RELICENSING STUDY 3.3.1

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

Final Study Report

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

Prepared for:

FirstLight Power Resources

Prepared by:

Gomez and Sullivan Engineers

Kleinschmidt

OCTOBER 2016

EXECUTIVE SUMMARY

FirstLight Hydro Generating Company (FirstLight), is the current licensee of the Northfield Mountain Pumped Storage Project (FERC No. 2485) and the Turners Falls Hydroelectric Project (FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the Projects using the FERC's Integrated Licensing Process (ILP). The current licenses for the Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both expiring on April 30, 2018. This report documents the results of Study No. 3.3.1 *Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station.*

The study purpose is to assess the potential effects of discharges from Turners Falls Dam, Station No. 1, and Cabot Station on wetted area and aquatic habitat suitability in the Connecticut River between Turners Falls Dam and Cabot Station (i.e., the bypass reach) and below Cabot Station downstream to the vicinity of Dinosaur Footprints Reservation.

The study area was delineated into the following five (5) reaches.

- Reach 1. Upper Bypass Reach. This reach is approximately one mile long extending from the Turners Falls Dam downstream to the confluence with the Station No. 1 tailrace.
- Reach 2. Lower Bypass Reach. This reach is approximately two miles long extending from the Station No. 1 tailrace downstream, terminating at the Rawson Island complex and a geological feature including a natural ledge drop known as "Rock Dam".
- Reach 3. Tailrace Reach. This reach extends from below the Rock Dam/Rawson Island complex downstream approximately 1.75 miles to the USGS gage on the Connecticut River at Montague City.
- Reach 4. This reach is approximately 9 miles long and extends from the Montague USGS Gage downstream to the Route 116 Sunderland Bridge.
- Reach 5. This reach extends 22 miles from the Route 116 Bridge downstream to a natural hydraulic control in the vicinity of Dinosaur Footprints Reservation.

Evaluation species were selected, in consultation with the stakeholders, from a list of species known to be present in the general study area. Depth, velocity and substrate Habitat Suitability Indices were developed from previous studies, scientific literature, and the professional judgment of FirstLight and stakeholder biologists. In addition, a separate analysis was conducted using hydraulic model outputs to assess habitat conditions for mussels in Reach 5.

The study results showed that the target species had a wide range of preferred flows and areas. Many species had divergent flow preferences, with no single flow or flow range providing optimal or near-optimal habitat for all target species. Most life stages of American shad, shortnose sturgeon, as well as the spawning life stage of walleye, the deep-fast habitat guild and macroinvertebrates preferred relatively higher flows. Most life stages of fallfish, longnose dace, white sucker, tessellated darter, the shallow-slow, shallow-fast, and deep-slow habitat guilds, as well as spawning sea lamprey generally preferred lower flows. The magnitude of available habitat also varied greatly by species. Some species did not appear to have substantial habitat at any of the modeled flows, including the fry, juvenile, and adult life stages of walleye, most life stages of longnose dace, the spawning life stage of sea lamprey, and the adult/juvenile life of tessellated dater.

Habitat persistence and dual flow analyses were conducted for all immobile species/life stages in Reach 3 and 4, respectively. For this analysis, all spawning/incubation and fry life stages were considered immobile, as were all of the macroinvertebrate species and habitat guilds. Persistent habitat analyses showed that more divergent minimum/generation flow pairs had less common, or persistent, habitat.

A habitat time series analysis was completed for Reach 4, a similar analysis will be released in a subsequent report for Reach 3 following the completion of the operations modeling study (Study No. 3.8.1). This report will compare the results of a "baseline" or existing conditions model run to additional operations model production runs that are designed in consultation with the resource agencies.

The habitat versus flow relationships developed for the various study reaches, as well as the other related analyses (i.e., habitat time series, habitat persistence) are tools that can be utilized to set future flow recommendations for the Project. Any flow recommendation should take into account habitat use by species and life stages throughout the year, the availability of water throughout the year, the varying hydrology during each bio-period of interest, and the operational constraints of the Project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

2D	two dimensional
ADCP	Acoustic Doppler Current Profiler
cfs	cubic feet per second
Corps	United States Army Corps of Engineers
DS	downstream
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
HSI	Habitat Suitability Indices
HSC	habitat suitability criteria
IFIM	Instream Flow Incremental Methodology
ILP	Integrated Licensing Process
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
PAD	Pre-Application Document
PHABSIM	Physical Habitat Simulation System
PSP	Proposed Study Plan
RSP	Revised Study Plan
SD1	Scoping Document 1
SD2	Scoping Document 2
US	upstream
SPDL	Study Plan Determination Letter
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
VY	Vermont Yankee Nuclear Power Plant
WSEL	water surface elevation
WSP	water surface profile
WUA	Weighted Usable Area

1 INTRODUCTION

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

On October 31, 2012, FirstLight filed its Pre-Application Document (PAD) and Notice of Intent with the FERC. The PAD included FirstLight's preliminary list of proposed studies. On December 21, 2012, FERC issued Scoping Document 1 (SD1) and preliminarily identified resource issues and concerns. On January 30 and 31, 2013, FERC held scoping meetings for the 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* 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.
- Transect Locations for Mussels- FERC recommended FirstLight include all habitat types when placing Instream Flow Incremental Methodology (IFIM) transects in Reach 4.

This report describes the results of the steady-state habitat analysis for Reaches 1 through 4. In addition, results for habitat persistence in Reach 3, dual flow analysis in Reach 4, as well as habitat time series in Reach 4 are provided in this report. An addendum will be provided at a later date containing habitat time series analysis for Reach 3.

Lastly, the screening level assessment for state and federally listed mussels in Reach 5 is included in this report. 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.

1.1 Study Goals and Objectives

The study purpose is to assess the potential effects of discharges from Turners Falls Dam, Station No. 1, and Cabot Station on wetted area and aquatic habitat suitability in the Connecticut River between Turners Falls Dam and Cabot Station (i.e., the bypass reach) and below Cabot Station downstream to the Route 116 Bridge in Sunderland, MA. For the reach between the Route 116 Bridge and Dinosaur Footprints Reservation (referred to as Reach 5), the assessment will focus on state or federally listed mussels.

2 PROJECT BACKGROUND

2.1 Project Location

The Turners Falls Project[1] is located on the Connecticut River in the states of Massachusetts (MA), New Hampshire (NH) and Vermont (VT) (Figure 2.1-1). The greater portion 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 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 TransCanada's Vernon Hydroelectric Project and Dam (FERC No. 1904). The Turners Falls Impoundment also serves as the lower reservoir for the Northfield Pumped Storage Project.

2.2 Project Description

The Turners Falls Dam is located on a "Z turn" in the river, and is oriented on a northeast-southwest axis, with the impounded area on the east side of the dam, and extending north. At the southwest end of the Turners Falls Dam is the gatehouse (Figure 2.2-1). Below the dam, originating at the gatehouse, is the Turners Falls power canal. Paralleling this power canal is a bypassed section of the Connecticut River. Associated with this power canal are the Station No. 1 and Cabot Station generating facilities. Station No. 1 is located approximately one-third of the way down the power canal. Water is conveyed from the power canal, to a small branch canal feeding the Station No. 1 turbines, before discharging into the bypass reach of the Connecticut River. Cabot Station is located at the downstream terminus of the power canal, where it rejoins the main stem of the Connecticut River. Station No. 1 and Cabot Station discharge into the Connecticut River approximately 0.9 miles and 2.7 miles downstream of the Turners Falls Dam, respectively. The Turners Falls Project is also equipped with three upstream fish passage facilities, including (in order from downstream to upstream): the Cabot fishway, the Spillway fishway, and the Gatehouse fishway.

2.3 Project Operation and Flow Release Requirements

2.3.1 Project Operations

Flow is maintained in the bypass reach at various times of the year either through fishway attraction flow, ladder flow or via a bascule gate. However, when the hydraulic capacity of the power canal, approximately 18,000 cfs, is exceeded and water elevations in the Turners Falls Impoundment start to rise, FirstLight will open bascule or tainter gates accordingly to spill water at the dam and into the bypass reach. The timing and frequency of spill events is summarized in Section 3.0 Basin Hydrology.

When flows into the power canal are less than 1,433 cfs, all flow is passed through Station No. 1. As flows increase into the 2,000 cfs range, Station No. 1 generation is ceased and flow is conveyed through Cabot Station. Cabot Station will continue to operate up to its maximum hydraulic capacity of 13,728 cfs. Cabot Station is operated as a peaking station resulting in flow and water level fluctuations downstream. Once

[1] Note that the datum used in this study is the National Geodetic Vertical Datum of 1929 (NGVD29). FirstLight has used the NGVD29 datum in reporting dam elevation and water level data over numerous years. Thus, all elevations discussed in this report are based on the NGVD29 datum.

inflows exceed Cabot's hydraulic capacity, Station No. 1 is operated up to its hydraulic capacity of 2,210 cfs, resulting in a total overall capacity of 15,938 cfs.

There are two other hydropower generating entities that can withdraw water from the canal. Both Southworth Paper and Turners Falls Hydro, LLC have indentured water rights. FirstLight has an agreement with each of these entities which provides that the entity will not generate power, thus providing FirstLight with additional flow for generation at its facilities. However, the agreements allow the Southworth Paper (hydraulic capacity = 113 cfs) and Turners Falls Hydro (hydraulic capacity = 288 cfs) facilities to generate power when the hydraulic capacity of the Station No. 1 and Cabot stations is exceeded.

2.3.2 Minimum Flow Requirements

Under the current FERC license for the Turners Falls Project, FirstLight is required to release a continuous minimum flow of 1,433 cfs or inflow, whichever is less below the Project. FirstLight typically maintains the minimum flow requirement through discharges at Cabot and/or Station No. 1.

A continuous minimum flow of 200 cfs is also maintained in the bypass reach starting on May 1, and increases to 400 cfs when fish passage starts by releasing flow through a bascule gate. The 400 cfs continuous minimum flow is provided through July 15, unless the upstream fish passage season has concluded early, in this case the 400 cfs flow is reduced to 120 cfs. The 120 cfs continuous minimum flow is maintained in the bypass reach from the date the fish ladders are closed (or by July 16) until the river temperature drops below 7°C, which typically occurs around November 15th.

2.3.3 Fish Passage Flow Requirements

The Turners Falls Project's three fish ladders (Cabot, Spillway and Gatehouse) require flow in the ladders and for fish attraction during the fish passage season—generally from May 1 to July 15. Table 2.3.1-1 lists the design flow capacity and maximum attraction flow for each fishway.

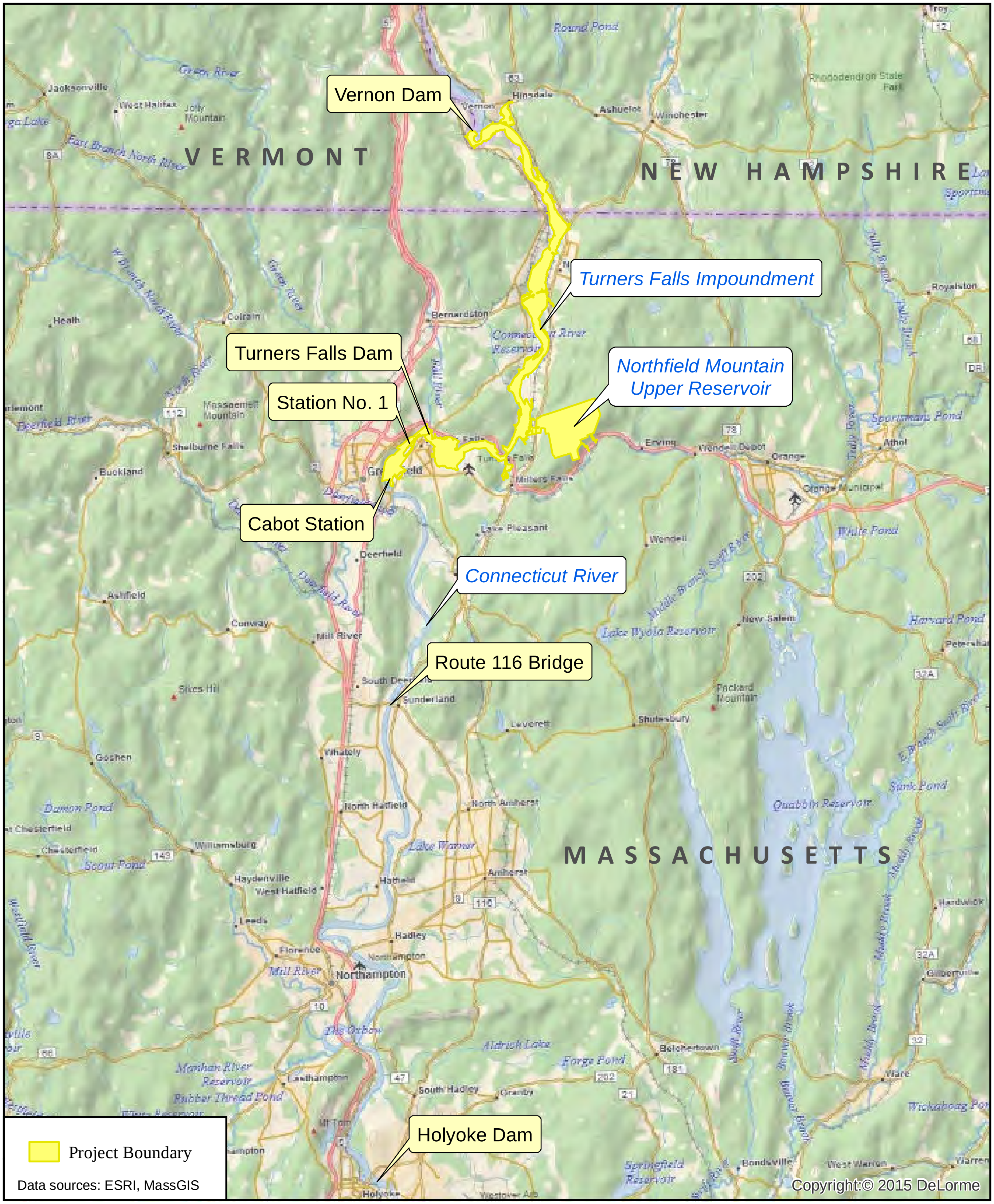
Table 2.3.1-1: Cabot, Spillway and Gatehouse Fish Ladders: Design Flows, Actual Flows and Attraction Flows

Facility	Fishway Passage Design Flow (cfs)	Fishway Passage Actual Flow (cfs)	Maximum Attraction Flow (cfs)
Cabot Fish Ladder[2]	67 cfs	33 cfs	335 cfs
Spillway Ladder[3]	36 cfs	18 cfs	300 cfs
Gatehouse Ladder	235 cfs	235 cfs	270 cfs

Relative to downstream fish passage, a flow of approximately 200 cfs is maintained through the log sluice located adjacent to Cabot Station from approximately April 7 through November 15.

[2] Attraction flow from the Cabot fish ladder during the May 1 to July 15 fish passage season is used to provide a portion of the continuous 1,433 cfs minimum flow requirement from the Project.

[3] Attraction flow from the spillway ladder during the May 1 to July 15 fish passage season is used to provide a portion of the required 400 cfs minimum bypass flow.



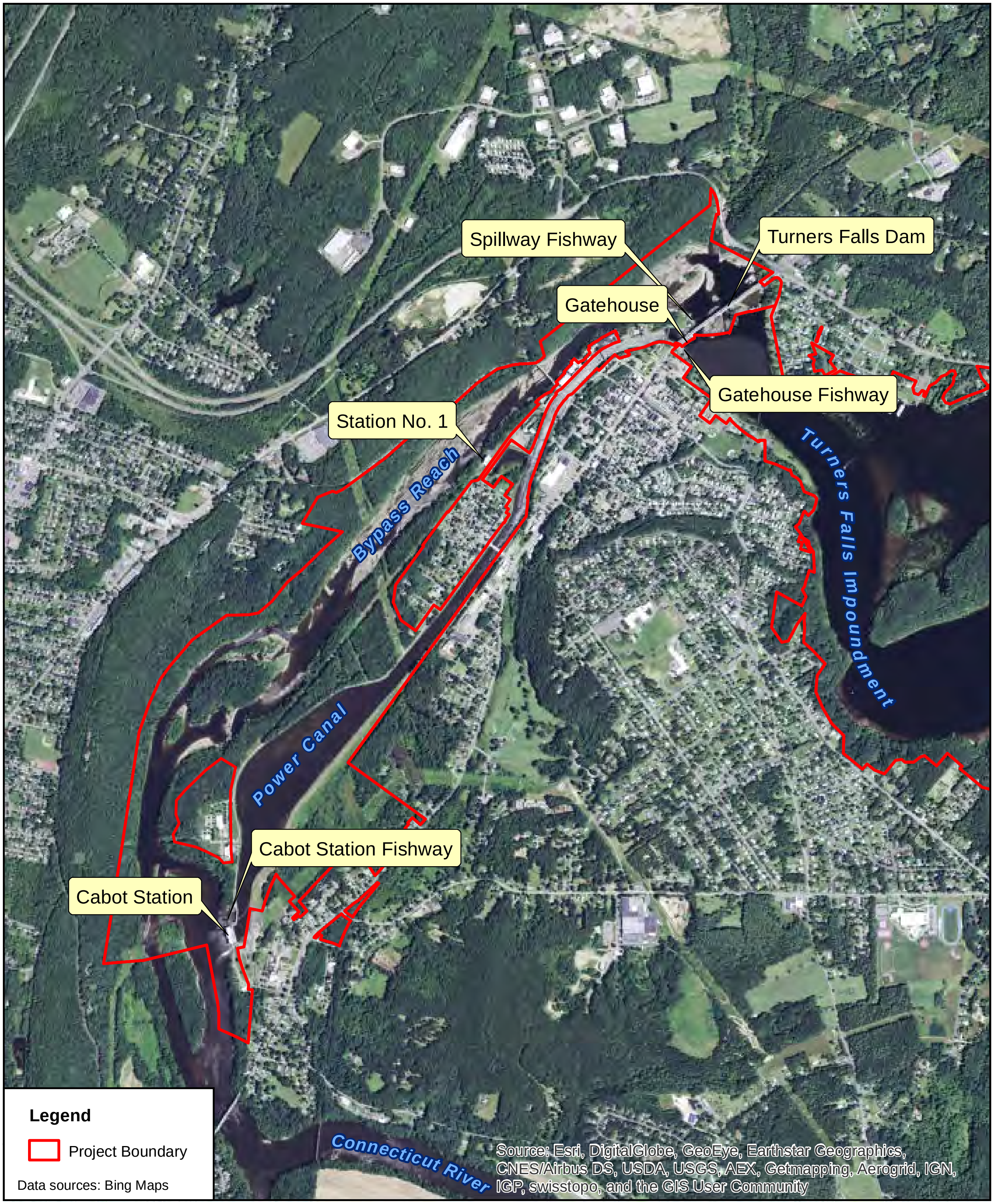
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

STUDY 3.3.1

0 2.5 5 10 Miles

Figure 2.1-1
Turners Falls Project and
Northfield Mountain Project
Location Map

Path: W:\gis\maps\IFIM\figure_2_1_1.mxd



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

STUDY 3.3.1

Figure 2.2-1
Turners Falls Project Features

N

0 1,000 2,000 4,000
Feet

Path: W:\gis\maps\IFIM\figure_2_2_1.mxd

3 BASIN HYDROLOGY

At Turners Falls Dam, the total drainage area is approximately 7,163 square miles (mi^2), or about 64% of the Connecticut River Basin drainage area (11,250 mi^2). The Connecticut River is the largest and longest river in New England, and is tidal up to Windsor Locks, CT, which is located approximately 60 miles from Long Island Sound. Table 3-1 list the drainage area at key locations in the study area.

Table 3-1: Drainage Areas at Key Locations

Location	*Drainage Area (square miles or mi^2)
Connecticut River at Turners Falls Dam	7,163[4]
Fall River at confluence with the Connecticut River	34.2
Connecticut River at Cabot Station	7,200
Deerfield River at confluence with the Connecticut River	665
Connecticut River at Montague USGS Gage	7,860
Connecticut River at Sunderland Bridge	7,920

*Computed using Massachusetts Streamstats (http://water.usgs.gov/osw/streamstats/massachusetts.html)

** The drainage area of the Montague gage is listed as 7,860 based on the figure by the USGS streamflow monitoring network, www.waterdata.usgs.gov.

3.1 Connecticut River Flow at Turners Falls Dam

As noted above, the hydraulic capacity of the Turners Falls Project generating stations (Cabot Station and Station No. 1) is 15,938 cfs and the hydraulic capacity of the power canal is approximately 18,000 cfs.

An analysis was conducted to estimate the flows on the Connecticut River at the Turners Falls Dam using the United States Geological Survey (USGS) gages on the Connecticut River in Montague, MA and on the Deerfield River in West Deerfield for overlapping periods of record. Table 3.1-1 provides background on the two gages.

Table 3.1-1: USGS Gages in the Project Area

Gage No.	Gage Name	Period of Record	Drainage Area	Comments
01170500	Connecticut River at Montague City, MA	1940-current	7,860 mi^2	Flows on the CT River are regulated by several seasonally operated storage reservoirs (First and Second CT Lakes, Lake Francis, Moore and Comerford Reservoirs).
01170000	Deerfield River near West Deerfield, MA	1940- current	557 mi^2	Flows on the Deerfield River are regulated by two seasonally operated storage reservoirs (Somerset and Harriman Reservoirs).

The Montague gage is located just downstream of Cabot Station and includes the discharge from the Deerfield River. The drainage area at the Turners Falls Dam is 7,163 mi^2. The difference in drainage area

[4] Streamstats computed a drainage area of 7,160 mi2 at Turners Falls Dam; however, the long-reported drainage area has been listed as 7,163 mi2. For purposes of this report, the long-reported value was used.

of the Connecticut River at the Montague Gage (7,860 mi^2) and at the Turners Falls Dam (7,163 mi^2) is 697 mi^2. Most of the increase is attributable to the Deerfield River (557 mi^2 at the USGS gage and 665 mi^2 as measured at its confluence with the Connecticut River). The Deerfield River USGS gage was prorated by a factor of 1.25 (697/557) to represent the additional flow from the 697 mi^2 drainage area. The prorated flow was then subtracted from the corresponding flow measured at the Montague gage to estimate flows at the Turners Falls Dam.

Using this approach, monthly Turners Falls Dam duration curves were computed as shown in Figures 3.1-1 through 3.1-5 (annual and 3 months/plot). These curves provide an approximation of the magnitude and duration of flow at the Turners Falls Dam over the common period of record. Shown in Table 3.1-2 are the approximate 25%, 50% (median) and 75% monthly and annual exceedance flows at Turners Falls Dam for the period of record.

Table 3.1-2. Estimated Flow at Turners Falls Dam (25%, 50% and 75% Exceedence Flows), Period of Record 1940-present. All flows in cfs.

Exc.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
25%	11,813	11,319	22,841	46,184	25,905	13,552	7,796	6,666	6,238	9,863	15,122	14,339	15,750
50%	7,963	7,711	13,200	30,238	17,316	8,900	4,965	4,147	4,059	6,058	9,845	9,613	8,489
75%	5,750	5,725	8,096	20,447	11,535	5,798	3,185	2,543	2,508	3,556	6,375	6,520	4,955

During spill events, the Fall River, Station No. 1, Cabot Station and the other mills will be conveying flow to the bypass reach as well. The Fall River contributes flow to the bypass reach just below the Turners Falls Dam. The Fall River is not gaged, so to estimate its contribution to the bypass flow, data from the nearby Green River USGS gage were used. The Green River gaged drainage area is 41.4 square miles versus 34.1 square miles at the Fall River and also shares similar drainage basin characteristics (i.e., land use, basin slope, surficial geology, etc.); given this, flows for the Fall River were derived using the following equation:

$Q_{\text{Estimated Fall River}} = Q_{\text{Green River gage}}$ * 34.2 sq. mi./41.4 sq. mi.

Monthly Fall River flow duration curves are shown in Figures 3.1-6 through 3.1-10. Also, the estimated 25%, 50% (median) and 75% monthly and annual exceedance flows are shown in Table 3.1-3.

Table 3.1-3. Estimated Flow Contribution from the Fall River (25%, 50% and 75% Exceedence Flows), Period of Record 1967-present. All flows in cfs.

Exc.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
25%	70	68	152	263	70	73	35	24	22	54	93	95	88
50%	48	44	83	153	32	39	19	13	12	25	51	58	44
75%	33	31	45	88	15	24	12	8	8	12	26	37	21

3.2 Connecticut River at Montague Gage to Sunderland Bridge

Flow in this section of river can be readily determined using the Montague USGS Gage. Monthly and annual flow duration curves were developed over the common period of record as shown in Figures 3.2-1 to 3.2-5 (annual and 3 months/plot). Shown in Table 3.2-1 are the 25%, 50% (median) and 75% monthly and annual exceedance flows in the Connecticut River at the Montague USGS Gage for the period of record.

Table 3.2-1. Connecticut River Flows at Montague USGS Gage (25%, 50% and 75% Exceedence Flows), Period of Record 1940-present.

Exc.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
25%	14,000	13,500	26,000	50,600	28,700	15,000	8,460	7,300	7,023	11,100	17,200	16,300	17,800
50%	9,550	9,330	15,700	33,700	19,000	9,870	5,610	4,630	4,720	6,835	11,200	11,100	9,770
75%	7,085	7,160	9,708	22,500	12,700	6,480	3,693	2,983	2,998	4,153	7,268	7,813	5,770

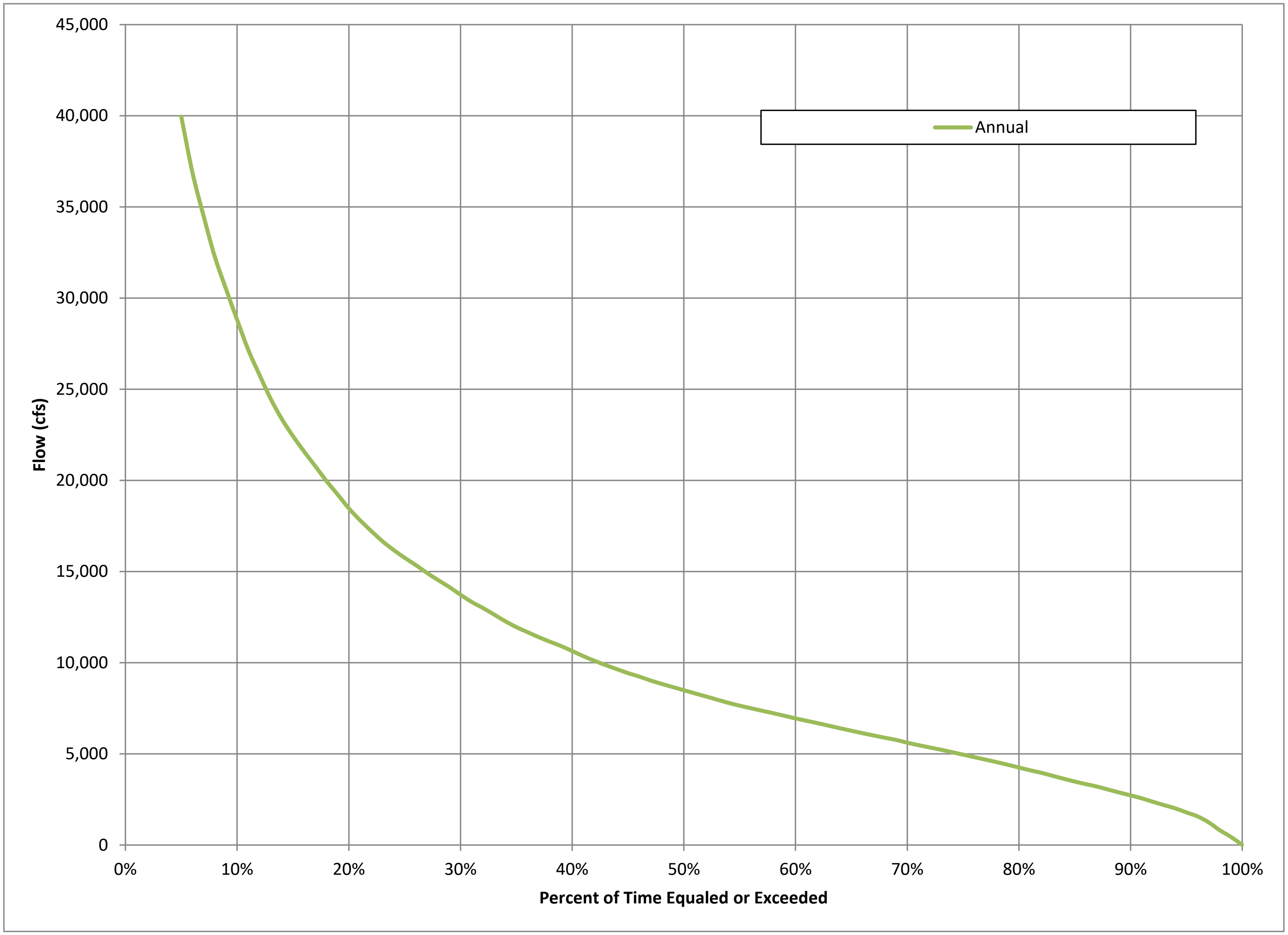


Figure 3.1-1: Connecticut River at Turners Falls Dam- Annual Flow Duration Curve (1940-present)

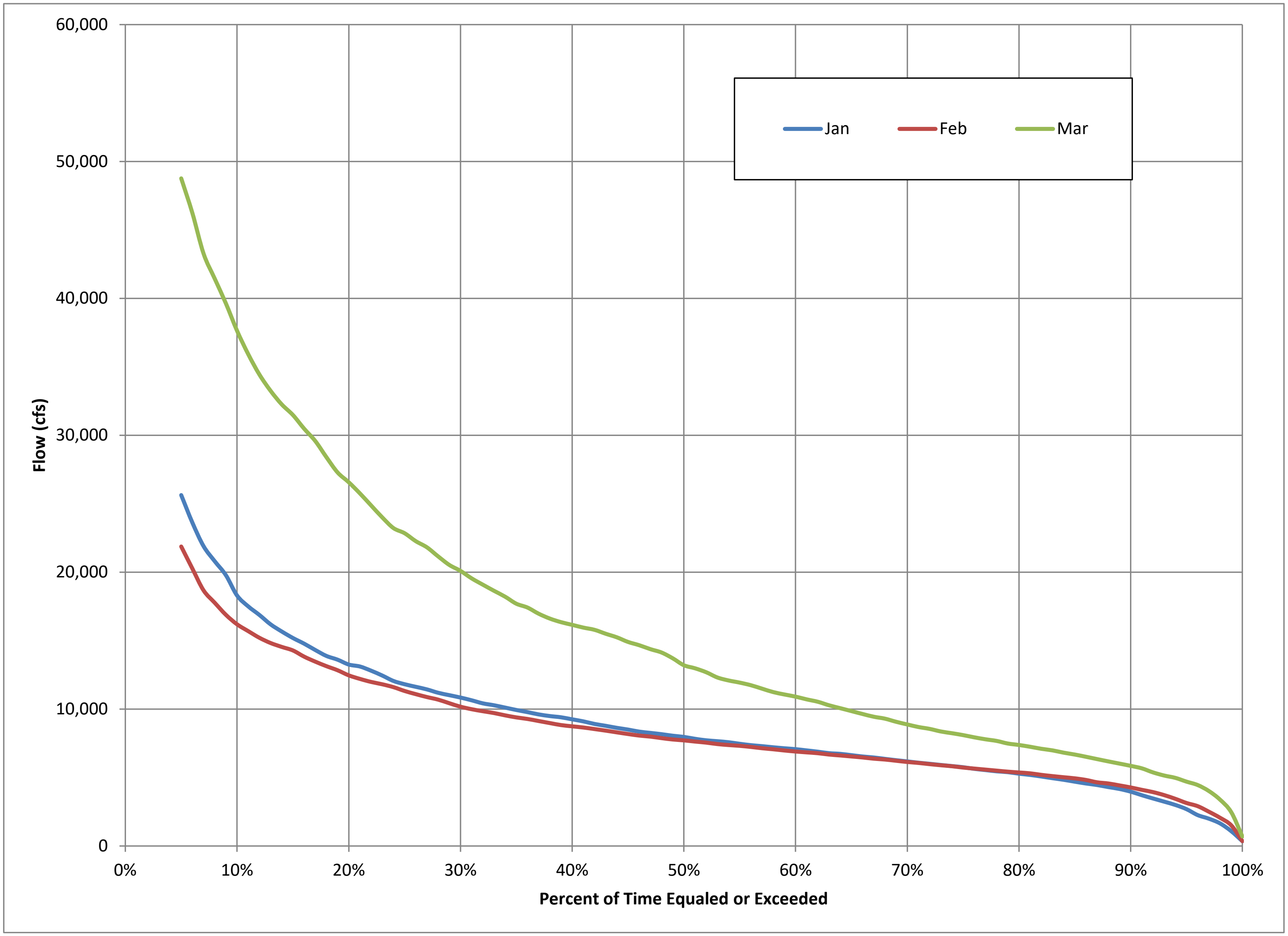


Figure 3.1-2: Connecticut River at Turners Falls Dam- Jan, Feb and Mar Flow Duration Curve (1940- present)

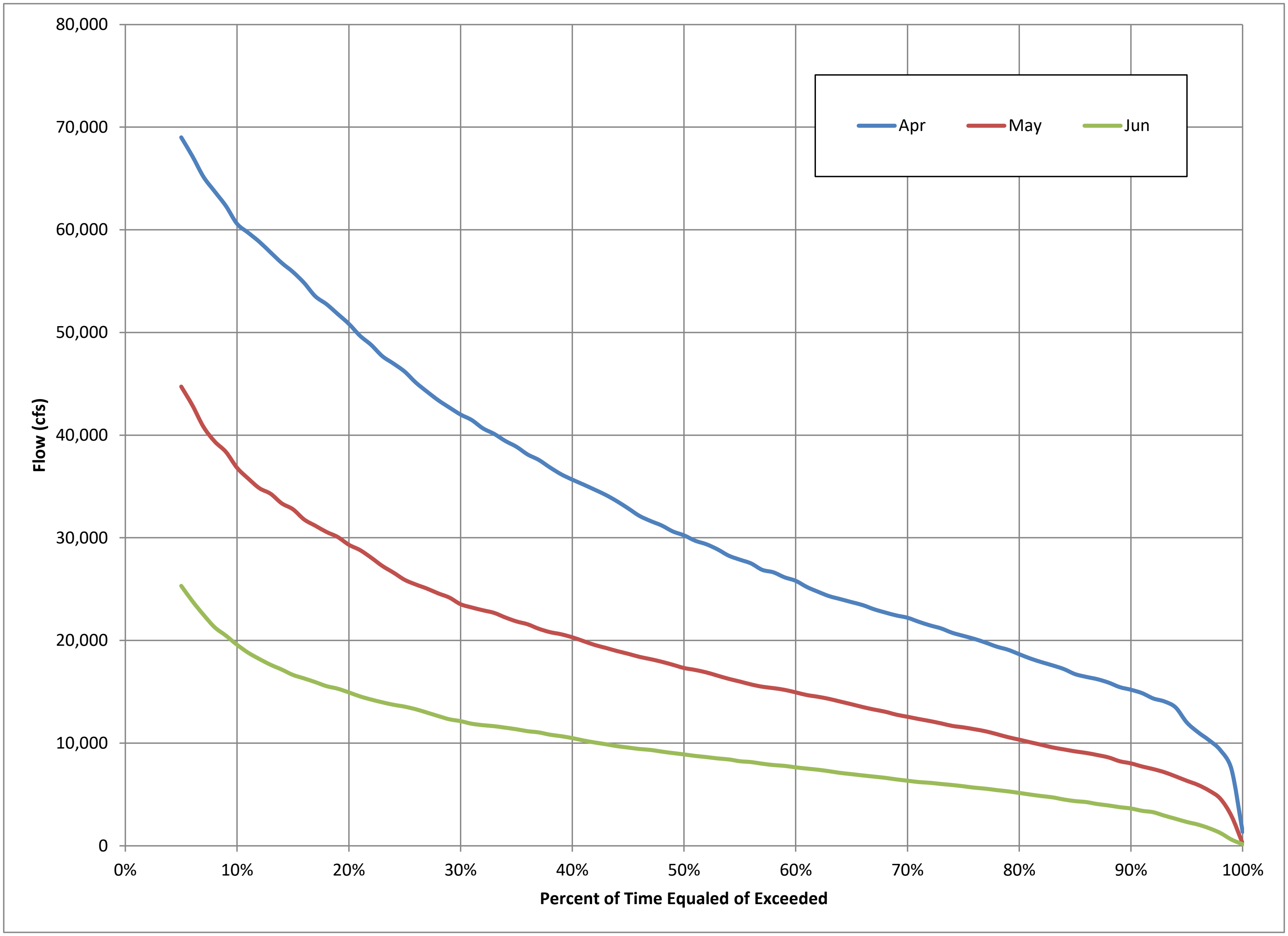


Figure 3.1-3: Connecticut River at Turners Falls Dam- Apr, May and Jun Flow Duration Curve (1940- present)

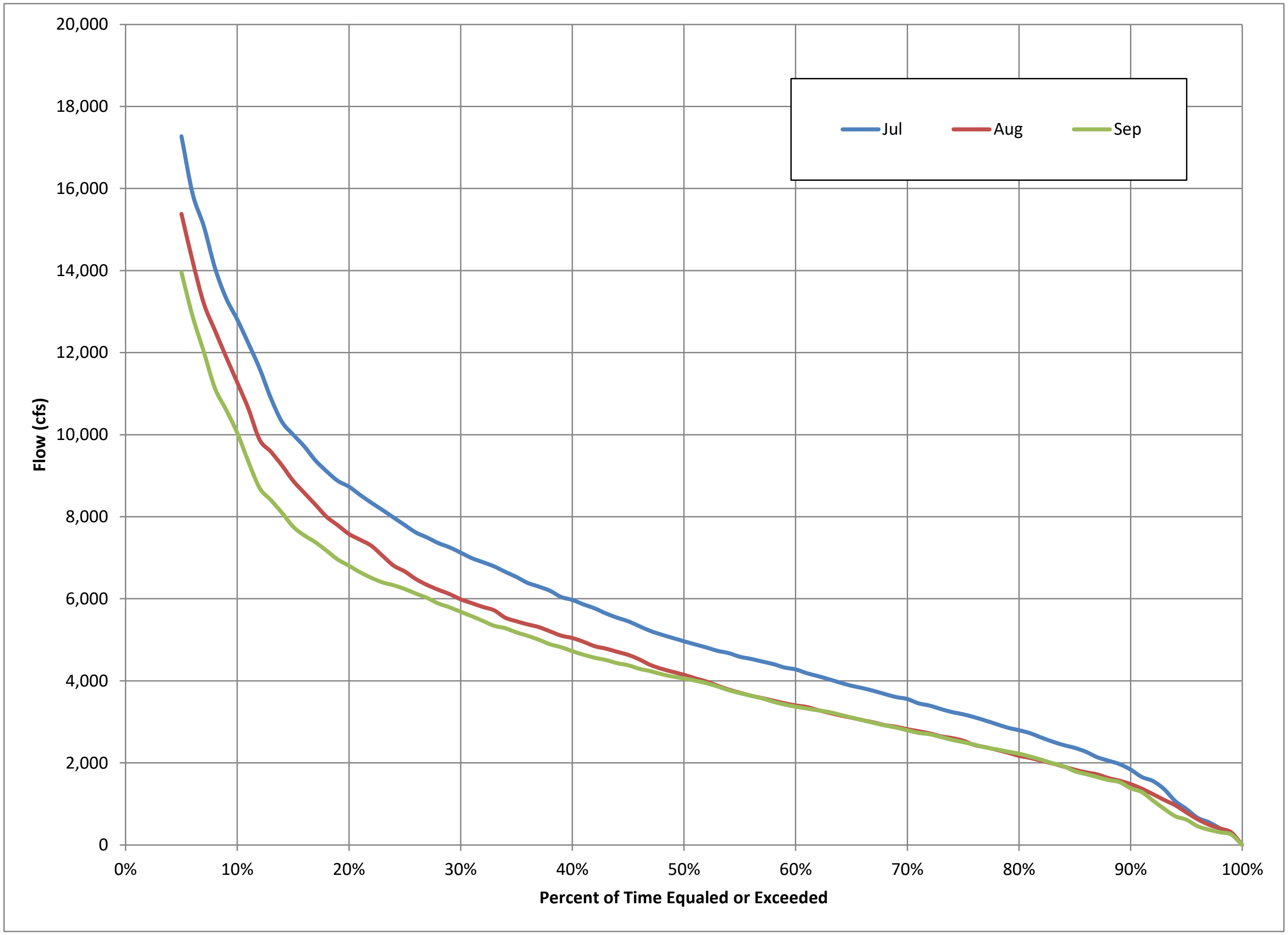


Figure 3.1-4: Connecticut River at Turners Falls Dam- Jul, Aug, and Sep Flow Duration Curve (1940- present)

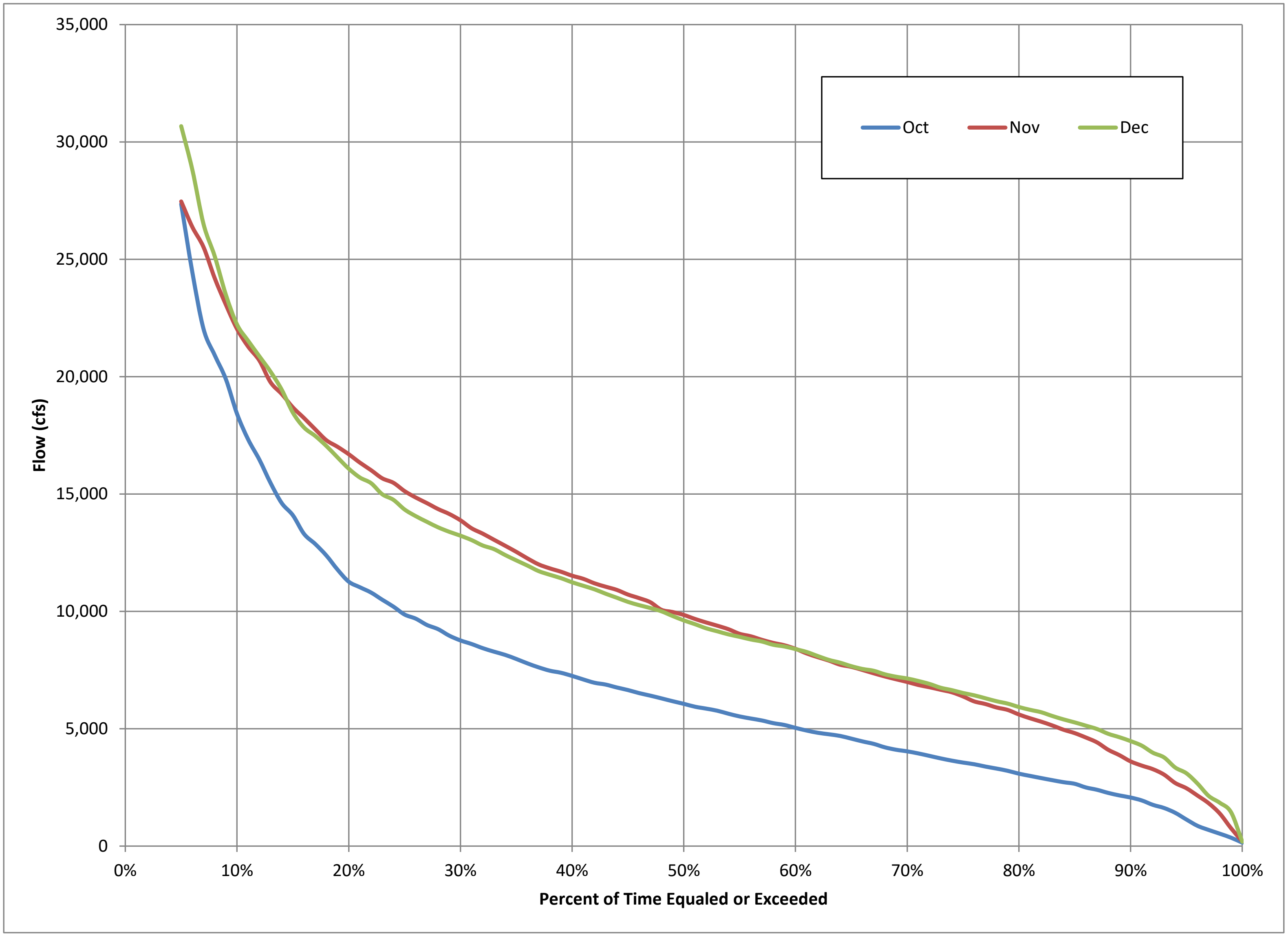


Figure 3.1-5: Connecticut River at Turners Falls Dam- Oct, Nov and Dec Flow Duration Curve (1940- present)

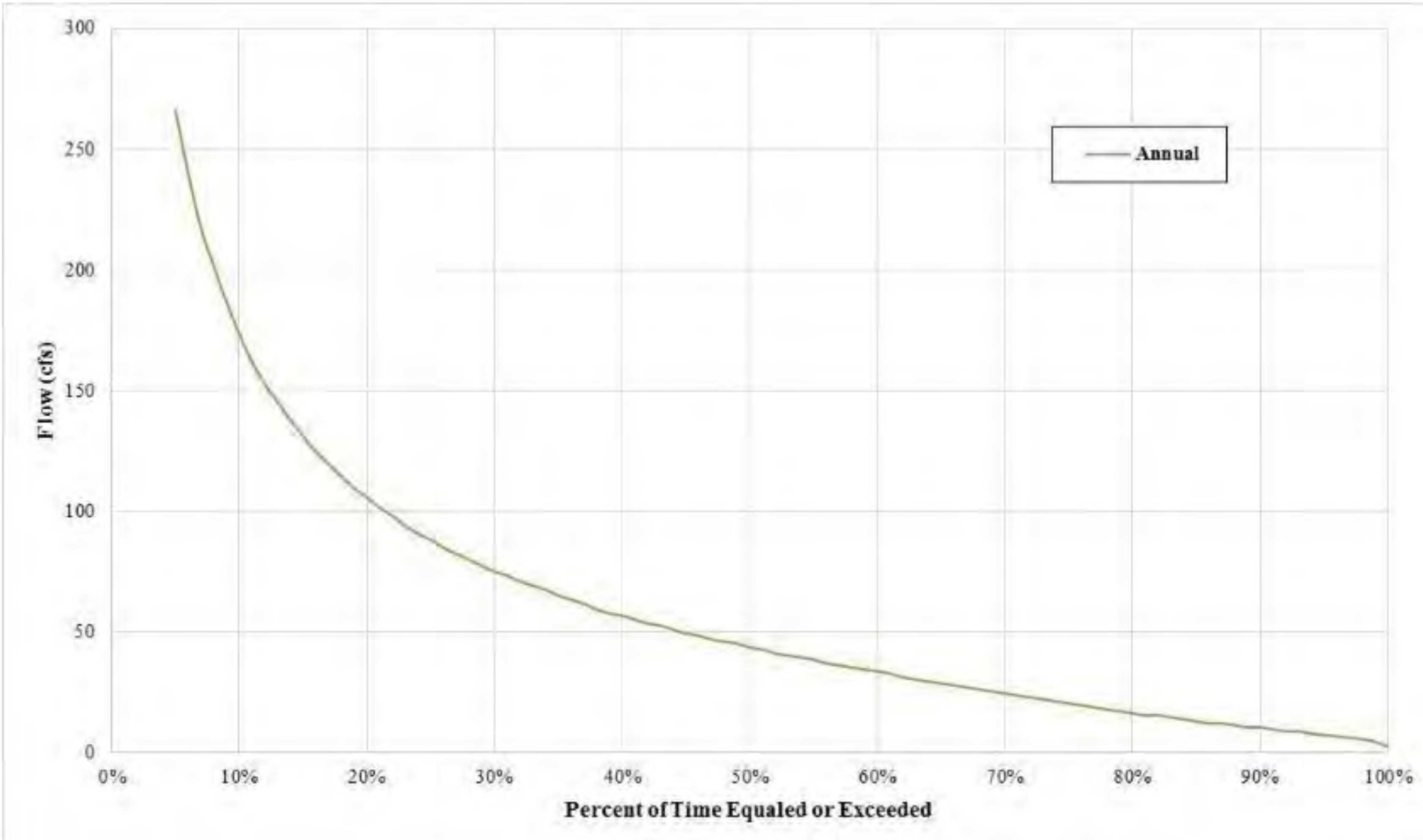


Figure 3.1-6: Fall River - Annual Flow Duration Curve (1967- present)

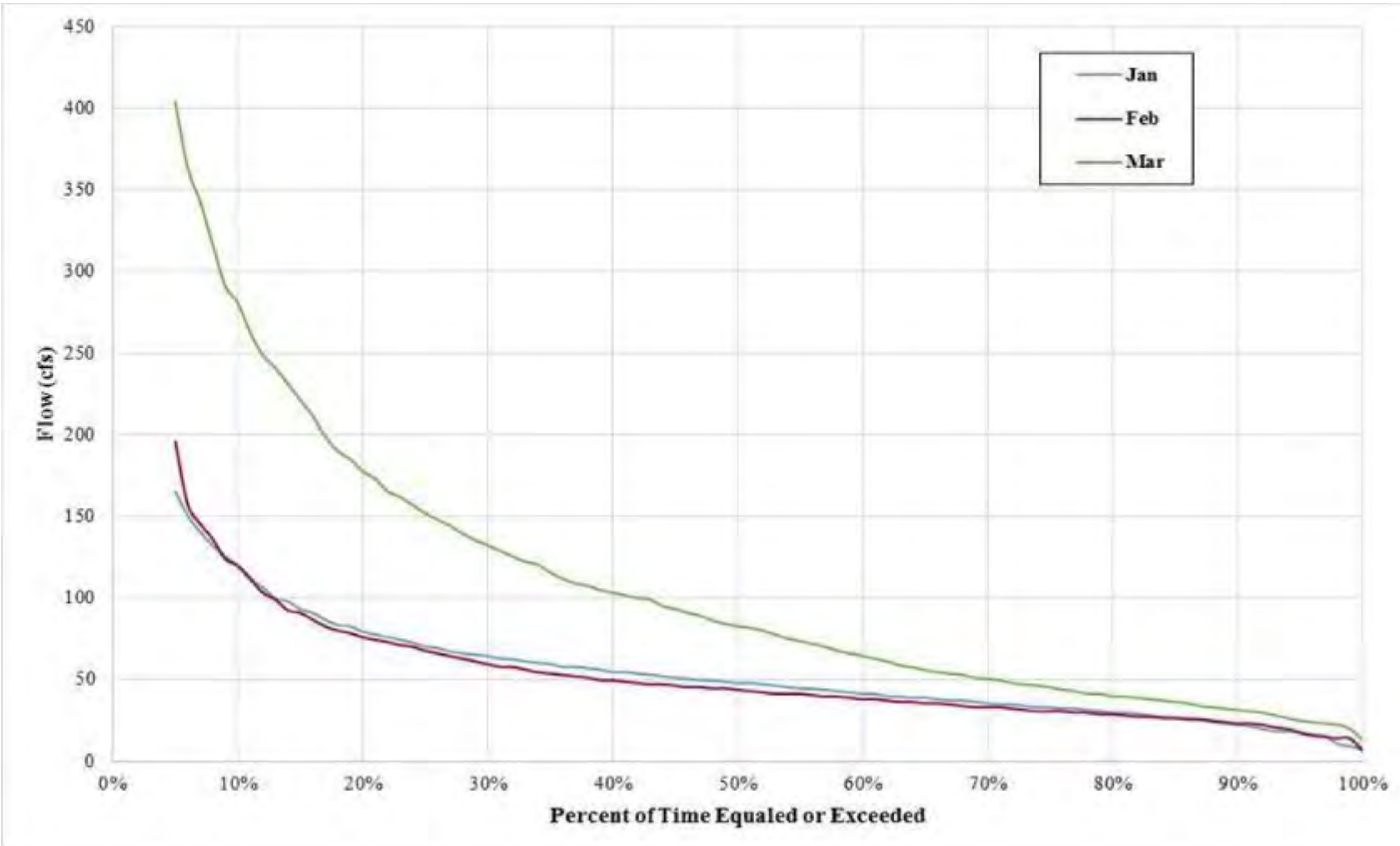


Figure 3.1-7: Fall River – Jan, Feb, Mar Flow Duration Curve (1967- present)

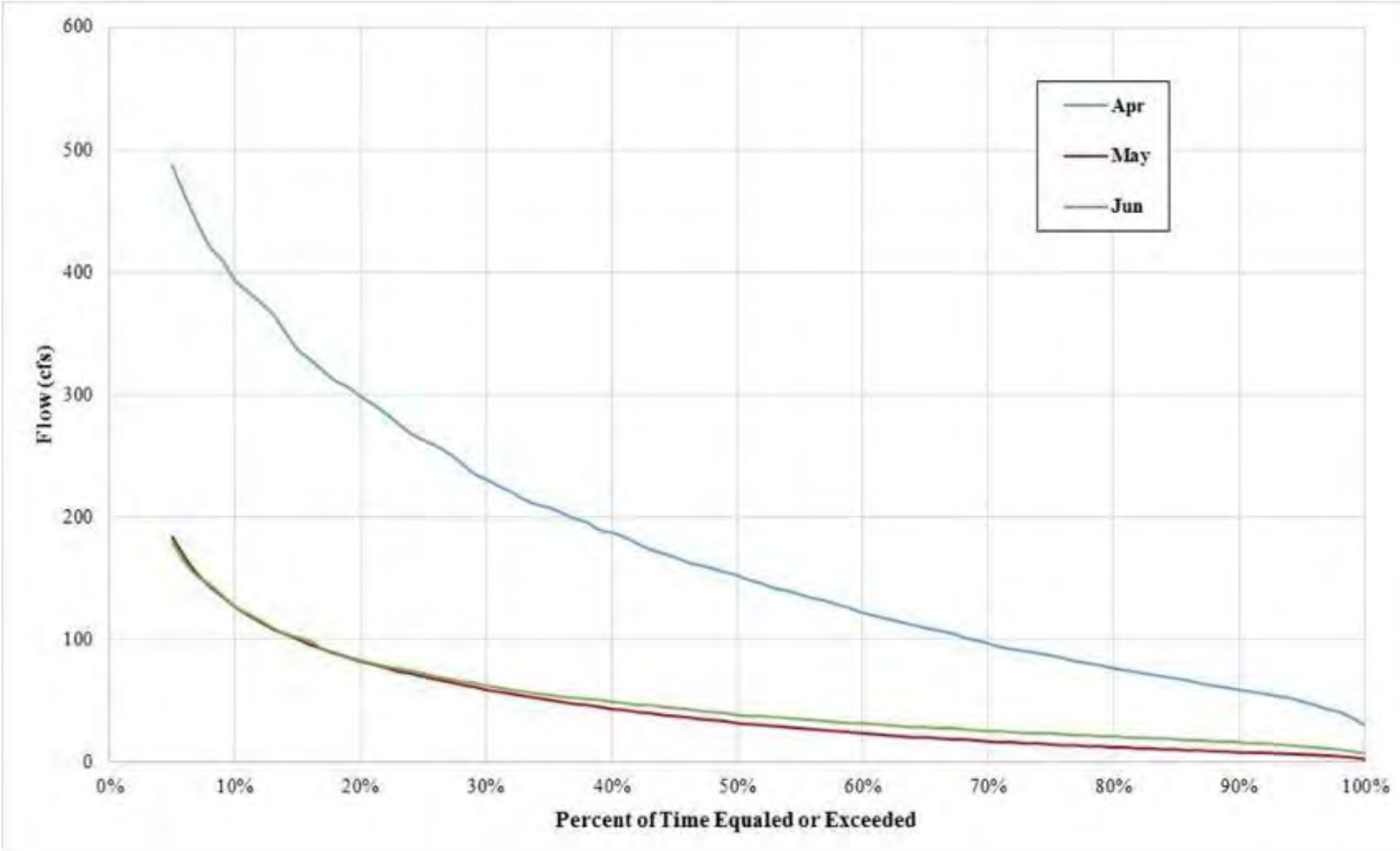


Figure 3.1-8: Fall River – Apr, May, Jun Flow Duration Curve (1967- present)

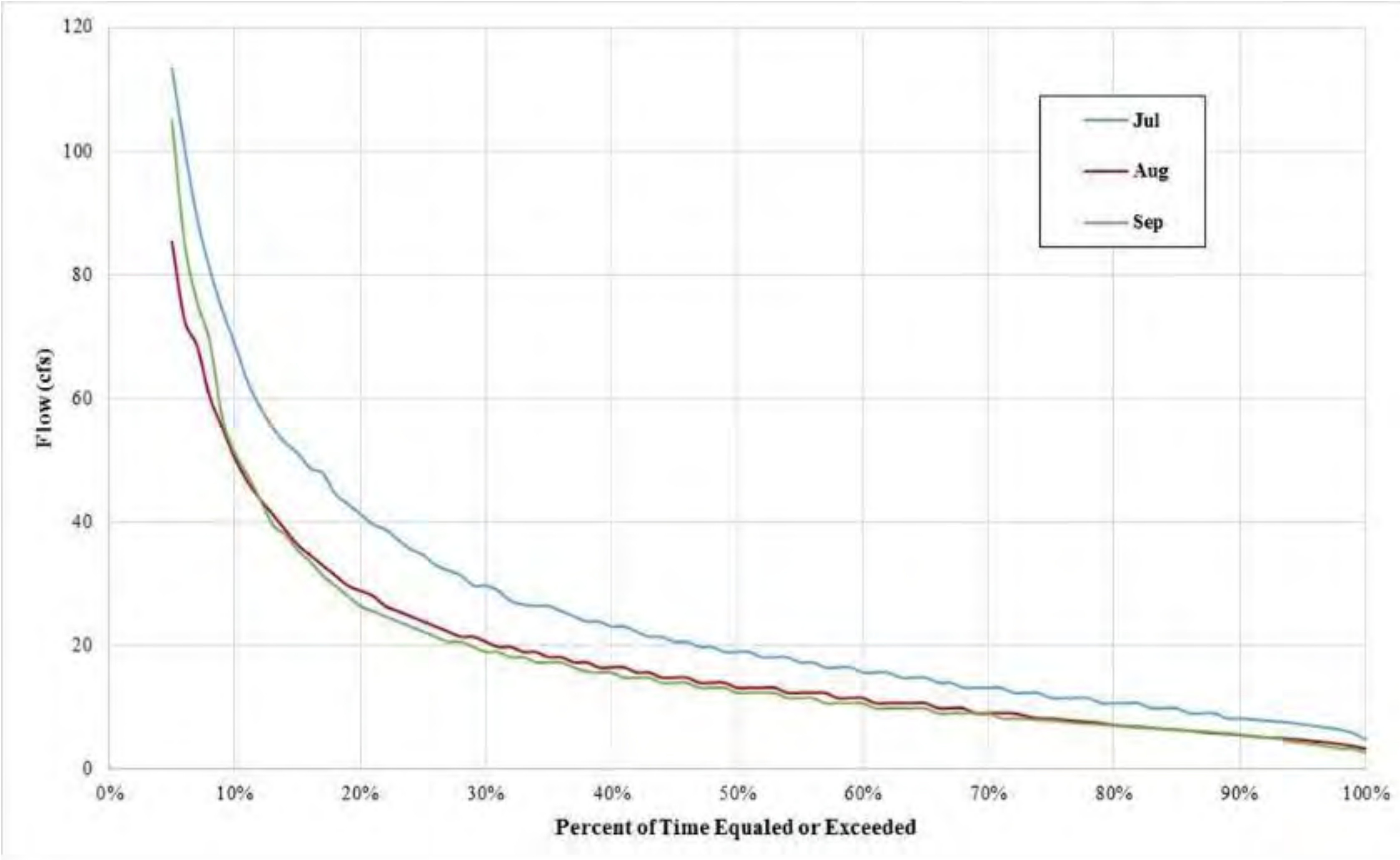


Figure 3.1-9: Fall River – Jul, Aug, Sep Flow Duration Curve (1967- present)

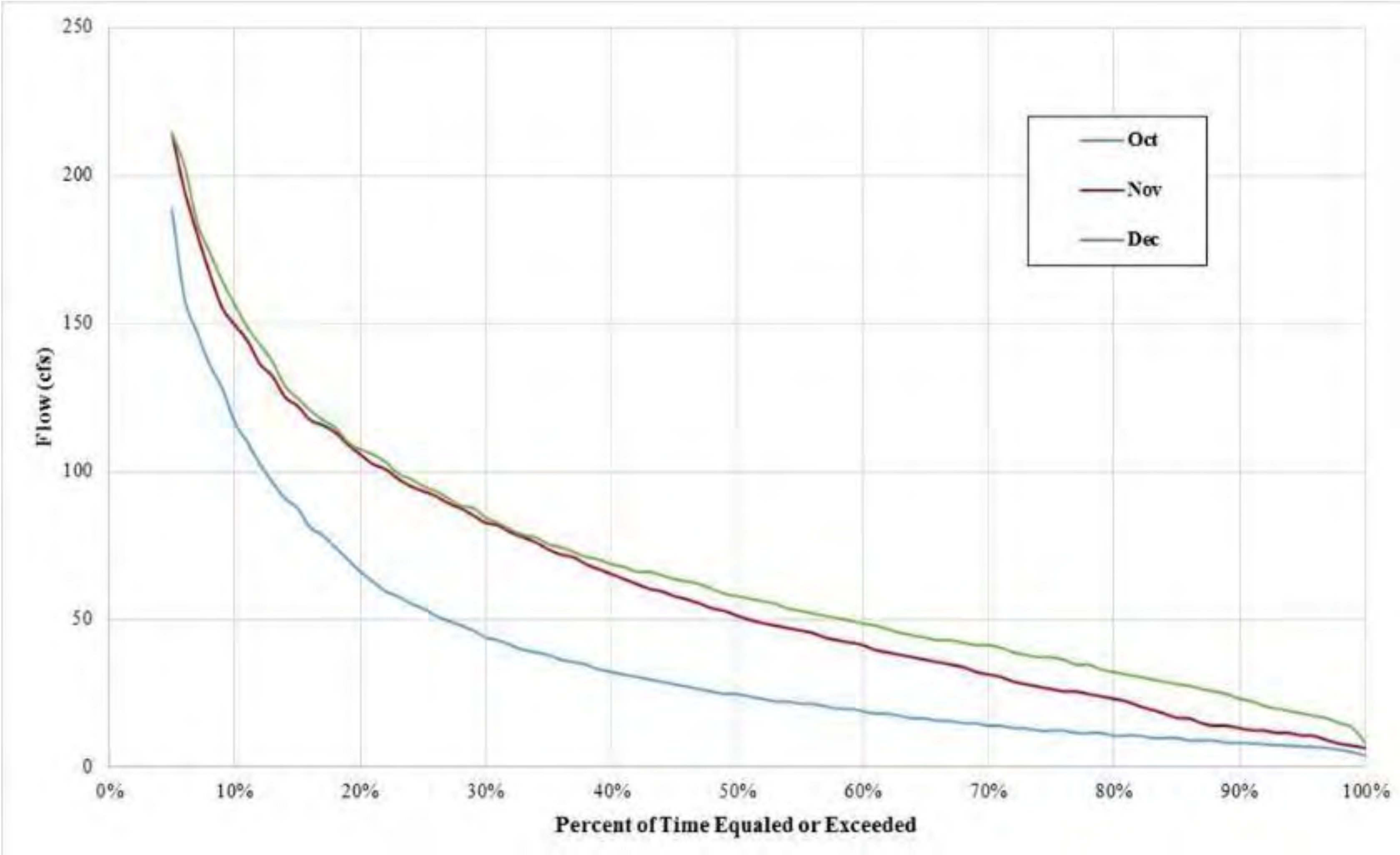


Figure 3.1-10: Fall River – Oct, Nov, Dec Flow Duration Curve (1967- present)

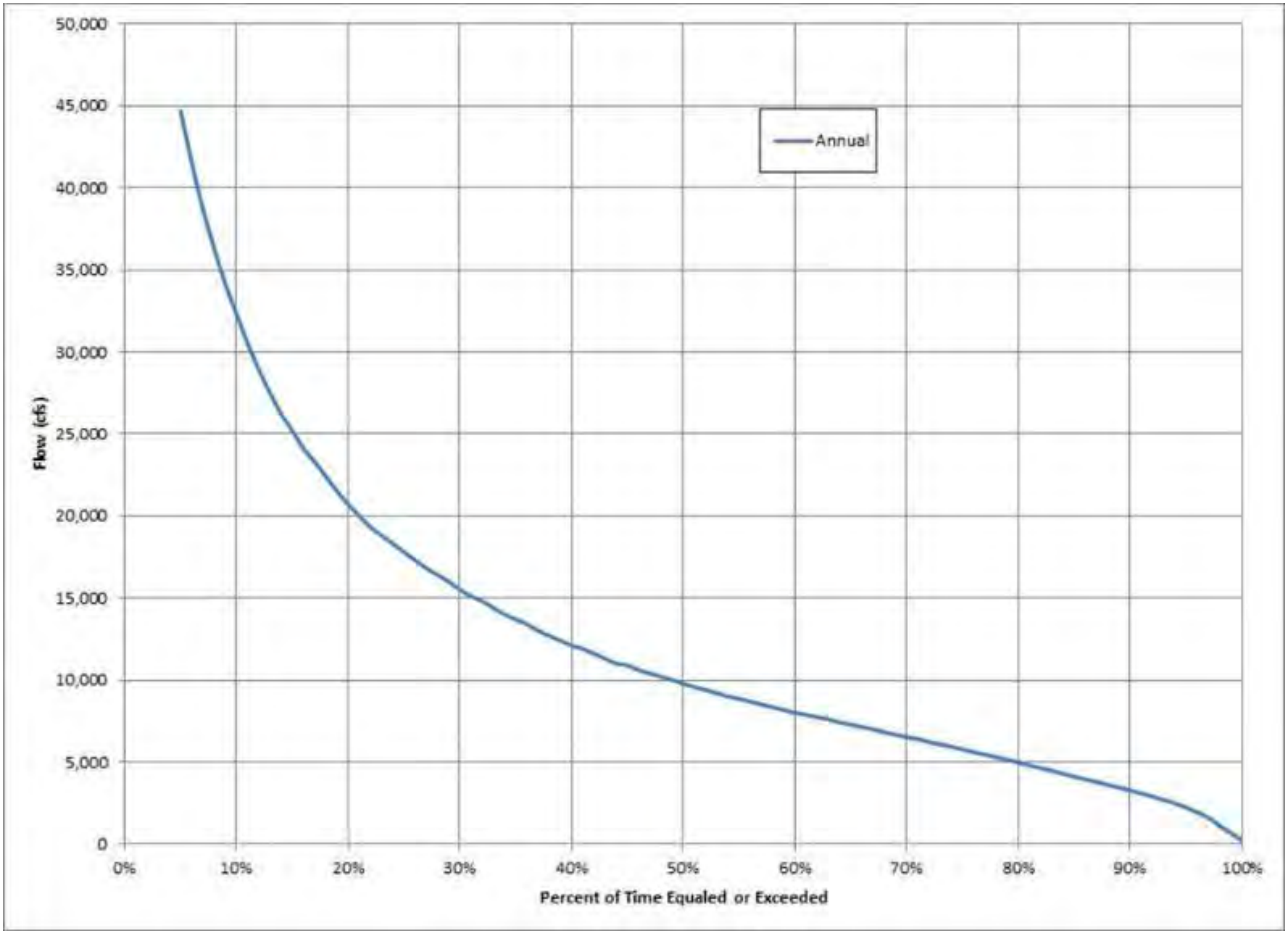


Figure 3.2-1: Connecticut River at Montague USGS Gage Annual Duration Curve (1940- present)

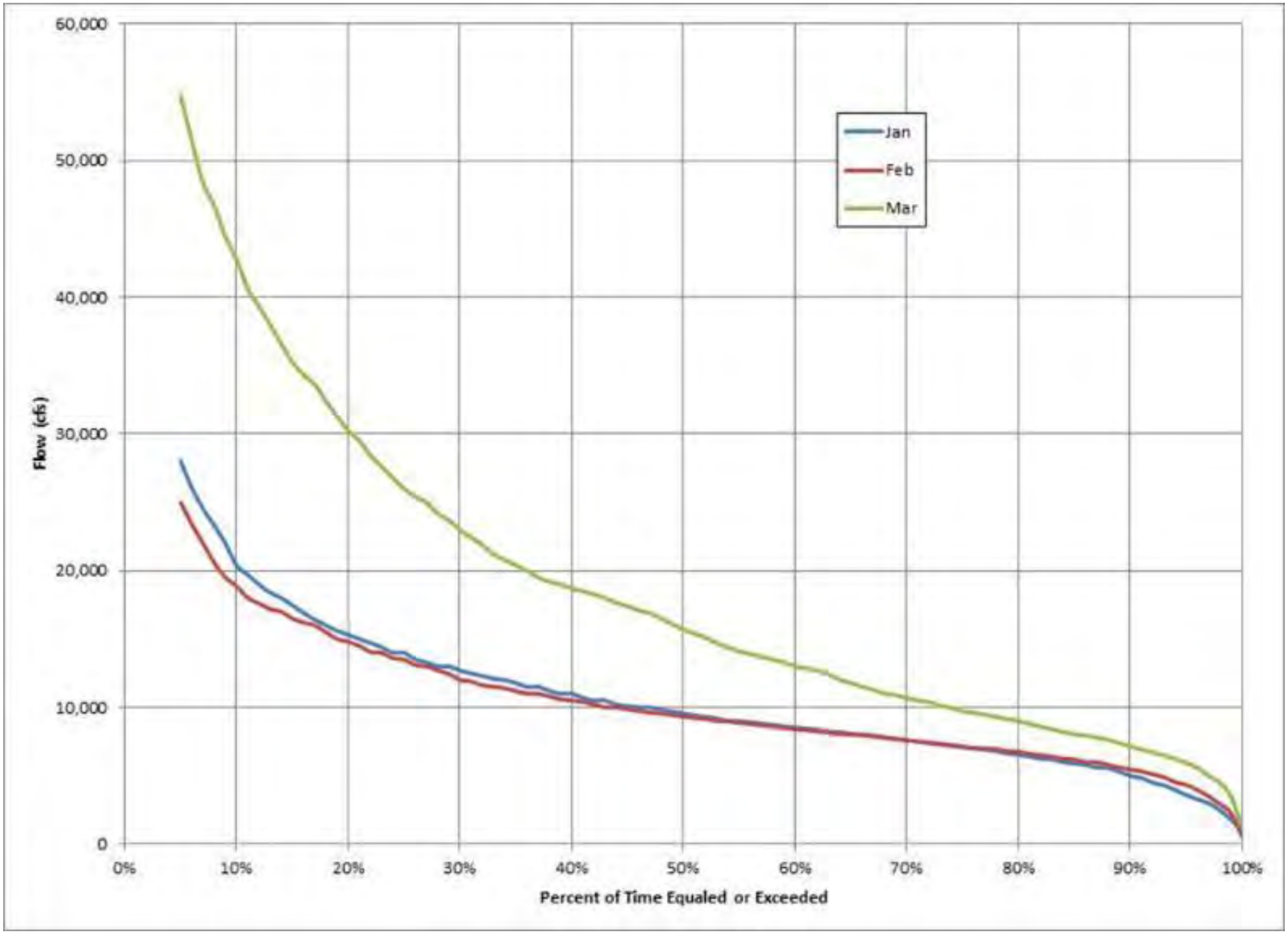


Figure 3.2-2: Connecticut River at Montague USGS Gage- Jan, Feb and Mar Duration Curve (1940- present)

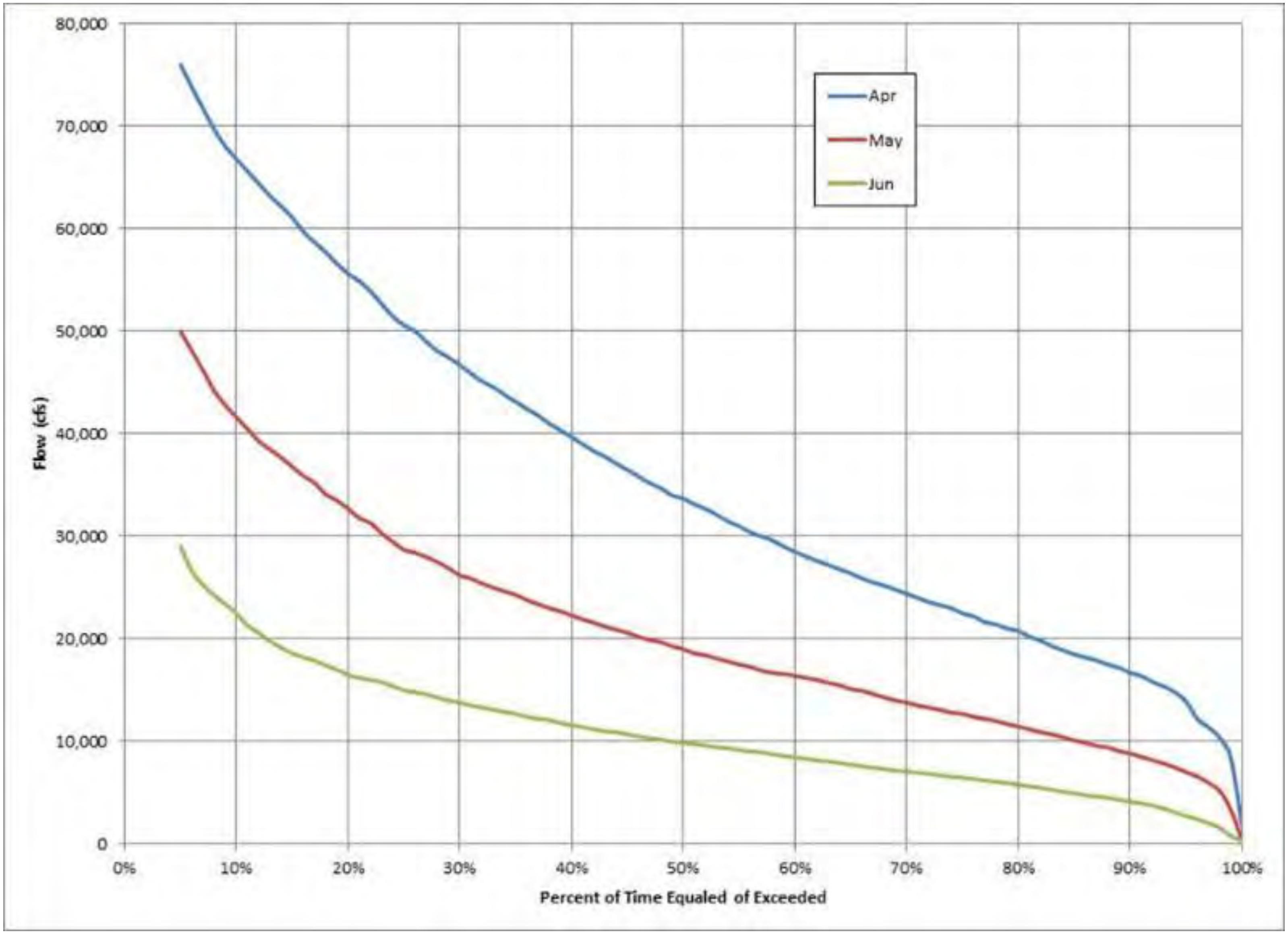


Figure 3.2-3: Connecticut River at Montague USGS Gage- Apr, May and Jun Mar Duration Curve (1940- present)

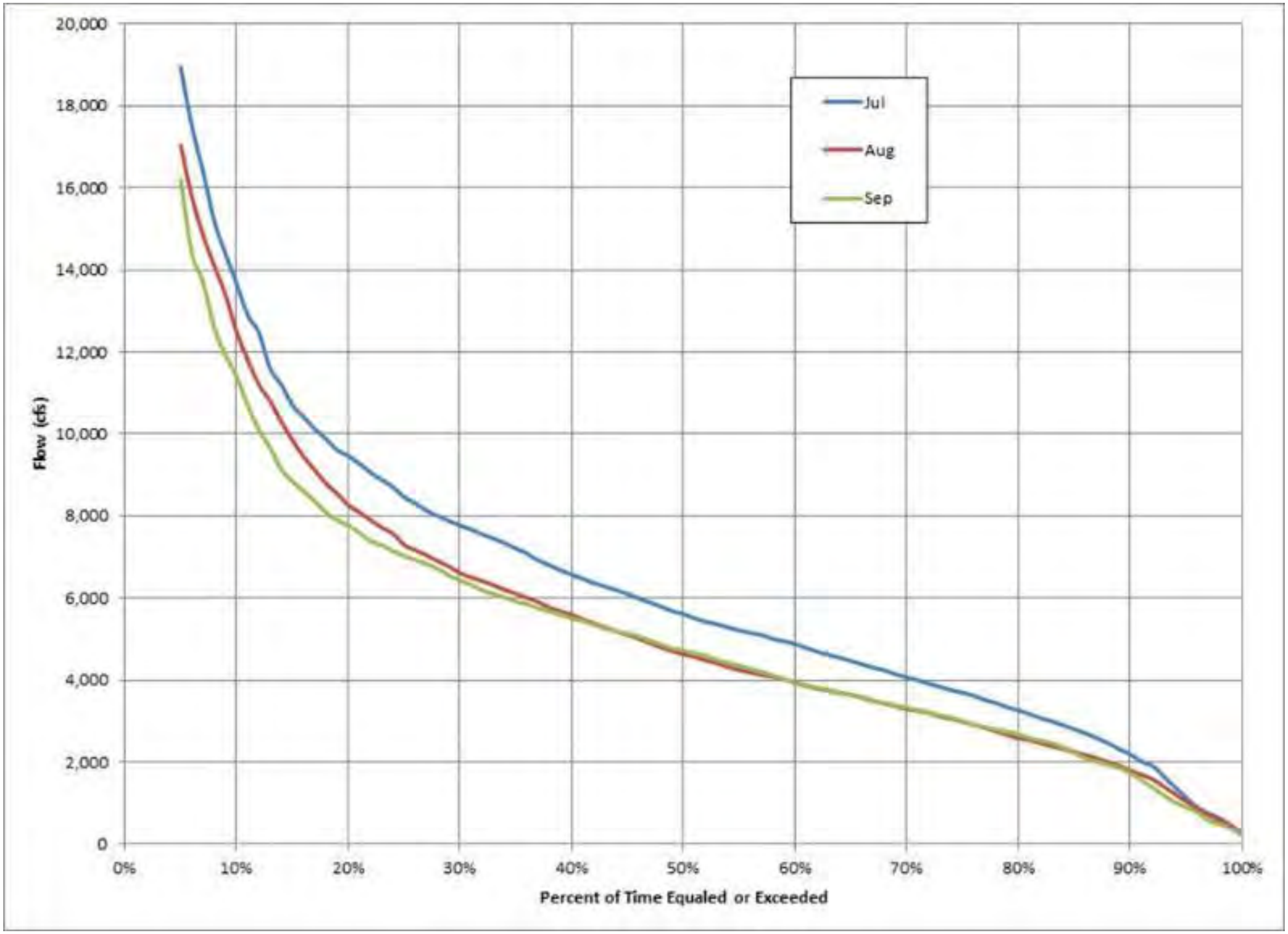


Figure 3.2-4: Connecticut River at Montague USGS Gage- Jul, Aug and Sep Duration Curve (1940- present)

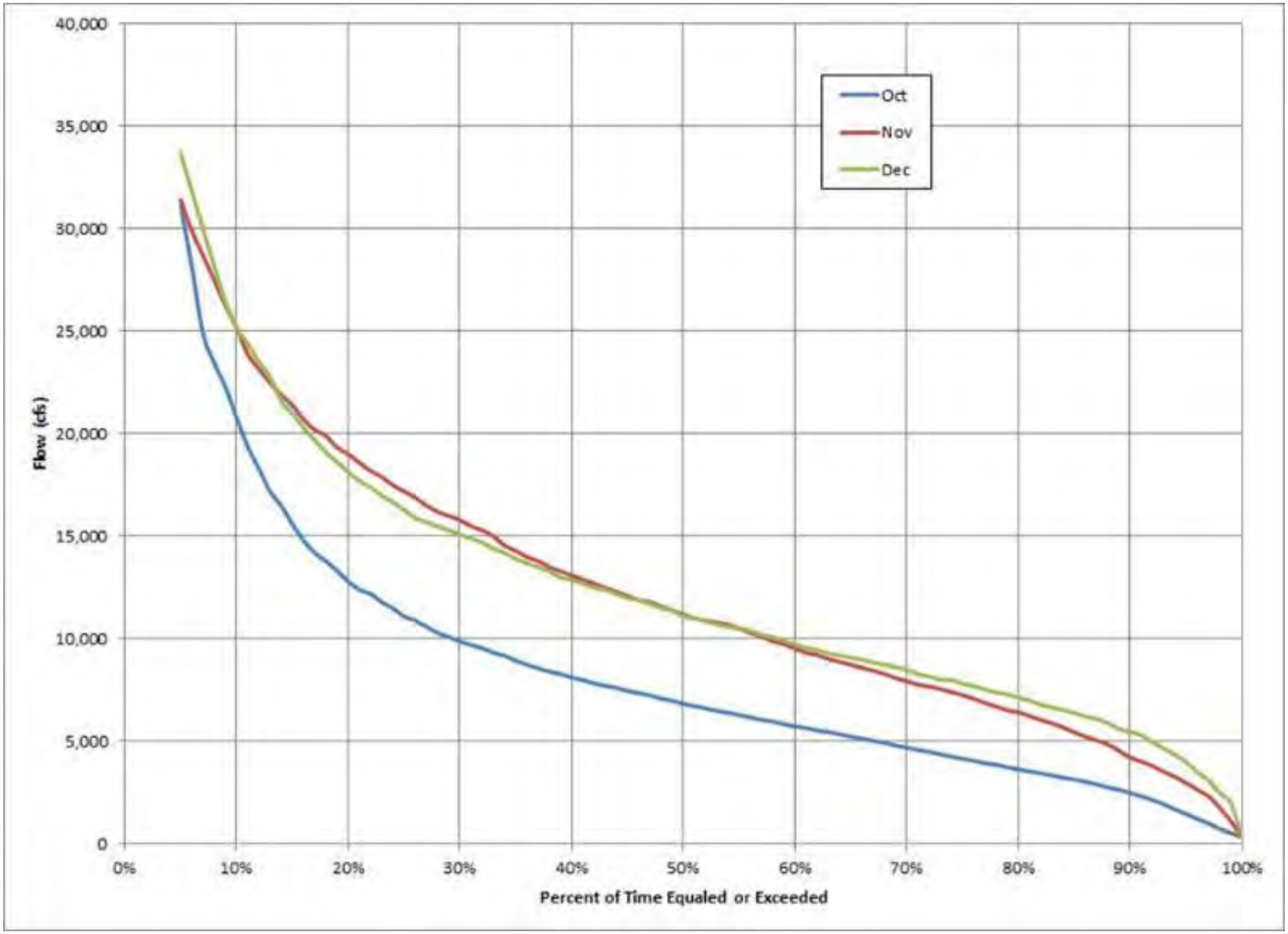


Figure 3.2-5: Connecticut River at Montague USGS Gage- Oct, Nov and Dec Duration Curve (1940- present)

4 STUDY AREA

The study area is managed to support restoration of native diadromous species including American shad, blueback herring, sea lamprey, and the Endangered Species Act (ESA)-listed shortnose sturgeon. The study area includes spawning and nursery habitat, and migration routes for these species. Study area waters also support an array of indigenous and non-indigenous coolwater and warmwater game and nongame fish species such as walleye, fallfish, white sucker, darter and dace species. No stocking of freshwater fishes is required to support game fishing. Freshwater mussel species are also an important aquatic fauna of interest to state and federal agencies.

4.1 Study Reach Descriptions

The study area was identified by stakeholders as the Connecticut River between the Turners Falls Dam and the Dinosaur Footprints Reservation. Five reaches were analyzed as part of this study (see an overview of locations in Figure 4.1-1 and a close-up of the bypass reach area in Figure 4.1-2.

Reach 1. Upper Bypass Reach. This reach is approximately one mile long extending from the Turners Falls Dam downstream to the confluence with the Station No. 1 tailrace. Stream channel structure and geomorphology are controlled primarily by bedrock. From the Turners Falls Dam to below the Fall River confluence approximately 0.16 miles downstream of the dam is the plunge pool, which remains wetted from leakage and Fall River flows. The bypass channel is dominated by scoured ledge substrate, and a poorly defined thalweg, before it begins to narrow upstream from the Station No.1 tailrace. Mesohabitat in this reach is dominated by a deep pool, but also includes run and riffle. Substrate is predominantly bedrock overlain with rubble and cobble. The upstream-most segment of Reach 1 extends from the toe of the Turners Falls dam downstream to the pool near the Turners Falls Road Bridge. This area includes a large expansive plunge pool at the base of the dam. Flow exiting the plunge pool has two major outlets. The river-right[5] channel follows the western shore and immediately bifurcates upon exiting the plunge pool. The two sub-channels are divided by a bedrock outcrop and both have well-defined channel cross-sections. The river-left channel has a poorly-defined channel and lacks a distinct thalweg. Flow passes over broken ledge and rubble through crevasses, and over short vertical drops. All channels converge near the upstream end of the large pool near the Turners Falls Road Bridge.

Reach 2. Lower Bypass Reach. This reach is approximately two miles long extending from the Station No. 1 tailrace downstream, terminating at the Rawson Island complex and a geological feature including a natural ledge drop known as “Rock Dam”. Stream channel structure is controlled primarily by bedrock. Reach 2 channel morphology is relatively well defined, and includes pool, run and riffle mesohabitats with bedrock overlaid with rubble and cobble substrates. On the right bank, the substrate consists of a wide bench of vertically folded bedrock along most of this reach. The downstream-most segment of this reach is a pool, and terminates in a bifurcated channel at the Rock Dam/Rawson Island complex. For hydraulic modeling purposes, this reach was subdivided into Reach 2A, which includes the area between Station No. 1 and about 1,000 feet upstream of Rawson Island, and Reach 2B which includes the remaining 1,000 feet of the reach down to Rock Dam/Rawson Island Complex.

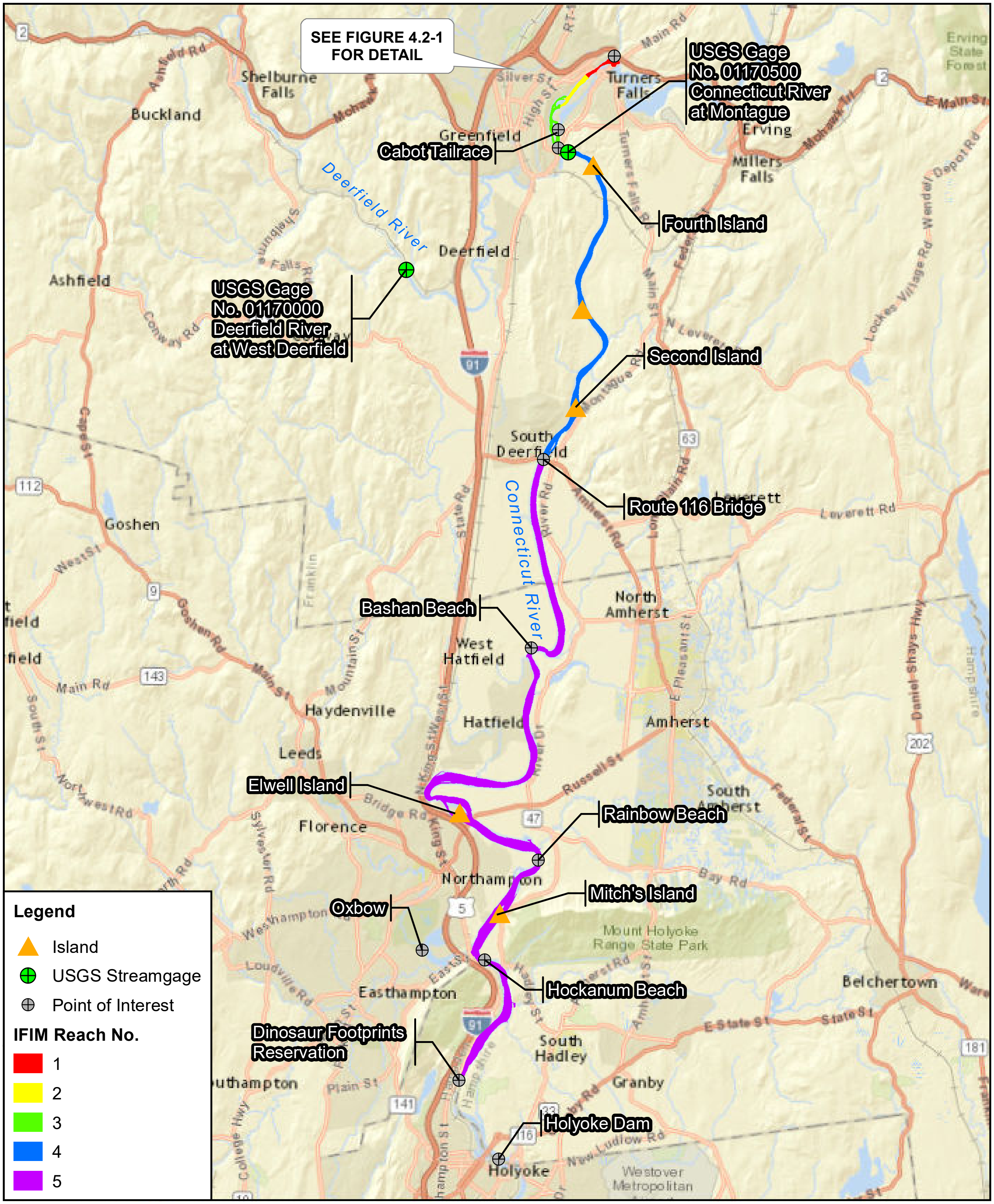
Reach 3. Tailrace Reach. This reach extends from below the Rock Dam/Rawson Island complex downstream approximately 1.75 miles to the USGS gage on the Connecticut River at Montague City (Gage No. 01170500). Stream channel structure is dominated by alluvial deposits, including an island and split channel complex both upstream, across, and downstream from the Cabot

[5] All terms such as “river-right” in this document are based on looking downstream.

Station powerhouse. Hydraulic effects are complex, and include backwatering from Cabot Station upstream to Rock Dam as well as flow between islands. Habitat is primarily riffle and run; substrate is dominated by gravel bars and cobble, and includes ledge outcrops at the General Pierce Bridge area.

Reach 4. This reach is approximately 9 miles long and extends from the Montague USGS Gage downstream to the Route 116 Sunderland Bridge. Habitat and flow in this reach are influenced by spill over the Turners Falls Dam, Cabot discharges, and Deerfield River discharges. This section of river is alluvial and low gradient, with a well-defined channel and embankments, and repeating patterns of pool and run habitat. Substrate varies but is dominated by cobble, gravel and fines.

Reach 5. This reach extends 22 miles from the Route 116 Bridge downstream to a natural hydraulic control in the vicinity of Dinosaur Footprints Reservation. It is a low gradient, alluvial reach with limited mesohabitat variability and in many cases very gradual transitions from one mesohabitat type to the next contiguous type. Over 75% of the mesohabitat in this reach is comprised of run and most of the remainder is pool. Hydraulics in this reach are influenced by Holyoke Dam operations (1.2 foot fluctuation) and the upstream hydropower projects.



FIRSTLIGHT POWER RESOURCES

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

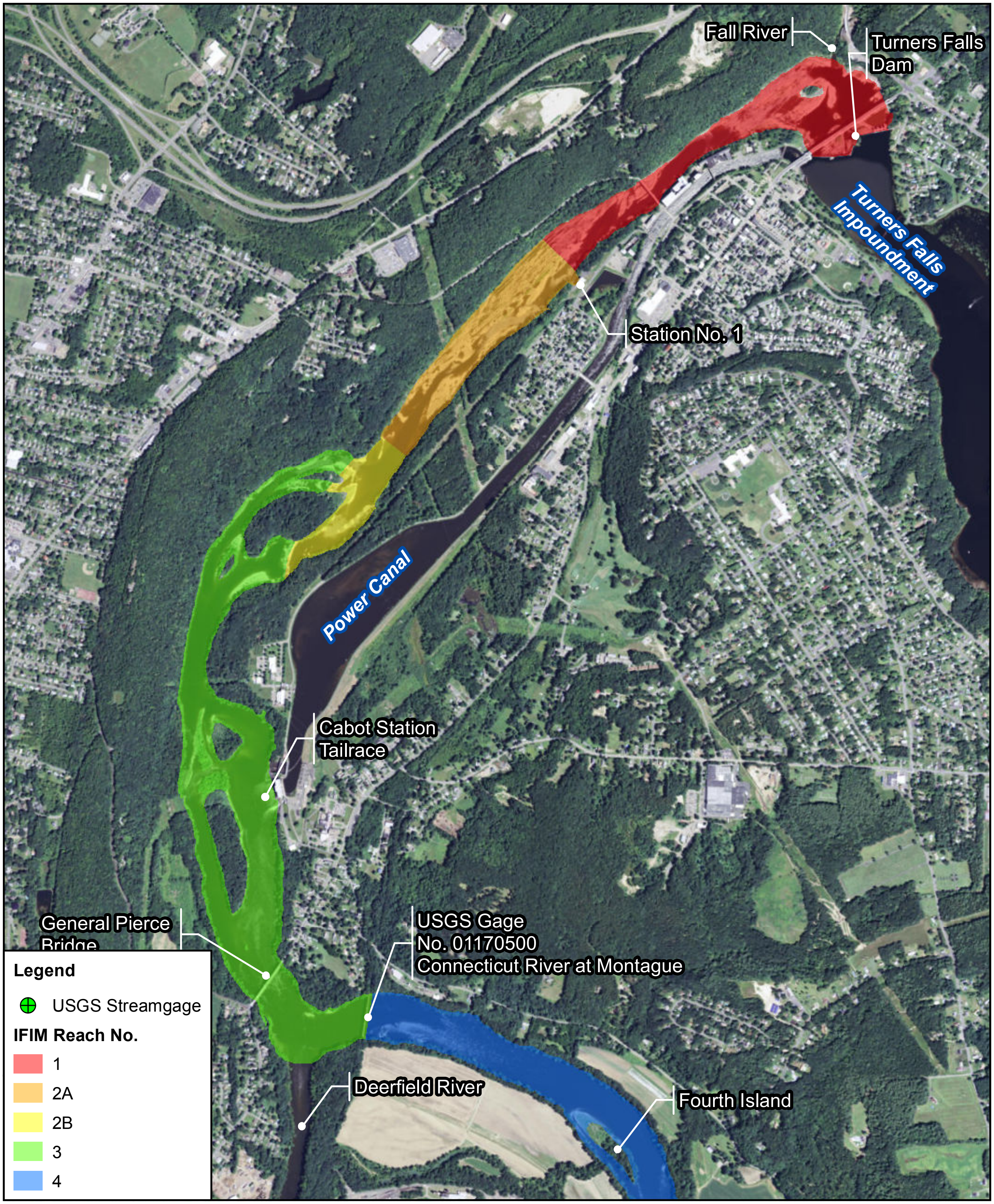
Figure 4.1-1: Instream Flow Study Reaches

FirstLight Power Resources

N

0 2 4 8 Miles

Path: W:\gis\maps\IFIM\figure_4_1_1.mxd



FirstLight Power Resources

N

FIRSTLIGHT POWER RESOURCES

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

0 0.25 0.5 1 Miles

Figure 4.1-2: Instream Flow Study Reaches 1 thru 3 - Bypass Reach

Path: W:\gis\studies\3_3_1\maps\Figure 4.2-1_v2.mxd

5 METHODS

5.1 Overview of PHABSIM Methodology

The PHABSIM methodology is based on the premise that aquatic organisms prefer a certain range of depths, velocities, substrates, and cover types, which are species and life stage-specific, and that the availability and quality of these preferred habitat conditions varies with stream flow. The PHABSIM methodology is designed to quantify potential physical habitat suitability for each evaluation species and life stage at various levels of stream flow, using a series of modeling techniques developed by the USFWS (Bovee, 1982; Bovee, *et al.,* 1998; Milhous *et al.,* 1989).

A natural stream is comprised of many different physical features in several combinations. One area, such as a riffle, may be shallow and fast-moving over a substrate of cobble and gravel with no cover while another area, such as a pool, may be deep and slow-moving over a substrate of silt, with a large root wad along the shore. One fish species may find the riffle desirable while another species may prefer the pool; a third species may not prefer either. It is also common for a fish species to prefer different habitats during its different life stages. For example, a species might prefer a riffle for spawning and another habitat, such as a pool with cover, for feeding, resting, or hiding. These different habitat types (e.g., pools, riffles, runs) are known as mesohabitats.

In general, a fish species or life stage prefers a particular mesohabitat type because the microhabitat characteristics (i.e., depth, velocity, substrate, and cover) comprising the mesohabitat are within its preferred range for the particular species/life stage. For example, brown trout prefer faster water with a rocky substrate, such as a boulder run, while common carp prefer slower water with silt or mud substrates, such as a pool. These microhabitat conditions of depth and velocity are not static; they vary with stream flow. Too much or too little flow through the riffle or pool may push the velocities and depths outside the preferred limits or tolerances of a particular species or life stage.

Using PHABSIM, the availability of preferred microhabitat conditions at any given flow can be modeled for instream flow decision making. In the field, microhabitat parameters of depth, velocity, substrate, and cover are measured at numerous points within the channel and along the length of the river. All measurements are usually taken at selected low, medium, and high flow releases. The PHABSIM model uses these measurements to predict habitat availability at flows other than those measured in the field. The product of the PHABSIM model is a habitat versus flow relationship that is expressed as Weighted Usable Area (WUA) over the range of simulated stream flows.

Major steps within the PHABSIM methodology include:

- Study scoping and agency consultation;
- Habitat mapping;
- Study area/transect selection;
- Field collection of hydraulic (depth, velocity and water surface elevation) and substrate data;
- Hydraulic model simulation to predict depths and velocities with respect to substrate and cover under a variety of discharges; and
- Habitat model simulation using Habitat Suitability Indices (HSI) to generate habitat versus flow relationships for each evaluation species/life stage.

5.2 Evaluation Species, Habitat Suitability Indices, and Substrate Coding

5.2.1 Evaluation Species

Evaluation species were selected by stakeholders from a list of species known to be present in the general study area. FirstLight consulted with stakeholders to finalize the target species and life stages by study reach in 2013 and 2014. Shown in Table 5.2.1-1 are the species, life stages and periodicity of life stages being evaluated as part of this study, organized by reach.

5.2.2 Habitat Suitability Indices

As discussed earlier, aquatic habitat in a river is comprised of both microhabitat and macrohabitat parameters. Microhabitat represents a particular location's physical characteristics within a river, such as slope, width, substrate, cover and the variation of depth and velocity with flow. Macrohabitat refers to broader characteristics impacting fish survival and movement such as food supply, predation and water quality. The following analyses implicitly assume that macrohabitat is suitable throughout the study reach.

Each species/life stage has a preferred range of microhabitat (depth, velocity, substrate and cover) conditions. For example, adult smallmouth bass may prefer greater depths and lower velocities than adult American shad. Biologists have conducted studies or used professional judgement to identify the depth, velocity, and substrate preferences for an array of species and life stages. Habitat Suitability Index (HSI) criteria have been developed from these studies for depth, velocity, substrate, and in some cases, cover.

HSI criteria rate the species/life stage preference using a 0 to 1 scale. A suitability index value of 0 indicates no habitat value, while a suitability index value of 1 indicates optimal habitat value. Quality habitat is defined as areas having a suitability index equal to or greater than 0.5 (Gomez and Sullivan *et al*. 2012).

The study team recommended HSI criteria for aquatic species of specific ecological and resource management interest. Several species and life stages were combined by habitat use guilds to ease interpretation. Specific guilds were assigned to study sites following Leonard and Orth (1988), based on overall depth and velocity characteristics existing at low to medium discharges. HSI criteria for all species and life stages adopted for this study except for mussels are presented in Appendix A.

Quantitative binary HSI criteria were developed for all state-listed mussel species documented in the study area [Yellow Lampmussel (*Lampsilis cariosa*), the Eastern Pondmussel (*Ligumia nasuta*), and the Tidewater Mucket (*Leptodea ochracea*)] using the Delphi technique. Under this method, a panel of mussel experts was 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 experiences. HSI criteria development for the three target mussel species is described in the report for 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 criteria are contained in Table 5.2.2-1 below.

5.2.3 Substrate Classification

HSI for each of the target species/life stages are based on habitat variables of depth, velocity and substrate. Substrate, like velocity and depth, plays a vital role for fish habitat, particularly as it relates to spawning. While velocity and depth are modeling outputs, substrate was field identified and classified using the classification system shown in Table 5.2.3-1. Substrate refers to the material armoring the channel bed (e.g., sand, gravel, bedrock) and is an important variable, as certain species and life stages of fish prefer different substrate types.

Table 5.2.1-1: Evaluation Species and Periodicity

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
American Shad												
Spawning and incubation												
Juvenile												
Adult												
Blueback Herring												
Spawning and incubation												
Shortnose Sturgeon												
Spawning												
Egg Larvae												
Fry												
Young of the Year Disperse downstream												
Adult & Juvenile Foraging												
Adult & Juvenile Overwintering												
Fallfish												
Spawning												
Fry												
Juvenile												
Adult												
Longnose Dace												
Juvenile and Adult												
White Sucker												
Spawning												
Fry												
Juvenile												
Adult												
Walleye												
Spawning												
Fry												
Juvenile												
Adult												
Tesselated Darter												
Juvenile and Adult												
Sea Lamprey												
Spawning and incubation												
Macroinvertebrates												
Larvae												
Freshwater Mussels												
All Species												
Habitat Guilds												
All Guilds												

Table 5.2.2-1: Binary HSI Scores for Three Massachusetts State-Listed Mussel Species (standard units)

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

Table 5.2.3-1: Substrate Classification System

Code	Substrate Type	Size Class (metric)	Size Class (English)
1	Detritus/Organic	NA	NA
2	Mud/soft clay	NA	NA
3	Silt	< 0.062 mm	< 0.00244 in
4	Sand	0.062 - 2 mm	0.00244 - 0.0787 in
5	Gravel	2 - 64 mm	0.0787 - 2.52 in
6	Cobble/rubble	64 - 250 mm	2.52 - 9.84 in
7	Boulder	250 - 4000 mm	9.84 - 157.5 in
8	Bedrock*	NA	NA

* There are four types of bedrock conditions that provide differing levels of habitat suitability. These are smooth bedrock ("Type 1"), complex bedrock ("Type 2"), bedrock densely overlain with smaller substrates such as cobble/boulder ("Type 3"), and bedrock sparsely overlain with smaller substrates such as cobble/boulder ("Type 4").

- **Type 1. Smooth bedrock.** This condition lacks sufficient cover, crevasses or other features that provide shelter or foraging opportunities for fish and is consistent with a low suitability rating.
- **Type 2. Complex Bedrock.** This condition provides a degree of shelter; based on the size and geometry of the folds and striations, the variability appears to generally mimic boulder-sized substrates.
- **Type 3. Bedrock densely overlain with smaller substrates**. This condition provides shelter and foraging opportunity. In situations where overlying substrates are abundant (*i.e. greater than 50% of the stream bottom*) substrate was classified as if it were the dominant overlying material and assigned the same suitability rating to this type of dominant smaller substrate.
- **Type 4. Bedrock sparsely overlain with smaller substrates**. This condition provides limited shelter and foraging opportunity. In situations where overlying substrates are sparse *(i.e. less than 50% of the stream bottom*) substrate was classified as if it was the bedrock material (type 1 or type 2).

5.3 Bathymetric, Hydraulic, and Substrate Field Data Collection

5.3.1 Reach 1 (Plunge Pool Assessment, Zone of Passage, and PHABSIM 1-D Single Transect Model)

During scoping of the IFIM study, interested stakeholders walked the entire bypass reach in September 2013. The upstream-most segment of Reach 1 (*i.e.*, the segment between the Turners Falls Dam downstream to the large pool near the Turners Falls Road bridge crossing) is comprised of a series of bedrock controlled channels with multiple channels and outlets.

This area includes a large expansive pool at the base of the dam. Flow exiting the pool has two major outlets. The right channel[6] follows the western shore and immediately bifurcates upon exiting the plunge pool. The two sub-channels are divided by a bedrock outcrop and both have well-defined channel cross-sections. The left channel has a poorly-defined channel and lacks a distinct thalweg. Flow passes over broken ledge and rubble through crevasses, and over short vertical drops.

Based on viewing the reach, all parties agreed it was an area that is not easily simulated using either 1-D or 2-D hydraulic modeling techniques, due to the hydraulic complexities. As an alternative, all parties agreed to assess the reach by collecting detailed empirical data at specific flow increments.

There were four areas (see inset above) of investigation for the upper portion of Reach 1, each with a different primary objective.

1) Plunge pool at the toe of the dam.
    a. The study objective was to develop a stage-discharge and wetted area relationship for the observed flow releases.
2) Left channel.
    a. The study objective was to determine the relative zone of passage characteristics of the most limiting migration barrier at various flow releases.
3) Center channel.
    a. The study objective was to describe channel hydraulics at various flows.

[6] This position of the three channels in this area are described from the vantage point of looking downstream (i.e., right channel looking downstream from dam).

4) Right channel.
    a. The study objective was to determine the relative habitat suitability in this channel for resident aquatic species at various flows.

Inflow through the study area was regulated by adjusting the bascule gate 1, located closest to the Spillway fishway. The gate was opened to provide the targeted flow, based on water surface elevation (WSEL) in the Turners Falls Impoundment. In addition, the study area received approximately 125 cfs via the Spillway fishway, and inflow from Fall River. A Sontek M9 Acoustic Doppler Current Profiler (ADCP) unit was used to gage inflow from Fall River (Q_{FB}), and also to determine flow routing. A staff gage was installed at the Fall River to verify that inflow remained stable during the study period. A gaging site was established at the plunge pool outlet providing inflow to both the right channel and center channel (Q_1), and an independent gaging site was located in the right channel at the habitat transect (Q_2). For each flow release, flow routing was calculated for each channel as follows:

CHANNEL	Inflow Data source
Right channel	Q_2
Center channel	$Q_1 - Q_2$
Left channel	Plunge pool inflow - Q_1
Plunge pool	Gate flow + fishway flow + Q_{FB}

5.3.1.1 Reach 1-Plunge Pool Assessment

Detailed cross-sectional depth and velocity data were collected at several transects within the plunge pool (Figure 5.3.1-1). Data were collected with an ADCP linked to a Real-Time Kinetic Global Positioning System (RTK GPS) at a flow of approximately 125 cfs from the Spillway fishway and no spill at the dam. The measured flow during cross-sectional data collection ranged between 100 cfs and 194 cfs.

Additional general bathymetry data were collected in the wetted areas of the plunge pool using an ADCP linked to an RTK GPS. Topography was also collected in areas where bathymetry was not possible using an RTK GPS in most areas, and a total station was utilized where GPS reception was not sufficient for RTK GPS point collection (i.e. under the bridge or close to the dam). All bathymetric and topographic data collection incorporated the use of multiple benchmarks, such that data were accurate and consistent among surveys and equipment.

Based on the bathymetry data collected within the plunge pool, wetted area and volume calculations were made a function of WSEL. Data from water level recorders placed within the immediate area of the plunge pool were used to convert WSEL to flow using the following relationship: $Q\ (cfs) = 400*(WSE\_feet\_NGVD29 - 134.46)^{2.4}$.

5.3.1.2 Reach 1-Left Channel

The stakeholder team walked the length of the channel at a flow of approximately 125 cfs (as released from the dam/Spillway fishway), to identify the most limiting passage barrier. A vertical ledge drop spanning the channel in a perpendicular plane was selected for study. Water level loggers were installed in the backwater at two locations across the toe of the drop, and staff gages were also placed at two locations along the crest of the drop. A transect line was erected across the crest of the drop with the headpin and tailpin anchored above the expected water line, and used as reference to establish a surveyed bed elevation of the crest. At each flow release an observer recorded water depth once flow stabilized following a release. These water depths were converted to elevations and correlated to the water elevations from corresponding times obtained from the level loggers. The analysis consisted of plotting the water depth relative to the bed elevation at the cross-section to determine the percentage of the cross-section that was sufficiently submerged to meet the fish passage criterion of meeting the full body depth (estimated to be 0.6 ft) of an adult American shad (T. Castro-Santos, pers. comm.).

5.3.1.3 Reach 1-Center Channel

The stakeholder team reviewed the characteristics of the center channel at a dam flow release of 125 cfs as well. This channel diverges from the right channel slightly downstream from the west outlet of the plunge pool, and is separated from the right channel by a bedrock terrace. It is bedrock controlled, relatively straight, flume-like, with little object cover.

At the low flow it was approximately 4 or more feet deep and observed to be fast flowing. Stakeholders observed that the channel would have limited habitat suitability at higher flows due to increases in velocity, and that it was already adequately deep for fish habitat and fish passage purposes at a low flow. Stakeholders therefore requested that FirstLight characterize the changes in depth and velocity at higher flows by using the US Army Corps of Engineers' (Corps) HEC-RAS hydraulic model.

Mean column velocity in the middle bypass channel was estimated using the HEC-RAS modeling software and the ArcGIS HEC-GeoRAS extension at five cross-sections. Elevation data input into the model was obtained from the MassGIS LiDAR Terrain Data program and was downloaded as a 2-meter resolution digital elevation model. The channel geometry and slope were estimated using the digital elevation model as well as with information that was provided by staff who performed a site visit. A Manning's roughness coefficient of 0.03 was assumed due to the straight, bedrock nature of the channel.

The channel velocity was analyzed at four gate flow releases. Flow through this channel was calculated by taking into account the released flow, measured inflow from Fall River, and measured outflow through two separate channels (Section 5.3.1.1). These flows were used as model input to analyze flow velocities through the channel.

5.3.1.4 Reach 1-Right Channel

The stakeholder team walked the full length of the right channel at 125 cfs (released from the Spillway fishway/dam), and observed that it was generally uniformly wide, and comprised of shallow run and riffle habitat. Base substrate is bedrock, with the riffle comprised of a layer of cobble and boulder scattered onto the bedrock. A single transect was located in a riffle area. A transect line was erected from bank to bank and a bed profile, WSEL, and substrate map was surveyed. A staff gage was erected and elevations obtained at each flow release. Velocities were recorded using the ADCP linked to an RTK-GPS. The ADCP unit was mounted to a raft and tethered to a line so that it could be drawn across the channel to continuously record velocity. These data were used for habitat analysis and also to gage the flow in this channel. The ADCP unit was deployed at the 500, 1,500 and 2,500 cfs flow releases, but could not be deployed at the 4,000 cfs release because the flow was too turbulent. A stage–discharge relationship was developed from the three lower flows to estimate velocities at the higher flow. The original concept for assessing habitat suitability at each flow envisioned the stakeholder group making direct empirical observations of depth, velocity, substrate and wetted area at each flow based on the HSI developed for IFIM modeling in the other study reaches. However during the flow demonstration, many stakeholders elected to observe reach flows from a distance and were not able to review and discuss the data as originally envisioned. Therefore an alternative method for analysis was required. Scrutiny of the collected transect data indicated that it was adequately surveyed to be used in a simple PHABSIM model as long as the modeled area was confined to the right channel and not used to extrapolate to other un-surveyed channel areas. PHABSIM modeling followed procedures consistent with those employed downstream in Reach 1 and in Reaches 2 and 4.

5.3.2 Reach 1 and 2A- PHABSIM 1-D Model

Study sites and longitudinal cell boundaries within the downstream portion of Reach 1 and Reach 2A (i.e., between Station No. 1 and about 1000 feet upstream of Rawson Island) were located in consultation with stakeholders in September 2013. Boundaries were placed within each study site to portray channel configuration, slope, hydraulics and/or substrate and cover of specific mesohabitat types of interest. Conditions within a pair of boundaries were considered to be homogenous, and transects were subsequently located within selected cells. This scheme resulted in a total of 11 transects selected (two (2) in Reach 1 and nine (9) in Reach 2A). Additional hydraulic control transects were also established to aid in hydraulic modeling (Figure 5.3.2-1).

Field data collection methods followed standardized procedures (Bovee *et al*., 1998). Transect data were collected in accordance with the requirements for completing hydraulic modeling with the Water Surface Profile (WSP) model within the USFWS's PHABSIM library of computer programs.

Each study transect was defined by head- and tailpins placed above the crest of each bank. Headpins were oriented along the right bank (looking downstream). Pin locations were field-blazed and semi-permanently fixed with either rebar or by using a large tree or other fixed object and then benchmarked by GPS survey. Fiberglass survey tape or high-strength Kevlar® lines were secured between each transect headpin and tailpin.

Stream hydraulic data (i.e., streambed and WSEL) were collected at three calibration flows (approximately 200 cfs, 700 cfs, and 4,000 cfs). Mean column velocity data were collected at the 200 cfs and 700 cfs calibration flows, and total discharge was measured at each calibration flow. Substrate data collection was conducted at low calibration flow to ease examination of stream channel characteristics.

Streambed elevation, mean column velocity, substrate and edge of water were recorded at a series of points (referred to as verticals) along each transect. Verticals were established wherever a major change in any of the above four parameters occurred. This typically resulted in about 80 or more verticals per transect. Additional verticals were inserted so that no more than 10% of total estimated transect discharge passed between any pair, to optimize the accuracy of the hydraulic model.

Streambed and WSELs were surveyed to the nearest 0.01-ft elevation using a level and standard surveying techniques. Pre-established benchmarks were used to normalize elevations among transects. Mean column velocity was measured to the nearest 0.1-ft/s using calibrated Marsh-McBirney Model 2000 Flowmate electronic current meters tethered to a top-setting wading rod. In unwadable areas, velocity was measured either manually from a tethered inflatable raft equipped with a USGS stationing rig, or remotely with a raft-mounted Sontek M9 ADCP linked to an RTK-GPS drawn across the channel to continuously record velocity. Substrate types were classified according to particle diameter corresponding to pre-defined standardized substrate suitability criteria (Table 5.2.3-1).

5.3.3 Reach 2B and Reach 3-River2-D Model

A two-dimensional (2-D) hydraulic model was developed for the upstream end of the Rawson Island complex downstream to just below the Deerfield River confluence. This includes the downstream-most segment of Reach 2 (i.e., Reach 2B) and all of Reach 3. A 2-D approach best represents hydraulics in this area due to the relatively wide and shallow river channel with complex multiple-channel characteristics and hydraulics.

The 2-D model relies on a fine scale mesh that was developed using a combination of topographic (RTK-GPS, total station, and LiDAR) and bathymetric survey data. Boatable areas were surveyed with an ADCP linked to an RTK GPS. Wadeable and dewatered areas were surveyed with an RTK-GPS or a total station.

All surveys incorporated the use of multiple benchmarks to ensure accuracy and consistency among different surveys and equipment (Figure 5.3.3-1).

To calibrate the model accuracy, under different bypass flow entering from Reach 2 and Cabot Station discharge combinations, water depth and velocity data were collected under flows of approximately:

- 300 cfs bypass and 8,000 cfs Cabot;
- 1,000 cfs bypass and 4,500 cfs Cabot;
- 1,300 cfs bypass and 13,500 cfs Cabot; and
- 900 cfs bypass and 4,600 cfs Cabot.

Flows were field-checked to verify that they were within the target range. Depth and velocity data were collected under approximately steady flow conditions from the bypass reach and Cabot Station. Depth and velocity data were primarily collected using an ADCP linked to an RTK-GPS, though a digital flow meter was also used for shallow transects.

5.3.4 Reach 4-PHABSIM 1-D Model

Study sites within Reach 4 were located in consultation with stakeholders during a field visit on August 10, 2015. A total of 12 transects were selected. Additional hydraulic control transects were also established to aid in hydraulic modeling (Figure 5.3.4-1). Field data collection methods followed standardized procedures (Bovee *et al*., 1998) consistent with those used in Reaches 1 and 2A.

Each study transect was defined by head- and tailpins placed above the crest of each bank. Headpins were oriented along the right bank (looking downstream). Pin locations were field-blazed and semi-permanently fixed with either rebar or by using a large tree or other fixed object and then benchmarked by GPS survey.

WSEL data were collected at three calibration flows (2,318 cfs, 5,988 cfs, and 14,844 cfs). Mean column velocity data was collected at the 5,988 cfs calibration flow, and total discharge was measured at each calibration flow. Both cross-sectional bed elevation and substrate data collection were completed over several days as they are not flow dependent.

Streambed elevations were collected with an ADCP unit affixed to a floating board or boat. Shallow and overbank elevations were collected with a GPS unit or a survey rod and level. Substrate and edge of water were recorded at verticals along each transect. This resulted in approximately 80 or more verticals per transect. Additional verticals were inserted so that no more than 10% of total estimated transect discharge passed between any pair, to optimize the accuracy of the hydraulic model.

Streambed and WSELs were surveyed to the nearest 0.01-ft elevation. Pre-established benchmarks were used to normalize elevations among transects. Mean column velocity was measured to the nearest 0.1-ft/s using calibrated Marsh-McBirney Model 2000 Flowmate electronic current meters tethered to a top-setting wading rod. In unwadable areas, velocity was measured from a raft tethered to the transect line with a USGS stationing rig or with an ADCP. Substrate types were classified according to particle diameter corresponding to pre-defined standardized substrate suitability criteria (Table 5.2.3-1).

5.3.5 Reach 5-HEC-RAS 1-D Model

As part of Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach, and Below Cabot*, transect data for the HEC-RAS hydraulic model was obtained from a combination of sources including: 1) cross sections from FEMA studies; 2), bridge data from the Massachusetts Department of Transportation; 3) FirstLight cross sections; and 4) cross sections from the Corps /The Nature Conservancy. The FEMA cross sections were from flood insurance studies conducted in the 1980s. The towns covering this reach include from upstream to downstream order: Montague, Deerfield, Sunderland, Whately, Hadley, Northampton, Easthampton, South Hadley, and Holyoke. FEMA cross sections were not available in the Hatfield Reach, so FirstLight in 2014 obtained 8 transects with a boat based ADCP unit and manually obtained bank survey data. More detailed transections in the Northampton Reach were obtained from The Nature Conservancy (TNC). TNC (Marks, 2014) had conducted a study of floodplain forests in the Connecticut River Basin and one of the study sites was in the Northampton, MA area of the Connecticut River. Bathymetry data was collected by the USACE in the fall of 2011. In 2016, FirstLight also obtained 7 additional transects with a boat based ADCP unit near key mussel locations. FirstLight combined all data from these sources to create a HEC-RAS hydraulic model from just upstream of the Holyoke Dam to the Montague Gage.

In terms of transect locations in Reach 5, the RSP stated that "*Using the binary HSI criteria developed in Study No. 3.3.16 for any state-listed species that are discovered in study reach 4 or 5, determine if any binary HSI thresholds are not met under a range of modeled operating conditions anywhere in study reach 4 or 5.*" There were no state-listed mussels found in Reach 4, so the analysis focused on Reach 5. Mussel surveys conducted in 2005, 2009 and 2013 for the Holyoke Hydroelectric Project detected Yellow Lampmussels at a variety of sites in Reach 5, with abundances varying between sites; Eastern Pondmussel and Tidewater Mucket were detected at one site. FirstLight selected 15 transects (Figure 5.3.5-1) based on recommendation from NHESP (letter submitted to FERC, November 14, 2014). In this letter, NHESP suggested selecting transects based on varying abundance of state-listed mussels, including areas containing high, moderate, and low abundances as well as areas where none were found. Transects intersected or were relatively near to the survey areas from the 2005, 2009, and/or 2013 mussel surveys performed for the Holyoke Hydroelectric Project.

5.4 Hydraulic Modeling

5.4.1 Reach 1-Right Channel PHABSIM 1-D Single Transect Model

A hydraulic model using IFG-4 in the USFWS's PHABSIM library of computer programs was developed to simulate hydraulic conditions for the right channel transect (USDI and USGS 2001). The first step involved using IFG4 to develop a stage-discharge relationship at the transect using the WSEL and flows data measured in the field. The stage-discharge equation takes the form:

$$\mathrm{WSEL} = a * Q^{b}$$

where: WSEL = water surface elevation
a = constant derived from measured values of discharge and stage
Q = discharge
b = constant derived from measured values of discharge and stage

A linear regression was performed between the log of the discharge and the log of the WSEL to determine the constants in the above equation. Once the constants were known, the stage-discharge equation was used to predict the WSEL for flows not measured in the field. The cellular velocities measured in the field were used to calculate the Manning's "n" roughness coefficient for each habitat cell. During the calibration process, an initial solution of Manning's equation to obtain an estimated Manning's n at each vertical along a cross section was completed. This approach treats the velocities measured in the field as a template for describing velocities for other flows. Since channel slope, WSEL, and cellular velocity are known as part of the calibration flow data collection, Manning's equation can be solved for "n" at each vertical:

$$n = [1.486 * Se^{1/2} * d^{2/3}]/v$$

where: n = estimated Manning's n value at vertical
Se = energy slope for transect
d = depth at vertical
v = measured velocity at vertical

Note in this equation, that depth at the vertical has been substituted for the hydraulic radius[7]. Once the individual Manning's n values are computed at each vertical, cellular velocities can be computed at any other flow by solving Manning's equation for velocity and using the initial Manning's n value derived from the equation above:

$$v = [1.486/n] * d^{2/3} * Se^{1/2}$$

Velocity calibration was developed using the data obtained at the 2,500 cfs gate release, which produced a flow of approximately 1,287 cfs in the right channel where the transect was located.

5.4.2 Reach 1 and 2A-PHABSIM 1-D Model

A hydraulic model using WSP from the USGS's PHABSIM library of computer programs was developed to simulate hydraulic conditions for each transect using the data collected in the field (USDI and USGS 2001). WSP is a standard step-backwater computation model that predicts the WSEL, depths, and mean column velocities across each stream transect as a function of flow.

The WSP hydraulic model was divided to account for the differences in flow within the reach caused by the leakage from Station No. 1, since the WSP program does not allow for inflow to the model. The downstream model covers the downstream extent of the study area from Transect 1 to Transect 9 (i.e., Reach 2A). The upstream model covers from Transect 10 to the upstream extent of the study area near Transect 11 (i.e., Reach 1).

The calibration flow for the downstream low and mid flow models was 293 cfs and 720 cfs, respectively. The calibration flow for the downstream high flow model was 4,000 cfs. The calibration flows for the upstream model were 210 cfs, 626 cfs and 3,904 cfs for the low, mid and high flow models, respectively. Table 5.4.2-1 provides a summary of the field measured flows at each transect.

The low, mid and high flow models were calibrated to the WSEL that were measured in the field for each flow. WSP calibration consisted of adjusting Manning's roughness (n) values until simulated WSELs were within +/-0.1 ft of observed WSELs for the calibration discharges.

The WSP hydraulic model velocities were modeled using VELSIM, which is the velocity distribution model embedded in the library of PHABSIM programs; it predicts how velocity distribution at each transect changes over a range of simulated discharges.

In VELSIM calibration, attempts were made to match simulated velocities, at each transect, with velocities from the calibration discharges. As the field-measured discharges at transects varied from the calibration discharges, the velocities at each vertical for several transects were adjusted by a constant factor such that their sum for a given transect would yield the calibration discharge.

Manning's equation states:

$$V = \frac{1.49}{n} * R^{\frac{2}{3}}\sqrt{s} \text{ where;}$$

V = Velocity (ft/s)

[7] The hydraulic radius is the ratio of the cross-sectional area to the wetted perimeter, R = A/P. For relatively wide shallow channels, the hydraulic radius (R) approximates the hydraulic depth.

R = Hydraulic Radius (ft)

S = Slope of the Energy Grade Line (ft/ft)

n = Manning's Roughness Coefficient

According to this equation velocity will increase as n decreases and velocity will decrease as n increases. Through iterating n manually, at local cells, a close fit to the calibration velocities could be achieved. The n value chosen for non-wetted areas was 0.055.

In the overbank, ineffective [8]flow areas n was set high in order to drive the simulated velocities down. An n value for when these overbank, ineffective flow areas became effective flow areas and a flow at which this happened also had to be determined. The flow was selected by examining a plan map of the reach and the simulated flow through the cross sections to determine a flow at which water would flow continuously, and not backwater, throughout the reach. After this was determined an appropriate n value for the overbank was selected on a transect by transect basis. This was achieved by averaging the calibration n values (for mid flow) over the center of the main channel at each transect.

5.4.3 Reach 2B and 3-PHABSIM 2-D Model

Hydraulic modeling was performed using River2D modeling software, which is described in Steffler and Blackburn (2002). River2D is a depth-averaged two-dimensional (lateral-longitudinal), finite-element hydraulic and habitat model. It requires input data for a set of spatially-distributed points or "nodes" throughout the study reach. It then creates a linearly-interpolated triangulated mesh from the set of nodes, with each triangle referred to as an "element". River2D solves for mass conservation and momentum balance in two (x,y) dimensions using the St. Venant flow equations. Input data include a digital bathymetric (riverbed topography) map, a stage-discharge relationship or boundary elevation at the downstream end of the study reach, and bed roughness throughout the study reach. Observed WSEL data are used for calibration purposes, but are not direct model inputs.

Accurate representation of the river bed's physical features is the most crucial factor in successful river flow modeling (Blackburn and Steffler 2002). Generally, elevation transitions in rivers are relatively continuous (except for the toe-of-bank contour), and most features are aligned longitudinally relative to the banks and thalweg.

A two-dimensional, finite-element computational mesh consisting of linear triangular elements was generated for the study reach, following the procedure described in Bovee *et al*. (2007). A uniform base mesh was initially applied across the study reach. The mesh was then modified with the primary objective of accurately representing bed structure in the model. This was done by visually assessing the raw bathymetry data, aerial photos and local knowledge of the river. At each node, bed elevation and roughness height were specified, and the model assumed a linear transition between each node. The final mesh contained 32,990 nodes and 65,055 triangulated elements. However, the node size was not uniform throughout the study reach. There was generally denser node spacing in wetted areas, particularly with complex geometry, and sparser node spacing in upland areas that never became wetted or are wetted only under very high flow. In particular, node spacing was greatly increased in the areas including near Rock

[8] Ineffective flow areas are portions of a channel cross section that contain water but are not actively being conveyed. This is a common occurrence at channel sections in close proximity to bridge and culvert sections with large embankment constrictions as well as channel sections with wide overbank areas.

Dam, Cabot Station, side channels near Rawson and Smead Islands to better represent the complex bed geometry of the reach.

Concurrent with the collection of bathymetric data, a direct-measurement survey of the water surface profile was conducted for the study reach. In addition, continuous WSEL data were used from 20 water level loggers that were placed in Reach 3 from May to October in 2014. Stage data was collected between flows of 120 cfs (in Reach 2B) and over 30,000 cfs.

With the measured inflow discharge and the measured WSEL as boundary conditions, River2D was run to produce a predicted water surface profile corresponding to the measured profile at the calibration discharge. To calibrate the model, adjustments were made to the finite element mesh where increased mesh density was warranted, and the roughness parameter was adjusted upward or downward to alter the resistance to flow provided by friction. For example, if the predicted water surface profile was uniformly lower than the measured profile, roughness height was increased. The increase in resistance caused the velocity to decrease and the depth to increase, thereby raising the elevation of the predicted water surface profile. This procedure was repeated until a reasonable match between the predicted and measured water surface profiles was obtained in the study area.

5.4.4 Reach 4-PHABSIM 1-D Model

Reach 4 was modeled with a HEC-RAS[9] hydraulic model using cross sectional data from a combination of sources including: 1) hydraulic cross sections from FEMA studies; 2) bridge data from the Massachusetts Department of Transportation; and 3) FirstLight habitat cross sections.

HEC-RAS model runs were simulated with two different downstream WSELs at Holyoke Dam of 99.47 feet and 100.67 feet and the results were averaged. In Reach 4, the majority of flow is represented by the USGS gage at Montague. Below the gage, only one substantial tributary, the Sawmill River[10] at RM 114.5, enters Reach 4. FirstLight used the same method for estimating tributary inflow in Reach 4 and 5 as summarized in Study Report No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot* (see Section 3.2.5 of that report, which was filed with FERC in March 2015). However, during most circumstances, the flow at the Montague gage is a reasonable representation of the flow in Reach 4.

As part of the field work associated with this study, FirstLight obtained cross sectional data at 16 new transects in Reach 4. In the HEC-RAS model, these new and more detailed transects replaced all but one of the existing cross sections in Reach 4. The existing transect that was not replaced was in a location where the new transects were over a mile apart and while the original transect does not have the detail of the new transect, the original cross section supplied a needed and representative cross section to the model.

The HEC-RAS model's WSELs were then copied into a PHABSIM WSP model, so that velocities and habitat could be modeled within that program. VELSIM, the velocity distribution model embedded in the library of PHABSIM programs, was used to predict how velocity distribution at each transect changes over a range of simulated discharges.

In VELSIM calibration, attempts were made to match simulated velocities, at each transect, with velocities from the calibration discharges.

Manning's equation states:

[9] This HEC-RAS model was developed as part of Study 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and Below Cabot*, which was filed with FERC in March 2015.

[10] The drainage area of the Sawmill River is approximately 32 square miles.

$$V = \frac{1.49}{n} * R^{\frac{2}{3}}\sqrt{S} \text{ where;}$$

V = Velocity (ft/s)

R = Hydraulic Radius (ft)

S = Slope of the Energy Grade Line (ft/ft)

n = Manning's Roughness Coefficient

According to this equation velocity will increase as n decreases and velocity will decrease as n increases. Through iterating n manually, at local cells, a close fit to the calibration velocities could be achieved. The n value chosen for non-wetted areas was 0.055. Velocities were calibrated at mid target flow (5,988 cfs).

5.4.5 Reach 5-HEC-RAS 1-D Model

Reach 5 was modeled with HEC-RAS using cross sectional data from a combination of sources including: 1) cross sections from FEMA studies; 2) bridge data from the Massachusetts Department of Transportation; 3) FirstLight cross sections; and 4) cross sections from the Corps/The Nature Conservancy.

HEC-RAS model runs were simulated with two different downstream WSELs of 99.47 feet and 100.67 feet at Holyoke Dam and the results were averaged. Inflows to Reach 5 are represented by the USGS gage at Montague. Below the gage, tributaries account for another 449 mi^2 of drainage area, resulting in a total drainage area at the Holyoke Dam of 8,309 mi^2. In the HEC-RAS modeling for the mussel habitat analysis, no inflow was modeled from the tributaries to focus the effects of water levels and velocities in Reach 5 on flows released by the Turners Falls Project. Table 5.4.5-1 provides a summary of the five scenarios that were modeled.

The HEC-RAS model, which by default produces a single average channel water velocity, was used to subdivide each model cross-section into a number of individual cells. Each cell represents a portion of the cross-section and the model was run to output a water depth and depth-averaged water column velocity for each cell for each scenario. Because mussels are benthic-dwelling organisms, a method was developed to calculate benthic velocity from the default model outputs (depth-averaged velocity for the entire transect).

Benthic velocity was calculated based on the logarithmic law, as detailed in the ASCE Manual 110 (Sedimentation Engineering). The logarithmic vertical flow velocity distribution is well represented by: $\frac{u}{u_*} = \frac{1}{\kappa} * \ln\left(\frac{z}{z_0}\right)$, where

u = time-averaged flow velocity at a distance z above the bed, u_* = shear velocity, z_0 = bed roughness length (i.e., distance above the bed where the flow velocity goes to zero), z = a distance above the bed, κ = von Karman's constant = 0.41. Shear velocity (u_*) is $\tau = \gamma * R_h * S$, where γ = water specific weight (62.4 lb/ft^3), R_h = hydraulic radius (commonly approximated as water depth), and S = energy grade slope (commonly approximated with water surface slope or bed slope).

In terms of the appropriate z_0 value to use, because bed boundaries in rivers are typically hydraulically rough, ASCE Manual 110 notes that the logarithmic velocity profile can be approximated by assuming $z_0 = k_s$, where k_s is a roughness height that is often proportional to the sediment size[11]. Therefore, based on this assumption the equation above was approximated as: $\frac{u}{u_*} = \frac{1}{\kappa} * \ln\left(\frac{z}{k_s}\right) + 8.5 = \frac{1}{\kappa} * \ln\left(30\frac{z}{k_s}\right)$.

[11] The formula to estimate roughness is often $k_s = \alpha_s * D_x$, where α_s ranges from 1.0 to 6.6 and D_x ranges from D_{35} to D_{90}, depending on which formula is used. See Table 2-1 in ASCE Manual 110 for more details.

The logarithmic law also has an equation to describe the mean column velocity: $\frac{U}{u_*} = \frac{1}{\kappa} * \ln\left(11 * \frac{H}{k_s}\right)$, where U = depth averaged water velocity, H = water depth, and the other terms are the same as the above equations.

Therefore, the two logarithmic law equations above (velocity at a specific depth and mean column velocity) were used to express water velocity at a specific depth as a function of mean column velocity. This cancelled out the shear velocity (u_*) component of the equation, eliminating a variable that cannot be directly measured in the field. The resulting equation is: $\frac{u}{U} = \frac{\frac{1}{\kappa}*\ln\left(30*\frac{z}{k_s}\right)}{\frac{1}{\kappa}*\ln\left(11*\frac{H}{k_s}\right)} = \frac{\ln\left(30*\frac{z}{k_s}\right)}{\ln\left(11*\frac{H}{k_s}\right)}$. As a reminder, u = water velocity at a distance z above the bed, U = depth-averaged water column velocity, z = a depth above the bottom (assume 0.25 feet), k_s is a roughness height (assume it is equal to d_{50}), and H is the water depth.

ADCP data were collected in 2016 from seven representative transects in Reach 5 to determine whether the theoretical velocity relationship reasonably approximated the conditions in the area. The ADCP could not measure benthic velocity accurately due to bottom interference with the multi-beam system and data from the bottom 10% of the water column were not evaluated. However, a non-linear relationship was apparent, with declining water velocities in the lowest portions of the measurable water column (Figure 5.4.5-1), which were lower than the mean water column velocity. Because the theoretical relationship only applies to areas near the bottom and to eliminate water surface effects (i.e. wind), only the lower 35% of the water columns was used in this analysis. The data were fitted to linear, parabolic, power, and logarithmic models. The samples were best-fitted by the non-linear models according to Akaike Information Criteria (AIC) (Mazerolle 2006) (Table 5.4.5-2). The lowest AIC indicates a higher likelihood of being the best-fit model, which for the Reach 5 data, was the logarithmic model (Table 5.4.5-2). This model was then compared visually to theoretical models utilizing different roughness values, and theoretical roughness values of 0.01 fit well with the empirical model. The roughness value of 0.01 feet would indicate a sand bottom (Figure 5.4.5-2), which is the dominant substrate in Reach 5. As such, the theoretical models were assumed to provide reasonable approximations of benthic velocities in Reach 5.

5.5 Habitat Modeling

5.5.1 Habitat Modeling (Reach 1, 2, 3 and 4)

The calibrated hydraulic models, which predicts velocities and depths over a range of flows, were then combined with a habitat model. The amount of aquatic habitat for a given species/life stage of fish is calculated using either the River2D or PHABSIM programs. Each habitat area is evaluated for its habitat suitability for a particular species/life stage based on the fixed characteristics (substrate) and the variable characteristics of the cell (depth and velocity).

Fish habitat suitability, as used in IFIM procedures, is an index quantified in terms of a variable known as Weighted Usable Area (WUA). A unit of WUA represents a unit of suitable habitat for the life stage evaluated. The following equation is used to calculate WUA:

$$WUA = \frac{\sum_{i=1}^{n} WUA(I)}{L} \times L_{mac}$$

where: WUA(I) = Weighted Usable Area (I);
n = Total number of cells/nodes;
L = Total length of the study reach; and

L_{mac} = Length of stream, which is represented by the reach, with suitable macrohabitat conditions.

The individual cell/node WUA(I) is calculated as follows:

$$WUA(I) = CF(I) \times Area(I)$$

where: Area(I) = Surface area of cell/node(I); and
CF(I) = Compound Function Index for cell/node(I)

The Compound Function Index, CF(I), is calculated as follows:

$$CF(I) = SI_V \times SI_D \times SI_S$$

where: SI_V = Suitability Index for Velocity;
SI_D = Suitability Index for Depth; and
SI_S = Suitability Index for Substrate/Cover.

The WUA is then computed for each cell/node area. In a given study section or reach, the WUA(i) for all the cell/node areas are summed and expressed in units of square feet.

Transect weighting was calculated differently for Reach 4 and the 1-D model portion of Reach 2 and Reach 1. For Reach 1 and 2, longitudinal cell boundaries were established prior to the IFIM field data collection. The WUA within these cells are represented by the transect(s) within or assigned to them. This implies that the habitat at each transect can be multiplied by the length of the cell(s) it represents to obtain WUA within those cells.

The transects that fell within each type of mesohabitat within Reach 4 were averaged together, such that there was a representative run, glide and pool transect that represented averages of those three mesohabitats. These representative transects were then multiplied by the length of the reach that was run, glide or pool, respectively, to obtain WUA for Reach 4.

5.5.2 Mussel Habitat Analysis (Reach 5)

Within Reach 5, habitat suitability was investigated for three species of mussel, which were selected due to their status as state or federally-listed species, and because they were found in this reach of river. These species of interest were the Yellow Lampmussel (*Lampsilis cariosa*), the Eastern Pondmussel (*Ligumia nasuta*), and the Tidewater Mucket (*Leptodea ochracea*). Three parameters were selected to determine the suitability of cross sections within the study reach for mussel habitat. The parameters were depth, velocity, and substrate.

The binary HSI criteria were applied to 15 cross sections within Reach 5. Suitability for each parameter for each species was rated on a scale from 0 to 1. Because a binary analysis was used, the suitability rating was rounded to either 0 (not suitable) or 1 (suitable). If the suitability rating for each of the three criteria was 1, then that cell was determined to be suitable for mussel habitat. For the purposes of this analysis, it was assumed that substrate was medium sand throughout the area and was considered suitable for all species and life stages. As such, depth and benthic velocity were the primary drivers of this analysis. Because many of the depth and velocity criteria were the same among various species and life stages, mussels were grouped into two sets of criteria, which included:

- Criteria 1: Yellow Lampmussel Juvenile; Eastern Pondmussel Juvenile and Adult; Tidewater Mucket Juvenile

- Criteria 2: Yellow Lampmussel Adult; Tidewater Mucket Adult

Five flow scenarios were analyzed in the HEC-RAS model (Table 5.4.5-1). The flows analyzed included low flow and high flow scenarios. For each cross section in each scenario, the hydraulic depth and benthic velocity were compared to the binary curves for each mussel species, and given ratings of 0 or 1, as described above. The overall method is depicted in Figure 5.5.2-1. For further comparison, the effects on suitability resulting from operational flow from Turners Falls, backwatering from Holyoke Dam, and mean April flows were evaluated qualitatively/categorically for each transect and both criteria (Figure 5.5.2-2). These categories were then compared with results from the 2005-2013 survey data to evaluate whether the effects of different flows and water levels on suitability were related to the presence/absence or abundance of state-listed mussels. Categories were based on the percent change observed as a result of flow and backwater variables (i.e. if both the low and high operational flow had suitability of 100%, then operational flow had no effect on suitability). These categories included:

- None (No effect) – 0%
- Minimal – up to 10%
- Low – 10-20%
- Moderate – 20-40%
- Moderate-High – 40-60%
- High – 60-80%
- Severe – 80-100%

5.5.3 Habitat Persistent Analysis (Reach 3) and Dual Flow Analysis (Reach 4)

Habitat persistence was evaluated in Reach 3 to assess the effects of the short-term hydrologic variability created by peaking operations at the Project. Habitat persistence was determined as the union of "quality" or "good" habitat (defined as CF(I) $\geqslant$ 0.5) polygon areas between a pair of Project flows for a particular species life stage. For example, the available quality habitat polygon areas for fallfish fry at a flow of 1,500 cfs was overlaid with the available quality habitat polygon areas for the same species at a flow of 12,000 cfs. Fallfish habitat persistence for that pair of flows was calculated as the area of overlap between the quality habitat polygons. The habitat persistence analysis was conducted for all immobile target species (macroinvertebrates) and life stages (spawning and fry), including habitat guilds. Immobile target species are those species and/or life stages that are considered unable to volitionally relocate to suitable locations in response to a typical peaking cycler, or are weak swimmers.

A dual flow analysis was conducted for Reach 4, and is similar to persistent habitat analysis but is the term applied when utilizing a 1-D hydraulic model. It calculates the quantity of quality habitat (defined as CF(I) $\geqslant$ 0.5) present over paired base flow and peak flows across a range of scenarios, as those that may be expected during a minimum flow/peaking flow hydropower operation. Dual flow habitat was calculated using the series of rectangular habitat cells for each transect. As streamflow varies, habitat quality may decrease in some cells, while increase in others. For immobile target species, an assumption was made that the available habitat is the minimum available in each cell between a given pair of Project flows. The PHABSIM program calculated these minimum habitat cell values for a dual flow combination (a base and generation flow) and summed them for a particular transect. The habitat for dual flow combinations is equal to, or less than, the minimum of the two steady state flow habitat values calculated for each of the two Project flows. The dual flow results for each transect in Reach 4 were weighted in the same manner used for the steady-state analysis. (Section 5.5.1). Flow combinations ranging from 1,200 cfs to 37,500 cfs were analyzed.

5.5.4 Habitat Time Series (Reaches 3 and 4)

Habitat time series was completed for Reach 4 for this version of the report. An addendum will be provided at a later date containing habitat time series analysis for Reach 3.

The habitat time series analysis followed the methodology described in Bovee *et al*. (1998), and used habitat/WUA versus discharge relationships to translate a streamflow time series (flow as a function of time) into a habitat time series (habitat as a function of time). Construction of the habitat time series required two components: 1) a time series of streamflow discharges and 2) a habitat versus discharge relationship.

In this analysis, units of habitat, or WUA, are expressed as the area of habitat within the study area. For every discharge in the streamflow time series, there is a corresponding habitat suitability value from the habitat versus discharge relationship. Thus, the habitat time series was produced by translating hourly discharges from the Project into associated WUA values and recording the translated values back to the hourly time step. The translation process is shown in Figure 5.5.4-1.

For this report, the habitat versus discharge relationships for all target species and life stages analyzed were merged with the Montague USGS gage hourly flow data to yield habitat time series for Reach 4.

In the future, habitat time series will be developed for Reaches 3 and 4 for baseline conditions and several alternative modes of operation using the HEC-ResSim (operations model- Study No. 3.8.1) hourly discharge data. The alternative operation scenarios will be developed in consultation with the relicensing stakeholders.

Table 5.4.2-1: Summary of Flows Measured during Field Data Collection for Reach 1 and 2A

Transect	Low Flow (cfs)	Mid Flow (cfs)
T-1	284	660
T-2	282	671
T-3	262	729
T-4	278	915
T-5	**293**	**720**
T-6	343	785
T-7	321	890
T-8	311	641
T-9	288	613
T-10	241	**626**
T-11	**210**	587

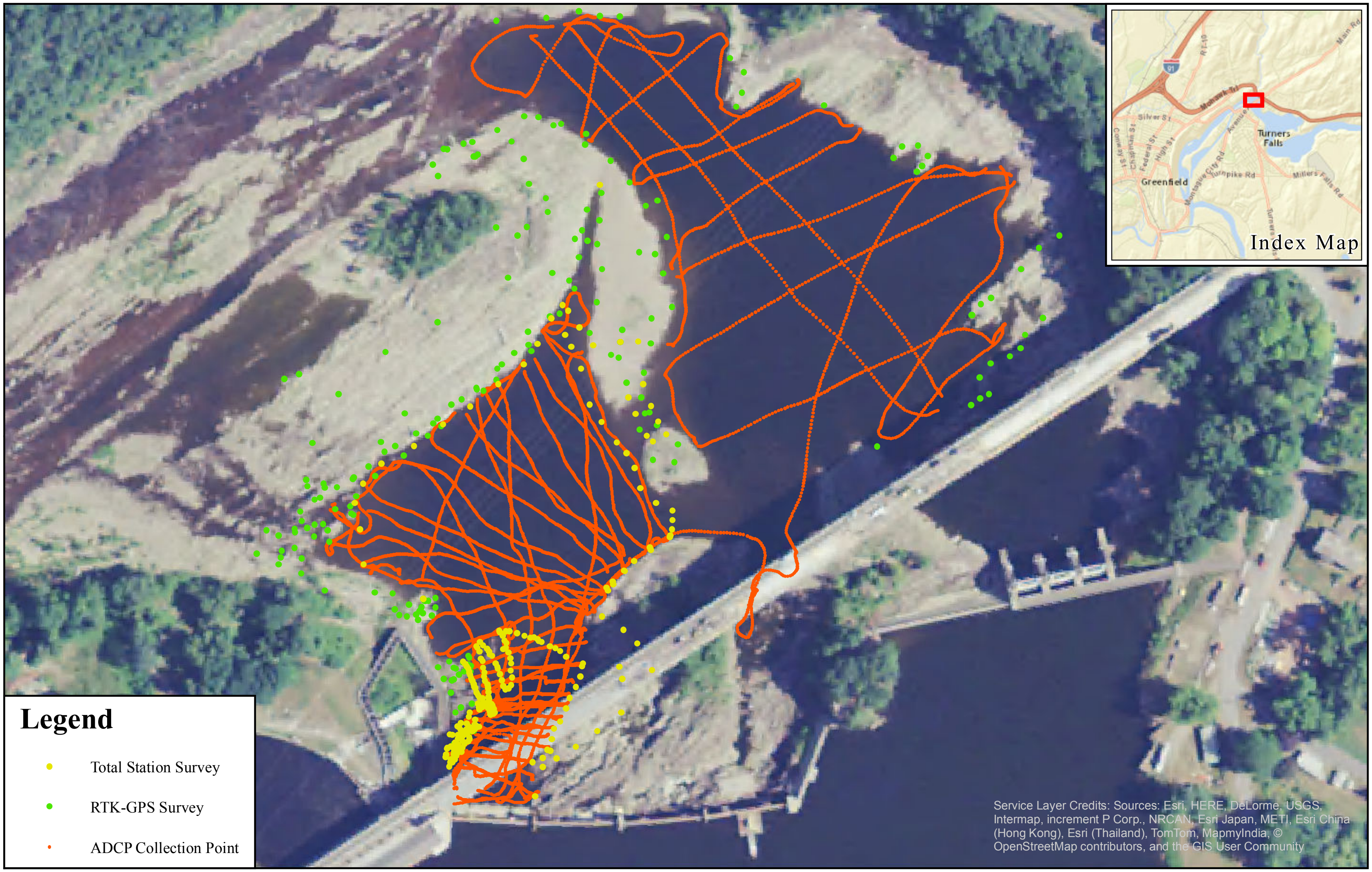
Bolded flows denote flows selected for model calibration purposes.

Table 5.4.5-1: Reach 5 Mussel Analysis HEC-RAS Model Scenarios

Scenario No.	Holyoke Dam Impoundment Elevation	Deerfield River Flow	Turners Falls Hydroelectric Project Flow	Total Flow
1	Min- 99.47 ft NGVD	Deerfield Hydroelectric Project Station No. 2 Min Flow 200 cfs	Turners Falls Project Min Flow 1,433 cfs	1,633 cfs
2	Max- 100.67 ft, NGVD	Deerfield Hydroelectric Project Station No. 2 Min Flow 200 cfs	Turners Falls Project Min Flow 1,433 cfs	1,633 cfs
3	Min- 99.47 ft NGVD	Deerfield Hydroelectric Project Station No. 2 Max Hydraulic Capacity 1,450 cfs	Cabot Station Hydraulic Capacity 13,728 cfs	15,178 cfs
4	Max- 100.67 ft, NGVD	Deerfield Hydroelectric Project Station No. 2 Max Hydraulic Capacity 1,450 cfs	Cabot Station Hydraulic Capacity 13,728 cfs	15,178 cfs
5	Min- 99.47 ft NGVD	Mean April Flow at the Montague USGS Gage		38,600 cfs

Table 5.4.5-2: Models Fitted to ADCP Data for the Bottom 35% of Total Depth

Model	Fitted Formula	AIC	ΔAIC
Logarithmic	$0.127\ln(x) + 1.187$	306.92	0
Power	$1.193x^{0.12}$	307.22	0.29
Parabolic	$-0.647(x - 0.7)^2 + 1.137$	307.74	0.81
Linear	$0.318x + 0.927$	311.74	4.82



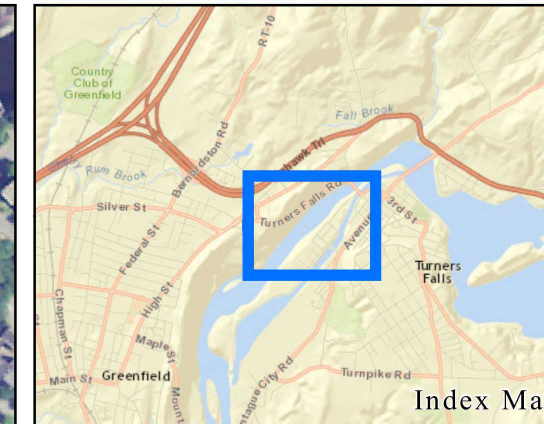
N

0 250 500 1,000 Feet

Northfield Mountain Pumped Storage Project (No. 2485)
and Turners Falls Hydroelectric Project (No. 1889)
RELICENSING STUDY 3.3.1

Figure 5.3.1-1: Reach 1 Plunge Pool Transect Locations

Path: W:\gis\studies\3_3_1\maps\Reach 1 Plunge Pool Transect Locations.mxd



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

RELICENSING STUDY 3.3.1

Figure 5.3.2-1 Reach 1 and 2
Transect Locations

Legend

N

1-D Transect

- Habitat Transect
- Hydraulic Transect
- Study Cell

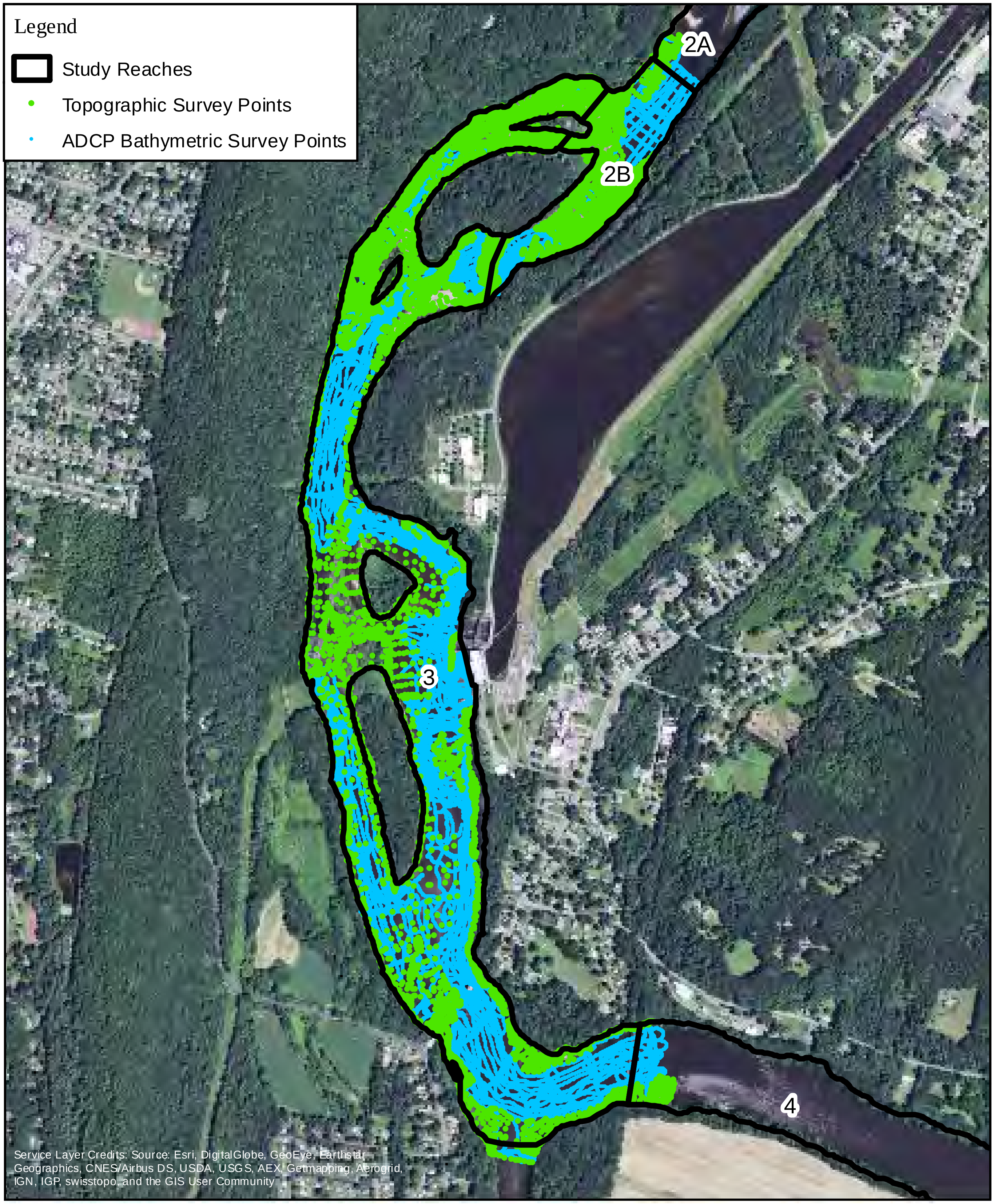
Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

0 200 400 800 Feet

1 inch = 400 feet

FirstLight Power Resources

Path: W:\gis\studies\3_3_1\maps\1-D Model_Working.mxd



FirstLight Power Resources

N

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

RELICENSING STUDY 3.3.1

0 500 1,000 2,000 Feet

Figure 5.3.3-1
Reach 2B and 3 Two-dimensional modeling and data collection area

Path: W:\gis\studies\3_3_1\maps\Two-D Model Data.mxd

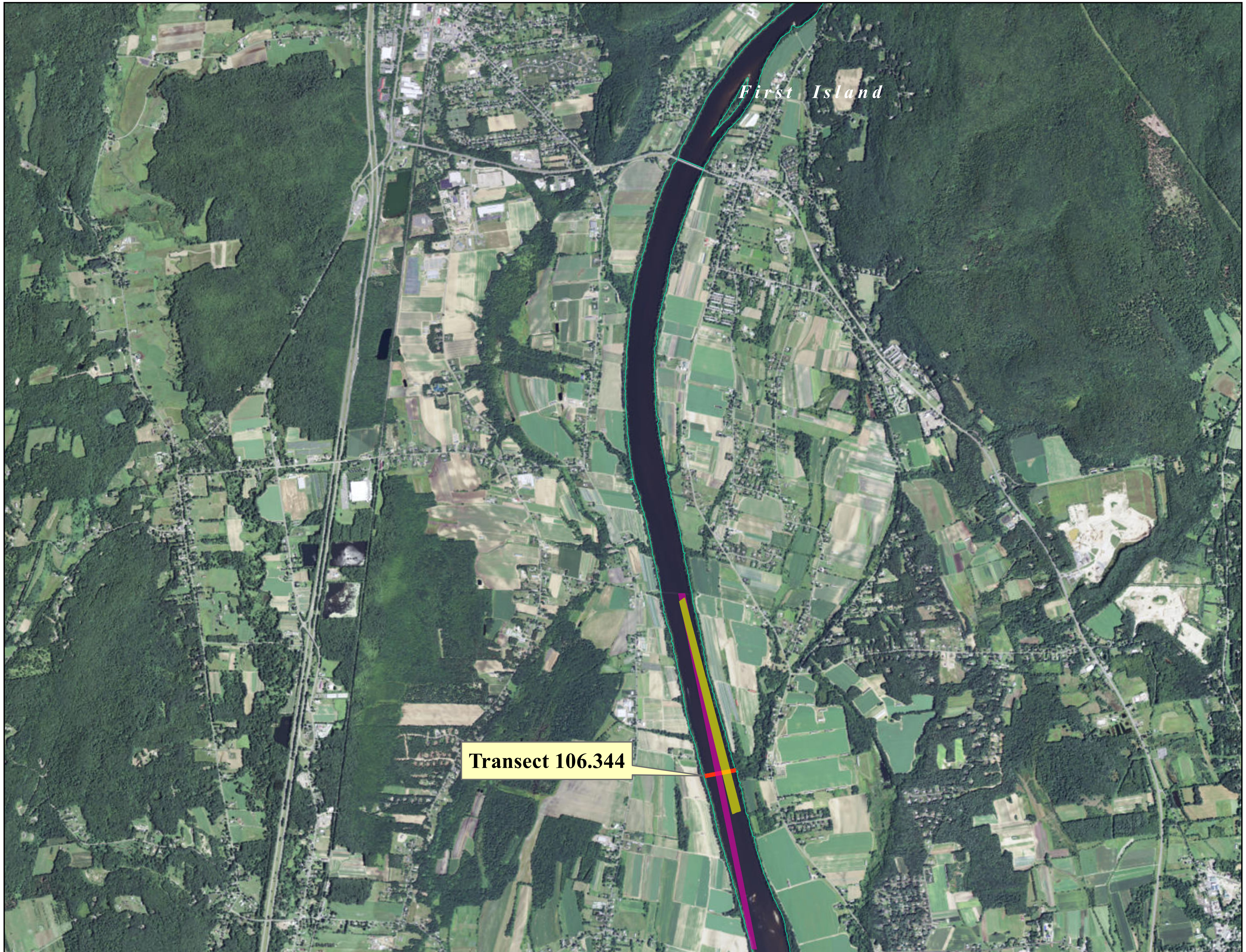
FirstLight Power Resources

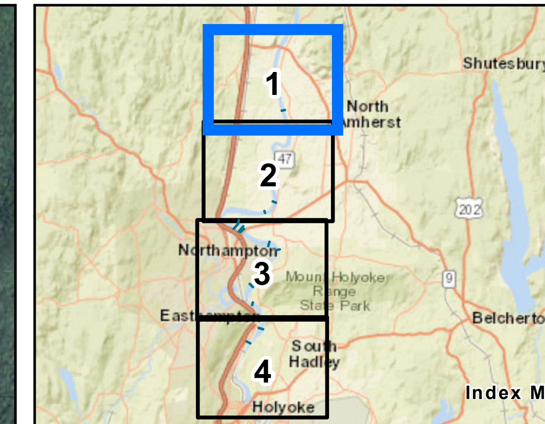
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Relicensing Study 3.3.1

Figure 5.3.4-1: Reach 4 Transect Locations

Path: W:\gis\studies\3_3_1\maps\Reach4_Transects.mxd





FIRSTLIGHT POWER RESOURCES

IFIM
Figure 5.3.5-1: Reach 5
HEC-RAS Transects
Page 1 of 4

Legend

Reach 5 Transects

HGE Mussel Surveys

2009

2013

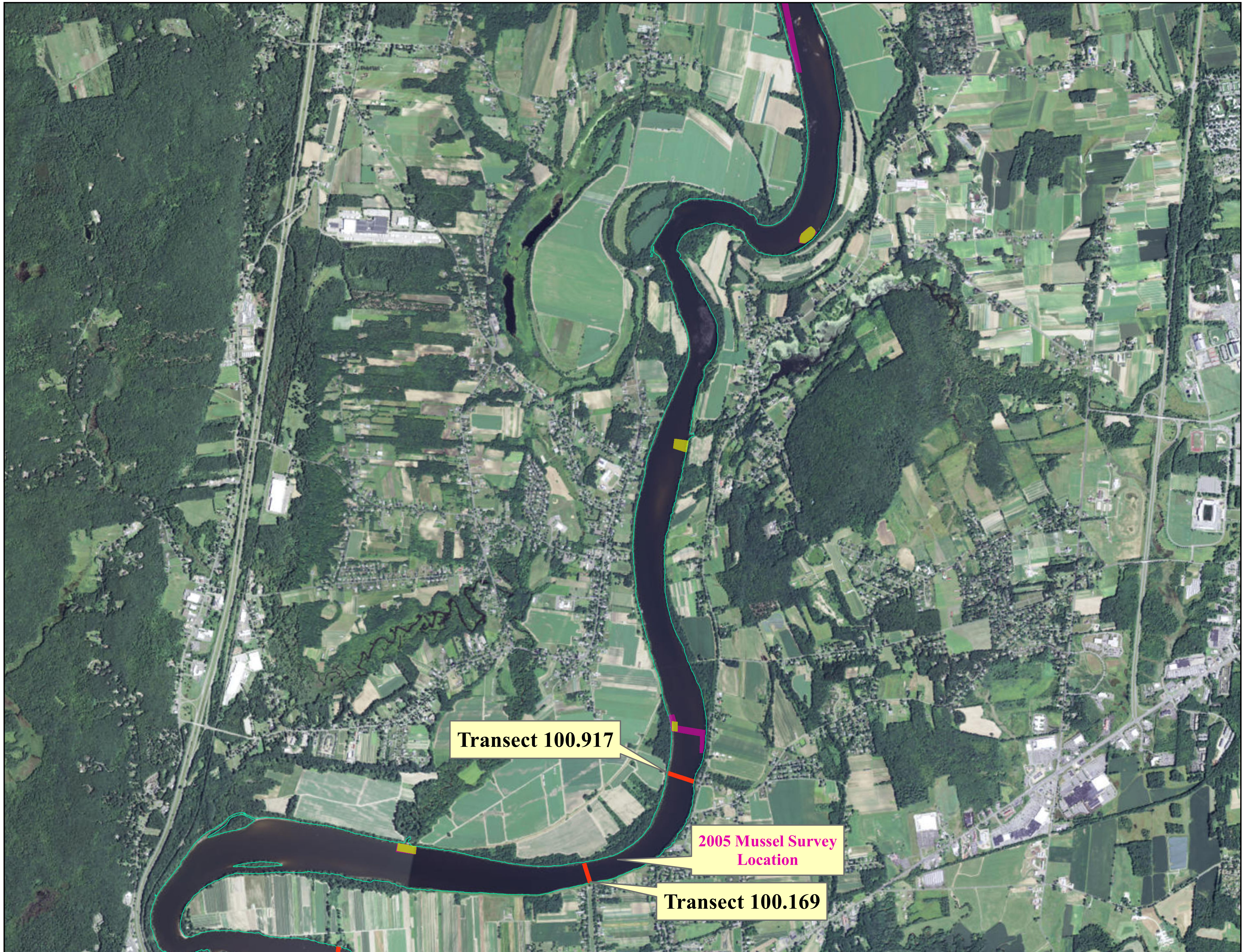
N

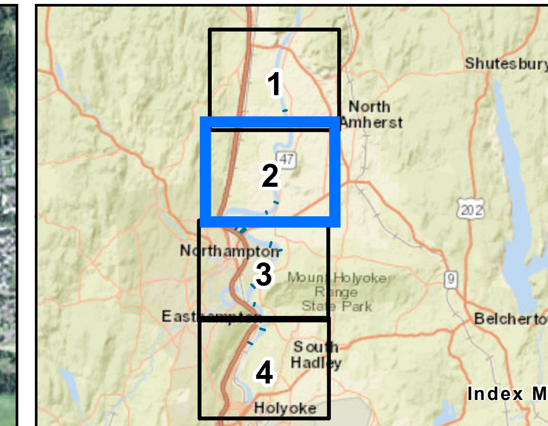
Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 0.25 0.5 1 Miles

1 inch = 0.5 miles

Path: W:\gis\studies\3_3_1\maps\ifim_reach_5 Mussel Transects Report.mxd





FIRSTLIGHT POWER RESOURCES

IFIM
Figure 5.3.5-1: Reach 5
HEC-RAS Transects
Page 2 of 4

Legend

Reach 5 Transects

HGE Mussel Surveys

2009

2013

N

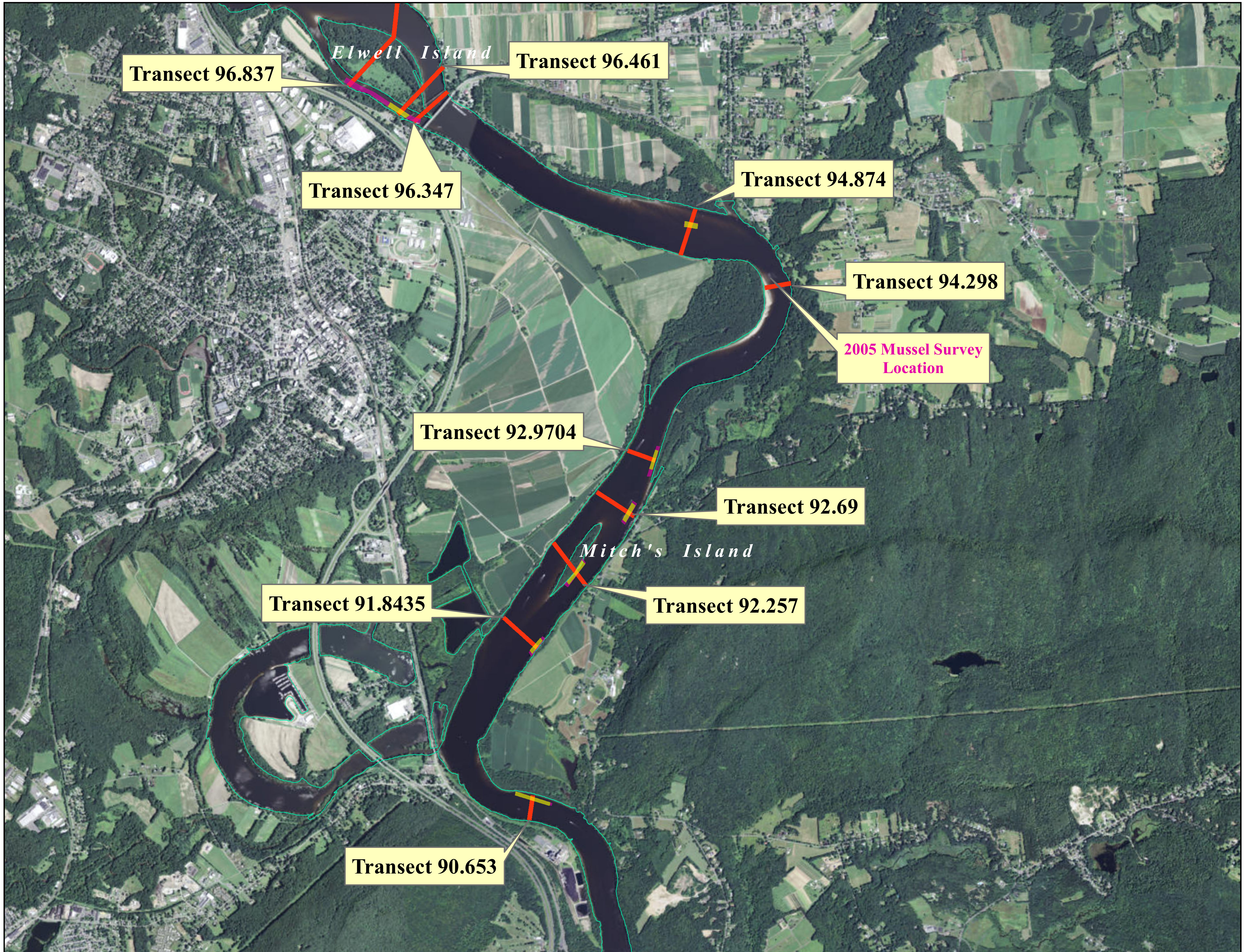
Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

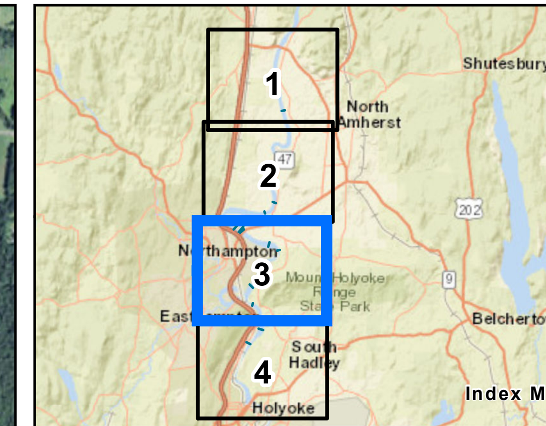
0 0.25 0.5 1 Miles

1 inch = 0.5 miles

FirstLight Power Resources

Path: W:\gis\studies\3_3_1\maps\ifim_reach_5 Mussel Transects Report.mxd





FIRSTLIGHT POWER RESOURCES

IFIM
Figure 5.3.5-1: Reach 5
HEC-RAS Transects
Page 3 of 4

Legend

- Reach 5 Transects

HGE Mussel Surveys

- 2009
- 2013

N

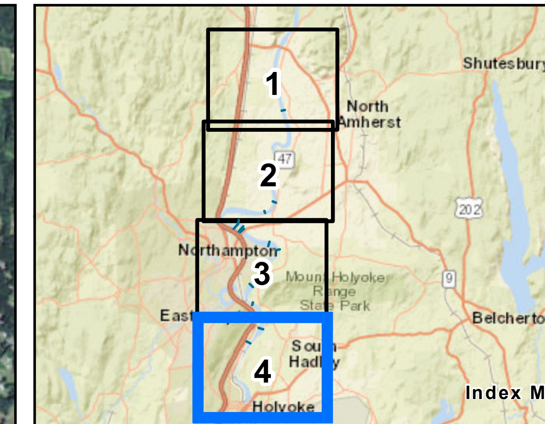
Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 0.25 0.5 1 Miles

1 inch = 0.5 miles

FirstLight Power Resources

Path: W:\gis\studies\3_3_1\maps\ifim_reach_5 Mussel Transects Report.mxd



FIRSTLIGHT POWER RESOURCES

IFIM
Figure 5.3.5-1: Reach 5
HEC-RAS Transects
Page 4 of 4

Legend

Reach 5 Transects

HGE Mussel Surveys

2009

2013

N

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 0.25 0.5 1 Miles

1 inch = 0.5 miles

FirstLight Power Resources

Path: W:\gis\studies\3_3_1\maps\ifim_reach_5 Mussel Transects Report.mxd

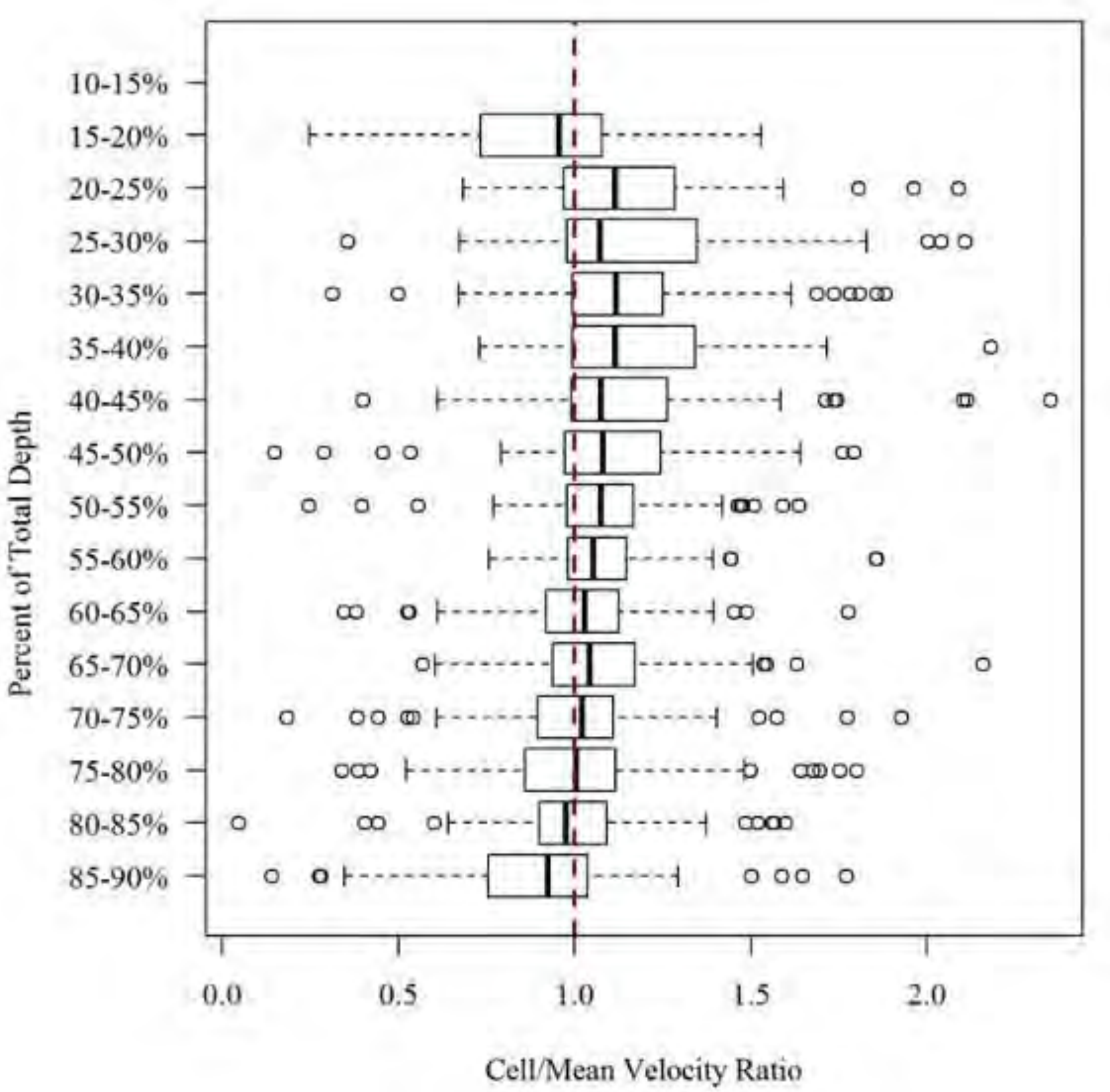


Figure 5.4.5-1: Boxplot of ADCP Samples Collected from Reach 5

*This plot compares the velocity measured at certain depths (cells) to the mean velocity for the entire water column.

