Relicensing Study 3.3.1

Conduct Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station

Addendum 2

IFIM Study for Mussels in Reach 5

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

Prepared for:

FirstLight Power Resources

Prepared by:

Kleinschmidt

Gomez and Sullivan Engineers

MAY 2018

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

1-D	One Dimensional
ADCP	Acoustic Doppler Current Profiler
ASCE	American Society of Civil Engineers
cfs	Cubic Feet per Second
CO	Colorado
CF(I)	Compound function index
Commission	Federal Energy Regulatory Commission
CRC	Connecticut River Conservancy
CSI	Combined suitability index
EGL	Energy Grade Line
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
ft	Feet
ft/s	Feet per second
HEC RAS	Hydrologic Engineering Center River Analysis System
HG&E	Holyoke Gas & Electric
Holyoke Project	Holyoke Hydroelectric Project
HSC	Habitat suitability criteria
HSI	Habitat Suitability Index
IFIM	Instream Flow Incremental Methodology
ILP	Integrated Licensing Process
in	Inch
MA	Massachusetts
MDFW	Massachusetts Division of Fisheries and Wildlife
mi	Mile(s)
NGVD29	National Geodetic Vertical Datum of 1929
NH	New Hampshire
NHESP	Massachusetts Natural Heritage and Endangered Species Program
NMFS	National Marine Fisheries Service
Northfield Mountain	Northfield Mountain Pumped Storage Project
PAD	Pre-Application Document
PSP	Proposed Study Plan
RM	River mile
RSP	Revised Study Plan
RTE	Rare, threatened, or endangered
RTK-GPS	Real-time Kinematic Global Positioning System
SD1	Scoping Document 1
SD2	Scoping Document 2
SI	Suitability Index
SPDL	Study Plan Determination Letter
sf	Square feet
Study No. 3.2.2	Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach, and Below Cabot*
Study No. 3.3.1	Study No. 3.3.1 *Conduct Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station*

Study No. 3.3.16	Study No. 3.3.16 *Habitat Assessment, Surveys and Modeling of Suitable Habitat for State-Listed Mussel Species in the Connecticut River below Cabot*
the Corps	U.S. Army Corps of Engineers
the Project	Turners Falls Hydroelectric Project
TNC	The Nature Conservancy
Turners Falls	Turners Falls Hydroelectric Project
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VT	Vermont
VY	Vermont Yankee Nuclear Power Plant
WSEL	Water Surface Elevation
WUA	Weighted Usable Area
WUA_C	Combined WUA and Shear Stress Analysis

1 INTRODUCTION

1.1 Background

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

On October 31, 2012, FirstLight filed its Pre-Application Document (PAD) and Notice of Intent with 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 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 Project Impoundment on the Connecticut River and upstream of the FirstLight Projects, was ceasing operation no later than December 29, 2014. With its closure on December 29, 2014, certain environmental baseline conditions would 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. 3.3.1 *Conduct Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station* (Study No. 3.3.1) 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. 3.3.1, FERC approved the RSP with the following modifications:

- Shad Spawning Sites: FERC recommended inclusion of transects within representative shad spawning habitat in Reach 5;
- Host Fish Habitat Modeling: FERC recommended FirstLight evaluate project effects on the primary host fish of all state-listed mussels present in the project-affected area;
- Velocity Profiles for Mussels: FERC recommended FirstLight collect mean column and benthic velocity data at representative transects at all three calibration flows in Reaches 4 and 5 to validate mean column velocities and any simulated benthic velocities;

- Water Surface Level Monitoring Locations: FERC recommended FirstLight install additional water level loggers to validate/calibrate the proposed models in this study; and

- Transect Locations for Mussels: FERC recommended FirstLight include all habitat types when placing Instream Flow Incremental Methodology (IFIM) transects in Reach 4.

1.2 Chronology of Events Relative to Mussels

Below is a chronology of events relative to the mussel evaluation. In addition, the consultation record for this study can be found in Appendix A.

- On October 14, 2016, the final study report for Study No. 3.3.1 was filed with FERC. As part of the October 14, 2016 filing, a screening level assessment for state listed mussels in Reach 5 was conducted. During the screening-level analysis, supplemental bathymetric and substrate data were collected at fifteen (15) transects in Reach 5, which were selected based on the abundance of state-listed mussel species as described in the final study report. The supplemental bathymetric and substrate data were added to the existing HEC-RAS 1-D model that had been developed as part of Relicensing Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach, and Below Cabot* in Reach 5. A similar analysis was originally contemplated for Reach 4; however, no state and/or federally listed mussels were documented in this reach during recent surveys, so the analysis within Reach 4 was deemed unnecessary.

  As outlined in the RSP for Study No. 3.3.1 (August 14, 2013), further evaluation of aquatic mussel habitat in Reach 5 would be completed based on the results of the screening-level analysis. Specifically, if the screening-level analysis indicated that state-listed mussels were potentially impacted by FirstLight Project operations, then a more detailed HEC-RAS hydraulic model would be developed to further assess impacts to the state-listed mussel species. As described in the final report for Study No. 3.3.1, operational effects were found to have some (though relatively limited) effects on habitat suitability for the mussels based on binary Habitat Suitability Index (HSI) criteria for mussels developed for Relicensing Study No. 3.3.16 *Habitat Assessment, Surveys and Modeling of Suitable Habitat for State-Listed Mussel Species in the Connecticut River below Cabot* (Study No. 3.3.16).

- On October 31 and November 1, 2016, FirstLight held its study report meeting. Study No. 3.3.1 was discussed on October 31.

- On November 15, 2016 meeting minutes were filed.

- Timely comments on Study No. 3.3.1 were filed by the United States Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Massachusetts Division of Fisheries & Wildlife (MDFW), the Massachusetts Natural Heritage and Endangered Species Program (NHESP) and the Connecticut River Watershed Council (now Connecticut River Conservancy, CRC). In their comments, NHESP and USFWS indicated that additional analysis was needed to evaluate mussel habitat relative to Project operations in Reach 5.

- On January 4, 2017, FirstLight, NHESP and USFWS had a conference call to discuss the method for evaluating mussels.

- On January 17, 2017, FirstLight filed its responsiveness summary and agreed to file an addendum (Addendum 1) to address the stakeholder questions. As part of the January 17, 2017 filing, FirstLight included (a) the January 4, 2017 conference call minutes, and (b) Attachment A - which included a study plan for evaluating mussels and an enhanced screening-level analysis. The screening analysis would assess mussel habitat using currently available datasets, including field data previously collected by FirstLight in Reach 5.

- On February 27, 2017, NHESP and USFWS emailed FirstLight comments on the proposed method for evaluating mussels in Reach 5. The comments indicated a need for additional hydraulic data collection, essentially requiring a full-scale instream flow study. In addition, NHESP and USFWS requested that a determination be made, via a shear stress analysis, as to whether Project operations create bed shear stresses that could potentially mobilize the mussels.
- On April 3, 2017, FirstLight filed Addendum 1 to Study No. 3.3.1 that addressed numerous comments. Relative to mussels, Attachment A of Addendum 1 included the emailed comments from NHESP and USFWS received on February 27, 2017. In Addendum 1, FirstLight stated that it was reviewing comments from USFWS and NHESP on next steps relative to mussels.
- On May 19, 2017, FirstLight emailed all stakeholders a RSP to conduct a full-scale instream flow study (or IFIM study- instream flow incremental methodology) in Reach 5 for state-listed mussels and host fish.
- On June 1, 2017, FirstLight had a meeting to discuss the study plan and to solicit comments. Those attending the meeting (or participating via phone) included NHESP, USFWS, The Nature Conservancy (TNC) and FERC. Comments on the RSP were received at the meeting.
- On June 5, 2017, FirstLight re-issued the RSP to address comments received at the June 1 meeting.
- On June 9, 2017, NHESP emailed FirstLight agreeing to the study, but had additional notes relative to shear stress. On June 9, 2017, USFWS and TNC emailed FirstLight concurring with NHESP comments.
- On July 28, 2017, the RSP was sent to stakeholders again, which included revisions addressing NHESP comments.
- On August 7, 2017, NHESP emailed FirstLight expressing its support of the final RSP. On August 8, 2017, USFWS and TNC also expressed their support of the final RSP.
- On August 23, 2017, FirstLight filed a letter with FERC summarizing the above consultation record. FirstLight noted in the letter that it was not seeking FERC's approval on the final RSP, since it was already approved by FERC on February 21, 2014. In short, FirstLight proposed to conduct an IFIM study for mussels in Reach 5 and to quantify the relationship between Project operations and aquatic habitat, along with shear stress. Field data collection, modeling, and analyses associated with this study were conducted throughout the latter part of 2017.
- On February 23, 2018, FirstLight filed a letter with FERC providing an update on outstanding addendums. In its filing, FirstLight indicated it was completing its analysis of rare, threatened and endangered (RTE) mussels in Reach 3 (Yellow Lampmussel) and Reach 5 (three RTE species) and would file it by May 1, 2018.
- On May 1, 2018, FirstLight is filing Addendum 2 to Study No. 3.3.1 to include its evaluation of mussels.

1.3 Study Goal and Representative Reach Approach

The goal for this study was to assess the potential effects of Turners Falls Project operations, when combined with water level management at Holyoke Dam, on the shear stress and aquatic habitat suitability for state-listed mussel resources and host fish (habitat only) between the Route 116 Bridge in Sunderland, Massachusetts (MA) and the Dinosaur Footprints Reservation in the Connecticut River. The target mussel species included the Yellow Lampmussel, Eastern Pondmussel, and Tidewater Mucket as well as host fish (see Table 1.3-1).

To satisfy the study goal, an IFIM representative reach approach was employed to evaluate fish habitat. The first step in this approach was to define the mesohabitat throughout the study reach. Once defined, representative reaches were selected to represent the various habitat features found throughout the study area. Sub-sections of each representative reach were then identified, and transects were established within those sub-sections. For the purpose of this study, three representative sub-reaches were identified, including the (1) Dry Brook sub-reach; (2) Hatfield sub-reach; and (3) Mitch's Island sub-reach. Within each sub-reach transects were established. At each transect, depth, velocity, and substrate information were collected for use in the hydraulic models. Two flows were modeled for each representative sub-reach to examine low flow and high flow conditions. In total, six independent hydraulic models were developed and calibrated.

Once each independent model was calibrated, the full HEC-RAS model (developed as part of Study No. 3.2.2) was used to conduct production runs which predicted the hydraulics at each transect under different downstream boundary conditions (i.e., varying Holyoke Dam water surface elevations) and flows. The output from the hydraulic model was then combined with the habitat model embedded within PHABSIM and the amount of aquatic habitat for a given species/life stage of mussel and host species was calculated and evaluated for its habitat suitability. The habitat suitability was quantified in terms of the Weighted Usable Area (WUA), where a unit of WUA represents a unit of suitable habitat for the life stage evaluated. Steady-state WUA figures depicting the relationship between the total amount of WUA in Reach 5 and flow were developed for the three target mussels (juvenile and adult) and host fish. Dual flow and shear stress analyses were then conducted for the three target mussel species. The results of the various data collection, modeling, and analysis efforts were then used to determine the potential effects of Turners Falls Project operations, combined with water level management at Holyoke Dam, on the shear stress and aquatic habitat suitability for the target mussel species found in the study area.

Each of the previously mentioned components to the approach laid out in the RSP are discussed in greater detail in the ensuing sections of this report. This includes discussion of: Study Area and Summary of Existing Information (Section 2); Methods (Section 3); Habitat Modeling Results (Section 4); and Discussion (Section 5), as well as various appendices.

Table 1.3-1: Target Mussels and Host Fish for Reach 5 Instream Flow Study

Species	Life Stages	Host Fish
Yellow Lampmussel	Juvenile, Adult	Deep Slow Guild, Deep Fast Guild
Eastern Pondmussel	Juvenile, Adult	Deep Slow Guild, Shallow Slow Guild
Tidewater Mucket	Juvenile, Adult	Deep Slow Guild, Deep Fast Guild, Shallow Slow Guild

2 STUDY AREA AND SUMMARY OF EXISTING INFORMATION

This section provides an overview of the Project Location (Section 2.1), Study Area (Section 2.2), and summary of existing information used to inform this study (Section 2.3).

2.1 Project Location

The Turners Falls Project is located on the Connecticut River in the states of MA, New Hampshire (NH) and Vermont (VT) (Figure 2.1-1). The majority of the Turners Falls Project, including developed facilities and most of the lands within the Project boundary, is located in Franklin County, MA in the towns of Erving, Gill, Greenfield, Montague and Northfield. The northern reaches of the Project boundary extend into the town of Hinsdale in Cheshire County, NH and the town of Vernon in Windham County, VT. The Turners Falls Dam is located at approximately river mile (RM) 122 *(*above Long Island Sound) on the Connecticut River, in the towns of Gill and Montague, MA.

The Turners Falls Dam creates the Turners Falls Impoundment, which is approximately 20 miles long and extends upstream to the base of Great River Hydro's Vernon Hydroelectric Project and Dam (FERC No. 1904). The Turners Falls Project is comprised of Cabot Station and Station No. 1. FirstLight operates Cabot Station (located on a canal downstream of Turners Falls Dam) as a peaking facility when flows are less than its hydraulic capacity (13,728 cubic feet per second (cfs)). FirstLight's Station No. 1, which is also located on the canal, has a hydraulic capacity of 2,210 cfs, but is generally not operated as a peaking facility. Project operations therefore have the potential to influence aquatic habitat in areas downstream of Cabot Station, including state-listed mussel species that have been documented within Reach 5.

2.2 Study Area

The study area encompasses Reach 5, which originates approximately 9.75 miles downstream of Cabot Station at the Route 116 Bridge in Sunderland, MA and extends approximately 22 miles downstream to a natural hydraulic control located near Dinosaur Footprints Reservation (Figure 2.2-1). This section of the Connecticut River is a low gradient, alluvial reach with limited mesohabitat variability and, in many cases, very gradual or subtle transitions from one mesohabitat type to the next contiguous type. Over 87% of this reach was classified as "run" mesohabitat. Sand substrates are prevalent in most of the reach, with the exception of the furthest upstream areas where gravel is more prevalent. Hydraulics in this reach are also influenced by backwatering effects from the downstream Holyoke Hydroelectric Project (FERC No. 2004) (Holyoke Project), located about 4 miles downstream of the natural hydraulic control located near Dinosaur Footprints Reservation. The backwatering effects are more prominent in the lower reaches of Reach 5, but are prevalent throughout the reach. The current FERC license for the Holyoke Project permits the water surface elevation (WSEL) at the Holyoke Dam to vary between 99.47 and 100.67 feet (ft.) (National Geodetic Vertical Datum of 1929 (NGVD29)).

As discussed briefly in Section 1.3 and in more detail in Section 3, this study utilized an IFIM representative reach approach, whereby reaches were identified within the study area representing the various habitat features present. For the purposes of this study, three representative sub-reaches were identified throughout Reach 5 including (from upstream to downstream): (1) Dry Brook sub-reach; (2) Hatfield sub-reach; and (3) Mitch's Island sub-reach. Furthermore, three transects were established within each representative sub-reach, with the exception of the Mitch's Island sub-reach which had four transects, for a total of ten transects. As discussed in Section 3, field data collection occurred along each transect to inform the modeling and analyses conducted within each representative sub-reach. Figure 2.2-2 depicts the representative sub-reaches and transects analyzed as part of this study.

The boundaries of the sub-reaches as described in the 2017 study plan had been established prior to conducting additional hydraulic modeling, including adding the ten additional transects to the Reach 5 hydraulic model, and collecting additional velocity and WSEL data in this reach. Given this, following completion of field data collection efforts, hydraulic modeling, and preliminary habitat modeling, FirstLight re-evaluated hydraulic conditions (i.e., WSEL and energy grade line (EGL)) of each sub-reach relative to the start and end points (i.e., the breakpoints) of those reaches. Based on this re-evaluation, it was determined that a different set of sub-reach breakpoints would be appropriate. More specifically, the breakpoints for the upstream end of the Mitch's Island and Hatfield sub-reaches were shifted, as discussed below.

Based on review of the EGL and WSEL under low and high downstream boundary conditions, the study team determined that the upstream boundary of the Mitch's Island sub-reach (which is also the downstream boundary of the Hatfield sub-reach) should be moved from RM 96.8 downstream to RM 93. The study team also concluded that the upstream end of the Hatfield sub-reach (which is also the downstream end of the Dry Brook sub-reach) should be moved from RM 102.8 upstream to RM 105.16. At this location, the hydraulic gradient and EGL slope increases significantly under all modeled flows. The shift in boundary locations does not impact substrate composition classifications within any reach. WSELs and sub-reach locations are provided in Figure 2.2-3. Appendix B provides a summary of the limited differences (generally about 10% lower amounts with the revised sub-reach boundaries) in WUA between the original and revised sub-reach breakpoints. These tables are for the 4 variable (with shear stress) and low downstream boundary scenario which result in slightly less WUAs than other scenarios.

2.3 Existing Information

A wealth of existing, relevant information was available and utilized to inform the modeling and analyses conducted during this study. Existing datasets utilized for this study included: aquatic habitat mapping conducted in 2012; mussel studies conducted from 2003-2014 during the Holyoke Project relicensing proceeding; binary HSI criteria developed during the Turners Falls relicensing (as part of earlier efforts associated with Study No. 3.3.1); and habitat verification data collected by FirstLight in 2016. Each of these datasets are discussed in more detail below.

Initial aquatic habitat mapping from the Cabot tailrace to Dinosaur Footprints was performed in 2012 and summarized in a report entitled "*Aquatic Mesohabitat Assessment and Mapping*" (FirstLight, 2012), which was filed with FERC on January 8, 2013 and is available on FirstLight's relicensing website.[1] Additional substrate surveys performed in 2016 found that substrate in much of Reach 5 was predominantly sand, with some silt mixed in along the banks. Gravel became more prominent in the far upstream section of Reach 5. It was also noted during the 2016 field survey that the lower reaches of Reach 5 are more influenced by the backwater created by the Holyoke Dam. The mapping also indicated that bedrock is the common substrate in the hydraulic control area near the Dinosaur Footprints Reservation and downstream towards Holyoke Dam. Mesohabitats for Reach 5 are shown in Figure 2.3-1.

As part of the FERC license for the Holyoke Project, freshwater mussel studies were required over a 12-year period (2003-2014), with interim reports required every four years. The mussel survey area extended from Dry Brook (near Sunderland) downstream to the Holyoke Dam. Holyoke Gas & Electric (HG&E) filed the final report with FERC on October 1, 2014. The report provided detailed information regarding the presence and relative abundance of mussel species within the examined reach, with an emphasis on state-listed mussel species. Yellow Lampmussel (*Lampsilis cariosa*), the Eastern Pondmussel (*Ligumia nasuta*), and the Tidewater Mucket (*Leptodea ochracea*) were documented in the study reach; however, most state-listed mussels were found to be Yellow Lampmussels, with the other two species only found at one location (i.e., the uppermost transect in the Mitch's Island sub-reach). The presence/absence of Yellow

[1] http://www.northfieldrelicensing.com

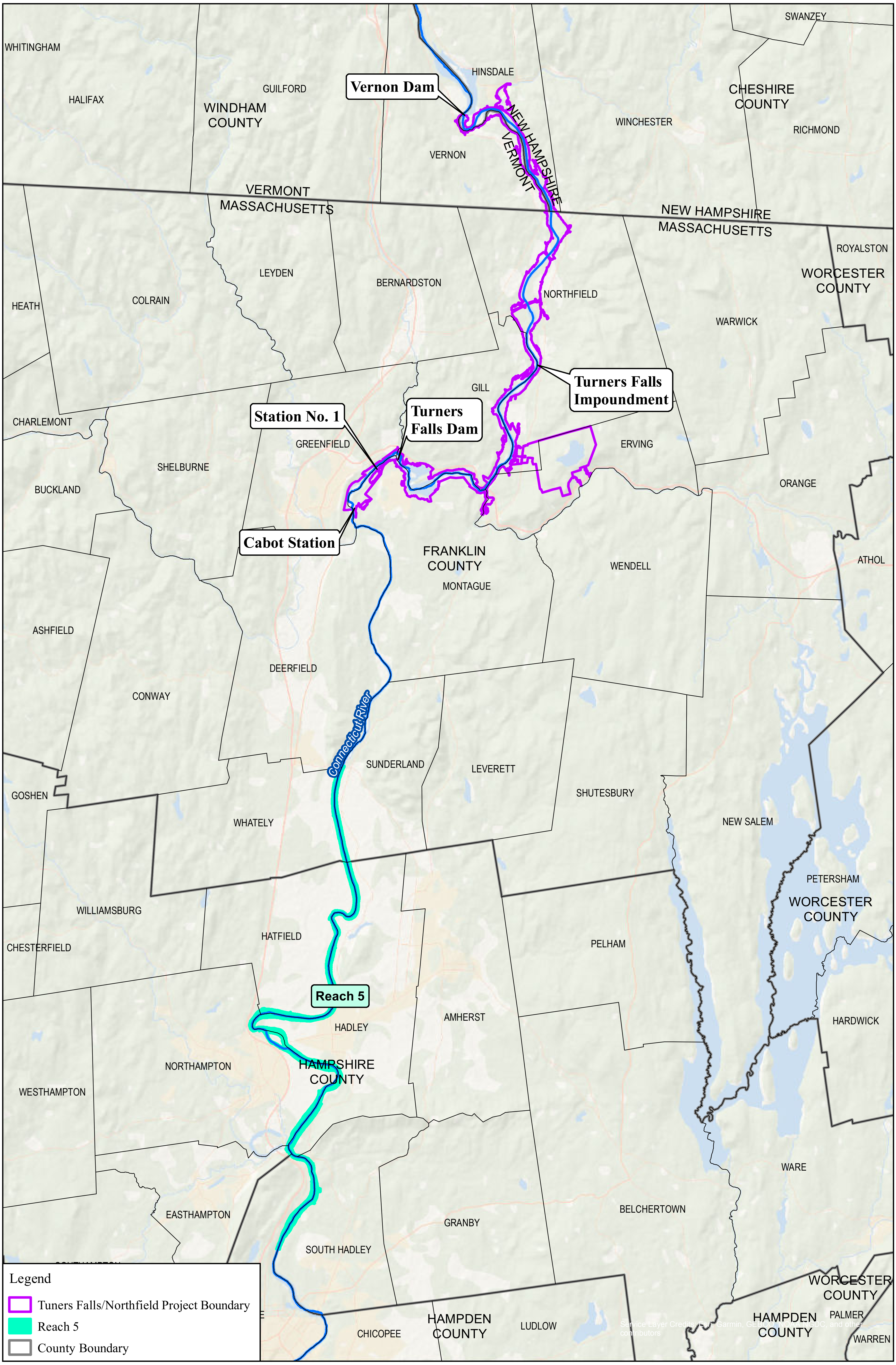
Lampmussels within the reach is shown in Figure 2.3-2. Mussel information depicted in the figure is based on the most recent surveys (2009 and 2013).

As part of the Turners Falls relicensing process, quantitative binary HSI criteria were developed for the three state-listed mussel species (juvenile and adult life stages) documented in the study area using the Delphi technique. Under this method, a panel of mussel experts were assembled and asked to develop and reach consensus on habitat criteria using information from studies conducted in the Connecticut River, other rivers and lakes throughout the range of each species, and from their research and professional experiences. HSI development criteria for the three target mussel species is described in the report for Study No. 3.3.16 (FirstLight, 2016a) and also summarized in Table 2.3-1. These data were analyzed as part of a detailed screening analysis, which utilized HEC-RAS modeling to incorporate the binary HSI criteria. The analyses found that, in general, operational effects from the Turners Falls Project on state-listed mussels in Reach 5 were minimal overall, and that the habitat suitability modeling at various flow rates did not appear to correlate with the abundance and presence/absence of the mussel species. The full results are presented in the Final Study Report for Study No. 3.3.1 (FirstLight, 2016b), which was filed with FERC on October 14, 2016.

Habitat verification data (depth, velocity, and substrate) were collected by FirstLight in 2016 at 15 transects located in areas with variable abundances of state-listed mussels (Figure 2.3-3). As shown on the figure, depth, velocity, substrate, WSEL, and flow data were collected at many of the 15 transects. FirstLight used these data, along with additional data collected, to assess habitat (for mussels and host fish) and shear stress (for mussels) as part of its instream flow study.

Table 2.3-1: Binary HSI Scores for Three Massachusetts State-Listed Mussel Species

Parameter		Yellow Lampmussel		Eastern Pondmussel		Tidewater Mucket	
		Juvenile	Adult	Juvenile	Adult	Juvenile	Adult
Class	**Benthic Velocity Range (ft/s)**						
1	<0.16	1	1	1	1	1	1
2	0.16-0.34	1	1	1	1	1	1
3	0.35-0.67	1	1	1	1	1	1
4	0.68-0.99	1	1	1	1	1	1
5	1.00-1.32	1	1	1	1	1	1
6	1.33-1.65	1	1	1	1	1	1
7	1.66-2.47	0	1	0	0	0	1
8	2.48-3.29	0	0	0	0	0	0
9	3.30-4.93	0	0	0	0	0	0
10	4.94-6.56	0	0	0	0	0	0
11	>6.56	0	0	0	0	0	0
Class	**Water Depth Range (feet)**						
1	0	0	0	0	0	0	0
2	0.03-0.34	0	0	0	0	0	0
3	0.35-0.83	1	1	1	1	1	1
4	0.84-1.65	1	1	1	1	1	1
5	1.66-2.47	1	1	1	1	1	1
6	2.48-3.29	1	1	1	1	1	1
7	3.30-4.93	1	1	1	1	1	1
8	4.94-6.56	1	1	1	1	1	1
9	6.57-9.85	1	1	1	1	1	1
10	9.86-13.12	1	1	1	1	1	1
11	>13.12	1	1	1	1	1	1
Class	**Particle Size**						
1	Organic Material	0	0	0	0	0	0
2	Clay	0	0	0	0	0	0
3	<0.002 in. [mud/silt]	1	1	1	1	1	1
4	0.002-0.08 in. [sand]	1	1	1	1	1	1
5	0.08-1.26 in. [fine gravel]	1	1	1	1	1	1
6	1.26-2.52 in. [coarse gravel]	1	1	0	1	1	1
7	2.52-5.90 in. [small cobble]	1	1	0	0	0	0
8	5.90-9.84 in. [large cobble]	0	0	0	0	0	0
9	9.84-157.5 in. [boulder]	0	0	0	0	0	0
10	Bedrock	0	0	0	0	0	0



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Study 3.3.1 - IFIM Reach 5

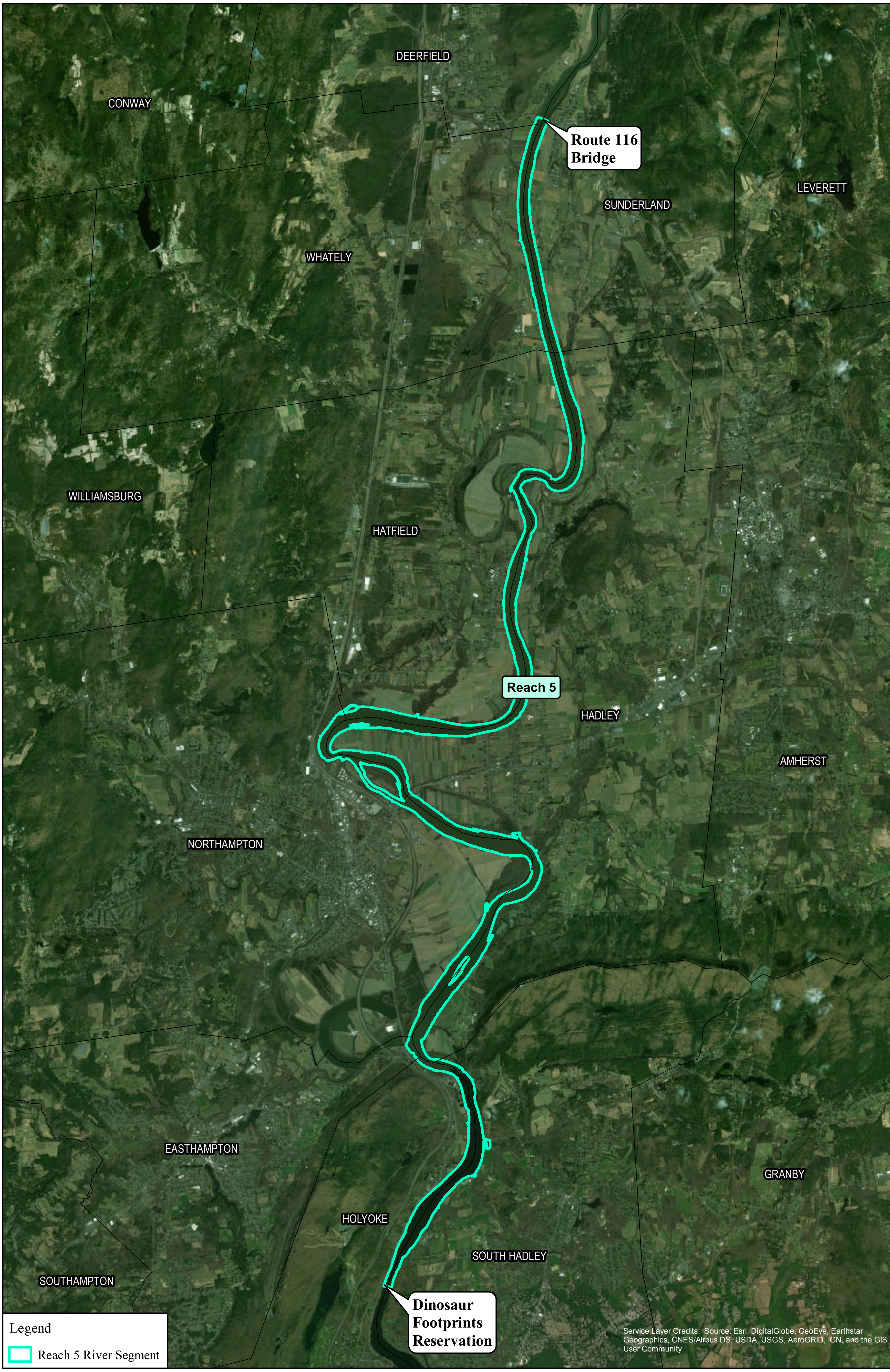
Figure 2.1-1:
Project Location

N

0 1.5 3 6 Miles

Copyright © 2018 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_may_2018\figure_2_1-1_project_location.mxd



FirstLight Power Resources

N

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

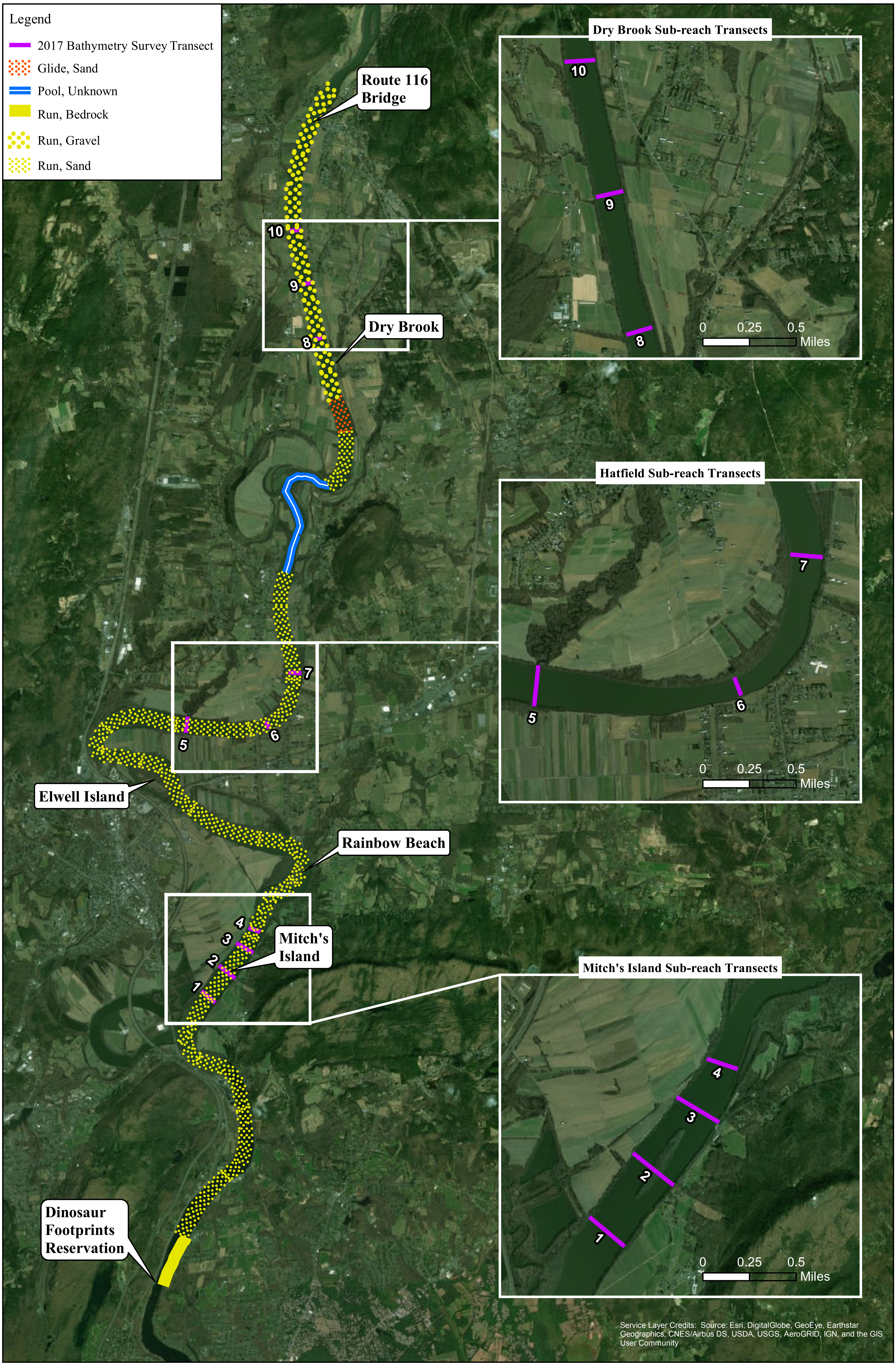
Study 3.3.1 - IFIM Reach 5

0 0.625 1.25 2.5
Miles

Figure 2.2-1:
Reach 5 River Segment
of the Connecticut River

Copyright © 2018 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_may_2018\figure_2_2-1_reach_5.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Study 3.3.1 - IFIM Reach 5

FirstLight Power Resources

N

0 0.625 1.25 2.5 Miles

Figure 2.2-2:
Reach 5 - Representative Sub-reaches and Transects

Copyright © 2018 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_may_2018\figure_2_2-2_representative_reaches.mxd

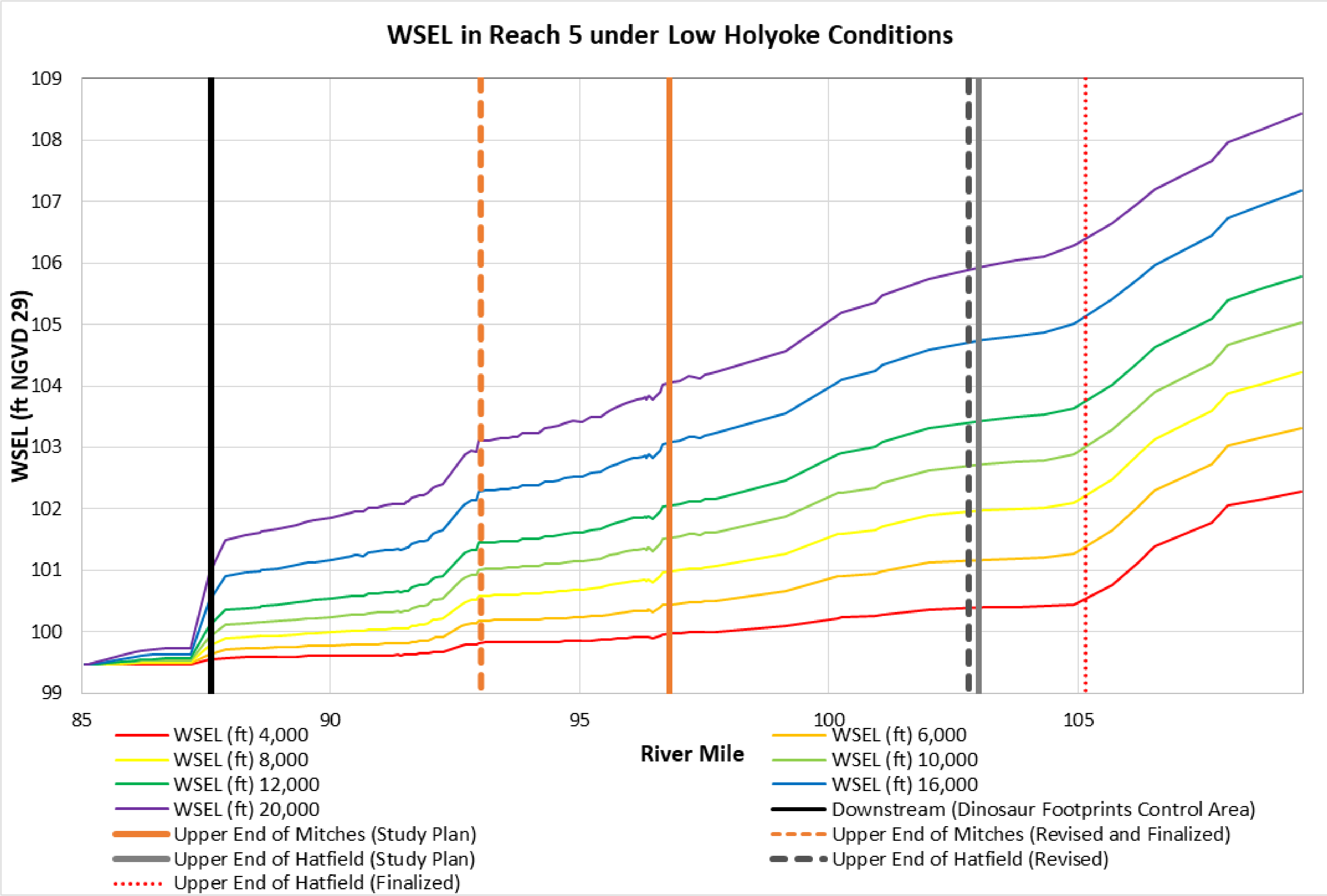
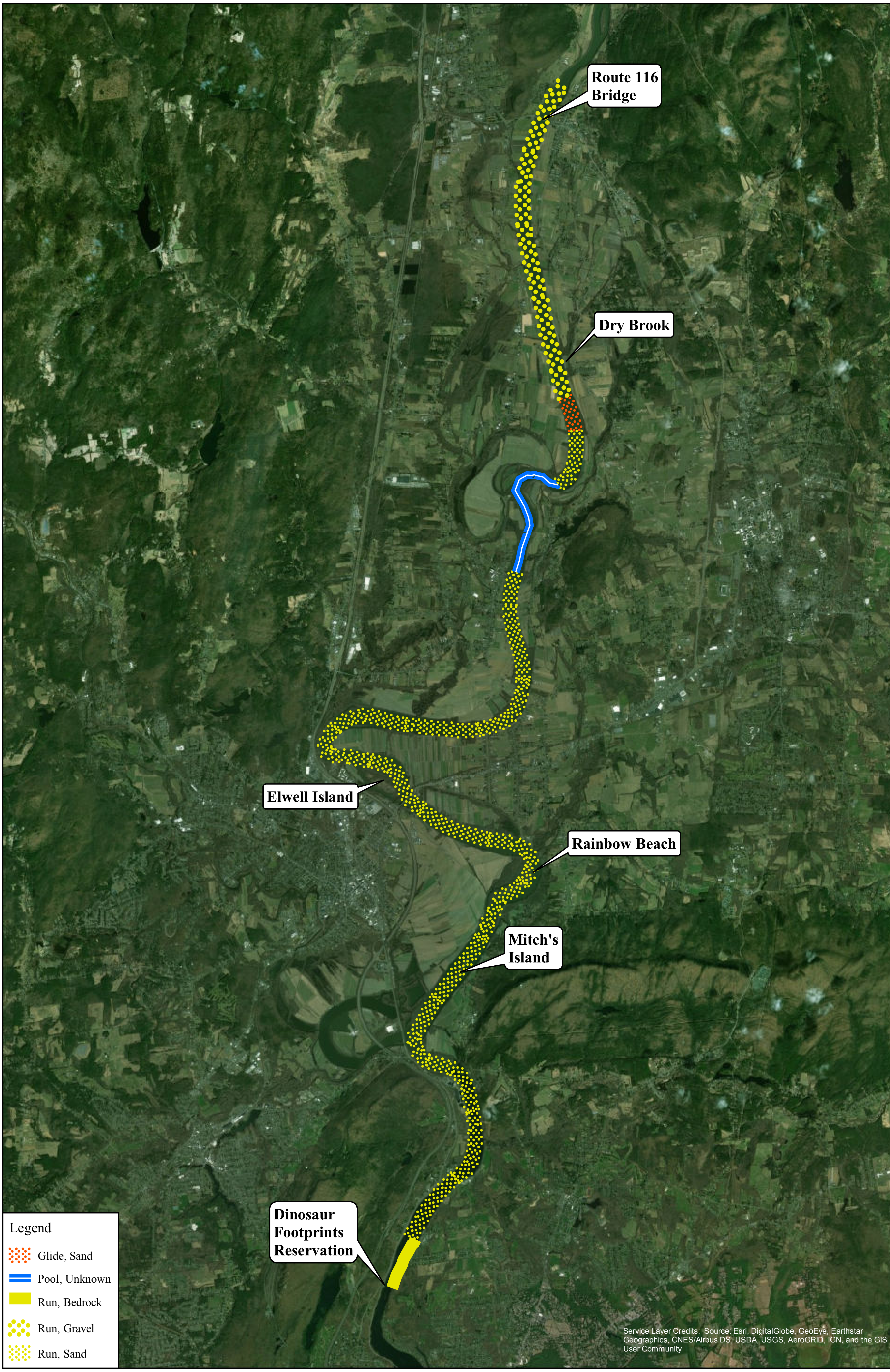


Figure 2.2-3: WSELs and Sub-Reach Locations



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Study 3.3.1 - IFIM Reach 5

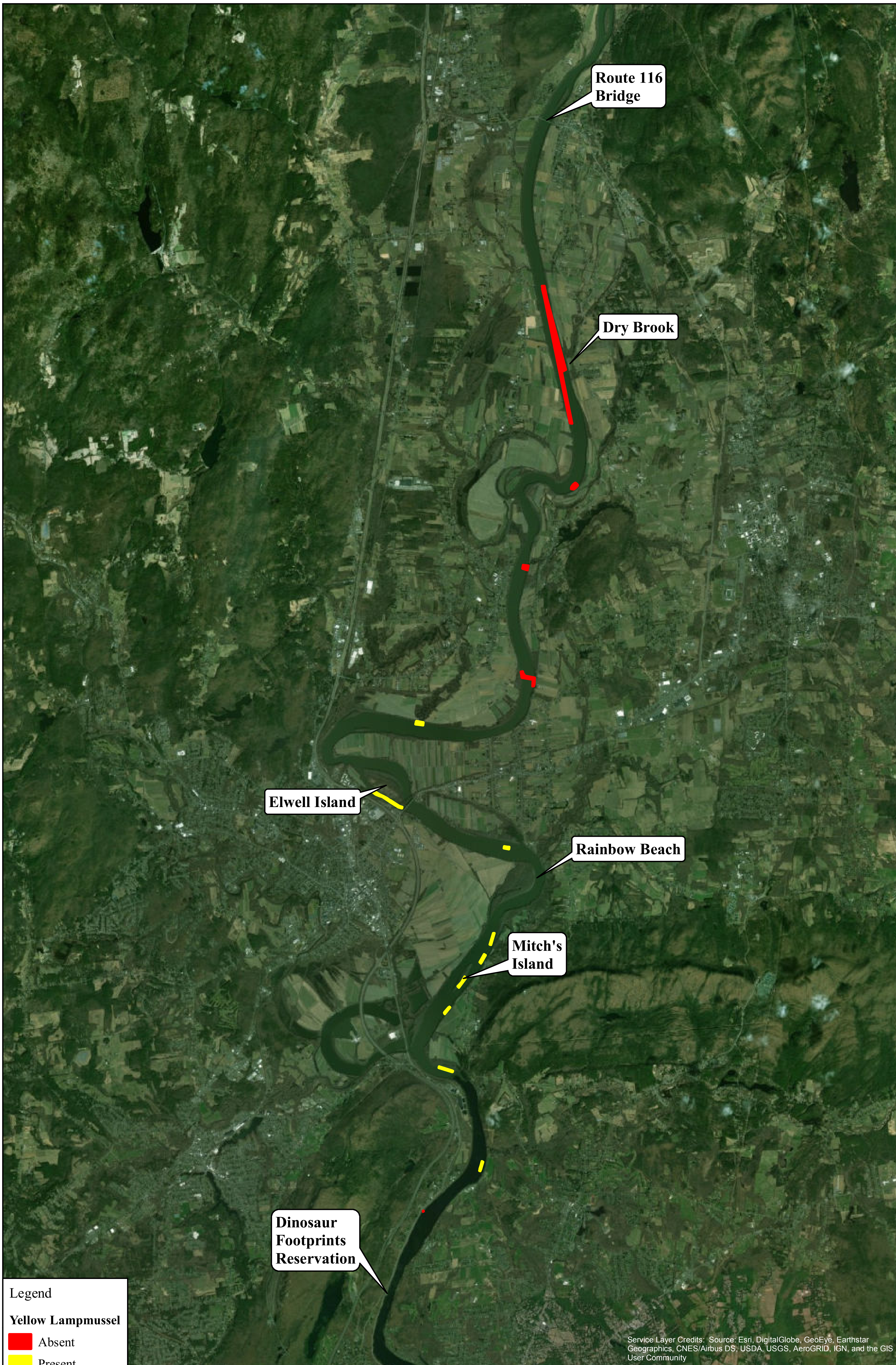
N

0 0.625 1.25 2.5
Miles

Figure 2.3-1:
Mesohabitat in the Reach 5 River Segment of the Connecticut River

Copyright © 2018 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_may_2018\figure_2_3-1_mesohabitats.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Study 3.3.1 - IFIM Reach 5

FirstLight Power Resources

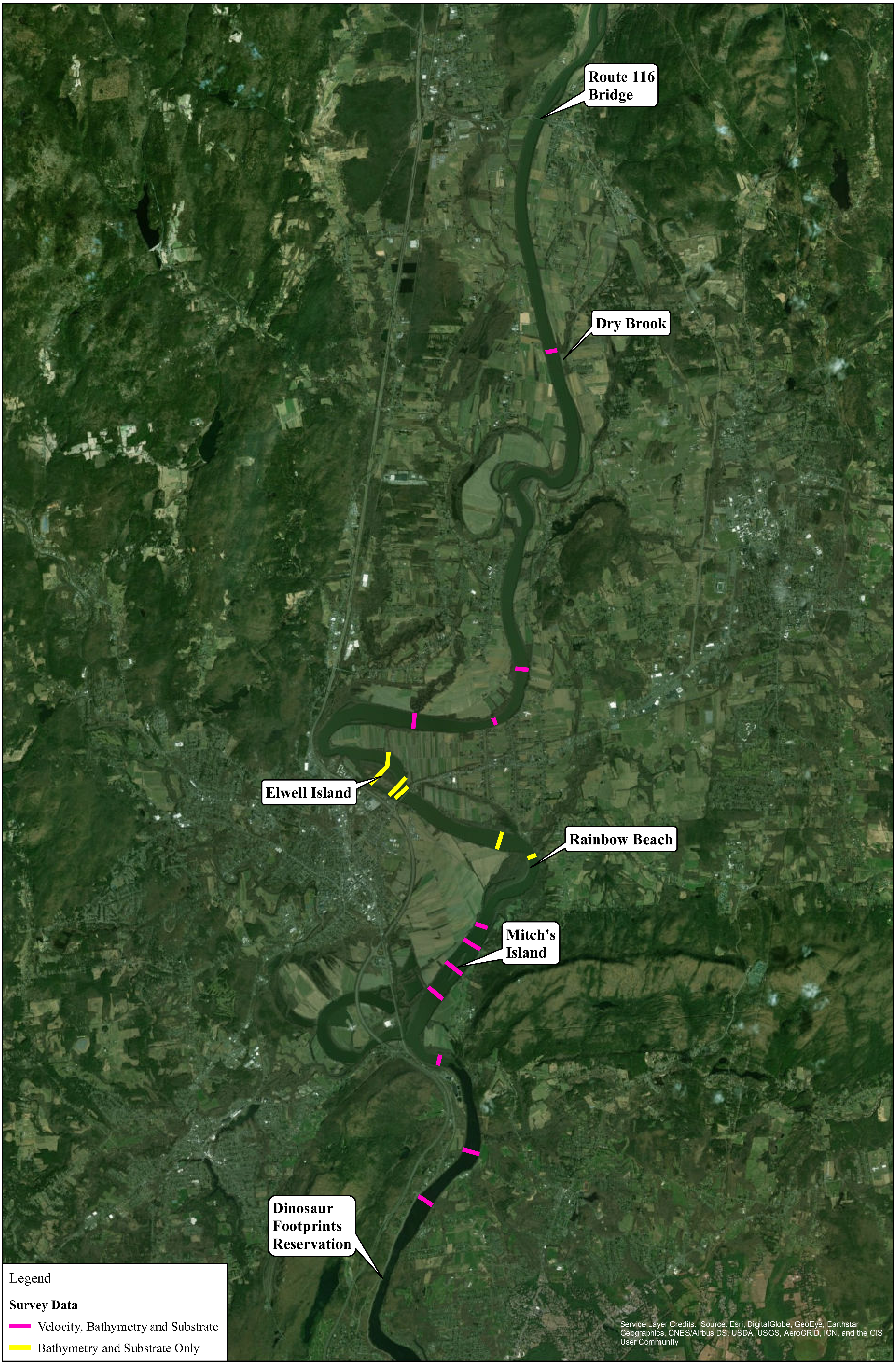
N

0 0.625 1.25 2.5 Miles

Figure 2.3-2:
Locations of HG&E Mussel Surveys in 2009 and 2013, showing presence/absence of Yellow Lampmussel

Copyright © 2018 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_may_2018\figure_2_3-2_mussel_surveys.mxd



FirstLight Power Resources

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Study 3.3.1 - IFIM Reach 5

N

0 0.625 1.25 2.5 Miles

Figure 2.3-3:
Location of Transects for Data Collected by FirstLight in 2016

Copyright © 2018 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_may_2018\figure_2_3-3_transects_2016.mxd

3 METHODS

As described in the 2017 study plan, an IFIM study was used to analyze key habitat suitability-flow relationships in the study area. A 1-D modeling approach was found to be suitable for Reach 5 and was completed using PHABSIM for Windows (V 1.5.1), which was developed by the USFWS and distributed by the U.S. Geological Survey (USGS) Fort Collins (CO) Science Center. The 1-D modeling approach used hydraulic data developed from transect depth, velocity, and substrate measurements following Milhouse *et al*., (1989) for the target mussel species and host fish. This section presents a detailed discussion pertaining to the methods employed for each component of the study.

3.1 Overview

FirstLight conducted the IFIM study using the representative reach approach which is consistent with IFIM protocols (Bovee *et al*., 1998) to evaluate fish habitat. As a first step in this approach, the mesohabitat in Reach 5 was documented. Mesohabitats are delineated by riffles, run, and pools, and further divided based on substrate, hydraulics, and other habitat features such as instream cover, overhead cover, etc. The mesohabitat classification and length of mesohabitat features were documented in Reach 5 in 2012. From these mapped features, rather than evaluating the entire 22 miles of habitat, representative reaches were selected to represent the various habitat features. The representative reach approach consists of selecting a sub-section of each representative reach and placing transects in each of the sub-sections. At each transect, depth, velocity, substrate, and WSEL data were collected under a given flow (a total flow measurement was also taken at each transect). Thus, a full set of hydraulic data was collected under a single flow. Using the measured depth and velocity data, a hydraulic model was developed for each subset. The hydraulic models were calibrated to the measured WSEL at each transect and velocities. Once calibrated, the hydraulic model predicted depths and velocities typically at 40-250% of the measured flow.

The number of hydraulic data sets needed (or the number of flows where hydraulic data were collected at each transect in the field), was dependent on Project operations. In this case, the Turners Falls Project can operate up to a flow of 13,728 cfs from Cabot Station and 2,210 cfs from Station No.1. As such, it was determined that two flow data sets would be adequate for FirstLight to evaluate the impact of Turners Falls operations on mussel and host fish habitat and shear stress for mussels. As described later, the two flow datasets could be used to extrapolate depths and velocities up to, and beyond, the total hydraulic capacity of Cabot and Station No. 1 (15,938 cfs).

From the hydraulic output data (depths, velocities), the habitat model was run to quantify the amount of habitat per unit length of river for each transect in a representative sub-reach. In the end, a relationship between WUA per foot of river was developed for each representative sub-reach. The WUA results for each representative sub-reach were then extrapolated based on the miles of river that sub-reach represents. The WUA for each of the three representative sub-reaches was subsequently added together to yield the WUA for the entire Reach 5.

