UPDATED STUDY REPORT

INSTREAM FLOW HABITAT ASSESSMENT BELOW CONOWINGO DAM

RSP 3.16

CONOWINGO HYDROELECTRIC PROJECT

FERC PROJECT NUMBER 405

Prepared for:

Exelon[SM]

Prepared by:

Gomez and Sullivan Engineers

Normandeau Associates, Inc.

January 2012

EXECUTIVE SUMMARY

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project (Conowingo Project). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. FERC issued the final study plan determination for the Conowingo Project on February 4, 2010, approving the revised study plan with certain modifications. The final study plan determination required Exelon to conduct an Instream Flow Assessment below Conowingo Dam, which is this report's subject.

An initial study report (ISR) was filed on May 6, 2011, containing Exelon's 2010 study findings. An ISR meeting was held on August 23 and 24, 2011 with resource agencies and interested members of the public. This updated study report (USR) addresses updates to the juvenile American shad habitat suitability criteria, as well as minor editorial changes.

This study's goal is to determine the relationship between flow and aquatic habitat conditions in the Susquehanna River below Conowingo Dam. This required the development of a two-dimensional (depth-averaged) hydraulic and habitat model of the study reach. The study reach extended from the downstream face of Conowingo Dam to the downstream end of Spencer Island, a length of approximately 4.5 miles. The study area also included the spillway portion below Conowingo Dam.

Evaluation species were selected, in consultation with the licensing stakeholders, for analysis from a list of species known to be present in the general study area. In consultation with stakeholders, several species of special concern were selected for detailed analysis, while the remaining target species were analyzed using a habitat guild-type approach. Depth, velocity and substrate Habitat Suitability Indices were developed from previous studies, scientific literature, and the professional judgment of Exelon and stakeholder biologists. In addition, a separate analysis was conducted using the model's hydraulic output to assess habitat for mussels.

The specific hydrodynamic model used was River2D, a two-dimensional (lateral-longitudinal, depth averaged), finite element hydraulic and habitat model. River2D input consisted of a bathymetric/topographic (x,y,z) characterization of the study reach, a roughness parameter and substrate code for each x,y location, inflow discharge, a downstream boundary water surface elevation and target species' Habitat Suitability Indices for depth, velocity and substrate. All input data were based on field data collection, including a bathymetry survey, substrate survey and LIDAR survey. The hydraulic model water surface elevation output was calibrated to +/- 0.15 ft for several flows between 5,000 cfs and

73,000 cfs, including a detailed calibration at 40,000 cfs. Following typical USGS calibration guidelines, model accuracy is usually maintained for a 40% to 250% range around the calibration flow (e.g calibration flow at 10,000 cfs is valid for 4,000 cfs to 25,000 cfs). This allows model production run flows of 2,000 cfs to 182,500 cfs, though the model was not run above 86,000 cfs. Once the model was calibrated, several production runs were conducted, simulating flows of 2,000 cfs, 3,500 cfs, 5,000 cfs, 7,500 cfs, 10,000 cfs, 15,000 cfs, 20,000 cfs, 30,000 cfs, 40,000 cfs, 50,000 cfs, 60,000 cfs, 70,000 cfs, 80,000 cfs and 86,000 cfs. Using the model's hydraulic outputs, several habitat analyses were run, including weighted usable area, persistent habitat and mussel habitat analyses.

Habitat modeling 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 and striped bass preferred higher flows. Smallmouth bass, macroinvertebrates, and the habitat guilds 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 shortnose sturgeon (fry, juveniles, adults), smallmouth bass (spawning, fry), ephemeroptera, plecoptera, the shallow-fast and deep-fast guilds.

There were several areas in the river that appeared to provide high-quality habitat for several species and life stages. These areas included downstream of Rowland Island, near the mouths of Octoraro and Deer Creeks, an area southwest of Bird Island, downstream of Snake Island and in-between Robert, Wood and Spencer Islands. The substrates available in these areas (sand, gravel, cobble) were generally finer than those found in the main channel (boulder, bedrock) and were well-suited for many species and life stages.

Habitat persistence analyses were conducted for all immobile life species/life stages. 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. Some species were more sensitive to flow changes than others. Striped bass were less sensitive to flow differences, while macroinvertebrates and smallmouth bass were more sensitive to flow differences.

Mussel habitat analyses were conducted using shear stress thresholds. The analyses showed that higher catch-per-unit-effort rates were associated with areas with lower shear stresses. Results also showed that higher flows tended to increase the area exceeding mussels' preferred shear stress range. Flows over 10,000 cfs had few areas below the low-flow (95% flow exceedance) threshold of 20 dynes/cm^2 (0.042

lb/ft^2), while areas below the high-flow (25% flow exceedance) threshold of 150 dynes/cm^2 (0.313 lb/ft^2) steadily decreased between 10,000 cfs and 86,000 cfs. Relative shear stress (shear stress/critical shear stress) thresholds were also investigated. The large amount of bedrock throughout the study made relative shear stress a somewhat ineffective comparison metric, as bedrock has a very high critical shear stress. The metrics relating mussel development to high-flow and low-flow thresholds were developed for unregulated, smaller streams. Thus, it is not clear how these thresholds would be used to inform flow management decisions in a highly regulated stream.

A habitat time series analysis, as described in task 7 of the RSP, will be released in a subsequent report following the completion of the operations modeling analysis. 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.

While the habitat modeling provided estimates of available habitat at various flows, the river flow available is an important consideration in flow and habitat management decisions. There are four hydroelectric projects on the lower Susquehanna River, three of which are main channel peaking hydroelectric plants (Safe Harbor, Holtwood, Conowingo), one of which is a pumped storage project (Muddy Run). All four have the ability to influence the river's flow regime, particularly on a sub-daily scale. The project with the largest hydraulic capacity is Safe Harbor, the farthest upstream project, with a maximum hydraulic capacity of 110,000 cfs. This is greater than the hydraulic capacity of Holtwood (61,460 cfs following expansion construction) and Conowingo (86,000 cfs). Safe Harbor has no minimum flow release requirements as stipulated in its current license, which expires in 2030. Conowingo has a seasonally-varying minimum flow release, and Holtwood will also provide a minimum flow release beginning no later than 2012. Thus, flow management decisions should consider not only the river's unregulated hydrology, but upstream projects' water availability influences, which can greatly impact the lower Susquehanna River's flow management effectiveness.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ADCP: Acoustic Doppler Current Profiler

CF(I): Compound Function Index

cfs: cubic feet per second

cm: centimeter

CPUE: Catch-Per-Unit-Effort

DEM: Digital Elevation Model

EAV: Emergent Aquatic Vegetation

FERC: Federal Energy Regulatory Commission

ft: foot/feet

GPS: Global Positioning System

HSI: Habitat Suitability Index

IFIM: Instream Flow Incremental Method

ILP: Integrated Licensing Process

kHz: kilohertz

lb: pound

mi: mile

MW: Megawatt

NGO: Non-Government Organization

NGVD: National Geodetic Vertical Datum

PAD: Pre-Application Document

Project: Conowingo Hydroelectric Project

psf: pounds per square foot

PSP: Proposed Study Plan

RSP: Revised Study Plan

RTK: Real-Time Kinematic

SAV: Submerged Aquatic Vegetation

sec: second

SI: Suitability Index

USGS: United States Geological Survey

WSE: Water Surface Elevation

WUA: Weighted Usable Area

1. INTRODUCTION

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt (MW) Conowingo Hydroelectric Project (Project). Exelon is applying for a new license using the FERC's Integrated Licensing Process (ILP). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014.

Exelon filed its Pre-Application Document (PAD) and Notice of Intent with FERC on March 12, 2009. On June 11 and 12, 2009, a site visit and two scoping meetings were held at the Project for resource agencies and interested members of the public. Following these meetings, formal study requests were filed with FERC by several resource agencies. Many of these study requests were included in Exelon's Proposed Study Plan (PSP), which was filed on August 24, 2009. On September 22 and 23, 2009, Exelon held a meeting with resource agencies and interested members of the public to discuss the PSP.

Formal comments on the PSP were filed with FERC on November 22, 2009 by Commission staff, and several resource agencies. Exelon filed a Revised Study Plan (RSP) for the Project on December 22, 2009. FERC issued the final study plan determination for the Project on February 4, 2010, approving the RSP with certain modifications.

The final study plan determination required Exelon to conduct an Instream Flow Assessment below Conowingo Dam, which is this report's subject. This study's goal is to determine the relationship between flow and aquatic habitat conditions in the Susquehanna River below Conowingo Dam.

An initial study report (ISR) was filed on May 6, 2011, containing Exelon's 2010 study findings. An ISR meeting was held on August 23 and 24, 2011 with resource agencies and interested members of the public. This updated study report (USR) addresses updates to the juvenile American shad habitat suitability criteria, as well as minor editorial changes.

2. BACKGROUND

2.1 Project Operation

The Conowingo Project has an installed capacity of 573 MW and a hydraulic capacity of 86,000 cfs. The reservoir, known as Conowingo Pond and formed by Conowingo Dam, extends approximately 14 miles upstream from Conowingo Dam to the lower end of the Holtwood Project tailrace. Conowingo Pond serves many diverse uses including hydropower generation, water supply, industrial cooling water, recreational activities and various environmental resources.

The Conowingo Project license allows for the Conowingo Pond to normally fluctuate between elevation 101.2 to 110.2 NGVD 1929[1]. The following factors also influence the management of water levels within the Conowingo Pond:

- The Conowingo Pond must be maintained at an elevation above 107.2 ft on weekends between Memorial Day and Labor Day to meet recreational needs;
- The Muddy Run Project cannot operate its pumps below elevation 104.7 ft due to cavitation;
- PBAPS begins experiencing cooling problems when the pool elevation drops to 104.2 ft;
- The CWA cannot withdraw water below elevation 100.5 ft;
- The Nuclear Regulatory Commission license for Peach Bottom Atomic Power Station requires the plant to shut down completely at pond elevations of 99.2 ft or below; and
- The City of Baltimore cannot withdraw water when the pond is below elevation 91.5 ft.

The current minimum flow regime below Conowingo Dam was formally established with the signing of a settlement agreement in 1989 between the project owners and several federal and state resource agencies. The established minimum flow regime below Conowingo Dam is the following:

March 1 – March 31	3,500 cfs or natural river flow[2], whichever is less

---

[1] The datum used in this document is NGVD 1929. The NGVD 1929 datum elevation is 0.7 ft higher than the Conowingo Datum.

[2] As measured at the Susquehanna River at Marietta USGS gage (No. 0157600).

April 1 – April 30	10,000 cfs or natural river flow, whichever is less
May 1 – May 31	7,500 cfs or natural river flow, whichever is less
June 1 – September 14	5,000 cfs or natural river flow, whichever is less
September 15 – November 30	3,500 cfs or natural river flow, whichever is less
December 1 – February 28	3,500 cfs intermittent (maximum six hours off followed by equal amount on)

The downstream discharge must equal these values or the discharge measured at the Susquehanna River at the Marietta United States Geological Survey (USGS) gage (No. 01576000), whichever is less. The Marietta USGS gage is located approximately 35 miles upstream of Conowingo Dam above the Safe Harbor Dam.

During periods of regional drought and low river flow, Exelon has requested and received FERC approval for a temporary variance in the required minimum flow release from the Conowingo Project. Specifically, in the summers of 1999, 2001, 2002, 2005, 2007, and 2010 Exelon has received approval to count the leakage from the Conowingo Project (approximately 800 cfs) as part of the minimum flow discharge.

2.2 Basin Hydrology

The total drainage area of the Susquehanna River basin is 27,510 mi^2, of which 6,270 mi^2 are in south-central New York, 20,950 mi^2 are in central Pennsylvania, and 280 mi^2 are in northeastern Maryland. The drainage area above Conowingo Dam is approximately 27,100 mi^2. Several statistical flow analyses were performed using the Conowingo and Marietta USGS gages as part of Conowingo Study 3.11-Hydrologic Study of the Lower Susquehanna River.

There are three hydroelectric generation projects located between the Marietta gage and Conowingo Dam. The projects are, from upstream to downstream, Safe Harbor Hydroelectric Project, Holtwood Hydroelectric Project and Muddy Run Pumped Storage Project. Safe Harbor and Holtwood are located on the Susquehanna River main stem, while Muddy Run is a pumped storage project that uses Conowingo Pond as the lower reservoir of a two-reservoir system. Conowingo is the fourth and most downstream hydroelectric project on the lower Susquehanna River. The two main stem projects upstream of Conowingo Dam have the ability to heavily influence river flows into Conowingo Pond, and are operated as peaking hydroelectric projects. Safe Harbor is licensed until 2030 and has no minimum flow release obligations, with an estimated hydraulic capacity of 110,000 cfs. Holtwood is also licensed until 2030, but as part of a recent expansion settlement Holtwood has agreed to supply Conowingo with a continuous inflow of 800 cfs or net inflow, and 98.7% of Conowingo's daily volumetric minimum flow requirement. Holtwood's maximum hydraulic capacity is currently approximately 31,500 cfs, and will be 61,460 cfs following the completion of the expansion project, which is expected to be completed in 2012. A detailed flow management timeline is presented in Conowingo Study 3.11: Hydrologic Study of the Lower Susquehanna River.

2.2.1 USGS Gages

There are two USGS flow gages on the lower Susquehanna River. One is located upstream of the hydroelectric stations (Marietta, PA), while one is downstream of all of the hydroelectric stations (Conowingo, MD). No USGS gages exist between the impoundments of Conowingo and Holtwood, or Holtwood and Safe Harbor.

The Marietta, PA USGS Gage No. 10576000 (Marietta) is located on the upper end of the lower Susquehanna River (RM 45), just upstream of the Safe Harbor Dam impoundment. The drainage area at this gage is 25,990 mi^2. The gage has daily average flow data available beginning water year[3] (WY) 1932. As of 4/1/2011, USGS-approved daily average flows range from 10/1/1931 to 12/9/2010 (79+ years). The gage also has 30-min instantaneous flow data, available from 10/1/1985 to 9/30/2009, with no data available for WY 1991 (10/1/1990 – 9/30/1991) (23 years). Marietta is generally considered reflective of the lower Susquehanna River's flow regime absent regulation from peaking hydroelectric projects[4].

The Conowingo, PA USGS Gage No. 01578310 is located on the downstream face of Conowingo Dam (RM 10). The drainage area is 27,100 mi^2. The gage has daily average flow data available beginning 10/1/1967 (WY 1968). As of 4/1/2011, USGS-approved daily average flows range from 10/1/1967 to 1/31/2011 (44+ years). The gage also has 15-min instantaneous flow data[5], available from 2/2/1988 to 9/30/2009, with no data available for WY 1994 (20+ years). The Conowingo gage is immediately downstream of Conowingo Dam, and thus directly reflects Project operations and the influences of the other lower Susquehanna water users.

---

[3] Water years begin October 1 and end September 30. For example, WY 1933 is 10/1/1932 to 9/30/1933.

[4] There are several hydroelectric dams, flood control dams, and various other water withdrawals/uses upstream of the Marietta USGS gage in the Susquehanna River and its tributaries.

[5] For consistency with the Marietta gage, all 15-minute Conowingo flow data were converted to 30-min flow data for all analyses

Conowingo sub-daily annual and monthly flow exceedances for the period WY 1988-2009 are shown in Table 2.2.1-1. Annual and monthly flow exceedances were calculated using the full period of record[6] daily flow data for both gages and are shown in Tables 2.2.1-2 and 2.2.1-3.

2.2.2 Unregulated Hydrology Downstream of Conowingo Dam

Major hydrologic influences have existed on the lower Susquehanna River since the late 1920's, predating all flow records downstream of Conowingo Dam. Thus, there are no measurements of unregulated hydrology downstream of Conowingo Dam. However, flow records at the Marietta USGS gage are considered reflective of an unregulated (by peaking hydropower) flow regime. Additionally, the Marietta and Conowingo gages are relatively close in total drainage area, draining 25,990 mi^2 and 27,100 mi^2, respectively. Thus, it is reasonable to assume that the Marietta flow records could be used to estimate the unregulated hydrology downstream of Conowingo Dam.

While a typical drainage area proration is commonly used to relate flow estimates between two gages, this report uses a different method. This study estimated the daily average unregulated river flow hydrology at Conowingo Dam by taking Marietta gage flow and adding the incremental flow estimates between the four hydroelectric projects on the lower Susquehanna. This is consistent with the methodology used in the Susquehanna River operations model described in the Conowingo and Muddy Run Operations Modeling Report (SRBC, 2009).

The operations model determines daily average river flow at the Marietta USGS gage and downstream watersheds by adding flow proportional to the incremental drainage area contributed by each reservoir. Starting at Marietta and going downstream, the model estimates incremental flow input between Marietta and Safe Harbor, Safe Harbor and Holtwood, Holtwood and Conowingo, and inflow from Muddy Run. The operations model uses prorated flows from the Lancaster, PA (USGS Gage No. 01576500) and Manchester, PA (USGS Gage No. 01574000) USGS gages. The specific incremental drainage areas and flow estimates are outlined in Table 2.2.2-1.

The estimated unregulated hydrology was then estimated for the common period of record for the three USGS gages[7] (Marietta, PA, Lancaster, PA and Manchester, PA), which was from WY 1934 to WY

[6] WY 2010 flow data were not used for any (daily or instantaneous) exceedance calculations because WY 2010 USGS-approved instantaneous flow data are not yet available.

2009. The unregulated hydrology was estimated by taking the Marietta USGS gage daily average flow and adding in the daily average incremental flows for the four incremental drainage areas between Marietta and Conowingo (Marietta-Safe Harbor, Safe Harbor-Holtwood, Holtwood-Conowingo, and Muddy Run). Annual and monthly exceedance percentiles were calculated for the estimated daily average unregulated hydrology, which are shown in Table 2.2.2-2.

---

[7] The Lancaster, PA gage's continuous records began in April 1933. Thus, the first complete WY was 1934 (10/1/1933-9/30/1934).

3. METHODS

The study required the development of a two-dimensional hydraulic and habitat model to examine the project operation's aquatic habitat impacts below Conowingo Dam.

3.1 Study Area

The investigation area for this study encompasses the river reach between Conowingo Dam and the downstream end of Spencer Island, which is approximately 4.5 miles in length. The study area also includes the spillway area below Conowingo Dam (Figure 3.1-1).

3.2 Evaluation Species, Habitat Suitability Indices, and Substrate Coding

3.2.1 Evaluation Species

Evaluation species were selected for analysis from a list of species known to be present in the general study area. In consultation with stakeholders (Appendix A), several species of special concern (American shad, striped bass, shortnose sturgeon, smallmouth bass, Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) were selected for detailed analysis. The remaining target species were analyzed using a habitat guild-type approach. In addition, a separate analysis was conducted using hydraulic model output (e.g., shear stress) to assess mussel habitat.

The guild-type approach was deemed necessary due to the diversity of the species and habitat types encountered in the study area. Additionally, by grouping species into guilds, the number of required Habitat Suitability Index (HSI) curves and resulting model output could be reduced to a manageable level for data organization and interpretation. Table 3.2.1-1 identifies the target species, their respective habitat guilds assignments and species of special concern.

Shown in Table 3.2.1-2 is a monthly periodicity chart, which summarizes when certain species and life stages are expected to be present in the study area.

3.2.2 Habitat Suitability Indices

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.

Referring to microhabitat characteristics, each species/life stage has a preference for a certain range of depth, velocity, substrate and cover conditions. For example, adult smallmouth bass may prefer higher depths and lower velocities when compared to adult American shad. Over the years, biologists have conducted studies to identify the depth, velocity, and substrate preferences for an array of species and life stages. Using the results of these studies, preference or HSI curves have been developed for depth, velocity, substrate, and in some cases, cover.

Suitability index curves describe 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. Shown in Figure 3.2.2-1 are juvenile shortnose sturgeon depth, velocity and substrate HSI curves. The optimal depth and velocity for this particular species is 5.0 to 20.0 ft, and 0.20 to 1.50 ft/sec, respectively. Quality habitat ($SI \geq 0.5$), although not optimal, is also available at values outside of these ranges as well.

The HSI values for this study were derived from previous IFIM studies, the scientific literature, and the professional judgment of Exelon and stakeholder biologists. Table 3.2.2-1 is a summary of the species/life stages, as well as the literature source for the HSI. HSI, as agreed to with the stakeholders, for the species and life stages evaluated as part of this study are shown in Appendix B.

The juvenile American shad HSI criteria were modified from those used in this study's ISR, released in May 2011. This process was initiated when Exelon compiled the ISR's habitat results and noticed that the juvenile American shad results appeared to be substantially different than the three other American shad life stages (spawning and incubation, fry and adult). Further investigation into the results revealed a notable difference between the juvenile American shad depth HSI relative to other American shad lifestages. After reviewing the source of the original juvenile American shad depth criteria, new information obtained from the Atlantic Stages Marine Fisheries Commission (Greene et al. 2009) suggested that the original depth HSI may have been inadequate. On June 15, 2011, Exelon, sent a memo outlining the differences between the original and newer HSI depth criteria to stakeholders that were previously involved with HSI discussions. In response to the June 2011 memo, stakeholders proposed alternative depth HSI criteria combining the new and old information sources with their system-specific field observations. As part of an August 2011 stakeholder meeting, Exelon held a discussion with stakeholders to determine the group's overall consensus. It was agreed that an alternative juvenile American shad depth HSI criteria would be adopted as a replacement for the original juvenile American shad depth HSI criteria in this study's ISR. Both juvenile American shad HSI criteria are compared in Figure 3.2.2-2. The results shown in this study report reflect only the updated juvenile American shad depth HSI criteria, as all further references to the original criteria have been removed and replaced with the new criteria.

3.2.3 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 3.2.3-1. 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.

3.3 Hydraulic Model Input Data

Input to the two-dimensional hydrodynamic model consisted of a bathymetric/topographic (x,y,z) characterization of the study reach, a roughness parameter and substrate code for each x,y location, inflow, and a downstream boundary water surface elevation.

3.3.1 Bathymetric, Hydraulic, and Substrate Field Data Collection

Bathymetric and hydraulic data collection followed similar USGS study procedures described in Elliot et al. (2004) and Jacobson et al. (2002). The bathymetric survey was conducted on June 14 to 17, 2010, and was carried out using an 18-ft long Kevlar-hull, jet-propelled vessel equipped with a 1000-kHz Sontek acoustic Doppler current profiler (ADCP), a 200-kHz Odom Hydrotrac single beam echosounder, a RoxAnn Seafloor Classification System and a Trimble real-time kinematic (RTK) global positioning system (GPS) system.

The survey was designed with pre-planned systematic transects orientated from bank to bank approximately perpendicular to flow and spaced 90-150 feet apart over the 4.5 mile study reach (Figure 3.3.1-1). Data collection occurred at a constant flow of approximately 40,000 cfs.

Geo-referenced water surface elevations, bed elevations, and water column velocities were collected using the single beam echo sounder and ADCP linked to an RTK-GPS system. The RTK-GPS equipment provided a three-dimensional position of the echosounder transducer. Thus, the horizontal and vertical position of the echosounder transducer was known for each sonar ping. Subtracting the depth from the transducer elevation for each ping gave an elevation of the river bottom. Since the RTK-GPS equipment provided x, y (horizontal) and z (elevation) data in real time, changes in water level due to standing waves, and turbulence are accounted for.

Substrate data were collected by field teams during August 2010, as part of Conowingo Study RSP 3.17-Downstream EAV/SAV Study, at an approximate 5,000 cfs flow release. During these surveys, the predominant bottom substrate was visually identified (Table 3.2.3-1) and mapped using GPS equipment over the entire study area.

In addition, 15-min water level stage data were collected at six locations[8] along the study reach during the 2010 season (Figure 3.3.1-2). Stage data were collected between flows of approximately 5,000 cfs and 73,000 cfs. Data from three of these stations[9] along with streamflow data measured at the Conowingo USGS gage were used to develop rating curves at all three locations to assist with model calibration.

3.3.2 Topographic Data Collection

Topographic data for streambanks, permanent islands, the Conowingo Dam spillway area, and other above-water features were obtained from LIDAR surveys. LIDAR data was provided in the form of 2-ft contours by Harford County on the Western side of the Susquehanna River. Multipoint-form LIDAR data on the Cecil County (Eastern) side of the Susquehanna River were available through NOAA's Digital Coast website. In addition, Exelon conducted a LIDAR survey of Conowingo Pond on September 18, 2010 as part of Conowingo Study 3.12-Water Level Management Study. During this survey, LIDAR data was also collected (at a flow release of 3,500 cfs) to define the topography of the Conowingo Dam spillway area.

3.4 Hydraulic Model Development, Calibration and Simulation

Hydraulic modeling was performed using River2D modeling software, 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

[8] While shown on the map, station 7 was not in the study reach.

[9] Stations 1, 5 and 6 were not used in the rating curve analysis. Station 1 was moved mid-deployment by natural flow events and/or human interference. Stations 5 and 6 were tidally influenced.

downstream end of the study reach, and bed roughness throughout the study reach. Observed water surface elevation data are used for calibration purposes, but are not direct model inputs.

3.4.1 Model Development

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. This was not the case for most of the modeled reach, as the lower Susquehanna is primarily a bedrock-controlled channel. The bedrock often transitioned in different angles than the river flowed, and bedrock outcrops were present throughout the reach (Figure 3.4.1-1). Triangulation of the collected bathymetry data occasionally resulted in localized areas of sharp transitions, discontinuities of contours in continuous features. Additional nodes were added when necessary to smooth out irregular features.

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 (65 ft spacing) 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 37,528 nodes and 75,018 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.

3.4.2 Model Calibration and Simulation

Concurrent with the collection of bathymetric data, a direct-measurement survey of the water surface profile was conducted for the study reach. The discharge (40,000 cfs) associated with the water surface profile was determined from station operation records. In addition, continuous water surface elevation data were used from the three locations used to create rating curves in Section 3.3.1. Stage data was collected between flows of 5,000 cfs and 73,000 cfs.

With the measured inflow discharge (40,000 cfs) and the measured low-tide outflow water surface elevation as boundary conditions, River2D was run to produce a predicted water surface profile corresponding to the measured profile at the 40,000 cfs 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 (+/- 0.15 ft) between the predicted and measured water surface profiles was obtained in the study area.

Water surface elevations were recorded at three point locations throughout the study reach, at flows between 5,000 cfs and 73,000 cfs. Using these data, additional model calibrations were performed at flows of 5,000, 7,500, 10,000, 15,000, 20,000, 60,000 and 73,000 cfs. Following typical USGS calibration guidelines, model accuracy is usually accepted for a 40% to 250% range around the calibration flow (e.g., a calibration flow at 10,000 cfs is valid for 4,000 cfs to 25,000 cfs). Thus, the model is accurate for production run flows of 2,000 cfs to 182,500 cfs, though no flows greater than 86,000 cfs were run.

Following calibration, a series of discharges ranging from 2,000 cfs to 86,000 cfs were simulated. The 14 simulated flows were 2,000 cfs, 3,500 cfs, 5,000 cfs, 7,500 cfs, 10,000 cfs, 15,000 cfs, 20,000 cfs, 30,000 cfs, 40,000 cfs, 50,000 cfs, 60,000 cfs, 70,000 cfs, 80,000 cfs and 86,000 cfs. These discharges were selected to cover the flow range experienced by the study reach due to project operations.

3.5 Habitat Modeling

The calibrated hydraulic model, which predicts velocities and depths over a range of flows, was then combined with a habitat model. The amount of aquatic habitat for a given species/life stage of fish is calculated using the River2D program. 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, as used in IFIM procedures, is 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 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 WUA(I) for a node is calculated as follows:

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

where: Area(i) = Surface area of represented by node(i); and

CF(i) = Compound Function Index for the node area(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.

The WUA is then computed for each node area. In a given study section or reach, the WUA(i) for all the node areas are summed and expressed in units of square feet. For this analysis it was assumed that L_{mac} was equal to L.

3.6 Habitat Persistence Analysis

Habitat persistence was evaluated to assess the effects of the short-term hydrologic variability created by peaking operation at the Conowingo Project. Habitat persistence was determined as the union of "quality" or "good" habitat ($CF(I) \geq 0.5$) polygon areas between a pair of project flows for a particular species life stage. For example, the available quality habitat polygon areas for adult striped bass at a flow of 5,000 cfs was overlaid with the available quality habitat polygon areas for the same species at a flow of 86,000 cfs. Adult striped bass habitat persistence for that pair of discharges 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.

3.7 Mussel Habitat Analysis

Several hydraulic parameters are useful in assessing mussel habitat, including water depth, velocity, shear stress, Froude number, Reynolds number, critical shear stress and relative shear stress (Pers. Communication, M. Ashton, 2011). Literature states differing threshold limits above which mussel habitat appears to be compromised. Layzer and Madison (1995) recommend that shear stress not exceed 50 dynes/cm^2 (0.103 psf[10]) over mussel beds. An MDNR interpretation of an Allen and Vaughn (2010) mussel study showed mussel richness and abundance are greatest in areas where shear stress did not exceed 150 dynes/cm^2 (0.31 psf) under high flows (>25% exceedance), nor exceed 20 dynes/cm^2 (0.042 psf) under low flows (<95% exceedance) (Pers. Communication, M. Ashton, 2011). Research also shows that relative shear stress, a unitless ratio of shear stress divided by critical shear stress (the shear stress threshold that initiates sediment transport), is an important parameter for evaluating mussel habitat (Allen and Vaughn, 2010). An MDNR interpretation of Allen and Vaughn (2010) results showed that mussel development is best when relative shear stress is below 0.4 at low flows (<95% exceedance) and below 2.0 at high flows (> 25% exceedance) (Pers. Communication, M. Ashton, 2011). In a modeling study, Morales et al. (2006) concluded that mussel density would be best if relative shear stress did not exceed 1.0 under most flow conditions, and found a maximum tolerance threshold of 1.25.

The hydraulic model output allows each of these parameters to be calculated and mapped over the entire study reach. This allows the model results to be compared to mussel catch-per-unit-effort (CPUE) observations made during Conowingo Study 3.19: Freshwater Mussel Characterization below Conowingo Dam.

3.8 Habitat Time Series

A habitat time series analysis, as described in task 7 of the RSP, ~~will be~~was released in a ~~subsequent~~ report addendum following the completion of the operations modeling ~~analysis~~"Baseline" modeling run. This report will ~~compare~~ contained the results of ~~a~~ the "~~b~~Baseline" or existing conditions model run, which will be the basis of comparison for ~~to~~ additional operations model production runs that are designed in consultation with the resource agencies.

[10] For consistency with existing mussel literature, mussel results are expressed in metric units. US Standard units will also be shown where possible. For reference, 1 dyne = 1 g*cm/s^2 = 10^{-5} Newtons (N) = 0.225×10^{-6} lb

4. RESULTS

4.1 Bathymetric and Topographic Mapping

Figure 4.1-1 illustrates the bathymetric and topographic characteristics of the study reach, which is typified by a very irregular stream bottom. The average stream channel slope of the study reach is 0.0007 ft/ft.

4.2 Hydraulic Model

4.2.1 Calibration Results

The hydraulic model was calibrated to the water surface profile collected at 40,000 cfs, following the calibration procedure described in Bovee et al. (2007). The final finite element mesh comprising the study reach contained approximately 37,500 nodes. Calibration to within +/- 0.15 ft (5 cm) of observed water surface elevations at 40,000 cfs was targeted. Table 4.2.1-1 shows the results of the calibration, while Figure 4.2.1-1 shows the error distribution. Most (72%) simulated water surface elevations were within the targeted +/- 0.15 ft threshold and 93% were within +/- 0.25 ft. All of the simulated water surface elevations fell within +/- 0.50 ft of observed water surface elevations.

The model was also calibrated using rating curves developed from water surface elevation data collected at the three continuous water level recorder stations for flows of 5,000 cfs, 20,000 cfs, 60,000 cfs and 80,000 cfs. Table 4.2.1-2 shows the results of this calibration. The predicted water surface elevations computed by the hydraulic model corresponded well with the field measured water surface elevations at the three sites, as the difference between the predicted and measured water surface elevations was within +/- 0.15 ft, except at 5,000 cfs for gage 2, which was within 0.25 ft.

Observed velocities were compared to model velocities at 40,000 cfs across several transects in the study reach. Across each transect, the water velocity profiles has 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 4.2.1-2 shows the velocity error distribution across the entire study reach.

4.2.2 Simulation Results

The hydraulic model was used to simulate 14 flows in the study reach of 2,000 cfs, 3,500 cfs, 5,000 cfs, 7,500 cfs, 10,000 cfs, 20,000 cfs, 30,000 cfs, 40,000 cfs, 50,000 cfs, 60,000 cfs, 70,000 cfs, 80,000 cfs and 86,000 cfs. Water velocity and depth maps for each simulation flow are shown in Appendix C and Appendix D, respectively.

4.3 Habitat Modeling Results

This section presents the results of the habitat modeling in terms of WUA (habitat) versus flow relationships. Table 4.3-1 summarizes for each species/life stage at what flow the WUA curve (i.e. habitat) peaks, the computed habitat area at maximum WUA flow, the total wetted area of the study reach, and the percentage of total habitat available at the peak WUA. This table puts into perspective how much habitat is available for a given species/life stage relative to the total area of the study reach.

4.3.1 Habitat versus Discharge Relationships

The following sections briefly describe the habitat preferences for each species/life stage based on the HSI curves contained in Appendix B. In addition, the WUA (habitat) versus flow relationships resulting from the habitat modeling are summarized for each species/life stage. Habitat maps showing combined suitability for each species/life stage for each simulated flow are shown in Appendix E.

4.3.1.1 American Shad

Shown in Figure 4.3.1.1-1 are the WUA curves for the spawning & incubation, fry, juvenile and adult life stages of American shad. ~~Notable is the marked difference between the juvenile flow preferences and spawning, fry and adult flow preferences. The HSI values used to develop the juvenile curve came from a study on the upper Delaware River by Ross et al. (1993). However, a 2009 Atlantic States Marine Fisheries Commission (ASMFC) report on Atlantic coast diadromous fish habitat indicates that the values chosen for this analysis may be too restrictive (Greene et al. 2009).~~

Spawning & Incubation: American shad spawning is known to occur in the lower Susquehanna River below Conowingo dam, primarily in the vicinity of Robert, Wood and Spencer Islands. The spawning and incubation HSI curve shows optimal velocities between 1.0 and 3.0 ft/sec (SI=1.0). The optimal depth range for the species/life stage is between 5.0 and 20.0 ft. American shad typically spawn over sand, gravel, and cobble substrates.

The American shad spawning and incubation WUA curve increases to a peak at 40,000 cfs, before declining gradually due to velocities above the optimal range. In general, habitat for the spawning and incubation life stage is reduced in the study reach due to the absence of ideal substrate; however, literature indicates that substrate is not a predictor of spawning and nursery habitat and that it is not important in spawning site selection (Bilkovic et al. 2002; Krauthamer and Richkus 1987). Usable habitat represents approximately 33% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was little habitat throughout the reach, and quality habitat was concentrated southwest of Bird Island. At the peak WUA flow (40,000 cfs), most of the quality habitat is found downstream of Rowland Island, near the mouth of Octoraro Creek, between Robert and Spencer Island and downstream of Snake Island. Additionally, the reach in between Rowland and Spencer islands becomes moderately suitable at 50,000 and 60,000 cfs, then generally declining to the maximum modeled flow of 86,000 cfs. To date, no studies have documented spawning in the Conowingo tailrace.

Fry: American shad eggs are fertilized and eventually sink to the bottom and become wedged under rocks, boulders and fractures or are swept into pools where they hatch. Sand and gravel also provide good substrate as they allow sufficient velocity to prevent the eggs from becoming buried (Greene et al. 2009). Optimal velocities for fry are 0.2 to 1.0 ft/sec (SI=1) and optimal depths are between 5.0 and 20.0 ft (SI=1). American shad fry have optimal preference for silt, sand, gravel, and cobble substrates.

The American shad fry WUA curve increases to a peak at 30,000 cfs, before declining gradually due to velocities above the optimal range. In general, habitat for the fry life stage is reduced in the study reach due to the absence of optimal substrate. As with spawning, substrate is not a good predictor of fry habitat. Greene et al. (2009) found that other factors such as velocity in relation to downstream transport and temperature are more important. Juvenile American shad are sampled annually by MDNR in the upper Chesapeake Bay and Susquehanna Flats to estimate production (SRAFRC 2010). Usable habitat represents approximately 26% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was little habitat throughout the reach, and quality habitat was primarily found southwest of Bird Island, downstream of Robert Island and downstream of Snake Island. At the peak WUA flow (30,000 cfs), most of the quality habitat is found downstream of Rowland Island, near the mouth of Octoraro Creek, between Robert and Spencer Island and downstream of Snake Island. At higher flows (>70,000 cfs) quality habitat was primarily found near the mouth of Octoraro Creek and between Spencer, Wood and Robert Islands.

Juvenile: Juvenile American shad are considered to be more habitat generalists than fry or spawning adults (Greene et al. 2009). Juvenile American shad prefer a velocity between 0.2 and 1.0 ft/sec, with the suitability steadily declining to a SI=0 as velocity increases to 4.5 ft/sec. Optimal depths for juvenile American shad are between ~~0.66 and 3.99~~4.90 and 6.60 ft~~. in the upper Delaware River~~, with a tolerated range of 0 to 50 ft~~(Ross et al. 1993)~~; however, water depth is not considered to be a critical factor in nursery habitat (Krauthamer and Richkus 1987). Silt, sand, gravel and cobble are the preferred substrates for juveniles. Juveniles have historically been sampled on the Susquehanna Flats by MDNR.

The WUA curve for juvenile American shad shows habitat increasing steadily before peaking at a flow of ~~5~~10,000 cfs, and then gradually decreasing as flow increases. The WUA curve declines due to water velocities and water depths exceeding the preferred range for the species/life stage. In general, habitat for the juvenile life stage is reduced in the study reach due to the absence of optimal substrate. However, Ross et al. (1997) found that there was no overall effect of habitat type on juveniles. This indicated that they utilize a variety of habitats, and that depth and substrate are not driving factors. Ross et al. (1997) did find a positive correlation between percent submersed aquatic vegetation (SAV) and juvenile shad abundance in the upper Delaware River. Useable habitat constitutes approximately 32~~1~~% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was little habitat throughout the reach, and quality habitat was primarily found downstream of Rowland Island, near the mouth of Octoraro Creek, and ~~downstream of Robert Island~~west of Bird Island. As flows increased above ~~10~~30,000 cfs, habitat generally became increasingly fragmented and of lower quality, though habitat became more suitable downstream of Robert Island. At higher flows (>60,000 cfs) there was very little habitat throughout the entire reach, with the ~~spillway area providing some moderate habitat~~exception of near Octoraro Creek's mouth and downstream of Robert Island.

Adult: Adult American shad prefer a velocity between 0.5 and 3.0 ft/sec and the suitability steadily decreases to a SI=0 at a velocity of 5.0 ft/sec. The adult American shad HSI curve shows that adults prefer depths of 5.0 and 20.0 ft and substrates of silt, sand, cobble, and gravel.

The adult American shad WUA curve shows habitat increasing with flow until 40,000 cfs, before peaking and gradually declining at higher flows. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the adult life stage is reduced in the study reach due to the absence of optimal substrate; however, popular literature indicates that substrate is not a predictor of spawning and that it is not important in spawning site selection (Bilkovic et al. 2002; Krauthamer and Richkus 1987). Usable habitat constitutes approximately 36% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was relatively poor habitat throughout the reach, and quality habitat was mostly limited to southwest of Bird Island and near the mouth of Octoraro Creek. At the peak WUA flow (40,000 cfs), there was quality habitat downstream of Rowland Island, near the mouth of Octoraro

Creek, southwest of Bird Island, downstream of Snake Island and between Robert, Wood and Spencer Islands. At higher flows (>60,000 cfs) habitat suitability generally declined in the study reach, but the high quality habitat areas remained fairly unaffected by increasing flows.

4.3.1.2 Shortnose Sturgeon

Shown in Figure 4.3.1.2-1 are the WUA curves for the spawning & incubation, fry, juvenile and adult life stages of shortnose sturgeon.

Spawning & Incubation: Shortnose sturgeon use deep channels within the main river to spawn (NMFS 1998). The spawning and incubation HSI curve shows optimal velocities between 1.0 and 3.0 ft/sec (SI=1.0). The optimal depth range for the species/life stage is between 5.0 and 40.0 ft. Shortnose sturgeon typically spawn on cobble substrates, and to lesser extents, gravel, rubble, boulder and ledge substrate.

The shortnose sturgeon spawning and incubation WUA curve increases to a peak at 50,000 cfs, before declining at higher flows. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the spawning and incubation life stage is reduced by the absence of ideal substrate. Useable habitat represents approximately 15% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was relatively poor habitat throughout the reach, with a patch of quality habitat located southwest of Bird Island. At the peak WUA flow (50,000 cfs) there was quality habitat downstream of Rowland Island, near the mouth of Octoraro Creek, southwest of Bird Island, downstream of Sterrit Island and between Robert and Wood Islands. The area just downstream of Rowland Island provides significant spawning habitat from approximately 20,000 cfs through the highest modeled flow of 86,000 cfs. However, at higher flows (>60,000 cfs) habitat quality degraded in most other areas but improved or stayed consistent in some tidally-influenced areas downstream of Deer Creek.

Fry: Shortnose sturgeon that have just hatched are considered to "swim-up" and drift downstream more than any active, directed movement until they are considered fry. At this point they resemble adults and actively migrate downstream (NMFS 1998). Optimal velocities for fry are 0.5 to 1.5 ft/sec (SI=1). Optimal depths are between 5.0 and 40.0 ft (SI=1) as they are generally found in the deepest water within the river channel (NMFS 1998). Shortnose sturgeon fry have optimal preference for sand substrate as they are likely to be found in the tidal section of rivers where this substrate would tend to dominate.

The shortnose sturgeon fry WUA curve increases to a peak at 30,000 cfs, before declining gradually. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the fry life stage is very limited in the study reach, due to the absence of suitable substrate, with useable habitat representing approximately 1% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was relatively poor habitat throughout the reach, with no sizable quality habitat areas. Above 10,000 cfs there was a small patch of quality habitat between Robert and Spencer Islands. This small patch remained relatively constant in size and quality through 86,000 cfs.

The behavior of shortnose sturgeon fry likely preclude them from being found within the study reach. The eggs are demersal and will drift until settled on bottom substrate and the fry drift close to the bottom after hatching until they are large enough for more directed movements. In light of these life history characteristics, the likelihood of shortnose sturgeon fry being present in the area affected by Conowingo Dam is low.

Juvenile: Juvenile shortnose sturgeon are found at the freshwater/saltwater interface in most rivers (NMFS 1998) and prefer a velocity between 0.2 and 1.5 ft/sec, with the suitability steadily declining to a SI=0 as velocity increases to 5.0 ft/sec. Optimal depths for juvenile shortnose sturgeon are between 5.0 and 20.0 ft. Sand and gravel are juveniles' preferred substrates, but they can be found over mud in some rivers as well (NMFS 1998).

The juvenile shortnose sturgeon WUA curve shows habitat increasing steadily before peaking at a flow of 30,000 cfs and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the juvenile life stage is very limited in the study reach, due to the absence of suitable substrate, with useable habitat constituting approximately 2% of the overall wetted study area at the peak WUA flow.

At all flows there was relatively poor habitat throughout the reach, though there were patches of quality habitat near the mouth of Octoraro Creek, between Robert and Spencer Islands and downstream of Snake Island.

Given that shortnose sturgeon juveniles are found at the freshwater/saltwater interface in most rivers, which is near the river mouth at Havre de Grace (Conowingo Study 3.20: Salinity and Salt Wedge Encroachment), there is a low likelihood that they will be found within the influence of the Project.

Adult: Adult shortnose sturgeon can be found in the freshwater or freshwater-tidal reaches of a river (NMFS 1998) and prefer a velocity between 0.2 and 1.5 ft/sec, with the suitability steadily decreasing to a SI=0 for a velocity of 5.0 ft/sec. The adult shortnose sturgeon HSI curve shows that adults prefer depths of 5.0 and 20.0 ft and substrates of sand and gravel.

The WUA curve for adult shortnose sturgeon shows habitat increasing steadily before peaking at a flow of 30,000 cfs and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the adult life stage is very limited in the study reach, due to the absence of suitable substrate, with useable habitat constituting approximately 2% of the overall wetted study area at the peak WUA flow.

At all flows there was relatively poor habitat throughout the reach, though there were patches of quality habitat near the mouth of Octoraro Creek , between Robert and Spencer Islands and downstream of Snake Island. The area between Robert and Spencer islands is persistent for all flows modeled.

Adult shortnose sturgeon in the warmer climates of its range tend to congregate in deeper water with thermal refugia (NMFS 1998) and may not be within the study reach. There has been documentation of individuals caught in the head of the Chesapeake Bay near the mouth of the Susquehanna River in the early 1980s and again in 1997 (NMFS 1998), but only anecdotal information exists that any have ever been caught in the Susquehanna River historically, even though there is a population present in the nearby Delaware River.

4.3.1.3 Striped Bass

The Chesapeake Bay is considered the epicenter of migratory striped bass abundance and production on the east coast, although there are other estuaries that contribute to the sustainability of the species (Greene et al. 2009). Many individuals are migratory; however, it has been recently discovered that some individuals may be freshwater residents or move between fresh and saltwater (Greene et al. 2009). Shown in Figure 4.3.1.3-1 are the WUA curves for the spawning & incubation, fry, juvenile and adult life stages of striped bass.

Spawning & Incubation: The spawning and incubation HSI curve shows optimal velocities between 1.64 and 3.0 ft/sec (SI=1.0). The optimal depth range for the species/life stage is between 6.0 and 30.0 ft. Striped bass typically spawn on sand, gravel, cobble, boulder and bedrock substrates.

The striped bass spawning and incubation WUA curve increases to a peak at 50,000 cfs, before declining gradually. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the spawning and incubation life stage is good throughout the study reach, with useable habitat representing approximately 77% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was relatively poor habitat throughout the reach, with quality habitat generally confined to the deeper, faster channel downstream of the dam powerhouse and west of Rowland Island. Habitat rapidly improved throughout the reach above 10,000 cfs, with large swaths of optimal habitat throughout the river between 30,000 cfs and 60,000 cfs. At higher flows (>60,000 cfs) habitat quality remained high, but optimal habitat began to become slightly more fragmented.

Fry: Optimal velocities for fry are 1.64 to 3.0 ft/sec (SI=1). Optimal depths are between 6.0 and 10.0 ft (SI=1). Striped bass fry have optimal preference for sand, gravel, cobble, boulder and bedrock substrates.

The striped bass fry WUA curve increases to a peak at 50,000 cfs, before declining gradually. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the fry life stage is good throughout the study reach, with useable habitat representing approximately 76% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) there was relatively poor habitat throughout the reach, quality habitat generally confined to the deeper, faster channel downstream of the dam powerhouse and west of Rowland Island. Habitat rapidly improved throughout the reach above 10,000 cfs, with large swaths of optimal habitat throughout the river between 40,000 cfs and 60,000 cfs. At higher flows (>60,000 cfs) habitat quality remained high, but optimal habitat became slightly more fragmented.

Juvenile: Juvenile striped bass prefer a velocity between 0.5 and 3.0 ft/sec, with the suitability steadily declining to a SI=0 as velocity increases to 13.1 ft/sec. Optimal depths for juvenile striped bass are between 6.0 and 30.0 ft. Sand, gravel, and cobble are juveniles' preferred substrates; however, they can be found over mud and rock as well (Greene et al 2009).

The WUA curve for juvenile striped bass shows habitat increasing steadily before peaking at a flow of 40,000 cfs, and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the juvenile life stage is reduced throughout the study reach due to the absence of ideal substrate. Useable habitat constitutes approximately 42% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs) quality habitat was generally confined to an area southwest of Bird Island. Habitat improved above 10,000 cfs, with quality habitat shifting from southwest of Bird Island to downstream of Rowland Island and between Spencer, Wood and Robert Islands.

Juvenile striped bass are generally found in streams, riverine, estuarine or even freshwater pond habitats, but young-of-the-year juveniles tend to move downstream to higher salinity estuarine areas during their first summer (Greene et al. 2009). Research has indicated that juveniles will use various nearshore areas without requiring specific microhabitats in the summer and move offshore in the fall (Greene et al. 2009). Given these observations, the lower Susquehanna River within the Project influence is not necessarily an important rearing area for striped bass juveniles. Stated another way, substrate is driving the WUA versus flow curve for juvenile striped bass; however, substrate may not be the most important factor influencing where the juveniles may be found at a given time of year.

Adult: Adult striped bass prefer a velocity between 0.9 and 4.0 ft/sec and the suitability steadily decreases to a SI=0 for a velocity of 13.1 ft/sec. The adult striped bass HSI curve shows that adults prefer depths of 6.0 and 30.0 ft and substrates of sand, gravel, cobble, boulder and bedrock.

The WUA curve for adult striped bass shows habitat increasing steadily before peaking at a flow of 80,000 cfs, and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat is excellent throughout the study reach, with useable habitat constituting approximately 85% of the overall wetted study area at the peak WUA flow.

At lower flows (<5,000 cfs), quality habitat was generally confined to the deeper, faster channel downstream of the dam powerhouse and west of Rowland Island, though isolated quality habitat patches were present throughout the river. Habitat rapidly improved throughout the reach above 15,000 cfs, with large swaths of optimal habitat throughout the river between 40,000 cfs and 86,000 cfs. At the peak WUA flow (80,000 cfs) the vast majority of the river was optimal habitat, except the channel downstream of the dam powerhouse west of Rowland Island.

4.3.1.4 Smallmouth Bass

The lower Susquehanna River generally does not provide large quantities of quality spawning and fry and juvenile rearing habitat. In spite of this, there is an adult population present below the Conowingo Dam. The population is likely being supported from the passage of fry, juveniles and adults from Conowingo

Pond past the station as well as inputs from downstream tributaries. Shown in Figure 4.3.1.4-1 are the WUA curves for the spawning & incubation, fry, juvenile and adult life stages of smallmouth bass.

Spawning & Incubation: The spawning and incubation HSI curve shows optimal velocities between 0.0 and 0.5 ft/sec (SI=1.0). The optimal depth range for the species/life stage is between 2.2 and 4.8 ft. Smallmouth bass typically spawn on gravel substrate, and to a lesser extent, sand substrate.

The smallmouth bass spawning and incubation WUA curve increases to a peak at 5,000 cfs, before declining gradually. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the spawning and incubation life stage is very limited in the study reach, due to the absence of suitable substrate, with useable habitat representing approximately 2% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs), quality habitat generally was confined to a small patch near the mouth of Octoraro Creek and downstream of Robert Island, with only small patches of lower quality habitat in the other parts of the river. Above 10,000 cfs all quality habitat patches slowly degraded until there were only a few small lower quality habitat areas available at 86,000 cfs.

Fry: Optimal velocities for fry are 0.0 to 0.2 ft/sec (SI=1). Optimal depths are between 0.5 and 2.0 ft (SI=1). Smallmouth bass fry have optimal preference for gravel, and to lesser extent, cobble substrate.

The smallmouth bass fry WUA curve peaked at 2,000 cfs, the lowest modeled flow. The habitat declined rapidly between 2,000 cfs and 10,000 cfs, before continuing to decline gradually. In general, habitat for the fry life stage is limited in the study reach, due to the absence of ideal substrate and high water velocities, with useable habitat representing approximately 6% of the overall wetted study area at the peak WUA flow.

There was very little habitat available at any flow throughout the study area. At 30,000 cfs and above there was some lower quality habitat available in the spillway area, but this dissipated at flows above 60,000 cfs.

Juvenile: Juvenile smallmouth bass prefer a velocity between 0.0 and 1.0 ft/sec, with the suitability steadily declining to a SI=0 as velocity increases to 4.92 ft/sec. Optimal depths for juvenile smallmouth bass are between 1.0 and 4.0 ft. Cobble is the preferred substrates for juveniles.

The WUA curve for juvenile smallmouth bass shows habitat increasing steadily before peaking at a flow of 5,000 cfs, and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the juvenile life stage is somewhat reduced throughout the study reach due to the absence of ideal substrate. Useable habitat constitutes approximately 39% of the overall wetted study area at the peak WUA flow.

At lower flows (<15,000 cfs), there was habitat found through much of the river, with quality habitat available downstream of Rowland Island, near the mouth of Octoraro Creek and between Spencer, Wood and Robert Islands. As flows increased above 15,000 cfs habitat degraded in all areas, though the spillway and areas around islands provided some lower quality habitat at flows above 40,000 cfs.

Adult: Adult smallmouth bass prefer a velocity between 0.0 and 1.0 ft/sec, and the suitability steadily decreases to a SI=0 for a velocity of 4.92 ft/sec. The adult smallmouth bass HSI curve shows that adults prefer depths of 3.0 and 7.0 ft, and substrates of boulder, and to a lesser extent cobble, gravel, and bedrock.

The WUA curve for adult smallmouth bass shows habitat increasing steadily before peaking at a flow of 15,000 cfs and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species/life stage. In general, habitat for the adult life stage is somewhat reduced throughout the study reach due to the absence of ideal substrate. Useable habitat constitutes approximately 42% of the overall wetted study area at the peak WUA flow.

At lower flows (<10,000 cfs), there was habitat found through much of the river, with quality habitat available near the mouths of Octoraro and Deer Creeks and at the upstream edge of Sterret Island. At the peak WUA flow (20,000 cfs) there was quality habitat available near the mouths of Deer and Octoraro Creeks, around the upstream and downstream ends of Sterret Island, between Robert and Wood Island and east of Robert Island. As flows increased above 60,000 cfs, habitat degraded through most of the reach, though quality habitat was still available between Spencer, Wood and Robert Islands.

In light of the fact that little spawning and fry or juvenile rearing habitat exists below Conowingo Dam, the population is likely being supported from Conowingo Pond and downstream tributaries. Any flow management for this species would likely have negligible effects on spawning or fry habitat and not influence the overall population.

4.3.1.5 Macroinvertebrates

Shown in Figure 4.3.1.5-1 are the WUA curves for Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies).

Ephemeroptera (Mayflies): This group prefers a velocity between 0.3 and 1.0 ft/sec, with the suitability steadily declining to a SI=0 as velocity increases to 3.0 ft/sec. Optimal depths for Ephemeroptera are between 1.6 and 2.3 ft. Cobble, and to a lesser extent, gravel and boulder are the preferred substrates.

The WUA curve for Ephemeroptera shows habitat increasing steadily before peaking at a flow of 5,000 cfs, and then gradually decreasing as flow increases. The WUA curve declines primarily due to both water velocities and water depths exceeding the preferred range for the species. In general, habitat is limited throughout the study reach, due to the absence of ideal substrate. Useable habitat constitutes approximately 9% of the overall wetted study area at the peak WUA flow.

At flows at or below 5,000 cfs habitat was generally poor, but quality habitat was available near the mouths of Octoraro and Deer Creeks and downstream of Rowland Island. As flows increased above 5,000 cfs, habitat quality degraded in the entire river, with nearly all quality habitat eliminated by 20,000 cfs.

Plecoptera (Stoneflies): This group prefers a velocity between 0.3 and 1.0 ft/sec, with the suitability steadily declining to a SI=0 as velocity increases to 3.0 ft/sec. Optimal depths for Plecoptera are between 1.6 and 2.6 ft. Cobble, and to a lesser extent, gravel and boulder are the preferred substrates.

The WUA curve for Plecoptera shows habitat increasing steadily before peaking at a flow of 5,000 cfs, and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities and water depths exceeding the preferred range for the species. In general, habitat is limited throughout the study reach, due to the absence of ideal substrate. Useable habitat constitutes approximately 7% of the overall wetted study area at the peak WUA flow.

At flows at or below 5,000 cfs habitat was generally poor, but quality habitat was available near the mouth of Octoraro Creek and downstream of Rowland Island. As flows increased above 5,000 cfs habitat quality degraded in the entire river, with nearly all quality habitat eliminated by 20,000 cfs.

Trichoptera (Caddisflies): This group prefers a velocity between 0.3 and 1.0 ft/sec, with the suitability steadily declining to a SI=0 as velocity increases to 3.0 ft/sec. Optimal depths for Trichoptera are between 1.6 and 3.3 ft. Cobble and boulder are the preferred substrates.

The WUA curve for Trichoptera shows habitat increasing steadily before peaking at a flow of 10,000 cfs and then gradually decreasing as flow increases. The WUA curve declines primarily due to water velocities exceeding the preferred range for the species. In general, habitat is reduced throughout the study reach due to the absence of ideal substrate. Useable habitat constitutes approximately 19% of the overall wetted study area at the peak WUA flow.

At flows at or below 10,000 cfs habitat was generally poor, but there were multiple patches of quality habitat located downstream of Rowland Island, near the mouths of Octoraro and Deer Creeks, upstream and downstream of Sterrit Island, downstream of Snake Island and around the edges of Robert Island. As flows increased above 20,000 cfs habitat quality degraded in the entire river, though quality habitat patches remained between Robert and Wood Islands and near the mouths of Octoraro and Deer Creeks.

4.3.1.6 Habitat Guilds

Shown in Figure 4.3.1.6-1 are the WUA curves for the shallow-slow, shallow-fast, deep-slow, and deep-fast habitat guilds.

Shallow-Slow: For this guild, preferred velocities are between 0.0 and 1.0 ft/sec. The shallow-slow guild HSI curve shows preferred depths of 0.5 and 2.0 ft and substrates of gravel, cobble, boulder, and bedrock.

The shallow-slow guild WUA curve peaked at 2,000 cfs, the lowest modeled flow. The habitat declined rapidly between 2,000 cfs and 15,000 cfs, before remaining roughly constant up to 86,000 cfs. There was a small secondary peak around 40,000 cfs, due to the spillway area becoming initially inundated. The WUA curve declined primarily due to water velocities and water depths exceeding the preferred range for the guild, with useable habitat representing approximately 45% of the overall wetted study area at the peak WUA flow.

There were large amounts of optimal habitat throughout the river channel below flows of 5,000 cfs. At flows above 30,000 cfs high quality habitat was available in the spillway area, with little habitat available elsewhere in the river.

Shallow-Fast: For this guild, preferred velocities are between 0.5 and 1.0 ft/sec. The shallow-fast guild HSI curve shows preferred depths of 0.75 and 1.5 ft and substrates of gravel, cobble, and boulder.

The shallow-fast guild WUA curve peaked at 2,000 cfs, the lowest modeled flow. The habitat declined rapidly between 2,000 cfs and 15,000 cfs, before gradually declining between 15,000 cfs and 86,000 cfs. The WUA curve declined primarily due to water velocities and water depths exceeding the preferred range for the guild and was also limited by a lack of suitable substrate. The useable habitat represented approximately 2% of the overall wetted study area at the peak WUA flow.

The majority of the river was unsuitable habitat for all flows. At flows below 5,000 cfs some quality habitat was available downstream of Rowland Island, near the mouths of Deer and Octoraro Creeks and near Sterrit Island. At flows above 15,000 cfs there was almost no habitat of any quality available in any part of the river.

Deep-Slow: For this guild, preferred velocities are between 0.0 and 1.0 ft/sec. The deep-slow guild HSI curve shows preferred depths of greater than 2.0 ft, and all substrates are considered optimal.

The deep-slow guild WUA curve peaked at 5,000 cfs. The habitat declined rapidly between 5,000 cfs and 30,000 cfs, before gradually declining between 30,000 cfs and 86,000 cfs. The WUA curve declined primarily due to water velocities exceeding the preferred range for the guild, with useable habitat representing approximately 52% of the overall wetted study area at the peak WUA flow.

There is optimal habitat throughout the river channel below flows of 20,000 cfs, though the majority of the habitat is in the tidally-influenced part of the study area downstream of Deer Creek. At flows above 30,000 cfs high quality habitat was primarily limited to the area around Spencer, Wood and Robert Islands, the spillway area and near the mouth of Octoraro Creek. River banks and island edges provided some quality habitat as well at higher flows.

Deep-Fast: For this guild, preferred velocities are between 1.0 and 3.5 ft/sec. The deep-fast guild HSI curve shows preferred depths between 2.5 and 4.0 ft, and gravel and cobble substrates are considered optimal.

The deep-fast guild WUA curve peaked at 20,000 cfs. The habitat declined rapidly between 20,000 cfs and 50,000 cfs, before gradually declining between 50,000 cfs and 86,000 cfs. The WUA curve declined primarily due to water velocities and water depths exceeding the preferred range for the guild and was also limited by a lack of suitable substrate, with useable habitat representing approximately 2% of the overall wetted study area at the peak WUA flow.

The majority of the river was unsuitable habitat for all flows. At flows below 5,000 cfs habitat was extremely limited. At flows above 5,000 cfs there was some quality habitat available downstream of Rowland and Robert Islands, as well as around the mouth of Octoraro Creek. As flows increased above 20,000 cfs the habitat quality degraded, with only very small pockets of habitat left at flows above 50,000 cfs.

4.3.2 Habitat Persistence

Habitat persistence was determined as the intersection of quality habitat polygon areas (combined suitability $\geq$ 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 each flow pair (3,500 cfs through 40,000 cfs paired with 86,000 cfs) for each species and life stage are located in Appendix F. Persistent habitat tables showing each flow pair for each species and life stage are located in Appendix G.

4.3.2.1 American Shad

The American shad spawning/incubation and fry habitat persistence curves for all modeled flows paired with full generation (86,000 cfs) are shown in Figure 4.3.2.1-1.

Spawning & Incubation:

Generation flows of 86,000 cfs paired with minimum flows below 7,500 cfs produced little American shad spawning and incubation persistent habitat. Increasing the minimum flow above 7,500 cfs resulted in a rapid persistent habitat increase up through a minimum flow of 15,000 cfs, followed by moderate persistent habitat increases above minimum flows of 15,000 cfs. The majority of the persistent habitat (paired with 86,000 cfs) is located downstream of Rowland Island, near the mouths of Deer and Octoraro Creeks, around Sterrit Island, and around Robert Island, though other small patches exist elsewhere.

Fry:

Generation flows of 86,000 cfs paired with minimum flows between 2,000 cfs and 20,000 cfs steadily increased American shad fry persistent habitat, with minimum flows above 20,000 cfs producing more gradual persistent habitat increases. The majority of the persistent habitat (paired with 86,000 cfs) is located downstream of Rowland Island, near the mouth of Octoraro Creek and between Spencer, Wood and Robert Islands, though other small patches exist elsewhere.

4.3.2.2 Shortnose Sturgeon

The shortnose sturgeon spawning/incubation and fry habitat persistence curves for all modeled flows paired with full generation (86,000 cfs) are shown in Figure 4.3.2.2-1.

Spawning & Incubation:

Generation flows of 86,000 cfs paired with minimum flows below 5,000 cfs resulted in little shortnose sturgeon spawning and incubation persistent habitat. Increasing the minimum flow above 5,000 cfs resulted in a rapid persistent habitat increase up through a minimum flow of 20,000 cfs, followed by moderate persistent habitat increases above minimum flows of 20,000 cfs. The majority of the persistent habitat (paired with 86,000 cfs) is located downstream of Rowland Island, but smaller patches exist southwest of Bird Island, near the mouth of Octoraro Creek, around Sterrit Island and downstream of Snake Island.

Fry:

Generation flows of 86,000 cfs paired with minimum flows below 5,000 cfs resulted in little shortnose sturgeon fry persistent habitat. Increasing the minimum flow above 5,000 cfs resulted in a steady persistent habitat increases up through a minimum flow of 86,000 cfs. Overall, there is very little total persistent habitat. The small amount that exists (paired with 86,000 cfs) is found between Robert and Spencer Islands.

4.3.2.3 Striped Bass

The striped bass spawning/incubation and fry habitat persistence curves for all modeled flows paired with full generation (86,000 cfs) are shown in Figure 4.3.2.3-1.

Spawning & Incubation:

Generation flows of 86,000 cfs paired with minimum flows below 7,500 cfs produced little striped bass spawning and incubation persistent habitat. Increasing the minimum flow above 7,500 cfs resulted in a rapid persistent habitat increase up through a minimum flow of 30,000 cfs, followed by gradual persistent habitat increases above minimum flows of 30,000 cfs. The persistent habitat at flows greater than 7,500 cfs (paired with 86,000 cfs) is distributed throughout the entire study area.

Fry:

Generation flows of 86,000 cfs paired with minimum flows below 7,500 cfs produced little striped bass fry persistent habitat. Increasing the minimum flow above 7,500 cfs resulted in a rapid persistent habitat increase up through a minimum flow of 20,000 cfs, followed by gradual persistent habitat increases above minimum flows of 20,000 cfs. The persistent habitat at flows greater than 7,500 cfs (paired with 86,000 cfs) is distributed throughout the entire study area.

4.3.2.4 Smallmouth Bass

The smallmouth bass spawning/incubation and fry habitat persistence curves for all modeled flows paired with full generation (86,000 cfs) are shown in Figure 4.3.2.4-1.

Spawning & Incubation:

Generation flows of 86,000 cfs paired with minimum flows below 10,000 cfs produced a small amount of smallmouth bass spawning and incubation persistent habitat. Increasing the minimum flow above 10,000 cfs resulted in a gradual persistent habitat increase up through a minimum flow of 86,000 cfs. The small amount of persistent habitat was located primarily between Robert and Spencer Islands.

Fry:

Generation flows of 86,000 cfs paired with minimum flows below 7,500 cfs produced little smallmouth bass fry persistent habitat. Increasing the minimum flow above 7,500 cfs resulted in a gradual persistent habitat increase up through a minimum flow of 50,000, followed by rapid persistent habitat increases above minimum flows of 50,000 cfs. The small amount of persistent habitat available was primarily found along the river edges and around islands.

4.3.2.5 Macroinvertebrates

The macroinvertebrate habitat persistence curves for all modeled flows paired with full generation (86,000 cfs) are shown in Figure 4.3.2.5-1, while only the Ephemeroptera and Plecoptera habitat persistence curves are shown in Figure 4.3.2.5-2.

Ephemeroptera (Mayfly):

Generation flows of 86,000 cfs paired with minimum flows below 10,000 cfs produced little Ephemeroptera persistent habitat. Increasing the minimum flow above 10,000 cfs resulted in a gradual persistent habitat increase up through a minimum flow of 50,000 cfs, followed by moderate persistent habitat increases above minimum flows of 50,000 cfs. The small amount of persistent habitat available was primarily found along the river edges and around islands.

Plecoptera (Stonefly):

Generation flows of 86,000 cfs paired with minimum flows at or below 20,000 cfs produced no Plecoptera persistent habitat. Increasing the minimum flow above 20,000 cfs resulted in a gradual persistent habitat increase up through a minimum flow of 60,000 cfs, followed by steady persistent habitat increases above minimum flows of 60,000 cfs. The small amount of persistent habitat available was primarily found along the river edges and around islands.

Trichoptera (Caddisfly):

Generation flows of 86,000 cfs paired with minimum flows resulted in steadily increasing Trichoptera persistent habitat as the minimum flow increased, through 86,000 cfs. Somewhat smaller incremental habitat increases occurred at higher minimum flows. The small amount of persistent habitat available was primarily found downstream of Rowland Island, around the mouth of Octoraro Creek and between Robert, Spencer and Wood Islands.

4.3.2.6 Habitat Guilds

The shallow-slow and shallow-fast habitat persistence curves for all modeled flows paired with full generation (86,000 cfs) are shown in Figure 4.3.2.6-1, and the deep-slow and deep-fast curves are shown in Figure 4.3.2.6-2.

Shallow-Slow:

Generation flows of 86,000 cfs paired with minimum flows between 2,000 cfs and 50,000 cfs resulted in gradual shallow-slow guild persistent habitat increases as minimum flow increased. Increasing the minimum flow above 50,000 cfs resulted in a rapid persistent habitat increase up through a minimum flow of 86,000 cfs. The small amount of persistent habitat available was primarily found along the river edges and around islands.

Shallow-Fast:

Generation flows of 86,000 cfs paired with minimum flows below 70,000 cfs produced no shallow-fast guild persistent habitat. Persistent habitat only marginally increased for minimum flows above 70,000 cfs.

Deep-Slow:

Generation flows of 86,000 cfs paired with minimum flows between 2,000 cfs and 86,000 cfs produced steadily increasing deep-slow guild persistent habitat as minimum flow increased. The small amount of persistent habitat available was primarily found between Spencer, Wood and Robert Islands, the mouths of Deer and Octoraro Creeks, as well as river edges and around islands.

Deep-Fast:

Generation flows of 86,000 cfs paired with minimum flows below 7,500 cfs resulted in a rapid deep-fast guild persistent habitat increase up through a minimum flow of 30,000 cfs, followed by a gradual persistent habitat increase as minimum flows increased between 30,000 cfs and 86,000 cfs. The small amount of persistent habitat available was primarily found along the river edges and around islands.

4.3.3 Mussel Habitat Assessment

Mussel habitat analyses primarily involved comparing mussel CPUE rates from semi-quantitative[11] mussel sampling locations (Conowingo Study 3.19: Freshwater Mussel Characterization Study below Conowingo Dam) to hydraulic parameters and substrate in the study reach (Figure 4.3.3-1).

Several hydraulic parameters are useful in assessing mussel habitat, but recent literature shows that bed shear stress(τ) and relative shear stress[12] (τ_c) are two of the more important metrics (Pers. Comm, M. Ashton, 2011). While River2D directly calculates bed shear velocity, which is easily converted to bed shear stress, the model does not calculate relative shear stress. Relative shear stress (τ_{rel}) is defined as the ratio of bed shear stress to critical shear stress ($\tau_{rel} = \tau/\tau_c$). Thus, to calculate relative shear stress, critical shear stress must also be known.

[11] As stated in Conowingo Study 3.19, semi-quantitative mussel sampling consists of only riverbed surface sampling, with no sub-surface sampling, as is done in quantitative mussel sampling.

[12] The "relative shear stress" calculations in this report are comparable to the "entrainment potential" calculations in Conowingo Study 3.15: Sediment Introduction and Transport, and differ in terminology in order to be consistent with each study's respective literature. The equations and methods used in both reports are identical, and the grain size classes are the only difference. The grain size classes in Conowingo Study 3.15 were chosen to be consistent with other sediment transport literature, while this report utilizes the HSI grain size classes described in Table 3.2.3-1 to be consistent with other analyses in this report.

Critical shear stress is the threshold that bed shear stress must meet or exceed to initiate particle movement and is defined in Allen and Vaughn (2010) as $\tau_c=\theta_c g D_{50}(\rho_s-\rho)$, where θ_c is Shield's parameter (unitless), D_{50} is the median substrate particle size (cm), ρ_s is substrate density (2.65 g/cm^3) [165.4 lb/ft^3][13], and ρ is water density (0.998 g/cm^3) [62.4 lb/ft^3]. Shield's parameter (θ_c) and median particle size (D_{50}) had to be estimated in order to estimate critical shear stress for each substrate type.

Allen and Vaughn (2010) conducted a mussel study that included six sampling sites on the Little River in Oklahoma. They used 0.065 as Shield's parameter, which they listed as appropriate for normally-packed gravel substrate[14]. The lower Susquehanna has a wide range of substrates, so θ_c values from Julien (2010) were used for each substrate type. The θ_c value used in Allen and Vaughn (2010) of 0.065 was noticeably larger than the gravel θ_c listed in Julien (2010) of 0.039. It appears the differences is that the θ_c of 0.065 is only applicable to normally-packed gravel, while a θ_c of 0.039 is a more general estimate for all types of gravel. For this analysis, a θ_c of 0.039 was used because it was more conservative (more sediment transport). The lower θ_c used results in a lower critical shear stress threshold, and thus a more conservative analysis.

D_{50} substrate estimates were categorized using the substrate codes in Table 3.2.3-1, with an additional differentiation between bedrock in the tidal and non-tidal portions of the study reach. With the exception of silt, the median particle size was conservatively estimated as the smallest value of the particle range for that substrate, which would tend to slightly overestimate the amount of sediment moving. For example, gravel ranged from 2 to 64 mm, so the D_{50} was estimated as 2 mm [0.079 inches]. For silt, the particle size was estimated as the "medium silt" size of 0.016 mm [0.0006 inches] as defined in Julien (2010). Though a critical shear stress cannot be accurately estimated for bedrock, it was acknowledged that areas designated as bedrock dominated in the habitat analysis were not composed completely of bedrock and that other sediment types were present. Thus, for bedrock only, all present substrates identified in the 2008 aquatic habitat study were used to create an estimated composite particle size distribution from which the median particle size could be calculated, calculated as:

D_{50} = (%gravel*$D_{50gravel}$) + (%cobble*$D_{50cobble}$) + ([%boulder+%bedrock]*$D_{50boulder}$).

---

[13] For consistency with existing mussel literature, mussel results will be expressed in SI units. US Standard units will also be shown where possible.

[14] No description of normally-packed gravel was provided.

Note that bedrock and boulder assumed the same D_{50} for calculation purposes. Additionally, field observations and local knowledge indicate that while the 2008 aquatic habitat study estimated substrate proportions correctly for non-tidal bedrock areas, substrate are slightly finer in tidally-influenced bedrock areas (Pers. Comm., M. Ashton, 2011). To account for this, bedrock was broken into tidal and non-tidal areas, which are shown in Figure 4.3.3-1. The makeup for the bedrock in non-tidal areas was 20% cobble, 15% boulder and 65% bedrock. The makeup for the bedrock in tidal areas was 5% gravel, 25% cobble, 20% boulder and 50% bedrock.

Table 4.3.3-1 shows the substrates used in the mussel analysis, as well as the estimated median particle sizes, Shield's parameter and calculated critical shear stresses for each substrate code.

Hydraulic parameters were matched with the semi-quantitative mussel sampling locations. Appendix H includes tables showing modeled depth, water velocity, Froude number, shear stress and relative shear stress as well as CPUE[15], alewife floater presence/absence, substrate and critical shear stress at each semi-quantitative mussel sampling location for all 14 modeled flows. Each table also highlights where shear stress and relative shear stress thresholds are exceeded for low flows in orange (20 dynes/cm^2 and 0.4, respectively) and high flows in red (150 dynes/cm^2 and 2.0, respectively). While there was a large variability in results, the semi-quantitative mussel surveying locations with the highest CPUE generally had low shear stress and relative shear stress values. A plot of CPUE vs. shear stress at several flows showed that stations with the highest CPUEs tended to have relatively low shear stresses (Figure 4.3.3-2). It also showed that at 3,500 cfs and 5,000 cfs the highest CPUEs were associated with shear stresses lower than 40-60 dynes/cm^2.

To understand the relative amount of area suitable for mussel development at different flows, the area above the low flow and high flow shear stress thresholds were plotted in Figure 4.3.3-3. Maps of shear stress at each modeled flow are shown in Appendix I. The results showed that a moderate to high percentage of the wetted study area exceeded the low flow threshold, while a low to moderate percentage exceeded the high flows. The low flow threshold curve showed a rapid increase in area exceeding 20 dynes/cm^2 between 2,000 cfs and 10,000 cfs, with a moderate increase between 10,000 cfs and 30,000 cfs, followed by a gradual increase between 30,000 and 86,000 cfs. The high flow threshold curve showed a gradual decrease increase in area exceeding 150 dynes/cm^2 between 2,000 cfs and 5,000 cfs,

[15] All CPUE numbers reflect overall mussel catch numbers, not any specific species

followed by a graduate increase in area between 5,000 cfs and 10,000 cfs, followed by a steady increase between 10,000 cfs and 86,000 cfs.

5. STEADY-STATE HABITAT ANALYSIS DISCUSSION

This purpose of this section is to summarize the results presented in Section 4 so that flow regime preferences are compared across all target species or guilds.

5.1 Monthly Analysis of WUA and Persistent Habitat Results

Shown in Table 5.1-1 is the flow that provides the maximum WUA for each species and life stage (second column). The table also depicts the range of flows that provide 90%, 80%, 70% and 60% of the maximum WUA. Based on Table 5.1-1, a series of flows were chosen, and the habitat values as a percentage of maximum habitat were calculated for each species/life stage analyzed. This information is presented in Table 5.1-2.

Habitat as a percentage of maximum WUA was plotted against flow for each species, with daily average flow exceedance percentiles from the Conowingo estimated daily average unregulated flow added for reference (Table 2.2.2-2). Several species/life stages are tolerant of a wide flow range (e.g., American Shad Adult, all Striped Bass life stages), while several prefer narrow flow ranges (e.g., Mayfly, Smallmouth Bass Spawning). Some year-round species' have no preferred flow range overlap (e.g., Striped Bass Adult vs. Deep-Slow Guild), indicating that some species/life stages will be subject to sub-optimal flow conditions regardless of the flow regime.

Based on the discussion relative to species and life stage use in Section 4.2, the estimated unregulated hydrology at Conowingo (Table 2.2.2-2) and the maximum available habitat as a percentage of the study area, we narrowed the list of target species and life stages (Table 3.2.1-2) to those we expect would utilize the lower river and be compatible with its structural habitat and unregulated flow regime. We then analyzed these species and life stages, on a monthly basis, to provide information that could be used in determining a monthly flow schedule.

5.1.1 January

Figure 5.1.1-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in January along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of January these species include:

- Striped bass adults;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.1-1 provides the above species' flow preferences and January's median monthly flow.

5.1.2 February

Figure 5.1.2-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in February along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of February these species include:

- Striped bass adults;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.2-1 provides the above species' flow preferences and February's median monthly flow.

5.1.3 March

Figure 5.1.3-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in March along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of March these species include:

- Striped bass adults;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.3-1 provides the above species' flow preferences and March's median monthly flow.

5.1.4 April

Figure 5.1.4-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in April along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of April these species include:

- American shad spawning;
- American shad adults;
- Striped bass spawning;
- Striped bass fry;
- Striped bass adults;
- Smallmouth bass adults;
- Shortnose sturgeon spawning;
- Trichoptera;

- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.4-1 provides the above species' flow preferences and April's median monthly flow.

5.1.5 May

Figure 5.1.5-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in May along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of May these species include:

- American shad spawning;
- American shad fry
- American shad adults;
- Striped bass spawning;
- Striped bass fry;
- Striped bass adults;
- Smallmouth bass adults;
- Shortnose sturgeon spawning;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.5-1 provides the above species' flow preferences and May's median monthly flow.

5.1.6 June

Figure 5.1.6-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in June along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of June these species include:

- American shad spawning;
- American shad fry
- American shad adults;
- Striped bass spawning;
- Striped bass fry;
- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.6-1 provides the above species' flow preferences and June's median monthly flow.

5.1.7 July

Figure 5.1.7-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in July along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of July these species include:

- American shad fry;
- American shad juveniles;
- Striped bass fry;
- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.7-1 provides the above species' flow preferences and July's median monthly flow.

5.1.8 August

Figure 5.1.8-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in August along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of August these species include:

- American shad juveniles;
- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass juveniles;

- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.8-1 provides the above species' flow preferences and August's median monthly flow.

5.1.9 September

Figure 5.1.9-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in September along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of September these species include:

- American shad juveniles;
- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass juveniles;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.9-1 provides the above species' flow preferences and September's median monthly flow.

5.1.10 October

Figure 5.1.10-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in October along with estimated unregulated flow exceedance percentiles from Table

2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of October these species include:

- American shad juveniles;
- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass juveniles;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.10-1 provides the above species' flow preferences and October's median monthly flow.

5.1.11 November

Figure 5.1.11-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in November along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of November these species include:

- American shad juveniles;
- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass juveniles;

- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.11-1 provides the above species' flow preferences and November's median monthly flow.

5.1.12 December

Figure 5.1.12-1 provides the flow preferences of all target species' that are potentially present below Conowingo Dam in December along with estimated unregulated flow exceedance percentiles from Table 2.2.2-2. We narrowed the broader list of target species down to the following species and lifestages for which there is a relatively high amount of structural habitat available (relative to total wetted area), are expected to be present in the study reach and have some compatibility with the unregulated flow regime. For the month of December these species include:

- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass juveniles;
- Smallmouth bass adults;
- Trichoptera;
- Members of the shallow-slow guild; and
- Members of the deep-slow guild.

Table 5.1.12-1 provides the above species' flow preferences and December's median monthly flow.

5.2 Mussel Habitat Analysis

The riverbed's primarily high critical shear stress, due to large amounts of boulder and bedrock, made comparing relative shear stresses to mussel catch rates (CPUE) ineffective. As a result, shear stress criteria were primarily used to analyze mussel habitat in the study reach. A plot of mussel CPUE vs. shear stress at various flows showed that stations with the highest CPUE tended to have relatively low shear stresses (Figure 4.3.3-2). Study area shear stresses were compared to low flow and high flow thresholds of 20 dynes/cm^2 and 150 dynes/cm^2, respectively, showing how higher flows reduced optimal mussel habitat availability (Figure 4.3.3-3). Results showed that the percent of the wetted study area exceeding the low flow threshold area rapidly increased between 2,000 cfs and 10,000 cfs and then leveled off, while the percent of the wetted study area exceeding the high flow threshold steadily increased between 10,000 cfs and 86,000 cfs.

The low-flow and high-flow shear stress thresholds predict that significant portions of the study area are not suitable for mussel development, particularly at high flows. While the high-flow shear stress thresholds appear to be related to preventing mussels from being carried downstream by current, the mechanisms driving low-flow shear stress thresholds are not entirely clear. Though Allen and Vaughn (2010) found a relationship between low-flow shear stress and mussel richness and abundance, they stated that better relationships were found with high-flow parameters. Thus, it was not clear whether low-flow shear stress plays a biological role in mussel development, or is simply cross-correlated with shear stresses at higher flows. Layzer and Madison (1995) suggest that adult mussel abundance is controlled at least partially by juvenile tolerances, such that adults are more abundant where juvenile development is best. They implied that adult mussels may be more tolerant of habitat changes than juveniles, but this topic was not investigated in their study. Thus, it is possible that the shear stress thresholds are more descriptive of juvenile habitat preferences than adult mussel tolerances.

Shear stress thresholds of 20 dynes/cm^2, 50 dynes/cm^2 and 150 dynes/cm^2 have all been related to mussel richness and abundance, showing considerable variability associated with what is best for mussel development. In addition to shear stress tolerances' variability in literature, using shear stress thresholds developed with data from other rivers and areas of the country may introduce more uncertainty. Allen and Vaughn's (2010) study was conducted on a river with no peaking hydroelectric influences (flood control only) and the Layzer and Madison (1995) study site was completely unregulated. It is not clear in a highly regulated stream how this information would be used to inform flow management decisions.

Mussel habitat is found exclusively on the riverbed, and in the main-channel is generally found behind small-scale local refugia, such as behind bedrock outcrops and large boulders (Pers. Communication, W. Ettinger). This merits consideration that the hydraulic model, while utilizing a dense mesh relative to the study area, does not capture microhabitat behind individual bed features smaller than the mesh size (20-65 ft). Thus, while the model may be appropriate for identifying hydraulic properties and habitat throughout the reach, the results may underestimate the amount of available mussel habitat. Regardless, the CPUE vs. shear stress plots show that model-predicted shear stress relates fairly well to mussel density, indicating that the model results are moderately capable at identifying large-scale mussel distribution.

5.3 Habitat Conclusions

Habitat analyses for most species were conducted using SI curves, and habitat vs. flow curves were developed. Additionally, mussel habitat and habitat persistence analyses were run.

There were several areas in the river that appeared to provide high-quality habitat for many species and life stages. These areas included downstream of Rowland Island, near the mouths of Octoraro and Deer Creeks, an area southwest of Bird Island, downstream of Snake Island and in-between Robert, Wood and Spencer Islands. These areas often provided unique combinations of depth, velocity and substrate, providing refugia for species and life stages that are not well suited for the conditions found in the river's main channel. Other than for striped bass, these areas often proved to be the highest quality habitat found in the river for the target species.

While the habitat modeling provided estimates of available habitat at various flows, the river flow available is an important consideration in flow and habitat management decisions. There are four hydroelectric projects on the lower Susquehanna River, three of which are main channel peaking hydroelectric plants (Safe Harbor, Holtwood, Conowingo), one of which is a pumped storage (Muddy Run). All four have the ability to influence the river's flow regime, particularly on a sub-daily scale. The project with the largest hydraulic capacity is Safe Harbor, the farthest upstream project, with a maximum hydraulic capacity of 110,000 cfs. This is greater than the hydraulic capacity of Holtwood (61,460 cfs following expansion construction) and Conowingo (86,000 cfs). Safe Harbor also has no minimum flow release requirements as stipulated in its current license, which expires in 2030. Conowingo has a seasonally-varying minimum flow release, and Holtwood will also provide a minimum flow release beginning no later than 2012. Thus, it is important to consider not only the river's unregulated hydrology, but upstream projects' water availability influences, which can greatly impact the effectiveness of flow management decisions in the lower Susquehanna River.

6. REFERENCES

Allen, D.C., C.C. Vaughn. 2010. Complex hydraulic and substrate parameters limit freshwater mussel species richness: a test of the substrate stability hypothesis. Journal of the North American Benthological Sociatety. 29:383-394

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.

Bovee, K. D., T. J. Waddle, and R. B. Jacobson. 2004. Quantification of habitat patch persistence in river affected by hydropeaking. Geographic Information systems and Water Resources III AWRA Spring Specialty Conference. Nashville, Tennessee, May 17-19, 2004.

Elliot, C.M., R.B. Jacobson, A.J. DeLonay. 2004. Physical Aquatic Habitat Assessment, Fort Randall Segment of the Missouri River, Nebraska and South Dakota. USGS Open-File Report 2004-1060

Greene, K.E., J.L. Zimmerman, R.W. Laney, and J.C. Thomas-Blate. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Jacobson, R.B., M.S. Laustrup, and J.M. Reuter. 2002. Habitat Assessment, Missouri River at Hermann, Missouri. USGS Open-File Report 02-32.

Julien, P. 2010. Erosion and Sedimentation. 2nd Edition. Cambridge University Press. UK. 371p.

Missouri Department of Conservation. November 2004. Assessment of Operational Alternatives for the Osage Hydroelectric Project, FERC Project No. 459.

Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC). 2010. Migratory Fish Management and Restoration Plan for the Susquehanna River Basin. Final Draft Approved by Policy Committee.

Susquehanna River Basin Commission (SRBC). June 2009. Extension of the Susquehanna River Basin Hydrology (October 2002-March 2008).

Morales, Y., L.J. Weber, A.E. Mynett, and T.J. Newton. 2006. Effects of substrate and hydrodynamic conditions on the formation of mussel beds in a large river. Journal of the North American Benthological Society. 25:664-676.

TABLE 2.2.1-1: CONOWINGO WY 1988-2009 30-MIN INSTANTANEOUS FLOW EXCEEDENCE PERCENTILES.

Exceedance Percentile	Annual	January	February	March	April	May	June	July	August	September	October	November	December
0	909,000	909,000	264,000	415,000	498,000	278,000	461,000	235,000	179,000	619,000	262,000	303,000	295,000
5	119,000	164,000	114,000	173,000	187,000	119,000	84,000	68,900	57,500	73,100	84,800	95,900	140,000
10	85,200	117,000	85,200	132,000	126,000	86,800	69,700	56,500	42,900	55,800	74,900	80,900	99,300
15	78,800	89,200	80,000	104,000	102,000	80,500	62,500	46,100	38,400	42,900	59,400	75,900	83,600
20	72,600	81,100	77,200	87,400	87,900	74,400	54,100	36,500	25,400	33,600	45,700	67,700	80,000
25	66,600	78,800	73,100	82,900	83,800	67,800	47,000	27,900	12,900	24,600	36,300	61,600	76,400
30	59,700	74,060	69,900	79,900	80,500	64,830	39,000	19,200	6,960	11,700	29,950	53,600	70,400
35	49,800	68,100	65,500	77,100	77,700	59,700	32,500	8,310	6,550	6,500	23,500	45,900	65,900
40	40,700	61,900	61,600	74,000	74,200	53,800	27,200	7,060	6,400	6,020	16,200	38,900	59,700
45	32,500	52,400	51,500	71,800	71,600	46,000	23,700	6,700	6,250	5,740	7,080	32,100	51,600
50	24,900	43,200	41,900	69,400	69,000	38,600	16,900	6,450	6,110	5,340	5,050	25,400	42,300
55	16,200	33,200	33,700	65,600	65,955	33,000	8,560	6,300	5,930	5,000	4,690	17,900	33,500
60	9,480	26,000	26,200	60,000	62,500	26,200	7,010	6,200	5,790	4,636	4,600	7,010	26,000
65	6,700	18,700	19,800	49,900	54,700	22,200	6,510	6,020	5,690	4,450	4,540	5,190	18,400
70	6,120	7,881	10,100	39,200	44,200	11,800	6,270	5,880	5,550	4,320	4,450	4,720	7,010
75	5,690	4,770	5,538	30,200	33,100	10,100	6,150	5,790	5,390	4,200	4,370	4,550	4,460
80	5,050	3,960	4,320	23,000	24,500	9,580	5,960	5,650	5,190	3,960	4,250	4,450	3,510
85	4,540	1,520	1,680	7,350	13,600	9,270	5,830	5,500	4,950	3,690	3,880	4,320	1,450
90	4,120	1,110	1,140	5,190	12,400	9,110	5,690	5,290	4,680	3,540	3,760	4,000	1,030
95	3,010	958	950	4,500	11,900	8,800	5,440	4,950	3,840	3,140	3,620	3,650	879
100	257	279	257	1,070	10,000	6,200	4,370	3,070	2,200	1,680	950	748	257

TABLE 2.2.1-2: MARIETTA USGS GAGE (#01576000) DAILY AVERAGE FLOW EXCEEDENCE PERCENTILES (CFS), WY 1932-2009.

Exceedance Percentile	Annual	January	February	March	April	May	June	July	August	September	October	November	December
0	1,040,000	556,000	446,000	700,000	431,000	450,000	1,040,000	223,000	287,000	545,000	252,000	396,000	348,000
5	118,000	127,000	121,000	188,000	196,050	114,150	67,810	41,800	32,515	43,405	65,090	85,045	114,150
10	84,800	90,990	92,000	148,000	146,000	90,200	51,500	30,430	23,100	26,800	41,000	63,300	83,690
15	67,400	71,200	74,710	123,000	123,000	76,200	43,400	24,800	18,700	20,100	29,490	50,630	70,045
20	56,120	59,920	63,200	108,000	105,000	66,320	37,000	21,600	16,600	16,700	22,860	42,440	59,300
25	47,400	50,100	54,325	95,675	93,900	60,300	31,900	19,400	14,800	13,700	19,000	37,000	51,500
30	40,800	43,500	47,610	85,590	85,400	54,300	29,000	17,300	13,100	11,800	16,090	33,230	45,000
35	35,000	38,205	42,600	77,300	77,800	50,100	26,300	16,000	11,700	10,200	13,605	29,900	40,400
40	30,200	34,000	38,600	70,300	71,840	45,800	23,900	14,400	10,600	9,110	11,700	27,100	36,200
45	26,300	30,435	34,665	64,800	66,800	41,400	21,600	13,300	9,590	8,285	10,400	24,600	32,335
50	23,000	27,000	31,000	59,700	62,700	37,650	19,900	12,300	8,690	7,580	9,495	22,300	29,000
55	20,000	24,000	28,135	54,365	58,755	34,300	18,600	11,300	7,900	6,996	8,680	19,400	25,965
60	17,500	21,500	26,200	48,780	54,300	31,900	17,200	10,400	7,368	6,386	7,908	17,200	23,100
65	15,200	19,400	23,800	44,800	50,100	29,000	15,600	9,490	6,710	5,920	7,090	14,765	21,000
70	13,000	17,500	21,700	41,000	46,100	26,300	14,300	8,750	6,190	5,540	6,451	12,800	19,200
75	11,100	16,000	19,400	37,400	42,200	24,100	13,100	7,983	5,740	5,068	5,743	11,200	17,900
80	9,310	14,500	17,160	32,900	38,340	21,800	12,180	7,210	5,350	4,590	5,150	9,508	16,000
85	7,600	13,000	15,045	28,300	34,100	20,100	11,200	6,397	4,886	4,130	4,640	7,809	13,400
90	6,070	11,170	13,000	24,170	30,700	17,800	9,880	5,530	4,360	3,690	4,080	6,080	11,000
95	4,690	9,081	11,000	18,970	25,095	14,900	8,380	4,629	3,760	3,000	3,650	4,980	8,200
100	1,380	4,000	6,000	6,500	15,300	8,680	4,830	2,580	2,610	1,380	1,450	2,100	3,300

TABLE 2.2.1-3: CONOWINGO USGS GAGE (#01578310) DAILY AVERAGE FLOW EXCEEDENCE PERCENTILES (CFS), WY 1968-2009

Exceedance Percentile	Annual	January	February	March	April	May	June	July	August	September	October	November	December
0	1,120,000	622,000	470,000	462,000	467,000	235,000	1,120,000	213,000	202,000	662,000	245,000	272,000	357,000
5	121,000	131,000	139,000	184,000	188,050	104,000	80,645	50,575	41,300	56,480	84,690	90,320	129,950
10	85,400	93,980	98,500	139,000	144,000	81,100	59,000	37,500	28,280	35,240	57,170	70,410	98,350
15	70,600	76,140	81,420	119,000	116,150	70,685	49,015	31,985	24,100	26,315	42,285	60,215	80,000
20	60,300	62,160	70,860	102,000	102,200	64,000	42,240	28,080	20,600	22,120	32,480	53,600	71,380
25	52,600	53,775	60,500	88,600	89,175	58,700	37,725	25,500	18,400	19,325	26,825	46,800	64,050
30	46,100	47,800	54,240	81,400	82,700	53,400	33,900	23,170	16,300	17,100	22,700	42,500	57,200
35	40,700	42,800	48,890	73,500	76,870	49,300	31,400	20,665	14,900	14,900	20,265	39,035	52,630
40	35,700	38,060	44,800	68,360	70,900	45,760	28,900	18,900	13,300	13,100	17,460	35,200	47,820
45	31,600	33,955	41,060	63,155	66,545	43,000	26,800	17,355	12,000	11,900	15,355	31,700	43,900
50	27,800	30,250	36,800	58,900	61,800	39,400	24,500	15,700	10,650	10,400	13,800	28,700	40,300
55	24,800	27,600	33,500	54,100	57,700	36,245	22,555	14,400	9,489	8,861	12,100	26,000	36,900
60	21,700	25,040	30,840	50,440	53,900	33,200	20,300	13,100	8,380	7,410	10,900	23,460	33,880
65	19,000	22,635	27,900	46,335	50,500	30,700	18,600	11,800	6,837	6,393	9,690	20,200	31,235
70	16,200	20,800	25,680	42,130	45,470	28,030	17,170	10,400	6,143	5,337	8,320	17,700	28,330
75	13,700	18,700	23,050	38,025	42,000	26,200	15,400	8,373	5,663	4,953	6,890	14,775	25,800
80	11,200	16,240	20,700	34,100	38,200	23,520	13,580	6,946	5,290	4,368	4,912	12,400	22,040
85	8,270	13,200	18,490	30,300	34,500	21,100	11,385	6,152	5,002	3,799	4,460	9,459	18,815
90	5,840	10,210	15,500	24,410	29,690	18,100	8,658	5,421	4,490	3,037	3,750	5,807	13,610
95	4,300	5,465	10,790	18,415	24,485	14,005	6,179	4,527	2,702	1,420	1,212	3,838	7,831
100	269	511	758	287	6,090	5,220	622	269	367	363	295	303	777

TABLE 2.2.2-1: INCREMENTAL RIVER REACHES USED TO ESTIMATE UNREGULATED CONOWINGO FLOW. MARIETTA WATERSHED SIZE IS 25,990 MI^2. CONOWINGO WATERSHED SIZE IS 27,100 MI^2.

River Reach	Incremental Drainage Area (mi^2)	Gage Used to Prorate Flows	Gage Proration Factor (Incr. Drainage Area/ Gage Drainage Area)
Marietta-Safe Harbor	100	Manchester, PA	0.196
Safe Harbor-Holtwood	696	Lancaster, PA	2.148
Muddy Run[16]	9.2	Lancaster, PA	0.029
Holtwood-Conowingo	304.8	Lancaster, PA	0.941
Total	1,110		

[16] Muddy Run is part of the Holtwood-Conowingo incremental reach, but was explicitly broken out in the model separately. The Holtwood-Conowingo incremental drainage areas accounts for this.

TABLE 2.2.2-2: CONOWINGO ESTIMATED DAILY AVERAGE UNREGULATED FLOW EXCEEDANCE PERCENTILES, WY 1934-2009

Exceedance Percentile	Annual	January	February	March	April	May	June	July	August	September	October	November	December
0	1,058,069	562,718	452,536	706,014	439,768	451,923	1,058,069	226,007	199,595	555,083	254,490	398,881	353,075
5	120,856	131,040	123,979	192,806	199,103	115,402	69,826	43,987	33,750	43,622	67,382	86,033	118,143
10	86,715	94,842	94,961	150,195	148,422	91,444	53,137	31,969	24,026	26,710	42,795	64,234	86,577
15	69,143	73,798	77,813	126,139	123,804	77,387	44,356	26,333	19,583	20,313	30,958	51,860	73,422
20	58,021	61,713	65,481	110,520	105,972	67,626	38,131	22,850	17,346	16,949	23,797	43,386	62,020
25	48,894	52,130	56,367	97,286	95,263	61,351	33,289	20,600	15,498	14,053	19,617	37,692	53,782
30	42,016	44,487	49,905	87,924	86,070	55,435	30,130	18,477	13,616	12,234	16,514	33,764	47,654
35	36,107	39,580	44,625	79,579	78,967	51,125	27,262	16,924	12,238	10,586	14,167	30,522	42,309
40	31,375	35,575	40,560	72,324	72,653	46,637	24,898	15,266	11,043	9,482	12,151	27,877	37,514
45	27,322	31,302	36,222	67,131	67,906	42,553	22,670	14,038	10,142	8,685	10,805	25,271	34,077
50	23,818	27,732	32,617	61,744	63,752	38,768	20,661	13,045	9,201	7,995	9,845	22,927	30,672
55	20,778	24,620	29,506	56,991	59,617	35,025	19,243	12,080	8,339	7,402	9,060	20,143	27,619
60	18,205	21,908	27,159	51,367	55,340	32,630	18,118	11,040	7,748	6,761	8,297	17,690	24,740
65	15,779	19,823	24,738	46,930	50,852	29,504	16,576	10,019	7,119	6,249	7,514	15,447	22,125
70	13,546	17,862	22,601	42,912	46,792	26,976	15,030	9,167	6,515	5,822	6,804	13,455	20,392
75	11,599	16,363	20,002	39,457	43,046	24,650	13,737	8,403	6,049	5,408	6,132	11,633	18,376
80	9,726	14,949	17,750	34,825	38,842	22,390	12,676	7,551	5,662	4,877	5,532	10,127	16,393
85	8,022	13,394	15,741	30,157	35,093	20,506	11,654	6,680	5,166	4,382	4,949	8,387	13,806
90	6,409	11,557	13,551	25,813	31,464	18,070	10,195	5,787	4,582	3,913	4,426	6,598	11,410
95	4,991	9,638	11,264	20,786	25,450	15,319	8,670	4,815	3,872	3,283	3,792	5,542	8,519
100	1,504	4,367	6,083	6,765	15,878	8,959	5,003	2,677	2,692	1,504	2,246	2,192	3,572

TABLE 3.2.1-1: TARGET SPECIES, HABITAT GUILD ASSIGNMENTS, AND SPECIES OF SPECIAL CONCERN. NOTE THAT ALL SPAWNING/INCUBATION AND FRY LIFE STAGES ARE CONSIDERED IMMOBILE.

A=Adult, J=Juvenile, F=Fry, S=Spawning

	Habitat Guild Assignment			
Target Species	**Shallow-slow (< 2 ft, < 1 ft/s)**	**Shallow-fast (< 2 ft, > 1 ft/s)**	**Deep slow (> 2 ft, < 1 ft/s)**	**Deep-fast (> 2 ft, > 1 ft/s)**
American shad*	F, J		J	A, S
Hickory shad	F		J, S	A
Blueback herring	F, J		A, S	
Alewife	F, J		A, S	
White perch	F, J	S	A, J	S
Yellow perch	F		A, J, S	
Striped bass *	F, J, S		F, J, S	A, S
Largemouth bass	F, J, S		A, F, J, S	
Smallmouth bass *	F		A, F, J, S	
Walleye			A, J, F	S
Shortnose sturgeon *	F	F	A, J, F	A, F, J, S
Atlantic sturgeon			A, J, F	A, F, J, S
American eel***	J		A, J	J
EPT**	√	√	√	√

*Species of special concern for instream flow assessment.

** Ephemeroptera-Plecoptera-Trichoptera

*** Juvenile refers to elver and yellow eels, while adult refers to silver eels

TABLE 3.2.1-2: SEASONAL PERIODICITY OF OCCURRENCE OF TARGET SPECIES IN THE SUSQUEHANNA RIVER BELOW CONOWINGO DAM. ITALICIZED LIFE STAGES ARE CONSIDERED IMMOBILE. HABITAT GUILDS ARE SHOWN IN PARENTHESES.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
American Shad												
Spawning				■	■	■						
Fry					■	■	■					
Juveniles							■	■	■	■	■	
Adults				■	■	■						
Hickory Shad												
Spawning (Deep-Slow)			■	■	■							
Fry(Shallow-Slow)				■	■	■						
Juveniles (Deep-Slow)						■						
Adults (Deep-Fast)			■	■	■							
Blueback Herring												
Spawning (Deep-Slow)				■	■	■						
Fry (Shallow-Slow)					■	■						
Juveniles (Shallow-Slow)							■	■	■	■		
Adults (Deep-Slow)				■	■	■						
Alewife												
Spawning (Deep-Slow)			■	■	■							
Fry (Shallow-Slow)			■	■	■							
Juveniles (Deep-Slow)						■	■	■	■	■		
Adults (Shallow-Slow)				■	■							
White Perch												
Spawning (Shallow-Fast, Deep-Fast)				■	■	■						
Fry (Shallow-Slow)				■	■	■	■					
Juveniles (Shallow-Slow, Deep-Slow)					■	■	■	■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Yellow Perch												
Spawning (Deep-Slow)			■	■								
Fry (Shallow-Slow)				■	■							
Juveniles (Deep-Slow)						■	■	■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Striped Bass												
Spawning				■	■	■						
Fry				■	■	■	■					
Juveniles						■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Largemouth Bass												
Spawning (Shallow-Slow, Deep-Slow)					■	■						
Fry (Shallow-Slow, Deep-Slow)						■	■					
Juveniles (Shallow-Slow, Deep-Slow)								■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Smallmouth Bass												
Spawning					■	■						
Fry						■	■					
Juveniles								■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Walleye												
Spawning (Deep-Fast)			■	■								
Fry (Deep-Slow)				■	■	■						
Juveniles (Deep-Slow)						■	■	■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Shortnose sturgeon												
Spawning				■	■							
Fry					■	■	■					
Juveniles/Adults	■	■	■	■	■	■	■	■	■	■	■	■
Atlantic sturgeon												
Spawning (Deep-Fast)				■	■							
Fry (Deep-Slow, Deep-Fast)					■	■	■					
Juveniles/Adults (Deep-Slow, Deep-Fast)	■	■	■	■	■	■	■	■	■	■	■	■
American eel												
Elver (Shallow-Slow, Deep-Slow, Deep-Fast)				■	■	■	■	■	■	■		
Yellow (Shallow-Slow,Deep-Slow,Deep-Fast)	■	■	■	■	■	■	■	■	■	■	■	■
Silver (Deep-Slow)									■	■	■	■
Alewife floater												
Adults/juveniles	■	■	■	■	■	■	■	■	■	■	■	■
Spawning										■	■	■
Larvae			■	■	■							
Eastern elliptio												
Adults/juveniles	■	■	■	■	■	■	■	■	■	■	■	■
Spawning	■	■	■									
Larvae				■	■	■	■	■				
Fingernail clams												
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Spawning/larvae	■	■	■	■	■	■	■	■	■	■	■	■
Ephemeroptera-Plecoptera-Trichoptera												
all life stages	■	■	■	■	■	■	■	■	■	■	■	■

TABLE 3.2.2-1: SOURCES OF HABITAT SUITABILITY INDICES FOR SPECIES OF SPECIAL CONCERN AND HABITAT-BASED GUILDS

	HSC Source		
Species	**Velocity**	**Depth**	**Substrate**
American shad[1, 2, 3]			
Spawning	Stier and Crance 1985.	Stier and Crance 1985.	ASMFC 2009.
Fry	Stier and Crance 1985.	Stier and Crance 1985.	Stier and Crance 1985.
Juvenile	Stier and Crance 1985.	Ross et al 1993. Greene et al. 2009.	Stier and Crance 1985.
Adult	Stier and Crance 1985.	Stier and Crance 1985.	Stier and Crance 1985.
Shortnose Sturgeon [4]			
Spawning	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Fry	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Juvenile	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Adult	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Striped bass [5]			
Spawning	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Fry	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Juvenile	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Adult	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Smallmouth bass [6, 7, 8]	Aadland and Kuitunen. 2006.	Aadland and Kuitunen. 2006.	Aadland and Kuitunen. 2006.
Adult	North Carolina Department of Water Resources, RMC (1992);	Angermeier (1987), Ross et al (1987), Todd and Rabeni (1989)	North Carolina Department of Water Resources, RMC (1992)
Juvenile	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)
Fry	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)
Spawning	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)
Shallow-slow guild [9]			
(< 2 ft, < 1 ft/sec)	Leonard and Orth (1988); Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
Shallow-fast guild [9]			
(< 2 ft, > 1 ft/sec)	Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
Deep-slow [9]			
(> 2 ft, < 1ft/sec)	Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
Deep-fast [9]			
(> 2 ft, > 1 ft/sec)	Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
EPT [10]	Gore et al. 2001		

1) Stier, D.J., and J.H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. United States Fish and Wildlife Service Biological Report 82(10.88). 34pp.
2) Ross, R.M.,T.W.W. Backman, and R.M.Bennett.1993. Evaluation of habitat suitability index models for riverine life satges of American shad, with proposed models for premigratory juveniles. U.S.Fish and Wildlife Service Bilogical Report 14.
3) Atlantic States Marine Fisheries Commission.2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Habitat Management Series No.9, Washington, D.C.
4) Crance, J.H. 1986. Habitat suitability information: Shortnose sturgeon. U.S. Fish Wildl. Serv. Biol. Rep. FWS/OBS-82/10.129. 31pp.
5) Crance, J.H. 1984. Habitat suitability index models and instream flow suitability curves: Inland stocks of striped bass. U.S. Fish Wildl. Serv. FWS/OBS-82/10.85. 63pp.
6) Aadland, L.P. and A. Kuitunen. 2006. Habitat suitability criteria for stream fishes and mussels of Minnesota. Division of Ecological Services, Special Publication No. 62. Minnesota Department of Natural Resources, St. Paul, MN
7) Original habitat suitability curves for smallmouth bass (Edwards *et al*. 1983; FWS/OBS-82/10.36) were modified in consultation with NCDWR for IFIM study in Pigeon River, NC (RMC 1992). RMC.1992. Results of an incremental flow study in the bypassed reach at the Walters Hydroelectric Project, Pigeon River,, North Carolina. Prepared for Carolina Power and Light Company, Raleigh, NC.
8) Angermeier, P. L. 1987. Spatiotemporal variation in habitat selection by fishes in small Illinois streams. 52–60. in W. J. Matthews and D. C. Heins, editors. Community and evolutionary ecology of North American stream fish. University of Oklahoma Press, Norman.

Ross, S. T., J. A. Baker, and K. E. Clark. 1987. Microhabitat partitioning of southeastern stream fishes: Temporal and spatial predictability. In: Matthews, W. J. and D. C. Heins (eds.). Symposium on the Evolutionary and Community Ecology of North American Stream Fishes. University of Oklahoma Press, p. 4251.

Todd, B.L. and C.F. Rabeni. 1989. Movement and habitat use by stream dwelling smallmouth bass. Transaction of the American Fisheries Society 118:229-242.

9) Leonard, P.M. and D.J. Orth. 1988. Use of habitat guilds of fishes to determine instream flow requirements. North American Journal of Fisheries Management 8:399-409.

Aadland, L.P. 1993. Stream habitat types: their fish assemblages and relationship to flow. North American Journal of Fisheries Management 13:790-806.

Normandeau Associates,Inc. 2000.An instream flow study in support of relicensing of the Piney Hydroelectric Station FERC Project No.309. Prepared for Foster Wheeler Environmental Corporation, Langhorne, PA and Sithe Pennsylvania Holdings LLC, Johnstown,PA

Progress Energy. 2003. Pee Dee River instream flow study (FERC No. 2206).

DTA. 2005. Duke Power Catawba-Wateree relicensing (FERC No.2232) Instream flow study report.

10) Gore, J.A., J.B. Layzer, and J.Mead. Macroinvertebrate instream flow studies after 20 years: a role in stream management and restoration. Regul. Rivers: Res. Mgmt. 17:527-542.

TABLE 3.2.3-1: SUBSTRATE CLASSIFICATION SYSTEM. CLASSIFICATIONS BASED ON PREVIOUS IFIM STUDIES AND THE PROFESSIONAL JUDGMENT OF EXELON AND STAKEHOLDER BIOLOGISTS.

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

TABLE 4.2.1-1: HYDRAULIC MODEL CALIBRATION (40,000 CFS) RESULTS

Range (+/-)	Percentage of Nodes within Range
0.15 ft	72
0.20 ft	85
0.25 ft	93
0.30 ft	96
0.50 ft	100

TABLE 4.2.1-2: HYDRAULIC MODEL CALIBRATION (5,000 CFS, 20,000 CFS, 60,000 CFS AND 80,000 CFS) RESULTS

	Site 2	Site 3	Site 4
Calibration = 5,000 cfs			
Observed WSE (ft)	13.10	9.24	5.38
Predicted WSE (ft)	12.85	9.15	5.28
Difference	-0.25	-0.09	-0.10
Calibration = 20,000 cfs			
Observed WSE (ft)	15.08	10.76	7.22
Predicted WSE (ft)	14.99	10.69	7.31
Difference	-0.09	-0.07	0.09
Calibration = 60,000 cfs			
Observed WSE (ft)	17.88	13.60	10.09
Predicted WSE (ft)	18.01	13.68	10.23
Difference	0.13	0.08	0.14
Calibration = 80,000 cfs			
Observed WSE (ft)	19.23	15.05	11.28
Predicted WSE (ft)	19.25	14.80	11.38
Difference	0.02	0.07	0.10
Refer to Figure 3.3.1-2 to see water level monitor locations			

TABLE 4.3-1: PERCENTAGE OF PEAK WUA RELATIVE TO TOTAL WETTED AREA

Species/Life Stage	Maximum WUA Flow (cfs)	Habitat Area at Maximum WUA Flow (ft^2)	Total Wetted Area at Maximum WUA Flow (ft^2)	% of Available Habitat at Max WUA Flow
American Shad:				
Spawning & Inc.	40,000	24,052,704	72,189,772	33.3
Fry	30,000	17,990,435	68,985,301	26.1
Juvenile	10,000	21,651,763	67,344,789	32.2
Adult	40,000	26,204,622	72,189,772	36.3
Shortnose Sturgeon:				
Spawning & Inc.	50,000	14,048,270	73,143,811	19.2
Fry	30,000	848,538	68,985,301	1.2
Juvenile	30,000	1,431,622	68,985,301	2.1
Adult	30,000	1,431,622	68,985,301	2.1
Striped Bass:				
Spawning & Inc.	50,000	56,216,898	73,143,811	76.9
Fry	50,000	55,545,960	73,143,811	75.9
Juvenile	40,000	30,036,145	72,189,772	41.6
Adult	80,000	63,530,991	75,027,993	84.7
Smallmouth Bass:				
Spawning & Inc.	5,000	1,141,787	66,071,508	1.7
Fry	2,000*	3,611,296	64,268,929	5.6
Juvenile	5,000	26,005,058	66,071,508	39.4
Adult	15,000	36,373,846	68,088,618	53.4
Macroinvertebrates				
Ephemeroptera	5,000	6,052,996	66,071,508	9.2
Plecoptera	5,000	4,432,285	66,071,508	6.7
Trichoptera	10,000	12,751,836	67,344,789	18.9
Habitat Guilds				
Shallow Slow	2,000*	29,171,737	64,268,929	45.4
Shallow Fast	2,000*	1,079,340	64,268,929	1.7
Deep Slow	5,000	34,257,996	66,071,508	51.8
Deep Fast	20,000	1,219,290	68,985,301	1.8

*Indicates that the flow range was limited by the lowest or highest production run flow, thus the true flow range providing this habitat falls outside of the modeled flows and is greater than shown.

TABLE 4.3.3-1: MUSSEL SUBSTRATE CODES AND CORRESPONDING CRITICAL SHEAR STRESS VALUES[17].

Substrate Type	Code	Size Class (metric)	Size Class (English)	Shield's Parameter (θ_c)	Estimated D_{50} (mm)	τ_c (dynes/cm^2)	τ_c (N/m^2)	τ_c (lb/ft^2)
Detritus/Organic	1	NA	NA	NA	NA	NA	NA	NA
Mud/soft clay	2	NA	NA	NA	NA	NA	NA	NA
Silt	3	< 0.062 mm	< 0.00244 in	0.25	0.016	0.65	0.065	0.0014
Sand	4	0.062 - 2 mm	0.00244 - 0.0787 in	0.109	0.062	1.09	0.109	0.0023
Gravel	5	2 - 64 mm	0.0787 - 2.52 in	0.039	2	12.6	1.26	0.026
Cobble/rubble	6	64 - 250 mm	2.52 - 9.84 in	0.052	64	534	53.4	1.11
Boulder	7	250 – 4,000 mm	9.84 - 157.5 in	0.054	250	2,186	219	4.56
Bedrock - US of Robert I.	8a	64-4,000 mm*	2.52 - 157.5 in	0.054	213	1,862	186	3.89
Bedrock - DS of Robert I.	8b	2-4,000 mm**	0.787 - 157.5 in	0.054	191	1,671	167	3.49

* For D_{50} estimations only, bedrock upstream of Robert Island was assumed to contain substrate ranging from cobble/rubble to boulders

** For D_{50} estimations only, bedrock downstream of Robert Island was assumed to contain substrate ranging from gravel to boulders

[17] Field observations and local knowledge indicate that non-dominant substrates are slightly finer in tidally-influenced bedrock-dominated areas than non-tidally influenced bedrock-dominated areas, thus they were broken into two categories for the mussel analysis only..

TABLE 5.1-1: FLOWS PROVIDING PERCENTAGES OF MAXIMUM WEIGHTED USABLE AREA (WUA)

Species/Life Stage	Months Present	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)
American Shad:						
Spawning & Inc.	Apr-Jun	40,000	24,200 – 61,325	18,144 – 72,765	14,472 – 82,757	11,801 – 86,000*
Fry	May-Jul	30,000	14,716 – 43,771	10,703 – 55,000	7,744 – 67,028	5,513 – 80,335
Juvenile	Jul-Nov	~~5,000~~10,000	4,011 – 29,062	2,670 – 42,383	2,000* – 52,641	2,000* – 65,469
Adult	Apr-Jun	40,000	25,090 – 69,495	18,332 – 84,715	13,861 – 86,000*	10,166 – 86,000*
Shortnose Sturgeon:						
Spawning & Inc.	Apr-May	50,000	24,234 – 86,000*	16,997 – 86,000*	13,008 – 86,000*	9,872 – 86,000*
Fry	May-Jul	30,000	16,917 – 62,164	11,835 – 79,017	8,546 – 86,000*	6,424 – 86,000*
Juvenile	All	30,000	14,068 – 54,906	9,240 – 77,199	6,228 – 86,000*	4,078 – 86,000*
Adult	All	30,000	14,068 – 54,906	9,240 – 77,199	6,228 – 86,000*	4,078 – 86,000*
Striped Bass:						
Spawning & Inc.	Apr-Jun	50,000	32,730 – 77,550	25,977 – 86,000*	20,450 – 86,000*	16,272 – 86,000*
Fry	Apr-Jul	50,000	34,705 – 76,746	27,846 – 86,000*	22,977 – 86,000*	18,547 – 86,000*
Juvenile	Jun-Dec	40,000	20,968 – 64,890	12,777 – 76,387	7,961 – 86,000*	5,290 – 86,000*
Adult	All	80,000	38,584 – 86,000*	28,570 – 86,000*	21,450 – 86,000*	16,057 – 86,000*
Smallmouth Bass:						
Spawning & Inc.	May-Jun	5,000	2,000* – 8,262	2,000* – 10,853	2,000* – 13,430	2,000* – 16,725
Fry	Jun-Jul	2,000*	2,000* – 2,556	2,000* – 3,111	2,000* – 3,778	2,000* – 4,703
Juvenile	Aug-Dec	5,000	2,000* – 10,552	2,000* – 14,474	2,000* – 18,051	2,000* – 21,757
Adult	All	15,000	6,737 – 24,531	4,623 – 33,522	3,127 – 44,491	2,000* – 58,145
Macroinvertebrates						
Ephemeroptera (Mayfly)	All	5,000	3,190 – 7,823	2,469 – 9,340	2,000* – 11,168	2,000* – 13,235
Plecoptera (Stonefly)	All	5,000	2,000* – 8,067	2,000* – 10,404	2,000* – 13,217	2,000* – 16,828
Trichoptera (Caddisfly)	All	10,000	4,289 – 17,762	3,038 – 23,884	2,000* – 29,890	2,000* – 36,612
Habitat Guilds						
Shallow Slow	All	2,000*	2,000* – 2,726	2,000* – 3,452	2,000* – 4,098	2,000* – 4,740
Shallow Fast	Apr-Jun	2,000*	2,000* – 3,143	2,000* – 4,007	2,000* – 4,743	2,000* – 5,921
Deep Slow	All	5,000	2,703 – 8,574	2,000* – 10,428	2,000* – 12,565	2,000* – 14,702
Deep Fast	All	20,000	14,376 – 22,424	12,866 – 24,848	11,355 – 27,271	9,888 – 26,695

*Indicates that the flow range was limited by the lowest or highest production run flow, thus the true flow range providing this habitat falls outside of the modeled flows and is greater than shown.

TABLE 5.1-2: PERCENTAGE OF THE MAXIMUM WEIGHTED USABLE AREA (WUA) FOR VARIOUS FLOWS

Species/Life Stage	Months Present	Maximum WUA Flow (cfs)	Maximum WUA (ft^2)	3,500 cfs	5,000 cfs	7,500 cfs	10,000 cfs	15,000 cfs	20,000 cfs	40,000 cfs	60,000 cfs	70,000 cfs	80,000 cfs	86,000 cfs
American Shad														
Spawning & Inc.	Apr-Jun	40,000	24,052,704	17.2%	26.3%	40.8%	53.3%	72.0%	84.7%	100.0%	91.1%	82.8%	72.8%	66.7%
Fry	May-Jul	30,000	17,990,453	48.9%	57.6%	69.1%	78.2%	90.7%	97.5%	93.4%	75.6%	67.6%	60.2%	56.1%
Juvenile	Jul-Nov	10,000	21,651,763	87.8%	94.2%	98.4%	100.0%	99.7%	97.3%	82.5%	64.0%	56.7%	49.9%	46.0%
Adult	Apr-Jun	40,000	26,204,622	35.2%	41.4%	51.1%	59.6%	73.1%	83.5%	100.0%	95.1%	89.7%	83.3%	79.1%
Shortnose Sturgeon														
Spawning & Inc.	Apr-May	50,000	14,048,270	24.1%	34.3%	49.0%	60.6%	76.2%	85.7%	99.5%	99.0%	96.6%	93.2%	90.6%
Fry	May-Jul	30,000	848,538	41.7%	52.1%	65.9%	75.7%	87.5%	94.0%	98.9%	91.3%	85.4%	79.4%	77.1%
Juvenile	All	30,000	1,431,622	56.8%	65.2%	75.0%	82.2%	91.8%	96.7%	96.7%	87.7%	83.4%	78.7%	76.6%
Adult	All	30,000	1,431,622	56.8%	65.2%	75.0%	82.2%	91.8%	96.7%	96.7%	87.7%	83.4%	78.7%	76.6%
Striped bass														
Spawning & Inc.	Apr-Jun	50,000	56,216,898	19.1%	24.9%	33.8%	42.1%	56.9%	69.2%	97.2%	97.9%	93.3%	88.9%	84.0%
Fry	Apr-Jul	50,000	55,545,960	13.2%	18.4%	26.9%	35.2%	50.5%	63.9%	96.3%	98.3%	93.8%	88.2%	84.6%
Juvenile	Jun-Dec	40,000	30,036,145	49.8%	58.9%	68.8%	75.4%	83.7%	89.3%	100.0%	93.9%	85.9%	76.6%	71.0%
Adult	All	80,000	63,530,991	18.9%	25.7%	35.9%	44.5%	57.9%	68.0%	91.3%	98.8%	99.7%	100.0%	99.9%
Smallmouth bass														
Spawning & Inc.	May-Jun	5,000	1,141,787	98.4%	100.0%	92.9%	83.3%	63.9%	52.6%	37.1%	29.4%	26.2%	23.8%	22.4%
Fry	Jun-Jul	2,000*	3,611,296	73.0%	56.8%	42.4%	35.4%	27.6%	24.0%	28.7%	25.6%	24.2%	22.2%	22.1%
Juvenile	Aug-Dec	5,000	26,005,058	99.5%	100.0%	96.7%	91.4%	78.7%	64.5%	23.3%	14.1%	13.2%	12.2%	11.7%
Adult	All	15,000	36,373,846	72.9%	82.4%	93.3%	98.9%	100.0%	95.4%	73.6%	58.7%	52.5%	46.7%	43.6%
Macroinvertebrates														
Ephemeroptera	All	5,000	6,052,996	94.3%	100.0%	92.1%	75.7%	51.5%	39.2%	25.1%	18.8%	16.2%	14.4%	13.4%
Plecoptera	All	5,000	4,432,285	99.4%	100.0%	92.5%	81.4%	63.7%	53.7%	36.5%	26.6%	23.1%	20.4%	19.2%
Trichoptera	All	10,000	12,751,836	85.2%	94.3%	100.0%	99.9%	94.4%	86.5%	55.0%	34.6%	28.7%	24.9%	23.1%
Habitat Guilds														
Shallow-Slow	All	2,000*	29,171,737	79.3%	55.9%	27.7%	15.6%	8.3%	7.1%	9.8%	6.5%	5.4%	4.5%	3.8%
Shallow-Fast	Apr-Jun	2,000*	1,079,340	86.9%	66.5%	48.8%	33.9%	19.0%	15.0%	8.5%	7.3%	5.6%	4.1%	4.2%
Deep-Slow	All	5,000	34,257,996	95.4%	100.0%	96.0%	82.0%	58.6%	41.9%	18.9%	18.2%	16.8%	15.5%	15.2%
Deep-Fast	All	20,000	1,219,290	6.0%	14.4%	38.2%	61.0%	94.1%	100.0%	26.7%	6.6%	5.8%	6.0%	5.9%
	* Indicates that the flow range was limited by the lowest production run flow													

TABLE 5.1.1-1: SELECT JANUARY SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
Striped Bass						
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	27,732
Smallmouth Bass						
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	27,732
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	27,732
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	27,732
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	27,732
*Indicates that the flow range was limited by the lowest or highest production run flow						

TABLE 5.1.2-1: SELECT FEBRUARY SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
Striped Bass						
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	32,617
Smallmouth Bass						
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	32,617
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	32,617
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	32,617
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	32,617
*Indicates that the flow range was limited by the lowest or highest production run flow						

TABLE 5.1.3-1: SELECT MARCH SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
Striped Bass						
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	61,744
Smallmouth Bass						
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	61,744
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	61,744
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	61,744
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	61,744
*Indicates that the flow range was limited by the lowest or highest production run flow						

TABLE 5.1.4-1: SELECT APRIL SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Spawning	40,000	24,200-61,325	18,144-72,765	14,472-82,757	11,801-86,000*	63,752
Adult	40,000	25,090-69,495	18,332-84,715	13,861-86,000*	10,166-86,000*	63,752
Shortnose Sturgeon						
Spawning	50,000	24,234-86,000*	16,997-86,000*	13,008-86,000*	9,872-86,000*	63,752
Striped Bass						
Spawning	50,000	32,730-77,550	25,977-86,000*	20,450-86,000*	16,272-86,000*	63,752
Fry	50,000	34,705-76,746	27,846-86,000*	22,977-86,000*	18,547-86,000*	63,752
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	63,752
Smallmouth Bass						
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	63,752
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	63,752
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	63,752
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	63,752
*Indicates that the flow range was limited by the lowest or highest production run flow						

TABLE 5.1.5-1: SELECT MAY SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Spawning	40,000	24,200-61,325	18,144-72,765	14,472-82,757	11,801-86,000*	38,768
Fry	30,000	14,716-43,771	10,703-55,000	7,744-67,028	5,513-80,335	38,768
Adult	40,000	25,090-69,495	18,332-84,715	13,861-86,000*	10,166-86,000*	38,768
Shortnose Sturgeon						
Spawning	50,000	24,234-86,000*	16,997-86,000*	13,008-86,000*	9,872-86,000*	38,768
Striped Bass						
Spawning	50,000	32,730-77,550	25,977-86,000*	20,450-86,000*	16,272-86,000*	38,768
Fry	50,000	34,705-76,746	27,846-86,000*	22,977-86,000*	18,547-86,000*	38,768
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	38,768
Smallmouth Bass						
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	38,768
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	38,768
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	38,768
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	38,768
*Indicates that the flow range was limited by the lowest or highest production run flow						

TABLE 5.1.6-1: SELECT JUNE SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Spawning	40,000	24,200-61,325	18,144-72,765	14,472-82,757	11,801-86,000*	20,661
Fry	30,000	14,716-43,771	10,703-55,000	7,744-67,028	5,513-80,335	20,661
Adult	40,000	25,090-69,495	18,332-84,715	13,861-86,000*	10,166-86,000*	20,661
Striped Bass						
Spawning	50,000	32,730-77,550	25,977-86,000*	20,450-86,000*	16,272-86,000*	20,661
Fry	50,000	34,705-76,746	27,846-86,000*	22,977-86,000*	18,547-86,000*	20,661
Juvenile	40,000	20,968-64,890	12,777-76387	7,961-86,000*	5,290-86,000*	20,661
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	20,661
Smallmouth Bass						
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	20,661
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	20,661
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	20,661
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	20,661
*Indicates that the flow range was limited by the lowest or highest production run flow						

TABLE 5.1.7-1: SELECT JULY SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Fry	30,000	14,716-43,771	10,703-55,000	7,744-67,028	5,513-80,335	13,045
Juvenile	~~5,000~~10,000	4,011-29,652	2,670-42,383	2,000*-52,641	2,000*-65,469	13,045
Striped Bass						
Fry	50,000	34,705-76,746	27,846-86,000*	22,977-86,000*	18,547-86,000*	13,045
Juvenile	40,000	20,968-64,890	12,777-76387	7,961-86,000*	5,290-86,000*	13,045
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	13,045
Smallmouth Bass						
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	13,045
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	13,045
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	13,045
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	13,045

*Indicates that the flow range was limited by the lowest or highest production run flow

TABLE 5.1.8-1: SELECT AUGUST SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Juvenile	10,000~~5,000~~	4,011-29,652	2,670-42,383	2,000*-52,641	2,000*-65,469	9,201
Striped Bass						
Juvenile	40,000	20,968-64,890	12,777-76387	7,961-86,000*	5,290-86,000*	9,201
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	9,201
Smallmouth Bass						
Juvenile	5,000	2,000*-10,552	2,000*-14,474	2,000*-18,051	2,000*-21,757	9,201
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	9,201
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	9,201
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	9,201
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	9,201

*Indicates that the flow range was limited by the lowest or highest production run flow

TABLE 5.1.9-1: SELECT SEPTEMBER SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Juvenile	10,000~~5,000~~	4,011-29,652	2,670-42,383	2,000*-52,641	2,000*-65,469	7,995
Striped Bass						
Juvenile	40,000	20,968-64,890	12,777-76387	7,961-86,000*	5,290-86,000*	7,995
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	7,995
Smallmouth Bass						
Juvenile	5,000	2,000*-10,552	2,000*-14,474	2,000*-18,051	2,000*-21,757	7,995
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	7,995
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	7,995
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	7,995
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	7,995

*Indicates that the flow range was limited by the lowest or highest production run flow

TABLE 5.1.10-1: SELECT OCTOBER SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Juvenile	10,000~~5,000~~	4,011-29,652	2,670-42,383	2,000*-52,641	2,000*-65,469	9,845
Striped Bass						
Juvenile	40,000	20,968-64,890	12,777-76387	7,961-86,000*	5,290-86,000*	9,845
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	9,845
Smallmouth Bass						
Juvenile	5,000	2,000*-10,552	2,000*-14,474	2,000*-18,051	2,000*-21,757	9,845
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	9,845
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	9,845
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	9,845
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	9,845

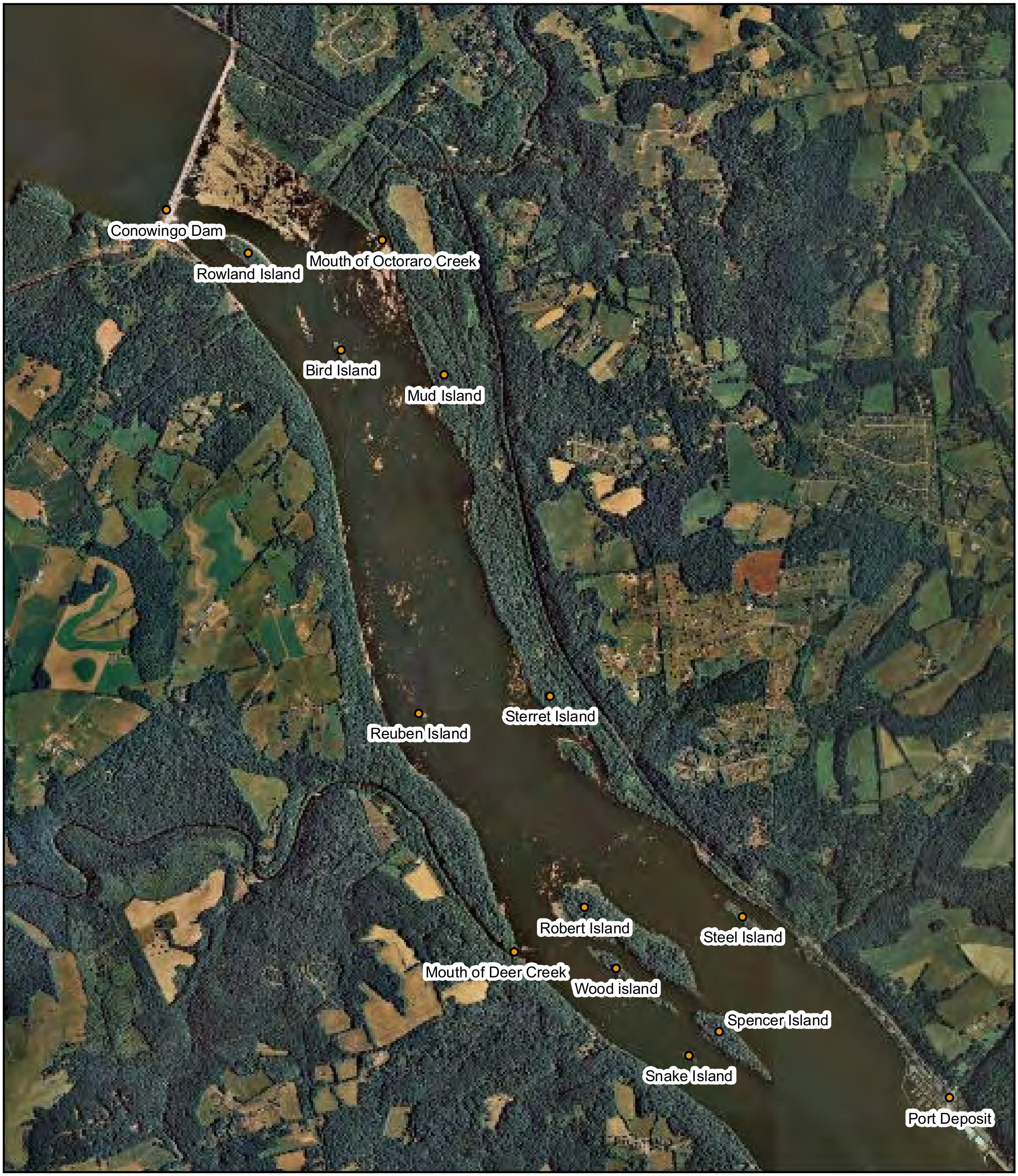
*Indicates that the flow range was limited by the lowest or highest production run flow

TABLE 5.1.11-1: SELECT NOVEMBER SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
American Shad						
Juvenile	10,000~~5,000~~	4,011-29,652	2,670-42,383	2,000*-52,641	2,000*-65,469	22,927
Striped Bass						
Juvenile	40,000	20,968-64,890	12,777-76387	7,961-86,000*	5,290-86,000*	22,927
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	22,927
Smallmouth Bass						
Juvenile	5,000	2,000*-10,552	2,000*-14,474	2,000*-18,051	2,000*-21,757	22,927
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	22,927
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	22,927
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	22,927
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	22,927
*Indicates that the flow range was limited by the lowest or highest production run flow						

TABLE 5.1.12-1: SELECT DECEMBER SPECIES/LIFE STAGES

Species/Life Stage	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)	Median Monthly Unregulated Flow (cfs)
Striped Bass						
Juvenile	40,000	20,968-64,890	12,777-76387	7,961-86,000*	5,290-86,000*	30,672
Adult	80,000	38,584-86,000*	28,570-86,000*	21,450-86,000*	16,057-86,000*	30,672
Smallmouth Bass						
Juvenile	5,000	2,000*-10,552	2,000*-14,474	2,000*-18,051	2,000*-21,757	30,672
Adult	15,000	6,737-24,531	4,623-33,522	3,127-44,491	2,000*-58,145	30,672
Macroinvertebrates						
Caddisfly	7,500	4,289-17,762	3,038-23,884	2,150-29,890	2,000*-36,612	30,672
Guilds						
Shallow-Slow	2,000*	2,000*-2,726	2,000*-3452	2,000*-4,098	2,000*-4,740	30,672
Deep-Slow	5,000	2,703-8,574	2,000*-10428	2,000*-12,565	2,000*-14,702	30,672
*Indicates that the flow range was limited by the lowest or highest production run flow						



N

Exelon.

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

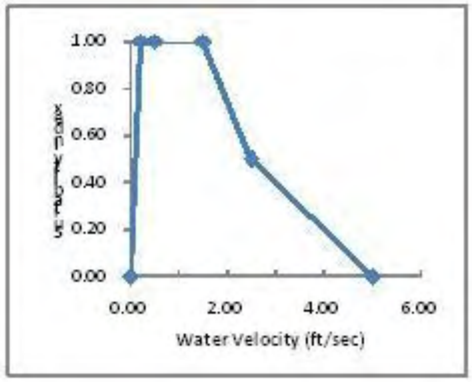
Figure 3.1-1
IFIM Study Area Map. Study Reach Extends From Conowingo Dam to Downstream Tip of Spencer Island

1 inch = 0.56 miles

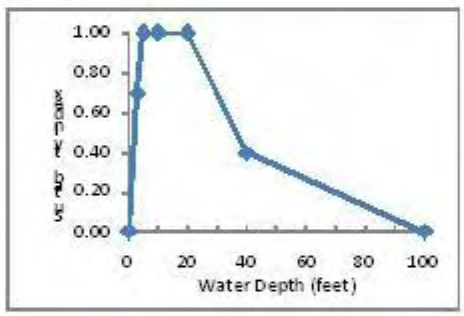
0 1,750 3,500 7,000 10,500 Feet

FIGURE 3.2.2-1: SHORTNOSE STURGEON, JUVENILE, HSI CURVES FOR DEPTH, VELOCITY AND SUBSTRATE

Proposed Final	
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



Proposed Final	
Depth	SI Value
0.00	0.00
3.00	0.70
5.00	1.00
10.00	1.00
20.00	1.00
40.00	0.40
100.00	0.00



Code	Final 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

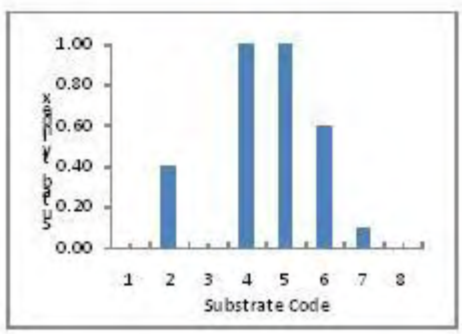
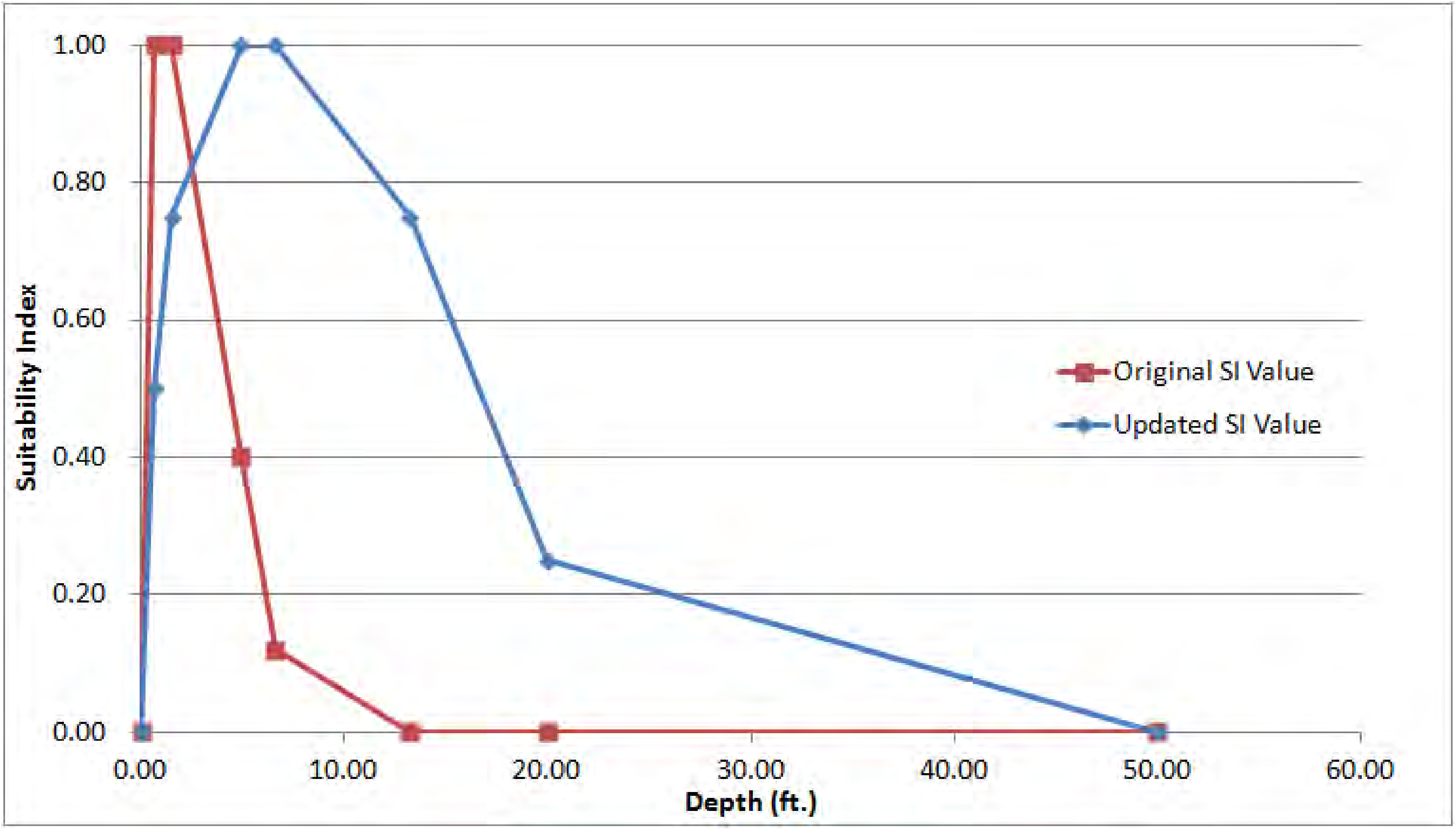
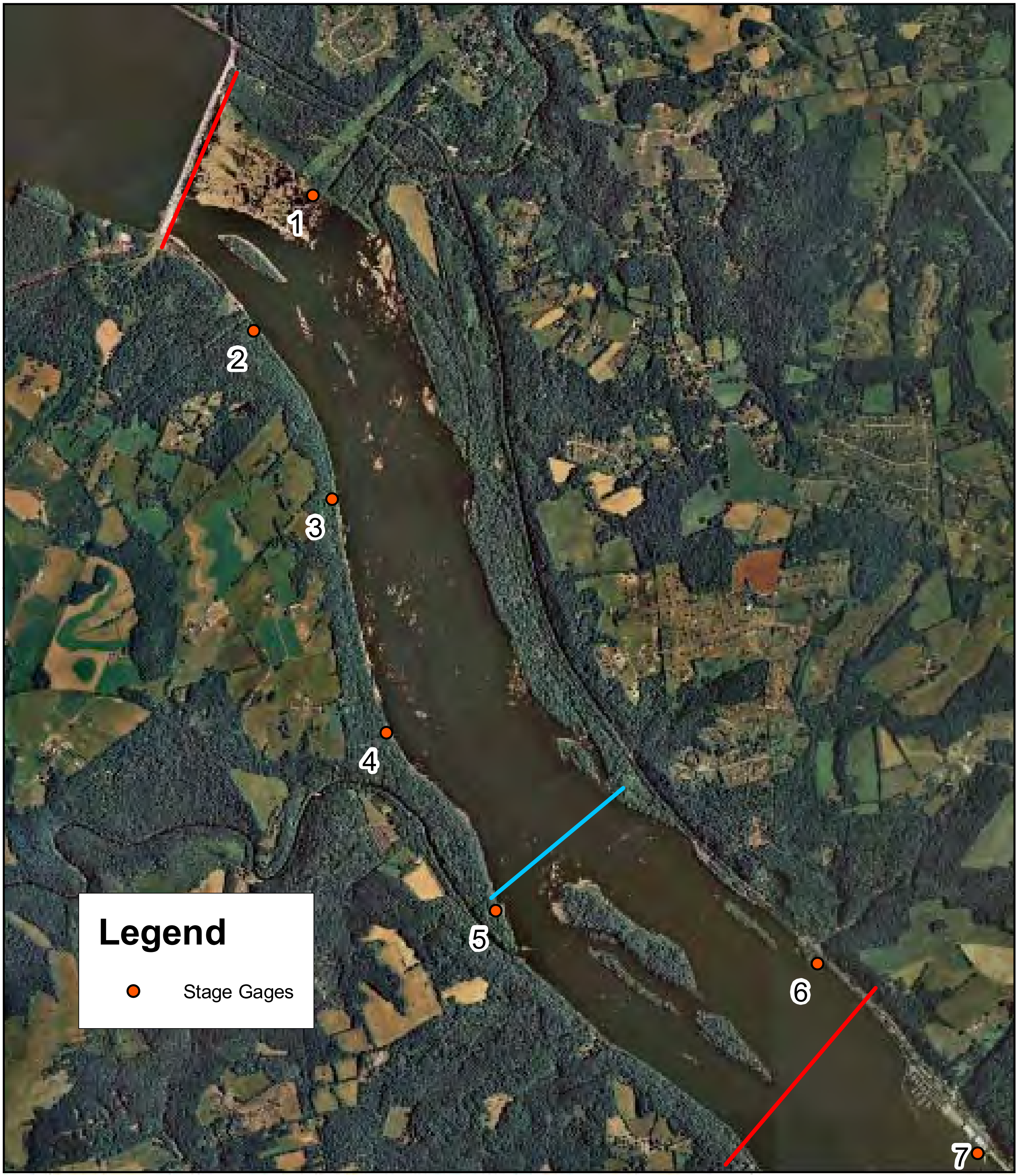


FIGURE 3.2.2-2: COMPARISON OF ORIGINAL AND UPDATED JUVENILE AMERICAN SHAD DEPTH HSI CRITERIA



EXELON GENERATION COMPANY, LLC
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 3.3.1-1
Bathymetric data collection transects



N

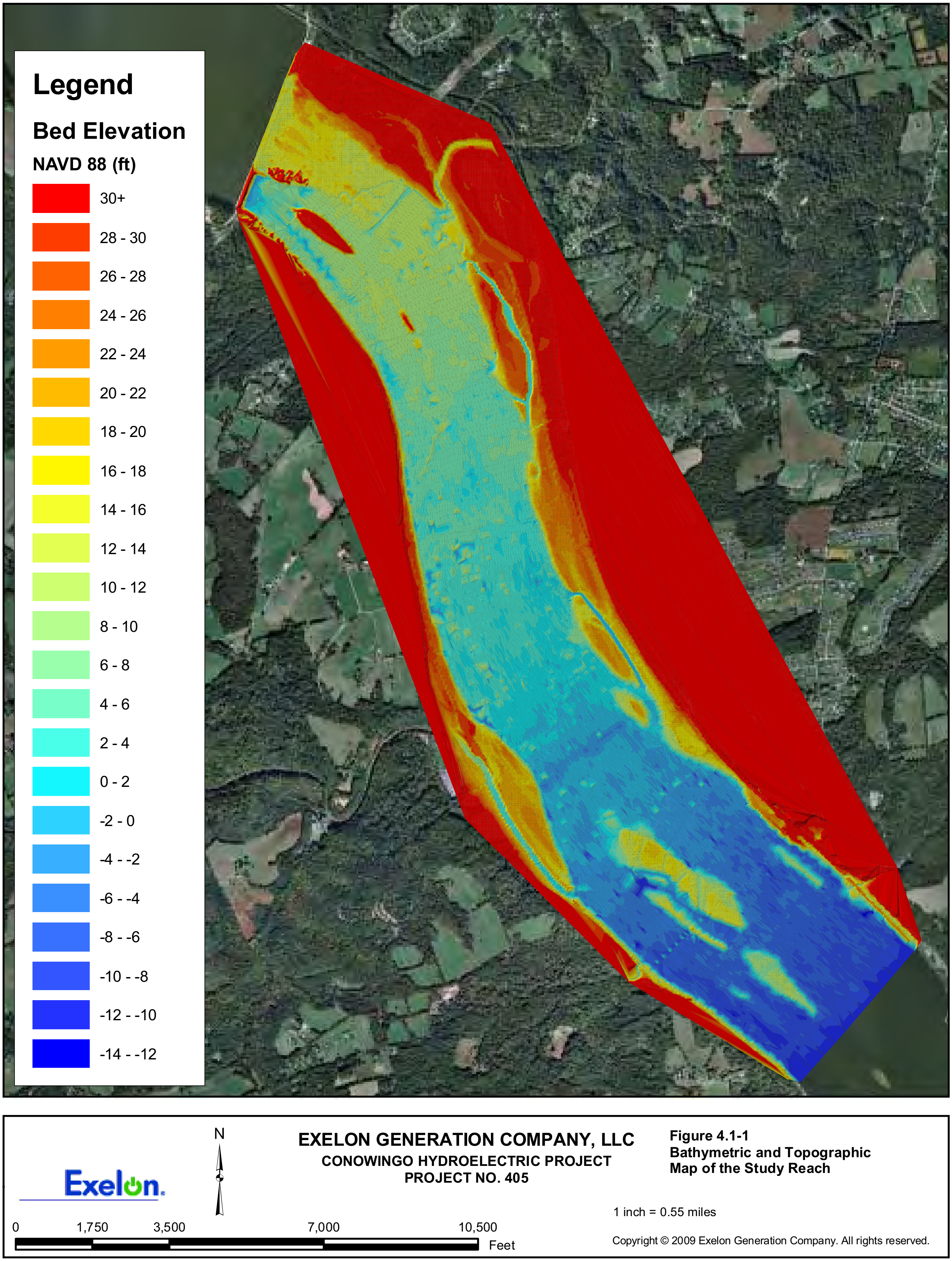
EXELON GENERATION COMPANY, LLC
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 3.3.1-2
Stage Gages Below Conowingo Dam. The Blue Line Indicates The Approximate Tidal Boundaries.

1 inch = 0.56 miles

0 1,700 3,400 6,800 10,200 Feet

Figure 3.4.1-1



EXELON GENERATION COMPANY, LLC
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 4.1-1
Bathymetric and Topographic Map of the Study Reach

1 inch = 0.55 miles

FIGURE 4.2.1-1: HISTOGRAM SHOWING MODEL CALIBRATION ERROR DISTRIBUTION OF 6935 CALIBRATION POINTS

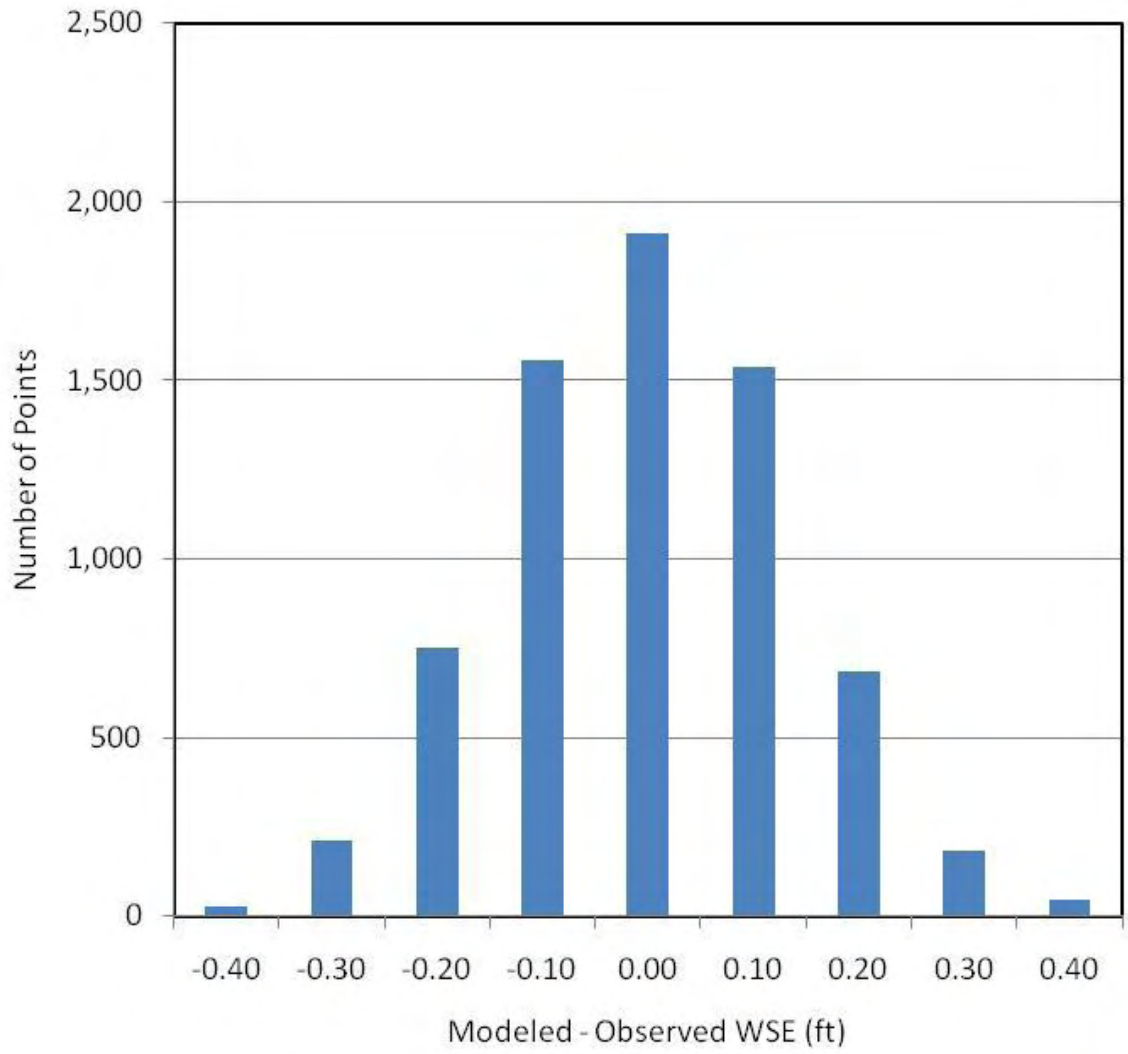


FIGURE 4.2.1-2: HISTOGRAM SHOWING VELOCITY ERROR DISTRIBUTION OF 6935 CALIBRATION POINTS

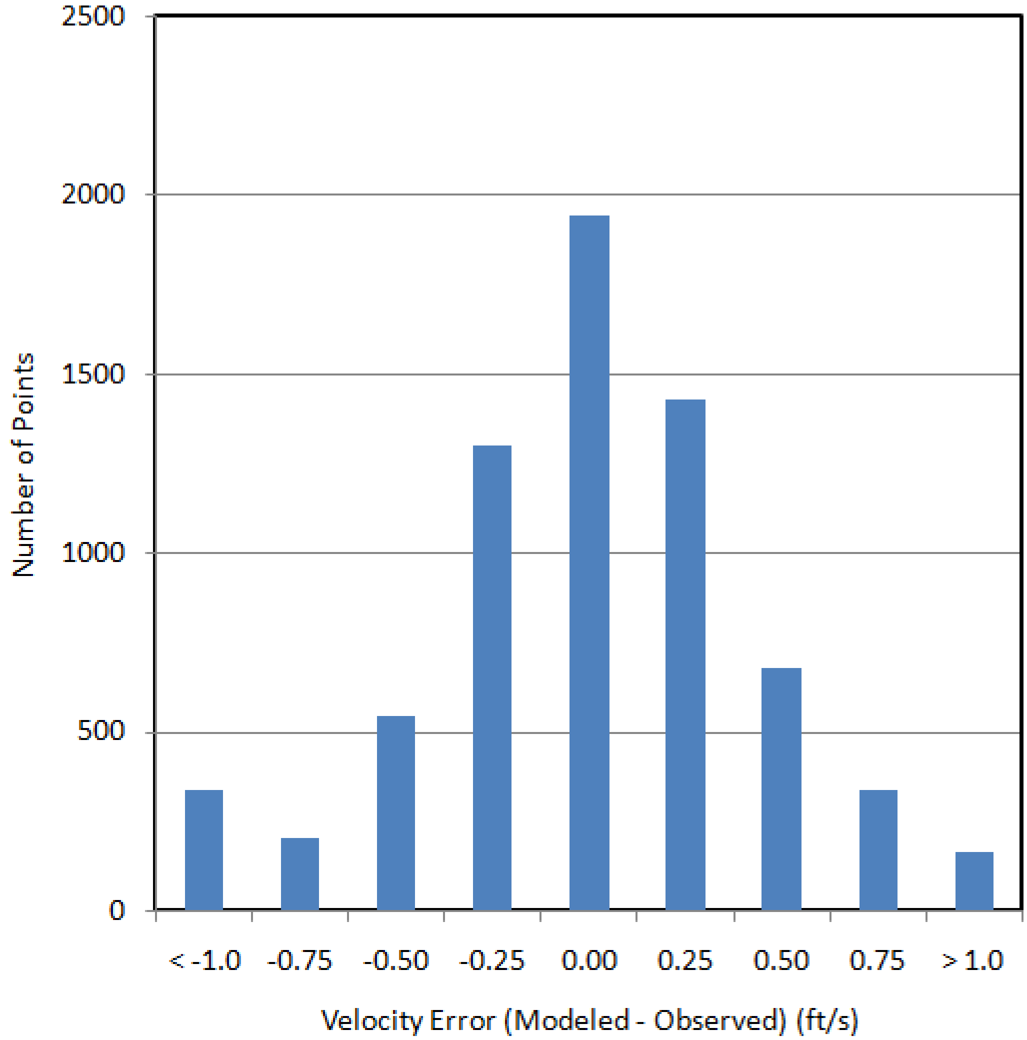


FIGURE 4.3.1.1-1: WUA CURVES FOR THE SPAWNING & INCUBATION, FRY, JUVENILE AND ADULT LIFE STAGES OF AMERICAN SHAD.

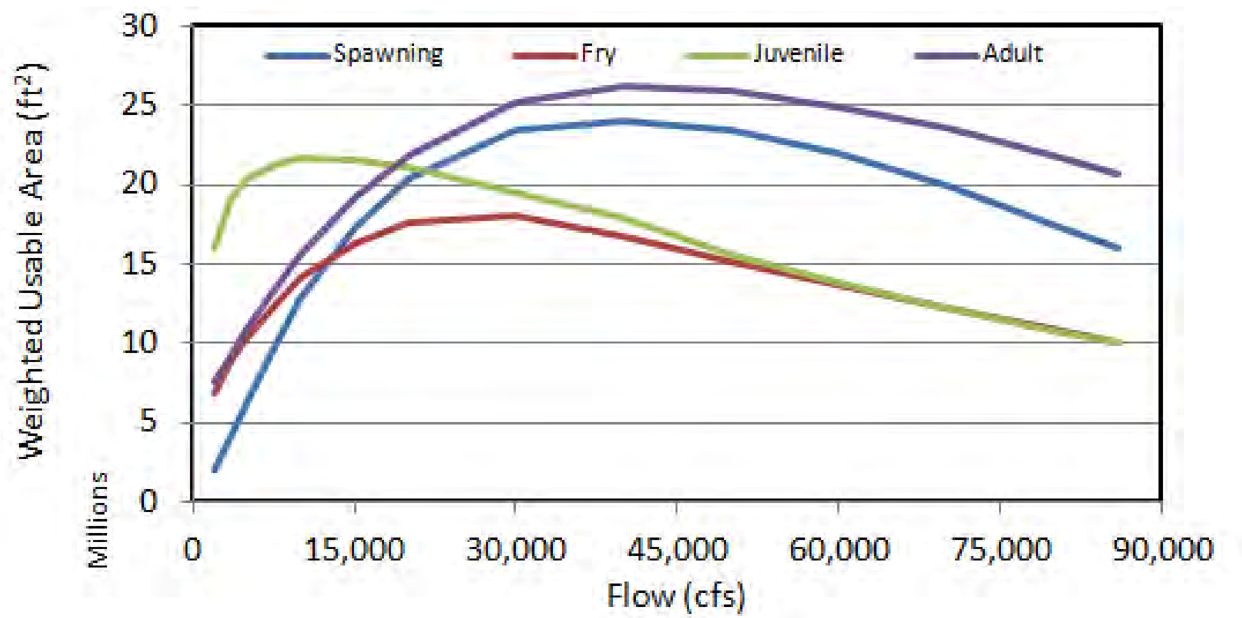
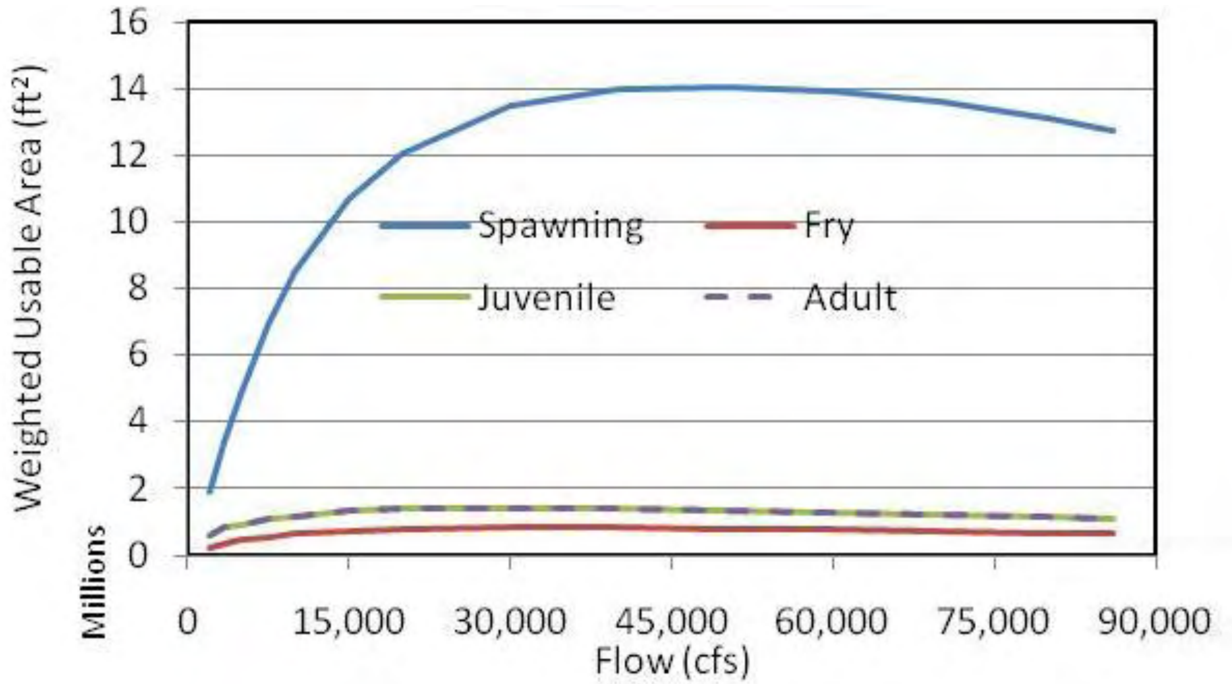


FIGURE 4.3.1.2-1: WUA CURVES FOR THE SPAWNING & INCUBATION, FRY, JUVENILE AND ADULT LIFE STAGES OF SHORTNOSE STURGEON.



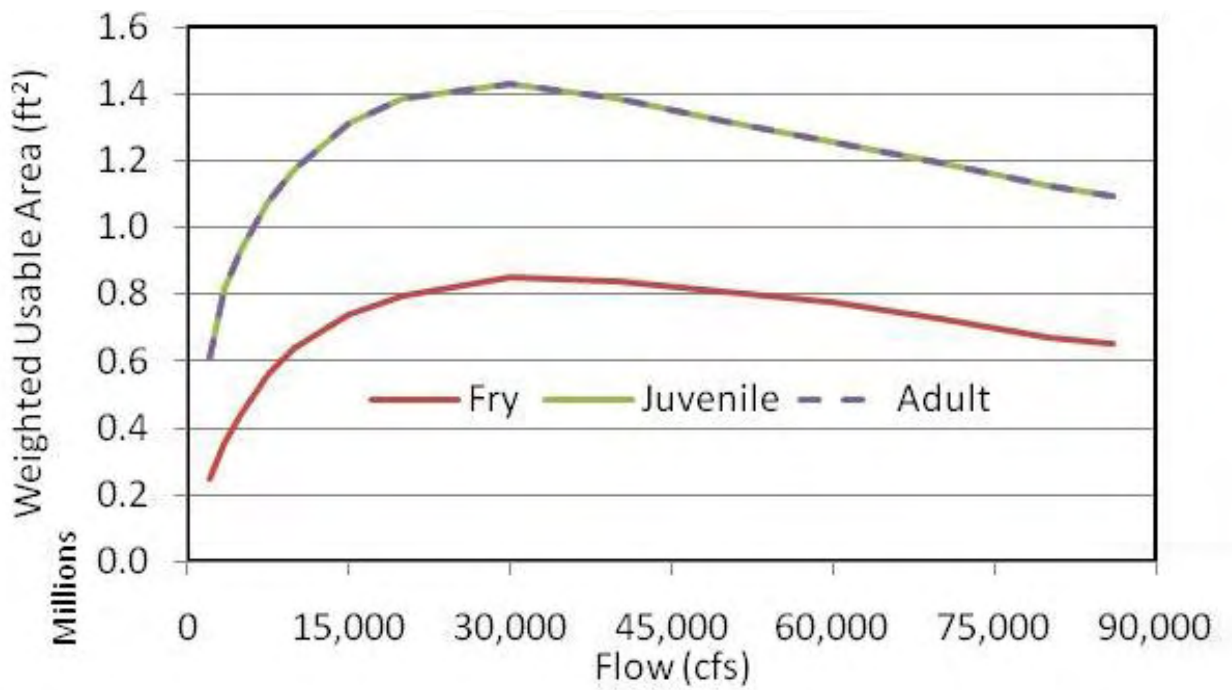


FIGURE 4.3.1.3-1: WUA CURVES FOR THE SPAWNING & INCUBATION, FRY, JUVENILE AND ADULT LIFE STAGES OF STRIPED BASS.