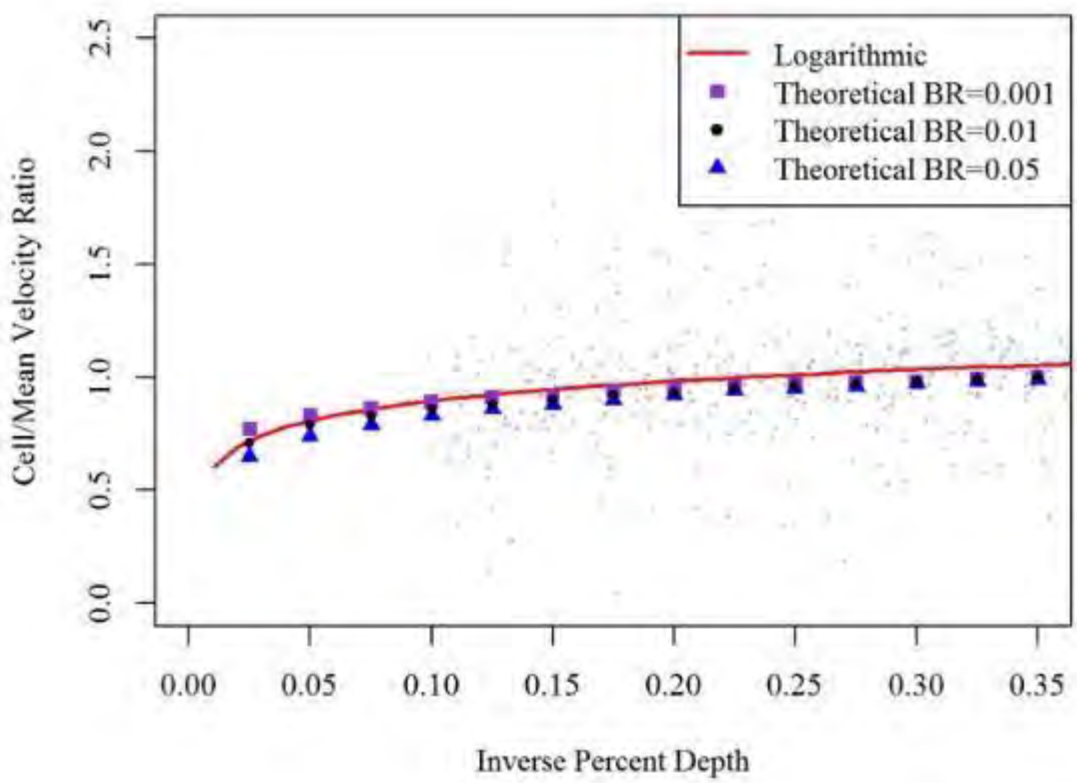
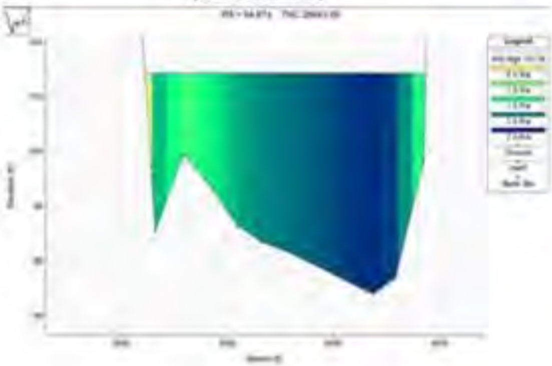


Figure 5.4.5-2: Comparison of Empirical Logarithmic Model with Theoretical Model Applying Different Bed Roughness Values

HEC-RAS Model Output (Provides Depths and Mean Water Column Velocities for 20 Equally-Spaced Intervals)



Converted Mean Water Column Velocities to Benthic Velocities (Logarithmic Functions)

Matrix of Parameters by Cross-Section Interval

Interval	Depth(ft)	Benthic Velocity (ft/s)
1	2.09	0.57
2	5.17	1.41
3	3.92	1.20
4	3.23	1.08
5	3.81	1.18
6	4.54	1.31
7	5.29	1.43
8	5.81	1.51
9	6.16	1.56
10	6.38	1.59
11	6.6	1.62
12	6.85	1.65
13	7.11	1.70
14	7.37	1.73
15	7.64	1.76
16	7.9	1.80
17	7.98	1.81
18	7.57	1.76
19	5.94	1.52
20	3.72	1.16

Evaluated Binary Suitability using Depth and Benthic Velocity (Substrate was Assumed Medium Sand)

Matrix of Suitability by Cross-Section Interval

Species/Life Stage Criteria 1				
Interval	Depth	Benthic Velocity	Substrate	Suitable
1	1	1	1	YES
2	1	1	1	YES
3	1	1	1	YES
4	1	1	1	YES
5	1	1	1	YES
6	1	1	1	YES
7	1	1	1	YES
8	1	1	1	YES
9	1	1	1	YES
10	1	1	1	YES
11	1	1	1	YES
12	1	0	1	NO
13	1	0	1	NO
14	1	0	1	NO
15	1	0	1	NO
16	1	0	1	NO
17	1	0	1	NO
18	1	0	1	NO
19	1	1	1	YES
20	1	1	1	YES

Calculated Cross-Section Suitability

13/20 Intervals Suitable = 65% of Cross-Section for this Species/Life Stage

Calculated Suitability for All Species/Life Stages

Transect	94.874	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	65.00%	100.00%

Calculated Suitability for All Modeling Scenarios

Transect	94.874	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	65.00%	100.00%
15,178	Low	45.00%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		13.64%	100.00%

Figure 5.5.2-1: Reach 5 Data Analysis Schematic

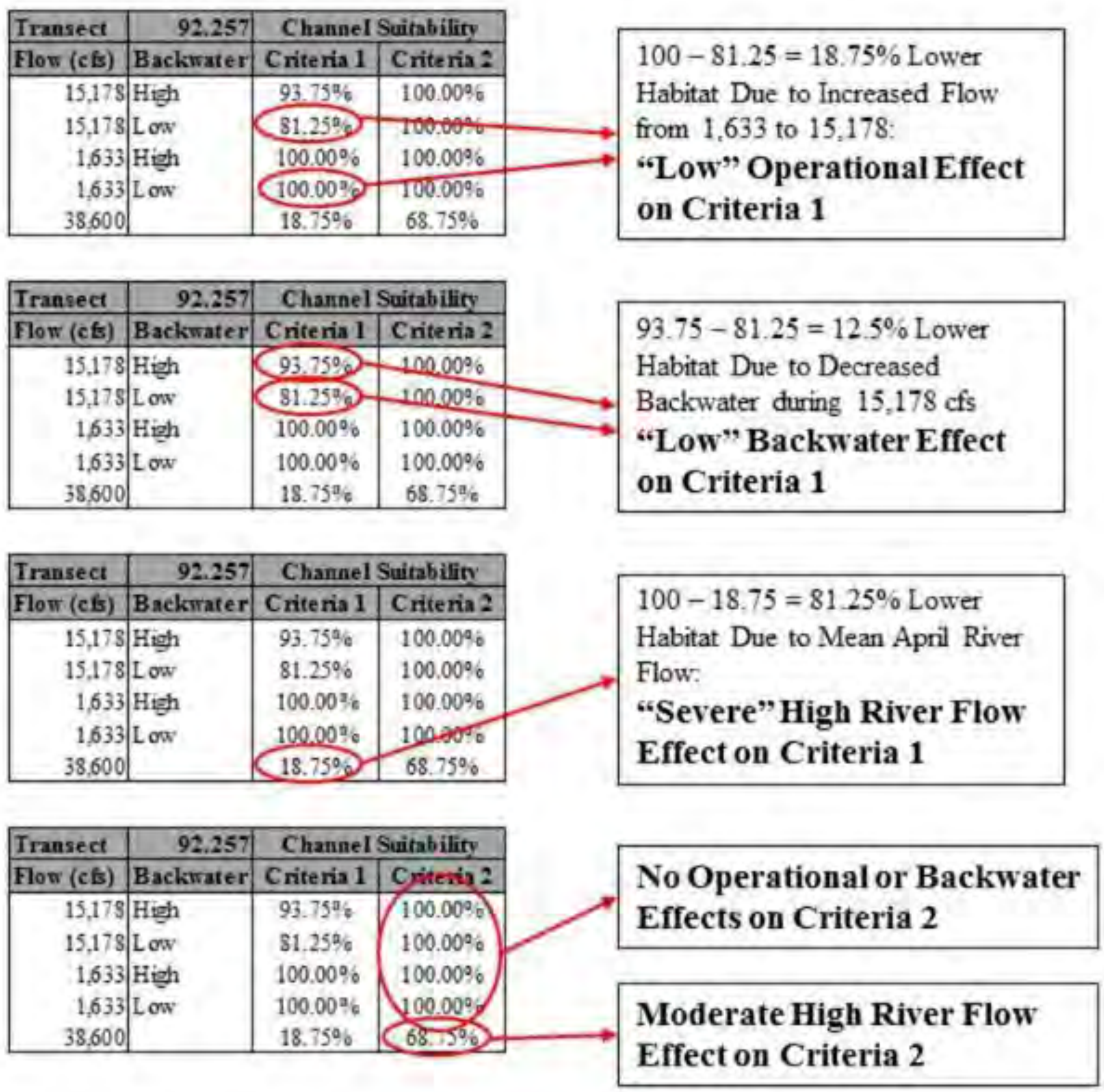


Figure 5.5.2-2: Schematic for Qualitative Categorization of Flow and Backwater Effects on Habitat Suitability for Mussel Criteria

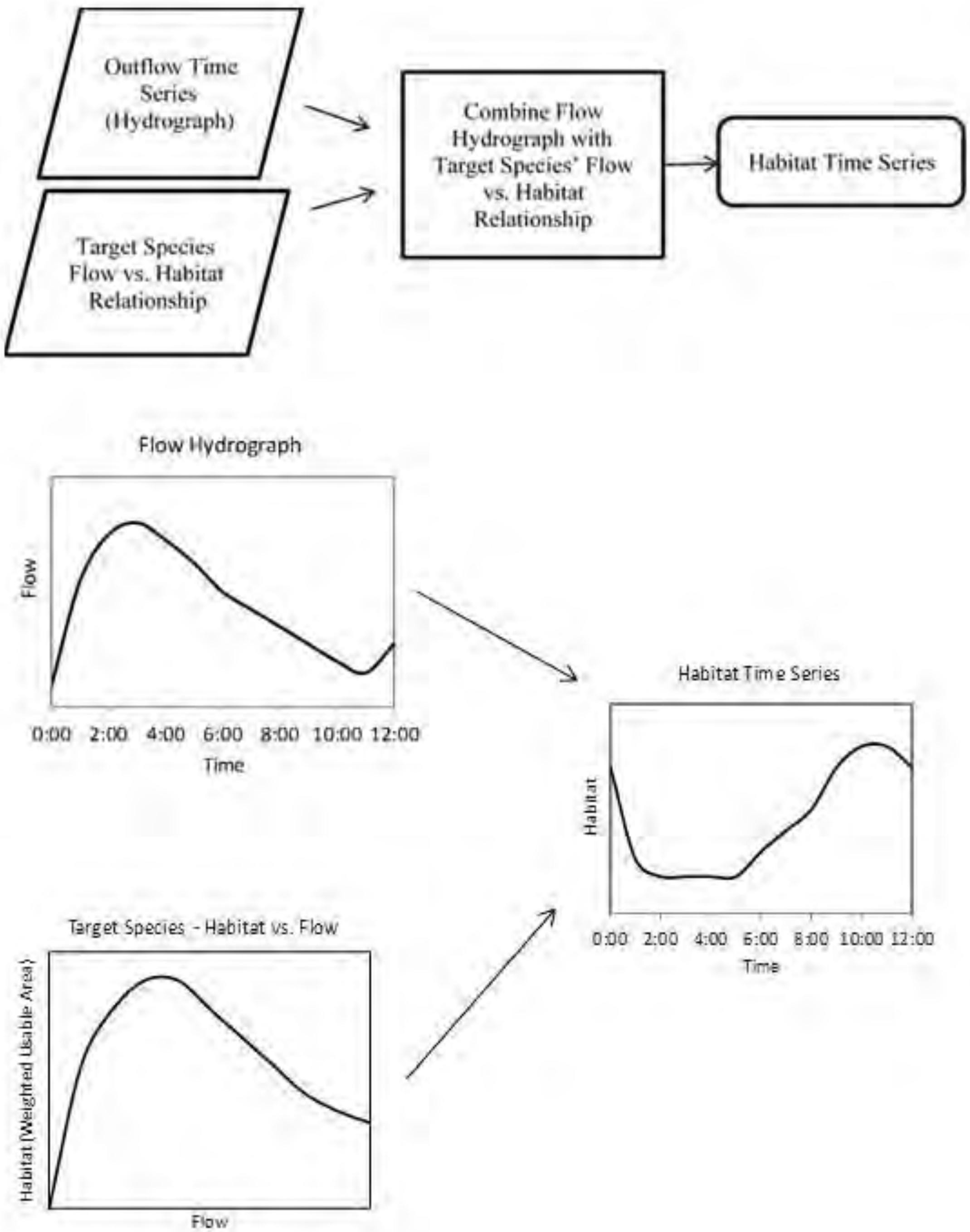


Figure 5.5.4-1: Habitat Time Series Schematic

6 RESULTS

6.1 Hydraulic Modeling

6.1.1 Reach 1 (Plunge Pool Assessment, Zone of Passage, and PHABSIM 1-D Single Transect Model)

6.1.1.1 Reach 1-Flow Distribution

Fall River flow was measured as 49 cfs and the staff gage remained stable during the field study. Table 6.1.1.1-1 summarizes flow distribution in the various channels at each gate release. At a 500 cfs release, the dominant component of the flow (45%) traveled via the left channel[12]; at higher flow the dominant flow was in the right channel (41-50%).

6.1.1.2 Reach 1-Plunge Pool Assessment

Figure 6.1.1.2-1 shows the resulting wetted area and volume versus flow relationship for the plunge pool. Wetted area increases sharply as flow increases from 0 cfs to 4,000 cfs; increases in wetted area become more gradual as flow increases from 4,000 cfs to 20,000 cfs. The relationship between wetted volume and flow exhibits a similar trend with sharp increases from 0 cfs to 3,000 cfs. For flows between 3,000 cfs and 20,000 cfs, increases in wetted volume are more gradual.

6.1.1.3 Reach 1-Left Channel

The channel passage barrier transect was 576 feet long; the deepest portion of the thalweg was 3.5 feet deep at a flow of 125 cfs within the bypass reach (Figure 6.1.1.3-1). Bypass flow releases less than 1,500 cfs wet only the right-most 300-ft portion of the channel (looking downstream), whereas higher flow wets the left-most 150 feet of the transect. Flows in the left portion of the transect crest the ledge area at an elevation of approximately 0.7 feet higher than those in the right most portion of the transect due to localized upstream hydraulic bedrock controls.

The depth at the toe of the barrier (measured with level loggers) ranged from one 1 foot near the headpin at a 500 cfs bypass flow, up to approximately 2.5 ft. at 4,000 cfs bypass flow (Figure 6.1.1.3-2). At the end of the transect nearest the tailpin, water depth ranged from approximately 1.5 ft. at 500 cfs to approximately 2.75 ft. at 4,000 cfs. At both parts of the barrier the greatest rate of increase in depth exists between bypass flow releases of 500 and 1,500 cfs.

The tailpin (left looking downstream) side of the transect characteristically had a narrower difference in crest to tailwater elevation difference at all flows (Figure 6.1.1.3-3). The toe and crest elevations come closest to matching each other on the tailpin segment of the transect at a 1,500 cfs bypass flow, where the net difference in elevation is approximately 0.3 ft. Overall the net elevation difference in water elevation on this part of the transect ranged up to 0.6 ft at other flows. On the headpin side of the transect (right, looking downstream) the difference in water elevation was more pronounced and stayed relatively constant across all flows, typically a 1.4 to 1.7 ft difference.

Figure 6.1.1.3-4 illustrates changes in zone of passage at each gate release flow using the criterion of providing a depth equal to, or exceeding the body depth of an adult American shad, estimated to be 0.6 ft.

[12] The position of the three channels in this area are described from the vantage point of looking downstream (i.e., right channel looking downstream from dam).

6.1.1.4 Reach 1-Center Channel

Adult American shad can swim approximately 2.5 ft/s at a sustained rate (Dodson & Leggett 1973), approximately 7 ft/s at a prolonged rate (Bell, 1991) and has a maximum burst speed of approximately 11.5-13.0 ft/s (Beamish,,1978). Center channel flows ranged from 182 cfs to 1,173 cfs (or 500 cfs to 4,000 cfs in respective total bypass flow) (Table 6.1.1.4-1). Velocity at the transects ranged between approximately 2.7 to 6 ft/s at the 500 cfs total bypass flow. At total bypass flows between 1,500 cfs and 4,000 cfs, velocities ranged from about 4 ft/s to as high as 12.2 ft/s.

6.1.1.5 Reach 1-Right Channel (PHABSIM 1-D Single Transect Model) Calibration Results

The IFG4 hydraulic model was successfully calibrated and the output was checked for reasonableness by examining the Velocity Adjustment Factors (VAF's). The VAF is a guideline that reflects the extent to which simulated velocities were adjusted by IFG4 to balance the flow volume based on the given WSELs at any particular flow; a VAF of 1.0 indicates a perfect correlation with no adjustments required. Generally VAF's between 0.7 and 1.3 are considered acceptable; for this model VAF's ranged between 0.915 and 0.989 indicating good agreement.

6.1.2 Reach 1 and 2A-PHABSIM 1-D Model Calibration Results

The WSEL within the WSP hydraulic models were successfully calibrated for all transects to within the +/- 0.1 ft tolerance except at three transects, where it was not met in order to aid in the overall fit of the model (since the WSEL at a transect will affect the WSEL at further upstream transects). Tables 6.1.2-1 thru 6.1.2-3 illustrate the fit of the model.

Overall, the velocity calibration fit is excellent with some minor deviations perhaps caused by human or instrumentation error at T-6 under low flow and T-4 and T-11 under mid flow. Tables 6.1.2-4 thru 6.1.2-5 present histograms of the model calibration results for the downstream and upstream low and mid flow models.

6.1.3 Reach 2B and 3-River2-D Model Calibration Results

The hydraulic model was calibrated to the water surface profile collected at inflows from Reach 2 of approximately 300 and 900 cfs, and Cabot generation flows of 2,200, 4,600, and 8,100 cfs, following the calibration procedure described in Bovee *et al*. (2007). In addition to the calibration periods in July and August 2014, discussed above, calibration was also completed during three periods in late September and early October when the Cabot canal was drawn down for maintenance purposes resulting in all of the flow from Turners Falls Dam being released to the bypass reach. The three flows during these periods were about: 2,200, 3,700, and 12,000 cfs. The final finite element mesh comprising the study reach contained approximately 32,990 nodes. Calibration to within +/- 0.25 ft of observed WSELs at both inflow cfs values were targeted. Most (53%) simulated WSELs were within the targeted +/- 0.20 ft threshold and 75% were within +/- 0.30 ft. All of the simulated WSELs fell within +/- 0.75 ft of observed WSELs. Figure 6.1.3-1 shows the WSEL error distribution at the water level loggers that were active during the calibration period. Table 6.1.3-1 provides the modeled minus observed differences for each calibration run.

The complexities of dynamics of flow in this reach include multiple channels around Rawson and Smead Islands and inflow from several sources. Flow estimates from the Turners Falls Dam especially when flow is released from the tainter or bascule gates, leakage from Station No. 1, and inflow from Fall River, result in limited accuracy of inflow. The accuracy of flow estimates, based from generation relationships and records from Station No. 1 and Cabot are higher than estimates of inflow from other sources including releases from the tainter and bascule gates. Detailed topographical, bathymetric, and WSEL information was obtained for this reach from several sources as described in Section 5.3.3. However, based on unit specifications, the equipment has a known amount of instrument error (+/-) as summarized in Table 6.1.3-2. The Montague USGS is rated as "good" by the USGS meaning that the flow records are normally within +/- 5% and the Deerfield USGS gage that was prorated to estimate inflow from the Deerfield is rated as fair (+/-8%). Based on the rating curve at the Montague gage, a stage difference from +/- 5% at a flow of about 5,000 cfs would be about 0.25 feet. Due to the complexities for the flow in this reach, and the possible errors associated with the topography, bathymetry, inflow, and water surface measurements, calibration of the River2D model was deemed to be very appropriate.

Observed velocities were compared to model velocities at several transects in the study reach. Across each transect, the water velocity profiles have similar shapes as those measured by the ADCP, with low velocities near the banks and higher velocities mid-channel. Flow and velocity distribution between islands and side channels is fairly good. The model tended to be least accurate near water line boundaries (e.g. islands, banks), and was generally better in the main channel. Figure 6.1.3-2 shows the velocity error distribution across the entire study reach.

6.1.4 Reach 4-PHABSIM 1-D Model Calibration Results

The calibration of the HEC-RAS model was completed by adjusting the Manning's n values such that modeled WSELs were close to measured WSELs. In mid-September of 2015, FirstLight had 19 water level loggers (WLL) in Reach 4, and was able to adjust flows from Cabot Station and Station No.1 to provide flows very close to the approximate calibration flows of 2,000, 6,000, and 15,000.

To determine the calibration flows for the model, FirstLight relied on the average reported flow from the Montague USGS gage during the period on September 13, 2015 from: 10:00 to 18:30 for low flow calibration. The low flow calibration is 2,318 cfs. For mid flow calibration there was less agreement between the average USGS gage flow (6,353 cfs) and the average measured flow (5,847 cfs). Upon examination of the channel configuration, transect shapes and velocity profiles of the transects measured during mid flow, the flow at T97 (5,988 cfs) was selected as the flow for mid flow calibration, as it was a good transect for flow gaging. Furthermore this flow is very close to the mean of all FirstLight measured flows that day (5,847 cfs).

Table 6.1.4-1 provides the calculated flows at each of the IFIM transects in Reach 4 as determined during the mid-flow calibration period. During the time period of 10:55 to 16:50 on September 16, 2015, the average flow at the Montague gage was 6,342 cfs with flows gradually decreasing. Earlier in the day at 09:21, the USGS conducted a calibration check at the Montague gage when the gage was reading 6,600 cfs. The USGS classfied the measurement rating during this check as "poor". Below are the accuracy ratings of USGS gages:

- Excellent: 95 percent of daily discharges are within 5 percent of the true value
- Good: 95 percent of daily discharges are within 10 percent of the true value
- Fair: 95 percent of daily discharges are within 15 percent of the true value
- Poor: less accuracy than "Fair"

These ratings indicate that the accuracy of FirstLight flow calculations at the new transects are probably as accurate or better than the USGS gage, especially when flow variations due to routing through the 9 mile section of Reach 4 are considered.

In addition, during the calibration process it was noticed that the calibration with the average flows from the Montague gage for the mid and high flow periods were problematic while the low calibration was close. Therefore, for the selection of a high flow calibration value, FirstLight chose 13,360 cfs, which is close to the flow measured at T82 and 10% less than the mean gage flow on September 14, 2015 from 15:30 to 23:45.

The final calibration resulted in Manning's n values of 0.03 or above in the lower section of Reach 4 and 0.02 and 0.025 in the upper area of Reach 4. Table 6.1.4-2 provides a summary of the calibration results showing that most of the differences between modeled and observed WSELs were less than +/-0.20 feet and the average difference per transect was 0.13 feet.

The velocity calibration fit is excellent at most transects with exceptions at T-100, T-99, -T98 and T-87 as indicated in Table 6.1.4-3. The difference in simulated versus observed WSEL is greatest at these transects and accounts for most of the velocity calibration error. A tighter fit between simulated and observed WSEL is not advisable since Manning's n is already low in the upper areas of Reach 4.

At T-100 there is a large eddy that may contribute to the error in calibration fit at this transect. There is an island immediately upstream of T-87 (Second Island) and the simulated velocities were consistently high behind the island. Table 6.1.4-3 presents a summary of the calibration results for the velocity model.

6.1.5 Reach 5-HEC-RAS 1-D Model Calibration Results

During the preparation of Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot*, the calibration of the HEC-RAS model used for Reach 5 was completed by adjusting the Manning's n values for the calibration of the modeled WSELs to measured WSELs. Two periods of nearly steady state flow, as determined by review of the flow and water level data, were used for calibration to the water level recorder that was placed at Mitch's Marina at River Mile 92.7 in 2012:

- June 3-5, 2012.
  - Montague average flow= 30,472 cfs (a high flow event)
- July 20-23, 2012.
  - Montague average flow = 2,473 cfs (a low flow period)

While 3 of the 4 modeling scenarios shown in Table 6.1.5-1 showed a calibration of less than 0.25 feet, the results for the July 20-22 period under a lower Holyoke water level was probably an indication that the water level just upstream of Holyoke Dam was closer to 100.67 ft, than at 99.47 ft.

6.2 Habitat Modeling

The following sections present the results of the habitat modeling in terms of WUA (habitat suitability) versus flow relationships. Tables 6.2-1 thru 6.2-5 summarize for each species/life stage the flow at which the WUA curve peaks, the computed habitat area at maximum WUA flow, the total wetted area of the study reach, and the percentage of total habitat suitability available at the peak WUA within each respective study reach. These tables put into perspective the degree of habitat suitability for a given species/life stage relative to the total area of the study reach.

6.2.1 Habitat versus Discharge Relationships Reach 1 (1-D Single Transect Model)

The flows that correspond to the WUA values discussed below, represent the total flow release to the bypass reach, as opposed to the total subset of flow to the right channel. Table 6.1.1.1-1 illustrates the relationship between the right channel flow and total flow in the bypass.

Shown in Figures B-1 through B-8 , located in Appendix B are the WUA curves for the species/life stages and guilds analyzed for the right channel within Reach 1. The flows shown in these figures also reflect total flow in the bypass reach, as opposed to total flow in the right channel. When examining the WUA curves as well as the information in Table 6.2.1-1, four general trends are apparent. The shallow-slow and shallow-fast guilds, walleye juvenile, white sucker spawning and fry, longnose dace adult, tessellated darter juvenile/adult, fallfish fry, have optimal suitability occurring at a total bypass flow of approximately 562 cfs that declines at higher flows.

Peak habitat suitability for longnose dace juvenile; fallfish spawning and juvenile occurs at or near 800 cfs. Peak habitat suitability for the deep-fast guild; walleye spawning; lamprey spawning, and benthic macroinvertebrates occurs at higher flows (approximately 1,719 cfs) and/or a gradually climbing and ascending level of suitability across the flow range modeled. Walleye spawning suitability peaks at a flow of approximately 2,700 cfs.

There is limited or no habitat suitability for walleye fry and adult; white sucker juvenile/adult, and the deep-slow guild, primarily due to the absence of suitable substrate and/or depth.

6.2.2 Habitat versus Discharge Relationships Reach 1 (Transects 10 and 11)

The following discussion details the habitat conditions in the lower portion of Reach 1, as defined by the area modeled by Transect 10 and 11 from the PHABSIM 1-D model. Shown in Figures C-1 through C-10 located in Appendix C are the WUA curves for high and low backwater conditions [13] for the species/life stages and guilds analyzed within Reach 1.

For both low and high backwater conditions, fallfish spawning, white sucker spawning, walleye fry and juvenile, and fallfish fry, have optimal suitability at relatively low flows occurring between 120 cfs and 800 cfs. Optimal suitability occurs at moderately high flows between 1,200 cfs and 3,000 cfs for deep fast and shallow fast guilds; American shad juvenile; shortnose sturgeon egg-larvae; fallfish juvenile and adult; longnose dace juvenile and adult; tessellated darter adult/juvenile; and walleye spawning. At high flows, between 4,000 cfs and 7,500 cfs, optimal suitability occurs for macroinvertebrates, shortnose sturgeon spawning, American shad spawning and adults.

A comparison of the WUA curves and Tables 6.2.2-1 and 6.2.2-2 shows that for white sucker fry and juvenile/adult, the deep slow and shallow slow guilds, walleye adult, and sea lamprey spawning, backwater conditions affect the amount of available habitat and at what flow WUA curves peak. Specifically, under low backwater conditions peak suitability occurs between flows of 800 cfs and 1,600 cfs for sea lamprey spawning, white sucker fry, shallow slow and deep slow guilds, and white sucker adult/juvenile. However, under high backwater conditions the peak suitability for these species/life stage occurs at lower flows between 120 cfs and 700 cfs. For walleye adults peak suitability occurs at a flow 3,000 cfs under low backwater conditions, and at a flow of 120 cfs under high backwater conditions.

Total habitat area is limited (less than 10% of the reach) under all flows and backwater conditions for deep fast guild; fallfish spawning and fry; white sucker spawning; walleye fry, juvenile, and adult; and sea lamprey spawning. This is due primarily to a lack of appropriate substrate. Under high backwater conditions, habitat area is less than 10% of the reach for tessellated darter adult/juvenile; and walleye spawning.

6.2.3 Habitat versus Discharge Relationships Reach 2 (1-D and 2-D Model)

The following discussion details the habitat conditions in Reach 2. Shown in Figures D-1 through D-10 located in Appendix D, are the WUA curves for the species/life stages and guilds analyzed within Reach 2.

[13] Due to the operational influence of Station No. 1, located just downstream of Transect 10, two hydraulic conditions were examined. High backwater conditions reflect Station No. 1 operating at it full hydraulic capacity, while low backwater conditions reflect Station No. 1 being shut down.

Table 6.2.3-1 shows that for walleye fry, juvenile, and adult; white sucker fry and adult/juvenile; shallow slow, deep slow, and shallow fast guilds; fallfish fry and adult; and tessellated darter adult/juvenile peak suitability occurs at flows between 400 cfs and 2,000 cfs. Peak suitability occurs at a flow of 3,000 cfs for American shad juvenile; fallfish spawning and juvenile; longnose dace juvenile and adult; and sea lamprey spawning. At flows between 5,000 cfs and 10,000 cfs peak suitability occurs for shortnose sturgeon spawning, egg-larvae, and fry; macroinvertebrates; deep fast guild; walleye spawning and adult; American shad spawning and adult; and white sucker spawning.

Total habitat area, is limited (less than 10% of the reach) under all flows for fallfish spawning and fry; white sucker spawning; walleye fry, juvenile, and adult; tessellated darter adult/juvenile; and sea lamprey spawning. This is due primarily to a lack of appropriate substrate.

6.2.4 Habitat versus Discharge Relationships Reach 3 (2-D Model)

Three Cabot Station flow scenarios were examined in Reach 3, representing approximately minimum hydraulic capacity (2,500 cfs) (Table 6.2.4-1), 50% of hydraulic capacity (7,000 cfs) (Table 6.2.4-2), and maximum hydraulic capacity (14,000 cfs[14]) (Table 6.2.4-3). For these scenarios, it was also assumed the flow contribution from the Deerfield River to Reach 3 was 200 cfs. Shown in Figures E-1 through E-28, located in Appendix E, are the WUA curves for the species/life stages and guilds analyzed within Reach 3.

Habitat maps showing combined suitability for each species/life stage analyzed in Reach 3 are also shown in Appendix E. The habitat maps were produced for each of the three aforementioned Cabot Station flow scenarios in combination with bypass flows of 1,000 cfs, 3,000 cfs, and 5,000 cfs, and a Deerfield River flow of 200 cfs.

When Cabot Station is releasing 2,500 cfs, Table 6.2.4-1 shows that for all life stages of American shad and shortnose sturgeon, macroinvertebrates, walleye spawning, and the deep fast guild, peak suitability occurs at a bypass flow of 5,000 cfs. For all life stages of fallfish; longnose dace juvenile and adult; white sucker spawning and adult/juvenile; tessellated darter adult/juvenile; sea lamprey spawning; and the shallow fast guild, peak suitability occurs at bypass flows of 2,000 cfs to 3,000 cfs. At bypass flows between 120 cfs and 200 cfs, peak suitability occurs for white sucker fry; walleye fry, juvenile, and adult; and the shallow slow guild. For this flow scenario (Cabot releasing 2,500 cfs), total habitat area is limited (less than 10% of the reach) under all flows for longnose dace juvenile; white sucker spawning; walleye fry and juvenile; tessellated darter juvenile/adult; and sea lamprey spawning.

When Cabot Station is releasing 7,000 cfs, Table 6.2.4-2 shows that for American shad spawning and adult; shortnose sturgeon spawning and egg-larvae; macroinvertebrates; and walleye spawning, peak suitability occurs at a bypass flow of 5,000 cfs. For American shad juvenile; shortnose sturgeon fry, juvenile, and adult; and the deep slow guild, peak suitability occurs at bypass flows of 3,000 cfs. At a bypass flow of 1,000 cfs peak suitability occurs for fallfish juvenile and adult; and sea lamprey spawning. Bypass flows of 120 cfs to 700 cfs provide peak suitability for fallfish spawning and fry; longnose dace juvenile and adult; white sucker spawning, fry, and adult/juvenile; walleye fry, juvenile, and adult; tessellated darter adult/juvenile, and the shallow slow, shallow fast, and deep fast guilds. For this flow scenario (Cabot releasing 7,000 cfs), total habitat area is limited (less than 10% of the reach) under all flows for longnose dace juvenile and adult; white sucker spawning; walleye fry and juvenile; tessellated darter juvenile/adult; and sea lamprey spawning.

When Cabot Station is releasing 14,000 cfs, Table 6.2.4-3 shows that for American shad spawning and adult; shortnose sturgeon spawning and egg-larvae; macroinvertebrates; white sucker spawning; and

[14] Technically, the maximum hydraulic capacity of Cabot is 13,728 cfs. It was rounded to 14,000 cfs for this analysis.

walleye spawning, peak suitability occurs at a bypass flow of 5,000 cfs. For American shad juvenile; shortnose sturgeon fry, juvenile, and adult; longnose dace juvenile and adult; tessellated darter adult/juvenile; sea lamprey spawning and the deep fast guild, peak suitability occurs at bypass flows of 2,000 to 3,000 cfs. At a bypass flow of 1,000 cfs, peak suitability occurs for fallfish spawning, juvenile, and adult; white sucker adult/juvenile, and the shallow fast guild. Bypass flows of 120 cfs to 700 cfs provide peak suitability for fallfish fry; white sucker fry; walleye fry, juvenile, and adult; and the shallow slow and deep slow guilds. For this flow scenario (Cabot releasing 14,000 cfs), total habitat area is limited (less than 10% of the reach) under all flows for longnose dace juvenile and adult; white sucker spawning; walleye fry and juvenile; tessellated darter juvenile/adult; and sea lamprey spawning.

6.2.5 Habitat versus Discharge Relationships Reach 4 (1-D Model)

Shown in Figures F-1 through F-10, located in Appendix F are the WUA curves for the species/life stages and guilds analyzed within Reach 4.

A comparison of the WUA curves and Table 6.2.5-1 show that for walleye juvenile and adult; white sucker fry and adult/juvenile; deep slow guild; and fallfish adult peak suitability occurs at flows between 800 cfs and 1,600 cfs. Optimal suitability occurs at moderately high flows between 2,400 cfs and 5,000 cfs for fallfish spawning, fry, juvenile; longnose dace juvenile and adult; shallow fast and shallow slow guilds; tessellated darter adult/juvenile; white sucker spawning; sea lamprey spawning; American shad juvenile; and shortnose sturgeon fry. At flows between 7,000 cfs and 15,000 cfs peak suitability occurs for shortnose sturgeon juvenile and adult; walleye spawning and fry; American shad spawning and adult; deep fast guild; and macroinvertebrates.

Total habitat area is limited (less than 10% of the reach) under all flows for fallfish spawning and fry; longnose dace juvenile and adult; white sucker spawning; walleye spawning, fry and juvenile; tessellated darter juvenile/adult; sea lamprey spawning; and the shallow-slow and shallow-fast habitat guilds.

6.2.6 Mussel Habitat Analysis (Reach 5)

Suitability was calculated for each criteria group[15], flow scenario, and transect (Table 6.2.6-1). Flow scenarios within the project capacity at Turners Falls were considered “Operational Flows” for the purpose of these analyses, whereas the Mean April Flow Scenario was considered representative of typical “High River Flows”. Suitability at most transects was generally high for operational flow scenarios, though it ranged from 9.09-100% for Criteria 1 (Figure 6.2.6-1) and from 60-100% for Criteria 2 (Figure 6.2.6-2). The lowest suitability values observed were for Criteria 1 at Transect 106.344, where operational flows resulted in approximately 9% suitability across the channel. Suitability values during mean April flows were typically much lower than for operational flows, with values ranging from 4.76-85.71% for Criteria 1 and 9.09-100% for Criteria 2.

With the exception of one transect (Transect 96.461), operational flows and backwatering had no effect on Criteria 2 suitability (Table 6.2.6-2). Operational effects at Transect 96.461 were classified as Moderate/Moderate-High with minimal effects due to backwatering. High river flow effects were classified as None or Low at nine out of the 15 transects for Criteria 2.

Criteria 1 suitability was generally more sensitive to flow and backwater conditions than Criteria 2 suitability (Table 6.2.6-2; Figures 6.2.6-1 and 6.2.6-2). As such, higher flow and lower water levels at Holyoke Dam typically reduced suitability for Criteria 1 mussels due to higher velocities that exceeded the

[15] Criteria 1: Yellow Lampmussel Juvenile; Eastern Pondmussel Juvenile and Adult; Tidewater Mucket Juvenile

Criteria 2: Yellow Lampmussel Adult; Tidewater Mucket Adult suitability criteria threshold in some areas. Alternatively, Criteria 1 suitability was typically affected none or minimally by operational flows, though the effects of operations was classified as Moderate to Moderate/High at Transects 94.874 and 96.347, High at Transect 96.461, and Severe at Transect 106.344. Backwatering effects for Criteria 1 suitability were typically classified as Minimal to Low, with three transects where backwatering effects were classified as Moderate. Overall, backwatering appeared to have limited effects on this analysis. High river flows (mean April flow) had considerably greater effects on Criteria 1 suitability, with most effects classified as Moderate-High to Severe when compared to the maximum suitability observed during the lower flow scenarios.

Yellow Lampmussel were the most commonly encountered state-listed mussel species in Reach 5. Among the different abundance categories for Yellow Lampmussel at the transects evaluated, there appeared to be no clear pattern for predicting presence/absence or abundance based on the effects of different model scenarios on suitability (Table 6.2.6-3). For example, for Criteria 1, four transects with no state-listed mussels were analyzed; suitability would be affected at three of those transects minimally by operations (plus one severely), and suitability at all four would be affected by high river flows to a High/Severe degree. Similarly, three transects with the highest abundance were also analyzed; of these transects, suitability for Criteria 1 was affected by operational flows minimally at two transects (none at the other), and suitability was affected by high river flow to a High/Severe degree. For Criteria 2, at the same four transects where Yellow Lampmussel were absent, suitability was not affected by operations or backwater at all. Additionally, suitability at only one of the transects was affected to a Severe degree during high river flow, another was affected to a low degree, and the remaining two were not affected by the modeled high river flow.

6.2.7 Persistent Habitat Analysis and Mapping (Reach 3)

Habitat persistence was determined as the intersection of quality habitat polygon areas (combined suitability $\geqslant 0.5$) for all immobile species (macroinvertebrates) and life stages (spawning and fry) for every modeled flow combination. Each flow combination consisted of a low flow matched with an equal or higher flow, to emulate a minimum flow and generation flow combination. Though it was typical for a species' persistent habitat to peak at the same flow as the WUA habitat, this was not necessarily true because the persistent habitat was calculated excluding lower-quality habitat areas (SI < 0.5).

Persistent habitat maps showing bypass flows of 200 cfs and 500 cfs paired with Cabot station flows of 2,500 cfs, 7,000 cfs, and 14,000 cfs for each immobile species and life stage are located in Appendix G. An addendum will be provided at a later date containing persistent habitat maps for additional bypass flow scenarios, which will be selected based on discussions with stakeholders.

Persistent habitat tables showing bypass flows of 200 cfs, 500 cfs, 1,000 cfs, 3,000 cfs and 5,000 cfs paired with a range Cabot station flows from approximately 2,000 cfs to 14,000 cfs for each immobile species and life stage are located in Appendix H. For all these scenarios, it was also assumed the contribution of flow from the Deerfield River to Reach 3 was 200 cfs. Persistent habitat tables were produced showing habitat in terms of absolute quantity, as well as a percentage of the maximum value.

6.2.8 Dual Flow Analysis (Reach 4)

Dual flow quality habitat tables showing each flow pair for each immobile species and life stage analyzed in Reach 4 are shown in Table I-1 through I-28 located in Appendix I. Dual flow quality habitat tables are shown as a percentage of the maximum available quality habitat as well.

6.2.9 Habitat Time Series (Reach 4)

Monthly habitat duration curves for all species analyzed in Reach 4 are shown in Appendix J (Figure J-1 through J-10). The duration curves are based on hourly flows recorded at the Montague USGS Gage for the period January 1, 2000 to October 1, 2015. Using the WUA vs flow curves, the habitat was computed for each hour over the period of record and then habitat duration curves developed. Though habitat time series plots were presented for immobile species, we believe the persistent habitat maps and tables presented in this report, when compared to seasonal minimum and maximum flows, are a more effective tool for assessing immobile species' habitat. Each habitat duration curve represents current Project operations or baseline conditions.

Table 6.1.1.1-1: Estimated Flow (cfs) Routing through each Channel in the Upper Portion of Reach 1

Dam Discharge	Fall River Discharge	Total Bypass Discharge	Left Channel[16] Discharge	Center Channel[16] Discharge	Right Channel Discharge (Q2)[16]	Gaging Cross Section Flow (Q1)[17]
500	49	549	249	182	118	300
1500	49	1549	329	580	640	1220
2500	49	2549	464	799	1286	2085
4000	49	4049	965	*1173*	*1911*	3084
Dam Discharge	**Fall River Discharge**	**Total Bypass Discharge**	**Left Channel Discharge**	**Center Channel Discharge**	**Right Channel Discharge (Q2)**	**Gaging Cross Section Flow (Q1)**
500	49	549	45%	33%	21%	55%
1500	49	1549	21%	37%	41%	79%
2500	49	2549	18%	31%	50%	82%
4000	49	4049	24%	*29%*	*42%*	76%

[16] Left, Center, and Right channel are based on a reference of looking downstream

[17] The gaging cross section captured flow in the Center and Right Channels.

Table 6.1.1.4-1. Estimated Mean Column Velocity in the Center Channel of Reach 1.

Dam Discharge (cfs)	Center Channel Flow (cfs)	XS 733.21 (ft/s)	XS 532.09 (ft/s)	XS 383.56 (ft/s)	XS 239.61 (ft/s)	XS 95.40 (ft/s)
500	182	2.67	5.78	5.47	6.04	2.7
1,500	580	4.35	8.26	9.16	8.61	4.04
2,500	799	4.92	9.01	10.47	9.56	4.25
4,000	1,173	3.51	10.01	12.18	10.87	3.58

1) Three swim speed modes are generally recognized for fishes. Sustained swim speed is that which can be maintained for an indefinite period (longer than 200 minutes) and does not involve fatigue; prolonged swim speed can last between 15 seconds and 200 minutes and if maintained will end in fatigue; and burst swim speed is characterized by rapid movements of short duration and high speed, maintained for less than 15 seconds.

2) Adult American shad can swim approximately 2.5 ft/s at a sustained rate, approximately 7 ft/s at a prolonged rate and has a maximum burst speed of approximately 11.5-13.0 ft/s.

Table 6.1.2-1: Low Flow WSP Model Calibration Results for Reach 1 and 2A

Low Flow Model				
Transect	**n**	**Observed WSEL**	**Simulated WSEL (NGVD 29)**	**Difference**
T-1	0.1100	119.18	119.12	-0.06
T-2	0.1100	119.25	119.16	-0.09
H-1	0.0900	119.29	119.35	0.06
T-3	0.0825	119.42	119.42	0.00
T-4	0.0600	119.45	119.55	0.10
T-5	0.0425	119.56	119.61	0.05
T-6	0.0300	119.83	119.74	-0.09
T-7	0.0700	122.60	122.56	-0.04
T-8	0.0700	123.34	123.24	-0.10
T-9	0.1300	124.06	123.95	-0.11
T-10	0.0450	124.66	124.56	-0.10
T-11	0.1100	124.77	124.68	-0.09

H- hydraulic control transect.

Table 6.1.2-2: Mid Flow WSP Model Calibration Results for Reach 1 and 2A

Mid Flow Model				
Transect	**n**	**Observed WSEL**	**Simulated WSEL (NGVD 29)**	**Difference**
T-1	0.0450	119.46	119.58	0.12
T-2	0.0400	119.56	119.60	0.04
H-1	0.0825	120.04	120.02	-0.02
T-3	0.1050	120.33	120.31	-0.02
T-4	0.0675	120.66	120.70	0.04
T-5	0.0450	120.72	120.79	0.07
T-6	0.0225	120.76	120.85	0.09
T-7	0.0600	123.34	123.23	-0.11
T-8	0.0525	124.01	124.10	0.09
T-9	0.0975	124.93	124.88	-0.05
T-10	0.0450	125.39	125.44	0.05
T-11	0.0500	125.64	125.57	-0.07

Table 6.1.2-3: High Flow WSP Model Calibration Results for Reach 1 and 2A

High Flow Model				
Transect	n	**Observed WSEL**	**Simulated WSEL (NGVD 29)**	**Difference**
T-1	0.0400	121.10	121.12	0.02
T-2	0.0475	121.34	121.43	0.09
H-1	0.1225	123.11	123.02	-0.09
T-3	0.0375	123.16	123.19	0.03
T-4	0.0475	123.55	123.56	0.01
T-5	0.0850	123.91	123.88	-0.03
T-6	0.0300	123.99	124.01	0.02
T-7	0.1150	125.61	125.53	-0.08
T-8	0.0550	126.05	126.05	0.00
T-9	0.0525	126.55	126.52	-0.03
T-10	0.0550	127.89	127.91	0.02
T-11	0.0475	128.12	128.13	0.01

Table 6.1.2-4: Low Flow Hydraulic Model Velocity Calibration Results for Reach 1 and 2A

Range (+/-)	Percentage of Hydraulic Model Nodes within the Targeted Calibration Tolerance Range - Low Flow										
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
0.15 ft/s	100.0	100.0	100.0	100.0	98.9	73.2	92.9	100.0	0.0	91.4	100.0
0.20 ft/s	0.0	0.0	0.0	0.0	1.1	0.0	7.1	0.0	0.0	4.3	0.0
0.25 ft/s	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	4.3	0.0
0.30 ft/s	0.0	0.0	0.0	0.0	0.0	8.9	0.0	0.0	0.0	0.0	0.0
0.50 ft/s	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0
>0.50 ft/s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.1.2-5: Mid Flow Hydraulic Model Velocity Calibration Results for Reach 1 and 2A

Range (+/-)	Percentage of Hydraulic Model Nodes within the Targeted Calibration Tolerance Range - Mid Flow										
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
0.15 ft/s	100.0	100.0	100.0	74.4	98.8	100.0	98.9	100.0	100.0	100.0	91.7
0.20 ft/s	0.0	0.0	0.0	7.3	1.2	0.0	0.0	0.0	0.0	0.0	8.3
0.25 ft/s	0.0	0.0	0.0	7.3	0.0	0.0	1.1	0.0	0.0	0.0	0.0
0.30 ft/s	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.50 ft/s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>0.50 ft/s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.1.3-1: Modeled Minus Observed Differences at each WLL Recorder and Calibration Run for Reach 2B and 3

	Difference (ft) Per Calibration Run						
WLL Recorder	**1**	**2**	**3**	**4**	**5**	**6**	**7**
WLL3-1				-0.16	-0.08	0.15	-0.25
WLL3-2	-0.17	-0.10	-0.16	-0.12	-0.12	0.09	0.10
WLL3-3	-0.10	-0.12	-0.22		-0.01	0.23	-0.03
WLL3-4					0.10	0.34	0.10
WLL3-5				0.16	0.33	0.46	0.40
WLL3-6	-0.05	-0.15	0.51	-0.02	0.15	0.19	0.34
WLL3-7	0.14	0.20	0.27	0.14	0.32	0.35	0.23
WLL3-8	-0.04	-0.32	-0.11	-0.43	-0.32	-0.11	-0.08
WLL3-9		-0.05	0.35		0.60	0.64	
WLL3-10	0.11	0.15	0.23		0.20	0.22	
WLL3-11	-0.26	-0.26	-0.16	-0.20	0.21	0.25	0.33
WLL3-12	-0.04	-0.05	0.10		0.19	0.23	
WLL3-13	0.18	0.22	0.31	-0.31	-0.25	-0.20	0.15
WLL3-14	0.02	0.09	0.09	-0.02	0.02	0.07	0.36
WLL3-15	-0.20	-0.20	-0.01	-0.43	-0.03	0.06	
WLL3-16	0.25	0.32	0.54	-0.18	-0.14	-0.09	0.28
WLL3-17	0.01	-0.43	-0.70	0.54	0.52	0.64	-0.15
WLL3-18	-0.05	-0.03	0.06				
WLL3-19							
WLL3-20	-0.25	-0.27	-0.32	-0.47	-0.47	-0.47	-0.13
Average	-0.03	-0.06	0.05	-0.11	0.07	0.17	0.12

Table 6.1.3-2: Summary of accumulation of possible equipment errors for Reach 2B and 3

Equipment	Combined Error ± (ft)	Typical Use
Water Level Loggers(0.175ft) + RTK-GPS(0.049ft)	0.22	Water Level Loggers Data
Total Station(0.016ft) + RTK-GPS(0.049ft)	0.07	Shallow Water Bathymetry and Shoreline Topography
ADCP(0.095ft) + RTK-GPS (0.049ft)	0.14	Deeper Bathymetry
RTK-GPS	0.05	Benchmarks, Shoreline Topography, Shallow Water Bathymetry and Surface Water Elevations
LiDAR	0.20	Overbank Topography

Table 6.1.4-1: Calculated Flows and WSELs during the Mid Flow Calibration Period for Reach 4

Transect	Calculated Flow (cfs)	Calibration WSEL (ft NGVD 1929)	Measurement Time on 9/16/2015
Rt116	-	103.92	
T87	4970	104.24	16:28
T88	-	-	
T89	6305	104.91	14:52
T90	5915	104.97	16:51
T91	5785	105.18	14:21
T92	5960	105.38	13:47
T82	-	105.77	13:10
T93	-	106.16	13:25
T94	-	106.61	13:10
T95	6159	106.90	13:08
T96	5285	107.01	12:42
T97	5988	107.07	12:13
T98	5820	107.22	14:03
T99	6253	107.77	11:34
T100	5881	107.98	10:55
Average Calculated Flow (cfs)	5847		

Table 6.1.4-2: Final WSEL Calibration Results for Reach 4

Transect	Low-Flow Modeled minus Observed (ft)	Mid-Flow Modeled minus Observed (ft)	High-Flow Modeled minus Observed (ft)	Average Difference (ft)per Transect	Distance (ft) between HEC-RAS Cross Section and WWL Location
T87	0.31	0.11	0.04	0.15	287
T90	-0.20	0.07	0.21	0.03	223
T91	-0.23	-0.02	0.18	-0.02	245
T92	-0.35	-0.13	0.10	-0.13	206
T82	0.01	-0.10	0.10	0.00	224
T93	0.20	0.12	0.16	0.16	426
T94	-0.03	0.06	0.12	0.05	433
T96	0.00	0.06	0.05	0.04	314
T97	0.03	0.09	0.05	0.06	347
T98	0.46	0.40	0.22	0.36	550
T99	0.28	0.24	0.17	0.23	602
T100	0.29	0.22	0.20	0.24	593
Average	**0.06**	**0.09**	**0.13**	**0.13**	

Table 6.1.4-3: Hydraulic Model Velocity Calibration Results for Reach 4

Range (+/-)	Percentage of Hydraulic Model Nodes within the Targeted Calibration Tolerance Range											
	T100	**T99**	**T98**	**T97**	**T96**	**T95**	**T92**	**T91**	**T90**	**T89**	**T88**	**T87**
0.15 ft/s	77.9	51.4	24.4	100.0	89.4	90.3	100.0	100.0	100.0	100.0	100.0	86.2
0.20 ft/s	19.5	28.8	20.8	0.0	6.4	9.7	0.0	0.0	0.0	0.0	0.0	4.4
0.25 ft/s	2.7	19.2	32.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
0.30 ft/s	0.0	0.6	17.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	3.0
0.50 ft/s	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
>0.50 ft/s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.1.5-1: WSEL Calibration in Reach 5

	June 3-5, 2012			July 20-23, 2012		
Mitch's Marina at River Mile 92.7	**Observed Average WSEL (ft)**	**Modeled WSEL (ft)**	**Difference (ft)**	**Observed Average WSEL (ft)**	**Modeled WSEL (ft)**	**Difference (ft)**
Holyoke at 100.67 ft	105.28	105.41	0.13	100.97	100.74	-0.23
Holyoke at 99.47 ft	105.28	105.24	-0.04	100.97	99.61	-1.36

Table 6.2.1-1: Flow Providing Maximum WUA for Reach 1 Right Channel

Species	Life stage	Maximum WUA Total Bypass Flow (cfs)	Maximum WUA Right Channel Flow (cfs)	Maximum WUA (ft^2)
Fallfish	Spawning/Incubation	802	250	86,628
Fallfish	Fry	591	140	66,936
Fallfish	Juvenile	802	250	83,561
Fallfish	Adult	1,583	662	33,506
Longnose Dace	Juvenile	802	250	83,561
Longnose Dace	Adult	591	140	74,344
White Sucker	Spawning/Incubation	591	140	41,330
White Sucker	Fry	591	140	66,936
White Sucker	Adult/Juvenile	562	0	
Walleye	Spawning	3,062	1,500	86,372
Walleye	Fry	562	125	13,105
Walleye	Juvenile	591	140	58,234
Walleye	Adult	562	-	-
Tessellated Darter	Adult/Juvenile	562	125	38,259
Sea Lamprey	Spawning/Incubation	1,583	662	18,221
Macroinvertebrates	Larva	1,719	750	74,190
Shallow Slow	Shallow Slow	562	125	45,830
Shallow Fast	Shallow Fast	562	125	56,586
Deep Slow	Deep Slow	1,281	500	14,944
Deep Fast	Deep Fast	1,719	750	94,816

Table 6.2.2-1: Percentage of Peak WUA relative to Total Wetted Area for Reach 1 (Transects 10 & 11) Low Backwater Condition

Species	Life stage	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad	Spawning	7,500	870,142	1,469,249	59.2%
American Shad	Juvenile	2,000	619,823	1,440,455	43.0%
American Shad	Adult	7,500	626,206	1,469,249	42.6%
Shortnose Sturgeon	Spawning	6,000	874,855	1,464,279	59.7%
Shortnose Sturgeon	Egg-Larvae	3,000	1,360,780	1,454,688	93.5%
Shortnose Sturgeon	Fry	700	59,453	1,046,616	5.7%
Fallfish	Spawning	120	6,038	373,887	1.6%
Fallfish	Fry	200	28,739	593,767	4.8%
Fallfish	Juvenile	2,000	233,847	1,440,455	16.2%
Fallfish	Adult	2,000	437,958	1,440,455	30.4%
Longnose Dace	Juvenile	2,000	196,805	1,440,455	13.7%
Longnose Dace	Adult	2,000	462,096	1,440,455	32.1%
White Sucker	Spawning	120	0	373,887	0.0%
White Sucker	Fry	1,200	639,270	1,314,770	48.6%
White Sucker	Adult/Juvenile	1,600	202,982	1,411,111	14.4%
Walleye	Spawning	3,000	151,950	1,454,688	10.4%
Walleye	Fry	120	0	373,887	0.0%
Walleye	Juvenile	150	179	425,349	0.0%
Walleye	Adult	3,000	6,289	1,454,688	0.4%
Tessellated Darter	Adult/Juvenile	2,000	169,159	1,440,455	11.7%
Sea Lamprey	Spawning	800	8,809	1,112,977	0.8%
Macroinvertebrates	Larva	4,000	961,042	1,458,339	65.9%
Habitat Guild	Shallow Slow	1,200	789,695	1,314,770	60.1%
Habitat Guild	Shallow Fast	1,800	556,171	1,426,872	39.0%
Habitat Guild	Deep Slow	1,400	385,669	1,396,493	27.6%
Habitat Guild	Deep Fast	3,000	126,639	1,454,688	8.7%

Table 6.2.2-2: Percentage of Peak WUA relative to Total Wetted Area for Reach 1 (Transects 10 & 11) High Backwater Condition

Species	Life stage	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad	Spawning	7,500	898,488	1,476,090	60.9%
American Shad	Juvenile	2,000	668,444	1,450,021	46.1%
American Shad	Adult	7,500	695,459	1,476,090	47.1%
Shortnose Sturgeon	Spawning	6,000	893,383	1,466,669	60.9%
Shortnose Sturgeon	Egg-Larvae	3,000	1,360,780	1,456,307	93.4%
Shortnose Sturgeon	Fry	500	64,776	1,260,721	5.1%
Fallfish	Spawning	120	0	1,193,585	0.0%
Fallfish	Fry	150	25,172	1,198,331	2.1%
Fallfish	Juvenile	1,800	260,011	1,446,164	18.0%
Fallfish	Adult	2,000	549,907	1,450,021	37.9%
Longnose Dace	Juvenile	1,800	155,504	1,446,164	10.8%
Longnose Dace	Adult	2,000	413,608	1,450,021	28.5%
White Sucker	Spawning	120	0	1,193,585	0.0%
White Sucker	Fry	120	1,000,248	1,193,585	83.8%
White Sucker	Adult/Juvenile	250	362,803	1,221,717	29.7%
Walleye	Spawning	3,000	139,817	1,456,307	9.6%
Walleye	Fry	120	0	1,193,585	0.0%
Walleye	Juvenile	120	870	1,193,585	0.1%
Walleye	Adult	120	36,453	1,193,585	3.1%
Tessellated Darter	Adult/Juvenile	1,800	133,736	1,446,164	9.2%
Sea Lamprey	Spawning	1,800	3,870	1,446,164	0.3%
Macroinvertebrates	Larva	4,000	918,412	1,460,061	62.9%
Habitat Guild	Shallow Slow	700	818,354	1,299,454	63.0%
Habitat Guild	Shallow Fast	1,600	535,297	1,439,878	37.2%
Habitat Guild	Deep Slow	500	615,160	1,260,721	48.8%
Habitat Guild	Deep Fast	3,000	124,411	1,456,307	8.5%

Table 6.2.3-1: Percentage of Peak WUA relative to Total Wetted Area for Reach 2

Species	Life stage	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad	Spawning	10,000	1,487,041	2,670,337	55.7%
American Shad	Juvenile	3,000	1,094,797	2,395,805	45.7%
American Shad	Adult	10,000	1,200,278	2,670,337	44.9%
Shortnose Sturgeon	Spawning	10,000	950,854	2,638,786	55.6%
Shortnose Sturgeon	Egg-Larvae	7,000	2,020,957	2,593,608	77.9%
Shortnose Sturgeon	Fry	6,000	437,325	2,559,738	17.1%
Fallfish	Spawning/Incubation	3,000	44,809	2,395,805	1.9%
Fallfish	Fry	1,600	107,763	2,115,502	5.1%
Fallfish	Juvenile	3,000	566,109	2,395,805	23.6%
Fallfish	Adult	1,800	822,519	2,196,043	37.5%
Longnose Dace	Juvenile	3,000	311,117	2,395,805	13.0%
Longnose Dace	Adult	3,000	615,175	2,395,805	25.7%
White Sucker	Spawning/Incubation	10,000	13,636	2,670,337	0.5%
White Sucker	Fry	1,000	1,036,376	1,866,419	55.5%
White Sucker	Adult/Juvenile	1,400	436,799	2,021,225	21.6%
Walleye	Spawning	8,000	482,932	2,617,950	18.4%
Walleye	Fry	1,000	19,515	1,866,419	1.0%
Walleye	Juvenile	1,600	11,769	2,115,502	0.6%
Walleye	Adult	400	108,908	1,402,619	7.8%
Tessellated Darter	Adult/Juvenile	2,000	221,890	2,245,420	9.9%
Sea Lamprey	Spawning/Incubation	3,000	40,615	2,395,805	1.7%
Macroinvertebrates	Larva	6,000	1,343,516	2,559,738	52.5%
Habitat Guild	Shallow Slow	1,200	750,888	1,951,165	38.5%
Habitat Guild	Shallow Fast	2,000	618,960	2,245,420	27.6%
Habitat Guild	Deep Slow	1,400	822,968	2,021,225	40.7%
Habitat Guild	Deep Fast	7,000	456,895	2,593,608	17.6%

Table 6.2.4-1: Percentage of Peak WUA relative to Total Wetted Area for Reach 3 with Cabot Station Operating at 2,500 cfs and a Deerfield River Flow of 200 cfs

Species	Life stage	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad	Spawning/Incubation	5,000	2,021,880	5,264,901	38.4%
American Shad	Juvenile	5,000	2,282,494	5,264,901	43.4%
American Shad	Adult	5,000	2,407,427	5,264,901	45.7%
Shortnose Sturgeon	Spawning	5,000	1,603,323	5,264,901	30.5%
Shortnose Sturgeon	Egg-Larvae	5,000	2,551,227	5,264,901	48.5%
Shortnose Sturgeon	Fry	5,000	1,444,450	5,264,901	27.4%
Shortnose Sturgeon	Juveniles	5,000	1,828,689	5,264,901	34.7%
Shortnose Sturgeon	Adults	5,000	1,919,802	5,264,901	36.5%
Fallfish	Spawning/Incubation	3,000	576,657	4,900,966	11.8%
Fallfish	Fry	3,000	825,053	4,900,966	16.8%
Fallfish	Juvenile	3,000	1,182,748	4,900,966	24.1%
Fallfish	Adult	3,000	1,780,779	4,900,966	36.3%
Longnose Dace	Juvenile	2,000	307,052	4,611,704	6.7%
Longnose Dace	Adult	3,000	547,316	4,900,966	11.2%
White Sucker	Spawning/Incubation	3,000	162,255	4,900,966	3.3%
White Sucker	Fry	120	2,032,500	3,569,993	56.9%
White Sucker	Adult/Juvenile	3,000	839,203	4,900,966	17.1%
Walleye	Spawning	5,000	1,106,733	5,264,901	21.0%
Walleye	Fry	120	161,031	3,569,993	4.5%
Walleye	Juvenile	120	121,311	3,569,993	3.4%
Walleye	Adult	120	495,345	3,569,993	13.9%
Tessellated Darter	Adult/Juvenile	2,000	203,019	4,611,704	4.4%
Sea Lamprey	Spawning/Incubation	3,000	134,296	4,900,966	2.7%
Macroinvertebrates	Larva	5,000	1,244,512	5,264,901	23.6%
Habitat Guild	Shallow Slow	120	961,128	3,569,993	26.9%
Habitat Guild	Shallow Fast	2,000	483,875	4,611,704	10.5%
Habitat Guild	Deep Slow	200	1,699,409	3,649,920	46.6%
Habitat Guild	Deep Fast	5,000	909,225	5,264,901	17.3%

Table 6.2.4-2: Percentage of Peak WUA relative to Total Wetted Area for Reach 3 with Cabot Station Operating at 7,000 cfs and a Deerfield River Flow of 200 cfs

Species	Life stage	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad	Spawning/Incubation	5,000	2,353,994	5,464,035	43.1%
American Shad	Juvenile	3,000	2,560,400	5,251,481	48.8%
American Shad	Adult	5,000	3,056,423	5,464,035	55.9%
Shortnose Sturgeon	Spawning	5,000	1,834,483	5,464,035	33.6%
Shortnose Sturgeon	Egg-Larvae	5,000	2,655,661	5,464,035	48.6%
Shortnose Sturgeon	Fry	3,000	1,580,583	5,251,481	30.1%
Shortnose Sturgeon	Juveniles	3,000	2,148,223	5,251,481	40.9%
Shortnose Sturgeon	Adults	3,000	2,217,608	5,251,481	42.2%
Fallfish	Spawning/Incubation	700	624,182	4,886,402	12.8%
Fallfish	Fry	300	854,381	4,764,555	17.9%
Fallfish	Juvenile	1,000	1,386,325	4,952,664	28.0%
Fallfish	Adult	1,000	2,274,836	4,952,664	45.9%
Longnose Dace	Juvenile	500	259,262	4,822,272	5.4%
Longnose Dace	Adult	700	478,847	4,886,402	9.8%
White Sucker	Spawning/Incubation	500	135,048	4,822,272	2.8%
White Sucker	Fry	120	2,672,529	4,686,165	57.0%
White Sucker	Adult/Juvenile	500	1,301,145	4,822,272	27.0%
Walleye	Spawning	5,000	1,080,048	5,464,035	19.8%
Walleye	Fry	120	259,689	4,686,165	5.5%
Walleye	Juvenile	120	191,660	4,686,165	4.1%
Walleye	Adult	120	643,593	4,686,165	13.7%
Tessellated Darter	Adult/Juvenile	200	158,733	4,731,280	3.4%
Sea Lamprey	Spawning/Incubation	1,000	119,562	4,952,664	2.4%
Macroinvertebrates	Larva	5,000	1,207,273	5,464,035	22.1%
Habitat Guild	Shallow Slow	120	991,787	4,686,165	21.2%
Habitat Guild	Shallow Fast	300	509,288	4,764,555	10.7%
Habitat Guild	Deep Slow	3,000	1,072,859	5,251,481	20.4%
Habitat Guild	Deep Fast	500	2,425,549	4,822,272	50.3%

Table 6.2.4-3: Percentage of Peak WUA relative to Total Wetted Area for Reach 3 with Cabot Station Operating at 14,000 cfs and a Deerfield River Flow of 200 cfs

Species	Life stage	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad	Spawning/Incubation	5,000	2,598,248	5,753,693	45.2%
American Shad	Juvenile	2,000	2,717,826	5,529,020	49.2%
American Shad	Adult	5,000	3,635,316	5,753,693	63.2%
Shortnose Sturgeon	Spawning	5,000	1,928,735	5,753,693	33.5%
Shortnose Sturgeon	Egg-Larvae	5,000	2,667,667	5,753,693	46.4%
Shortnose Sturgeon	Fry	3,000	1,623,320	5,612,533	28.9%
Shortnose Sturgeon	Juveniles	3,000	2,387,667	5,612,533	42.5%
Shortnose Sturgeon	Adults	3,000	2,411,756	5,612,533	43.0%
Fallfish	Spawning/Incubation	1,000	252,755	5,439,761	4.6%
Fallfish	Fry	500	355,081	5,369,470	6.6%
Fallfish	Juvenile	1,000	835,584	5,439,761	15.4%
Fallfish	Adult	1,000	2,510,275	5,439,761	46.1%
Longnose Dace	Juvenile	2,000	75,967	5,529,020	1.4%
Longnose Dace	Adult	2,000	136,099	5,529,020	2.5%
White Sucker	Spawning/Incubation	5,000	25,775	5,753,693	0.4%
White Sucker	Fry	300	2,435,547	5,341,766	45.6%
White Sucker	Adult/Juvenile	1,000	1,138,261	5,439,761	20.9%
Walleye	Spawning	5,000	610,523	5,753,693	10.6%
Walleye	Fry	120	240,438	5,298,908	4.5%
Walleye	Juvenile	700	239,227	5,393,620	4.4%
Walleye	Adult	300	938,220	5,341,766	17.6%
Tessellated Darter	Adult/Juvenile	2,000	47,029	5,529,020	0.9%
Sea Lamprey	Spawning/Incubation	3,000	22,772	5,612,533	0.4%
Macroinvertebrates	Larva	5,000	890,587	5,753,693	15.5%
Habitat Guild	Shallow Slow	120	386,037	5,298,908	7.3%
Habitat Guild	Shallow Fast	1,000	192,388	5,439,761	3.5%
Habitat Guild	Deep Slow	200	2,509,621	5,313,816	47.2%
Habitat Guild	Deep Fast	3,000	612,567	5,612,533	10.9%

Table 6.2.5-1: Percentage of Peak WUA relative to Total Wetted Area for Reach 4

Species	Life stage	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad	Spawning/Incubation	15,000	14,182,397	30,829,620	46.0%
American Shad	Juvenile	5,000	20,970,703	28,799,760	72.8%
American Shad	Adult	14,000	26,411,552	30,829,620	85.7%
Shortnose Sturgeon	Fry	5,000	16,338,131	29,527,302	55.3%
Shortnose Sturgeon	Juveniles	8,000	20,325,318	29,527,302	68.8%
Shortnose Sturgeon	Adults	7,000	20,657,503	29,527,302	70.0%
Fallfish	Spawning/Incubation	3,200	5,014,615	23,581,071	21.3%
Fallfish	Fry	2,400	7,657,464	23,581,071	32.5%
Fallfish	Juvenile	4,000	8,226,027	23,581,071	34.9%
Fallfish	Adult	1,600	18,844,747	26,727,091	70.5%
Longnose Dace	Juvenile	2,800	1,226,425	27,402,563	4.5%
Longnose Dace	Adult	3,200	2,146,515	27,402,563	7.8%
White Sucker	Spawning/Incubation	2,800	654,203	25,865,473	2.5%
White Sucker	Fry	800	17,311,497	23,581,071	73.4%
White Sucker	Adult/Juvenile	800	11,466,039	24,315,954	47.2%
Walleye	Spawning	8,000	2,557,617	29,527,302	8.7%
Walleye	Fry	8,000	955,697	30,275,346	3.2%
Walleye	Juvenile	800	1,789,966	23,581,071	7.6%
Walleye	Adult	800	7,030,738	23,581,071	29.8%
Tessellated Darter	Adult/Juvenile	2,800	1,097,027	25,865,473	4.2%
Sea Lamprey	Spawning/Incubation	3,200	209,778	27,825,581	0.8%
Macroinvertebrates	Larva	8,000	3,812,597	29,527,302	12.9%
Shallow Slow	Shallow Slow	3,200	2,811,288	23,581,071	11.9%
Shallow Fast	Shallow Fast	2,800	2,627,730	23,581,071	11.1%
Deep Slow	Deep Slow	1,000	19,235,977	24,315,954	79.1%
Deep Fast	Deep Fast	8,000	4,451,275	25,865,473	17.2%

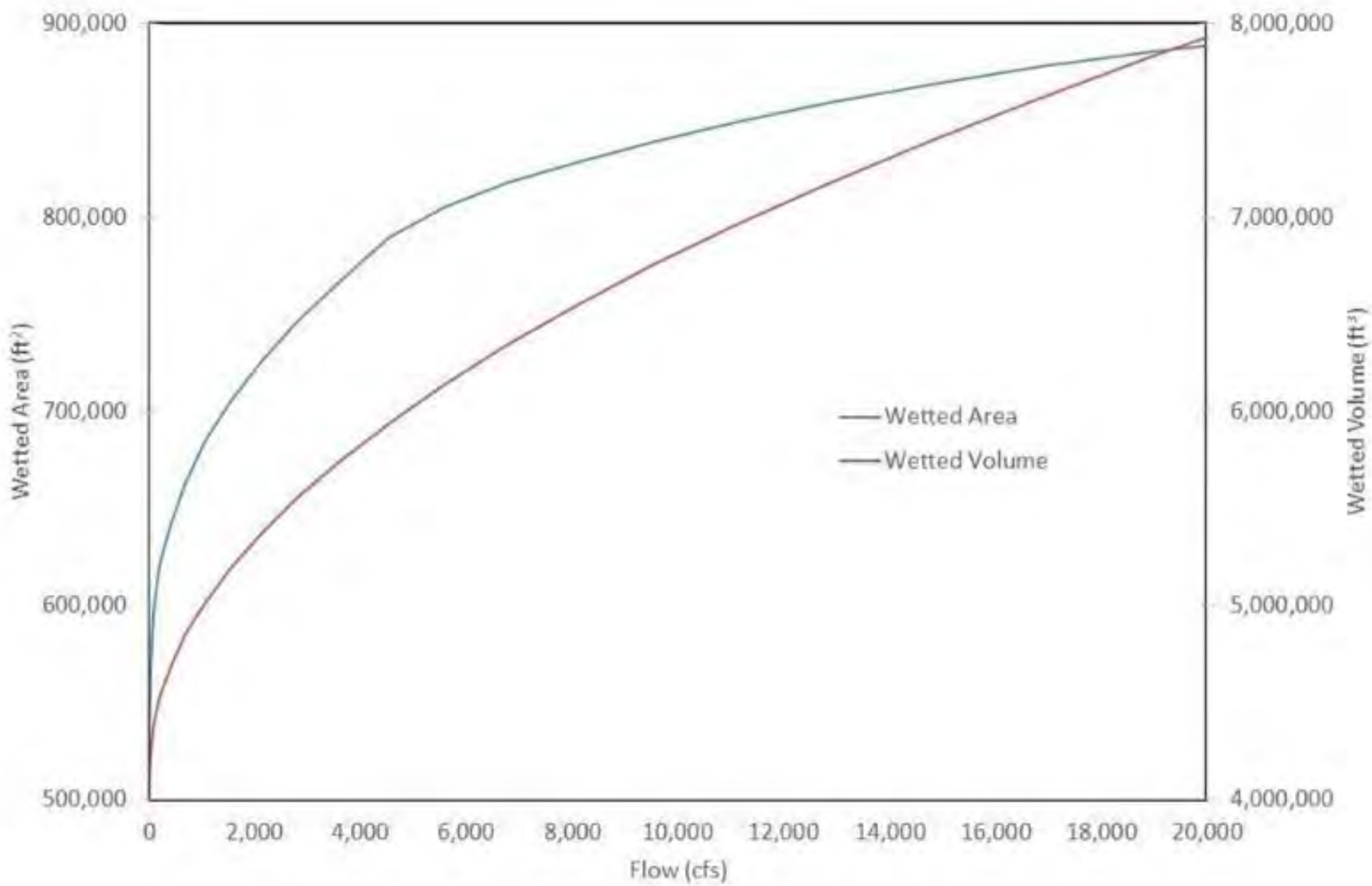


Figure 6.1.1.2-1: Wetted Area and Volume versus Flow Relationship for Reach 1 Plunge Pool

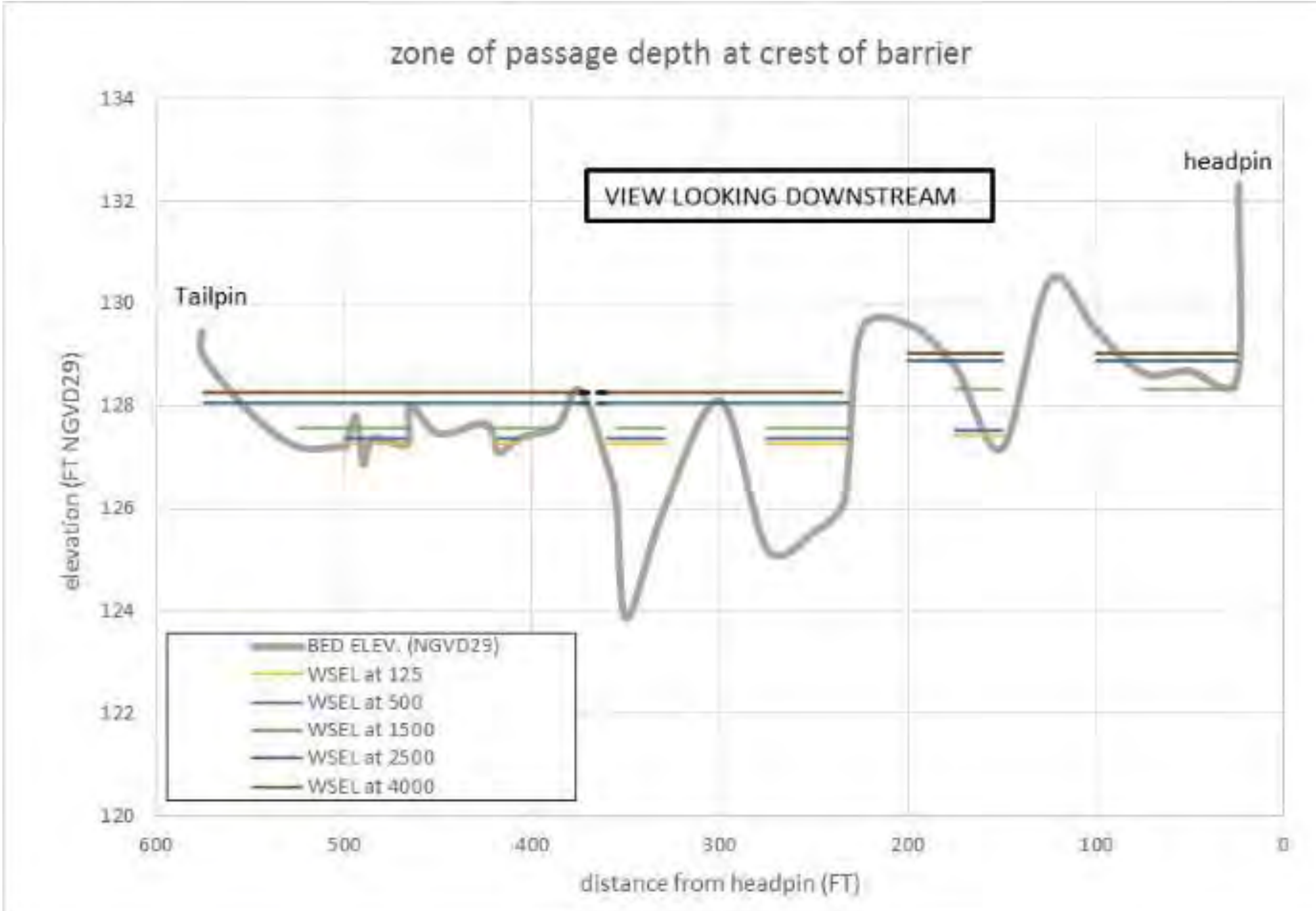


Figure 6.1.1.3-1: Left Channel Transect Elevation Survey in Upper Bypass Reach (Flow values relate to gate releases, not flow in channel)

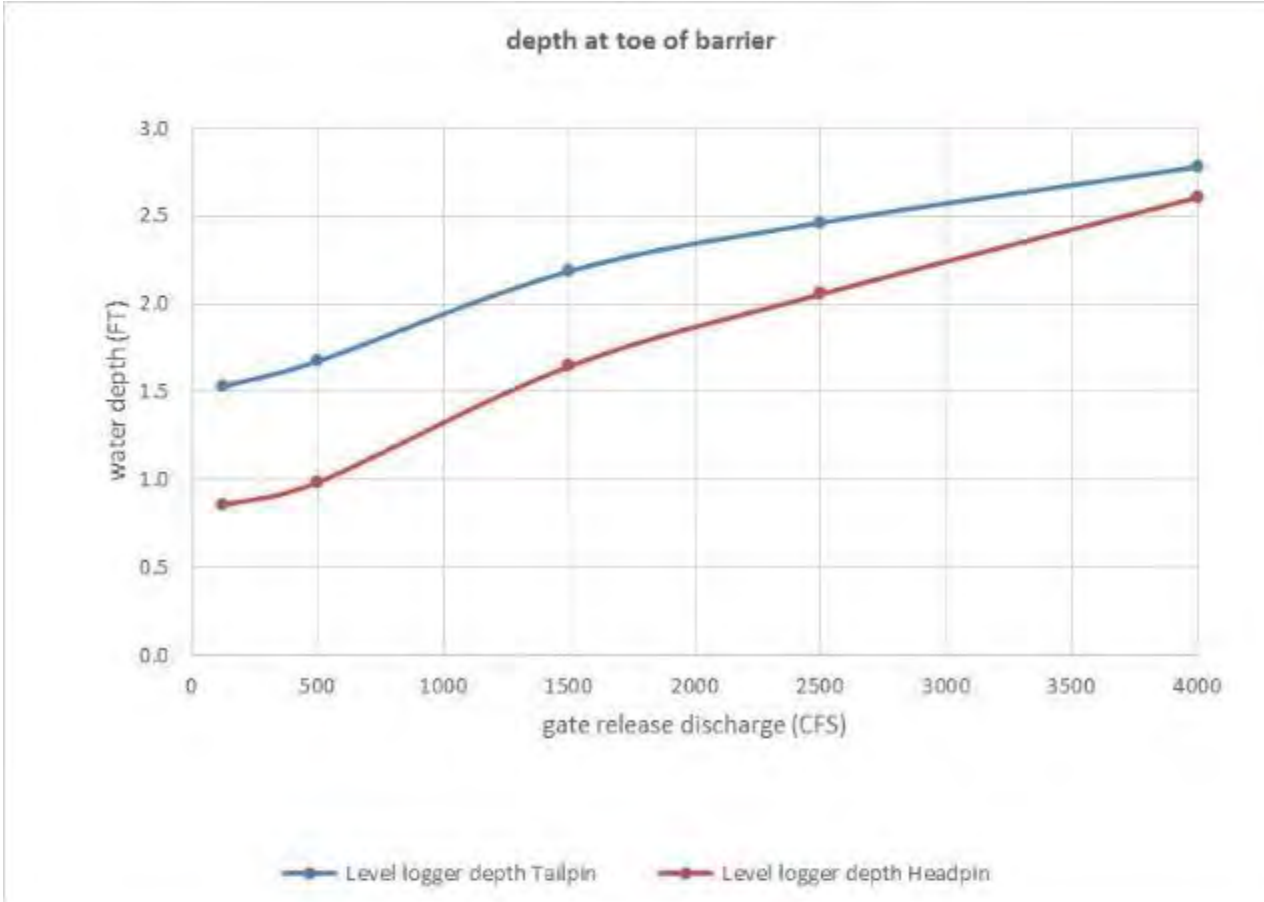


Figure 6.1.1.3-2: Water depth at Toe of Passage Barrier in Left Channel as Measured by Water Level Loggers (Flow values relate to gate releases, not flow in channel)

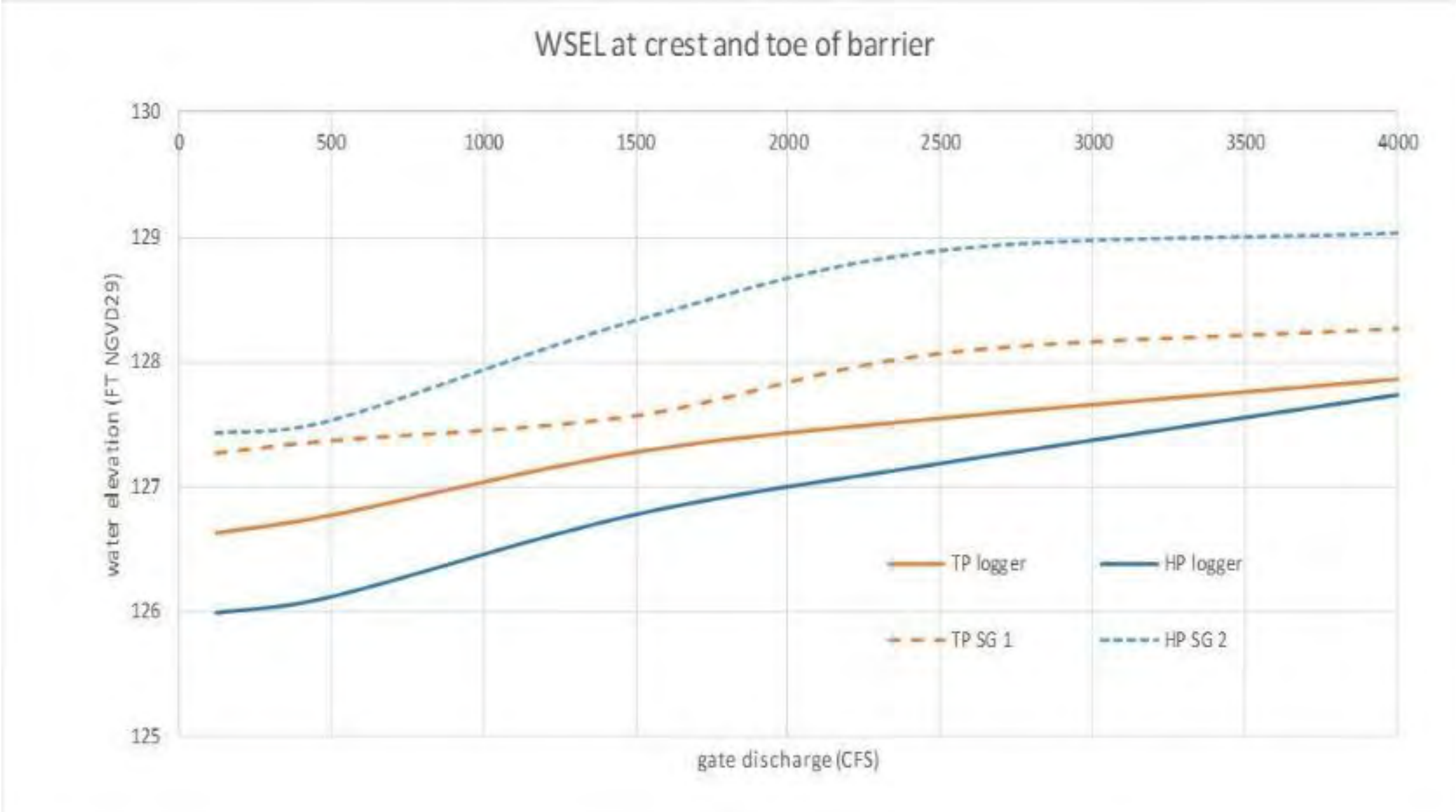


Figure 6.1.1.3-3: Water Elevations at Toe and Crest of Passage Barrier in Left Channel (Flow values relate to gate releases, not flow in channel)

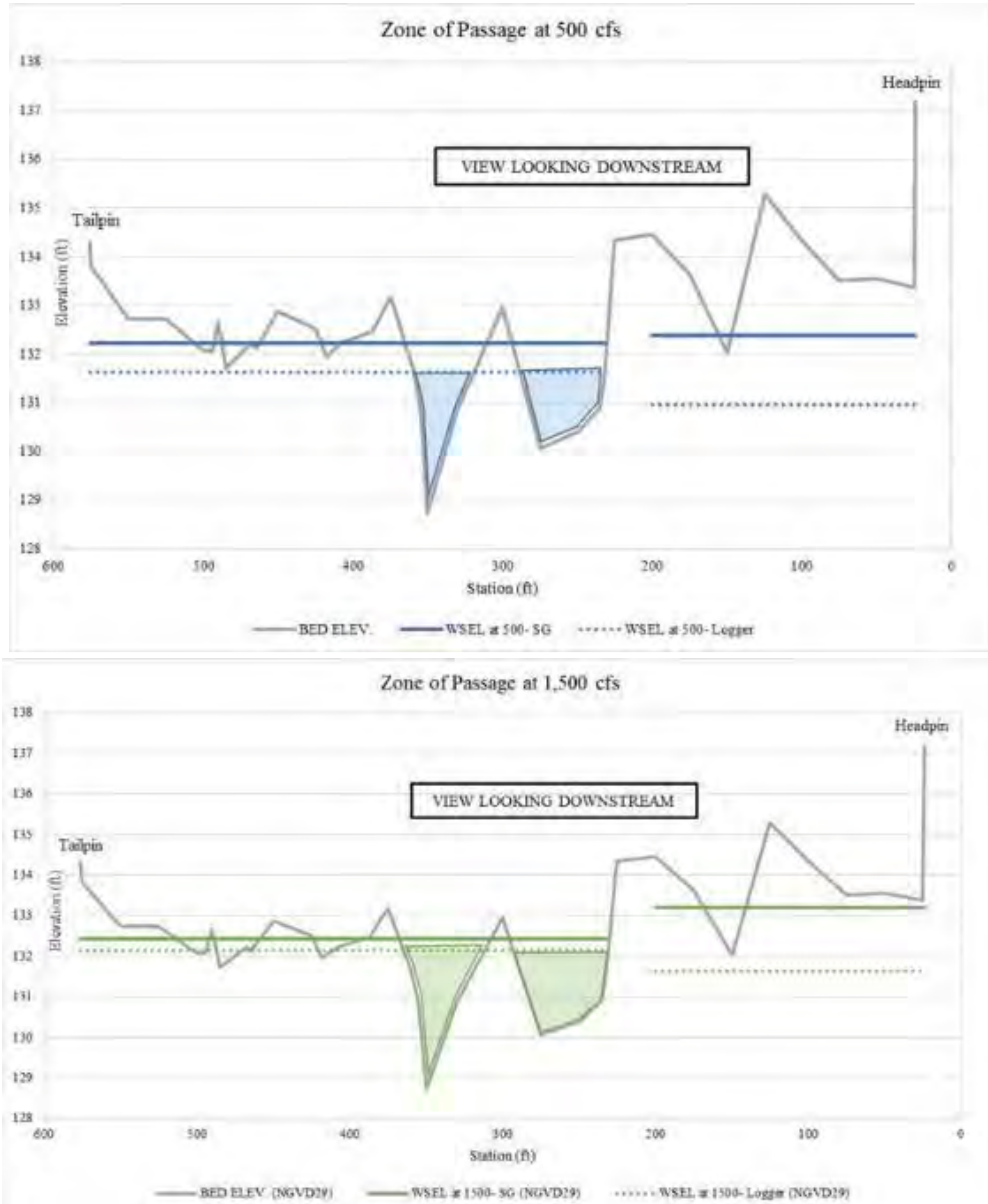


Figure 6.1.1.3-4: Cross Sectional Area (Shaded) Meeting Body Depth Requirements of American shad at Passage Barrier in Left Channel (Flow values relate to gate releases, not flow in channel)

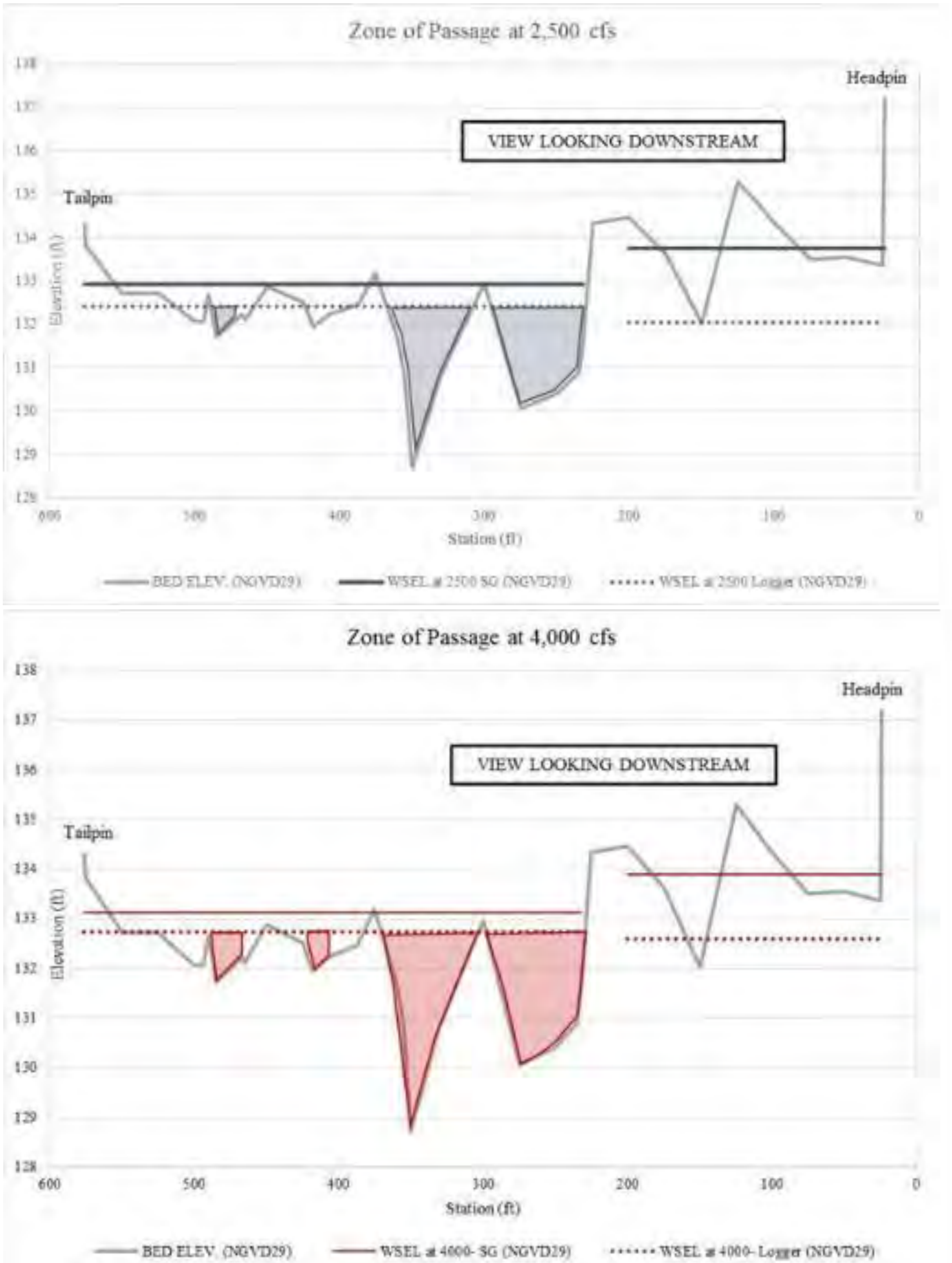


Figure 6.1.1.3-4 (cont): Cross Sectional Area (Shaded) Meeting Body Depth Requirements of American shad at Passage Barrier in Left Channel (Flow values relate to gate releases, not flow in channel)

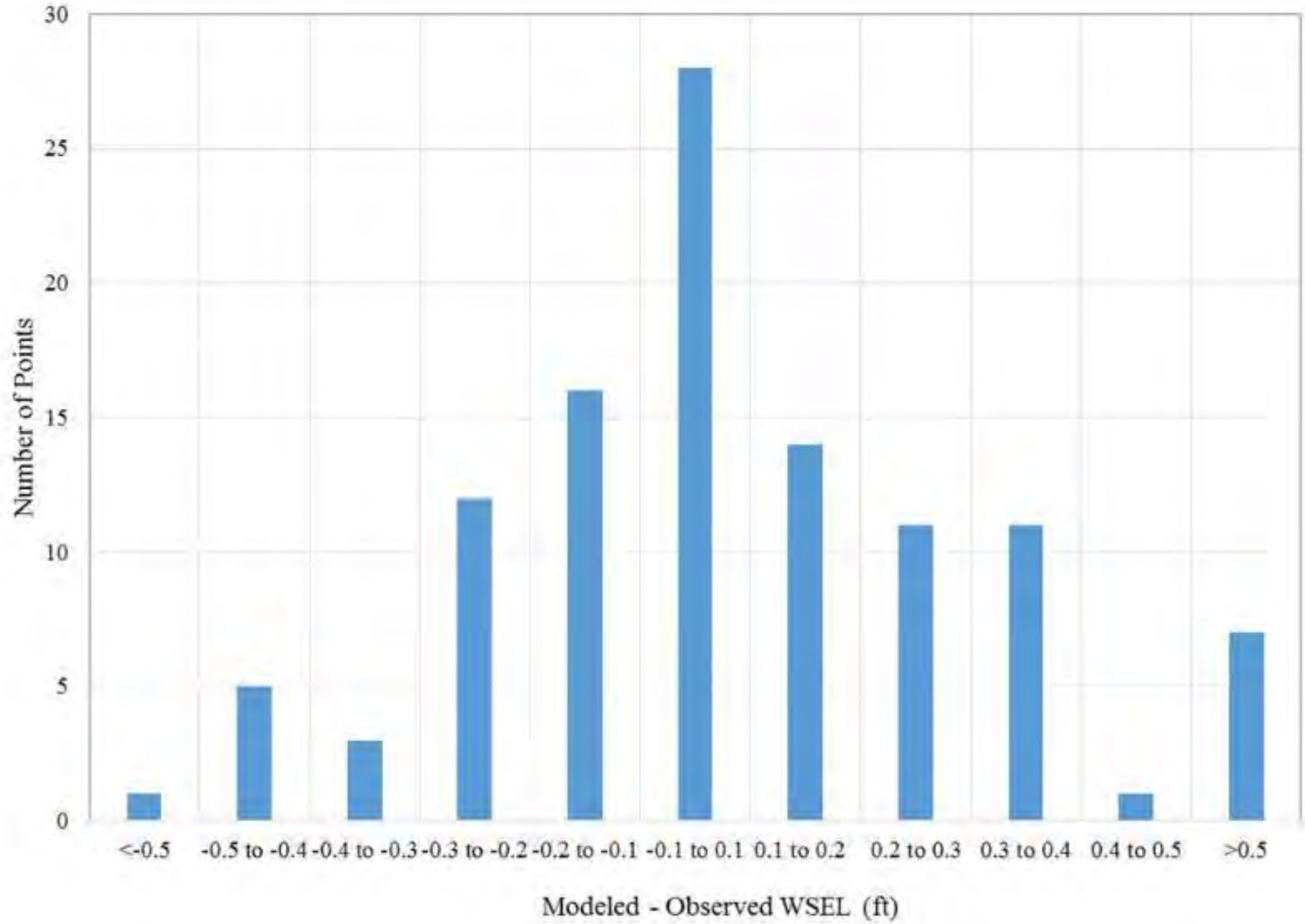


Figure 6.1.3-1: WSEL Error Distribution for Reach 2B and 3

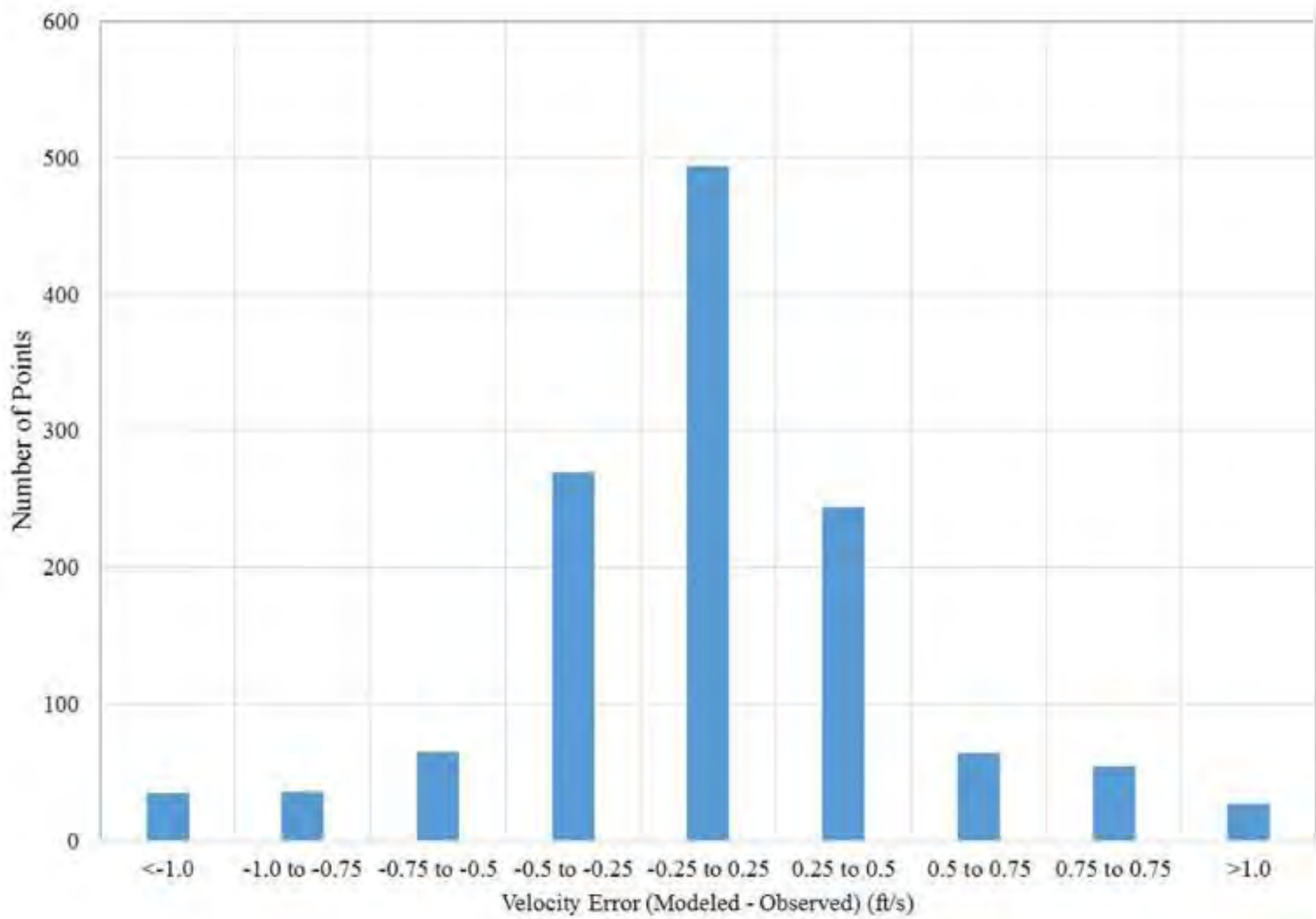


Figure 6.1.3-2: Velocity Error Distribution Reach 2B and 3

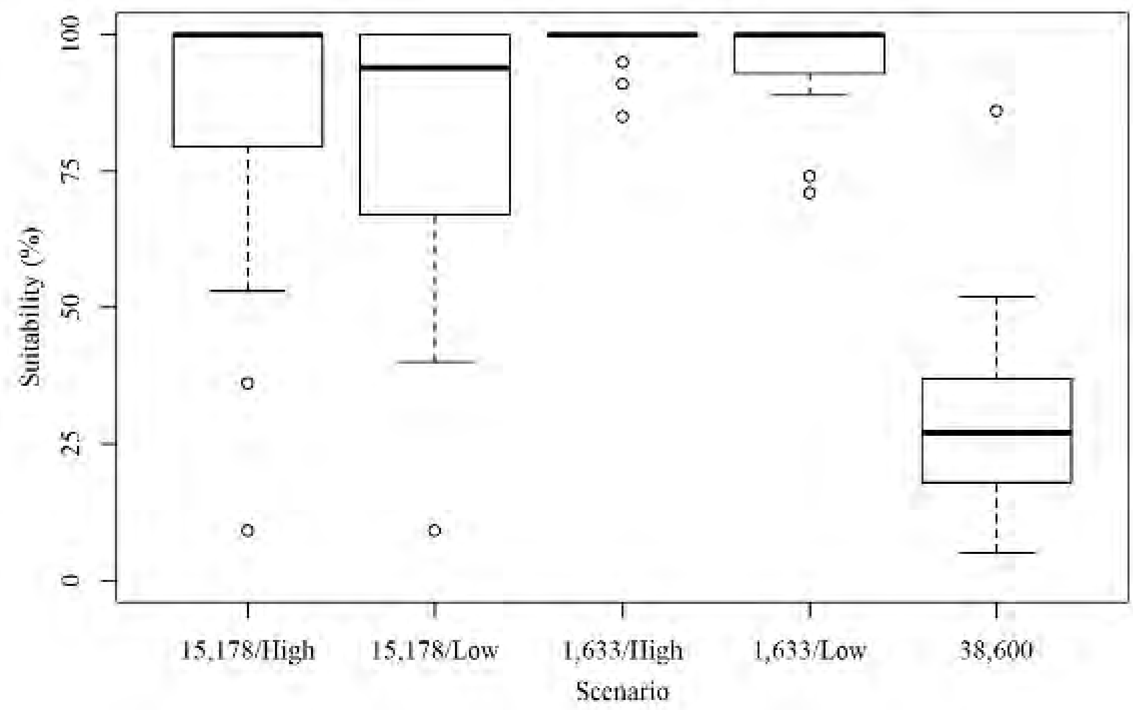


Figure 6.2.6-1: Suitability at 15 Reach 5 Transects for Criteria 1 Mussels

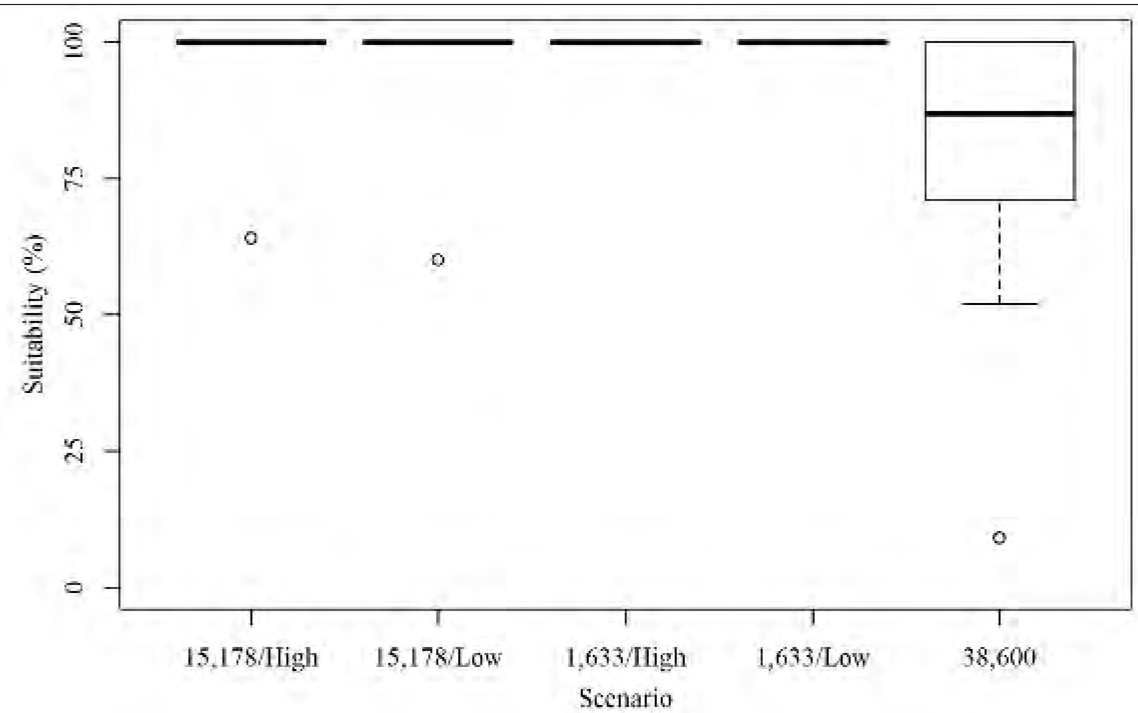


Figure 6.2.6-2: Suitability at 15 Reach 5 Transects for Criteria 2 Mussels

Table 6.2.6-1: Habitat Suitability for State-Listed Freshwater Mussels at Reach 5 Transects

15,178 cfs= 13,728 cfs (Cabot Max Capacity) + 1,450 cfs (Deerfield Station No. 2 Max Capacity)
1,633 cfs= 1,433 (Existing Turners Falls Project Min Flow) = 200 cfs (Deerfield River Station No. 2 Min Flow)
38,600 cfs= mean April flow

Transect	88.5988	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	90.91%	100.00%
1,633	High	90.91%	100.00%
1,633	Low	100.00%	100.00%
38,600		18.18%	100.00%

Transect	92.69	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	100.00%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		19.05%	100.00%

Transect	96.461	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	36.36%	63.64%
15,178	Low	40.00%	60.00%
1,633	High	100.00%	100.00%
1,633	Low	71.43%	100.00%
38,600		40.91%	72.73%

Transect	89.5413	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	95.45%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		31.82%	100.00%

Transect	92.9704	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	95.00%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	89.47%	100.00%
38,600		31.82%	100.00%

Transect	96.837	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	100.00%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		52.17%	86.96%

Transect	90.653	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	90.48%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		4.76%	52.38%

Transect	94.298	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	93.75%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		39.13%	73.91%

Transect	100.169	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	100.00%	100.00%
1,633	High	95.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		27.27%	81.82%

Transect	91.8435	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	100.00%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	95.00%	100.00%
38,600		85.71%	100.00%

Transect	94.874	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	65.00%	100.00%
15,178	Low	45.00%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		13.64%	100.00%

Transect	100.917	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	100.00%	100.00%
15,178	Low	100.00%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	95.00%	100.00%
38,600		18.18%	100.00%

Transect	92.257	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	93.75%	100.00%
15,178	Low	81.25%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	100.00%	100.00%
38,600		18.75%	68.75%

Transect	96.347	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	52.94%	100.00%
15,178	Low	52.94%	100.00%
1,633	High	84.62%	100.00%
1,633	Low	90.91%	100.00%
38,600		35.00%	60.00%

Transect	106.344	Channel Suitability	
Flow (cfs)	Backwater	Criteria 1	Criteria 2
15,178	High	9.09%	100.00%
15,178	Low	9.09%	100.00%
1,633	High	100.00%	100.00%
1,633	Low	73.68%	100.00%
38,600		9.09%	9.09%

Table 6.2.6-2: Qualitative Analysis of Flow and Backwater Effects on Mussel Habitat Suitability in Reach 5

	Criteria 1				Criteria 2				
Transect (River Mile)	**Operational Flow Effect**	**Backwater Effect**	**High River Flow Effect**		**Operational Flow Effect**	**Backwater Effect**	**High River Flow Effect**		**Mussel Abundance Description from Previous Surveys**
88.5988	Minimal	Low	Severe		None	None	None		State-Listed Mussels Absent
89.5413	Minimal	Minimal	High		None	None	None		High abundance of Yellow Lampmussel
90.653	Minimal	Minimal	Severe		None	None	Moderate-High		High abundance of Yellow Lampmussel
91.8435	Minimal	Minimal	Low		None	None	None		Medium-High abundance of Yellow Lampmussel
92.257	Minimal/Low	Low	Severe		None	None	Moderate		Medium-High abundance of Yellow Lampmussel
92.69	None	None	Severe		None	None	None		High abundance of Yellow Lampmussel
92.9704	Minimal	Minimal/Low	High		None	None	None		Medium-High abundance of Yellow Lampmussel. Eastern Pondmussel and Tidewater Mucket documented in 2013
94.298	Minimal	Minimal	High		None	None	Moderate		Low abundance of Yellow Lampmussel
94.874	Moderate/Moderate-High	Moderate	Severe		None	None	None		Medium abundance of Yellow Lampmussel
96.347*	Moderate	Minimal	High		None	None	Moderate-High		Medium abundance of Yellow Lampmussel
96.461	High	Moderate	Moderate-High		Moderate/Moderate-High	Minimal	Moderate		Medium abundance of Yellow Lampmussel
96.837	None	None	Moderate-High		None	None	Low		Medium abundance of Yellow Lampmussel
100.169	Minimal	Minimal	High		None	None	Low		State-Listed Mussels Absent
100.917	Minimal	Minimal	Severe		None	None	None		State-Listed Mussels Absent
106.344	Severe	Moderate	Severe		None	None	Severe		State-Listed Mussels Absent

*Habitat Suitability was below 100% for all flow scenarios for Criteria 1

Table 6.2.6-3: Comparison of Yellow Lampmussel Abundance with Modeled Effects in Reach 5

Yellow Lampmussel Abundance	Number of Transects	Criteria 1 (Includes Yellow Lampmussel Juveniles)		Criteria 2 (Includes Yellow Lampmussel Adults)	
		Operational Effect Range	High River Flow Effect Range	Operational Effect Range	High River Flow Effect Range
Absent (n = 0)	4	Minimal - Severe[1]	High - Severe	None	None - Severe[2]
Low (n = 1-4)	1	Minimal	High	None	Moderate
Medium (n = 5-50)	4	None - Moderate/High	Moderate/High - Severe	None - Moderate/High	None - Moderate/High
Medium-High*	3	Minimal - Low	Low - Severe	None	None - Moderate
High (n > 50)	3	None - Minimal	High - Severe	None	None - Moderate/High

*Medium-High was included for transects where values from 2009/2013 varied between medium and high
[1]Only one Severe value, the remaining three were Minimal
[2]Only one Severe value, the remaining three were None/Low

7 ANALYSIS OF HABITAT RESULTS AND DISCUSSION

The WUA versus flow relationships discussed in the previous section show that a range of flows typically provides suitable habitat for a given species and life stage. A flow recommendation for the Project should take into account habitat use by species and life stages throughout the year, the availability of water throughout the year, the varying hydrology during each bio-period of interest, and the operational constraints of the Project (Bovee *et al*. 1998).

7.1 Analysis of Habitat Results

Determining instream flows requires more than choosing the peak WUA flow for one life stage of one species from the IFIM study. No specific flow will provide optimum conditions for all life stages and species, since multiple life stages exist simultaneously in a river. Setting instream flows requires ranking and balancing the importance of co-occurring fish species and life stages and requires considering long-range management plans for fishery resources as determined by the state and federal natural resource agencies.

7.1.1 Reach 1

7.1.1.1 Reach 1 (1-D Single Transect Model)

Habitat suitability values as a percentage of maximum habitat were calculated for each species/life stage analyzed at select bypass flows for Reach 1 (Table 7.1.1.1-1).

7.1.1.2 Reach 1 (Transects 10 and 11)

Habitat suitability values as a percentage of maximum habitat were calculated for each species/life stage analyzed at select bypass flows for this reach[18] (Tables 7.1.1.2-1, and 7.1.1.2-2).

7.1.2 Reach 2

Habitat suitability values as a percentage of maximum habitat were calculated for each species/life stage analyzed at select bypass flows for this reach (Table 7.1.2-1).

7.1.3 Reach 3

Habitat suitability values as a percentage of maximum habitat were calculated for each species/life stage analyzed at select bypass flows for this reach. In addition, three Cabot Station flow scenario were examined, representing approximately minimum hydraulic capacity (2,500 cfs) (Table 7.1.3-1), 50% of hydraulic capacity (7,000 cfs) (Table 7.1.3-2), and maximum hydraulic capacity (14,000 cfs) (Table 7.1.3-3). For all scenarios, it was assumed the contribution of flow from the Deerfield River to Reach 3 was 200 cfs.

7.1.4 Reach 4

Habitat suitability values as a percentage of maximum habitat were calculated for each species/life stage analyzed at select bypass flows for this reach (Table 7.1.4-1).

[18] Due to the operational influence of Station No. 1, located just downstream of Transect 10, two hydraulic conditions were examined. High backwater conditions reflect Station No. 1 operating at it full hydraulic capacity, while low backwater conditions reflect Station No. 1 being shut down.

7.1.5 Reach 5

The variable abundance and presence/absence of state-listed mussel species did not correlate with the effects of the various flow scenarios on suitability. Therefore, the distribution and abundance of state-listed mussels in Reach 5 is not likely to be controlled by the depths and benthic velocities observed for these scenarios.

Substrate grain size is an important variable for habitat suitability, and substrate was assumed to be medium sand at all transects modeled. For the purpose of modeling, the use of sand results in conservative benthic velocity calculations because larger substrates add bed roughness which would result in lower benthic velocities. However, variability of substrate across transects and within the reach would affect the distribution of mussels, particularly if areas of unsuitable substrate (i.e. large cobble/boulder/bedrock) were present. Coarse-scale substrate survey data collected during the 2016 ADCP surveys in the lower part of Reach 5 indicated that most areas were characterized by a sand bottom, sometimes combined with limited amounts of gravel (Transects 88.5988 to 92.9704). One transect contained some cobble embedded in sand near the right bank (Transect 90.653). The high prevalence of sand and gravel would suggest a large amount of suitable substrate for mussels at these transects in general, though mussel beds documented by the previous surveys were restricted to certain areas along transects rather than distributed across the river. The furthest downstream Transect (Transect 88.5988) was conspicuous in that it lacked state-listed mussels, though sandy and presumably suitable substrate was present across the entire channel. Substrate data at transects further upstream were not collected, and it is possible that substrate may become a more limiting factor in the upstream areas of Reach 5.

According to Study Report 3.3.16, *"Existing studies and feedback from Delphi panelists suggest that high-flow shear stress and relative shear stress are the most relevant for mussel habitat, and based on Connecticut River flow data, these high-flows occur well outside of the operating range of the Turners Falls Project."* Though shear stress and relative shear stress are based on some of the same parameters as this suitability analysis (i.e. depth, velocity, and substrate grain size), their usage differs fundamentally from this suitability analysis because their effects pertain to the displacement of mussels and mussel beds during high-flow events rather than persistent habitat suitability under typical flow conditions. Regardless, the effects of shear stress and relative shear stress on mussel distributions would occur under considerably higher flows than the hydraulic capacity at the Turners Falls Project. These effects have likely limited the distribution of mussels to specific areas that have remained relatively undisturbed by high flow events in recent decades.

Though the physical factors of habitat suitability have been described here and have also been documented in a variety of studies, relatively little is known about larger-scale dispersal patterns. Success and dispersal of early life-stage mussels is linked to the availability, abundance, and movement patterns of host fish, which transport mussel glochidia on their gills. For example, even if suitable habitat exists in the upstream areas of Reach 5, host fish may not be transporting glochidia of these species from the areas where they are most abundant to upstream areas at a high enough rate for reliable colonization. Many of the known hosts to Yellow Lampmussel glochidia (i.e. White Perch, Yellow Perch, Chain Pickerel, and Largemouth/Smallmouth Bass) are not far-ranging or migratory species, and would be unlikely to make routine movements upriver in the summer. Dispersal upriver would be limited, and successful colonization would be a slow process. Dispersal to these areas and successful colonization would be further influenced by the amount and distribution of suitable substrate present, along with the probability of host fish accessing these areas. With no state-listed mussels found in Reach 4 during the 2014 surveys for Study 3.3.16, dispersal from nearby upstream areas would be unlikely. Given the most recent survey information, it appears as though the upstream extent of the Yellow Lampmussel, Tidewater Mucket, and Eastern Pondmussel lies within Reach 5. As such, these mussels may be absent from the transects evaluated in the upstream areas of Reach 5 due to factors independent of the operational effects modeled here.

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.

Table 7.1.1.1-1: Percentage of the Maximum Weighted Usable Area (WUA) for Various Flows within Reach 1 (Right Channel-Flow shown is full bypass flow)

Species	Life stage	Months Present	Maximum WUA Total Flow (cfs)	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	562 (cfs)	591 (cfs)	802 (cfs)	1,281 (cfs)	1,583 (cfs)	1,719 (cfs)	2,106 (cfs)	2,551 (cfs)	3,062 (cfs)	4,105 (cfs)
						0.08 (cfsm)	0.08 (cfsm)	0.11 (cfsm)	0.18 (cfsm)	0.22 (cfsm)	0.24 (cfsm)	0.3 (cfsm)	0.38 (cfsm)	0.43 (cfsm)	0.53 (cfsm)
Fallfish	Spawning/Incu	May-June	802	250	86,628	90%	95%	100%	88%	68%	56%	34%	26%	20%	13%
Fallfish	Fry	May-June	591	140	66,936	99%	100%	79%	65%	43%	39%	32%	17%	12%	8%
Fallfish	Juvenile	Year Round	802	250	83,561	83%	89%	100%	83%	77%	68%	46%	35%	32%	24%
Fallfish	Adult	Year Round	1583	662	33,506	49%	52%	72%	96%	100%	98%	88%	76%	66%	39%
Longnose Dace	Juvenile	Year Round	802	250	83,561	83%	89%	100%	83%	77%	68%	46%	35%	32%	24%
Longnose Dace	Adult	Year Round	591	140	74,344	98%	100%	97%	63%	43%	37%	29%	23%	21%	13%
White Sucker	Spawning/Incu	May-June	591	140	41,330	98%	100%	87%	70%	48%	37%	26%	28%	21%	8%
White Sucker	Fry	Apr-May	591	140	66,936	99%	100%	79%	65%	43%	39%	32%	17%	12%	8%
White Sucker	Adult/Juvenile	Year Round	562	0	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Walleye	Spawning/Incu	April-May	3062	1,500	86,372	8%	10%	21%	45%	60%	72%	92%	98%	100%	99%
Walleye	Fry	April-May	562	125	13,105	100%	92%	42%	16%	5%	9%	16%	1%	3%	2%
Walleye	Juvenile	Year Round	591	140	58,234	98%	100%	75%	47%	30%	25%	18%	24%	13%	5%
Walleye	Adult	Year Round	562	0	-	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tessellated Darter	Adult/Juvenile	Year Round	562	125	38,259	100%	98%	54%	28%	16%	12%	17%	17%	5%	5%
Sea Lamprey	Spawning/Incu	May-June	1583	662	18,221	60%	65%	77%	83%	100%	87%	58%	32%	33%	16%
Macroinvertebrates	Larva	Year Round	1719	750	74,190	41%	45%	68%	95%	99%	100%	96%	93%	87%	79%
Shallow Slow	Shallow Slow	Year Round	562	125	45,830	100%	91%	44%	23%	3%	7%	23%	1%	2%	4%
Shallow Fast	Shallow Fast	Year Round	562	125	56,586	100%	97%	69%	32%	23%	20%	22%	16%	8%	5%
Deep Slow	Deep Slow	Year Round	1281	500	14,944	7%	17%	66%	100%	36%	16%	0%	0%	0%	0%
Deep Fast	Deep Fast	Year Round	1719	1,000	98,741	0%	3%	24%	70%	89%	96%	100%	89%	80%	63%

Table 7.1.1.2-1: Percentage of the Maximum Weighted Usable Area (WUA) for Various Flows within Reach 1 (Transects 10 & 11) for Low Backwater Condition

Species	Life stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	120 (cfs)	150 (cfs)	200 (cfs)	250 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	1000 (cfs)	1200 (cfs)	1400 (cfs)	1600 (cfs)	1800 (cfs)	2000 (cfs)	3000 (cfs)	4000 (cfs)	5000 (cfs)
					0.02 (cfsm)	0.02 (cfsm)	0.03 (cfsm)	0.03 (cfsm)	0.06 (cfsm)	0.07 (cfsm)	0.08 (cfsm)	0.1 (cfsm)	0.11 (cfsm)	0.14 (cfsm)	017 (cfsm)	0.2 (cfsm)	0.22 (cfsm)	0.25 (cfsm)	0.28 (cfsm)	0.42 (cfsm)	0.56 (cfsm)	0.70 (cfsm)
American Shad	Spawning/Incu	May-June	7,500	870,142	9.5%	11.0%	13.3%	15.4%	18.9%	21.6%	24.1%	26.5%	28.8%	32.8%	37.9%	43.1%	47.5%	52.9%	58.2%	71.7%	81.6%	88.8%
American Shad	Juvenile	June-Oct	2,000	619,823	27.3%	29.7%	33.6%	36.9%	42.1%	43.8%	45.0%	46.1%	47.6%	52.8%	66.3%	78.8%	86.1%	93.8%	100.0%	96.9%	89.1%	80.4%
American Shad	Adult	May-June	7,500	626,206	10.8%	12.5%	14.8%	17.0%	18.8%	21.1%	23.5%	25.5%	27.5%	31.4%	35.7%	39.7%	42.2%	46.0%	49.7%	65.8%	80.6%	89.3%
Shortnose Sturgeon	Spawning	April-May	6,000	874,855	7.2%	10.1%	13.7%	16.3%	21.4%	23.8%	26.4%	28.6%	30.5%	33.0%	37.2%	43.0%	49.0%	56.7%	65.5%	84.2%	94.4%	98.8%
Shortnose Sturgeon	Egg-Larvae	May	3,000	1,360,780	20.3%	22.2%	25.1%	27.9%	32.4%	33.7%	35.1%	37.4%	41.4%	51.0%	67.4%	80.2%	87.5%	94.3%	99.4%	100.0%	99.9%	99.2%
Shortnose Sturgeon	Fry	May	700	59,453	57.3%	63.0%	71.0%	79.1%	89.9%	94.9%	98.2%	100.0%	100.0%	97.5%	95.4%	94.5%	91.5%	91.3%	91.8%	70.6%	52.7%	38.0%
Fallfish	Spawning/Incu	May-June	120	6,038	100.0%	91.1%	78.0%	66.5%	58.5%	44.5%	31.8%	20.3%	8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fallfish	Fry	May-June	200	28,739	85.9%	96.3%	100.0%	97.6%	86.8%	82.2%	68.5%	53.3%	46.0%	33.6%	28.2%	25.4%	21.9%	18.5%	15.5%	4.8%	1.5%	0.7%
Fallfish	Juvenile	Year Round	2,000	233,847	49.6%	48.0%	50.7%	58.0%	67.2%	72.5%	73.0%	72.8%	75.5%	77.0%	80.6%	89.6%	95.2%	99.3%	100.0%	89.7%	67.8%	47.7%
Fallfish	Adult	Year Round	2,000	437,958	41.4%	44.3%	49.3%	52.4%	49.9%	48.0%	45.9%	44.6%	45.2%	49.3%	63.5%	78.3%	85.2%	94.3%	100.0%	93.2%	77.5%	64.7%
Longnose Dace	Juvenile	Year Round	2,000	196,805	13.0%	14.5%	17.5%	22.5%	44.0%	43.4%	35.0%	31.2%	29.0%	31.0%	49.1%	68.0%	83.9%	95.4%	100.0%	46.2%	17.1%	5.4%
Longnose Dace	Adult	Year Round	2,000	462,096	9.5%	10.1%	12.5%	14.4%	28.5%	29.8%	27.3%	26.7%	25.6%	23.3%	41.7%	62.0%	79.8%	93.0%	100.0%	68.6%	29.4%	8.8%
White Sucker	Spawning/Incu	Apr-May	120	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
White Sucker	Fry	May-June	1,200	639,270	38.2%	38.7%	42.1%	49.0%	39.4%	47.3%	58.4%	70.1%	79.3%	96.8%	100.0%	91.8%	73.5%	52.8%	28.4%	6.5%	1.4%	1.1%
White Sucker	Adult/Juvenile	Year Round	1,600	202,982	87.2%	82.8%	77.1%	73.5%	58.0%	47.4%	40.0%	35.2%	32.9%	43.5%	70.4%	95.9%	100.0%	97.6%	79.0%	38.5%	10.9%	3.4%
Walleye	Spawning/Incu	April-May	3,000	151,950	8.8%	9.9%	11.3%	12.5%	18.9%	23.4%	28.2%	34.5%	40.9%	50.0%	55.8%	57.6%	68.0%	69.1%	69.2%	100.0%	95.4%	86.4%
Walleye	Fry	April-May	120	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walleye	Juvenile	Year Round	150	179	71.4%	100.0%	100.0%	100.0%	71.4%	57.1%	57.1%	42.9%	28.6%	14.3%	5.7%	11.4%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%
Walleye	Adult	Year Round	3,000	6,289	38.2%	47.6%	53.3%	54.1%	47.6%	53.3%	58.2%	62.6%	65.9%	70.0%	74.7%	76.9%	77.7%	78.9%	83.4%	100.0%	39.0%	1.4%
Tessellated Darter	Adult/Juvenile	Year Round	2,000	169,159	8.6%	8.6%	11.5%	14.1%	32.9%	32.5%	21.5%	18.7%	19.4%	26.1%	47.4%	68.0%	85.3%	97.3%	100.0%	39.3%	5.5%	0.0%
Sea Lamprey	Spawning/Incu	May-June	800	8,809	15.0%	17.2%	23.3%	25.9%	68.7%	89.8%	92.6%	95.2%	100.0%	93.4%	59.5%	58.9%	57.5%	64.0%	68.0%	26.2%	12.4%	3.6%
Macroinvertebrates	Larva	Year Round	4,000	961,042	1.9%	3.0%	4.9%	6.6%	13.8%	18.0%	21.7%	24.7%	26.7%	28.7%	31.5%	37.0%	45.1%	55.4%	68.0%	91.8%	100.0%	98.0%
Shallow Slow	Shallow Slow	Year Round	1,200	789,695	22.3%	25.5%	31.7%	46.9%	58.3%	62.2%	68.3%	70.7%	78.5%	92.4%	100.0%	88.6%	78.8%	75.9%	71.6%	20.7%	0.0%	0.0%
Shallow Fast	Shallow Fast	Year Round	1,800	556,171	15.8%	18.5%	21.5%	23.5%	30.8%	30.3%	26.6%	21.7%	22.2%	33.4%	64.6%	85.2%	96.0%	100.0%	96.1%	43.8%	12.0%	3.0%
Deep Slow	Deep Slow	Year Round	1,400	385,669	49.4%	54.3%	60.7%	68.0%	37.5%	31.6%	25.5%	25.1%	37.3%	61.4%	83.7%	100.0%	84.7%	65.2%	54.3%	18.2%	3.5%	1.3%
Deep Fast	Deep Fast	Year Round	3,000	126,639	25.0%	33.7%	47.3%	57.5%	71.1%	63.4%	61.0%	56.0%	49.3%	53.7%	74.7%	87.8%	89.4%	91.4%	93.9%	100.0%	86.0%	69.2%

Table 7.1.1.2-2: Percentage of the Maximum Weighted Usable Area (WUA) for Various Flows within Reach 1 (Transects 10 & 11) for High Backwater Condition

Species	Life stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft²)	120 (cfs)	150 (cfs)	200 (cfs)	250 (cfs)	400 cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	1000 (cfs)	1200 (cfs)	1400 (cfs)	1600 (cfs)	1800 (cfs)	2000 (cfs)	3000 (cfs)	4000 (cfs)	5000 (cfs)
					0.02 (cfsm)	0.02 (cfsm)	0.03 (cfsm)	0.03 (cfsm)	0.06 (cfsm)	0.07 (cfsm)	0.08 (cfsm)	0.1 (cfsm)	0.11 (cfsm)	0.14 (cfsm)	017 (cfsm)	0.2 (cfsm)	0.22 (cfsm)	0.25 (cfsm)	0.28 (cfsm)	.42 (cfsm)	0.56 (cfsm)	0.7 (cfsm)
American Shad	Spawning/Incu	May-June	7,500	898,488	17.6%	18.7%	20.6%	22.5%	27.2%	29.1%	30.6%	32.2%	33.7%	36.6%	40.9%	45.5%	49.8%	54.5%	59.8%	72.4%	81.9%	89.0%
American Shad	Juvenile	June-Oct	2,000	668,444	43.9%	47.7%	53.5%	58.6%	52.9%	55.3%	57.5%	59.2%	61.2%	64.6%	74.4%	83.0%	88.7%	94.4%	100.0%	95.5%	88.1%	80.6%
American Shad	Adult	May-June	7,500	695,459	23.1%	24.0%	25.7%	27.2%	29.1%	30.1%	31.1%	32.2%	33.3%	35.2%	37.7%	40.7%	43.1%	46.3%	50.3%	66.2%	80.2%	90.7%
Shortnose Sturgeon	Spawning	April-May	6,000	893,383	0.5%	1.6%	5.6%	9.7%	23.1%	27.9%	31.0%	32.6%	33.5%	35.0%	39.6%	45.4%	52.3%	60.8%	70.8%	87.7%	96.0%	99.5%
Shortnose Sturgeon	Egg-Larvae	May	3,000	1,360,780	38.9%	43.8%	51.1%	57.5%	42.9%	46.9%	51.0%	55.0%	59.3%	66.6%	77.6%	85.8%	91.5%	95.9%	99.9%	100.0%	100.0%	99.7%
Shortnose Sturgeon	Fry	May	500	64,776	44.5%	54.9%	71.4%	85.1%	99.3%	100.0%	99.9%	99.8%	99.9%	98.3%	94.8%	93.8%	91.8%	91.3%	92.4%	73.1%	56.9%	43.5%
Fallfish	Spawning/Incu	May-June	120	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fallfish	Fry	May-June	150	25,172	96.3%	100.0%	99.7%	98.5%	87.3%	82.4%	75.3%	61.6%	50.7%	39.0%	32.6%	28.2%	24.3%	20.9%	17.8%	6.1%	1.8%	1.0%
Fallfish	Juvenile	Year Round	1,800	260,011	57.8%	63.6%	71.2%	77.0%	73.3%	74.3%	76.2%	77.6%	79.5%	82.8%	89.5%	93.4%	98.0%	100.0%	99.5%	80.4%	61.6%	44.0%
Fallfish	Adult	Year Round	2,000	549,907	67.5%	70.9%	76.2%	80.6%	75.7%	75.7%	71.2%	67.1%	63.5%	59.8%	70.4%	80.6%	86.7%	93.4%	100.0%	89.6%	74.3%	60.5%
Longnose Dace	Juvenile	Year Round	1,800	155,504	13.0%	16.4%	22.0%	27.6%	23.1%	27.7%	31.3%	34.2%	37.4%	44.0%	64.0%	81.7%	95.7%	100.0%	94.9%	39.8%	12.7%	3.6%
Longnose Dace	Adult	Year Round	2,000	413,608	9.3%	11.7%	15.8%	19.8%	16.1%	18.5%	20.4%	22.8%	25.4%	31.5%	51.4%	69.4%	84.2%	94.0%	100.0%	54.4%	17.0%	4.2%
White Sucker	Spawning/Incu	Apr-May	120	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
White Sucker	Fry	May-June	120	1,000,248	100.0%	99.6%	97.6%	95.7%	84.7%	79.3%	75.2%	74.9%	76.4%	79.7%	75.7%	66.4%	51.8%	36.6%	20.8%	4.3%	1.0%	0.8%
White Sucker	Adult/Juvenile	Year Round	250	362,803	75.0%	85.5%	95.4%	100.0%	82.0%	71.1%	60.5%	50.9%	43.7%	45.5%	63.6%	77.0%	78.1%	73.4%	63.4%	29.9%	8.2%	2.6%
Walleye	Spawning	April-May	3,000	139,817	14.5%	14.9%	15.5%	16.2%	19.3%	21.4%	25.8%	29.8%	35.2%	45.0%	51.0%	55.9%	59.7%	64.4%	62.8%	100.0%	96.3%	85.7%
Walleye	Fry	April-May	120	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Walleye	Juvenile	Year Round	120	870	100.0%	82.4%	52.9%	32.4%	26.5%	23.5%	17.6%	14.7%	11.8%	8.8%	4.7%	3.5%	3.5%	2.4%	2.9%	0.0%	0.0%	0.0%
Walleye	Adult	Year Round	120	36,453	100.0%	80.4%	48.8%	24.5%	19.4%	15.8%	13.0%	12.9%	12.9%	13.1%	13.5%	14.1%	14.6%	14.9%	15.6%	20.0%	14.3%	4.4%
Tessellated Darter	Adult/Juvenile	Year Round	1,800	133,736	12.2%	15.4%	20.9%	26.5%	18.0%	22.0%	26.7%	31.9%	36.7%	45.3%	66.1%	84.5%	98.2%	100.0%	96.7%	28.7%	0.9%	0.0%
Sea Lamprey	Spawning/Incu	May-June	1,800	3,870	0.0%	0.0%	0.0%	0.3%	41.4%	56.6%	69.4%	62.8%	59.0%	69.8%	56.4%	74.0%	91.3%	100.0%	94.8%	34.9%	12.3%	2.3%
Macroinvertebrates	Larva	Year Round	4,000	918,412	0.0%	0.1%	0.4%	0.9%	6.0%	10.0%	14.0%	17.7%	21.3%	26.9%	30.4%	36.1%	44.7%	55.2%	67.1%	91.6%	100.0%	97.6%
Shallow Slow	Shallow Slow	Year Round	700	818,354	93.6%	94.1%	95.4%	97.1%	96.6%	97.5%	98.3%	100.0%	100.0%	93.0%	80.8%	78.2%	75.5%	71.7%	68.0%	21.5%	0.0%	0.0%
Shallow Fast	Shallow Fast	Year Round	1,600	535,297	24.8%	30.7%	40.4%	49.7%	26.1%	31.1%	36.2%	41.7%	49.0%	63.3%	83.5%	96.4%	100.0%	97.1%	88.9%	32.3%	9.1%	2.9%
Deep Slow	Deep Slow	Year Round	500	615,160	90.7%	91.4%	93.3%	95.7%	96.1%	100.0%	88.5%	65.6%	59.0%	67.0%	73.3%	78.9%	80.3%	64.2%	54.8%	22.2%	3.6%	1.2%
Deep Fast	Deep Fast	Year Round	3,000	124,411	2.4%	6.7%	15.0%	23.1%	37.8%	53.4%	69.1%	79.4%	82.8%	89.5%	88.3%	89.1%	91.6%	94.4%	99.6%	100.0%	89.8%	52.9%

Table 7.1.2-1: Percentage of the Maximum Weighted Usable Area (WUA) for Various Flows within Reach 2

Species	Life stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft²)	120 (cfs)	150 (cfs)	200 (cfs)	250 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	1000 (cfs)	1200 (cfs)	1400 (cfs)	1600 (cfs)	1800 (cfs)	2000 (cfs)	3000 (cfs)	4000 (cfs)	5000 (cfs)
					0.02 (cfsm)	0.02 (cfsm)	0.03 (cfsm)	0.03 (cfsm)	0.06 (cfsm)	0.07 (cfsm)	0.08 (cfsm)	0.1 (cfsm)	0.11 (cfsm)	0.14 (cfsm)	017 (cfsm)	0.2 (cfsm)	0.22 (cfsm)	0.25 (cfsm)	0.28 (cfsm)	.42 (cfsm)	0.56 (cfsm)	0.7 (cfsm)
American Shad	Spawning/Incu	May-June	10,000	1,487,041	13.0%	14.1%	15.8%	17.4%	21.8%	24.1%	26.3%	28.4%	30.3%	34.0%	38.0%	41.9%	45.3%	48.6%	52.1%	62.8%	70.6%	78.0%
American Shad	Juvenile	June-Oct	3,000	1,094,797	26.0%	29.1%	33.9%	38.6%	49.3%	52.4%	55.3%	57.5%	59.5%	64.9%	73.5%	81.0%	86.4%	91.3%	95.7%	100.0%	97.6%	94.3%
American Shad	Adult	May-June	10,000	1,200,278	19.6%	20.7%	22.4%	24.0%	28.8%	31.3%	33.8%	35.9%	37.8%	41.4%	44.3%	47.0%	49.1%	51.2%	53.7%	60.4%	66.2%	74.6%
Shortnose Sturgeon	Spawning/Incu	April-May	10,000	950,854	2.7%	3.8%	5.4%	6.8%	10.6%	13.0%	15.0%	17.5%	19.9%	24.2%	29.2%	34.5%	39.3%	44.0%	48.9%	62.6%	74.2%	85.1%
Shortnose Sturgeon	Egg-Larvae	May	7,000	2,020,957	22.9%	25.2%	28.8%	32.2%	39.1%	41.6%	43.9%	45.9%	47.8%	54.9%	64.5%	71.7%	77.6%	83.2%	88.6%	95.5%	97.7%	99.2%
Shortnose Sturgeon	Fry	May	6,000	437,325	17.6%	21.5%	27.7%	33.8%	48.7%	52.8%	56.7%	59.2%	61.6%	65.7%	71.0%	76.7%	81.0%	85.0%	88.7%	94.9%	97.8%	99.6%
Fallfish	Spawning/Incu	May-June	3,000	44,809	28.8%	29.7%	31.3%	32.6%	33.8%	34.7%	36.2%	38.7%	41.3%	44.9%	53.7%	63.4%	73.1%	76.9%	81.3%	100.0%	94.4%	80.2%
Fallfish	Fry	May-June	1,600	107,763	61.8%	62.9%	64.7%	68.5%	73.8%	75.3%	76.2%	77.5%	80.3%	89.4%	95.3%	98.7%	92.1%	99.5%	98.0%	80.7%	59.9%	49.0%
Fallfish	Juvenile	Year Round	3,000	566,109	34.8%	38.4%	44.1%	49.4%	59.7%	61.4%	62.9%	64.5%	66.5%	69.3%	76.2%	85.3%	90.6%	95.4%	99.1%	100.0%	88.3%	74.2%
Fallfish	Adult	Year Round	1,800	822,519	45.4%	50.5%	57.4%	63.3%	71.6%	75.0%	77.8%	80.0%	81.8%	84.9%	90.7%	96.7%	92.1%	100.0%	99.0%	91.8%	82.5%	75.6%
Longnose Dace	Juvenile	Year Round	3,000	311,117	32.3%	33.0%	34.0%	35.6%	37.1%	37.5%	37.4%	36.7%	35.8%	38.3%	51.7%	66.0%	77.6%	88.8%	99.7%	100.0%	66.6%	40.6%
Longnose Dace	Adult	Year Round	3,000	615,175	22.3%	23.0%	24.1%	25.6%	29.0%	29.9%	30.3%	30.4%	30.6%	33.2%	46.3%	60.4%	71.9%	82.3%	92.2%	100.0%	89.3%	60.1%
White Sucker	Spawning/Incu	April-May	10,000	13,636	10.1%	8.0%	8.8%	10.1%	11.3%	12.1%	13.1%	15.3%	19.3%	27.4%	35.3%	41.9%	49.8%	56.6%	65.2%	86.4%	51.8%	43.5%
White Sucker	Fry	May-June	1,000	1,036,376	74.6%	75.4%	77.0%	79.5%	84.8%	87.4%	89.7%	91.9%	94.7%	100.0%	97.4%	89.7%	78.2%	65.6%	52.3%	34.9%	24.3%	19.1%
White Sucker	Adult/Juvenile	Year Round	1,400	436,799	42.9%	46.9%	52.4%	57.9%	71.2%	75.4%	80.2%	83.6%	85.8%	89.5%	95.6%	100.0%	98.2%	92.8%	85.0%	67.2%	49.7%	39.2%
Walleye	Spawning/Incu	April-May	8,000	482,932	6.4%	7.3%	9.0%	10.8%	16.8%	20.3%	24.4%	28.4%	31.6%	36.8%	39.0%	41.6%	45.3%	49.0%	52.4%	67.9%	80.5%	88.0%
Walleye	Fry	April-May	1,000	19,515	74.0%	77.0%	80.4%	82.8%	88.6%	91.1%	93.2%	95.5%	97.8%	100.0%	96.7%	92.5%	86.7%	79.6%	72.9%	61.8%	63.5%	61.4%
Walleye	Juvenile	Year Round	1,600	11,769	91.5%	91.4%	91.2%	91.1%	92.6%	93.8%	94.5%	94.0%	93.4%	94.2%	95.9%	98.2%	100.0%	99.5%	95.9%	79.1%	79.6%	77.7%
Walleye	Adult	Year Round	400	108,908	90.1%	91.4%	93.7%	96.0%	100.0%	95.4%	90.8%	83.5%	76.1%	62.8%	55.5%	51.5%	48.5%	46.1%	43.9%	37.5%	35.3%	35.2%
Tessellated Darter	Adult/Juvenile	Year Round	2,000	221,890	23.6%	23.2%	23.2%	23.9%	24.1%	24.3%	24.2%	24.0%	23.5%	26.5%	46.2%	66.6%	79.8%	90.9%	100.0%	93.7%	51.5%	25.5%
Sea Lamprey	Spawning/Incu	May-June	3,000	40,615	30.6%	36.5%	44.3%	49.8%	60.3%	61.9%	63.1%	62.4%	63.0%	63.3%	66.9%	71.4%	77.0%	81.3%	86.5%	100.0%	94.1%	72.0%
Macroinvertebrates	Larva	Year Round	6,000	1,343,516	5.9%	7.1%	9.0%	10.7%	15.1%	16.9%	18.5%	19.6%	20.7%	22.6%	25.9%	30.9%	37.6%	45.7%	55.5%	80.0%	93.5%	98.8%
Habitat Guild	Shallow Slow	Year Round	1,200	750,888	59.6%	59.0%	59.1%	63.4%	66.4%	66.7%	70.8%	75.8%	82.9%	95.8%	100.0%	99.0%	95.8%	90.0%	82.7%	50.4%	24.6%	15.6%
Habitat Guild	Shallow Fast	Year Round	2,000	618,960	28.2%	28.4%	29.4%	30.5%	32.4%	32.1%	32.2%	32.8%	33.4%	42.5%	64.5%	80.2%	89.7%	96.5%	100.0%	78.3%	49.5%	29.6%
Habitat Guild	Deep Slow	Year Round	1,400	822,968	72.4%	73.7%	75.7%	78.1%	83.6%	84.6%	86.8%	89.0%	90.6%	96.7%	98.9%	100.0%	95.2%	88.1%	78.6%	51.5%	40.2%	35.9%
Habitat Guild	Deep Fast	Year Round	7,000	456,895	2.8%	4.7%	8.8%	11.8%	17.2%	20.6%	24.7%	28.9%	32.1%	36.7%	40.6%	43.4%	46.8%	51.6%	57.4%	67.9%	75.8%	82.8%

Table 7.1.3-1: Percentage of the Maximum Weighted Usable Area (WUA) for Various Bypass Flows within Reach 3 with Cabot Station Operating at 2,500 cfs and a Deerfield River Flow of 200 cfs

Species	Life stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	120 (cfs)	200 (cfs)	300 (cfs)	500 (cfs)	700 (cfs)	1000 (cfs)	2000 (cfs)	3000 (cfs)	5000 (cfs)
					0.02 (cfsm)	0.03 (cfsm)	0.04 (cfsm)	0.07 (cfsm)	0.1 (cfsm)	0.14 (cfsm)	0.28 (cfsm)	0.40 (cfsm)	0.70 (cfsm)
American Shad	Spawning/Incu	May-June	5,000	2,021,880	39.2%	41.7%	44.3%	48.5%	52.1%	56.9%	70.9%	82.7%	100.0%
American Shad	Juvenile	June-Oct	5,000	2,282,494	55.4%	60.8%	64.9%	69.5%	72.6%	77.4%	90.5%	97.2%	100.0%
American Shad	Adult	May-June	5,000	2,407,427	50.5%	52.3%	54.2%	57.4%	60.0%	63.8%	74.9%	84.8%	100.0%
Shortnose Sturgeon	Spawning/Incu	April-May	5,000	1,603,323	27.3%	30.6%	34.9%	41.5%	46.8%	52.8%	68.6%	82.0%	100.0%
Shortnose Sturgeon	Egg-Larvae	May	5,000	2,551,227	52.3%	56.4%	59.7%	63.8%	67.5%	73.2%	87.3%	95.0%	100.0%
Shortnose Sturgeon	Fry	May	5,000	1,444,450	48.0%	52.9%	57.9%	63.9%	67.7%	73.0%	84.8%	93.3%	100.0%
Shortnose Sturgeon	Juvenile	June	5,000	1,828,689	48.9%	53.4%	57.2%	61.9%	64.5%	68.3%	79.0%	87.4%	100.0%
Shortnose Sturgeon	Adult	Year Round	5,000	1,919,802	49.5%	54.1%	58.1%	62.9%	65.6%	69.5%	80.7%	89.4%	100.0%
Fallfish	Spawning/Incu	May-June	3,000	576,657	53.1%	58.1%	61.3%	65.1%	68.9%	73.8%	93.1%	100.0%	91.9%
Fallfish	Fry	May-June	3,000	825,053	66.4%	69.9%	71.4%	74.6%	79.3%	85.2%	98.7%	100.0%	77.5%
Fallfish	Juvenile	Year Round	3,000	1,182,748	59.7%	65.8%	69.9%	72.9%	74.6%	78.6%	95.2%	100.0%	91.9%
Fallfish	Adult	Year Round	3,000	1,780,779	75.5%	81.5%	85.2%	87.9%	88.7%	90.3%	96.5%	100.0%	98.1%
Longnose Dace	Juvenile	Year Round	2,000	307,052	76.7%	84.7%	85.1%	80.1%	77.5%	80.9%	100.0%	94.8%	69.3%
Longnose Dace	Adult	Year Round	3,000	547,316	65.2%	74.8%	80.0%	82.6%	82.3%	82.8%	97.4%	100.0%	76.8%
White Sucker	Spawning/Incu	April-May	3,000	162,255	71.8%	79.9%	83.2%	83.3%	84.2%	86.9%	99.0%	100.0%	82.9%
White Sucker	Fry	May-June	120	2,032,500	100.0%	97.4%	94.5%	90.6%	89.8%	89.2%	86.4%	78.2%	61.2%
White Sucker	Adult/Juvenile	Year Round	3,000	839,203	69.6%	76.6%	79.1%	77.3%	74.9%	76.5%	93.6%	100.0%	87.6%
Walleye	Spawning/Incu	April-May	5,000	1,106,733	26.9%	28.1%	30.2%	35.3%	41.3%	49.6%	69.9%	83.5%	100.0%
Walleye	Fry	April-May	120	161,031	100.0%	90.7%	85.8%	79.0%	79.2%	70.7%	74.5%	86.9%	80.4%
Walleye	Juvenile	Year Round	120	121,311	100.0%	94.6%	88.0%	80.7%	79.8%	75.1%	79.2%	85.2%	97.9%
Walleye	Adult	Year Round	120	495,345	100.0%	95.6%	88.2%	78.8%	72.6%	65.9%	64.1%	62.5%	63.1%
Tessellated Darter	Adult/Juvenile	Year Round	2,000	203,019	78.6%	81.8%	77.0%	74.7%	75.7%	84.1%	100.0%	88.3%	58.3%
Sea Lamprey	Spawning/Incu	May-June	3,000	134,296	58.1%	69.9%	82.3%	93.5%	96.1%	94.3%	94.3%	100.0%	98.8%
Macroinvertebrates	Larva	Year Round	5,000	1,244,512	28.1%	32.9%	38.7%	47.3%	53.5%	59.9%	75.6%	86.3%	100.0%
Habitat Guild	Shallow Slow	Year Round	120	961,128	100.0%	96.3%	91.7%	90.5%	92.8%	96.9%	89.4%	77.4%	47.9%
Habitat Guild	Shallow Fast	Year Round	2,000	483,875	84.2%	87.4%	83.6%	78.6%	79.3%	86.9%	100.0%	94.5%	66.0%
Habitat Guild	Deep Slow	Year Round	200	1,699,409	98.7%	100.0%	99.9%	98.1%	95.4%	92.5%	94.0%	96.0%	85.2%
Habitat Guild	Deep Fast	Year Round	5,000	909,225	21.7%	24.5%	28.4%	35.8%	42.1%	49.8%	68.1%	82.4%	100.0%

Table 7.1.3-2: Percentage of the Maximum Weighted Usable Area (WUA) for Various Bypass Flows within Reach 3 with Cabot Station Operating at 7,000 cfs and a Deerfield River Flow of 200 cfs

Species	Life stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	120 (cfs)	200 (cfs)	300 (cfs)	500 (cfs)	700 (cfs)	1000 (cfs)	2000 (cfs)	3000 (cfs)	5000 (cfs)
					0.02 (cfsm)	0.03 (cfsm)	0.04 (cfsm)	0.07 (cfsm)	0.1 (cfsm)	0.14 (cfsm)	0.28 (cfsm)	0.40 (cfsm)	0.70 (cfsm)
American Shad	Spawning/Incu	May-June	5,000	2,353,994	49.7%	52.4%	54.5%	58.7%	62.2%	65.9%	77.5%	86.7%	100.0%
American Shad	Juvenile	June-Oct	3,000	2,560,400	69.9%	80.0%	84.3%	89.1%	92.6%	95.2%	99.4%	100.0%	94.9%
American Shad	Adult	May-June	5,000	3,056,423	58.4%	60.3%	61.8%	64.7%	67.2%	70.1%	79.7%	88.4%	100.0%
Shortnose Sturgeon	Spawning/Incu	April-May	5,000	1,834,483	29.2%	31.5%	34.9%	43.3%	50.6%	57.1%	75.3%	86.9%	100.0%
Shortnose Sturgeon	Egg-Larvae	May	5,000	2,655,661	66.9%	73.9%	77.2%	81.2%	83.8%	86.9%	93.6%	97.0%	100.0%
Shortnose Sturgeon	Fry	May	3,000	1,580,583	62.6%	69.5%	73.8%	81.6%	87.1%	91.1%	98.0%	100.0%	95.6%
Shortnose Sturgeon	Juvenile	June	3,000	2,148,223	62.2%	70.4%	74.2%	79.3%	83.2%	86.8%	95.4%	100.0%	99.2%
Shortnose Sturgeon	Adult	Year Round	3,000	2,217,608	64.4%	72.8%	76.7%	81.8%	85.7%	89.1%	96.5%	100.0%	97.9%
Fallfish	Spawning/Incu	May-June	700	624,182	87.4%	93.3%	95.5%	98.1%	100.0%	99.7%	91.2%	73.8%	44.6%
Fallfish	Fry	May-June	300	854,381	96.6%	100.0%	100.0%	98.2%	96.5%	92.7%	75.5%	58.5%	37.8%
Fallfish	Juvenile	Year Round	1,000	1,386,325	80.3%	89.5%	93.0%	97.1%	99.4%	100.0%	93.7%	80.4%	57.9%
Fallfish	Adult	Year Round	1,000	2,274,836	82.1%	90.3%	94.3%	97.8%	99.4%	100.0%	96.5%	91.6%	78.8%
Longnose Dace	Juvenile	Year Round	500	259,262	89.0%	98.3%	99.1%	100.0%	96.5%	93.4%	74.3%	53.3%	31.1%
Longnose Dace	Adult	Year Round	700	478,847	76.9%	87.3%	91.9%	98.2%	100.0%	99.0%	82.3%	60.2%	36.1%
White Sucker	Spawning/Incu	April-May	500	135,048	84.9%	94.2%	97.0%	100.0%	97.4%	93.2%	68.7%	44.6%	23.1%
White Sucker	Fry	May-June	120	2,672,529	100.0%	98.0%	96.6%	89.6%	89.6%	76.6%	61.0%	51.7%	41.3%
White Sucker	Adult/Juvenile	Year Round	500	1,301,145	78.1%	92.9%	99.0%	100.0%	96.9%	91.3%	76.8%	66.5%	49.6%
Walleye	Spawning/Incu	April-May	5,000	1,080,048	41.5%	42.5%	43.4%	45.8%	48.5%	53.2%	71.1%	86.2%	100.0%
Walleye	Fry	April-May	120	259,689	100.0%	88.4%	80.5%	75.4%	69.9%	68.2%	55.5%	55.3%	64.0%
Walleye	Juvenile	Year Round	120	191,660	100.0%	95.4%	92.5%	87.1%	83.5%	81.9%	77.7%	75.1%	77.5%
Walleye	Adult	Year Round	120	643,593	100.0%	96.8%	92.9%	81.4%	73.6%	69.0%	63.6%	63.3%	64.0%
Tessellated Darter	Adult/Juvenile	Year Round	200	158,733	93.7%	100.0%	96.2%	94.6%	89.4%	86.0%	66.6%	46.5%	28.1%
Sea Lamprey	Spawning/Incu	May-June	1,000	119,562	58.3%	67.5%	75.2%	86.6%	94.4%	100.0%	94.2%	71.2%	38.3%
Macroinvertebrates	Larva	Year Round	5,000	991,787	33.0%	35.9%	38.5%	45.5%	53.6%	62.9%	85.5%	96.1%	100.0%
Habitat Guild	Shallow Slow	Year Round	120	509,288	100.0%	97.1%	93.3%	87.7%	80.6%	74.4%	54.9%	39.9%	26.9%
Habitat Guild	Shallow Fast	Year Round	300	1,072,859	89.6%	99.2%	100.0%	98.4%	95.3%	90.8%	67.7%	51.0%	31.8%
Habitat Guild	Deep Slow	Year Round	3,000	2,425,549	23.0%	26.5%	30.3%	40.1%	50.5%	58.9%	83.6%	100.0%	95.6%
Habitat Guild	Deep Fast	Year Round	500	2,353,994	97.0%	97.9%	99.3%	100.0%	98.0%	93.7%	80.6%	70.7%	55.0%

Table 7.1.3-3: Percentage of the Maximum Weighted Usable Area (WUA) for Various Bypass Flows within Reach 3 with Cabot Station Operating at 14,000 cfs and a Deerfield River Flow of 200 cfs

Species	Life stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	120 (cfs)	200 (cfs)	300 (cfs)	500 (cfs)	700 (cfs)	1000 (cfs)	2000 (cfs)	3000 (cfs)	5000 (cfs)
					0.02 (cfsm)	0.03 (cfsm)	0.04 (cfsm)	0.07 (cfsm)	0.1 (cfsm)	0.14 (cfsm)	0.28 (cfsm)	0.40 (cfsm)	0.70 (cfsm)
American Shad	Spawning/Incu	May-June	5,000	2,598,248	67.7%	68.3%	69.6%	70.8%	72.3%	75.7%	85.3%	91.2%	100.0%
American Shad	Juvenile	June-Oct	2,000	2,717,826	78.4%	83.3%	87.5%	89.0%	87.5%	94.7%	100.0%	99.9%	94.3%
American Shad	Adult	May-June	5,000	3,635,316	78.7%	79.2%	79.9%	80.7%	81.6%	84.2%	90.5%	94.6%	100.0%
Shortnose Sturgeon	Spawning	April-May	5,000	1,928,735	48.2%	48.0%	48.7%	51.1%	54.1%	59.3%	79.5%	90.3%	100.0%
Shortnose Sturgeon	Egg-Larvae	May	5,000	2,667,667	73.6%	78.2%	83.5%	85.0%	83.6%	91.0%	95.6%	97.6%	100.0%
Shortnose Sturgeon	Fry	May	3,000	1,623,320	73.3%	75.6%	76.8%	79.0%	79.9%	85.2%	97.3%	100.0%	98.1%
Shortnose Sturgeon	Juvenile	June	3,000	2,387,667	78.5%	83.0%	86.9%	88.4%	87.2%	93.3%	99.2%	100.0%	95.9%
Shortnose Sturgeon	Adult	Year Round	3,000	2,411,756	78.7%	83.3%	87.3%	88.9%	87.6%	93.7%	99.4%	100.0%	95.7%
Fallfish	Spawning/Incu	May-June	1,000	252,755	79.1%	91.7%	96.9%	99.8%	99.5%	100.0%	97.2%	80.5%	53.0%
Fallfish	Fry	May-June	500	355,081	81.8%	93.1%	98.1%	100.0%	97.7%	96.2%	82.6%	69.6%	53.3%
Fallfish	Juvenile	Year Round	1,000	835,584	82.8%	90.8%	95.9%	97.1%	95.3%	100.0%	98.3%	87.9%	68.0%
Fallfish	Adult	Year Round	1,000	2,510,275	83.4%	91.3%	97.7%	97.7%	93.9%	100.0%	98.3%	92.1%	76.3%
Longnose Dace	Juvenile	Year Round	2,000	75,967	58.1%	64.8%	71.2%	77.6%	81.4%	88.4%	100.0%	91.9%	74.0%
Longnose Dace	Adult	Year Round	2,000	136,099	59.7%	68.8%	76.3%	82.4%	85.5%	89.9%	100.0%	96.7%	76.7%
White Sucker	Spawning/Incu	April-May	5,000	25,775	36.3%	44.3%	55.9%	66.4%	74.4%	80.3%	92.6%	99.0%	100.0%
White Sucker	Fry	May-June	300	2,435,547	99.5%	99.6%	100.0%	98.2%	95.3%	90.3%	70.7%	57.1%	44.9%
White Sucker	Adult/Juvenile	Year Round	1,000	1,138,261	82.4%	91.9%	98.7%	99.8%	94.2%	100.0%	89.2%	71.6%	50.9%
Walleye	Spawning	April-May	5,000	610,523	84.7%	85.3%	85.4%	85.8%	86.7%	87.4%	91.0%	94.2%	100.0%
Walleye	Fry	April-May	120	240,438	100.0%	96.7%	91.6%	86.8%	84.8%	84.9%	73.9%	65.6%	66.6%
Walleye	Juvenile	Year Round	700	239,227	98.8%	97.7%	99.9%	99.1%	100.0%	97.1%	85.6%	78.0%	73.4%
Walleye	Adult	Year Round	300	938,220	94.0%	95.6%	100.0%	98.5%	96.2%	89.9%	67.3%	61.7%	55.6%
Tessellated Darter	Adult/Juvenile	Year Round	2,000	47,029	53.4%	60.4%	68.2%	78.1%	82.5%	91.5%	100.0%	87.7%	81.4%
Sea Lamprey	Spawning/Incu	May-June	3,000	22,772	38.6%	45.1%	50.2%	54.0%	58.4%	61.1%	77.8%	100.0%	99.7%
Macroinvertebrates	Larva	Year Round	5,000	890,587	58.4%	59.1%	60.0%	62.1%	65.2%	69.6%	84.3%	94.9%	100.0%
Habitat Guild	Shallow Slow	Year Round	120	386,037	100.0%	99.1%	97.4%	94.6%	90.7%	88.9%	70.5%	58.3%	46.5%
Habitat Guild	Shallow Fast	Year Round	1,000	192,388	73.6%	83.0%	91.2%	94.2%	94.5%	100.0%	95.5%	79.5%	57.8%
Habitat Guild	Deep Slow	Year Round	200	2,509,621	99.2%	100.0%	99.9%	99.7%	98.7%	97.7%	87.9%	76.4%	54.6%
Habitat Guild	Deep Fast	Year Round	3,000	612,567	70.5%	70.6%	70.1%	73.4%	76.8%	83.4%	98.3%	100.0%	78.2%

Table 7.1.4-1: Percentage of the Maximum Weighted Usable Area (WUA) for Various Flows within Reach 4

Species	Life stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	1200 (cfs)	1600 (cfs)	2000 (cfs)	2800 (cfs)	4000 (cfs)	5000 (cfs)	6000 (cfs)	8000 (cfs)	10000 (cfs)	12000 (cfs)	14000 (cfs)	15000 (cfs)	17500 (cfs)	20000 (cfs)	25000 (cfs)	30000 (cfs)	37500 (cfs)
					0.15 (cfsm)	0.2 (cfsm)	0.25 (cfsm)	0.36 (cfsm)	0.51 (cfsm)	0.64 (cfsm)	0.76 (cfsm)	1.02 (cfsm)	1.27 (cfsm)	1.53 (cfsm)	1.78 (cfsm)	1.91 (cfsm)	2.23 (cfsm)	2.54 (cfsm)	2.86 (cfsm)	3.82 (cfsm)	4.77 (cfsm)
American Shad	Spawning/Incu	May-June	12,000	14,182,397	46.8%	53.6%	59.3%	68.0%	77.4%	83.4%	88.2%	94.8%	98.5%	100.0%	99.6%	98.9%	96.0%	92.0%	82.3%	72.5%	59.4%
American Shad	Juvenile	June-Oct	4,000	20,970,703	87.3%	92.5%	95.8%	99.3%	100.0%	98.4%	95.7%	89.4%	83.2%	77.9%	72.1%	69.3%	62.9%	57.2%	47.4%	39.5%	32.2%
American Shad	Adult	May-June	12,000	26,411,552	52.7%	59.2%	64.9%	72.8%	80.6%	85.6%	89.7%	95.9%	99.1%	100.0%	99.3%	98.6%	96.0%	93.0%	86.6%	79.9%	70.8%
Shortnose Sturgeon	Fry	May	5,000	16,338,131	69.9%	79.8%	86.6%	95.3%	99.7%	100.0%	98.8%	95.1%	90.0%	84.7%	79.3%	76.7%	70.4%	64.7%	55.1%	47.8%	39.8%
Shortnose Sturgeon	Juveniles	June	5,000	20,325,318	78.8%	84.3%	88.9%	94.8%	98.8%	100.0%	99.8%	97.0%	92.2%	86.9%	81.8%	79.5%	73.8%	68.7%	59.8%	52.9%	45.3%
Shortnose Sturgeon	Adults	Year Round	5,000	20,657,503	79.8%	85.6%	90.1%	95.6%	99.3%	100.0%	99.3%	95.9%	90.9%	85.8%	80.8%	78.5%	72.8%	67.6%	58.9%	52.1%	44.6%
Fallfish	Spawning/Incu	May-June	800	5,014,615	88.5%	78.9%	73.1%	66.1%	55.6%	44.6%	34.3%	17.7%	10.8%	7.9%	6.6%	6.1%	4.4%	2.4%	0.2%	0.0%	2.2%
Fallfish	Fry	May-June	800	7,657,464	91.2%	82.0%	73.7%	61.9%	44.9%	35.4%	27.7%	18.3%	13.5%	11.7%	9.4%	8.0%	4.7%	2.9%	2.3%	2.6%	5.9%
Fallfish	Juvenile	Year Round	800	8,226,027	98.3%	95.0%	91.5%	88.5%	82.0%	73.0%	62.6%	43.3%	32.2%	27.2%	23.0%	21.4%	16.9%	13.1%	8.7%	7.1%	7.3%
Fallfish	Adult	Year Round	2,000	18,844,747	96.9%	99.3%	100.0%	98.2%	93.1%	87.7%	82.1%	71.3%	62.7%	57.4%	53.2%	51.5%	47.3%	43.3%	37.4%	33.5%	30.5%
Longnose Dace	Juvenile	Year Round	2,400	1,226,425	89.2%	98.7%	99.7%	96.4%	65.1%	38.4%	21.9%	9.4%	10.9%	11.8%	7.0%	4.7%	2.2%	1.2%	0.7%	1.3%	8.9%
Longnose Dace	Adult	Year Round	2,400	2,146,515	86.0%	92.9%	98.8%	96.0%	73.2%	49.3%	27.5%	9.2%	8.4%	10.3%	10.3%	8.3%	2.2%	1.3%	1.8%	2.2%	5.9%
White Sucker	Spawning/Incu	Apr-May	1,600	654,203	96.6%	100.0%	92.5%	91.4%	52.4%	23.9%	11.3%	8.9%	12.7%	12.1%	9.2%	6.7%	4.1%	3.3%	4.0%	5.8%	24.1%
White Sucker	Fry	May-June	800	17,311,497	93.3%	84.4%	76.9%	63.6%	49.6%	42.5%	38.2%	33.4%	31.1%	28.7%	26.4%	25.1%	22.7%	21.1%	19.0%	17.8%	17.8%
White Sucker	Adult/Juvenile	Year Round	1,000	11,466,039	98.6%	91.5%	83.1%	68.4%	52.9%	44.6%	38.2%	29.1%	24.3%	23.5%	22.2%	21.0%	17.6%	14.7%	10.8%	8.4%	7.0%
Walleye	Spawning	April-May	5,000	2,557,617	58.7%	68.1%	76.9%	89.4%	99.2%	100.0%	95.3%	84.4%	68.9%	49.4%	30.9%	24.1%	11.3%	7.1%	4.7%	2.4%	0.9%
Walleye	Fry	April-May	8,000	955,697	77.2%	85.4%	94.0%	93.6%	84.9%	77.5%	83.1%	100.0%	90.9%	67.5%	45.8%	39.9%	25.6%	11.6%	0.0%	0.0%	0.0%
Walleye	Juvenile	Year Round	800	1,789,966	88.8%	80.1%	74.1%	68.9%	64.7%	61.2%	58.0%	55.9%	59.0%	58.4%	55.2%	53.5%	47.4%	41.5%	30.8%	25.0%	21.4%
Walleye	Adult	Year Round	800	7,030,738	89.7%	80.0%	72.8%	61.3%	54.9%	53.9%	53.6%	52.8%	51.9%	53.3%	55.3%	54.7%	52.5%	50.0%	44.8%	41.0%	37.3%
Tessellated Darter	Adult/Juvenile	Year Round	1,600	1,097,027	92.5%	100.0%	86.3%	82.9%	51.8%	27.3%	15.2%	8.5%	13.8%	15.2%	8.8%	5.4%	4.3%	3.7%	3.7%	6.1%	25.8%
Sea Lamprey	Spawning/Incu	May-June	2,800	209,778	67.1%	83.7%	94.3%	100.0%	78.8%	44.0%	20.1%	3.4%	6.0%	8.3%	7.0%	6.9%	1.2%	0.5%	0.2%	0.3%	6.7%
Macroinvertebrates	Larva	Year Round	5,000	3,812,597	41.0%	54.5%	67.8%	87.3%	98.4%	100.0%	97.2%	87.2%	76.9%	67.9%	61.4%	59.1%	54.7%	51.7%	46.4%	42.6%	40.2%
Shallow Slow	Shallow Slow	Year Round	800	2,811,288	88.2%	89.5%	92.9%	84.6%	64.2%	60.6%	51.6%	34.2%	15.8%	12.3%	9.4%	7.8%	1.7%	1.3%	1.6%	0.2%	4.7%
Shallow Fast	Shallow Fast	Year Round	800	2,627,730	93.4%	94.6%	97.1%	89.2%	60.5%	41.8%	29.0%	16.3%	14.0%	12.7%	10.7%	6.8%	3.7%	2.4%	0.7%	0.5%	5.0%
Deep Slow	Deep Slow	Year Round	1,000	19,235,977	99.1%	96.4%	93.6%	87.4%	76.7%	66.8%	55.9%	43.6%	38.0%	36.0%	34.1%	33.1%	30.0%	27.4%	23.9%	21.7%	20.6%
Deep Fast	Deep Fast	Year Round	1,600	4,451,275	86.0%	100.0%	98.4%	90.7%	79.1%	72.0%	68.1%	62.3%	38.5%	19.4%	8.7%	6.2%	9.4%	8.4%	1.7%	0.5%	0.3%

8 LITERATURE CITED

Beamish, F.W.H. (1978). Swimming capacity. *In*: Fish Physiology. Vol. VII. Locomotion. Academic Press, London. pp. 101-187.

Bell, M.C. (1991). Swimming speeds of adult and juvenile fish. *In*: Fisheries Handbook of Engineering Requirements and Biological Criteria. Fish Passage Development and Evaluation Program, U.S. Army Corps of Engineers.

Bovee, K.D. (1982). A guide to stream habitat analysis using the instream flow incremental methodology. (Office of Biol. Service FWS/OBS-82-26). Washington, DC.: USFWS, U.S. Dept. of Interior.

Bovee, K.D. (1982). A guide to stream habitat analysis using the instream flow incremental Bovee, K.D., Lamb, B.L., Bartholow, J.M., Stalnaker, C.B., Taylor, J. & Henriksen, J. (1998). Stream habitat analysis using the instream flow incremental methodology. (Biological Resources Division Information and Technology Report USGS/BRD-1998-0004/ viii). U.S. Geological Survey.

Bovee, K.D., B.L.Lamb, J.M. Bartholow, C.B. Stalnaker, J. Taylor, and J. Henriksen. 1998. Stream habitat analysis using the Instream Flow Incremental Methodology. U.S. Geological Survey, USGS/BRD/ITR--1998-0004. VIII + 131 pp.

Bovee, K.D., Waddle, T.J., Bartholow, J., and Burris, L. (2007). A decision support framework for water management in the upper Delaware River: U.S. Geological Survey Open-File Report 2007-1172, 122 p.

Dodson, J.J., & Leggett, W.C. (1973). The behavior of American shad (*Alosa sapidissima*) homing to the Connecticut River from Long Island Sound. J. Fish Res. Bd. Can. 30:1847-1860.

Gomez and Sullivan Engineers and Normandeau Associates. (2012). Instream flow habitat assessment below Conowingo Dam (RSP 3.16). Kennett Square, PA: Exelon Generation, LLC.

García, 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

Maloney, K.O., Lellis, W.A., Bennett, R.M., Waddle, T.J. (2012). Habitat persistence for sedentary organisms in managed rivers: the case for the federally endangered dwarf wedgemussel (*Alasmidona heterodon*) in the Delaware River. Freshwater Biology (57) pp 1315-1327.

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

Mazerolle, M.J. (2006). Improving data analysis in herpetology: using Akaike's Information Criterion (AIC) to assess the strength of biological hypotheses. Amphibia-Reptilia 27(2006): 169-180.

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.

Steffler, P. & Blackburn, J. (2002). River2D: Two-dimensional depth-averaged model of river hydrodynamics and fish habitats. University of Alberta, Edmonton, Canada.

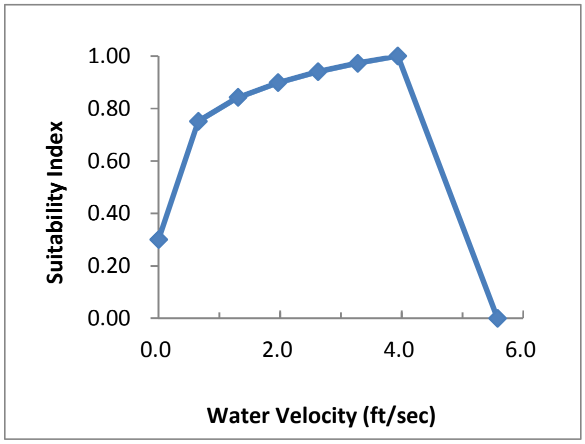
U.S. Department of the Interior (USDI) and U.S. Geological Survey (USGS). (2001). November 2001, PHABSIM for Windows User's Manual and Exercises, Midcontinent Ecological Science Center, Open File Report 01-340.

APPENDIX A– HABITAT SUITABILITY CRITERIA

Species: American Shad
Lifestage: Spawning

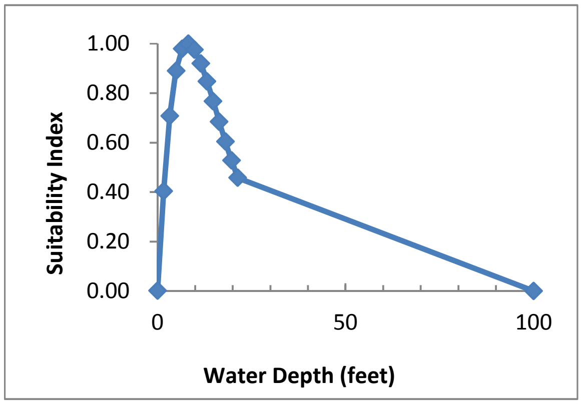
Velocity

Velocity	SI Value
0.0	0.30
0.7	0.75
1.3	0.84
2.0	0.90
2.6	0.94
3.3	0.97
3.9	1.00
5.6	0.00



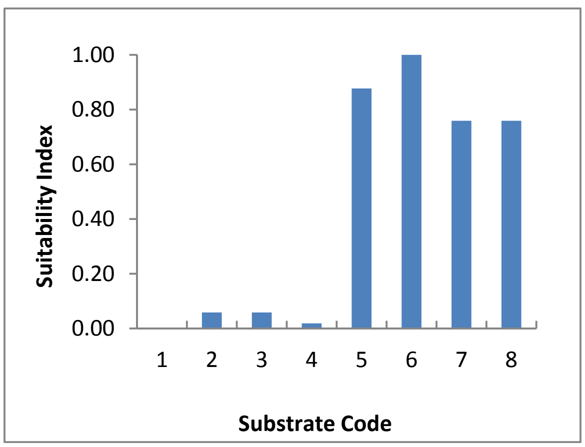
Depth

Depth (ft)	SI Value
0.0	0.00
1.6	0.40
3.3	0.71
4.9	0.89
6.6	0.98
8.2	1.00
9.8	0.97
11.5	0.92
13.1	0.85
14.8	0.77
16.4	0.68
18.0	0.60
19.7	0.53
21.3	0.46
100.0	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.06	Mud/soft clay
3	0.06	Silt
4	0.02	Sand
5	0.88	Gravel
6	1.00	Cobble/rubble
7	0.76	Boulder
8	0.76	Bedrock



Source: Hightower et al, 2012

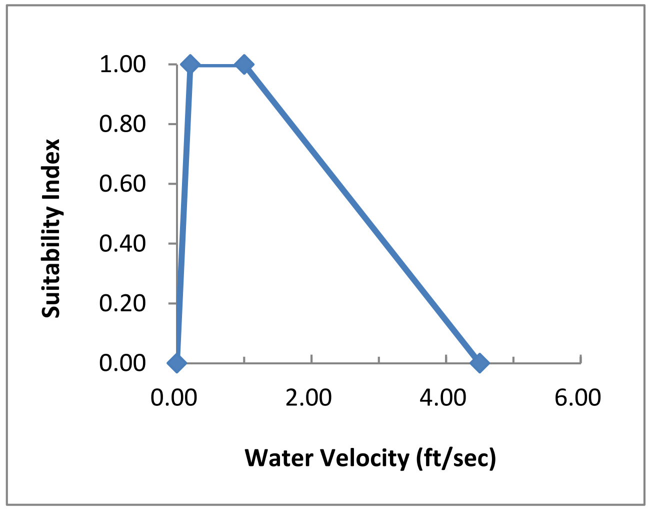
Joseph E. Hightower, Julianne E. Harris, Joshua K. Raabe, Prescott Brownell, and C. Ashton Drew (2012) A Bayesian Spawning Habitat Suitability Model for American Shad in Southeastern United States Rivers. Journal of Fish and Wildlife Management: December 2012, Vol. 3, No. 2, pp. 184-198.

