July 2014	Logger Found and Downloaded October 2014	Logger Installed October 2014
2	Yes	Yes	Yes	Yes	Yes
26	Yes	Yes	Yes	Yes	Yes
29	Yes	Yes	Yes	Yes	Yes
32	Yes	No	Yes	No	Yes
49	Yes	Yes	Yes	Yes	Yes
53	Yes	No	Yes	No	Yes
56	No – diving aborted	-	No - original presumed still in place	No – original presumed lost	Yes
70	Yes	No	Yes	Yes	Yes
73	Yes	Yes	Yes	Yes	Yes



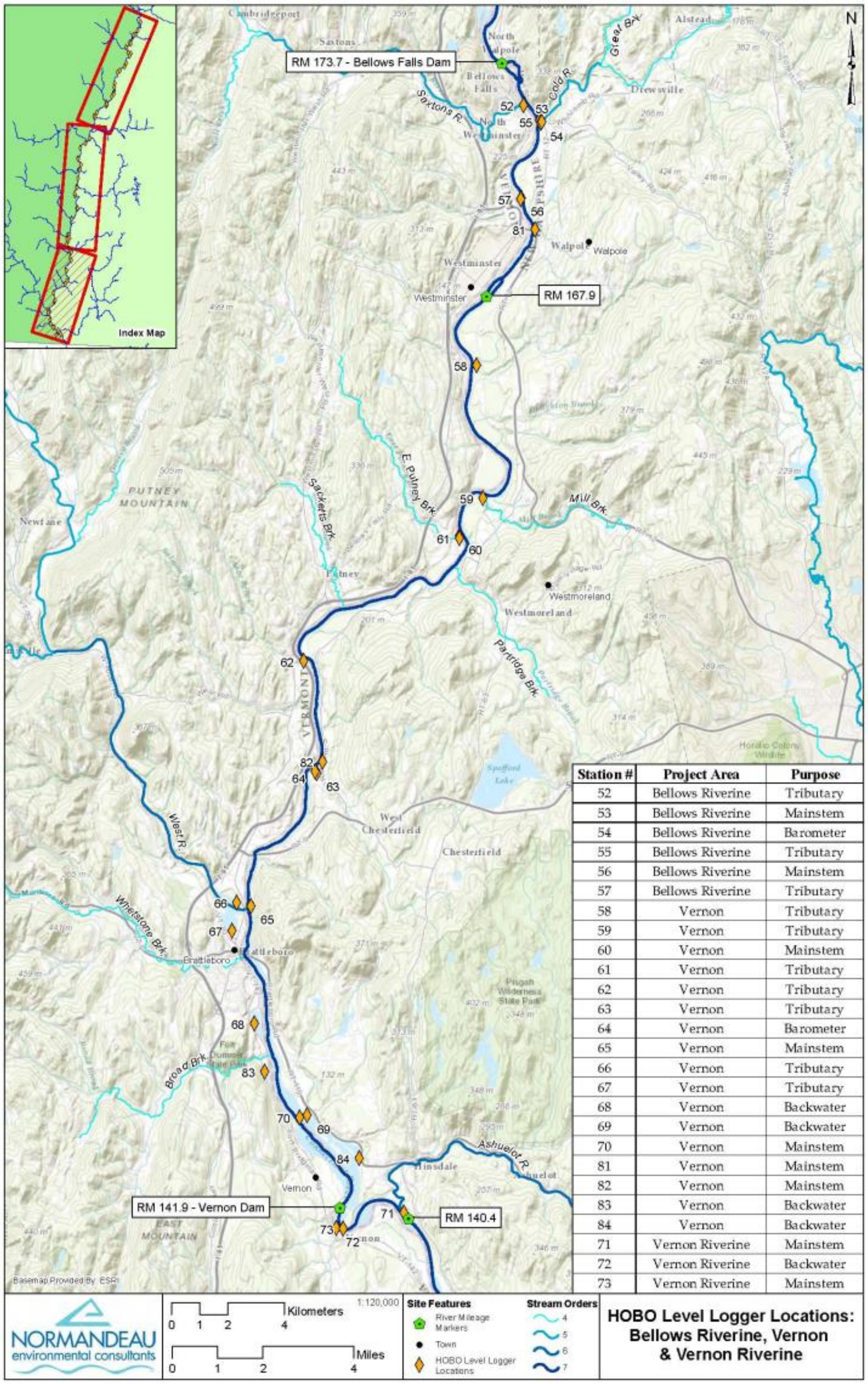
Station #	Project Area	Purpose
1	Wilder	Mainstem
2	Wilder	Mainstem
3	Wilder	Tributary
4	Wilder	Mainstem
5	Wilder	Mainstem
6	Wilder	Backwater
7	Wilder	Backwater
8	Wilder	Barometer
9	Wilder	Backwater
10	Wilder	Tributary
11	Wilder	Mainstem
12	Wilder	Mainstem
13	Wilder	Backwater
14	Wilder	Mainstem
15	Wilder	Backwater
16	Wilder	Backwater
17	Wilder	Mainstem
18	Wilder	Mainstem
19	Wilder	Mainstem
20	Wilder	Backwater
21	Wilder	Tributary
22	Wilder	Barometer
23	Wilder	Tributary
24	Wilder	Mainstem
25	Wilder	Backwater
26	Wilder	Mainstem
27	Wilder	Tributary
28	Wilder	Tributary
74	Wilder	Backwater

Figure 8-1. Installation locations of HOBO level loggers within the Wilder impoundment during July through November 2013.



Station #	Project Area	Purpose
29	Wilder Riverine	Mainstem
30	Wilder Riverine	Tributary
32	Wilder Riverine	Mainstem
33	Wilder Riverine	Backwater
34	Wilder Riverine	Barometer
35	Wilder Riverine	Mainstem
36	Wilder Riverine	Tributary
37	Wilder Riverine	Tributary
38	Wilder Riverine	Tributary
76	Wilder Riverine	Mainstem
77	Wilder Riverine	Mainstem
39	Bellows	Mainstem
40	Bellows	Tributary
41	Bellows	Mainstem
42	Bellows	Tributary
43	Bellows	Mainstem
44	Bellows	Barometer
45	Bellows	Tributary
46	Bellows	Tributary
48	Bellows	Backwater
49	Bellows	Mainstem
50	Bellows	Backwater
51	Bellows	Backwater
78	Bellows	Mainstem
79	Bellows	Backwater
80	Bellows	Backwater

Figure 8-2. Installation locations of HOBO level loggers within the riverine reach downstream of Wilder and Bellows Falls impoundment during July through November 2013.



Station #	Project Area	Purpose
52	Bellows Riverine	Tributary
53	Bellows Riverine	Mainstem
54	Bellows Riverine	Barometer
55	Bellows Riverine	Tributary
56	Bellows Riverine	Mainstem
57	Bellows Riverine	Tributary
58	Vernon	Tributary
59	Vernon	Tributary
60	Vernon	Mainstem
61	Vernon	Tributary
62	Vernon	Tributary
63	Vernon	Tributary
64	Vernon	Barometer
65	Vernon	Mainstem
66	Vernon	Tributary
67	Vernon	Tributary
68	Vernon	Backwater
69	Vernon	Backwater
70	Vernon	Mainstem
81	Vernon	Mainstem
82	Vernon	Mainstem
83	Vernon	Backwater
84	Vernon	Backwater
71	Vernon Riverine	Mainstem
72	Vernon Riverine	Backwater
73	Vernon Riverine	Mainstem

Figure 8-3. Installation locations of HOBO level loggers within the riverine reach downstream of Bellows Falls, Vernon impoundment, and riverine reach downstream of Vernon during July through November 2013.

Figure 8-4. Installation set-up used for HOBO level loggers.

9.0 DATA SETS

The completion of the data collection and processing of the 2013 data sets has resulted in work products available for application in other ILP studies that will conducted in 2014 and 2015. Content contained within the ArcGIS geodatabase file was provided to the aquatics working group at a May 23, 2014 consultation meeting, and is provided separately in association with this report. Data can be viewed using ArcGIS Explorer (a free program available online from ESRI). ArcGIS (version 10 or higher) is required to utilize the created layers beyond simple viewing.

9.1 Impoundment Data

The final work product consists of an ArcGIS geodatabase file for each of the three impoundments. Each geodatabase file is composed of six GIS layers. These layers are:

- *1ft-countours*: contains 1-ft contour lines for all mapped elevations (see Figure 5-4 for example)
- *Depths*: contains the measured depth points used in bathymetric interpolation process (see Figure 5-5 for example)
- *Full Pool*: contains line representing upper extent of mapped bathymetry (see Figure 5-6 for example)
- *Bathymetry*: contains impoundment bathymetry in raster format (see Figure 5-7 for example)
- *Water Line*: contains the “waterline” created by U.S. Imaging based on wetted area at the time of their aerial survey (see Figure 5-8 for example)
- *Habitat*: contains results of habitat mapping (see Figure 5-9 for example and Section 6.0 of this report for detailed information). The “habitat” layer contained in each geodatabase file contains all habitat polygons created based on sonar imagery.

9.2 Riverine Mesohabitat Data

The final work products for riverine segments and the Bellows Falls bypassed reach include:

- Excel spreadsheet of the habitat mapping database and summary.
- ArcGIS database and shape files of depth and mesohabitat type layers that were used to create the mesohabitat maps in Appendix B.