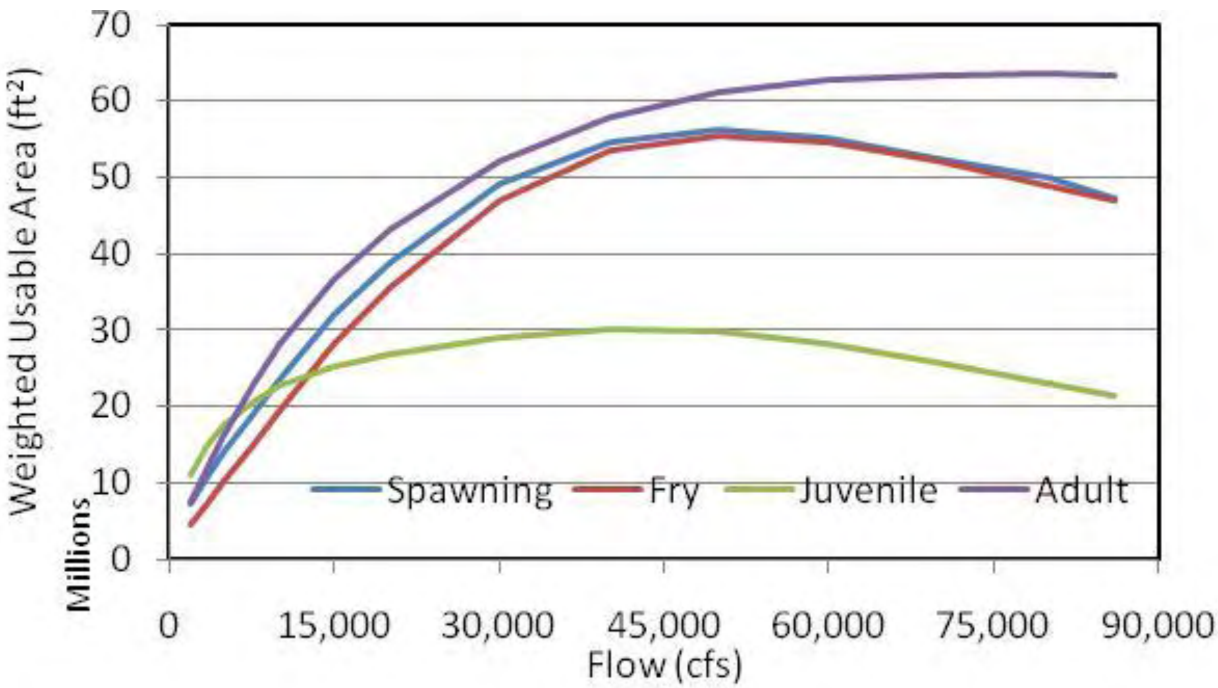
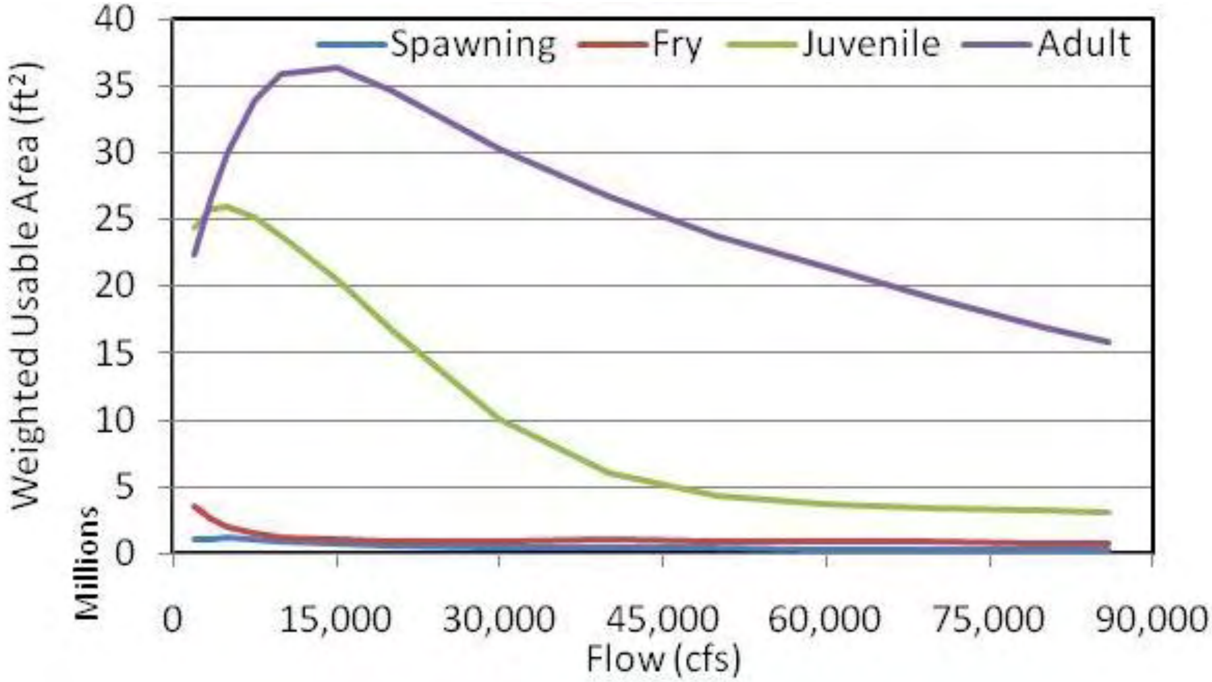


FIGURE 4.3.1.4-1: WUA CURVES FOR THE SPAWNING & INCUBATION, FRY, JUVENILE AND ADULT LIFE STAGES OF SMALLMOUTH BASS.



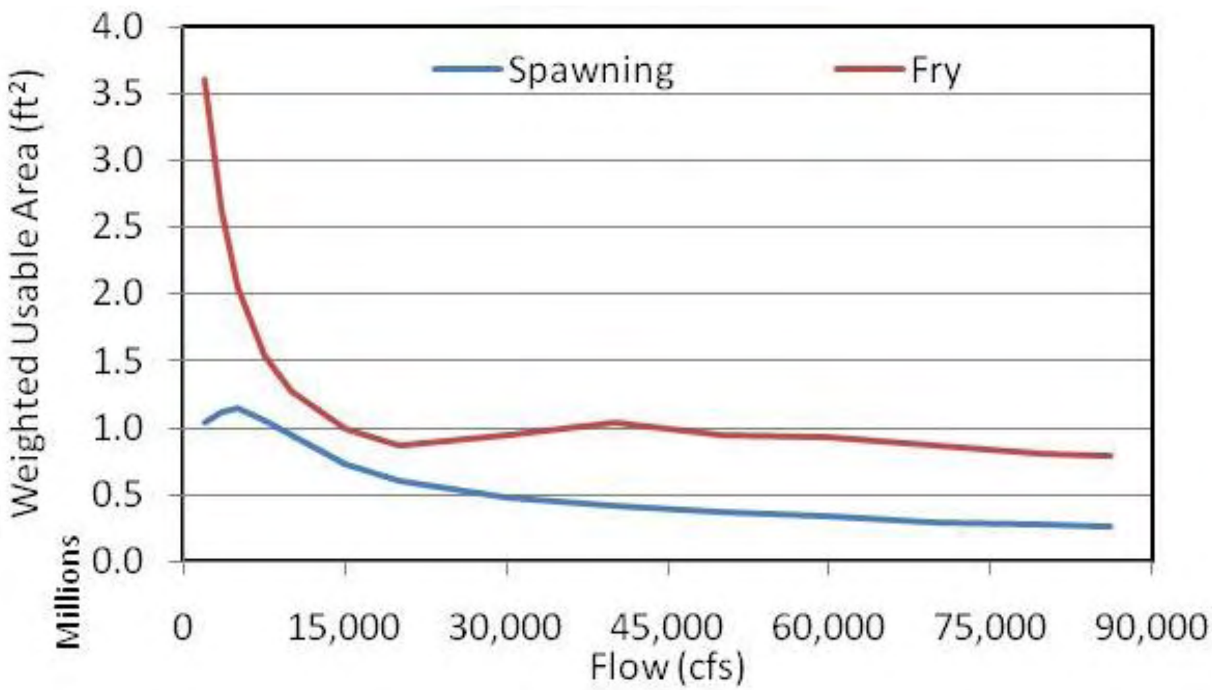


FIGURE 4.3.1.5-1: WUA CURVES FOR EPHEMEROPTERA (MAYFLIES), PLECOPTERA (STONEFLIES), AND TRICHOPTERA (CADDISFLIES).

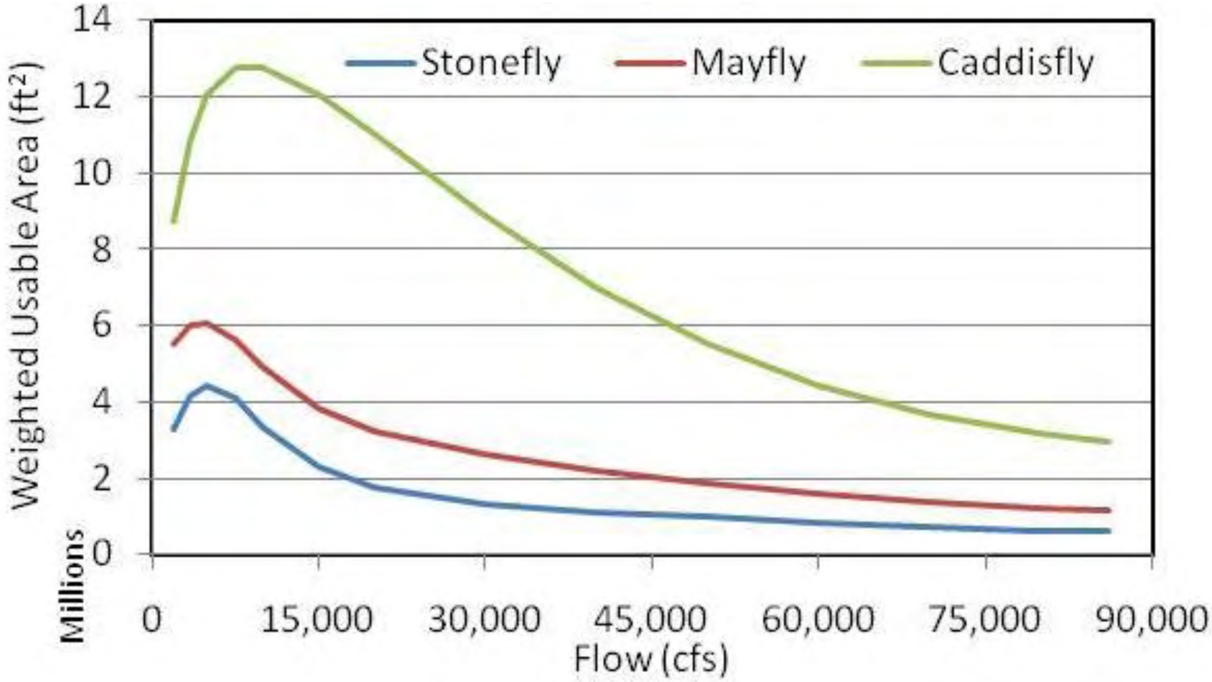
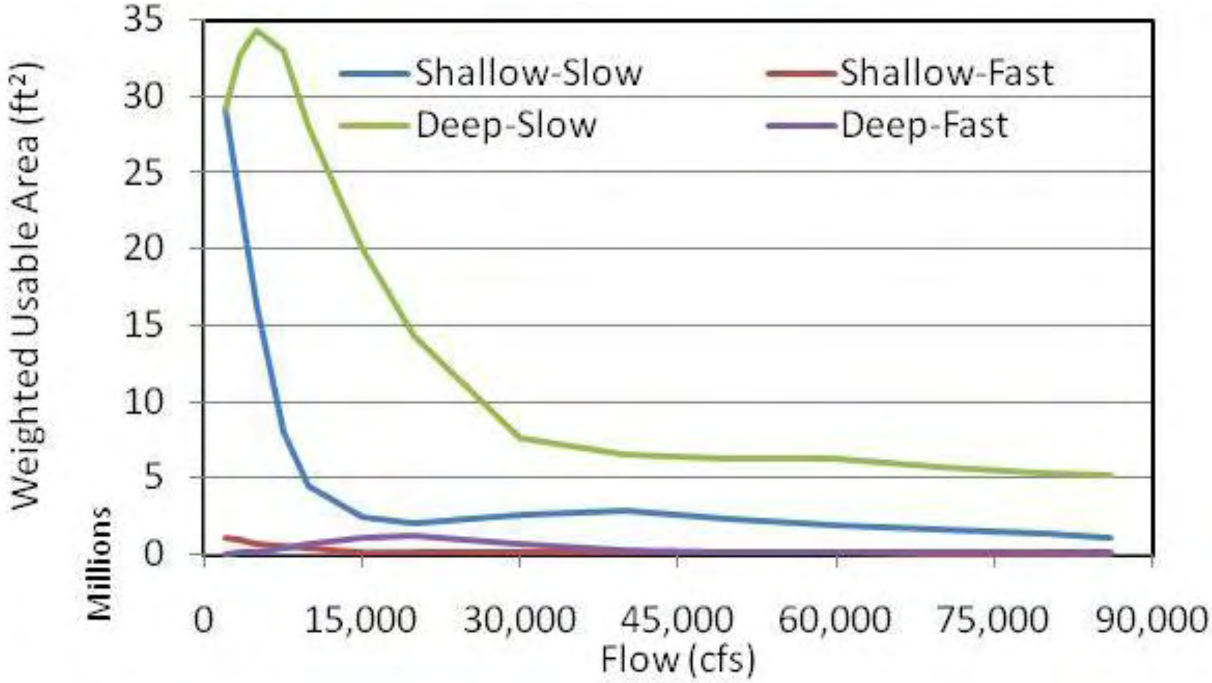


FIGURE 4.3.1.6-1: WUA CURVES FOR THE SHALLOW-SLOW, SHALLOW-FAST, DEEP-SLOW, AND DEEP-FAST HABITAT GUILDS.



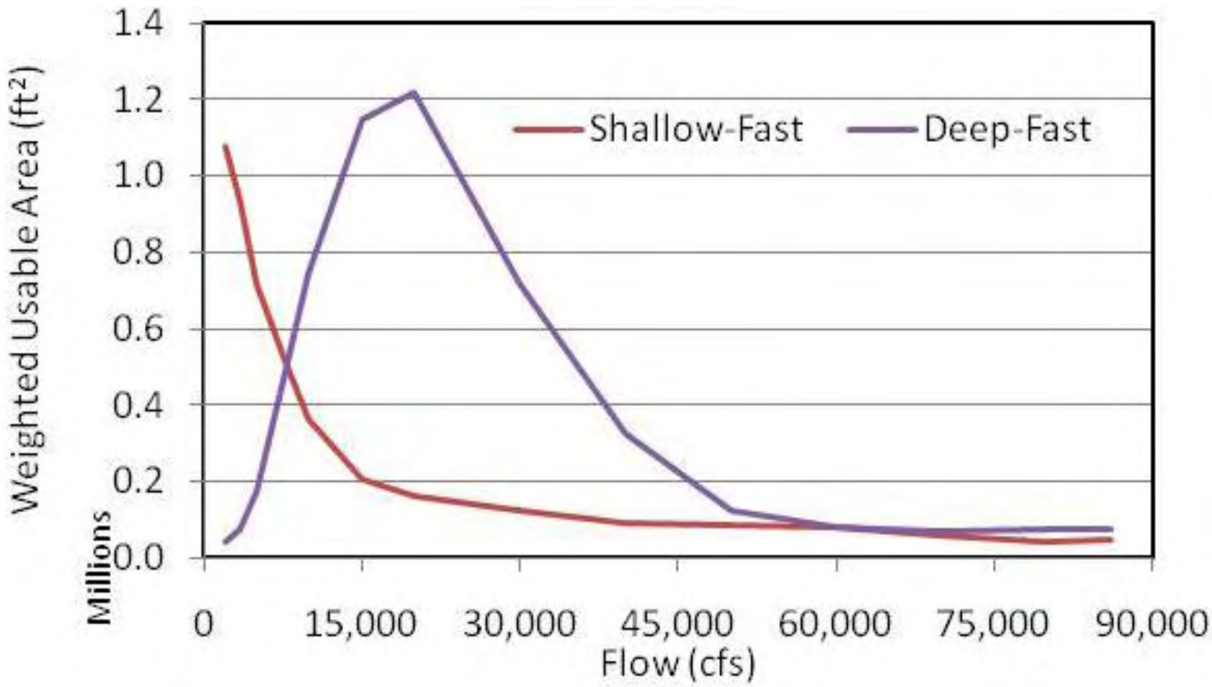


FIGURE 4.3.2.1-1: AMERICAN SHAD PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)

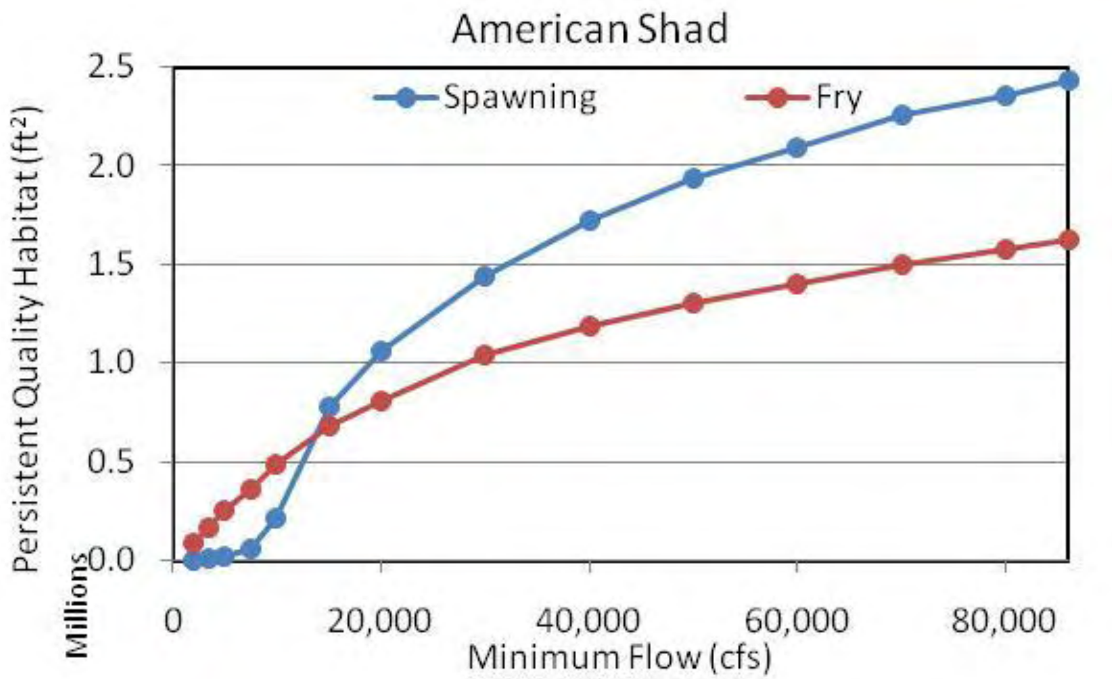


FIGURE 4.3.2.2-1: SHORTNOSE STURGEON PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)

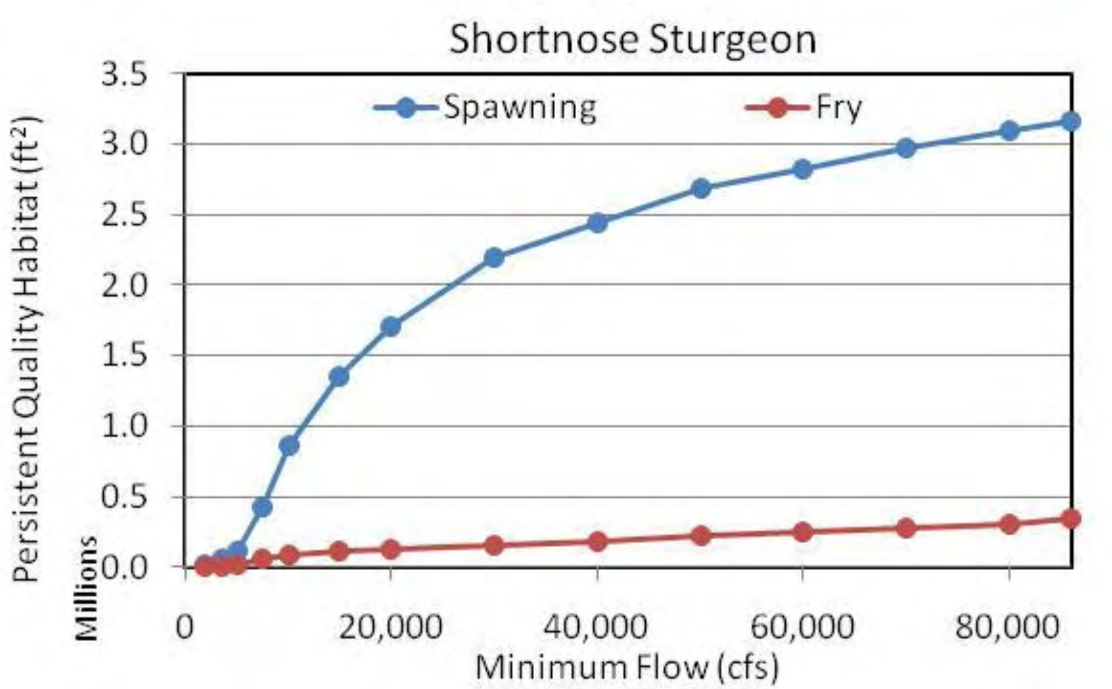


FIGURE 4.3.2.3-1: STRIPED BASS PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)

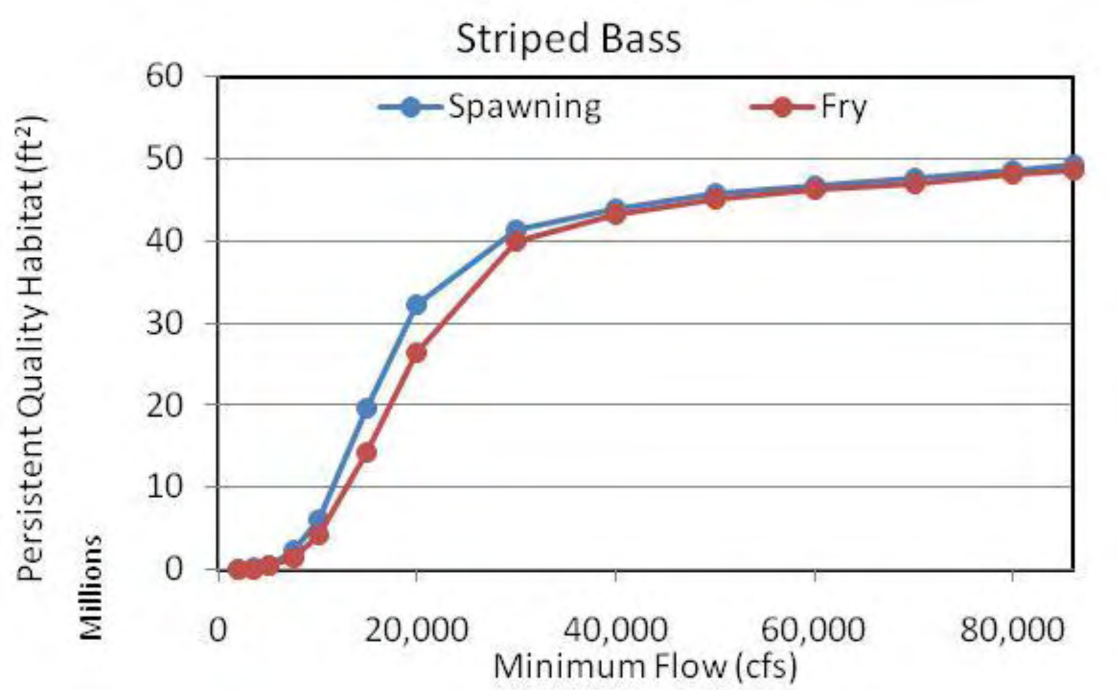


FIGURE 4.3.2.4-1: SMALLMOUTH BASS PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)

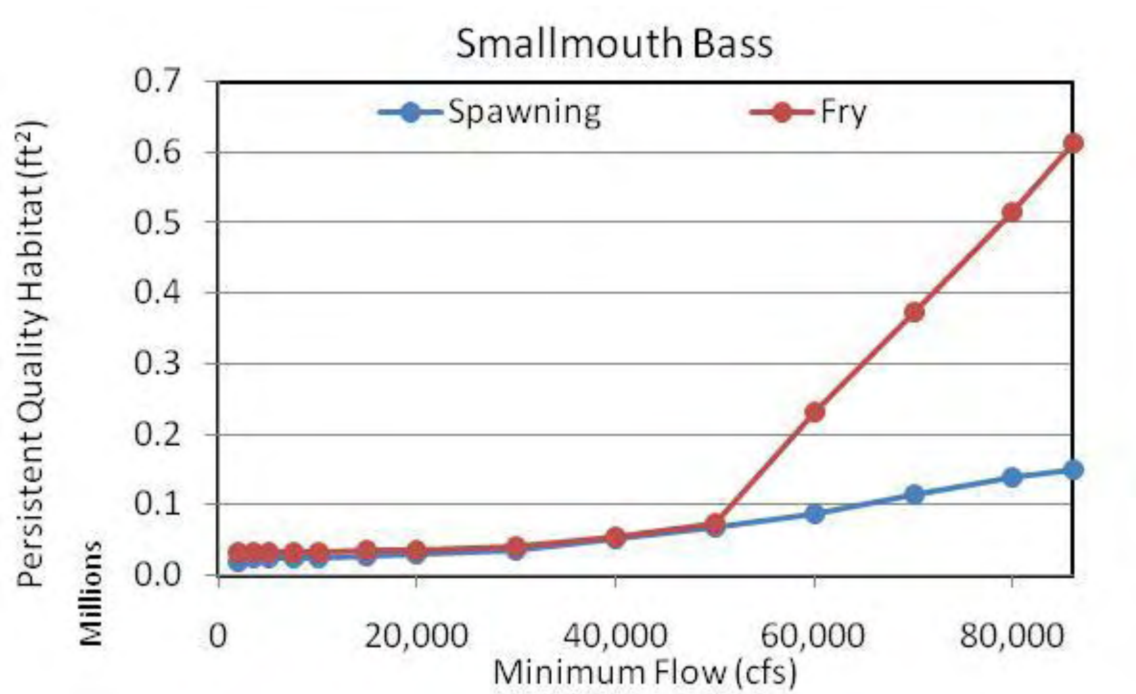


FIGURE 4.3.2.5-1: MACROINVERTEBRATE PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)

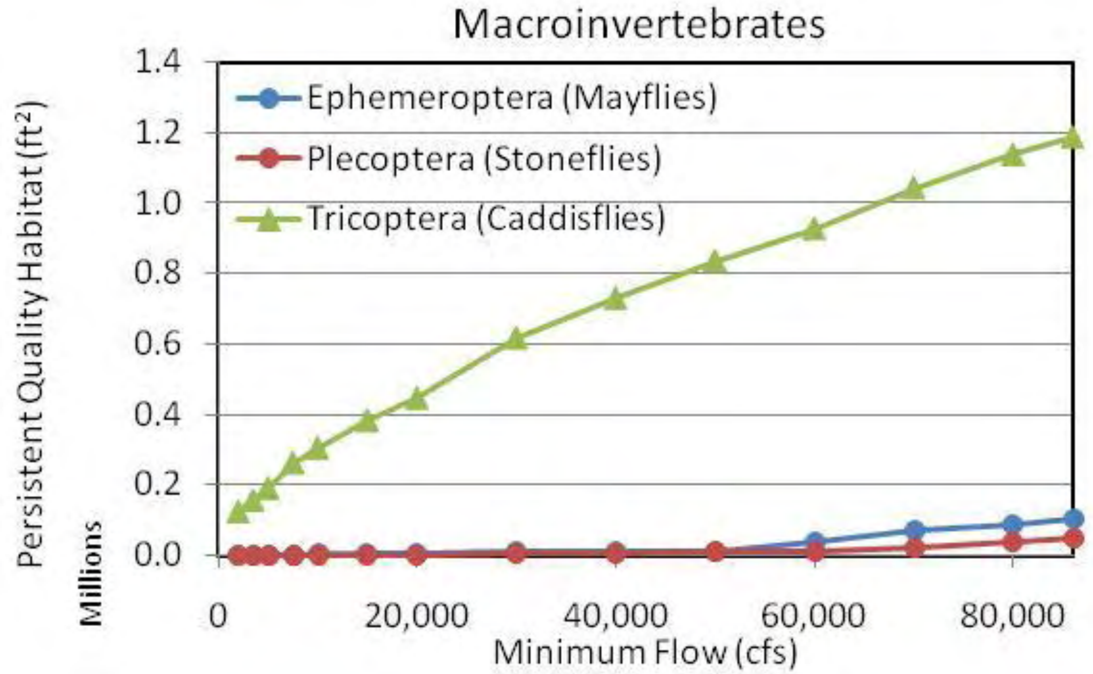


FIGURE 4.3.2.5-2: MAYFLY AND STONEFLY PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)

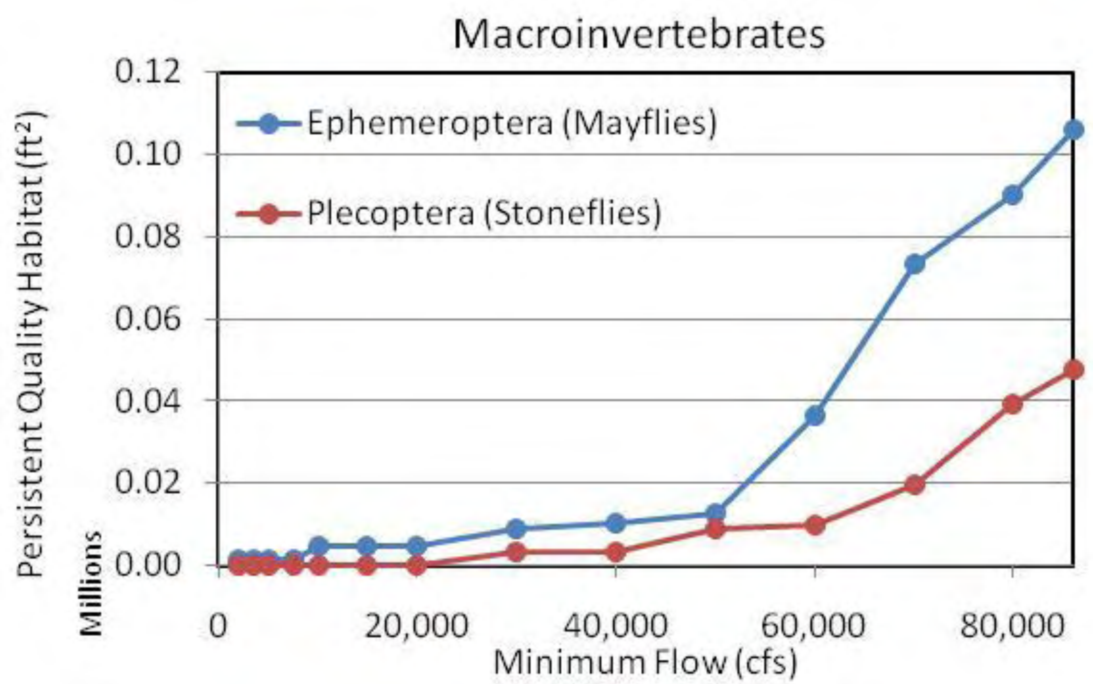


FIGURE 4.3.2.6-1: SHALLOW-FAST AND SHALLOW-SLOW GUILD PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)

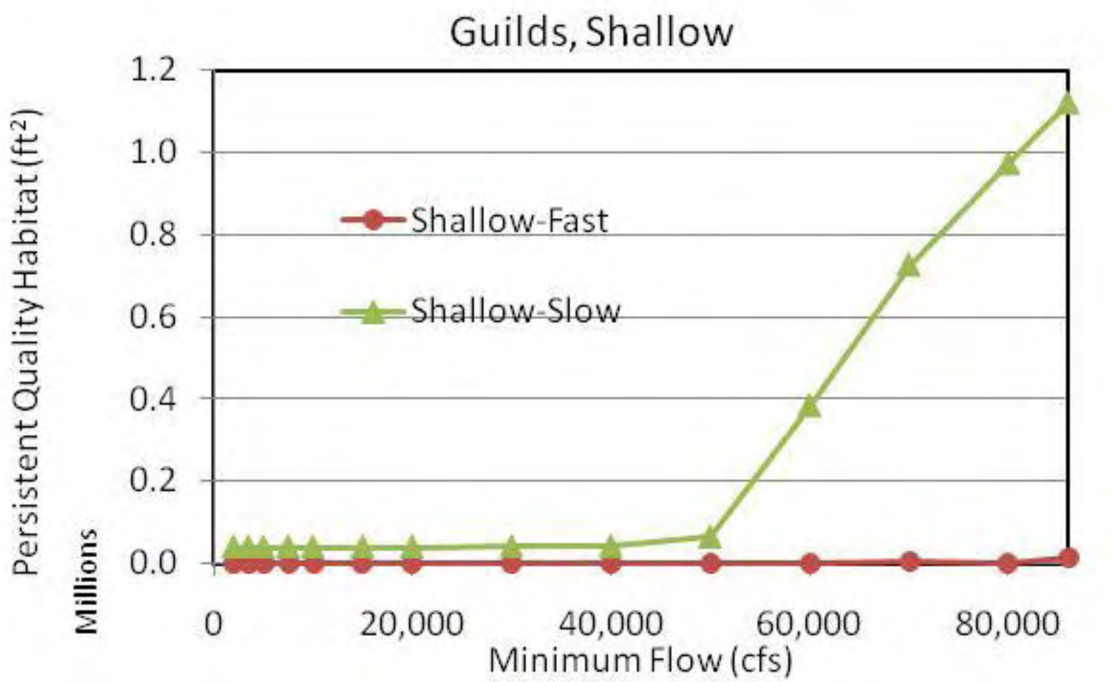
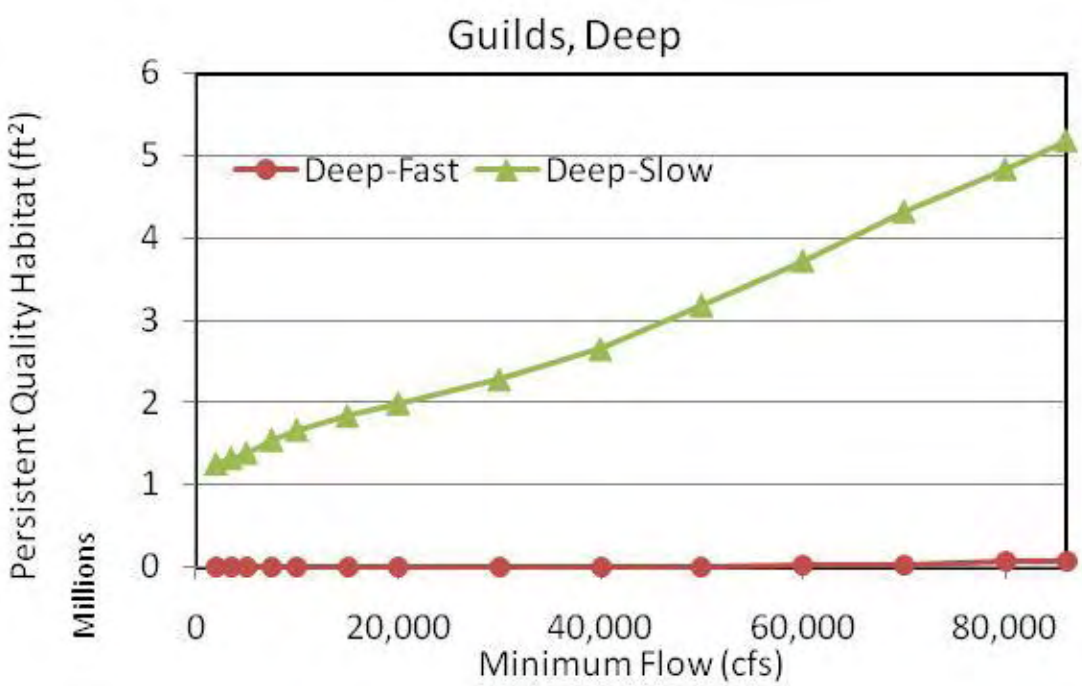
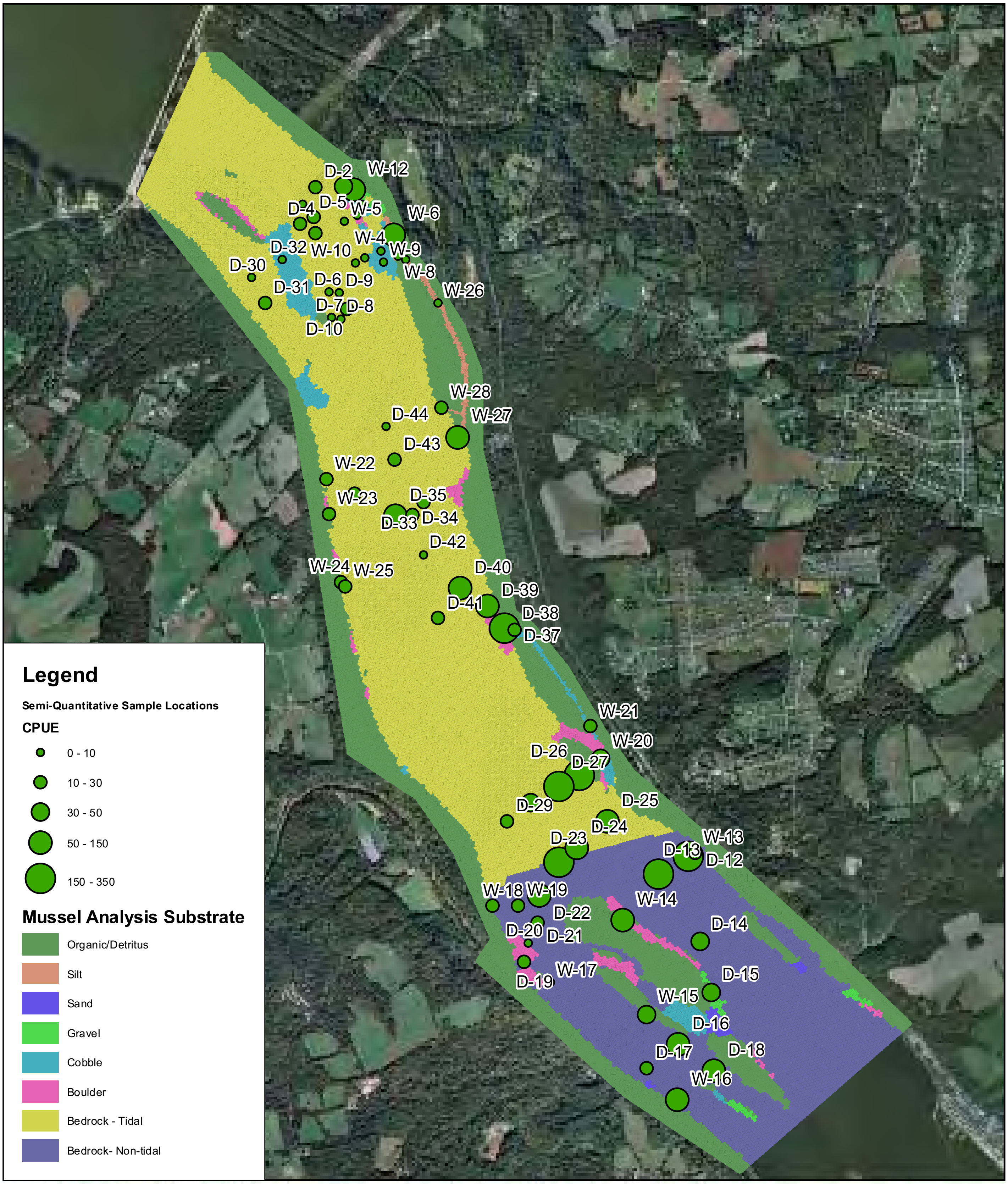


FIGURE 4.3.2.6-2: DEEP-FAST AND DEEP-SLOW GUILD PERSISTENT QUALITY HABITAT VERSUS MINIMUM FLOWS PAIRED WITH FULL GENERATION (86,000 CFS)





Exelon.

N

1 inch = 0.52 miles

0 1,875 3,750 7,500 11,250 Feet

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure 4.3.3-1
Mussel semi-quantitative survey locations mapped with riverbed substrate.

FIGURE 4.3.3-2: MUSSEL SEMI-QUANTITATIVE SURVEY LOCATIONS' CATCH-PER-UNIT-EFFORT (NUMBER OF MUSSELS PER HOUR) VS. SHEAR STRESS AT 3,500 CFS, 5,000 CFS, 40,000 CFS AND 86,000 CFS.

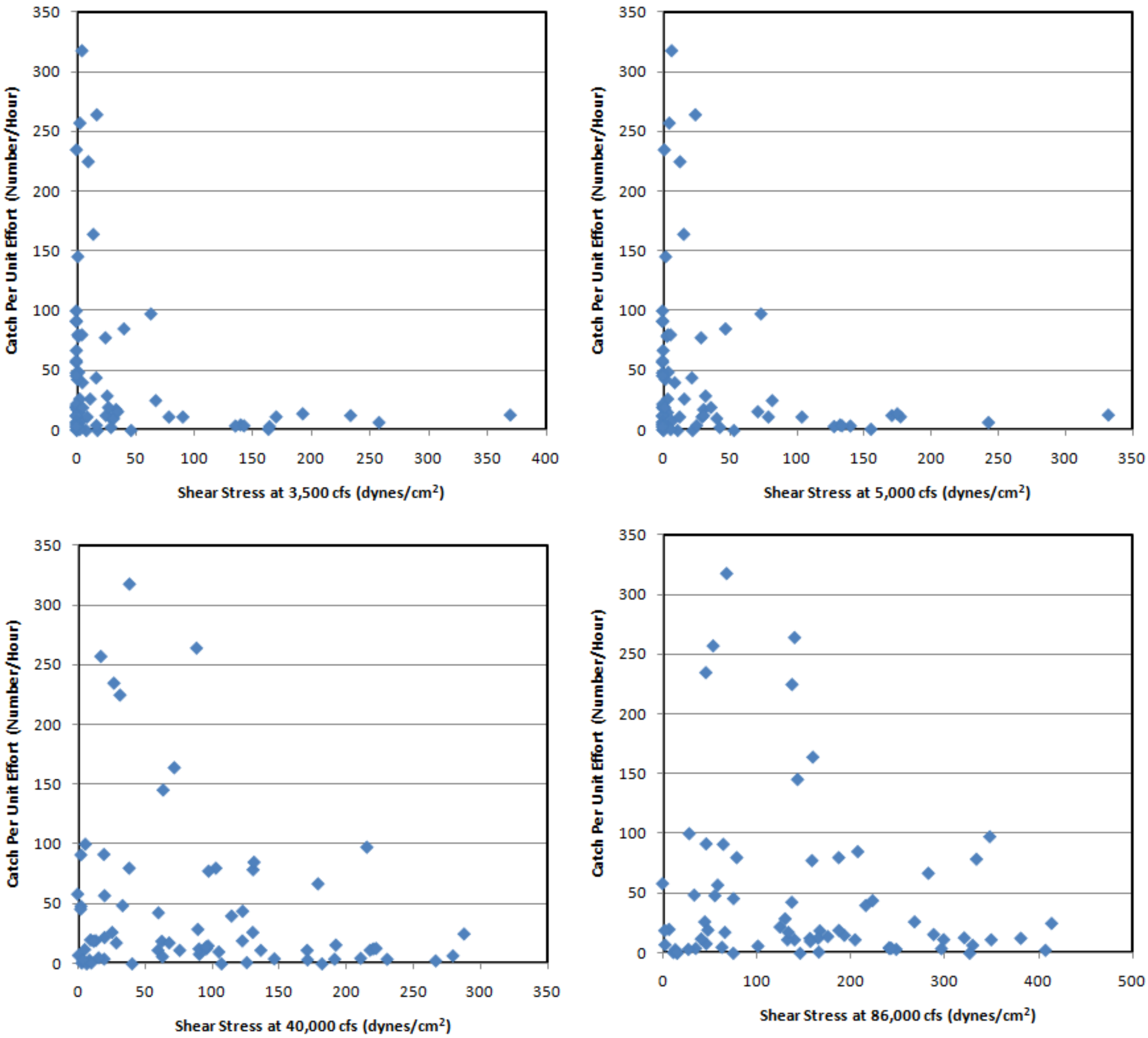


FIGURE 4.3.3-3: PERCENTAGE OF WETTED STUDY AREA THAT DOES NOT EXCEED THE MUSSEL LOW-FLOW THRESHOLD (20 DYNES/CM^2) AND HIGH-FLOW THRESHOLD (150 DYNES/CM^2).

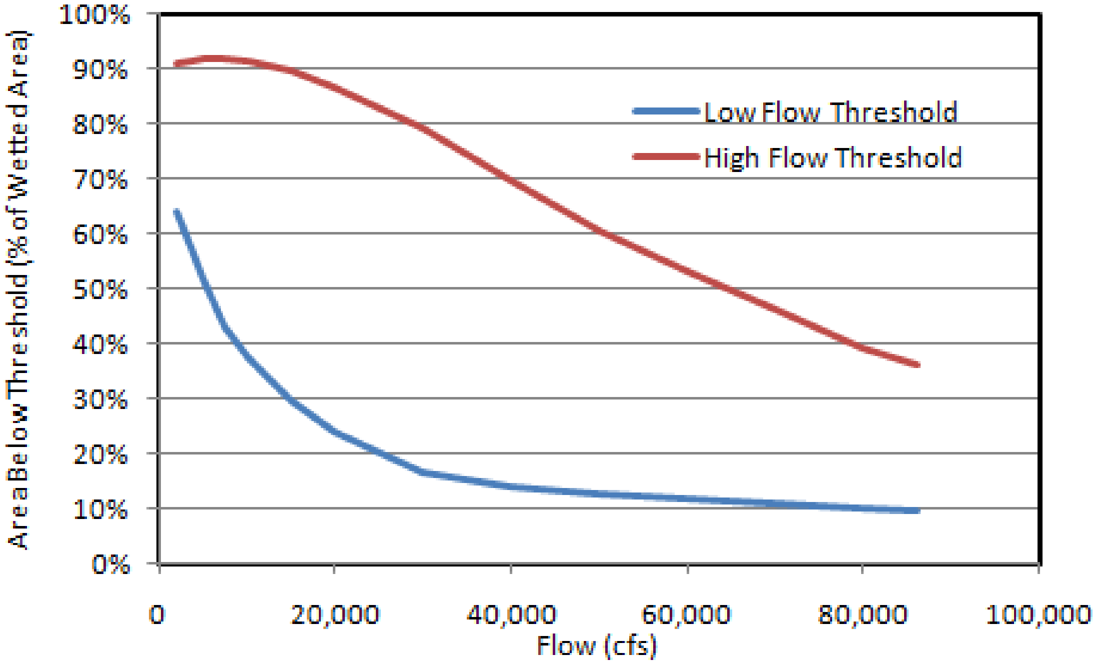


FIGURE 5.1.1-1: JANUARY FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

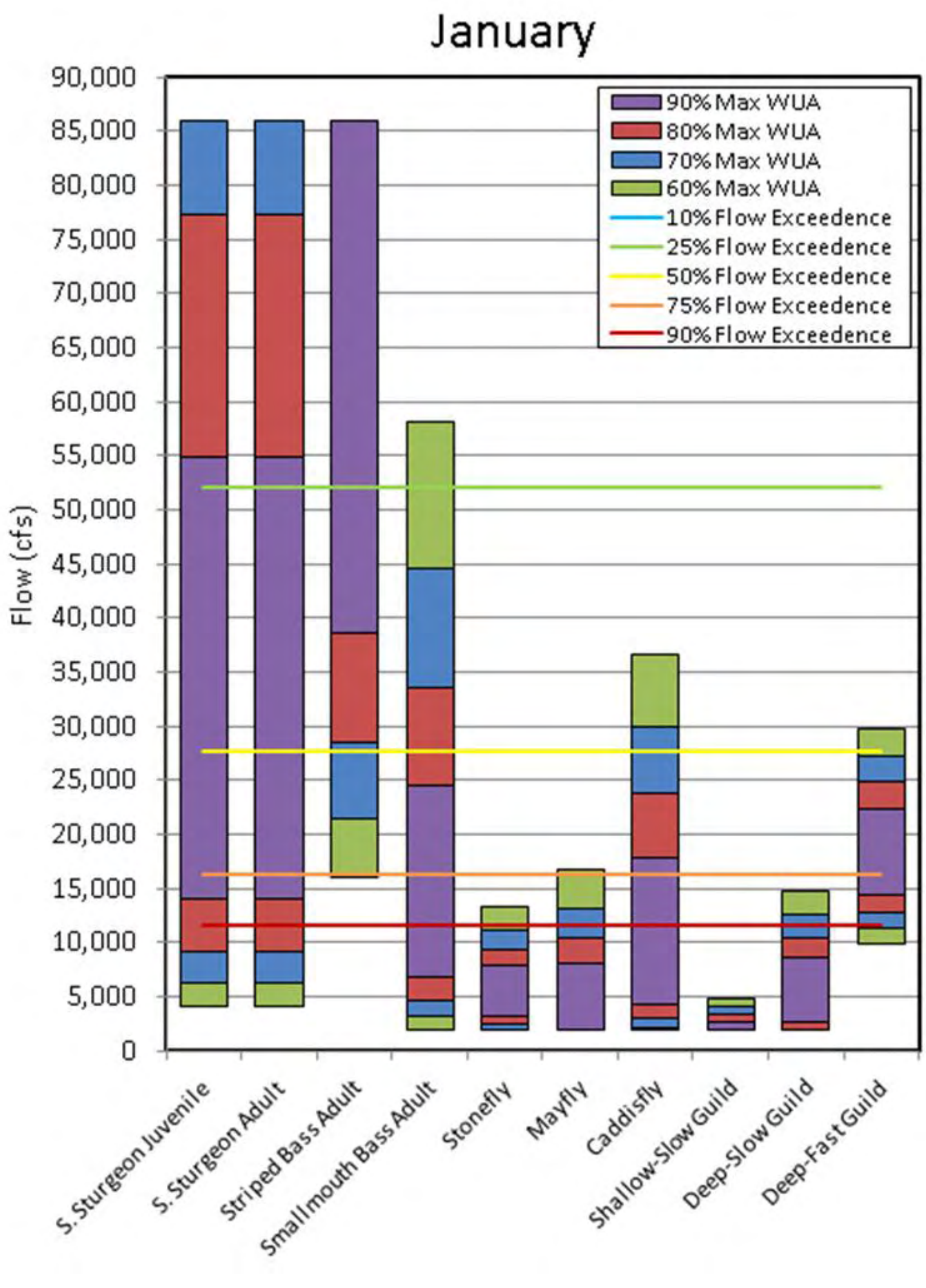


FIGURE 5.1.2-1: FEBRUARY FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

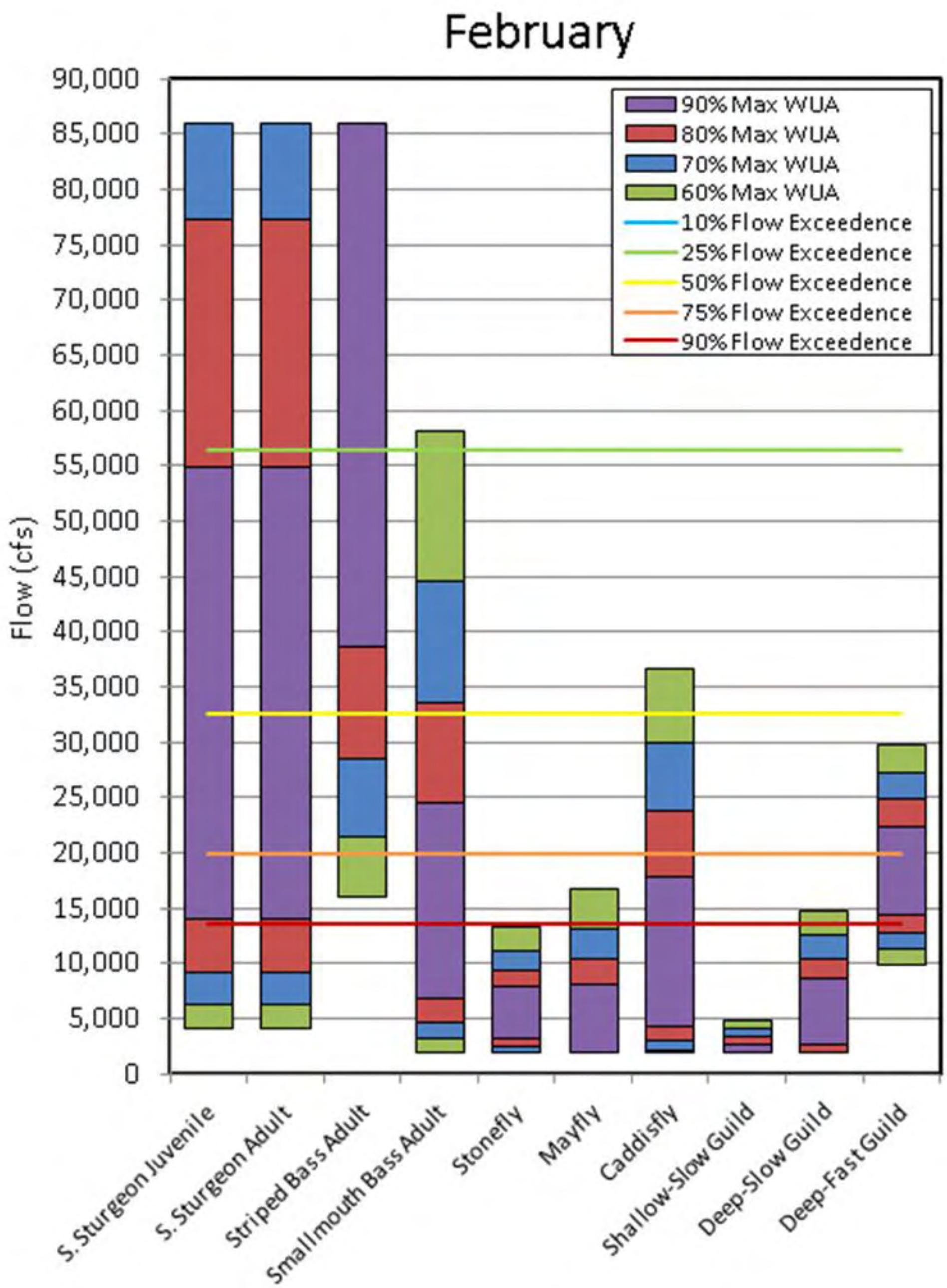


FIGURE 5.1.3-1: MARCH FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

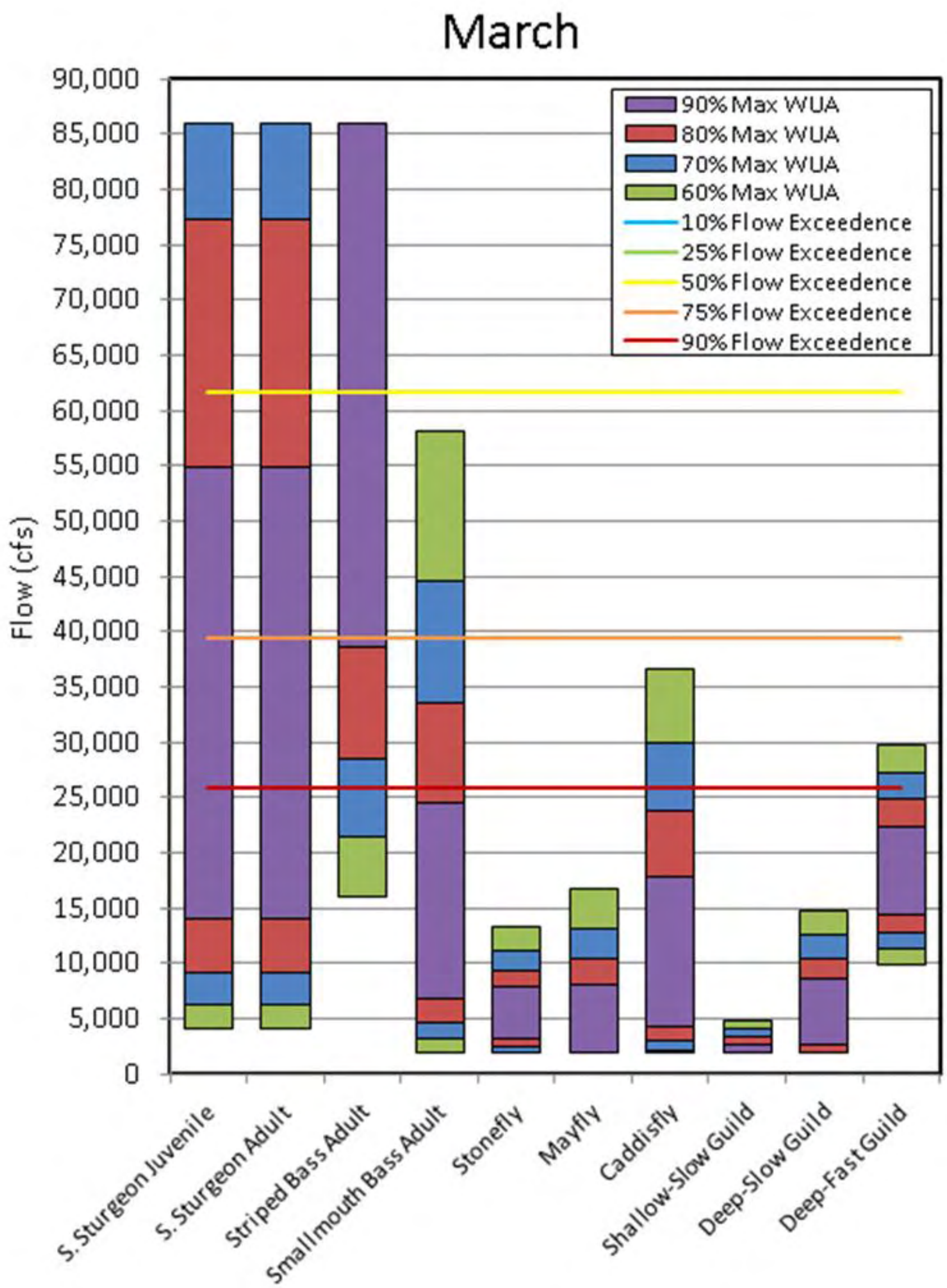


FIGURE 5.1.4-1: APRIL FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

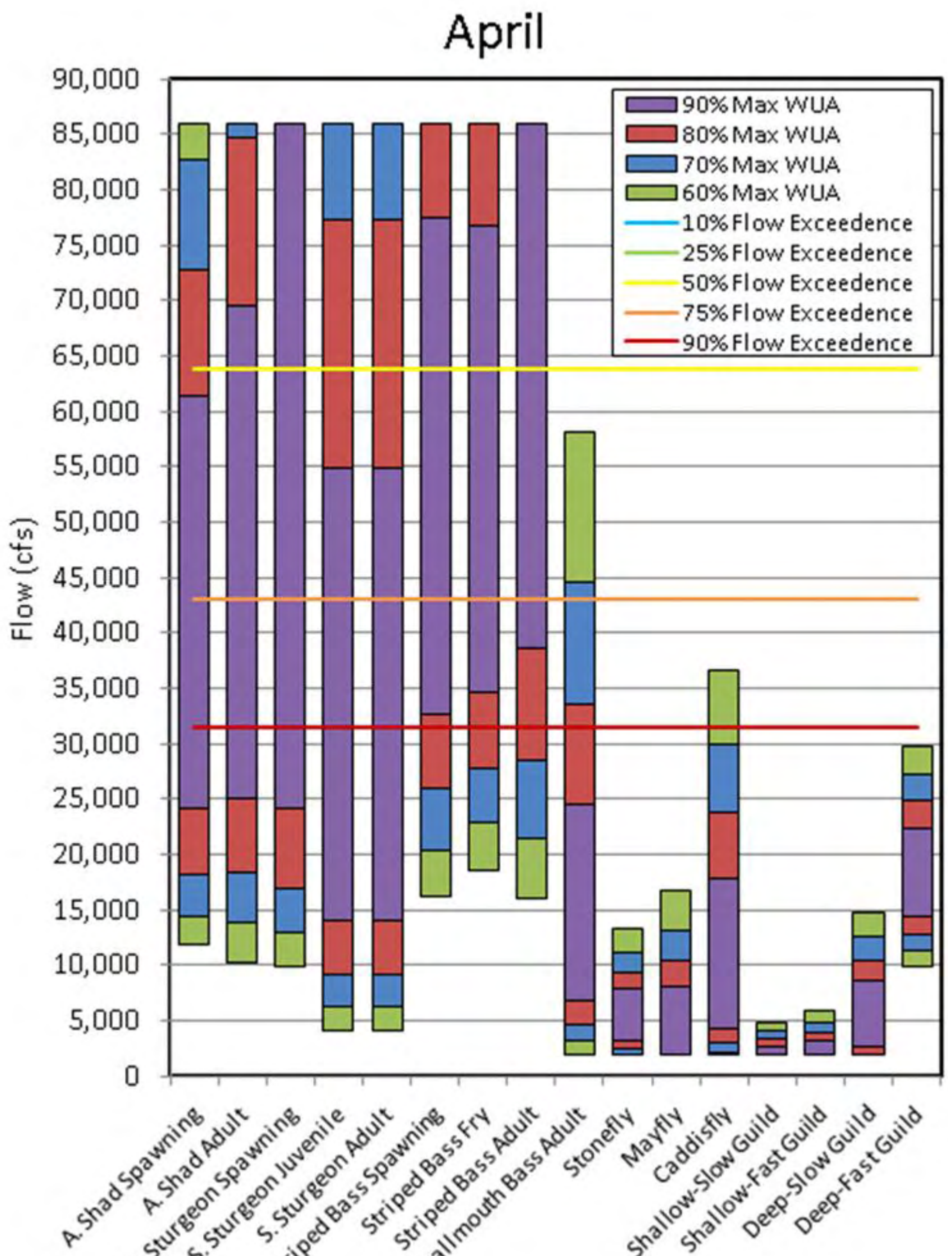


FIGURE 5.1.5-1: MAY FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

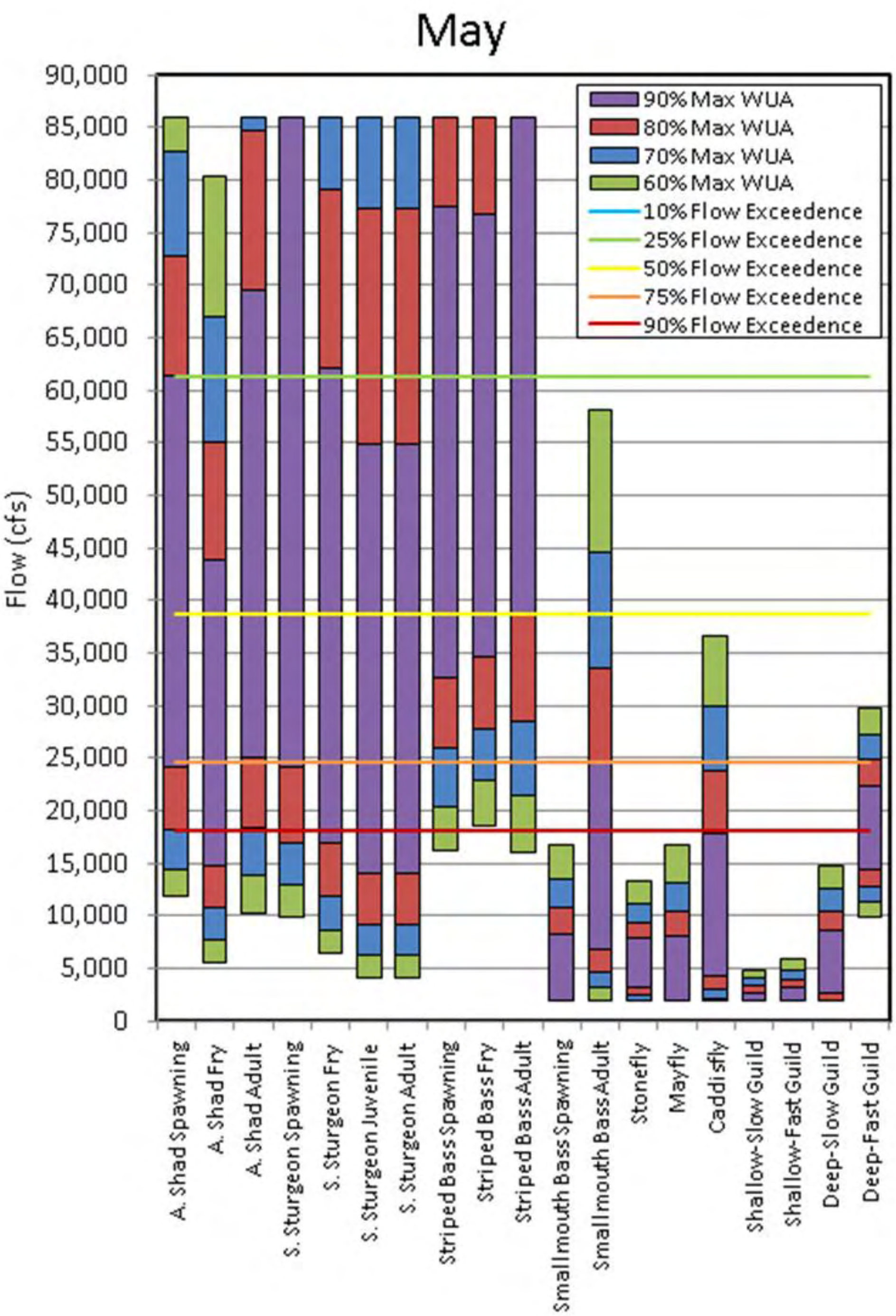


FIGURE 5.1.6-1: JUNE FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

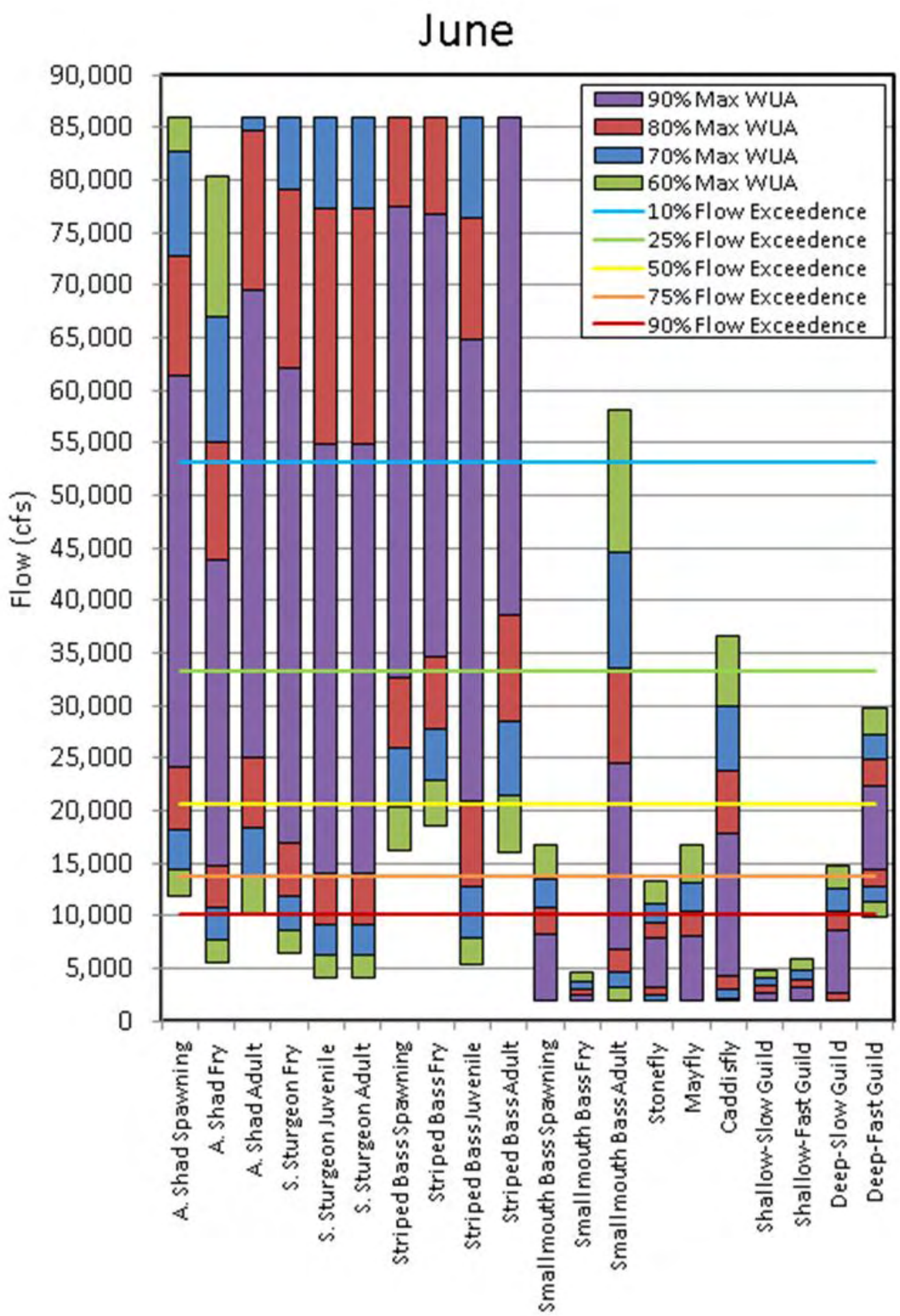


FIGURE 5.1.7-1: JULY FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

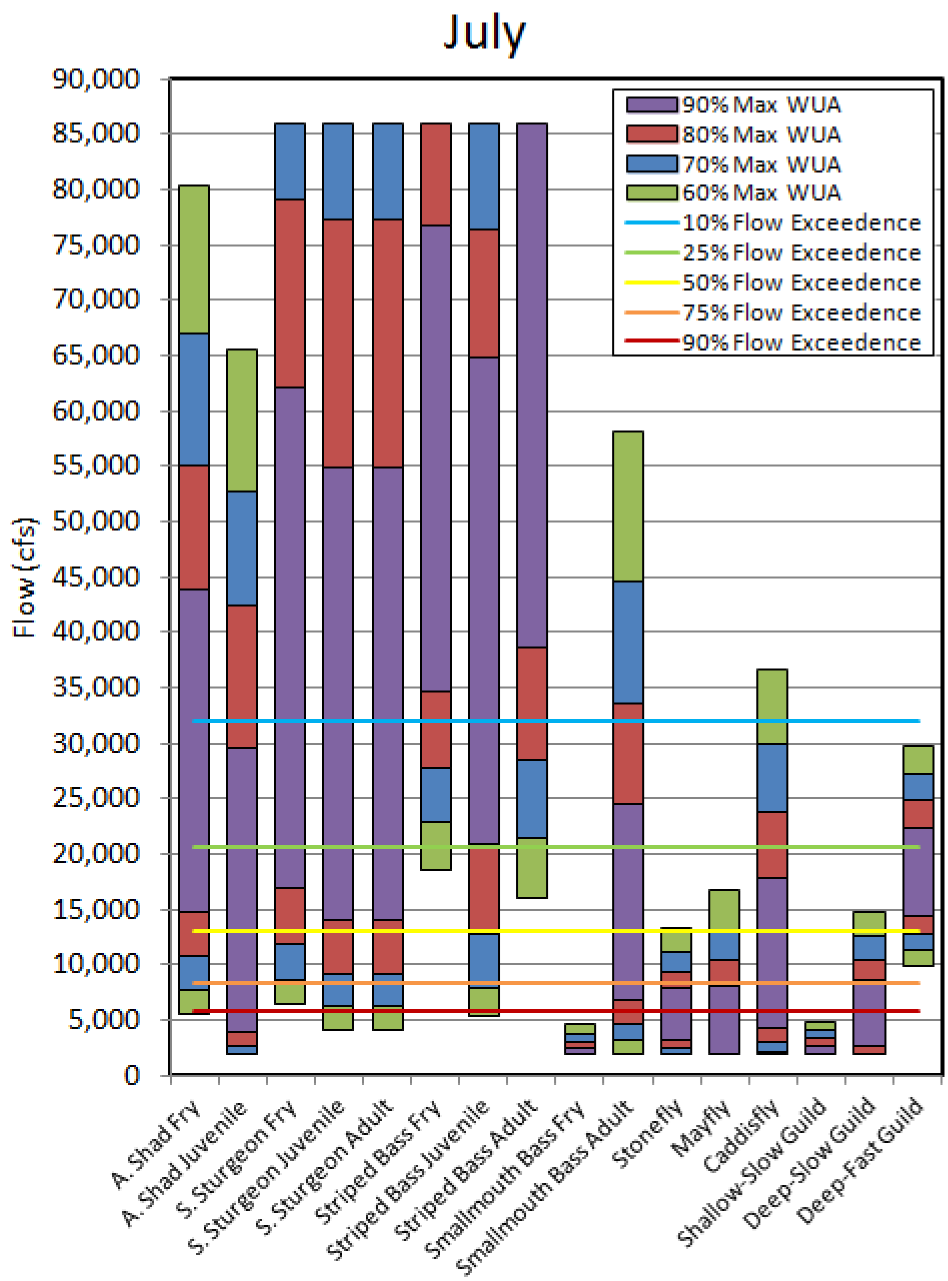


FIGURE 5.1.8-1: AUGUST FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

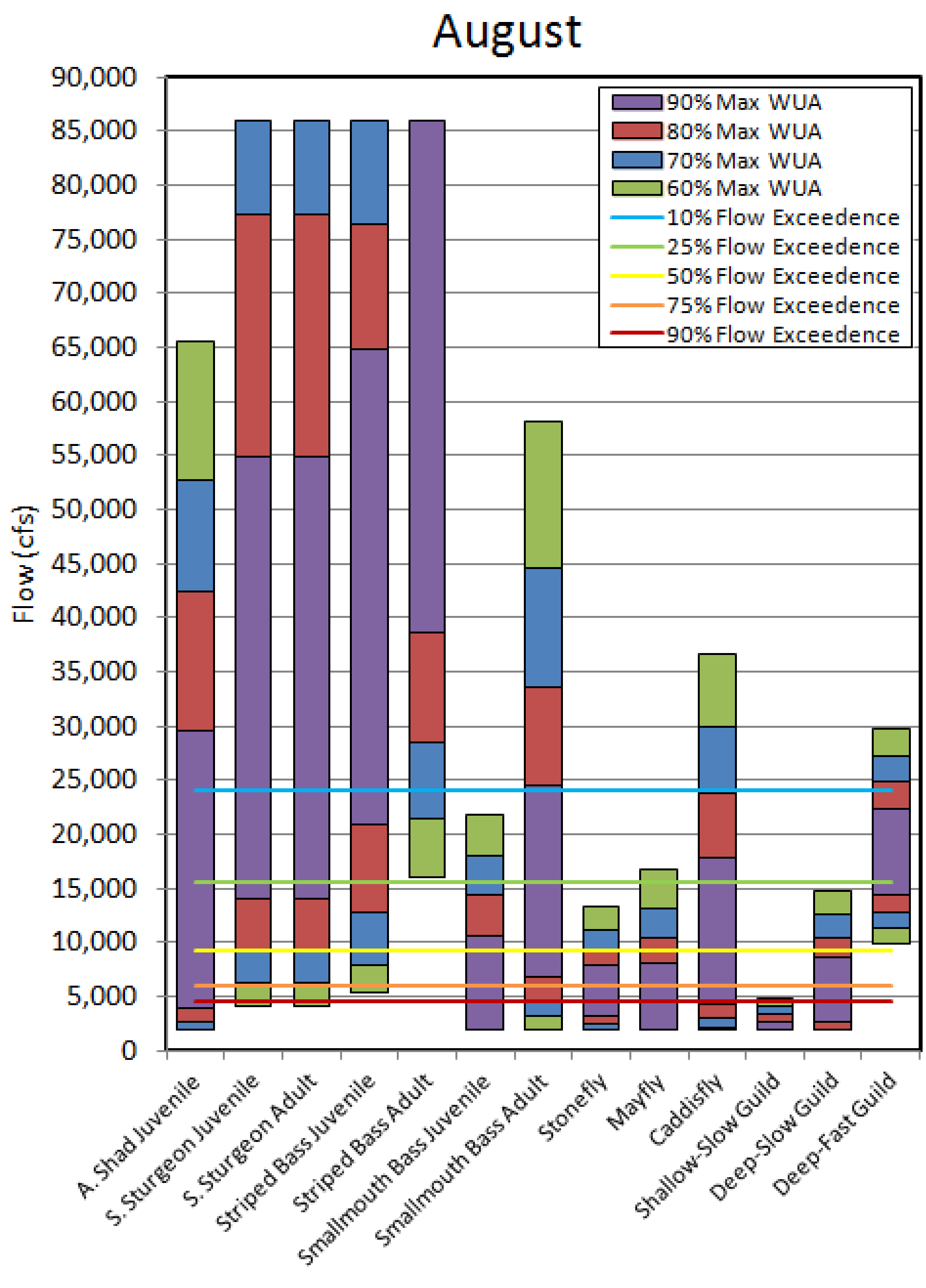


FIGURE 5.1.9-1: SEPTEMBER FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

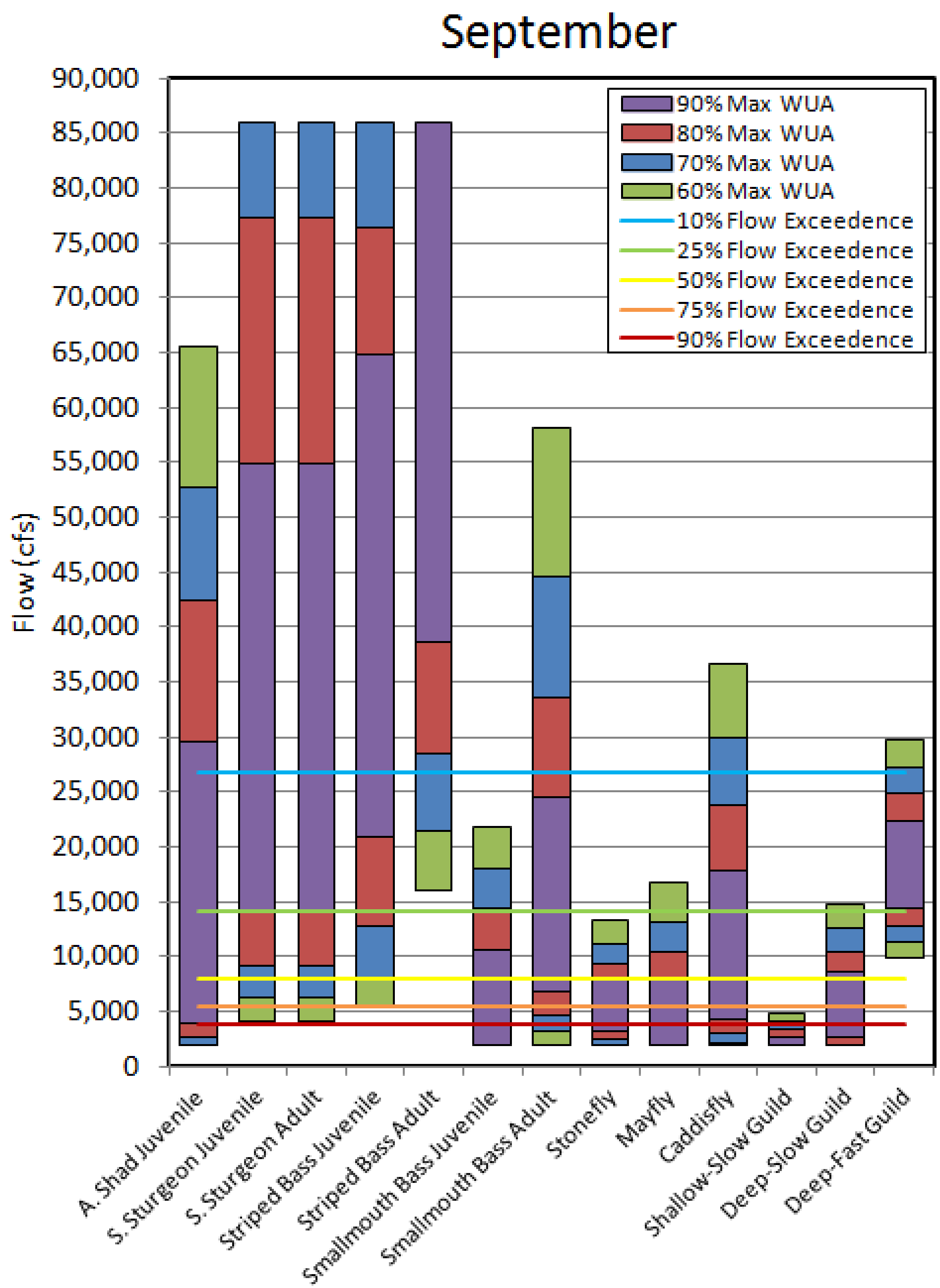


FIGURE 5.1.10-1: OCTOBER FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

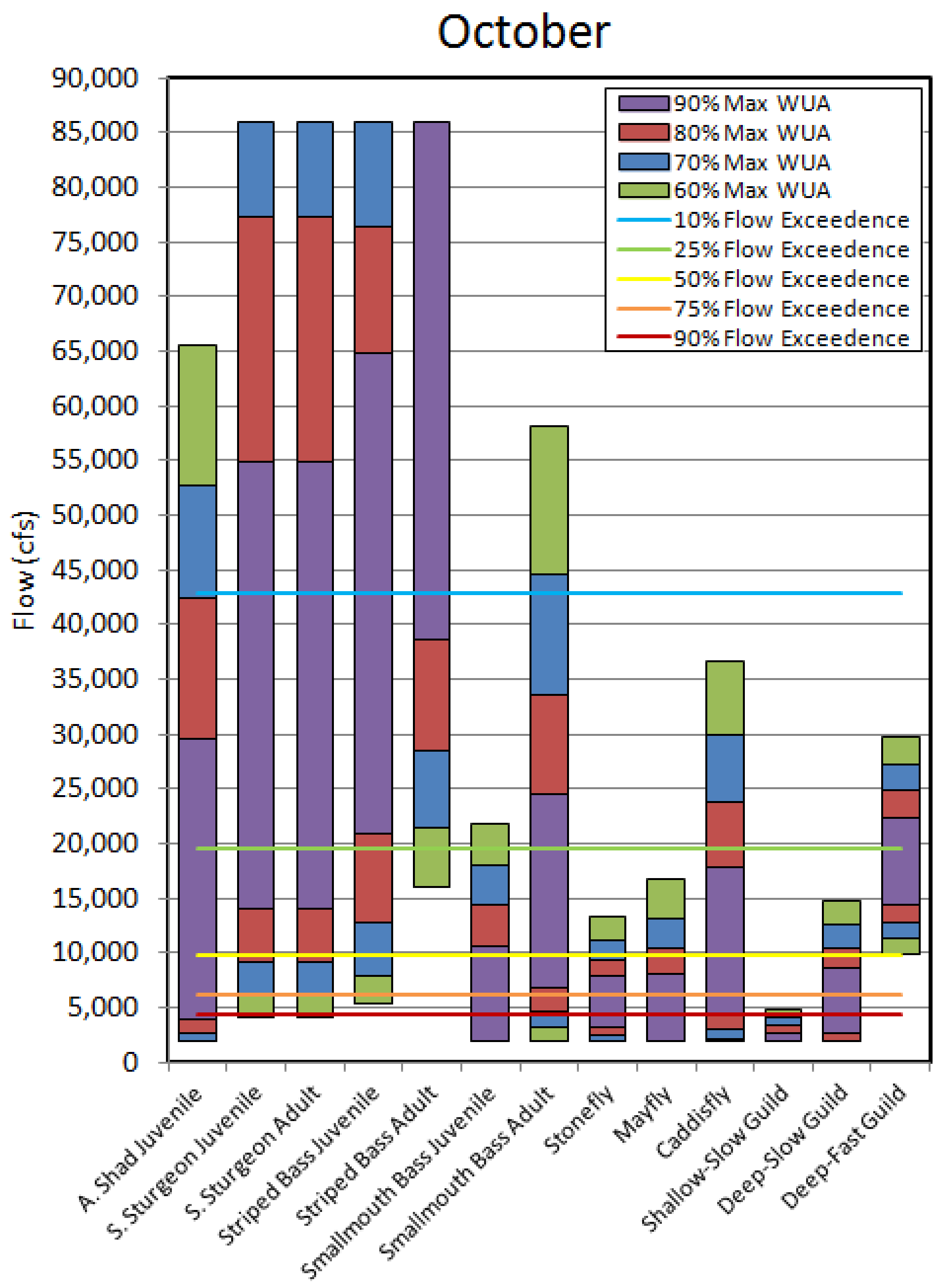


FIGURE 5.1.11-1: NOVEMBER FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD WY 1934-2009.

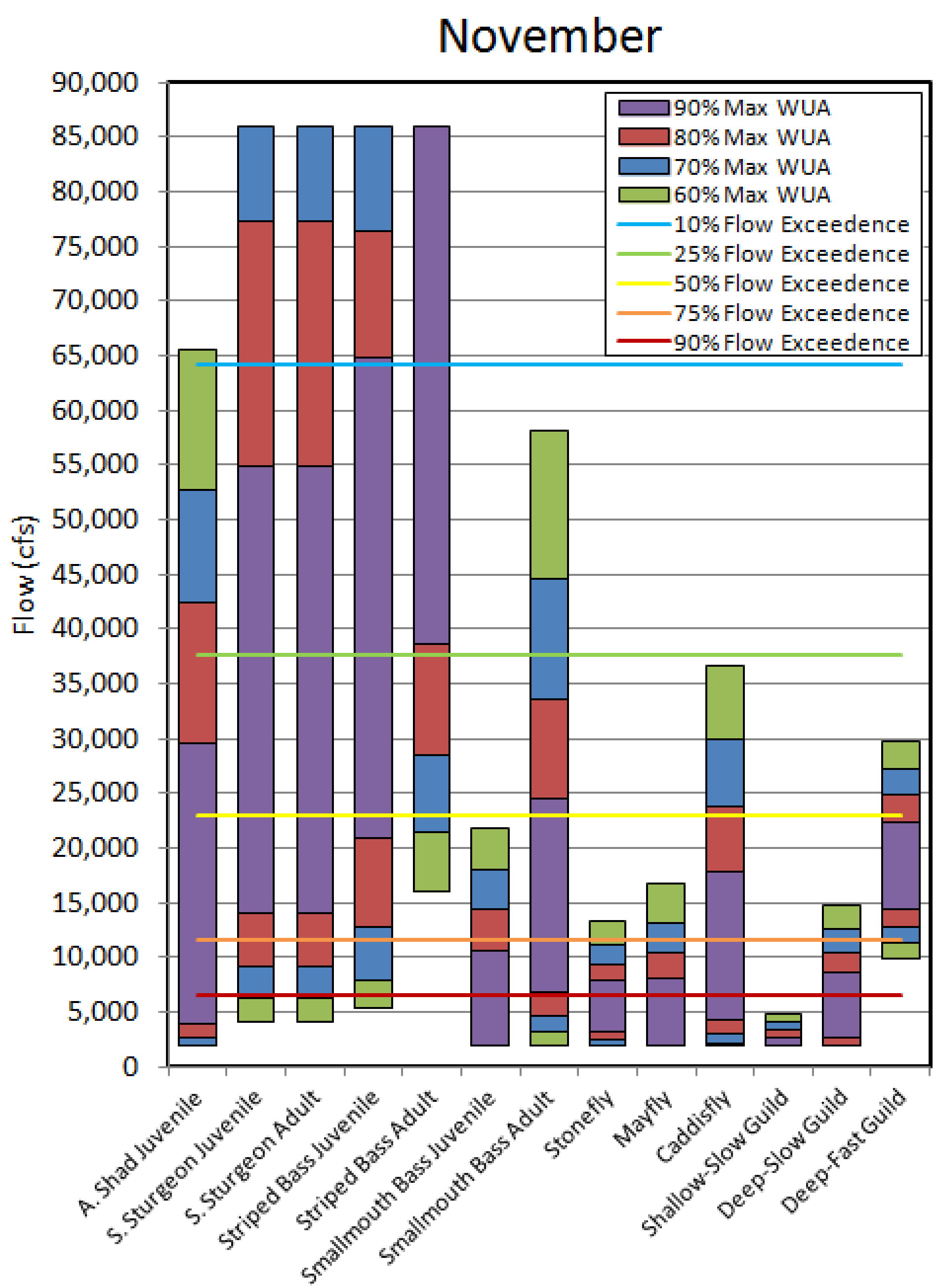
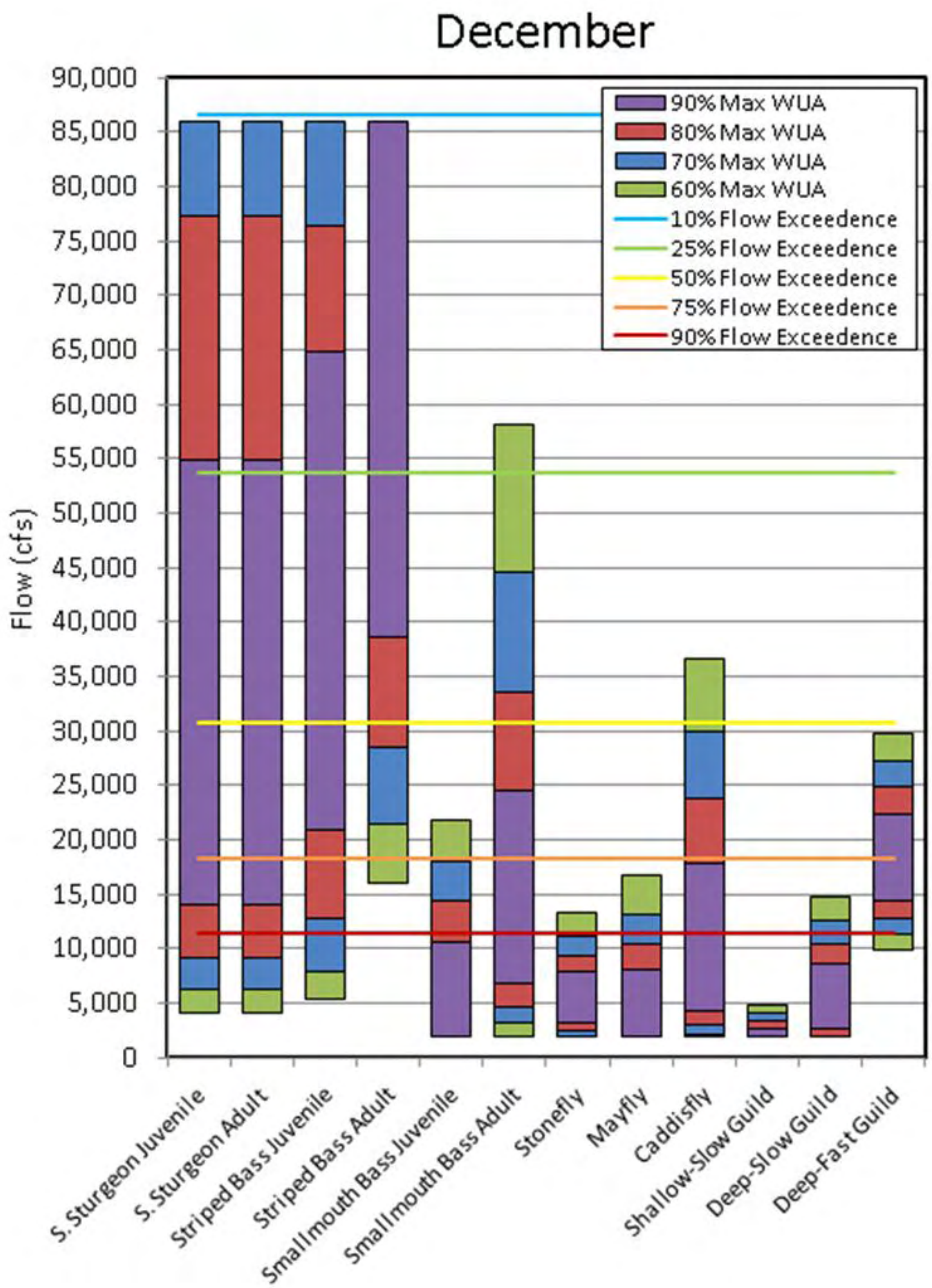


FIGURE 5.1.12-1: DECEMBER FLOW VS. HABITAT COMPARISON. FLOW EXCEEDANCES ARE FROM CONOWINGO ESTIMATED UNREGULATED FLOWS, PERIOD OF RECORD 1934-2009.



APPENDIX A- HABITAT SUITABILITY INDICES CONSULTATION

MEMORANDUM

December 9, 2010

TO: Larry Miller (USFWS), Andy Shiels (PFBC), Mike Hendricks (PFBC), Jim Richenderfer (SRBC), Andrew Dehoff (SRBC), Julie Crocker (NOAA), Shawn Seaman (MDNR), Bob Sadzinski (MDNR), Steve Schreiner (Versar Inc.), Bill Richkus (Versar Inc.), Jim Spontak (PaDEP), Janet Norman (USFWS), Jeremy Miller (PaDEP), John Smith (FERC), Mark Bryer (The Nature Conservancy), John Seebach (American Rivers), Don Pugh (American Rivers), Keith Whiteford (MDNR), Tyler Shenk (SRBC), John Balay (SRBC), Josh Treneski (PFBC), Matt Ashton (MDNR), Jessica Pruden (NMFS)

FROM: Gomez and Sullivan Engineers

Re: **Proposed Final Habitat Suitability Criteria Selection for the Instream Flow Habitat Assessment below Conowingo Dam (RSP 3.16). Conowingo Hydroelectric Project, FERC No. 405, Relicensing.**

INTRODUCTION

On August 19, 2010, Exelon sponsored a meeting with the stakeholders to discuss the initial habitat suitability curves, periodicity chart and habitat assignment guilds. Subsequently, further changes were made to specific curves after discussions with sub-groups. Specifically, the additional changes were made to the striped bass, shortnose sturgeon and smallmouth bass curves. This purpose of this memo is present to the group the proposed final periodicity table, habitat guild assignment and habitat suitability criteria for target species to be analyzed within the Instream Flow Habitat Assessment Study for the Conowingo Hydroelectric Project.

PROPOSED FINAL HABITAT SUITABILITY CURVES

There were several modifications proposed at the August meeting to the individual HSI curves of American shad, shortnose sturgeon, striped bass and smallmouth bass as well as the removal of the mussels and community macroinvertebrate curves from the analysis. The analysis of the mussels will be incorporated into the hydraulic analysis. The mussel habitat analysis will rely on output from the 2-dimensional hydraulic model, which is the basis for the instream flow study. Specifically, modeled hydraulic parameters, such as bottom shear stress, depth, and average column velocity, will be analyzed for specific areas of interest (i.e., known mussel bed locations) in the study reach, to determine the habitat impacts of the existing and alternative flow regimes.

Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), or EPT, curves were added to take the place of the community macroinvertebrate curve, as was discussed at the meeting. The EPT curves were developed from Gore et al. 2001. The Gore (2001) document provides a correlation between habitat suitability criteria for fish and the diversity of the macroinvertabrate community. The paper developed habitat suitability criteria for the EPT community that is commonly used during instream flow evaluations.

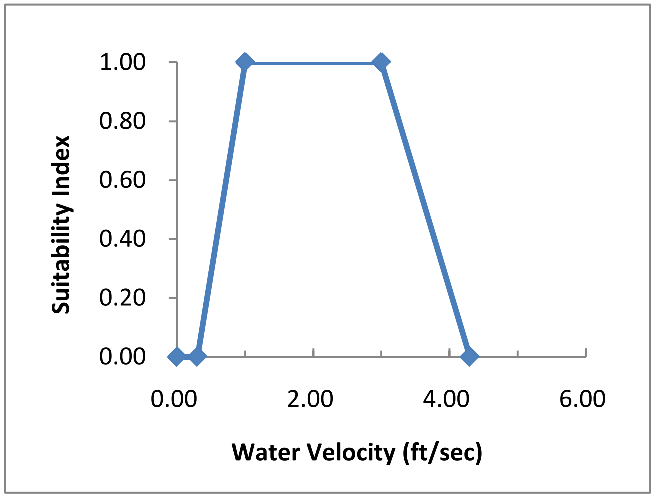
Further changes to the striped bass curves were made following discussions with Bob Sadzinski and Eric Durell of MDNR. The shortnose sturgeon curves were modified after a conference call with Don Pugh (American Rivers) and Jessica Pruden (NMFS). Smallmouth bass curves were further modified after information was provided by Mike Hendricks (PFBC). All of the information provided during the August 19 meeting and the subsequent discussions has been used to develop curves for the current analysis. Any changes made since the meeting are plotted on the same graph as the original curve so that the group can view the changes.

The appendices at the end of this memo provide a proposed final set of habitat suitability criteria, habitat guild assignment and periodicity table for review. All references used in the development of the curves are provided in Appendix D. Please review the information and respond with comments by December 24, 2010.

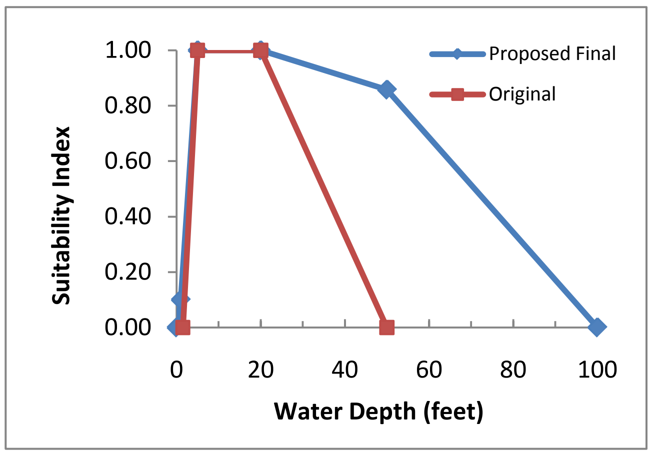
Appendix A- Revised Habitat Suitability Criteria

Species: American Shad
Lifestage: Spawning

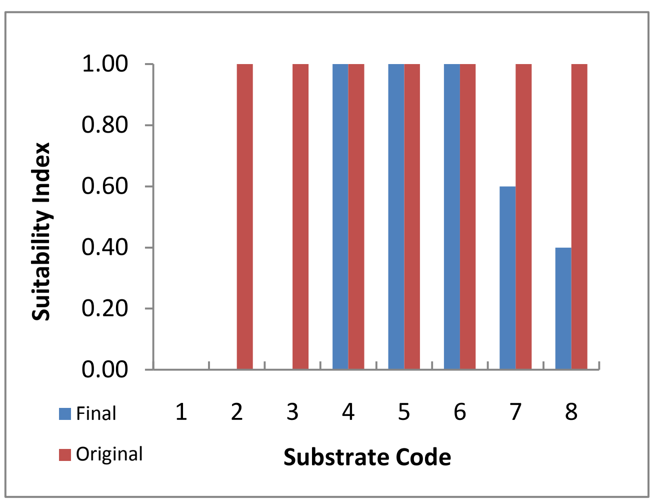
Velocity	SI Value
0.00	0.00
0.30	0.00
1.00	1.00
3.00	1.00
4.30	0.00



Proposed Final		Original	
Depth	SI Value	Depth	SI Value
0.00	0.00	1.50	0.00
1.00	0.10	5.00	1.00
5.00	1.00	20.00	1.00
20.00	1.00	50.00	0.00
50.00	0.86		
100.00	0.00		

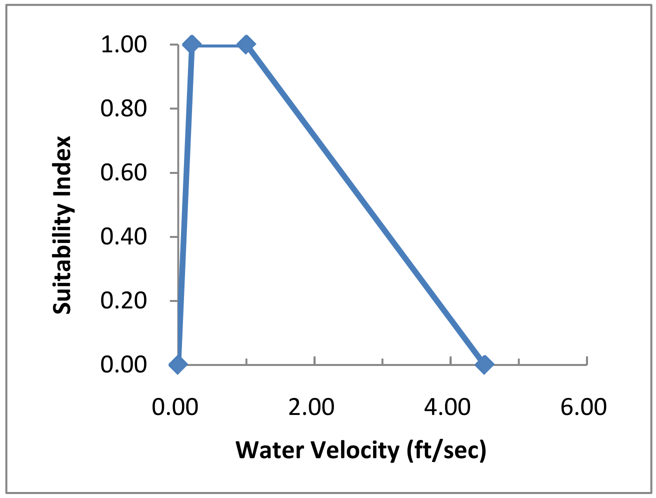


Code	Final SI Value	Original SI Value	Type
1	0.00	0.00	Detritus
2	0.00	1.00	Mud
3	0.00	1.00	Silt
4	1.00	1.00	Sand
5	1.00	1.00	Gravel
6	1.00	1.00	Cobble
7	0.60	1.00	Boulder
8	0.40	1.00	Bedrock

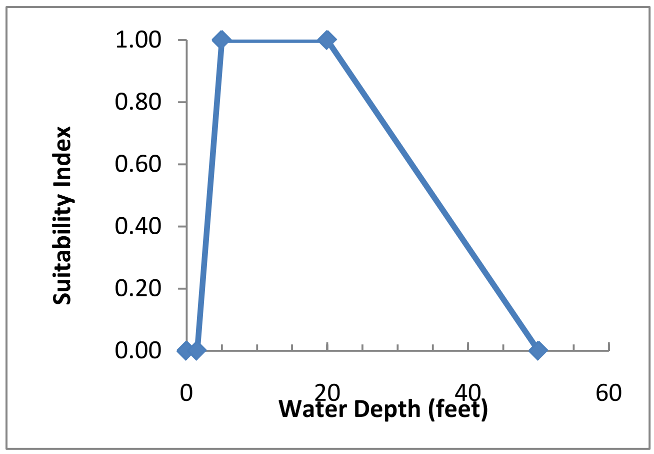


Species: American Shad
Lifestage: Fry

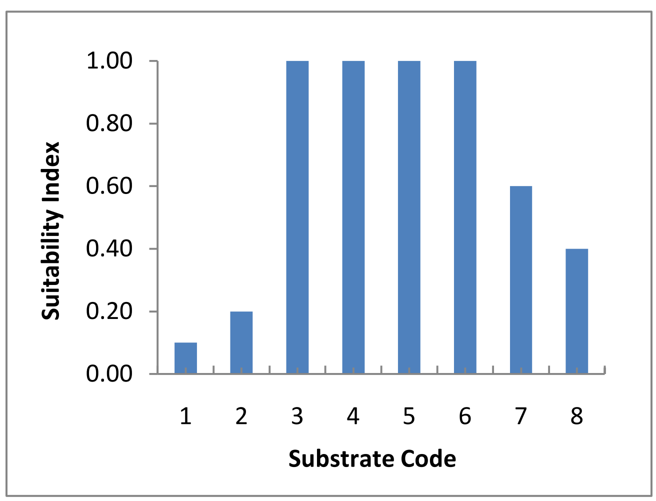
Velocity	SI Value
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



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

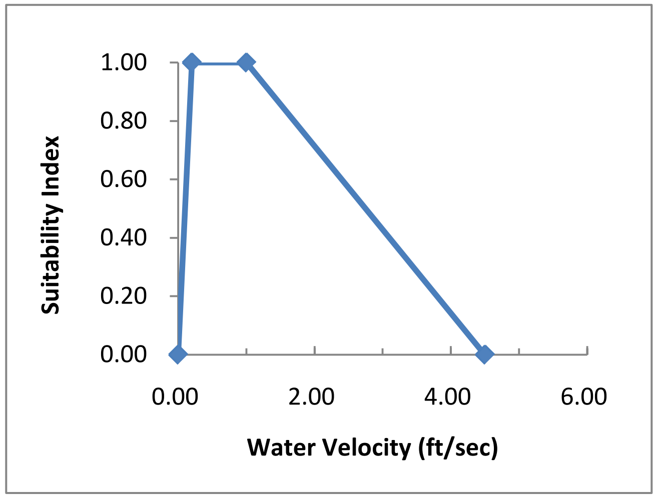


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

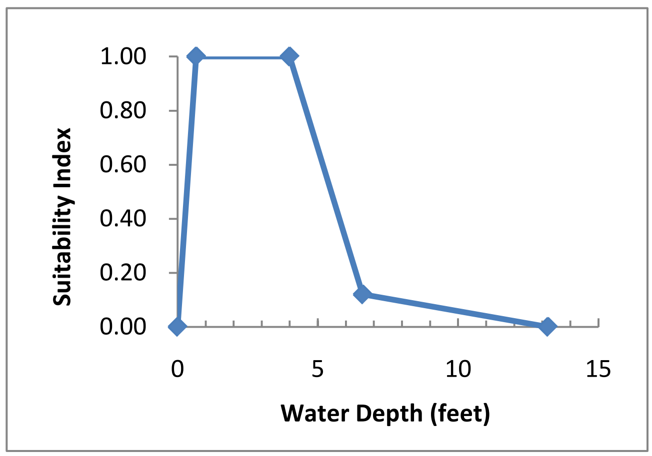


Species: American Shad
Lifestage: Juvenile

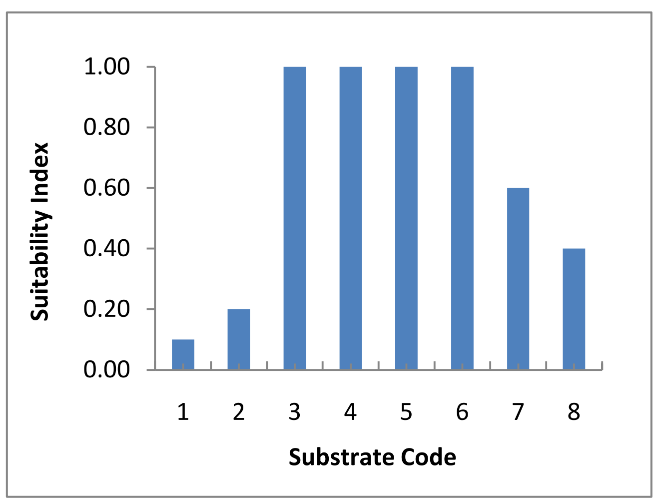
Velocity	SI Value
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



Depth	SI Value
0.00	0.00
0.66	1.00
3.99	1.00
6.60	0.12
13.20	0.00

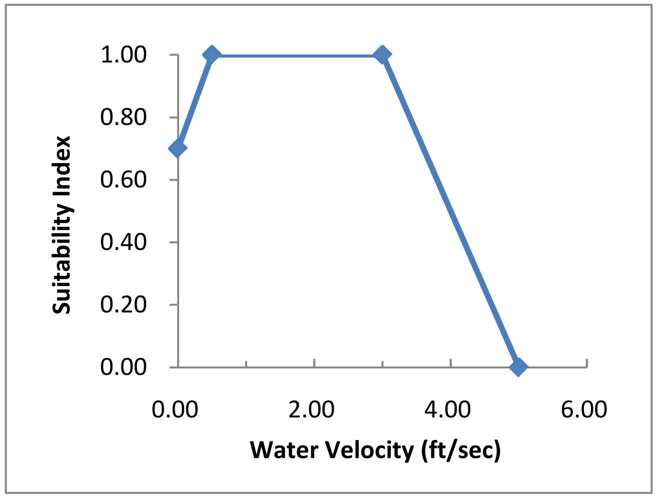


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

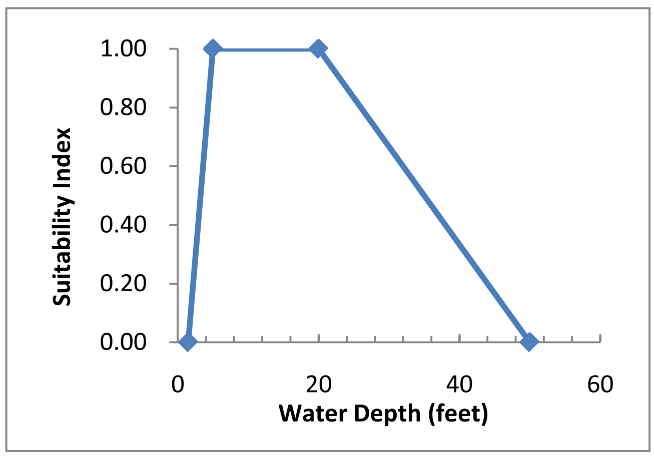


Species: American Shad
Lifestage: Adult

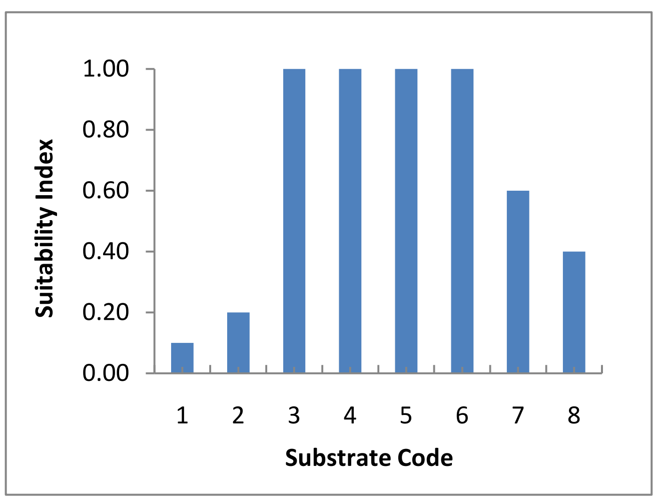
Velocity	SI Value
0.00	0.70
0.50	1.00
3.00	1.00
5.00	0.00



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

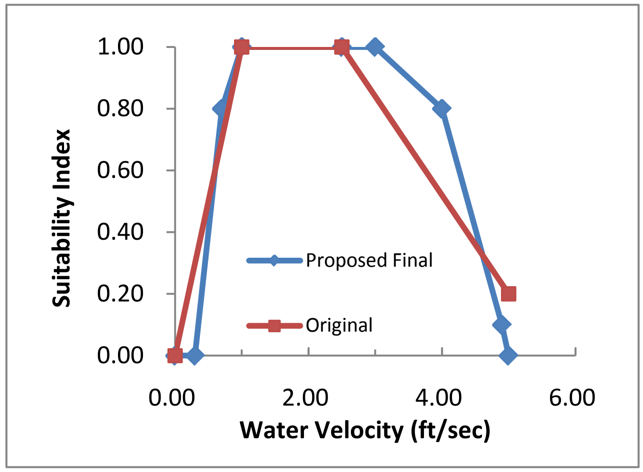


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

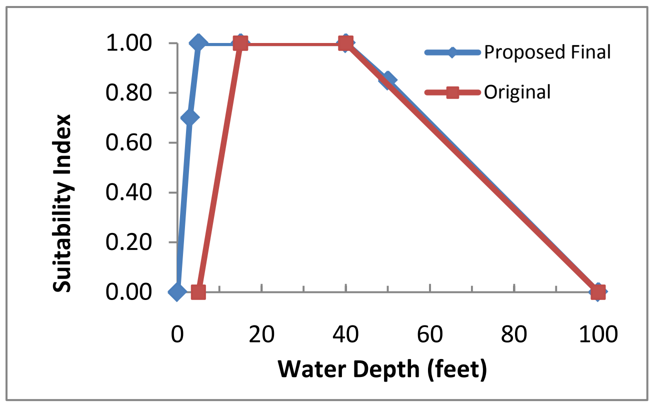


Species: Shortnose Sturgeon
Lifestage: Spawning

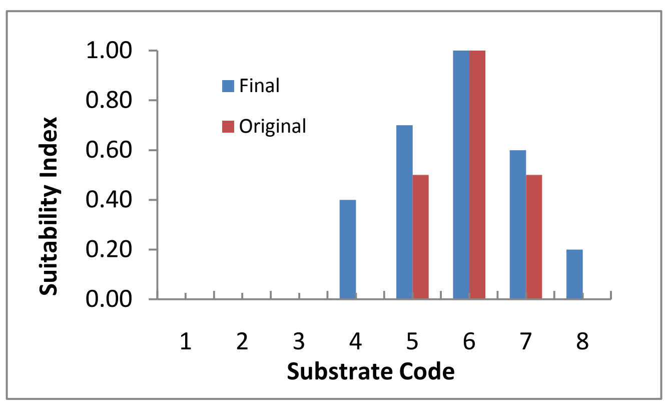
Proposed Final		Original	
Velocity	SI Value	Velocity	SI Value
0.00	0.00	0.00	0.00
0.30	0.00	1.00	1.00
0.70	0.80	2.50	1.00
1.00	1.00	5.00	0.20
2.50	1.00		
3.00	1.00		
4.00	0.80		
4.90	0.10		
5.00	0.00		



Proposed Final		Original	
Depth	SI Value	Depth	SI Value
0.00	0.00	5.00	0.00
3.00	0.70	15.00	1.00
5.00	1.00	40.00	1.00
15.00	1.00	100.00	0.00
40.00	1.00		
50.00	0.85		
100.00	0.00		

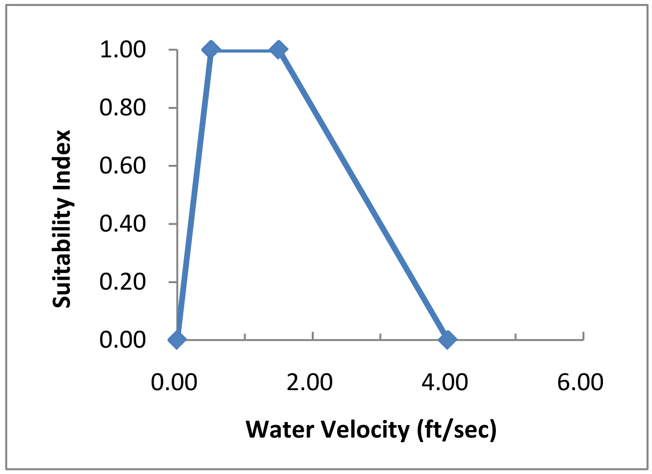


Code	Final SI Value	Original SI Value	Type
1	0.00	0.00	Detritus/Organic
2	0.00	0.00	Mud/soft clay
3	0.00	0.00	Silt
4	0.40	0.00	Sand
5	0.70	0.50	Gravel
6	1.00	1.00	Cobble/rubble
7	0.60	0.50	Boulder
8	0.20	0.00	Bedrock

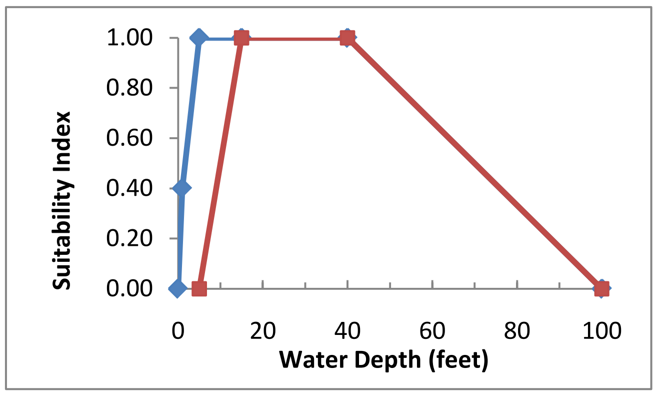


Species: Shortnose Sturgeon
Lifestage: Fry

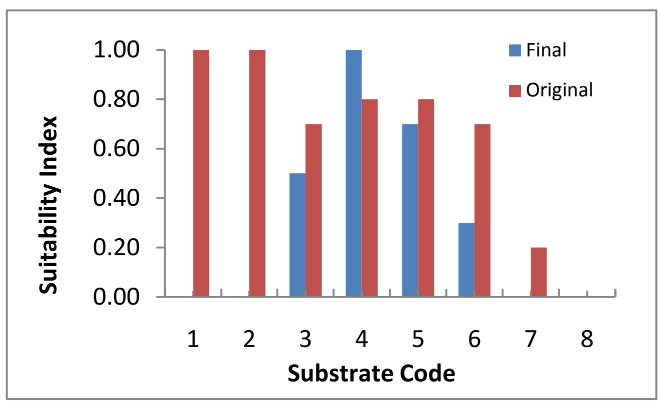
Velocity	SI Value
0.00	0.00
0.50	1.00
1.50	1.00
4.00	0.00



Proposed Final		Original	
Depth	SI Value	Depth	SI Value
0.00	0.00	5.00	0.00
1.00	0.40	15.00	1.00
5.00	1.00	40.00	1.00
15.00	1.00	100.00	0.00
40.00	1.00		
100.00	0.00		

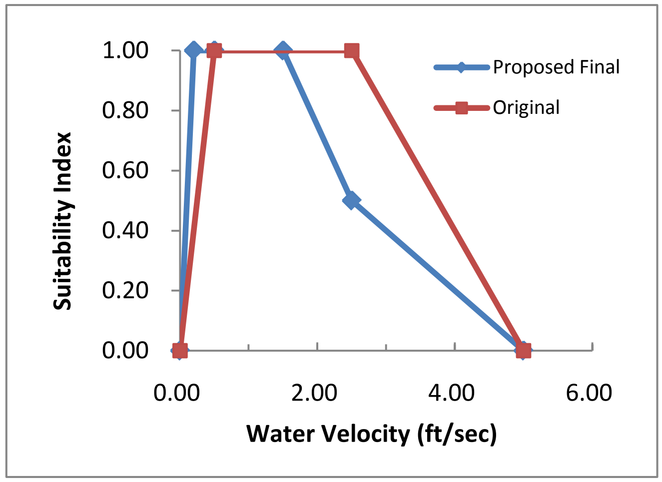


Code	Final SI Value	Original SI Value	Type
1	0.00	1.00	Detritus/Organic
2	0.00	1.00	Mud/soft clay
3	0.50	0.70	Silt
4	1.00	0.80	Sand
5	0.70	0.80	Gravel
6	0.30	0.70	Cobble/rubble
7	0.00	0.20	Boulder
8	0.00	0.00	Bedrock

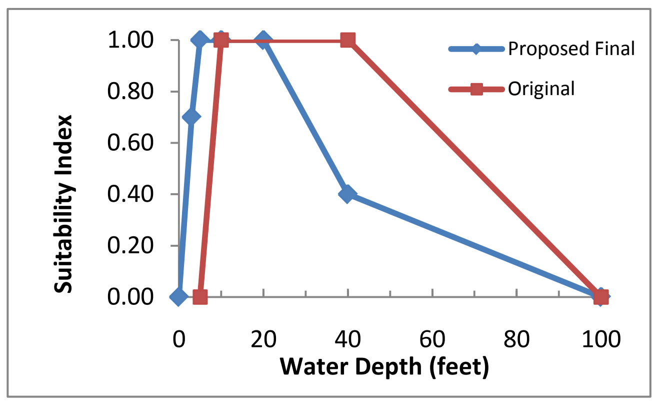


Species: Shortnose Sturgeon
Lifestage: Juveniles

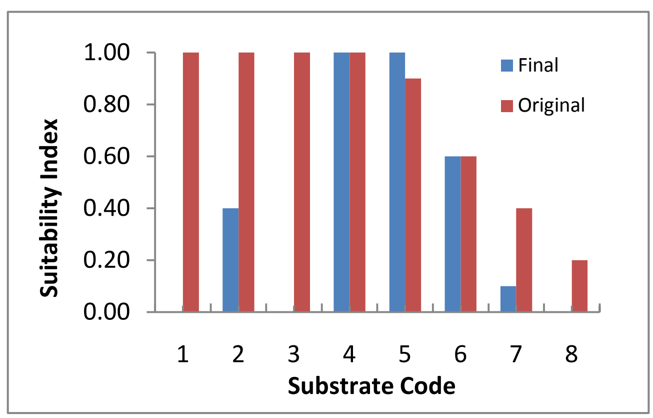
Proposed Final Velocity	Proposed Final SI Value	Original Velocity	Original SI Value
0.00	0.00	0.00	0.00
0.20	1.00	0.50	1.00
0.50	1.00	2.50	1.00
1.50	1.00	5.00	0.00
2.50	0.50		
5.00	0.00		



Proposed Final Depth	Proposed Final SI Value	Original Depth	Original SI Value
0.00	0.00	5.00	0.00
3.00	0.70	10.00	1.00
5.00	1.00	40.00	1.00
10.00	1.00	100.00	0.00
20.00	1.00		
40.00	0.40		
100.00	0.00		

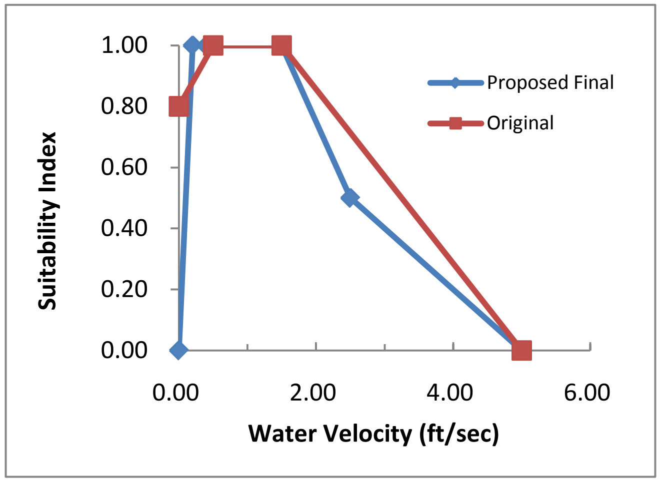


Code	Final SI Value	Original SI Value	Type
1	0.00	1.00	Detritus/Organic
2	0.40	1.00	Mud/soft clay
3	0.00	1.00	Silt
4	1.00	1.00	Sand
5	1.00	0.90	Gravel
6	0.60	0.60	Cobble/rubble
7	0.10	0.40	Boulder
8	0.00	0.20	Bedrock

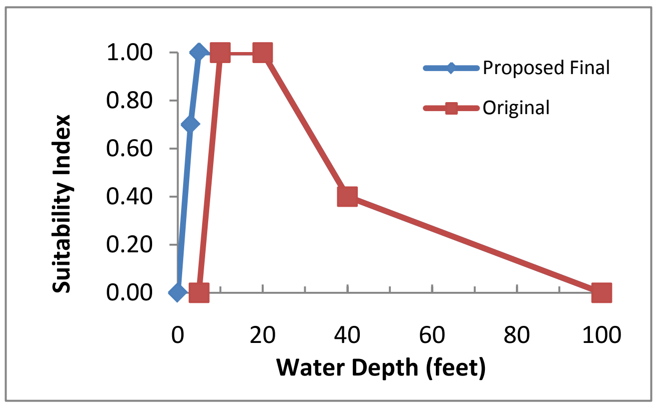


Species: Shortnose Sturgeon
Lifestage: Adults

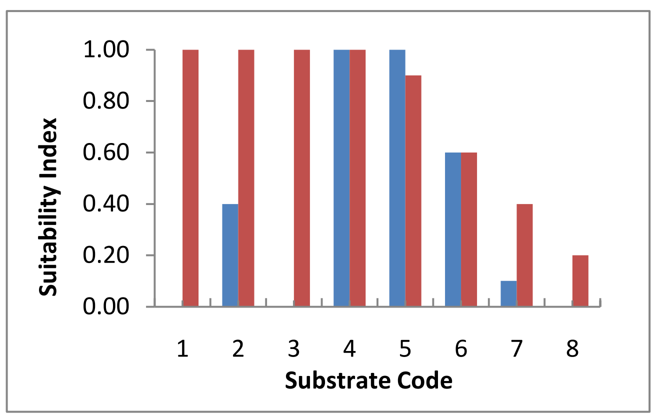
Proposed Final Velocity	Proposed Final SI Value	Original Velocity	Original SI Value
0.00	0.00	0.00	0.80
0.20	1.00	0.50	1.00
0.40	1.00	1.50	1.00
0.50	1.00	5.00	0.00
1.50	1.00		
2.50	0.50		
5.00	0.00		



Proposed Final Depth	Proposed Final SI Value	Original Depth	Original SI Value
0.00	0.00	5.00	0.00
3.00	0.70	10.00	1.00
5.00	1.00	20.00	1.00
10.00	1.00	40.00	0.40
20.00	1.00	100.00	0.00
40.00	0.40		
100.00	0.00		

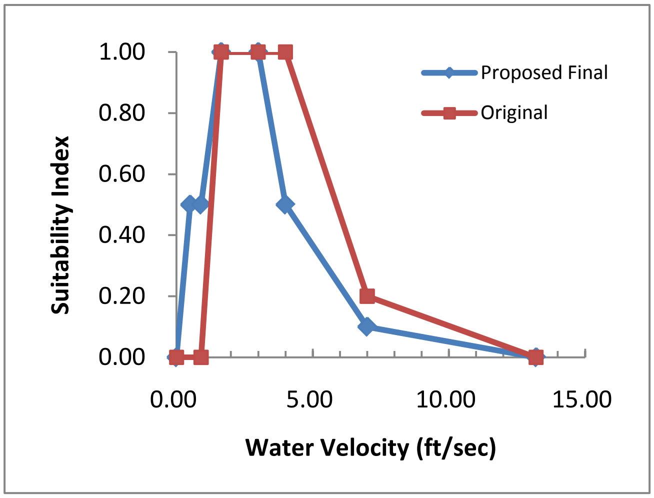


Code	Final SI Value	Original SI Value	Type
1	0.00	1.00	Detritus/Organic
2	0.40	1.00	Mud/soft clay
3	0.00	1.00	Silt
4	1.00	1.00	Sand
5	1.00	0.90	Gravel
6	0.60	0.60	Cobble/rubble
7	0.10	0.40	Boulder
8	0.00	0.20	Bedrock

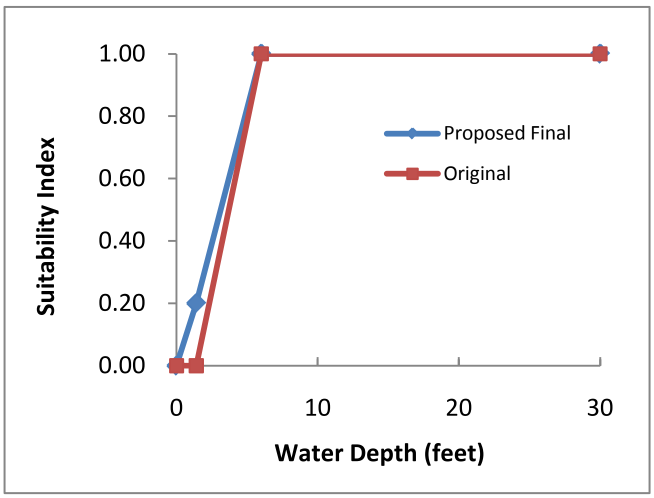


Species: Striped Bass
Lifestage: Spawning

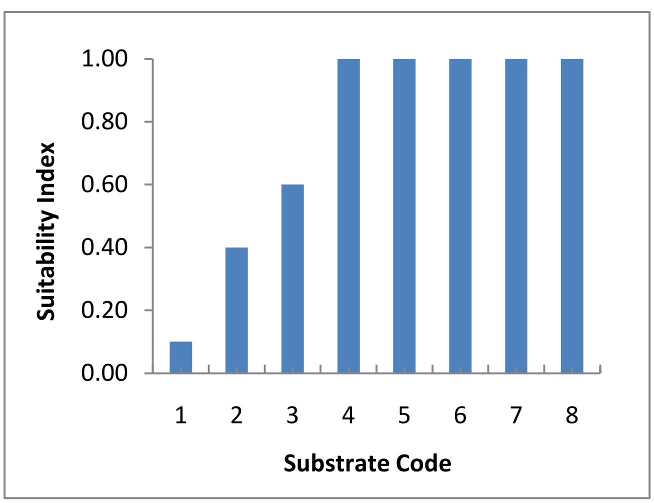
Proposed Final		Original	
Velocity	SI Value	Velocity	SI Value
0.00	0.00	0.00	0.00
0.50	0.50	0.90	0.00
0.90	0.50	1.64	1.00
1.64	1.00	3.00	1.00
3.00	1.00	4.00	1.00
4.00	0.50	7.00	0.20
7.00	0.10	13.20	0.00
13.20	0.00		



Proposed Final		Original	
Depth	SI Value	Depth	SI Value
0.00	0.00	0.0	0.00
1.40	0.20	1.4	0.00
6.00	1.00	6.0	1.00
30.0	1.00	30.0	1.00

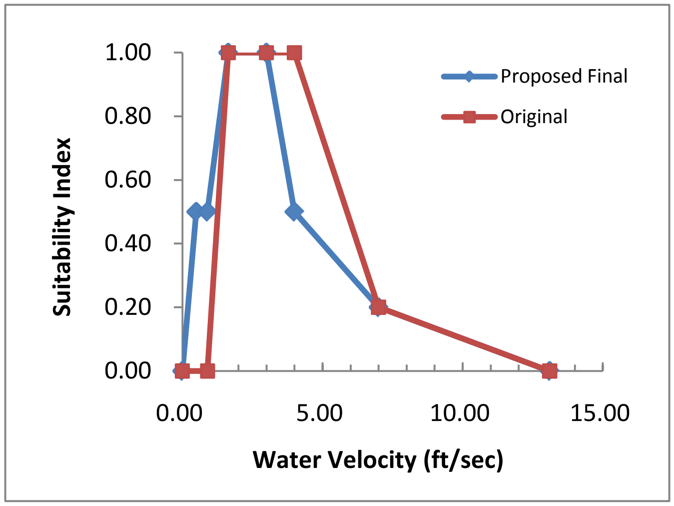


Code	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock

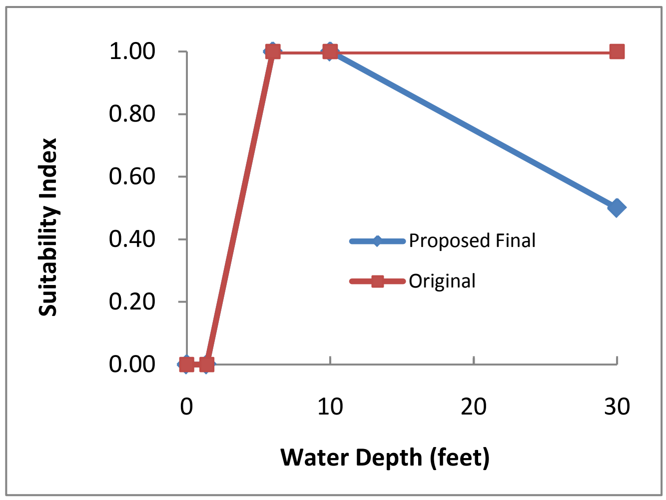


Species: Striped Bass
Lifestage: Fry

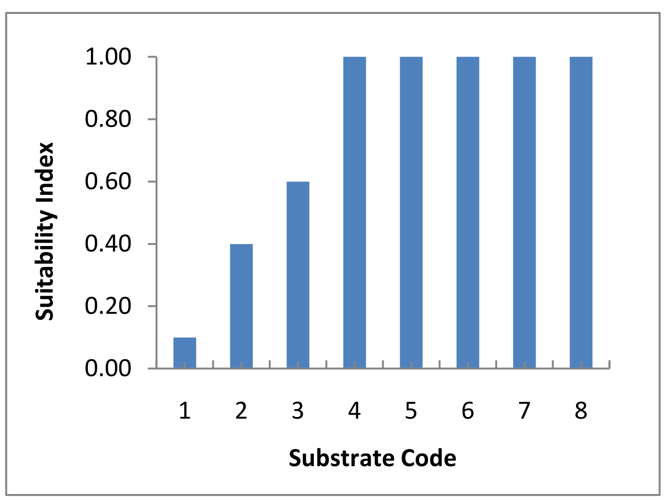
Proposed Final		Original	
Velocity	SI Value	Velocity	SI Value
0.00	0.00	0.00	0.00
0.50	0.50	0.90	0.00
0.90	0.50	1.64	1.00
1.64	1.00	3.00	1.00
3.00	1.00	4.00	1.00
4.00	0.50	7.00	0.20
7.00	0.20	13.10	0.00
13.10	0.00		



Proposed Final		Original	
Depth	SI Value	Depth	SI Value
0.00	0.00	0.0	0.00
1.40	0.00	1.4	0.00
6.00	1.00	6.0	1.00
10.0	1.00	10.0	1.00
30.0	0.50	30.0	1.00

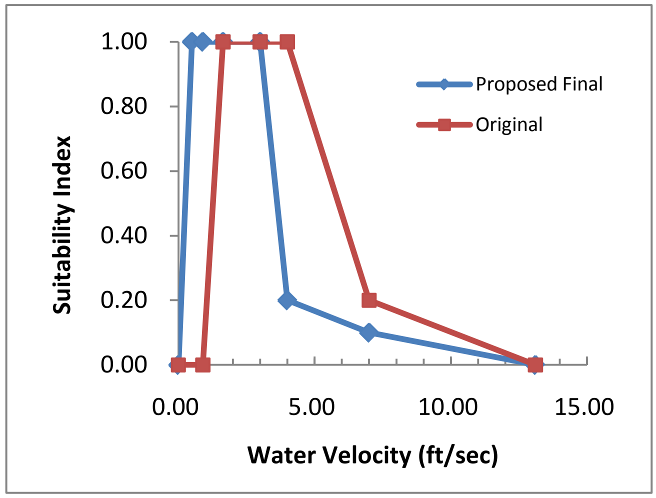


Code	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock

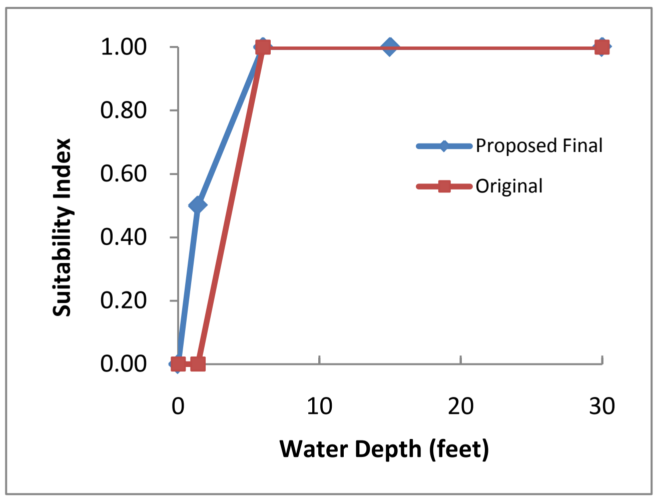


Species: Striped Bass
Lifestage: Juvenile

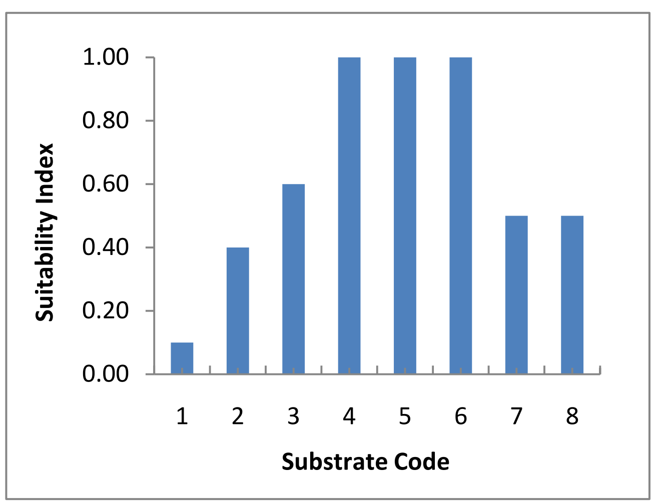
Proposed Final		Original	
Velocity	SI Value	Velocity	SI Value
0.00	0.00	0.00	0.00
0.50	1.00	0.90	0.00
0.90	1.00	1.64	1.00
1.64	1.00	3.00	1.00
3.00	1.00	4.00	1.00
4.00	0.20	7.00	0.20
7.00	0.10	13.10	0.00
13.10	0.00		



Proposed Final		Original	
Depth	SI Value	Depth	SI Value
0.00	0.00	0.0	0.00
1.40	0.50	1.4	0.00
6.00	1.00	6.0	1.00
15.0	1.00	30.0	1.00
30.0	1.00		

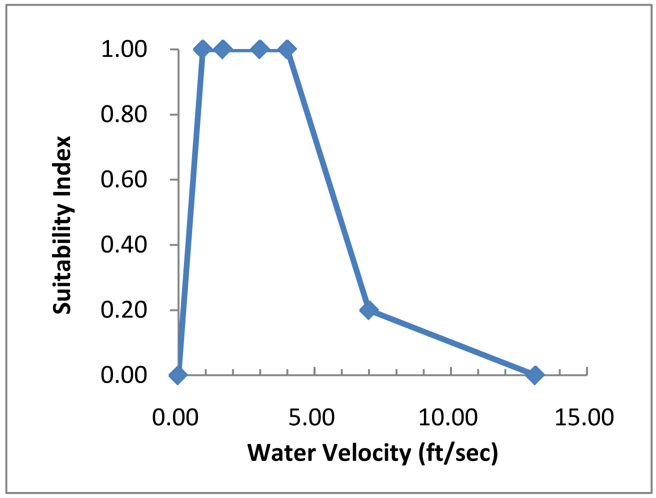


Code	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	0.5	Boulder
8	0.5	Bedrock

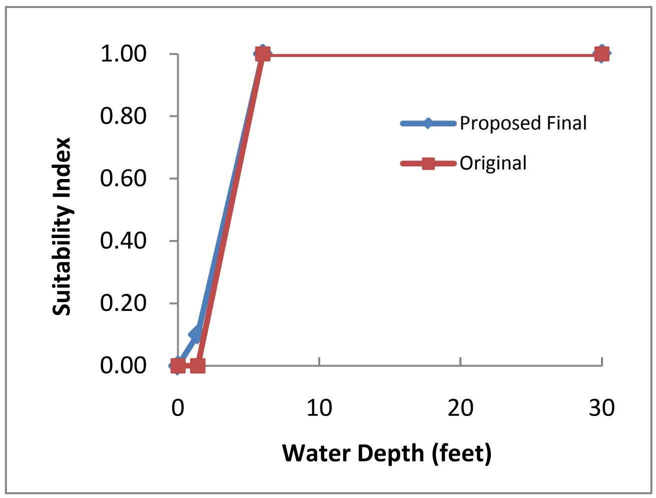


Species: Striped Bass
Lifestage: Adult

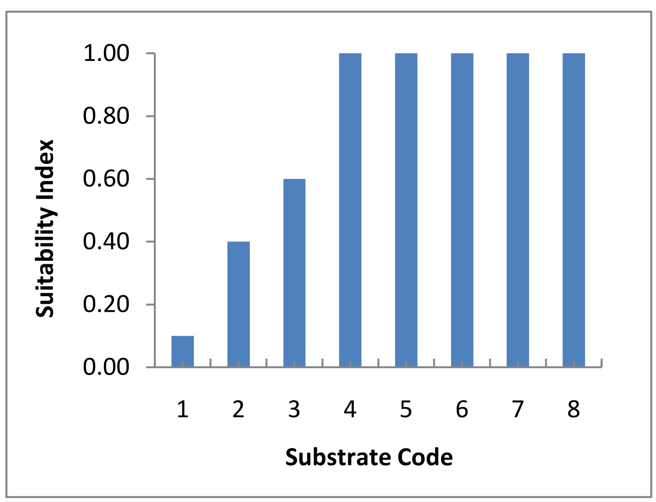
Velocity	SI Value
0.00	0.00
0.90	1.00
1.64	1.00
3.00	1.00
4.00	1.00
7.00	0.20
13.10	0.00



Proposed Final		Original	
Depth	SI Value	Depth	SI Value
0.00	0.00	0.0	0.00
1.40	0.10	1.4	0.00
6.00	1.00	6.0	1.00
30.0	1.00	30.0	1.00

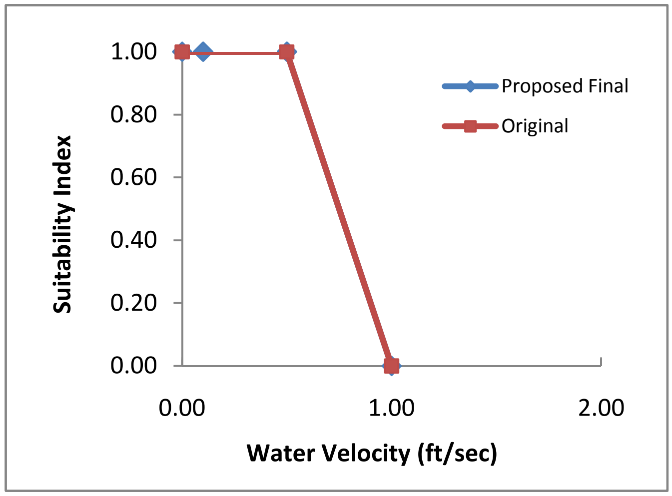


Code	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock

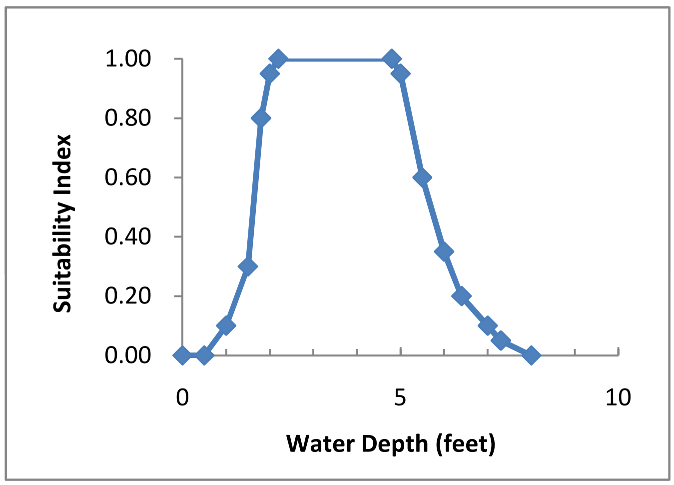


Species: Smallmouth Bass
Lifestage: Spawning

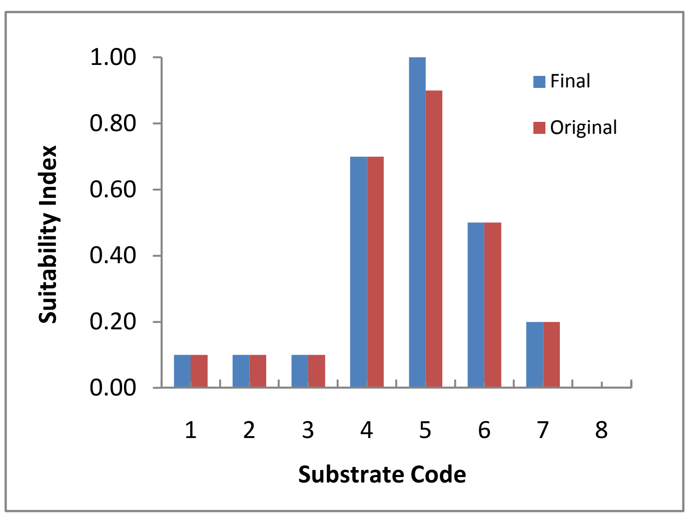
Proposed Final		Original	
Velocity	SI Value	Velocity	SI Value
0.00	1.00	0.00	1.00
0.10	1.00	0.50	1.00
0.50	1.00	1.00	0.00
1.00	0.00		



Depth	SI Value
0.00	0.00
0.50	0.00
1.00	0.10
1.50	0.30
1.80	0.80
2.00	0.95
2.20	1.00
4.80	1.00
5.00	0.95
5.50	0.60
6.00	0.35
6.40	0.20
7.00	0.10
7.30	0.05
8.00	0.00

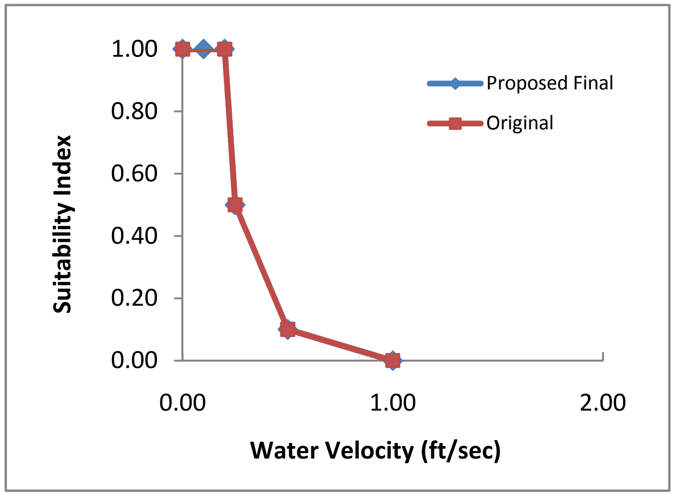


Code	Final SI Value	Original SI Value	Type
1	0.10	0.10	Detritus
2	0.10	0.10	Mud
3	0.10	0.10	Silt
4	0.70	0.70	Sand
5	1.00	0.90	Gravel
6	0.50	0.50	Cobble
7	0.20	0.20	Boulder
8	0.00	0.00	Bedrock

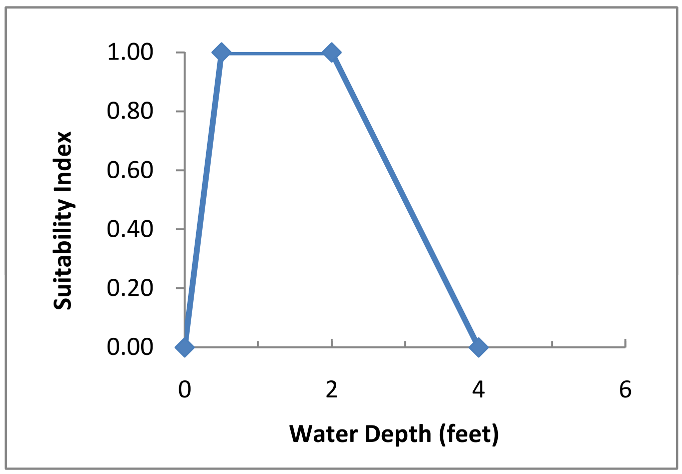


Species: Smallmouth Bass
Lifestage: Fry

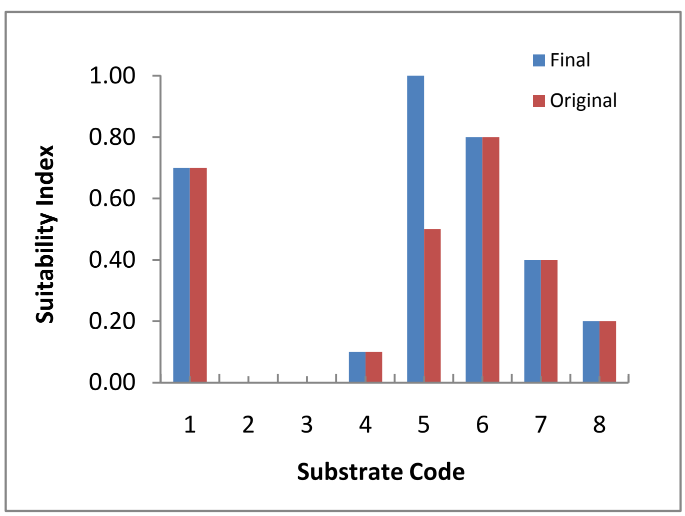
Proposed Final		Original	
Velocity	SI Value	Velocity	SI Value
0.00	1.00	0.00	1.00
0.10	1.00	0.20	1.00
0.20	1.00	0.25	0.50
0.25	0.50	0.50	0.10
0.50	0.10	1.00	0.00
1.00	0.00		



Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
4.00	0.00

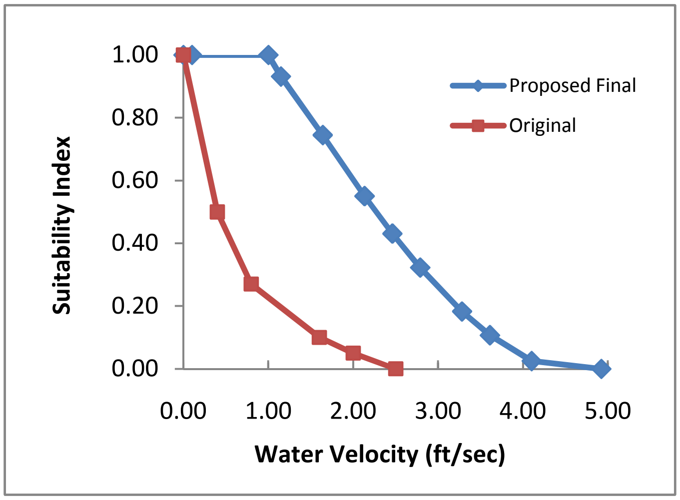


Code	Final SI Value	Original SI Value	Type
1	0.70	0.70	Detritus
2	0.00	0.00	Mud
3	0.00	0.00	Silt
4	0.10	0.10	Sand
5	1.00	0.50	Gravel
6	0.80	0.80	Cobble
7	0.40	0.40	Boulder
8	0.20	0.20	Bedrock

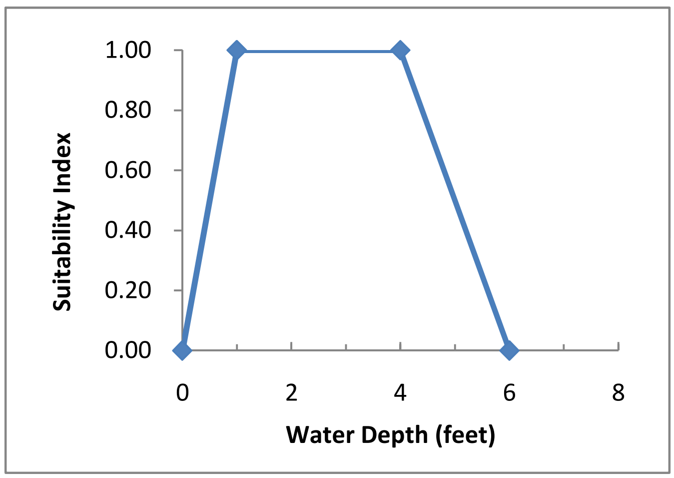


Species: Smallmouth Bass
Lifestage: Juvenile

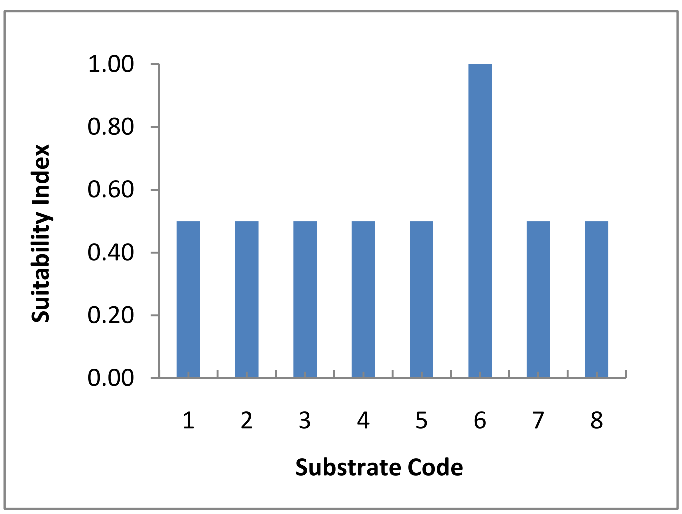
Proposed Final		Original	
Velocity	SI Value	Velocity	SI Value
0.00	1.00	0.00	1.00
0.10	1.00	0.40	0.50
1.00	1.00	0.80	0.27
1.15	0.93	1.60	0.10
1.64	0.75	2.00	0.05
2.13	0.55	2.50	0.00
2.46	0.43		
2.79	0.32		
3.28	0.18		
3.61	0.11		
4.10	0.02		
4.92	0.00		



Depth	SI Value
0.00	0.00
1.00	1.00
4.00	1.00
6.00	0.00

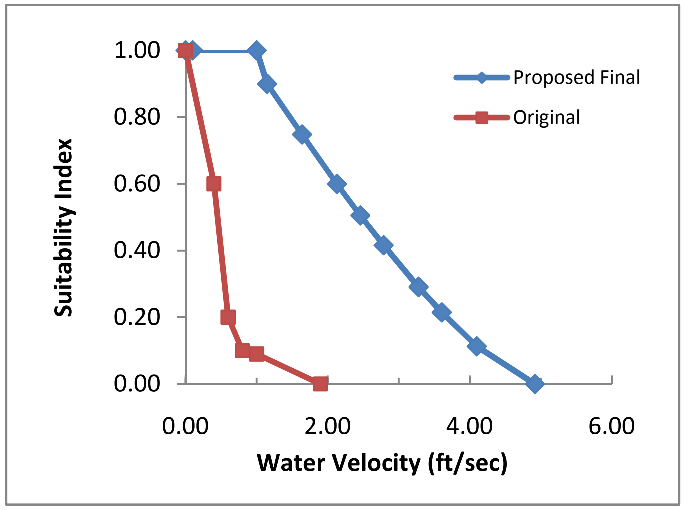


Code	SI Value	Type
1	0.50	Detritus/Organic
2	0.50	Mud/soft clay
3	0.50	Silt
4	0.50	Sand
5	0.50	Gravel
6	1.00	Cobble/rubble
7	0.50	Boulder
8	0.50	Bedrock

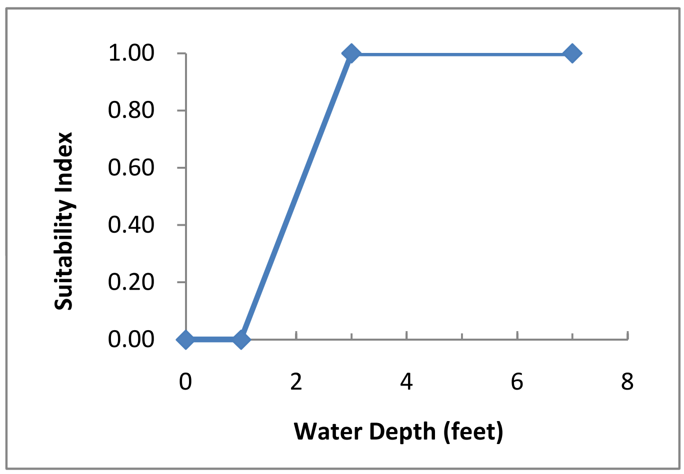


Species: Smallmouth Bass
Lifestage: Adult

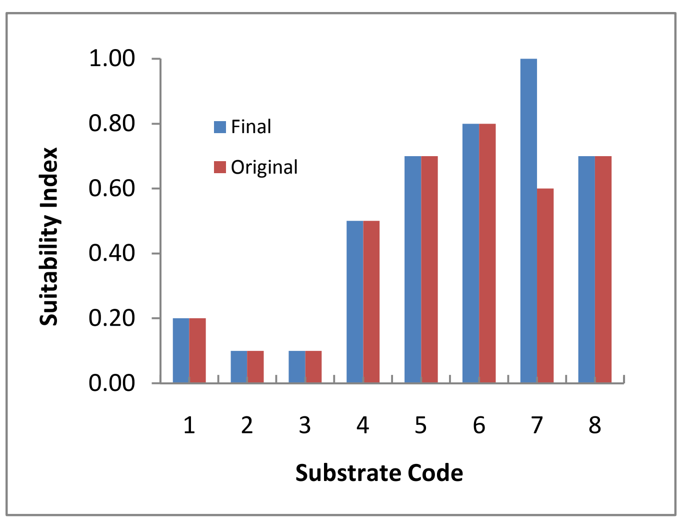
Proposed Final Velocity	Proposed Final SI Value	Original Velocity	Original SI Value
0.00	1.00	0.00	1.00
0.10	1.00	0.40	0.60
1.00	1.00	0.60	0.20
1.15	0.90	0.80	0.10
1.64	0.75	1.00	0.09
2.13	0.60	1.90	0.00
2.46	0.51		
2.79	0.42		
3.28	0.29		
3.61	0.21		
4.10	0.11		
4.92	0.00		



Depth	SI Value
0.00	0.00
1.00	0.00
3.00	1.00
7.00	1.00

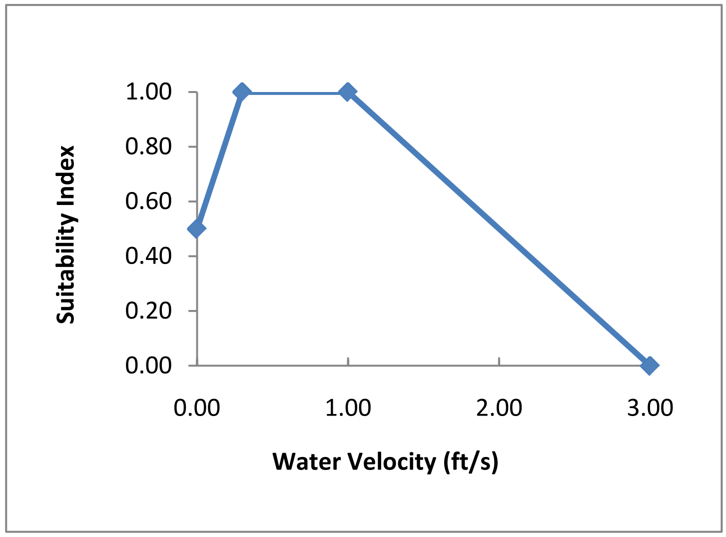


Code	Final SI Value	Original SI Value	Type
1	0.20	0.20	Detritus
2	0.10	0.10	Mud
3	0.10	0.10	Silt
4	0.50	0.50	Sand
5	0.70	0.70	Gravel
6	0.80	0.80	Cobble
7	1.00	0.60	Boulder
8	0.70	0.70	Bedrock

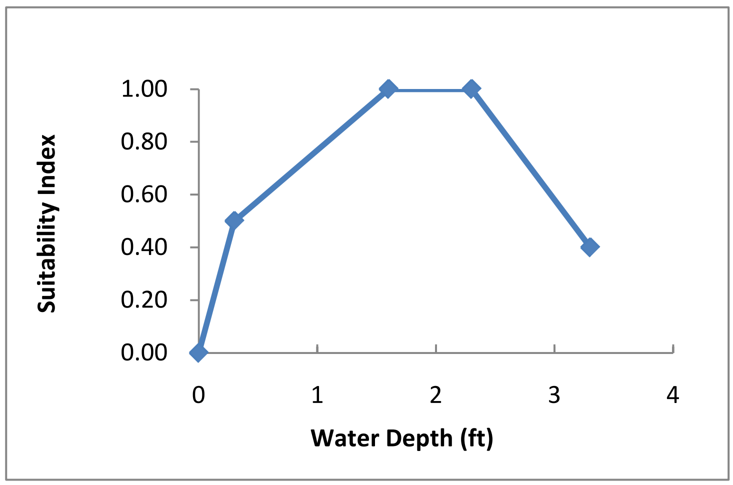


Species: Ephemeroptera (Mayflies)
Lifestage: Community Diversity -Large River

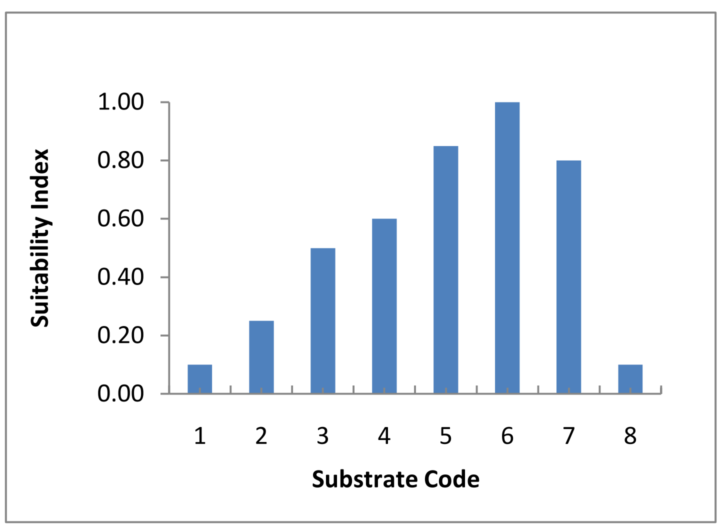
Velocity	SI Value
0.00	0.50
0.30	1.00
1.00	1.00
3.00	0.00



Depth	SI Value
0.00	0.00
0.30	0.50
1.60	1.00
2.30	1.00
3.30	0.40

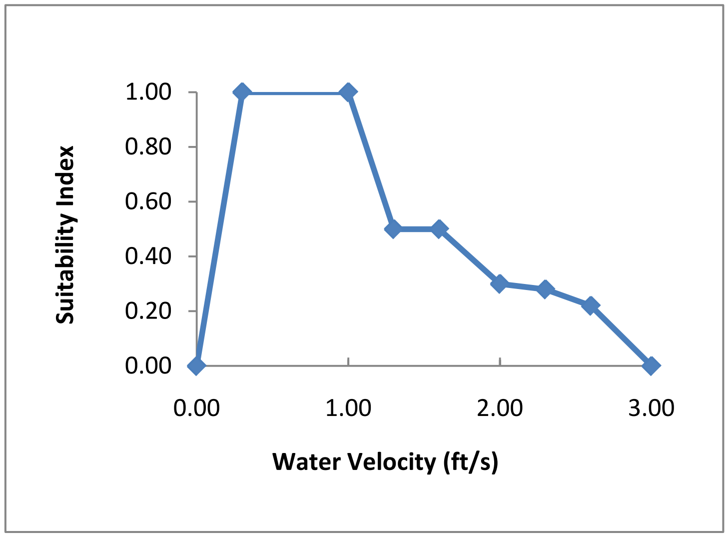


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.25	Mud/soft clay
3	0.50	Silt
4	0.60	Sand
5	0.85	Gravel
6	1.00	Cobble/rubble
7	0.80	Boulder
8	0.10	Bedrock

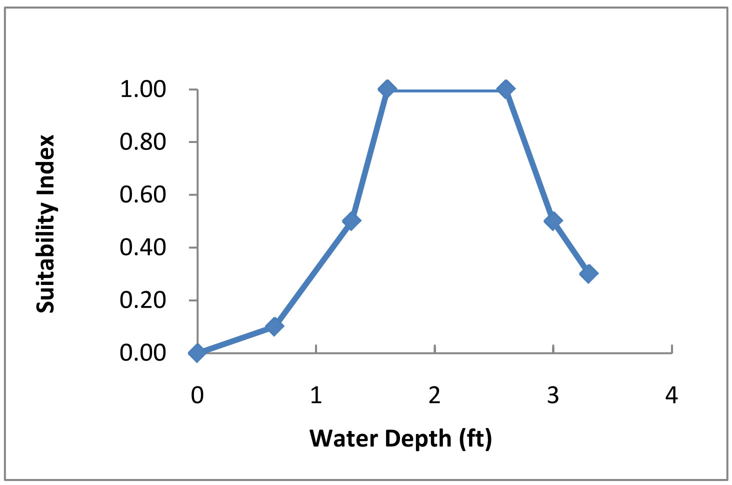


Species: Plecoptera (Stoneflies)
Lifestage: Community Diversity -Large River

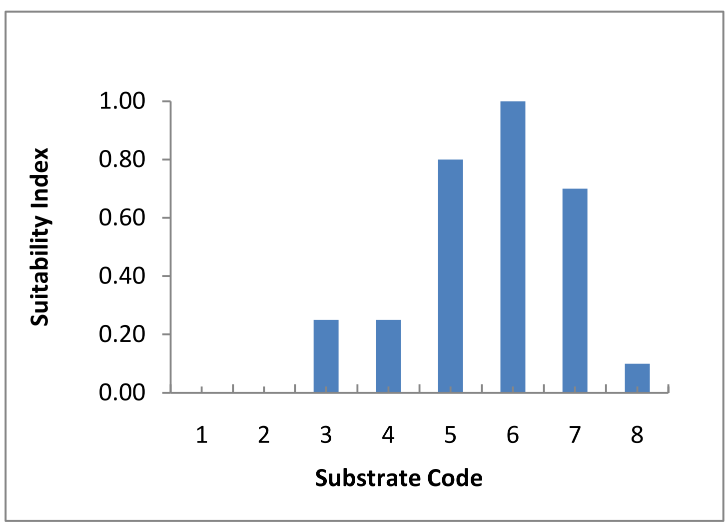
Velocity	SI Value
0.00	0.00
0.30	1.00
1.00	1.00
1.30	0.50
1.60	0.50
2.00	0.30
2.30	0.28
2.60	0.22
3.00	0.00



Depth	SI Value
0.00	0.00
0.65	0.10
1.30	0.50
1.60	1.00
2.60	1.00
3.00	0.50
3.30	0.30

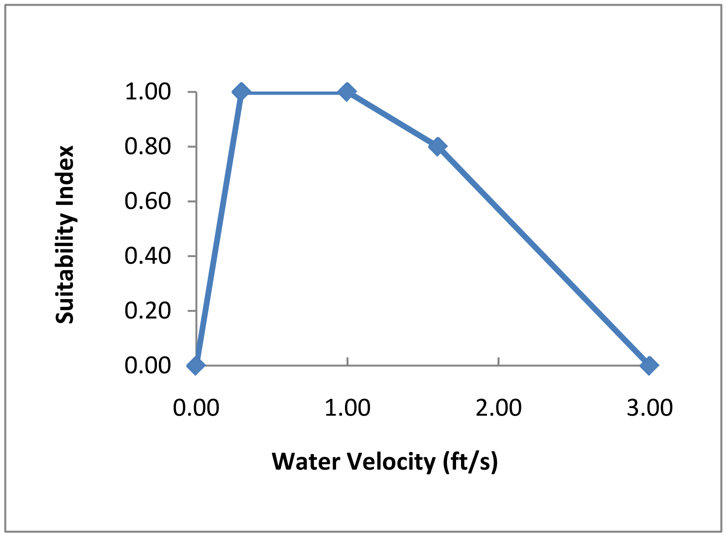


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.25	Silt
4	0.25	Sand
5	0.80	Gravel
6	1.00	Cobble/rubble
7	0.70	Boulder
8	0.10	Bedrock

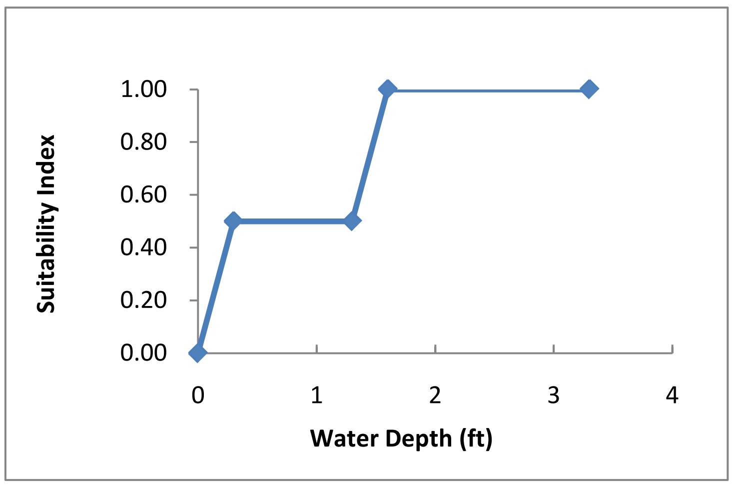


Species: Tricoptera (Caddisflies)
Lifestage: Community Diversity -Large River

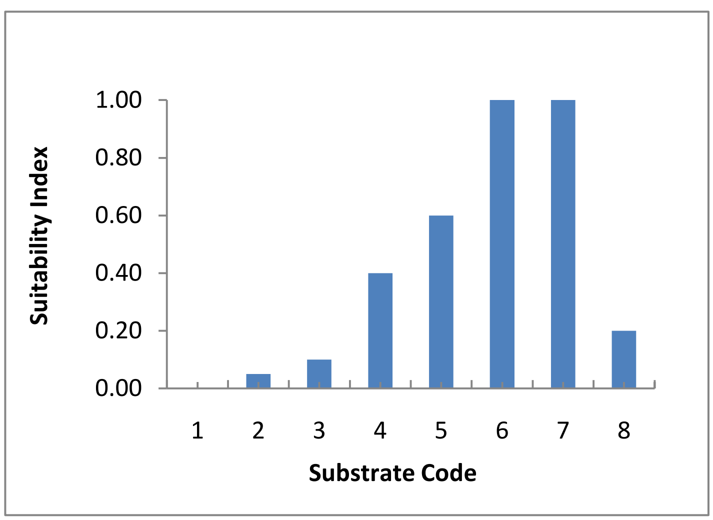
Velocity	SI Value
0.00	0.00
0.30	1.00
1.00	1.00
1.60	0.80
3.00	0.00



Depth	SI Value
0.00	0.00
0.30	0.50
1.30	0.50
1.60	1.00
3.30	1.00

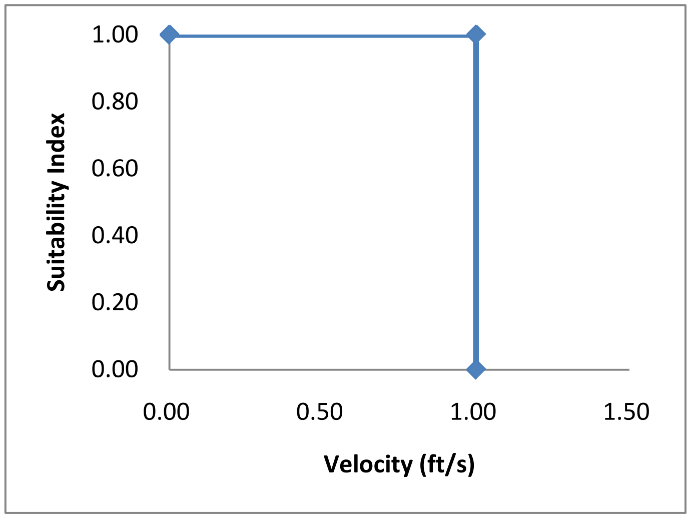


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.05	Mud/soft clay
3	0.10	Silt
4	0.40	Sand
5	0.60	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	0.20	Bedrock

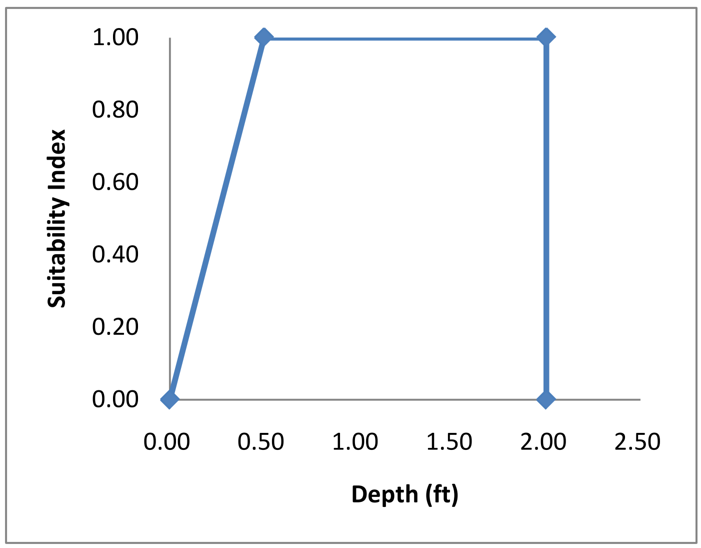


Species: Shallow-Slow Guild

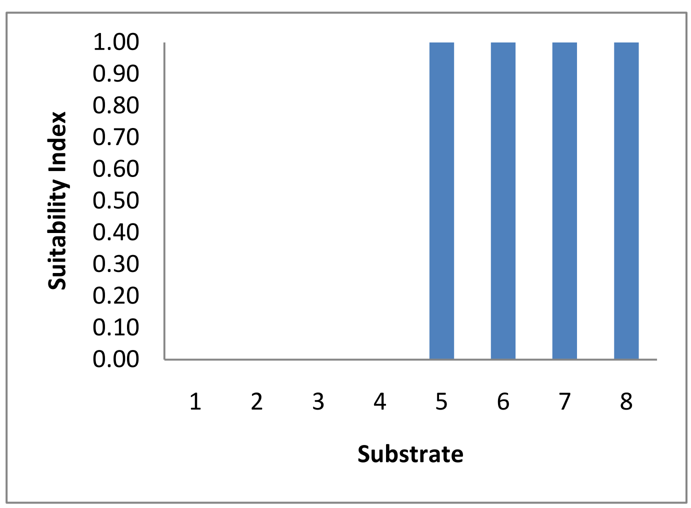
Velocity	SI Value
0.00	1.00
1.00	1.00
1.00	0.00



Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
2.00	0.00

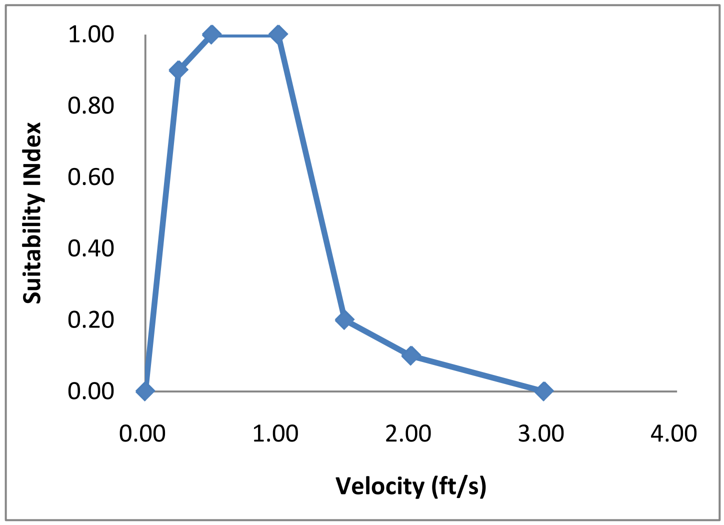


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock

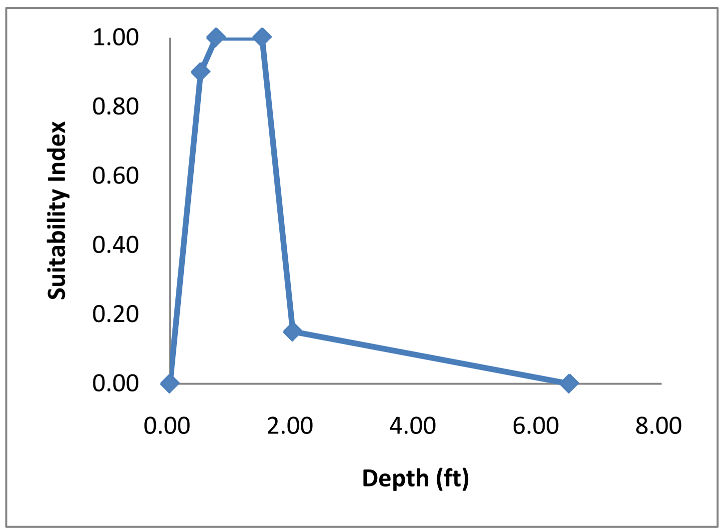


Species: Shallow-Fast Guild

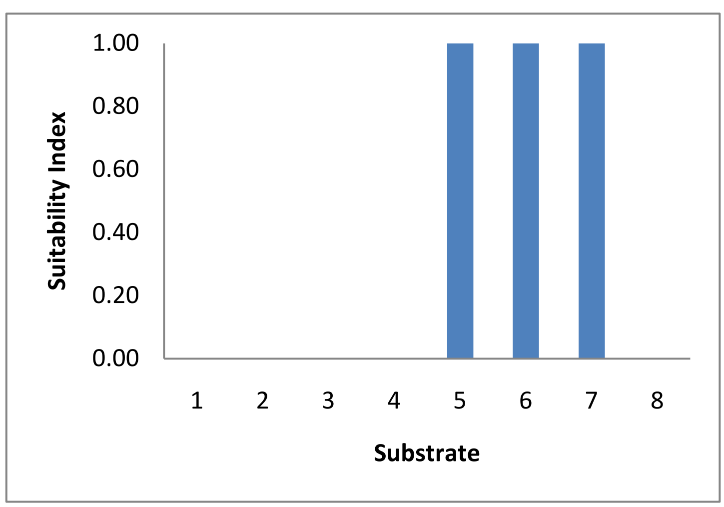
Velocity	SI Value
0.00	0.00
0.25	0.90
0.50	1.00
1.00	1.00
1.50	0.20
2.00	0.10
3.00	0.00



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

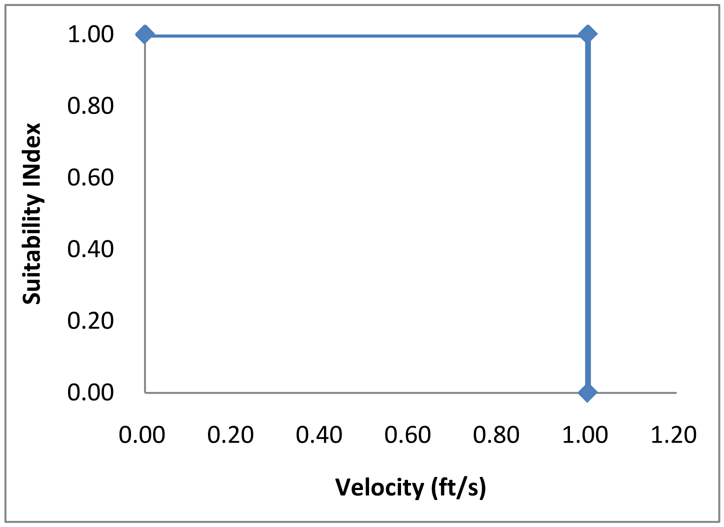


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	0.00	Bedrock

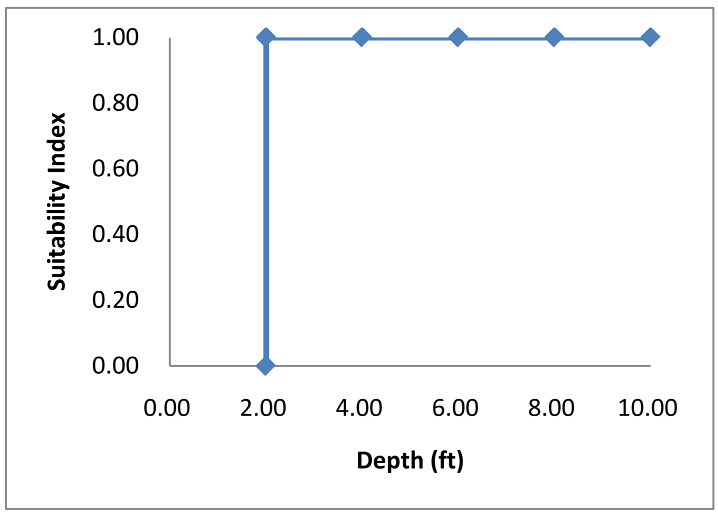


Species: Deep-Slow Guild

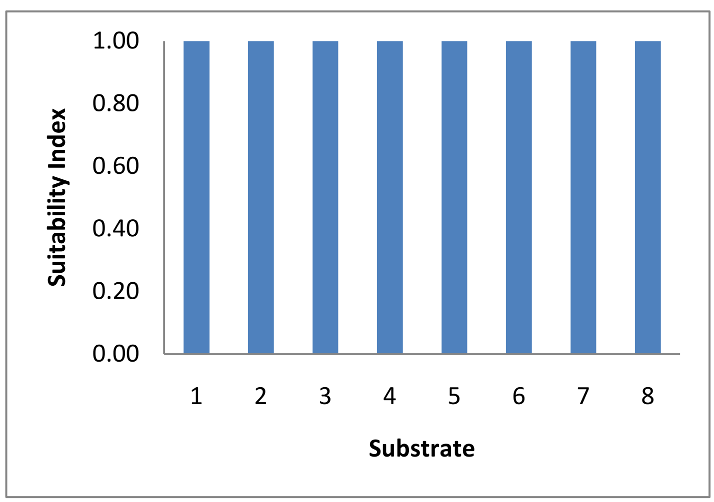
Velocity	SI Value
0.00	1.00
1.00	1.00
1.00	0.00



Depth	SI Value
2.00	0.00
2.00	1.00
4.00	1.00
6.00	1.00
8.00	1.00
10.00	1.00

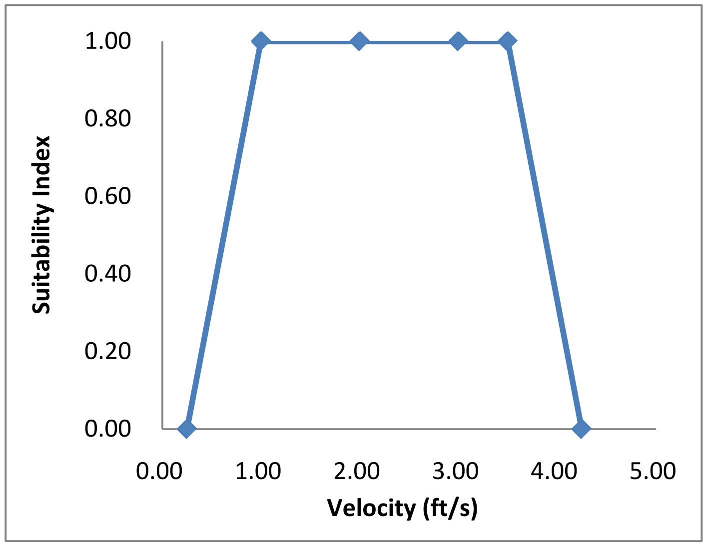


Code	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock

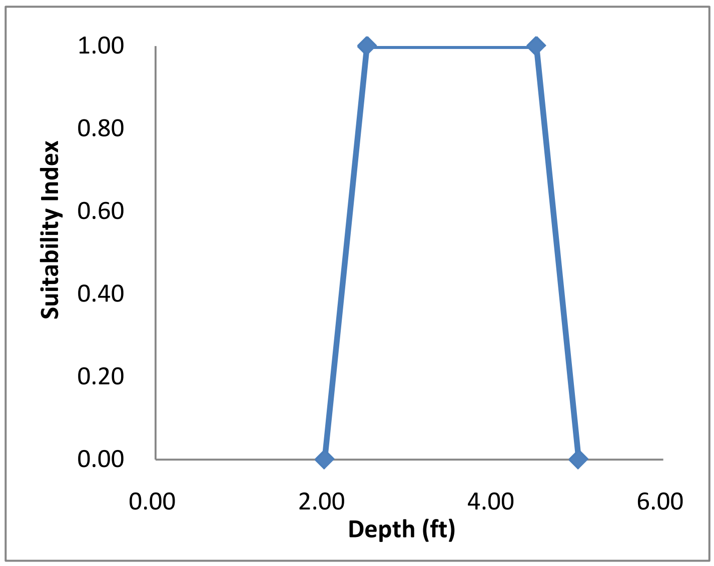


Species: Deep-Fast Guild

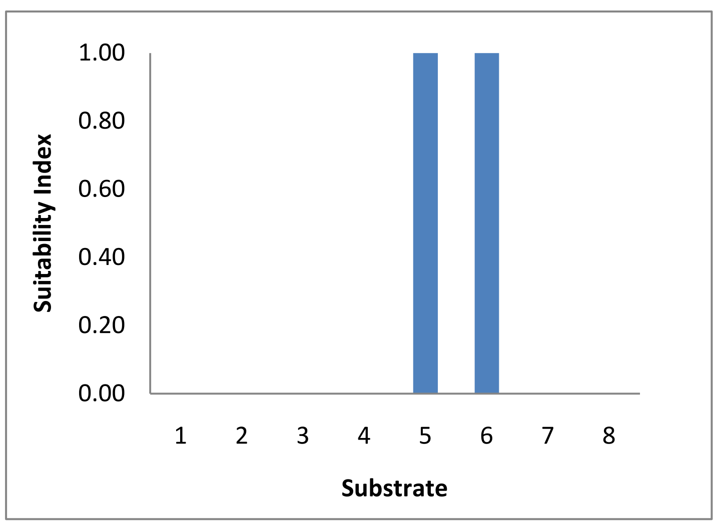
Velocity	SI Value
0.25	0.00
1.00	1.00
2.00	1.00
3.00	1.00
3.50	1.00
4.25	0.00



Depth	SI Value
2.00	0.00
2.50	1.00
4.50	1.00
5.00	0.00



Code	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



Appendix B- Revised Periodicity Table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
American shad												
Spawning				■	■	■						
Fry					■	■	■					
Juveniles							■	■	■	■	■	
Adults				■	■	■						
Hickory shad												
Spawning			■	■	■							
Fry				■	■	■						
Juveniles						■						
Adults			■	■	■							
Blueback herring												
Spawning				■	■	■						
Fry					■	■						
Juveniles							■	■	■	■		
Adults				■	■	■						
Alewife												
Spawning				■	■							
Fry			■	■	■							
Juveniles						■	■	■	■	■		
Adults				■	■							
White perch												
Spawning				■	■	■						
Fry				■	■	■	■					
Juveniles					■	■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Yellow perch												
Spawning			■	■								
Fry				■	■							
Juveniles						■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Striped bass												
Spawning				■	■	■						
Fry				■	■	■	■					
Juveniles						■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Largemouth bass												
Spawning					■	■						
Fry						■	■					
Juveniles								■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Smallmouth bass												
Spawning					■	■						
Fry						■	■					
Juveniles								■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Walleye												
Spawning			■	■								
Fry				■	■	■						
Juveniles						■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Shortnose sturgeon												
Spawning				■	■							
Fry					■	■	■					
Juveniles/Adults	■	■	■	■	■	■	■	■	■	■	■	■
Atlantic sturgeon												
Spawning				■	■							
Fry					■	■	■					
Juveniles/Adults	■	■	■	■	■	■	■	■	■	■	■	■
American eel												
Elver				■	■	■	■	■	■	■		
Yellow	■	■	■	■	■	■	■	■	■	■	■	■
Silver									■	■	■	■
Alewife floater												
Adults/juveniles	■	■	■	■	■	■	■	■	■	■	■	■
Spawning										■	■	■
Larvae			■	■	■							
Eastern elliptio												
Adults/juveniles	■	■	■	■	■	■	■	■	■	■	■	■
Spawning	■	■	■									
Larvae				■	■	■	■	■				
Fingernail clams												
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Spawning/larvae	■	■	■	■	■	■	■	■	■	■	■	■
Ephemeroptera-Plecoptera-Trichoptera												
all life stages	■	■	■	■	■	■	■	■	■	■	■	■

Appendix C- Revised Habitat Guild Assignment Table

A=Adult, J=Juvenile, F=Fry, S=Spawning

Species	Habitat Guild			
	Shallow-slow (< 2 ft, < 1 ft/s)	**Shallow-fast (< 2 ft, > 1 ft/s)**	**Deep slow (> 2 ft, < 1 ft/s)**	**Deep-fast (> 2 ft, > 1 ft/s)**
American shad*	F, J		J	A, S
Hickory shad	F		J, S	A
Blueback herring	F, J		A, S	
Alewife	F, J		A, S	
White perch	F, J	S	A, J	S
Yellow perch	F		A, J, S	
Striped bass *	F, J, S		F, J, S	A, S
Largemouth bass	F, J, S		A, F, J, S	
Smallmouth bass *	F		A, F, J, S	
Walleye			A, J, F	S
Shortnose sturgeon *	F	F	A, J, F	A, F, J, S
Atlantic sturgeon			A, J, F	A, F, J, S
American eel	J		A, J	J
EPT**	√	√	√	√

*Species of special concern for instream flow assessment.
** Ephemeroptera-Plecoptera-Trichoptera

Appendix D- HSI References

Aadland, L.P. 1993. Stream habitat types: their fish assemblages and relationship to flow. North American Journal of Fisheries Management 13:790-806.