Endpoint for velocity and depth determined by B Kulik in consultation with J Hightower.

Species: American Shad
Lifestage: Juvenile

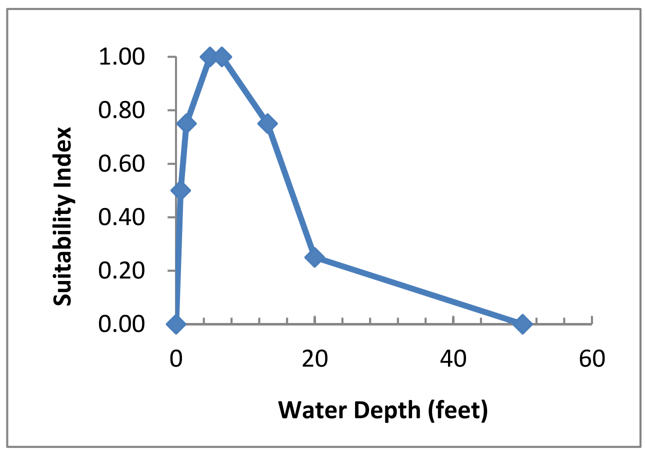
Velocity

Velocity	SI Value
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



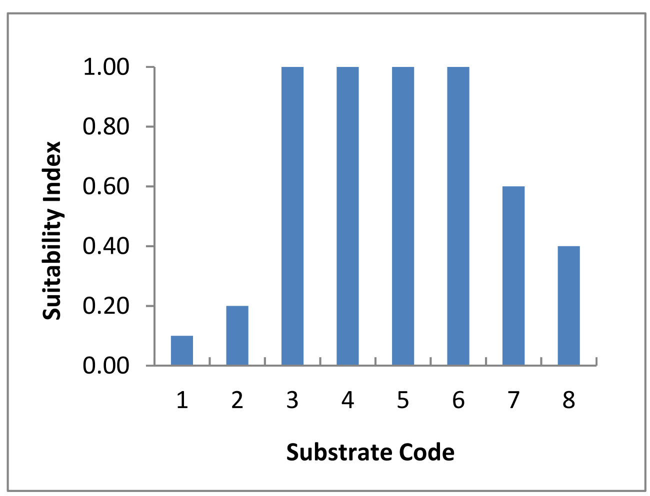
Depth

Depth	SI Value
0.00	0.00
0.66	0.50
1.50	0.75
4.90	1.00
6.60	1.00
13.20	0.75
20.00	0.25
50.00	0.00



Substrate

Substrate	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

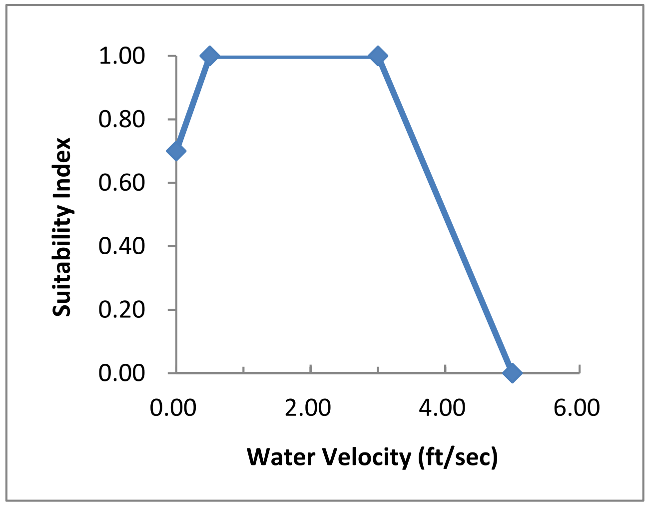


Source: Conowingo IFIM
Stier and Crance, 1985
Depth from Ross et al, 1993

Species: American Shad
Lifestage: Adult

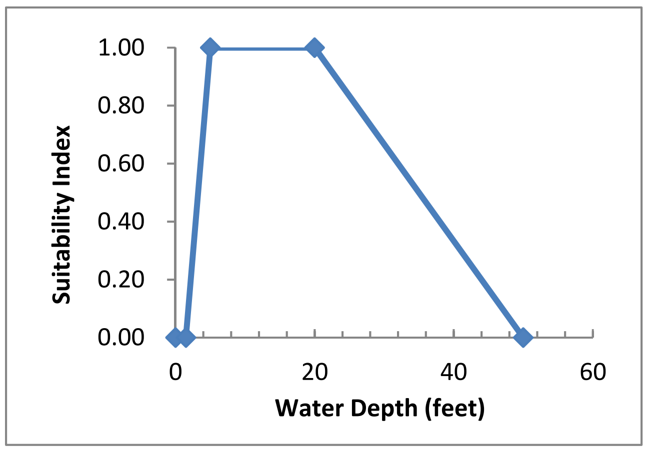
Velocity

Velocity	SI Value
0.00	0.70
0.50	1.00
3.00	1.00
5.00	0.00



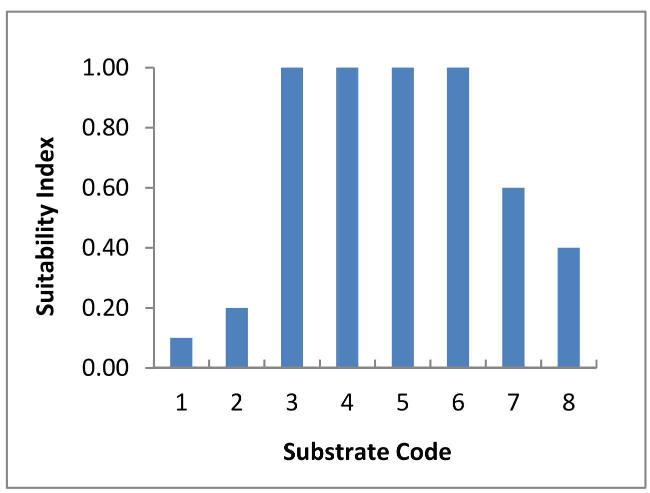
Depth

Depth	SI Value
0.00	0.00
1.50	0.00
5.00	1.00
20.00	1.00
50.00	0.00



Substrate

Substrate	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

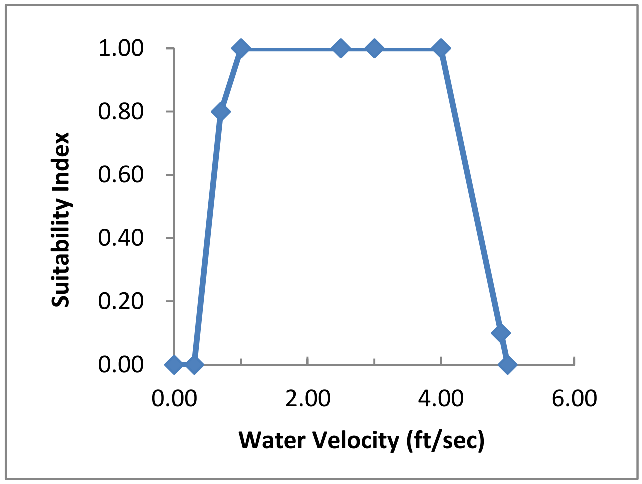


Source: Conowingo IFIM
Stier and Crance, 1985

Species: Shortnose Sturgeon
Lifestage: Spawning

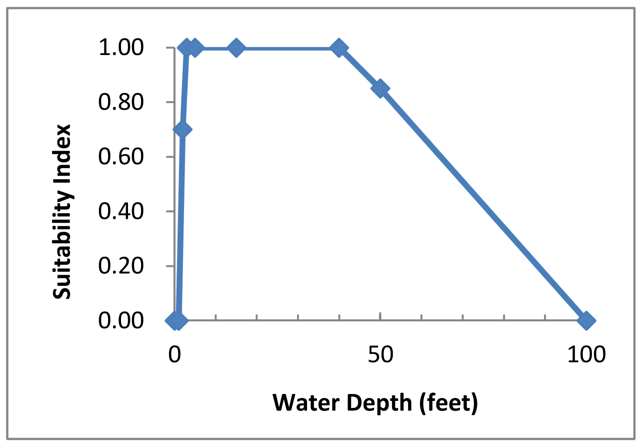
Velocity

Velocity	SI Value
0.00	0.00
0.30	0.00
0.70	0.80
1.00	1.00
2.50	1.00
3.00	1.00
4.00	1.00
4.90	0.10
5.00	0.00



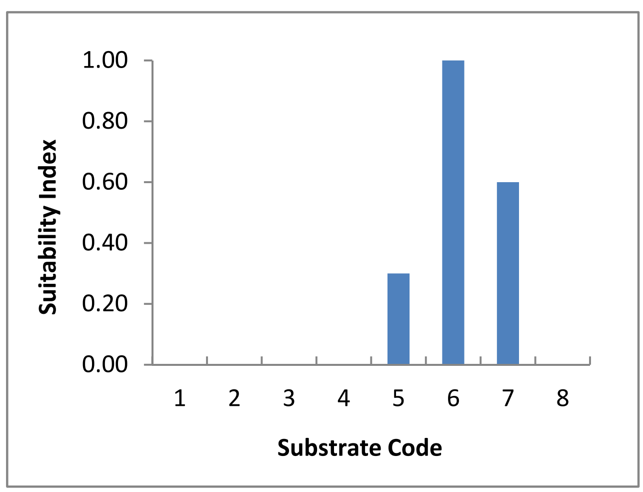
Depth

Depth	SI Value
0.00	0.00
1.00	0.00
2.00	0.70
3.00	1.00
5.00	1.00
15.00	1.00
40.00	1.00
50.00	0.85
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	0.30	Gravel
6	1.00	Cobble/rubble
7	0.60	Boulder
8	0.00	Bedrock

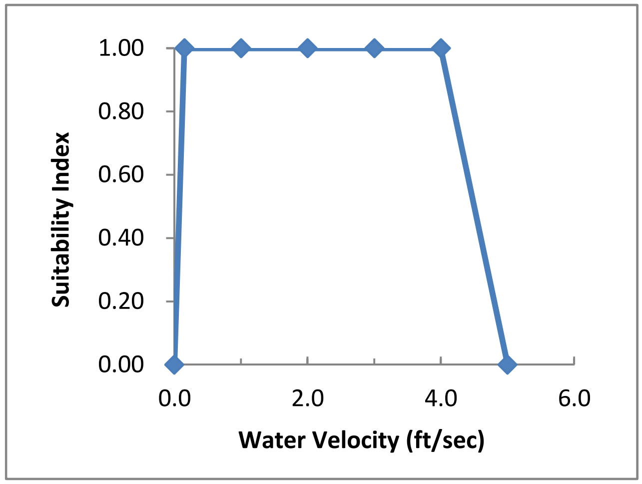


Source: Adapted from Conowingo IFIM by NOAA.

Species: Shortnose Sturgeon
Lifestage: Egg/ Embryo/larvae (non-mobile stage)

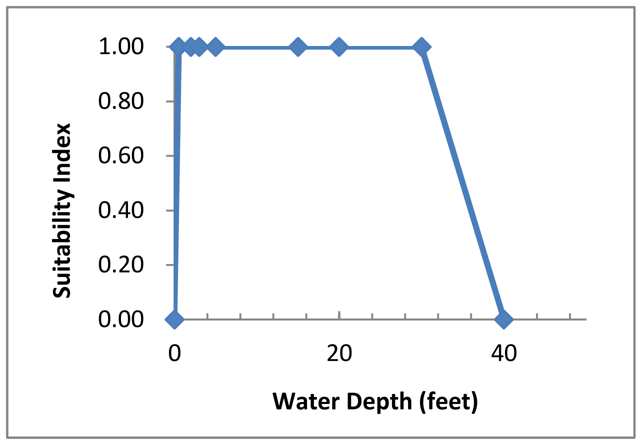
Velocity

Velocity	SI Value
0.00	0.00
0.15	1.00
1.00	1.00
2.00	1.00
3.00	1.00
4.00	1.00
5.00	0.00



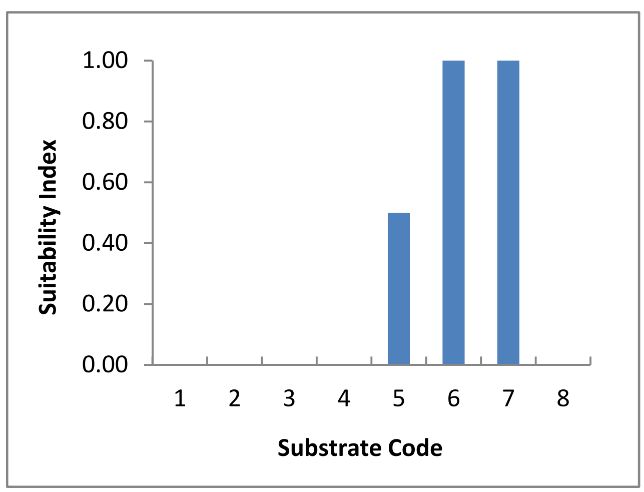
Depth

Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
3.00	1.00
5.00	1.00
15.00	1.00
20.00	1.00
30.00	1.00
40.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	0.50	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	0.00	Bedrock



Source: NOAA 2013.

Change made per J. Pruden

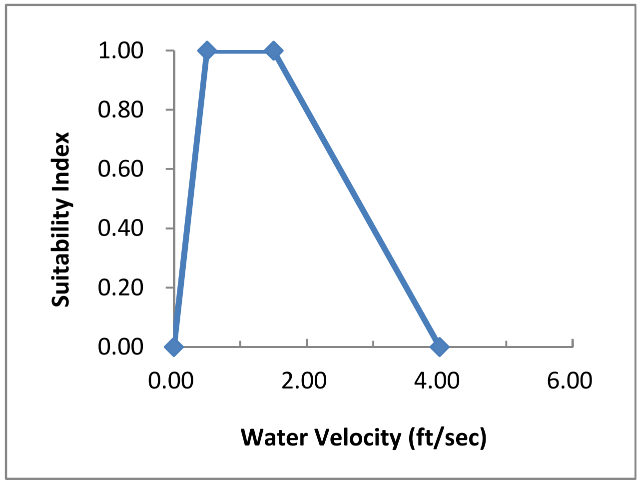
The values that have changed are the SI values associated with the velocities(3.0 and 4.0) for the egg/embryo stage. ("Normal" vs. premature embryos)

Species: Shortnose Sturgeon

Lifestage: Fry (post drift/ exogenous feeding stage) 16-57mm

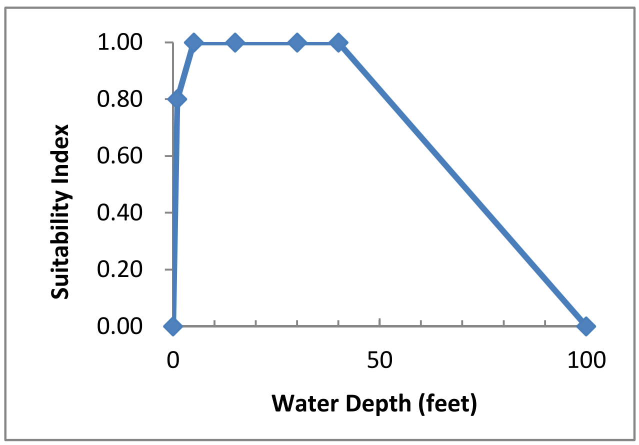
Velocity

Velocity	SI Value
0.00	0.00
0.50	1.00
1.50	1.00
4.00	0.00



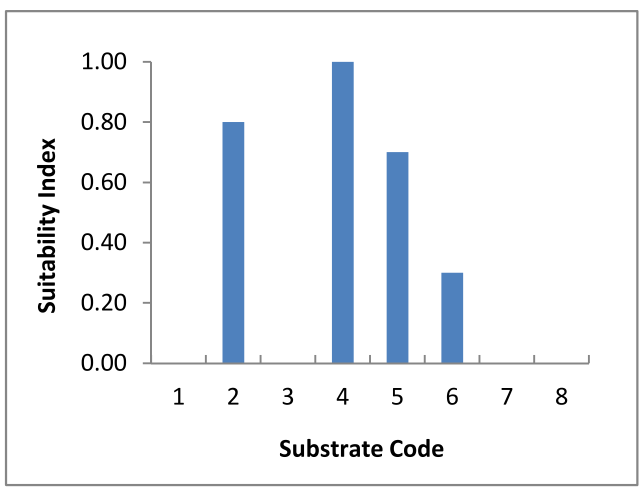
Depth

Depth	SI Value
0.00	0.00
1.00	0.80
5.00	1.00
15.00	1.00
30.00	1.00
40.00	1.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.80	Mud/soft clay
3	0.00	Silt
4	1.00	Sand
5	0.70	Gravel
6	0.30	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock

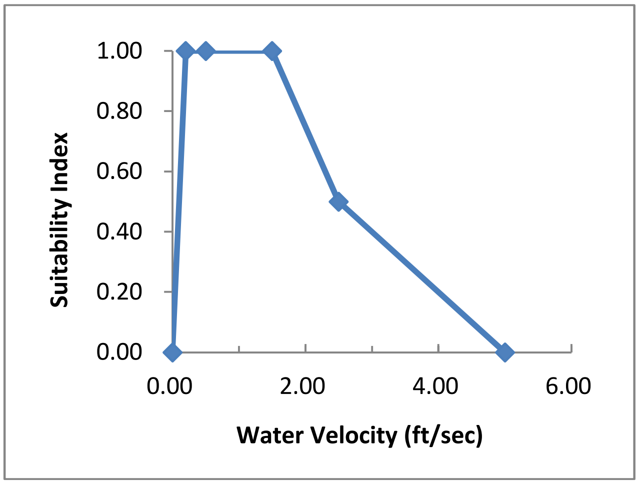


Source: Adapted from Conowingo IFIM by NOAA.

Species: Shortnose Sturgeon
Lifestage: Juveniles (60 - 650 mm)

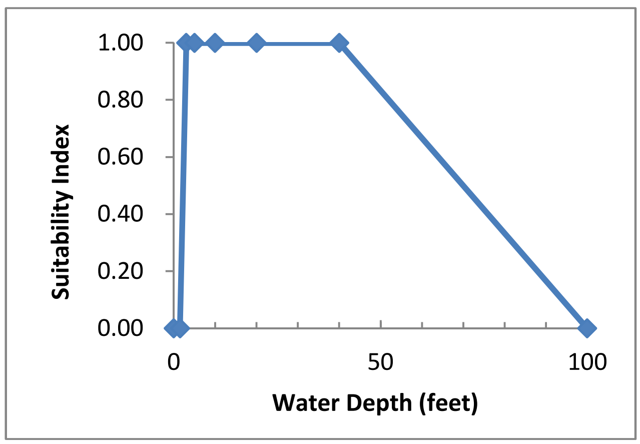
Velocity

Velocity	SI Value
0.00	0.00
0.20	1.00
0.50	1.00
1.50	1.00
2.50	0.50
5.00	0.00



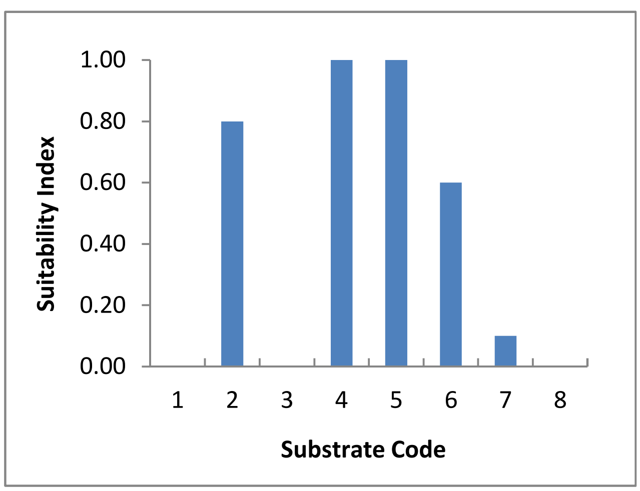
Depth

Depth	SI Value
0.00	0.00
1.50	0.00
3.00	1.00
5.00	1.00
10.00	1.00
20.00	1.00
40.00	1.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.80	Mud/soft clay
3	0.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	0.60	Cobble/rubble
7	0.10	Boulder
8	0.00	Bedrock

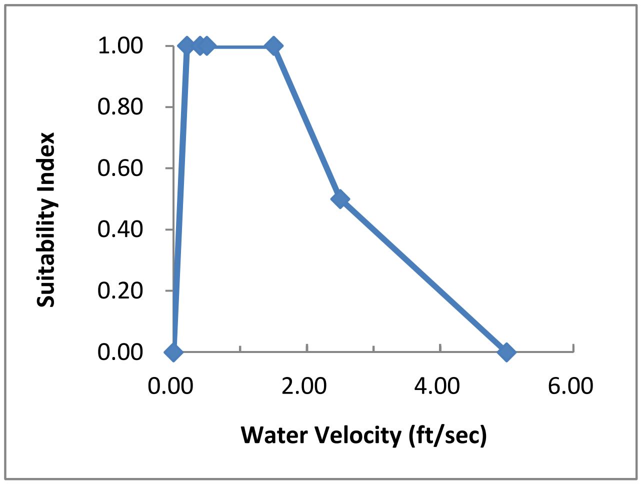


Source: Adapted from Conowingo IFIM by NOAA.

Species: Shortnose Sturgeon
Lifestage: Adults

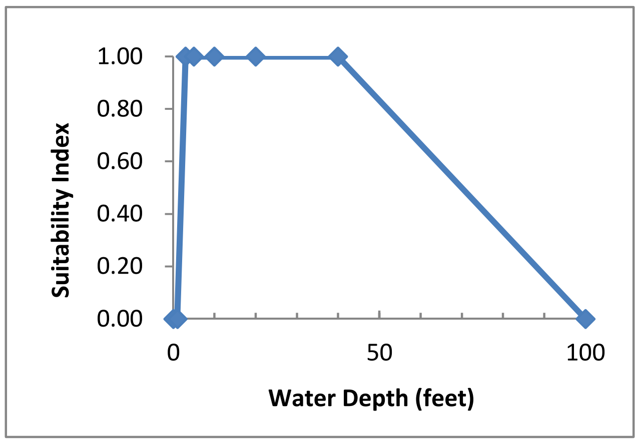
Velocity

Velocity	SI Value
0.00	0.00
0.20	1.00
0.40	1.00
0.50	1.00
1.50	1.00
2.50	0.50
5.00	0.00



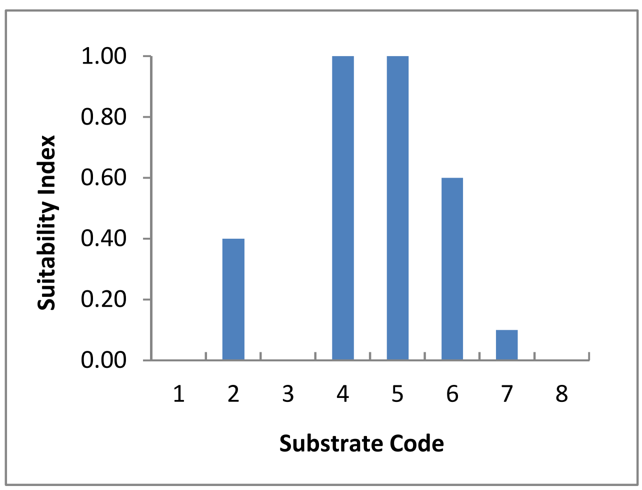
Depth

Depth	SI Value
0.00	0.00
1.00	0.00
3.00	1.00
5.00	1.00
10.00	1.00
20.00	1.00
40.00	1.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.40	Mud/soft clay
3	0.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	0.60	Cobble/rubble
7	0.10	Boulder
8	0.00	Bedrock

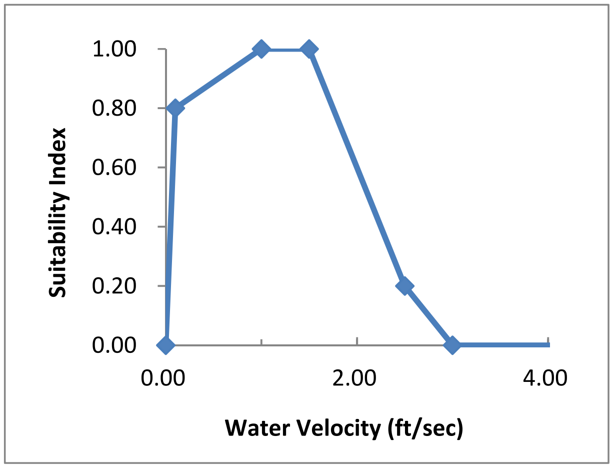


Source: Adapted from Conowingo IFIM by NOAA.

Species: Fallfish
Lifestage: Spawning and Incubation

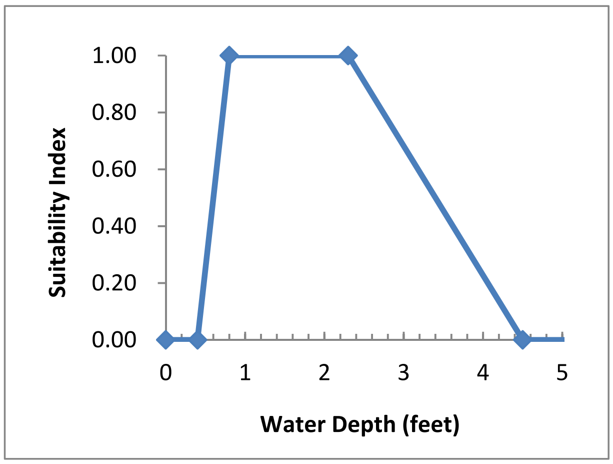
Velocity

Velocity	SI Value
0.00	0.00
0.10	0.80
1.00	1.00
1.50	1.00
2.50	0.20
3.00	0.00
100.00	0.00



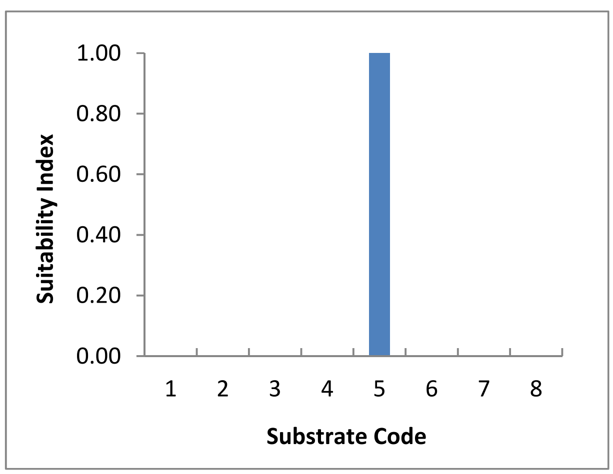
Depth

Depth	SI Value
0.00	0.00
0.40	0.00
0.80	1.00
2.30	1.00
4.50	0.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	0.00	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock

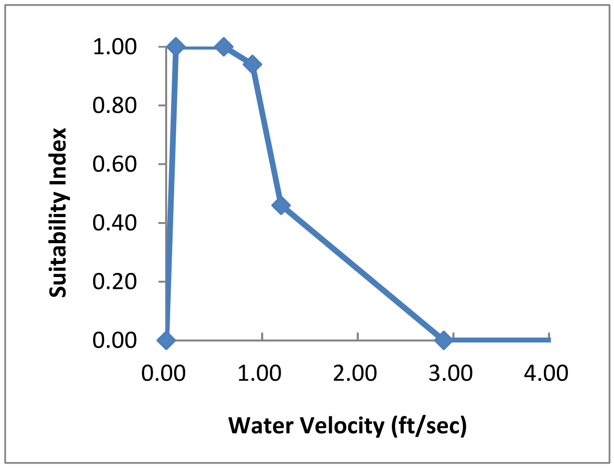


Source: Glendale Hydro Project IFIM
Consolidated Substrate Codes
Removed embeddedness and cover from substrate

Species: Fallfish
Lifestage: Fry

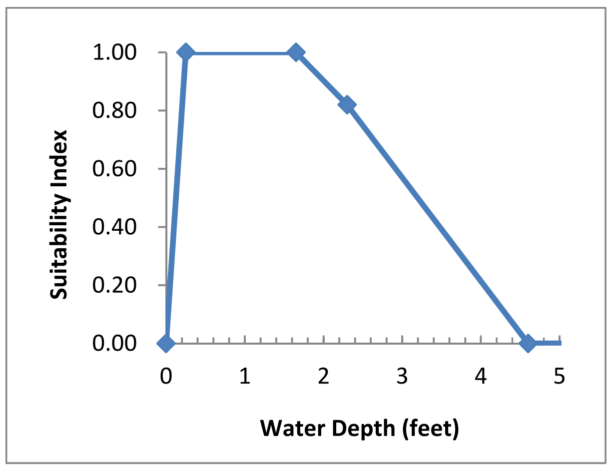
Velocity

Velocity	SI Value
0.00	0.00
0.10	1.00
0.60	1.00
0.90	0.94
1.20	0.46
2.90	0.00
100.00	0.00



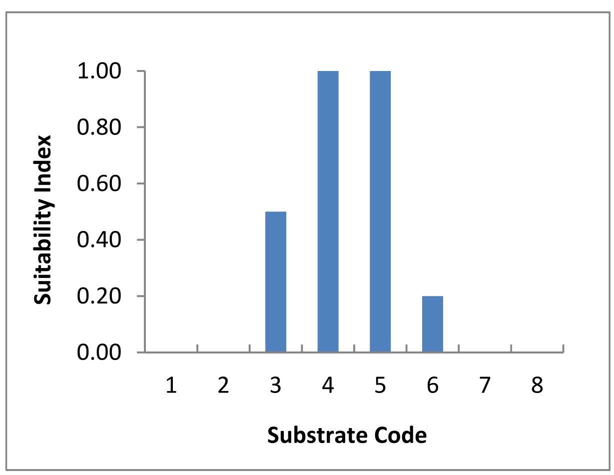
Depth

Depth	SI Value
0.00	0.00
0.25	1.00
1.65	1.00
2.30	0.82
4.60	0.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.50	Silt
4	1.00	Sand
5	1.00	Gravel
6	0.20	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock

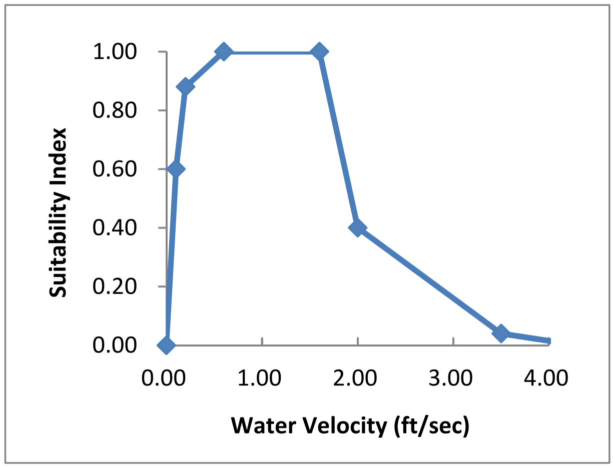


Source: Glendale Hydro Project IFIM
Consolidated Substrate Codes
Removed embeddedness and cover from substrate

Species: Fallfish
Lifestage: Juvenile

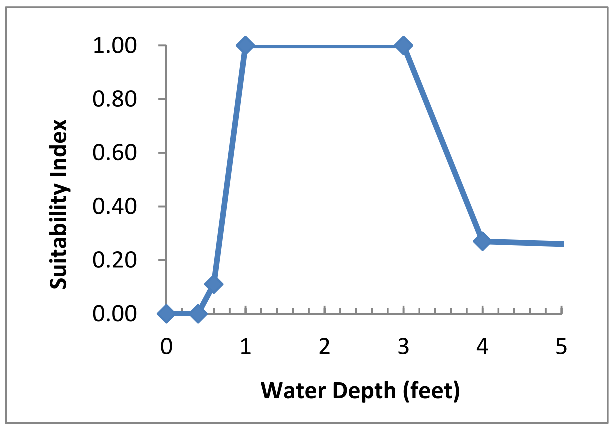
Velocity

Velocity	SI Value
0.00	0.00
0.10	0.60
0.20	0.88
0.60	1.00
1.60	1.00
2.00	0.40
3.50	0.04
4.30	0.00
100.00	0.00



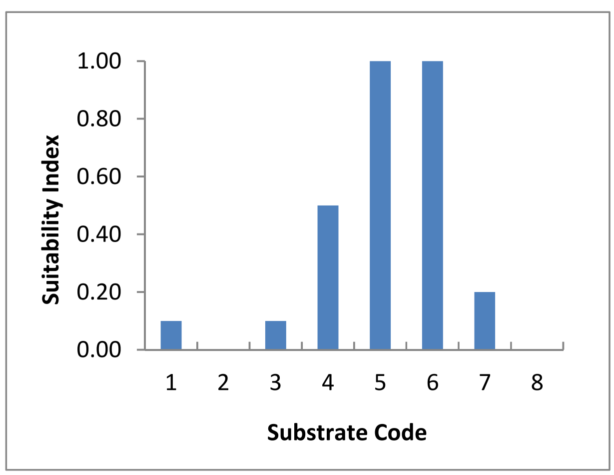
Depth

Depth	SI Value
0.00	0.00
0.40	0.00
0.60	0.11
1.00	1.00
3.00	1.00
4.00	0.27
7.00	0.24
8.00	0.07
100.00	0.07



Substrate

Substrate	SI Value	Type
1	0.10	Detritus/Organic
2	0.00	Mud/soft clay
3	0.10	Silt
4	0.50	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	0.20	Boulder
8	0.00	Bedrock

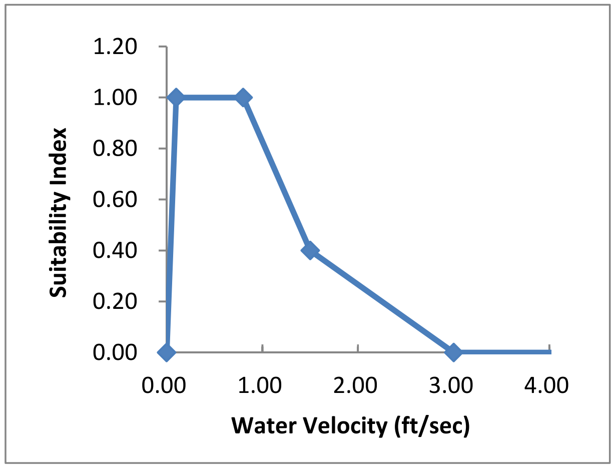


Source: Glendale Hydro Project IFIM
Consolidated Substrate Codes
Removed embeddedness and cover from substrate

Species: Fallfish
Lifestage: Adult

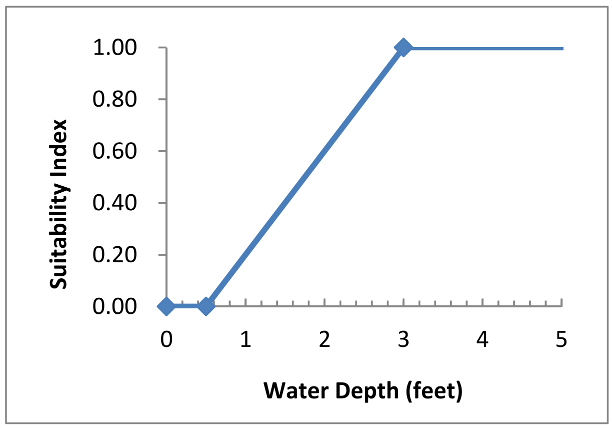
Velocity

Velocity	SI Value
0.00	0.00
0.10	1.00
0.80	1.00
1.50	0.40
3.00	0.00
100.00	0.00



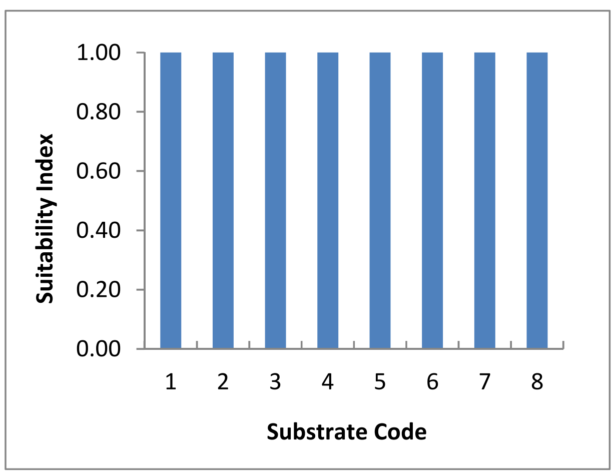
Depth

Depth	SI Value
0.00	0.00
0.50	0.00
3.00	1.00
100.00	1.00



Substrate

Substrate	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock

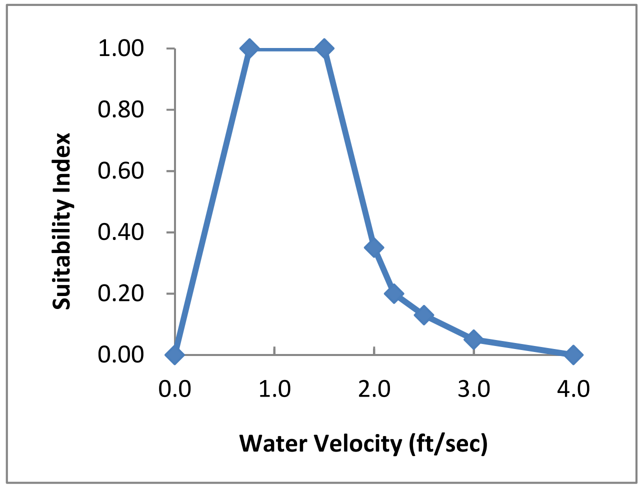


Source: Glendale Hydro Project IFIM
Consolidated Substrate Codes
Removed embeddedness and cover from substrate

Species: Longnose dace
Lifestage: Juvenile

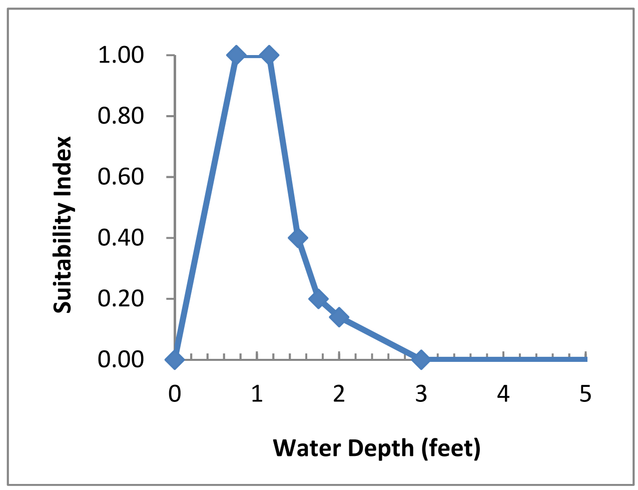
Velocity

Velocity	SI Value
0.00	0.00
0.75	1.00
1.50	1.00
2.00	0.35
2.20	0.20
2.50	0.13
3.00	0.05
4.00	0.00
100.00	0.00



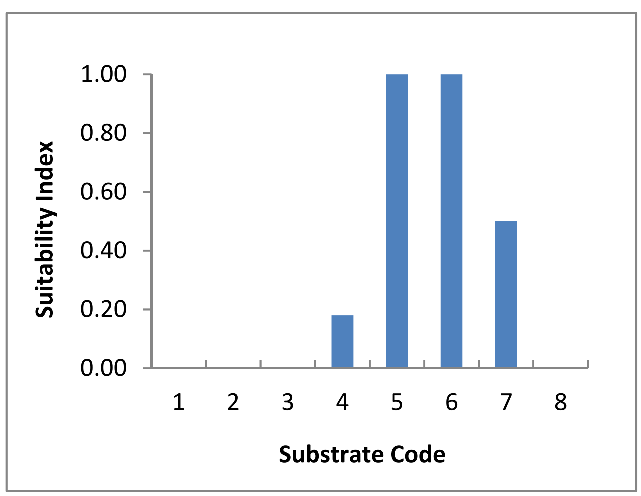
Depth

Depth	SI Value
0.00	0.00
0.75	1.00
1.15	1.00
1.50	0.40
1.75	0.20
2.00	0.14
3.00	0.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.18	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	0.50	Boulder
8	0.00	Bedrock

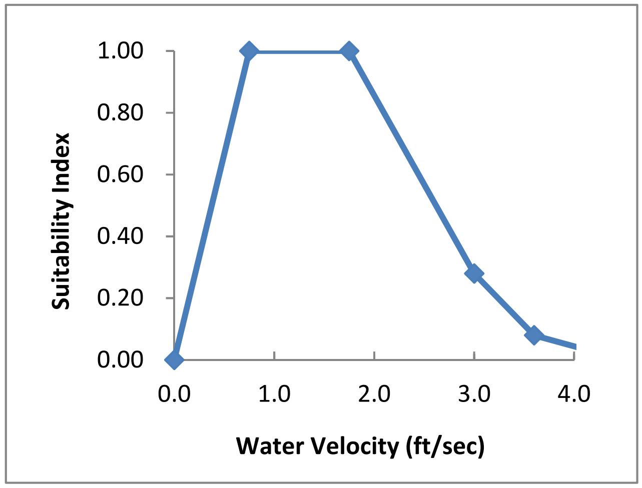


Source: Lamoille River IFIM
Consolidated Substrate Codes
Removed embeddedness and cover from substrate

Species: Longnose dace
Lifestage: Adult

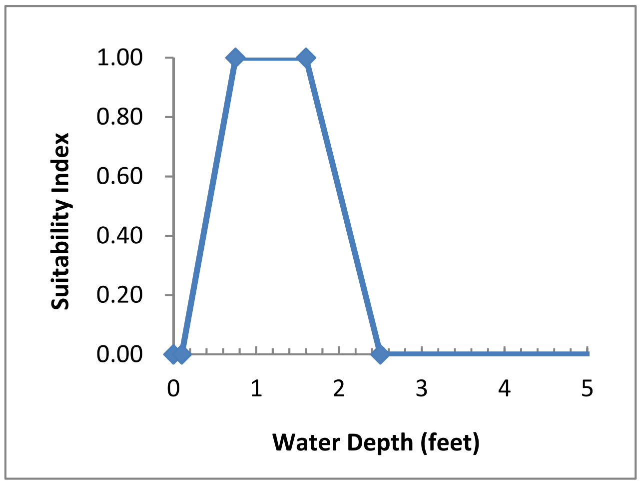
Velocity

Velocity	SI Value
0.00	0.00
0.75	1.00
1.75	1.00
3.00	0.28
3.60	0.08
4.50	0.00
100.00	0.00



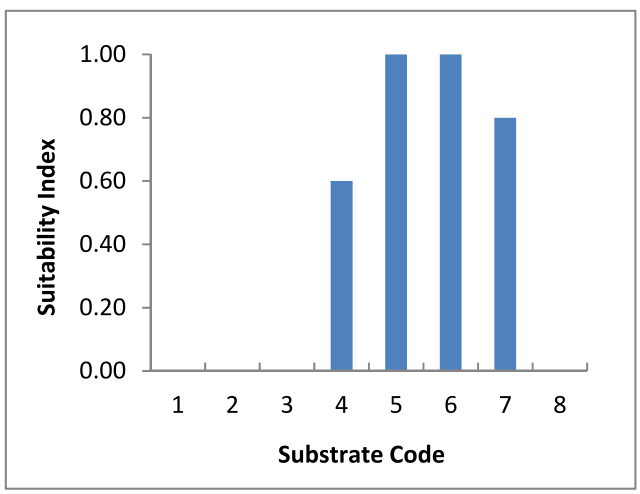
Depth

Depth	SI Value
0.00	0.00
0.10	0.00
0.75	1.00
1.60	1.00
2.50	0.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.60	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	0.80	Boulder
8	0.00	Bedrock

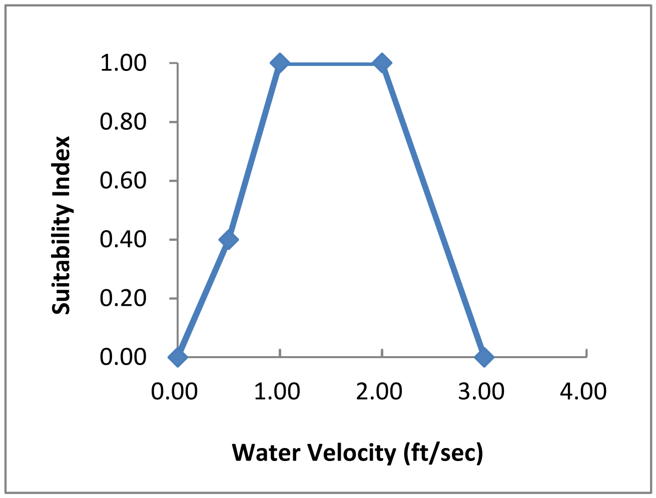


Source: Lamoille River IFIM
Consolidated Substrate Codes
Removed embeddedness and cover from substrate

Species: White Sucker
Lifestage: Spawning and Incubation

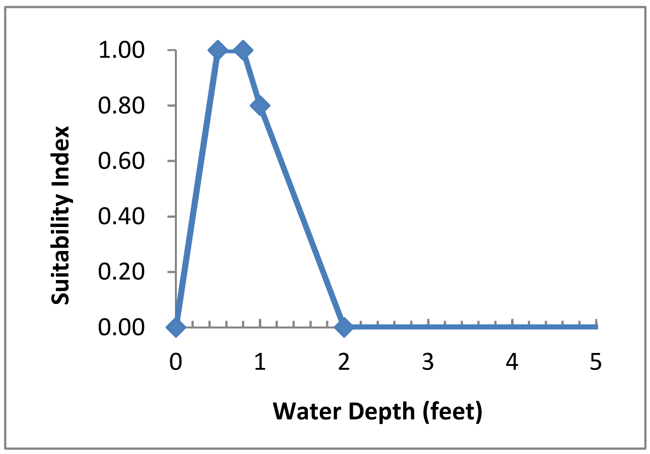
Velocity

Velocity	SI Value
0.00	0.00
0.50	0.40
1.00	1.00
2.00	1.00
3.00	0.00
100.00	0.00



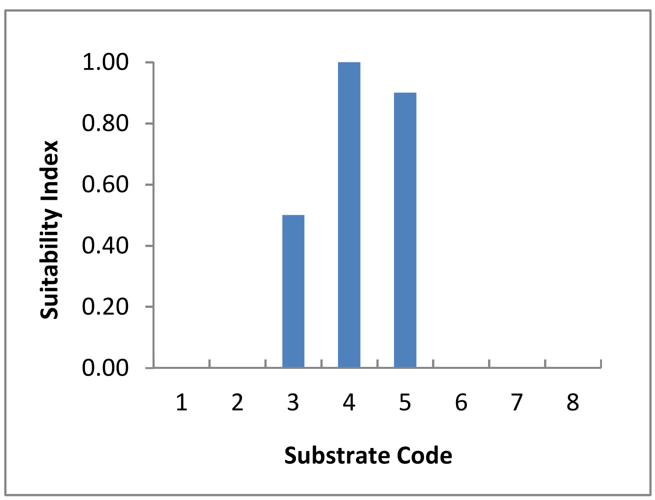
Depth

Depth	SI Value
0.00	0.00
0.50	1.00
0.80	1.00
1.00	0.80
2.00	0.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.50	Silt
4	1.00	Sand
5	0.90	Gravel
6	0.00	Cobble
7	0.00	Boulder
8	0.00	Bedrock

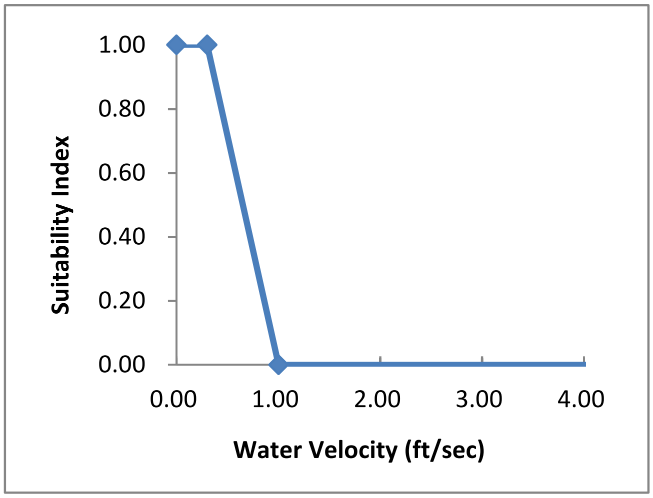


Source: Glendale Hydro IFIM

Species: White Sucker
Lifestage: Fry

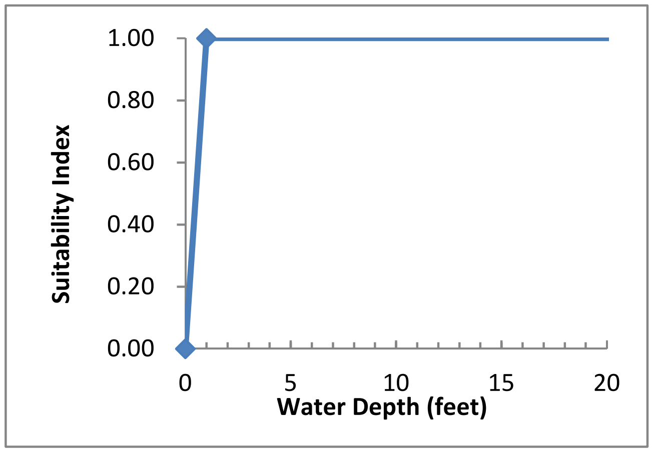
Velocity

Velocity	SI Value
0.00	1.00
0.30	1.00
1.00	0.00
100.00	0.00



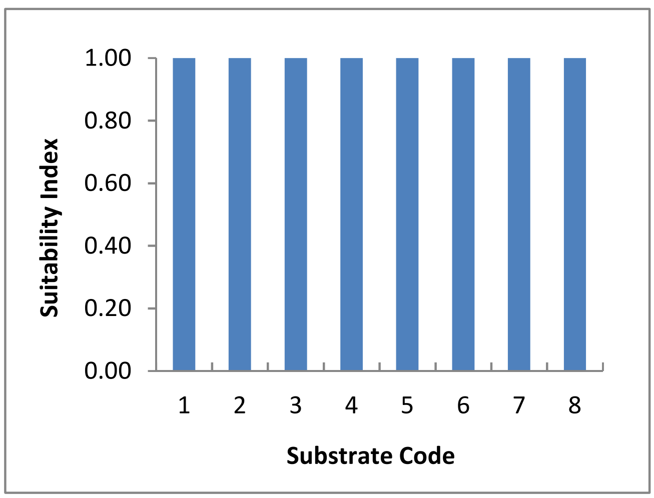
Depth

Depth	SI Value
0.00	0.00
1.00	1.00
100.00	1.00



Substrate

Substrate	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	1.00	Boulder
8	1.00	Bedrock

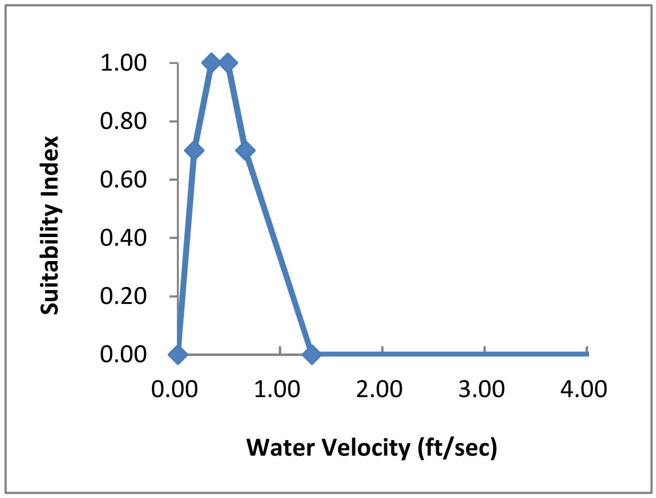


Source: Twomey et al., 1984

Species: White Sucker
Lifestage: Adult/Juvenile

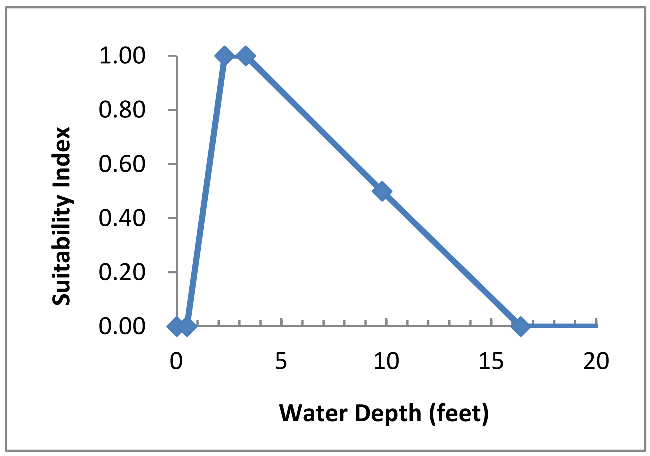
Velocity

Velocity	SI Value
0.00	0.00
0.16	0.70
0.33	1.00
0.49	1.00
0.66	0.70
1.31	0.00
100.00	0.00



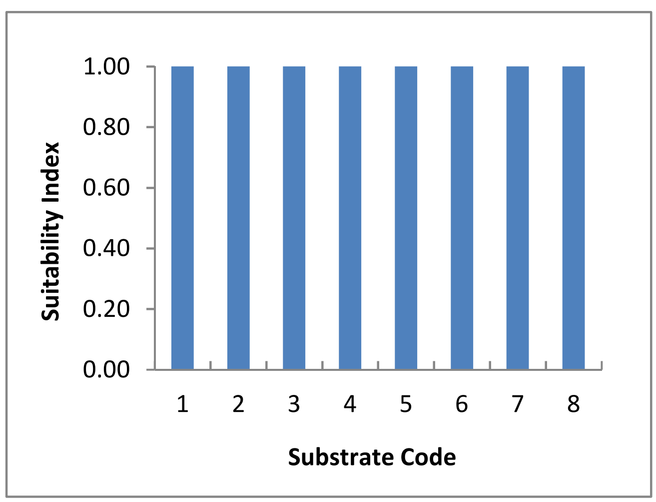
Depth

Depth	SI Value
0.00	0.00
0.50	0.00
2.30	1.00
3.30	1.00
9.80	0.50
16.40	0.00
100.00	0.00



Substrate

Substrate	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	1.00	Boulder
8	1.00	Bedrock

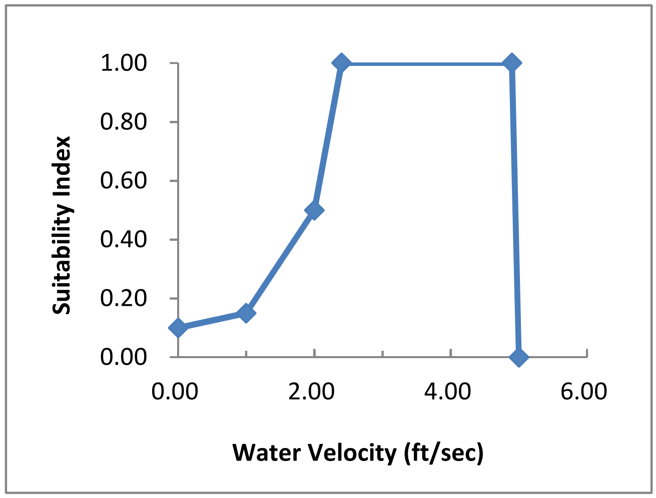


Source: Twomey et al., 1984

Species: Walleye
Lifestage: Spawning

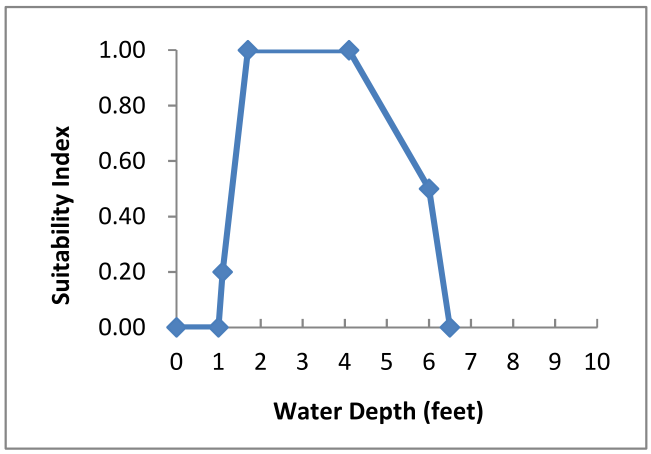
Velocity

Velocity	SI Value
0.00	0.10
1.00	0.15
2.00	0.50
2.40	1.00
4.90	1.00
5.00	0.00



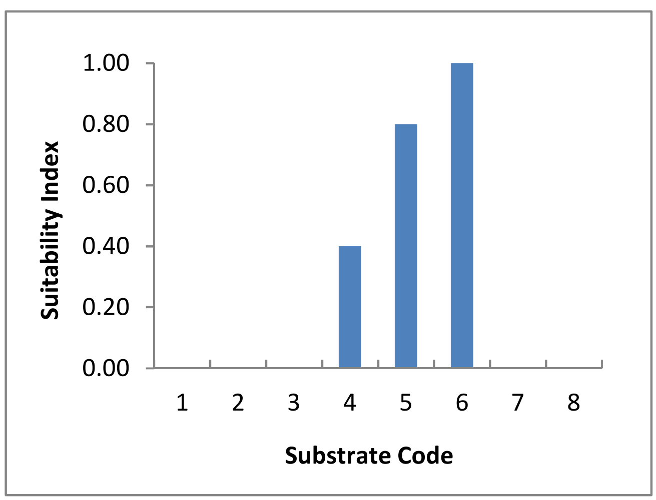
Depth

Depth	SI Value
0.00	0.00
1.00	0.00
1.10	0.20
1.70	1.00
4.10	1.00
6.00	0.50
6.50	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.40	Sand
5	0.80	Gravel
6	1.00	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock



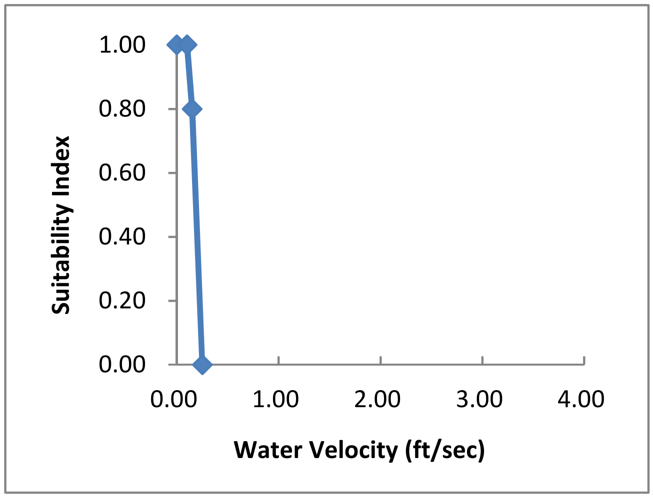
Source: McMahon, et al., 1984.

Modified to include velocity and depth data from Bozek, et al., 2011.

Species: Walleye
Lifestage: Fry

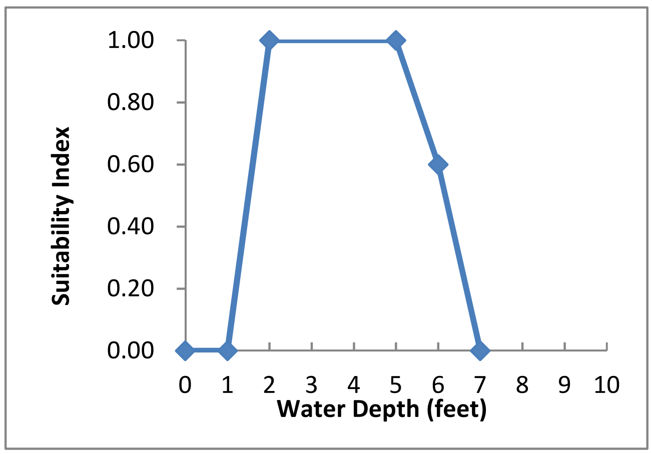
Velocity

Velocity	SI Value
0.00	1.00
0.10	1.00
0.15	0.80
0.25	0.00
2.00	0.00



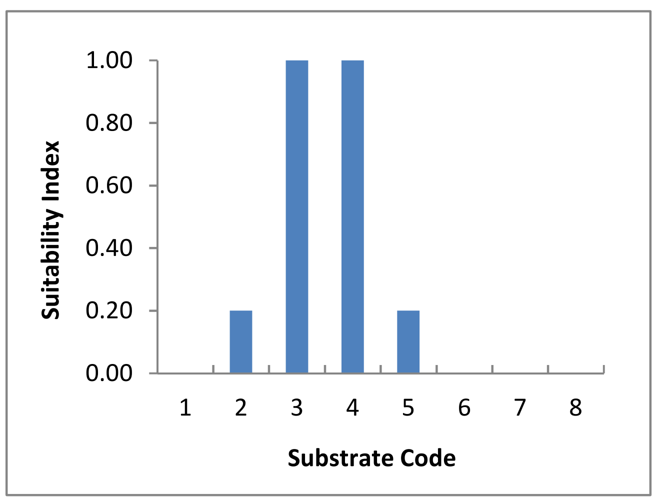
Depth

Depth	SI Value
0.00	0.00
1.00	0.00
2.00	1.00
5.00	1.00
6.00	0.60
7.00	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	0.20	Gravel
6	0.00	Cobble
7	0.00	Boulder
8	0.00	Bedrock

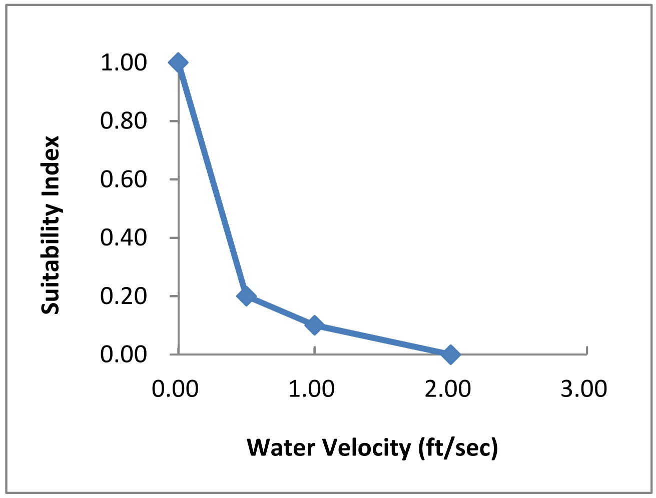


Source: McMahon, et al., 1984.

Species: Walleye
Lifestage: Juvenile

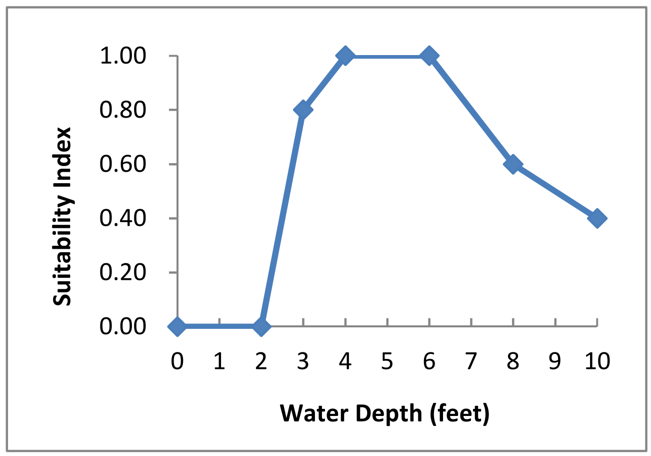
Velocity

Velocity	SI Value
0.00	1.00
0.50	0.20
1.00	0.10
2.00	0.00



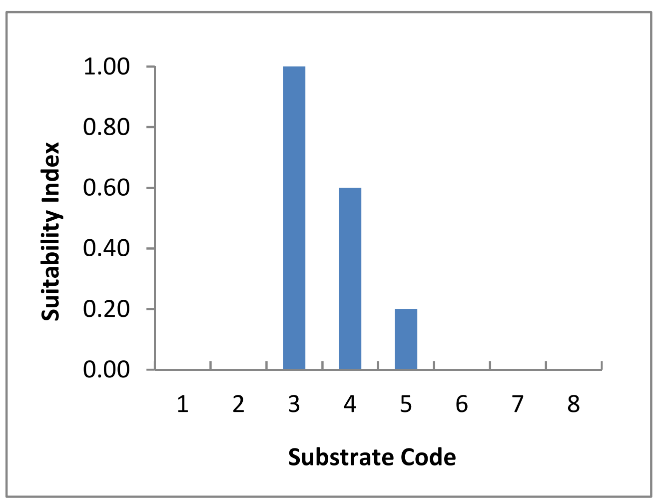
Depth

Depth	SI Value
0.00	0.00
2.00	0.00
3.00	0.80
4.00	1.00
6.00	1.00
8.00	0.60
10.00	0.40
50.00	0.40



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	1.00	Silt
4	0.60	Sand
5	0.20	Gravel
6	0.00	Cobble
7	0.00	Boulder
8	0.00	Bedrock

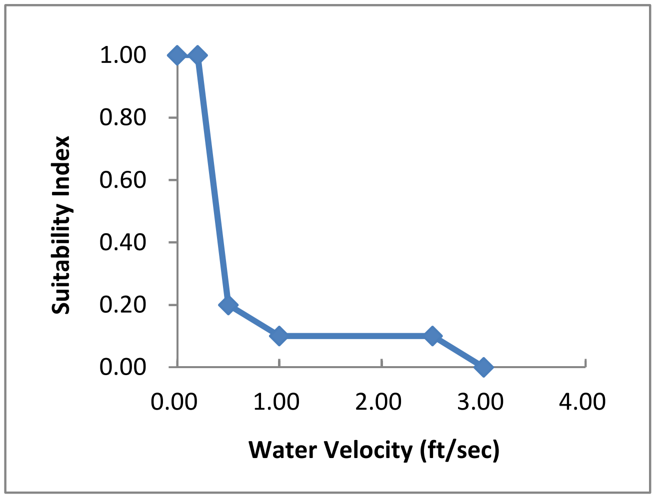


Source: McMahon, et al., 1984.

Species: Walleye
Lifestage: Adult

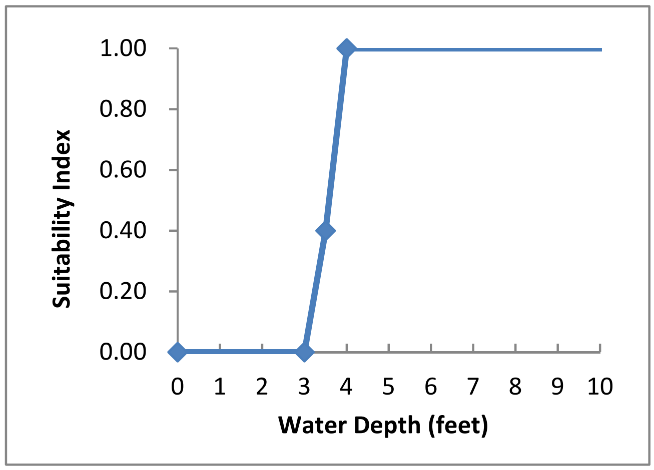
Velocity

Velocity	SI Value
0.00	1.00
0.20	1.00
0.50	0.20
1.00	0.10
2.50	0.10
3.00	0.00



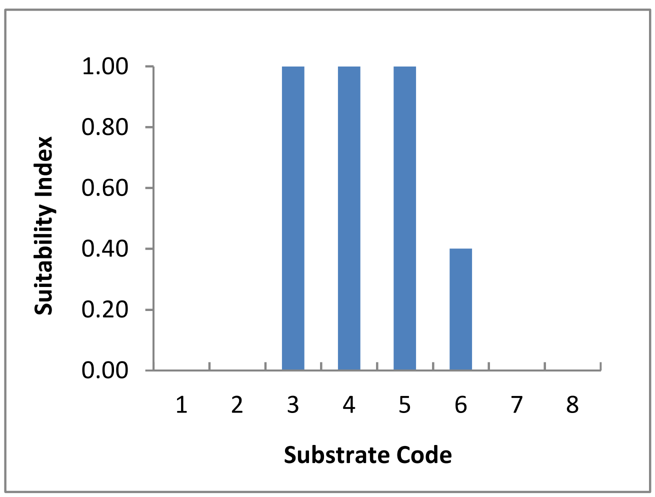
Depth

Depth	SI Value
0.00	0.00
3.00	0.00
3.50	0.40
4.00	1.00
50.00	1.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	0.40	Cobble
7	0.00	Boulder
8	0.00	Bedrock

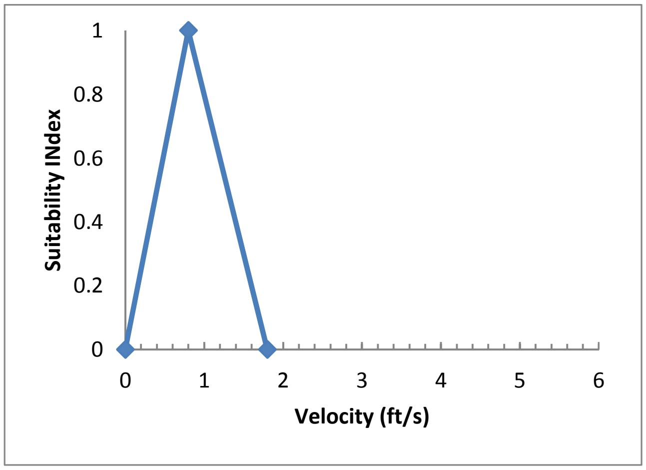


Source: McMahon, et al., 1984.

Species: Tessellated Darter
Lifestage: Adult and Juvenile

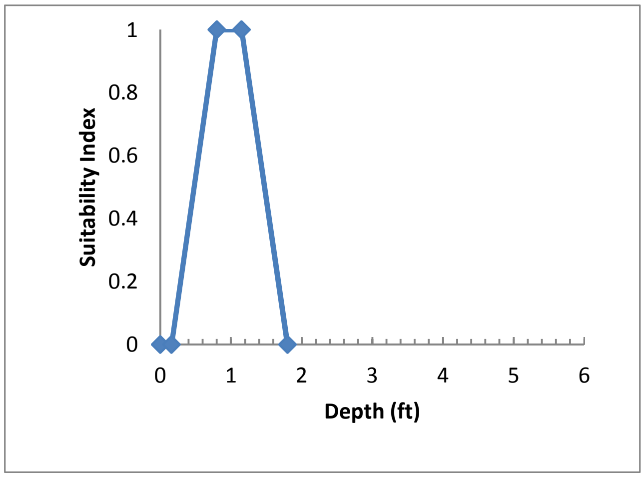
Velocity

Velocity	SI Value
0	0
0.8	1
1.8	0



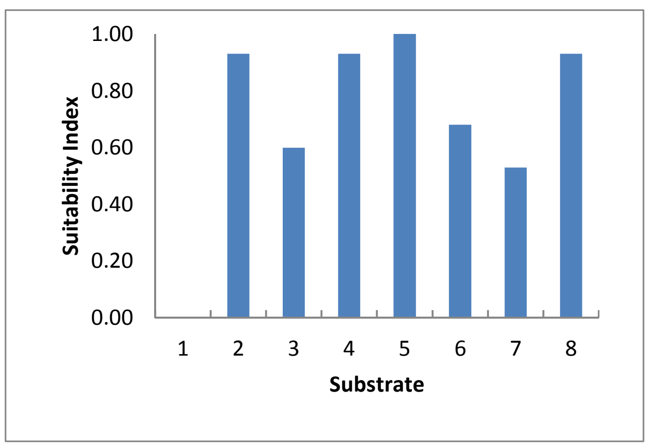
Depth

Depth	SI Value
0	0
0.16	0
0.8	1
1.15	1
1.8	0



Substrate

Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.93	Mud/soft clay
3	0.60	Silt
4	0.93	Sand
5	1.00	Gravel
6	0.68	Cobble
7	0.53	Boulder
8	0.93	Bedrock

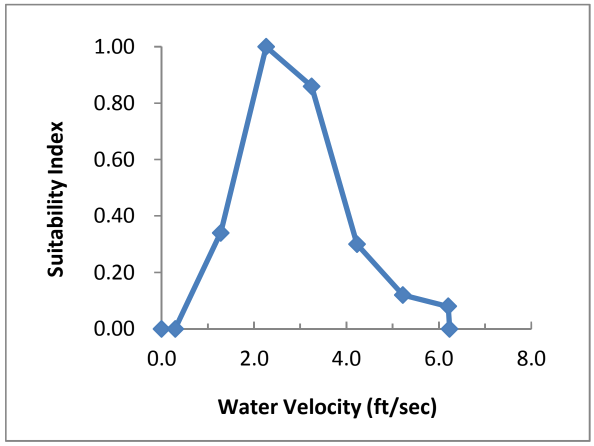


Source: Bell Bend IFIM Study

Species: Sea lamprey
Lifestage: Spawning and Incubation

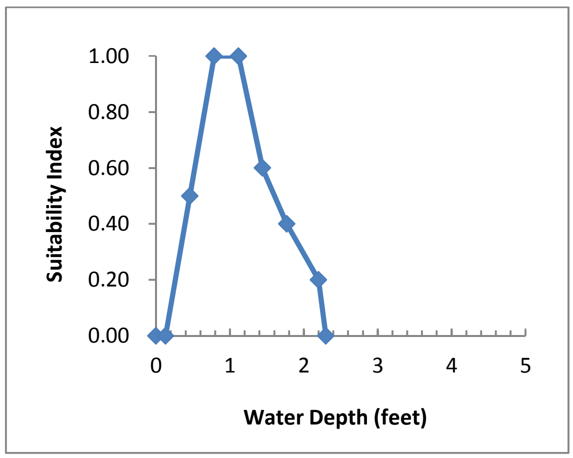
Velocity

Velocity	SI Value
0.00	0.00
0.30	0.00
1.28	0.34
2.26	1.00
3.25	0.86
4.23	0.30
5.22	0.12
6.20	0.08
6.23	0.00



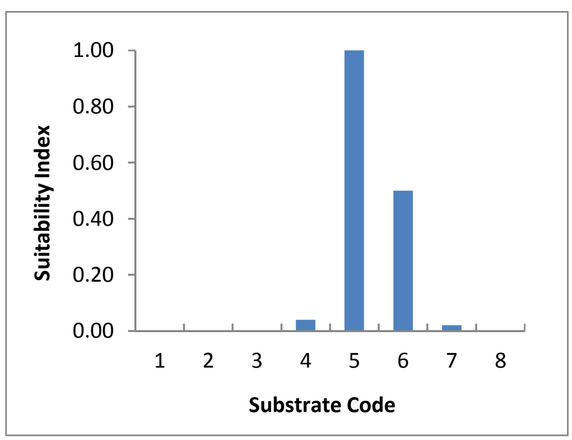
Depth

Depth	SI Value
0.00	0.00
0.13	0.00
0.46	0.50
0.79	1.00
1.12	1.00
1.44	0.60
1.77	0.40
2.20	0.20
2.30	0.00



Substrate

Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.04	Sand
5	1.00	Gravel
6	0.50	Cobble/rubble
7	0.02	Boulder
8	0.00	Bedrock

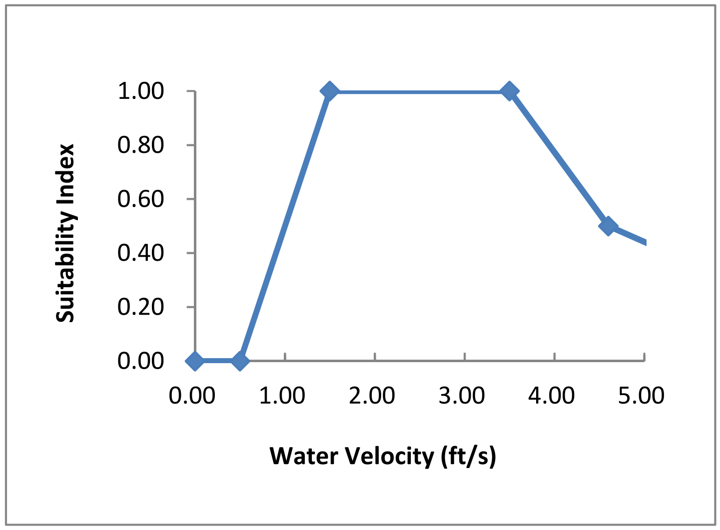


Source: Habitat Suitability Index for Sea Lamprey redds
Kynard and Horgan 2013
Revised depth and substrate per USFWS July 3, 2014 letter, extrapolated from Yergeau, 1983

Species: Macroinvertebrates

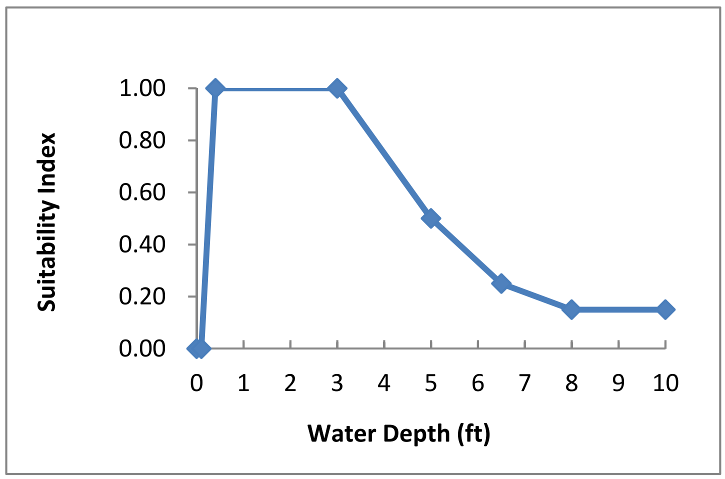
Velocity

Velocity	SI Value
0.00	0.00
0.50	0.00
1.50	1.00
3.50	1.00
4.60	0.50
8.00	0.00



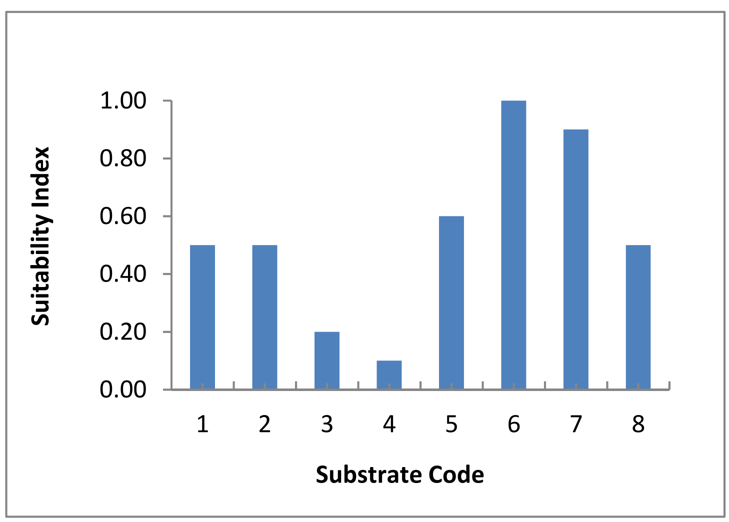
Depth

Depth	SI Value
0.00	0.00
0.10	0.00
0.40	1.00
3.00	1.00
5.00	0.50
6.50	0.25
8.00	0.15
10.00	0.15
100.00	0.00



Substrate

Code	SI Value	Type
1	0.50	Detritus/Organic
2	0.50	Mud/soft clay
3	0.20	Silt
4	0.10	Sand
5	0.60	Gravel
6	1.00	Cobble/rubble
7	0.90	Boulder
8	0.50	Bedrock

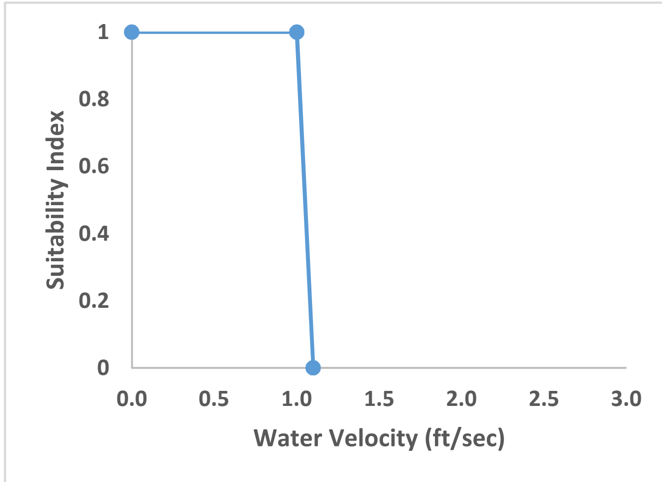


Source: Lamoille River IFIM

Guild: Shallow-Slow

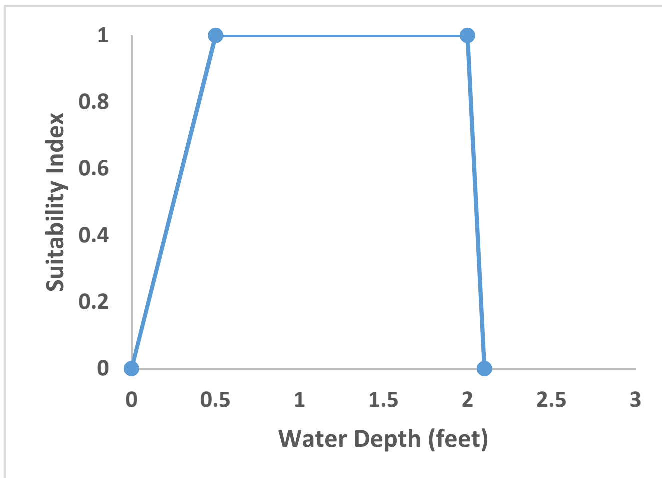
Velocity

Velocity	SI Value
0.00	1.00
1.00	1.00
1.10	0.00
100.00	0.00



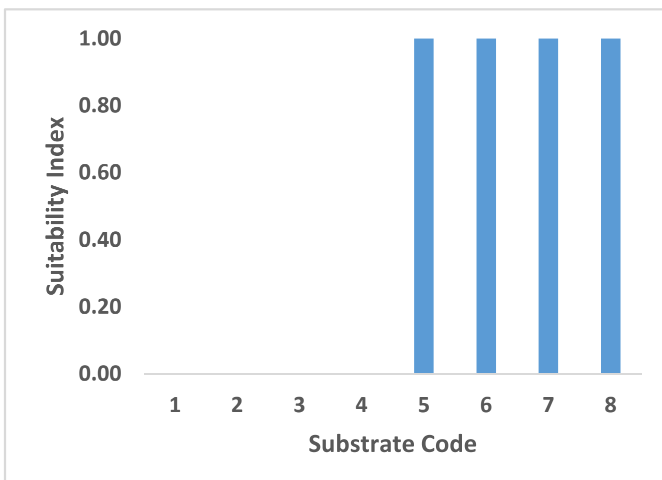
Depth

Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
2.10	0.00
100.00	0.00



Substrate

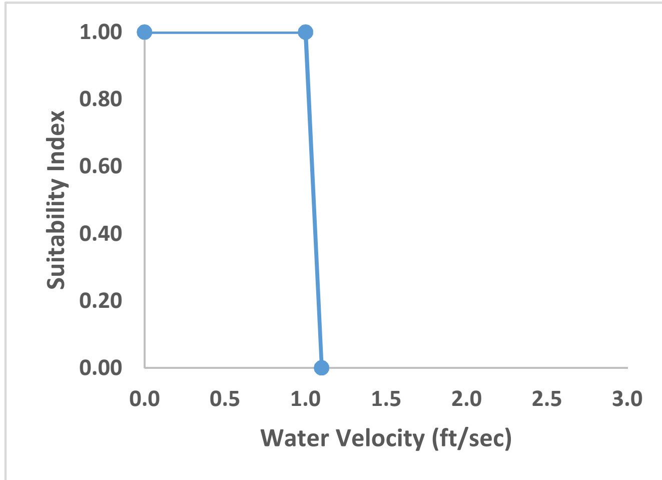
Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock



Guild: Deep-Slow

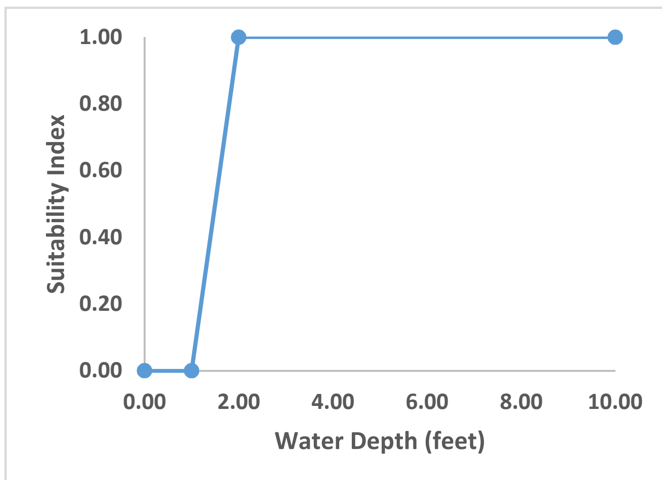
Velocity

Velocity	SI Value
0.00	1.00
1.00	1.00
1.10	0.00
100.00	0.00



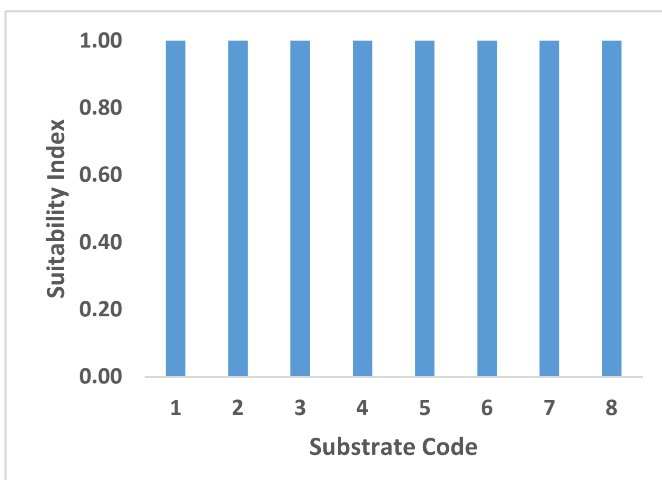
Depth

Depth	SI Value
0.00	0.00
1.00	0.00
2.00	1.00
10.00	1.00
100.00	1.00



Substrate

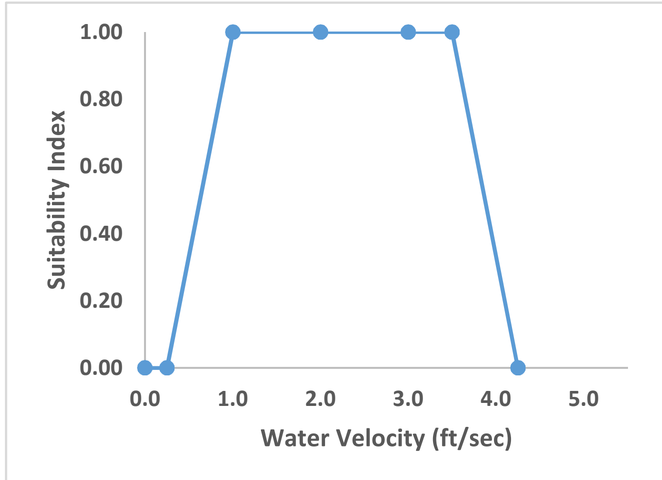
Substrate	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock



Guild: Deep-Fast

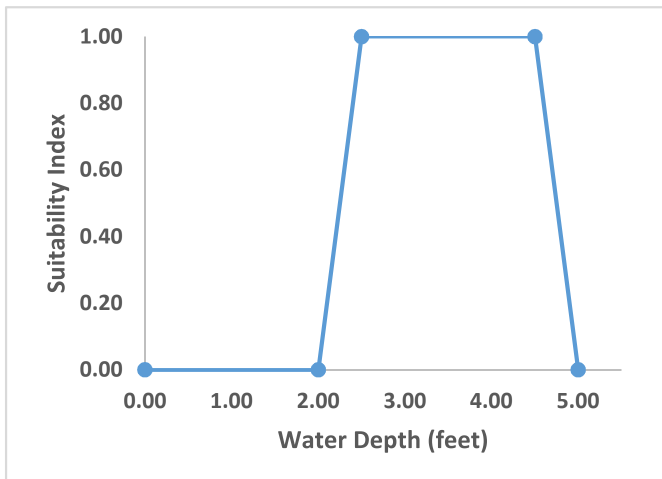
Velocity

Velocity	SI Value
0.00	0.00
0.25	0.00
1.00	1.00
2.00	1.00
3.00	1.00
3.50	1.00
4.25	0.00
100.00	0.00



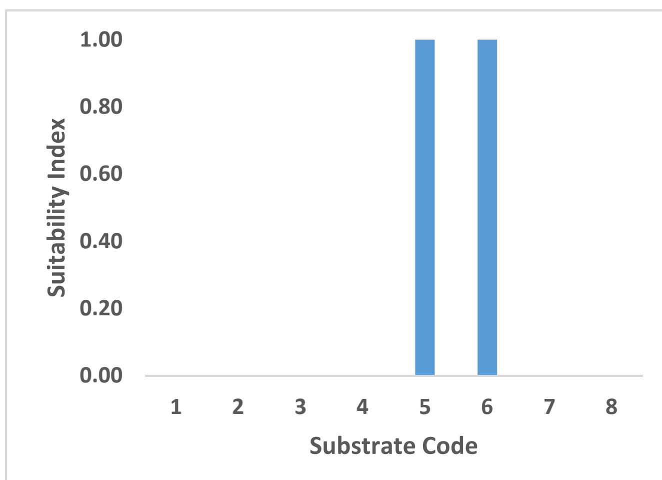
Depth

Depth	SI Value
0.00	0.00
2.00	0.00
2.50	1.00
4.50	1.00
5.00	0.00
100.00	0.00



Substrate

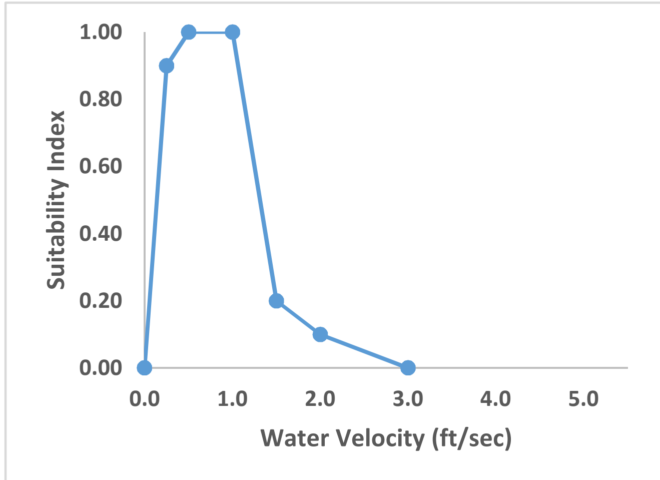
Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock



Guild: Shallow-Fast

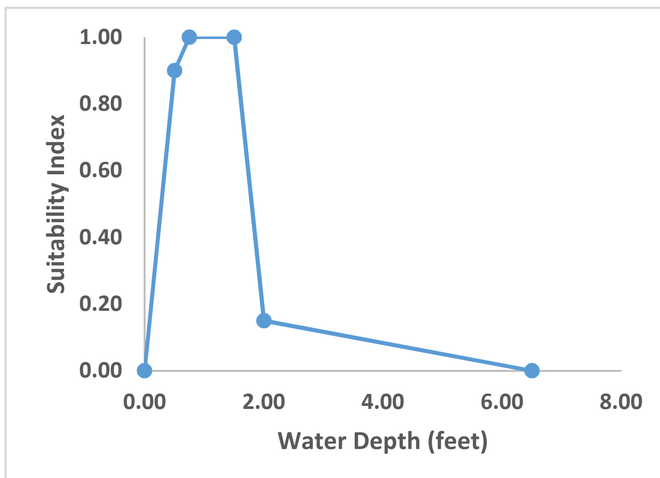
Velocity

Velocity	SI Value
0.00	0.00
0.25	0.90
0.50	1.00
1.00	1.00
1.50	0.20
2.00	0.10
3.00	0.00
100.00	0.00



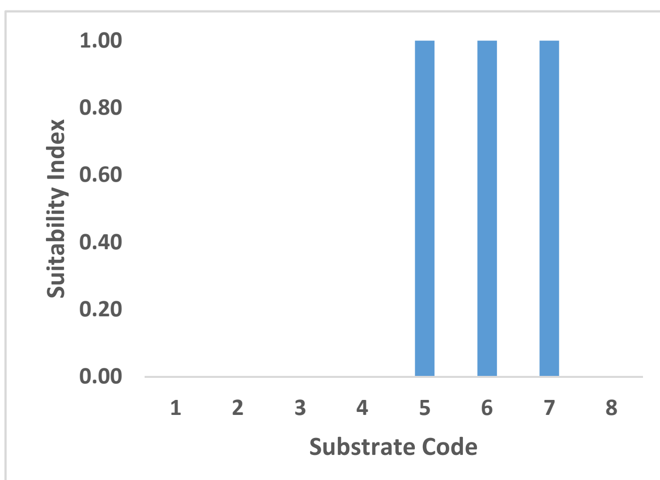
Depth

Depth	SI Value
0.00	0.00
0.50	0.90
0.75	1.00
1.50	1.00
2.00	0.15
6.50	0.00
100	0



Substrate

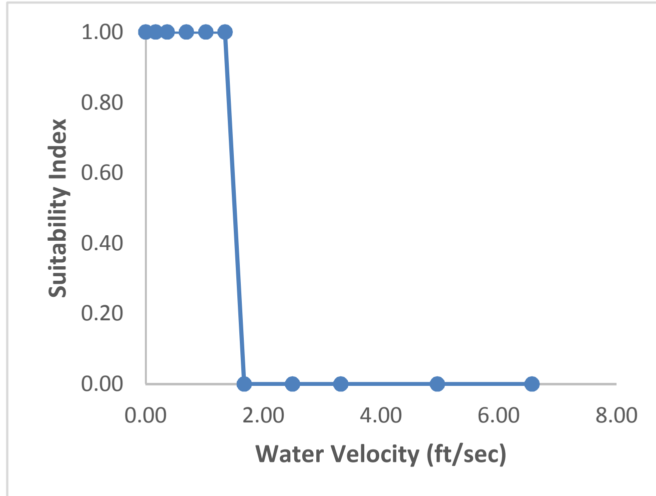
Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	0.00	Bedrock



Species: Yellow Lampmussel
Lifestage: Juvenile

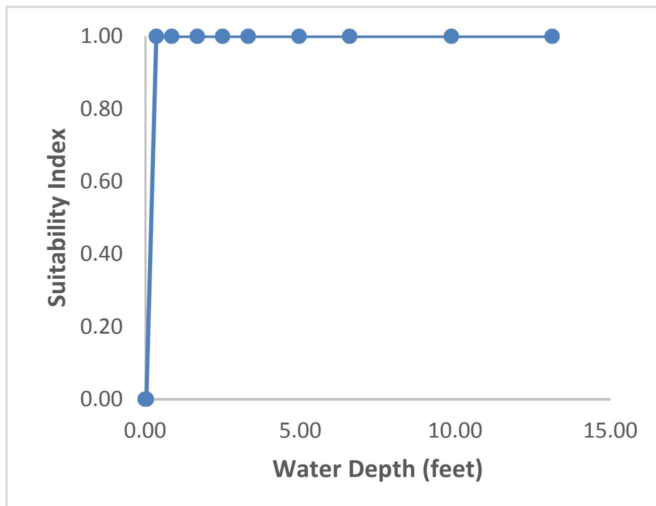
Velocity

Velocity	SI Value
0.00	1.00
0.16	1.00
0.36	1.00
0.69	1.00
1.02	1.00
1.35	1.00
1.67	0.00
2.49	0.00
3.31	0.00
4.95	0.00
6.56	0.00



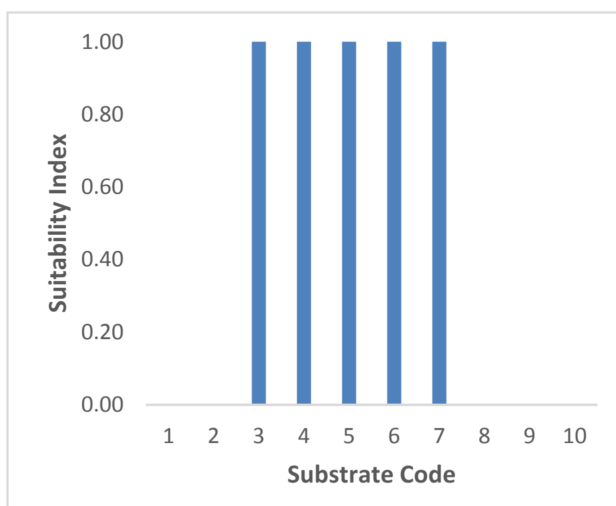
Depth

Depth	SI Value
0.00	0.00
0.03	0.00
0.36	1.00
0.85	1.00
1.67	1.00
2.49	1.00
3.31	1.00
4.95	1.00
6.59	1.00
9.88	1.00
13.12	1.00



Substrate

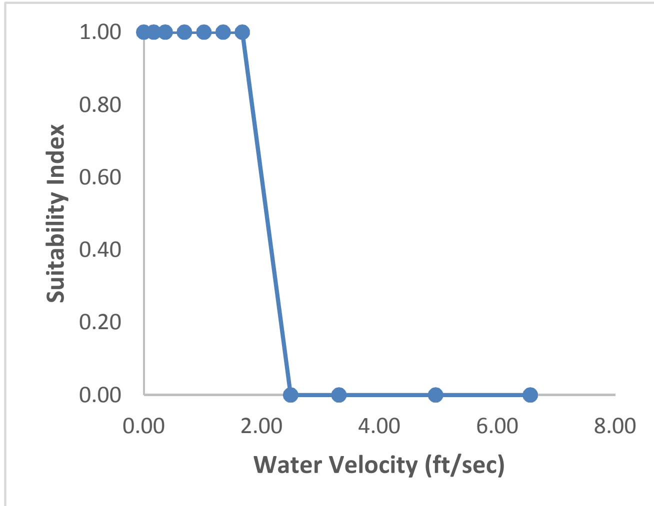
Substrate	SI Value	Type
1	0.00	Organic Material
2	0.00	Clay
3	1.00	Mud/Silt
4	1.00	Sand
5	1.00	Fine Gravel
6	1.00	Coarse Gravel
7	1.00	Small Cobble
8	0.00	Large Cobble
9	0.00	Boulder
10	0.00	Bedrock



Species: Yellow Lampmussel
Lifestage: Adult

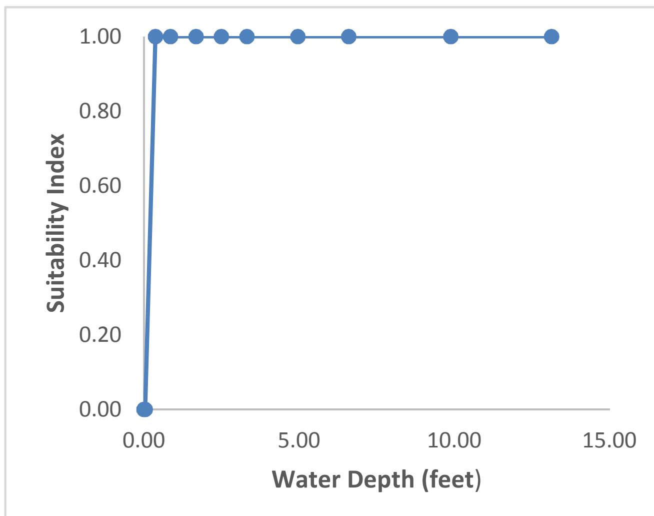
Velocity

Velocity	SI Value
0.00	1.00
0.16	1.00
0.36	1.00
0.69	1.00
1.02	1.00
1.35	1.00
1.67	1.00
2.49	0.00
3.31	0.00
4.95	0.00
6.56	0.00



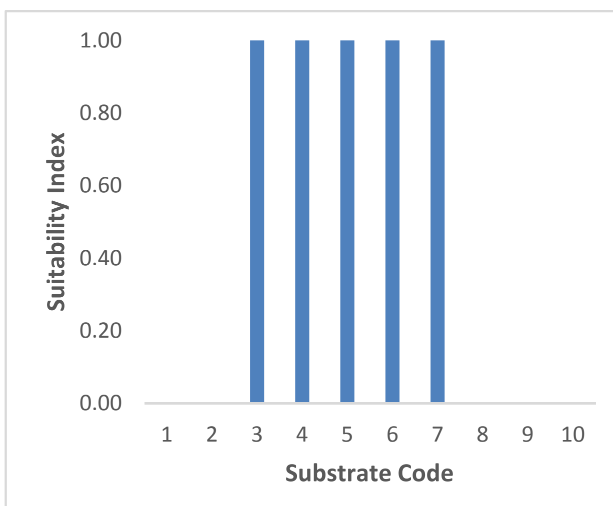
Depth

Depth	SI Value
0.00	0.00
0.03	0.00
0.36	1.00
0.85	1.00
1.67	1.00
2.49	1.00
3.31	1.00
4.95	1.00
6.59	1.00
9.88	1.00
13.12	1.00



Substrate

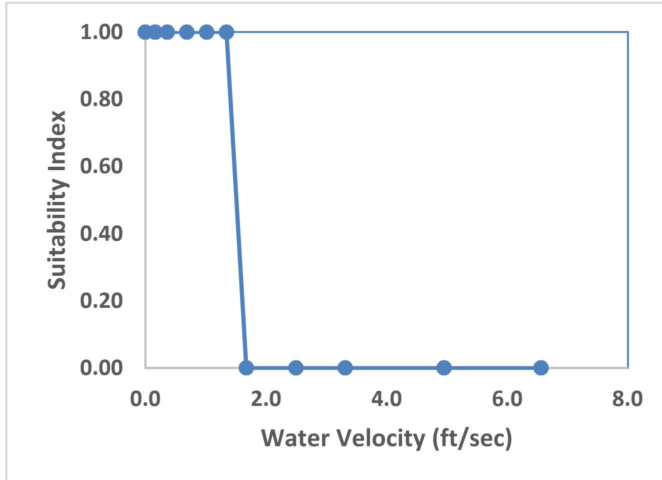
Substrate	SI Value	Type
1	0.00	Organic Material
2	0.00	Clay
3	1.00	Mud/Silt
4	1.00	Sand
5	1.00	Fine Gravel
6	1.00	Coarse Gravel
7	1.00	Small Cobble
8	0.00	Large Cobble
9	0.00	Boulder
10	0.00	Bedrock



Species: Eastern Pondmussel
Lifestage: Juvenile

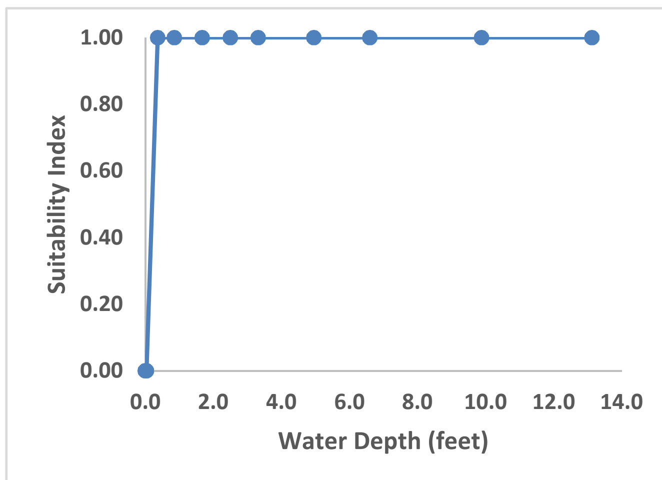
Velocity

Velocity	SI Value
0.00	1.00
0.16	1.00
0.36	1.00
0.69	1.00
1.02	1.00
1.35	1.00
1.67	0.00
2.49	0.00
3.31	0.00
4.95	0.00
6.56	0.00



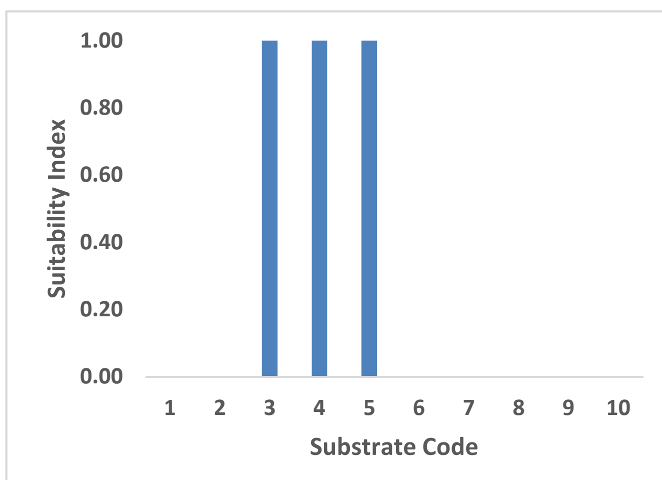
Depth

Depth	SI Value
0.00	0.00
0.03	0.00
0.36	1.00
0.85	1.00
1.67	1.00
2.49	1.00
3.31	1.00
4.95	1.00
6.59	1.00
9.88	1.00
13.12	1.00



Substrate

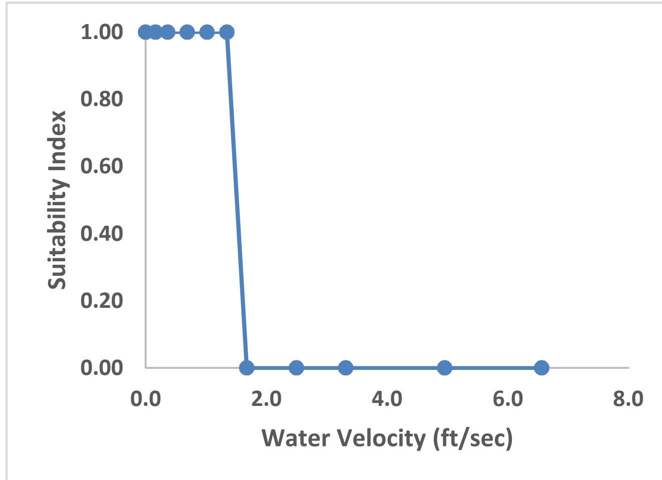
Substrate	SI Value	Type
1	0.00	Organic Material
2	0.00	Clay
3	1.00	Mud/Silt
4	1.00	Sand
5	1.00	Fine Gravel
6	0.00	Coarse Gravel
7	0.00	Small Cobble
8	0.00	Large Cobble
9	0.00	Boulder
10	0.00	Bedrock



Species: Eastern Pondmussel
Lifestage: Adult

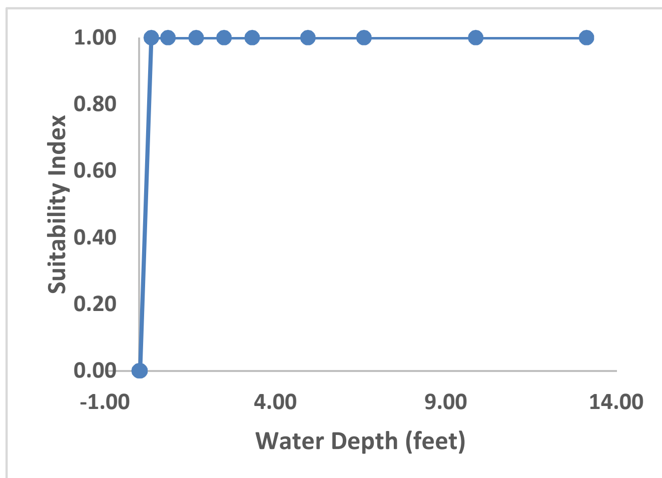
Velocity

Velocity	SI Value
0.00	1.00
0.16	1.00
0.36	1.00
0.69	1.00
1.02	1.00
1.35	1.00
1.67	0.00
2.49	0.00
3.31	0.00
4.95	0.00
6.56	0.00



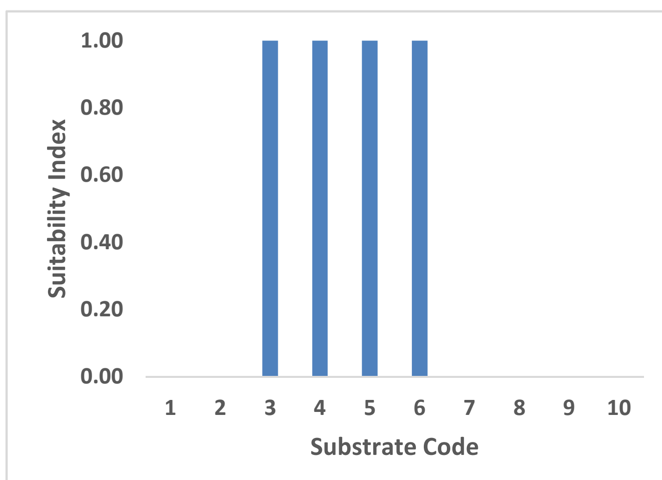
Depth

Depth	SI Value
0.00	0.00
0.03	0.00
0.36	1.00
0.85	1.00
1.67	1.00
2.49	1.00
3.31	1.00
4.95	1.00
6.59	1.00
9.88	1.00
13.12	1.00



Substrate

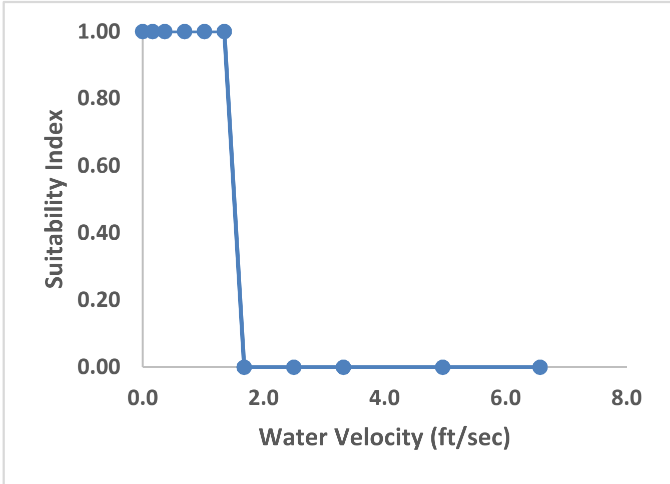
Substrate	SI Value	Type
1	0.00	Organic Material
2	0.00	Clay
3	1.00	Mud/Silt
4	1.00	Sand
5	1.00	Fine Gravel
6	1.00	Coarse Gravel
7	0.00	Small Cobble
8	0.00	Large Cobble
9	0.00	Boulder
10	0.00	Bedrock



Species: Tidewater Mucket
Lifestage: Juvenile

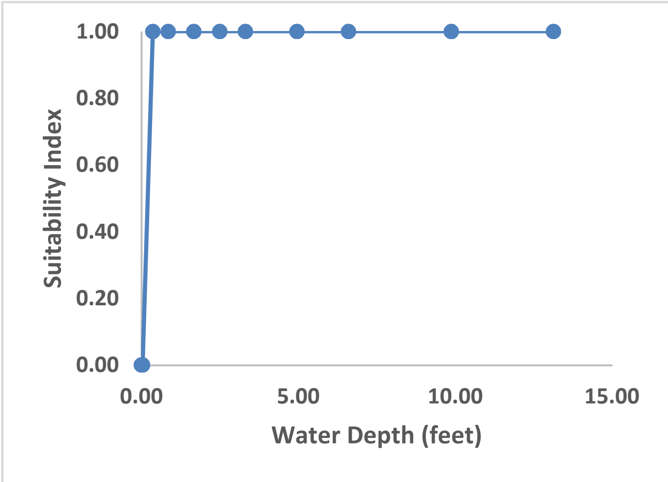
Velocity

Velocity	SI Value
0.00	1.00
0.16	1.00
0.36	1.00
0.69	1.00
1.02	1.00
1.35	1.00
1.67	0.00
2.49	0.00
3.31	0.00
4.95	0.00
6.56	0.00



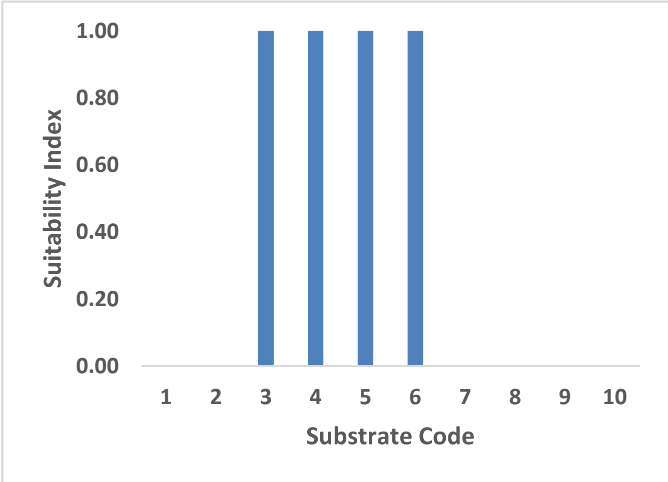
Depth

Depth	SI Value
0.00	0.00
0.03	0.00
0.36	1.00
0.85	1.00
1.67	1.00
2.49	1.00
3.31	1.00
4.95	1.00
6.59	1.00
9.88	1.00
13.12	1.00



Substrate

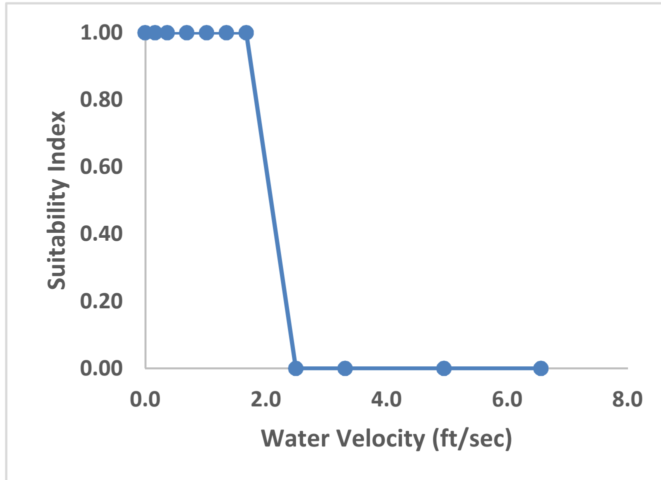
Substrate	SI Value	Type
1	0.00	Organic Material
2	0.00	Clay
3	1.00	Mud/Silt
4	1.00	Sand
5	1.00	Fine Gravel
6	1.00	Coarse Gravel
7	0.00	Small Cobble
8	0.00	Large Cobble
9	0	Boulder
10	0	Bedrock



Species: Tidewater Mucket
Lifestage: Adult

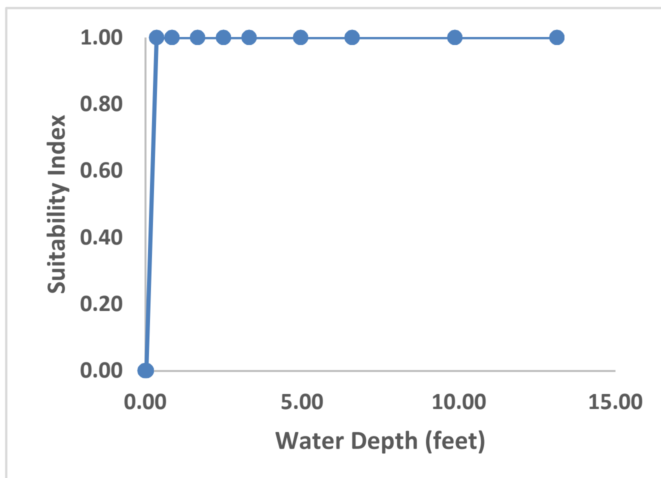
Velocity

Velocity	SI Value
0.00	1.00
0.16	1.00
0.36	1.00
0.69	1.00
1.02	1.00
1.35	1.00
1.67	1.00
2.49	0.00
3.31	0.00
4.95	0.00
6.56	0.00



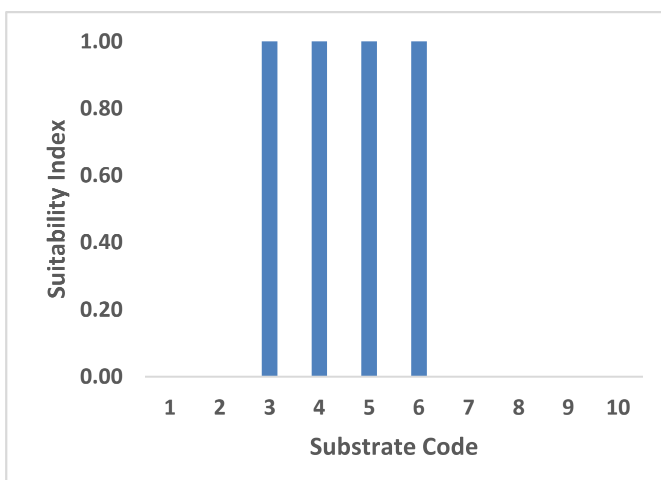
Depth

Depth	SI Value
0.00	0.00
0.03	0.00
0.36	1.00
0.85	1.00
1.67	1.00
2.49	1.00
3.31	1.00
4.95	1.00
6.59	1.00
9.88	1.00
13.12	1.00



Substrate

Substrate	SI Value	Type
1	0.00	Organic Material
2	0.00	Clay
3	1.00	Mud/Silt
4	1.00	Sand
5	1.00	Fine Gravel
6	1.00	Coarse Gravel
7	0.00	Small Cobble
8	0.00	Large Cobble
9	0	Boulder
10	0	Bedrock



APPENDIX B – REACH 1 (RIGHT CHANNEL SINGLE TRANSECT MODEL) HABITAT VERSUS DISCHARGE RELATIONSHIPS

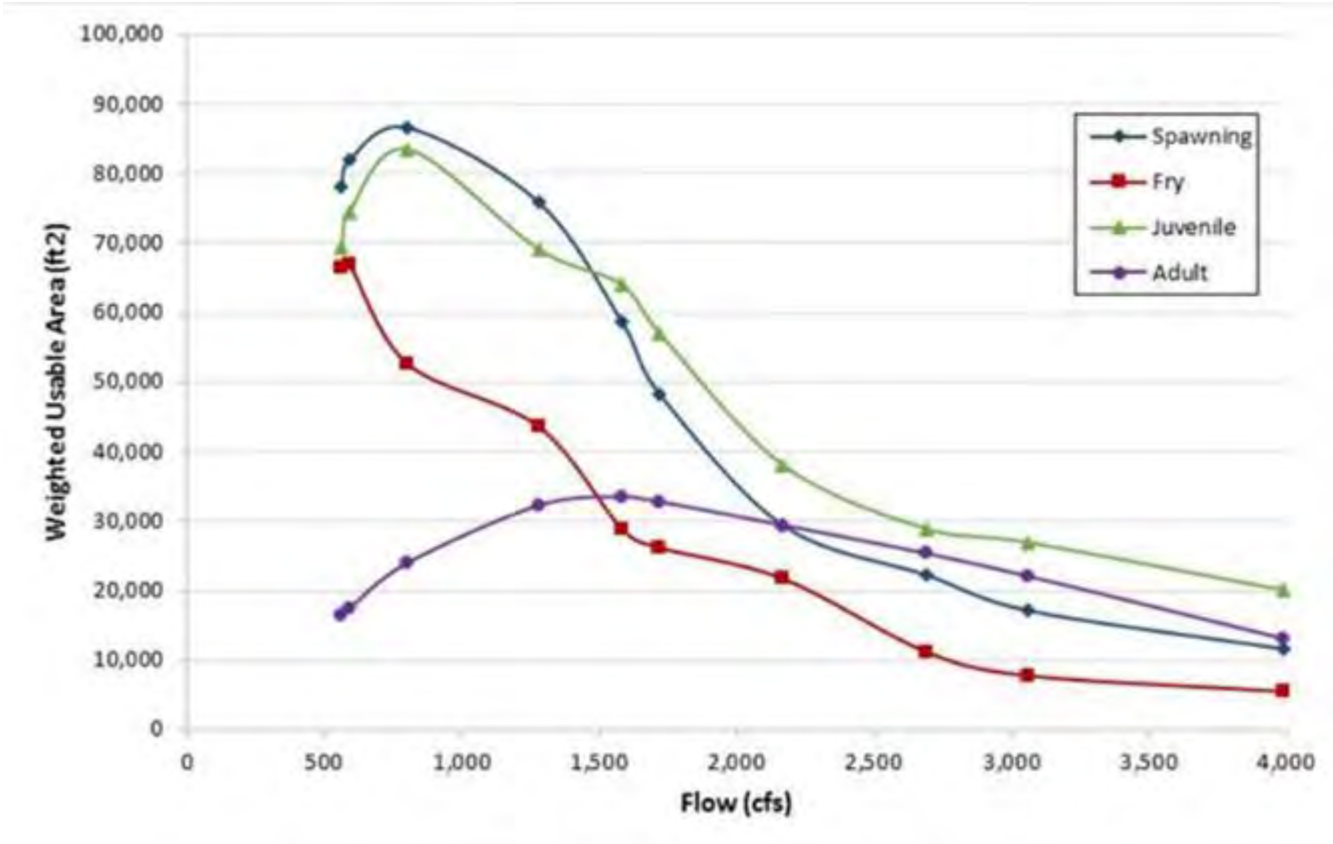


Figure B-1: Reach 1 WUA curves for the spawning & incubation, fry, juvenile, and adult life stages of Fallfish

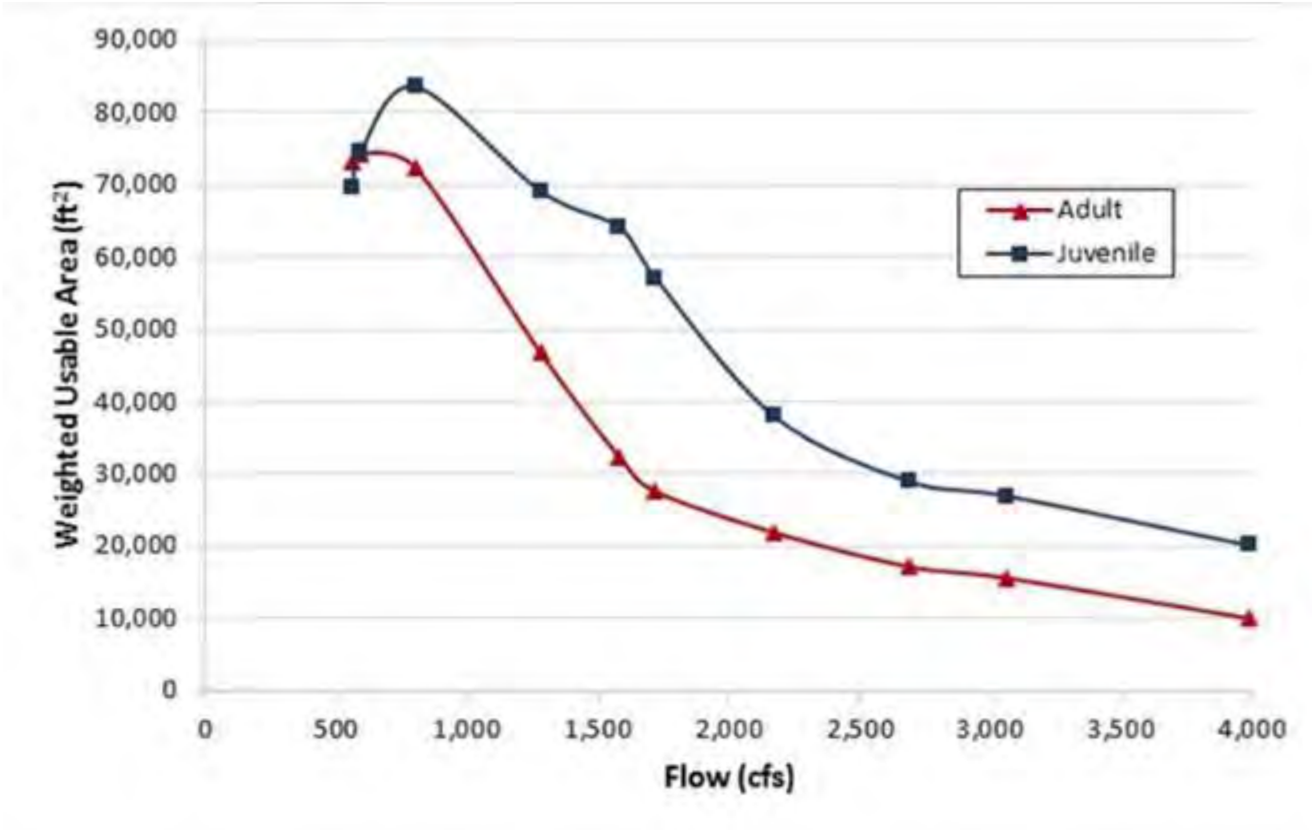


Figure B-2: Reach 1 WUA curves for the juvenile and adult life stages of Longnose Dace

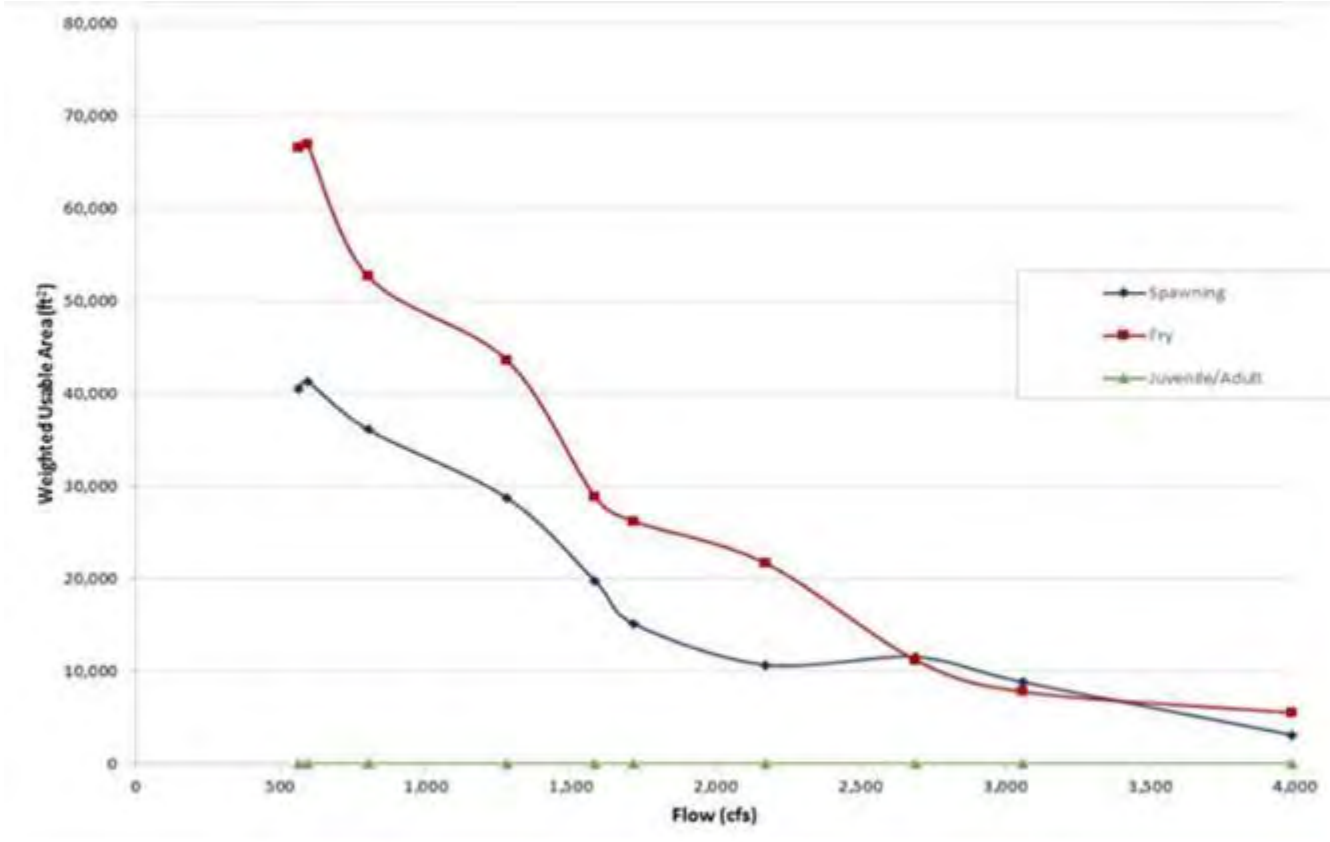


Figure B-3: Reach 1 WUA curves for the spawning, fry, and juvenile and adult life stages of White Sucker

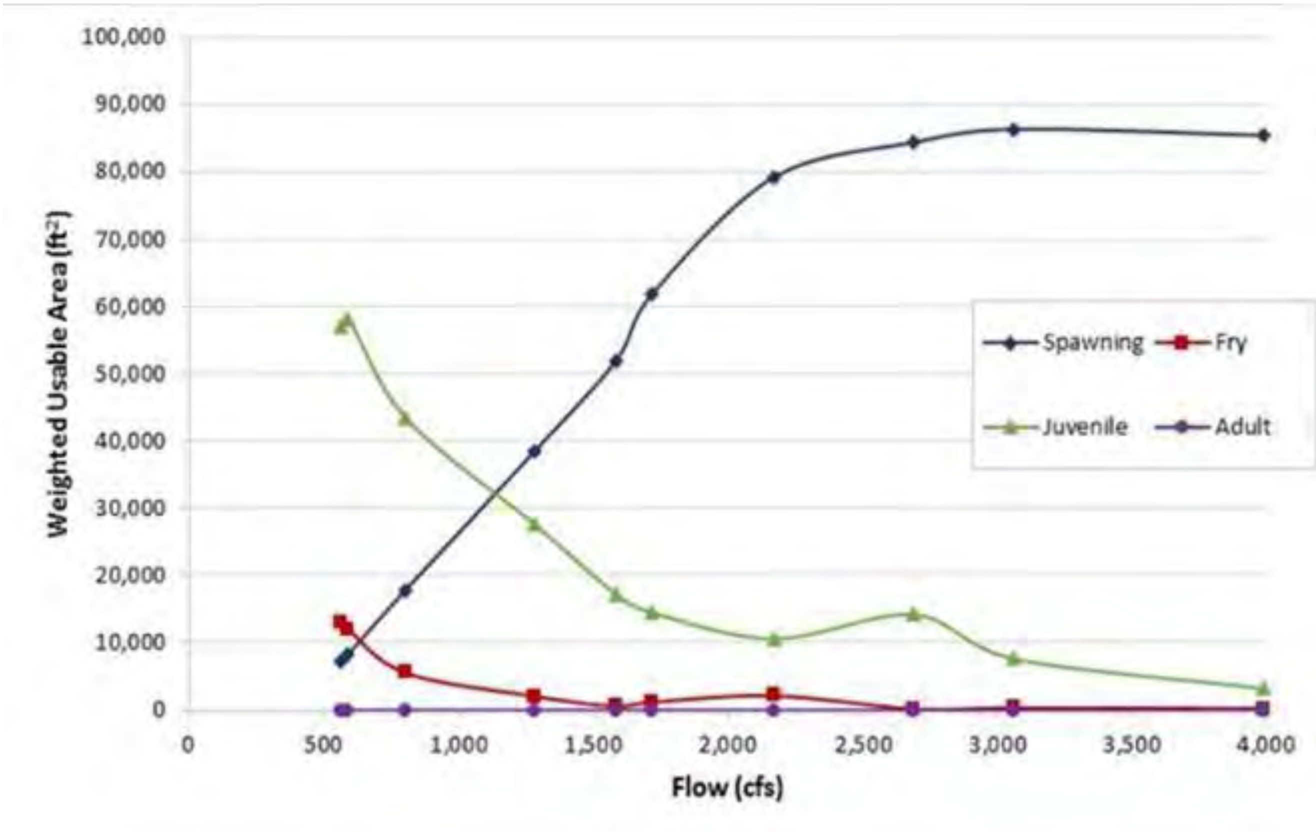


Figure B-4: Reach 1 WUA curves for the spawning, fry, juvenile, and adult life stages of Walleye

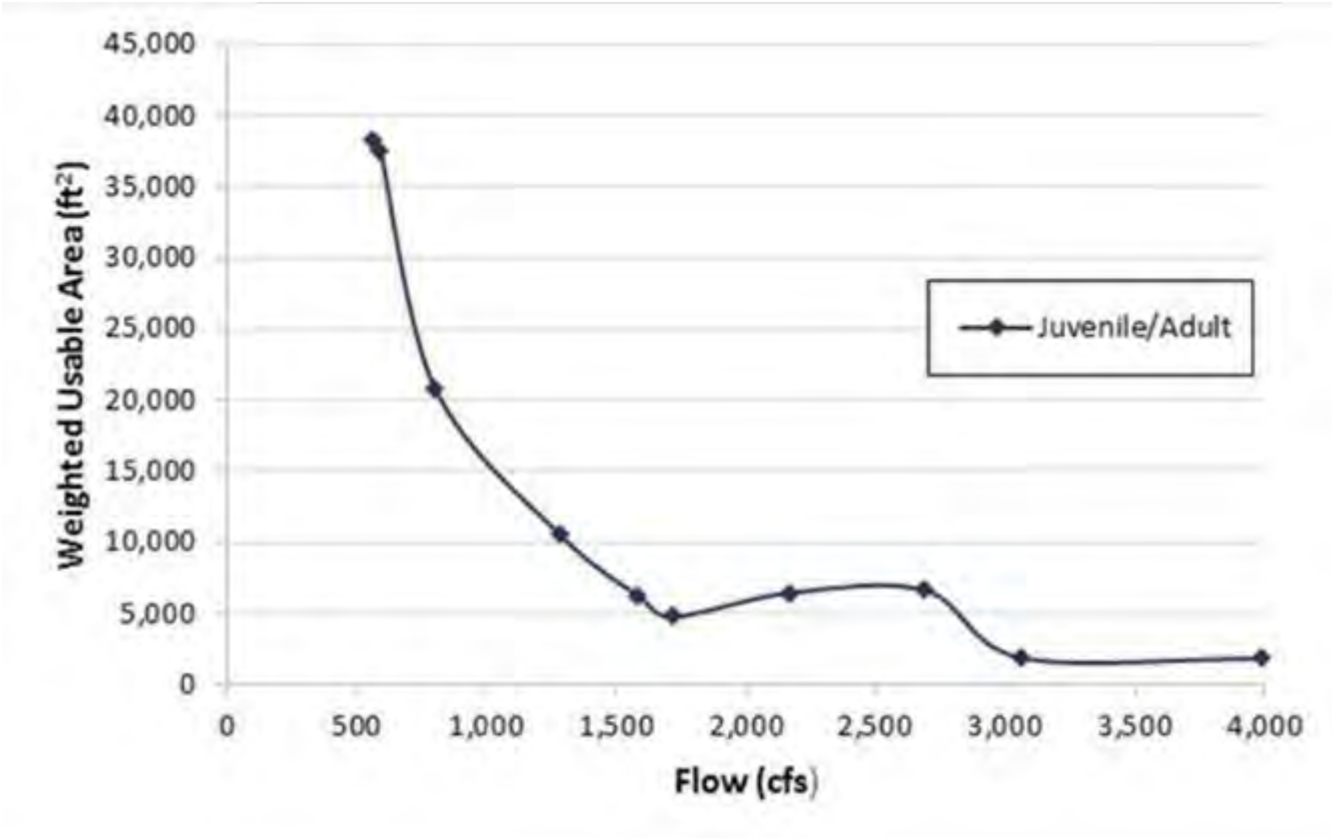


Figure B-5: Reach 1 WUA curves for the juvenile and adult life stages of Tessellated Darter

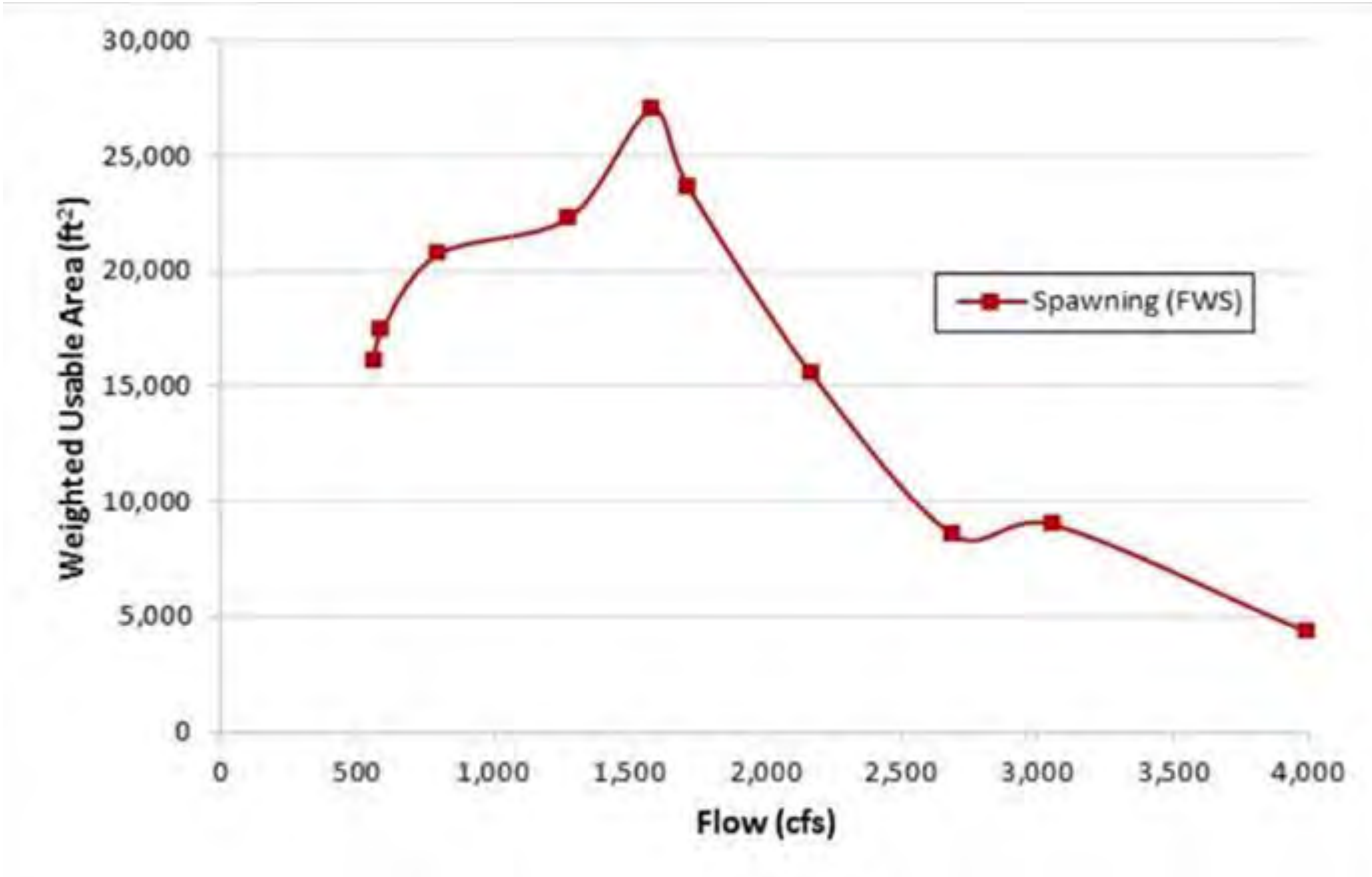


Figure B-6: Reach 1 WUA curves for the spawning life stage of Sea Lamprey

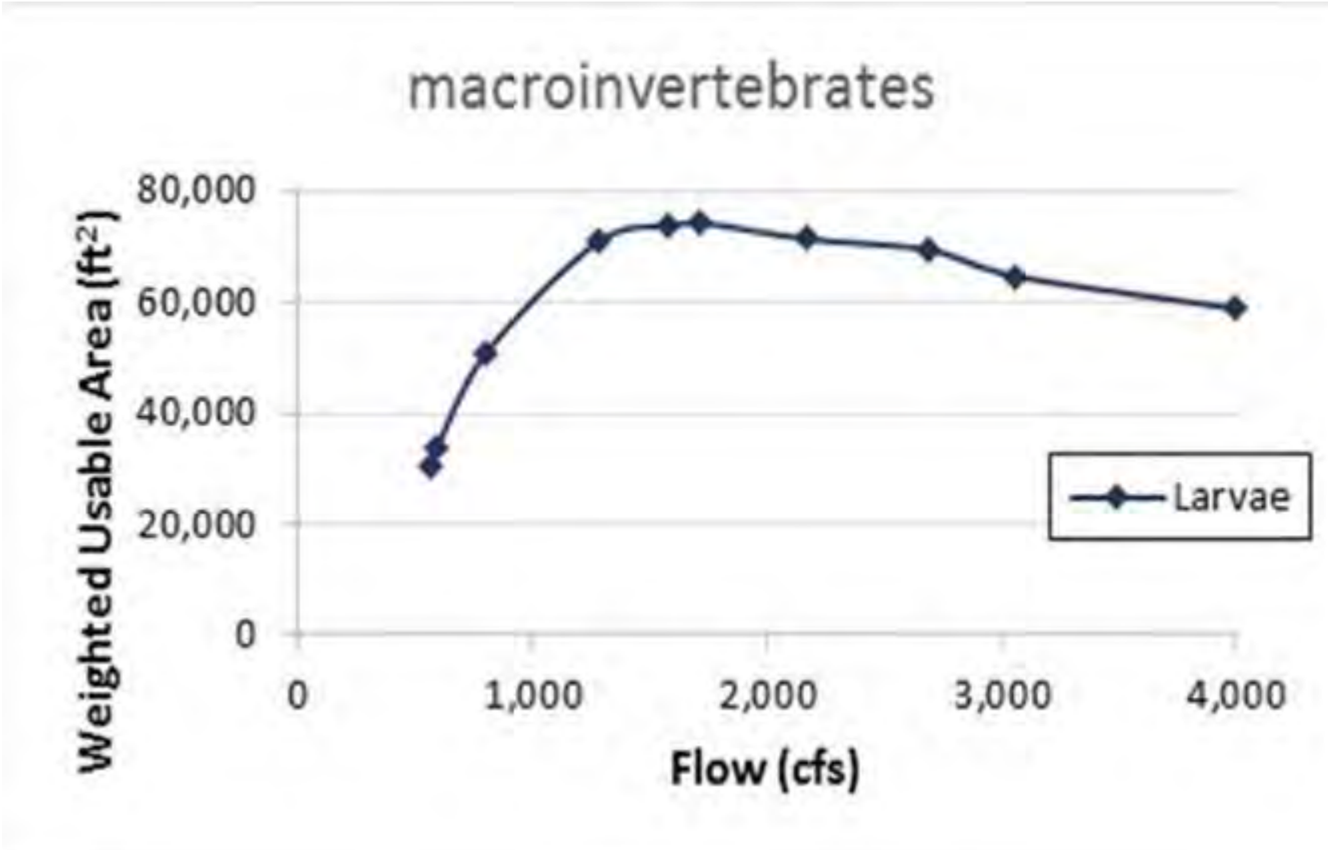


Figure B-7: Reach 1 WUA curves for the larvae life stage of Macroinvertebrates

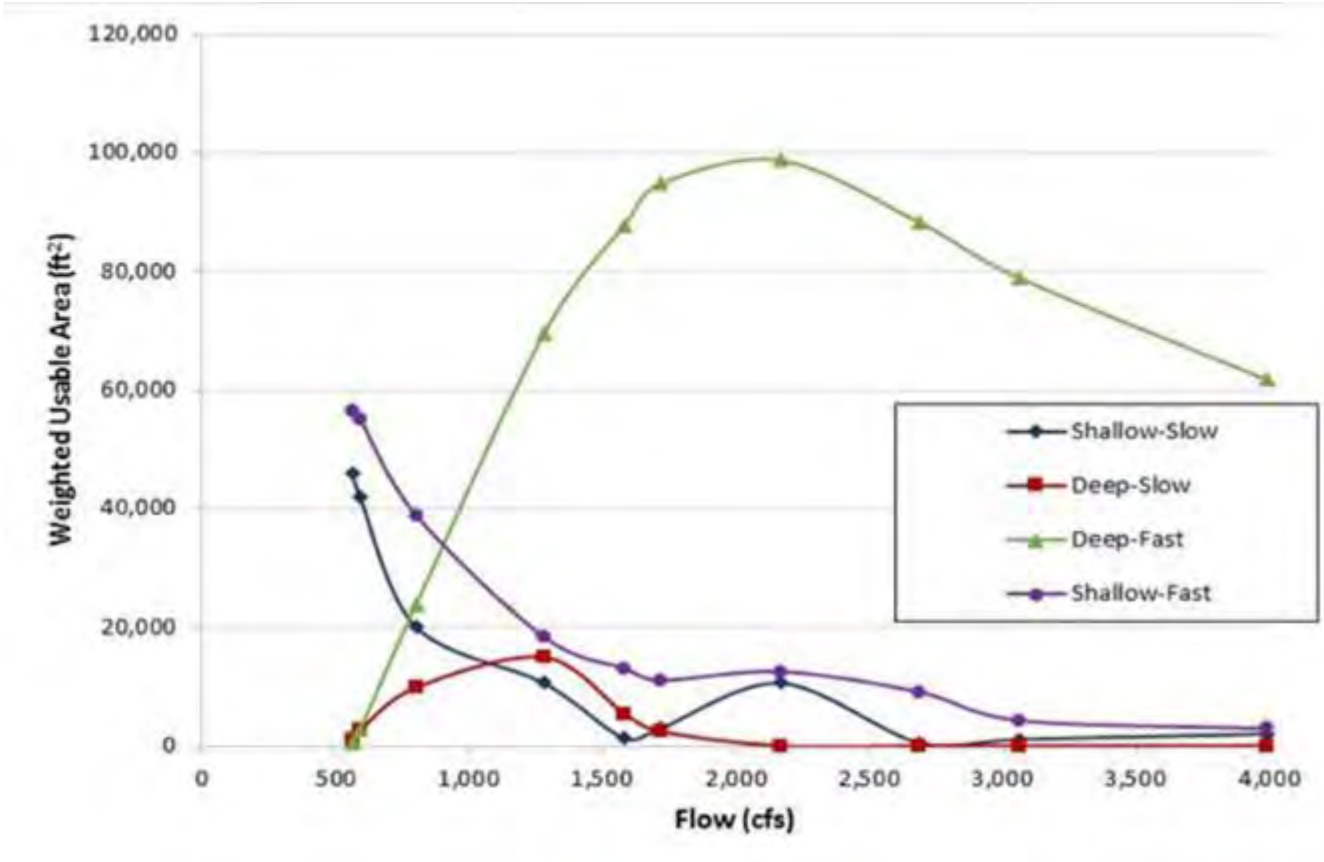


Figure B-8: Reach 1 WUA curves for shallow-slow, deep-slow, deep-fast, and shallow-fast Habitat Guilds

APPENDIX C – REACH 1 (TRANSECTS 10 & 11) HABITAT VERSUS DISCHARGE RELATIONSHIPS

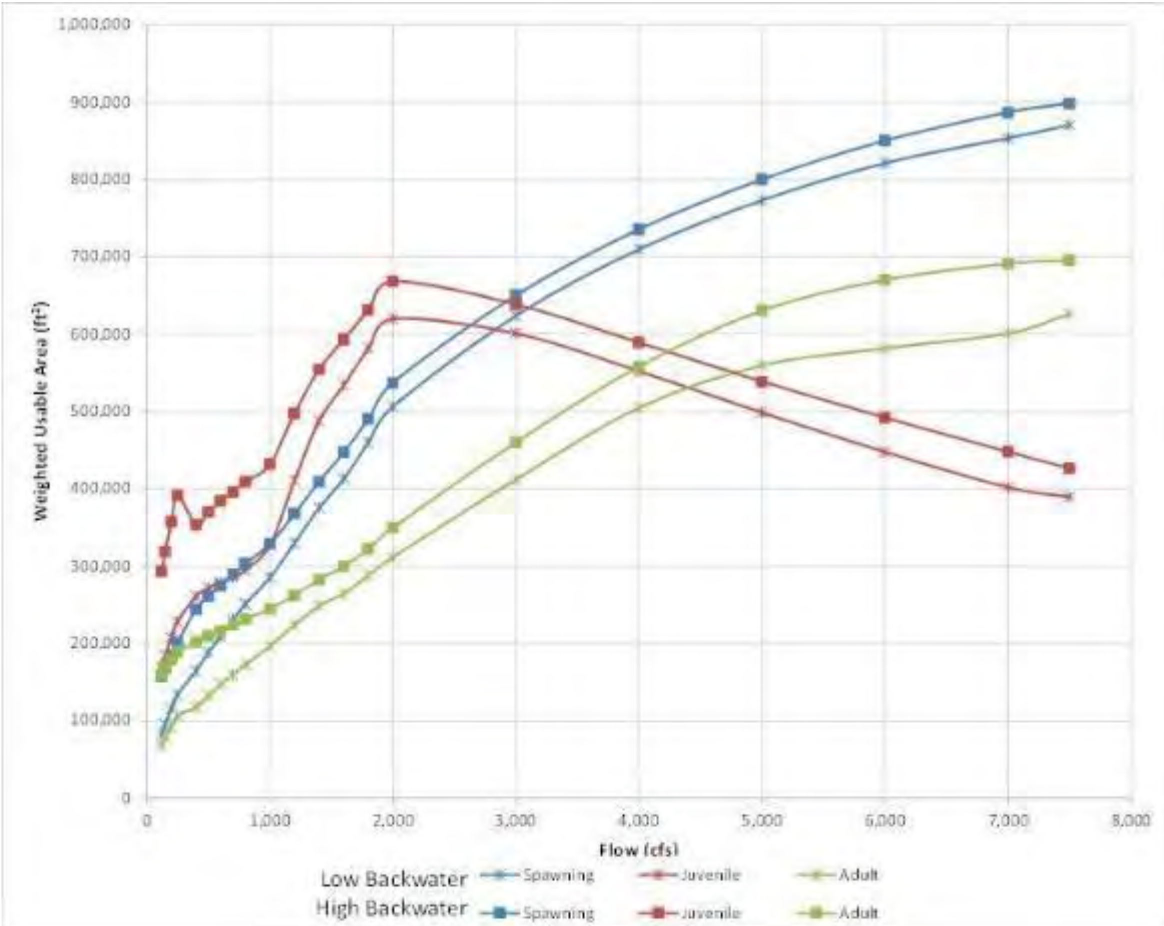


Figure C-1: Reach 1 (Transects 10 & 11) WUA curves for the spawning & incubation, juvenile, and adult life stages of American Shad

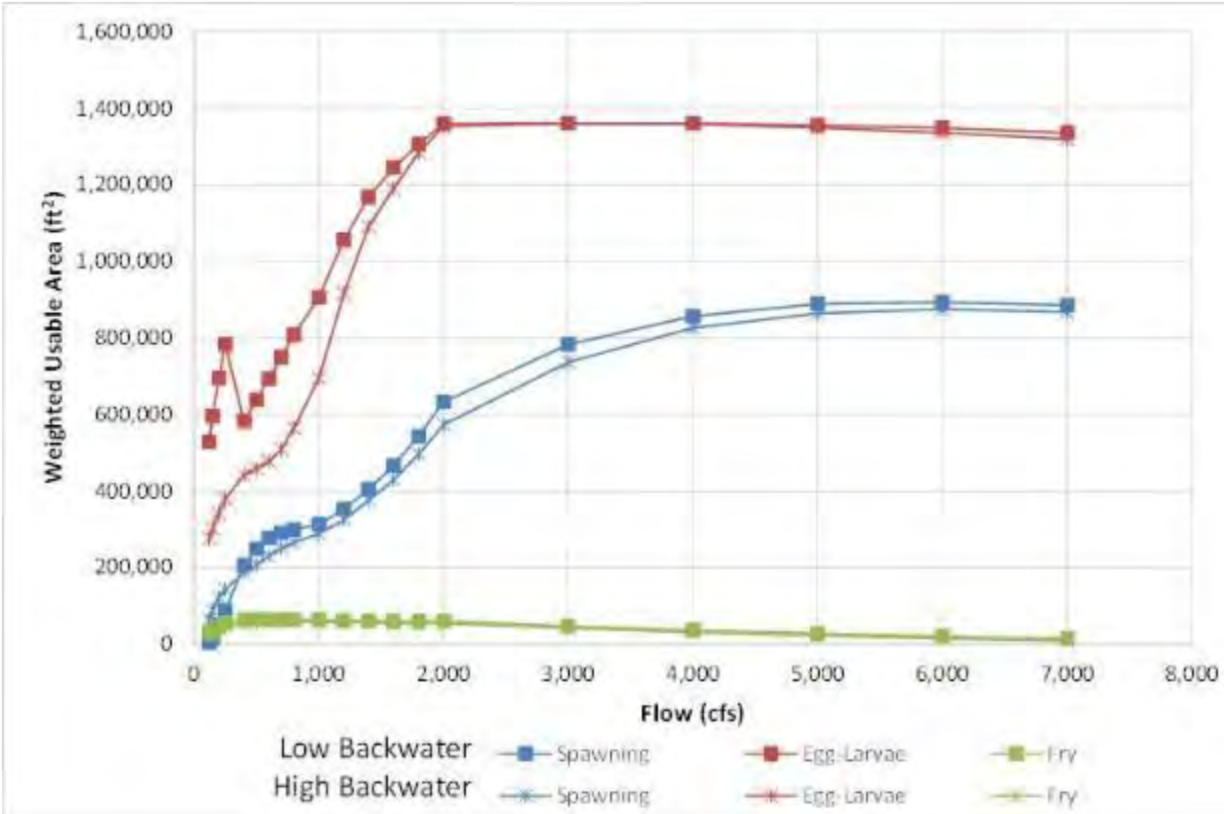


Figure C-2: Reach 1 (Transects 10 & 11) WUA curves for the spawning & incubation, egg-larvae, and fry life stages of Shortnose Sturgeon

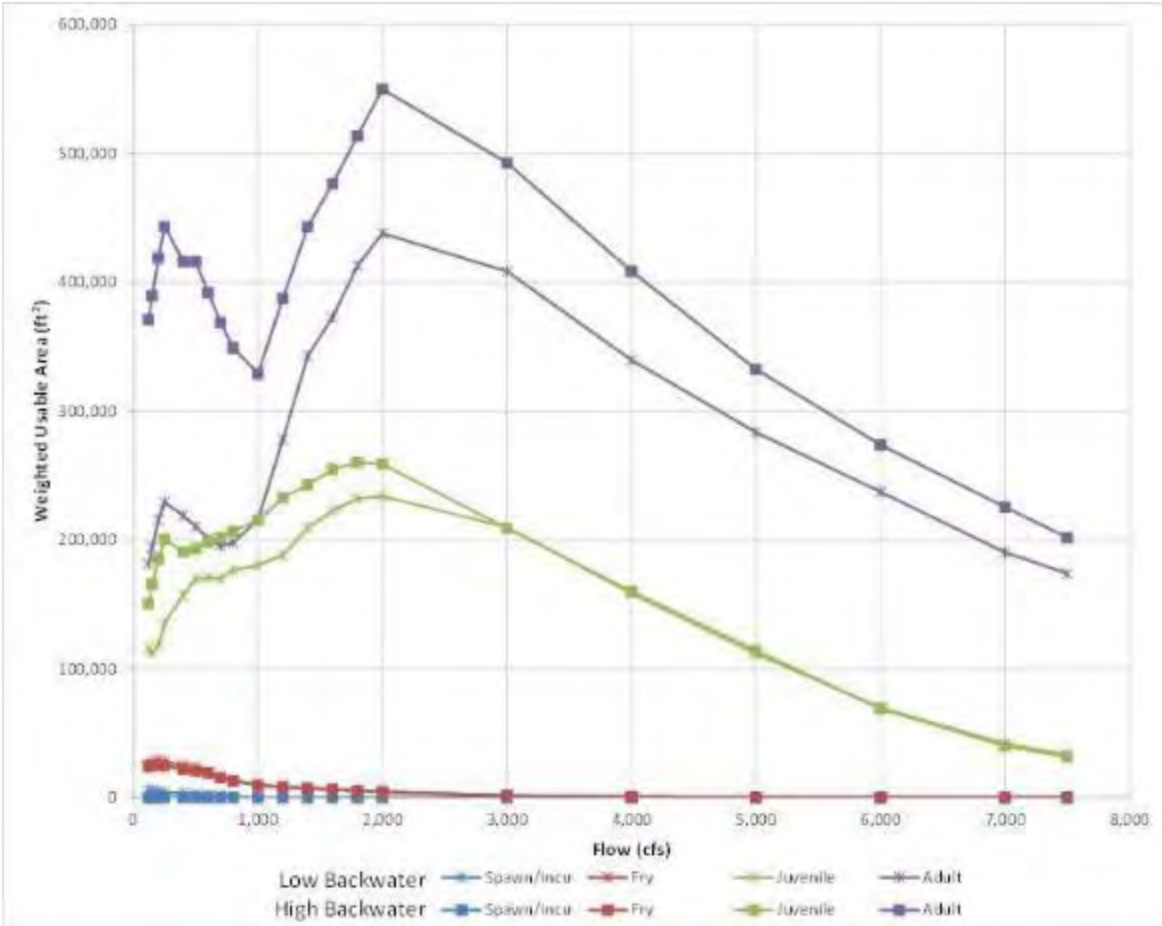


Figure C-3: Reach 1 (Transects 10 & 11) WUA curves for the spawning & incubation, fry, juvenile, and adult life stages of Fallfish

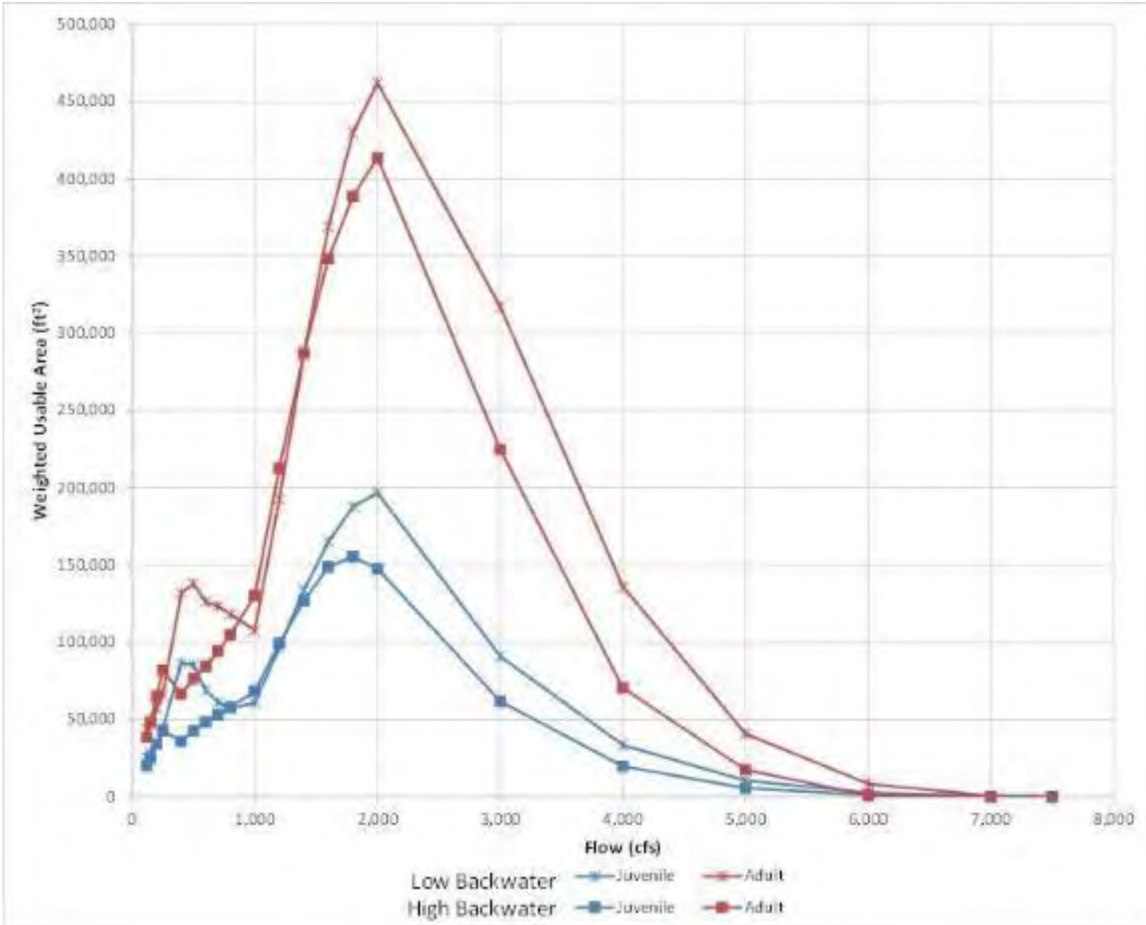


Figure C-4: Reach 1 (Transects 10 & 11) WUA curves for the juvenile and adult life stages of Longnose Dace

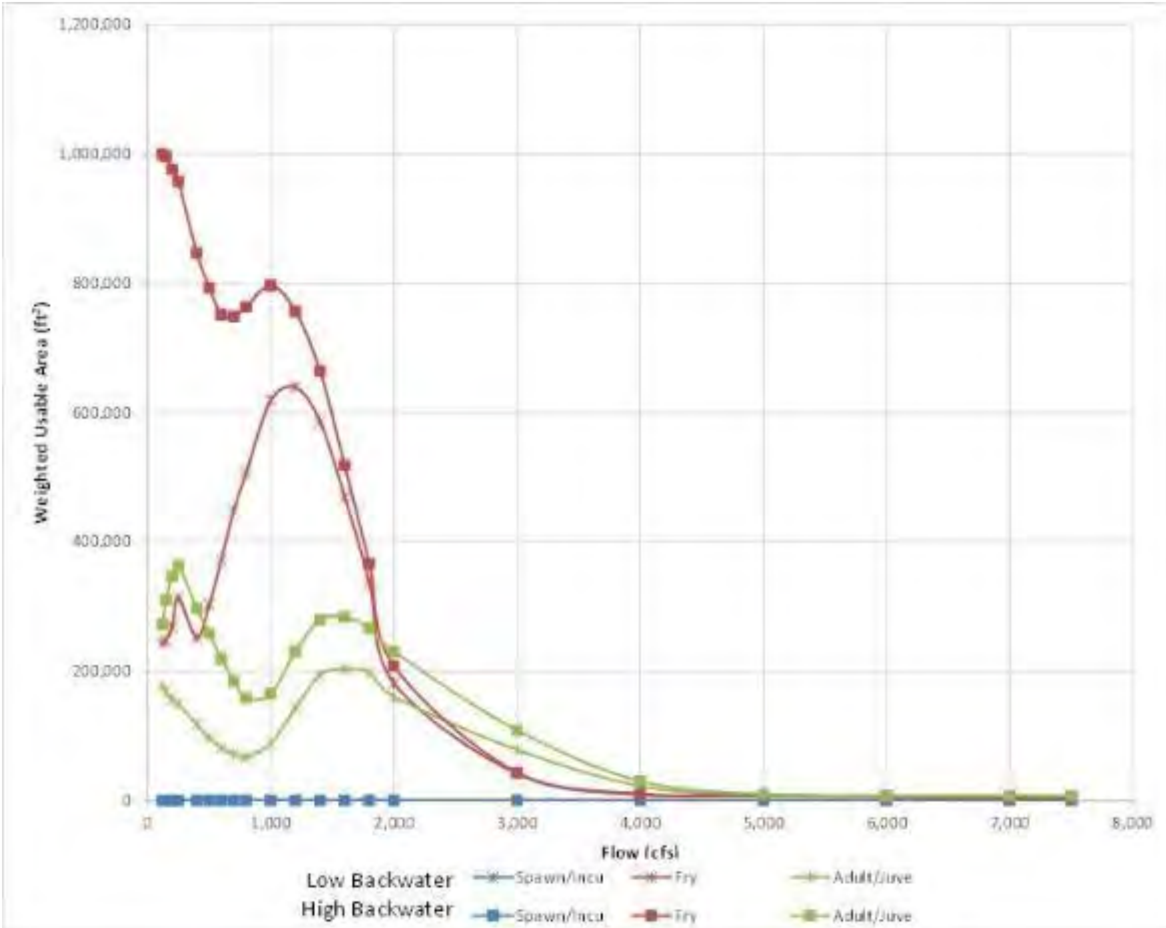


Figure C-5: Reach 1 (Transects 10 & 11) WUA curves for the spawning & incubation, fry, and juvenile & adult life stages of White Sucker

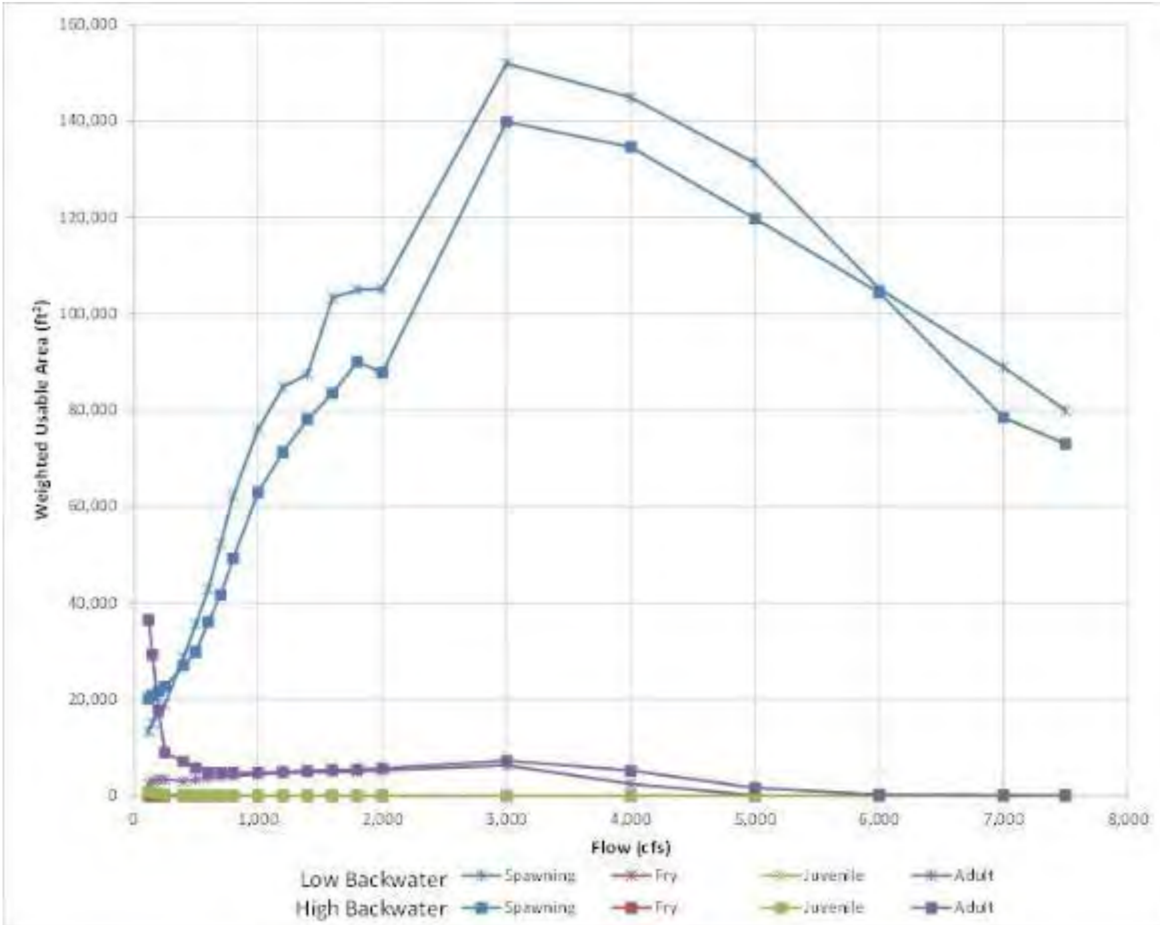


Figure C-6: Reach 1 (Transects 10 & 11) WUA curves for the spawning & incubation, fry, juvenile, and adult life stages of Walleye

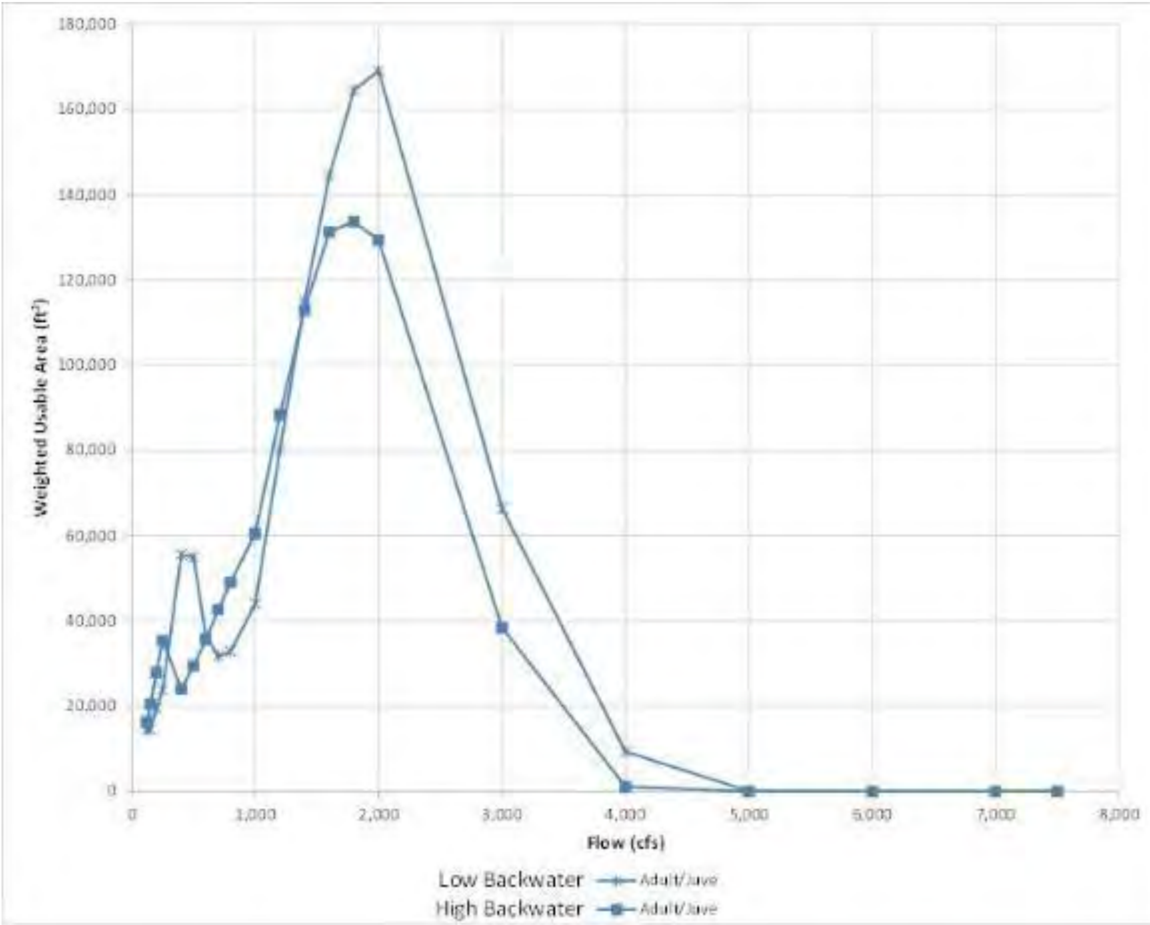


Figure C-7: Reach 1 (Transects 10 & 11) WUA curves for the juvenile & adult life stage of Tessellated Darter

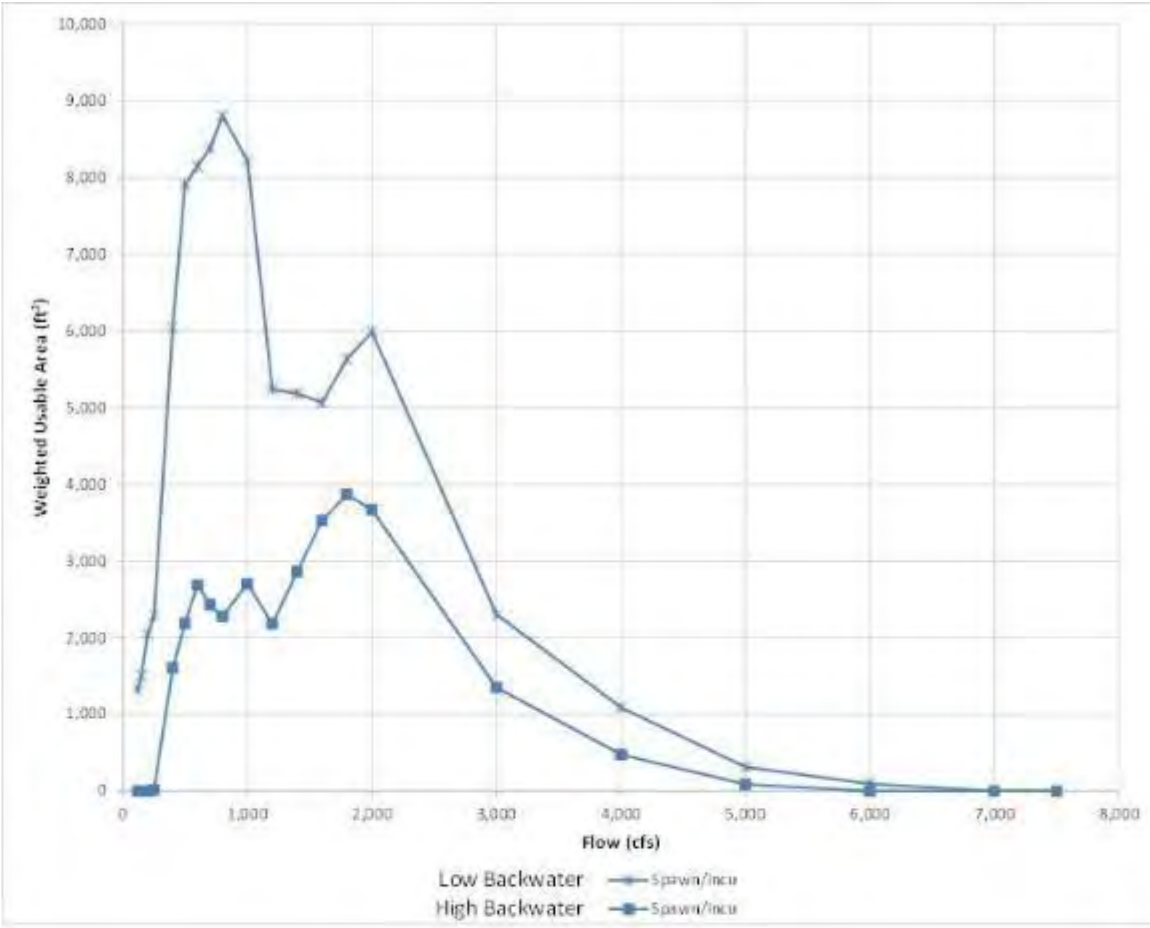


Figure C-8: Reach 1 (Transects 10 & 11) WUA curves for the spawning & incubation life stage of Sea Lamprey