9.3 Level Logger Data

The level logger work product is a data set comprised of multiple variables including station ID, logger serial number, logger coordinates, logger elevation relative to project structures, date and time of reading, recorded water temperature, recorded sensor pressure, calculated sensor depth and use code. Level logger data was also collected at locations where equipment was overwintered in 2013/2014. Additional data will be collected in 2015 from level loggers overwintered in 2014/2015 and from other sites as part of the erosion studies and some aquatic studies.

Data available at this time (2013 Study 7 and 2013/2014 overwintered water level logger data) is incorporated into this Final Study Report as Attachments A - D to Volume I (Study 7 Final Study Report) of this March 2, 2015 FERC filing.

10.0 LITERATURE CITED

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Appendix A

2013 Riverine Aquatic Habitat Mapping Data

Table A-1. Wilder Reaches Habitat Mapping Data

Habitat Type[a]	Length (ft)	Maximum Depth (ft)	Average Depth (ft)	Substrate[b] Dom/Sub	Note
Pool	849	24.4	11.0	CB/GR	Below Wilder Dam
Riffle	125	3.4	3.2	CB/GR	
Pool	779	39.4	12.3	-----	
LC Run	854	7.7	5.1	GR/CB	First Island
LC Glide	783	10.3	5.2	CB/GR	
RC Run	1576	8.7	5.0	GR/SA	
Pool	1093	41.0	14.1	-----	
LC Run	730	5.8	4.2	BR/GR	Second Island
RC Run	992	10.4	5.7	CB/GR	
SC Run	345	6.0	5.0	BR/SA	Small Island SC
Pool	1880	15.1	7.8	SA/CB	
Glide	413	6.3	4.2	GR/CB	White River
					End Reach 1
Run/Riffle	407	4.8	3.8	GR/SA	
Run	643	8.0	5.5	GR/SA	
Riffle	277	5.2	4.8	GR/SA	
Run	977	6.7	5.1	GR/SA	
Glide	1702	7.8	5.0	CB/GR	
Pool	2291	11.8	6.8	SA/GR	
Pool	1858	16.4	8.6	-----	Mascoma River
Pool	654	39.6	22.0	-----	
Pool	705	26.4	13.3	-----	
Glide	823	7.5	4.1	CB/GR	
RC Riffle	195	-----	-----	CB/GR	Johnston Island RC
RC Run	694	9.2	5.1	CB/GR	
RC Riffle	677	2.1	1.7	CB/GR	
LC Riffle	511	3.9	3.1	CB/GR	Johnston Island LC
LC Run	445	3.5	2.8	-----	
LC Riffle	166	3.5	-----	CB/GR	
LC Pool	496	31.3	16.1	CB/GR	
LC Run	784	9.9	4.6	CB/GR	
SC Riffle	621	-----	-----	GR/SA	
SC Pool	189	-----	-----	SA/MUD	
Pool	1381	15.7	8.4	-----	
Pool	1076	10.2	6.4	BR/??	
Run/Pool	709	10	4.8	BR/CB	
Run	683	8.3	6.2	CB/GR	
Pool	1102	11	5.4	GR/CB	
Run/Glide	811	8.2	5.6	GR/CB	
Pool	686	13.2	7.1	CB/GR	
Run	534	10	6.6	CB/BD	Blood's Brook
Pool	1150	13.2	9.4	-----	

Habitat Type[a]	Length (ft)	Maximum Depth (ft)	Average Depth (ft)	Substrate[b] Dom/Sub	Note
Pool	4241	20.6	9.1	CB/ST	
Glide	414	7.5	4.1	CB/GR	
LC Run	673	9.6	8.0	CB/GR	Burnaps Island LC
LC Pool	580	9.4	7.1	GR/SA	
LC Pool	353	13.8	10.5	SA	
RC Run	644	7.7	6.4	CB/GR	Burnaps Island RC
RC Pool	528	8.2	5.1	-----	
Pool	1045	20.2	11.6	-----	Ottauquechee River
					End Reach 2
Pool	1682	17.6	8.5	-----	
Pool	736	13.9	5.8	-----	
Glide	488	7.8	5.9	CB/GR	Small SC RB
Pool	2711	15.6	6.2	-----	
Glide	3221	9.9	5.7	SA/GR	
Pool	2904	8.8	4.1	SA/SI	
Pool	970	9.1	6.4	SI/CB	
Run	549	7.0	-----	BR/CB	
Rapid	1284	-----	-----	BR	Sumner Falls
Pool	1361	31.6	12.7	SA/SI	BW Pool
Glide	973	10.6	3.9	CB/CB	
Pool	1589	8.0	5.4	CB/CB	
Glide	507	5.3	3.4	CB/GR	
Riffle	828	2.8	2.0	GR/CB	
Run/Glide	1152	10.9	4.9	CB/GR	
Riffle	548	2.0	-----	GR/CB	
Run	1286	9.8	4.8	GR/CB	
Pool	158	10.8	7.7	GR/SA	
Riffle	320	3.0	-----	GR/CB	
Run	455	4.3	3.3	CB/GR	
Glide	680	6.7	4.2	GR/CB	
Pool	302	7.9	6.0	CB/BD	
Pool	435	6.6	4.5	GR/CB	
Glide	1017	5.6	4.0	CB/GR	
Pool	3168	12.5	7.8	BD/CB	
Glide	871	5.6	3.9	CB	
RC Riffle	271	-----	-----	GR/CB	Hart Island RC
RC Run	579	-----	-----	SA/GR	Mapped at no flow
RC Pool	262	-----	-----	SA/SI	Habitat types assumed
RC Run	200	-----	-----	SA/GR	
RC Pool	987	-----	-----	SA/SI	
RC Run/Glide	383	-----	-----	GR/CB	
RC Riffle	173	-----	-----	GR/CB	
RC Run	228	-----	-----	GR/CB	
RC Glide	249	-----	-----	GR/SA	
RC Pool	369	-----	-----	SI/SA	

Habitat Type[a]	Length (ft)	Maximum Depth (ft)	Average Depth (ft)	Substrate[b] Dom/Sub	Note
LC Pool	296	8.6	6.4	-----	Hart Island LC
LC Glide	887	5.0	3.2	CB/GR	
LC Riffle	553	2.5	-----	CB/GR	
LC Pool	875	11.4	8.0	CB/GR	
LC Glide	211	6.6	4.4	CB/CB	
Riffle	201	3.9	3.1	CB/GR	
Riffle/Run	246	4.3	2.7	GR/CB	
Pool	1045	11.4	5.2	CB/SA/GR	
Glide	862	4.5	3.0	CB/SA/GR	
Riffle	88	-----	-----	CB/GR	
Run	340	7.2	5.2	CB/GR	
Pool	1380	17.5	6.5	GR/CB/SA	
Pool	505	10.2	5.8	CB/GR/SA	
Pool	964	12.9	6.2	CB/CB	
Glide	646	3.2	2.3	CB/GR	
Glide	374	3.1	2.1	GR/SA	
Glide	1686	4.9	3.4	CB/GR/SA	
Glide	381	5.0	4.2	GR/CB/SA	
Pool	583	7.2	5.0	CB/SA/GR	
Glide	1246	5.5	3.5	GR/CB/SA	
Pool	1033	8.0	5.0	GR/SA/CB	
Glide	390	5.2	3.8	GR/CB	
Pool	1206	12.9	6.4	GR/CB	
Pool	1066	6.3	4.0	GR/SA/CB	
Glide	881	4.7	3.1	GR/SA	
Pool	430	5.6	3.7	SA/GR	
Glide	1378	4.5	2.9	GR/SA	Cornish Boat Launch
Pool	1805	9.6	5.0	SA/GR/CB	
Pool	687	21.0	10.5	CB/SA	Covered Bridge
Glide	485	8.0	4.1	GR/CB	
Run	728	7.5	4.1	CB/GR	
Pool	953	11.5	7.0	SA/SI	
Glide	461	4.5	3.4	CB/GR/SA	
LC Riffle	356	-----	-----	GR/CB	Chase Island LC
LC Run	471	-----	-----	GR/SA	
LC Glide	256	-----	-----	GR/SA	
LC Pool	138	-----	-----	GR/SA	
LC Pool	1342	7.9	3.8	GR/SA	
RC Riffle	565	3.1	2.0	GR/SA/CB	Chase Island RC
RC Run	650	4.2	2.5	GR/CB	
RC Run	543	5.4	4.1	CB/GR	
RC Pool	1075	17.1	5.9	CB/SA/GR	
					End Reach 3

a RC = Right Channel, LC = Left Channel, SC = Side Channel
b Substrate codes from Table 7-1; Dom = Dominant, Sub= Sub-dominant