Aadland, L.P. and A. Kuitunen. 2006. Habitat suitability criteria for stream fishes and mussels of Minnesota. Division of Ecological Services, Special Publication No. 62. Minnesota Department of Natural Resources, St. Paul, MN.

Angermeier, P. L. 1987. Spatiotemporal variation in habitat selection by fishes in small Illinois streams. 52–60. in W. J. Matthews and D. C. Heins, editors. Community and evolutionary ecology of North American stream fish. University of Oklahoma Press, Norman.

Atlantic States Marine Fisheries Commission.2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Habitat Management Series No.9, Washington, D.C.

Crance, J.H. 1986. Habitat suitability information: Shortnose sturgeon. U.S. Fish Wildl. Serv. Biol. Rep. FWS/OBS-82/10.129. 31pp.

Crance, J.H. 1984. Habitat suitability index models and instream flow suitability curves: Inland stocks of striped bass. U.S. Fish Wildl. Serv. FWS/OBS-82/10.85. 63pp.

DTA. 2005. Duke Power Catawba-Wateree relicensing (FERC No.2232) Instream flow study report.

Gore, J.A., J.B. Layzer, and J.Mead. Macroinvertebrate instream flow studies after 20 years: a role in stream management and restoration. Regul. Rivers: Res. Mgmt. 17:527-542.

Kieffer, M., B. Kynard. Spawning of Connecticut River Shortnose Sturgeon: Migration, Homing, Timing, Adult Demography, Suitability Windows, Sites and Habitat, Failures, and the Effect of River Regulation on Spawning Success. In press.

Kynard, B., D. Pugh, T. Parker, and M. Kieffer. Spawning of shortnose sturgeon in an artificial stream: adult behavior and early life history. In press.

Kynard, B., M. Horgan, M. Kieffer, and D. Seibel. 2000. Habitats used by shortnose sturgeon in two Massachusetts rivers, with notes on estuarine Atlantic sturgeon: a hierarchical approach. Transactions of the American Fisheries Society 129: 487 – 503.

Leonard, P.M. and D.J. Orth. 1988. Use of habitat guilds of fishes to determine instream flow requirements. North American Journal of Fisheries Management 8:399-409.

Normandeau Associates,Inc. 2000.An instream flow study in support of relicensing of the Piney Hydroelectric Station FERC Project No.309. Prepared for Foster Wheeler Environmental Corporation, Langhorne, PA and Sithe Pennsylvania Holdings LLC, Johnstown,PA.

Progress Energy. 2003. Pee Dee River instream flow study (FERC No. 2206).

Richmond, A. M., and B. Kynard. 1995. Ontogenetic behavior of shortnose sturgeon, *Acipenser brevirostrum*. Copeia 1995:172–182.

RMC.1992. Results of an incremental flow study in the bypassed reach at the Walters Hydroelectric Project, Pigeon River,, North Carolina. Prepared for Carolina Power and Light Company, Raleigh, NC.

Ross, R.M.,T.W.W. Backman, and R.M.Bennett.1993. Evaluation of habitat suitability index models for riverine life satges of American shad, with proposed models for premigratory juveniles. U.S.Fish and Wildlife Service Bilogical Report 14.

Ross, S. T., J. A. Baker, and K. E. Clark. 1987. Microhabitat partitioning of southeastern stream fishes: Temporal and spatial predictability. In: Matthews, W. J. and D. C. Heins (eds.). Symposium on the Evolutionary and Community Ecology of North American Stream Fishes. University of Oklahoma Press, p. 4251.

Seibel, D. 1991. Habitat selection, movements, and response to illumination by shortnose sturgeon in the Connecticut River. Master's thesis. University of Massachusetts, Amherst.

Stier, D.J., and J.H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. United States Fish and Wildlife Service Biological Report 82(10.88). 34pp.

Todd, B.L. and C.F. Rabeni. 1989. Movement and habitat use by stream dwelling smallmouth bass. Transaction of the American Fisheries Society 118:229-242.

CONOWINGO HYDROELECTRIC PROJECT (FERC No. 405)

Meeting Agenda to Discuss Habitat Suitability Criteria Selection for the Instream Flow Habitat Assessment below Conowingo Dam (RSP 3.16)

Thursday August 19, 2010
10:30 am to 12:30 pm
Conowingo Project Visitors Center, Darlington, MD
Teleconference Participation: 1-866-763-1619, Code 4531781#

1.	Verify target species and life stages	1:00 – 1:15
2.	Discuss periodicity chart	1:15 – 1:30
3.	Discuss habitat guilds	1:30 – 1:45
4.	Discuss selection of species of concern	1:45 – 2:00
5.	Review and Come to Agreement on Habitat Suitability Curves	2:00 – 3:00

MEMORANDUM

July 13, 2010

TO: Larry Miller (USFWS), Andy Shiels (PFBC), Mike Hendricks (PFBC), Jim Richenderfer (SRBC), Andrew Dehoff (SRBC), Julie Crocker (NOAA), Shawn Seaman (MDNR), Bob Sadzinski (MDNR), Steve Schreiner (Versar Inc.), Bill Richkus (Versar Inc.), Jim Spontak (PaDEP), Janet Norman (USFWS), Jeremy Miller (PaDEP), John Smith (FERC), Mark Bryer (The Nature Conservancy), John Seebach (American Rivers), Don Pugh (American Rivers)

FROM: Colleen Hicks, Exelon Power

Re: Habitat Suitability Criteria Selection for the Instream Flow Habitat Assessment below Conowingo Dam (RSP 3.16). Conowingo Hydroelectric Project, FERC No. 405, Relicensing.

INTRODUCTION

This memo's purpose is to initiate the consultation process with resource agencies to select appropriate habitat suitability criteria for target species to be analyzed within the Instream Flow Habitat Assessment Study for the Conowingo Hydroelectric Project. The following sections describe the habitat suitability criteria selection methodology proposed by Exelon. This information is being provided so that it can be reviewed by resource agencies and subsequently discussed in order to finalize selection of habitat suitability criteria. Exelon is proposing a review period for resource agencies, followed by a meeting the week of August16th with the goal of finalizing the habitat suitability criteria at that time.

HABITAT SUITABILITY CRITERIA

As part of the Integrated Licensing Process (ILP) study scoping process, resource agencies proposed the following target fish species for analysis in the study: American shad, hickory shad, blueback herring, alewife, white perch, striped bass, yellow perch, walleye, largemouth bass, smallmouth bass, shortnose sturgeon, Atlantic sturgeon and American eel. In addition, macroinvertebrates, mussels, and aquatic plants were proposed for analysis.

Habitat suitability criteria for this study will rely upon pre-existing literature and the professional judgment of resource agency and Exelon biologists. In the case of mussels, site-specific data (i.e., depth, velocity, and substrate) will be collected during the mussel surveys conducted as part of Conowingo RSP 3.19-Freshwater Mussel Characterization Study below Conowingo Dam, and used to corroborate the mussel habitat suitability criteria described below.

Exelon is proposing that the Instream Flow Habitat Assessment Study examine the relationships between aquatic habitat and river flow for several species of special concern (American shad, Striped bass, shortnose sturgeon, which will also act as a surrogate for Atlantic sturgeon, smallmouth bass, yellow lamp mussel, and green floater) and rely on habitat-based species guilds for examining project impacts on the remaining target species. This approach will allow for analysis of aquatic habitat available at a range of Conowingo Hydroelectric Project generation levels and Susquehanna River flows.

The IFIM Instream flow procedure provides a widely used tool for explicitly analyzing habitat availability for fishes and other biota as a function of flow regimes through the use of species-specific habitat suitability criteria. To facilitate decision making, such analyses are typically conducted only for a limited suite of evaluation species and life stages. Thus, the selection of appropriate habitat suitability criteria of the targeted species and life stages is typically an important determinant of the results of IFIM studies (Aadland 1993; Bowen *et al*. 1998). However, in species-rich communities typically inhabiting warmwater streams, decision making using species-specific models is more difficult (Bowen *et al*. 1998). One method for reducing the complexity of habitat requirements for a species-rich community and to overcome the above limitation is to aggregate species into habitat “guilds” (defined as a group of species that exploit the same class of environmental resources in a similar way). As such, habitat guilds are being proposed for use in the analysis of this study, along with the more focused analysis for species of special concern.

Several IFIM studies (*e.g.*, Bowen *et al*. 1998; Normandeau Associates 2000; Progress Energy 2004; DTA 2005) have utilized the habitat-based guild approach to show variation in aquatic habitat of organisms as a function of flow. Normandeau (2000) utilized this approach for the warm-water fish community inhabiting the Clarion River, PA with the concurrence of the Pennsylvania Fish and Boat Commission (PFBC).

Leonard and Orth (1988) and Aadland (1993) identified four primary habitat-use guilds that are proposed for use in this study. They are identified as follows:

- Shallow-fast (< 2 ft depth, > 1 ft/sec velocity) guild;
- Shallow-slow (< 2 ft depth, < 1 ft/sec) guild;
- Deep-fast (> 2 ft depth, > 1 ft/sec) ; and,
- Deep-slow (> 2 ft depth, < 1 ft/sec).

The following species have been identified as being of special concern:

- American shad: targeted for population enhancement in the Susquehanna River:
- Striped bass: important migratory species:
- Shortnose sturgeon: Rare, threatened, endangered species:
- Smallmouth bass: important resident species: and,
- Green floater and yellow lamp mussels: species are listed as endangered by the state of Maryland.
- Macroinvertebrates: important from a water quality and ecosystem perspective.

Appendix A provides literature sources used for habitat suitability curves for species of special concern and for each habitat-based guild. Appendix B provides the periodicity that selected species and life stage are expected to be below Conowingo Dam. Appendix C illustrates the habitat guild assignments for target species in the Project area. Appendix D shows the habitat suitability criteria proposed for use in the study. Should it become necessary, upon consultation or recommendation of resource agencies, these curves can be modified in advance of initiating habitat modeling. Modification of habitat suitability curves is a common practice in implementing an IFIM study. This may become necessary as new information becomes available or specific experience dictates modification of habitat suitability curves. For example, smallmouth bass habitat suitability curves were modified in consultation with resource agencies for an IFIM study conducted by RMC (1992) in Pigeon River, NC because additional information had become available since the initial habitat suitability criteria published by Edwards *et al* (1983).

Please review the information included in this memo to develop habitat suitability criteria. Exelon is proposing to rely on the methodology described above, in addition to the professional expertise of resource agencies involved in this relicensing process. Solid selection criteria will greatly aid in the success of the study.

Appendix A-Literature Sources for Habitat Suitability Curves

Sources of habitat suitability curves for species of special concern and habitat-based guilds.

	HSC Source		
Species	**Velocity**	**Depth**	**Substrate**
American shad[1, 2, 3]			
Spawning	Stier and Crance 1985.	Stier and Crance 1985.	ASMFC 2009.
Fry	Stier and Crance 1985.	Stier and Crance 1985.	Stier and Crance 1985.
Juvenile	Stier and Crance 1985.	Ross et al 1993.	Stier and Crance 1985.
Adult	Stier and Crance 1985.	Stier and Crance 1985.	Stier and Crance 1985.
Shortnose Sturgeon [4]			
Spawning	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Fry	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Juvenile	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Adult	Crance, J.H. 1986.	Crance, J.H. 1986.	Crance, J.H. 1986.
Striped bass [5]			
Spawning	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Fry	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Juvenile	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Adult	Crance, J.H. 1984.	Crance, J.H. 1984.	Crance, J.H. 1984.
Smallmouth bass [6, 7]			
Adult	North Carolina Department of Water Resources, RMC (1992)	Angermeier (1987), Ross et al (1987), Todd and Rabeni (1989)	North Carolina Department of Water Resources, RMC (1992)
Juvenile	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)
Fry	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)
Spawning	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)	North Carolina Department of Water Resources, RMC (1992)
Yellow lamp mussel [8]	Normandeau (2008); Normandeau numerous surveys		
Green floater [8]	Normandeau (2008); Normandeau numerous surveys		
Shallow-slow guild [9] (< 2 ft, < 1 ft/sec)	Leonard and Orth (1988); Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
Shallow-fast guild [9] (< 2 ft, > 1 ft/sec)	Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
Deep-slow [9] (> 2 ft, < 1ft/sec)	Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
Deep-fast [9] (> 2 ft, > 1 ft/sec)	Aadland (1993); Normandeau (2000); Progress Energy (2003); DTA (2005)		
Macroinvertebrates [10]	DTA 2005; Substrate Codes modified by Normandeau based on numerous studies		

1) Stier, D.J., and J.H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. United States Fish and Wildlife Service Biological Report 82(10.88). 34pp.

2) Ross, R.M.,T.W.W. Backman, and R.M.Bennett.1993. Evaluation of habitat suitability index models for riverine life satges of American shad, with proposed models for premigratory juveniles. U.S.Fish and Wildlife Service Bilogical Report 14.

3) Atlantic States Marine Fisheries Commission.2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Habitat Management Series No.9, Washington, D.C.

4) Crance, J.H. 1986. Habitat suitability information: Shortnose sturgeon. U.S. Fish Wildl. Serv. Biol. Rep. FWS/OBS-82/10.129. 31pp.

5) Crance, J.H. 1984. Habitat suitability index models and instream flow suitability curves: Inland stocks of striped bass. U.S. Fish Wildl. Serv. FWS/OBS-82/10.85. 63pp.

6) Original habitat suitability curves for smallmouth bass (Edwards *et al*. 1983; FWS/OBS-82/10.36) were modified in consultation with NCDWR for IFIM study in Pigeon River, NC (RMC 1992). RMC.1992. Results of an incremental flow study in the bypassed reach at the Walters Hydroelectric Project, Pigeon River,, North Carolina. Prepared for Carolina Power and Light Company, Raleigh, NC.

7) Angermeier, P. L. 1987. Spatiotemporal variation in habitat selection by fishes in small Illinois streams. 52–60. in W. J. Matthews and D. C. Heins, editors. Community and evolutionary ecology of North American stream fish. University of Oklahoma Press, Norman.

Ross, S. T., J. A. Baker, and K. E. Clark. 1987. Microhabitat partitioning of southeastern stream fishes: Temporal and spatial predictability. In: Matthews, W. J. and D. C. Heins (eds.).

Symposium on the Evolutionary and Community Ecology of North American Stream Fishes. University of Oklahoma Press, p. 4251.

Todd, B.L. and C.F. Rabeni. 1989. Movement and habitat use by stream dwelling smallmouth bass. Transaction of the American Fisheries Society 118:229-242.

8) Normandeau Associates, Inc. 2008. Preliminary mussel survey in the Susquehanna River in the vicinity of the proposed Bell Bend Nuclear Power Plant Site, Luzerne County, Pennsylvania.

9) Leonard, P.M. and D.J. Orth. 1988. Use of habitat guilds of fishes to determine instream flow requirements. North American Journal of Fisheries Management 8:399-409.

Aadland, L.P. 1993. Stream habitat types: their fish assemblages and relationship to flow. North American Journal of Fisheries Management 13:790-806.

Normandeau Associates,Inc. 2000.An instream flow study in support of relicensing of the Piney Hydroelectric Station FERC Project No.309. Prepared for Foster Wheeler Environmental Corporation, Langhorne, PA and Sithe Pennsylvania Holdings LLC, Johnstown,PA

Progress Energy. 2003. Pee Dee River instream flow study (FERC No. 2206).

DTA. 2005. Duke Power Catawba-Wateree relicensing (FERC No.2232) Instream flow study report.

Appendix B-Periodicity Chart for Target Species

Seasonal Periodicity of Occurrence of Target Species in the Susquehanna River below Conowingo Dam

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
American shad												
Spawning				■	■	■						
Fry					■	■	■					
Juvenile							■	■	■	■		
Adults				■	■	■						
Hickory shad												
Spawning				■	■	■						
Fry					■	■	■					
Juvenile												
Adults			■	■	■							
Blueback herring												
Spawning				■	■	■						
Fry					■	■						
Juvenile							■	■	■	■		
Adults				■	■	■						
Alewife												
Spawning				■	■							
Fry				■	■							
Juvenile						■	■	■	■	■		
Adults				■	■							
White perch												
Spawning				■	■	■						
Fry				■	■	■	■					
Juvenile						■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Yellow perch												
Spawning			■	■								
Fry				■	■							
Juvenile						■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Striped bass												
Spawning				■	■	■						
Fry				■	■	■	■					
Juvenile							■	■	■	■	■	■
Adults				■	■	■	■	■	■	■	■	■

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Largemouth bass												
Spawning					■	■						
Fry						■	■					
Juvenile								■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Smallmouth bass												
Spawning					■	■						
Fry						■	■					
Juvenile								■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Walleye												
Spawning			■	■								
Fry				■	■	■	■					
Juvenile								■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Shortnose sturgeon												
Spawning				■	■							
Fry					■	■	■					
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adults				■	■	■	■	■	■	■		
Atlantic sturgeon												
Spawning				■	■							
Fry					■	■	■					
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adults				■	■	■	■	■	■	■		
American eel												
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adults									■	■	■	■
Yellow lamp mussel												
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Spawning/larvae			■	■	■							
Green floater												
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Spawning/larvae			■	■	■							
Eastern elliptio												
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Spawning/larvae							■	■	■			
Fingernail clams												
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Spawning/larvae	■	■	■	■	■	■	■	■	■	■	■	■

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Macroinvertebrates												
All												
Aquatic Plants												
All												

Appendix C-Habitat Guild Assignments for Target Species

Species and Habitat Guild Assignments
A=Adult, J=Juvenile, F=Fry, S=Spawning

Species	Habitat Guild			
	Shallow-slow (< 2 ft, < 1 ft/s)	**Shallow-fast (< 2 ft, > 1 ft/s)**	**Deep slow (> 2 ft, < 1 ft/s)**	**Deep-fast (> 2 ft, > 1 ft/s)**
American shad*	F		J	A, J, S
Hickory shad	F		J, S	A
Blueback herring	F		A, J, S	
Alewife	F		A, J, S	
White perch	J, F	S	A, J	S
Yellow perch	F		A, J, S	
Striped bass *				A, J, F, S
Largemouth bass	J, S, F		A, J, F, S	
Smallmouth bass *	F		A, J, F, S	
Walleye			A, J, F	S
Shortnose sturgeon *			F	A, J, F, S
Atlantic sturgeon			F	A, J, F, S
American eel	J		A, J	J
Macroinvertebrates				
All *	✓	✓	✓	✓
Mussels				
Yellow lamp mussel *	✓	✓	✓	✓
Green floater *	✓	✓	✓	✓
Eastern elliptio	✓	✓	✓	✓
Fingernail clams	✓	✓	✓	✓
Aquatic Plants				
All	✓	✓	✓	✓

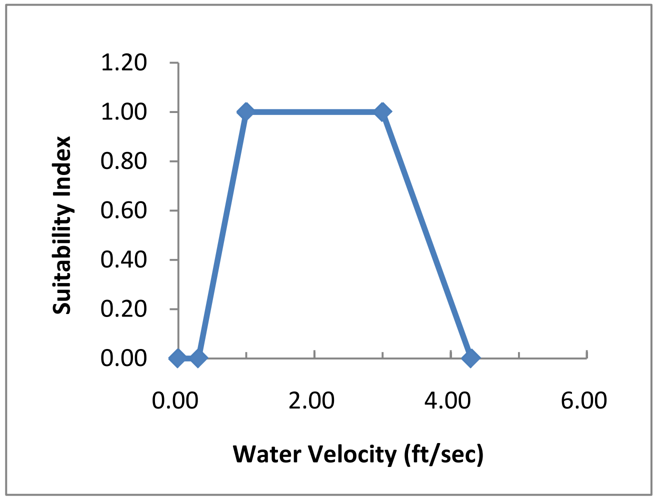
*Species of special concern for instream flow assessment.

Appendix D-Proposed Habitat Suitability Criteria

Species: American Shad
Lifestage: Spawning

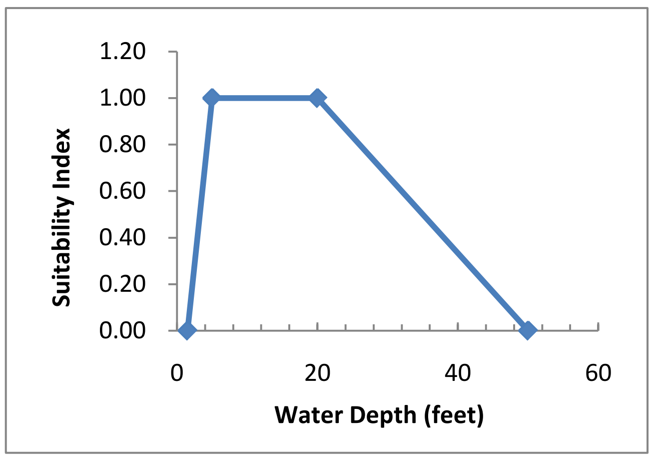
Velocity

Velocity	SI Value
0.00	0.00
0.30	0.00
1.00	1.00
3.00	1.00
4.30	0.00



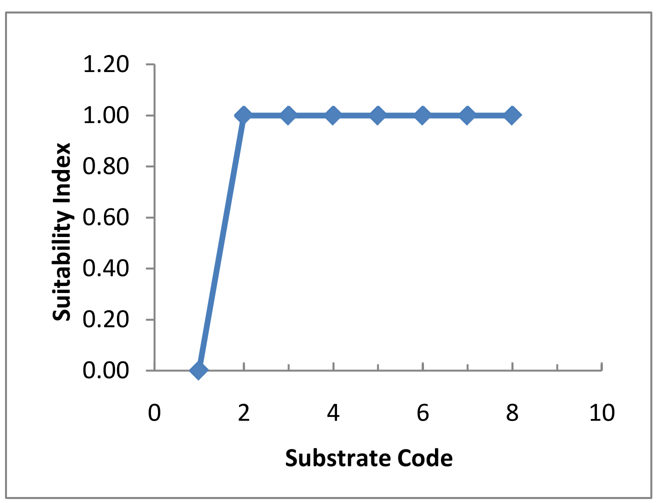
Depth

Depth	SI Value
1.50	0.00
5.00	1.00
20.00	1.00
50.00	0.00



Substrate

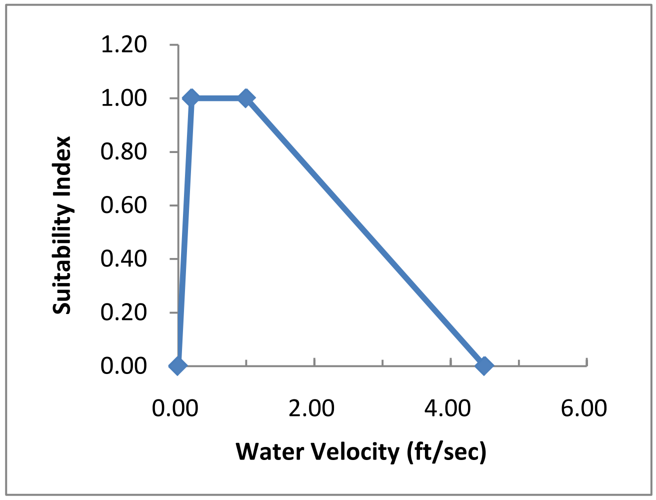
Substrate	SI Value	Type
1	0.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock



Species: American Shad
Lifestage: Fry

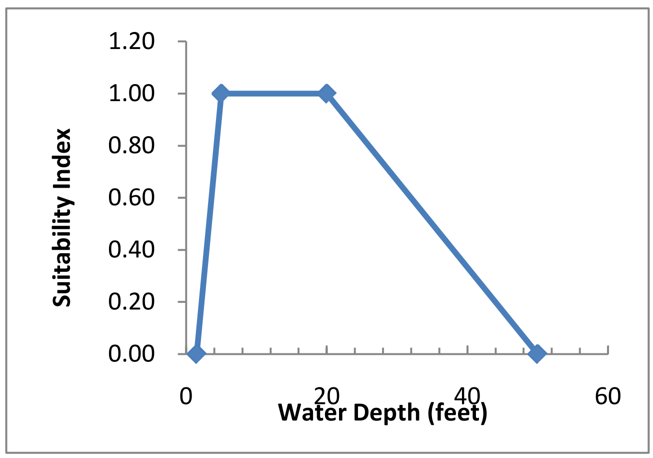
Velocity

Velocity	SI Value
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



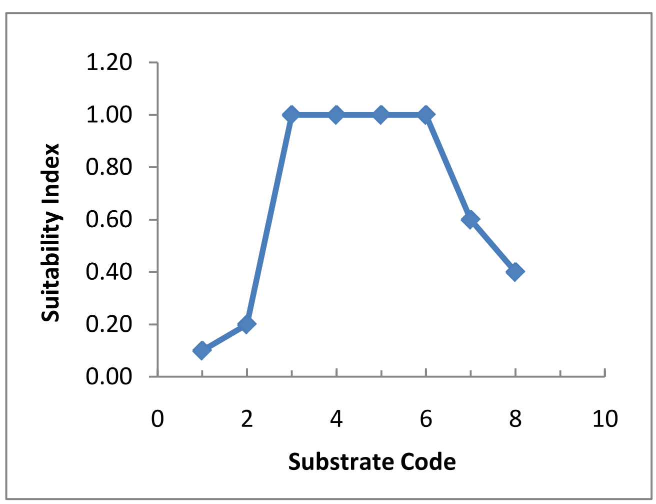
Depth

Depth	SI Value
1.50	0.00
5.00	1.00
20.00	1.00
50.00	0.00



Substrate

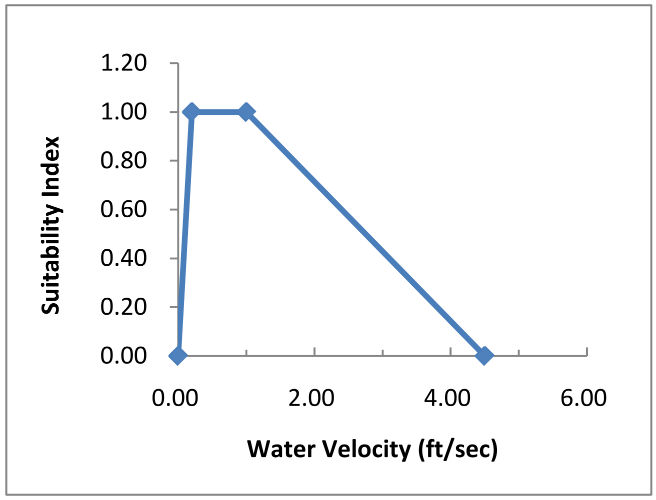
Substrate	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock



Species: American Shad
Lifestage: Juvenile

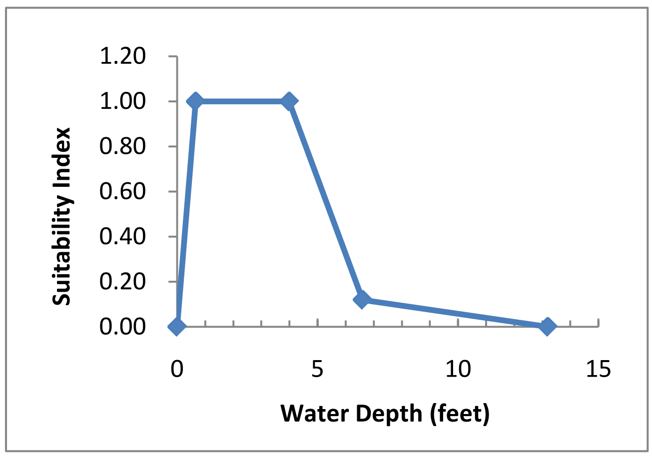
Velocity

Velocity	SI Value
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



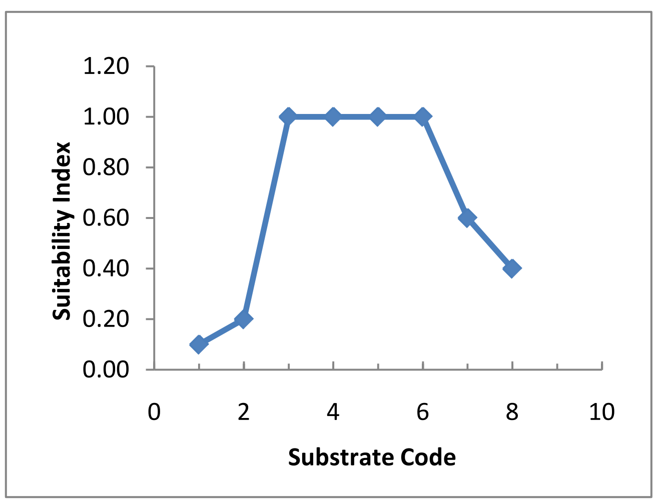
Depth

Depth	SI Value
0.00	0.00
0.66	1.00
3.99	1.00
6.60	0.12
13.20	0.00



Substrate

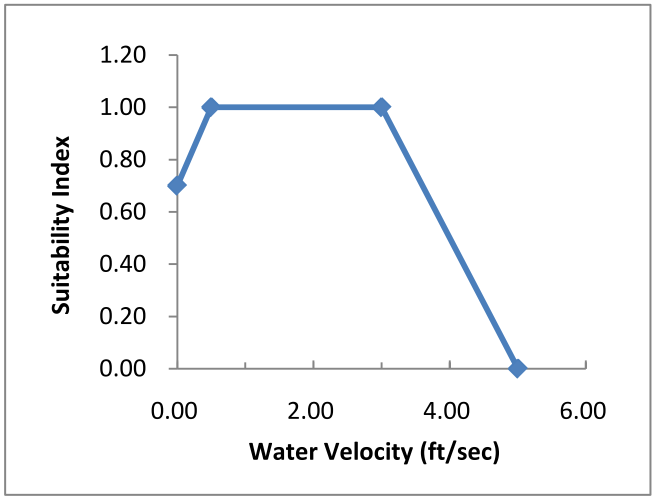
Substrate	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock



Species: American Shad
Lifestage: Adult

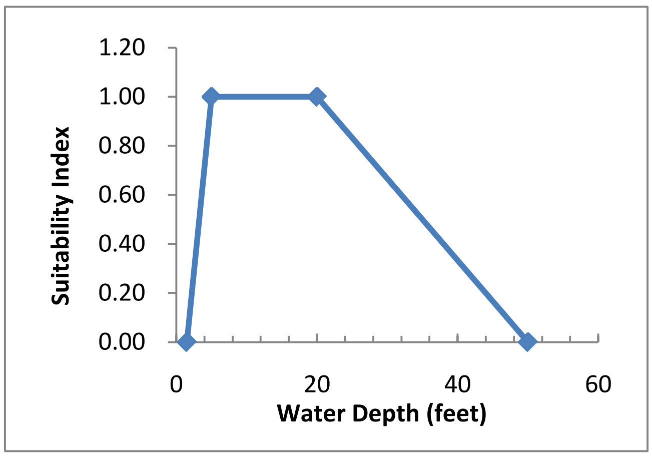
Velocity

Velocity	SI Value
0.00	0.70
0.50	1.00
3.00	1.00
5.00	0.00



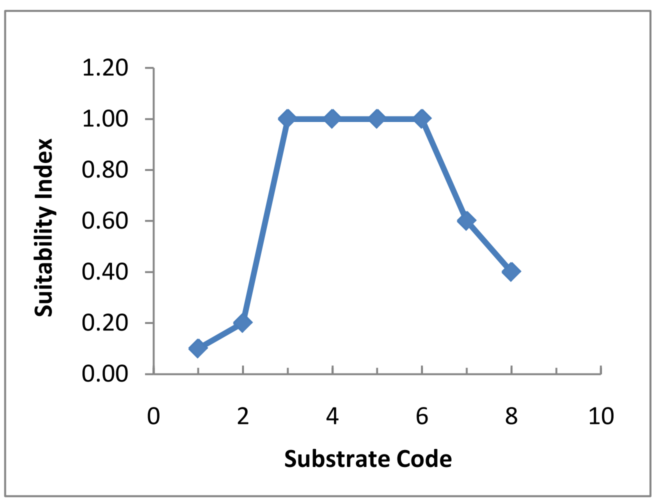
Depth

Depth	SI Value
1.50	0.00
5.00	1.00
20.00	1.00
50.00	0.00



Substrate

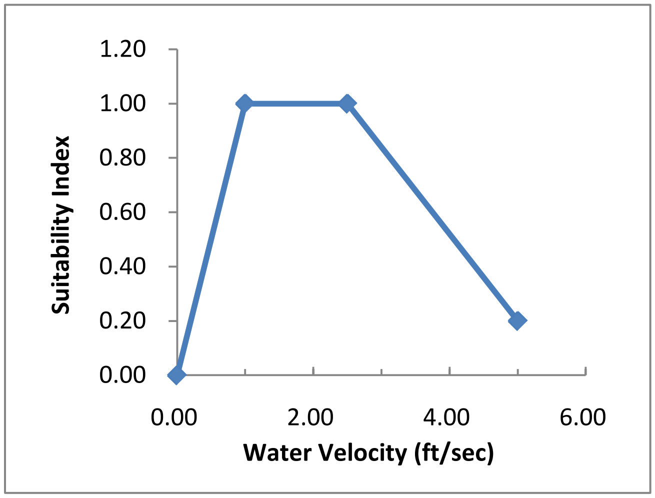
Substrate	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock



Species: Shortnose Sturgeon
Lifestage: Spawning

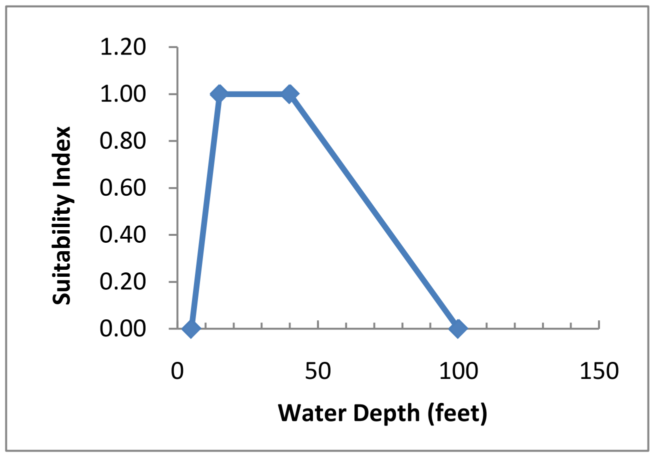
Velocity

Velocity	SI Value
0.00	0.00
1.00	1.00
2.50	1.00
5.00	0.20



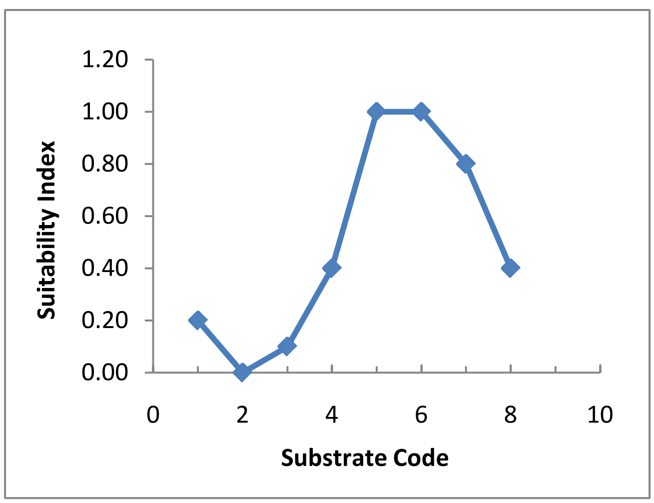
Depth

Depth	SI Value
5.00	0.00
15.00	1.00
40.00	1.00
100.00	0.00



Substrate

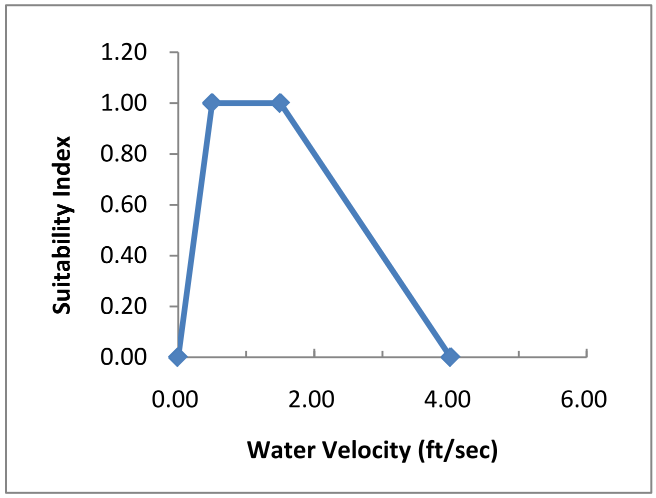
Substrate	SI Value	Type
1	0.20	Detritus/Organic
2	0.00	Mud/soft clay
3	0.10	Silt
4	0.40	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	0.80	Boulder
8	0.40	Bedrock



Species: Shortnose Sturgeon
Lifestage: Fry

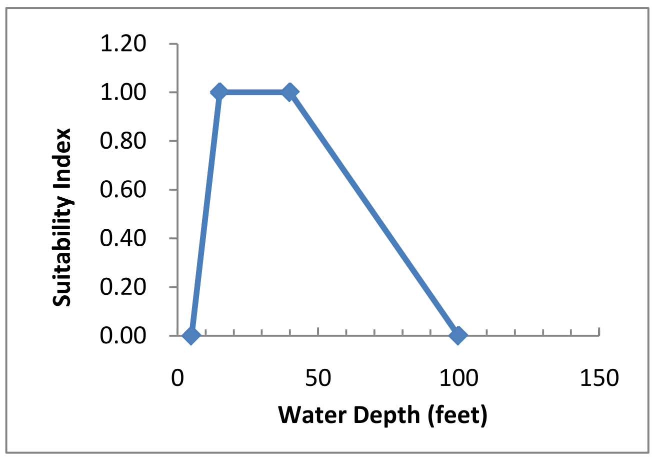
Velocity

Velocity	SI Value
0.00	0.00
0.50	1.00
1.50	1.00
4.00	0.00



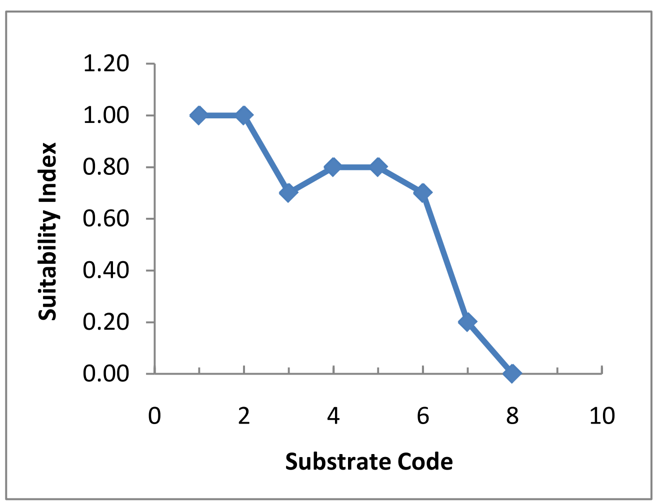
Depth

Depth	SI Value
5.00	0.00
15.00	1.00
40.00	1.00
100.00	0.00



Substrate

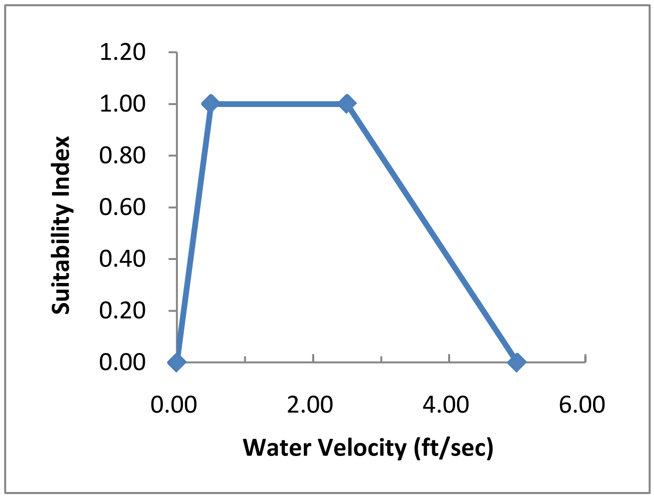
Substrate	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	0.70	Silt
4	0.80	Sand
5	0.80	Gravel
6	0.70	Cobble/rubble
7	0.20	Boulder
8	0.00	Bedrock



Species: Shortnose Sturgeon
Lifestage: Juveniles

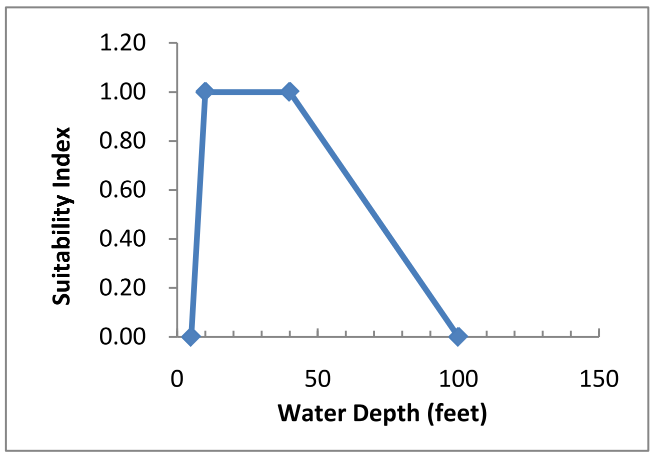
Velocity

Velocity	SI Value
0.00	0.00
0.50	1.00
2.50	1.00
5.00	0.00



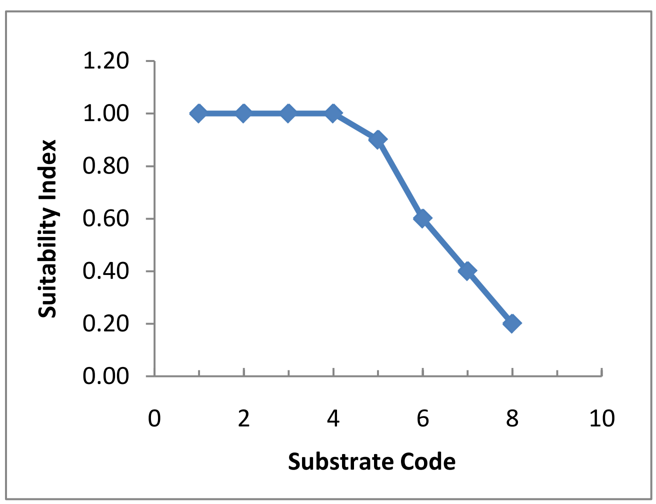
Depth

Depth	SI Value
5.00	0.00
10.00	1.00
40.00	1.00
100.00	0.00



Substrate

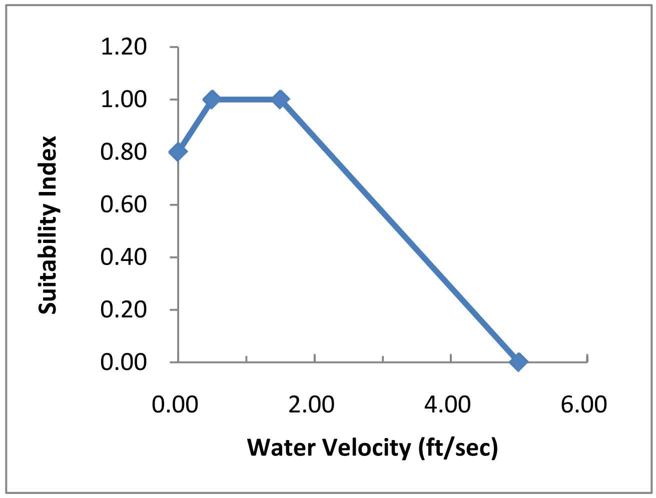
Substrate	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	0.90	Gravel
6	0.60	Cobble/rubble
7	0.40	Boulder
8	0.20	Bedrock



Species: Shortnose Sturgeon
Lifestage: Adults

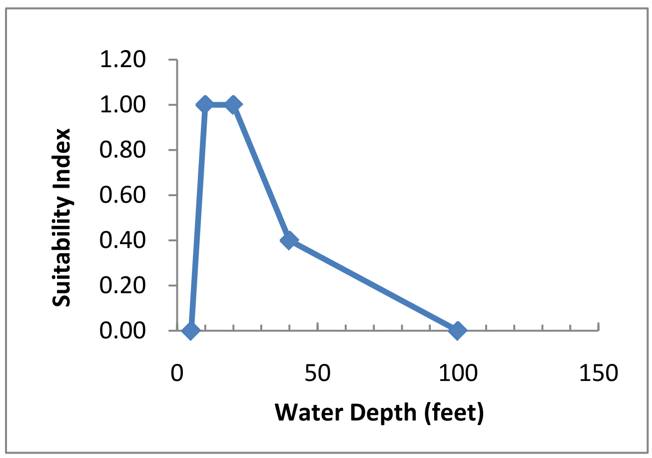
Velocity

Velocity	SI Value
0.00	0.80
0.50	1.00
1.50	1.00
5.00	0.00



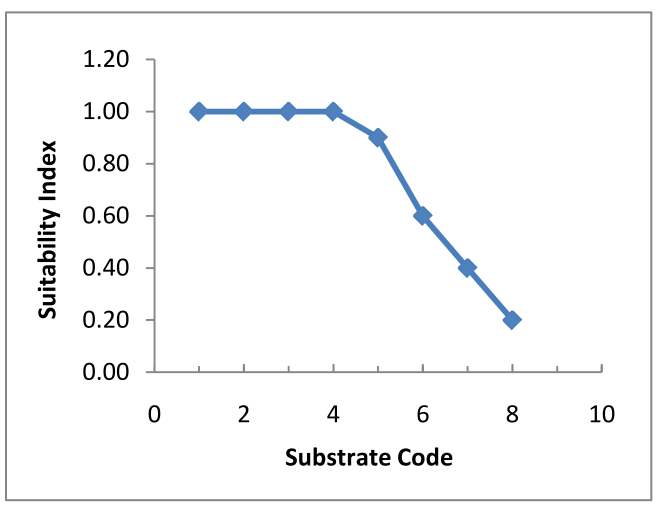
Depth

Depth	SI Value
5.00	0.00
10.00	1.00
20.00	1.00
40.00	0.40
100.00	0.00



Substrate

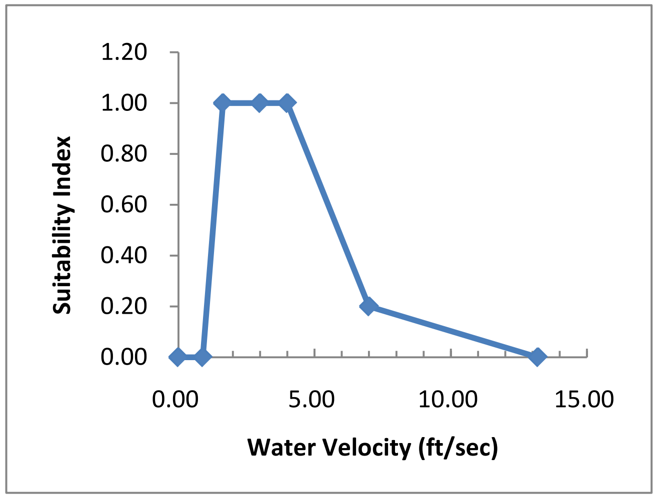
Substrate	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	0.90	Gravel
6	0.60	Cobble/rubble
7	0.40	Boulder
8	0.20	Bedrock



Species: Striped Bass
Lifestage: Spawning

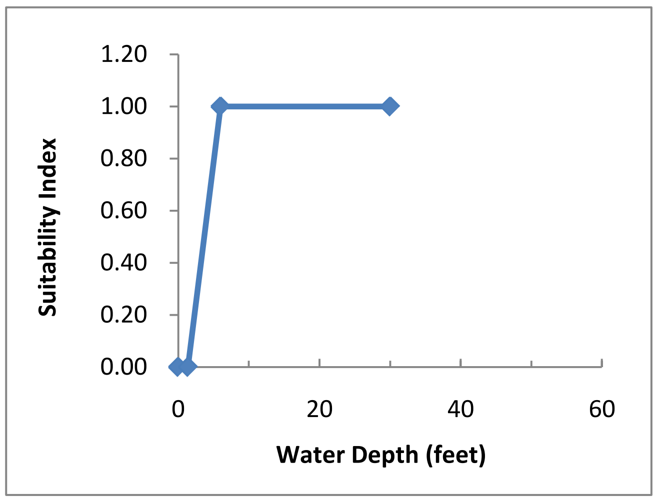
Velocity

Velocity	SI Value
0.00	0.00
0.90	0.00
1.64	1.00
3.00	1.00
4.00	1.00
7.00	0.20
13.20	0.00



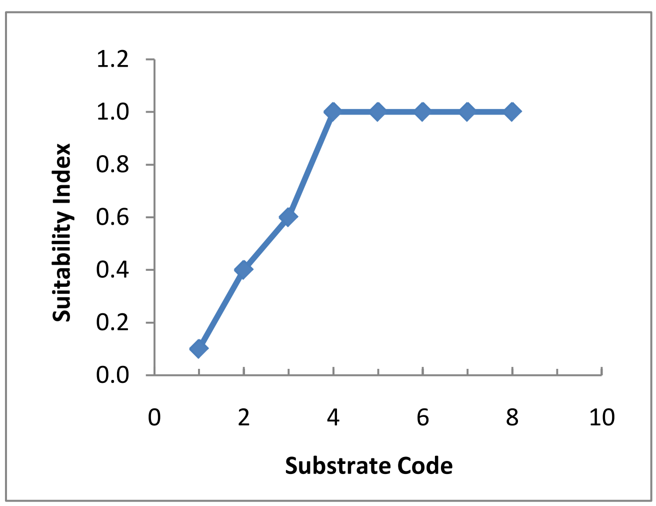
Depth

Depth	SI Value
0.0	0.00
1.4	0.00
6.0	1.00
30.0	1.00



Substrate

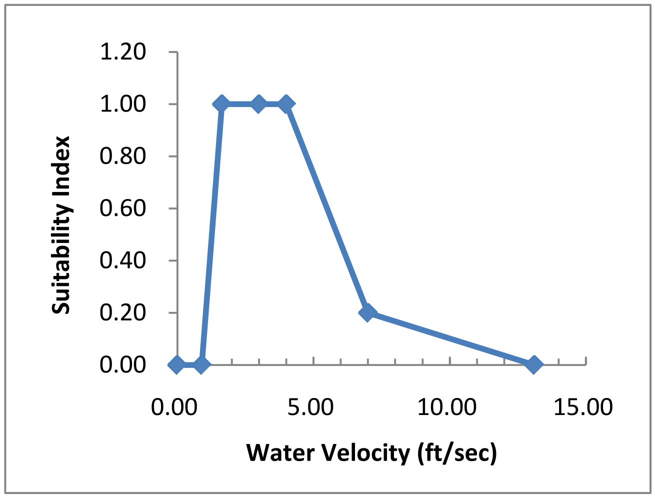
Substrate	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock



Species: Striped Bass
Lifestage: Fry

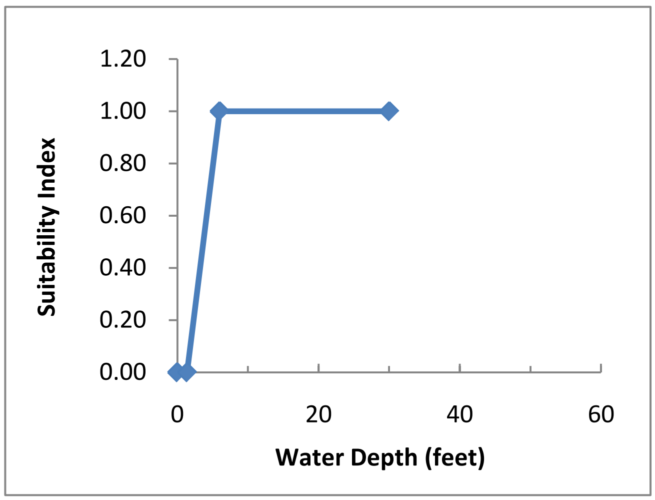
Velocity

Velocity	SI Value
0.00	0.00
0.90	0.00
1.64	1.00
3.00	1.00
4.00	1.00
7.00	0.20
13.10	0.00



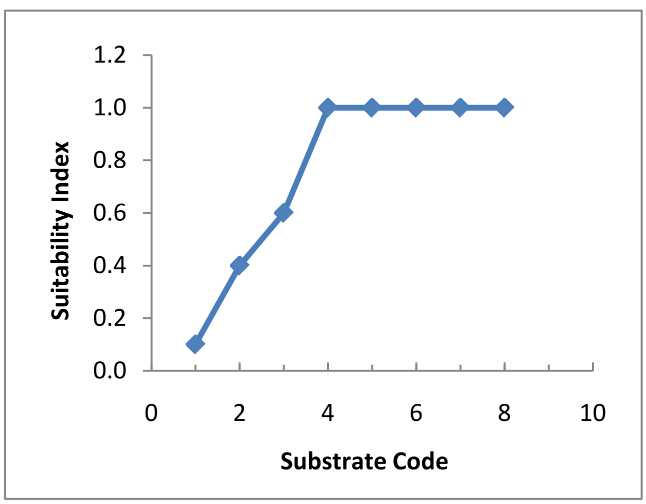
Depth

Depth	SI Value
0.0	0.00
1.4	0.00
6.0	1.00
30.0	1.00



Substrate

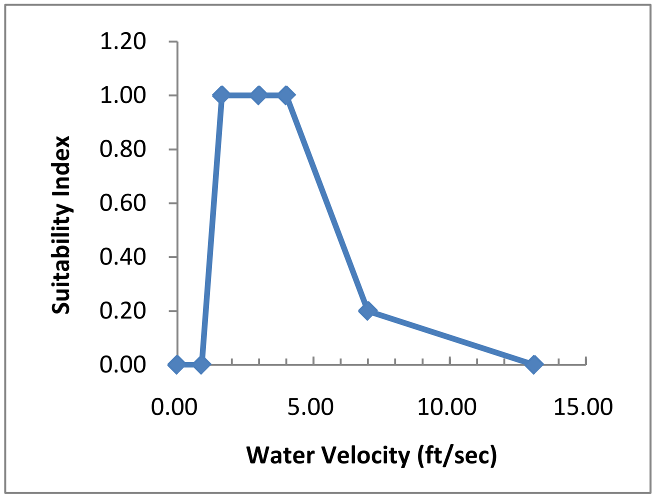
Substrate	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock



Species: Striped Bass
Lifestage: Juvenile

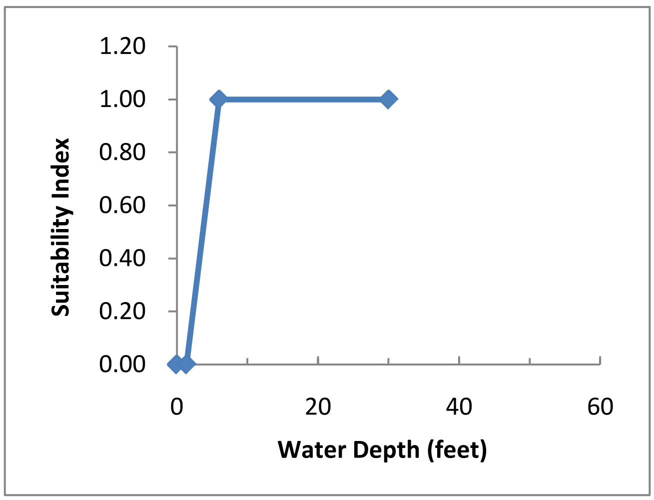
Velocity

Velocity	SI Value
0.00	0.00
0.90	0.00
1.64	1.00
3.00	1.00
4.00	1.00
7.00	0.20
13.10	0.00



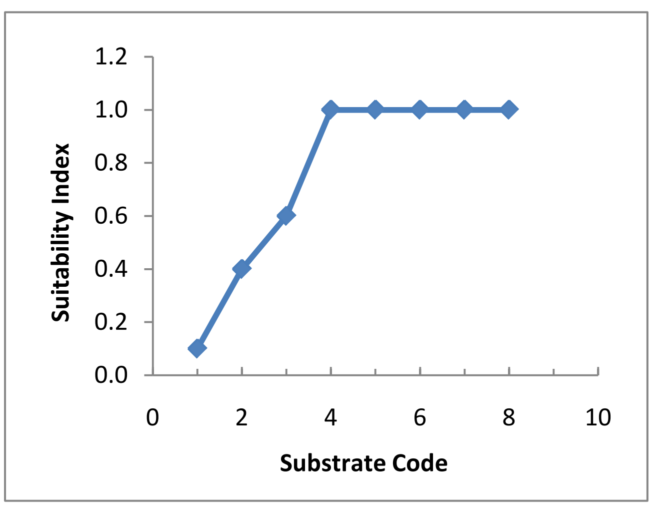
Depth

Depth	SI Value
0.0	0.00
1.4	0.00
6.0	1.00
30.0	1.00



Substrate

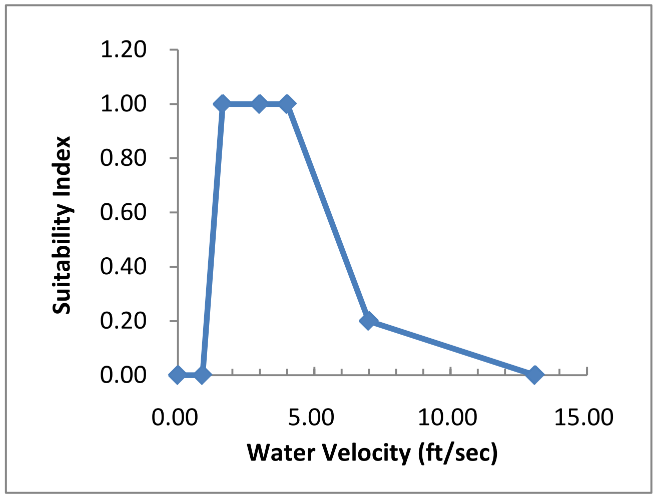
Substrate	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock



Species: Striped Bass
Lifestage: Adult

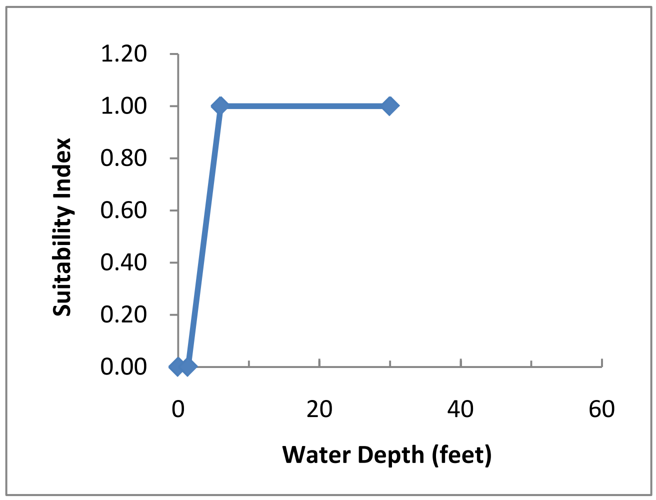
Velocity

Velocity	SI Value
0.00	0.00
0.90	0.00
1.64	1.00
3.00	1.00
4.00	1.00
7.00	0.20
13.10	0.00



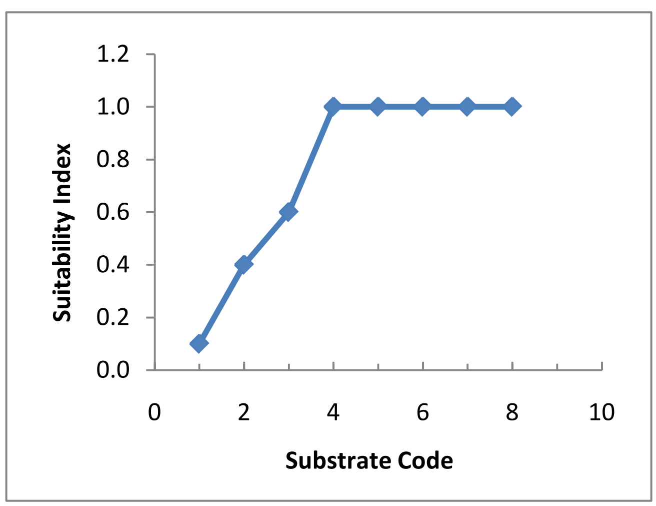
Depth

Depth	SI Value
0.0	0.00
1.4	0.00
6.0	1.00
30.0	1.00



Substrate

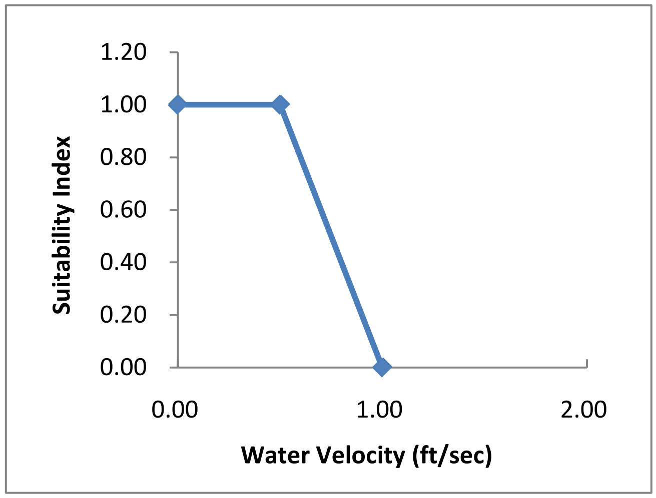
Substrate	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock



Species: Smallmouth Bass
Lifestage: Spawning

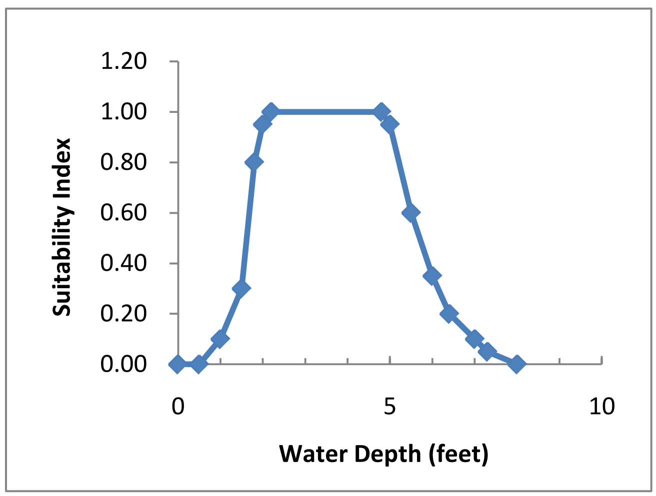
Velocity

Velocity	SI Value
0.00	1.00
0.50	1.00
1.00	0.00



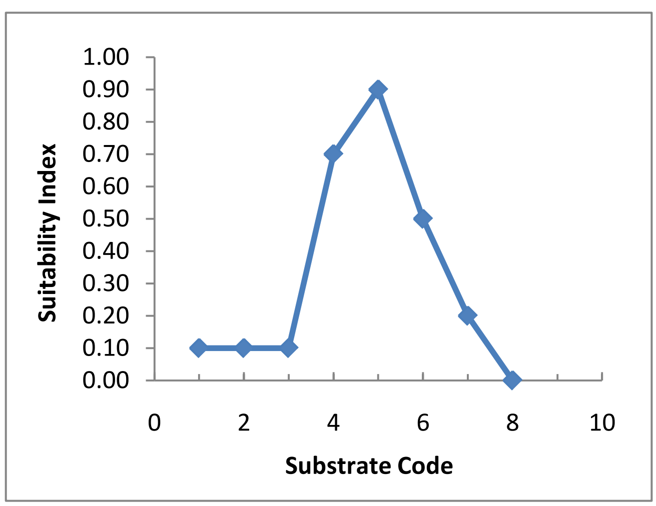
Depth

Depth	SI Value
0.00	0.00
0.50	0.00
1.00	0.10
1.50	0.30
1.80	0.80
2.00	0.95
2.20	1.00
4.80	1.00
5.00	0.95
5.50	0.60
6.00	0.35
6.40	0.20
7.00	0.10
7.30	0.05
8.00	0.00



Substrate

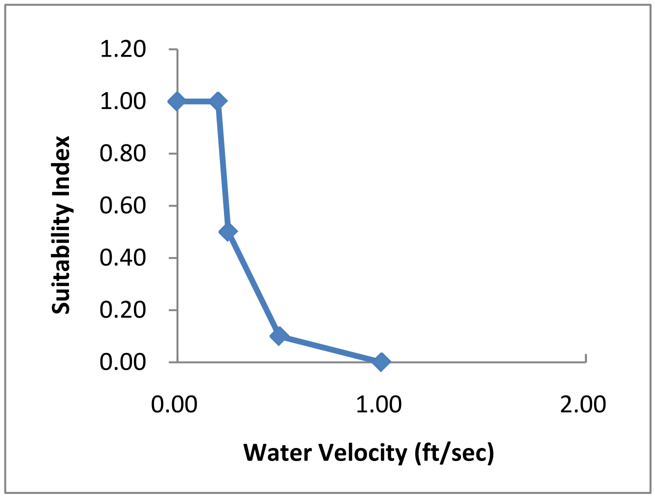
Substrate	SI Value	Type
1	0.10	Detritus/Organic
2	0.10	Mud/soft clay
3	0.10	Silt
4	0.70	Sand
5	0.90	Gravel
6	0.50	Cobble/rubble
7	0.20	Boulder
8	0.00	Bedrock



Species: Smallmouth Bass
Lifestage: Fry

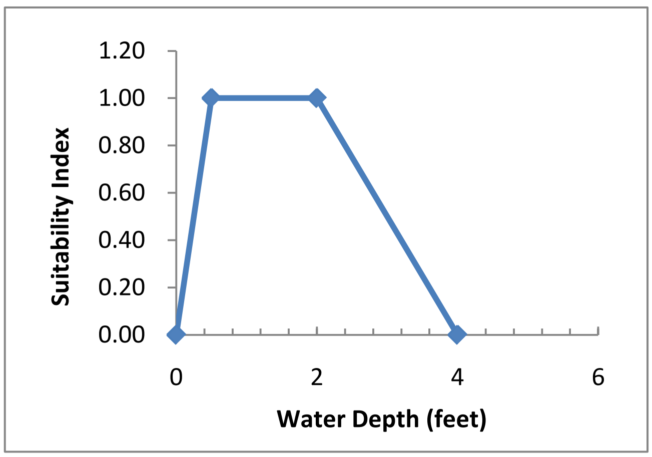
Velocity

Velocity	SI Value
0.00	1.00
0.20	1.00
0.25	0.50
0.50	0.10
1.00	0.00



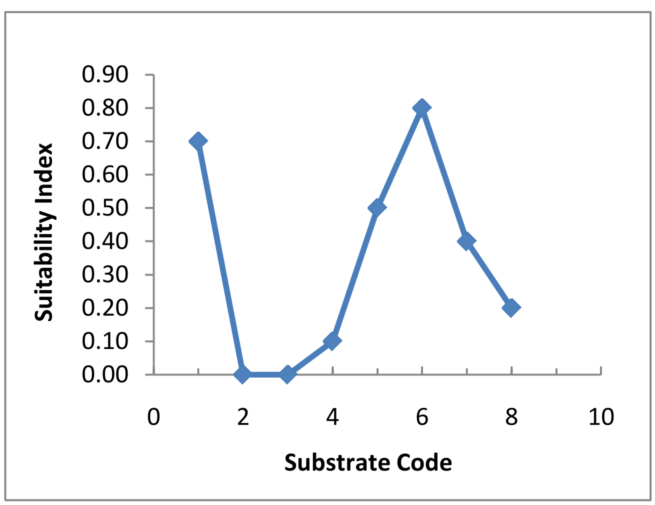
Depth

Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
4.00	0.00



Substrate

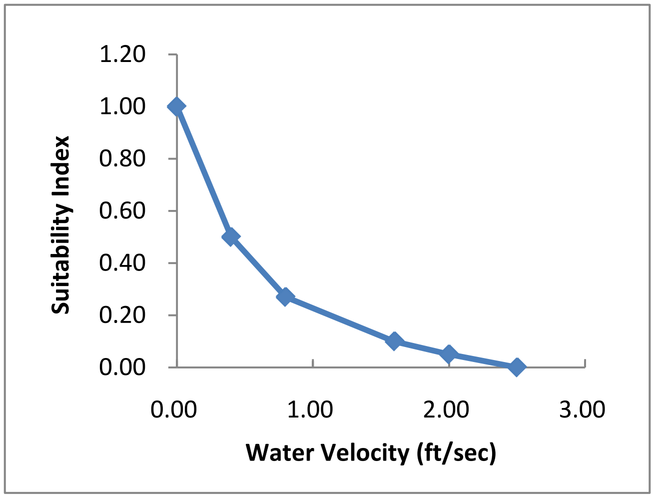
Substrate	SI Value	Type
1	0.70	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.10	Sand
5	0.50	Gravel
6	0.80	Cobble/rubble
7	0.40	Boulder
8	0.20	Bedrock



Species: Smallmouth Bass
Lifestage: Juvenile

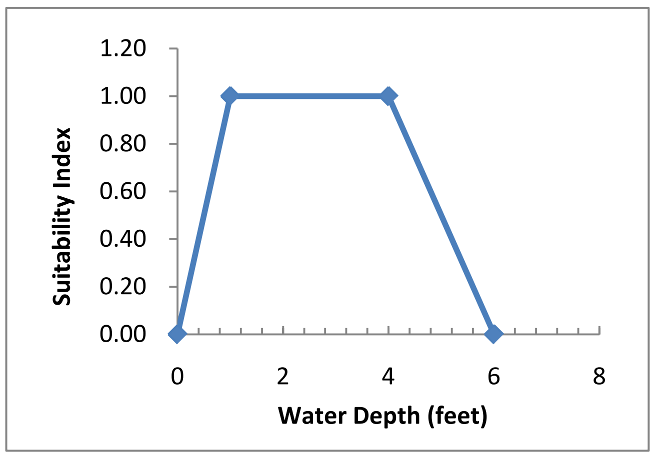
Velocity

Velocity	SI Value
0.00	1.00
0.40	0.50
0.80	0.27
1.60	0.10
2.00	0.05
2.50	0.00



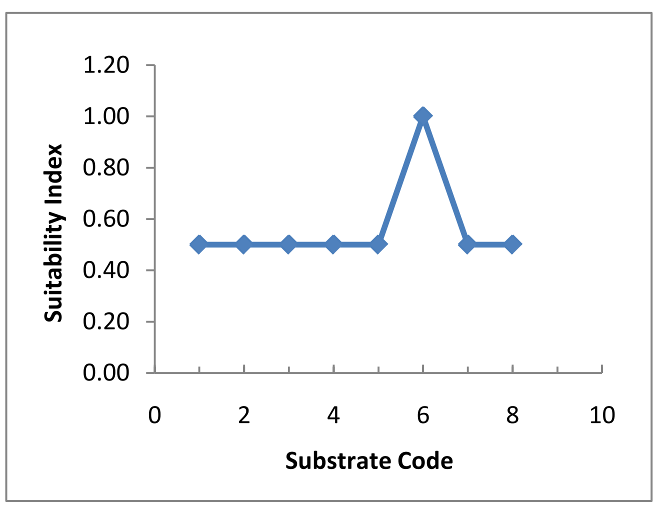
Depth

Depth	SI Value
0.00	0.00
1.00	1.00
4.00	1.00
6.00	0.00



Substrate

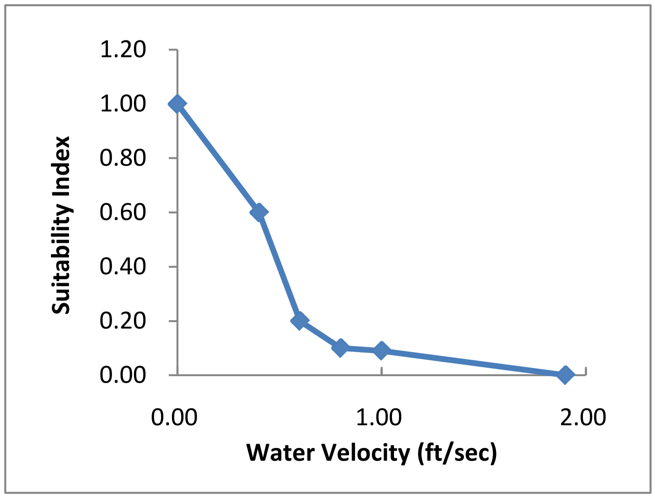
Substrate	SI Value	Type
1	0.50	Detritus/Organic
2	0.50	Mud/soft clay
3	0.50	Silt
4	0.50	Sand
5	0.50	Gravel
6	1.00	Cobble/rubble
7	0.50	Boulder
8	0.50	Bedrock



Species: Smallmouth Bass
Lifestage: Adult

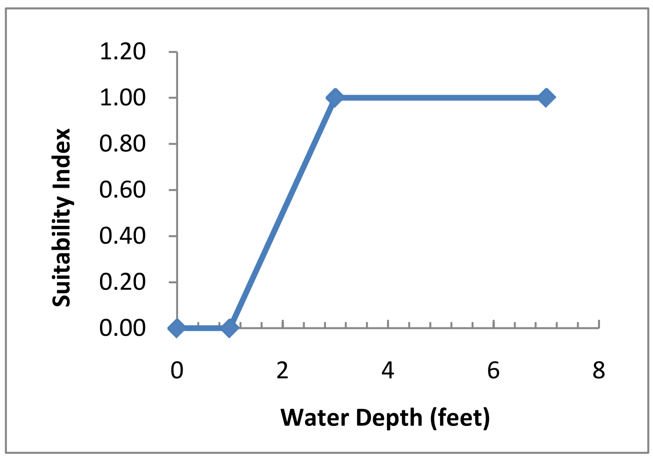
Velocity

Velocity	SI Value
0.00	1.00
0.40	0.60
0.60	0.20
0.80	0.10
1.00	0.09
1.90	0.00



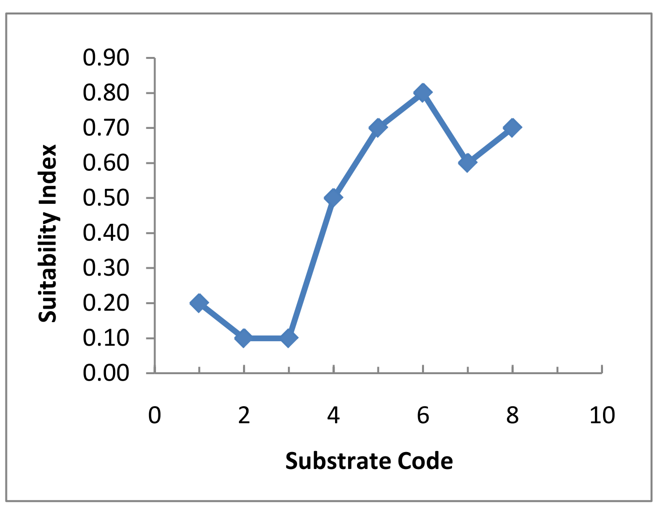
Depth

Depth	SI Value
0.00	0.00
1.00	0.00
3.00	1.00
7.00	1.00



Substrate

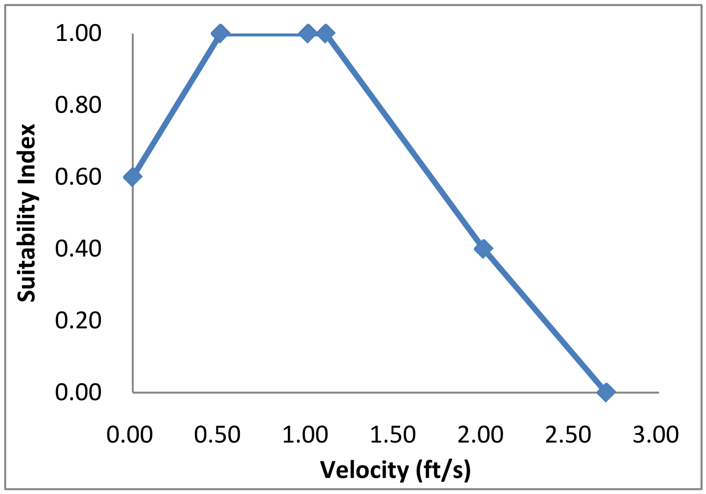
Substrate	SI Value	Type
1	0.20	Detritus/Organic
2	0.10	Mud/soft clay
3	0.10	Silt
4	0.50	Sand
5	0.70	Gravel
6	0.80	Cobble/rubble
7	0.60	Boulder
8	0.70	Bedrock



Species: Yellow Lamp Mussel

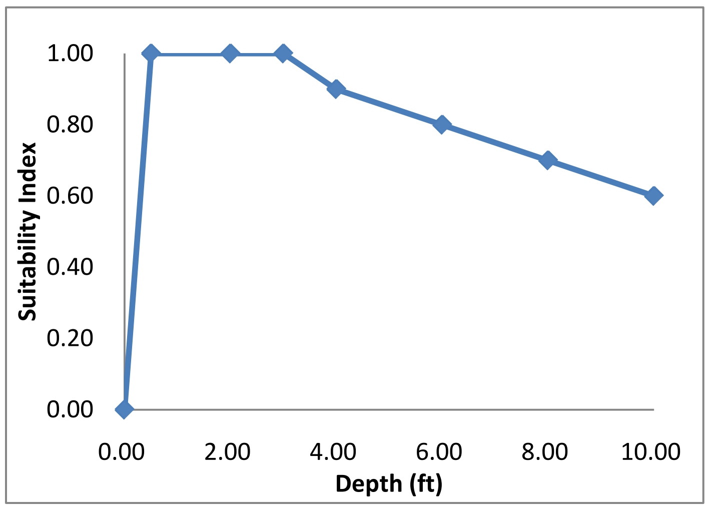
Velocity

Velocity	SI Value
0.00	0.60
0.50	1.00
1.00	1.00
1.10	1.00
2.00	0.40
2.70	0.00



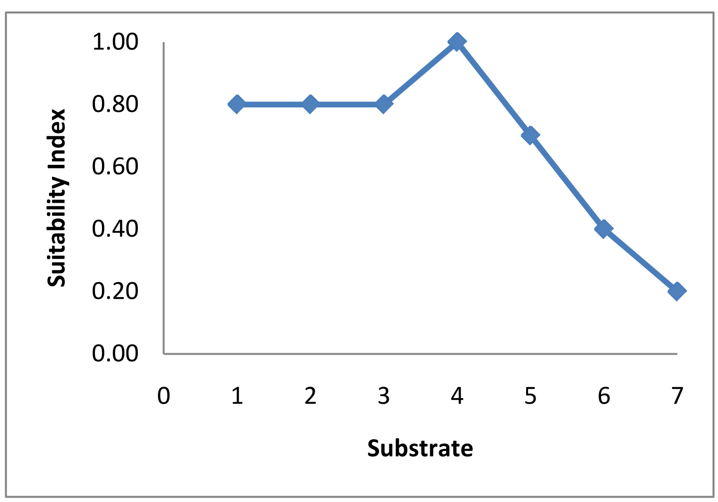
Water Depth

Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
3.00	1.00
4.00	0.90
6.00	0.80
8.00	0.70
10.00	0.60



Substrate

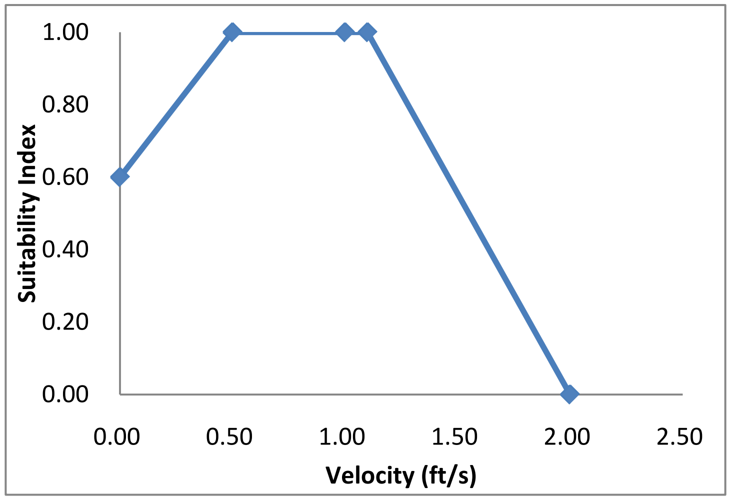
Code	SI Value	Type
1	0.80	Detritus/Organic
2	0.80	Mud/soft clay
3	0.80	Silt
4	1.00	Sand
5	0.70	Gravel
6	0.40	Cobble/rubble
7	0.20	Boulder
8	0.20	Bedrock



Species: Green Floater

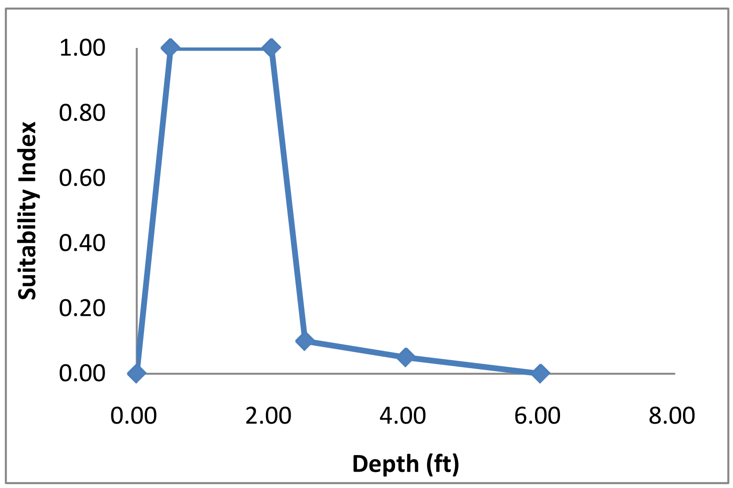
Velocity

Velocity	SI Value
0.00	0.60
0.50	1.00
1.00	1.00
1.10	1.00
2.00	0.00



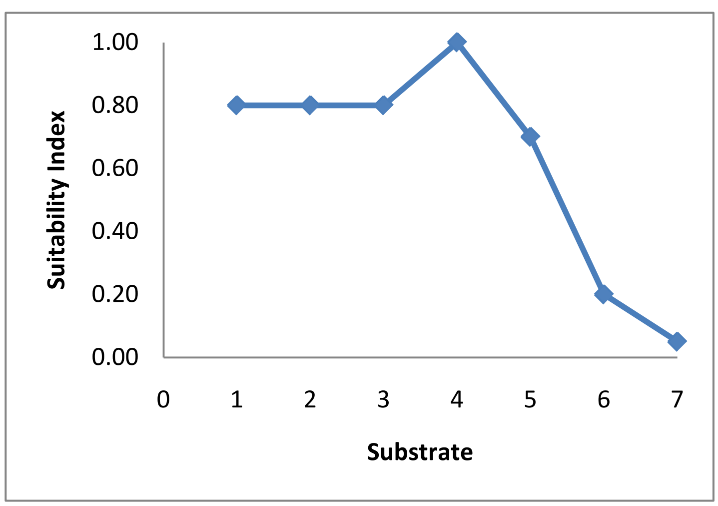
Water Depth

Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
2.50	0.10
4.00	0.05
6.00	0.00



Substrate

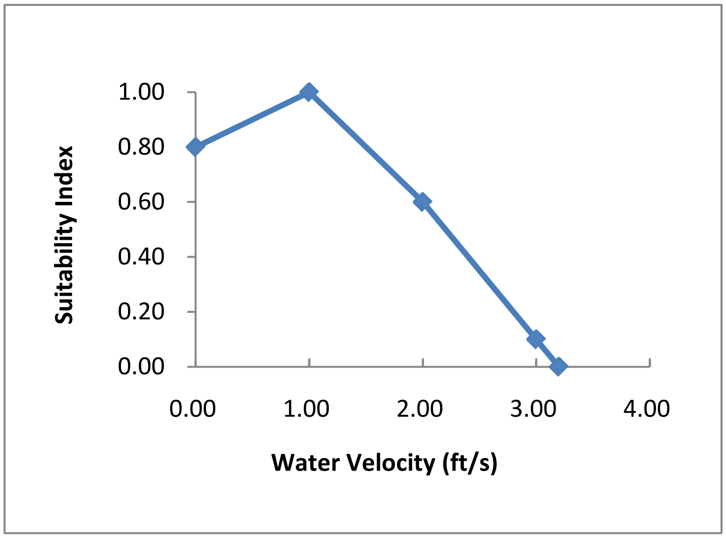
Code	SI Value	Type
1	0.80	Detritus/Organic
2	0.80	Mud/soft clay
3	0.80	Silt
4	1.00	Sand
5	0.70	Gravel
6	0.20	Cobble/rubble
7	0.05	Boulder
8	0.05	Bedrock



Species: Macroinvertebrates
Lifestage: Community Diversity -Large River

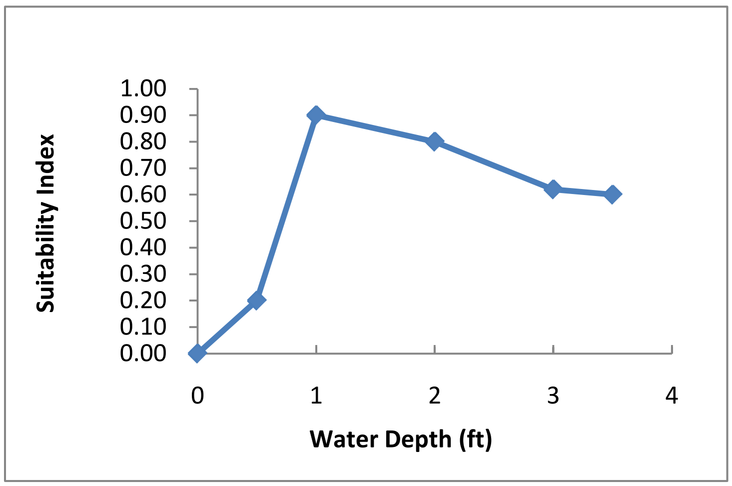
Velocity

Velocity	SI Value
0.00	0.80
1.00	1.00
2.00	0.60
3.00	0.10
3.20	0.00



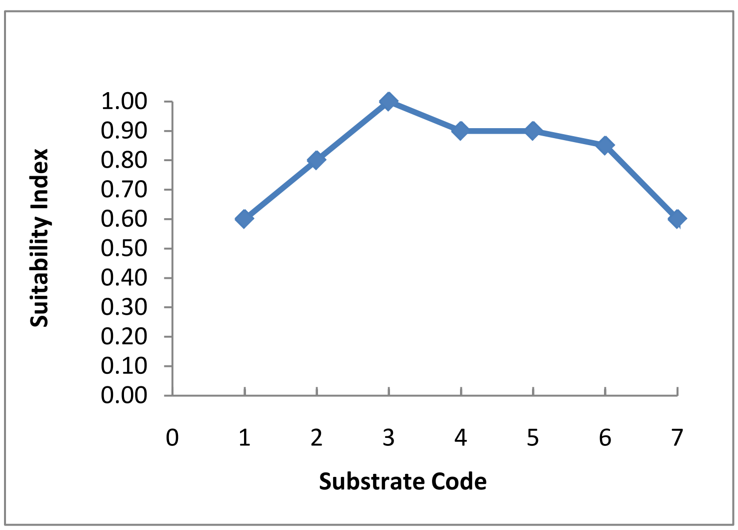
Depth

Depth	SI Value
0.00	0.00
0.50	0.20
1.00	0.90
2.00	0.80
3.00	0.62
3.50	0.60



Substrate

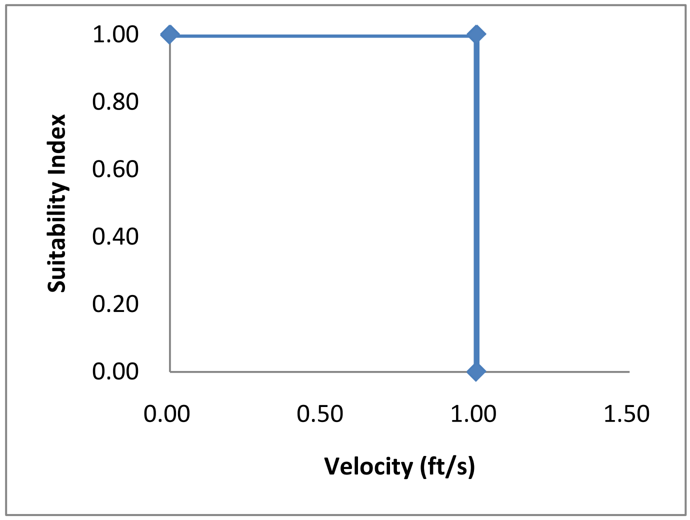
Code	SI Value	Type
1	0.60	Detritus/Organic
2	0.80	Mud/soft clay
3	1.00	Silt
4	0.90	Sand
5	0.90	Gravel
6	0.85	Cobble/rubble
7	0.60	Boulder
8	0.20	Bedrock



Species: Shallow-Slow Guild

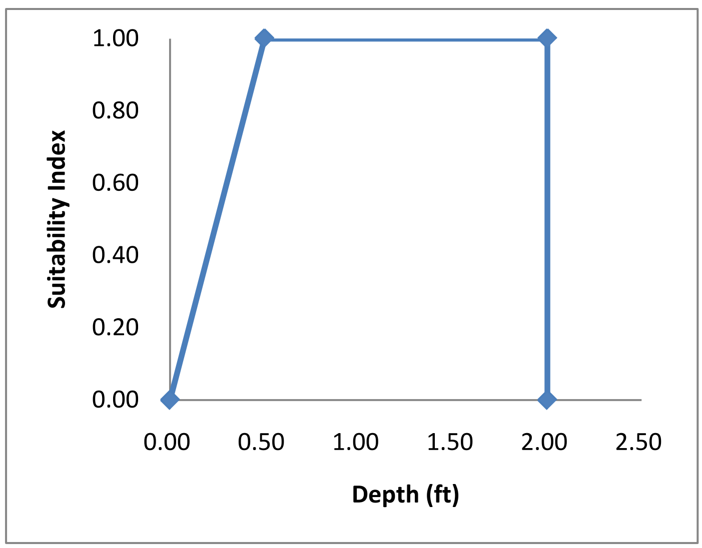
Velocity

Velocity	SI Value
0.00	1.00
1.00	1.00
1.00	0.00



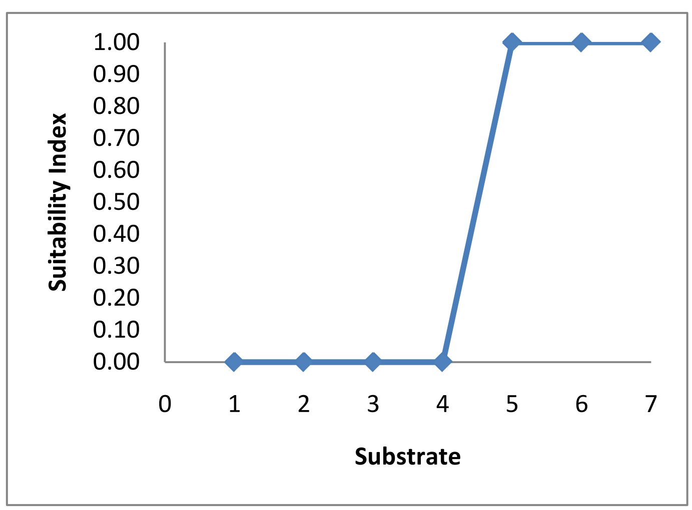
Water Depth

Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
2.00	0.00



Substrate

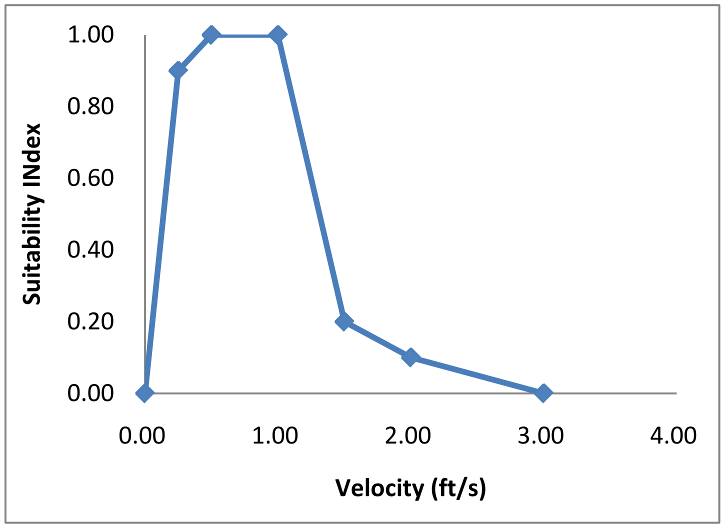
Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock



Species: Shallow-Fast Guild

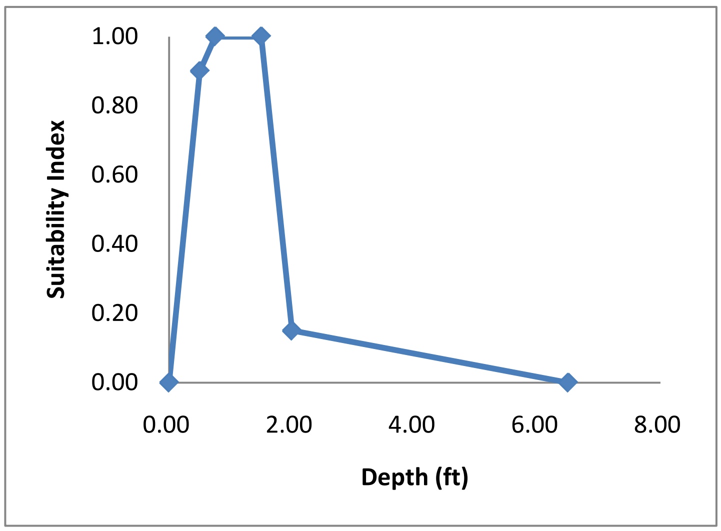
Velocity

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



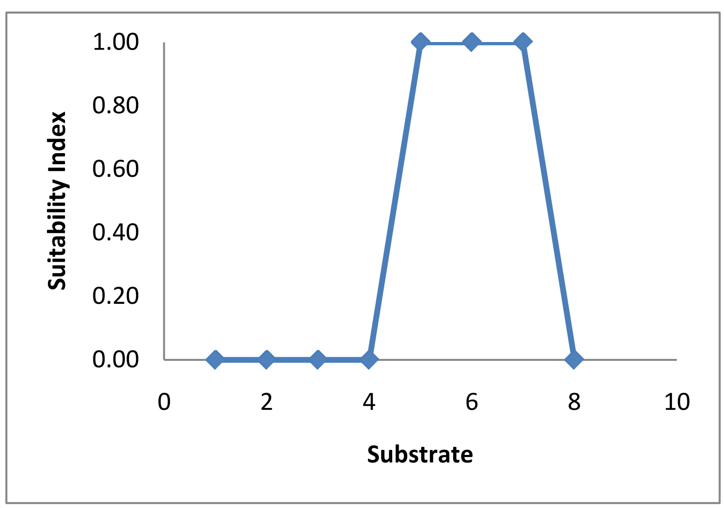
Water Depth

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



Substrate

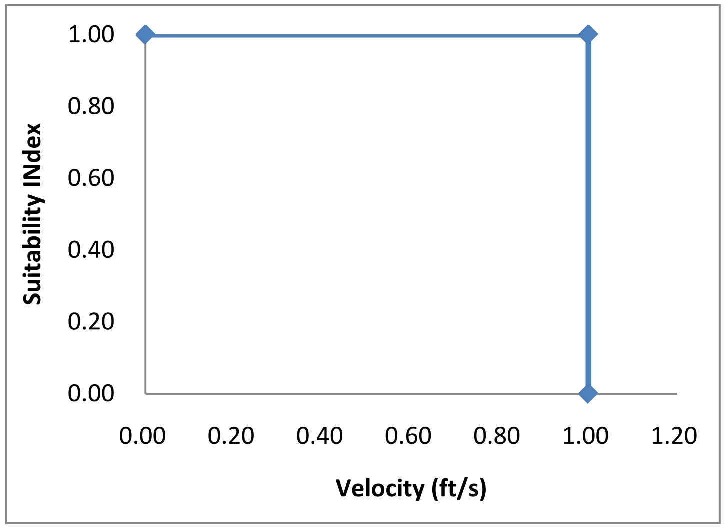
Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	0.00	Bedrock



Species: Deep-Slow Guild

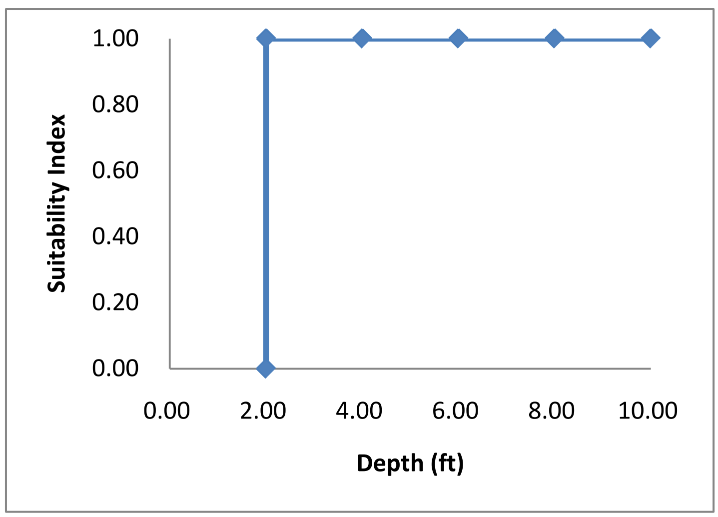
Velocity

Velocity	SI Value
0.00	1.00
1.00	1.00
1.00	0.00



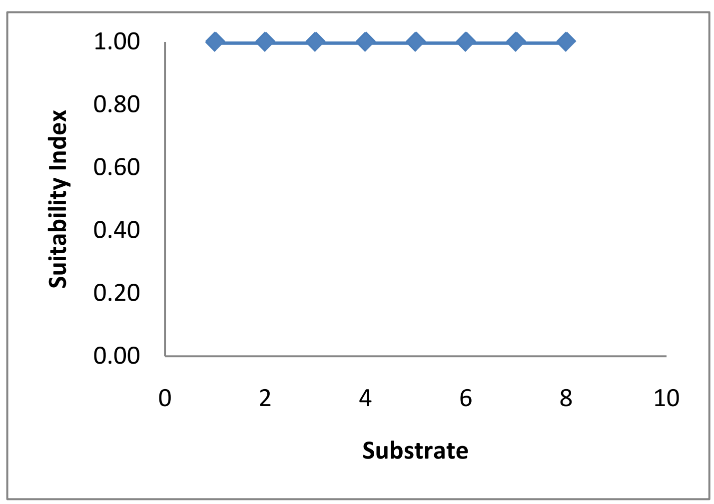
Depth

Depth	SI Value
2.00	0.00
2.00	1.00
4.00	1.00
6.00	1.00
8.00	1.00
10.00	1.00



Substrate

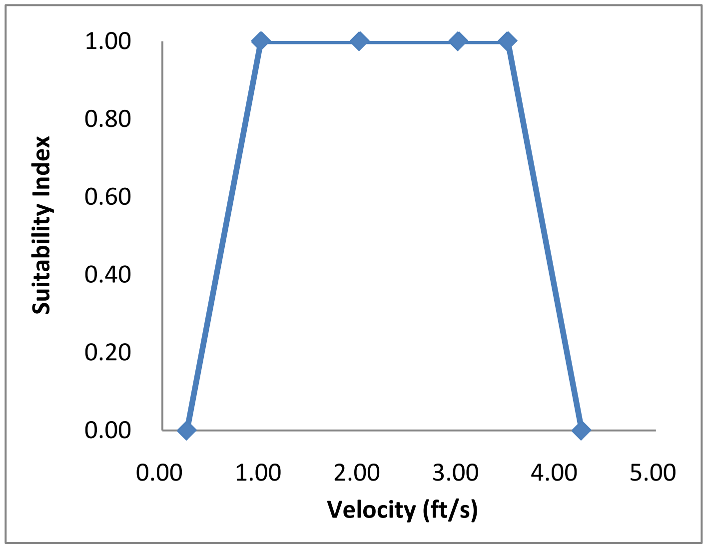
Code	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock



Species: Deep-Fast Guild

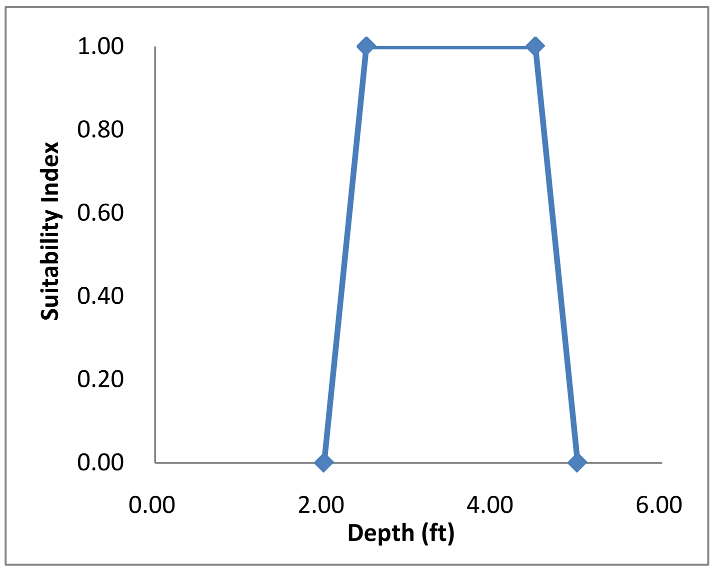
Velocity

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



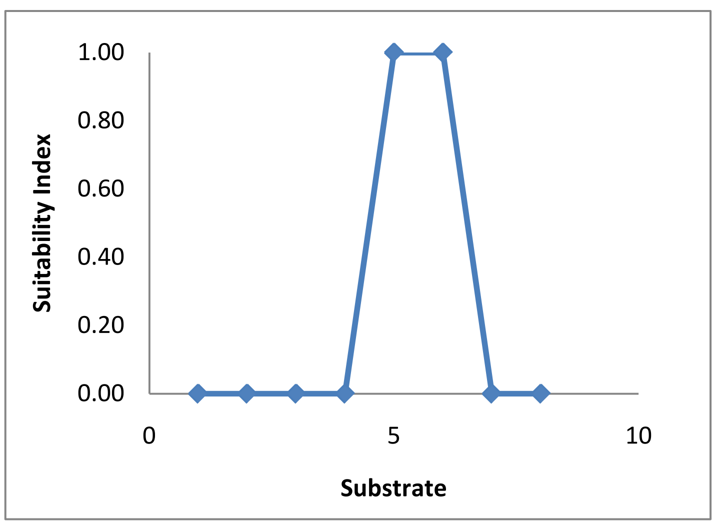
Depth

Depth	SI Value
2.00	0.00
2.50	1.00
4.50	1.00
5.00	0.00



Substrate

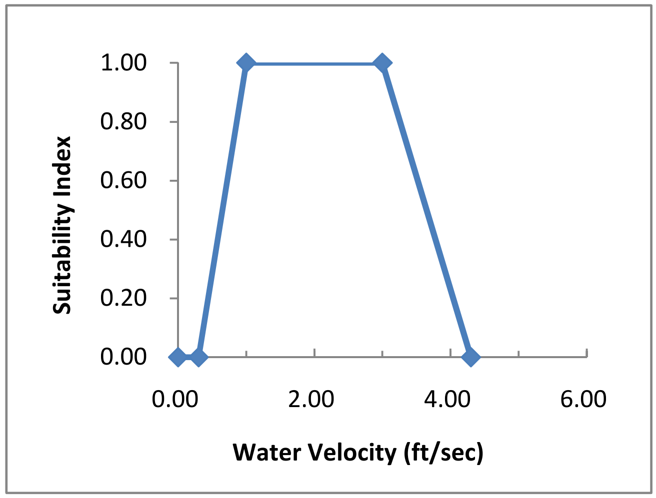
Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock



APPENDIX B-HABITAT SUITABILITY INDICES

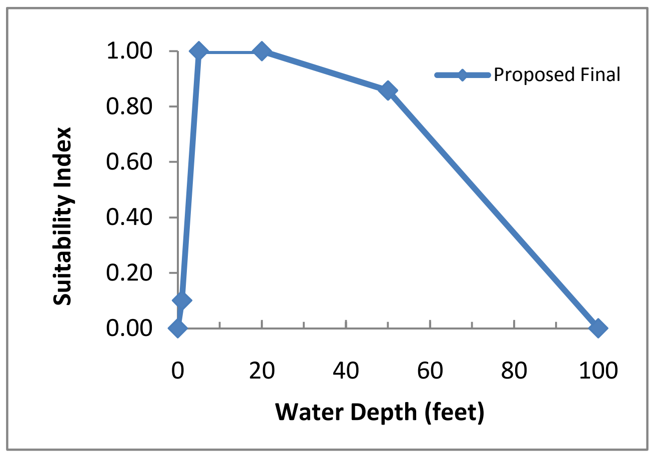
Species: American Shad
Lifestage: Spawning

Velocity	SI Value
0.00	0.00
0.30	0.00
1.00	1.00
3.00	1.00
4.30	0.00

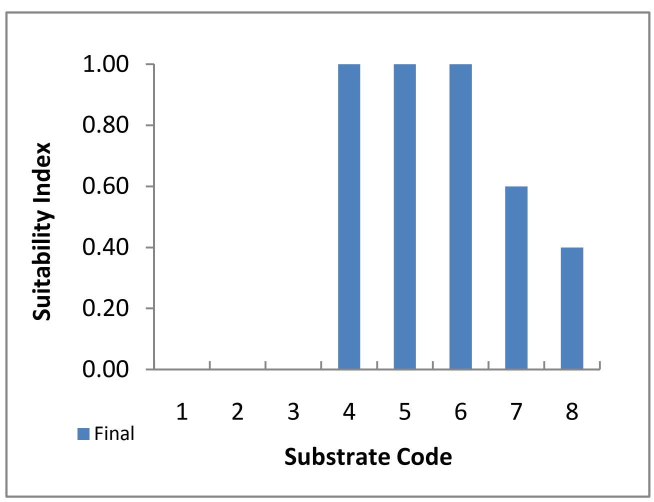


Proposed Final

Depth	SI Value
0.00	0.00
1.00	0.10
5.00	1.00
20.00	1.00
50.00	0.86
100.00	0.00

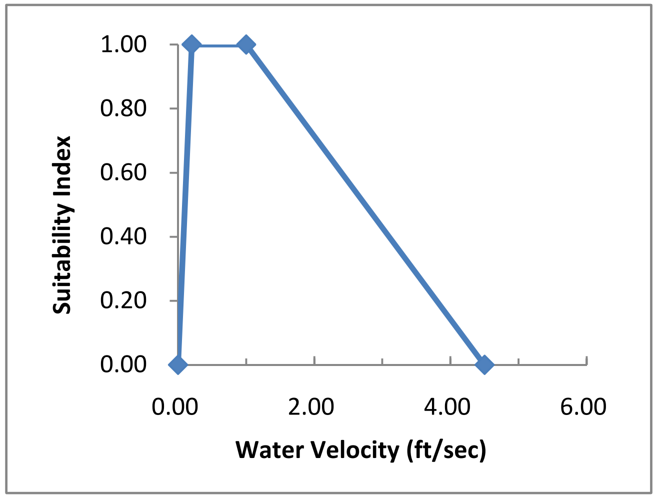


Code	Final SI Value	Type
1	0.00	Detritus
2	0.00	Mud
3	0.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

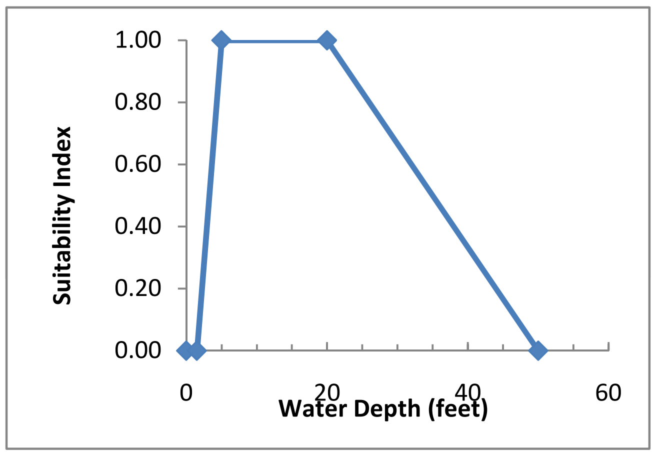


Species: American Shad
Lifestage: Fry

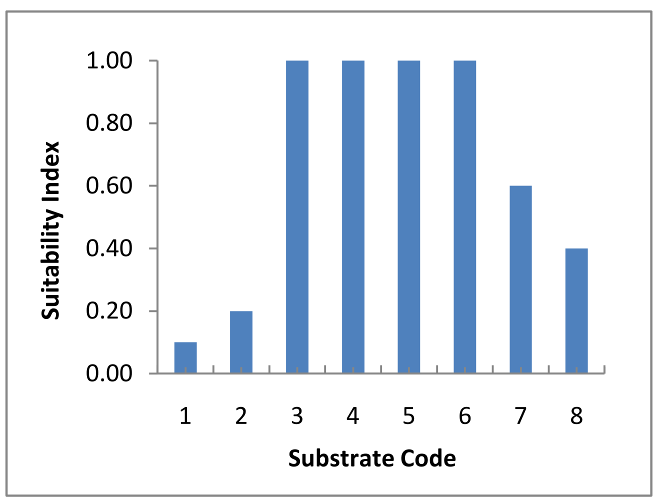
Velocity	SI Value
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



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

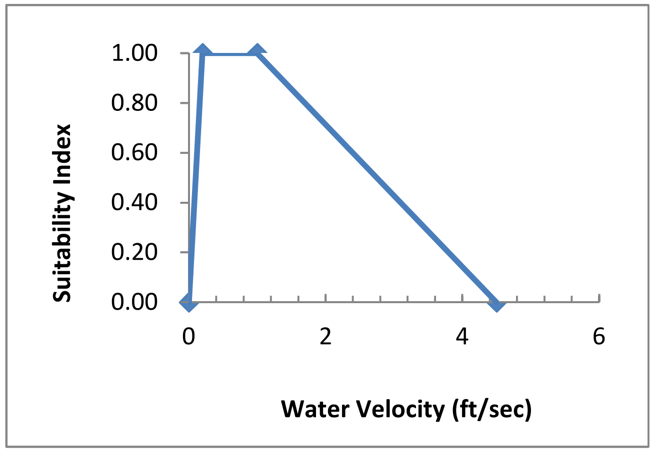


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

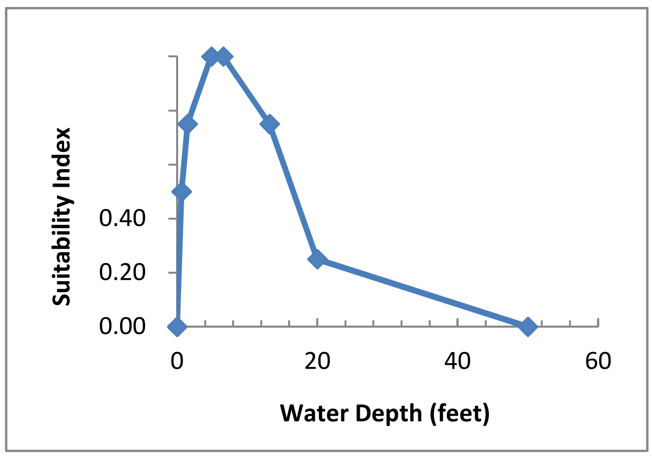


Species: American Shad
Lifestage: Juvenile

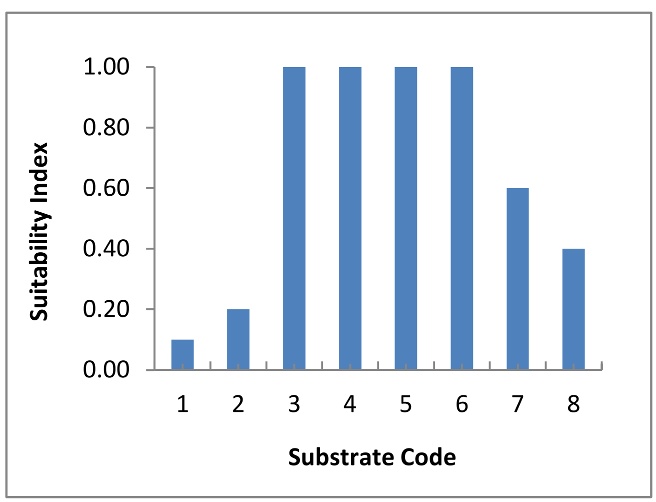
Velocity	SI Value
0.00	0.00
0.20	1.00
1.00	1.00
4.50	0.00



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

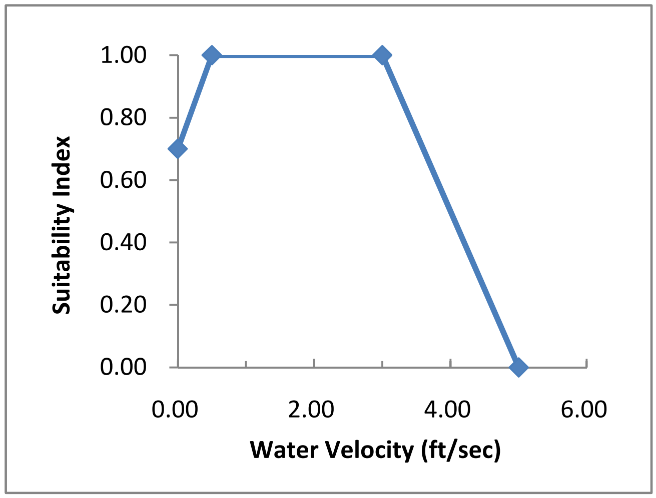


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

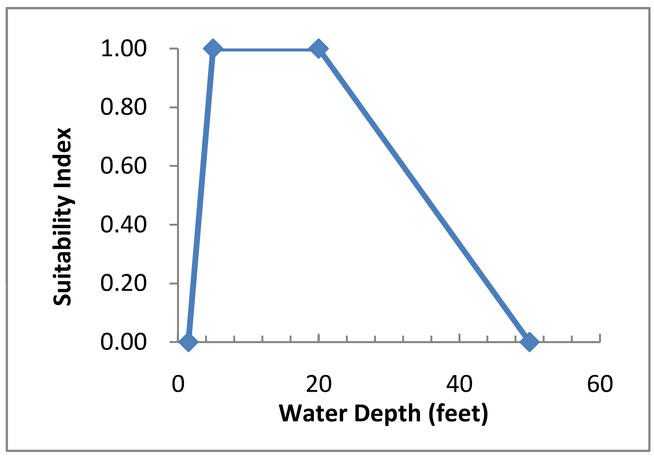


Species: American Shad
Lifestage: Adult

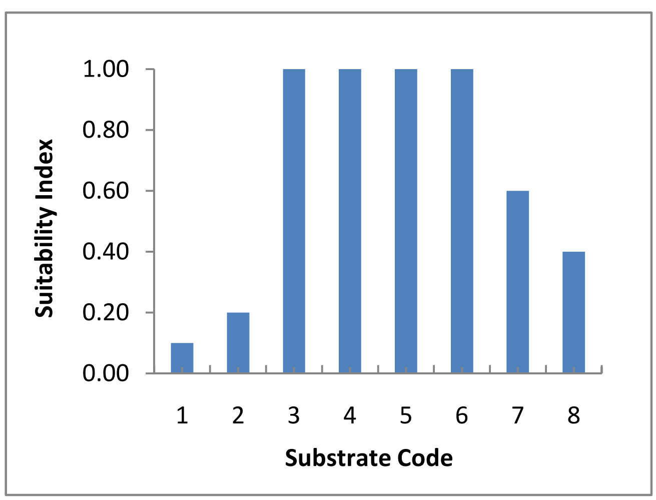
Velocity	SI Value
0.00	0.70
0.50	1.00
3.00	1.00
5.00	0.00



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

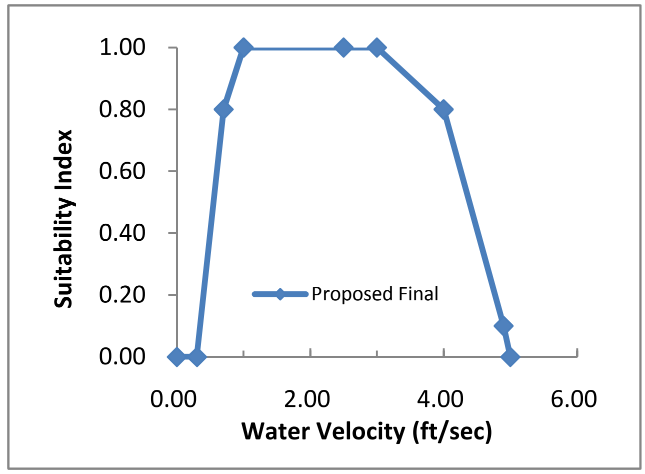


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.20	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble
7	0.60	Boulder
8	0.40	Bedrock

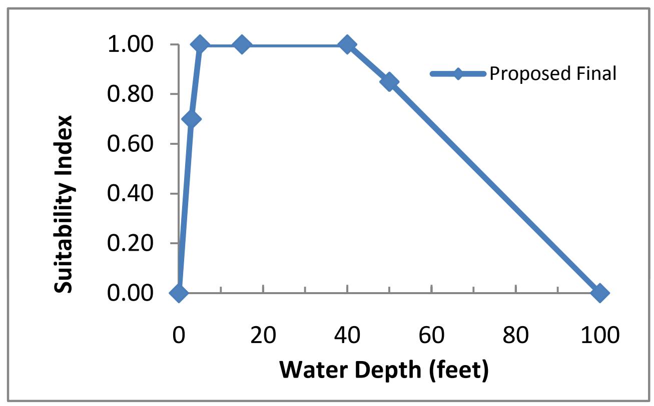


Species: Shortnose Sturgeon
Lifestage: Spawning

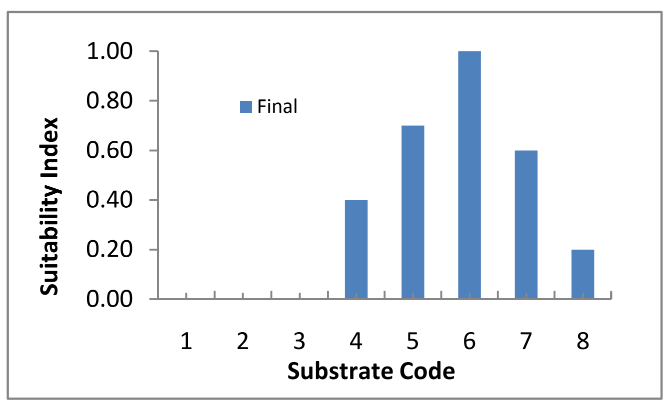
Proposed Final	
Velocity	SI Value
0.00	0.00
0.30	0.00
0.70	0.80
1.00	1.00
2.50	1.00
3.00	1.00
4.00	0.80
4.90	0.10
5.00	0.00



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

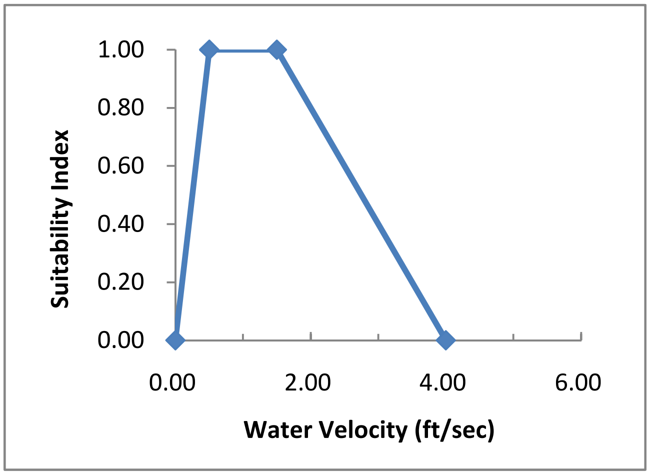


Code	Final SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.40	Sand
5	0.70	Gravel
6	1.00	Cobble/rubble
7	0.60	Boulder
8	0.20	Bedrock

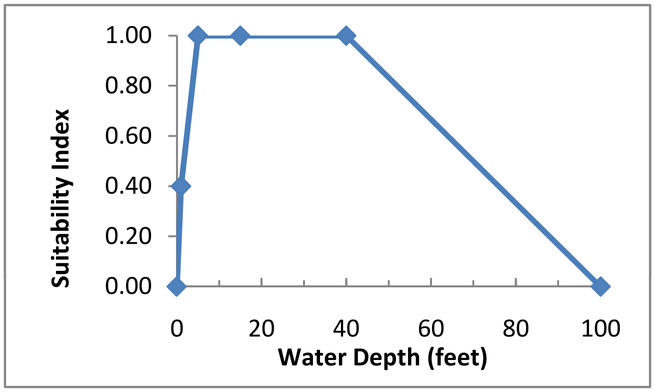


Species: Shortnose Sturgeon
Lifestage: Fry

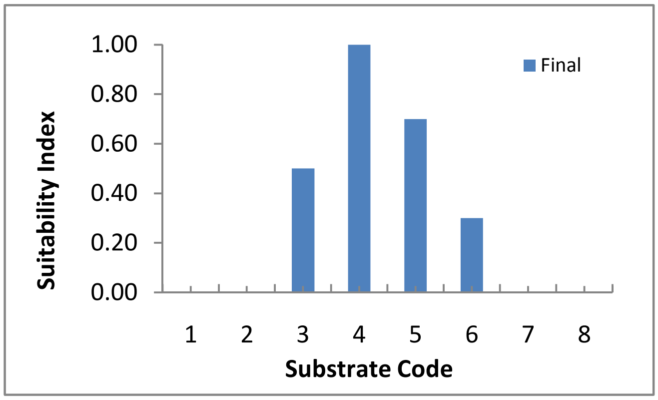
Velocity	SI Value
0.00	0.00
0.50	1.00
1.50	1.00
4.00	0.00



Depth	Proposed Final SI Value
0.00	0.00
1.00	0.40
5.00	1.00
15.00	1.00
40.00	1.00
100.00	0.00

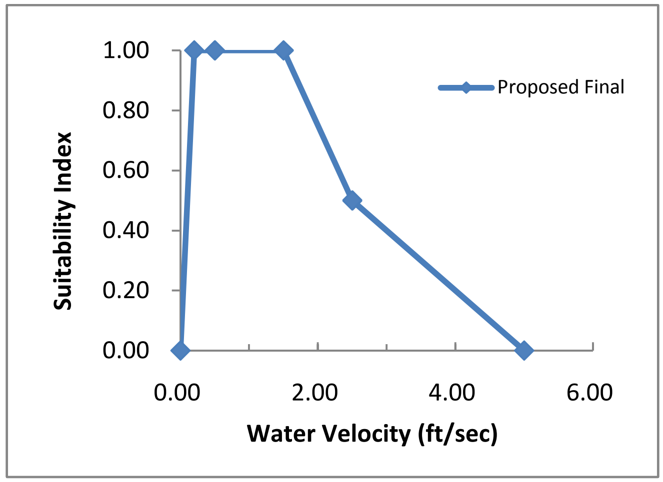


Code	Final SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.50	Silt
4	1.00	Sand
5	0.70	Gravel
6	0.30	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock

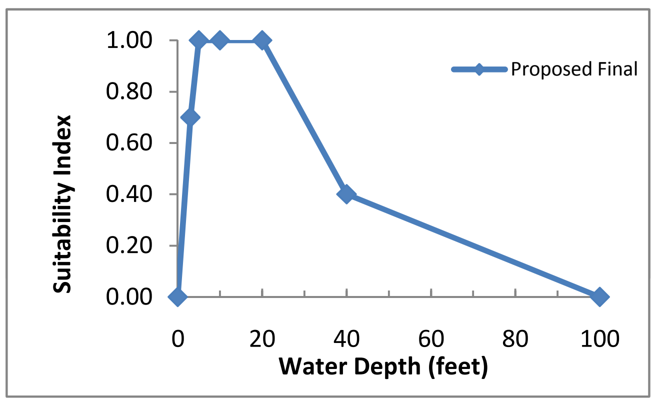


Species: Shortnose Sturgeon
Lifestage: Juveniles

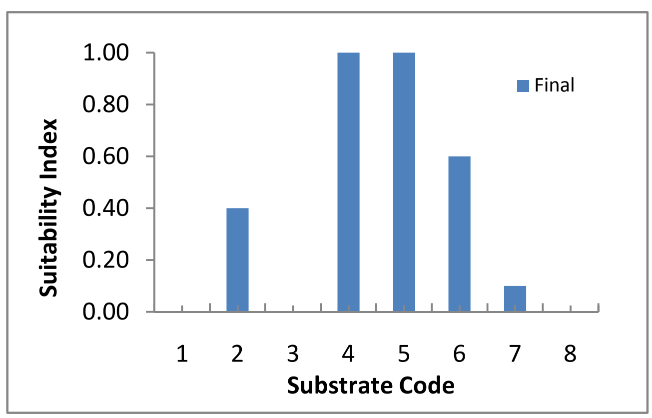
Proposed Final	
Velocity	SI Value
0.00	0.00
0.20	1.00
0.50	1.00
1.50	1.00
2.50	0.50
5.00	0.00



Proposed Final	
Depth	SI Value
0.00	0.00
3.00	0.70
5.00	1.00
10.00	1.00
20.00	1.00
40.00	0.40
100.00	0.00

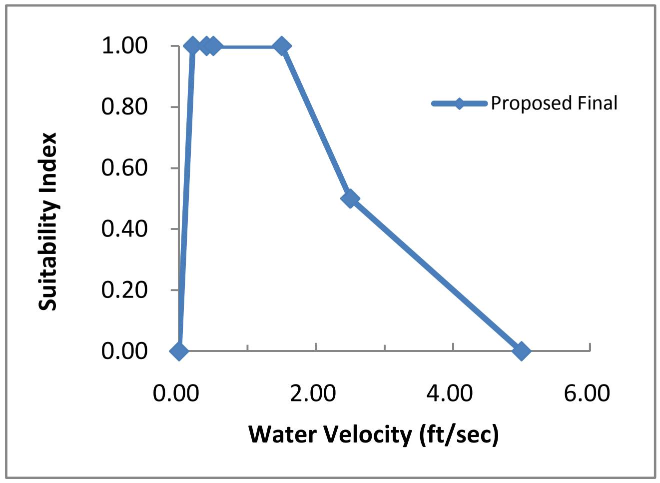


Code	Final SI Value	Type
1	0.00	Detritus/Organic
2	0.40	Mud/soft clay
3	0.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	0.60	Cobble/rubble
7	0.10	Boulder
8	0.00	Bedrock

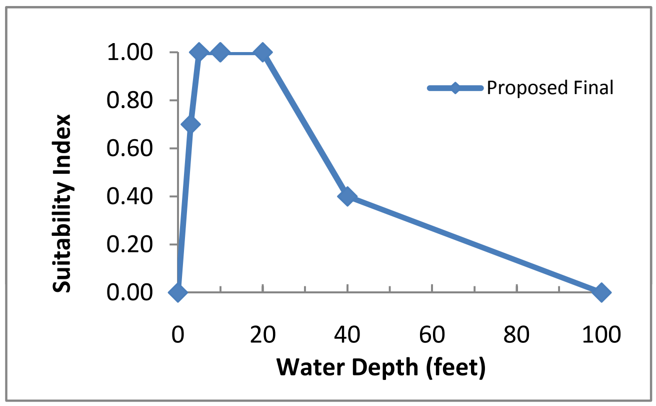


Species: Shortnose Sturgeon
Lifestage: Adults

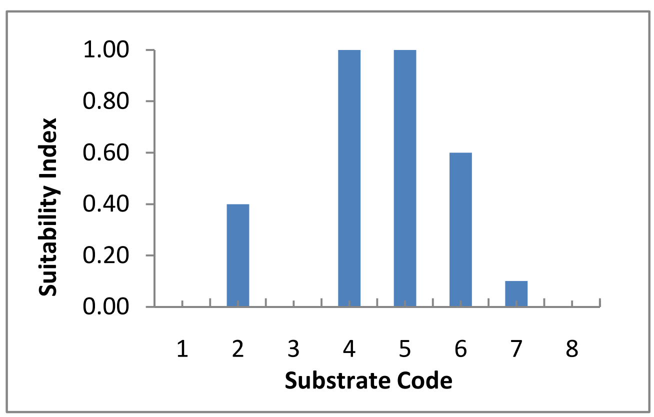
Proposed Final	
Velocity	SI Value
0.00	0.00
0.20	1.00
0.40	1.00
0.50	1.00
1.50	1.00
2.50	0.50
5.00	0.00



Proposed Final	
Depth	SI Value
0.00	0.00
3.00	0.70
5.00	1.00
10.00	1.00
20.00	1.00
40.00	0.40
100.00	0.00



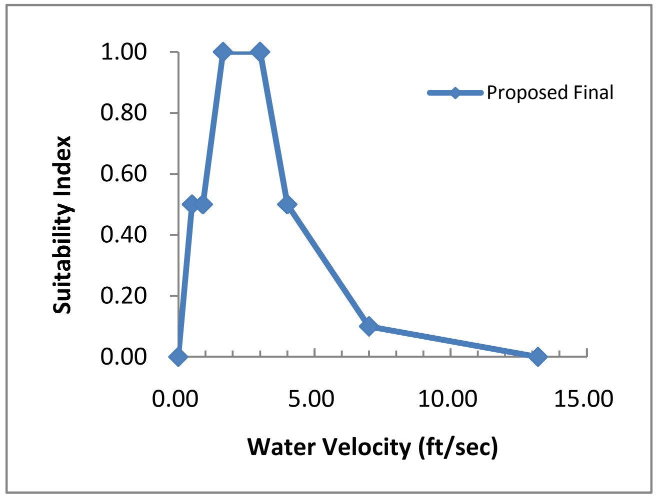
Code	Final SI Value	Type
1	0.00	Detritus/Organic
2	0.40	Mud/soft clay
3	0.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	0.60	Cobble/rubble
7	0.10	Boulder
8	0.00	Bedrock



Species: Striped Bass
Lifestage: Spawning

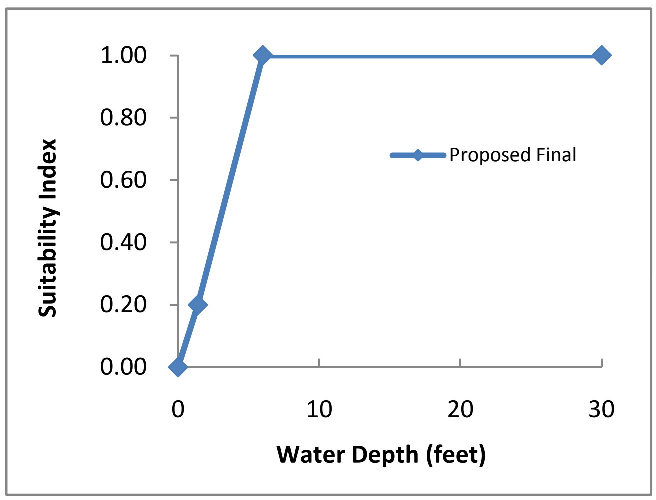
Proposed Final

Velocity	SI Value
0.00	0.00
0.50	0.50
0.90	0.50
1.64	1.00
3.00	1.00
4.00	0.50
7.00	0.10
13.20	0.00

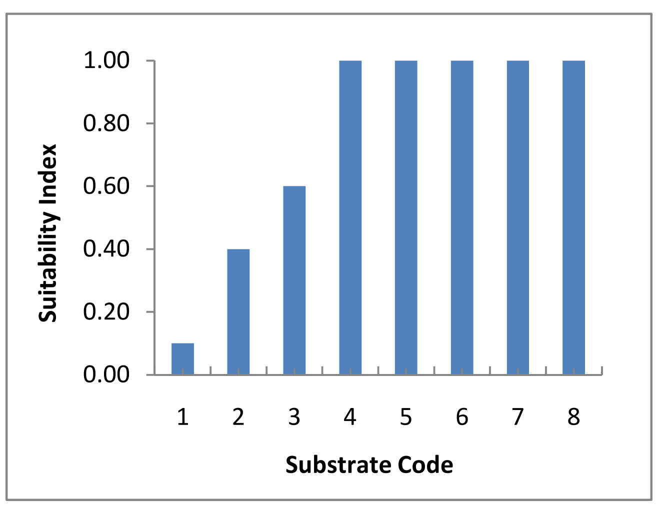


Proposed Final

Depth	SI Value
0.00	0.00
1.40	0.20
6.00	1.00
30.0	1.00



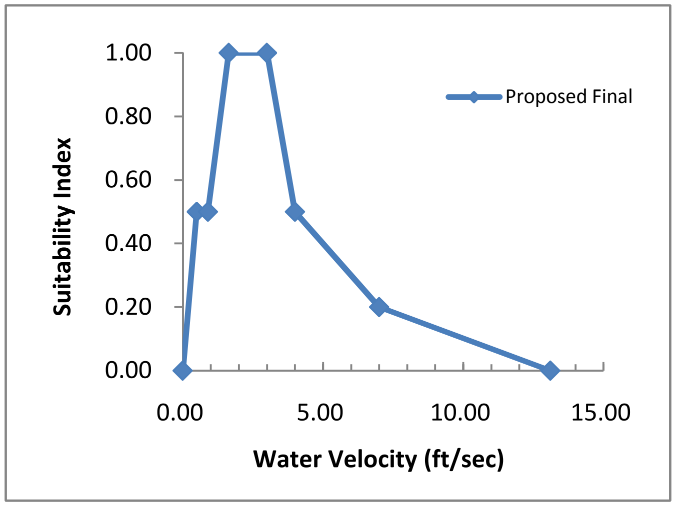
Code	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock



Species: Striped Bass
Lifestage: Fry

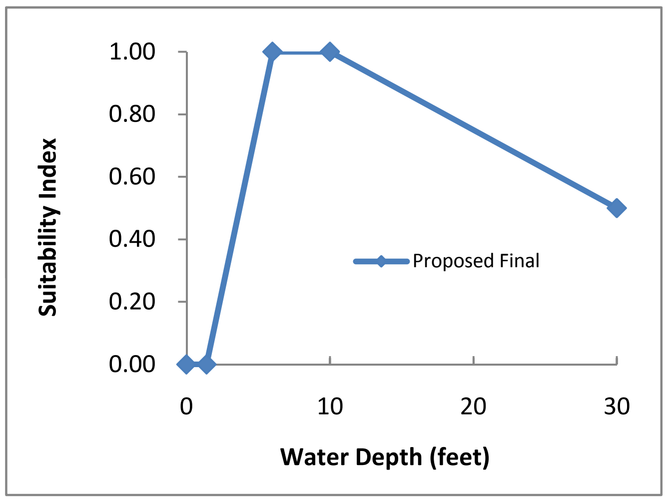
Proposed Final

Velocity	SI Value
0.00	0.00
0.50	0.50
0.90	0.50
1.64	1.00
3.00	1.00
4.00	0.50
7.00	0.20
13.10	0.00

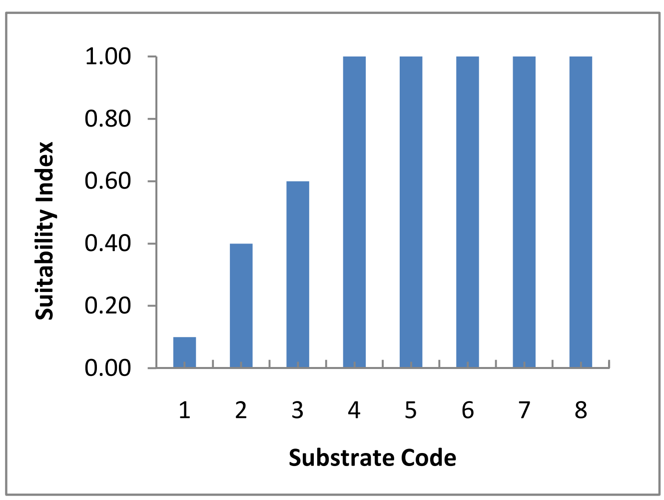


Proposed Final

Depth	SI Value
0.00	0.00
1.40	0.00
6.00	1.00
10.0	1.00
30.0	0.50

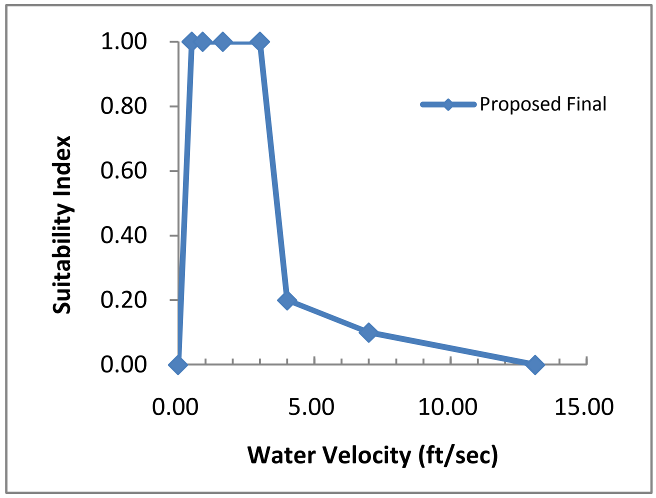


Code	SI Value	
1	0.1	
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock

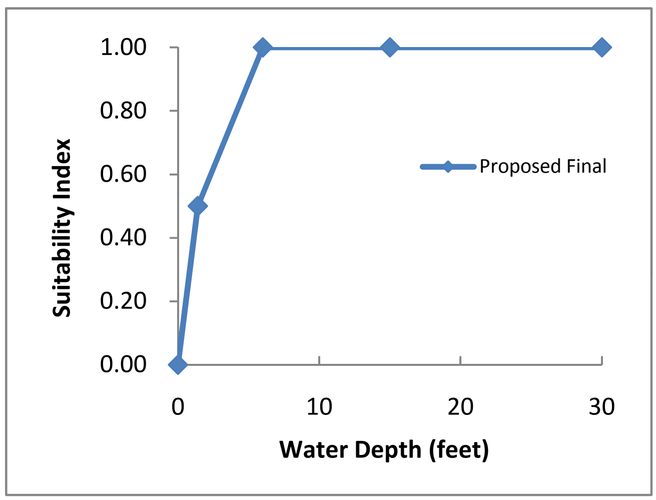


Species: Striped Bass
Lifestage: Juvenile

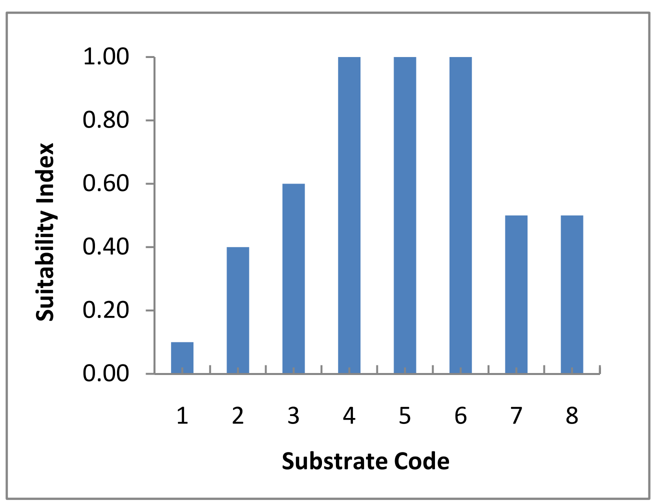
Proposed Final	
Velocity	SI Value
0.00	0.00
0.50	1.00
0.90	1.00
1.64	1.00
3.00	1.00
4.00	0.20
7.00	0.10
13.10	0.00



Proposed Final	
Depth	SI Value
0.00	0.00
1.40	0.50
6.00	1.00
15.0	1.00
30.0	1.00

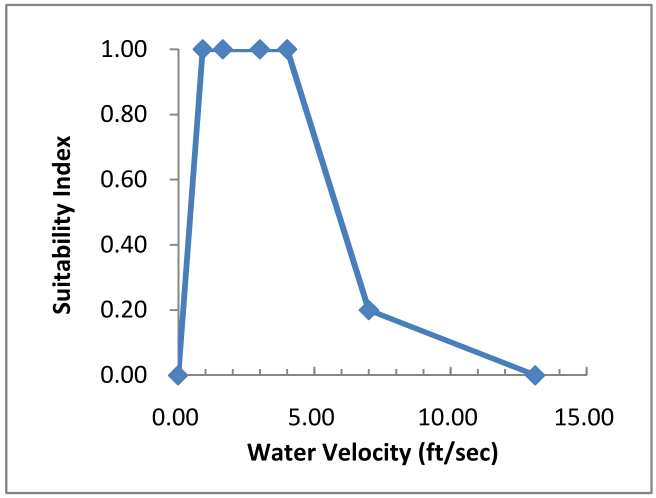


Code	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	0.5	Boulder
8	0.5	Bedrock



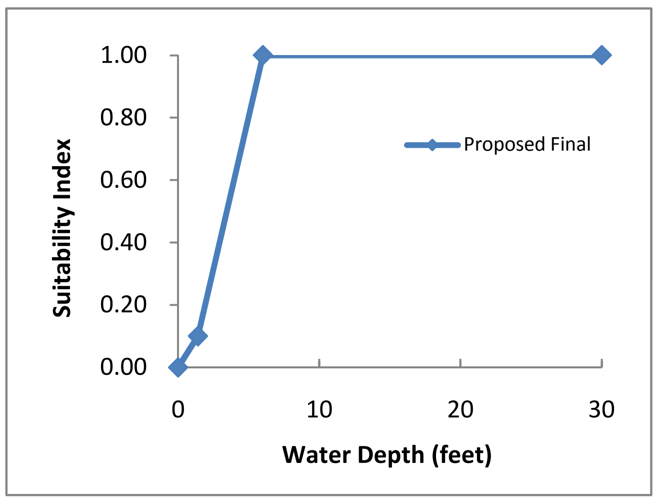
Species: Striped Bass
Lifestage: Adult

Velocity	SI Value
0.00	0.00
0.90	1.00
1.64	1.00
3.00	1.00
4.00	1.00
7.00	0.20
13.10	0.00

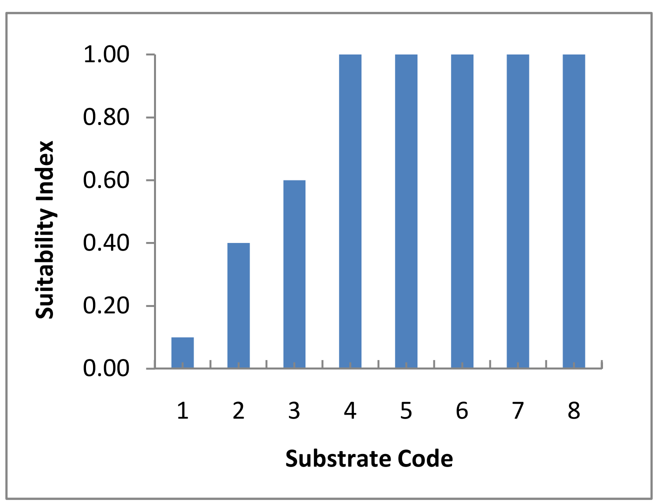


Proposed Final

Depth	SI Value
0.00	0.00
1.40	0.10
6.00	1.00
30.0	1.00



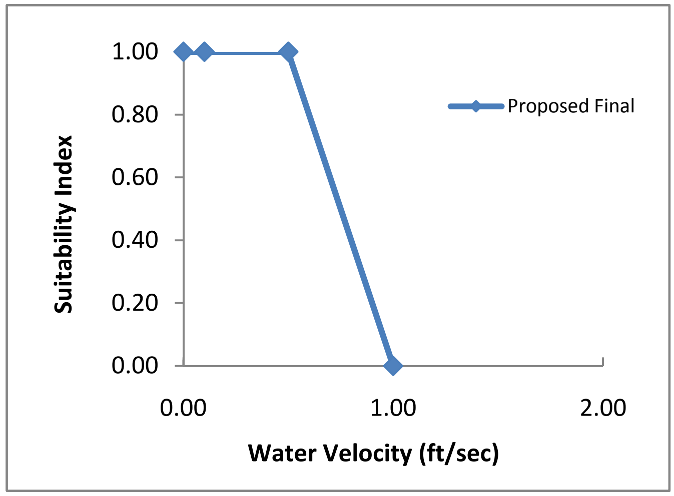
Code	SI Value	Type
1	0.1	Detritus/Organic
2	0.4	Mud/Soft Clay
3	0.6	Silt
4	1.0	Sand
5	1.0	Gravel
6	1.0	Cobble
7	1.0	Boulder
8	1.0	Bedrock



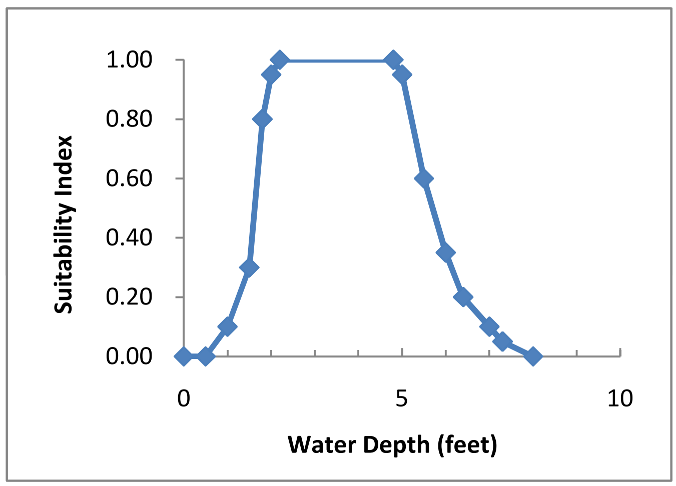
Species: Smallmouth Bass
Lifestage: Spawning

Proposed Final

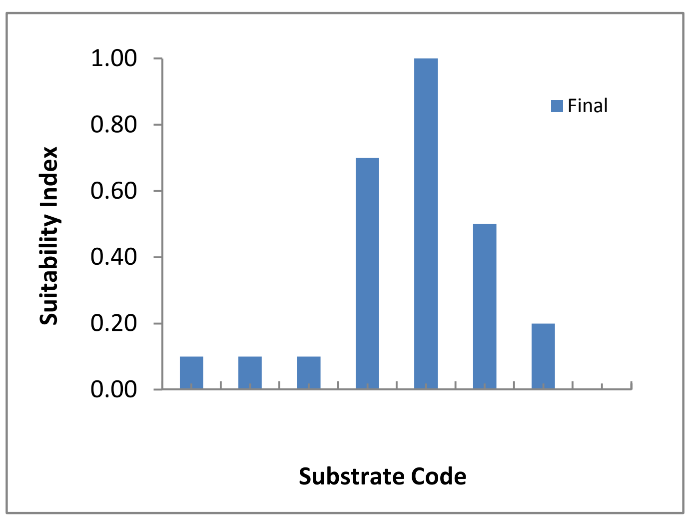
Velocity	SI Value
0.00	1.00
0.10	1.00
0.50	1.00
1.00	0.00



Depth	SI Value
0.00	0.00
0.50	0.00
1.00	0.10
1.50	0.30
1.80	0.80
2.00	0.95
2.20	1.00
4.80	1.00
5.00	0.95
5.50	0.60
6.00	0.35
6.40	0.20
7.00	0.10
7.30	0.05
8.00	0.00

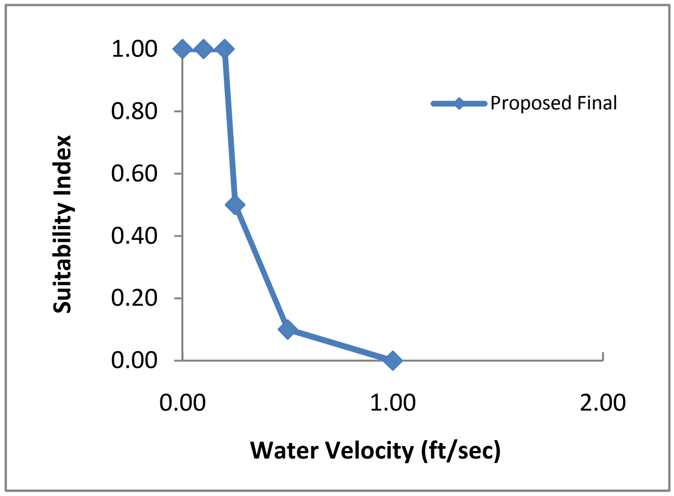


Code	Final SI Value	Type
1	0.10	Detritus
2	0.10	Mud
3	0.10	Silt
4	0.70	Sand
5	1.00	Gravel
6	0.50	Cobble
7	0.20	Boulder
8	0.00	Bedrock