3.2 Mesohabitat Delineation

The study methodology was based on the mesohabitat distribution throughout the study area as mapped in 2012. The mapping and characterization of aquatic mesohabitat provided essential information regarding the extent, location, and composition of aquatic habitats that may be affected by Turners Falls Project operations, and provided a framework for selecting strategic study sites and transects. Ten (10) transects were used to represent the primary mesohabitats in three representative sub-reaches within Reach 5 (Figure 2.2-2). The representative sub-reach names, representative habitat types, the number of miles represented by each sub-reach, and existing hydraulic data sets are listed in Table 3.2-1. The sub-reaches are listed from upstream to downstream order.

The Dry Brook, Hatfield, and Mitch's Island representative sub-reaches collectively represent 19.15 miles of the ~22 miles of Reach 5. Pool habitat (1.9 miles of Reach 5) was eliminated from this analysis, given that there is limited pool habitat within Reach 5. No information from previous mussel bed surveys suggests that the pool areas contain critical mussel habitat in Reach 5, and any mussel habitat that may exist there would be least-affected by Project operations due to the deeper, slower nature of pool habitat. Bedrock and glide mesohabitats (0.75 and 0.5 miles of Reach 5, respectively) were also eliminated from this analysis given the very small amount of those mesohabitats within Reach 5.

Table 3.2-1: Representative Reaches and Proposed No. of Transects

Representative Sub-reach Name	No. of Transects	Miles represented	Representative Habitat Type	Existing Data Sets
Dry Brook Sub-reach	3	3.75 mi.	Run with gravel substrates	None
Hatfield Sub-reach	3	6.2 mi.	Run with sand substrates	Depth, velocity, and substrate data were collected at a flow of ~5,500 cfs in 2016. FirstLight used these data.
Mitch's Island Sub-reach	4	9.2 mi.	Run with fine substrates. This reach is hydraulically distinct from the other two representative reaches – under low flows, there is a greater influence from the HG&E Project	Depth, velocity, and substrate data were collected at a flow of ~3,100 cfs in 2016. FirstLight used these data.
Total	10	19.15 mi.		

3.3 Field Data Collection

Field data gathered in 2017 to support this study were collected in accordance with the protocols laid out in the 2017 study plan. Data collection efforts described throughout this section occurred at the ten transects established throughout the three sub-reaches in Reach 5 (Dry Brook, Hatfield, and Mitch's Island) as shown in Figure 3.3-1.

In June of 2017, Onset Hobo U20 pressure sensors were installed at the ten transects to collect WSEL data prior to, and after, depth and velocity data collection occurred. These sensors were installed to determine if flows, and hence hydraulics, remained relatively steady while the depth, velocity, and substrate data were collected along the transects. WSEL data collected by these sensors were also used to provide calibration data for the hydraulic model. The sensors were programmed to collect data on 5-minute intervals. The HOBO loggers are non-vented and thus must be barometrically compensated using an atmospheric pressure logger. As such, two additional loggers were used to record the atmospheric pressure in Reach 5. Elevations of all water level sensors were surveyed using a Real-time Kinematic Global Positioning System (RTK-GPS).

Depth and mean-column velocity measurements were collected along each transect during both calibration flows (discussed in Section 3.4.1.1), with a Sontek M9 Acoustic Doppler Current Profiler (ADCP).[2] The ADCP was set to record measurements every second, and was linked to an RTK-GPS for survey-grade precision. Because all areas were accessible by boat, all velocity measurements were collected by the ADCP; the Marsh-McBirney Model 2000 Flowmate electronic current meter was not needed. Depths were converted to riverbed bathymetric elevations by subtracting the depth from the recorded WSEL. Substrate data were collected at each transect visually where depth and water clarity allowed, or by probing the riverbed when visual observation was not possible. Changes in the dominant substrate type along each transect were recorded with a GPS and in a field notebook. Substrate were delineated based on types and grain sizes pertaining directly to the mussel HSI criteria, as shown in Table 3.3-1.

Table 3.3-1: Substrate Particle Diameter for the IFIM Study in Reach 5

Substrate	Particle Diameter (inches)
Organic Material	-
Clay	-
Mud/Silt	<0.002
Sand	0.002 – 0.08
Fine Gravel	0.08 – 1.26

For the High Flow Calibration Event on July 11, 2017, FirstLight decreased generation at Cabot Station to three units for about 8 hours, resulting in flows as measured at the Montague USGS Gage (USGS Gage No. 01170500) to be about 9,000 cfs. Reach 5 WSELs and flows are affected by:

- Flow releases from the Turners Falls Project including Cabot Station, Station No.1, and the Turners Falls Dam;

[2] Though mussel habitat is based on benthic velocity, which the ADCP cannot measure directly due to side-lobe interference in close proximity to the bed, the relationship between bed roughness, depth, mean column velocity, and benthic velocity is well-defined in the literature. FirstLight examined the applicability of the theoretical function to ADCP data by fitting a logarithmic function for the velocity data collected in Reaches 4 and 5 previously. The resulting logarithmic function fit to the data were similar to curves from the theoretical functions based on larger substrates with greater bed roughness in Reach 4 relative to the finer substrates with lower bed roughness in Reach 5 (see figures in Appendix A of the 2017 Study Plan).

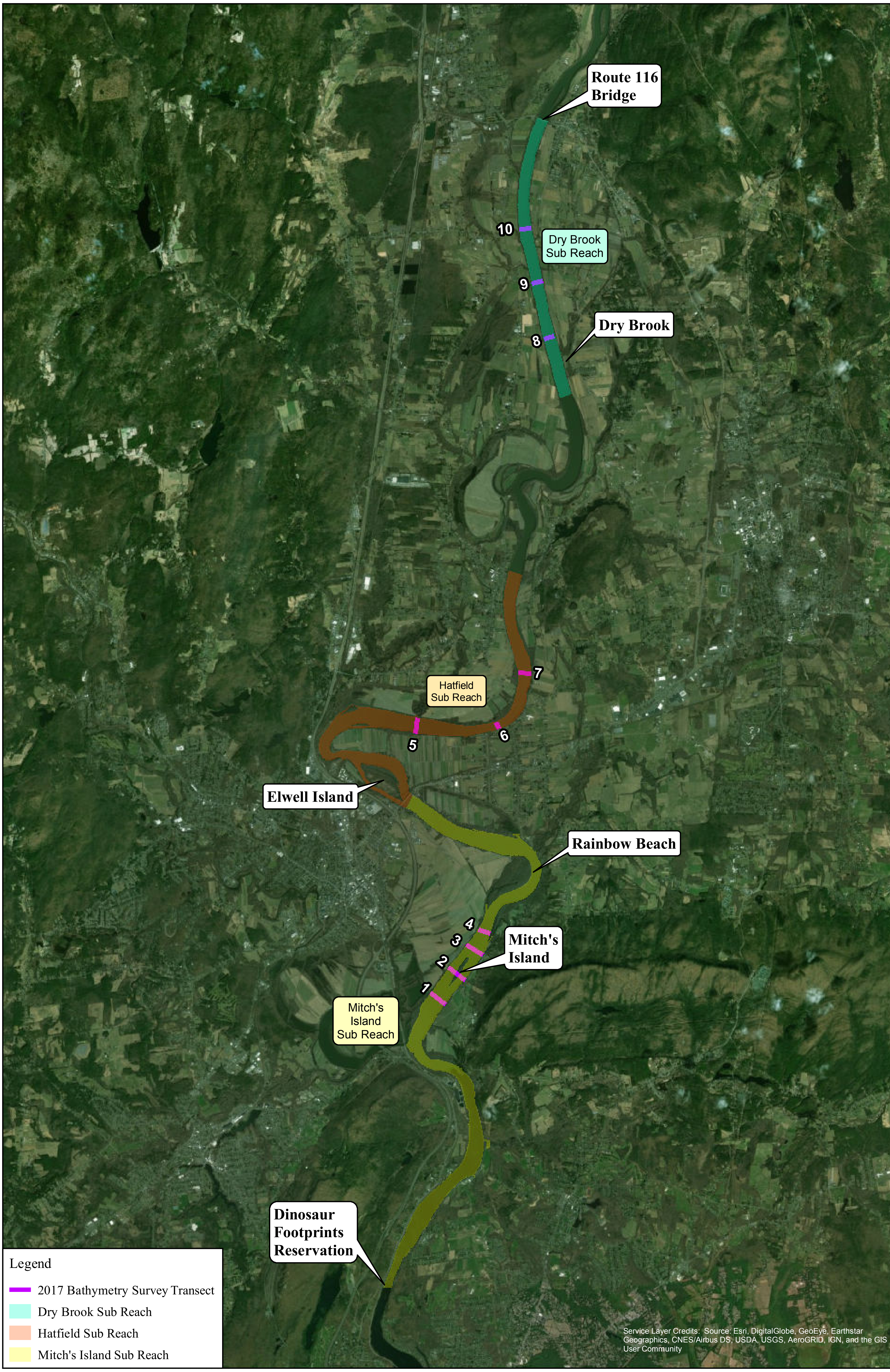
- Inflow from the Deerfield River (including peaking operations at Station No. 2 owned by Great River Hydro);
- Inflow from tributaries downstream of the Montague USGS Gage;
- Holyoke Impoundment WSEL controlled by Holyoke Gas & Electric; and
- Travel time and attenuation.

Figure 3.3-2 provides the WSELs as measured at the transects from July 10 to July 12, 2017, the flows as measured at the Montague USGS Gage, and average flows as measured with the ADCP unit at the Dry Brook, Hatfield, and Mitch's Island sub-reaches on July 11. As can be seen in this figure, the WSELs at the transects had not reached steady state conditions and were still decreasing during the transect flow measurement periods, but at a rate of generally less than 0.1 ft per hour and less at the lower transects at Mitch's Island. Based on detailed hydraulic analyses of this reach utilizing the hydraulic model and WSEL data in Reach 5 (collected during this study and other studies), it is observed that steady-state WSEL conditions never occur due to the multiple influences found in this area as discussed above. Many of these influences are beyond the control of FirstLight, including inflow from the Deerfield River and downstream tributaries and Holyoke impoundment fluctuations. However, as shown in Table 3.3-2, the variation of flow during the ADCP surveys of the sub-reach transects were very small.

Table 3.3-2: Variation of ADCP Measured Flows on July 11, 2017

Sub-reach	Survey Duration (hours)	Mean Flow (cfs)	Range of Flow (cfs)	Max Diff from Mean Flow (cfs)	Max Diff from Mean Flow %
Dry Brook	1:04	9,409	111	57	0.6%
Hatfield	1:09	9,656	438	223	2.3%
Mitch's	1:34	10,096	424	265	2.6%

Flows and WSELs were collected in the Dry Brook sub-reach in the late morning (10:05 to 11:15) on August 3, 2017. During this time period, the flows as measured at the Montague USGS Gage were slightly below 5,000 cfs and were measured with FirstLight's ADCP as between 5,522 and 5,542 cfs (average of 5,529 cfs) at transects 8, 9, and 10. As shown in Figure 3.3-3, WSEL's were dropping slightly but only dropped about 0.05 feet during the flow measurement periods at transects 8, 9, and 10. As summarized in the 2016 IFIM Report, flow and WSEL data were collected in 2016 at the Hatfield and Mitch's Island sub-reaches under ADCP measured flow conditions of 5,500 and 3,100 cfs, respectively.



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Study 3.3.1 - IFIM Reach 5

N

0 0.625 1.25 2.5 Miles

Figure 3.3-1:
Locations of Transects for Bathymetry Data Collected by FirstLight in 2017

Copyright © 2018 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_may_2018\figure_3_3-1_transects_2017.mxd

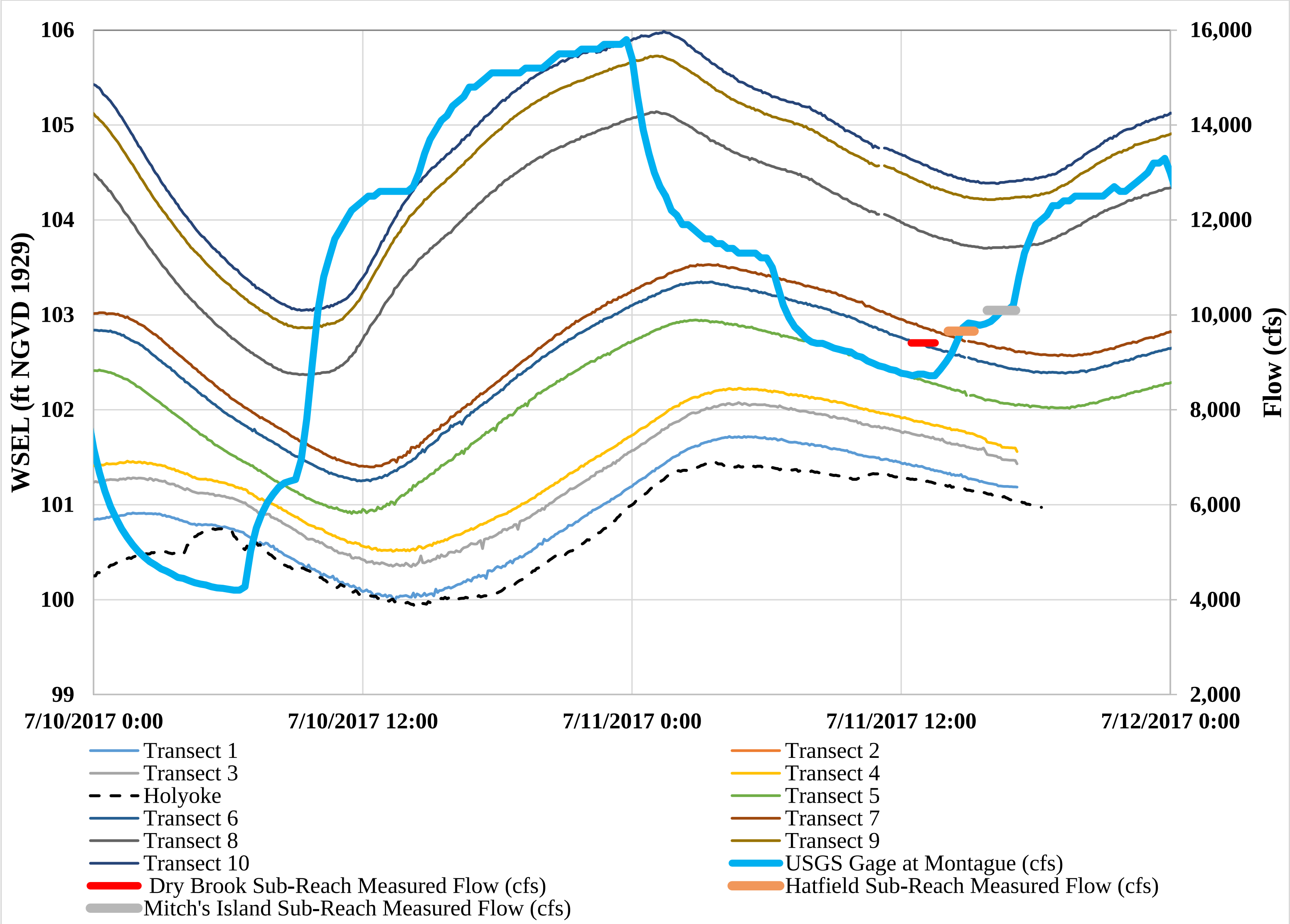


Figure 3.3-2: WSEL and Flows during High Flow Event

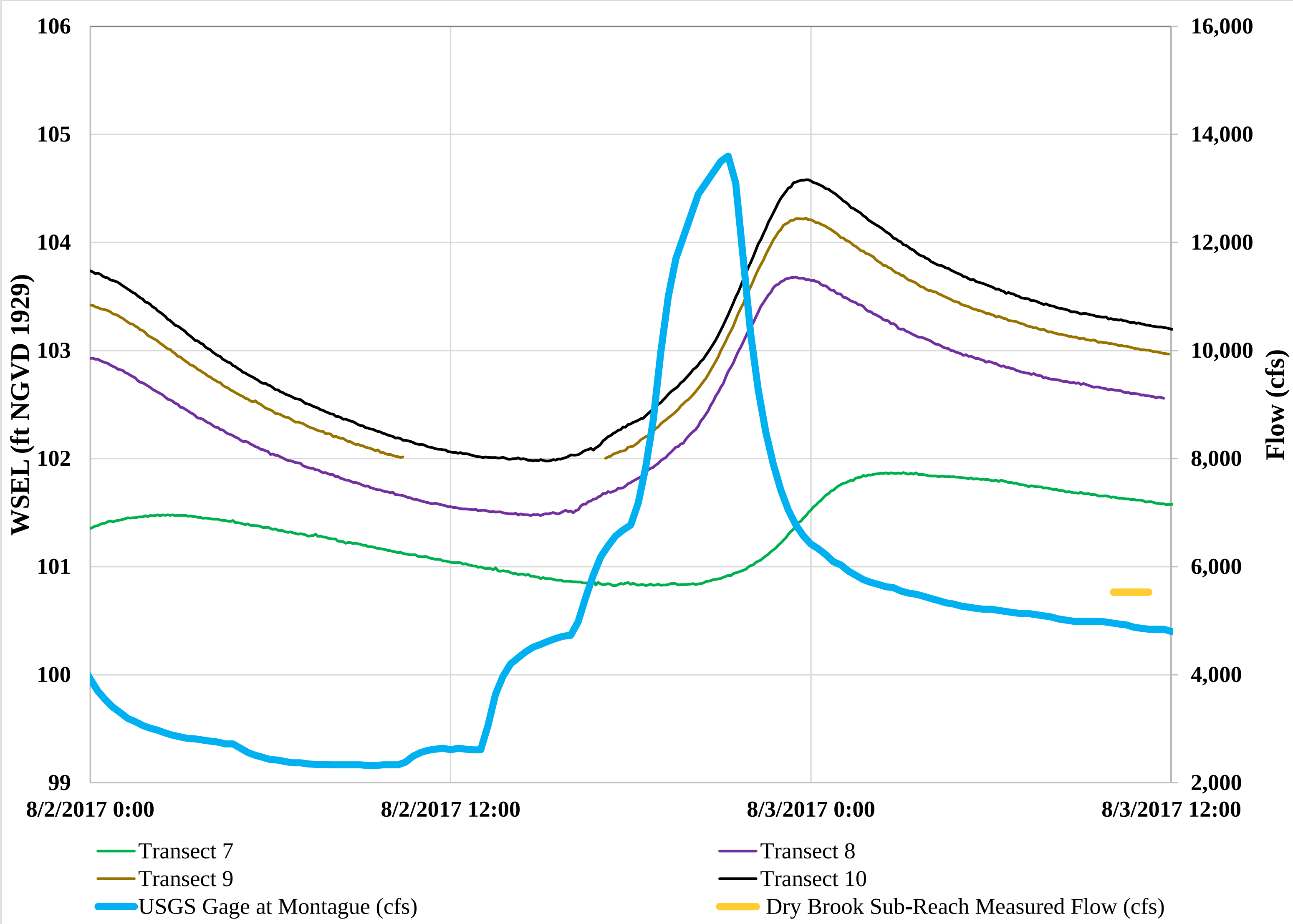


Figure 3.3-3: WSEL and Flows during Low Flow Event on August 3, 2017

3.4 Modeling

Modeling associated with this study had two components – hydraulic modeling and habitat modeling. Each of these components are discussed in greater detail in Section 3.4.1 (hydraulic modeling) and Section 3.4.2 (habitat modeling).

3.4.1 Hydraulic Modeling

Hydraulic modeling conducted for this study utilized the 1-dimensional HEC-RAS modeling software developed by the U.S. Army Corps of Engineers (the Corps) and consisted of the development of three[3] independent models for calibration purposes (i.e., one for each sub-reach) based on the existing HEC-RAS model developed as part of Study No. 3.2.2 and updated with bathymetric data collected as part of this study.

The existing hydraulic model was developed during Study No. 3.2.2 and encompasses the Connecticut River from the Montague USGS Gage downstream to the Holyoke Dam. The existing model was based on cross-sectional data from a combination of sources including:

- hydraulic cross sections from Federal Emergency Management Agency (FEMA) studies;
- bridge data from the Massachusetts Department of Transportation;
- TNC hydraulic model of Northampton, MA;
- Corps bathymetric data;
- FirstLight cross sections from the HEC-RAS hydraulic model developed for Study No. 3.2.2; and
- FirstLight cross sections obtained for the screening level analysis conducted in 2016

The FEMA cross sections were from flood insurance studies conducted in the 1980s. The towns covering this reach include (from upstream to downstream): Montague, Deerfield, Sunderland, Whately, Hadley, Northampton, Easthampton, South Hadley, and Holyoke. FEMA cross sections were not available in the Hatfield Reach, so in 2014 FirstLight obtained eight (8) transects with a boat based ADCP unit and manually obtained bank survey data. More detailed transects in the Northampton Reach were obtained from TNC, which had conducted a study of floodplain forests in the Connecticut River Basin with one of the study sites in the Northampton, MA area of the Connecticut River (Marks, 2014). Bathymetry data was collected by the Corps in the fall of 2011. In 2016, as part of the preparation for Study No. 3.3.1, FirstLight obtained seven (7) additional transects with a boat based ADCP unit near key mussel locations. Finally, in 2017, FirstLight obtained ten (10) additional transects with a boat based ADCP unit at the representative sub-reach transects. FirstLight combined all data from these sources to create the revised HEC-RAS hydraulic model, which encompasses the area from the Montague USGS Gage to just upstream of the Holyoke Dam. Modeling efforts associated with this study are discussed further below.

3.4.1.1 Sub-reach Modeling

In total, three independent hydraulic models were developed and calibrated to analyze the hydraulics within the three sub-reaches (i.e., one model per sub-reach). Calibration of the HEC-RAS models occurred at the high flow values listed in Table 3.4.1.1-1, all of which were approximately 10,000 cfs. Calibration flows were provided by FirstLight via scheduled releases from the Project via a combination of unit operation, gate and/or fishway flow settings. Other sources of inflow affecting Reach 5 include inflow from the

[3] The study plan called for the development of six independent HEC-RAS models (i.e., one a low flow and one at high flow conditions for each sub-reach); however, this was not necessary as the high flow calibration covered both the low and high flow range originally proposed. As such, the HEC-RAS model was calibrated to the WSELs observed in the high flow condition and validated to the multiple low flow conditions. Cellular velocity calibration occurred during the PHABSIM modeling.

Deerfield River and tributaries downstream of the Montague Gage, as discussed in Section 3.3. The Montague USGS Gage provided general information of the flow in the Connecticut River, but Reach 5 is also substantially affected by travel time and attenuation, inflow from tributaries, and flow changes associated with impoundment level control at Holyoke Dam. Therefore, FirstLight relied on the ADCP flow measurements at the individual transects to determine the calibration flow values, which showed limited flow changes during the ADCP measurements at the transects within the sub-reaches (Section 3.3). Flow input from the tributaries downstream of the Montague Gage were estimated to be very small and were captured by the ADCP flow measurements at the individual transects.

The hydraulic models were calibrated to the measured WSEL at each of the 10 transects established in 2017 (Figure 3.3-1). The downstream boundary of each model was represented by the WSEL at the uppermost transect at the next downstream sub reach. For example, the model for the Hatfield sub-reach used the Transect 4 WSEL (the uppermost transect of the Mitch's Island sub-reach) as the downstream boundary condition. Calibration was achieved by matching the measured WSEL at the ten transects to less than 0.1 feet. Results are shown in Table 3.4.1.1-2. As observed in the table calibration to the measured WSELs was excellent. Calibration to the ADCP measured cellular velocities at the transects occurred during the PHABSIM modeling and is discussed in Section 3.4.2.

Based on common hydraulic modeling practice, depth and velocities at flows other than the measured flows can be extrapolated from 40-250% of the measured flow. Given this, as shown in Table 3.4.1.1-1, the range of modeling flows that are suitable for this calibration are generally between 4,000 and 25,000 cfs based on extrapolating the measured flows by 40-250%. As such, and after calibration of the model, the low flow values and corresponding WSELs were used to validate the model at the low flow values listed in Table 3.4.1.1-1.

Following calibration and validation, the updated HEC-RAS model was then used to execute a series of production runs (discussed in greater detail in the following section).

Table 3.4.1.1-1: Range of Flows Simulated at each Sub-Reach

Flow (Dry Brook Reach)	**5,529 cfs (Low Flow - Validation)**	**9,409 cfs (High Flow - Calibration)**
40%	2,200 cfs	3,800 cfs
250%	13,900 cfs	23,500 cfs
Flow (Hatfield Reach)	***5,500 cfs (Low Flow - Validation)**	**9,656 cfs (High Flow - Calibration)**
40%	2,200 cfs	3,900 cfs
250%	13,750 cfs	24,100 cfs
Flow (Mitch's Island Reach)	***3,100 cfs (Low Flow - Validation)**	**10,096 cfs (High Flow - Calibration)**
40%	1,240 cfs	4,000 cfs
250%	7,750 cfs	25,200 cfs

* Existing data sets.

Table 3.4.1.1-2: WSEL Calibration Results

Sub-Reach	Transect	Measured WSEL (ft. NGVD29)	Modeled WSEL (ft. NGVD29)	Difference (ft.)
Dry Brook	8	103.89	103.89	0.00
Dry Brook	9	104.36	104.31	-0.05
Dry Brook	10	104.53	104.58	0.05
Dry Brook		**(Flow 9,409 cfs)**	**Average WSEL difference for Sub-Reach**	**0.00**
Hatfield	5	102.18	102.21	0.03
Hatfield	6	102.54	102.53	-0.01
Hatfield	7	102.71	102.67	-0.04
Hatfield		**(Flow: 9,656 cfs)**	**Average WSEL difference for Sub-Reach**	**-0.01**
Mitch's Island	1	101.19	101.21	0.02
Mitch's Island	2	101.19	101.29	0.10
Mitch's Island	3	101.52	101.51	-0.01
Mitch's Island	4	101.70	101.61	-0.09
Mitch's Island		**(Flow 10,096 cfs)**	**Average WSEL difference for Sub-Reach**	**0.01**

3.4.1.2 Production Runs

The revised HEC-RAS model was used to conduct 48 production runs for flows ranging from 2,000 cfs up to 25,000 cfs at 1,000 cfs intervals. These production runs included model runs with the downstream boundary condition as the licensed low and high WSELs at the Holyoke Dam (i.e., 99.47 and 100.67 ft. NGVD29). The hydraulic model output (depth) from these production runs at each of the 10 transects were used as input to the PHABSIM model, discussed in the following section.

3.4.2 Habitat Modeling

Cellular calibration of the PHABSIM model was completed for both low and high flow conditions utilizing the ADCP measured velocity and a model cell length of 5 feet. Table 3.4.2-1 provides a summary of the velocity calibration results at each transect for both high and low flow conditions. After calibration, the majority of the cells within the transects achieved a calibration to observed velocities of within +/-0.10 feet per second (ft/s) and all cells within all transects were within +/-0.5 ft/s. PHABSIM was then used to calculate the amount of aquatic habitat per unit length of the river for each transect in a sub-reach for a given species/life stage of mussel and host species. Each representative transect was then evaluated for its habitat suitability for a particular species/life stage based on fixed characteristics (i.e., substrate) and variable characteristics of the cell (i.e., depth and mean column velocity for host fish or depth and benthic velocity for mussels). For mussels, mean column velocities were converted to benthic velocities using a rearrangement of the log-law velocity profile (Garcia, 2006). This method, described in detail in Appendix A of the 2017 study plan, calculates benthic velocity as a function of bed roughness (approximated by substrate), water depth, and mean column velocity. The equation, after some re-arrangement is:

$$u = U * \frac{\ln\left(30*\frac{z}{k_s}\right)}{\ln\left(11*\frac{H}{k_s}\right)}, \text{ where:}$$

u = benthic velocity (ft/s);

U = mean column velocity (ft/s);

z = distance above the riverbed (ft);

k_s = bed roughness (ft);

H = water column depth (ft); and

Z = distance above the riverbed (ft) = 0.25 ft for all Reach 5 benthic velocity calculations.

Habitat suitability, as used in IFIM procedures, is an index quantified in terms of a variable known as WUA. A unit of WUA represents a unit of suitable habitat for the life stage evaluated. The following equations were used to calculate the total WUA in Reach 5. The equations start at the cellular basis and end with computing WUA for the entire ~22 miles of Reach 5. WUA calculations were completed for three (3) variables (i.e., velocity, depth, and substrate) and four (4) variables (i.e., velocity, depth, substrate, and shear stress).

The Compound Function Index (CF(I)) for the 3 variable analysis was calculated for each cell along the transects as follows:

CF(I) = SI_V x SI_D x SI_S, (unitless) where:

SI_V = Suitability Index for Velocity (or in the case of mussels, benthic velocity);

SI_D = Suitability Index for Depth; and

SI_S = Suitability Index for Substrate.

In addition, the CF(I) for the 4 variable analysis (including shear stress) was calculated for each cell along the transects as follows:

CF(I) = SI_V x SI_D x SI_S x SI_{SS} (unitless) where:

SI_V = Suitability Index for Velocity (or in the case of mussels, benthic velocity);

SI_D = Suitability Index for Depth;

SI_S = Suitability Index for Substrate; and

SI_{SS} = Suitability Index for Shear Stress.

The individual cell WUA(I) (area per unit length of stream) was calculated for each transect as follows:

WUA(I) = CF(I) x Area(I), (typically the Area is defined as the length upstream and downstream of the transect represented by the habitat features in that transect) where:

Area(I) = Surface area of cell; and

CF(I) = Compound Function Index for cell(I)

The total WUA (area per unit length of stream) was computed for each representative reach by multiplying WUA/ft by the representative stream length. An example for the Dry Brook reach is below.

$$WUA_{\text{Dry Brook}} = \left(\sum_{i=1}^{n} WUA(I)_{T8} + \sum_{i=1}^{n} WUA(I)_{T9} + \sum_{i=1}^{n} WUA(I)_{T10} \right) \times L_{\text{Dry Brook}}$$

T8, T9 and T10 represent the WUA at Transects 8, 9, and 10 respectively.

L= the length of river representative of the Dry Brook reach

The total WUA for Reach 5 was then computed as follows:

Total $WUA_{\text{Reach 5}} = WUA_{\text{Dry Brook}} + WUA_{\text{Hatfield}} + WUA_{\text{Mitch's Island}}$

Steady-state WUA figures depicting the relationship between the total amount of WUA in Reach 5 and flow were developed for the three target mussels (juvenile and adult) and host fish. WUA was calculated for the 3 variable and 4 variable (with shear stress) analyses under a low and high backwater condition at the Holyoke Dam of 99.47 and 100.67 ft. NGVD 1929, respectively. The results of these analyses are discussed in Section 4.

Table 3.4.2-1: PHABSIM Cellular Velocity Calibration Results

	Percent of Cells With Specified Range at each Transect (Low Flow)									
Range (+/-)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**
0.05 ft/s	99	52	35	99	100	75	98	60	95	11
0.10 ft/s	100	57	97	99	100	100	100	75	100	13
0.15 ft/s	100	69	98	99	100	100	100	89	100	18
0.20 ft/s	100	77	99	99	100	100	100	100	100	31
0.25 ft/s	100	88	100	99	100	100	100	100	100	53
0.30 ft/s	100	98	100	99	100	100	100	100	100	72
0.50 ft/s	100	100	100	100	100	100	100	100	100	100
	Percent of Cells With Specified Range at each Transect (High Flow)									
Range (+/-)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**
0.05 ft/s	99	100	100	100	98	100	29	100	14	30
0.10 ft/s	100	100	100	100	100	100	98	100	26	96
0.15 ft/s	100	100	100	100	100	100	100	100	39	98
0.20 ft/s	100	100	100	100	100	100	100	100	50	98
0.25 ft/s	100	100	100	100	100	100	100	100	60	98
0.30 ft/s	100	100	100	100	100	100	100	100	69	99
0.50 ft/s	100	100	100	100	100	100	100	100	100	100

3.5 Analyses

Three types of analyses were conducted as part of this study, including dual flow analyses (Section 3.5.1), shear stress analyses (Section 3.5.2), and combined WUA and shear stress analyses (Section 3.5.3). Each of these analyses are discussed below.

3.5.1 Dual Flow Analysis

When streamflow varies, habitat quality may decrease in some habitat cells, while increasing in others. A dual flow analysis is commonly used to calculate the quantity of habitat that is present over a flow range, such as those that may be expected during a minimum flow/peaking flow hydroelectric operation. A dual flow analysis assesses peaking operations' impact on low-mobility species such as mussels as it assesses the amount of habitat remaining over a given cell over a range of flows. For immobile aquatic biota, a dual flow analysis typically assumes the available habitat at a transect is equal to the sum of the individual cells' minimum habitat for a given flow pair. This analysis is somewhat simplified when using binary habitat suitability criteria (HSC), as habitat is either described as 'suitable' (meets all habitat criteria) or 'unsuitable' (does not meet one or more habitat criteria).

FirstLight conducted dual-flow analyses for the three target mussel species (Yellow Lampmussel, Eastern Pondmussel, Tidewater Mucket) for the juvenile and adult life stages. Dual flow analyses were not conducted for the mussel host fish, as adult life stages are generally assumed to be mobile and able to travel between areas of suitable and unsuitable habitat throughout a peaking cycle. For the purpose of this study, dual flow habitat was defined as habitat that is suitable across a given flow pair (e.g., 4,000 cfs to 18,000 cfs) plus all modeled flows in-between the pair. For example, a cell would be considered dual-flow habitat for the 4,000-18,000 cfs flow pair if steady-state habitat was suitable at 4,000, 5,000, 6,000, 7,000, 8,000, 9,000, 10,000, 11,000, 12,000, 13,000, 14,000, 15,000, 16,000, 17,000 and 18,000 cfs. Dual flow habitat was calculated for both low and high WSELs at the Holyoke Dam. The dual flow analysis was completed for all modeled steady-state flow combinations including up to 25,000 cfs, which is substantially above the combined hydraulic generating capacity of Cabot Station and Station No. 1 (15,938 cfs). A dual flow analysis limited at the high end to only 25,000 cfs does not include the common and higher naturally varying flows which are outside of the range of project control and can limit suitable habitat for species with limited mobility. Results of the dual flow analyses are described in Section 4.

3.5.2 Shear Stress Analysis

Shear stress analyses were conducted at the request of the agencies to determine whether Project operations create bed shear stresses that could potentially mobilize mussels within the study reach. Cellular shear stress was evaluated at the ten transects in Reach 5 for the same set of flows and Holyoke Dam downstream boundary conditions as described in Section 3.5.1 (i.e., 2,000 to 25,000 cfs at 1,000 cfs intervals under high and low Holyoke WSELs).

As requested by NHESP (email of June 9, 2017 and included in Appendix A), the shear stress analysis was not based on the entire water column, but instead on the linear distance at the substrate surface. Furthermore, as discussed with the USFWS on July 21, 2017 (conference call with Brett Towler), FirstLight calculated cellular shear stress at the ten transects using the two equations below and solving for the shear stress as follows (Garcia, 2006):

$$\frac{u}{u_*} = \frac{1}{K} * \ln\left(30 * \frac{z}{k_s}\right), \qquad \text{(Eq. 1)}$$

$$u_* = \sqrt{\frac{\tau_b}{\rho}}, \text{ substituting for } u_* \qquad \text{(Eq. 2)}$$

$$\frac{u}{\sqrt{\frac{\tau_b}{\rho}}} = \frac{1}{K} * \ln\left(30 * \frac{z}{k_s}\right)$$

$$\rightarrow \tau_b = \rho * \left(\frac{u * K}{\ln\left(30 * \frac{z}{k_s}\right)}\right)^2, \text{ where}$$

τ_b = shear stress (lb/ft^2);
ρ = density of water (slugs/ft^3) = 1.94 slugs/ft^3 for all of Reach 5;
u_* = shear velocity (ft/s);
u = time-averaged flow velocity at a distance z above the bed (ft/s);
z = distance above the riverbed (ft) = 0.25 ft for all of Reach 5;
K = von Karman's constant = 0.41;
k_s = bed roughness (ft);

Finally, MDFW recommended shear stress thresholds for juvenile and adult mussels, which are shown in Table 3.5.2-1. As described in more detail in Section 4, this analysis resulted in a series of maps for each sub-reach to determine in which transect cell shear stress becomes a limiting factor for adult and juvenile mussels.

Table 3.5.2-1: Shear Stress Thresholds for Juvenile and Adult State-Listed Mussels in Reach 5

Mussel Species	Adult Shear Stress Threshold	Juvenile Shear Stress Threshold
Yellow Lampmussel	150 dynes/cm^2	10 dynes/cm^2
Eastern Pondmussel	150 dynes/cm^2	10 dynes/cm^2
Tidewater Mucket	150 dynes/cm^2	10 dynes/cm^2

3.5.3 Combined WUA and Shear Stress Analysis

For the purpose of this study, the combined WUA and shear stress analysis (WUA_C) was defined as a habitat suitability analysis based on four suitability criteria, including: (1) depth; (2) velocity; (3) substrate; and (4) shear stress. The goal of the combined approach was to assess how shear stress affects habitat modeling and WUA. This analysis was requested by NHESP at a June 1, 2017 meeting and in their June 9, 2017 email (included in Appendix A).

For the purpose of this study, the same shear stress calculations and criteria discussed in Section 3.5.2 were used. Under this iteration, WUA was calculated with the addition of a Suitability Index for Shear Stress as a fourth parameter to the Compound Function Index. The Combined Compound Function Index for the combined WUA and shear stress analysis, was calculated for each cell along a transect as follows:

$CF(I)_C = SI_V \times SI_D \times SI_S \times SI_{SS}$ (unitless) where:

SI_V = Suitability Index for Velocity (or in the case of mussels, benthic velocity);

SI_D = Suitability Index for Depth;

SI_S = Suitability Index for Substrate; and

SI_{SS} = Suitability Index for Shear Stress

The individual cell WUA_C, total WUA_C for each sub-reach (i.e., Dry Brook, Hatfield, and Mitch's Island), and the total WUA_C for Reach 5 were calculated in the same manner as described in Section 3.4.2. Steady-state combined WUA and shear stress analysis figures depicting the relationship between the total amount of WUA_C in Reach 5 and flow were then developed for the three target mussel species for both juvenile and adult life stages (Section 4). WUA_C was also calculated under a low and high backwater condition at the Holyoke Dam of 99.47 and 100.67 ft. NGVD29, respectively.

In addition, FirstLight conducted a dual-flow analysis based on the results of the combined WUA and shear stress analysis for the three target mussel species for both juvenile and adult life stages. Dual flow habitat was calculated independently for low and high Holyoke impoundment levels. The dual flow analysis was run for all modeled steady-state flow combinations including 25,000 cfs, which is substantially above the combined hydraulic generating capacity of Cabot and Station No. 1 (15,938 cfs). Results of the dual-flow analysis for the different flow combinations are discussed in Section 4.

4 HABITAT MODELING RESULTS

4.1 Weighted Useable Area

Figures 4.1-1 through 4.1-14 located in Appendix C depict the WUA curves for the species/life stages and guilds analyzed in Reach 5. These figures show the WUA curves for the 3 variable and 4 variable (with shear stress) Combined Suitability Index (CSI)[4] under both low and high Holyoke impoundment downstream boundary conditions for:

- Adult and Juvenile Yellow Lampmussels
- Adult and Juvenile Tidewater Mucket
- Adult and Juvenile Eastern Pondmussel
- Shallow & Slow Guild
- Deep & Slow Guild
- Deep & Fast Guild

The figures found in Appendix C show that for Adult Yellow Lampmussel and Adult Tidewater Mucket, the CSI values generally increase slightly with higher flows and very limited differences between the 3 and 4 variable CSI or low vs. high downstream boundary conditions. For Juvenile Yellow Lampmussel and Juvenile Tidewater Mucket, CSI values under all conditions reach a peak at flows of about 8,000 cfs then fall to less than half the peak CSI values at flows of 25,000 cfs. The WUA figures for Adult and Juvenile Eastern Pondmussels are similar to each other and peak at about 8,000 cfs and then fall to less than half of their maximum values at flows of 25,000 cfs. The 4 variable CSI WUA figures for Adult and Juvenile Eastern Pondmussels indicate slightly lower values than with a 3 variable CSI. The WUA figures for the Guilds show limited habitat under all flow ranges for the Shallow & Slow Guild and the Deep & Fast, however, there is a steep decrease in WUA for the Deep & Slow Guild at flows between 4,000 and 10,000 cfs.

4.2 Dual Flow

The Dual Flow Tables are provided as Tables 4.2-1 through 4.2-48 in Appendix D for the same life species, variables (with and without shear stress), and boundary conditions as the WUA tables. However, as described in the Study Plan, the guilds, representing host fish, were not included for the dual flow analyses.

4.2.1 *Juvenile* Yellow Lampmussels and Juvenile Tidewater Mucket

The tables found in Appendix D indicated that for 3 variables and low Holyoke impoundment conditions, the available habitat in Reach 5 decreases from about 79 million square feet (sf) to about 25 million sf (Yellow Lampmussels) between flows of 2,000 to 25,000 cfs. The tables in Appendix D also include the percent of decrease from the maximum habitat flow, which in the case described in the prior sentence occurs at a flow of 8,000 cfs. Under high Holyoke impoundment conditions, the total habitat is slightly higher and the percent of decrease from higher flows is slightly smaller. Under the 4 variable criteria and low Holyoke impoundment conditions the amount of habitat is slightly smaller, a similar decrease occurs with higher flows, and the peak habitat occurs at a flow 6,000 cfs.

4.2.2 *Adult* Yellow Lampmussels and Adult Tidewater Mucket

The tables found in Appendix D indicate higher flows generally result in larger amounts of habitat due to adults mussels having a higher threshold for velocity and shear stress before the habitat becomes unsuitable. For example, the maximum habitat for Yellow Lampmussels occurs at 19,000 cfs for both the 3 and 4

[4] Only 3 variable CSI values were calculated for the Guilds

variable and low Holyoke impoundment condition scenarios. For adult mussels, lower flows result in lower habitat areas due to shallower depths and a smaller amount of habitat. For example, about 89% of the habitat exists at a flow of 2,000 cfs as compared to 19,000 cfs for Yellow Lampmussel habitat for the scenario described earlier in the paragraph. However, the tables also indicate a slow decrease in the suitable habitat as flows increase towards 25,000 cfs; this trend would increase at higher flows that are common in the spring.

4.2.3 Juvenile and Adult Eastern Pondmussel

The Delphi Panel HSC velocity parameter for the Adult Eastern Pondmussels is the same as the velocity parameter of the juvenile lifestages of the three mussel species (i.e., velocities above 1.66 ft/s are unsuitable). Therefore, the dual flow relationship for the adult and juvenile Eastern Pondmussel are very similar and are similar to the juvenile lifestages of the Yellow Lampmussel and Tidewater Mucket. This lower velocity parameter for Adult Eastern Pondmussel results in a much larger effect than differences in the low or high Holyoke boundary conditions or the 3 or 4 variable analysis.

4.3 Shear Stress Analysis Mapping

For both the adult and juvenile mussel thresholds for shear stress, maps of each sub-reach were created to indicate at what flows and locations the shear stress thresholds become a limiting factor. These maps are included as Appendix E-1 (Dry Brook sub-reach), E-2 (Hatfield sub-reach), and E-3 (Mitch's Island sub-reach). Maps were created under both low and high Holyoke downstream boundary condition at flows of:

- 2,000 cfs;
- 5,000 cfs;
- 10,000 cfs;
- 15,000 cfs;
- 20,000 cfs; and
- 25,000 cfs.

These maps indicate that shear stress is not a limiting factor for adult mussels in any of the sub-reaches for the flow and downstream boundary conditions that were modeled. However, for juvenile mussels, shear stress starts becoming a limiting factor in some areas of the Dry Brook sub-reach at flows over 5,000 cfs and by 25,000 cfs the thresholds are exceeded in most areas of the sub-reach. In the Dry Brook sub-reach, a low Holyoke downstream boundary condition has slightly more areas that exceed the threshold but the differences are limited, partly because of hydraulic controls in the Connecticut River such as near Dinosaur Footprints. Similarly for the Hatfield sub-reach, the shear stress thresholds begin to be exceeded at 10,000 cfs and by 25,000 cfs about a third of the sub-reach has shear stress values above the threshold. Only a slightly higher amount of areas in this sub-reach exceed the shear stress threshold in low Holyoke impoundment conditions. In the Mitch's Island sub-reach, only very limited areas exceed the shear stress threshold at the modeled flows.

4.4 Elwell Island Transects & Transect Data

At the June 1, 2017 meeting, NHESP requested that FirstLight provide data previously collected at three transects in the vicinity of Elwell Island. Rather than model the habitat at these transects, it was agreed that FirstLight will provide the bathymetric and substrate data collected at these three transects, along with WSEL data under a subset of scenarios bounding the Turners Falls Project hydraulic range, including Scenarios of flows at 2,000 and 14,000 cfs under high and low WSELs at Holyoke Dam. Appendix F contains additional information pertaining to this. In addition, the 2017 study plan notes that FirstLight will include transect survey data, raw field data, and reference photographs of the transect sites in the final report. Additional information pertaining to this can be found in Appendix F.

5 DISCUSSION

The WUA versus flow relationships, dual flow analyses, and shear stress analyses discussed in the previous sections determined the extent of suitable habitat variability over a range of flows and downstream boundary conditions for the three target mussel species and host fish. Unlike the Reach 5 screening analysis conducted as part of the 2016 Study Report (FirstLight, 2016b), this analysis used a combination of HEC-RAS and PHABSIM models with the addition of shear stress as a fourth variable.

In general, for the flows modeled (i.e., up to and including 25,000 cfs, which is about 1.6 times the combined generation capacity of Cabot and Station No. 1), a decrease in WUA values are not observed for Adult Yellow Lampmussels and Adult Tidewater Mucket, even with shear stress included as an additional binary variable. Therefore, flows within the range of Project control, and within the range of peaking operations, were not observed to have an effect on the life stages of these mussels in Reach 5.

As discussed in Section 4, the dual flow tables, results of the shear stress analyses, and WUA figures for the juvenile life stages of the three state-listed mussels and the Adult Eastern Pondmussel indicate a minor decrease in habitat at flows within Project control due to the effects of velocity and shear stress on the binary habitat suitability criteria. However, as shown in Figures 4.1-1 through 4.1-14 (Appendix C), and summarized in Figure 5-1, the decrease from the peak habitat at flows around 8,000 cfs to the Project's peaking capacity of about 16,000 cfs is about 20%. Although a 20% decrease is observed, it is important to note that the estimated WUA in Reach 5 at a flow of 16,000 cfs under low boundary conditions and shear stress as a CSI variable is still about 63,000,000 sf, a very large amount of habitat. In other words, although a decrease in habitat is observed it is relatively minor when the total amount of habitat available is taken into consideration. Larger decreases in habitat occur may occur at higher flows that are representative of the natural variation in flows that occur above the range of control by the project.

A low boundary condition at Holyoke results in only slightly less habitat for mussels due to slightly higher water velocities; however, this effect is limited partly due to the hydraulic constriction near Dinosaur Footprints. This hydraulic control is located about 4 miles upstream of the Holyoke Dam and begins to act as a key hydraulic control for Reach 5 at flows greater than 11,000 cfs. In addition, as described in detail in the Report for Study No. 3.2.2 (FirstLight, 2015), peaking flows from Cabot are attenuated substantially by the time they arrive at Reach 5 which greatly limits the effects of peaking in this reach.

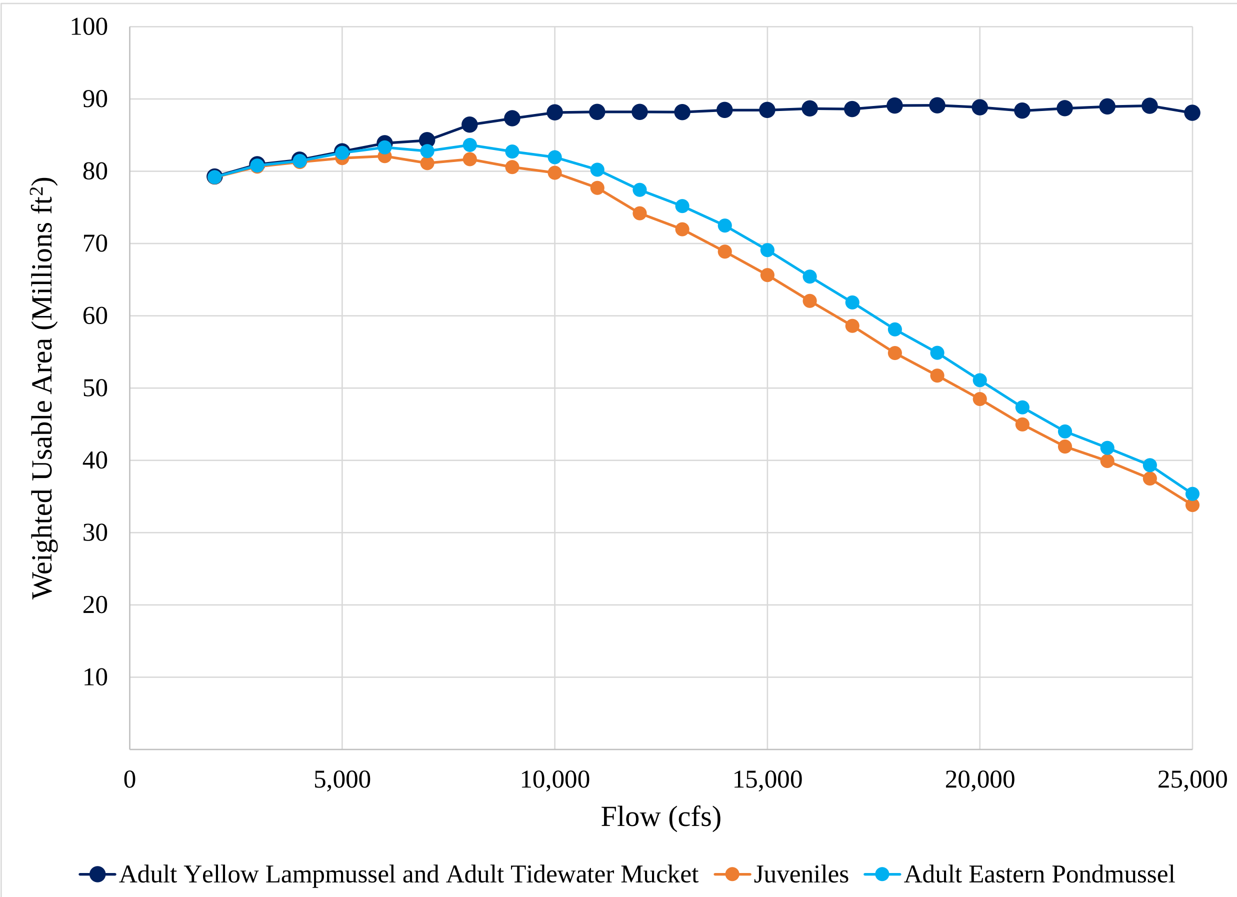
Flows in excess for 16,000 cfs, which is greater than the combined capacity of Cabot and Station No. 1, have a steeper decrease in WUA. The total WUA observed at flows of 25,000 cfs (which is 1.6 times the capacity of the Project) is approximately 35,000,000 sf. A steep decrease in WUA also occurs at higher flows above 25,000 cfs, which are common throughout the year but have no relation to Project impacts as they are well beyond the capacity of the Project.

Finally, the results of this IFIM analysis were found to be similar to the results for Reach 5 summarized in Section 7 of the 2016 report for Study No. 3.3.1 (FirstLight, 2016b). In that document it was observed that:

> *In general, operational effects from the Turners Falls Project on habitat suitability for state-listed mussels in Reach 5 are minimal overall, and do not appear to be affecting their distribution and abundance. The distribution and abundance of these species is more likely to be controlled by larger scale effects, such as habitat persistence during high-flow events and dispersal mechanisms that are not currently well understood.*

In addition, this IFIM analysis confirms that high-flows and their associated shear stress characteristics are the most relevant limitations for mussel habitat, and that these high-flows occur well outside of the operating range of the Turners Falls Project. These findings are consistent with feedback from Delphi panelists, along with a variety of studies suggesting that a potential limiting factor of freshwater mussel habitat is stream channel stability, which is limited by the effects of shear stress during high flow events (i.e. Allen and Vaughn 2010; Westover 2010. Gangloff and Feminella 2006; Howard and Cuffey 2003; Strayer 1999). Therefore, based on our findings and relevant literature, the current mussel distribution in Reach 5 is likely constrained more by the characteristics of the reach during high flow events that are outside of Project control, rather than by the effects of Project operations.

Figure 5-1: Total WUA for 4 Variable CSI (with Shear Stress), Low Boundary Conditions for Adult and Juvenile Mussels



6 LITERATURE CITED

Allen, D.C. and C.C. Vaughn. 2010. Complex hydraulic and substrate variables limit freshwater mussel species richness and abundance. Journal of the North American Benthological Society 29(2): 383-394.

Bovee, K., Lamb, J., Bartholow, J., Stalnaker, C., Taylor, J. and Henriksen, J. (1998). Stream Habitat Analysis Using the Instream Flow Incremental Methodology. U.S. Department of Interior, U.S. Geological Survey. Report No. USGS/BRD/ITR-1998-0004.