Table A-2. Bellows Falls Reach Habitat Mapping Data

Habitat Type[a]	Length (ft)	Maximum Depth (ft)	Average Depth (ft)	Substrate[b] Dom/Sub	Note
Pool	975	36.7	13.3	CB/GR	Below Dam
Glide	1392	20.3	5.4	GR/CB	
Run	513	13.0	7.2	CB/BD	Saxtons River
Glide	228	6.9	4.9	CB/GR	
Riffle	509	4.9	2.7	CB/GR	
Run	1536	9.9	4.8	CB	
Run	904	7.1	6.1	CB	Cold River
Pool	484	9.8	6.0	CB	
Glide	848	5.0	3.4	CB	
Run	919	8.0	5.5	CB/GR	
Pool	1003	9.4	5.6	GR/SA	
Glide	1374	7.3	4.5	GR/CB	
Pool	2793	29.6	8.9	GR/SA	
Pool	587	11.4	6.9	GR/SA	
Glide	200	4.5	4.3	GR/SA	
Run	576	5.0	3.2	CB/GR	
Pool	1942	13.8	6.3	GR/SA	
Glide	719	8.9	5.2	GR/CB	
SC Run	370	-----	-----	SA/GR	Side Channel
Pool	2414	16.7	9.9	CB/GR	
Pool	376	49.8	24.7	-----	Walpole Bridge
RC Run	161	3.2	-----	GR/SA	Island
RC Pool	213	5.5	-----	GR/SA	
RC Glide	550	2.3	-----	GR/SA	
LC Pool	886	9.8	6.4	GR/SA	
Glide	481	5.4	3.1	GR/SA	
Glide	699	5.2	3.7	GR/CB	
Pool	860	8.4	4.2	GR/SA	
Pool	2995	8.8	6.1	GR/CB	
Pool	820	8.7	5.4	GR/SA	
RC Pool	1613	7.3	5.1	GR/SA	Dunshee Island RC
RC Pool	702	8.2	6.5	SA/GR	
LC Pool	1192	5.0	3.1	GR/SA	Dunshee Island LC
LC Pool	1114	8.9	5.9	-----	End of Reach
Pool	3712	14.5	8.7	SI/SA	Vernon Impoundment Influence

[a] RC = Right Channel, LC = Left Channel, SC = Side Channel
[b] Substrate codes from Table 7-1; Dom = Dominant, Sub= Sub-dominant

Table A-3. Bellows Falls Bypassed Reach Habitat Mapping Data

Habitat Type[a]	Length (ft)	Maximum Depth (ft)	Average Depth (ft)	Substrate[b] Dom/Sub	Note
Start	-----	-----	-----	-----	Base of Dam
Pool	553	-----	-----	BD/BR	
Run	201	-----	-----	BD/BR	
Riffle	51	-----	-----	BD/BR	
Riffle	193	-----	-----	BD/CB	
Run	127	-----	-----	BD/CB	Corner
Riffle	88	-----	-----	BD/CB	
Pool	258	-----	-----	BD/CB	
Run/Riffle	119	-----	-----	BD/CB	Corner
Pool	606	-----	-----	BD/BR	
Fish Barrier	98	-----	-----	-----	Cascade
Pool	242	-----	-----	BD/BR	
Pool	180	-----	-----	BD/BR	
Pool	164	-----	-----	BD/BR	Trench Pool
Pool	449	-----	-----	BD/BR	
Run	191	-----	-----	BD/BR	
BW Pool	372	-----	-----	BD/CB	
					End of Reach

[b] Substrate codes from Table 7-1; Dom = Dominant, Sub= Sub-dominant

Table A-4. Vernon Reach Habitat Mapping Data

Habitat Type[a]	Length (ft)	Maximum Depth (ft)	Average Depth (ft)	Substrate[b] Dom/Sub	Note
SC Pool	370	-----	-----	GR/CB	SC at top of reach
SC Run/Riffle	354	-----	-----	CB/GR	Mapped at low flow
SC Run	193	-----	-----	CB/GR	Channel all Run
SC Riffle	71	-----	-----	CB/GR	at Higher Flows
SC Pool	720	9.2	6.6	SA/BR	
Pool Below Dam	-----	-----	-----	-----	Start at Control
Run	493	21.2	5.7	CB/GR	
Run	468	15.6	9.6	CB/GR	
Pool	1147	44.9	19.6	SA	
Pool	506	38.5	23.3	SA	
Glide	354	11.4	9.1	CB	
RC Pool	276	15.5	13.1	-----	Stebbins Island RC
RC Run	382	-----	-----	CB/GR	
RC Pool	1476	27.2	14.0	SA	
RC Run	563	7.7	5.5	CB/GR	
RC Pool	742	6.2	4.5	-----	
LC Run	693	10.2	7.7	GR/CB	Stebbins Island LC
LC Glide	713	6.8	6.1	GR/SA	
LC Run	671	14.2	7.5	-----	
LC Glide	634	7.7	5.6	GR/SA	
LC Pool	978	11.8	7.7	GR/SA	
					End of Reach

[a] RC = Right Channel, LC = Left Channel, SC = Side Channel
[b] Substrate codes from Table 7-1; Dom = Dominant, Sub= Sub-dominant

Appendix B

2013 Aquatic Mesohabitat Maps

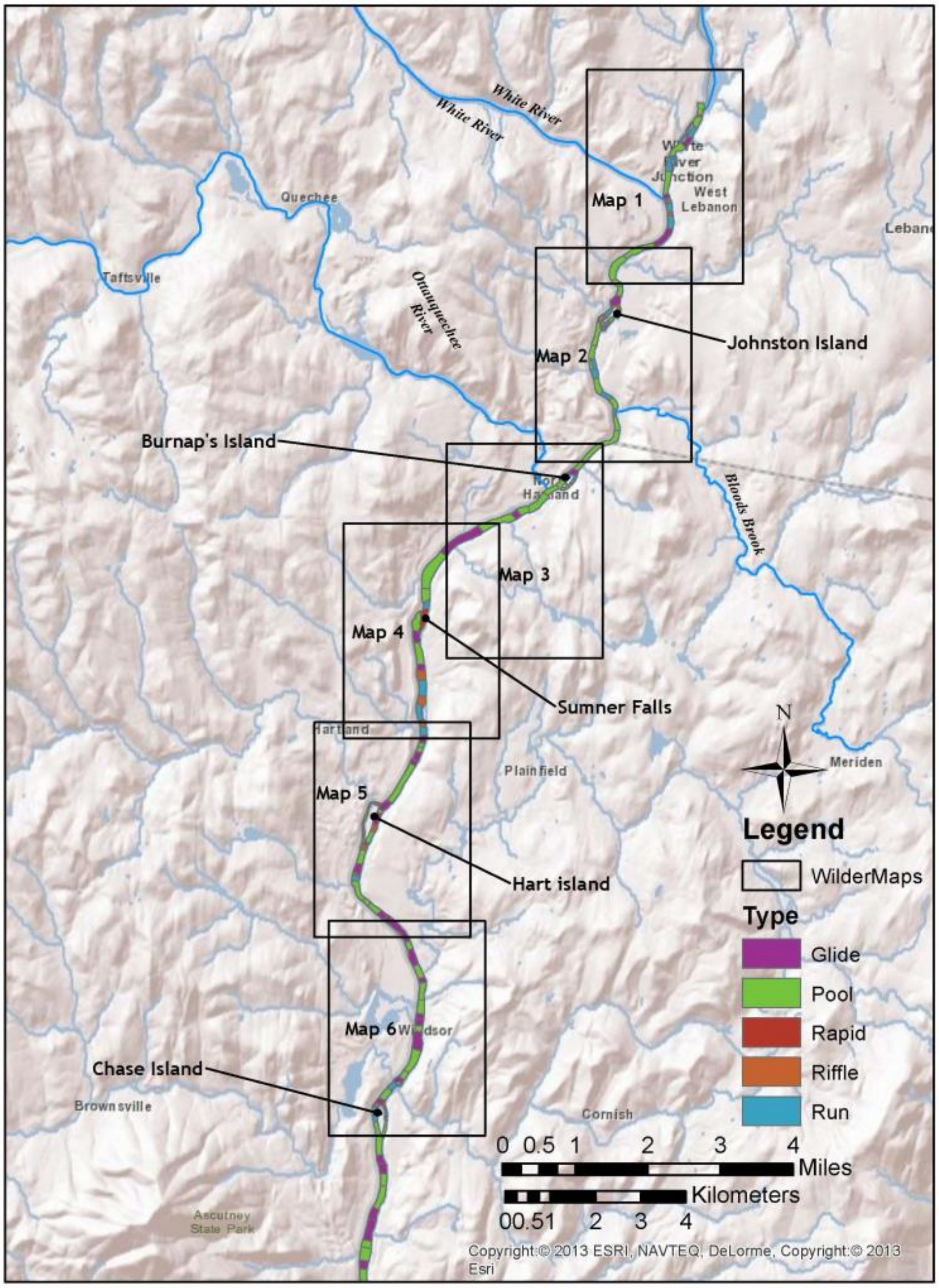

Figure B.1. Wilder riverine segment aquatic habitat mapping index.