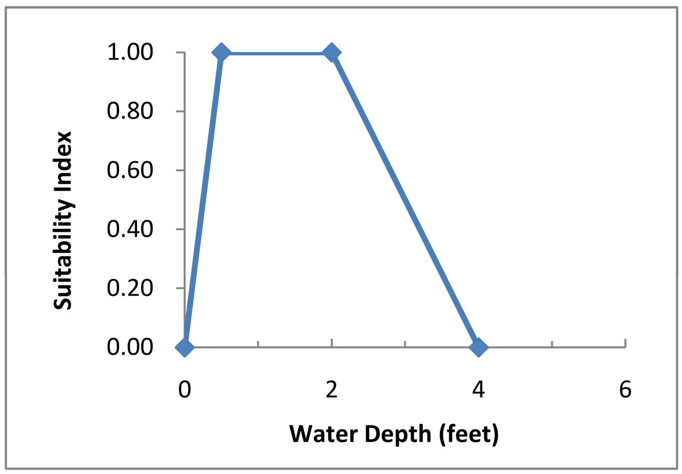


Species: Smallmouth Bass
Lifestage: Fry

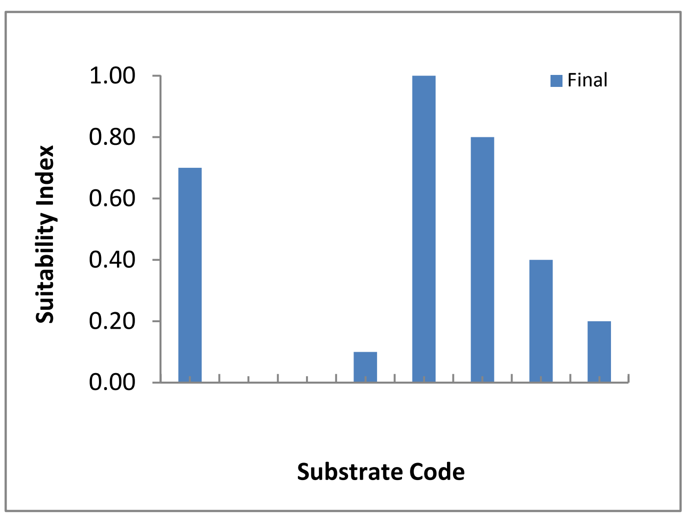
Proposed Final	
Velocity	SI Value
0.00	1.00
0.10	1.00
0.20	1.00
0.25	0.50
0.50	0.10
1.00	0.00



Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
4.00	0.00

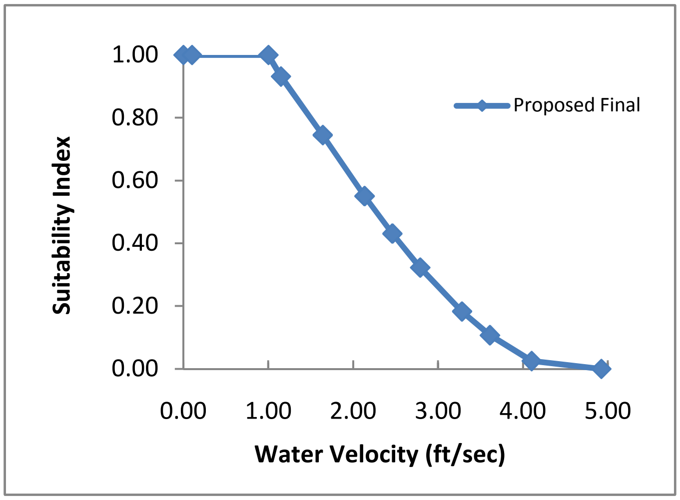


Code	Final SI Value	Type
1	0.70	Detritus
2	0.00	Mud
3	0.00	Silt
4	0.10	Sand
5	1.00	Gravel
6	0.80	Cobble
7	0.40	Boulder
8	0.20	Bedrock

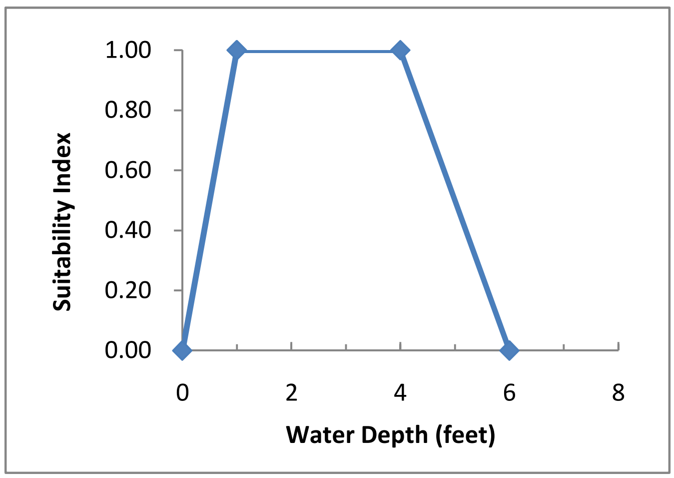


Species: Smallmouth Bass
Lifestage: Juvenile

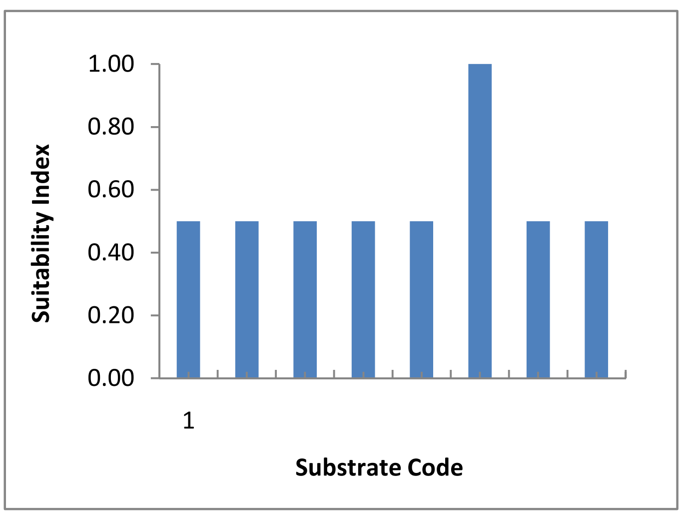
Proposed Final	
Velocity	SI Value
0.00	1.00
0.10	1.00
1.00	1.00
1.15	0.93
1.64	0.75
2.13	0.55
2.46	0.43
2.79	0.32
3.28	0.18
3.61	0.11
4.10	0.02
4.92	0.00



Depth	SI Value
0.00	0.00
1.00	1.00
4.00	1.00
6.00	0.00

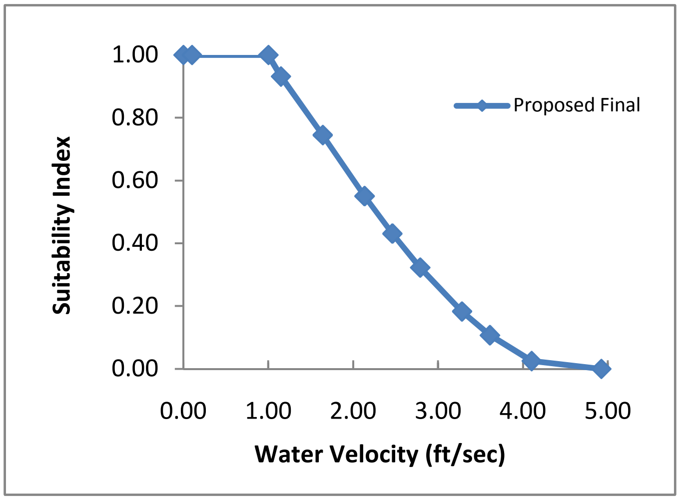


Code	SI Value	Type
1	0.50	Detritus/Organic
2	0.50	Mud/soft clay
3	0.50	Silt
4	0.50	Sand
5	0.50	Gravel
6	1.00	Cobble/rubble
7	0.50	Boulder
8	0.50	Bedrock

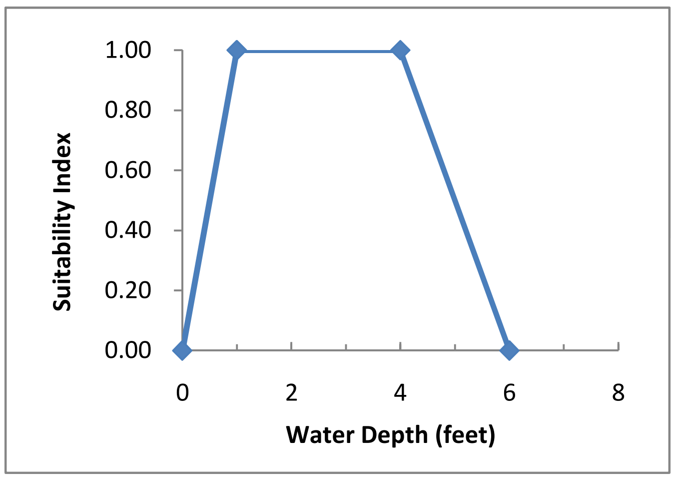


Species: Smallmouth Bass
Lifestage: Juvenile

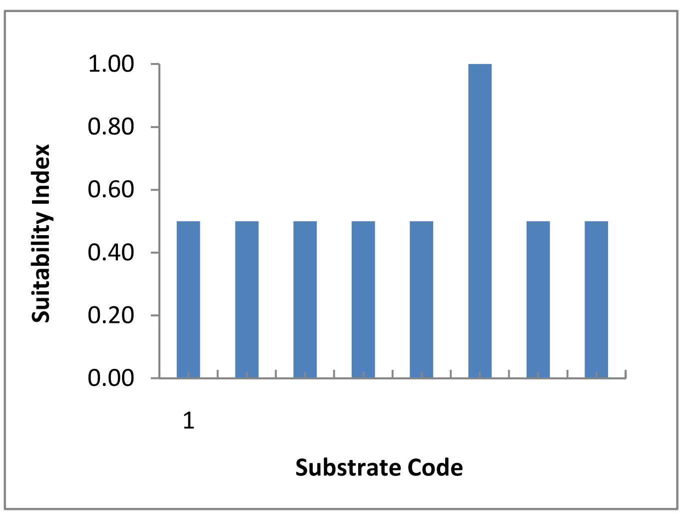
Proposed Final	
Velocity	SI Value
0.00	1.00
0.10	1.00
1.00	1.00
1.15	0.93
1.64	0.75
2.13	0.55
2.46	0.43
2.79	0.32
3.28	0.18
3.61	0.11
4.10	0.02
4.92	0.00



Depth	SI Value
0.00	0.00
1.00	1.00
4.00	1.00
6.00	0.00

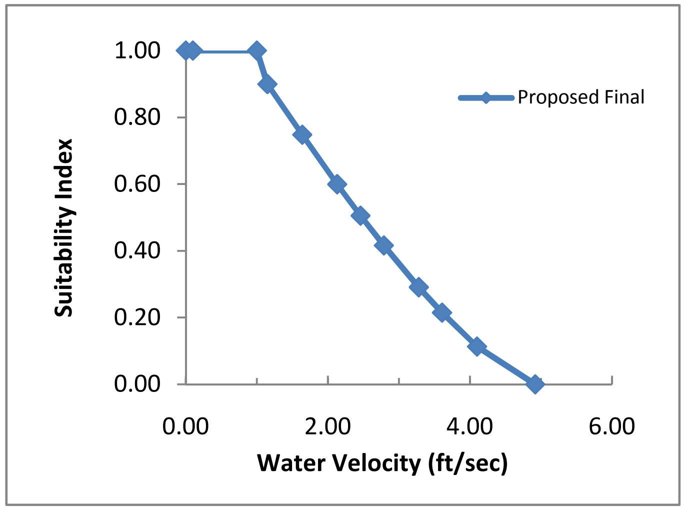


Code	SI Value	Type
1	0.50	Detritus/Organic
2	0.50	Mud/soft clay
3	0.50	Silt
4	0.50	Sand
5	0.50	Gravel
6	1.00	Cobble/rubble
7	0.50	Boulder
8	0.50	Bedrock

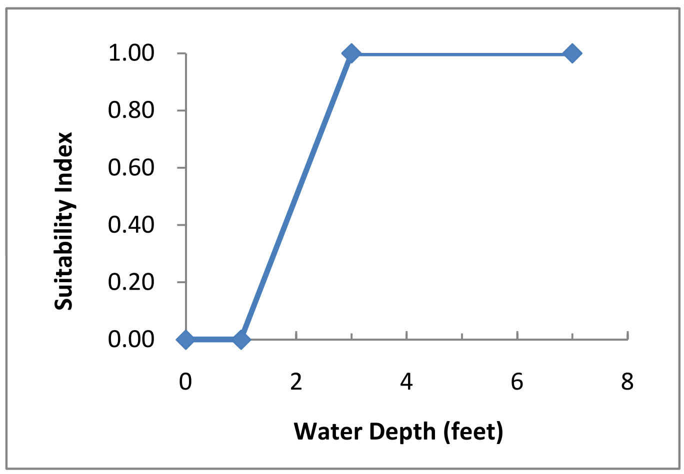


Species: Smallmouth Bass
Lifestage: Adult

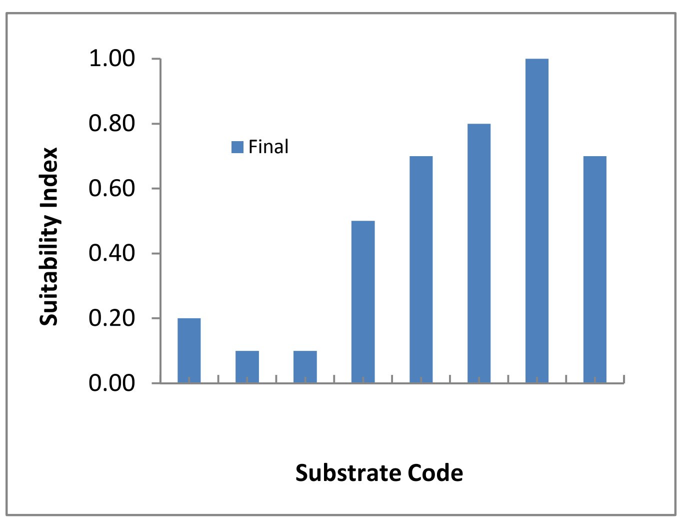
Proposed Final Velocity	SI Value
0.00	1.00
0.10	1.00
1.00	1.00
1.15	0.90
1.64	0.75
2.13	0.60
2.46	0.51
2.79	0.42
3.28	0.29
3.61	0.21
4.10	0.11
4.92	0.00



Depth	SI Value
0.00	0.00
1.00	0.00
3.00	1.00
7.00	1.00

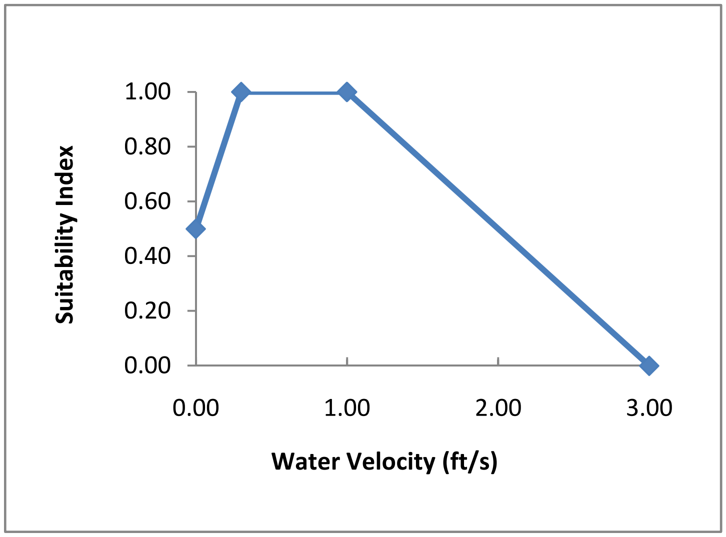


Code	Final SI Value	Type
1	0.20	Detritus
2	0.10	Mud
3	0.10	Silt
4	0.50	Sand
5	0.70	Gravel
6	0.80	Cobble
7	1.00	Boulder
8	0.70	Bedrock

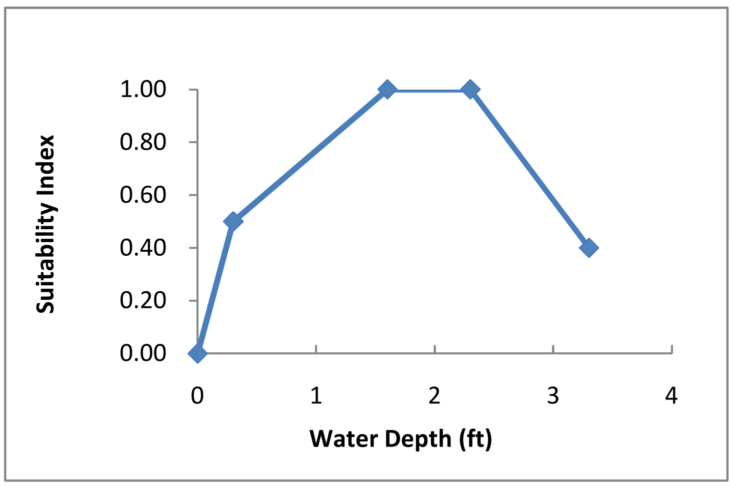


Species: Ephemeroptera (Mayflies)
Lifestage: Community Diversity -Large River

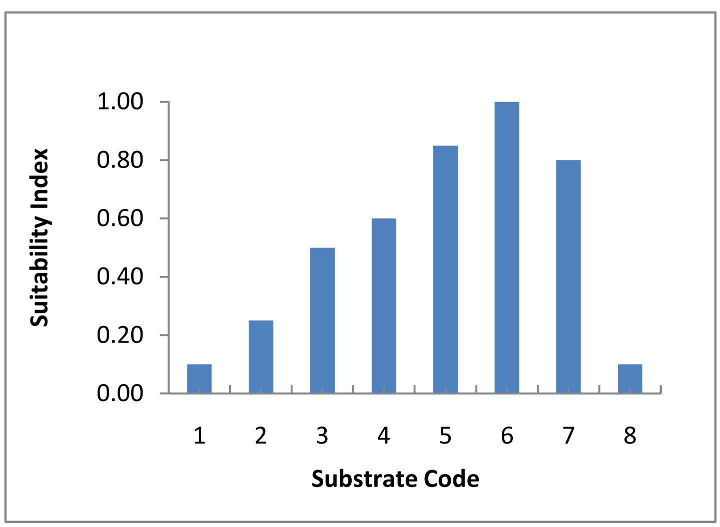
Velocity	SI Value
0.00	0.50
0.30	1.00
1.00	1.00
3.00	0.00



Depth	SI Value
0.00	0.00
0.30	0.50
1.60	1.00
2.30	1.00
3.30	0.40

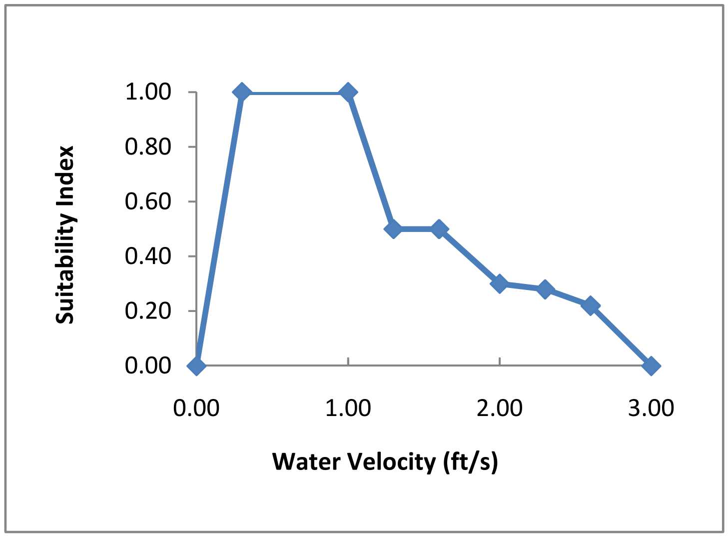


Code	SI Value	Type
1	0.10	Detritus/Organic
2	0.25	Mud/soft clay
3	0.50	Silt
4	0.60	Sand
5	0.85	Gravel
6	1.00	Cobble/rubble
7	0.80	Boulder
8	0.10	Bedrock

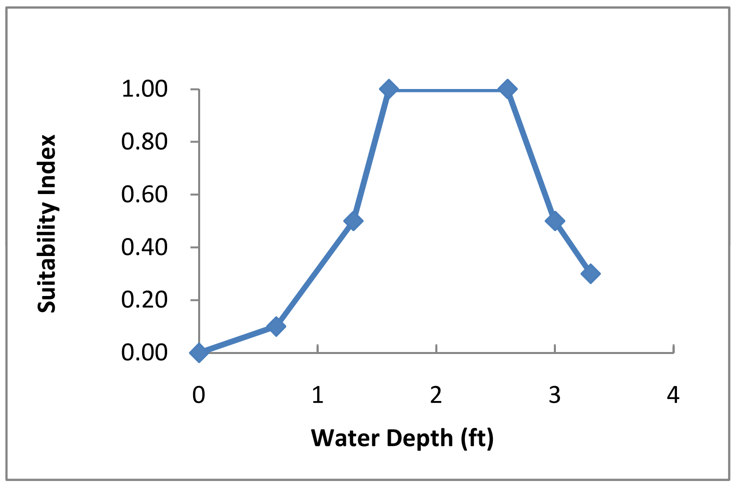


Species: Plecoptera (Stoneflies)
Lifestage: Community Diversity -Large River

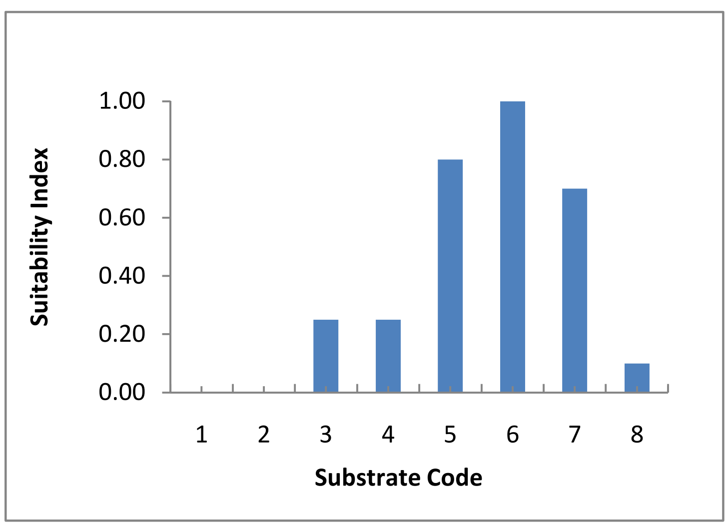
Velocity	SI Value
0.00	0.00
0.30	1.00
1.00	1.00
1.30	0.50
1.60	0.50
2.00	0.30
2.30	0.28
2.60	0.22
3.00	0.00



Depth	SI Value
0.00	0.00
0.65	0.10
1.30	0.50
1.60	1.00
2.60	1.00
3.00	0.50
3.30	0.30

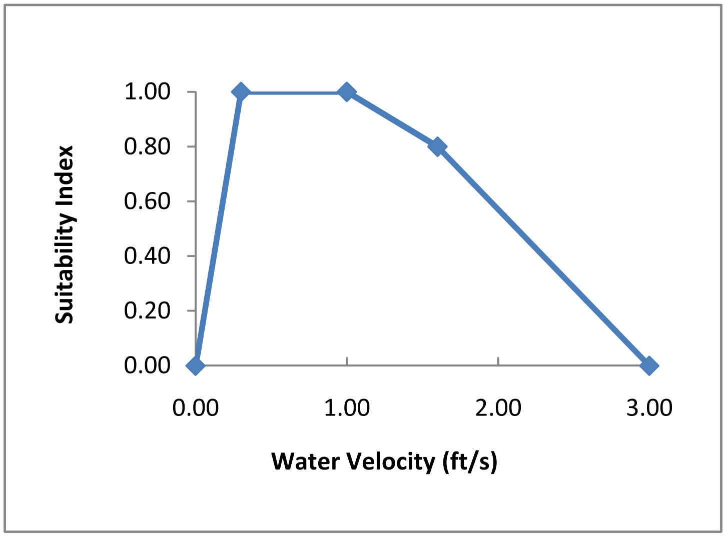


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.25	Silt
4	0.25	Sand
5	0.80	Gravel
6	1.00	Cobble/rubble
7	0.70	Boulder
8	0.10	Bedrock

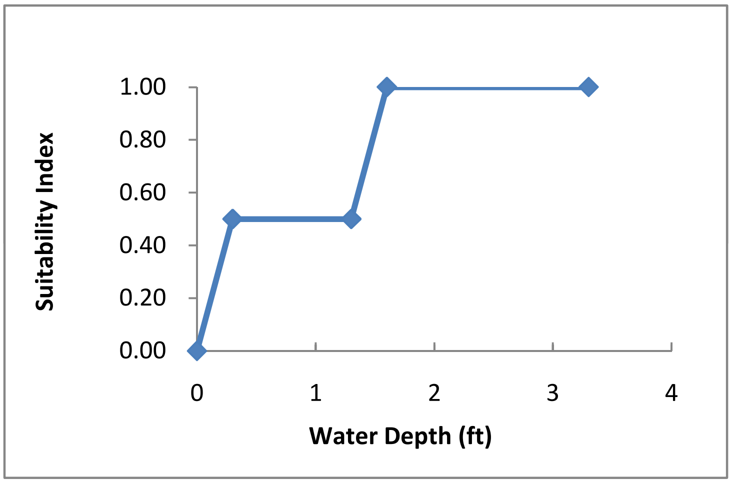


Species: Tricoptera (Caddisflies)
Lifestage: Community Diversity -Large River

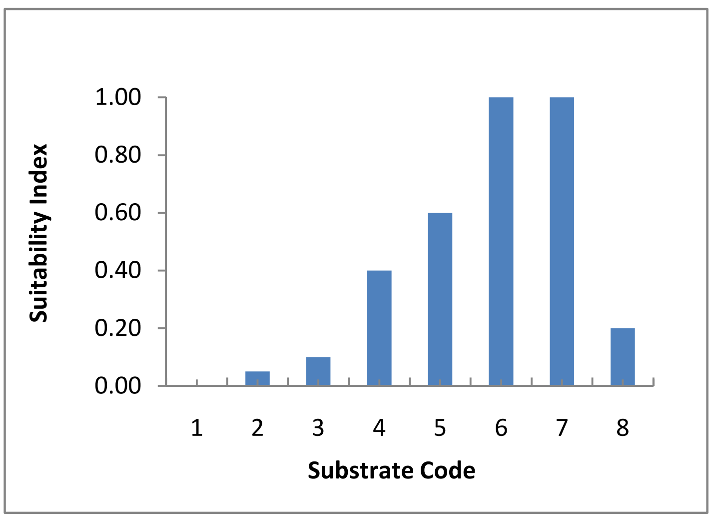
Velocity	SI Value
0.00	0.00
0.30	1.00
1.00	1.00
1.60	0.80
3.00	0.00



Depth	SI Value
0.00	0.00
0.30	0.50
1.30	0.50
1.60	1.00
3.30	1.00

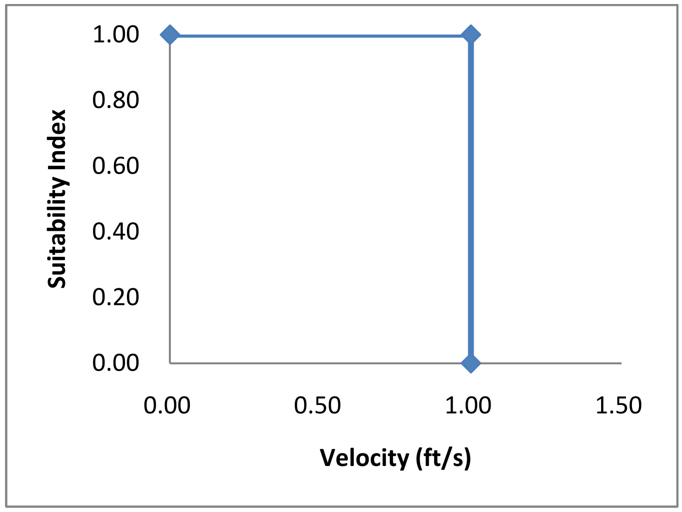


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.05	Mud/soft clay
3	0.10	Silt
4	0.40	Sand
5	0.60	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	0.20	Bedrock

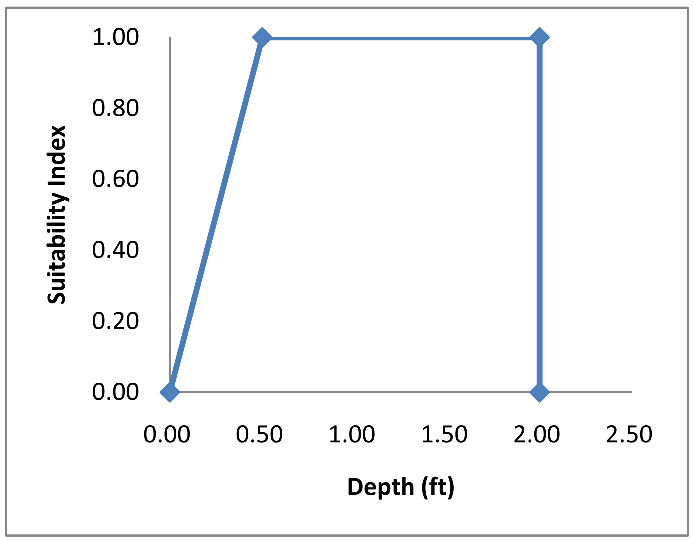


Species: Shallow-Slow Guild

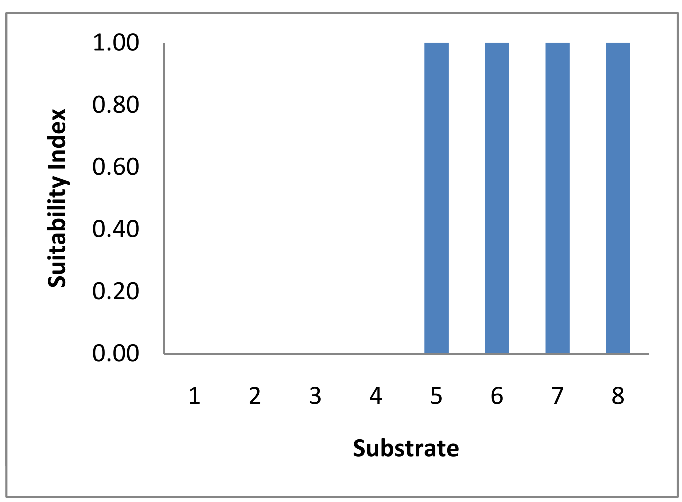
Velocity	SI Value
0.00	1.00
1.00	1.00
1.00	0.00



Depth	SI Value
0.00	0.00
0.50	1.00
2.00	1.00
2.00	0.00

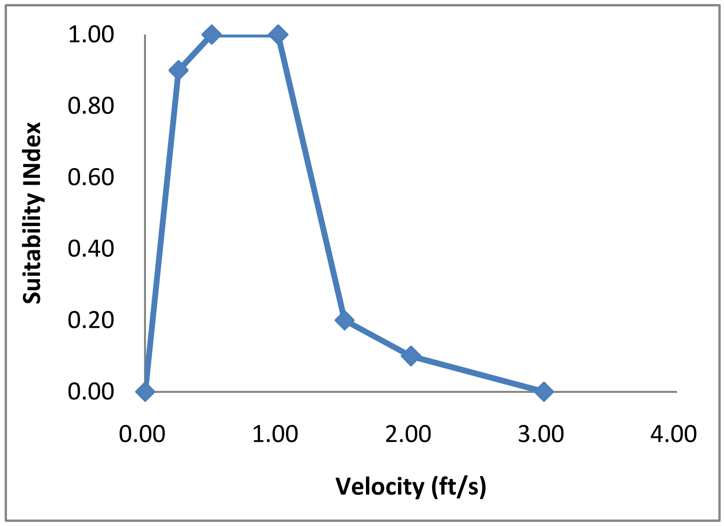


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock

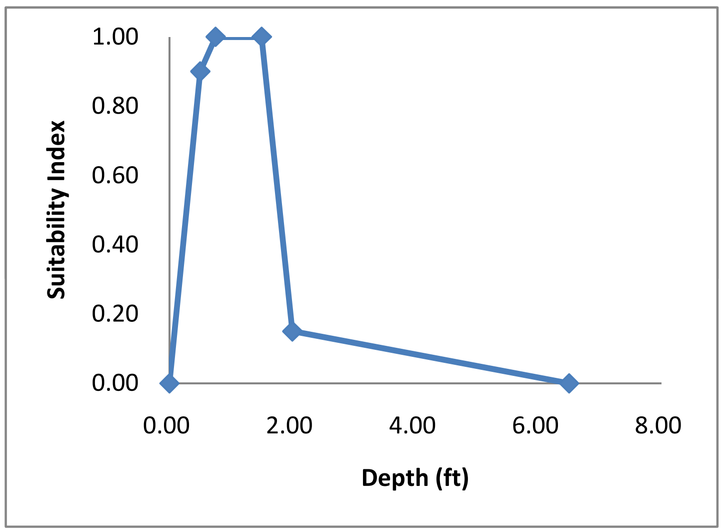


Species: Shallow-Fast Guild

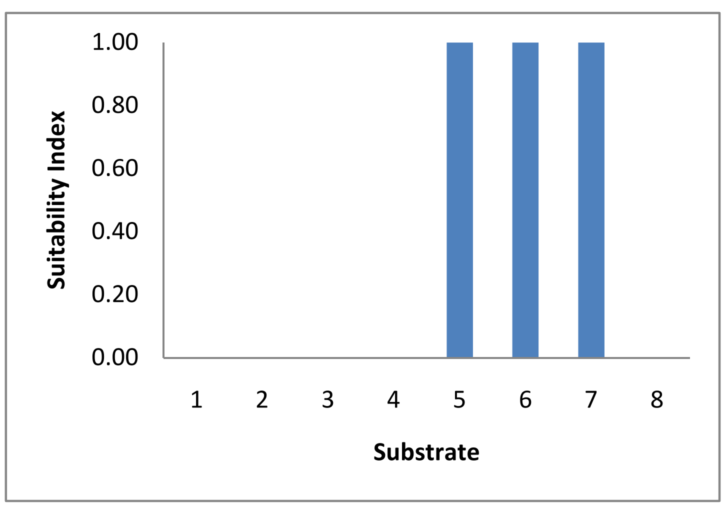
Velocity	SI Value
0.00	0.00
0.25	0.90
0.50	1.00
1.00	1.00
1.50	0.20
2.00	0.10
3.00	0.00



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

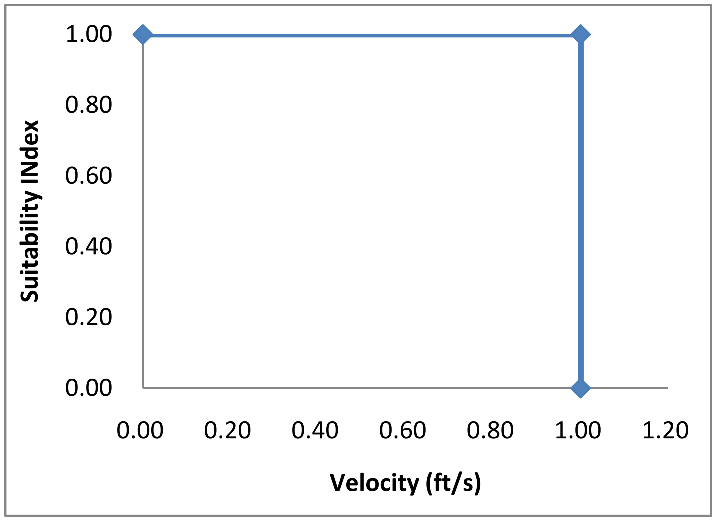


Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	0.00	Bedrock

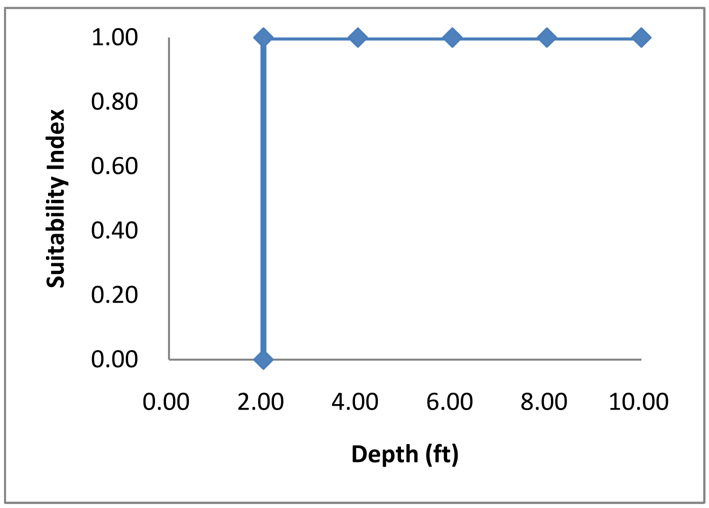


Species: Deep-Slow Guild

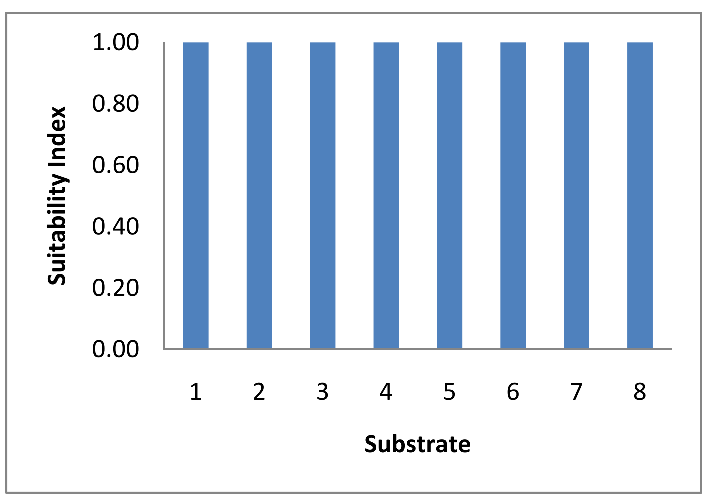
Velocity	SI Value
0.00	1.00
1.00	1.00
1.00	0.00



Depth	SI Value
2.00	0.00
2.00	1.00
4.00	1.00
6.00	1.00
8.00	1.00
10.00	1.00

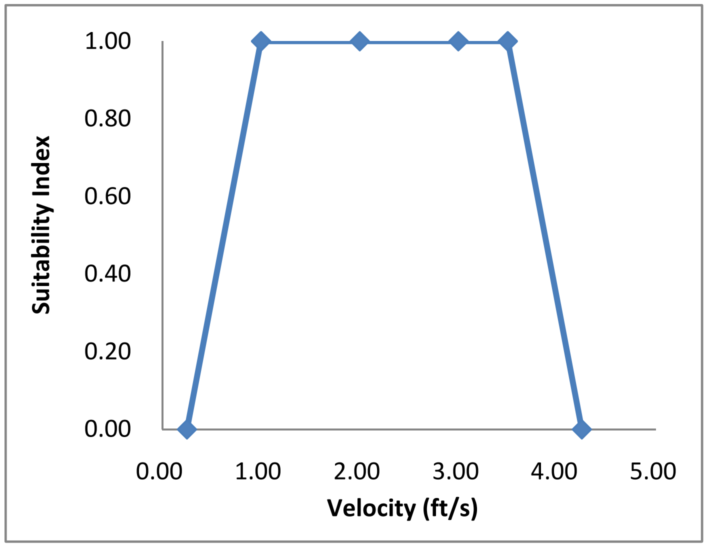


Code	SI Value	Type
1	1.00	Detritus/Organic
2	1.00	Mud/soft clay
3	1.00	Silt
4	1.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	1.00	Boulder
8	1.00	Bedrock

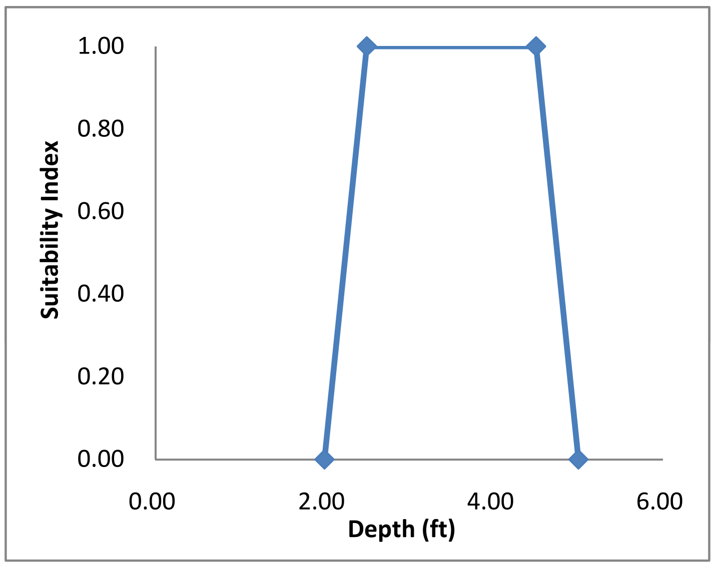


Species: Deep-Fast Guild

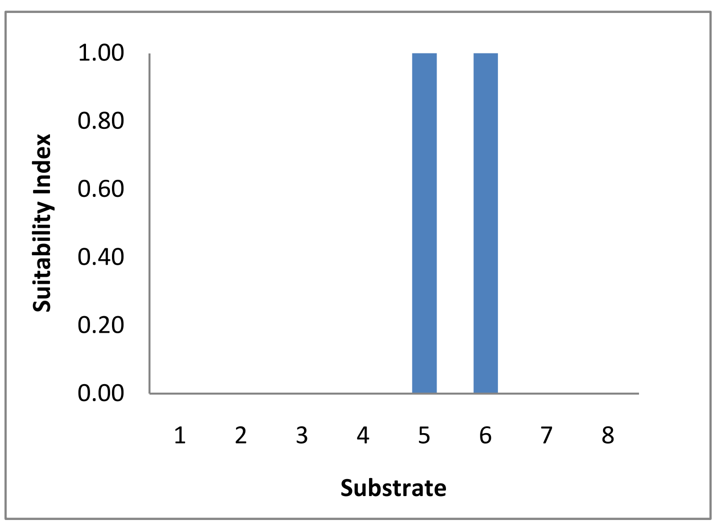
Velocity	SI Value
0.25	0.00
1.00	1.00
2.00	1.00
3.00	1.00
3.50	1.00
4.25	0.00



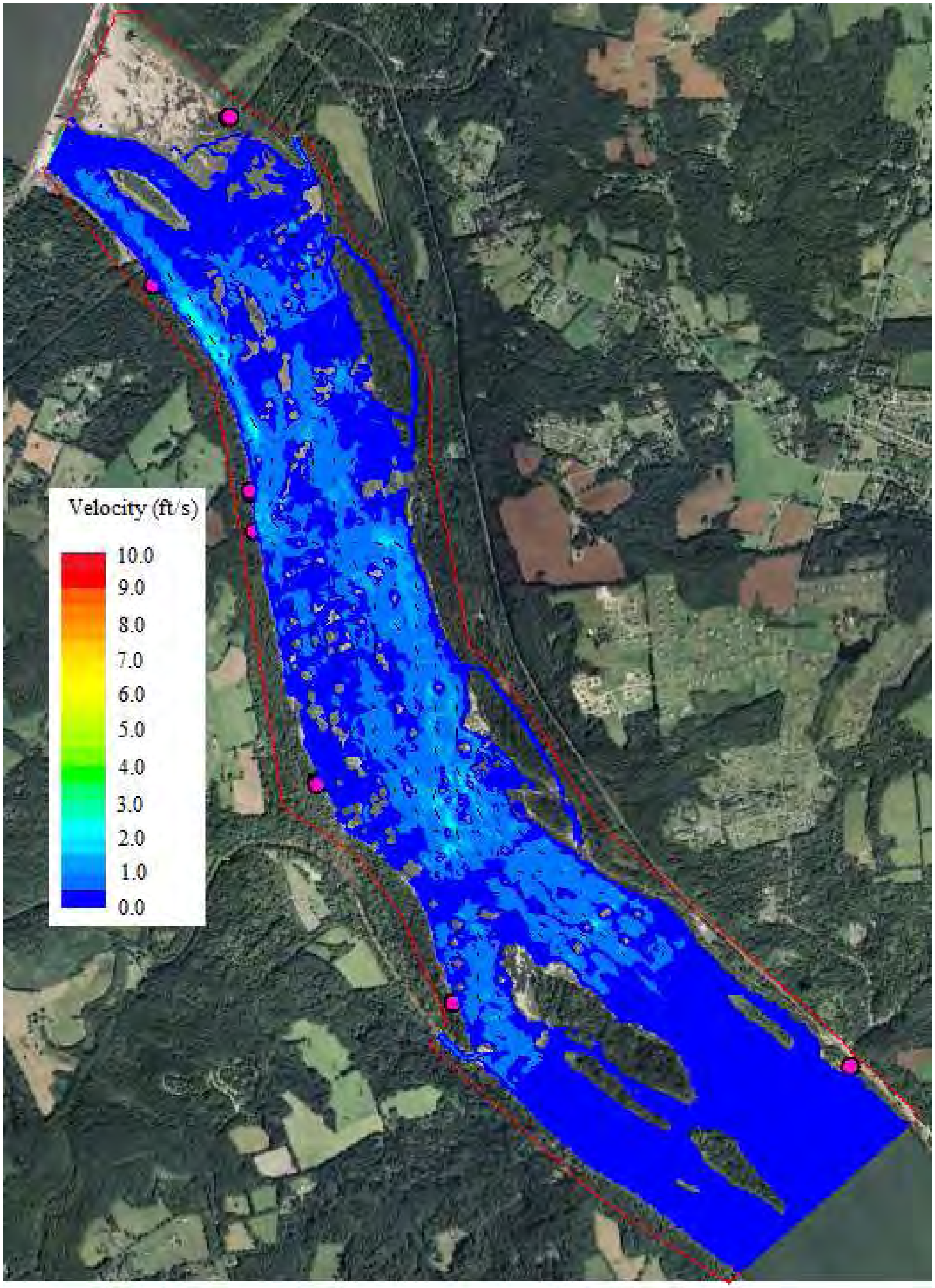
Depth	SI Value
2.00	0.00
2.50	1.00
4.50	1.00
5.00	0.00



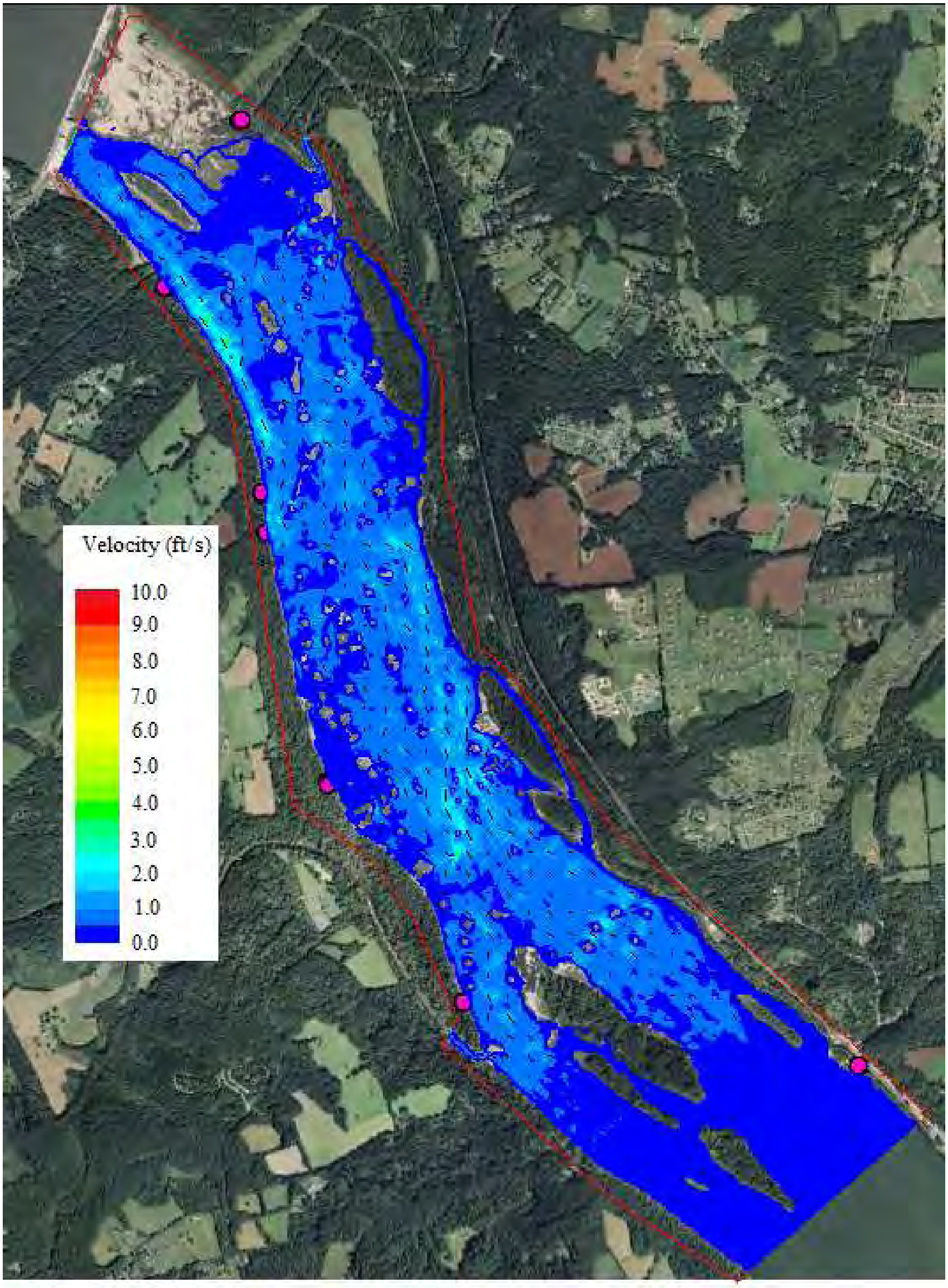
Code	SI Value	Type
1	0.00	Detritus/Organic
2	0.00	Mud/soft clay
3	0.00	Silt
4	0.00	Sand
5	1.00	Gravel
6	1.00	Cobble/rubble
7	0.00	Boulder
8	0.00	Bedrock



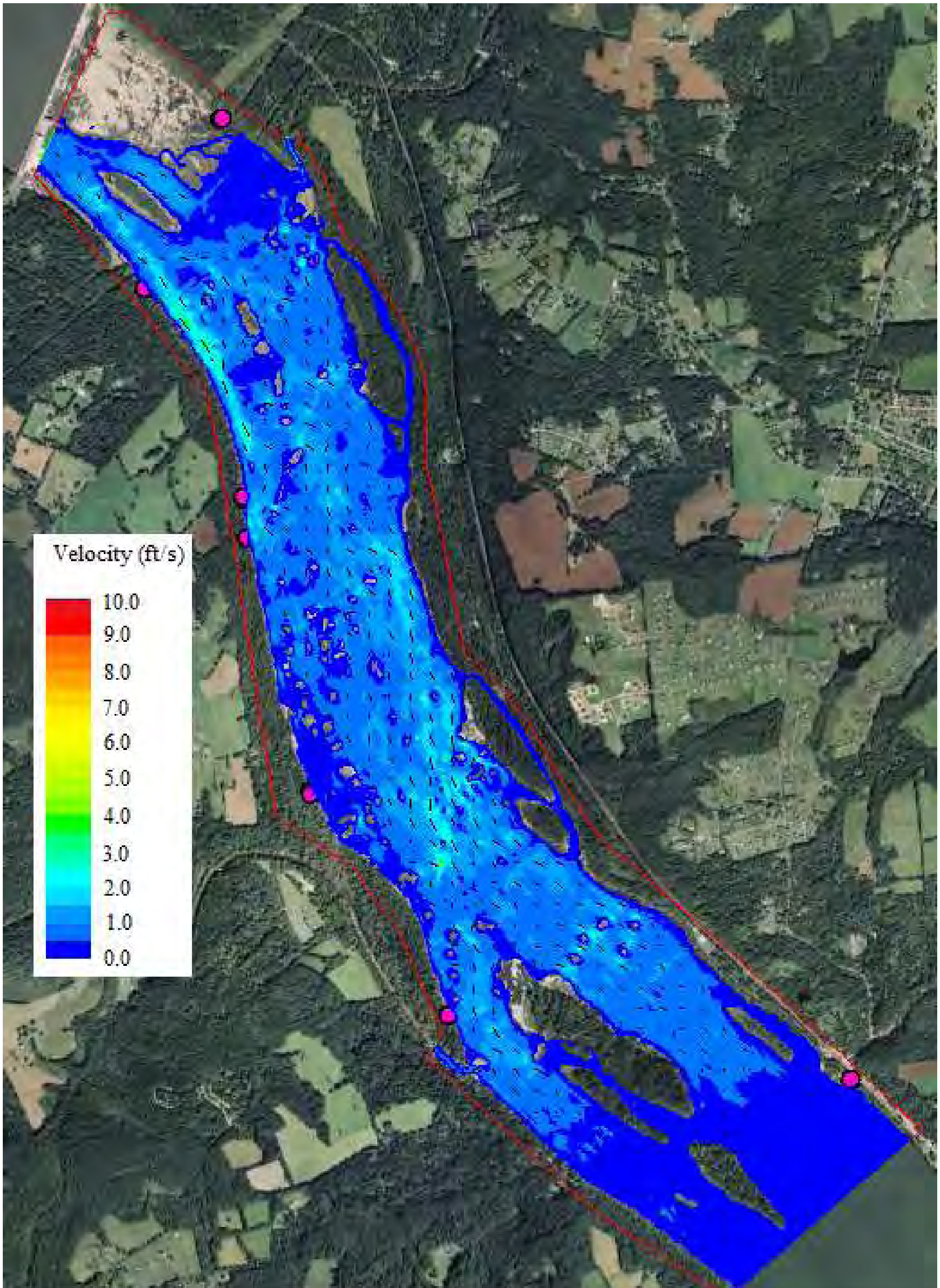
APPENDIX C-WATER VELOCITY PLOTS FOR SIMULATION FLOWS



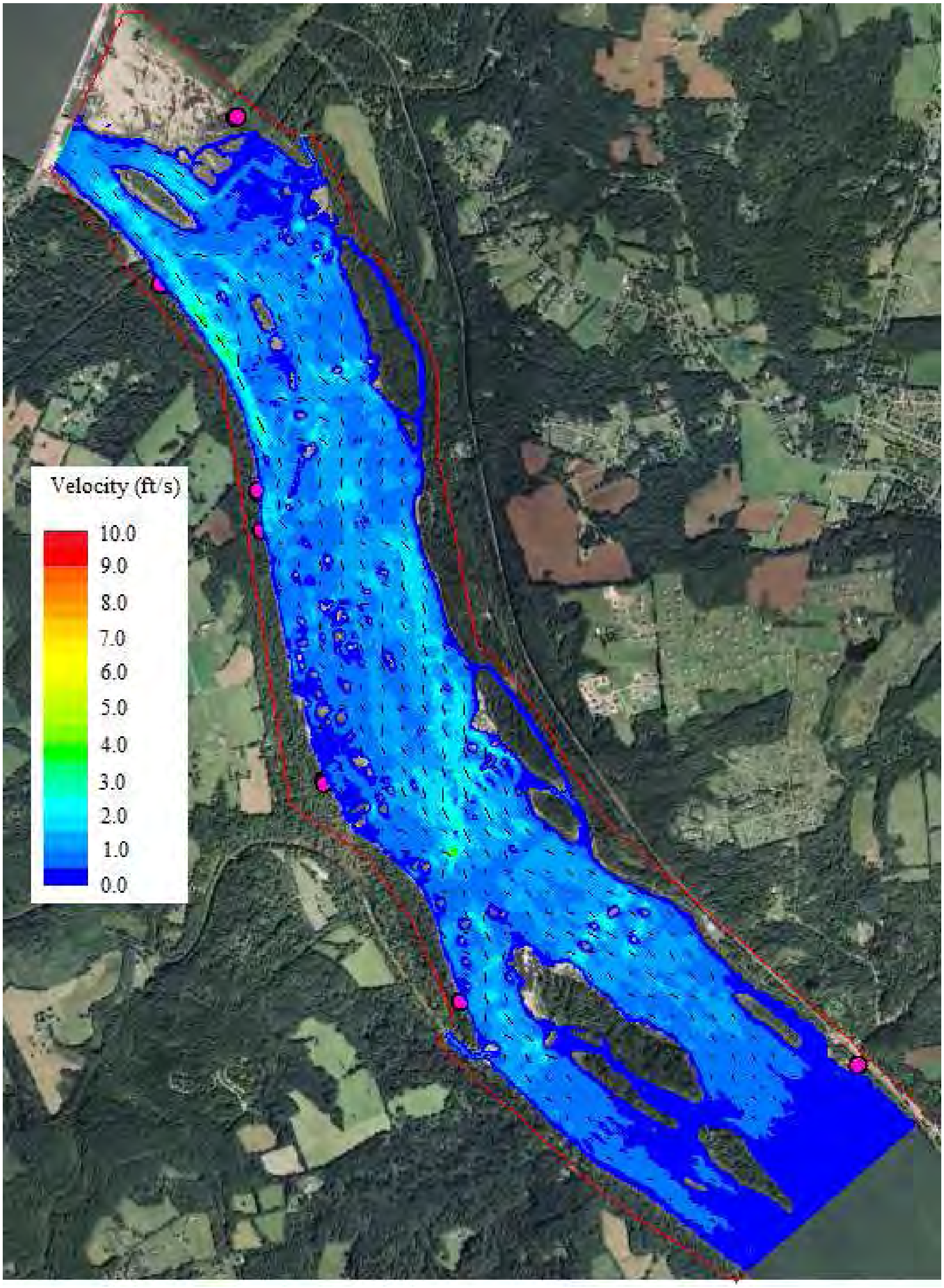
2,000 CFS



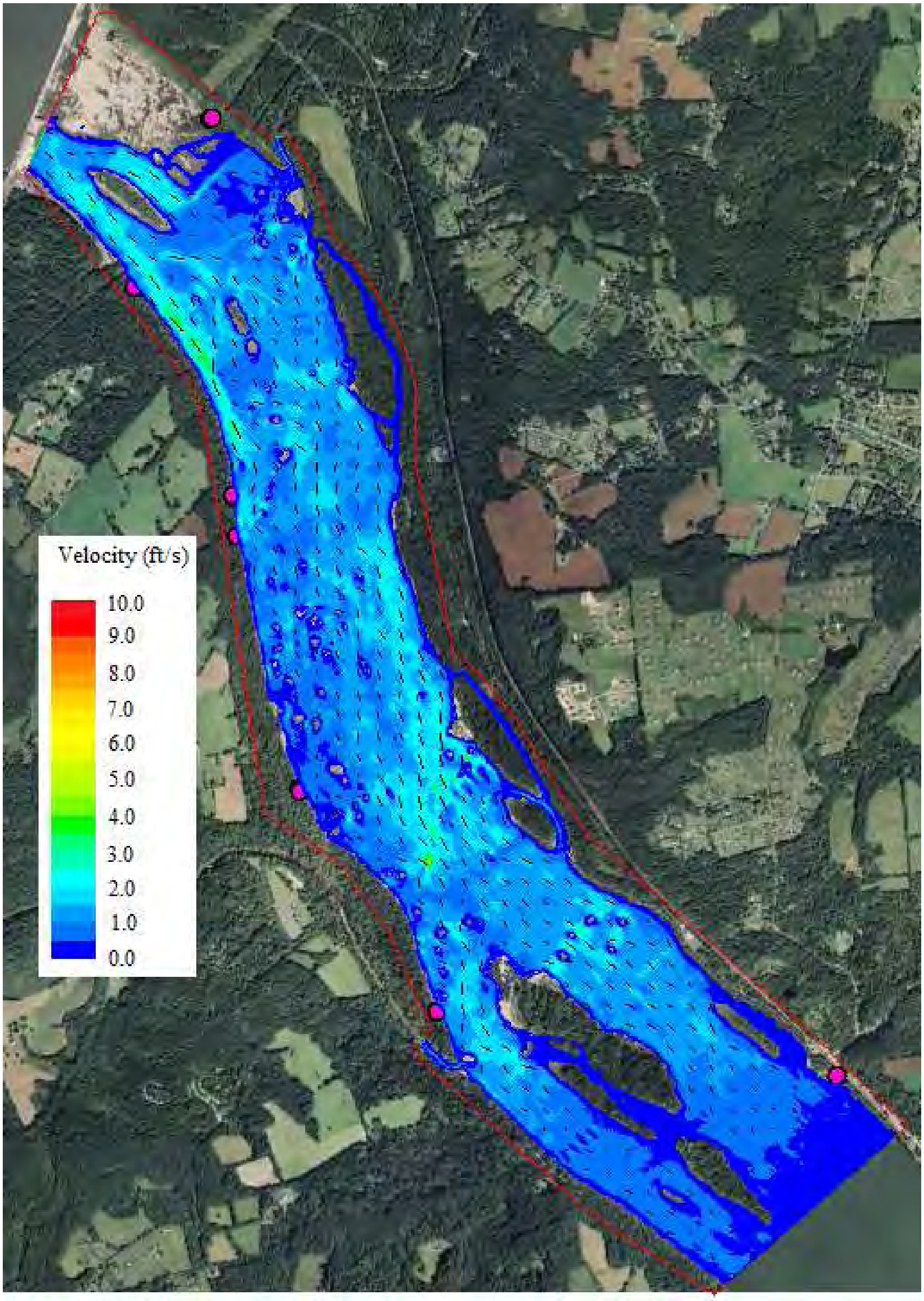
3,500 CFS



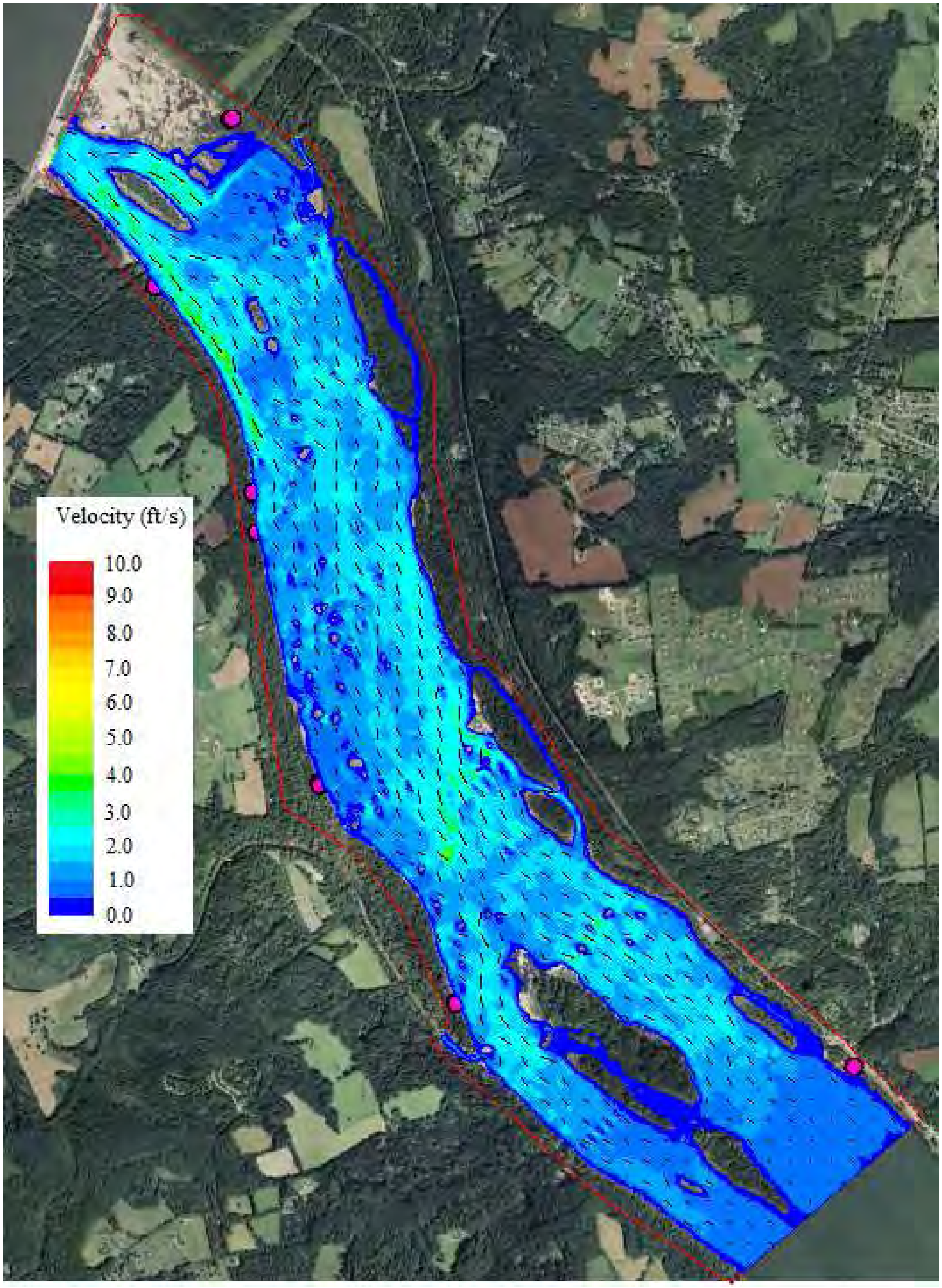
5,000 CFS



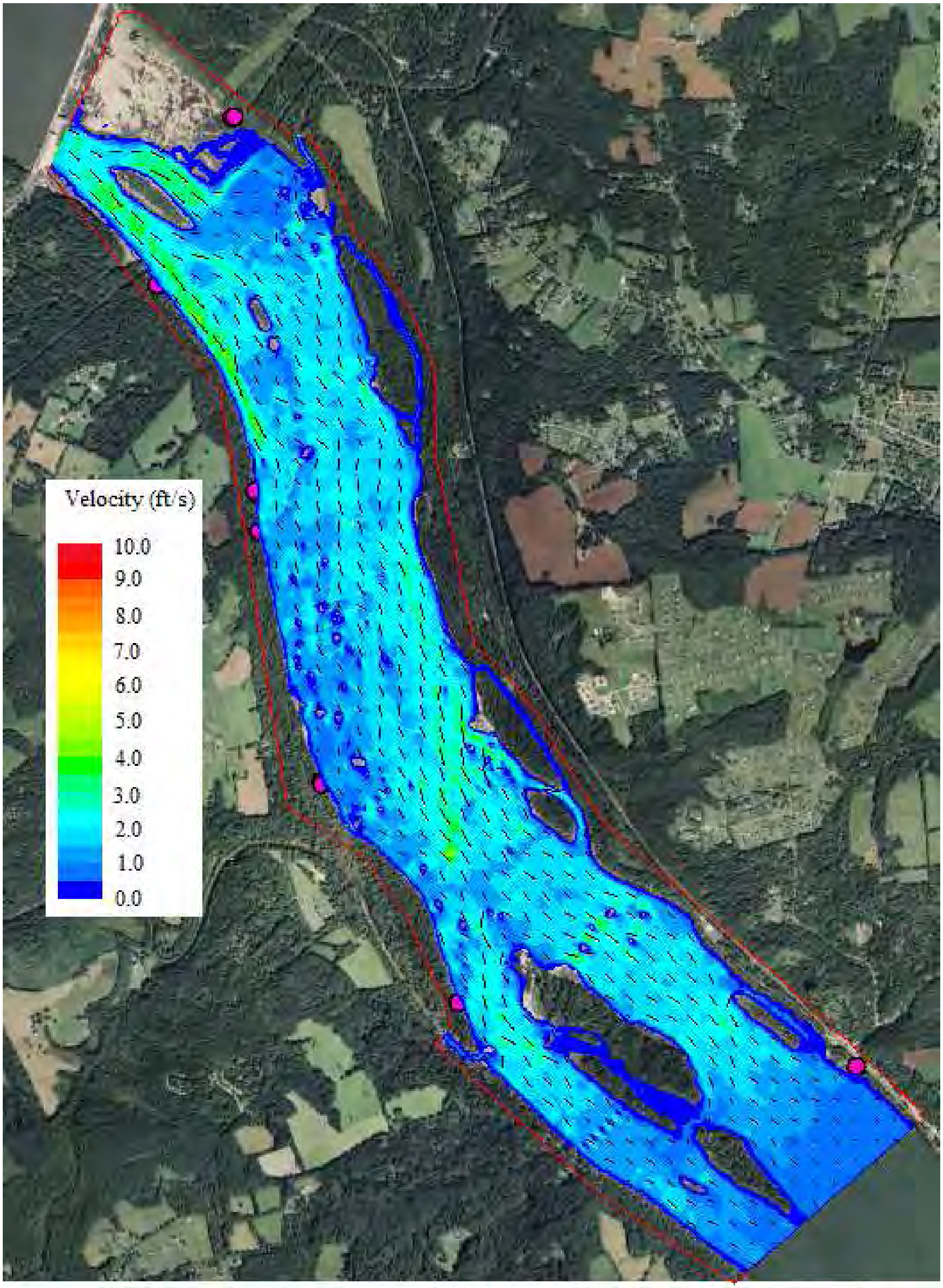
7,500 CFS



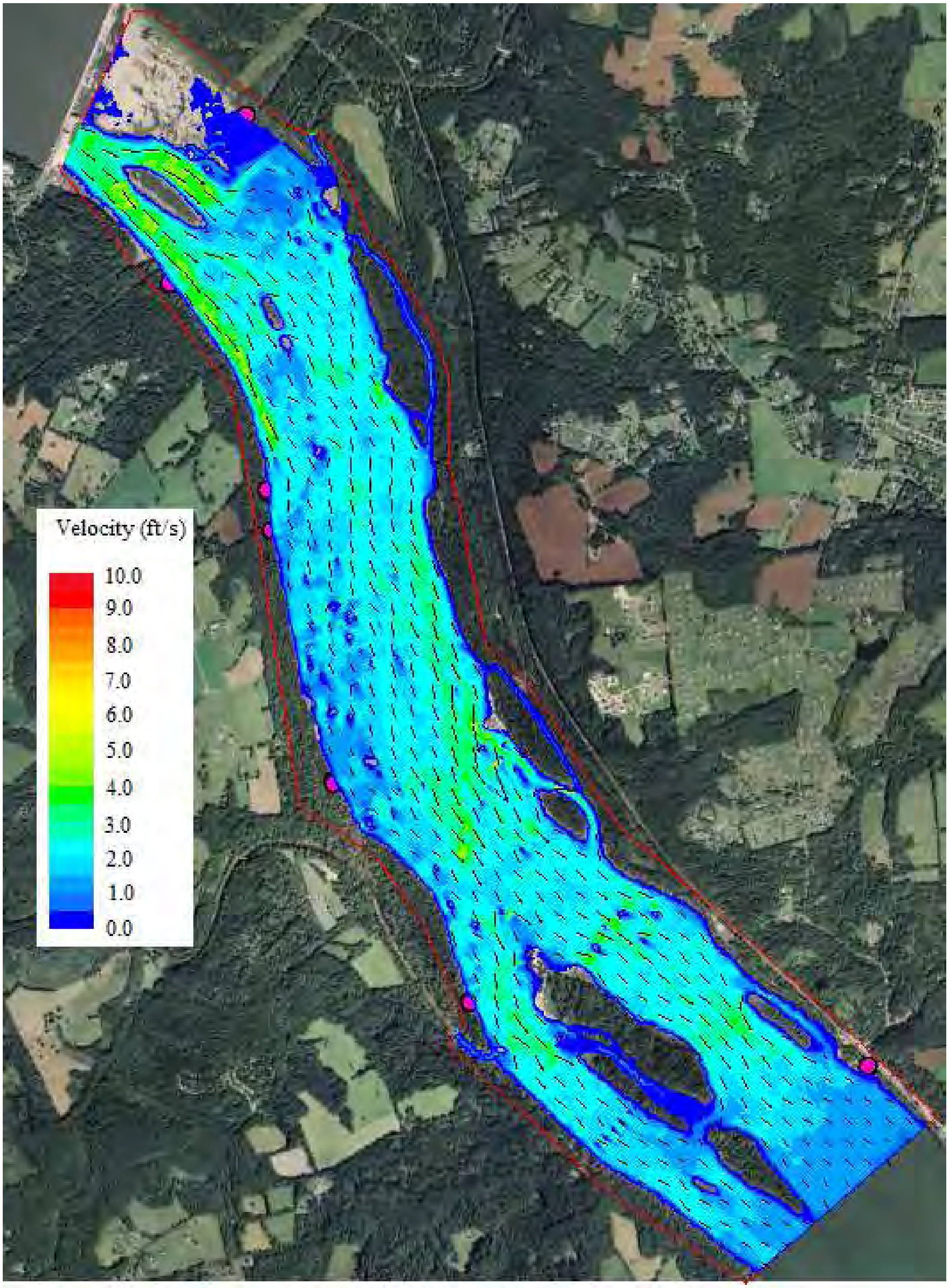
10,000 CFS



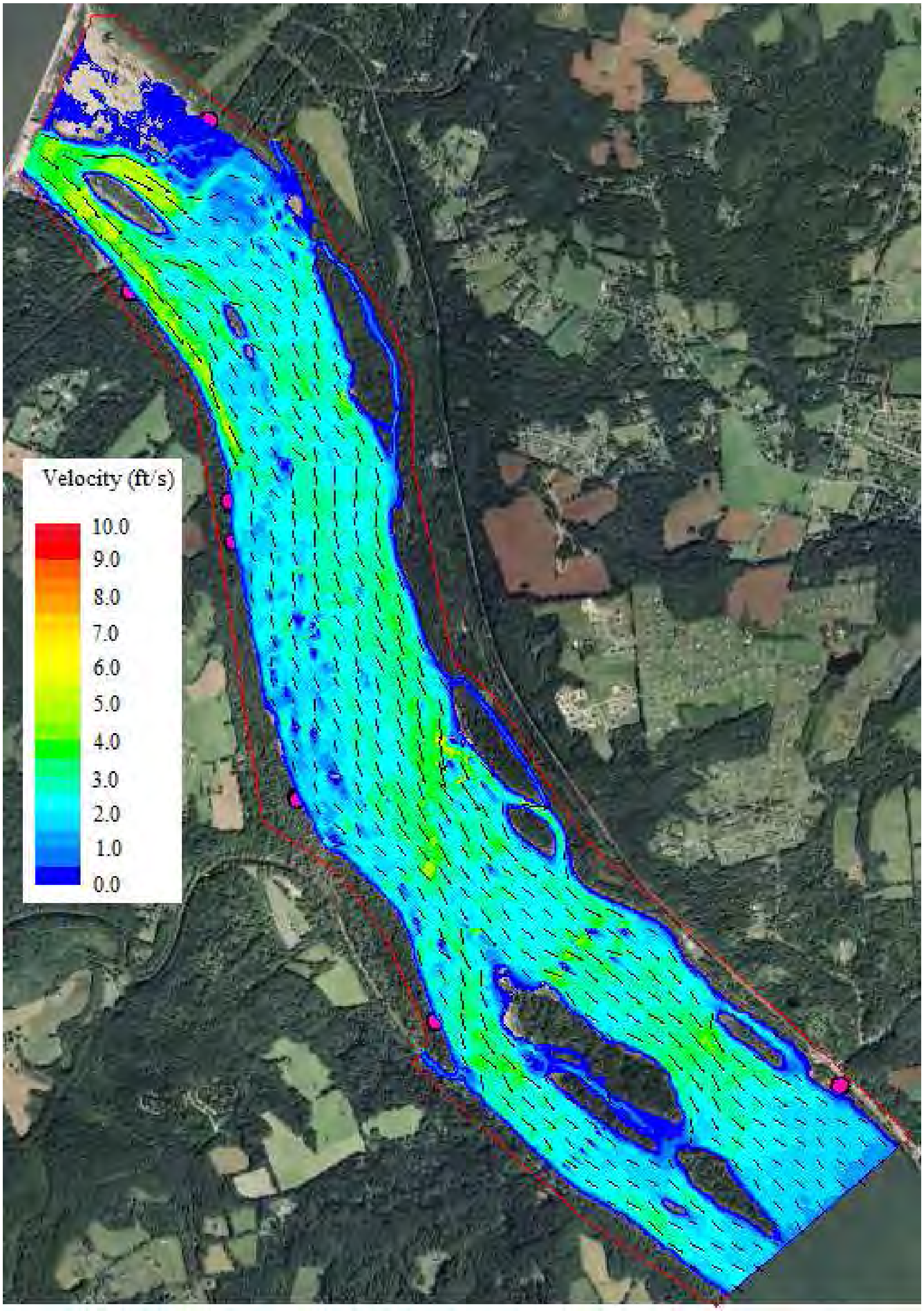
15,000 CFS



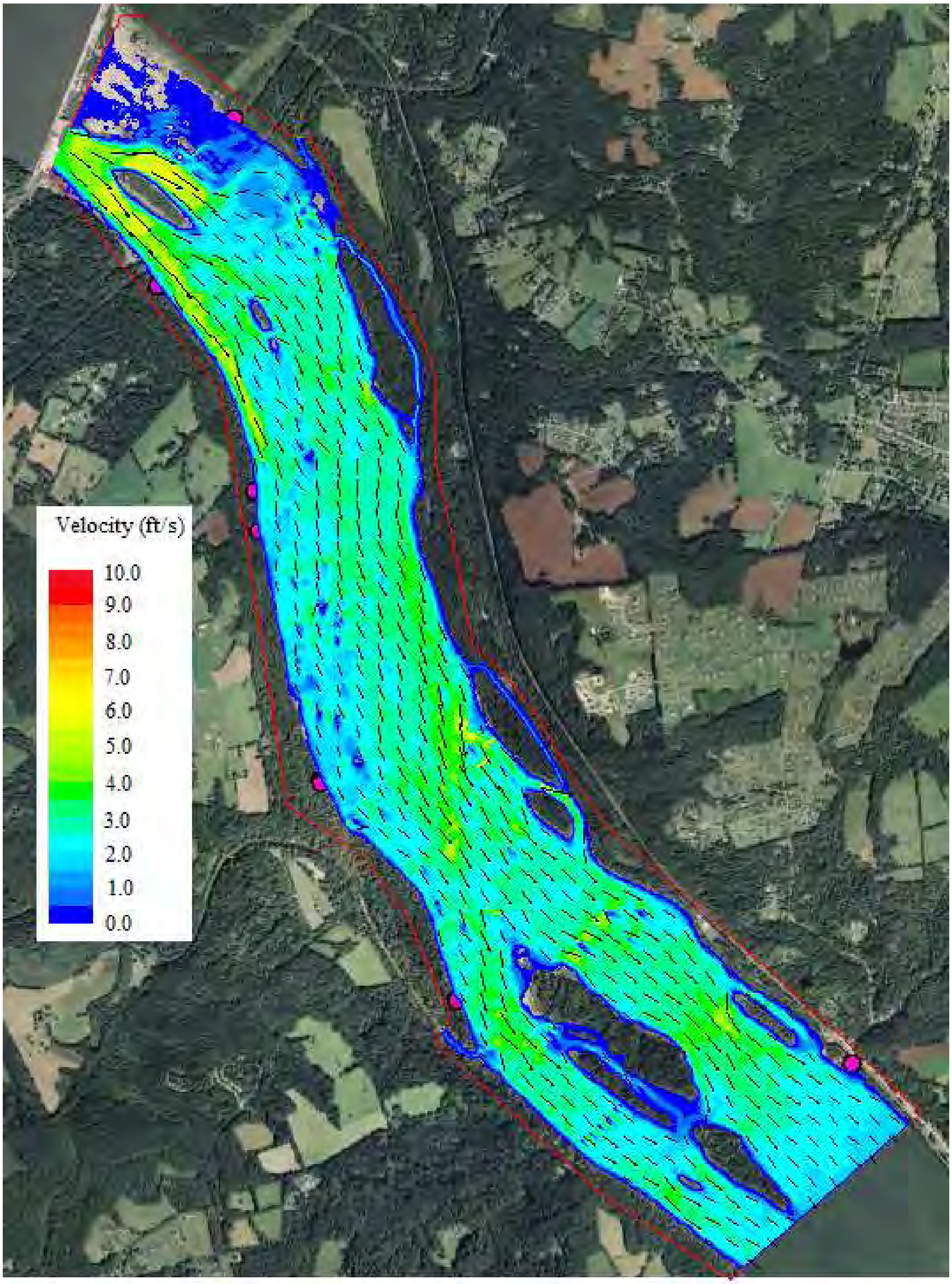
20,000 CFS



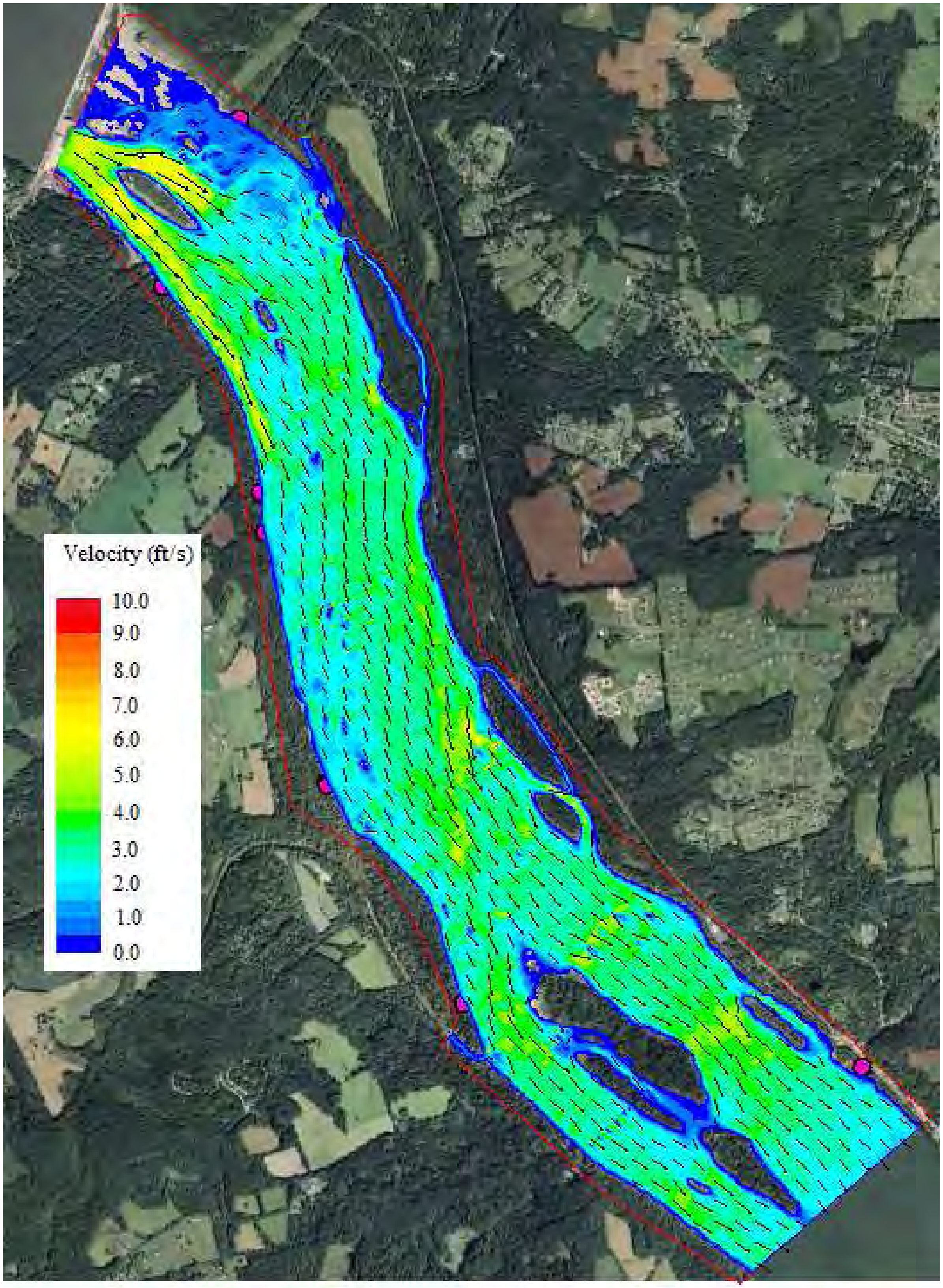
30,000 CFS



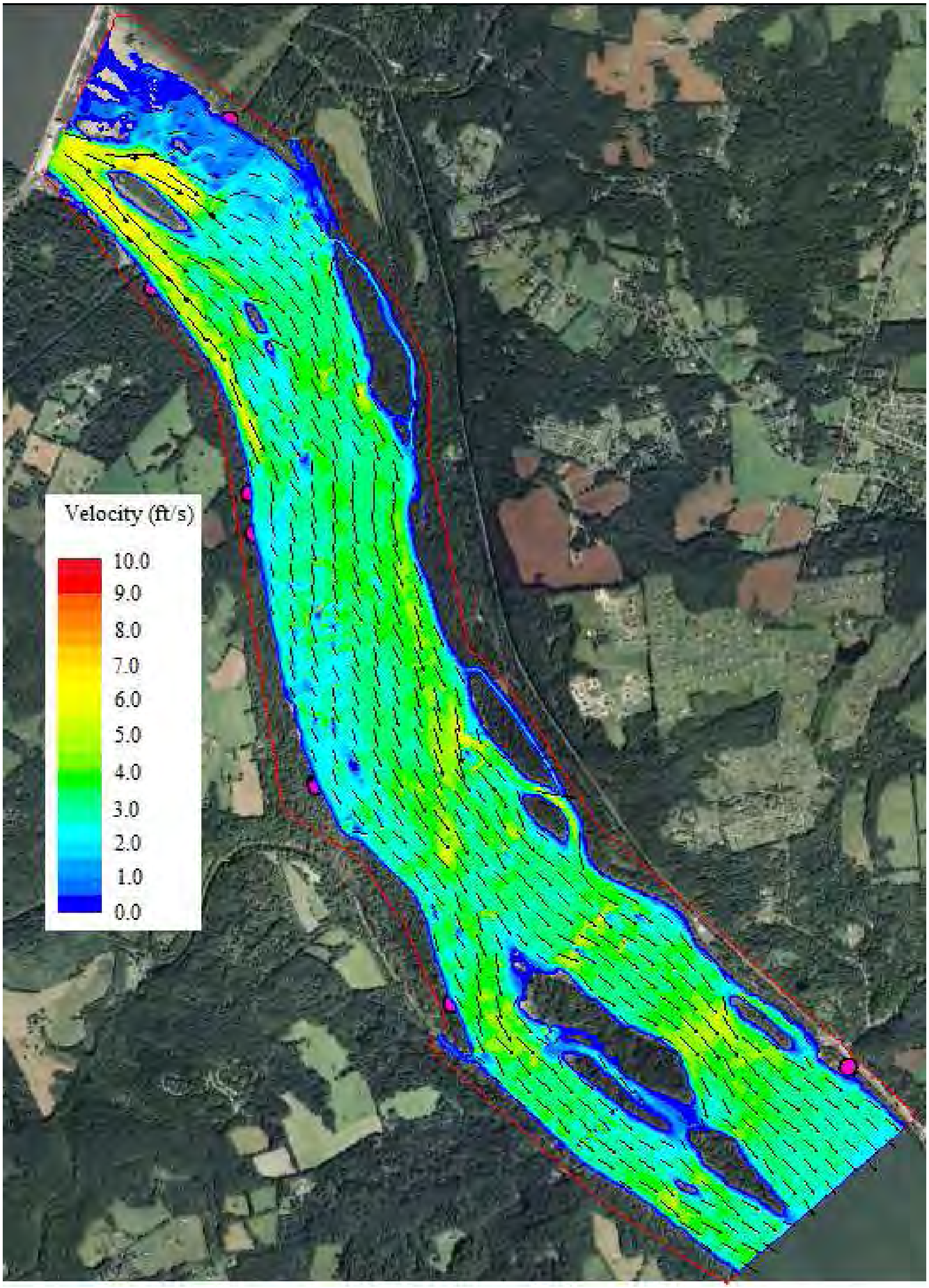
40,000 CFS



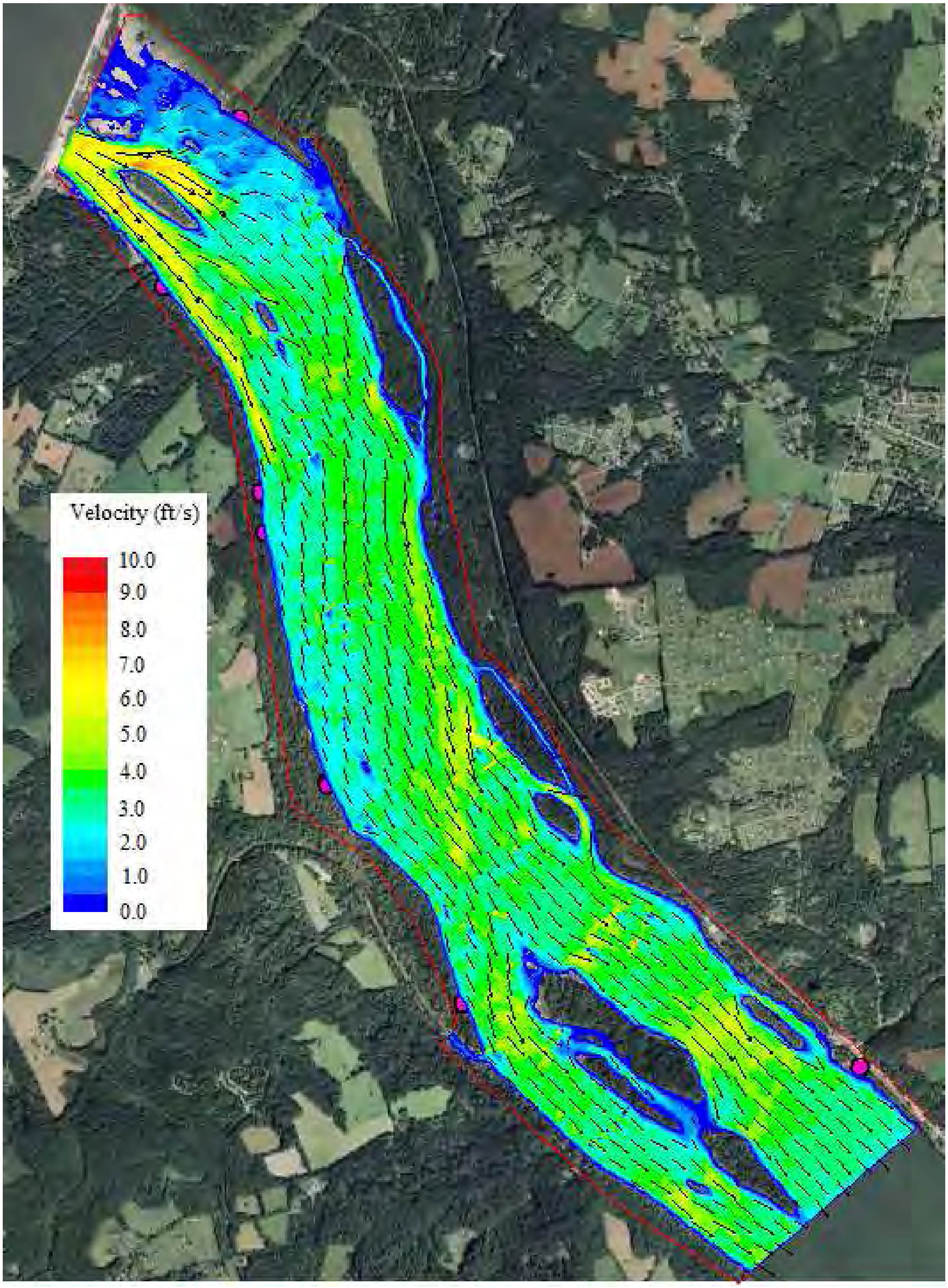
50,000 CFS



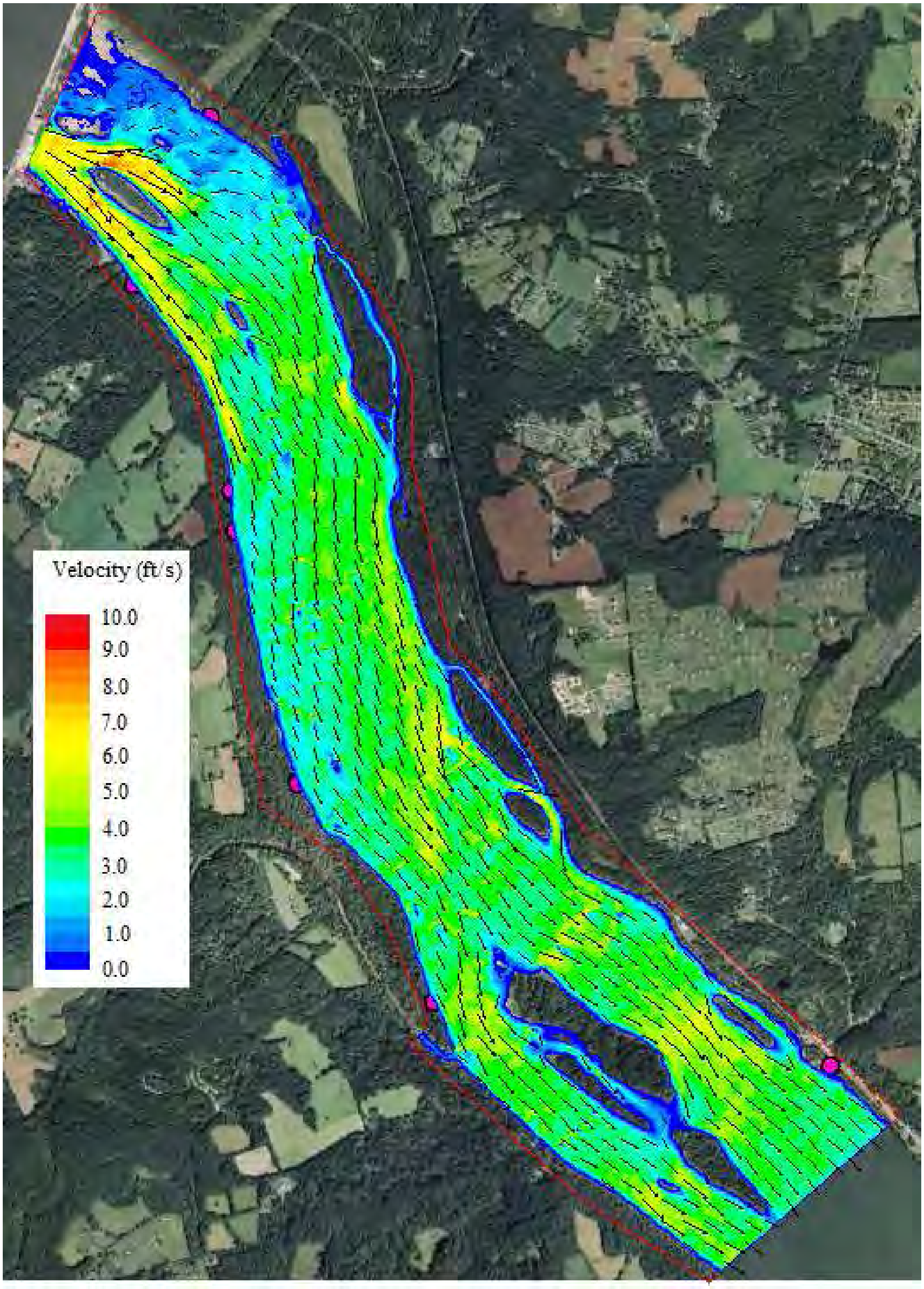
60,000 CFS



70,000 CFS

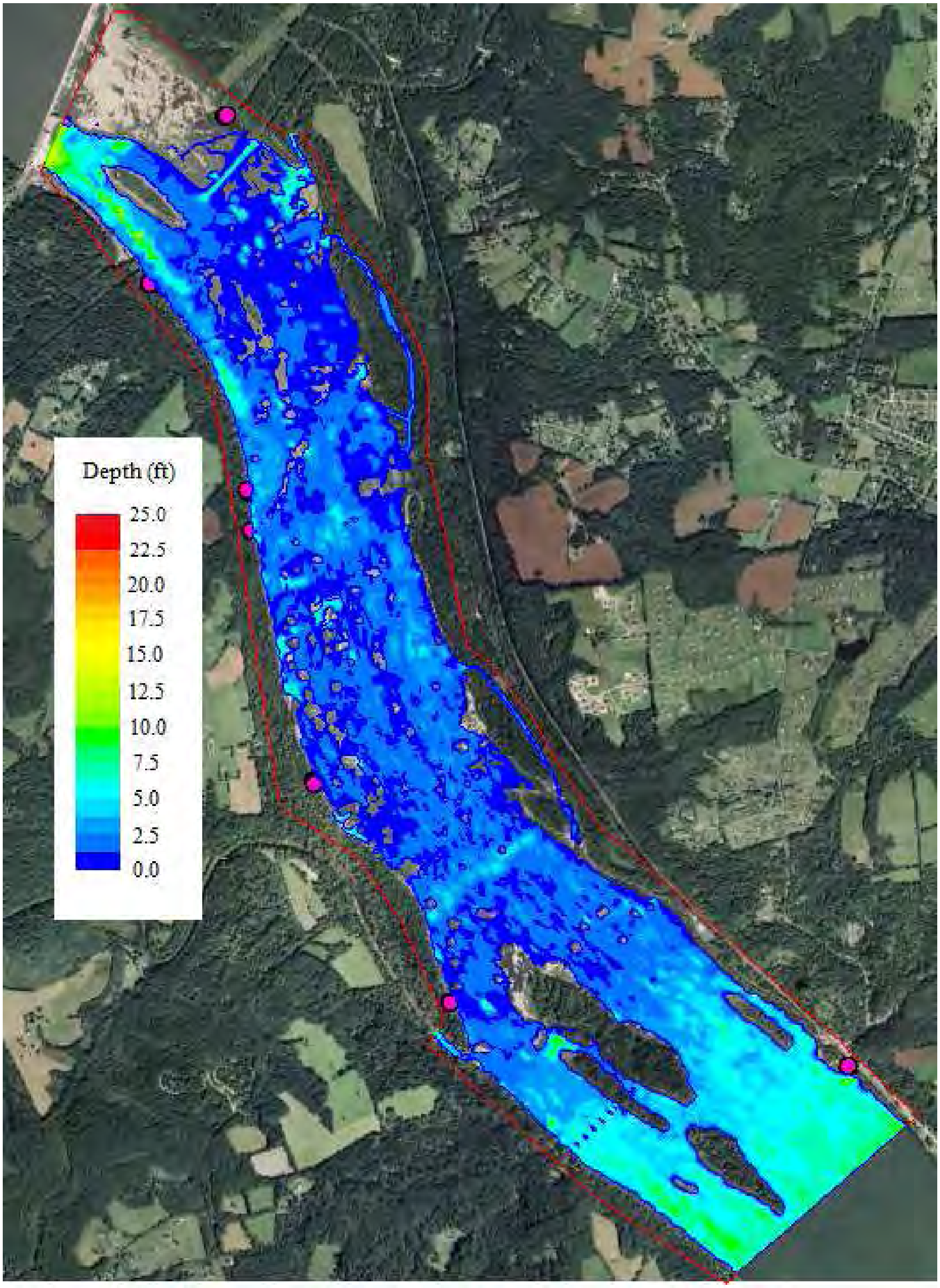


80,000 CFS

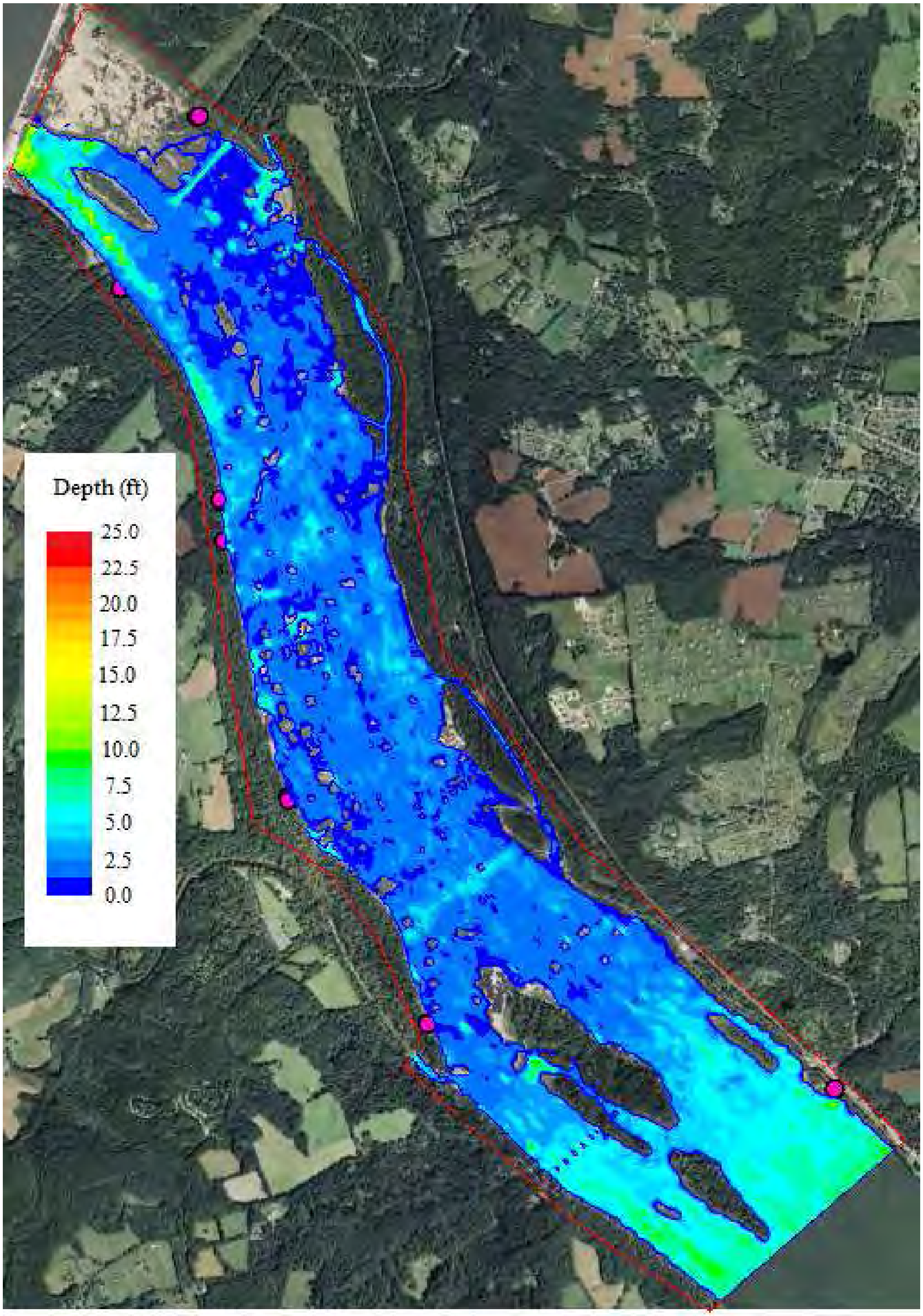


86,000 CFS

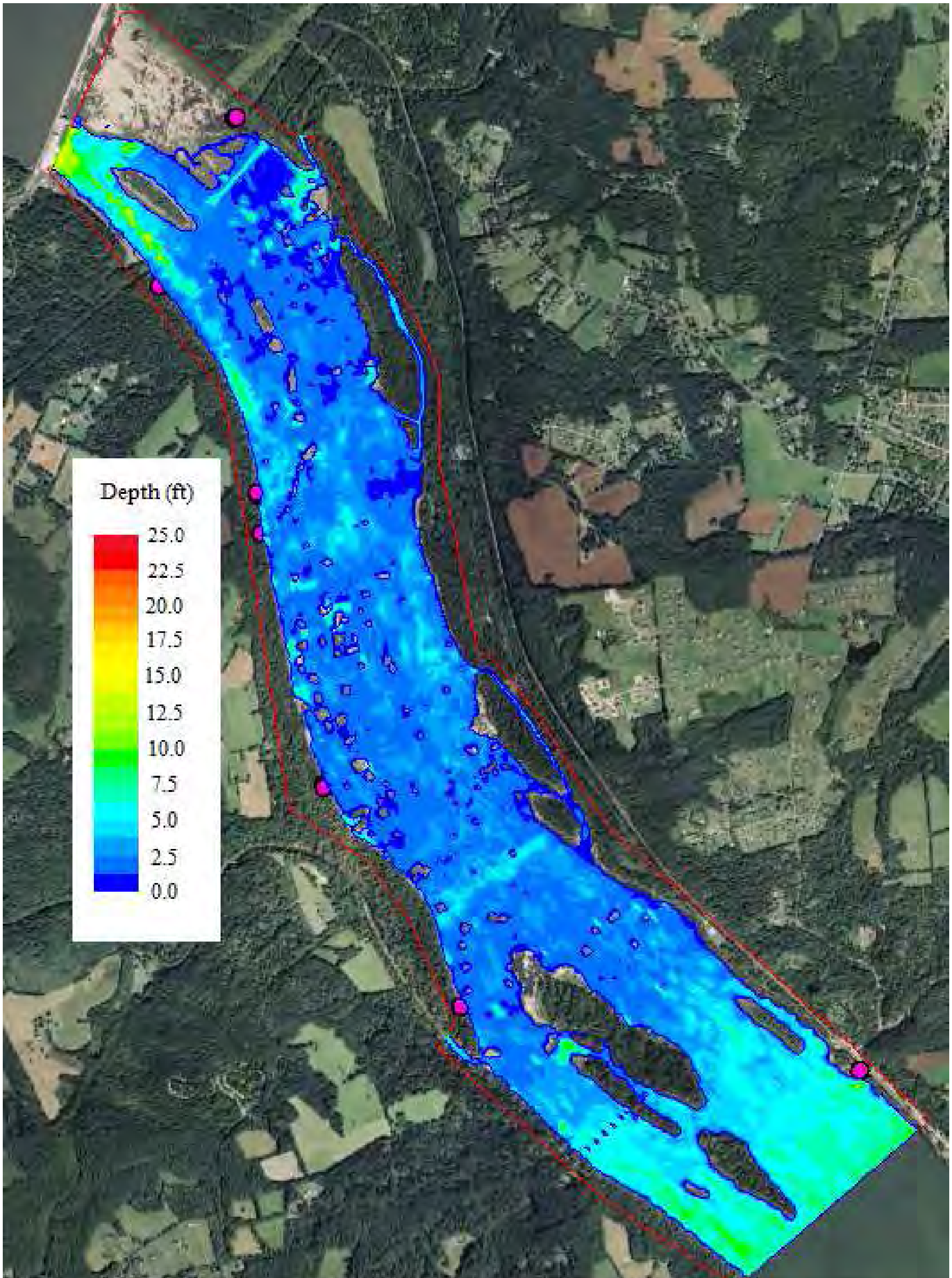
APPENDIX D-DEPTH PLOTS FOR SIMULATION FLOWS