FirstLight. (2012). Aquatic Mesohabitat Assessment and Mapping Report. Prepared by Gomez and Sullivan Engineers, P.C. and Kleinschmidt. Northfield, MA: Author.

FirstLight. (2015). Relicensing Study 3.2.2 Hydraulic Study of Turners Falls Impoundment, Bypass Reach, and Below Cabot. Prepared by Gomez and Sullivan Engineers, D.P.C. Northfield, MA: Author.

FirstLight. (2016a). Relicensing Study 3.3.16 Habitat Suitability Criteria for State-listed Mussel Species in the Connecticut River below Cabot Station. October 2016. Prepared by Biodrawversity and Gomez and Sullivan Engineers, D.P.C. Northfield, MA: Author.

FirstLight. (2016b). Relicensing Study 3.3.1 Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station. October 2016. Prepared by Gomez and Sullivan Engineers, D.P.C. and Kleinschmidt. Northfield, MA: Author.

Gangloff, M.M. and J.W. Feminella. 2006. Stream channel geomorphology influences mussel abundance in southern Appalachian streams, U.S.A.. Freshwater Biology 52: 64-74.

Garcia, M. (2006). ASCE Manual of Practice 110 – Sedimentation Engineering: Processes, Measurements, Modeling and Practice. World Environmental and Water Resource Congress 2006. doi:10.1061/40856(200)94

Howard, J.K. and K.M. Cuffey. Freshwater mussels in a California North Coast river: occurrence, distribution, and controls. Journal of the North American Benthological Society 22: 63-77.

Marks, C. O., Nislow, K. H., & Magilligan, F. J. (2014). Quantifying flooding regime in floodplain forests to guide river restoration. Elementa: Science of the Anthropocene 2:000031. Retrieved from: http://elementascience.org/article/info:doi/10.12952/journal.elementa.000031.

Milhouse, R.T., Updike, M.A., & Schneider, D.M. (1989). *Physical habitat simulation system reference manual: version 2, Instream flow information paper 26* (Biological Report 89(16)). Washington, D.C.: U.S. Fish and Wildlife Service.

Strayer, D.L. 1999. Use of flow refuges by unionid mussels in rivers. Journal of the North American Benthological Society 18(4): 468-476.

Westover, M.L. 2010. Freshwater mussel distribution, abundance, and habitat use in the Middle Klamath River. M.S. Thesis, Whitman College.

APPENDIX A – CONSULTATION RECORD

APPENDIX A: CONSULTATION RECORD ON DRAFT/FINAL REACH 5 IFIM STUDY PLAN FOR MUSSELS

From:	Leddick, Jesse (FWE)
To:	Mark Wamser; Warner, John; Ken Sprankle (ken_sprankle@fws.gov); Melissa Grader (melissa_grader@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; "Don Pugh"; kkennedy@tnc.org; "Karl Meyer"; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net; Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com)
Cc:	Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah
Subject:	RE: Reach 5 Mussels
Date:	Friday, June 09, 2017 1:49:48 PM
Attachments:	2017_Study_Plan_3_3_1_IFIM_Reach_REV1.pdf

Mark,

Overall, we (NHESP) concur with the updated IFIM Study Plan for Reach 5 (Revision 1: June 2017). However, please note the following:

Shear Stress Analysis

1. As discussed during our June 1 meeting, we highlighted that the shear stress analysis should not be based on the entire water column but on the linear distance at the substrate surface. We didn't see this articulated in the updated Study Plan.
2. We also highlighted the need to define the flows for which the shear stress analysis will be completed. We didn't see this articulated in the updated Study Plan; will FL be running this analysis for all flows shown in Table 1.7-4, or a subset of flows?
3. Finally, we highlighted - based on the results of the separate analyses (one for depth/velocity/substrate and the other for shear stress) – the need to run all 4 parameters together in PHABSIM to assess how shear stress affects habitat modeling and WUA. We didn't see this articulated in the updated Study Plan.

General Comment

4. As discussed during our June 1 meeting ,we highlighted the need to update the mussel habitat suitability analysis for Reach 3 to include shear stress as a 4th parameter. FL should submit an updated study plan to the working group for review and comment. This needn't hold up data collection and analysis efforts related to Reach 5, but it remains an important, outstanding element of the mussel analysis.

Many thanks to you and your team for your work on this.

Jesse Leddick
Endangered Species Review Biologist
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road, Westborough, MA 01581
p: (508) 389-6386 | e: Jesse.Leddick@state.ma.us

mass.gov/masswildlife | facebook.com/masswildlife

From: Mark Wamser [mailto:mwamser@gomezandsullivan.com]
Sent: Monday, June 05, 2017 9:16 AM
To: Warner, John; Ken Sprankle (ken_sprankle@fws.gov); Melissa Grader (melissa_grader@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Leddick, Jesse (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; 'Don Pugh'; kkennedy@tnc.org; 'Karl Meyer'; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net; Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com)
Cc: Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah
Subject: RE: Reach 5 Mussels

Dear Relicensing Participant-

On May 19, 2017, FL sent you a draft study plan for conducting a Reach 5 IFIM study for mussels and notified parties that a meeting to discuss the plan would occur on June 1, 2017. On June 1, 2017, FL held an afternoon meeting to discuss the plan. Present at the meeting was FL, Gomez and Sullivan, Jesse Leddick, Misty-Anne Marold and Pete Hazelton (NHESP), Katie Kennedy (TNC), Melissa Grader, Julianne Rosset (USFWS), Andrea Donlon (CRC), and Steve Kartalia (FERC). At the meeting, comments were provided on the Draft IFIM Study plan. Please find attached a Final IFIM Study plan based on the comments received at the meeting. As noted at the meeting, we will not have time to go through the full FERC process of obtaining FERC's Study Plan Determination because field data needs to be collected under higher flows. Given this, we respectfully request an email from those who attended the meeting- NHESP TNC, USFWS, and CRC -- supporting the plan. We would like to file with FERC the Final IFIM Study plan along with emails supporting the plan (to be included in Appendix B). If you could provide these emails by Friday of this week it would be greatly appreciated. Please feel free to call me if you have any questions.

Thanks Mark

Mark Wamser, PE
Senior Water Resource Engineer
Gomez and Sullivan Engineers, DPC
41 Liberty Hill Road
PO Box 2179
Henniker, NH 03242

P 603-428-4960
C 603-568-6088
F 603-428-3973
Gomez and Sullivan Engineers

From: Mark Wamser
Sent: Friday, May 19, 2017 12:38 PM
To: John Warner - US Fish and Wildlife Service (john_warner@fws.gov) <john_warner@fws.gov>; Ken Sprankle (ken_sprankle@fws.gov) <ken_sprankle@fws.gov>; Melissa Grader (melissa_grader@fws.gov) <melissa_grader@fws.gov>; 'julianne_rosset@fws.gov' <julianne_rosset@fws.gov>; brett_towler@fws.gov; Caleb Slater (caleb.slater@state.ma.us) <caleb.slater@state.ma.us>; Jesse Leddick (jesse.leddick@state.ma.us) <jesse.leddick@state.ma.us>; peter.hazelton@state.ma.us; Bob Kubit (robert.kubit@state.ma.us) <robert.kubit@state.ma.us>; Foulis, David (DEP) (david.foulis@state.ma.us) <david.foulis@state.ma.us>; Harrington, Brian D (DEP) (brian.d.harrington@state.ma.us) <brian.d.harrington@state.ma.us>; 'david.cameron@state.ma.us' <david.cameron@state.ma.us>; Julie Crocker (julie.crocker@noaa.gov) <julie.crocker@noaa.gov>; 'William McDavitt - NOAA Affiliate' <william.mcdavitt@noaa.gov>; 'jeff.murphy@noaa.gov' <jeff.murphy@noaa.gov>; 'Bjorn Lake - NOAA Federal' <bjorn.lake@noaa.gov>; susan.tuxbury@noaa.gov; Kevin R. Mendik - National Park Service North Atlantic Region (kevin_mendik@nps.gov) <kevin_mendik@nps.gov>; 'Don Pugh' <don.pugh@yahoo.com>; kkennedy@tnc.org; 'Karl Meyer' <karlmeyer1809@verizon.net>; Andrea Donlon (adonlon@ctriver.org) <adonlon@ctriver.org>; johnbenn@sover.net; Tom Miner (wtminer@crocker.com) <wtminer@crocker.com>; Kimberly Noake MacPhee (kmacphee@frcog.org) <kmacphee@frcog.org>; mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov) <brandon.cherry@ferc.gov>; 'stephen.kartalia@ferc.gov' <stephen.kartalia@ferc.gov>; 'william.connelly@ferc.gov' <william.connelly@ferc.gov>; 'patrick.crile@ferc.gov' <patrick.crile@ferc.gov>; 'john.baummer@ferc.gov' <john.baummer@ferc.gov>; 'nicholas.ettema@ferc.gov' <nicholas.ettema@ferc.gov>; aharo@usgs.gov; 'TCastro_Santos@usgs.gov' <TCastro_Santos@usgs.gov>; Norm Sims (normsims@me.com) <normsims@me.com>; Bob Nasdor (bob@americanwhitewater.org) <bob@americanwhitewater.org>; Tom Christopher (tom.christopher@comcast.net) <tom.christopher@comcast.net>; John Ragonese - Great River Hydro (jragonese@greatriverhydro.com) <jragonese@greatriverhydro.com>; Jennifer Griffin (jennifer_griffin@transcanada.com) <jennifer_griffin@transcanada.com>; Paul Ducheney (ducheney@hged.com) <ducheney@hged.com>; Kristen Sykes <KSykes@outdoors.org>; 'A. Fisk' <afisk@ctriver.org>; Peggy Sloan <PSloan@frcog.org>; Frost, Karro (FWE) <karro.frost@state.ma.us>; Marold, Misty-Anne (FWE) <misty-anne.marold@state.ma.us>; 'mike.nelson@state.ma.us' <mike.nelson@state.ma.us>; 'robert.wernerhl@state.ma.us' <robert.wernerhl@state.ma.us>; 'Christopher Boelke - NOAA Federal' <christopher.boelke@noaa.gov>; John Ward (selectman.ward@gmail.com) <selectman.ward@gmail.com>
Cc: Jason George <jgeorge@gomezandsullivan.com>; Tom Sullivan <tsullivan@gomezandsullivan.com>; Gary Lemay <glemay@gomezandsullivan.com>; John Hart <jhart@gomezandsullivan.com>; Aaron Rubin <arubin@gomezandsullivan.com>; Ian Kiraly

<ikiraly@gomezandsullivan.com>; Doug Bennett (Douglas.bennett@firstlightpower.com) <Douglas.bennett@firstlightpower.com>; Don Traester (donald.traester@firstlightpower.com) <donald.traester@firstlightpower.com>; Stira, Robert <Robert.Stira@firstlightpower.com>; 'mas@vnf.com' <mas@vnf.com>; 'Julia Wood (jsw@vnf.com)' <jsw@vnf.com>; Sarah Verville (sverville@trcsolutions.com) <sverville@trcsolutions.com>
Subject: Reach 5 Mussels

Dear Relicensing Participant-

Based on discussions with the USFWS and NHESP, additional work is being requested in Reach 5 (below Cabot from Route 116 to Dinosaur Footprint) relative to state-listed mussels. Please find attached a study plan to conduct an instream flow study in Reach 5 for state-listed mussels and host fish. FirstLight will have a meeting on June 1, 2017, starting at 9:00 am at the Northfield Visitors Center to discuss the plan. FirstLight is proposing to collect velocity, depth and substrate data in Reach 5 under two flows. Because time is critical (some of the field data will be collected under a higher flow and that window will be closing as we approach summer low flows), we would like to reach agreement on the study plan as soon as possible. Given that, if NHESP, USFWS, or other stakeholders have comments on the plan prior to the meeting, it would be greatly appreciated.

If you have any questions, please fee free to contact me. Much appreciated, Mark

Mark Wamser, PE
Senior Water Resource Engineer
Gomez and Sullivan Engineers, DPC
41 Liberty Hill Road
PO Box 2179
Henniker, NH 03242
P 603-428-4960
C 603-568-6088
F 603-428-3973

GOMEZ AND SULLIVAN ENGINEERS

GSE CONFIDENTIALITY NOTICE: *This email and any files transmitted with it are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you are not the intended recipient, please do not read or review the content and/or metadata and do not disseminate, distribute or copy this communication. Anyone who receives this message in error should notify the sender (mwamser@gomezandsullivan.com) immediately by return e-mail and delete it from his or her computer.*

From:	Leddick, Jesse (FWE)
To:	Mark Wamser; Warner, John; Ken Sprankle (ken_sprankle@fws.gov); Melissa Grader (melissa_grader@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; "Don Pugh"; kkennedy@tnc.org; "Karl Meyer"; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net; Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com)
Cc:	Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah
Subject:	RE: Reach 5 Mussels
Date:	Monday, August 07, 2017 2:56:21 PM

Hi Mark,

This is to confirm that the Division approves the final Reach 5 Mussel Study Plan, as revised. Thanks for everyone's ongoing work on this.

As an aside, we look forward to receiving an updated Reach 3 Mussel Study Plan (including shear stress as a 4th parameter) as soon as possible.

Best regards,

Jesse Leddick
Endangered Species Review Biologist
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road, Westborough, MA 01581
p: (508) 389-6386 | e: Jesse.Leddick@state.ma.us
mass.gov/masswildlife | facebook.com/masswildlife

From: Mark Wamser [mailto:mwamser@gomezandsullivan.com]
Sent: Monday, August 07, 2017 12:52 PM
To: Leddick, Jesse (FWE); Warner, John; Ken Sprankle (ken_sprankle@fws.gov); Melissa Grader (melissa_grader@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; 'Don Pugh'; kkennedy@tnc.org; 'Karl Meyer'; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net; Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com)
Cc: Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah

From: Grader, Melissa
To: Mark Wamser
Cc: Leddick, Jesse (FWE); Hazelton, Peter (FWE); Marold, Misty-Anne (FWE); Andrea Donlon; Katie Kennedy; Warner, John; Rosset, Julianne
Subject: Re: Reach 5 Mussels
Date: Friday, June 09, 2017 2:22:36 PM

Mark,

The Service concurs with and supports the comments made by NHESP.

Regards,

Melissa Grader
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service - New England Field Office
103 East Plumtree Road
Sunderland, MA 01375
413-548-8002 x8124
melissa_grader@fws.gov

On Fri, Jun 9, 2017 at 1:47 PM, Leddick, Jesse (FWE) <Jesse.Leddick@massmail.state.ma.us> wrote:

> Mark,
>
> Overall, we (NHESP) concur with the updated IFIM Study Plan for Reach 5 (Revision 1: June 2017). However, please note the following:
>
> Shear Stress Analysis
>
> 1. As discussed during our June 1 meeting, we highlighted that the shear stress analysis should not be based on the entire water column but on the linear distance at the substrate surface. We didn't see this articulated in the updated Study Plan.
>
> 2. We also highlighted the need to define the flows for which the shear stress analysis will be completed. We didn't see this articulated in the updated Study Plan; will FL be running this analysis for all flows shown in Table 1.7-4, or a subset of flows?
>
> 3. Finally, we highlighted - based on the results of the separate analyses (one for depth/velocity/substrate and the other for shear stress) – the need to run all 4 parameters together in PHABSIM to assess how shear stress affects habitat modeling and WUA. We didn't see this articulated in the updated Study Plan.

General Comment

4. As discussed during our June 1 meeting ,we highlighted the need to update the mussel habitat suitability analysis for Reach 3 to include shear stress as a 4th parameter. FL should submit an updated study plan to the working group for review and comment. This needn't hold up data collection and analysis efforts related to Reach 5, but it remains an important, outstanding element of the mussel analysis.

Many thanks to you and your team for your work on this.

Jesse Leddick
Endangered Species Review Biologist
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road, Westborough, MA 01581
p: (508) 389-6386 | e: Jesse.Leddick@state.ma.us
mass.gov/masswildlife | facebook.com/masswildlife

From: Mark Wamser [mailto:mwamser@gomezandsullivan.com]
Sent: Monday, June 05, 2017 9:16 AM
To: Warner, John; Ken Sprankle (ken_sprankle@fws.gov); Melissa Grader (melissa_grader@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Leddick, Jesse (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; 'Don Pugh'; kkennedy@tnc.org; 'Karl Meyer'; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net; Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com)
Cc: Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah
Subject: RE: Reach 5 Mussels

Dear Relicensing Participant-

On May 19, 2017, FL sent you a draft study plan for conducting a Reach 5 IFIM study for mussels and notified parties that a meeting to discuss the plan would occur on June 1, 2017. On June 1, 2017, FL held an afternoon meeting to discuss the plan. Present at the meeting was FL, Gomez and Sullivan, Jesse Leddick, Misty-Anne Marold and Pete Hazelton (NHESP), Katie Kennedy (TNC), Melissa Grader, Julianne Rosset (USFWS), Andrea Donlon (CRC), and Steve Kartalia (FERC). At the meeting, comments were provided on the Draft IFIM Study plan. Please find attached a Final IFIM Study plan based on the comments received at the meeting. As noted at the meeting, we will not have time to go through the full FERC process of obtaining FERC's Study Plan Determination because field data needs to be collected under higher flows. Given this, we respectfully request an email from those who attended the meeting- NHESP TNC, USFWS, and CRC -- supporting the plan. We would like to file with FERC the Final IFIM Study plan along with emails supporting the plan (to be included in Appendix B). If you could provide these emails by Friday of this week it would be greatly appreciated. Please feel free to call me if you have any questions.

Thanks Mark

Mark Wamser, PE

Senior Water Resource Engineer

Gomez and Sullivan Engineers, DPC

41 Liberty Hill Road

PO Box 2179

Henniker, NH 03242

P 603-428-4960

C 603-568-6088

F 603-428-3973

GOMEZ AND SULLIVAN ENGINEERS

From: Mark Wamser
Sent: Friday, May 19, 2017 12:38 PM
To: John Warner - US Fish and Wildlife Service (john_warner@fws.gov) <john_warner@fws.gov>; Ken Sprankle (ken_sprankle@fws.gov) <ken_sprankle@fws.gov>; Melissa Grader (melissa_grader@fws.gov) <melissa_grader@fws.gov>; 'julianne_rosset@fws.gov' <julianne_rosset@fws.gov>;

brett_towler@fws.gov; Caleb Slater (caleb.slater@state.ma.us) <caleb.slater@state.ma.us>; Jesse Leddick (jesse.leddick@state.ma.us) <jesse.leddick@state.ma.us>; peter.hazelton@state.ma.us; Bob Kubit (robert.kubit@state.ma.us) <robert.kubit@state.ma.us>; Foulis, David (DEP) (david.foulis@state.ma.us) <david.foulis@state.ma.us>; Harrington, Brian D (DEP) (brian.d.harrington@state.ma.us) <brian.d.harrington@state.ma.us>; 'david.cameron@state.ma.us' <david.cameron@state.ma.us>; Julie Crocker (julie.crocker@noaa.gov) <julie.crocker@noaa.gov>; 'William McDavitt - NOAA Affiliate' <william.mcdavitt@noaa.gov>; 'jeff.murphy@noaa.gov' <jeff.murphy@noaa.gov>; 'Bjorn Lake - NOAA Federal' <bjorn.lake@noaa.gov>; susan.tuxbury@noaa.gov; Kevin R. Mendik - National Park Service North Atlantic Region (kevin_mendik@nps.gov) <kevin_mendik@nps.gov>; 'Don Pugh' <don.pugh@yahoo.com>; kkennedy@tnc.org; 'Karl Meyer' <karlmeyer1809@verizon.net>; Andrea Donlon (adonlon@ctriver.org) <adonlon@ctriver.org>; johnbenn@sover.net; Tom Miner (wtminer@crocker.com) <wtminer@crocker.com>; Kimberly Noake MacPhee (kmacphee@frcog.org) <kmacphee@frcog.org>; mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov) <brandon.cherry@ferc.gov>; 'stephen.kartalia@ferc.gov' <stephen.kartalia@ferc.gov>; 'william.connelly@ferc.gov' <william.connelly@ferc.gov>; 'patrick.crile@ferc.gov' <patrick.crile@ferc.gov>; 'john.baummer@ferc.gov' <john.baummer@ferc.gov>; 'nicholas.ettema@ferc.gov' <nicholas.ettema@ferc.gov>; aharo@usgs.gov; 'TCastro_Santos@usgs.gov' <TCastro_Santos@usgs.gov>; Norm Sims (normsims@me.com) <normsims@me.com>; Bob Nasdor (bob@americanwhitewater.org) <bob@americanwhitewater.org>; Tom Christopher (tom.christopher@comcast.net) <tom.christopher@comcast.net>; John Ragonese - Great River Hydro (jragonese@greatriverhydro.com) <jragonese@greatriverhydro.com>; Jennifer Griffin (jennifer_griffin@transcanada.com) <jennifer_griffin@transcanada.com>; Paul Ducheney (ducheney@hged.com) <ducheney@hged.com>; Kristen Sykes <KSykes@outdoors.org>; 'A. Fisk' <afisk@ctriver.org>; Peggy Sloan <PSloan@frcog.org>; Frost, Karro (FWE) <karro.frost@state.ma.us>; Marold, Misty-Anne (FWE) <misty-anne.marold@state.ma.us>; 'mike.nelson@state.ma.us' <mike.nelson@state.ma.us>; 'robert.wernerhl@state.ma.us' <robert.wernerhl@state.ma.us>; 'Christopher Boelke - NOAA Federal' <christopher.boelke@noaa.gov>; John Ward (selectman.ward@gmail.com) <selectman.ward@gmail.com>
Cc: Jason George <jgeorge@gomezandsullivan.com>; Tom Sullivan <tsullivan@gomezandsullivan.com>; Gary Lemay <glemay@gomezandsullivan.com>; John Hart <jhart@gomezandsullivan.com>; Aaron Rubin <arubin@gomezandsullivan.com>; Ian Kiraly <ikiraly@gomezandsullivan.com>; Doug Bennett (Douglas.bennett@firstlightpower.com) <Douglas.bennett@firstlightpower.com>; Don Traester (donald.traester@firstlightpower.com) <donald.traester@firstlightpower.com>; Stira, Robert <Robert.Stira@firstlightpower.com>; 'mas@vnf.com' <mas@vnf.com>; 'Julia Wood (jsw@vnf.com)' <jsw@vnf.com>; Sarah Verville (sverville@trcsolutions.com) <sverville@trcsolutions.com>
Subject: Reach 5 Mussels

Dear Relicensing Participant-

Based on discussions with the USFWS and NHESP, additional work is being requested in

Reach 5 (below Cabot from Route 116 to Dinosaur Footprint) relative to state-listed mussels. Please find attached a study plan to conduct an instream flow study in Reach 5 for state-listed mussels and host fish. FirstLight will have a meeting on June 1, 2017, starting at 9:00 am at the Northfield Visitors Center to discuss the plan. FirstLight is proposing to collect velocity, depth and substrate data in Reach 5 under two flows. Because time is critical (some of the field data will be collected under a higher flow and that window will be closing as we approach summer low flows), we would like to reach agreement on the study plan as soon as possible. Given that, if NHESP, USFWS, or other stakeholders have comments on the plan prior to the meeting, it would be greatly appreciated.

If you have any questions, please fee free to contact me. Much appreciated, Mark

Mark Wamser, PE

Senior Water Resource Engineer

Gomez and Sullivan Engineers, DPC

41 Liberty Hill Road

PO Box 2179

Henniker, NH 03242

P 603-428-4960

C 603-568-6088

F 603-428-3973

GOMEZ AND SULLIVAN ENGINEERS

GSE CONFIDENTIALITY NOTICE: *This email and any files transmitted with it are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you are not the intended recipient, please do not read or review the content and/or metadata and do not disseminate, distribute or copy this communication. Anyone who receives this message in error should notify the sender (mwamser@gomezandsullivan.com) immediately by return e-mail and delete it from his or her computer.*

From:	Grader, Melissa
To:	Mark Wamser
Cc:	Warner, John; Leddick, Jesse (FWE); Ken Sprankle (ken_sprankle@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; Don Pugh; kkennedy@tnc.org; Karl Meyer; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net; Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com); Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah
Subject:	Re: Reach 5 Mussels
Date:	Thursday, August 17, 2017 4:28:33 PM

The FWS has no objections to the final Reach 5 Mussel Study Plan, as revised.

Regards,

Melissa Grader
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service - New England Field Office
103 East Plumtree Road
Sunderland, MA 01375
413-548-8002 x8124
melissa_grader@fws.gov

On Mon, Aug 7, 2017 at 2:54 PM, Leddick, Jesse (FWE) <Jesse.Leddick@massmail.state.ma.us> wrote:

> Hi Mark,
>
> This is to confirm that the Division approves the final Reach 5 Mussel Study Plan, as revised. Thanks for everyone's ongoing work on this.
>
> As an aside, we look forward to receiving an updated Reach 3 Mussel Study Plan (including shear stress as a 4th parameter) as soon as possible.
>
> Best regards,
>
> **Jesse Leddick**
> Endangered Species Review Biologist

From: Katie Kennedy
To: Mark Wamser
Cc: Leddick, Jesse (FWE); Grader, Melissa; Hazelton, Peter (FWE); Marold, Misty-Anne (FWE); Andrea Donlon; Warner, John; Rosset, Julianne
Subject: RE: Reach 5 Mussels
Date: Friday, June 09, 2017 2:29:44 PM

Mark, TNC also concurs with and supports NHESP's comments.

Katie.

Katie Kennedy, PhD
Applied River Scientist
kkennedy@tnc.org

(413) 586-2349 (office)
(413) 588 1959 (cell)

The Nature Conservancy
Connecticut River Program
136 West Street, Suite 5
Northampton MA 01060

From: Grader, Melissa [mailto:melissa_grader@fws.gov]
Sent: Friday, June 09, 2017 2:22 PM
To: Mark Wamser <mwamser@gomezandsullivan.com>
Cc: Leddick, Jesse (FWE) <Jesse.Leddick@massmail.state.ma.us>; Hazelton, Peter (FWE) <peter.hazelton@massmail.state.ma.us>; Marold, Misty-Anne (FWE) <misty-anne.marold@massmail.state.ma.us>; Andrea Donlon <adonlon@ctriver.org>; Katie Kennedy <kkennedy@TNC.ORG>; John Warner <John_Warner@fws.gov>; Rosset, Julianne <julianne_rosset@fws.gov>
Subject: Re: Reach 5 Mussels

Mark,

The Service concurs with and supports the comments made by NHESP.

Regards,

Melissa Grader
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service - New England Field Office
103 East Plumtree Road
Sunderland, MA 01375
413-548-8002 x8124
melissa_grader@fws.gov

On Fri, Jun 9, 2017 at 1:47 PM, Leddick, Jesse (FWE) <Jesse.Leddick@massmail.state.ma.us> wrote:

Mark,

Overall, we (NHESP) concur with the updated IFIM Study Plan for Reach 5 (Revision 1: June 2017). However, please note the following:

Shear Stress Analysis

1. As discussed during our June 1 meeting, we highlighted that the shear stress analysis should not be based on the entire water column but on the linear distance at the substrate surface. We didn't see this articulated in the updated Study Plan.

2. We also highlighted the need to define the flows for which the shear stress analysis will be completed. We didn't see this articulated in the updated Study Plan; will FL be running this analysis for all flows shown in Table 1.7-4, or a subset of flows?

3. Finally, we highlighted - based on the results of the separate analyses (one for depth/velocity/substrate and the other for shear stress) – the need to run all 4 parameters together in PHABSIM to assess how shear stress affects habitat modeling and WUA. We didn't see this articulated in the updated Study Plan.

General Comment

4. As discussed during our June 1 meeting ,we highlighted the need to update the mussel habitat suitability analysis for Reach 3 to include shear stress as a 4th parameter. FL should submit an updated study plan to the working group for review and comment. This needn't hold up data collection and analysis efforts related to Reach 5, but it remains an important, outstanding element of the mussel analysis.

Many thanks to you and your team for your work on this.

Jesse Leddick
Endangered Species Review Biologist
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road, Westborough, MA 01581
p: (508) 389-6386 | e: Jesse.Leddick@state.ma.us
mass.gov/masswildlife | facebook.com/masswildlife

From: Mark Wamser [mailto:mwamser@gomezandsullivan.com]
Sent: Monday, June 05, 2017 9:16 AM
To: Warner, John; Ken Sprankle (ken_sprankle@fws.gov); Melissa Grader (melissa_grader@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Leddick, Jesse (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; 'Don Pugh'; kkennedy@tnc.org; 'Karl Meyer'; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net;

Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com)
Cc: Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah
Subject: RE: Reach 5 Mussels

Dear Relicensing Participant-

On May 19, 2017, FL sent you a draft study plan for conducting a Reach 5 IFIM study for mussels and notified parties that a meeting to discuss the plan would occur on June 1, 2017. On June 1, 2017, FL held an afternoon meeting to discuss the plan. Present at the meeting was FL, Gomez and Sullivan, Jesse Leddick, Misty-Anne Marold and Pete Hazelton (NHESP), Katie Kennedy (TNC), Melissa Grader, Julianne Rosset (USFWS), Andrea Donlon (CRC), and Steve Kartalia (FERC). At the meeting, comments were provided on the Draft IFIM Study plan. Please find attached a Final IFIM Study plan based on the comments received at the meeting. As noted at the meeting, we will not have time to go through the full FERC process of obtaining FERC's Study Plan Determination because field data needs to be collected under higher flows. Given this, we respectfully request an email from those who attended the meeting- NHESP TNC, USFWS, and CRC -- supporting the plan. We would like to file with FERC the Final IFIM Study plan along with emails supporting the plan (to be included in Appendix B). If you could provide these emails by Friday of this week it would be greatly appreciated. Please feel free to call me if you have any questions.

Thanks Mark

Mark Wamser, PE
Senior Water Resource Engineer
Gomez and Sullivan Engineers, DPC
41 Liberty Hill Road
PO Box 2179
Henniker, NH 03242
P 603-428-4960
C 603-568-6088
F 603-428-3973

GOMEZ AND SULLIVAN ENGINEERS

From: Mark Wamser
Sent: Friday, May 19, 2017 12:38 PM
To: John Warner - US Fish and Wildlife Service (john_warner@fws.gov) <john_warner@fws.gov>; Ken Sprankle (ken_sprankle@fws.gov) <ken_sprankle@fws.gov>; Melissa Grader (melissa_grader@fws.gov)

<melissa_grader@fws.gov>; 'julianne_rosset@fws.gov' <julianne_rosset@fws.gov>; brett_towler@fws.gov; Caleb Slater (caleb.slater@state.ma.us) <caleb.slater@state.ma.us>; Jesse Leddick (jesse.leddick@state.ma.us) <jesse.leddick@state.ma.us>; peter.hazelton@state.ma.us; Bob Kubit (robert.kubit@state.ma.us) <robert.kubit@state.ma.us>; Foulis, David (DEP) (david.foulis@state.ma.us) <david.foulis@state.ma.us>; Harrington, Brian D (DEP) (brian.d.harrington@state.ma.us) <brian.d.harrington@state.ma.us>; 'david.cameron@state.ma.us' <david.cameron@state.ma.us>; Julie Crocker (julie.crocker@noaa.gov) <julie.crocker@noaa.gov>; 'William McDavitt - NOAA Affiliate' <william.mcdavitt@noaa.gov>; 'jeff.murphy@noaa.gov' <jeff.murphy@noaa.gov>; 'Bjorn Lake - NOAA Federal' <bjorn.lake@noaa.gov>; susan.tuxbury@noaa.gov; Kevin R. Mendik - National Park Service North Atlantic Region (kevin_mendik@nps.gov) <kevin_mendik@nps.gov>; 'Don Pugh' <don.pugh@yahoo.com>; kkennedy@tnc.org; 'Karl Meyer' <karlmeyer1809@verizon.net>; Andrea Donlon (adonlon@ctriver.org) <adonlon@ctriver.org>; johnbenn@sover.net; Tom Miner (wtminer@crocker.com) <wtminer@crocker.com>; Kimberly Noake MacPhee (kmacphee@frcog.org) <kmacphee@frcog.org>; mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov) <brandon.cherry@ferc.gov>; 'stephen.kartalia@ferc.gov' <stephen.kartalia@ferc.gov>; 'william.connelly@ferc.gov' <william.connelly@ferc.gov>; 'patrick.crile@ferc.gov' <patrick.crile@ferc.gov>; 'john.baummer@ferc.gov' <john.baummer@ferc.gov>; 'nicholas.ettema@ferc.gov' <nicholas.ettema@ferc.gov>; aharo@usgs.gov; 'TCastro_Santos@usgs.gov' <TCastro_Santos@usgs.gov>; Norm Sims (normsims@me.com) <normsims@me.com>; Bob Nasdor (bob@americanwhitewater.org) <bob@americanwhitewater.org>; Tom Christopher (tom.christopher@comcast.net) <tom.christopher@comcast.net>; John Ragonese - Great River Hydro (jragonese@greatriverhydro.com) <jragonese@greatriverhydro.com>; Jennifer Griffin (jennifer_griffin@transcanada.com) <jennifer_griffin@transcanada.com>; Paul Ducheney (ducheney@hged.com) <ducheney@hged.com>; Kristen Sykes <KSykes@outdoors.org>; 'A. Fisk' <afisk@ctriver.org>; Peggy Sloan <PSloan@frcog.org>; Frost, Karro (FWE) <karro.frost@state.ma.us>; Marold, Misty-Anne (FWE) <misty-anne.marold@state.ma.us>; 'mike.nelson@state.ma.us' <mike.nelson@state.ma.us>; 'robert.wernerhl@state.ma.us' <robert.wernerhl@state.ma.us>; 'Christopher Boelke - NOAA Federal' <christopher.boelke@noaa.gov>; John Ward (selectman.ward@gmail.com) <selectman.ward@gmail.com>
Cc: Jason George <jgeorge@gomezandsullivan.com>; Tom Sullivan <tsullivan@gomezandsullivan.com>; Gary Lemay <glemay@gomezandsullivan.com>; John Hart <jhart@gomezandsullivan.com>; Aaron Rubin <arubin@gomezandsullivan.com>; Ian Kiraly <ikiraly@gomezandsullivan.com>; Doug Bennett (Douglas.bennett@firstlightpower.com) <Douglas.bennett@firstlightpower.com>; Don Traester (donald.traester@firstlightpower.com) <donald.traester@firstlightpower.com>; Stira, Robert <Robert.Stira@firstlightpower.com>; 'mas@vnf.com' <mas@vnf.com>; 'Julia Wood (jsw@vnf.com)' <jsw@vnf.com>; Sarah Verville (sverville@trcsolutions.com) <sverville@trcsolutions.com>
Subject: Reach 5 Mussels

Dear Relicensing Participant-

Based on discussions with the USFWS and NHESP, additional work is being requested in Reach 5 (below Cabot from Route 116 to Dinosaur Footprint) relative to state-listed mussels. Please find attached a study plan to conduct an instream flow study in Reach 5 for state-listed mussels and host fish. FirstLight will have a meeting on June 1, 2017, starting at 9:00 am at the Northfield Visitors Center to discuss the plan. FirstLight is proposing to collect velocity, depth and substrate data in Reach 5 under two flows. Because time is critical (some of the field data will be collected under a higher flow and that window will be closing as we approach summer low flows), we would like to reach agreement on the study plan as soon as possible. Given that, if NHESP, USFWS, or other stakeholders have comments on the plan prior to the meeting, it would be greatly appreciated.

If you have any questions, please fee free to contact me. Much appreciated, Mark

Mark Wamser, PE
Senior Water Resource Engineer
Gomez and Sullivan Engineers, DPC
41 Liberty Hill Road
PO Box 2179
Henniker, NH 03242
P 603-428-4960
C 603-568-6088
F 603-428-3973

GOMEZ AND SULLIVAN ENGINEERS

GSE CONFIDENTIALITY NOTICE: *This email and any files transmitted with it are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you are not the intended recipient, please do not read or review the content and/or metadata and do not disseminate, distribute or copy this communication. Anyone who receives this message in error should notify the sender (mwamser@gomezandsullivan.com) immediately by return e-mail and delete it from his or her computer.*

From: Katie Kennedy
To: Grader, Melissa; Mark Wamser
Cc: Warner, John; Leddick, Jesse (FWE); Ken Sprankle (ken_sprankle@fws.gov); julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE); Hazelton, Peter (FWE); Kubit, Robert (DEP); Foulis, David (DEP); Harrington, Brian (DEP); Cameron, David (DEP); Julie Crocker (julie.crocker@noaa.gov); William McDavitt - NOAA Affiliate; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal; susan.tuxbury@noaa.gov; Mendik, Kevin; Don Pugh; Karl Meyer; Andrea Donlon (adonlon@ctriver.org); johnbenn@sover.net; Tom Miner (wtminer@crocker.com); Kimberly Noake MacPhee (kmacphee@frcog.org); mjbathory@comcast.net; Brandon Cherry (brandon.cherry@ferc.gov); stephen.kartalia@ferc.gov; william.connelly@ferc.gov; patrick.crile@ferc.gov; john.baummer@ferc.gov; nicholas.ettema@ferc.gov; aharo@usgs.gov; TCastro_Santos@usgs.gov; Norm Sims (normsims@me.com); Bob Nasdor (bob@americanwhitewater.org); Tom Christopher (tom.christopher@comcast.net); John Ragonese - Great River Hydro (jragonese@greatriverhydro.com); Jennifer Griffin (jennifer_griffin@transcanada.com); Paul Ducheney (ducheney@hged.com); Kristen Sykes; A. Fisk; Peggy Sloan; Frost, Karro (FWE); Marold, Misty-Anne (FWE); Nelson, Mike (FWE); robert.wernerhl@state.ma.us; Christopher Boelke - NOAA Federal; John Ward (selectman.ward@gmail.com); Jason George; Tom Sullivan; Gary Lemay; John Hart; Aaron Rubin; Ian Kiraly; Doug Bennett (Douglas.bennett@firstlightpower.com); Don Traester (donald.traester@firstlightpower.com); Stira, Robert; Swiger, Mike; Wood, Julia; Verville, Sarah
Subject: RE: Reach 5 Mussels
Date: Thursday, August 17, 2017 4:31:43 PM

Hi Mark – TNC is also in concurrence that the final Reach 5 Mussel Study Plan is acceptable as revised.

Katie.

Katie Kennedy, PhD
Applied River Scientist
kkennedy@tnc.org

(413) 586-2349 (office)
(413) 588 1959 (cell)

The Nature Conservancy
Connecticut River Program
136 West Street, Suite 5
Northampton MA 01060

From: Grader, Melissa [mailto:melissa_grader@fws.gov]
Sent: Thursday, August 17, 2017 4:28 PM
To: Mark Wamser <mwamser@gomezandsullivan.com>
Cc: Warner, John <john_warner@fws.gov>; Leddick, Jesse (FWE) <Jesse.Leddick@massmail.state.ma.us>; Ken Sprankle (ken_sprankle@fws.gov) <ken_sprankle@fws.gov>; julianne_rosset@fws.gov; brett_towler@fws.gov; Slater, Caleb (FWE) <caleb.slater@state.ma.us>; Hazelton, Peter (FWE) <peter.hazelton@state.ma.us>; Kubit, Robert (DEP) <robert.kubit@state.ma.us>; Foulis, David (DEP) <david.foulis@state.ma.us>; Harrington, Brian (DEP) <brian.d.harrington@state.ma.us>; Cameron, David (DEP) <david.cameron@state.ma.us>; Julie Crocker (julie.crocker@noaa.gov) <julie.crocker@noaa.gov>; William McDavitt - NOAA Affiliate <william.mcdavitt@noaa.gov>; jeff.murphy@noaa.gov; Bjorn Lake - NOAA Federal <bjorn.lake@noaa.gov>; susan.tuxbury@noaa.gov; Mendik, Kevin <kevin_mendik@nps.gov>; Don Pugh <don.pugh@yahoo.com>; Katie Kennedy

APPENDIX B – COMPARISON OF ORIGINAL AND REVISED SUB-REACH BREAKPOINTS

Table 2.2-1: Juvenile Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.94	7.91	7.91	7.95	7.96	8.00	8.14	8.39	8.68	9.00	9.18	9.40	9.52	9.65	9.46	8.82	7.85	7.19	6.70	6.01	5.25	4.75	4.19	3.73
3,000		7.82	7.82	7.83	7.83	7.88	8.02	8.27	8.56	8.88	9.06	9.28	9.40	9.53	9.36	8.73	7.75	7.10	6.61	5.92	5.12	4.63	4.06	3.57
4,000			7.68	7.69	7.69	7.73	7.87	8.13	8.42	8.74	8.92	9.14	9.26	9.39	9.24	8.61	7.64	7.00	6.52	5.87	5.10	4.60	4.04	3.55
5,000				7.55	7.56	7.60	7.74	7.99	8.29	8.61	8.79	9.01	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.04	4.60	4.03	3.54
6,000					7.56	7.60	7.74	7.99	8.28	8.60	8.78	9.00	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.03	4.60	4.03	3.54
7,000						7.58	7.72	7.97	8.27	8.59	8.76	8.98	9.11	9.24	9.12	8.48	7.51	6.88	6.41	5.78	5.01	4.57	4.01	3.52
8,000							7.67	7.92	8.22	8.54	8.72	8.94	9.06	9.19	9.07	8.43	7.46	6.83	6.36	5.73	4.96	4.52	3.96	3.47
9,000								8.21	8.50	8.83	9.00	9.22	9.35	9.48	9.35	8.72	7.75	7.11	6.65	6.02	5.24	4.81	4.23	3.54
10,000									8.35	8.67	8.85	9.07	9.19	9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
11,000										8.71	8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
12,000											8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
13,000												9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
14,000													9.19	9.33	9.20	8.57	7.59	6.96	6.50	5.86	5.09	4.65	4.08	3.32
15,000														9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
16,000															9.23	8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
17,000																8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
18,000																	7.93	7.29	6.83	6.20	5.42	4.99	4.41	3.65
19,000																		7.46	7.00	6.36	5.59	5.15	4.58	3.82
20,000																			7.00	6.36	5.59	5.15	4.58	3.82
21,000																				6.36	5.59	5.15	4.58	3.82
22,000																					5.87	5.43	4.86	4.10
23,000																						5.25	4.68	3.91
24,000																							4.57	3.81
25,000																								3.81

Table 2.2-2: Juvenile Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.8%	90.7%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.9%	86.1%	85.6%	85.7%	86.1%	86.3%	86.1%	86.3%	86.7%	87.0%	87.4%	87.4%
3,000		91.2%	91.2%	91.1%	91.1%	91.0%	90.7%	90.2%	89.7%	89.1%	88.6%	88.0%	87.3%	86.6%	86.0%	86.1%	86.5%	86.7%	86.6%	86.9%	87.3%	87.6%	88.1%	88.2%
4,000			91.4%	91.4%	91.3%	91.2%	90.9%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.8%	86.3%	86.4%	86.8%	87.0%	86.9%	87.0%	87.5%	87.7%	88.2%	88.3%
5,000				91.6%	91.6%	91.4%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.2%	86.7%	86.8%	87.3%	87.4%	87.3%	87.4%	87.9%	88.0%	88.5%	88.6%
6,000					91.7%	91.6%	91.3%	90.8%	90.4%	89.8%	89.3%	88.7%	88.1%	87.4%	86.9%	87.0%	87.5%	87.7%	87.5%	87.7%	88.2%	88.3%	88.8%	89.0%
7,000						91.6%	91.3%	90.9%	90.4%	89.9%	89.3%	88.8%	88.2%	87.5%	87.0%	87.1%	87.6%	87.8%	87.7%	87.9%	88.4%	88.5%	89.0%	89.2%
8,000							91.6%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.4%	87.6%	88.1%	88.3%	88.2%	88.5%	89.0%	89.2%	89.7%	90.0%
9,000								91.0%	90.5%	90.0%	89.5%	89.0%	88.4%	87.7%	87.2%	87.4%	87.8%	88.1%	88.0%	88.2%	88.7%	88.8%	89.3%	89.9%
10,000									90.8%	90.2%	89.7%	89.2%	88.7%	88.0%	87.5%	87.7%	88.2%	88.4%	88.4%	88.6%	89.2%	89.3%	89.9%	90.7%
11,000										90.2%	89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
12,000											89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
13,000												89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
14,000													88.7%	88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
15,000														88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
16,000															87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
17,000																87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
18,000																	88.0%	88.2%	88.1%	88.4%	88.8%	89.0%	89.5%	90.2%
19,000																		88.0%	88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
20,000																			88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
21,000																				88.1%	88.6%	88.8%	89.2%	89.9%
22,000																					88.2%	88.3%	88.8%	89.4%
23,000																						88.8%	89.3%	90.0%
24,000																							89.6%	90.3%
25,000																								90.3%

Table 2.2-3: Juvenile Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.94	7.92	7.92	7.96	7.98	8.05	8.33	8.62	8.94	9.39	9.76	9.92	10.12	10.17	10.00	9.30	8.31	7.62	7.07	6.32	5.50	4.97	4.42	3.89
3,000		7.83	7.83	7.84	7.86	7.93	8.21	8.50	8.82	9.27	9.64	9.80	10.00	10.05	9.91	9.21	8.22	7.53	6.98	6.23	5.38	4.85	4.30	3.74
4,000			7.68	7.70	7.72	7.79	8.07	8.36	8.67	9.13	9.50	9.65	9.86	9.91	9.79	9.09	8.10	7.43	6.88	6.18	5.36	4.82	4.28	3.71
5,000				7.57	7.59	7.66	7.93	8.23	8.54	9.00	9.37	9.52	9.73	9.78	9.68	8.98	7.99	7.33	6.80	6.12	5.30	4.82	4.27	3.71
6,000					7.58	7.65	7.93	8.22	8.54	8.99	9.36	9.52	9.73	9.78	9.68	8.98	7.99	7.32	6.80	6.12	5.29	4.82	4.27	3.71
7,000						7.64	7.91	8.21	8.52	8.98	9.35	9.50	9.71	9.76	9.66	8.96	7.97	7.31	6.78	6.09	5.27	4.79	4.24	3.68
8,000							7.87	8.16	8.47	8.93	9.30	9.45	9.67	9.71	9.61	8.91	7.93	7.26	6.73	6.04	5.22	4.74	4.20	3.63
9,000								8.44	8.76	9.22	9.59	9.74	9.95	10.00	9.90	9.20	8.21	7.55	7.02	6.33	5.50	5.03	4.47	3.71
10,000									8.60	9.06	9.43	9.59	9.80	9.84	9.74	9.04	8.06	7.39	6.86	6.17	5.35	4.87	4.32	3.48
11,000										9.10	9.47	9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
12,000											9.47	9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
13,000												9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
14,000													9.80	9.85	9.75	9.05	8.06	7.39	6.87	6.18	5.35	4.87	4.32	3.48
15,000														9.84	9.74	9.04	8.06	7.39	6.86	6.17	5.35	4.87	4.32	3.48
16,000															9.77	9.07	8.08	7.42	6.89	6.20	5.38	4.90	4.34	3.51
17,000																9.07	8.08	7.42	6.89	6.20	5.38	4.90	4.34	3.51
18,000																	8.39	7.72	7.20	6.51	5.68	5.21	4.65	3.82
19,000																		7.89	7.37	6.68	5.85	5.37	4.82	3.98
20,000																			7.37	6.68	5.85	5.37	4.82	3.98
21,000																				6.68	5.85	5.37	4.82	3.98
22,000																					6.13	5.65	5.10	4.26
23,000																						5.47	4.92	4.08
24,000																							4.81	3.98
25,000																								3.98

Table 2.2-4: Juvenile Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.8%	90.7%	90.4%	89.9%	89.4%	88.8%	88.0%	87.0%	86.4%	85.5%	84.8%	84.1%	84.2%	84.5%	84.7%	84.7%	85.0%	85.5%	85.8%	86.1%	86.2%
3,000		91.2%	91.1%	91.1%	91.0%	90.7%	90.3%	89.7%	89.2%	88.4%	87.4%	86.8%	86.0%	85.2%	84.6%	84.7%	85.0%	85.2%	85.2%	85.5%	86.1%	86.5%	86.8%	87.1%
4,000			91.4%	91.3%	91.2%	90.9%	90.5%	89.9%	89.4%	88.6%	87.7%	87.1%	86.3%	85.5%	84.9%	85.0%	85.3%	85.5%	85.5%	85.7%	86.2%	86.6%	86.9%	87.2%
5,000				91.5%	91.4%	91.2%	90.8%	90.2%	89.7%	88.9%	88.0%	87.5%	86.6%	86.0%	85.3%	85.4%	85.8%	86.0%	85.9%	86.2%	86.7%	86.9%	87.3%	87.6%
6,000					91.5%	91.3%	90.9%	90.4%	89.8%	89.1%	88.2%	87.7%	86.8%	86.2%	85.5%	85.7%	86.0%	86.2%	86.2%	86.5%	87.0%	87.2%	87.6%	87.9%
7,000						91.4%	90.9%	90.4%	89.9%	89.2%	88.3%	87.7%	86.9%	86.3%	85.6%	85.8%	86.2%	86.4%	86.4%	86.6%	87.2%	87.4%	87.8%	88.2%
8,000							91.2%	90.7%	90.2%	89.5%	88.6%	88.1%	87.3%	86.7%	86.1%	86.3%	86.7%	87.0%	87.0%	87.3%	87.9%	88.2%	88.6%	89.1%
9,000								90.5%	90.0%	89.3%	88.4%	87.9%	87.2%	86.5%	85.9%	86.1%	86.5%	86.7%	86.8%	87.0%	87.6%	87.8%	88.3%	89.0%
10,000									90.3%	89.5%	88.7%	88.2%	87.5%	86.9%	86.3%	86.5%	86.9%	87.1%	87.2%	87.5%	88.1%	88.4%	88.9%	89.8%
11,000										89.5%	88.7%	88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
12,000											88.7%	88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
13,000												88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
14,000													87.5%	86.9%	86.4%	86.6%	87.0%	87.2%	87.3%	87.6%	88.3%	88.5%	89.0%	90.0%
15,000														87.0%	86.4%	86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
16,000															86.4%	86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
17,000																86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
18,000																	86.7%	86.9%	87.0%	87.3%	87.8%	88.1%	88.5%	89.4%
19,000																		86.8%	86.8%	87.1%	87.6%	87.8%	88.2%	89.1%
20,000																			86.8%	87.1%	87.6%	87.8%	88.2%	89.1%
21,000																				87.1%	87.6%	87.8%	88.2%	89.1%
22,000																					87.2%	87.4%	87.8%	88.5%
23,000																						87.9%	88.3%	89.1%
24,000																							88.6%	89.5%
25,000																								89.5%

Table 2.2-5-: Juvenile Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.94	7.91	7.91	7.95	7.96	8.00	8.14	8.39	8.68	9.00	9.18	9.40	9.52	9.65	9.46	8.82	7.85	7.19	6.70	6.01	5.25	4.75	4.19	3.73
3,000		7.82	7.82	7.83	7.83	7.88	8.02	8.27	8.56	8.88	9.06	9.28	9.40	9.53	9.36	8.73	7.75	7.10	6.61	5.92	5.12	4.63	4.06	3.57
4,000			7.68	7.69	7.69	7.73	7.87	8.13	8.42	8.74	8.92	9.14	9.26	9.39	9.24	8.61	7.64	7.00	6.52	5.87	5.10	4.60	4.04	3.55
5,000				7.55	7.56	7.60	7.74	7.99	8.29	8.61	8.79	9.01	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.04	4.60	4.03	3.54
6,000					7.56	7.60	7.74	7.99	8.28	8.60	8.78	9.00	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.03	4.60	4.03	3.54
7,000						7.58	7.72	7.97	8.27	8.59	8.76	8.98	9.11	9.24	9.12	8.48	7.51	6.88	6.41	5.78	5.01	4.57	4.01	3.52
8,000							7.67	7.92	8.22	8.54	8.72	8.94	9.06	9.19	9.07	8.43	7.46	6.83	6.36	5.73	4.96	4.52	3.96	3.47
9,000								8.21	8.50	8.83	9.00	9.22	9.35	9.48	9.35	8.72	7.75	7.11	6.65	6.02	5.24	4.81	4.23	3.54
10,000									8.35	8.67	8.85	9.07	9.19	9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
11,000										8.71	8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
12,000											8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
13,000												9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
14,000													9.19	9.33	9.20	8.57	7.59	6.96	6.50	5.86	5.09	4.65	4.08	3.32
15,000														9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
16,000															9.23	8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
17,000																8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
18,000																	7.93	7.29	6.83	6.20	5.42	4.99	4.41	3.65
19,000																		7.46	7.00	6.36	5.59	5.15	4.58	3.82
20,000																			7.00	6.36	5.59	5.15	4.58	3.82
21,000																				6.36	5.59	5.15	4.58	3.82
22,000																					5.87	5.43	4.86	4.10
23,000																						5.25	4.68	3.91
24,000																							4.57	3.81
25,000																								3.81

