RELICENSING STUDY 3.3.14

AQUATIC HABITAT MAPPING OF TURNERS FALLS IMPOUNDMENT

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

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EXECUTIVE SUMMARY

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

FERC issued its first study plan determination letter (SPDL) for the Northfield Mountain and Turners Falls Projects on September 13, 2013, which did not address Study No. 3.3.14 *Aquatic Habitat Mapping of the Turners Falls Impoundment*. FERC issued its second SPDL on February 21, 2014, approving the Revised Study Plan (RSP) for Study No. 3.3.14 with no modifications.

The study produced habitat mapping and accompanying characterization of aquatic mesohabitat regarding the character and extent of aquatic habitat that may potentially be affected by Project operation (i.e., Turners Falls Impoundment (TFI) fluctuations).

The study included two phases. Phase 1 delineated dominant TFI littoral zone habitats, and quantified their abundance and spatial distribution. Phase 2 used transects to provide surveyed elevation of bed slope, substrate, and cover information that can be used in conjunction with Study No 3.2.2 *Hydraulic Study of the Turners Falls Impoundment* to assess the effect of Project operations on TFI aquatic habitat.

The impoundment is composed of two distinctly different geomorphic reaches.

The *upstream reach* extends downstream a distance of approximately 13 miles, from below a point about 1 mile below the Vernon Dam[1] tailrace area to the vicinity of the Northfield Mountain Project tailwater. This reach is relatively uniform and located within a broad floodplain. There are a few narrow islands comprised of alluvial materials such as gravel, cobble and fines. The *downstream reach* extends from the Northfield Mountain Project tailrace approximately five miles to the Turners Falls Dam, and is dominated by bedrock, which controls much of the stream geometry and substrate features. The lower reach impoundment geometry is complex. It is defined by both bedrock and depositional features, and includes a complex of embayment, points, coves, islands, and a wide range of substrates, and features shallow lacustrine littoral habitat with a deeply incised thalweg, in contrast to the riverine TFI habitat found further upstream in the study area.

A total of eight (8) distinct littoral habitats were identified based on substrate. Littoral zone substrates composed of fines and cobble collectively accounted for about 50% of all littoral substrate. Bedrock and gravel were the next most common substrates. Wetlands occurred as isolated pockets in the upstream reach and as larger fringes in the lower reach particularly in areas of embayments where fine substrates accumulate.

A total of 14 transects were surveyed including seven (Transects 1-7) transects in the upper reach, and seven (Transects 8-14) in the lower reach. Transects varied in length depending on the steepness of the slope between the headpin and minimum water level elevation. Long transects were required to document the fluctuation zone in several embayed areas with large shoals.

In addition to this Aquatic Habitat Mapping study, FirstLight is conducting Study No. 3.3.13 *Impacts of the Turners Falls Project and Northfield Mountain project on Littoral Zone Habitat and Spawning Habitat* (Littoral Zone Study). One of the goals of the Littoral Zone Study is to evaluate the impact of project operations, specifically water level fluctuations, on the littoral zone. The third bullet listed under Study

[1] The Vernon Hydroelectric Project is located above the upstream end of the Turners Falls Impoundment. Based on fluvial-geomorphic indicators, the first mile downstream from the Vernon Dam is lotic rather than lentic

Goals and Objectives for the Littoral Zone Study states "Evaluate the potential impacts of impoundment fluctuations on nest abandonment, spawning fish displacement and egg dewatering".

Because the Littoral Zone study will include an evaluation of the impact of water level fluctuations on habitat and the littoral zone, this document provides a baseline inventory of the habitat conditions mapped in the Turners Falls Impoundment. As part of the impact analysis, FirstLight will rely heavily on the hydraulic model developed as part of Study No. 3.2.2 *Hydraulic Model of the Turners Falls Impoundment, Bypass Rach and below Cabot*.

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cfs	cubic feet per second
EAV	Emergent Aquatic Vegetation
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
GIS	Geographic Information System
ft	feet
ILP	Integrated Licensing Process
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
PAD	Pre-Application Document
PSP	Proposed Study Plan
RSP	Revised Study Plan
RTK-GPS	Real-Time Kinematic-Global Positioning System
SAV	Submerged Aquatic Vegetation
SD1	Scoping Document 1
SD2	Scoping Document 2
SPDL	Study Plan Determination Letter
TFI	Turners Falls Impoundment
VY	Vermont Yankee Nuclear Power Plant
WSEL	water surface elevation
WSP	water surface profile

1 INTRODUCTION

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

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

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

On August 27, 2013 Entergy Corp. announced that the Vermont Yankee Nuclear Power Plant (VY), located on the downstream end of the Vernon Impoundment on the Connecticut River and upstream of the FirstLight Projects, was to close no later than December 29, 2014. With the closure of VY, certain environmental baseline conditions were anticipated to change during the relicensing study period. On September 13, 2013, FERC issued its first Study Plan Determination Letter (SPDL) in which many of the studies were approved or approved with FERC modification. However, due to the impending closure of VY, FERC did not act on 19 proposed or requested studies pertaining to aquatic resources. RSP Study No. 3.3.14 *Aquatic Habitat Mapping of Turners Falls Impoundment* was one of the studies that FERC did not act upon. The SPDL for these 19 studies was deferred until after FERC held a technical meeting with stakeholders on November 25, 2013 regarding any necessary adjustments to the proposed and requested study designs and/or schedules due to the impending VY closure. FERC issued its second SPDL on the remaining 19 studies on February 21, 2014, approving the RSP with certain modifications. Relative to Study No. 3.3.14, FERC approved the RSP without any modifications.

1.1 Study Goals and Objectives

Per the RSP, the purpose of the study is to map the distribution and abundance of aquatic habitat within the Turners Falls Impoundment (TFI) in the Connecticut River, evaluate the types of aquatic habitats that occur there, and identify any potential effects of operations of the Turners Falls Project and Northfield Mountain Project on this habitat. The habitat mapping and accompanying characterization of aquatic mesohabitat will provide essential information regarding the character and extent of aquatic habitat that may potentially be affected by Project operation. The quantified spatial data generated by this survey will help to provide a framework for upcoming data analysis efforts relative to operations and impoundment modeling.

In addition to this Aquatic Habitat Mapping study, FirstLight is conducting Study No. 3.3.13 *Impacts of the Turners Falls Project and Northfield Mountain project on Littoral Zone Habitat and Spawning Habitat* (Littoral Zone Study). One of the goals of the Littoral Zone Study is to evaluate the impact of project operations, specifically water level fluctuations, on the littoral zone. The third bullet listed under Study

Goals and Objectives for the Littoral Zone Study states "Evaluate the potential impacts of impoundment fluctuations on nest abandonment, spawning fish displacement and egg dewatering".

Because the Littoral Zone study will include an evaluation of the impact of water level fluctuations on habitat and the littoral zone, this document provides a baseline inventory of the habitat conditions mapped in the TFI. As part of the impact analysis, FirstLight will rely heavily on the hydraulic model developed as part of Study No. 3.2.2 *Hydraulic Model of the Turners Falls Impoundment, Bypass Rach and below Cabot*.

1.2 Survey Area

Shown in Figure 1.2-1 is the littoral zone study area of the TFI, which extends from approximately one mile below the Vernon Dam to just upstream of the Turners Falls Dam.

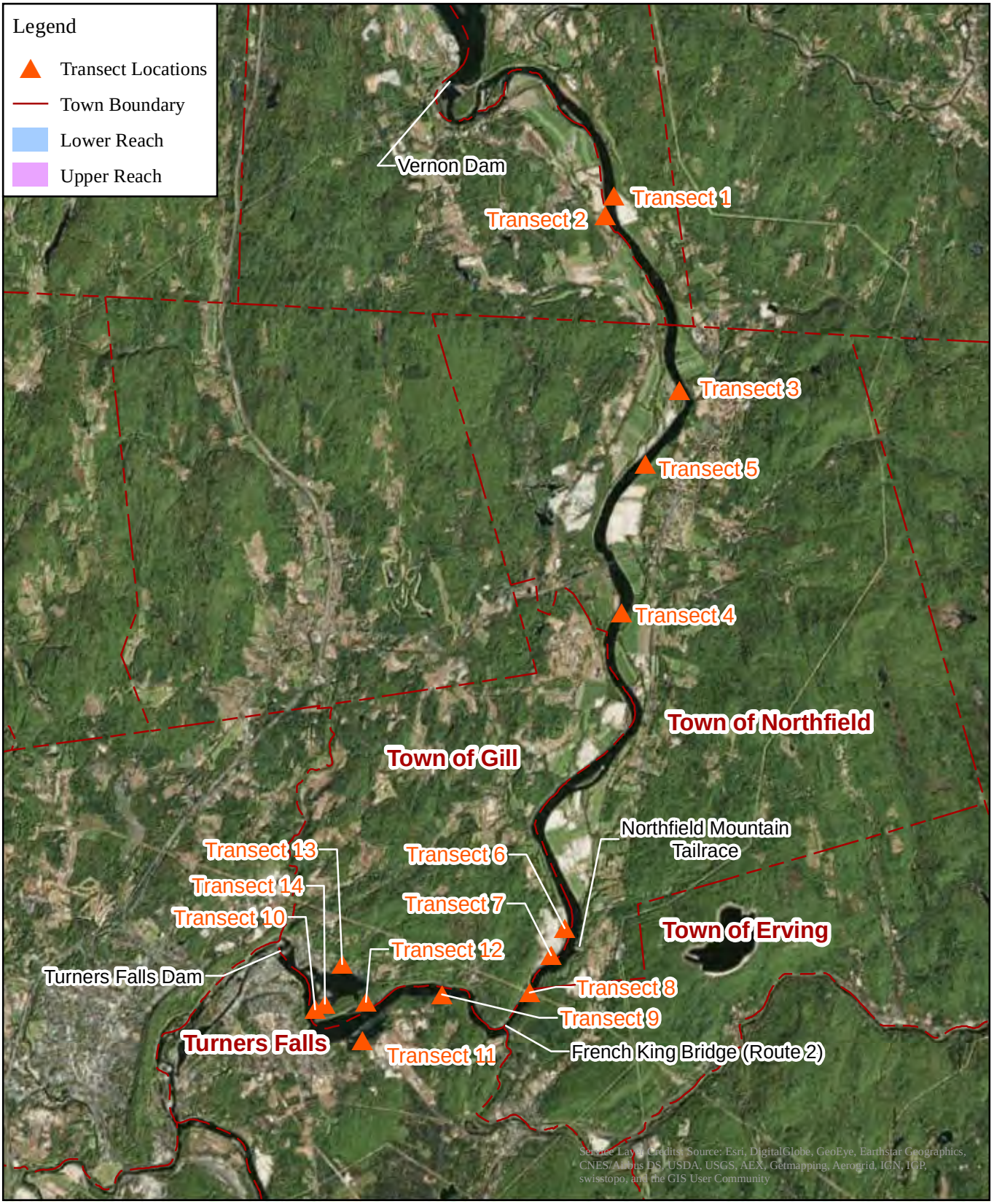
The distribution and abundance of littoral aquatic habitat was mapped within the TFI in two phases. During the first phase, major habitat and shoreline substrate types were classified, and during the second phase detailed microhabitat data were collected at representative transects.

1.3 Vertical Datum

Note that the datum used in this study is the National Geodetic Vertical Datum of 1929 (NGVD29). Although a more up-to-date datum is available[2], FirstLight has used the NGVD29 datum in reporting dam elevation data, water level data, etc. over numerous years. Thus, all water level data discussed in this report is based on the NGVD29 datum.

Note: All figures and larger tables appear at the end of each Section.

[2] NAVD88- North American Vertical Datum of 1988 (NAVD88).



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

Figure 1.2-1. Turners Falls Impoundment Aquatic Habitat Littoral Zone Study Area

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2 METHODS

2.1 Data Collection

2.1.1 Delineation of Major Aquatic Habitats

Delineation of major aquatic habitats in the TFI was conducted by boat, and occurred from August 25-28, 2014. The survey boat traveled the length of the TFI parallel to both shores so that the littoral zone could be qualitatively observed along both shorelines. The field crew recorded major aquatic habitat attributes such as substrate, cover type, cover density, depth and geo-referenced upstream and downstream boundaries with a Trimble geo XH 6000 with sub-meter accuracy. A Garmin EchoMap depth sounder mounted to the boat was used to monitor depth. A boundary was placed where a pronounced change in substrate and/or depth/slope occurred. Waypoints were also collected at key cover nodes such as major boulder outcrops and submerged aquatic vegetation (SAV) beds. Substrates were defined according to Wolman (1954) (Table 2.1-1). The data were recorded in a dedicated field book, a Trimble GPS, and on ortho maps. These data were then used to plan for transect placement, based on littoral habitat patterns.

Table 2.1-1. TFI Littoral Zone Survey Substrate Classification (Wolman, 1954).

SUBSTRATE TYPE	DIAMETER (MM)
Soils/silt/clay	< 0.06
sand	0.6 to 2
gravel	2 to 64
cobble	64 to 256
small boulder	256 to 2048
bedrock	> 2048

2.1.2 Microhabitat

Transect data were gathered in representative littoral zone habitats from September 23-25, 2014. The distribution and number of transects was dictated by the variability observed during delineation. Each transect accounted for a major type of shoreline slope/littoral substrate/depth condition; however, in areas where the shoreline was composed of vertical walls extending well below the TFI operation depths, or in areas modified by infrastructure, such as bridges, boat launches, etc., no transect data were collected. Transects were numbered chronologically from upstream to downstream.