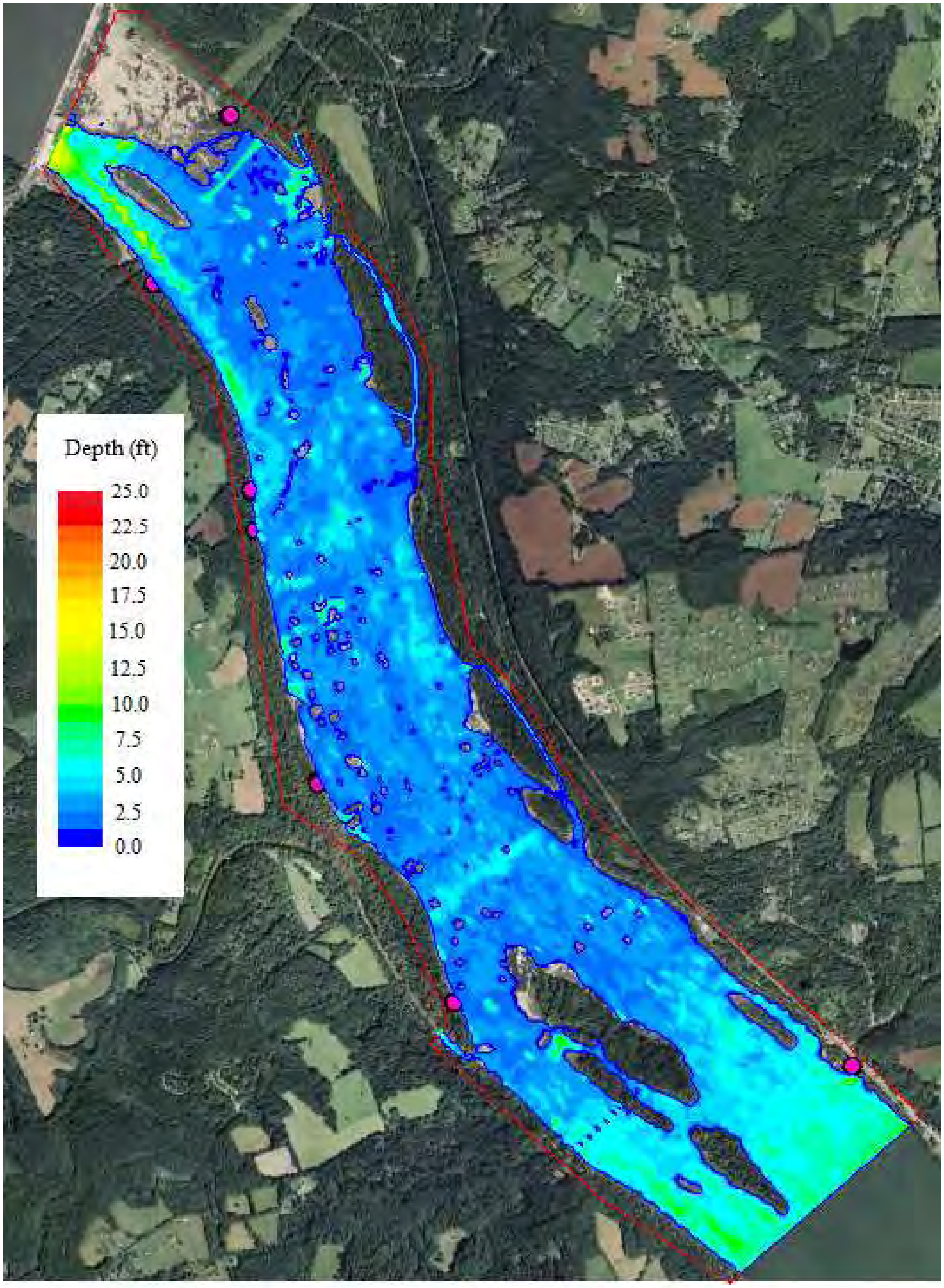
2,000 CFS



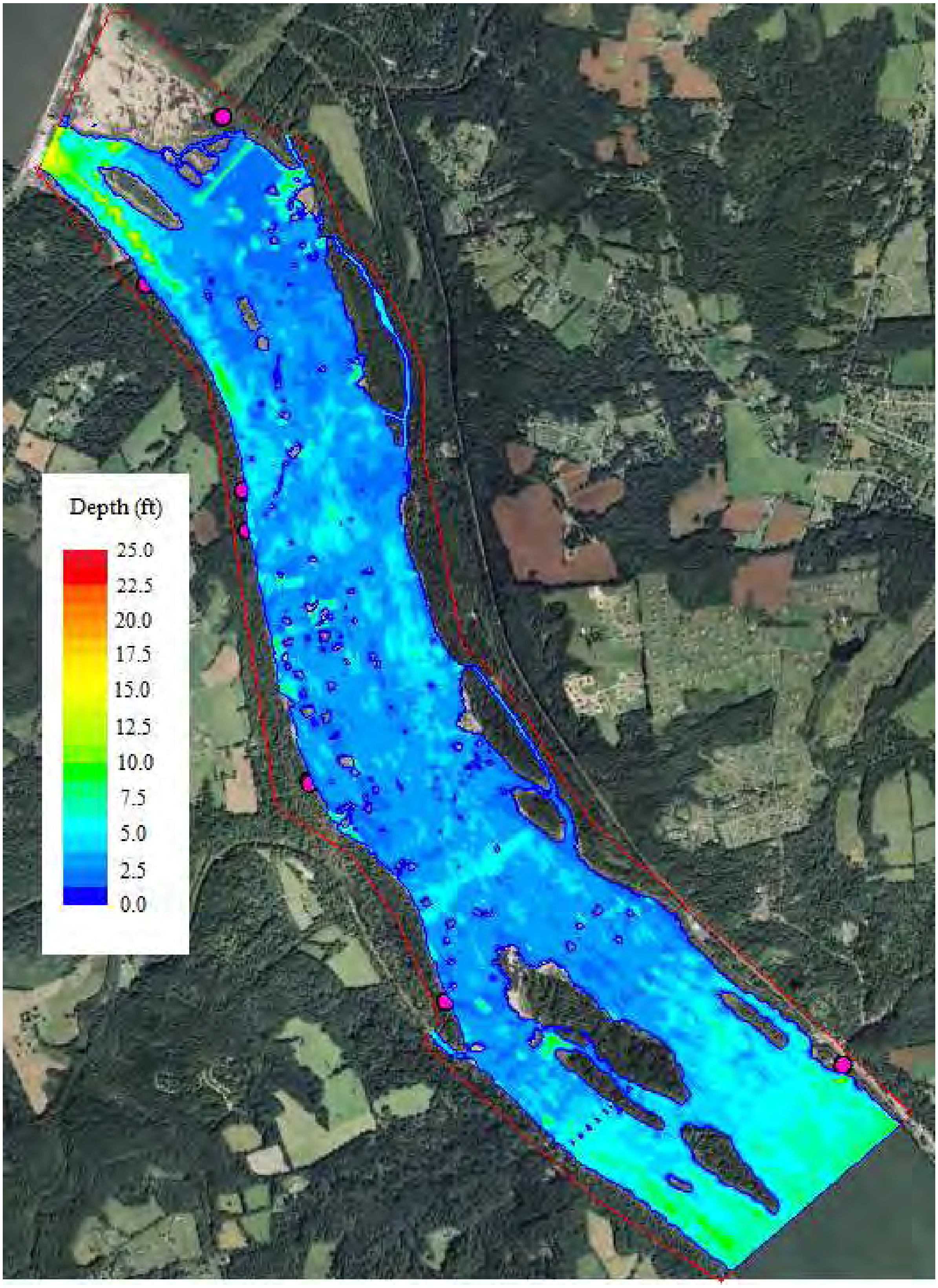
3,500 CFS



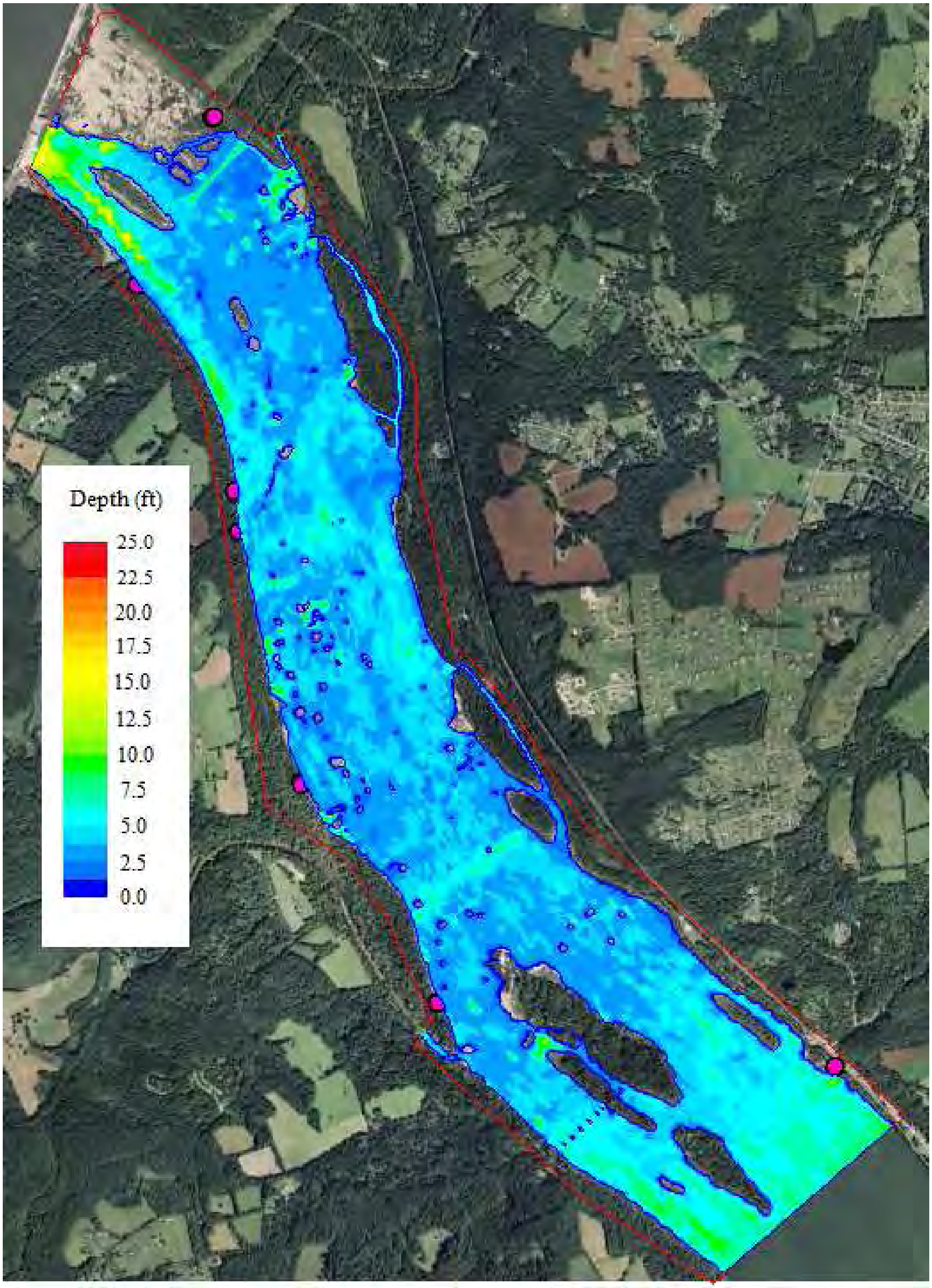
5,000 CFS



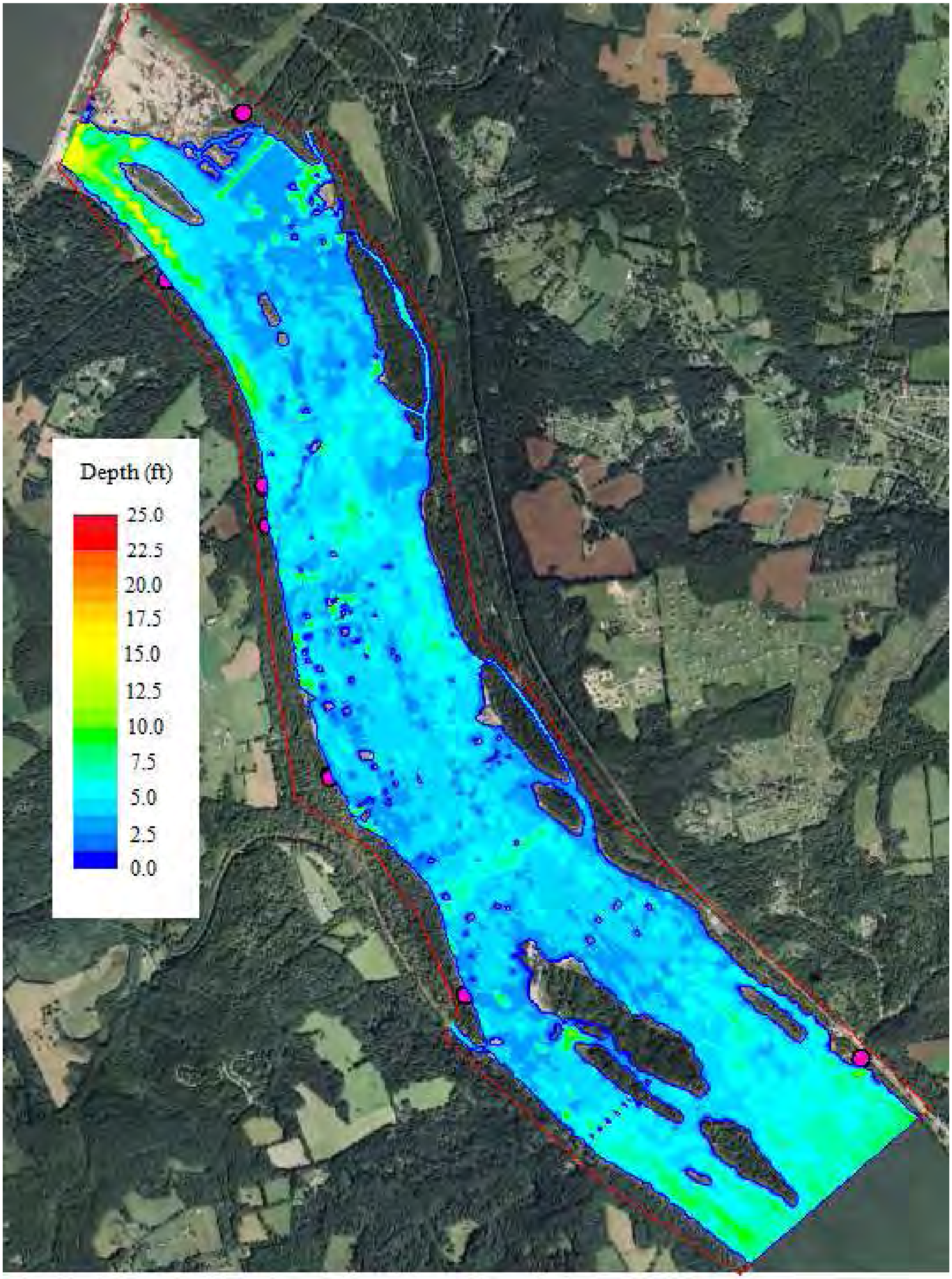
7,500 CFS



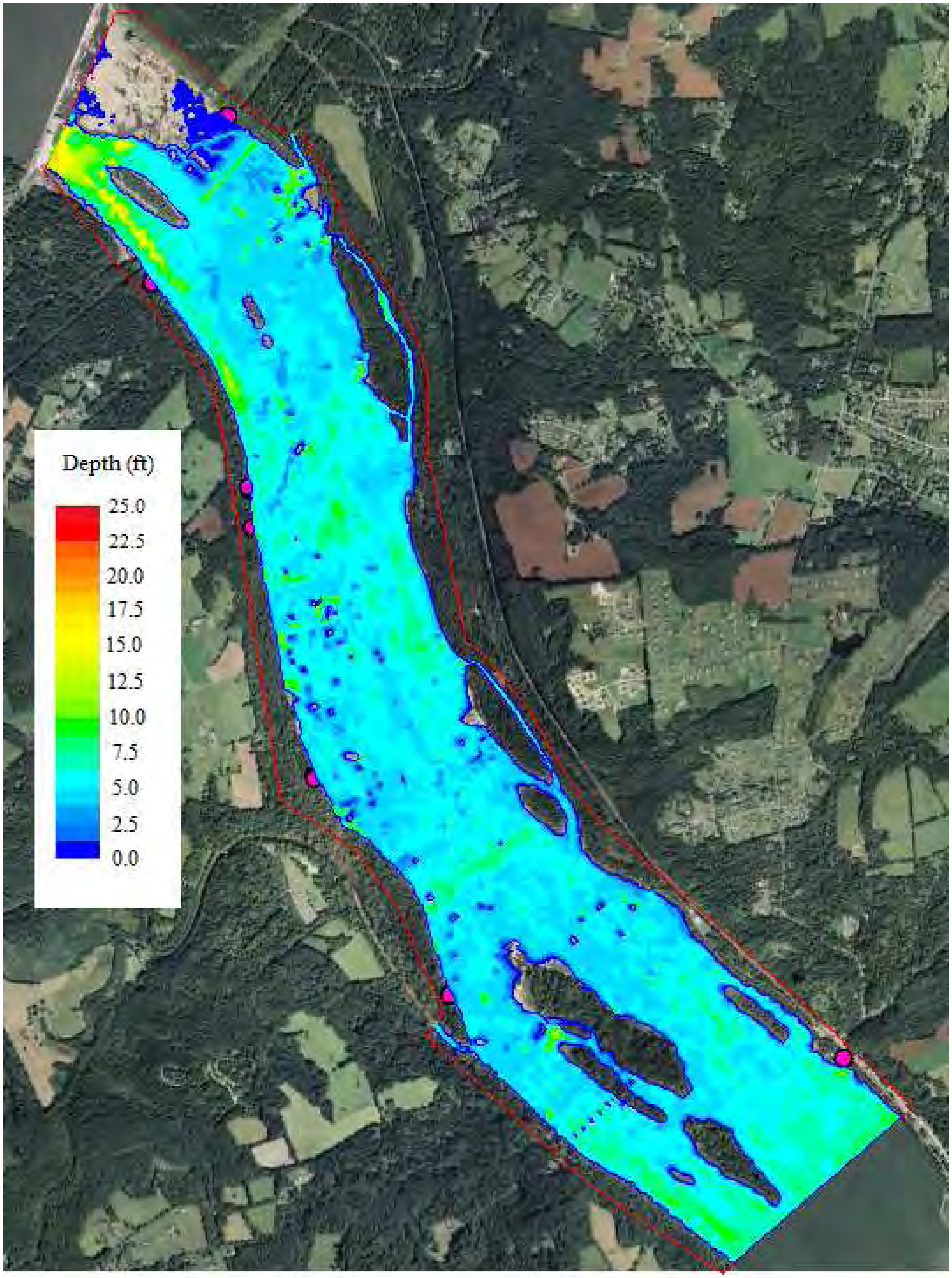
10,000 CFS



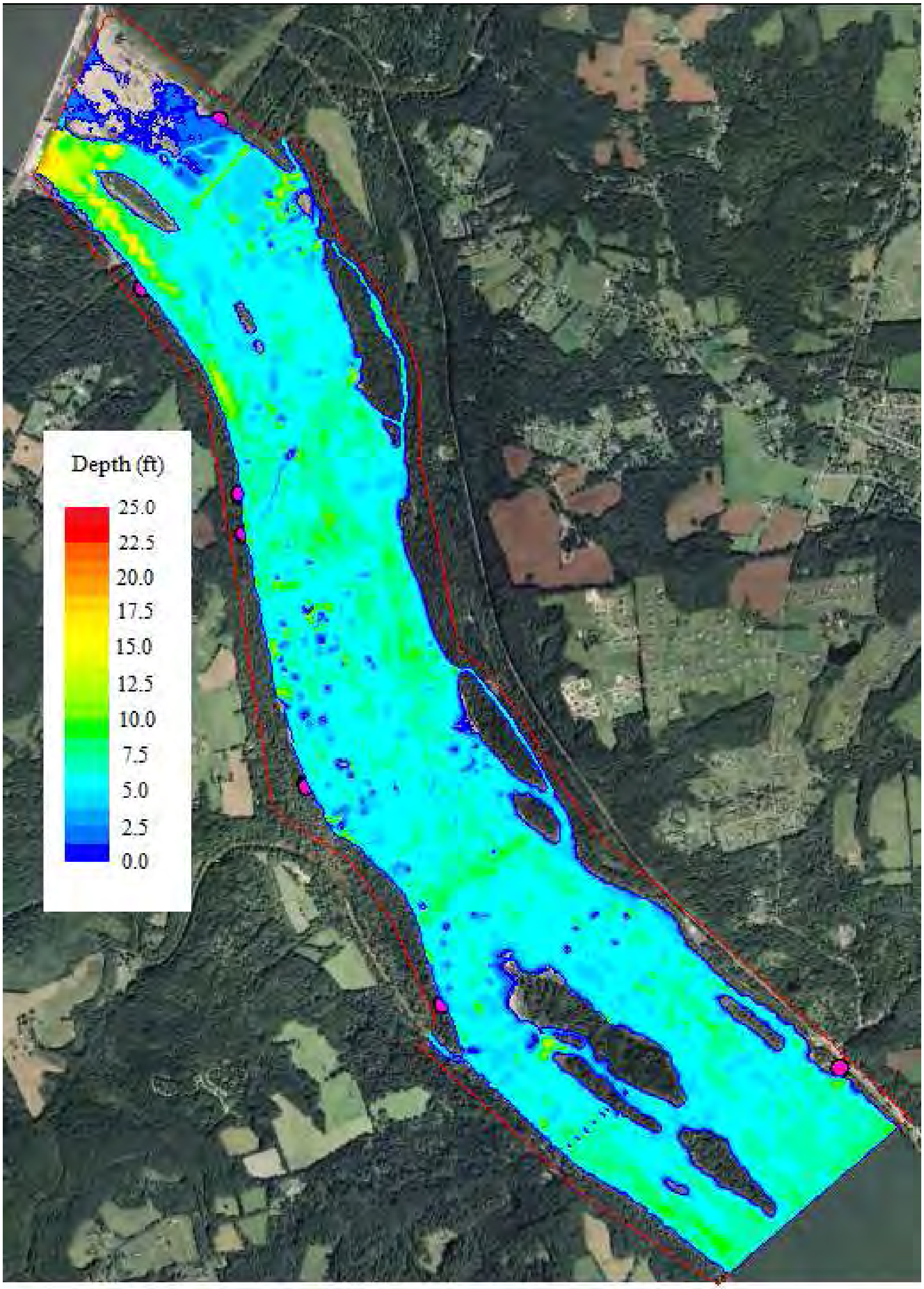
15,000 CFS



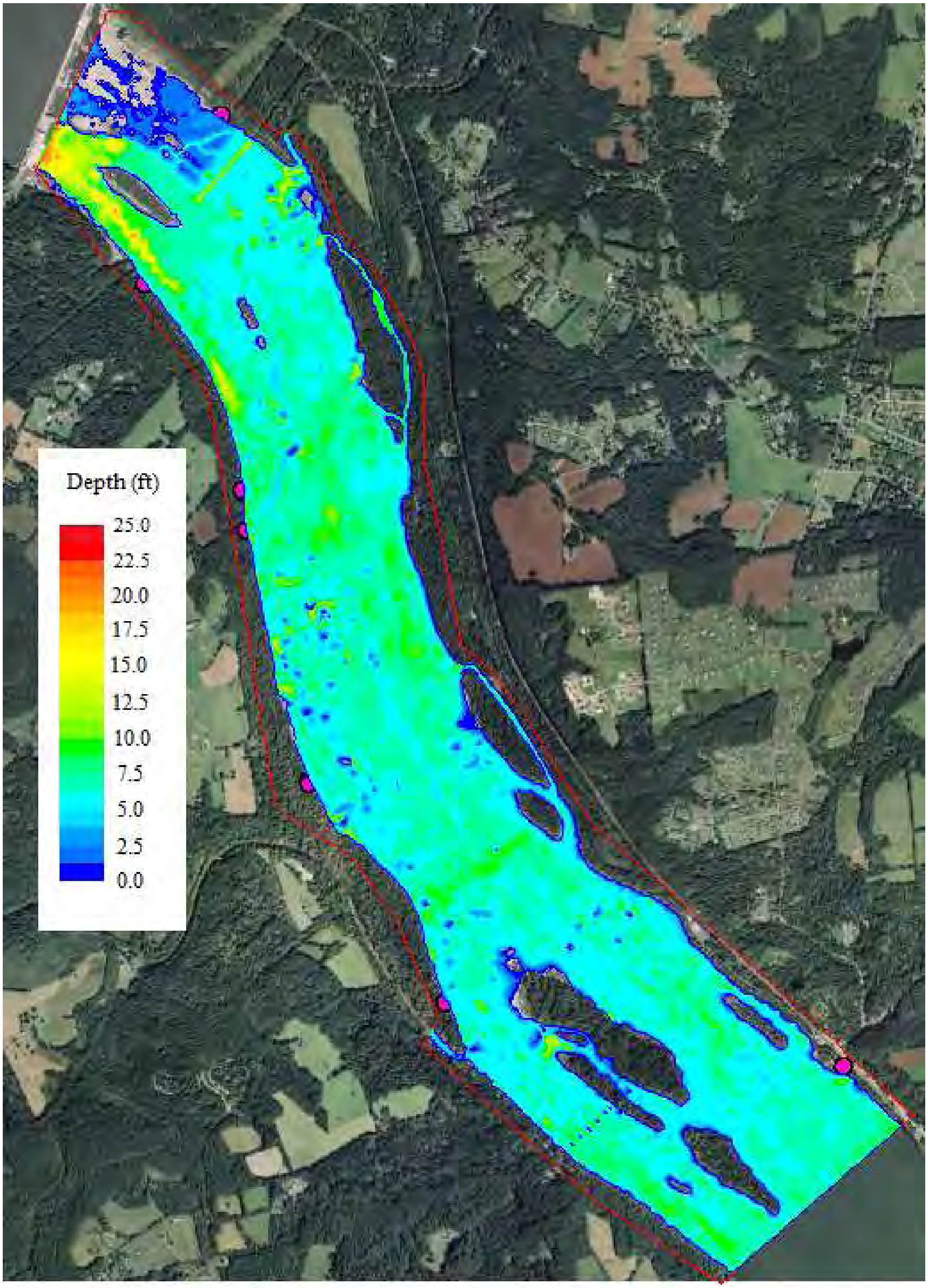
20,000 CFS



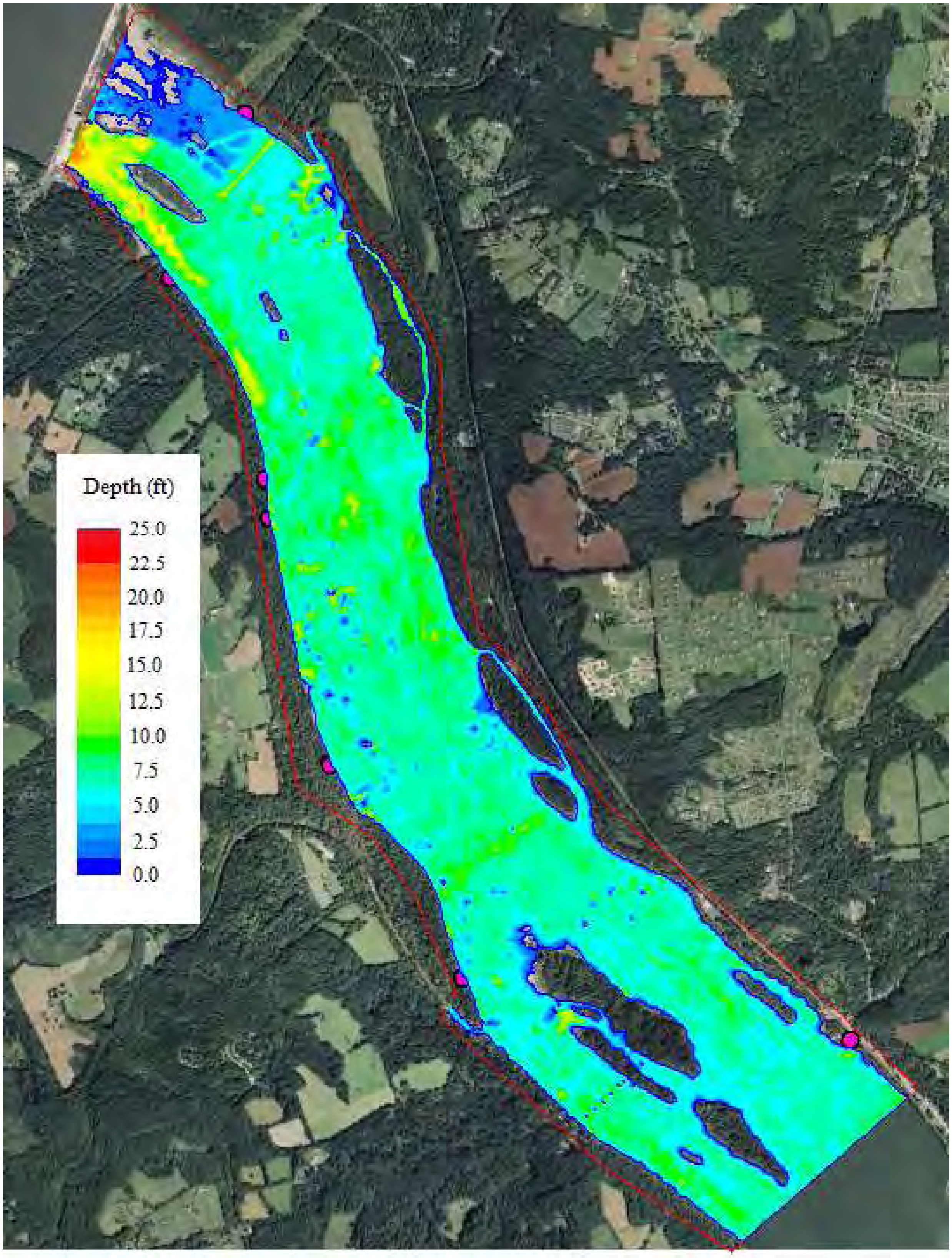
30,000 CFS



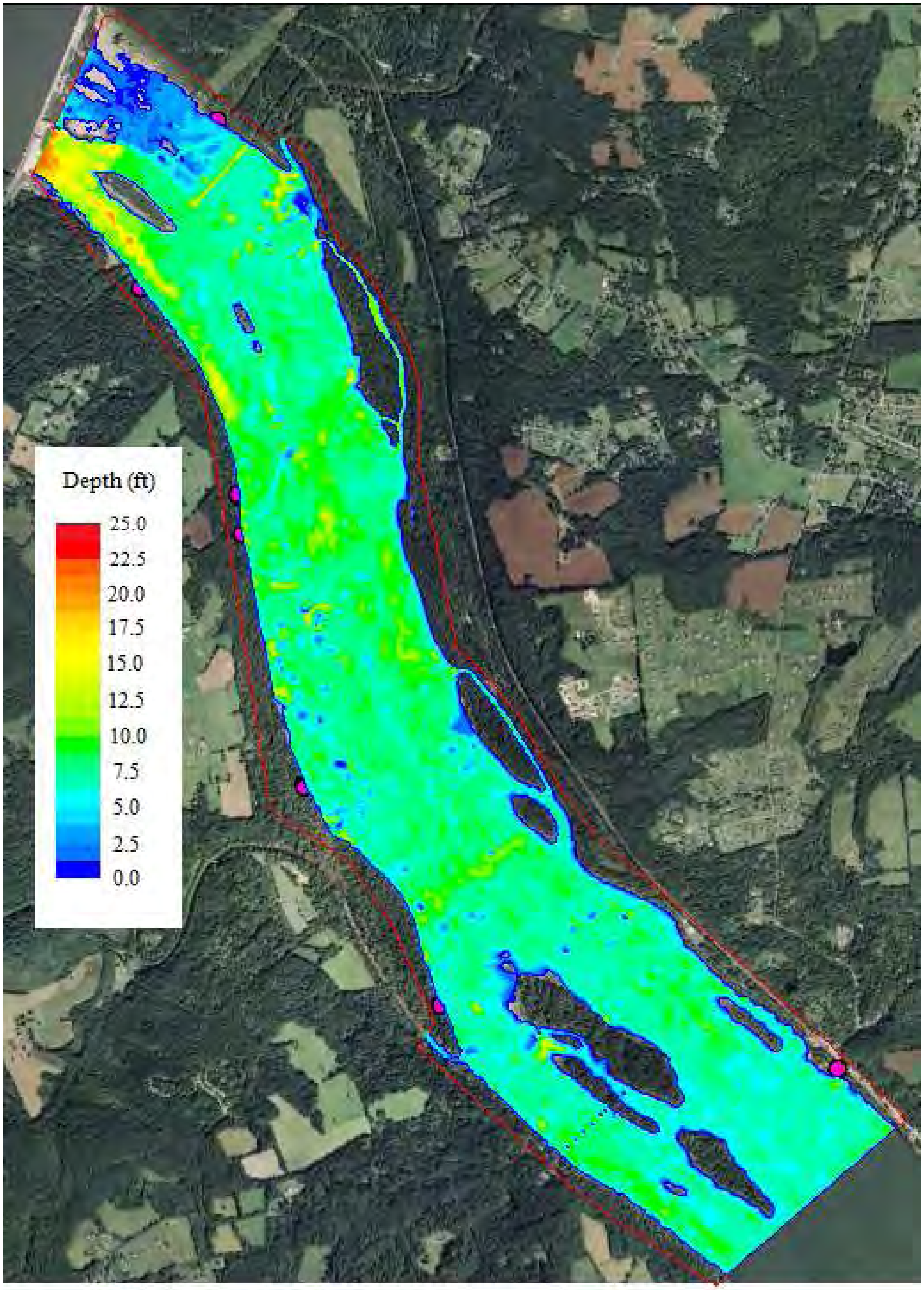
40,000 CFS



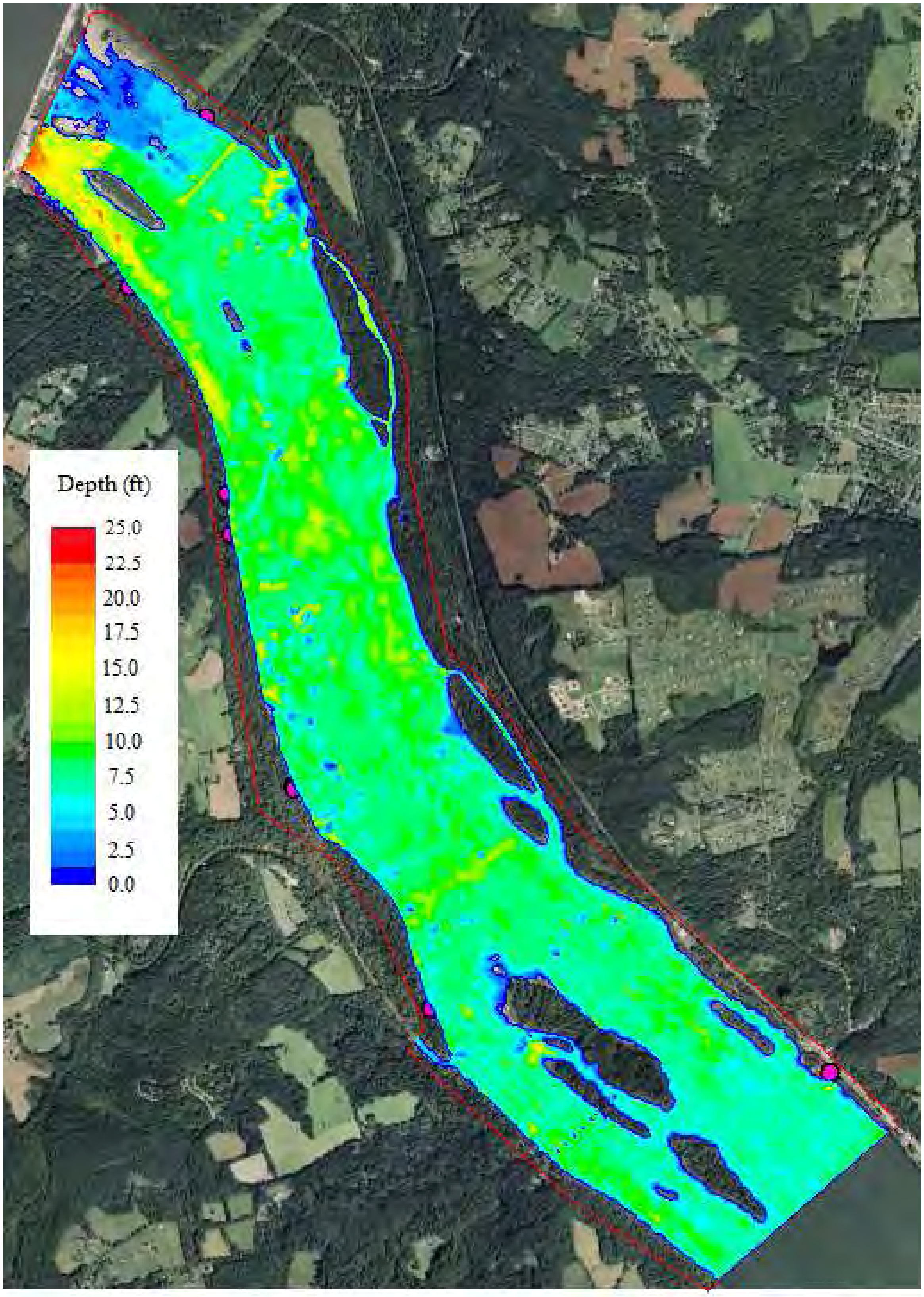
50,000 CFS



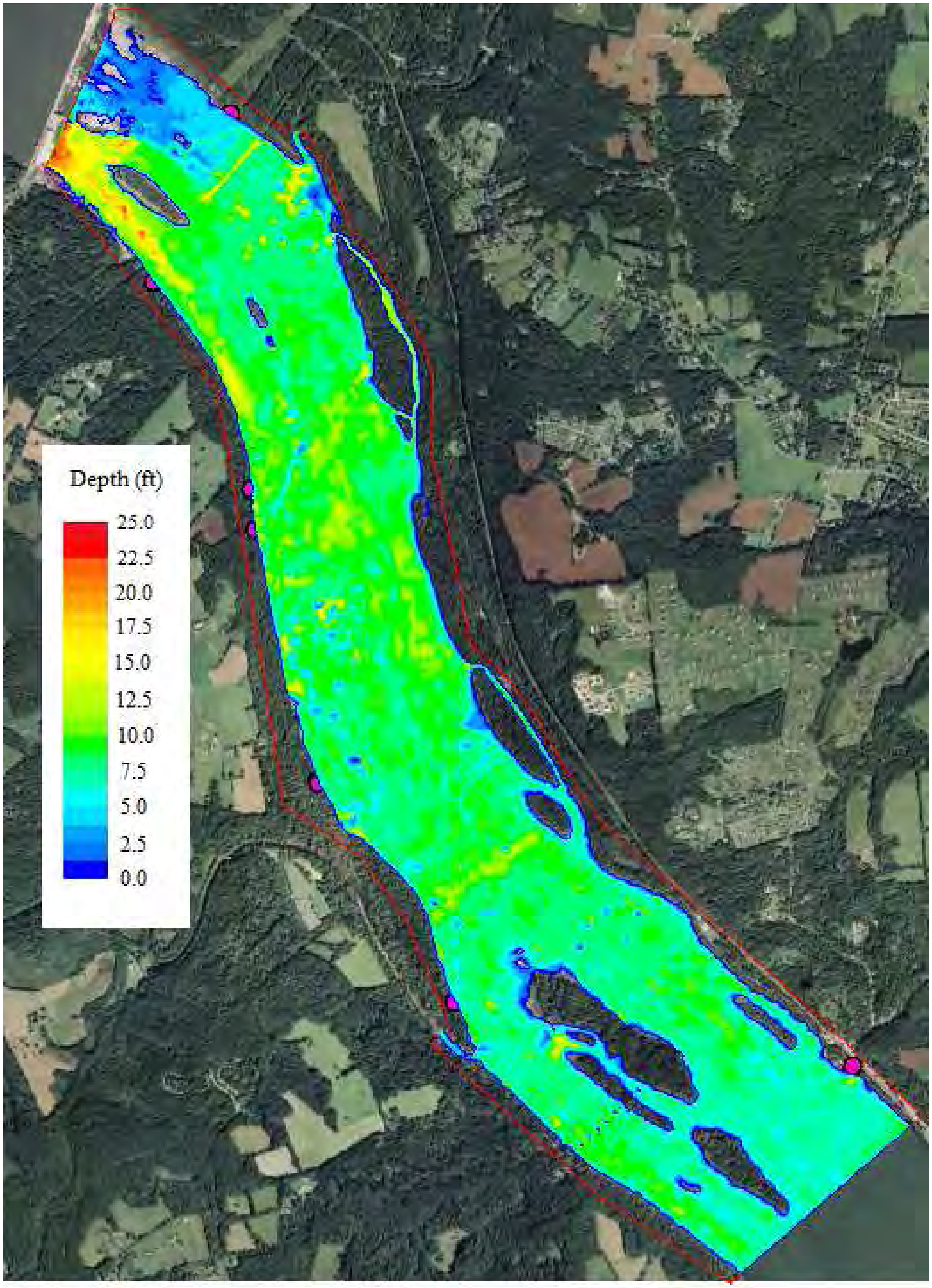
60,000 CFS



70,000 CFS

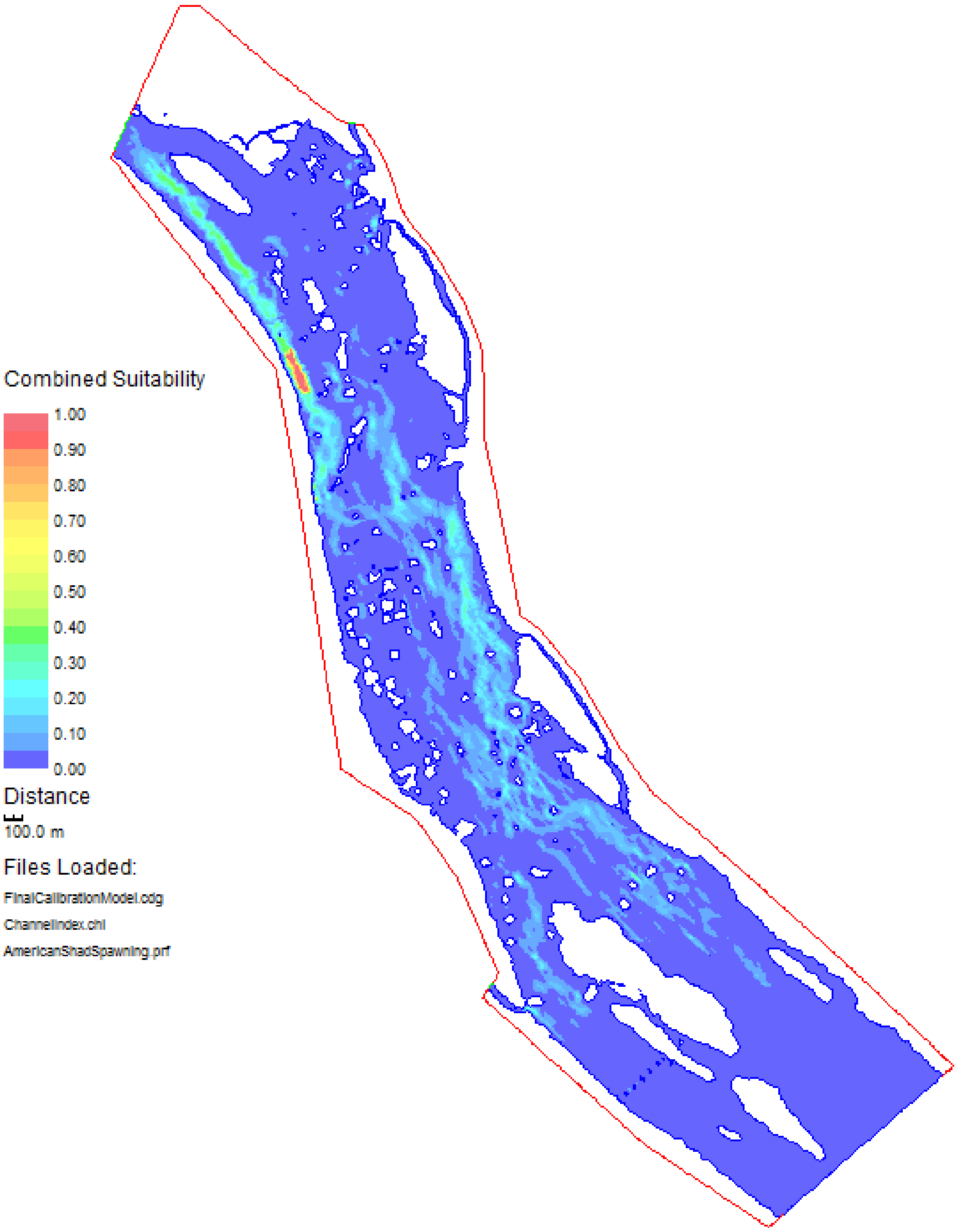


80,000 CFS

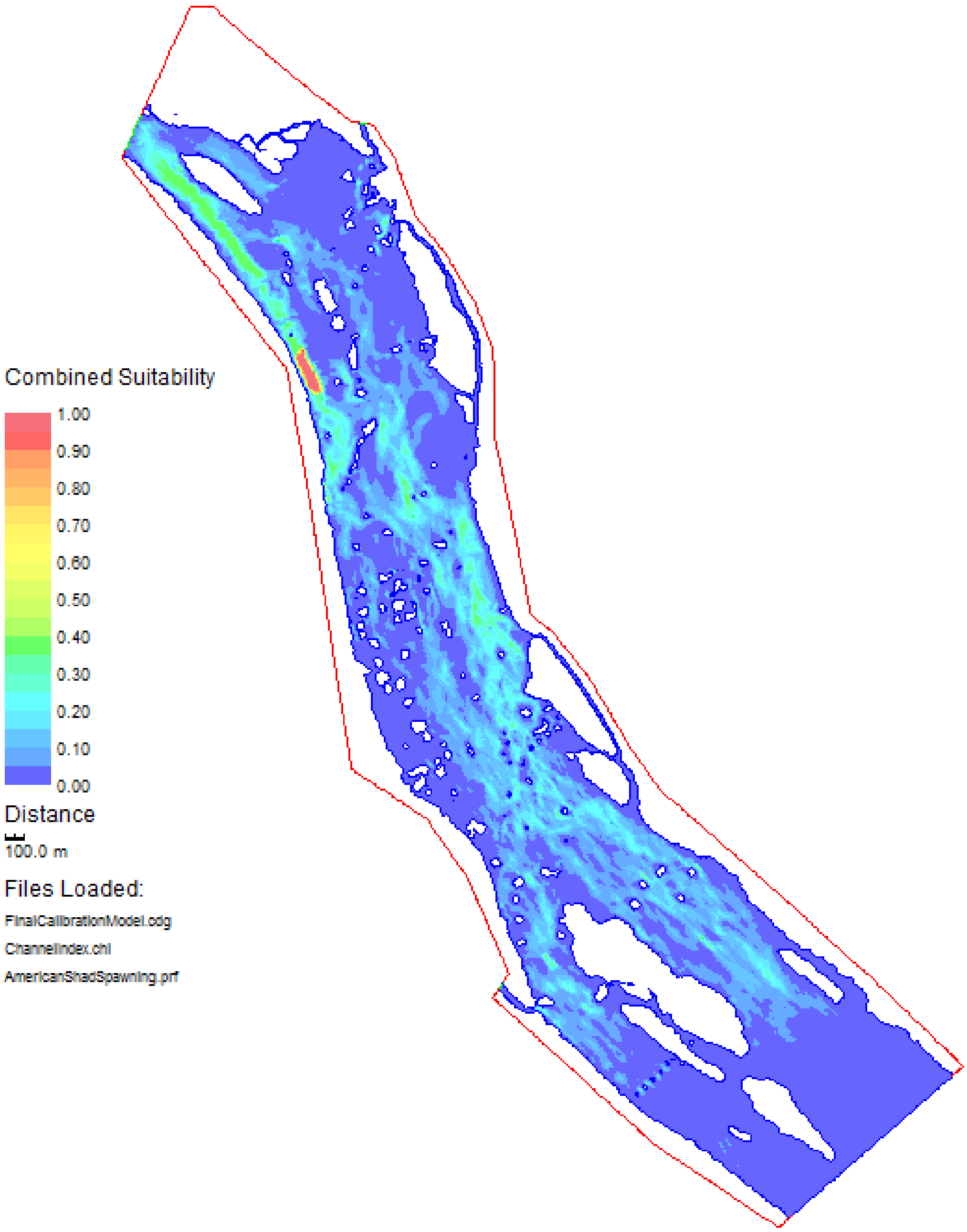


86,000 CFS

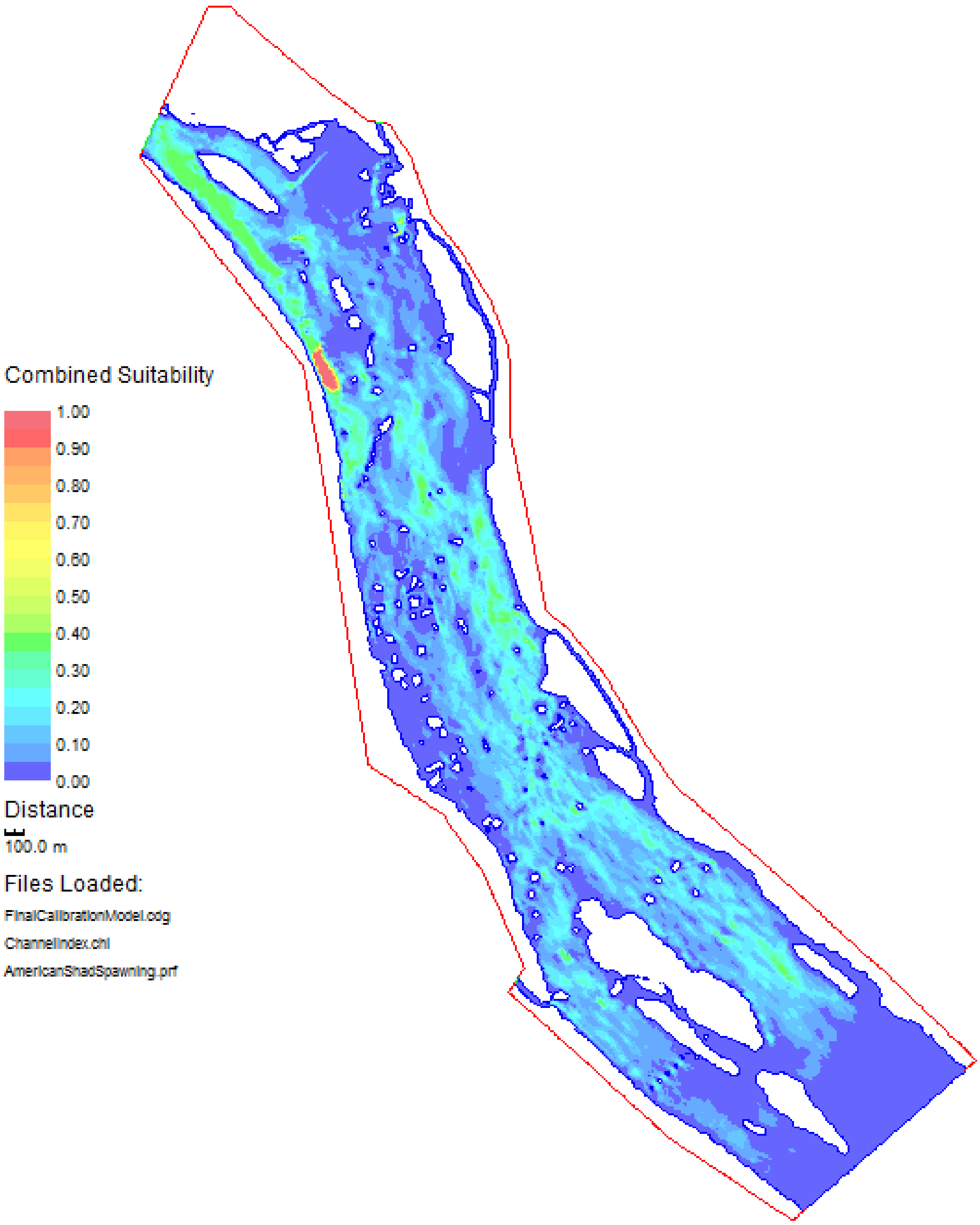
APPENDIX E-COMBINED SUITABILITY HABITAT MAPS FOR SIMULATION FLOWS



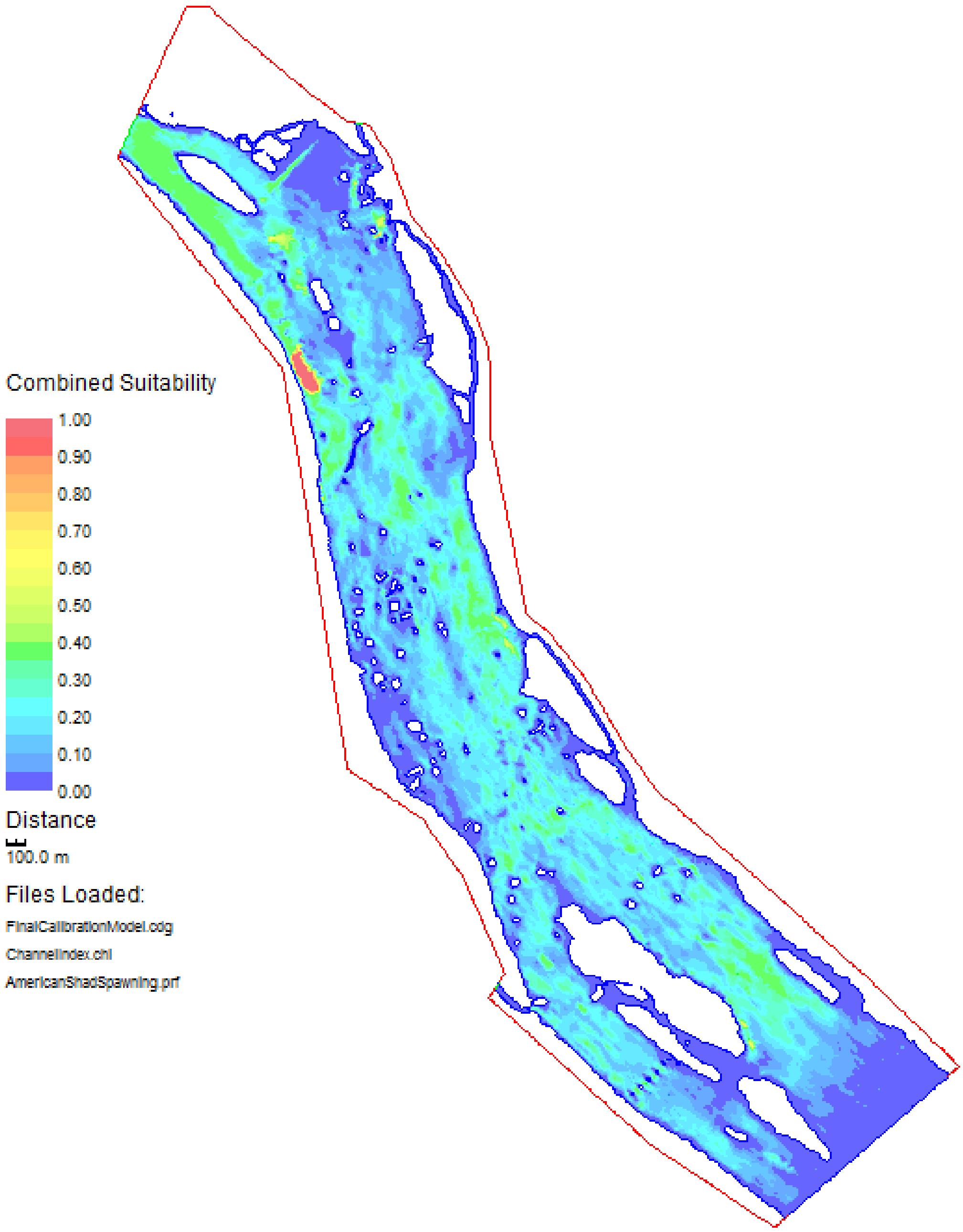
American Shad Spawning – 2,000 cfs



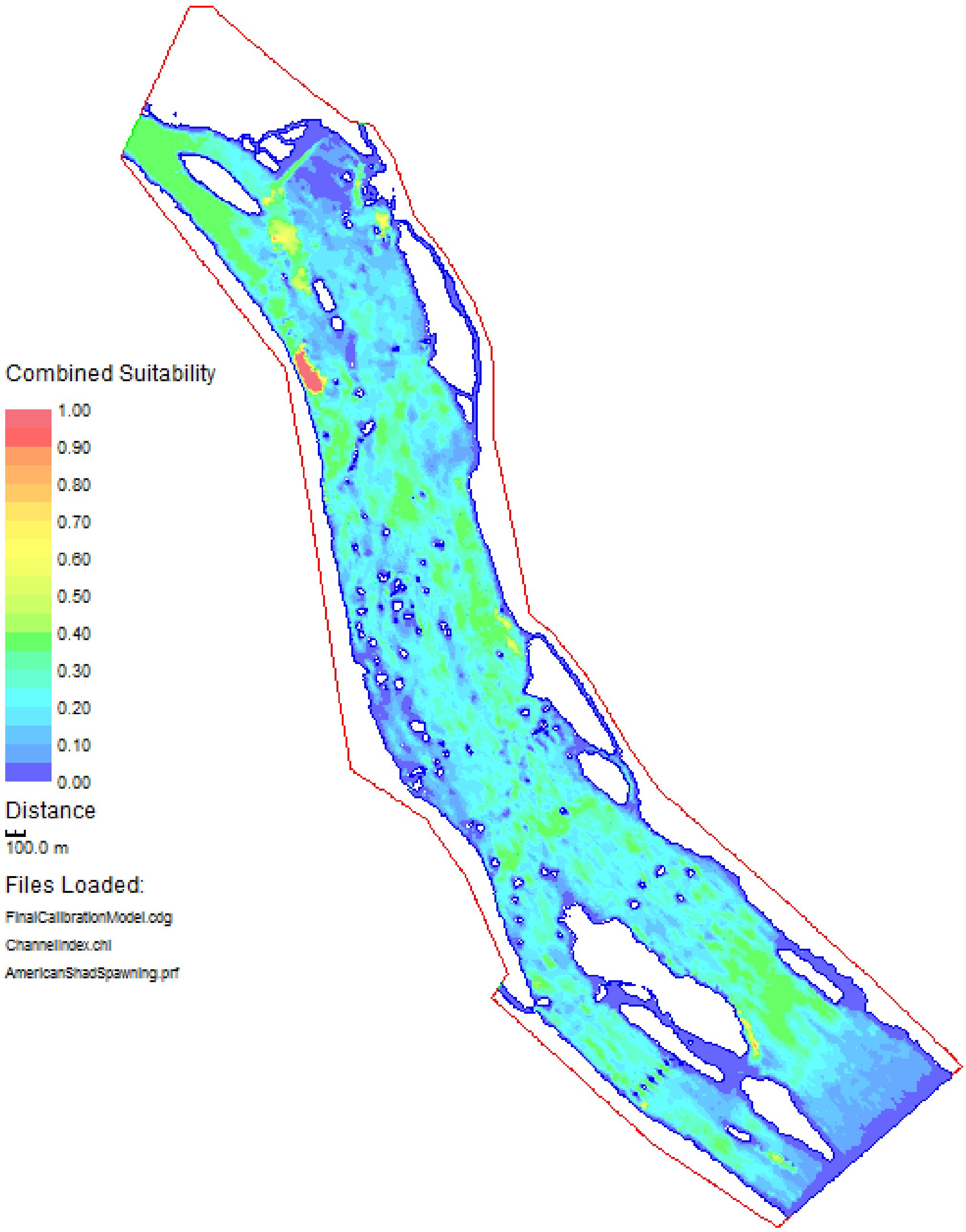
American Shad Spawning – 3,500 cfs



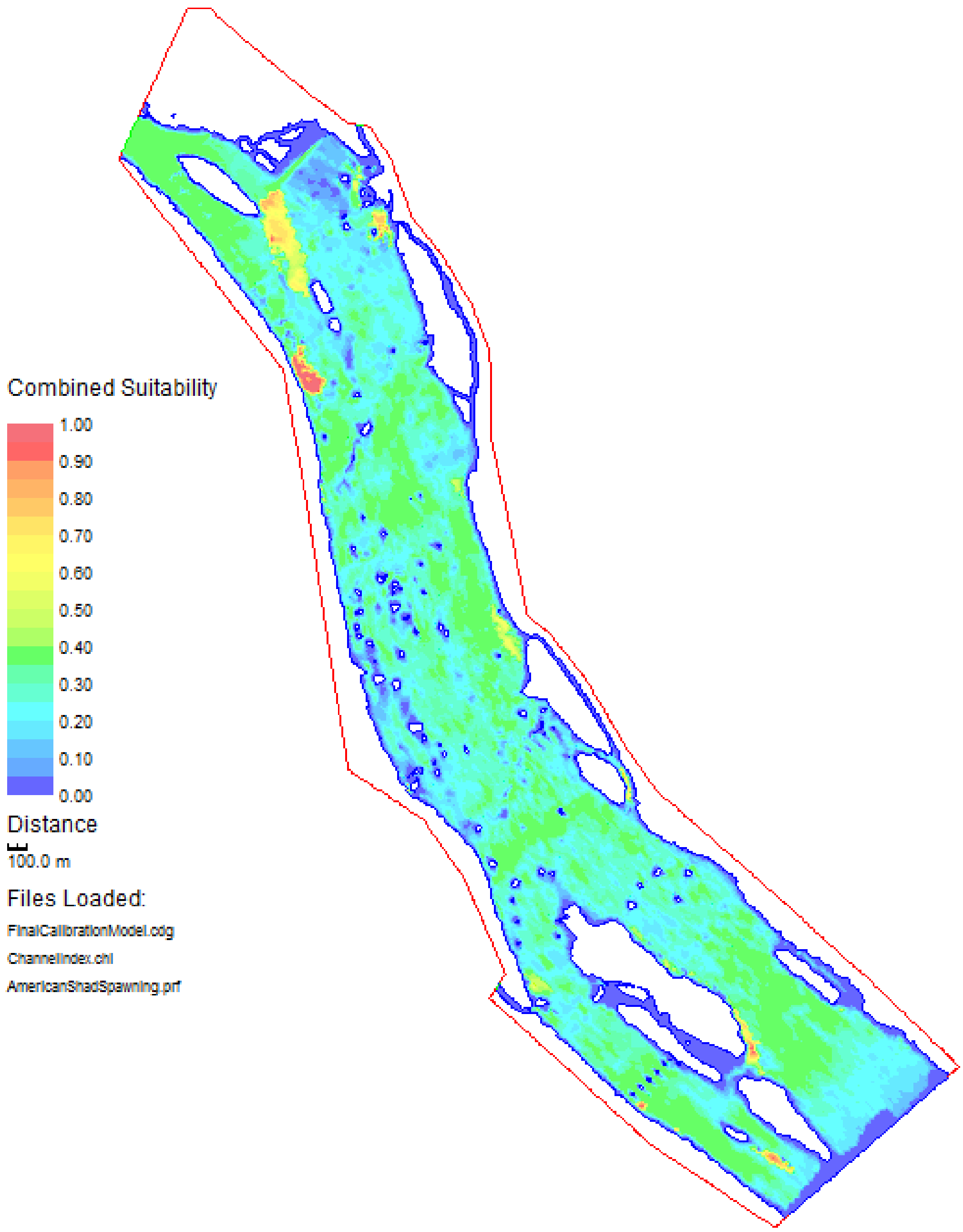
American Shad Spawning – 5,000 cfs



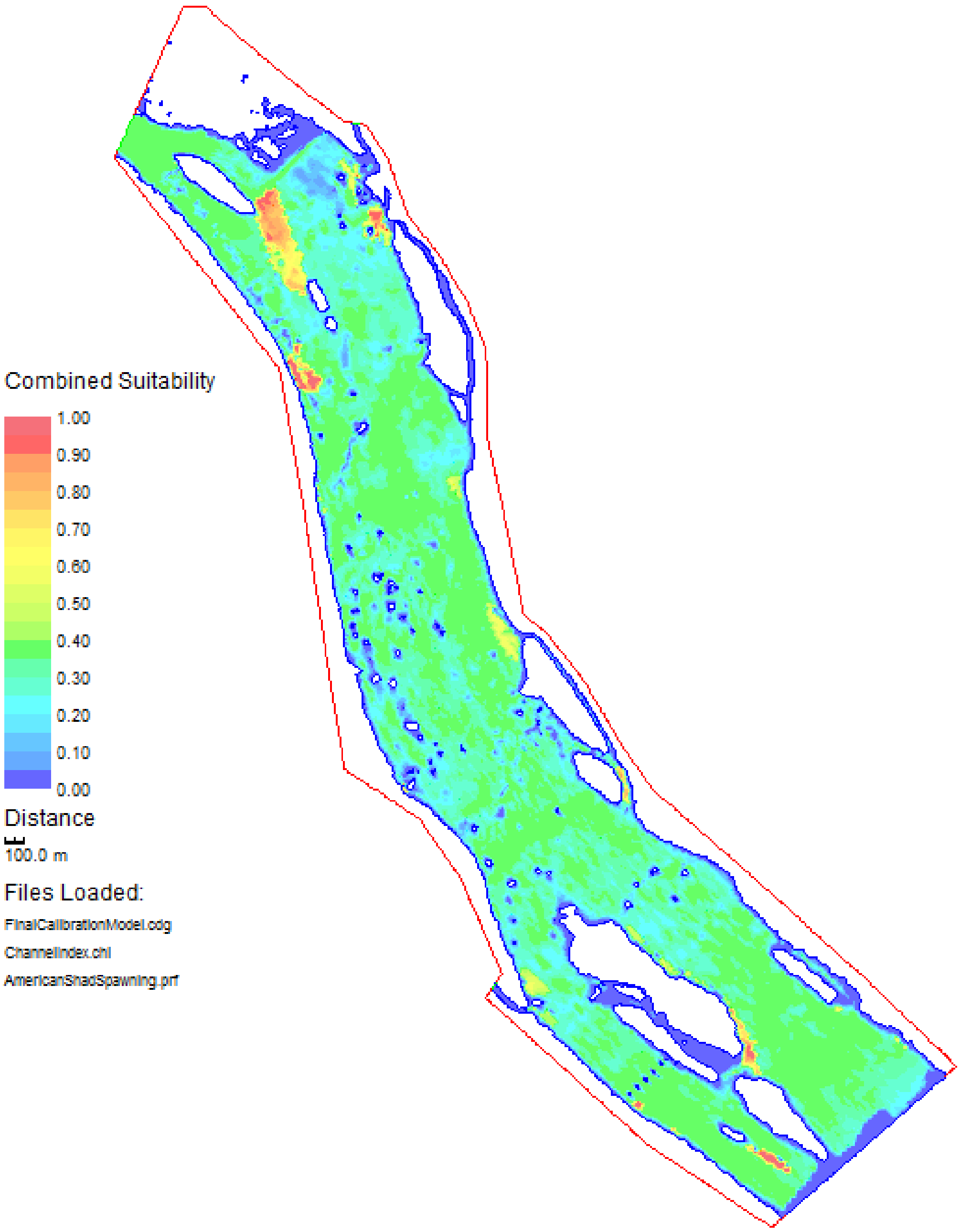
American Shad Spawning – 7,500 cfs



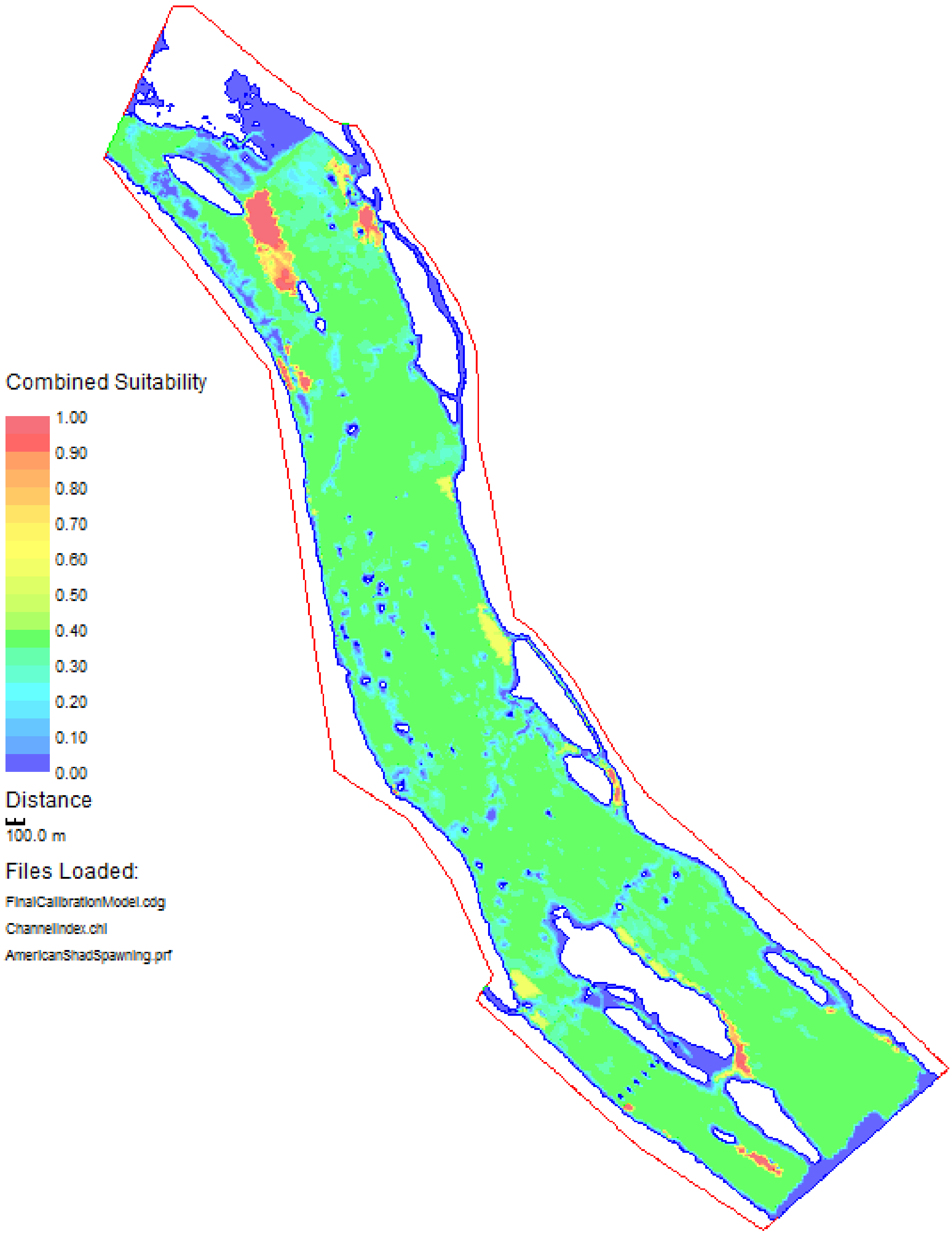
American Shad Spawning – 10,000 cfs



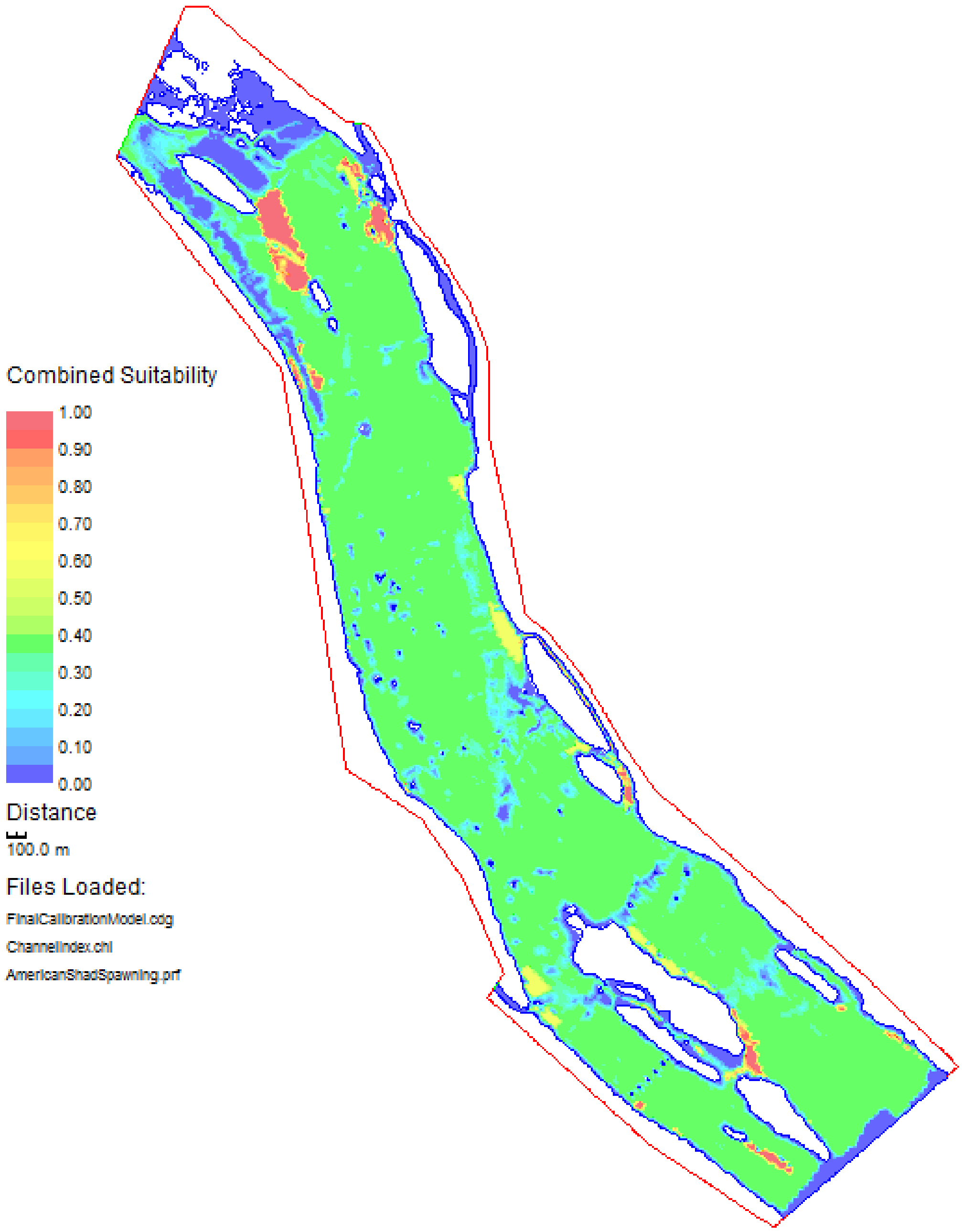
American Shad Spawning – 15,000 cfs



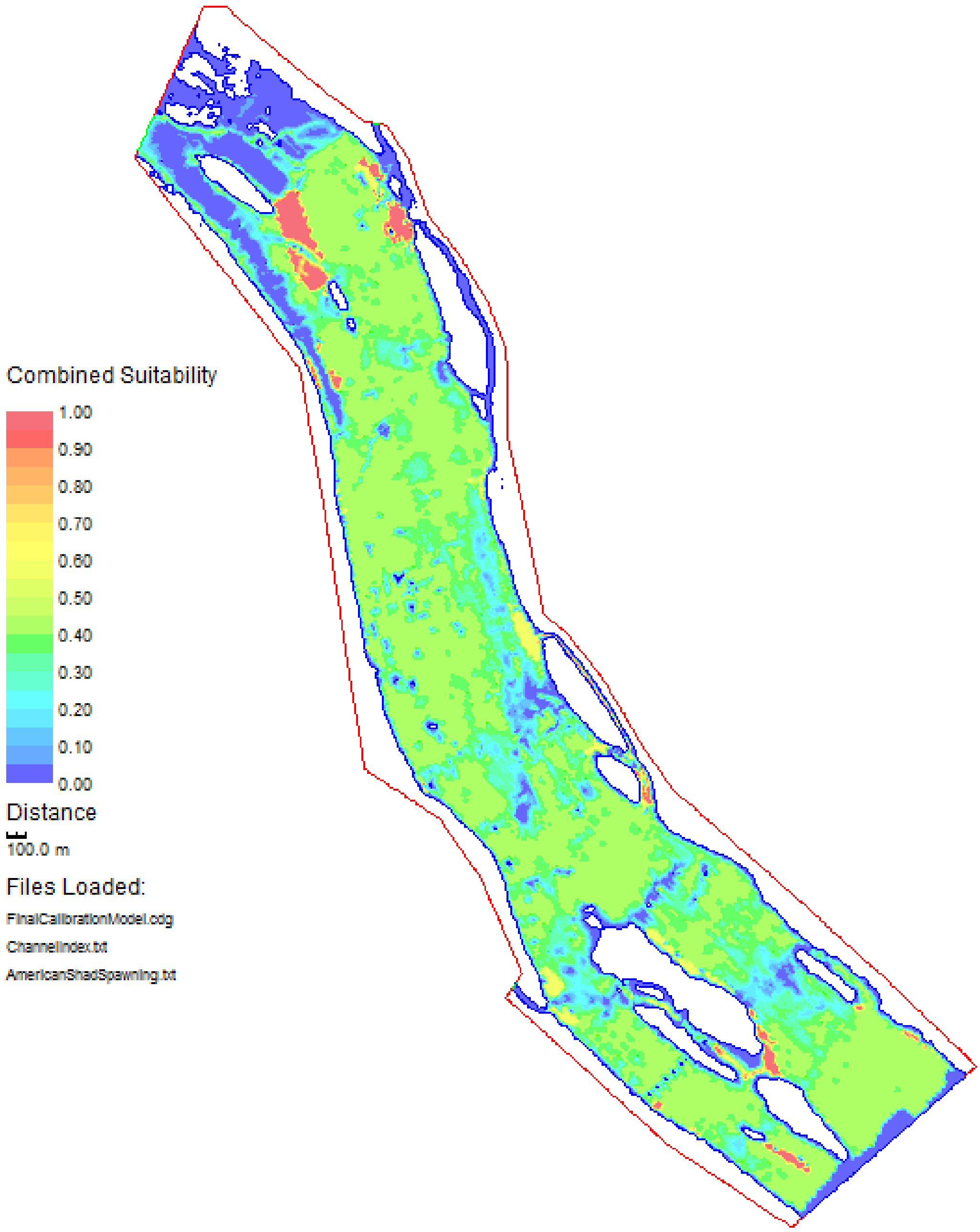
American Shad Spawning – 20,000 cfs



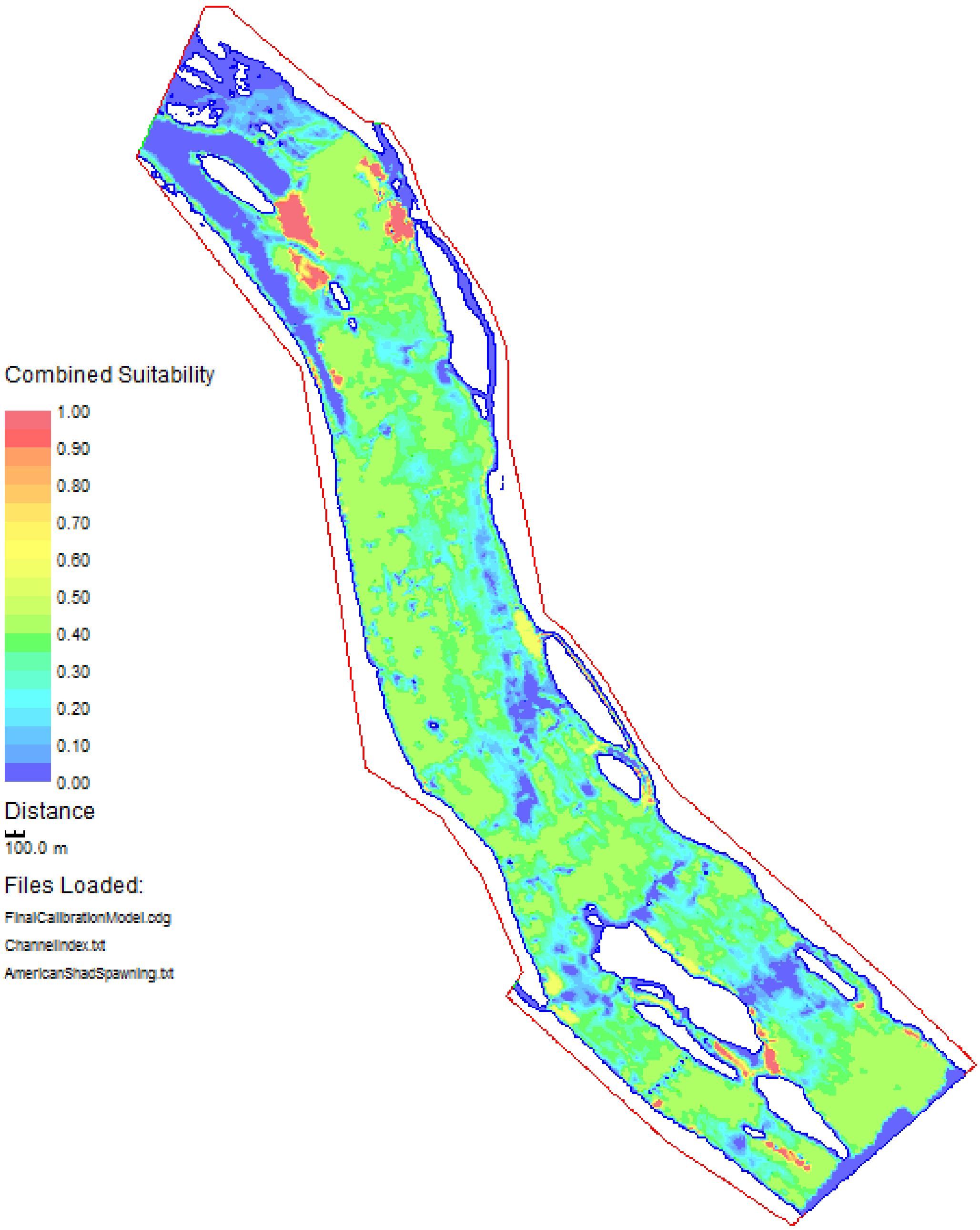
American Shad Spawning – 30,000 cfs



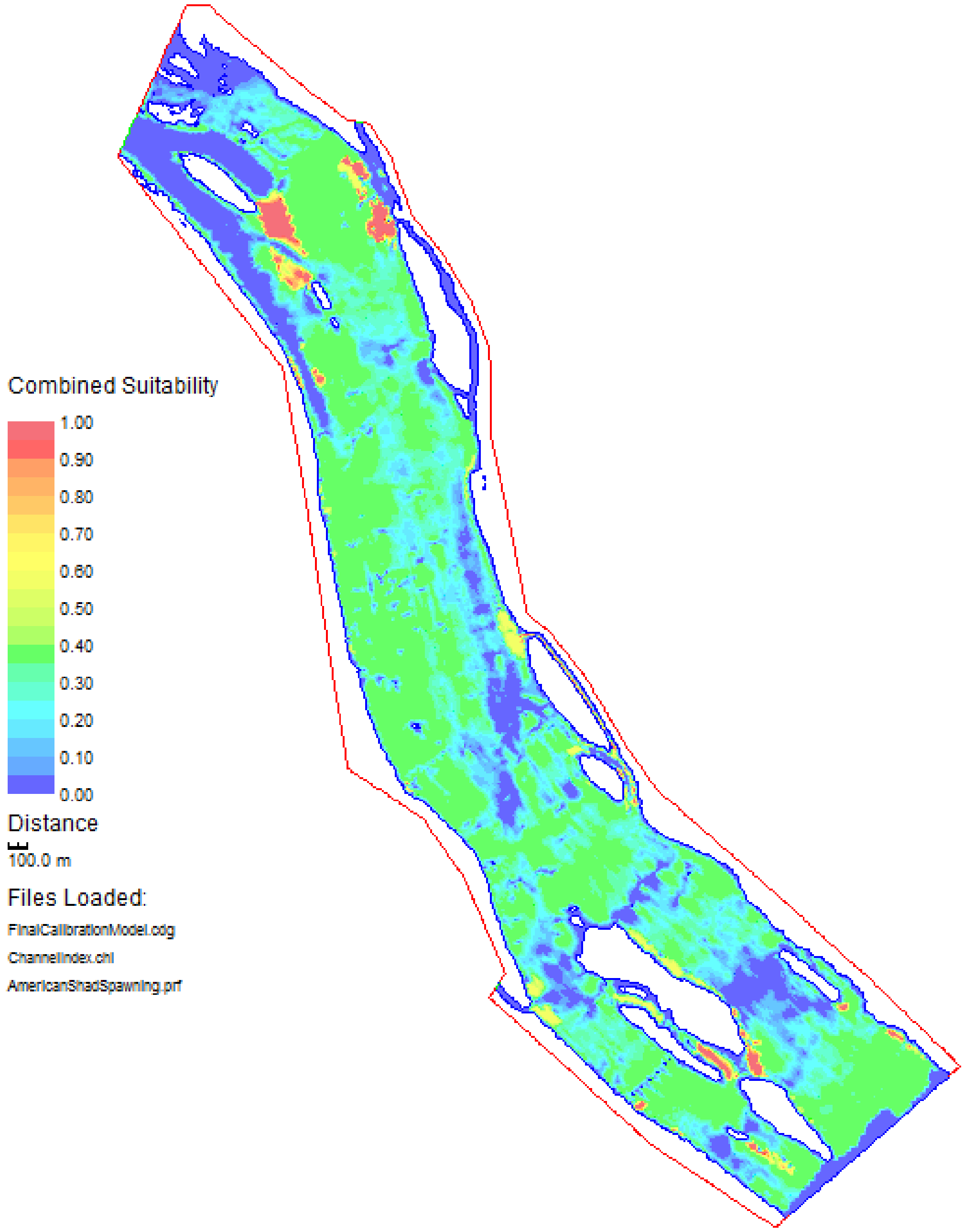
American Shad Spawning – 40,000 cfs



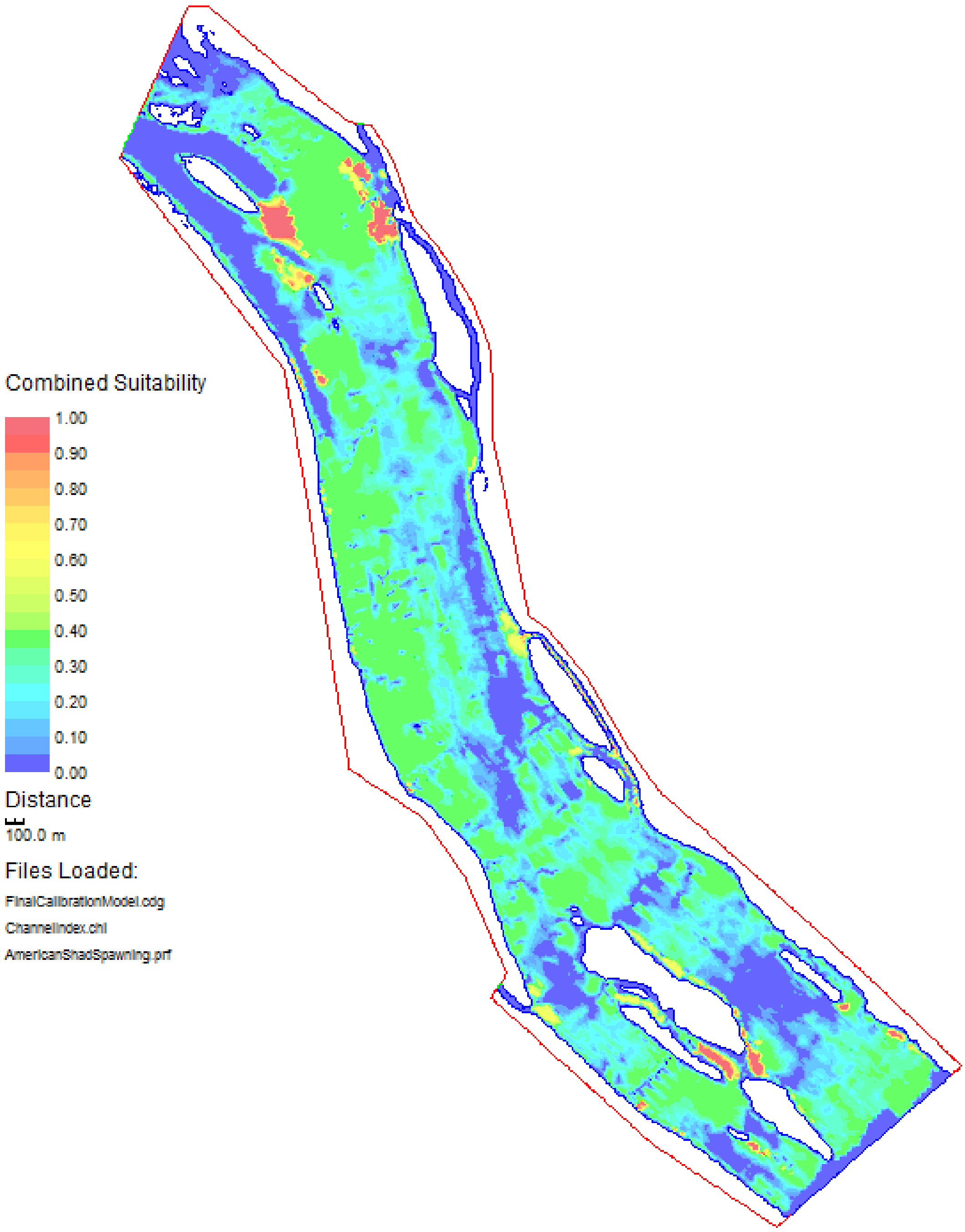
American Shad Spawning – 50,000 cfs



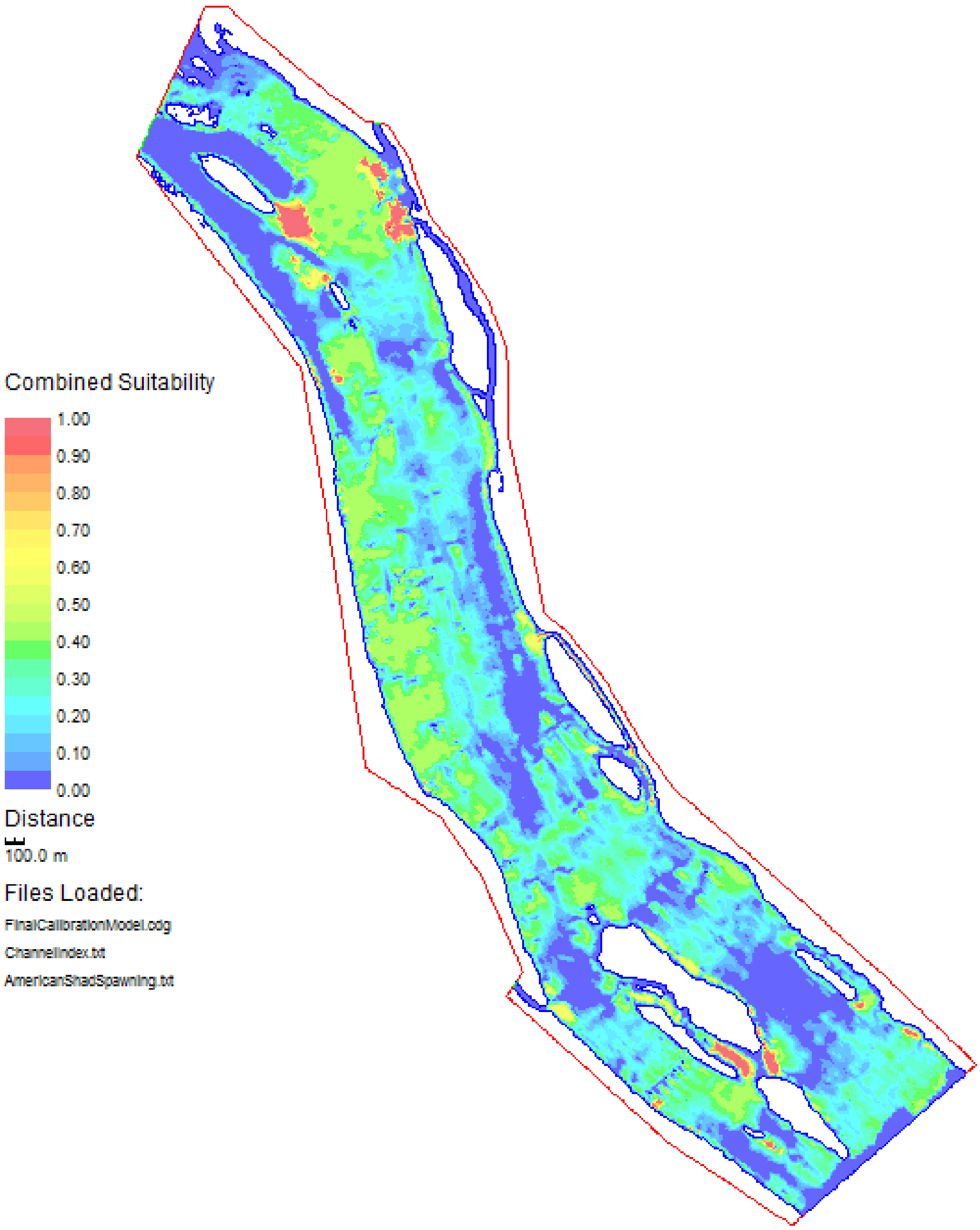
American Shad Spawning – 60,000 cfs



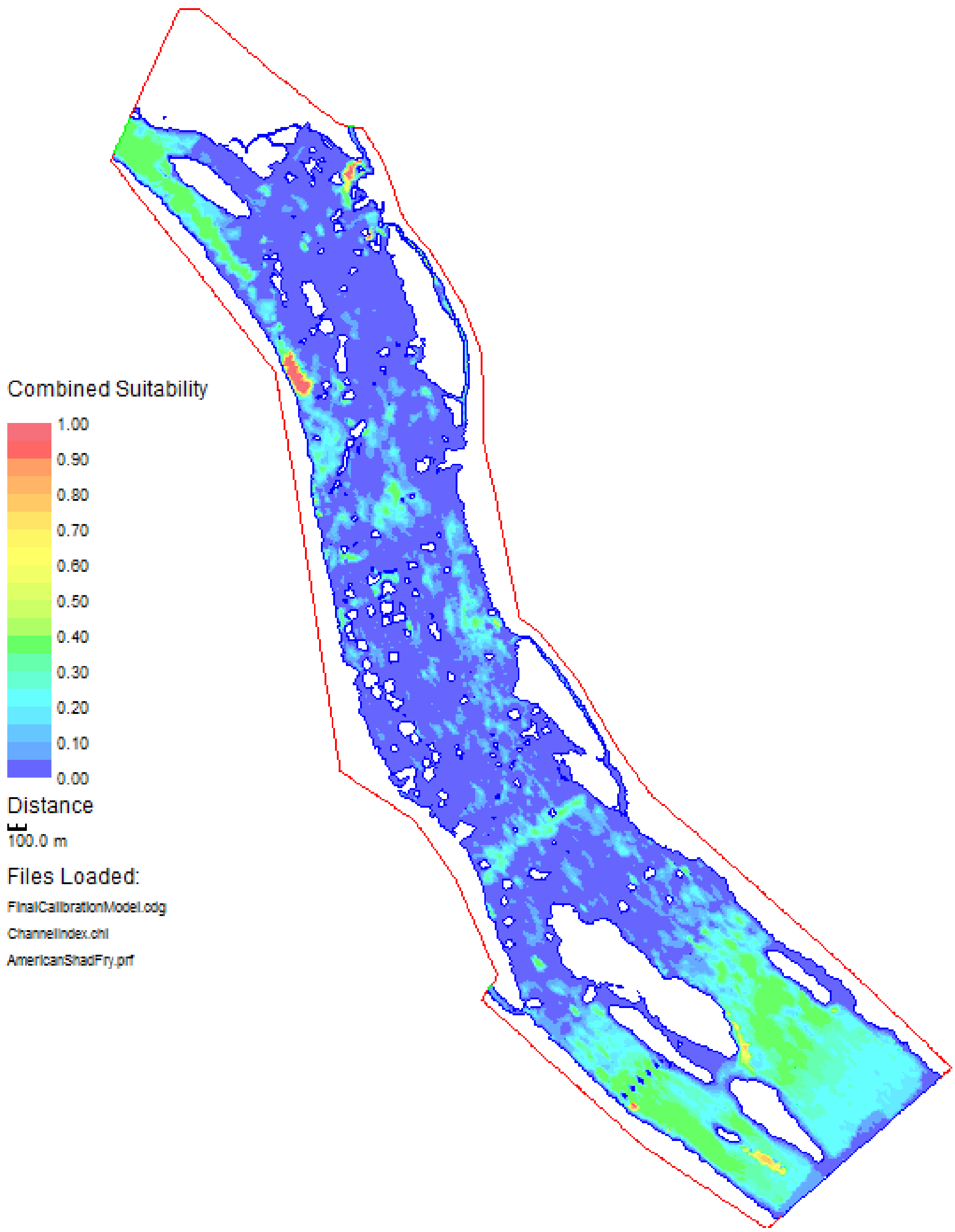
American Shad Spawning – 70,000 cfs



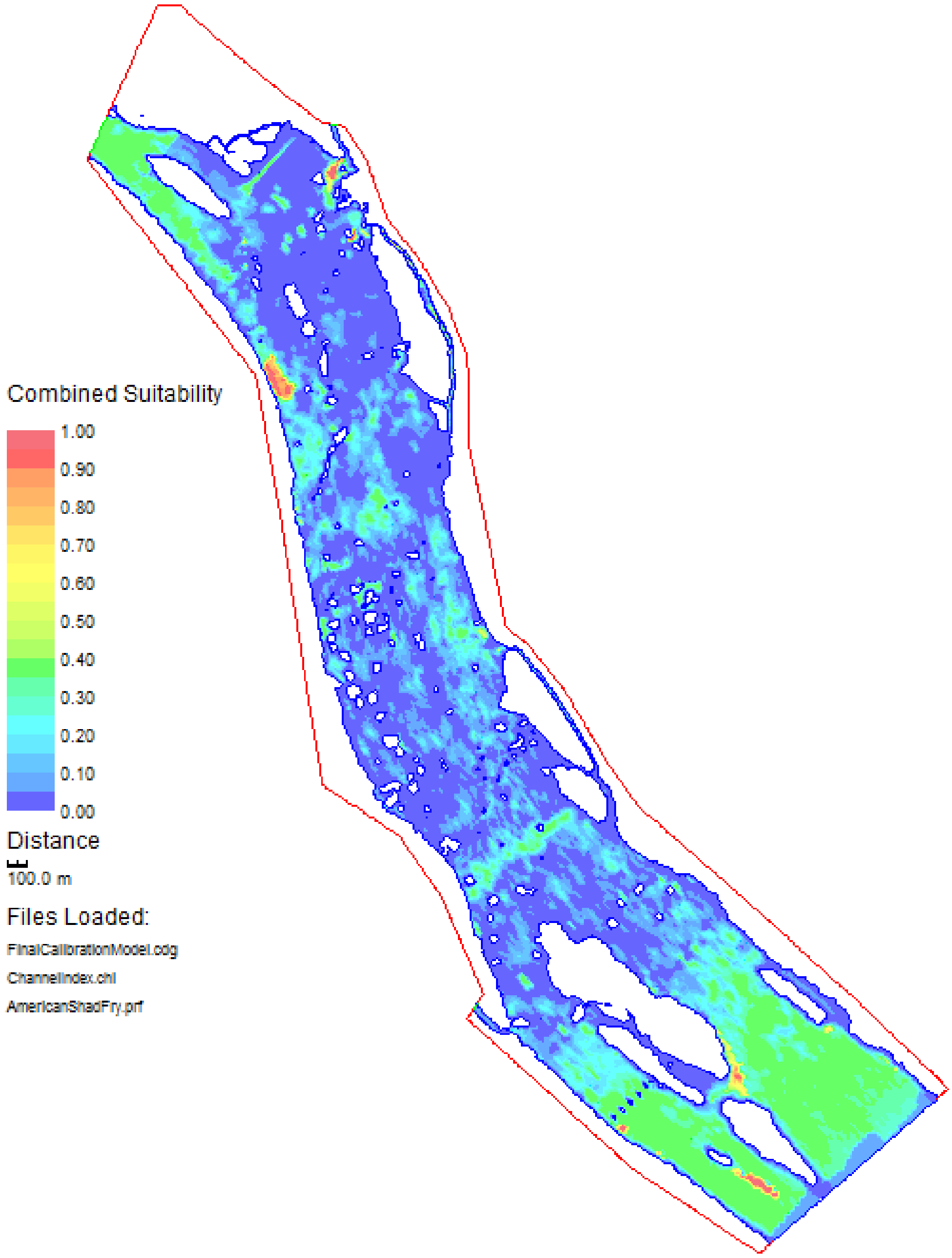
American Shad Spawning – 80,000 cfs



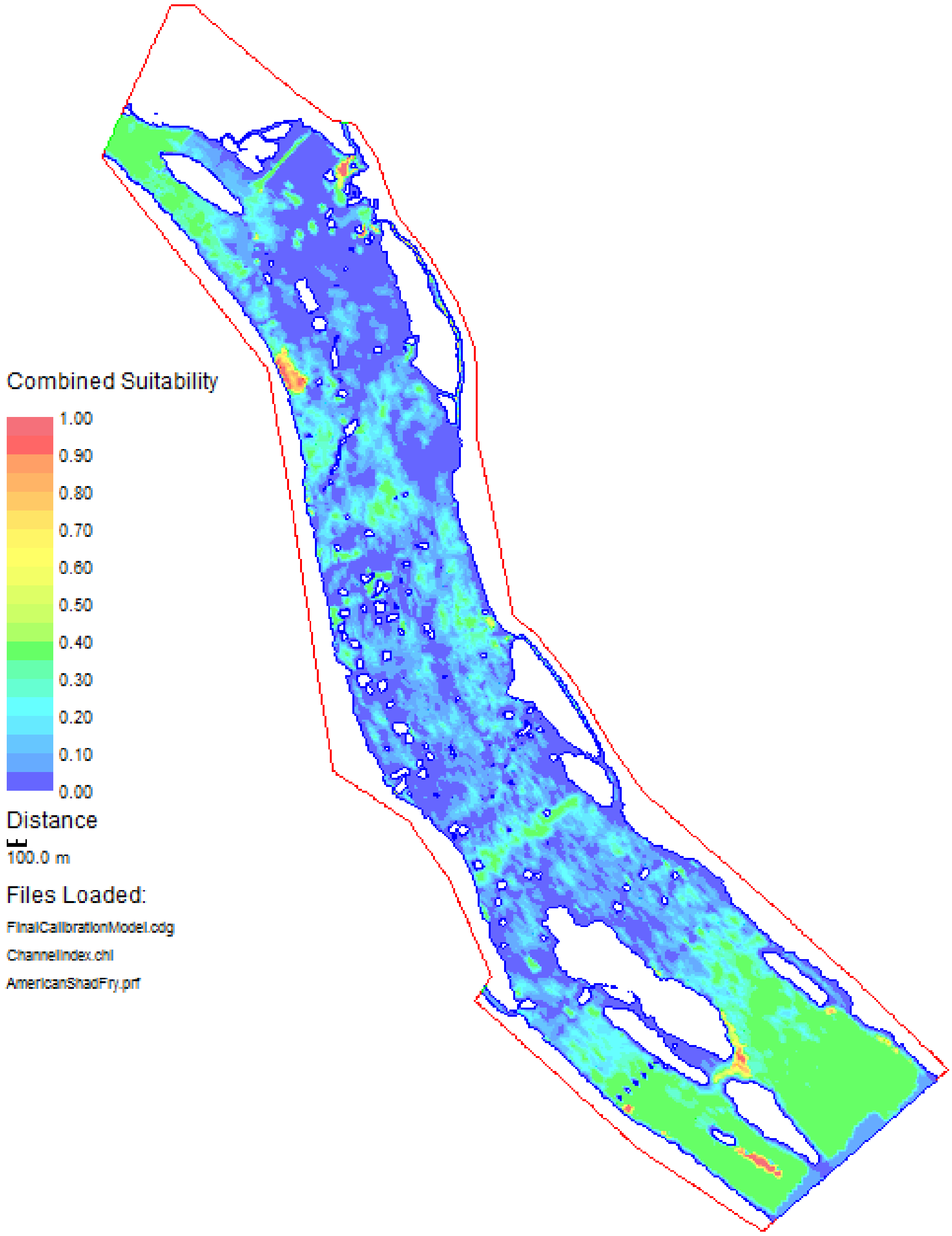
American Shad Spawning – 86,000 cfs



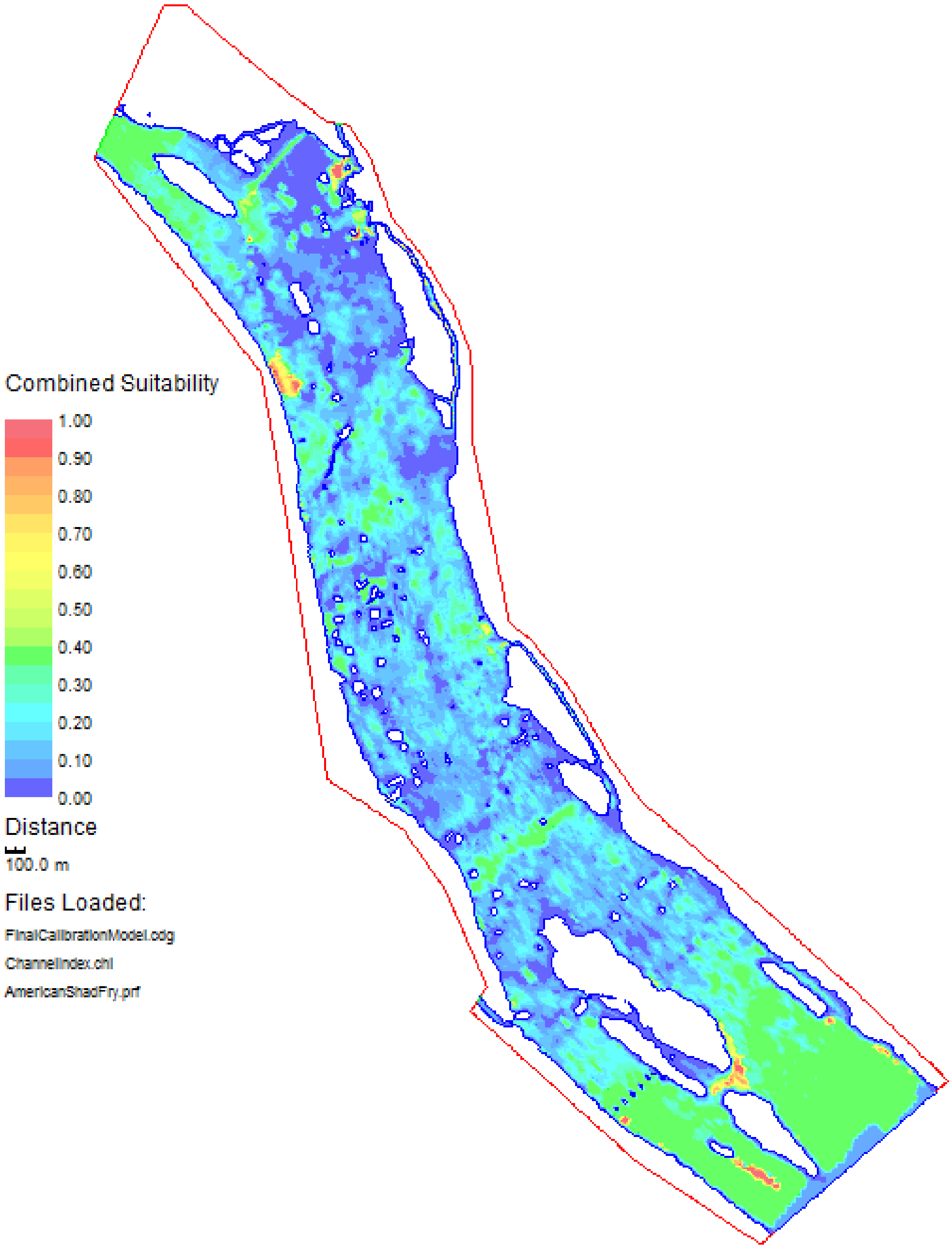
American Shad Fry – 2,000 cfs



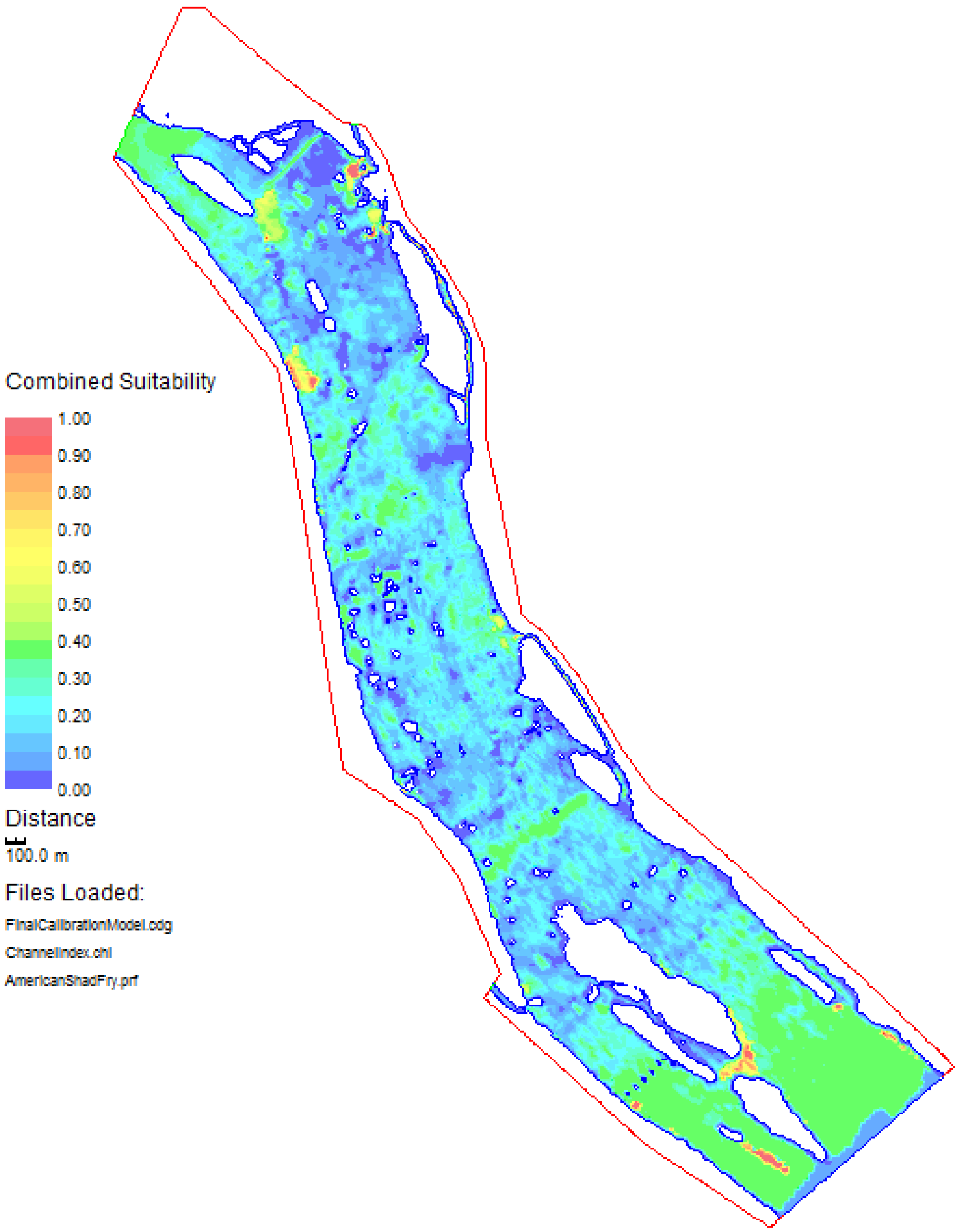
American Shad Fry – 3,500 cfs



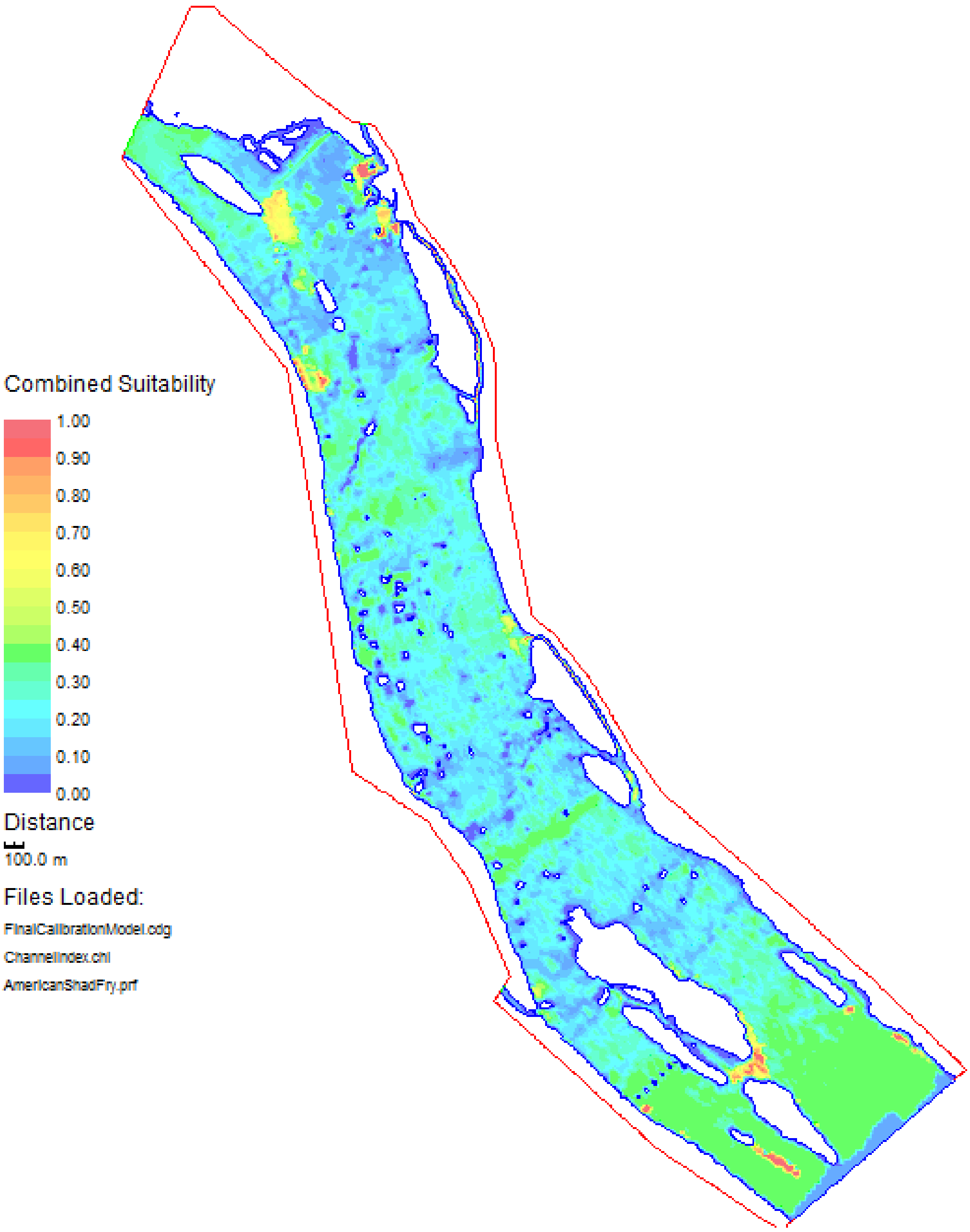
American Shad Fry – 5,000 cfs



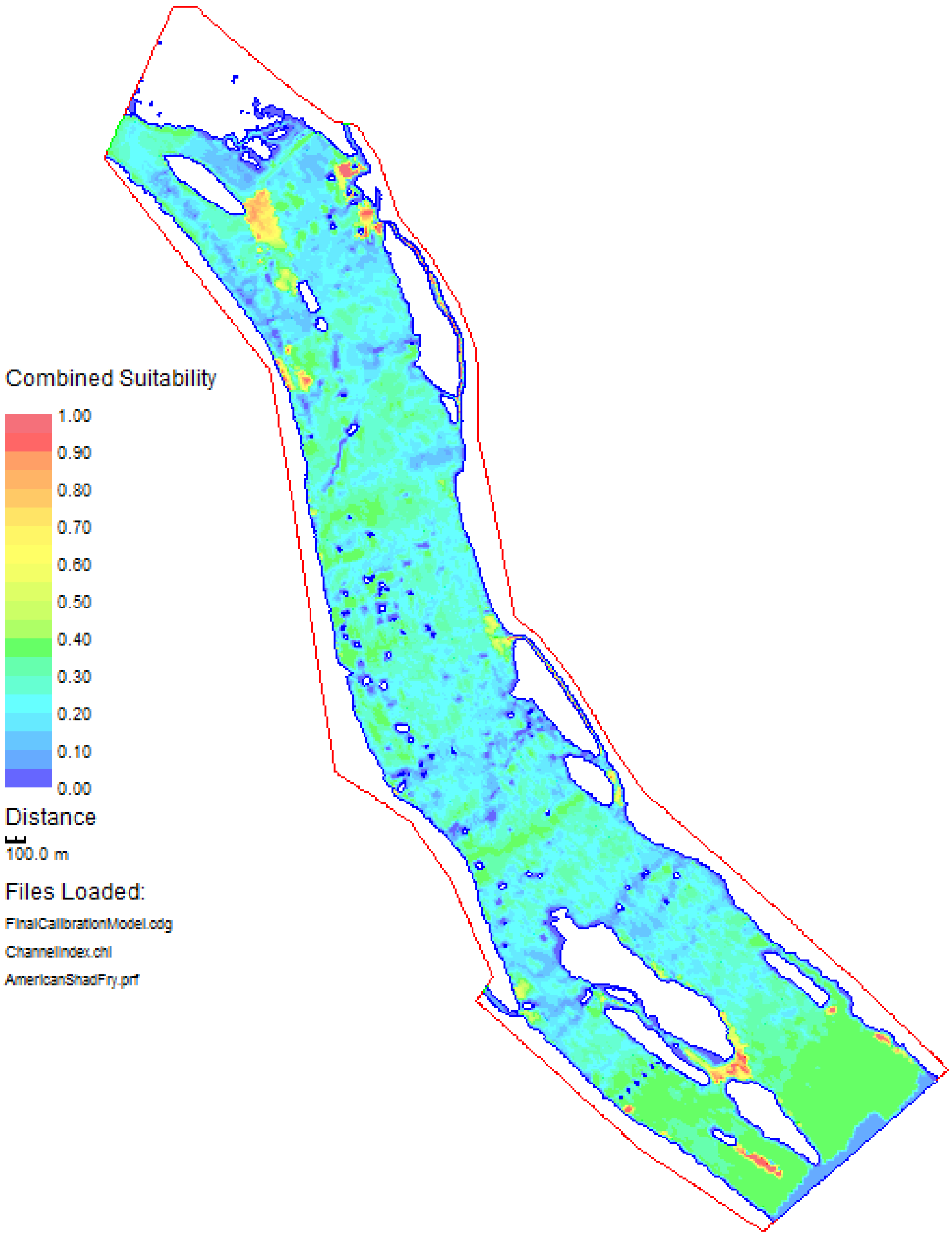
American Shad Fry – 7,500 cfs



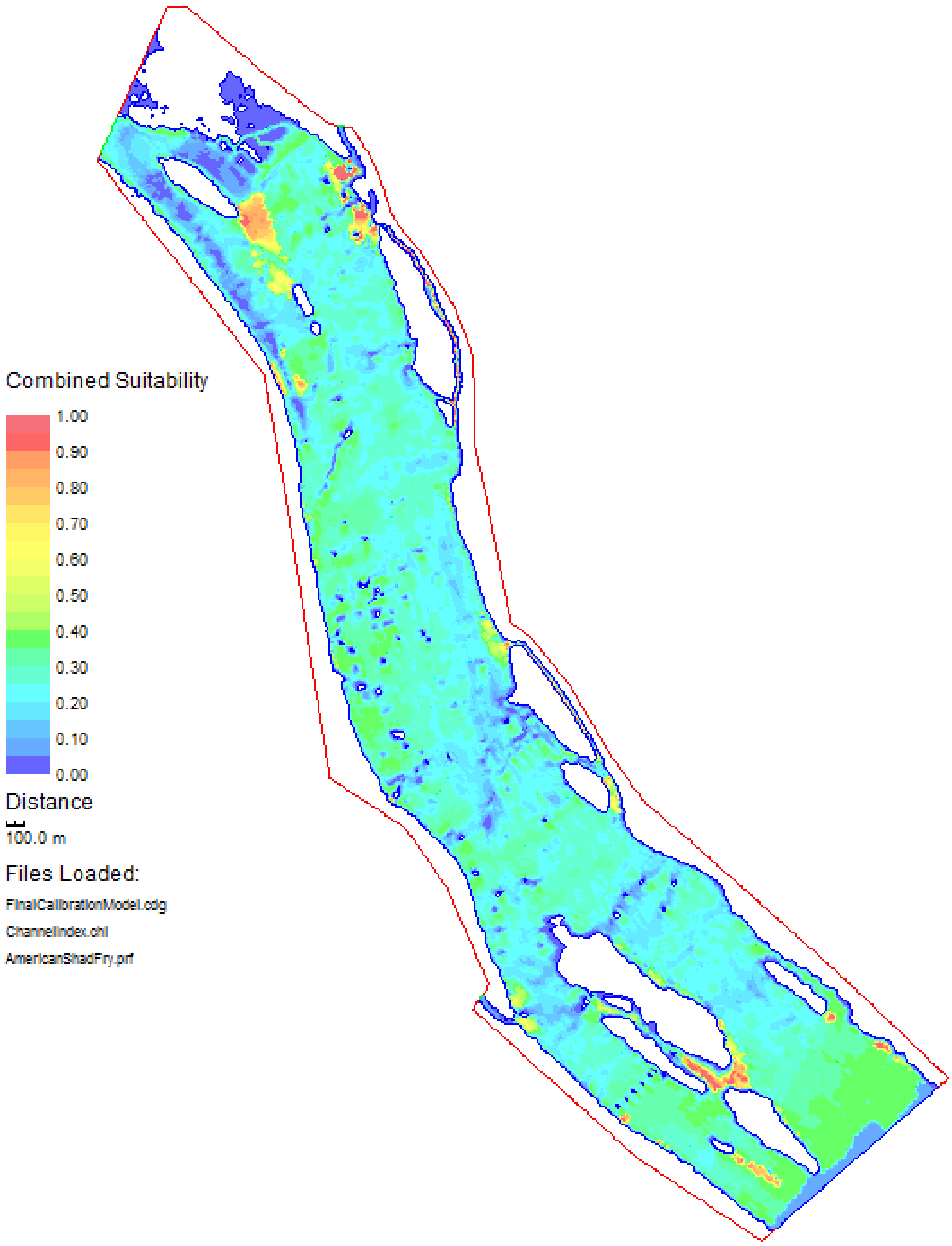
American Shad Fry – 10,000 cfs



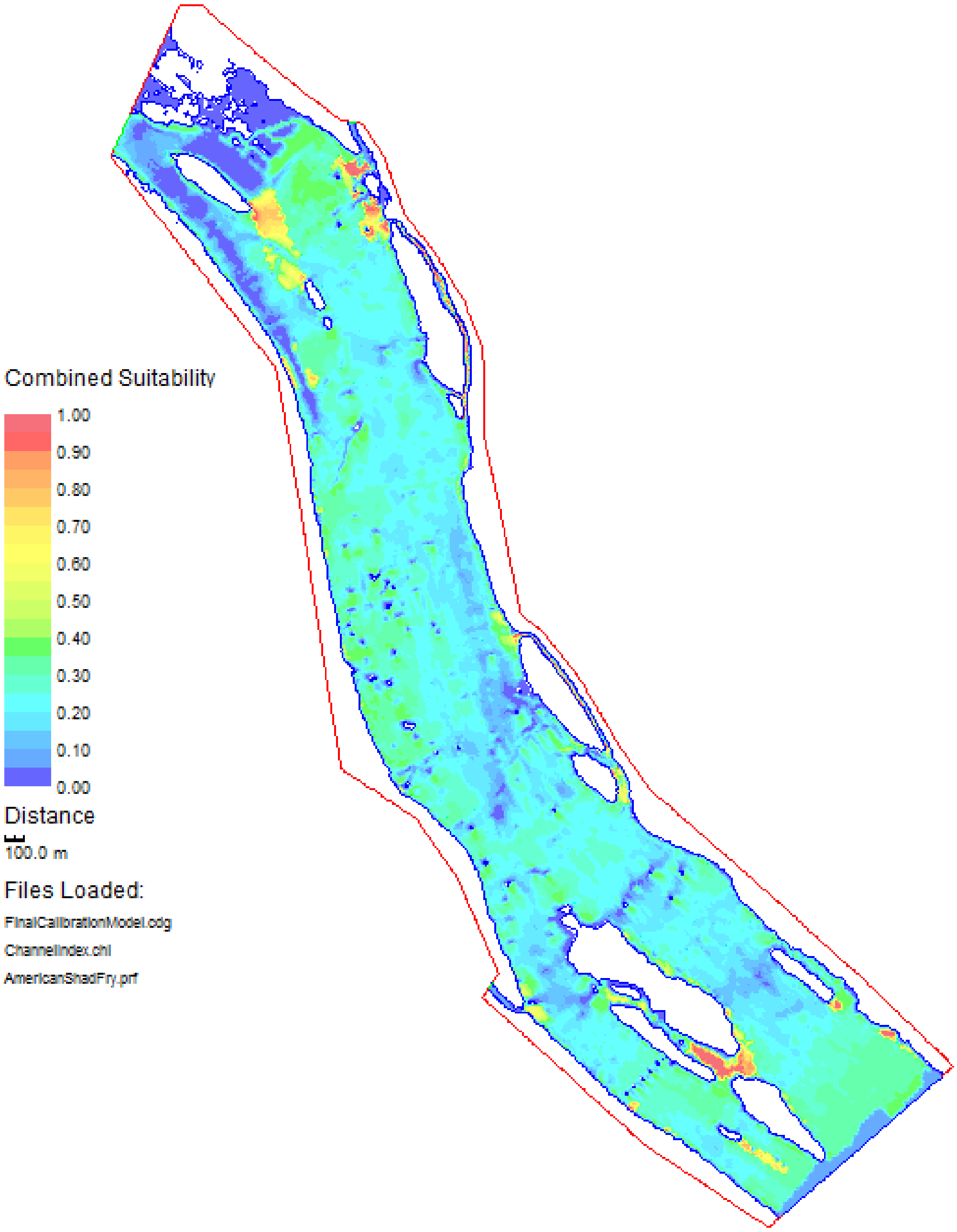
American Shad Fry - 15,000 cfs



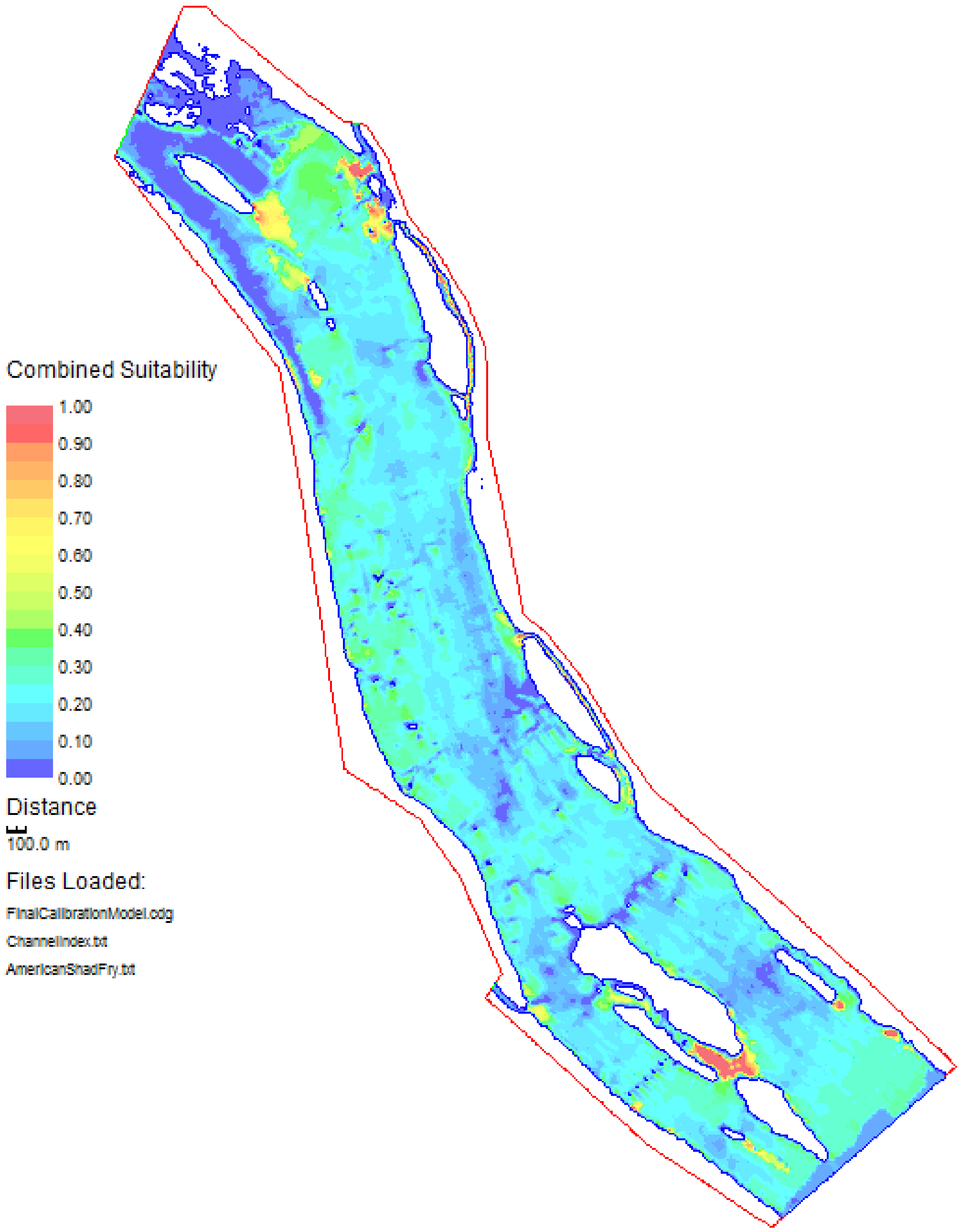
American Shad Fry - 20,000 cfs



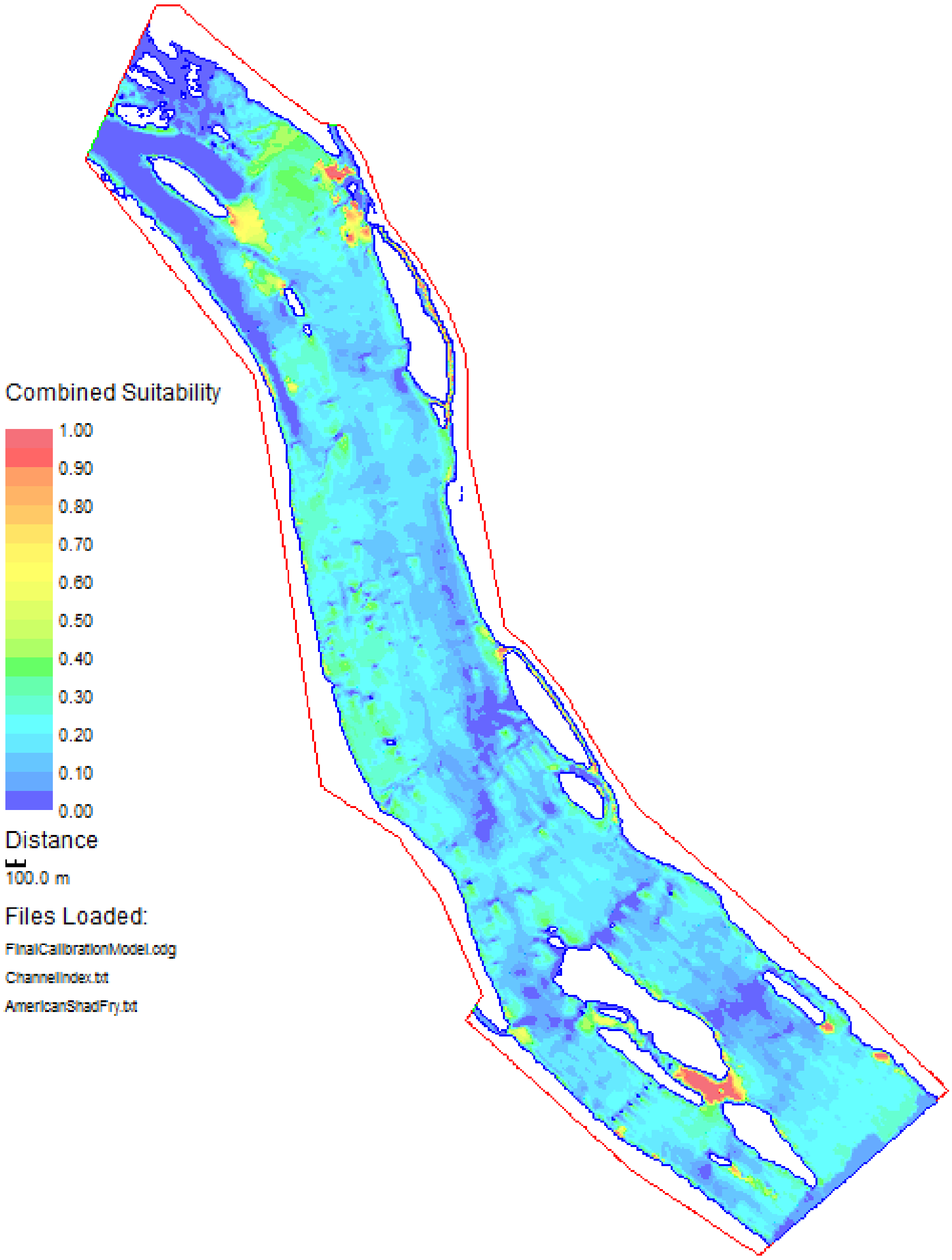
American Shad Fry – 30,000 cfs



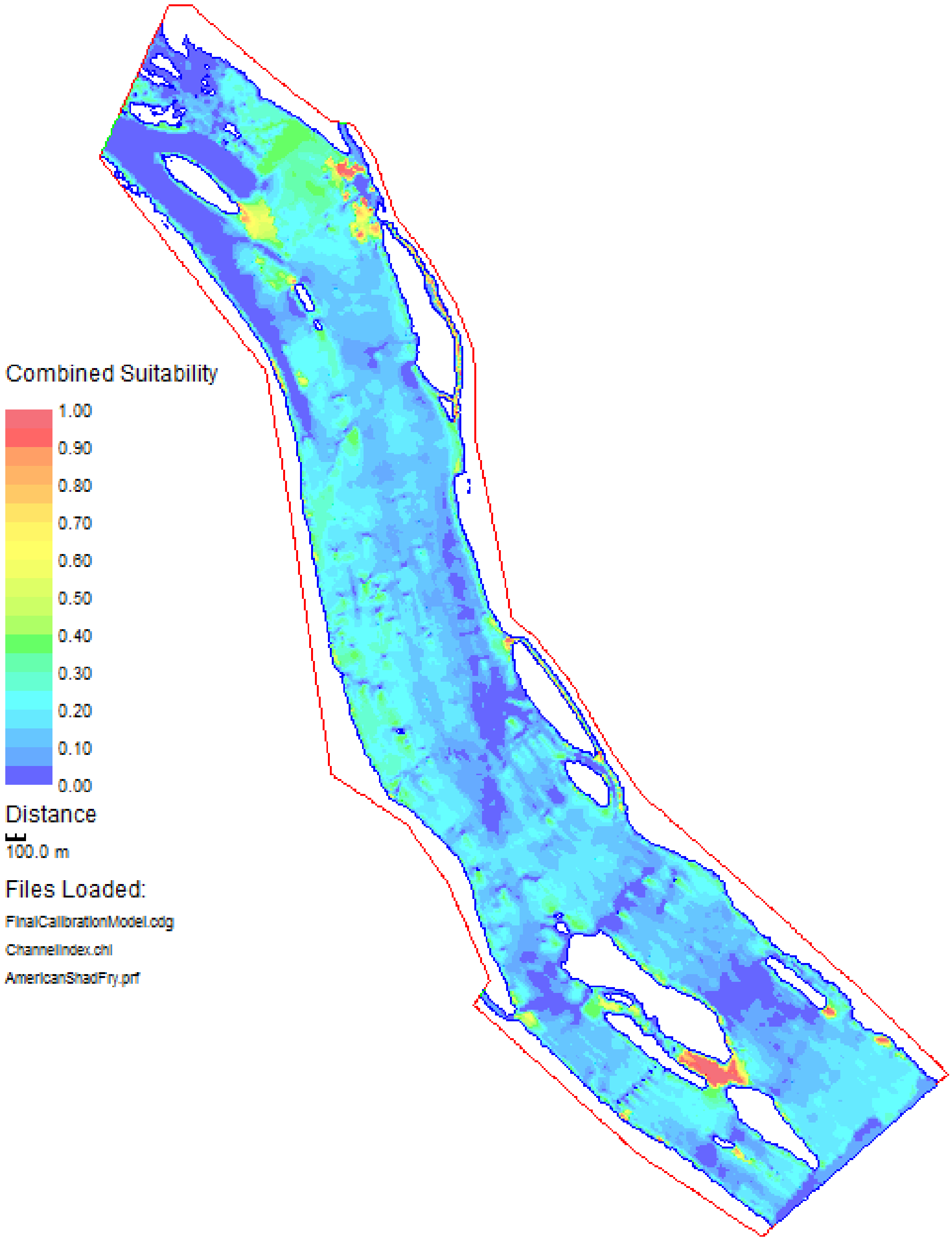
American Shad Fry – 40,000 cfs



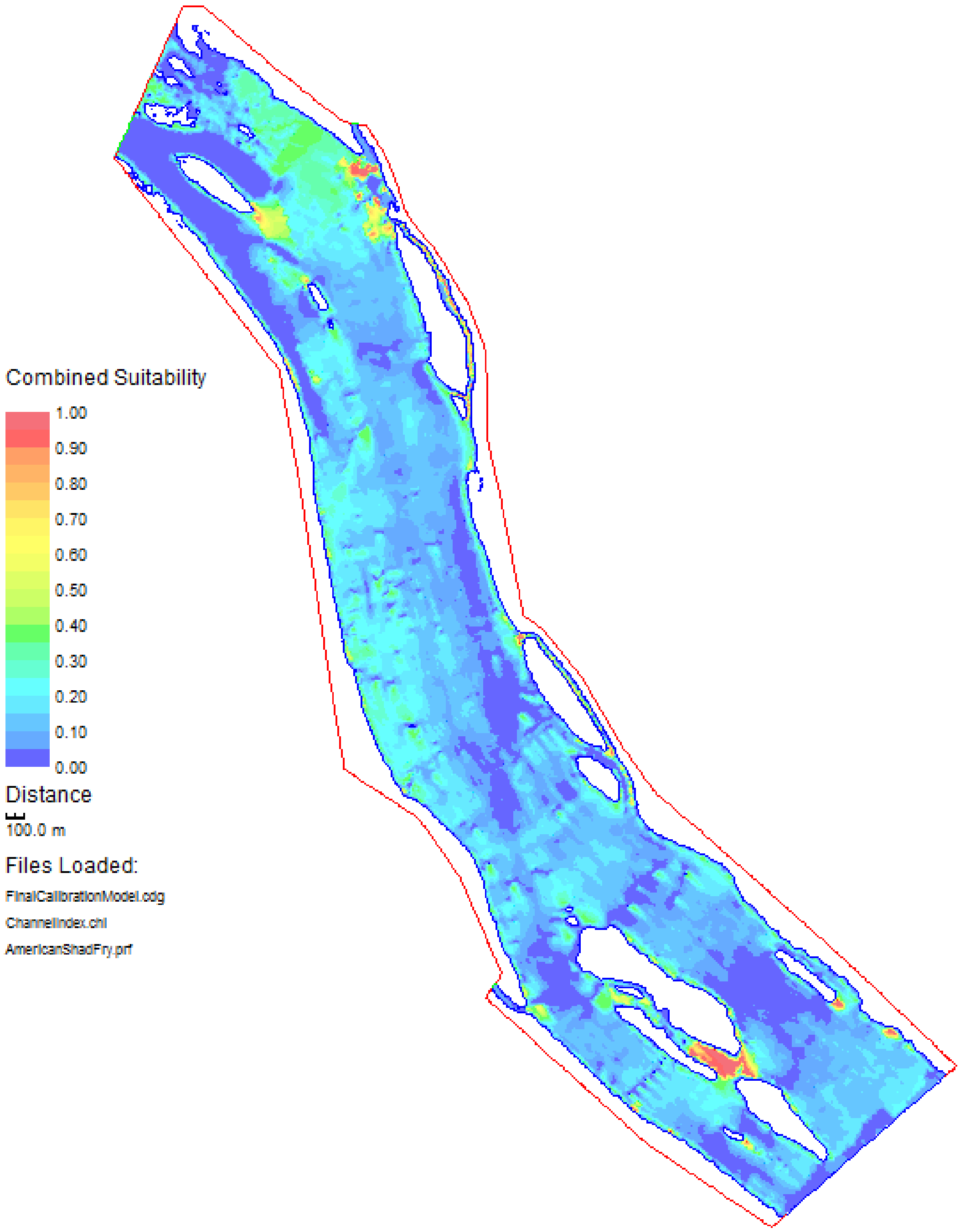
American Shad Fry – 50,000 cfs



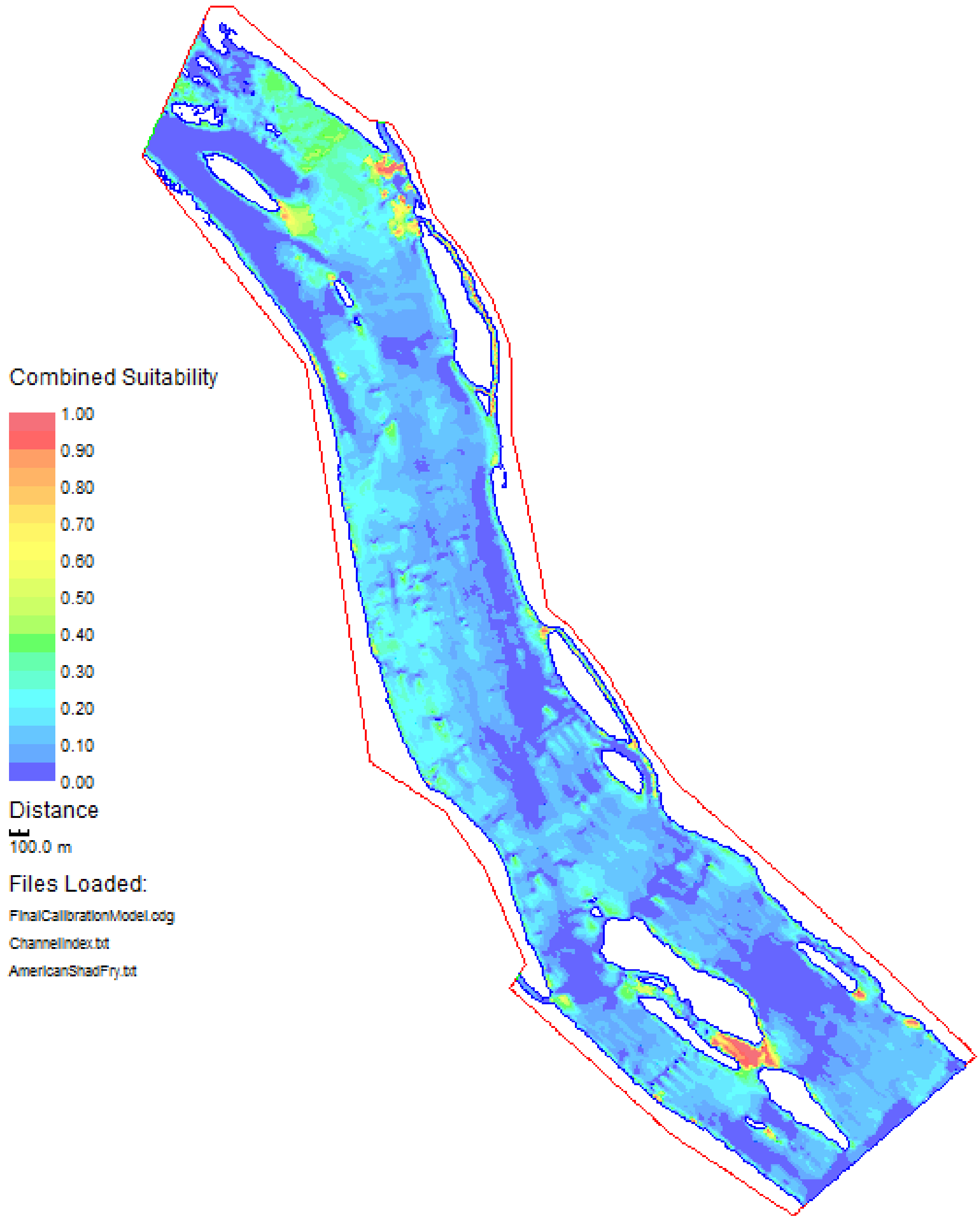
American Shad Fry – 60,000 cfs



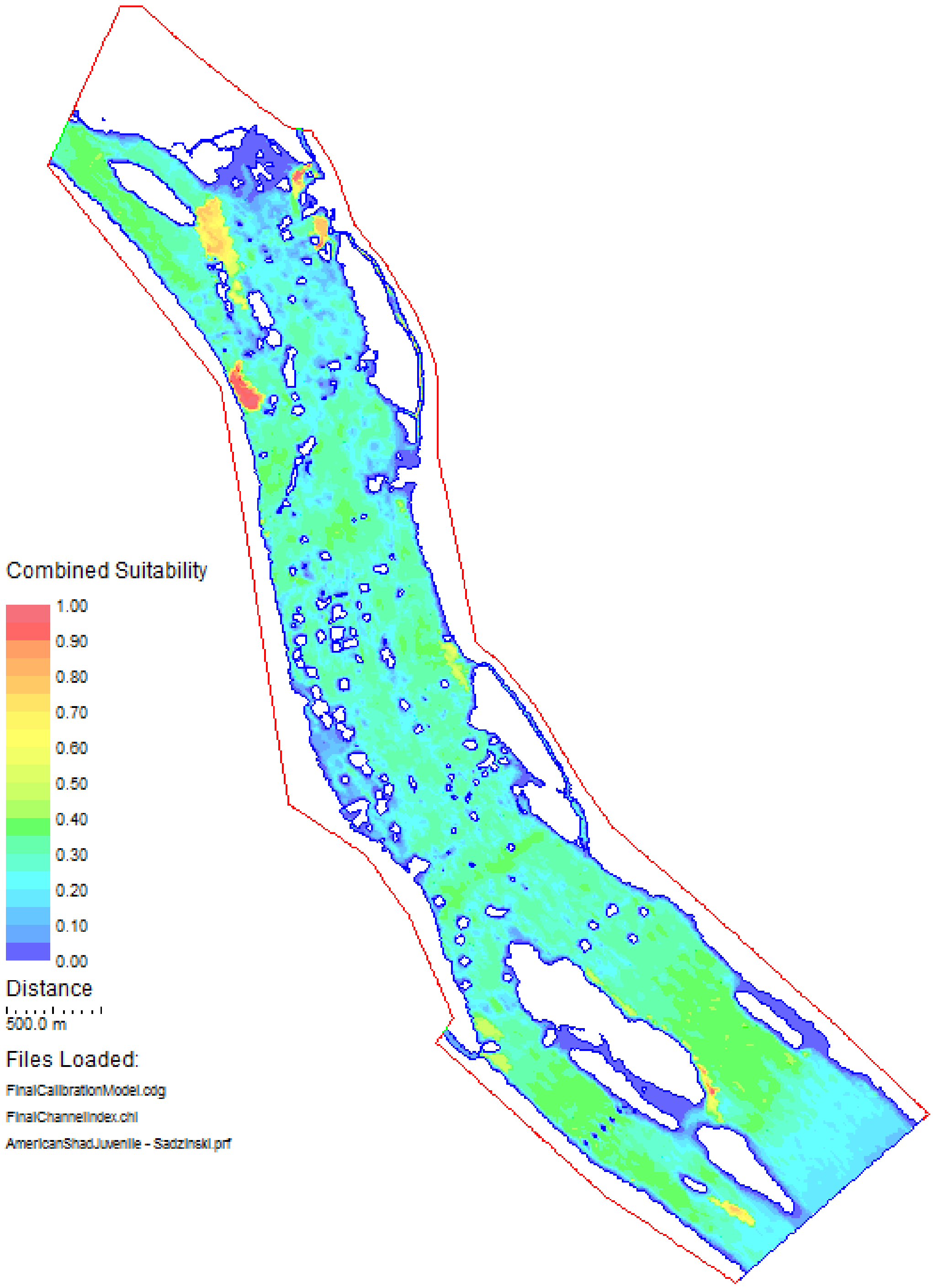
American Shad Fry – 70,000 cfs



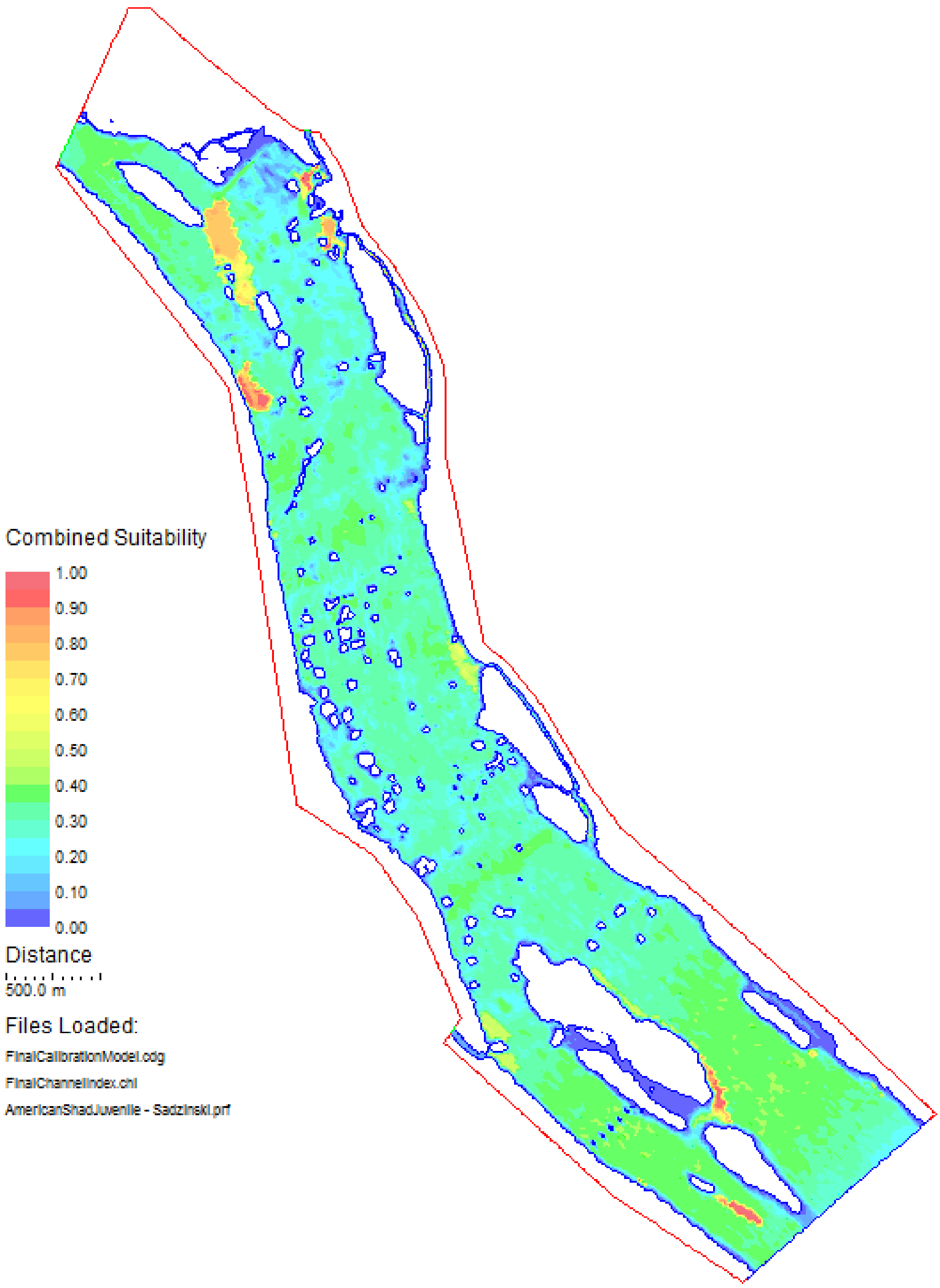
American Shad Fry – 80,000 cfs



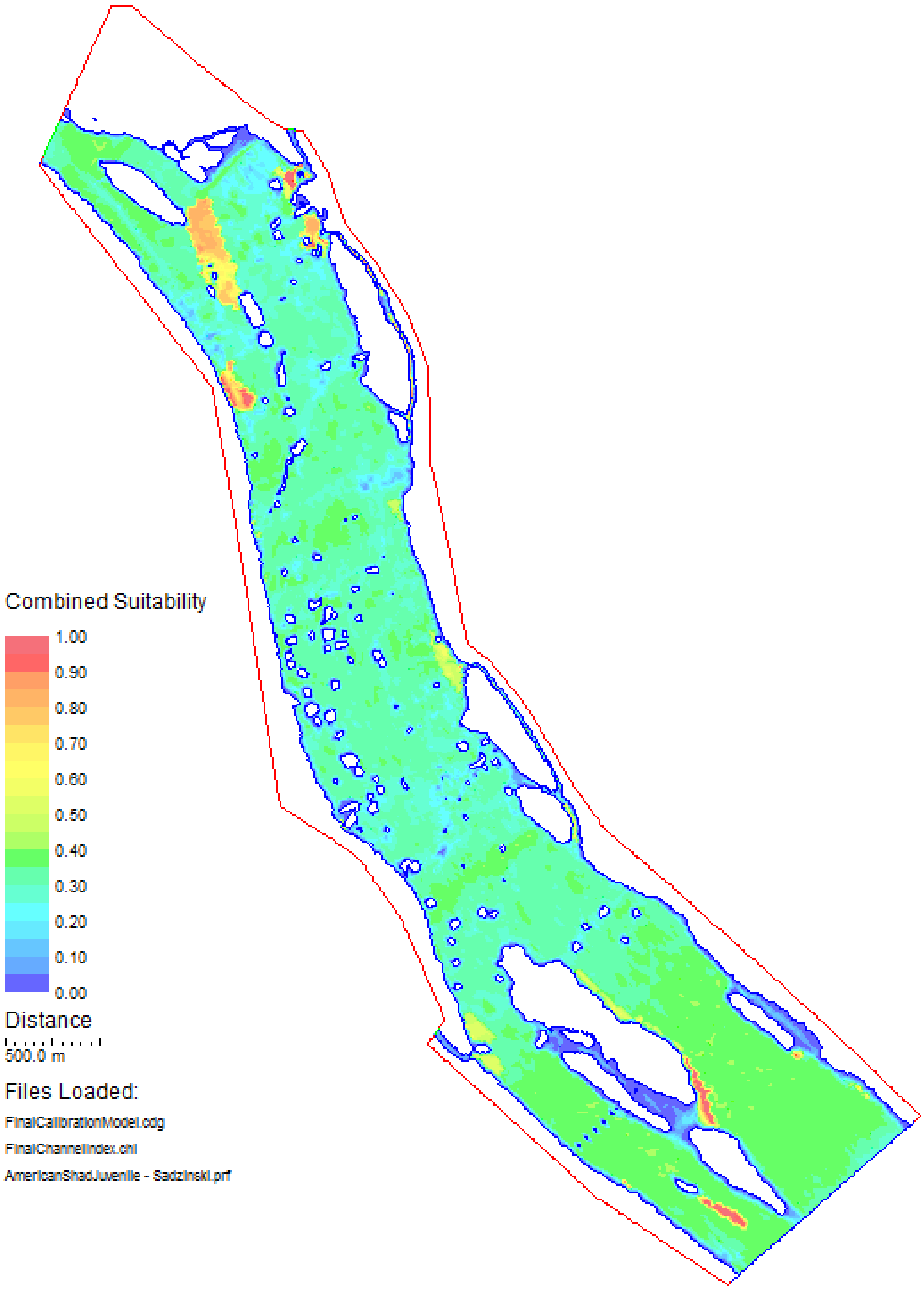
American Shad Fry – 86,000 cfs



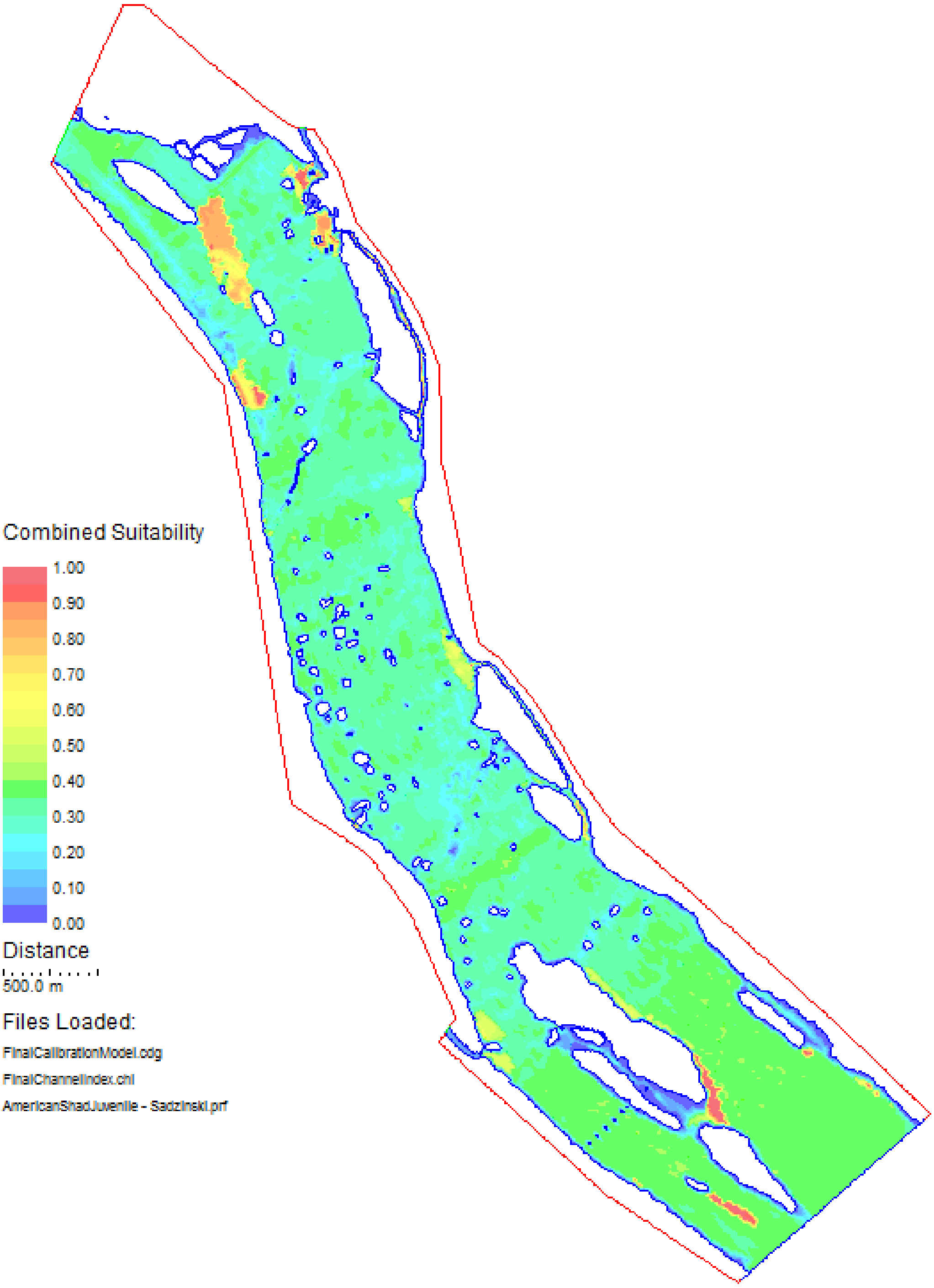
American Shad Juvenile – 2,000 cfs



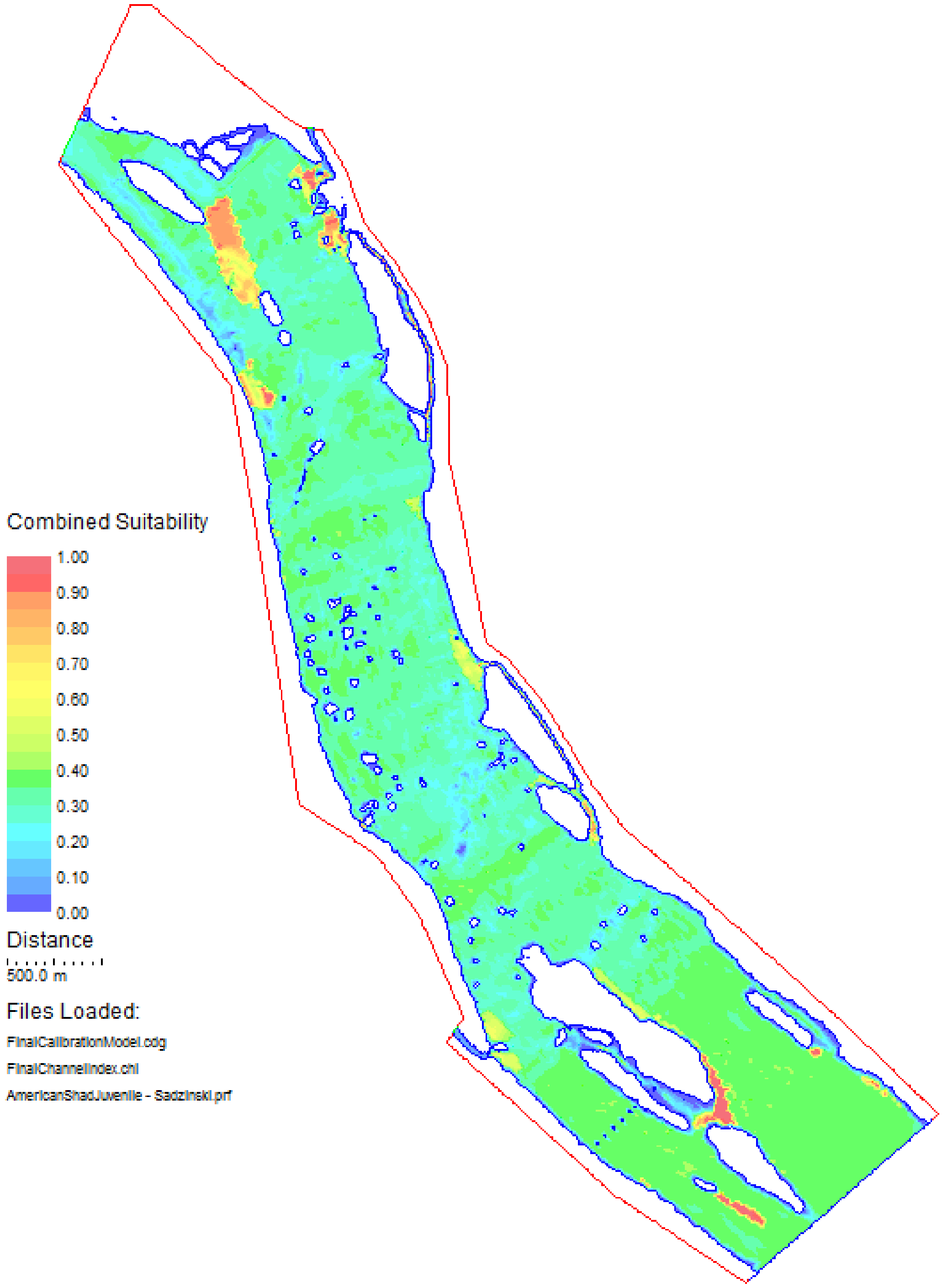
American Shad Juvenile – 3,500 cfs



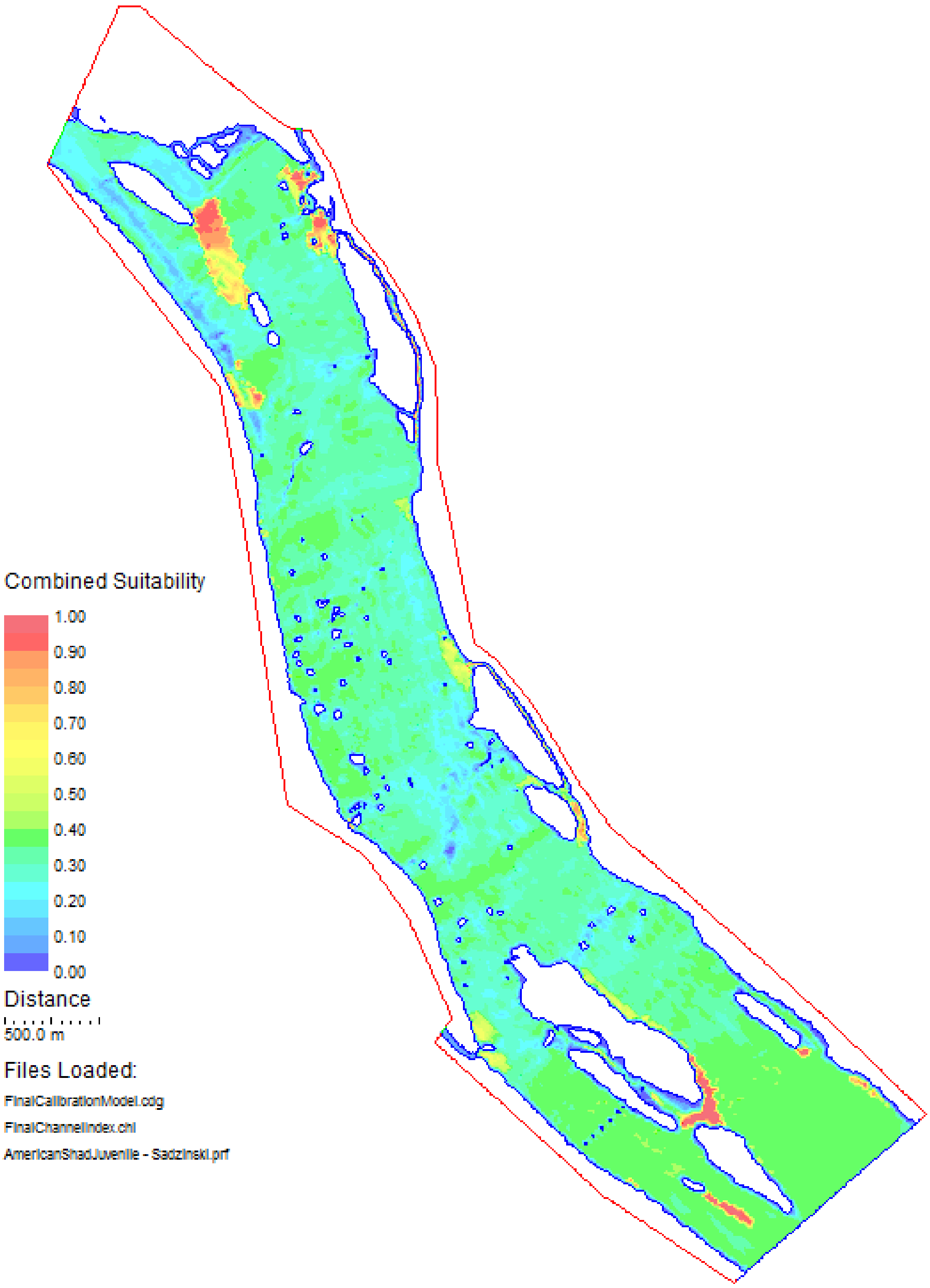
American Shad Juvenile – 5,000 cfs



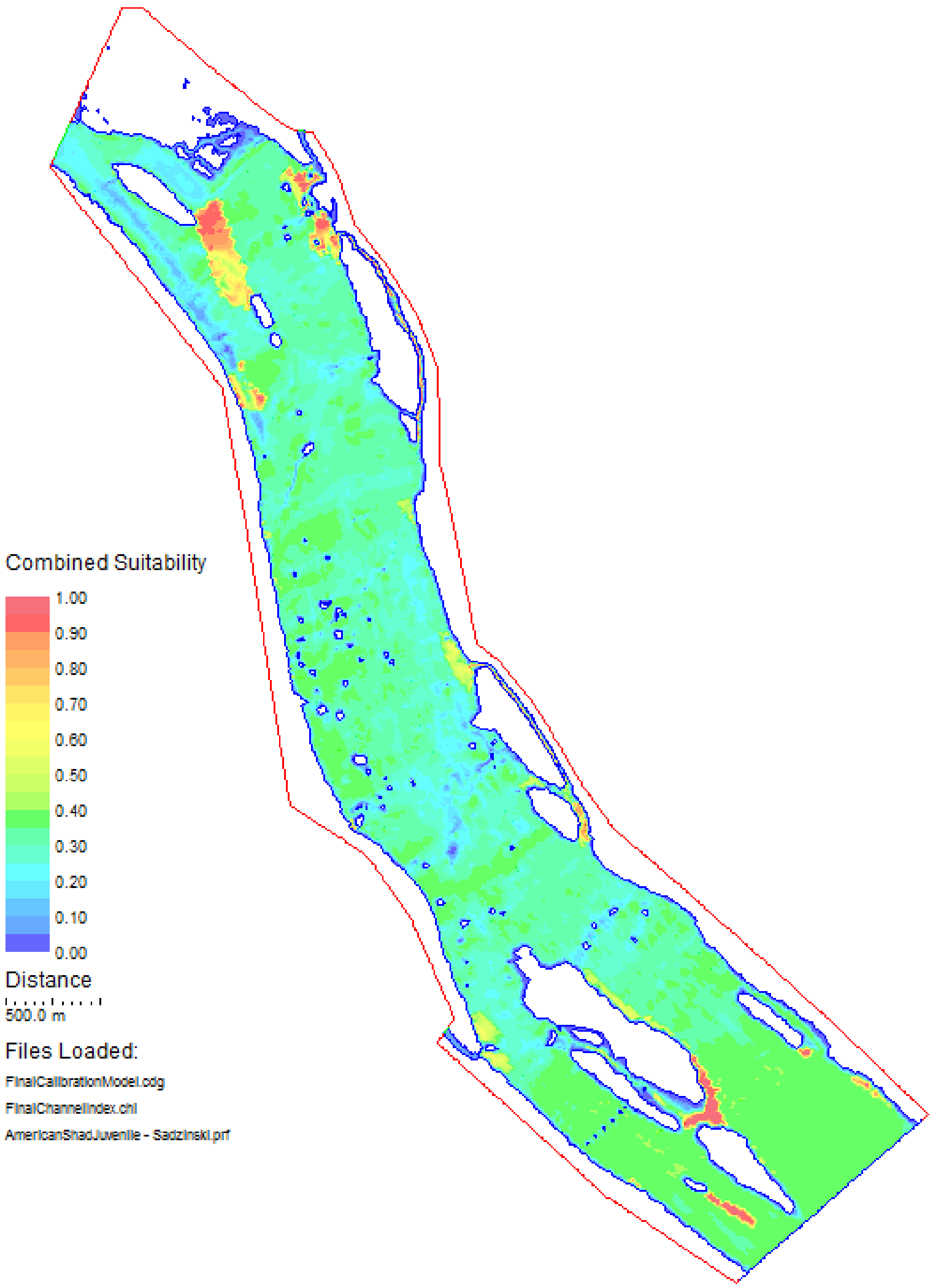
American Shad Juvenile – 7,500 cfs



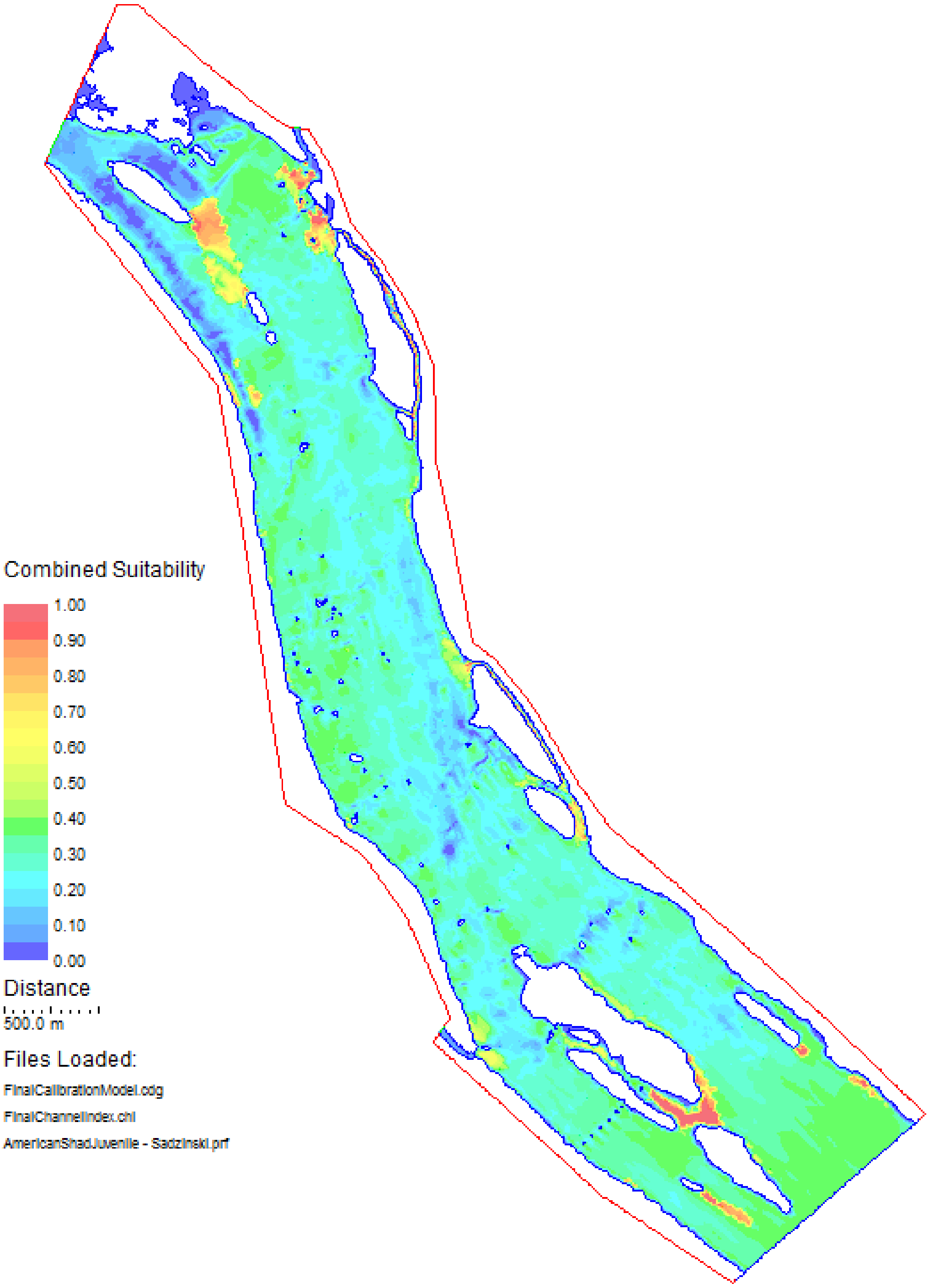
American Shad Juvenile – 10,000 cfs



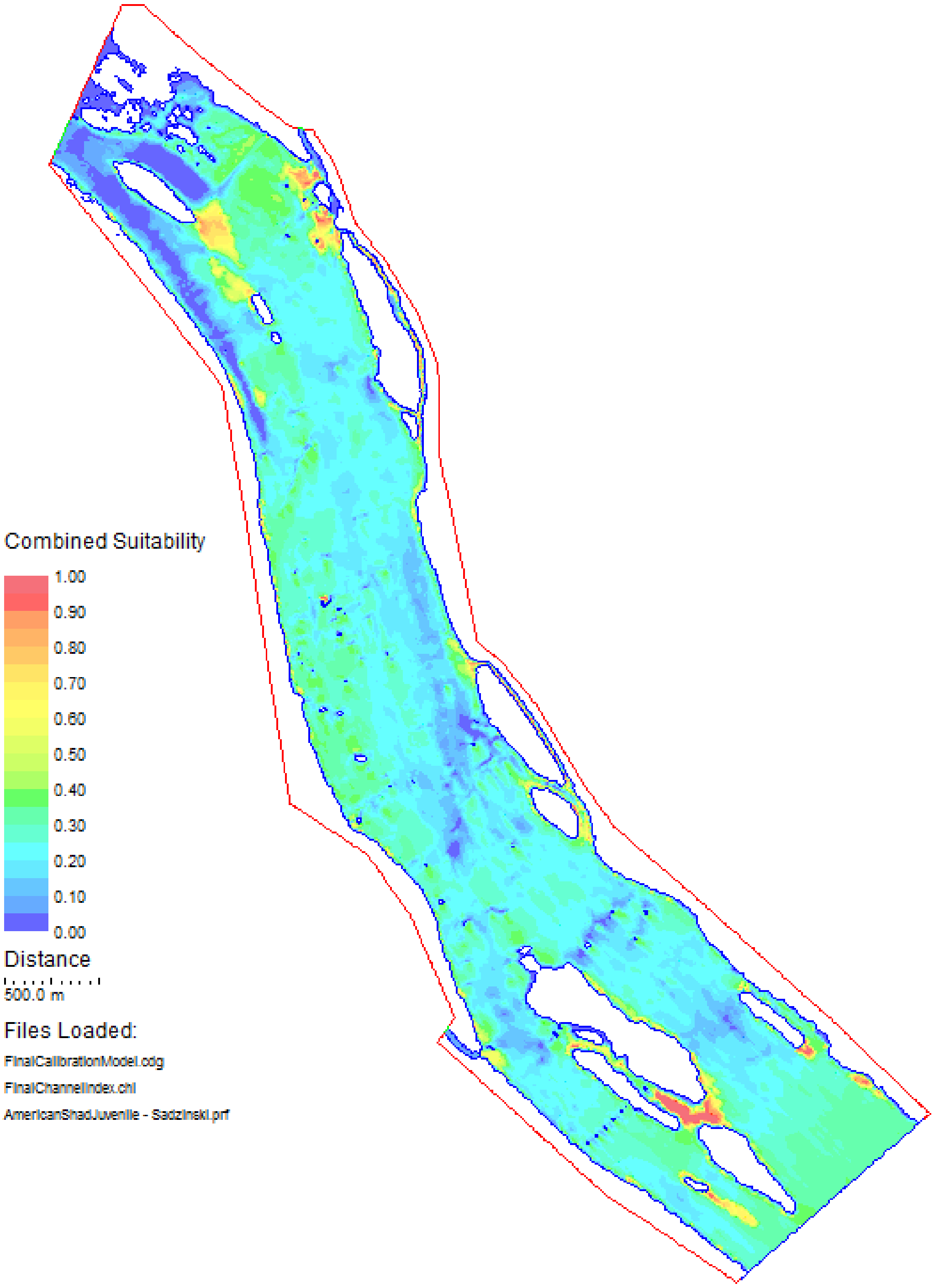
American Shad Juvenile – 15,000 cfs



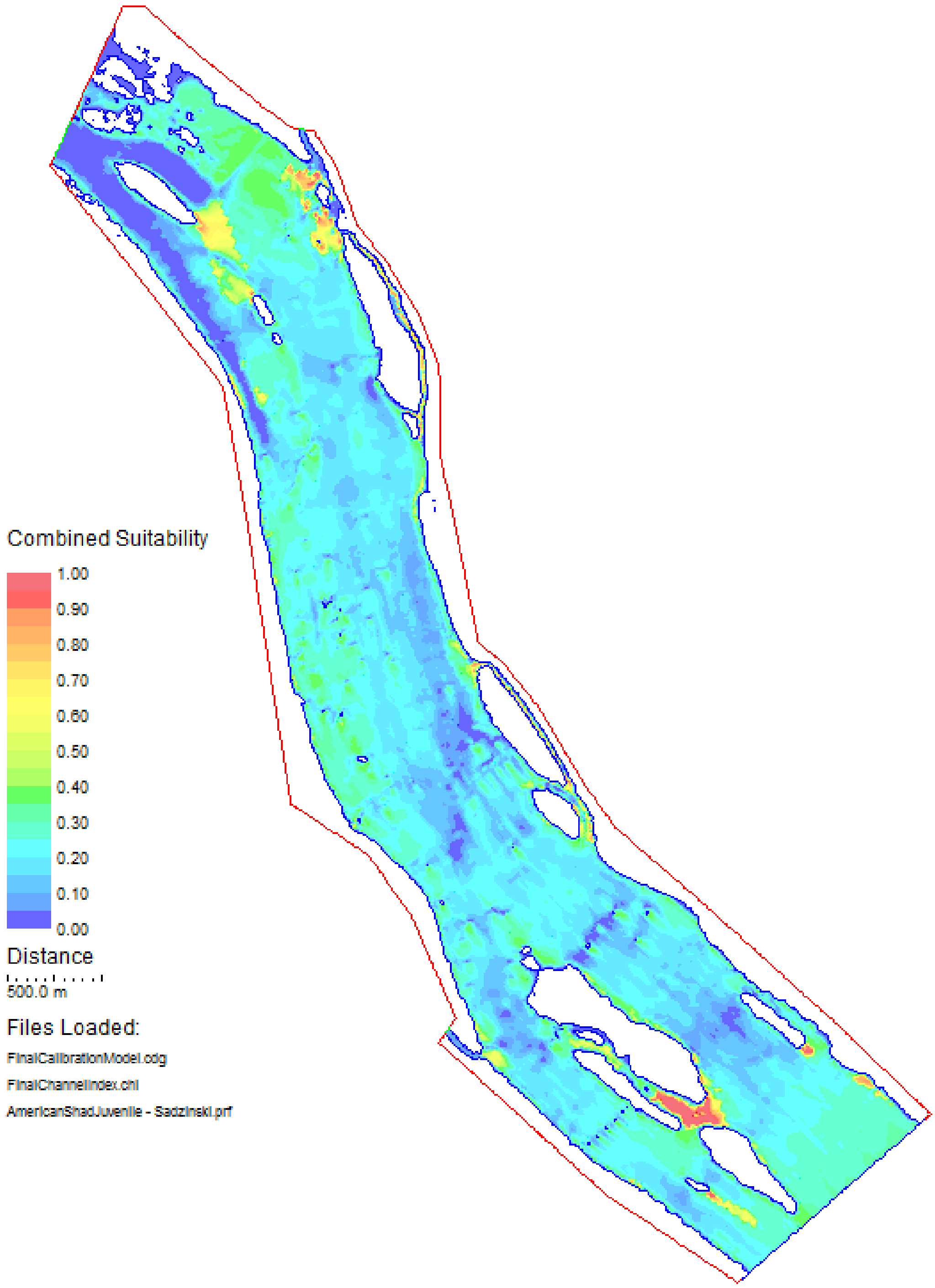
American Shad Juvenile – 20,000 cfs



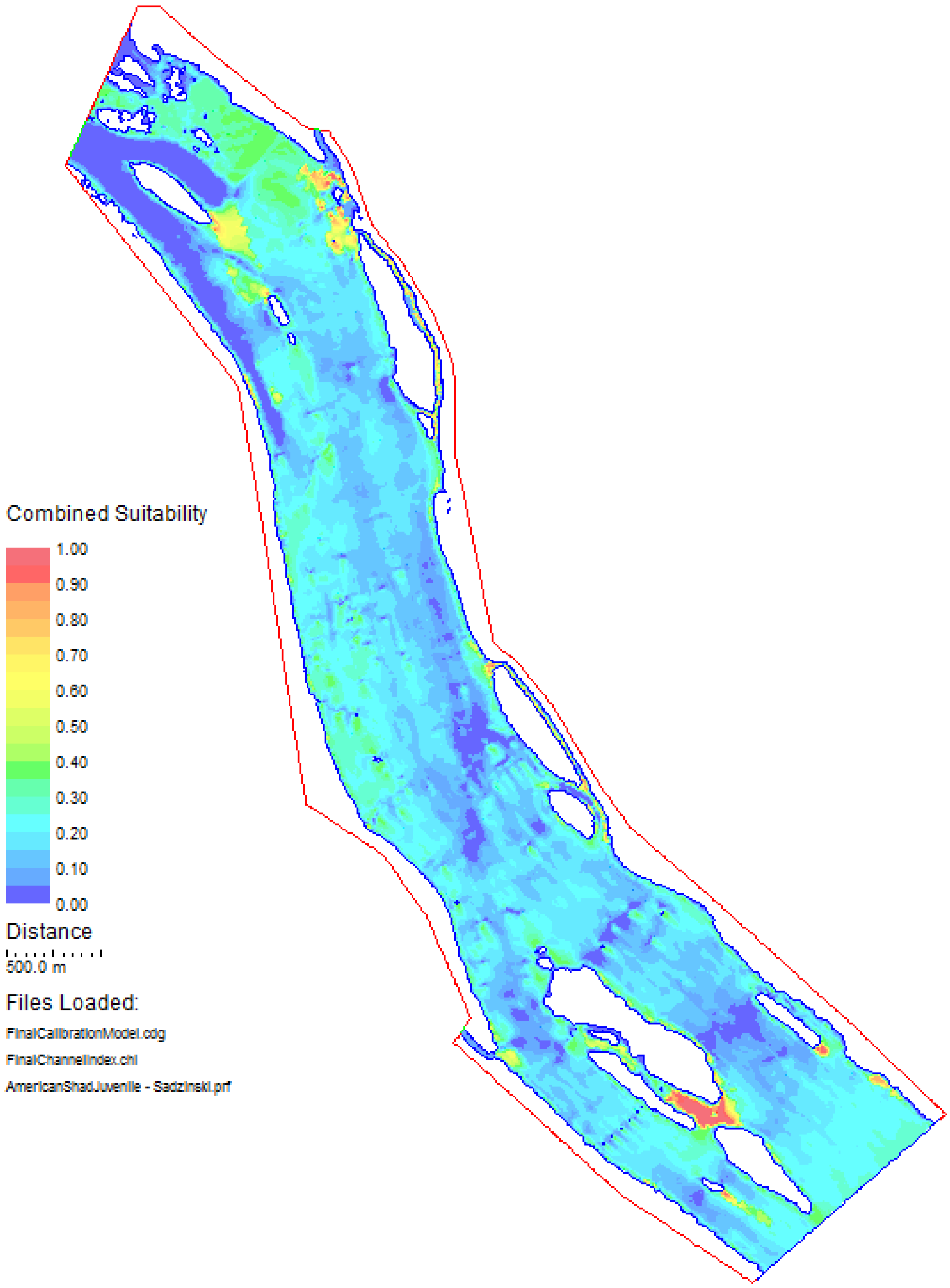
American Shad Juvenile – 30,000 cfs



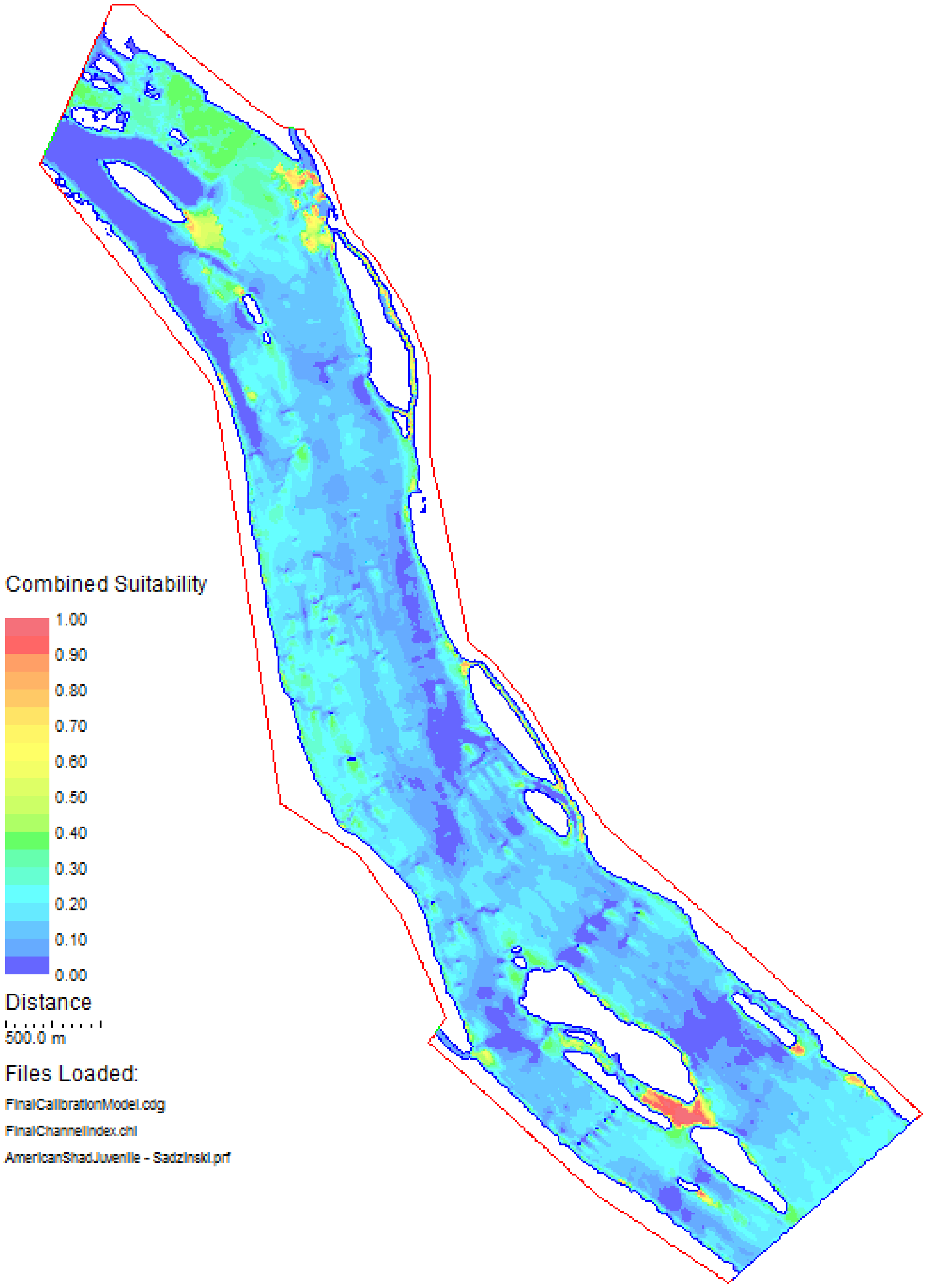
American Shad Juvenile – 40,000 cfs



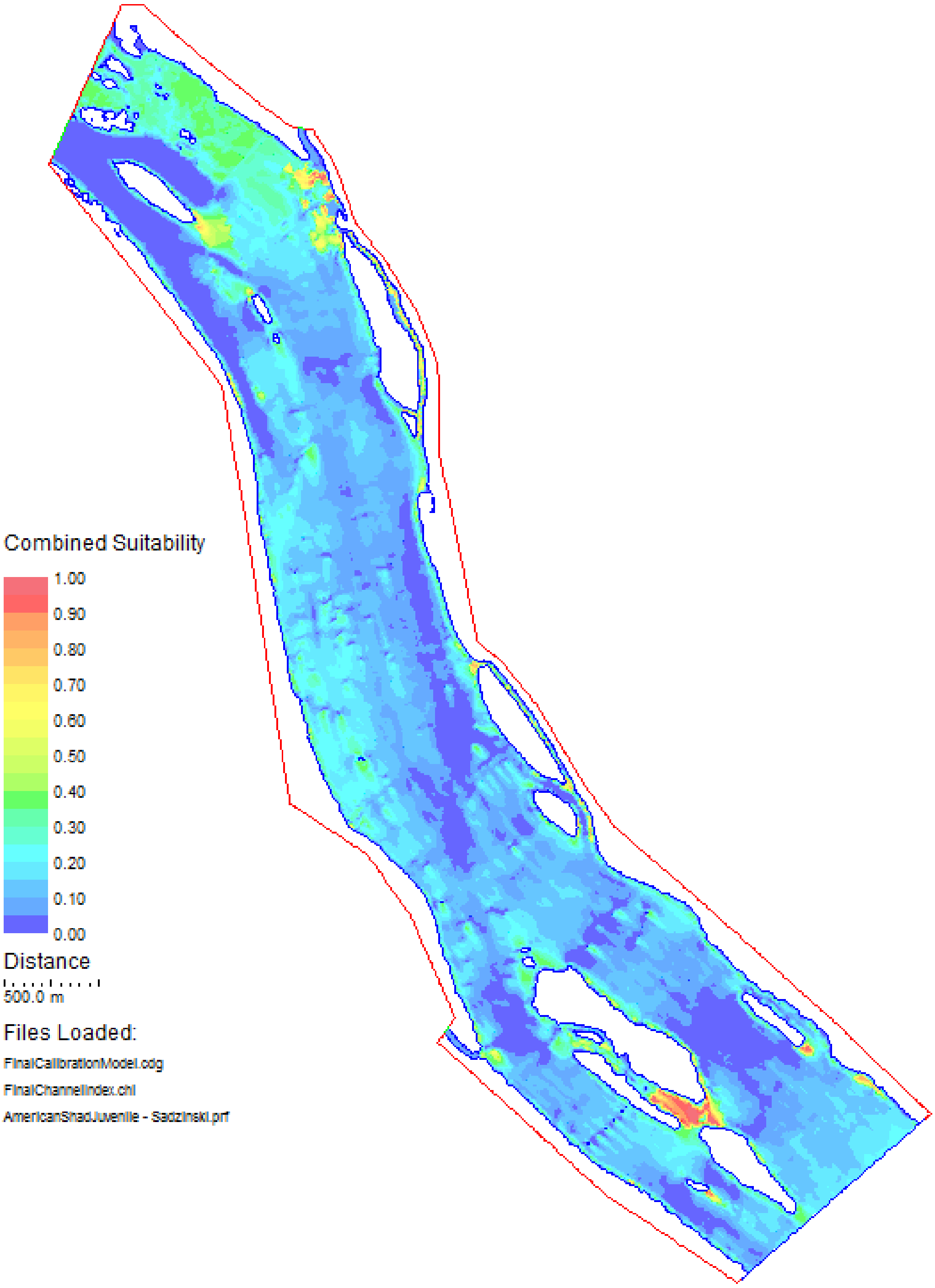
American Shad Juvenile – 50,000 cfs



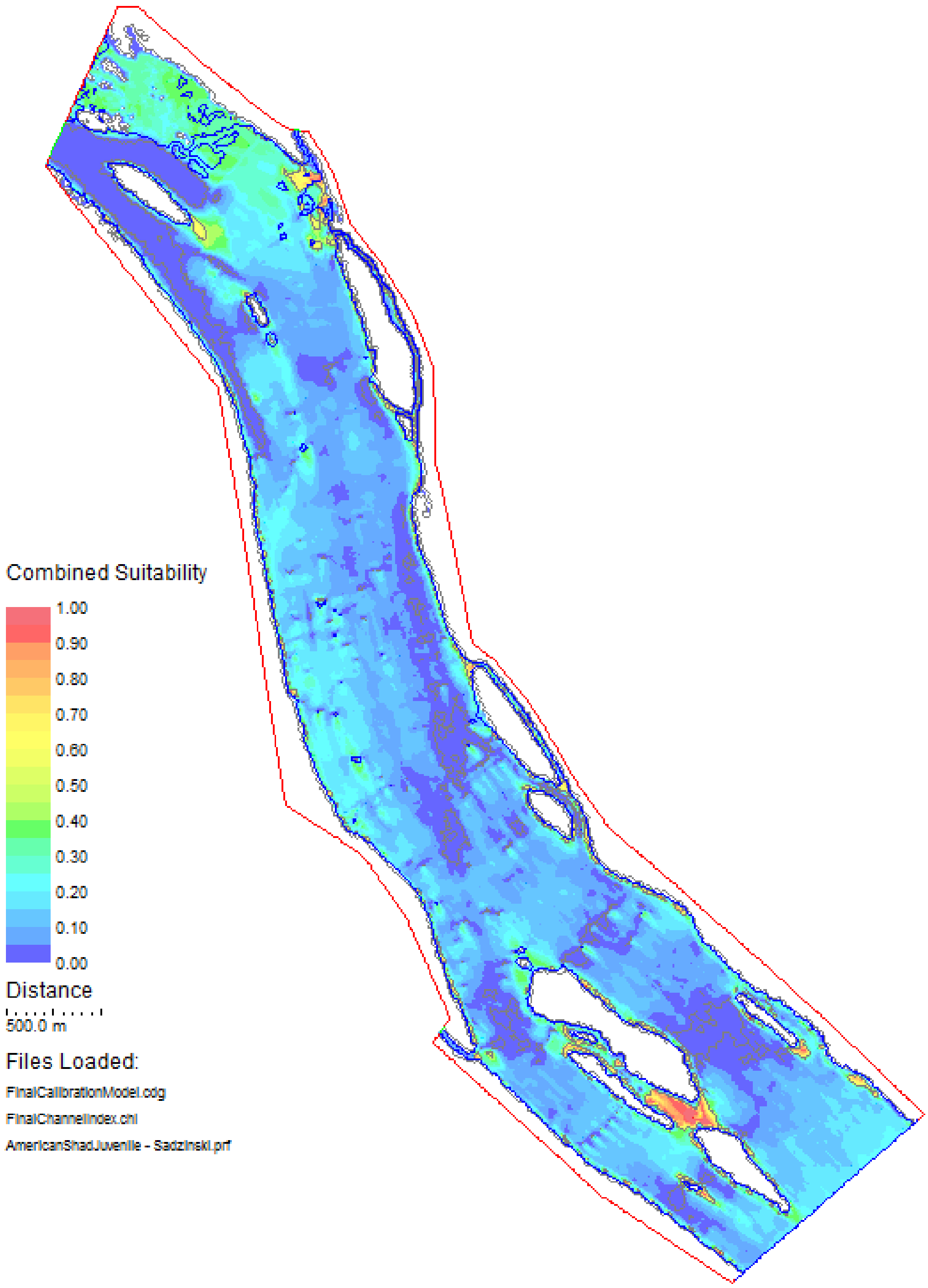
American Shad Juvenile – 60,000 cfs



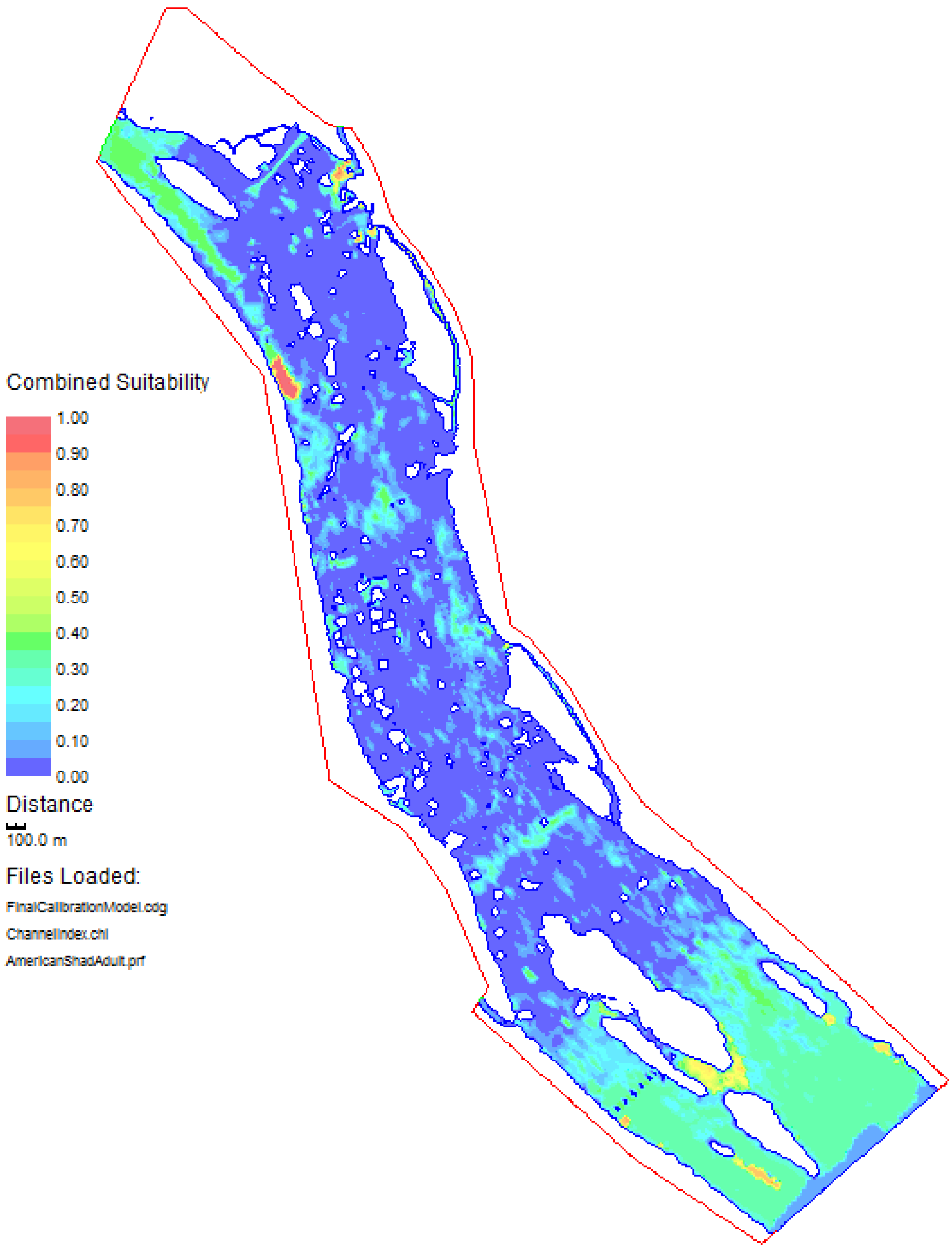
American Shad Juvenile – 70,000 cfs



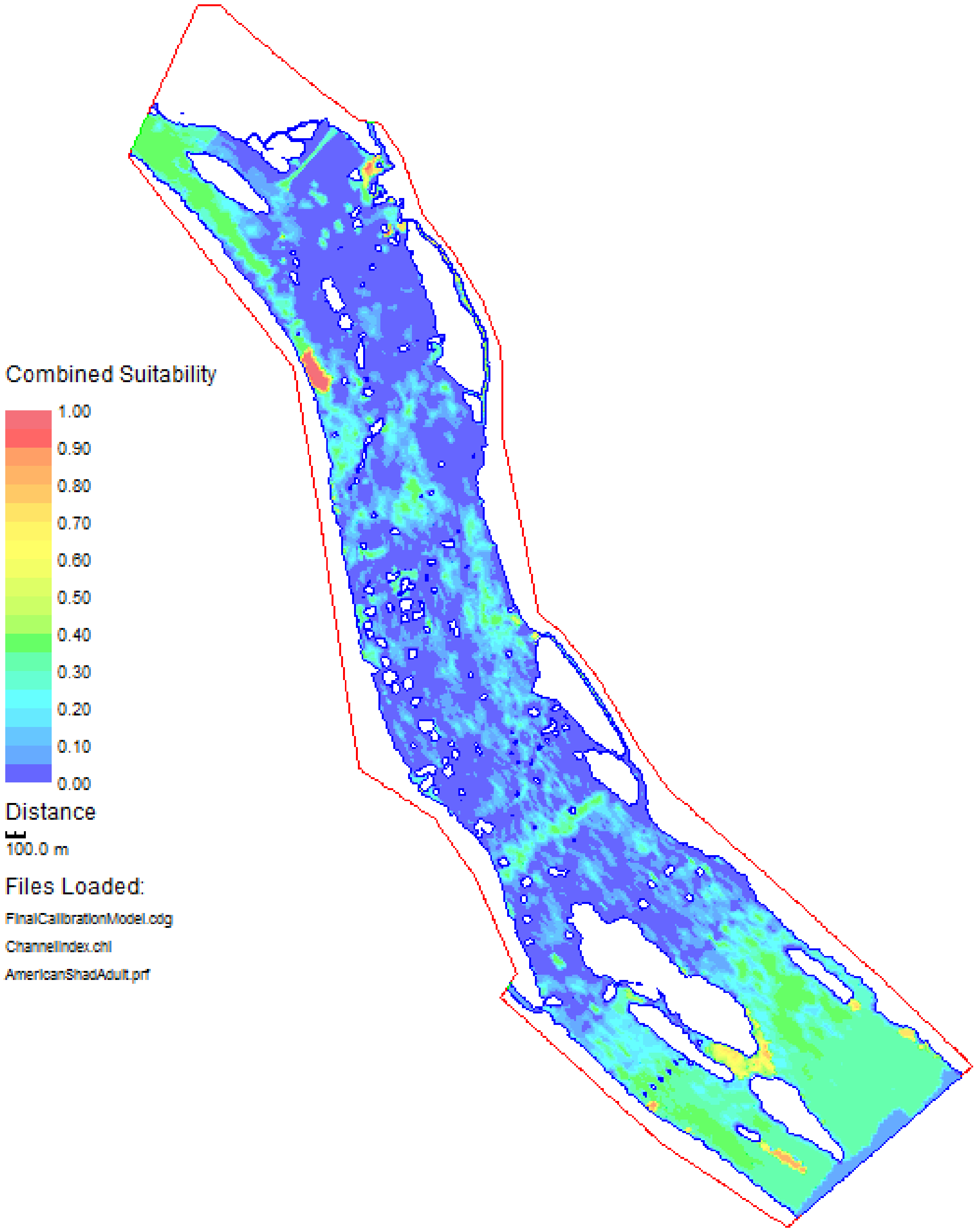