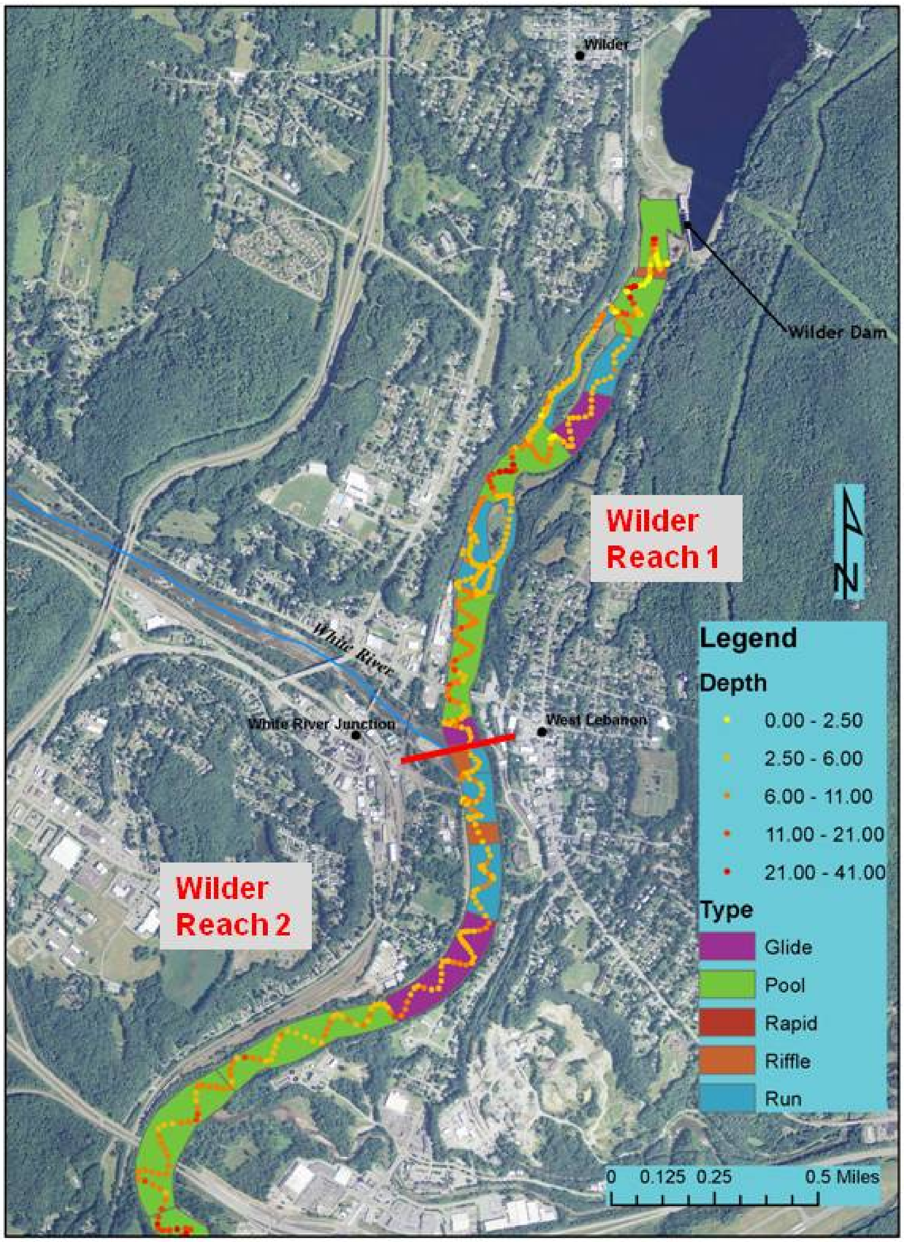

Figure B.2. Wilder Map 1, Wilder reach 1 and 2.

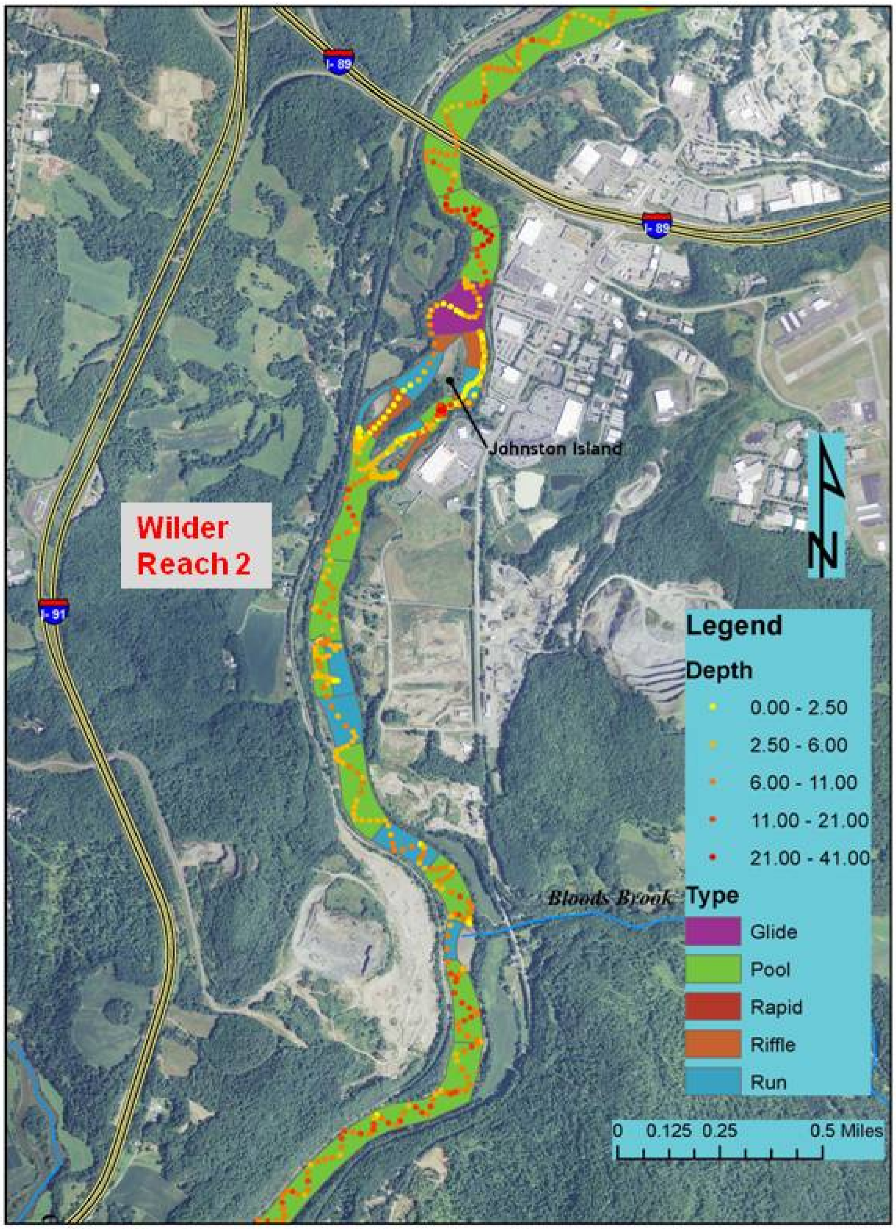

Figure B.3. Wilder Map 1, Wilder reach 2.

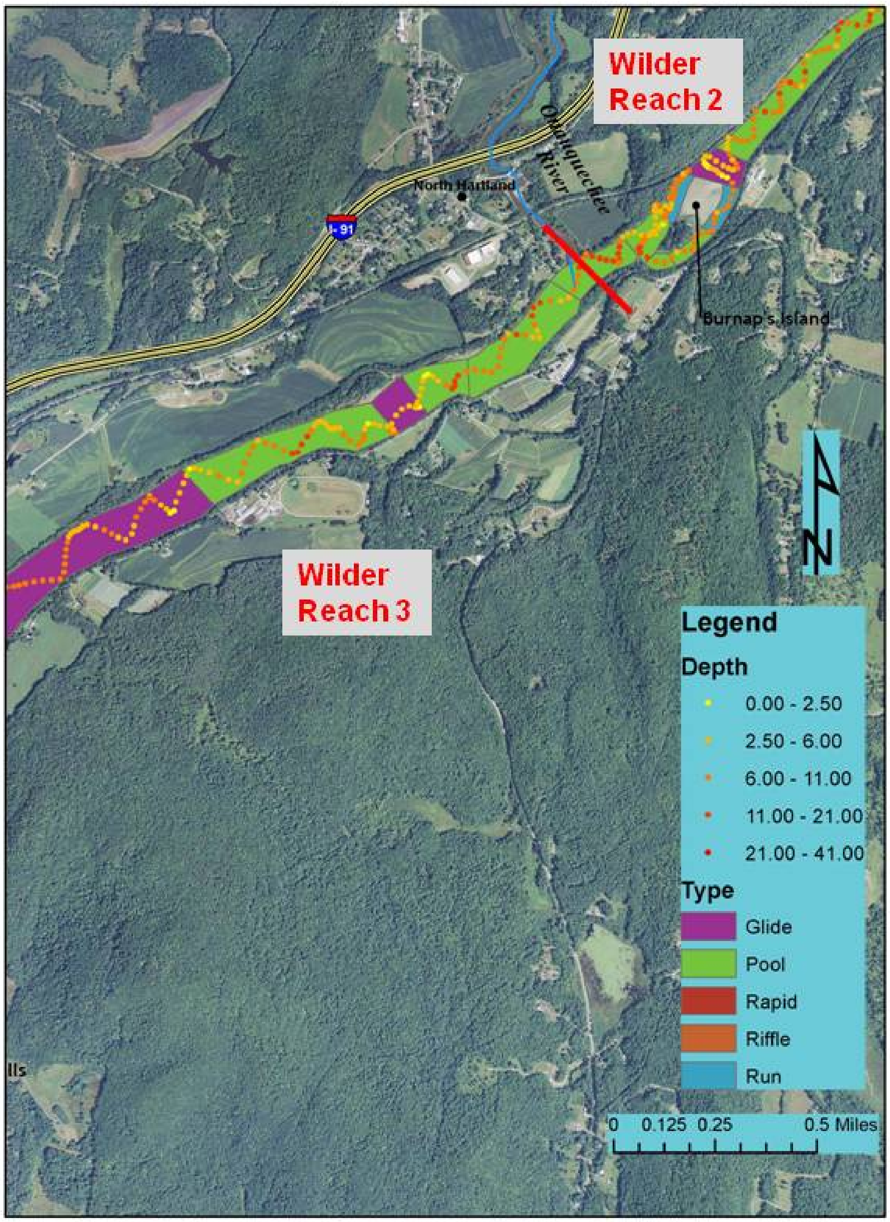

Figure B.4. Wilder Map 1, Wilder reach 2 and 3.