The current FERC licensed operating range of the TFI is from EL 185 ft to EL 176 ft, a 9 ft fluctuation as measured at the Turners Falls Dam. Each transect extended from a headpin established at the top of bank at an elevation above normal impoundment operating levels (i.e., at least EL 185 ft), to a depth of at least EL 176 ft. The prevailing TFI elevation at the time of the survey was determined by contacting the FirstLight Power Control Room prior to commencement of each transect survey. This relative elevation was used at the time of the survey as a temporary reference point to help establish that the lowest elevation of the bed profile extended to at least EL 176 ft.

Headpins were established with rebar or other semi-permanent fixture, paint blazed. The headpin elevation was surveyed and geo-referenced with GPS, and benchmarked to Project (NGVD29) datum using a Real-Time Kinematic-Global Positioning System (RTK-GPS) unit. A temporary staff gage was established in the vicinity of each transect to verify water elevations were reasonably stable during the survey period. Although the impoundment elevation was dynamic overall during the course of the study, the duration of individual transect surveys was generally brief (i.e. less than 30 minutes), and thus did not affect the accuracy of survey work.

A marked tape or Kevlar line was extended from the headpin a sufficient distance offshore to allow measurements to be located to a depth corresponding to at least EL 176 ft. In some instances where wading was unsafe, and use of a tape measure impractical, verticals were positioned from a boat with the Trimble GPS.

Each transect was arrayed to extend to capture top of bank, normal high water, upper TFI elevation (if different than normal high water), normal TFI elevation, toe of bank, and an elevation approximately 2 ft below normal low pool elevation. Additional verticals were established at intervals wherever pronounced changes in slope, substrate, or cover were encountered.

Geospatial mesohabitat data were transferred to a Geographic Information System (GIS) format and used to develop both visual maps depicting distribution as well as tabular information quantifying the abundance and distribution of common mesohabitat littoral zone substrates in the study area. The littoral zone area was defined based on a hydraulic model of the TFI.

Field data describing substrate type were transposed to corresponding GIS polygons depicting the littoral zone boundaries determined from the hydraulic model. These polygons were then analyzed to calculate linear distance represented by each substrate category.

Transects representing substrates and bed profiles and relative depths, in representative littoral habitats were also developed from the survey data by entering coordinates in MS Excel® and creating graphic plots. These data were archived in a format that will provide a framework for future data analysis efforts relative to operations and TFI hydraulic modeling.

3 HYDRAULIC MODELING SUMMARY

As noted above, a hydraulic model of the TFI Impoundment was conducted as part of a separate relicensing study entitled Study No. 3.2.2: *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot Station*. A separate report for Study No. 3.2.2 has been completed and was uploaded to the FirstLight northfieldrelicensing.com website on March 31, 2015. The hydraulic model will be used to determine the vertical and horizontal zone of TFI fluctuations due to FirstLight Project operations and Vernon Hydroelectric Project operations. This information will be used to determine the potential impacts of water level fluctuations on aquatic habitat and the littoral zone habitat. As noted above, this assessment will be included in the Littoral Zone Study (Study No. 3.3.13).

In 2014, water level loggers were installed in the TFI to record the water surface elevation (WSEL) every 15 minutes. The water level loggers were installed in March or April 2014 and remained in place until November 2014, covering a wide magnitude of flow conditions. The purpose for installing the water level loggers was to collect WSEL data for use in calibrating the hydraulic model. Figure 3.0-1 is a map showing the water level logger locations. In addition to the WSEL data collected, FirstLight recorded the Vernon discharge, the Northfield Mountain Project pumping and generating flows and the inflows from two major tributaries equipped with United States Geological Survey (USGS) gages (the Ashuelot and Millers Rivers). With observed flow and WSEL data, the TFI hydraulic model was successfully calibrated as described in more detail in Study Report No. 3.2.2.

WSEL fluctuations in the TFI are a function of:

- Vernon Project peaking discharges (maximum hydraulic capacity of 17,130 cfs),
- Northfield Mountain Project operations (maximum hydraulic generating capacity of 20,000 cfs and maximum hydraulic pumping capacity of 15,200 cfs),
- Cabot Station peaking operations (maximum hydraulic capacity of 13,728 cfs),
- naturally high flows, and
- boat wakes.

The hydraulic model showed that when flows start to exceed approximately 20,000 cfs, the French King Gorge, a natural constriction of the river downstream of the Northfield Mountain Project tailrace, starts to control the upstream WSEL. The gorge serves as a pinch point or hydraulic control resulting in water "backing up" upstream of the gorge.

Based on the hydraulic modeling conducted under Study No. 3.2.2, the upstream extent of the TFI varies based on several variables including: the Vernon Project discharge, Northfield Mountain Project operations, tributary inflow to the TFI, and the TFI WSEL elevation at the Turners Falls Dam. Based on the hydraulic modeling study, depending on the above variables, there are times when the TFI does not backwater to the base of the Vernon Dam. In some instances, there is a free-flowing section of the Connecticut River below Vernon Dam. In other instances, particularly under high flows, the French King Gorge backwater extends to the base of the Vernon Dam.

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Figure 3.0-1:
Location of Water Level Loggers
used for Calibrating the TFI Hydraulic Model

Legend

- USGS Stream Gage
- Water Level Logger
- HEC-RAS Hydraulic Model Extent

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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1 inch = 1.5 miles

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4 RESULTS

4.1 Delineation

The delineation survey was conducted from August 25-28, 2014. As noted above, water level loggers were operational during the delineation survey. Figure 4.1-1 shows the flow and WSELs throughout the TFI during the delineation survey. Figure 4.1-1 includes the Vernon discharge as reported by TransCanada, the Northfield Mountain Project pump or generation flows, and the WSEL's as measured at the various water level loggers located throughout the TFI (logger locations shown in Figure 3.0-1). As Figure 4.1-1 shows, WSEL fluctuations in the TFI are partially due to Vernon Project operations and Northfield Mountain Project operations.

For the period when the delineation survey was conducted (8 am-6 pm, August 25-28), the maximum and minimum hourly Vernon discharge and TFI elevation as measured at the Turners Falls Dam are summarized in Table 4.1-1.

Table 4.1-1: Min/Max Vernon Discharge, Min/Max TFI Elevation at Turners Falls Dam during the TFI Delineation Survey August 25-28, 2014

Date	Min Vernon Discharge (cfs)	Max Vernon Discharge (cfs)	Vernon Discharge Delta (Max-Min) (cfs)	Min TFI WSEL at Turners Falls Dam (ft)	Max TFI WSEL at Turners Falls Dam (ft)	TFI at Turners Falls Dam Delta (Max-Min) (ft)
8/25/2014	1,809	10,866	9,057	180.3	182.4	2.1
8/26/2014	1,732	9,646	7,914	178.7	183.0	4.3
8/27/2014	1,725	4,124	2,399	179.7	182.2	2.5
8/28/2014	1,667	8,771	7,104	181.7	182.5	0.8

The TFI is composed of two distinctly different geomorphic reaches.

The entire river was cruised up to Vernon Dam during the delineation effort. The river reach for approximately the first mile downstream from the Vernon Dam exhibits riverine features such as strong currents, eddies, and bankside scour indicators characteristic of riverine habitat[3].

At a point approximately one mile downstream, the river distinctly broadens, and geomorphic features reflect deposition rather than scour, reflecting an impounded influence. Based on geomorphology, the *upstream reach* of the impoundment therefore starts approximately 1 mile below the Vernon Dam, at a point below the confluence with the Ashuelot River and terminates near the Northfield Mountain Project tailwater (~13 miles). This reach is relatively uniform, is oriented north to south, riverine and relatively shallow, with gentle bends, but no pronounced serpentine meanders, and located within a broad floodplain. There are a few narrow islands comprised of alluvial materials such as gravel, cobble and fines. Scour holes and shoals generally are confined to locations downstream of features such as bridge piers and there are few deep pools. Scour holes provide the most extensive cover; object cover in the littoral zone is sparse, and limited to isolated patches of SAV and clusters of woody debris (Photo 4.1-1) Abutting land use is rural and agricultural with relatively little shoreline disturbance other than at locations where bridges or boat

[3] On August 27, at approximately 1:00 PM, the field crew boated to the upstream extent of the TFI which terminated approximately 1 mile downstream from the Vernon Dam at a discharge was 1,732 cfs and a WSEL at the TF Dam of 180.2 ft. A distinct transition between the upstream riverine habitat below Vernon Dam and the backwater created by the TFI was evident.

landings are located. Littoral substrates in this reach are alluvial and predominantly cobble, gravel and fine sediments.

Photo 4.1-1. Typical patches of SAV and woody debris cover in TFI Upper Reach.

The *downstream reach* extends from the Northfield Mountain tailrace to the Turners Falls Dam (approximately 5.4 miles). The geomorphology of this reach is dominated by bedrock, which controls much of the stream geometry and substrate features. Between the Northfield Mountain Project tailrace to below the French King Bridge (1.5 miles), the TFI passes through a high banked, narrow, steeply sloped gorge dominated by bedrock substrate—commonly referred to as the French King Gorge. The littoral zone in this segment is confined to a narrow, almost vertical zone of bedrock on both banks, with some outcrops and boulders. Under high flows in the vicinity of 20,000 cfs, the French King Gorge acts as a hydraulic control or choke point resulting in a steeper WSP above the gorge. Immediately downstream from the French King Bridge, the Connecticut River is deflected sharply west and follows a meandering course toward Turners Falls Dam. The TFI geometry is complex, and alternately defined by both bedrock and depositional features, and includes a complex of embayment, points, coves, islands and a wide range of substrates, and features shallow lacustrine littoral habitat with a deeply incised thalweg, in contrast to the riverine TFI habitat found further upstream in the study area.

The littoral zone is composed of varied substrates. In some locations the littoral zone is absent due to vertical bedrock cliffs (Photo 4.1-2), while in others there are broad horizontal shoals composed of gravel, sand or other fines, particularly in embayed sections. The thalweg is deeply incised. Patches of SAV and wetlands, emergent aquatic vegetation (EAV) such as lily pads or cattail patches occur in areas with finer substrates. Areas with bedrock substrates have limited or no riparian vegetation. Most embankments are wooded and composed of predominantly deciduous trees. Shoreline development ranges from residential (seasonal and year round homes) to urban. The least developed shorelines are those furthest upstream from Gill and Turners Falls.

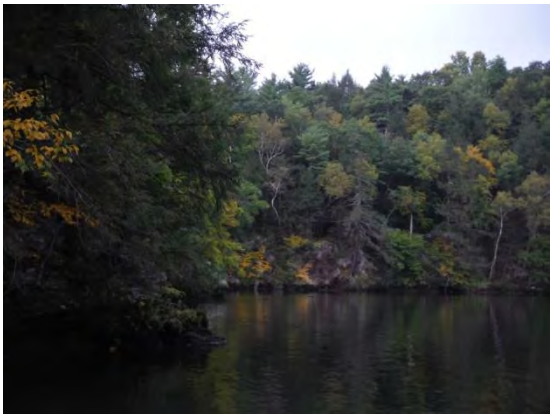


Photo 4.1-2. Typical vertical bedrock cliffs with no littoral zone in TFI Lower Reach.

Figures 4.1-2 to 4.1-10 (see Appendix A) are plan maps of the TFI illustrating the pattern and distribution of littoral habitat throughout the study area. A total of eight distinct littoral habitats were identified based on dominant substrate. Littoral zone substrates composed of fines (e.g., sand/silt, clay) and cobble collectively accounted for about 50% of all littoral substrate (Table 4.1-2 below). Fines comprised 29% of the study area, followed by cobble (21%), then bedrock (17%) and gravel (16%). Littoral areas where cobble substrates were combined with either fines (6%) or boulder (1 %) also occurred. However these patches were scattered and small. Littoral areas with fines were widely distributed throughout the study area; however, cobble and gravel were most common above the French King Gorge area. Bedrock and wetland areas were most abundant in the reach from French King Gorge downstream. Riprap accounted for approximately 7% of littoral substrates and occurred in patches throughout the study area where either erosion abatement or other infrastructure such as bridges or developed shorefronts were located.

There are a few locations where geotextile material is positioned parallel to the shoreline in the transition between the river and bank toe. Most embankments are steep to moderately steep and vegetated with a combination of woody or perennial riparian vegetation rooted in sedimentary substrates. Wetlands are small, isolated, and scattered at the mouths of tributaries.

Table 4.1-2. TFI Littoral Zone Survey. Relative abundance of littoral habitat substrate.

Habitat Type	Length (ft)	Length (miles)	Percentage of Total
Fines	53,715	10.2	29%
Cobble	39,115	7.4	21%
Bedrock	30,850	5.8	17%
Gravel	30,555	5.8	16%
Riprap	12,945	2.5	7%
Fines / Cobble Patch	10,895	2.1	6%
Wetlands	7,045	1.3	4%
Boulder / Cobble Patch	1,260	0.2	1%
Total	186,380	35	100%

4.2 Microhabitat

A total of 14 transects were surveyed (Figure 1.2-1) between September 23-25, including seven (Transects 1-7) transects in the upper reach between Vernon Dam and the Northfield Mountain Project tailrace, and seven (Transects 8-14) in the lower reach downstream of Northfield Mountain Project tailrace. Shown in Figure 4.2-1 is the following: WSELs at various locations along the TFI, the Vernon discharge and the Northfield Mountain pumping and generating flow for the period when the microhabitat analysis was conducted. As Figure 4.2-1 shows, during the afternoon of September 24, the Vernon Project discharge increased resulting in a direct increase in the WSEL at the water level loggers located closest to the Vernon Project. For the period when the microhabitat survey was conducted (8 am-6 pm, September 23-25), the maximum and minimum hourly Vernon discharge and TFI WSEL as measured at the Turners Falls Dam are summarized in Table 4.2-1.