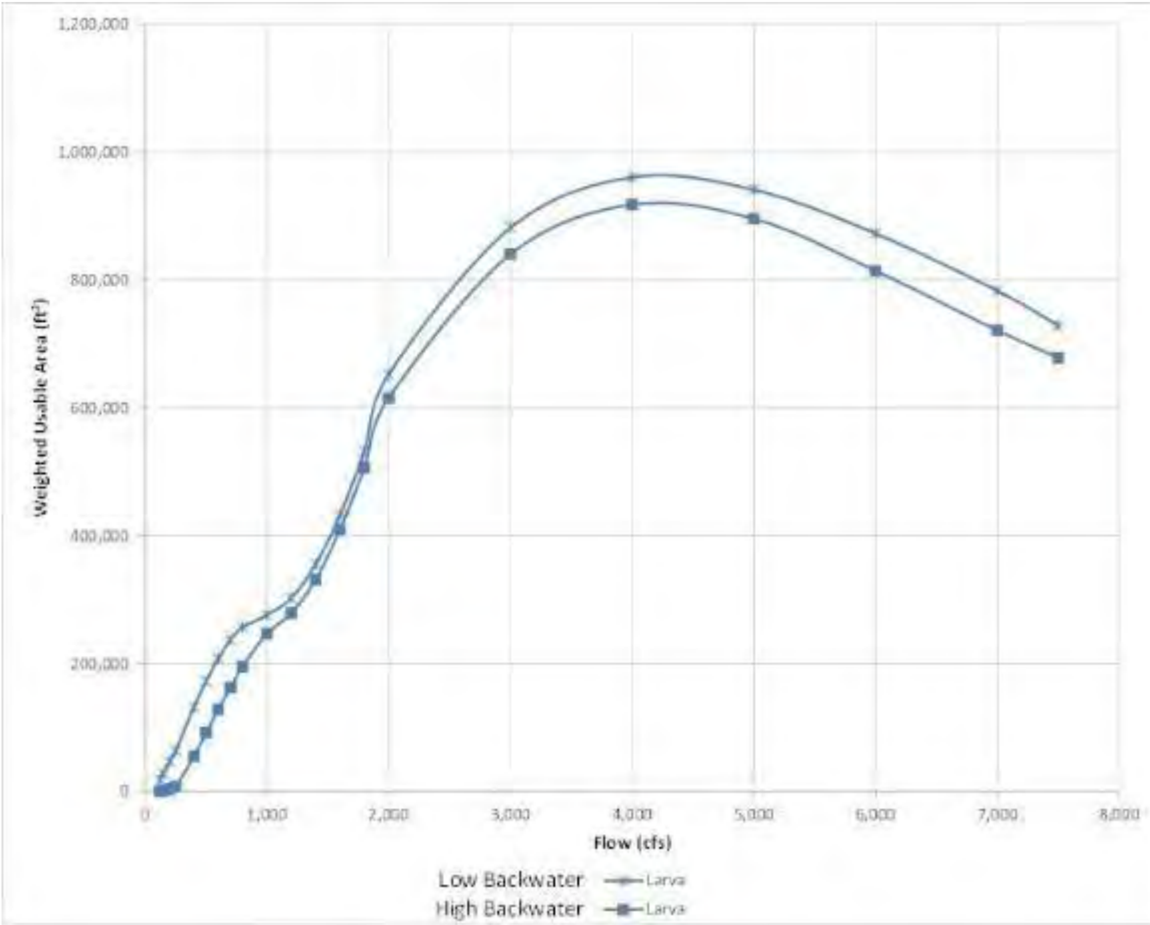


Figure C-9: Reach 1 (Transects 10 & 11) WUA curves for the larva life stage of Macroinvertebrates

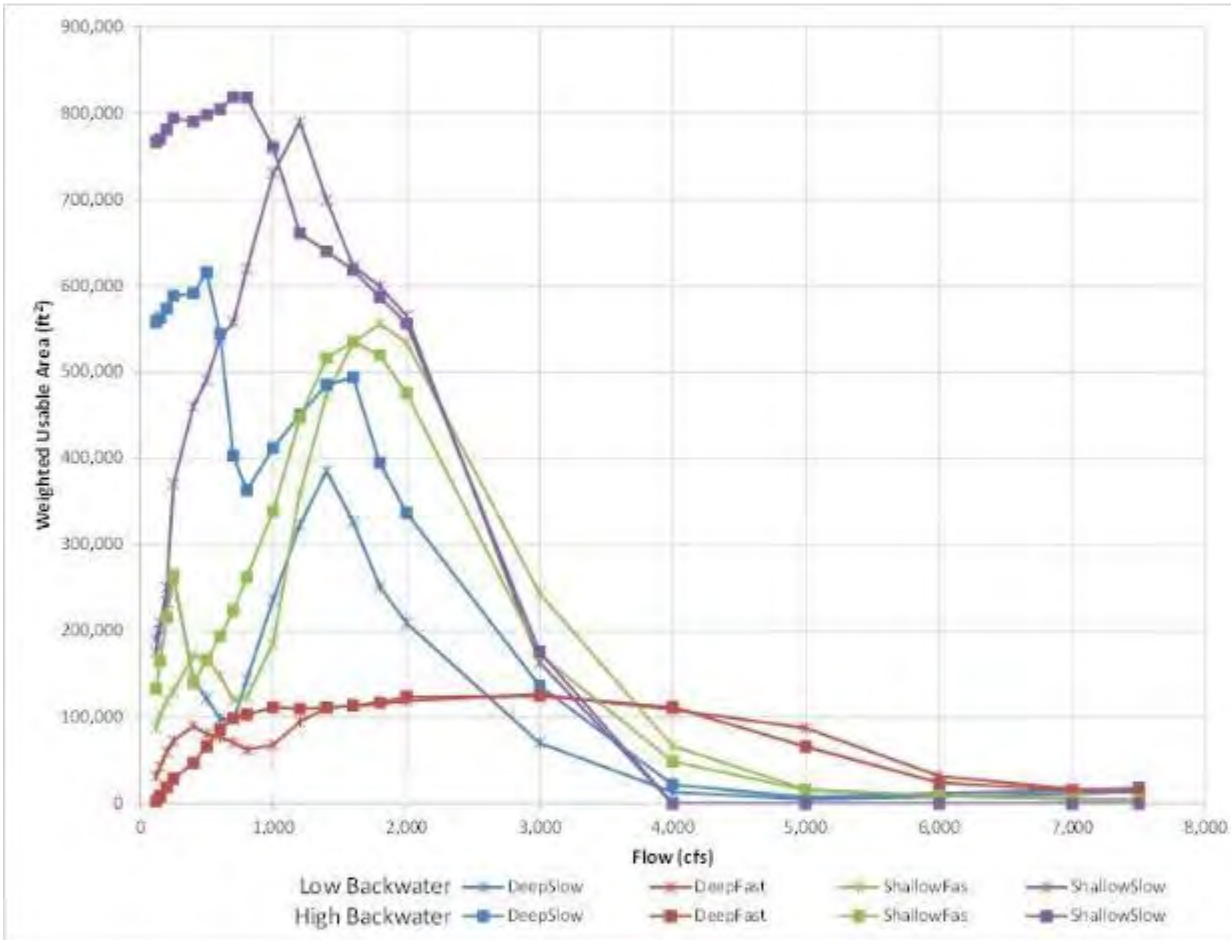


Figure C-10: Reach 1 (Transects 10 & 11) WUA curves for deep-slow, deep-fast, shallow-fast, and shallow-slow Habitat Guilds

APPENDIX D - REACH 2 HABITAT VERSUS DISCHARGE RELATIONSHIPS

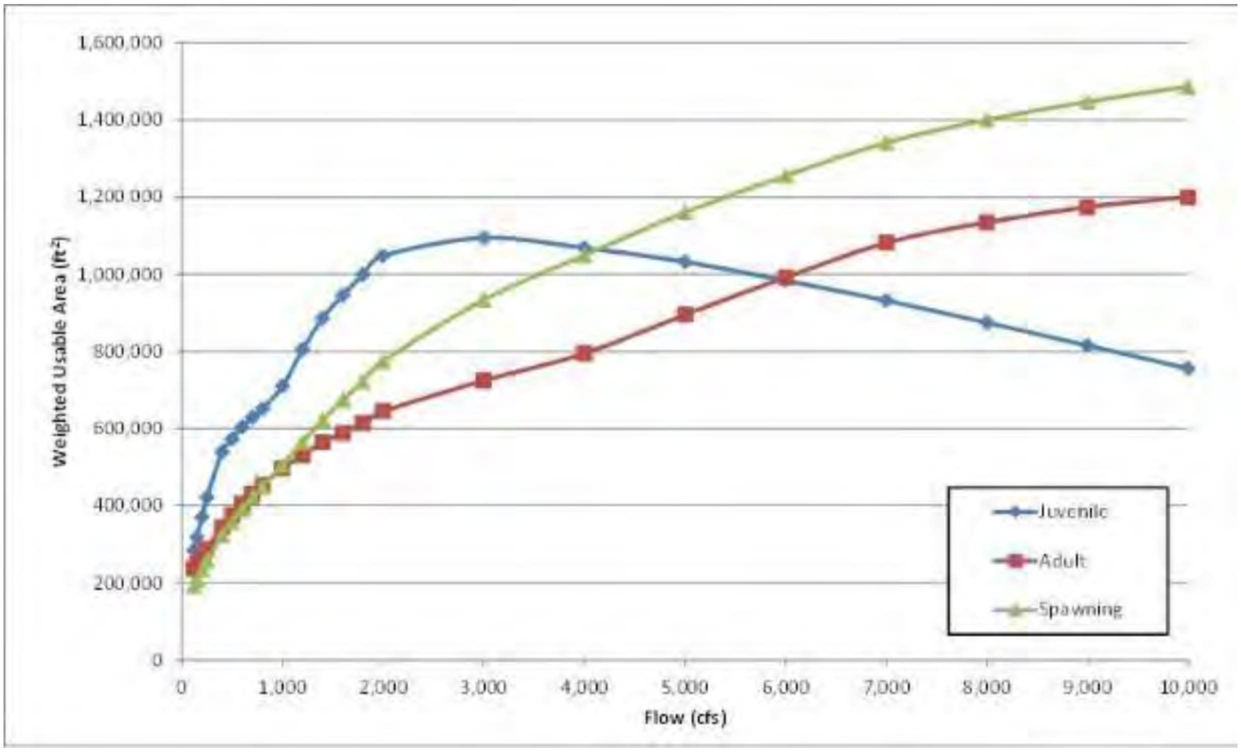


Figure D-1: Reach 2 WUA curves for the spawning & incubation, juvenile and adult life stages of American Shad

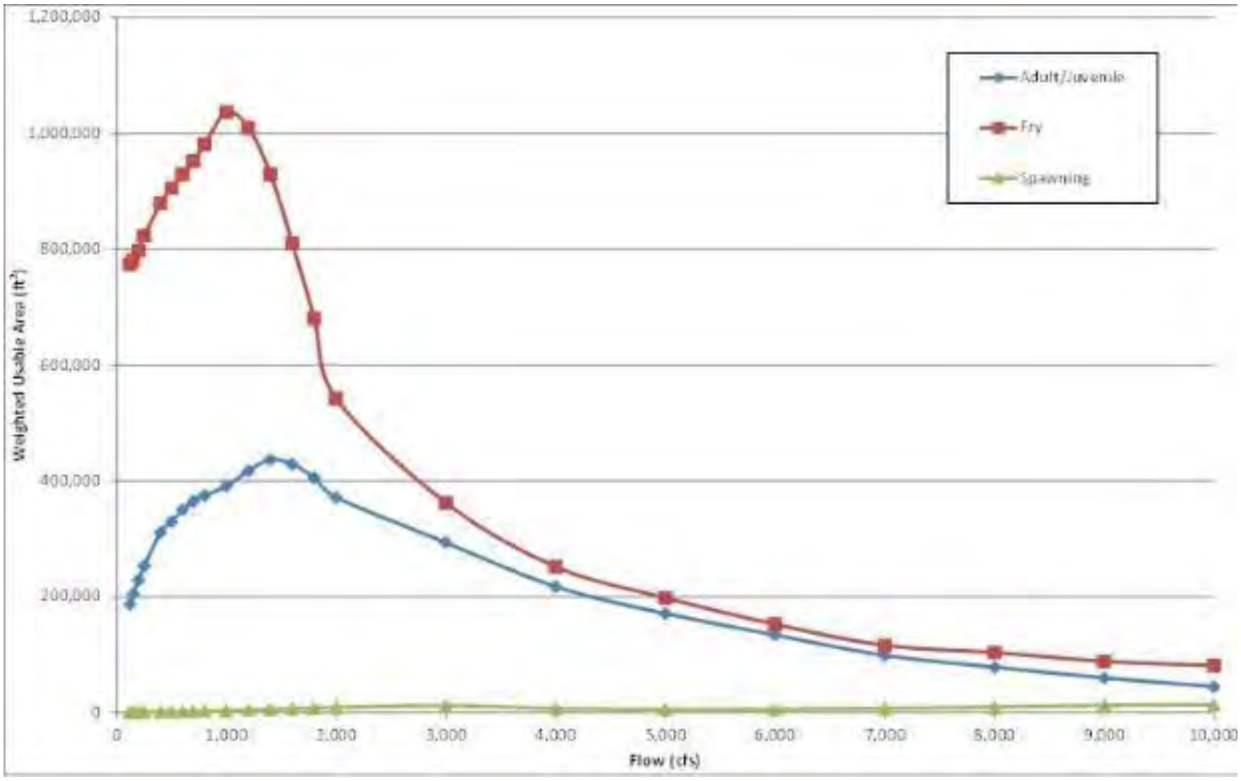


Figure D-2: Reach 2 WUA curves for the spawning & incubation, fry, juvenile/adult life stages of White Sucker

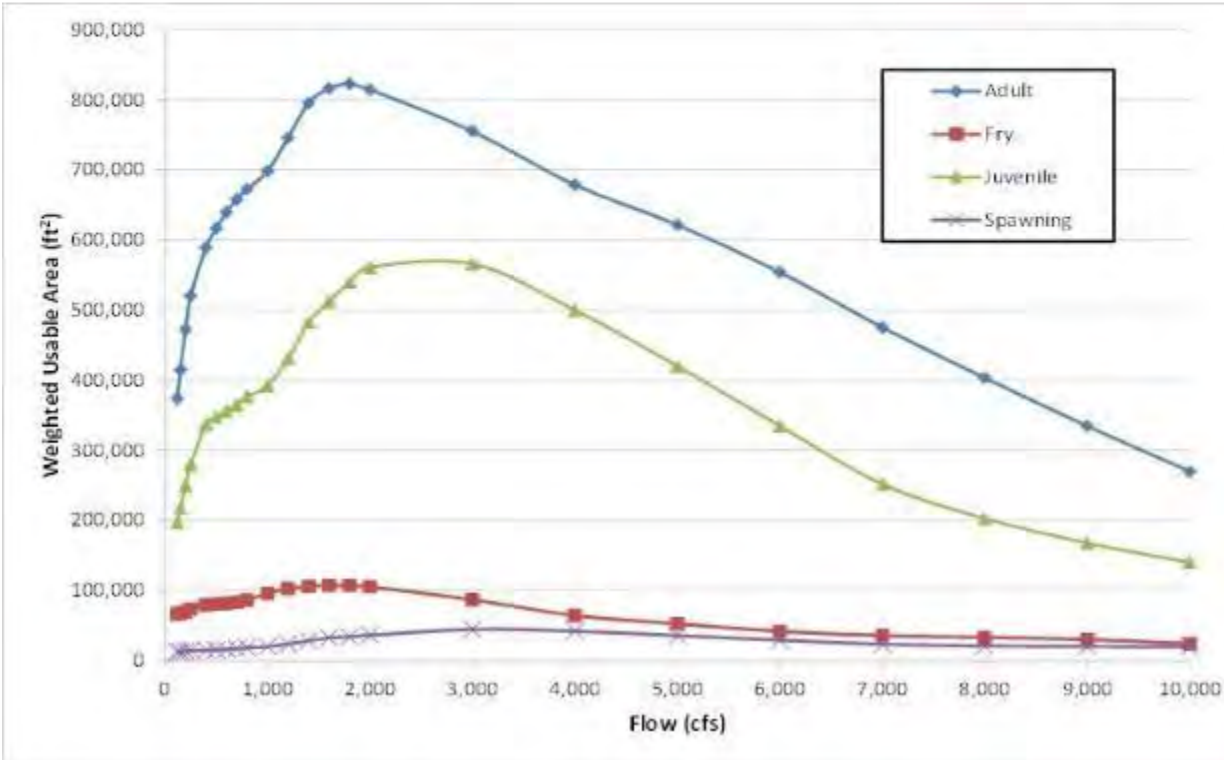
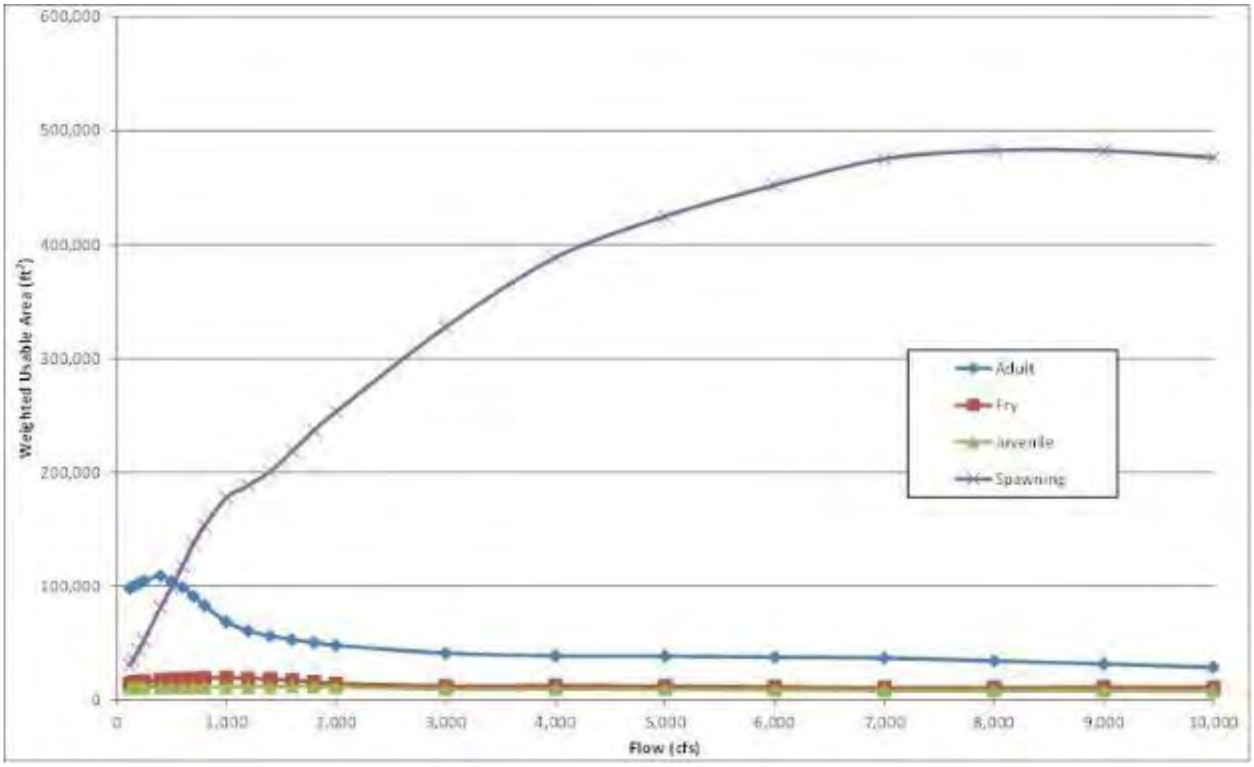


Figure D-3: Reach 2 WUA curves for the spawning & incubation, fry, juvenile and adult life stages of Fallfish



Figures D-4: Reach 2 WUA curves for the spawning & incubation, fry, juvenile and adult life stages of Walleye

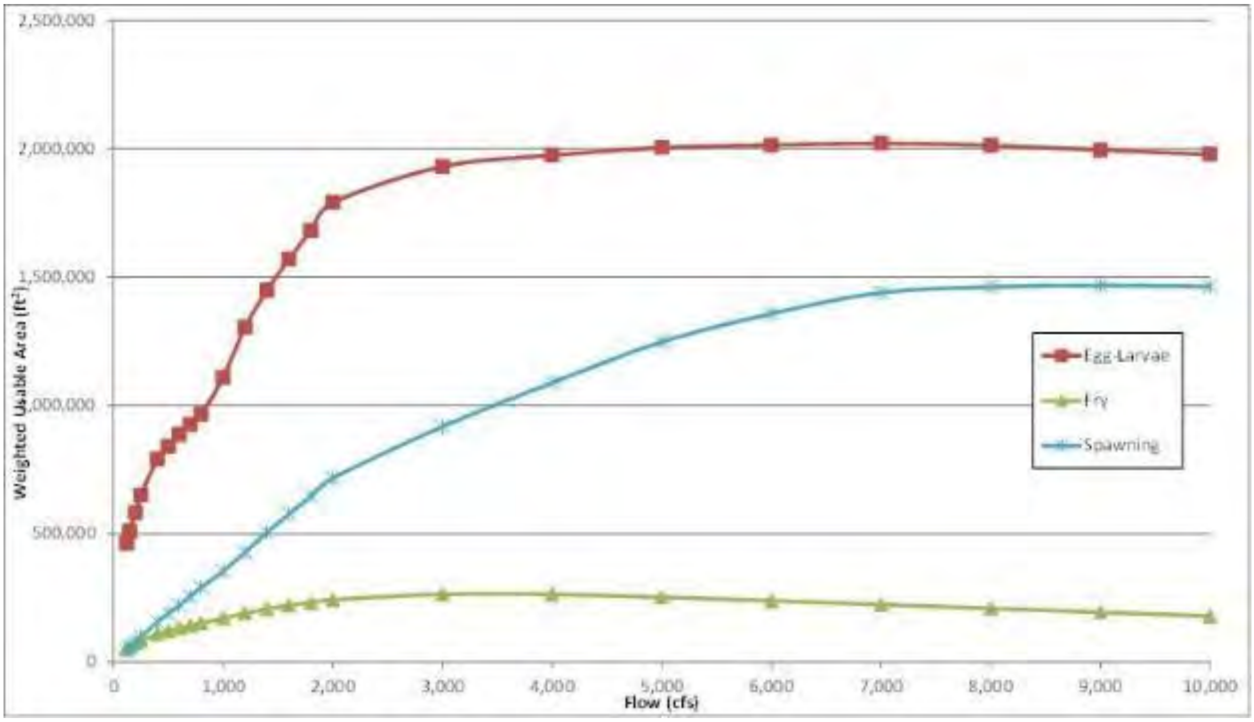


Figure D-5: Reach 2 WUA curves for the spawning & incubation, egg-larvae, fry, juvenile, and adult life stages of Shortnose Sturgeon

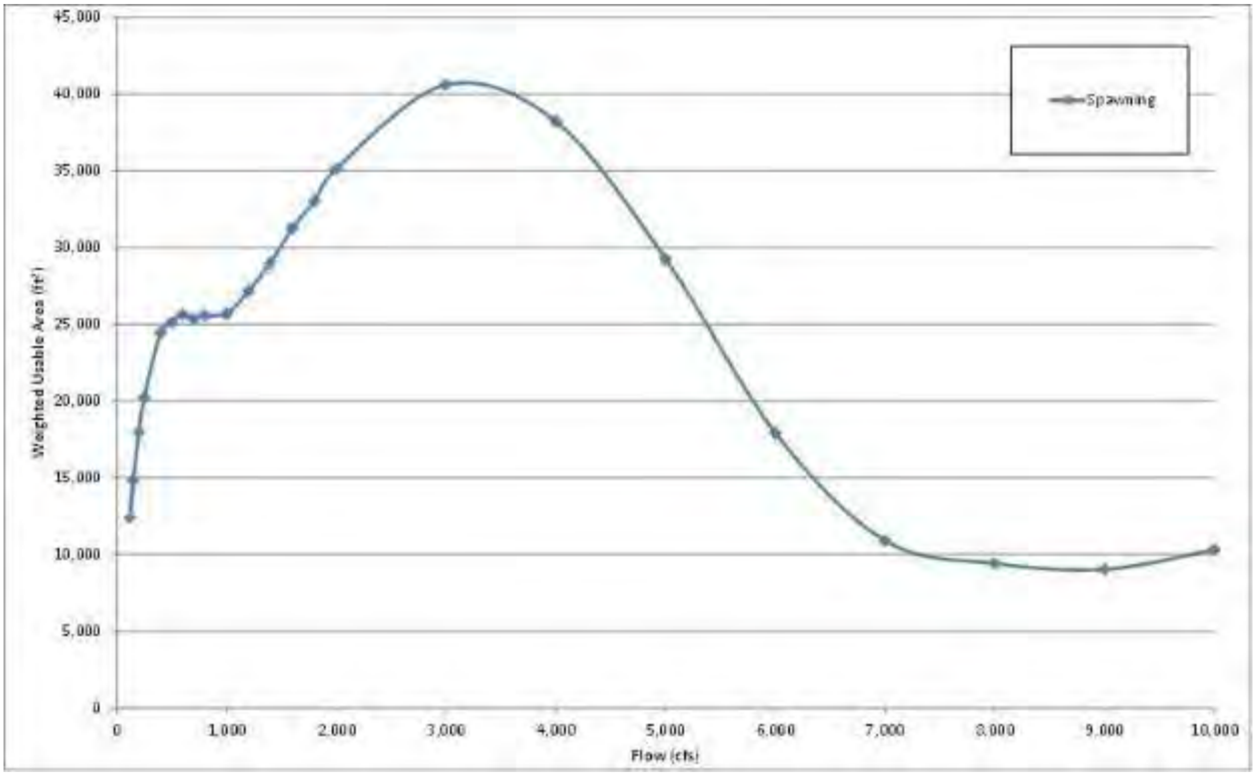


Figure D-6: Reach 2 WUA curves for the FWS spawning life stage of Sea Lamprey

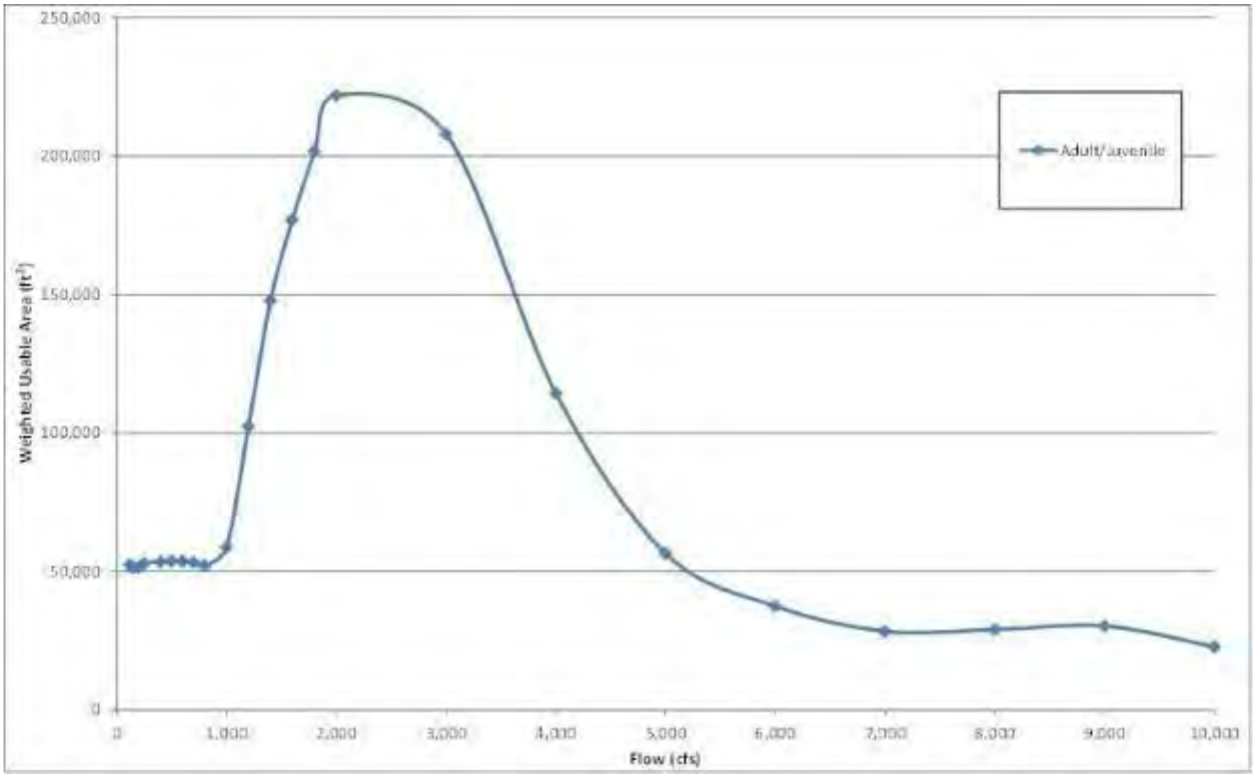


Figure D-7: Reach 2 WUA curves for the juvenile/adult life stages of Tessellated Darter

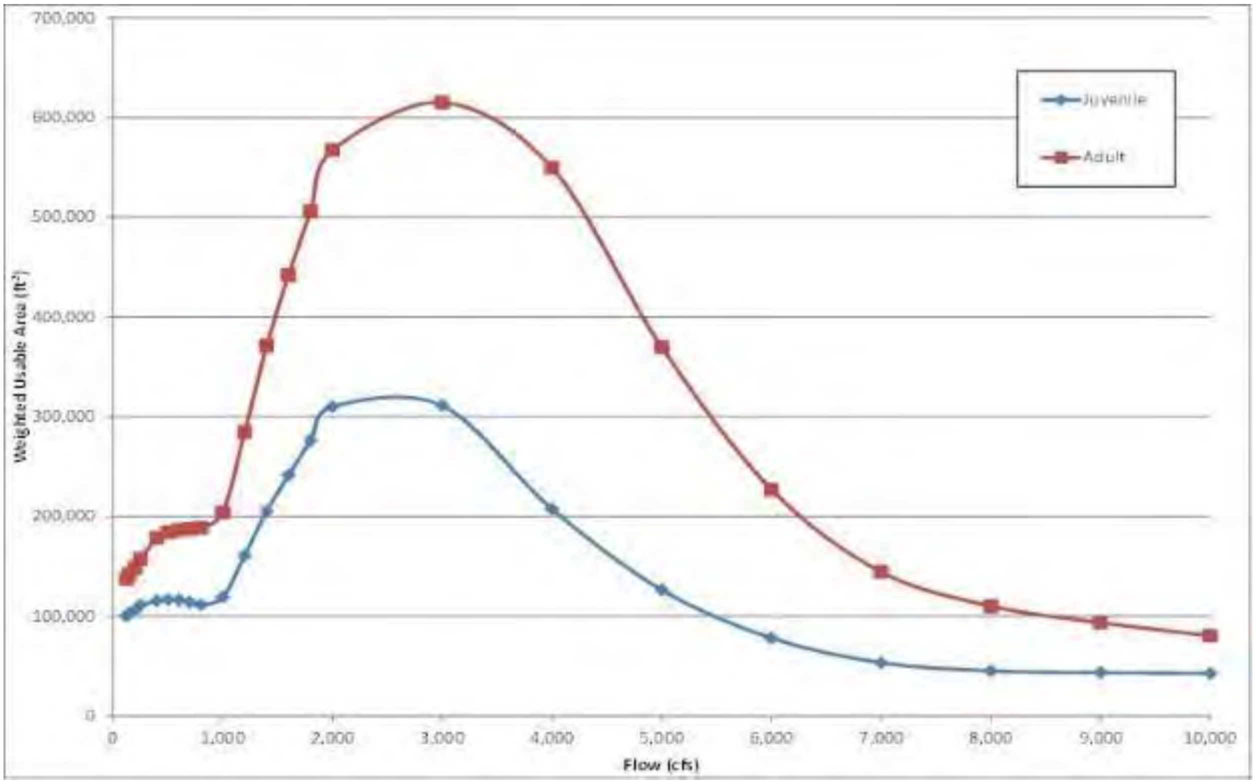


Figure D-8: Reach 2 WUA curves for the juvenile and adult life stages of Longnose Dace

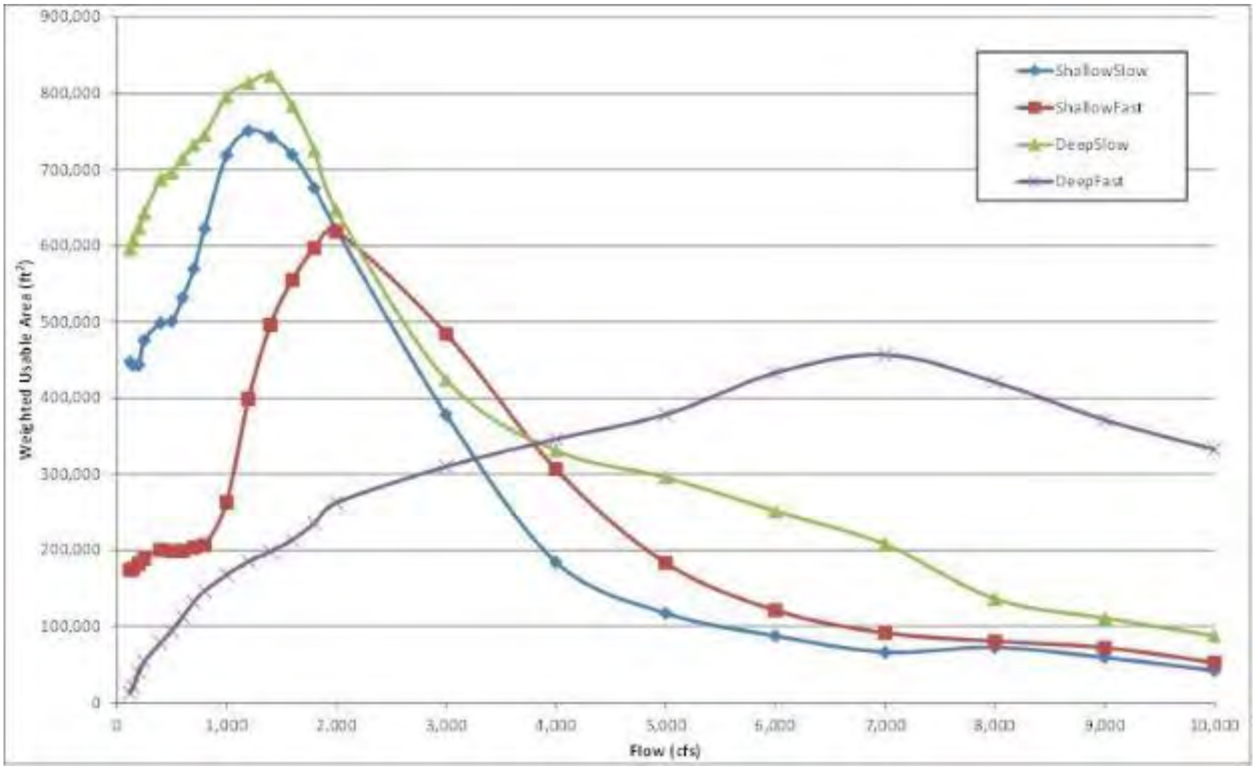


Figure D-9: Reach 2 WUA curves for the Habitat Guilds

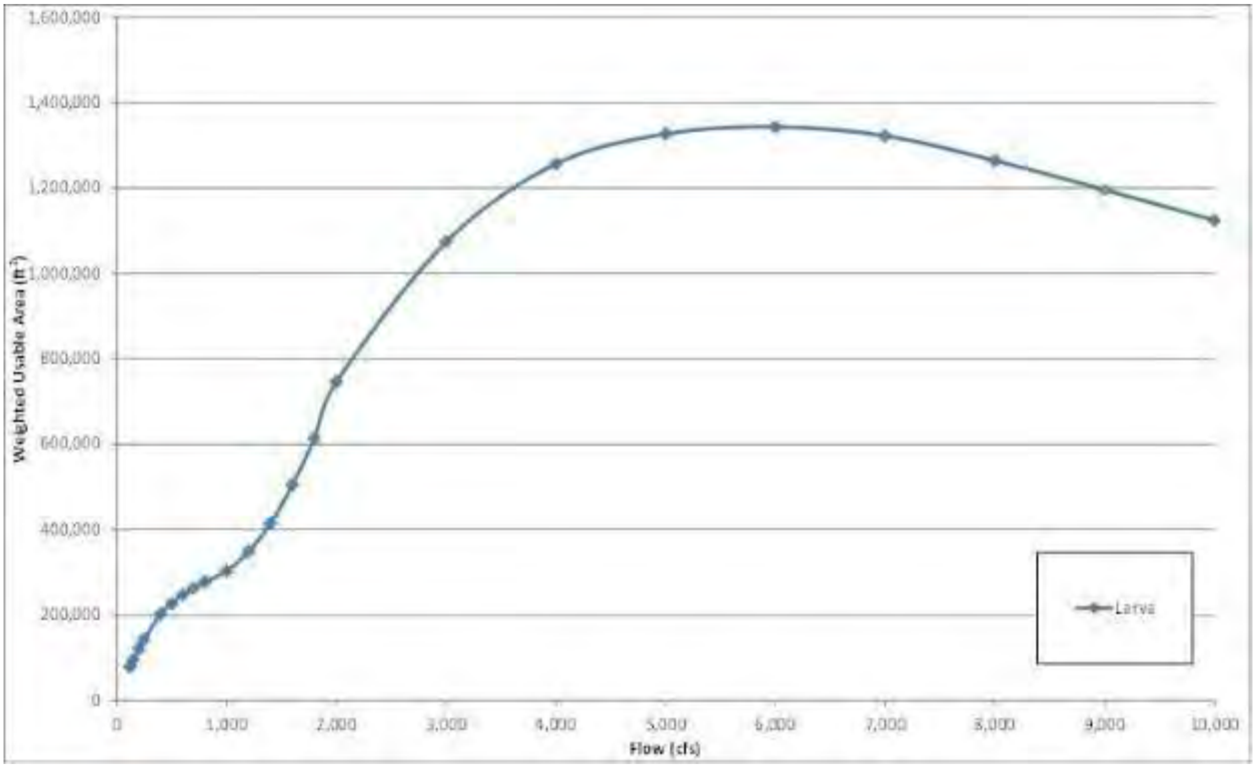
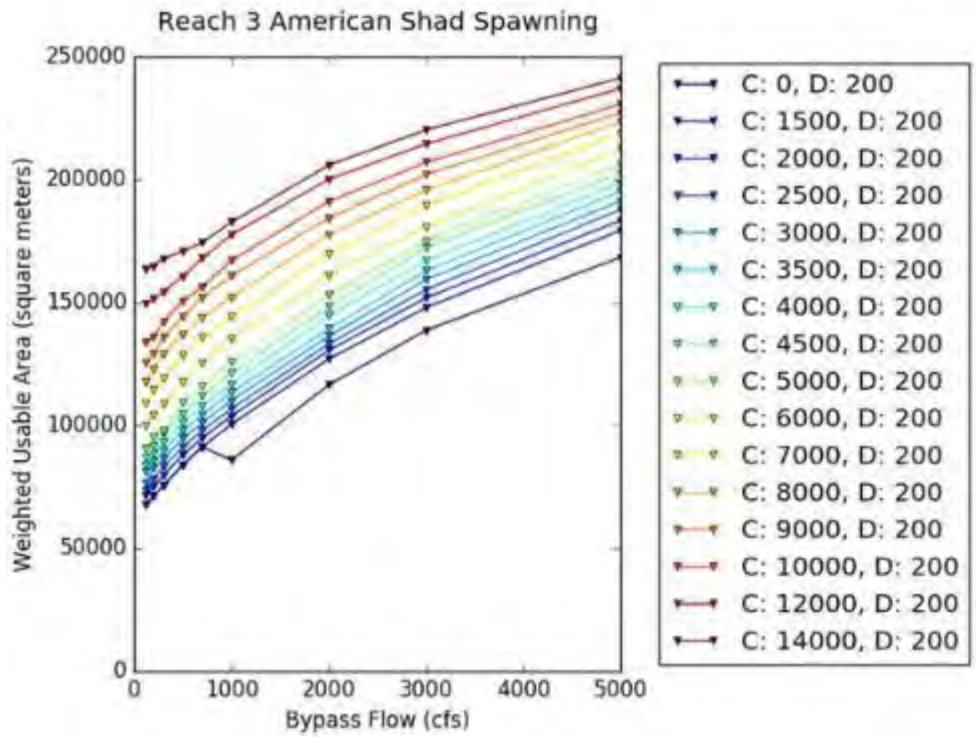


Figure D-10: Reach 2 WUA curves for Macroinvertebrates

APPENDIX E – REACH 3 COMBINED SUITABILITY HABITAT MAPS AND HABITAT VERSUS DISCHARGE RELATIONSHIPS

Due to file size the Appendix E Maps have been attached as a separate pdf to his filing submission.

See appendix_e.pdf



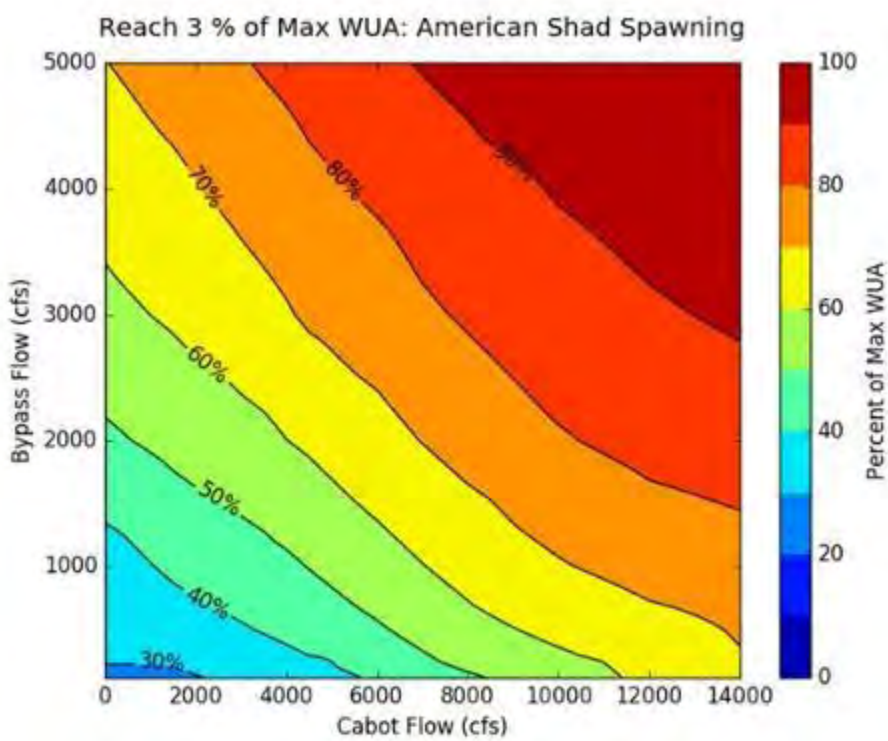


Figure E-1: Reach 3 WUA curves for the spawning & incubation life stage of American Shad

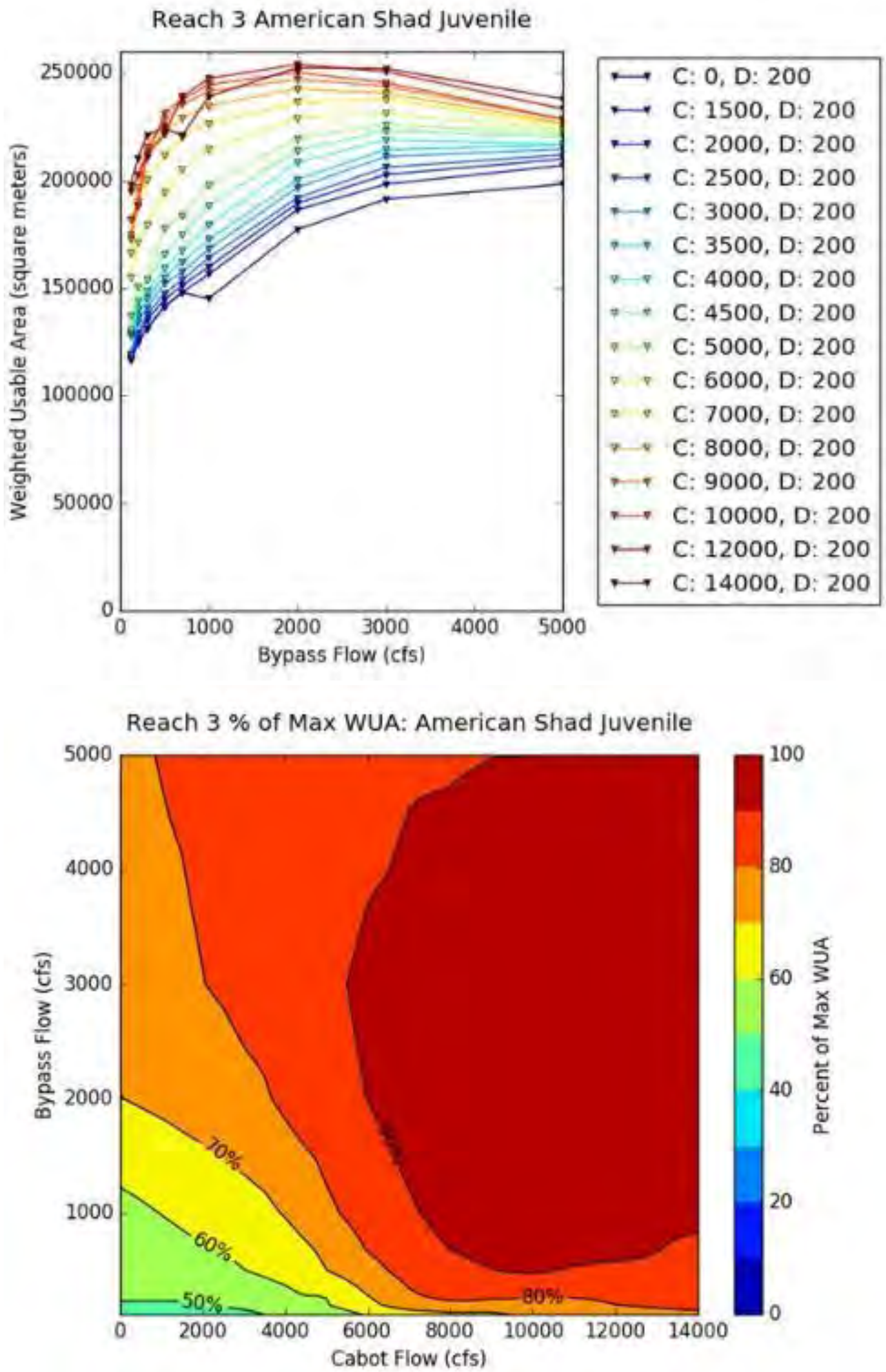


Figure E-2: Reach 3 WUA curves for the juvenile life stage of American Shad

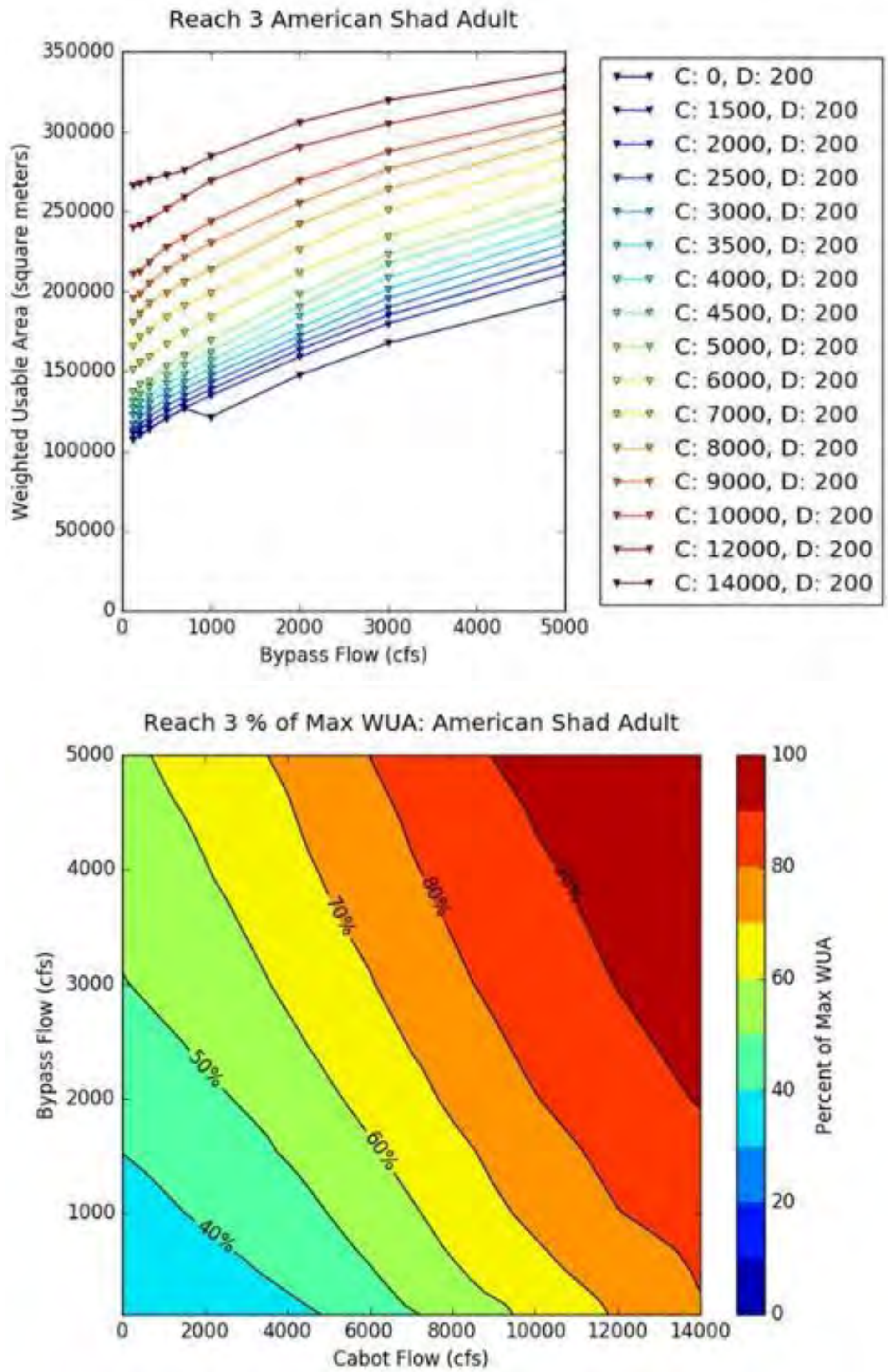


Figure E-3: Reach 3 WUA curves for the adult life stage of American Shad

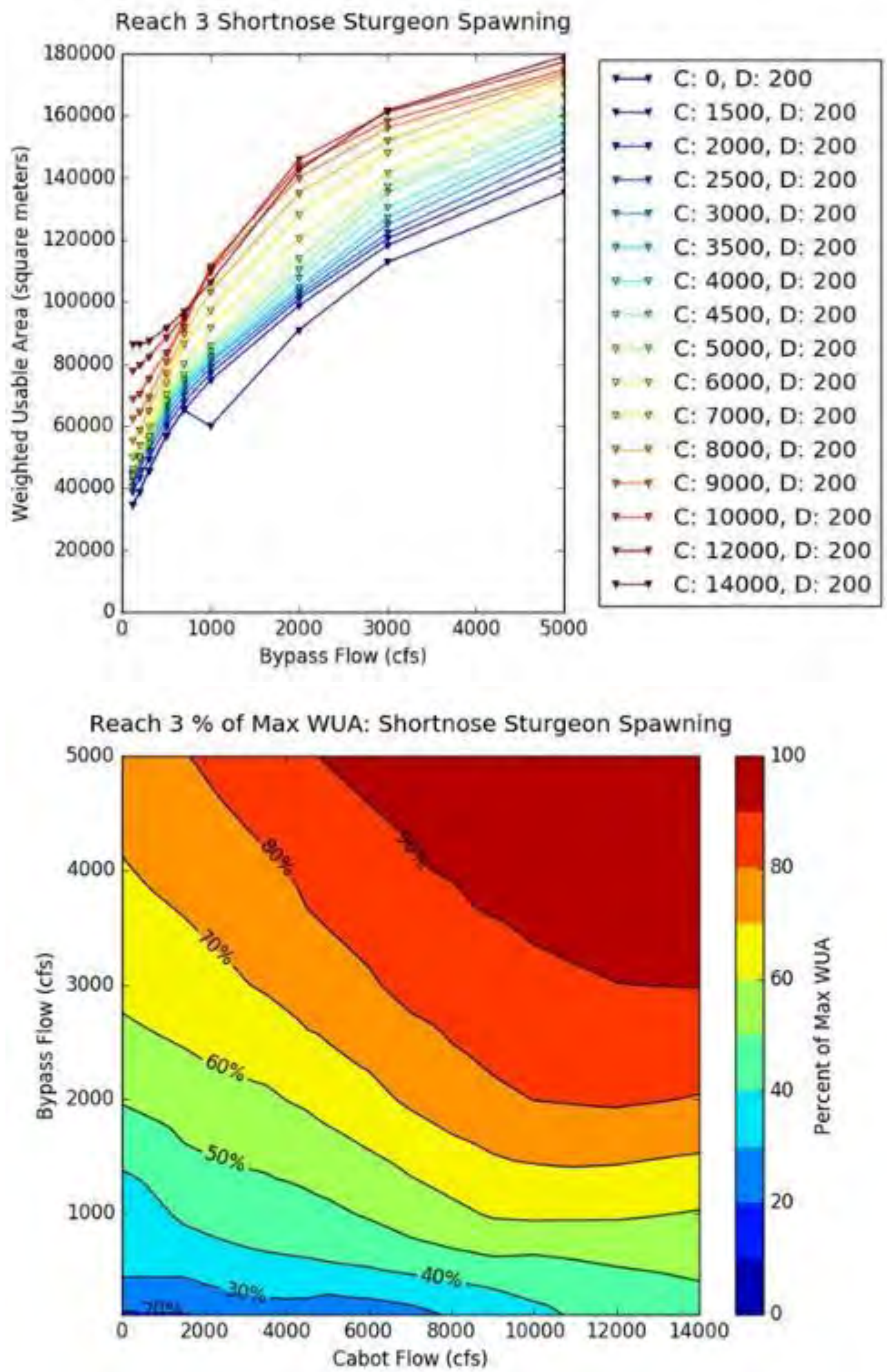


Figure E-4: Reach 3 WUA curves for the spawning & incubation life stage of Shortnose Sturgeon

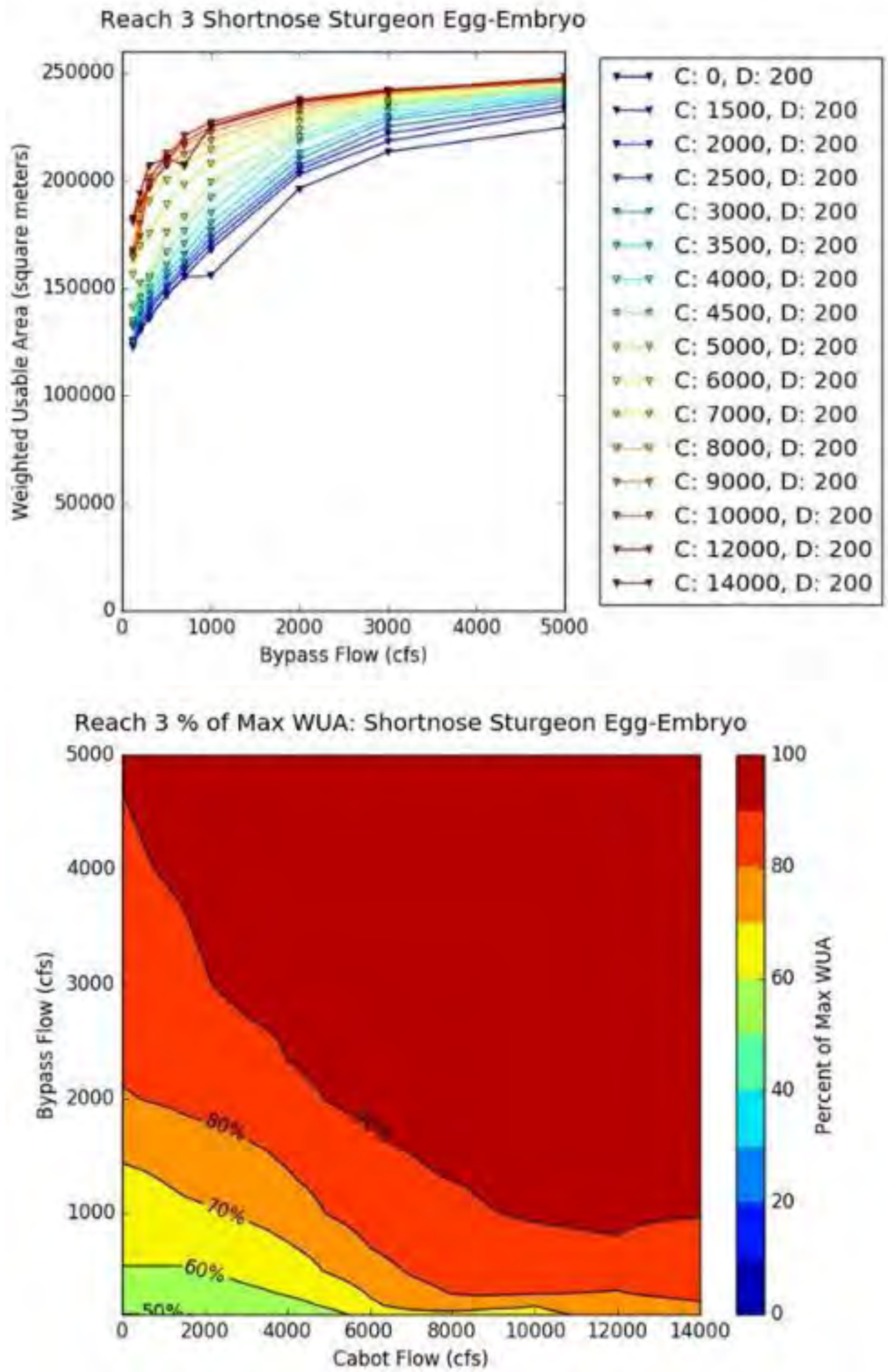


Figure E-5: Reach 3 WUA curves for the egg-larvae life stage of Shortnose Sturgeon

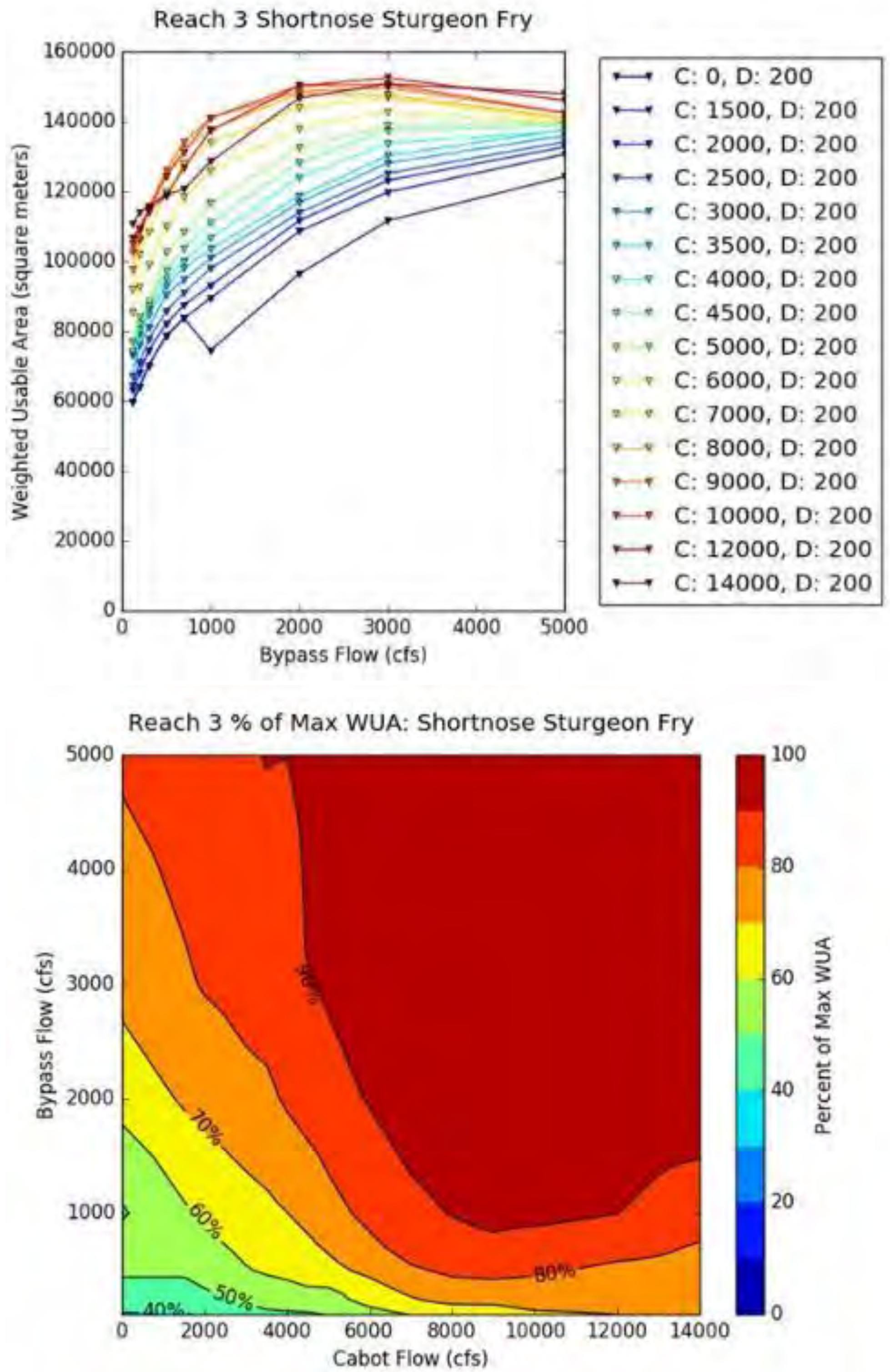


Figure E-6: Reach 3 WUA curves for the fry life stage of Shortnose Sturgeon

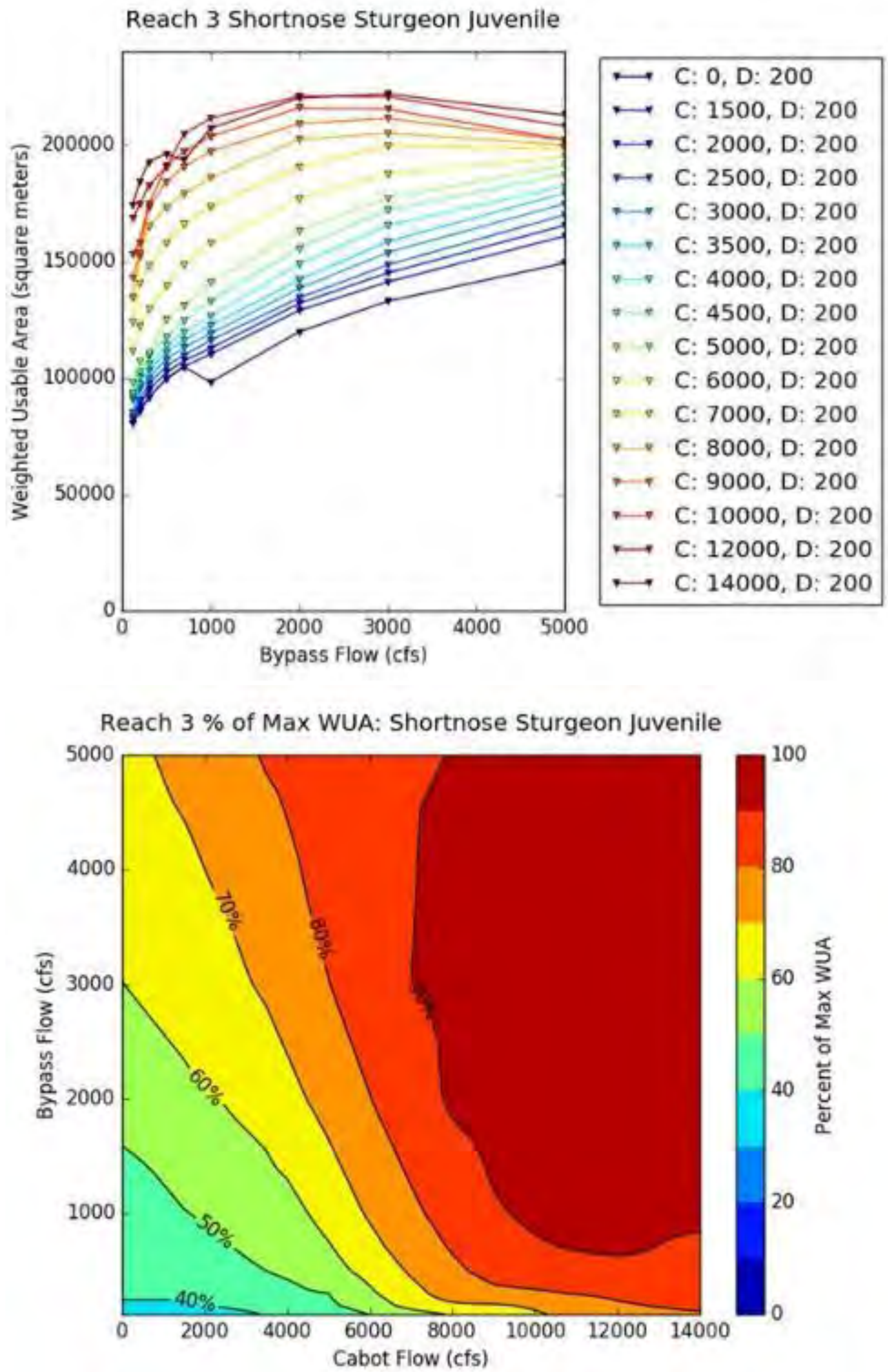


Figure E-7: Reach 3 WUA curves for the juvenile life stage of Shortnose Sturgeon

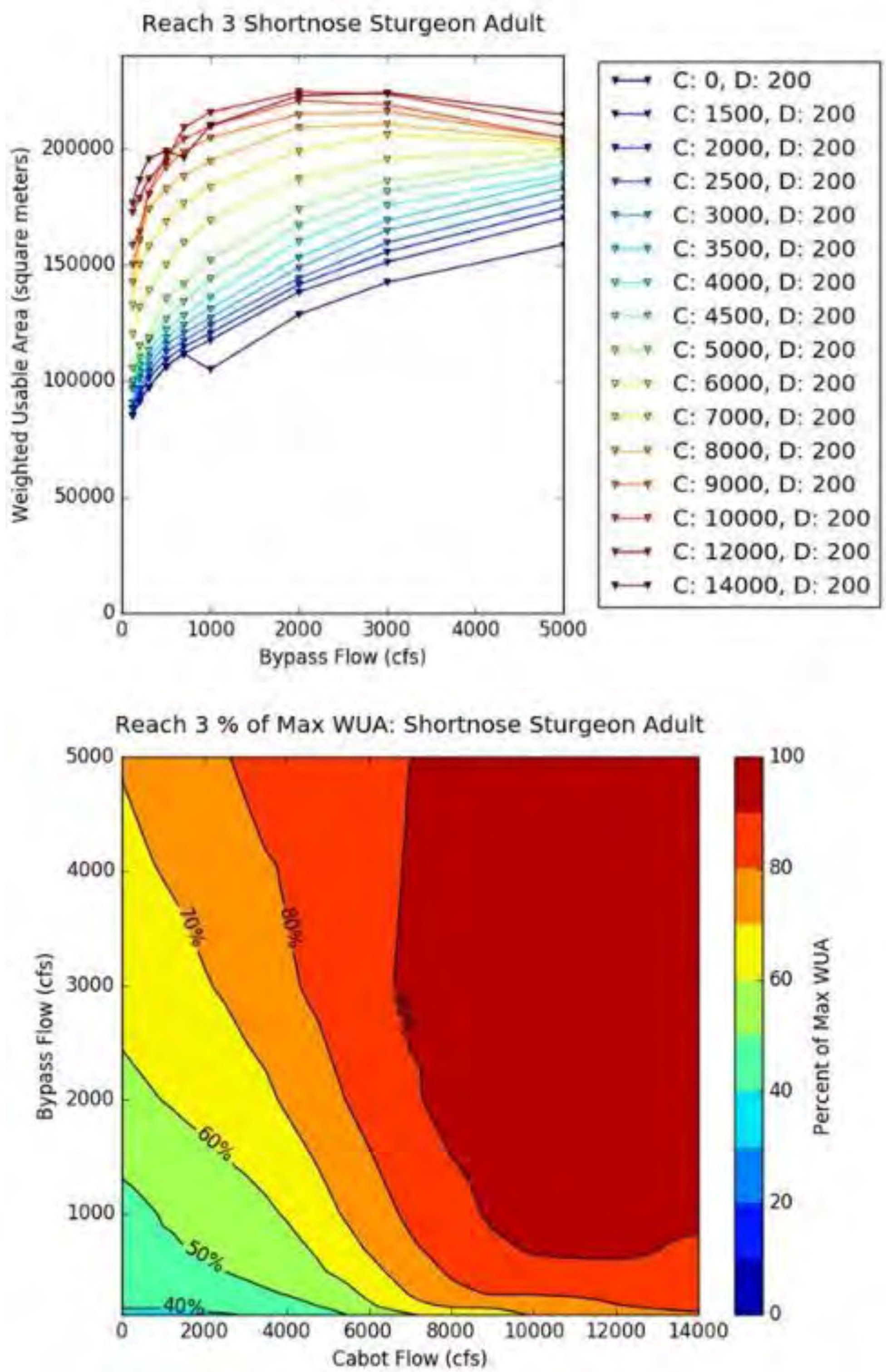
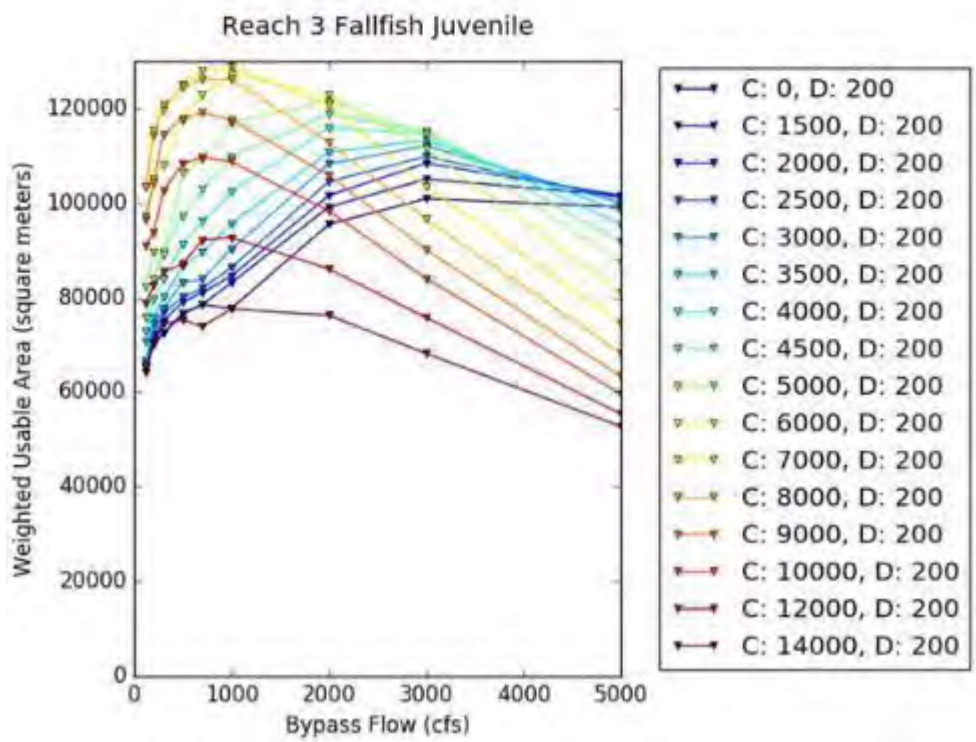


Figure E-8: Reach 3 WUA curves for the adult life stage of Shortnose Sturgeon



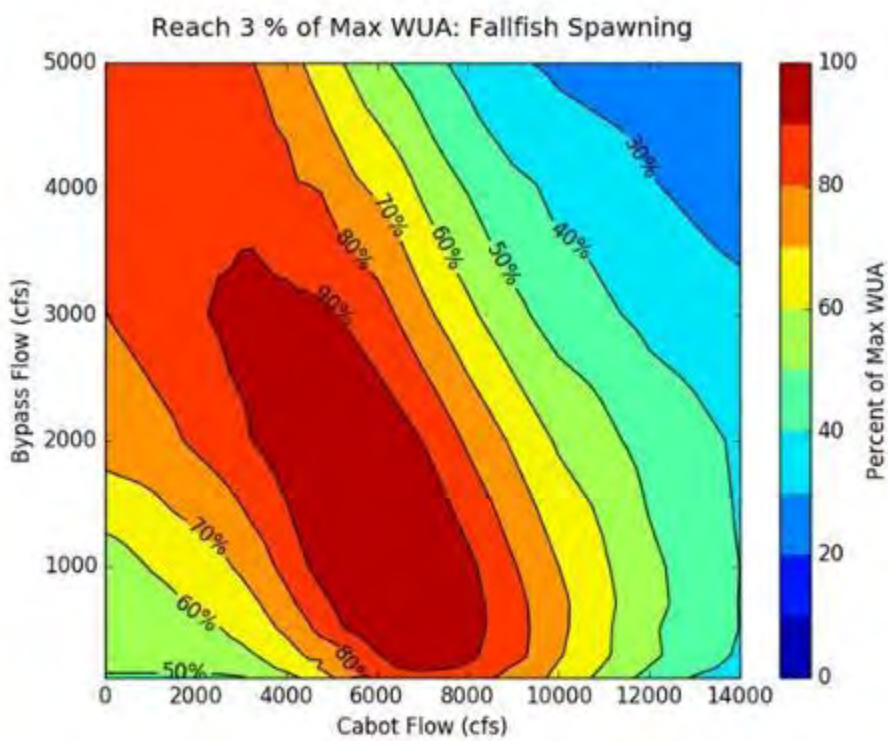


Figure E-9: Reach 3 WUA curves for the spawning & incubation life stage of Fallfish

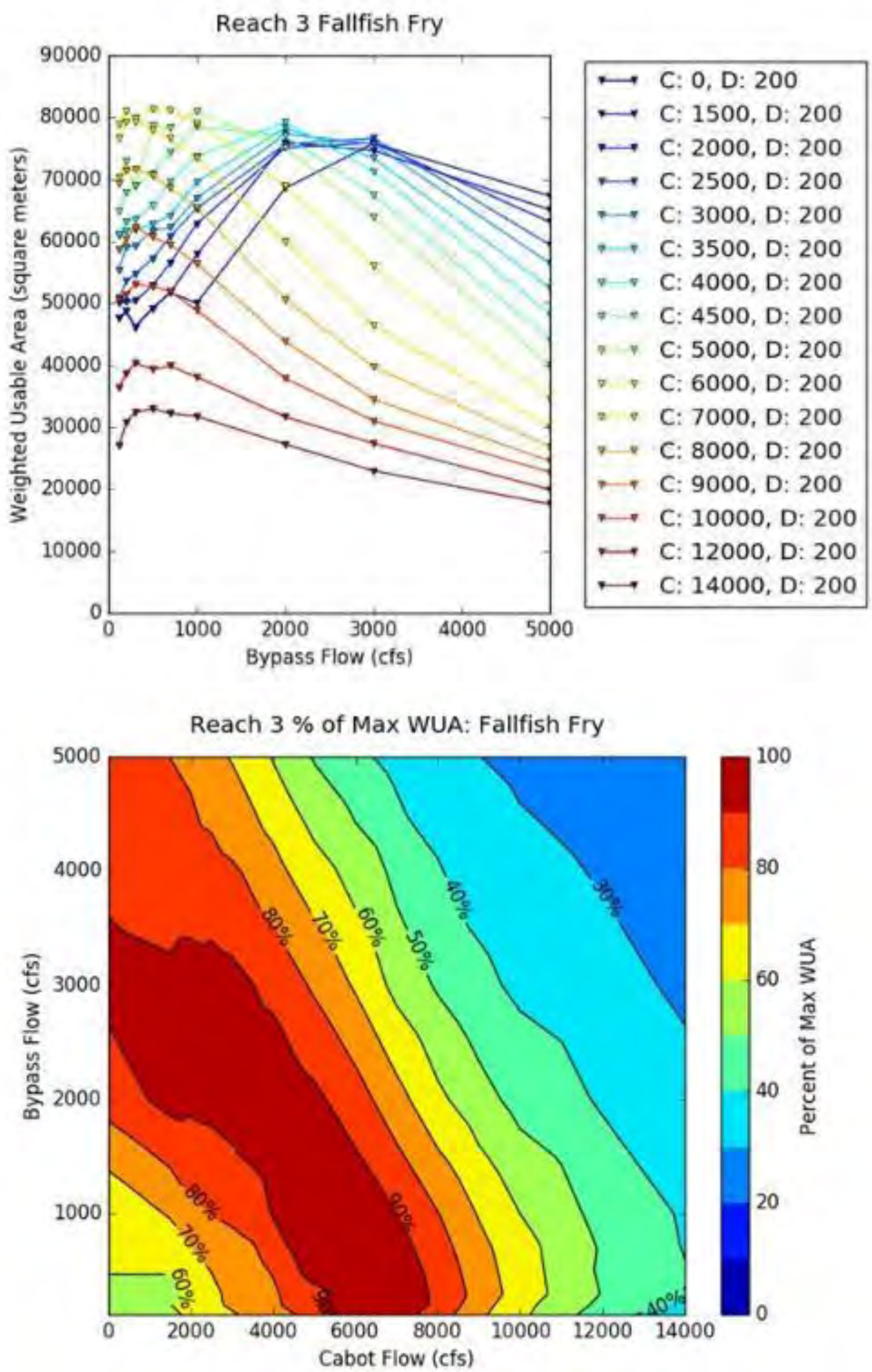


Figure E-10: Reach 3 WUA curves for the fry life stage of Fallfish

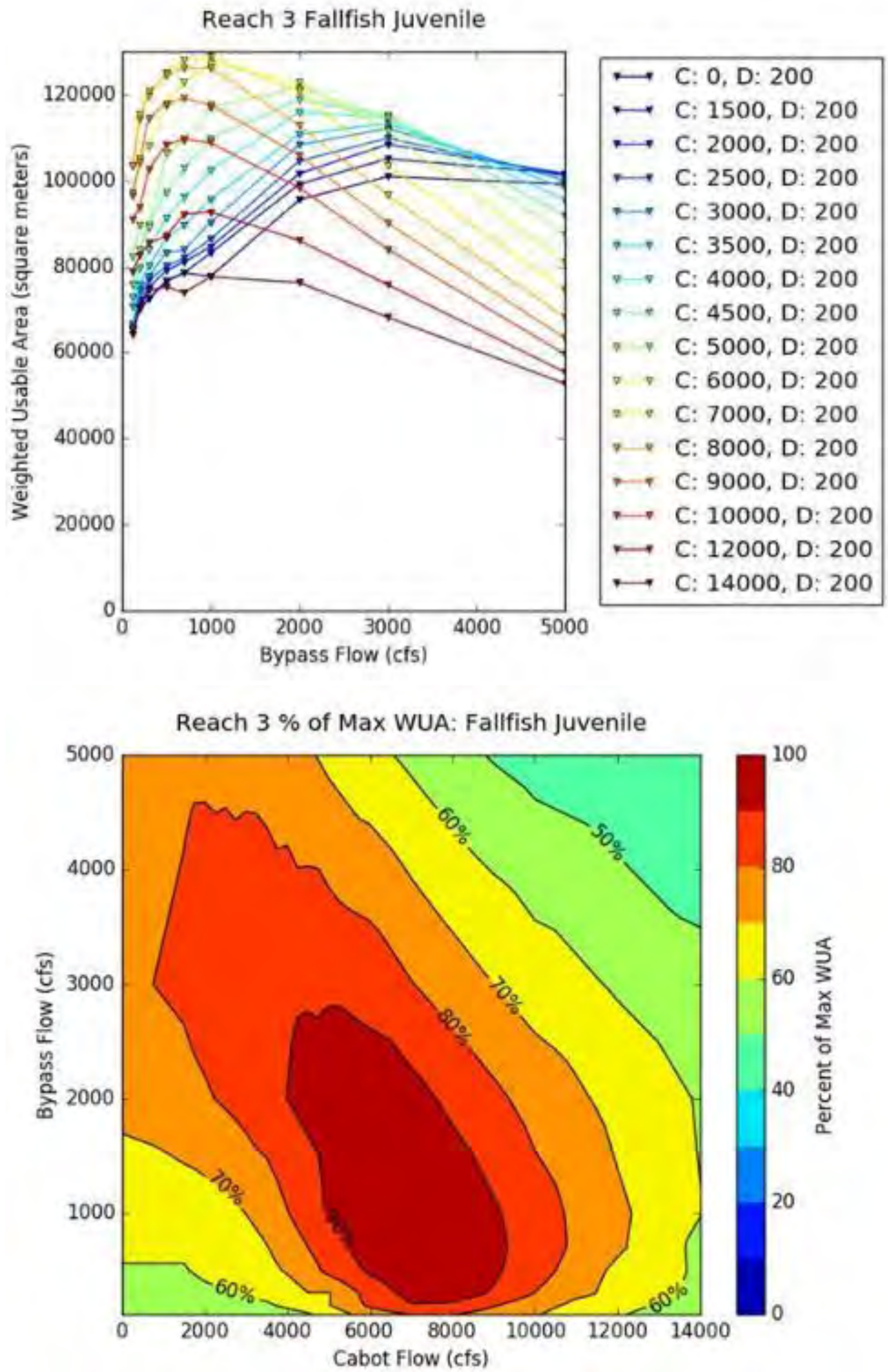


Figure E-11: Reach 3 WUA curves for the juvenile life stage of Fallfish

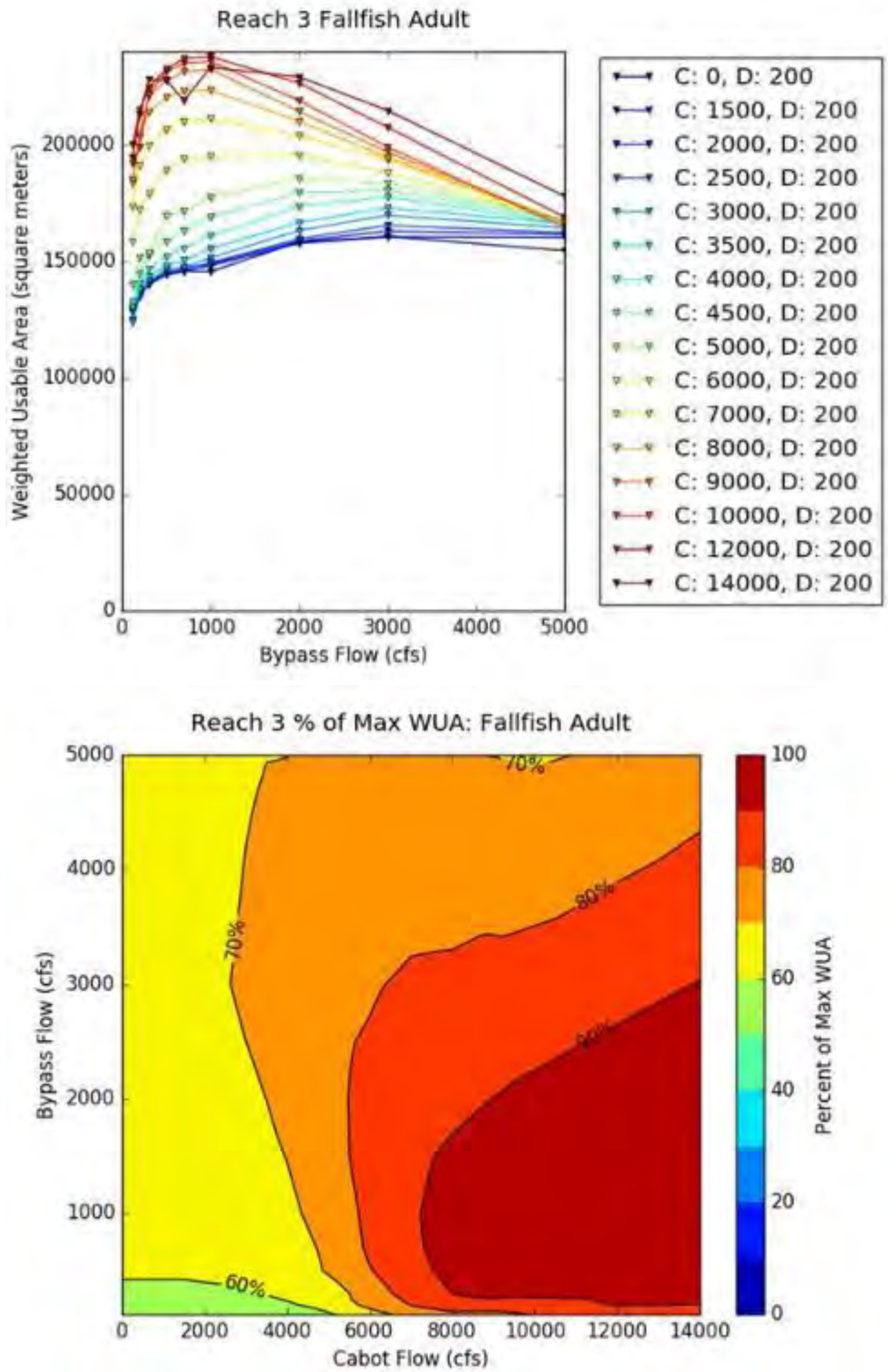


Figure E-12: Reach 3 WUA curves for the adult life stage of Fallfish

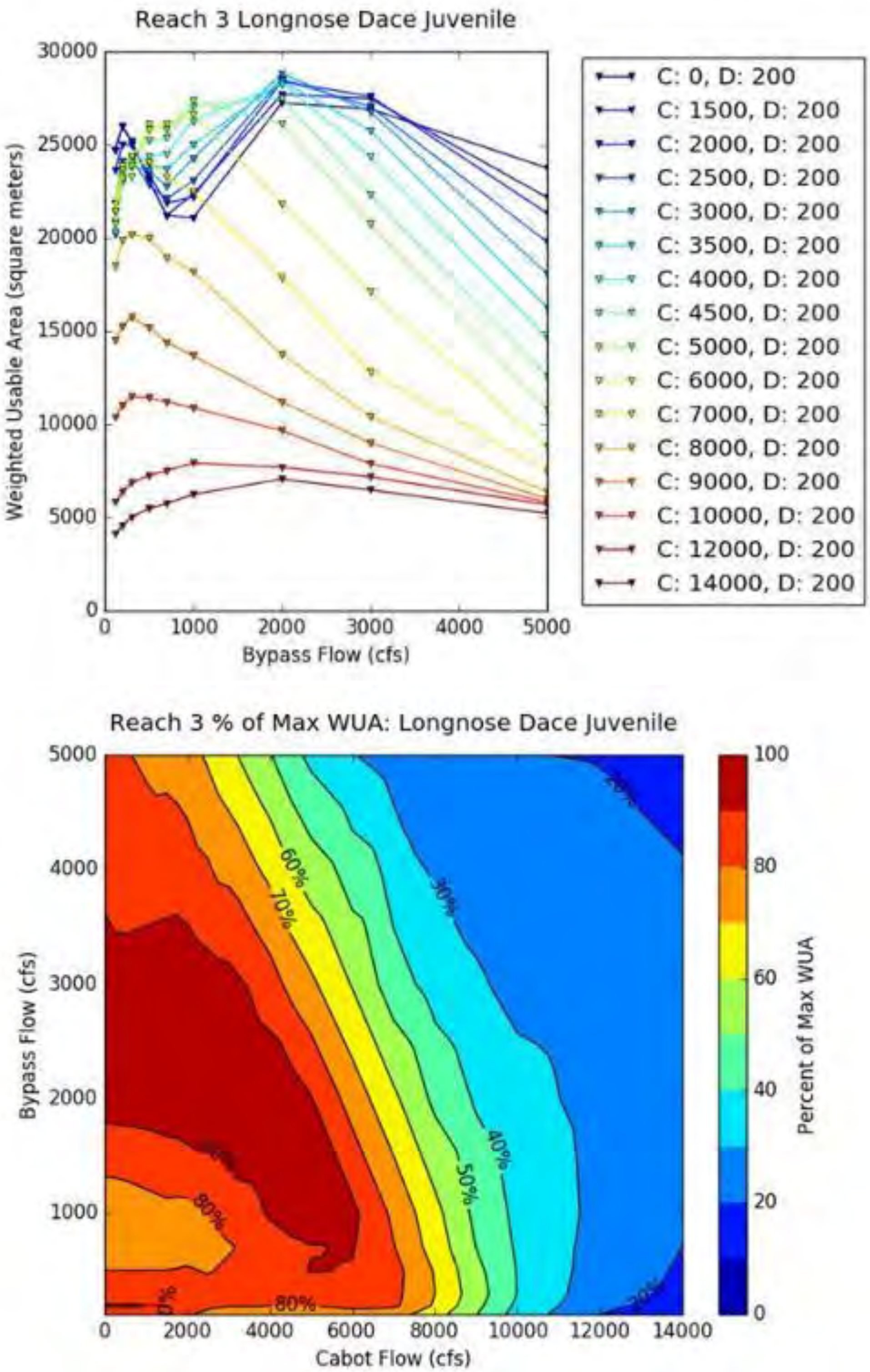


Figure E-13: Reach 3 WUA curves for the juvenile life stage of Longnose Dace

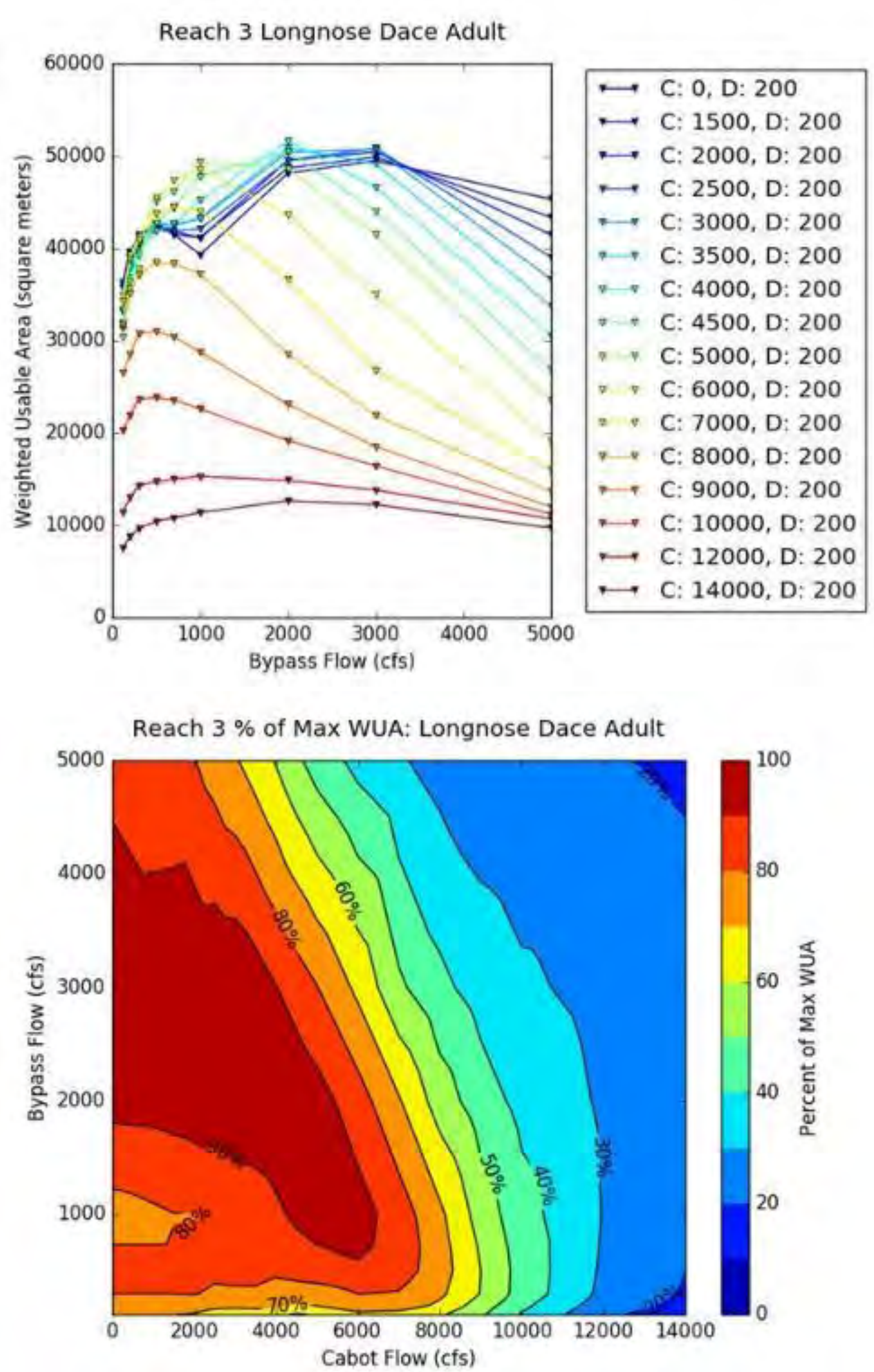


Figure E-14: Reach 3 WUA curves for the adult life stage of Longnose Dace

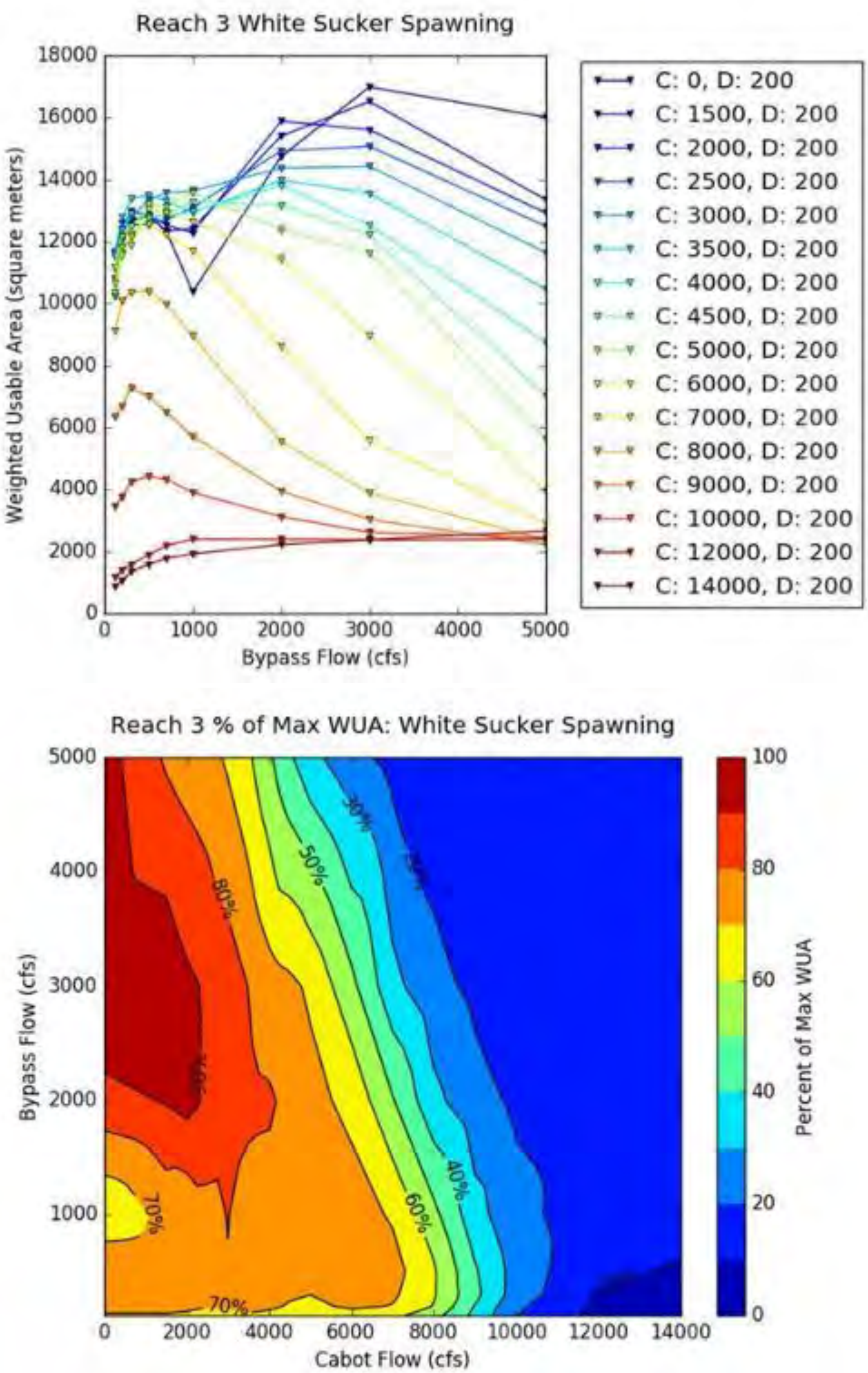


Figure E-15: Reach 3 WUA curves for the spawning & incubation life stage of White Sucker

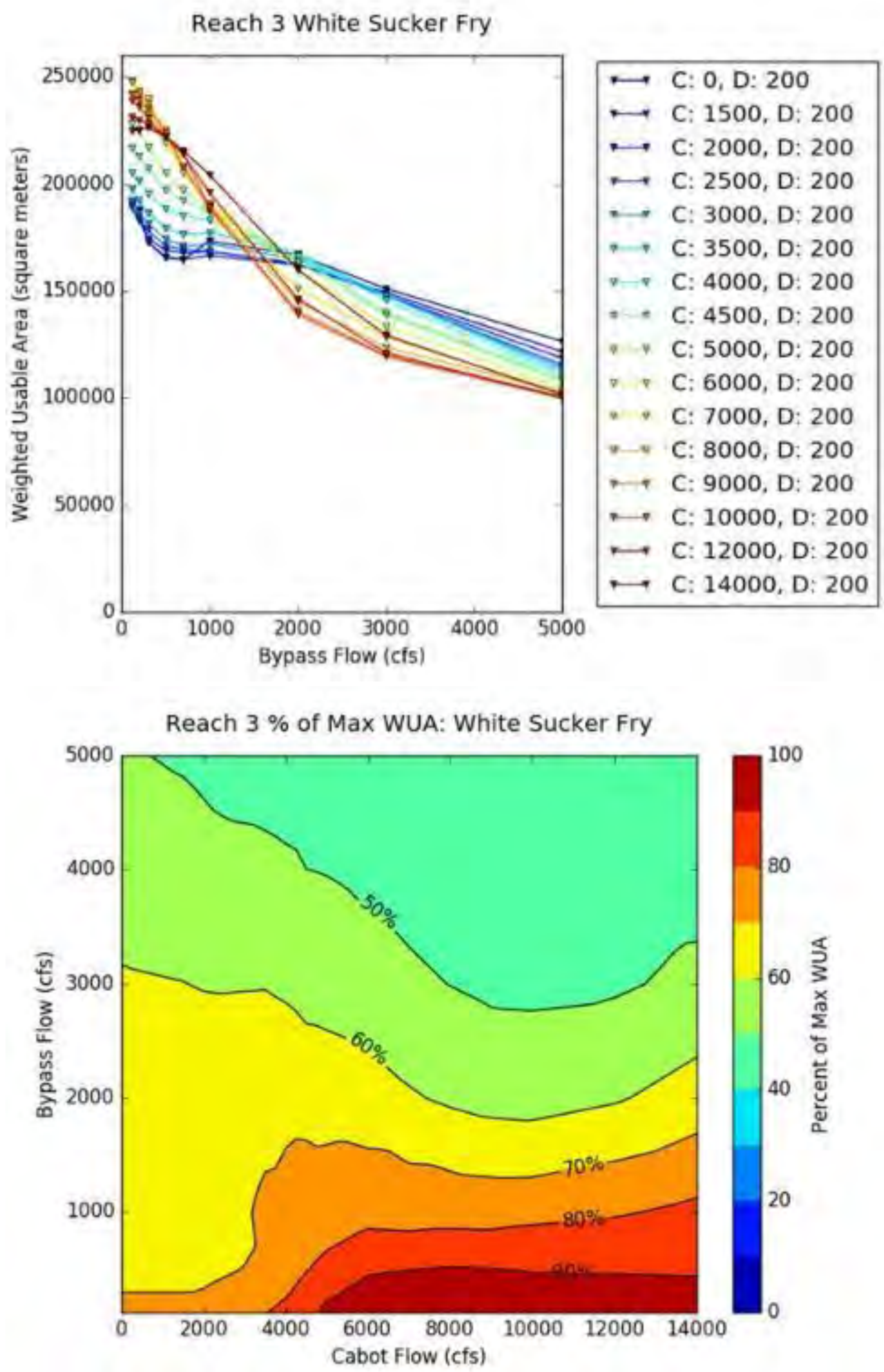


Figure E-16: Reach 3 WUA curves for the fry life stage of White Sucker

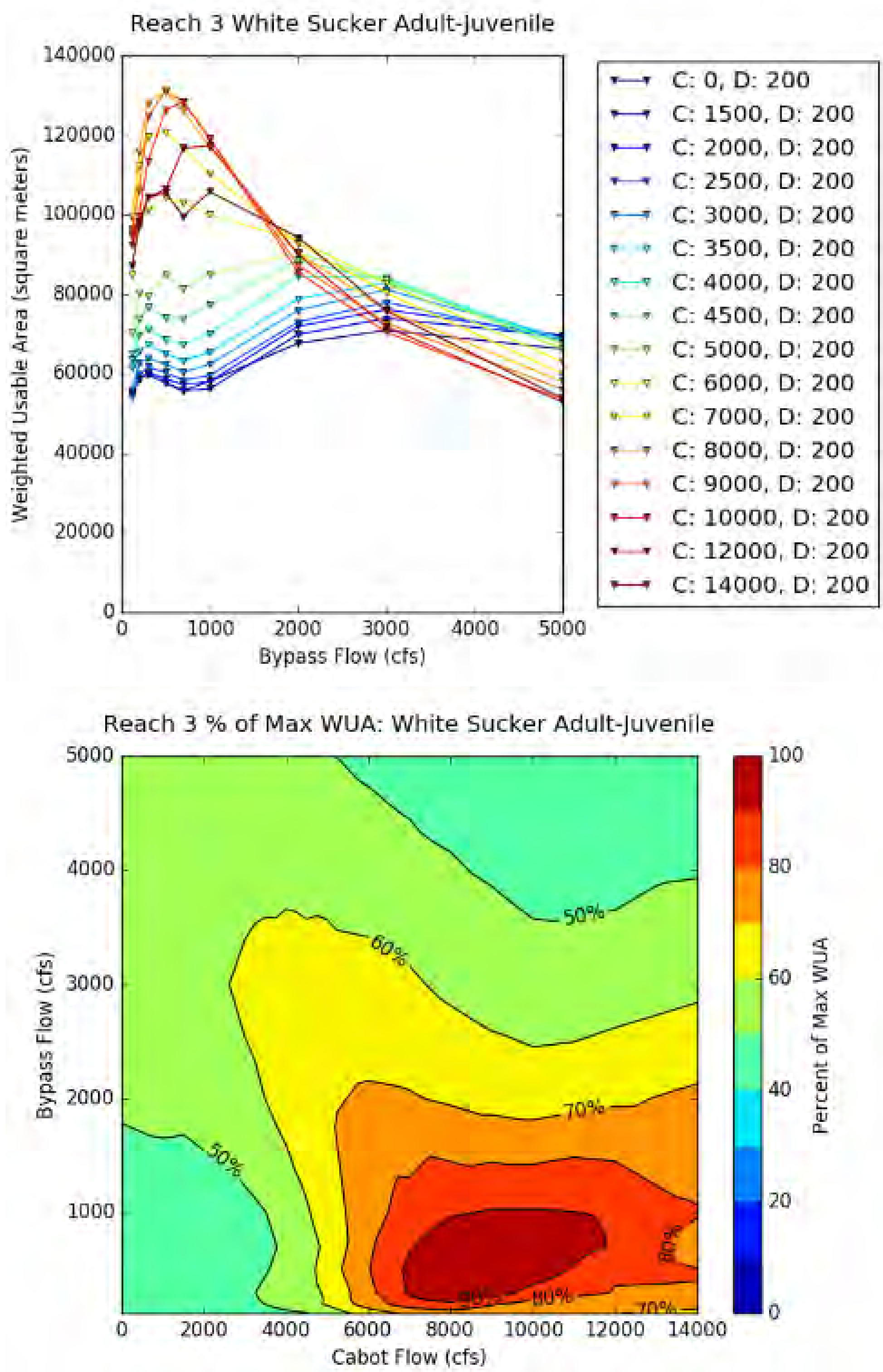


Figure E-17: Reach 3 WUA curves for the adult/juvenile life stage of White Sucker

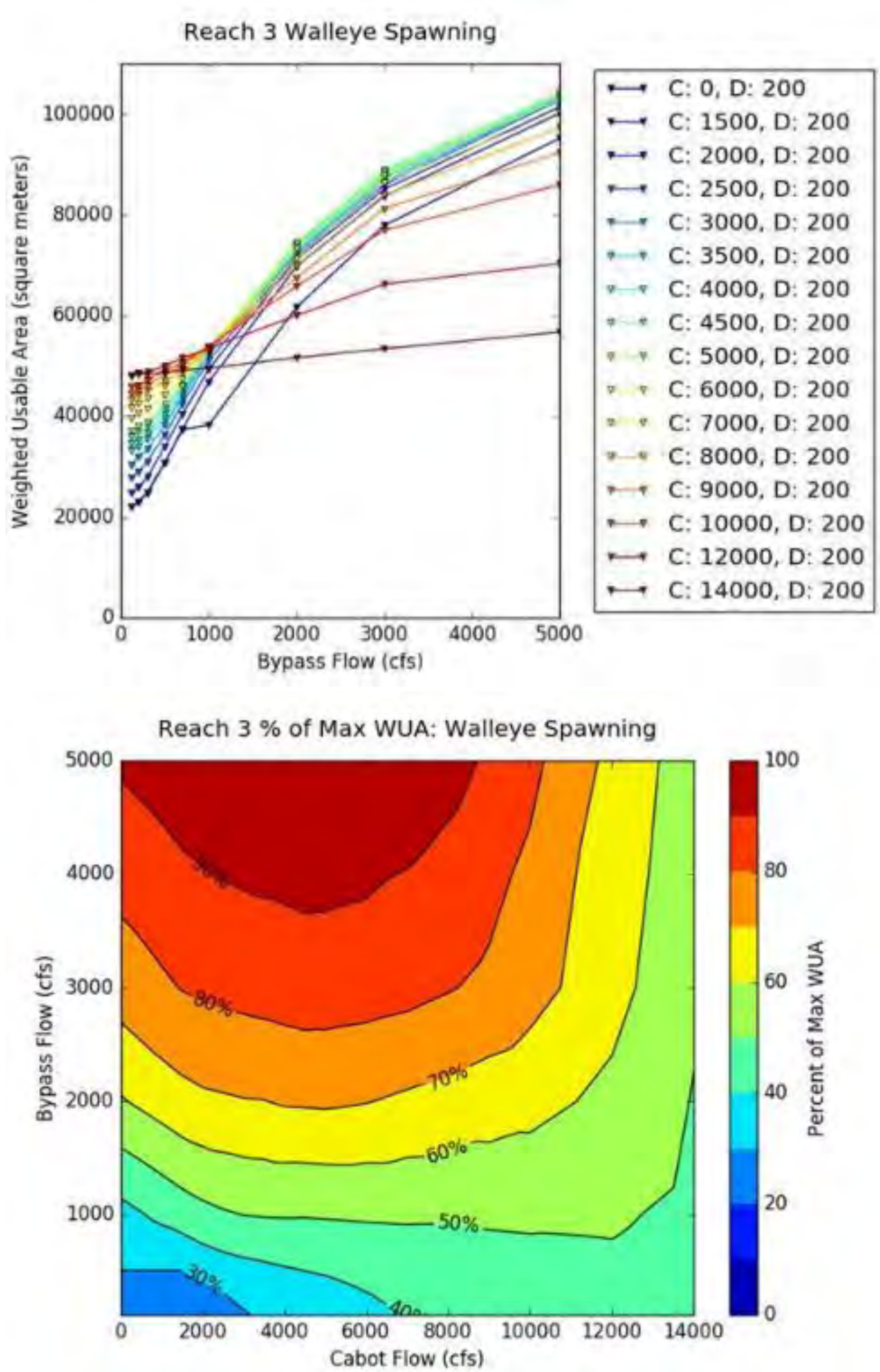


Figure E-18: Reach 3 WUA curves for the spawning & incubation life stage of Walleye

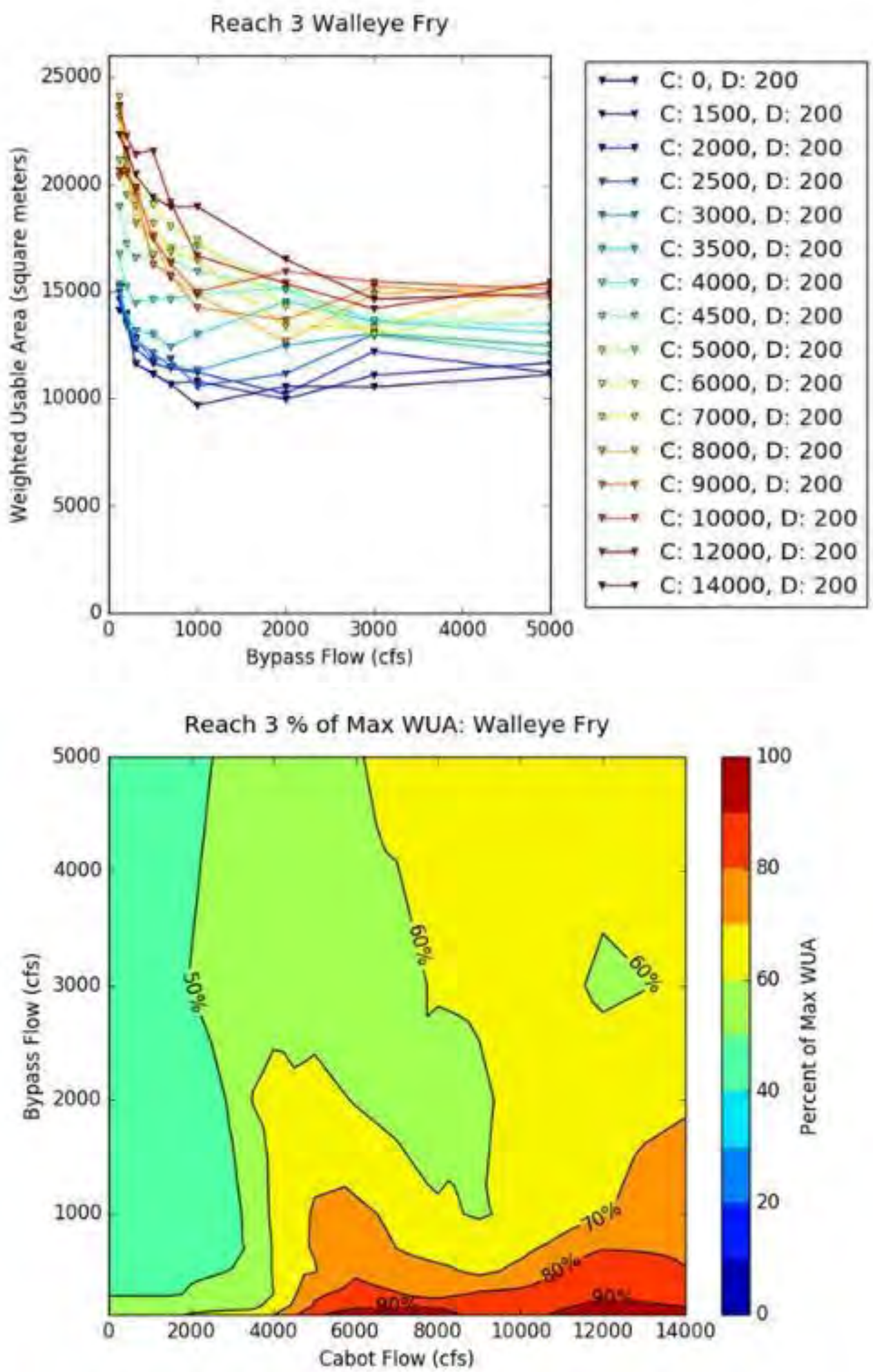


Figure E-19: Reach 3 WUA curves for the fry life stage of Walleye

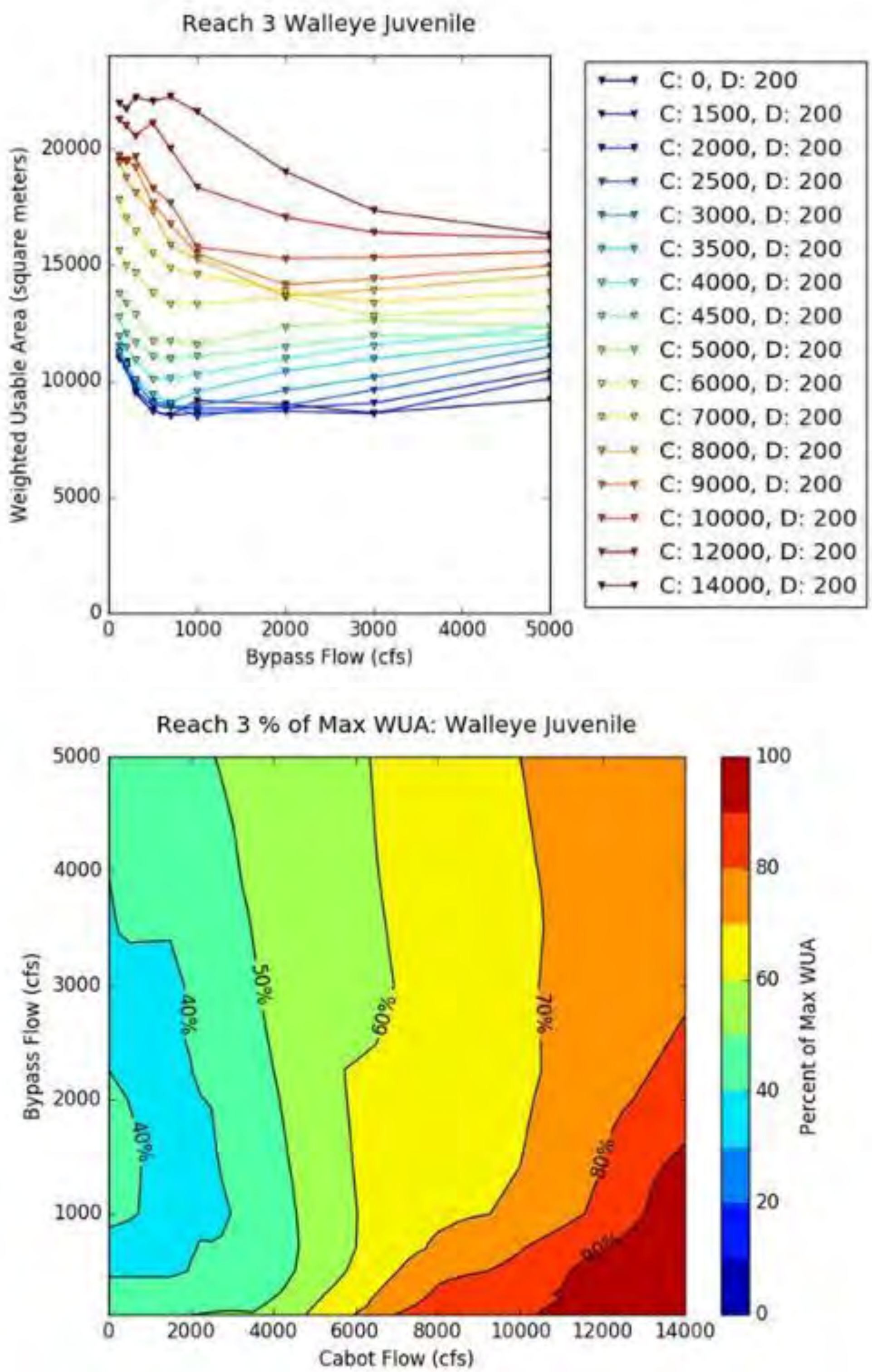


Figure E-20: Reach 3 WUA curves for the juvenile life stage of Walleye

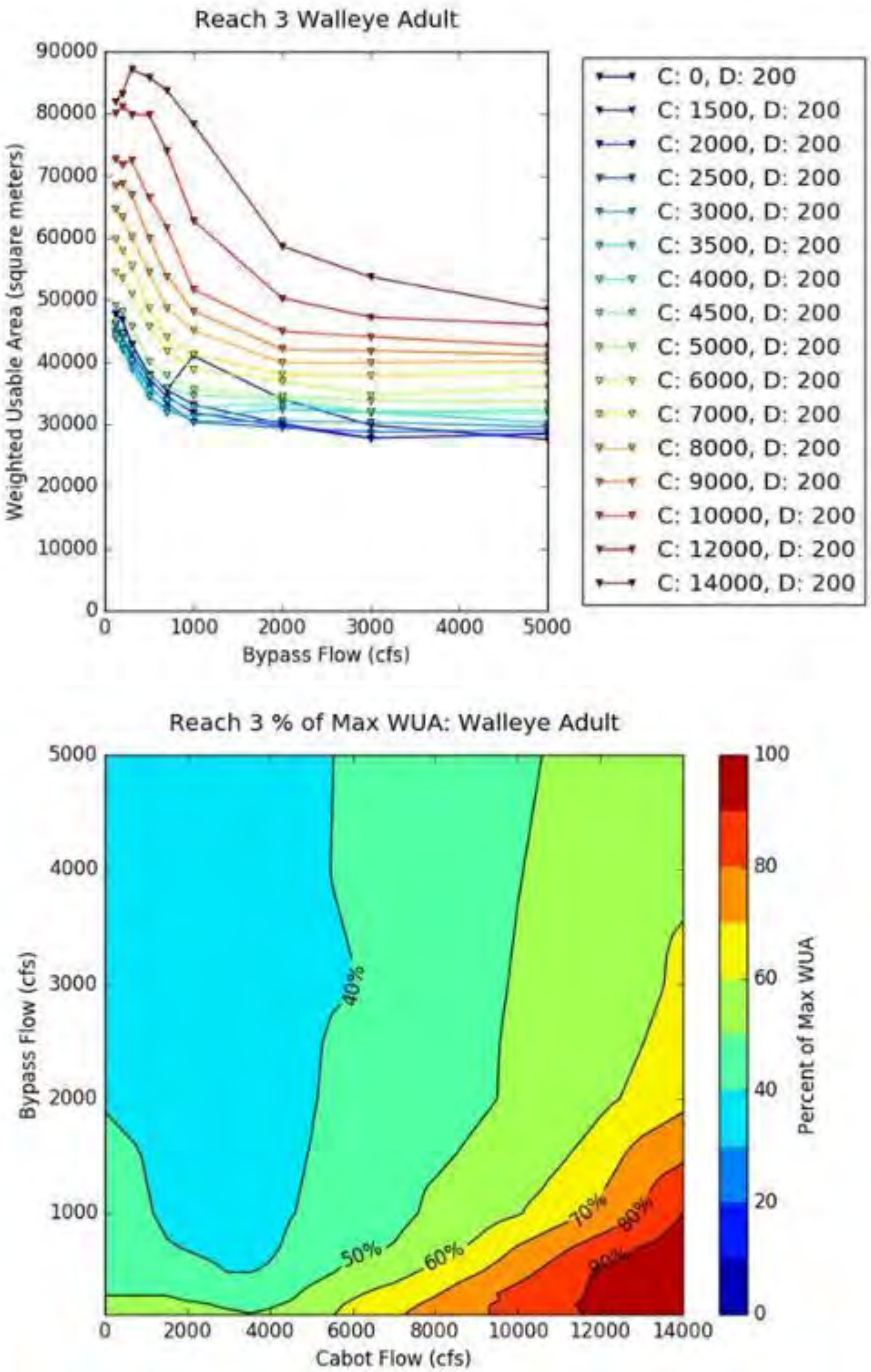
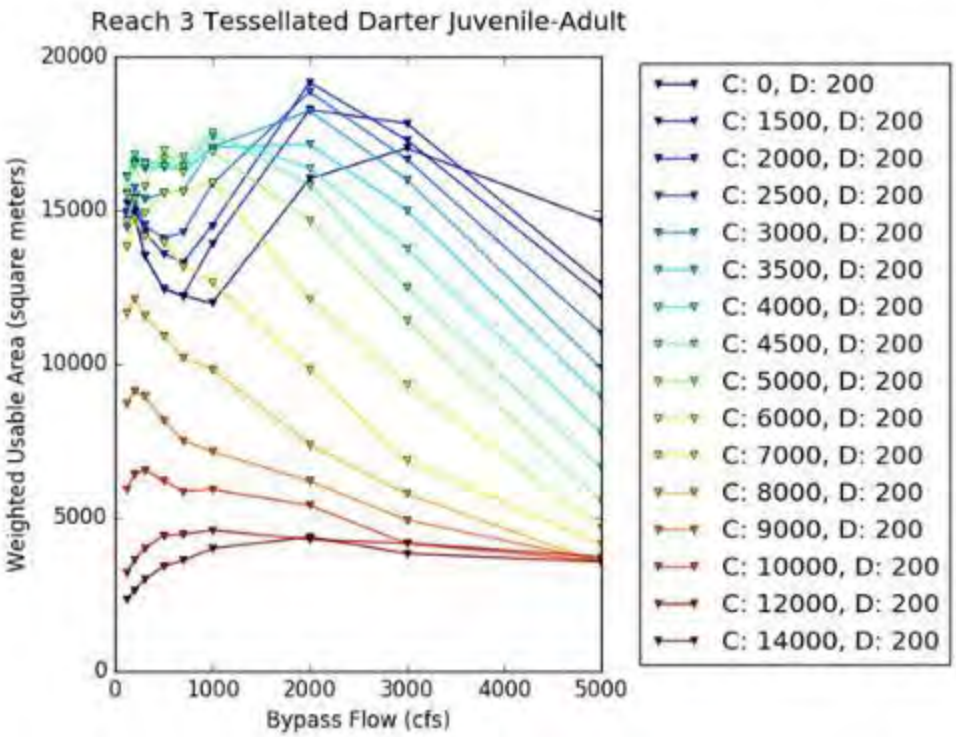


Figure E-21: Reach 3 WUA curves for the adult life stage of Walleye



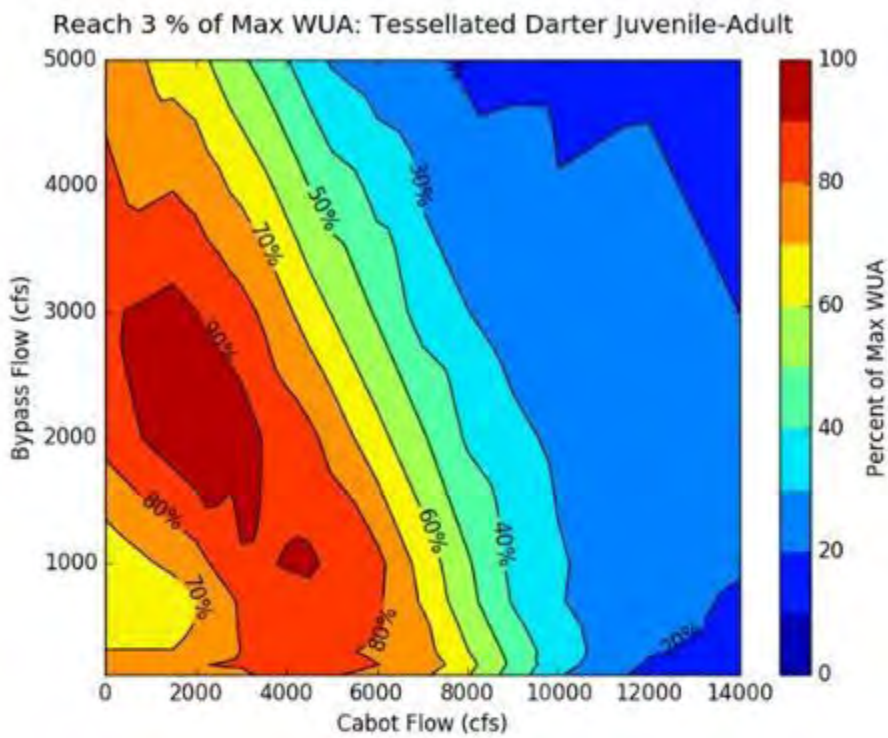


Figure E-22: Reach 3 WUA curves for the adult/juvenile life stage of Tessellated Darter

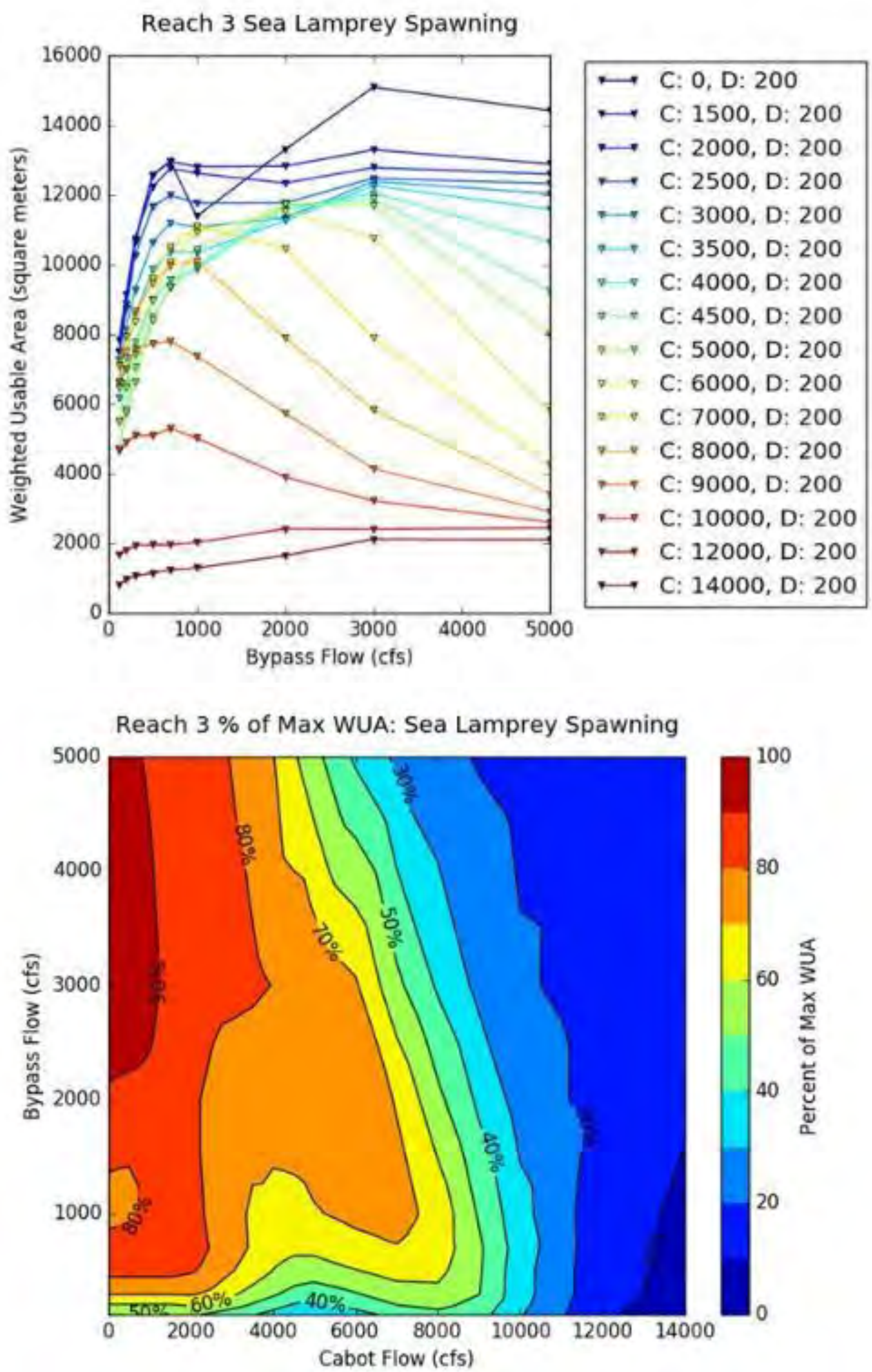
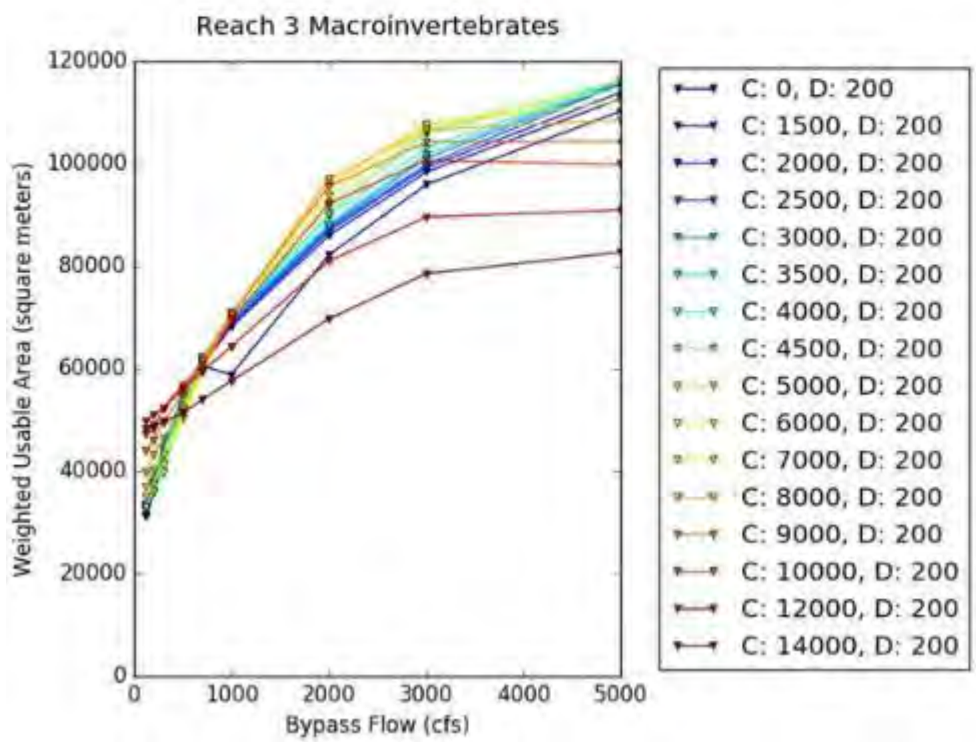


Figure E-23: Reach 3 WUA curves for the spawning & incubation life stage of Sea Lamprey



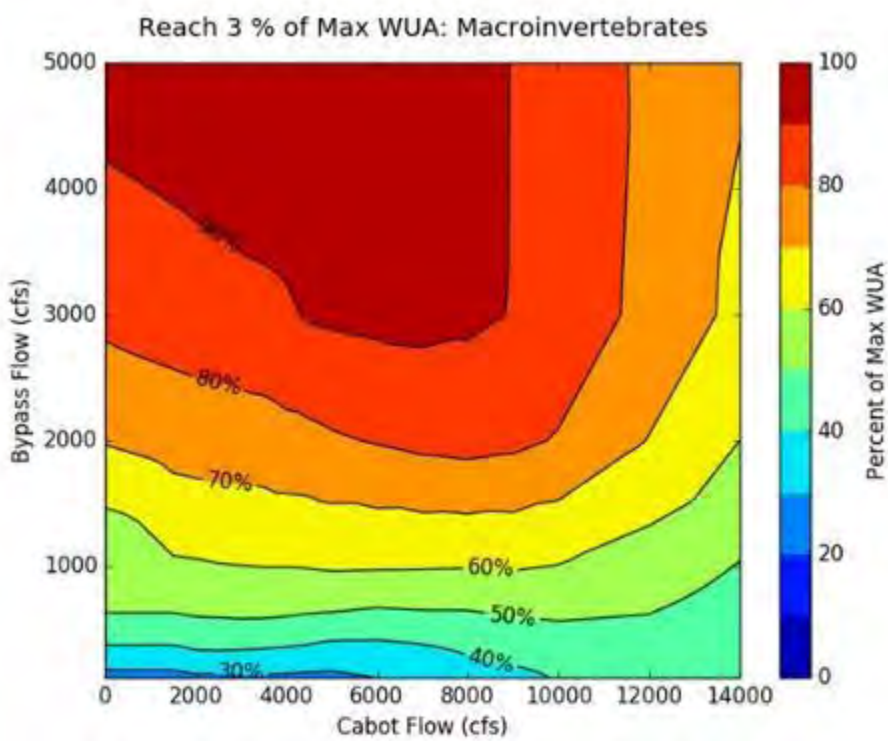


Figure E-24: Reach 3 WUA curves for Macroinvertebrates

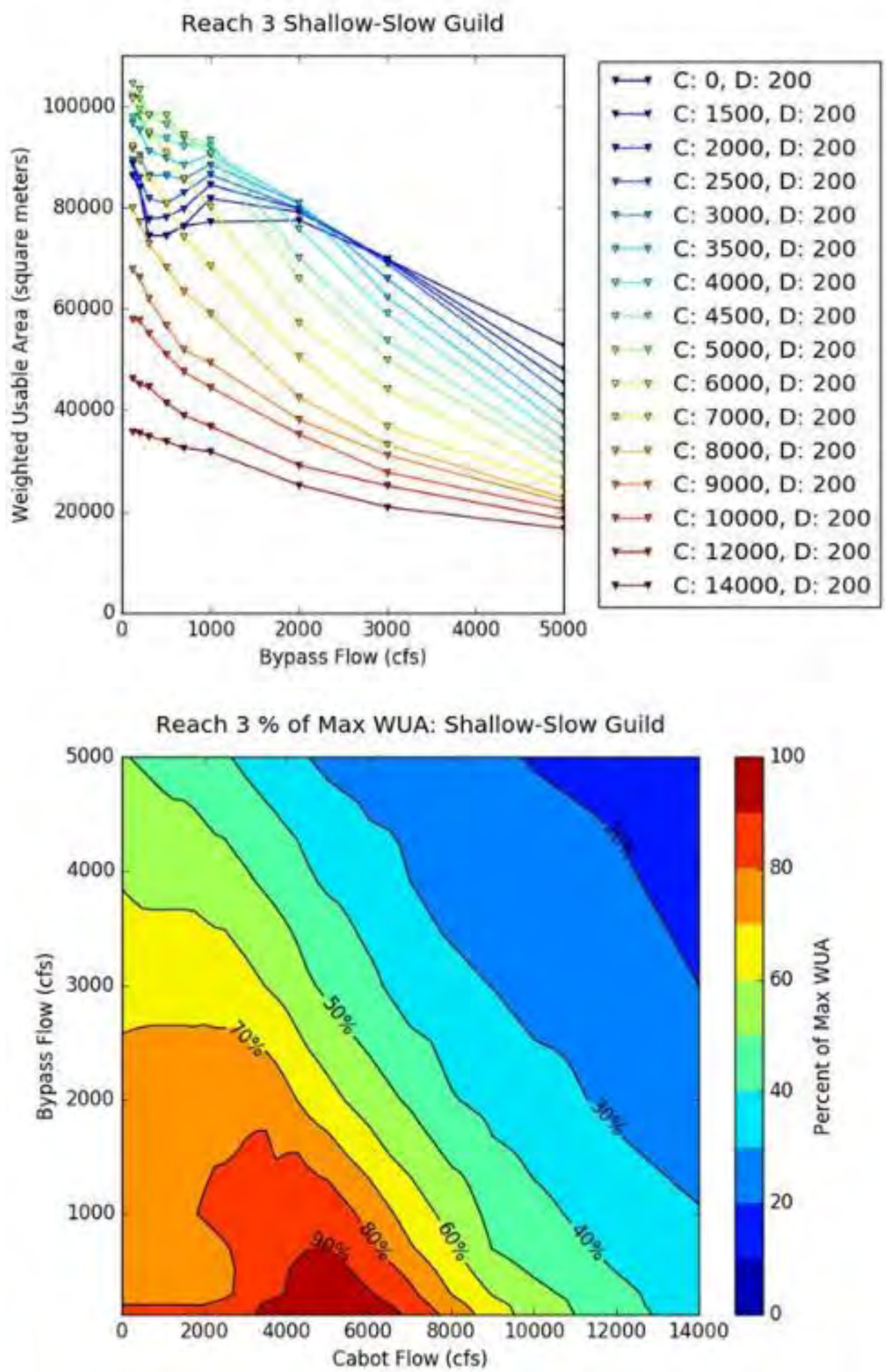


Figure E-25: Reach 3 WUA curves for the Shallow-Slow Habitat Guild

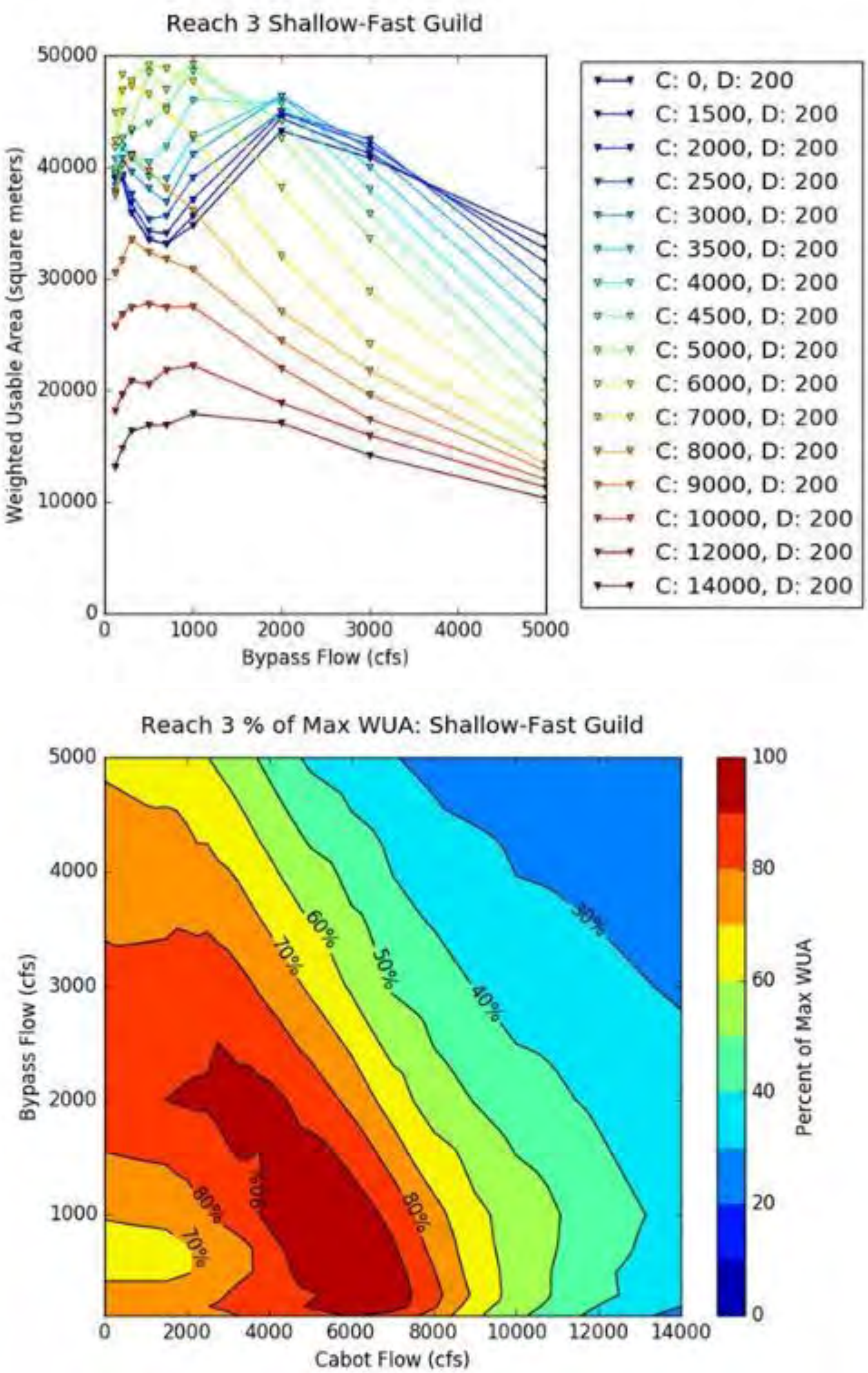
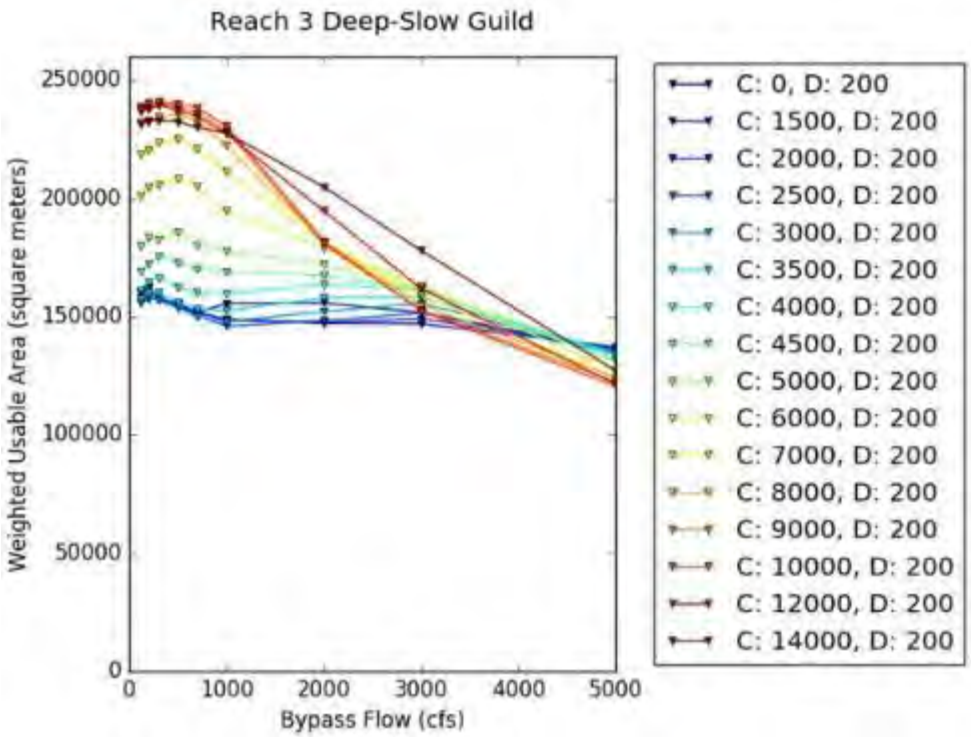


Figure E-26: Reach 3 WUA curves for the Shallow-Fast Habitat Guild



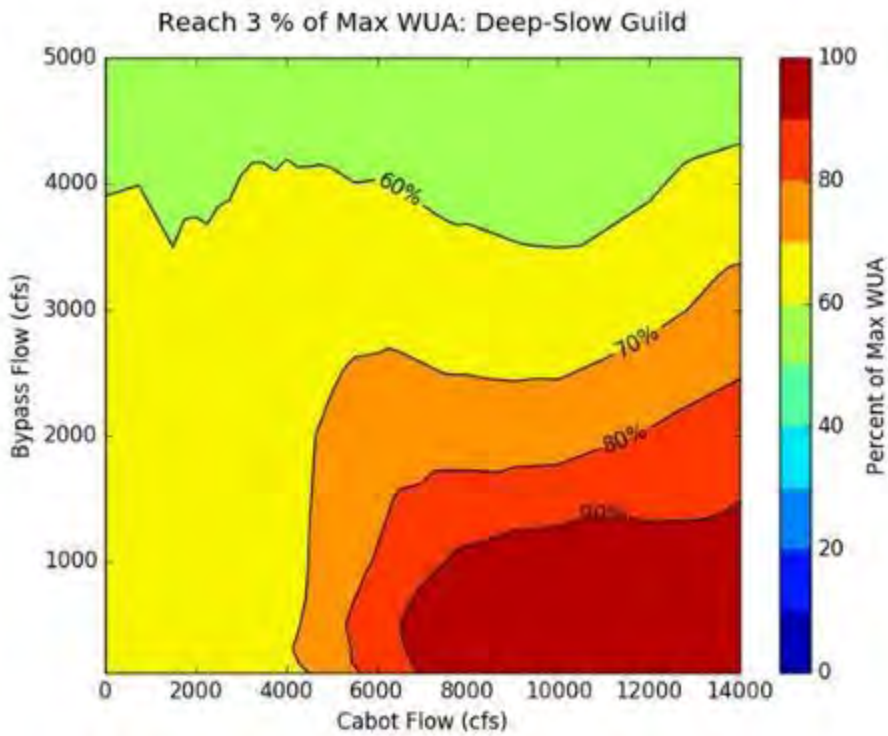


Figure E-27: Reach 3 WUA curves for the Deep-Slow Habitat Guild

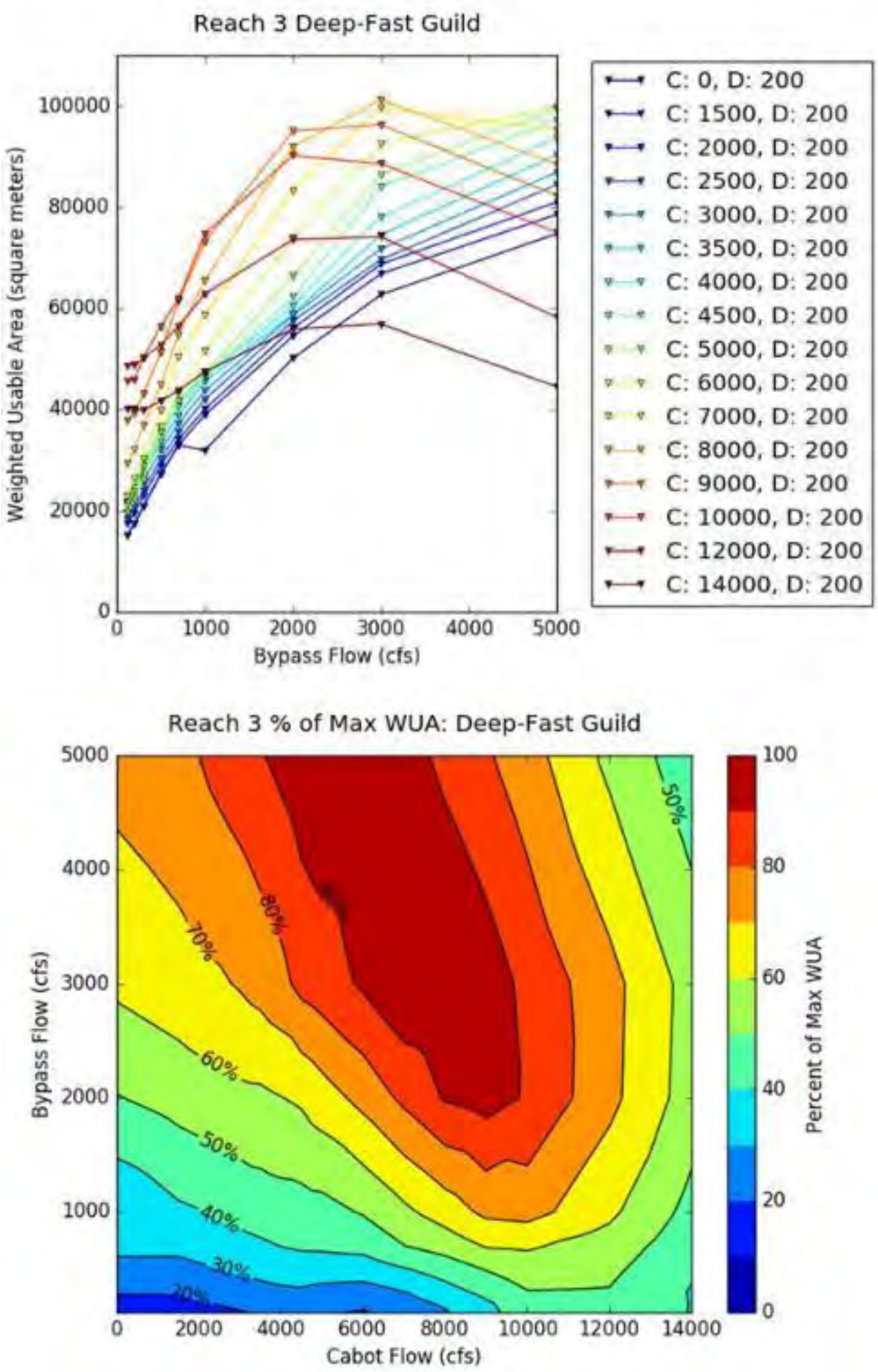


Figure E-28: Reach 3 WUA curves for the Deep-Fast Habitat Guild

APPENDIX F – REACH 4 HABITAT VERSUS DISCHARGE RELATIONSHIPS

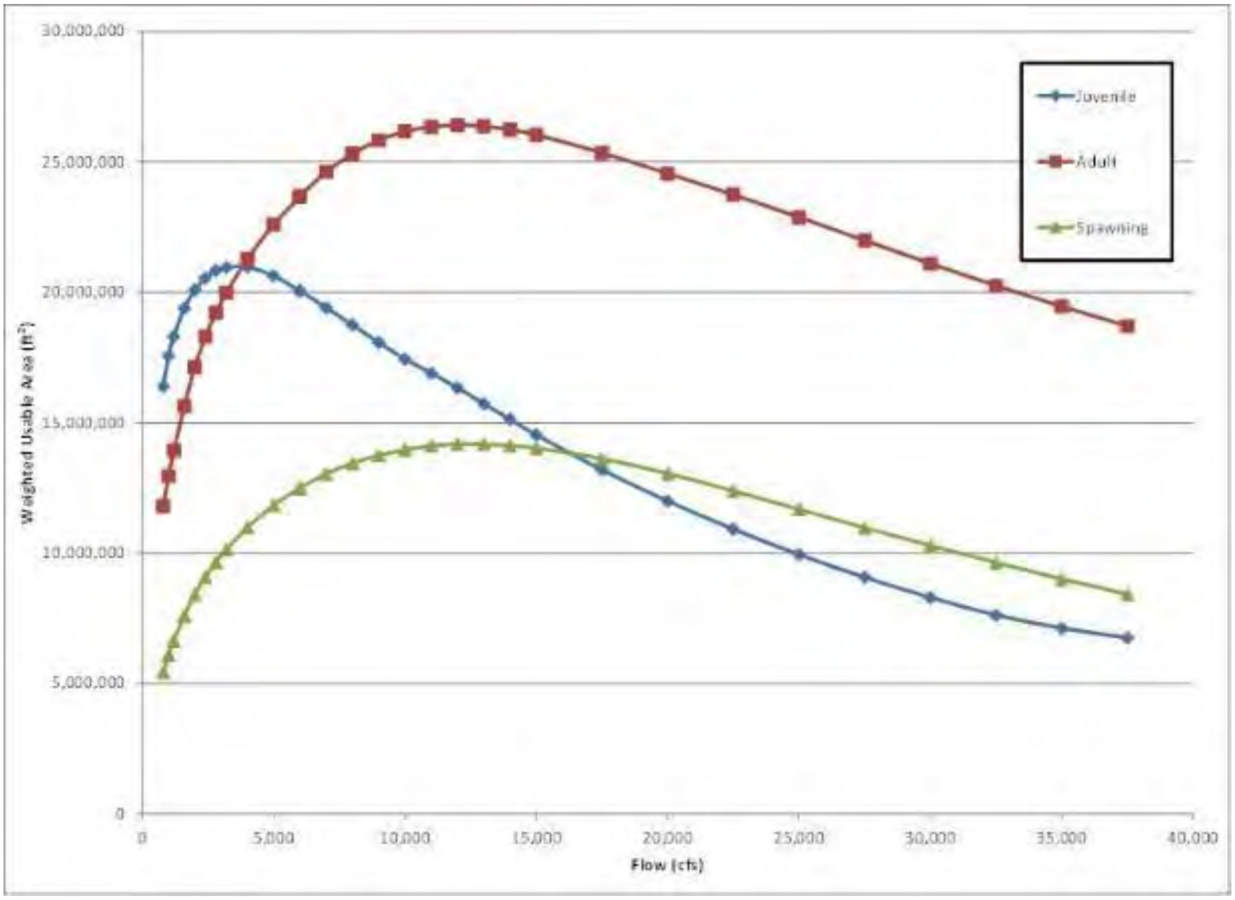


Figure F-1: Reach 4 WUA Curves for the Spawning, Juvenile and Adult Life Stages of American Shad

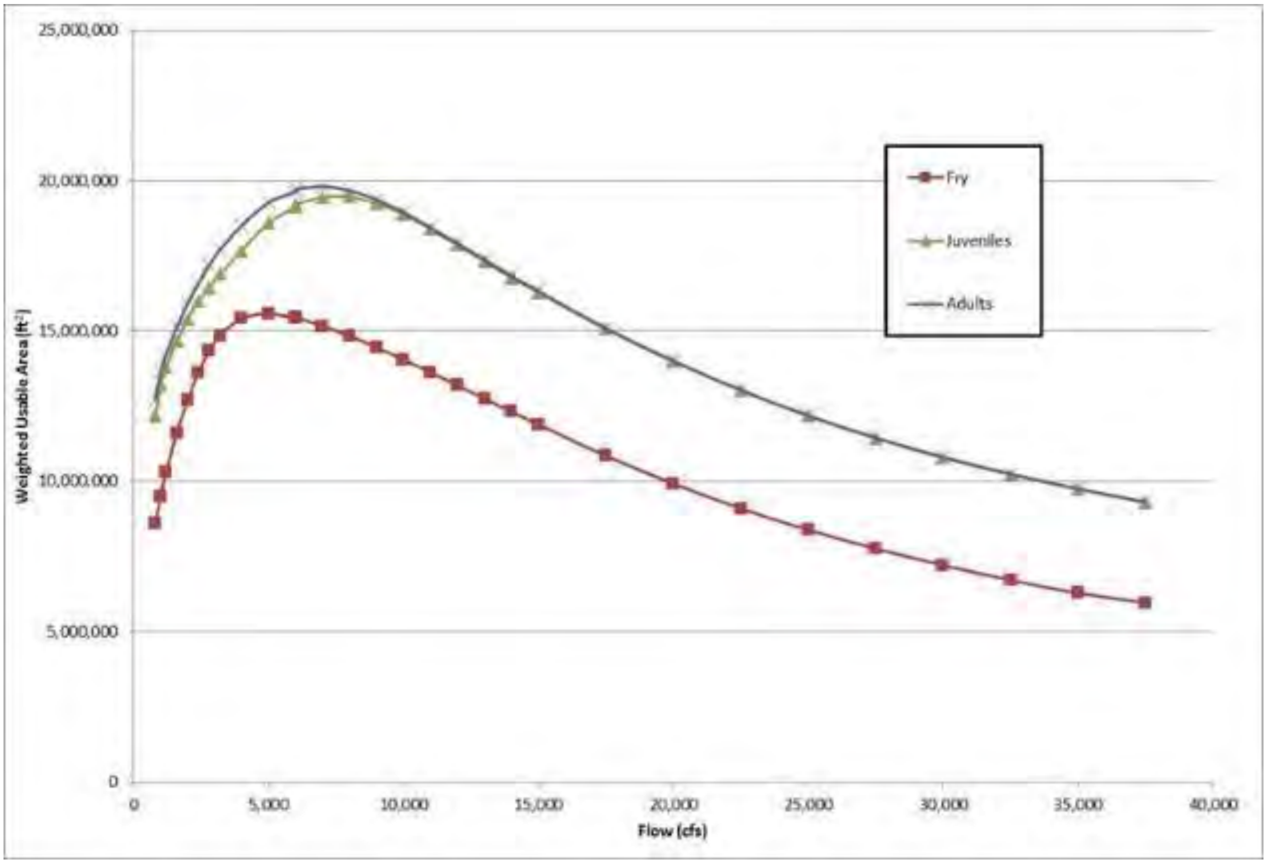


Figure F-2: Reach 4 WUA Curves for the Fry, Juvenile, and Adult Life Stages of Shortnose Sturgeon

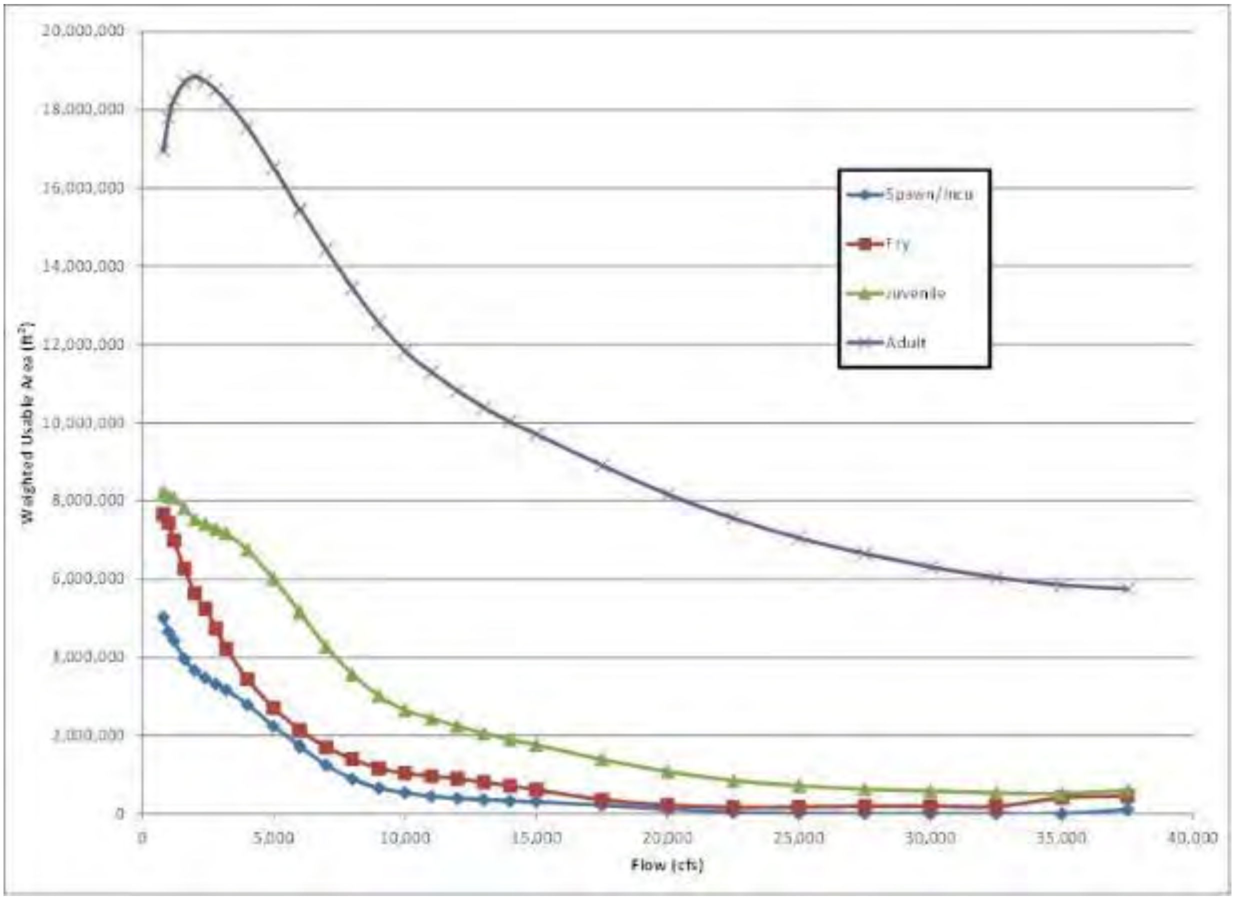


Figure F-3: Reach 4 WUA Curves for the Spawning & Incubation, Fry, Juvenile and Adult Life Stages of Fallfish

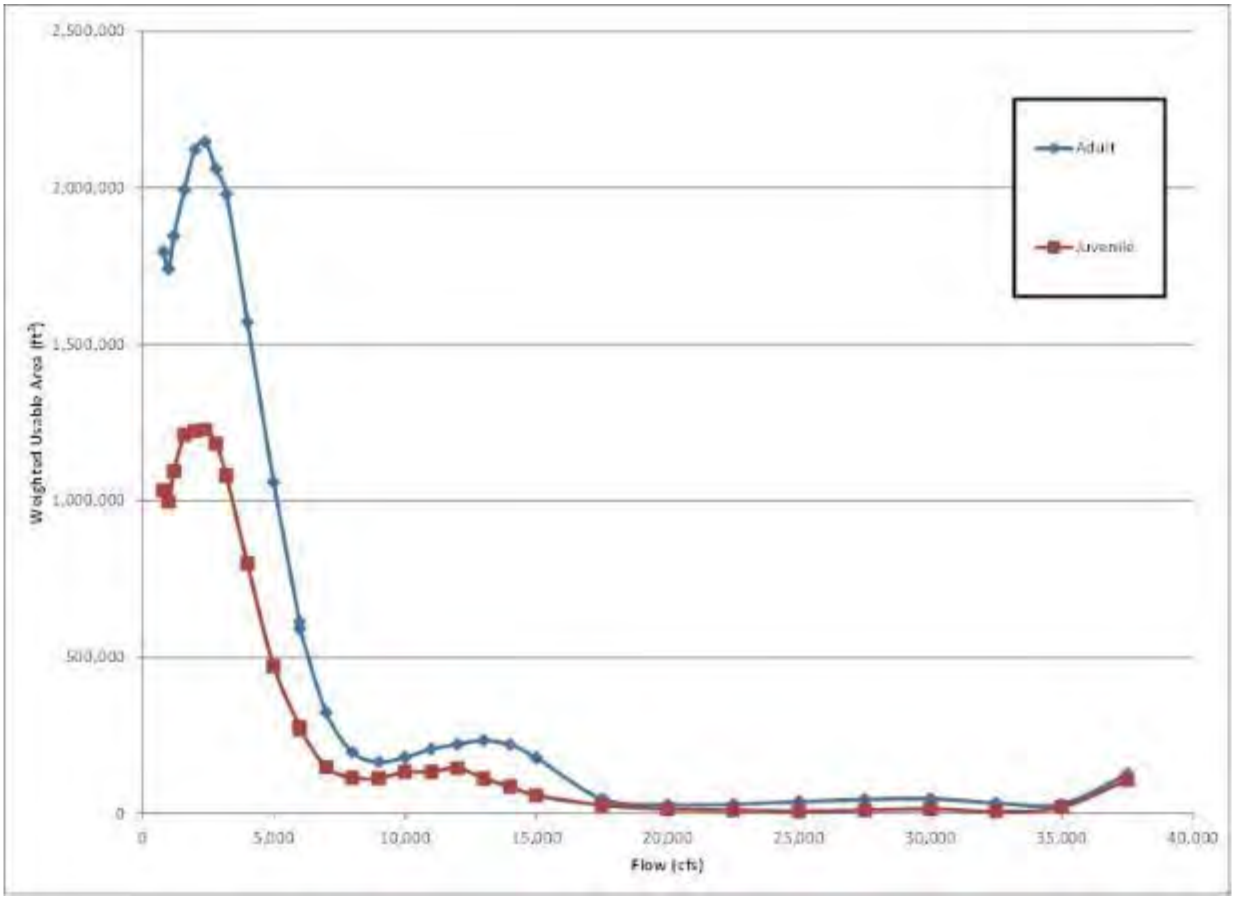


Figure F-4: Reach 4 WUA Curves for the Juvenile and Adult Life Stages of Longnose Dace

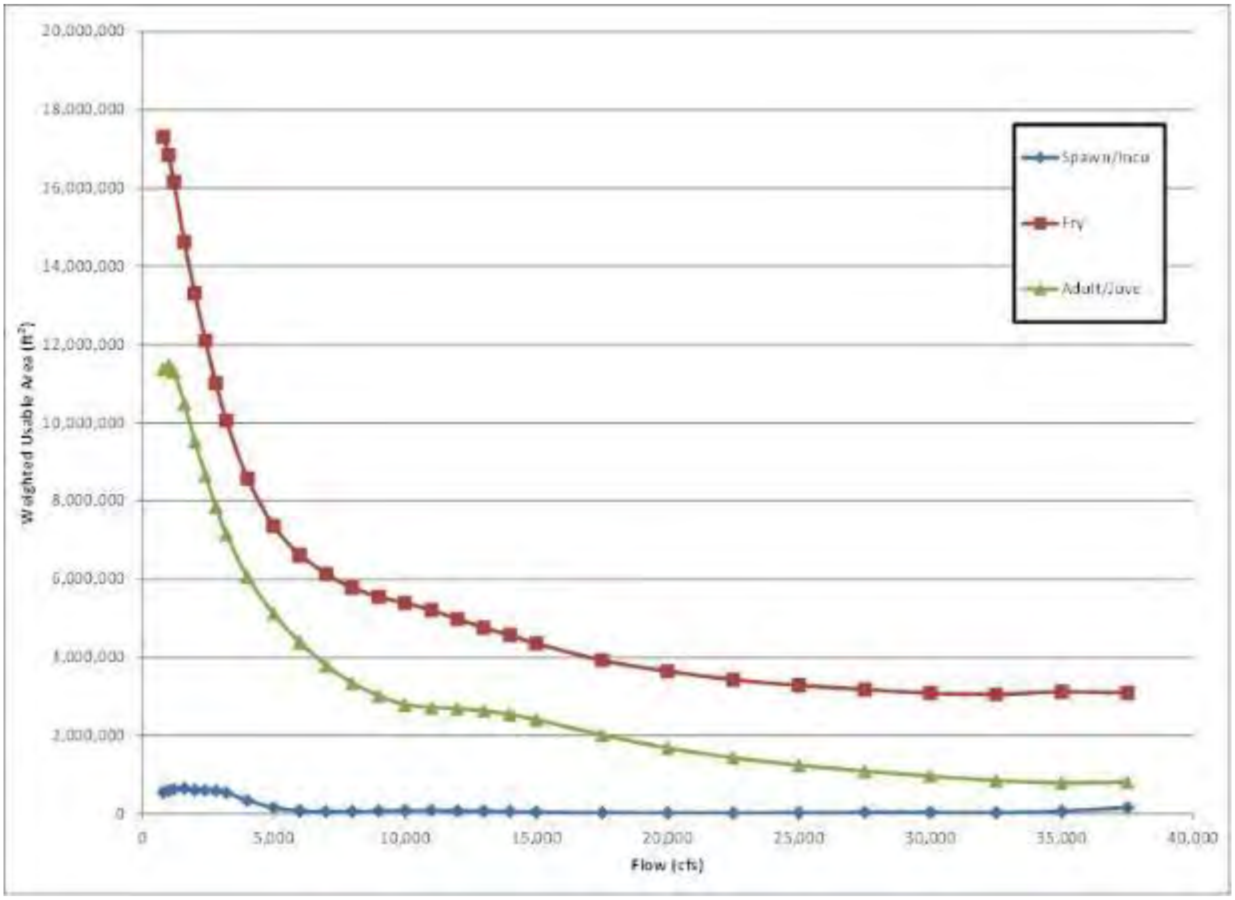


Figure F-5: Reach 4 WUA curves for the Spawning & Incubation, Fry, and Adult Life Stages of White Sucker

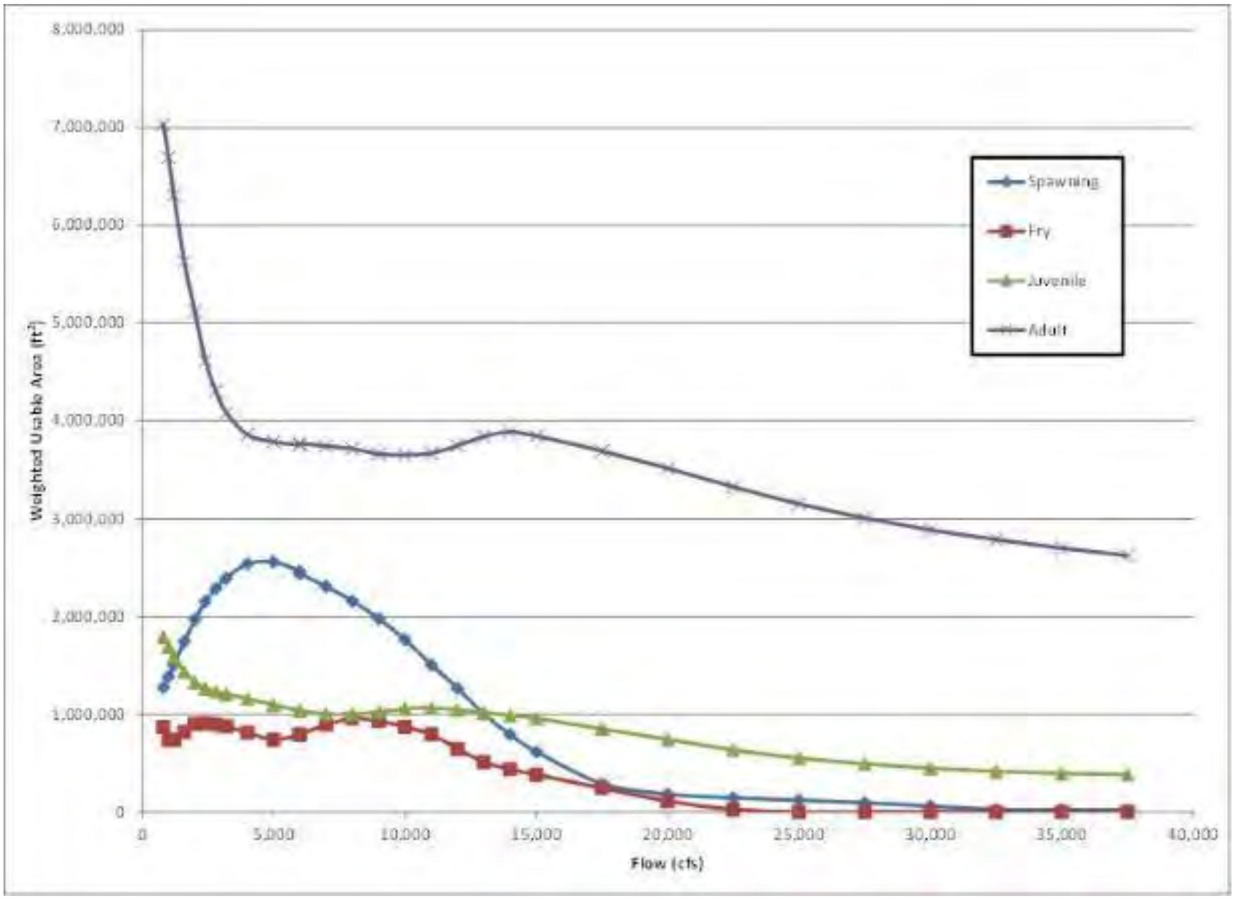


Figure F-6: Reach 4 WUA Curves for the Spawning, Fry, Juvenile, and Adult Life Stages of Walleye