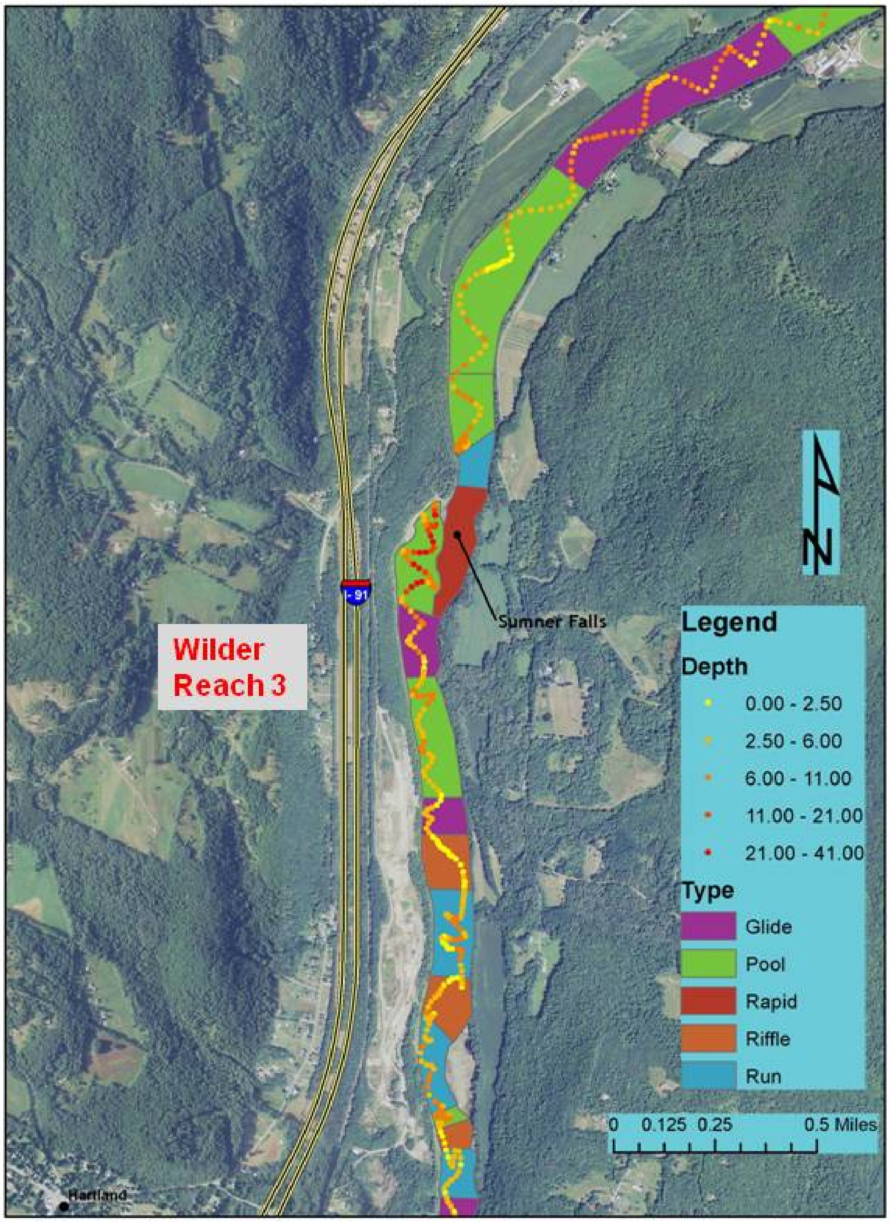

Figure B.5. Wilder Map 1, Wilder reach 3.

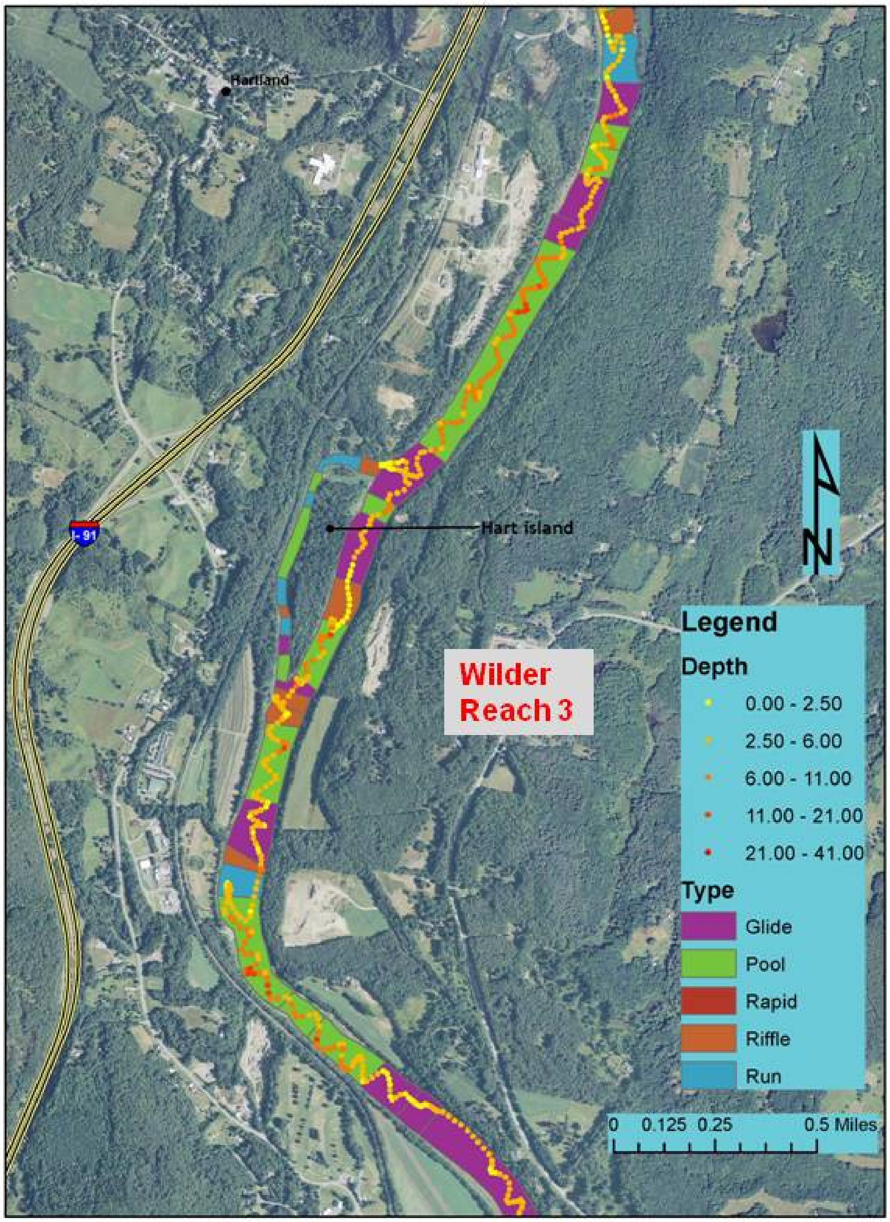

Figure B.6. Wilder Map 1, Wilder reach 3.