Table 4.2-1: Min/Max Vernon Discharge, Min/Max TFI Elevation at Turners Falls Dam during the TFI Microhabitat Survey September 23-25, 2014

Date	Min Vernon Discharge (cfs)	Max Vernon Discharge (cfs)	Vernon Discharge Delta (Max-Min) (cfs)	Min TFI WSEL at Turners Falls Dam (ft)	Max TFI WSEL at Turners Falls Dam (ft)	TFI at Turners Falls Dam Delta (Max-Min) (ft)
9/23/2014	1,821	1,854	33	180.3	180.6	0.3
9/24/2014	1,697	4,953	3,257	181.0	182.6	1.6
9/25/2014	1,756	3,414	1,658	181.2	181.9	0.7

Transects varied in length from 20 feet (Transect 8) up to approximately 1,900 feet (Transect 13), depending on the steepness of the slope between the headpin and minimum WSEL. Longer transects were required to traverse extensive horizontal flats and shoals located in large embayments in the lower TFI. Most transects ranged in length between approximately 50 to 225 feet.

Table 4.2-2 provides coordinates for each transect headpin, along with information describing what kind of littoral habitat each represents. Transect cross-sections are attached as Appendix B.

Table 4.2-2. TFI littoral zone survey. Summary of transect location and shoal habitat characteristics.[4]

TRANSECT	HEADPIN LATITUDE	HEADPIN LONGITUDE	HABITAT DESCRIPTION
1	42.7505	-72.4717	Steep-sloped, dominated by cobble and gravel, no cover
2	42.7470	-72.4737	Shallow-sloped dominated by fines, no cover
3	42.7149	-72.4547	Steep-sloped, cobble and boulder cover
4	42.6738	-72.4686	Moderate-sloped, dominated by fines, no cover
5	42.7012	-72.4630	Moderate-sloped, cobble, scattered woody debris and SAV
6	42.6154	-72.4818	Moderate-sloped, cobble and sand substrate, no cover
7	42.6104	-72.4852	Moderate-sloped, cobble and silt substrate, no cover
8	42.6035	-72.4904	Steep-sloped, bedrock, boulder and crevasse cover
9	42.6029	-72.5122	Sand and silt shoal, some SAV beds provide cover
10	42.5999	-72.5439	Sand and silt shoal, some SAV patches provide cover
11	42.5942	-72.5320	Moderate-sloped, sand substrate, poor cover
12	42.6015	-72.5313	Shallow-sloped dominated by fines, with EAV beds for cover
13	42.6083	-72.5373	Embayment with sand and silt shoal area with SAV cover
14	42.6009	-72.5415	Embayment with silt shoal area with SAV and EAV cover

[4] The habitat classifications identified as part of this effort (i.e. slope, substrate, vegetation) may differ from the results set forth in Study No. 3.1.1, *Full River Reconnaissance* (FRR), because the littoral zone survey generally investigated the exposed lower riverbank to the bed at a far greater extent than that of the FRR, which only investigated to the edge of water on the day of the survey.

Figure 4.1-1: Water Elevations and Flows in the TFI during Delineation Survey (August 25-28, 2014)

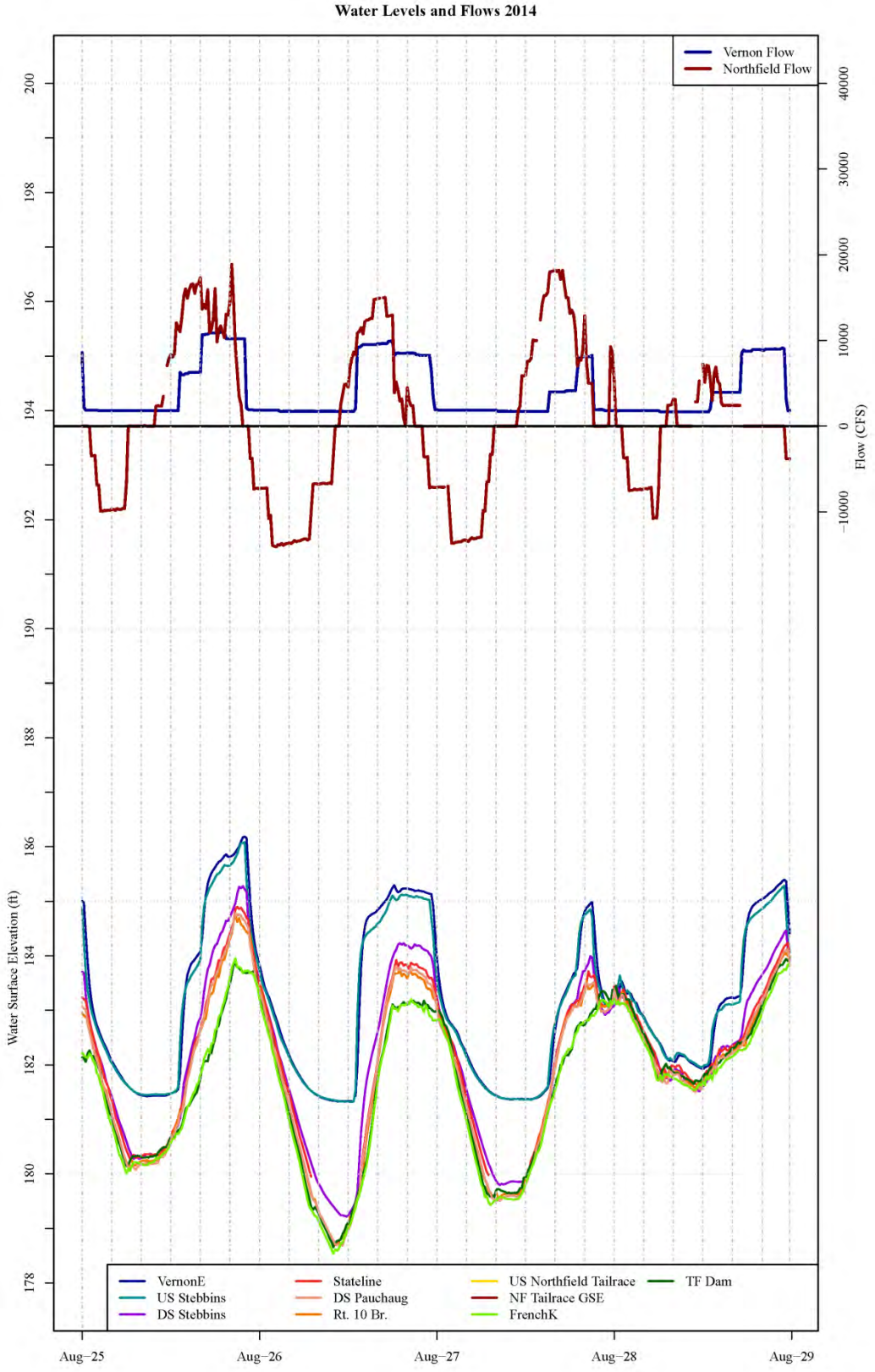
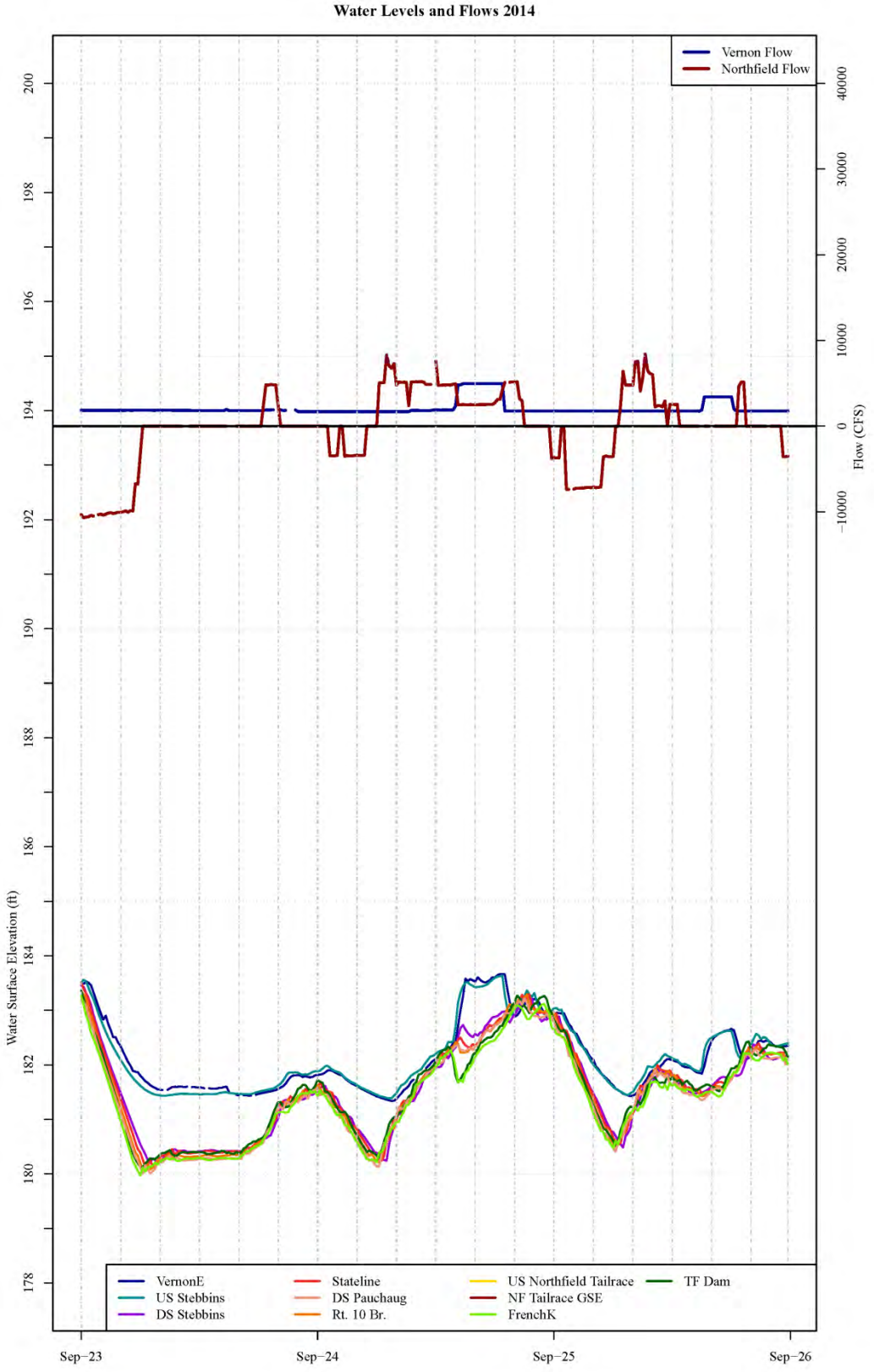


Figure 4.2-1: Water Elevations and Flows in the TFI during Transect Surveys (September 23-25, 2014)



5 DISCUSSION

Water levels in the TFI fluctuate due to the Vernon Hydroelectric Project, Northfield Mountain Project, Turners Falls Project, naturally high flows and boat wakes. As a result, littoral aquatic habitat and aquatic species that utilize the habitat may be affected by water level fluctuations. This study establishes the baseline condition and the health of the aquatic habitat that supports Connecticut River aquatic species in the TFI.

The TFI can be classified into two geomorphic units. The upstream reach (13 miles) is riverine with alluvial substrates ranging from fines to gravels and cobbles. In general object cover in this reach is poor, and limited to occasional patches of woody debris or fringe SAV beds. Additional cover is furnished by occasional scour holes, and structures such as bridge piers. In this reach although there is some variability in bed slope profile, the typical horizontal range of exposed substrate in shallow-sloped littoral areas between the maximum and minimum operating level is approximately 55 feet based on the trends in the transect data with the lower elevation exposed substrates predominantly composed of fines such as silt/clay. The typical range of exposed substrate between the maximum and normal operating water level in more steeply-sloped areas is approximately 10 to 15 feet based on the trends in the transect data with the exposed substrates predominantly composed of coarser substrates such a gravel or cobble.

The downstream reach (5.3 miles) is bedrock controlled, with more variability relative to cover, substrate, and bed profile. Generally cover in the form of SAV and/or EAV beds, boulders, and ledge crevasses and adjacent areas of deeper water and lentic conditions that provide relatively good cover. Transect 14 includes some areas that are either very shallow or become exposed at elevations less than the maximum operating levels (this will be evaluated further with use of the hydraulic model and impact assessment). Transects 7 and 8 represent areas with relatively steep slopes and good nearshore cover. There are minimal areas of exposed substrates in the range between maximum and normal operating levels. Up to 30 feet of substrate is exposed during minimum operating levels. Transects 9 through 11 represent shoreline areas with shallower slopes; transects 9 and 11 include areas of fringe wetland or SAV beds that provide cover. Several areas of the impoundment include large embayments with extensive flats of fine sediments that may become shallow or exposed during periods of minimum operating levels, as depicted by transects 12 through 14.

Aquatic fauna may use these habitats for spawning, nursery, and /or foraging habitat. The use will vary according to species and life stage (Scott and Crossman, 1973; Smith, 1985). For example lithophilic spawning species such as fallfish, or white sucker have specific substrate preferences such as small gravel, whereas centrarchids prefer a range of fine substrates adjacent to cover; and depth-driven requirements for nesting, whereas broadcast-spawning species such as shad or blueback herring do not. Other species, such as yellow perch and esocids extrude egg masses that adhere to aquatic vegetation during incubation. Similarly, benthic feeding species and life stages such as brown bullhead may require fine substrates, and ambush predators such as juvenile and adult black bass require object cover such as boulders woody debris or vegetation; whereas pelagic grazers such as shad or herring may not require a critical littoral substrate or cover. As noted above, (see Section 1.1) the extent to which project operation inundates these littoral zone features will be analyzed in the upcoming data analysis efforts relative to operations and hydraulic modeling of the TFI.