Table 2.2-6-: Juvenile Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.8%	90.7%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.9%	86.1%	85.6%	85.7%	86.1%	86.3%	86.1%	86.3%	86.7%	87.0%	87.4%	87.4%
3,000		91.2%	91.2%	91.1%	91.1%	91.0%	90.7%	90.2%	89.7%	89.1%	88.6%	88.0%	87.3%	86.6%	86.0%	86.1%	86.5%	86.7%	86.6%	86.9%	87.3%	87.6%	88.1%	88.2%
4,000			91.4%	91.4%	91.3%	91.2%	90.9%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.8%	86.3%	86.4%	86.8%	87.0%	86.9%	87.0%	87.5%	87.7%	88.2%	88.3%
5,000				91.6%	91.6%	91.4%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.2%	86.7%	86.8%	87.3%	87.4%	87.3%	87.4%	87.9%	88.0%	88.5%	88.6%
6,000					91.7%	91.6%	91.3%	90.8%	90.4%	89.8%	89.3%	88.7%	88.1%	87.4%	86.9%	87.0%	87.5%	87.7%	87.5%	87.7%	88.2%	88.3%	88.8%	89.0%
7,000						91.6%	91.3%	90.9%	90.4%	89.9%	89.3%	88.8%	88.2%	87.5%	87.0%	87.1%	87.6%	87.8%	87.7%	87.9%	88.4%	88.5%	89.0%	89.2%
8,000							91.6%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.4%	87.6%	88.1%	88.3%	88.2%	88.5%	89.0%	89.2%	89.7%	90.0%
9,000								91.0%	90.5%	90.0%	89.5%	89.0%	88.4%	87.7%	87.2%	87.4%	87.8%	88.1%	88.0%	88.2%	88.7%	88.8%	89.3%	89.9%
10,000									90.8%	90.2%	89.7%	89.2%	88.7%	88.0%	87.5%	87.7%	88.2%	88.4%	88.4%	88.6%	89.2%	89.3%	89.9%	90.7%
11,000										90.2%	89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
12,000											89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
13,000												89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
14,000													88.7%	88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
15,000														88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
16,000															87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
17,000																87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
18,000																	88.0%	88.2%	88.1%	88.4%	88.8%	89.0%	89.5%	90.2%
19,000																		88.0%	88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
20,000																			88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
21,000																				88.1%	88.6%	88.8%	89.2%	89.9%
22,000																					88.2%	88.3%	88.8%	89.4%
23,000																						88.8%	89.3%	90.0%
24,000																							89.6%	90.3%
25,000																								90.3%

Table 2.2-7-: Juvenile Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.94	7.92	7.92	7.96	7.98	8.05	8.33	8.62	8.94	9.39	9.76	9.92	10.12	10.17	10.00	9.30	8.31	7.62	7.07	6.32	5.50	4.97	4.42	3.89
3,000		7.83	7.83	7.84	7.86	7.93	8.21	8.50	8.82	9.27	9.64	9.80	10.00	10.05	9.91	9.21	8.22	7.53	6.98	6.23	5.38	4.85	4.30	3.74
4,000			7.68	7.70	7.72	7.79	8.07	8.36	8.67	9.13	9.50	9.65	9.86	9.91	9.79	9.09	8.10	7.43	6.88	6.18	5.36	4.82	4.28	3.71
5,000				7.57	7.59	7.66	7.93	8.23	8.54	9.00	9.37	9.52	9.73	9.78	9.68	8.98	7.99	7.33	6.80	6.12	5.30	4.82	4.27	3.71
6,000					7.58	7.65	7.93	8.22	8.54	8.99	9.36	9.52	9.73	9.78	9.68	8.98	7.99	7.32	6.80	6.12	5.29	4.82	4.27	3.71
7,000						7.64	7.91	8.21	8.52	8.98	9.35	9.50	9.71	9.76	9.66	8.96	7.97	7.31	6.78	6.09	5.27	4.79	4.24	3.68
8,000							7.87	8.16	8.47	8.93	9.30	9.45	9.67	9.71	9.61	8.91	7.93	7.26	6.73	6.04	5.22	4.74	4.20	3.63
9,000								8.44	8.76	9.22	9.59	9.74	9.95	10.00	9.90	9.20	8.21	7.55	7.02	6.33	5.50	5.03	4.47	3.71
10,000									8.60	9.06	9.43	9.59	9.80	9.84	9.74	9.04	8.06	7.39	6.86	6.17	5.35	4.87	4.32	3.48
11,000										9.10	9.47	9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
12,000											9.47	9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
13,000												9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
14,000													9.80	9.85	9.75	9.05	8.06	7.39	6.87	6.18	5.35	4.87	4.32	3.48
15,000														9.84	9.74	9.04	8.06	7.39	6.86	6.17	5.35	4.87	4.32	3.48
16,000															9.77	9.07	8.08	7.42	6.89	6.20	5.38	4.90	4.34	3.51
17,000																9.07	8.08	7.42	6.89	6.20	5.38	4.90	4.34	3.51
18,000																	8.39	7.72	7.20	6.51	5.68	5.21	4.65	3.82
19,000																		7.89	7.37	6.68	5.85	5.37	4.82	3.98
20,000																			7.37	6.68	5.85	5.37	4.82	3.98
21,000																				6.68	5.85	5.37	4.82	3.98
22,000																					6.13	5.65	5.10	4.26
23,000																						5.47	4.92	4.08
24,000																							4.81	3.98
25,000																								3.98

Table 2.2-8-: Juvenile Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.8%	90.7%	90.4%	89.9%	89.4%	88.8%	88.0%	87.0%	86.4%	85.5%	84.8%	84.1%	84.2%	84.5%	84.7%	84.7%	85.0%	85.5%	85.8%	86.1%	86.2%
3,000		91.2%	91.1%	91.1%	91.0%	90.7%	90.3%	89.7%	89.2%	88.4%	87.4%	86.8%	86.0%	85.2%	84.6%	84.7%	85.0%	85.2%	85.2%	85.5%	86.1%	86.5%	86.8%	87.1%
4,000			91.4%	91.3%	91.2%	90.9%	90.5%	89.9%	89.4%	88.6%	87.7%	87.1%	86.3%	85.5%	84.9%	85.0%	85.3%	85.5%	85.5%	85.7%	86.2%	86.6%	86.9%	87.2%
5,000				91.5%	91.4%	91.2%	90.8%	90.2%	89.7%	88.9%	88.0%	87.5%	86.6%	86.0%	85.3%	85.4%	85.8%	86.0%	85.9%	86.2%	86.7%	86.9%	87.3%	87.6%
6,000					91.5%	91.3%	90.9%	90.4%	89.8%	89.1%	88.2%	87.7%	86.8%	86.2%	85.5%	85.7%	86.0%	86.2%	86.2%	86.5%	87.0%	87.2%	87.6%	87.9%
7,000						91.4%	90.9%	90.4%	89.9%	89.2%	88.3%	87.7%	86.9%	86.3%	85.6%	85.8%	86.2%	86.4%	86.4%	86.6%	87.2%	87.4%	87.8%	88.2%
8,000							91.2%	90.7%	90.2%	89.5%	88.6%	88.1%	87.3%	86.7%	86.1%	86.3%	86.7%	87.0%	87.0%	87.3%	87.9%	88.2%	88.6%	89.1%
9,000								90.5%	90.0%	89.3%	88.4%	87.9%	87.2%	86.5%	85.9%	86.1%	86.5%	86.7%	86.8%	87.0%	87.6%	87.8%	88.3%	89.0%
10,000									90.3%	89.5%	88.7%	88.2%	87.5%	86.9%	86.3%	86.5%	86.9%	87.1%	87.2%	87.5%	88.1%	88.4%	88.9%	89.8%
11,000										89.5%	88.7%	88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
12,000											88.7%	88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
13,000												88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
14,000													87.5%	86.9%	86.4%	86.6%	87.0%	87.2%	87.3%	87.6%	88.3%	88.5%	89.0%	90.0%
15,000														87.0%	86.4%	86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
16,000															86.4%	86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
17,000																86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
18,000																	86.7%	86.9%	87.0%	87.3%	87.8%	88.1%	88.5%	89.4%
19,000																		86.8%	86.8%	87.1%	87.6%	87.8%	88.2%	89.1%
20,000																			86.8%	87.1%	87.6%	87.8%	88.2%	89.1%
21,000																				87.1%	87.6%	87.8%	88.2%	89.1%
22,000																					87.2%	87.4%	87.8%	88.5%
23,000																						87.9%	88.3%	89.1%
24,000																							88.6%	89.5%
25,000																								89.5%

Table 2.2-9: Juvenile Eastern Pondmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.95	7.92	7.92	7.96	7.96	8.00	8.15	8.40	8.69	9.01	9.18	9.40	9.53	9.66	9.46	8.82	7.85	7.19	6.70	6.01	5.25	4.75	4.19	3.73
3,000		7.83	7.83	7.83	7.84	7.88	8.02	8.27	8.57	8.89	9.06	9.28	9.41	9.54	9.36	8.73	7.76	7.10	6.61	5.92	5.12	4.63	4.06	3.57
4,000			7.69	7.69	7.70	7.74	7.88	8.13	8.42	8.75	8.92	9.14	9.26	9.40	9.24	8.61	7.64	7.00	6.52	5.87	5.10	4.60	4.04	3.55
5,000				7.56	7.57	7.61	7.75	8.00	8.29	8.61	8.79	9.01	9.13	9.27	9.14	8.50	7.53	6.90	6.43	5.81	5.04	4.60	4.04	3.55
6,000					7.56	7.60	7.75	8.00	8.29	8.61	8.79	9.01	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.03	4.60	4.03	3.54
7,000						7.59	7.73	7.98	8.27	8.59	8.77	8.99	9.11	9.24	9.12	8.48	7.51	6.88	6.41	5.78	5.01	4.57	4.01	3.52
8,000							7.68	7.93	8.22	8.54	8.72	8.94	9.06	9.20	9.07	8.44	7.46	6.83	6.37	5.73	4.96	4.52	3.96	3.47
9,000								8.22	8.51	8.83	9.01	9.23	9.35	9.48	9.36	8.72	7.75	7.12	6.65	6.02	5.25	4.81	4.23	3.54
10,000									8.35	8.68	8.85	9.07	9.19	9.33	9.20	8.57	7.59	6.96	6.50	5.86	5.09	4.65	4.08	3.32
11,000										8.72	8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.91	5.13	4.69	4.12	3.36
12,000											8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.91	5.13	4.69	4.12	3.36
13,000												9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.91	5.13	4.69	4.12	3.36
14,000													9.20	9.33	9.20	8.57	7.60	6.96	6.50	5.86	5.09	4.65	4.08	3.32
15,000														9.33	9.20	8.57	7.59	6.96	6.50	5.86	5.09	4.65	4.08	3.32
16,000															9.23	8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.11	3.34
17,000																8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.11	3.34
18,000																	7.93	7.30	6.83	6.20	5.42	4.99	4.41	3.65
19,000																		7.46	7.00	6.36	5.59	5.15	4.58	3.82
20,000																			7.00	6.36	5.59	5.15	4.58	3.82
21,000																				6.36	5.59	5.15	4.58	3.82
22,000																					5.87	5.43	4.86	4.10
23,000																						5.25	4.68	3.92
24,000																							4.57	3.81
25,000																								3.81

Table 2.2-10: Juvenile Eastern Pondmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.8%	90.9%	90.9%	90.8%	90.8%	90.6%	90.3%	89.8%	89.3%	88.7%	88.1%	87.5%	86.9%	86.1%	85.6%	85.6%	86.0%	86.2%	86.1%	86.3%	86.7%	87.0%	87.4%	87.3%
3,000		91.1%	91.1%	91.1%	91.1%	90.9%	90.6%	90.2%	89.7%	89.1%	88.5%	87.9%	87.3%	86.5%	86.0%	86.1%	86.5%	86.7%	86.6%	86.8%	87.3%	87.6%	88.1%	88.2%
4,000			91.3%	91.3%	91.3%	91.1%	90.9%	90.4%	89.9%	89.3%	88.8%	88.2%	87.6%	86.8%	86.3%	86.4%	86.8%	87.0%	86.8%	87.0%	87.4%	87.7%	88.2%	88.3%
5,000				91.6%	91.5%	91.4%	91.1%	90.7%	90.2%	89.6%	89.1%	88.5%	87.9%	87.2%	86.6%	86.8%	87.2%	87.4%	87.3%	87.4%	87.9%	88.0%	88.5%	88.6%
6,000					91.6%	91.5%	91.2%	90.8%	90.3%	89.8%	89.2%	88.7%	88.1%	87.4%	86.8%	87.0%	87.4%	87.6%	87.5%	87.7%	88.2%	88.3%	88.8%	89.0%
7,000						91.6%	91.3%	90.9%	90.4%	89.8%	89.3%	88.8%	88.2%	87.5%	86.9%	87.1%	87.6%	87.8%	87.7%	87.9%	88.3%	88.5%	89.0%	89.2%
8,000							91.6%	91.1%	90.7%	90.1%	89.6%	89.1%	88.6%	87.9%	87.4%	87.5%	88.1%	88.3%	88.2%	88.5%	89.0%	89.2%	89.7%	90.0%
9,000								90.9%	90.5%	89.9%	89.4%	88.9%	88.4%	87.7%	87.2%	87.3%	87.8%	88.0%	88.0%	88.2%	88.6%	88.8%	89.3%	89.9%
10,000									90.7%	90.2%	89.7%	89.2%	88.7%	88.0%	87.5%	87.7%	88.2%	88.4%	88.4%	88.6%	89.1%	89.3%	89.9%	90.7%
11,000										90.2%	89.7%	89.2%	88.6%	88.0%	87.5%	87.6%	88.1%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
12,000											89.7%	89.2%	88.6%	88.0%	87.5%	87.6%	88.1%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
13,000												89.2%	88.6%	88.0%	87.5%	87.6%	88.1%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
14,000													88.7%	88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.2%	89.4%	90.0%	90.8%
15,000														88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
16,000															87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
17,000																87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
18,000																	88.0%	88.2%	88.1%	88.3%	88.8%	89.0%	89.5%	90.2%
19,000																		88.0%	87.9%	88.1%	88.6%	88.7%	89.2%	89.9%
20,000																			87.9%	88.1%	88.6%	88.7%	89.2%	89.9%
21,000																				88.1%	88.6%	88.7%	89.2%	89.9%
22,000																					88.2%	88.3%	88.8%	89.4%
23,000																						88.8%	89.3%	89.9%
24,000																							89.6%	90.3%
25,000																								90.3%

Table 2.2-11: Juvenile Eastern Pondmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.95	7.92	7.92	7.96	7.98	8.05	8.33	8.62	8.94	9.39	9.76	9.92	10.12	10.17	10.00	9.30	8.31	7.62	7.07	6.32	5.50	4.97	4.42	3.89
3,000		7.83	7.83	7.84	7.86	7.93	8.21	8.50	8.82	9.27	9.64	9.80	10.00	10.05	9.91	9.21	8.22	7.53	6.98	6.23	5.38	4.85	4.30	3.74
4,000			7.69	7.70	7.72	7.79	8.07	8.36	8.67	9.13	9.50	9.65	9.86	9.91	9.79	9.09	8.10	7.43	6.88	6.18	5.36	4.82	4.28	3.71
5,000				7.57	7.59	7.66	7.93	8.23	8.54	9.00	9.37	9.52	9.73	9.78	9.68	8.98	7.99	7.33	6.80	6.12	5.30	4.82	4.27	3.71
6,000					7.58	7.65	7.93	8.22	8.54	8.99	9.36	9.52	9.73	9.78	9.68	8.98	7.99	7.32	6.80	6.12	5.29	4.82	4.27	3.71
7,000						7.64	7.91	8.21	8.52	8.98	9.35	9.50	9.71	9.76	9.66	8.96	7.97	7.31	6.78	6.09	5.27	4.79	4.24	3.68
8,000							7.87	8.16	8.47	8.93	9.30	9.45	9.67	9.71	9.61	8.91	7.93	7.26	6.73	6.04	5.22	4.74	4.20	3.63
9,000								8.44	8.76	9.22	9.59	9.74	9.95	10.00	9.90	9.20	8.21	7.55	7.02	6.33	5.50	5.03	4.47	3.71
10,000									8.60	9.06	9.43	9.59	9.80	9.84	9.74	9.04	8.06	7.39	6.86	6.17	5.35	4.87	4.32	3.48
11,000										9.10	9.47	9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
12,000											9.47	9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
13,000												9.63	9.84	9.89	9.79	9.09	8.10	7.43	6.91	6.22	5.39	4.92	4.36	3.52
14,000													9.80	9.85	9.75	9.05	8.06	7.39	6.87	6.18	5.35	4.87	4.32	3.48
15,000														9.84	9.74	9.04	8.06	7.39	6.86	6.17	5.35	4.87	4.32	3.48
16,000															9.77	9.07	8.08	7.42	6.89	6.20	5.38	4.90	4.34	3.51
17,000																9.07	8.08	7.42	6.89	6.20	5.38	4.90	4.34	3.51
18,000																	8.39	7.72	7.20	6.51	5.68	5.21	4.65	3.82
19,000																		7.89	7.37	6.68	5.85	5.37	4.82	3.98
20,000																			7.37	6.68	5.85	5.37	4.82	3.98
21,000																				6.68	5.85	5.37	4.82	3.98
22,000																					6.13	5.65	5.10	4.26
23,000																						5.47	4.92	4.08
24,000																							4.81	3.98
25,000																								3.98

Table 2.2-12: Juvenile Eastern Pondmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.8%	90.8%	90.8%	90.8%	90.6%	90.4%	89.9%	89.4%	88.8%	88.0%	87.0%	86.4%	85.5%	84.8%	84.1%	84.2%	84.5%	84.7%	84.7%	85.0%	85.5%	85.8%	86.1%	86.2%
3,000		91.1%	91.1%	91.0%	90.9%	90.7%	90.3%	89.7%	89.2%	88.4%	87.4%	86.8%	86.0%	85.2%	84.6%	84.7%	85.0%	85.2%	85.2%	85.5%	86.1%	86.5%	86.8%	87.1%
4,000			91.3%	91.3%	91.2%	90.9%	90.5%	89.9%	89.4%	88.6%	87.7%	87.1%	86.3%	85.5%	84.9%	85.0%	85.3%	85.5%	85.5%	85.7%	86.2%	86.6%	86.9%	87.2%
5,000				91.5%	91.4%	91.2%	90.8%	90.2%	89.7%	88.9%	88.0%	87.5%	86.6%	86.0%	85.3%	85.4%	85.8%	86.0%	85.9%	86.2%	86.7%	86.9%	87.3%	87.6%
6,000					91.5%	91.3%	90.9%	90.4%	89.8%	89.1%	88.2%	87.7%	86.8%	86.2%	85.5%	85.7%	86.0%	86.2%	86.2%	86.5%	87.0%	87.2%	87.6%	87.9%
7,000						91.4%	90.9%	90.4%	89.9%	89.2%	88.3%	87.7%	86.9%	86.3%	85.6%	85.8%	86.2%	86.4%	86.4%	86.6%	87.2%	87.4%	87.8%	88.2%
8,000							91.2%	90.7%	90.2%	89.5%	88.6%	88.1%	87.3%	86.7%	86.1%	86.3%	86.7%	87.0%	87.0%	87.3%	87.9%	88.2%	88.6%	89.1%
9,000								90.5%	90.0%	89.3%	88.4%	87.9%	87.2%	86.5%	85.9%	86.1%	86.5%	86.7%	86.8%	87.0%	87.6%	87.8%	88.3%	89.0%
10,000									90.3%	89.5%	88.7%	88.2%	87.5%	86.9%	86.3%	86.5%	86.9%	87.1%	87.2%	87.5%	88.1%	88.4%	88.9%	89.8%
11,000										89.5%	88.7%	88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
12,000											88.7%	88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
13,000												88.2%	87.4%	86.8%	86.3%	86.4%	86.9%	87.1%	87.2%	87.5%	88.1%	88.3%	88.8%	89.7%
14,000													87.5%	86.9%	86.4%	86.6%	87.0%	87.2%	87.3%	87.6%	88.3%	88.5%	89.0%	90.0%
15,000														87.0%	86.4%	86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
16,000															86.4%	86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
17,000																86.6%	87.0%	87.3%	87.3%	87.7%	88.3%	88.6%	89.0%	90.0%
18,000																	86.7%	86.9%	87.0%	87.3%	87.8%	88.1%	88.5%	89.4%
19,000																		86.8%	86.8%	87.1%	87.6%	87.8%	88.2%	89.1%
20,000																			86.8%	87.1%	87.6%	87.8%	88.2%	89.1%
21,000																				87.1%	87.6%	87.8%	88.2%	89.1%
22,000																					87.2%	87.4%	87.8%	88.5%
23,000																						87.9%	88.3%	89.1%
24,000																							88.6%	89.5%
25,000																								89.5%

Table 2.2-13: Adult Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.98	7.94	7.94	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.97	7.97	8.00	8.01	8.03	7.97	7.95	7.79
3,000		7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.86	7.86	7.86	7.86	7.86	7.84	7.85	7.88	7.89	7.91	7.85	7.83	7.67
4,000			7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.72	7.72	7.72	7.72	7.70	7.71	7.74	7.75	7.77	7.70	7.69	7.53
5,000				7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.54	7.54	7.57	7.58	7.60	7.54	7.52	7.37
6,000					7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.55	7.55	7.55	7.55	7.53	7.54	7.57	7.58	7.60	7.53	7.52	7.36
7,000						7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.52	7.52	7.55	7.56	7.58	7.52	7.50	7.34
8,000							7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.47	7.47	7.50	7.51	7.53	7.47	7.46	7.30
9,000								7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.75	7.76	7.79	7.80	7.82	7.76	7.74	7.58
10,000									7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
11,000										7.65	7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
12,000											7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
13,000												7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
14,000													7.61	7.62	7.62	7.62	7.60	7.61	7.64	7.65	7.66	7.60	7.59	7.43
15,000														7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
16,000															7.64	7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
17,000																7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
18,000																	7.93	7.94	7.97	7.98	8.00	7.93	7.92	7.76
19,000																		8.11	8.14	8.15	8.16	8.10	8.09	7.93
20,000																			8.14	8.15	8.16	8.10	8.09	7.93
21,000																				8.15	8.16	8.10	8.09	7.93
22,000																					8.44	8.38	8.37	8.21
23,000																						8.20	8.19	8.03
24,000																							8.08	7.92
25,000																								7.92

Table 2.2-14: Adult Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.7%	90.6%	90.7%	90.7%	90.7%
3,000		91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.0%	91.0%	90.9%	91.0%	91.0%	91.0%
4,000			91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.3%	91.3%	91.3%	91.3%	91.3%	91.3%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%
5,000				91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.5%	91.4%	91.5%	91.5%	91.5%
6,000					91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
7,000						91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.6%	91.6%	91.6%	91.7%
8,000							92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
9,000								91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.7%	91.7%	91.7%
10,000									92.1%	92.1%	92.1%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
11,000										92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
12,000											92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
13,000												92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
14,000													92.1%	92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
15,000														92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
16,000															92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
17,000																92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
18,000																	91.8%	91.8%	91.7%	91.7%	91.7%	91.7%	91.7%	91.8%
19,000																		91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
20,000																			91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
21,000																				91.6%	91.5%	91.6%	91.6%	91.6%
22,000																					91.3%	91.3%	91.3%	91.4%
23,000																						91.6%	91.6%	91.6%
24,000																							91.7%	91.7%
25,000																								91.7%

Table 2.2-15: Adult Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.98	7.94	7.94	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.97	7.97	8.00	8.01	8.03	7.97	7.95	7.79
3,000		7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.86	7.86	7.86	7.86	7.86	7.84	7.85	7.88	7.89	7.91	7.85	7.83	7.67
4,000			7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.72	7.72	7.72	7.72	7.70	7.71	7.74	7.75	7.77	7.70	7.69	7.53
5,000				7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.54	7.54	7.57	7.58	7.60	7.54	7.52	7.37
6,000					7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.55	7.55	7.55	7.55	7.53	7.54	7.57	7.58	7.60	7.53	7.52	7.36
7,000						7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.52	7.52	7.55	7.56	7.58	7.52	7.50	7.34
8,000							7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.47	7.47	7.50	7.51	7.53	7.47	7.46	7.30
9,000								7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.75	7.76	7.79	7.80	7.82	7.76	7.74	7.58
10,000									7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
11,000										7.65	7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
12,000											7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
13,000												7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
14,000													7.61	7.62	7.62	7.62	7.60	7.61	7.64	7.65	7.66	7.60	7.59	7.43
15,000														7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
16,000															7.64	7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
17,000																7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
18,000																	7.93	7.94	7.97	7.98	8.00	7.93	7.92	7.76
19,000																		8.11	8.14	8.15	8.16	8.10	8.09	7.93
20,000																			8.14	8.15	8.16	8.10	8.09	7.93
21,000																				8.15	8.16	8.10	8.09	7.93
22,000																					8.44	8.38	8.37	8.21
23,000																						8.20	8.19	8.03
24,000																							8.08	7.92
25,000																								7.92

Table 2.2-16: Adult Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.7%	90.6%	90.7%	90.7%	90.7%
3,000		91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.0%	91.0%	90.9%	91.0%	91.0%	91.0%
4,000			91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.3%	91.3%	91.3%	91.3%	91.3%	91.3%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%
5,000				91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.5%	91.4%	91.5%	91.5%	91.5%
6,000					91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
7,000						91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.6%	91.6%	91.6%	91.7%
8,000							92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
9,000								91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.7%	91.7%	91.7%
10,000									92.1%	92.1%	92.1%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
11,000										92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
12,000											92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
13,000												92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
14,000													92.1%	92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
15,000														92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
16,000															92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
17,000																92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
18,000																	91.8%	91.8%	91.7%	91.7%	91.7%	91.7%	91.7%	91.8%
19,000																		91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
20,000																			91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
21,000																				91.6%	91.5%	91.6%	91.6%	91.6%
22,000																					91.3%	91.3%	91.3%	91.4%
23,000																						91.6%	91.6%	91.6%
24,000																							91.7%	91.7%
25,000																								91.7%

Table 2.2-17: Adult Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.98	7.94	7.94	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.97	7.97	8.00	8.01	8.03	7.97	7.95	7.79
3,000		7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.86	7.86	7.86	7.86	7.86	7.84	7.85	7.88	7.89	7.91	7.85	7.83	7.67
4,000			7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.72	7.72	7.72	7.72	7.70	7.71	7.74	7.75	7.77	7.70	7.69	7.53
5,000				7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.54	7.54	7.57	7.58	7.60	7.54	7.52	7.37
6,000					7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.55	7.55	7.55	7.55	7.53	7.54	7.57	7.58	7.60	7.53	7.52	7.36
7,000						7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.52	7.52	7.55	7.56	7.58	7.52	7.50	7.34
8,000							7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.47	7.47	7.50	7.51	7.53	7.47	7.46	7.30
9,000								7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.75	7.76	7.79	7.80	7.82	7.76	7.74	7.58
10,000									7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
11,000										7.65	7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
12,000											7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
13,000												7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
14,000													7.61	7.62	7.62	7.62	7.60	7.61	7.64	7.65	7.66	7.60	7.59	7.43
15,000														7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
16,000															7.64	7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
17,000																7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
18,000																	7.93	7.94	7.97	7.98	8.00	7.93	7.92	7.76
19,000																		8.11	8.14	8.15	8.16	8.10	8.09	7.93
20,000																			8.14	8.15	8.16	8.10	8.09	7.93
21,000																				8.15	8.16	8.10	8.09	7.93
22,000																					8.44	8.38	8.37	8.21
23,000																						8.20	8.19	8.03
24,000																							8.08	7.92
25,000																								7.92

Table 2.2-18: Adult Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.7%	90.6%	90.7%	90.7%	90.7%
3,000		91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.0%	91.0%	90.9%	91.0%	91.0%	91.0%
4,000			91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.3%	91.3%	91.3%	91.3%	91.3%	91.3%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%
5,000				91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.5%	91.4%	91.5%	91.5%	91.5%
6,000					91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
7,000						91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.6%	91.6%	91.6%	91.7%
8,000							92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
9,000								91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.7%	91.7%	91.7%
10,000									92.1%	92.1%	92.1%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
11,000										92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
12,000											92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
13,000												92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
14,000													92.1%	92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
15,000														92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
16,000															92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
17,000																92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
18,000																	91.8%	91.8%	91.7%	91.7%	91.7%	91.7%	91.7%	91.8%
19,000																		91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
20,000																			91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
21,000																				91.6%	91.5%	91.6%	91.6%	91.6%
22,000																					91.3%	91.3%	91.3%	91.4%
23,000																						91.6%	91.6%	91.6%
24,000																							91.7%	91.7%
25,000																								91.7%

Table 2.2-19: Adult Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.98	7.94	7.94	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.97	7.97	8.00	8.01	8.03	7.97	7.95	7.79
3,000		7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.86	7.86	7.86	7.86	7.86	7.84	7.85	7.88	7.89	7.91	7.85	7.83	7.67
4,000			7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.72	7.72	7.72	7.72	7.70	7.71	7.74	7.75	7.77	7.70	7.69	7.53
5,000				7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.55	7.54	7.54	7.57	7.58	7.60	7.54	7.52	7.37
6,000					7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.54	7.55	7.55	7.55	7.55	7.53	7.54	7.57	7.58	7.60	7.53	7.52	7.36
7,000						7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.53	7.52	7.52	7.55	7.56	7.58	7.52	7.50	7.34
8,000							7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.48	7.47	7.47	7.50	7.51	7.53	7.47	7.46	7.30
9,000								7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.75	7.76	7.79	7.80	7.82	7.76	7.74	7.58
10,000									7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
11,000										7.65	7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
12,000											7.65	7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
13,000												7.65	7.66	7.66	7.66	7.66	7.64	7.65	7.68	7.69	7.71	7.64	7.63	7.47
14,000													7.61	7.62	7.62	7.62	7.60	7.61	7.64	7.65	7.66	7.60	7.59	7.43
15,000														7.61	7.61	7.62	7.60	7.60	7.63	7.64	7.66	7.60	7.59	7.43
16,000															7.64	7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
17,000																7.64	7.63	7.63	7.66	7.67	7.69	7.63	7.61	7.45
18,000																	7.93	7.94	7.97	7.98	8.00	7.93	7.92	7.76
19,000																		8.11	8.14	8.15	8.16	8.10	8.09	7.93
20,000																			8.14	8.15	8.16	8.10	8.09	7.93
21,000																				8.15	8.16	8.10	8.09	7.93
22,000																					8.44	8.38	8.37	8.21
23,000																						8.20	8.19	8.03
24,000																							8.08	7.92
25,000																								7.92

Table 2.2-20: Adult Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.9%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.7%	90.6%	90.7%	90.7%	90.7%
3,000		91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%	91.1%	91.1%	91.1%	91.1%	91.1%	91.1%	91.0%	91.0%	90.9%	91.0%	91.0%	91.0%
4,000			91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.4%	91.3%	91.3%	91.3%	91.3%	91.3%	91.3%	91.2%	91.2%	91.2%	91.2%	91.2%	91.2%
5,000				91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.5%	91.4%	91.5%	91.5%	91.5%
6,000					91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
7,000						91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.6%	91.6%	91.6%	91.7%
8,000							92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
9,000								91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.8%	91.7%	91.7%	91.6%	91.7%	91.7%	91.7%
10,000									92.1%	92.1%	92.1%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
11,000										92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
12,000											92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
13,000												92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	92.0%	91.9%	91.9%	91.8%	91.9%	91.9%	91.9%
14,000													92.1%	92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
15,000														92.1%	92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
16,000															92.1%	92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
17,000																92.1%	92.1%	92.0%	92.0%	91.9%	91.9%	91.9%	91.9%	92.0%
18,000																	91.8%	91.8%	91.7%	91.7%	91.7%	91.7%	91.7%	91.8%
19,000																		91.7%	91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
20,000																			91.6%	91.6%	91.5%	91.6%	91.6%	91.6%
21,000																				91.6%	91.5%	91.6%	91.6%	91.6%
22,000																					91.3%	91.3%	91.3%	91.4%
23,000																						91.6%	91.6%	91.6%
24,000																							91.7%	91.7%
25,000																								91.7%

Table 2.2-21: Adult Eastern Pondmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.94	7.91	7.91	7.95	7.96	8.00	8.14	8.39	8.68	9.00	9.18	9.40	9.52	9.65	9.46	8.82	7.85	7.19	6.70	6.01	5.25	4.75	4.19	3.73
3,000		7.82	7.82	7.83	7.83	7.88	8.02	8.27	8.56	8.88	9.06	9.28	9.40	9.53	9.36	8.73	7.75	7.10	6.61	5.92	5.12	4.63	4.06	3.57
4,000			7.68	7.69	7.69	7.73	7.87	8.13	8.42	8.74	8.92	9.14	9.26	9.39	9.24	8.61	7.64	7.00	6.52	5.87	5.10	4.60	4.04	3.55
5,000				7.55	7.56	7.60	7.74	7.99	8.29	8.61	8.79	9.01	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.04	4.60	4.03	3.54
6,000					7.56	7.60	7.74	7.99	8.28	8.60	8.78	9.00	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.03	4.60	4.03	3.54
7,000						7.58	7.72	7.97	8.27	8.59	8.76	8.98	9.11	9.24	9.12	8.48	7.51	6.88	6.41	5.78	5.01	4.57	4.01	3.52
8,000							7.67	7.92	8.22	8.54	8.72	8.94	9.06	9.19	9.07	8.43	7.46	6.83	6.36	5.73	4.96	4.52	3.96	3.47
9,000								8.21	8.50	8.83	9.00	9.22	9.35	9.48	9.35	8.72	7.75	7.11	6.65	6.02	5.24	4.81	4.23	3.54
10,000									8.35	8.67	8.85	9.07	9.19	9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
11,000										8.71	8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
12,000											8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
13,000												9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
14,000													9.19	9.33	9.20	8.57	7.59	6.96	6.50	5.86	5.09	4.65	4.08	3.32
15,000														9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
16,000															9.23	8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
17,000																8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
18,000																	7.93	7.29	6.83	6.20	5.42	4.99	4.41	3.65
19,000																		7.46	7.00	6.36	5.59	5.15	4.58	3.82
20,000																			7.00	6.36	5.59	5.15	4.58	3.82
21,000																				6.36	5.59	5.15	4.58	3.82
22,000																					5.87	5.43	4.86	4.10
23,000																						5.25	4.68	3.91
24,000																							4.57	3.81
25,000																								3.81

Table 2.2-22: Adult Eastern Pondmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.8%	90.7%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.9%	86.1%	85.6%	85.7%	86.1%	86.3%	86.1%	86.3%	86.7%	87.0%	87.4%	87.4%
3,000		91.2%	91.2%	91.1%	91.1%	91.0%	90.7%	90.2%	89.7%	89.1%	88.6%	88.0%	87.3%	86.6%	86.0%	86.1%	86.5%	86.7%	86.6%	86.9%	87.3%	87.6%	88.1%	88.2%
4,000			91.4%	91.4%	91.3%	91.2%	90.9%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.8%	86.3%	86.4%	86.8%	87.0%	86.9%	87.0%	87.5%	87.7%	88.2%	88.3%
5,000				91.6%	91.6%	91.4%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.2%	86.7%	86.8%	87.3%	87.4%	87.3%	87.4%	87.9%	88.0%	88.5%	88.6%
6,000					91.7%	91.6%	91.3%	90.8%	90.4%	89.8%	89.3%	88.7%	88.1%	87.4%	86.9%	87.0%	87.5%	87.7%	87.5%	87.7%	88.2%	88.3%	88.8%	89.0%
7,000						91.6%	91.3%	90.9%	90.4%	89.9%	89.3%	88.8%	88.2%	87.5%	87.0%	87.1%	87.6%	87.8%	87.7%	87.9%	88.4%	88.5%	89.0%	89.2%
8,000							91.6%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.4%	87.6%	88.1%	88.3%	88.2%	88.5%	89.0%	89.2%	89.7%	90.0%
9,000								91.0%	90.5%	90.0%	89.5%	89.0%	88.4%	87.7%	87.2%	87.4%	87.8%	88.1%	88.0%	88.2%	88.7%	88.8%	89.3%	89.9%
10,000									90.8%	90.2%	89.7%	89.2%	88.7%	88.0%	87.5%	87.7%	88.2%	88.4%	88.4%	88.6%	89.2%	89.3%	89.9%	90.7%
11,000										90.2%	89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
12,000											89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
13,000												89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
14,000													88.7%	88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
15,000														88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
16,000															87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
17,000																87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
18,000																	88.0%	88.2%	88.1%	88.4%	88.8%	89.0%	89.5%	90.2%
19,000																		88.0%	88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
20,000																			88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
21,000																				88.1%	88.6%	88.8%	89.2%	89.9%
22,000																					88.2%	88.3%	88.8%	89.4%
23,000																						88.8%	89.3%	90.0%
24,000																							89.6%	90.3%
25,000																								90.3%

Table 2.2-23: Adult Eastern Pondmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	7.94	7.91	7.91	7.95	7.96	8.00	8.14	8.39	8.68	9.00	9.18	9.40	9.52	9.65	9.46	8.82	7.85	7.19	6.70	6.01	5.25	4.75	4.19	3.73
3,000		7.82	7.82	7.83	7.83	7.88	8.02	8.27	8.56	8.88	9.06	9.28	9.40	9.53	9.36	8.73	7.75	7.10	6.61	5.92	5.12	4.63	4.06	3.57
4,000			7.68	7.69	7.69	7.73	7.87	8.13	8.42	8.74	8.92	9.14	9.26	9.39	9.24	8.61	7.64	7.00	6.52	5.87	5.10	4.60	4.04	3.55
5,000				7.55	7.56	7.60	7.74	7.99	8.29	8.61	8.79	9.01	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.04	4.60	4.03	3.54
6,000					7.56	7.60	7.74	7.99	8.28	8.60	8.78	9.00	9.13	9.26	9.13	8.50	7.53	6.89	6.43	5.81	5.03	4.60	4.03	3.54
7,000						7.58	7.72	7.97	8.27	8.59	8.76	8.98	9.11	9.24	9.12	8.48	7.51	6.88	6.41	5.78	5.01	4.57	4.01	3.52
8,000							7.67	7.92	8.22	8.54	8.72	8.94	9.06	9.19	9.07	8.43	7.46	6.83	6.36	5.73	4.96	4.52	3.96	3.47
9,000								8.21	8.50	8.83	9.00	9.22	9.35	9.48	9.35	8.72	7.75	7.11	6.65	6.02	5.24	4.81	4.23	3.54
10,000									8.35	8.67	8.85	9.07	9.19	9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
11,000										8.71	8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
12,000											8.89	9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
13,000												9.11	9.24	9.37	9.24	8.61	7.64	7.00	6.54	5.90	5.13	4.69	4.12	3.36
14,000													9.19	9.33	9.20	8.57	7.59	6.96	6.50	5.86	5.09	4.65	4.08	3.32
15,000														9.32	9.20	8.56	7.59	6.96	6.49	5.86	5.09	4.65	4.08	3.31
16,000															9.23	8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
17,000																8.59	7.62	6.99	6.52	5.89	5.12	4.68	4.10	3.34
18,000																	7.93	7.29	6.83	6.20	5.42	4.99	4.41	3.65
19,000																		7.46	7.00	6.36	5.59	5.15	4.58	3.82
20,000																			7.00	6.36	5.59	5.15	4.58	3.82
21,000																				6.36	5.59	5.15	4.58	3.82
22,000																					5.87	5.43	4.86	4.10
23,000																						5.25	4.68	3.91
24,000																							4.57	3.81
25,000																								3.81

Table 2.2-24: Adult Eastern Pondmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Comparison Between Final Reach Lengths and Study Plan Reach Lengths (%), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	90.9%	90.9%	90.9%	90.9%	90.8%	90.7%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.9%	86.1%	85.6%	85.7%	86.1%	86.3%	86.1%	86.3%	86.7%	87.0%	87.4%	87.4%
3,000		91.2%	91.2%	91.1%	91.1%	91.0%	90.7%	90.2%	89.7%	89.1%	88.6%	88.0%	87.3%	86.6%	86.0%	86.1%	86.5%	86.7%	86.6%	86.9%	87.3%	87.6%	88.1%	88.2%
4,000			91.4%	91.4%	91.3%	91.2%	90.9%	90.4%	89.9%	89.4%	88.8%	88.2%	87.6%	86.8%	86.3%	86.4%	86.8%	87.0%	86.9%	87.0%	87.5%	87.7%	88.2%	88.3%
5,000				91.6%	91.6%	91.4%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.2%	86.7%	86.8%	87.3%	87.4%	87.3%	87.4%	87.9%	88.0%	88.5%	88.6%
6,000					91.7%	91.6%	91.3%	90.8%	90.4%	89.8%	89.3%	88.7%	88.1%	87.4%	86.9%	87.0%	87.5%	87.7%	87.5%	87.7%	88.2%	88.3%	88.8%	89.0%
7,000						91.6%	91.3%	90.9%	90.4%	89.9%	89.3%	88.8%	88.2%	87.5%	87.0%	87.1%	87.6%	87.8%	87.7%	87.9%	88.4%	88.5%	89.0%	89.2%
8,000							91.6%	91.2%	90.7%	90.2%	89.7%	89.1%	88.6%	87.9%	87.4%	87.6%	88.1%	88.3%	88.2%	88.5%	89.0%	89.2%	89.7%	90.0%
9,000								91.0%	90.5%	90.0%	89.5%	89.0%	88.4%	87.7%	87.2%	87.4%	87.8%	88.1%	88.0%	88.2%	88.7%	88.8%	89.3%	89.9%
10,000									90.8%	90.2%	89.7%	89.2%	88.7%	88.0%	87.5%	87.7%	88.2%	88.4%	88.4%	88.6%	89.2%	89.3%	89.9%	90.7%
11,000										90.2%	89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
12,000											89.7%	89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
13,000												89.2%	88.6%	88.0%	87.5%	87.7%	88.2%	88.4%	88.3%	88.6%	89.1%	89.3%	89.8%	90.6%
14,000													88.7%	88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
15,000														88.1%	87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
16,000															87.6%	87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
17,000																87.8%	88.3%	88.5%	88.5%	88.7%	89.3%	89.5%	90.0%	90.8%
18,000																	88.0%	88.2%	88.1%	88.4%	88.8%	89.0%	89.5%	90.2%
19,000																		88.0%	88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
20,000																			88.0%	88.1%	88.6%	88.8%	89.2%	89.9%
21,000																				88.1%	88.6%	88.8%	89.2%	89.9%
22,000																					88.2%	88.3%	88.8%	89.4%
23,000																						88.8%	89.3%	90.0%
24,000																							89.6%	90.3%
25,000																								90.3%

APPENDIX C – WUA FIGURES

Figure 4.1-1: Reach 5 Total WUA Curves (3 Variable CSI, Low Boundary Conditions) for the Adult and Juvenile Yellow Lampmussel

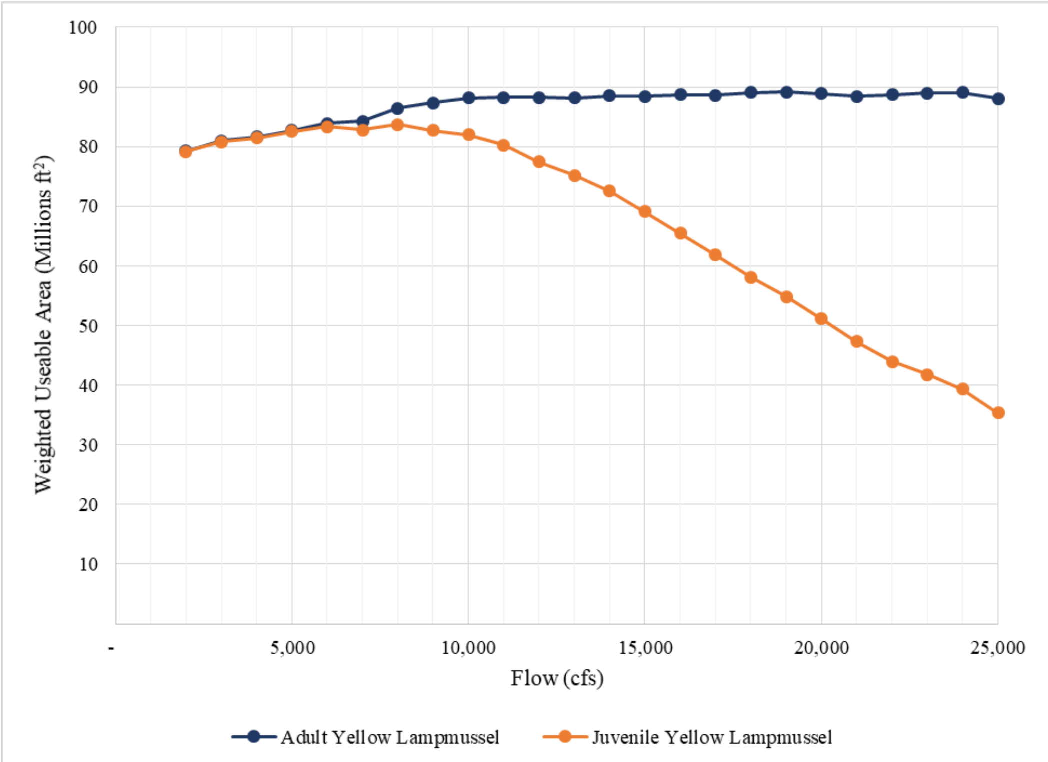


Figure 4.1-2: Reach 5 Total WUA Curves (4 Variable CSI, Low Boundary Conditions) for the Adult and Juvenile Yellow Lampmussel

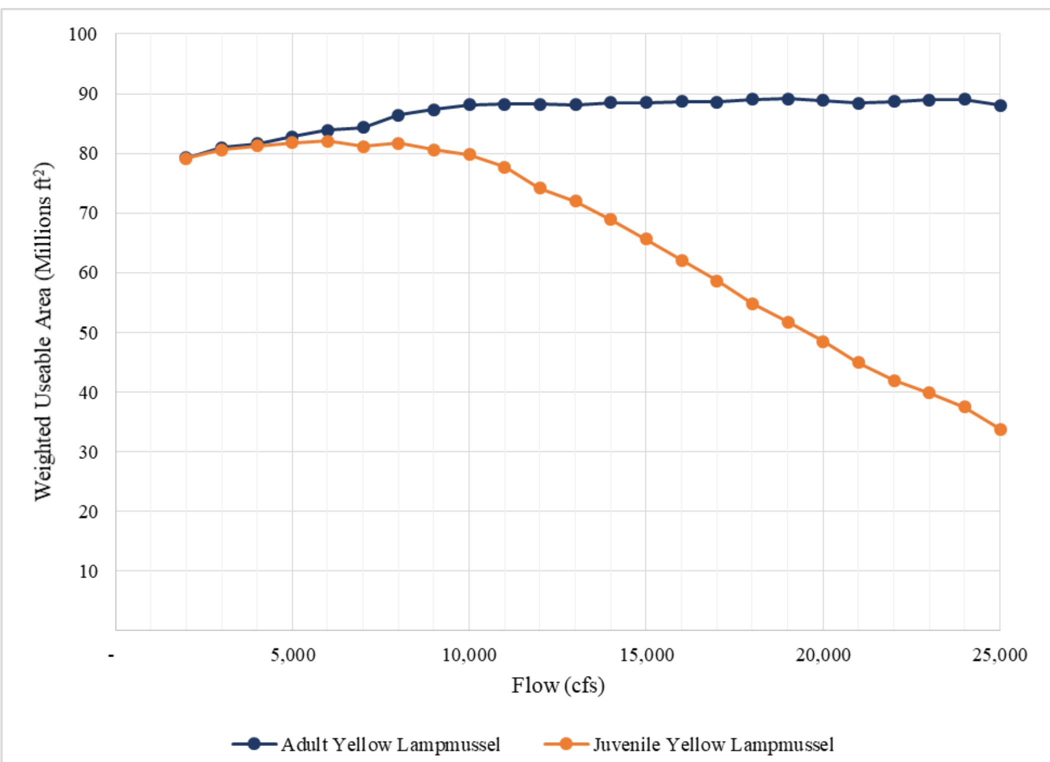


Figure 4.1-3: Reach 5 Total WUA Curves (3 Variable CSI, High Boundary Conditions) for the Adult and Juvenile Yellow Lampmussel

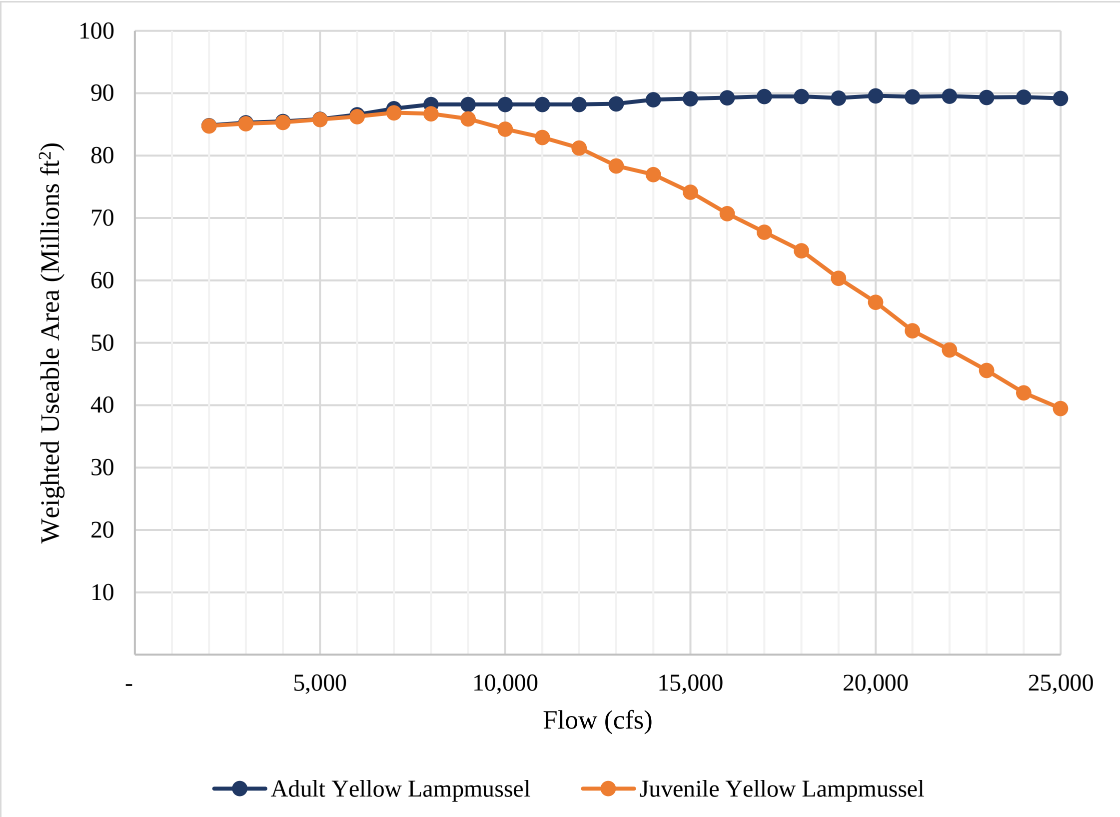


Figure 4.1-4: Reach 5 Total WUA Curves (4 Variable CSI, High Boundary Conditions) for the Adult and Juvenile Yellow Lampmussel

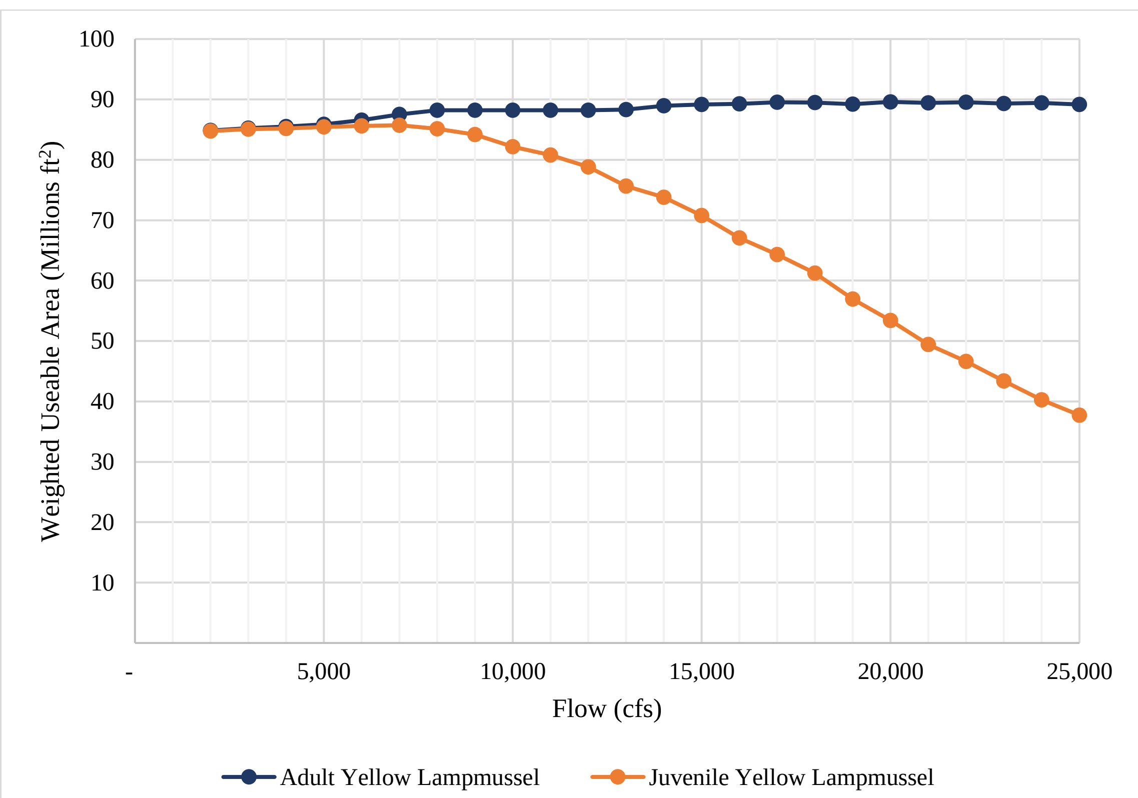


Figure 4.1-5: Reach 5 Total WUA Curves (3 Variable CSI, Low Boundary Conditions) for the Adult and Juvenile Tidewater Mucket