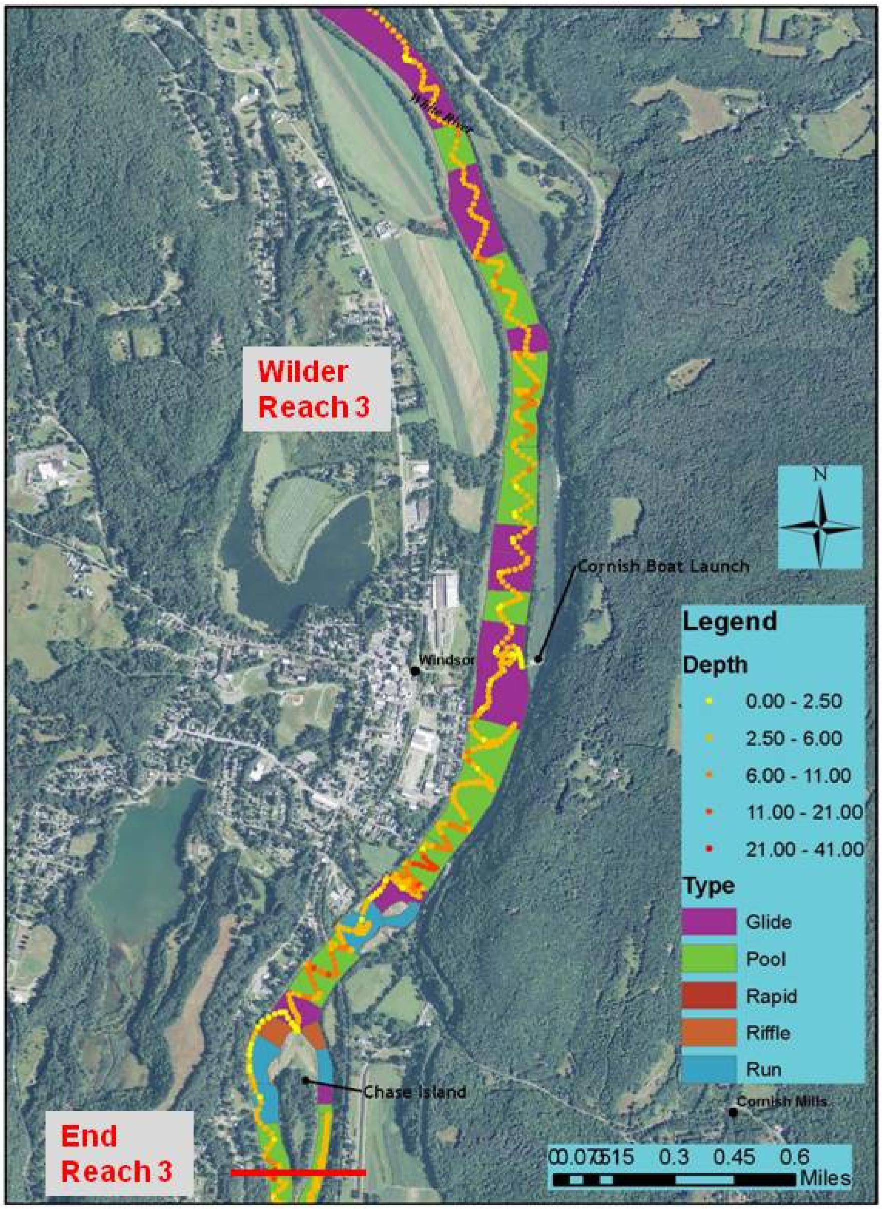

Figure B.7. Wilder Map 1, Wilder reach 3.

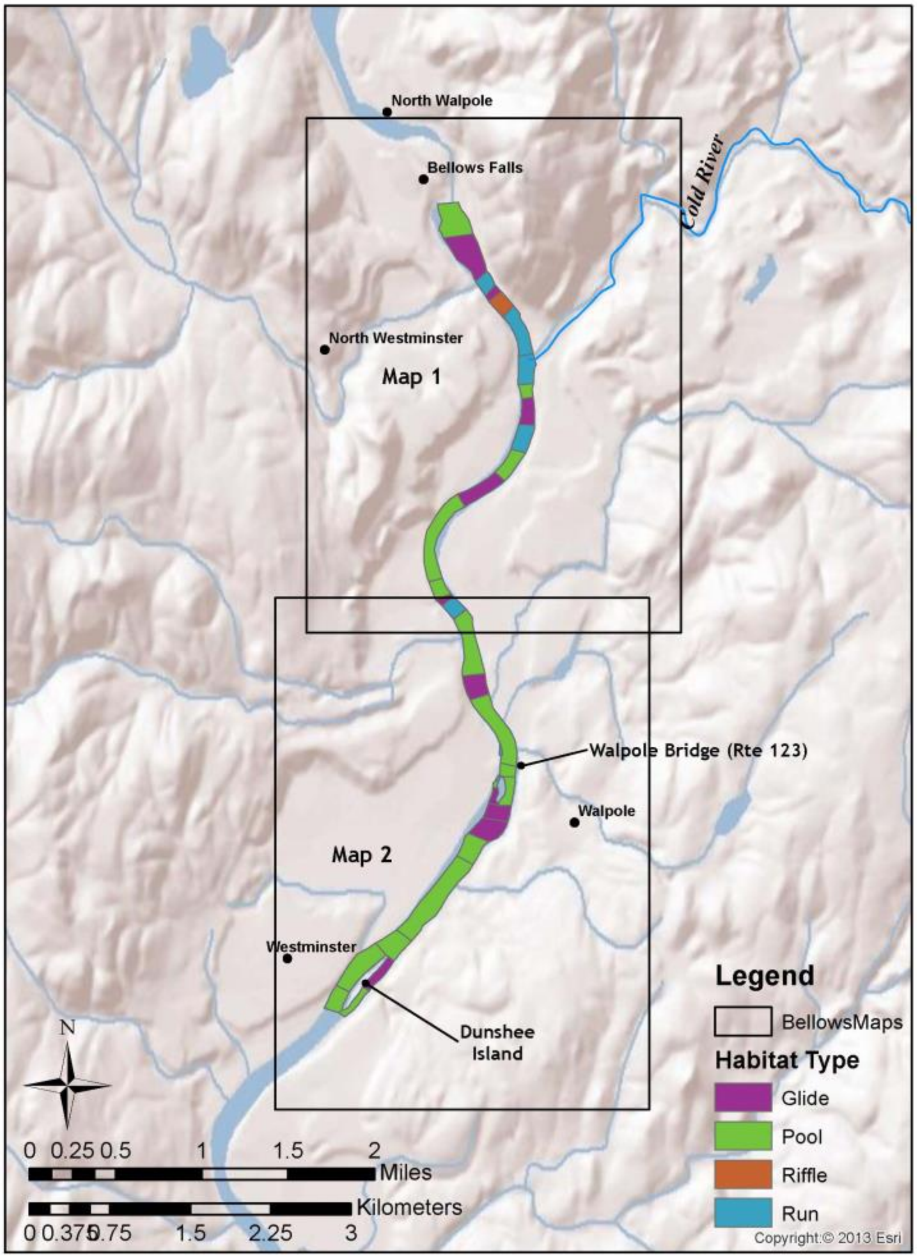

Figure B.8. Bellows Falls reach aquatic habitat mapping index.

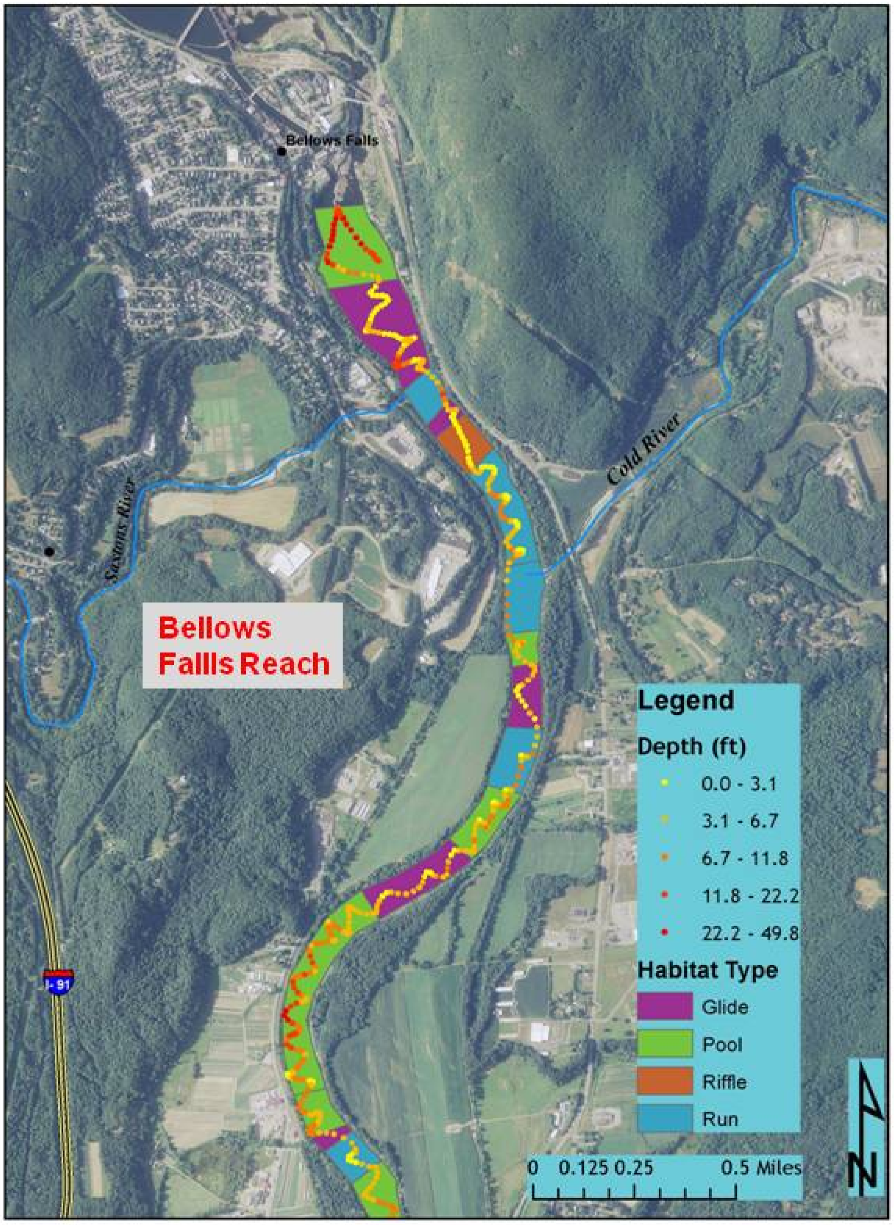

Figure B.9. Bellows Falls Map 1.