The TFI hydraulic model (GSE 2015) was developed to facilitate the simulation of site specific water level fluctuations under a wide range of operating scenarios. Thus littoral habitat suitability can be site-specifically assessed at points of interest throughout the TFI by applying the model to littoral areas represented by the family of transects available from this survey, combined with applicable habitat suitability criteria for targeted species and life stages.

6 LITERATURE CITED

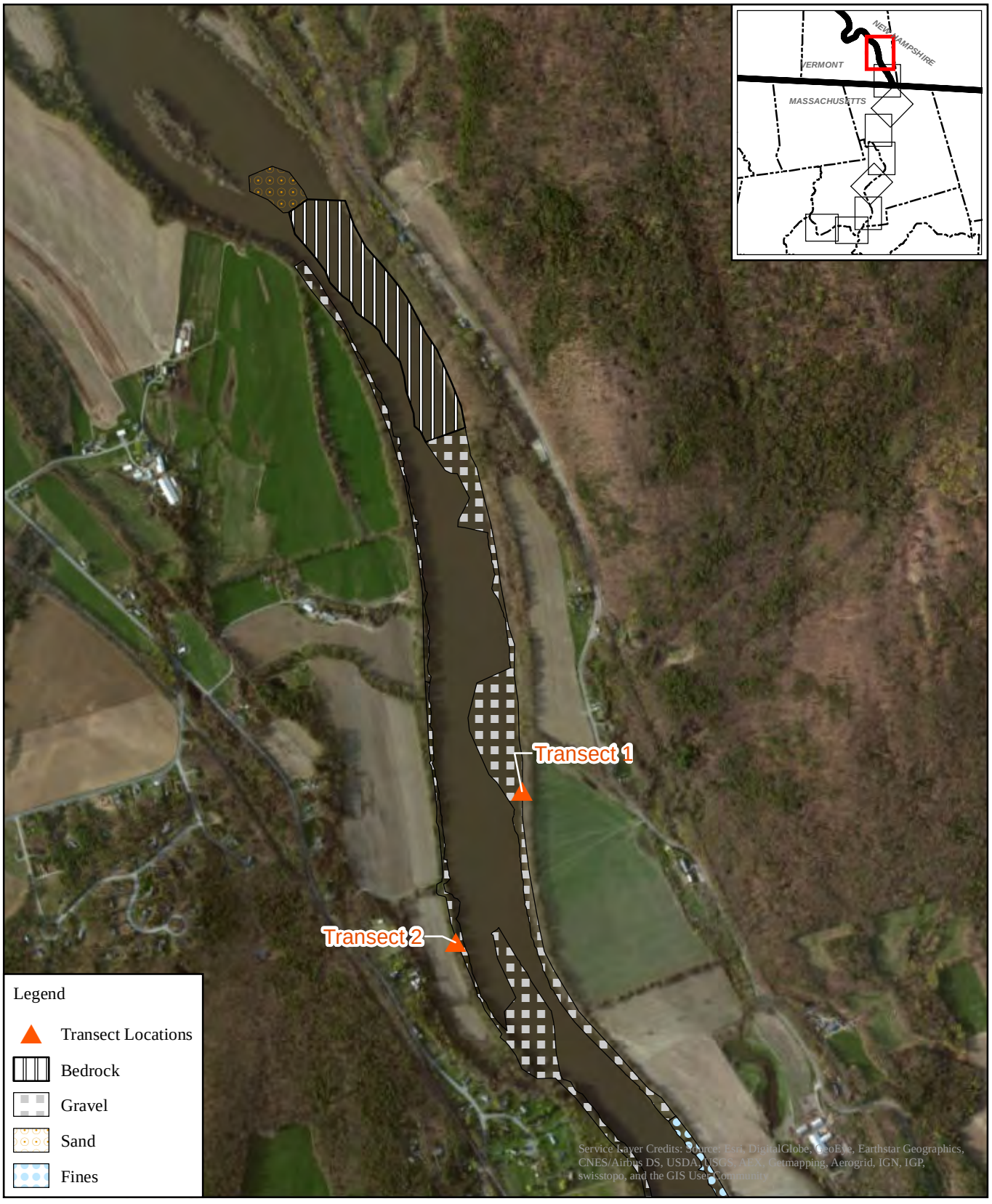
GSE 2015, Study No. 3.2.2 Hydraulic Study Turners Falls Impoundment, Bypass Reach, and below Cabot, March 2015.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184. Fish> Res. Bd. Canada. 966 pp.

Smith, C.L. 1985. The inland fishes of New York State. NY State Dept. of Env. Cons. Albany, NY. 522 pp.

Wolman, M.G., 1954. A method of sampling coarse river-bed material. Transactions of American Geophysical Union 35.

APPENDIX A - LITTORAL HABITATS



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GDF SUEZ

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

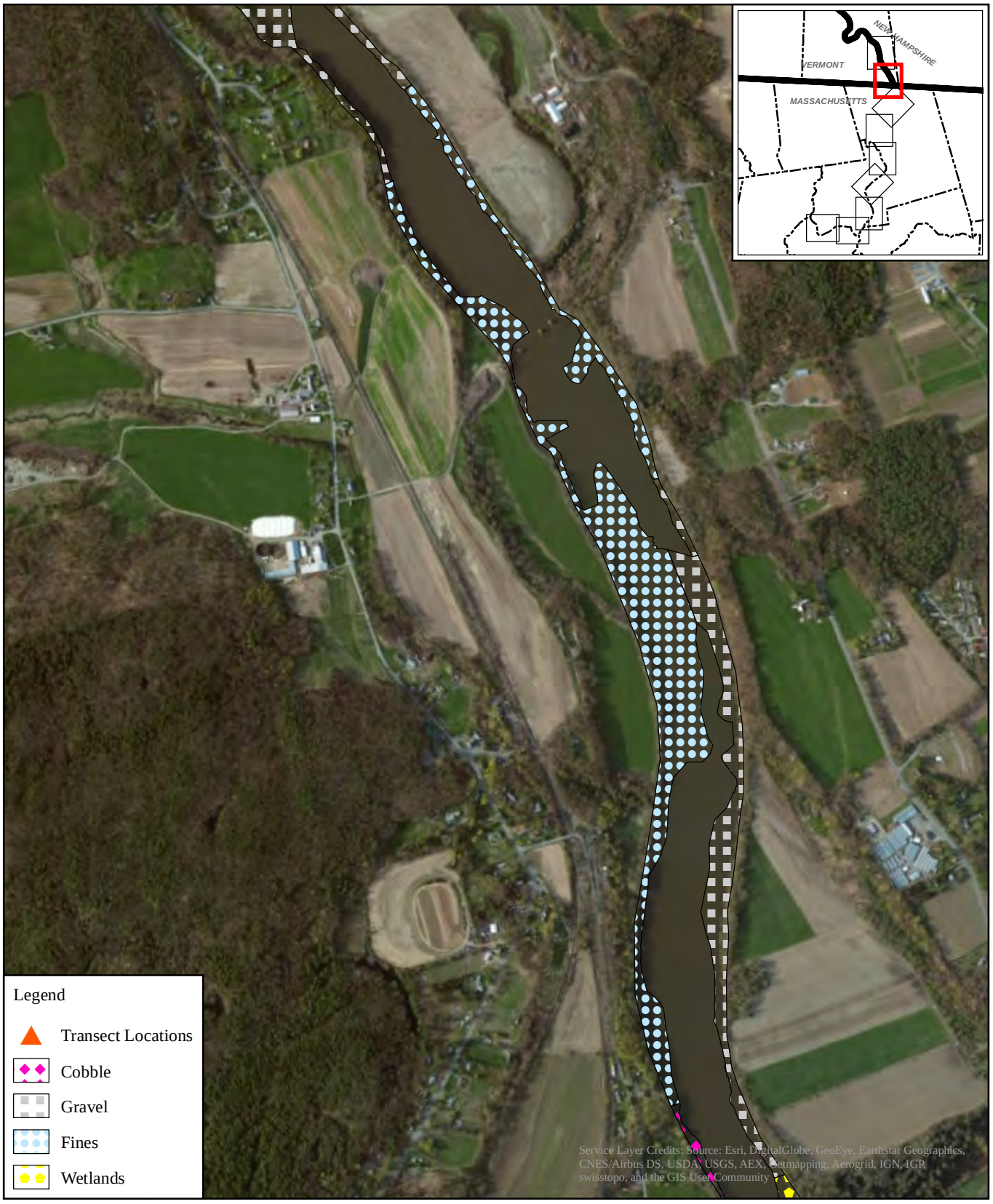
Study No. 3.3.14
Aquatic Habitat Mapping of
Turners Falls Impoundment

N

0 600 1,200 2,400
Feet

Appendix A:
Littoral Habitat Mapping

Path: W:\gis\studies\3_3_14\maps\appendix_a.mxd



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Study No. 3.3.14
Aquatic Habitat Mapping of
Turners Falls Impoundment

N

0 600 1,200 2,400
Feet

Appendix A:
Littoral Habitat Mapping

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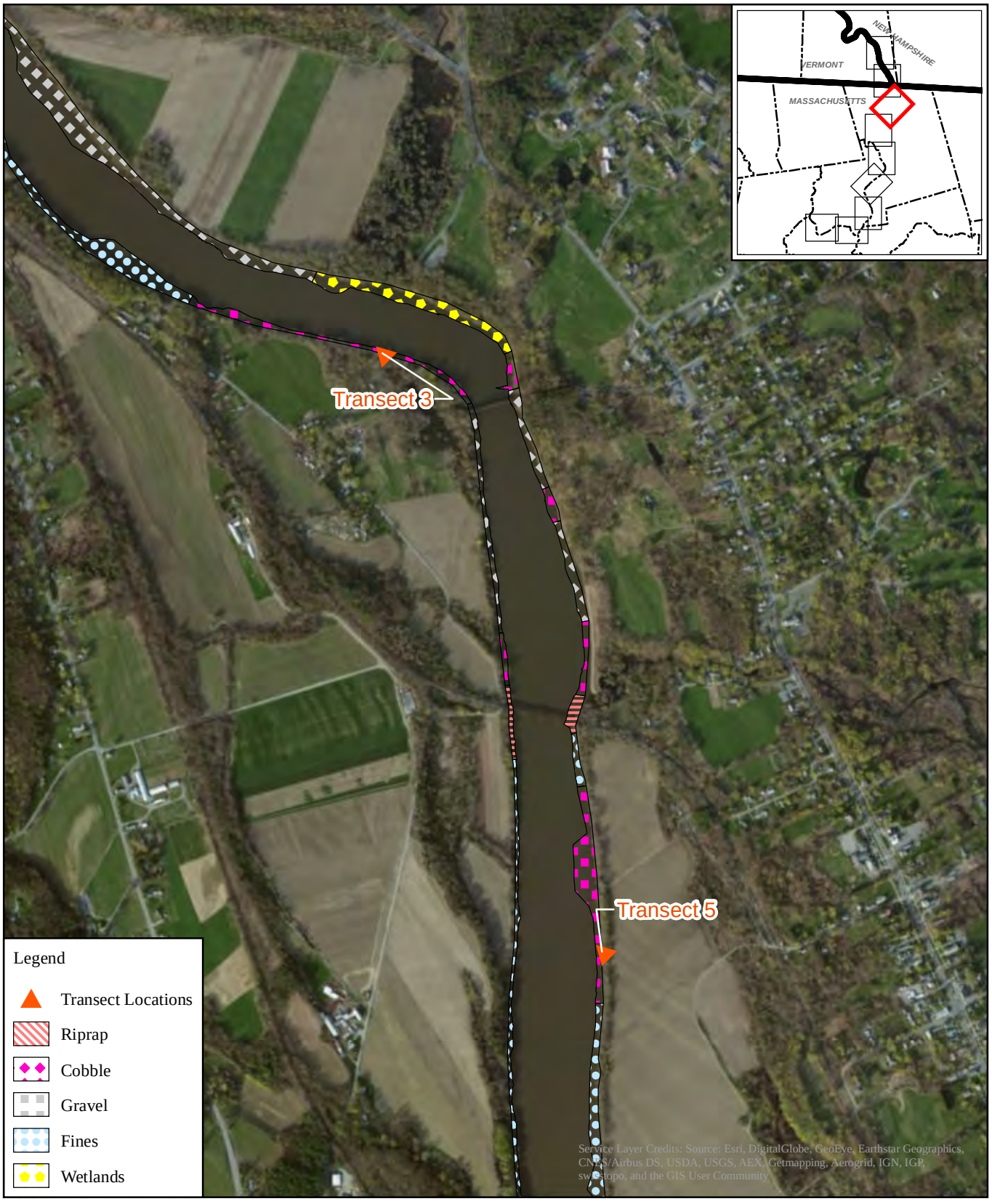

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Study No. 3.3.14
Aquatic Habitat Mapping of
Turners Falls Impoundment