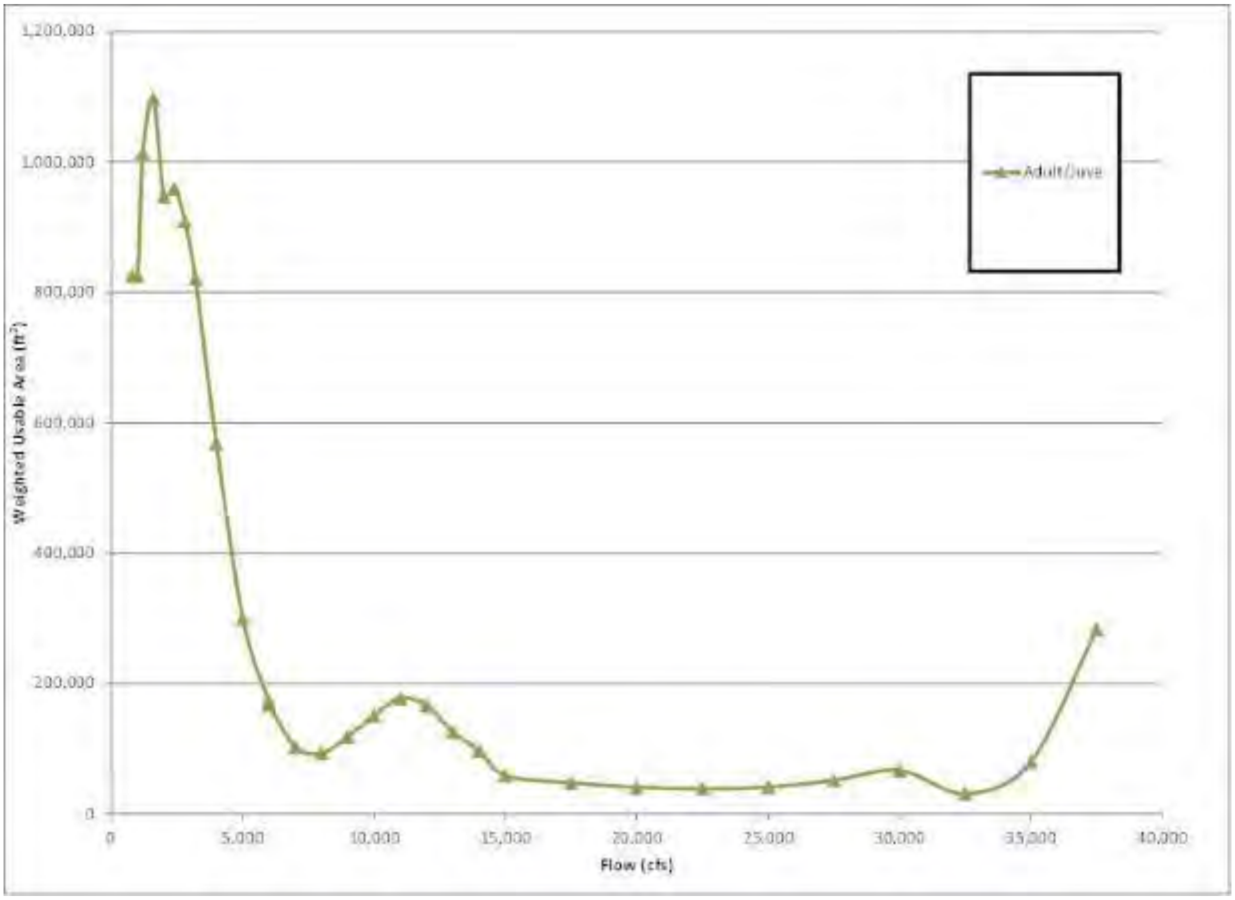


Figure F-7: Reach 4 WUA Curves for the Juvenile & Adult Life Stages of Tessellated Darter

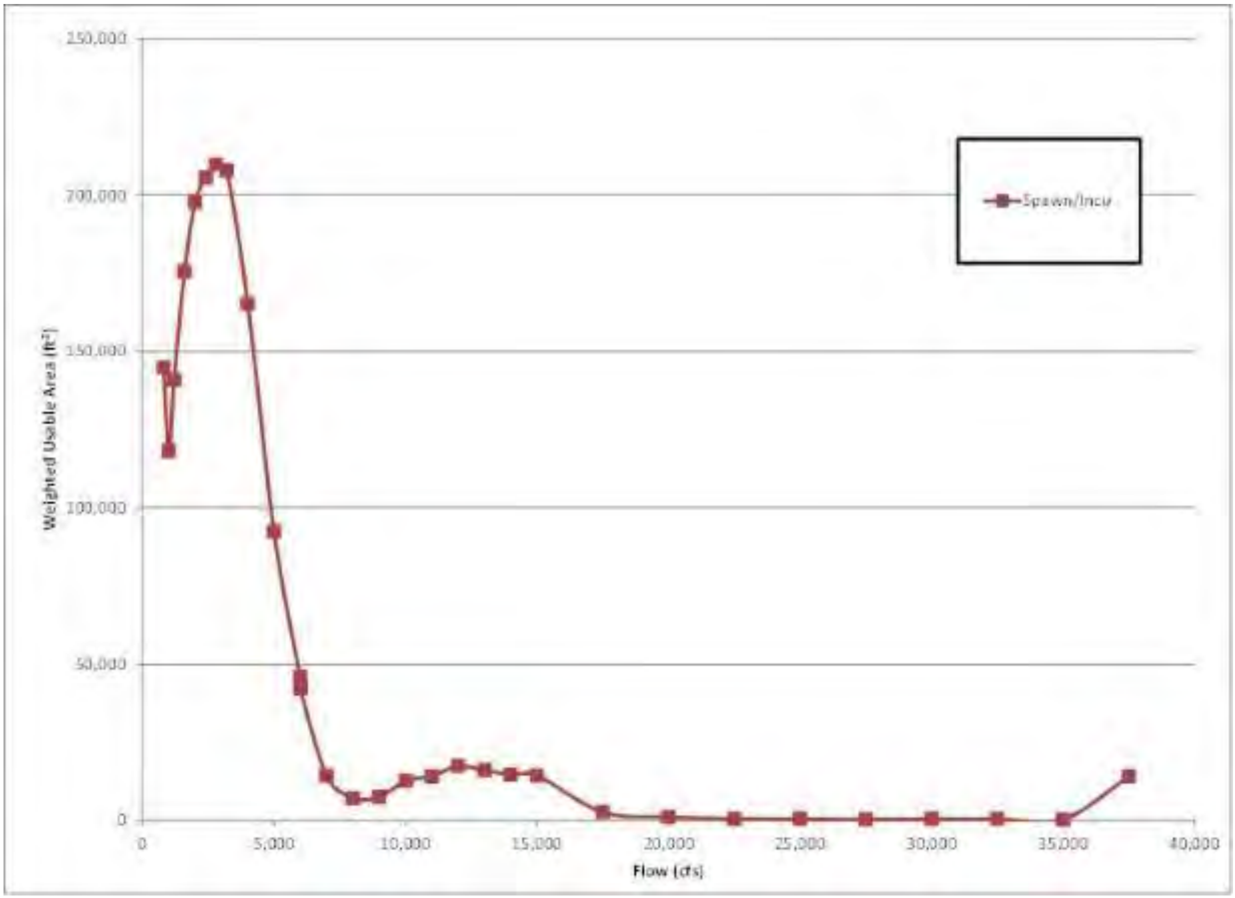


Figure F-8: Reach 4 WUA Curves for the Spawning & Incubation Life Stage of Sea Lamprey

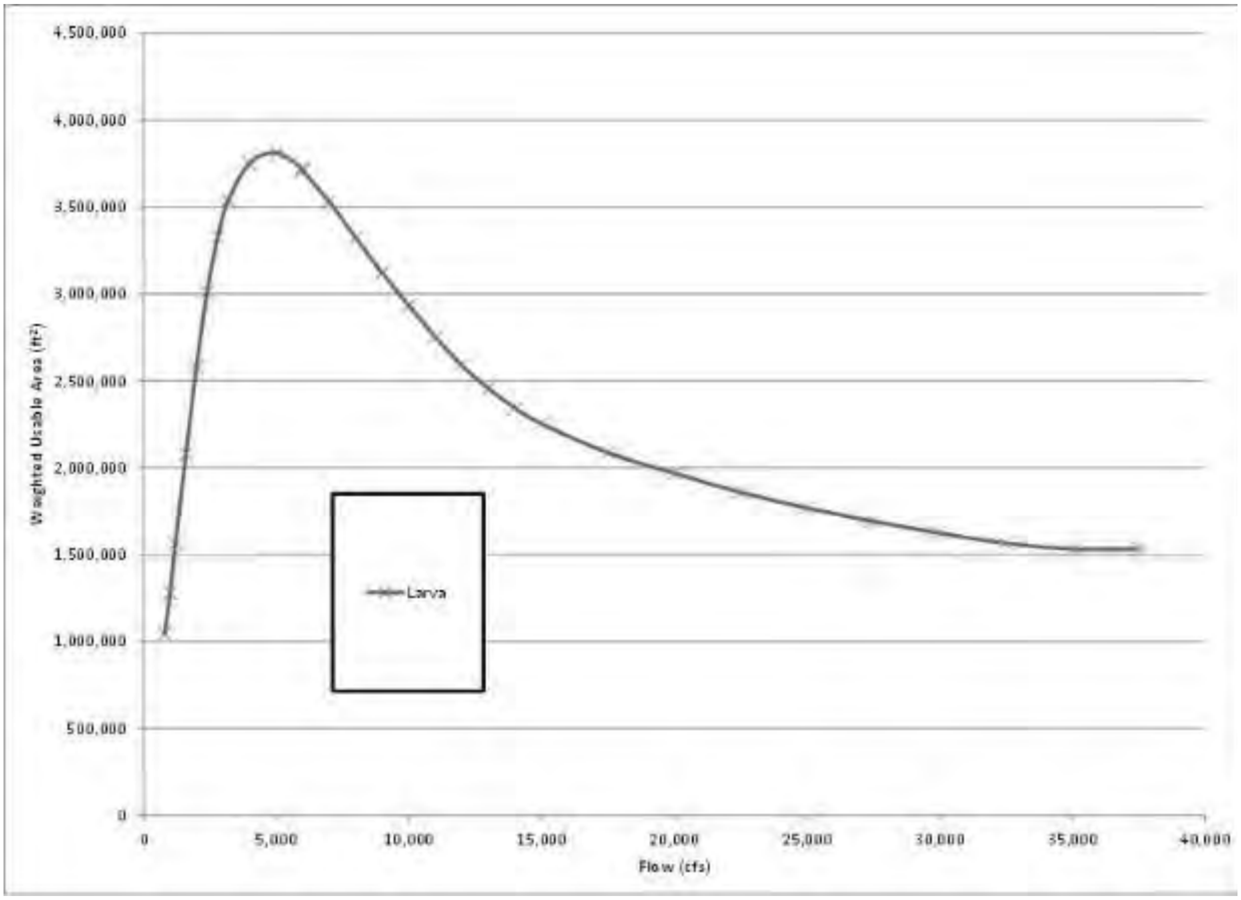


Figure F-9: Reach 4 WUA Curves for the Larva Life Stage of Macroinvertebrates

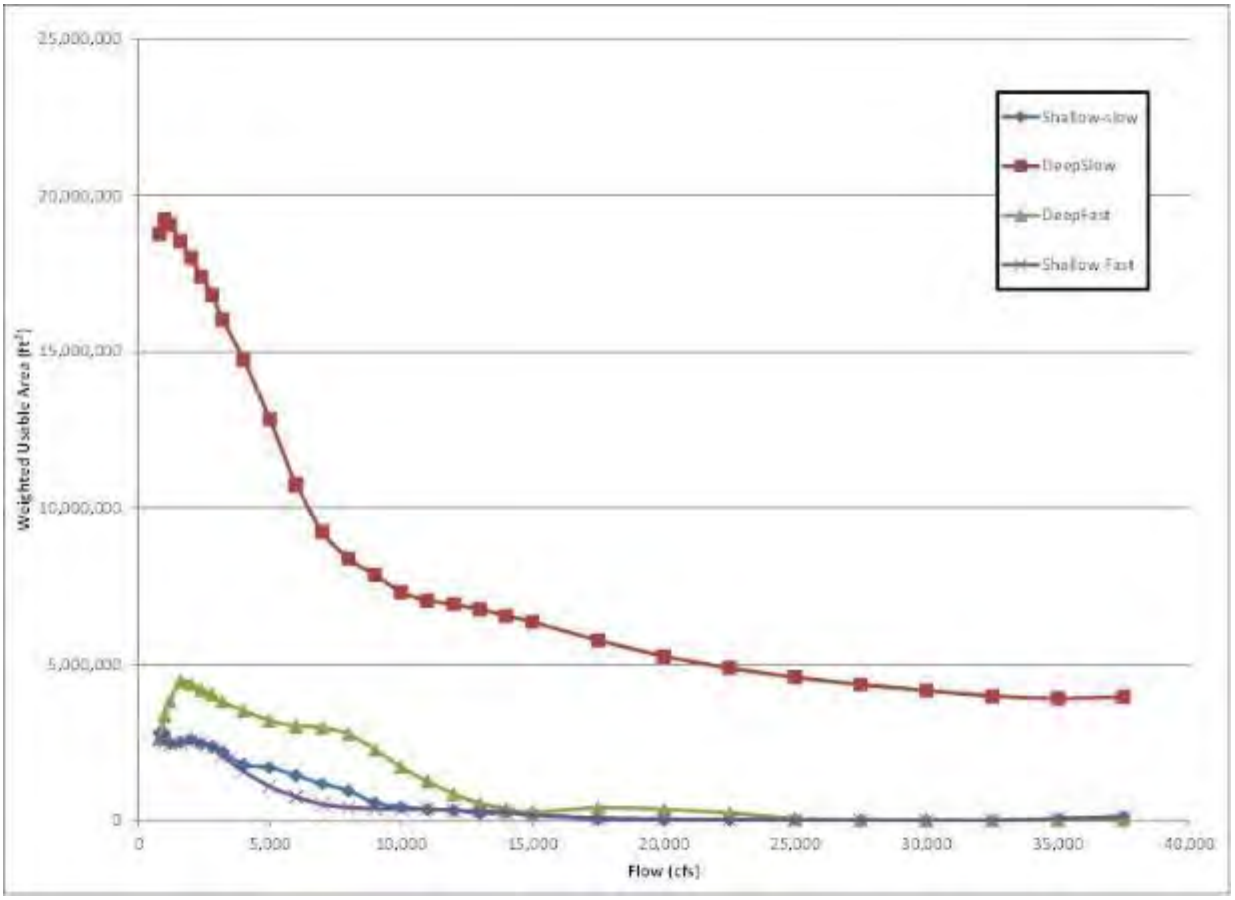
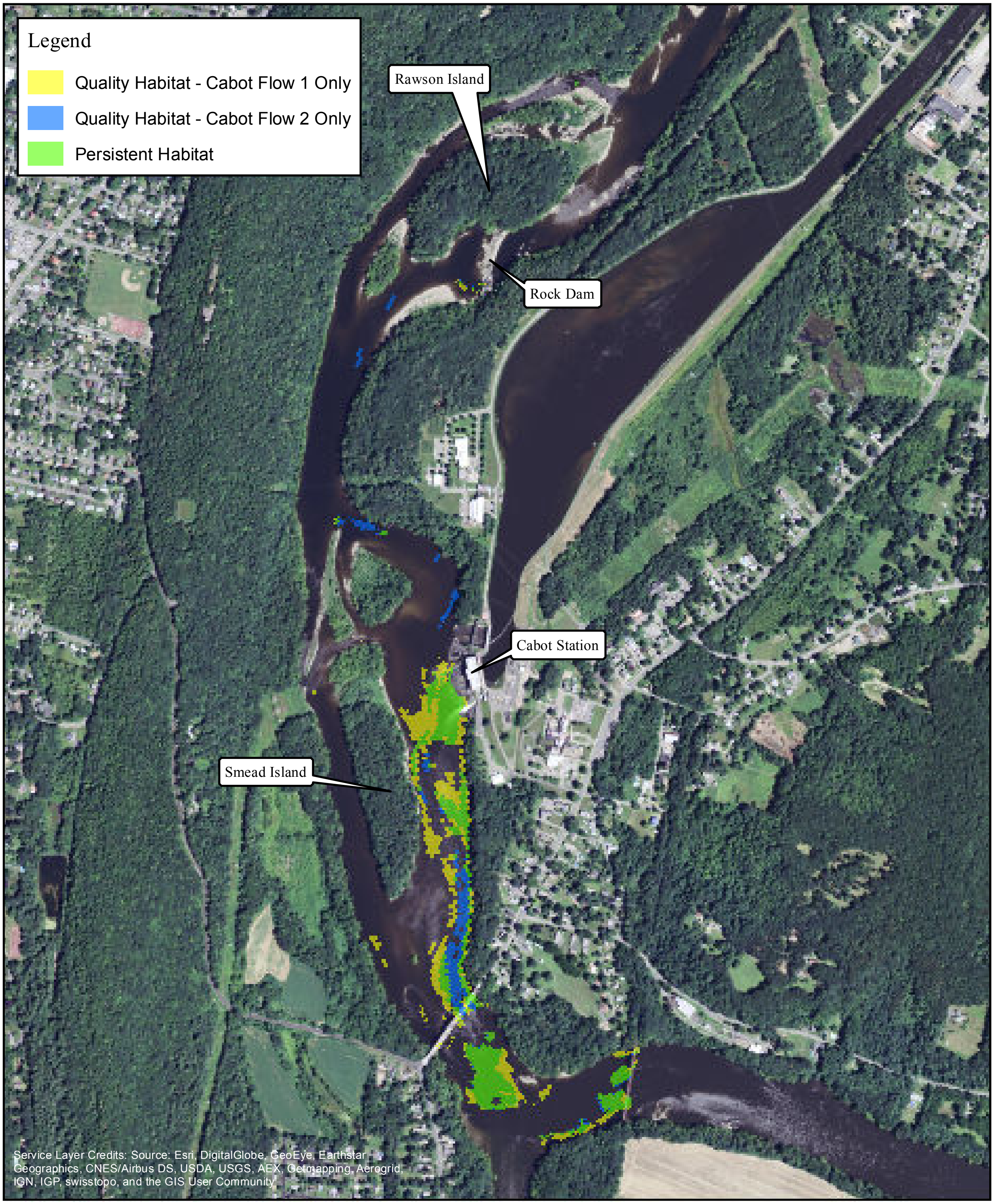


Figure F-10: Reach 4 WUA Curves for Shallow-Slow, Deep-Slow, Deep-Fast, and Shallow-Fast Habitat Guilds

APPENDIX G – REACH 3 HABITAT PERSISTANCE MAPS



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

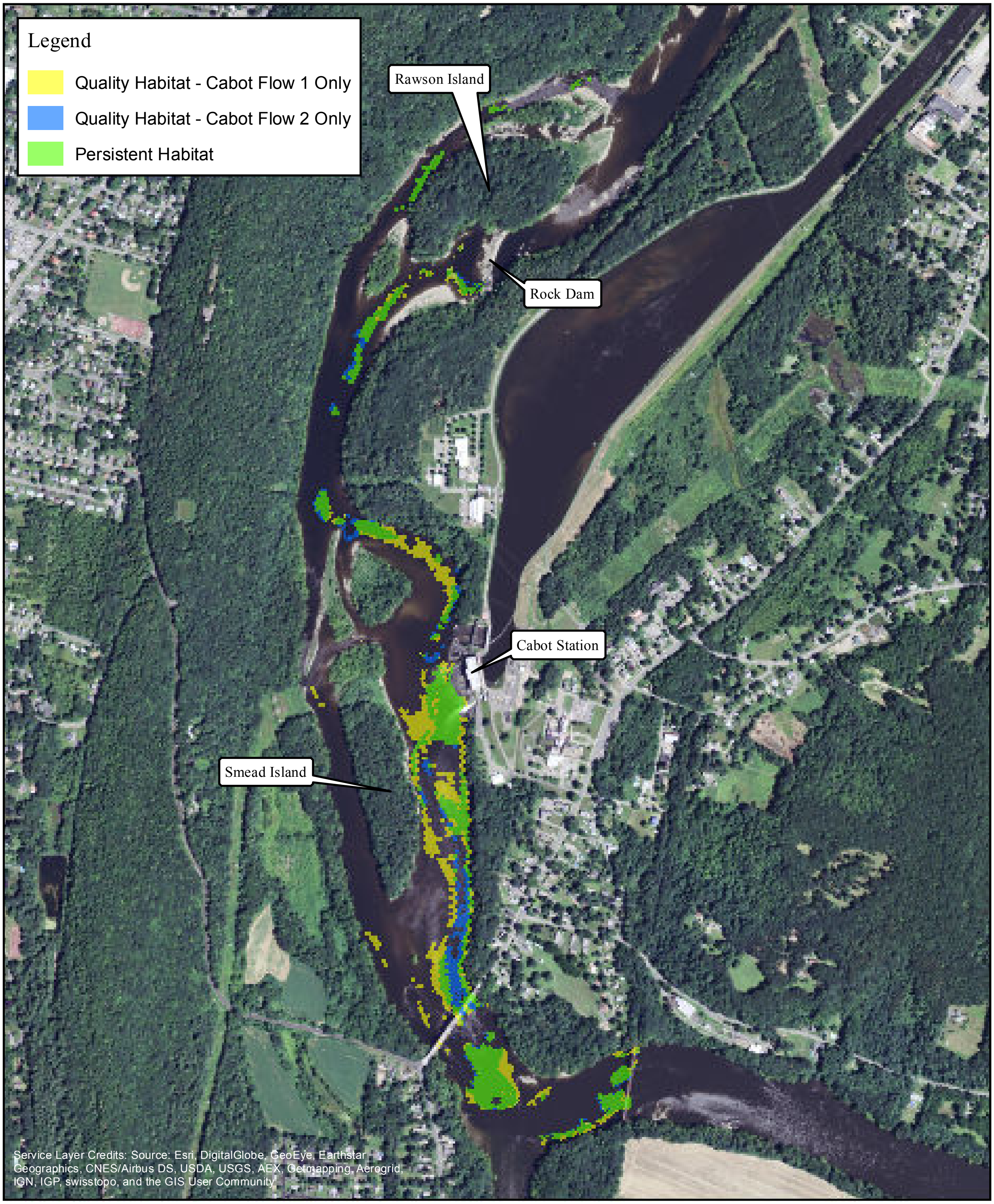
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
American Shad Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

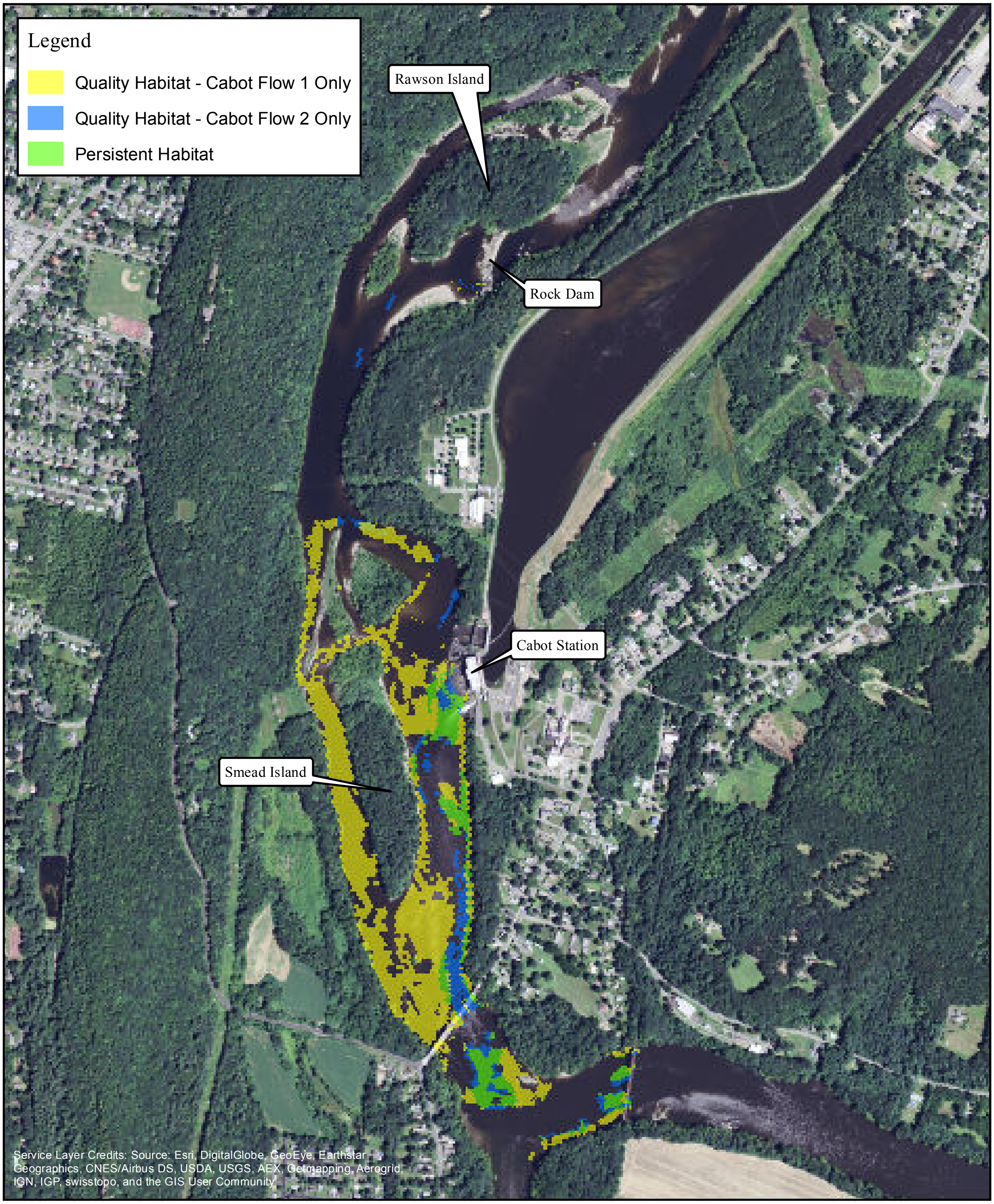
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
American Shad Spawning

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

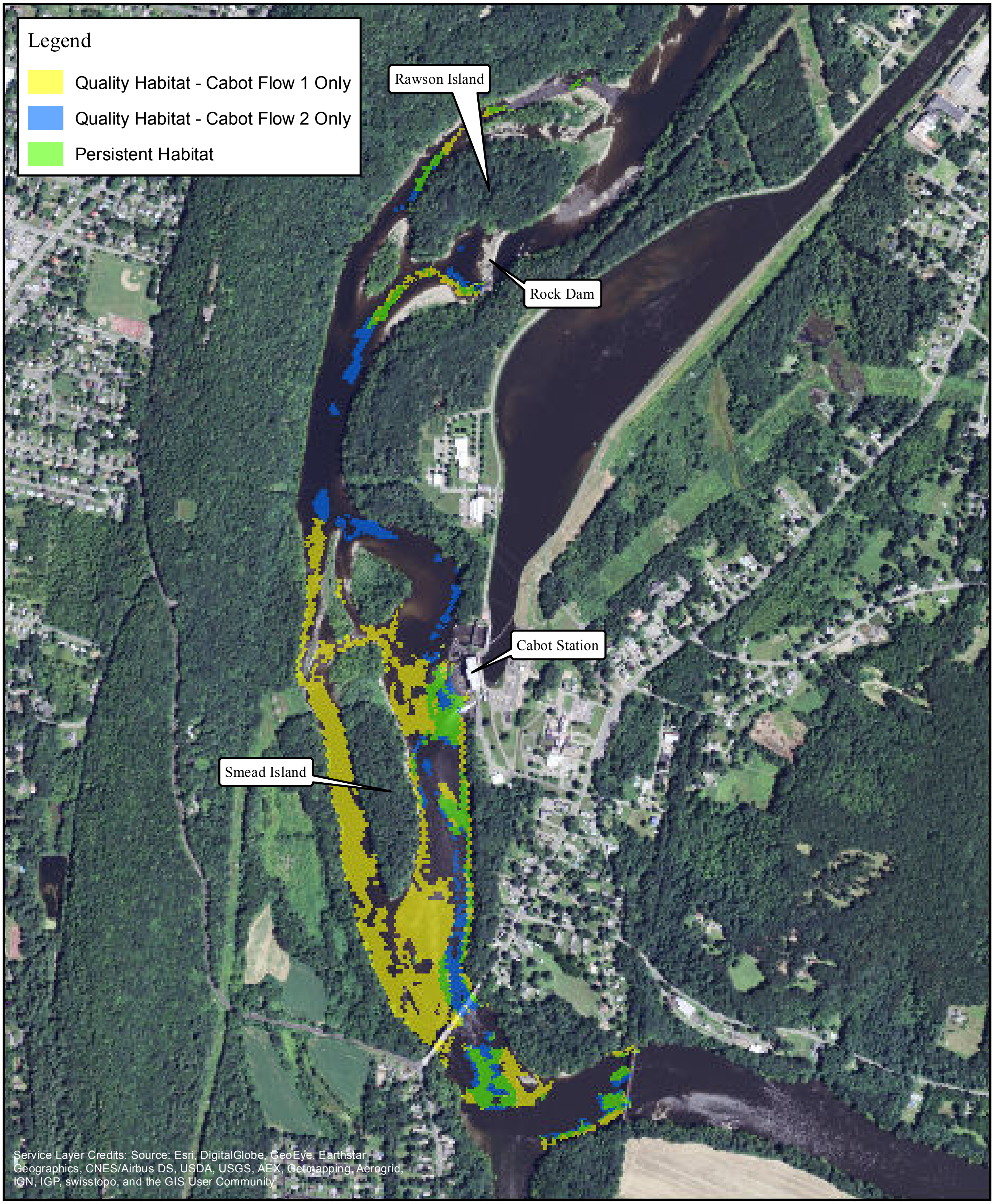
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
American Shad Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

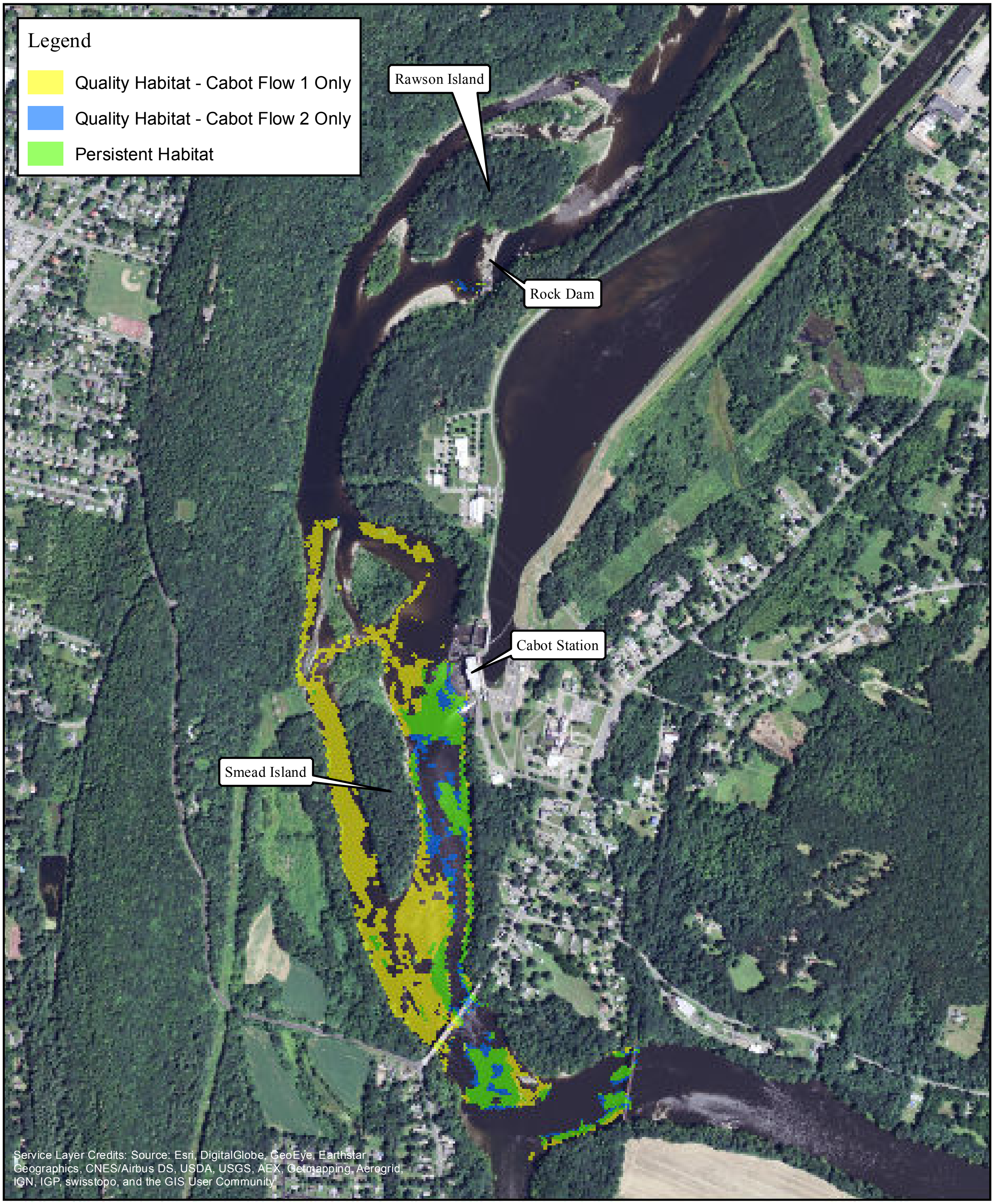
RELICENSING STUDY 3.3.1

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
American Shad Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

N

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

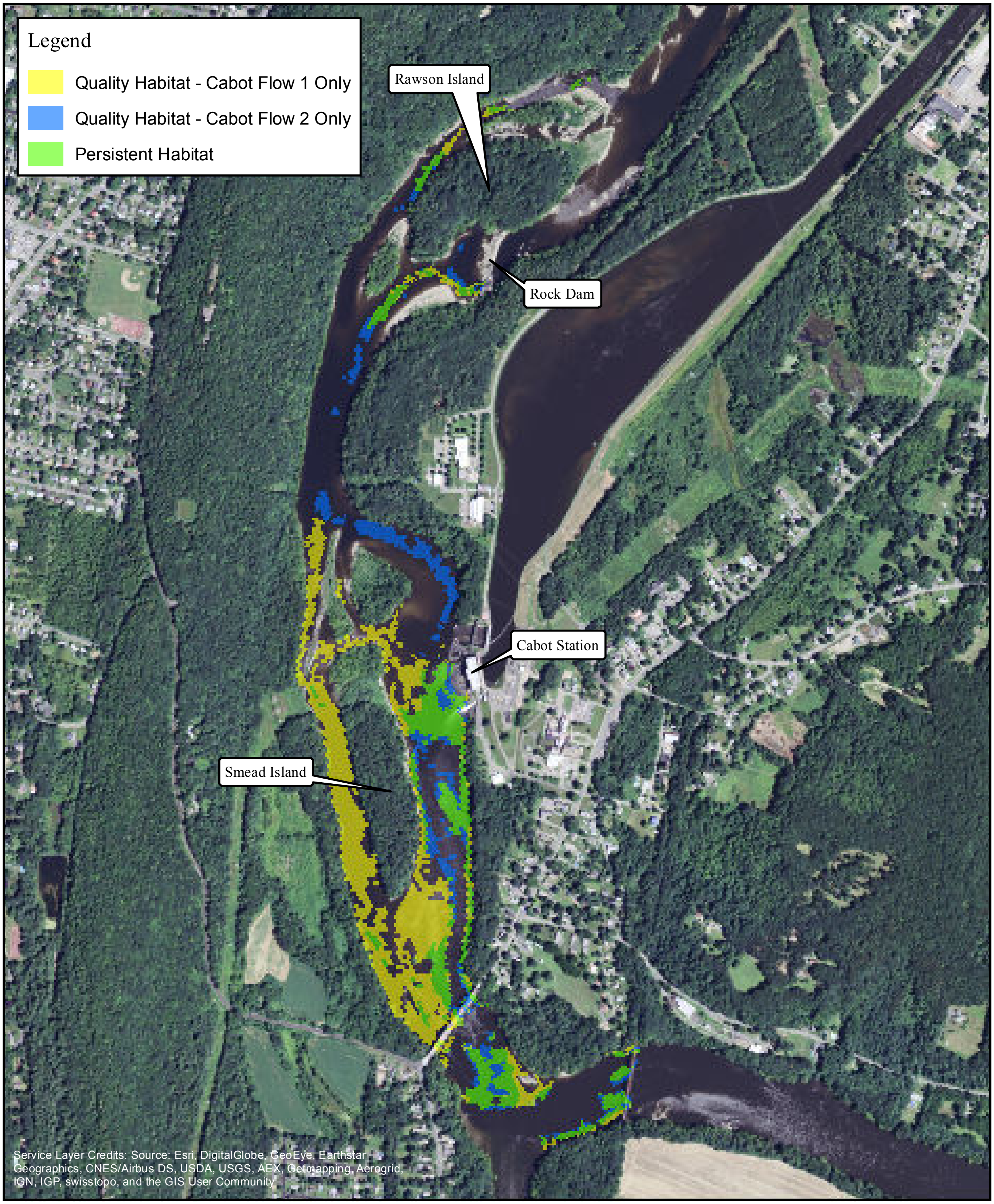
RELICENSING STUDY 3.3.1

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
American Shad Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

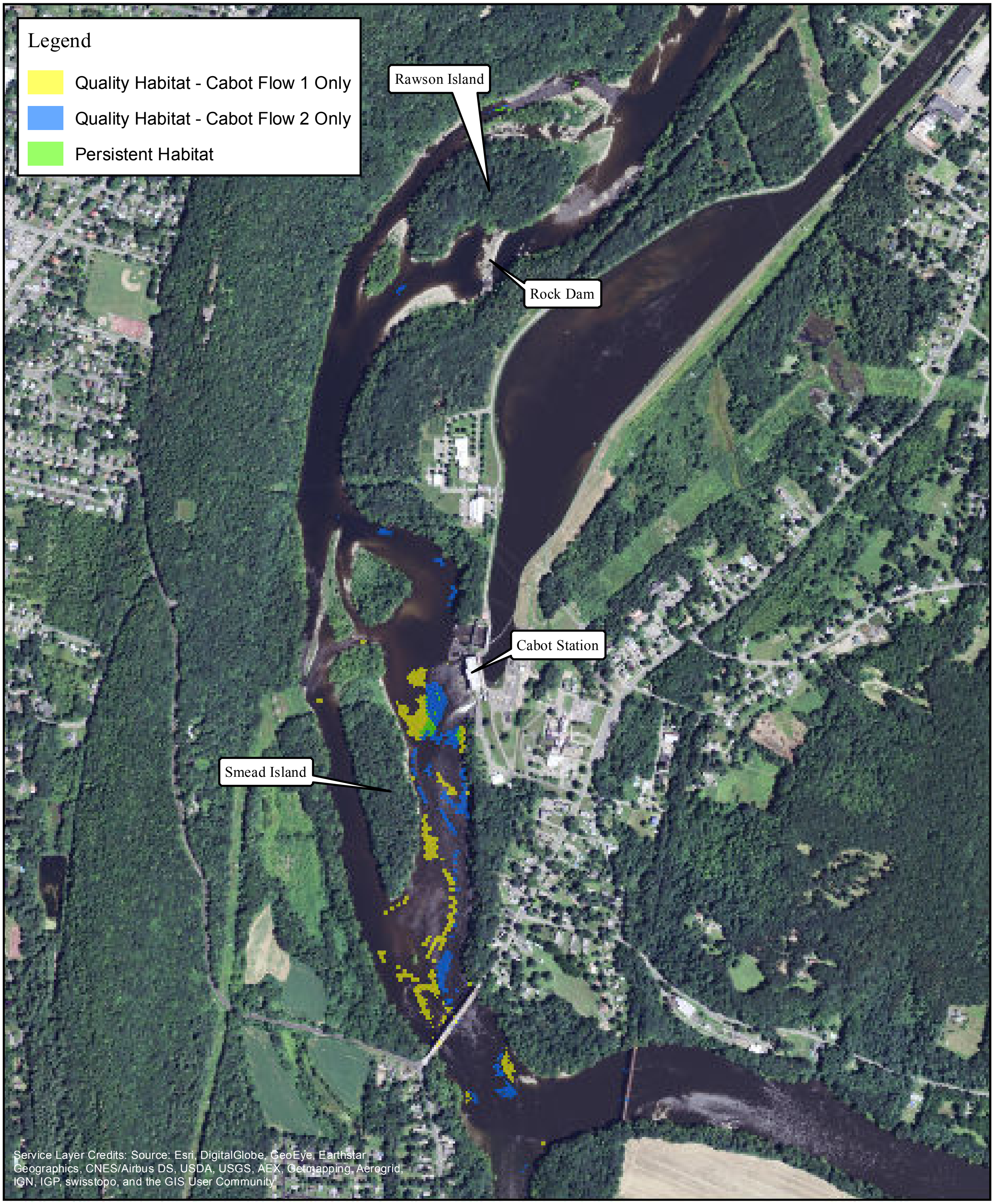
N

0 500 1,000 2,000
Feet

Persistent Habitat
Species/Life Stage:
American Shad Spawning

Bypass Flow:	500	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

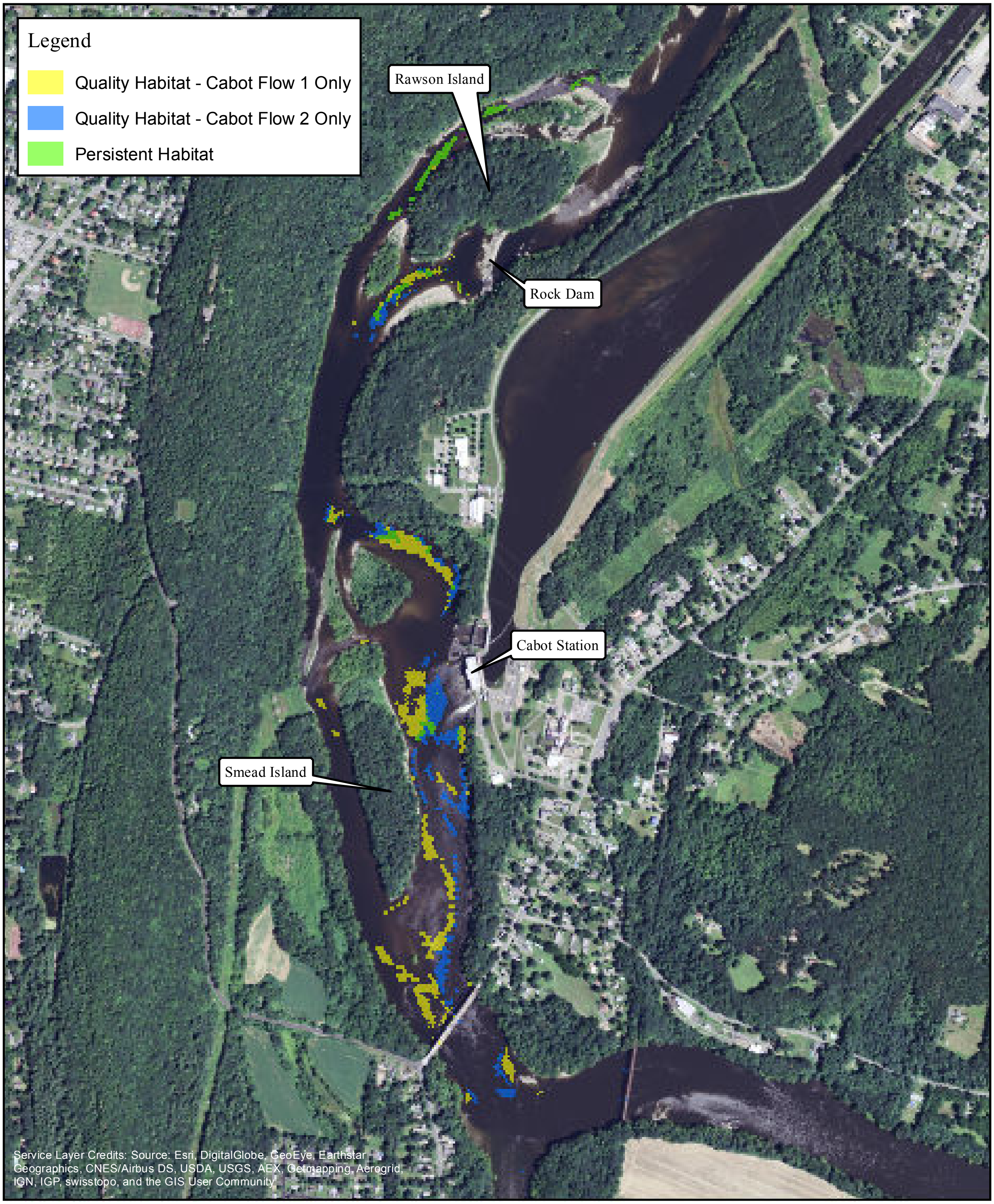
N

0 500 1,000 2,000
Feet

Persistent Habitat
Species/Life Stage:
Deep-Fast Guild

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

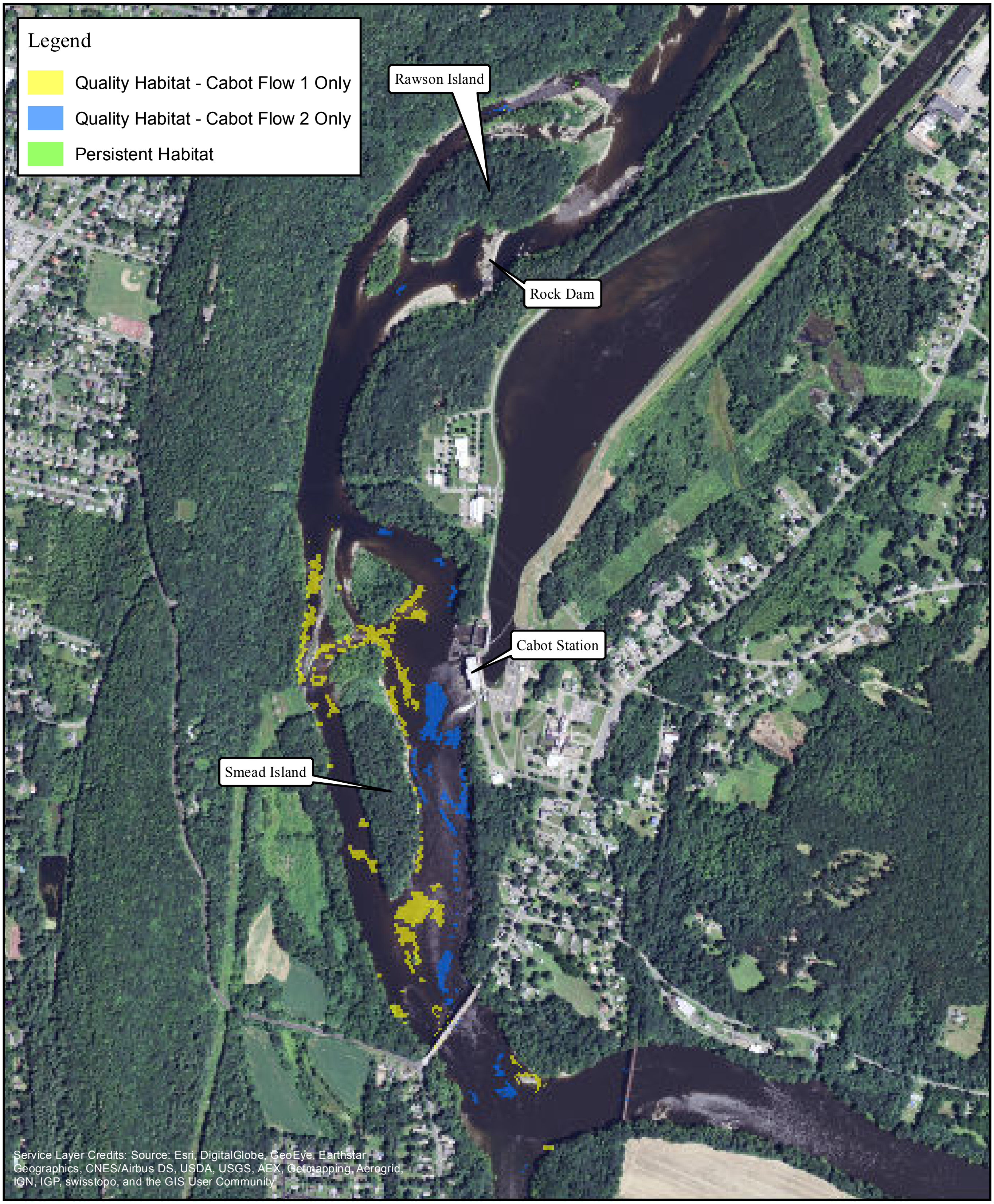
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Fast Guild

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

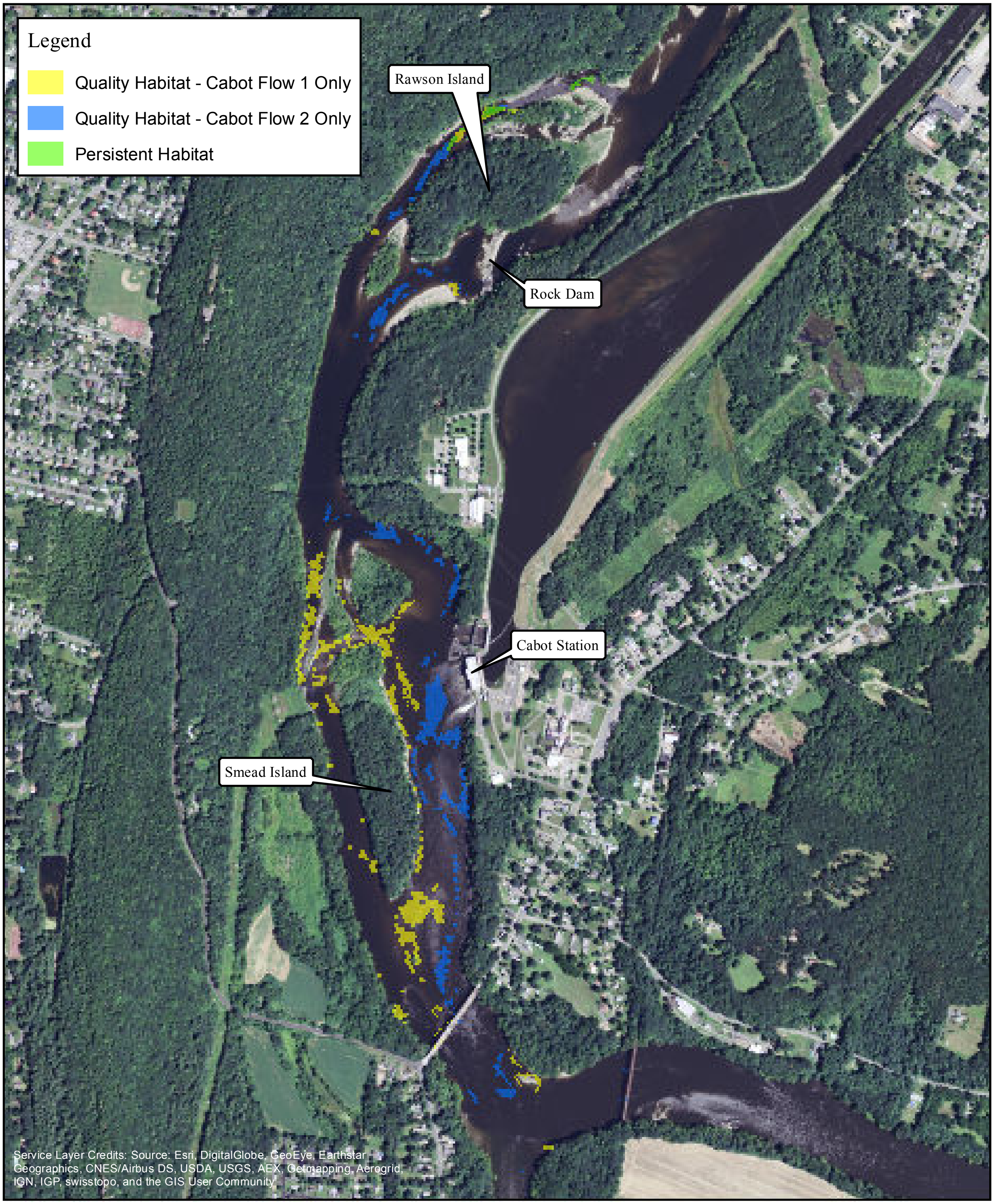
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Fast Guild

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

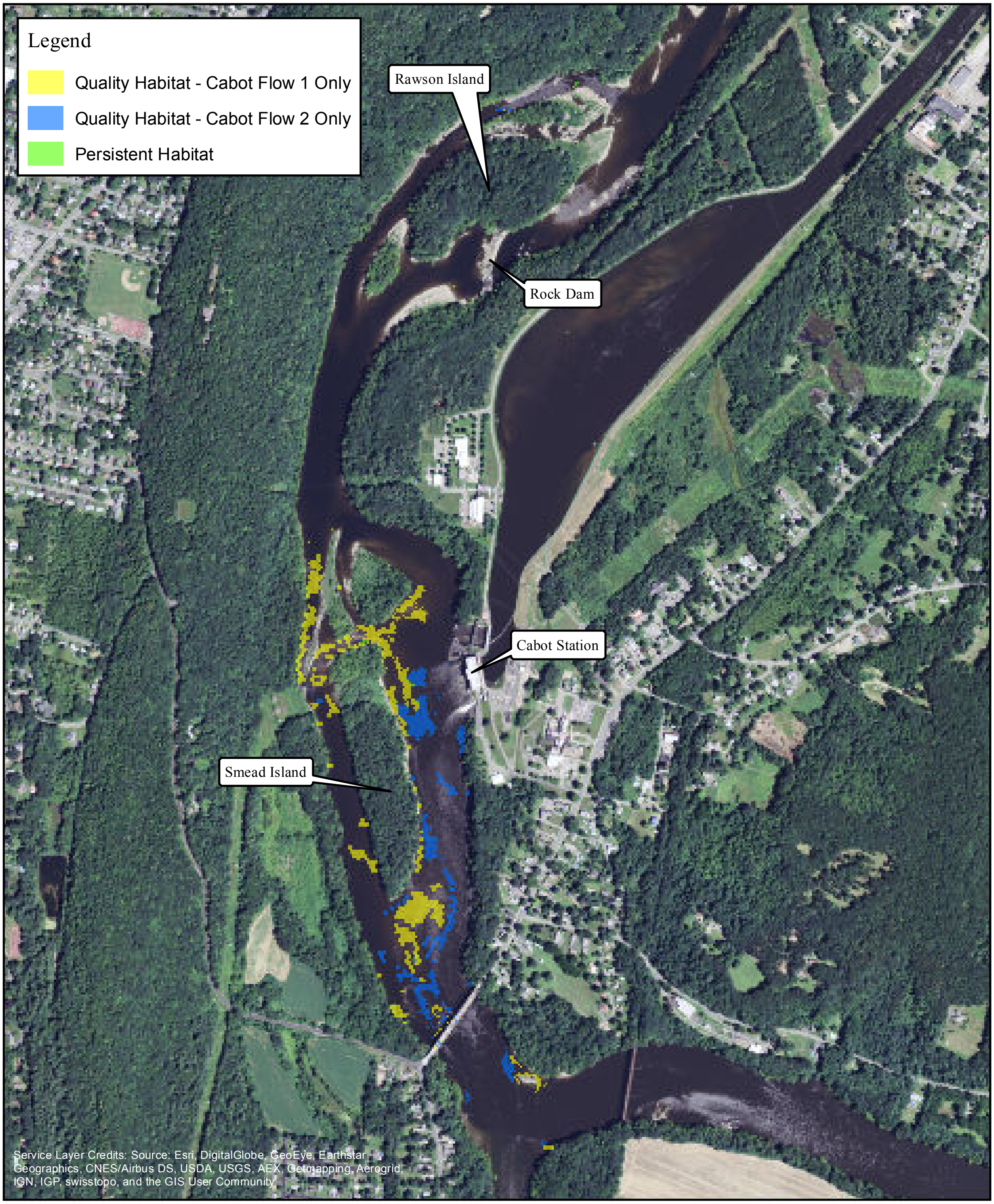
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Fast Guild

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

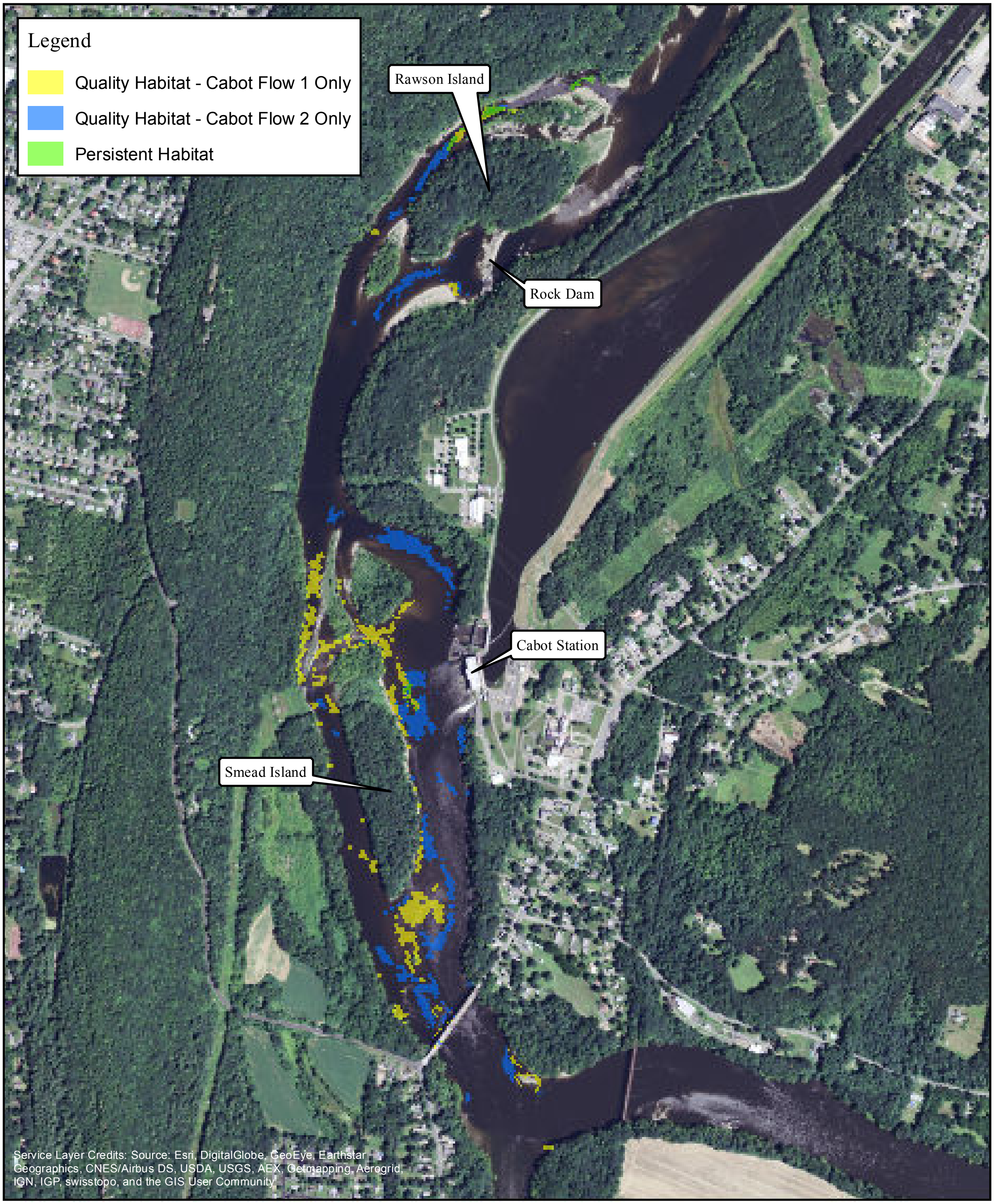
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Fast Guild

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

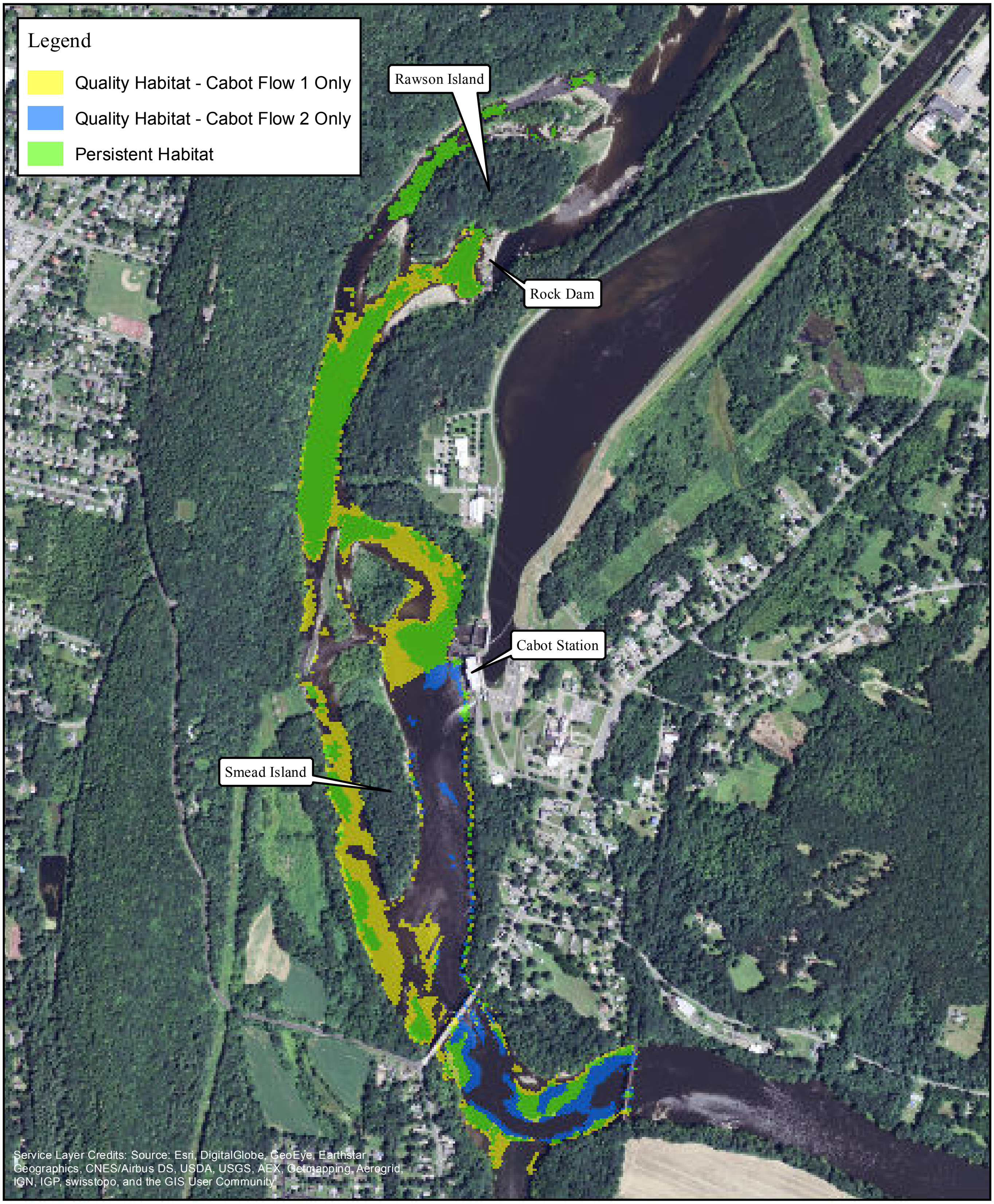
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Fast Guild

Bypass Flow:	500 cfs
Cabot Flow 1:	7000 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

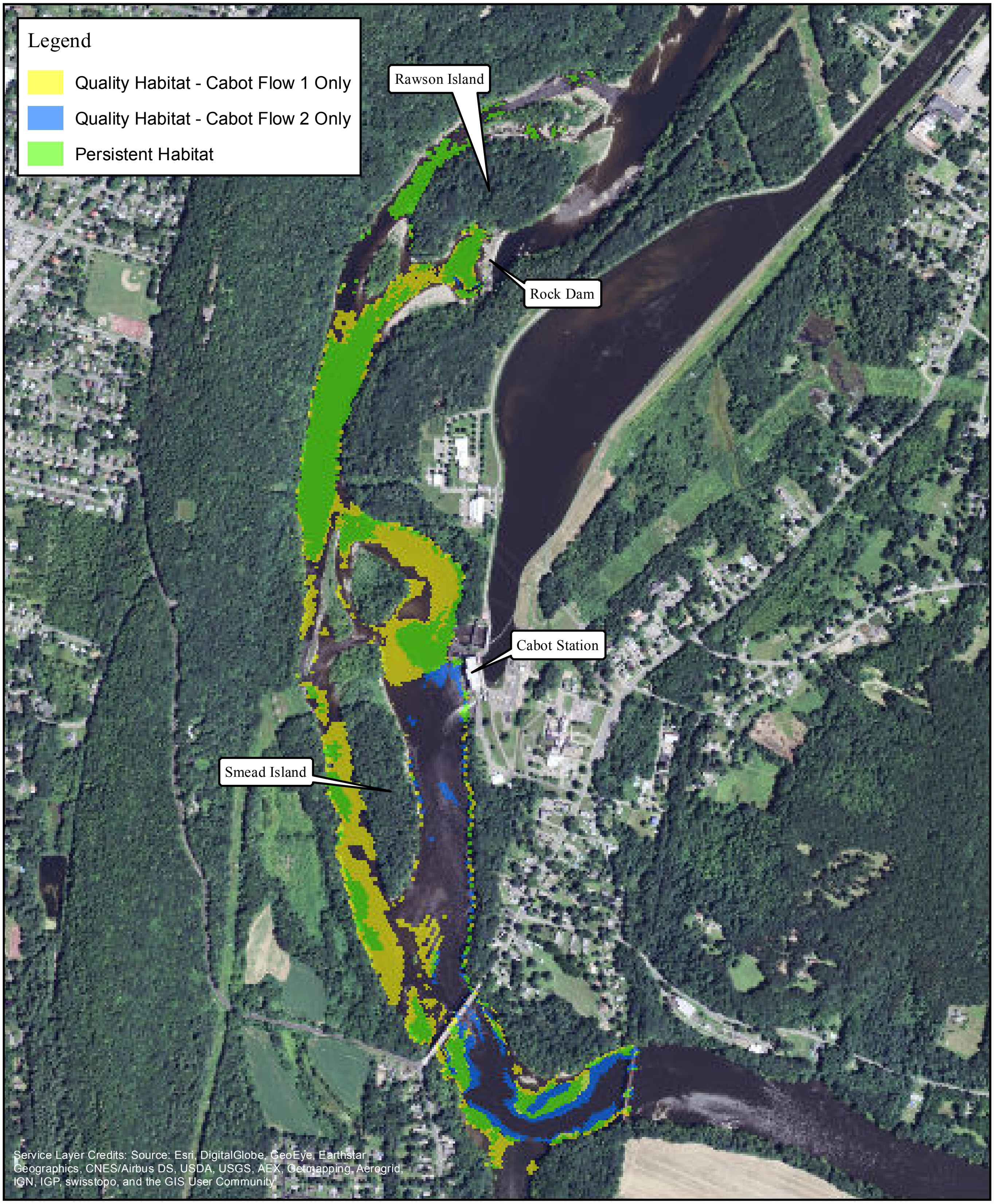
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Deep-Slow Guild

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



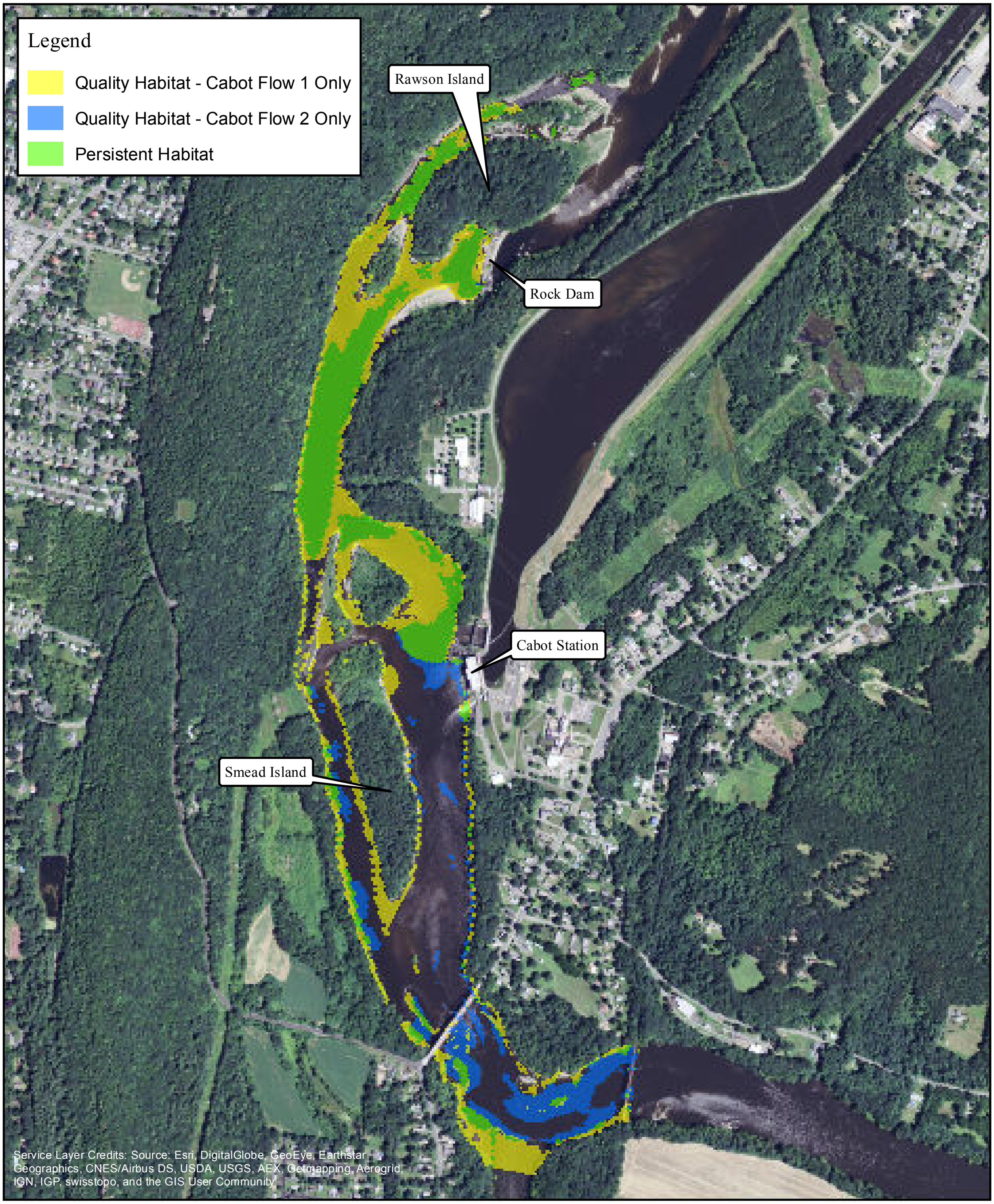
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Deep-Slow Guild

Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

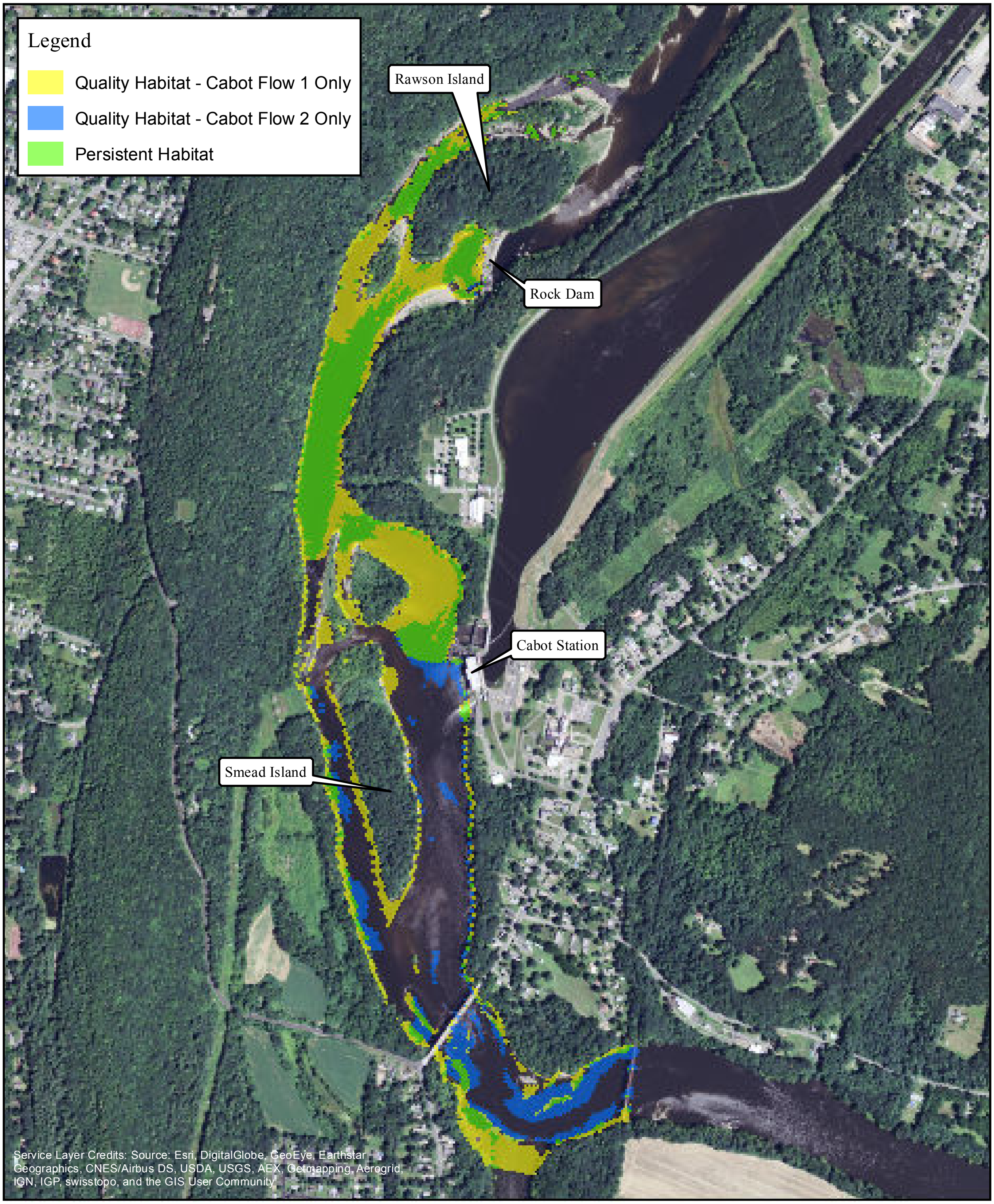
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Slow Guild

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

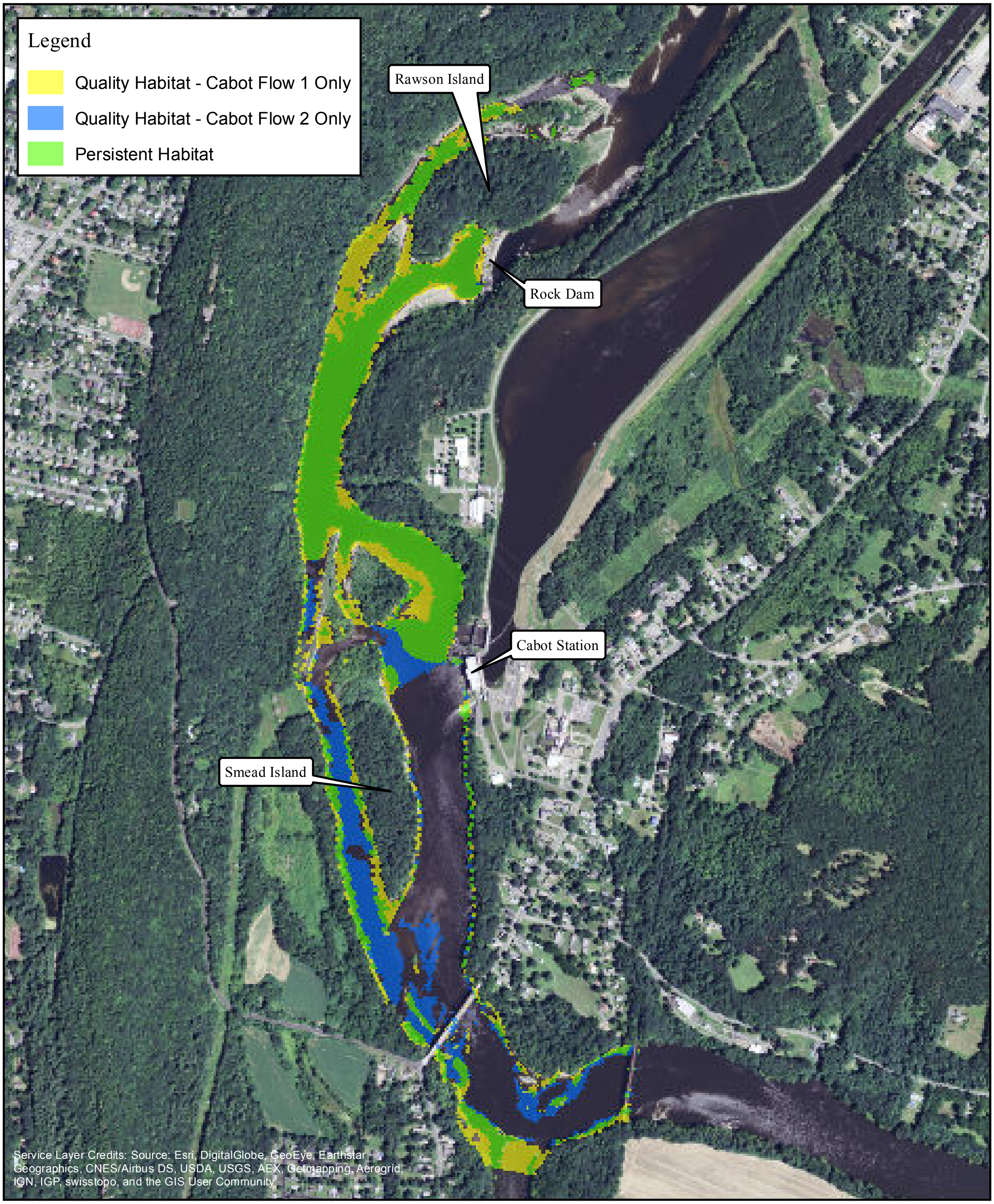
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Slow Guild

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

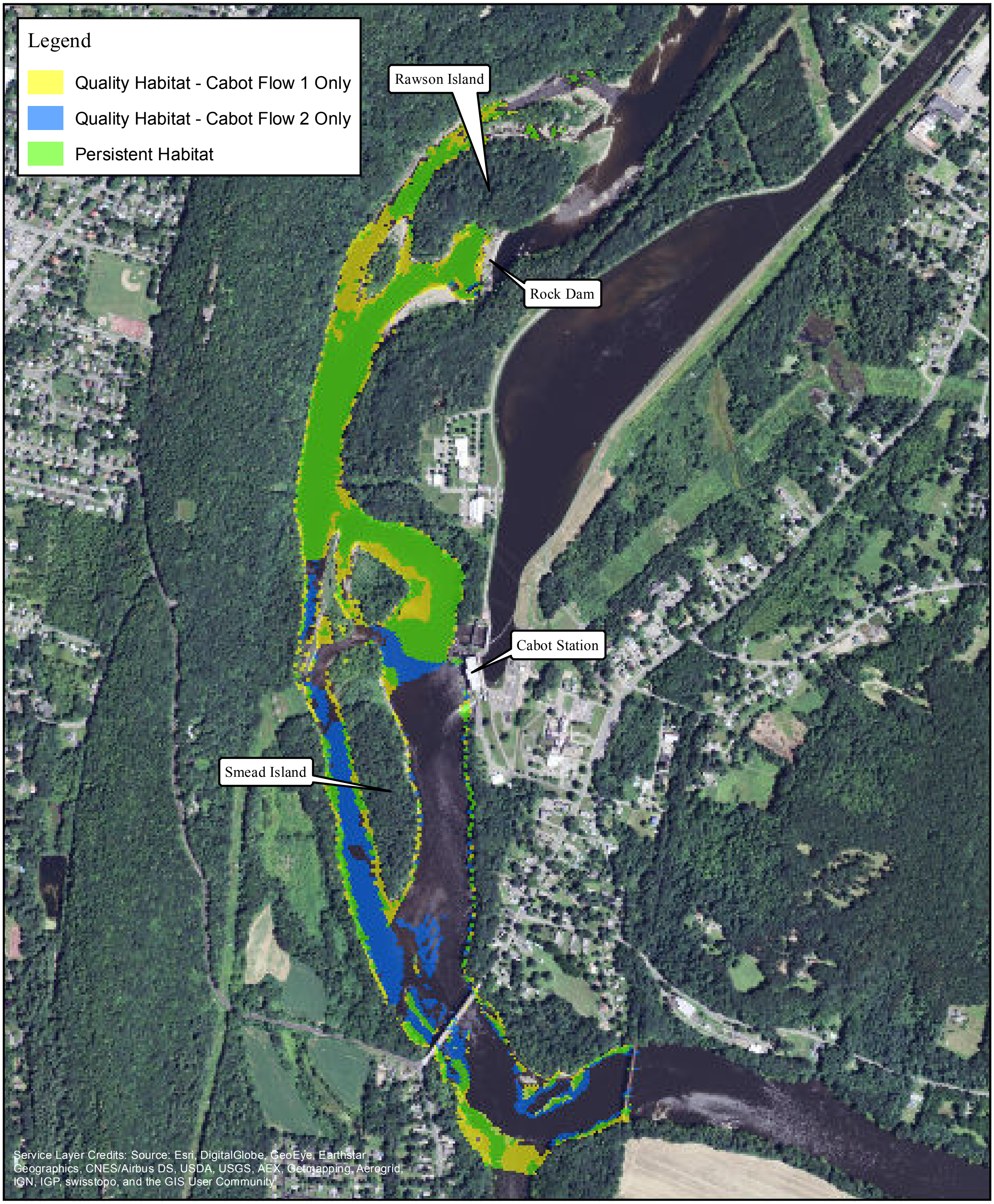
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Slow Guild

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

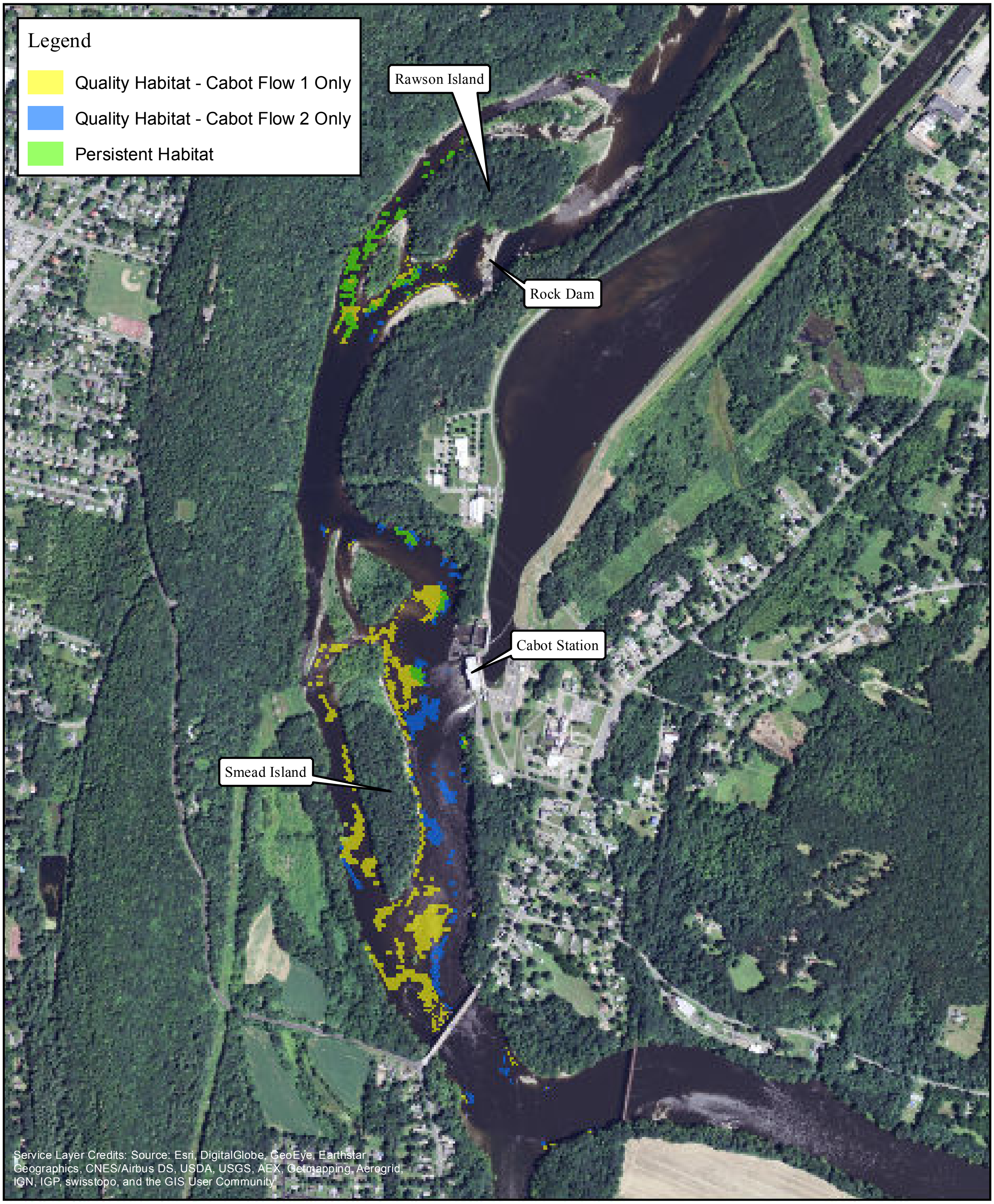
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Deep-Slow Guild

Bypass Flow:	500 cfs
Cabot Flow 1:	7000 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

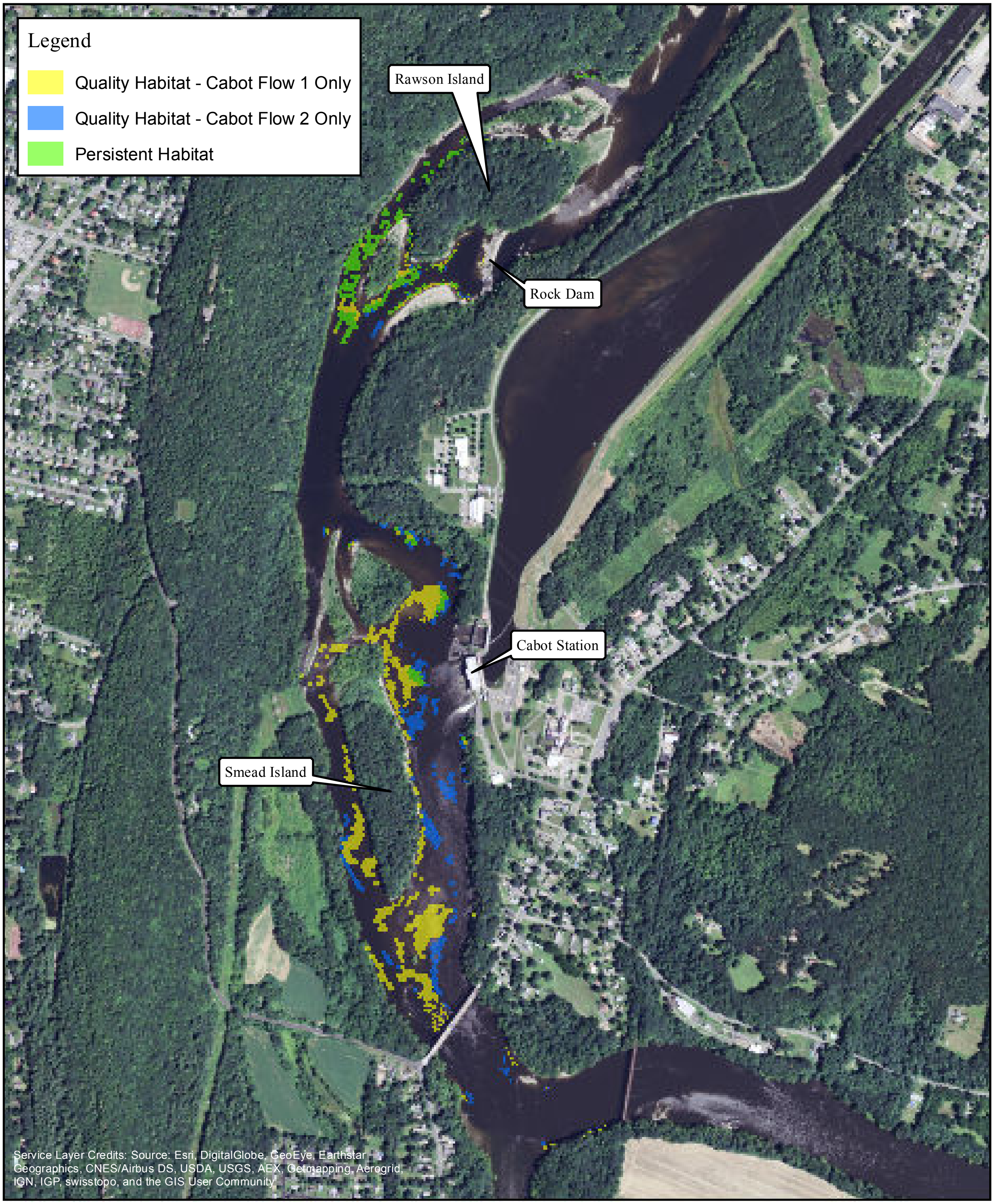
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

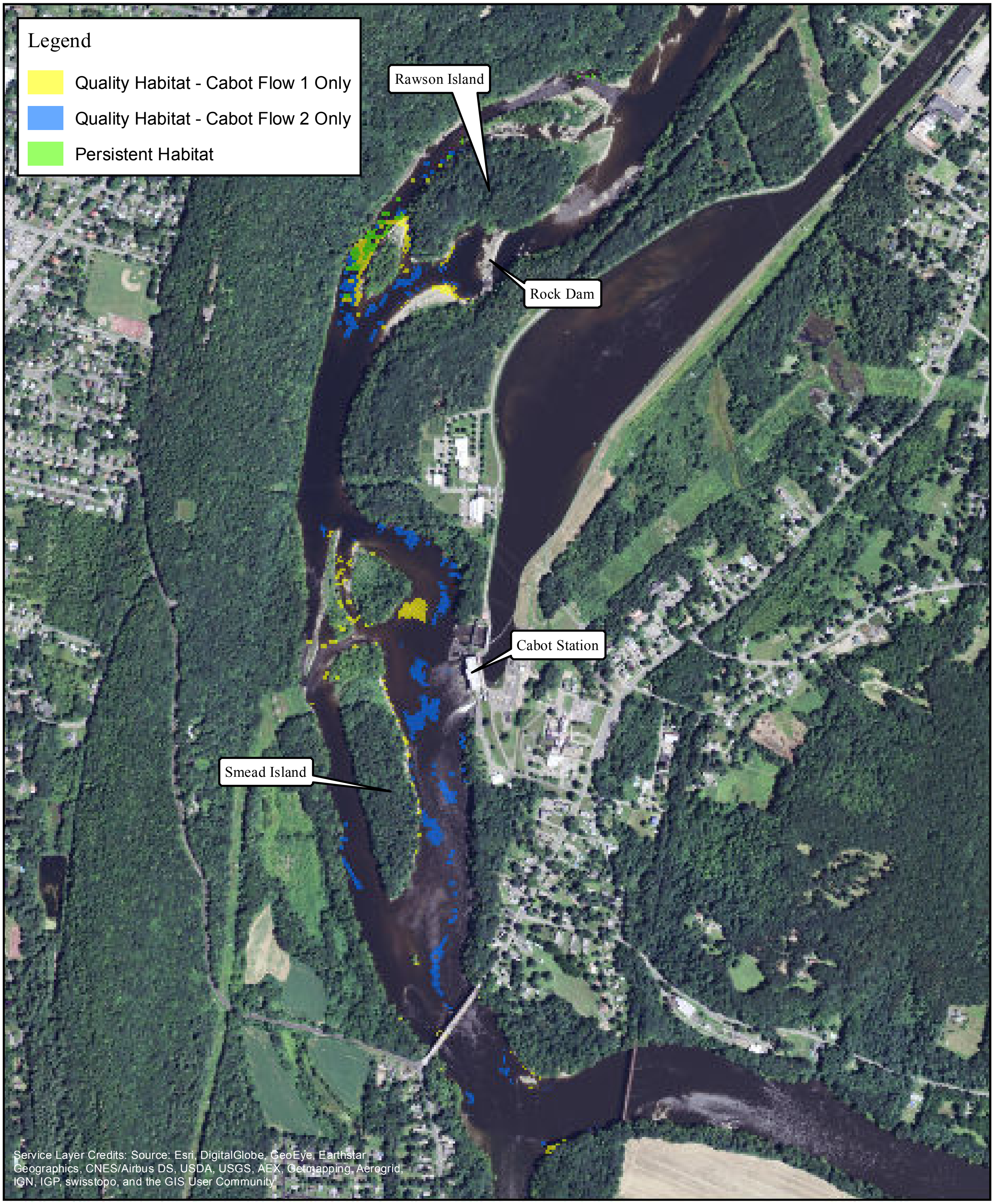
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Spawning

Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

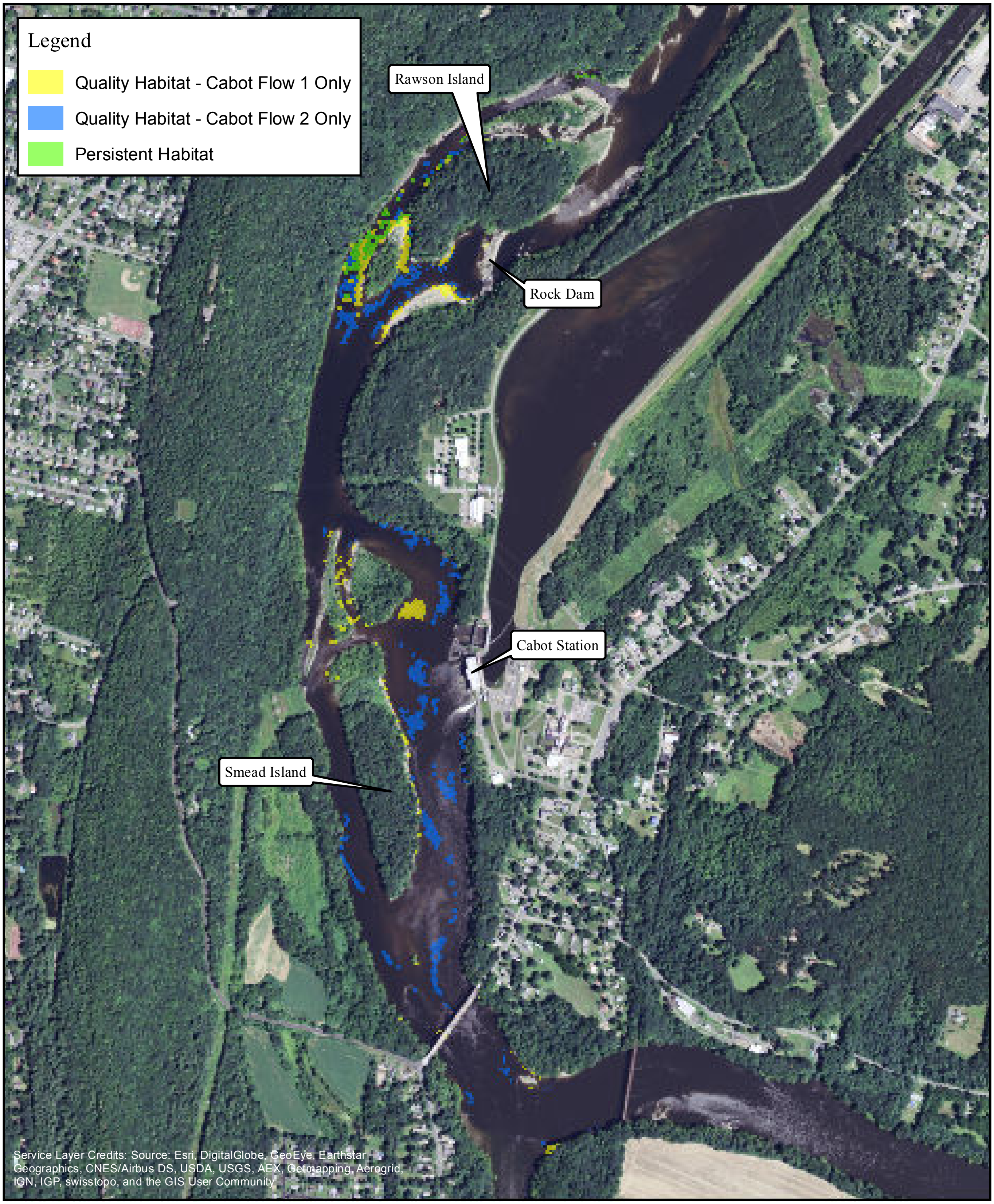
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Fallfish Spawning

Bypass Flow: 200 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

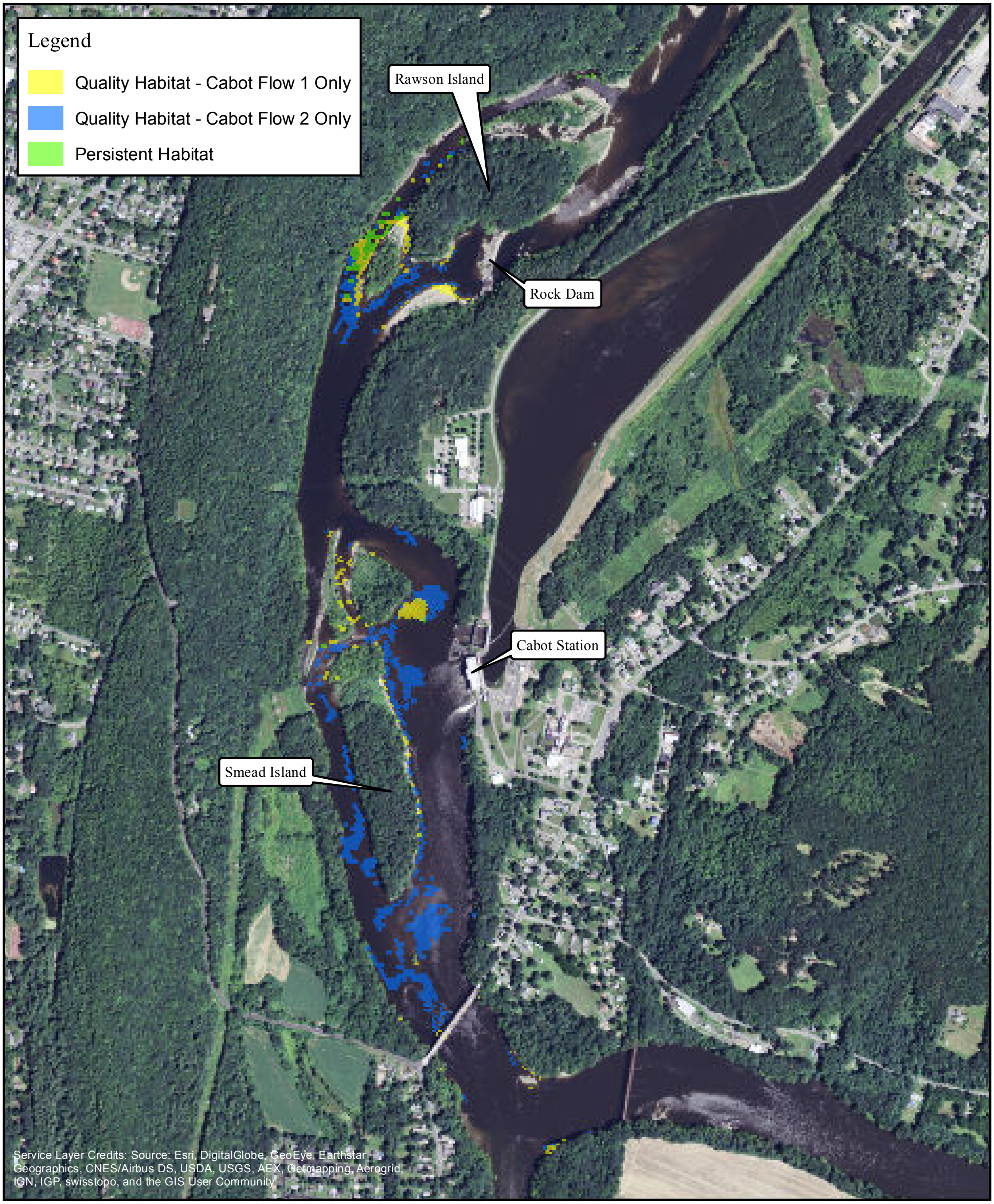
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Spawning

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

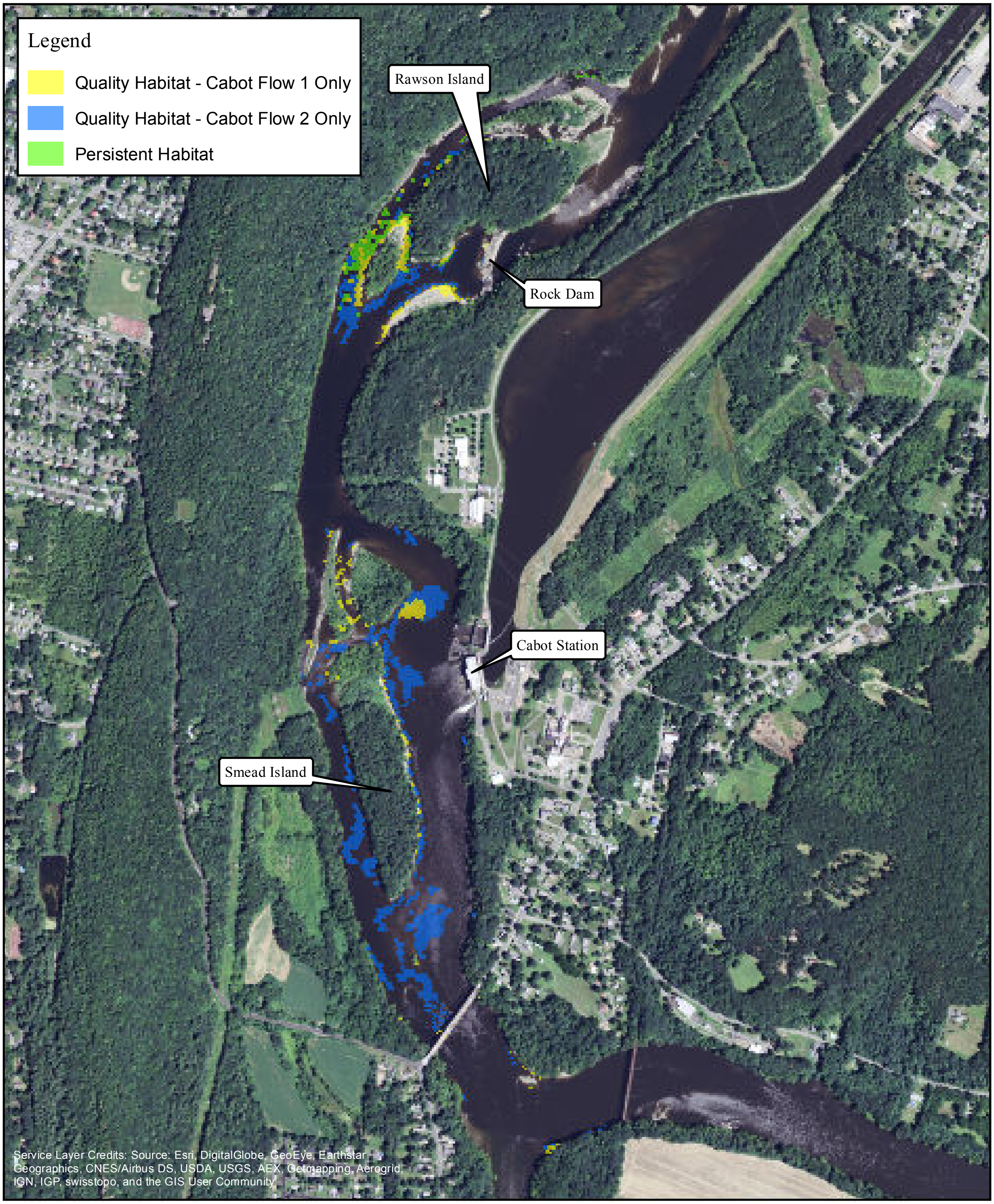
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

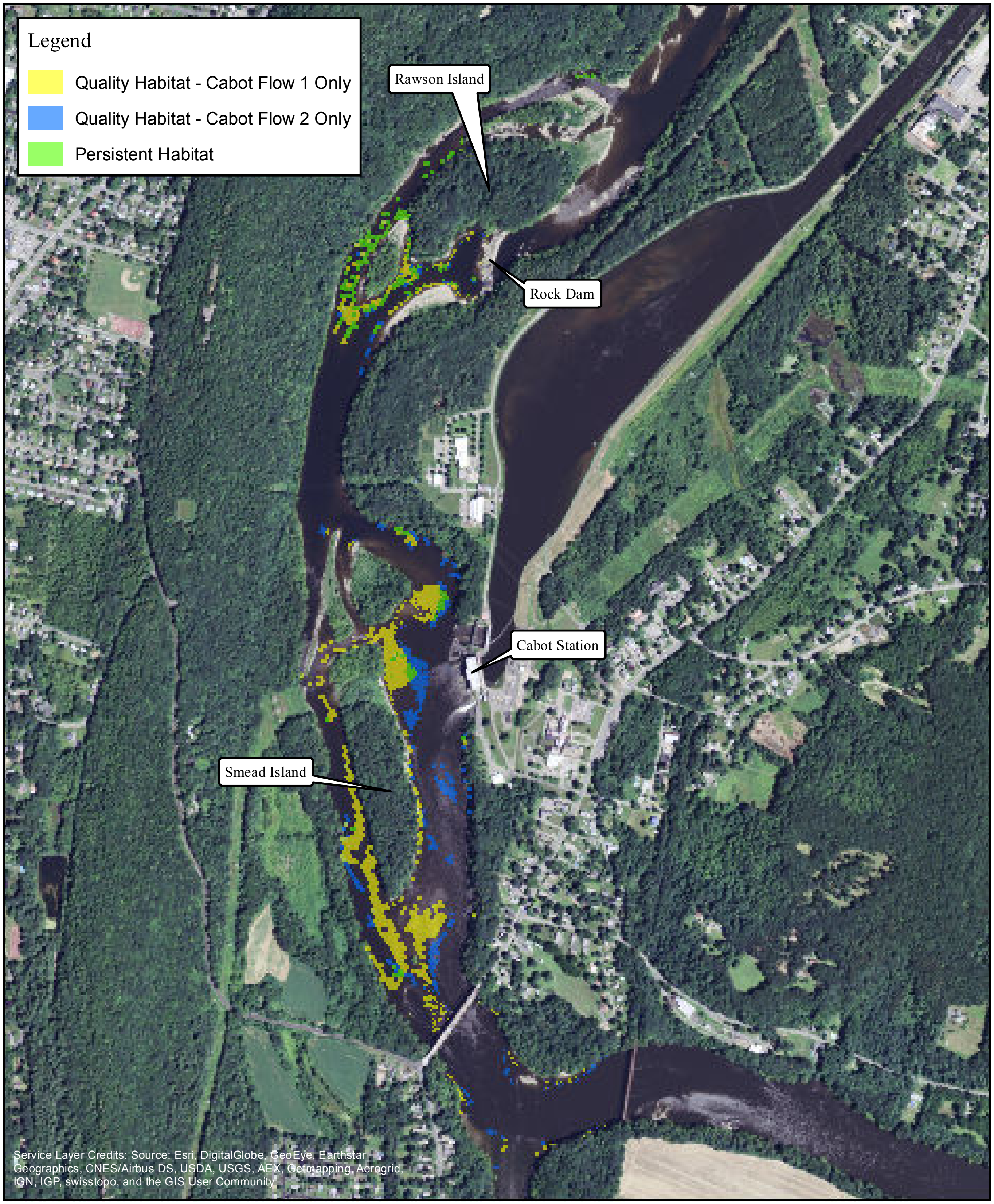
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Spawning

Bypass Flow: 500 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

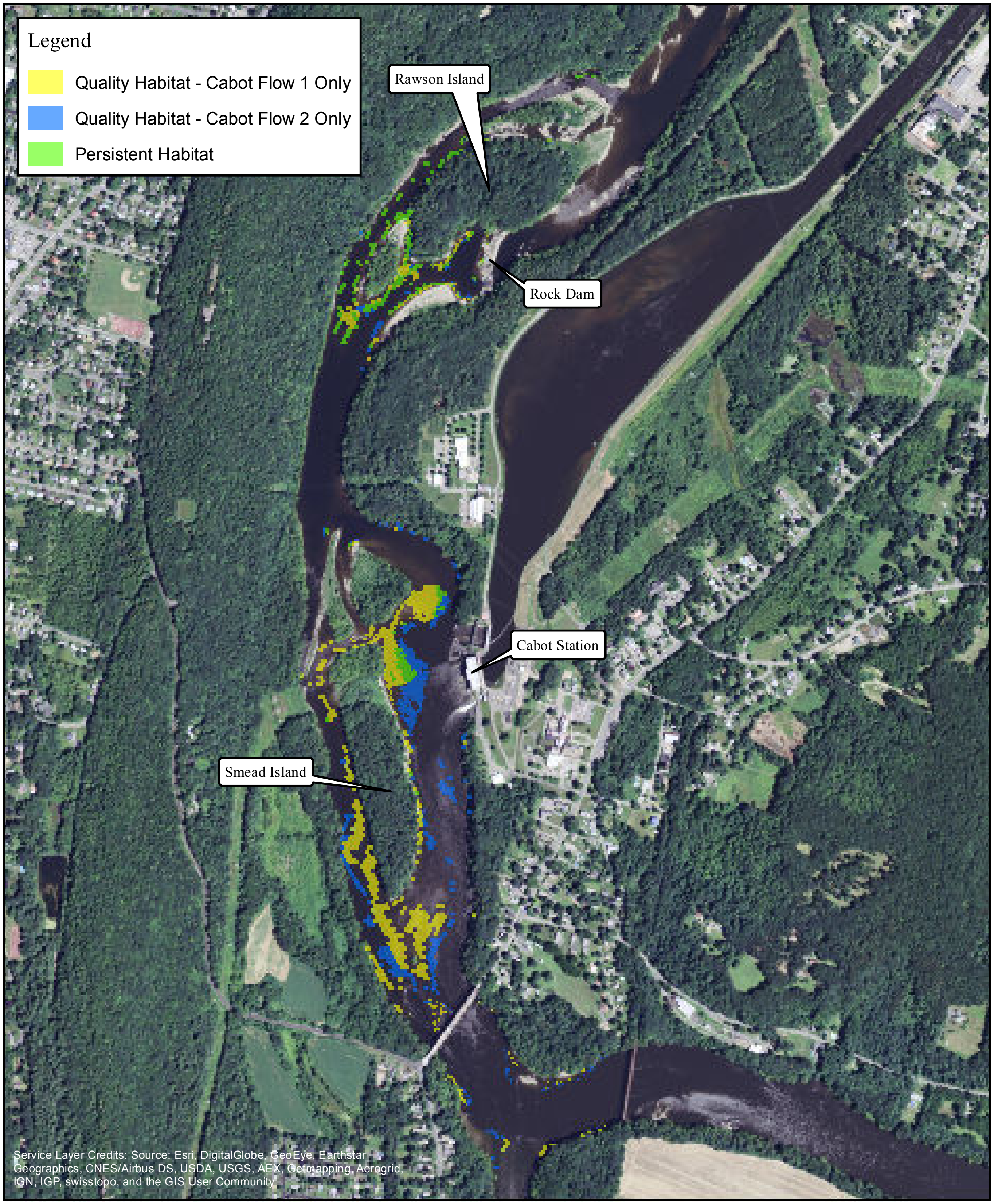
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Fry

Bypass Flow: 200 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

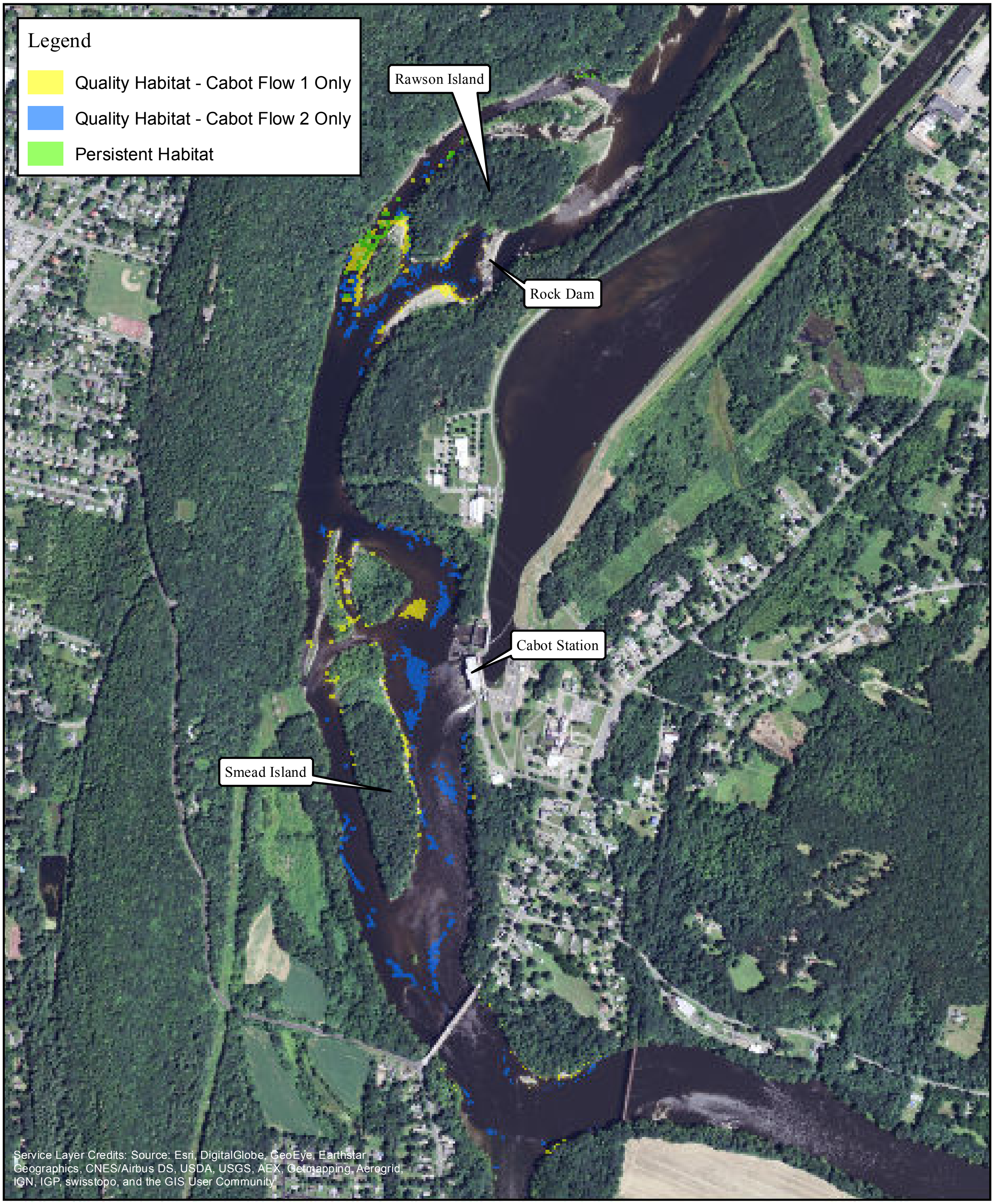
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Fry

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

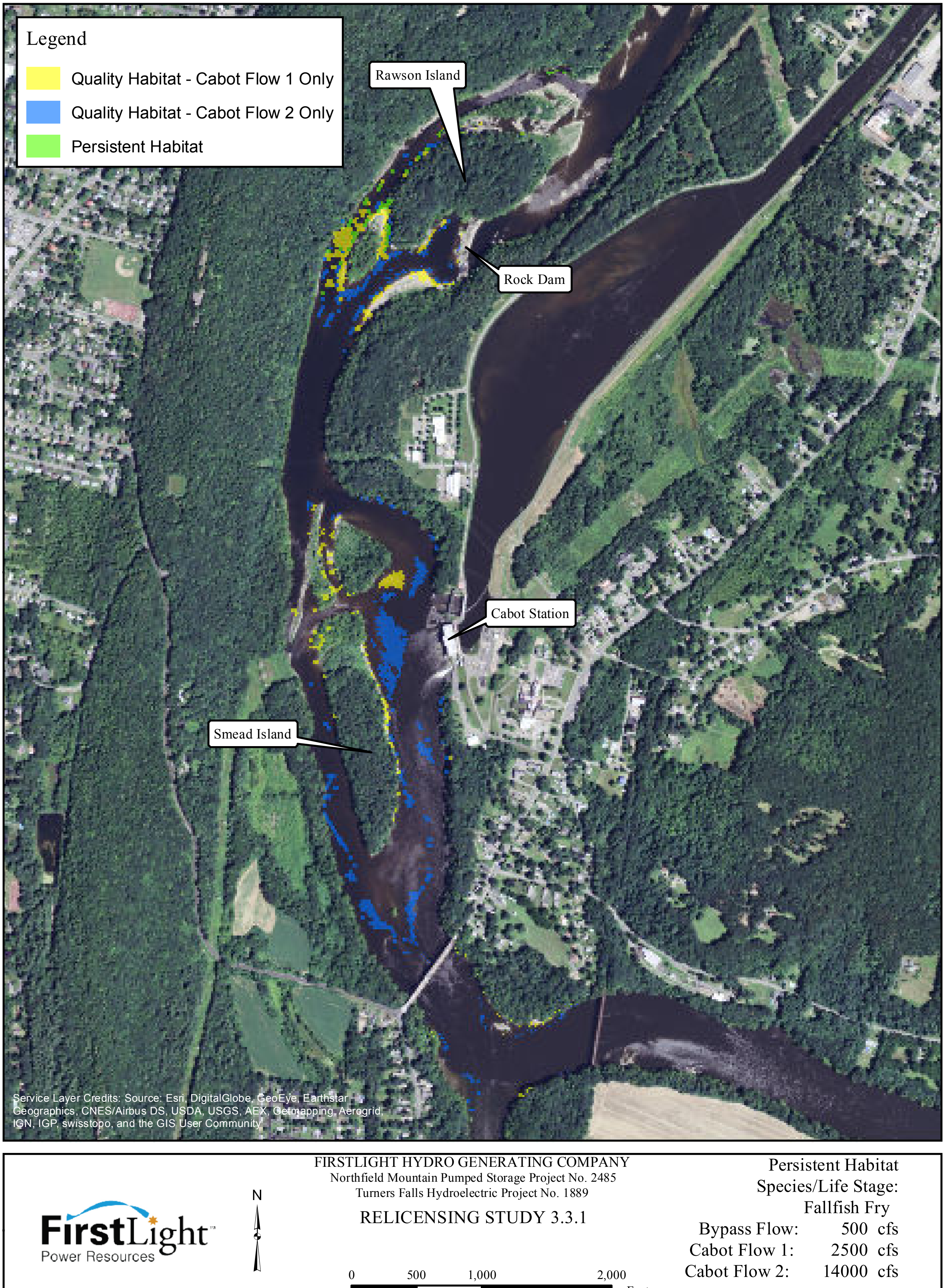
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Fry

Bypass Flow: 200 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

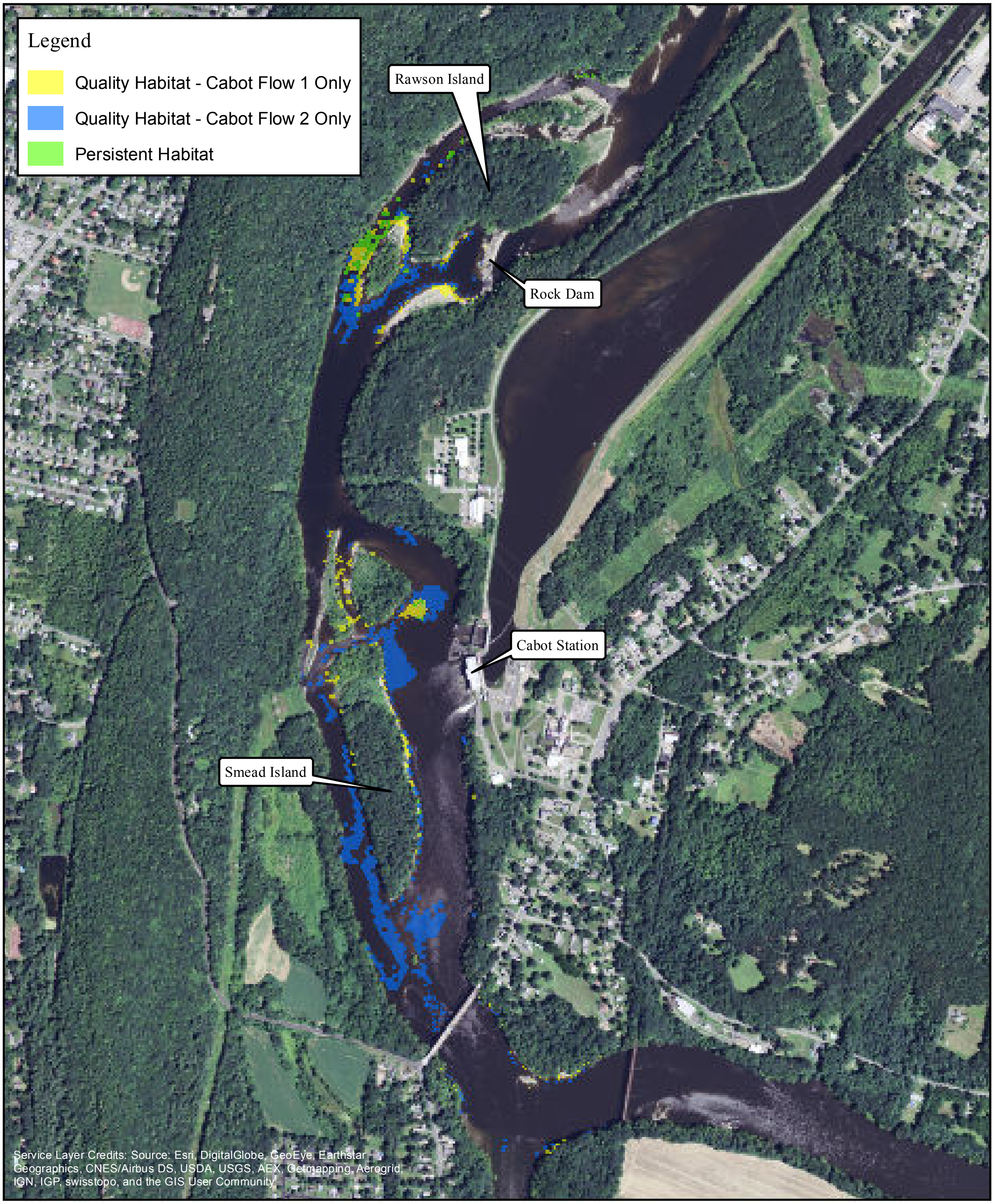
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Fallfish Fry

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

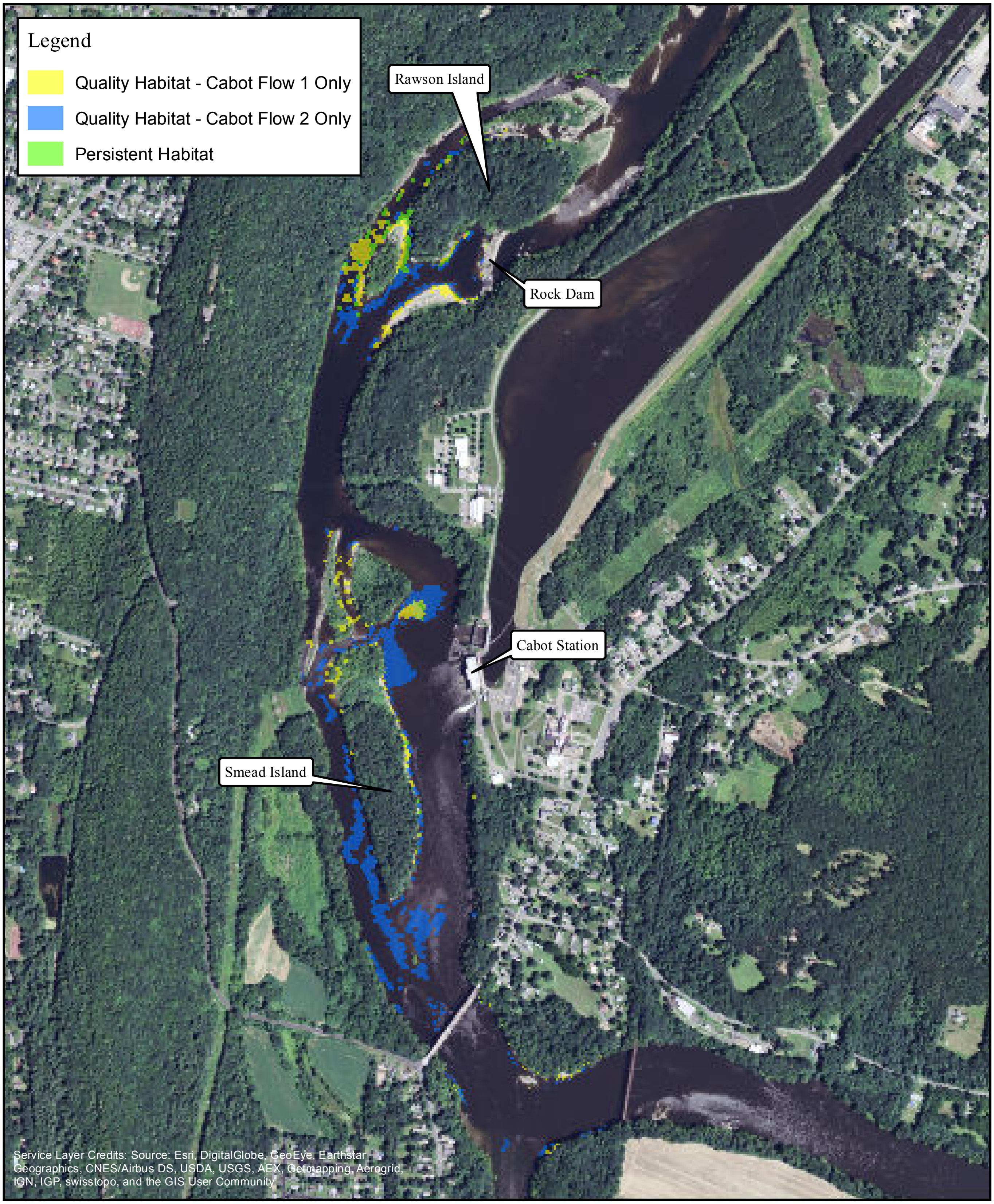
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Fry

Bypass Flow: 200 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

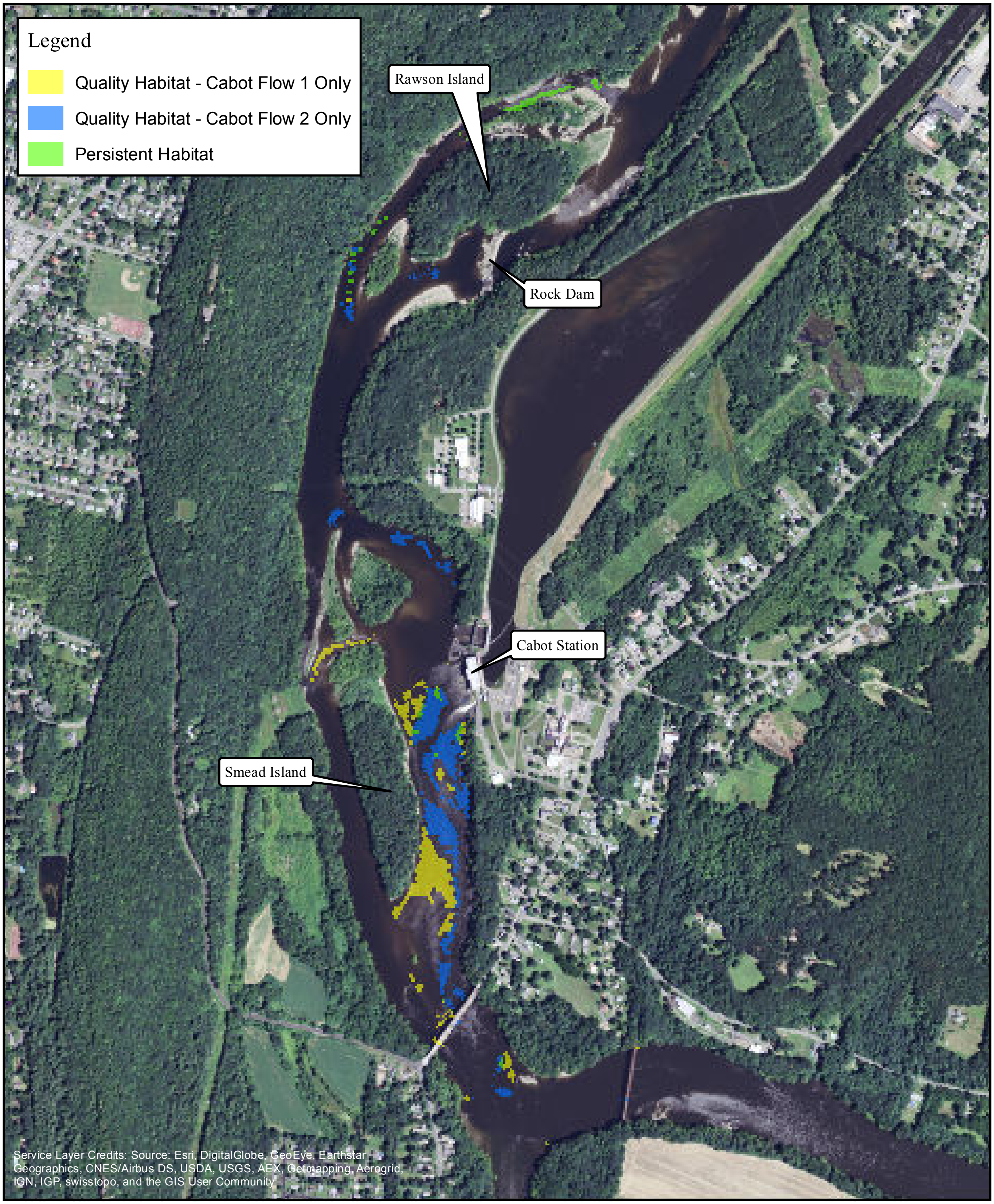
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Fallfish Fry

Bypass Flow:	500	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

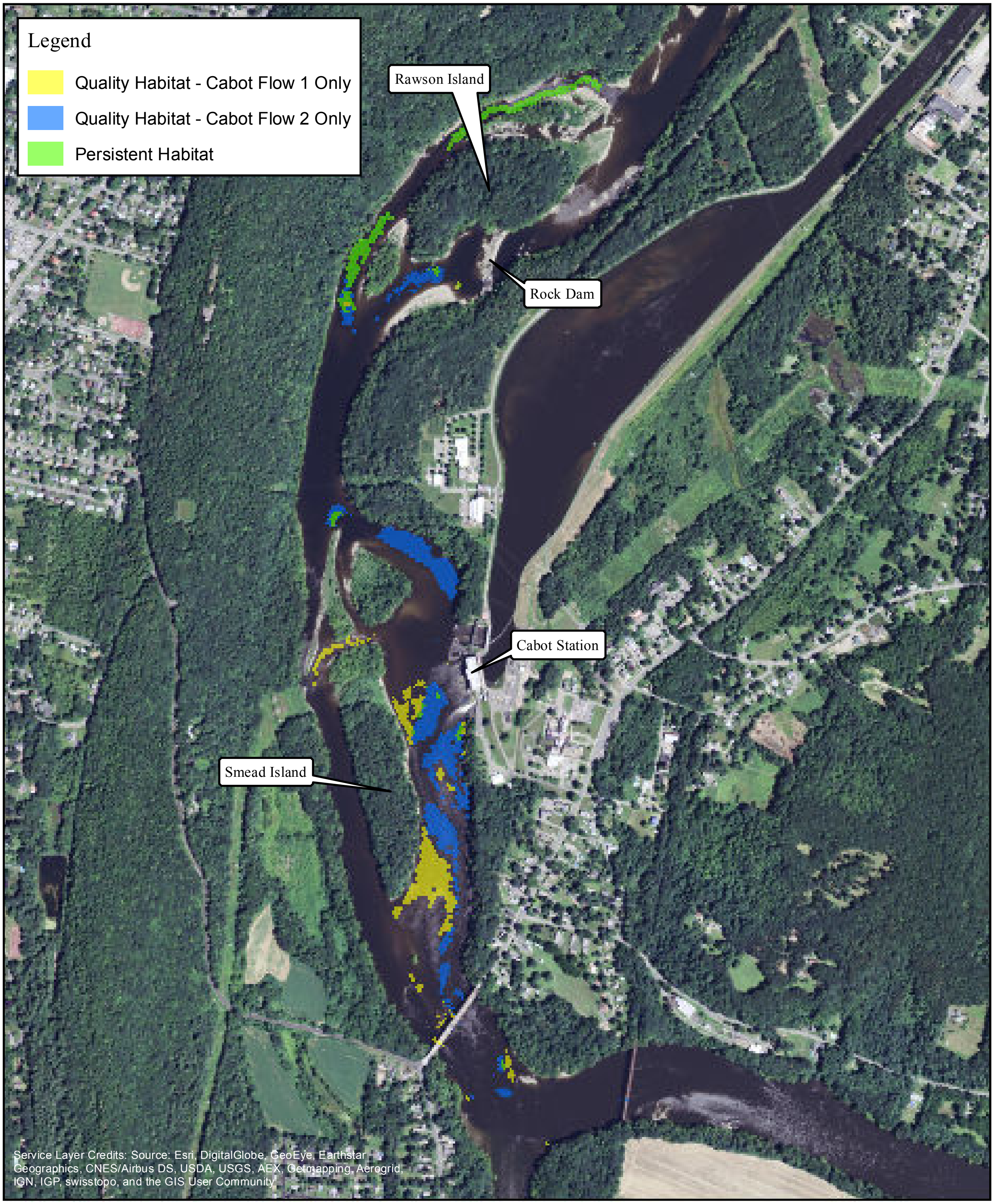
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Macroinvertebrates

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

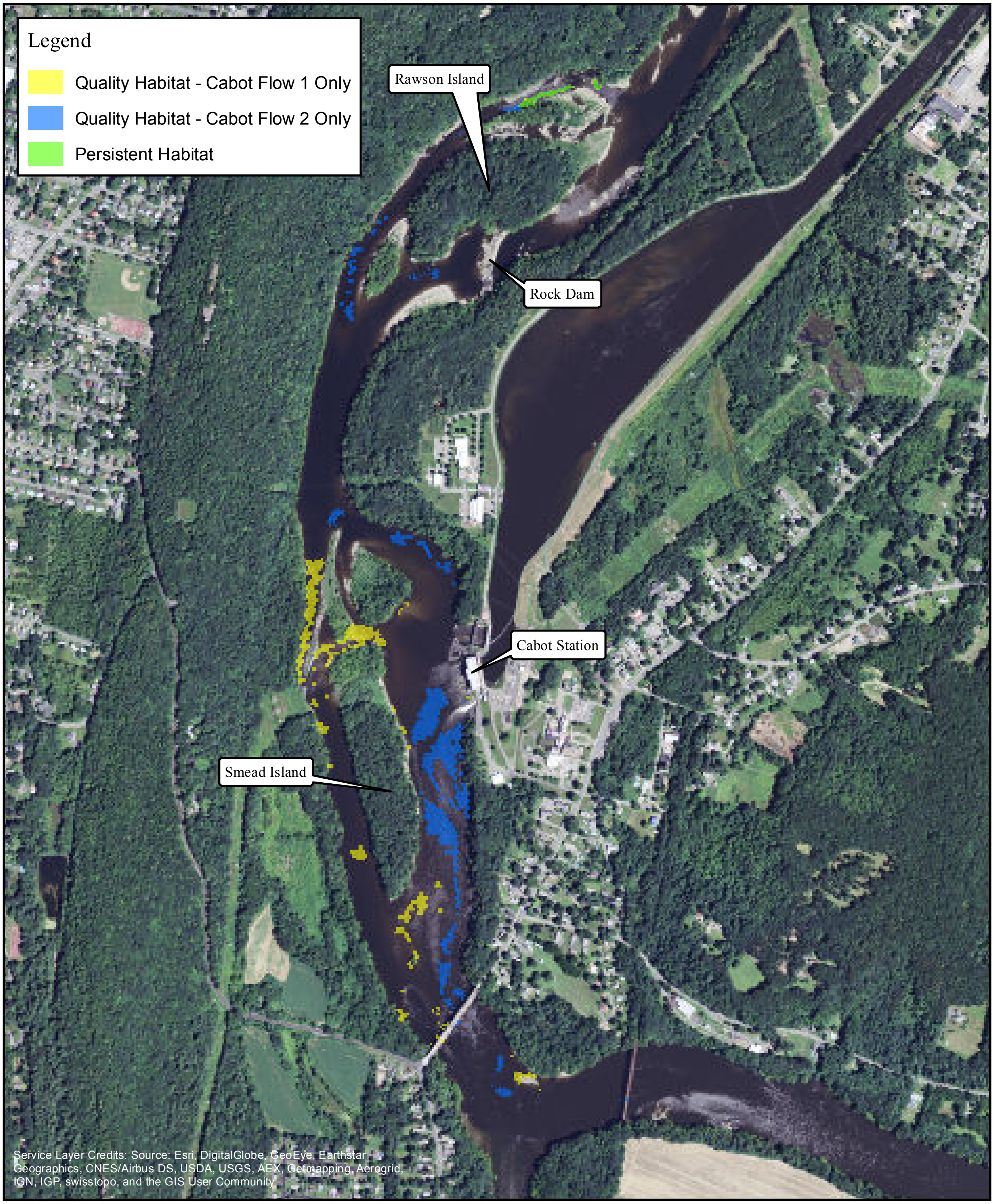
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Macroinvertebrates

Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



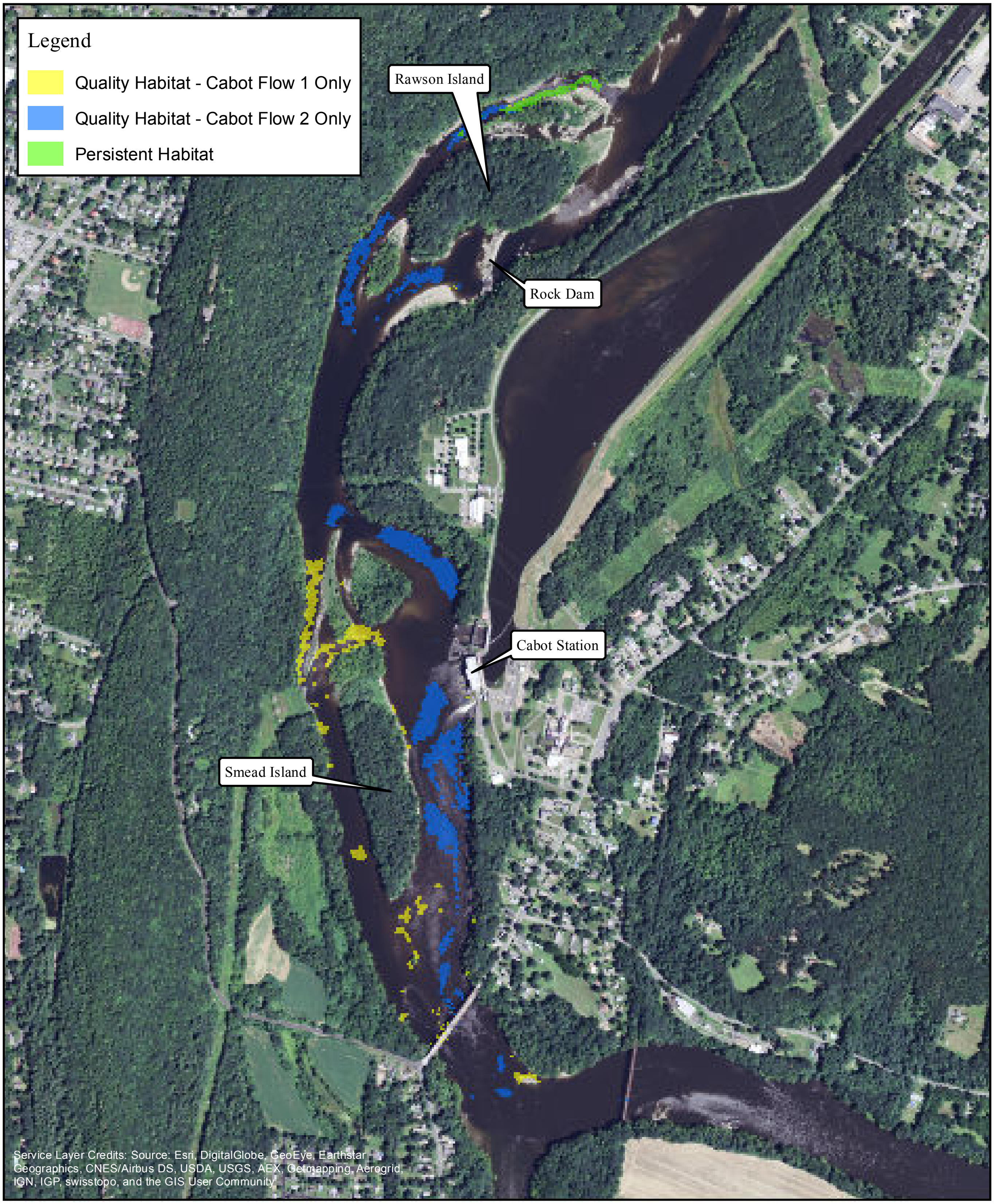
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Macroinvertebrates

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

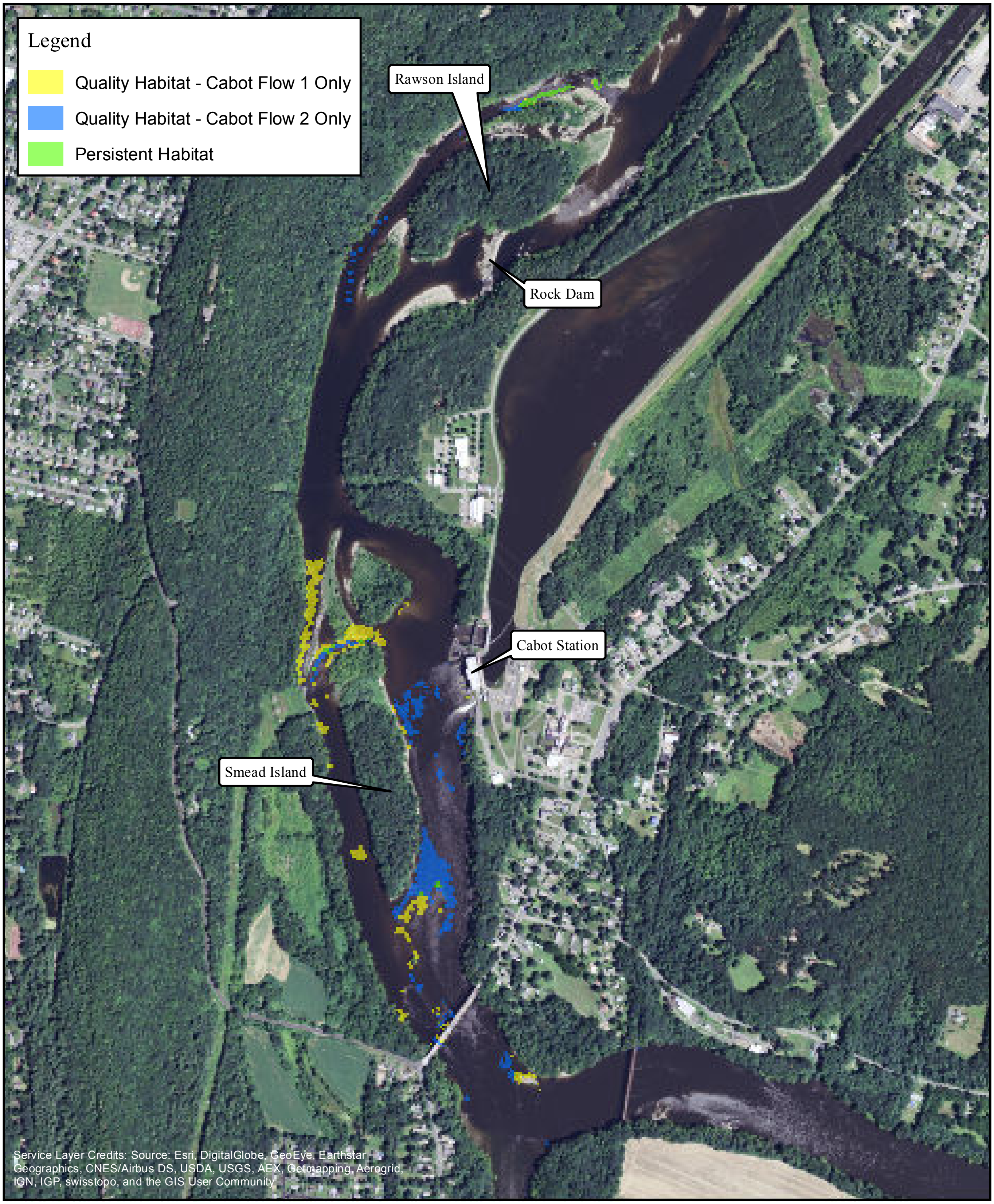
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Macroinvertebrates

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

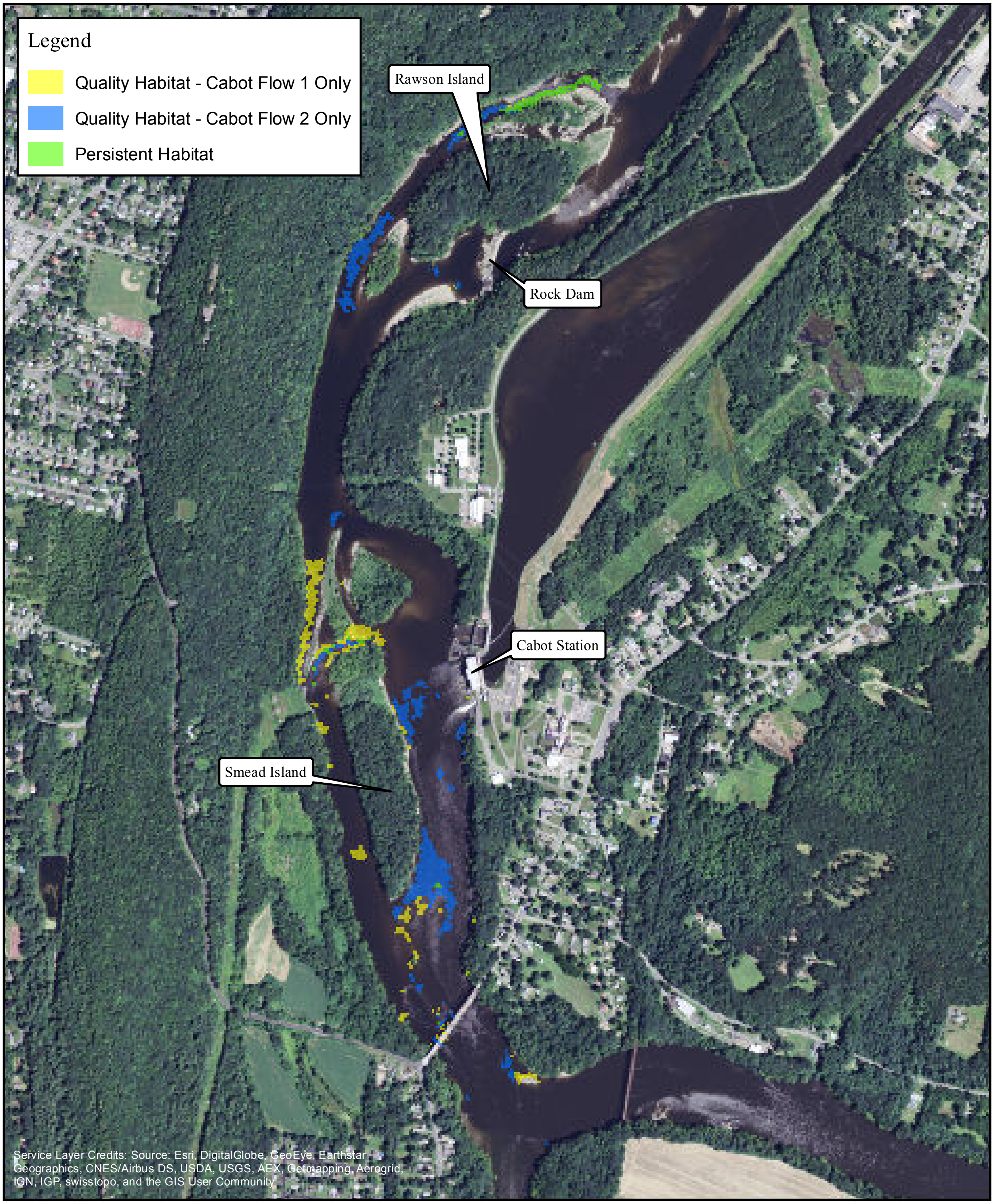
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Macroinvertebrates

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

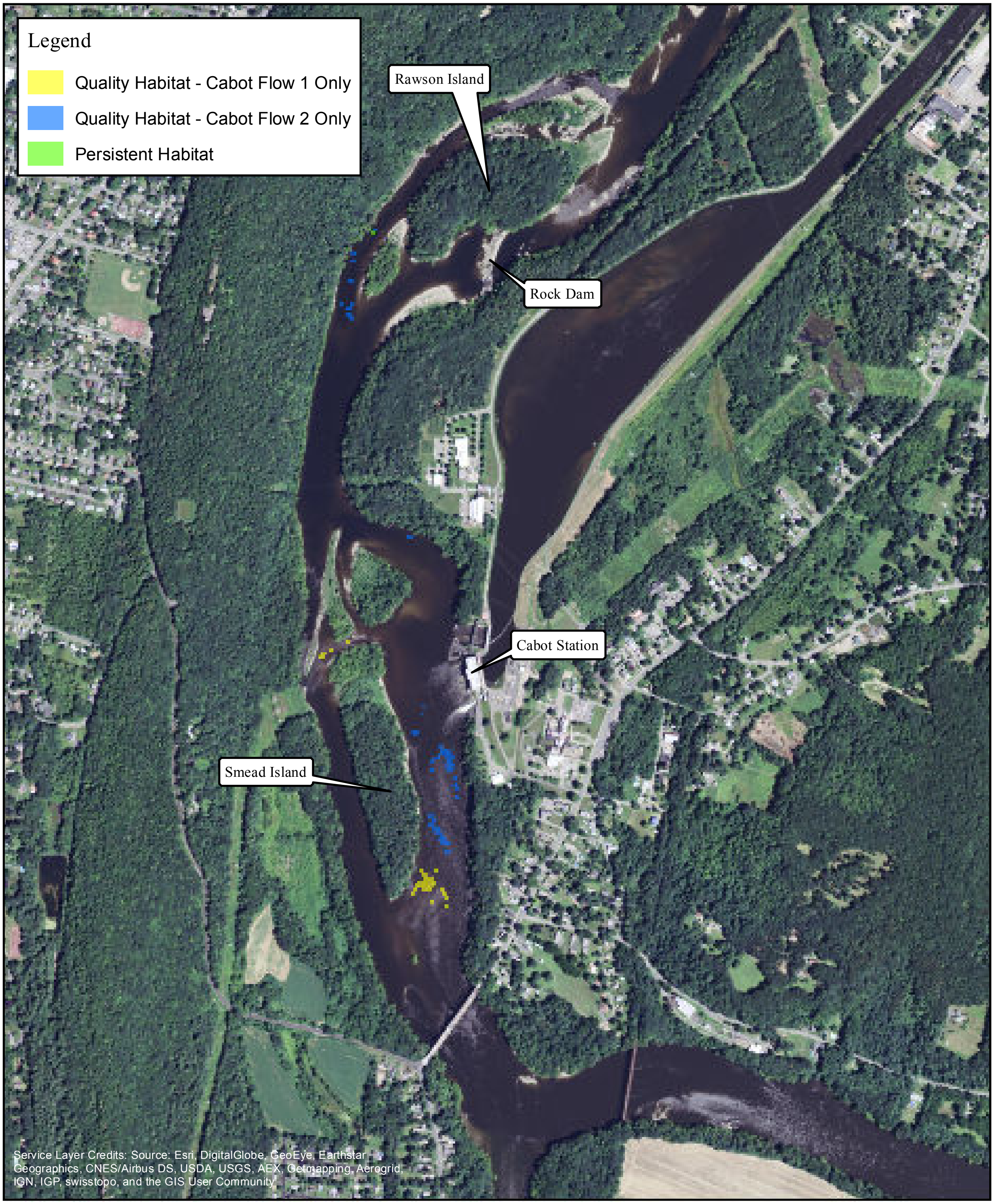
FirstLight Power Resources

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Macroinvertebrates
Bypass Flow: 500 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

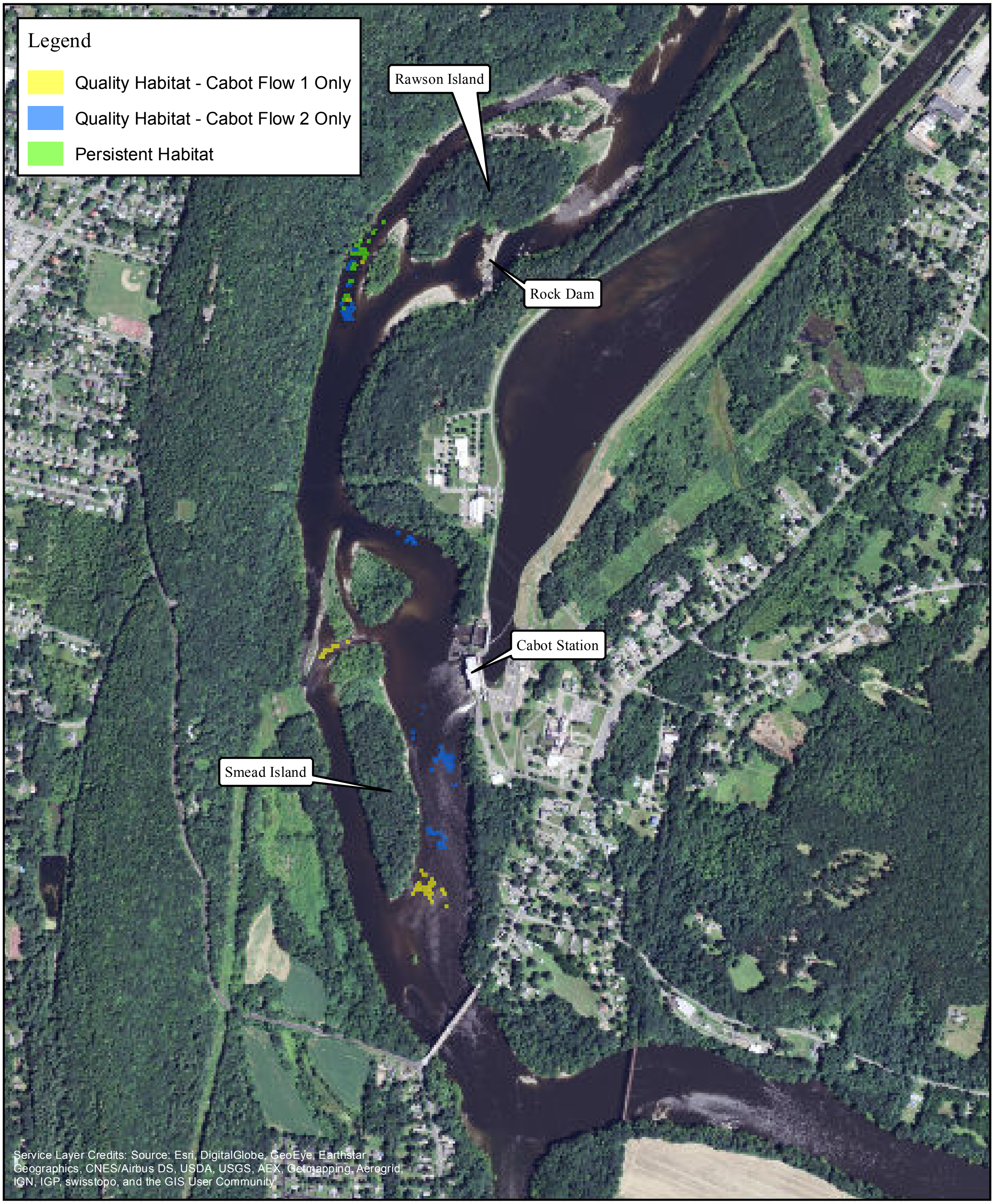
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Sea Lamprey Spawning

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

N

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

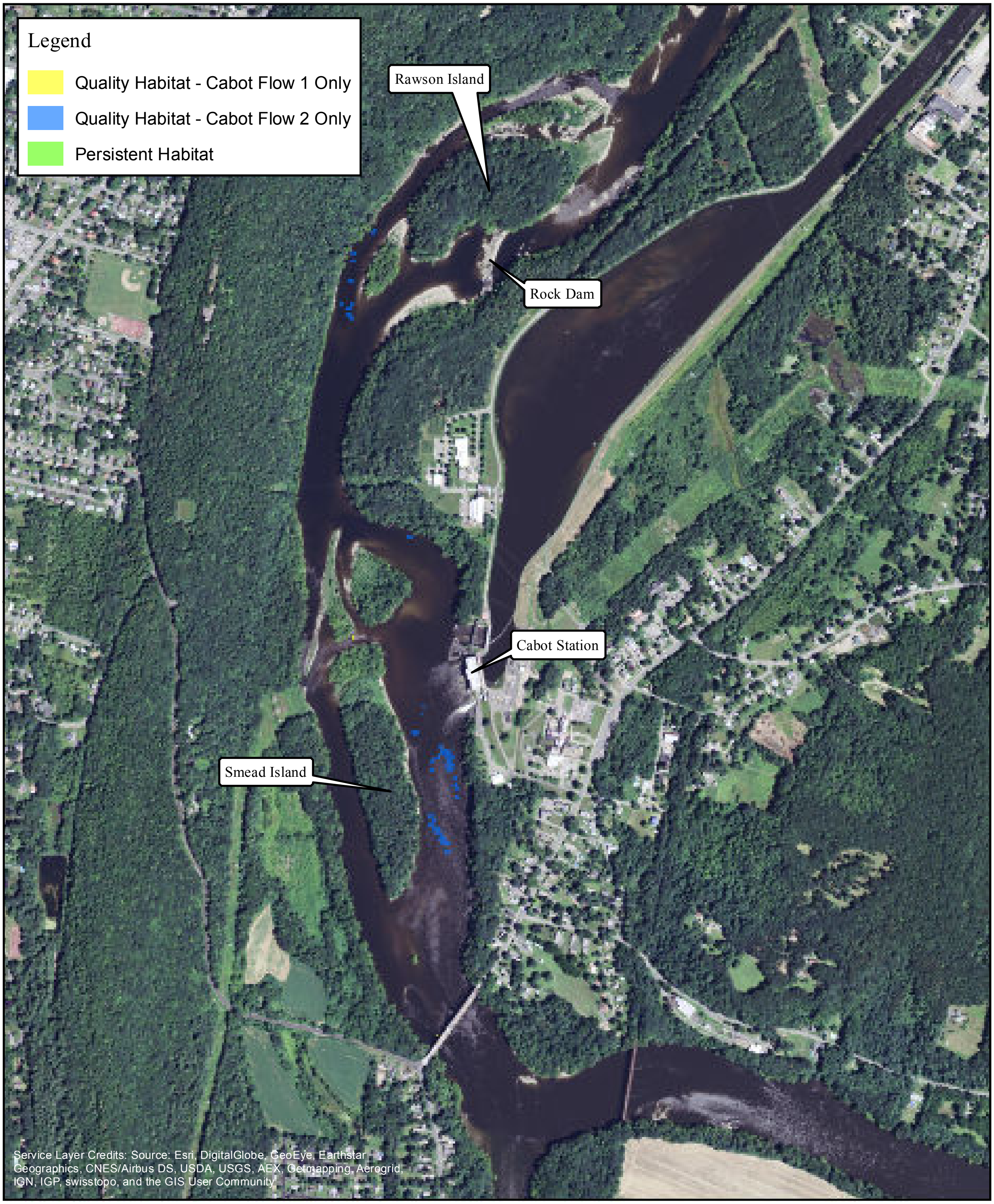
RELICENSING STUDY 3.3.1

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Sea Lamprey Spawning

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

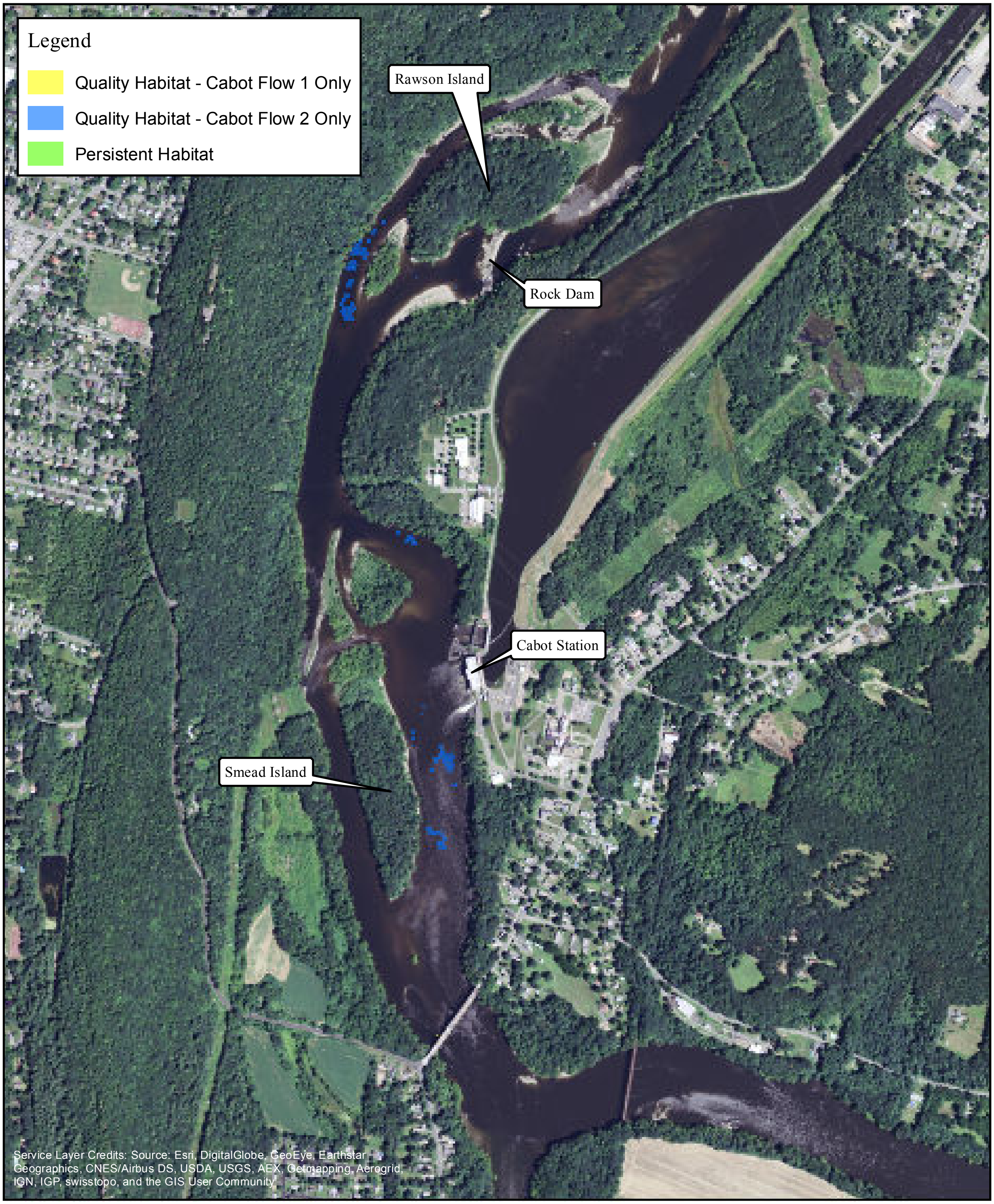
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Sea Lamprey Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd

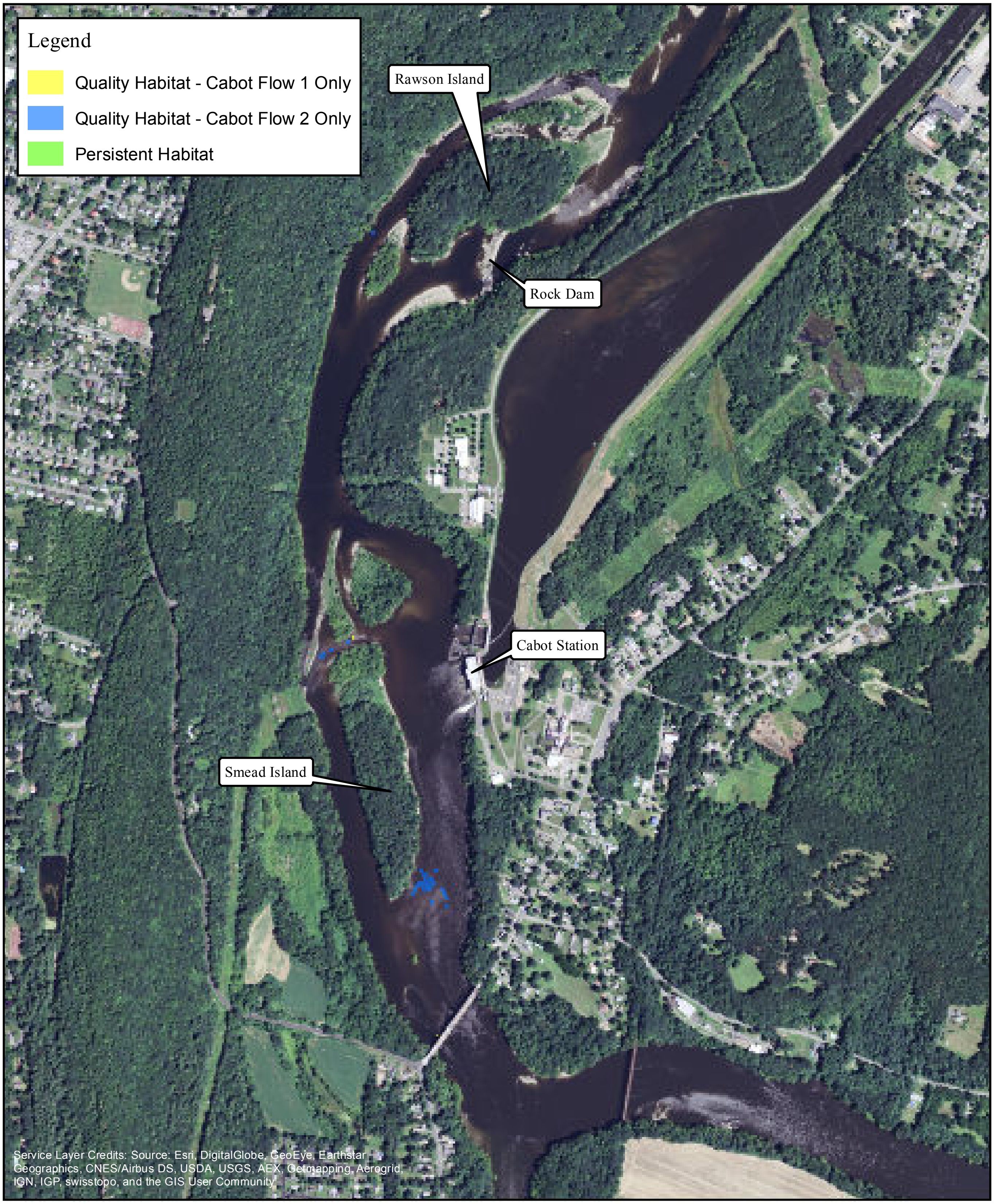


FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Sea Lamprey Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

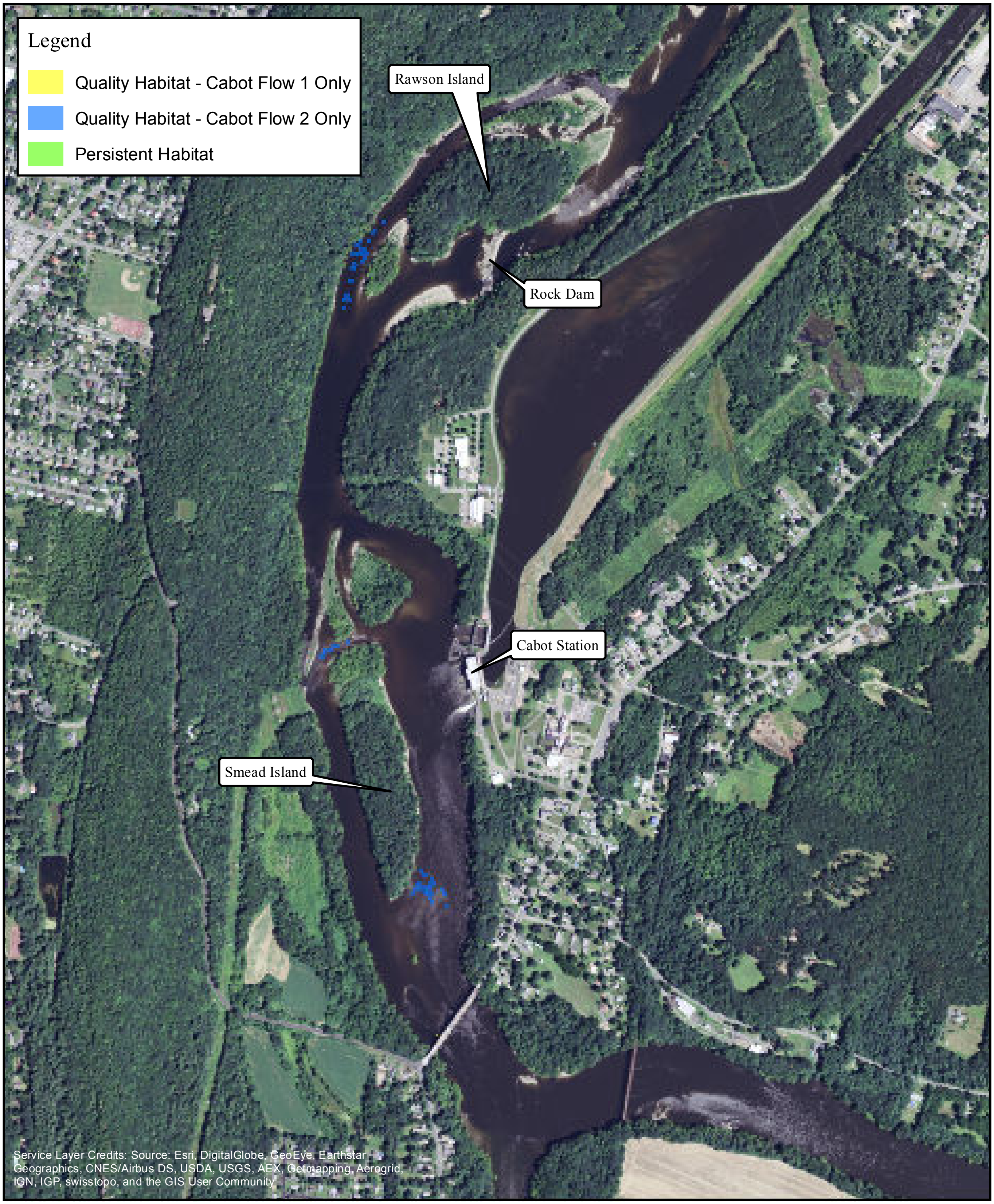
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Sea Lamprey Spawning

Bypass Flow:	200 cfs
Cabot Flow 1:	7000 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

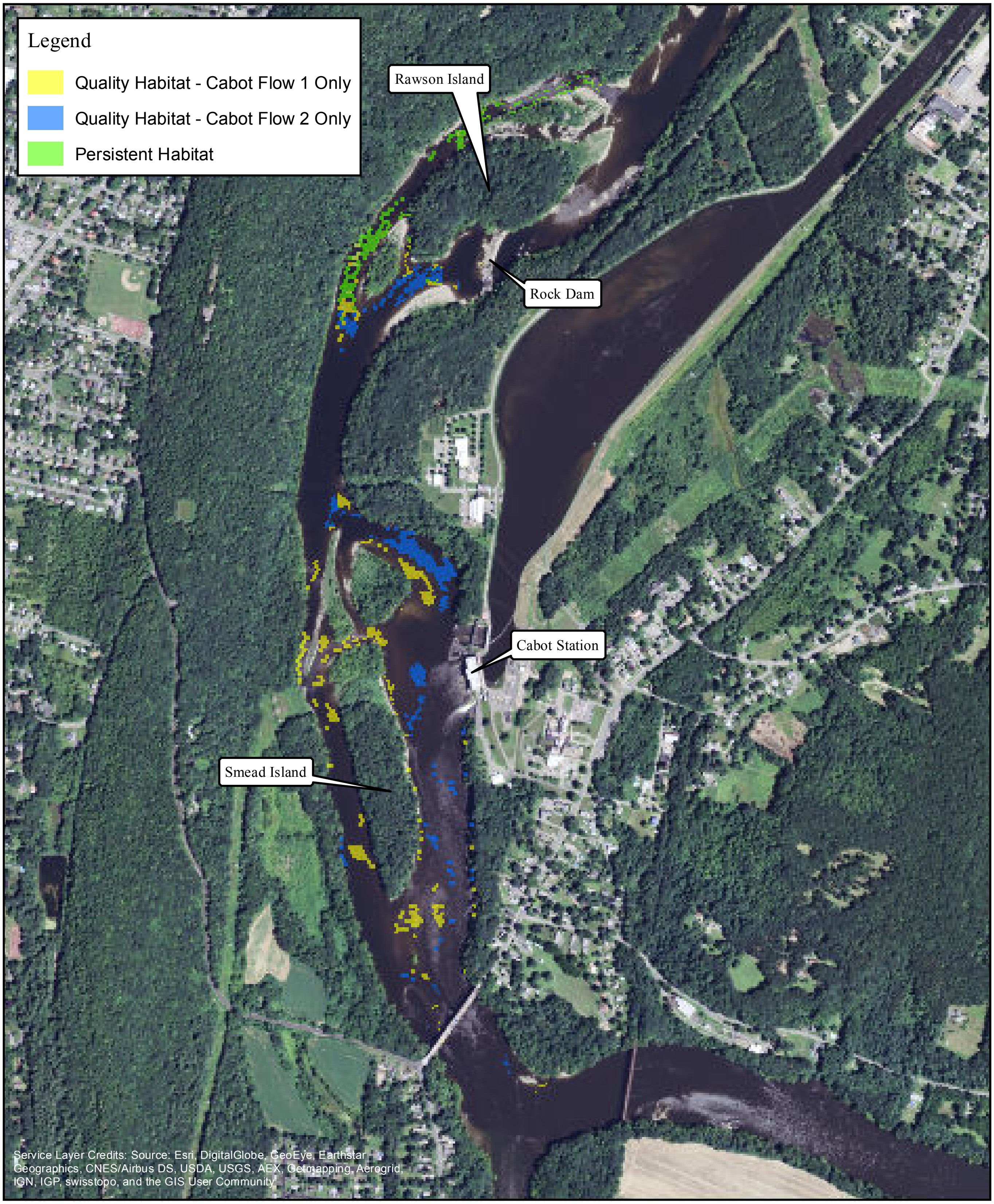
FirstLight Power Resources

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Sea Lamprey Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight™ Power Resources