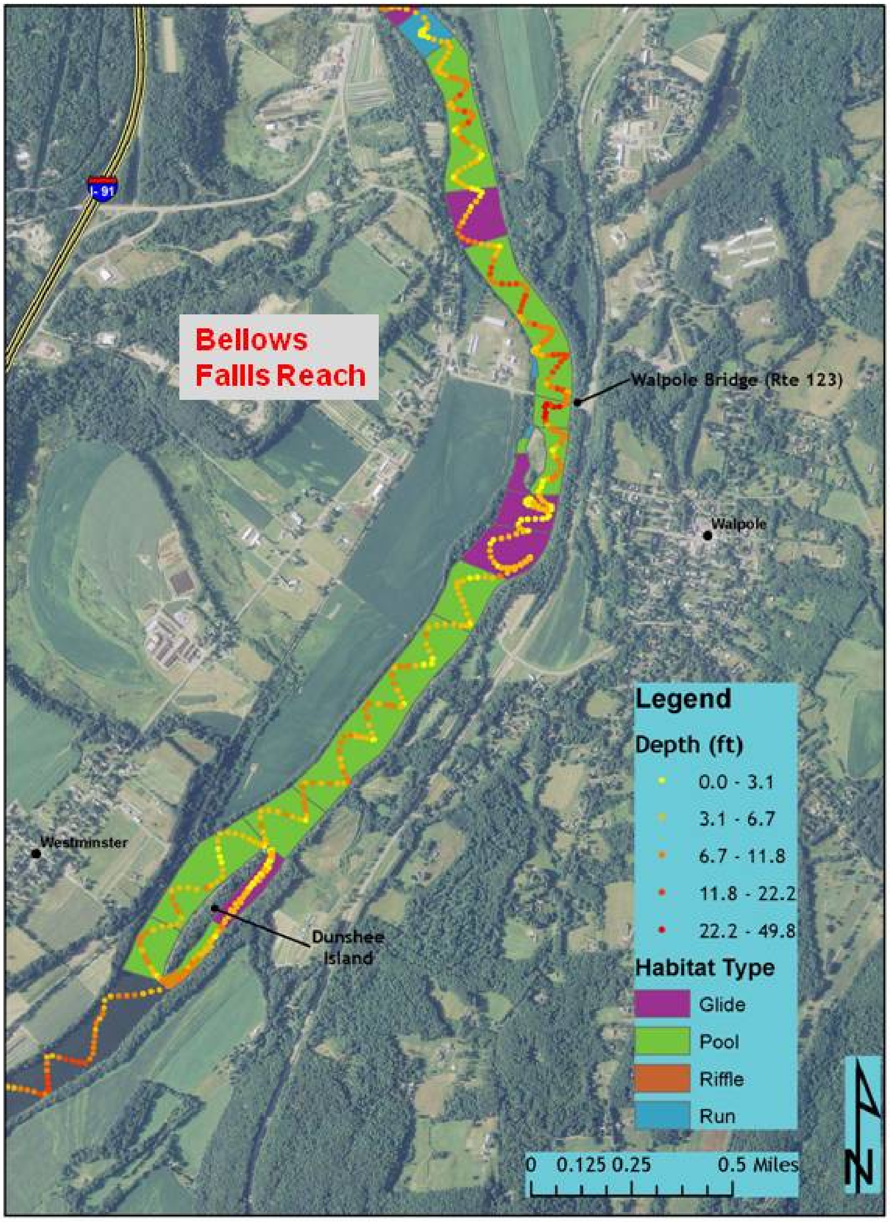

Figure B.10. Bellows Falls Map 2.

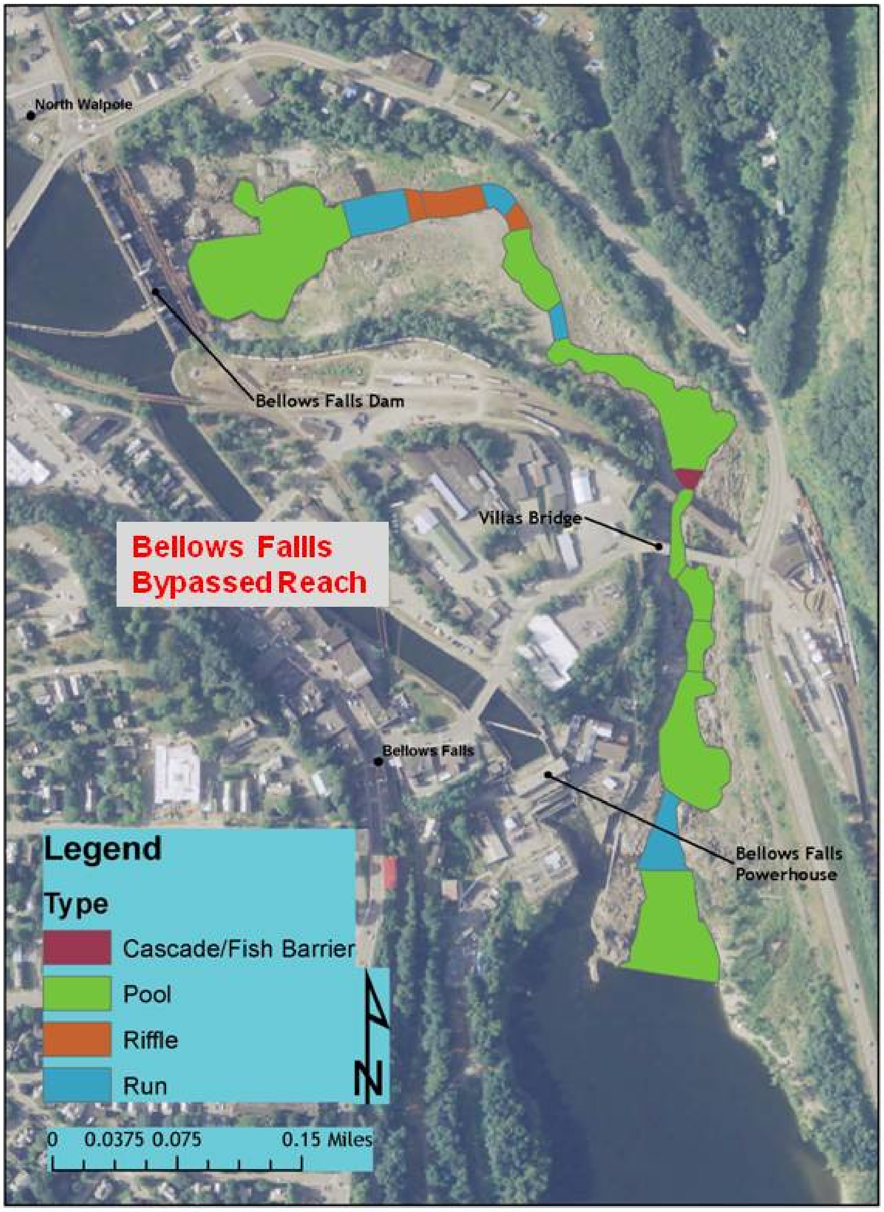

Figure B.11. Bellows Falls Bypassed reach.

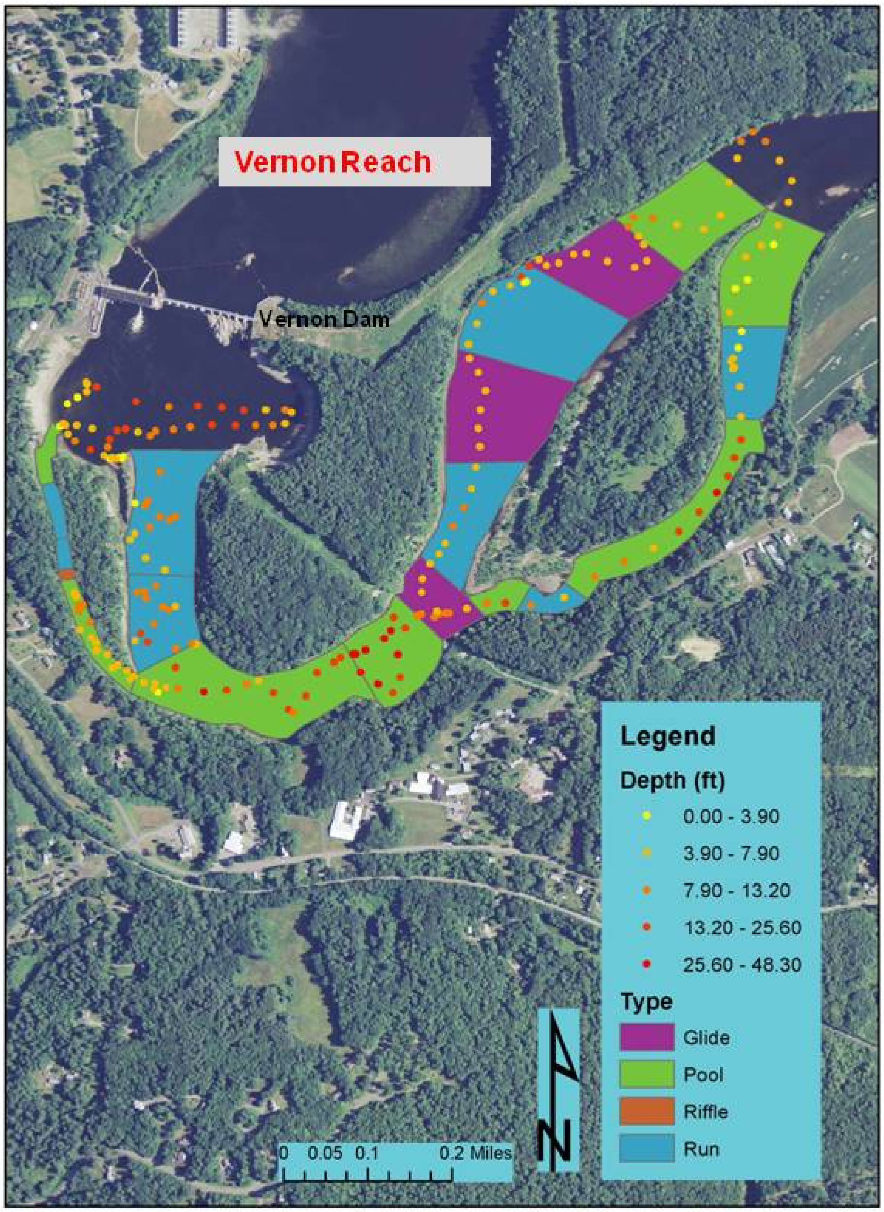

Figure B.12. Vernon reach.