0 600 1,200 2,400
Feet

Appendix A:
Littoral Habitat Mapping

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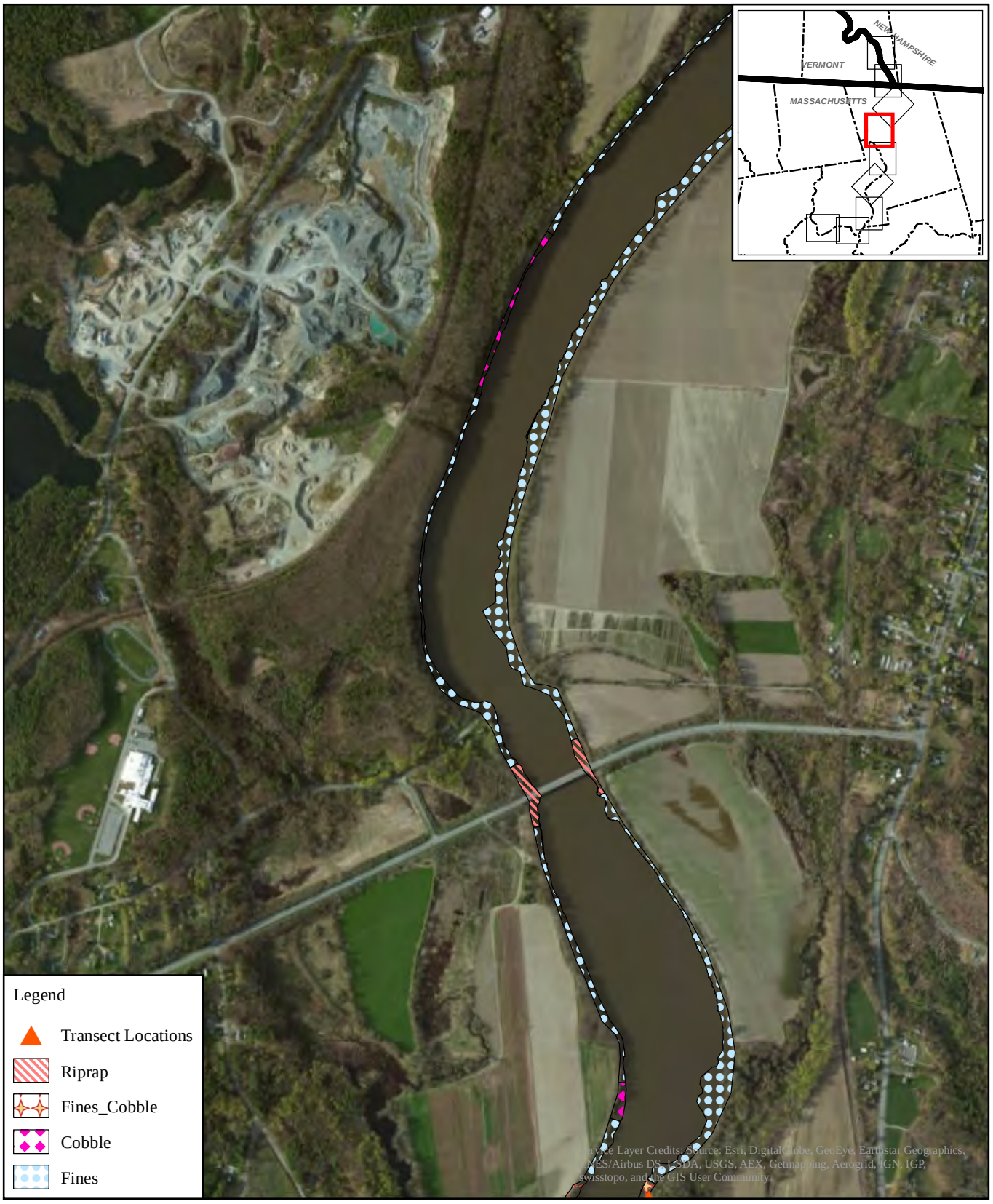

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N

0 600 1,200 2,400
Feet

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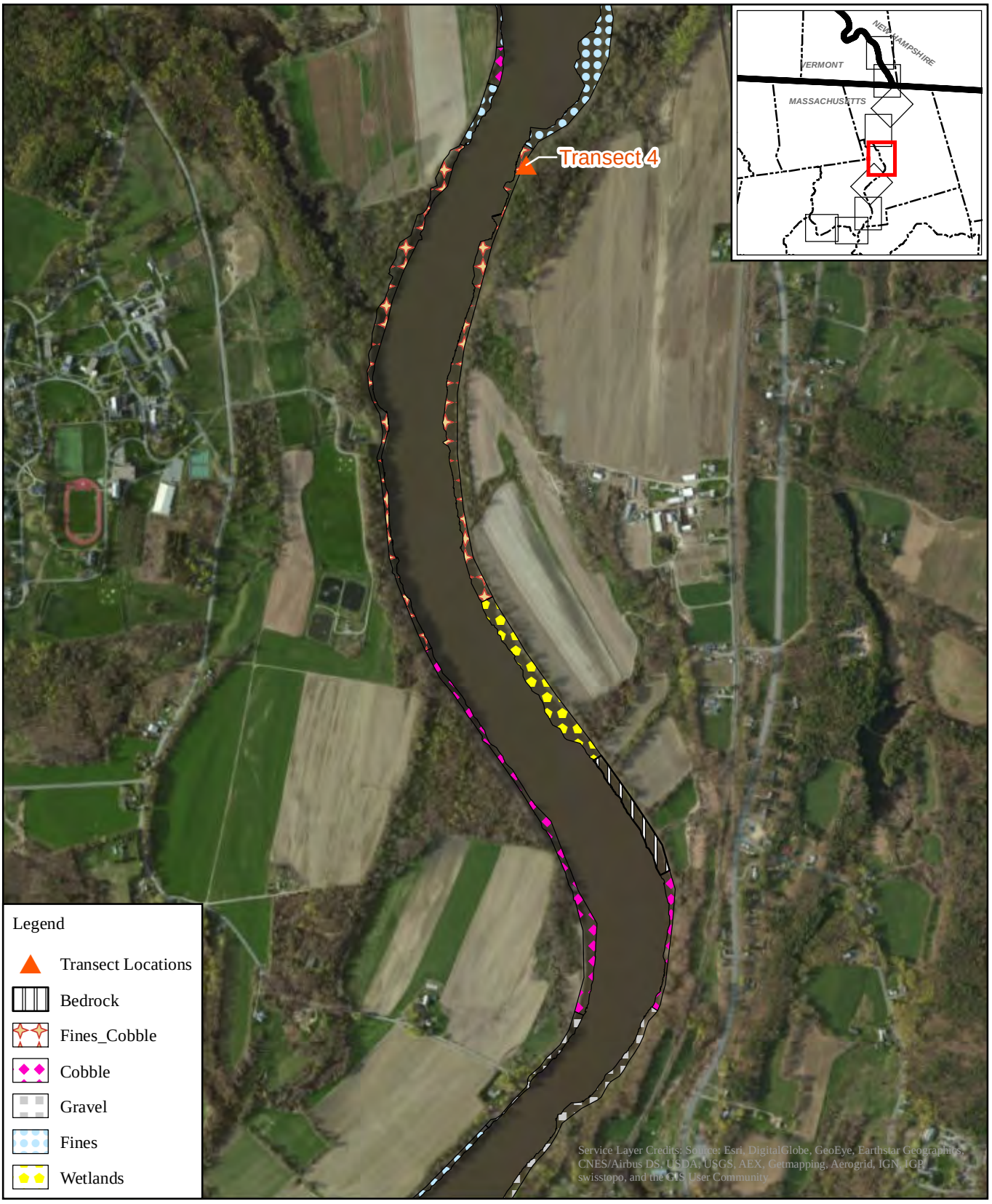

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N

0 600 1,200 2,400
Feet

Appendix A:
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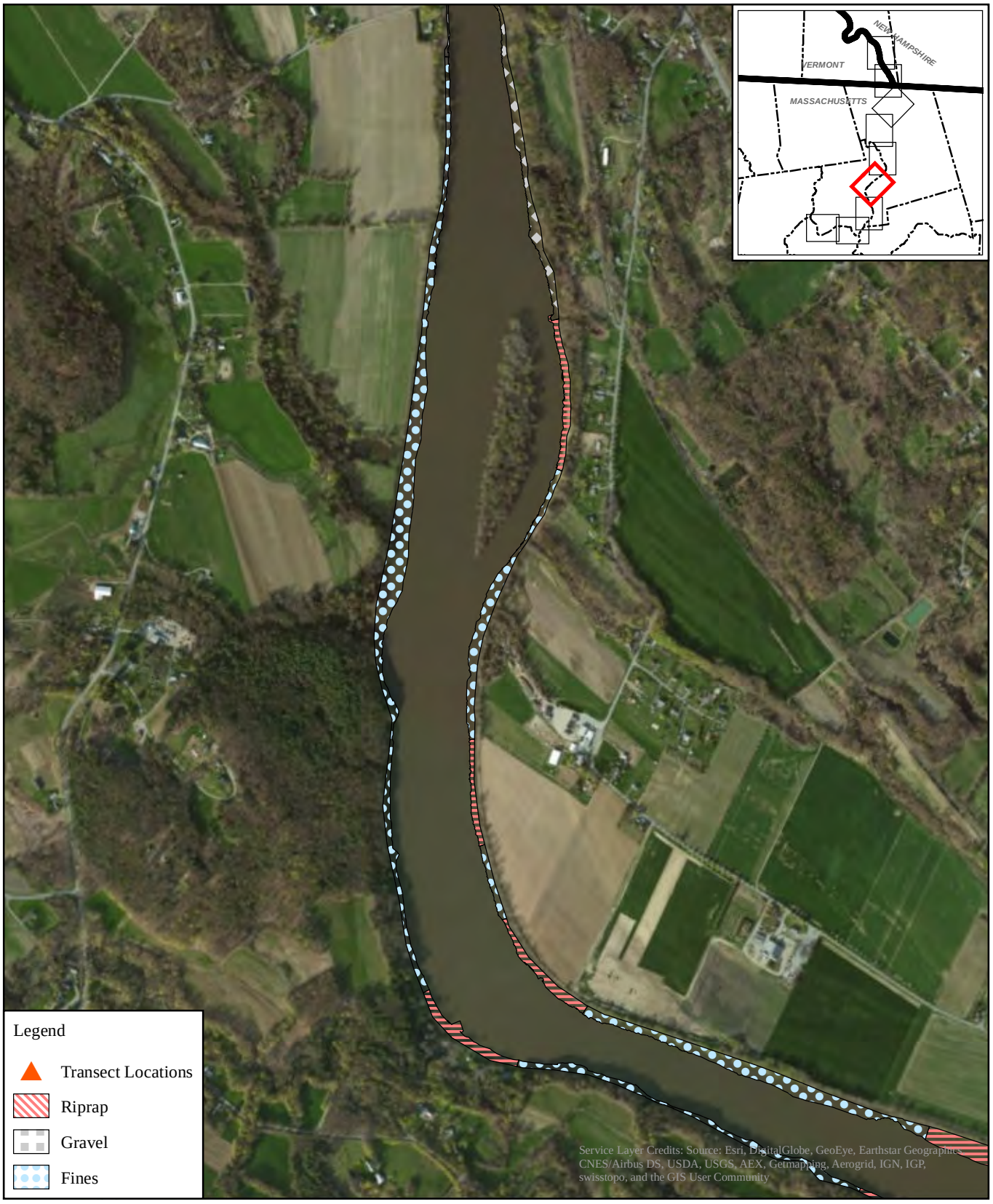

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0 600 1,200 2,400
Feet

Appendix A:
Littoral Habitat Mapping

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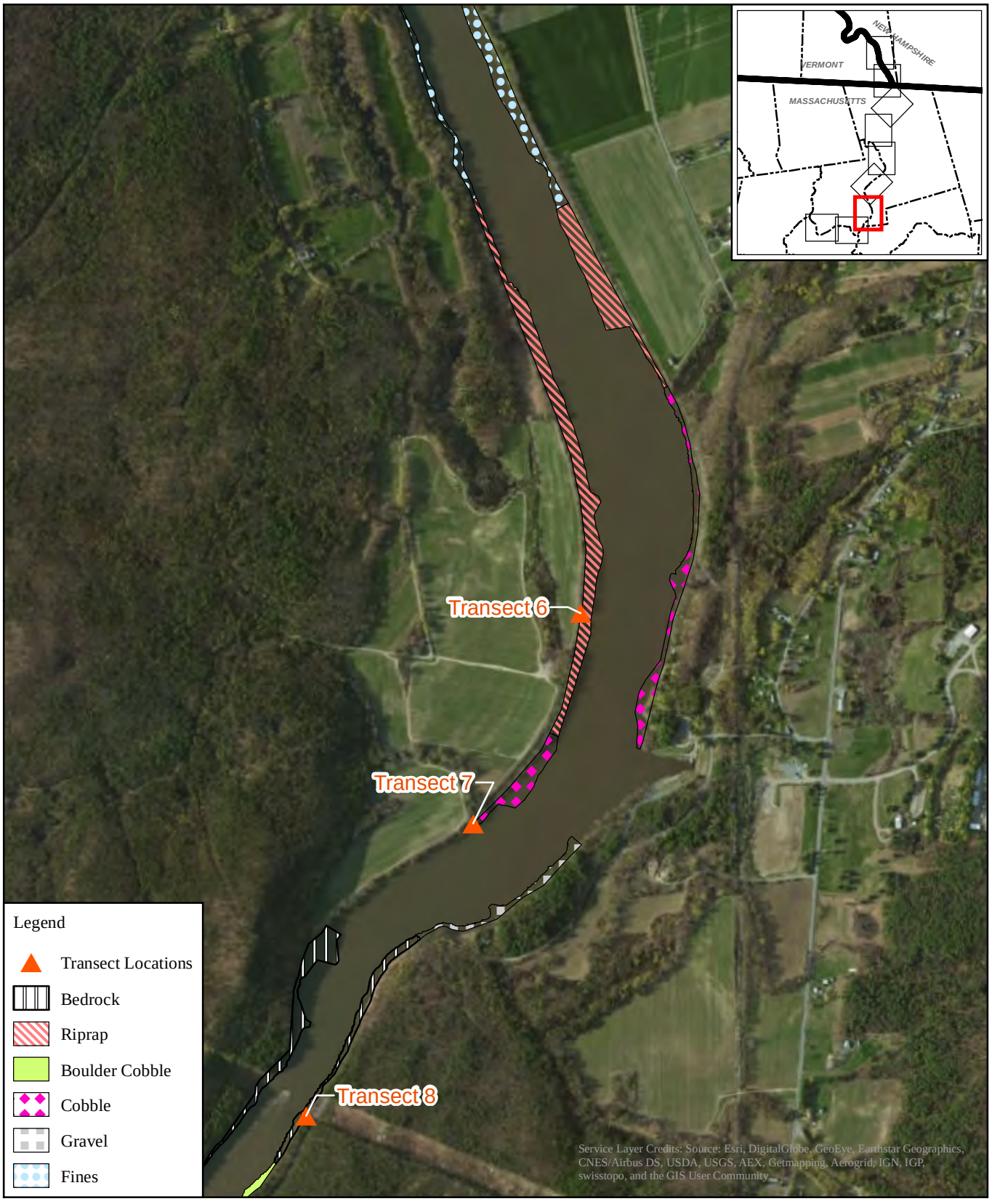