American Shad Juvenile – 80,000 cfs



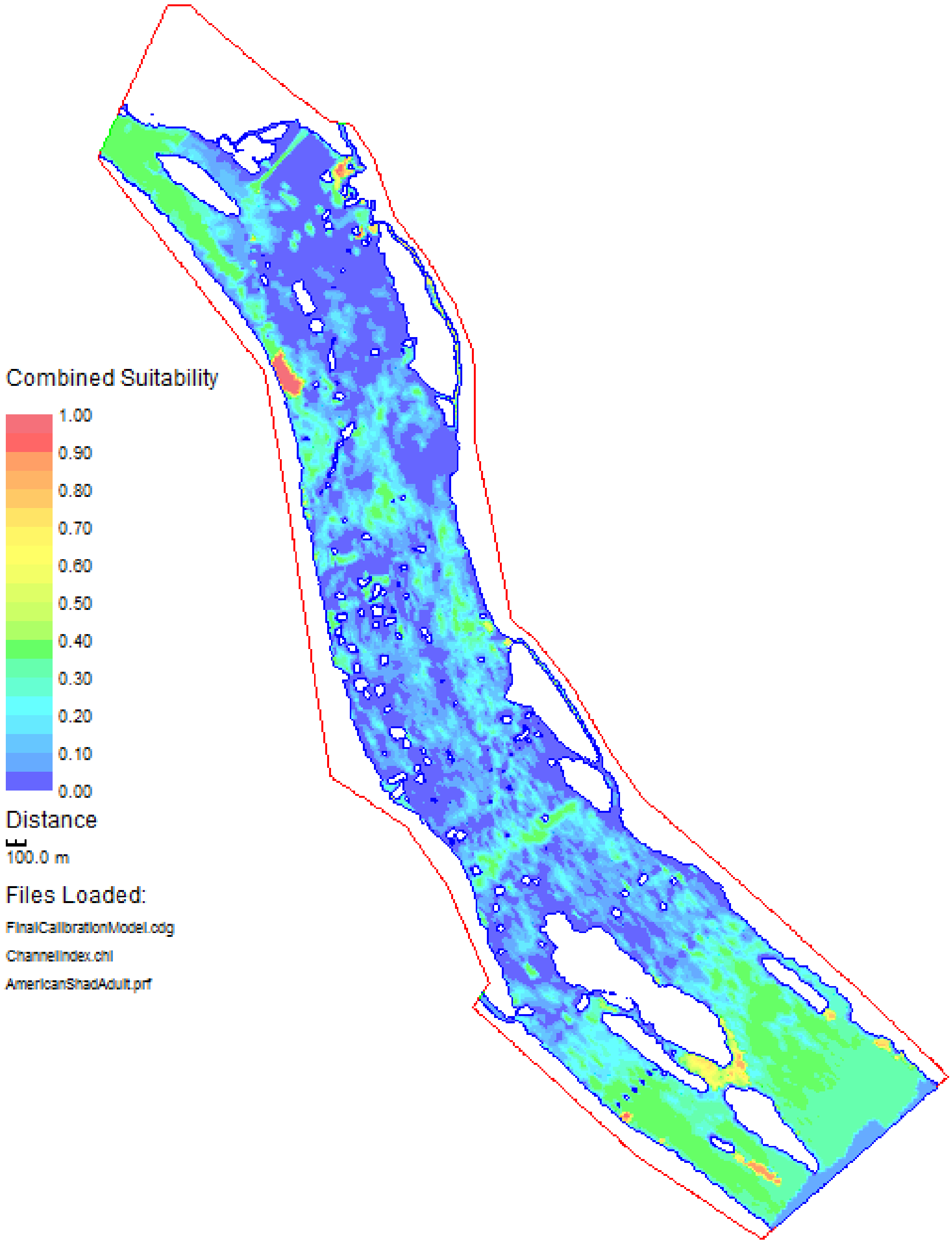
American Shad Juvenile – 86,000 cfs



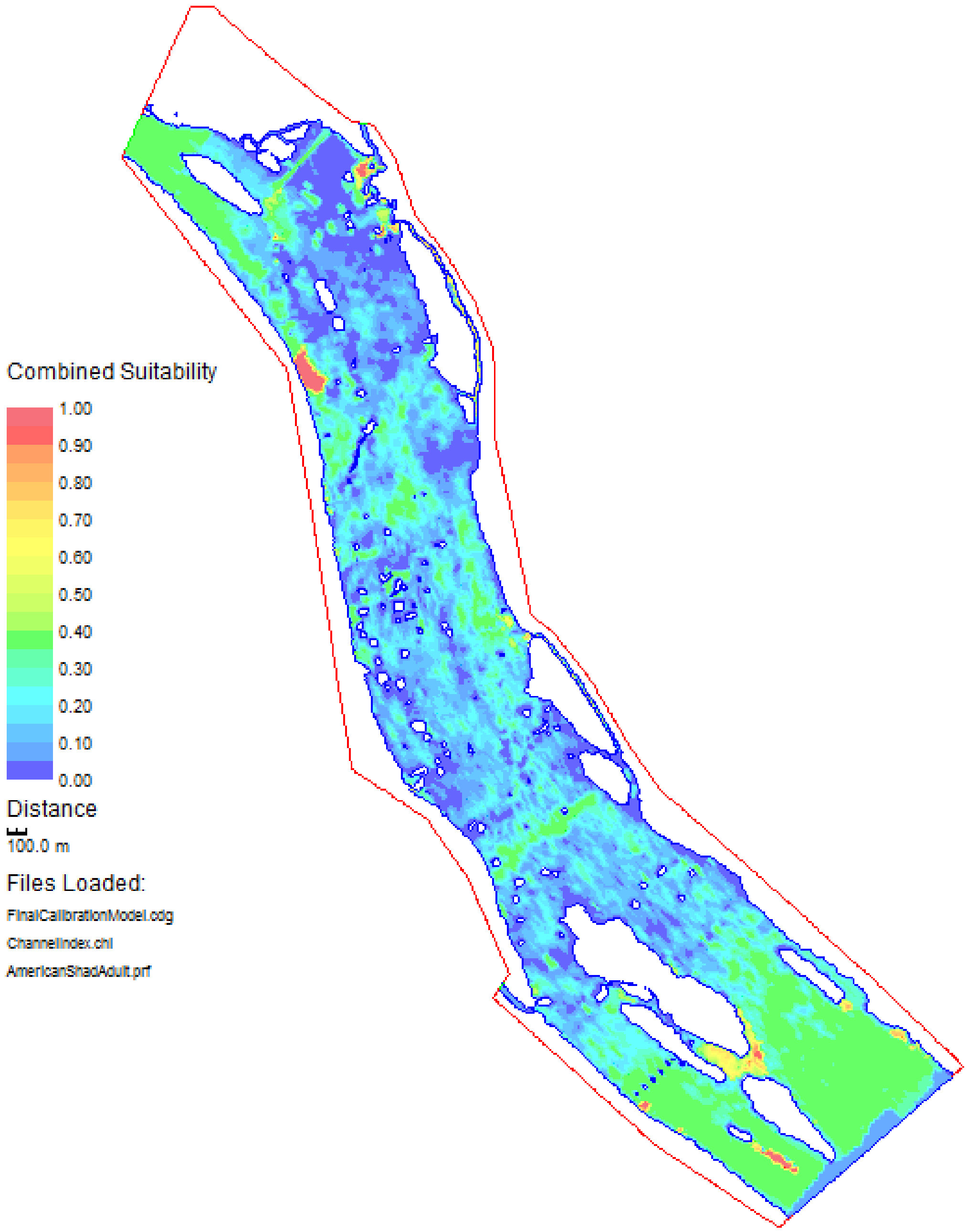
American Shad Adult – 2,000 cfs



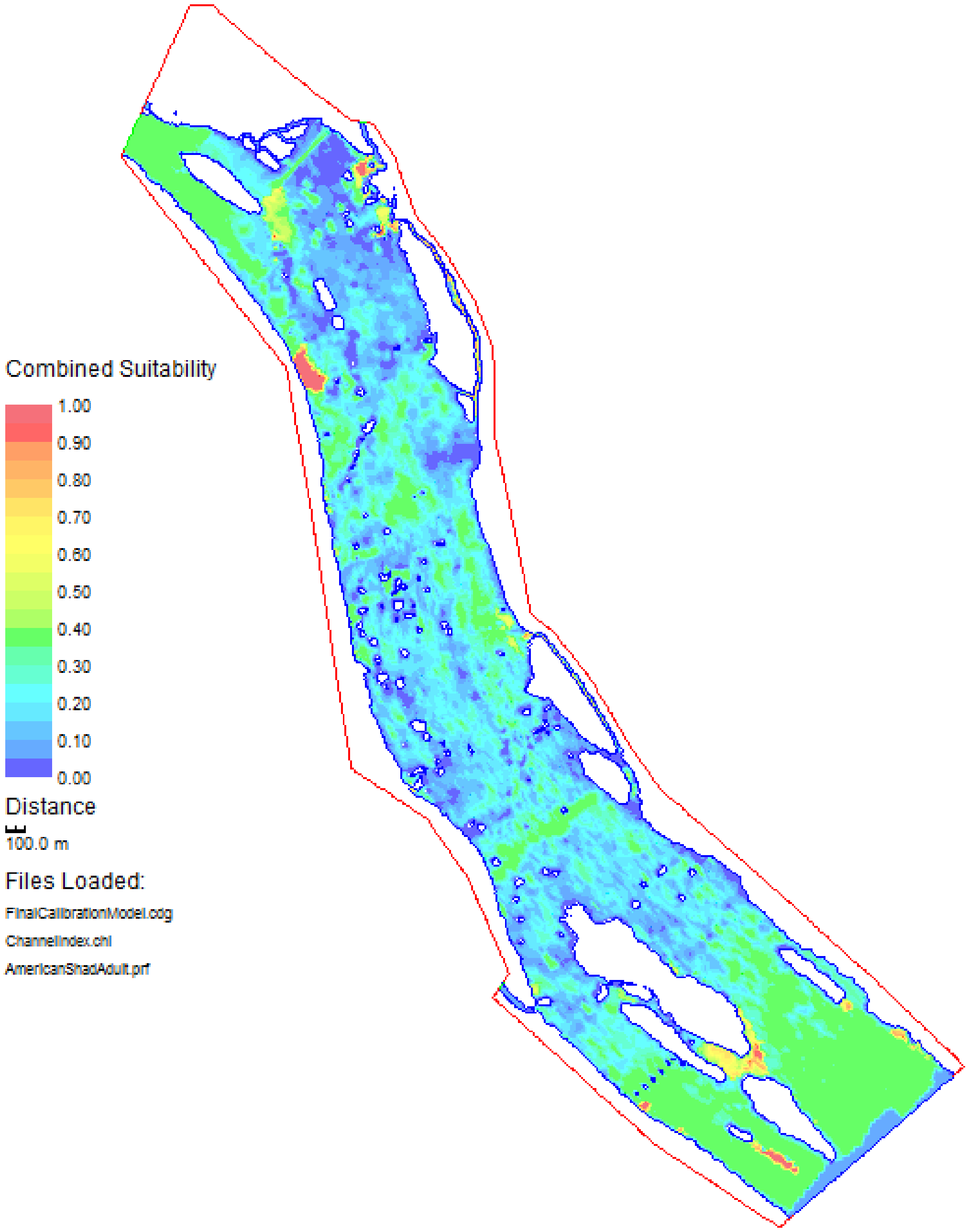
American Shad Adult – 3,500 cfs



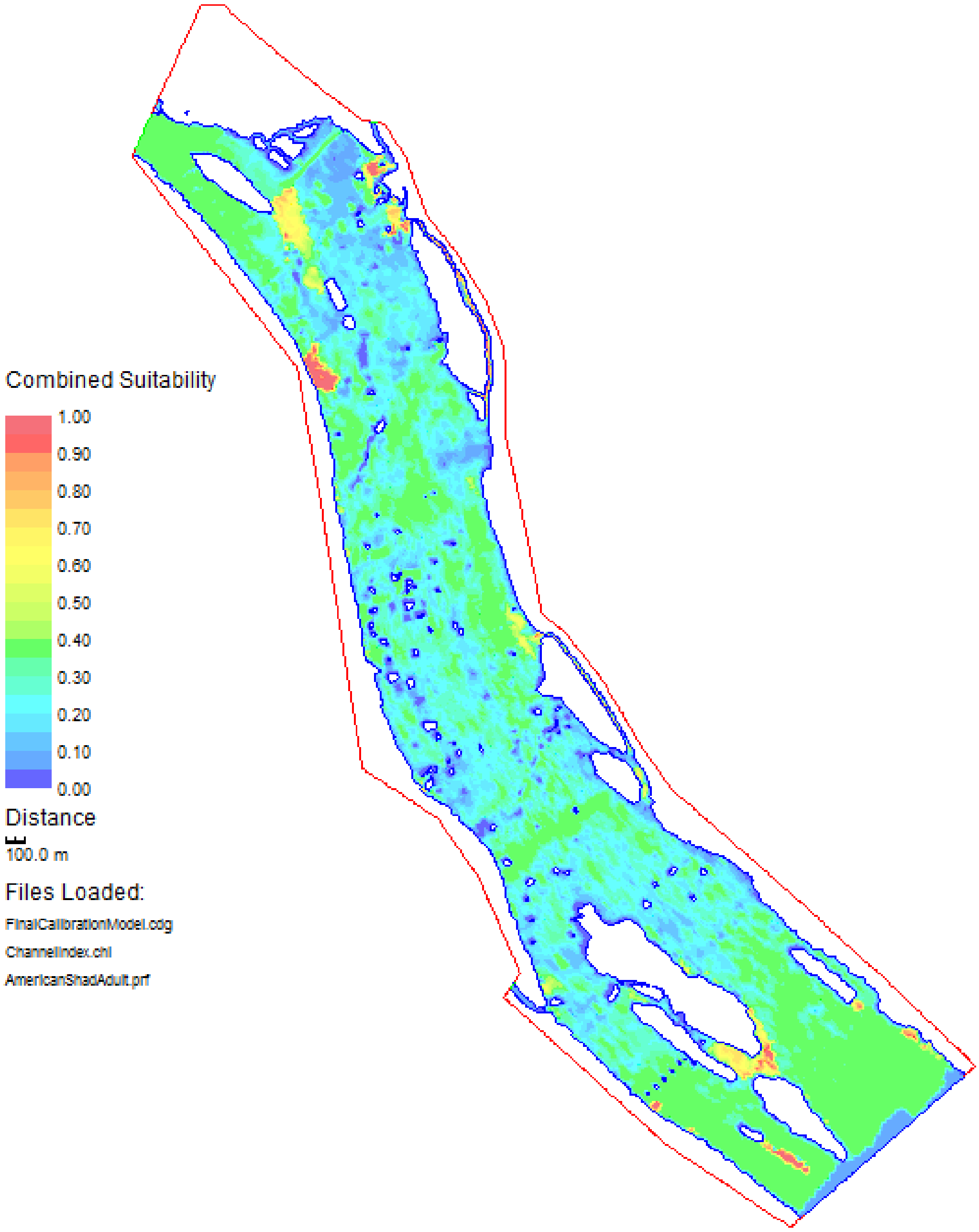
American Shad Adult – 5,000 cfs



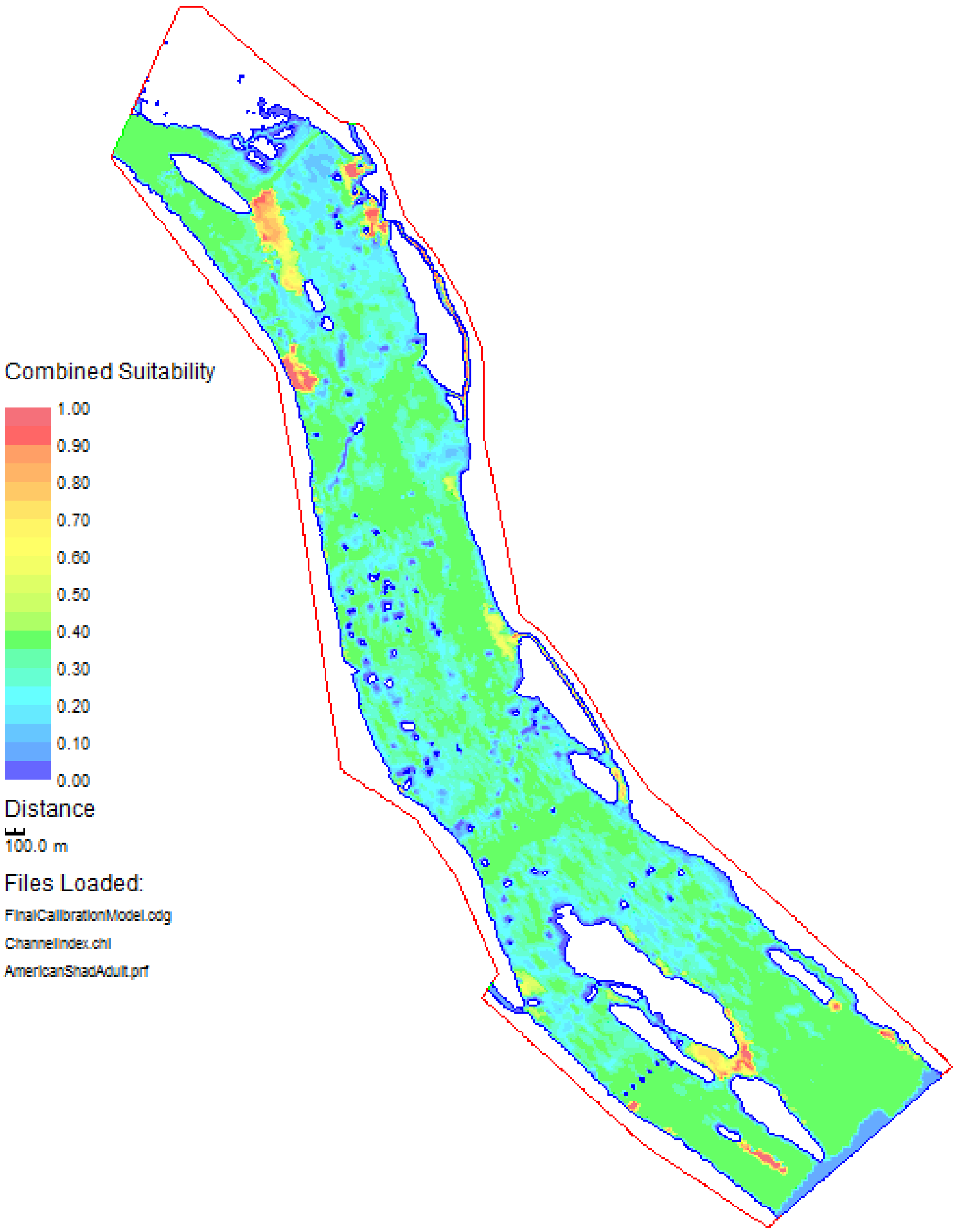
American Shad Adult – 7,500 cfs



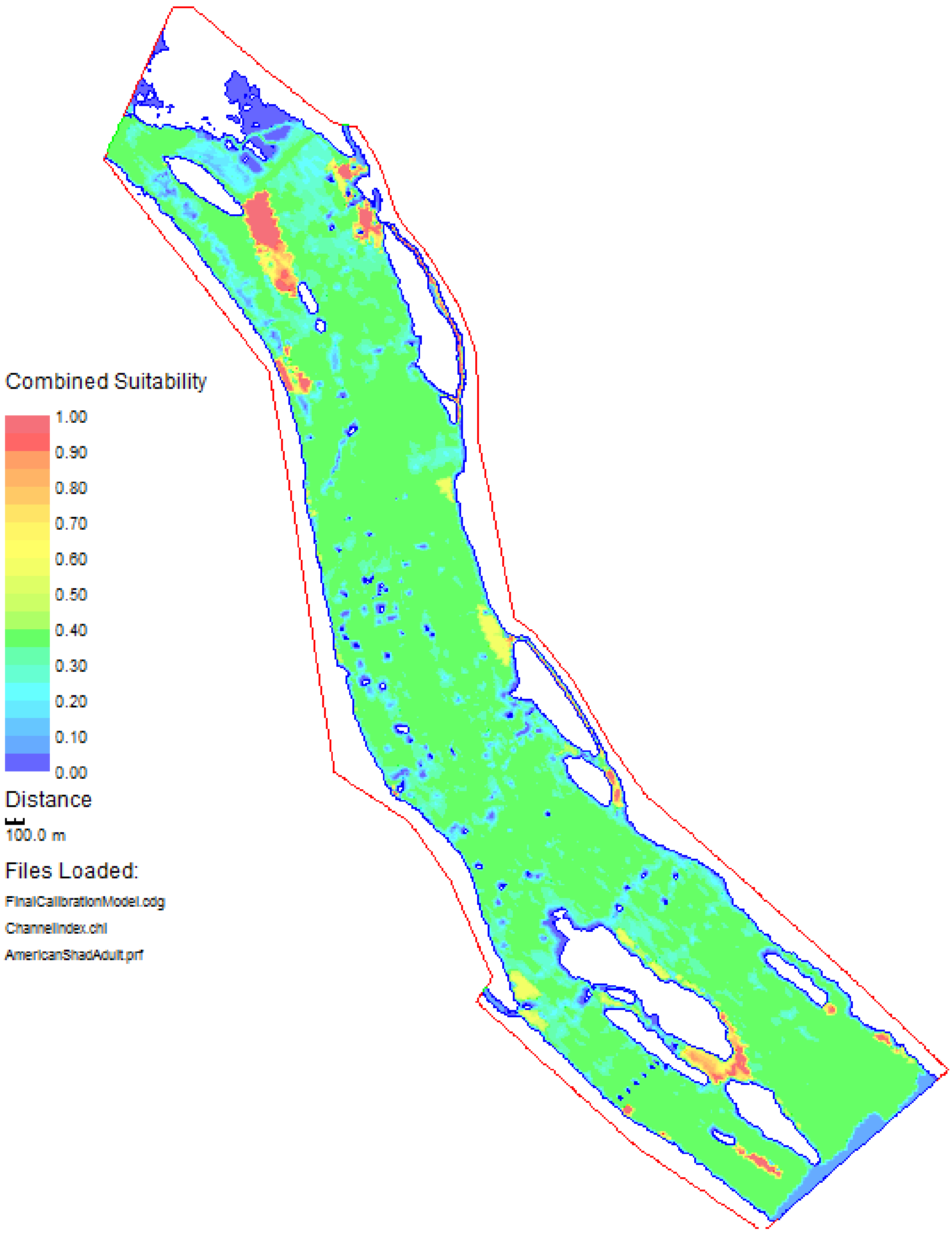
American Shad Adult – 10,000 cfs



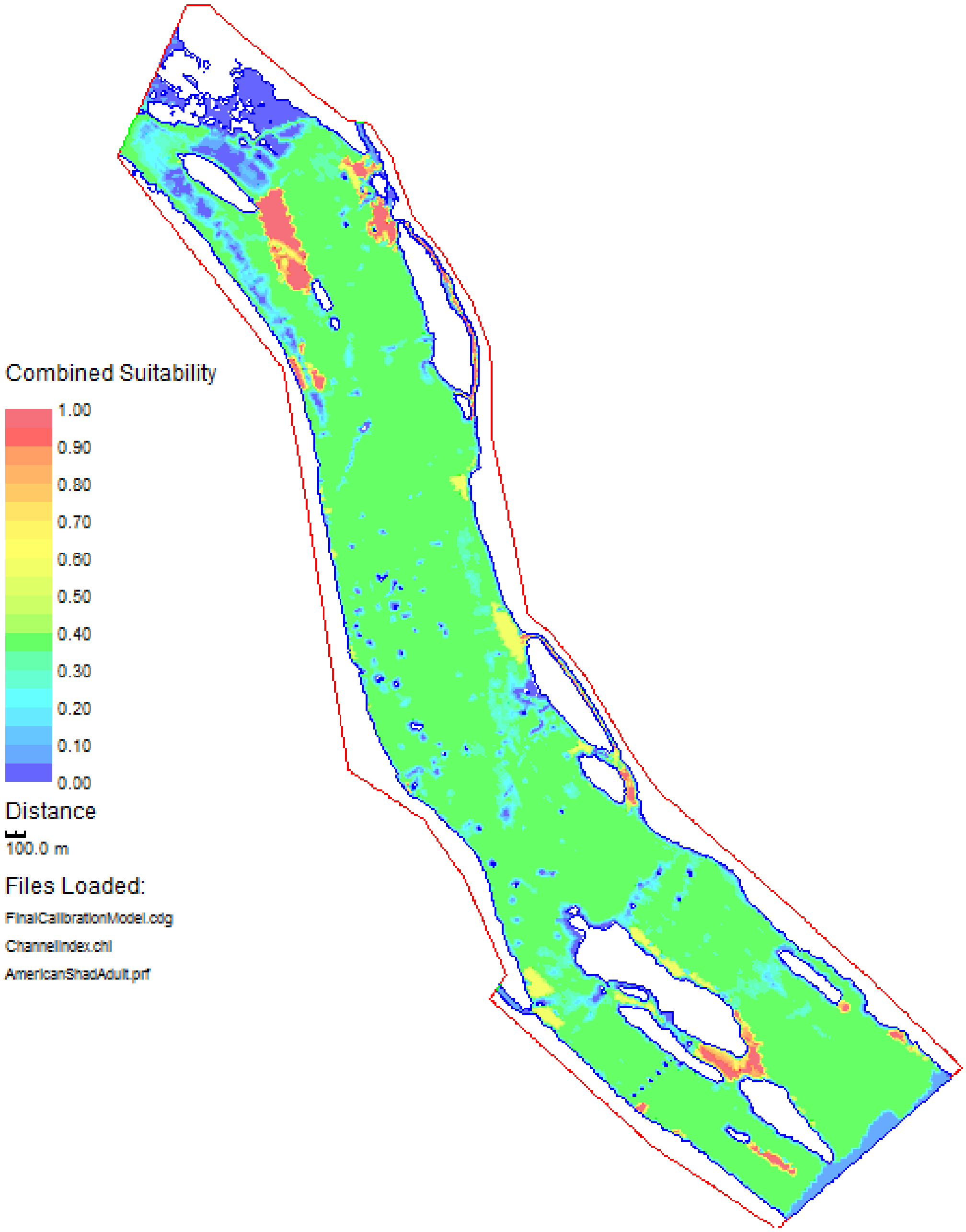
American Shad Adult – 15,000 cfs



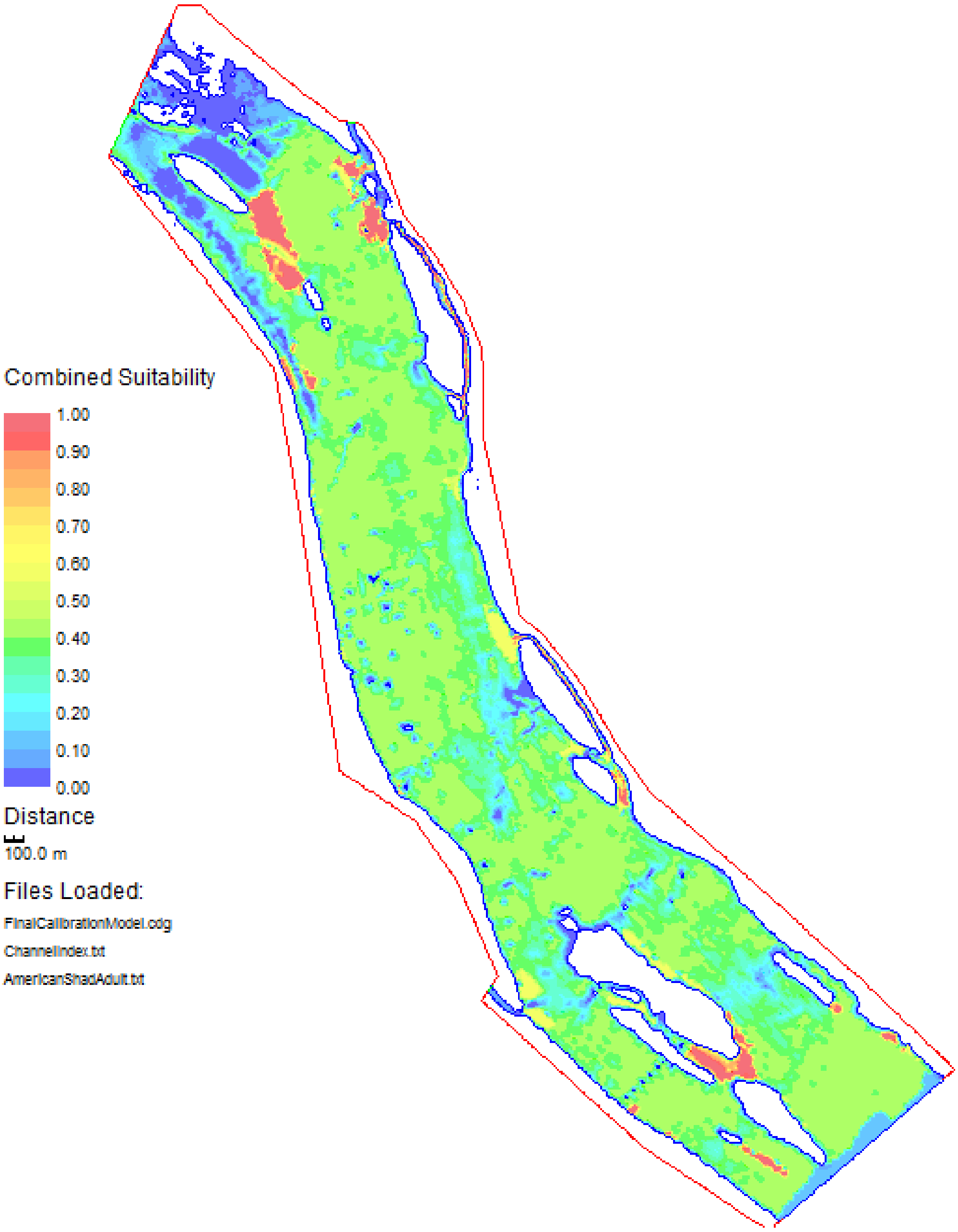
American Shad Adult – 20,000 cfs



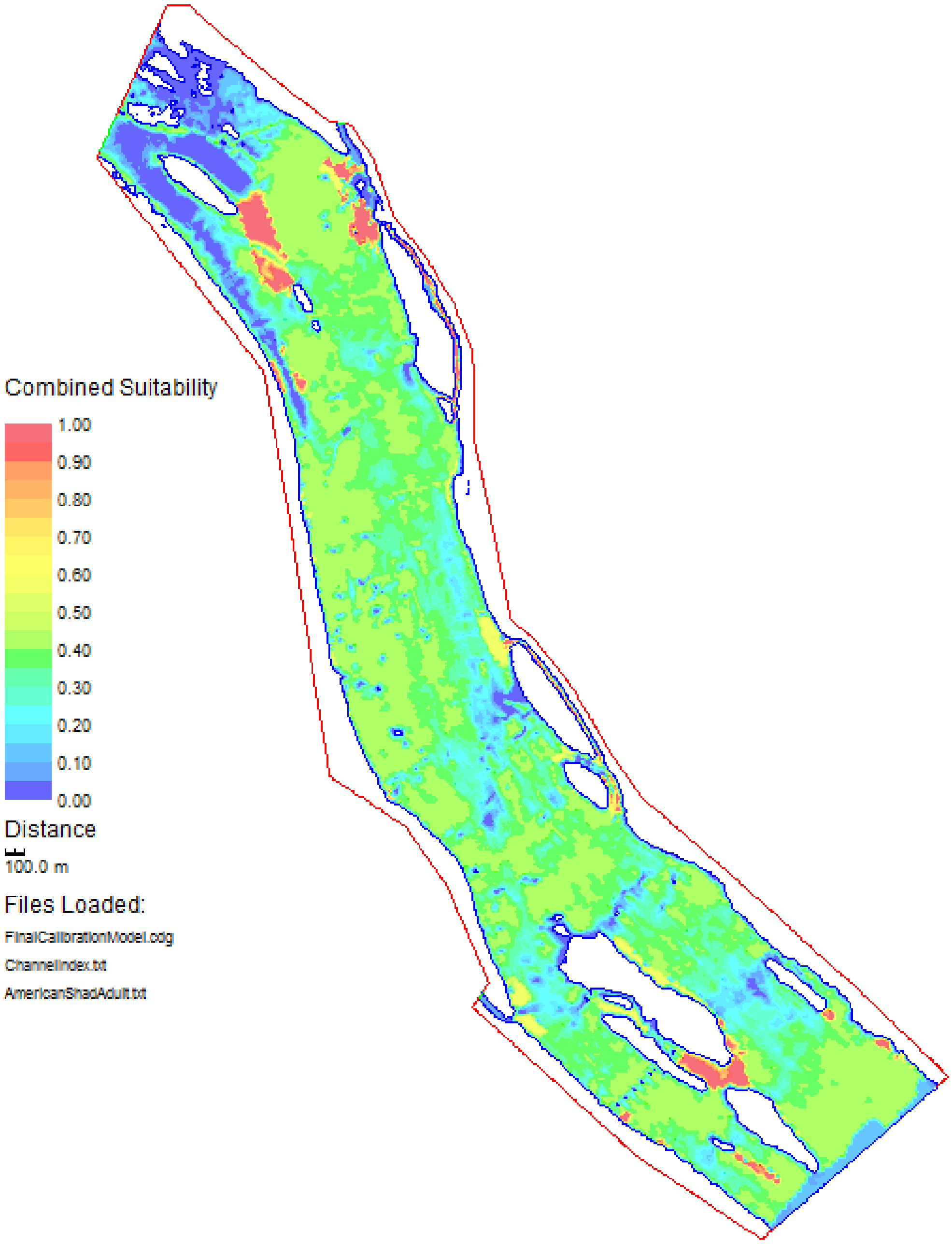
American Shad Adult – 30,000 cfs



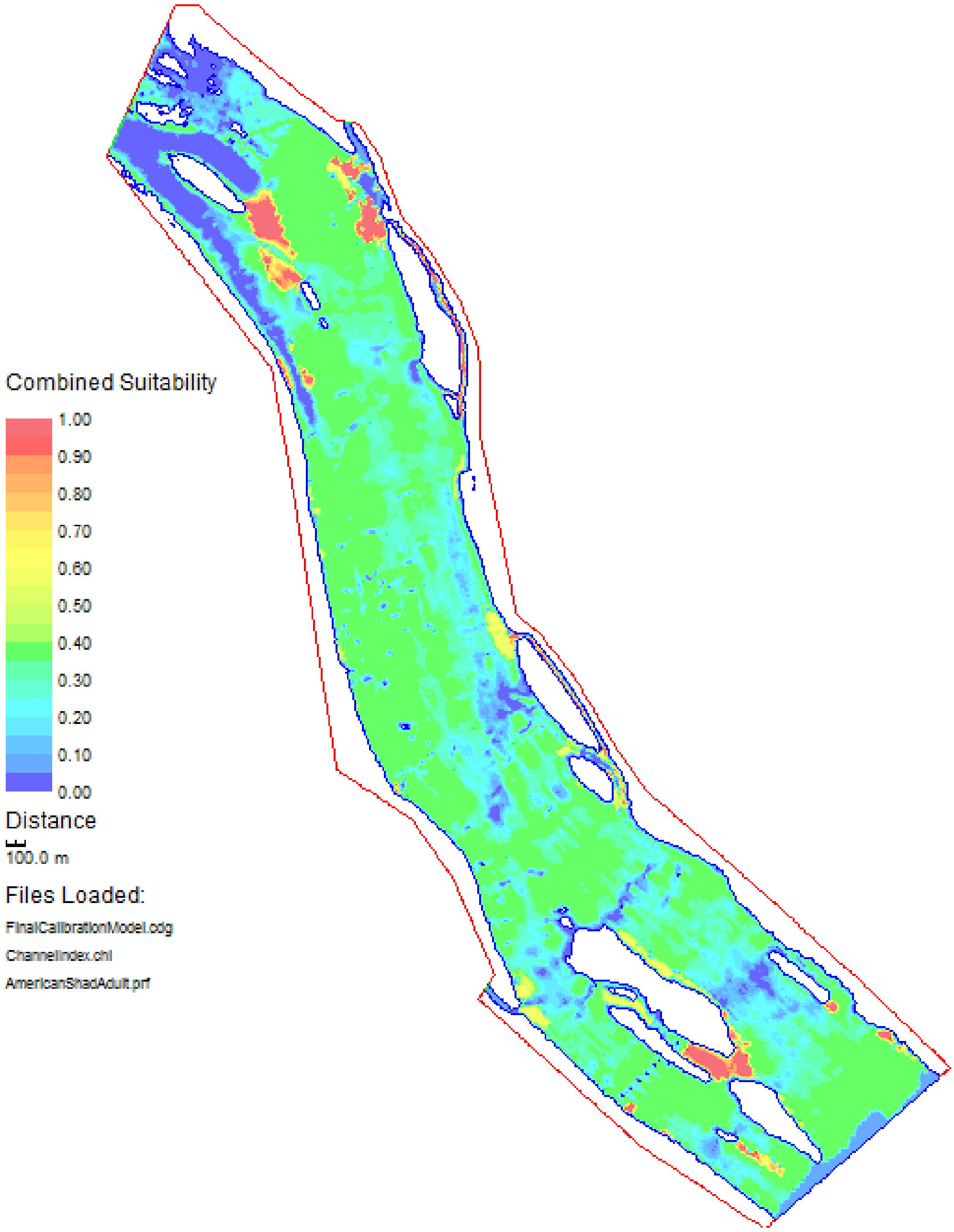
American Shad Adult – 40,000 cfs



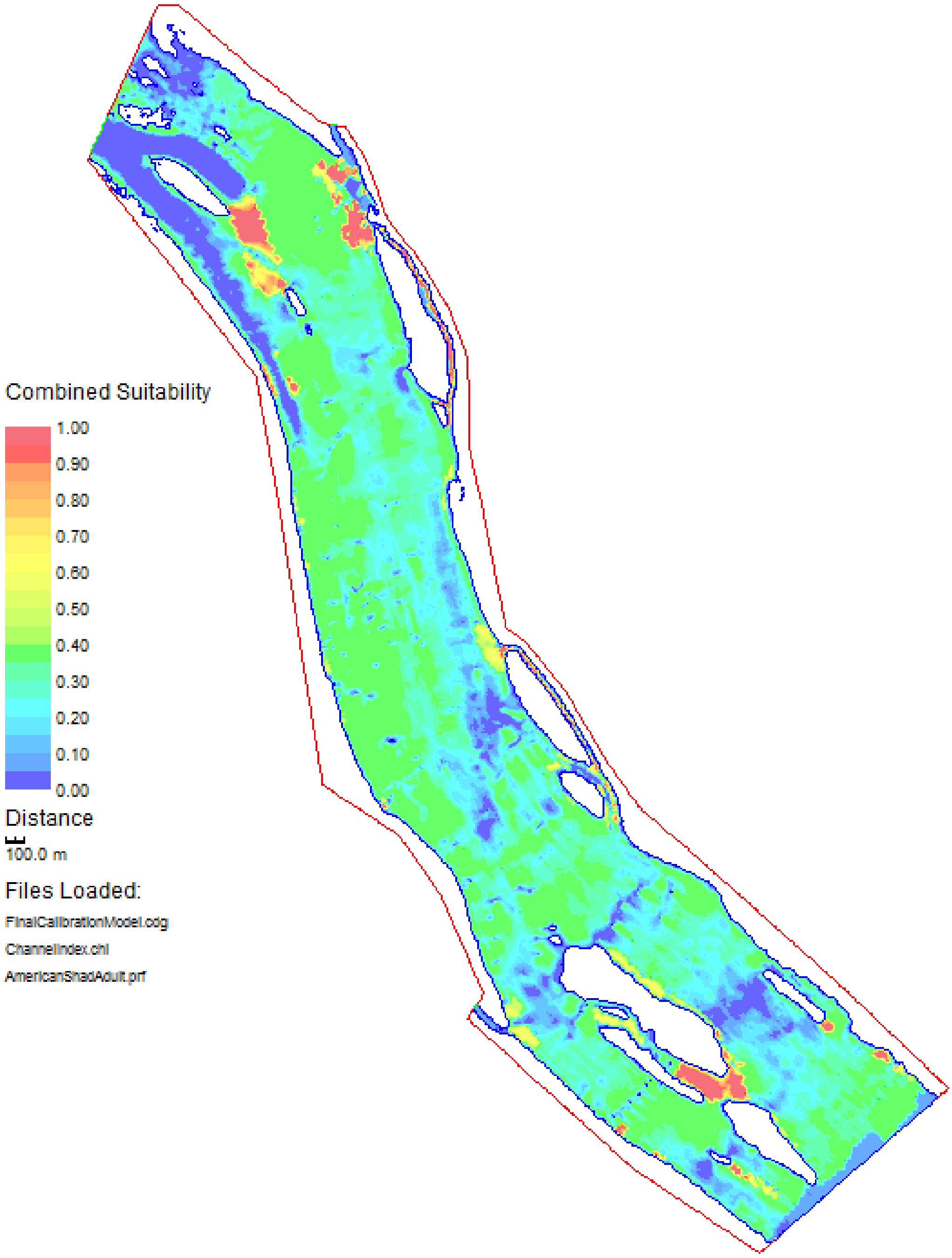
American Shad Adult – 50,000 cfs



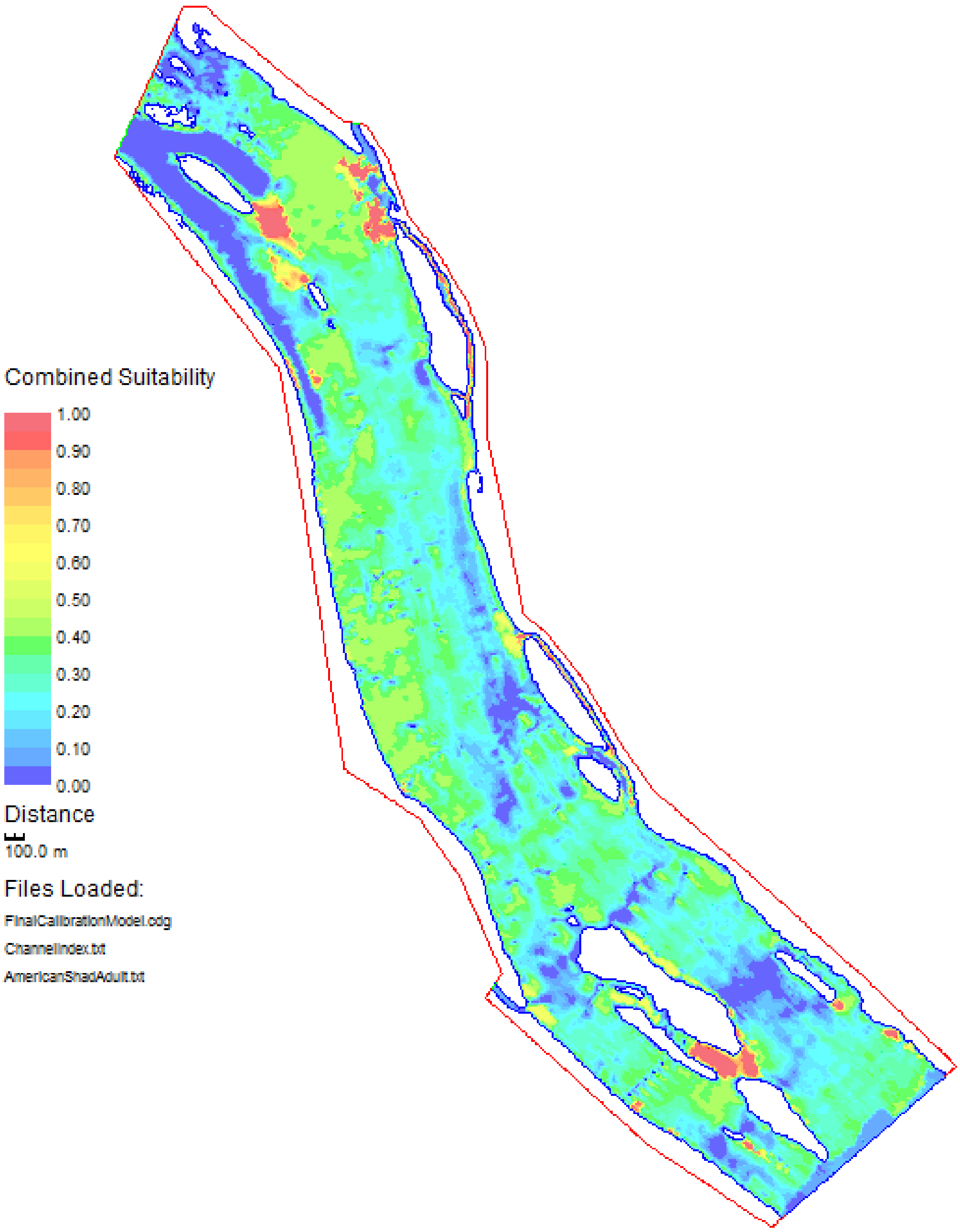
American Shad Adult – 60,000 cfs



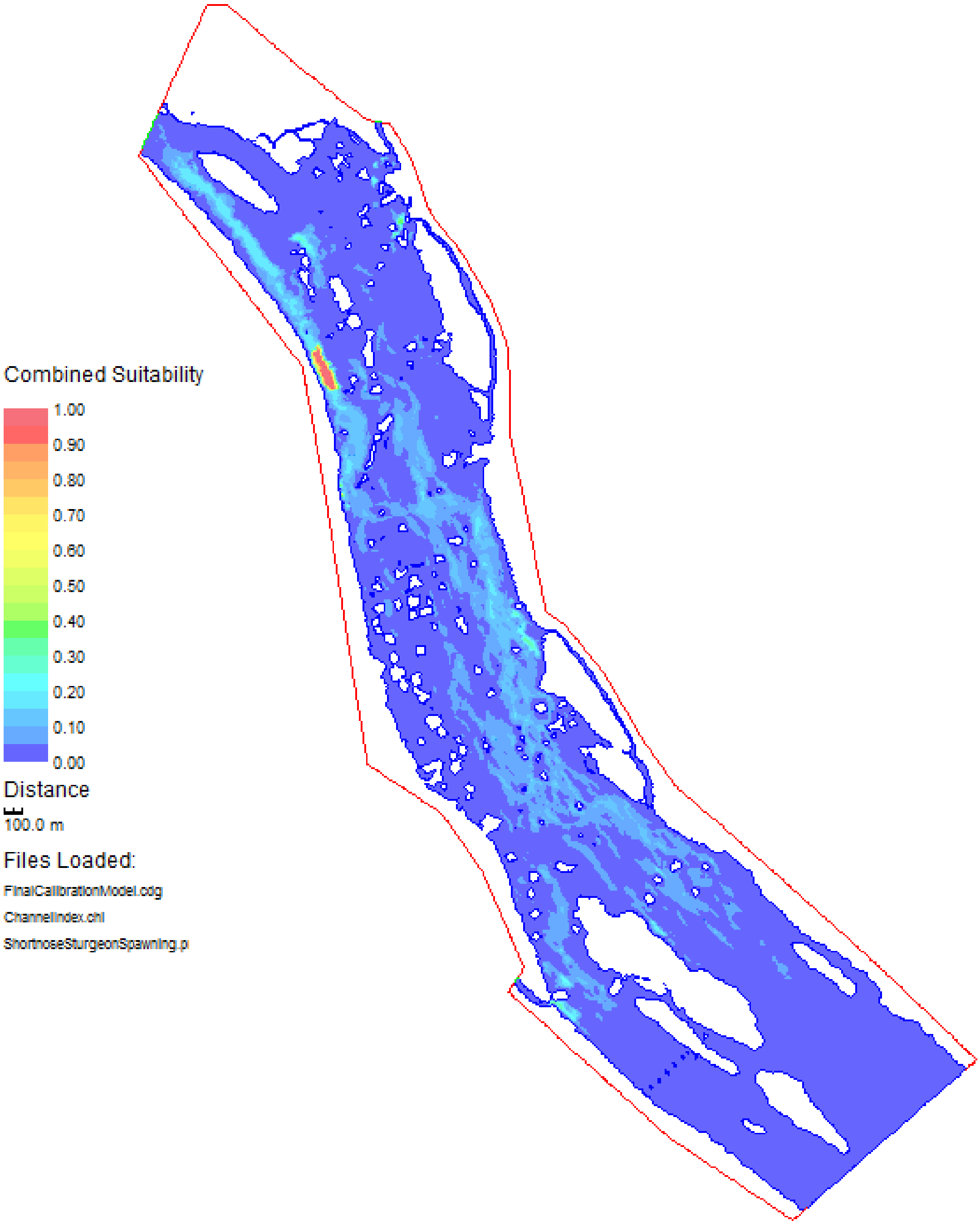
American Shad Adult – 70,000 cfs



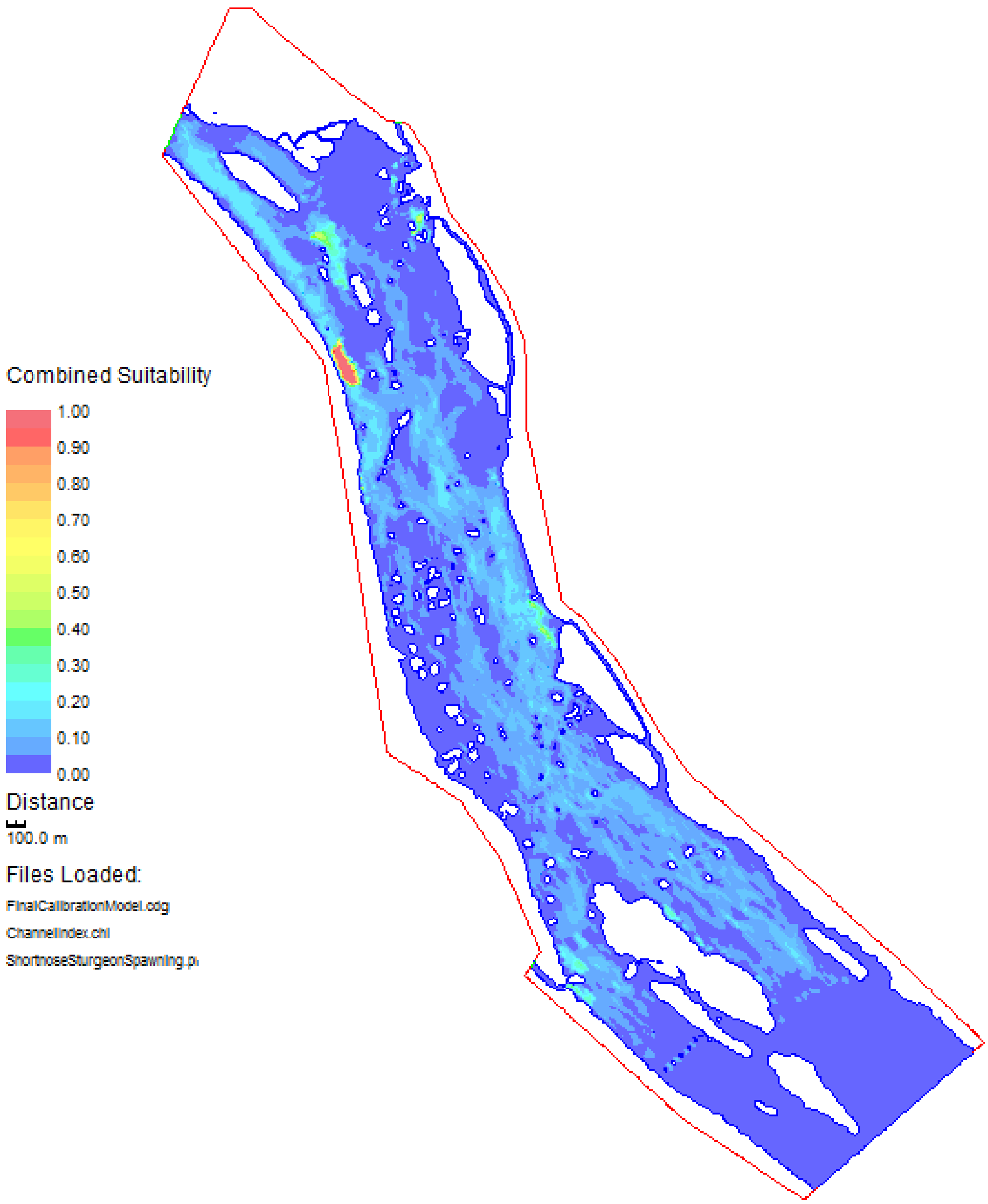
American Shad Adult – 80,000 cfs



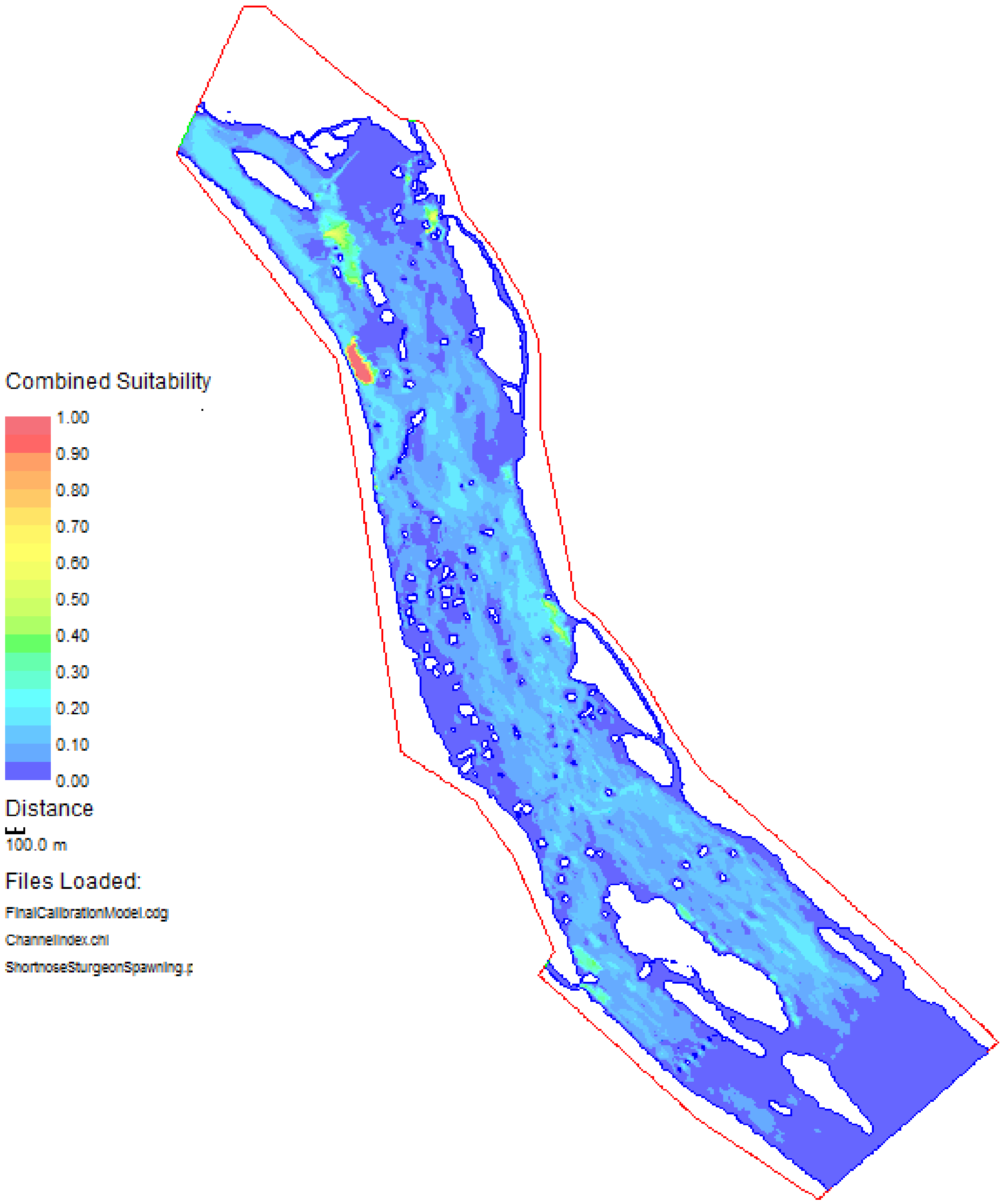
American Shad Adult – 86,000 cfs



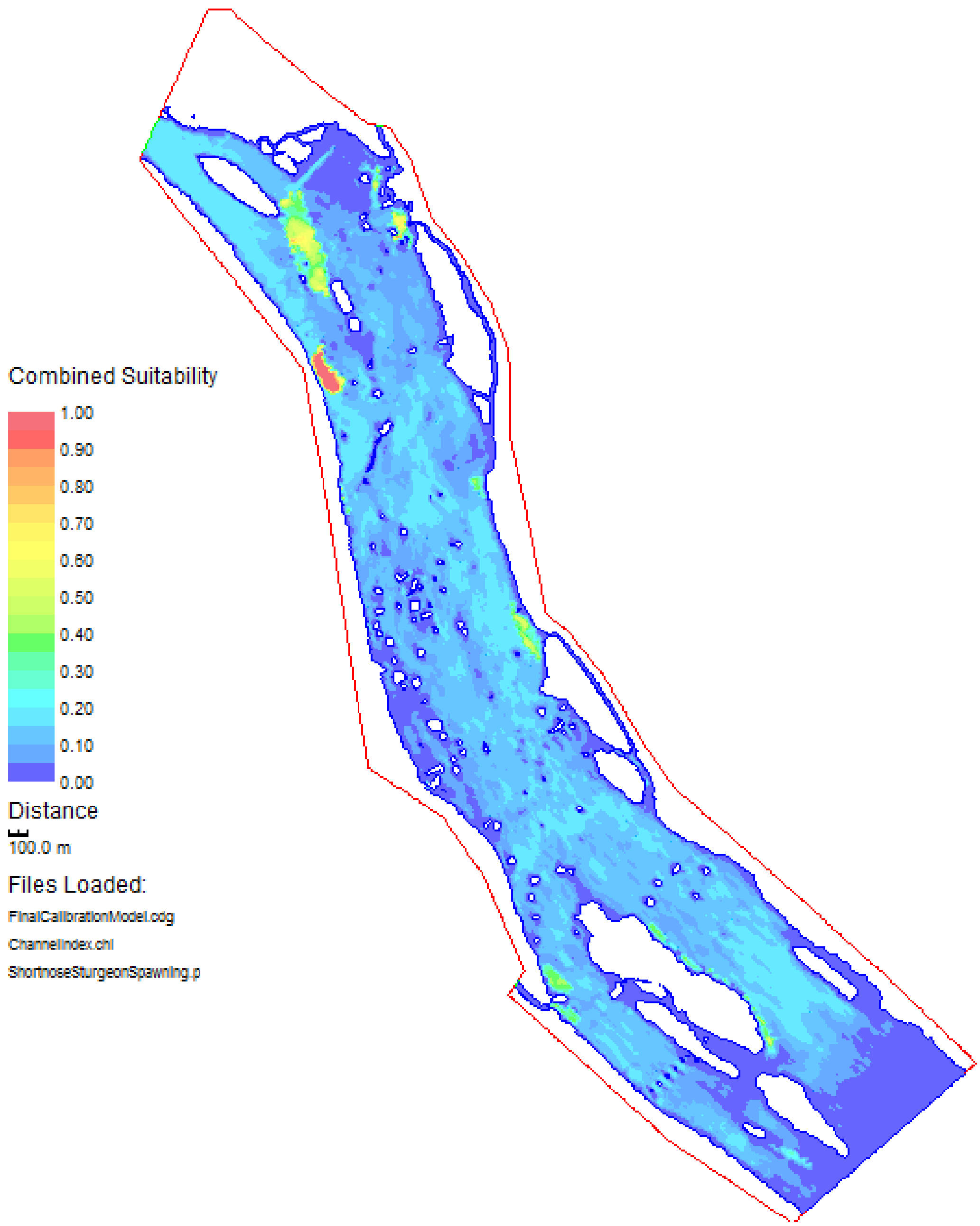
Shortnose Sturgeon Spawning – 2,000 cfs



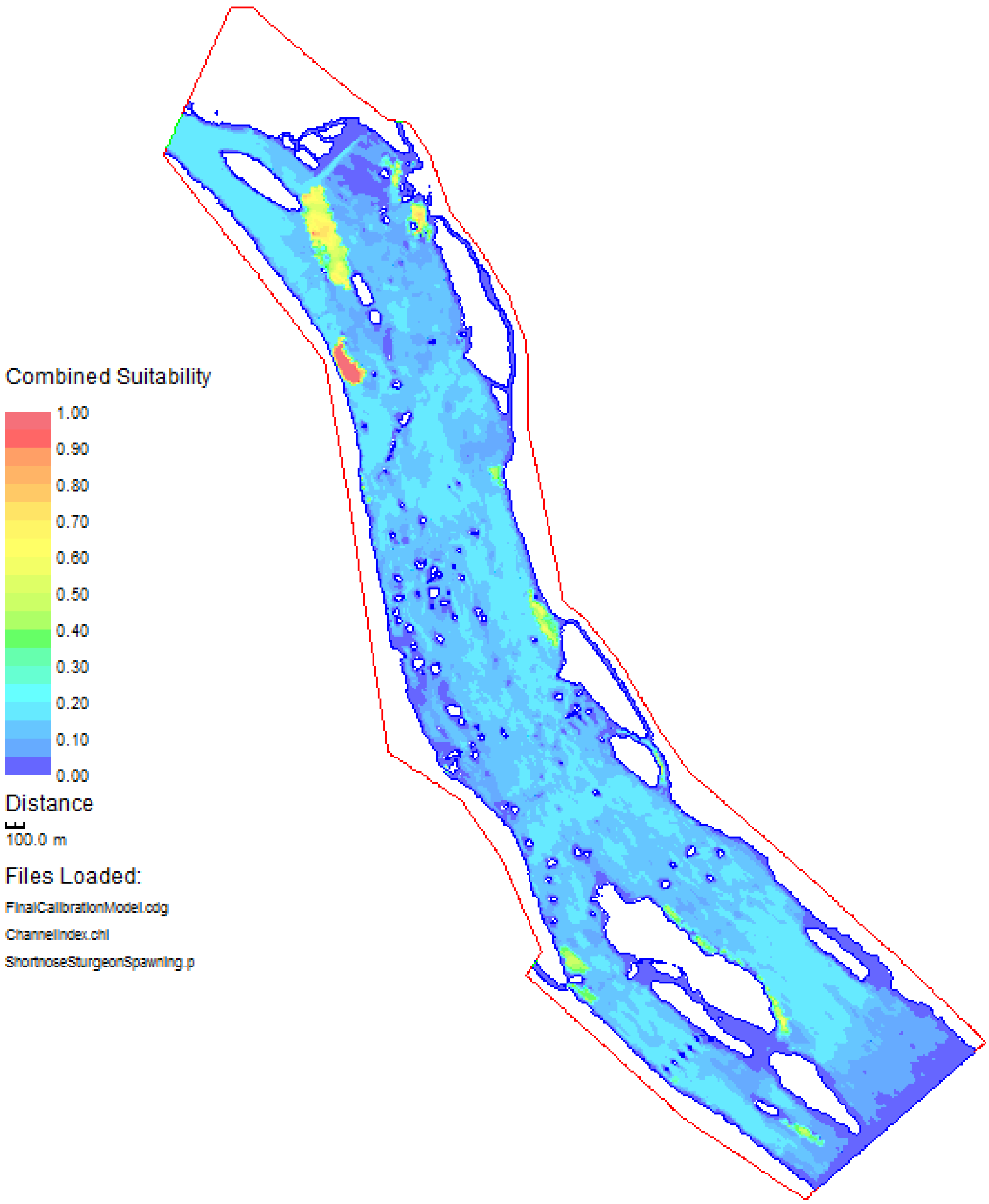
Shortnose Sturgeon Spawning – 3,500 cfs



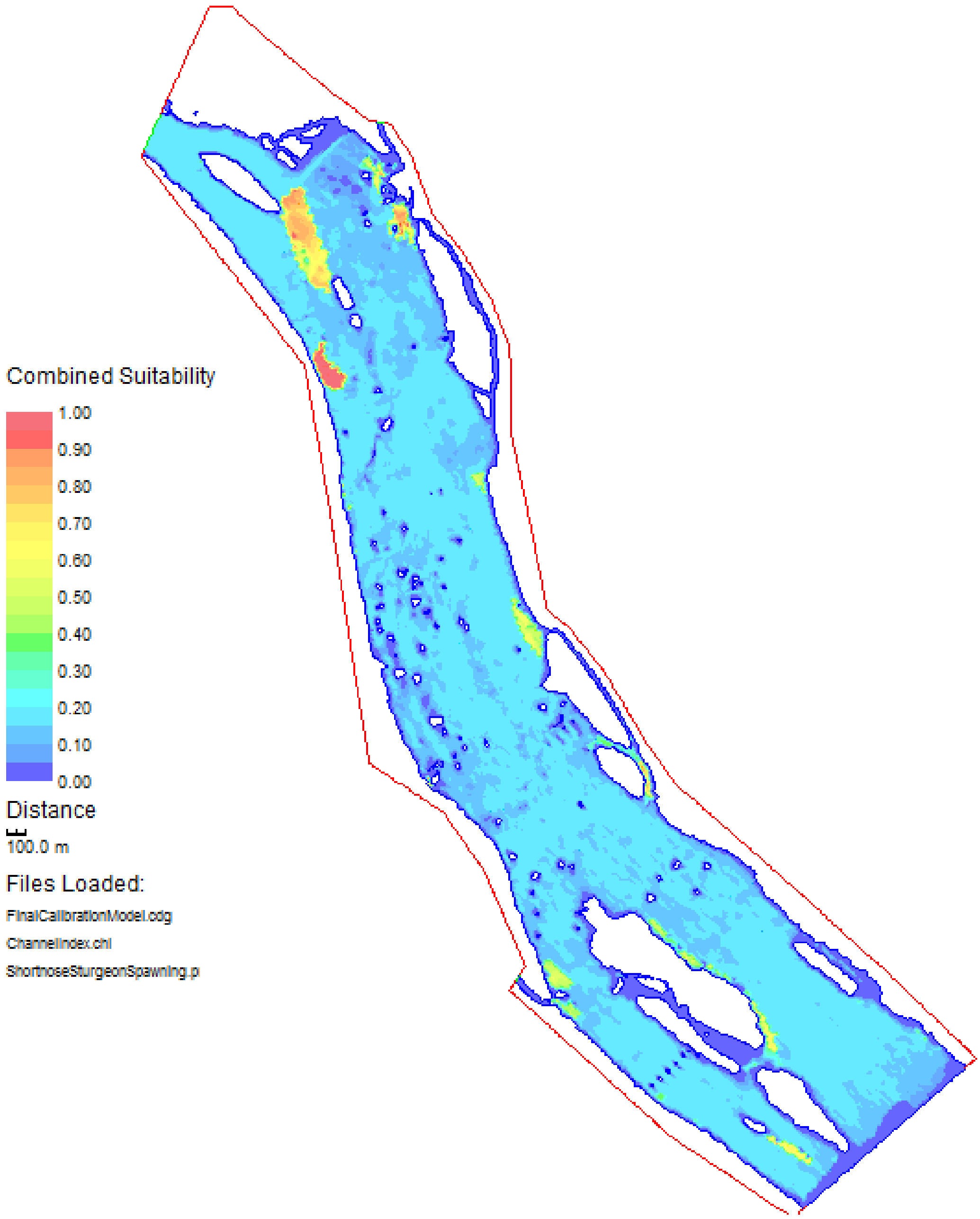
Shortnose Sturgeon Spawning – 5,000 cfs



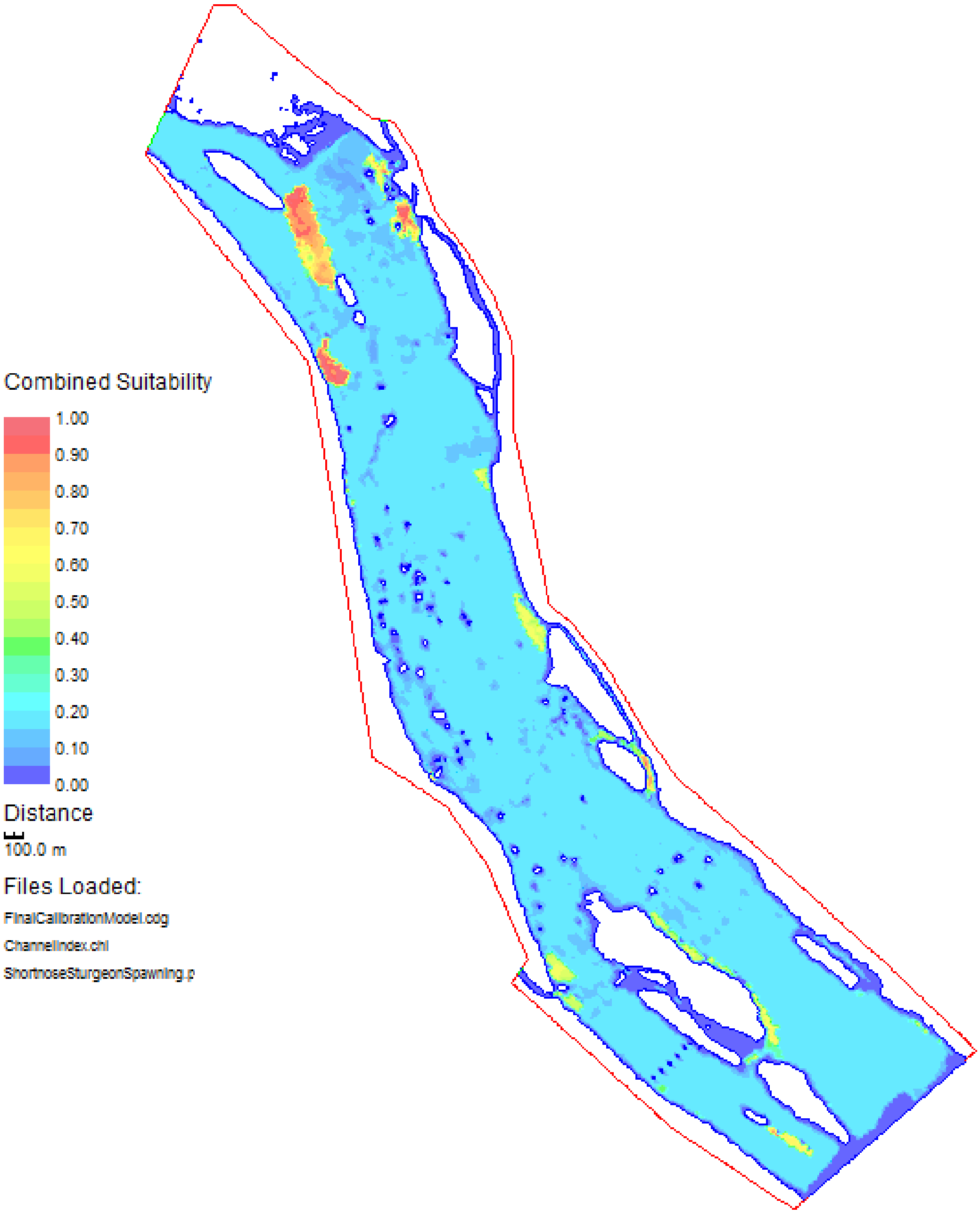
Shortnose Sturgeon Spawning – 7,500 cfs



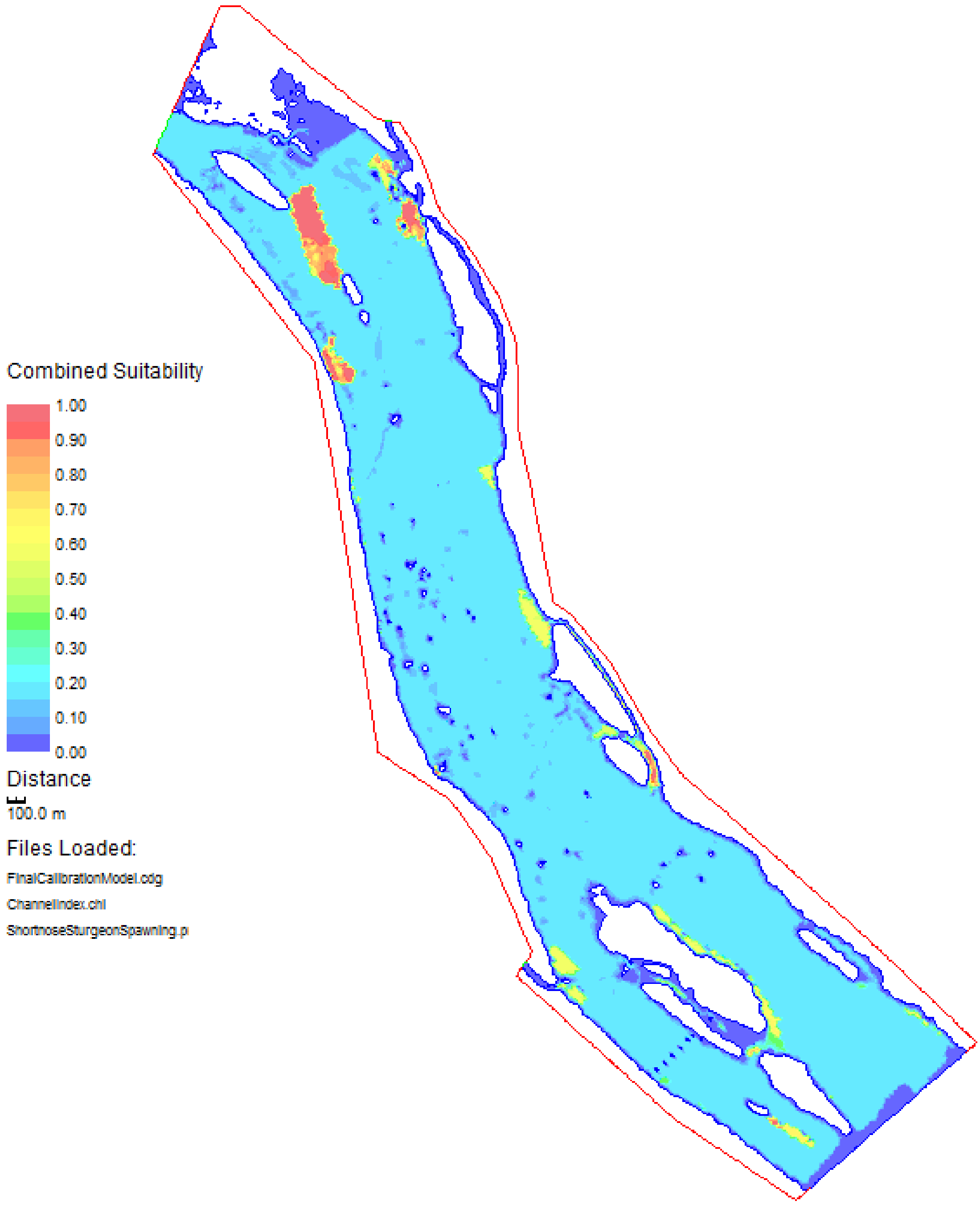
Shortnose Sturgeon Spawning – 10,000 cfs



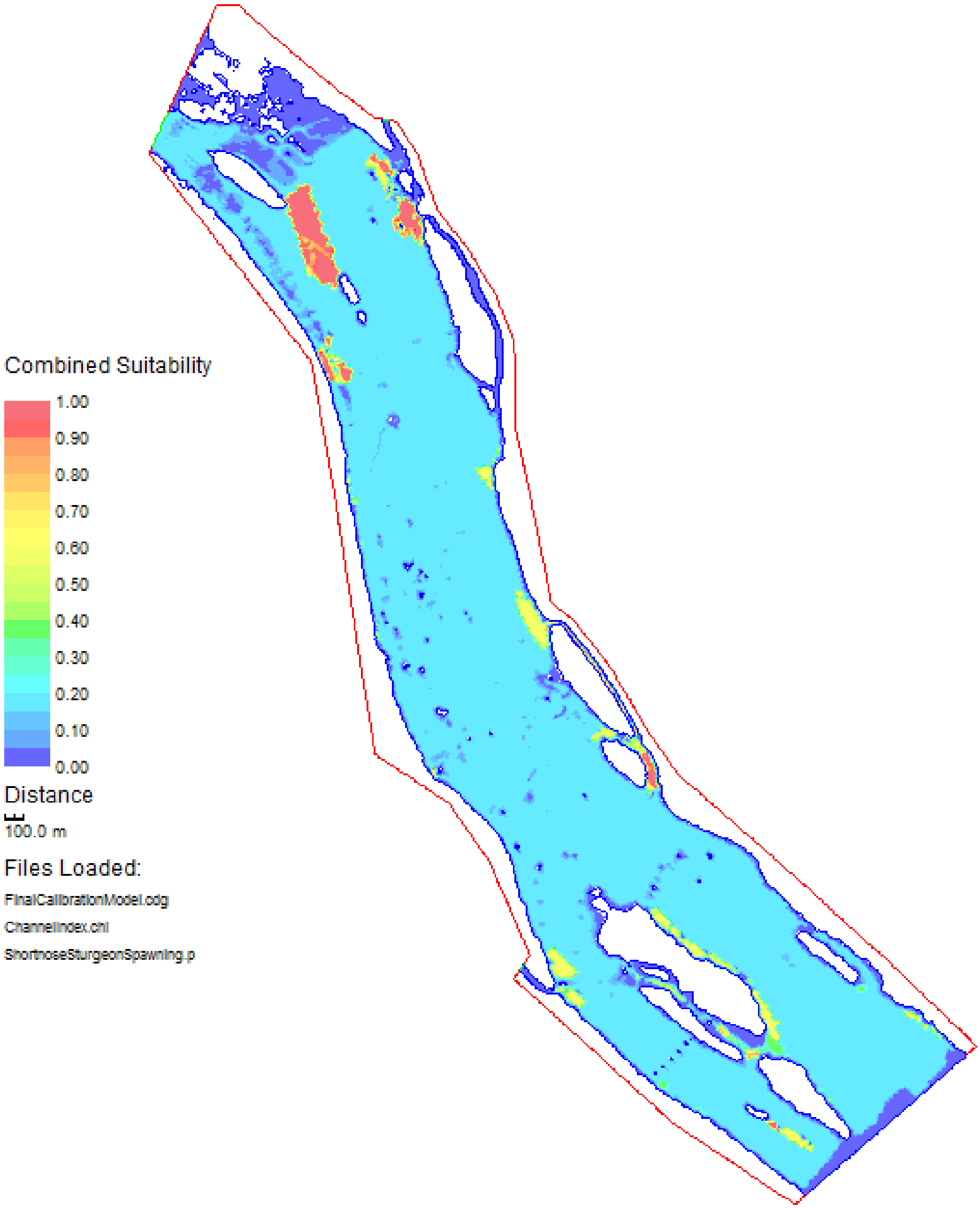
Shortnose Sturgeon Spawning – 15,000 cfs



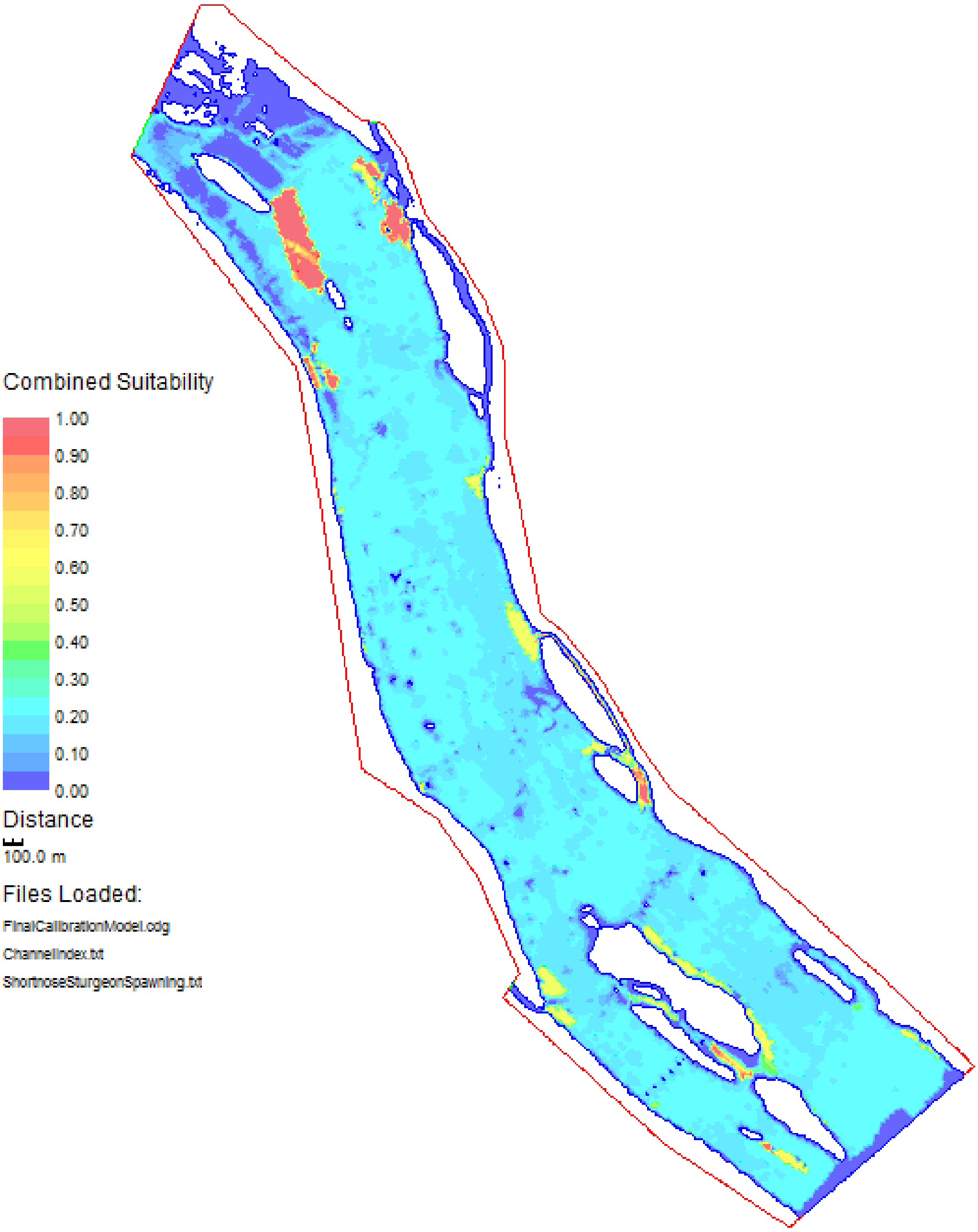
Shortnose Sturgeon Spawning – 20,000 cfs



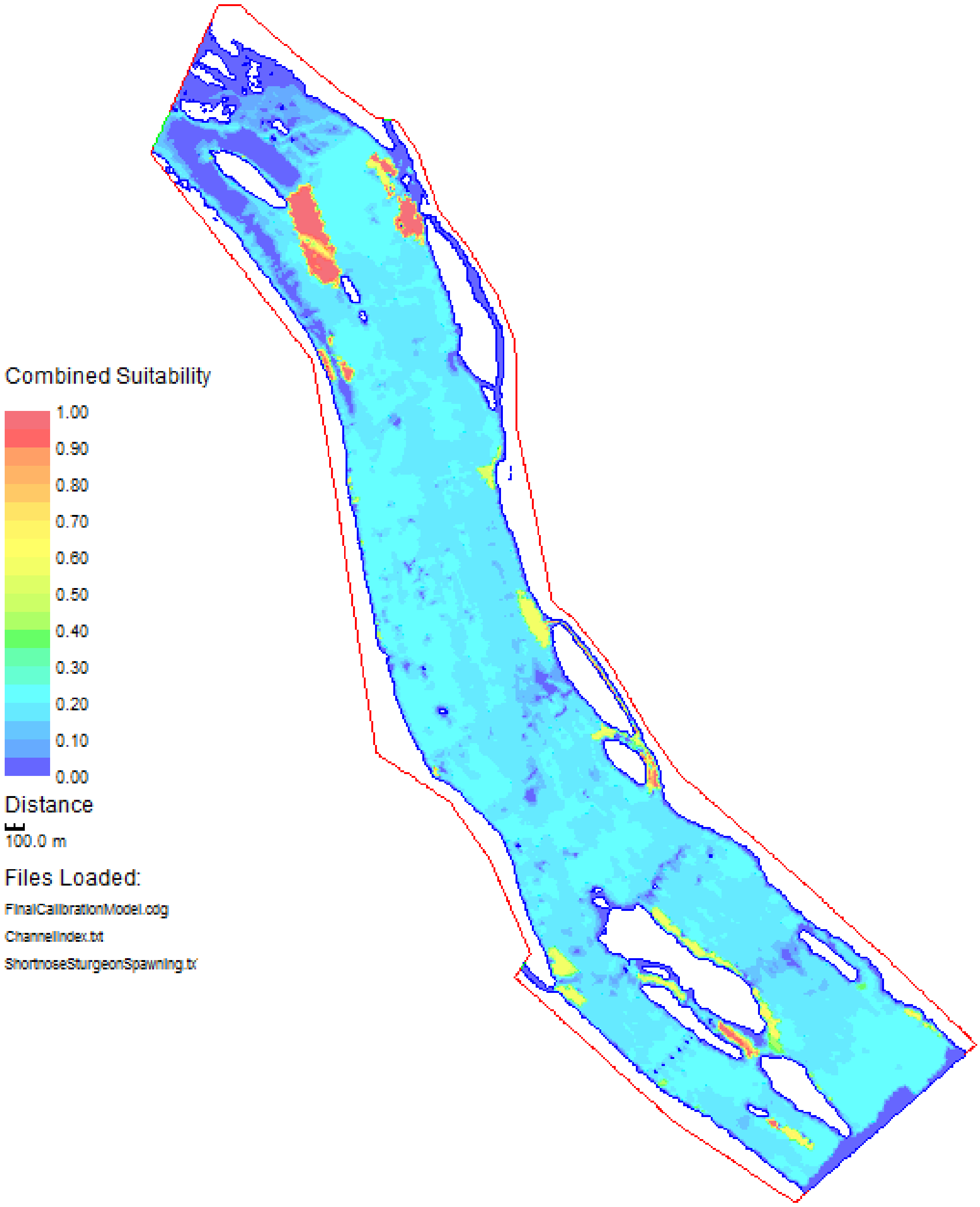
Shortnose Sturgeon Spawning – 30,000 cfs



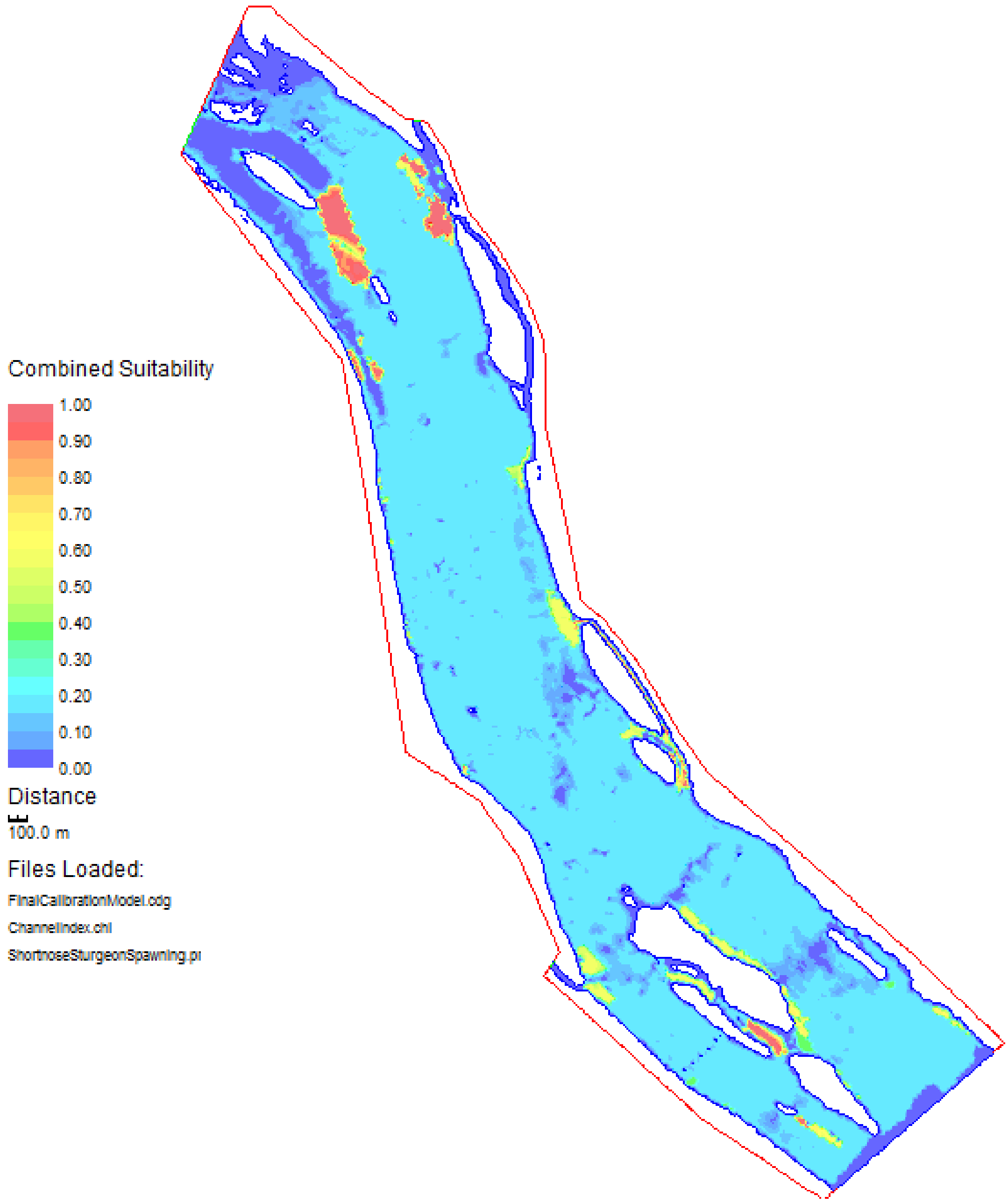
Shortnose Sturgeon Spawning – 40,000 cfs



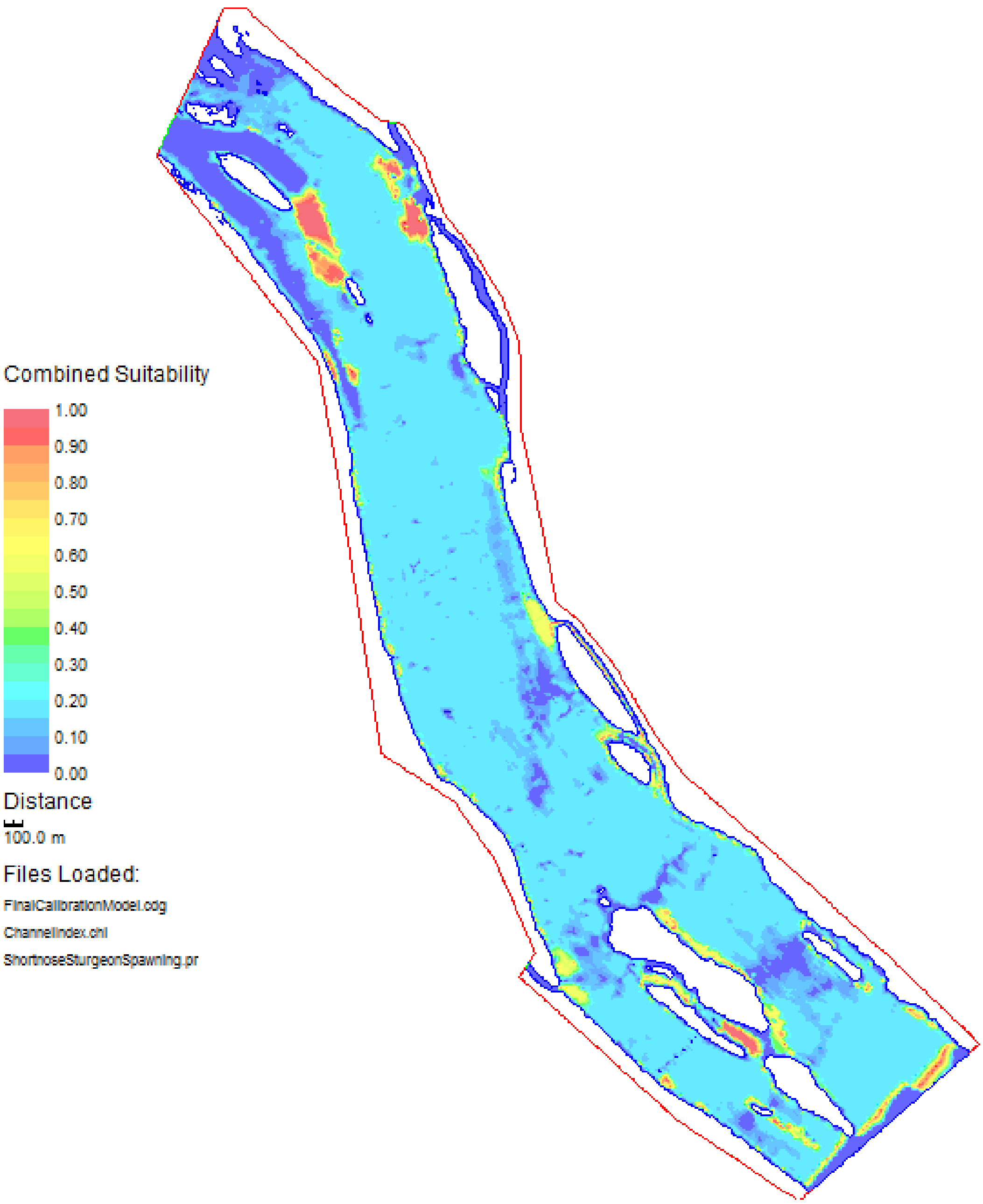
Shortnose Sturgeon Spawning – 50,000 cfs



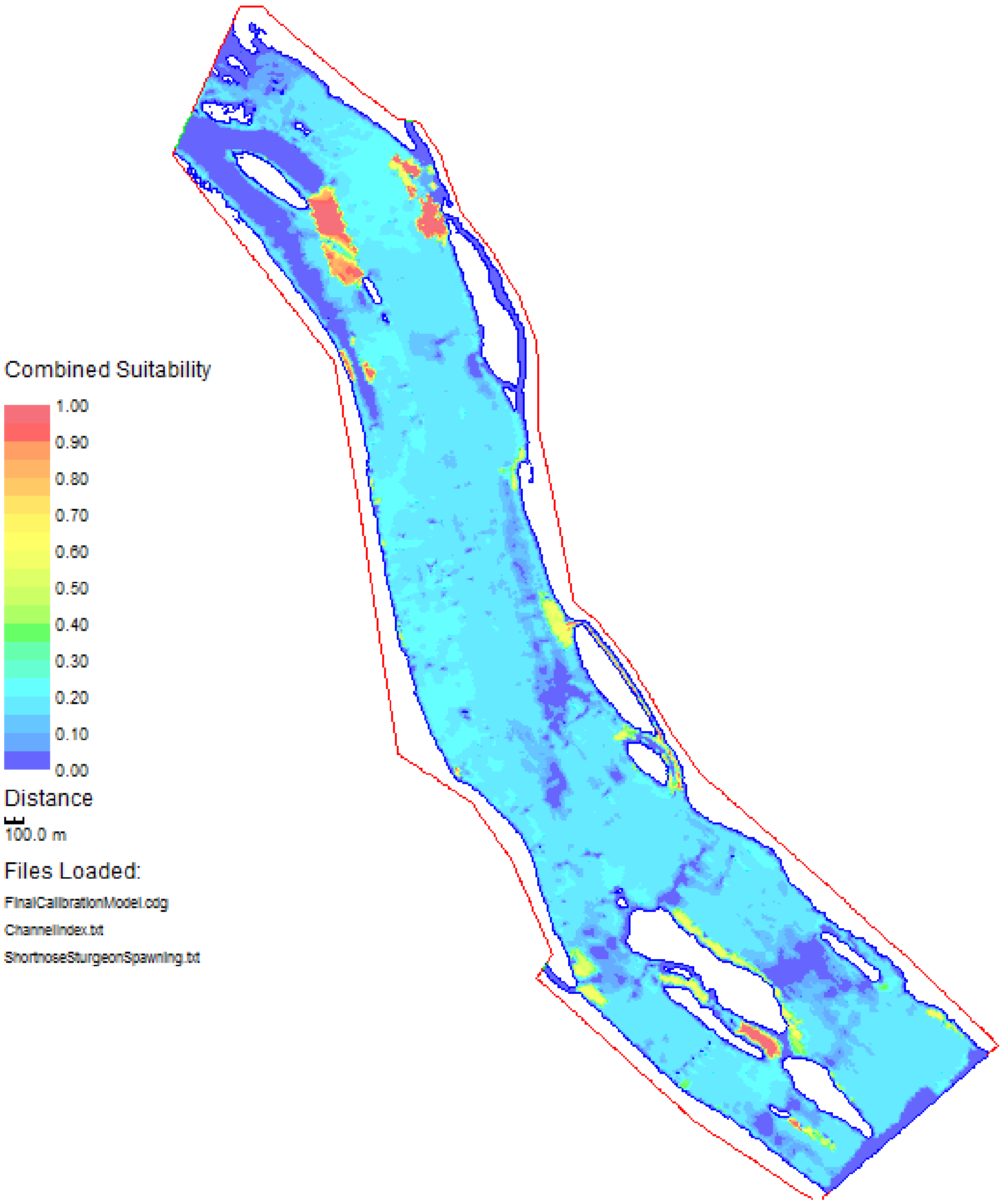
Shortnose Sturgeon Spawning – 60,000 cfs



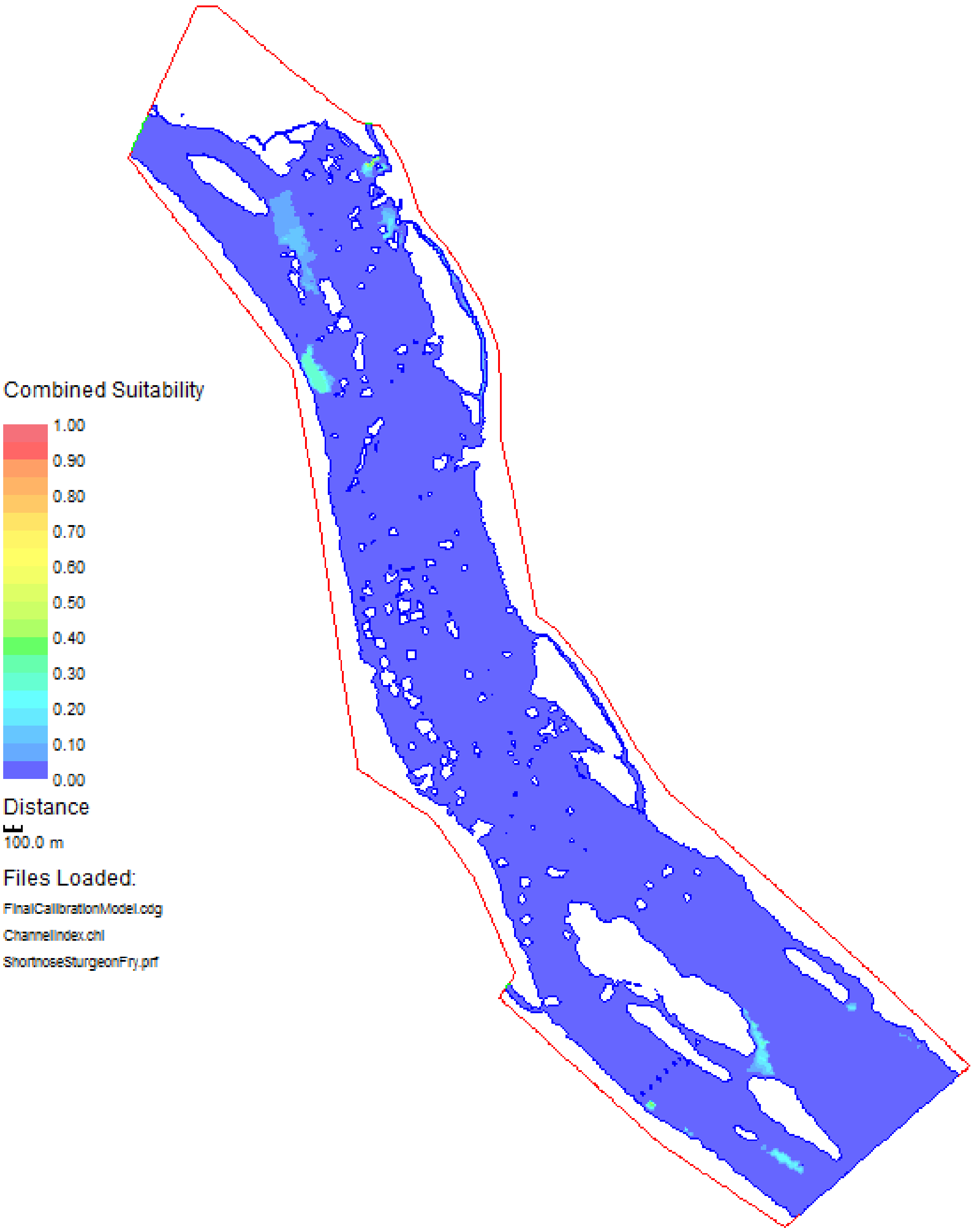
Shortnose Sturgeon Spawning – 70,000 cfs



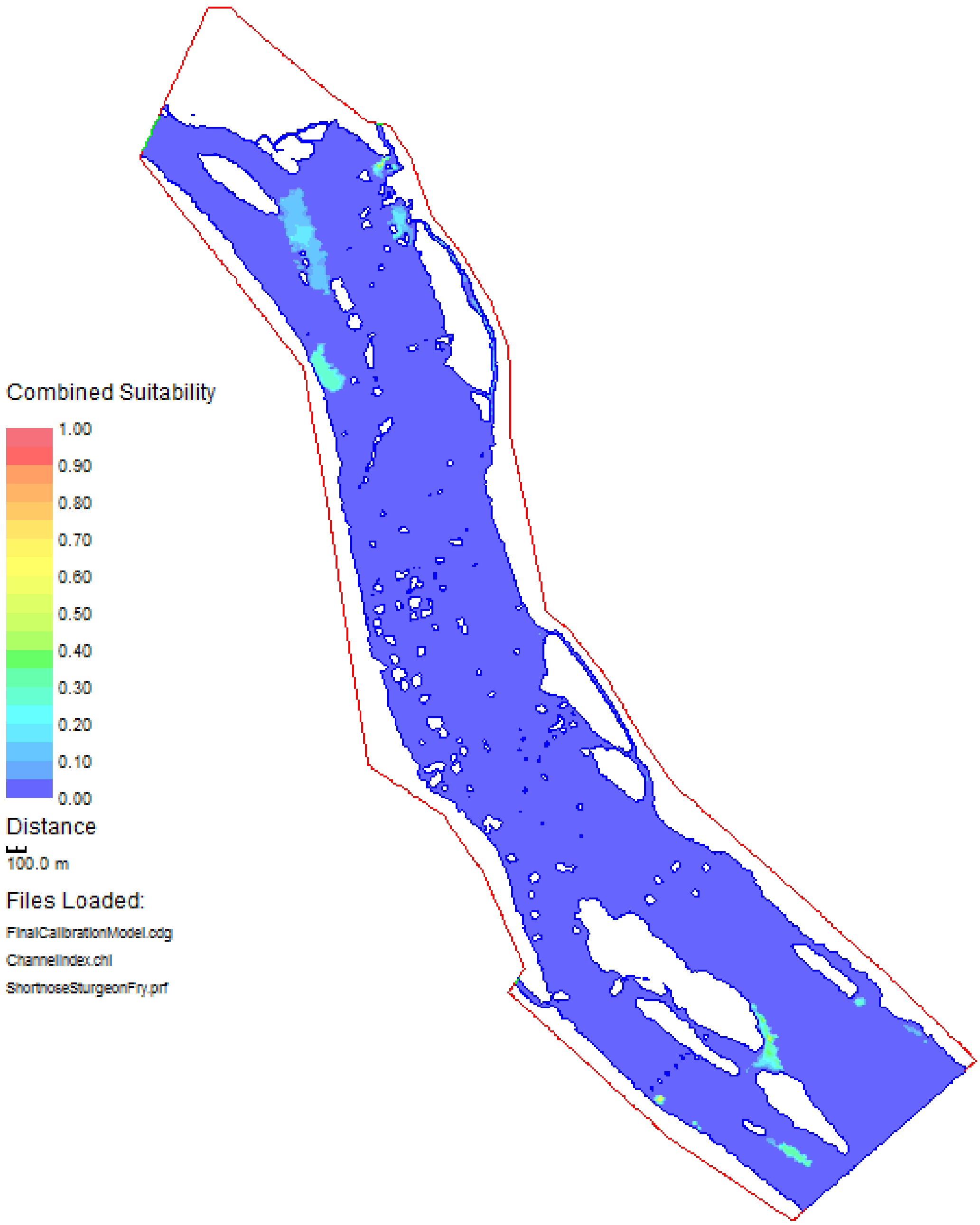
Shortnose Sturgeon Spawning – 80,000 cfs



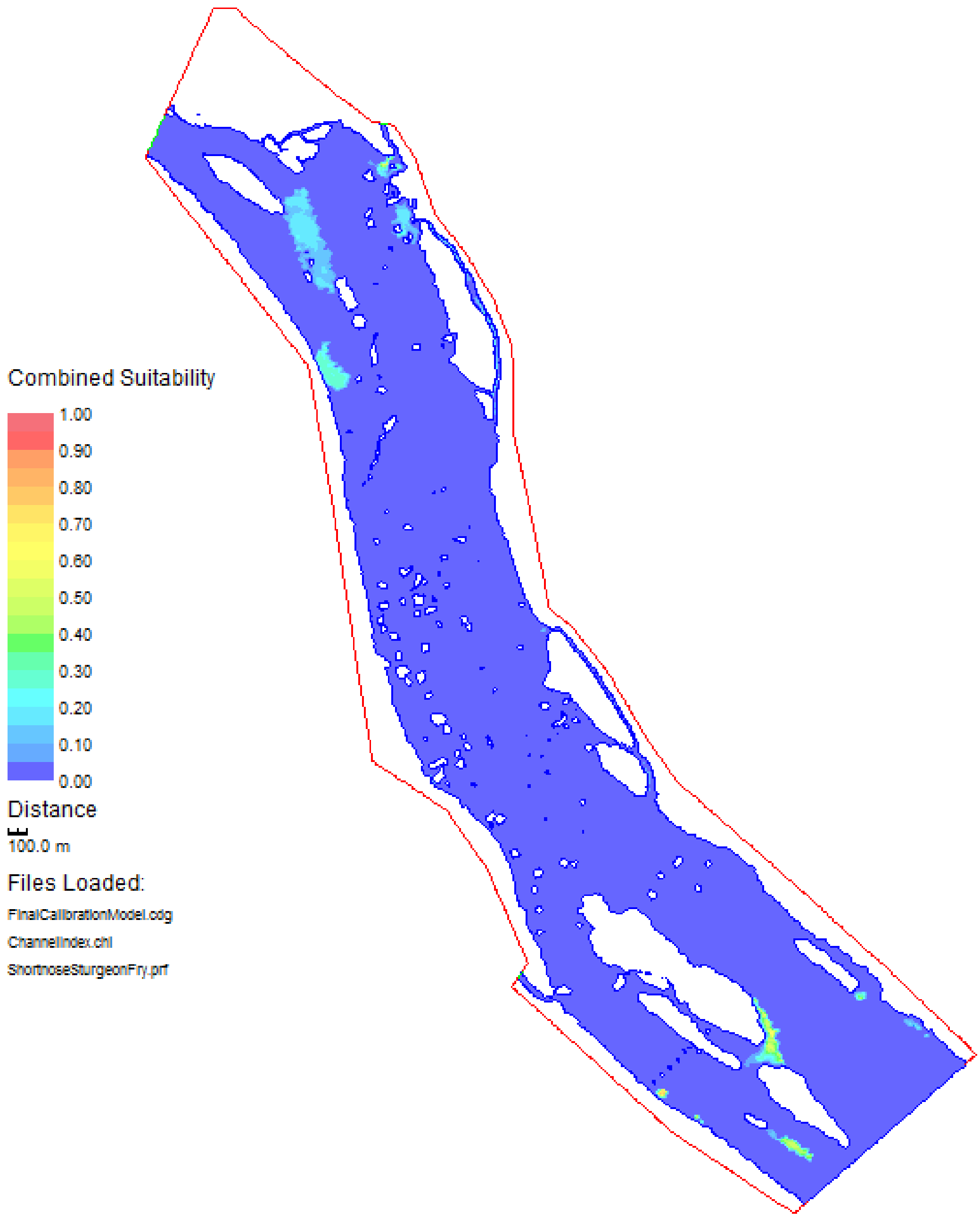
Shortnose Sturgeon Spawning – 86,000 cfs



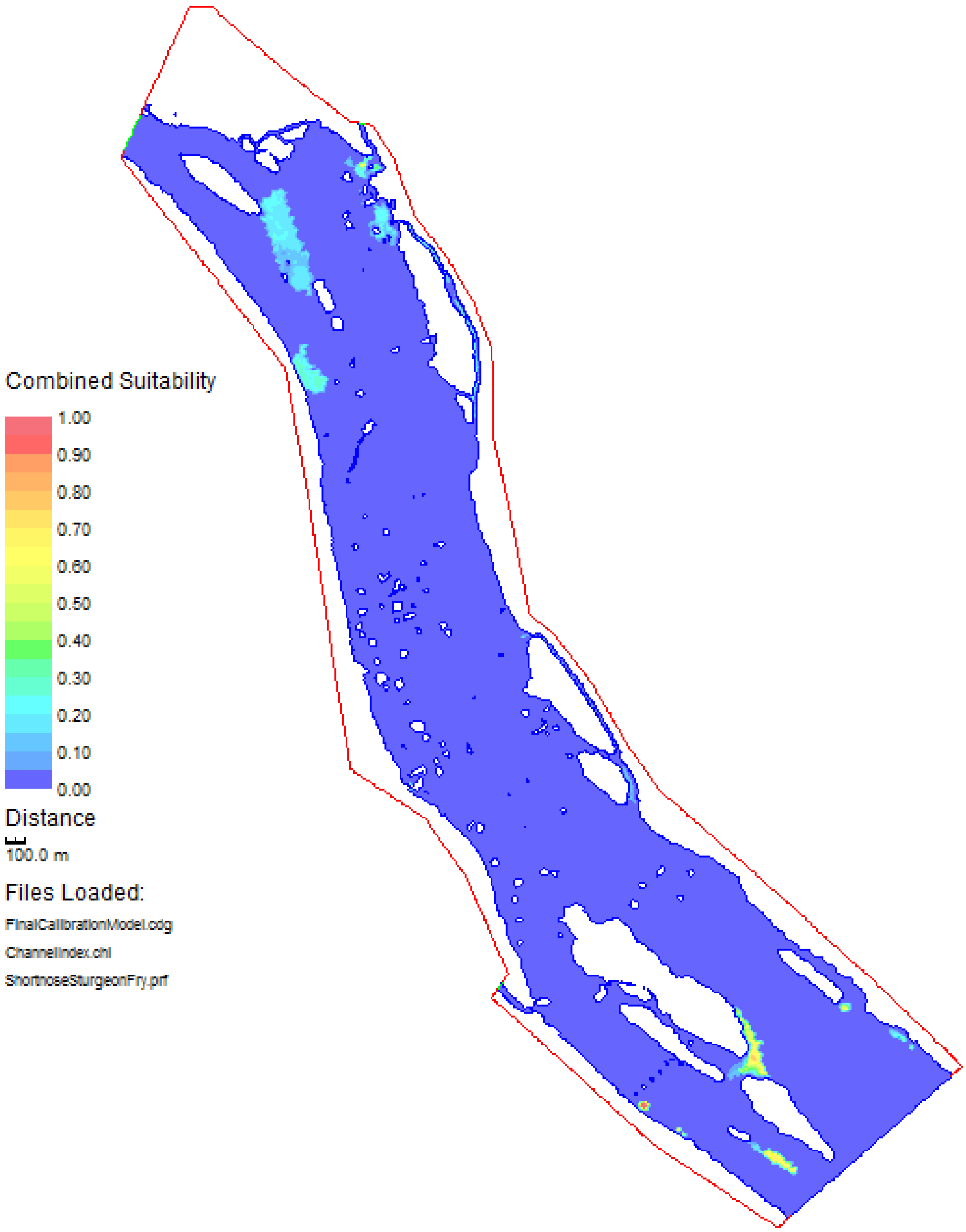
Shortnose Sturgeon Fry – 2,000 cfs



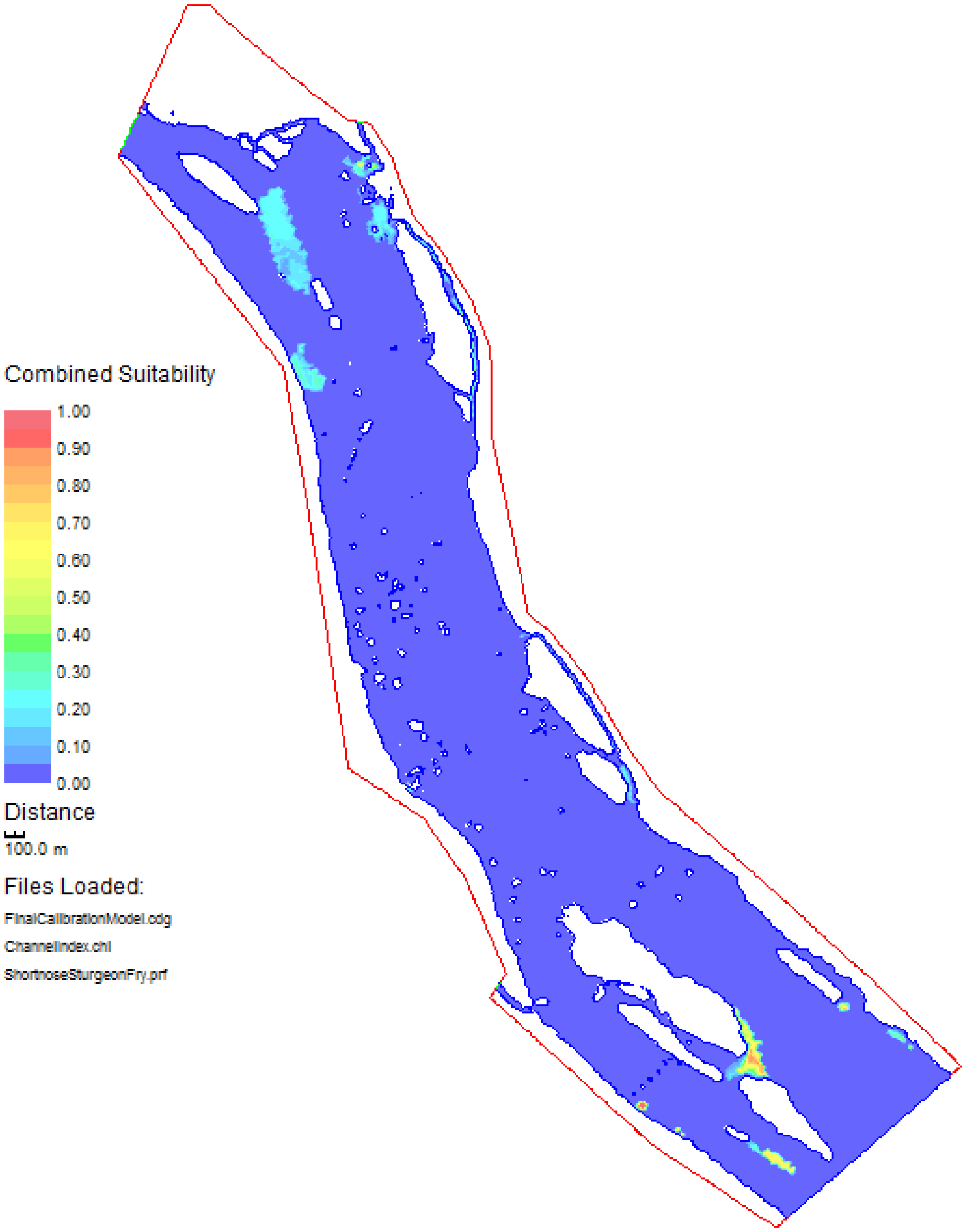
Shortnose Sturgeon Fry – 3,500 cfs



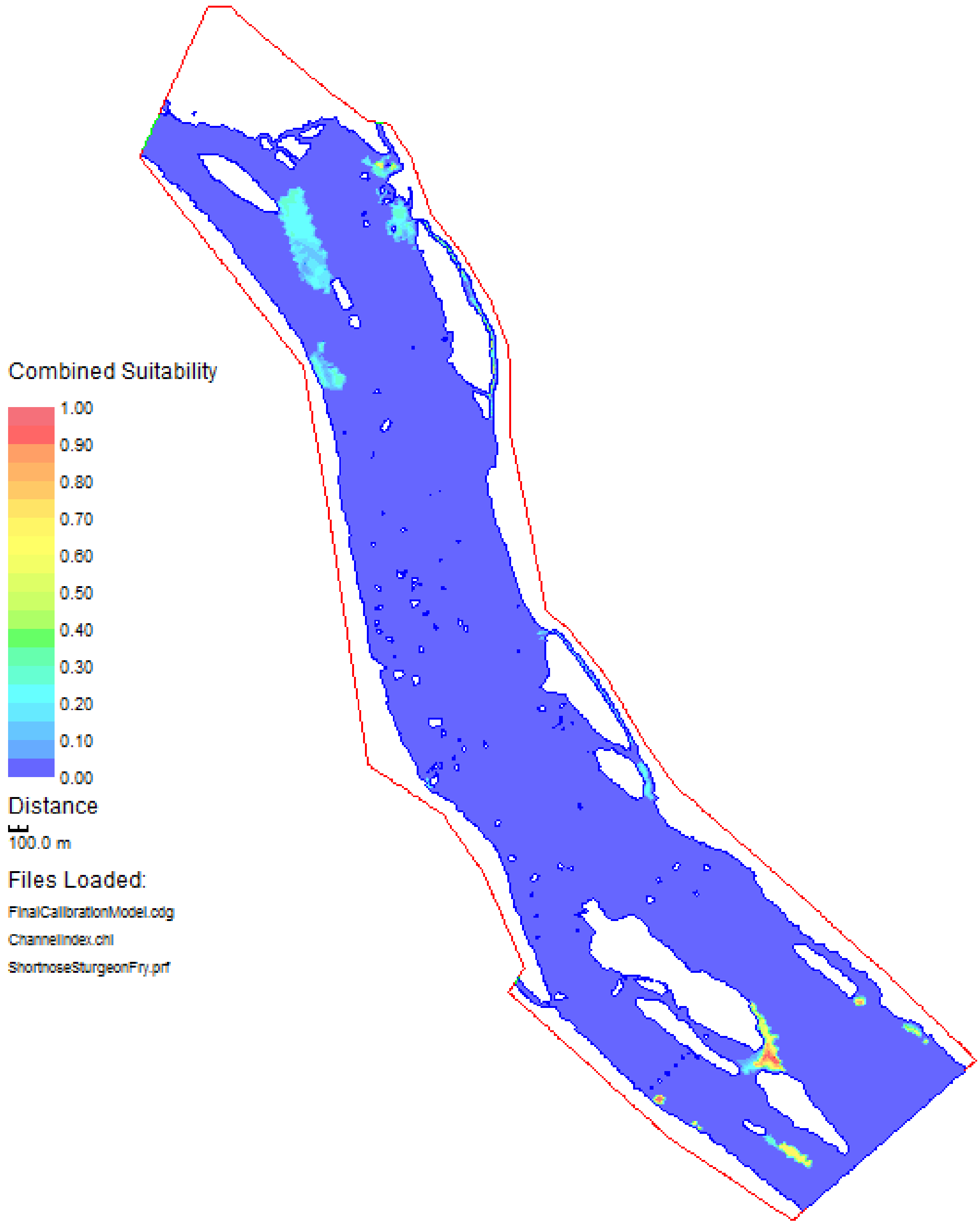
Shortnose Sturgeon Fry – 5,000 cfs



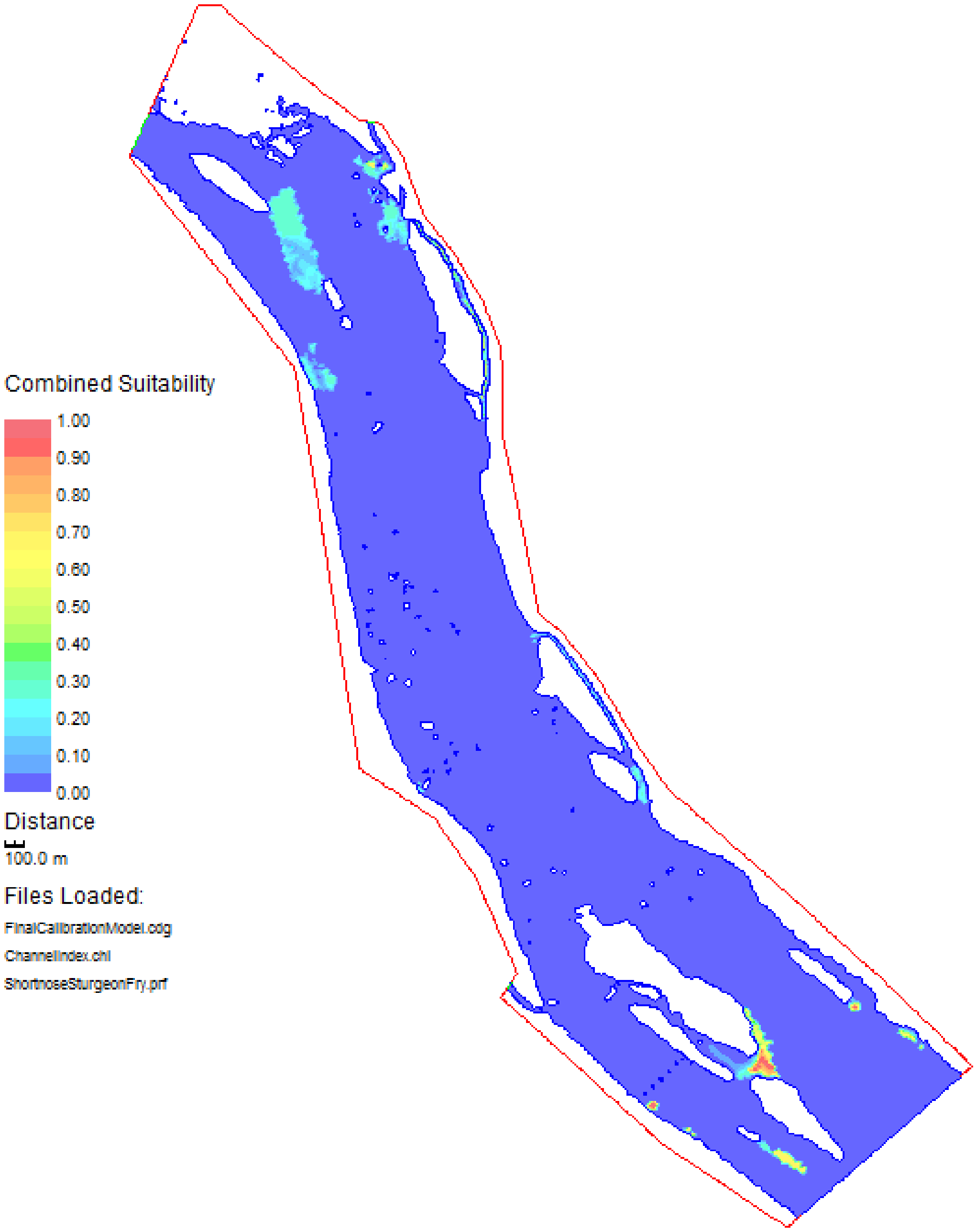
Shortnose Sturgeon Fry – 7,500 cfs



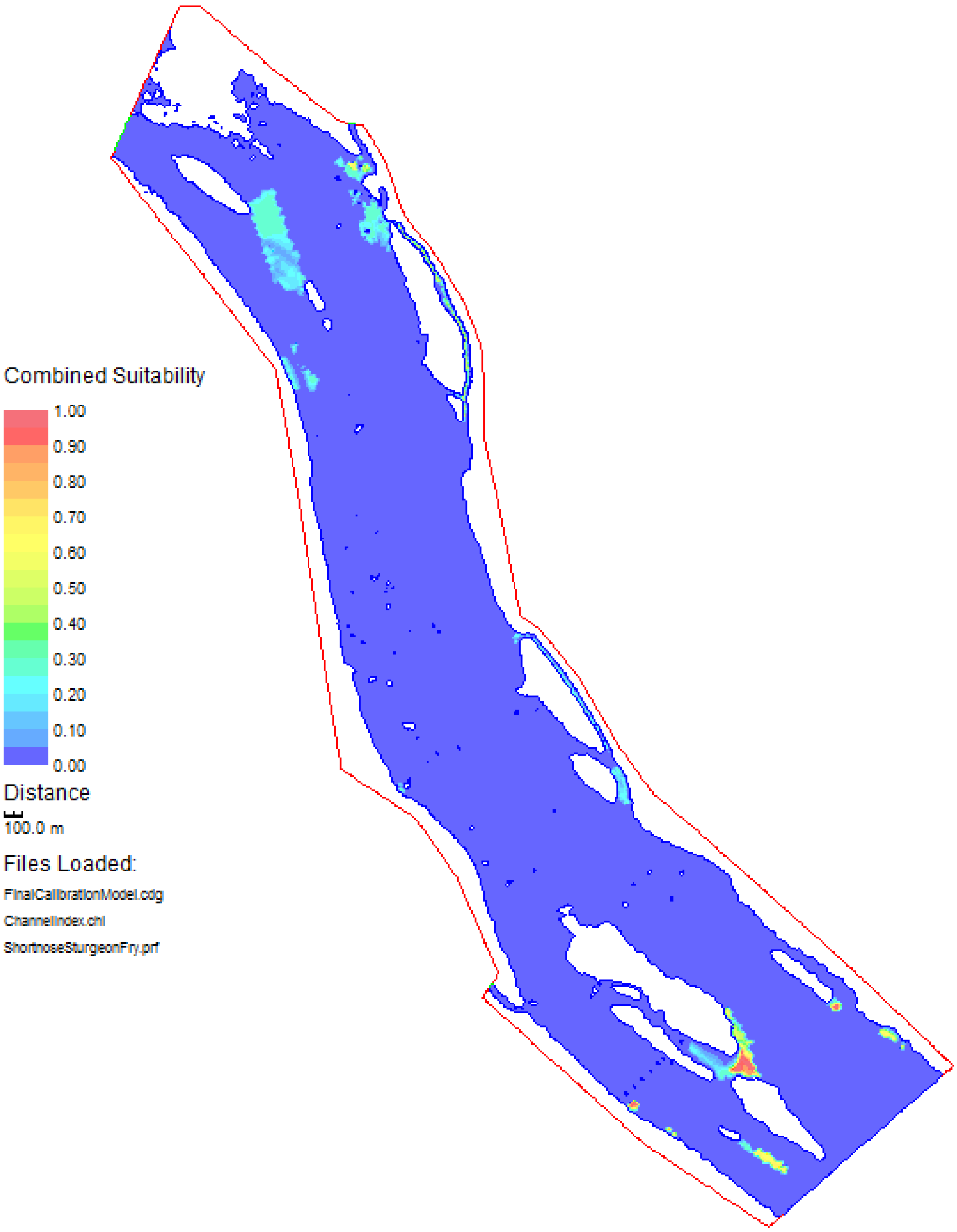
Shortnose Sturgeon Fry – 10,000 cfs



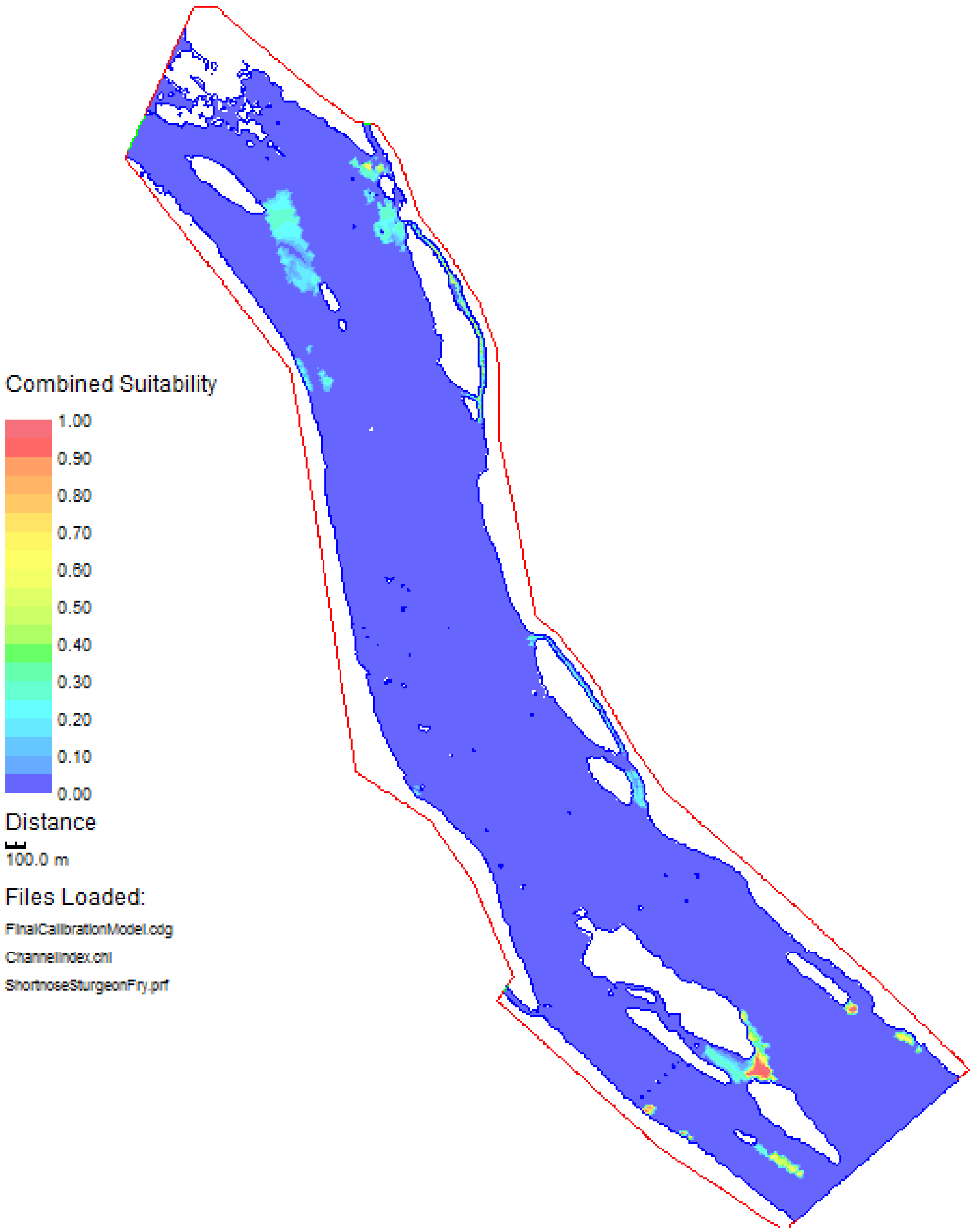
Shortnose Sturgeon Fry – 15,000 cfs



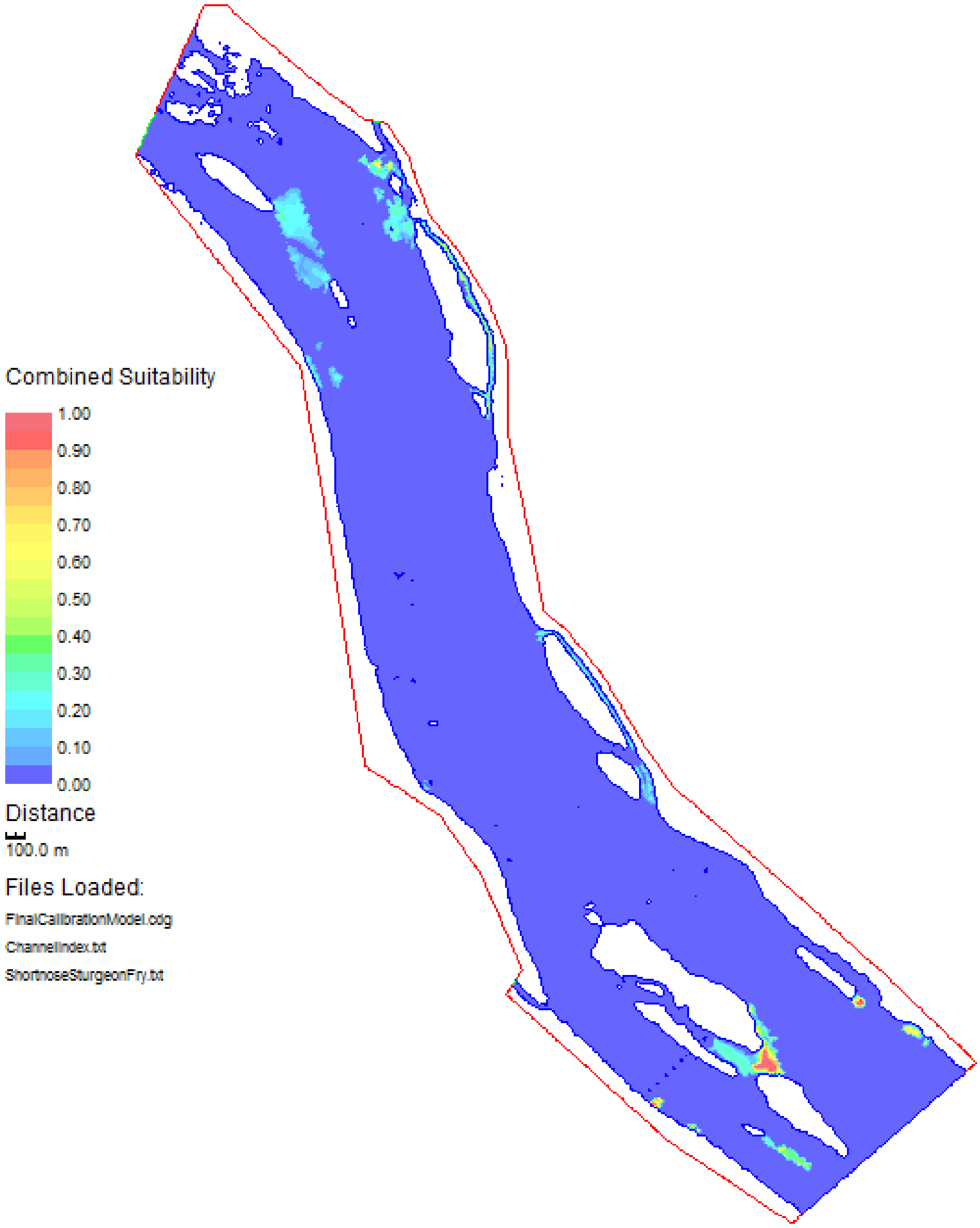
Shortnose Sturgeon Fry – 20,000 cfs



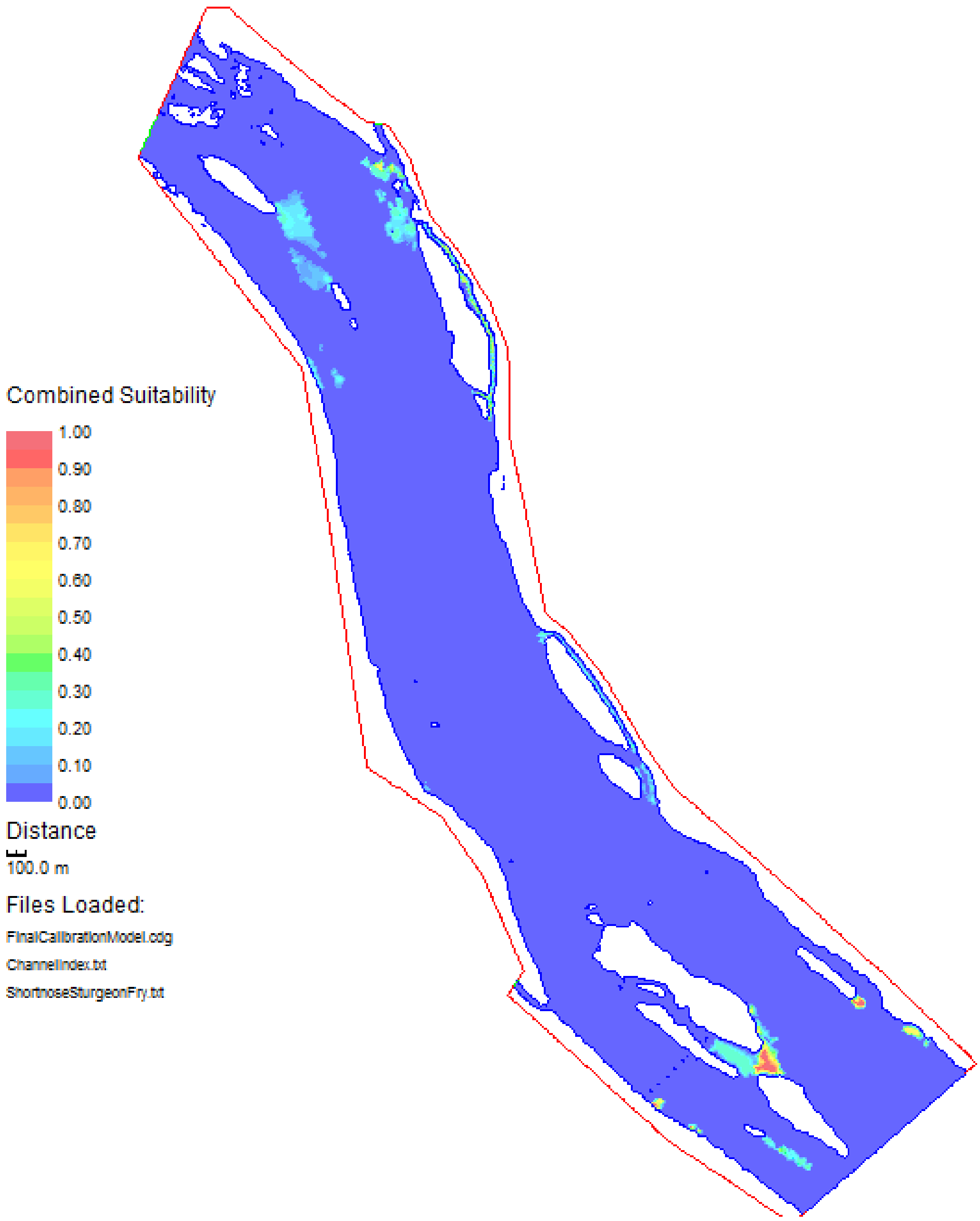
Shortnose Sturgeon Fry – 30,000 cfs



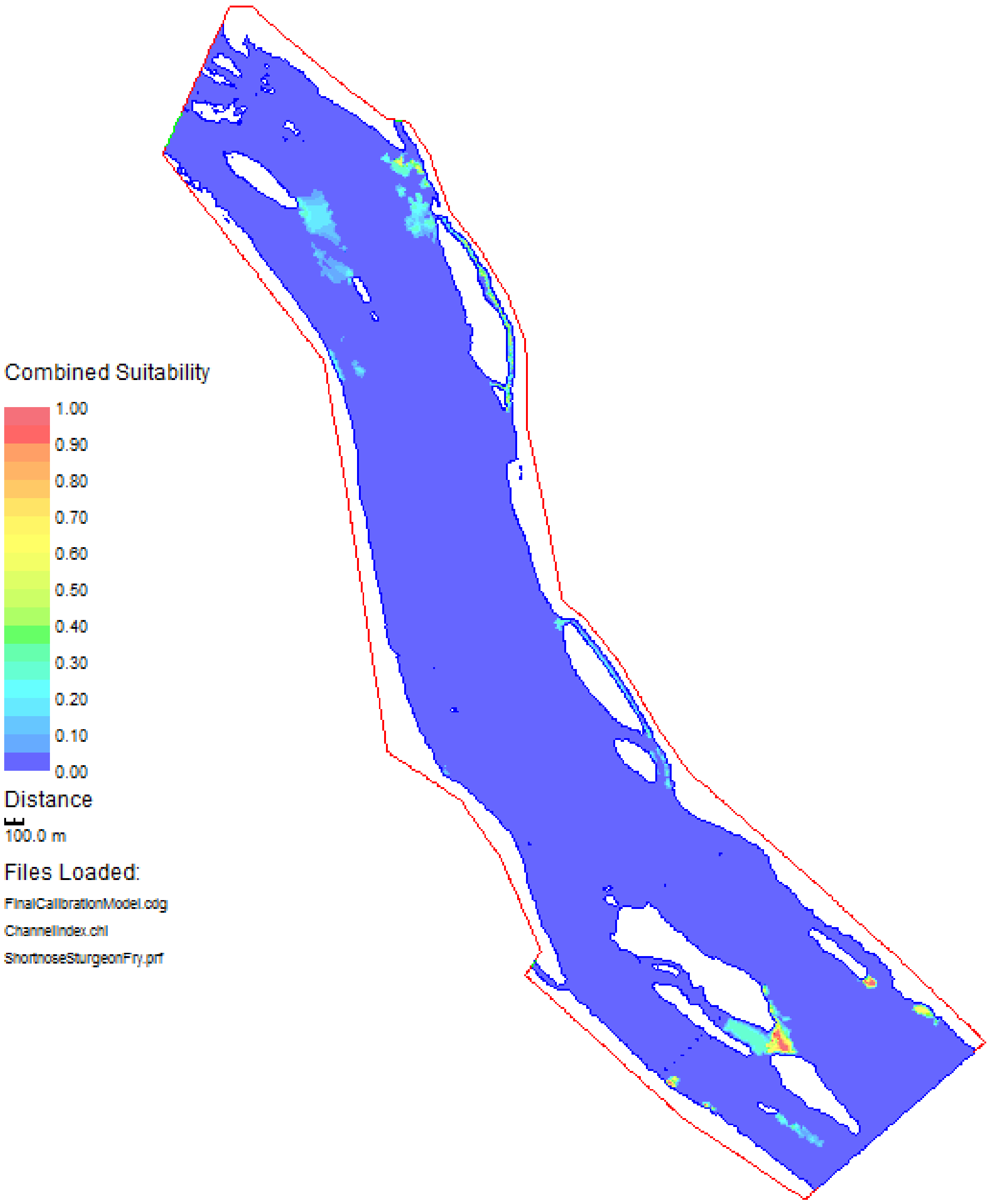
Shortnose Sturgeon Fry – 40,000



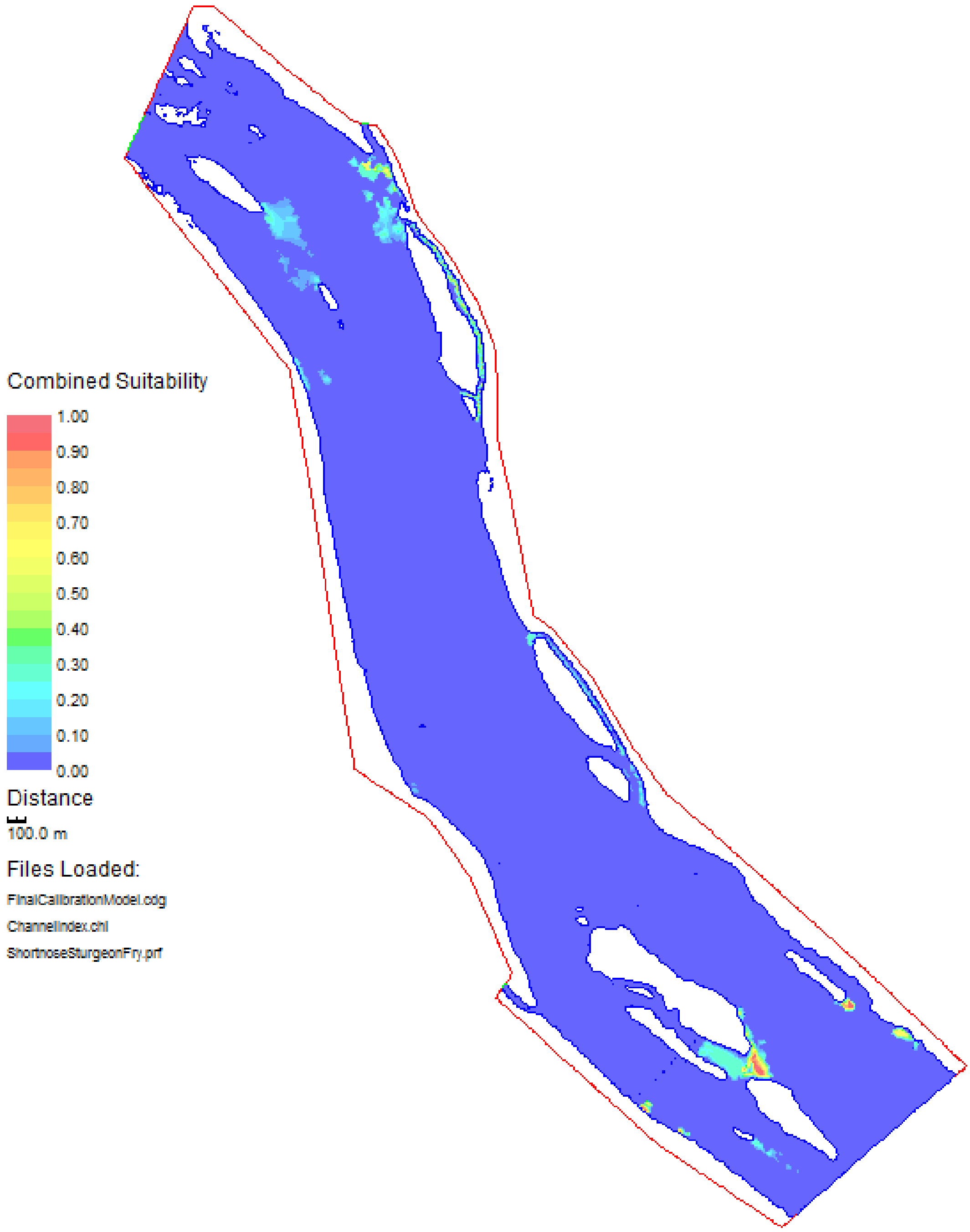
Shortnose Sturgeon Fry – 50,000 cfs



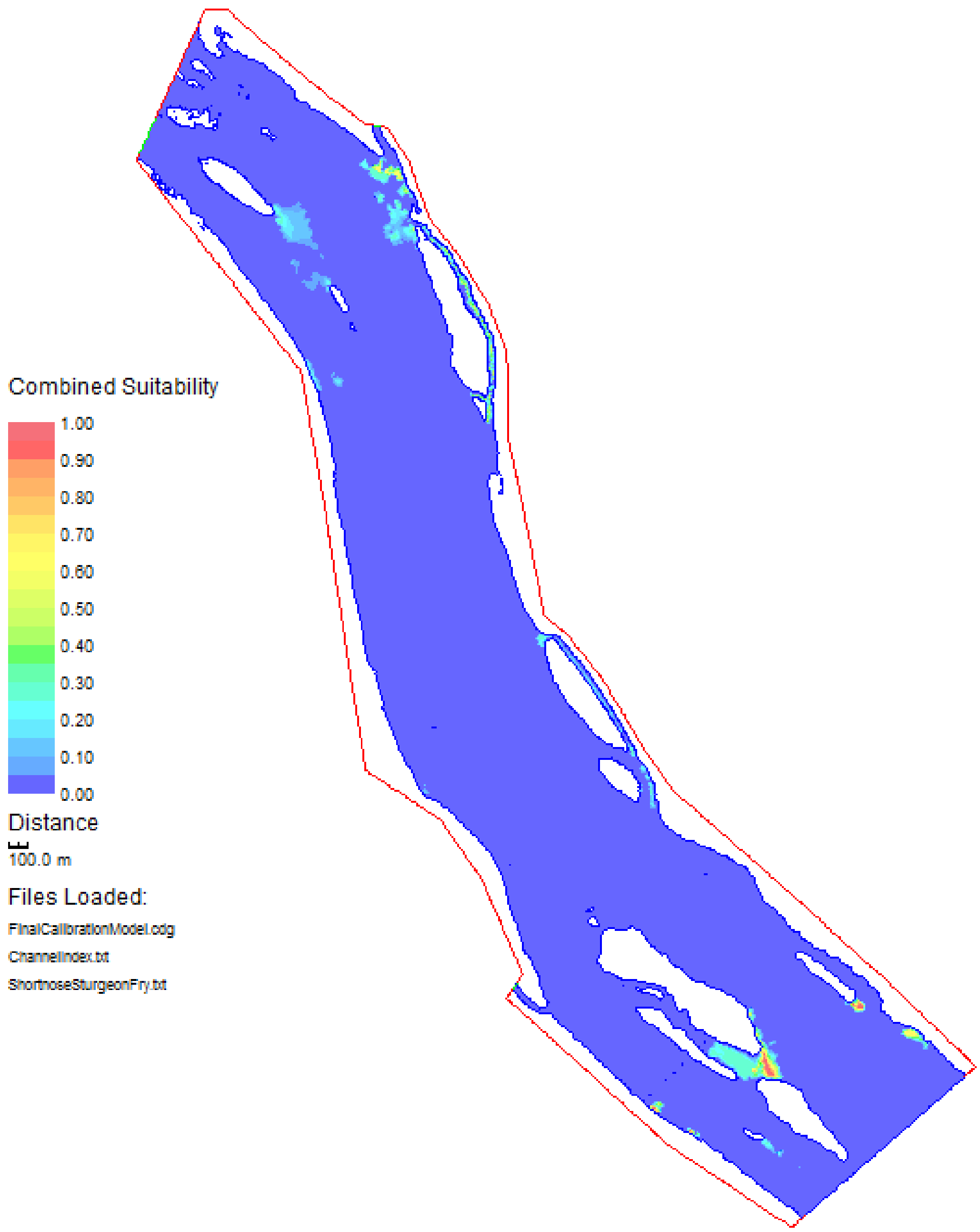
Shortnose Sturgeon Fry – 60,000 cfs



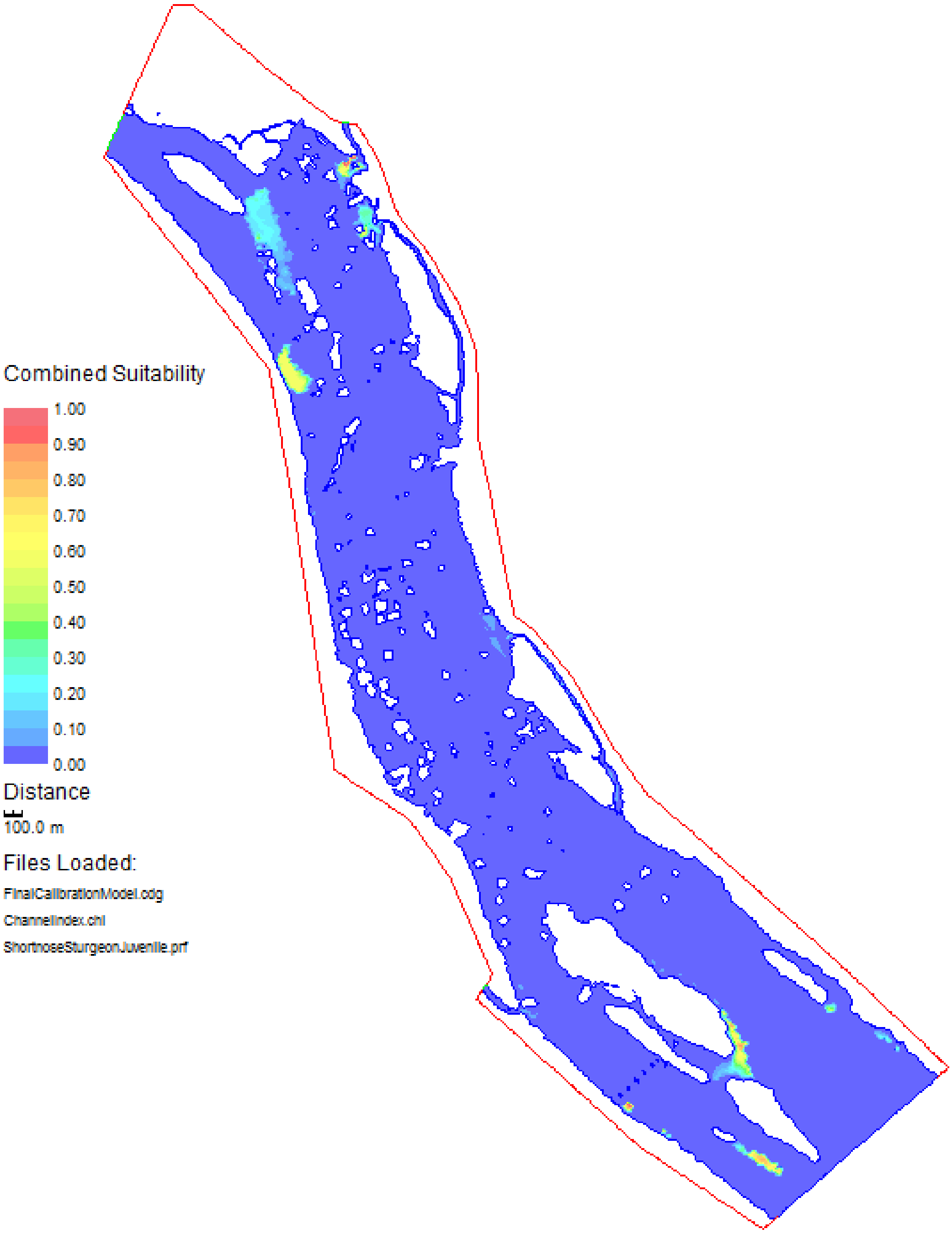
Shortnose Sturgeon Fry – 70,000 cfs



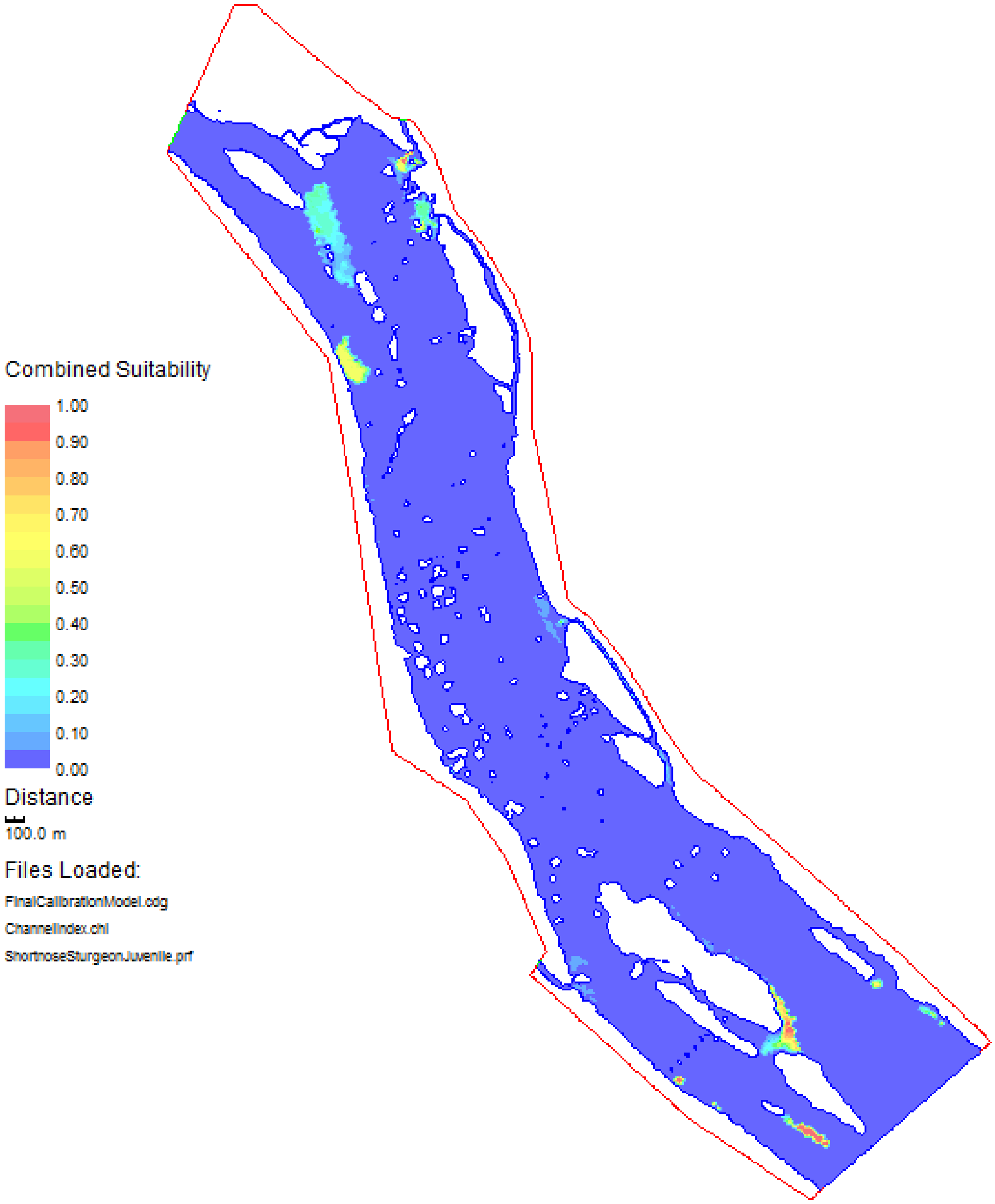
Shortnose Sturgeon Fry – 80,000 cfs



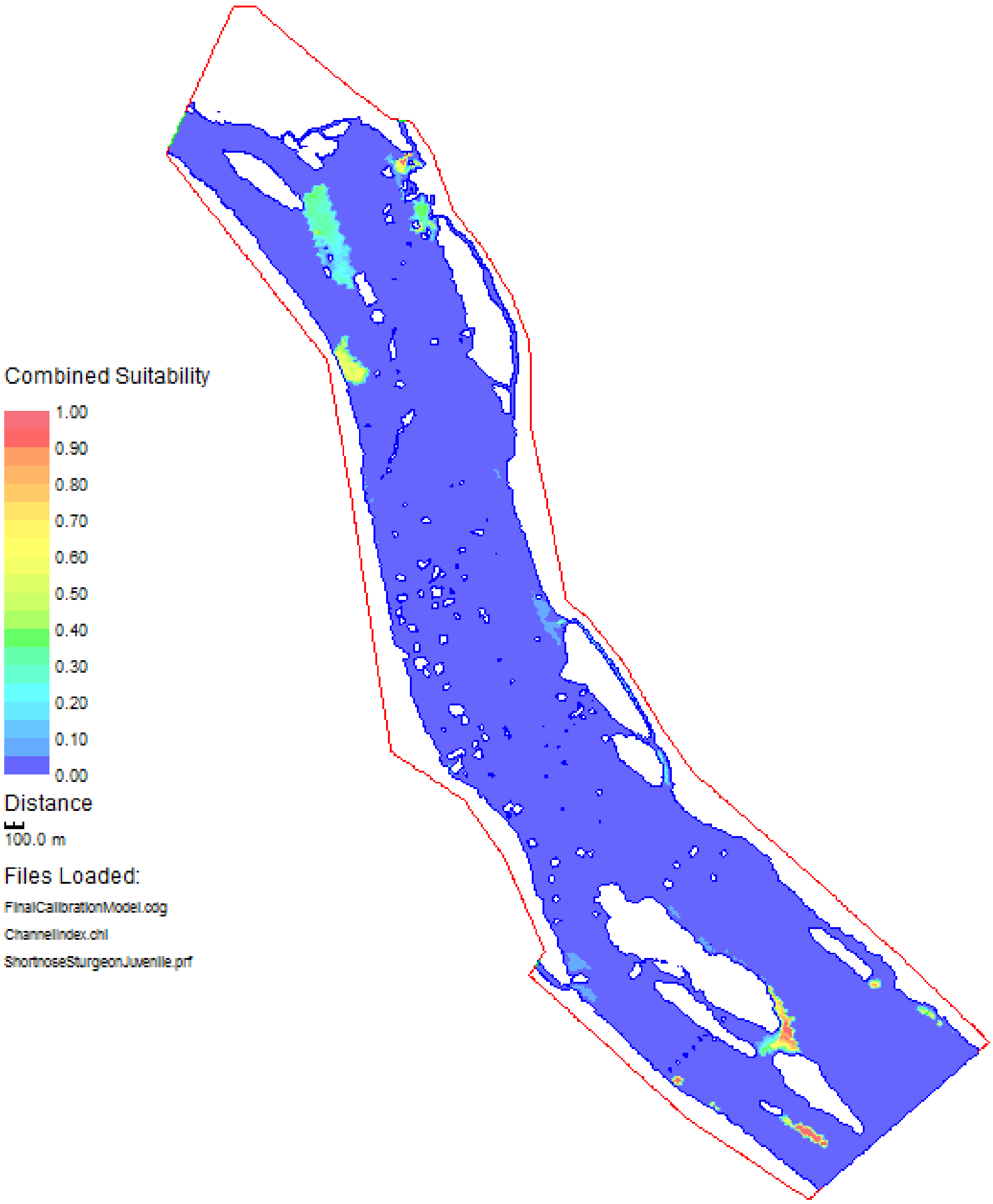
Shortnose Sturgeon Fry – 86,000 cfs



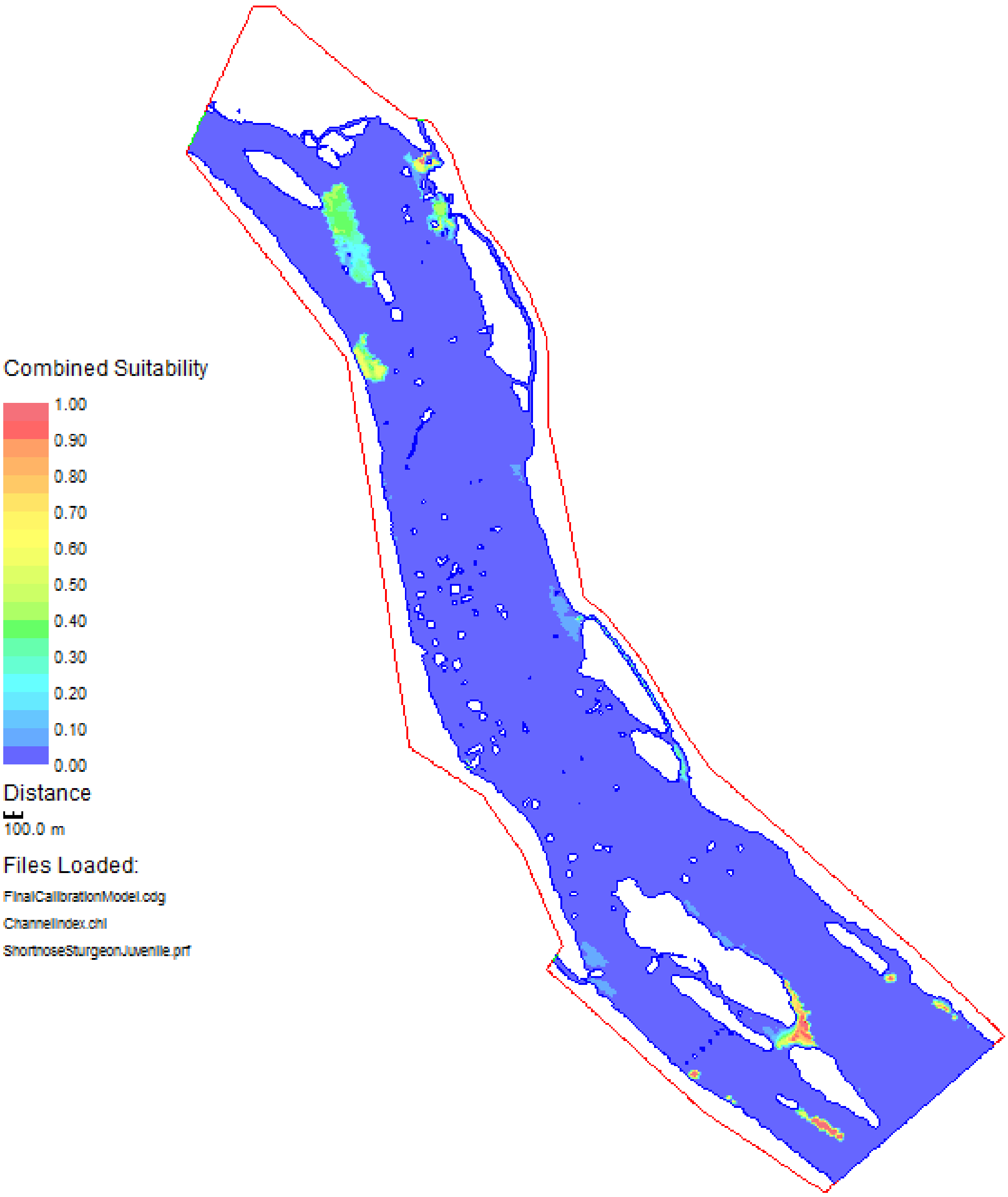
Shortnose Sturgeon Juvenile – 2,000 cfs



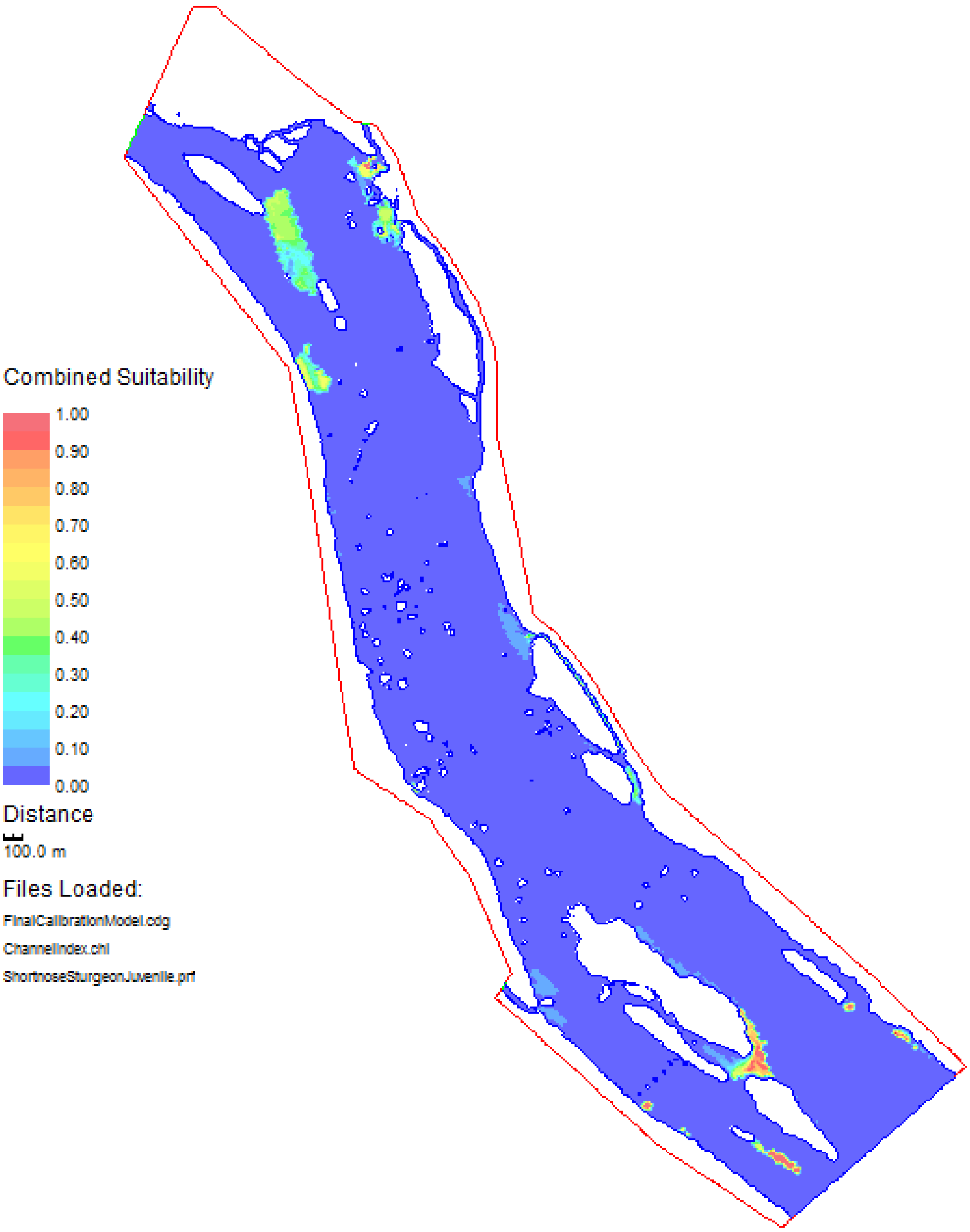
Shortnose Sturgeon Juvenile – 3,500 cfs



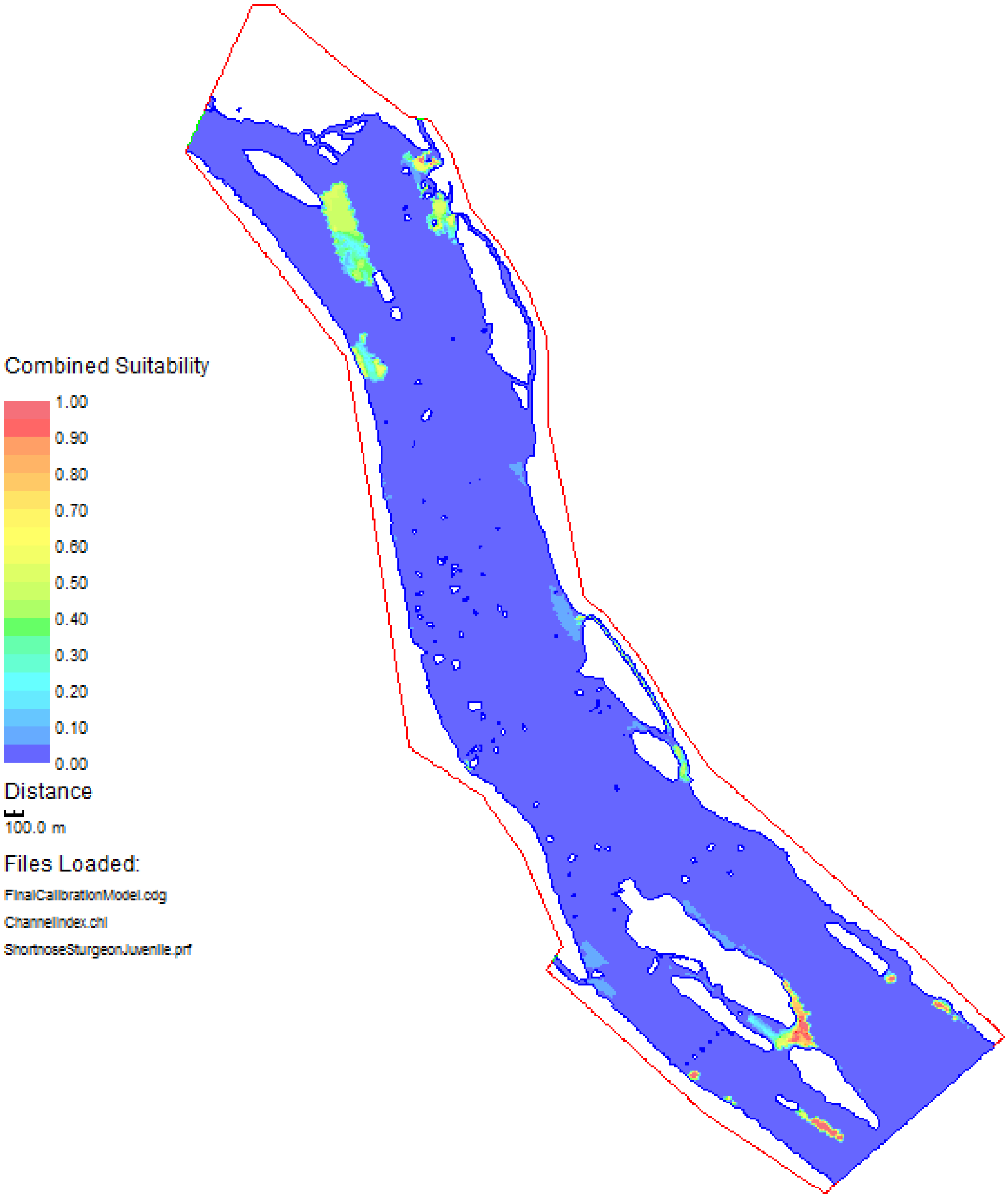
Shortnose Sturgeon Juvenile – 5,000 cfs



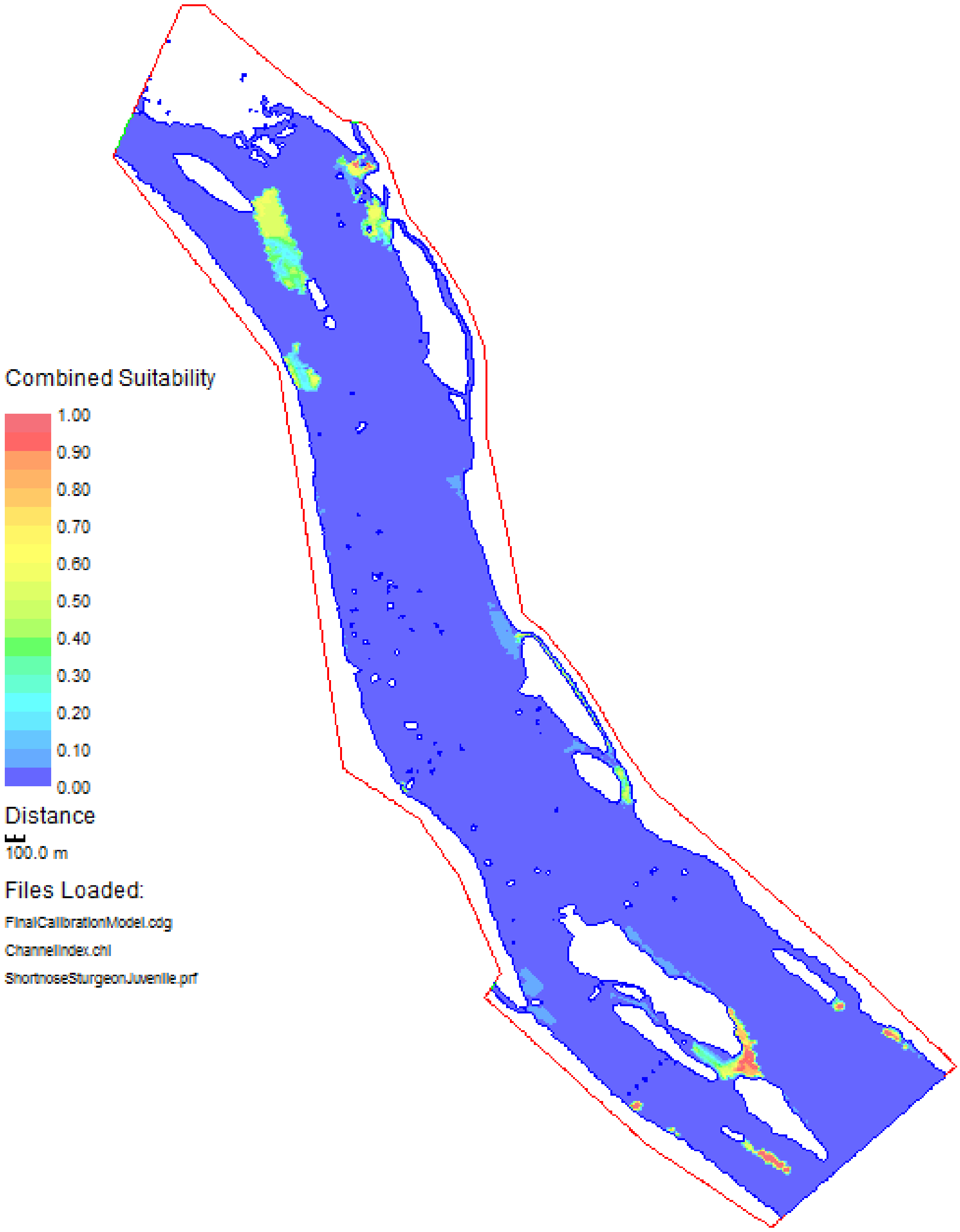
Shortnose Sturgeon Juvenile – 7,500 cfs



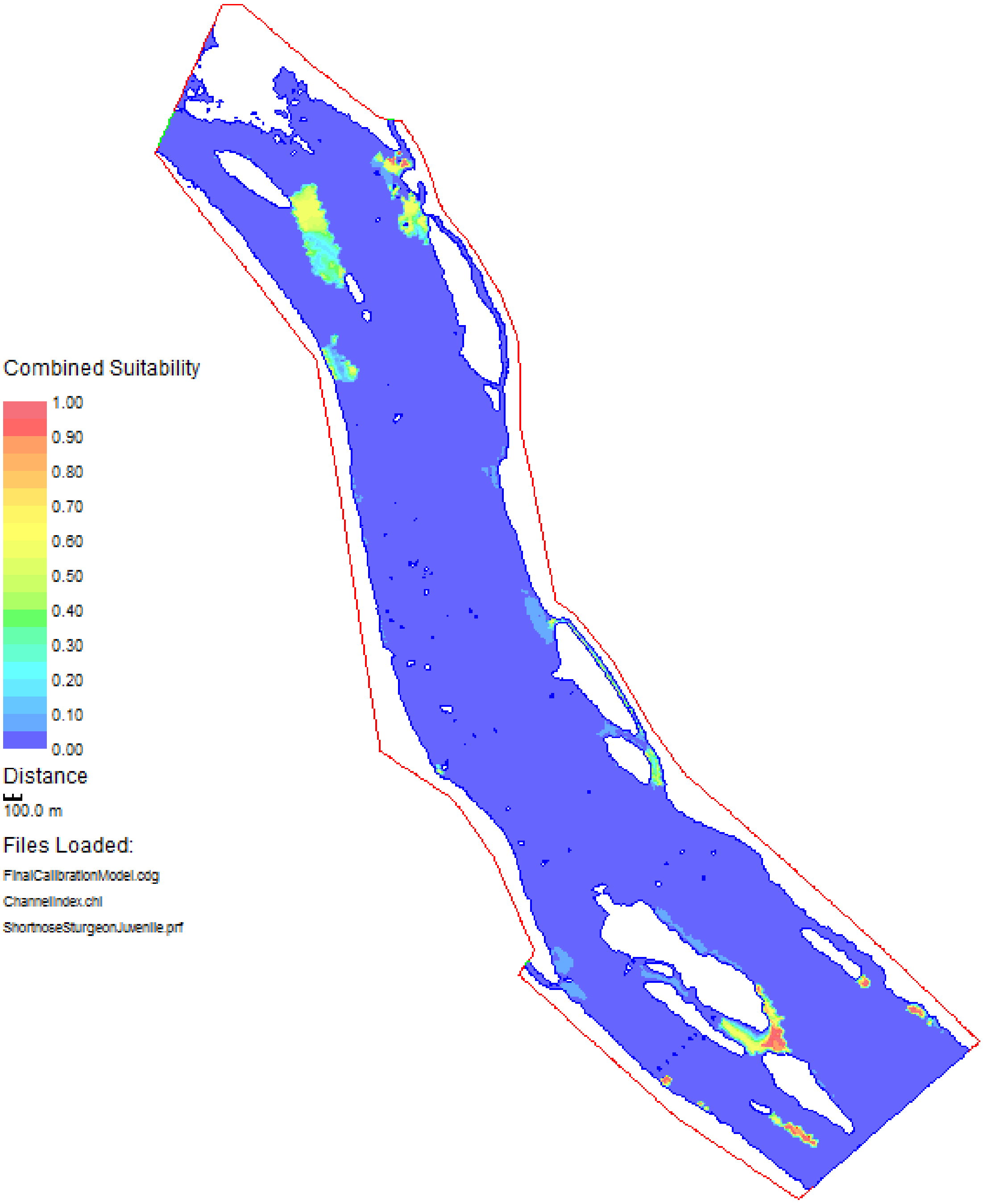
Shortnose Sturgeon Juvenile – 10,000 cfs



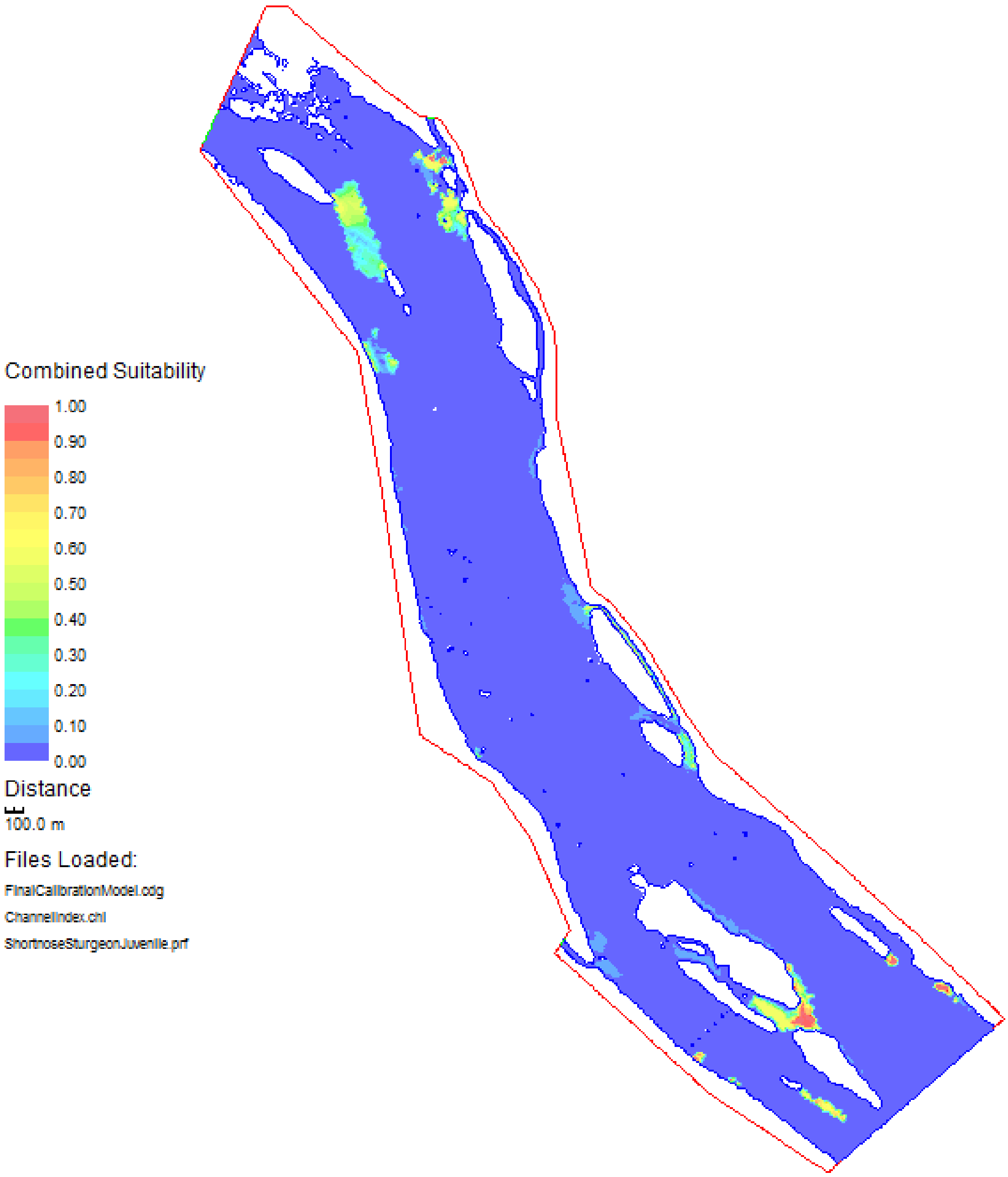
Shortnose Sturgeon Juvenile – 15,000 cfs