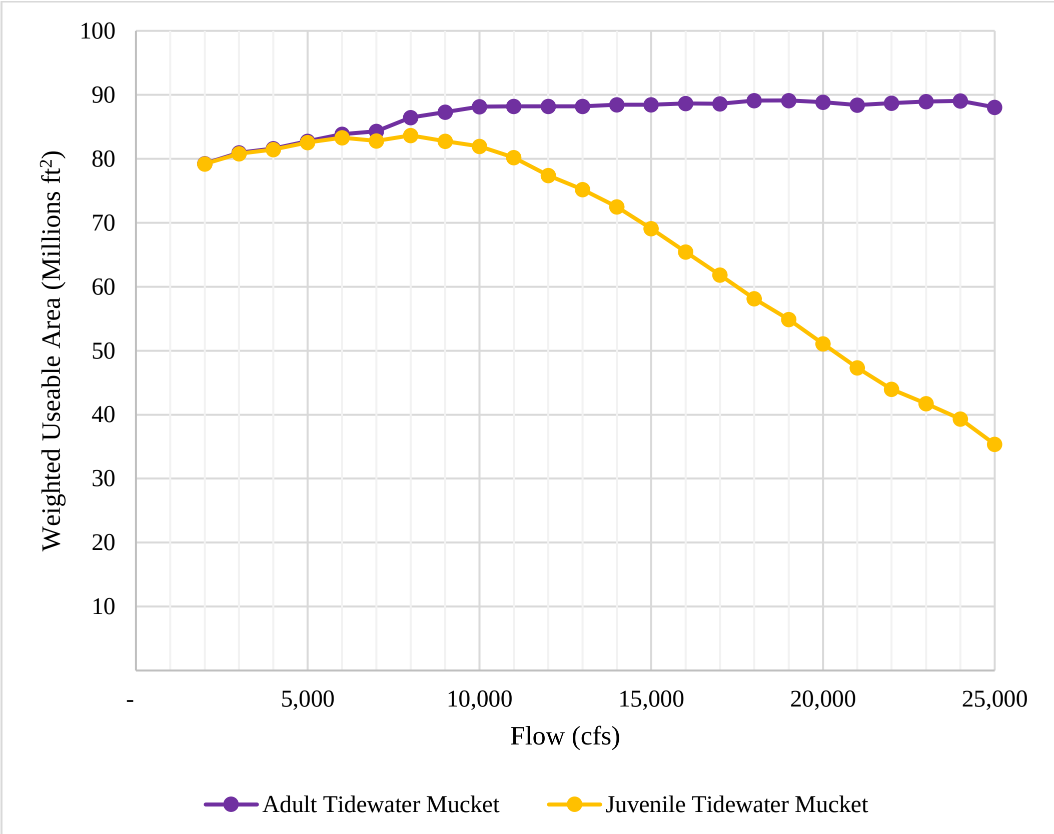


Figure 4.1-6: Reach 5 Total WUA Curves (4 Variable CSI, Low Boundary Conditions) for the Adult and Juvenile Tidewater Mucket

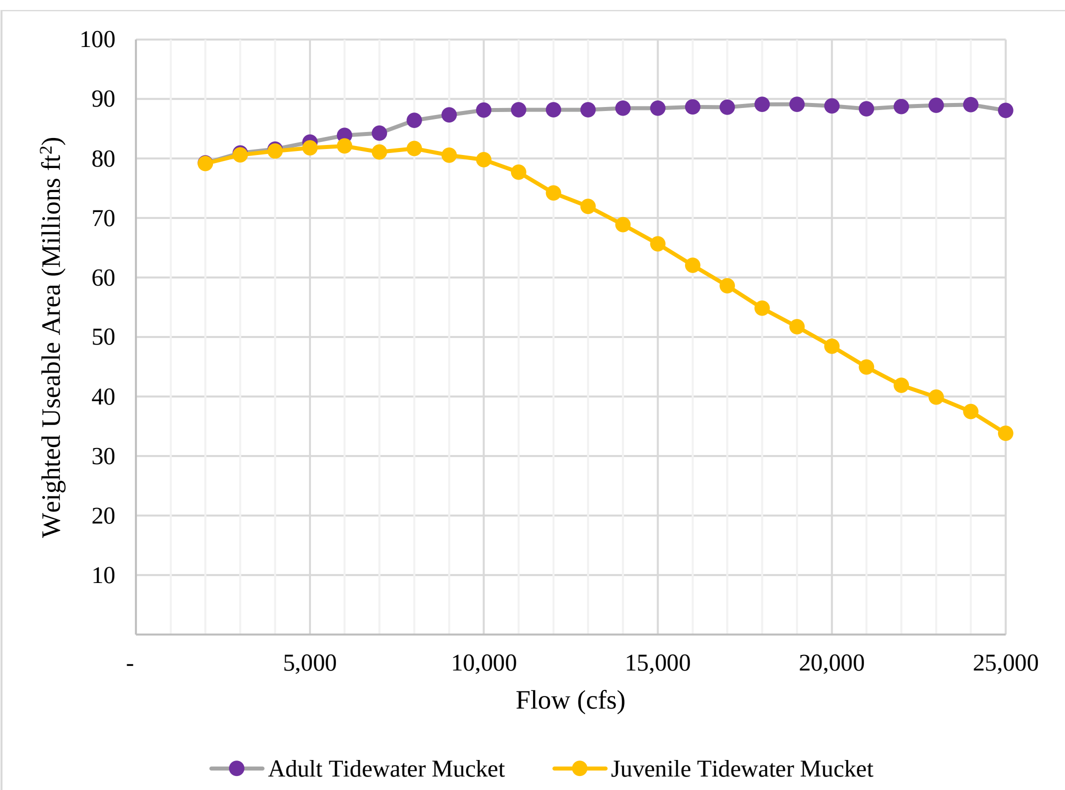


Figure 4.1-7: Reach 5 Total WUA Curves (3 Variable CSI, High Boundary Conditions) for the Adult and Juvenile Tidewater Mucket

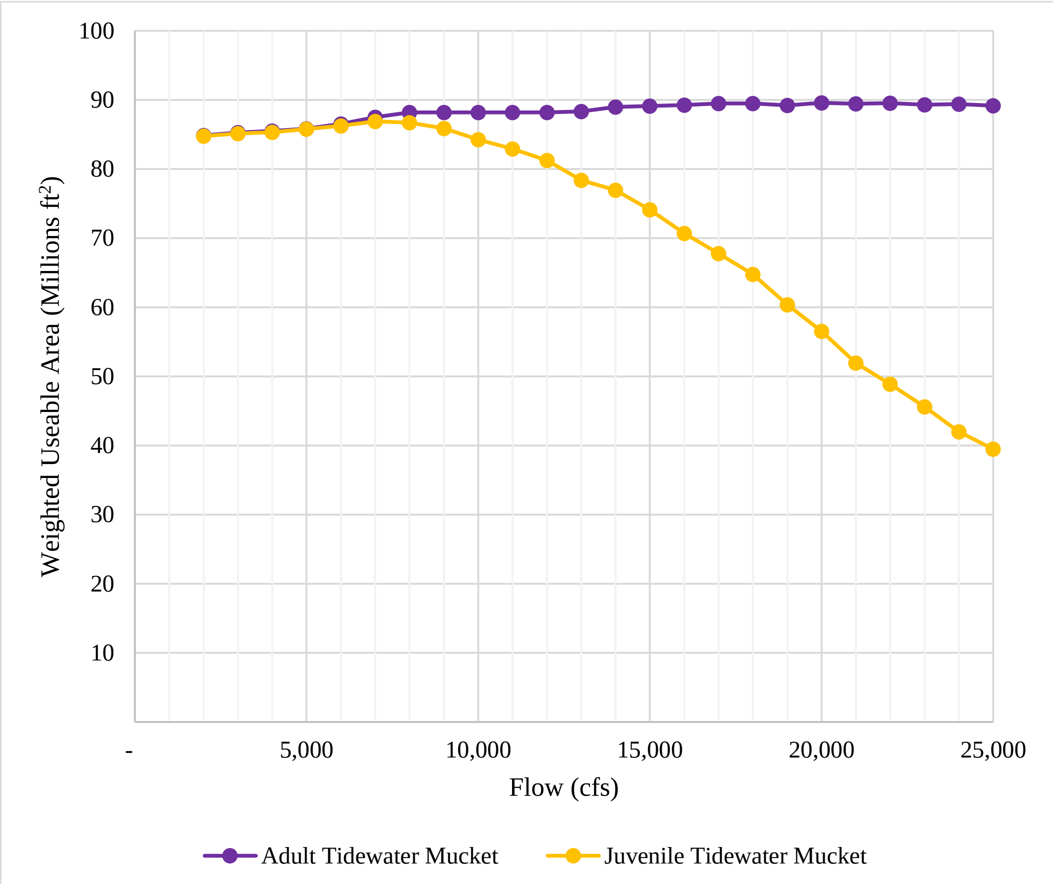


Figure 4.1-8: Reach 5 Total WUA Curves (4 Variable CSI, High Boundary Conditions) for the Adult and Juvenile Tidewater Mucket

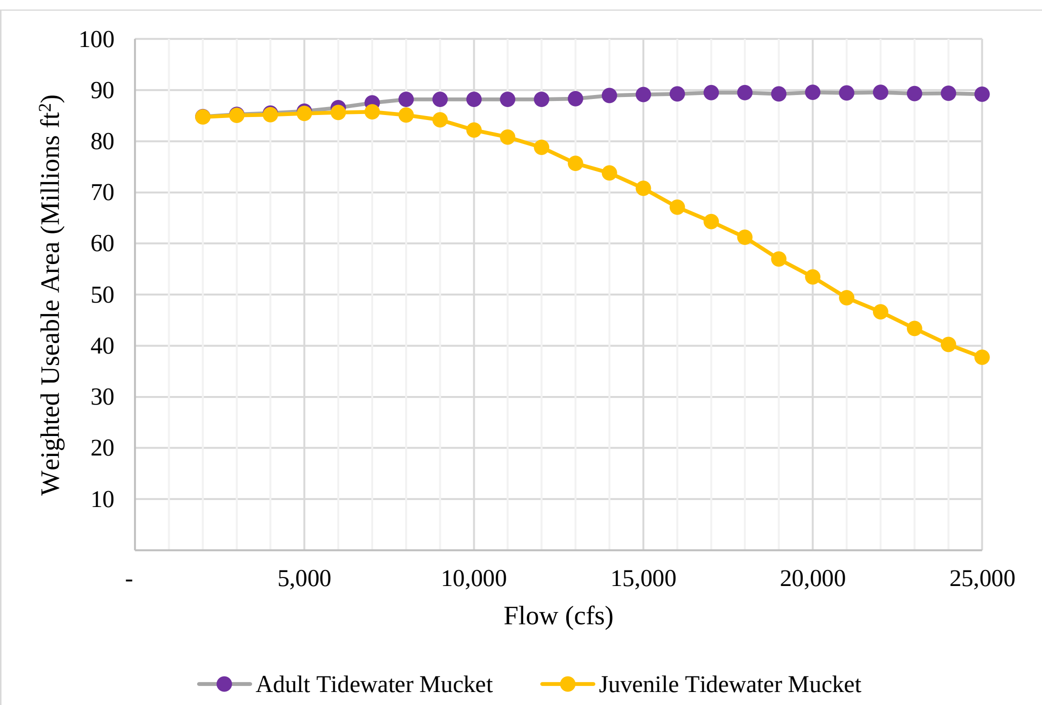


Figure 4.1-9: Reach 5 Total WUA Curves (3 Variable CSI, Low Boundary Conditions) for the Adult and Juvenile Eastern Pondmussel

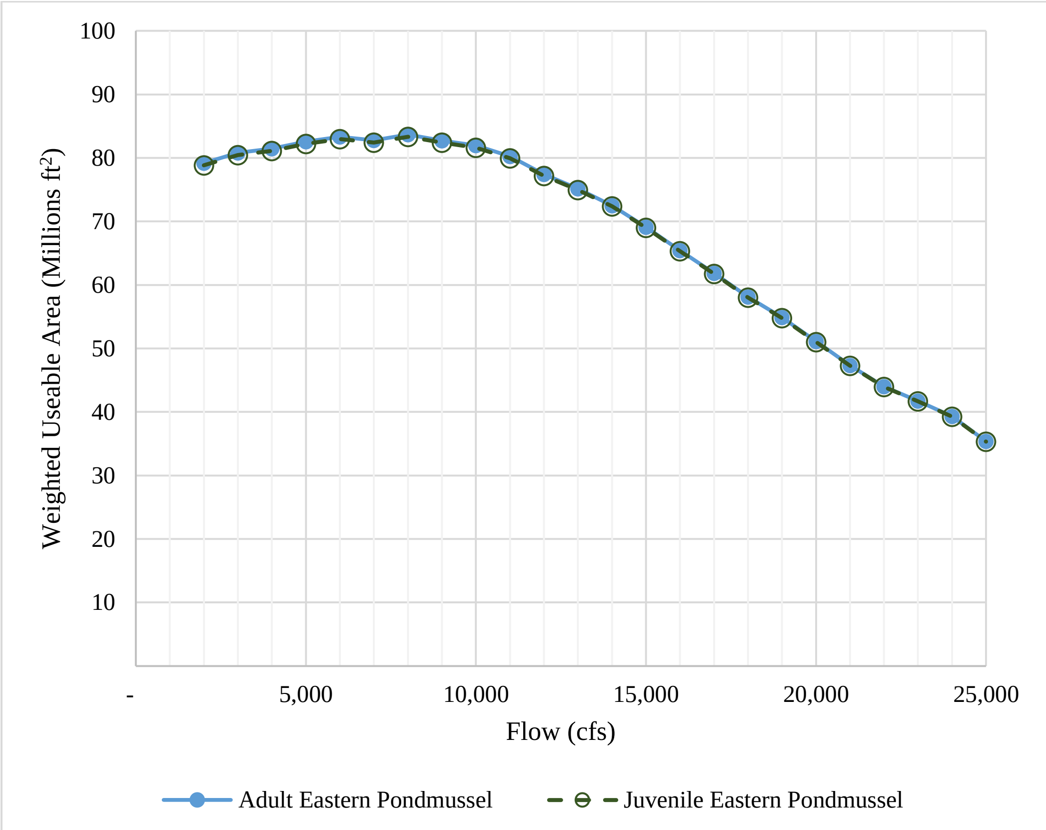


Figure 4.1-10: Reach 5 Total WUA Curves (4 Variable CSI, Low Boundary Conditions) for the Adult and Juvenile Eastern Pondmussel

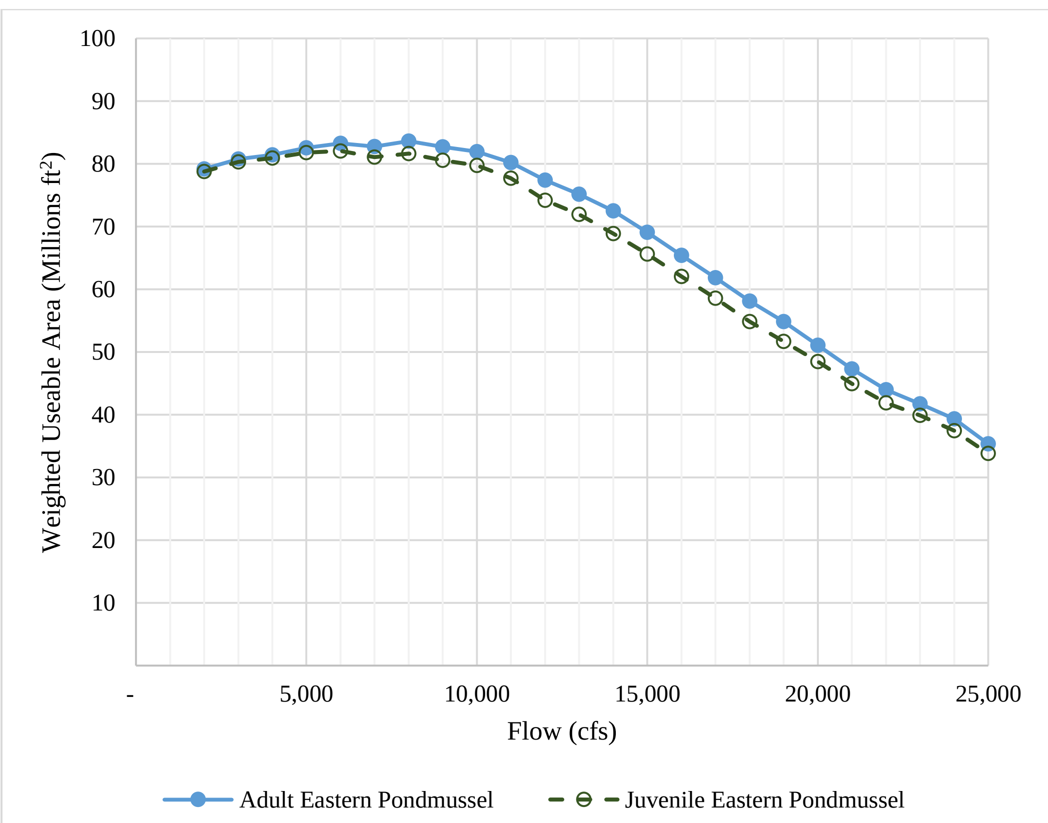


Figure 4.1-11: Reach 5 Total WUA Curves (3 Variable CSI, High Boundary Conditions) for the Adult and Juvenile Eastern Pondmussel

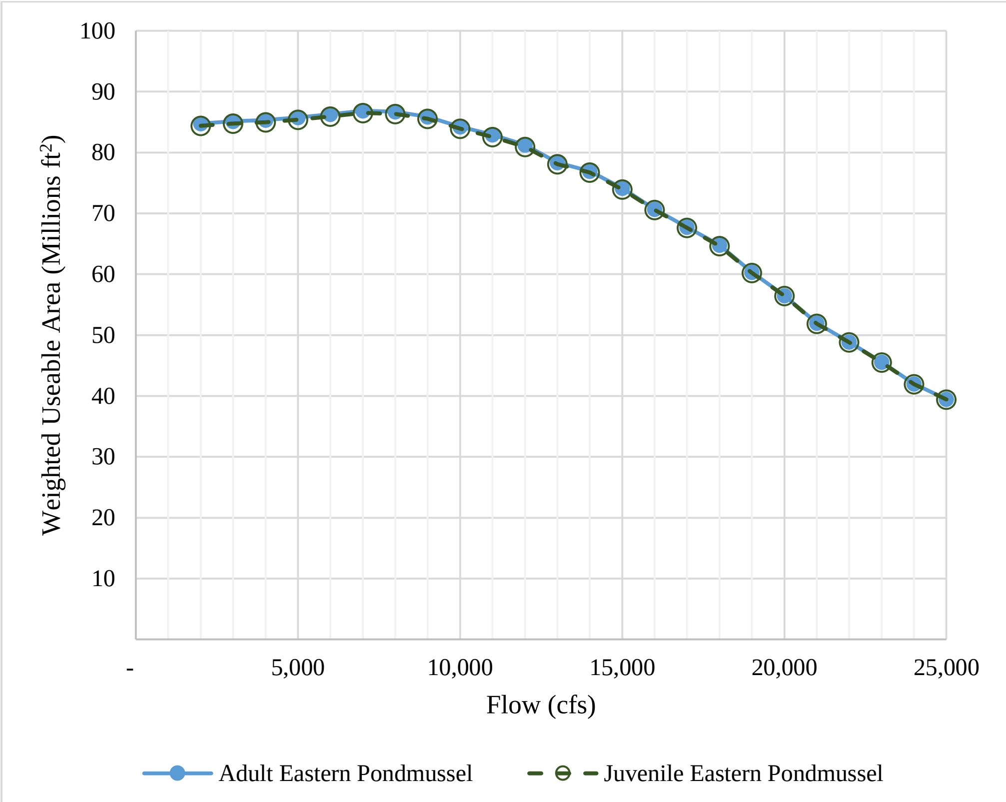


Figure 4.1-12: Reach 5 Total WUA Curves (4 Variable CSI, High Boundary Conditions) for the Adult and Juvenile Eastern Pondmussel

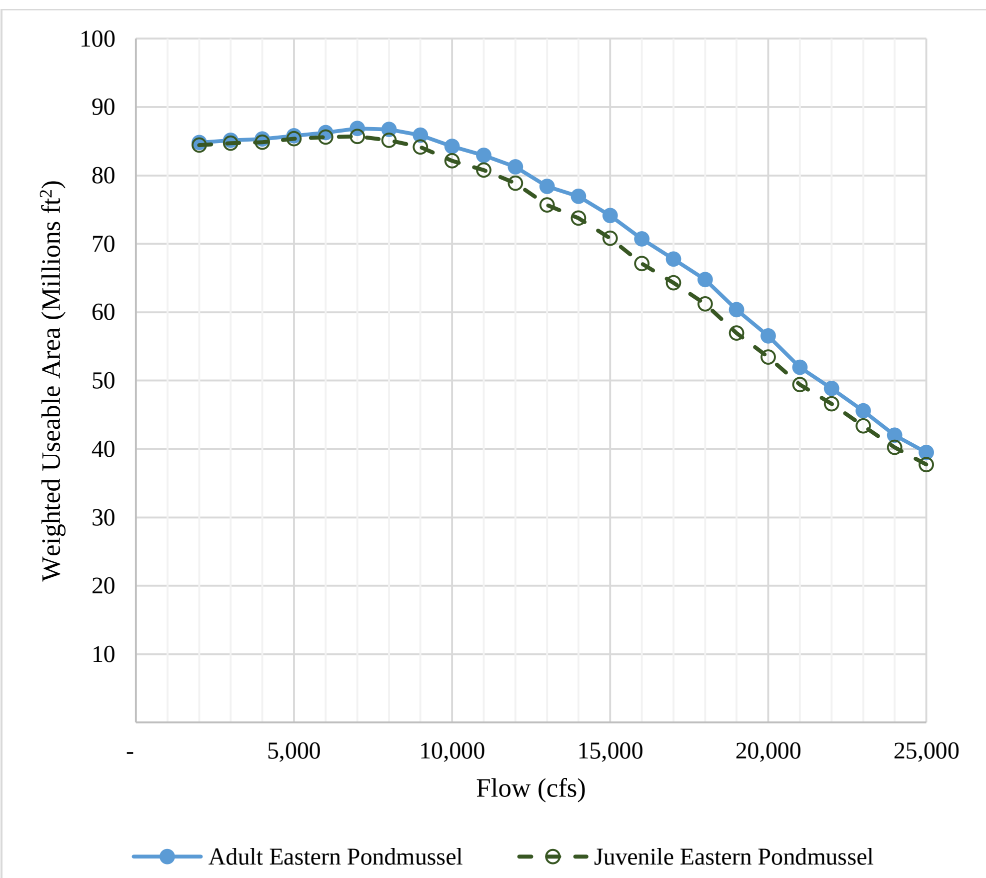


Figure 4.1-13: Reach 5 Total WUA Curves (3 Variable CSI, Low Boundary Conditions) Based on Guild

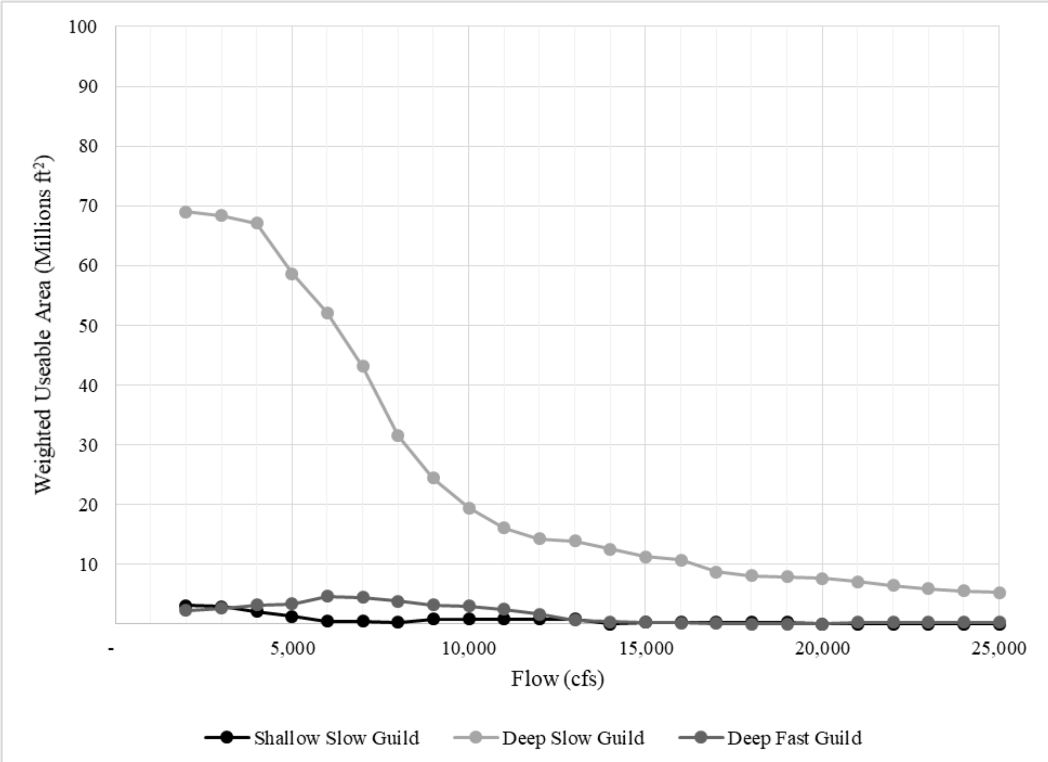
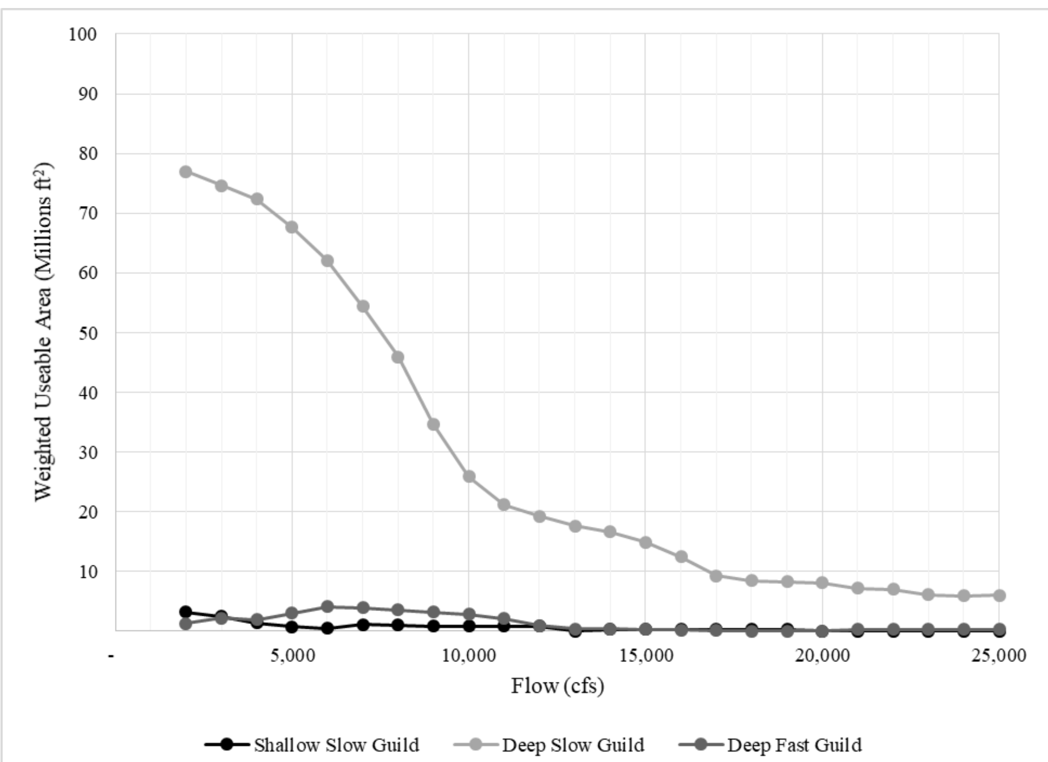


Figure 4.1-14: Reach 5 Total WUA Curves (3 Variable CSI, High Boundary Conditions) Based on Guild



APPENDIX D – DUAL FLOW ANALYSIS TABLES

Table 4.2-1: Juvenile Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.19	79.03	79.03	78.99	78.62	77.68	76.41	74.62	73.04	71.23	68.44	66.25	63.26	59.88	56.30	52.78	48.47	45.11	41.46	37.95	34.34	31.73	29.13	25.80
3,000		80.79	80.79	80.60	80.25	79.31	78.06	76.29	74.69	72.87	70.07	67.85	64.81	61.35	57.71	54.15	49.83	46.35	42.66	39.12	35.37	32.74	30.09	26.69
4,000			81.43	81.24	80.89	79.95	78.70	76.94	75.33	73.52	70.71	68.49	65.43	61.97	58.26	54.69	50.38	46.83	43.11	39.44	35.57	32.93	30.28	26.89
5,000				82.55	82.17	81.24	79.96	78.18	76.57	74.75	71.95	69.71	66.64	63.19	59.41	55.84	51.52	47.98	44.19	40.45	36.58	33.77	31.12	27.67
6,000					83.30	82.36	81.09	79.30	77.70	75.88	73.07	70.83	67.77	64.31	60.41	56.84	52.53	48.98	45.19	41.45	37.58	34.77	32.06	28.62
7,000						82.78	81.50	79.71	78.11	76.29	73.49	71.25	68.18	64.73	60.83	57.26	52.94	49.40	45.60	41.84	37.97	35.16	32.45	29.01
8,000							83.65	81.87	80.27	78.45	75.64	73.40	70.34	66.88	62.98	59.41	55.09	51.55	47.76	44.00	40.13	37.32	34.61	31.16
9,000								82.74	81.14	79.32	76.51	74.27	71.21	67.75	63.85	60.28	55.97	52.42	48.63	44.87	41.00	38.19	35.46	31.64
10,000									81.96	80.14	77.33	75.09	72.03	68.57	64.67	61.10	56.79	53.24	49.45	45.69	41.82	39.01	36.28	32.33
11,000										80.22	77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
12,000											77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
13,000												75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
14,000													72.50	69.04	65.14	61.58	57.26	53.71	49.92	46.16	42.29	39.48	36.75	32.80
15,000														69.11	65.21	61.64	57.32	53.78	49.98	46.22	42.35	39.54	36.81	32.86
16,000															65.42	61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
17,000																61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
18,000																	58.11	54.57	50.77	47.01	43.15	40.33	37.60	33.65
19,000																		54.88	51.08	47.32	43.46	40.64	37.91	33.96
20,000																			51.08	47.32	43.46	40.64	37.91	33.96
21,000																				47.32	43.46	40.64	37.91	33.96
22,000																					43.98	41.17	38.44	34.49
23,000																						41.74	39.01	35.05
24,000																							39.32	35.37
25,000																								35.37

Table 4.2-2: Juvenile Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.5%	94.5%	94.4%	94.0%	92.9%	91.3%	89.2%	87.3%	85.1%	81.8%	79.2%	75.6%	71.6%	67.3%	63.1%	57.9%	53.9%	49.6%	45.4%	41.0%	37.9%	34.8%	30.8%
3,000		96.6%	96.6%	96.3%	95.9%	94.8%	93.3%	91.2%	89.3%	87.1%	83.8%	81.1%	77.5%	73.3%	69.0%	64.7%	59.6%	55.4%	51.0%	46.8%	42.3%	39.1%	36.0%	31.9%
4,000			97.3%	97.1%	96.7%	95.6%	94.1%	92.0%	90.1%	87.9%	84.5%	81.9%	78.2%	74.1%	69.6%	65.4%	60.2%	56.0%	51.5%	47.1%	42.5%	39.4%	36.2%	32.1%
5,000				98.7%	98.2%	97.1%	95.6%	93.5%	91.5%	89.4%	86.0%	83.3%	79.7%	75.5%	71.0%	66.8%	61.6%	57.4%	52.8%	48.3%	43.7%	40.4%	37.2%	33.1%
6,000					99.6%	98.5%	96.9%	94.8%	92.9%	90.7%	87.3%	84.7%	81.0%	76.9%	72.2%	67.9%	62.8%	58.6%	54.0%	49.5%	44.9%	41.6%	38.3%	34.2%
7,000						99.0%	97.4%	95.3%	93.4%	91.2%	87.8%	85.2%	81.5%	77.4%	72.7%	68.4%	63.3%	59.0%	54.5%	50.0%	45.4%	42.0%	38.8%	34.7%
8,000							100.0 %	97.9%	95.9%	93.8%	90.4%	87.7%	84.1%	79.9%	75.3%	71.0%	65.9%	61.6%	57.1%	52.6%	48.0%	44.6%	41.4%	37.3%
9,000								98.9%	97.0%	94.8%	91.5%	88.8%	85.1%	81.0%	76.3%	72.1%	66.9%	62.7%	58.1%	53.6%	49.0%	45.6%	42.4%	37.8%
10,000									98.0%	95.8%	92.4%	89.8%	86.1%	82.0%	77.3%	73.0%	67.9%	63.6%	59.1%	54.6%	50.0%	46.6%	43.4%	38.6%
11,000										95.9%	92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
12,000											92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
13,000												89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
14,000													86.7%	82.5%	77.9%	73.6%	68.4%	64.2%	59.7%	55.2%	50.6%	47.2%	43.9%	39.2%
15,000														82.6%	77.9%	73.7%	68.5%	64.3%	59.7%	55.3%	50.6%	47.3%	44.0%	39.3%
16,000															78.2%	73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
17,000																73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
18,000																	69.5%	65.2%	60.7%	56.2%	51.6%	48.2%	44.9%	40.2%
19,000																		65.6%	61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
20,000																			61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
21,000																				56.6%	51.9%	48.6%	45.3%	40.6%
22,000																					52.6%	49.2%	45.9%	41.2%
23,000																						49.9%	46.6%	41.9%
24,000																							47.0%	42.3%
25,000																								42.3%

Table 4.2-3: Juvenile Yellow Lampmussel 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.78	84.72	84.62	84.71	84.51	84.14	83.30	82.47	80.82	79.48	77.81	74.85	72.73	69.64	66.15	62.92	59.94	55.63	51.31	46.77	43.20	39.89	35.99	33.48
3,000		85.13	85.04	85.06	84.86	84.49	83.65	82.82	81.17	79.83	78.15	75.20	73.08	69.97	66.47	63.25	60.27	55.84	51.49	46.92	43.28	39.97	36.07	33.56
4,000			85.33	85.26	85.06	84.71	83.87	83.07	81.44	80.10	78.42	75.47	73.38	70.26	66.76	63.54	60.56	56.13	51.78	47.21	43.57	40.26	36.36	33.80
5,000				85.78	85.58	85.21	84.36	83.54	81.89	80.55	78.87	75.92	73.80	70.68	67.07	63.84	60.86	56.44	52.09	47.52	43.88	40.57	36.67	34.04
6,000					86.27	85.90	85.06	84.23	82.59	81.24	79.57	76.61	74.49	71.38	67.76	64.54	61.56	57.13	52.78	48.21	44.57	41.26	37.36	34.74
7,000						86.88	86.04	85.21	83.56	82.22	80.55	77.59	75.47	72.36	68.74	65.52	62.54	58.11	53.76	49.19	45.55	42.24	38.34	35.71
8,000							86.72	85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
9,000								85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
10,000									84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
11,000										82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
12,000											81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
13,000												78.38	76.27	73.15	69.53	66.31	63.33	58.90	54.55	49.99	46.34	43.03	39.13	36.51
14,000													76.95	73.84	70.22	66.99	64.02	59.59	55.24	50.67	47.03	43.72	39.82	37.19
15,000														74.13	70.51	67.29	64.31	59.88	55.53	50.96	47.32	44.01	40.11	37.49
16,000															70.70	67.48	64.50	60.07	55.72	51.16	47.51	44.20	40.30	37.68
17,000																67.76	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
18,000																	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
19,000																		60.35	56.00	51.43	47.79	44.48	40.58	37.96
20,000																			56.53	51.96	48.31	45.01	41.10	38.48
21,000																				51.96	48.31	45.01	41.10	38.48
22,000																					48.86	45.55	41.65	39.03
23,000																						45.57	41.67	39.05
24,000																							41.99	39.37
25,000																								39.48

Table 4.2-4: Juvenile Yellow Lampmussel 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	97.6%	97.5%	97.4%	97.5%	97.3%	96.8%	95.9%	94.9%	93.0%	91.5%	89.6%	86.2%	83.7%	80.2%	76.1%	72.4%	69.0%	64.0%	59.1%	53.8%	49.7%	45.9%	41.4%	38.5%
3,000		98.0%	97.9%	97.9%	97.7%	97.2%	96.3%	95.3%	93.4%	91.9%	90.0%	86.6%	84.1%	80.5%	76.5%	72.8%	69.4%	64.3%	59.3%	54.0%	49.8%	46.0%	41.5%	38.6%
4,000			98.2%	98.1%	97.9%	97.5%	96.5%	95.6%	93.7%	92.2%	90.3%	86.9%	84.5%	80.9%	76.8%	73.1%	69.7%	64.6%	59.6%	54.3%	50.2%	46.3%	41.9%	38.9%
5,000				98.7%	98.5%	98.1%	97.1%	96.2%	94.3%	92.7%	90.8%	87.4%	84.9%	81.4%	77.2%	73.5%	70.1%	65.0%	60.0%	54.7%	50.5%	46.7%	42.2%	39.2%
6,000					99.3%	98.9%	97.9%	97.0%	95.1%	93.5%	91.6%	88.2%	85.7%	82.2%	78.0%	74.3%	70.9%	65.8%	60.8%	55.5%	51.3%	47.5%	43.0%	40.0%
7,000						100.0 %	99.0%	98.1%	96.2%	94.6%	92.7%	89.3%	86.9%	83.3%	79.1%	75.4%	72.0%	66.9%	61.9%	56.6%	52.4%	48.6%	44.1%	41.1%
8,000							99.8%	98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
9,000								98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
10,000									97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
11,000										95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
12,000											93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
13,000												90.2%	87.8%	84.2%	80.0%	76.3%	72.9%	67.8%	62.8%	57.5%	53.3%	49.5%	45.0%	42.0%
14,000													88.6%	85.0%	80.8%	77.1%	73.7%	68.6%	63.6%	58.3%	54.1%	50.3%	45.8%	42.8%
15,000														85.3%	81.2%	77.5%	74.0%	68.9%	63.9%	58.7%	54.5%	50.7%	46.2%	43.1%
16,000															81.4%	77.7%	74.2%	69.1%	64.1%	58.9%	54.7%	50.9%	46.4%	43.4%
17,000																78.0%	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
18,000																	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
19,000																		69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
20,000																			65.1%	59.8%	55.6%	51.8%	47.3%	44.3%
21,000																				59.8%	55.6%	51.8%	47.3%	44.3%
22,000																					56.2%	52.4%	47.9%	44.9%
23,000																						52.5%	48.0%	44.9%
24,000																							48.3%	45.3%
25,000																								45.4%

Table 4.2-5: Juvenile Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.17	78.86	78.86	78.24	77.40	75.99	74.40	72.48	70.92	68.78	65.31	63.13	59.87	56.59	53.05	49.63	45.38	42.12	39.00	35.80	32.40	29.98	27.38	24.28
3,000		80.63	80.58	79.80	79.00	77.65	76.07	74.15	72.54	70.39	66.86	64.64	61.30	58.02	54.36	50.92	46.64	43.27	40.09	36.87	33.36	30.94	28.34	25.18
4,000			81.27	80.39	79.62	78.26	76.71	74.79	73.18	71.03	67.51	65.28	61.92	58.64	54.91	51.44	47.11	43.67	40.49	37.14	33.55	31.14	28.49	25.33
5,000				81.82	80.98	79.57	77.98	76.01	74.40	72.24	68.72	66.50	63.13	59.85	56.06	52.59	48.26	44.82	41.57	38.10	34.51	31.92	29.27	26.11
6,000					82.10	80.70	79.10	77.13	75.52	73.37	69.85	67.62	64.14	60.86	57.06	53.59	49.26	45.82	42.57	39.10	35.51	32.93	30.21	27.05
7,000						81.11	79.52	77.55	75.94	73.78	70.26	68.04	64.55	61.27	57.48	54.01	49.68	46.23	42.99	39.49	35.91	33.32	30.60	27.44
8,000							81.67	79.70	78.09	75.94	72.41	70.19	66.70	63.42	59.63	56.16	51.83	48.39	45.14	41.65	38.06	35.47	32.76	29.60
9,000								80.57	78.96	76.81	73.29	71.06	67.58	64.30	60.50	57.03	52.70	49.26	46.01	42.52	38.93	36.35	33.61	30.07
10,000									79.78	77.63	74.11	71.88	68.40	65.12	61.32	57.85	53.52	50.08	46.84	43.34	39.75	37.17	34.43	30.76
11,000										77.71	74.19	71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
12,000											74.19	71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
13,000												71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
14,000													68.87	65.59	61.79	58.33	53.99	50.55	47.31	43.81	40.22	37.64	34.90	31.23
15,000														65.65	61.86	58.39	54.06	50.61	47.37	43.87	40.29	37.70	34.96	31.29
16,000															62.07	58.60	54.27	50.83	47.58	44.09	40.50	37.92	35.18	31.51
17,000																58.60	54.27	50.83	47.58	44.09	40.50	37.92	35.18	31.51
18,000																	54.85	51.40	48.16	44.66	41.08	38.49	35.75	32.08
19,000																		51.72	48.47	44.97	41.39	38.80	36.06	32.40
20,000																			48.47	44.97	41.39	38.80	36.06	32.40
21,000																				44.97	41.39	38.80	36.06	32.40
22,000																					41.91	39.33	36.59	32.92
23,000																						39.89	37.16	33.49
24,000																							37.48	33.81
25,000																								33.81

Table 4.2-6: Juvenile Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	96.4%	96.1%	96.1%	95.3%	94.3%	92.6%	90.6%	88.3%	86.4%	83.8%	79.6%	76.9%	72.9%	68.9%	64.6%	60.5%	55.3%	51.3%	47.5%	43.6%	39.5%	36.5%	33.3%	29.6%
3,000		98.2%	98.1%	97.2%	96.2%	94.6%	92.7%	90.3%	88.4%	85.7%	81.4%	78.7%	74.7%	70.7%	66.2%	62.0%	56.8%	52.7%	48.8%	44.9%	40.6%	37.7%	34.5%	30.7%
4,000			99.0%	97.9%	97.0%	95.3%	93.4%	91.1%	89.1%	86.5%	82.2%	79.5%	75.4%	71.4%	66.9%	62.7%	57.4%	53.2%	49.3%	45.2%	40.9%	37.9%	34.7%	30.8%
5,000				99.7%	98.6%	96.9%	95.0%	92.6%	90.6%	88.0%	83.7%	81.0%	76.9%	72.9%	68.3%	64.1%	58.8%	54.6%	50.6%	46.4%	42.0%	38.9%	35.6%	31.8%
6,000					100.0 %	98.3%	96.3%	93.9%	92.0%	89.4%	85.1%	82.4%	78.1%	74.1%	69.5%	65.3%	60.0%	55.8%	51.9%	47.6%	43.3%	40.1%	36.8%	32.9%
7,000						98.8%	96.9%	94.5%	92.5%	89.9%	85.6%	82.9%	78.6%	74.6%	70.0%	65.8%	60.5%	56.3%	52.4%	48.1%	43.7%	40.6%	37.3%	33.4%
8,000							99.5%	97.1%	95.1%	92.5%	88.2%	85.5%	81.2%	77.3%	72.6%	68.4%	63.1%	58.9%	55.0%	50.7%	46.4%	43.2%	39.9%	36.1%
9,000								98.1%	96.2%	93.6%	89.3%	86.6%	82.3%	78.3%	73.7%	69.5%	64.2%	60.0%	56.0%	51.8%	47.4%	44.3%	40.9%	36.6%
10,000									97.2%	94.6%	90.3%	87.6%	83.3%	79.3%	74.7%	70.5%	65.2%	61.0%	57.0%	52.8%	48.4%	45.3%	41.9%	37.5%
11,000										94.7%	90.4%	87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.1%	52.9%	48.5%	45.4%	42.0%	37.6%
12,000											90.4%	87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.1%	52.9%	48.5%	45.4%	42.0%	37.6%
13,000												87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.1%	52.9%	48.5%	45.4%	42.0%	37.6%
14,000													83.9%	79.9%	75.3%	71.0%	65.8%	61.6%	57.6%	53.4%	49.0%	45.8%	42.5%	38.0%
15,000														80.0%	75.3%	71.1%	65.8%	61.6%	57.7%	53.4%	49.1%	45.9%	42.6%	38.1%
16,000															75.6%	71.4%	66.1%	61.9%	58.0%	53.7%	49.3%	46.2%	42.8%	38.4%
17,000																71.4%	66.1%	61.9%	58.0%	53.7%	49.3%	46.2%	42.8%	38.4%
18,000																	66.8%	62.6%	58.7%	54.4%	50.0%	46.9%	43.5%	39.1%
19,000																		63.0%	59.0%	54.8%	50.4%	47.3%	43.9%	39.5%
20,000																			59.0%	54.8%	50.4%	47.3%	43.9%	39.5%
21,000																				54.8%	50.4%	47.3%	43.9%	39.5%
22,000																					51.1%	47.9%	44.6%	40.1%
23,000																						48.6%	45.3%	40.8%
24,000																							45.6%	41.2%
25,000																								41.2%

Table 4.2-7: Juvenile Yellow Lampmussel 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.78	84.67	84.48	84.38	83.88	82.99	81.72	80.74	78.73	77.36	75.41	72.13	69.68	66.42	62.53	59.48	56.41	52.29	48.26	44.31	40.99	37.74	34.35	31.78
3,000		85.09	84.90	84.68	84.18	83.30	82.05	81.06	79.05	77.71	75.76	72.48	70.03	66.75	62.85	59.78	56.71	52.42	48.39	44.42	41.08	37.82	34.43	31.86
4,000			85.19	84.81	84.33	83.49	82.27	81.33	79.35	78.00	76.05	72.78	70.32	67.04	63.15	60.07	57.01	52.71	48.68	44.66	41.32	38.06	34.62	32.05
5,000				85.45	84.95	84.06	82.79	81.80	79.80	78.42	76.48	73.20	70.63	67.34	63.45	60.37	57.31	53.02	48.98	44.97	41.62	38.36	34.92	32.29
6,000					85.64	84.76	83.48	82.50	80.49	79.12	77.17	73.90	71.32	68.04	64.14	61.07	58.00	53.71	49.68	45.66	42.32	39.06	35.62	32.99
7,000						85.73	84.46	83.48	81.47	80.10	78.15	74.87	72.30	69.02	65.12	62.05	58.98	54.69	50.65	46.64	43.29	40.04	36.60	33.96
8,000							85.15	84.16	82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
9,000								84.16	82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
10,000									82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
11,000										80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
12,000											78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
13,000												75.67	73.09	69.81	65.92	62.84	59.78	55.48	51.45	47.43	44.09	40.83	37.39	34.76
14,000													73.78	70.50	66.60	63.53	60.46	56.17	52.13	48.12	44.77	41.52	38.08	35.44
15,000														70.79	66.90	63.82	60.76	56.46	52.43	48.41	45.07	41.81	38.37	35.74
16,000															67.09	64.01	60.95	56.65	52.62	48.60	45.26	42.00	38.56	35.93
17,000																64.29	61.22	56.93	52.90	48.88	45.54	42.28	38.84	36.21
18,000																	61.22	56.93	52.90	48.88	45.54	42.28	38.84	36.21
19,000																		56.93	52.90	48.88	45.54	42.28	38.84	36.21
20,000																			53.42	49.40	46.06	42.80	39.36	36.73
21,000																				49.40	46.06	42.80	39.36	36.73
22,000																					46.61	43.35	39.91	37.28
23,000																						43.37	39.93	37.30
24,000																							40.25	37.62
25,000																								37.73

Table 4.2-8: Juvenile Yellow Lampmussel 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	98.9%	98.8%	98.5%	98.4%	97.8%	96.8%	95.3%	94.2%	91.8%	90.2%	88.0%	84.1%	81.3%	77.5%	72.9%	69.4%	65.8%	61.0%	56.3%	51.7%	47.8%	44.0%	40.1%	37.1%
3,000		99.2%	99.0%	98.8%	98.2%	97.2%	95.7%	94.5%	92.2%	90.6%	88.4%	84.5%	81.7%	77.9%	73.3%	69.7%	66.1%	61.1%	56.4%	51.8%	47.9%	44.1%	40.2%	37.2%
4,000			99.4%	98.9%	98.4%	97.4%	96.0%	94.9%	92.5%	91.0%	88.7%	84.9%	82.0%	78.2%	73.7%	70.1%	66.5%	61.5%	56.8%	52.1%	48.2%	44.4%	40.4%	37.4%
5,000				99.7%	99.1%	98.0%	96.6%	95.4%	93.1%	91.5%	89.2%	85.4%	82.4%	78.6%	74.0%	70.4%	66.8%	61.8%	57.1%	52.4%	48.5%	44.7%	40.7%	37.7%
6,000					99.9%	98.9%	97.4%	96.2%	93.9%	92.3%	90.0%	86.2%	83.2%	79.4%	74.8%	71.2%	67.7%	62.6%	57.9%	53.3%	49.4%	45.6%	41.5%	38.5%
7,000						100.0 %	98.5%	97.4%	95.0%	93.4%	91.2%	87.3%	84.3%	80.5%	76.0%	72.4%	68.8%	63.8%	59.1%	54.4%	50.5%	46.7%	42.7%	39.6%
8,000							99.3%	98.2%	95.8%	94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
9,000								98.2%	95.8%	94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
10,000									95.8%	94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
11,000										94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
12,000											92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
13,000												88.3%	85.3%	81.4%	76.9%	73.3%	69.7%	64.7%	60.0%	55.3%	51.4%	47.6%	43.6%	40.5%
14,000													86.1%	82.2%	77.7%	74.1%	70.5%	65.5%	60.8%	56.1%	52.2%	48.4%	44.4%	41.3%
15,000														82.6%	78.0%	74.4%	70.9%	65.9%	61.2%	56.5%	52.6%	48.8%	44.8%	41.7%
16,000															78.2%	74.7%	71.1%	66.1%	61.4%	56.7%	52.8%	49.0%	45.0%	41.9%
17,000																75.0%	71.4%	66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
18,000																	71.4%	66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
19,000																		66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
20,000																			62.3%	57.6%	53.7%	49.9%	45.9%	42.8%
21,000																				57.6%	53.7%	49.9%	45.9%	42.8%
22,000																					54.4%	50.6%	46.5%	43.5%
23,000																						50.6%	46.6%	43.5%
24,000																							46.9%	43.9%
25,000																								44.0%

Table 4.2-9-: Juvenile Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.19	79.03	79.03	78.99	78.62	77.68	76.41	74.62	73.04	71.23	68.44	66.25	63.26	59.88	56.30	52.78	48.47	45.11	41.46	37.95	34.34	31.73	29.13	25.80
3,000		80.79	80.79	80.60	80.25	79.31	78.06	76.29	74.69	72.87	70.07	67.85	64.81	61.35	57.71	54.15	49.83	46.35	42.66	39.12	35.37	32.74	30.09	26.69
4,000			81.43	81.24	80.89	79.95	78.70	76.94	75.33	73.52	70.71	68.49	65.43	61.97	58.26	54.69	50.38	46.83	43.11	39.44	35.57	32.93	30.28	26.89
5,000				82.55	82.17	81.24	79.96	78.18	76.57	74.75	71.95	69.71	66.64	63.19	59.41	55.84	51.52	47.98	44.19	40.45	36.58	33.77	31.12	27.67
6,000					83.30	82.36	81.09	79.30	77.70	75.88	73.07	70.83	67.77	64.31	60.41	56.84	52.53	48.98	45.19	41.45	37.58	34.77	32.06	28.62
7,000						82.78	81.50	79.71	78.11	76.29	73.49	71.25	68.18	64.73	60.83	57.26	52.94	49.40	45.60	41.84	37.97	35.16	32.45	29.01
8,000							83.65	81.87	80.27	78.45	75.64	73.40	70.34	66.88	62.98	59.41	55.09	51.55	47.76	44.00	40.13	37.32	34.61	31.16
9,000								82.74	81.14	79.32	76.51	74.27	71.21	67.75	63.85	60.28	55.97	52.42	48.63	44.87	41.00	38.19	35.46	31.64
10,000									81.96	80.14	77.33	75.09	72.03	68.57	64.67	61.10	56.79	53.24	49.45	45.69	41.82	39.01	36.28	32.33
11,000										80.22	77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
12,000											77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
13,000												75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
14,000													72.50	69.04	65.14	61.58	57.26	53.71	49.92	46.16	42.29	39.48	36.75	32.80
15,000														69.11	65.21	61.64	57.32	53.78	49.98	46.22	42.35	39.54	36.81	32.86
16,000															65.42	61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
17,000																61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
18,000																	58.11	54.57	50.77	47.01	43.15	40.33	37.60	33.65
19,000																		54.88	51.08	47.32	43.46	40.64	37.91	33.96
20,000																			51.08	47.32	43.46	40.64	37.91	33.96
21,000																				47.32	43.46	40.64	37.91	33.96
22,000																					43.98	41.17	38.44	34.49
23,000																						41.74	39.01	35.05
24,000																							39.32	35.37
25,000																								35.37