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N

0 600 1,200 2,400
Feet

Appendix A:
Littoral Habitat Mapping

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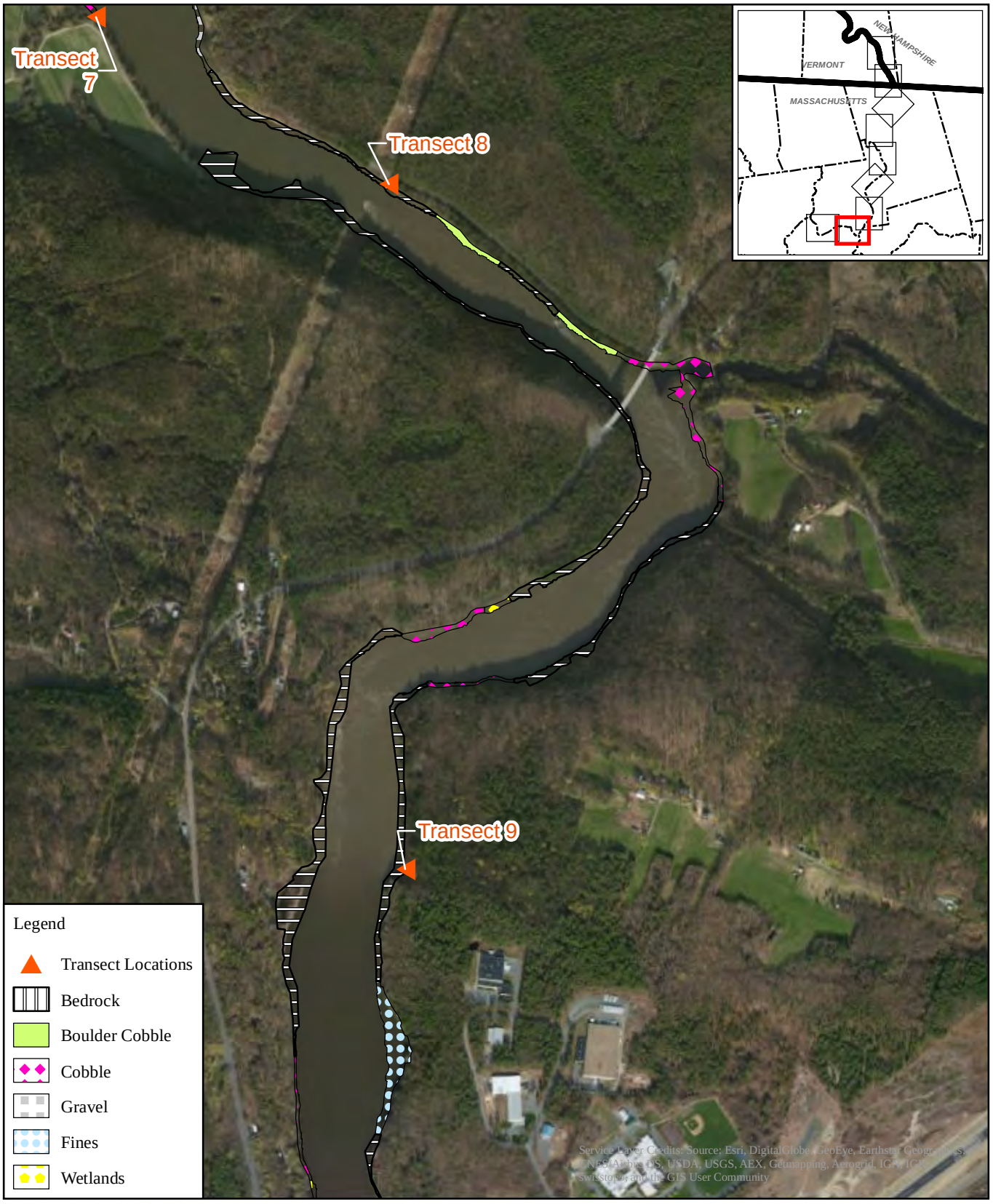

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Study No. 3.3.14
Aquatic Habitat Mapping of
Turners Falls Impoundment

0 600 1,200 2,400
Feet

Appendix A:
Littoral Habitat Mapping

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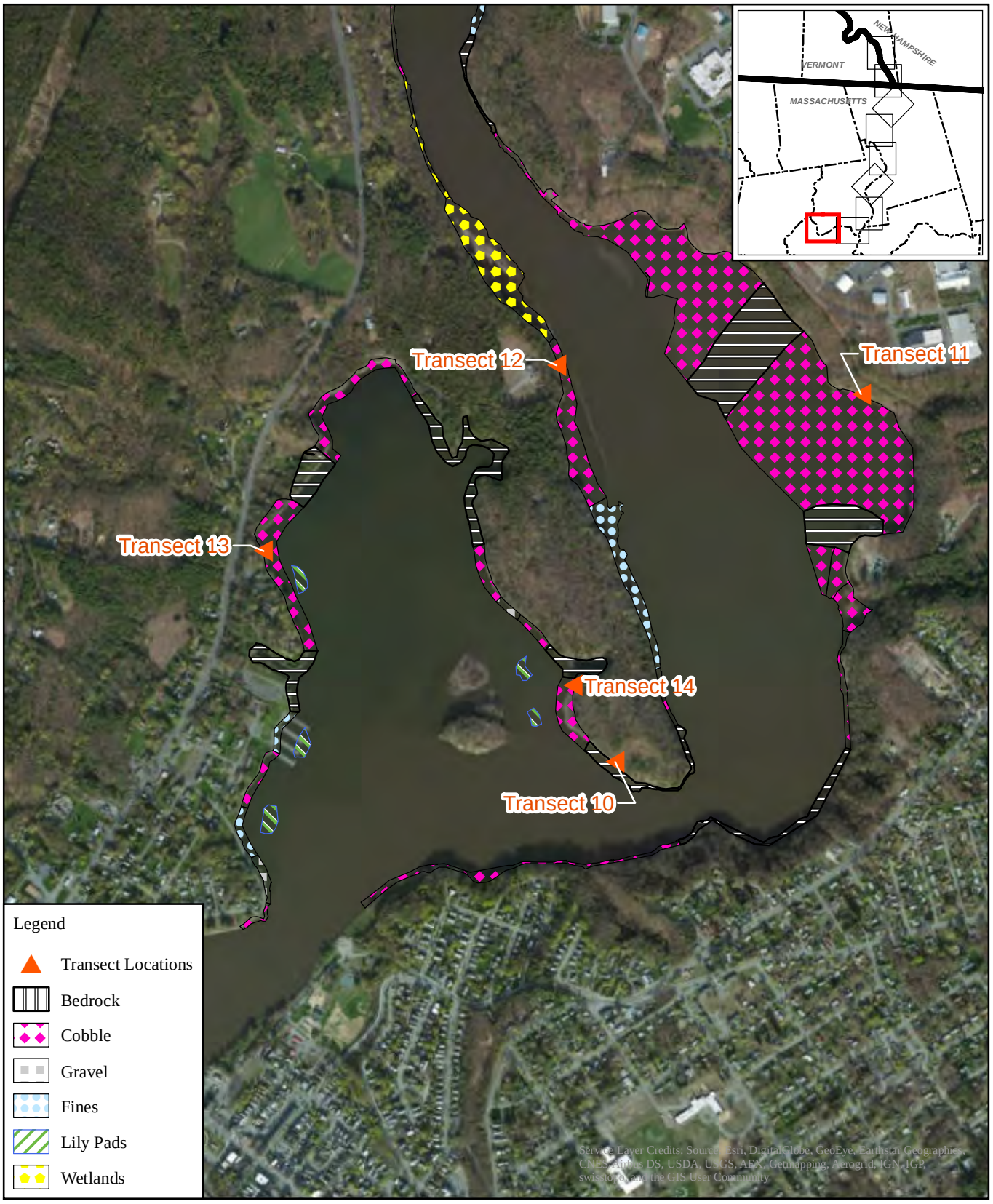

Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)