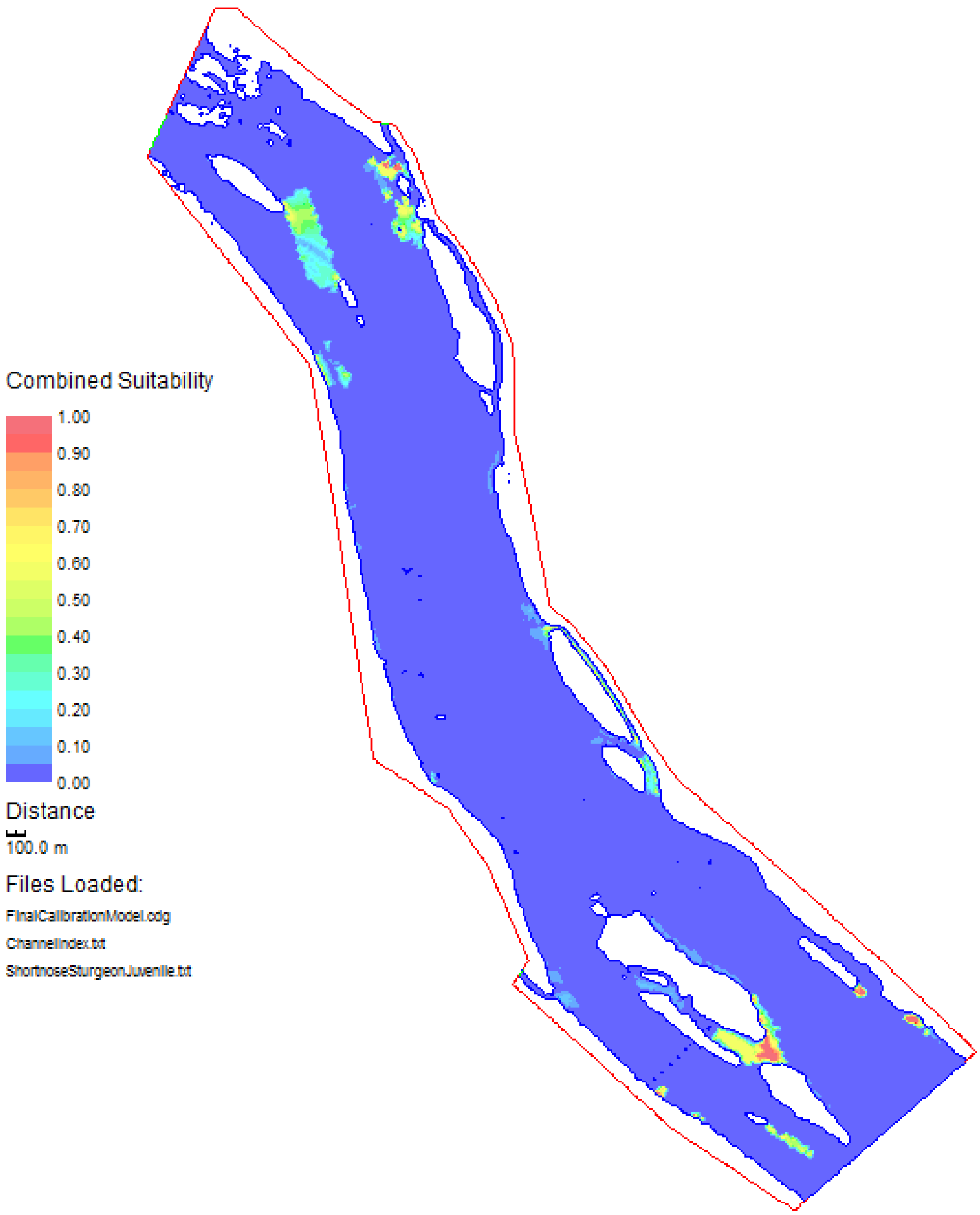
Shortnose Sturgeon Juvenile – 20,000 cfs



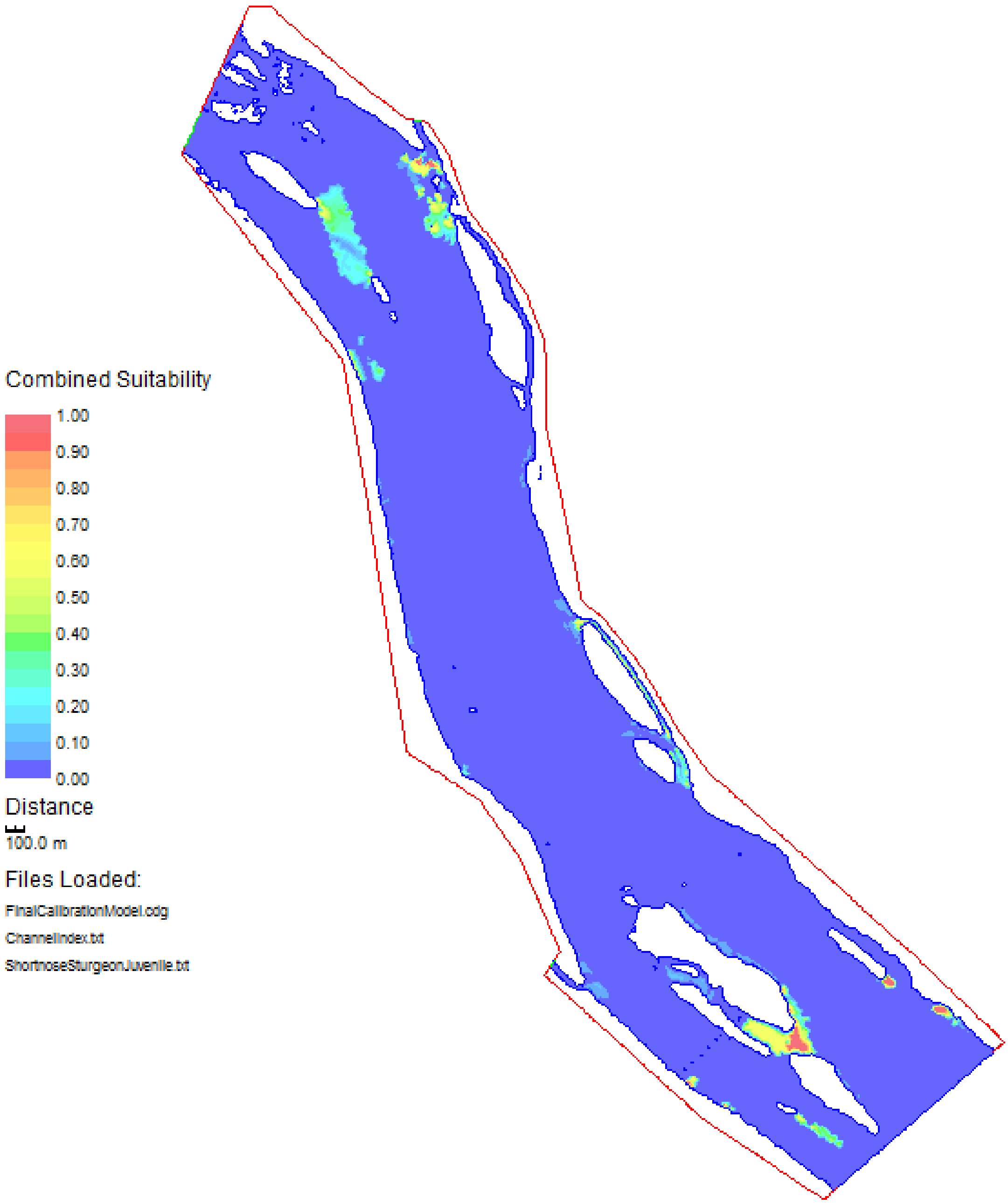
Shortnose Sturgeon Juvenile – 30,000 cfs



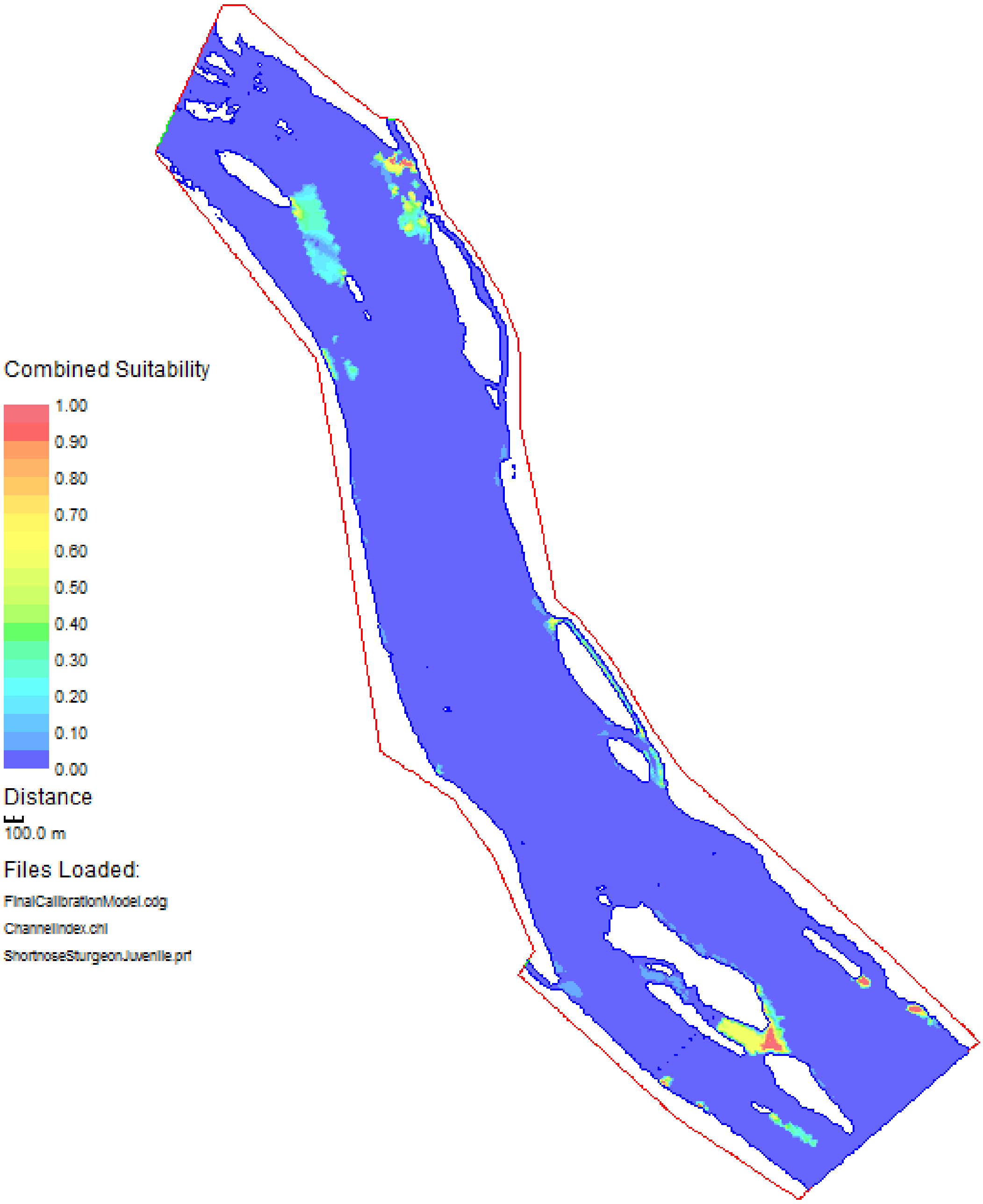
Shortnose Sturgeon Juvenile – 40,000 cfs



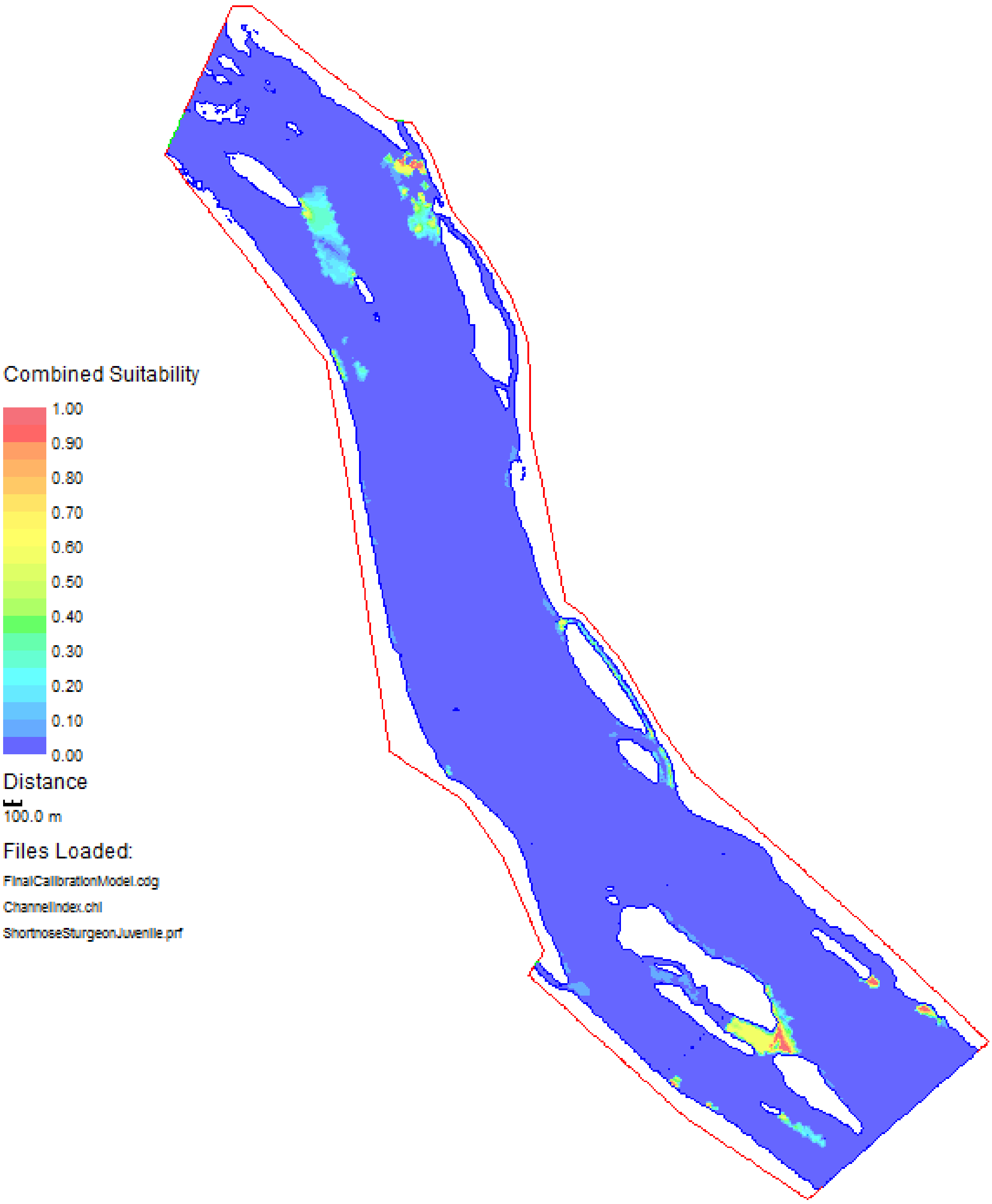
Shortnose Sturgeon Juvenile – 50,000 cfs



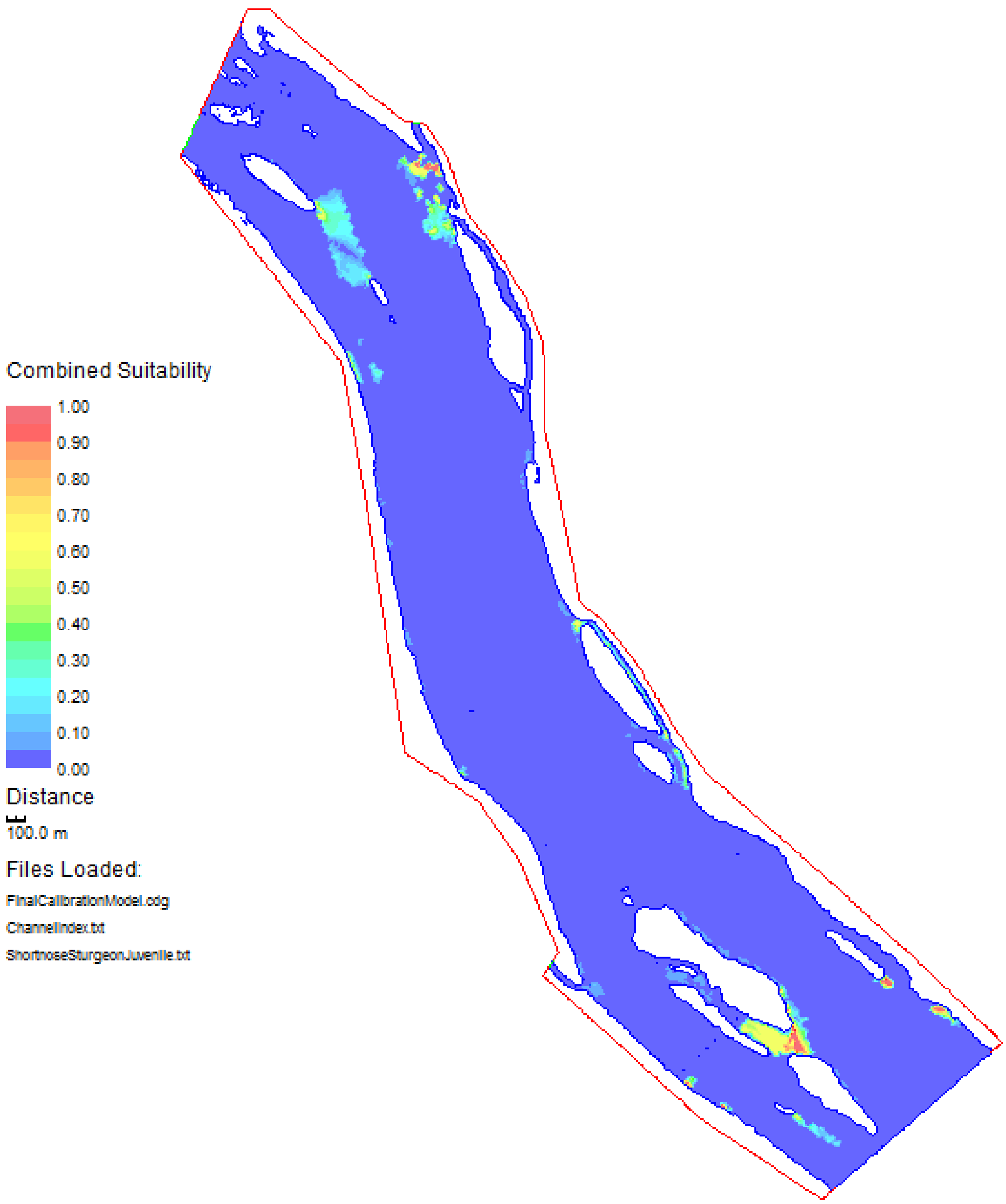
Shortnose Sturgeon Juvenile – 60,000 cfs



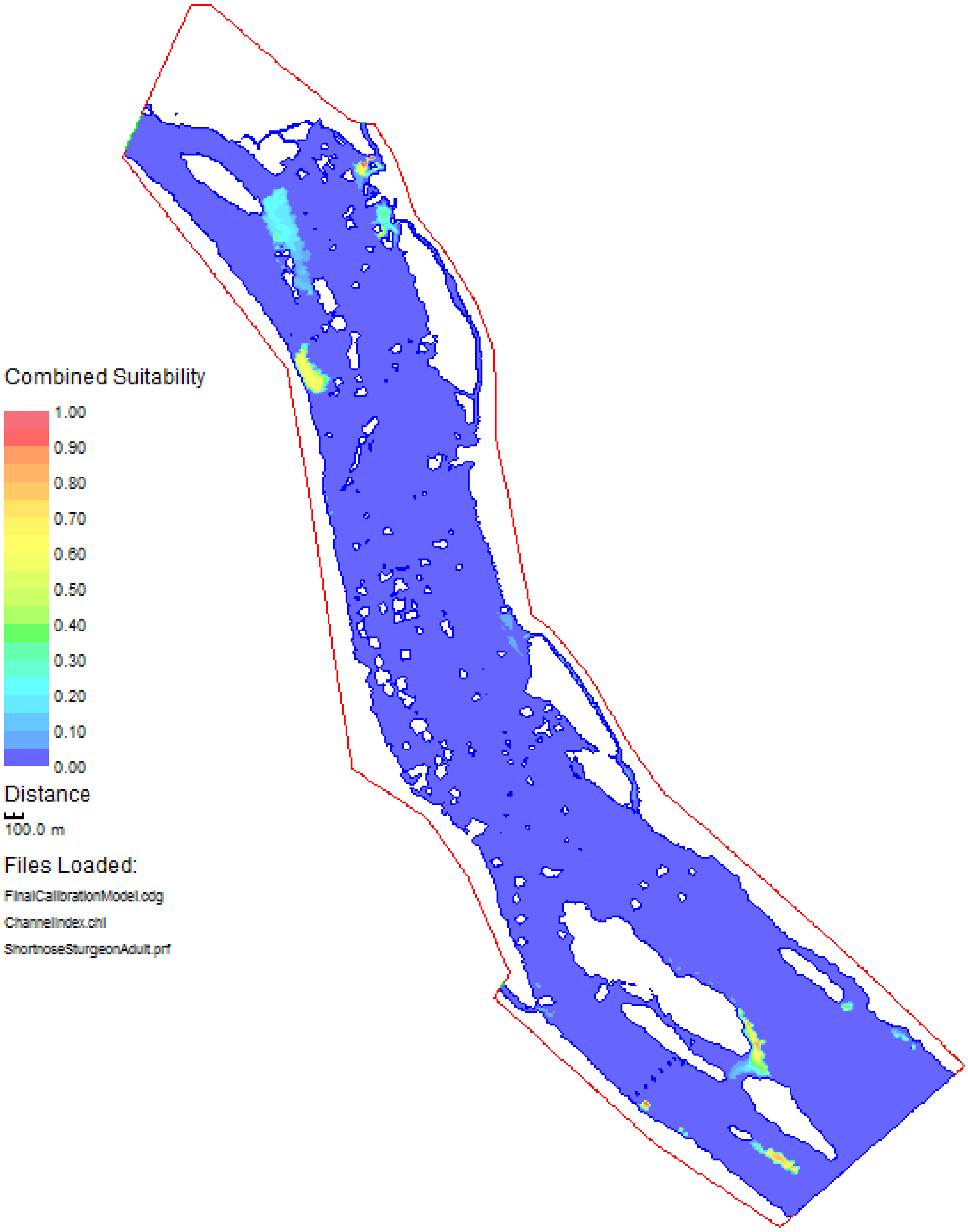
Shortnose Sturgeon Juvenile – 70,000 cfs



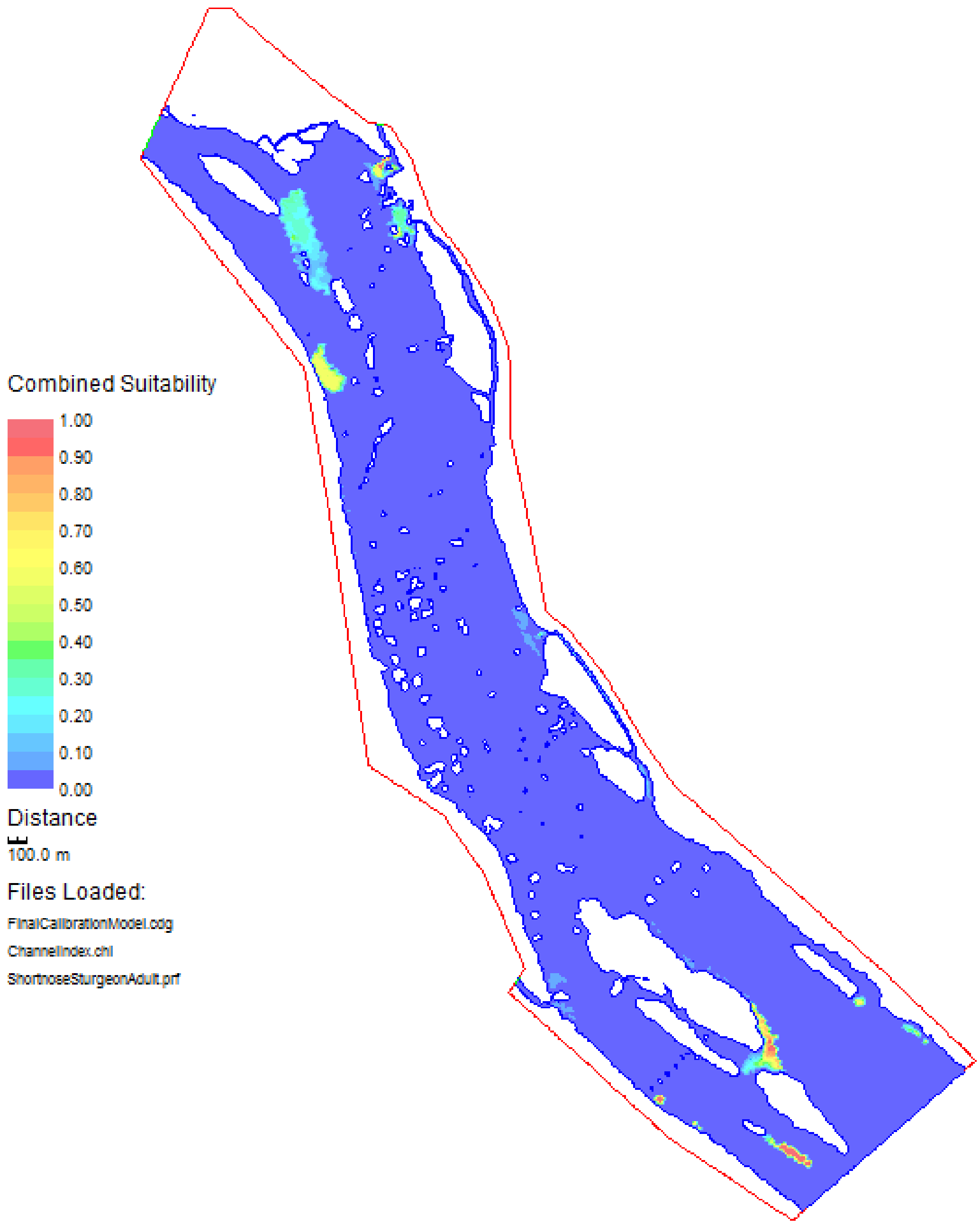
Shortnose Sturgeon Juvenile – 80,000 cfs



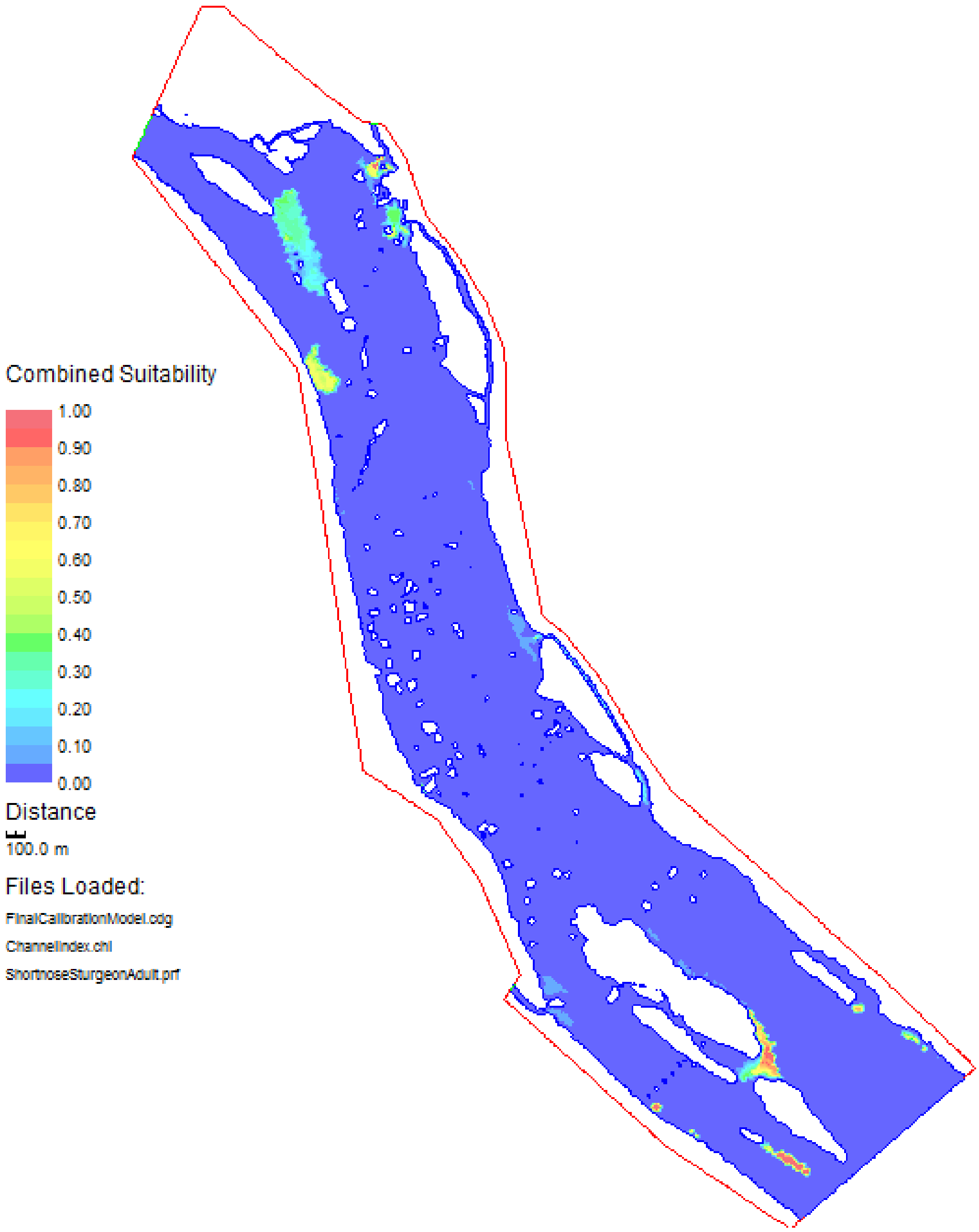
Shortnose Sturgeon Juvenile – 86,000 cfs