Table 4.2-10-: Juvenile Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.5%	94.5%	94.4%	94.0%	92.9%	91.3%	89.2%	87.3%	85.1%	81.8%	79.2%	75.6%	71.6%	67.3%	63.1%	57.9%	53.9%	49.6%	45.4%	41.0%	37.9%	34.8%	30.8%
3,000		96.6%	96.6%	96.3%	95.9%	94.8%	93.3%	91.2%	89.3%	87.1%	83.8%	81.1%	77.5%	73.3%	69.0%	64.7%	59.6%	55.4%	51.0%	46.8%	42.3%	39.1%	36.0%	31.9%
4,000			97.3%	97.1%	96.7%	95.6%	94.1%	92.0%	90.1%	87.9%	84.5%	81.9%	78.2%	74.1%	69.6%	65.4%	60.2%	56.0%	51.5%	47.1%	42.5%	39.4%	36.2%	32.1%
5,000				98.7%	98.2%	97.1%	95.6%	93.5%	91.5%	89.4%	86.0%	83.3%	79.7%	75.5%	71.0%	66.8%	61.6%	57.4%	52.8%	48.3%	43.7%	40.4%	37.2%	33.1%
6,000					99.6%	98.5%	96.9%	94.8%	92.9%	90.7%	87.3%	84.7%	81.0%	76.9%	72.2%	67.9%	62.8%	58.6%	54.0%	49.5%	44.9%	41.6%	38.3%	34.2%
7,000						99.0%	97.4%	95.3%	93.4%	91.2%	87.8%	85.2%	81.5%	77.4%	72.7%	68.4%	63.3%	59.0%	54.5%	50.0%	45.4%	42.0%	38.8%	34.7%
8,000							100.0 %	97.9%	95.9%	93.8%	90.4%	87.7%	84.1%	79.9%	75.3%	71.0%	65.9%	61.6%	57.1%	52.6%	48.0%	44.6%	41.4%	37.3%
9,000								98.9%	97.0%	94.8%	91.5%	88.8%	85.1%	81.0%	76.3%	72.1%	66.9%	62.7%	58.1%	53.6%	49.0%	45.6%	42.4%	37.8%
10,000									98.0%	95.8%	92.4%	89.8%	86.1%	82.0%	77.3%	73.0%	67.9%	63.6%	59.1%	54.6%	50.0%	46.6%	43.4%	38.6%
11,000										95.9%	92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
12,000											92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
13,000												89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
14,000													86.7%	82.5%	77.9%	73.6%	68.4%	64.2%	59.7%	55.2%	50.6%	47.2%	43.9%	39.2%
15,000														82.6%	77.9%	73.7%	68.5%	64.3%	59.7%	55.3%	50.6%	47.3%	44.0%	39.3%
16,000															78.2%	73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
17,000																73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
18,000																	69.5%	65.2%	60.7%	56.2%	51.6%	48.2%	44.9%	40.2%
19,000																		65.6%	61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
20,000																			61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
21,000																				56.6%	51.9%	48.6%	45.3%	40.6%
22,000																					52.6%	49.2%	45.9%	41.2%
23,000																						49.9%	46.6%	41.9%
24,000																							47.0%	42.3%
25,000																								42.3%

Table 4.2-11: Juvenile Tidewater Mucket 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.78	84.72	84.62	84.71	84.51	84.14	83.30	82.47	80.82	79.48	77.81	74.85	72.73	69.64	66.15	62.92	59.94	55.63	51.31	46.77	43.20	39.89	35.99	33.48
3,000		85.13	85.04	85.06	84.86	84.49	83.65	82.82	81.17	79.83	78.15	75.20	73.08	69.97	66.47	63.25	60.27	55.84	51.49	46.92	43.28	39.97	36.07	33.56
4,000			85.33	85.26	85.06	84.71	83.87	83.07	81.44	80.10	78.42	75.47	73.38	70.26	66.76	63.54	60.56	56.13	51.78	47.21	43.57	40.26	36.36	33.80
5,000				85.78	85.58	85.21	84.36	83.54	81.89	80.55	78.87	75.92	73.80	70.68	67.07	63.84	60.86	56.44	52.09	47.52	43.88	40.57	36.67	34.04
6,000					86.27	85.90	85.06	84.23	82.59	81.24	79.57	76.61	74.49	71.38	67.76	64.54	61.56	57.13	52.78	48.21	44.57	41.26	37.36	34.74
7,000						86.88	86.04	85.21	83.56	82.22	80.55	77.59	75.47	72.36	68.74	65.52	62.54	58.11	53.76	49.19	45.55	42.24	38.34	35.71
8,000							86.72	85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
9,000								85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
10,000									84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
11,000										82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
12,000											81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
13,000												78.38	76.27	73.15	69.53	66.31	63.33	58.90	54.55	49.99	46.34	43.03	39.13	36.51
14,000													76.95	73.84	70.22	66.99	64.02	59.59	55.24	50.67	47.03	43.72	39.82	37.19
15,000														74.13	70.51	67.29	64.31	59.88	55.53	50.96	47.32	44.01	40.11	37.49
16,000															70.70	67.48	64.50	60.07	55.72	51.16	47.51	44.20	40.30	37.68
17,000																67.76	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
18,000																	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
19,000																		60.35	56.00	51.43	47.79	44.48	40.58	37.96
20,000																			56.53	51.96	48.31	45.01	41.10	38.48
21,000																				51.96	48.31	45.01	41.10	38.48
22,000																					48.86	45.55	41.65	39.03
23,000																						45.57	41.67	39.05
24,000																							41.99	39.37
25,000																								39.48

Table 4.2-12: Juvenile Tidewater Mucket 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	97.6%	97.5%	97.4%	97.5%	97.3%	96.8%	95.9%	94.9%	93.0%	91.5%	89.6%	86.2%	83.7%	80.2%	76.1%	72.4%	69.0%	64.0%	59.1%	53.8%	49.7%	45.9%	41.4%	38.5%
3,000		98.0%	97.9%	97.9%	97.7%	97.2%	96.3%	95.3%	93.4%	91.9%	90.0%	86.6%	84.1%	80.5%	76.5%	72.8%	69.4%	64.3%	59.3%	54.0%	49.8%	46.0%	41.5%	38.6%
4,000			98.2%	98.1%	97.9%	97.5%	96.5%	95.6%	93.7%	92.2%	90.3%	86.9%	84.5%	80.9%	76.8%	73.1%	69.7%	64.6%	59.6%	54.3%	50.2%	46.3%	41.9%	38.9%
5,000				98.7%	98.5%	98.1%	97.1%	96.2%	94.3%	92.7%	90.8%	87.4%	84.9%	81.4%	77.2%	73.5%	70.1%	65.0%	60.0%	54.7%	50.5%	46.7%	42.2%	39.2%
6,000					99.3%	98.9%	97.9%	97.0%	95.1%	93.5%	91.6%	88.2%	85.7%	82.2%	78.0%	74.3%	70.9%	65.8%	60.8%	55.5%	51.3%	47.5%	43.0%	40.0%
7,000						100.0%	99.0%	98.1%	96.2%	94.6%	92.7%	89.3%	86.9%	83.3%	79.1%	75.4%	72.0%	66.9%	61.9%	56.6%	52.4%	48.6%	44.1%	41.1%
8,000							99.8%	98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
9,000								98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
10,000									97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
11,000										95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
12,000											93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
13,000												90.2%	87.8%	84.2%	80.0%	76.3%	72.9%	67.8%	62.8%	57.5%	53.3%	49.5%	45.0%	42.0%
14,000													88.6%	85.0%	80.8%	77.1%	73.7%	68.6%	63.6%	58.3%	54.1%	50.3%	45.8%	42.8%
15,000														85.3%	81.2%	77.5%	74.0%	68.9%	63.9%	58.7%	54.5%	50.7%	46.2%	43.1%
16,000															81.4%	77.7%	74.2%	69.1%	64.1%	58.9%	54.7%	50.9%	46.4%	43.4%
17,000																78.0%	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
18,000																	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
19,000																		69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
20,000																			65.1%	59.8%	55.6%	51.8%	47.3%	44.3%
21,000																				59.8%	55.6%	51.8%	47.3%	44.3%
22,000																					56.2%	52.4%	47.9%	44.9%
23,000																						52.5%	48.0%	44.9%
24,000																							48.3%	45.3%
25,000																								45.4%

Table 4.2-13-: Juvenile Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.17	78.86	78.86	78.24	77.40	75.99	74.40	72.48	70.92	68.78	65.31	63.13	59.87	56.59	53.05	49.63	45.38	42.12	39.00	35.80	32.40	29.98	27.38	24.28
3,000		80.63	80.58	79.80	79.00	77.65	76.07	74.15	72.54	70.39	66.86	64.64	61.30	58.02	54.36	50.92	46.64	43.27	40.09	36.87	33.36	30.94	28.34	25.18
4,000			81.27	80.39	79.62	78.26	76.71	74.79	73.18	71.03	67.51	65.28	61.92	58.64	54.91	51.44	47.11	43.67	40.49	37.14	33.55	31.14	28.49	25.33
5,000				81.82	80.98	79.57	77.98	76.01	74.40	72.24	68.72	66.50	63.13	59.85	56.06	52.59	48.26	44.82	41.57	38.10	34.51	31.92	29.27	26.11
6,000					82.10	80.70	79.10	77.13	75.52	73.37	69.85	67.62	64.14	60.86	57.06	53.59	49.26	45.82	42.57	39.10	35.51	32.93	30.21	27.05
7,000						81.11	79.52	77.55	75.94	73.78	70.26	68.04	64.55	61.27	57.48	54.01	49.68	46.23	42.99	39.49	35.91	33.32	30.60	27.44
8,000							81.67	79.70	78.09	75.94	72.41	70.19	66.70	63.42	59.63	56.16	51.83	48.39	45.14	41.65	38.06	35.47	32.76	29.60
9,000								80.57	78.96	76.81	73.29	71.06	67.58	64.30	60.50	57.03	52.70	49.26	46.01	42.52	38.93	36.35	33.61	30.07
10,000									79.78	77.63	74.11	71.88	68.40	65.12	61.32	57.85	53.52	50.08	46.84	43.34	39.75	37.17	34.43	30.76
11,000										77.71	74.19	71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
12,000											74.19	71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
13,000												71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
14,000													68.87	65.59	61.79	58.33	53.99	50.55	47.31	43.81	40.22	37.64	34.90	31.23
15,000														65.65	61.86	58.39	54.06	50.61	47.37	43.87	40.29	37.70	34.96	31.29
16,000															62.07	58.60	54.27	50.83	47.58	44.09	40.50	37.92	35.18	31.51
17,000																58.60	54.27	50.83	47.58	44.09	40.50	37.92	35.18	31.51
18,000																	54.85	51.40	48.16	44.66	41.08	38.49	35.75	32.08
19,000																		51.72	48.47	44.97	41.39	38.80	36.06	32.40
20,000																			48.47	44.97	41.39	38.80	36.06	32.40
21,000																				44.97	41.39	38.80	36.06	32.40
22,000																					41.91	39.33	36.59	32.92
23,000																						39.89	37.16	33.49
24,000																							37.48	33.81
25,000																								33.81

Table 4.2-14-: Juvenile Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	96.4%	96.1%	96.1%	95.3%	94.3%	92.6%	90.6%	88.3%	86.4%	83.8%	79.6%	76.9%	72.9%	68.9%	64.6%	60.5%	55.3%	51.3%	47.5%	43.6%	39.5%	36.5%	33.3%	29.6%
3,000		98.2%	98.1%	97.2%	96.2%	94.6%	92.7%	90.3%	88.4%	85.7%	81.4%	78.7%	74.7%	70.7%	66.2%	62.0%	56.8%	52.7%	48.8%	44.9%	40.6%	37.7%	34.5%	30.7%
4,000			99.0%	97.9%	97.0%	95.3%	93.4%	91.1%	89.1%	86.5%	82.2%	79.5%	75.4%	71.4%	66.9%	62.7%	57.4%	53.2%	49.3%	45.2%	40.9%	37.9%	34.7%	30.8%
5,000				99.7%	98.6%	96.9%	95.0%	92.6%	90.6%	88.0%	83.7%	81.0%	76.9%	72.9%	68.3%	64.1%	58.8%	54.6%	50.6%	46.4%	42.0%	38.9%	35.6%	31.8%
6,000					100.0 %	98.3%	96.3%	93.9%	92.0%	89.4%	85.1%	82.4%	78.1%	74.1%	69.5%	65.3%	60.0%	55.8%	51.9%	47.6%	43.3%	40.1%	36.8%	32.9%
7,000						98.8%	96.9%	94.5%	92.5%	89.9%	85.6%	82.9%	78.6%	74.6%	70.0%	65.8%	60.5%	56.3%	52.4%	48.1%	43.7%	40.6%	37.3%	33.4%
8,000							99.5%	97.1%	95.1%	92.5%	88.2%	85.5%	81.2%	77.3%	72.6%	68.4%	63.1%	58.9%	55.0%	50.7%	46.4%	43.2%	39.9%	36.1%
9,000								98.1%	96.2%	93.6%	89.3%	86.6%	82.3%	78.3%	73.7%	69.5%	64.2%	60.0%	56.0%	51.8%	47.4%	44.3%	40.9%	36.6%
10,000									97.2%	94.6%	90.3%	87.6%	83.3%	79.3%	74.7%	70.5%	65.2%	61.0%	57.0%	52.8%	48.4%	45.3%	41.9%	37.5%
11,000										94.7%	90.4%	87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.1%	52.9%	48.5%	45.4%	42.0%	37.6%
12,000											90.4%	87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.1%	52.9%	48.5%	45.4%	42.0%	37.6%
13,000												87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.1%	52.9%	48.5%	45.4%	42.0%	37.6%
14,000													83.9%	79.9%	75.3%	71.0%	65.8%	61.6%	57.6%	53.4%	49.0%	45.8%	42.5%	38.0%
15,000														80.0%	75.3%	71.1%	65.8%	61.6%	57.7%	53.4%	49.1%	45.9%	42.6%	38.1%
16,000															75.6%	71.4%	66.1%	61.9%	58.0%	53.7%	49.3%	46.2%	42.8%	38.4%
17,000																71.4%	66.1%	61.9%	58.0%	53.7%	49.3%	46.2%	42.8%	38.4%
18,000																	66.8%	62.6%	58.7%	54.4%	50.0%	46.9%	43.5%	39.1%
19,000																		63.0%	59.0%	54.8%	50.4%	47.3%	43.9%	39.5%
20,000																			59.0%	54.8%	50.4%	47.3%	43.9%	39.5%
21,000																				54.8%	50.4%	47.3%	43.9%	39.5%
22,000																					51.1%	47.9%	44.6%	40.1%
23,000																						48.6%	45.3%	40.8%
24,000																							45.6%	41.2%
25,000																								41.2%

Table 4.2-15-: Juvenile Tidewater Mucket 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.78	84.67	84.48	84.38	83.88	82.99	81.72	80.74	78.73	77.36	75.41	72.13	69.68	66.42	62.53	59.48	56.41	52.29	48.26	44.31	40.99	37.74	34.35	31.78
3,000		85.09	84.90	84.68	84.18	83.30	82.05	81.06	79.05	77.71	75.76	72.48	70.03	66.75	62.85	59.78	56.71	52.42	48.39	44.42	41.08	37.82	34.43	31.86
4,000			85.19	84.81	84.33	83.49	82.27	81.33	79.35	78.00	76.05	72.78	70.32	67.04	63.15	60.07	57.01	52.71	48.68	44.66	41.32	38.06	34.62	32.05
5,000				85.45	84.95	84.06	82.79	81.80	79.80	78.42	76.48	73.20	70.63	67.34	63.45	60.37	57.31	53.02	48.98	44.97	41.62	38.36	34.92	32.29
6,000					85.64	84.76	83.48	82.50	80.49	79.12	77.17	73.90	71.32	68.04	64.14	61.07	58.00	53.71	49.68	45.66	42.32	39.06	35.62	32.99
7,000						85.73	84.46	83.48	81.47	80.10	78.15	74.87	72.30	69.02	65.12	62.05	58.98	54.69	50.65	46.64	43.29	40.04	36.60	33.96
8,000							85.15	84.16	82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
9,000								84.16	82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
10,000									82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
11,000										80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
12,000											78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
13,000												75.67	73.09	69.81	65.92	62.84	59.78	55.48	51.45	47.43	44.09	40.83	37.39	34.76
14,000													73.78	70.50	66.60	63.53	60.46	56.17	52.13	48.12	44.77	41.52	38.08	35.44
15,000														70.79	66.90	63.82	60.76	56.46	52.43	48.41	45.07	41.81	38.37	35.74
16,000															67.09	64.01	60.95	56.65	52.62	48.60	45.26	42.00	38.56	35.93
17,000																64.29	61.22	56.93	52.90	48.88	45.54	42.28	38.84	36.21
18,000																	61.22	56.93	52.90	48.88	45.54	42.28	38.84	36.21
19,000																		56.93	52.90	48.88	45.54	42.28	38.84	36.21
20,000																			53.42	49.40	46.06	42.80	39.36	36.73
21,000																				49.40	46.06	42.80	39.36	36.73
22,000																					46.61	43.35	39.91	37.28
23,000																						43.37	39.93	37.30
24,000																							40.25	37.62
25,000																								37.73

Table 4.2-16-: Juvenile Tidewater Mucket 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	98.9%	98.8%	98.5%	98.4%	97.8%	96.8%	95.3%	94.2%	91.8%	90.2%	88.0%	84.1%	81.3%	77.5%	72.9%	69.4%	65.8%	61.0%	56.3%	51.7%	47.8%	44.0%	40.1%	37.1%
3,000		99.2%	99.0%	98.8%	98.2%	97.2%	95.7%	94.5%	92.2%	90.6%	88.4%	84.5%	81.7%	77.9%	73.3%	69.7%	66.1%	61.1%	56.4%	51.8%	47.9%	44.1%	40.2%	37.2%
4,000			99.4%	98.9%	98.4%	97.4%	96.0%	94.9%	92.5%	91.0%	88.7%	84.9%	82.0%	78.2%	73.7%	70.1%	66.5%	61.5%	56.8%	52.1%	48.2%	44.4%	40.4%	37.4%
5,000				99.7%	99.1%	98.0%	96.6%	95.4%	93.1%	91.5%	89.2%	85.4%	82.4%	78.6%	74.0%	70.4%	66.8%	61.8%	57.1%	52.4%	48.5%	44.7%	40.7%	37.7%
6,000					99.9%	98.9%	97.4%	96.2%	93.9%	92.3%	90.0%	86.2%	83.2%	79.4%	74.8%	71.2%	67.7%	62.6%	57.9%	53.3%	49.4%	45.6%	41.5%	38.5%
7,000						100.0%	98.5%	97.4%	95.0%	93.4%	91.2%	87.3%	84.3%	80.5%	76.0%	72.4%	68.8%	63.8%	59.1%	54.4%	50.5%	46.7%	42.7%	39.6%
8,000							99.3%	98.2%	95.8%	94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
9,000								98.2%	95.8%	94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
10,000									95.8%	94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
11,000										94.2%	92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
12,000											92.0%	88.1%	85.1%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
13,000												88.3%	85.3%	81.4%	76.9%	73.3%	69.7%	64.7%	60.0%	55.3%	51.4%	47.6%	43.6%	40.5%
14,000													86.1%	82.2%	77.7%	74.1%	70.5%	65.5%	60.8%	56.1%	52.2%	48.4%	44.4%	41.3%
15,000														82.6%	78.0%	74.4%	70.9%	65.9%	61.2%	56.5%	52.6%	48.8%	44.8%	41.7%
16,000															78.2%	74.7%	71.1%	66.1%	61.4%	56.7%	52.8%	49.0%	45.0%	41.9%
17,000																75.0%	71.4%	66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
18,000																	71.4%	66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
19,000																		66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
20,000																			62.3%	57.6%	53.7%	49.9%	45.9%	42.8%
21,000																				57.6%	53.7%	49.9%	45.9%	42.8%
22,000																					54.4%	50.6%	46.5%	43.5%
23,000																						50.6%	46.6%	43.5%
24,000																							46.9%	43.9%
25,000																								44.0%

Table 4.2-17: Juvenile Eastern Pondmussel ~~Mussel~~ 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	78.83	78.67	78.67	78.64	78.26	77.33	76.07	74.29	72.71	70.94	68.18	66.01	63.14	59.76	56.18	52.66	48.37	45.01	41.39	37.90	34.29	31.68	29.08	25.75
3,000		80.44	80.44	80.24	79.89	78.96	77.73	75.96	74.36	72.59	69.81	67.61	64.69	61.24	57.59	54.03	49.73	46.26	42.58	39.07	35.33	32.69	30.04	26.65
4,000			81.08	80.88	80.53	79.60	78.37	76.60	75.00	73.23	70.45	68.26	65.31	61.85	58.14	54.58	50.28	46.74	43.04	39.39	35.52	32.89	30.24	26.84
5,000				82.19	81.82	80.88	79.63	77.84	76.24	74.47	71.69	69.47	66.53	63.07	59.29	55.72	51.43	47.89	44.12	40.40	36.53	33.72	31.07	27.63
6,000					82.94	82.01	80.75	78.97	77.37	75.59	72.81	70.60	67.65	64.19	60.29	56.72	52.43	48.89	45.12	41.40	37.53	34.72	32.01	28.57
7,000						82.42	81.17	79.38	77.78	76.01	73.23	71.01	68.06	64.61	60.71	57.14	52.85	49.30	45.53	41.79	37.93	35.11	32.40	28.96
8,000							83.32	81.54	79.93	78.16	75.38	73.17	70.22	66.76	62.86	59.29	55.00	51.46	47.69	43.95	40.08	37.27	34.56	31.12
9,000								82.41	80.81	79.03	76.25	74.04	71.09	67.63	63.73	60.16	55.87	52.33	48.56	44.82	40.95	38.14	35.41	31.59
10,000									81.63	79.86	77.07	74.86	71.91	68.45	64.55	60.99	56.69	53.15	49.38	45.64	41.77	38.96	36.23	32.28
11,000										79.94	77.15	74.94	71.99	68.54	64.64	61.07	56.77	53.23	49.46	45.72	41.85	39.04	36.31	32.36
12,000											77.15	74.94	71.99	68.54	64.64	61.07	56.77	53.23	49.46	45.72	41.85	39.04	36.31	32.36
13,000												74.94	71.99	68.54	64.64	61.07	56.77	53.23	49.46	45.72	41.85	39.04	36.31	32.36
14,000													72.38	68.93	65.02	61.46	57.16	53.62	49.85	46.11	42.24	39.43	36.70	32.75
15,000														68.99	65.09	61.52	57.23	53.68	49.91	46.17	42.31	39.49	36.76	32.81
16,000															65.30	61.73	57.44	53.90	50.13	46.39	42.52	39.71	36.98	33.03
17,000																61.73	57.44	53.90	50.13	46.39	42.52	39.71	36.98	33.03
18,000																	58.02	54.47	50.70	46.96	43.10	40.28	37.55	33.60
19,000																		54.78	51.01	47.28	43.41	40.60	37.87	33.91
20,000																			51.01	47.28	43.41	40.60	37.87	33.91
21,000																				47.28	43.41	40.60	37.87	33.91
22,000																					43.93	41.12	38.39	34.44
23,000																						41.69	38.96	35.01
24,000																							39.28	35.32
25,000																								35.32

Table 4.2-18: Juvenile Eastern Pondmussel ~~Mussel~~ 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.6%	94.4%	94.4%	94.4%	93.9%	92.8%	91.3%	89.2%	87.3%	85.1%	81.8%	79.2%	75.8%	71.7%	67.4%	63.2%	58.1%	54.0%	49.7%	45.5%	41.2%	38.0%	34.9%	30.9%
3,000		96.5%	96.5%	96.3%	95.9%	94.8%	93.3%	91.2%	89.2%	87.1%	83.8%	81.1%	77.6%	73.5%	69.1%	64.8%	59.7%	55.5%	51.1%	46.9%	42.4%	39.2%	36.1%	32.0%
4,000			97.3%	97.1%	96.7%	95.5%	94.1%	91.9%	90.0%	87.9%	84.5%	81.9%	78.4%	74.2%	69.8%	65.5%	60.3%	56.1%	51.7%	47.3%	42.6%	39.5%	36.3%	32.2%
5,000				98.6%	98.2%	97.1%	95.6%	93.4%	91.5%	89.4%	86.0%	83.4%	79.8%	75.7%	71.2%	66.9%	61.7%	57.5%	52.9%	48.5%	43.8%	40.5%	37.3%	33.2%
6,000					99.5%	98.4%	96.9%	94.8%	92.9%	90.7%	87.4%	84.7%	81.2%	77.0%	72.4%	68.1%	62.9%	58.7%	54.1%	49.7%	45.0%	41.7%	38.4%	34.3%
7,000						98.9%	97.4%	95.3%	93.3%	91.2%	87.9%	85.2%	81.7%	77.5%	72.9%	68.6%	63.4%	59.2%	54.6%	50.2%	45.5%	42.1%	38.9%	34.8%
8,000							100.0%	97.9%	95.9%	93.8%	90.5%	87.8%	84.3%	80.1%	75.4%	71.2%	66.0%	61.8%	57.2%	52.7%	48.1%	44.7%	41.5%	37.3%
9,000								98.9%	97.0%	94.9%	91.5%	88.9%	85.3%	81.2%	76.5%	72.2%	67.1%	62.8%	58.3%	53.8%	49.1%	45.8%	42.5%	37.9%
10,000									98.0%	95.8%	92.5%	89.8%	86.3%	82.2%	77.5%	73.2%	68.0%	63.8%	59.3%	54.8%	50.1%	46.8%	43.5%	38.7%
11,000										95.9%	92.6%	89.9%	86.4%	82.3%	77.6%	73.3%	68.1%	63.9%	59.4%	54.9%	50.2%	46.9%	43.6%	38.8%
12,000											92.6%	89.9%	86.4%	82.3%	77.6%	73.3%	68.1%	63.9%	59.4%	54.9%	50.2%	46.9%	43.6%	38.8%
13,000												89.9%	86.4%	82.3%	77.6%	73.3%	68.1%	63.9%	59.4%	54.9%	50.2%	46.9%	43.6%	38.8%
14,000													86.9%	82.7%	78.0%	73.8%	68.6%	64.4%	59.8%	55.3%	50.7%	47.3%	44.0%	39.3%
15,000														82.8%	78.1%	73.8%	68.7%	64.4%	59.9%	55.4%	50.8%	47.4%	44.1%	39.4%
16,000															78.4%	74.1%	68.9%	64.7%	60.2%	55.7%	51.0%	47.7%	44.4%	39.6%
17,000																74.1%	68.9%	64.7%	60.2%	55.7%	51.0%	47.7%	44.4%	39.6%
18,000																	69.6%	65.4%	60.9%	56.4%	51.7%	48.3%	45.1%	40.3%
19,000																		65.7%	61.2%	56.7%	52.1%	48.7%	45.4%	40.7%
20,000																			61.2%	56.7%	52.1%	48.7%	45.4%	40.7%
21,000																				56.7%	52.1%	48.7%	45.4%	40.7%
22,000																					52.7%	49.4%	46.1%	41.3%
23,000																						50.0%	46.8%	42.0%
24,000																							47.1%	42.4%
25,000																								42.4%

Table 4.2-19: Juvenile Eastern Pondmussel ~~Mussel~~ 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.43	84.36	84.27	84.36	84.15	83.78	82.94	82.12	80.49	79.15	77.50	74.56	72.50	69.47	66.03	62.80	59.82	55.54	51.24	46.70	43.15	39.84	35.94	33.43
3,000		84.78	84.68	84.71	84.50	84.13	83.29	82.47	80.84	79.50	77.85	74.91	72.85	69.80	66.35	63.13	60.15	55.75	51.42	46.85	43.23	39.92	36.02	33.51
4,000			84.97	84.90	84.70	84.35	83.51	82.71	81.11	79.77	78.12	75.18	73.14	70.09	66.64	63.42	60.44	56.04	51.71	47.14	43.52	40.22	36.31	33.75
5,000				85.43	85.22	84.85	84.01	83.18	81.56	80.22	78.57	75.63	73.56	70.52	66.95	63.72	60.75	56.34	52.02	47.45	43.83	40.52	36.62	34.00
6,000					85.92	85.54	84.70	83.88	82.25	80.91	79.26	76.33	74.26	71.21	67.64	64.42	61.44	57.04	52.71	48.14	44.52	41.21	37.31	34.69
7,000						86.52	85.68	84.86	83.23	81.89	80.24	77.31	75.24	72.19	68.62	65.40	62.42	58.01	53.69	49.12	45.50	42.19	38.29	35.67
8,000							86.37	85.54	83.92	82.58	80.93	77.99	75.92	72.88	69.31	66.08	63.11	58.70	54.38	49.81	46.19	42.88	38.98	36.35
9,000								85.54	83.92	82.58	80.93	77.99	75.92	72.88	69.31	66.08	63.11	58.70	54.38	49.81	46.19	42.88	38.98	36.35
10,000									83.92	82.58	80.93	77.99	75.92	72.88	69.31	66.08	63.11	58.70	54.38	49.81	46.19	42.88	38.98	36.35
11,000										82.58	80.93	77.99	75.92	72.88	69.31	66.08	63.11	58.70	54.38	49.81	46.19	42.88	38.98	36.35
12,000											80.93	77.99	75.92	72.88	69.31	66.08	63.11	58.70	54.38	49.81	46.19	42.88	38.98	36.35
13,000												78.10	76.03	72.99	69.42	66.19	63.21	58.81	54.48	49.92	46.30	42.99	39.09	36.46
14,000													76.72	73.67	70.10	66.88	63.90	59.49	55.17	50.60	46.98	43.67	39.77	37.15
15,000														73.96	70.39	67.17	64.19	59.79	55.46	50.89	47.27	43.97	40.06	37.44
16,000															70.59	67.36	64.38	59.98	55.65	51.08	47.47	44.16	40.25	37.63
17,000																67.64	64.66	60.26	55.93	51.36	47.74	44.43	40.53	37.91
18,000																	64.66	60.26	55.93	51.36	47.74	44.43	40.53	37.91
19,000																		60.26	55.93	51.36	47.74	44.43	40.53	37.91
20,000																			56.45	51.89	48.27	44.96	41.06	38.43
21,000																				51.89	48.27	44.96	41.06	38.43
22,000																					48.81	45.50	41.60	38.98
23,000																						45.53	41.63	39.00
24,000																							41.94	39.32
25,000																								39.43

Table 4.2-20: Juvenile Eastern Pondmussel ~~Mussel~~ 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	97.6%	97.5%	97.4%	97.5%	97.3%	96.8%	95.9%	94.9%	93.0%	91.5%	89.6%	86.2%	83.8%	80.3%	76.3%	72.6%	69.1%	64.2%	59.2%	54.0%	49.9%	46.0%	41.5%	38.6%
3,000		98.0%	97.9%	97.9%	97.7%	97.2%	96.3%	95.3%	93.4%	91.9%	90.0%	86.6%	84.2%	80.7%	76.7%	73.0%	69.5%	64.4%	59.4%	54.1%	50.0%	46.1%	41.6%	38.7%
4,000			98.2%	98.1%	97.9%	97.5%	96.5%	95.6%	93.7%	92.2%	90.3%	86.9%	84.5%	81.0%	77.0%	73.3%	69.9%	64.8%	59.8%	54.5%	50.3%	46.5%	42.0%	39.0%
5,000				98.7%	98.5%	98.1%	97.1%	96.1%	94.3%	92.7%	90.8%	87.4%	85.0%	81.5%	77.4%	73.6%	70.2%	65.1%	60.1%	54.8%	50.7%	46.8%	42.3%	39.3%
6,000					99.3%	98.9%	97.9%	96.9%	95.1%	93.5%	91.6%	88.2%	85.8%	82.3%	78.2%	74.5%	71.0%	65.9%	60.9%	55.6%	51.5%	47.6%	43.1%	40.1%
7,000						100.0%	99.0%	98.1%	96.2%	94.6%	92.7%	89.3%	87.0%	83.4%	79.3%	75.6%	72.1%	67.1%	62.1%	56.8%	52.6%	48.8%	44.3%	41.2%
8,000							99.8%	98.9%	97.0%	95.4%	93.5%	90.1%	87.8%	84.2%	80.1%	76.4%	72.9%	67.8%	62.8%	57.6%	53.4%	49.6%	45.0%	42.0%
9,000								98.9%	97.0%	95.4%	93.5%	90.1%	87.8%	84.2%	80.1%	76.4%	72.9%	67.8%	62.8%	57.6%	53.4%	49.6%	45.0%	42.0%
10,000									97.0%	95.4%	93.5%	90.1%	87.8%	84.2%	80.1%	76.4%	72.9%	67.8%	62.8%	57.6%	53.4%	49.6%	45.0%	42.0%
11,000										95.4%	93.5%	90.1%	87.8%	84.2%	80.1%	76.4%	72.9%	67.8%	62.8%	57.6%	53.4%	49.6%	45.0%	42.0%
12,000											93.5%	90.1%	87.8%	84.2%	80.1%	76.4%	72.9%	67.8%	62.8%	57.6%	53.4%	49.6%	45.0%	42.0%
13,000												90.3%	87.9%	84.4%	80.2%	76.5%	73.1%	68.0%	63.0%	57.7%	53.5%	49.7%	45.2%	42.1%
14,000													88.7%	85.1%	81.0%	77.3%	73.8%	68.8%	63.8%	58.5%	54.3%	50.5%	46.0%	42.9%
15,000														85.5%	81.4%	77.6%	74.2%	69.1%	64.1%	58.8%	54.6%	50.8%	46.3%	43.3%
16,000															81.6%	77.9%	74.4%	69.3%	64.3%	59.0%	54.9%	51.0%	46.5%	43.5%
17,000																78.2%	74.7%	69.6%	64.6%	59.4%	55.2%	51.4%	46.8%	43.8%
18,000																	74.7%	69.6%	64.6%	59.4%	55.2%	51.4%	46.8%	43.8%
19,000																		69.6%	64.6%	59.4%	55.2%	51.4%	46.8%	43.8%
20,000																			65.2%	60.0%	55.8%	52.0%	47.5%	44.4%
21,000																				60.0%	55.8%	52.0%	47.5%	44.4%
22,000																					56.4%	52.6%	48.1%	45.1%
23,000																						52.6%	48.1%	45.1%
24,000																							48.5%	45.4%
25,000																								45.6%

Table 4.2-21: Juvenile Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	78.81	78.58	78.53	78.22	77.37	75.99	74.40	72.48	70.92	68.78	65.31	63.13	59.87	56.59	53.05	49.63	45.38	42.12	39.00	35.80	32.40	29.98	27.38	24.28
3,000		80.34	80.30	79.77	78.98	77.65	76.07	74.15	72.54	70.39	66.86	64.64	61.30	58.02	54.36	50.92	46.64	43.27	40.09	36.87	33.36	30.94	28.34	25.18
4,000			80.94	80.37	79.59	78.26	76.71	74.79	73.18	71.03	67.51	65.28	61.92	58.64	54.91	51.44	47.11	43.67	40.49	37.14	33.55	31.14	28.49	25.33
5,000				81.80	80.95	79.57	77.98	76.01	74.40	72.24	68.72	66.50	63.13	59.85	56.06	52.59	48.26	44.82	41.57	38.10	34.51	31.92	29.27	26.11
6,000					82.08	80.70	79.10	77.13	75.52	73.37	69.85	67.62	64.14	60.86	57.06	53.59	49.26	45.82	42.57	39.10	35.51	32.93	30.21	27.05
7,000						81.11	79.52	77.55	75.94	73.78	70.26	68.04	64.55	61.27	57.48	54.01	49.68	46.23	42.99	39.49	35.91	33.32	30.60	27.44
8,000							81.67	79.70	78.09	75.94	72.41	70.19	66.70	63.42	59.63	56.16	51.83	48.39	45.14	41.65	38.06	35.47	32.76	29.60
9,000								80.57	78.96	76.81	73.29	71.06	67.58	64.30	60.50	57.03	52.70	49.26	46.01	42.52	38.93	36.35	33.61	30.07
10,000									79.78	77.63	74.11	71.88	68.40	65.12	61.32	57.85	53.52	50.08	46.84	43.34	39.75	37.17	34.43	30.76
11,000										77.71	74.19	71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
12,000											74.19	71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
13,000												71.96	68.48	65.20	61.40	57.94	53.60	50.16	46.92	43.42	39.83	37.25	34.51	30.84
14,000													68.87	65.59	61.79	58.33	53.99	50.55	47.31	43.81	40.22	37.64	34.90	31.23
15,000														65.65	61.86	58.39	54.06	50.61	47.37	43.87	40.29	37.70	34.96	31.29
16,000															62.07	58.60	54.27	50.83	47.58	44.09	40.50	37.92	35.18	31.51
17,000																58.60	54.27	50.83	47.58	44.09	40.50	37.92	35.18	31.51
18,000																	54.85	51.40	48.16	44.66	41.08	38.49	35.75	32.08
19,000																		51.72	48.47	44.97	41.39	38.80	36.06	32.40
20,000																			48.47	44.97	41.39	38.80	36.06	32.40
21,000																				44.97	41.39	38.80	36.06	32.40
22,000																					41.91	39.33	36.59	32.92
23,000																						39.89	37.16	33.49
24,000																							37.48	33.81
25,000																								33.81

Table 4.2-22: Juvenile Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	96.0%	95.7%	95.7%	95.3%	94.3%	92.6%	90.6%	88.3%	86.4%	83.8%	79.6%	76.9%	72.9%	68.9%	64.6%	60.5%	55.3%	51.3%	47.5%	43.6%	39.5%	36.5%	33.4%	29.6%
3,000		97.9%	97.8%	97.2%	96.2%	94.6%	92.7%	90.3%	88.4%	85.8%	81.5%	78.8%	74.7%	70.7%	66.2%	62.0%	56.8%	52.7%	48.8%	44.9%	40.6%	37.7%	34.5%	30.7%
4,000			98.6%	97.9%	97.0%	95.4%	93.5%	91.1%	89.2%	86.5%	82.2%	79.5%	75.4%	71.4%	66.9%	62.7%	57.4%	53.2%	49.3%	45.2%	40.9%	37.9%	34.7%	30.9%
5,000				99.7%	98.6%	97.0%	95.0%	92.6%	90.6%	88.0%	83.7%	81.0%	76.9%	72.9%	68.3%	64.1%	58.8%	54.6%	50.7%	46.4%	42.0%	38.9%	35.7%	31.8%
6,000					100.0%	98.3%	96.4%	94.0%	92.0%	89.4%	85.1%	82.4%	78.1%	74.1%	69.5%	65.3%	60.0%	55.8%	51.9%	47.6%	43.3%	40.1%	36.8%	33.0%
7,000						98.8%	96.9%	94.5%	92.5%	89.9%	85.6%	82.9%	78.6%	74.6%	70.0%	65.8%	60.5%	56.3%	52.4%	48.1%	43.7%	40.6%	37.3%	33.4%
8,000							99.5%	97.1%	95.1%	92.5%	88.2%	85.5%	81.3%	77.3%	72.7%	68.4%	63.1%	59.0%	55.0%	50.7%	46.4%	43.2%	39.9%	36.1%
9,000								98.2%	96.2%	93.6%	89.3%	86.6%	82.3%	78.3%	73.7%	69.5%	64.2%	60.0%	56.1%	51.8%	47.4%	44.3%	40.9%	36.6%
10,000									97.2%	94.6%	90.3%	87.6%	83.3%	79.3%	74.7%	70.5%	65.2%	61.0%	57.1%	52.8%	48.4%	45.3%	41.9%	37.5%
11,000										94.7%	90.4%	87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.2%	52.9%	48.5%	45.4%	42.0%	37.6%
12,000											90.4%	87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.2%	52.9%	48.5%	45.4%	42.0%	37.6%
13,000												87.7%	83.4%	79.4%	74.8%	70.6%	65.3%	61.1%	57.2%	52.9%	48.5%	45.4%	42.0%	37.6%
14,000													83.9%	79.9%	75.3%	71.1%	65.8%	61.6%	57.6%	53.4%	49.0%	45.9%	42.5%	38.1%
15,000														80.0%	75.4%	71.1%	65.9%	61.7%	57.7%	53.5%	49.1%	45.9%	42.6%	38.1%
16,000															75.6%	71.4%	66.1%	61.9%	58.0%	53.7%	49.3%	46.2%	42.9%	38.4%
17,000																71.4%	66.1%	61.9%	58.0%	53.7%	49.3%	46.2%	42.9%	38.4%
18,000																	66.8%	62.6%	58.7%	54.4%	50.0%	46.9%	43.6%	39.1%
19,000																		63.0%	59.1%	54.8%	50.4%	47.3%	43.9%	39.5%
20,000																			59.1%	54.8%	50.4%	47.3%	43.9%	39.5%
21,000																				54.8%	50.4%	47.3%	43.9%	39.5%
22,000																					51.1%	47.9%	44.6%	40.1%
23,000																						48.6%	45.3%	40.8%
24,000																							45.7%	41.2%
25,000																								41.2%

Table 4.2-23: Juvenile Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.43	84.32	84.15	84.28	83.85	82.97	81.70	80.74	78.73	77.36	75.41	72.13	69.68	66.42	62.53	59.48	56.41	52.29	48.26	44.31	40.99	37.74	34.35	31.78
3,000		84.73	84.56	84.58	84.16	83.27	82.03	81.06	79.05	77.71	75.76	72.48	70.03	66.75	62.85	59.78	56.71	52.42	48.39	44.42	41.08	37.82	34.43	31.86
4,000			84.86	84.73	84.31	83.47	82.25	81.33	79.35	78.00	76.05	72.78	70.32	67.04	63.15	60.07	57.01	52.71	48.68	44.66	41.32	38.06	34.62	32.05
5,000				85.35	84.92	84.04	82.77	81.80	79.80	78.42	76.48	73.20	70.63	67.34	63.45	60.37	57.31	53.02	48.98	44.97	41.62	38.36	34.92	32.29
6,000					85.62	84.73	83.46	82.50	80.49	79.12	77.17	73.90	71.32	68.04	64.14	61.07	58.00	53.71	49.68	45.66	42.32	39.06	35.62	32.99
7,000						85.71	84.44	83.48	81.47	80.10	78.15	74.87	72.30	69.02	65.12	62.05	58.98	54.69	50.65	46.64	43.29	40.04	36.60	33.96
8,000							85.13	84.16	82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
9,000								84.16	82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
10,000									82.16	80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
11,000										80.78	78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
12,000											78.84	75.56	72.99	69.70	65.81	62.73	59.67	55.38	51.34	47.33	43.98	40.72	37.28	34.65
13,000												75.67	73.09	69.81	65.92	62.84	59.78	55.48	51.45	47.43	44.09	40.83	37.39	34.76
14,000													73.78	70.50	66.60	63.53	60.46	56.17	52.13	48.12	44.77	41.52	38.08	35.44
15,000														70.79	66.90	63.82	60.76	56.46	52.43	48.41	45.07	41.81	38.37	35.74
16,000															67.09	64.01	60.95	56.65	52.62	48.60	45.26	42.00	38.56	35.93
17,000																64.29	61.22	56.93	52.90	48.88	45.54	42.28	38.84	36.21
18,000																	61.22	56.93	52.90	48.88	45.54	42.28	38.84	36.21
19,000																		56.93	52.90	48.88	45.54	42.28	38.84	36.21
20,000																			53.42	49.40	46.06	42.80	39.36	36.73
21,000																				49.40	46.06	42.80	39.36	36.73
22,000																					46.61	43.35	39.91	37.28
23,000																						43.37	39.93	37.30
24,000																							40.25	37.62
25,000																								37.73

Table 4.2-24: Juvenile Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	98.5%	98.4%	98.2%	98.3%	97.8%	96.8%	95.3%	94.2%	91.9%	90.3%	88.0%	84.2%	81.3%	77.5%	73.0%	69.4%	65.8%	61.0%	56.3%	51.7%	47.8%	44.0%	40.1%	37.1%
3,000		98.9%	98.7%	98.7%	98.2%	97.2%	95.7%	94.6%	92.2%	90.7%	88.4%	84.6%	81.7%	77.9%	73.3%	69.7%	66.2%	61.2%	56.5%	51.8%	47.9%	44.1%	40.2%	37.2%
4,000			99.0%	98.9%	98.4%	97.4%	96.0%	94.9%	92.6%	91.0%	88.7%	84.9%	82.0%	78.2%	73.7%	70.1%	66.5%	61.5%	56.8%	52.1%	48.2%	44.4%	40.4%	37.4%
5,000				99.6%	99.1%	98.0%	96.6%	95.4%	93.1%	91.5%	89.2%	85.4%	82.4%	78.6%	74.0%	70.4%	66.9%	61.9%	57.1%	52.5%	48.6%	44.8%	40.7%	37.7%
6,000					99.9%	98.9%	97.4%	96.3%	93.9%	92.3%	90.0%	86.2%	83.2%	79.4%	74.8%	71.2%	67.7%	62.7%	58.0%	53.3%	49.4%	45.6%	41.6%	38.5%
7,000						100.0%	98.5%	97.4%	95.1%	93.4%	91.2%	87.4%	84.4%	80.5%	76.0%	72.4%	68.8%	63.8%	59.1%	54.4%	50.5%	46.7%	42.7%	39.6%
8,000							99.3%	98.2%	95.9%	94.3%	92.0%	88.2%	85.2%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
9,000								98.2%	95.9%	94.3%	92.0%	88.2%	85.2%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
10,000									95.9%	94.3%	92.0%	88.2%	85.2%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
11,000										94.3%	92.0%	88.2%	85.2%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
12,000											92.0%	88.2%	85.2%	81.3%	76.8%	73.2%	69.6%	64.6%	59.9%	55.2%	51.3%	47.5%	43.5%	40.4%
13,000												88.3%	85.3%	81.5%	76.9%	73.3%	69.7%	64.7%	60.0%	55.3%	51.4%	47.6%	43.6%	40.6%
14,000													86.1%	82.2%	77.7%	74.1%	70.5%	65.5%	60.8%	56.1%	52.2%	48.4%	44.4%	41.4%
15,000														82.6%	78.0%	74.5%	70.9%	65.9%	61.2%	56.5%	52.6%	48.8%	44.8%	41.7%
16,000															78.3%	74.7%	71.1%	66.1%	61.4%	56.7%	52.8%	49.0%	45.0%	41.9%
17,000																75.0%	71.4%	66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
18,000																	71.4%	66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
19,000																		66.4%	61.7%	57.0%	53.1%	49.3%	45.3%	42.2%
20,000																			62.3%	57.6%	53.7%	49.9%	45.9%	42.9%
21,000																				57.6%	53.7%	49.9%	45.9%	42.9%
22,000																					54.4%	50.6%	46.6%	43.5%
23,000																						50.6%	46.6%	43.5%
24,000																							47.0%	43.9%
25,000																								44.0%

Table 4.2-25: Adult Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.25	79.19	79.19	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.23	79.13	79.05	79.05	78.97	78.89	78.64	78.36	77.89	77.70	77.37	77.16	76.17
3,000		80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.92	80.82	80.75	80.75	80.67	80.59	80.31	80.04	79.57	79.37	79.04	78.83	77.84
4,000			81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.57	81.47	81.39	81.39	81.31	81.23	80.95	80.68	80.21	80.02	79.68	79.47	78.48
5,000				82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.72	82.62	82.54	82.54	82.47	82.38	82.10	81.83	81.36	81.17	80.83	80.62	79.63
6,000					83.87	83.87	83.87	83.87	83.87	83.87	83.87	83.84	83.74	83.67	83.67	83.59	83.50	83.23	82.95	82.48	82.29	81.96	81.75	80.76
7,000						84.28	84.28	84.28	84.28	84.28	84.28	84.26	84.16	84.08	84.08	84.00	83.92	83.64	83.37	82.90	82.71	82.37	82.16	81.17
8,000							86.44	86.44	86.44	86.44	86.44	86.41	86.31	86.24	86.24	86.16	86.07	85.79	85.52	85.05	84.86	84.52	84.32	83.33
9,000								87.31	87.31	87.31	87.31	87.28	87.18	87.11	87.11	87.03	86.95	86.67	86.39	85.92	85.73	85.40	85.19	84.20
10,000									88.13	88.13	88.13	88.10	88.00	87.93	87.93	87.85	87.77	87.49	87.21	86.74	86.55	86.22	86.01	85.02
11,000										88.21	88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
12,000											88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
13,000												88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
14,000													88.47	88.40	88.40	88.32	88.24	87.96	87.68	87.21	87.02	86.69	86.48	85.49
15,000														88.46	88.46	88.38	88.30	88.02	87.75	87.28	87.09	86.75	86.54	85.55
16,000															88.68	88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
17,000																88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
18,000																	89.09	88.81	88.54	88.07	87.88	87.54	87.33	86.34
19,000																		89.12	88.85	88.38	88.19	87.85	87.64	86.65
20,000																			88.85	88.38	88.19	87.85	87.64	86.65
21,000																				88.38	88.19	87.85	87.64	86.65
22,000																					88.71	88.38	88.17	87.18
23,000																						88.95	88.74	87.75
24,000																							89.05	88.07
25,000																								88.07

Table 4.2-26: Adult Yellow Lampmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.8%	88.7%	88.7%	88.6%	88.5%	88.2%	87.9%	87.4%	87.2%	86.8%	86.6%	85.5%
3,000		90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.6%	90.6%	90.5%	90.4%	90.1%	89.8%	89.3%	89.1%	88.7%	88.5%	87.3%
4,000			91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.4%	91.3%	91.3%	91.2%	91.1%	90.8%	90.5%	90.0%	89.8%	89.4%	89.2%	88.1%
5,000				92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.7%	92.6%	92.6%	92.5%	92.4%	92.1%	91.8%	91.3%	91.1%	90.7%	90.5%	89.4%
6,000					94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.0%	93.9%	93.9%	93.8%	93.7%	93.4%	93.1%	92.6%	92.3%	92.0%	91.7%	90.6%
7,000						94.6%	94.6%	94.6%	94.6%	94.6%	94.6%	94.5%	94.4%	94.3%	94.3%	94.3%	94.2%	93.8%	93.5%	93.0%	92.8%	92.4%	92.2%	91.1%
8,000							97.0%	97.0%	97.0%	97.0%	97.0%	97.0%	96.8%	96.8%	96.8%	96.7%	96.6%	96.3%	96.0%	95.4%	95.2%	94.8%	94.6%	93.5%
9,000								98.0%	98.0%	98.0%	98.0%	97.9%	97.8%	97.7%	97.7%	97.7%	97.6%	97.2%	96.9%	96.4%	96.2%	95.8%	95.6%	94.5%
10,000									98.9%	98.9%	98.9%	98.9%	98.7%	98.7%	98.7%	98.6%	98.5%	98.2%	97.9%	97.3%	97.1%	96.7%	96.5%	95.4%
11,000										99.0%	99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
12,000											99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
13,000												98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
14,000													99.3%	99.2%	99.2%	99.1%	99.0%	98.7%	98.4%	97.9%	97.6%	97.3%	97.0%	95.9%
15,000														99.3%	99.3%	99.2%	99.1%	98.8%	98.5%	97.9%	97.7%	97.3%	97.1%	96.0%
16,000															99.5%	99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
17,000																99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
18,000																	100.0%	99.7%	99.3%	98.8%	98.6%	98.2%	98.0%	96.9%
19,000																		100.0%	99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
20,000																			99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
21,000																				99.2%	99.0%	98.6%	98.3%	97.2%
22,000																					99.5%	99.2%	98.9%	97.8%
23,000																						99.8%	99.6%	98.5%
24,000																							99.9%	98.8%
25,000																								98.8%

Table 4.2-27: Adult Yellow Lampmussel 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.85	84.85	84.78	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.82	84.70	84.65	84.59	84.57	84.32	84.15	84.00	83.57	83.31	83.08	82.73
3,000		85.26	85.20	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.23	85.11	85.06	85.01	84.98	84.73	84.57	84.41	83.98	83.73	83.49	83.15
4,000			85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.46	85.34	85.29	85.24	85.21	84.96	84.79	84.64	84.21	83.96	83.72	83.37
5,000				85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.82	85.70	85.65	85.60	85.57	85.32	85.16	85.01	84.57	84.32	84.08	83.74
6,000					86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.52	86.39	86.34	86.29	86.26	86.01	85.85	85.70	85.27	85.01	84.77	84.43
7,000						87.52	87.52	87.52	87.52	87.52	87.52	87.52	87.50	87.37	87.32	87.27	87.24	86.99	86.83	86.68	86.25	85.99	85.75	85.41
8,000							88.21	88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
9,000								88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
10,000									88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
11,000										88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
12,000											88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
13,000												88.32	88.29	88.17	88.12	88.07	88.04	87.79	87.62	87.47	87.04	86.78	86.55	86.20
14,000													88.98	88.85	88.80	88.75	88.72	88.47	88.31	88.16	87.73	87.47	87.23	86.89
15,000														89.15	89.09	89.04	89.02	88.76	88.60	88.45	88.02	87.76	87.53	87.18
16,000															89.29	89.24	89.21	88.96	88.79	88.64	88.21	87.95	87.72	87.37
17,000																89.51	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
18,000																	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
19,000																		89.23	89.07	88.92	88.49	88.23	87.99	87.65
20,000																			89.60	89.44	89.01	88.76	88.52	88.17
21,000																				89.44	89.01	88.76	88.52	88.17
22,000																					89.56	89.30	89.06	88.72
23,000																						89.32	89.09	88.74
24,000																							89.41	89.06
25,000																								89.17