Study No. 3.3.14

Aquatic Habitat Mapping of Turners Falls Impoundment

0 600 1,200 2,400 Feet

Appendix A:
Littoral Habitat Mapping

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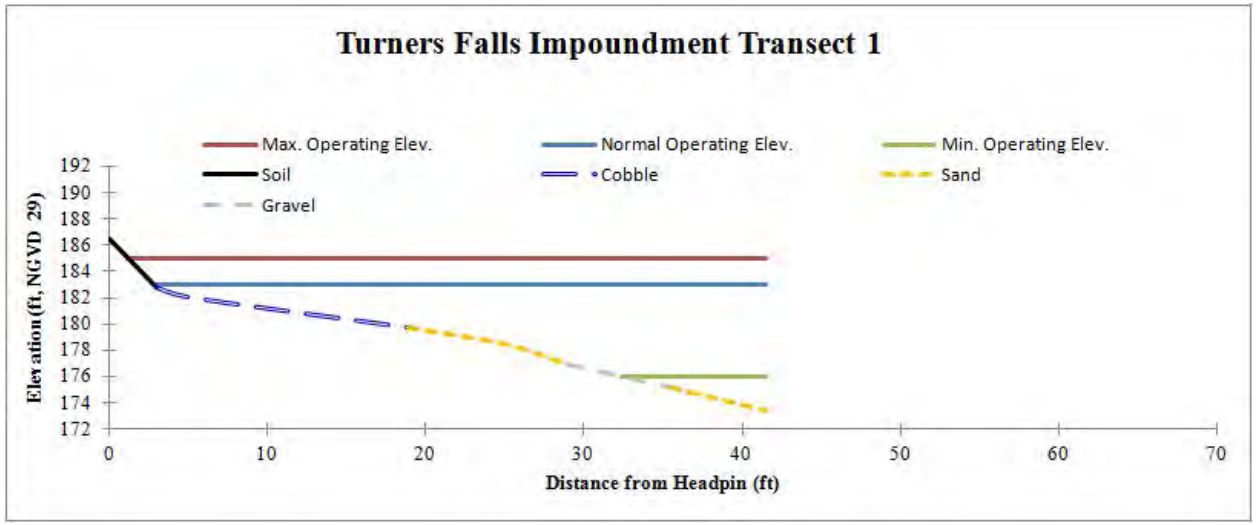
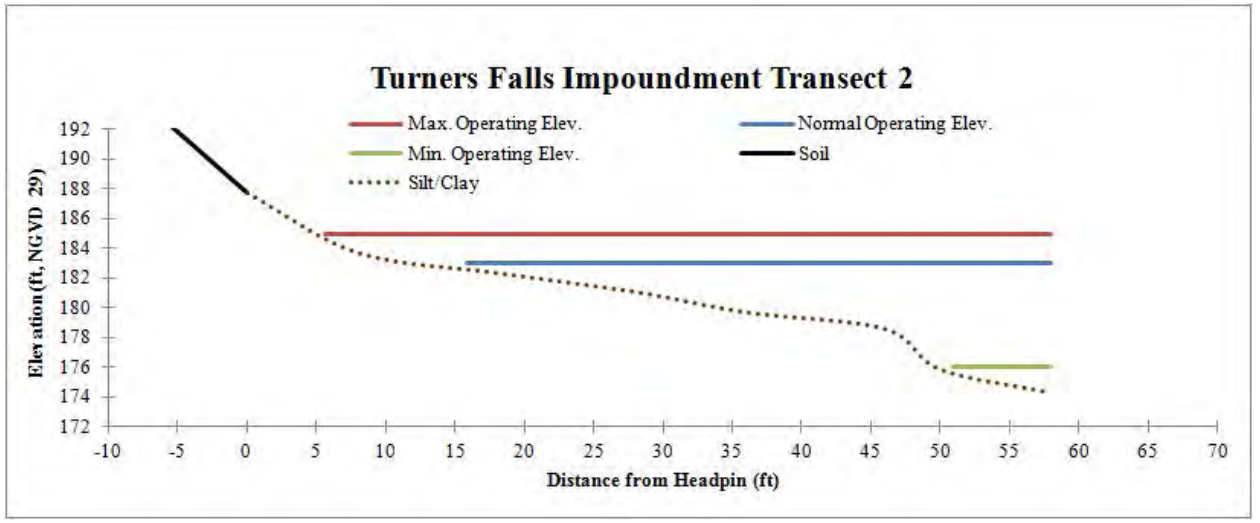
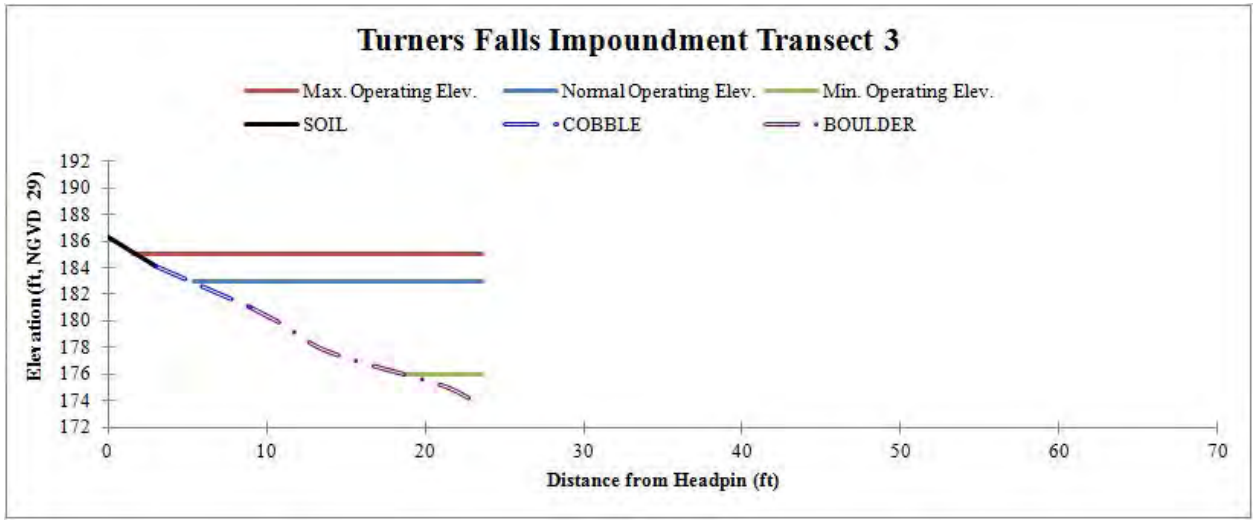
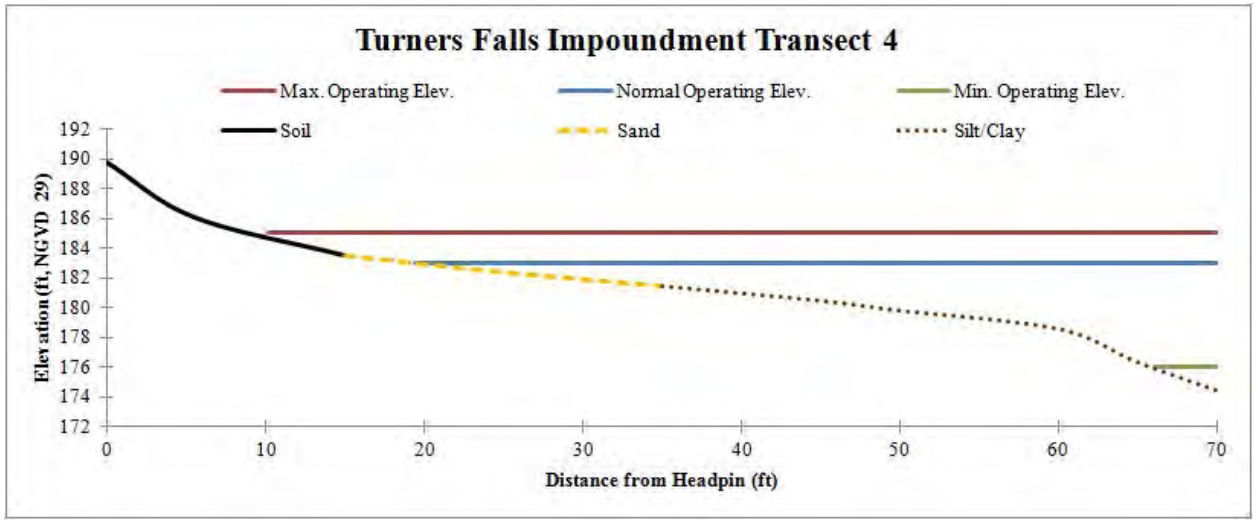
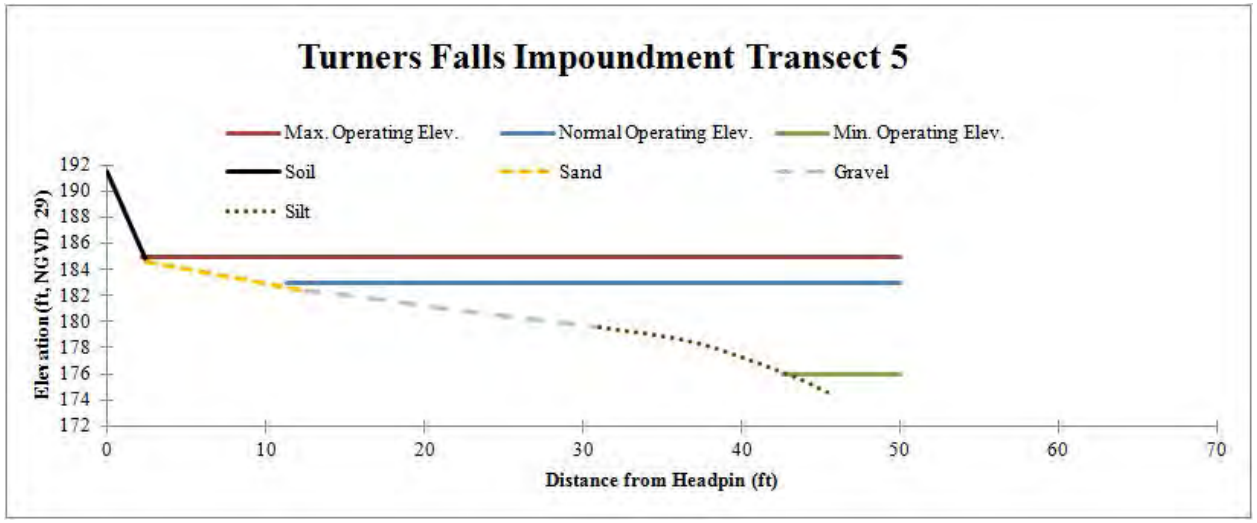
APPENDIX B – TRANSECTS


Turners Falls Impoundment Transect 1
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Cobble
Sand
Gravel
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)

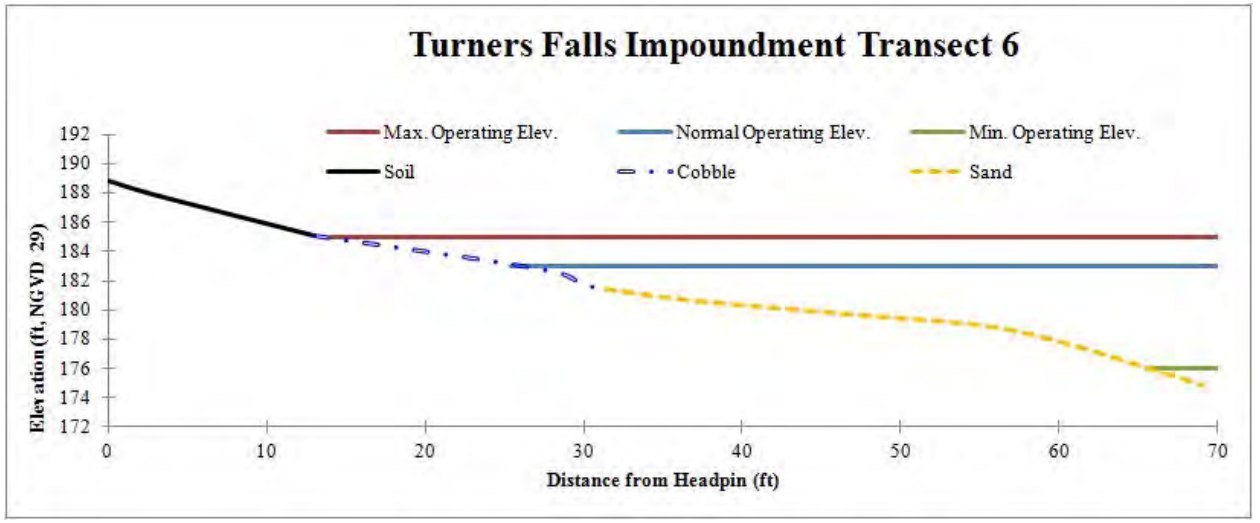

Turners Falls Impoundment Transect 2
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
-10
-5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Distance from Headpin (ft)

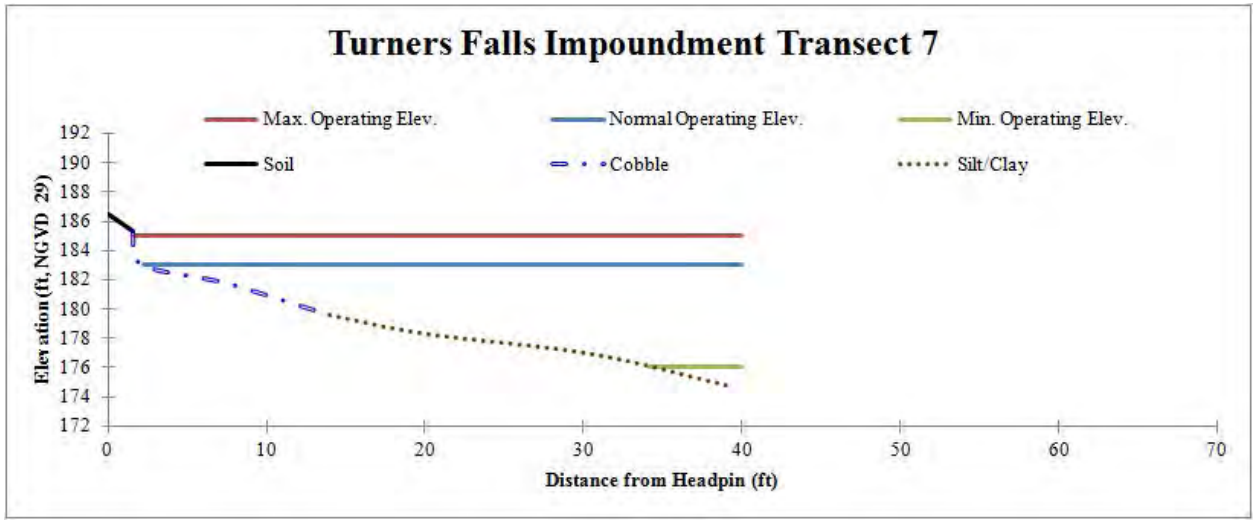

Turners Falls Impoundment Transect 3
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
SOIL
COBBLE
BOULDER
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)

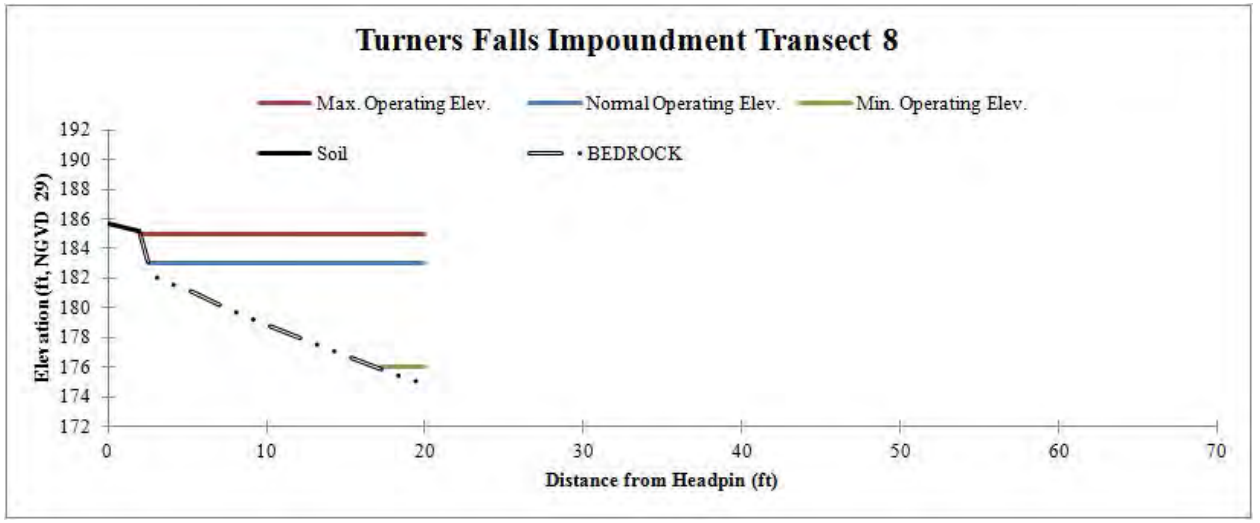

Turners Falls Impoundment Transect 4
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Sand
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)