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

RELICENSING STUDY 3.3.1

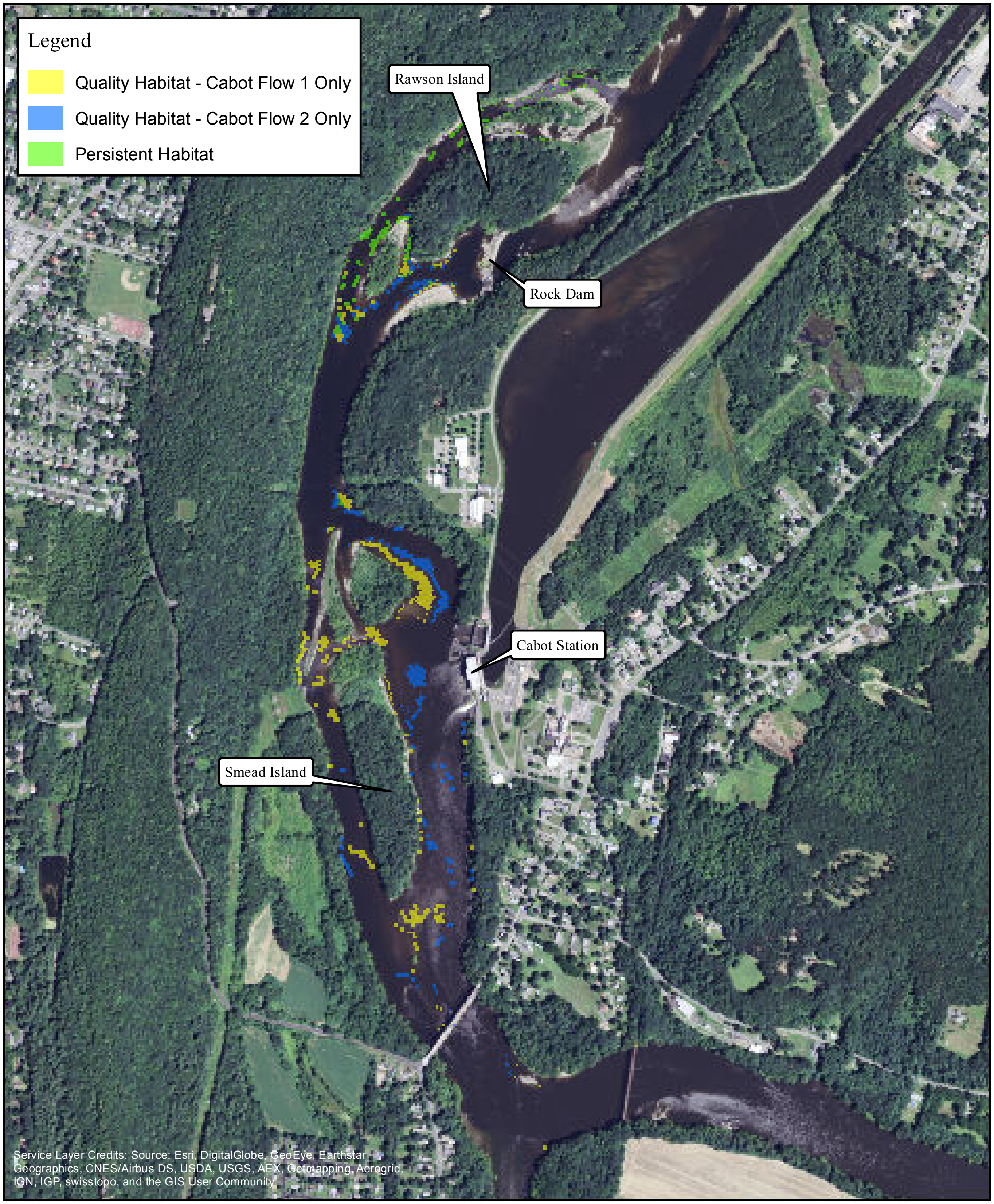
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shallow-Fast Guild

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

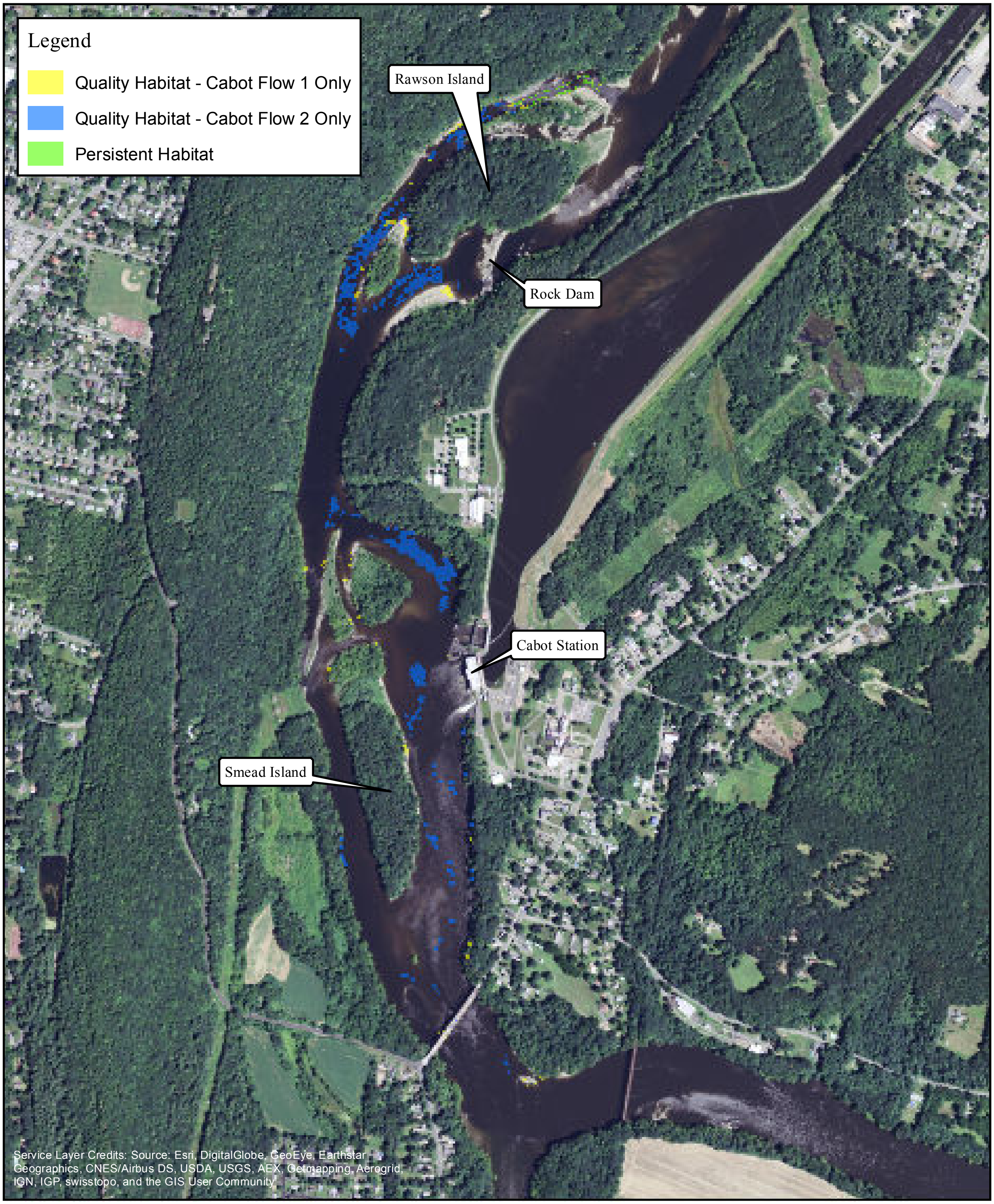
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shallow-Fast Guild

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

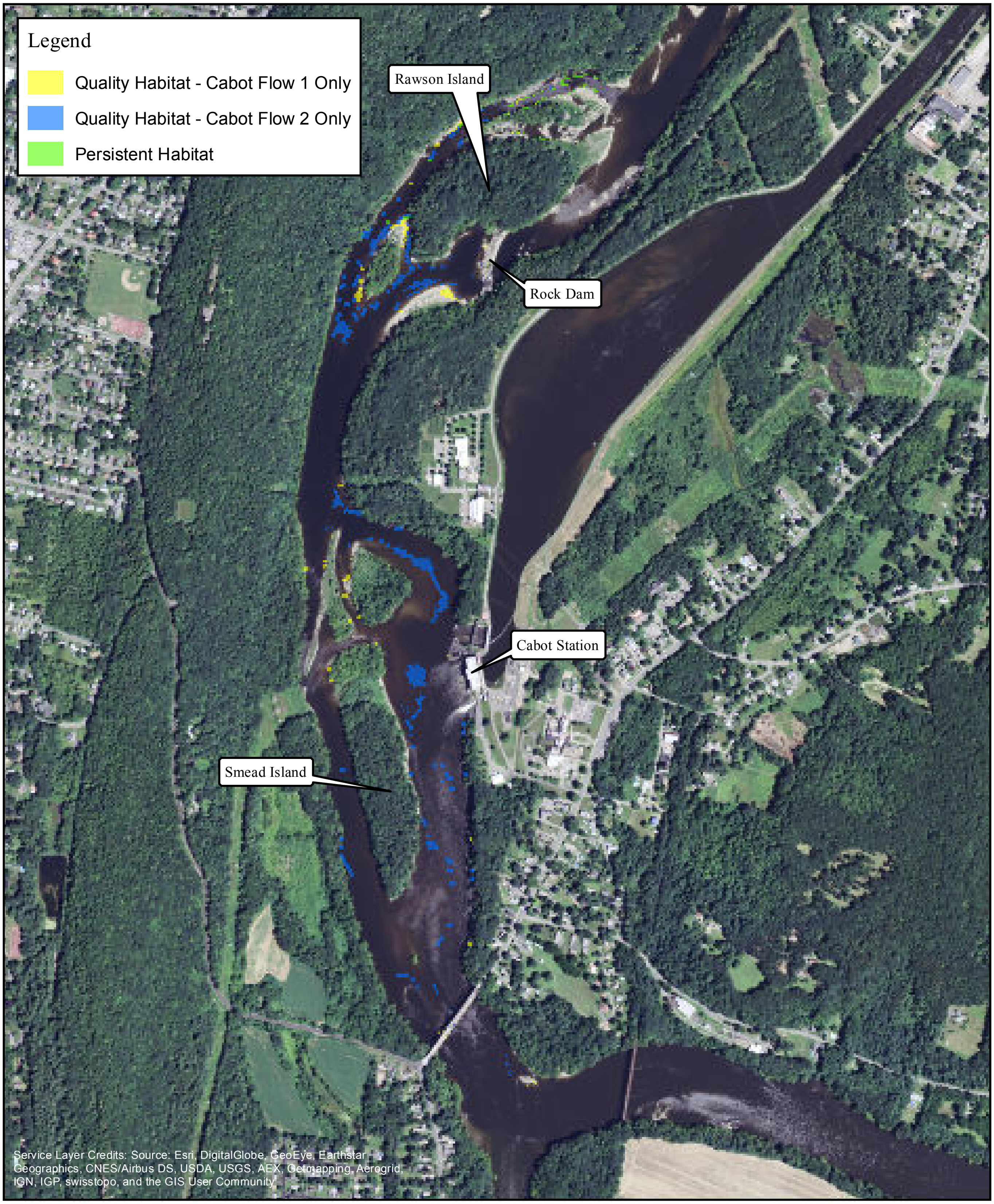
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Shallow-Fast Guild

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

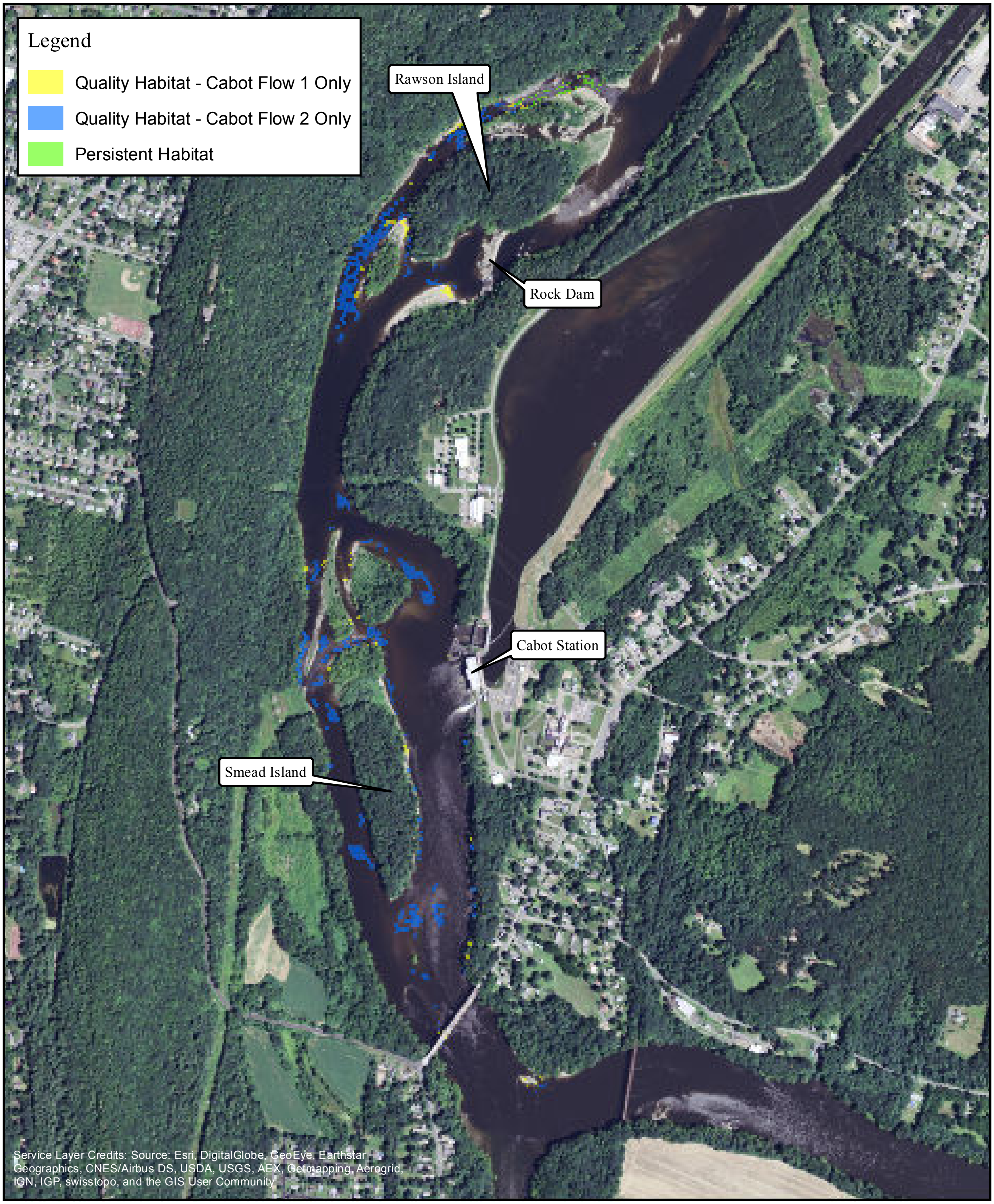
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Shallow-Fast Guild

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

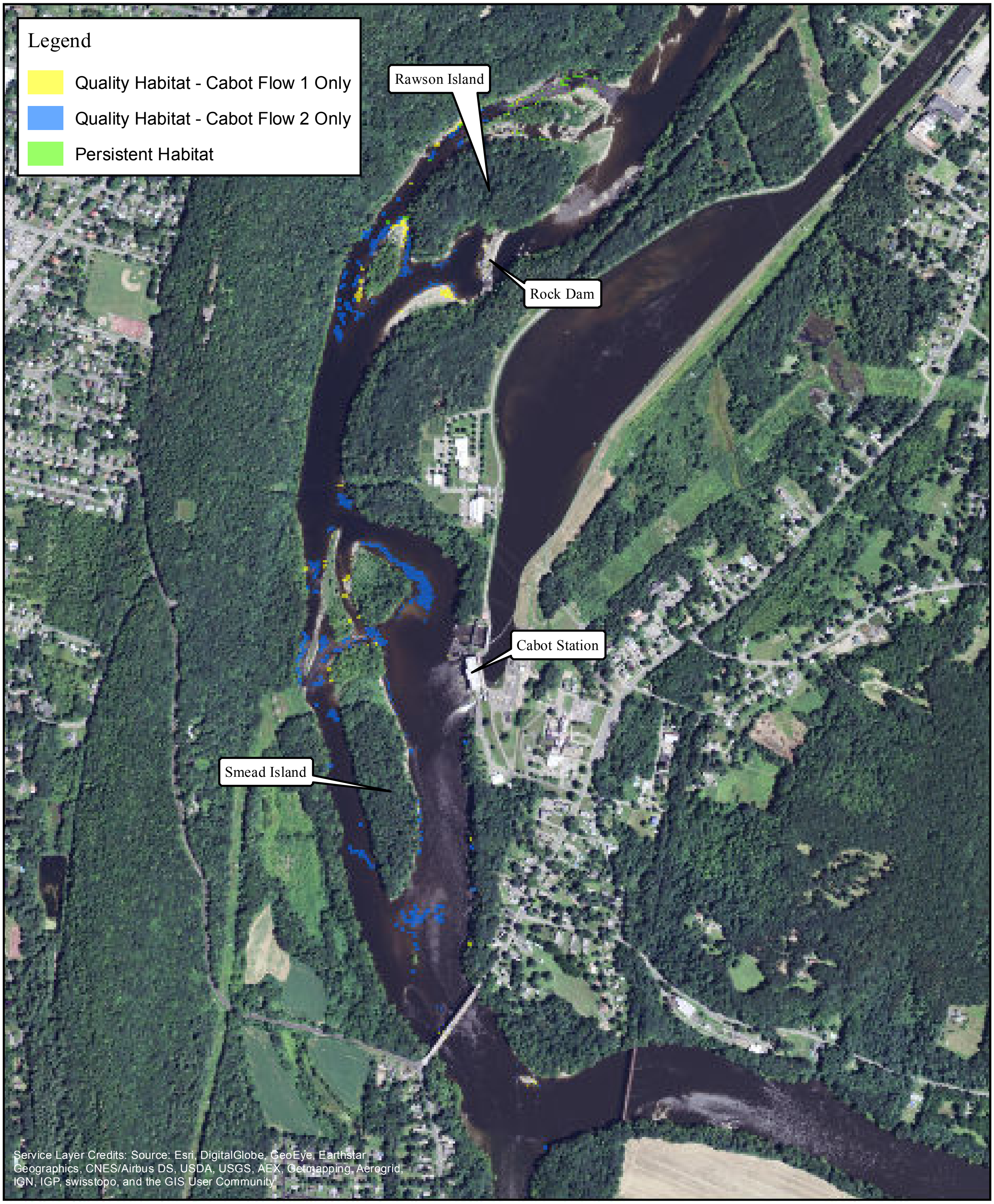
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shallow-Fast Guild

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

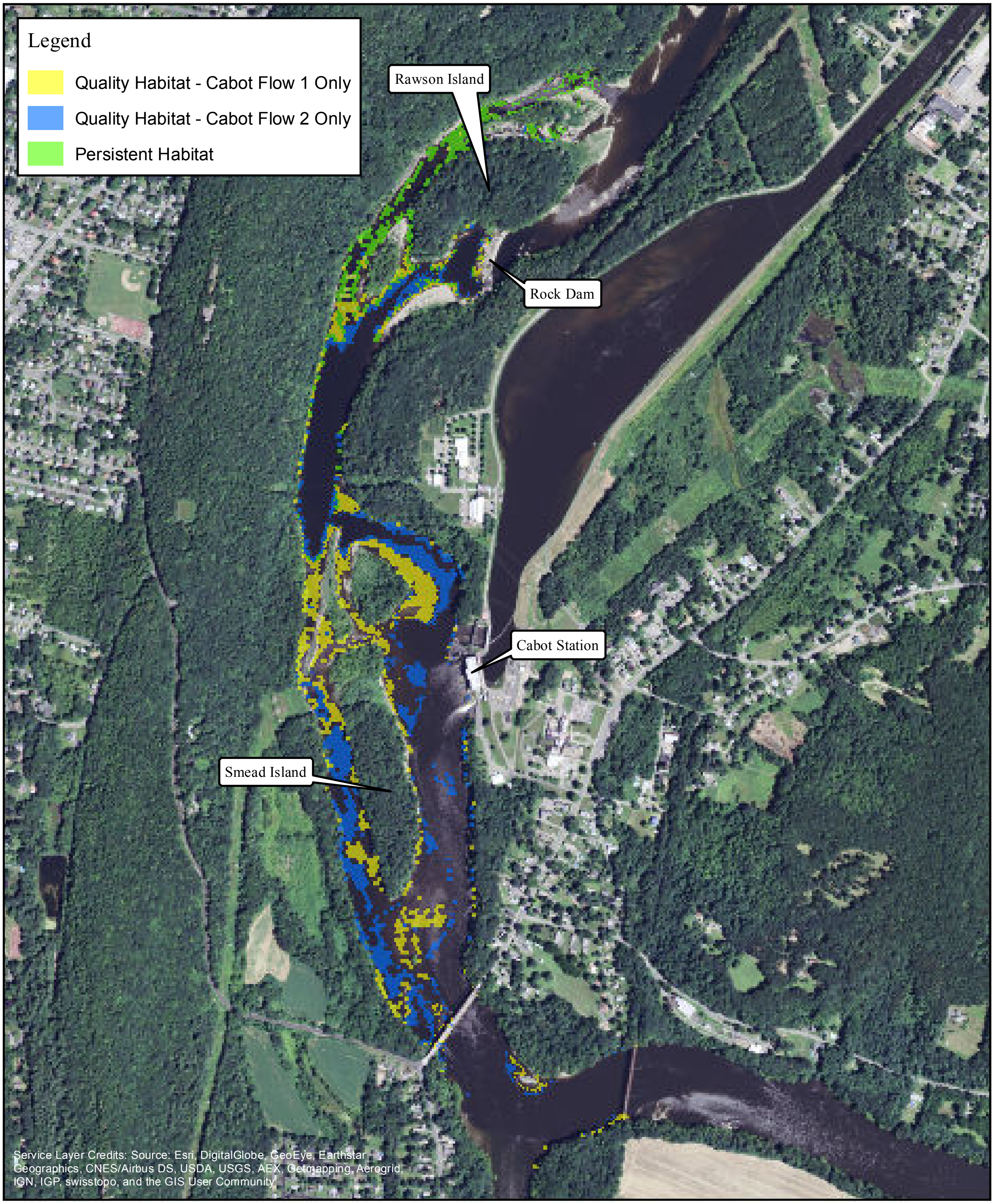
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shallow-Fast Guild

Bypass Flow:	500	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

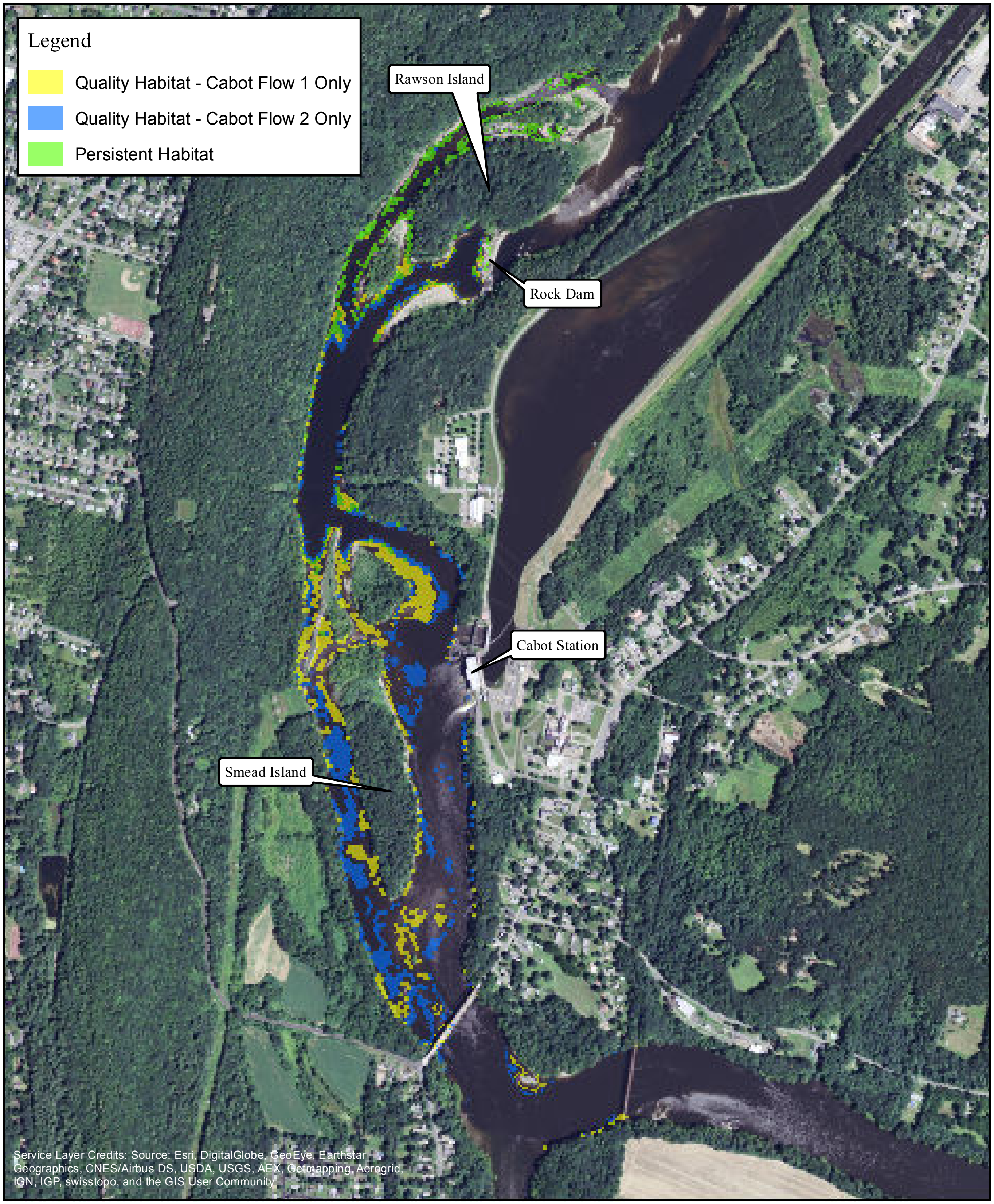
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shallow-Slow Guild

Bypass Flow: 200 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

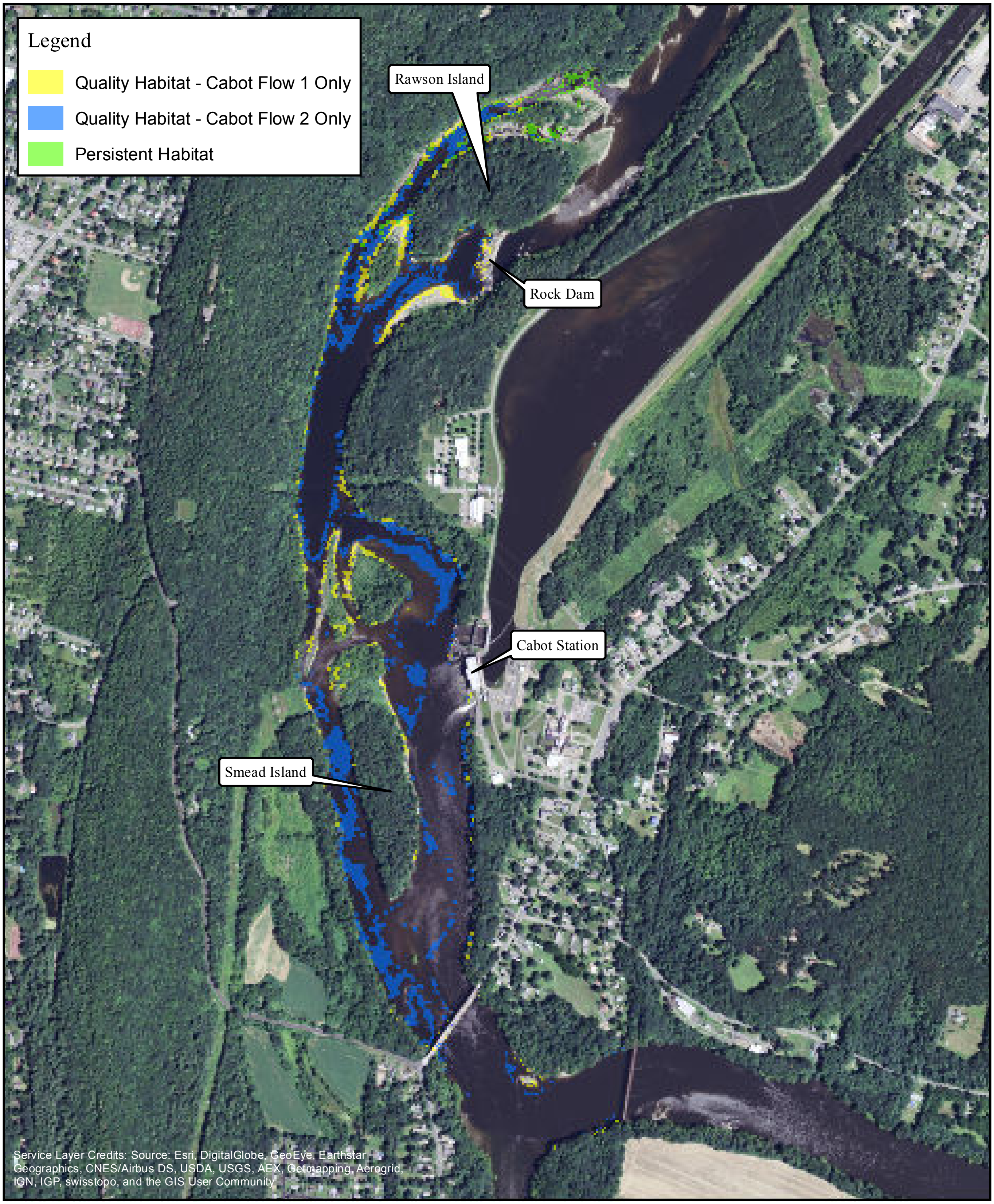
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shallow-Slow Guild

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

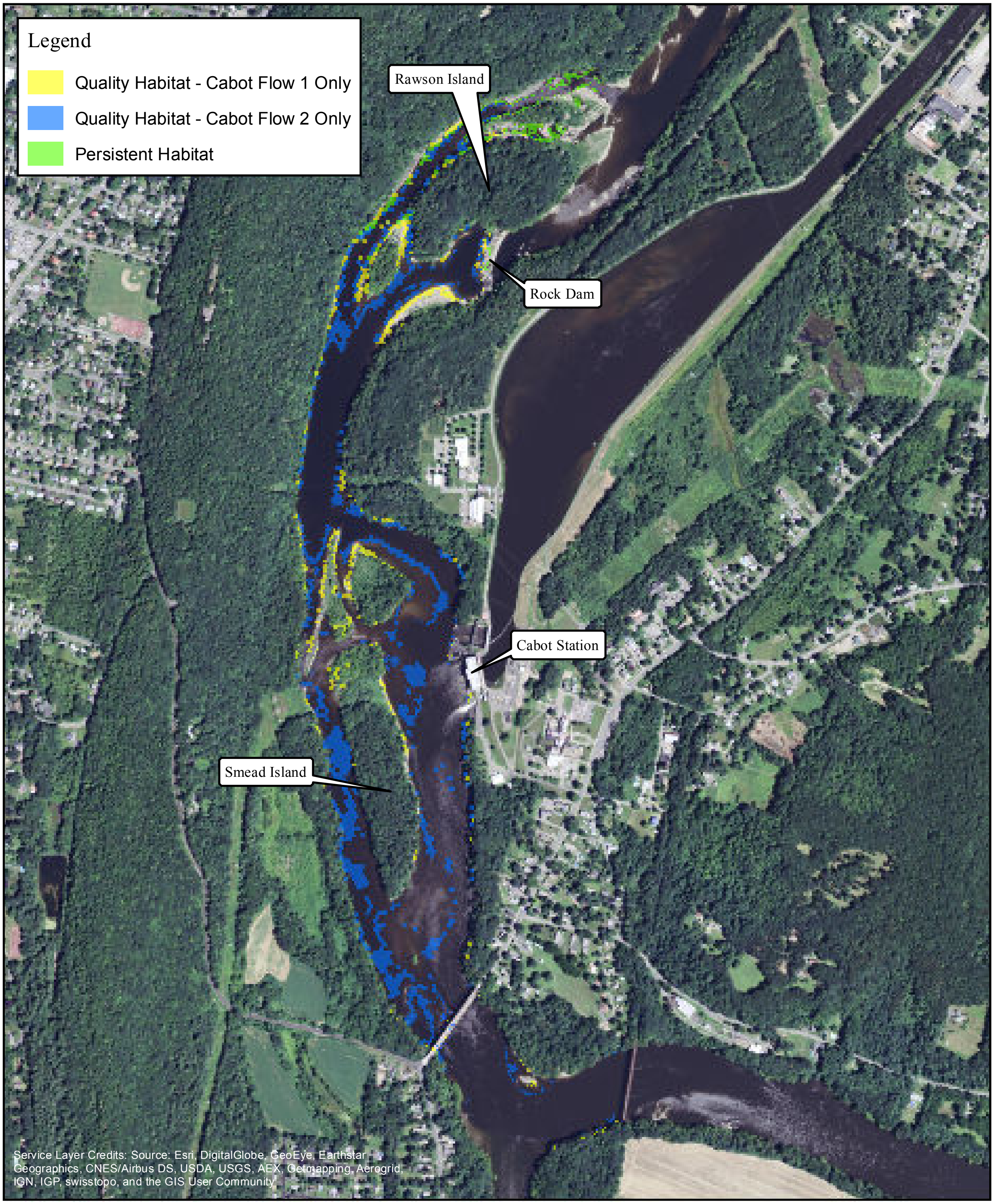
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shallow-Slow Guild

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

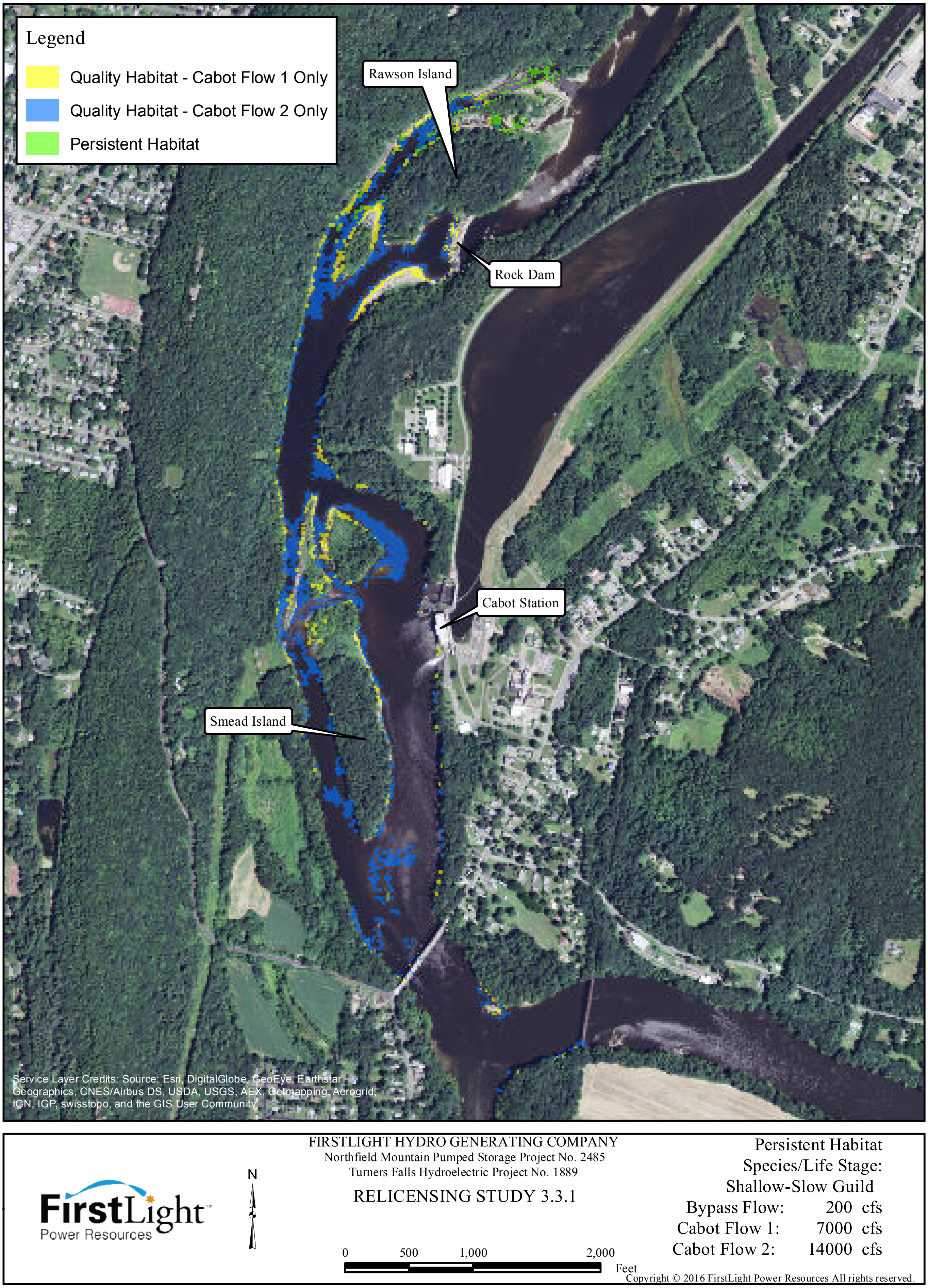
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Shallow-Slow Guild

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



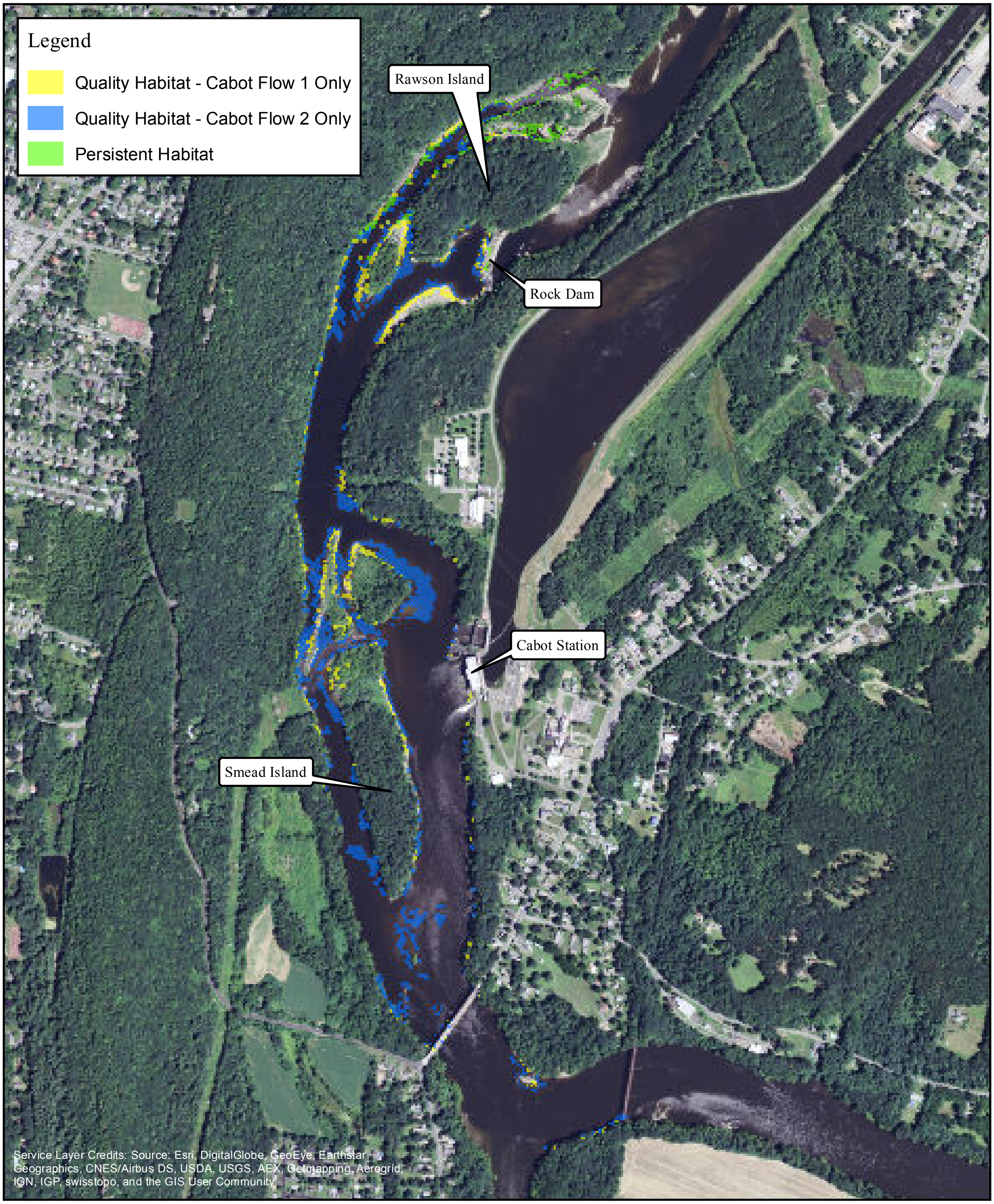
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Shallow-Slow Guild

Bypass Flow: 200 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

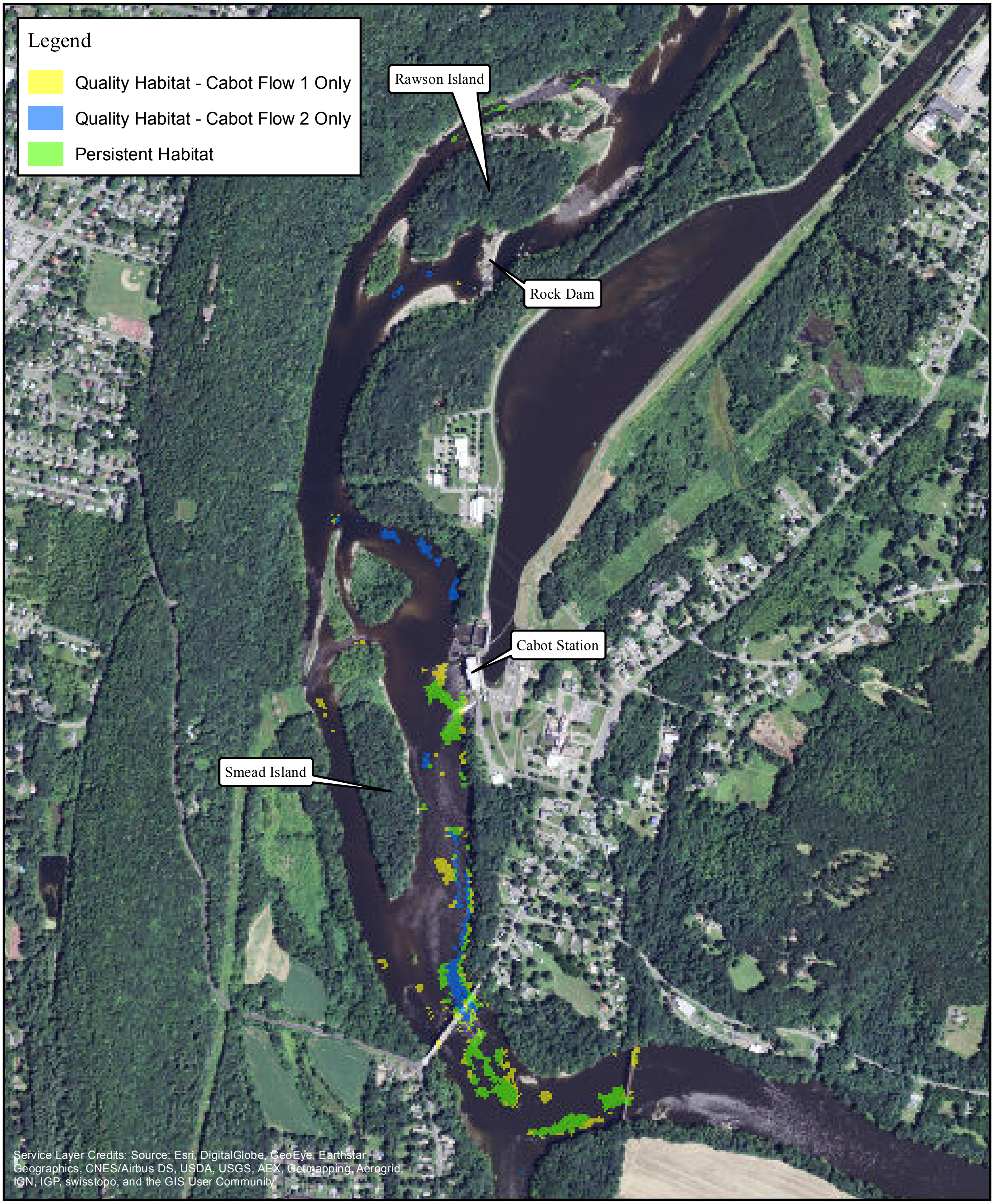
N

0 500 1,000 2,000
Feet

Persistent Habitat
Species/Life Stage:
Shallow-Slow Guild

Bypass Flow: 500 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

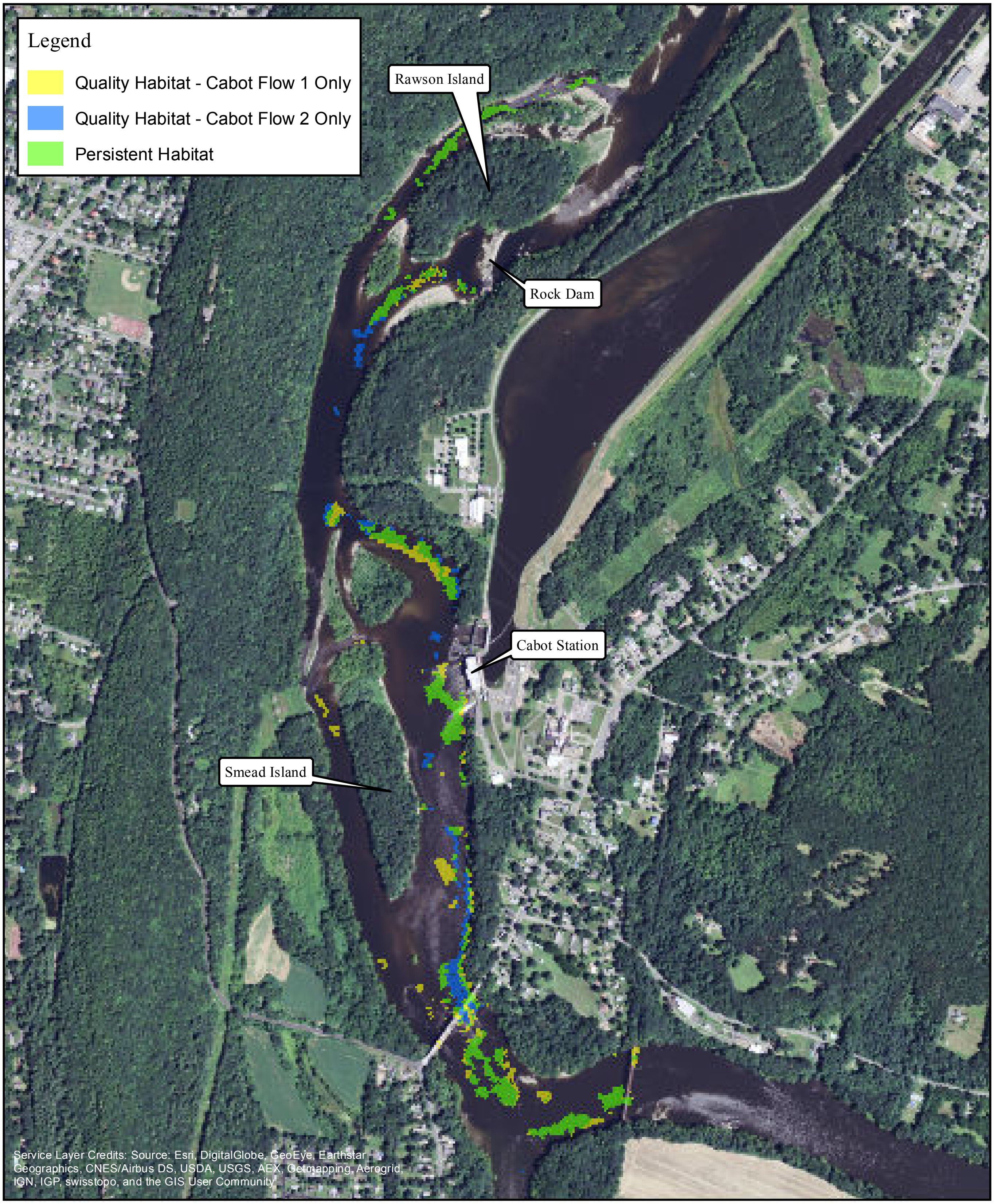
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Spawning

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

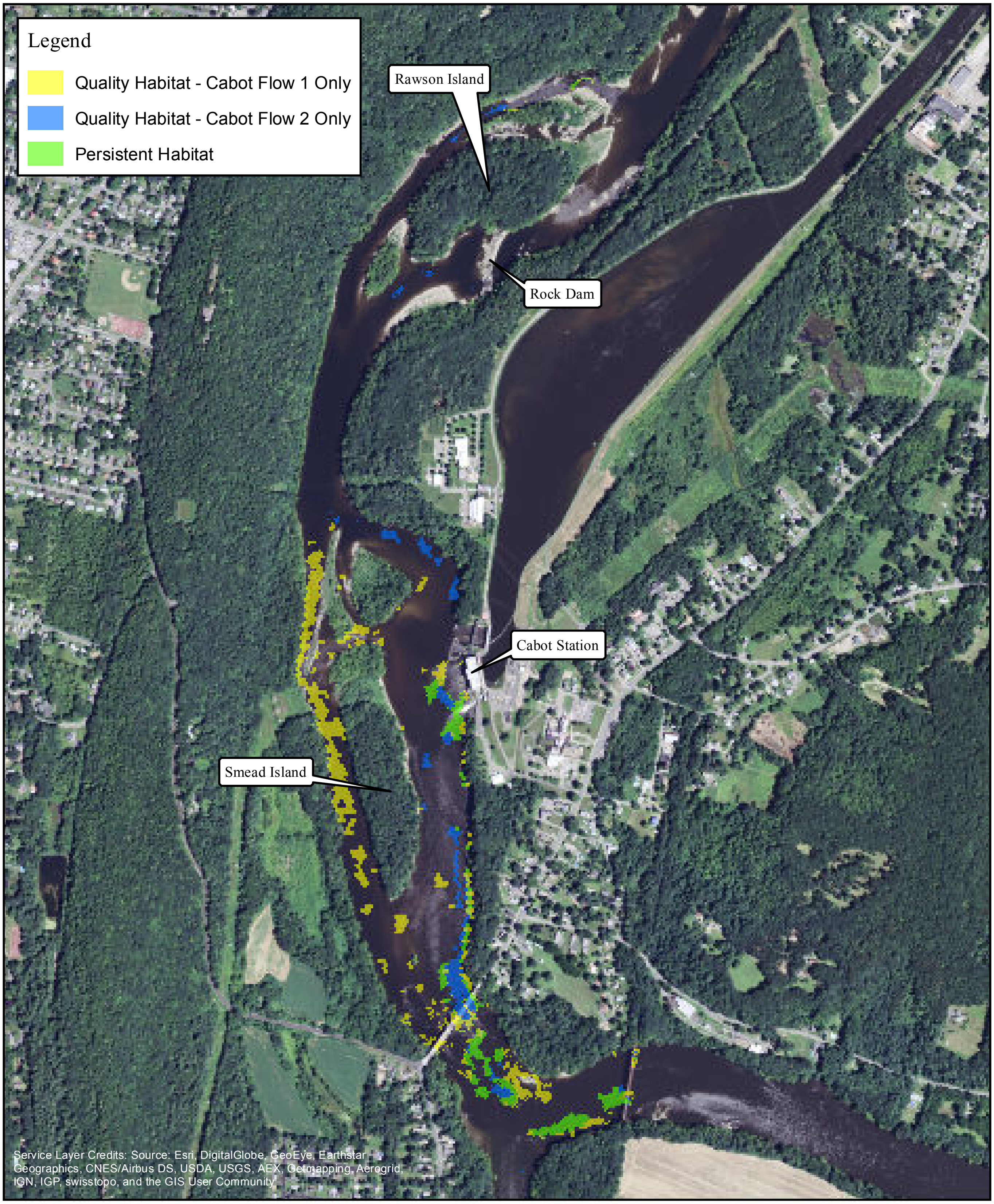
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Spawning

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight™ Power Resources

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

RELICENSING STUDY 3.3.1

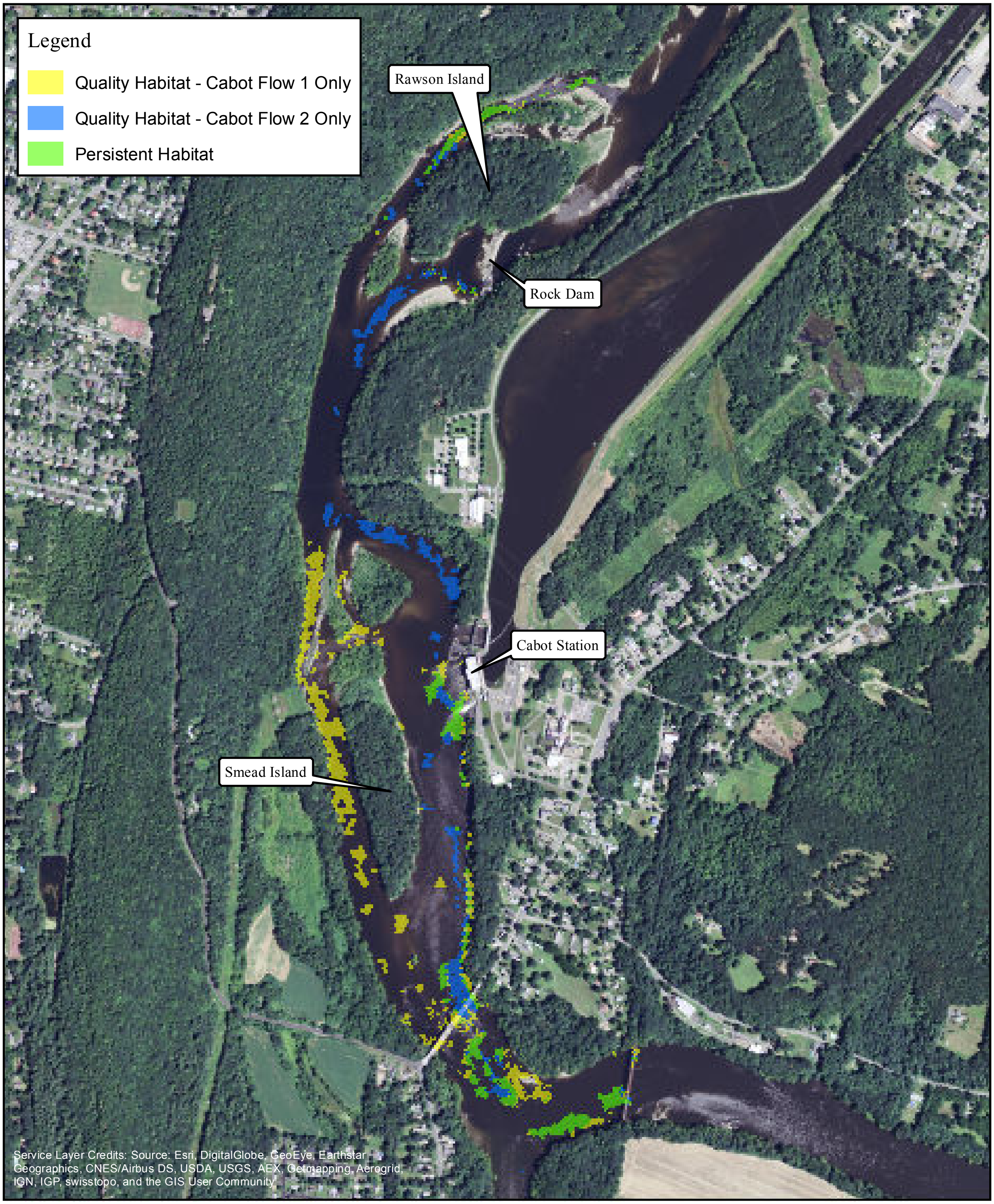
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

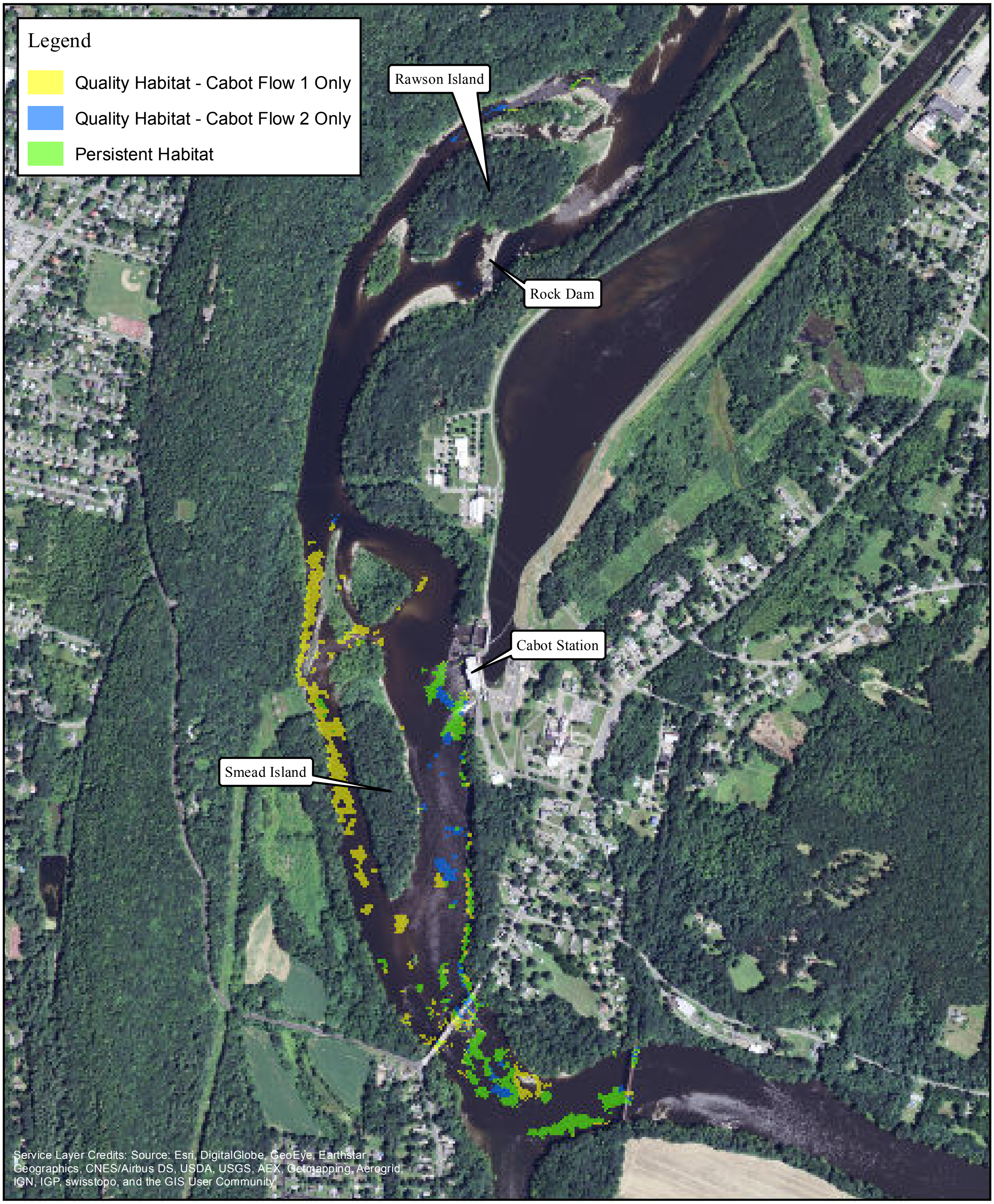
FirstLight Power Resources

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

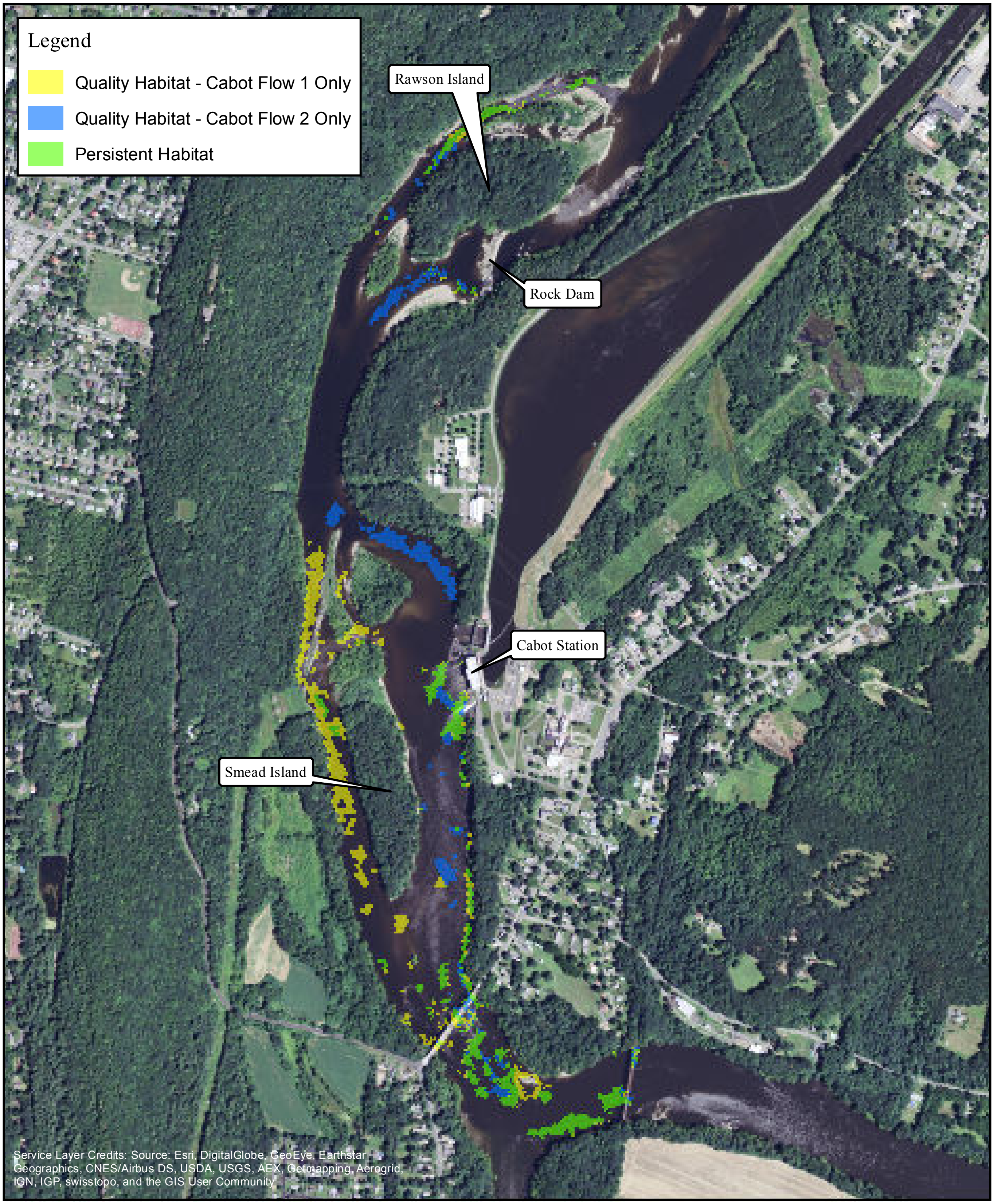
FirstLight Power Resources

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Spawning
Bypass Flow: 200 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

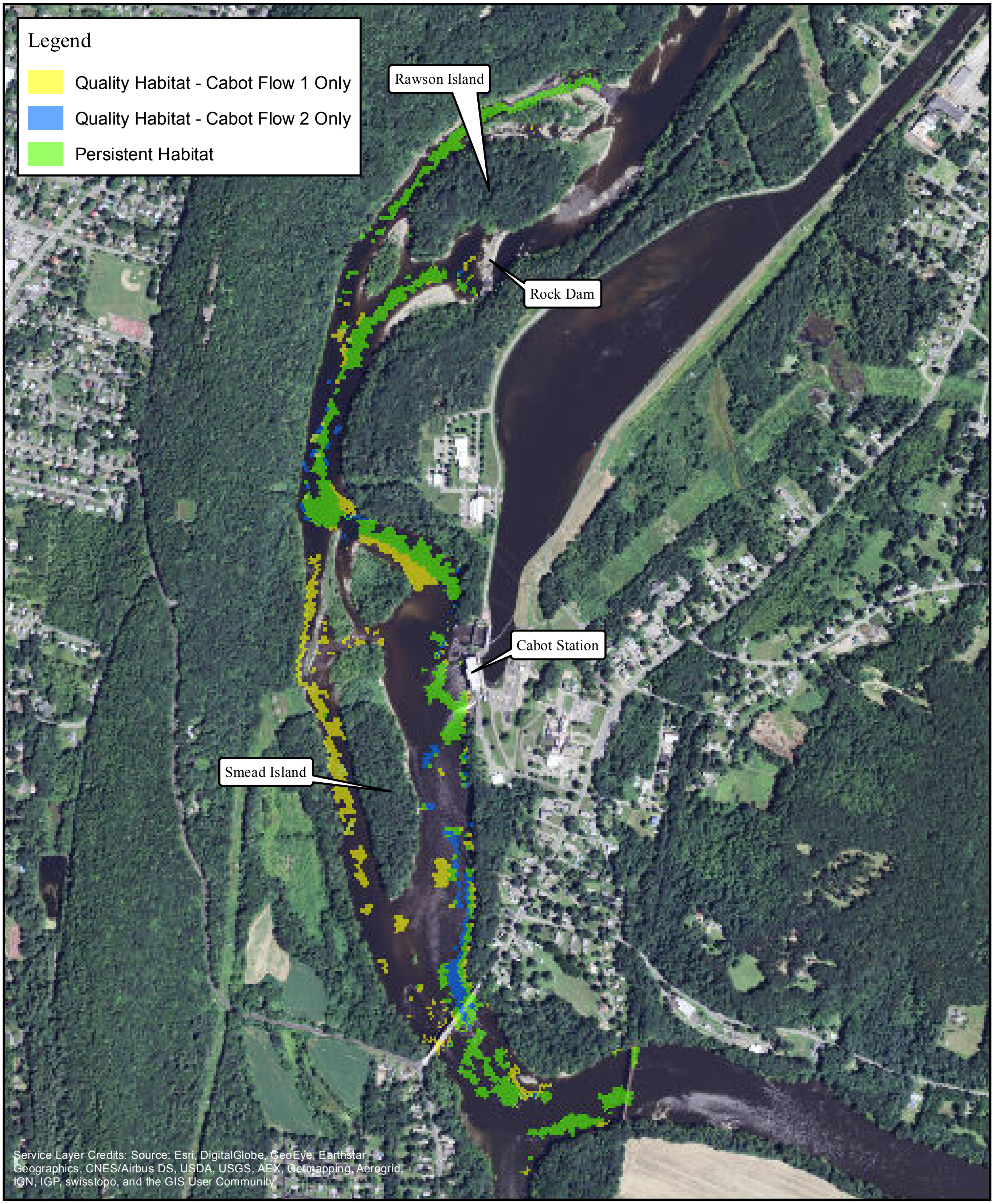
RELICENSING STUDY 3.3.1

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

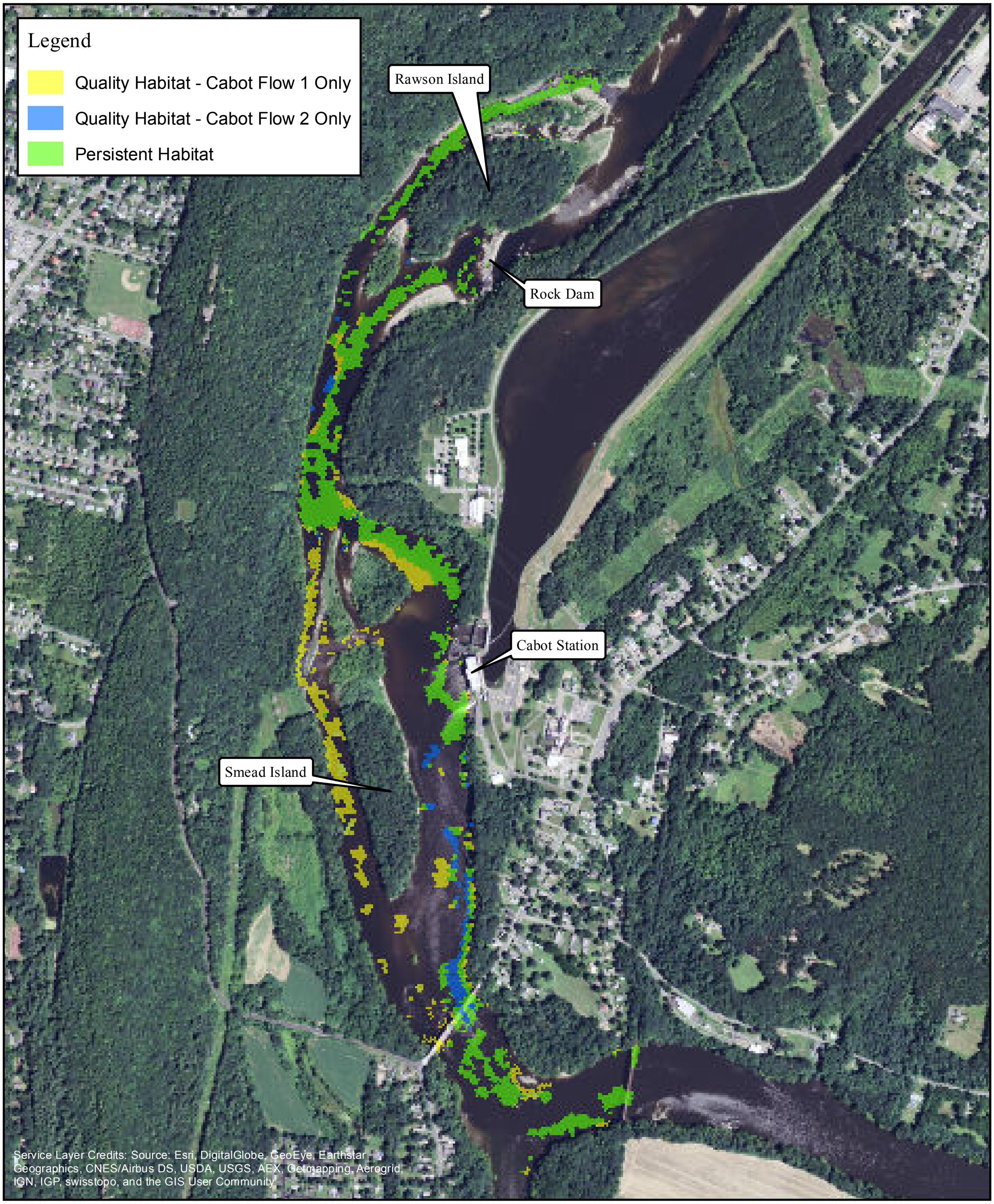
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Egg-Embryo

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



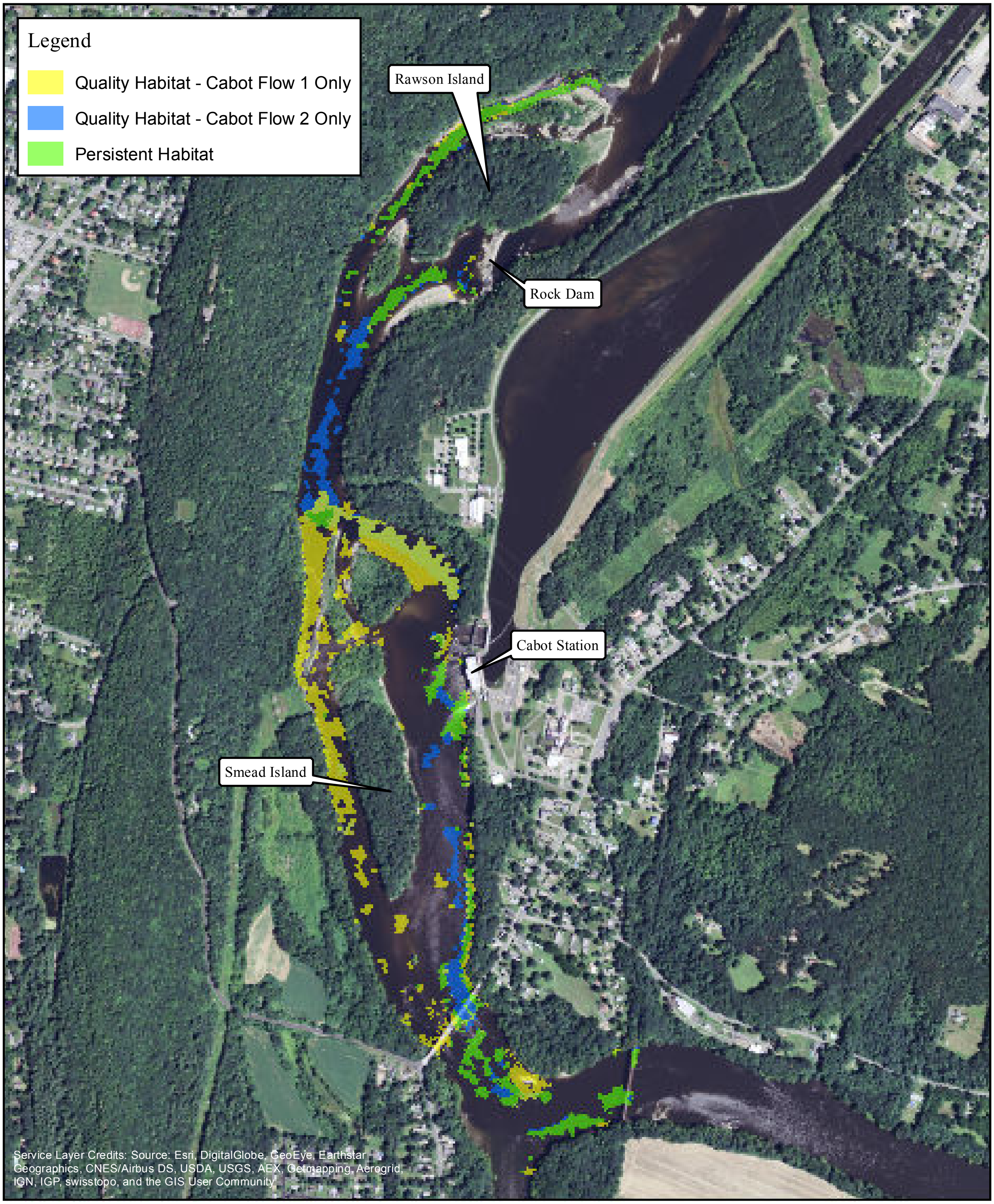
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Egg-Embryo
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd

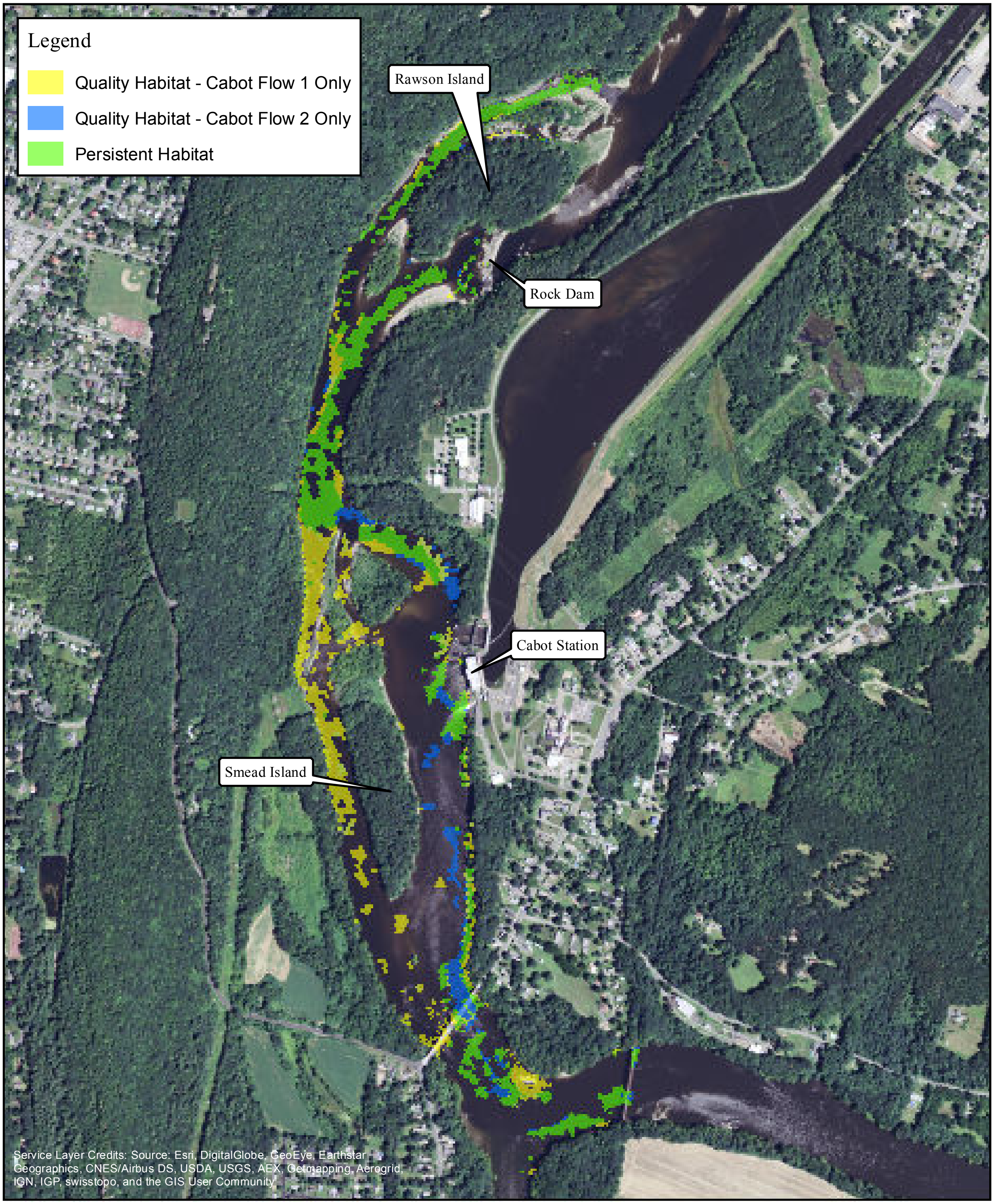


FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Egg-Embryo
Bypass Flow: 200 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



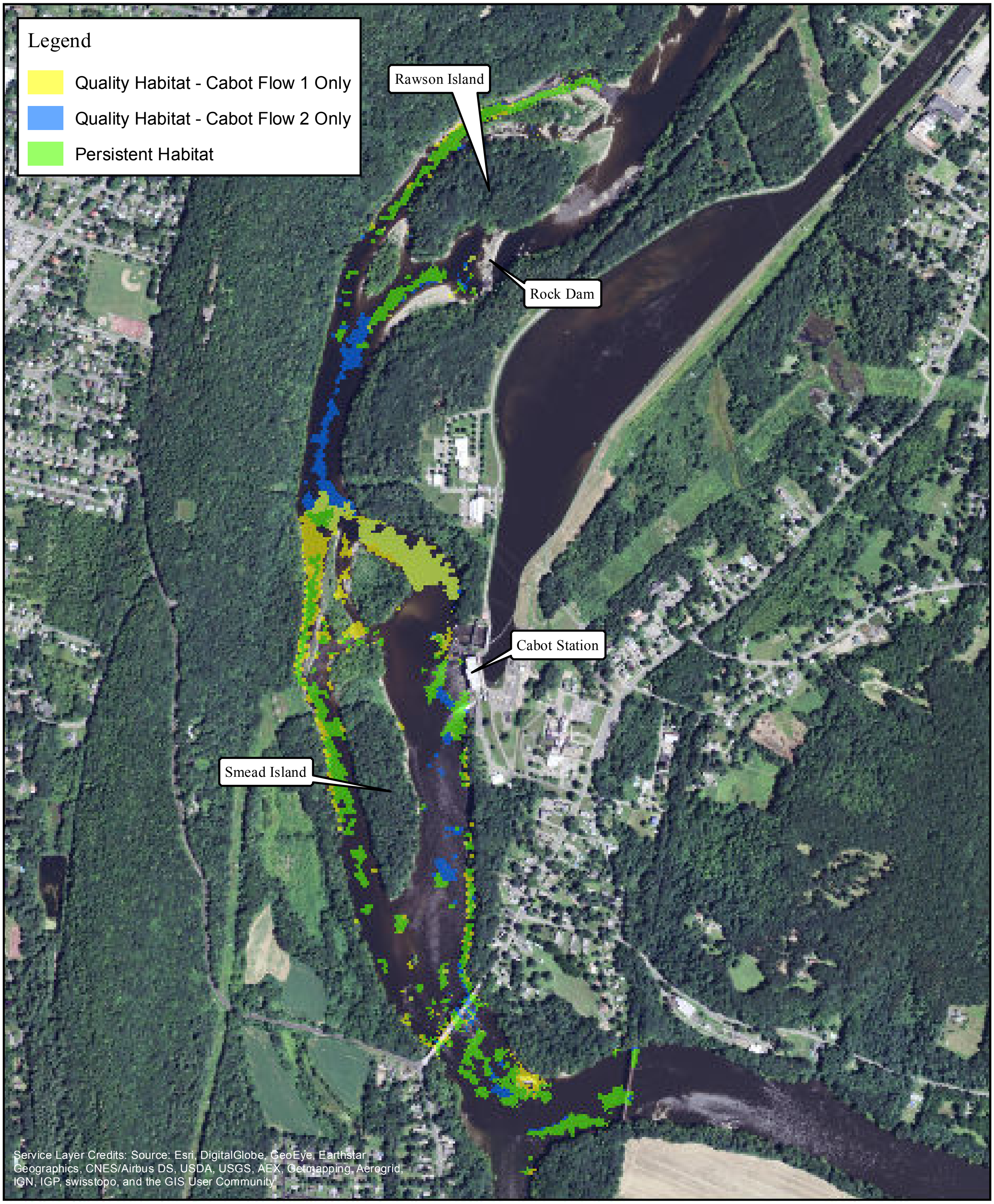
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Egg-Embryo
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

N

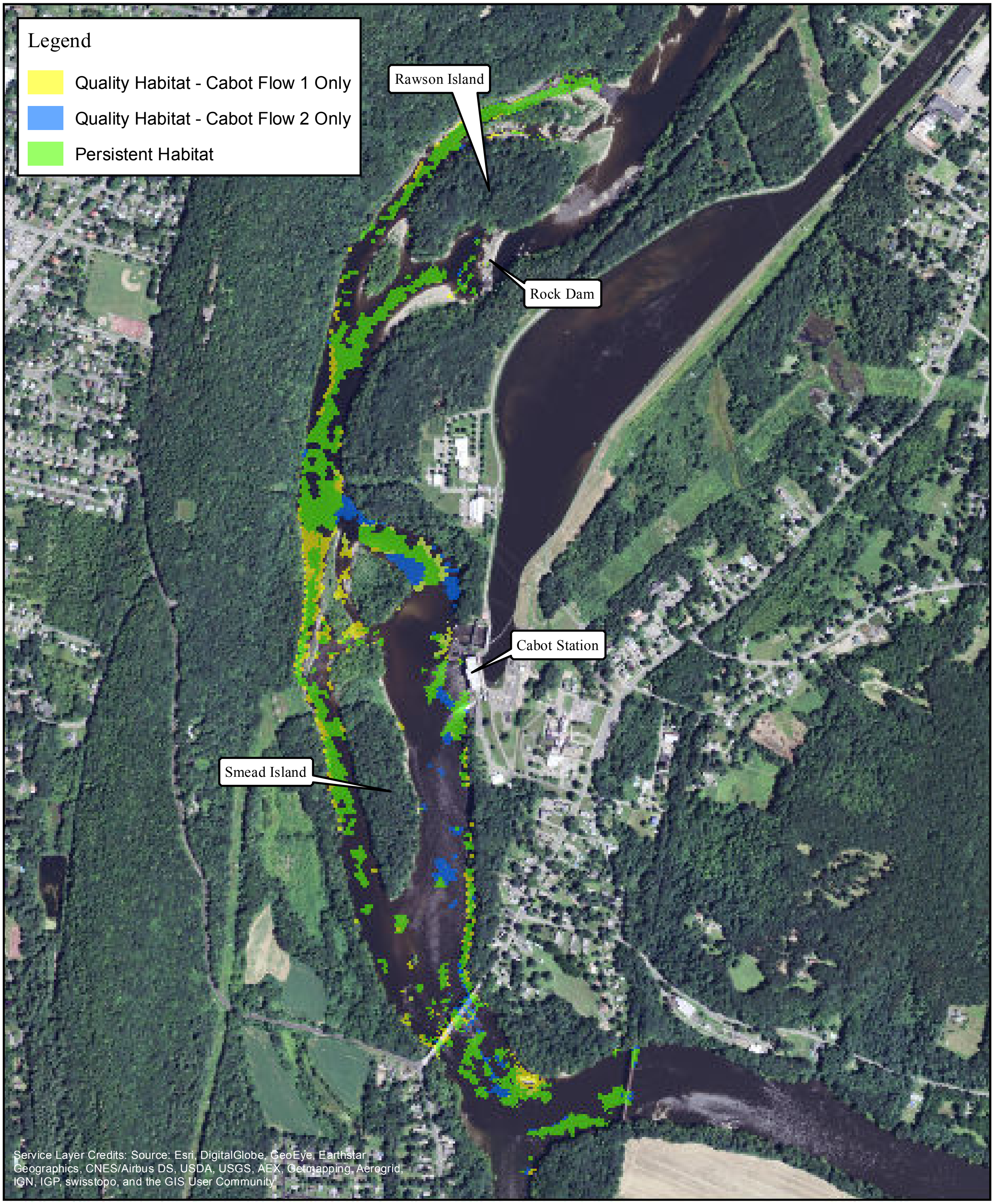
0 500 1,000 2,000 Feet

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

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Egg-Embryo
Bypass Flow: 200 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



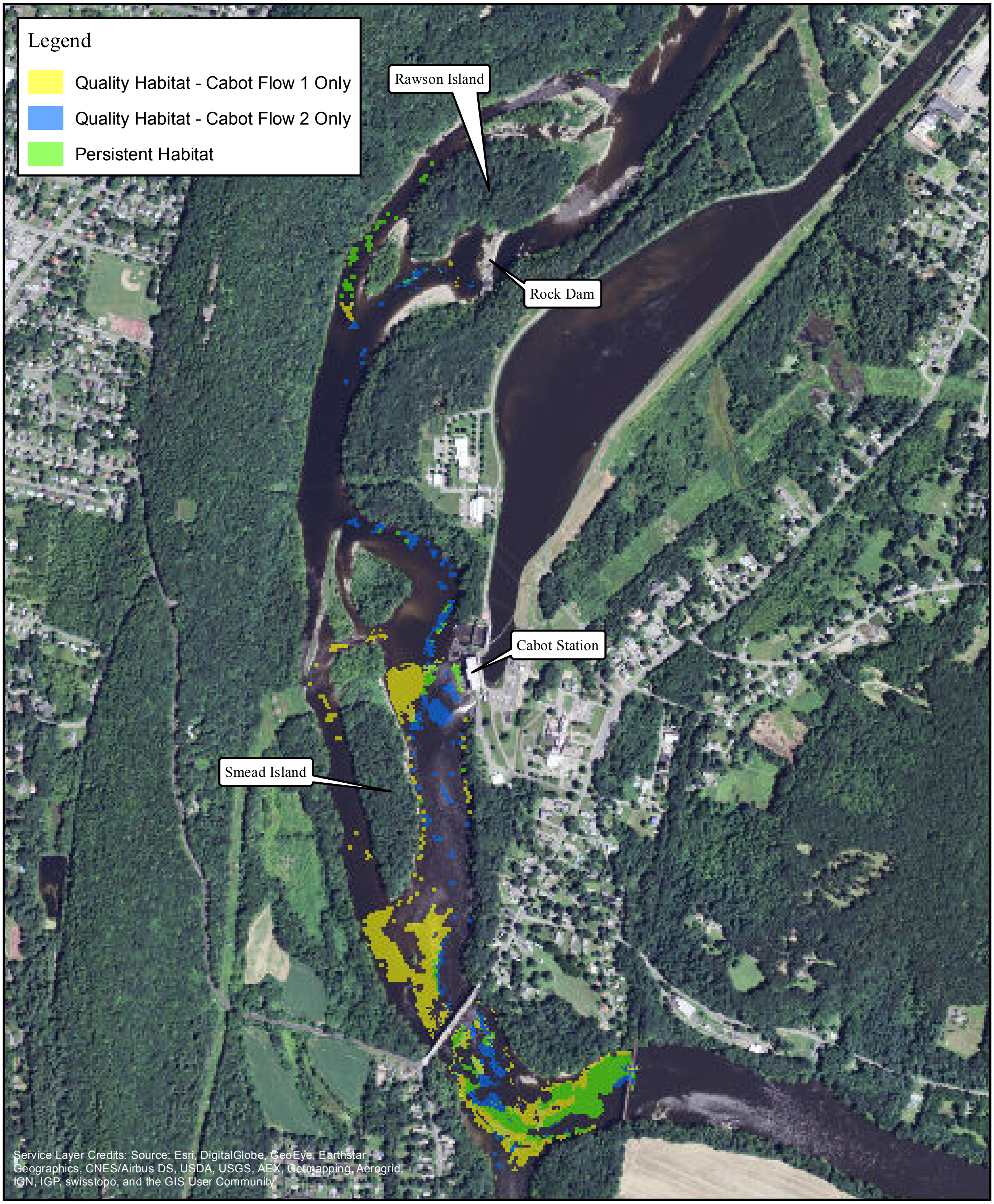
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Egg-Embryo
Bypass Flow: 500 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

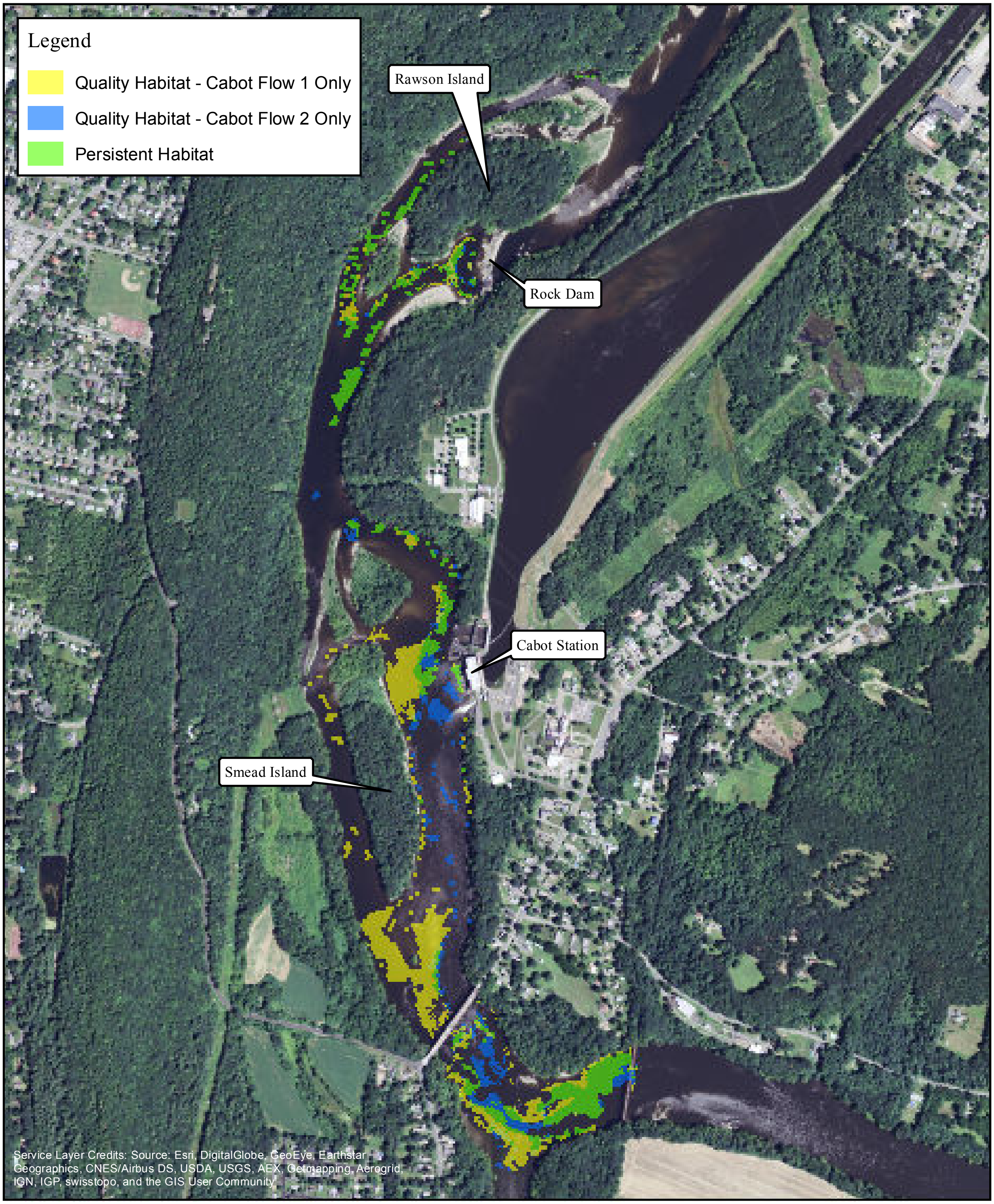
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Fry

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd

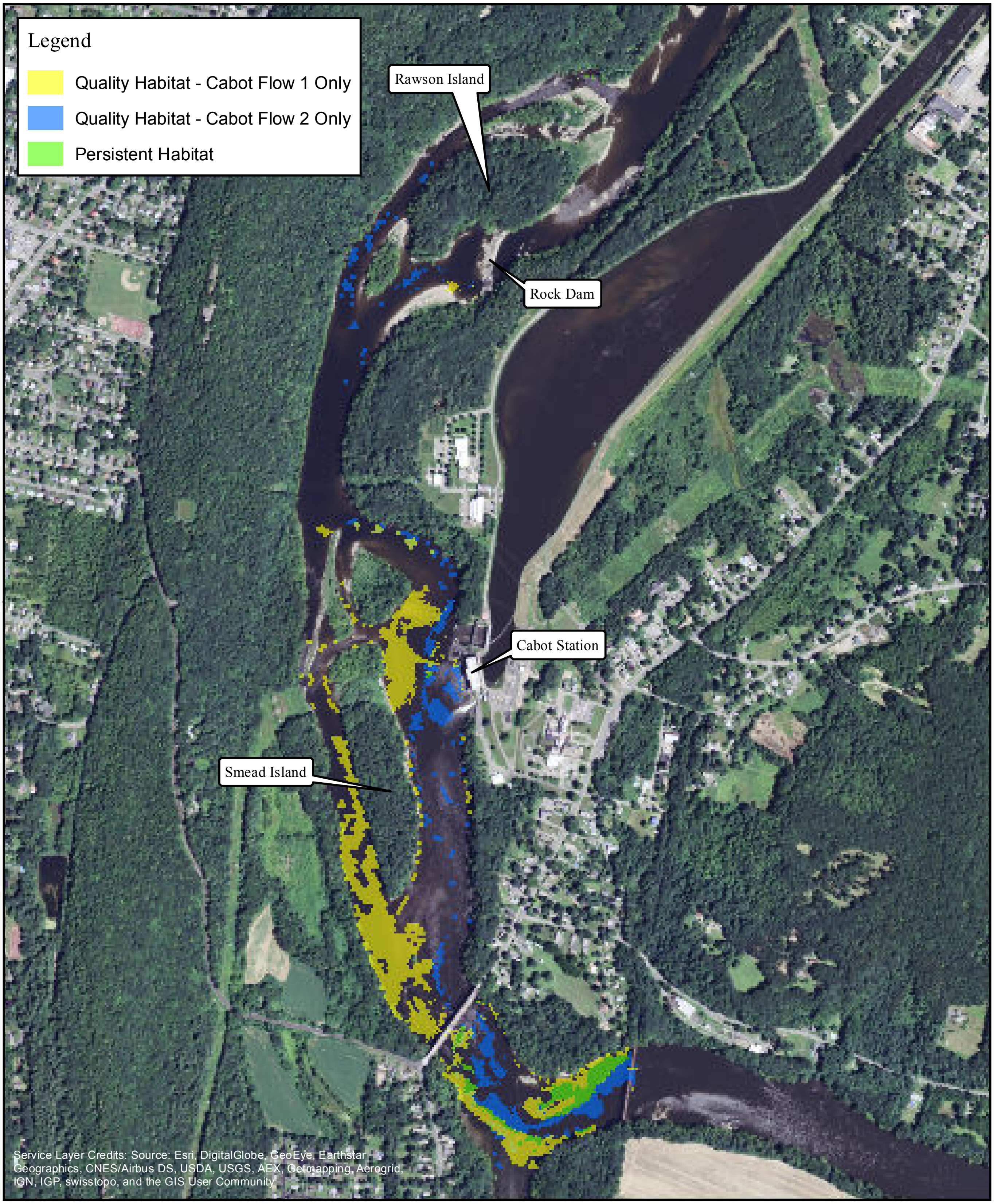


FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Fry
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

N

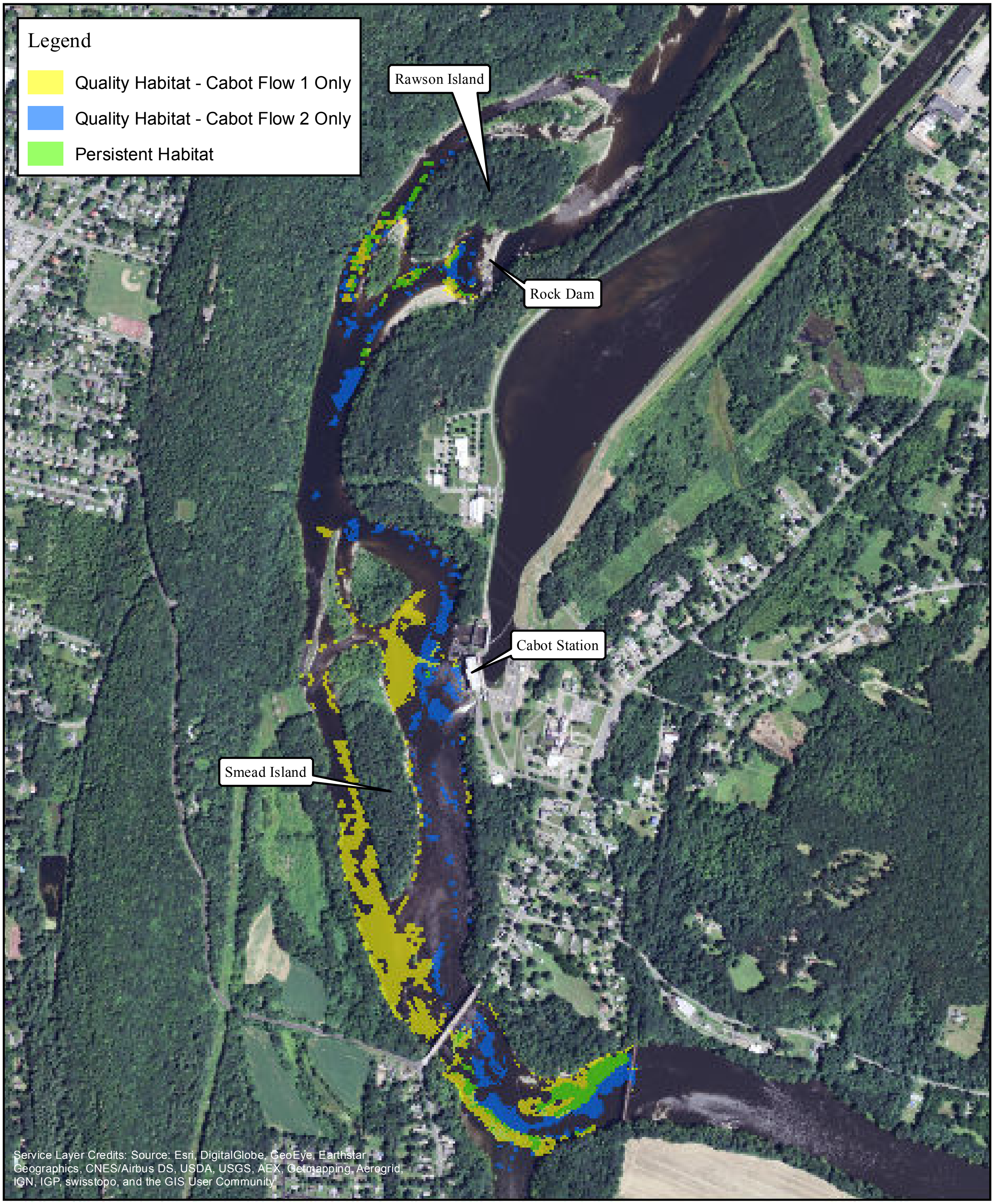
0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Fry

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

FirstLight Power Resources

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

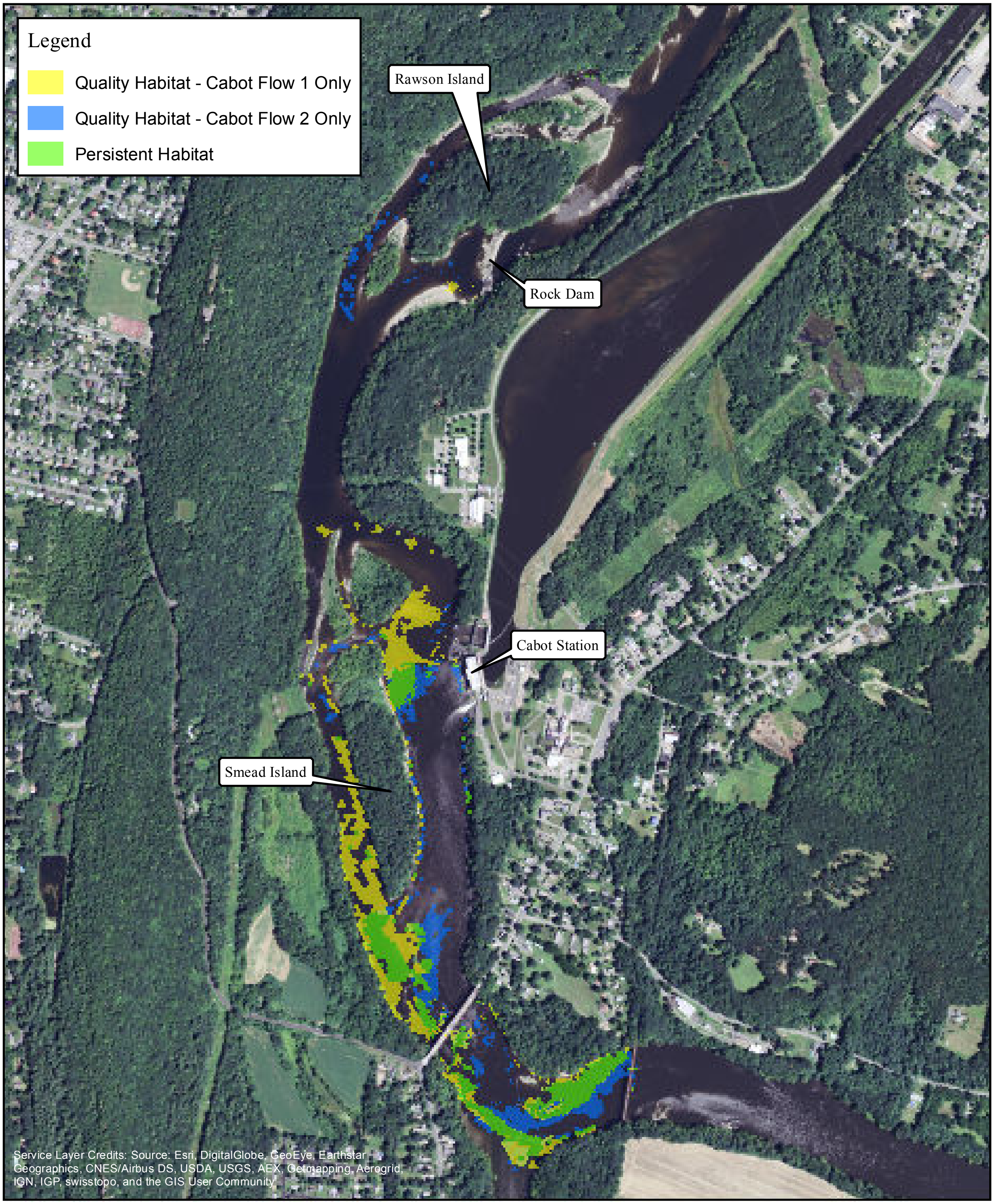
FirstLight Power Resources

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Fry
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

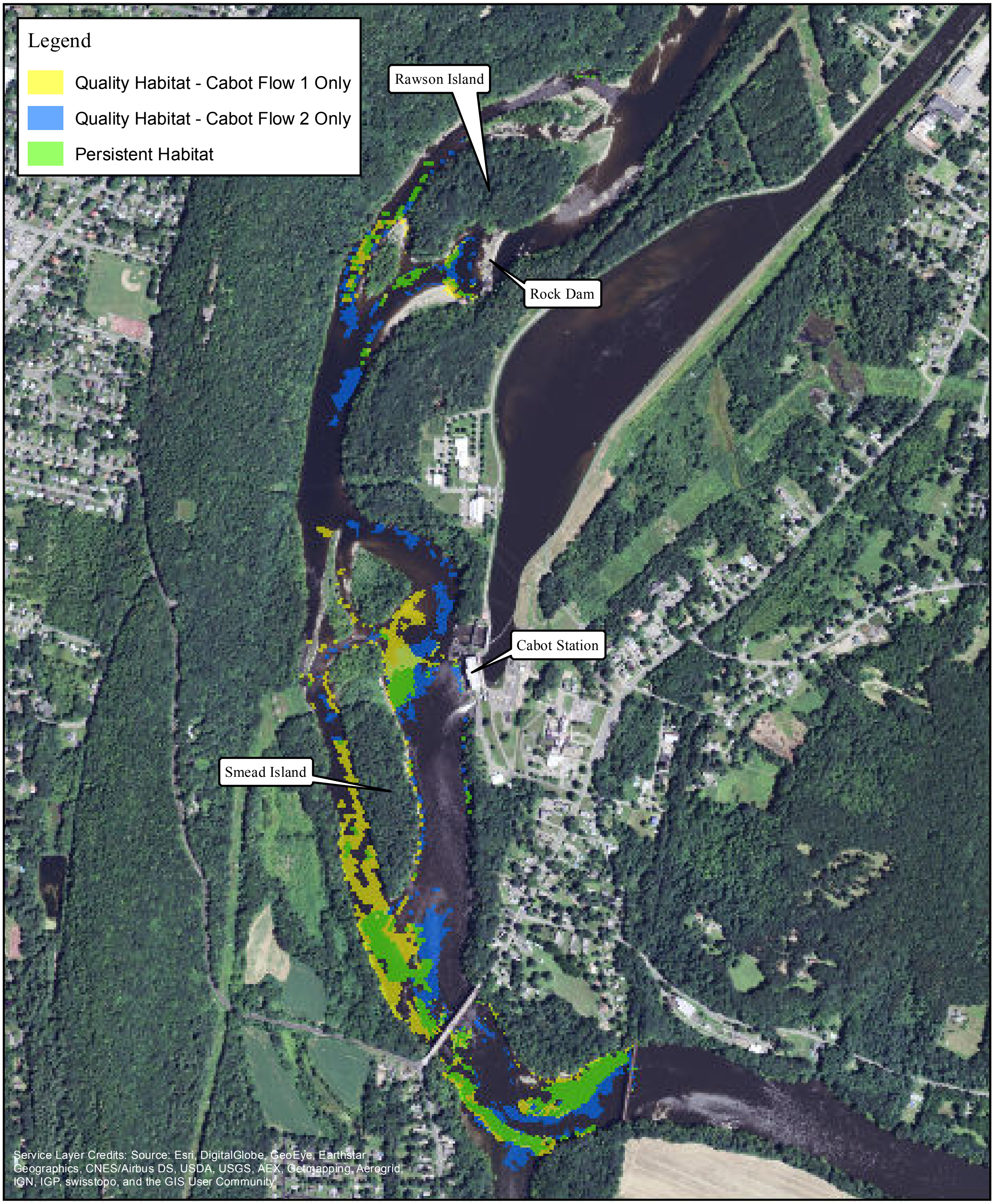
RELICENSING STUDY 3.3.1

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Fry
Bypass Flow: 200 cfs
Cabot Flow 1: 7000 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

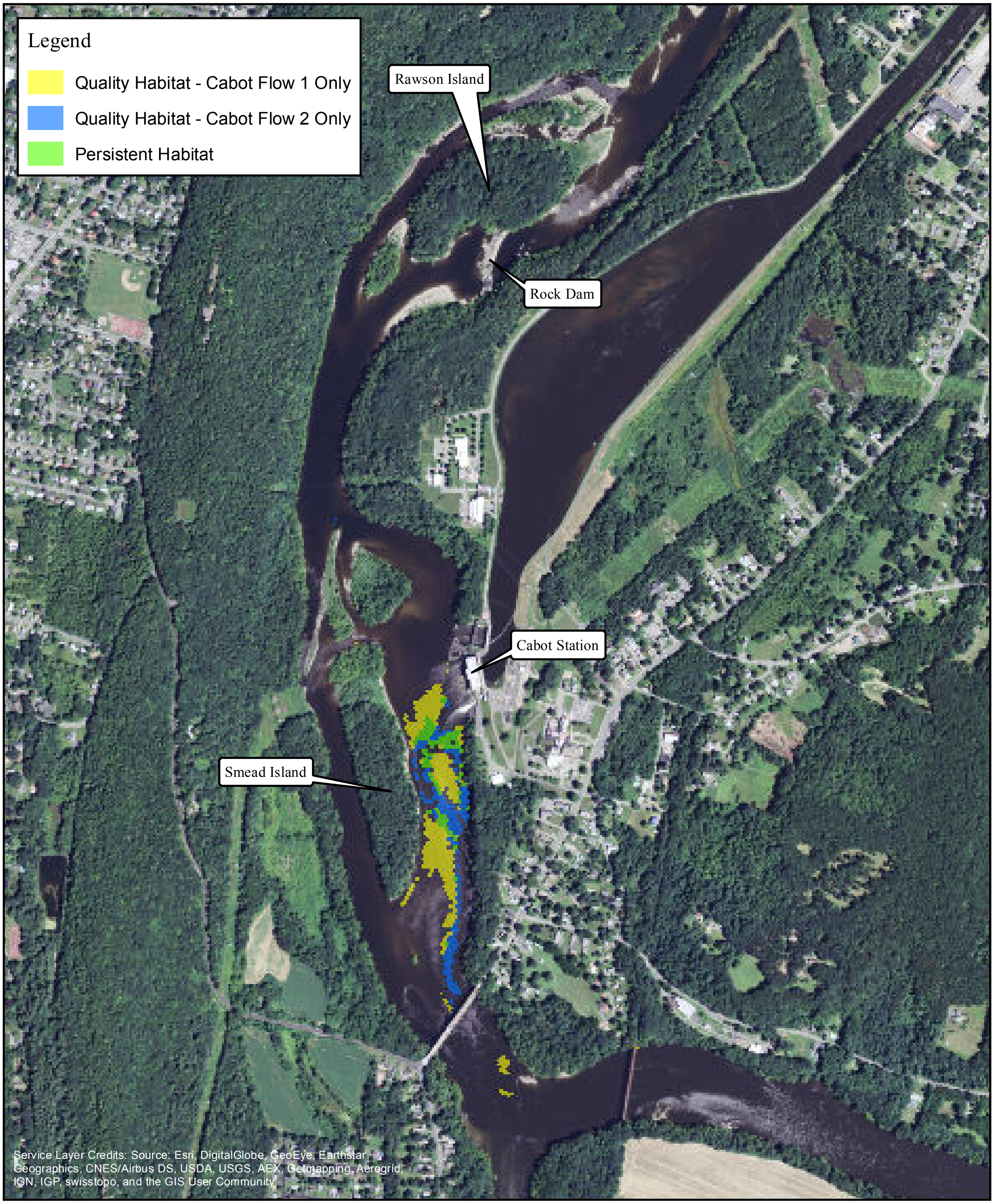
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Shortnose Sturgeon Fry

Bypass Flow:	500 cfs
Cabot Flow 1:	7000 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

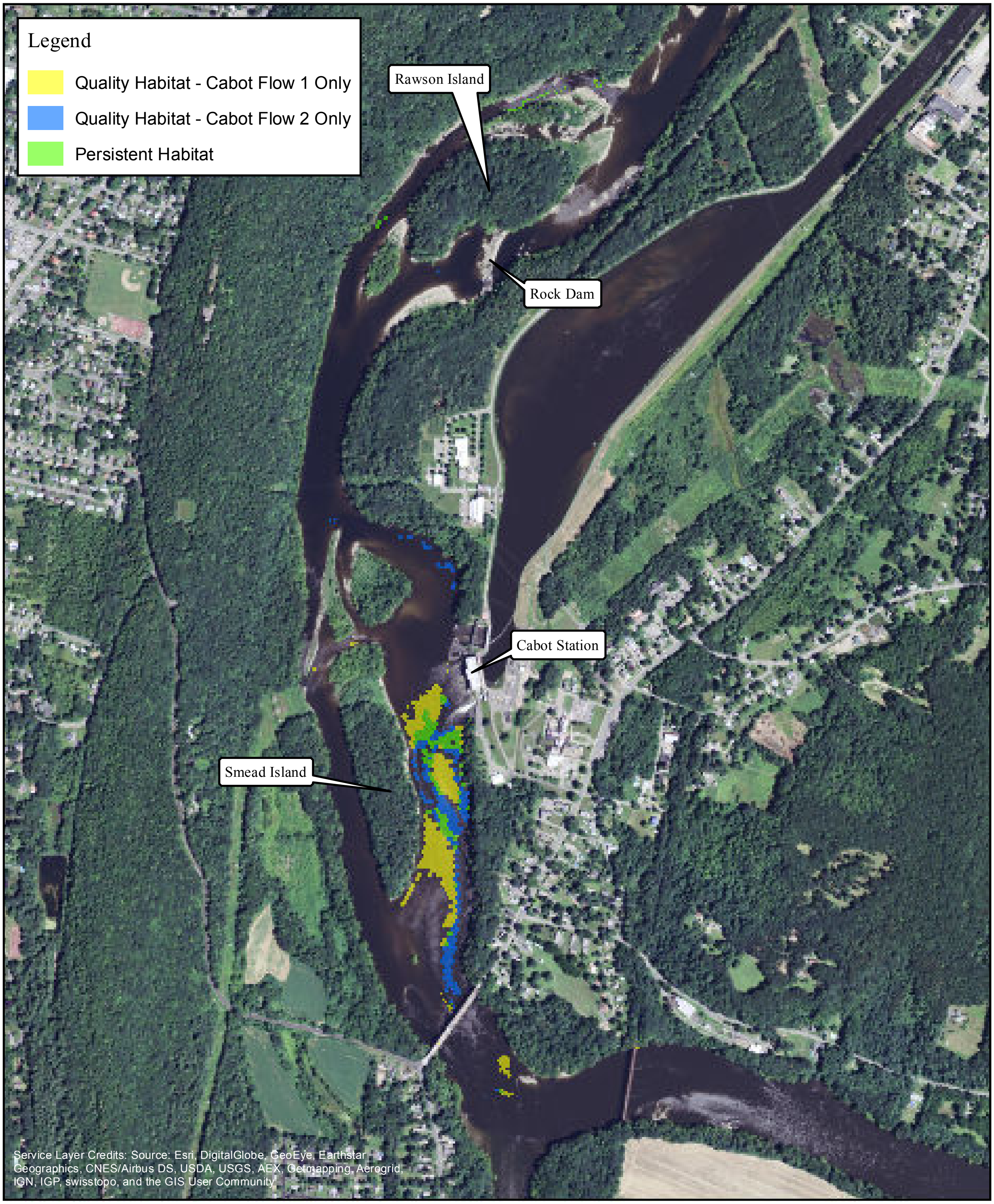
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Walleye Spawning

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

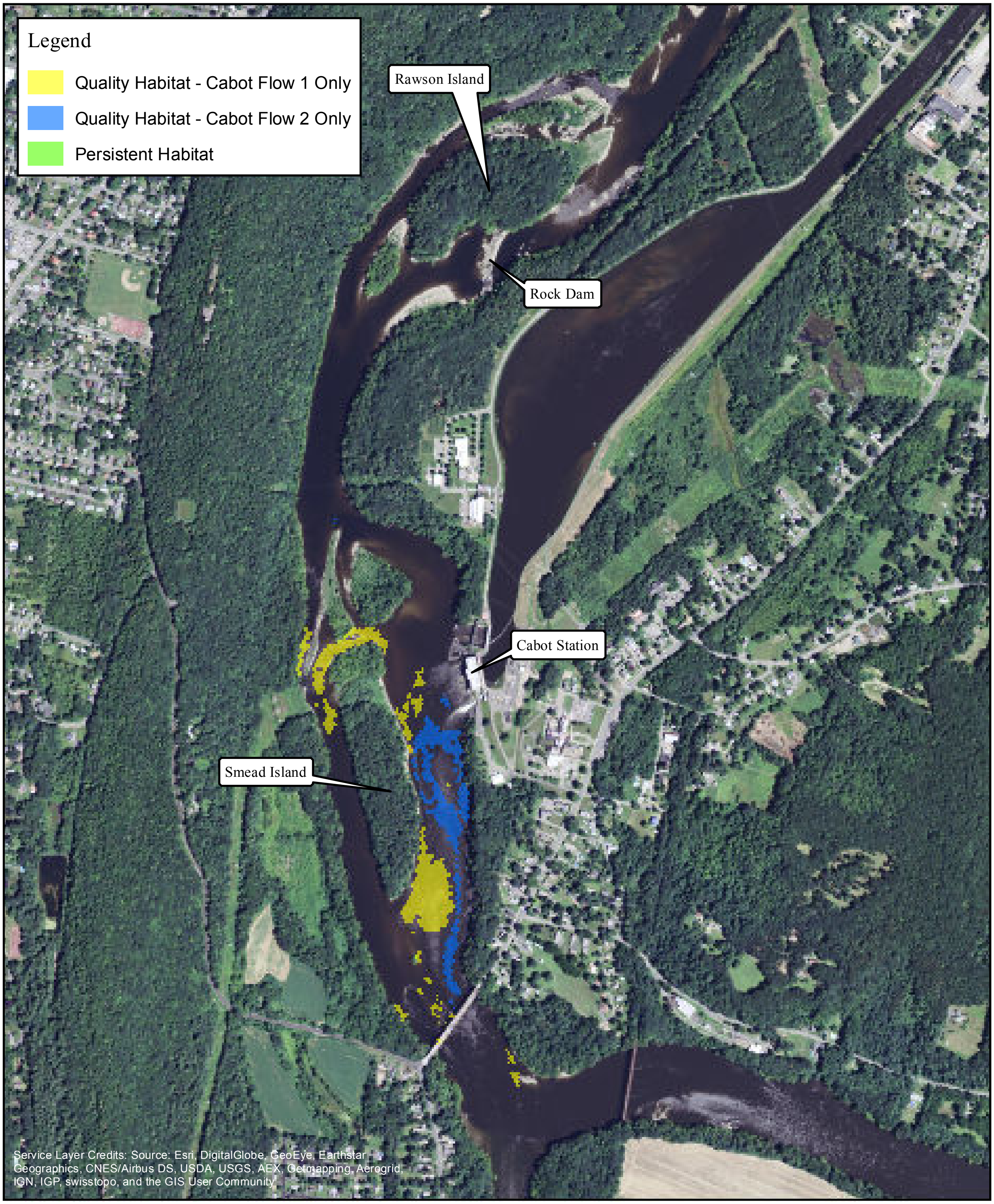
RELICENSING STUDY 3.3.1

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Walleye Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

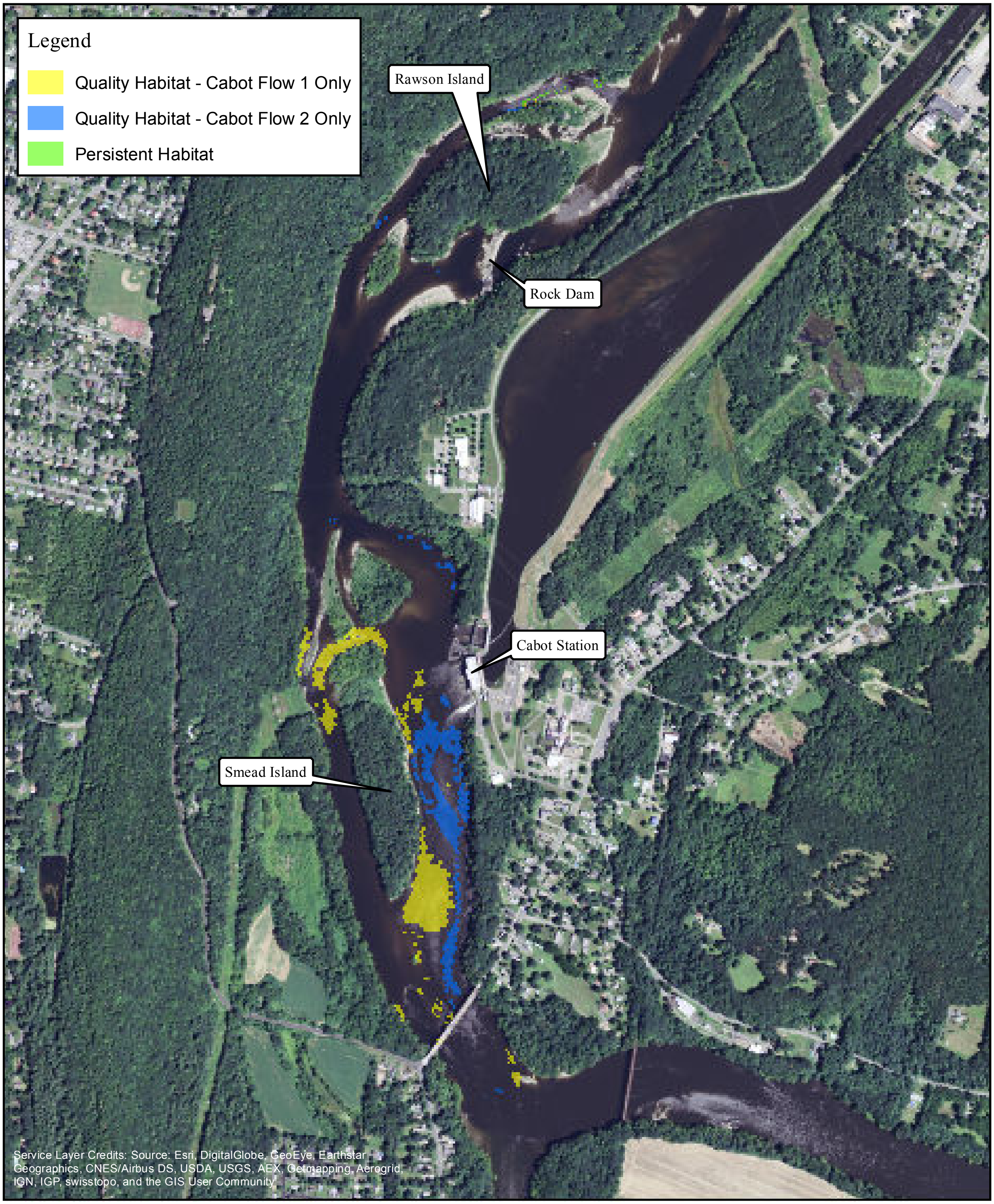
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Walleye Spawning

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



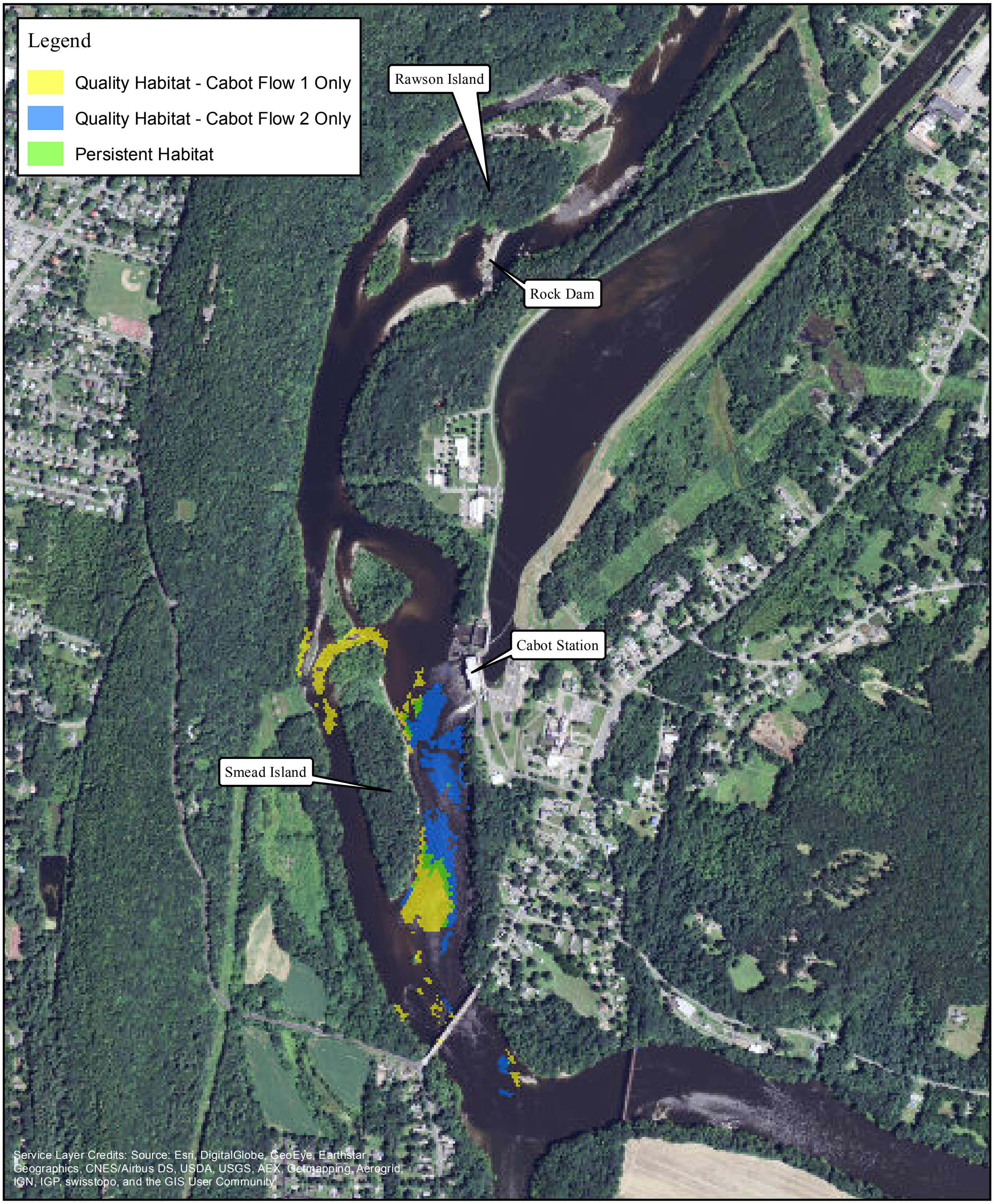
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
Walleye Spawning

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

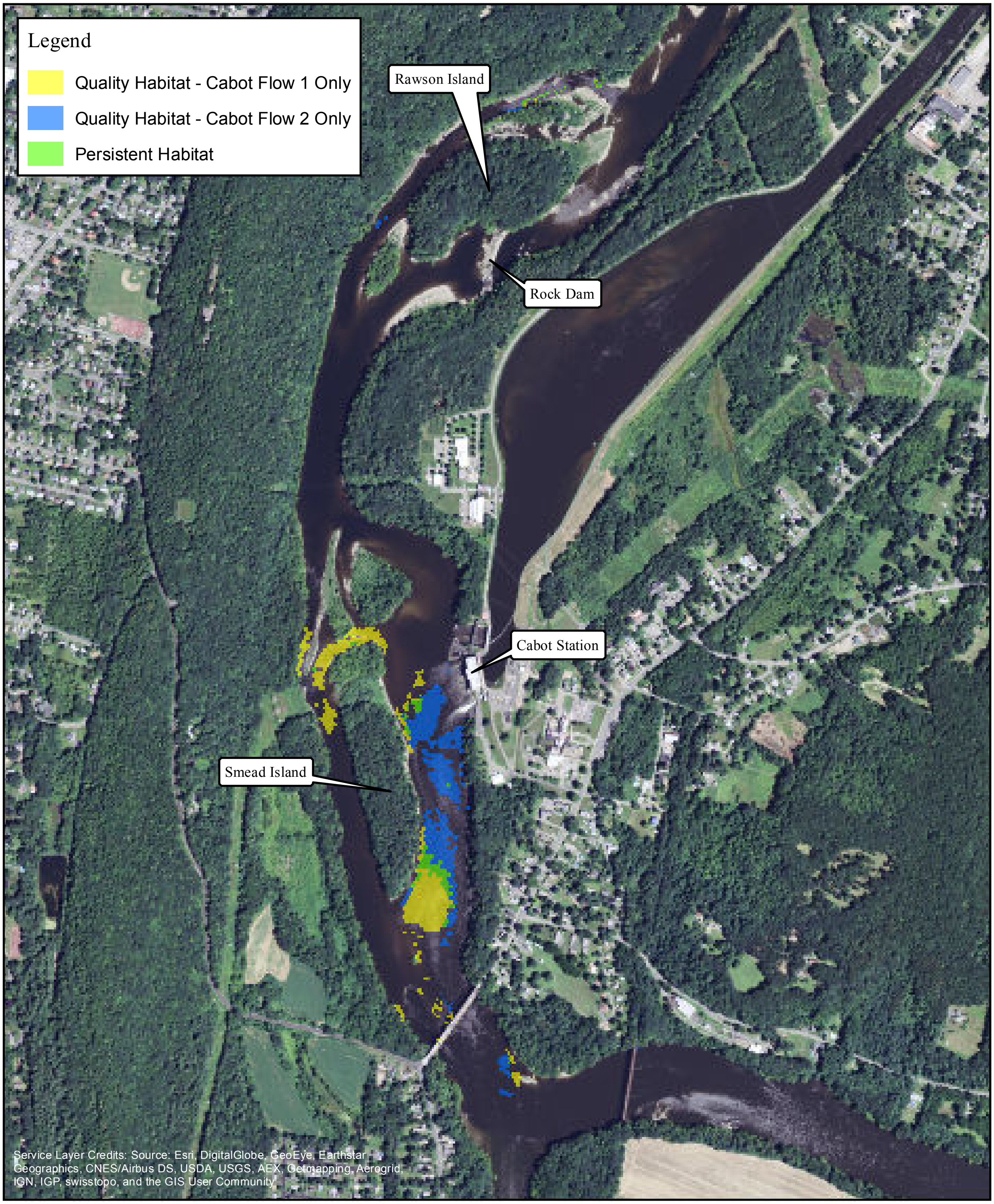
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Walleye Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

N

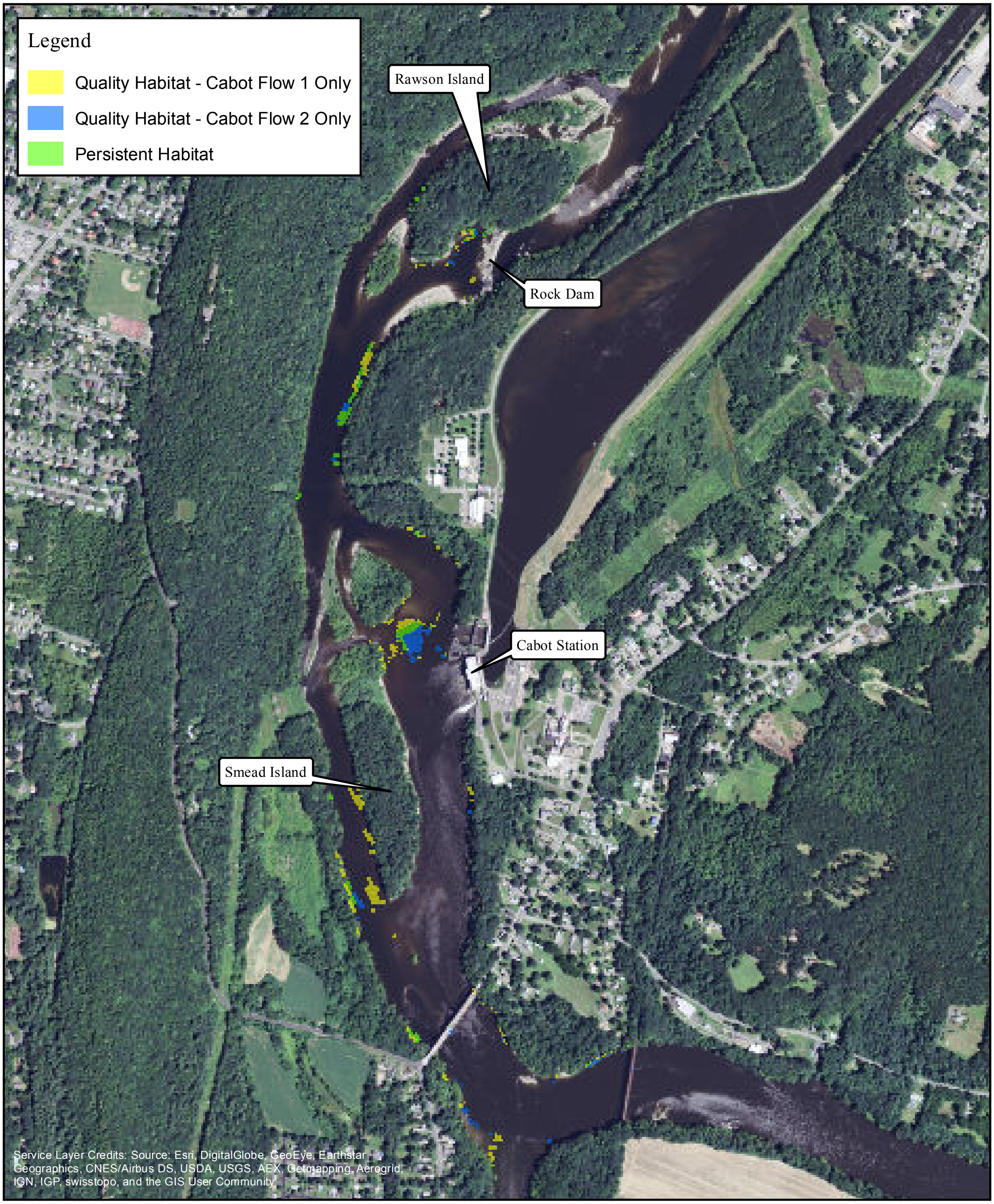
0 500 1,000 2,000 Feet

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Walleye Spawning

Bypass Flow:	500 cfs
Cabot Flow 1:	7000 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

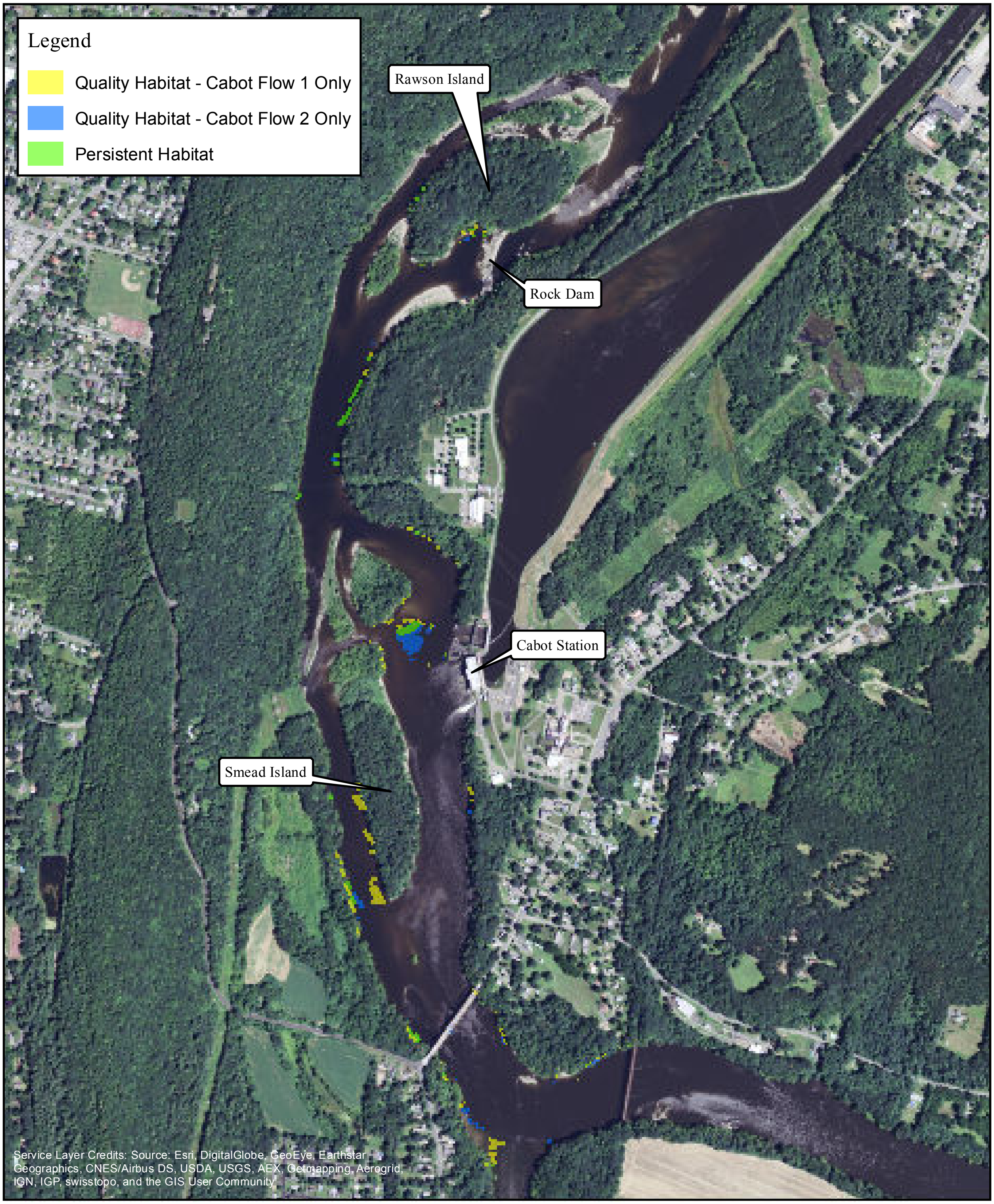
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Walleye Fry

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

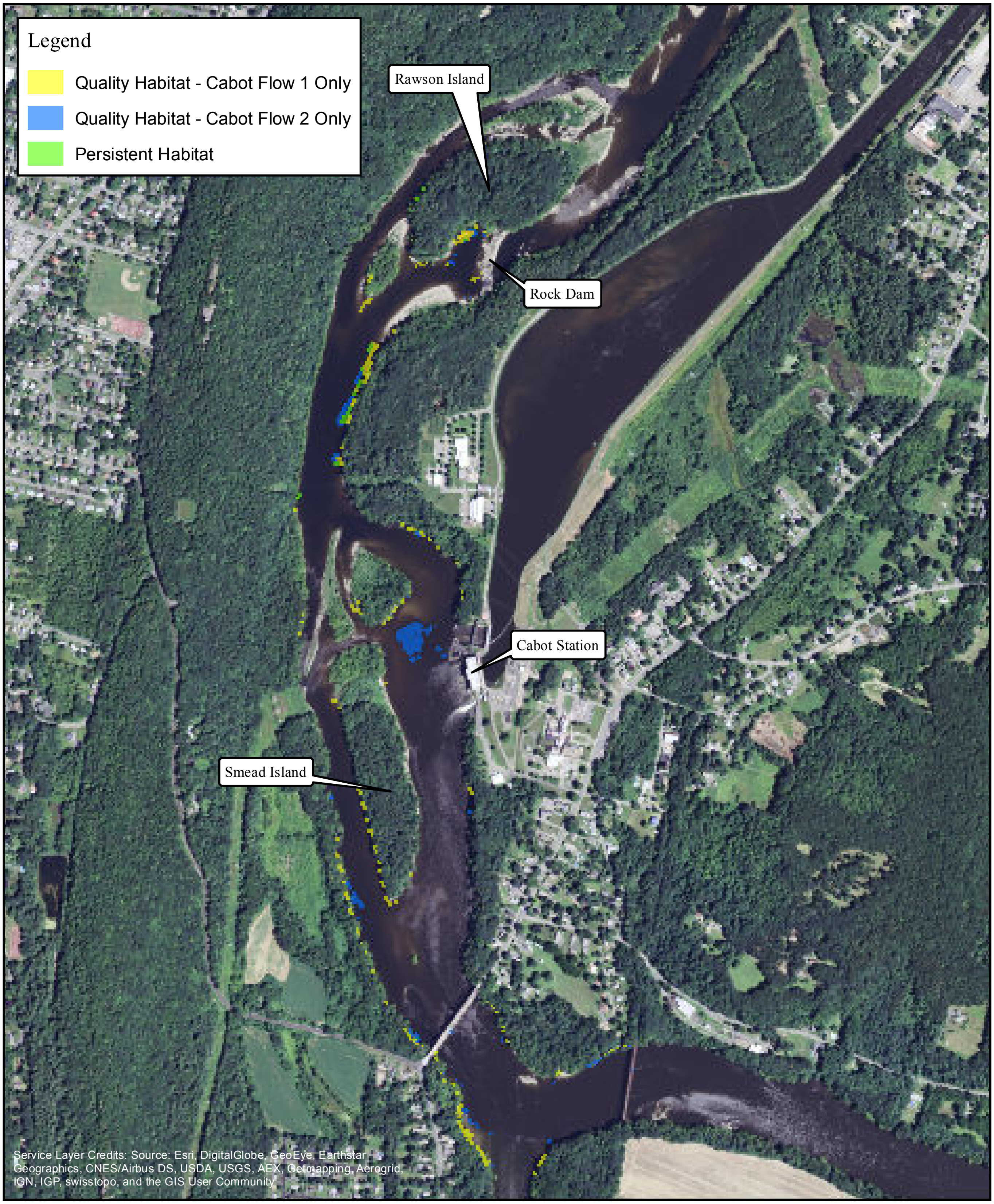
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Walleye Fry

Bypass Flow:	500 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

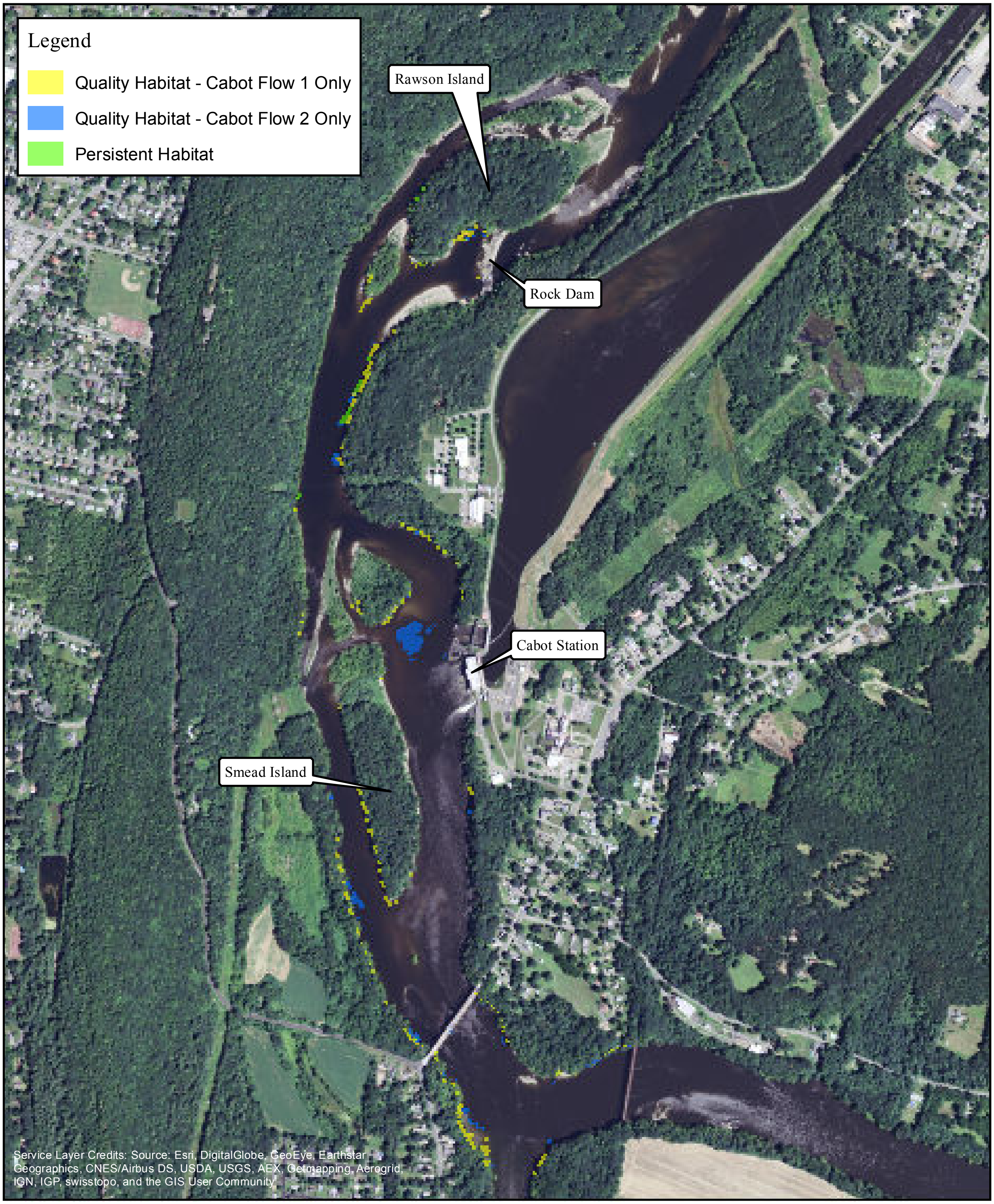
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Walleye Fry

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

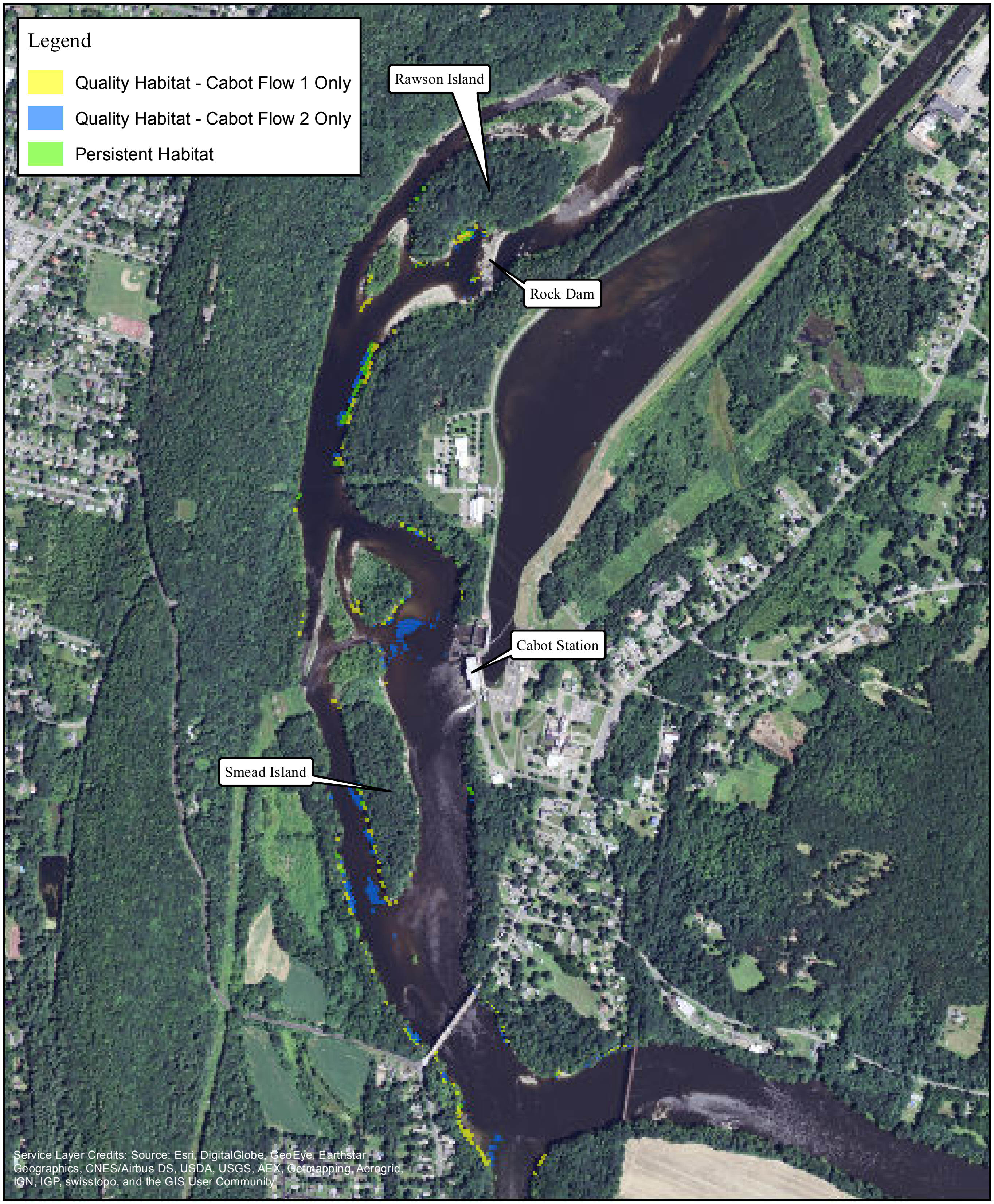
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Walleye Fry

Bypass Flow:	500	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

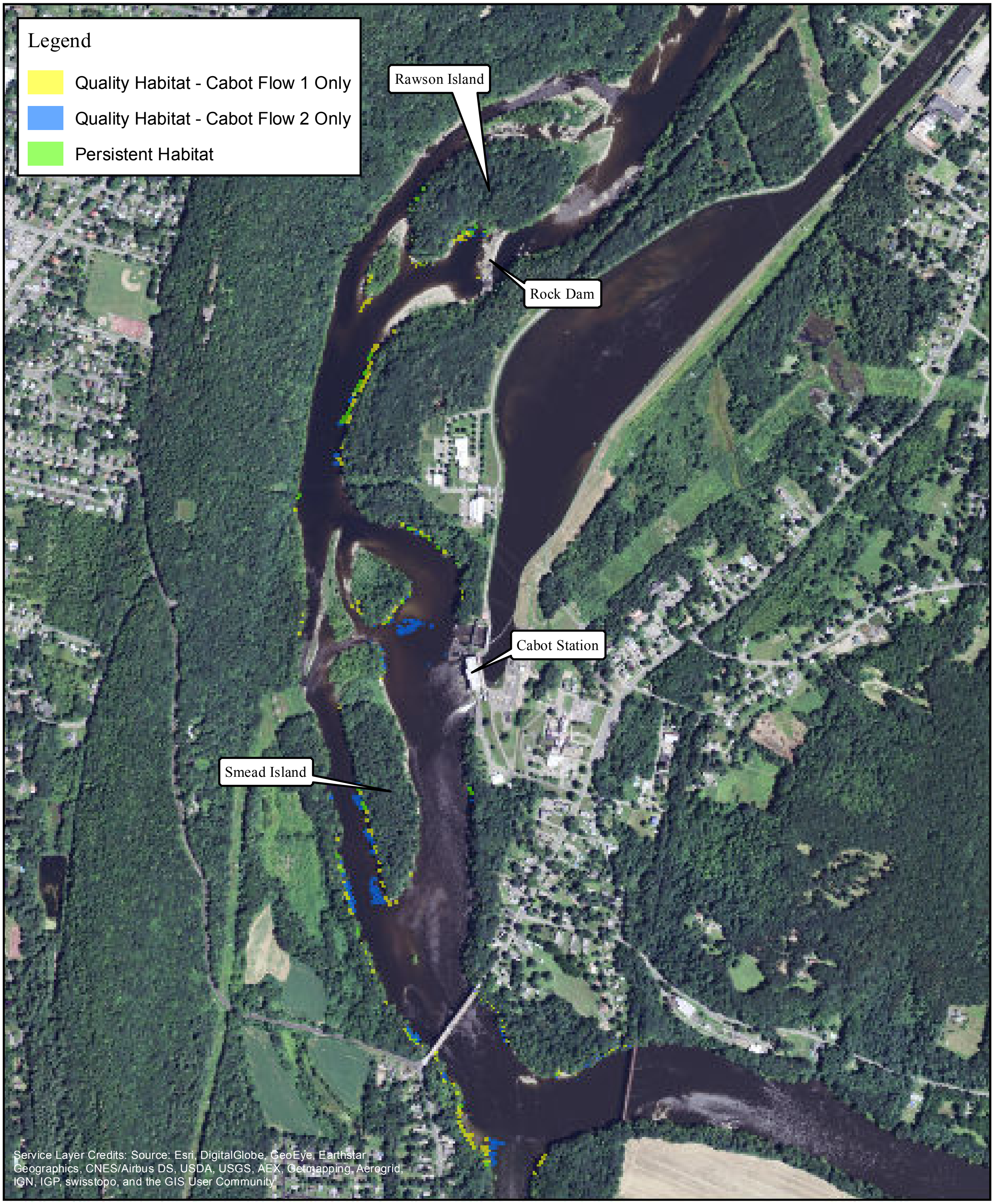
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
Walleye Fry

Bypass Flow:	200 cfs
Cabot Flow 1:	7000 cfs
Cabot Flow 2:	14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

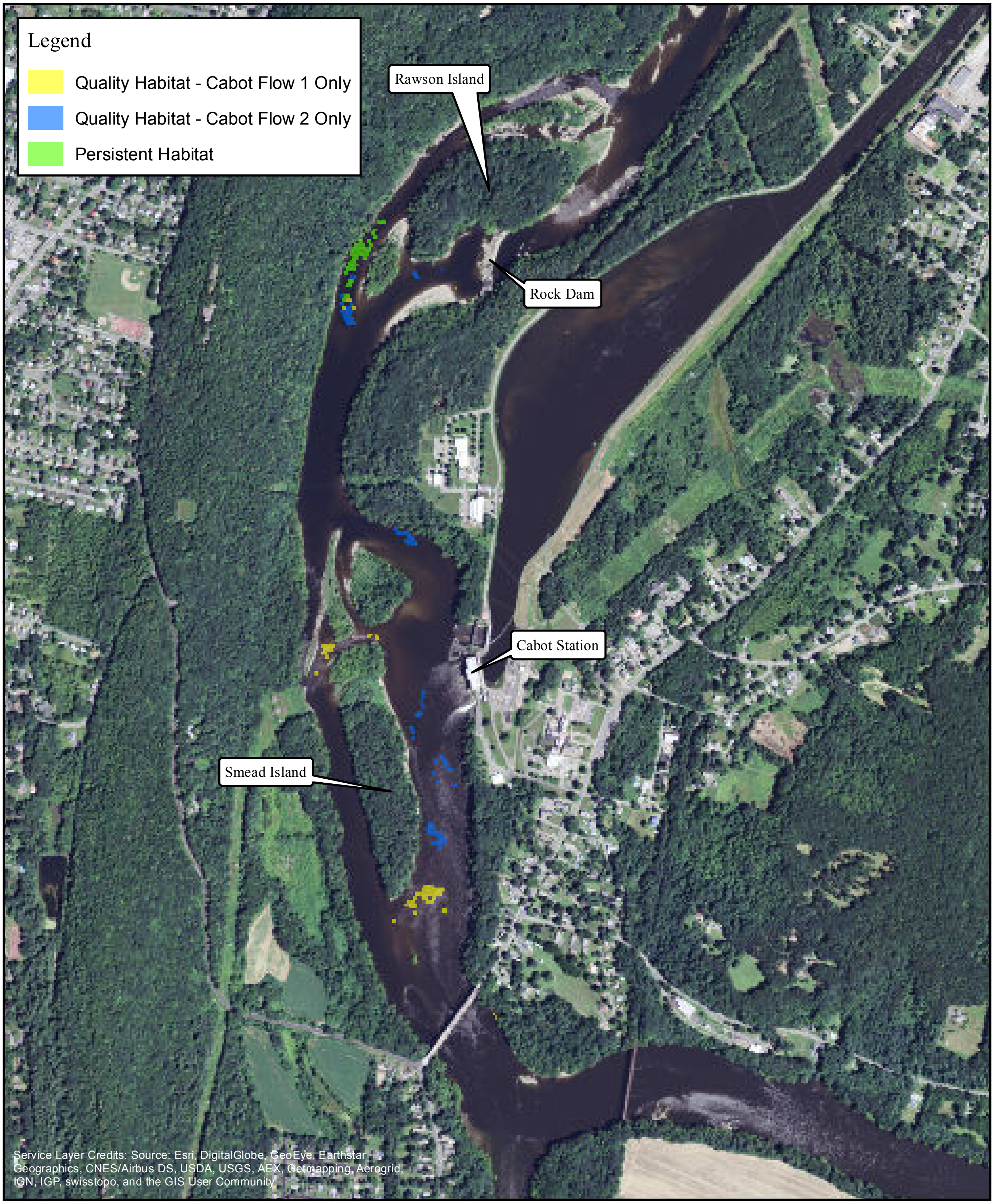
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
Walleye Fry

Bypass Flow:	500	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

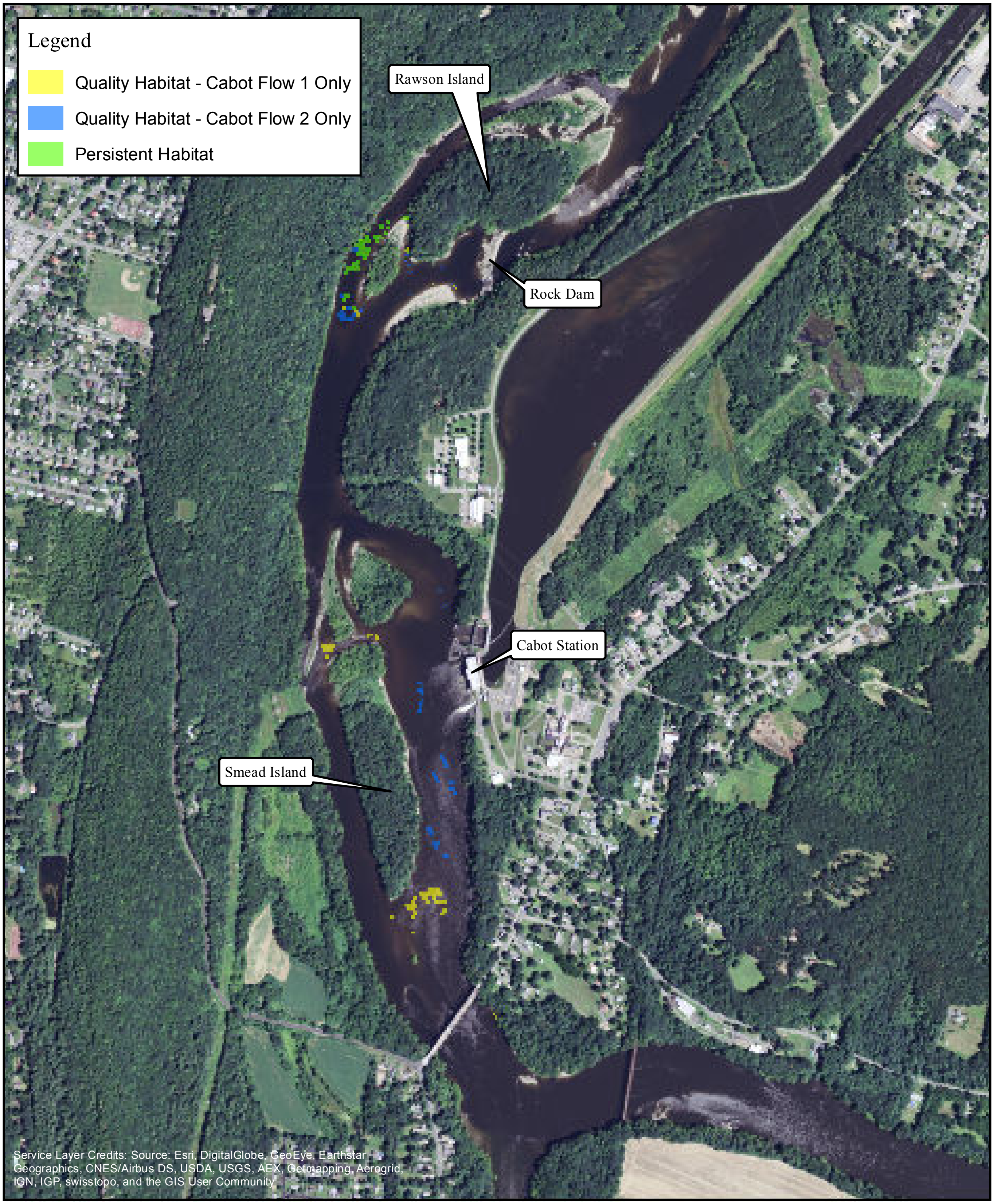
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	7000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



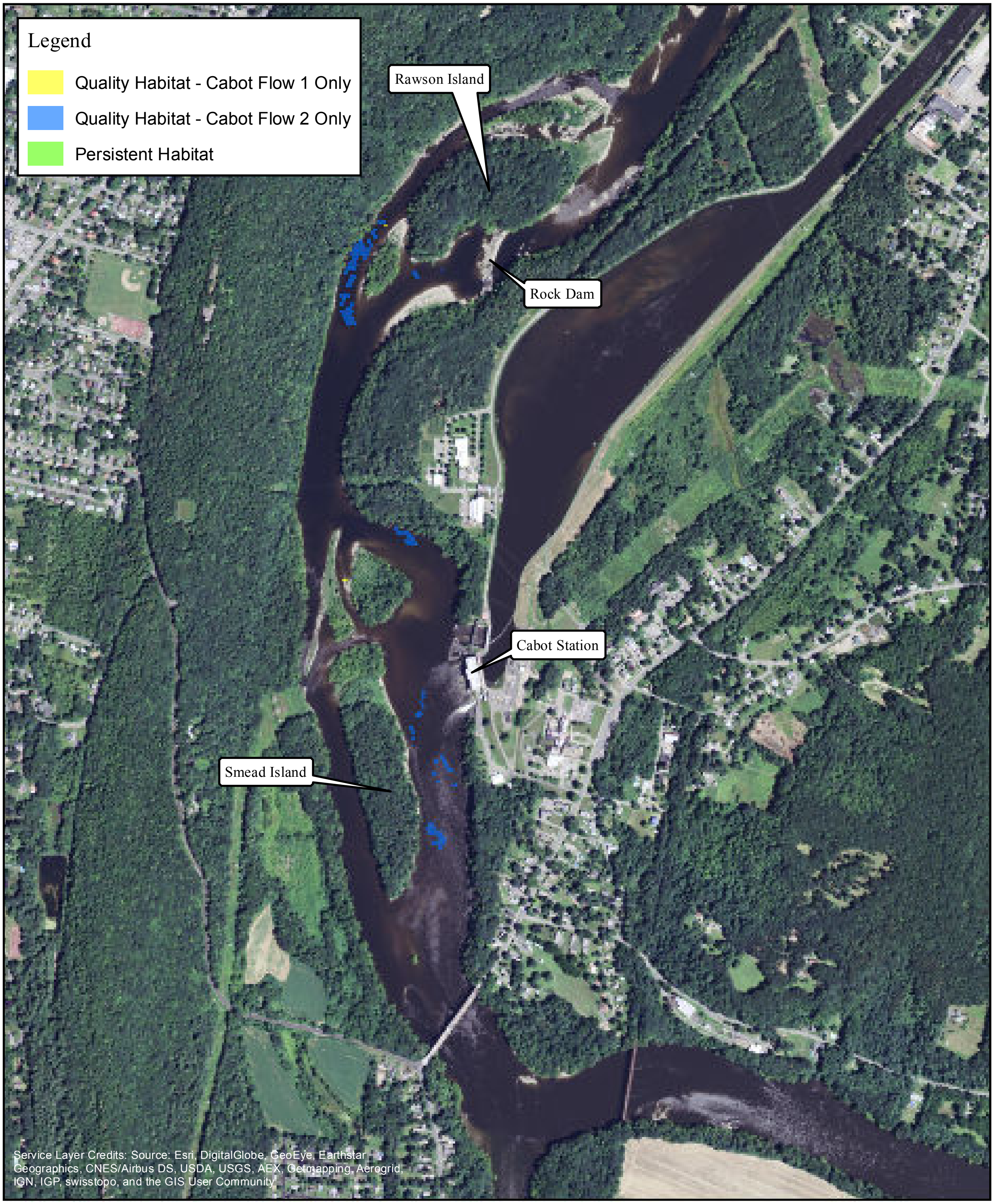
FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
White Sucker Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

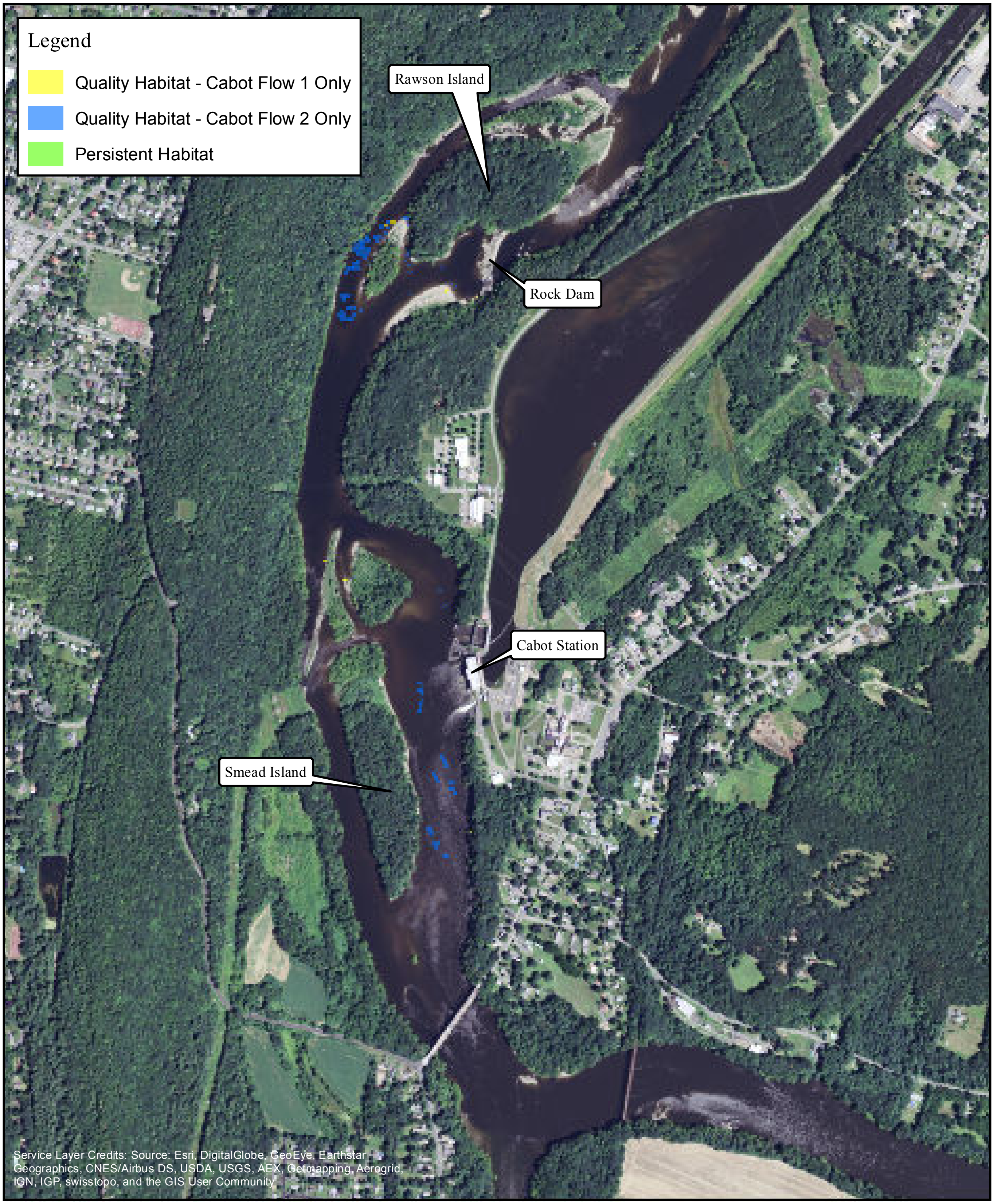
RELICENSING STUDY 3.3.1

FirstLight Power Resources

Persistent Habitat
Species/Life Stage:
White Sucker Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

N

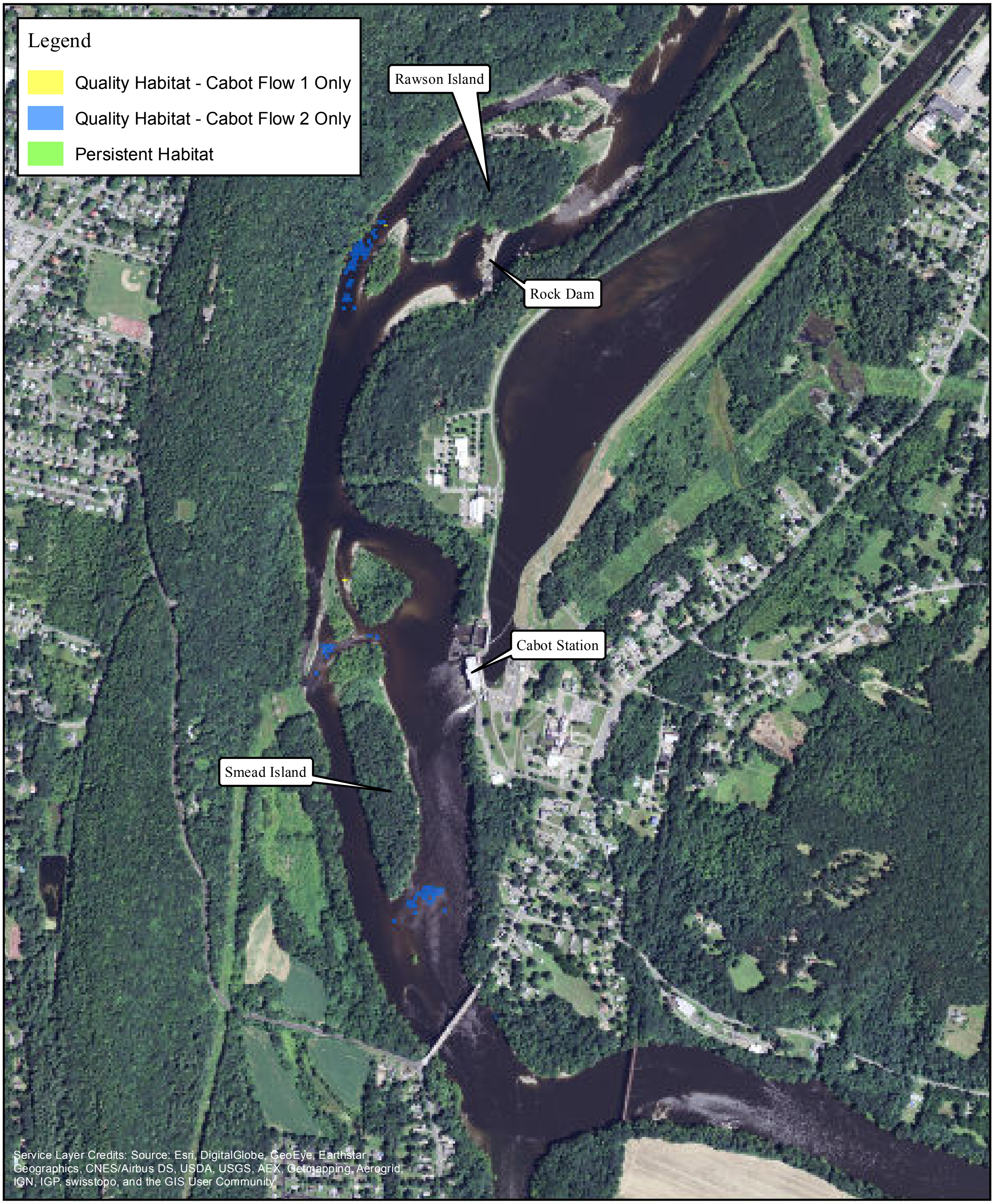
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Spawning
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