Table 4.2-28: Adult Yellow Lampmussel 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.7%	94.6%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.5%	94.5%	94.4%	94.4%	94.1%	93.9%	93.8%	93.3%	93.0%	92.7%	92.3%
3,000		95.2%	95.1%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.1%	95.0%	94.9%	94.9%	94.9%	94.6%	94.4%	94.2%	93.7%	93.5%	93.2%	92.8%
4,000			95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.2%	95.2%	95.1%	95.1%	94.8%	94.6%	94.5%	94.0%	93.7%	93.4%	93.1%
5,000				95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.7%	95.6%	95.5%	95.5%	95.2%	95.0%	94.9%	94.4%	94.1%	93.8%	93.5%
6,000					96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.4%	96.4%	96.3%	96.3%	96.0%	95.8%	95.7%	95.2%	94.9%	94.6%	94.2%
7,000						97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.5%	97.5%	97.4%	97.4%	97.1%	96.9%	96.7%	96.3%	96.0%	95.7%	95.3%
8,000							98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
9,000								98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
10,000									98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
11,000										98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
12,000											98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
13,000												98.6%	98.5%	98.4%	98.3%	98.3%	98.3%	98.0%	97.8%	97.6%	97.2%	96.9%	96.6%	96.2%
14,000													99.3%	99.2%	99.1%	99.1%	99.0%	98.7%	98.6%	98.4%	97.9%	97.6%	97.4%	97.0%
15,000														99.5%	99.4%	99.4%	99.4%	99.1%	98.9%	98.7%	98.2%	98.0%	97.7%	97.3%
16,000															99.7%	99.6%	99.6%	99.3%	99.1%	98.9%	98.5%	98.2%	97.9%	97.5%
17,000																99.9%	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
18,000																	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
19,000																		99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
20,000																			100.0%	99.8%	99.4%	99.1%	98.8%	98.4%
21,000																				99.8%	99.4%	99.1%	98.8%	98.4%
22,000																					100.0%	99.7%	99.4%	99.0%
23,000																						99.7%	99.4%	99.0%
24,000																							99.8%	99.4%
25,000																								99.5%

Table 4.2-29: Adult Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft²) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.25	79.19	79.19	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.23	79.13	79.05	79.05	78.97	78.89	78.64	78.36	77.89	77.70	77.37	77.16	76.17
3,000		80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.92	80.82	80.75	80.75	80.67	80.59	80.31	80.04	79.57	79.37	79.04	78.83	77.84
4,000			81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.57	81.47	81.39	81.39	81.31	81.23	80.95	80.68	80.21	80.02	79.68	79.47	78.48
5,000				82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.72	82.62	82.54	82.54	82.47	82.38	82.10	81.83	81.36	81.17	80.83	80.62	79.63
6,000					83.87	83.87	83.87	83.87	83.87	83.87	83.87	83.84	83.74	83.67	83.67	83.59	83.50	83.23	82.95	82.48	82.29	81.96	81.75	80.76
7,000						84.28	84.28	84.28	84.28	84.28	84.28	84.26	84.16	84.08	84.08	84.00	83.92	83.64	83.37	82.90	82.71	82.37	82.16	81.17
8,000							86.44	86.44	86.44	86.44	86.44	86.41	86.31	86.24	86.24	86.16	86.07	85.79	85.52	85.05	84.86	84.52	84.32	83.33
9,000								87.31	87.31	87.31	87.31	87.28	87.18	87.11	87.11	87.03	86.95	86.67	86.39	85.92	85.73	85.40	85.19	84.20
10,000									88.13	88.13	88.13	88.10	88.00	87.93	87.93	87.85	87.77	87.49	87.21	86.74	86.55	86.22	86.01	85.02
11,000										88.21	88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
12,000											88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
13,000												88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
14,000													88.47	88.40	88.40	88.32	88.24	87.96	87.68	87.21	87.02	86.69	86.48	85.49
15,000														88.46	88.46	88.38	88.30	88.02	87.75	87.28	87.09	86.75	86.54	85.55
16,000															88.68	88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
17,000																88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
18,000																	89.09	88.81	88.54	88.07	87.88	87.54	87.33	86.34
19,000																		89.12	88.85	88.38	88.19	87.85	87.64	86.65
20,000																			88.85	88.38	88.19	87.85	87.64	86.65
21,000																				88.38	88.19	87.85	87.64	86.65
22,000																					88.71	88.38	88.17	87.18
23,000																						88.95	88.74	87.75
24,000																							89.05	88.07
25,000																								88.07

Table 4.2-30: Adult Yellow Lampmussel 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.8%	88.7%	88.7%	88.6%	88.5%	88.2%	87.9%	87.4%	87.2%	86.8%	86.6%	85.5%
3,000		90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.6%	90.6%	90.5%	90.4%	90.1%	89.8%	89.3%	89.1%	88.7%	88.5%	87.3%
4,000			91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.4%	91.3%	91.3%	91.2%	91.1%	90.8%	90.5%	90.0%	89.8%	89.4%	89.2%	88.1%
5,000				92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.7%	92.6%	92.6%	92.5%	92.4%	92.1%	91.8%	91.3%	91.1%	90.7%	90.5%	89.4%
6,000					94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.0%	93.9%	93.9%	93.8%	93.7%	93.4%	93.1%	92.6%	92.3%	92.0%	91.7%	90.6%
7,000						94.6%	94.6%	94.6%	94.6%	94.6%	94.6%	94.5%	94.4%	94.3%	94.3%	94.3%	94.2%	93.8%	93.5%	93.0%	92.8%	92.4%	92.2%	91.1%
8,000							97.0%	97.0%	97.0%	97.0%	97.0%	97.0%	96.8%	96.8%	96.8%	96.7%	96.6%	96.3%	96.0%	95.4%	95.2%	94.8%	94.6%	93.5%
9,000								98.0%	98.0%	98.0%	98.0%	97.9%	97.8%	97.7%	97.7%	97.7%	97.6%	97.2%	96.9%	96.4%	96.2%	95.8%	95.6%	94.5%
10,000									98.9%	98.9%	98.9%	98.9%	98.7%	98.7%	98.7%	98.6%	98.5%	98.2%	97.9%	97.3%	97.1%	96.7%	96.5%	95.4%
11,000										99.0%	99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
12,000											99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
13,000												98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
14,000													99.3%	99.2%	99.2%	99.1%	99.0%	98.7%	98.4%	97.9%	97.6%	97.3%	97.0%	95.9%
15,000														99.3%	99.3%	99.2%	99.1%	98.8%	98.5%	97.9%	97.7%	97.3%	97.1%	96.0%
16,000															99.5%	99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
17,000																99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
18,000																	100.0%	99.7%	99.3%	98.8%	98.6%	98.2%	98.0%	96.9%
19,000																		100.0%	99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
20,000																			99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
21,000																				99.2%	99.0%	98.6%	98.3%	97.2%
22,000																					99.5%	99.2%	98.9%	97.8%
23,000																						99.8%	99.6%	98.5%
24,000																							99.9%	98.8%
25,000																								98.8%

Table 4.2-31: Adult Yellow Lampmussel 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.85	84.85	84.78	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.82	84.70	84.65	84.59	84.57	84.32	84.15	84.00	83.57	83.31	83.08	82.73
3,000		85.26	85.20	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.23	85.11	85.06	85.01	84.98	84.73	84.57	84.41	83.98	83.73	83.49	83.15
4,000			85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.46	85.34	85.29	85.24	85.21	84.96	84.79	84.64	84.21	83.96	83.72	83.37
5,000				85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.82	85.70	85.65	85.60	85.57	85.32	85.16	85.01	84.57	84.32	84.08	83.74
6,000					86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.52	86.39	86.34	86.29	86.26	86.01	85.85	85.70	85.27	85.01	84.77	84.43
7,000						87.52	87.52	87.52	87.52	87.52	87.52	87.52	87.50	87.37	87.32	87.27	87.24	86.99	86.83	86.68	86.25	85.99	85.75	85.41
8,000							88.21	88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
9,000								88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
10,000									88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
11,000										88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
12,000											88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
13,000												88.32	88.29	88.17	88.12	88.07	88.04	87.79	87.62	87.47	87.04	86.78	86.55	86.20
14,000													88.98	88.85	88.80	88.75	88.72	88.47	88.31	88.16	87.73	87.47	87.23	86.89
15,000														89.15	89.09	89.04	89.02	88.76	88.60	88.45	88.02	87.76	87.53	87.18
16,000															89.29	89.24	89.21	88.96	88.79	88.64	88.21	87.95	87.72	87.37
17,000																89.51	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
18,000																	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
19,000																		89.23	89.07	88.92	88.49	88.23	87.99	87.65
20,000																			89.60	89.44	89.01	88.76	88.52	88.17
21,000																				89.44	89.01	88.76	88.52	88.17
22,000																					89.56	89.30	89.06	88.72
23,000																						89.32	89.09	88.74
24,000																							89.41	89.06
25,000																								89.17

Table 4.2-32: Adult Yellow Lampmussel 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.7%	94.6%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.5%	94.5%	94.4%	94.4%	94.1%	93.9%	93.8%	93.3%	93.0%	92.7%	92.3%
3,000		95.2%	95.1%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.1%	95.0%	94.9%	94.9%	94.9%	94.6%	94.4%	94.2%	93.7%	93.5%	93.2%	92.8%
4,000			95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.2%	95.2%	95.1%	95.1%	94.8%	94.6%	94.5%	94.0%	93.7%	93.4%	93.1%
5,000				95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.7%	95.6%	95.5%	95.5%	95.2%	95.0%	94.9%	94.4%	94.1%	93.8%	93.5%
6,000					96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.4%	96.4%	96.3%	96.3%	96.0%	95.8%	95.7%	95.2%	94.9%	94.6%	94.2%
7,000						97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.5%	97.5%	97.4%	97.4%	97.1%	96.9%	96.7%	96.3%	96.0%	95.7%	95.3%
8,000							98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
9,000								98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
10,000									98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
11,000										98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
12,000											98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
13,000												98.6%	98.5%	98.4%	98.3%	98.3%	98.3%	98.0%	97.8%	97.6%	97.2%	96.9%	96.6%	96.2%
14,000													99.3%	99.2%	99.1%	99.1%	99.0%	98.7%	98.6%	98.4%	97.9%	97.6%	97.4%	97.0%
15,000														99.5%	99.4%	99.4%	99.4%	99.1%	98.9%	98.7%	98.2%	98.0%	97.7%	97.3%
16,000															99.7%	99.6%	99.6%	99.3%	99.1%	98.9%	98.5%	98.2%	97.9%	97.5%
17,000																99.9%	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
18,000																	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
19,000																		99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
20,000																			100.0 %	99.8%	99.4%	99.1%	98.8%	98.4%
21,000																				99.8%	99.4%	99.1%	98.8%	98.4%
22,000																					100.0 %	99.7%	99.4%	99.0%
23,000																						99.7%	99.4%	99.0%
24,000																							99.8%	99.4%
25,000																								99.5%

Table 4.2-33: Adult Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft²) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.25	79.19	79.19	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.23	79.13	79.05	79.05	78.97	78.89	78.64	78.36	77.89	77.70	77.37	77.16	76.17
3,000		80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.92	80.82	80.75	80.75	80.67	80.59	80.31	80.04	79.57	79.37	79.04	78.83	77.84
4,000			81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.57	81.47	81.39	81.39	81.31	81.23	80.95	80.68	80.21	80.02	79.68	79.47	78.48
5,000				82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.72	82.62	82.54	82.54	82.47	82.38	82.10	81.83	81.36	81.17	80.83	80.62	79.63
6,000					83.87	83.87	83.87	83.87	83.87	83.87	83.87	83.84	83.74	83.67	83.67	83.59	83.50	83.23	82.95	82.48	82.29	81.96	81.75	80.76
7,000						84.28	84.28	84.28	84.28	84.28	84.28	84.26	84.16	84.08	84.08	84.00	83.92	83.64	83.37	82.90	82.71	82.37	82.16	81.17
8,000							86.44	86.44	86.44	86.44	86.44	86.41	86.31	86.24	86.24	86.16	86.07	85.79	85.52	85.05	84.86	84.52	84.32	83.33
9,000								87.31	87.31	87.31	87.31	87.28	87.18	87.11	87.11	87.03	86.95	86.67	86.39	85.92	85.73	85.40	85.19	84.20
10,000									88.13	88.13	88.13	88.10	88.00	87.93	87.93	87.85	87.77	87.49	87.21	86.74	86.55	86.22	86.01	85.02
11,000										88.21	88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
12,000											88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
13,000												88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
14,000													88.47	88.40	88.40	88.32	88.24	87.96	87.68	87.21	87.02	86.69	86.48	85.49
15,000														88.46	88.46	88.38	88.30	88.02	87.75	87.28	87.09	86.75	86.54	85.55
16,000															88.68	88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
17,000																88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
18,000																	89.09	88.81	88.54	88.07	87.88	87.54	87.33	86.34
19,000																		89.12	88.85	88.38	88.19	87.85	87.64	86.65
20,000																			88.85	88.38	88.19	87.85	87.64	86.65
21,000																				88.38	88.19	87.85	87.64	86.65
22,000																					88.71	88.38	88.17	87.18
23,000																						88.95	88.74	87.75
24,000																							89.05	88.07
25,000																								88.07

Table 4.2-34: Adult Tidewater Mucket 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.8%	88.7%	88.7%	88.6%	88.5%	88.2%	87.9%	87.4%	87.2%	86.8%	86.6%	85.5%
3,000		90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.6%	90.6%	90.5%	90.4%	90.1%	89.8%	89.3%	89.1%	88.7%	88.5%	87.3%
4,000			91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.4%	91.3%	91.3%	91.2%	91.1%	90.8%	90.5%	90.0%	89.8%	89.4%	89.2%	88.1%
5,000				92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.7%	92.6%	92.6%	92.5%	92.4%	92.1%	91.8%	91.3%	91.1%	90.7%	90.5%	89.4%
6,000					94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.0%	93.9%	93.9%	93.8%	93.7%	93.4%	93.1%	92.6%	92.3%	92.0%	91.7%	90.6%
7,000						94.6%	94.6%	94.6%	94.6%	94.6%	94.6%	94.5%	94.4%	94.3%	94.3%	94.3%	94.2%	93.8%	93.5%	93.0%	92.8%	92.4%	92.2%	91.1%
8,000							97.0%	97.0%	97.0%	97.0%	97.0%	97.0%	96.8%	96.8%	96.8%	96.7%	96.6%	96.3%	96.0%	95.4%	95.2%	94.8%	94.6%	93.5%
9,000								98.0%	98.0%	98.0%	98.0%	97.9%	97.8%	97.7%	97.7%	97.7%	97.6%	97.2%	96.9%	96.4%	96.2%	95.8%	95.6%	94.5%
10,000									98.9%	98.9%	98.9%	98.9%	98.7%	98.7%	98.7%	98.6%	98.5%	98.2%	97.9%	97.3%	97.1%	96.7%	96.5%	95.4%
11,000										99.0%	99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
12,000											99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
13,000												98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
14,000													99.3%	99.2%	99.2%	99.1%	99.0%	98.7%	98.4%	97.9%	97.6%	97.3%	97.0%	95.9%
15,000														99.3%	99.3%	99.2%	99.1%	98.8%	98.5%	97.9%	97.7%	97.3%	97.1%	96.0%
16,000															99.5%	99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
17,000																99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
18,000																	100.0%	99.7%	99.3%	98.8%	98.6%	98.2%	98.0%	96.9%
19,000																		100.0%	99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
20,000																			99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
21,000																				99.2%	99.0%	98.6%	98.3%	97.2%
22,000																					99.5%	99.2%	98.9%	97.8%
23,000																						99.8%	99.6%	98.5%
24,000																							99.9%	98.8%
25,000																								98.8%

Table 4.2-35: Adult Tidewater Mucket 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.85	84.85	84.78	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.82	84.70	84.65	84.59	84.57	84.32	84.15	84.00	83.57	83.31	83.08	82.73
3,000		85.26	85.20	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.23	85.11	85.06	85.01	84.98	84.73	84.57	84.41	83.98	83.73	83.49	83.15
4,000			85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.46	85.34	85.29	85.24	85.21	84.96	84.79	84.64	84.21	83.96	83.72	83.37
5,000				85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.82	85.70	85.65	85.60	85.57	85.32	85.16	85.01	84.57	84.32	84.08	83.74
6,000					86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.52	86.39	86.34	86.29	86.26	86.01	85.85	85.70	85.27	85.01	84.77	84.43
7,000						87.52	87.52	87.52	87.52	87.52	87.52	87.52	87.50	87.37	87.32	87.27	87.24	86.99	86.83	86.68	86.25	85.99	85.75	85.41
8,000							88.21	88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
9,000								88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
10,000									88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
11,000										88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
12,000											88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
13,000												88.32	88.29	88.17	88.12	88.07	88.04	87.79	87.62	87.47	87.04	86.78	86.55	86.20
14,000													88.98	88.85	88.80	88.75	88.72	88.47	88.31	88.16	87.73	87.47	87.23	86.89
15,000														89.15	89.09	89.04	89.02	88.76	88.60	88.45	88.02	87.76	87.53	87.18
16,000															89.29	89.24	89.21	88.96	88.79	88.64	88.21	87.95	87.72	87.37
17,000																89.51	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
18,000																	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
19,000																		89.23	89.07	88.92	88.49	88.23	87.99	87.65
20,000																			89.60	89.44	89.01	88.76	88.52	88.17
21,000																				89.44	89.01	88.76	88.52	88.17
22,000																					89.56	89.30	89.06	88.72
23,000																						89.32	89.09	88.74
24,000																							89.41	89.06
25,000																								89.17

Table 4.2-36: Adult Tidewater Mucket 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.7%	94.6%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.5%	94.5%	94.4%	94.4%	94.1%	93.9%	93.8%	93.3%	93.0%	92.7%	92.3%
3,000		95.2%	95.1%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.1%	95.0%	94.9%	94.9%	94.9%	94.6%	94.4%	94.2%	93.7%	93.5%	93.2%	92.8%
4,000			95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.2%	95.2%	95.1%	95.1%	94.8%	94.6%	94.5%	94.0%	93.7%	93.4%	93.1%
5,000				95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.7%	95.6%	95.5%	95.5%	95.2%	95.0%	94.9%	94.4%	94.1%	93.8%	93.5%
6,000					96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.4%	96.4%	96.3%	96.3%	96.0%	95.8%	95.7%	95.2%	94.9%	94.6%	94.2%
7,000						97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.5%	97.5%	97.4%	97.4%	97.1%	96.9%	96.7%	96.3%	96.0%	95.7%	95.3%
8,000							98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
9,000								98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
10,000									98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
11,000										98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
12,000											98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
13,000												98.6%	98.5%	98.4%	98.3%	98.3%	98.3%	98.0%	97.8%	97.6%	97.2%	96.9%	96.6%	96.2%
14,000													99.3%	99.2%	99.1%	99.1%	99.0%	98.7%	98.6%	98.4%	97.9%	97.6%	97.4%	97.0%
15,000														99.5%	99.4%	99.4%	99.4%	99.1%	98.9%	98.7%	98.2%	98.0%	97.7%	97.3%
16,000															99.7%	99.6%	99.6%	99.3%	99.1%	98.9%	98.5%	98.2%	97.9%	97.5%
17,000																99.9%	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
18,000																	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
19,000																		99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
20,000																			100.0 %	99.8%	99.4%	99.1%	98.8%	98.4%
21,000																				99.8%	99.4%	99.1%	98.8%	98.4%
22,000																					100.0 %	99.7%	99.4%	99.0%
23,000																						99.7%	99.4%	99.0%
24,000																							99.8%	99.4%
25,000																								99.5%

Table 4.2-37: Adult Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft²) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.25	79.19	79.19	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.25	79.23	79.13	79.05	79.05	78.97	78.89	78.64	78.36	77.89	77.70	77.37	77.16	76.17
3,000		80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.95	80.92	80.82	80.75	80.75	80.67	80.59	80.31	80.04	79.57	79.37	79.04	78.83	77.84
4,000			81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.59	81.57	81.47	81.39	81.39	81.31	81.23	80.95	80.68	80.21	80.02	79.68	79.47	78.48
5,000				82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.74	82.72	82.62	82.54	82.54	82.47	82.38	82.10	81.83	81.36	81.17	80.83	80.62	79.63
6,000					83.87	83.87	83.87	83.87	83.87	83.87	83.87	83.84	83.74	83.67	83.67	83.59	83.50	83.23	82.95	82.48	82.29	81.96	81.75	80.76
7,000						84.28	84.28	84.28	84.28	84.28	84.28	84.26	84.16	84.08	84.08	84.00	83.92	83.64	83.37	82.90	82.71	82.37	82.16	81.17
8,000							86.44	86.44	86.44	86.44	86.44	86.41	86.31	86.24	86.24	86.16	86.07	85.79	85.52	85.05	84.86	84.52	84.32	83.33
9,000								87.31	87.31	87.31	87.31	87.28	87.18	87.11	87.11	87.03	86.95	86.67	86.39	85.92	85.73	85.40	85.19	84.20
10,000									88.13	88.13	88.13	88.10	88.00	87.93	87.93	87.85	87.77	87.49	87.21	86.74	86.55	86.22	86.01	85.02
11,000										88.21	88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
12,000											88.21	88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
13,000												88.18	88.08	88.01	88.01	87.93	87.85	87.57	87.29	86.83	86.63	86.30	86.09	85.10
14,000													88.47	88.40	88.40	88.32	88.24	87.96	87.68	87.21	87.02	86.69	86.48	85.49
15,000														88.46	88.46	88.38	88.30	88.02	87.75	87.28	87.09	86.75	86.54	85.55
16,000															88.68	88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
17,000																88.60	88.51	88.24	87.96	87.49	87.30	86.97	86.76	85.77
18,000																	89.09	88.81	88.54	88.07	87.88	87.54	87.33	86.34
19,000																		89.12	88.85	88.38	88.19	87.85	87.64	86.65
20,000																			88.85	88.38	88.19	87.85	87.64	86.65
21,000																				88.38	88.19	87.85	87.64	86.65
22,000																					88.71	88.38	88.17	87.18
23,000																						88.95	88.74	87.75
24,000																							89.05	88.07
25,000																								88.07

Table 4.2-38: Adult Tidewater Mucket 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.9%	88.8%	88.7%	88.7%	88.6%	88.5%	88.2%	87.9%	87.4%	87.2%	86.8%	86.6%	85.5%
3,000		90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.8%	90.7%	90.6%	90.6%	90.5%	90.4%	90.1%	89.8%	89.3%	89.1%	88.7%	88.5%	87.3%
4,000			91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.6%	91.5%	91.4%	91.3%	91.3%	91.2%	91.1%	90.8%	90.5%	90.0%	89.8%	89.4%	89.2%	88.1%
5,000				92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.8%	92.7%	92.6%	92.6%	92.5%	92.4%	92.1%	91.8%	91.3%	91.1%	90.7%	90.5%	89.4%
6,000					94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.1%	94.0%	93.9%	93.9%	93.8%	93.7%	93.4%	93.1%	92.6%	92.3%	92.0%	91.7%	90.6%
7,000						94.6%	94.6%	94.6%	94.6%	94.6%	94.6%	94.5%	94.4%	94.3%	94.3%	94.3%	94.2%	93.8%	93.5%	93.0%	92.8%	92.4%	92.2%	91.1%
8,000							97.0%	97.0%	97.0%	97.0%	97.0%	97.0%	96.8%	96.8%	96.8%	96.7%	96.6%	96.3%	96.0%	95.4%	95.2%	94.8%	94.6%	93.5%
9,000								98.0%	98.0%	98.0%	98.0%	97.9%	97.8%	97.7%	97.7%	97.7%	97.6%	97.2%	96.9%	96.4%	96.2%	95.8%	95.6%	94.5%
10,000									98.9%	98.9%	98.9%	98.9%	98.7%	98.7%	98.7%	98.6%	98.5%	98.2%	97.9%	97.3%	97.1%	96.7%	96.5%	95.4%
11,000										99.0%	99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
12,000											99.0%	98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
13,000												98.9%	98.8%	98.8%	98.8%	98.7%	98.6%	98.3%	98.0%	97.4%	97.2%	96.8%	96.6%	95.5%
14,000													99.3%	99.2%	99.2%	99.1%	99.0%	98.7%	98.4%	97.9%	97.6%	97.3%	97.0%	95.9%
15,000														99.3%	99.3%	99.2%	99.1%	98.8%	98.5%	97.9%	97.7%	97.3%	97.1%	96.0%
16,000															99.5%	99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
17,000																99.4%	99.3%	99.0%	98.7%	98.2%	98.0%	97.6%	97.3%	96.2%
18,000																	100.0%	99.7%	99.3%	98.8%	98.6%	98.2%	98.0%	96.9%
19,000																		100.0%	99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
20,000																			99.7%	99.2%	99.0%	98.6%	98.3%	97.2%
21,000																				99.2%	99.0%	98.6%	98.3%	97.2%
22,000																					99.5%	99.2%	98.9%	97.8%
23,000																						99.8%	99.6%	98.5%
24,000																							99.9%	98.8%
25,000																								98.8%

Table 4.2-39: Adult Tidewater Mucket 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.85	84.85	84.78	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.85	84.82	84.70	84.65	84.59	84.57	84.32	84.15	84.00	83.57	83.31	83.08	82.73
3,000		85.26	85.20	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.26	85.23	85.11	85.06	85.01	84.98	84.73	84.57	84.41	83.98	83.73	83.49	83.15
4,000			85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.49	85.46	85.34	85.29	85.24	85.21	84.96	84.79	84.64	84.21	83.96	83.72	83.37
5,000				85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.85	85.82	85.70	85.65	85.60	85.57	85.32	85.16	85.01	84.57	84.32	84.08	83.74
6,000					86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.54	86.52	86.39	86.34	86.29	86.26	86.01	85.85	85.70	85.27	85.01	84.77	84.43
7,000						87.52	87.52	87.52	87.52	87.52	87.52	87.52	87.50	87.37	87.32	87.27	87.24	86.99	86.83	86.68	86.25	85.99	85.75	85.41
8,000							88.21	88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
9,000								88.21	88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
10,000									88.21	88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
11,000										88.21	88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
12,000											88.21	88.21	88.18	88.06	88.01	87.96	87.93	87.68	87.52	87.37	86.93	86.68	86.44	86.10
13,000												88.32	88.29	88.17	88.12	88.07	88.04	87.79	87.62	87.47	87.04	86.78	86.55	86.20
14,000													88.98	88.85	88.80	88.75	88.72	88.47	88.31	88.16	87.73	87.47	87.23	86.89
15,000														89.15	89.09	89.04	89.02	88.76	88.60	88.45	88.02	87.76	87.53	87.18
16,000															89.29	89.24	89.21	88.96	88.79	88.64	88.21	87.95	87.72	87.37
17,000																89.51	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
18,000																	89.49	89.23	89.07	88.92	88.49	88.23	87.99	87.65
19,000																		89.23	89.07	88.92	88.49	88.23	87.99	87.65
20,000																			89.60	89.44	89.01	88.76	88.52	88.17
21,000																				89.44	89.01	88.76	88.52	88.17
22,000																					89.56	89.30	89.06	88.72
23,000																						89.32	89.09	88.74
24,000																							89.41	89.06
25,000																								89.17

Table 4.2-40: Adult Tidewater Mucket 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.7%	94.6%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.7%	94.5%	94.5%	94.4%	94.4%	94.1%	93.9%	93.8%	93.3%	93.0%	92.7%	92.3%
3,000		95.2%	95.1%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.2%	95.1%	95.0%	94.9%	94.9%	94.9%	94.6%	94.4%	94.2%	93.7%	93.5%	93.2%	92.8%
4,000			95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.4%	95.2%	95.2%	95.1%	95.1%	94.8%	94.6%	94.5%	94.0%	93.7%	93.4%	93.1%
5,000				95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.8%	95.7%	95.6%	95.5%	95.5%	95.2%	95.0%	94.9%	94.4%	94.1%	93.8%	93.5%
6,000					96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.6%	96.4%	96.4%	96.3%	96.3%	96.0%	95.8%	95.7%	95.2%	94.9%	94.6%	94.2%
7,000						97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.7%	97.5%	97.5%	97.4%	97.4%	97.1%	96.9%	96.7%	96.3%	96.0%	95.7%	95.3%
8,000							98.5%	98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
9,000								98.5%	98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
10,000									98.5%	98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
11,000										98.5%	98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
12,000											98.5%	98.5%	98.4%	98.3%	98.2%	98.2%	98.1%	97.9%	97.7%	97.5%	97.0%	96.7%	96.5%	96.1%
13,000												98.6%	98.5%	98.4%	98.3%	98.3%	98.3%	98.0%	97.8%	97.6%	97.2%	96.9%	96.6%	96.2%
14,000													99.3%	99.2%	99.1%	99.1%	99.0%	98.7%	98.6%	98.4%	97.9%	97.6%	97.4%	97.0%
15,000														99.5%	99.4%	99.4%	99.4%	99.1%	98.9%	98.7%	98.2%	98.0%	97.7%	97.3%
16,000															99.7%	99.6%	99.6%	99.3%	99.1%	98.9%	98.5%	98.2%	97.9%	97.5%
17,000																99.9%	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
18,000																	99.9%	99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
19,000																		99.6%	99.4%	99.2%	98.8%	98.5%	98.2%	97.8%
20,000																			100.0%	99.8%	99.4%	99.1%	98.8%	98.4%
21,000																				99.8%	99.4%	99.1%	98.8%	98.4%
22,000																					100.0%	99.7%	99.4%	99.0%
23,000																						99.7%	99.4%	99.0%
24,000																							99.8%	99.4%
25,000																								99.5%

Table 4.2-41: Adult Eastern Pondmussel 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.19	79.03	79.03	78.99	78.62	77.68	76.41	74.62	73.04	71.23	68.44	66.25	63.26	59.88	56.30	52.78	48.47	45.11	41.46	37.95	34.34	31.73	29.13	25.80
3,000		80.79	80.79	80.60	80.25	79.31	78.06	76.29	74.69	72.87	70.07	67.85	64.81	61.35	57.71	54.15	49.83	46.35	42.66	39.12	35.37	32.74	30.09	26.69
4,000			81.43	81.24	80.89	79.95	78.70	76.94	75.33	73.52	70.71	68.49	65.43	61.97	58.26	54.69	50.38	46.83	43.11	39.44	35.57	32.93	30.28	26.89
5,000				82.55	82.17	81.24	79.96	78.18	76.57	74.75	71.95	69.71	66.64	63.19	59.41	55.84	51.52	47.98	44.19	40.45	36.58	33.77	31.12	27.67
6,000					83.30	82.36	81.09	79.30	77.70	75.88	73.07	70.83	67.77	64.31	60.41	56.84	52.53	48.98	45.19	41.45	37.58	34.77	32.06	28.62
7,000						82.78	81.50	79.71	78.11	76.29	73.49	71.25	68.18	64.73	60.83	57.26	52.94	49.40	45.60	41.84	37.97	35.16	32.45	29.01
8,000							83.65	81.87	80.27	78.45	75.64	73.40	70.34	66.88	62.98	59.41	55.09	51.55	47.76	44.00	40.13	37.32	34.61	31.16
9,000								82.74	81.14	79.32	76.51	74.27	71.21	67.75	63.85	60.28	55.97	52.42	48.63	44.87	41.00	38.19	35.46	31.64
10,000									81.96	80.14	77.33	75.09	72.03	68.57	64.67	61.10	56.79	53.24	49.45	45.69	41.82	39.01	36.28	32.33
11,000										80.22	77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
12,000											77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
13,000												75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
14,000													72.50	69.04	65.14	61.58	57.26	53.71	49.92	46.16	42.29	39.48	36.75	32.80
15,000														69.11	65.21	61.64	57.32	53.78	49.98	46.22	42.35	39.54	36.81	32.86
16,000															65.42	61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
17,000																61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
18,000																	58.11	54.57	50.77	47.01	43.15	40.33	37.60	33.65
19,000																		54.88	51.08	47.32	43.46	40.64	37.91	33.96
20,000																			51.08	47.32	43.46	40.64	37.91	33.96
21,000																				47.32	43.46	40.64	37.91	33.96
22,000																					43.98	41.17	38.44	34.49
23,000																						41.74	39.01	35.05
24,000																							39.32	35.37
25,000																								35.37

Table 4.2-42: Adult Eastern Pondmussel ~~Mussel~~ 3-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.5%	94.5%	94.4%	94.0%	92.9%	91.3%	89.2%	87.3%	85.1%	81.8%	79.2%	75.6%	71.6%	67.3%	63.1%	57.9%	53.9%	49.6%	45.4%	41.0%	37.9%	34.8%	30.8%
3,000		96.6%	96.6%	96.3%	95.9%	94.8%	93.3%	91.2%	89.3%	87.1%	83.8%	81.1%	77.5%	73.3%	69.0%	64.7%	59.6%	55.4%	51.0%	46.8%	42.3%	39.1%	36.0%	31.9%
4,000			97.3%	97.1%	96.7%	95.6%	94.1%	92.0%	90.1%	87.9%	84.5%	81.9%	78.2%	74.1%	69.6%	65.4%	60.2%	56.0%	51.5%	47.1%	42.5%	39.4%	36.2%	32.1%
5,000				98.7%	98.2%	97.1%	95.6%	93.5%	91.5%	89.4%	86.0%	83.3%	79.7%	75.5%	71.0%	66.8%	61.6%	57.4%	52.8%	48.3%	43.7%	40.4%	37.2%	33.1%
6,000					99.6%	98.5%	96.9%	94.8%	92.9%	90.7%	87.3%	84.7%	81.0%	76.9%	72.2%	67.9%	62.8%	58.6%	54.0%	49.5%	44.9%	41.6%	38.3%	34.2%
7,000						99.0%	97.4%	95.3%	93.4%	91.2%	87.8%	85.2%	81.5%	77.4%	72.7%	68.4%	63.3%	59.0%	54.5%	50.0%	45.4%	42.0%	38.8%	34.7%
8,000							100.0%	97.9%	95.9%	93.8%	90.4%	87.7%	84.1%	79.9%	75.3%	71.0%	65.9%	61.6%	57.1%	52.6%	48.0%	44.6%	41.4%	37.3%
9,000								98.9%	97.0%	94.8%	91.5%	88.8%	85.1%	81.0%	76.3%	72.1%	66.9%	62.7%	58.1%	53.6%	49.0%	45.6%	42.4%	37.8%
10,000									98.0%	95.8%	92.4%	89.8%	86.1%	82.0%	77.3%	73.0%	67.9%	63.6%	59.1%	54.6%	50.0%	46.6%	43.4%	38.6%
11,000										95.9%	92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
12,000											92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
13,000												89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
14,000													86.7%	82.5%	77.9%	73.6%	68.4%	64.2%	59.7%	55.2%	50.6%	47.2%	43.9%	39.2%
15,000														82.6%	77.9%	73.7%	68.5%	64.3%	59.7%	55.3%	50.6%	47.3%	44.0%	39.3%
16,000															78.2%	73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
17,000																73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
18,000																	69.5%	65.2%	60.7%	56.2%	51.6%	48.2%	44.9%	40.2%
19,000																		65.6%	61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
20,000																			61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
21,000																				56.6%	51.9%	48.6%	45.3%	40.6%
22,000																					52.6%	49.2%	45.9%	41.2%
23,000																						49.9%	46.6%	41.9%
24,000																							47.0%	42.3%
25,000																								42.3%

Table 4.2-43: Adult Eastern Pondmussel ~~Mussel~~ 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.78	84.72	84.62	84.71	84.51	84.14	83.30	82.47	80.82	79.48	77.81	74.85	72.73	69.64	66.15	62.92	59.94	55.63	51.31	46.77	43.20	39.89	35.99	33.48
3,000		85.13	85.04	85.06	84.86	84.49	83.65	82.82	81.17	79.83	78.15	75.20	73.08	69.97	66.47	63.25	60.27	55.84	51.49	46.92	43.28	39.97	36.07	33.56
4,000			85.33	85.26	85.06	84.71	83.87	83.07	81.44	80.10	78.42	75.47	73.38	70.26	66.76	63.54	60.56	56.13	51.78	47.21	43.57	40.26	36.36	33.80
5,000				85.78	85.58	85.21	84.36	83.54	81.89	80.55	78.87	75.92	73.80	70.68	67.07	63.84	60.86	56.44	52.09	47.52	43.88	40.57	36.67	34.04
6,000					86.27	85.90	85.06	84.23	82.59	81.24	79.57	76.61	74.49	71.38	67.76	64.54	61.56	57.13	52.78	48.21	44.57	41.26	37.36	34.74
7,000						86.88	86.04	85.21	83.56	82.22	80.55	77.59	75.47	72.36	68.74	65.52	62.54	58.11	53.76	49.19	45.55	42.24	38.34	35.71
8,000							86.72	85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
9,000								85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
10,000									84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
11,000										82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
12,000											81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
13,000												78.38	76.27	73.15	69.53	66.31	63.33	58.90	54.55	49.99	46.34	43.03	39.13	36.51
14,000													76.95	73.84	70.22	66.99	64.02	59.59	55.24	50.67	47.03	43.72	39.82	37.19
15,000														74.13	70.51	67.29	64.31	59.88	55.53	50.96	47.32	44.01	40.11	37.49
16,000															70.70	67.48	64.50	60.07	55.72	51.16	47.51	44.20	40.30	37.68
17,000																67.76	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
18,000																	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
19,000																		60.35	56.00	51.43	47.79	44.48	40.58	37.96
20,000																			56.53	51.96	48.31	45.01	41.10	38.48
21,000																				51.96	48.31	45.01	41.10	38.48
22,000																					48.86	45.55	41.65	39.03
23,000																						45.57	41.67	39.05
24,000																							41.99	39.37
25,000																								39.48

Table 4.2-44: Adult Eastern Pondmussel ~~Mussel~~ 3-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	97.6%	97.5%	97.4%	97.5%	97.3%	96.8%	95.9%	94.9%	93.0%	91.5%	89.6%	86.2%	83.7%	80.2%	76.1%	72.4%	69.0%	64.0%	59.1%	53.8%	49.7%	45.9%	41.4%	38.5%
3,000		98.0%	97.9%	97.9%	97.7%	97.2%	96.3%	95.3%	93.4%	91.9%	90.0%	86.6%	84.1%	80.5%	76.5%	72.8%	69.4%	64.3%	59.3%	54.0%	49.8%	46.0%	41.5%	38.6%
4,000			98.2%	98.1%	97.9%	97.5%	96.5%	95.6%	93.7%	92.2%	90.3%	86.9%	84.5%	80.9%	76.8%	73.1%	69.7%	64.6%	59.6%	54.3%	50.2%	46.3%	41.9%	38.9%
5,000				98.7%	98.5%	98.1%	97.1%	96.2%	94.3%	92.7%	90.8%	87.4%	84.9%	81.4%	77.2%	73.5%	70.1%	65.0%	60.0%	54.7%	50.5%	46.7%	42.2%	39.2%
6,000					99.3%	98.9%	97.9%	97.0%	95.1%	93.5%	91.6%	88.2%	85.7%	82.2%	78.0%	74.3%	70.9%	65.8%	60.8%	55.5%	51.3%	47.5%	43.0%	40.0%
7,000						100.0%	99.0%	98.1%	96.2%	94.6%	92.7%	89.3%	86.9%	83.3%	79.1%	75.4%	72.0%	66.9%	61.9%	56.6%	52.4%	48.6%	44.1%	41.1%
8,000							99.8%	98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
9,000								98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
10,000									97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
11,000										95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
12,000											93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
13,000												90.2%	87.8%	84.2%	80.0%	76.3%	72.9%	67.8%	62.8%	57.5%	53.3%	49.5%	45.0%	42.0%
14,000													88.6%	85.0%	80.8%	77.1%	73.7%	68.6%	63.6%	58.3%	54.1%	50.3%	45.8%	42.8%
15,000														85.3%	81.2%	77.5%	74.0%	68.9%	63.9%	58.7%	54.5%	50.7%	46.2%	43.1%
16,000															81.4%	77.7%	74.2%	69.1%	64.1%	58.9%	54.7%	50.9%	46.4%	43.4%
17,000																78.0%	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
18,000																	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
19,000																		69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
20,000																			65.1%	59.8%	55.6%	51.8%	47.3%	44.3%
21,000																				59.8%	55.6%	51.8%	47.3%	44.3%
22,000																					56.2%	52.4%	47.9%	44.9%
23,000																						52.5%	48.0%	44.9%
24,000																							48.3%	45.3%
25,000																								45.4%

Table 4.2-45: Adult Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	79.19	79.03	79.03	78.99	78.62	77.68	76.41	74.62	73.04	71.23	68.44	66.25	63.26	59.88	56.30	52.78	48.47	45.11	41.46	37.95	34.34	31.73	29.13	25.80
3,000		80.79	80.79	80.60	80.25	79.31	78.06	76.29	74.69	72.87	70.07	67.85	64.81	61.35	57.71	54.15	49.83	46.35	42.66	39.12	35.37	32.74	30.09	26.69
4,000			81.43	81.24	80.89	79.95	78.70	76.94	75.33	73.52	70.71	68.49	65.43	61.97	58.26	54.69	50.38	46.83	43.11	39.44	35.57	32.93	30.28	26.89
5,000				82.55	82.17	81.24	79.96	78.18	76.57	74.75	71.95	69.71	66.64	63.19	59.41	55.84	51.52	47.98	44.19	40.45	36.58	33.77	31.12	27.67
6,000					83.30	82.36	81.09	79.30	77.70	75.88	73.07	70.83	67.77	64.31	60.41	56.84	52.53	48.98	45.19	41.45	37.58	34.77	32.06	28.62
7,000						82.78	81.50	79.71	78.11	76.29	73.49	71.25	68.18	64.73	60.83	57.26	52.94	49.40	45.60	41.84	37.97	35.16	32.45	29.01
8,000							83.65	81.87	80.27	78.45	75.64	73.40	70.34	66.88	62.98	59.41	55.09	51.55	47.76	44.00	40.13	37.32	34.61	31.16
9,000								82.74	81.14	79.32	76.51	74.27	71.21	67.75	63.85	60.28	55.97	52.42	48.63	44.87	41.00	38.19	35.46	31.64
10,000									81.96	80.14	77.33	75.09	72.03	68.57	64.67	61.10	56.79	53.24	49.45	45.69	41.82	39.01	36.28	32.33
11,000										80.22	77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
12,000											77.41	75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
13,000												75.18	72.11	68.65	64.75	61.19	56.87	53.32	49.53	45.77	41.90	39.09	36.36	32.41
14,000													72.50	69.04	65.14	61.58	57.26	53.71	49.92	46.16	42.29	39.48	36.75	32.80
15,000														69.11	65.21	61.64	57.32	53.78	49.98	46.22	42.35	39.54	36.81	32.86
16,000															65.42	61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
17,000																61.85	57.54	53.99	50.20	46.44	42.57	39.76	37.03	33.07
18,000																	58.11	54.57	50.77	47.01	43.15	40.33	37.60	33.65
19,000																		54.88	51.08	47.32	43.46	40.64	37.91	33.96
20,000																			51.08	47.32	43.46	40.64	37.91	33.96
21,000																				47.32	43.46	40.64	37.91	33.96
22,000																					43.98	41.17	38.44	34.49
23,000																						41.74	39.01	35.05
24,000																							39.32	35.37
25,000																								35.37

Table 4.2-46: Adult Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, Low Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	94.7%	94.5%	94.5%	94.4%	94.0%	92.9%	91.3%	89.2%	87.3%	85.1%	81.8%	79.2%	75.6%	71.6%	67.3%	63.1%	57.9%	53.9%	49.6%	45.4%	41.0%	37.9%	34.8%	30.8%
3,000		96.6%	96.6%	96.3%	95.9%	94.8%	93.3%	91.2%	89.3%	87.1%	83.8%	81.1%	77.5%	73.3%	69.0%	64.7%	59.6%	55.4%	51.0%	46.8%	42.3%	39.1%	36.0%	31.9%
4,000			97.3%	97.1%	96.7%	95.6%	94.1%	92.0%	90.1%	87.9%	84.5%	81.9%	78.2%	74.1%	69.6%	65.4%	60.2%	56.0%	51.5%	47.1%	42.5%	39.4%	36.2%	32.1%
5,000				98.7%	98.2%	97.1%	95.6%	93.5%	91.5%	89.4%	86.0%	83.3%	79.7%	75.5%	71.0%	66.8%	61.6%	57.4%	52.8%	48.3%	43.7%	40.4%	37.2%	33.1%
6,000					99.6%	98.5%	96.9%	94.8%	92.9%	90.7%	87.3%	84.7%	81.0%	76.9%	72.2%	67.9%	62.8%	58.6%	54.0%	49.5%	44.9%	41.6%	38.3%	34.2%
7,000						99.0%	97.4%	95.3%	93.4%	91.2%	87.8%	85.2%	81.5%	77.4%	72.7%	68.4%	63.3%	59.0%	54.5%	50.0%	45.4%	42.0%	38.8%	34.7%
8,000							100.0%	97.9%	95.9%	93.8%	90.4%	87.7%	84.1%	79.9%	75.3%	71.0%	65.9%	61.6%	57.1%	52.6%	48.0%	44.6%	41.4%	37.3%
9,000								98.9%	97.0%	94.8%	91.5%	88.8%	85.1%	81.0%	76.3%	72.1%	66.9%	62.7%	58.1%	53.6%	49.0%	45.6%	42.4%	37.8%
10,000									98.0%	95.8%	92.4%	89.8%	86.1%	82.0%	77.3%	73.0%	67.9%	63.6%	59.1%	54.6%	50.0%	46.6%	43.4%	38.6%
11,000										95.9%	92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
12,000											92.5%	89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
13,000												89.9%	86.2%	82.1%	77.4%	73.1%	68.0%	63.7%	59.2%	54.7%	50.1%	46.7%	43.5%	38.7%
14,000													86.7%	82.5%	77.9%	73.6%	68.4%	64.2%	59.7%	55.2%	50.6%	47.2%	43.9%	39.2%
15,000														82.6%	77.9%	73.7%	68.5%	64.3%	59.7%	55.3%	50.6%	47.3%	44.0%	39.3%
16,000															78.2%	73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
17,000																73.9%	68.8%	64.5%	60.0%	55.5%	50.9%	47.5%	44.3%	39.5%
18,000																	69.5%	65.2%	60.7%	56.2%	51.6%	48.2%	44.9%	40.2%
19,000																		65.6%	61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
20,000																			61.1%	56.6%	51.9%	48.6%	45.3%	40.6%
21,000																				56.6%	51.9%	48.6%	45.3%	40.6%
22,000																					52.6%	49.2%	45.9%	41.2%
23,000																						49.9%	46.6%	41.9%
24,000																							47.0%	42.3%
25,000																								42.3%

Table 4.2-47: Adult Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area (1,000,000 ft^2) Analysis, by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	84.78	84.72	84.62	84.71	84.51	84.14	83.30	82.47	80.82	79.48	77.81	74.85	72.73	69.64	66.15	62.92	59.94	55.63	51.31	46.77	43.20	39.89	35.99	33.48
3,000		85.13	85.04	85.06	84.86	84.49	83.65	82.82	81.17	79.83	78.15	75.20	73.08	69.97	66.47	63.25	60.27	55.84	51.49	46.92	43.28	39.97	36.07	33.56
4,000			85.33	85.26	85.06	84.71	83.87	83.07	81.44	80.10	78.42	75.47	73.38	70.26	66.76	63.54	60.56	56.13	51.78	47.21	43.57	40.26	36.36	33.80
5,000				85.78	85.58	85.21	84.36	83.54	81.89	80.55	78.87	75.92	73.80	70.68	67.07	63.84	60.86	56.44	52.09	47.52	43.88	40.57	36.67	34.04
6,000					86.27	85.90	85.06	84.23	82.59	81.24	79.57	76.61	74.49	71.38	67.76	64.54	61.56	57.13	52.78	48.21	44.57	41.26	37.36	34.74
7,000						86.88	86.04	85.21	83.56	82.22	80.55	77.59	75.47	72.36	68.74	65.52	62.54	58.11	53.76	49.19	45.55	42.24	38.34	35.71
8,000							86.72	85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
9,000								85.90	84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
10,000									84.25	82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
11,000										82.91	81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
12,000											81.23	78.28	76.16	73.04	69.43	66.20	63.22	58.80	54.45	49.88	46.24	42.93	39.03	36.40
13,000												78.38	76.27	73.15	69.53	66.31	63.33	58.90	54.55	49.99	46.34	43.03	39.13	36.51
14,000													76.95	73.84	70.22	66.99	64.02	59.59	55.24	50.67	47.03	43.72	39.82	37.19
15,000														74.13	70.51	67.29	64.31	59.88	55.53	50.96	47.32	44.01	40.11	37.49
16,000															70.70	67.48	64.50	60.07	55.72	51.16	47.51	44.20	40.30	37.68
17,000																67.76	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
18,000																	64.78	60.35	56.00	51.43	47.79	44.48	40.58	37.96
19,000																		60.35	56.00	51.43	47.79	44.48	40.58	37.96
20,000																			56.53	51.96	48.31	45.01	41.10	38.48
21,000																				51.96	48.31	45.01	41.10	38.48
22,000																					48.86	45.55	41.65	39.03
23,000																						45.57	41.67	39.05
24,000																							41.99	39.37
25,000																								39.48

Table 4.2-48: Adult Eastern Pondmussel ~~Mussel~~ 4-Variable-WUA, High Boundary Conditions Dual Flow Habitat Area Analysis (% max habitat), by Flow Pairs (cfs)

Flow (cfs)	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000
2,000	97.6%	97.5%	97.4%	97.5%	97.3%	96.8%	95.9%	94.9%	93.0%	91.5%	89.6%	86.2%	83.7%	80.2%	76.1%	72.4%	69.0%	64.0%	59.1%	53.8%	49.7%	45.9%	41.4%	38.5%
3,000		98.0%	97.9%	97.9%	97.7%	97.2%	96.3%	95.3%	93.4%	91.9%	90.0%	86.6%	84.1%	80.5%	76.5%	72.8%	69.4%	64.3%	59.3%	54.0%	49.8%	46.0%	41.5%	38.6%
4,000			98.2%	98.1%	97.9%	97.5%	96.5%	95.6%	93.7%	92.2%	90.3%	86.9%	84.5%	80.9%	76.8%	73.1%	69.7%	64.6%	59.6%	54.3%	50.2%	46.3%	41.9%	38.9%
5,000				98.7%	98.5%	98.1%	97.1%	96.2%	94.3%	92.7%	90.8%	87.4%	84.9%	81.4%	77.2%	73.5%	70.1%	65.0%	60.0%	54.7%	50.5%	46.7%	42.2%	39.2%
6,000					99.3%	98.9%	97.9%	97.0%	95.1%	93.5%	91.6%	88.2%	85.7%	82.2%	78.0%	74.3%	70.9%	65.8%	60.8%	55.5%	51.3%	47.5%	43.0%	40.0%
7,000						100.0 %	99.0%	98.1%	96.2%	94.6%	92.7%	89.3%	86.9%	83.3%	79.1%	75.4%	72.0%	66.9%	61.9%	56.6%	52.4%	48.6%	44.1%	41.1%
8,000							99.8%	98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
9,000								98.9%	97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
10,000									97.0%	95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
11,000										95.4%	93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
12,000											93.5%	90.1%	87.7%	84.1%	79.9%	76.2%	72.8%	67.7%	62.7%	57.4%	53.2%	49.4%	44.9%	41.9%
13,000												90.2%	87.8%	84.2%	80.0%	76.3%	72.9%	67.8%	62.8%	57.5%	53.3%	49.5%	45.0%	42.0%
14,000													88.6%	85.0%	80.8%	77.1%	73.7%	68.6%	63.6%	58.3%	54.1%	50.3%	45.8%	42.8%
15,000														85.3%	81.2%	77.5%	74.0%	68.9%	63.9%	58.7%	54.5%	50.7%	46.2%	43.1%
16,000															81.4%	77.7%	74.2%	69.1%	64.1%	58.9%	54.7%	50.9%	46.4%	43.4%
17,000																78.0%	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
18,000																	74.6%	69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
19,000																		69.5%	64.5%	59.2%	55.0%	51.2%	46.7%	43.7%
20,000																			65.1%	59.8%	55.6%	51.8%	47.3%	44.3%
21,000																				59.8%	55.6%	51.8%	47.3%	44.3%
22,000																					56.2%	52.4%	47.9%	44.9%
23,000																						52.5%	48.0%	44.9%
24,000																							48.3%	45.3%
25,000																								45.4%