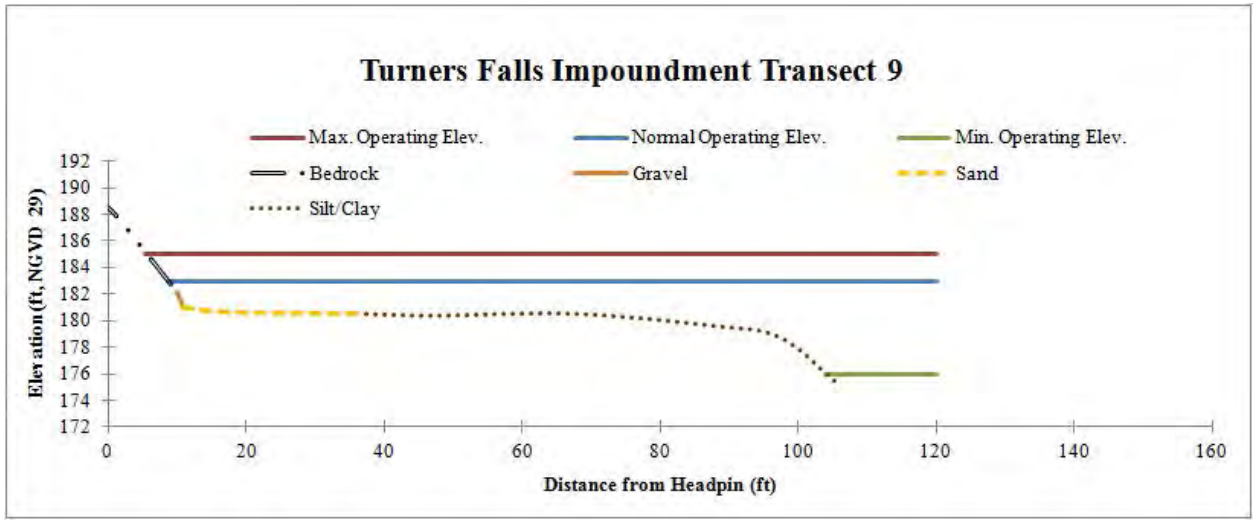

Turners Falls Impoundment Transect 5
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Sand
Gravel
Silt
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)

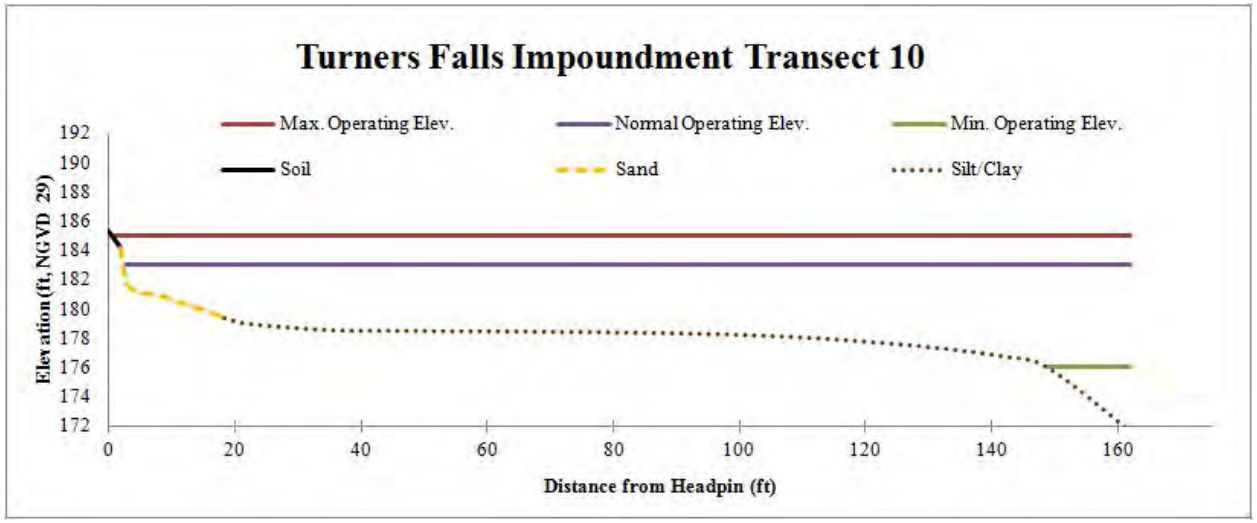

CT 6809 AY
Kleinschmidt

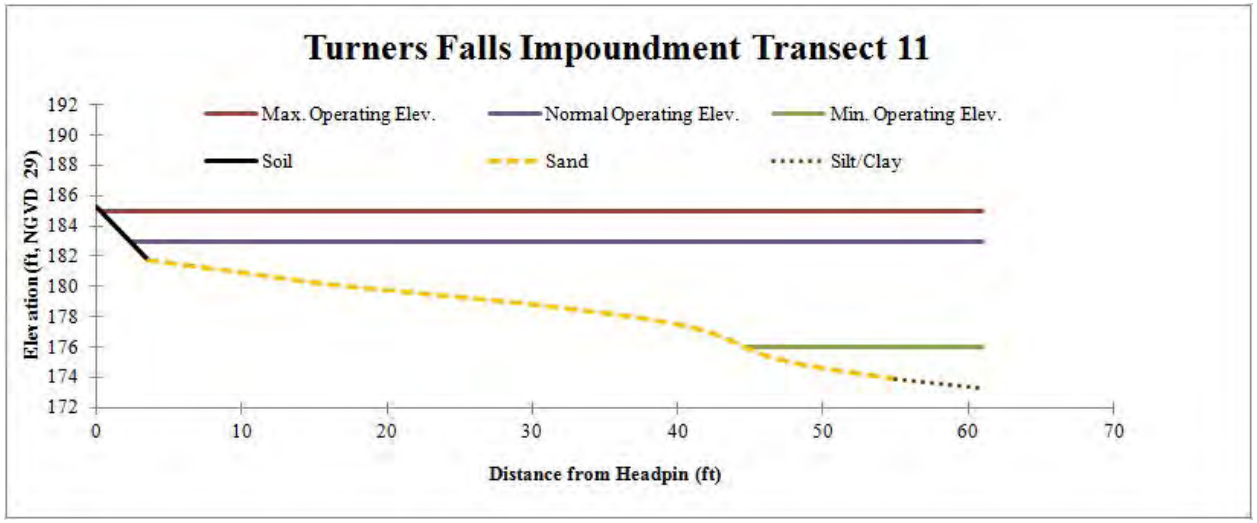

Turners Falls Impoundment Transect 6
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Cobble
Sand
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)

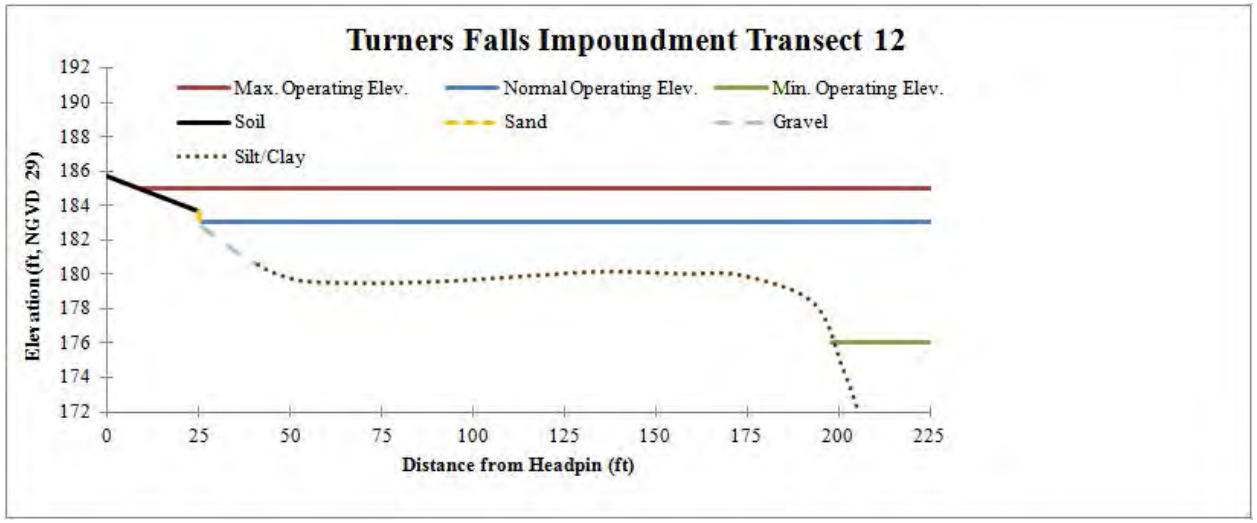

Turners Falls Impoundment Transect 7
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Cobble
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)

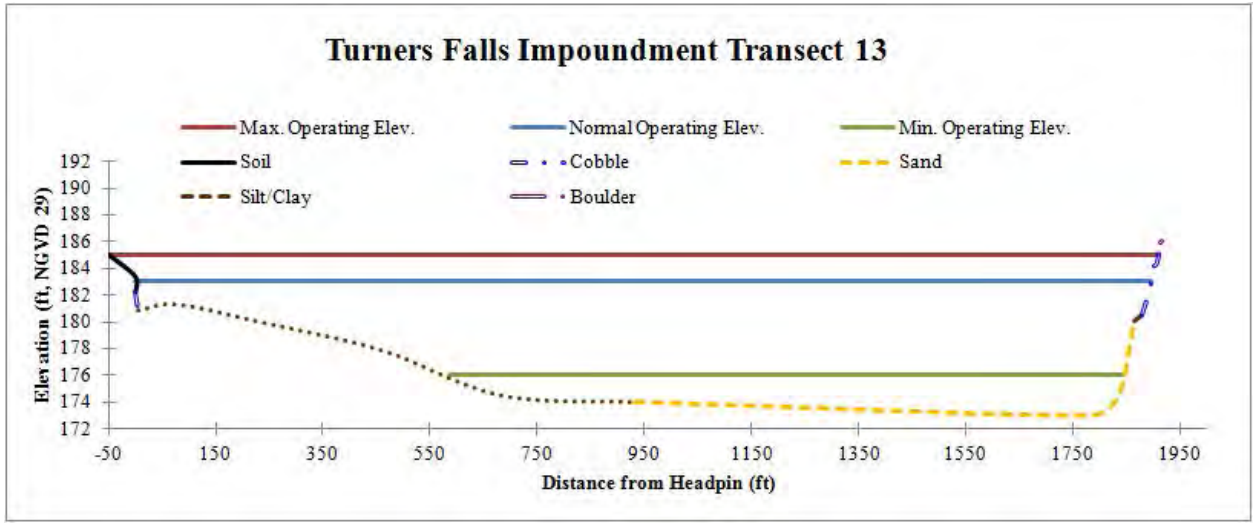

Turners Falls Impoundment Transect 8
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
BEDROCK
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)

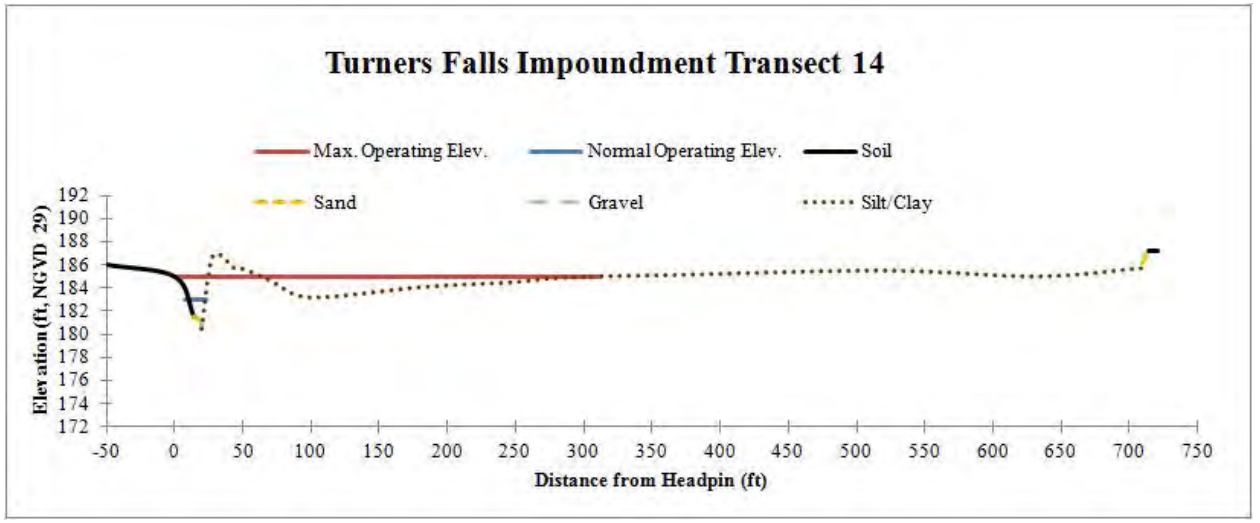

Turners Falls Impoundment Transect 9
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Bedrock
Gravel
Sand
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
20
40
60
80
100
120
140
160
Distance from Headpin (ft)


Turners Falls Impoundment Transect 10
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Sand
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
20
40
60
80
100
120
140
160
Distance from Headpin (ft)


Turners Falls Impoundment Transect 11
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Sand
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
10
20
30
40
50
60
70
Distance from Headpin (ft)


Turners Falls Impoundment Transect 12
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Sand
Gravel
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
0
25
50
75
100
125
150
175
200
225
Distance from Headpin (ft)


Turners Falls Impoundment Transect 13
Max. Operating Elev.
Normal Operating Elev.
Min. Operating Elev.
Soil
Cobble
Sand
Silt/Clay
Boulder
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
-50
150
350
550
750
950
1150
1350
1550
1750
1950
Distance from Headpin (ft)


Turners Falls Impoundment Transect 14
Max. Operating Elev.
Normal Operating Elev.
Soil
Sand
Gravel
Silt/Clay
Elevation (ft, NGVD 29)
192
190
188
186
184
182
180
178
176
174
172
-50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
Distance from Headpin (ft)