Appendix C

2013 Aquatic Habitat Mapping Photos

Photo 1. Wilder Reach 1; upstream view of Wilder dam (to right) at ~1,000 cfs.

Photo 2. Wilder Reach 1; 1st island below Wilder dam, right channel at ~1,000 cfs.

Photo 3. Wilder Reach 2; Upstream view of right channel Johnston Island at ~5,000 cfs.

Photo 4. Wilder Reach 2; Bloods Brook cobble bar at ~9,500 cfs, right bank.

Photo 5. Wilder Reach 2; Blood's Brook bar at ~9,500 cfs, left bank

Photo 6. Wilder Reach 3; Upper Sumner Falls at ~9,500 cfs


Photo 7. Wilder Reach 3; Upper Sumner Falls at ~5,000 cfs


Photo 8. Wilder Reach 3; Upper Sumner Falls at ~1,500 cfs.

Photo 9. Wilder Reach 3; Lower Sumner Falls at ~5,000 cfs.

Photo 10. Wilder Reach 3; Lower Sumner Falls at ~1,500 cfs

Photo 11. Wilder Reach 3; Riffle ~0.8 miles downstream of Sumner Falls.

Photo 12. Wilder Reach 3; Hart Island bar at entrance to right channel at ~1,500 cfs


Photo 13. Wilder Reach 3; Hart Island right channel at ~1,500 cfs, upstream.


Photo 14. Wilder Reach 3; Hart Island right channel at ~1,500 cfs, downstream.

Photo 15. Bellows Falls Reach; Saxtons River bar at ~2,000 cfs.

Photo 16. Bellows Falls Reach; Cold River bar at ~3,500 cfs.

Photo 17. Bellow Falls Reach; Riffle downstream of Saxtons River ~3,500 cfs.

Photo 18. Bellows Falls Reach; Dry side channel upstream of Walpole Bridge at ~3,500 cfs.

Photo 19. Bellows Falls Reach; Dry side channel upstream of Walpole Bridge at ~3,500 cfs.

Photo 20. Bellows Falls Reach; Right channel of unnamed island downstream of Walpole Bridge at ~3,500 cfs

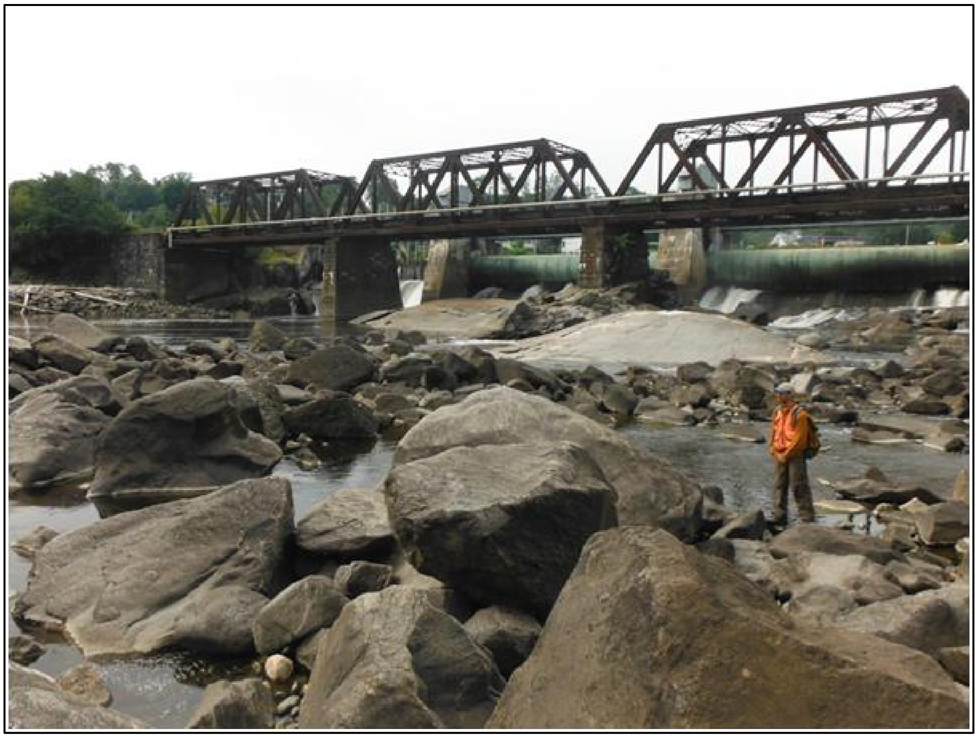

Photo 21. Bellows Falls Bypassed Reach; below dam.

Photo 22. Bellows Falls Bypassed Reach; pool downstream of dam.

Photo 23. Bellows Falls Bypassed Reach; run riffle section downstream of dam.

Photo 24. Bellows Falls Bypassed Reach; pool immediately upstream of fish barrier and cascade.

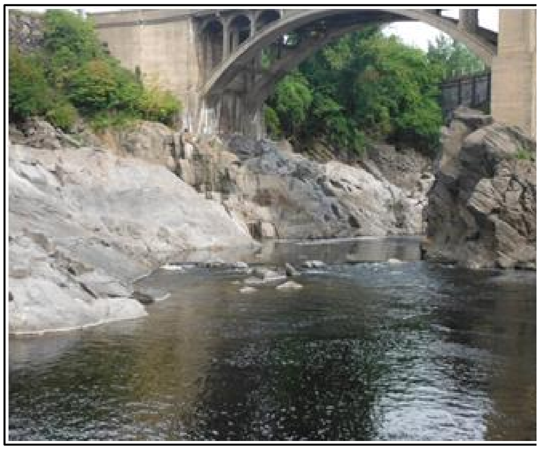

Photo 25. Bellows Falls Bypassed Reach; right and left channels under Vilas Bridge (top stadia rod 25 feet).

Photo 26. Bellows Falls Bypassed Reach; looking upstream right channel toward fish barrier from Vilas Bridge.

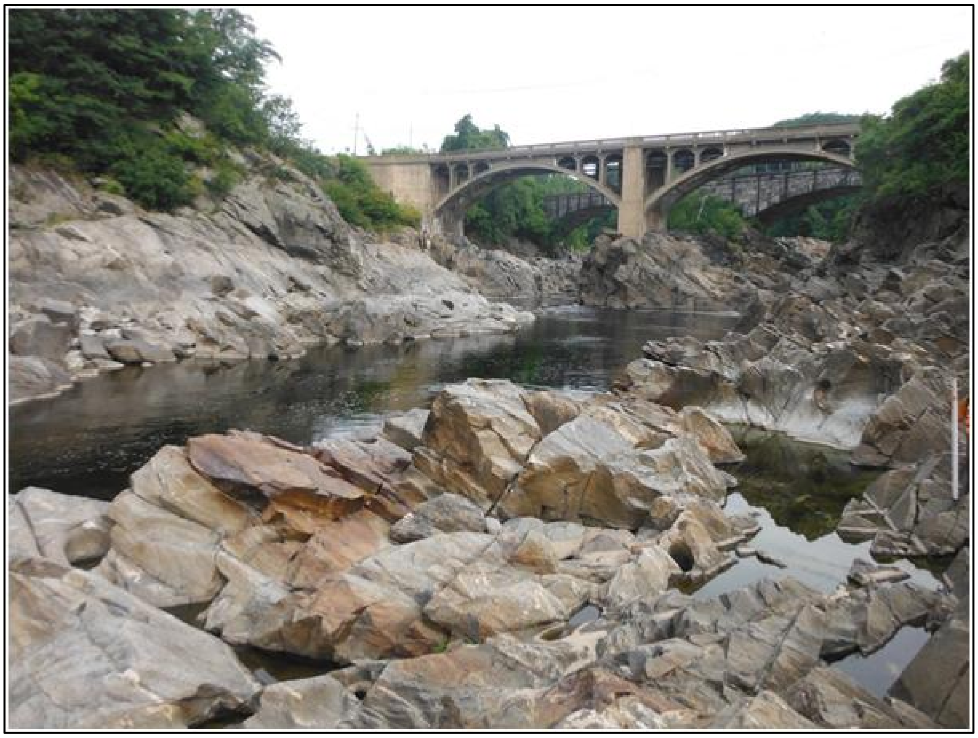

Photo 27. Bellows Falls Bypassed Reach; looking upstream toward Vilas Bridge.

Photo 28. Bellows Falls Bypassed Reach; looking downstream from Vilas Bridge.


Photo 29. Vernon Reach; upstream view of dam and pool at ~3,500 cfs.


Photo 30. Vernon Reach; downstream view from downstream end of pool below dam at ~3,500 cfs.

Photo 31. Vernon Reach; downstream view of side channel near top of reach at ~3,500 cfs.

Photo 32. Vernon Reach; downstream view of side channel near top of reach at ~9,600 cfs.