APPENDIX E-1 – DRY BROOK SUB-REACH SHEAR STRESS MAPS

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
High Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Dry Brook
Low Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

APPENDIX E-2 – HATFIELD SUB-REACH SHEAR STRESS MAPS

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

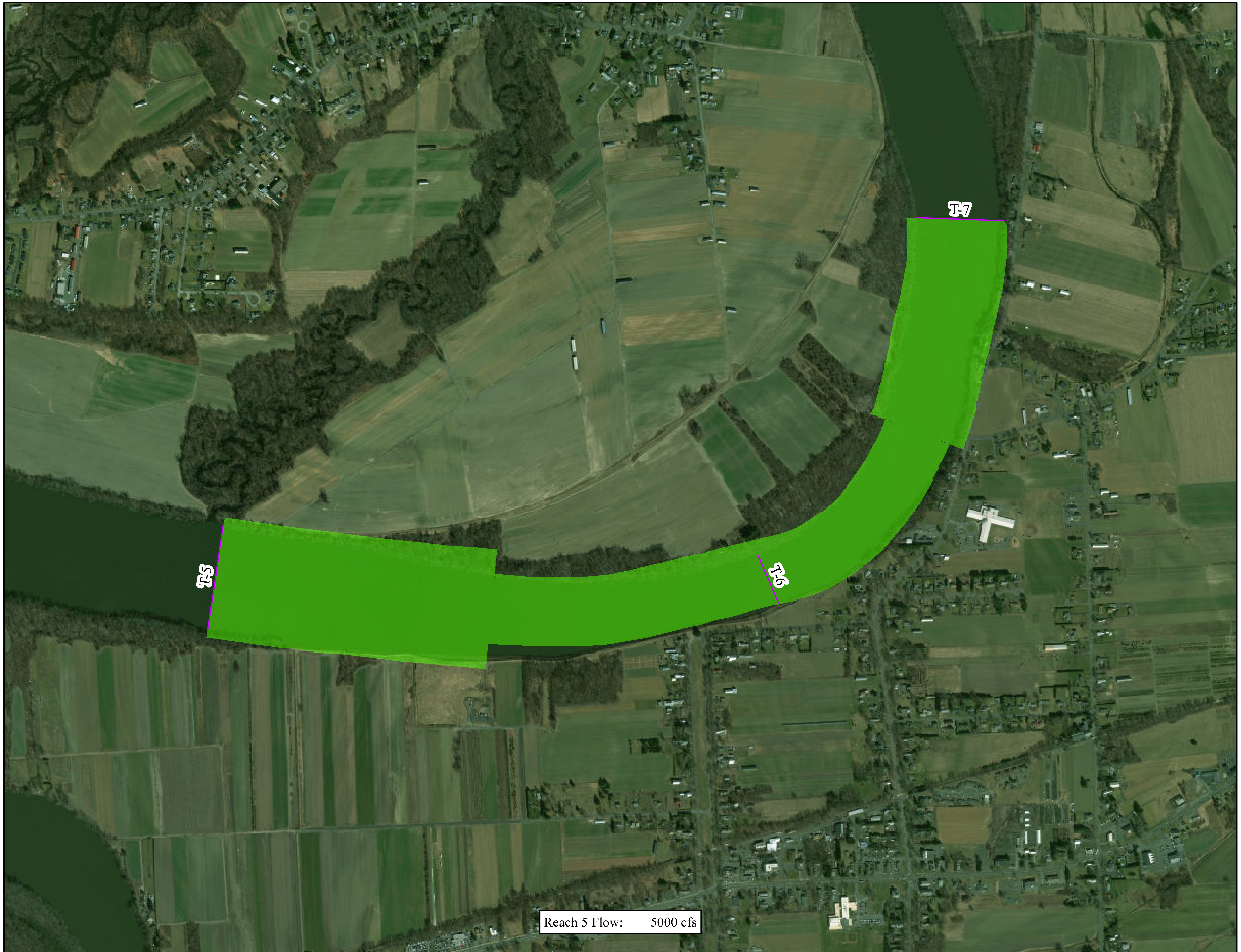
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

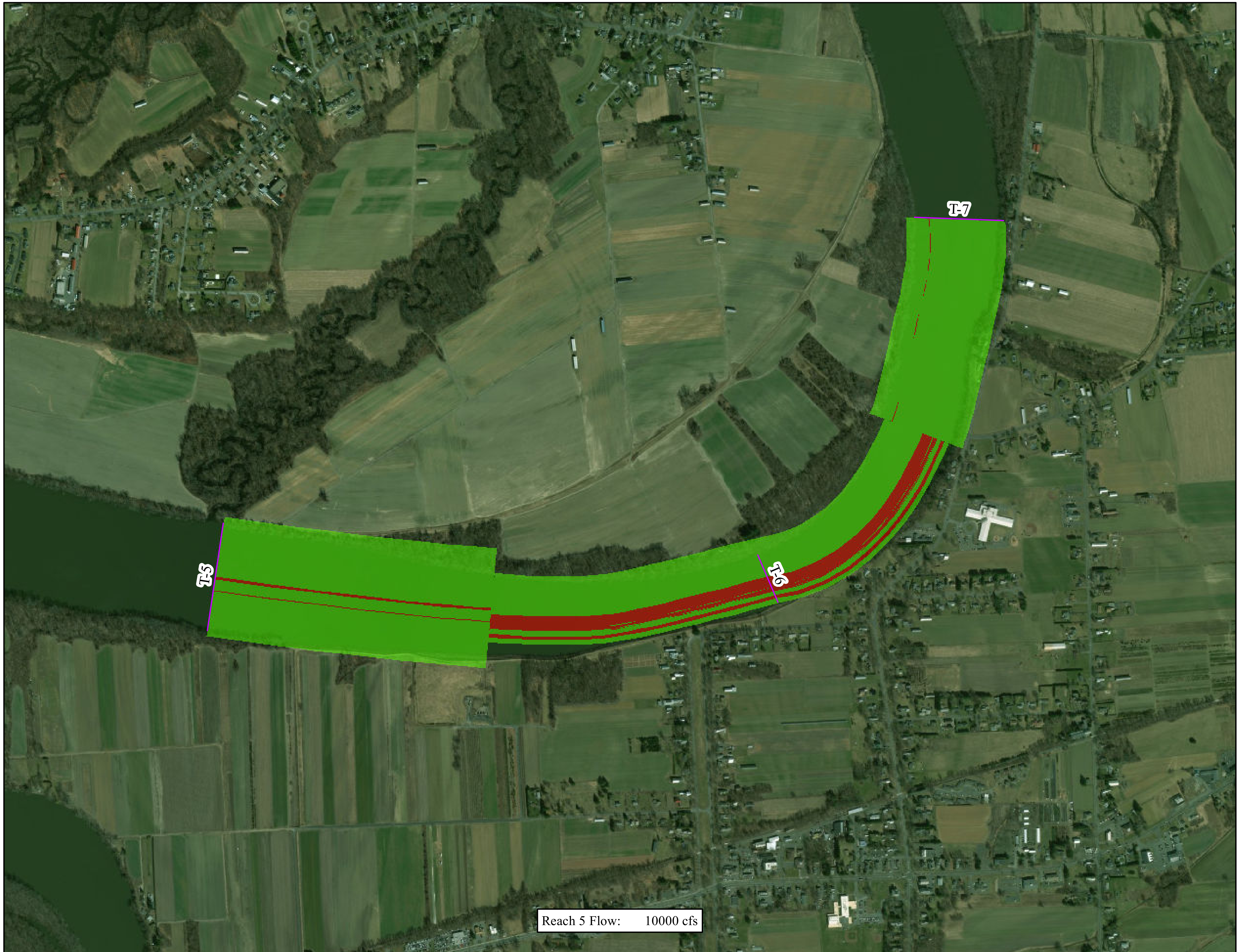
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

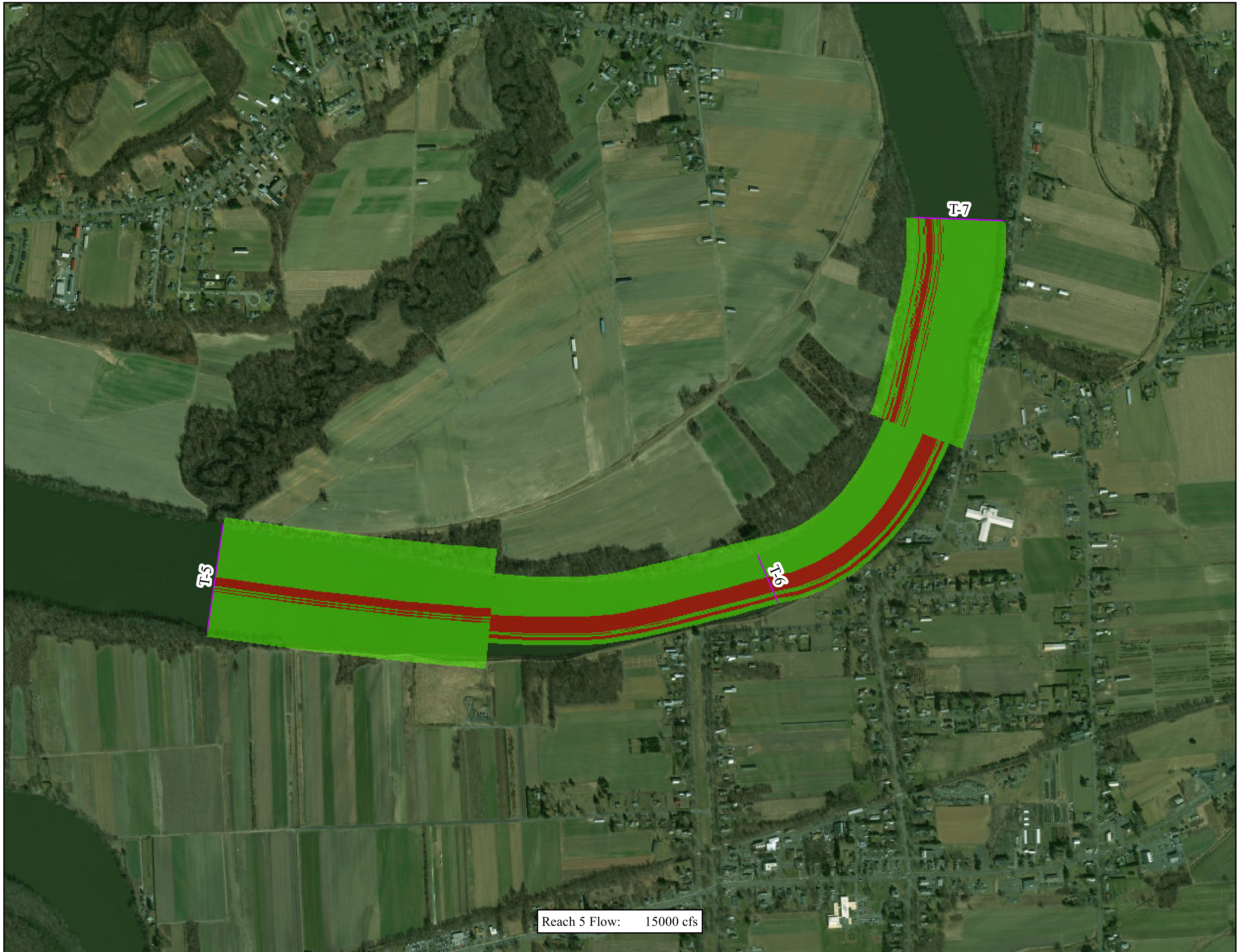
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

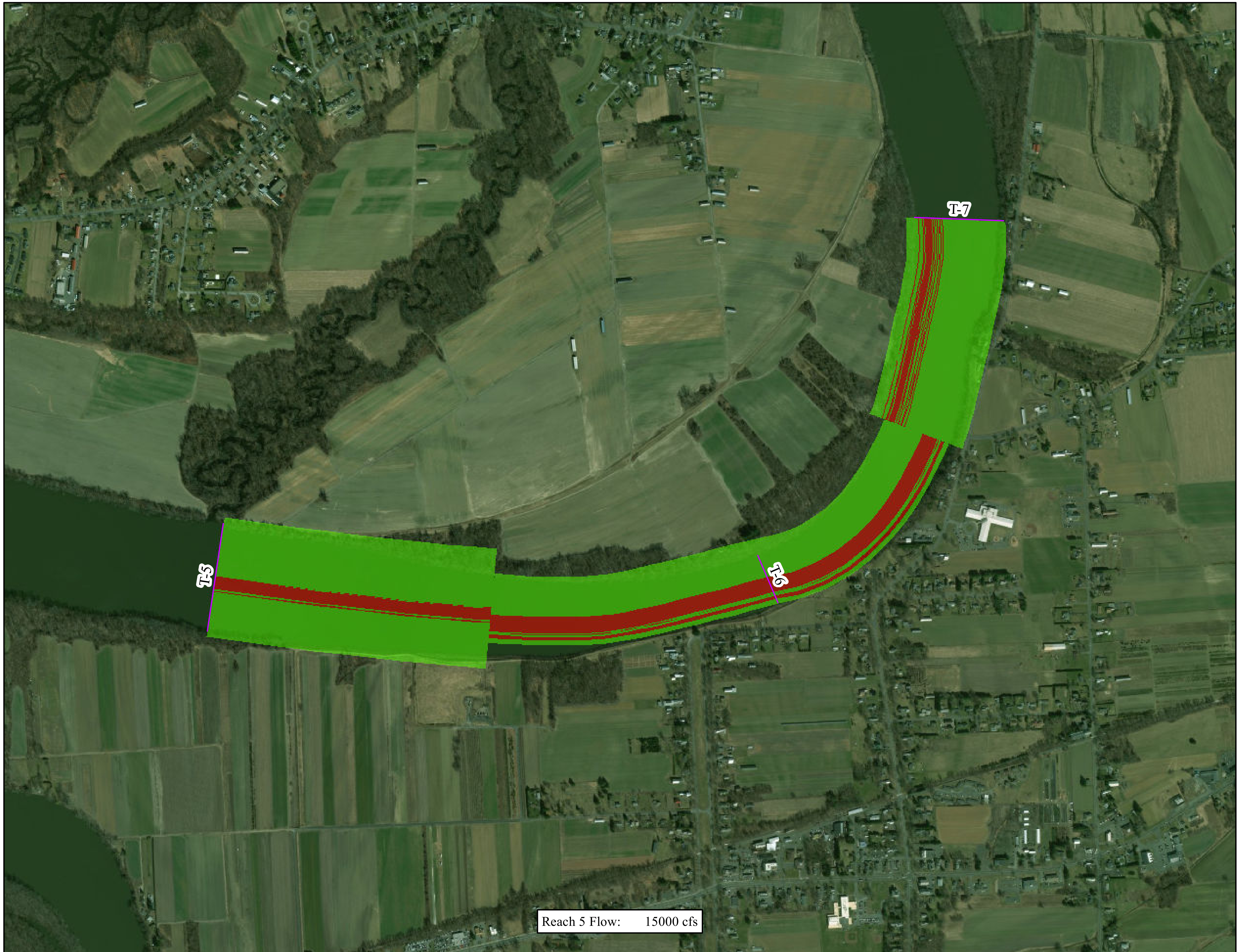
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

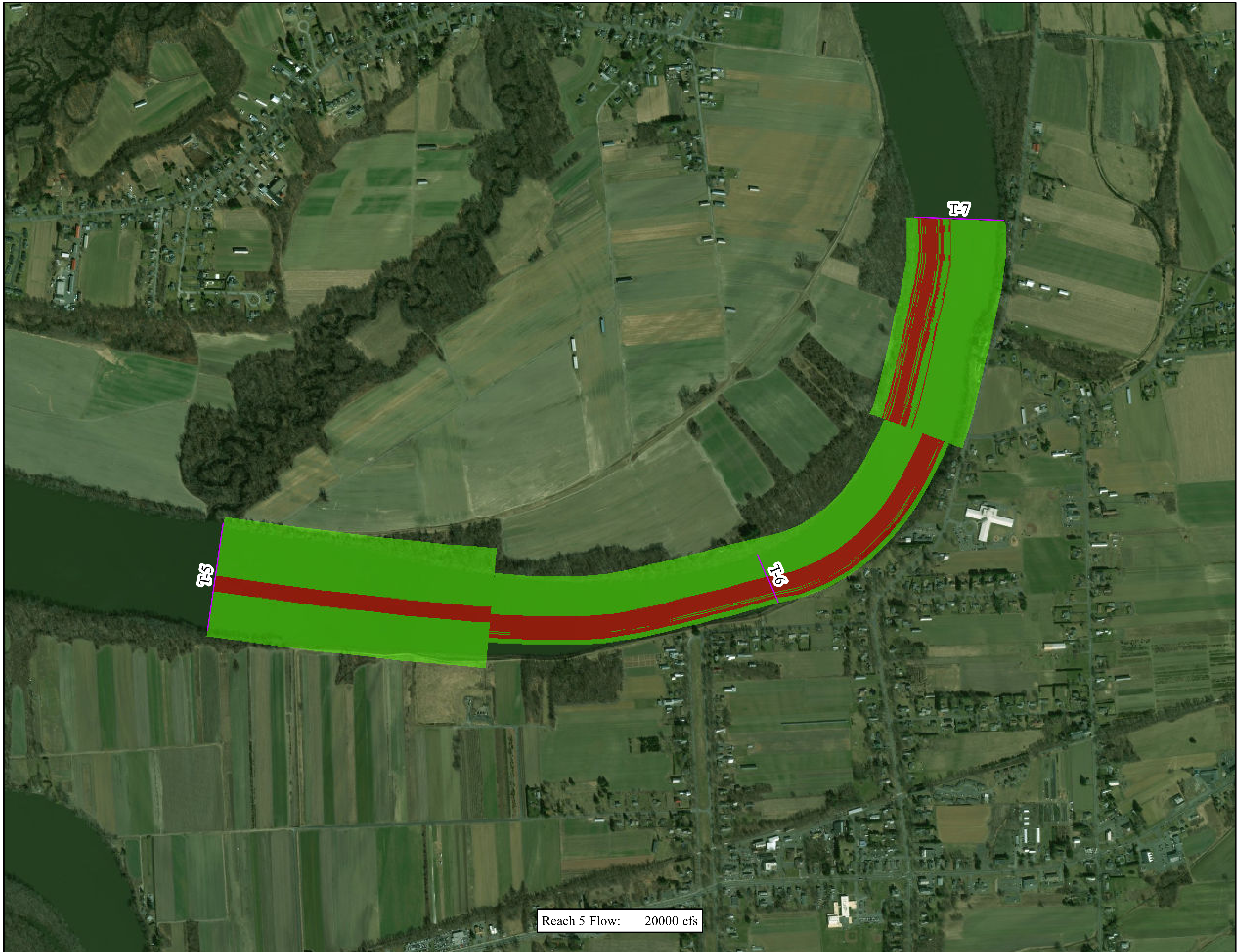
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

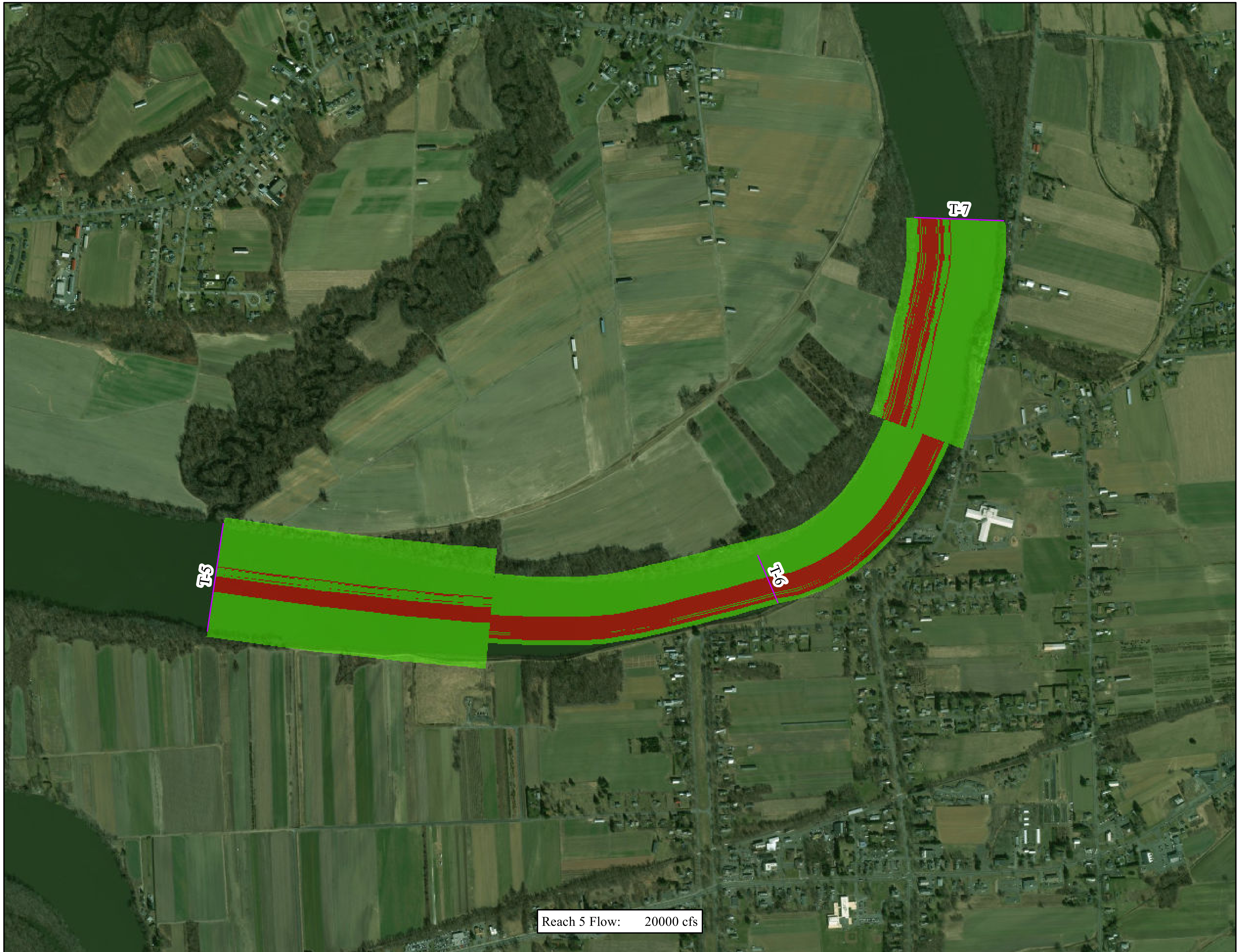
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

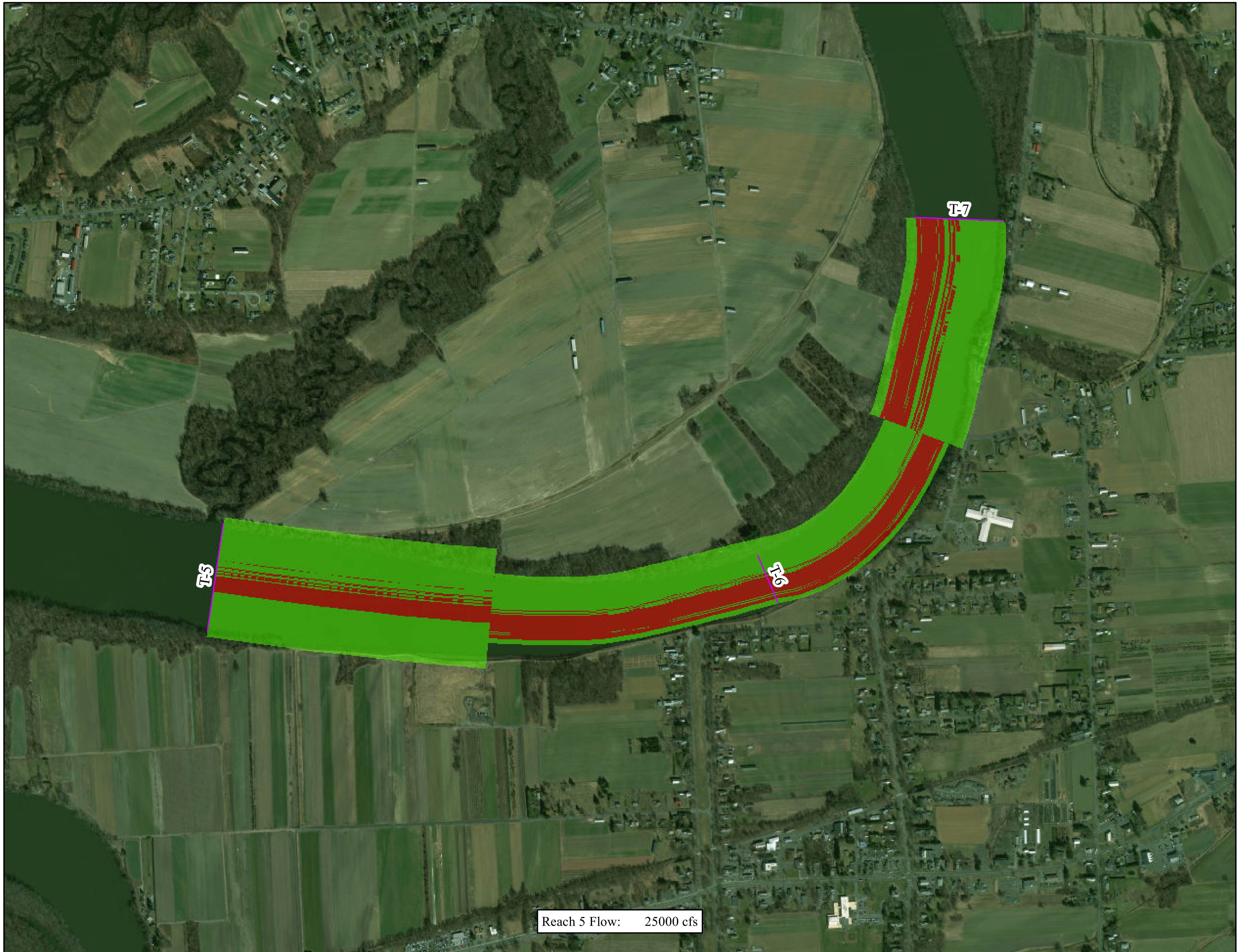
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

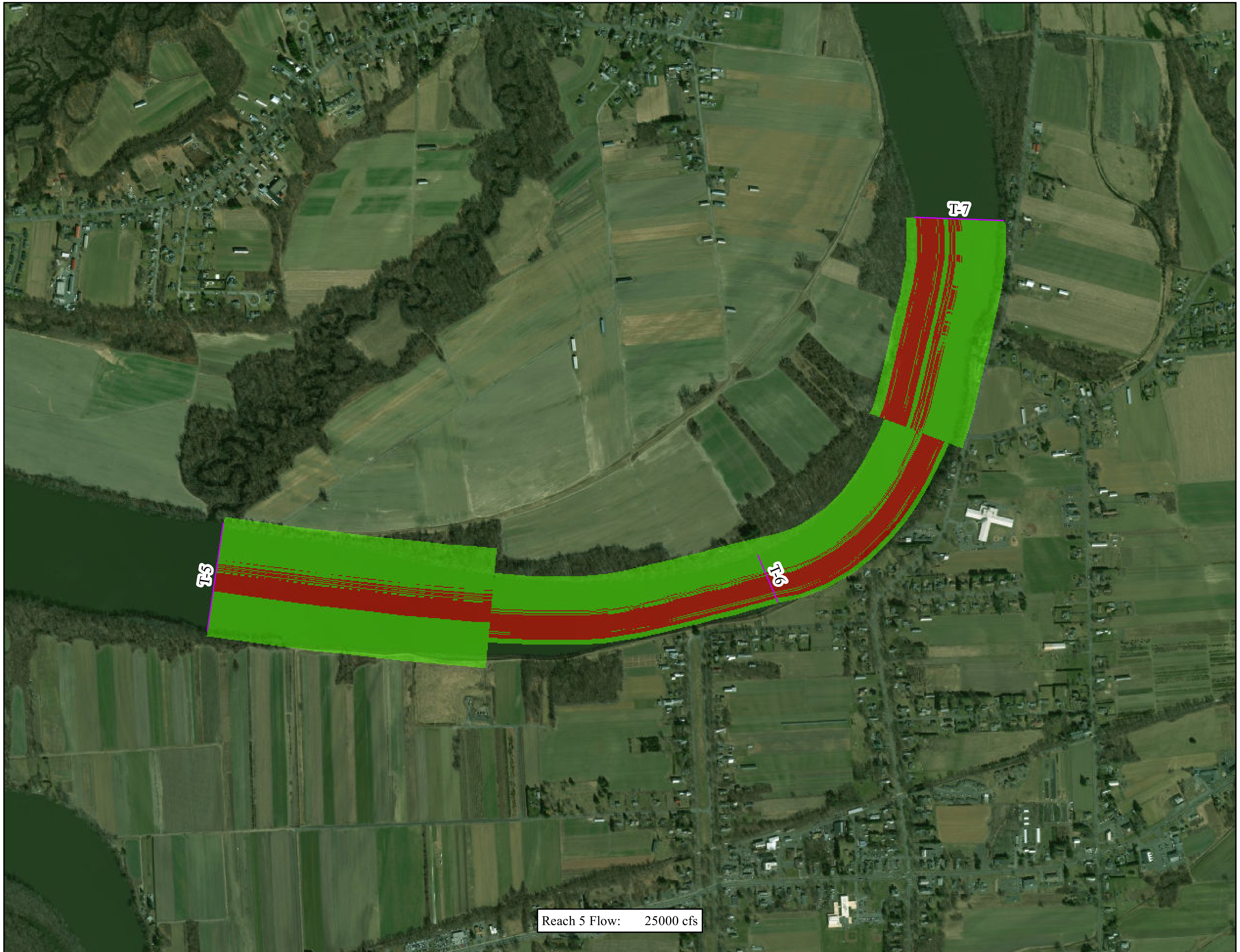
N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
High Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Hatfield
Low Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

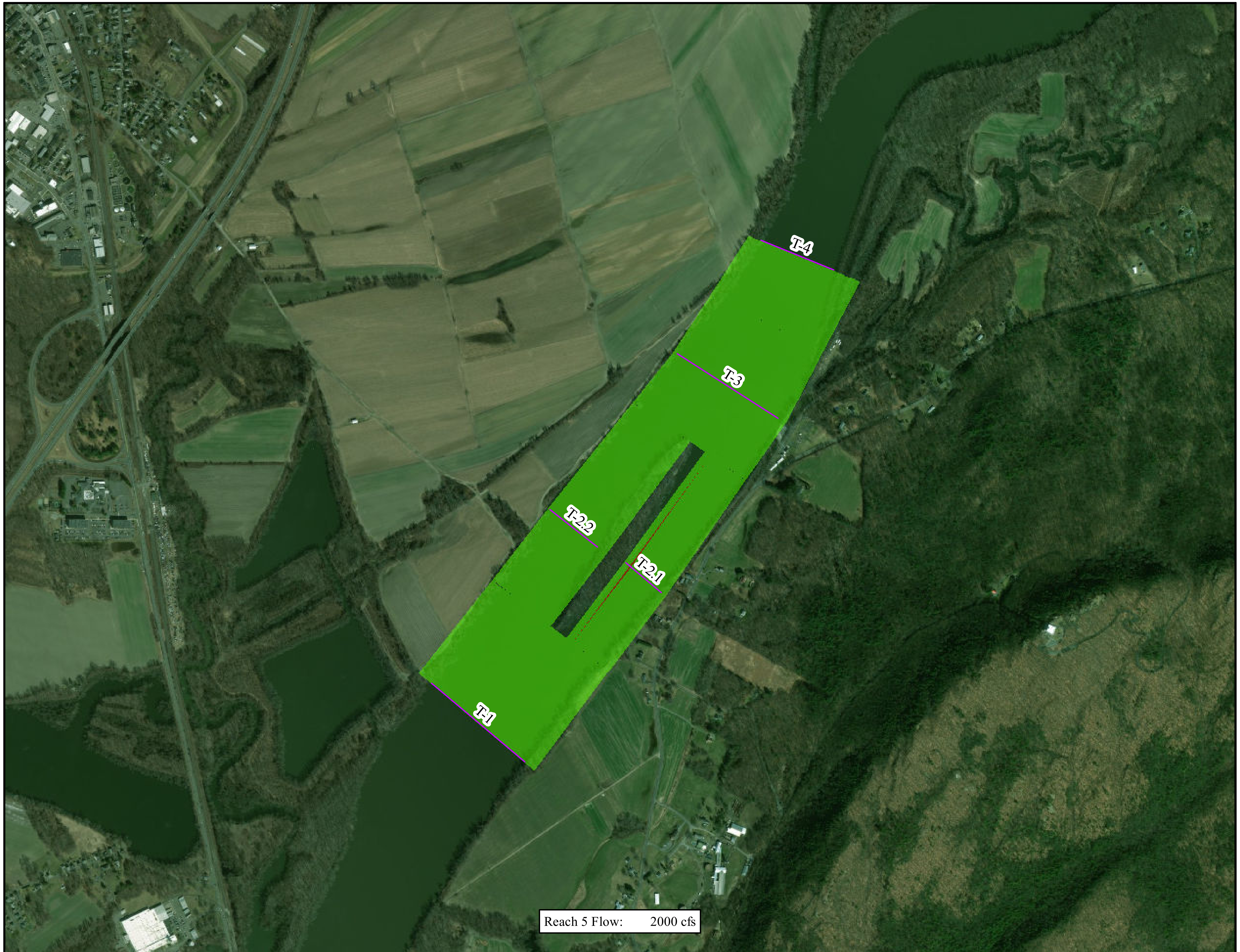
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

APPENDIX E-3 – MITCH'S ISLAND SUB-REACH SHEAR STRESS MAPS



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

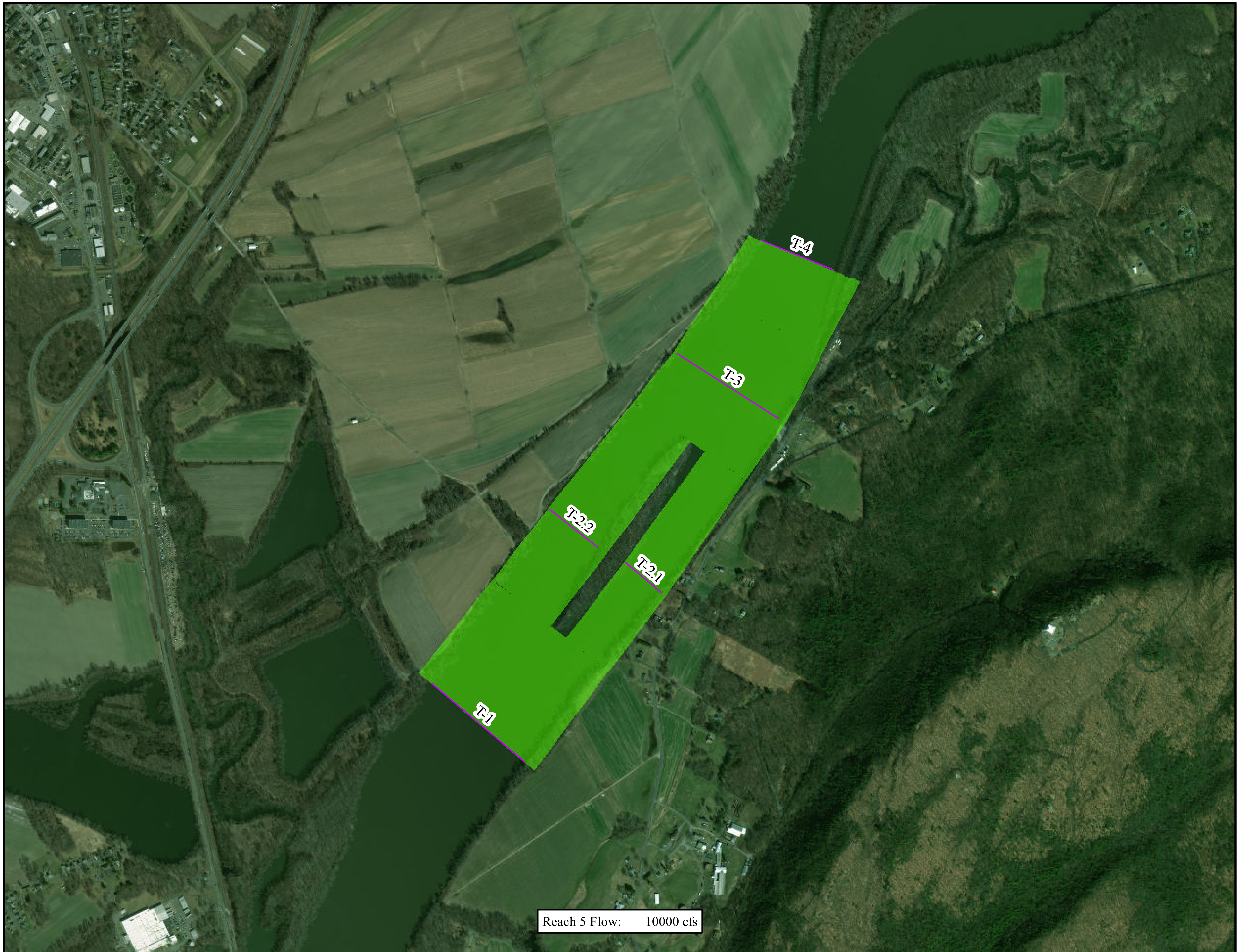
N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

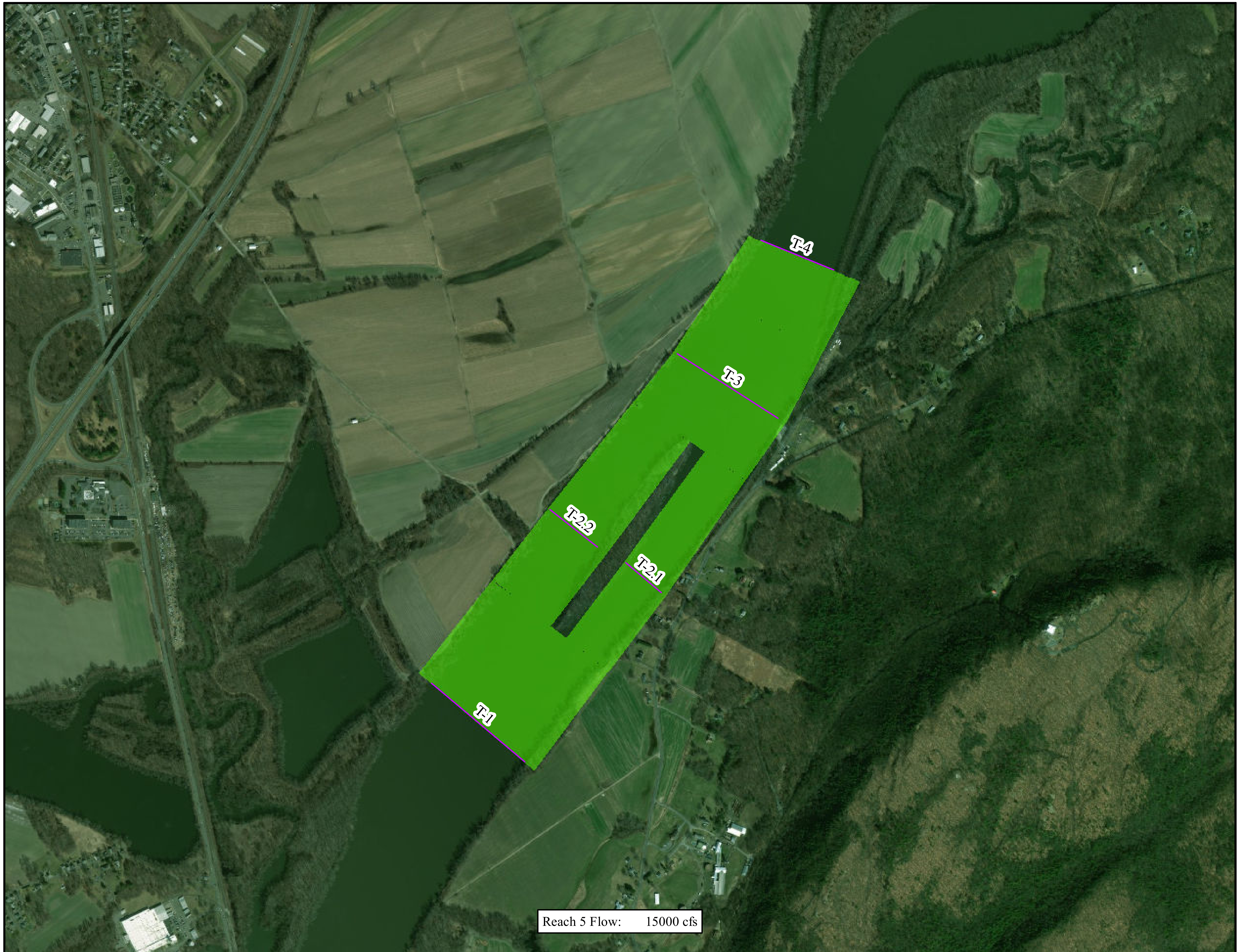
N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Juvenile Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

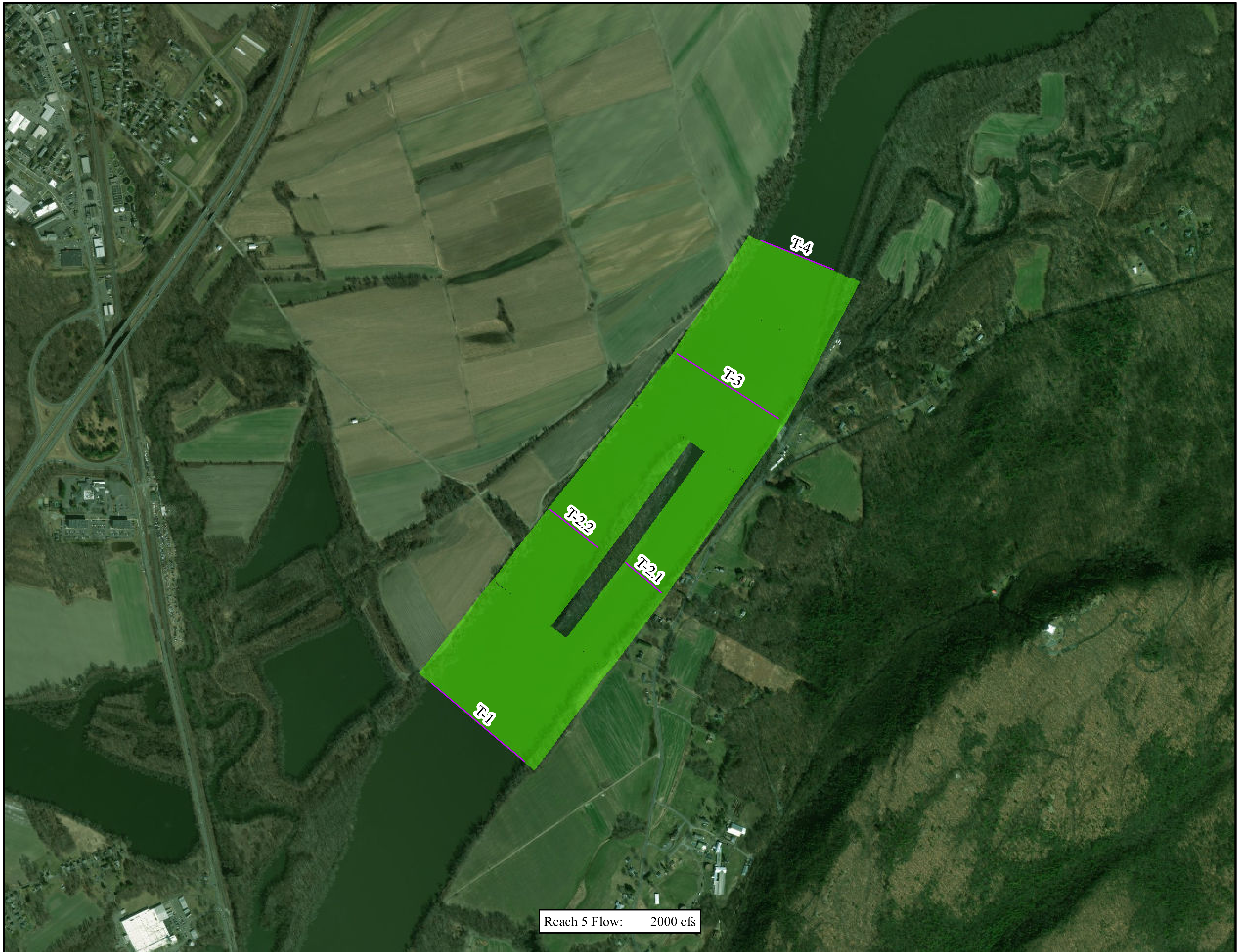
N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 2000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 5000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

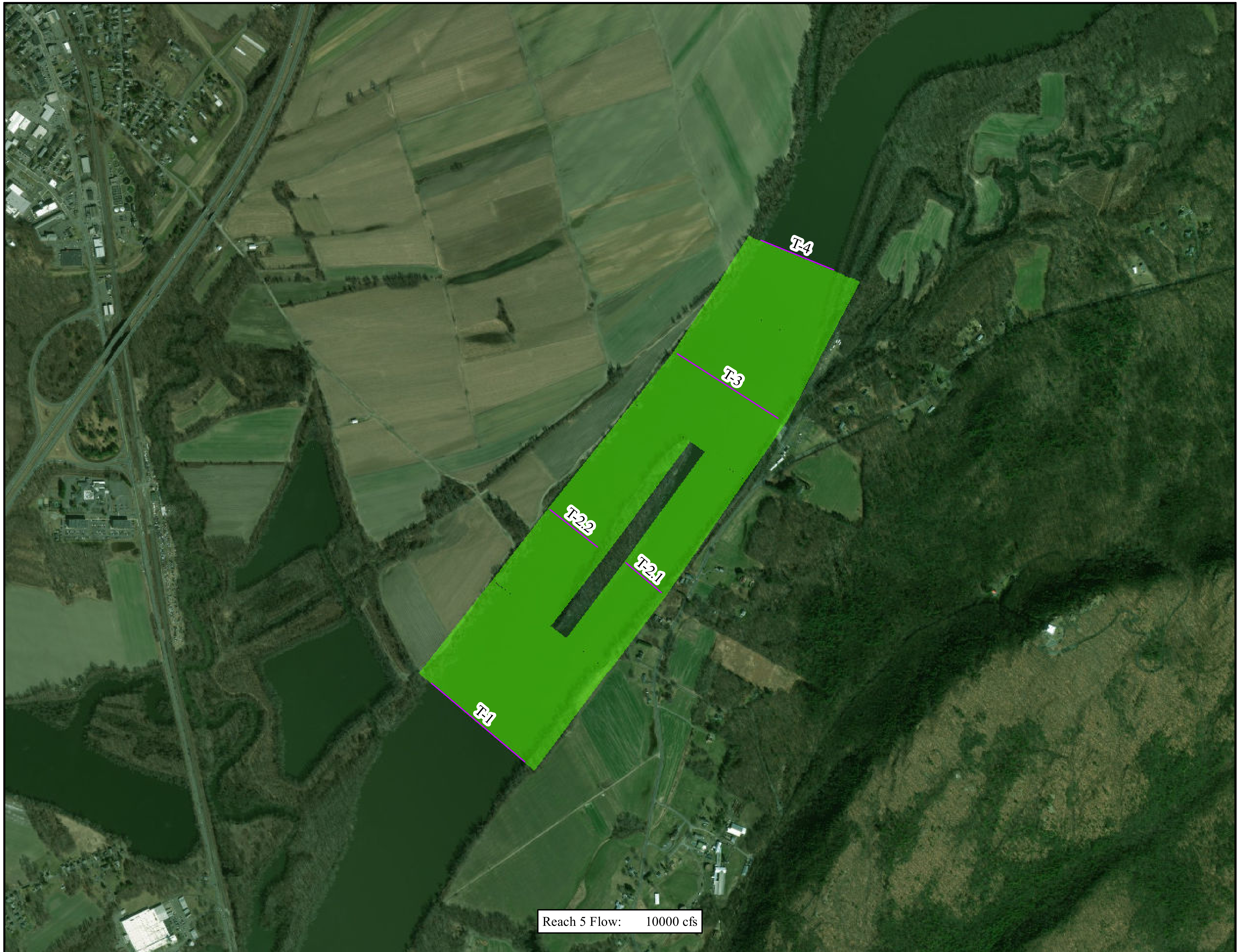
Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 10000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 15000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 20000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
High Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

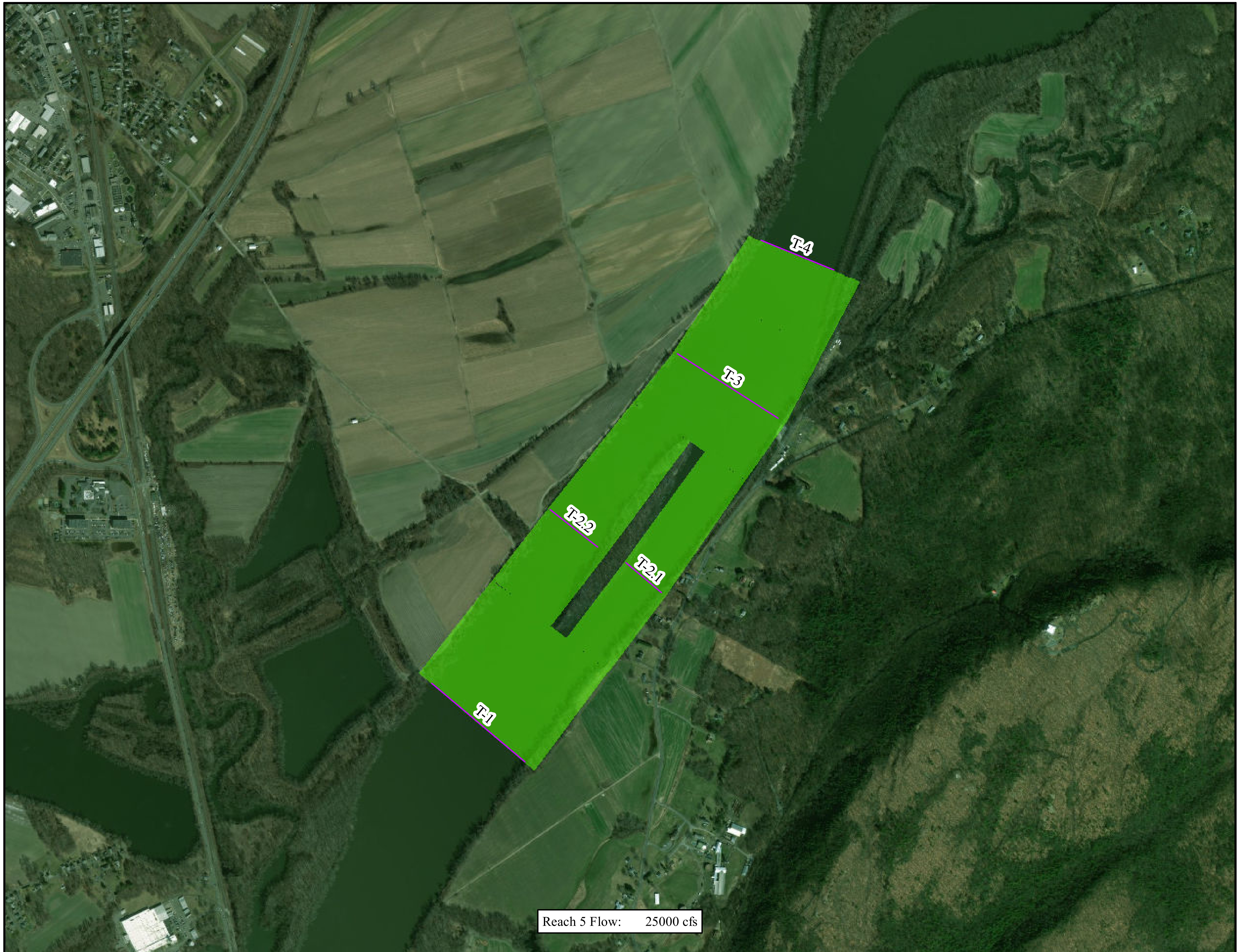
N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Adult Mussel Species
Reach 5 - Mitch's Island
Low Holyoke Impoundment Level - 25000 cfs

Legend

Reach 5 Transects

Shear Stress Threshold

Shear Stress Threshold Exceeded

Shear Stress Threshold Not Exceeded

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FirstLight
Power Resources

Copyright © 2017 FirstLight Power Resources All rights reserved.

Path: W:\gis\studies\3_3_1\maps\reach_5_mussel_sheer_si.mxd

APPENDIX F – ELWELL ISLAND & SUB-REACH TRANSECT INFORMATION (DIGITAL APPENDIX)

APPENDIX F: ELWELL ISLAND & SUB-REACH TRANSECT INFORMATION

Digital files pertaining to Elwell Island transect information, sub-reach transect survey data, raw field data, and photographs of the transect sites, as discussed in Section 4.4, are available upon request. Please submit requests via email to FirstLight@gomezandsullivan.com or use the 'Contact Us' link found on the relicensing website (http://www.northfieldrelicensing.com).