N

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

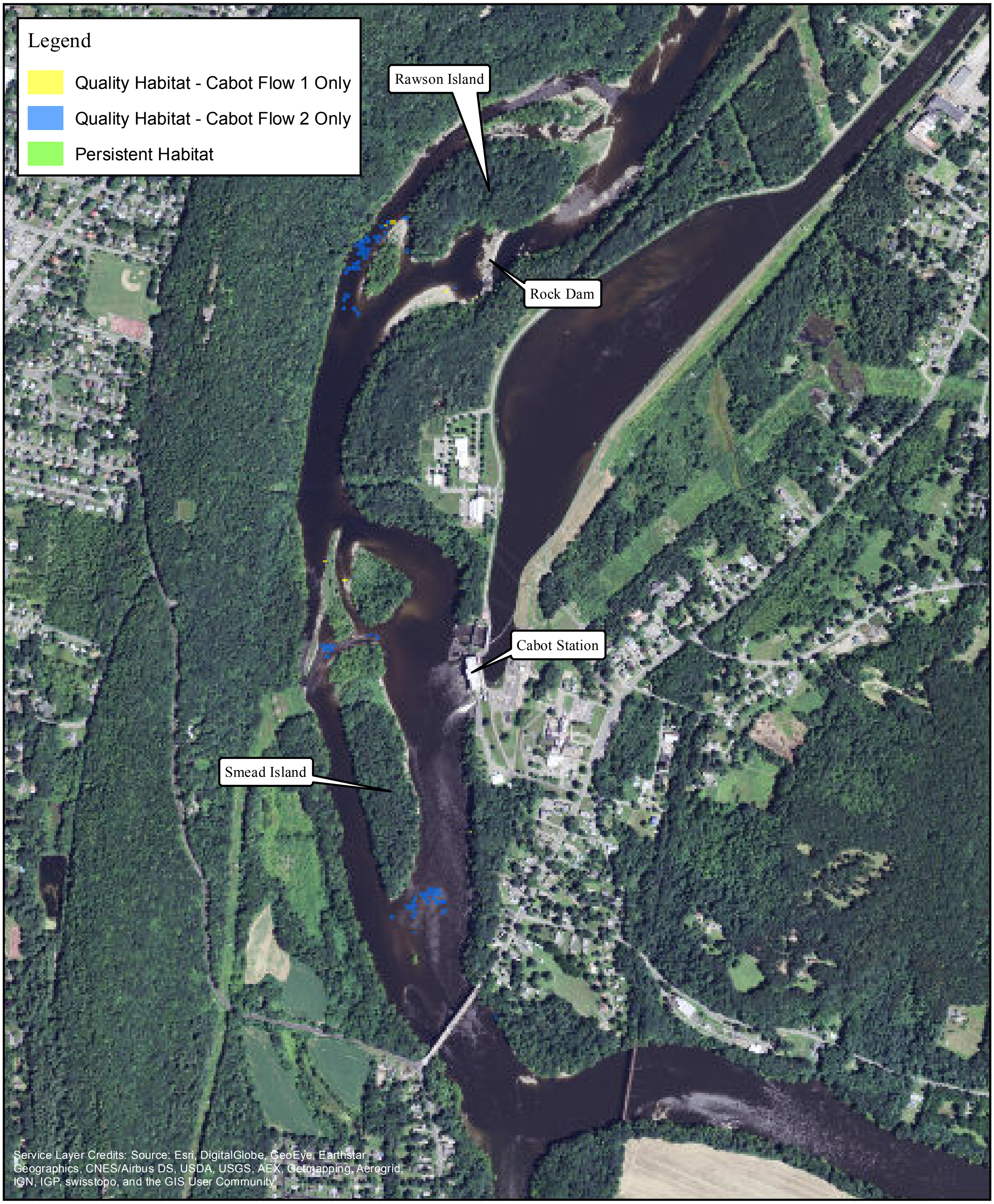
RELICENSING STUDY 3.3.1

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Spawning

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

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

RELICENSING STUDY 3.3.1

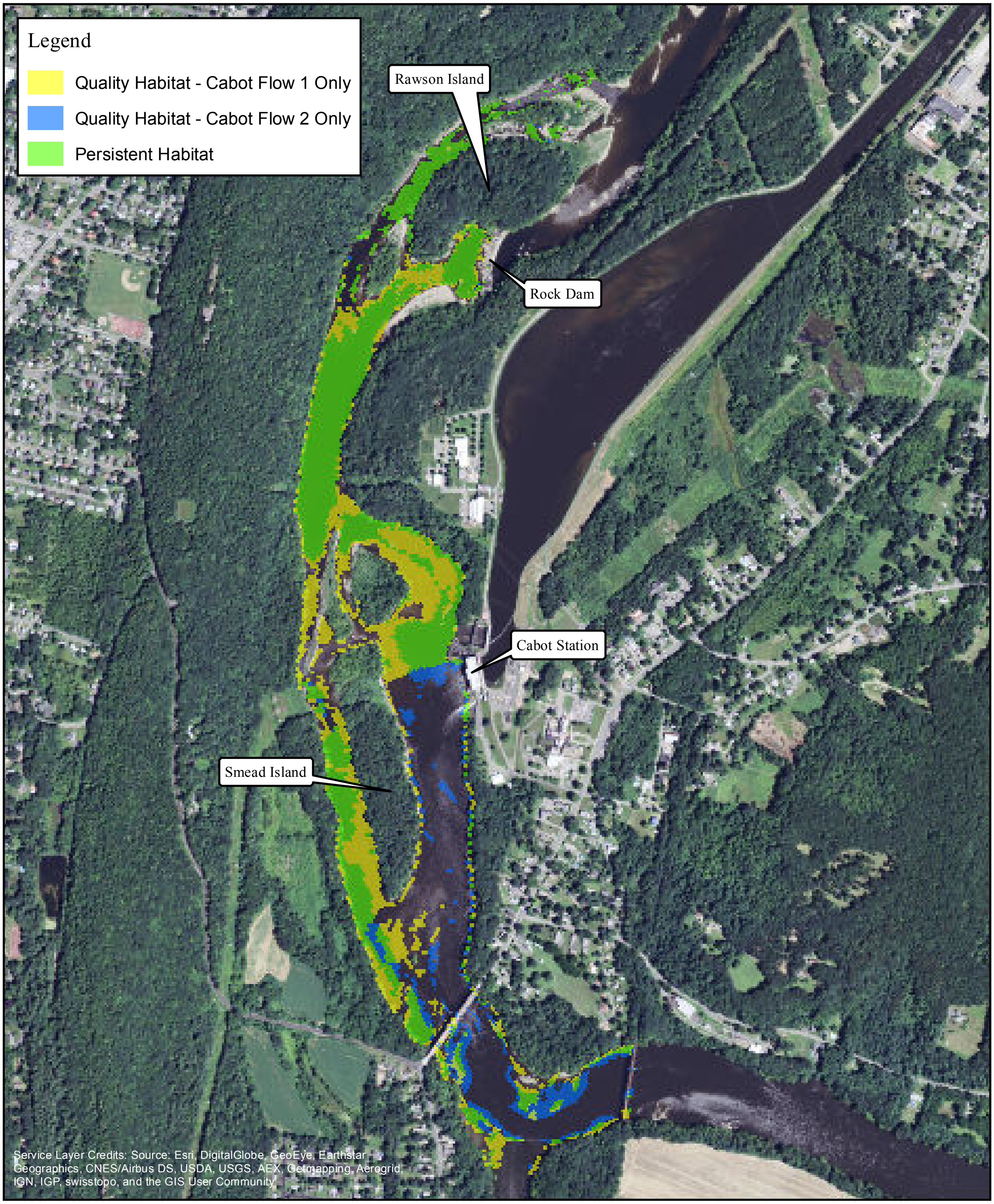
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Spawning

Bypass Flow:	500	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



FirstLight Power Resources

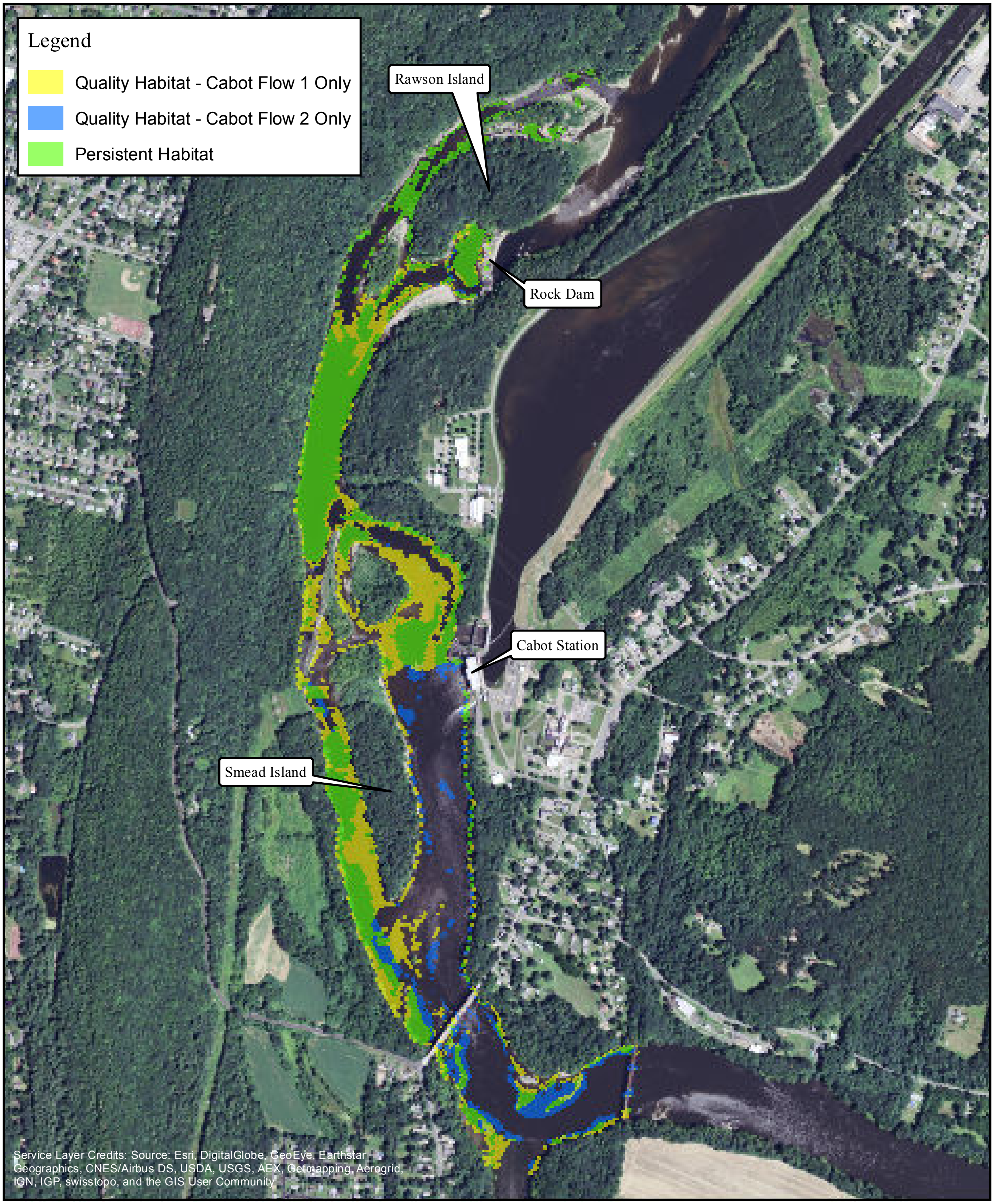
FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Persistent Habitat
Species/Life Stage:
White Sucker Fry

Bypass Flow:	200 cfs
Cabot Flow 1:	2500 cfs
Cabot Flow 2:	7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

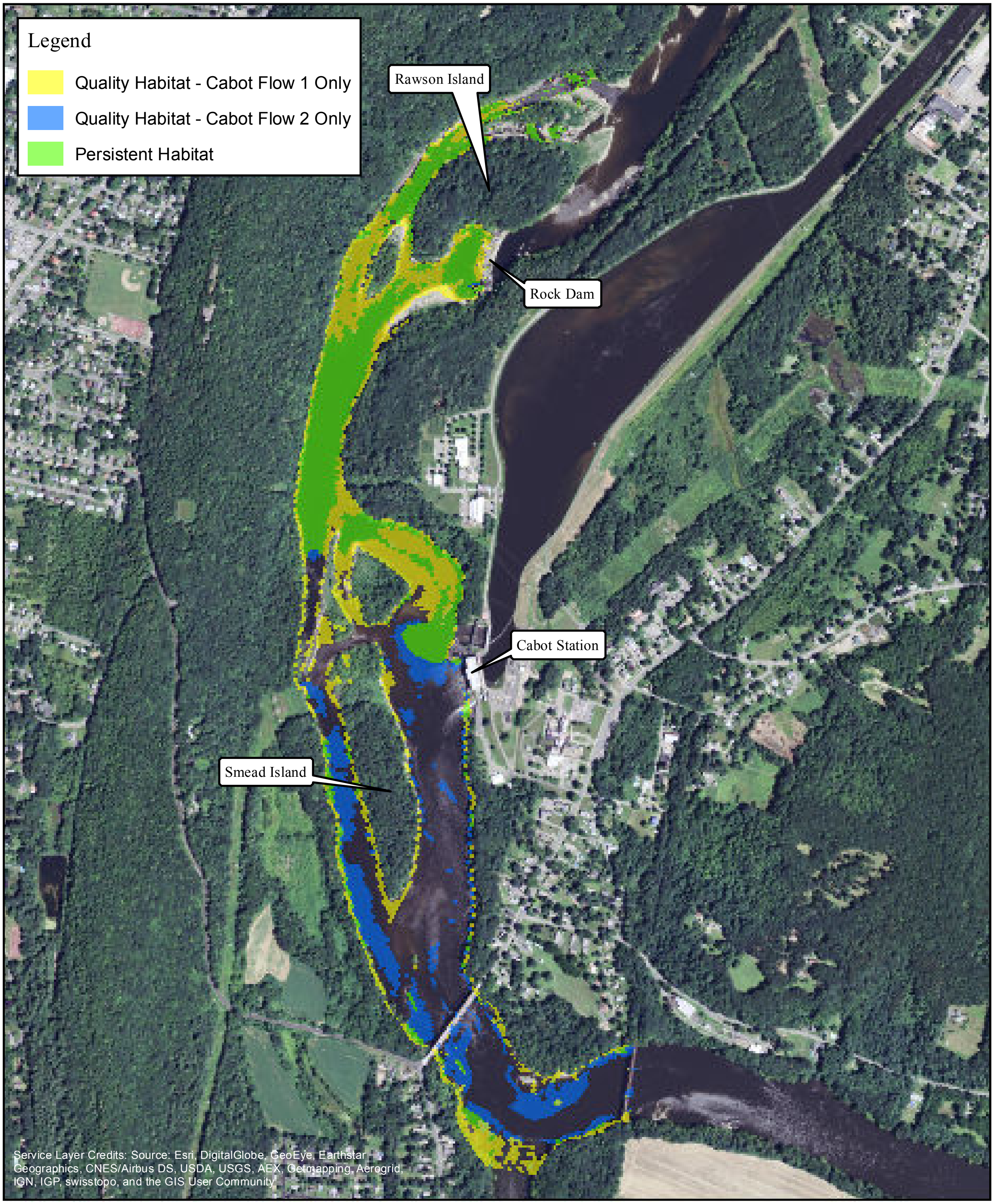
N

0 500 1,000 2,000
Feet

Persistent Habitat
Species/Life Stage:
White Sucker Fry

Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 7000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

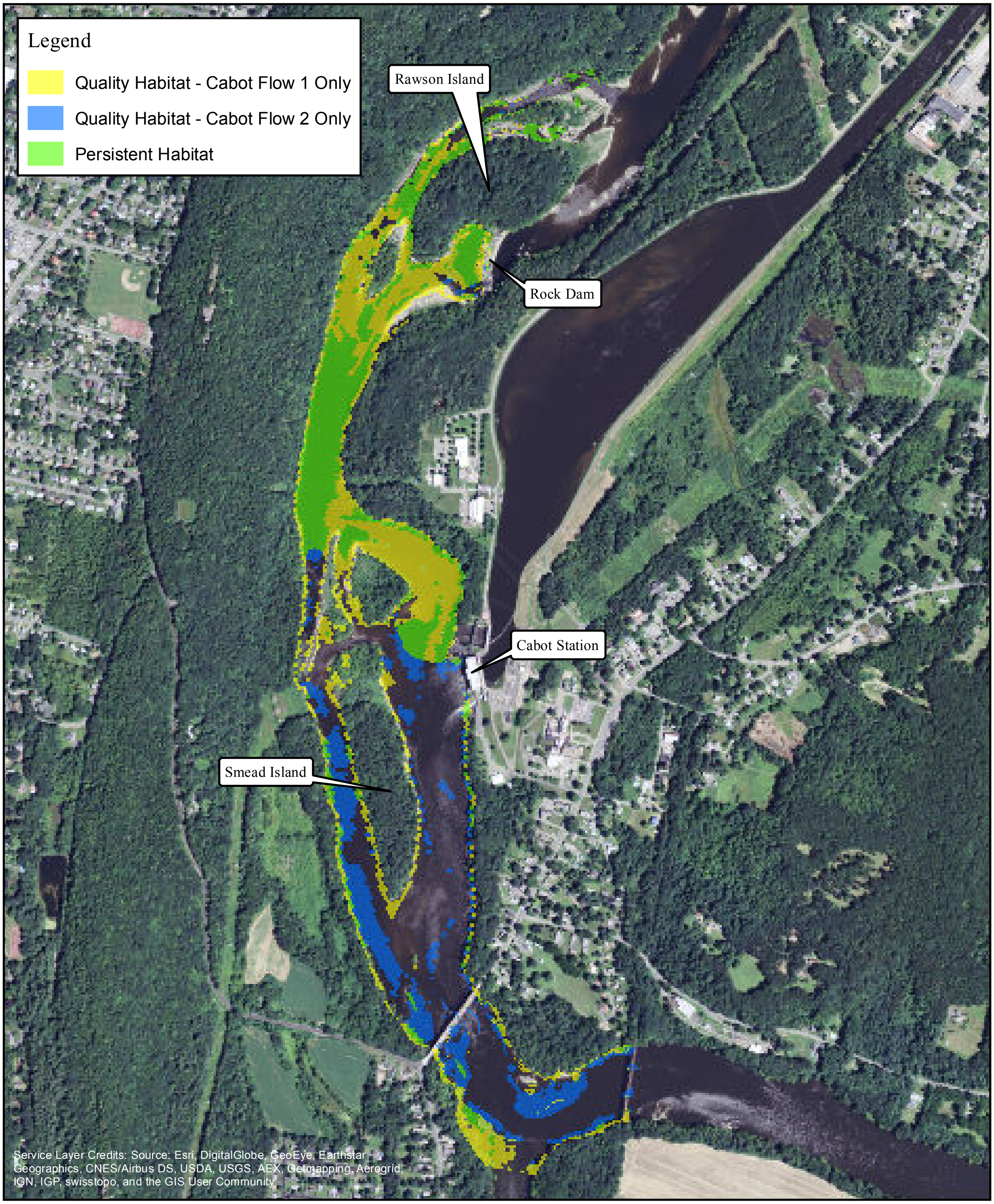
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Fry

Bypass Flow:	200	cfs
Cabot Flow 1:	2500	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

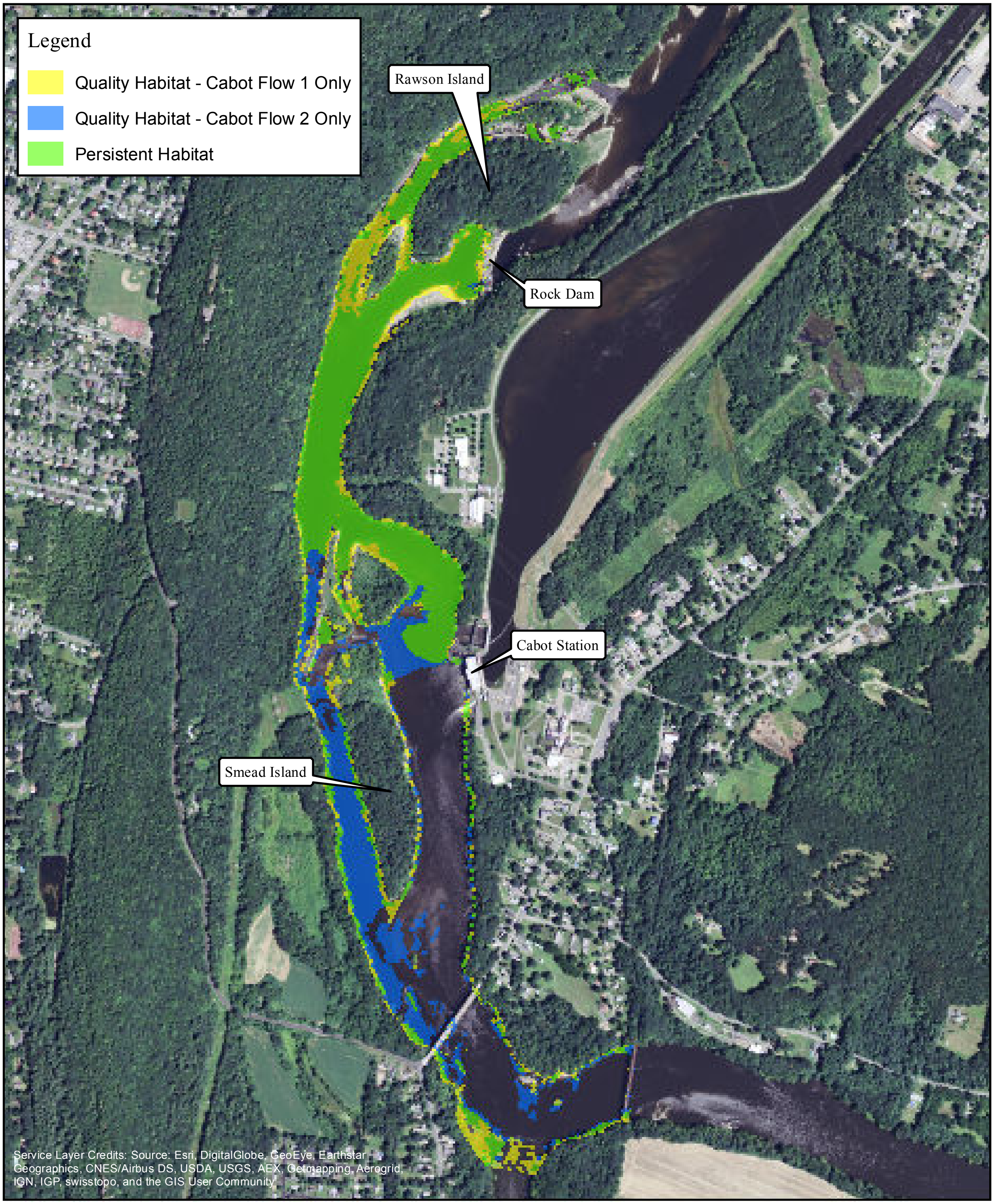
FirstLight Power Resources

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Fry
Bypass Flow: 500 cfs
Cabot Flow 1: 2500 cfs
Cabot Flow 2: 14000 cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

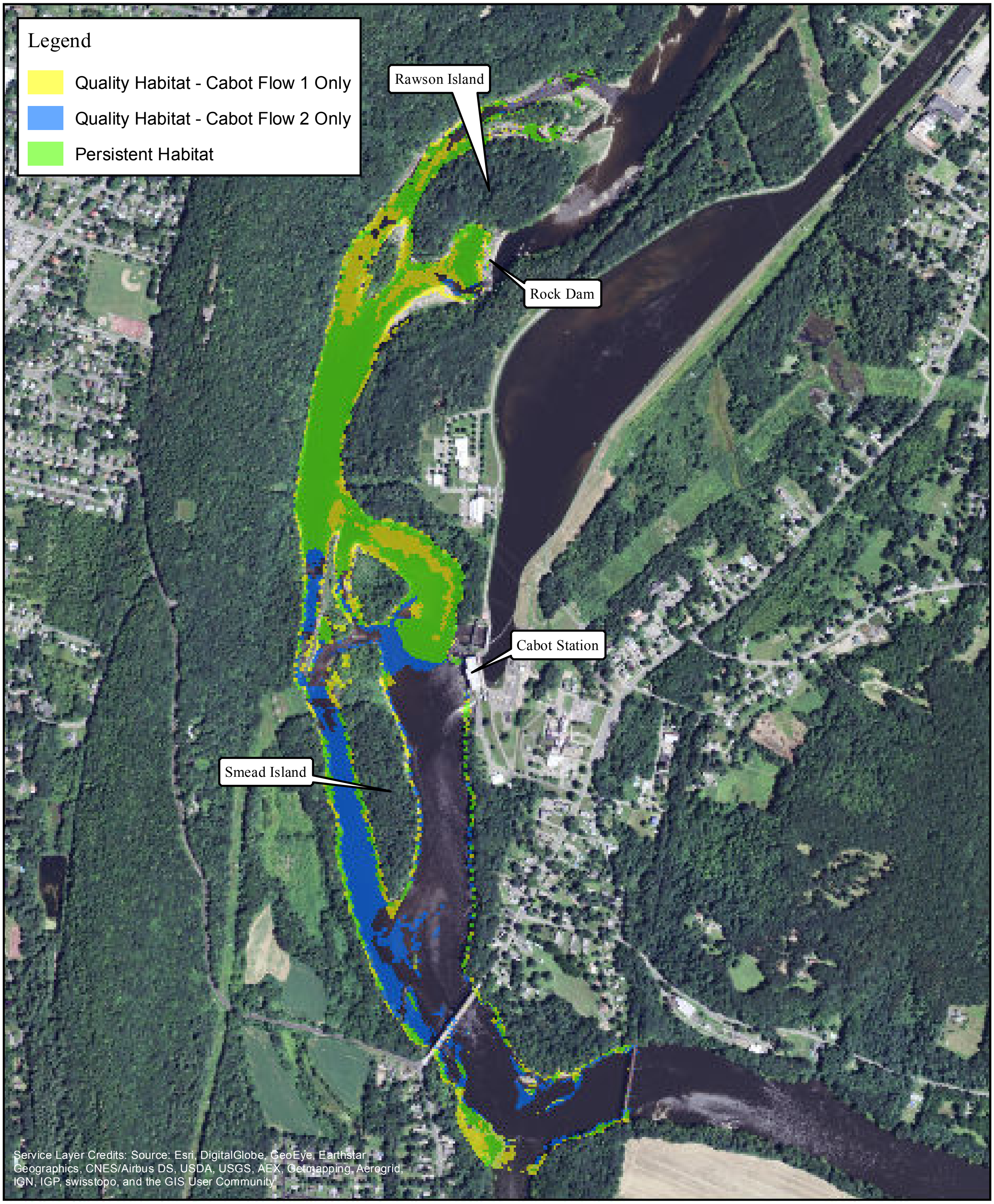
N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Fry

Bypass Flow:	200	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd



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

RELICENSING STUDY 3.3.1

FirstLight Power Resources

N

0 500 1,000 2,000 Feet

Persistent Habitat
Species/Life Stage:
White Sucker Fry

Bypass Flow:	500	cfs
Cabot Flow 1:	7000	cfs
Cabot Flow 2:	14000	cfs

Path: W:\gis\studies\3_3_1\maps\persistent_habitat_10-13-2016.mxd

APPENDIX H - REACH 3 HABITAT PERSISTENCE TABLES

Table H-1: Reach 3 American Shad Spawning Persistent Habitat (ft²), Bypass Q = 200 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	402,710	402,710	391,085	366,267	342,337	328,681	317,450	300,635	286,144	262,375	252,885	245,326	238,897	235,630	215,779	189,269
1,500		402,710	391,085	366,267	342,337	328,681	317,450	300,635	286,144	262,375	252,885	245,326	238,897	235,630	215,779	189,269
2,000			467,073	438,368	411,399	396,349	383,114	366,019	347,681	321,590	310,304	299,644	292,470	288,582	263,482	232,874
2,500				498,959	466,101	449,261	434,515	415,242	395,443	368,364	357,011	345,780	337,719	331,245	301,926	267,736
3,000					539,166	515,940	497,938	474,630	452,818	421,502	409,643	397,989	388,129	381,213	347,552	309,835
3,500						570,321	546,953	521,809	497,431	461,753	445,087	429,845	417,918	410,782	373,498	333,282
4,000							591,667	565,435	538,048	499,813	480,791	463,143	448,094	439,979	400,655	357,962
4,500								607,500	577,757	532,171	510,720	491,776	474,616	465,349	423,185	380,278
5,000									629,243	578,684	552,479	528,542	507,403	495,872	448,960	403,963
6,000										638,206	606,844	578,282	550,201	536,519	485,178	437,831
7,000											671,194	635,165	603,155	588,070	532,518	481,381
8,000												751,422	714,934	698,371	637,667	584,523
9,000													886,977	867,906	804,111	745,299
10,000														1,046,062	977,602	912,108
12,000															1,325,422	1,249,352
14,000																1,536,540

Table H-2: Reach 3 American Shad Spawning Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	26.2%	26.2%	25.5%	23.8%	22.3%	21.4%	20.7%	19.6%	18.6%	17.1%	16.5%	16.0%	15.5%	15.3%	14.0%	12.3%
1,500		26.2%	25.5%	23.8%	22.3%	21.4%	20.7%	19.6%	18.6%	17.1%	16.5%	16.0%	15.5%	15.3%	14.0%	12.3%
2,000			30.4%	28.5%	26.8%	25.8%	24.9%	23.8%	22.6%	20.9%	20.2%	19.5%	19.0%	18.8%	17.1%	15.2%
2,500				32.5%	30.3%	29.2%	28.3%	27.0%	25.7%	24.0%	23.2%	22.5%	22.0%	21.6%	19.6%	17.4%
3,000					35.1%	33.6%	32.4%	30.9%	29.5%	27.4%	26.7%	25.9%	25.3%	24.8%	22.6%	20.2%
3,500						37.1%	35.6%	34.0%	32.4%	30.1%	29.0%	28.0%	27.2%	26.7%	24.3%	21.7%
4,000							38.5%	36.8%	35.0%	32.5%	31.3%	30.1%	29.2%	28.6%	26.1%	23.3%
4,500								39.5%	37.6%	34.6%	33.2%	32.0%	30.9%	30.3%	27.5%	24.7%
5,000									41.0%	37.7%	36.0%	34.4%	33.0%	32.3%	29.2%	26.3%
6,000										41.5%	39.5%	37.6%	35.8%	34.9%	31.6%	28.5%
7,000											43.7%	41.3%	39.3%	38.3%	34.7%	31.3%
8,000												48.9%	46.5%	45.5%	41.5%	38.0%
9,000													57.7%	56.5%	52.3%	48.5%
10,000														68.1%	63.6%	59.4%
12,000															86.3%	81.3%
14,000																100.0%

Table H-3: Reach 3 American Shad Spawning Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	607,830	607,830	590,077	564,742	541,798	531,403	513,351	499,493	483,078	456,534	442,679	417,101	389,081	356,960	308,203	269,057
1,500		607,830	590,077	564,742	541,798	531,403	513,351	499,493	483,078	456,534	442,679	417,101	389,081	356,960	308,203	269,057
2,000			654,442	625,862	598,571	586,785	567,429	552,062	534,440	506,021	490,120	463,190	434,673	400,129	347,848	305,551
2,500				694,585	664,154	651,495	628,801	610,314	590,243	557,666	541,432	512,846	482,840	443,207	387,136	341,177
3,000					715,590	701,398	675,415	656,378	635,552	601,313	581,829	550,648	517,683	475,598	415,760	366,251
3,500						757,190	727,238	706,575	681,672	644,636	619,797	584,218	549,633	503,564	440,041	388,470
4,000							779,539	757,696	732,127	689,854	663,003	623,736	586,138	530,202	465,656	413,462
4,500								811,091	780,538	734,296	704,248	662,044	617,752	553,760	488,832	435,443
5,000									838,886	786,407	751,103	702,661	653,273	581,147	513,936	457,567
6,000										859,783	815,811	759,828	697,842	622,373	549,400	489,547
7,000											919,274	852,006	778,532	697,887	616,294	550,688
8,000												992,322	912,245	829,052	744,304	673,643
9,000													1,097,026	1,008,332	920,476	846,128
10,000														1,213,042	1,119,829	1,037,919
12,000															1,443,273	1,350,959
14,000																1,566,015

Table H-4: Reach 3 American Shad Spawning Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	38.8%	38.8%	37.7%	36.1%	34.6%	33.9%	32.8%	31.9%	30.8%	29.2%	28.3%	26.6%	24.8%	22.8%	19.7%	17.2%
1,500		38.8%	37.7%	36.1%	34.6%	33.9%	32.8%	31.9%	30.8%	29.2%	28.3%	26.6%	24.8%	22.8%	19.7%	17.2%
2,000			41.8%	40.0%	38.2%	37.5%	36.2%	35.3%	34.1%	32.3%	31.3%	29.6%	27.8%	25.6%	22.2%	19.5%
2,500				44.4%	42.4%	41.6%	40.2%	39.0%	37.7%	35.6%	34.6%	32.7%	30.8%	28.3%	24.7%	21.8%
3,000					45.7%	44.8%	43.1%	41.9%	40.6%	38.4%	37.2%	35.2%	33.1%	30.4%	26.5%	23.4%
3,500						48.4%	46.4%	45.1%	43.5%	41.2%	39.6%	37.3%	35.1%	32.2%	28.1%	24.8%
4,000							49.8%	48.4%	46.8%	44.1%	42.3%	39.8%	37.4%	33.9%	29.7%	26.4%
4,500								51.8%	49.8%	46.9%	45.0%	42.3%	39.4%	35.4%	31.2%	27.8%
5,000									53.6%	50.2%	48.0%	44.9%	41.7%	37.1%	32.8%	29.2%
6,000										54.9%	52.1%	48.5%	44.6%	39.7%	35.1%	31.3%
7,000											58.7%	54.4%	49.7%	44.6%	39.4%	35.2%
8,000												63.4%	58.3%	52.9%	47.5%	43.0%
9,000													70.1%	64.4%	58.8%	54.0%
10,000														77.5%	71.5%	66.3%
12,000															92.2%	86.3%
14,000																100.0%

Table H-5: Reach 3 American Shad Spawning Persistent Habitat (ft^2), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	635,602	611,702	594,422	578,788	570,647	557,563	547,472	539,643	526,974	512,649	495,462	478,936	469,678	449,869	404,303	324,028
1,500		830,634	801,224	778,694	768,422	751,618	738,195	726,791	709,909	692,787	671,255	649,952	637,158	608,472	542,517	443,380
2,000			869,971	845,080	831,827	812,178	793,835	781,452	762,395	743,069	721,060	697,583	683,636	650,420	580,582	476,980
2,500				899,718	884,534	861,446	842,919	830,070	809,603	787,983	765,302	739,425	723,568	689,341	613,906	501,944
3,000					942,559	915,188	895,170	879,338	856,734	831,886	806,659	776,319	758,589	722,089	640,908	524,159
3,500						968,568	947,547	929,606	904,252	876,063	849,619	816,714	795,348	755,260	671,930	548,533
4,000							1,008,177	985,510	958,821	929,279	899,013	859,972	833,961	789,631	703,664	572,649
4,500								1,039,265	1,008,183	975,765	940,937	898,319	870,833	824,706	737,785	597,729
5,000									1,055,226	1,019,472	983,268	936,967	905,979	858,718	766,567	614,402
6,000										1,105,045	1,060,675	1,005,180	971,221	921,724	818,969	657,635
7,000											1,181,942	1,120,740	1,081,080	1,029,202	916,227	743,678
8,000												1,293,170	1,250,643	1,195,848	1,072,468	894,356
9,000													1,490,670	1,428,395	1,293,608	1,106,481
10,000														1,638,873	1,487,217	1,293,680
12,000															1,802,370	1,595,758
14,000																1,784,221

Table H-6: Reach 3 American Shad Spawning Persistent Habitat (% of maximum possible), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	35.3%	33.9%	33.0%	32.1%	31.7%	30.9%	30.4%	29.9%	29.2%	28.4%	27.5%	26.6%	26.1%	25.0%	22.4%	18.0%
1,500		46.1%	44.5%	43.2%	42.6%	41.7%	41.0%	40.3%	39.4%	38.4%	37.2%	36.1%	35.4%	33.8%	30.1%	24.6%
2,000			48.3%	46.9%	46.2%	45.1%	44.0%	43.4%	42.3%	41.2%	40.0%	38.7%	37.9%	36.1%	32.2%	26.5%
2,500				49.9%	49.1%	47.8%	46.8%	46.1%	44.9%	43.7%	42.5%	41.0%	40.1%	38.2%	34.1%	27.8%
3,000					52.3%	50.8%	49.7%	48.8%	47.5%	46.2%	44.8%	43.1%	42.1%	40.1%	35.6%	29.1%
3,500						53.7%	52.6%	51.6%	50.2%	48.6%	47.1%	45.3%	44.1%	41.9%	37.3%	30.4%
4,000							55.9%	54.7%	53.2%	51.6%	49.9%	47.7%	46.3%	43.8%	39.0%	31.8%
4,500								57.7%	55.9%	54.1%	52.2%	49.8%	48.3%	45.8%	40.9%	33.2%
5,000									58.5%	56.6%	54.6%	52.0%	50.3%	47.6%	42.5%	34.1%
6,000										61.3%	58.8%	55.8%	53.9%	51.1%	45.4%	36.5%
7,000											65.6%	62.2%	60.0%	57.1%	50.8%	41.3%
8,000												71.7%	69.4%	66.3%	59.5%	49.6%
9,000													82.7%	79.3%	71.8%	61.4%
10,000														90.9%	82.5%	71.8%
12,000															100.0%	88.5%
14,000																99.0%

Table H-7: Reach 3 American Shad Spawning Persistent Habitat (ft^2), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	1,321,919	1,266,747	1,248,536	1,236,001	1,228,960	1,218,092	1,209,080	1,199,337	1,194,142	1,180,095	1,173,447	1,155,741	1,136,141	1,111,116	1,058,366	994,752
1,500		1,423,658	1,398,265	1,377,013	1,364,410	1,349,027	1,335,373	1,323,224	1,312,942	1,289,738	1,279,916	1,257,042	1,232,977	1,205,045	1,146,130	1,076,222
2,000			1,466,788	1,436,727	1,419,451	1,402,926	1,389,272	1,373,265	1,361,976	1,336,289	1,324,236	1,298,392	1,273,350	1,243,474	1,183,338	1,112,042
2,500				1,500,959	1,481,134	1,461,736	1,443,865	1,426,127	1,413,889	1,383,331	1,368,719	1,342,354	1,316,999	1,287,124	1,224,952	1,151,475
3,000					1,543,628	1,521,370	1,501,553	1,482,454	1,469,074	1,436,229	1,420,245	1,393,847	1,366,540	1,335,344	1,270,821	1,196,384
3,500						1,581,161	1,556,980	1,536,235	1,521,711	1,485,633	1,467,061	1,440,440	1,413,133	1,380,964	1,314,806	1,238,364
4,000							1,608,003	1,583,422	1,568,059	1,529,798	1,509,899	1,481,746	1,453,484	1,421,106	1,352,656	1,274,885
4,500								1,703,084	1,682,115	1,641,286	1,620,021	1,589,826	1,559,301	1,525,915	1,456,088	1,376,509
5,000									1,763,983	1,716,562	1,692,059	1,661,638	1,629,111	1,595,489	1,524,502	1,443,077
6,000										1,861,446	1,835,025	1,801,556	1,766,255	1,730,144	1,656,868	1,569,797
7,000											2,050,476	2,012,643	1,972,913	1,936,218	1,858,052	1,763,664
8,000												2,208,617	2,164,476	2,127,066	2,041,457	1,939,080
9,000													2,351,007	2,308,754	2,217,216	2,107,891
10,000														2,458,457	2,363,319	2,248,922
12,000															2,539,580	2,417,358
14,000																2,590,676

Table H-8: Reach 3 American Shad Spawning Persistent Habitat (% of maximum possible), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	51.0%	48.9%	48.2%	47.7%	47.4%	47.0%	46.7%	46.3%	46.1%	45.6%	45.3%	44.6%	43.9%	42.9%	40.9%	38.4%
1,500		55.0%	54.0%	53.2%	52.7%	52.1%	51.5%	51.1%	50.7%	49.8%	49.4%	48.5%	47.6%	46.5%	44.2%	41.5%
2,000			56.6%	55.5%	54.8%	54.2%	53.6%	53.0%	52.6%	51.6%	51.1%	50.1%	49.2%	48.0%	45.7%	42.9%
2,500				57.9%	57.2%	56.4%	55.7%	55.0%	54.6%	53.4%	52.8%	51.8%	50.8%	49.7%	47.3%	44.4%
3,000					59.6%	58.7%	58.0%	57.2%	56.7%	55.4%	54.8%	53.8%	52.7%	51.5%	49.1%	46.2%
3,500						61.0%	60.1%	59.3%	58.7%	57.3%	56.6%	55.6%	54.5%	53.3%	50.8%	47.8%
4,000							62.1%	61.1%	60.5%	59.1%	58.3%	57.2%	56.1%	54.9%	52.2%	49.2%
4,500								65.7%	64.9%	63.4%	62.5%	61.4%	60.2%	58.9%	56.2%	53.1%
5,000									68.1%	66.3%	65.3%	64.1%	62.9%	61.6%	58.8%	55.7%
6,000										71.9%	70.8%	69.5%	68.2%	66.8%	64.0%	60.6%
7,000											79.1%	77.7%	76.2%	74.7%	71.7%	68.1%
8,000												85.3%	83.5%	82.1%	78.8%	74.8%
9,000													90.7%	89.1%	85.6%	81.4%
10,000														94.9%	91.2%	86.8%
12,000															98.0%	93.3%
14,000																100.0%

Table H-9: Reach 3 American Shad Spawning Persistent Habitat (ft^2), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	1,763,312	1,695,972	1,683,939	1,673,437	1,665,037	1,657,614	1,646,098	1,637,687	1,632,593	1,606,360	1,590,003	1,564,188	1,536,357	1,501,403	1,458,478	1,401,639
1,500		1,865,330	1,847,673	1,832,400	1,821,754	1,809,025	1,792,319	1,774,348	1,766,715	1,734,953	1,715,527	1,688,693	1,657,612	1,619,773	1,571,736	1,508,498
2,000			1,922,087	1,901,161	1,887,856	1,874,807	1,857,914	1,838,724	1,831,091	1,798,201	1,777,152	1,749,924	1,717,515	1,679,676	1,629,337	1,565,348
2,500				1,988,201	1,971,947	1,956,847	1,938,631	1,918,482	1,910,849	1,875,967	1,853,275	1,825,091	1,791,342	1,751,314	1,700,444	1,635,401
3,000					2,051,991	2,033,920	2,015,082	1,992,884	1,984,857	1,947,828	1,923,080	1,893,701	1,859,879	1,819,584	1,768,495	1,703,052
3,500						2,129,868	2,108,428	2,085,415	2,075,925	2,038,623	2,012,714	1,982,396	1,948,540	1,906,924	1,855,024	1,788,020
4,000							2,185,912	2,159,412	2,149,651	2,112,072	2,084,871	2,053,761	2,019,554	1,973,862	1,918,364	1,850,680
4,500								2,263,481	2,251,143	2,210,623	2,182,147	2,150,507	2,115,136	2,069,219	2,013,355	1,945,399
5,000									2,360,195	2,317,084	2,284,374	2,251,882	2,216,101	2,168,435	2,110,152	2,040,487
6,000										2,480,033	2,443,442	2,408,532	2,371,246	2,318,474	2,258,812	2,187,200
7,000											2,590,142	2,552,162	2,512,360	2,456,821	2,394,793	2,319,706
8,000												2,686,669	2,642,669	2,584,273	2,519,046	2,443,693
9,000													2,740,472	2,676,635	2,607,702	2,531,488
10,000														2,760,445	2,688,646	2,611,150
12,000															2,834,114	2,750,871
14,000																2,854,225

Table H-10: Reach 3 American Shad Spawning Persistent Habitat (% of maximum possible), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	61.8%	59.4%	59.0%	58.6%	58.3%	58.1%	57.7%	57.4%	57.2%	56.3%	55.7%	54.8%	53.8%	52.6%	51.1%	49.1%
1,500		65.4%	64.7%	64.2%	63.8%	63.4%	62.8%	62.2%	61.9%	60.8%	60.1%	59.2%	58.1%	56.8%	55.1%	52.9%
2,000			67.3%	66.6%	66.1%	65.7%	65.1%	64.4%	64.2%	63.0%	62.3%	61.3%	60.2%	58.8%	57.1%	54.8%
2,500				69.7%	69.1%	68.6%	67.9%	67.2%	66.9%	65.7%	64.9%	63.9%	62.8%	61.4%	59.6%	57.3%
3,000					71.9%	71.3%	70.6%	69.8%	69.5%	68.2%	67.4%	66.3%	65.2%	63.8%	62.0%	59.7%
3,500						74.6%	73.9%	73.1%	72.7%	71.4%	70.5%	69.5%	68.3%	66.8%	65.0%	62.6%
4,000							76.6%	75.7%	75.3%	74.0%	73.0%	72.0%	70.8%	69.2%	67.2%	64.8%
4,500								79.3%	78.9%	77.5%	76.5%	75.3%	74.1%	72.5%	70.5%	68.2%
5,000									82.7%	81.2%	80.0%	78.9%	77.6%	76.0%	73.9%	71.5%
6,000										86.9%	85.6%	84.4%	83.1%	81.2%	79.1%	76.6%
7,000											90.7%	89.4%	88.0%	86.1%	83.9%	81.3%
8,000												94.1%	92.6%	90.5%	88.3%	85.6%
9,000													96.0%	93.8%	91.4%	88.7%
10,000														96.7%	94.2%	91.5%
12,000															99.3%	96.4%
14,000																100.0%

Table H-11: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (ft^2), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	321,914	321,914	312,685	290,123	273,204	265,637	247,862	236,152	217,073	202,313	195,715	188,540	176,828	172,615	160,086	144,940
1,500		321,914	312,685	290,123	273,204	265,637	247,862	236,152	217,073	202,313	195,715	188,540	176,828	172,615	160,086	144,940
2,000			356,869	329,952	310,799	300,976	281,094	268,182	248,083	231,459	223,979	216,437	204,352	199,207	184,380	167,196
2,500				367,420	346,451	335,540	311,161	293,737	269,093	251,508	241,980	233,657	220,374	215,229	199,722	181,616
3,000					395,313	379,948	346,050	325,462	297,205	275,546	265,934	253,633	239,250	234,105	218,153	198,592
3,500						408,185	371,230	348,369	316,042	293,827	282,114	268,545	253,186	247,091	230,964	210,913
4,000							385,559	360,987	327,436	304,947	292,755	276,942	261,156	254,708	238,485	217,883
4,500								373,432	337,744	314,472	302,060	285,377	268,277	261,828	245,353	224,400
5,000									350,928	326,402	313,098	295,704	276,551	270,102	250,950	229,824
6,000										349,991	332,428	312,819	293,050	286,528	265,339	244,165
7,000											370,493	347,994	327,332	320,581	292,431	269,313
8,000												394,783	372,793	365,157	334,978	310,054
9,000													435,781	427,341	396,875	370,273
10,000														503,315	468,923	440,464
12,000															557,031	523,778
14,000																604,379

Table H-12: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	53.3%	53.3%	51.7%	48.0%	45.2%	44.0%	41.0%	39.1%	35.9%	33.5%	32.4%	31.2%	29.3%	28.6%	26.5%	24.0%
1,500		53.3%	51.7%	48.0%	45.2%	44.0%	41.0%	39.1%	35.9%	33.5%	32.4%	31.2%	29.3%	28.6%	26.5%	24.0%
2,000			59.0%	54.6%	51.4%	49.8%	46.5%	44.4%	41.0%	38.3%	37.1%	35.8%	33.8%	33.0%	30.5%	27.7%
2,500				60.8%	57.3%	55.5%	51.5%	48.6%	44.5%	41.6%	40.0%	38.7%	36.5%	35.6%	33.0%	30.1%
3,000					65.4%	62.9%	57.3%	53.9%	49.2%	45.6%	44.0%	42.0%	39.6%	38.7%	36.1%	32.9%
3,500						67.5%	61.4%	57.6%	52.3%	48.6%	46.7%	44.4%	41.9%	40.9%	38.2%	34.9%
4,000							63.8%	59.7%	54.2%	50.5%	48.4%	45.8%	43.2%	42.1%	39.5%	36.1%
4,500								61.8%	55.9%	52.0%	50.0%	47.2%	44.4%	43.3%	40.6%	37.1%
5,000									58.1%	54.0%	51.8%	48.9%	45.8%	44.7%	41.5%	38.0%
6,000										57.9%	55.0%	51.8%	48.5%	47.4%	43.9%	40.4%
7,000											61.3%	57.6%	54.2%	53.0%	48.4%	44.6%
8,000												65.3%	61.7%	60.4%	55.4%	51.3%
9,000													72.1%	70.7%	65.7%	61.3%
10,000														83.3%	77.6%	72.9%
12,000															92.2%	86.7%
14,000																100.0%

Table H-13: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	506,868	506,868	487,488	468,504	452,263	437,040	427,135	408,344	394,276	369,494	353,725	325,005	282,256	260,066	241,234	211,927
1,500		506,868	487,488	468,504	452,263	437,040	427,135	408,344	394,276	369,494	353,725	325,005	282,256	260,066	241,234	211,927
2,000			519,203	496,896	479,812	463,773	453,200	433,481	418,304	391,346	375,262	342,053	296,513	273,751	254,319	224,254
2,500				538,857	520,618	502,597	489,441	468,605	451,454	424,246	404,789	367,687	315,270	292,294	272,170	241,111
3,000					561,657	542,179	525,925	504,710	486,403	455,769	433,285	389,732	331,474	308,240	288,116	255,273
3,500						568,783	551,620	530,100	511,577	478,533	453,734	402,143	338,953	315,539	295,182	261,446
4,000							570,544	548,348	528,998	495,330	469,596	414,959	348,313	324,580	303,897	269,397
4,500								562,224	541,470	506,297	479,538	424,189	355,455	330,905	308,645	273,832
5,000									561,596	524,083	496,453	437,481	366,996	341,546	316,680	281,217
6,000										561,195	531,668	468,536	394,722	364,592	334,954	296,466
7,000											572,547	505,051	427,099	395,852	363,023	320,628
8,000												557,351	477,535	444,370	410,384	365,593
9,000													561,853	526,727	489,730	441,481
10,000														603,582	565,106	514,735
12,000															640,797	582,729
14,000																662,256

Table H-14: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	76.5%	76.5%	73.6%	70.7%	68.3%	66.0%	64.5%	61.7%	59.5%	55.8%	53.4%	49.1%	42.6%	39.3%	36.4%	32.0%
1,500		76.5%	73.6%	70.7%	68.3%	66.0%	64.5%	61.7%	59.5%	55.8%	53.4%	49.1%	42.6%	39.3%	36.4%	32.0%
2,000			78.4%	75.0%	72.5%	70.0%	68.4%	65.5%	63.2%	59.1%	56.7%	51.6%	44.8%	41.3%	38.4%	33.9%
2,500				81.4%	78.6%	75.9%	73.9%	70.8%	68.2%	64.1%	61.1%	55.5%	47.6%	44.1%	41.1%	36.4%
3,000					84.8%	81.9%	79.4%	76.2%	73.4%	68.8%	65.4%	58.8%	50.1%	46.5%	43.5%	38.5%
3,500						85.9%	83.3%	80.0%	77.2%	72.3%	68.5%	60.7%	51.2%	47.6%	44.6%	39.5%
4,000							86.2%	82.8%	79.9%	74.8%	70.9%	62.7%	52.6%	49.0%	45.9%	40.7%
4,500								84.9%	81.8%	76.5%	72.4%	64.1%	53.7%	50.0%	46.6%	41.3%
5,000									84.8%	79.1%	75.0%	66.1%	55.4%	51.6%	47.8%	42.5%
6,000										84.7%	80.3%	70.7%	59.6%	55.1%	50.6%	44.8%
7,000											86.5%	76.3%	64.5%	59.8%	54.8%	48.4%
8,000												84.2%	72.1%	67.1%	62.0%	55.2%
9,000													84.8%	79.5%	73.9%	66.7%
10,000														91.1%	85.3%	77.7%
12,000															96.8%	88.0%
14,000																100.0%

Table H-15: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (ft^2), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	545,714	520,450	505,147	493,285	484,378	474,079	463,722	453,699	449,614	436,943	424,391	404,919	384,027	365,722	271,858	238,673
1,500		678,071	658,724	645,326	634,808	622,302	608,864	595,695	589,607	574,731	559,572	533,407	504,717	480,186	367,515	325,501
2,000			695,357	680,951	667,227	650,560	636,738	621,502	613,940	597,774	581,239	552,836	523,774	497,676	382,216	339,061
2,500				712,559	696,245	677,228	662,739	646,522	638,359	619,842	600,259	571,052	540,849	514,305	394,222	349,269
3,000					714,478	693,029	678,540	662,117	652,949	634,433	612,695	582,129	551,925	524,505	399,595	353,277
3,500						711,065	694,891	677,631	666,571	647,196	625,141	592,871	562,463	534,102	407,294	359,674
4,000							711,599	692,089	680,675	661,300	638,986	605,551	575,085	546,725	417,194	367,500
4,500								708,886	695,201	674,984	652,131	617,536	587,027	556,513	425,416	373,994
5,000									716,973	694,892	670,918	635,354	603,673	572,543	436,808	382,063
6,000										744,827	717,096	680,050	647,080	611,413	462,740	404,210
7,000											779,398	739,642	705,956	666,739	506,942	444,352
8,000												818,814	782,154	732,206	565,449	498,617
9,000													872,579	818,525	647,463	576,079
10,000														875,793	701,085	626,361
12,000															774,789	695,809
14,000																781,836

Table H-16: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (% of maximum possible), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	62.3%	59.4%	57.7%	56.3%	55.3%	54.1%	52.9%	51.8%	51.3%	49.9%	48.5%	46.2%	43.8%	41.8%	31.0%	27.3%
1,500		77.4%	75.2%	73.7%	72.5%	71.1%	69.5%	68.0%	67.3%	65.6%	63.9%	60.9%	57.6%	54.8%	42.0%	37.2%
2,000			79.4%	77.8%	76.2%	74.3%	72.7%	71.0%	70.1%	68.3%	66.4%	63.1%	59.8%	56.8%	43.6%	38.7%
2,500				81.4%	79.5%	77.3%	75.7%	73.8%	72.9%	70.8%	68.5%	65.2%	61.8%	58.7%	45.0%	39.9%
3,000					81.6%	79.1%	77.5%	75.6%	74.6%	72.4%	70.0%	66.5%	63.0%	59.9%	45.6%	40.3%
3,500						81.2%	79.3%	77.4%	76.1%	73.9%	71.4%	67.7%	64.2%	61.0%	46.5%	41.1%
4,000							81.3%	79.0%	77.7%	75.5%	73.0%	69.1%	65.7%	62.4%	47.6%	42.0%
4,500								80.9%	79.4%	77.1%	74.5%	70.5%	67.0%	63.5%	48.6%	42.7%
5,000									81.9%	79.3%	76.6%	72.5%	68.9%	65.4%	49.9%	43.6%
6,000										85.0%	81.9%	77.6%	73.9%	69.8%	52.8%	46.2%
7,000											89.0%	84.5%	80.6%	76.1%	57.9%	50.7%
8,000												93.5%	89.3%	83.6%	64.6%	56.9%
9,000													99.6%	93.5%	73.9%	65.8%
10,000														100.0%	80.1%	71.5%
12,000															88.5%	79.4%
14,000																89.3%

Table H-17: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (ft^2), Bypass Q = 3,000 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	1,030,705	989,956	971,292	961,769	952,346	945,299	940,349	932,869	928,080	914,909	910,700	901,140	895,152	878,903	848,799	822,609
1,500		1,056,870	1,033,033	1,020,964	1,008,778	1,001,198	993,859	986,340	979,606	964,319	956,139	946,216	939,848	923,445	889,307	859,736
2,000			1,057,359	1,040,734	1,027,586	1,019,480	1,011,177	1,003,657	996,530	981,243	971,676	961,753	955,268	937,878	902,804	871,495
2,500				1,070,626	1,055,546	1,046,396	1,037,372	1,028,136	1,020,821	1,004,330	994,763	983,817	976,270	957,944	922,687	888,273
3,000					1,075,684	1,064,076	1,054,075	1,044,497	1,036,265	1,018,970	1,009,403	998,370	990,824	972,498	936,924	900,757
3,500						1,096,289	1,083,893	1,074,014	1,065,611	1,048,096	1,038,339	1,026,274	1,014,822	996,402	960,038	921,375
4,000							1,111,746	1,101,250	1,092,548	1,073,831	1,063,489	1,050,816	1,039,334	1,020,915	984,177	944,580
4,500								1,158,458	1,147,060	1,126,530	1,115,629	1,102,523	1,088,939	1,070,451	1,029,097	988,836
5,000									1,171,982	1,149,093	1,137,654	1,124,156	1,110,023	1,091,501	1,049,956	1,007,098
6,000										1,202,949	1,189,354	1,174,694	1,160,167	1,140,875	1,097,617	1,052,802
7,000											1,245,769	1,227,754	1,211,352	1,191,144	1,145,586	1,098,414
8,000												1,259,105	1,239,213	1,218,762	1,172,453	1,123,863
9,000													1,291,531	1,269,230	1,219,202	1,167,466
10,000														1,313,174	1,260,173	1,207,214
12,000															1,328,473	1,272,279
14,000																1,340,093

Table H-18: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (% of maximum possible), Bypass Q = 3,000 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	76.9%	73.9%	72.5%	71.8%	71.1%	70.5%	70.2%	69.6%	69.3%	68.3%	68.0%	67.2%	66.8%	65.6%	63.3%	61.4%
1,500		78.9%	77.1%	76.2%	75.3%	74.7%	74.2%	73.6%	73.1%	72.0%	71.3%	70.6%	70.1%	68.9%	66.4%	64.2%
2,000			78.9%	77.7%	76.7%	76.1%	75.5%	74.9%	74.4%	73.2%	72.5%	71.8%	71.3%	70.0%	67.4%	65.0%
2,500				79.9%	78.8%	78.1%	77.4%	76.7%	76.2%	74.9%	74.2%	73.4%	72.9%	71.5%	68.9%	66.3%
3,000					80.3%	79.4%	78.7%	77.9%	77.3%	76.0%	75.3%	74.5%	73.9%	72.6%	69.9%	67.2%
3,500						81.8%	80.9%	80.1%	79.5%	78.2%	77.5%	76.6%	75.7%	74.4%	71.6%	68.8%
4,000							83.0%	82.2%	81.5%	80.1%	79.4%	78.4%	77.6%	76.2%	73.4%	70.5%
4,500								86.4%	85.6%	84.1%	83.3%	82.3%	81.3%	79.9%	76.8%	73.8%
5,000									87.5%	85.7%	84.9%	83.9%	82.8%	81.4%	78.3%	75.2%
6,000										89.8%	88.8%	87.7%	86.6%	85.1%	81.9%	78.6%
7,000											93.0%	91.6%	90.4%	88.9%	85.5%	82.0%
8,000												94.0%	92.5%	90.9%	87.5%	83.9%
9,000													96.4%	94.7%	91.0%	87.1%
10,000														98.0%	94.0%	90.1%
12,000															99.1%	94.9%
14,000																100.0%

Table H-19: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (ft^2), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	1,213,622	1,181,864	1,172,552	1,167,076	1,161,086	1,151,653	1,145,694	1,141,029	1,133,634	1,121,518	1,114,962	1,107,764	1,095,227	1,077,210	1,062,578	1,045,521
1,500		1,242,397	1,230,878	1,224,325	1,217,790	1,207,932	1,201,170	1,195,439	1,187,895	1,175,705	1,164,908	1,155,961	1,142,822	1,122,613	1,105,965	1,085,708
2,000			1,267,495	1,258,395	1,249,933	1,240,075	1,232,737	1,226,805	1,219,053	1,205,905	1,193,768	1,183,681	1,170,542	1,150,190	1,131,966	1,109,879
2,500				1,291,849	1,282,247	1,271,919	1,263,538	1,257,606	1,249,414	1,235,813	1,223,444	1,211,477	1,196,344	1,174,803	1,156,162	1,133,313
3,000					1,309,774	1,296,707	1,287,930	1,281,998	1,273,339	1,259,738	1,247,015	1,235,048	1,219,915	1,198,331	1,176,969	1,152,039
3,500						1,319,602	1,308,825	1,302,469	1,292,667	1,279,066	1,266,343	1,254,375	1,238,916	1,217,033	1,194,569	1,168,412
4,000							1,336,026	1,327,582	1,316,746	1,301,621	1,288,114	1,275,685	1,260,225	1,237,894	1,213,852	1,187,050
4,500								1,361,880	1,350,014	1,333,410	1,319,322	1,306,786	1,290,928	1,267,306	1,242,314	1,214,995
5,000									1,386,034	1,368,057	1,350,253	1,337,457	1,321,554	1,296,888	1,269,606	1,242,078
6,000										1,405,665	1,385,323	1,371,641	1,355,124	1,329,538	1,302,190	1,274,610
7,000											1,433,310	1,414,928	1,396,894	1,369,422	1,339,954	1,311,645
8,000												1,454,976	1,434,187	1,405,382	1,374,856	1,345,800
9,000													1,469,795	1,437,620	1,404,685	1,374,958
10,000														1,467,744	1,432,100	1,400,605
12,000															1,488,952	1,453,869
14,000																1,510,083

Table H-20: Reach 3 Shortnose Sturgeon Spawning Persistent Habitat (% of maximum possible), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	80.4%	78.3%	77.6%	77.3%	76.9%	76.3%	75.9%	75.6%	75.1%	74.3%	73.8%	73.4%	72.5%	71.3%	70.4%	69.2%
1,500		82.3%	81.5%	81.1%	80.6%	80.0%	79.5%	79.2%	78.7%	77.9%	77.1%	76.5%	75.7%	74.3%	73.2%	71.9%
2,000			83.9%	83.3%	82.8%	82.1%	81.6%	81.2%	80.7%	79.9%	79.1%	78.4%	77.5%	76.2%	75.0%	73.5%
2,500				85.5%	84.9%	84.2%	83.7%	83.3%	82.7%	81.8%	81.0%	80.2%	79.2%	77.8%	76.6%	75.0%
3,000					86.7%	85.9%	85.3%	84.9%	84.3%	83.4%	82.6%	81.8%	80.8%	79.4%	77.9%	76.3%
3,500						87.4%	86.7%	86.3%	85.6%	84.7%	83.9%	83.1%	82.0%	80.6%	79.1%	77.4%
4,000							88.5%	87.9%	87.2%	86.2%	85.3%	84.5%	83.5%	82.0%	80.4%	78.6%
4,500								90.2%	89.4%	88.3%	87.4%	86.5%	85.5%	83.9%	82.3%	80.5%
5,000									91.8%	90.6%	89.4%	88.6%	87.5%	85.9%	84.1%	82.3%
6,000										93.1%	91.7%	90.8%	89.7%	88.0%	86.2%	84.4%
7,000											94.9%	93.7%	92.5%	90.7%	88.7%	86.9%
8,000												96.4%	95.0%	93.1%	91.0%	89.1%
9,000													97.3%	95.2%	93.0%	91.1%
10,000														97.2%	94.8%	92.8%
12,000															98.6%	96.3%
14,000																100.0%

Table H-21: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (ft^2), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	958,124	958,124	940,045	920,101	898,190	884,268	862,905	847,092	829,082	795,234	781,238	762,095	570,137	542,614	519,090	468,542
1,500		958,124	940,045	920,101	898,190	884,268	862,905	847,092	829,082	795,234	781,238	762,095	570,137	542,614	519,090	468,542
2,000			964,030	941,636	919,211	905,061	882,602	866,571	848,561	813,749	797,493	776,156	581,814	554,291	530,721	479,779
2,500				961,923	937,904	922,906	898,976	881,952	863,942	829,104	812,848	791,230	591,237	563,714	539,106	488,090
3,000					970,525	948,468	920,776	901,996	883,286	847,512	830,821	808,767	600,259	572,735	547,818	496,207
3,500						969,005	938,430	919,134	899,612	863,090	845,435	822,541	610,542	581,893	554,125	502,455
4,000							965,545	943,003	921,601	884,806	866,920	843,104	624,038	595,296	564,585	511,558
4,500								981,231	955,892	917,487	899,084	874,785	642,612	613,504	577,871	523,873
5,000									1,013,074	973,262	954,174	929,594	673,735	644,627	608,994	551,712
6,000										1,121,448	1,101,636	1,075,321	801,675	772,226	736,545	676,747
7,000											1,212,172	1,176,611	890,580	860,294	823,388	762,670
8,000												1,246,796	949,251	918,965	881,408	818,839
9,000													997,341	965,094	925,215	862,297
10,000														1,014,571	969,695	905,865
12,000															1,238,767	1,143,364
14,000																1,255,401

Table H-22: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	76.3%	76.3%	74.9%	73.3%	71.5%	70.4%	68.7%	67.5%	66.0%	63.3%	62.2%	60.7%	45.4%	43.2%	41.3%	37.3%
1,500		76.3%	74.9%	73.3%	71.5%	70.4%	68.7%	67.5%	66.0%	63.3%	62.2%	60.7%	45.4%	43.2%	41.3%	37.3%
2,000			76.8%	75.0%	73.2%	72.1%	70.3%	69.0%	67.6%	64.8%	63.5%	61.8%	46.3%	44.2%	42.3%	38.2%
2,500				76.6%	74.7%	73.5%	71.6%	70.3%	68.8%	66.0%	64.7%	63.0%	47.1%	44.9%	42.9%	38.9%
3,000					77.3%	75.6%	73.3%	71.8%	70.4%	67.5%	66.2%	64.4%	47.8%	45.6%	43.6%	39.5%
3,500						77.2%	74.8%	73.2%	71.7%	68.8%	67.3%	65.5%	48.6%	46.4%	44.1%	40.0%
4,000							76.9%	75.1%	73.4%	70.5%	69.1%	67.2%	49.7%	47.4%	45.0%	40.7%
4,500								78.2%	76.1%	73.1%	71.6%	69.7%	51.2%	48.9%	46.0%	41.7%
5,000									80.7%	77.5%	76.0%	74.0%	53.7%	51.3%	48.5%	43.9%
6,000										89.3%	87.8%	85.7%	63.9%	61.5%	58.7%	53.9%
7,000											96.6%	93.7%	70.9%	68.5%	65.6%	60.8%
8,000												99.3%	75.6%	73.2%	70.2%	65.2%
9,000													79.4%	76.9%	73.7%	68.7%
10,000														80.8%	77.2%	72.2%
12,000															98.7%	91.1%
14,000																100.0%

Table H-23: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	1,098,561	1,098,561	1,081,826	1,064,172	1,047,218	1,022,924	1,007,538	989,001	974,380	958,649	946,920	933,593	919,332	904,877	838,246	798,893
1,500		1,098,561	1,081,826	1,064,172	1,047,218	1,022,924	1,007,538	989,001	974,380	958,649	946,920	933,593	919,332	904,877	838,246	798,893
2,000			1,101,069	1,079,875	1,062,896	1,038,261	1,020,883	1,002,346	986,761	970,244	958,459	943,955	927,885	913,431	846,800	806,087
2,500				1,094,668	1,076,703	1,050,930	1,033,187	1,014,470	998,885	982,089	970,162	955,658	939,363	924,635	856,234	813,611
3,000					1,105,315	1,076,542	1,056,419	1,037,702	1,022,117	1,004,407	990,849	976,345	957,108	942,380	871,690	827,106
3,500						1,095,936	1,074,937	1,055,999	1,040,311	1,022,023	1,008,439	993,733	974,496	958,184	886,360	837,994
4,000							1,111,729	1,091,333	1,075,323	1,056,876	1,043,132	1,027,109	1,007,718	991,406	910,539	856,217
4,500								1,138,898	1,121,913	1,102,093	1,088,167	1,071,559	1,051,240	1,034,065	945,999	878,460
5,000									1,168,593	1,147,159	1,132,514	1,115,906	1,093,576	1,076,399	987,051	916,100
6,000										1,279,247	1,262,290	1,244,493	1,221,669	1,203,504	1,108,446	1,035,151
7,000											1,364,924	1,343,745	1,319,588	1,300,017	1,203,090	1,129,314
8,000												1,412,323	1,385,388	1,365,118	1,266,761	1,191,313
9,000													1,432,803	1,408,877	1,307,881	1,231,770
10,000														1,462,904	1,355,187	1,278,539
12,000															1,425,336	1,347,646
14,000																1,441,985

Table H-24: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	75.1%	75.1%	74.0%	72.7%	71.6%	69.9%	68.9%	67.6%	66.6%	65.5%	64.7%	63.8%	62.8%	61.9%	57.3%	54.6%
1,500		75.1%	74.0%	72.7%	71.6%	69.9%	68.9%	67.6%	66.6%	65.5%	64.7%	63.8%	62.8%	61.9%	57.3%	54.6%
2,000			75.3%	73.8%	72.7%	71.0%	69.8%	68.5%	67.5%	66.3%	65.5%	64.5%	63.4%	62.4%	57.9%	55.1%
2,500				74.8%	73.6%	71.8%	70.6%	69.3%	68.3%	67.1%	66.3%	65.3%	64.2%	63.2%	58.5%	55.6%
3,000					75.6%	73.6%	72.2%	70.9%	69.9%	68.7%	67.7%	66.7%	65.4%	64.4%	59.6%	56.5%
3,500						74.9%	73.5%	72.2%	71.1%	69.9%	68.9%	67.9%	66.6%	65.5%	60.6%	57.3%
4,000							76.0%	74.6%	73.5%	72.2%	71.3%	70.2%	68.9%	67.8%	62.2%	58.5%
4,500								77.9%	76.7%	75.3%	74.4%	73.2%	71.9%	70.7%	64.7%	60.0%
5,000									79.9%	78.4%	77.4%	76.3%	74.8%	73.6%	67.5%	62.6%
6,000										87.4%	86.3%	85.1%	83.5%	82.3%	75.8%	70.8%
7,000											93.3%	91.9%	90.2%	88.9%	82.2%	77.2%
8,000												96.5%	94.7%	93.3%	86.6%	81.4%
9,000													97.9%	96.3%	89.4%	84.2%
10,000														100.0%	92.6%	87.4%
12,000															97.4%	92.1%
14,000																98.6%

Table H-25: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (ft²), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	1,205,216	1,177,940	1,160,917	1,148,299	1,134,899	1,123,801	1,111,125	1,099,852	1,092,496	1,083,345	1,076,751	1,065,582	1,056,533	1,044,215	1,015,336	966,105
1,500		1,262,194	1,243,938	1,229,001	1,205,907	1,188,868	1,174,475	1,160,289	1,152,698	1,139,753	1,128,841	1,114,702	1,105,653	1,093,335	1,063,806	1,008,708
2,000			1,263,595	1,248,142	1,223,633	1,204,168	1,189,595	1,175,192	1,167,602	1,154,514	1,143,602	1,129,291	1,119,857	1,107,410	1,076,826	1,020,350
2,500				1,270,450	1,245,540	1,225,795	1,211,221	1,196,643	1,187,959	1,174,739	1,162,903	1,146,601	1,136,216	1,121,825	1,090,967	1,033,517
3,000					1,269,969	1,249,351	1,234,213	1,219,532	1,210,845	1,197,446	1,184,876	1,168,574	1,157,387	1,141,882	1,110,931	1,052,979
3,500						1,287,040	1,271,346	1,255,642	1,246,449	1,232,213	1,218,536	1,201,977	1,190,403	1,173,696	1,136,946	1,078,047
4,000							1,315,996	1,300,128	1,290,530	1,276,114	1,262,437	1,245,872	1,234,299	1,216,025	1,177,332	1,117,282
4,500								1,353,262	1,343,550	1,328,777	1,313,536	1,295,785	1,283,605	1,265,113	1,226,249	1,161,250
5,000									1,386,626	1,370,774	1,354,934	1,337,183	1,324,449	1,305,911	1,266,838	1,197,609
6,000										1,442,795	1,426,536	1,408,785	1,395,628	1,376,872	1,337,799	1,265,690
7,000											1,484,143	1,465,069	1,451,731	1,432,725	1,393,445	1,320,031
8,000												1,516,072	1,501,592	1,480,809	1,440,970	1,366,648
9,000													1,549,494	1,526,636	1,485,616	1,411,117
10,000														1,579,368	1,533,946	1,459,082
12,000															1,602,496	1,524,355
14,000																1,574,330

Table H-26: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (% of maximum possible), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	75.2%	73.5%	72.4%	71.7%	70.8%	70.1%	69.3%	68.6%	68.2%	67.6%	67.2%	66.5%	65.9%	65.2%	63.4%	60.3%
1,500		78.8%	77.6%	76.7%	75.3%	74.2%	73.3%	72.4%	71.9%	71.1%	70.4%	69.6%	69.0%	68.2%	66.4%	62.9%
2,000			78.9%	77.9%	76.4%	75.1%	74.2%	73.3%	72.9%	72.0%	71.4%	70.5%	69.9%	69.1%	67.2%	63.7%
2,500				79.3%	77.7%	76.5%	75.6%	74.7%	74.1%	73.3%	72.6%	71.6%	70.9%	70.0%	68.1%	64.5%
3,000					79.2%	78.0%	77.0%	76.1%	75.6%	74.7%	73.9%	72.9%	72.2%	71.3%	69.3%	65.7%
3,500						80.3%	79.3%	78.4%	77.8%	76.9%	76.0%	75.0%	74.3%	73.2%	70.9%	67.3%
4,000							82.1%	81.1%	80.5%	79.6%	78.8%	77.7%	77.0%	75.9%	73.5%	69.7%
4,500								84.4%	83.8%	82.9%	82.0%	80.9%	80.1%	78.9%	76.5%	72.5%
5,000									86.5%	85.5%	84.6%	83.4%	82.6%	81.5%	79.1%	74.7%
6,000										90.0%	89.0%	87.9%	87.1%	85.9%	83.5%	79.0%
7,000											92.6%	91.4%	90.6%	89.4%	87.0%	82.4%
8,000												94.6%	93.7%	92.4%	89.9%	85.3%
9,000													96.7%	95.3%	92.7%	88.1%
10,000														98.6%	95.7%	91.1%
12,000															100.0%	95.1%
14,000																98.2%

Table H-27: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (ft^2), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	1,585,904	1,540,740	1,520,930	1,514,147	1,503,650	1,494,344	1,488,761	1,479,656	1,473,664	1,460,687	1,453,611	1,442,920	1,434,844	1,420,590	1,395,349	1,375,208
1,500		1,594,120	1,571,760	1,564,186	1,552,772	1,543,170	1,537,454	1,527,237	1,518,714	1,504,751	1,494,728	1,482,158	1,467,076	1,452,823	1,427,215	1,403,753
2,000			1,596,666	1,587,521	1,575,652	1,566,049	1,560,333	1,549,825	1,541,023	1,526,872	1,516,713	1,503,279	1,488,193	1,473,940	1,445,421	1,421,776
2,500				1,620,057	1,607,204	1,597,335	1,591,332	1,579,441	1,570,041	1,555,048	1,544,074	1,530,608	1,515,291	1,500,483	1,469,808	1,444,099
3,000					1,628,523	1,617,269	1,610,719	1,598,310	1,588,728	1,573,547	1,562,573	1,549,047	1,533,682	1,518,829	1,487,231	1,459,054
3,500						1,634,146	1,627,289	1,613,882	1,604,111	1,588,930	1,577,956	1,564,372	1,549,007	1,534,154	1,502,556	1,473,323
4,000							1,645,558	1,631,571	1,621,176	1,605,147	1,594,173	1,580,590	1,565,224	1,550,145	1,518,488	1,489,255
4,500								1,647,555	1,635,805	1,619,419	1,608,445	1,594,862	1,579,496	1,564,417	1,532,351	1,503,011
5,000									1,652,667	1,635,073	1,624,099	1,609,996	1,594,630	1,579,372	1,546,094	1,515,961
6,000										1,663,365	1,650,652	1,635,967	1,620,185	1,604,927	1,571,032	1,540,686
7,000											1,678,816	1,662,734	1,646,290	1,630,908	1,596,595	1,565,098
8,000												1,694,619	1,674,323	1,658,575	1,622,722	1,590,765
9,000													1,701,492	1,685,522	1,649,612	1,617,654
10,000														1,707,777	1,669,068	1,637,110
12,000															1,707,818	1,671,852
14,000																1,705,914

Table H-28: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (% of maximum possible), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	92.9%	90.2%	89.1%	88.7%	88.0%	87.5%	87.2%	86.6%	86.3%	85.5%	85.1%	84.5%	84.0%	83.2%	81.7%	80.5%
1,500		93.3%	92.0%	91.6%	90.9%	90.4%	90.0%	89.4%	88.9%	88.1%	87.5%	86.8%	85.9%	85.1%	83.6%	82.2%
2,000			93.5%	93.0%	92.3%	91.7%	91.4%	90.7%	90.2%	89.4%	88.8%	88.0%	87.1%	86.3%	84.6%	83.3%
2,500				94.9%	94.1%	93.5%	93.2%	92.5%	91.9%	91.1%	90.4%	89.6%	88.7%	87.9%	86.1%	84.6%
3,000					95.4%	94.7%	94.3%	93.6%	93.0%	92.1%	91.5%	90.7%	89.8%	88.9%	87.1%	85.4%
3,500						95.7%	95.3%	94.5%	93.9%	93.0%	92.4%	91.6%	90.7%	89.8%	88.0%	86.3%
4,000							96.4%	95.5%	94.9%	94.0%	93.3%	92.6%	91.7%	90.8%	88.9%	87.2%
4,500								96.5%	95.8%	94.8%	94.2%	93.4%	92.5%	91.6%	89.7%	88.0%
5,000									96.8%	95.7%	95.1%	94.3%	93.4%	92.5%	90.5%	88.8%
6,000										97.4%	96.7%	95.8%	94.9%	94.0%	92.0%	90.2%
7,000											98.3%	97.4%	96.4%	95.5%	93.5%	91.6%
8,000												99.2%	98.0%	97.1%	95.0%	93.1%
9,000													99.6%	98.7%	96.6%	94.7%
10,000														100.0%	97.7%	95.9%
12,000															100.0%	97.9%
14,000																99.9%

Table H-29: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (ft²), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	1,593,627	1,561,422	1,552,345	1,545,121	1,539,196	1,532,058	1,526,827	1,520,953	1,513,356	1,498,521	1,486,875	1,472,856	1,457,178	1,439,058	1,419,804	1,400,767
1,500		1,620,810	1,610,020	1,602,207	1,595,950	1,587,971	1,582,614	1,575,730	1,568,134	1,553,299	1,541,380	1,527,317	1,511,469	1,490,886	1,465,781	1,445,351
2,000			1,637,789	1,629,323	1,622,633	1,613,637	1,608,280	1,600,753	1,592,146	1,577,311	1,565,393	1,551,251	1,535,347	1,514,764	1,489,580	1,469,150
2,500				1,649,105	1,641,260	1,630,646	1,625,289	1,617,762	1,609,155	1,594,134	1,582,215	1,568,074	1,551,600	1,530,616	1,505,433	1,484,797
3,000					1,657,958	1,645,555	1,640,014	1,632,093	1,623,357	1,608,336	1,596,036	1,581,716	1,565,062	1,544,079	1,517,750	1,497,114
3,500						1,663,342	1,655,891	1,647,780	1,638,645	1,623,516	1,611,143	1,596,823	1,580,169	1,558,328	1,531,999	1,511,364
4,000							1,679,984	1,671,872	1,661,083	1,645,575	1,633,021	1,618,701	1,600,930	1,578,958	1,551,174	1,530,367
4,500								1,697,430	1,685,386	1,669,324	1,656,770	1,642,450	1,624,679	1,602,707	1,574,922	1,554,116
5,000									1,707,050	1,689,809	1,673,838	1,659,518	1,641,623	1,618,684	1,590,900	1,570,093
6,000										1,731,484	1,714,258	1,698,744	1,680,620	1,657,503	1,629,492	1,607,056
7,000											1,744,339	1,725,837	1,707,327	1,684,210	1,655,348	1,632,828
8,000												1,748,128	1,727,623	1,702,745	1,673,211	1,650,309
9,000													1,747,434	1,719,997	1,688,192	1,665,236
10,000														1,737,603	1,704,092	1,680,909
12,000															1,749,242	1,722,234
14,000																1,756,208

Table H-30: Reach 3 Shortnose Sturgeon Egg-Larvae Persistent Habitat (% of maximum possible), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	90.7%	88.9%	88.4%	88.0%	87.6%	87.2%	86.9%	86.6%	86.2%	85.3%	84.7%	83.9%	83.0%	81.9%	80.8%	79.8%
1,500		92.3%	91.7%	91.2%	90.9%	90.4%	90.1%	89.7%	89.3%	88.4%	87.8%	87.0%	86.1%	84.9%	83.5%	82.3%
2,000			93.3%	92.8%	92.4%	91.9%	91.6%	91.1%	90.7%	89.8%	89.1%	88.3%	87.4%	86.3%	84.8%	83.7%
2,500				93.9%	93.5%	92.9%	92.5%	92.1%	91.6%	90.8%	90.1%	89.3%	88.3%	87.2%	85.7%	84.5%
3,000					94.4%	93.7%	93.4%	92.9%	92.4%	91.6%	90.9%	90.1%	89.1%	87.9%	86.4%	85.2%
3,500						94.7%	94.3%	93.8%	93.3%	92.4%	91.7%	90.9%	90.0%	88.7%	87.2%	86.1%
4,000							95.7%	95.2%	94.6%	93.7%	93.0%	92.2%	91.2%	89.9%	88.3%	87.1%
4,500								96.7%	96.0%	95.1%	94.3%	93.5%	92.5%	91.3%	89.7%	88.5%
5,000									97.2%	96.2%	95.3%	94.5%	93.5%	92.2%	90.6%	89.4%
6,000										98.6%	97.6%	96.7%	95.7%	94.4%	92.8%	91.5%
7,000											99.3%	98.3%	97.2%	95.9%	94.3%	93.0%
8,000												99.5%	98.4%	97.0%	95.3%	94.0%
9,000													99.5%	97.9%	96.1%	94.8%
10,000														98.9%	97.0%	95.7%
12,000															99.6%	98.1%
14,000																100.0%

Table H-31: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (ft²), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	438,363	438,363	403,500	377,534	352,983	327,075	302,062	285,353	265,898	225,576	192,675	159,741	135,477	115,743	77,967	56,856
1,500		438,363	403,500	377,534	352,983	327,075	302,062	285,353	265,898	225,576	192,675	159,741	135,477	115,743	77,967	56,856
2,000			493,707	445,639	416,503	387,567	360,764	340,310	315,353	269,974	233,927	193,972	167,732	146,900	107,041	84,843
2,500				532,262	488,196	450,904	420,924	394,558	366,815	317,251	276,993	230,002	200,654	177,061	133,896	110,413
3,000					577,447	524,066	480,690	449,117	417,519	361,644	316,462	266,506	234,232	207,992	156,918	131,683
3,500						606,668	550,488	511,296	473,049	407,011	354,097	303,660	270,714	242,299	183,094	155,091
4,000							626,670	577,440	533,222	461,455	398,942	342,818	306,482	274,964	210,097	180,040
4,500								643,989	589,323	506,359	442,166	380,440	342,473	309,705	240,329	206,127
5,000									657,008	555,384	483,840	414,339	372,972	338,308	264,054	227,777
6,000										692,976	604,969	526,029	475,427	437,022	346,025	300,744
7,000											810,624	701,681	639,206	592,682	474,244	400,758
8,000												879,020	798,897	741,649	604,049	517,981
9,000													960,295	893,594	739,801	642,070
10,000														996,804	828,045	721,563
12,000															935,733	818,849
14,000																967,655

Table H-32: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	44.0%	44.0%	40.5%	37.9%	35.4%	32.8%	30.3%	28.6%	26.7%	22.6%	19.3%	16.0%	13.6%	11.6%	7.8%	5.7%
1,500		44.0%	40.5%	37.9%	35.4%	32.8%	30.3%	28.6%	26.7%	22.6%	19.3%	16.0%	13.6%	11.6%	7.8%	5.7%
2,000			49.5%	44.7%	41.8%	38.9%	36.2%	34.1%	31.6%	27.1%	23.5%	19.5%	16.8%	14.7%	10.7%	8.5%
2,500				53.4%	49.0%	45.2%	42.2%	39.6%	36.8%	31.8%	27.8%	23.1%	20.1%	17.8%	13.4%	11.1%
3,000					57.9%	52.6%	48.2%	45.1%	41.9%	36.3%	31.7%	26.7%	23.5%	20.9%	15.7%	13.2%
3,500						60.9%	55.2%	51.3%	47.5%	40.8%	35.5%	30.5%	27.2%	24.3%	18.4%	15.6%
4,000							62.9%	57.9%	53.5%	46.3%	40.0%	34.4%	30.7%	27.6%	21.1%	18.1%
4,500								64.6%	59.1%	50.8%	44.4%	38.2%	34.4%	31.1%	24.1%	20.7%
5,000									65.9%	55.7%	48.5%	41.6%	37.4%	33.9%	26.5%	22.9%
6,000										69.5%	60.7%	52.8%	47.7%	43.8%	34.7%	30.2%
7,000											81.3%	70.4%	64.1%	59.5%	47.6%	40.2%
8,000												88.2%	80.1%	74.4%	60.6%	52.0%
9,000													96.3%	89.6%	74.2%	64.4%
10,000														100.0%	83.1%	72.4%
12,000															93.9%	82.1%
14,000																97.1%

Table H-33: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	616,029	616,029	579,345	561,682	531,562	509,807	495,121	477,103	460,118	421,047	376,420	344,454	304,981	245,062	188,630	138,712
1,500		616,029	579,345	561,682	531,562	509,807	495,121	477,103	460,118	421,047	376,420	344,454	304,981	245,062	188,630	138,712
2,000			655,255	626,244	589,929	560,615	542,170	522,481	502,601	461,668	412,466	377,435	333,717	268,791	210,155	157,676
2,500				707,928	661,621	622,162	599,309	573,225	552,331	505,071	451,745	413,286	365,987	295,851	230,471	174,719
3,000					743,736	692,481	661,578	632,602	607,330	552,082	493,568	451,422	397,551	325,544	253,608	195,710
3,500						782,653	737,749	702,022	672,755	608,304	542,572	493,191	432,308	356,315	282,062	222,159
4,000							826,145	782,787	747,997	674,389	602,924	547,746	476,563	395,983	315,419	252,963
4,500								845,014	797,645	713,663	641,098	578,723	500,568	418,237	332,116	266,128
5,000									876,322	770,473	689,165	622,507	536,460	451,944	359,050	291,887
6,000										943,946	833,086	750,878	657,189	563,492	455,894	375,890
7,000											1,047,712	945,884	840,286	734,908	591,351	477,044
8,000												1,113,363	993,011	873,409	709,494	582,253
9,000													1,177,005	1,044,347	850,098	711,477
10,000														1,140,203	936,210	790,509
12,000															1,038,932	880,528
14,000																1,014,634

Table H-34: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	52.3%	52.3%	49.2%	47.7%	45.2%	43.3%	42.1%	40.5%	39.1%	35.8%	32.0%	29.3%	25.9%	20.8%	16.0%	11.8%
1,500		52.3%	49.2%	47.7%	45.2%	43.3%	42.1%	40.5%	39.1%	35.8%	32.0%	29.3%	25.9%	20.8%	16.0%	11.8%
2,000			55.7%	53.2%	50.1%	47.6%	46.1%	44.4%	42.7%	39.2%	35.0%	32.1%	28.4%	22.8%	17.9%	13.4%
2,500				60.1%	56.2%	52.9%	50.9%	48.7%	46.9%	42.9%	38.4%	35.1%	31.1%	25.1%	19.6%	14.8%
3,000					63.2%	58.8%	56.2%	53.7%	51.6%	46.9%	41.9%	38.4%	33.8%	27.7%	21.5%	16.6%
3,500						66.5%	62.7%	59.6%	57.2%	51.7%	46.1%	41.9%	36.7%	30.3%	24.0%	18.9%
4,000							70.2%	66.5%	63.6%	57.3%	51.2%	46.5%	40.5%	33.6%	26.8%	21.5%
4,500								71.8%	67.8%	60.6%	54.5%	49.2%	42.5%	35.5%	28.2%	22.6%
5,000									74.5%	65.5%	58.6%	52.9%	45.6%	38.4%	30.5%	24.8%
6,000										80.2%	70.8%	63.8%	55.8%	47.9%	38.7%	31.9%
7,000											89.0%	80.4%	71.4%	62.4%	50.2%	40.5%
8,000												94.6%	84.4%	74.2%	60.3%	49.5%
9,000													100.0%	88.7%	72.2%	60.4%
10,000														96.9%	79.5%	67.2%
12,000															88.3%	74.8%
14,000																86.2%

Table H-35: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (ft^2), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	561,461	492,239	471,378	449,895	434,228	423,855	416,387	407,485	395,951	368,828	341,601	315,263	295,600	276,641	226,957	184,672
1,500		709,946	675,193	641,930	616,780	597,872	582,672	565,071	545,649	504,637	467,832	423,297	390,415	362,668	304,002	249,944
2,000			766,492	719,002	681,544	659,323	638,024	615,020	593,164	548,338	505,823	460,306	425,657	394,942	330,231	269,001
2,500				802,000	753,003	721,472	696,688	666,151	639,622	587,684	540,725	493,773	457,692	424,094	350,700	283,498
3,000					846,437	802,454	767,893	734,017	700,134	635,032	586,075	536,547	497,223	462,141	380,802	308,765
3,500						891,746	850,888	806,968	768,153	696,646	644,049	591,161	550,932	510,791	418,407	340,706
4,000							912,421	862,076	815,905	742,103	686,790	632,390	590,002	544,998	441,214	358,189
4,500								951,206	888,128	805,537	743,920	684,438	639,960	591,151	474,771	389,502
5,000									1,007,025	903,774	836,271	771,881	725,264	671,705	539,851	448,289
6,000										1,107,113	1,021,222	941,255	887,132	824,275	648,692	531,911
7,000											1,214,091	1,120,823	1,053,617	979,697	784,871	633,248
8,000												1,304,517	1,226,740	1,134,695	926,745	752,852
9,000													1,368,028	1,266,589	1,045,784	860,031
10,000														1,360,869	1,127,020	926,490
12,000															1,248,250	1,028,079
14,000																1,131,598

Table H-36: Reach 3 Shortnose Sturgeon Fry Habitat (% of maximum possible), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	41.0%	36.0%	34.5%	32.9%	31.7%	31.0%	30.4%	29.8%	28.9%	27.0%	25.0%	23.0%	21.6%	20.2%	16.6%	13.5%
1,500		51.9%	49.4%	46.9%	45.1%	43.7%	42.6%	41.3%	39.9%	36.9%	34.2%	30.9%	28.5%	26.5%	22.2%	18.3%
2,000			56.0%	52.6%	49.8%	48.2%	46.6%	45.0%	43.4%	40.1%	37.0%	33.6%	31.1%	28.9%	24.1%	19.7%
2,500				58.6%	55.0%	52.7%	50.9%	48.7%	46.8%	43.0%	39.5%	36.1%	33.5%	31.0%	25.6%	20.7%
3,000					61.9%	58.7%	56.1%	53.7%	51.2%	46.4%	42.8%	39.2%	36.3%	33.8%	27.8%	22.6%
3,500						65.2%	62.2%	59.0%	56.2%	50.9%	47.1%	43.2%	40.3%	37.3%	30.6%	24.9%
4,000							66.7%	63.0%	59.6%	54.2%	50.2%	46.2%	43.1%	39.8%	32.3%	26.2%
4,500								69.5%	64.9%	58.9%	54.4%	50.0%	46.8%	43.2%	34.7%	28.5%
5,000									73.6%	66.1%	61.1%	56.4%	53.0%	49.1%	39.5%	32.8%
6,000										80.9%	74.6%	68.8%	64.8%	60.3%	47.4%	38.9%
7,000											88.7%	81.9%	77.0%	71.6%	57.4%	46.3%
8,000												95.4%	89.7%	82.9%	67.7%	55.0%
9,000													100.0%	92.6%	76.4%	62.9%
10,000														99.5%	82.4%	67.7%
12,000															91.2%	75.2%
14,000																82.7%

Table H-37: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (ft^2), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	902,167	809,047	777,728	749,163	728,455	704,378	686,662	647,392	626,081	603,581	590,470	560,223	544,666	530,895	501,334	459,790
1,500		1,031,317	972,122	927,754	888,740	849,235	814,999	768,185	739,618	710,536	689,352	654,433	635,409	619,950	581,349	520,685
2,000			1,071,650	1,004,681	953,722	909,060	872,362	823,192	791,964	758,752	735,565	697,572	672,384	656,224	612,529	549,589
2,500				1,090,030	1,019,999	964,898	927,088	874,029	840,325	800,838	775,735	735,409	705,580	689,180	640,347	571,657
3,000					1,112,243	1,035,397	988,507	928,536	889,903	848,662	822,682	779,616	745,910	727,643	676,521	601,984
3,500						1,145,068	1,080,063	1,011,290	968,648	917,925	889,633	842,412	802,289	779,094	716,830	632,700
4,000							1,179,005	1,091,483	1,038,405	980,058	948,078	896,213	852,580	826,740	758,697	668,747
4,500								1,223,122	1,147,752	1,081,808	1,044,808	982,009	931,785	898,618	825,242	729,179
5,000									1,234,147	1,154,572	1,111,428	1,045,330	991,691	954,167	872,486	770,355
6,000										1,308,754	1,255,311	1,174,340	1,110,778	1,068,644	969,990	856,937
7,000											1,390,453	1,298,996	1,229,539	1,183,682	1,075,499	955,597
8,000												1,389,361	1,310,064	1,259,692	1,143,250	1,019,082
9,000													1,398,918	1,334,254	1,208,810	1,077,768
10,000														1,415,481	1,280,328	1,143,740
12,000															1,400,978	1,256,440
14,000																1,396,657

Table H-38: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (% of maximum possible), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	63.7%	57.2%	54.9%	52.9%	51.5%	49.8%	48.5%	45.7%	44.2%	42.6%	41.7%	39.6%	38.5%	37.5%	35.4%	32.5%
1,500		72.9%	68.7%	65.5%	62.8%	60.0%	57.6%	54.3%	52.3%	50.2%	48.7%	46.2%	44.9%	43.8%	41.1%	36.8%
2,000			75.7%	71.0%	67.4%	64.2%	61.6%	58.2%	56.0%	53.6%	52.0%	49.3%	47.5%	46.4%	43.3%	38.8%
2,500				77.0%	72.1%	68.2%	65.5%	61.7%	59.4%	56.6%	54.8%	52.0%	49.8%	48.7%	45.2%	40.4%
3,000					78.6%	73.1%	69.8%	65.6%	62.9%	60.0%	58.1%	55.1%	52.7%	51.4%	47.8%	42.5%
3,500						80.9%	76.3%	71.4%	68.4%	64.8%	62.9%	59.5%	56.7%	55.0%	50.6%	44.7%
4,000							83.3%	77.1%	73.4%	69.2%	67.0%	63.3%	60.2%	58.4%	53.6%	47.2%
4,500								86.4%	81.1%	76.4%	73.8%	69.4%	65.8%	63.5%	58.3%	51.5%
5,000									87.2%	81.6%	78.5%	73.8%	70.1%	67.4%	61.6%	54.4%
6,000										92.5%	88.7%	83.0%	78.5%	75.5%	68.5%	60.5%
7,000											98.2%	91.8%	86.9%	83.6%	76.0%	67.5%
8,000												98.2%	92.6%	89.0%	80.8%	72.0%
9,000													98.8%	94.3%	85.4%	76.1%
10,000														100.0%	90.5%	80.8%
12,000															99.0%	88.8%
14,000																98.7%

Table H-39: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (ft^2), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	1,122,700	1,005,885	952,473	903,031	870,485	848,379	828,844	808,531	792,344	770,680	738,152	713,856	690,804	671,036	623,636	574,821
1,500		1,194,600	1,126,974	1,065,342	1,022,217	993,040	966,345	941,648	920,191	886,754	839,658	800,559	767,373	741,431	682,267	625,272
2,000			1,207,168	1,128,308	1,079,713	1,048,615	1,015,772	985,774	961,972	922,125	872,375	830,412	795,520	766,603	705,406	645,403
2,500				1,212,584	1,148,318	1,112,734	1,076,205	1,043,547	1,017,946	969,265	909,825	859,703	823,533	791,601	727,587	663,635
3,000					1,211,591	1,166,550	1,125,881	1,086,423	1,057,457	1,006,258	945,302	893,119	856,411	820,330	752,588	686,730
3,500						1,245,476	1,187,784	1,142,138	1,107,977	1,049,443	986,156	930,277	891,994	852,608	780,745	713,369
4,000							1,255,881	1,204,365	1,165,995	1,104,200	1,038,551	979,256	940,501	894,819	820,009	748,758
4,500								1,279,680	1,227,038	1,151,086	1,078,110	1,017,181	975,222	926,308	849,918	776,258
5,000									1,281,320	1,194,813	1,115,388	1,052,772	1,009,662	958,313	880,774	805,183
6,000										1,268,288	1,183,564	1,116,972	1,068,879	1,013,995	933,108	855,268
7,000											1,254,902	1,177,356	1,127,161	1,070,762	985,025	905,905
8,000												1,258,630	1,200,030	1,140,336	1,051,030	963,740
9,000													1,263,922	1,200,456	1,106,195	1,012,393
10,000														1,276,602	1,172,851	1,072,765
12,000															1,328,033	1,206,747
14,000																1,324,576

Table H-40: Reach 3 Shortnose Sturgeon Fry Persistent Habitat (% of maximum possible), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	84.5%	75.7%	71.7%	68.0%	65.5%	63.9%	62.4%	60.9%	59.7%	58.0%	55.6%	53.8%	52.0%	50.5%	47.0%	43.3%
1,500		90.0%	84.9%	80.2%	77.0%	74.8%	72.8%	70.9%	69.3%	66.8%	63.2%	60.3%	57.8%	55.8%	51.4%	47.1%
2,000			90.9%	85.0%	81.3%	79.0%	76.5%	74.2%	72.4%	69.4%	65.7%	62.5%	59.9%	57.7%	53.1%	48.6%
2,500				91.3%	86.5%	83.8%	81.0%	78.6%	76.7%	73.0%	68.5%	64.7%	62.0%	59.6%	54.8%	50.0%
3,000					91.2%	87.8%	84.8%	81.8%	79.6%	75.8%	71.2%	67.3%	64.5%	61.8%	56.7%	51.7%
3,500						93.8%	89.4%	86.0%	83.4%	79.0%	74.3%	70.0%	67.2%	64.2%	58.8%	53.7%
4,000							94.6%	90.7%	87.8%	83.1%	78.2%	73.7%	70.8%	67.4%	61.7%	56.4%
4,500								96.4%	92.4%	86.7%	81.2%	76.6%	73.4%	69.8%	64.0%	58.5%
5,000									96.5%	90.0%	84.0%	79.3%	76.0%	72.2%	66.3%	60.6%
6,000										95.5%	89.1%	84.1%	80.5%	76.4%	70.3%	64.4%
7,000											94.5%	88.7%	84.9%	80.6%	74.2%	68.2%
8,000												94.8%	90.4%	85.9%	79.1%	72.6%
9,000													95.2%	90.4%	83.3%	76.2%
10,000														96.1%	88.3%	80.8%
12,000															100.0%	90.9%
14,000																99.7%

Table H-41: Reach 3 Fallfish Spawning Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	293,640	293,640	252,329	217,474	187,518	170,281	150,985	140,872	134,794	124,186	110,274	95,597	82,853	74,260	62,484	40,055
1,500		293,640	252,329	217,474	187,518	170,281	150,985	140,872	134,794	124,186	110,274	95,597	82,853	74,260	62,484	40,055
2,000			295,039	255,785	218,660	196,771	173,295	159,085	144,954	132,859	115,666	95,624	82,871	74,260	62,484	40,055
2,500				299,248	256,104	225,494	199,860	182,586	165,884	147,259	127,311	99,421	83,060	74,449	62,484	40,055
3,000					302,987	263,019	233,534	213,041	193,581	166,395	137,758	107,177	85,680	74,921	62,484	40,055
3,500						314,489	275,468	253,991	228,623	198,134	162,922	120,204	94,702	76,007	62,484	40,055
4,000							332,698	309,350	280,636	243,324	201,519	143,224	110,536	87,762	62,484	40,055
4,500								388,808	349,274	300,080	245,910	170,922	118,779	94,821	62,484	40,055
5,000									426,913	366,766	299,896	213,469	143,140	103,564	64,382	40,055
6,000										541,449	447,315	331,450	221,742	139,153	75,133	40,055
7,000											557,667	417,847	288,747	191,051	86,873	42,693
8,000												503,114	349,433	239,592	113,459	52,909
9,000													392,044	275,247	132,724	62,118
10,000														326,018	177,447	92,959
12,000															237,334	134,481
14,000																179,324

Table H-42: Reach 3 Fallfish Spawning Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	52.7%	52.7%	45.2%	39.0%	33.6%	30.5%	27.1%	25.3%	24.2%	22.3%	19.8%	17.1%	14.9%	13.3%	11.2%	7.2%
1,500		52.7%	45.2%	39.0%	33.6%	30.5%	27.1%	25.3%	24.2%	22.3%	19.8%	17.1%	14.9%	13.3%	11.2%	7.2%
2,000			52.9%	45.9%	39.2%	35.3%	31.1%	28.5%	26.0%	23.8%	20.7%	17.1%	14.9%	13.3%	11.2%	7.2%
2,500				53.7%	45.9%	40.4%	35.8%	32.7%	29.7%	26.4%	22.8%	17.8%	14.9%	13.4%	11.2%	7.2%
3,000					54.3%	47.2%	41.9%	38.2%	34.7%	29.8%	24.7%	19.2%	15.4%	13.4%	11.2%	7.2%
3,500						56.4%	49.4%	45.5%	41.0%	35.5%	29.2%	21.6%	17.0%	13.6%	11.2%	7.2%
4,000							59.7%	55.5%	50.3%	43.6%	36.1%	25.7%	19.8%	15.7%	11.2%	7.2%
4,500								69.7%	62.6%	53.8%	44.1%	30.6%	21.3%	17.0%	11.2%	7.2%
5,000									76.6%	65.8%	53.8%	38.3%	25.7%	18.6%	11.5%	7.2%
6,000										97.1%	80.2%	59.4%	39.8%	25.0%	13.5%	7.2%
7,000											100.0%	74.9%	51.8%	34.3%	15.6%	7.7%
8,000												90.2%	62.7%	43.0%	20.3%	9.5%
9,000													70.3%	49.4%	23.8%	11.1%
10,000														58.5%	31.8%	16.7%
12,000															42.6%	24.1%
14,000																32.2%

Table H-43: Reach 3 Fallfish Spawning Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	319,116	319,116	284,539	253,790	229,674	201,309	191,353	177,799	173,398	160,694	140,858	131,631	116,746	105,069	77,574	55,211
1,500		319,116	284,539	253,790	229,674	201,309	191,353	177,799	173,398	160,694	140,858	131,631	116,746	105,069	77,574	55,211
2,000			336,883	298,962	267,194	230,756	218,450	199,299	191,146	173,411	150,922	131,836	116,951	105,274	77,779	55,211
2,500				345,345	308,412	265,148	246,841	225,730	215,577	189,612	161,545	137,441	117,154	105,477	77,982	55,211
3,000					350,330	298,691	278,830	256,213	241,452	212,300	175,972	149,758	120,155	105,688	77,991	55,211
3,500						349,870	326,051	300,840	284,095	250,361	208,144	167,825	134,176	108,160	77,991	55,211
4,000							407,300	370,521	350,191	300,157	245,485	187,065	147,483	119,137	79,479	55,211
4,500								446,360	420,803	355,953	290,337	219,922	161,472	130,804	81,844	55,211
5,000									498,938	422,533	344,170	266,367	184,982	142,854	83,850	55,211
6,000										583,505	475,638	376,643	270,784	191,998	93,506	55,895
7,000											571,276	455,223	340,495	246,105	112,176	63,503
8,000												540,139	414,776	307,282	141,760	77,518
9,000													457,032	344,317	162,079	87,858
10,000														374,160	184,211	104,062
12,000															232,899	143,478
14,000																206,894

Table H-44: Reach 3 Fallfish Spawning Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	54.7%	54.7%	48.8%	43.5%	39.4%	34.5%	32.8%	30.5%	29.7%	27.5%	24.1%	22.6%	20.0%	18.0%	13.3%	9.5%
1,500		54.7%	48.8%	43.5%	39.4%	34.5%	32.8%	30.5%	29.7%	27.5%	24.1%	22.6%	20.0%	18.0%	13.3%	9.5%
2,000			57.7%	51.2%	45.8%	39.5%	37.4%	34.2%	32.8%	29.7%	25.9%	22.6%	20.0%	18.0%	13.3%	9.5%
2,500				59.2%	52.9%	45.4%	42.3%	38.7%	36.9%	32.5%	27.7%	23.6%	20.1%	18.1%	13.4%	9.5%
3,000					60.0%	51.2%	47.8%	43.9%	41.4%	36.4%	30.2%	25.7%	20.6%	18.1%	13.4%	9.5%
3,500						60.0%	55.9%	51.6%	48.7%	42.9%	35.7%	28.8%	23.0%	18.5%	13.4%	9.5%
4,000							69.8%	63.5%	60.0%	51.4%	42.1%	32.1%	25.3%	20.4%	13.6%	9.5%
4,500								76.5%	72.1%	61.0%	49.8%	37.7%	27.7%	22.4%	14.0%	9.5%
5,000									85.5%	72.4%	59.0%	45.6%	31.7%	24.5%	14.4%	9.5%
6,000										100.0%	81.5%	64.5%	46.4%	32.9%	16.0%	9.6%
7,000											97.9%	78.0%	58.4%	42.2%	19.2%	10.9%
8,000												92.6%	71.1%	52.7%	24.3%	13.3%
9,000													78.3%	59.0%	27.8%	15.1%
10,000														64.1%	31.6%	17.8%
12,000															39.9%	24.6%
14,000																35.5%

Table H-45: Reach 3 Fallfish Spawning Persistent Habitat (ft^2), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	316,080	251,488	224,956	215,691	198,098	194,068	188,578	181,809	175,360	159,153	146,845	136,142	124,826	111,233	79,968	53,263
1,500		370,732	330,358	301,886	263,882	249,348	231,014	217,324	206,003	185,380	156,317	136,779	125,462	111,233	79,968	53,263
2,000			375,610	339,965	296,807	276,273	255,769	239,849	223,303	194,702	163,900	139,036	125,462	111,233	79,968	53,263
2,500				383,472	335,336	313,368	291,358	271,279	252,103	219,828	181,907	152,106	126,627	111,500	80,235	53,263
3,000					390,264	364,772	340,621	317,733	294,351	256,596	207,305	170,130	139,283	111,730	80,465	53,493
3,500						447,773	420,302	393,589	363,388	308,897	245,042	187,982	154,018	116,969	81,759	54,225
4,000							500,647	470,286	433,568	362,470	287,958	213,012	164,740	126,551	83,265	54,652
4,500								547,855	506,786	423,889	339,116	255,312	183,585	139,697	86,420	56,046
5,000									585,427	499,785	402,801	306,659	213,659	153,574	91,502	56,864
6,000										608,276	493,795	379,873	278,974	192,059	109,737	61,507
7,000											574,209	447,272	336,388	240,167	130,899	67,571
8,000												504,083	387,989	283,367	154,698	76,318
9,000													432,423	322,129	187,677	96,256
10,000														357,720	214,673	117,234
12,000															265,147	158,712
14,000																201,049

Table H-46: Reach 3 Fallfish Spawning Habitat (% of maximum possible), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	52.0%	41.3%	37.0%	35.5%	32.6%	31.9%	31.0%	29.9%	28.8%	26.2%	24.1%	22.4%	20.5%	18.3%	13.1%	8.8%
1,500		60.9%	54.3%	49.6%	43.4%	41.0%	38.0%	35.7%	33.9%	30.5%	25.7%	22.5%	20.6%	18.3%	13.1%	8.8%
2,000			61.7%	55.9%	48.8%	45.4%	42.0%	39.4%	36.7%	32.0%	26.9%	22.9%	20.6%	18.3%	13.1%	8.8%
2,500				63.0%	55.1%	51.5%	47.9%	44.6%	41.4%	36.1%	29.9%	25.0%	20.8%	18.3%	13.2%	8.8%
3,000					64.2%	60.0%	56.0%	52.2%	48.4%	42.2%	34.1%	28.0%	22.9%	18.4%	13.2%	8.8%
3,500						73.6%	69.1%	64.7%	59.7%	50.8%	40.3%	30.9%	25.3%	19.2%	13.4%	8.9%
4,000							82.3%	77.3%	71.3%	59.6%	47.3%	35.0%	27.1%	20.8%	13.7%	9.0%
4,500								90.1%	83.3%	69.7%	55.8%	42.0%	30.2%	23.0%	14.2%	9.2%
5,000									96.2%	82.2%	66.2%	50.4%	35.1%	25.2%	15.0%	9.3%
6,000										100.0%	81.2%	62.5%	45.9%	31.6%	18.0%	10.1%
7,000											94.4%	73.5%	55.3%	39.5%	21.5%	11.1%
8,000												82.9%	63.8%	46.6%	25.4%	12.5%
9,000													71.1%	53.0%	30.9%	15.8%
10,000														58.8%	35.3%	19.3%
12,000															43.6%	26.1%
14,000																33.1%

Table H-47: Reach 3 Fallfish Spawning Persistent Habitat (ft²), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	470,174	389,579	363,741	346,558	322,142	300,765	278,896	245,402	219,011	171,424	133,995	118,543	102,662	88,446	62,038	47,340
1,500		511,383	480,402	450,464	415,435	383,645	352,221	306,245	270,378	201,475	153,739	125,967	106,068	90,763	63,051	47,349
2,000			542,757	510,893	472,538	432,621	397,256	348,836	307,849	226,528	170,127	133,850	111,074	93,033	63,051	47,349
2,500				550,296	510,731	466,365	426,797	373,817	330,257	242,807	178,942	139,821	115,085	95,433	63,361	47,349
3,000					553,037	507,981	465,922	411,771	364,449	274,332	197,118	149,800	121,342	99,610	64,693	48,357
3,500						549,971	506,166	447,882	398,168	303,581	219,636	161,259	126,384	102,524	64,693	48,357
4,000							545,383	483,888	432,256	333,241	246,981	181,255	140,292	111,651	68,860	49,729
4,500								537,109	480,918	373,683	278,877	207,378	157,877	121,408	75,693	52,078
5,000									512,195	397,021	299,567	223,882	169,792	128,963	79,826	52,320
6,000										434,962	335,109	252,929	193,731	145,825	92,905	57,306
7,000											367,616	279,348	217,004	167,039	106,149	67,217
8,000												296,843	233,440	178,255	111,830	69,631
9,000													250,221	193,350	125,473	78,588
10,000														213,271	142,716	91,520
12,000															175,943	121,051
14,000																157,140

Table H-48: Reach 3 Fallfish Spawning Persistent Habitat (% of maximum possible), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	85.0%	70.4%	65.8%	62.7%	58.2%	54.4%	50.4%	44.4%	39.6%	31.0%	24.2%	21.4%	18.6%	16.0%	11.2%	8.6%
1,500		92.5%	86.9%	81.5%	75.1%	69.4%	63.7%	55.4%	48.9%	36.4%	27.8%	22.8%	19.2%	16.4%	11.4%	8.6%
2,000			98.1%	92.4%	85.4%	78.2%	71.8%	63.1%	55.7%	41.0%	30.8%	24.2%	20.1%	16.8%	11.4%	8.6%
2,500				99.5%	92.4%	84.3%	77.2%	67.6%	59.7%	43.9%	32.4%	25.3%	20.8%	17.3%	11.5%	8.6%
3,000					100.0%	91.9%	84.2%	74.5%	65.9%	49.6%	35.6%	27.1%	21.9%	18.0%	11.7%	8.7%
3,500						99.4%	91.5%	81.0%	72.0%	54.9%	39.7%	29.2%	22.9%	18.5%	11.7%	8.7%
4,000							98.6%	87.5%	78.2%	60.3%	44.7%	32.8%	25.4%	20.2%	12.5%	9.0%
4,500								97.1%	87.0%	67.6%	50.4%	37.5%	28.5%	22.0%	13.7%	9.4%
5,000									92.6%	71.8%	54.2%	40.5%	30.7%	23.3%	14.4%	9.5%
6,000										78.6%	60.6%	45.7%	35.0%	26.4%	16.8%	10.4%
7,000											66.5%	50.5%	39.2%	30.2%	19.2%	12.2%
8,000												53.7%	42.2%	32.2%	20.2%	12.6%
9,000													45.2%	35.0%	22.7%	14.2%
10,000														38.6%	25.8%	16.5%
12,000															31.8%	21.9%
14,000																28.4%

Table H-49: Reach 3 Fallfish Spawning Persistent Habitat (ft^2), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	518,385	393,833	364,139	326,717	297,306	248,131	211,505	184,205	157,986	113,338	94,260	82,843	72,722	64,308	47,683	32,749
1,500		507,707	468,200	424,202	382,600	322,353	279,919	238,802	192,930	132,428	106,216	88,274	74,440	65,470	48,331	33,396
2,000			497,294	452,363	409,179	346,063	299,491	258,374	212,502	147,051	115,351	93,520	79,003	67,492	49,345	34,119
2,500				495,596	447,542	377,998	328,898	285,233	229,266	159,492	123,206	98,796	83,440	69,042	49,345	34,119
3,000					470,710	399,053	349,451	305,372	249,118	174,584	135,491	106,951	87,608	71,806	50,470	34,119
3,500						416,922	366,152	320,191	262,517	186,847	145,133	112,871	92,267	76,465	52,208	34,619
4,000							386,581	340,620	279,930	198,182	153,396	117,457	96,358	79,809	54,564	34,950
4,500								353,545	291,356	208,251	163,263	125,560	101,354	83,747	58,502	35,211
5,000									303,155	218,507	172,474	132,246	107,166	89,342	62,920	36,379
6,000										236,754	188,578	145,135	116,897	97,404	65,484	37,555
7,000											201,374	156,031	126,338	105,489	69,900	40,569
8,000												168,330	135,293	114,175	75,816	44,624
9,000													147,489	125,489	86,197	50,289
10,000														140,056	100,174	62,271
12,000															123,974	82,781
14,000																101,285

Table H-50: Reach 3 Fallfish Spawning Persistent Habitat (% of maximum possible), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	100.0%	76.0%	70.2%	63.0%	57.4%	47.9%	40.8%	35.5%	30.5%	21.9%	18.2%	16.0%	14.0%	12.4%	9.2%	6.3%
1,500		97.9%	90.3%	81.8%	73.8%	62.2%	54.0%	46.1%	37.2%	25.5%	20.5%	17.0%	14.4%	12.6%	9.3%	6.4%
2,000			95.9%	87.3%	78.9%	66.8%	57.8%	49.8%	41.0%	28.4%	22.3%	18.0%	15.2%	13.0%	9.5%	6.6%
2,500				95.6%	86.3%	72.9%	63.4%	55.0%	44.2%	30.8%	23.8%	19.1%	16.1%	13.3%	9.5%	6.6%
3,000					90.8%	77.0%	67.4%	58.9%	48.1%	33.7%	26.1%	20.6%	16.9%	13.9%	9.7%	6.6%
3,500						80.4%	70.6%	61.8%	50.6%	36.0%	28.0%	21.8%	17.8%	14.8%	10.1%	6.7%
4,000							74.6%	65.7%	54.0%	38.2%	29.6%	22.7%	18.6%	15.4%	10.5%	6.7%
4,500								68.2%	56.2%	40.2%	31.5%	24.2%	19.6%	16.2%	11.3%	6.8%
5,000									58.5%	42.2%	33.3%	25.5%	20.7%	17.2%	12.1%	7.0%
6,000										45.7%	36.4%	28.0%	22.6%	18.8%	12.6%	7.2%
7,000											38.8%	30.1%	24.4%	20.3%	13.5%	7.8%
8,000												32.5%	26.1%	22.0%	14.6%	8.6%
9,000													28.5%	24.2%	16.6%	9.7%
10,000														27.0%	19.3%	12.0%
12,000															23.9%	16.0%
14,000																19.5%

Table H-51: Reach 3 Fallfish Fry Persistent Habitat (ft²), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	325,559	325,559	263,541	236,481	215,363	200,364	181,356	165,350	149,241	135,705	114,620	93,615	77,800	67,370	56,401	38,362
1,500		325,559	263,541	236,481	215,363	200,364	181,356	165,350	149,241	135,705	114,620	93,615	77,800	67,370	56,401	38,362
2,000			317,836	278,818	249,979	229,841	204,333	184,345	164,436	147,172	122,763	93,698	77,818	67,370	56,401	38,362
2,500				341,409	297,813	272,035	242,551	213,419	190,524	163,688	131,736	99,751	79,565	67,370	56,401	38,362
3,000					399,911	360,556	311,875	269,132	240,478	209,016	164,295	125,685	94,333	68,611	56,634	38,362
3,500						431,641	372,298	323,723	290,067	249,240	191,164	141,181	105,137	70,922	56,812	38,362
4,000							419,791	365,170	323,192	276,816	210,330	154,668	113,023	74,777	56,820	38,362
4,500								489,233	426,089	348,220	256,878	178,164	128,298	82,276	60,320	38,362
5,000									522,406	424,498	313,928	214,044	145,723	92,688	65,894	41,235
6,000										634,478	481,332	324,432	208,613	115,689	76,316	42,369
7,000											612,914	419,160	264,395	154,571	96,011	52,359
8,000												498,546	319,140	195,466	115,405	63,983
9,000													367,406	234,874	142,659	79,648
10,000														284,765	179,060	99,808
12,000															249,839	144,118
14,000																197,832

Table H-52: Reach 3 Fallfish Fry Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	51.3%	51.3%	41.5%	37.3%	33.9%	31.6%	28.6%	26.1%	23.5%	21.4%	18.1%	14.8%	12.3%	10.6%	8.9%	6.0%
1,500		51.3%	41.5%	37.3%	33.9%	31.6%	28.6%	26.1%	23.5%	21.4%	18.1%	14.8%	12.3%	10.6%	8.9%	6.0%
2,000			50.1%	43.9%	39.4%	36.2%	32.2%	29.1%	25.9%	23.2%	19.3%	14.8%	12.3%	10.6%	8.9%	6.0%
2,500				53.8%	46.9%	42.9%	38.2%	33.6%	30.0%	25.8%	20.8%	15.7%	12.5%	10.6%	8.9%	6.0%
3,000					63.0%	56.8%	49.2%	42.4%	37.9%	32.9%	25.9%	19.8%	14.9%	10.8%	8.9%	6.0%
3,500						68.0%	58.7%	51.0%	45.7%	39.3%	30.1%	22.3%	16.6%	11.2%	9.0%	6.0%
4,000							66.2%	57.6%	50.9%	43.6%	33.2%	24.4%	17.8%	11.8%	9.0%	6.0%
4,500								77.1%	67.2%	54.9%	40.5%	28.1%	20.2%	13.0%	9.5%	6.0%
5,000									82.3%	66.9%	49.5%	33.7%	23.0%	14.6%	10.4%	6.5%
6,000										100.0%	75.9%	51.1%	32.9%	18.2%	12.0%	6.7%
7,000											96.6%	66.1%	41.7%	24.4%	15.1%	8.3%
8,000												78.6%	50.3%	30.8%	18.2%	10.1%
9,000													57.9%	37.0%	22.5%	12.6%
10,000														44.9%	28.2%	15.7%
12,000															39.4%	22.7%
14,000																31.2%

Table H-53: Reach 3 Fallfish Fry Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	318,605	318,605	275,243	247,902	230,464	183,944	171,120	157,590	151,571	135,814	112,086	94,554	87,350	77,388	55,599	38,419
1,500		318,605	275,243	247,902	230,464	183,944	171,120	157,590	151,571	135,814	112,086	94,554	87,350	77,388	55,599	38,419
2,000			347,093	307,884	280,437	219,311	197,683	180,936	169,117	148,679	121,278	98,995	88,429	77,593	55,599	38,419
2,500				385,199	347,022	275,453	241,673	216,653	199,933	169,674	137,063	113,096	93,605	77,593	55,599	38,419
3,000					412,154	326,608	282,443	250,989	230,926	197,051	159,781	133,042	104,817	79,106	55,599	38,419
3,500						380,292	331,502	292,092	266,018	224,257	176,087	146,590	115,171	84,883	55,877	38,688
4,000							458,041	400,899	365,370	298,261	208,855	161,551	125,983	93,687	55,877	38,688
4,500								496,156	450,216	360,457	254,506	191,288	143,867	108,665	57,172	38,921
5,000									570,821	457,844	331,099	247,184	174,937	123,502	60,855	39,798
6,000										615,268	441,763	324,191	221,361	152,044	68,873	44,125
7,000											564,565	413,507	282,060	197,884	85,951	53,724
8,000												495,472	346,128	251,330	107,244	63,963
9,000													390,032	286,678	127,910	76,294
10,000														343,217	170,007	105,186
12,000															238,315	155,496
14,000																229,510

Table H-54: Reach 3 Fallfish Fry Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	51.8%	51.8%	44.7%	40.3%	37.5%	29.9%	27.8%	25.6%	24.6%	22.1%	18.2%	15.4%	14.2%	12.6%	9.0%	6.2%
1,500		51.8%	44.7%	40.3%	37.5%	29.9%	27.8%	25.6%	24.6%	22.1%	18.2%	15.4%	14.2%	12.6%	9.0%	6.2%
2,000			56.4%	50.0%	45.6%	35.6%	32.1%	29.4%	27.5%	24.2%	19.7%	16.1%	14.4%	12.6%	9.0%	6.2%
2,500				62.6%	56.4%	44.8%	39.3%	35.2%	32.5%	27.6%	22.3%	18.4%	15.2%	12.6%	9.0%	6.2%
3,000					67.0%	53.1%	45.9%	40.8%	37.5%	32.0%	26.0%	21.6%	17.0%	12.9%	9.0%	6.2%
3,500						61.8%	53.9%	47.5%	43.2%	36.4%	28.6%	23.8%	18.7%	13.8%	9.1%	6.3%
4,000							74.4%	65.2%	59.4%	48.5%	33.9%	26.3%	20.5%	15.2%	9.1%	6.3%
4,500								80.6%	73.2%	58.6%	41.4%	31.1%	23.4%	17.7%	9.3%	6.3%
5,000									92.8%	74.4%	53.8%	40.2%	28.4%	20.1%	9.9%	6.5%
6,000										100.0%	71.8%	52.7%	36.0%	24.7%	11.2%	7.2%
7,000											91.8%	67.2%	45.8%	32.2%	14.0%	8.7%
8,000												80.5%	56.3%	40.8%	17.4%	10.4%
9,000													63.4%	46.6%	20.8%	12.4%
10,000														55.8%	27.6%	17.1%
12,000															38.7%	25.3%
14,000																37.3%

Table H-55: Reach 3 Fallfish Fry Persistent Habitat (ft²), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	332,677	229,401	214,977	210,437	192,457	185,597	179,268	172,113	166,471	136,864	110,711	98,098	88,940	77,512	56,593	41,898
1,500		381,029	345,275	317,507	276,204	251,402	237,561	221,191	208,478	165,563	120,661	100,739	89,677	77,893	56,593	41,898
2,000			431,618	389,326	340,365	300,384	278,680	258,255	241,050	191,780	141,487	116,259	93,033	78,147	56,593	41,898
2,500				451,907	395,150	344,103	316,323	293,082	273,341	219,322	164,353	134,497	103,326	81,324	56,593	41,898
3,000					454,480	398,296	363,902	332,858	309,802	245,360	178,946	146,563	113,059	86,778	57,010	42,108
3,500						493,828	449,594	407,884	366,580	287,667	204,740	162,016	125,519	96,572	59,346	42,125
4,000							544,474	489,609	440,111	344,305	238,496	182,729	136,377	104,296	62,128	42,733
4,500								588,107	529,577	417,272	287,372	216,527	154,370	111,391	66,333	43,498
5,000									617,415	494,721	343,383	251,705	174,853	120,056	71,864	44,573
6,000										598,192	419,366	300,215	210,684	144,269	87,030	50,331
7,000											494,736	352,572	252,551	175,381	109,847	56,749
8,000												408,313	297,382	205,143	123,011	64,964
9,000													339,387	237,164	140,444	75,948
10,000														281,226	170,226	92,119
12,000															241,454	135,804
14,000																199,052

Table H-56: Reach 3 Fallfish Fry Habitat (% of maximum possible), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	53.9%	37.2%	34.8%	34.1%	31.2%	30.1%	29.0%	27.9%	27.0%	22.2%	17.9%	15.9%	14.4%	12.6%	9.2%	6.8%
1,500		61.7%	55.9%	51.4%	44.7%	40.7%	38.5%	35.8%	33.8%	26.8%	19.5%	16.3%	14.5%	12.6%	9.2%	6.8%
2,000			69.9%	63.1%	55.1%	48.7%	45.1%	41.8%	39.0%	31.1%	22.9%	18.8%	15.1%	12.7%	9.2%	6.8%
2,500				73.2%	64.0%	55.7%	51.2%	47.5%	44.3%	35.5%	26.6%	21.8%	16.7%	13.2%	9.2%	6.8%
3,000					73.6%	64.5%	58.9%	53.9%	50.2%	39.7%	29.0%	23.7%	18.3%	14.1%	9.2%	6.8%
3,500						80.0%	72.8%	66.1%	59.4%	46.6%	33.2%	26.2%	20.3%	15.6%	9.6%	6.8%
4,000							88.2%	79.3%	71.3%	55.8%	38.6%	29.6%	22.1%	16.9%	10.1%	6.9%
4,500								95.3%	85.8%	67.6%	46.5%	35.1%	25.0%	18.0%	10.7%	7.0%
5,000									100.0%	80.1%	55.6%	40.8%	28.3%	19.4%	11.6%	7.2%
6,000										96.9%	67.9%	48.6%	34.1%	23.4%	14.1%	8.2%
7,000											80.1%	57.1%	40.9%	28.4%	17.8%	9.2%
8,000												66.1%	48.2%	33.2%	19.9%	10.5%
9,000													55.0%	38.4%	22.7%	12.3%
10,000														45.5%	27.6%	14.9%
12,000															39.1%	22.0%
14,000																32.2%

Table H-57: Reach 3 Fallfish Fry Persistent Habitat (ft^2), Bypass Q = 3,000 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	586,837	458,986	425,414	398,939	368,119	335,333	305,377	248,515	210,589	142,461	100,670	86,541	69,579	62,415	48,351	30,018
1,500		555,023	504,546	462,614	418,575	375,667	336,864	270,813	226,013	152,700	107,514	88,311	69,977	62,813	48,563	30,230
2,000			576,515	520,557	470,600	421,379	374,946	297,940	243,341	164,681	114,742	93,013	72,431	63,760	48,918	30,230
2,500				578,718	517,332	460,398	410,175	323,741	265,516	177,865	123,837	95,693	73,205	64,264	48,918	30,230
3,000					569,289	505,409	448,854	354,989	288,418	192,566	135,229	101,249	77,850	68,692	51,294	30,283
3,500						539,730	475,894	377,388	307,484	204,702	143,430	104,417	80,162	70,674	52,214	30,293
4,000							526,149	419,530	344,186	229,319	161,555	114,844	87,955	75,768	55,460	30,322
4,500								471,223	392,198	265,313	185,815	130,376	99,932	86,389	62,727	32,368
5,000									421,149	282,786	200,022	141,518	107,917	92,442	67,625	36,117
6,000										319,330	232,447	159,704	119,865	101,421	73,715	40,234
7,000											259,855	180,124	136,570	111,009	78,533	42,503
8,000												209,487	161,275	128,523	88,050	47,000
9,000													185,888	148,169	103,558	58,244
10,000														170,403	117,852	68,490
12,000															159,269	99,180
14,000																127,826

Table H-58: Reach 3 Fallfish Fry Persistent Habitat (% of maximum possible), Bypass Q = 3,000 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	100.0%	78.2%	72.5%	68.0%	62.7%	57.1%	52.0%	42.3%	35.9%	24.3%	17.2%	14.7%	11.9%	10.6%	8.2%	5.1%
1,500		94.6%	86.0%	78.8%	71.3%	64.0%	57.4%	46.1%	38.5%	26.0%	18.3%	15.0%	11.9%	10.7%	8.3%	5.2%
2,000			98.2%	88.7%	80.2%	71.8%	63.9%	50.8%	41.5%	28.1%	19.6%	15.8%	12.3%	10.9%	8.3%	5.2%
2,500				98.6%	88.2%	78.5%	69.9%	55.2%	45.2%	30.3%	21.1%	16.3%	12.5%	11.0%	8.3%	5.2%
3,000					97.0%	86.1%	76.5%	60.5%	49.1%	32.8%	23.0%	17.3%	13.3%	11.7%	8.7%	5.2%
3,500						92.0%	81.1%	64.3%	52.4%	34.9%	24.4%	17.8%	13.7%	12.0%	8.9%	5.2%
4,000							89.7%	71.5%	58.7%	39.1%	27.5%	19.6%	15.0%	12.9%	9.5%	5.2%
4,500								80.3%	66.8%	45.2%	31.7%	22.2%	17.0%	14.7%	10.7%	5.5%
5,000									71.8%	48.2%	34.1%	24.1%	18.4%	15.8%	11.5%	6.2%
6,000										54.4%	39.6%	27.2%	20.4%	17.3%	12.6%	6.9%
7,000											44.3%	30.7%	23.3%	18.9%	13.4%	7.2%
8,000												35.7%	27.5%	21.9%	15.0%	8.0%
9,000													31.7%	25.2%	17.6%	9.9%
10,000														29.0%	20.1%	11.7%
12,000															27.1%	16.9%
14,000																21.8%

Table H-59: Reach 3 Fallfish Fry Persistent Habitat (ft^2), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	517,945	362,572	309,908	266,958	227,914	187,018	158,287	133,433	108,834	82,947	73,206	61,682	54,305	47,510	32,326	21,842
1,500		470,465	395,482	330,736	282,033	225,578	186,017	156,594	126,384	91,337	77,006	63,949	55,989	48,252	32,345	21,852
2,000			434,010	366,117	314,550	251,051	203,415	167,730	134,334	97,351	79,468	64,531	56,277	48,540	32,363	21,852
2,500				402,087	344,613	277,051	223,471	184,753	148,850	106,717	86,591	70,340	60,868	52,289	33,463	21,852
3,000					369,948	295,361	238,817	195,954	159,111	114,515	91,626	72,713	63,241	53,782	33,975	21,861
3,500						308,929	248,576	203,848	164,406	119,260	93,703	73,786	64,046	54,587	34,780	21,870
4,000							269,534	219,976	178,647	127,586	100,626	78,566	67,520	56,634	36,818	22,074
4,500								235,270	189,758	134,822	106,391	79,906	68,668	57,290	37,240	22,487
5,000									203,635	145,122	115,180	88,047	74,092	61,382	39,101	24,339
6,000										164,576	129,521	98,470	83,247	68,542	42,965	26,175
7,000											145,370	112,152	94,373	77,356	47,657	29,362
8,000												130,531	109,300	88,896	54,290	33,287
9,000													131,406	107,769	67,101	37,369
10,000														128,468	82,875	47,972
12,000															115,625	71,183
14,000																87,438

Table H-60: Reach 3 Fallfish Fry Persistent Habitat (% of maximum possible), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	100.0%	70.0%	59.8%	51.5%	44.0%	36.1%	30.6%	25.8%	21.0%	16.0%	14.1%	11.9%	10.5%	9.2%	6.2%	4.2%
1,500		90.8%	76.4%	63.9%	54.5%	43.6%	35.9%	30.2%	24.4%	17.6%	14.9%	12.3%	10.8%	9.3%	6.2%	4.2%
2,000			83.8%	70.7%	60.7%	48.5%	39.3%	32.4%	25.9%	18.8%	15.3%	12.5%	10.9%	9.4%	6.2%	4.2%
2,500				77.6%	66.5%	53.5%	43.1%	35.7%	28.7%	20.6%	16.7%	13.6%	11.8%	10.1%	6.5%	4.2%
3,000					71.4%	57.0%	46.1%	37.8%	30.7%	22.1%	17.7%	14.0%	12.2%	10.4%	6.6%	4.2%
3,500						59.6%	48.0%	39.4%	31.7%	23.0%	18.1%	14.2%	12.4%	10.5%	6.7%	4.2%
4,000							52.0%	42.5%	34.5%	24.6%	19.4%	15.2%	13.0%	10.9%	7.1%	4.3%
4,500								45.4%	36.6%	26.0%	20.5%	15.4%	13.3%	11.1%	7.2%	4.3%
5,000									39.3%	28.0%	22.2%	17.0%	14.3%	11.9%	7.5%	4.7%
6,000										31.8%	25.0%	19.0%	16.1%	13.2%	8.3%	5.1%
7,000											28.1%	21.7%	18.2%	14.9%	9.2%	5.7%
8,000												25.2%	21.1%	17.2%	10.5%	6.4%
9,000													25.4%	20.8%	13.0%	7.2%
10,000														24.8%	16.0%	9.3%
12,000															22.3%	13.7%
14,000																16.9%

Table H-61: Reach 3 White Sucker Spawning Persistent Habitat (ft^2), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	92,697	92,697	65,627	55,153	49,852	44,767	43,571	41,970	37,848	34,881	29,214	21,403	5,868	1,188	249	249
1,500		92,697	65,627	55,153	49,852	44,767	43,571	41,970	37,848	34,881	29,214	21,403	5,868	1,188	249	249
2,000			89,920	67,798	51,266	45,013	43,571	41,970	37,848	34,881	29,214	21,403	5,868	1,188	249	249
2,500				82,797	56,352	45,330	43,571	41,970	37,848	34,881	29,214	21,403	5,868	1,188	249	249
3,000					73,139	54,086	46,688	42,499	38,141	34,881	29,214	21,403	5,868	1,188	249	249
3,500						80,656	68,572	59,131	46,225	34,881	29,214	21,403	5,868	1,188	249	249
4,000							82,767	69,585	50,718	34,881	29,214	21,403	5,868	1,188	249	249
4,500								78,956	57,661	35,827	30,160	21,403	5,868	1,188	249	249
5,000									70,700	38,319	30,160	21,403	5,868	1,188	249	249
6,000										69,987	40,899	21,613	5,868	1,188	249	249
7,000											68,665	31,097	6,951	1,188	249	249
8,000												52,408	12,120	1,659	249	249
9,000													18,390	2,184	249	249
10,000														6,409	249	249
12,000															600	249
14,000																2,431

Table H-62: Reach 3 White Sucker Spawning Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	100.0%	100.0%	70.8%	59.5%	53.8%	48.3%	47.0%	45.3%	40.8%	37.6%	31.5%	23.1%	6.3%	1.3%	0.3%	0.3%
1,500		100.0%	70.8%	59.5%	53.8%	48.3%	47.0%	45.3%	40.8%	37.6%	31.5%	23.1%	6.3%	1.3%	0.3%	0.3%
2,000			97.0%	73.1%	55.3%	48.6%	47.0%	45.3%	40.8%	37.6%	31.5%	23.1%	6.3%	1.3%	0.3%	0.3%
2,500				89.3%	60.8%	48.9%	47.0%	45.3%	40.8%	37.6%	31.5%	23.1%	6.3%	1.3%	0.3%	0.3%
3,000					78.9%	58.3%	50.4%	45.8%	41.1%	37.6%	31.5%	23.1%	6.3%	1.3%	0.3%	0.3%
3,500						87.0%	74.0%	63.8%	49.9%	37.6%	31.5%	23.1%	6.3%	1.3%	0.3%	0.3%
4,000							89.3%	75.1%	54.7%	37.6%	31.5%	23.1%	6.3%	1.3%	0.3%	0.3%
4,500								85.2%	62.2%	38.6%	32.5%	23.1%	6.3%	1.3%	0.3%	0.3%
5,000									76.3%	41.3%	32.5%	23.1%	6.3%	1.3%	0.3%	0.3%
6,000										75.5%	44.1%	23.3%	6.3%	1.3%	0.3%	0.3%
7,000											74.1%	33.5%	7.5%	1.3%	0.3%	0.3%
8,000												56.5%	13.1%	1.8%	0.3%	0.3%
9,000													19.8%	2.4%	0.3%	0.3%
10,000														6.9%	0.3%	0.3%
12,000															0.6%	0.3%
14,000																2.6%

Table H-63: Reach 3 White Sucker Spawning Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	74,602	74,602	51,214	42,549	41,192	40,314	39,351	37,157	36,218	32,649	28,819	24,820	14,800	10,958	852	0
1,500		74,602	51,214	42,549	41,192	40,314	39,351	37,157	36,218	32,649	28,819	24,820	14,800	10,958	852	0
2,000			72,236	49,302	41,438	40,314	39,351	37,157	36,218	32,649	28,819	24,820	14,800	10,958	852	0
2,500				63,514	48,333	43,463	39,971	37,591	36,653	32,881	28,819	24,820	14,800	10,958	852	0
3,000					72,332	61,928	52,282	45,401	36,653	32,881	28,819	24,820	14,800	10,958	852	0
3,500						91,560	76,593	60,940	42,659	34,154	29,101	25,102	14,800	10,958	852	0
4,000							85,992	68,202	47,736	35,374	29,101	25,102	14,800	10,958	852	0
4,500								83,820	57,916	37,209	29,971	25,102	14,800	10,958	852	0
5,000									67,336	39,981	30,268	25,102	14,800	10,958	852	0
6,000										71,298	41,093	25,617	14,800	10,958	852	0
7,000											68,317	35,187	14,800	10,958	852	0
8,000												55,576	19,423	12,862	852	0
9,000													23,353	15,394	852	0
10,000														17,598	852	0
12,000															2,038	307
14,000																4,323

Table H-64: Reach 3 White Sucker Spawning Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	81.5%	81.5%	55.9%	46.5%	45.0%	44.0%	43.0%	40.6%	39.6%	35.7%	31.5%	27.1%	16.2%	12.0%	0.9%	0.0%
1,500		81.5%	55.9%	46.5%	45.0%	44.0%	43.0%	40.6%	39.6%	35.7%	31.5%	27.1%	16.2%	12.0%	0.9%	0.0%
2,000			78.9%	53.8%	45.3%	44.0%	43.0%	40.6%	39.6%	35.7%	31.5%	27.1%	16.2%	12.0%	0.9%	0.0%
2,500				69.4%	52.8%	47.5%	43.7%	41.1%	40.0%	35.9%	31.5%	27.1%	16.2%	12.0%	0.9%	0.0%
3,000					79.0%	67.6%	57.1%	49.6%	40.0%	35.9%	31.5%	27.1%	16.2%	12.0%	0.9%	0.0%
3,500						100.0%	83.7%	66.6%	46.6%	37.3%	31.8%	27.4%	16.2%	12.0%	0.9%	0.0%
4,000							93.9%	74.5%	52.1%	38.6%	31.8%	27.4%	16.2%	12.0%	0.9%	0.0%
4,500								91.5%	63.3%	40.6%	32.7%	27.4%	16.2%	12.0%	0.9%	0.0%
5,000									73.5%	43.7%	33.1%	27.4%	16.2%	12.0%	0.9%	0.0%
6,000										77.9%	44.9%	28.0%	16.2%	12.0%	0.9%	0.0%
7,000											74.6%	38.4%	16.2%	12.0%	0.9%	0.0%
8,000												60.7%	21.2%	14.0%	0.9%	0.0%
9,000													25.5%	16.8%	0.9%	0.0%
10,000														19.2%	0.9%	0.0%
12,000															2.2%	0.3%
14,000																4.7%

Table H-65: Reach 3 White Sucker Spawning Persistent Habitat (ft^2), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	54,607	26,698	26,340	26,087	26,087	24,216	24,040	22,531	21,233	20,233	16,711	11,830	9,937	6,270	1,362	475
1,500		68,159	43,560	29,434	26,961	25,090	24,040	22,531	21,233	20,233	16,711	11,830	9,937	6,270	1,362	475
2,000			59,353	36,814	31,548	25,931	24,297	22,788	21,491	20,490	16,968	11,830	9,937	6,270	1,362	475
2,500				62,732	51,699	40,654	33,866	22,788	21,491	20,490	16,968	11,830	9,937	6,270	1,362	475
3,000					83,830	67,463	53,426	30,967	22,082	21,082	17,307	11,980	9,937	6,270	1,362	475
3,500						75,299	58,026	34,229	23,290	21,082	17,307	11,980	9,937	6,270	1,362	475
4,000							74,490	46,158	29,637	21,082	17,307	11,980	9,937	6,270	1,362	475
4,500								61,793	43,526	22,557	17,824	11,980	9,937	6,270	1,362	475
5,000									68,940	36,197	21,432	12,236	9,937	6,270	1,362	475
6,000										66,358	30,931	14,382	9,937	6,270	1,362	475
7,000											55,934	18,175	11,011	6,270	1,362	475
8,000												31,434	13,887	6,795	1,362	475
9,000													19,775	8,303	2,329	475
10,000														13,802	3,080	475
12,000															8,455	1,627
14,000																7,343

Table H-66: Reach 3 White Sucker Spawning Habitat (% of maximum possible), Bypass Q = 1,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	65.1%	31.8%	31.4%	31.1%	31.1%	28.9%	28.7%	26.9%	25.3%	24.1%	19.9%	14.1%	11.9%	7.5%	1.6%	0.6%
1,500		81.3%	52.0%	35.1%	32.2%	29.9%	28.7%	26.9%	25.3%	24.1%	19.9%	14.1%	11.9%	7.5%	1.6%	0.6%
2,000			70.8%	43.9%	37.6%	30.9%	29.0%	27.2%	25.6%	24.4%	20.2%	14.1%	11.9%	7.5%	1.6%	0.6%
2,500				74.8%	61.7%	48.5%	40.4%	27.2%	25.6%	24.4%	20.2%	14.1%	11.9%	7.5%	1.6%	0.6%
3,000					100.0%	80.5%	63.7%	36.9%	26.3%	25.1%	20.6%	14.3%	11.9%	7.5%	1.6%	0.6%
3,500						89.8%	69.2%	40.8%	27.8%	25.1%	20.6%	14.3%	11.9%	7.5%	1.6%	0.6%
4,000							88.9%	55.1%	35.4%	25.1%	20.6%	14.3%	11.9%	7.5%	1.6%	0.6%
4,500								73.7%	51.9%	26.9%	21.3%	14.3%	11.9%	7.5%	1.6%	0.6%
5,000									82.2%	43.2%	25.6%	14.6%	11.9%	7.5%	1.6%	0.6%
6,000										79.2%	36.9%	17.2%	11.9%	7.5%	1.6%	0.6%
7,000											66.7%	21.7%	13.1%	7.5%	1.6%	0.6%
8,000												37.5%	16.6%	8.1%	1.6%	0.6%
9,000													23.6%	9.9%	2.8%	0.6%
10,000														16.5%	3.7%	0.6%
12,000															10.1%	1.9%
14,000																8.8%

Table H-67: Reach 3 White Sucker Spawning Persistent Habitat (ft^2), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	108,361	59,268	49,599	40,597	35,056	27,283	21,845	17,201	16,505	13,839	10,849	10,287	6,077	4,295	2,678	2,380
1,500		113,019	90,736	59,892	37,989	27,673	22,235	17,591	16,895	13,866	10,877	10,315	6,105	4,322	2,678	2,380
2,000			106,323	72,503	44,990	30,479	23,841	18,900	18,204	13,866	10,877	10,315	6,105	4,322	2,678	2,380
2,500				89,996	58,350	39,173	27,943	21,149	19,413	13,866	10,877	10,315	6,105	4,322	2,678	2,380
3,000					78,232	54,822	39,784	24,592	21,692	13,866	10,877	10,315	6,105	4,322	2,678	2,380
3,500						70,391	52,348	33,088	25,701	15,614	11,799	11,237	7,027	5,245	2,678	2,380
4,000							69,096	42,063	31,581	18,015	11,808	11,246	7,037	5,254	2,678	2,380
4,500								70,582	56,193	23,499	13,723	11,456	7,246	5,464	2,678	2,380
5,000									70,452	28,070	15,398	11,465	7,256	5,464	2,678	2,380
6,000										42,283	19,436	12,092	7,633	5,677	2,678	2,380
7,000											24,653	12,961	7,697	5,723	2,687	2,380
8,000												16,718	9,400	6,446	2,697	2,380
9,000													15,196	9,515	4,392	2,380
10,000														12,045	6,300	2,380
12,000															10,886	4,853
14,000																8,935

Table H-68: Reach 3 White Sucker Spawning Persistent Habitat (% of maximum possible), Bypass Q = 3,000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**6,000**	**7,000**	**8,000**	**9,000**	**10,000**	**12,000**	**14,000**
0	95.9%	52.4%	43.9%	35.9%	31.0%	24.1%	19.3%	15.2%	14.6%	12.2%	9.6%	9.1%	5.4%	3.8%	2.4%	2.1%
1,500		100.0%	80.3%	53.0%	33.6%	24.5%	19.7%	15.6%	14.9%	12.3%	9.6%	9.1%	5.4%	3.8%	2.4%	2.1%
2,000			94.1%	64.2%	39.8%	27.0%	21.1%	16.7%	16.1%	12.3%	9.6%	9.1%	5.4%	3.8%	2.4%	2.1%
2,500				79.6%	51.6%	34.7%	24.7%	18.7%	17.2%	12.3%	9.6%	9.1%	5.4%	3.8%	2.4%	2.1%
3,000					69.2%	48.5%	35.2%	21.8%	19.2%	12.3%	9.6%	9.1%	5.4%	3.8%	2.4%	2.1%
3,500						62.3%	46.3%	29.3%	22.7%	13.8%	10.4%	9.9%	6.2%	4.6%	2.4%	2.1%
4,000							61.1%	37.2%	27.9%	15.9%	10.4%	10.0%	6.2%	4.6%	2.4%	2.1%
4,500								62.5%	49.7%	20.8%	12.1%	10.1%	6.4%	4.8%	2.4%	2.1%
5,000									62.3%	24.8%	13.6%	10.1%	6.4%	4.8%	2.4%	2.1%
6,000										37.4%	17.2%	10.7%	6.8%	5.0%	2.4%	2.1%
7,000											21.8%	11.5%	6.8%	5.1%	2.4%	2.1%
8,000												14.8%	8.3%	5.7%	2.4%	2.1%
9,000													13.4%	8.4%	3.9%	2.1%
10,000														10.7%	5.6%	2.1%
12,000															9.6%	4.3%
14,000																7.9%

Table H-69: Reach 3 White Sucker Spawning Persistent Habitat (ft²), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	120,969	34,455	27,538	23,155	19,593	18,025	16,403	14,002	12,844	10,426	8,029	4,969	4,204	3,607	2,242	1,111
1,500		66,025	51,119	37,562	28,406	23,313	20,483	17,716	15,756	10,640	8,243	5,184	4,204	3,607	2,242	1,111
2,000			78,209	55,863	42,285	27,955	22,698	19,383	16,609	10,640	8,243	5,184	4,204	3,607	2,242	1,111
2,500				77,105	59,407	35,224	25,113	21,527	18,146	10,640	8,243	5,184	4,204	3,607	2,242	1,111
3,000					73,383	46,065	30,906	24,790	21,409	12,019	9,305	6,245	4,388	3,790	2,242	1,111
3,500						56,095	37,006	26,960	23,579	12,846	9,314	6,254	4,397	3,799	2,242	1,111
4,000							44,512	31,671	26,244	13,889	9,350	6,290	4,433	3,836	2,278	1,111
4,500								35,355	29,333	14,536	9,997	6,318	4,461	3,863	2,306	1,111
5,000									29,342	14,545	10,006	6,318	4,461	3,863	2,306	1,111
6,000										17,781	11,196	7,269	5,061	4,243	2,333	1,111
7,000											12,110	8,182	5,974	5,156	2,600	1,111
8,000												9,615	7,407	6,244	2,682	1,120
9,000													10,827	9,453	3,665	1,661
10,000														15,137	5,977	2,075
12,000															15,765	7,954
14,000																11,851

Table H-70: Reach 3 White Sucker Spawning Persistent Habitat (% of maximum possible), Bypass Q = 5,000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
0	100.0%	28.5%	22.8%	19.1%	16.2%	14.9%	13.6%	11.6%	10.6%	8.6%	6.6%	4.1%	3.5%	3.0%	1.9%	0.9%
1,500		54.6%	42.3%	31.1%	23.5%	19.3%	16.9%	14.6%	13.0%	8.8%	6.8%	4.3%	3.5%	3.0%	1.9%	0.9%
2,000			64.7%	46.2%	35.0%	23.1%	18.8%	16.0%	13.7%	8.8%	6.8%	4.3%	3.5%	3.0%	1.9%	0.9%
2,500				63.7%	49.1%	29.1%	20.8%	17.8%	15.0%	8.8%	6.8%	4.3%	3.5%	3.0%	1.9%	0.9%
3,000					60.7%	38.1%	25.5%	20.5%	17.7%	9.9%	7.7%	5.2%	3.6%	3.1%	1.9%	0.9%
3,500						46.4%	30.6%	22.3%	19.5%	10.6%	7.7%	5.2%	3.6%	3.1%	1.9%	0.9%
4,000							36.8%	26.2%	21.7%	11.5%	7.7%	5.2%	3.7%	3.2%	1.9%	0.9%
4,500								29.2%	24.2%	12.0%	8.3%	5.2%	3.7%	3.2%	1.9%	0.9%
5,000									24.3%	12.0%	8.3%	5.2%	3.7%	3.2%	1.9%	0.9%
6,000										14.7%	9.3%	6.0%	4.2%	3.5%	1.9%	0.9%
7,000											10.0%	6.8%	4.9%	4.3%	2.1%	0.9%
8,000												7.9%	6.1%	5.2%	2.2%	0.9%
9,000													9.0%	7.8%	3.0%	1.4%
10,000														12.5%	4.9%	1.7%
12,000															13.0%	6.6%
14,000																9.8%

Table H-71: Reach 3 White Sucker Fry Persistent Habitat (ft^2), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	1,834,005	1,834,005	1,727,855	1,674,782	1,622,514	1,582,711	1,552,804	1,517,427	1,494,538	1,456,897	1,389,717	1,338,090	1,278,958	1,223,864	1,114,075	1,061,168
1500		1,834,005	1,727,855	1,674,782	1,622,514	1,582,711	1,552,804	1,517,427	1,494,538	1,456,897	1,389,717	1,338,090	1,278,958	1,223,864	1,114,075	1,061,168
2000			1,807,173	1,739,300	1,675,747	1,630,469	1,598,838	1,559,723	1,536,001	1,494,121	1,422,317	1,368,799	1,307,615	1,250,355	1,138,249	1,084,006
2500				1,838,469	1,753,778	1,701,740	1,664,496	1,621,342	1,595,782	1,547,366	1,467,225	1,408,267	1,343,842	1,281,390	1,166,863	1,108,291
3000					1,855,513	1,793,840	1,749,270	1,702,056	1,672,739	1,620,532	1,531,230	1,467,517	1,394,760	1,323,294	1,198,068	1,135,686
3500						1,948,072	1,890,352	1,834,681	1,799,409	1,733,372	1,633,865	1,559,182	1,474,016	1,391,267	1,256,524	1,188,773
4000							2,047,428	1,972,222	1,929,229	1,853,559	1,736,295	1,654,836	1,557,346	1,467,847	1,322,385	1,246,918
4500								2,108,490	2,059,425	1,971,688	1,835,242	1,746,783	1,637,848	1,542,453	1,380,620	1,296,441
5000									2,288,706	2,176,185	2,019,869	1,917,778	1,797,208	1,691,349	1,508,559	1,413,890
6000										2,473,516	2,284,306	2,145,602	2,009,047	1,879,814	1,675,128	1,563,160
7000											2,497,619	2,316,948	2,166,156	2,023,990	1,798,384	1,669,647
8000												2,485,169	2,317,879	2,157,787	1,915,790	1,768,177
9000													2,458,993	2,285,745	2,026,561	1,864,156
10000														2,403,891	2,131,066	1,954,318
12000															2,347,291	2,153,391
14000																2,337,874

Table H-72: Reach 3 White Sucker Fry Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	73.4%	73.4%	69.2%	67.1%	65.0%	63.4%	62.2%	60.8%	59.8%	58.3%	55.6%	53.6%	51.2%	49.0%	44.6%	42.5%
1500		73.4%	69.2%	67.1%	65.0%	63.4%	62.2%	60.8%	59.8%	58.3%	55.6%	53.6%	51.2%	49.0%	44.6%	42.5%
2000			72.4%	69.6%	67.1%	65.3%	64.0%	62.4%	61.5%	59.8%	56.9%	54.8%	52.4%	50.1%	45.6%	43.4%
2500				73.6%	70.2%	68.1%	66.6%	64.9%	63.9%	62.0%	58.7%	56.4%	53.8%	51.3%	46.7%	44.4%
3000					74.3%	71.8%	70.0%	68.1%	67.0%	64.9%	61.3%	58.8%	55.8%	53.0%	48.0%	45.5%
3500						78.0%	75.7%	73.5%	72.0%	69.4%	65.4%	62.4%	59.0%	55.7%	50.3%	47.6%
4000							82.0%	79.0%	77.2%	74.2%	69.5%	66.3%	62.4%	58.8%	52.9%	49.9%
4500								84.4%	82.5%	78.9%	73.5%	69.9%	65.6%	61.8%	55.3%	51.9%
5000									91.6%	87.1%	80.9%	76.8%	72.0%	67.7%	60.4%	56.6%
6000										99.0%	91.5%	85.9%	80.4%	75.3%	67.1%	62.6%
7000											100.0%	92.8%	86.7%	81.0%	72.0%	66.8%
8000												99.5%	92.8%	86.4%	76.7%	70.8%
9000													98.5%	91.5%	81.1%	74.6%
10000														96.2%	85.3%	78.2%
12000															94.0%	86.2%
14000																93.6%

Table H-73: Reach 3 White Sucker Fry Persistent Habitat (ft²), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	1,598,834	1,598,834	1,531,535	1,484,880	1,434,635	1,388,016	1,359,490	1,340,380	1,320,961	1,281,537	1,220,799	1,179,812	1,118,402	1,053,509	972,712	919,674
1500		1,598,834	1,531,535	1,484,880	1,434,635	1,388,016	1,359,490	1,340,380	1,320,961	1,281,537	1,220,799	1,179,812	1,118,402	1,053,509	972,712	919,674
2000			1,653,112	1,588,823	1,529,588	1,474,477	1,442,679	1,421,089	1,400,413	1,354,503	1,277,372	1,229,276	1,160,012	1,089,966	995,438	937,452
2500				1,672,443	1,602,589	1,540,402	1,503,877	1,478,185	1,453,575	1,402,237	1,318,921	1,268,889	1,197,863	1,126,313	1,021,333	960,272
3000					1,736,377	1,665,223	1,624,247	1,593,014	1,565,060	1,502,852	1,409,070	1,352,263	1,268,204	1,186,321	1,058,833	994,770
3500						1,787,050	1,738,111	1,700,454	1,666,933	1,590,477	1,483,133	1,422,148	1,328,691	1,235,766	1,097,816	1,026,903
4000							1,887,713	1,839,617	1,797,058	1,706,057	1,580,504	1,509,820	1,406,769	1,302,852	1,151,750	1,072,099
4500								1,972,941	1,916,539	1,814,468	1,677,551	1,598,048	1,485,071	1,371,866	1,211,710	1,124,728
5000									2,076,051	1,961,145	1,799,540	1,710,201	1,580,622	1,453,958	1,284,460	1,188,063
6000										2,255,300	2,045,278	1,932,366	1,781,252	1,634,356	1,450,527	1,333,561
7000											2,267,427	2,119,628	1,957,063	1,796,676	1,594,818	1,467,952
8000												2,369,436	2,188,273	2,011,234	1,798,374	1,658,792
9000													2,364,381	2,176,547	1,946,494	1,793,046
10000														2,284,171	2,042,678	1,883,806
12000															2,266,558	2,083,902
14000																2,304,305

Table H-74: Reach 3 White Sucker Fry Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	67.5%	67.5%	64.6%	62.7%	60.5%	58.6%	57.4%	56.6%	55.8%	54.1%	51.5%	49.8%	47.2%	44.5%	41.1%	38.8%
1500		67.5%	64.6%	62.7%	60.5%	58.6%	57.4%	56.6%	55.8%	54.1%	51.5%	49.8%	47.2%	44.5%	41.1%	38.8%
2000			69.8%	67.1%	64.6%	62.2%	60.9%	60.0%	59.1%	57.2%	53.9%	51.9%	49.0%	46.0%	42.0%	39.6%
2500				70.6%	67.6%	65.0%	63.5%	62.4%	61.3%	59.2%	55.7%	53.6%	50.6%	47.5%	43.1%	40.5%
3000					73.3%	70.3%	68.5%	67.2%	66.1%	63.4%	59.5%	57.1%	53.5%	50.1%	44.7%	42.0%
3500						75.4%	73.4%	71.8%	70.4%	67.1%	62.6%	60.0%	56.1%	52.2%	46.3%	43.3%
4000							79.7%	77.6%	75.8%	72.0%	66.7%	63.7%	59.4%	55.0%	48.6%	45.2%
4500								83.3%	80.9%	76.6%	70.8%	67.4%	62.7%	57.9%	51.1%	47.5%
5000									87.6%	82.8%	75.9%	72.2%	66.7%	61.4%	54.2%	50.1%
6000										95.2%	86.3%	81.6%	75.2%	69.0%	61.2%	56.3%
7000											95.7%	89.5%	82.6%	75.8%	67.3%	62.0%
8000												100.0%	92.4%	84.9%	75.9%	70.0%
9000													99.8%	91.9%	82.2%	75.7%
10000														96.4%	86.2%	79.5%
12000															95.7%	87.9%
14000																97.3%

Table H-75: Reach 3 White Sucker Fry Persistent Habitat (ft^2), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	1,654,804	1,383,794	1,343,620	1,302,484	1,272,514	1,246,900	1,228,387	1,211,329	1,172,240	1,134,229	1,081,272	1,023,189	950,087	881,192	825,521	784,252
1500		1,638,404	1,578,172	1,517,774	1,467,591	1,429,712	1,403,556	1,373,528	1,322,114	1,252,707	1,181,332	1,109,442	1,020,062	938,732	869,354	817,910
2000			1,668,469	1,596,285	1,537,872	1,495,871	1,465,921	1,429,953	1,374,193	1,297,912	1,221,923	1,147,579	1,056,041	970,128	894,796	837,659
2500				1,669,438	1,600,925	1,553,916	1,519,002	1,480,529	1,422,629	1,340,836	1,260,043	1,182,435	1,087,452	995,409	914,726	851,836
3000					1,701,821	1,646,168	1,601,293	1,556,333	1,491,255	1,391,953	1,307,086	1,226,042	1,124,074	1,026,398	938,645	871,711
3500						1,764,212	1,706,518	1,654,564	1,581,058	1,465,042	1,370,733	1,279,823	1,173,986	1,066,601	968,963	897,126
4000							1,820,344	1,749,694	1,670,409	1,541,782	1,438,263	1,336,694	1,219,114	1,103,359	1,002,001	928,610
4500								1,861,750	1,771,213	1,622,865	1,505,758	1,393,456	1,264,763	1,142,007	1,036,328	957,849
5000									1,900,685	1,727,690	1,595,165	1,478,092	1,331,353	1,203,008	1,092,539	1,006,365
6000										1,921,419	1,757,333	1,619,498	1,455,453	1,314,804	1,190,664	1,094,469
7000											1,920,811	1,759,552	1,581,563	1,430,413	1,295,280	1,189,886
8000												1,939,659	1,738,858	1,575,759	1,425,041	1,310,068
9000													1,911,263	1,737,781	1,568,151	1,439,541
10000														1,925,321	1,734,568	1,595,984
12000															2,061,457	1,902,572
14000																2,118,932

Table H-76: Reach 3 White Sucker Fry Persistent Habitat (% of maximum possible), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	78.1%	65.3%	63.4%	61.5%	60.1%	58.8%	58.0%	57.2%	55.3%	53.5%	51.0%	48.3%	44.8%	41.6%	39.0%	37.0%
1500		77.3%	74.5%	71.6%	69.3%	67.5%	66.2%	64.8%	62.4%	59.1%	55.8%	52.4%	48.1%	44.3%	41.0%	38.6%
2000			78.7%	75.3%	72.6%	70.6%	69.2%	67.5%	64.9%	61.3%	57.7%	54.2%	49.8%	45.8%	42.2%	39.5%
2500				78.8%	75.6%	73.3%	71.7%	69.9%	67.1%	63.3%	59.5%	55.8%	51.3%	47.0%	43.2%	40.2%
3000					80.3%	77.7%	75.6%	73.4%	70.4%	65.7%	61.7%	57.9%	53.0%	48.4%	44.3%	41.1%
3500						83.3%	80.5%	78.1%	74.6%	69.1%	64.7%	60.4%	55.4%	50.3%	45.7%	42.3%
4000							85.9%	82.6%	78.8%	72.8%	67.9%	63.1%	57.5%	52.1%	47.3%	43.8%
4500								87.9%	83.6%	76.6%	71.1%	65.8%	59.7%	53.9%	48.9%	45.2%
5000									89.7%	81.5%	75.3%	69.8%	62.8%	56.8%	51.6%	47.5%
6000										90.7%	82.9%	76.4%	68.7%	62.1%	56.2%	51.7%
7000											90.6%	83.0%	74.6%	67.5%	61.1%	56.2%
8000												91.5%	82.1%	74.4%	67.3%	61.8%
9000													90.2%	82.0%	74.0%	67.9%
10000														90.9%	81.9%	75.3%
12000															97.3%	89.8%
14000																100.0%

Table H-77: White Sucker Fry Persistent Habitat (ft^2), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	1,508,883	1,348,971	1,267,009	1,222,786	1,162,241	1,117,443	1,085,183	1,011,724	989,559	906,230	825,410	769,290	709,646	665,855	577,755	526,780
1500		1,490,109	1,393,688	1,334,516	1,267,401	1,210,744	1,165,965	1,082,406	1,057,292	963,901	875,279	811,718	747,726	696,851	603,535	550,618
2000			1,460,641	1,384,925	1,314,601	1,254,563	1,205,935	1,117,022	1,090,208	992,656	898,939	831,710	767,285	713,347	615,268	560,840
2500				1,454,995	1,373,560	1,303,660	1,248,974	1,145,927	1,115,653	1,012,108	916,194	846,619	780,627	725,006	625,739	570,445
3000					1,445,821	1,362,680	1,297,019	1,185,975	1,152,495	1,042,564	941,928	868,514	799,426	741,255	639,720	582,741
3500						1,434,450	1,354,927	1,233,934	1,193,122	1,073,010	967,697	891,432	820,663	759,735	653,660	594,882
4000							1,423,802	1,275,439	1,226,558	1,103,287	994,423	912,982	839,745	778,303	668,745	606,104
4500								1,345,092	1,283,740	1,149,929	1,034,818	948,636	869,010	805,130	695,002	628,361
5000									1,340,702	1,181,827	1,060,410	972,803	890,534	824,787	712,776	645,022
6000										1,276,965	1,143,402	1,049,953	958,699	888,247	767,830	698,708
7000											1,241,097	1,127,579	1,026,419	950,183	821,691	748,343
8000												1,201,475	1,086,049	1,007,596	872,970	796,352
9000													1,163,659	1,073,610	930,994	848,876
10000														1,173,506	1,013,206	922,037
12000															1,171,386	1,062,595
14000																1,289,238

Table H-78: Reach 3 White Sucker Fry Persistent Habitat (% of maximum possible), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	100.0%	89.4%	84.0%	81.0%	77.0%	74.1%	71.9%	67.1%	65.6%	60.1%	54.7%	51.0%	47.0%	44.1%	38.3%	34.9%
1500		98.8%	92.4%	88.4%	84.0%	80.2%	77.3%	71.7%	70.1%	63.9%	58.0%	53.8%	49.6%	46.2%	40.0%	36.5%
2000			96.8%	91.8%	87.1%	83.1%	79.9%	74.0%	72.3%	65.8%	59.6%	55.1%	50.9%	47.3%	40.8%	37.2%
2500				96.4%	91.0%	86.4%	82.8%	75.9%	73.9%	67.1%	60.7%	56.1%	51.7%	48.0%	41.5%	37.8%
3000					95.8%	90.3%	86.0%	78.6%	76.4%	69.1%	62.4%	57.6%	53.0%	49.1%	42.4%	38.6%
3500						95.1%	89.8%	81.8%	79.1%	71.1%	64.1%	59.1%	54.4%	50.4%	43.3%	39.4%
4000							94.4%	84.5%	81.3%	73.1%	65.9%	60.5%	55.7%	51.6%	44.3%	40.2%
4500								89.1%	85.1%	76.2%	68.6%	62.9%	57.6%	53.4%	46.1%	41.6%
5000									88.9%	78.3%	70.3%	64.5%	59.0%	54.7%	47.2%	42.7%
6000										84.6%	75.8%	69.6%	63.5%	58.9%	50.9%	46.3%
7000											82.3%	74.7%	68.0%	63.0%	54.5%	49.6%
8000												79.6%	72.0%	66.8%	57.9%	52.8%
9000													77.1%	71.2%	61.7%	56.3%
10000														77.8%	67.1%	61.1%
12000															77.6%	70.4%
14000																85.4%

Table H-79: Reach White Sucker Fry Persistent Habitat (ft^2), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	1,235,884	1,018,959	953,717	904,933	868,551	835,981	803,606	765,809	733,023	682,325	637,223	596,239	562,381	530,705	469,593	429,649
1500		1,157,072	1,073,842	1,011,508	960,701	915,820	875,182	831,772	795,581	734,963	681,472	638,568	601,685	566,568	501,975	457,536
2000			1,122,948	1,042,600	986,826	940,168	897,734	851,141	814,198	751,089	696,339	651,352	613,276	576,071	508,707	463,975
2500				1,102,068	1,030,223	974,478	927,373	877,597	837,361	770,341	711,510	665,272	625,405	587,783	520,040	474,232
3000					1,075,988	1,006,806	955,677	902,706	861,396	792,138	730,962	683,305	641,853	601,340	532,792	486,119
3500						1,062,563	1,002,319	946,760	904,466	832,961	768,315	718,651	672,307	626,915	556,673	507,156
4000							1,050,313	988,187	942,856	868,555	799,468	746,094	694,042	647,241	575,463	522,144
4500								1,034,993	981,080	902,158	829,744	773,609	717,556	669,466	594,158	535,997
5000									1,017,404	930,759	850,944	792,173	733,979	685,828	609,421	546,679
6000										996,197	902,630	841,368	779,150	725,732	646,399	579,940
7000											975,112	904,678	838,913	781,474	698,634	627,629
8000												988,236	904,280	841,421	751,459	674,959
9000													961,937	893,831	799,108	713,202
10000														960,651	856,279	762,249
12000															1,015,593	901,405
14000																1,009,325

Table H-80: Reach 3 White Sucker Fry Persistent Habitat (% of maximum possible), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	100.0%	82.4%	77.2%	73.2%	70.3%	67.6%	65.0%	62.0%	59.3%	55.2%	51.6%	48.2%	45.5%	42.9%	38.0%	34.8%
1500		93.6%	86.9%	81.8%	77.7%	74.1%	70.8%	67.3%	64.4%	59.5%	55.1%	51.7%	48.7%	45.8%	40.6%	37.0%
2000			90.9%	84.4%	79.8%	76.1%	72.6%	68.9%	65.9%	60.8%	56.3%	52.7%	49.6%	46.6%	41.2%	37.5%
2500				89.2%	83.4%	78.8%	75.0%	71.0%	67.8%	62.3%	57.6%	53.8%	50.6%	47.6%	42.1%	38.4%
3000					87.1%	81.5%	77.3%	73.0%	69.7%	64.1%	59.1%	55.3%	51.9%	48.7%	43.1%	39.3%
3500						86.0%	81.1%	76.6%	73.2%	67.4%	62.2%	58.1%	54.4%	50.7%	45.0%	41.0%
4000							85.0%	80.0%	76.3%	70.3%	64.7%	60.4%	56.2%	52.4%	46.6%	42.2%
4500								83.7%	79.4%	73.0%	67.1%	62.6%	58.1%	54.2%	48.1%	43.4%
5000									82.3%	75.3%	68.9%	64.1%	59.4%	55.5%	49.3%	44.2%
6000										80.6%	73.0%	68.1%	63.0%	58.7%	52.3%	46.9%
7000											78.9%	73.2%	67.9%	63.2%	56.5%	50.8%
8000												80.0%	73.2%	68.1%	60.8%	54.6%
9000													77.8%	72.3%	64.7%	57.7%
10000														77.7%	69.3%	61.7%
12000															82.2%	72.9%
14000																81.7%

Table H-81: Reach 3 Walleye Spawning Persistent Habitat (ft^2), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	135,007	135,007	123,430	114,613	103,080	88,495	70,783	58,662	48,554	35,544	23,947	14,742	8,934	3,636	0	0
1500		135,007	123,430	114,613	103,080	88,495	70,783	58,662	48,554	35,544	23,947	14,742	8,934	3,636	0	0
2000			163,331	154,332	140,635	125,885	105,109	91,843	78,531	58,924	44,687	31,659	17,120	7,254	0	0
2500				207,764	191,759	174,725	153,773	140,209	121,825	95,441	72,687	57,224	33,369	13,800	1,926	0
3000					234,303	215,968	193,301	178,780	159,190	126,380	99,406	75,059	45,977	20,826	5,707	0
3500						265,740	242,374	224,971	204,564	169,034	136,711	100,584	60,685	28,981	8,140	0
4000							280,446	261,569	240,950	203,739	169,227	130,750	84,875	46,401	14,378	274
4500								293,229	271,314	232,693	195,449	154,524	106,609	63,373	21,577	2,467
5000									287,891	248,194	208,675	166,603	116,590	72,404	26,851	4,891
6000										291,501	250,239	206,955	153,032	104,805	47,843	13,584
7000											303,903	258,912	201,173	148,756	85,813	42,558
8000												304,664	245,078	192,442	125,649	76,981
9000													280,835	227,693	158,988	107,525
10000														279,758	206,456	151,301
12000															302,962	241,225
14000																308,691

Table H-82: Reach 3 Walleye Spawning Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	43.7%	43.7%	40.0%	37.1%	33.4%	28.7%	22.9%	19.0%	15.7%	11.5%	7.8%	4.8%	2.9%	1.2%	0.0%	0.0%
1500		43.7%	40.0%	37.1%	33.4%	28.7%	22.9%	19.0%	15.7%	11.5%	7.8%	4.8%	2.9%	1.2%	0.0%	0.0%
2000			52.9%	50.0%	45.6%	40.8%	34.0%	29.8%	25.4%	19.1%	14.5%	10.3%	5.5%	2.3%	0.0%	0.0%
2500				67.3%	62.1%	56.6%	49.8%	45.4%	39.5%	30.9%	23.5%	18.5%	10.8%	4.5%	0.6%	0.0%
3000					75.9%	70.0%	62.6%	57.9%	51.6%	40.9%	32.2%	24.3%	14.9%	6.7%	1.8%	0.0%
3500						86.1%	78.5%	72.9%	66.3%	54.8%	44.3%	32.6%	19.7%	9.4%	2.6%	0.0%
4000							90.9%	84.7%	78.1%	66.0%	54.8%	42.4%	27.5%	15.0%	4.7%	0.1%
4500								95.0%	87.9%	75.4%	63.3%	50.1%	34.5%	20.5%	7.0%	0.8%
5000									93.3%	80.4%	67.6%	54.0%	37.8%	23.5%	8.7%	1.6%
6000										94.4%	81.1%	67.0%	49.6%	34.0%	15.5%	4.4%
7000											98.4%	83.9%	65.2%	48.2%	27.8%	13.8%
8000												98.7%	79.4%	62.3%	40.7%	24.9%
9000													91.0%	73.8%	51.5%	34.8%
10000														90.6%	66.9%	49.0%
12000															98.1%	78.1%
14000																100.0%

Table H-83: Reach 3 Walleye Spawning Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	190,458	190,458	171,961	153,552	130,254	112,820	95,574	83,173	71,676	57,704	45,174	33,264	21,377	13,380	7,967	6,584
1500		190,458	171,961	153,552	130,254	112,820	95,574	83,173	71,676	57,704	45,174	33,264	21,377	13,380	7,967	6,584
2000			223,329	204,060	176,719	157,929	139,295	122,512	107,956	88,008	71,345	57,347	34,559	17,988	7,967	6,584
2500				245,661	217,128	197,704	176,409	159,626	141,006	115,266	94,394	75,514	43,636	24,135	10,745	6,584
3000					263,378	243,779	220,426	202,155	180,860	148,453	121,015	91,703	53,738	31,386	13,454	6,584
3500						289,341	264,534	245,299	223,161	188,486	155,086	120,430	69,901	39,680	14,378	6,584
4000							296,242	276,173	252,920	216,285	179,206	143,734	88,759	51,359	19,871	6,584
4500								298,297	274,766	236,731	197,796	160,576	103,050	62,634	27,293	8,859
5000									294,402	252,774	213,385	174,982	116,827	73,795	32,795	9,387
6000										302,438	261,603	221,163	159,478	112,041	59,617	23,018
7000											317,698	271,985	207,234	157,601	97,514	53,852
8000												315,415	248,691	198,403	135,962	87,180
9000													297,816	246,094	179,758	127,014
10000														295,020	226,488	171,039
12000															316,404	249,148
14000																311,889

Table H-84: Reach 3 Walleye Spawning Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	59.9%	59.9%	54.1%	48.3%	41.0%	35.5%	30.1%	26.2%	22.6%	18.2%	14.2%	10.5%	6.7%	4.2%	2.5%	2.1%
1500		59.9%	54.1%	48.3%	41.0%	35.5%	30.1%	26.2%	22.6%	18.2%	14.2%	10.5%	6.7%	4.2%	2.5%	2.1%
2000			70.3%	64.2%	55.6%	49.7%	43.8%	38.6%	34.0%	27.7%	22.5%	18.1%	10.9%	5.7%	2.5%	2.1%
2500				77.3%	68.3%	62.2%	55.5%	50.2%	44.4%	36.3%	29.7%	23.8%	13.7%	7.6%	3.4%	2.1%
3000					82.9%	76.7%	69.4%	63.6%	56.9%	46.7%	38.1%	28.9%	16.9%	9.9%	4.2%	2.1%
3500						91.1%	83.3%	77.2%	70.2%	59.3%	48.8%	37.9%	22.0%	12.5%	4.5%	2.1%
4000							93.2%	86.9%	79.6%	68.1%	56.4%	45.2%	27.9%	16.2%	6.3%	2.1%
4500								93.9%	86.5%	74.5%	62.3%	50.5%	32.4%	19.7%	8.6%	2.8%
5000									92.7%	79.6%	67.2%	55.1%	36.8%	23.2%	10.3%	3.0%
6000										95.2%	82.3%	69.6%	50.2%	35.3%	18.8%	7.2%
7000											100.0%	85.6%	65.2%	49.6%	30.7%	17.0%
8000												99.3%	78.3%	62.5%	42.8%	27.4%
9000													93.7%	77.5%	56.6%	40.0%
10000														92.9%	71.3%	53.8%
12000															99.6%	78.4%
14000																98.2%

Table H-85: Reach 3 Walleye Spawning Persistent Habitat (ft^2), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	261,575	216,774	203,563	188,850	171,257	153,797	133,211	109,783	87,454	71,150	56,667	46,375	39,933	35,347	22,296	18,438
1500		365,178	348,367	324,102	293,711	259,871	226,991	193,333	160,827	130,051	105,641	80,324	59,029	39,910	22,296	18,438
2000			388,222	363,565	332,417	295,916	262,738	225,016	188,848	154,673	125,397	94,327	66,182	45,107	23,208	18,438
2500				413,714	382,079	343,772	308,914	268,228	229,856	188,946	151,961	108,597	73,349	51,266	25,408	18,438
3000					426,739	387,917	352,096	310,570	271,599	226,702	184,285	130,393	83,959	56,550	26,565	18,438
3500						420,091	382,864	340,223	300,120	254,206	208,204	152,948	100,614	65,199	30,314	18,438
4000							405,930	361,721	321,181	274,205	226,288	169,453	113,246	76,317	35,638	18,764
4500								378,772	337,112	288,457	240,322	182,998	126,159	87,093	37,860	18,973
5000									369,240	318,355	267,783	208,355	148,739	106,967	50,084	22,362
6000										372,682	319,836	254,841	191,802	148,704	82,192	42,349
7000											359,028	293,416	229,031	185,357	113,544	68,439
8000												335,999	268,109	224,004	147,782	95,898
9000													323,375	278,622	199,653	143,628
10000														325,741	244,826	182,644
12000															331,096	254,016
14000																305,368

Table H-86: Reach 3 Walleye Spawning Persistent Habitat (% of maximum possible), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	61.3%	50.8%	47.7%	44.3%	40.1%	36.0%	31.2%	25.7%	20.5%	16.7%	13.3%	10.9%	9.4%	8.3%	5.2%	4.3%
1500		85.6%	81.6%	75.9%	68.8%	60.9%	53.2%	45.3%	37.7%	30.5%	24.8%	18.8%	13.8%	9.4%	5.2%	4.3%
2000			91.0%	85.2%	77.9%	69.3%	61.6%	52.7%	44.3%	36.2%	29.4%	22.1%	15.5%	10.6%	5.4%	4.3%
2500				96.9%	89.5%	80.6%	72.4%	62.9%	53.9%	44.3%	35.6%	25.4%	17.2%	12.0%	6.0%	4.3%
3000					100.0%	90.9%	82.5%	72.8%	63.6%	53.1%	43.2%	30.6%	19.7%	13.3%	6.2%	4.3%
3500						98.4%	89.7%	79.7%	70.3%	59.6%	48.8%	35.8%	23.6%	15.3%	7.1%	4.3%
4000							95.1%	84.8%	75.3%	64.3%	53.0%	39.7%	26.5%	17.9%	8.4%	4.4%
4500								88.8%	79.0%	67.6%	56.3%	42.9%	29.6%	20.4%	8.9%	4.4%
5000									86.5%	74.6%	62.8%	48.8%	34.9%	25.1%	11.7%	5.2%
6000										87.3%	74.9%	59.7%	44.9%	34.8%	19.3%	9.9%
7000											84.1%	68.8%	53.7%	43.4%	26.6%	16.0%
8000												78.7%	62.8%	52.5%	34.6%	22.5%
9000													75.8%	65.3%	46.8%	33.7%
10000														76.3%	57.4%	42.8%
12000															77.6%	59.5%
14000																71.6%

Table H-87: Walleye Spawning Persistent Habitat (ft^2), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	729,661	667,772	647,823	628,050	603,833	587,954	575,186	558,349	532,312	488,906	428,434	357,195	289,063	227,334	151,202	97,055
1500		796,972	770,597	747,882	717,634	694,437	677,637	654,139	619,158	557,867	472,026	379,556	303,515	235,602	152,497	98,161
2000			804,268	781,129	748,750	725,010	707,135	683,204	648,023	585,545	491,345	396,672	315,766	242,215	152,666	98,329
2500				803,243	768,078	743,146	724,106	699,257	663,842	599,137	504,724	408,936	323,868	245,725	153,500	98,329
3000					804,750	776,066	757,026	731,036	695,304	627,563	529,925	429,619	339,837	259,395	159,670	98,892
3500						802,339	781,170	753,782	715,869	646,873	547,868	447,562	355,413	272,283	166,240	101,678
4000							820,988	792,953	752,932	682,843	582,344	481,690	385,889	297,852	183,686	111,812
4500								820,431	779,623	707,599	606,207	504,756	407,898	317,960	200,894	126,038
5000									801,462	727,223	625,830	523,643	423,986	332,474	212,717	135,383
6000										765,712	662,760	559,629	457,798	365,660	240,718	160,274
7000											718,529	615,127	510,723	418,152	286,943	196,527
8000												669,041	562,334	469,349	331,666	227,180
9000													603,623	508,737	366,055	250,530
10000														549,019	396,118	269,417
12000															453,505	313,169
14000																347,324

Table H-88: Reach 3 Walleye Spawning Persistent Habitat (% of maximum possible), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	88.9%	81.3%	78.9%	76.5%	73.5%	71.6%	70.1%	68.0%	64.8%	59.6%	52.2%	43.5%	35.2%	27.7%	18.4%	11.8%
1500		97.1%	93.9%	91.1%	87.4%	84.6%	82.5%	79.7%	75.4%	68.0%	57.5%	46.2%	37.0%	28.7%	18.6%	12.0%
2000			98.0%	95.1%	91.2%	88.3%	86.1%	83.2%	78.9%	71.3%	59.8%	48.3%	38.5%	29.5%	18.6%	12.0%
2500				97.8%	93.6%	90.5%	88.2%	85.2%	80.9%	73.0%	61.5%	49.8%	39.4%	29.9%	18.7%	12.0%
3000					98.0%	94.5%	92.2%	89.0%	84.7%	76.4%	64.5%	52.3%	41.4%	31.6%	19.4%	12.0%
3500						97.7%	95.1%	91.8%	87.2%	78.8%	66.7%	54.5%	43.3%	33.2%	20.2%	12.4%
4000							100.0%	96.6%	91.7%	83.2%	70.9%	58.7%	47.0%	36.3%	22.4%	13.6%
4500								99.9%	95.0%	86.2%	73.8%	61.5%	49.7%	38.7%	24.5%	15.4%
5000									97.6%	88.6%	76.2%	63.8%	51.6%	40.5%	25.9%	16.5%
6000										93.3%	80.7%	68.2%	55.8%	44.5%	29.3%	19.5%
7000											87.5%	74.9%	62.2%	50.9%	35.0%	23.9%
8000												81.5%	68.5%	57.2%	40.4%	27.7%
9000													73.5%	62.0%	44.6%	30.5%
10000														66.9%	48.2%	32.8%
12000															55.2%	38.1%
14000																42.3%

Table H-89: Reach Walleye Spawning Persistent Habitat (ft²), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	962,570	856,659	833,865	812,582	794,177	759,729	731,328	699,234	674,394	620,858	576,837	545,225	492,512	427,902	324,938	239,631
1500		972,488	947,456	923,679	903,041	867,123	835,491	800,452	772,171	710,594	656,732	607,680	532,664	451,758	331,248	239,631
2000			990,616	964,702	943,692	907,292	875,614	840,515	811,843	748,908	691,300	636,313	556,303	470,637	341,328	241,116
2500				1,003,060	980,058	943,076	908,636	872,185	843,514	778,499	716,582	660,762	578,011	487,749	354,842	244,347
3000					1,016,311	975,688	940,628	903,924	875,252	807,626	742,610	682,811	596,126	504,311	364,936	247,464
3500						1,008,026	972,786	935,443	906,553	837,306	770,592	708,779	621,342	526,552	385,919	257,064
4000							1,004,446	966,011	936,765	866,459	798,962	736,571	648,168	547,675	404,007	266,281
4500								1,006,759	976,061	905,240	836,417	770,044	680,298	575,910	423,746	281,720
5000									1,006,598	935,530	865,813	798,457	705,975	597,353	440,013	294,760
6000										988,177	915,753	846,404	748,720	630,144	466,475	313,919
7000											950,217	878,538	777,970	656,832	485,946	324,302
8000												918,345	814,340	689,223	507,656	341,396
9000													840,936	713,102	529,303	359,231
10000														734,908	549,519	374,749
12000															590,769	405,832
14000																439,776

Table H-90: Reach 3 Walleye Spawning Persistent Habitat (% of maximum possible), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	94.7%	84.3%	82.0%	80.0%	78.1%	74.8%	72.0%	68.8%	66.4%	61.1%	56.8%	53.6%	48.5%	42.1%	32.0%	23.6%
1500		95.7%	93.2%	90.9%	88.9%	85.3%	82.2%	78.8%	76.0%	69.9%	64.6%	59.8%	52.4%	44.5%	32.6%	23.6%
2000			97.5%	94.9%	92.9%	89.3%	86.2%	82.7%	79.9%	73.7%	68.0%	62.6%	54.7%	46.3%	33.6%	23.7%
2500				98.7%	96.4%	92.8%	89.4%	85.8%	83.0%	76.6%	70.5%	65.0%	56.9%	48.0%	34.9%	24.0%
3000					100.0%	96.0%	92.6%	88.9%	86.1%	79.5%	73.1%	67.2%	58.7%	49.6%	35.9%	24.3%
3500						99.2%	95.7%	92.0%	89.2%	82.4%	75.8%	69.7%	61.1%	51.8%	38.0%	25.3%
4000							98.8%	95.1%	92.2%	85.3%	78.6%	72.5%	63.8%	53.9%	39.8%	26.2%
4500								99.1%	96.0%	89.1%	82.3%	75.8%	66.9%	56.7%	41.7%	27.7%
5000									99.0%	92.1%	85.2%	78.6%	69.5%	58.8%	43.3%	29.0%
6000										97.2%	90.1%	83.3%	73.7%	62.0%	45.9%	30.9%
7000											93.5%	86.4%	76.5%	64.6%	47.8%	31.9%
8000												90.4%	80.1%	67.8%	50.0%	33.6%
9000													82.7%	70.2%	52.1%	35.3%
10000														72.3%	54.1%	36.9%
12000															58.1%	39.9%
14000																43.3%

Table H-91: Reach 3 Walleye Fry Persistent Habitat (ft^2), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	100,367	100,367	93,925	87,057	82,034	76,411	72,996	66,274	64,136	56,326	42,939	38,168	29,489	25,743	20,203	14,913
1500		100,367	93,925	87,057	82,034	76,411	72,996	66,274	64,136	56,326	42,939	38,168	29,489	25,743	20,203	14,913
2000			103,563	95,684	88,096	82,006	78,592	70,614	68,304	60,494	46,279	40,188	29,557	25,743	20,203	14,913
2500				104,893	94,522	86,607	82,443	73,857	71,547	63,510	49,295	42,557	30,322	26,309	20,769	15,255
3000					102,139	92,404	87,479	78,087	74,770	66,395	52,029	44,272	30,667	26,654	21,113	15,599
3500						102,609	96,467	84,852	81,534	71,544	56,847	47,752	32,544	27,174	21,431	15,917
4000							111,214	93,711	89,642	78,978	63,915	54,821	38,692	33,102	26,881	19,463
4500								109,084	101,433	88,810	73,247	63,871	46,717	39,708	31,486	21,631
5000									130,025	111,148	89,826	73,726	54,957	47,398	36,152	24,511
6000										157,782	125,059	96,403	73,276	63,885	48,361	31,896
7000											154,883	115,689	86,434	73,997	57,880	40,472
8000												148,573	106,965	90,765	69,245	51,792
9000													124,705	104,526	79,696	61,252
10000														126,330	97,678	74,677
12000															139,070	110,567
14000																142,400

Table H-92: Reach 3 Walleye Fry Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	63.6%	63.6%	59.5%	55.2%	52.0%	48.4%	46.3%	42.0%	40.6%	35.7%	27.2%	24.2%	18.7%	16.3%	12.8%	9.5%
1500		63.6%	59.5%	55.2%	52.0%	48.4%	46.3%	42.0%	40.6%	35.7%	27.2%	24.2%	18.7%	16.3%	12.8%	9.5%
2000			65.6%	60.6%	55.8%	52.0%	49.8%	44.8%	43.3%	38.3%	29.3%	25.5%	18.7%	16.3%	12.8%	9.5%
2500				66.5%	59.9%	54.9%	52.3%	46.8%	45.3%	40.3%	31.2%	27.0%	19.2%	16.7%	13.2%	9.7%
3000					64.7%	58.6%	55.4%	49.5%	47.4%	42.1%	33.0%	28.1%	19.4%	16.9%	13.4%	9.9%
3500						65.0%	61.1%	53.8%	51.7%	45.3%	36.0%	30.3%	20.6%	17.2%	13.6%	10.1%
4000							70.5%	59.4%	56.8%	50.1%	40.5%	34.7%	24.5%	21.0%	17.0%	12.3%
4500								69.1%	64.3%	56.3%	46.4%	40.5%	29.6%	25.2%	20.0%	13.7%
5000									82.4%	70.4%	56.9%	46.7%	34.8%	30.0%	22.9%	15.5%
6000										100.0%	79.3%	61.1%	46.4%	40.5%	30.7%	20.2%
7000											98.2%	73.3%	54.8%	46.9%	36.7%	25.7%
8000												94.2%	67.8%	57.5%	43.9%	32.8%
9000													79.0%	66.2%	50.5%	38.8%
10000														80.1%	61.9%	47.3%
12000															88.1%	70.1%
14000																90.3%

Table H-93: Reach 3 Walleye Fry Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	82,163	82,163	75,948	73,328	68,789	63,489	62,768	58,480	55,097	47,859	36,315	29,875	27,763	22,566	16,648	12,611
1500		82,163	75,948	73,328	68,789	63,489	62,768	58,480	55,097	47,859	36,315	29,875	27,763	22,566	16,648	12,611
2000			84,970	80,676	75,621	69,919	69,064	64,776	61,393	53,407	41,024	34,035	31,365	25,354	18,038	12,953
2500				88,894	81,376	75,146	73,695	69,223	65,113	56,709	43,876	36,648	32,046	26,036	18,521	12,953
3000					89,609	82,314	79,592	75,119	69,027	60,623	46,888	38,356	33,754	26,581	18,839	13,271
3500						91,112	85,679	80,323	73,482	65,079	50,401	41,602	36,775	29,516	21,118	14,989
4000							97,493	91,640	82,838	73,762	57,881	48,835	44,007	36,531	27,276	18,631
4500								110,973	94,657	84,344	63,843	53,417	47,487	38,888	28,747	18,631
5000									112,583	100,646	72,997	58,235	52,306	43,389	32,954	19,138
6000										139,027	99,089	74,968	64,940	54,696	42,337	25,844
7000											125,239	93,523	77,827	65,728	53,086	35,356
8000												115,503	99,054	81,049	66,514	45,731
9000													113,334	92,683	76,268	53,988
10000														127,649	97,948	70,676
12000															142,671	104,371
14000																138,439

Table H-94: Reach 3 Walleye Fry Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	57.6%	57.6%	53.2%	51.4%	48.2%	44.5%	44.0%	41.0%	38.6%	33.5%	25.5%	20.9%	19.5%	15.8%	11.7%	8.8%
1500		57.6%	53.2%	51.4%	48.2%	44.5%	44.0%	41.0%	38.6%	33.5%	25.5%	20.9%	19.5%	15.8%	11.7%	8.8%
2000			59.6%	56.5%	53.0%	49.0%	48.4%	45.4%	43.0%	37.4%	28.8%	23.9%	22.0%	17.8%	12.6%	9.1%
2500				62.3%	57.0%	52.7%	51.7%	48.5%	45.6%	39.7%	30.8%	25.7%	22.5%	18.2%	13.0%	9.1%
3000					62.8%	57.7%	55.8%	52.7%	48.4%	42.5%	32.9%	26.9%	23.7%	18.6%	13.2%	9.3%
3500						63.9%	60.1%	56.3%	51.5%	45.6%	35.3%	29.2%	25.8%	20.7%	14.8%	10.5%
4000							68.3%	64.2%	58.1%	51.7%	40.6%	34.2%	30.8%	25.6%	19.1%	13.1%
4500								77.8%	66.3%	59.1%	44.7%	37.4%	33.3%	27.3%	20.1%	13.1%
5000									78.9%	70.5%	51.2%	40.8%	36.7%	30.4%	23.1%	13.4%
6000										97.4%	69.5%	52.5%	45.5%	38.3%	29.7%	18.1%
7000											87.8%	65.6%	54.5%	46.1%	37.2%	24.8%
8000												81.0%	69.4%	56.8%	46.6%	32.1%
9000													79.4%	65.0%	53.5%	37.8%
10000														89.5%	68.7%	49.5%
12000															100.0%	73.2%
14000																97.0%

Table H-95: Reach 3 Walleye Fry Persistent Habitat (ft^2), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	68,787	50,418	46,853	42,936	41,412	41,222	40,976	40,548	39,211	32,761	30,044	24,554	21,627	18,020	13,685	9,389
1500		76,123	70,009	60,527	57,948	55,739	53,142	50,946	49,608	41,789	38,504	29,600	24,584	18,558	14,223	9,707
2000			76,060	64,528	60,917	58,708	56,110	53,624	52,013	43,384	39,863	30,347	25,111	19,085	14,750	10,235
2500				70,150	66,181	63,071	59,985	56,925	55,164	46,332	41,825	31,225	25,989	19,726	15,390	10,875
3000					72,512	68,356	63,611	60,551	58,195	48,871	44,196	33,370	28,057	21,794	15,876	11,361
3500						82,504	76,724	71,834	69,181	57,885	52,013	40,507	34,269	27,789	20,175	14,093
4000							98,451	90,445	86,111	72,043	60,133	45,706	38,211	30,357	22,025	15,421
4500								111,122	104,559	87,430	70,712	53,513	45,285	36,097	25,029	15,421
5000									124,797	100,506	82,717	62,595	53,382	42,852	30,130	17,404
6000										125,878	100,711	72,304	62,324	50,818	36,833	23,235
7000											121,024	88,745	76,806	62,988	47,325	33,441
8000												106,546	92,358	73,031	56,176	41,865
9000													111,388	90,774	71,425	55,418
10000														110,639	88,968	71,847
12000															130,121	101,208
14000																139,808

Table H-96: Reach 3 Walleye Fry Persistent Habitat (% of maximum possible), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	49.2%	36.1%	33.5%	30.7%	29.6%	29.5%	29.3%	29.0%	28.0%	23.4%	21.5%	17.6%	15.5%	12.9%	9.8%	6.7%
1500		54.4%	50.1%	43.3%	41.4%	39.9%	38.0%	36.4%	35.5%	29.9%	27.5%	21.2%	17.6%	13.3%	10.2%	6.9%
2000			54.4%	46.2%	43.6%	42.0%	40.1%	38.4%	37.2%	31.0%	28.5%	21.7%	18.0%	13.7%	10.6%	7.3%
2500				50.2%	47.3%	45.1%	42.9%	40.7%	39.5%	33.1%	29.9%	22.3%	18.6%	14.1%	11.0%	7.8%
3000					51.9%	48.9%	45.5%	43.3%	41.6%	35.0%	31.6%	23.9%	20.1%	15.6%	11.4%	8.1%
3500						59.0%	54.9%	51.4%	49.5%	41.4%	37.2%	29.0%	24.5%	19.9%	14.4%	10.1%
4000							70.4%	64.7%	61.6%	51.5%	43.0%	32.7%	27.3%	21.7%	15.8%	11.0%
4500								79.5%	74.8%	62.5%	50.6%	38.3%	32.4%	25.8%	17.9%	11.0%
5000									89.3%	71.9%	59.2%	44.8%	38.2%	30.7%	21.6%	12.4%
6000										90.0%	72.0%	51.7%	44.6%	36.3%	26.3%	16.6%
7000											86.6%	63.5%	54.9%	45.1%	33.8%	23.9%
8000												76.2%	66.1%	52.2%	40.2%	29.9%
9000													79.7%	64.9%	51.1%	39.6%
10000														79.1%	63.6%	51.4%
12000															93.1%	72.4%
14000																100.0%

Table H-97: Walleye Fry Persistent Habitat (ft²), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	75,739	59,556	54,151	52,475	48,826	45,880	44,686	42,437	42,193	37,798	34,357	29,343	27,421	24,805	18,420	16,433
1500		77,366	66,698	64,305	57,855	53,998	52,249	49,648	48,471	41,836	38,101	33,088	31,165	28,348	21,351	16,433
2000			81,403	76,538	67,831	59,575	55,694	52,651	50,607	43,757	39,796	34,782	32,860	29,658	22,140	16,433
2500				88,820	76,832	67,487	60,280	55,417	53,166	46,316	42,046	36,745	34,822	30,875	22,140	16,433
3000					90,078	75,561	66,852	59,364	56,847	48,789	44,520	38,964	36,834	31,887	23,153	16,433
3500						89,424	76,826	66,595	62,303	52,517	47,456	41,680	39,113	33,619	23,666	16,433
4000							89,753	77,148	71,775	56,412	51,125	44,777	42,210	36,707	26,754	19,521
4500								94,147	82,802	64,261	56,122	48,802	45,791	40,014	29,774	22,265
5000									99,024	74,053	62,734	54,453	50,468	43,930	33,690	25,008
6000										89,105	72,790	61,958	56,885	50,346	39,712	31,031
7000											89,427	74,944	68,042	60,005	47,902	37,411
8000												97,869	85,239	75,737	63,457	50,847
9000													108,285	95,298	77,852	64,447
10000														107,715	90,174	75,155
12000															115,406	97,377
14000																127,851

Table H-98: Reach 3 Walleye Fry Persistent Habitat (% of maximum possible), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	59.2%	46.6%	42.4%	41.0%	38.2%	35.9%	35.0%	33.2%	33.0%	29.6%	26.9%	23.0%	21.4%	19.4%	14.4%	12.9%
1500		60.5%	52.2%	50.3%	45.3%	42.2%	40.9%	38.8%	37.9%	32.7%	29.8%	25.9%	24.4%	22.2%	16.7%	12.9%
2000			63.7%	59.9%	53.1%	46.6%	43.6%	41.2%	39.6%	34.2%	31.1%	27.2%	25.7%	23.2%	17.3%	12.9%
2500				69.5%	60.1%	52.8%	47.1%	43.3%	41.6%	36.2%	32.9%	28.7%	27.2%	24.1%	17.3%	12.9%
3000					70.5%	59.1%	52.3%	46.4%	44.5%	38.2%	34.8%	30.5%	28.8%	24.9%	18.1%	12.9%
3500						69.9%	60.1%	52.1%	48.7%	41.1%	37.1%	32.6%	30.6%	26.3%	18.5%	12.9%
4000							70.2%	60.3%	56.1%	44.1%	40.0%	35.0%	33.0%	28.7%	20.9%	15.3%
4500								73.6%	64.8%	50.3%	43.9%	38.2%	35.8%	31.3%	23.3%	17.4%
5000									77.5%	57.9%	49.1%	42.6%	39.5%	34.4%	26.4%	19.6%
6000										69.7%	56.9%	48.5%	44.5%	39.4%	31.1%	24.3%
7000											69.9%	58.6%	53.2%	46.9%	37.5%	29.3%
8000												76.5%	66.7%	59.2%	49.6%	39.8%
9000													84.7%	74.5%	60.9%	50.4%
10000														84.3%	70.5%	58.8%
12000															90.3%	76.2%
14000																100.0%

Table H-99: Reach Walleye Fry Persistent Habitat (ft²), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	82,494	64,952	61,835	58,940	55,772	53,066	52,386	51,958	49,217	46,128	46,110	41,910	38,226	34,720	27,733	25,154
1500		86,000	77,102	71,974	67,042	62,432	61,179	60,751	57,831	53,781	53,247	49,047	44,464	40,054	32,271	27,150
2000			83,725	77,484	72,076	65,572	63,868	63,439	60,194	56,144	55,292	51,092	46,509	42,099	34,029	27,431
2500				91,424	81,631	72,462	69,946	67,787	63,942	59,434	58,582	54,118	49,534	44,256	36,177	27,431
3000					94,344	80,936	76,516	73,868	67,730	62,344	61,335	56,871	52,287	47,009	38,556	27,431
3500						95,833	85,235	79,529	71,883	65,058	63,680	59,216	54,632	48,906	40,367	29,029
4000							95,523	87,881	78,280	69,007	66,808	62,343	57,760	52,033	42,801	31,463
4500								95,356	83,108	73,168	70,968	65,593	60,565	54,829	44,211	32,873
5000									88,796	78,204	75,548	69,573	64,299	57,877	46,697	35,359
6000										97,960	93,382	85,083	78,756	70,487	58,247	46,132
7000											109,347	98,131	91,805	83,200	70,652	56,143
8000												109,464	102,958	93,429	78,908	61,889
9000													115,069	105,289	89,278	70,617
10000														119,161	101,311	78,083
12000															137,344	103,960
14000																128,414

Table H-100: Reach 3 Walleye Fry Persistent Habitat (% of maximum possible), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	60.1%	47.3%	45.0%	42.9%	40.6%	38.6%	38.1%	37.8%	35.8%	33.6%	33.6%	30.5%	27.8%	25.3%	20.2%	18.3%
1500		62.6%	56.1%	52.4%	48.8%	45.5%	44.5%	44.2%	42.1%	39.2%	38.8%	35.7%	32.4%	29.2%	23.5%	19.8%
2000			61.0%	56.4%	52.5%	47.7%	46.5%	46.2%	43.8%	40.9%	40.3%	37.2%	33.9%	30.7%	24.8%	20.0%
2500				66.6%	59.4%	52.8%	50.9%	49.4%	46.6%	43.3%	42.7%	39.4%	36.1%	32.2%	26.3%	20.0%
3000					68.7%	58.9%	55.7%	53.8%	49.3%	45.4%	44.7%	41.4%	38.1%	34.2%	28.1%	20.0%
3500						69.8%	62.1%	57.9%	52.3%	47.4%	46.4%	43.1%	39.8%	35.6%	29.4%	21.1%
4000							69.6%	64.0%	57.0%	50.2%	48.6%	45.4%	42.1%	37.9%	31.2%	22.9%
4500								69.4%	60.5%	53.3%	51.7%	47.8%	44.1%	39.9%	32.2%	23.9%
5000									64.7%	56.9%	55.0%	50.7%	46.8%	42.1%	34.0%	25.7%
6000										71.3%	68.0%	61.9%	57.3%	51.3%	42.4%	33.6%
7000											79.6%	71.4%	66.8%	60.6%	51.4%	40.9%
8000												79.7%	75.0%	68.0%	57.5%	45.1%
9000													83.8%	76.7%	65.0%	51.4%
10000														86.8%	73.8%	56.9%
12000															100.0%	75.7%
14000																93.5%

Table H-101: Reach 3 Sea Lamprey Spawning Persistent Habitat (ft²), Bypass Q = 200 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	38,410	38,410	29,076	19,295	12,523	9,586	7,648	6,702	5,758	3,932	938	938	0	0	0	0
1500		38,410	29,076	19,295	12,523	9,586	7,648	6,702	5,758	3,932	938	938	0	0	0	0
2000			44,796	30,198	15,343	10,501	7,648	6,702	5,758	3,932	938	938	0	0	0	0
2500				45,951	23,291	13,346	8,605	6,702	5,758	3,932	938	938	0	0	0	0
3000					32,276	19,138	10,501	6,702	5,758	3,932	938	938	0	0	0	0
3500						26,445	15,860	6,912	5,758	3,932	938	938	0	0	0	0
4000							24,360	14,476	10,461	3,932	938	938	0	0	0	0
4500								16,012	11,427	4,434	938	938	0	0	0	0
5000									16,157	6,651	938	938	0	0	0	0
6000										19,228	2,888	938	0	0	0	0
7000											26,181	9,888	1,084	0	0	0
8000												31,634	14,227	1,083	0	0
9000													25,287	4,635	0	0
10000														6,653	304	0
12000															1,631	0
14000																562

Table H-102: Reach 3 Sea Lamprey Spawning Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	83.6%	83.6%	63.3%	42.0%	27.3%	20.9%	16.6%	14.6%	12.5%	8.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
1500		83.6%	63.3%	42.0%	27.3%	20.9%	16.6%	14.6%	12.5%	8.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
2000			97.5%	65.7%	33.4%	22.9%	16.6%	14.6%	12.5%	8.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
2500				100.0%	50.7%	29.0%	18.7%	14.6%	12.5%	8.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
3000					70.2%	41.6%	22.9%	14.6%	12.5%	8.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
3500						57.6%	34.5%	15.0%	12.5%	8.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
4000							53.0%	31.5%	22.8%	8.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
4500								34.8%	24.9%	9.6%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
5000									35.2%	14.5%	2.0%	2.0%	0.0%	0.0%	0.0%	0.0%
6000										41.8%	6.3%	2.0%	0.0%	0.0%	0.0%	0.0%
7000											57.0%	21.5%	2.4%	0.0%	0.0%	0.0%
8000												68.8%	31.0%	2.4%	0.0%	0.0%
9000													55.0%	10.1%	0.0%	0.0%
10000														14.5%	0.7%	0.0%
12000															3.5%	0.0%
14000																1.2%

Table H-103: Reach 3 Sea Lamprey Spawning Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	73,982	73,982	57,767	49,079	35,188	34,274	30,801	28,774	28,774	25,924	18,274	11,481	2,801	0	0	0
1500		73,982	57,767	49,079	35,188	34,274	30,801	28,774	28,774	25,924	18,274	11,481	2,801	0	0	0
2000			70,753	52,286	36,297	34,477	30,801	28,774	28,774	25,924	18,274	11,481	2,801	0	0	0
2500				69,014	45,975	37,330	30,801	28,774	28,774	25,924	18,274	11,481	2,801	0	0	0
3000					52,711	43,154	31,761	28,774	28,774	25,924	18,274	11,481	2,801	0	0	0
3500						50,361	38,968	32,773	28,774	25,924	18,274	11,481	2,801	0	0	0
4000							42,223	36,028	28,991	25,924	18,274	11,481	2,801	0	0	0
4500								39,374	31,491	26,562	18,274	11,481	2,801	0	0	0
5000									34,354	27,536	18,274	11,481	2,801	0	0	0
6000										41,362	22,198	13,465	2,801	0	0	0
7000											48,444	27,224	4,819	0	0	0
8000												51,367	10,653	0	0	0
9000													18,625	3,420	0	0
10000														6,856	304	0
12000															585	0
14000																211

Table H-104: Reach 3 Sea Lamprey Spawning Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	100.0%	100.0%	78.1%	66.3%	47.6%	46.3%	41.6%	38.9%	38.9%	35.0%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
1500		100.0%	78.1%	66.3%	47.6%	46.3%	41.6%	38.9%	38.9%	35.0%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
2000			95.6%	70.7%	49.1%	46.6%	41.6%	38.9%	38.9%	35.0%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
2500				93.3%	62.1%	50.5%	41.6%	38.9%	38.9%	35.0%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
3000					71.2%	58.3%	42.9%	38.9%	38.9%	35.0%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
3500						68.1%	52.7%	44.3%	38.9%	35.0%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
4000							57.1%	48.7%	39.2%	35.0%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
4500								53.2%	42.6%	35.9%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
5000									46.4%	37.2%	24.7%	15.5%	3.8%	0.0%	0.0%	0.0%
6000										55.9%	30.0%	18.2%	3.8%	0.0%	0.0%	0.0%
7000											65.5%	36.8%	6.5%	0.0%	0.0%	0.0%
8000												69.4%	14.4%	0.0%	0.0%	0.0%
9000													25.2%	4.6%	0.0%	0.0%
10000														9.3%	0.4%	0.0%
12000															0.8%	0.0%
14000																0.3%

Table H-105: Reach 3 Sea Lamprey Spawning Persistent Habitat (ft^2), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	56,799	37,583	36,670	36,670	36,406	36,228	34,939	33,030	30,602	27,617	21,330	15,946	9,801	3,624	278	278
1500		67,935	51,513	38,490	36,406	36,228	34,939	33,030	30,602	27,617	21,330	15,946	9,801	3,624	278	278
2000			68,833	49,034	40,125	36,228	34,939	33,030	30,602	27,617	21,330	15,946	9,801	3,624	278	278
2500				55,732	46,823	38,061	34,939	33,030	30,602	27,617	21,330	15,946	9,801	3,624	278	278
3000					54,030	45,269	38,938	33,030	30,602	27,617	21,330	15,946	9,801	3,624	278	278
3500						48,524	42,194	33,247	30,819	27,617	21,330	15,946	9,801	3,624	278	278
4000							45,210	35,929	31,712	27,970	21,330	15,946	9,801	3,624	278	278
4500								38,792	34,575	27,970	21,330	15,946	9,801	3,624	278	278
5000									43,120	30,827	21,330	15,946	9,801	3,624	278	278
6000										49,430	30,309	19,070	10,917	4,591	278	278
7000											53,805	28,086	10,917	4,591	278	278
8000												42,697	15,060	4,591	278	278
9000													19,718	5,873	278	278
10000														8,721	560	278
12000															3,283	278
14000																1,182

Table H-106: Reach 3 Sea Lamprey Spawning Persistent Habitat (% of maximum possible), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	82.5%	54.6%	53.3%	53.3%	52.9%	52.6%	50.8%	48.0%	44.5%	40.1%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
1500		98.7%	74.8%	55.9%	52.9%	52.6%	50.8%	48.0%	44.5%	40.1%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
2000			100.0%	71.2%	58.3%	52.6%	50.8%	48.0%	44.5%	40.1%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
2500				81.0%	68.0%	55.3%	50.8%	48.0%	44.5%	40.1%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
3000					78.5%	65.8%	56.6%	48.0%	44.5%	40.1%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
3500						70.5%	61.3%	48.3%	44.8%	40.1%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
4000							65.7%	52.2%	46.1%	40.6%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
4500								56.4%	50.2%	40.6%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
5000									62.6%	44.8%	31.0%	23.2%	14.2%	5.3%	0.4%	0.4%
6000										71.8%	44.0%	27.7%	15.9%	6.7%	0.4%	0.4%
7000											78.2%	40.8%	15.9%	6.7%	0.4%	0.4%
8000												62.0%	21.9%	6.7%	0.4%	0.4%
9000													28.6%	8.5%	0.4%	0.4%
10000														12.7%	0.8%	0.4%
12000															4.8%	0.4%
14000																1.7%

Table H-107: Sea Lamprey Spawning Persistent Habitat (ft^2), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	82,005	36,857	31,330	27,665	26,513	22,010	18,228	14,462	13,333	11,841	11,604	10,326	8,715	4,162	1,907	1,276
1500		55,956	42,436	33,149	29,705	23,413	19,126	14,805	13,333	11,841	11,604	10,326	8,715	4,162	1,907	1,276
2000			50,712	39,129	34,875	26,730	22,158	17,367	15,619	13,066	12,829	11,345	8,715	4,162	1,907	1,276
2500				44,416	38,045	28,497	22,951	17,808	15,619	13,066	12,829	11,345	8,715	4,162	1,907	1,276
3000					47,734	35,341	28,818	19,682	17,493	14,151	12,829	11,345	8,715	4,162	1,907	1,276
3500						41,423	33,936	21,507	18,037	14,151	12,829	11,345	8,715	4,162	1,907	1,276
4000							47,120	33,725	23,673	15,729	13,328	11,844	9,213	4,660	1,907	1,276
4500								46,714	33,563	19,567	13,337	11,853	9,222	4,669	1,907	1,276
5000									46,652	26,800	14,397	11,853	9,222	4,669	1,907	1,276
6000										36,570	17,691	12,120	9,490	4,678	1,907	1,276
7000											21,709	13,619	10,260	5,144	2,373	1,468
8000												18,462	13,125	6,682	2,582	1,468
9000													13,689	6,934	2,833	1,468
10000														8,088	2,833	1,468
12000															5,190	1,468
14000																4,725

Table H-108: Reach 3 Sea Lamprey Spawning Persistent Habitat (% of maximum possible), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	100.0%	44.9%	38.2%	33.7%	32.3%	26.8%	22.2%	17.6%	16.3%	14.4%	14.2%	12.6%	10.6%	5.1%	2.3%	1.6%
1500		68.2%	51.7%	40.4%	36.2%	28.6%	23.3%	18.1%	16.3%	14.4%	14.2%	12.6%	10.6%	5.1%	2.3%	1.6%
2000			61.8%	47.7%	42.5%	32.6%	27.0%	21.2%	19.0%	15.9%	15.6%	13.8%	10.6%	5.1%	2.3%	1.6%
2500				54.2%	46.4%	34.8%	28.0%	21.7%	19.0%	15.9%	15.6%	13.8%	10.6%	5.1%	2.3%	1.6%
3000					58.2%	43.1%	35.1%	24.0%	21.3%	17.3%	15.6%	13.8%	10.6%	5.1%	2.3%	1.6%
3500						50.5%	41.4%	26.2%	22.0%	17.3%	15.6%	13.8%	10.6%	5.1%	2.3%	1.6%
4000							57.5%	41.1%	28.9%	19.2%	16.3%	14.4%	11.2%	5.7%	2.3%	1.6%
4500								57.0%	40.9%	23.9%	16.3%	14.5%	11.2%	5.7%	2.3%	1.6%
5000									56.9%	32.7%	17.6%	14.5%	11.2%	5.7%	2.3%	1.6%
6000										44.6%	21.6%	14.8%	11.6%	5.7%	2.3%	1.6%
7000											26.5%	16.6%	12.5%	6.3%	2.9%	1.8%
8000												22.5%	16.0%	8.1%	3.1%	1.8%
9000													16.7%	8.5%	3.5%	1.8%
10000														9.9%	3.5%	1.8%
12000															6.3%	1.8%
14000																5.8%

Table H-109: Reach 3 Sea Lamprey Spawning Persistent Habitat (ft²), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	84,957	30,949	26,499	21,995	18,261	15,991	12,138	10,843	9,879	8,231	7,141	4,653	4,448	3,296	2,224	1,629
1500		51,828	36,246	26,317	20,497	16,972	13,120	11,825	10,565	8,596	7,507	5,018	4,813	3,662	2,590	1,995
2000			45,219	34,897	28,128	20,400	14,153	12,858	11,303	9,131	8,041	5,553	5,348	4,196	3,124	1,995
2500				49,557	41,839	29,238	19,158	14,781	11,646	9,131	8,041	5,553	5,348	4,196	3,124	1,995
3000					56,587	42,872	27,081	19,878	12,967	9,407	8,041	5,553	5,348	4,196	3,124	1,995
3500						52,494	32,617	22,964	13,633	9,407	8,041	5,553	5,348	4,196	3,124	1,995
4000							37,038	27,385	15,840	9,761	8,395	5,907	5,702	4,541	3,124	1,995
4500								34,883	21,715	12,639	11,070	6,877	6,673	5,512	4,095	1,995
5000									26,325	14,763	11,375	6,877	6,673	5,512	4,095	1,995
6000										15,759	12,370	7,592	7,387	6,226	4,614	2,207
7000											15,257	9,859	9,654	8,494	4,911	2,207
8000												10,955	10,750	8,512	4,929	2,207
9000													11,315	8,521	4,929	2,207
10000														8,539	4,938	2,207
12000															7,359	2,539
14000																4,757

Table H-110: Reach 3 Sea Lamprey Spawning Persistent Habitat (% of maximum possible), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	100.0%	36.4%	31.2%	25.9%	21.5%	18.8%	14.3%	12.8%	11.6%	9.7%	8.4%	5.5%	5.2%	3.9%	2.6%	1.9%
1500		61.0%	42.7%	31.0%	24.1%	20.0%	15.4%	13.9%	12.4%	10.1%	8.8%	5.9%	5.7%	4.3%	3.0%	2.3%
2000			53.2%	41.1%	33.1%	24.0%	16.7%	15.1%	13.3%	10.7%	9.5%	6.5%	6.3%	4.9%	3.7%	2.3%
2500				58.3%	49.2%	34.4%	22.6%	17.4%	13.7%	10.7%	9.5%	6.5%	6.3%	4.9%	3.7%	2.3%
3000					66.6%	50.5%	31.9%	23.4%	15.3%	11.1%	9.5%	6.5%	6.3%	4.9%	3.7%	2.3%
3500						61.8%	38.4%	27.0%	16.0%	11.1%	9.5%	6.5%	6.3%	4.9%	3.7%	2.3%
4000							43.6%	32.2%	18.6%	11.5%	9.9%	7.0%	6.7%	5.3%	3.7%	2.3%
4500								41.1%	25.6%	14.9%	13.0%	8.1%	7.9%	6.5%	4.8%	2.3%
5000									31.0%	17.4%	13.4%	8.1%	7.9%	6.5%	4.8%	2.3%
6000										18.5%	14.6%	8.9%	8.7%	7.3%	5.4%	2.6%
7000											18.0%	11.6%	11.4%	10.0%	5.8%	2.6%
8000												12.9%	12.7%	10.0%	5.8%	2.6%
9000													13.3%	10.0%	5.8%	2.6%
10000														10.1%	5.8%	2.6%
12000															8.7%	3.0%
14000																5.6%

Table H-111: Reach 3 Macroinvertebrates Persistent Habitat (ft²), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	301,836	301,836	274,524	231,476	195,709	154,880	125,033	100,099	83,478	57,145	41,754	29,415	20,565	20,565	18,158	15,927
1500		301,836	274,524	231,476	195,709	154,880	125,033	100,099	83,478	57,145	41,754	29,415	20,565	20,565	18,158	15,927
2000			336,007	289,727	251,928	207,727	166,782	124,717	100,147	63,537	43,288	29,606	20,565	20,565	18,158	15,927
2500				333,992	293,918	247,645	202,895	154,750	123,174	75,378	48,167	32,074	21,942	21,765	18,158	15,927
3000					321,732	272,869	223,163	174,143	141,423	84,691	51,128	33,179	22,368	21,974	18,158	15,927
3500						304,558	253,747	201,293	165,955	99,993	56,468	35,011	22,913	22,193	18,158	15,927
4000							277,615	225,040	187,721	118,249	69,472	43,707	29,014	25,307	18,443	15,927
4500								257,985	220,132	147,131	94,577	62,044	42,202	36,337	20,944	15,927
5000									245,898	171,475	116,177	80,044	55,284	44,661	22,097	15,927
6000										226,775	168,976	127,287	97,791	74,725	32,958	20,405
7000											238,602	189,759	157,580	127,701	54,920	25,807
8000												257,883	221,380	185,403	89,281	41,830
9000													289,612	246,854	131,659	66,142
10000														315,989	178,950	92,346
12000															259,140	143,748
14000																192,658

Table H-112: Reach 3 Macroinvertebrates Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	89.8%	89.8%	81.7%	68.9%	58.2%	46.1%	37.2%	29.8%	24.8%	17.0%	12.4%	8.8%	6.1%	6.1%	5.4%	4.7%
1500		89.8%	81.7%	68.9%	58.2%	46.1%	37.2%	29.8%	24.8%	17.0%	12.4%	8.8%	6.1%	6.1%	5.4%	4.7%
2000			100.0%	86.2%	75.0%	61.8%	49.6%	37.1%	29.8%	18.9%	12.9%	8.8%	6.1%	6.1%	5.4%	4.7%
2500				99.4%	87.5%	73.7%	60.4%	46.1%	36.7%	22.4%	14.3%	9.5%	6.5%	6.5%	5.4%	4.7%
3000					95.8%	81.2%	66.4%	51.8%	42.1%	25.2%	15.2%	9.9%	6.7%	6.5%	5.4%	4.7%
3500						90.6%	75.5%	59.9%	49.4%	29.8%	16.8%	10.4%	6.8%	6.6%	5.4%	4.7%
4000							82.6%	67.0%	55.9%	35.2%	20.7%	13.0%	8.6%	7.5%	5.5%	4.7%
4500								76.8%	65.5%	43.8%	28.1%	18.5%	12.6%	10.8%	6.2%	4.7%
5000									73.2%	51.0%	34.6%	23.8%	16.5%	13.3%	6.6%	4.7%
6000										67.5%	50.3%	37.9%	29.1%	22.2%	9.8%	6.1%
7000											71.0%	56.5%	46.9%	38.0%	16.3%	7.7%
8000												76.7%	65.9%	55.2%	26.6%	12.4%
9000													86.2%	73.5%	39.2%	19.7%
10000														94.0%	53.3%	27.5%
12000															77.1%	42.8%
14000																57.3%

Table H-113: Reach 3 Macroinvertebrates Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	520,664	520,664	493,328	456,673	424,493	380,901	330,164	288,094	236,389	163,288	134,525	115,538	96,459	79,594	62,844	42,042
1500		520,664	493,328	456,673	424,493	380,901	330,164	288,094	236,389	163,288	134,525	115,538	96,459	79,594	62,844	42,042
2000			541,543	501,778	468,345	416,968	359,046	309,020	250,163	169,341	137,424	116,950	97,659	80,610	62,844	42,042
2500				533,241	498,551	443,055	383,458	329,818	266,458	177,572	140,004	118,209	97,876	80,610	62,844	42,042
3000					528,006	470,784	408,902	351,806	286,309	188,301	143,445	120,134	98,630	80,819	62,844	42,042
3500						496,372	434,317	376,183	308,814	206,922	153,476	124,785	103,099	81,402	62,844	42,042
4000							463,364	404,277	335,915	228,567	174,014	136,621	112,354	89,333	63,197	42,042
4500								431,119	360,310	250,541	193,145	152,114	121,894	97,087	63,206	42,050
5000									389,727	276,531	216,043	172,657	139,558	108,295	65,736	42,060
6000										334,511	270,403	223,181	178,783	139,320	76,731	45,776
7000											338,258	287,163	239,592	191,319	97,474	52,661
8000												356,907	305,005	248,188	138,069	71,652
9000													384,709	321,037	182,048	94,508
10000														380,970	223,130	118,270
12000															300,311	171,691
14000																211,005

Table H-114: Reach 3 Macroinvertebrates Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	96.1%	96.1%	91.1%	84.3%	78.4%	70.3%	61.0%	53.2%	43.7%	30.2%	24.8%	21.3%	17.8%	14.7%	11.6%	7.8%
1500		96.1%	91.1%	84.3%	78.4%	70.3%	61.0%	53.2%	43.7%	30.2%	24.8%	21.3%	17.8%	14.7%	11.6%	7.8%
2000			100.0%	92.7%	86.5%	77.0%	66.3%	57.1%	46.2%	31.3%	25.4%	21.6%	18.0%	14.9%	11.6%	7.8%
2500				98.5%	92.1%	81.8%	70.8%	60.9%	49.2%	32.8%	25.9%	21.8%	18.1%	14.9%	11.6%	7.8%
3000					97.5%	86.9%	75.5%	65.0%	52.9%	34.8%	26.5%	22.2%	18.2%	14.9%	11.6%	7.8%
3500						91.7%	80.2%	69.5%	57.0%	38.2%	28.3%	23.0%	19.0%	15.0%	11.6%	7.8%
4000							85.6%	74.7%	62.0%	42.2%	32.1%	25.2%	20.7%	16.5%	11.7%	7.8%
4500								79.6%	66.5%	46.3%	35.7%	28.1%	22.5%	17.9%	11.7%	7.8%
5000									72.0%	51.1%	39.9%	31.9%	25.8%	20.0%	12.1%	7.8%
6000										61.8%	49.9%	41.2%	33.0%	25.7%	14.2%	8.5%
7000											62.5%	53.0%	44.2%	35.3%	18.0%	9.7%
8000												65.9%	56.3%	45.8%	25.5%	13.2%
9000													71.0%	59.3%	33.6%	17.5%
10000														70.3%	41.2%	21.8%
12000															55.5%	31.7%
14000																39.0%

Table H-115: Reach 3 Macroinvertebrates Persistent Habitat (ft^2), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	601,376	520,452	496,724	479,146	463,636	449,025	441,080	427,934	411,187	374,529	305,845	232,850	194,438	170,646	124,786	89,959
1500		695,673	653,543	621,259	575,491	529,312	497,429	465,767	439,261	383,639	310,975	235,039	195,638	171,662	124,786	89,959
2000			690,118	656,740	606,854	559,291	523,912	487,160	456,583	390,864	313,345	235,674	195,879	171,662	124,786	89,959
2500				685,974	635,733	585,088	546,645	506,803	473,819	397,982	315,938	236,909	196,919	171,948	124,786	89,959
3000					665,650	614,966	575,267	534,243	497,983	413,952	327,052	241,771	199,443	172,400	124,786	89,959
3500						643,483	602,885	560,443	522,298	434,425	344,770	252,672	207,911	176,530	124,786	89,959
4000							633,794	589,815	551,057	460,716	365,049	269,105	220,397	184,454	125,139	89,959
4500								619,255	579,221	484,373	387,519	289,123	237,365	194,675	127,383	90,109
5000									620,134	523,371	422,746	318,500	258,021	207,342	134,307	91,436
6000										588,967	484,713	375,286	310,106	248,471	146,783	94,883
7000											546,286	434,169	364,740	300,208	175,044	108,792
8000												506,601	428,392	351,414	210,505	122,972
9000													502,255	417,758	250,788	141,229
10000														465,795	287,828	165,449
12000															354,599	210,510
14000																251,498

Table H-116: Reach 3 Macroinvertebrates Persistent Habitat (% of maximum possible), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	86.4%	74.8%	71.4%	68.9%	66.6%	64.5%	63.4%	61.5%	59.1%	53.8%	44.0%	33.5%	27.9%	24.5%	17.9%	12.9%
1500		100.0%	93.9%	89.3%	82.7%	76.1%	71.5%	67.0%	63.1%	55.1%	44.7%	33.8%	28.1%	24.7%	17.9%	12.9%
2000			99.2%	94.4%	87.2%	80.4%	75.3%	70.0%	65.6%	56.2%	45.0%	33.9%	28.2%	24.7%	17.9%	12.9%
2500				98.6%	91.4%	84.1%	78.6%	72.9%	68.1%	57.2%	45.4%	34.1%	28.3%	24.7%	17.9%	12.9%
3000					95.7%	88.4%	82.7%	76.8%	71.6%	59.5%	47.0%	34.8%	28.7%	24.8%	17.9%	12.9%
3500						92.5%	86.7%	80.6%	75.1%	62.4%	49.6%	36.3%	29.9%	25.4%	17.9%	12.9%
4000							91.1%	84.8%	79.2%	66.2%	52.5%	38.7%	31.7%	26.5%	18.0%	12.9%
4500								89.0%	83.3%	69.6%	55.7%	41.6%	34.1%	28.0%	18.3%	13.0%
5000									89.1%	75.2%	60.8%	45.8%	37.1%	29.8%	19.3%	13.1%
6000										84.7%	69.7%	53.9%	44.6%	35.7%	21.1%	13.6%
7000											78.5%	62.4%	52.4%	43.2%	25.2%	15.6%
8000												72.8%	61.6%	50.5%	30.3%	17.7%
9000													72.2%	60.1%	36.0%	20.3%
10000														67.0%	41.4%	23.8%
12000															51.0%	30.3%
14000																36.2%

Table H-117: Macroinvertebrates Persistent Habitat (ft^2), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	954,954	828,221	776,924	743,766	714,032	691,911	677,272	656,079	648,400	624,237	592,654	559,562	513,077	461,313	365,048	258,695
1500		929,925	872,207	836,797	797,527	763,104	742,314	708,684	698,930	659,433	617,685	572,746	514,443	462,023	365,757	259,404
2000			917,297	878,559	837,825	801,814	780,127	744,650	730,101	682,343	634,374	583,409	519,974	462,375	365,757	259,404
2500				919,455	877,065	840,091	815,196	778,796	760,857	709,057	654,938	599,799	527,668	467,226	368,514	261,155
3000					923,914	883,925	858,589	819,833	801,893	744,686	684,595	617,252	537,440	474,892	372,050	262,744
3500						915,448	888,967	848,570	828,724	768,462	704,447	631,992	547,018	479,948	372,767	262,744
4000							926,084	885,250	865,343	802,048	735,327	657,507	564,571	487,202	374,326	264,004
4500								948,136	926,183	857,447	784,149	700,396	595,565	508,843	382,837	268,301
5000									961,802	891,827	815,130	728,242	617,098	524,306	386,650	269,470
6000										956,256	870,820	773,176	651,906	553,373	399,019	275,304
7000											946,950	841,046	711,518	603,708	427,904	285,570
8000												881,128	746,951	636,386	446,048	297,604
9000													781,264	667,092	465,102	311,906
10000														696,837	487,016	325,886
12000															525,418	354,709
14000																397,111

Table H-118: Reach 3 Macroinvertebrates Persistent Habitat (% of maximum possible), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	99.3%	86.1%	80.8%	77.3%	74.2%	71.9%	70.4%	68.2%	67.4%	64.9%	61.6%	58.2%	53.3%	48.0%	38.0%	26.9%
1500		96.7%	90.7%	87.0%	82.9%	79.3%	77.2%	73.7%	72.7%	68.6%	64.2%	59.5%	53.5%	48.0%	38.0%	27.0%
2000			95.4%	91.3%	87.1%	83.4%	81.1%	77.4%	75.9%	70.9%	66.0%	60.7%	54.1%	48.1%	38.0%	27.0%
2500				95.6%	91.2%	87.3%	84.8%	81.0%	79.1%	73.7%	68.1%	62.4%	54.9%	48.6%	38.3%	27.2%
3000					96.1%	91.9%	89.3%	85.2%	83.4%	77.4%	71.2%	64.2%	55.9%	49.4%	38.7%	27.3%
3500						95.2%	92.4%	88.2%	86.2%	79.9%	73.2%	65.7%	56.9%	49.9%	38.8%	27.3%
4000							96.3%	92.0%	90.0%	83.4%	76.5%	68.4%	58.7%	50.7%	38.9%	27.4%
4500								98.6%	96.3%	89.2%	81.5%	72.8%	61.9%	52.9%	39.8%	27.9%
5000									100.0%	92.7%	84.8%	75.7%	64.2%	54.5%	40.2%	28.0%
6000										99.4%	90.5%	80.4%	67.8%	57.5%	41.5%	28.6%
7000											98.5%	87.4%	74.0%	62.8%	44.5%	29.7%
8000												91.6%	77.7%	66.2%	46.4%	30.9%
9000													81.2%	69.4%	48.4%	32.4%
10000														72.5%	50.6%	33.9%
12000															54.6%	36.9%
14000																41.3%

Table H-119: Reach 3 Macroinvertebrates Persistent Habitat (ft²), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	974,029	810,806	777,902	747,795	720,472	694,019	668,461	644,430	623,181	581,154	522,926	485,224	445,282	415,478	329,996	241,704
1500		920,157	881,503	846,729	815,201	781,622	747,785	718,901	690,999	628,621	553,958	504,578	456,961	422,379	332,450	243,761
2000			923,648	887,943	855,290	820,516	784,621	755,058	724,739	657,770	574,844	516,740	463,274	427,218	334,387	243,980
2500				932,834	899,573	862,384	824,318	793,207	760,548	690,062	601,373	534,004	470,592	429,905	335,095	244,420
3000					942,503	900,975	861,269	828,800	794,937	723,740	625,884	553,520	483,182	436,478	337,463	246,354
3500						945,054	904,650	870,646	834,737	756,678	653,125	573,653	494,923	444,950	342,065	250,519
4000							939,986	902,247	865,160	778,175	670,649	588,374	506,532	453,637	346,727	254,666
4500								935,470	896,335	804,697	690,921	604,662	516,731	461,387	350,182	256,213
5000									934,264	837,823	717,574	627,140	531,138	469,932	354,852	260,399
6000										877,998	755,651	660,620	557,306	490,233	366,553	270,655
7000											796,722	697,699	590,623	521,641	385,741	284,886
8000												729,556	619,129	546,200	402,543	295,618
9000													641,413	566,271	415,557	304,365
10000														587,281	432,535	319,424
12000															471,492	352,547
14000																374,921

Table H-120: Reach 3 Macroinvertebrates Persistent Habitat (% of maximum possible), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	100.0%	83.2%	79.9%	76.8%	74.0%	71.3%	68.6%	66.2%	64.0%	59.7%	53.7%	49.8%	45.7%	42.7%	33.9%	24.8%
1500		94.5%	90.5%	86.9%	83.7%	80.2%	76.8%	73.8%	70.9%	64.5%	56.9%	51.8%	46.9%	43.4%	34.1%	25.0%
2000			94.8%	91.2%	87.8%	84.2%	80.6%	77.5%	74.4%	67.5%	59.0%	53.1%	47.6%	43.9%	34.3%	25.0%
2500				95.8%	92.4%	88.5%	84.6%	81.4%	78.1%	70.8%	61.7%	54.8%	48.3%	44.1%	34.4%	25.1%
3000					96.8%	92.5%	88.4%	85.1%	81.6%	74.3%	64.3%	56.8%	49.6%	44.8%	34.6%	25.3%
3500						97.0%	92.9%	89.4%	85.7%	77.7%	67.1%	58.9%	50.8%	45.7%	35.1%	25.7%
4000							96.5%	92.6%	88.8%	79.9%	68.9%	60.4%	52.0%	46.6%	35.6%	26.1%
4500								96.0%	92.0%	82.6%	70.9%	62.1%	53.1%	47.4%	36.0%	26.3%
5000									95.9%	86.0%	73.7%	64.4%	54.5%	48.2%	36.4%	26.7%
6000										90.1%	77.6%	67.8%	57.2%	50.3%	37.6%	27.8%
7000											81.8%	71.6%	60.6%	53.6%	39.6%	29.2%
8000												74.9%	63.6%	56.1%	41.3%	30.4%
9000													65.9%	58.1%	42.7%	31.2%
10000														60.3%	44.4%	32.8%
12000															48.4%	36.2%
14000																38.5%

Table H-121: Reach 3 Deep Slow Guild Persistent Habitat (ft^2), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	1,666,822	1,666,822	1,556,921	1,464,256	1,391,566	1,353,469	1,316,615	1,270,792	1,244,484	1,196,604	1,155,181	1,124,306	1,096,463	1,080,219	1,027,770	967,566
1500		1,666,822	1,556,921	1,464,256	1,391,566	1,353,469	1,316,615	1,270,792	1,244,484	1,196,604	1,155,181	1,124,306	1,096,463	1,080,219	1,027,770	967,566
2000			1,608,445	1,511,904	1,437,091	1,395,556	1,355,441	1,304,982	1,276,177	1,226,847	1,184,257	1,151,695	1,123,221	1,105,228	1,051,450	988,456
2500				1,581,203	1,497,417	1,454,326	1,409,804	1,354,515	1,325,122	1,274,762	1,230,849	1,195,909	1,165,916	1,146,614	1,087,615	1,019,486
3000					1,567,560	1,517,193	1,470,160	1,411,292	1,379,732	1,326,933	1,280,894	1,239,771	1,208,137	1,187,757	1,125,470	1,053,105
3500						1,612,409	1,555,954	1,495,591	1,461,974	1,408,294	1,361,165	1,312,790	1,279,205	1,255,923	1,186,853	1,111,274
4000							1,640,545	1,578,896	1,543,296	1,487,874	1,436,176	1,381,887	1,344,849	1,314,768	1,239,995	1,157,145
4500								1,685,275	1,645,243	1,586,584	1,529,785	1,466,950	1,426,259	1,390,663	1,301,205	1,210,551
5000									1,825,464	1,752,370	1,685,665	1,612,997	1,560,421	1,515,713	1,390,362	1,273,168
6000										2,069,328	1,975,405	1,883,123	1,814,270	1,748,480	1,562,373	1,409,723
7000											2,257,716	2,131,212	2,050,347	1,968,054	1,740,502	1,554,703
8000												2,398,202	2,295,796	2,197,678	1,936,600	1,730,523
9000													2,456,744	2,341,675	2,060,636	1,846,049
10000														2,500,939	2,197,531	1,968,490
12000															2,468,613	2,212,833
14000																2,406,143

Table H-122: Reach 3 Deep Slow Guild Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	66.6%	66.6%	62.3%	58.5%	55.6%	54.1%	52.6%	50.8%	49.8%	47.8%	46.2%	45.0%	43.8%	43.2%	41.1%	38.7%
1500		66.6%	62.3%	58.5%	55.6%	54.1%	52.6%	50.8%	49.8%	47.8%	46.2%	45.0%	43.8%	43.2%	41.1%	38.7%
2000			64.3%	60.5%	57.5%	55.8%	54.2%	52.2%	51.0%	49.1%	47.4%	46.1%	44.9%	44.2%	42.0%	39.5%
2500				63.2%	59.9%	58.2%	56.4%	54.2%	53.0%	51.0%	49.2%	47.8%	46.6%	45.8%	43.5%	40.8%
3000					62.7%	60.7%	58.8%	56.4%	55.2%	53.1%	51.2%	49.6%	48.3%	47.5%	45.0%	42.1%
3500						64.5%	62.2%	59.8%	58.5%	56.3%	54.4%	52.5%	51.1%	50.2%	47.5%	44.4%
4000							65.6%	63.1%	61.7%	59.5%	57.4%	55.3%	53.8%	52.6%	49.6%	46.3%
4500								67.4%	65.8%	63.4%	61.2%	58.7%	57.0%	55.6%	52.0%	48.4%
5000									73.0%	70.1%	67.4%	64.5%	62.4%	60.6%	55.6%	50.9%
6000										82.7%	79.0%	75.3%	72.5%	69.9%	62.5%	56.4%
7000											90.3%	85.2%	82.0%	78.7%	69.6%	62.2%
8000												95.9%	91.8%	87.9%	77.4%	69.2%
9000													98.2%	93.6%	82.4%	73.8%
10000														100.0%	87.9%	78.7%
12000															98.7%	88.5%
14000																96.2%

Table H-123: Reach 3 Deep Slow Guild Persistent Habitat (ft²), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	1,591,411	1,591,411	1,482,360	1,409,091	1,358,178	1,315,000	1,270,063	1,244,788	1,224,763	1,179,065	1,137,963	1,117,753	1,096,965	1,069,559	1,014,025	948,558
1500		1,591,411	1,482,360	1,409,091	1,358,178	1,315,000	1,270,063	1,244,788	1,224,763	1,179,065	1,137,963	1,117,753	1,096,965	1,069,559	1,014,025	948,558
2000			1,544,384	1,462,286	1,407,602	1,360,855	1,312,328	1,284,079	1,263,122	1,216,950	1,175,419	1,153,402	1,130,993	1,101,938	1,040,386	968,247
2500				1,518,102	1,459,706	1,411,699	1,360,522	1,330,214	1,307,797	1,259,536	1,215,849	1,187,686	1,164,109	1,134,197	1,067,497	991,996
3000					1,517,244	1,463,976	1,411,287	1,378,248	1,354,762	1,305,713	1,258,591	1,227,613	1,202,863	1,170,178	1,096,459	1,017,258
3500						1,538,488	1,480,847	1,445,646	1,420,977	1,370,180	1,318,102	1,279,847	1,254,049	1,217,345	1,138,823	1,053,193
4000							1,596,343	1,557,243	1,527,769	1,475,659	1,419,212	1,373,389	1,345,364	1,303,363	1,211,094	1,117,489
4500								1,709,352	1,673,288	1,614,671	1,553,298	1,501,049	1,459,852	1,411,201	1,296,552	1,184,516
5000									1,851,619	1,784,913	1,711,067	1,653,670	1,602,635	1,544,948	1,392,138	1,252,118
6000										2,110,062	2,012,070	1,944,219	1,871,453	1,798,259	1,595,719	1,420,189
7000											2,289,585	2,192,623	2,098,614	2,011,249	1,772,666	1,570,906
8000												2,431,900	2,306,328	2,203,757	1,931,339	1,719,234
9000													2,468,763	2,353,635	2,064,104	1,843,483
10000														2,488,453	2,185,248	1,959,603
12000															2,460,485	2,201,924
14000																2,422,470

Table H-124: Reach 3 Deep Slow Guild Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	64.0%	64.0%	59.6%	56.6%	54.6%	52.8%	51.0%	50.0%	49.2%	47.4%	45.7%	44.9%	44.1%	43.0%	40.7%	38.1%
1500		64.0%	59.6%	56.6%	54.6%	52.8%	51.0%	50.0%	49.2%	47.4%	45.7%	44.9%	44.1%	43.0%	40.7%	38.1%
2000			62.1%	58.8%	56.6%	54.7%	52.7%	51.6%	50.8%	48.9%	47.2%	46.4%	45.4%	44.3%	41.8%	38.9%
2500				61.0%	58.7%	56.7%	54.7%	53.5%	52.6%	50.6%	48.9%	47.7%	46.8%	45.6%	42.9%	39.9%
3000					61.0%	58.8%	56.7%	55.4%	54.4%	52.5%	50.6%	49.3%	48.3%	47.0%	44.1%	40.9%
3500						61.8%	59.5%	58.1%	57.1%	55.1%	53.0%	51.4%	50.4%	48.9%	45.8%	42.3%
4000							64.2%	62.6%	61.4%	59.3%	57.0%	55.2%	54.1%	52.4%	48.7%	44.9%
4500								68.7%	67.2%	64.9%	62.4%	60.3%	58.7%	56.7%	52.1%	47.6%
5000									74.4%	71.7%	68.8%	66.5%	64.4%	62.1%	55.9%	50.3%
6000										84.8%	80.9%	78.1%	75.2%	72.3%	64.1%	57.1%
7000											92.0%	88.1%	84.3%	80.8%	71.2%	63.1%
8000												97.7%	92.7%	88.6%	77.6%	69.1%
9000													99.2%	94.6%	82.9%	74.1%
10000														100.0%	87.8%	78.7%
12000															98.9%	88.5%
14000																97.3%

Table H-125: Reach 3 Deep Slow Guild Persistent Habitat (ft^2), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	1,602,832	1,306,030	1,240,304	1,197,460	1,160,522	1,125,647	1,102,595	1,076,133	1,046,375	1,023,264	997,009	969,906	951,658	929,057	871,398	827,413
1500		1,475,241	1,399,528	1,348,376	1,307,336	1,262,269	1,232,878	1,201,275	1,168,229	1,140,940	1,105,654	1,068,929	1,040,861	1,007,509	937,434	877,292
2000			1,449,247	1,395,266	1,351,227	1,303,990	1,272,459	1,239,775	1,205,577	1,176,543	1,135,830	1,097,329	1,067,679	1,032,379	958,761	893,464
2500				1,441,165	1,390,709	1,341,630	1,307,512	1,273,414	1,237,955	1,207,952	1,162,816	1,123,836	1,092,425	1,052,048	977,952	911,992
3000					1,454,108	1,399,885	1,363,550	1,327,802	1,290,641	1,258,268	1,208,590	1,165,240	1,128,990	1,084,373	1,005,086	935,595
3500						1,492,157	1,446,223	1,405,029	1,365,982	1,331,510	1,276,087	1,228,076	1,187,847	1,139,772	1,048,226	972,449
4000							1,579,437	1,531,817	1,487,021	1,446,840	1,385,250	1,327,454	1,277,696	1,216,708	1,105,046	1,013,179
4500								1,679,181	1,623,107	1,575,413	1,503,855	1,438,657	1,377,743	1,307,076	1,169,994	1,052,611
5000									1,781,390	1,712,654	1,631,761	1,554,703	1,485,588	1,402,882	1,248,114	1,113,670
6000										1,974,808	1,867,752	1,770,713	1,689,453	1,590,842	1,398,712	1,237,202
7000											2,143,458	2,020,269	1,923,337	1,813,410	1,589,631	1,416,156
8000												2,281,751	2,157,891	2,034,044	1,780,551	1,598,430
9000													2,371,898	2,233,706	1,961,979	1,770,960
10000														2,395,380	2,107,883	1,907,317
12000															2,370,883	2,142,711
14000																2,368,062

Table H-126: Reach 3 Deep Slow Guild Persistent Habitat (% of maximum possible), Bypass Q = 1000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	66.9%	54.5%	51.8%	50.0%	48.4%	47.0%	46.0%	44.9%	43.7%	42.7%	41.6%	40.5%	39.7%	38.8%	36.4%	34.5%
1500		61.6%	58.4%	56.3%	54.6%	52.7%	51.5%	50.1%	48.8%	47.6%	46.2%	44.6%	43.5%	42.1%	39.1%	36.6%
2000			60.5%	58.2%	56.4%	54.4%	53.1%	51.8%	50.3%	49.1%	47.4%	45.8%	44.6%	43.1%	40.0%	37.3%
2500				60.2%	58.1%	56.0%	54.6%	53.2%	51.7%	50.4%	48.5%	46.9%	45.6%	43.9%	40.8%	38.1%
3000					60.7%	58.4%	56.9%	55.4%	53.9%	52.5%	50.5%	48.6%	47.1%	45.3%	42.0%	39.1%
3500						62.3%	60.4%	58.7%	57.0%	55.6%	53.3%	51.3%	49.6%	47.6%	43.8%	40.6%
4000							65.9%	63.9%	62.1%	60.4%	57.8%	55.4%	53.3%	50.8%	46.1%	42.3%
4500								70.1%	67.8%	65.8%	62.8%	60.1%	57.5%	54.6%	48.8%	43.9%
5000									74.4%	71.5%	68.1%	64.9%	62.0%	58.6%	52.1%	46.5%
6000										82.4%	78.0%	73.9%	70.5%	66.4%	58.4%	51.6%
7000											89.5%	84.3%	80.3%	75.7%	66.4%	59.1%
8000												95.3%	90.1%	84.9%	74.3%	66.7%
9000													99.0%	93.3%	81.9%	73.9%
10000														100.0%	88.0%	79.6%
12000															99.0%	89.5%
14000																98.9%

Table H-127: Reach 3 Deep Slow Guild Persistent Habitat (ft²), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	1,503,364	1,356,801	1,304,917	1,267,939	1,244,774	1,220,710	1,196,981	1,161,419	1,137,752	1,082,322	997,824	928,365	878,500	806,864	738,278	686,922
1500		1,454,027	1,393,142	1,352,369	1,326,445	1,300,534	1,273,930	1,231,025	1,201,860	1,139,532	1,051,422	978,369	925,901	853,430	782,099	727,063
2000			1,483,536	1,430,615	1,401,692	1,373,063	1,343,473	1,296,843	1,263,396	1,196,050	1,102,747	1,024,250	965,873	885,632	807,014	750,425
2500				1,507,065	1,462,166	1,430,203	1,399,104	1,342,594	1,308,461	1,238,551	1,141,692	1,061,996	1,000,143	915,776	831,226	771,550
3000					1,545,545	1,504,449	1,463,247	1,399,935	1,361,715	1,285,000	1,186,148	1,100,633	1,032,160	945,638	856,183	792,018
3500						1,579,862	1,528,937	1,459,708	1,417,737	1,334,212	1,229,464	1,141,346	1,067,141	977,094	880,680	812,378
4000							1,606,049	1,513,813	1,464,976	1,375,450	1,262,784	1,169,749	1,091,700	998,689	898,410	827,825
4500								1,605,010	1,544,385	1,445,823	1,327,243	1,224,894	1,138,013	1,038,750	930,752	855,488
5000									1,626,602	1,507,226	1,377,514	1,266,147	1,174,631	1,072,914	962,897	881,862
6000										1,638,580	1,490,814	1,366,846	1,266,267	1,158,589	1,043,200	955,323
7000											1,635,964	1,485,459	1,368,231	1,254,322	1,129,741	1,036,727
8000												1,593,757	1,464,049	1,344,252	1,208,264	1,107,309
9000													1,580,625	1,449,483	1,296,476	1,186,364
10000														1,563,840	1,392,835	1,277,599
12000															1,652,901	1,524,006
14000																1,829,589

Table H-128: Reach 3 Deep Slow Guild Persistent Habitat (% of maximum possible), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	82.2%	74.2%	71.3%	69.3%	68.0%	66.7%	65.4%	63.5%	62.2%	59.2%	54.5%	50.7%	48.0%	44.1%	40.4%	37.5%
1500		79.5%	76.1%	73.9%	72.5%	71.1%	69.6%	67.3%	65.7%	62.3%	57.5%	53.5%	50.6%	46.6%	42.7%	39.7%
2000			81.1%	78.2%	76.6%	75.0%	73.4%	70.9%	69.1%	65.4%	60.3%	56.0%	52.8%	48.4%	44.1%	41.0%
2500				82.4%	79.9%	78.2%	76.5%	73.4%	71.5%	67.7%	62.4%	58.0%	54.7%	50.1%	45.4%	42.2%
3000					84.5%	82.2%	80.0%	76.5%	74.4%	70.2%	64.8%	60.2%	56.4%	51.7%	46.8%	43.3%
3500						86.4%	83.6%	79.8%	77.5%	72.9%	67.2%	62.4%	58.3%	53.4%	48.1%	44.4%
4000							87.8%	82.7%	80.1%	75.2%	69.0%	63.9%	59.7%	54.6%	49.1%	45.2%
4500								87.7%	84.4%	79.0%	72.5%	66.9%	62.2%	56.8%	50.9%	46.8%
5000									88.9%	82.4%	75.3%	69.2%	64.2%	58.6%	52.6%	48.2%
6000										89.6%	81.5%	74.7%	69.2%	63.3%	57.0%	52.2%
7000											89.4%	81.2%	74.8%	68.6%	61.7%	56.7%
8000												87.1%	80.0%	73.5%	66.0%	60.5%
9000													86.4%	79.2%	70.9%	64.8%
10000														85.5%	76.1%	69.8%
12000															90.3%	83.3%
14000																100.0%

Table H-129: Reach 3 Deep Slow Guild Persistent Habitat (ft^2), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	1,345,478	1,204,816	1,152,467	1,099,690	1,059,137	1,029,188	993,316	948,444	907,985	842,895	785,570	750,622	714,780	680,110	612,633	574,849
1500		1,344,948	1,279,957	1,215,602	1,168,516	1,132,829	1,089,006	1,037,851	992,668	923,400	860,852	822,407	780,608	740,895	664,757	620,376
2000			1,347,964	1,269,018	1,214,420	1,173,848	1,125,452	1,073,383	1,024,869	952,000	887,405	845,639	803,012	759,548	680,023	633,281
2500				1,341,199	1,269,756	1,221,896	1,169,050	1,115,007	1,065,124	986,241	918,030	875,315	831,964	785,546	704,142	653,188
3000					1,332,449	1,269,137	1,214,056	1,148,455	1,097,592	1,014,692	941,025	896,977	853,152	803,942	718,991	665,235
3500						1,347,689	1,277,559	1,208,021	1,152,536	1,066,916	987,009	939,631	892,340	840,842	750,489	693,341
4000							1,345,933	1,262,956	1,202,623	1,111,668	1,023,268	972,267	922,165	869,971	776,317	718,180
4500								1,335,510	1,261,386	1,164,917	1,070,728	1,017,927	964,591	910,773	814,202	752,360
5000									1,321,726	1,214,330	1,111,747	1,053,308	997,971	942,380	842,863	779,417
6000										1,301,923	1,182,734	1,119,278	1,062,601	1,002,699	900,213	833,454
7000											1,254,057	1,180,560	1,115,823	1,052,044	944,838	872,245
8000												1,262,325	1,183,324	1,109,949	997,813	921,346
9000													1,249,691	1,168,936	1,051,993	970,206
10000														1,228,839	1,102,240	1,015,223
12000															1,256,678	1,144,701
14000																1,301,584

Table H-130: Reach 3 Deep Slow Guild Persistent Habitat (% of maximum possible), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	99.8%	89.4%	85.5%	81.6%	78.6%	76.4%	73.7%	70.4%	67.4%	62.5%	58.3%	55.7%	53.0%	50.5%	45.4%	42.6%
1500		99.8%	95.0%	90.2%	86.7%	84.0%	80.8%	77.0%	73.6%	68.5%	63.9%	61.0%	57.9%	55.0%	49.3%	46.0%
2000			100.0%	94.1%	90.1%	87.1%	83.5%	79.6%	76.0%	70.6%	65.8%	62.7%	59.6%	56.3%	50.4%	47.0%
2500				99.5%	94.2%	90.6%	86.7%	82.7%	79.0%	73.2%	68.1%	64.9%	61.7%	58.3%	52.2%	48.5%
3000					98.8%	94.2%	90.1%	85.2%	81.4%	75.3%	69.8%	66.5%	63.3%	59.6%	53.3%	49.4%
3500						100.0%	94.8%	89.6%	85.5%	79.2%	73.2%	69.7%	66.2%	62.4%	55.7%	51.4%
4000							99.8%	93.7%	89.2%	82.5%	75.9%	72.1%	68.4%	64.5%	57.6%	53.3%
4500								99.1%	93.6%	86.4%	79.4%	75.5%	71.6%	67.6%	60.4%	55.8%
5000									98.1%	90.1%	82.5%	78.1%	74.0%	69.9%	62.5%	57.8%
6000										96.6%	87.7%	83.0%	78.8%	74.4%	66.8%	61.8%
7000											93.0%	87.6%	82.8%	78.0%	70.1%	64.7%
8000												93.6%	87.8%	82.3%	74.0%	68.4%
9000													92.7%	86.7%	78.0%	72.0%
10000														91.2%	81.8%	75.3%
12000															93.2%	84.9%
14000																96.6%

Table H-131: Reach 3 Deep Fast Guild Persistent Habitat (ft²), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	142,578	142,578	111,534	91,232	75,695	62,221	43,567	34,626	31,844	14,492	2,425	2,425	586	586	586	586
1500		142,578	111,534	91,232	75,695	62,221	43,567	34,626	31,844	14,492	2,425	2,425	586	586	586	586
2000			163,316	139,306	122,261	104,565	81,896	66,775	49,454	25,801	6,501	2,425	586	586	586	586
2500				174,972	152,919	131,028	106,646	86,055	66,801	35,810	15,921	3,414	586	586	586	586
3000					203,712	170,833	140,779	113,275	90,042	49,759	22,338	7,989	586	586	586	586
3500						206,391	171,492	140,393	112,176	67,153	30,424	13,840	3,961	586	586	586
4000							211,117	172,794	141,326	93,187	50,017	22,447	10,631	3,035	586	586
4500								202,538	166,261	111,756	62,488	32,513	15,165	6,398	586	586
5000									187,378	128,717	76,293	42,364	22,400	12,115	586	586
6000										177,804	119,230	79,237	53,548	30,958	7,060	586
7000											203,529	153,707	122,391	86,810	22,899	2,225
8000												266,428	226,406	174,955	64,720	20,607
9000													345,212	286,217	142,097	42,079
10000														430,091	244,124	105,866
12000															409,218	226,399
14000																318,420

Table H-132: Reach 3 Deep Fast Guild Persistent Habitat (% of maximum possible), Bypass Q = 200 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	33.2%	33.2%	25.9%	21.2%	17.6%	14.5%	10.1%	8.1%	7.4%	3.4%	0.6%	0.6%	0.1%	0.1%	0.1%	0.1%
1500		33.2%	25.9%	21.2%	17.6%	14.5%	10.1%	8.1%	7.4%	3.4%	0.6%	0.6%	0.1%	0.1%	0.1%	0.1%
2000			38.0%	32.4%	28.4%	24.3%	19.0%	15.5%	11.5%	6.0%	1.5%	0.6%	0.1%	0.1%	0.1%	0.1%
2500				40.7%	35.6%	30.5%	24.8%	20.0%	15.5%	8.3%	3.7%	0.8%	0.1%	0.1%	0.1%	0.1%
3000					47.4%	39.7%	32.7%	26.3%	20.9%	11.6%	5.2%	1.9%	0.1%	0.1%	0.1%	0.1%
3500						48.0%	39.9%	32.6%	26.1%	15.6%	7.1%	3.2%	0.9%	0.1%	0.1%	0.1%
4000							49.1%	40.2%	32.9%	21.7%	11.6%	5.2%	2.5%	0.7%	0.1%	0.1%
4500								47.1%	38.7%	26.0%	14.5%	7.6%	3.5%	1.5%	0.1%	0.1%
5000									43.6%	29.9%	17.7%	9.9%	5.2%	2.8%	0.1%	0.1%
6000										41.3%	27.7%	18.4%	12.5%	7.2%	1.6%	0.1%
7000											47.3%	35.7%	28.5%	20.2%	5.3%	0.5%
8000												61.9%	52.6%	40.7%	15.0%	4.8%
9000													80.3%	66.5%	33.0%	9.8%
10000														100.0%	56.8%	24.6%
12000															95.1%	52.6%
14000																74.0%

Table H-133: Reach 3 Deep Fast Guild Persistent Habitat (ft^2), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	271,055	271,055	237,491	212,351	193,238	173,819	157,583	139,821	126,957	92,526	66,212	54,407	43,678	39,692	30,521	17,172
1500		271,055	237,491	212,351	193,238	173,819	157,583	139,821	126,957	92,526	66,212	54,407	43,678	39,692	30,521	17,172
2000			278,508	250,096	227,619	202,172	184,758	161,757	139,763	103,878	72,107	54,407	43,678	39,692	30,521	17,172
2500				293,348	265,706	236,480	214,548	189,244	165,446	116,161	81,167	55,606	44,017	39,692	30,521	17,172
3000					311,843	280,304	253,321	223,616	197,667	141,610	96,576	62,094	44,017	39,692	30,521	17,172
3500						325,150	297,752	264,966	234,031	173,108	115,092	72,182	50,607	40,616	30,521	17,172
4000							347,175	309,621	275,978	205,242	139,847	82,690	53,789	40,750	30,655	17,172
4500								362,446	324,518	242,918	171,884	100,962	63,011	48,398	31,184	17,172
5000									365,463	277,824	194,991	117,976	71,974	55,225	31,210	17,172
6000										343,077	246,967	163,143	107,988	76,476	40,962	17,233
7000											365,826	263,907	195,035	144,184	60,992	23,191
8000												376,670	290,937	224,474	102,629	33,256
9000													423,224	344,848	180,968	53,688
10000														506,726	295,677	130,134
12000															447,772	241,672
14000																319,280

Table H-134: Reach 3 Deep Fast Guild Persistent Habitat (% of maximum possible), Bypass Q = 500 cfs																
Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	53.5%	53.5%	46.9%	41.9%	38.1%	34.3%	31.1%	27.6%	25.1%	18.3%	13.1%	10.7%	8.6%	7.8%	6.0%	3.4%
1500		53.5%	46.9%	41.9%	38.1%	34.3%	31.1%	27.6%	25.1%	18.3%	13.1%	10.7%	8.6%	7.8%	6.0%	3.4%
2000			55.0%	49.4%	44.9%	39.9%	36.5%	31.9%	27.6%	20.5%	14.2%	10.7%	8.6%	7.8%	6.0%	3.4%
2500				57.9%	52.4%	46.7%	42.3%	37.3%	32.6%	22.9%	16.0%	11.0%	8.7%	7.8%	6.0%	3.4%
3000					61.5%	55.3%	50.0%	44.1%	39.0%	27.9%	19.1%	12.3%	8.7%	7.8%	6.0%	3.4%
3500						64.2%	58.8%	52.3%	46.2%	34.2%	22.7%	14.2%	10.0%	8.0%	6.0%	3.4%
4000							68.5%	61.1%	54.5%	40.5%	27.6%	16.3%	10.6%	8.0%	6.0%	3.4%
4500								71.5%	64.0%	47.9%	33.9%	19.9%	12.4%	9.6%	6.2%	3.4%
5000									72.1%	54.8%	38.5%	23.3%	14.2%	10.9%	6.2%	3.4%
6000										67.7%	48.7%	32.2%	21.3%	15.1%	8.1%	3.4%
7000											72.2%	52.1%	38.5%	28.5%	12.0%	4.6%
8000												74.3%	57.4%	44.3%	20.3%	6.6%
9000													83.5%	68.1%	35.7%	10.6%
10000														100.0%	58.4%	25.7%
12000															88.4%	47.7%
14000																63.0%

Table H-135: Reach 3 Deep Fast Guild Persistent Habitat (ft²), Bypass Q = 1000 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	316,039	258,593	237,012	228,304	222,304	218,252	212,340	202,220	199,792	185,828	170,971	153,684	131,754	109,070	79,639	64,661
1500		388,053	358,560	337,424	315,575	297,408	276,927	251,798	238,954	203,911	173,058	154,839	132,909	110,225	79,639	64,661
2000			397,828	371,919	347,168	324,635	301,863	274,728	253,956	215,889	180,215	156,053	133,095	110,411	79,824	64,661
2500				423,660	394,955	367,135	339,961	310,527	288,532	240,467	200,693	170,393	141,839	116,190	81,377	65,662
3000					441,470	413,177	383,044	350,181	327,248	273,068	223,703	190,817	152,443	119,149	81,377	65,662
3500						458,495	423,612	388,420	364,974	303,966	246,558	209,872	163,597	121,857	81,726	65,662
4000							472,602	432,791	405,419	340,381	280,483	239,807	191,903	142,771	82,670	65,662
4500								464,780	436,989	369,852	304,806	261,259	208,321	155,117	84,883	65,818
5000									472,267	401,659	334,343	287,531	230,563	167,043	85,827	65,818
6000										499,136	422,097	369,504	301,482	213,914	107,277	70,057
7000											553,186	484,352	402,037	287,518	134,782	76,094
8000												637,160	540,083	393,459	188,866	93,762
9000													720,224	543,074	292,957	121,599
10000														658,580	377,806	175,940
12000															545,492	306,212
14000																389,086

Table H-136: Reach 3 Deep Fast Guild Persistent Habitat (% of maximum possible), Bypass Q = 1000 cfs

Minimum Flow (cfs)	Generation Flow (cfs)															
	0	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000	8000	9000	10000	12000	14000
0	43.9%	35.9%	32.9%	31.7%	30.9%	30.3%	29.5%	28.1%	27.7%	25.8%	23.7%	21.3%	18.3%	15.1%	11.1%	9.0%
1500		53.9%	49.8%	46.8%	43.8%	41.3%	38.5%	35.0%	33.2%	28.3%	24.0%	21.5%	18.5%	15.3%	11.1%	9.0%
2000			55.2%	51.6%	48.2%	45.1%	41.9%	38.1%	35.3%	30.0%	25.0%	21.7%	18.5%	15.3%	11.1%	9.0%
2500				58.8%	54.8%	51.0%	47.2%	43.1%	40.1%	33.4%	27.9%	23.7%	19.7%	16.1%	11.3%	9.1%
3000					61.3%	57.4%	53.2%	48.6%	45.4%	37.9%	31.1%	26.5%	21.2%	16.5%	11.3%	9.1%
3500						63.7%	58.8%	53.9%	50.7%	42.2%	34.2%	29.1%	22.7%	16.9%	11.3%	9.1%
4000							65.6%	60.1%	56.3%	47.3%	38.9%	33.3%	26.6%	19.8%	11.5%	9.1%
4500								64.5%	60.7%	51.4%	42.3%	36.3%	28.9%	21.5%	11.8%	9.1%
5000									65.6%	55.8%	46.4%	39.9%	32.0%	23.2%	11.9%	9.1%
6000										69.3%	58.6%	51.3%	41.9%	29.7%	14.9%	9.7%
7000											76.8%	67.3%	55.8%	39.9%	18.7%	10.6%
8000												88.5%	75.0%	54.6%	26.2%	13.0%
9000													100.0%	75.4%	40.7%	16.9%
10000														91.4%	52.5%	24.4%
12000															75.7%	42.5%
14000																54.0%

Table H-137: Reach 3 Deep Fast Guild Persistent Habitat (ft^2), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	622,472	553,106	522,822	502,309	476,577	461,074	444,736	431,134	420,545	401,352	386,483	365,427	334,193	307,569	255,826	187,435
1500		671,994	625,607	595,834	562,190	538,030	513,198	486,197	466,657	435,807	403,712	372,808	338,625	312,001	260,258	189,925
2000			675,904	637,455	599,958	572,646	544,911	514,947	492,441	453,382	419,273	380,859	339,892	313,268	261,525	190,954
2500				673,372	632,583	603,832	574,996	543,257	517,830	475,548	435,354	394,594	346,221	315,736	263,993	191,492
3000					698,477	667,478	634,511	602,601	573,215	524,476	474,573	419,488	364,654	323,905	271,297	196,900
3500						735,183	695,373	658,096	624,832	570,846	509,609	438,203	377,378	333,619	274,089	198,535
4000							770,998	729,936	695,773	636,632	570,247	483,526	397,958	352,359	281,098	203,304
4500								840,054	797,809	723,465	645,738	540,627	431,576	371,864	285,985	205,261
5000									877,940	794,757	711,149	597,824	481,401	399,280	303,306	209,510
6000										932,939	838,884	707,394	580,014	475,103	334,365	222,253
7000											1,005,299	859,131	710,131	597,357	385,021	257,945
8000												965,781	806,268	683,566	458,700	291,677
9000													911,512	780,636	539,802	340,686
10000														851,455	601,466	394,893
12000															677,586	461,236
14000																536,088

Table H-138: Reach 3 Deep Fast Guild Persistent Habitat (% of maximum possible), Bypass Q = 3000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	61.9%	55.0%	52.0%	50.0%	47.4%	45.9%	44.2%	42.9%	41.8%	39.9%	38.4%	36.4%	33.2%	30.6%	25.4%	18.6%
1500		66.8%	62.2%	59.3%	55.9%	53.5%	51.0%	48.4%	46.4%	43.4%	40.2%	37.1%	33.7%	31.0%	25.9%	18.9%
2000			67.2%	63.4%	59.7%	57.0%	54.2%	51.2%	49.0%	45.1%	41.7%	37.9%	33.8%	31.2%	26.0%	19.0%
2500				67.0%	62.9%	60.1%	57.2%	54.0%	51.5%	47.3%	43.3%	39.3%	34.4%	31.4%	26.3%	19.0%
3000					69.5%	66.4%	63.1%	59.9%	57.0%	52.2%	47.2%	41.7%	36.3%	32.2%	27.0%	19.6%
3500						73.1%	69.2%	65.5%	62.2%	56.8%	50.7%	43.6%	37.5%	33.2%	27.3%	19.7%
4000							76.7%	72.6%	69.2%	63.3%	56.7%	48.1%	39.6%	35.1%	28.0%	20.2%
4500								83.6%	79.4%	72.0%	64.2%	53.8%	42.9%	37.0%	28.4%	20.4%
5000									87.3%	79.1%	70.7%	59.5%	47.9%	39.7%	30.2%	20.8%
6000										92.8%	83.4%	70.4%	57.7%	47.3%	33.3%	22.1%
7000											100.0%	85.5%	70.6%	59.4%	38.3%	25.7%
8000												96.1%	80.2%	68.0%	45.6%	29.0%
9000													90.7%	77.7%	53.7%	33.9%
10000														84.7%	59.8%	39.3%
12000															67.4%	45.9%
14000																53.3%

Table H-139: Reach 3 Deep Fast Guild Persistent Habitat (ft²), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	792,417	655,163	629,316	599,179	574,354	541,194	512,352	484,845	458,245	388,324	357,131	345,253	332,827	314,357	239,988	158,654
1500		787,810	755,298	718,133	684,896	643,349	610,009	575,547	540,432	445,243	382,330	356,650	340,038	321,568	244,436	160,901
2000			818,644	780,335	746,139	702,207	665,690	629,889	589,890	484,150	407,246	370,049	344,094	324,402	244,436	160,901
2500				854,996	818,858	771,729	729,621	690,712	650,713	539,213	442,847	385,996	355,172	328,620	247,799	162,426
3000					901,638	851,380	803,486	762,215	715,904	595,113	493,480	418,177	378,839	342,338	253,507	163,267
3500						915,388	866,762	821,957	774,206	650,259	544,690	457,435	397,606	358,600	259,320	164,969
4000							941,231	895,801	842,603	709,800	597,430	507,880	419,629	372,195	267,516	168,192
4500								981,108	927,026	790,028	662,528	566,645	472,357	396,629	281,341	173,162
5000									993,438	849,105	712,886	613,351	514,791	422,157	294,838	176,531
6000										951,521	809,010	698,674	591,871	492,624	325,028	186,955
7000											904,114	787,239	672,976	564,925	373,707	212,849
8000												854,903	738,705	624,541	426,925	245,188
9000													789,812	670,473	466,878	281,071
10000														716,086	507,458	313,862
12000															560,453	357,352
14000																402,259

Table H-140: Reach 3 Deep Fast Guild Persistent Habitat (% of maximum possible), Bypass Q = 5000 cfs																
Minimum Flow (cfs)	**Generation Flow (cfs)**															
	0	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**	**12000**	**14000**
0	79.8%	65.9%	63.3%	60.3%	57.8%	54.5%	51.6%	48.8%	46.1%	39.1%	35.9%	34.8%	33.5%	31.6%	24.2%	16.0%
1500		79.3%	76.0%	72.3%	68.9%	64.8%	61.4%	57.9%	54.4%	44.8%	38.5%	35.9%	34.2%	32.4%	24.6%	16.2%
2000			82.4%	78.5%	75.1%	70.7%	67.0%	63.4%	59.4%	48.7%	41.0%	37.2%	34.6%	32.7%	24.6%	16.2%
2500				86.1%	82.4%	77.7%	73.4%	69.5%	65.5%	54.3%	44.6%	38.9%	35.8%	33.1%	24.9%	16.3%
3000					90.8%	85.7%	80.9%	76.7%	72.1%	59.9%	49.7%	42.1%	38.1%	34.5%	25.5%	16.4%
3500						92.1%	87.2%	82.7%	77.9%	65.5%	54.8%	46.0%	40.0%	36.1%	26.1%	16.6%
4000							94.7%	90.2%	84.8%	71.4%	60.1%	51.1%	42.2%	37.5%	26.9%	16.9%
4500								98.8%	93.3%	79.5%	66.7%	57.0%	47.5%	39.9%	28.3%	17.4%
5000									100.0%	85.5%	71.8%	61.7%	51.8%	42.5%	29.7%	17.8%
6000										95.8%	81.4%	70.3%	59.6%	49.6%	32.7%	18.8%
7000											91.0%	79.2%	67.7%	56.9%	37.6%	21.4%
8000												86.1%	74.4%	62.9%	43.0%	24.7%
9000													79.5%	67.5%	47.0%	28.3%
10000														72.1%	51.1%	31.6%
12000															56.4%	36.0%
14000																40.5%

APPENDIX I – REACH 4 DUAL FLOW ANALYSIS TABLES

Table I-1: American Shad Spawning Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	3,114,338	3,114,338	3,114,338	3,114,338	3,114,338	3,114,338	3,114,338	3,114,338	3,109,330	3,061,892	2,852,947	2,666,275	2,307,746	1,979,326	1,716,621	1,375,901	842,374
1,600		4,692,641	4,692,641	4,692,641	4,692,641	4,692,641	4,692,641	4,690,137	4,682,404	4,621,760	4,388,916	4,170,963	3,724,737	3,338,313	2,839,595	2,271,165	1,390,491
2,000			5,781,355	5,781,355	5,781,355	5,781,355	5,781,355	5,777,544	5,766,100	5,698,921	5,445,432	5,217,825	4,733,360	4,317,220	3,725,947	3,015,847	1,873,079
2,800				7,109,382	7,109,382	7,109,382	7,109,024	7,102,645	7,075,261	6,982,463	6,699,454	6,453,900	5,915,565	5,446,932	4,694,891	3,733,749	2,211,103
4,000					8,386,139	8,366,003	8,359,905	8,340,518	8,278,638	8,139,606	7,790,523	7,515,888	6,914,098	6,374,992	5,440,685	4,296,603	2,554,476
5,000						9,263,371	9,254,892	9,224,808	9,146,899	8,994,145	8,628,500	8,337,152	7,706,312	7,123,972	6,000,285	4,669,406	2,822,522
6,000							10,076,249	10,038,687	9,943,550	9,775,384	9,391,677	9,087,686	8,424,463	7,794,626	6,557,659	5,079,143	3,115,527
8,000								11,409,130	11,256,159	11,048,361	10,629,220	10,300,735	9,579,536	8,877,259	7,467,473	5,810,846	3,685,585
10,000									12,035,376	11,812,006	11,373,688	11,029,487	10,269,021	9,529,587	8,048,467	6,332,021	4,155,870
12,000										12,293,997	11,839,686	11,486,037	10,711,464	9,947,913	8,411,388	6,663,683	4,447,493
14,000											12,146,895	11,789,963	10,997,110	10,217,043	8,654,251	6,887,086	4,635,042
15,000												11,904,963	11,107,455	10,319,155	8,746,902	6,972,955	4,703,972
17,500													11,350,684	10,549,923	8,954,560	7,164,188	4,867,620
20,000														10,742,127	9,129,351	7,325,485	5,011,323
25,000															9,234,862	7,418,794	5,085,580
30,000																7,487,743	5,151,749
37,500																	5,172,452

Table I-2: American Shad Spawning Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	25.3%	25.3%	25.3%	25.3%	25.3%	25.3%	25.3%	25.3%	25.3%	24.9%	23.2%	21.7%	18.8%	16.1%	14.0%	11.2%	6.9%
1,600		38.2%	38.2%	38.2%	38.2%	38.2%	38.2%	38.1%	38.1%	37.6%	35.7%	33.9%	30.3%	27.2%	23.1%	18.5%	11.3%
2,000			47.0%	47.0%	47.0%	47.0%	47.0%	47.0%	46.9%	46.4%	44.3%	42.4%	38.5%	35.1%	30.3%	24.5%	15.2%
2,800				57.8%	57.8%	57.8%	57.8%	57.8%	57.6%	56.8%	54.5%	52.5%	48.1%	44.3%	38.2%	30.4%	18.0%
4,000					68.2%	68.0%	68.0%	67.8%	67.3%	66.2%	63.4%	61.1%	56.2%	51.9%	44.3%	34.9%	20.8%
5,000						75.3%	75.3%	75.0%	74.4%	73.2%	70.2%	67.8%	62.7%	57.9%	48.8%	38.0%	23.0%
6,000							82.0%	81.7%	80.9%	79.5%	76.4%	73.9%	68.5%	63.4%	53.3%	41.3%	25.3%
8,000								92.8%	91.6%	89.9%	86.5%	83.8%	77.9%	72.2%	60.7%	47.3%	30.0%
10,000									97.9%	96.1%	92.5%	89.7%	83.5%	77.5%	65.5%	51.5%	33.8%
12,000										100.0%	96.3%	93.4%	87.1%	80.9%	68.4%	54.2%	36.2%
14,000											98.8%	95.9%	89.5%	83.1%	70.4%	56.0%	37.7%
15,000												96.8%	90.3%	83.9%	71.1%	56.7%	38.3%
17,500													92.3%	85.8%	72.8%	58.3%	39.6%
20,000														87.4%	74.3%	59.6%	40.8%
25,000															75.1%	60.3%	41.4%
30,000																60.9%	41.9%
37,500																	42.1%

Table I-3: Shortnose Sturgeon Fry Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	8,275,594	8,242,685	8,200,117	8,089,131	7,694,533	7,064,742	6,369,940	5,269,127	4,741,465	4,406,051	4,122,228	3,965,087	3,447,054	2,915,476	1,710,226	1,150,644	830,847
1,600		9,972,138	9,928,497	9,794,975	9,374,265	8,716,327	7,951,829	6,674,514	5,999,517	5,520,124	5,057,299	4,861,671	4,230,637	3,603,347	2,278,255	1,562,272	1,065,010
2,000			11,260,779	11,121,176	10,682,222	10,014,534	9,232,674	7,845,901	7,041,184	6,465,765	5,882,272	5,603,681	4,814,185	4,092,900	2,649,543	1,872,706	1,305,366
2,800				12,711,746	12,249,184	11,551,423	10,734,750	9,215,938	8,241,303	7,503,861	6,785,128	6,458,241	5,548,343	4,747,409	3,160,615	2,300,924	1,664,121
4,000					13,684,363	12,956,296	12,084,974	10,500,861	9,499,867	8,732,844	7,960,525	7,576,365	6,580,574	5,683,163	3,934,307	2,986,541	2,207,960
5,000						13,392,431	12,505,476	10,910,791	9,904,361	9,130,211	8,344,795	7,951,224	6,944,468	6,017,200	4,228,569	3,237,367	2,422,076
6,000							12,779,007	11,176,992	10,165,720	9,385,641	8,595,491	8,198,481	7,180,540	6,245,539	4,418,506	3,398,585	2,553,120
8,000								11,472,528	10,451,447	9,661,763	8,857,897	8,456,512	7,430,645	6,484,253	4,639,376	3,606,823	2,743,040
10,000									10,707,584	9,909,137	9,097,249	8,694,089	7,658,152	6,683,431	4,831,551	3,793,288	2,925,695
12,000										10,060,097	9,244,536	8,840,068	7,797,018	6,820,509	4,966,744	3,924,794	3,043,250
14,000											9,377,004	8,970,515	7,925,346	6,947,653	5,092,223	4,042,046	3,160,437
15,000												9,029,340	7,984,170	7,006,010	5,149,150	4,098,381	3,216,643
17,500													8,082,358	7,103,840	5,245,906	4,194,780	3,301,694
20,000														7,171,873	5,312,509	4,261,025	3,366,184
25,000															5,416,392	4,363,998	3,467,144
30,000																4,483,301	3,585,959
37,500																	3,677,951

Table I-4: Shortnose Sturgeon Fry Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	**1,600**	**2,000**	**2,800**	**4,000**	**5,000**	**6,000**	**8,000**	**10,000**	**12,000**	**14,000**	**15,000**	**17,500**	**20,000**	**25,000**	**30,000**	**37,500**
1,200	60.5%	60.2%	59.9%	59.1%	56.2%	51.6%	46.5%	38.5%	34.6%	32.2%	30.1%	29.0%	25.2%	21.3%	12.5%	8.4%	6.1%
1,600		72.9%	72.6%	71.6%	68.5%	63.7%	58.1%	48.8%	43.8%	40.3%	37.0%	35.5%	30.9%	26.3%	16.6%	11.4%	7.8%
2,000			82.3%	81.3%	78.1%	73.2%	67.5%	57.3%	51.5%	47.2%	43.0%	40.9%	35.2%	29.9%	19.4%	13.7%	9.5%
2,800				92.9%	89.5%	84.4%	78.4%	67.3%	60.2%	54.8%	49.6%	47.2%	40.5%	34.7%	23.1%	16.8%	12.2%
4,000					100.0%	94.7%	88.3%	76.7%	69.4%	63.8%	58.2%	55.4%	48.1%	41.5%	28.8%	21.8%	16.1%
5,000						97.9%	91.4%	79.7%	72.4%	66.7%	61.0%	58.1%	50.7%	44.0%	30.9%	23.7%	17.7%
6,000							93.4%	81.7%	74.3%	68.6%	62.8%	59.9%	52.5%	45.6%	32.3%	24.8%	18.7%
8,000								83.8%	76.4%	70.6%	64.7%	61.8%	54.3%	47.4%	33.9%	26.4%	20.0%
10,000									78.2%	72.4%	66.5%	63.5%	56.0%	48.8%	35.3%	27.7%	21.4%
12,000										73.5%	67.6%	64.6%	57.0%	49.8%	36.3%	28.7%	22.2%
14,000											68.5%	65.6%	57.9%	50.8%	37.2%	29.5%	23.1%
15,000												66.0%	58.3%	51.2%	37.6%	29.9%	23.5%
17,500													59.1%	51.9%	38.3%	30.7%	24.1%
20,000														52.4%	38.8%	31.1%	24.6%
25,000															39.6%	31.9%	25.3%
30,000																32.8%	26.2%
37,500																	26.9%

Table I-5: Fallfish Spawning Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	3,389,586	2,520,040	1,875,888	1,114,422	424,790	81,172	4,143	0	0	0	0	0	0	0	0	0	0
1,600		3,056,902	2,400,652	1,620,870	871,682	377,578	33,118	0	0	0	0	0	0	0	0	0	0
2,000			2,872,681	2,084,135	1,307,505	736,437	216,558	0	0	0	0	0	0	0	0	0	0
2,800				2,776,547	1,970,396	1,340,057	679,431	26,361	0	0	0	0	0	0	0	0	0
4,000					2,451,027	1,777,226	1,072,876	238,019	0	0	0	0	0	0	0	0	0
5,000						1,952,329	1,237,372	384,023	80,776	0	0	0	0	0	0	0	0
6,000							1,332,950	468,582	156,625	0	0	0	0	0	0	0	0
8,000								549,369	224,590	59,022	22,536	16,812	0	0	0	0	0
10,000									291,482	123,768	80,127	60,811	11,447	0	0	0	0
12,000										164,189	115,183	92,289	17,886	0	0	0	0
14,000											129,133	106,240	30,048	8,227	0	0	0
15,000												119,833	43,283	21,105	0	0	0
17,500													44,714	22,178	0	0	0
20,000														22,178	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	111,606

Table I-6: Fallfish Spawning Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	**1,600**	**2,000**	**2,800**	**4,000**	**5,000**	**6,000**	**8,000**	**10,000**	**12,000**	**14,000**	**15,000**	**17,500**	**20,000**	**25,000**	**30,000**	**37,500**
1,200	100.0%	74.3%	55.3%	32.9%	12.5%	2.4%	0.1%	0	0	0	0	0	0	0	0	0	0
1,600		90.2%	70.8%	47.8%	25.7%	11.1%	1.0%	0	0	0	0	0	0	0	0	0	0
2,000			84.8%	61.5%	38.6%	21.7%	6.4%	0	0	0	0	0	0	0	0	0	0
2,800				81.9%	58.1%	39.5%	20.0%	0.8%	0	0	0	0	0	0	0	0	0
4,000					72.3%	52.4%	31.7%	7.0%	0	0	0	0	0	0	0	0	0
5,000						57.6%	36.5%	11.3%	2.4%	0	0	0	0	0	0	0	0
6,000							39.3%	13.8%	4.6%	0	0	0	0	0	0	0	0
8,000								16.2%	6.6%	1.7%	0.7%	0.5%	0	0	0	0	0
10,000									8.6%	3.7%	2.4%	1.8%	0.3%	0	0	0	0
12,000										4.8%	3.4%	2.7%	0.5%	0	0	0	0
14,000											3.8%	3.1%	0.9%	0.2%	0	0	0
15,000												3.5%	1.3%	0.6%	0	0	0
17,500													1.3%	0.7%	0	0	0
20,000														0.7%	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	3.3%

Table I-7: Fallfish Fry Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	5,165,524	4,003,181	3,071,455	1,822,882	602,506	149,483	36,386	194	0	0	0	0	0	0	0	0	0
1,600		4,759,928	3,821,831	2,529,037	1,050,206	410,843	116,879	3,107	0	0	0	0	0	0	0	0	0
2,000			4,374,054	3,061,133	1,491,155	737,749	305,629	9,969	712	0	0	0	0	0	0	0	0
2,800				3,819,930	2,081,765	1,212,737	667,142	85,864	3,172	324	0	0	0	0	0	0	0
4,000					2,466,359	1,591,805	1,014,410	316,620	34,424	1,295	65	0	0	0	0	0	0
5,000						1,697,334	1,116,019	389,990	76,999	1,877	324	194	0	0	0	0	0
6,000							1,258,988	517,547	181,605	21,194	4,467	3,043	712	194	0	0	0
8,000								680,163	306,927	94,502	23,157	18,292	4,531	1,100	0	0	0
10,000									402,102	160,345	63,606	47,948	4,531	1,100	0	0	0
12,000										300,936	156,622	128,444	31,640	18,629	1,942	1,748	0
14,000											217,536	187,570	66,730	30,509	5,697	2,913	0
15,000												198,645	75,659	33,013	5,697	2,913	0
17,500													111,659	61,170	13,924	10,425	0
20,000														87,261	23,679	18,033	0
25,000															104,803	71,614	0
30,000																139,393	7,154
37,500																	259,340

Table I-8: Fallfish Fry Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	100.0%	77.5%	59.5%	35.3%	11.7%	2.9%	0.7%	0.0%	0	0	0	0	0	0	0	0	0
1,600		92.1%	74.0%	49.0%	20.3%	8.0%	2.3%	0.1%	0	0	0	0	0	0	0	0	0
2,000			84.7%	59.3%	28.9%	14.3%	5.9%	0.2%	0.0%	0	0	0	0	0	0	0	0
2,800				74.0%	40.3%	23.5%	12.9%	1.7%	0.1%	0.0%	0	0	0	0	0	0	0
4,000					47.7%	30.8%	19.6%	6.1%	0.7%	0.0%	0.0%	0	0	0	0	0	0
5,000						32.9%	21.6%	7.5%	1.5%	0.0%	0.0%	0.0%	0	0	0	0	0
6,000							24.4%	10.0%	3.5%	0.4%	0.1%	0.1%	0.0%	0.0%	0	0	0
8,000								13.2%	5.9%	1.8%	0.4%	0.4%	0.1%	0.0%	0	0	0
10,000									7.8%	3.1%	1.2%	0.9%	0.1%	0.0%	0	0	0
12,000										5.8%	3.0%	2.5%	0.6%	0.4%	0.0%	0.0%	0
14,000											4.2%	3.6%	1.3%	0.6%	0.1%	0.1%	0
15,000												3.8%	1.5%	0.6%	0.1%	0.1%	0
17,500													2.2%	1.2%	0.3%	0.2%	0
20,000														1.7%	0.5%	0.3%	0
25,000															2.0%	1.4%	0
30,000																2.7%	0.1%
37,500																	5.0%

Table I-9: White Sucker Spawning Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	218,603	140,610	36,268	259	0	0	0	0	0	0	0	0	0	0	0	0	0
1,600		159,078	52,103	518	0	0	0	0	0	0	0	0	0	0	0	0	0
2,000			76,257	18,526	518	0	0	0	0	0	0	0	0	0	0	0	0
2,800				147,612	42,200	259	65	0	0	0	0	0	0	0	0	0	0
4,000					76,928	518	194	0	0	0	0	0	0	0	0	0	0
5,000						906	324	0	0	0	0	0	0	0	0	0	0
6,000							1,100	453	65	0	0	0	0	0	0	0	0
8,000								2,072	906	388	0	0	0	0	0	0	0
10,000									24,120	1,295	0	0	0	0	0	0	0
12,000										2,654	1,165	1,165	65	65	0	0	0
14,000											3,301	2,719	906	906	0	0	0
15,000												3,043	1,230	971	0	0	0
17,500													1,295	971	0	0	0
20,000														971	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	0

Table I-10: White Sucker Spawning Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	100.0%	64.3%	16.6%	0.1%	0	0	0	0	0	0	0	0	0	0	0	0	0
1,600		72.8%	23.8%	0.2%	0	0	0	0	0	0	0	0	0	0	0	0	0
2,000			34.9%	8.5%	0.2%	0	0	0	0	0	0	0	0	0	0	0	0
2,800				67.5%	19.3%	0.1%	0.0%	0	0	0	0	0	0	0	0	0	0
4,000					35.2%	0.2%	0.1%	0	0	0	0	0	0	0	0	0	0
5,000						0.4%	0.1%	0	0	0	0	0	0	0	0	0	0
6,000							0.5%	0.2%	0.0%	0	0	0	0	0	0	0	0
8,000								0.9%	0.4%	0.2%	0	0	0	0	0	0	0
10,000									11.0%	0.6%	0	0	0	0	0	0	0
12,000										1.2%	0.5%	0.5%	0.0%	0.0%	0	0	0
14,000											1.5%	1.2%	0.4%	0.4%	0	0	0
15,000												1.4%	0.6%	0.4%	0	0	0
17,500													0.6%	0.4%	0	0	0
20,000														0.4%	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	0

Table I-11: White Sucker Fry Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	13,894,155	12,086,038	10,412,271	7,352,551	4,513,063	3,560,228	3,010,538	2,324,791	1,950,751	1,742,141	1,616,413	1,587,114	1,503,902	1,444,753	1,338,232	1,257,253	1,192,456
1,600		12,707,573	10,953,108	7,759,275	4,784,972	3,786,186	3,188,062	2,469,895	2,079,597	1,840,284	1,711,599	1,678,106	1,592,295	1,530,028	1,418,577	1,334,028	1,258,990
2,000			11,508,121	8,223,457	5,104,636	4,009,732	3,337,171	2,600,016	2,195,977	1,951,243	1,801,662	1,760,958	1,660,466	1,595,119	1,471,002	1,381,970	1,304,278
2,800				9,070,709	5,756,077	4,427,146	3,687,150	2,837,904	2,374,377	2,093,050	1,924,957	1,876,688	1,757,303	1,677,313	1,529,901	1,428,624	1,350,051
4,000					6,605,527	5,128,576	4,276,238	3,264,055	2,738,125	2,428,588	2,225,545	2,157,735	1,991,194	1,893,555	1,729,470	1,616,783	1,534,831
5,000						5,713,638	4,807,167	3,674,629	3,088,810	2,768,456	2,552,173	2,482,176	2,296,772	2,189,308	2,017,203	1,895,131	1,790,642
6,000							5,437,092	4,286,227	3,682,345	3,348,582	3,120,446	3,034,432	2,827,314	2,689,718	2,488,880	2,353,931	2,223,754
8,000								4,805,542	4,170,784	3,805,247	3,501,741	3,399,686	3,144,767	2,965,802	2,680,704	2,531,056	2,396,140
10,000									4,485,244	4,108,103	3,687,115	3,560,565	3,228,807	2,997,712	2,683,565	2,532,845	2,396,140
12,000										4,174,883	3,730,229	3,593,937	3,253,374	3,016,829	2,684,571	2,533,492	2,396,140
14,000											3,827,742	3,689,185	3,312,587	3,056,400	2,700,940	2,535,604	2,396,140
15,000												3,721,931	3,333,358	3,068,324	2,703,373	2,536,677	2,396,140
17,500													3,394,052	3,115,945	2,738,589	2,558,482	2,396,140
20,000														3,182,283	2,781,131	2,580,490	2,396,140
25,000															2,868,294	2,634,867	2,407,145
30,000																2,698,114	2,450,733
37,500																	2,540,127

Table I-12: White Sucker Fry Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	100.0%	87.0%	74.9%	52.9%	32.5%	25.6%	21.7%	16.7%	14.0%	12.5%	11.6%	11.4%	10.8%	10.4%	9.6%	9.0%	8.6%
1,600		91.5%	78.8%	55.8%	34.4%	27.3%	22.9%	17.8%	15.0%	13.2%	12.3%	12.1%	11.5%	11.0%	10.2%	9.6%	9.1%
2,000			82.8%	59.2%	36.7%	28.9%	24.0%	18.7%	15.8%	14.0%	13.0%	12.7%	12.0%	11.5%	10.6%	9.9%	9.4%
2,800				65.3%	41.4%	31.9%	26.5%	20.4%	17.1%	15.1%	13.9%	13.5%	12.6%	12.1%	11.0%	10.3%	9.7%
4,000					47.5%	36.9%	30.8%	23.5%	19.7%	17.5%	16.0%	15.5%	14.3%	13.6%	12.4%	11.6%	11.0%
5,000						41.1%	34.6%	26.4%	22.2%	19.9%	18.4%	17.9%	16.5%	15.8%	14.5%	13.6%	12.9%
6,000							39.1%	30.8%	26.5%	24.1%	22.5%	21.8%	20.3%	19.4%	17.9%	16.9%	16.0%
8,000								34.6%	30.0%	27.4%	25.2%	24.5%	22.6%	21.3%	19.3%	18.2%	17.2%
10,000									32.3%	29.6%	26.5%	25.6%	23.2%	21.6%	19.3%	18.2%	17.2%
12,000										30.0%	26.8%	25.9%	23.4%	21.7%	19.3%	18.2%	17.2%
14,000											27.5%	26.6%	23.8%	22.0%	19.4%	18.2%	17.2%
15,000												26.8%	24.0%	22.1%	19.5%	18.3%	17.2%
17,500													24.4%	22.4%	19.7%	18.4%	17.2%
20,000														22.9%	20.0%	18.6%	17.2%
25,000															20.6%	19.0%	17.3%
30,000																19.4%	17.6%
37,500																	18.3%

Table I-13: Walleye Spawning Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	388,301	382,928	376,001	356,223	275,188	182,003	42,442	13,506	324	0	0	0	0	0	0	0	0
1,600		524,764	512,574	483,666	375,023	266,265	83,554	49,197	19,679	0	0	0	0	0	0	0	0
2,000			684,192	652,589	522,483	398,344	198,756	143,624	76,560	65	0	0	0	0	0	0	0
2,800				860,525	722,485	587,325	374,409	257,669	147,660	17,266	0	0	0	0	0	0	0
4,000					905,275	748,336	498,579	352,616	187,561	28,385	6,211	0	0	0	0	0	0
5,000						861,508	595,399	438,621	238,683	49,197	18,437	4,000	65	0	0	0	0
6,000							789,003	582,739	325,267	72,414	29,785	6,405	194	0	0	0	0
8,000								1,079,180	693,313	242,715	75,603	12,809	388	129	0	0	0
10,000									938,518	359,308	129,239	31,033	5,390	388	0	0	0
12,000										409,519	157,671	51,044	14,876	518	129	0	0
14,000											191,734	81,062	28,467	777	388	65	0
15,000												94,492	31,702	971	583	259	0
17,500													40,921	1,165	777	388	65
20,000														25,748	1,036	583	194
25,000															1,295	712	324
30,000																777	388
37,500																	453

Table I-14: Walleye Spawning Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	36.0%	35.5%	34.8%	33.0%	25.5%	16.9%	3.9%	1.3%	0.0%	0	0	0	0	0	0	0	0
1,600		48.6%	47.5%	44.8%	34.8%	24.7%	7.7%	4.6%	1.8%	0	0	0	0	0	0	0	0
2,000			63.4%	60.5%	48.4%	36.9%	18.4%	13.3%	7.1%	0.0%	0	0	0	0	0	0	0
2,800				79.7%	66.9%	54.4%	34.7%	23.9%	13.7%	1.6%	0	0	0	0	0	0	0
4,000					83.9%	69.3%	46.2%	32.7%	17.4%	2.6%	0.6%	0	0	0	0	0	0
5,000						79.8%	55.2%	40.6%	22.1%	4.6%	1.7%	0.4%	0.0%	0	0	0	0
6,000							73.1%	54.0%	30.1%	6.7%	2.8%	0.6%	0.0%	0	0	0	0
8,000								100.0%	64.2%	22.5%	7.0%	1.2%	0.0%	0.0%	0	0	0
10,000									87.0%	33.3%	12.0%	2.9%	0.5%	0.0%	0	0	0
12,000										37.9%	14.6%	4.7%	1.4%	0.0%	0.0%	0	0
14,000											17.8%	7.5%	2.6%	0.1%	0.0%	0.0%	0
15,000												8.8%	2.9%	0.1%	0.1%	0.0%	0
17,500													3.8%	0.1%	0.1%	0.0%	0.0%
20,000														2.4%	0.1%	0.1%	0.0%
25,000															0.1%	0.1%	0.0%
30,000																0.1%	0.0%
37,500																	0.0%

Table I-15: Walleye Fry Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	459,887	374,914	336,811	255,874	183,040	131,502	101,672	49,722	0	0	0	0	0	0	0	0	0
1,600		594,733	554,395	462,790	387,650	333,250	301,632	232,512	161,327	0	0	0	0	0	0	0	0
2,000			717,521	608,014	508,907	451,652	418,603	340,182	205,683	9,300	0	0	0	0	0	0	0
2,800				744,524	624,213	522,315	489,266	397,416	253,259	45,787	8,943	0	0	0	0	0	0
4,000					696,949	580,395	539,342	437,837	293,322	74,761	24,324	3,935	0	0	0	0	0
5,000						598,989	556,246	449,734	305,219	86,300	34,790	13,685	1,165	129	0	0	0
6,000							686,481	568,306	423,434	204,158	143,347	112,942	57,990	1,813	0	0	0
8,000								817,846	642,823	397,211	308,863	270,042	171,603	37,533	0	0	0
10,000									730,166	433,807	334,907	296,087	191,635	43,972	0	0	0
12,000										457,899	334,907	296,087	191,635	43,972	0	0	0
14,000											340,988	301,453	191,635	43,972	0	0	0
15,000												301,453	191,635	43,972	0	0	0
17,500													191,635	43,972	0	0	0
20,000														43,972	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	0

Table I-16: Walleye Fry Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	56.2%	45.8%	41.2%	31.3%	22.4%	16.1%	12.4%	6.1%	0	0	0	0	0	0	0	0	0
1,600		72.7%	67.8%	56.6%	47.4%	40.7%	36.9%	28.4%	19.7%	0	0	0	0	0	0	0	0
2,000			87.7%	74.3%	62.2%	55.2%	51.2%	41.6%	25.1%	1.1%	0	0	0	0	0	0	0
2,800				91.0%	76.3%	63.9%	59.8%	48.6%	31.0%	5.6%	1.1%	0	0	0	0	0	0
4,000					85.2%	71.0%	65.9%	53.5%	35.9%	9.1%	3.0%	0.5%	0	0	0	0	0
5,000						73.2%	68.0%	55.0%	37.3%	10.6%	4.3%	1.7%	0.1%	0.0%	0	0	0
6,000							83.9%	69.5%	51.8%	25.0%	17.5%	13.8%	7.1%	0.2%	0	0	0
8,000								100.0%	78.6%	48.6%	37.8%	33.0%	21.0%	4.6%	0	0	0
10,000									89.3%	53.0%	40.9%	36.2%	23.4%	5.4%	0	0	0
12,000										56.0%	40.9%	36.2%	23.4%	5.4%	0	0	0
14,000											41.7%	36.9%	23.4%	5.4%	0	0	0
15,000												36.9%	23.4%	5.4%	0	0	0
17,500													23.4%	5.4%	0	0	0
20,000														5.4%	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	0

Table I-17: Sea Lamprey Spawning Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	7,833	4,920	2,460	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,600		8,221	4,855	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,000			4,855	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,800				0	0	0	0	0	0	0	0	0	0	0	0	0	0
4,000					0	0	0	0	0	0	0	0	0	0	0	0	0
5,000						0	0	0	0	0	0	0	0	0	0	0	0
6,000							0	0	0	0	0	0	0	0	0	0	0
8,000								0	0	0	0	0	0	0	0	0	0
10,000									0	0	0	0	0	0	0	0	0
12,000										0	0	0	0	0	0	0	0
14,000											0	0	0	0	0	0	0
15,000												0	0	0	0	0	0
17,500													0	0	0	0	0
20,000														0	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	0

Table I-18: Sea Lamprey Spawning Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	95.3%	59.8%	29.9%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,600		100.0%	59.1%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,000			59.1%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,800				0	0	0	0	0	0	0	0	0	0	0	0	0	0
4,000					0	0	0	0	0	0	0	0	0	0	0	0	0
5,000						0	0	0	0	0	0	0	0	0	0	0	0
6,000							0	0	0	0	0	0	0	0	0	0	0
8,000								0	0	0	0	0	0	0	0	0	0
10,000									0	0	0	0	0	0	0	0	0
12,000										0	0	0	0	0	0	0	0
14,000											0	0	0	0	0	0	0
15,000												0	0	0	0	0	0
17,500													0	0	0	0	0
20,000														0	0	0	0
25,000															0	0	0
30,000																0	0
37,500																	0

Table I-19: Macroinvertebrates Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	542,250	483,585	415,620	254,293	204,571	180,605	154,785	25,945	22,010	22,010	20,456	19,809	19,356	19,356	19,356	19,356	19,162
1,600		727,167	659,202	450,657	381,977	332,777	282,152	110,880	70,626	69,461	67,519	66,548	65,318	64,670	64,411	63,117	58,326
2,000			889,048	644,016	562,101	505,617	438,118	209,889	111,589	100,663	95,549	93,413	91,017	88,557	84,803	81,113	72,892
2,800				1,121,447	917,195	826,732	735,829	411,448	210,555	117,818	111,021	108,561	105,971	103,511	99,239	95,419	86,227
4,000					1,392,001	1,267,998	1,073,626	513,314	253,212	148,313	119,695	117,235	114,646	112,186	107,913	104,094	94,772
5,000						1,567,457	1,330,119	599,928	279,015	168,750	123,320	120,860	118,271	115,811	111,538	107,719	98,397
6,000							1,484,803	696,534	315,168	200,858	140,321	124,226	121,637	119,177	114,905	111,085	101,763
8,000								824,528	419,304	279,307	173,917	152,208	127,269	124,809	120,537	116,717	107,395
10,000									472,473	314,879	194,480	169,965	136,138	133,354	129,082	124,097	114,581
12,000										332,605	206,139	180,898	142,029	139,116	134,455	128,499	118,595
14,000											245,536	220,229	155,118	149,994	137,432	129,988	120,019
15,000												221,980	156,382	150,900	138,209	130,635	120,666
17,500													176,110	170,499	139,957	131,865	121,896
20,000														181,265	142,008	132,383	122,155
25,000															146,099	135,272	123,255
30,000																142,648	124,291
37,500																	125,068

Table I-20: Macroinvertebrates Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	34.6%	30.9%	26.5%	16.2%	13.1%	11.5%	9.9%	1.7%	1.4%	1.4%	1.3%	1.3%	1.2%	1.2%	1.2%	1.2%	1.2%
1,600		46.4%	42.1%	28.8%	24.4%	21.2%	18.0%	7.1%	4.5%	4.4%	4.3%	4.2%	4.2%	4.1%	4.1%	4.0%	3.7%
2,000			56.7%	41.1%	35.9%	32.3%	28.0%	13.4%	7.1%	6.4%	6.1%	6.0%	5.8%	5.6%	5.4%	5.2%	4.7%
2,800				71.5%	58.5%	52.7%	46.9%	26.2%	13.4%	7.5%	7.1%	6.9%	6.8%	6.6%	6.3%	6.1%	5.5%
4,000					88.8%	80.9%	68.5%	32.7%	16.2%	9.5%	7.6%	7.5%	7.3%	7.2%	6.9%	6.6%	6.0%
5,000						100.0%	84.9%	38.3%	17.8%	10.8%	7.9%	7.7%	7.5%	7.4%	7.1%	6.9%	6.3%
6,000							94.7%	44.4%	20.1%	12.8%	9.0%	7.9%	7.8%	7.6%	7.3%	7.1%	6.5%
8,000								52.6%	26.8%	17.8%	11.1%	9.7%	8.1%	8.0%	7.7%	7.4%	6.9%
10,000									30.1%	20.1%	12.4%	10.8%	8.7%	8.5%	8.2%	7.9%	7.3%
12,000										21.2%	13.2%	11.5%	9.1%	8.9%	8.6%	8.2%	7.6%
14,000											15.7%	14.1%	9.9%	9.6%	8.8%	8.3%	7.7%
15,000												14.2%	10.0%	9.6%	8.8%	8.3%	7.7%
17,500													11.2%	10.9%	8.9%	8.4%	7.8%
20,000														11.6%	9.1%	8.4%	7.8%
25,000															9.3%	8.6%	7.9%
30,000																9.1%	7.9%
37,500																	8.0%

Table I-21: Shallow-Slow Habitat Guild Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	2,252,189	1,603,737	1,159,796	326,173	715	0	0	0	0	0	0	0	0	0	0	0	0
1,600		2,311,736	1,822,723	940,217	60,247	0	0	0	0	0	0	0	0	0	0	0	0
2,000			2,486,684	1,490,427	384,215	13,290	0	0	0	0	0	0	0	0	0	0	0
2,800				2,299,979	1,022,782	448,494	9,658	0	0	0	0	0	0	0	0	0	0
4,000					1,699,924	1,117,050	589,654	6,384	0	0	0	0	0	0	0	0	0
5,000						1,622,082	1,094,686	398,837	2,862	2,862	0	0	0	0	0	0	0
6,000							1,380,919	684,712	65,274	23,967	0	0	0	0	0	0	0
8,000								911,456	258,915	109,817	12,520	0	0	0	0	0	0
10,000									355,407	178,951	44,810	1,170	0	0	0	0	0
12,000										218,861	80,785	24,983	715	0	0	0	0
14,000											100,779	44,976	17,886	0	0	0	0
15,000												52,755	25,665	6,348	6,348	0	0
17,500													38,110	18,794	18,794	0	0
20,000														28,817	28,817	0	0
25,000															45,792	1,789	1,789
30,000																5,366	5,366
37,500																	131,280

Table I-22: Shallow-Slow Habitat Guild Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	90.6%	64.5%	46.6%	13.1%	0.0%	0	0	0	0	0	0	0	0	0	0	0	0
1,600		93.0%	73.3%	37.8%	2.4%	0	0	0	0	0	0	0	0	0	0	0	0
2,000			100.0%	59.9%	15.5%	0.5%	0	0	0	0	0	0	0	0	0	0	0
2,800				92.5%	41.1%	18.0%	0.4%	0	0	0	0	0	0	0	0	0	0
4,000					68.4%	44.9%	23.7%	0.3%	0	0	0	0	0	0	0	0	0
5,000						65.2%	44.0%	16.0%	0.1%	0.1%	0	0	0	0	0	0	0
6,000							55.5%	27.5%	2.6%	1.0%	0	0	0	0	0	0	0
8,000								36.7%	10.4%	4.4%	0.5%	0	0	0	0	0	0
10,000									14.3%	7.2%	1.8%	0.0%	0	0	0	0	0
12,000										8.8%	3.2%	1.0%	0.0%	0	0	0	0
14,000											4.1%	1.8%	0.7%	0	0	0	0
15,000												2.1%	1.0%	0.3%	0.3%	0	0
17,500													1.5%	0.8%	0.8%	0	0
20,000														1.2%	1.2%	0	0
25,000															1.8%	0.1%	0.1%
30,000																0.2%	0.2%
37,500																	5.3%

Table I-23: Deep-Slow Habitat Guild Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	**1,600**	**2,000**	**2,800**	**4,000**	**5,000**	**6,000**	**8,000**	**10,000**	**12,000**	**14,000**	**15,000**	**17,500**	**20,000**	**25,000**	**30,000**	**37,500**
1,200	17,285,411	15,575,072	14,061,768	12,313,084	10,575,597	8,475,262	6,255,885	3,921,778	3,122,699	2,675,795	2,307,611	2,183,105	1,867,328	1,678,211	1,454,082	1,374,297	1,285,591
1,600		16,606,850	15,049,549	13,199,595	11,100,605	8,983,080	6,748,679	4,361,755	3,485,245	3,004,496	2,619,772	2,476,988	2,152,207	1,944,263	1,703,611	1,614,321	1,521,322
2,000			16,023,162	14,080,983	11,665,722	9,503,784	7,205,711	4,727,708	3,817,215	3,297,985	2,862,175	2,701,148	2,359,823	2,127,756	1,865,705	1,772,487	1,672,692
2,800				14,999,550	12,337,079	10,062,075	7,673,143	5,100,855	4,136,616	3,590,581	3,122,441	2,949,592	2,587,376	2,277,110	1,994,005	1,879,368	1,773,468
4,000					13,377,075	10,992,459	8,472,023	5,688,459	4,572,091	3,941,058	3,448,579	3,268,218	2,877,780	2,514,637	2,197,368	2,040,278	1,914,908
5,000						11,825,348	9,237,716	6,199,620	4,897,970	4,223,336	3,679,003	3,485,214	3,075,962	2,700,374	2,362,684	2,162,080	2,010,688
6,000							9,911,132	6,783,949	5,366,719	4,634,755	4,056,274	3,844,957	3,435,705	3,046,506	2,678,905	2,421,233	2,230,308
8,000								7,847,816	6,357,170	5,567,543	4,939,999	4,676,349	4,248,299	3,853,354	3,455,288	3,168,645	2,968,110
10,000									6,819,057	6,029,072	5,377,076	5,103,658	4,670,817	4,261,904	3,762,146	3,457,914	3,234,691
12,000										6,437,496	5,781,208	5,506,359	5,057,063	4,622,037	4,028,944	3,638,940	3,254,111
14,000											5,986,399	5,705,111	5,175,688	4,718,729	4,099,897	3,676,557	3,260,193
15,000												5,733,984	5,190,611	4,731,781	4,104,905	3,681,565	3,261,266
17,500													5,299,677	4,813,551	4,156,859	3,696,619	3,275,932
20,000														4,891,996	4,179,170	3,710,550	3,283,444
25,000															4,313,498	3,821,937	3,351,040
30,000																3,941,636	3,433,896
37,500																	3,733,519

Table I-24: Deep-Slow Habitat Guild Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	100.0%	90.1%	81.4%	71.2%	61.2%	49.0%	36.2%	22.7%	18.1%	15.5%	13.4%	12.6%	10.8%	9.7%	8.4%	8.0%	7.4%
1,600		96.1%	87.1%	76.4%	64.2%	52.0%	39.0%	25.2%	20.2%	17.4%	15.2%	14.3%	12.5%	11.2%	9.9%	9.3%	8.8%
2,000			92.7%	81.5%	67.5%	55.0%	41.7%	27.4%	22.1%	19.1%	16.6%	15.6%	13.7%	12.3%	10.8%	10.3%	9.7%
2,800				86.8%	71.4%	58.2%	44.4%	29.5%	23.9%	20.8%	18.1%	17.1%	15.0%	13.2%	11.5%	10.9%	10.3%
4,000					77.4%	63.6%	49.0%	32.9%	26.5%	22.8%	20.0%	18.9%	16.6%	14.5%	12.7%	11.8%	11.1%
5,000						68.4%	53.4%	35.9%	28.3%	24.4%	21.3%	20.2%	17.8%	15.6%	13.7%	12.5%	11.6%
6,000							57.3%	39.2%	31.0%	26.8%	23.5%	22.2%	19.9%	17.6%	15.5%	14.0%	12.9%
8,000								45.4%	36.8%	32.2%	28.6%	27.1%	24.6%	22.3%	20.0%	18.3%	17.2%
10,000									39.4%	34.9%	31.1%	29.5%	27.0%	24.7%	21.8%	20.0%	18.7%
12,000										37.2%	33.4%	31.9%	29.3%	26.7%	23.3%	21.1%	18.8%
14,000											34.6%	33.0%	29.9%	27.3%	23.7%	21.3%	18.9%
15,000												33.2%	30.0%	27.4%	23.7%	21.3%	18.9%
17,500													30.7%	27.8%	24.0%	21.4%	19.0%
20,000														28.3%	24.2%	21.5%	19.0%
25,000															25.0%	22.1%	19.4%
30,000																22.8%	19.9%
37,500																	21.6%

Table I-25: Deep-Fast Habitat Guild Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	**1,600**	**2,000**	**2,800**	**4,000**	**5,000**	**6,000**	**8,000**	**10,000**	**12,000**	**14,000**	**15,000**	**17,500**	**20,000**	**25,000**	**30,000**	**37,500**
1,200	3,199,462	2,809,506	2,369,670	1,637,852	284,808	0	0	0	0	0	0	0	0	0	0	0	0
1,600		3,752,078	3,230,807	2,400,230	923,110	246,467	0	0	0	0	0	0	0	0	0	0	0
2,000			3,780,822	2,846,422	1,305,137	538,872	45,764	0	0	0	0	0	0	0	0	0	0
2,800				3,512,396	1,902,529	1,070,205	459,676	13,235	0	0	0	0	0	0	0	0	0
4,000					3,033,331	2,141,566	1,452,115	634,621	0	0	0	0	0	0	0	0	0
5,000						2,889,768	2,182,431	1,315,504	205,273	0	0	0	0	0	0	0	0
6,000							2,766,212	1,880,244	646,737	14,308	0	0	0	0	0	0	0
8,000								2,591,952	1,289,708	443,599	49,105	0	0	0	0	0	0
10,000									1,540,346	642,905	175,093	66,592	0	0	0	0	0
12,000										696,603	212,240	90,352	19,316	0	0	0	0
14,000											296,371	172,007	99,801	43,283	0	0	0
15,000												176,657	104,451	43,283	0	0	0
17,500													218,520	148,051	10,112	0	0
20,000														193,714	26,567	0	0
25,000															30,144	0	0
30,000																14,639	7,485
37,500																	13,800

Table I-26: Deep-Fast Habitat Guild Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	84.6%	74.3%	62.7%	43.3%	7.5%	0	0	0	0	0	0	0	0	0	0	0	0
1,600		99.2%	85.5%	63.5%	24.4%	6.5%	0	0	0	0	0	0	0	0	0	0	0
2,000			100.0%	75.3%	34.5%	14.3%	1.2%	0	0	0	0	0	0	0	0	0	0
2,800				92.9%	50.3%	28.3%	12.2%	0.4%	0	0	0	0	0	0	0	0	0
4,000					80.2%	56.6%	38.4%	16.8%	0	0	0	0	0	0	0	0	0
5,000						76.4%	57.7%	34.8%	5.4%	0	0	0	0	0	0	0	0
6,000							73.2%	49.7%	17.1%	0.4%	0	0	0	0	0	0	0
8,000								68.6%	34.1%	11.7%	1.3%	0	0	0	0	0	0
10,000									40.7%	17.0%	4.6%	1.8%	0	0	0	0	0
12,000										18.4%	5.6%	2.4%	0.5%	0	0	0	0
14,000											7.8%	4.5%	2.6%	1.1%	0	0	0
15,000												4.7%	2.8%	1.1%	0	0	0
17,500													5.8%	3.9%	0.3%	0	0
20,000														5.1%	0.7%	0	0
25,000															0.8%	0	0
30,000																0.4%	0.2%
37,500																	0.4%

Table I-27: Shallow-Fast Habitat Guild Dual Flow Quality Habitat Area (sq. ft.) Analysis, by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	1,487,677	1,021,788	697,637	139,954	32,044	10,940	3,301	0	0	0	0	0	0	0	0	0	0
1,600		1,577,390	1,185,035	448,617	32,044	10,940	3,301	0	0	0	0	0	0	0	0	0	0
2,000			1,848,142	950,218	69,961	10,940	3,301	0	0	0	0	0	0	0	0	0	0
2,800				1,694,178	538,089	68,133	3,301	0	0	0	0	0	0	0	0	0	0
4,000					1,025,735	391,747	125,519	0	0	0	0	0	0	0	0	0	0
5,000						668,086	321,578	0	0	0	0	0	0	0	0	0	0
6,000							373,427	12,520	0	0	0	0	0	0	0	0	0
8,000								131,724	39,706	0	0	0	0	0	0	0	0
10,000									92,991	40,408	702	702	0	0	0	0	0
12,000										68,405	12,603	12,135	715	0	0	0	0
14,000											40,820	38,453	13,593	0	0	0	0
15,000												44,329	15,244	936	0	0	0
17,500													28,916	14,608	0	0	0
20,000														26,875	0	0	0
25,000															1,431	1,431	0
30,000																5,366	0
37,500																	121,621

Table I-28: Shallow-Fast Habitat Guild Percent Maximum Dual Flow Quality Habitat Area Analysis (%), by Flow Pairs (cfs)

	1,200	1,600	2,000	2,800	4,000	5,000	6,000	8,000	10,000	12,000	14,000	15,000	17,500	20,000	25,000	30,000	37,500
1,200	80.5%	55.3%	37.7%	7.6%	1.7%	0.6%	0.2%	0	0	0	0	0	0	0	0	0	0
1,600		85.4%	64.1%	24.3%	1.7%	0.6%	0.2%	0	0	0	0	0	0	0	0	0	0
2,000			100.0%	51.4%	3.8%	0.6%	0.2%	0	0	0	0	0	0	0	0	0	0
2,800				91.7%	29.1%	3.7%	0.2%	0	0	0	0	0	0	0	0	0	0
4,000					55.5%	21.2%	6.8%	0	0	0	0	0	0	0	0	0	0
5,000						36.1%	17.4%	0	0	0	0	0	0	0	0	0	0
6,000							20.2%	0.7%	0	0	0	0	0	0	0	0	0
8,000								7.1%	2.1%	0	0	0	0	0	0	0	0
10,000									5.0%	2.2%	0.0%	0.0%	0	0	0	0	0
12,000										3.7%	0.7%	0.7%	0.0%	0	0	0	0
14,000											2.2%	2.1%	0.7%	0	0	0	0
15,000												2.4%	0.8%	0.1%	0	0	0
17,500													1.6%	0.8%	0	0	0
20,000														1.5%	0	0	0
25,000															0.1%	0.1%	0
30,000																0.3%	0
37,500																	6.6%

APPENDIX J – REACH 4 HABITAT TIME SERIES RESULTS – MONTHLY HABITAT DURATION CURVES

Figure J-1: Reach 4 Habitat Duration Exceedance Curves for the Spawning, Juvenile and Adult Life Stages of American Shad

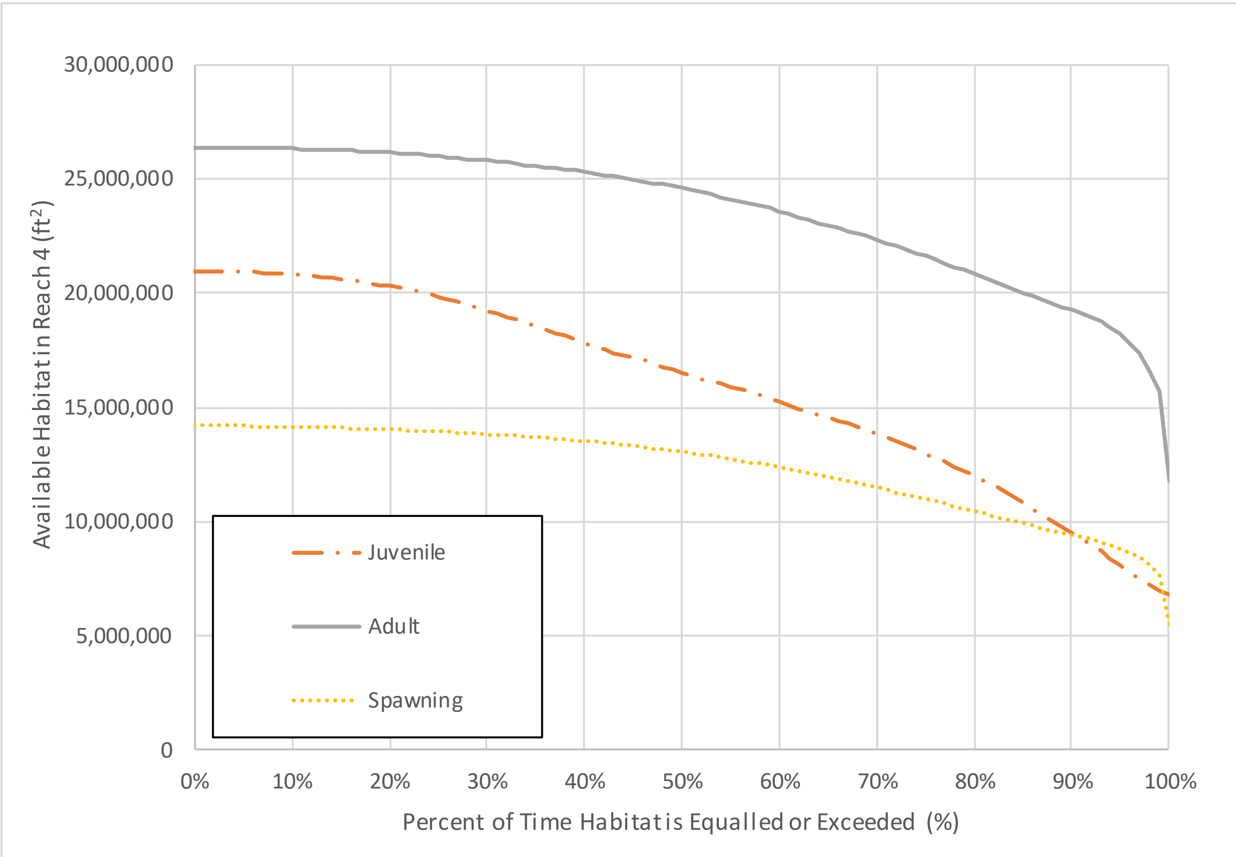


Figure J-2: Reach 4 Habitat Duration Exceedance Curves for the Egg & Larva, Spawning, Fry, Juvenile, and Adult Life Stages of Shortnose Sturgeon

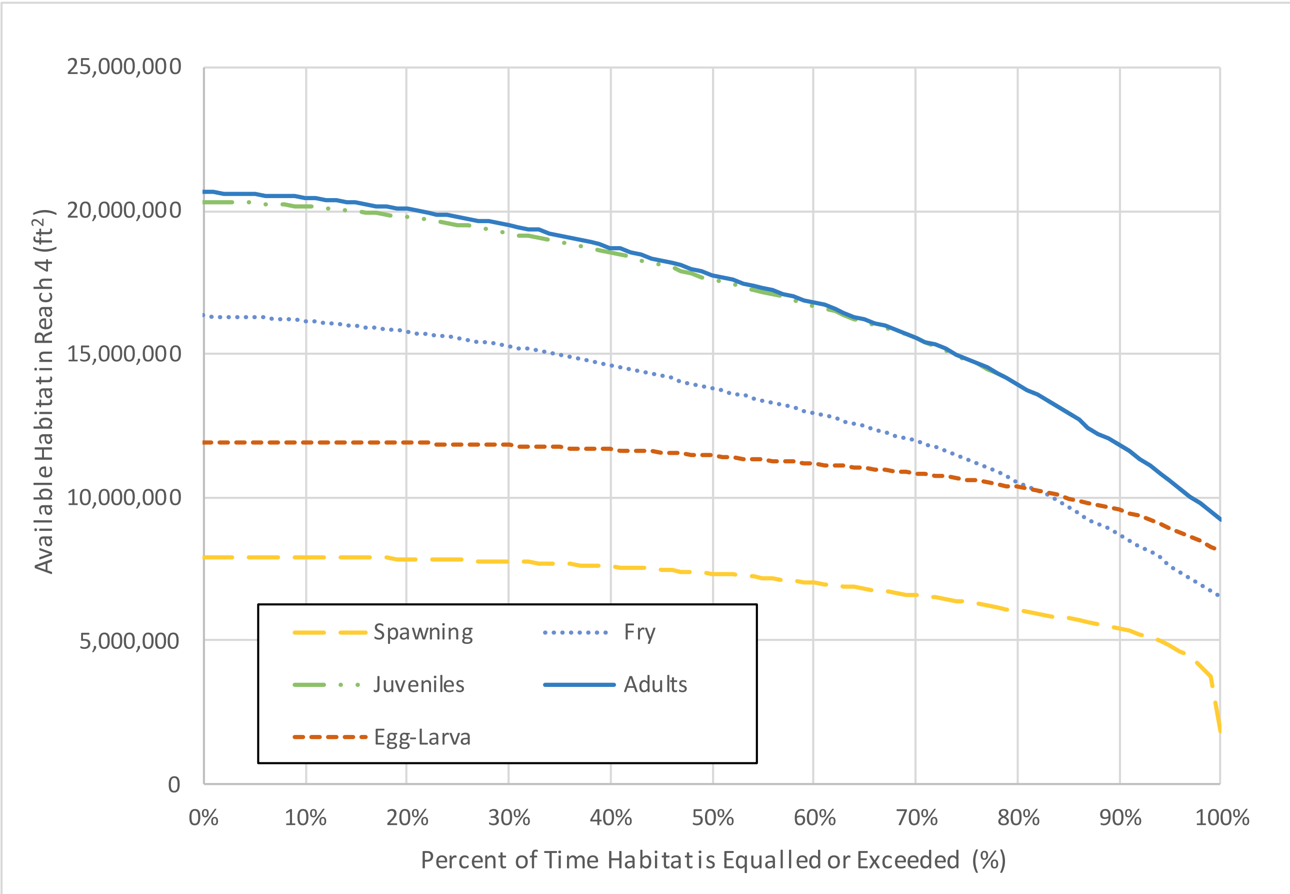


Figure J-3: Reach 4 Habitat Duration Exceedance Curves for the Spawning & Incubation, Fry, Juvenile and Adult Life Stages of Fallfish

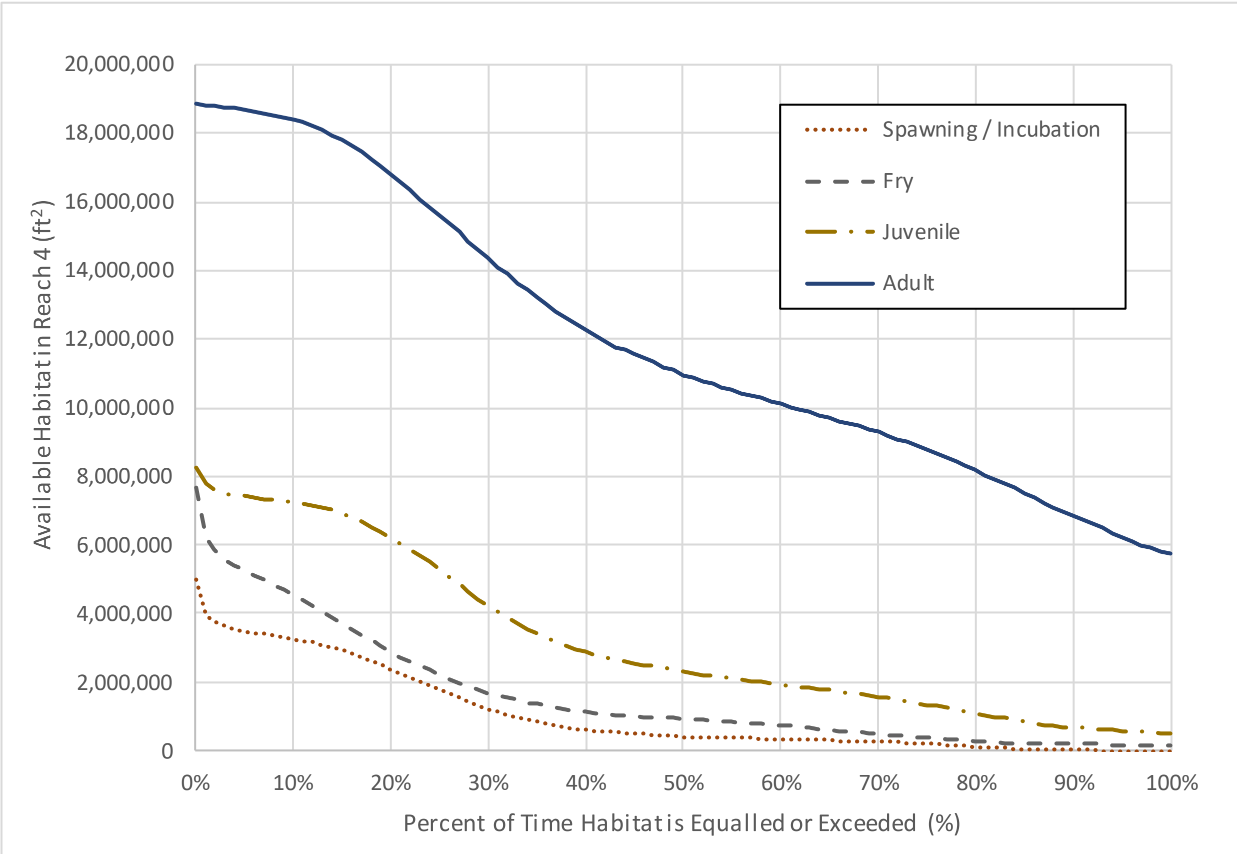


Figure J-4: Reach 4 Habitat Duration Exceedance Curves for the Juvenile and Adult Life Stages of Longnose Dace

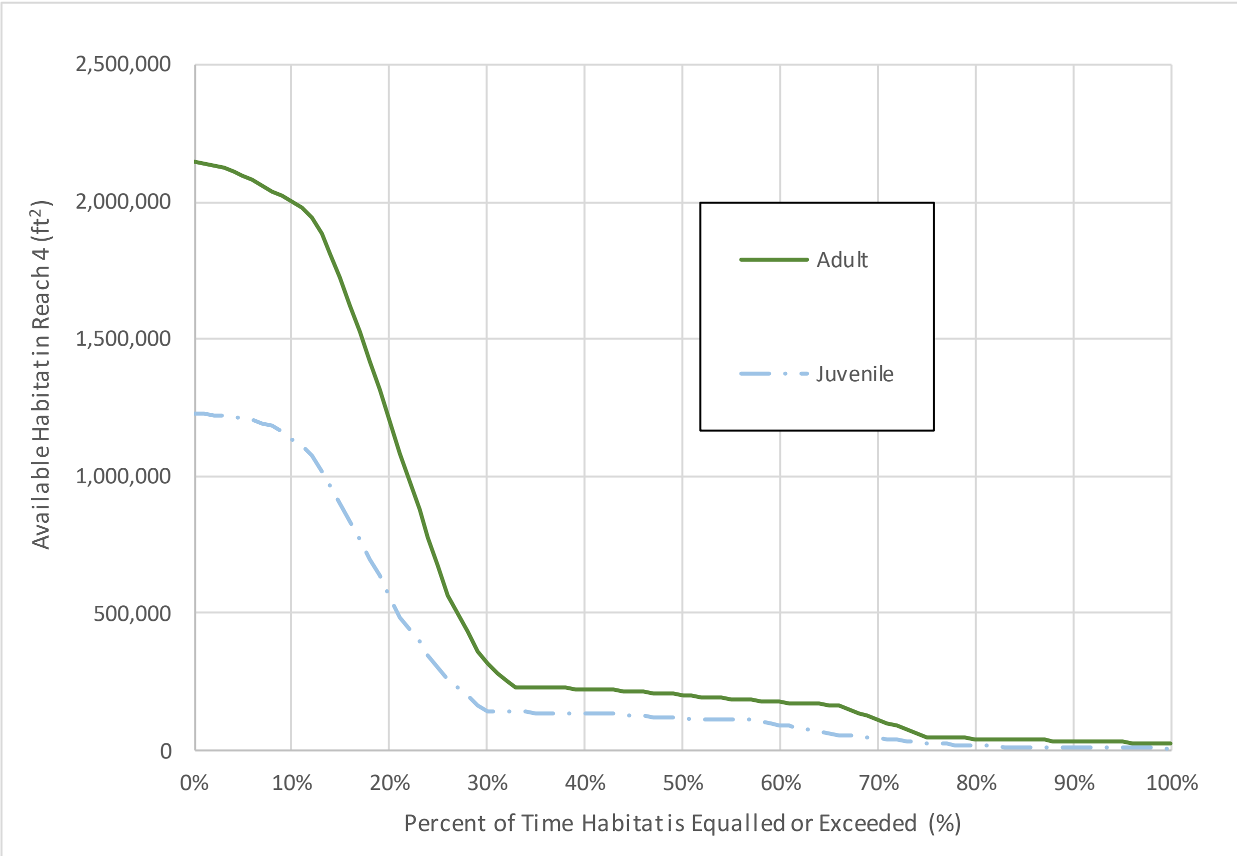


Figure J-5: Reach 4 Habitat Duration Exceedance Curves for the Spawning & Incubation, Fry, and Juvenile & Adult Life Stages of White Sucker

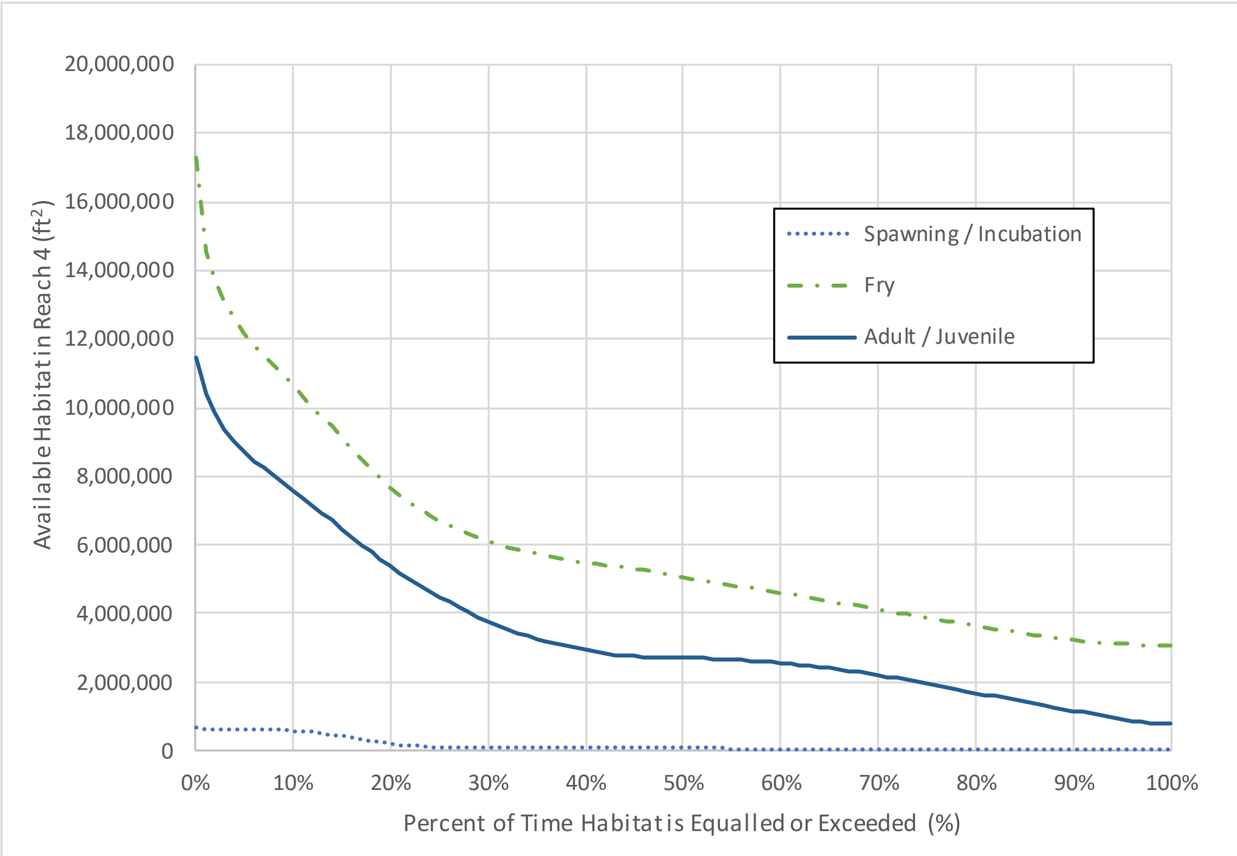


Figure J-6: Reach 4 Habitat Duration Exceedance Curves for the Spawning, Fry, Juvenile, and Adult Life Stages of Walleye

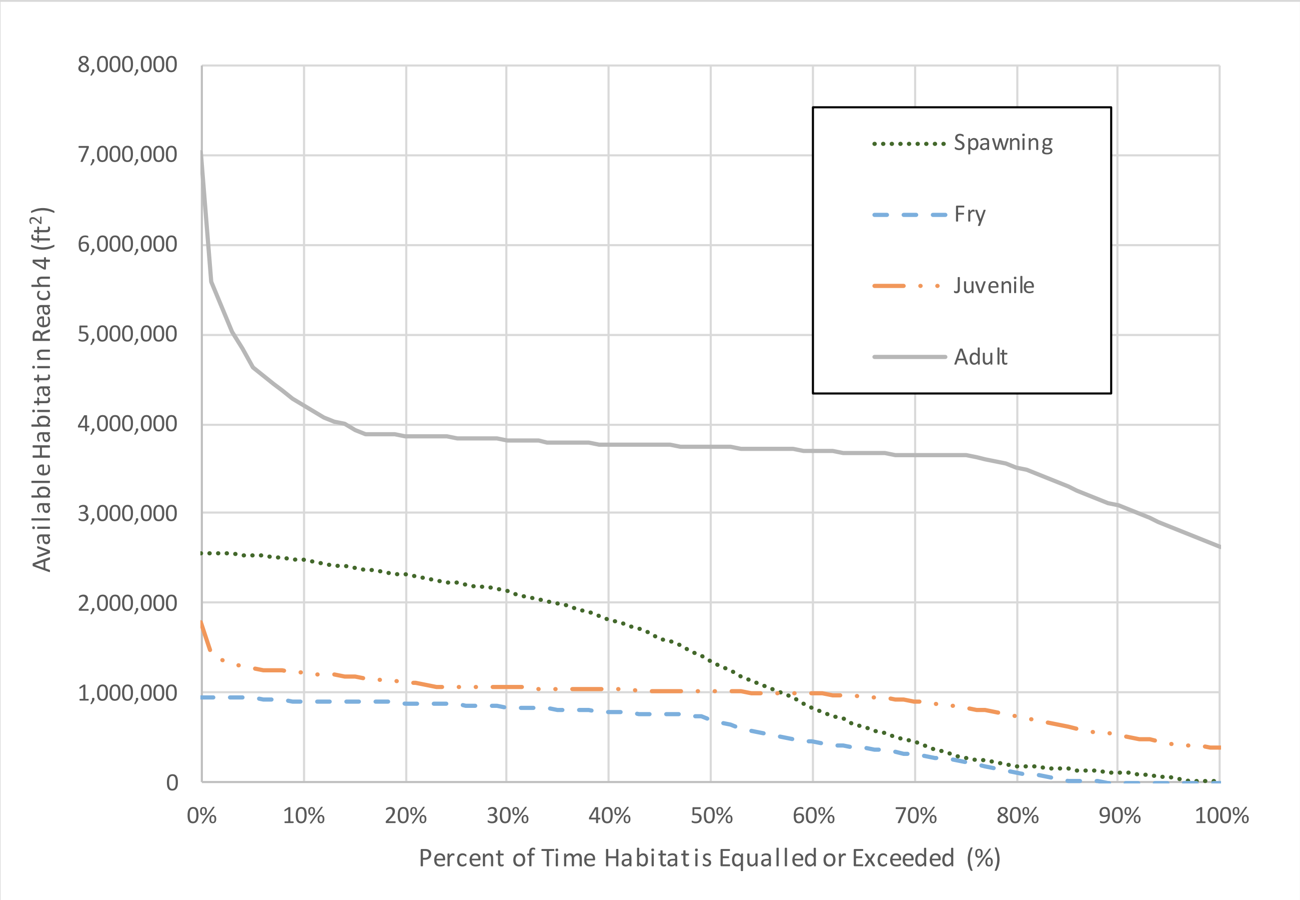


Figure J-7: Reach 4 Habitat Duration Exceedance Curves for the Juvenile & Adult Life Stages of Tessellated Darter

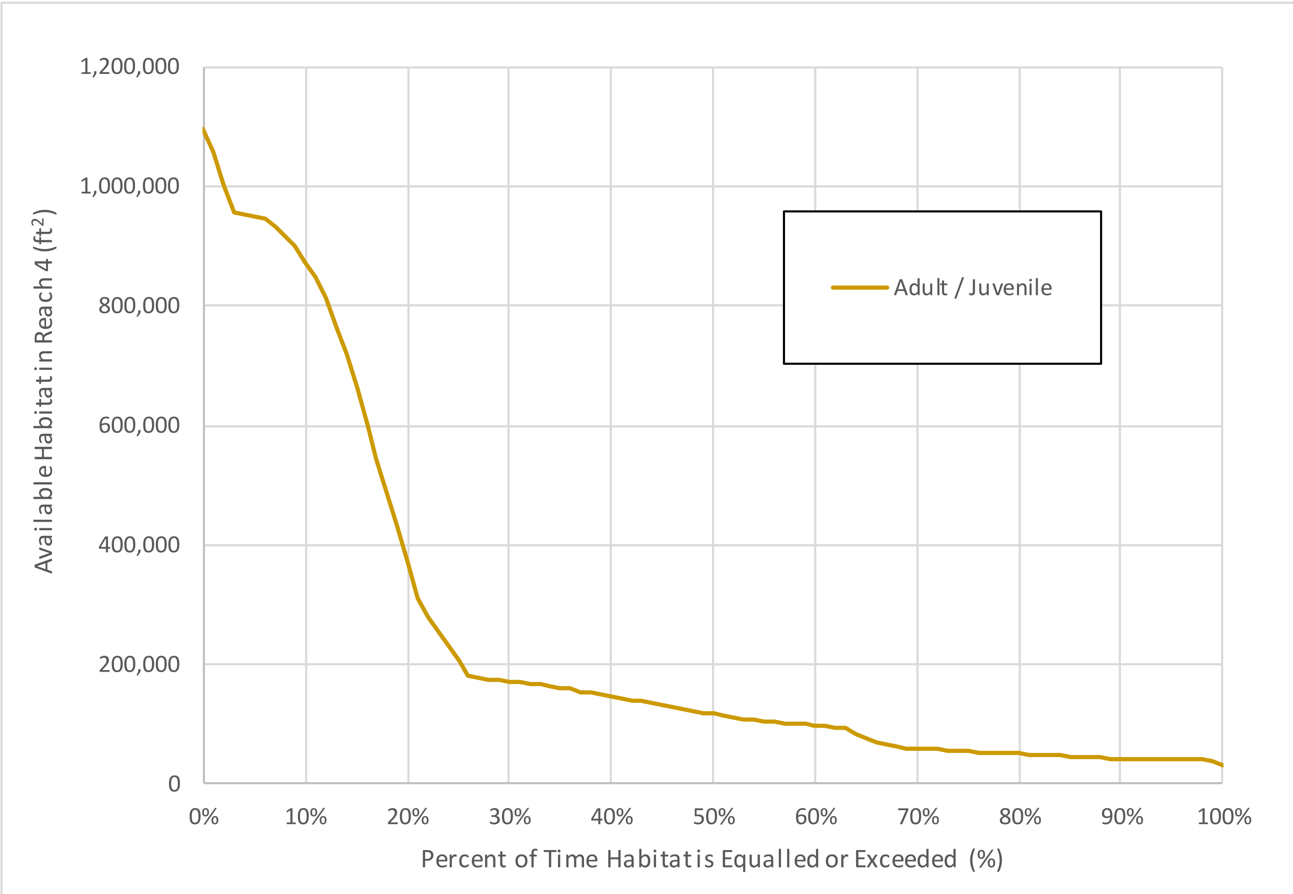


Figure J-8: Reach 4 Habitat Duration Exceedance Curves for the Spawning & Incubation Life Stages of Sea Lamprey

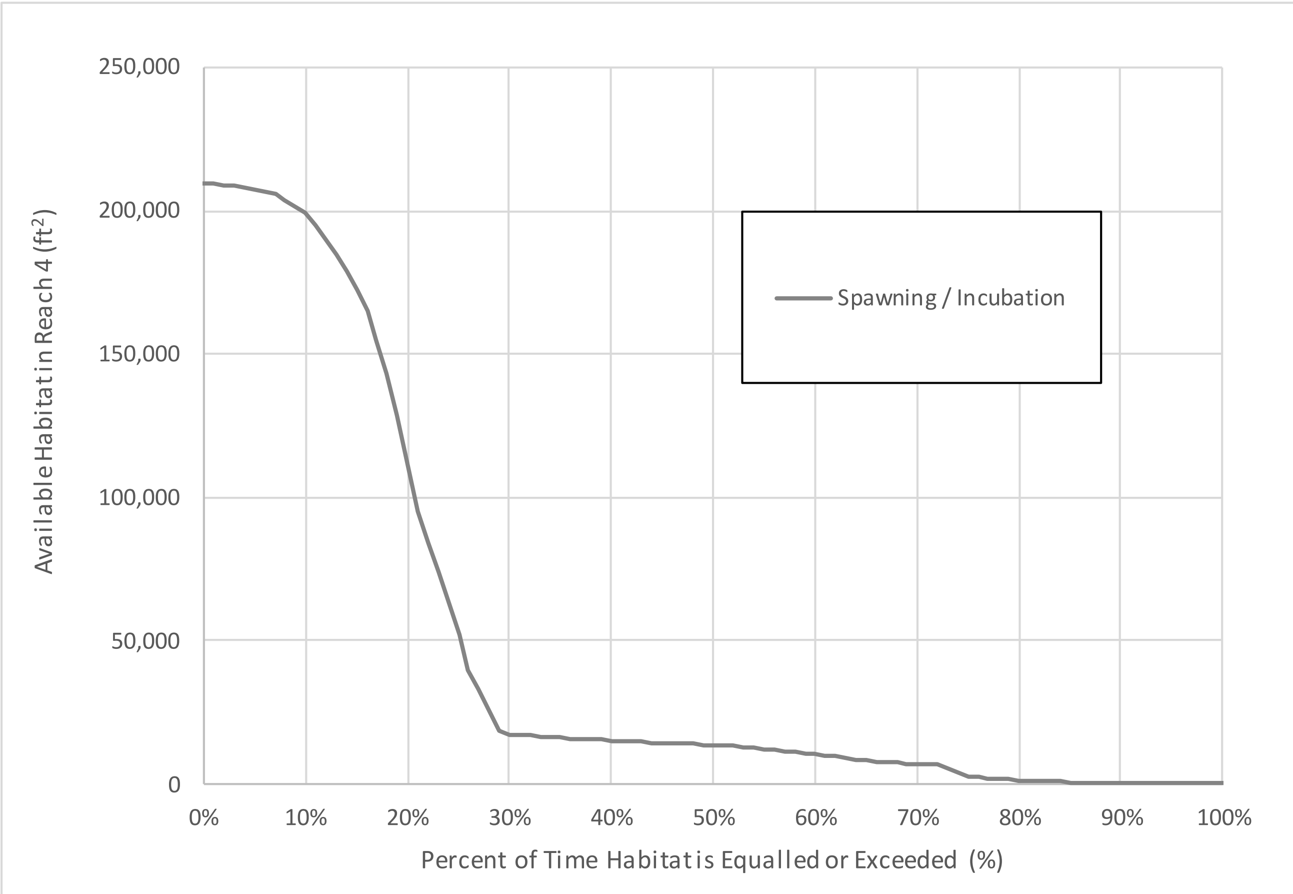


Figure J-9: Reach 4 Habitat Duration Exceedance Curves for the Larva Life Stage of Macroinvertebrates

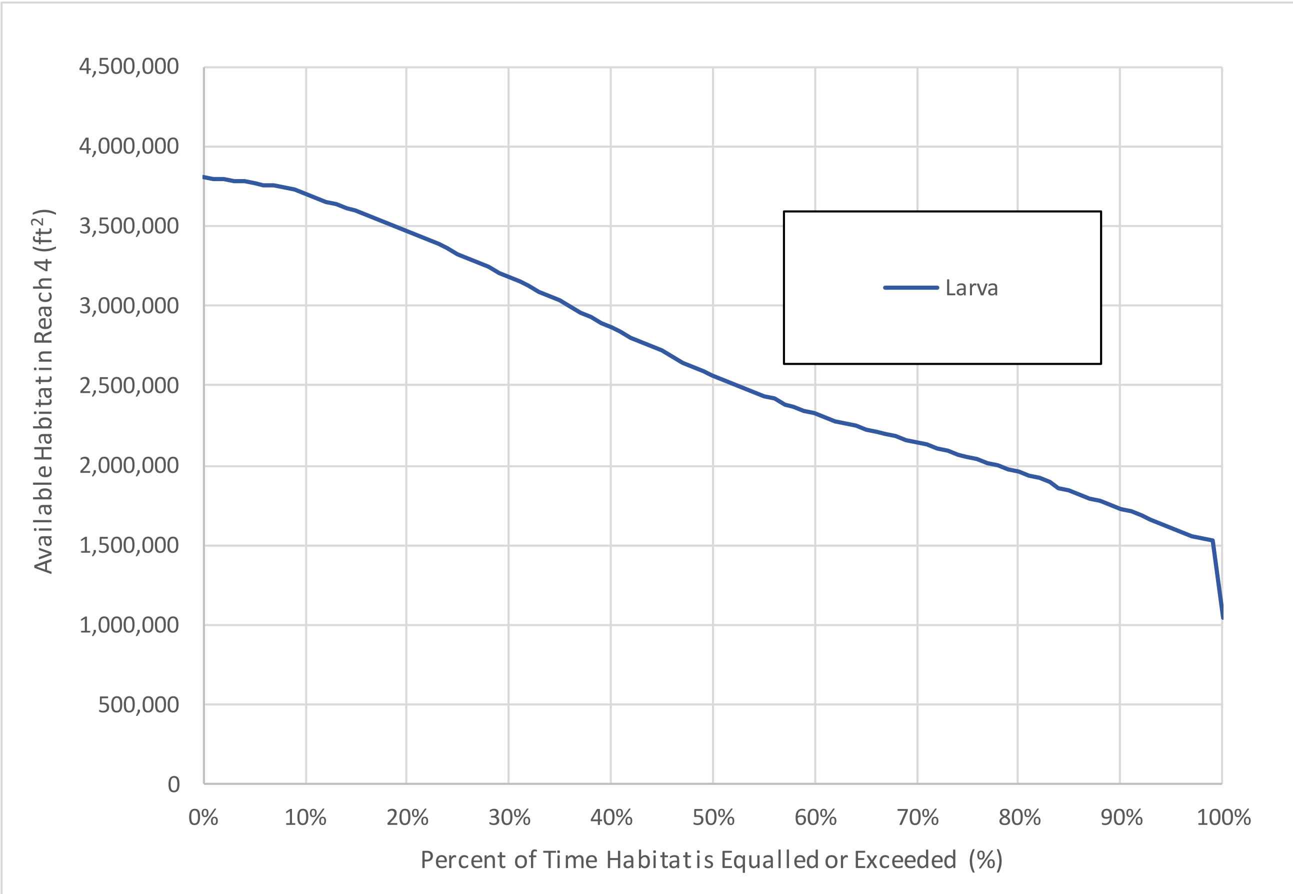


Figure J-10: Reach 4 Habitat Duration Exceedance Curves for the Shallow-Slow, Deep-Slow, Deep-Fast, and Shallow-Fast Habitat Guilds