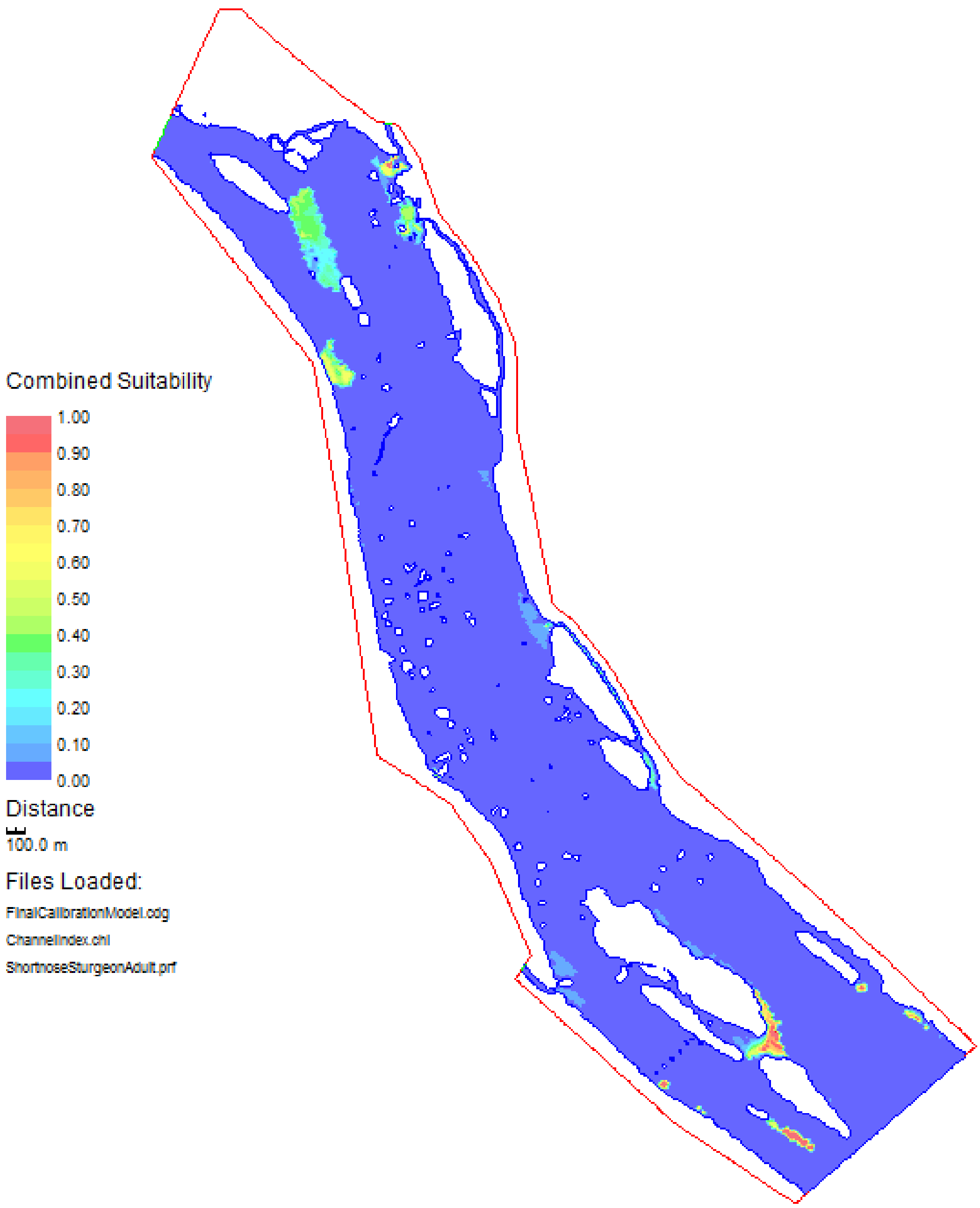
Shortnose Sturgeon Adult – 2,000 cfs



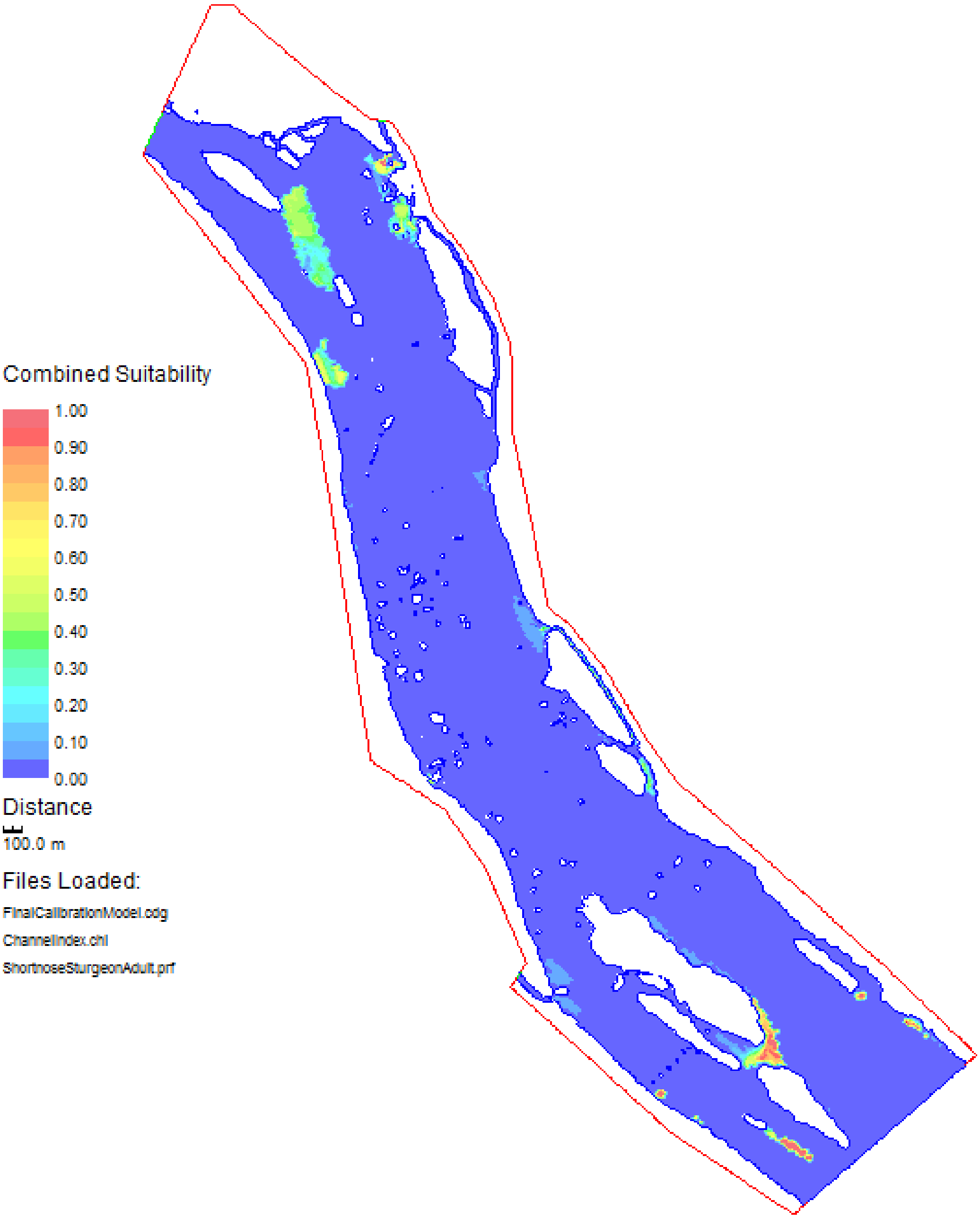
Shortnose Sturgeon Adult – 3,500 cfs



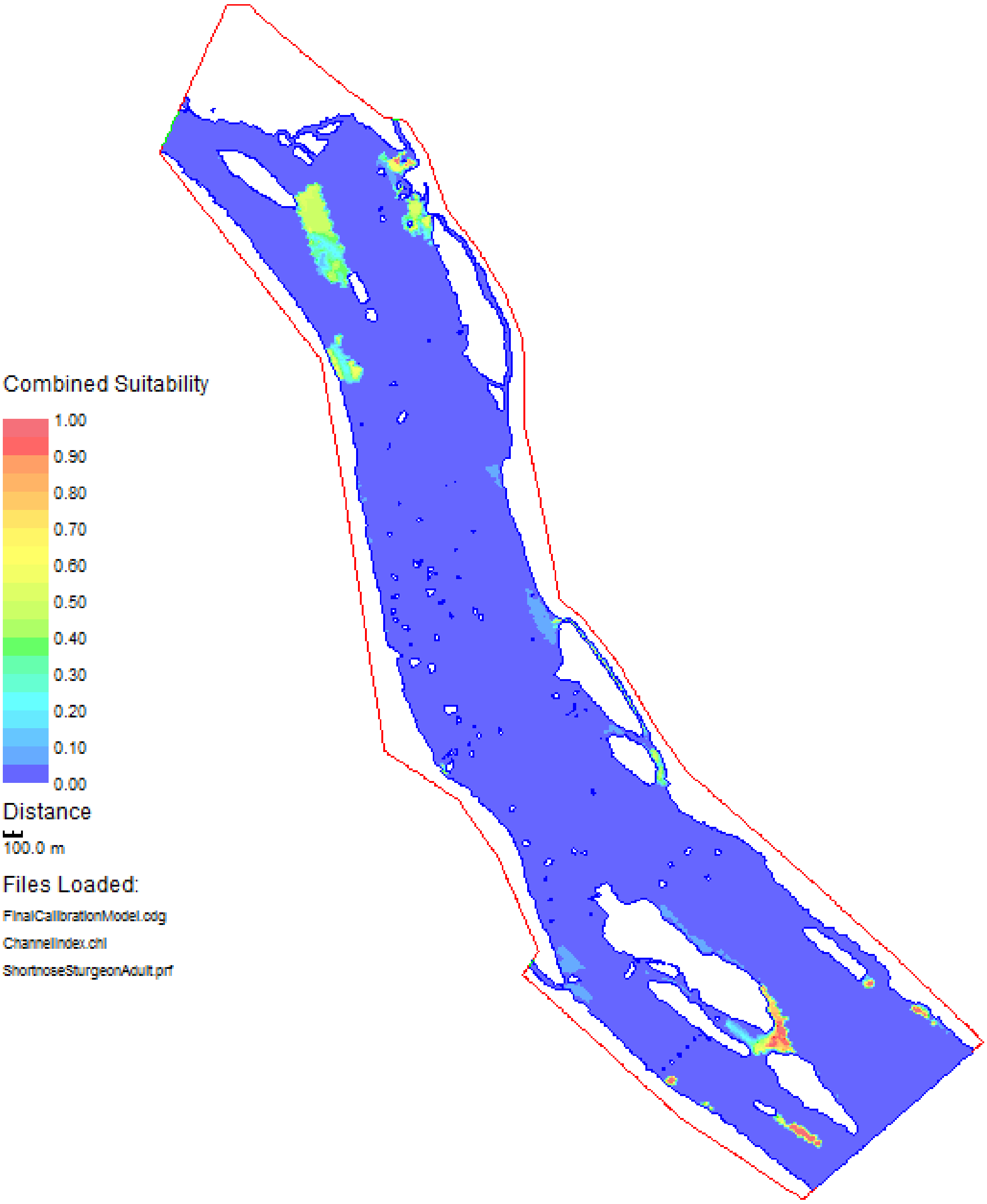
Shortnose Sturgeon Adult – 5,000 cfs



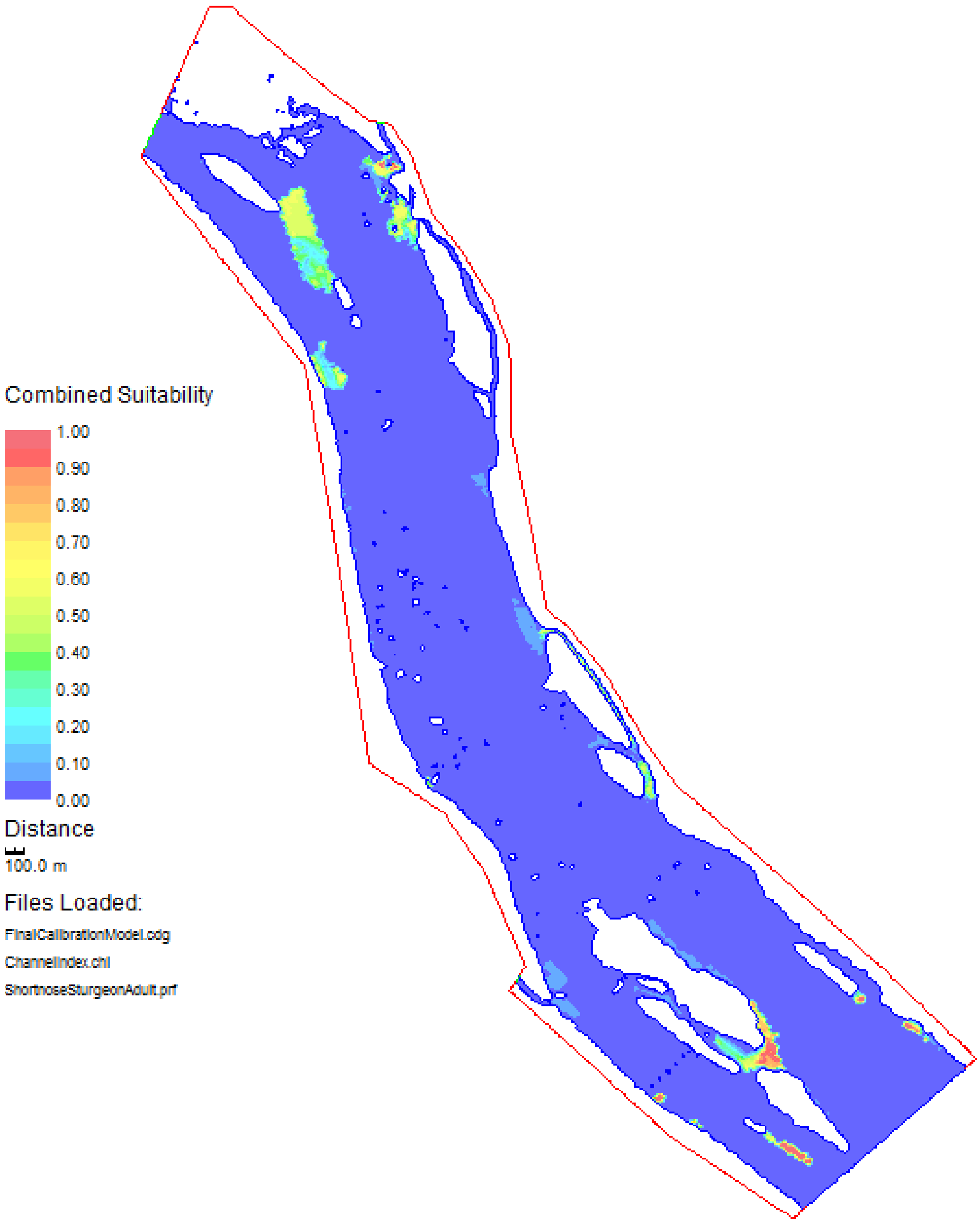
Shortnose Sturgeon Adult – 7,500 cfs



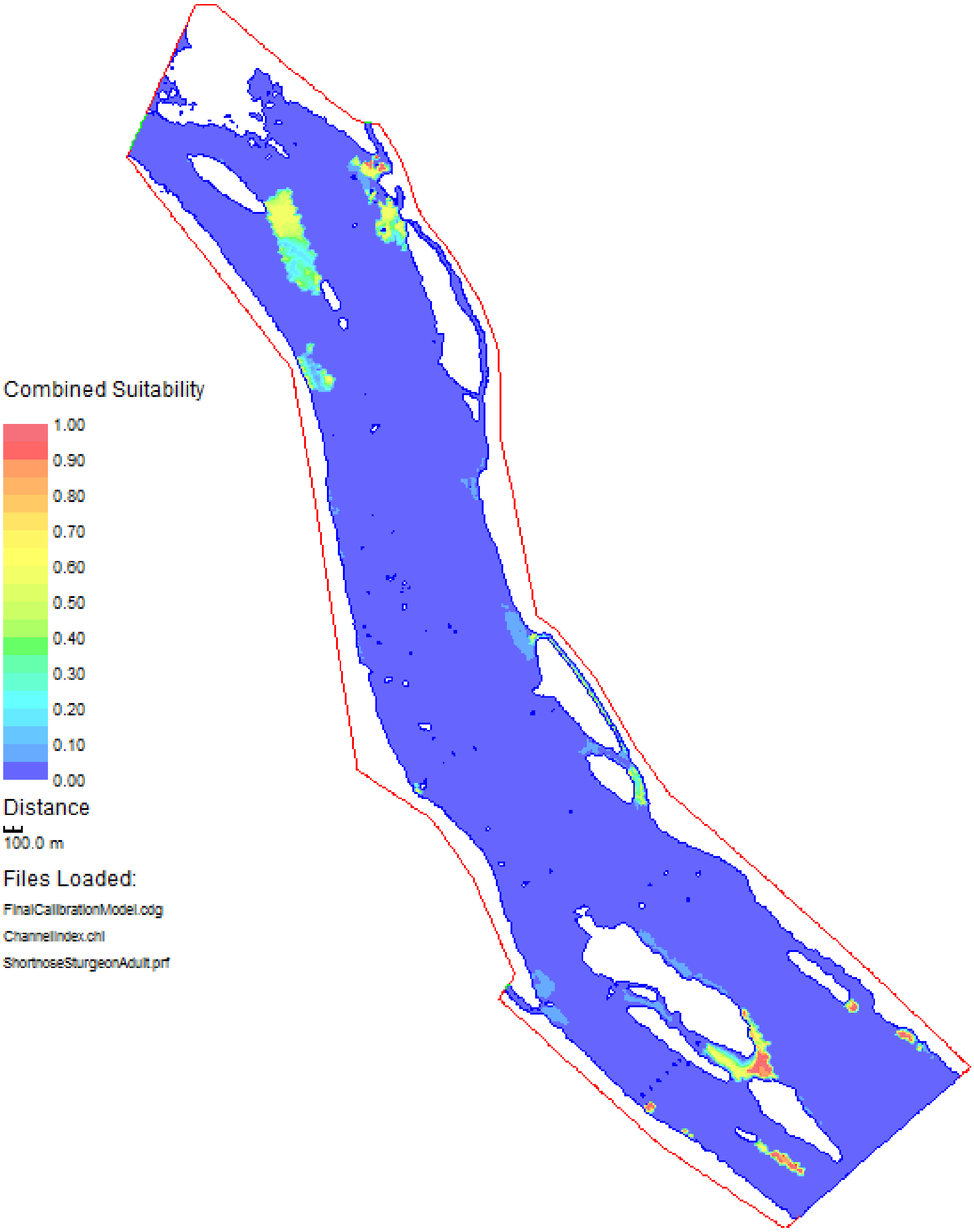
Shortnose Sturgeon Adult – 10,000 cfs



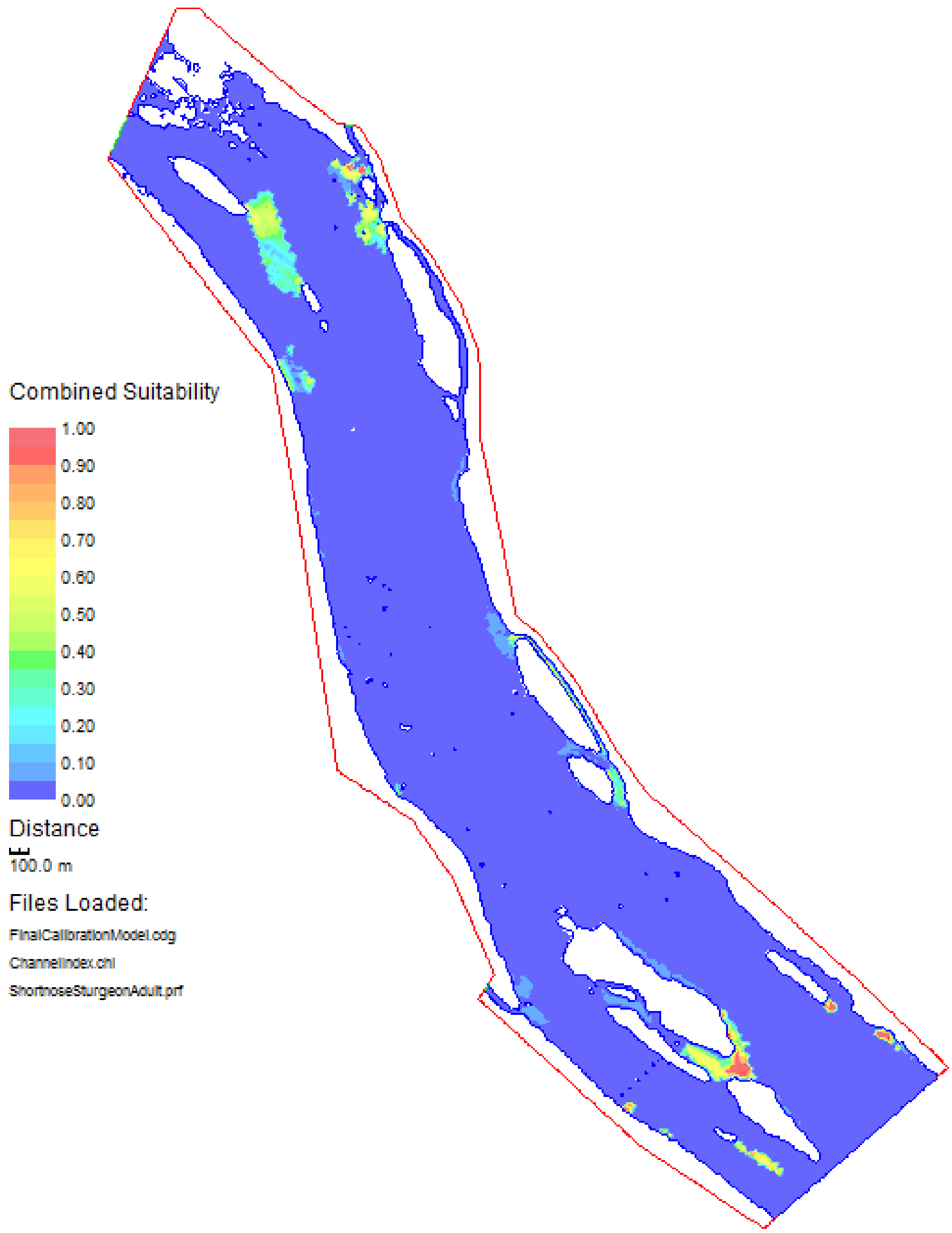
Shortnose Sturgeon Adult – 15,000 cfs



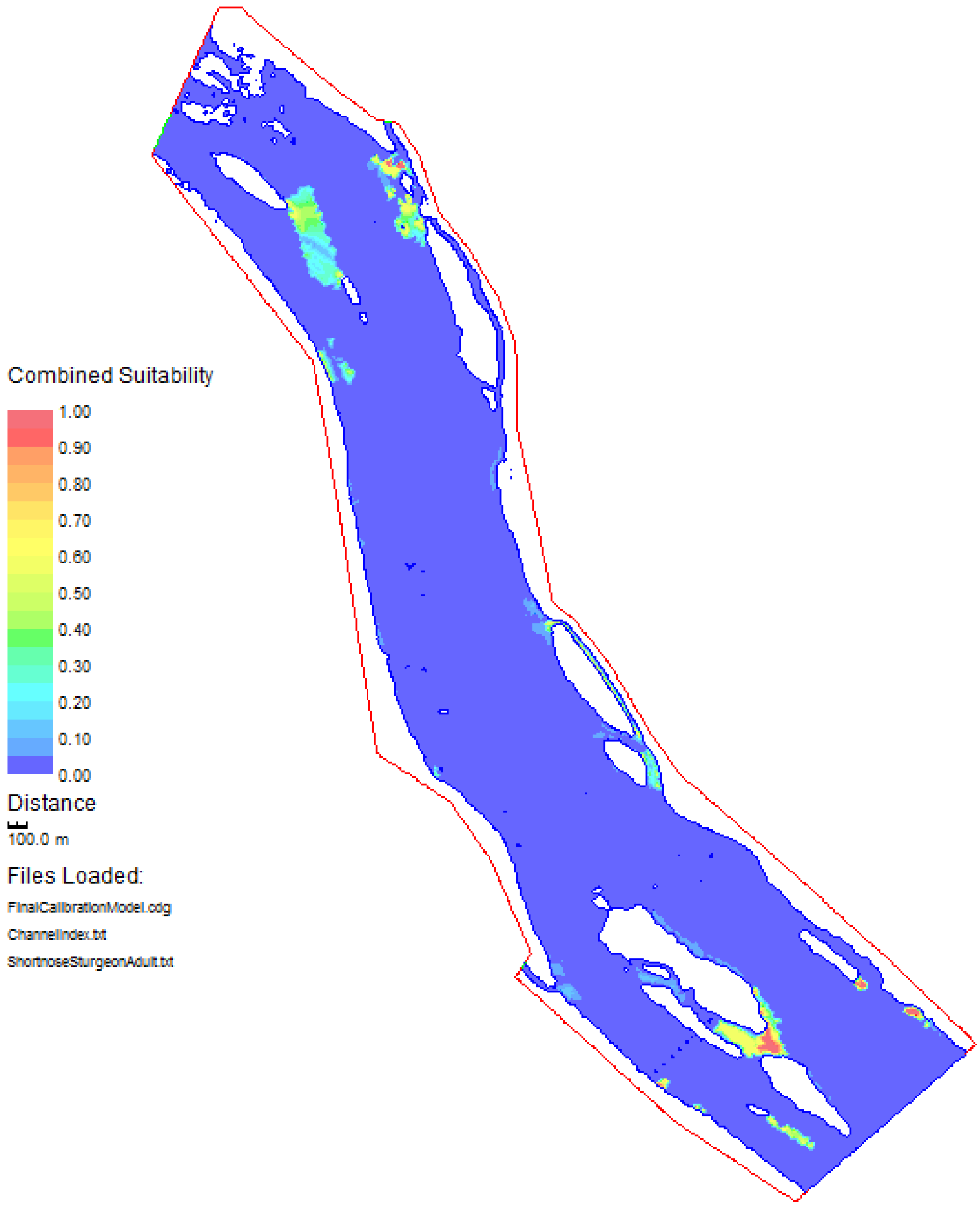
Shortnose Sturgeon Adult – 20,000 cfs



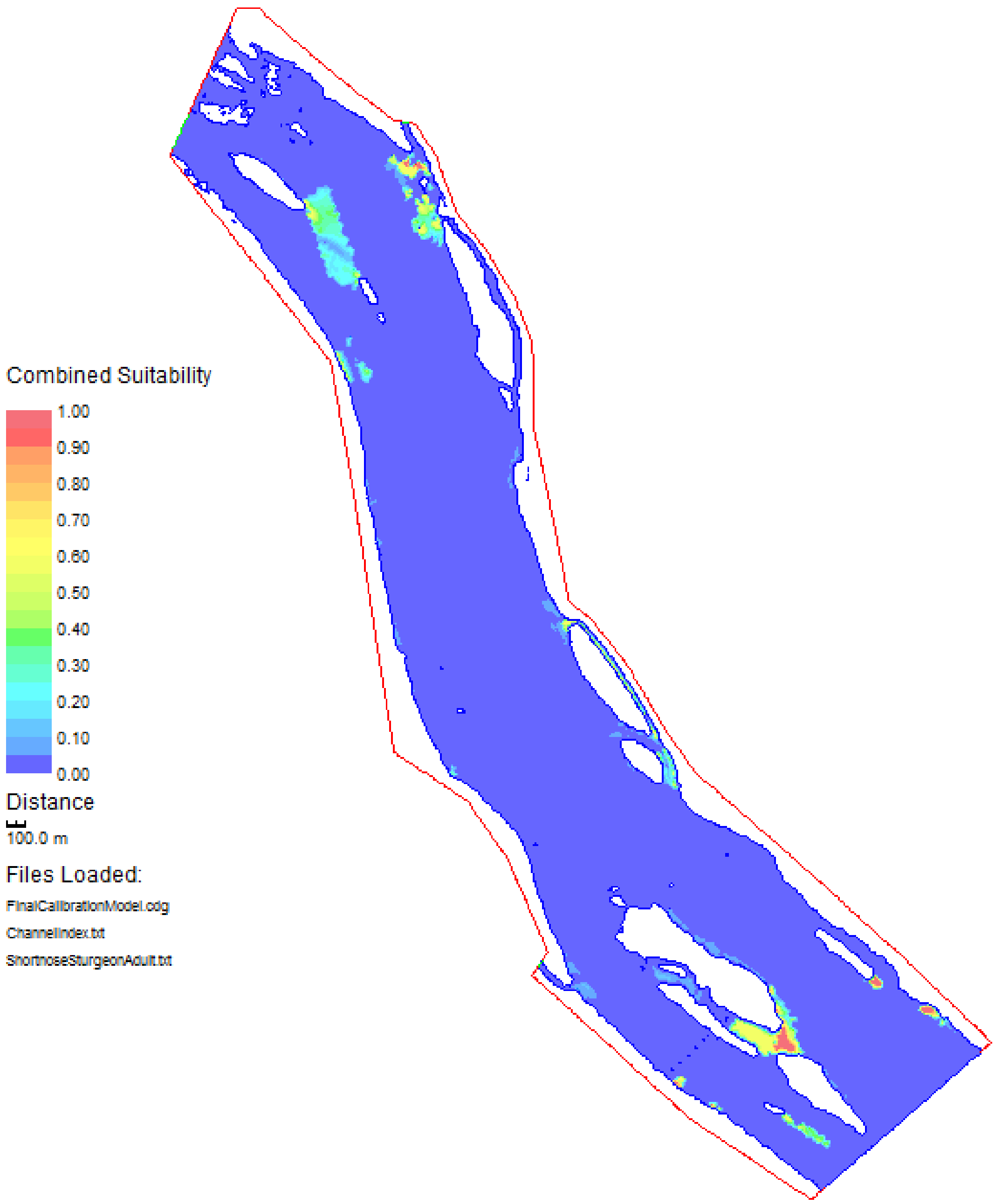
Shortnose Sturgeon Adult – 30,000 cfs



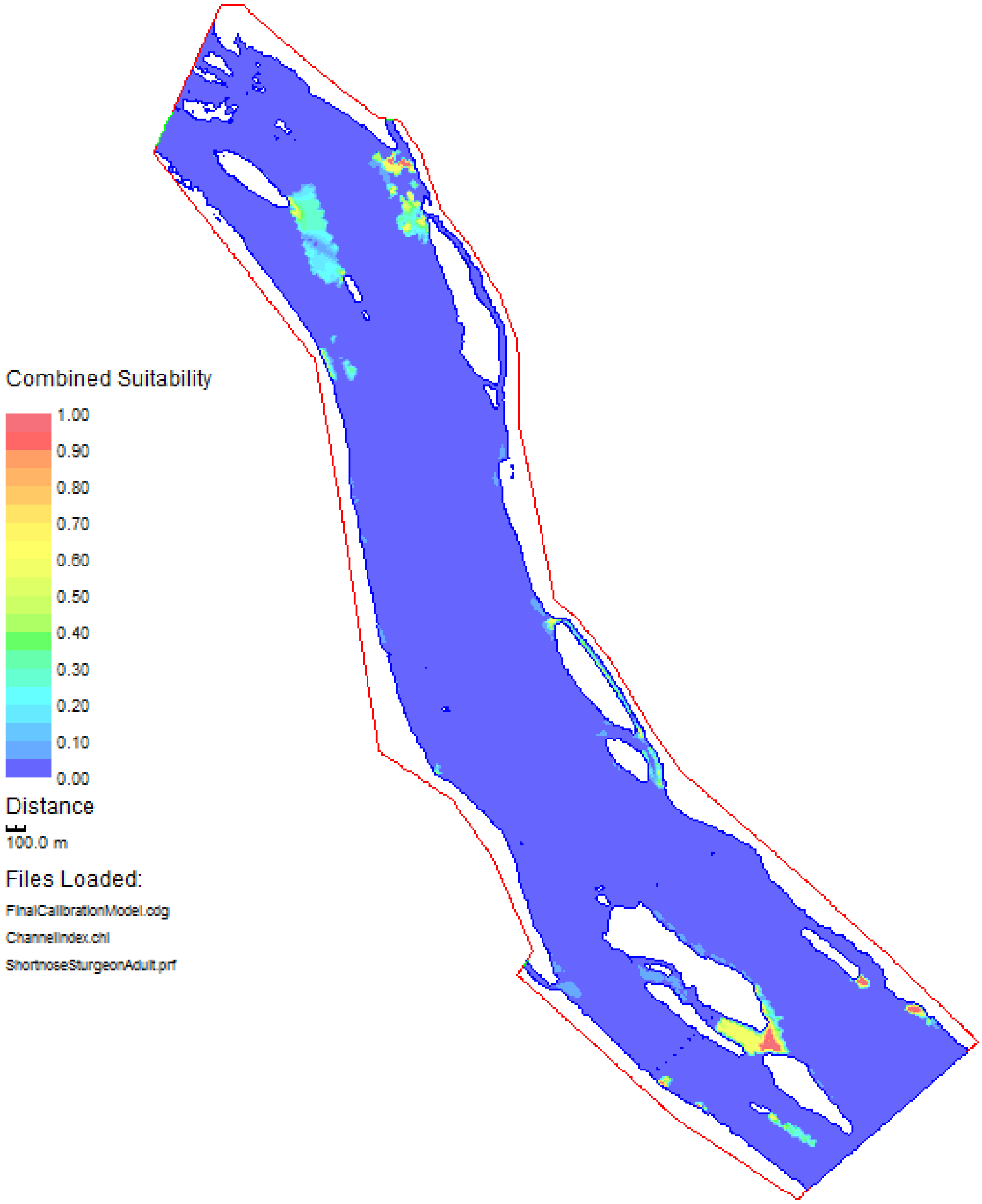
Shortnose Sturgeon Adult – 40,000 cfs



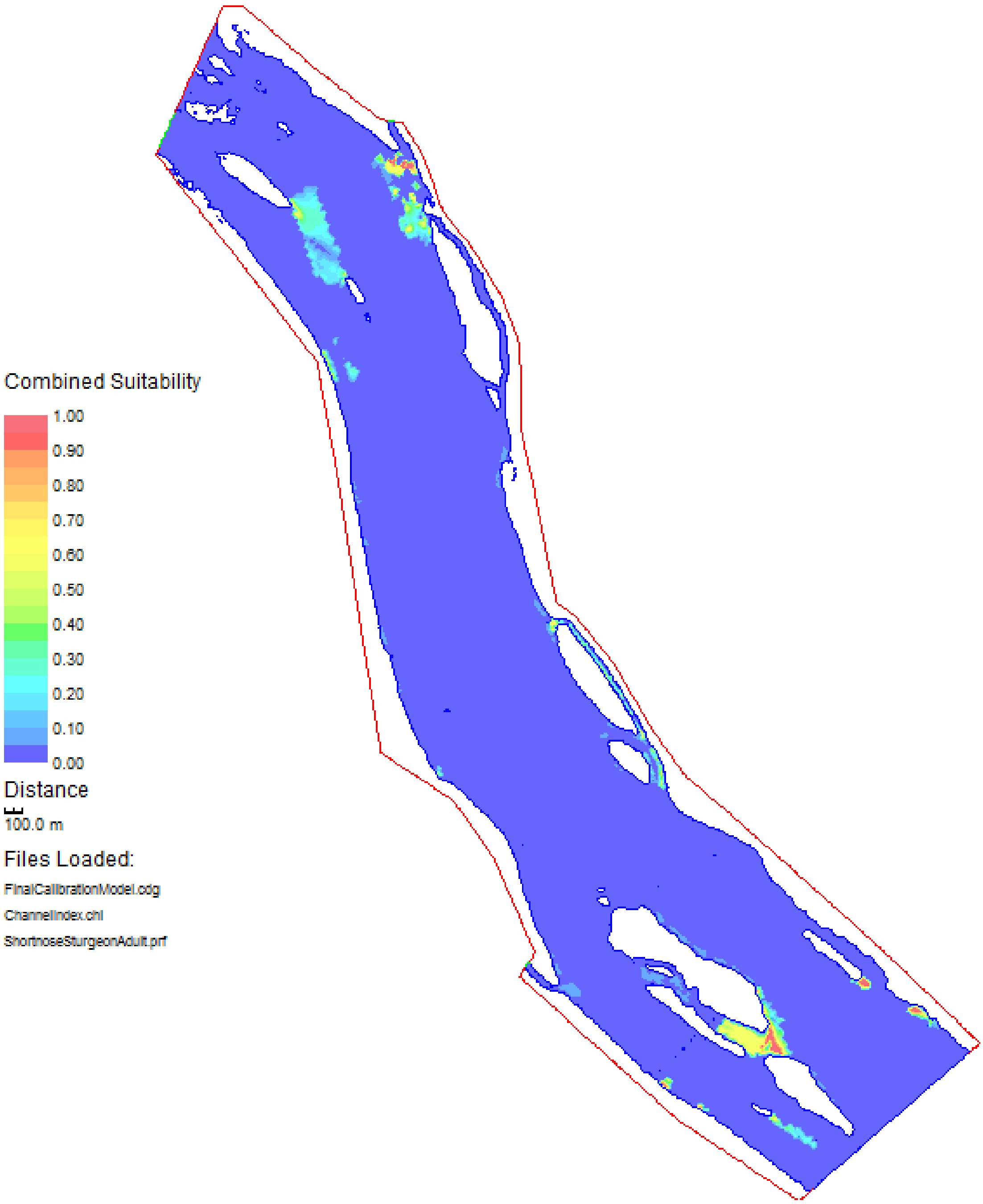
Shortnose Sturgeon Adult – 50,000 cfs



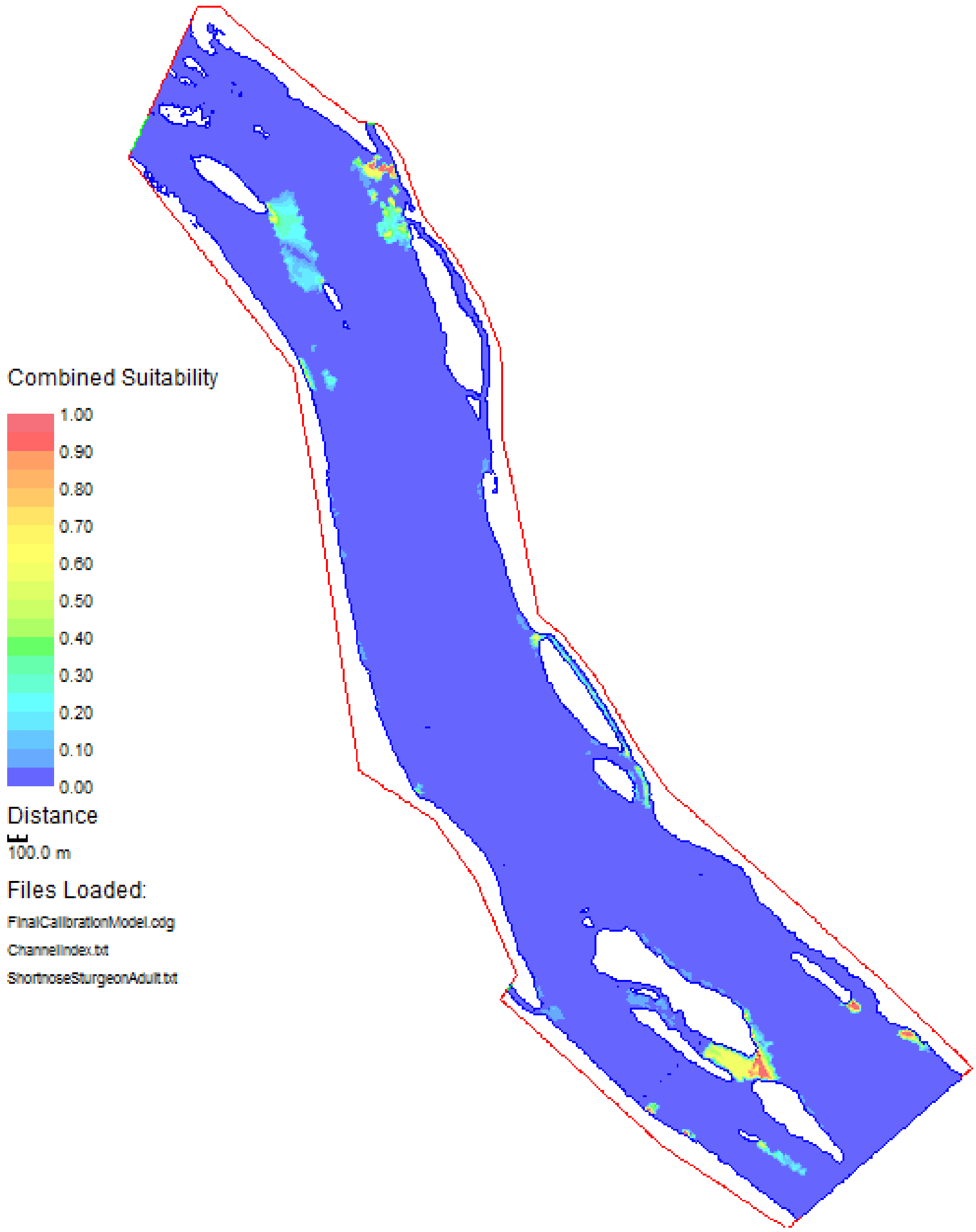
Shortnose Sturgeon Adult – 60,000 cfs



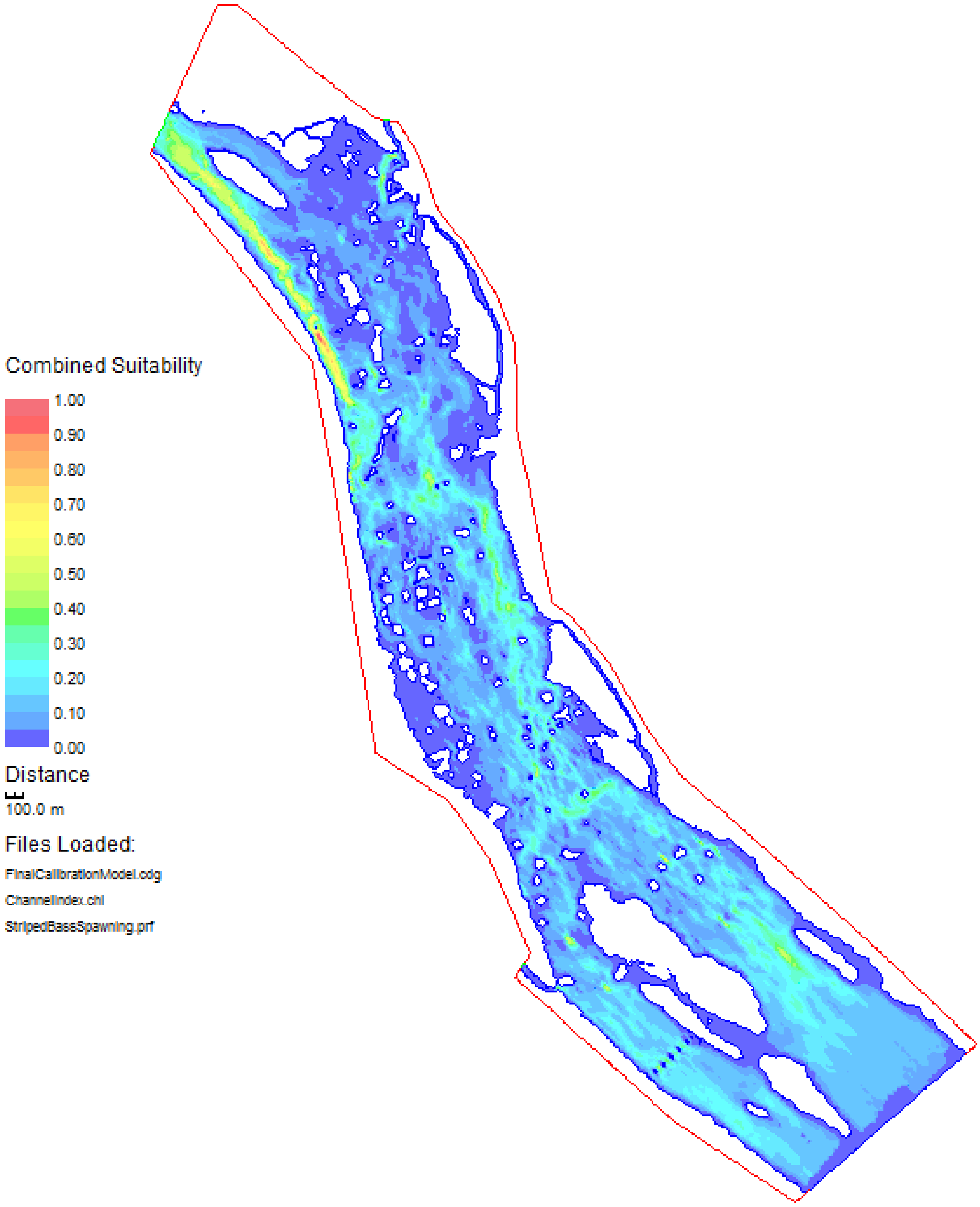
Shortnose Sturgeon Adult – 70,000 cfs



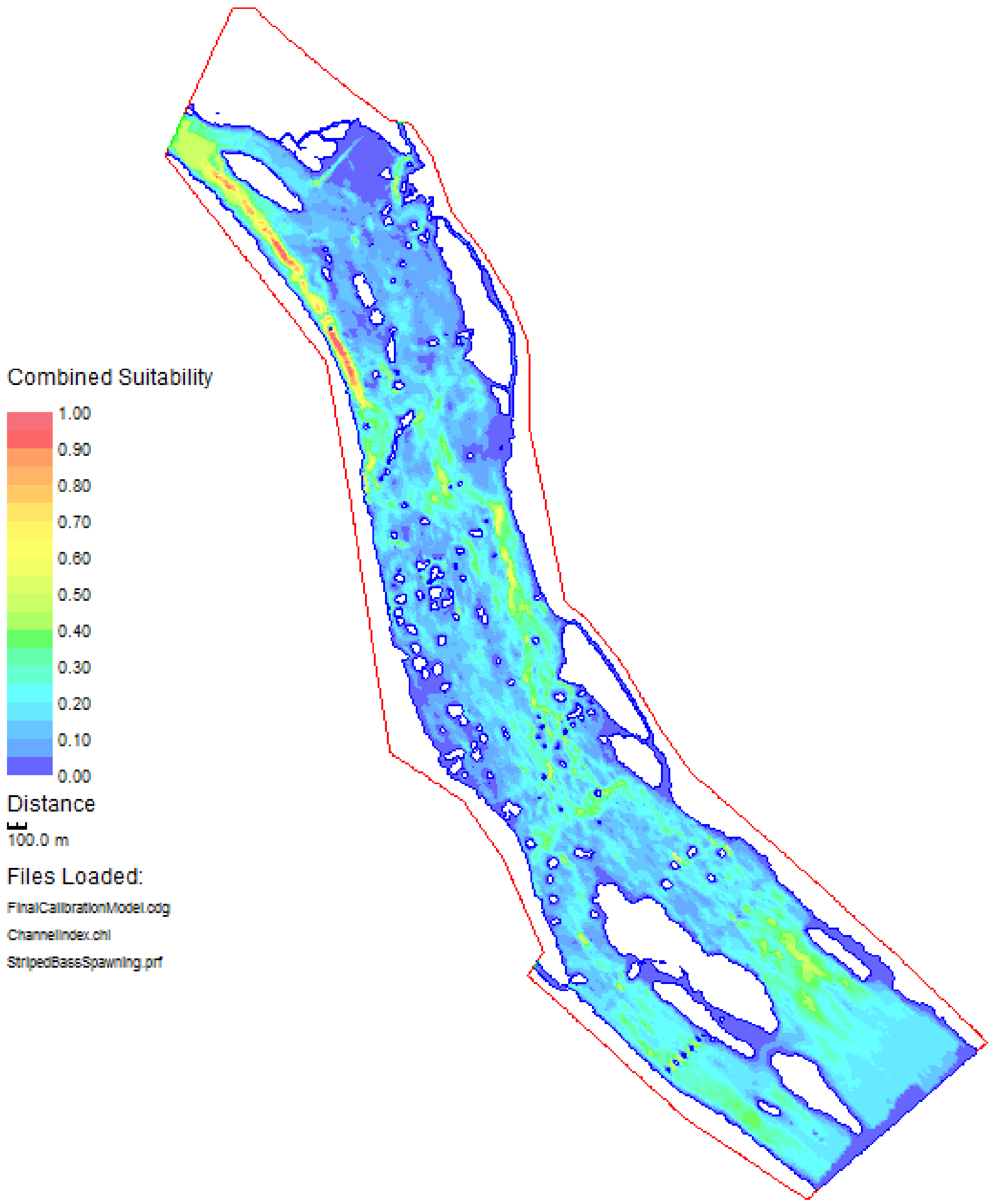
Shortnose Sturgeon Adult – 80,000 cfs



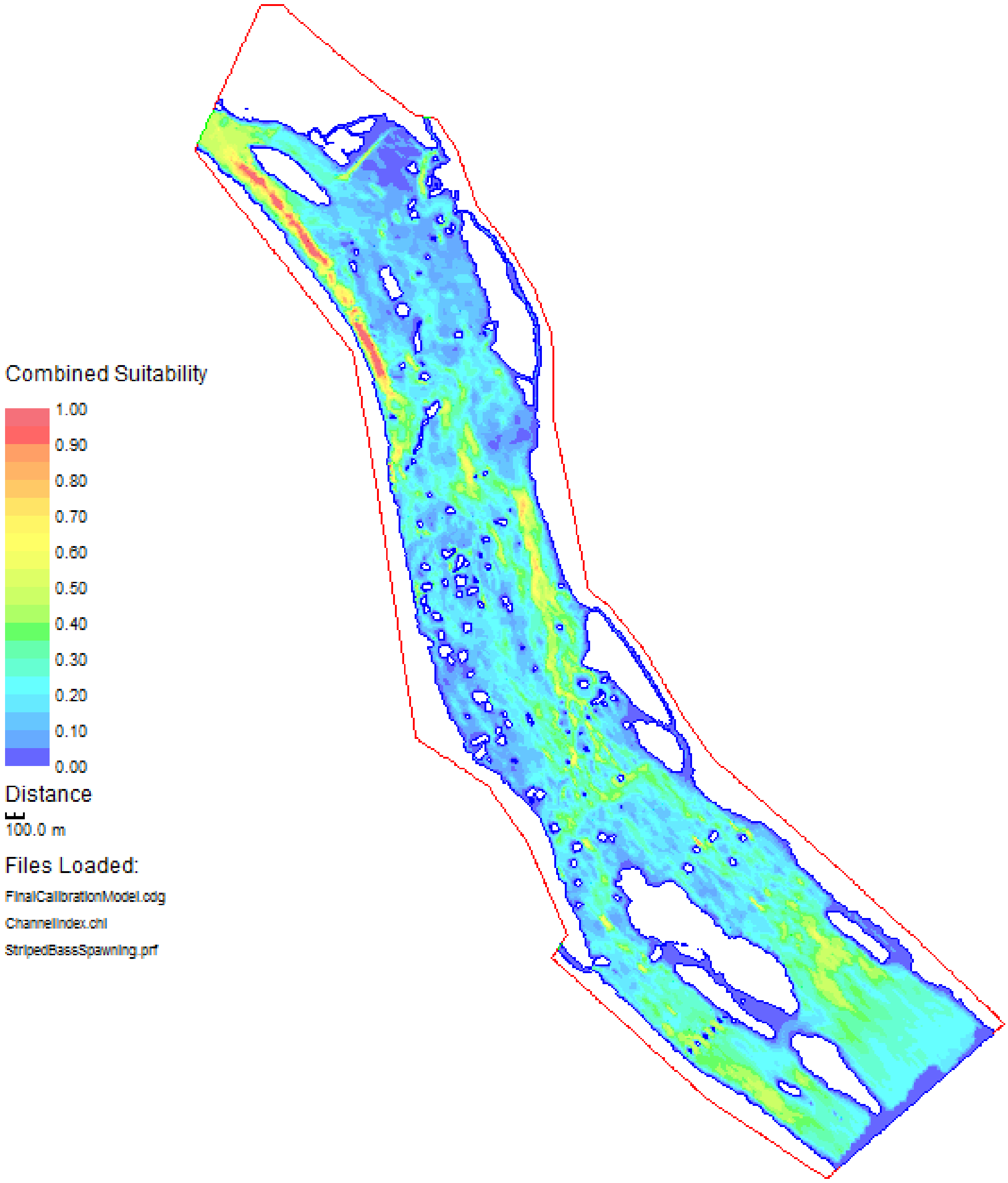
Shortnose Sturgeon Adult – 86,000 cfs



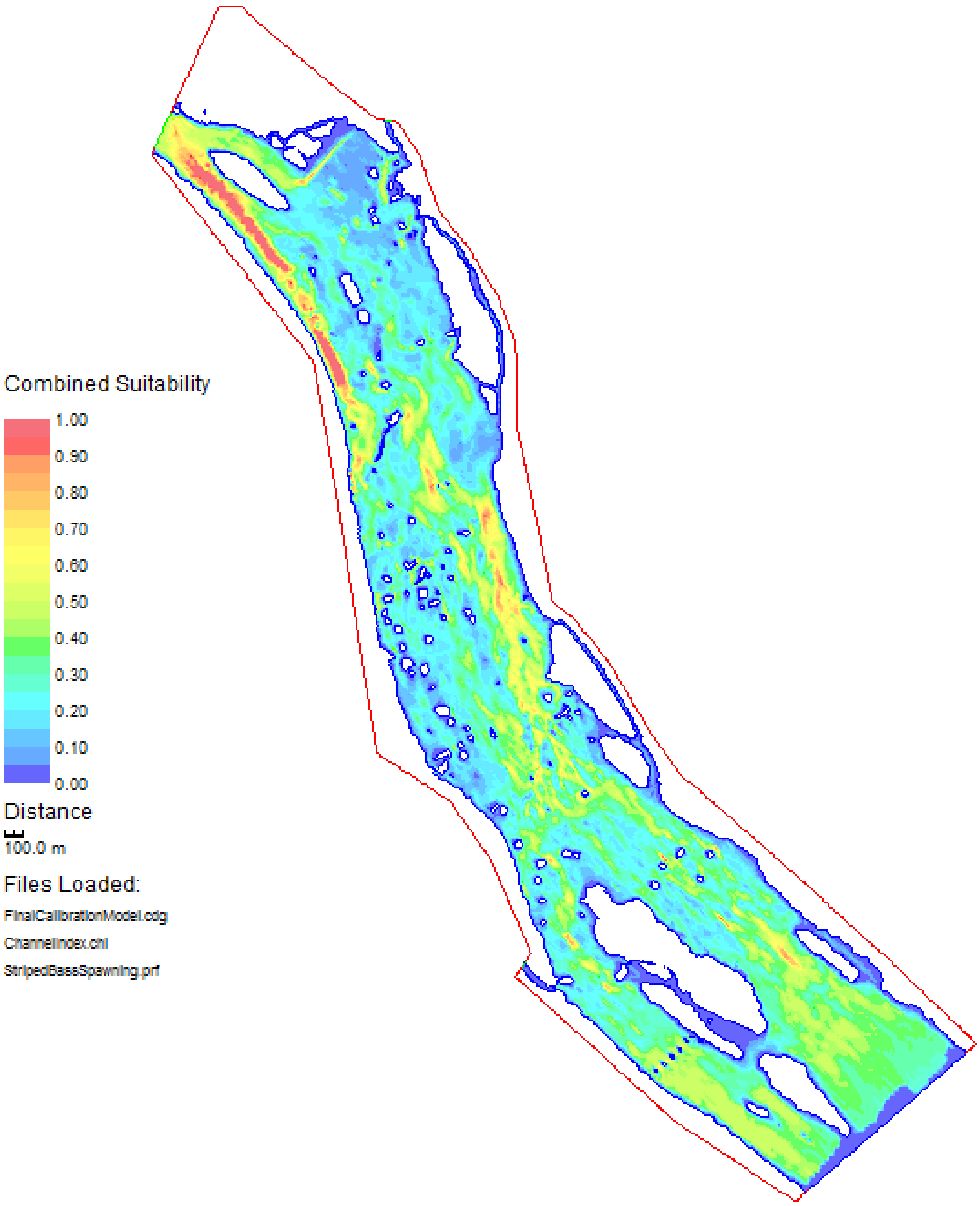
Striped Bass Spawning – 2,000 cfs



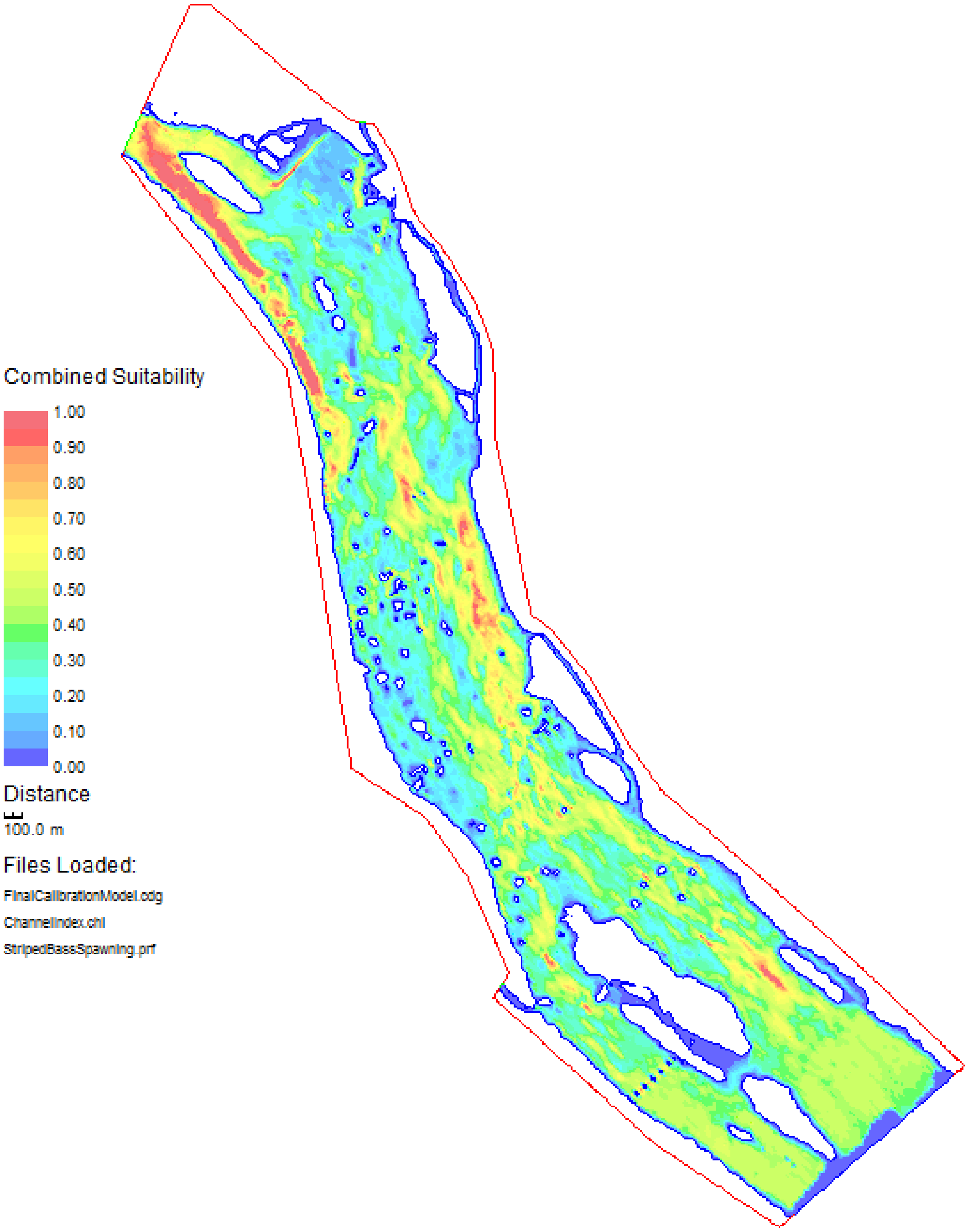
Striped Bass Spawning – 3,500 cfs



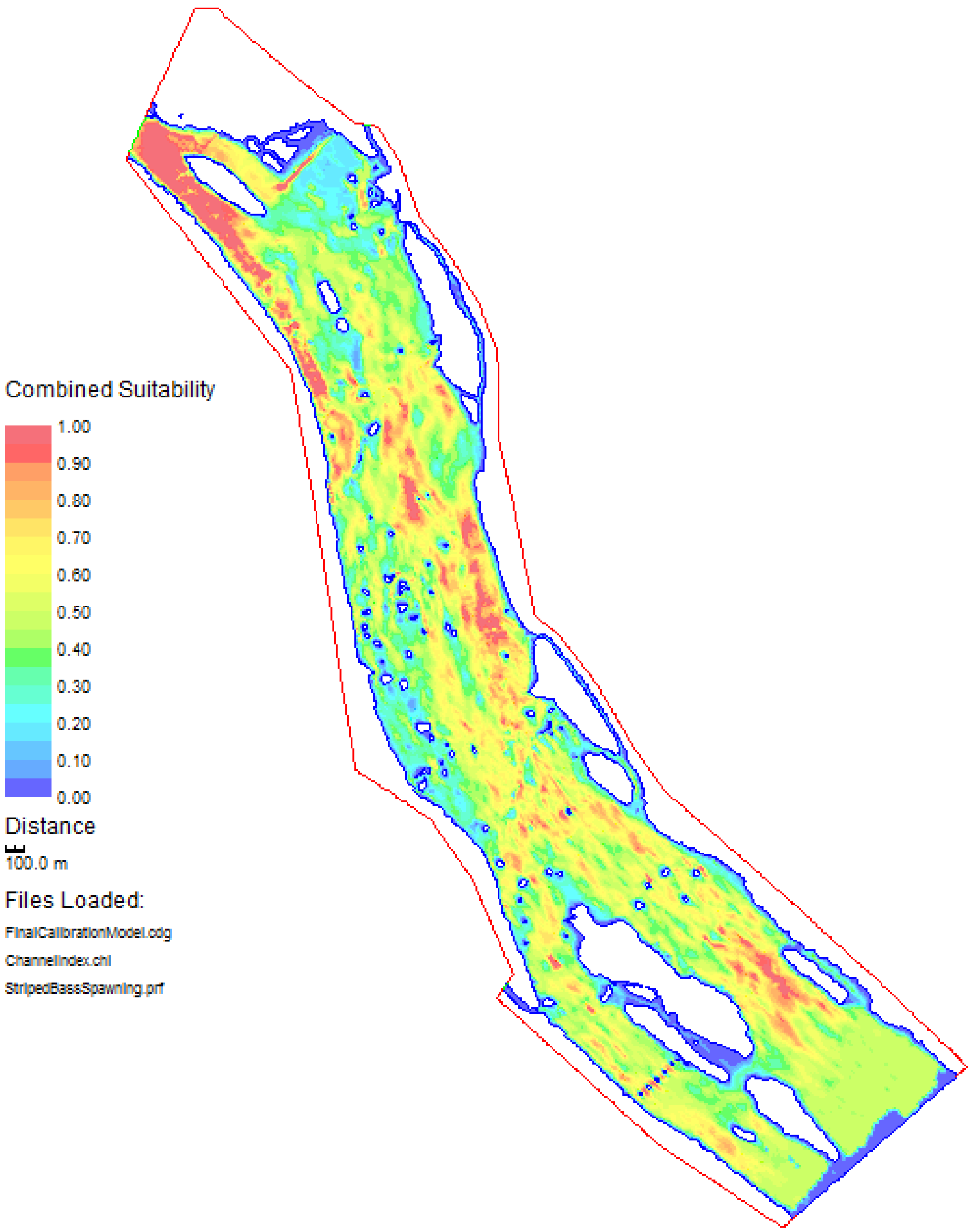
Striped Bass Spawning – 5,000 cfs



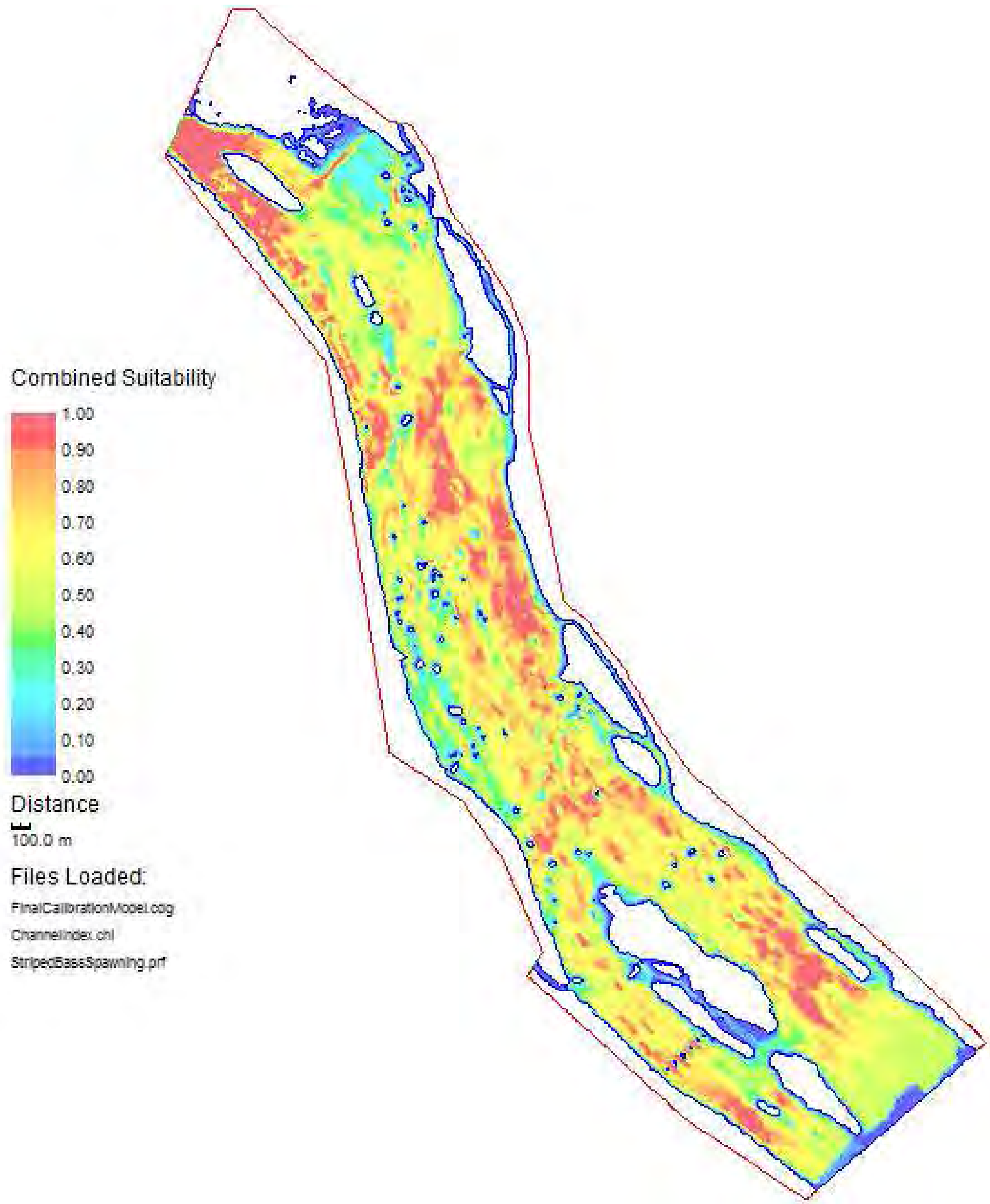
Striped Bass Spawning – 7,500 cfs



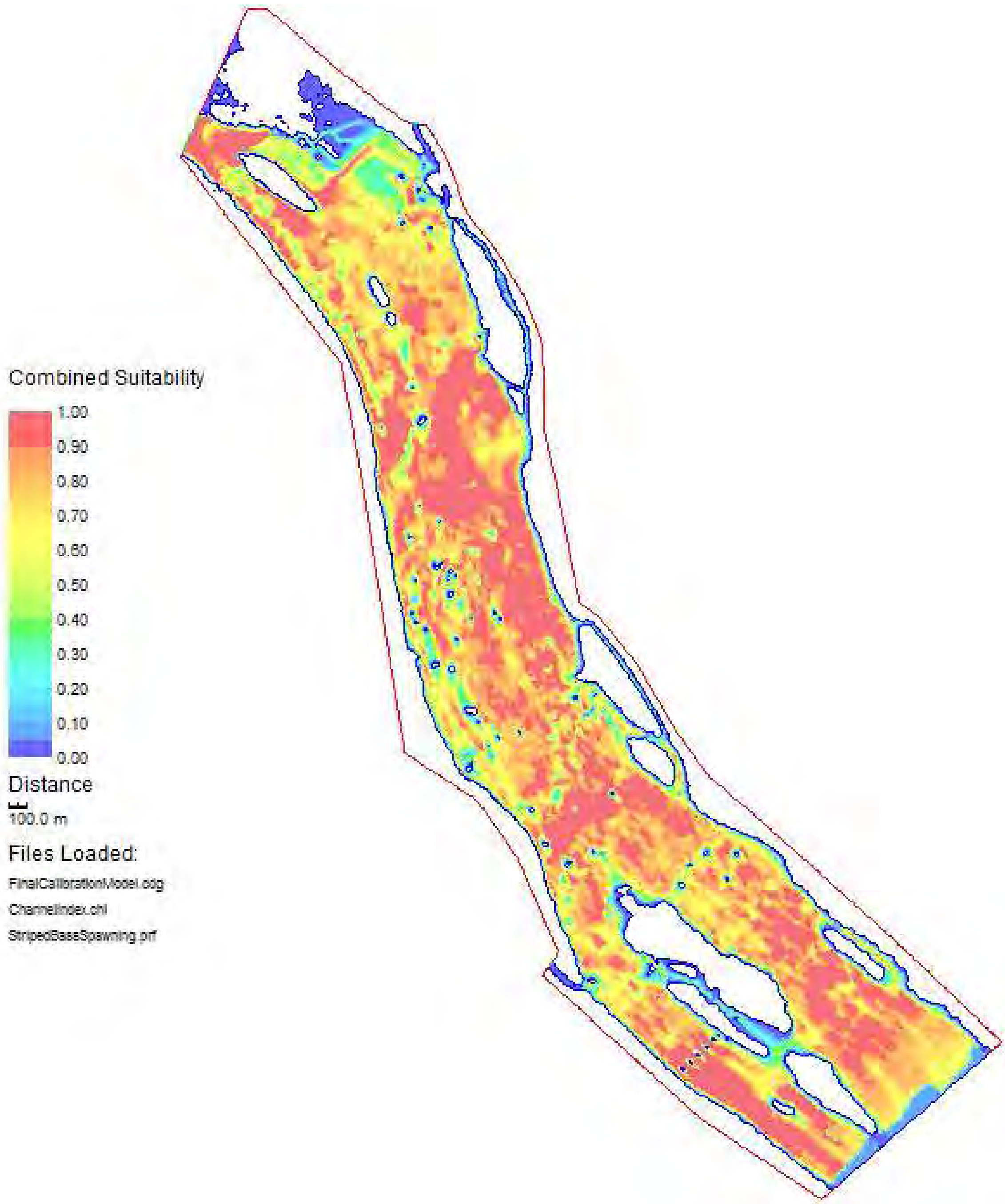
Striped Bass Spawning – 10,000 cfs



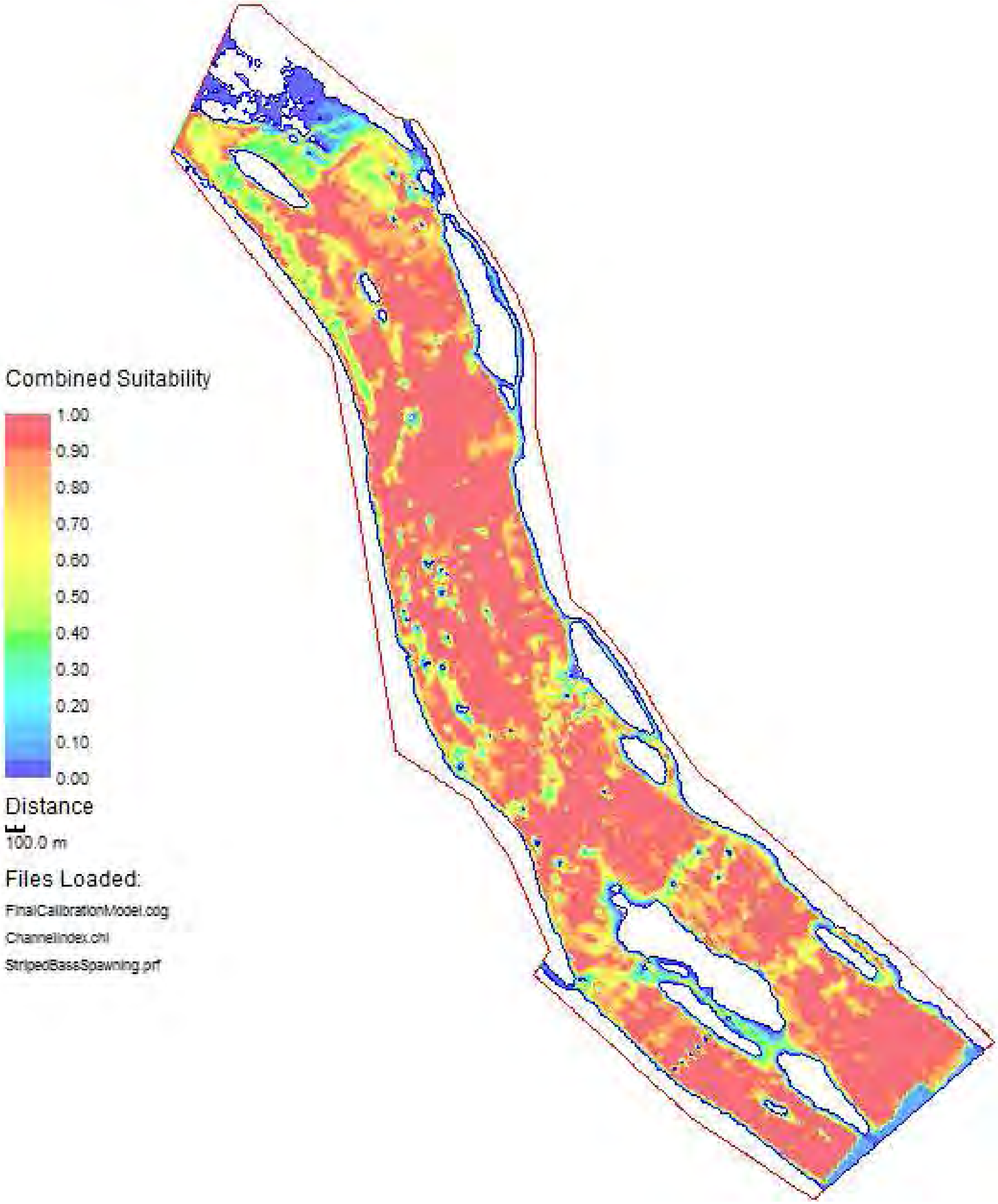
Striped Bass Spawning – 15,000 cfs



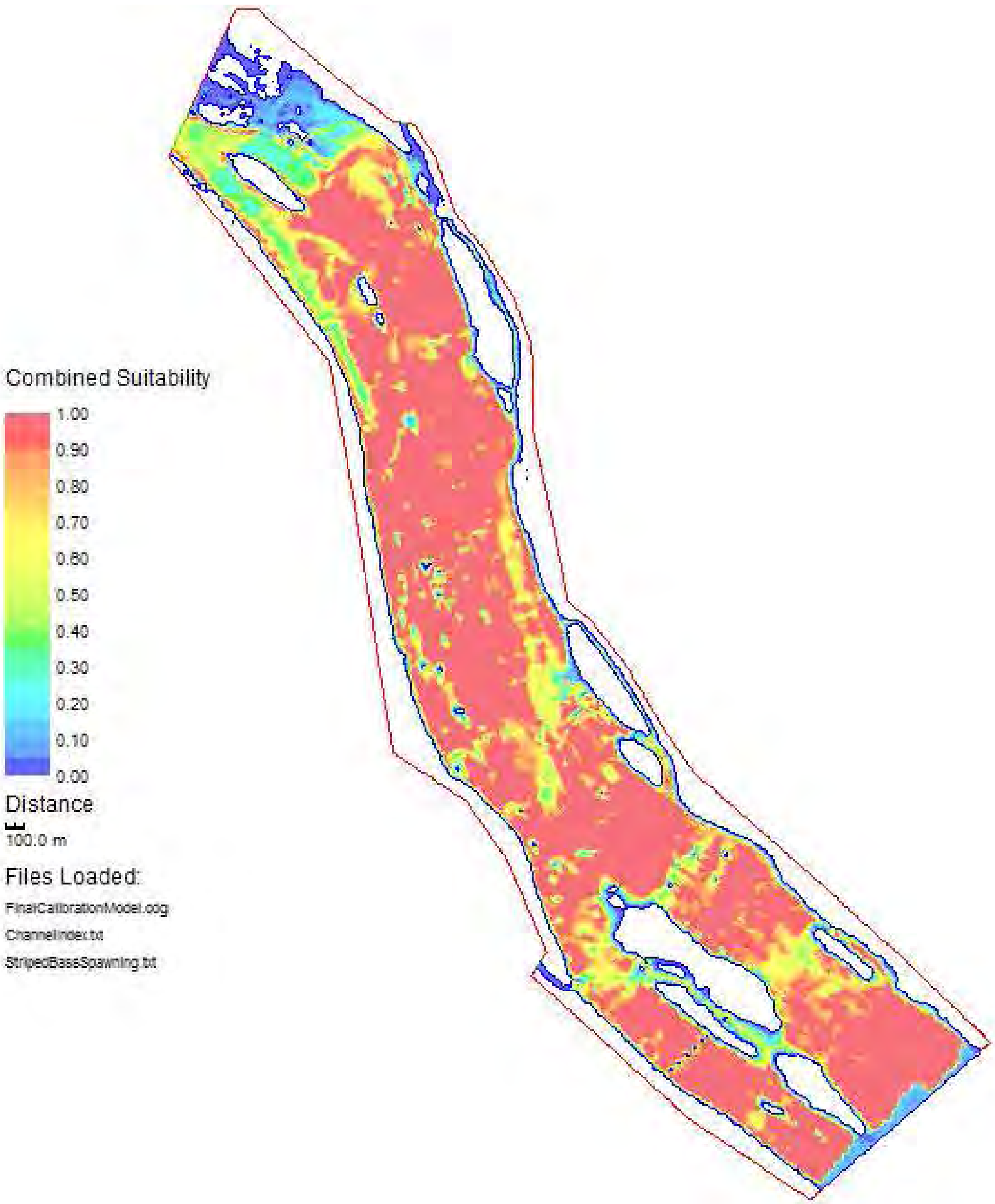
Striped Bass Spawning – 20,000 cfs



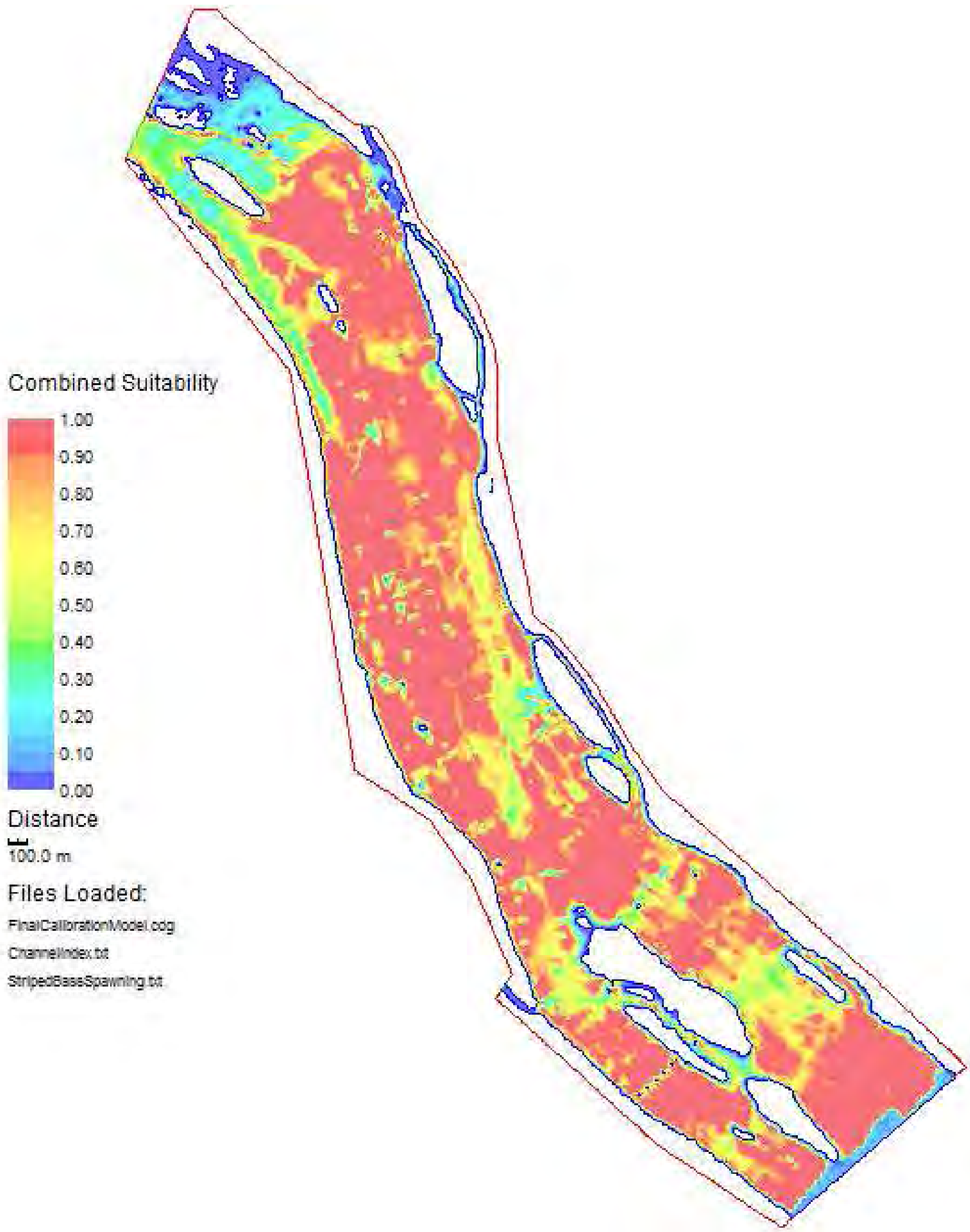
Striped Bass Spawning – 30,000 cfs



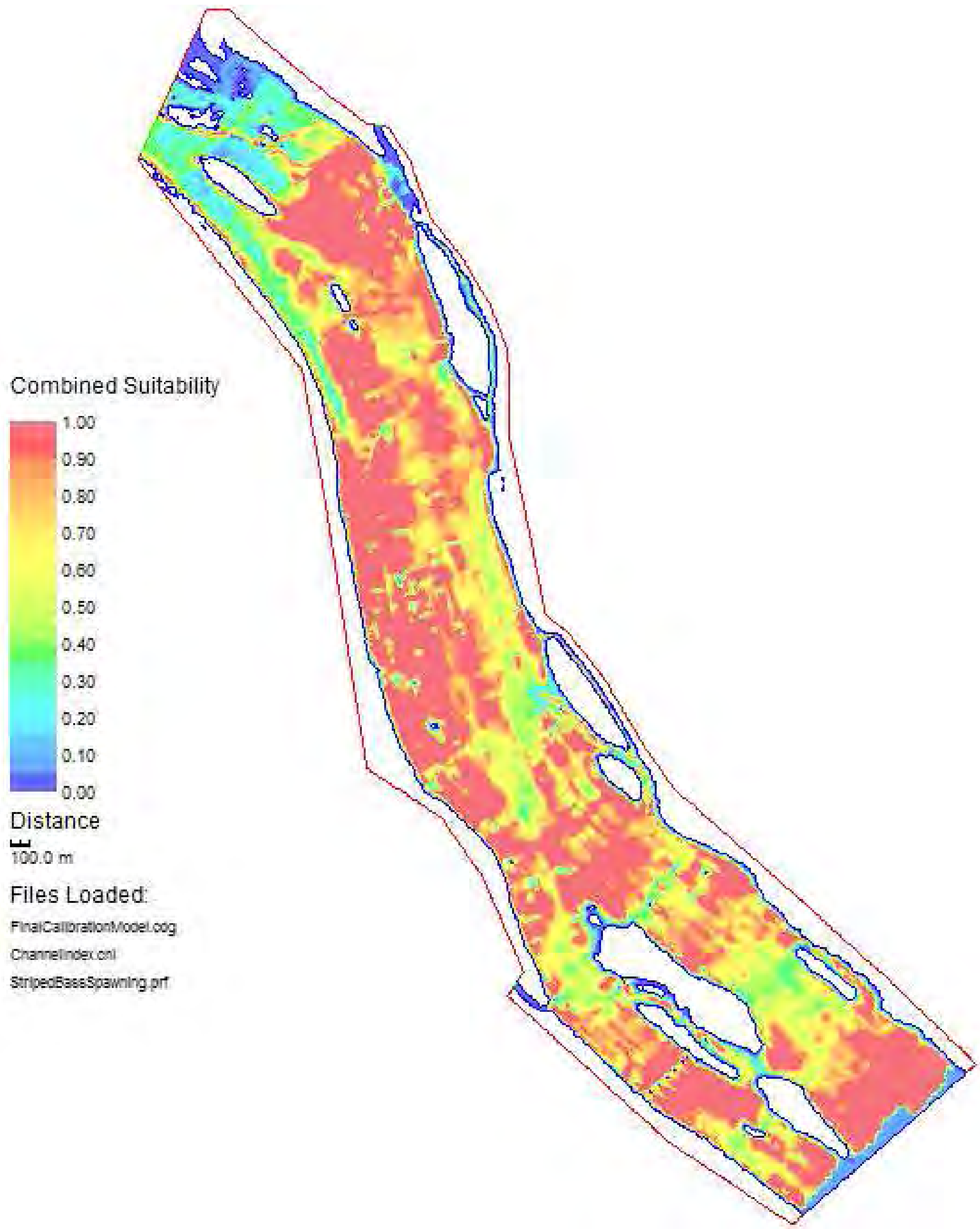
Striped Bass Spawning – 40,000 cfs



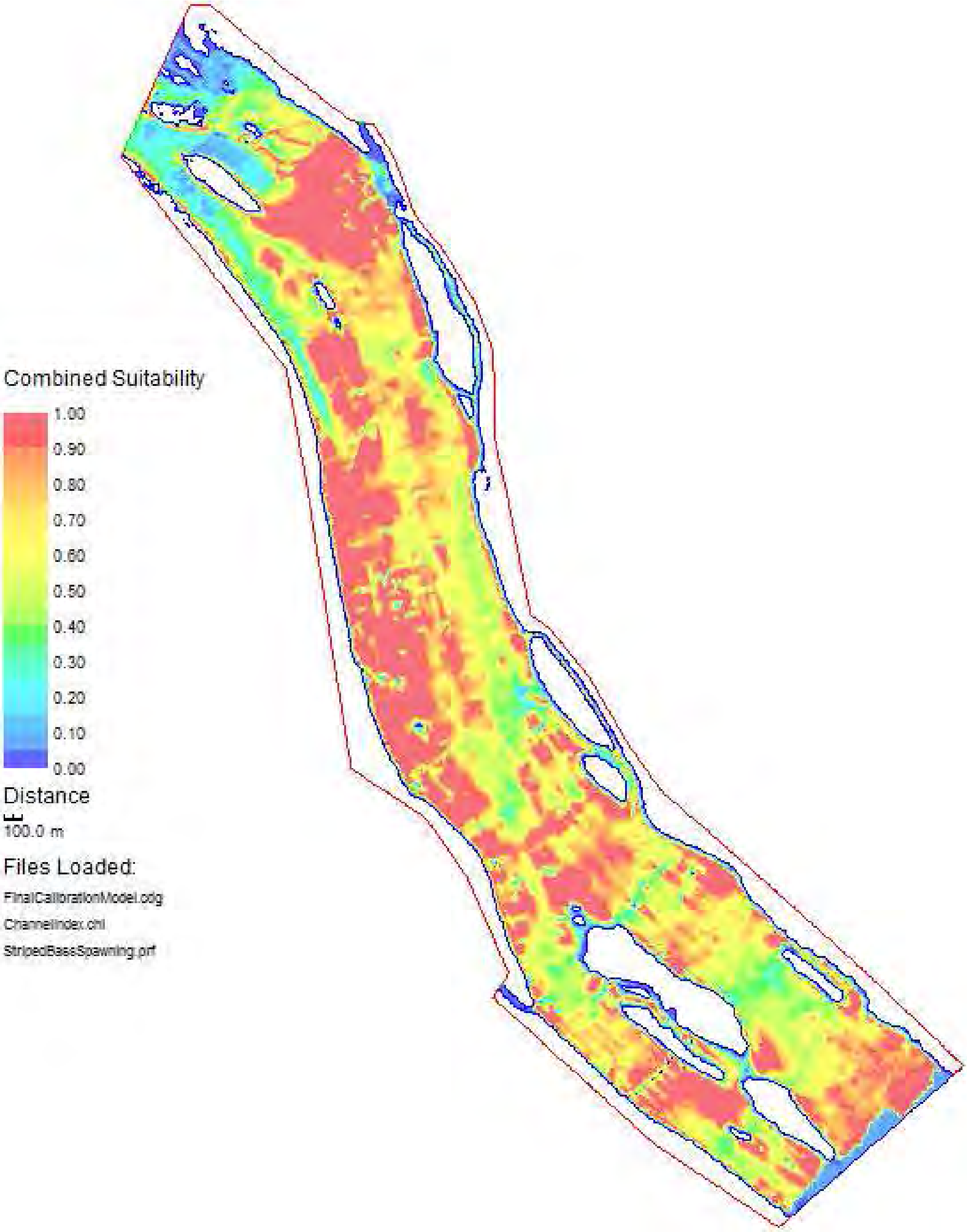
Striped Bass Spawning – 50,000 cfs



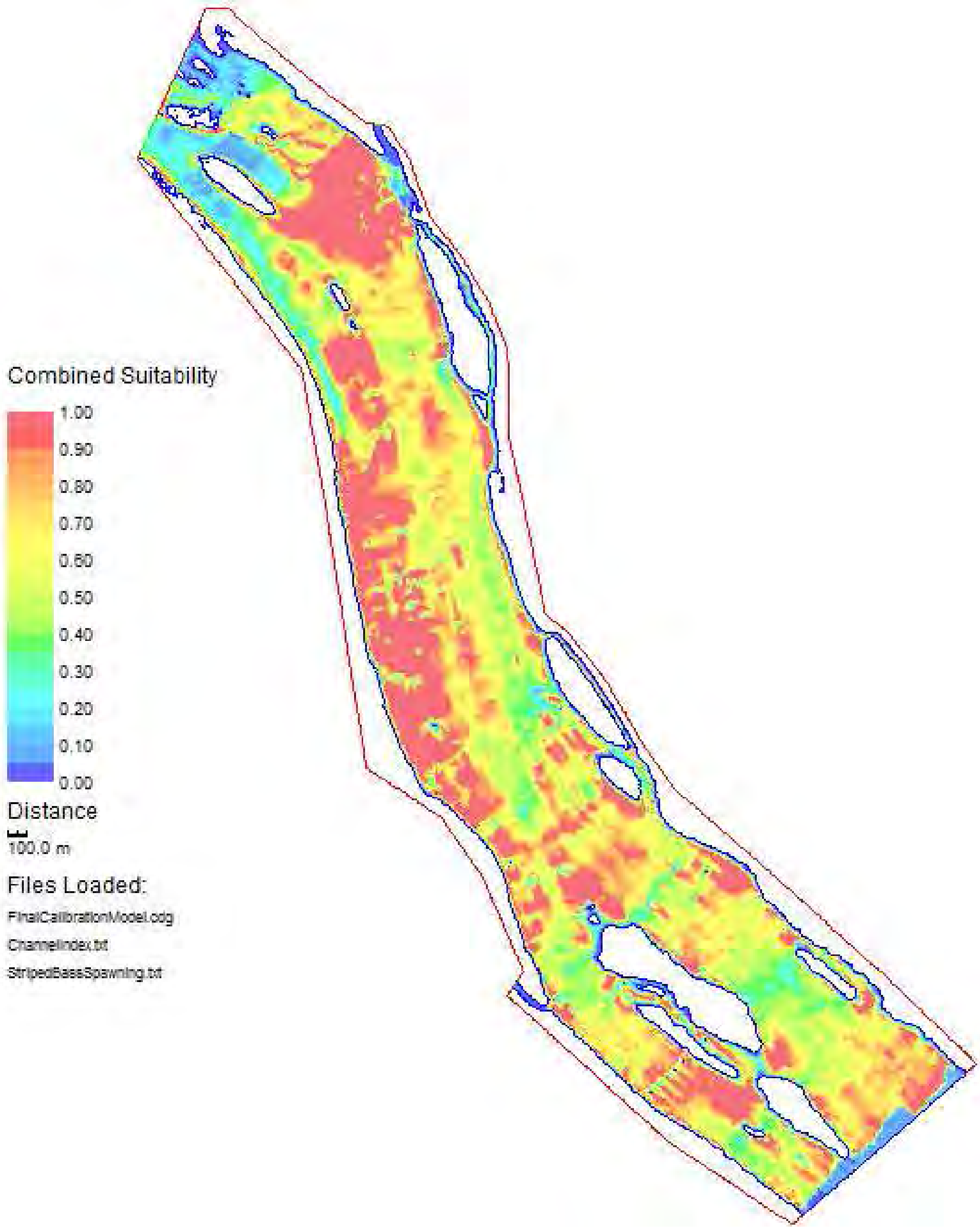
Striped Bass Spawning – 60,000 cfs



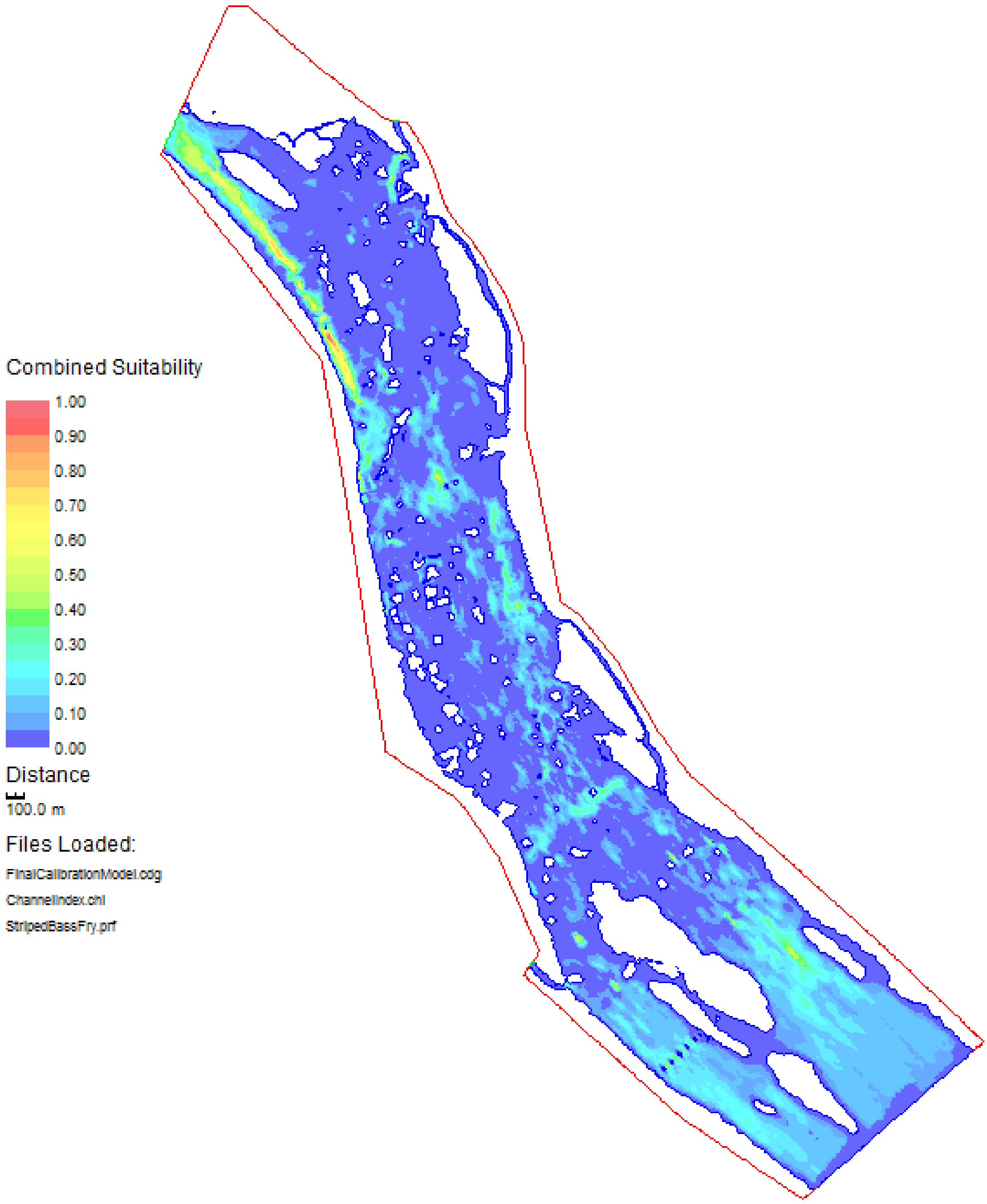
Striped Bass Spawning – 70,000 cfs



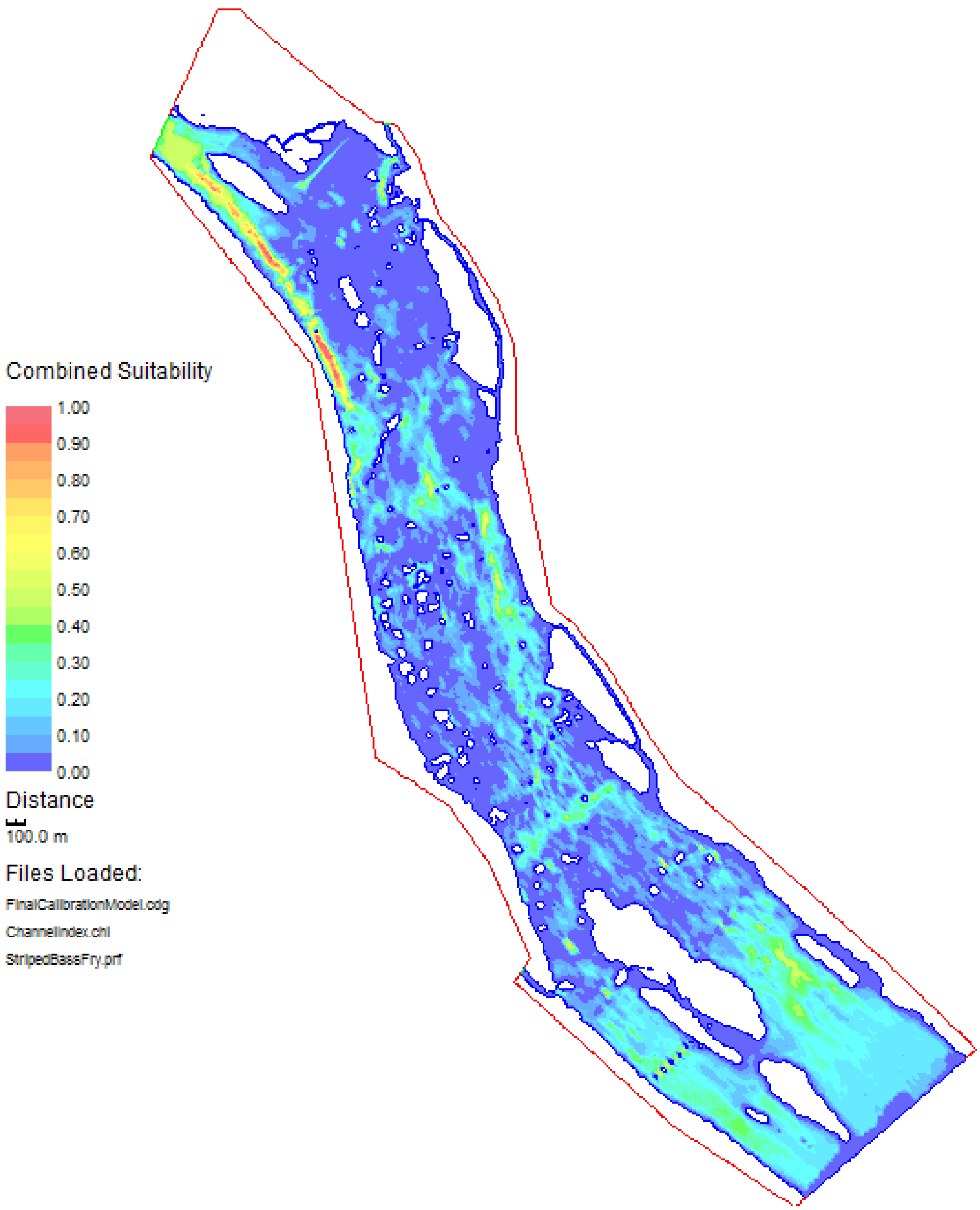
Striped Bass Spawning – 80,000 cfs



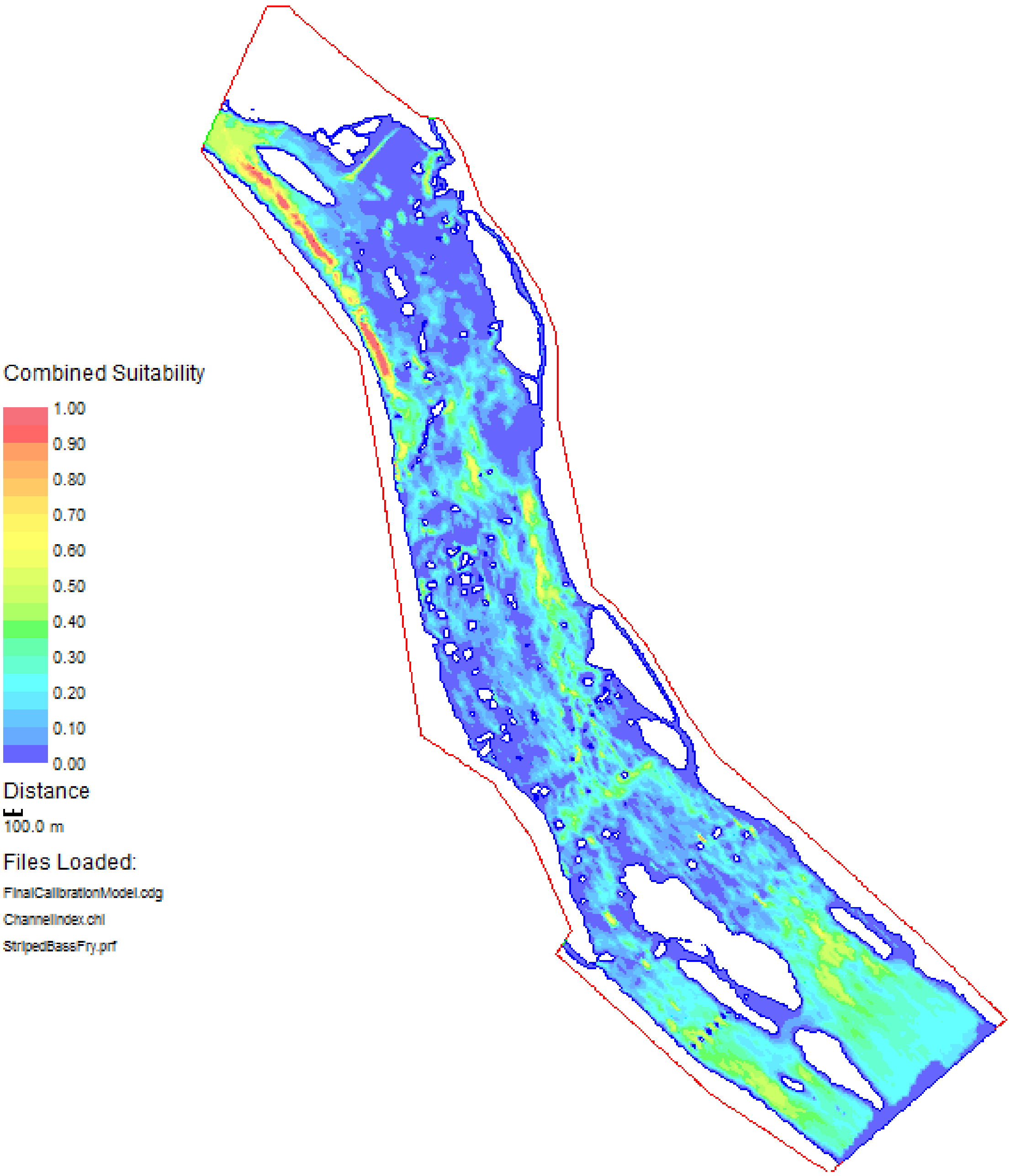
Striped Bass Spawning – 86,000 cfs



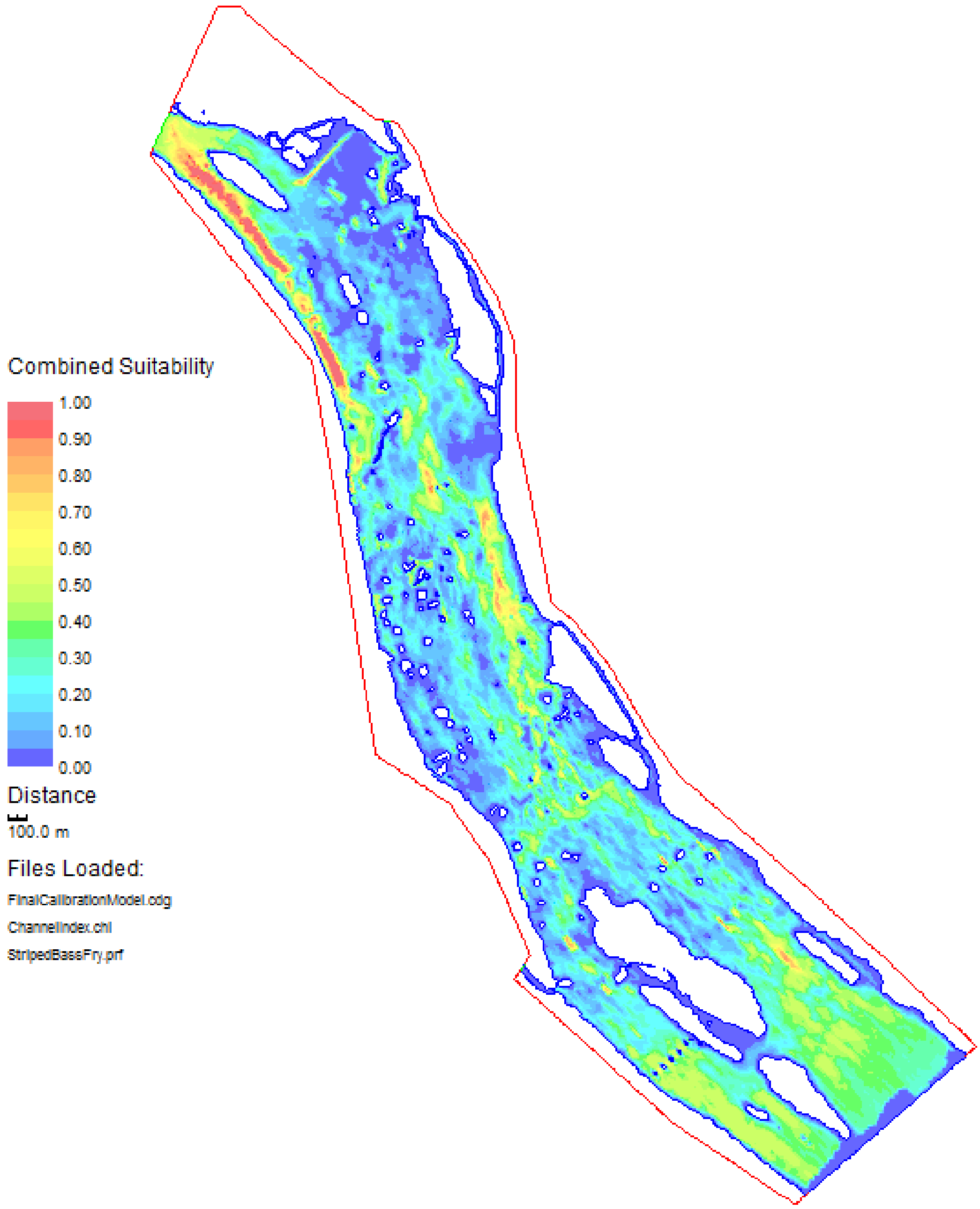
Striped Bass Fry – 2,000 cfs



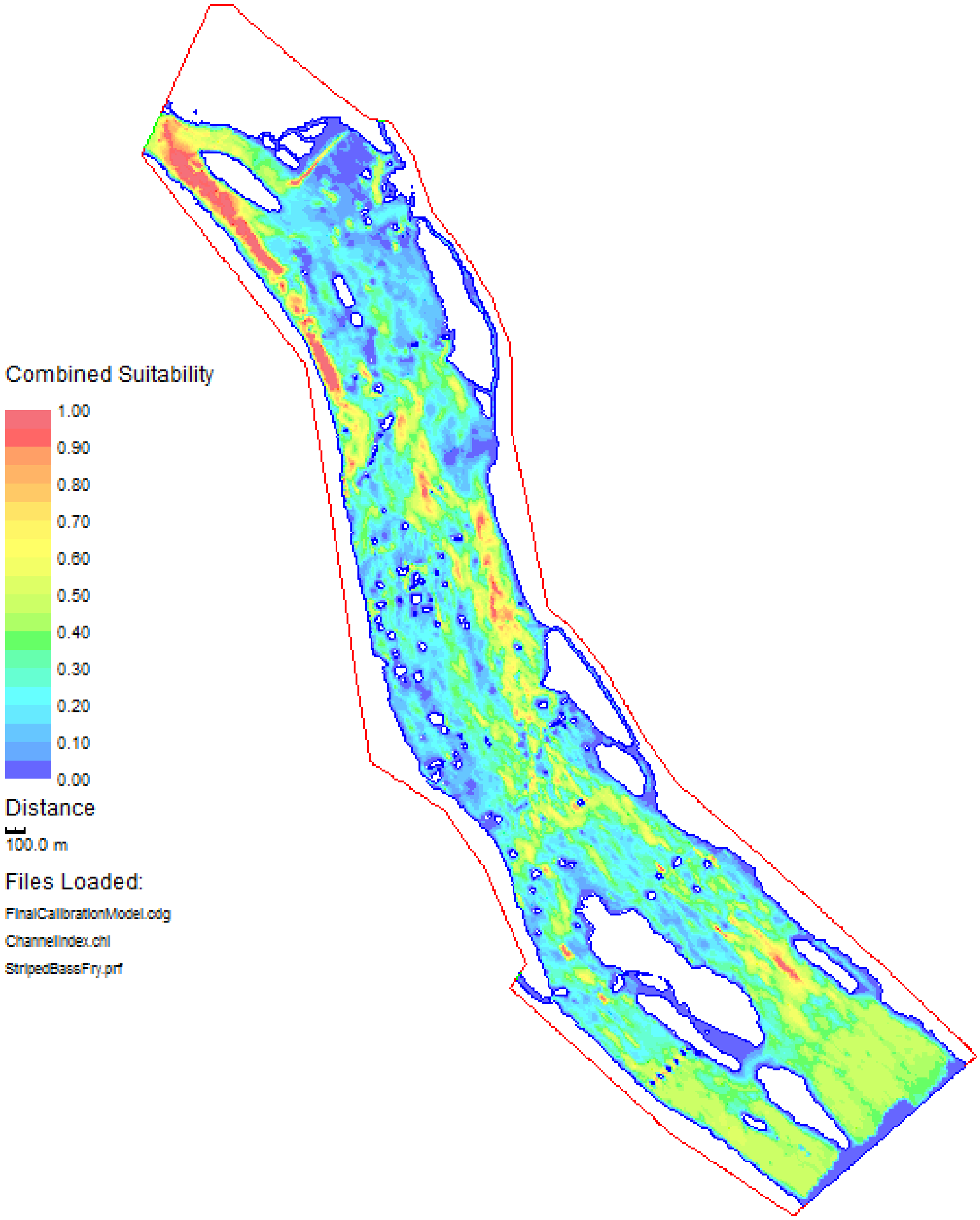
Striped Bass Fry – 3,500 cfs



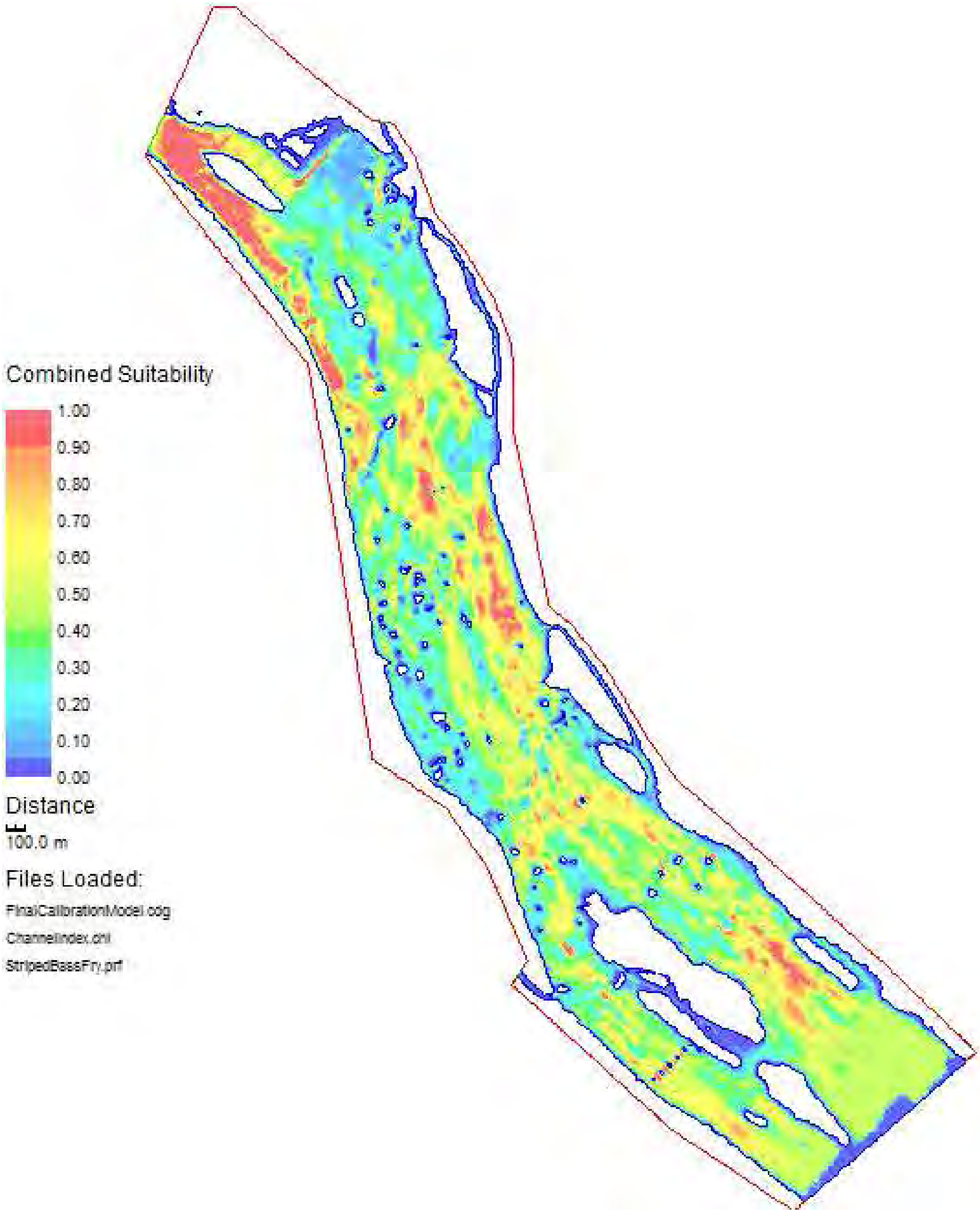
Striped Bass Fry – 5,000 cfs



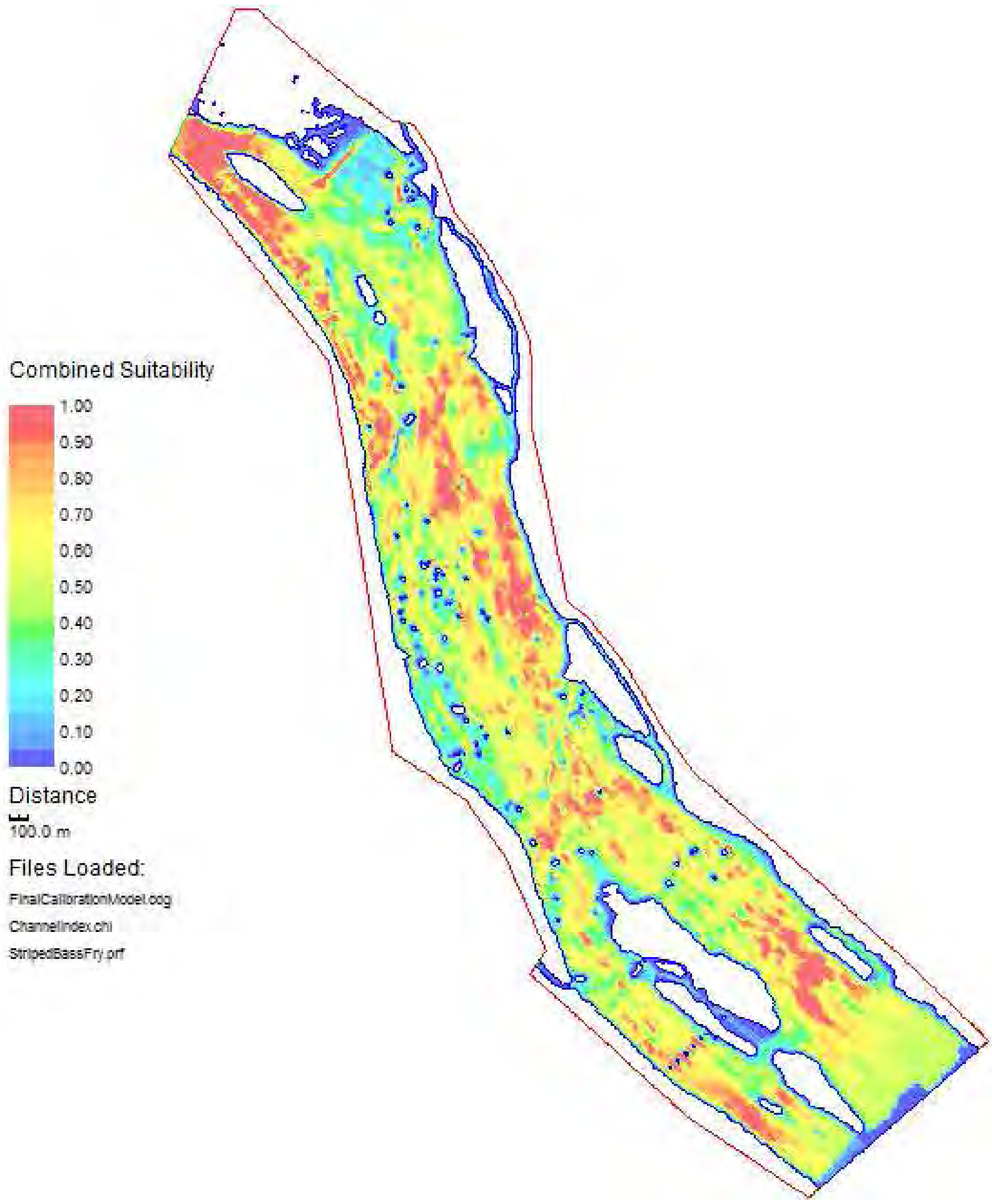
Striped Bass Fry – 7,500 cfs



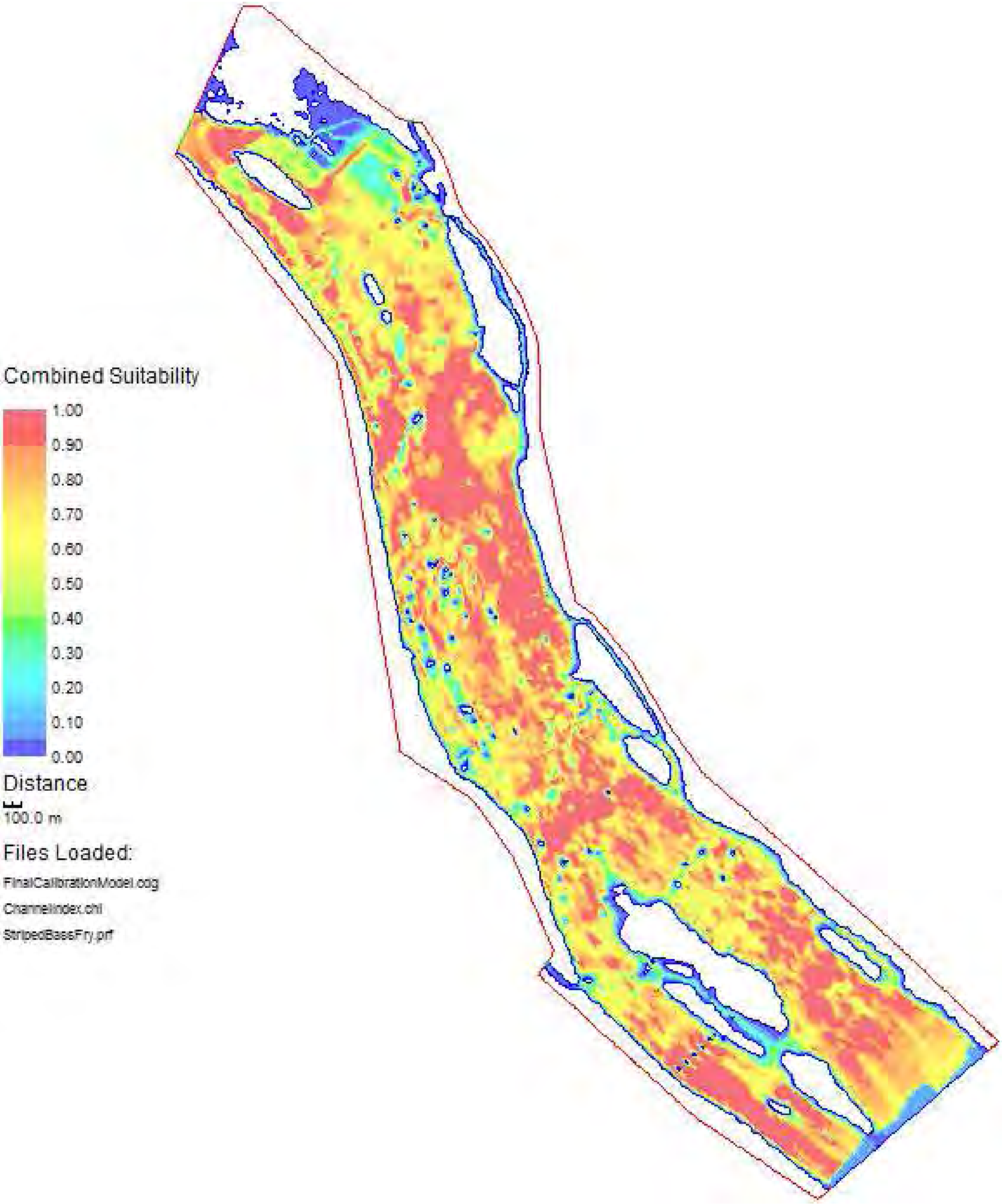
Striped Bass Fry – 10,000 cfs



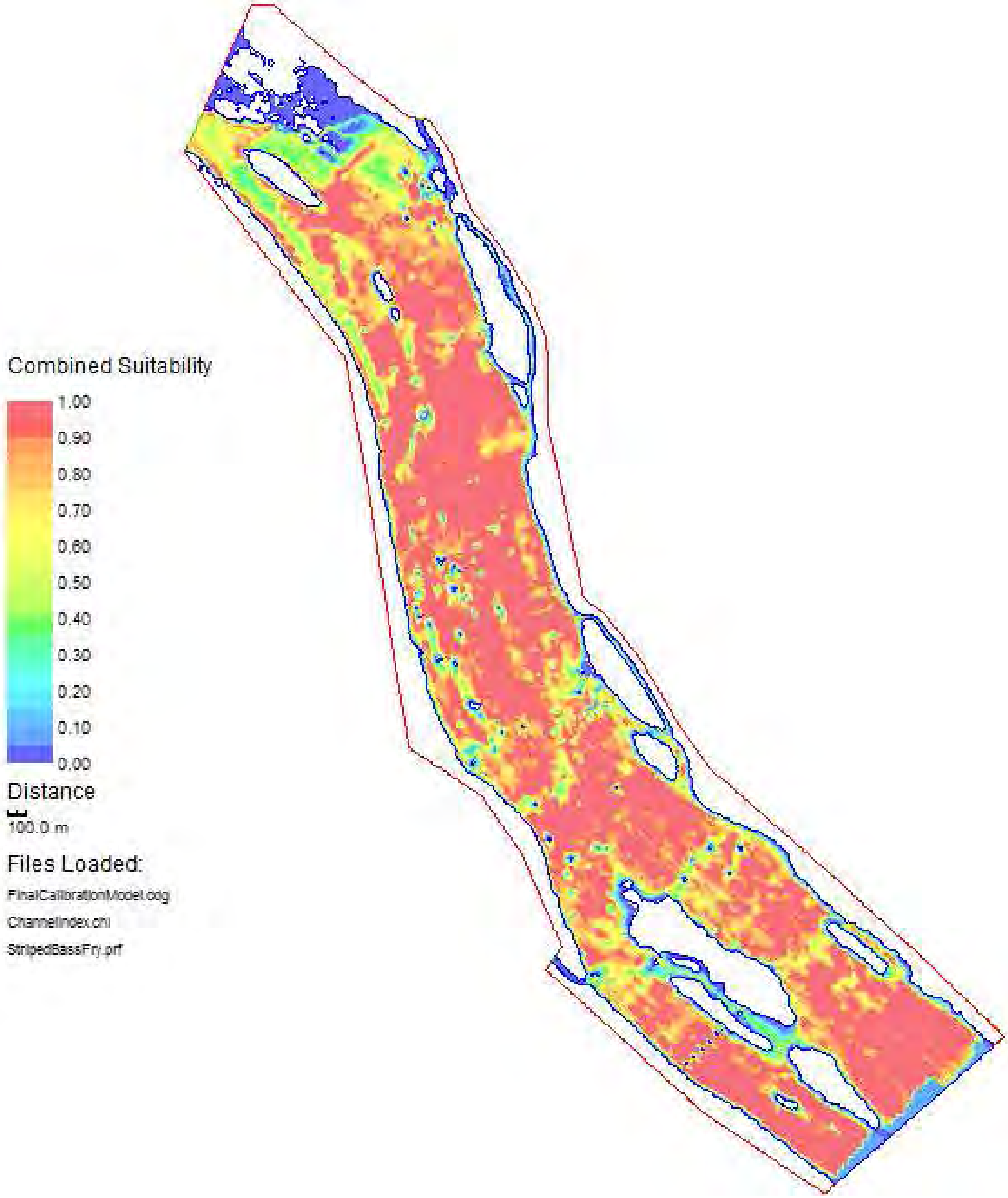
Striped Bass Fry – 15,000 cfs



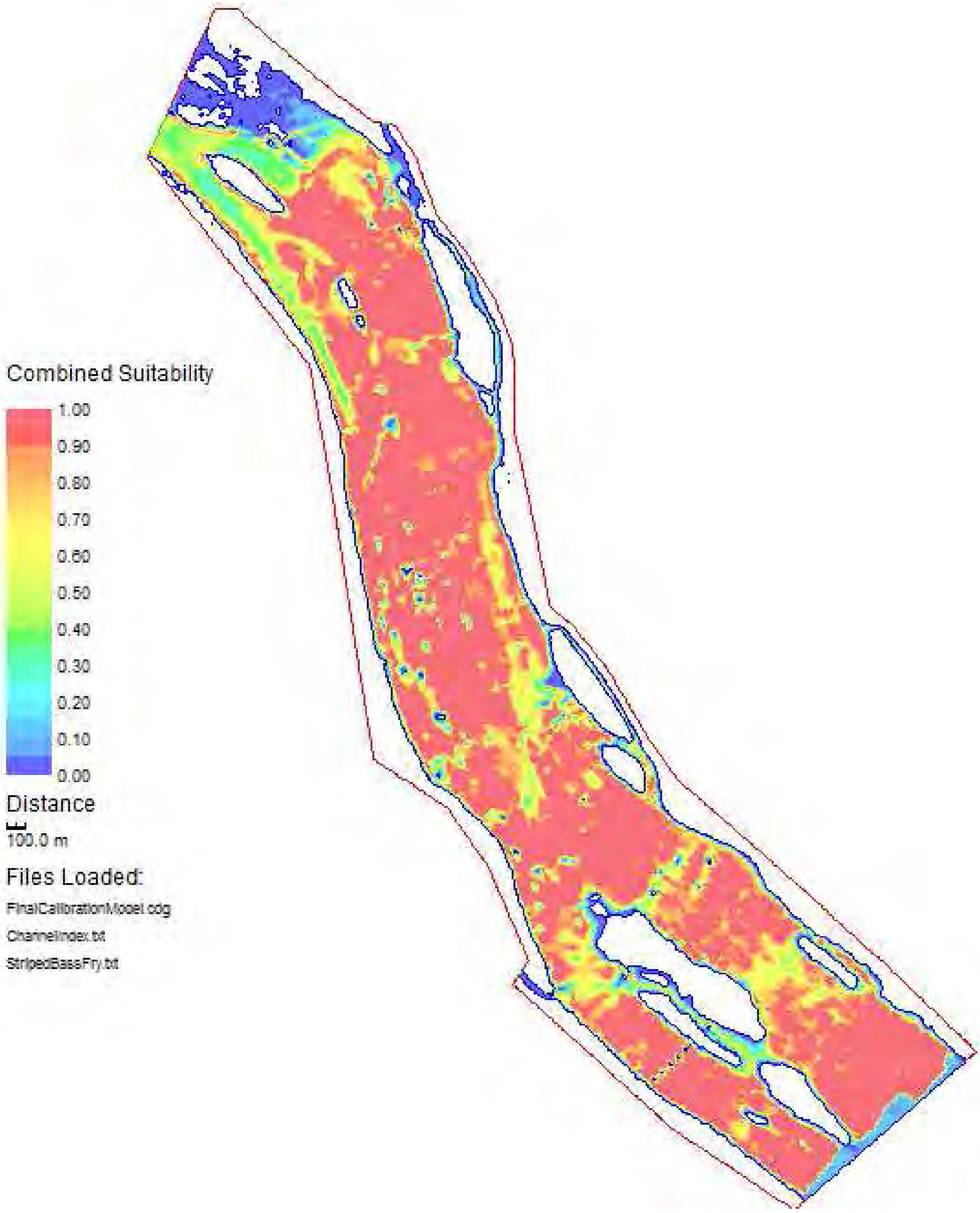
Striped Bass Fry – 20,000 cfs



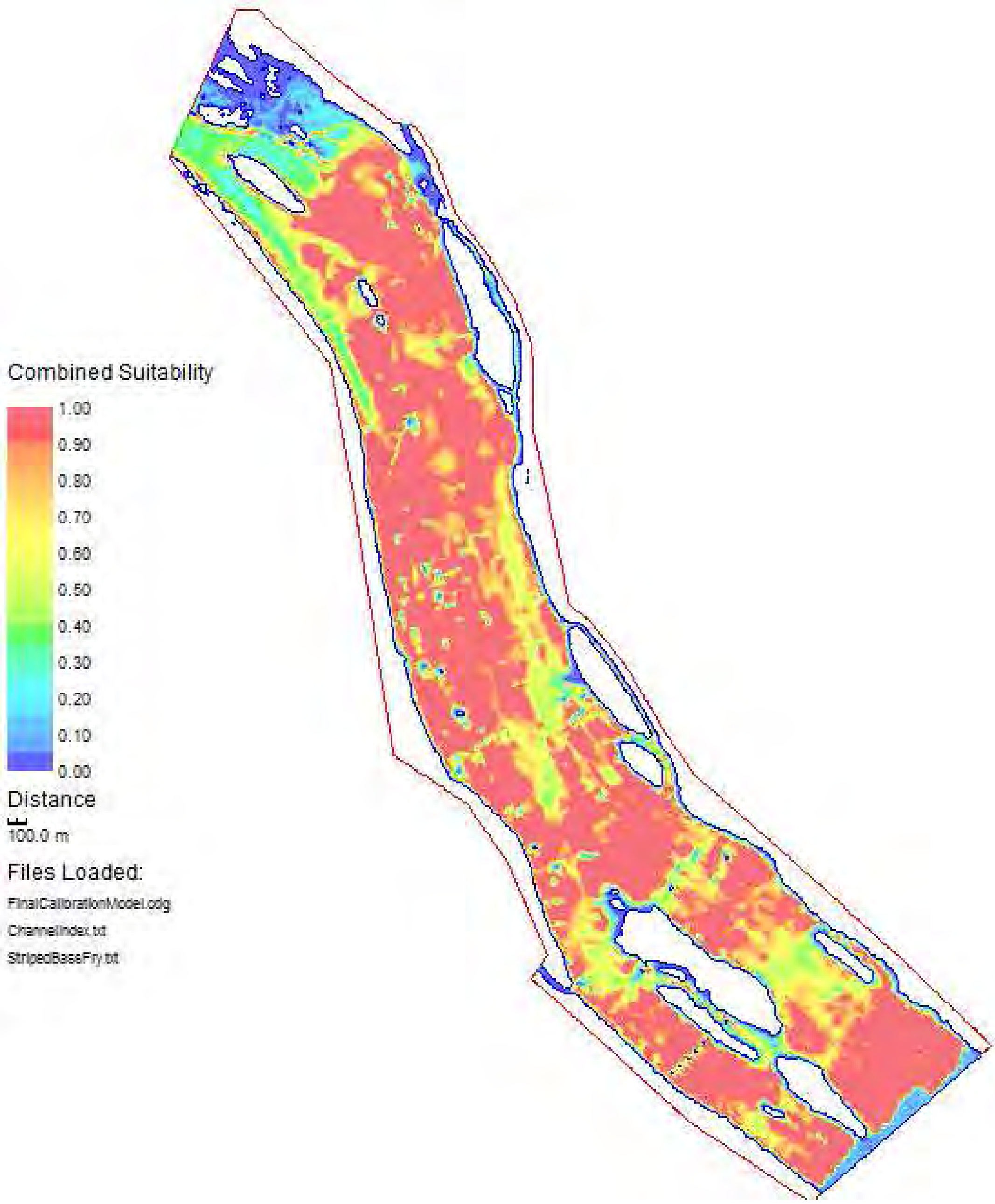
Striped Bass Fry – 30,000 cfs



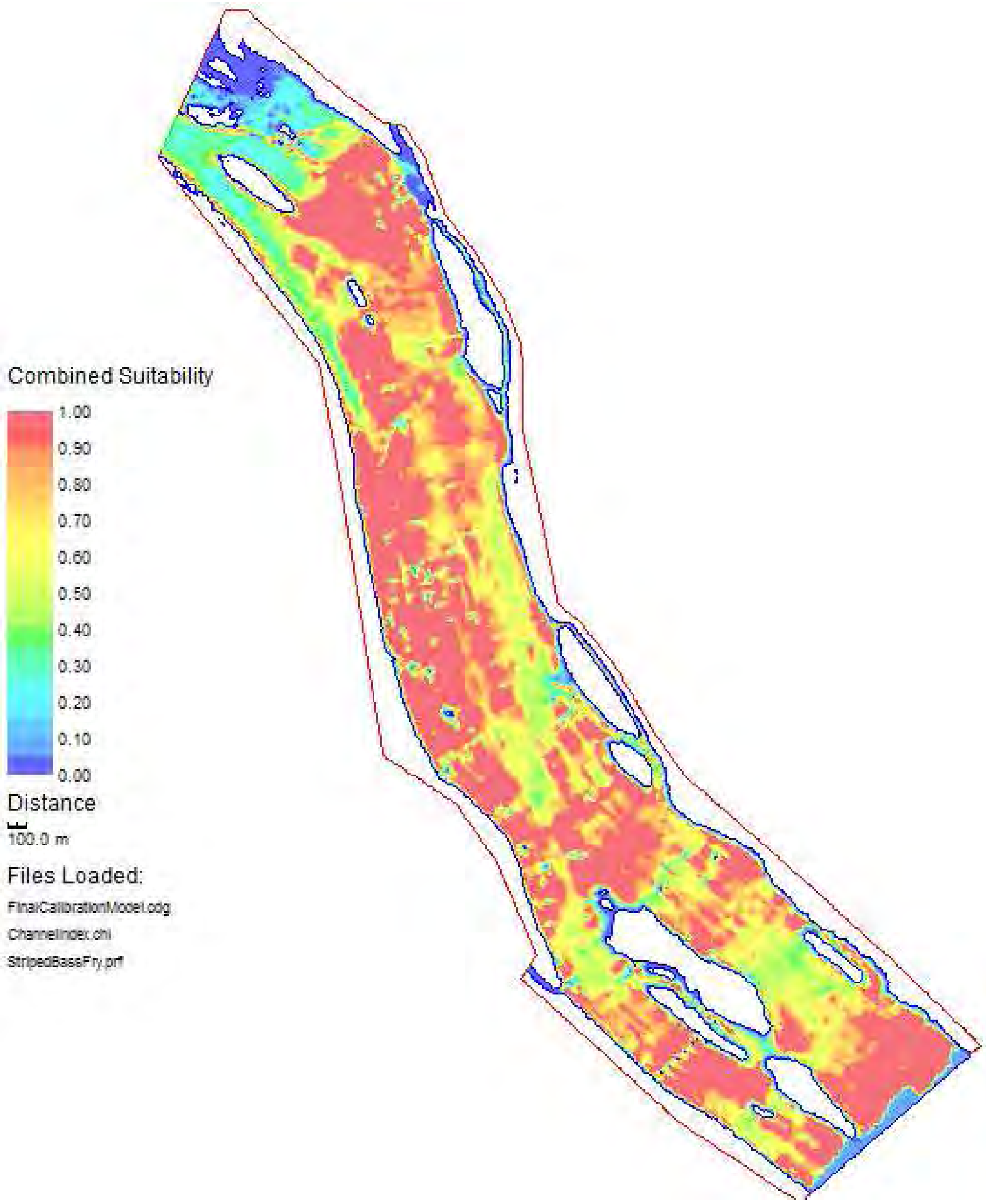
Striped Bass Fry – 40,000 cfs



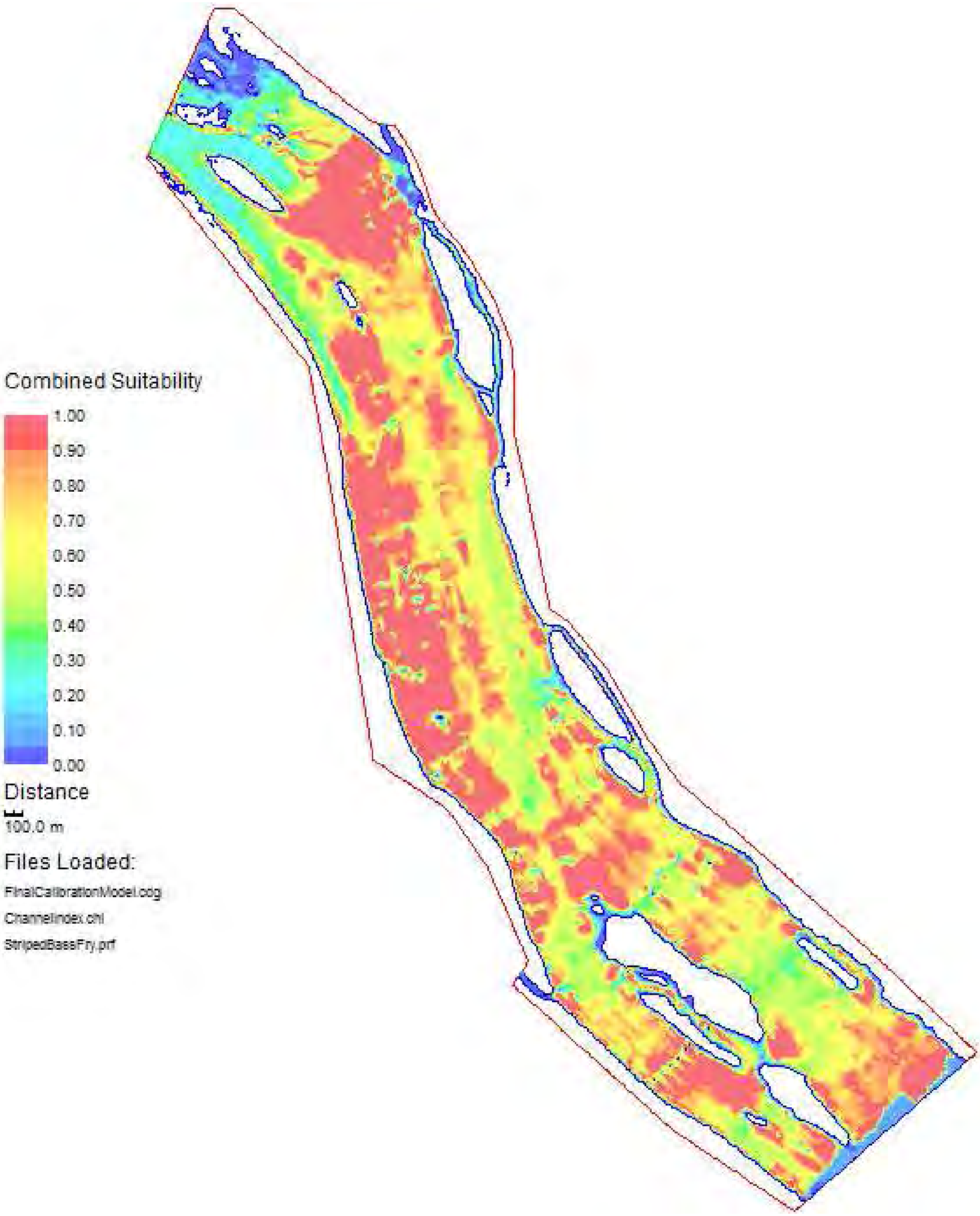
Striped Bass Fry – 50,000 cfs



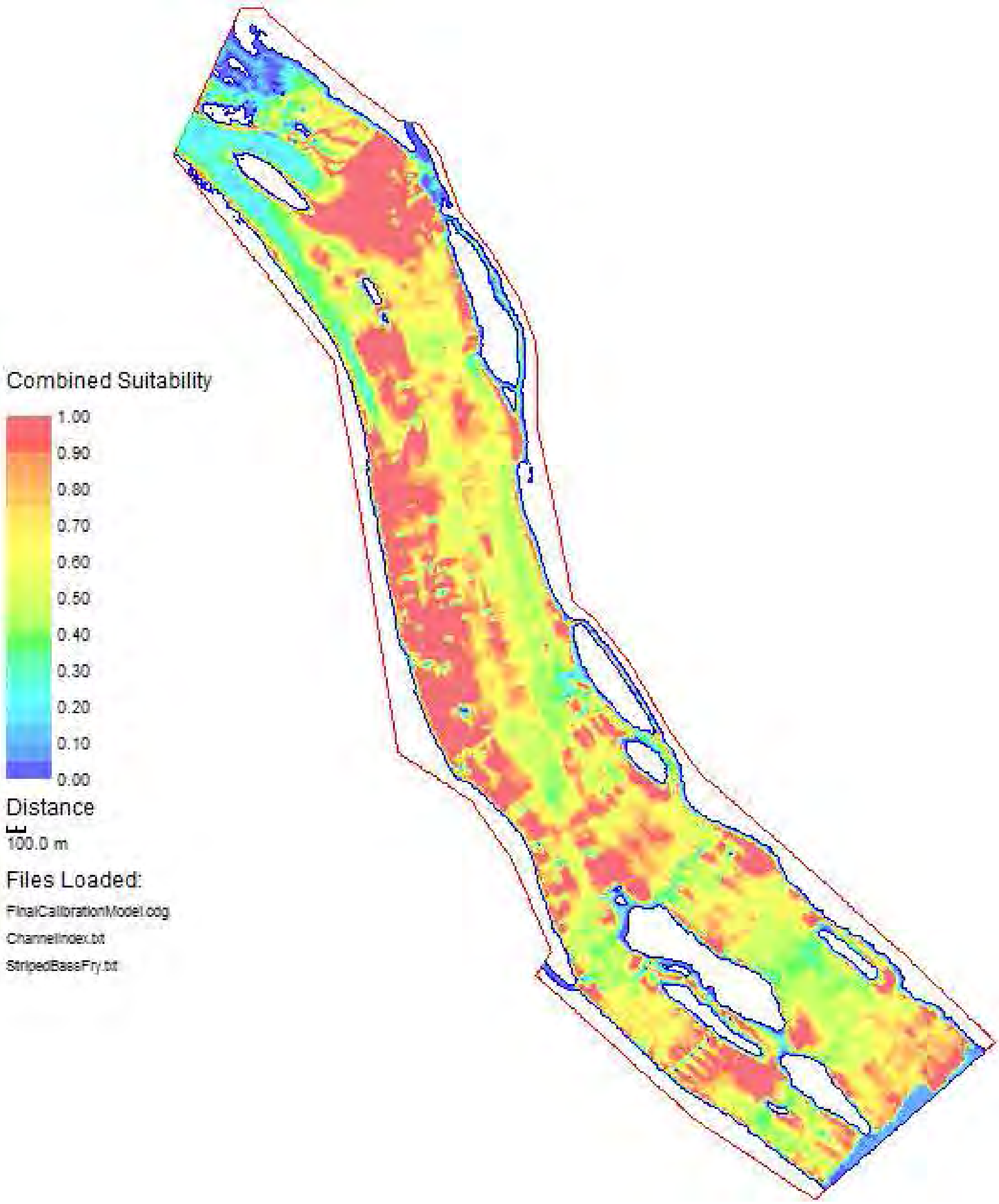
Striped Bass Fry – 60,000 cfs



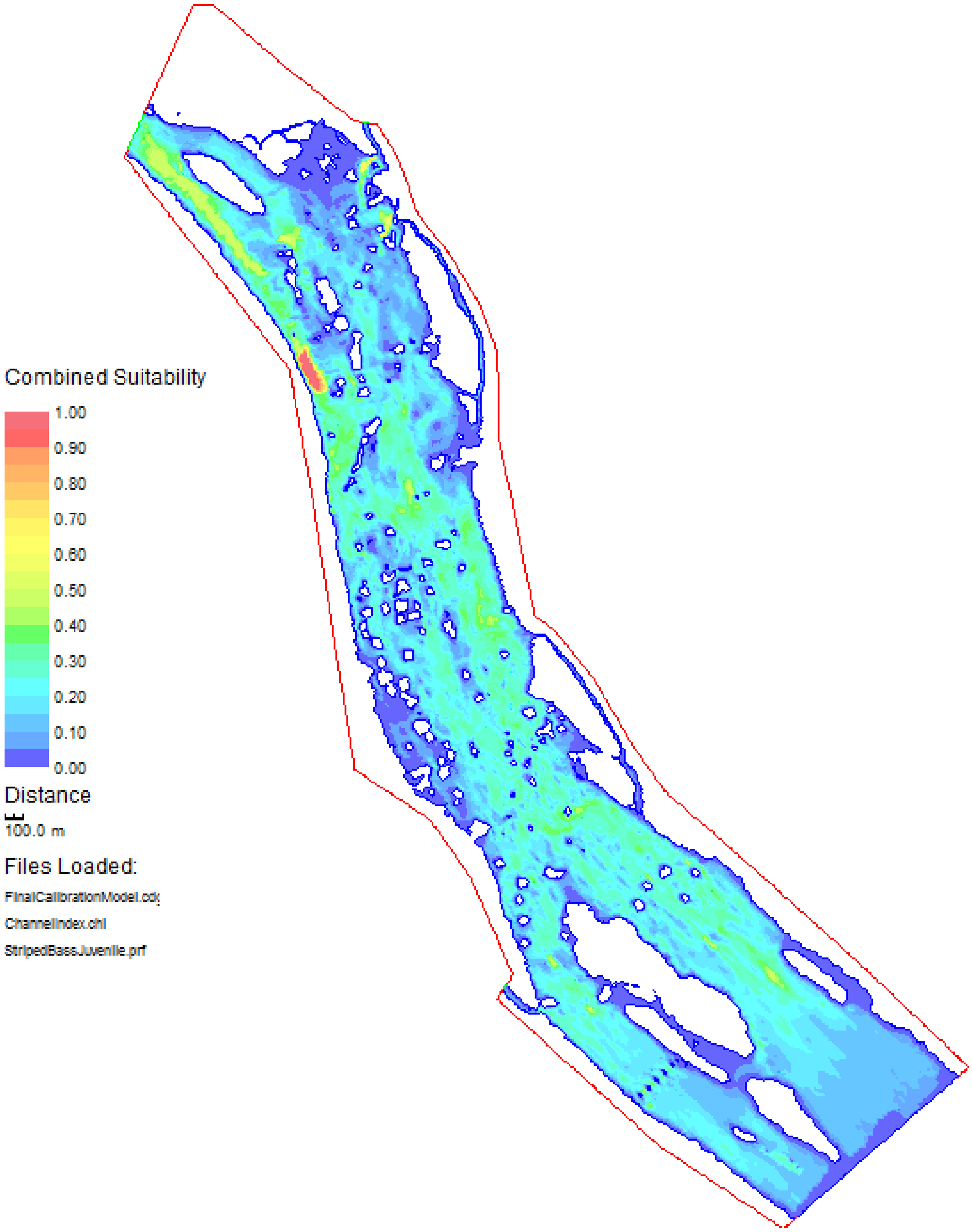
Striped Bass Fry – 70,000 cfs



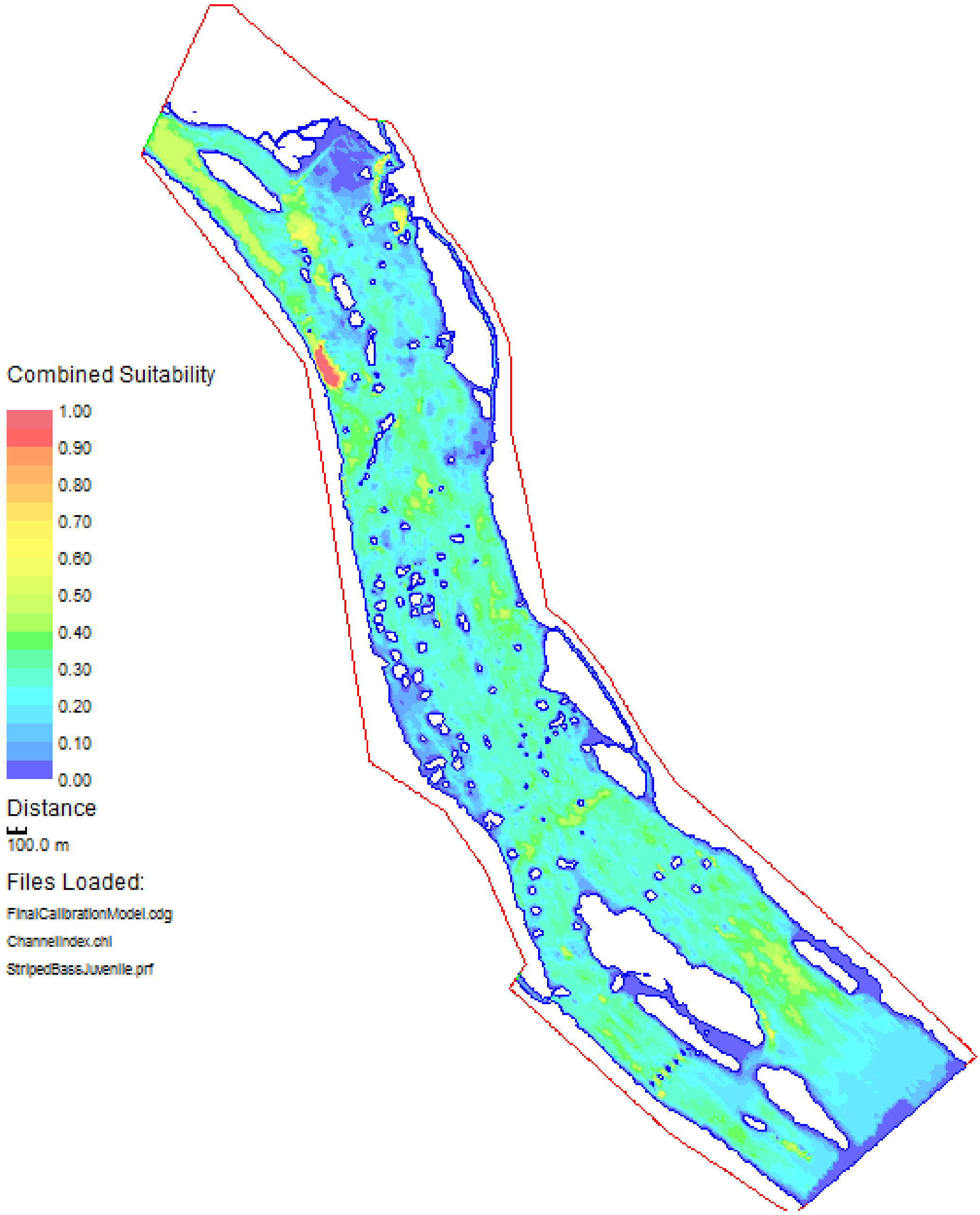
Striped Bass Fry – 80,000 cfs



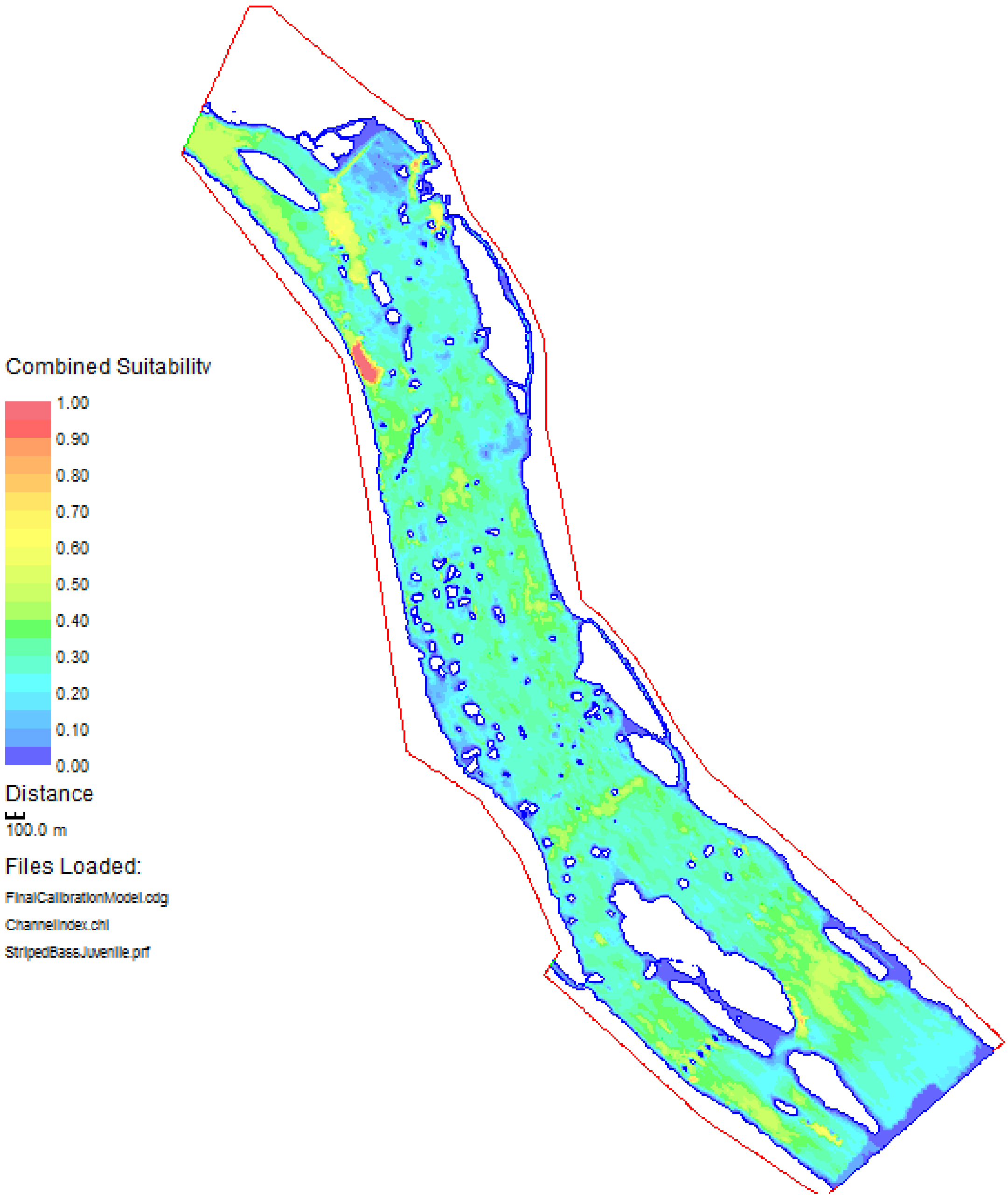
Striped Bass Fry – 86,000 cfs



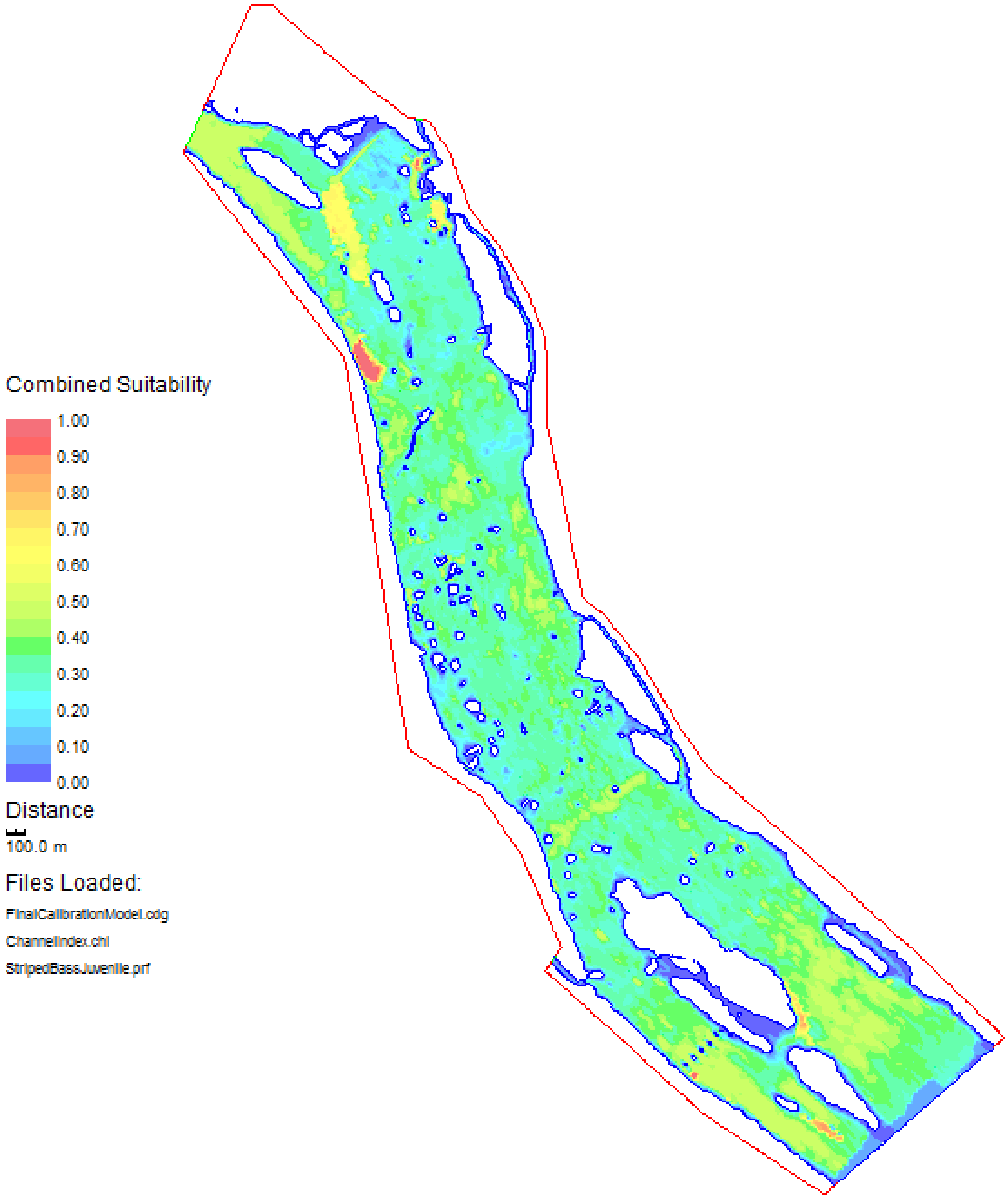
Striped Bass Juvenile – 2,000 cfs



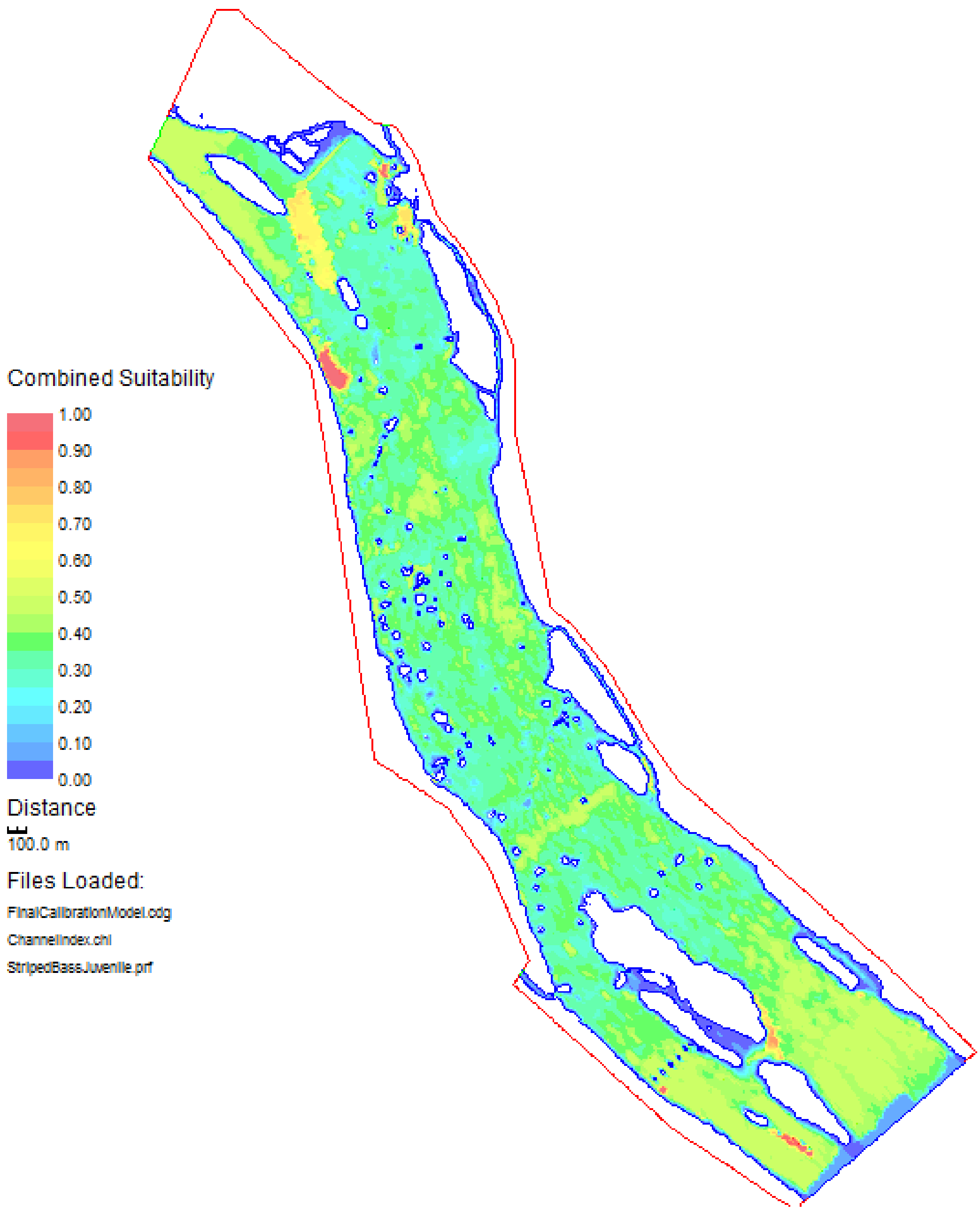
Striped Bass Juvenile – 3,500 cfs



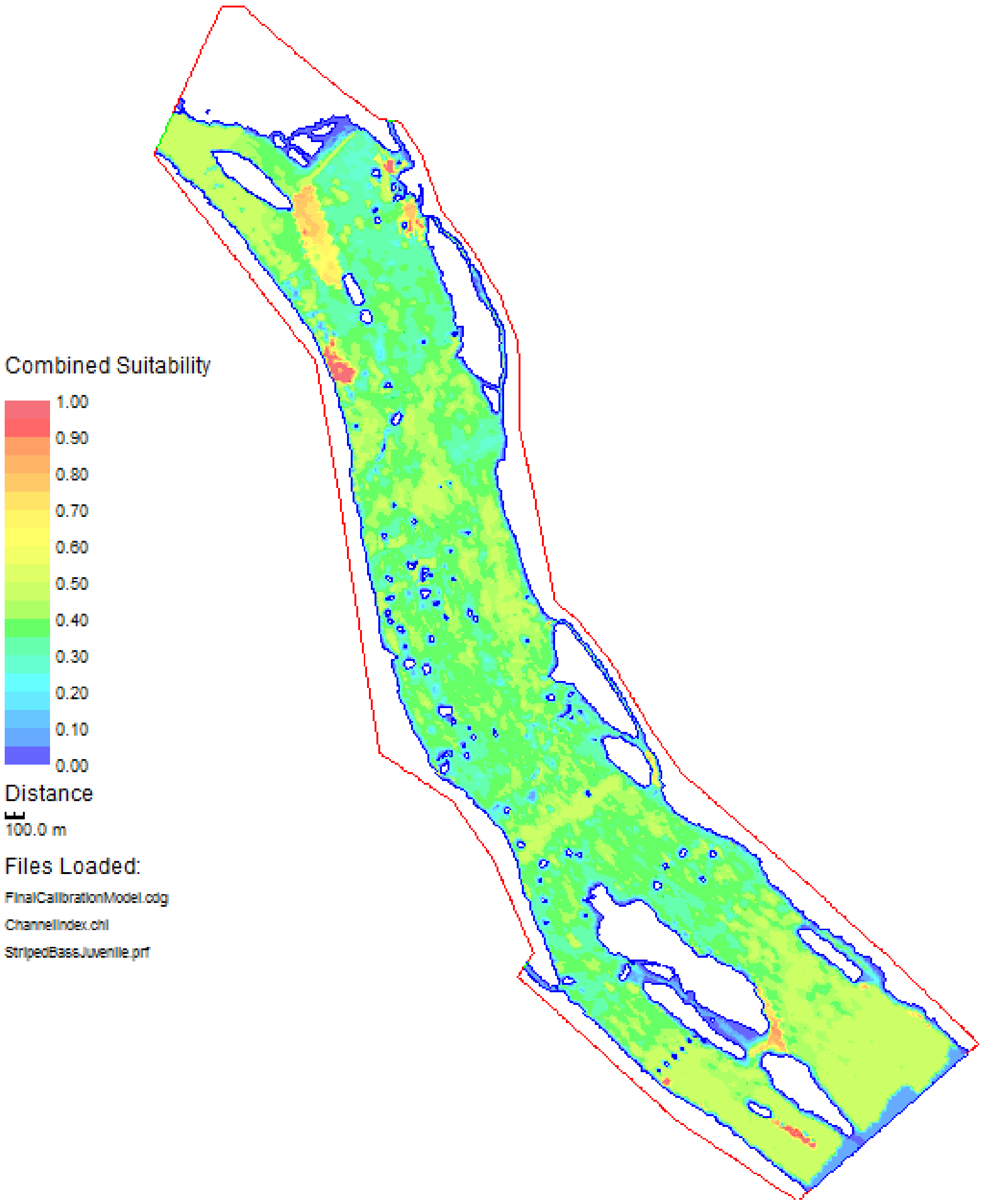
Striped Bass Juvenile – 5,000 cfs



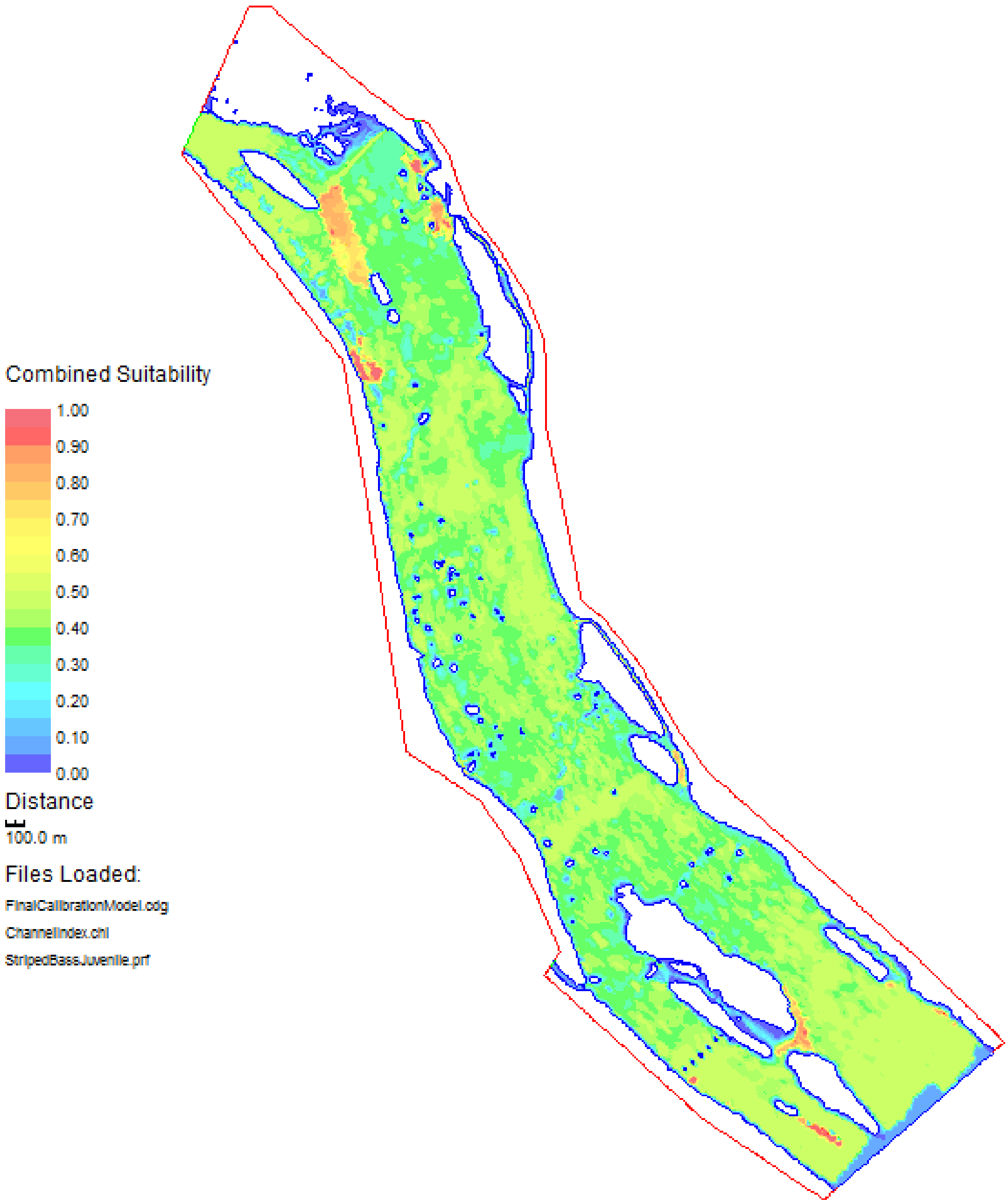
Striped Bass Juvenile – 7,500 cfs



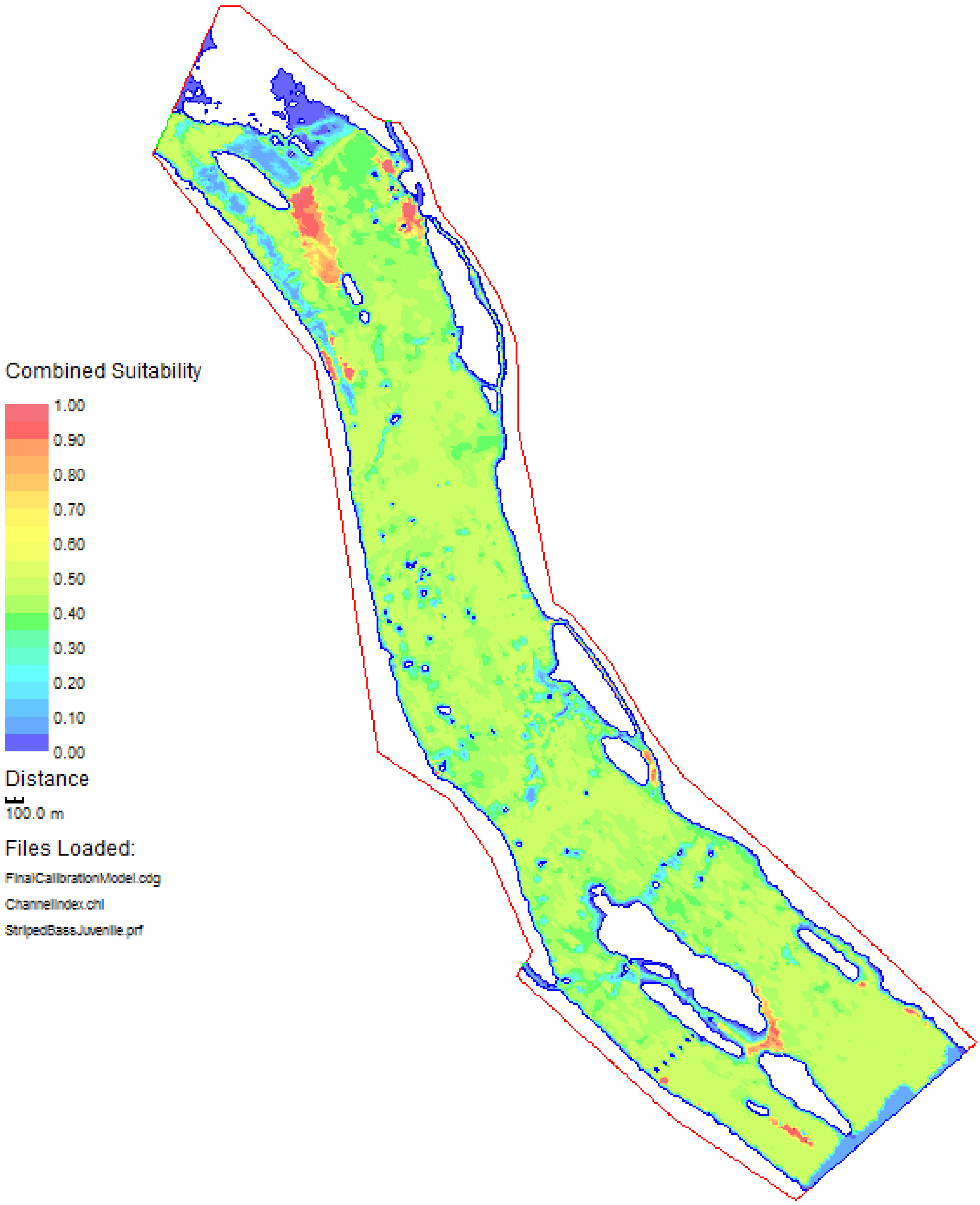
Striped Bass Juvenile – 10,000 cfs



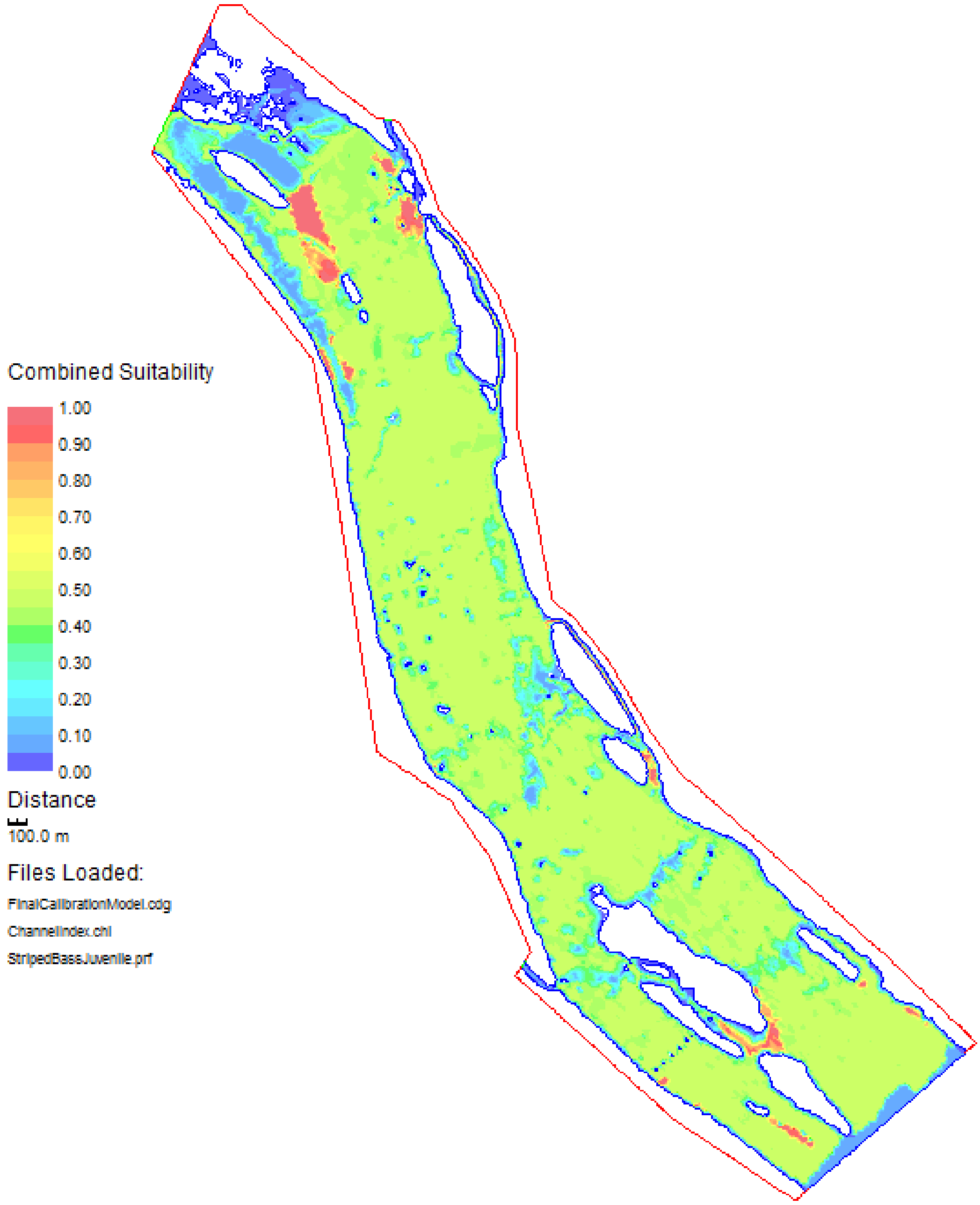
Striped Bass Juvenile – 15,000 cfs



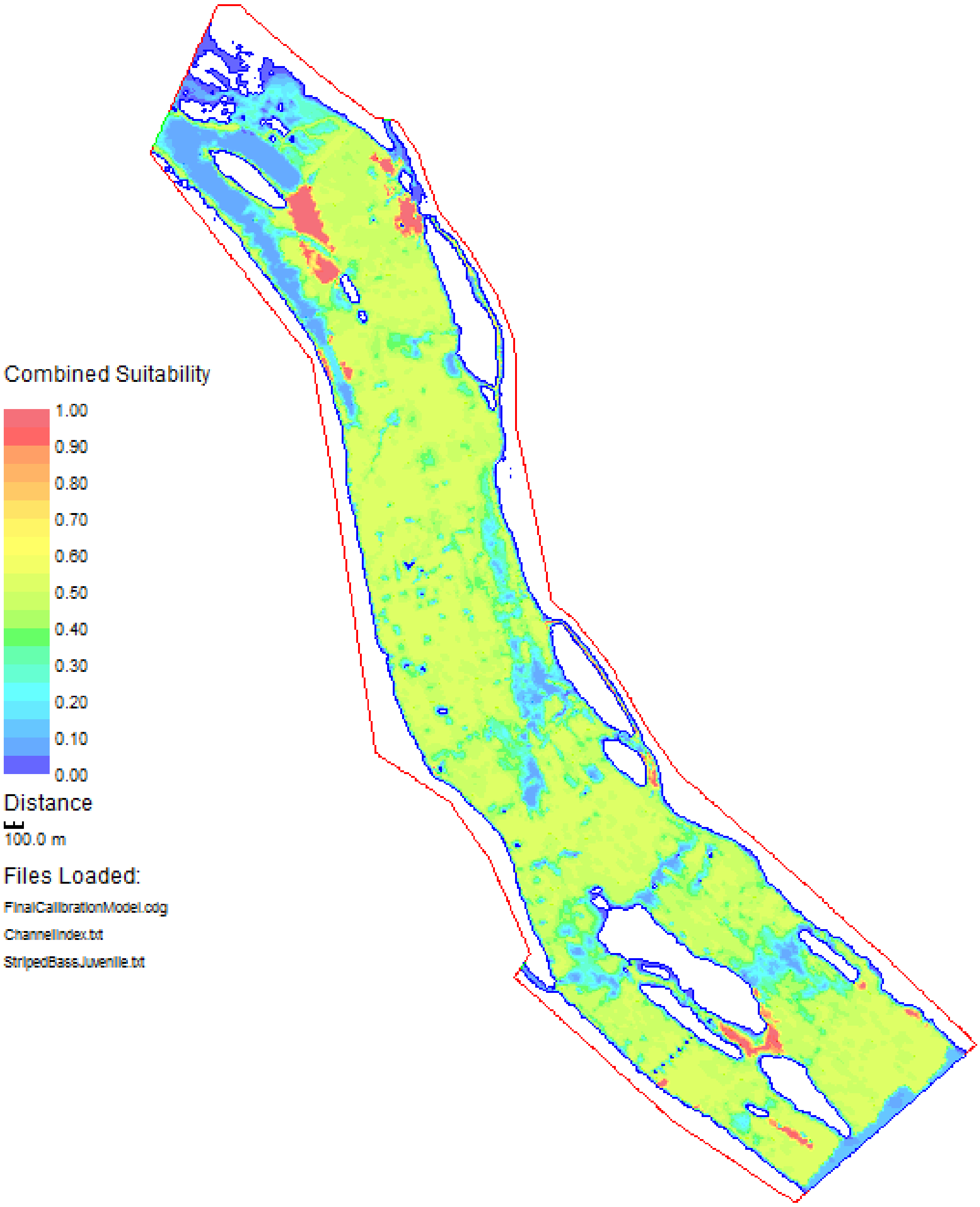
Striped Bass Juvenile – 20,000 cfs



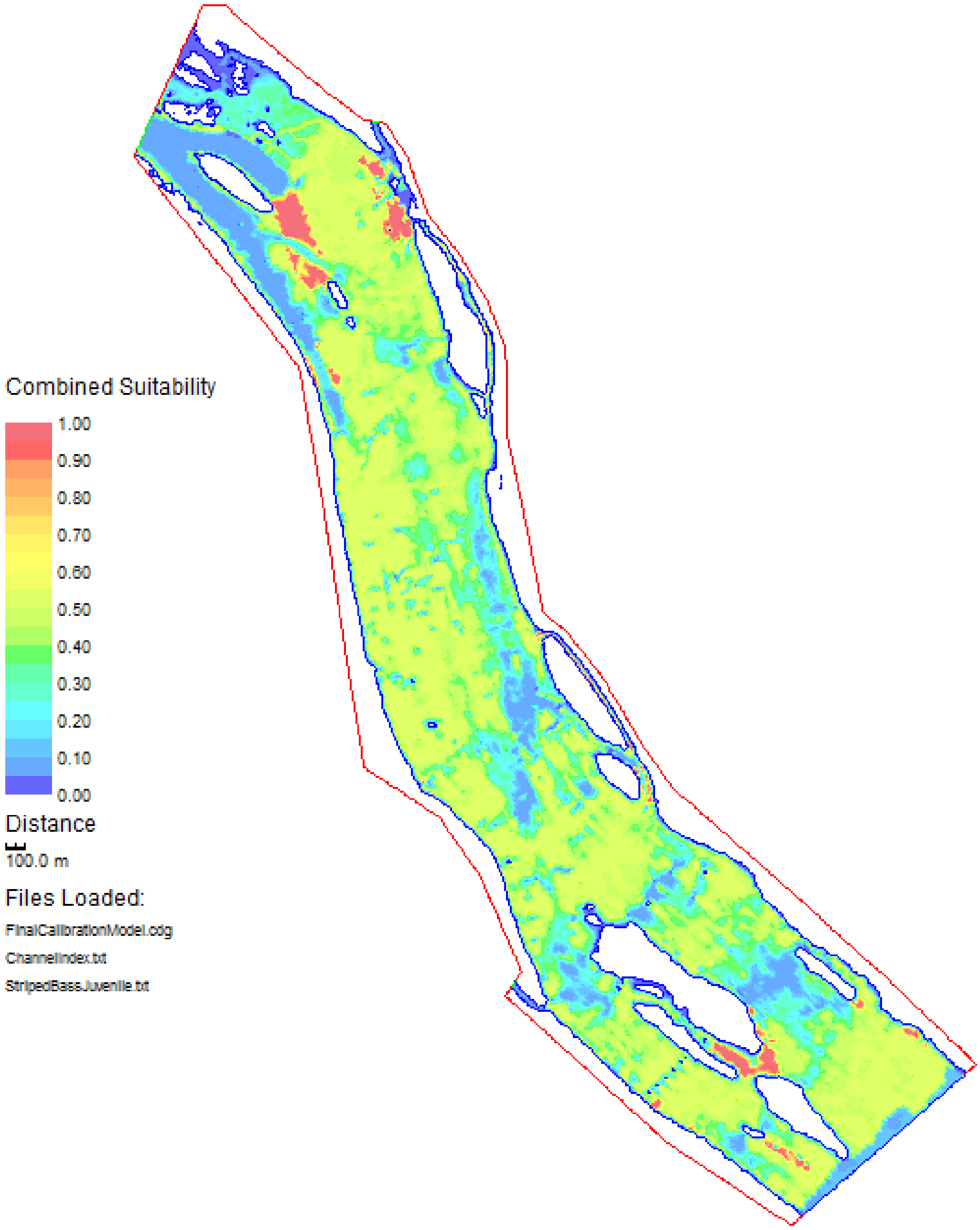
Striped Bass Juvenile – 30,000 cfs



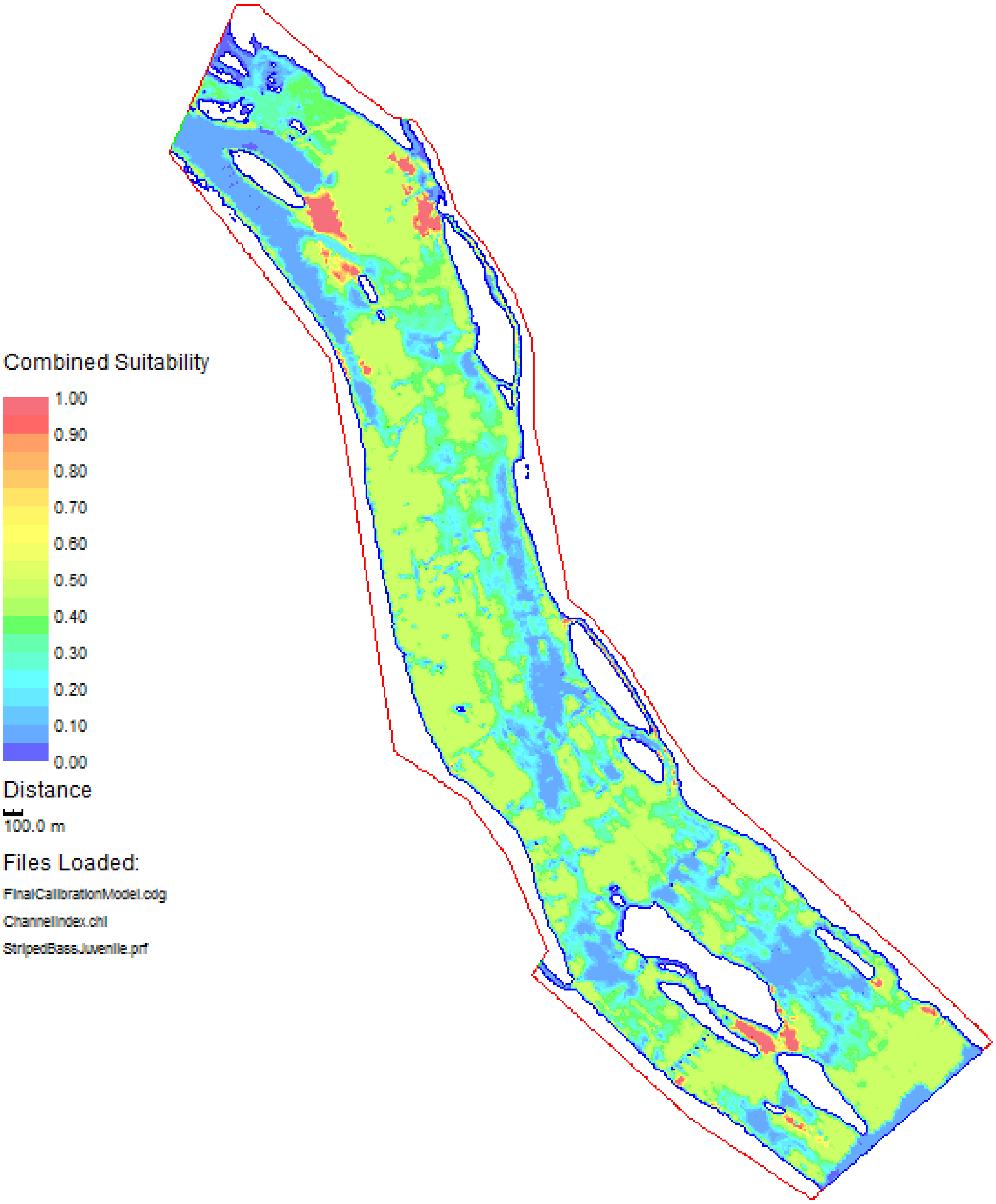
Striped Bass Juvenile – 40,000 cfs



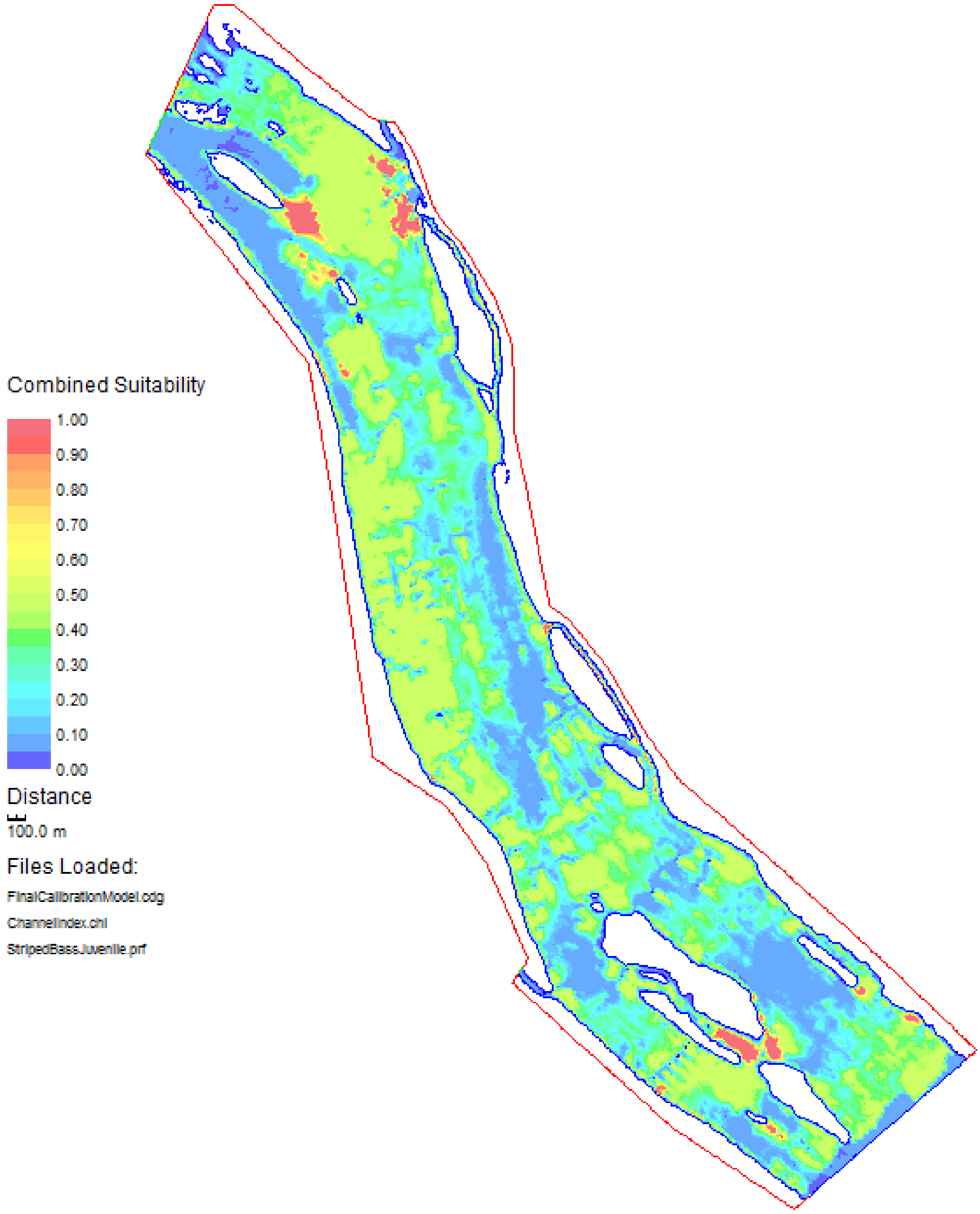
Striped Bass Juvenile – 50,000 cfs



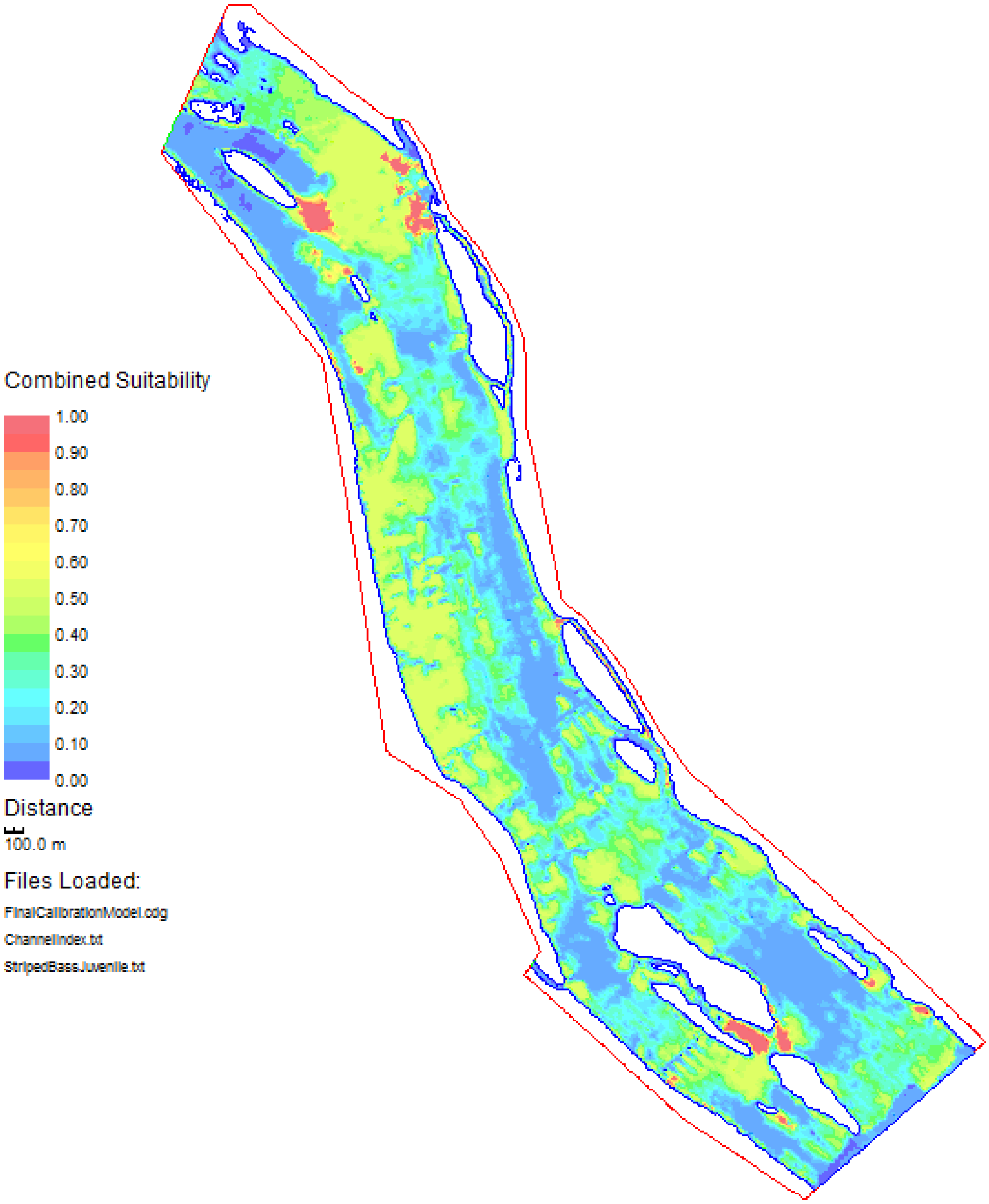
Striped Bass Juvenile – 60,000 cfs



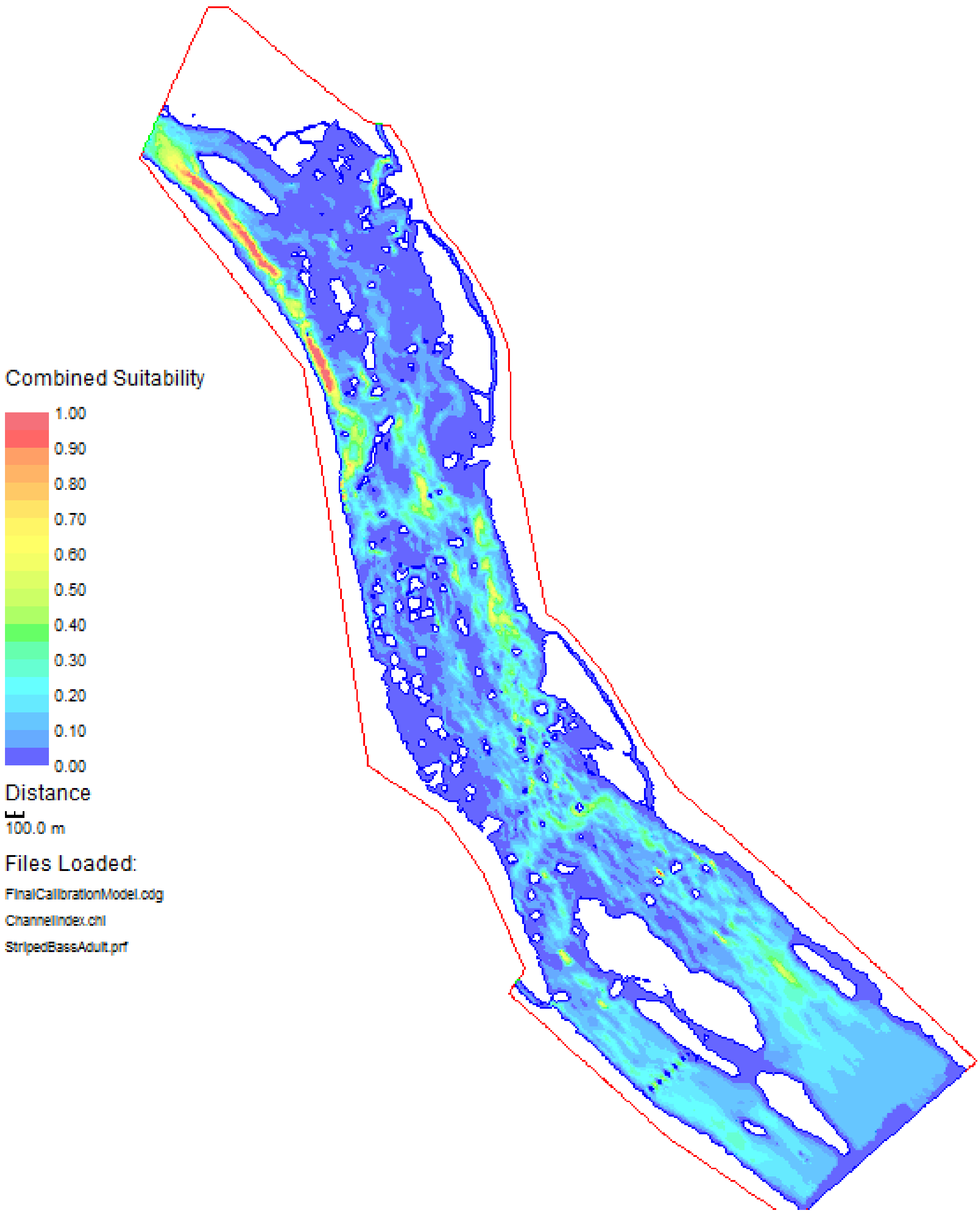
Striped Bass Juvenile – 70,000 cfs



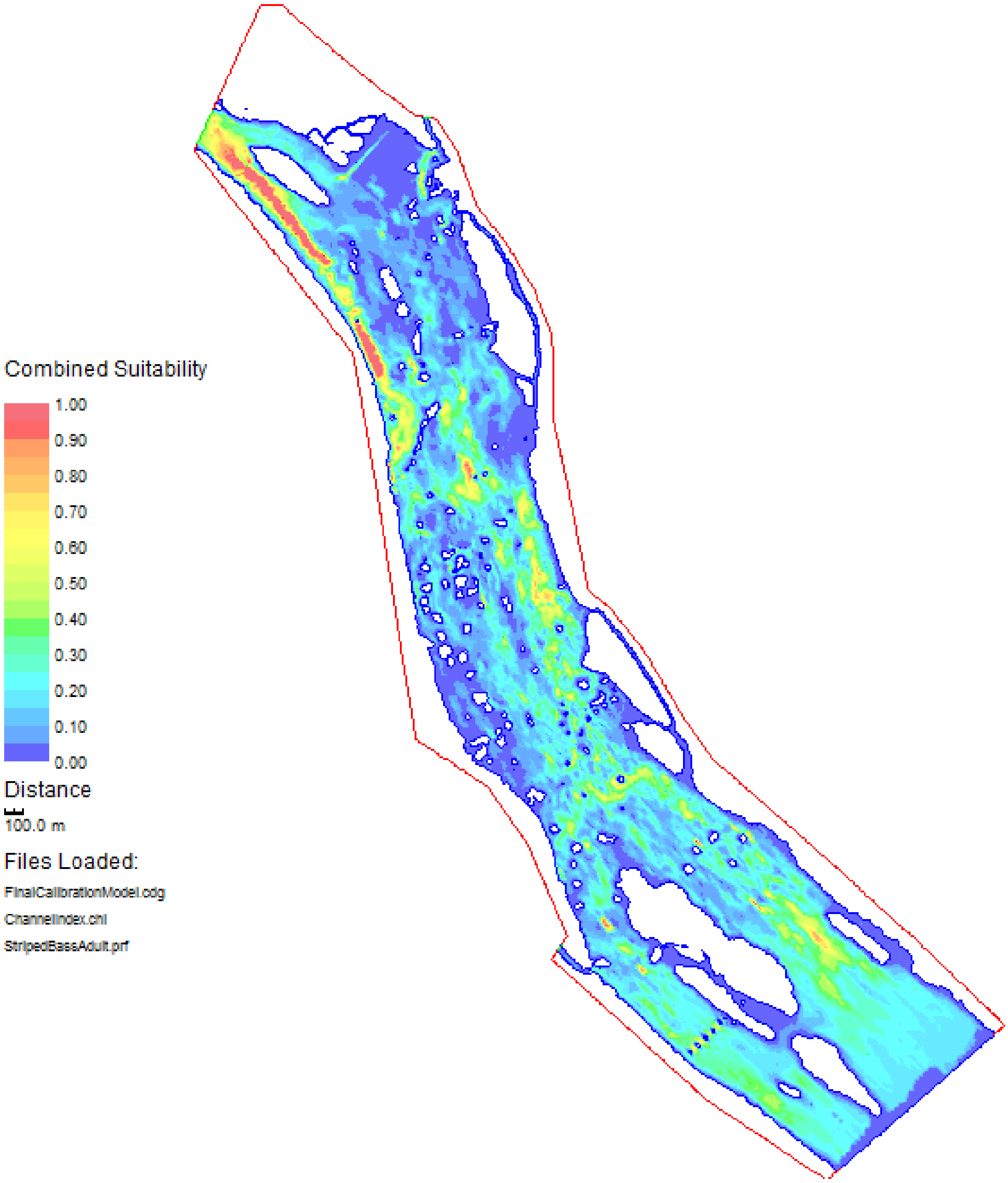
Striped Bass Juvenile – 80,000 cfs



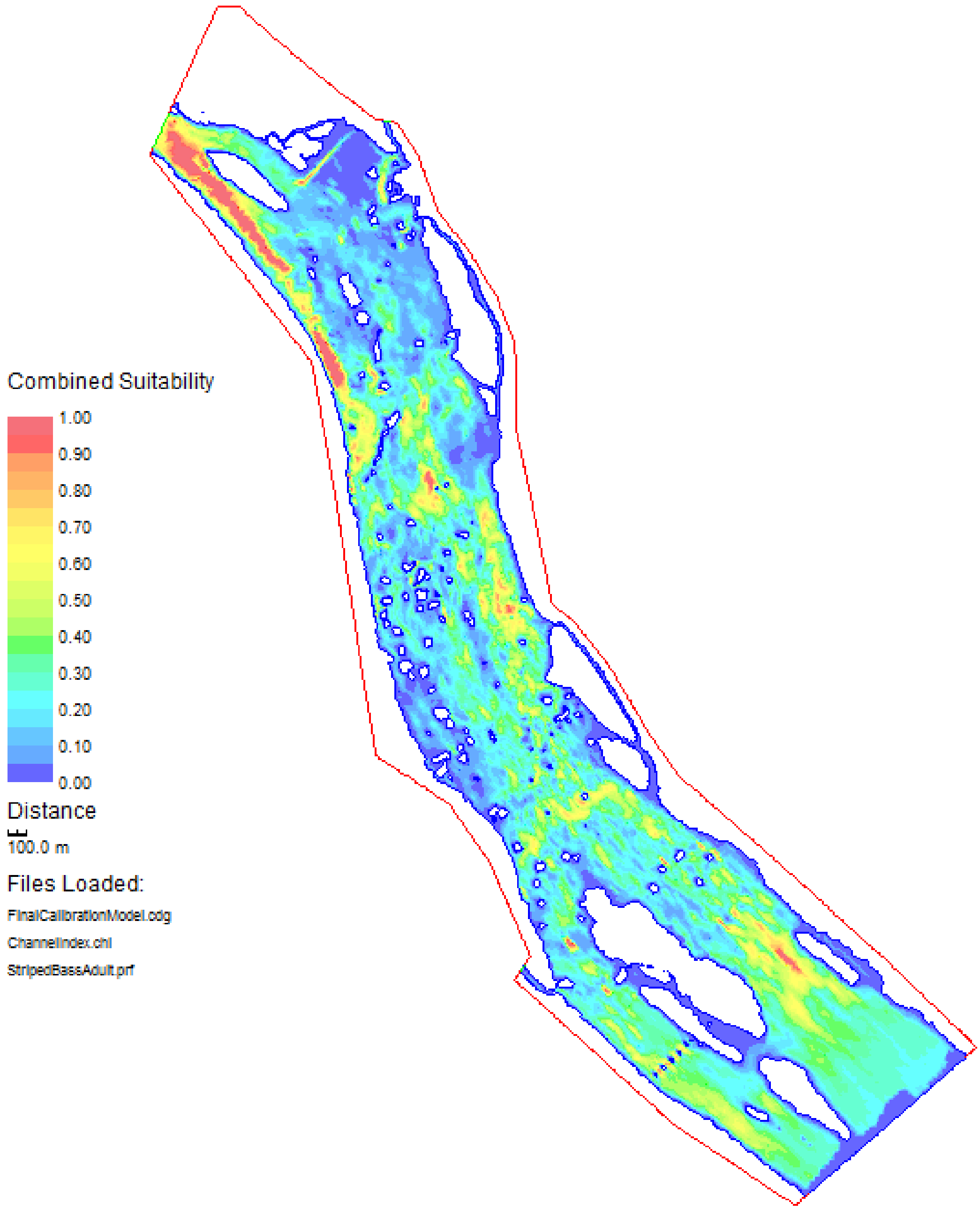
Striped Bass Juvenile – 86,000 cfs



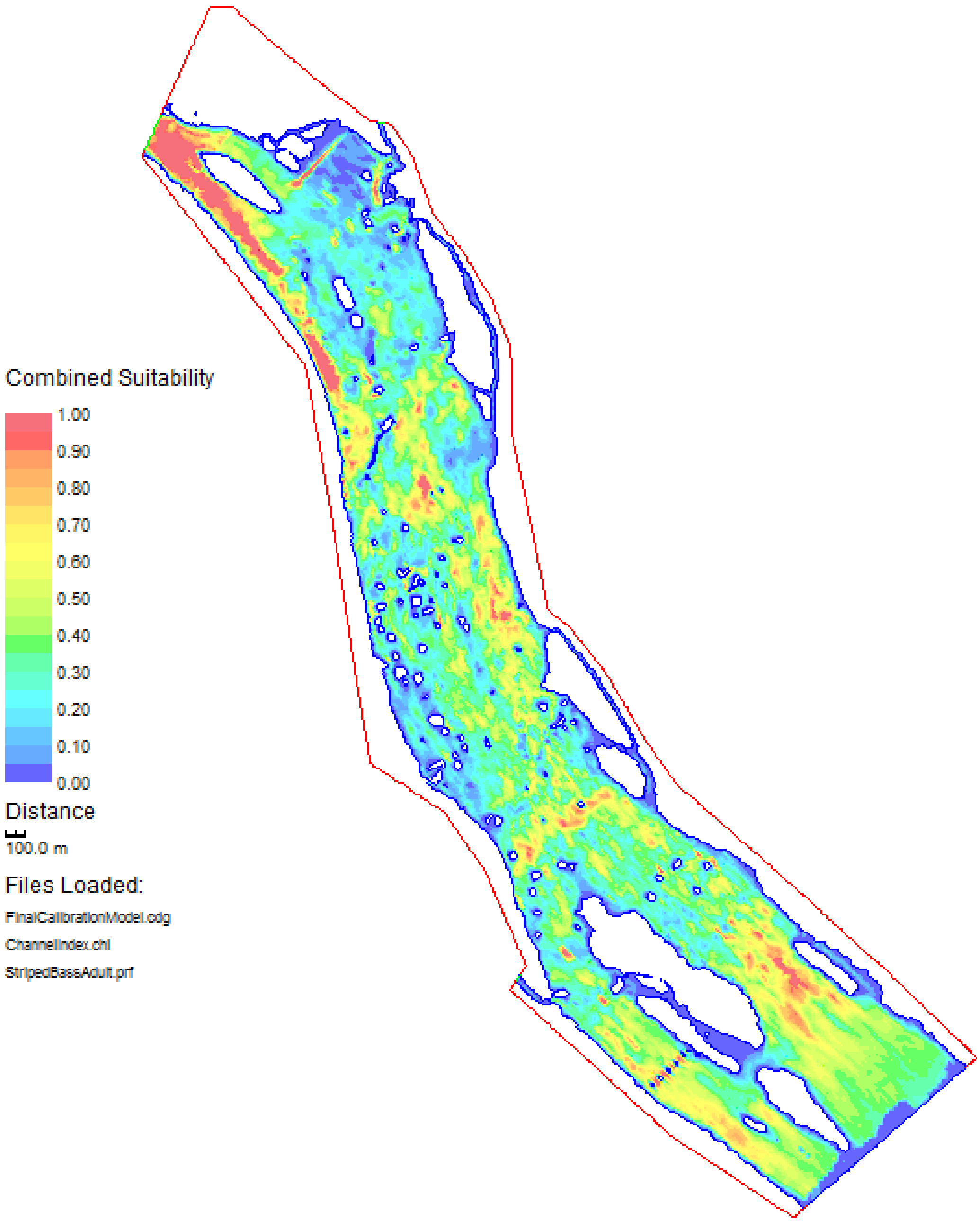
Striped Bass Adult – 2,000 cfs



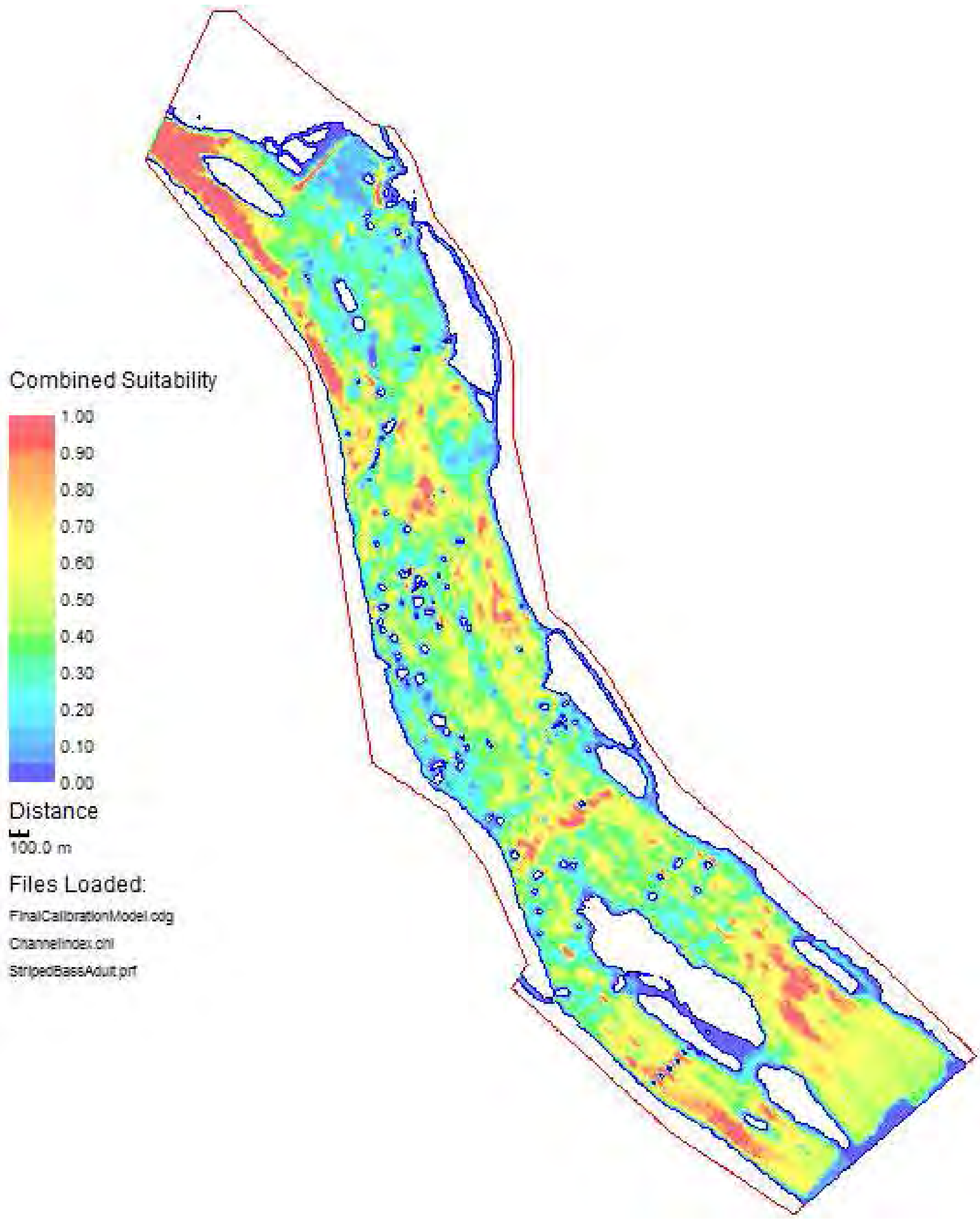
Striped Bass Adult – 3,500 cfs



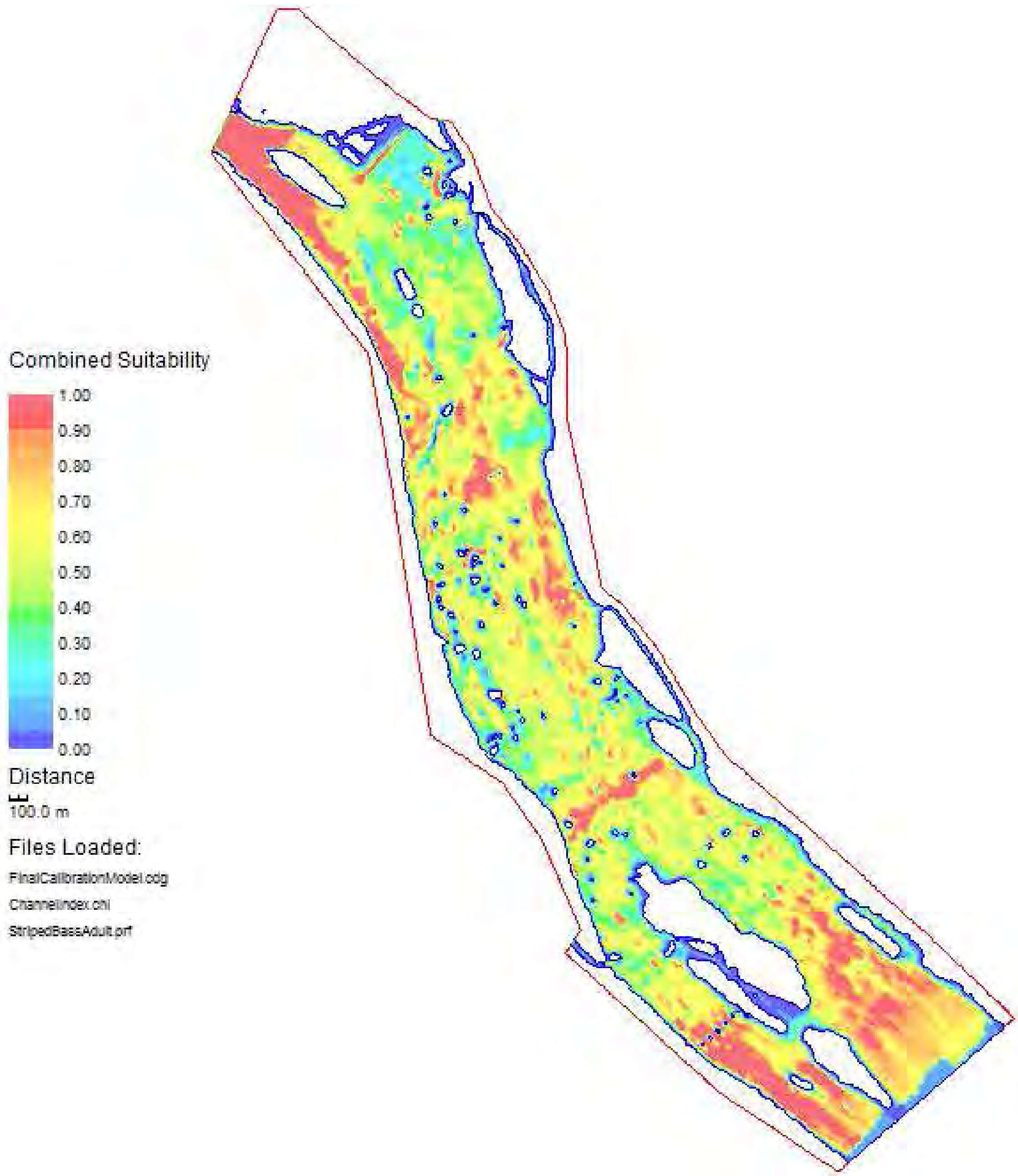
Striped Bass Adult – 5,000 cfs



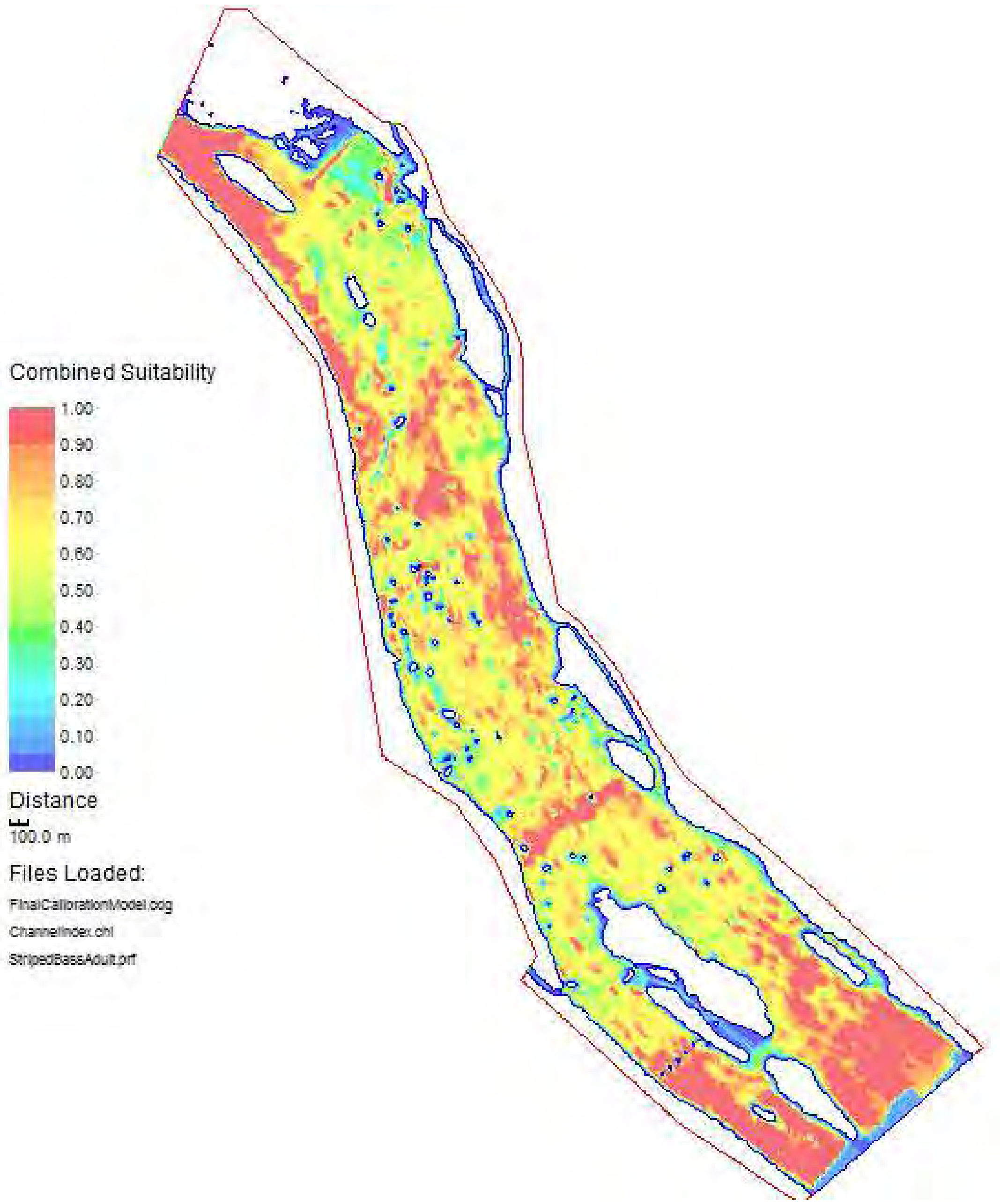
Striped Bass Adult – 7,500 cfs



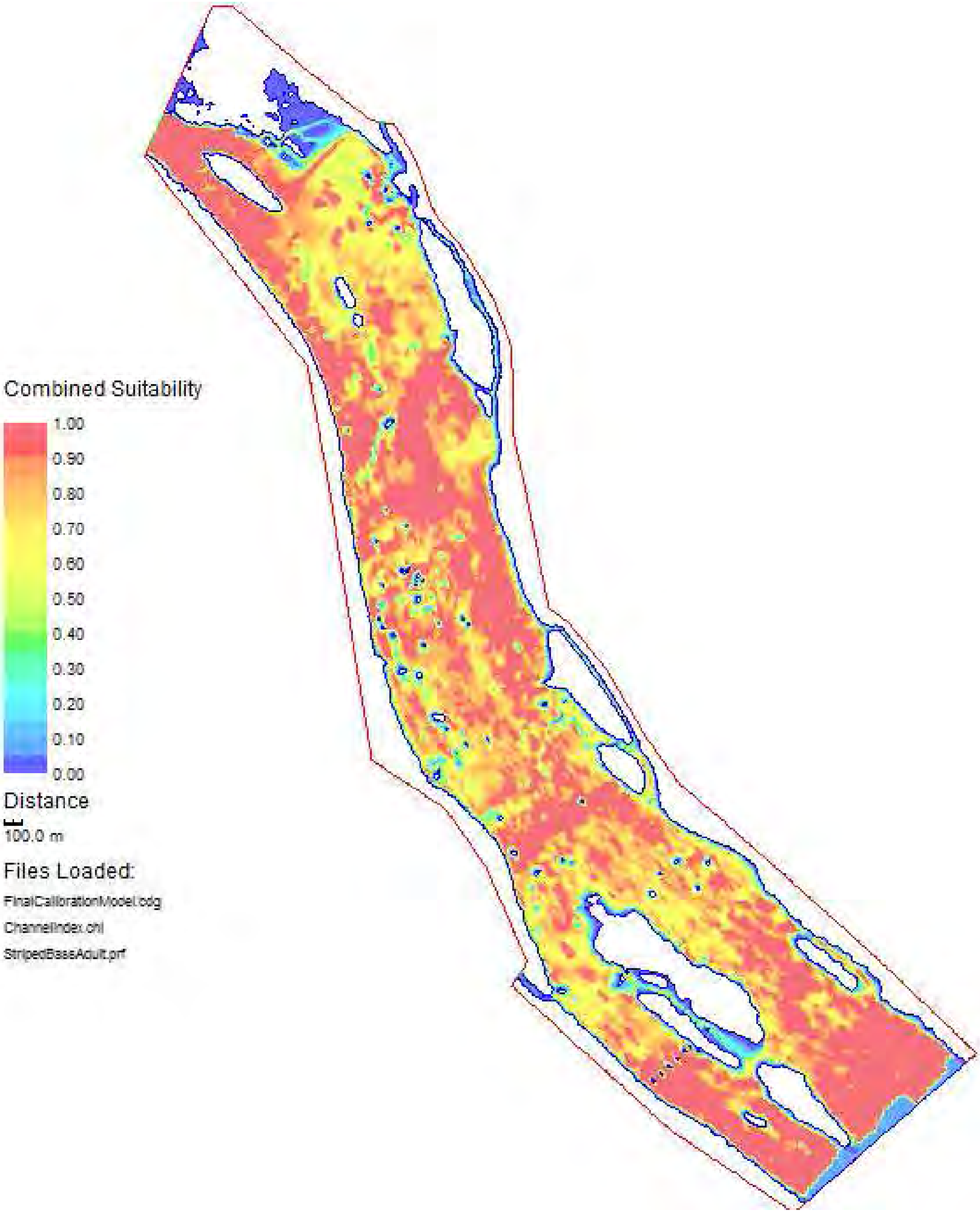
Striped Bass Adult – 10,000 cfs



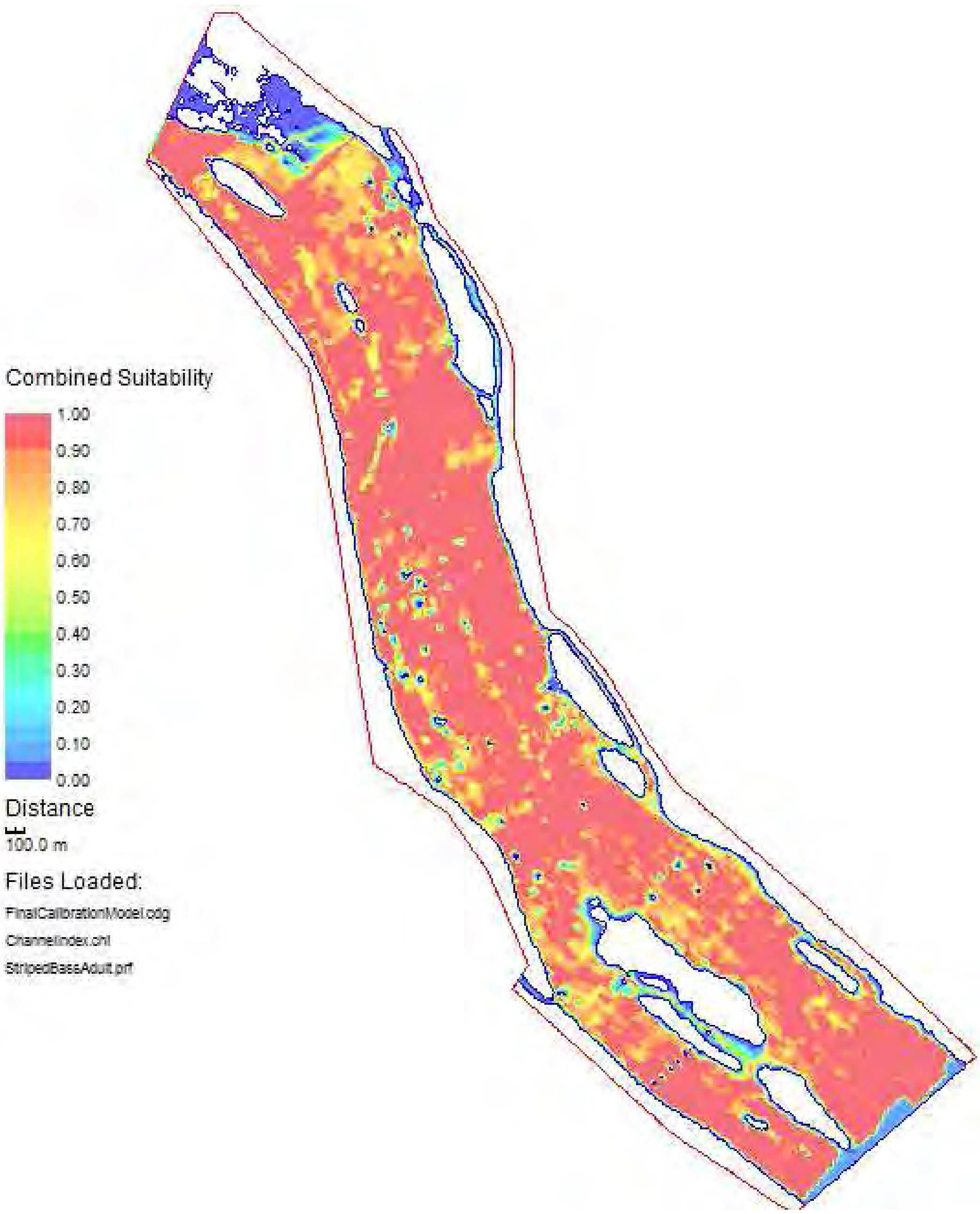
Striped Bass Adult – 15,000 cfs



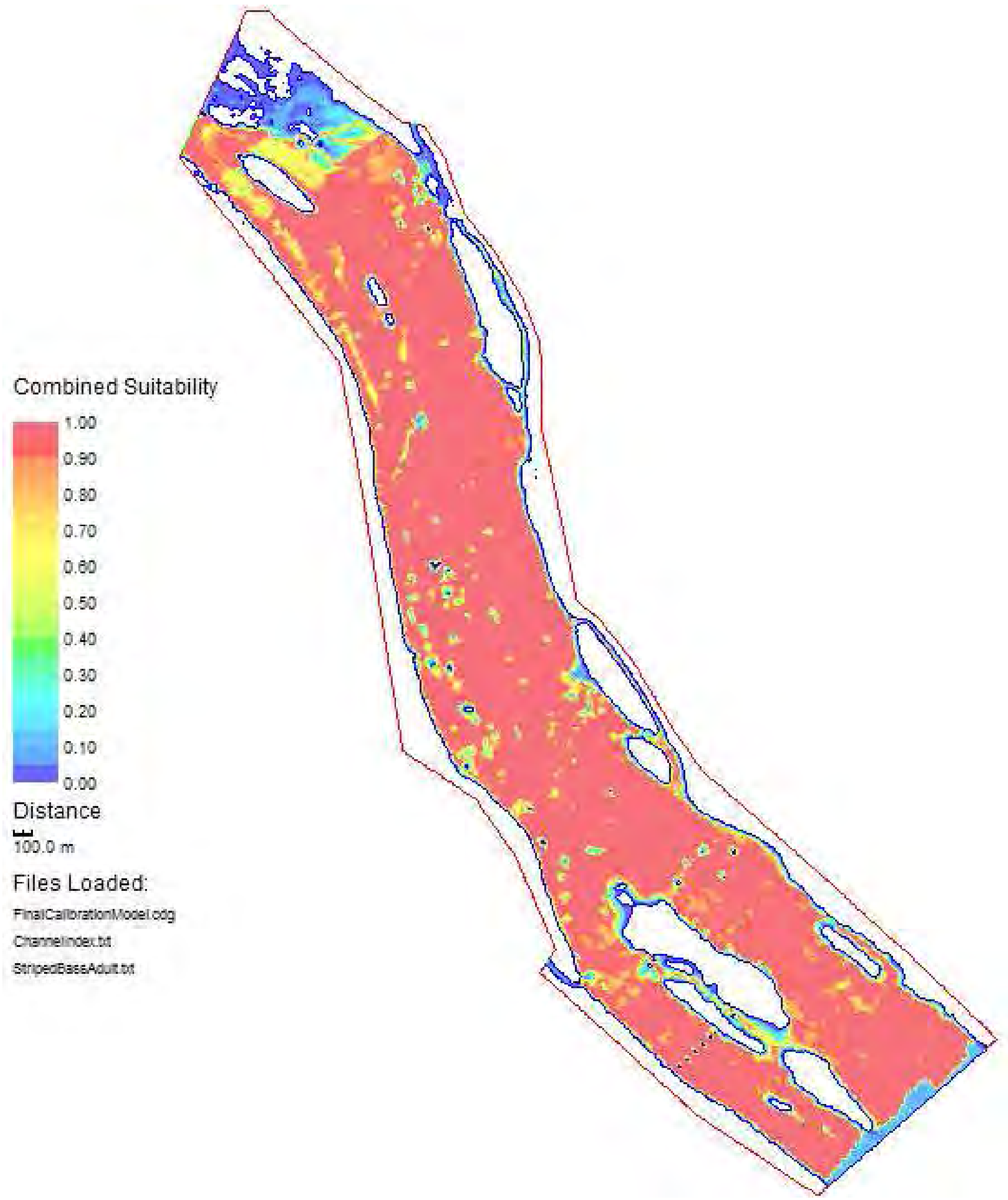
Striped Bass Adult – 20,000 cfs



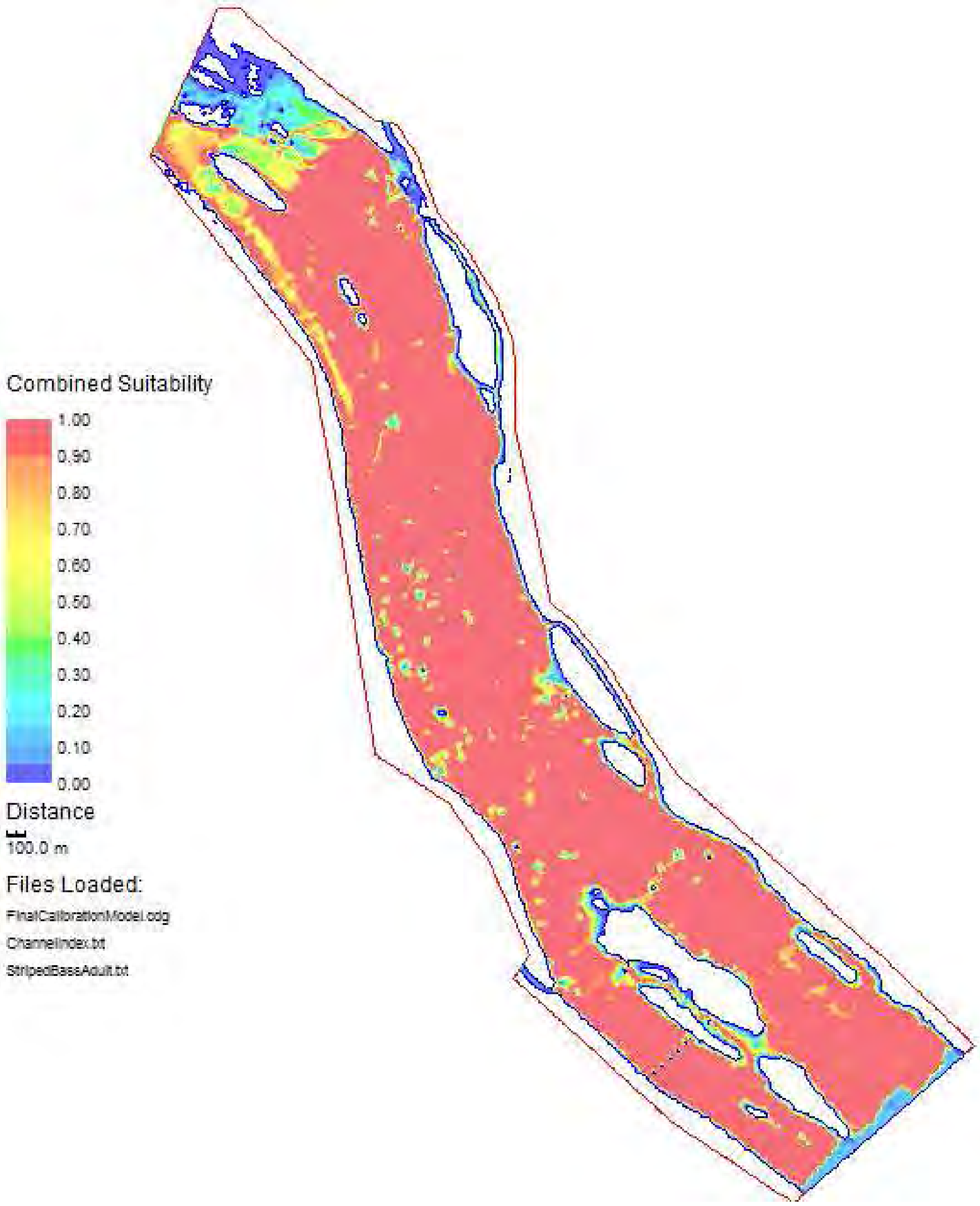
Striped Bass Adult – 30,000 cfs



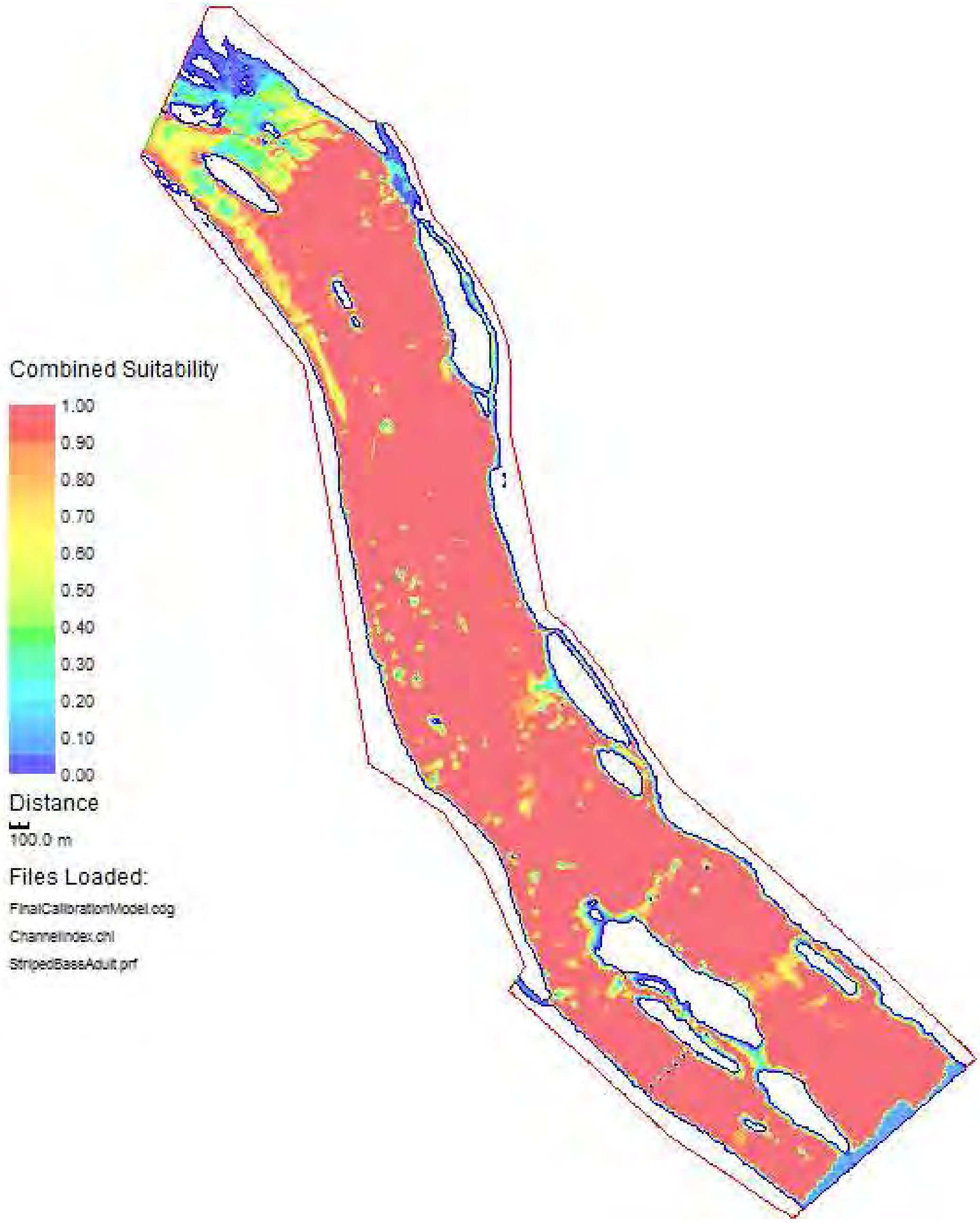
Striped Bass Adult – 40,000 cfs



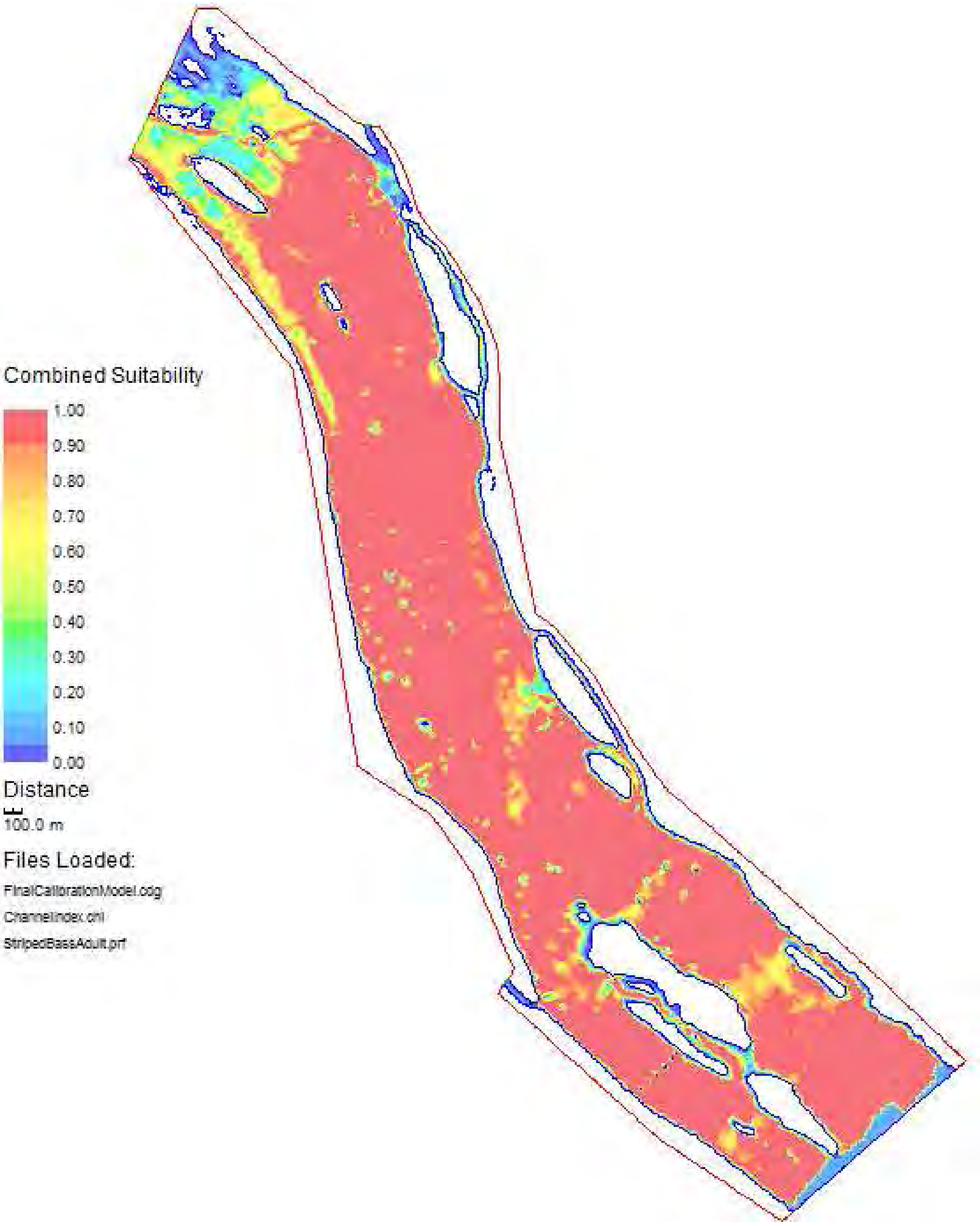
Striped Bass Adult – 50,000 cfs



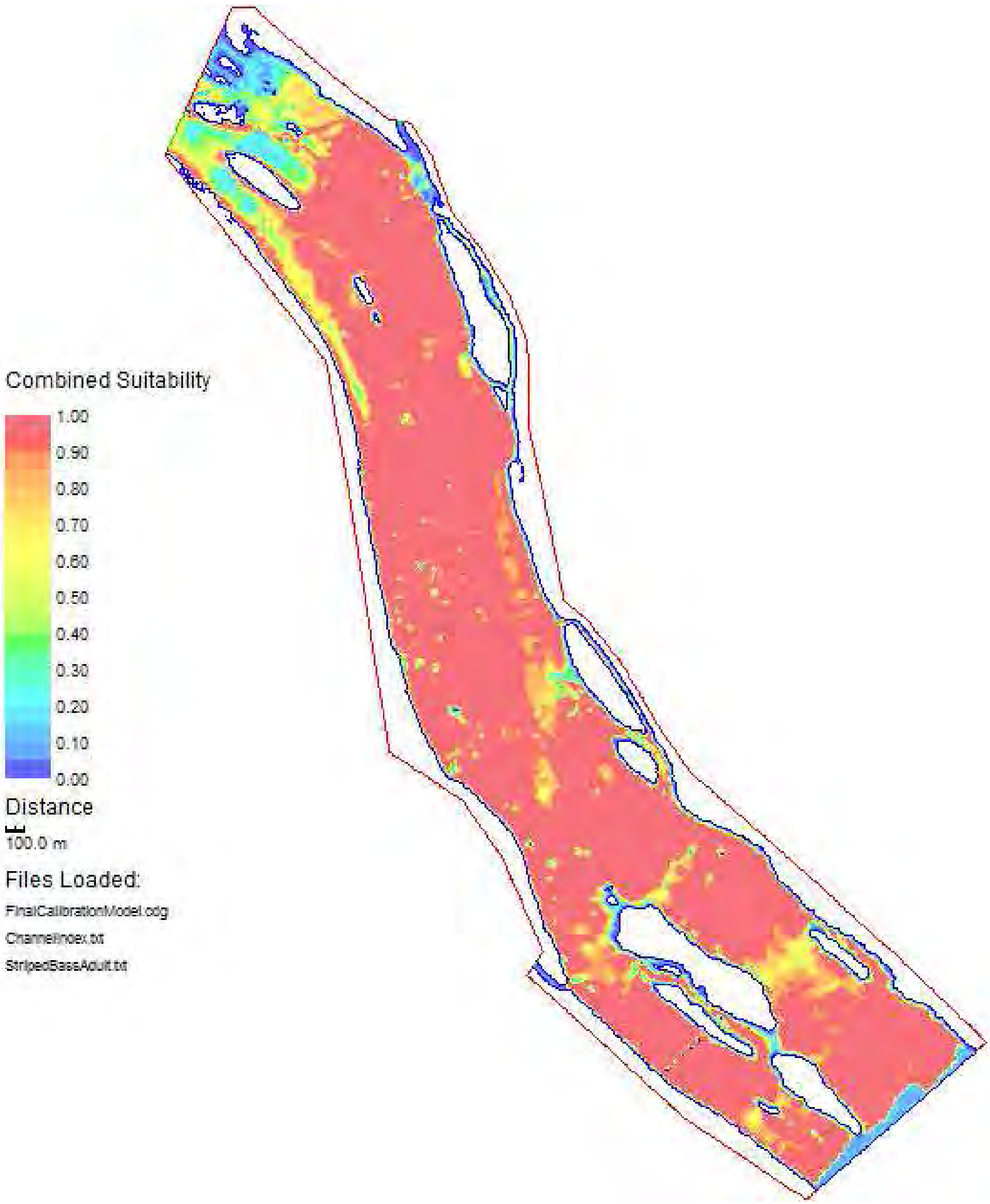
Striped Bass Adult – 60,000 cfs



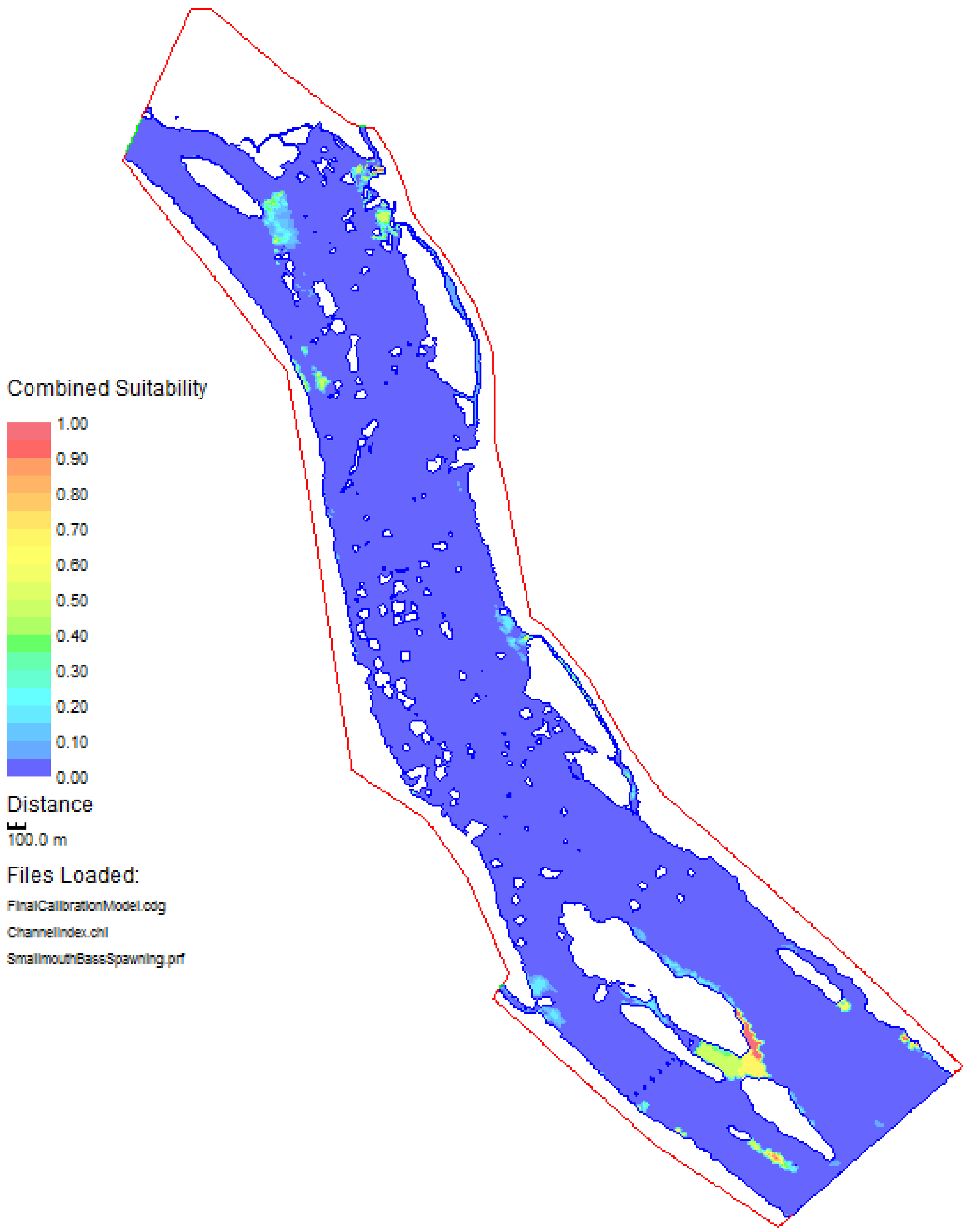
Striped Bass Adult – 70,000 cfs



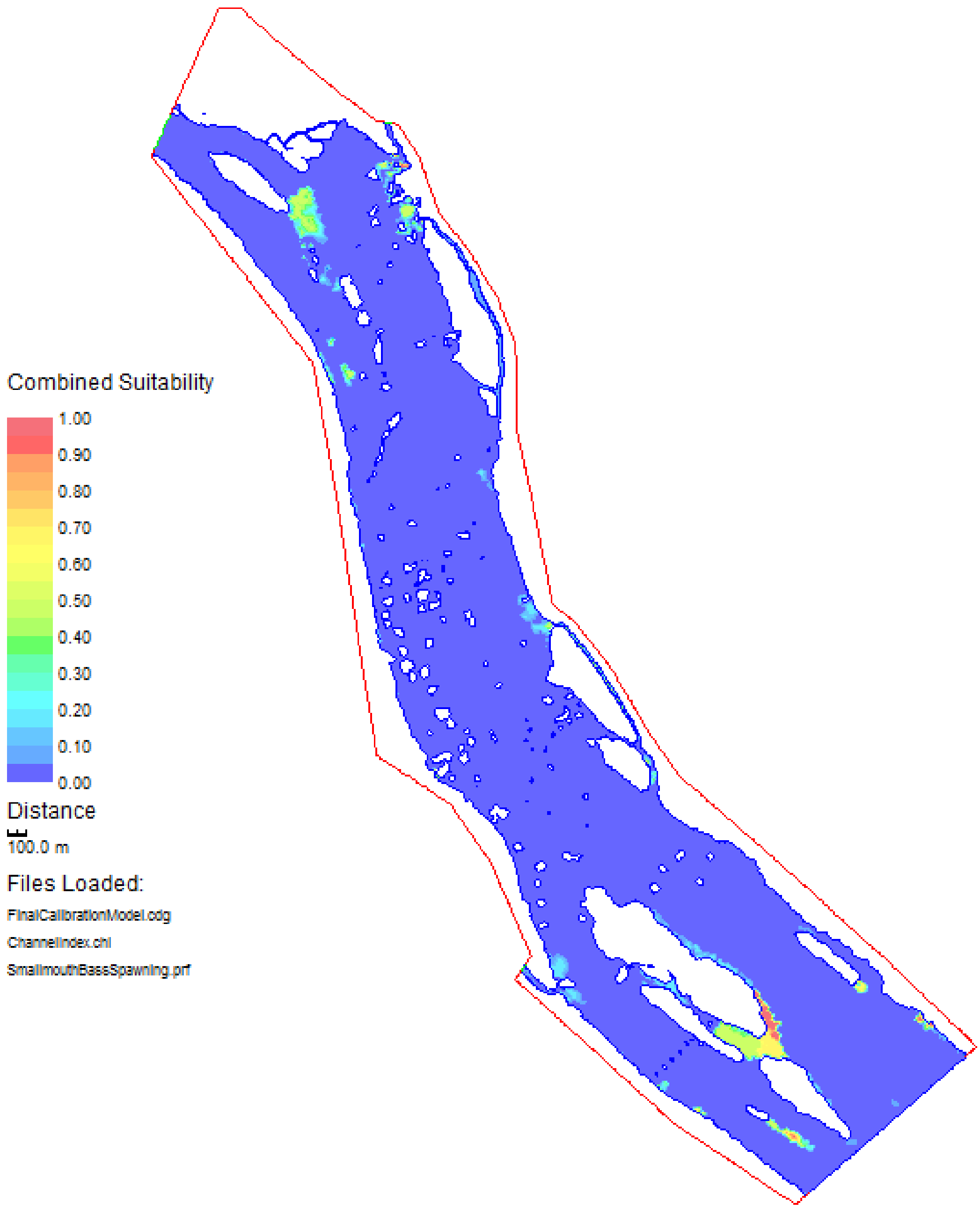
Striped Bass Adult – 80,000 cfs



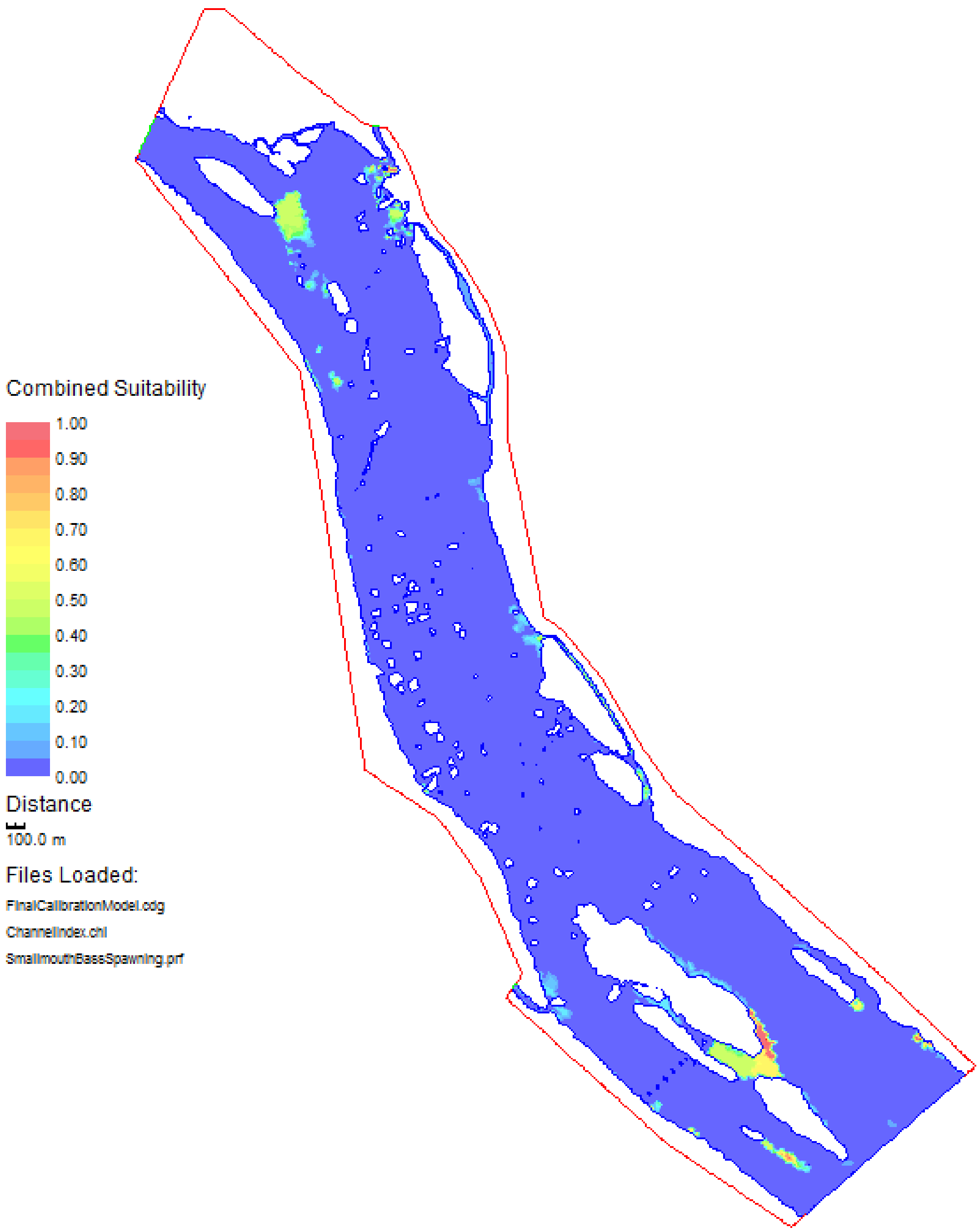
Striped Bass Adult – 86,000 cfs



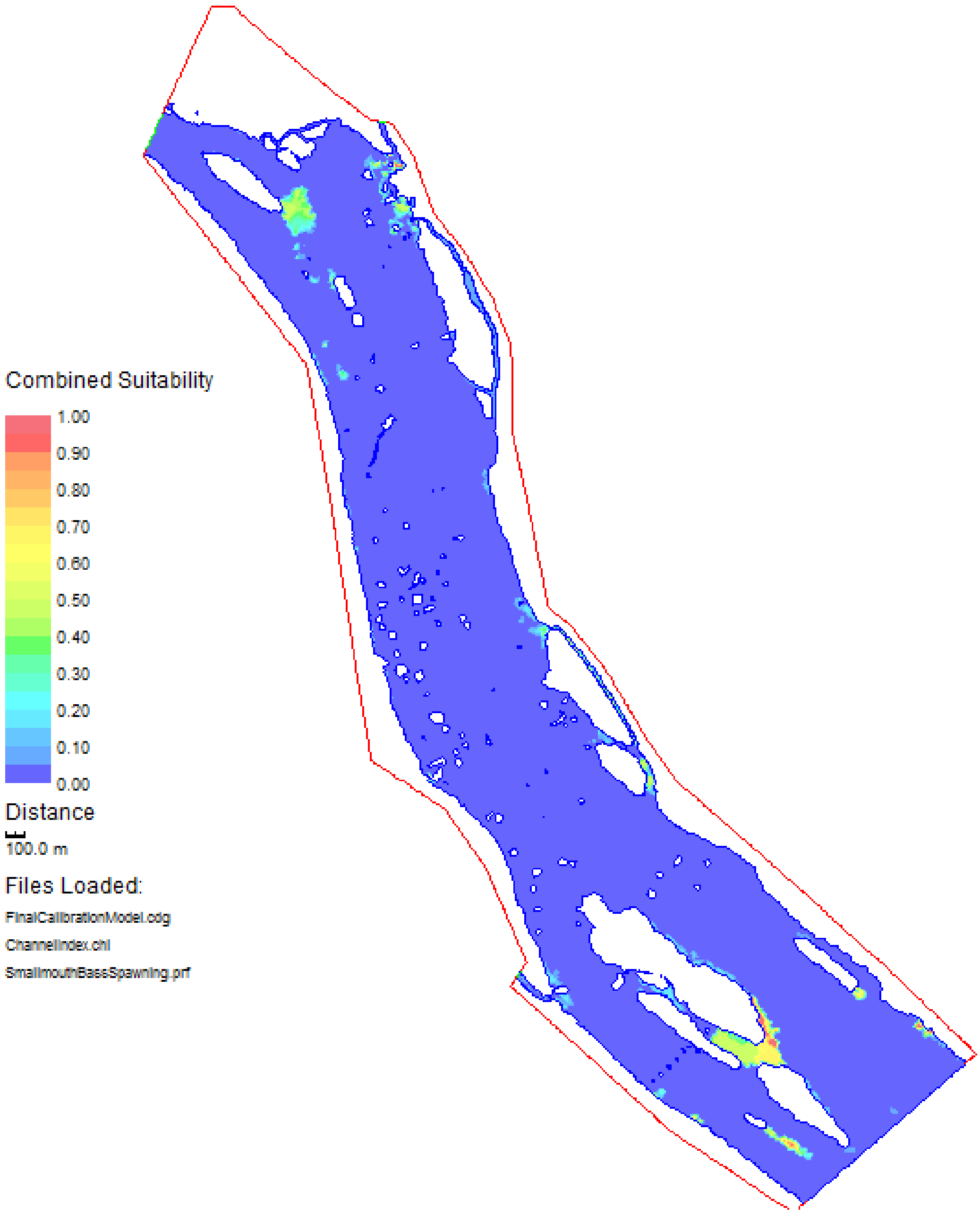
Smallmouth Bass Spawning – 2,000 cfs



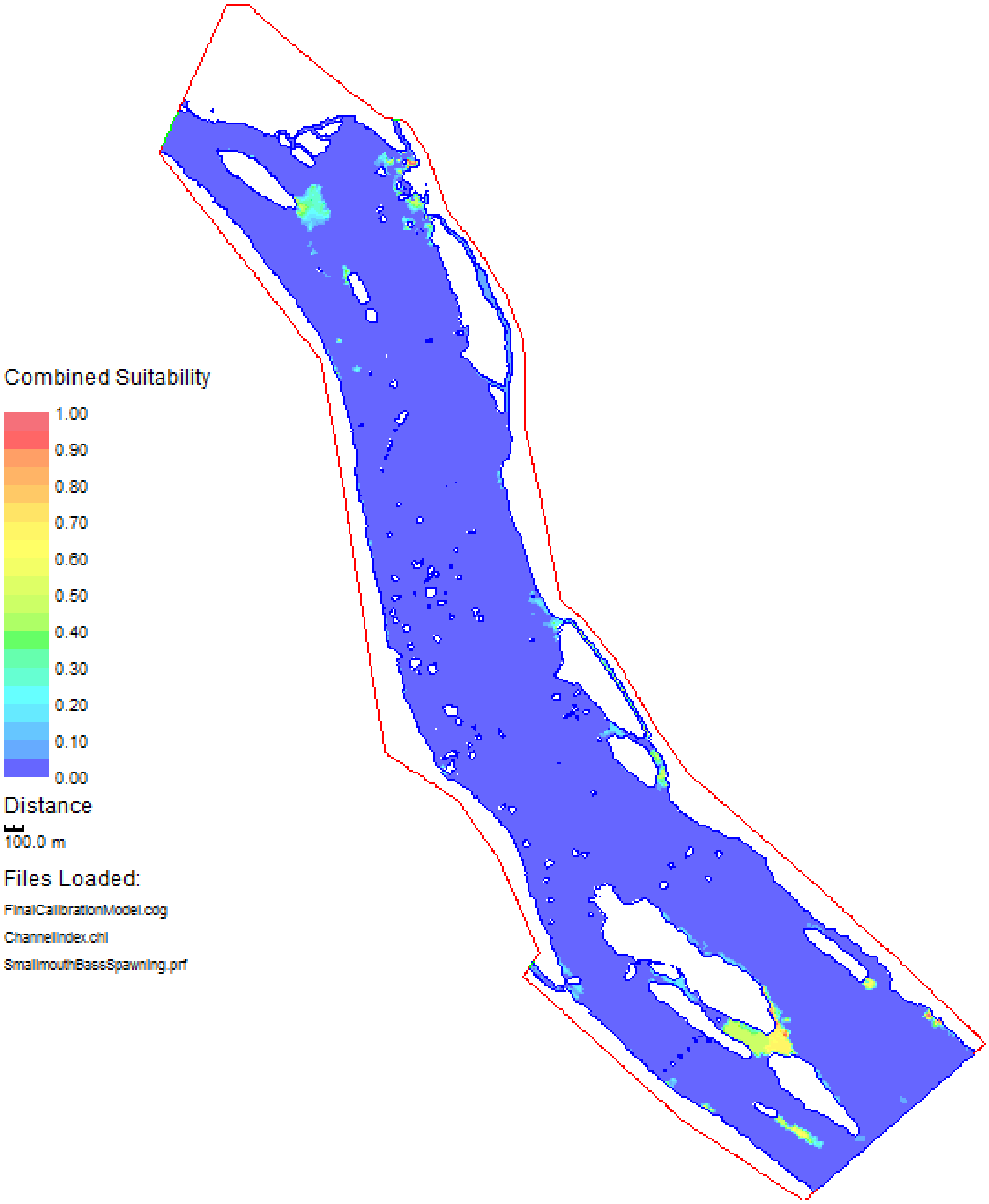
Smallmouth Bass Spawning – 3,500 cfs



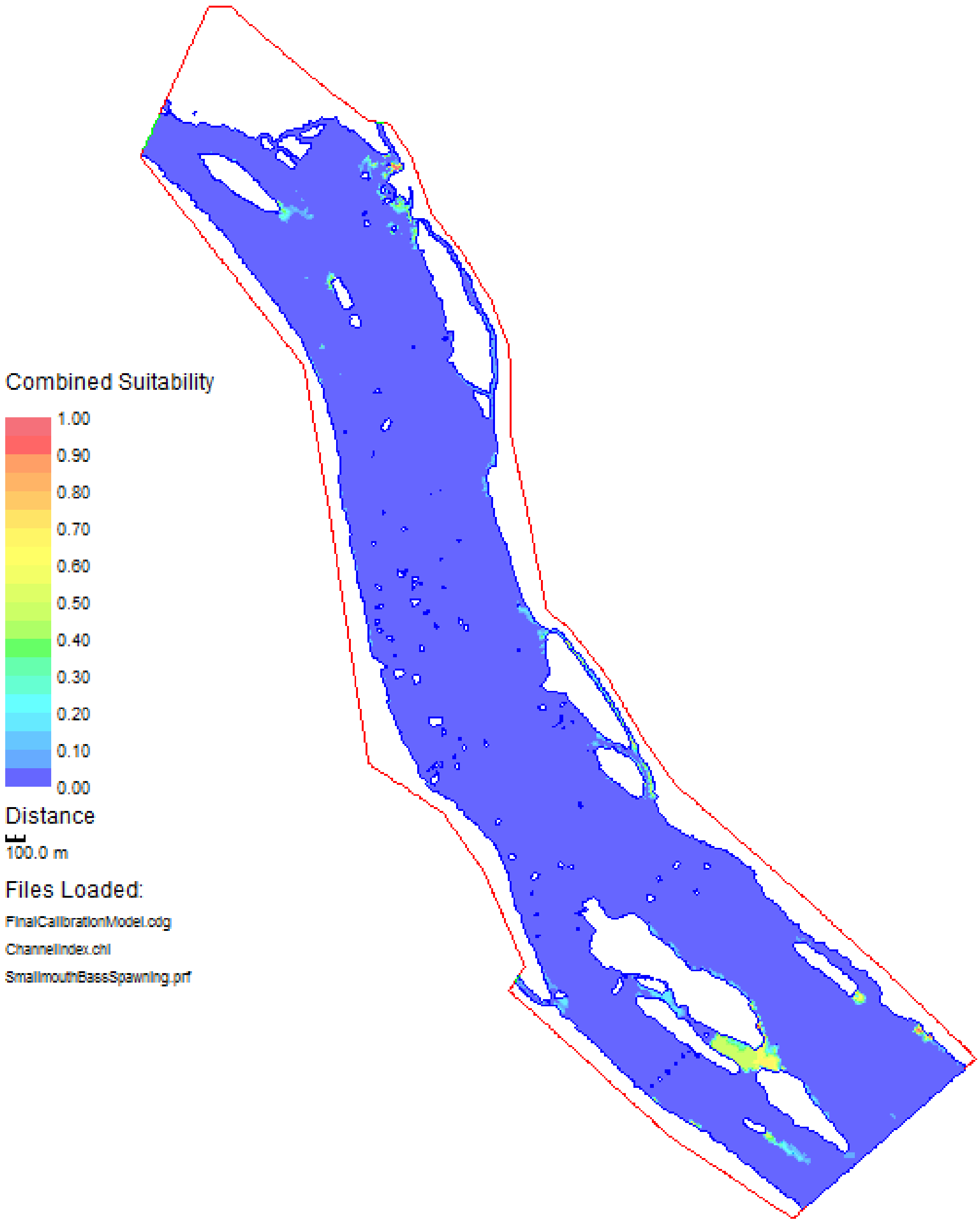
Smallmouth Bass Spawning – 5,000 cfs



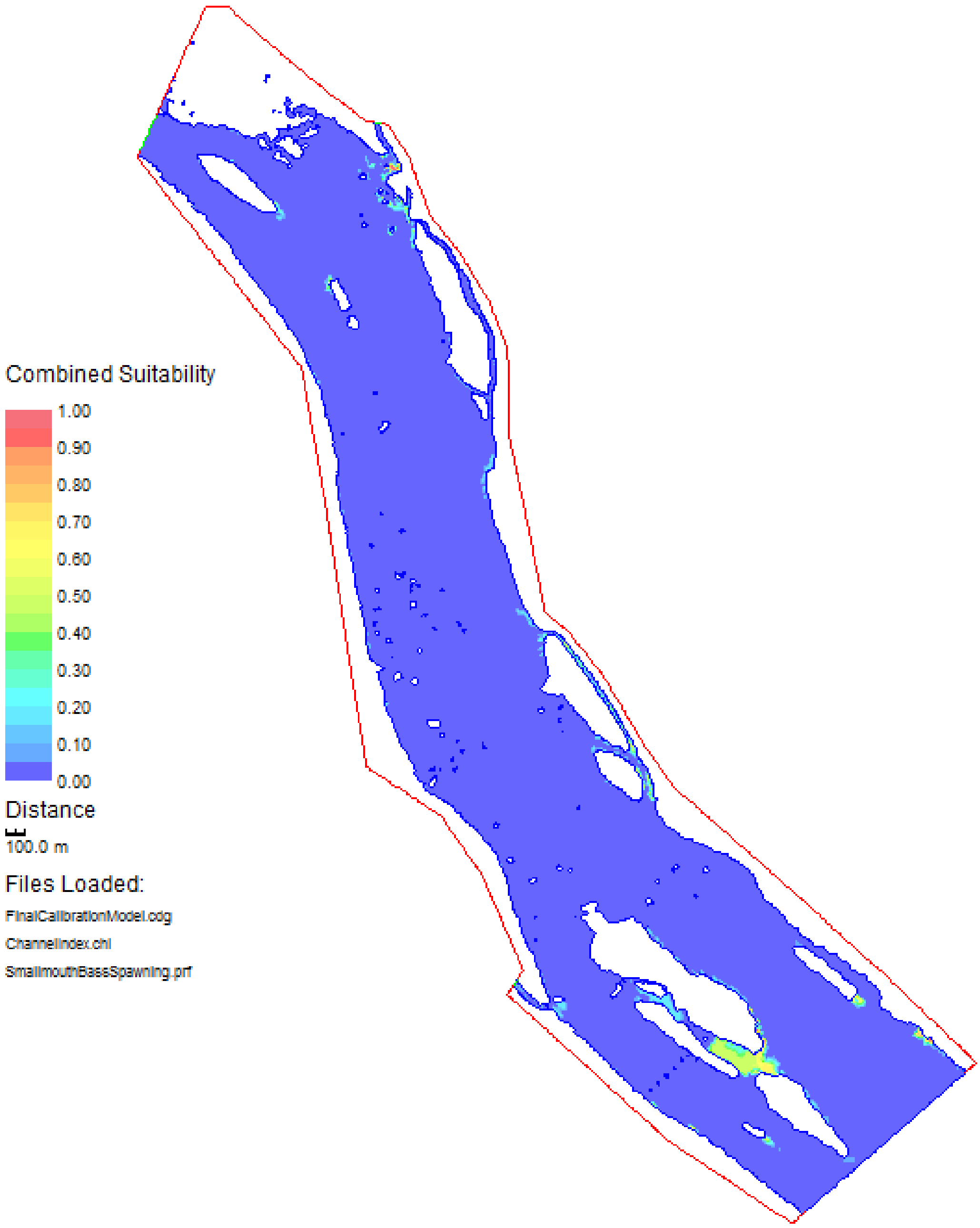
Smallmouth Bass Spawning – 7,500 cfs



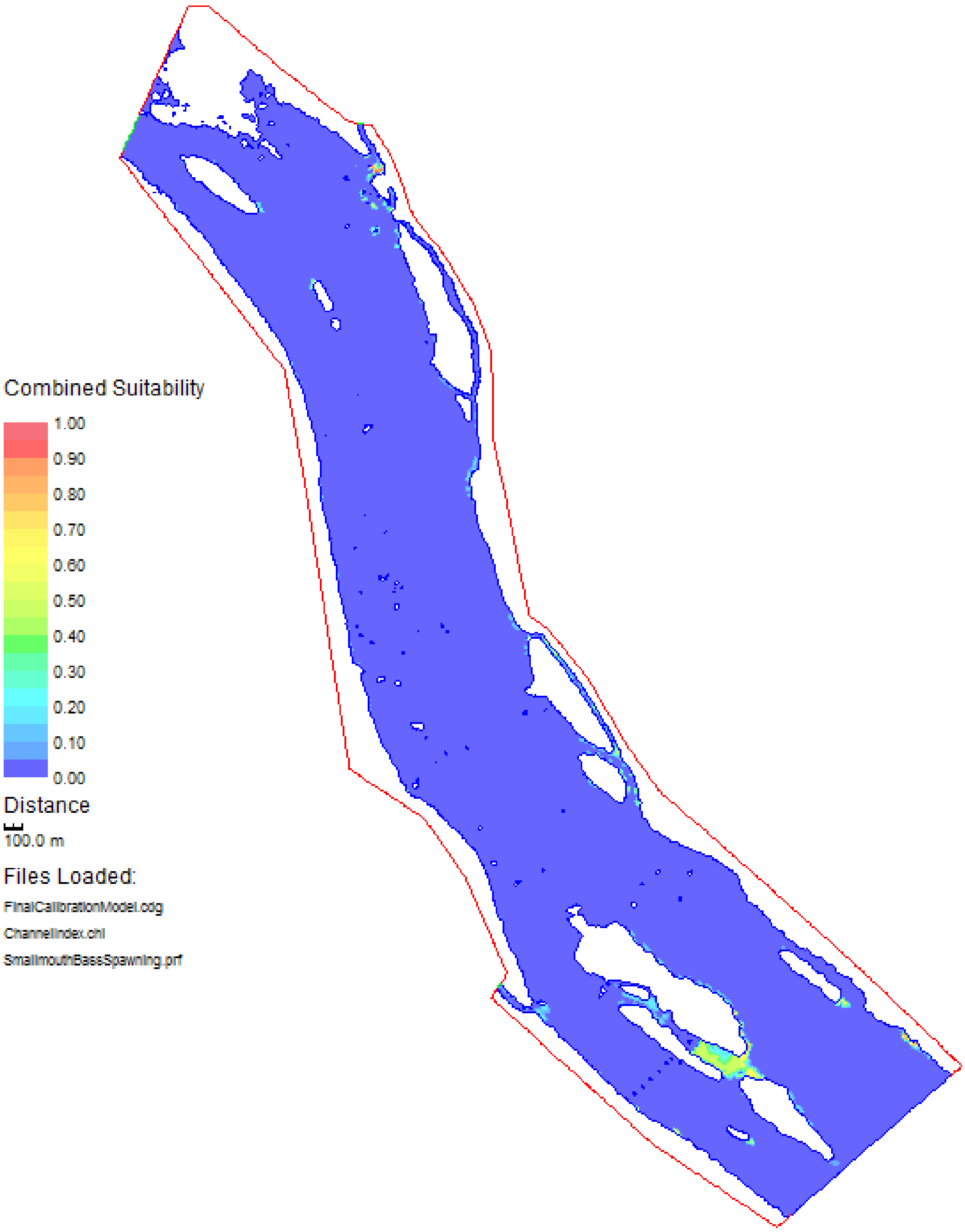
Smallmouth Bass Spawning – 10,000 cfs



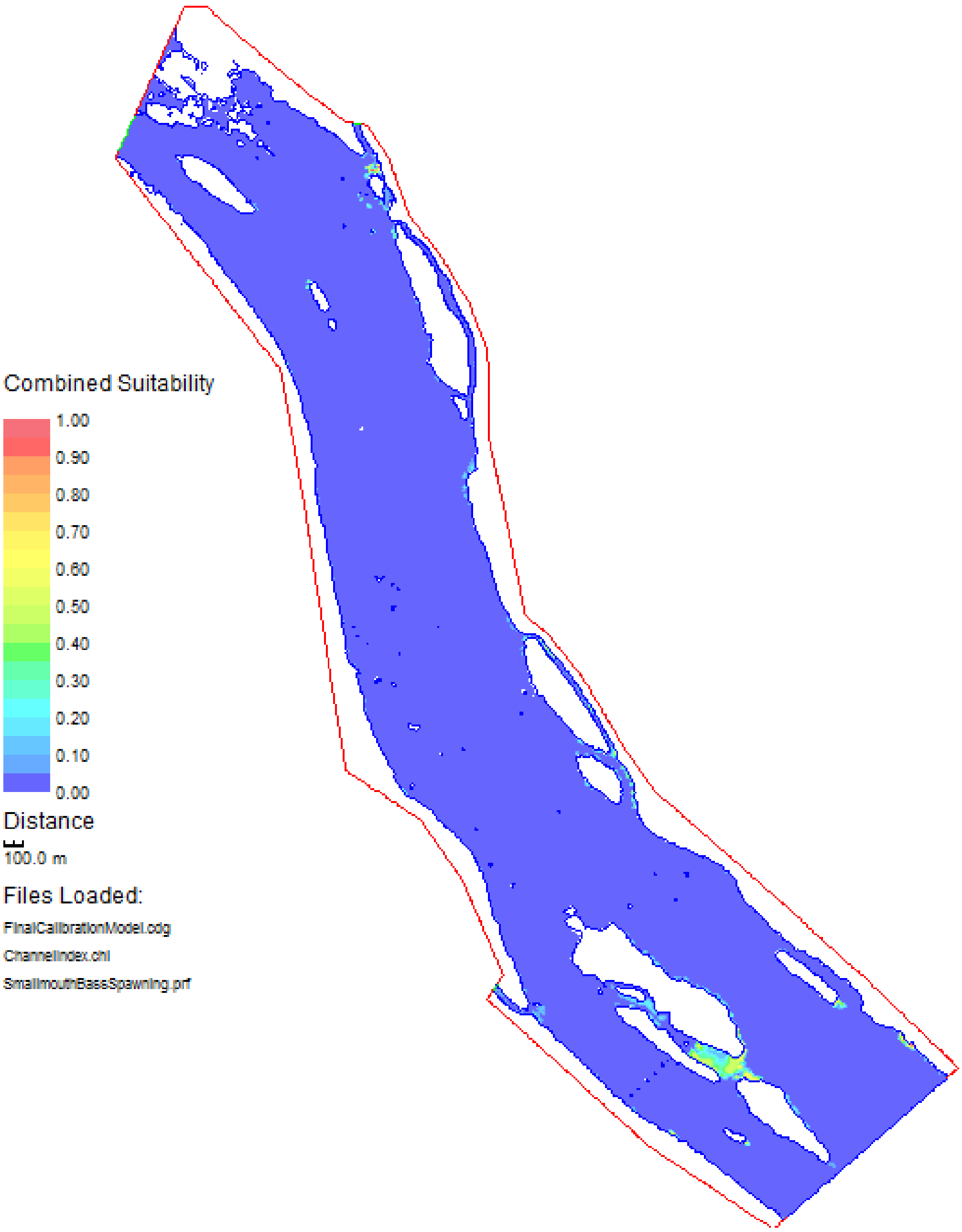
Smallmouth Bass Spawning – 15,000 cfs



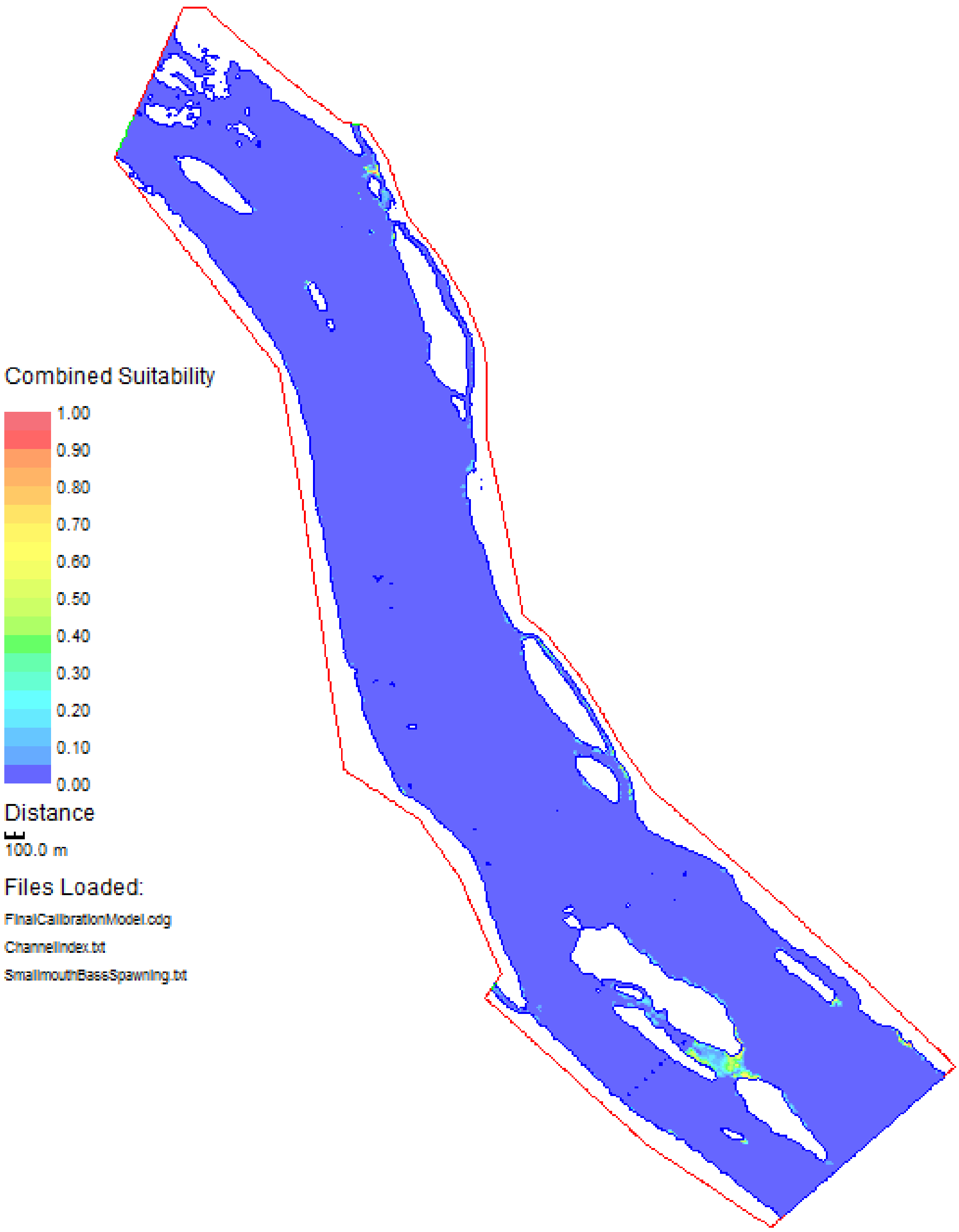
Smallmouth Bass Spawning – 20,000 cfs



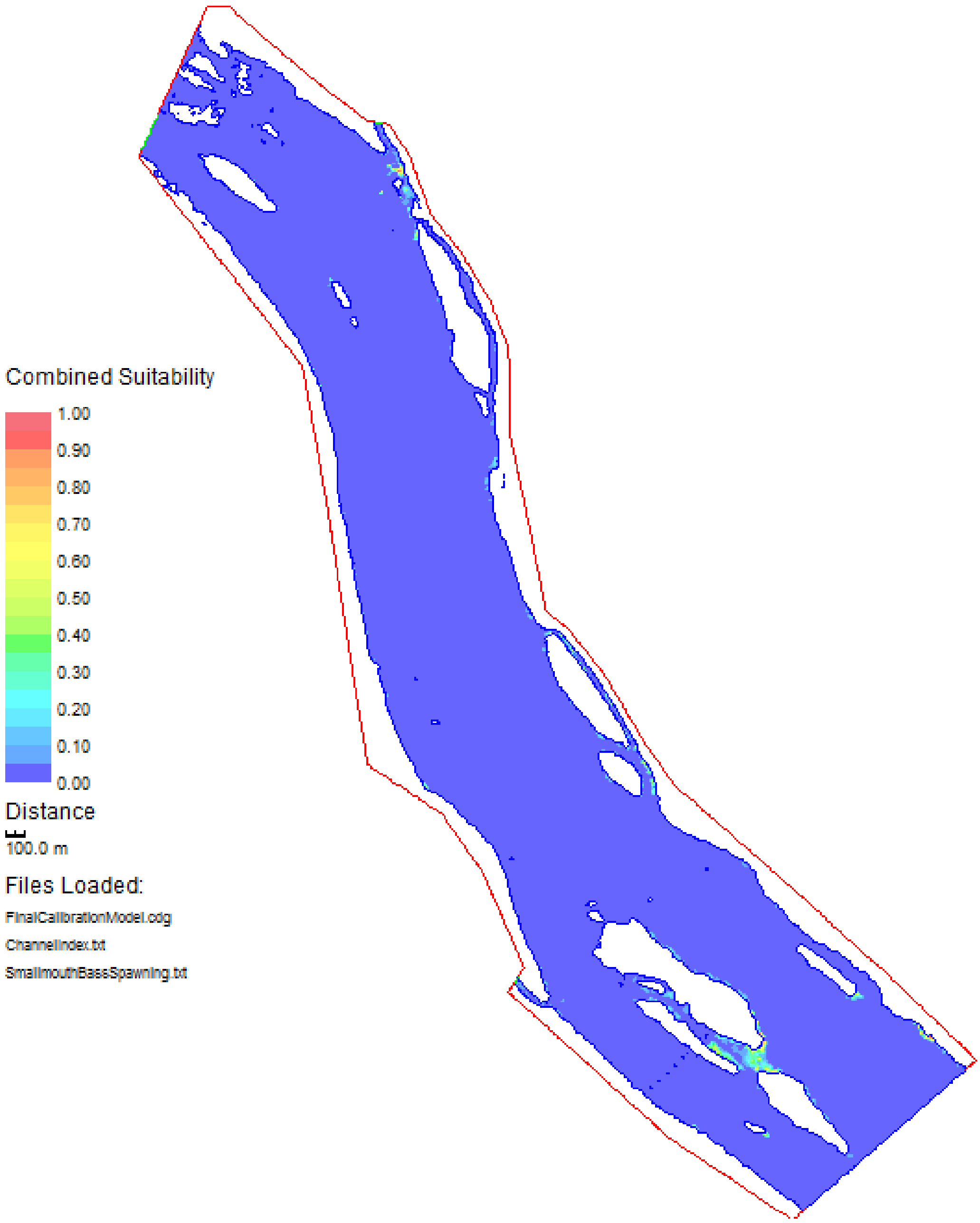
Smallmouth Bass Spawning – 30,000 cfs



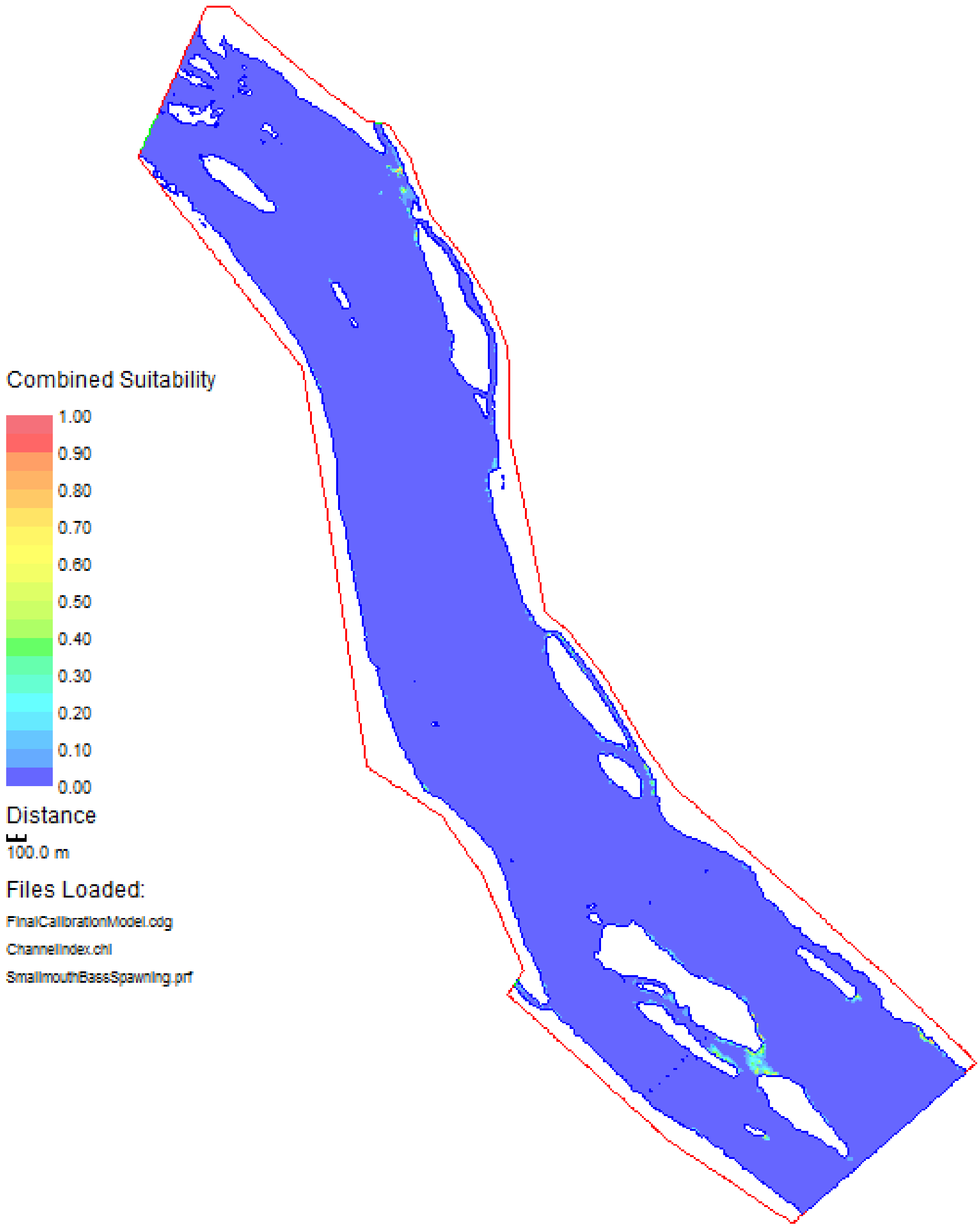
Smallmouth Bass Spawning – 40,000 cfs



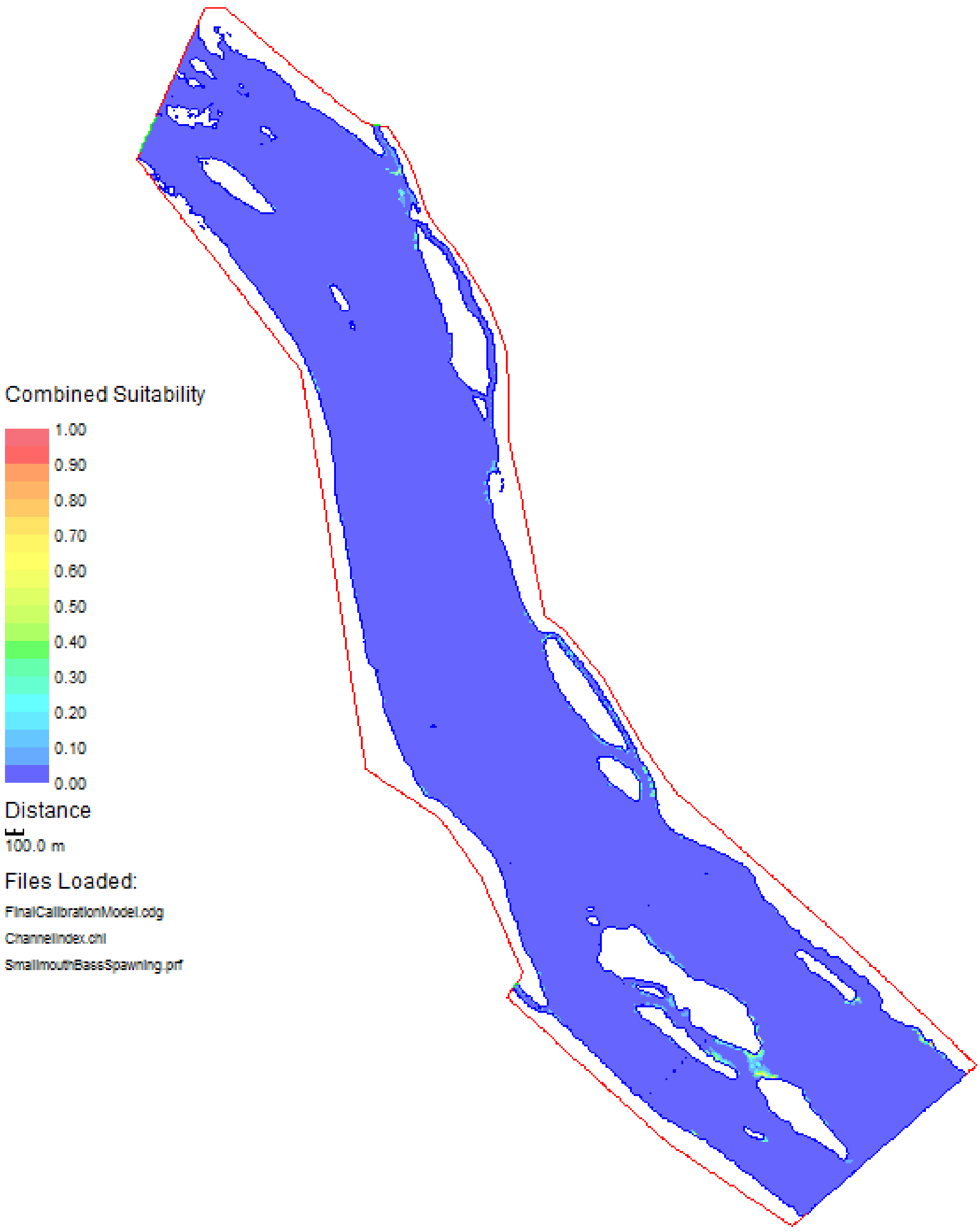
Smallmouth Bass Spawning – 50,000 cfs



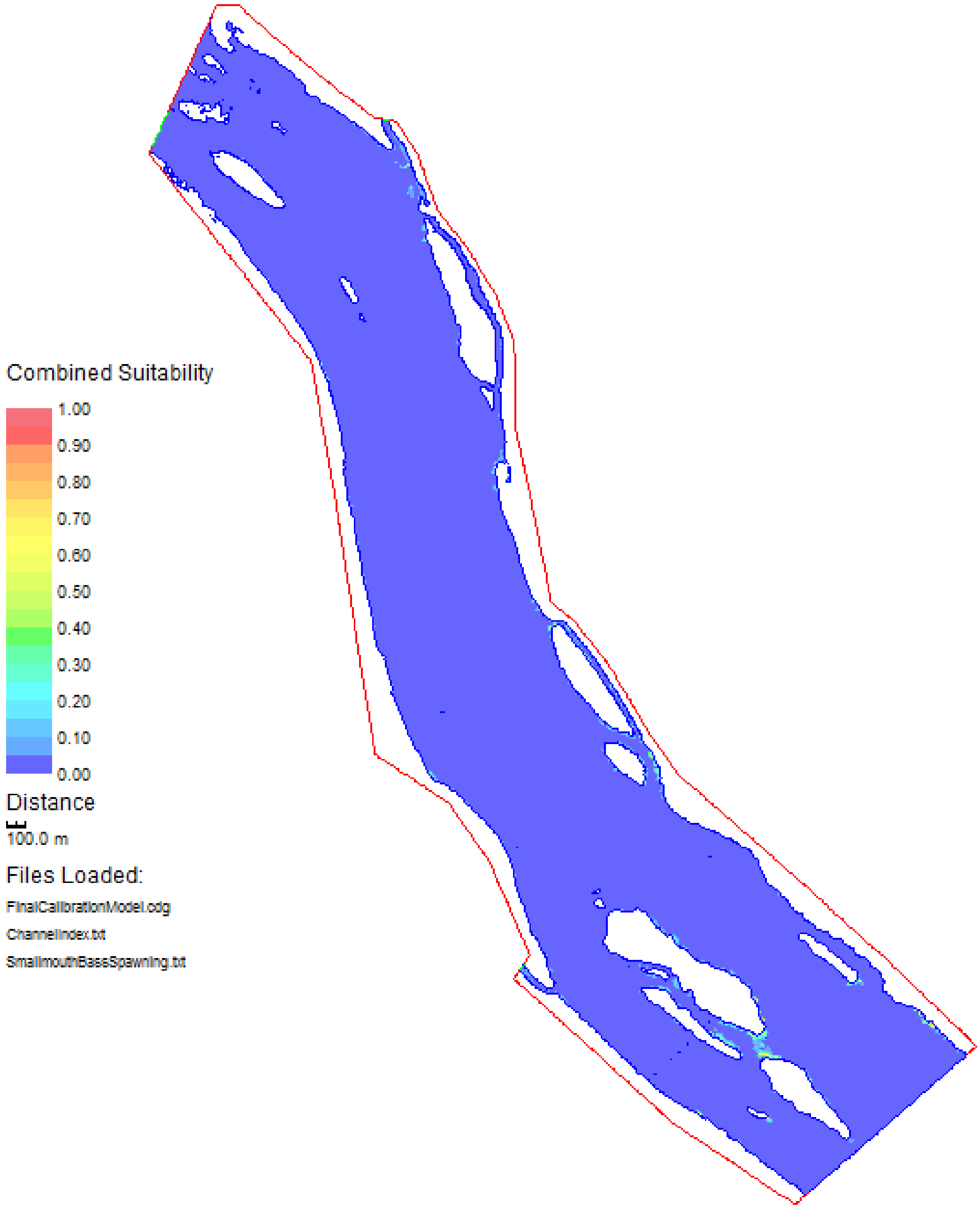
Smallmouth Bass Spawning – 60,000 cfs



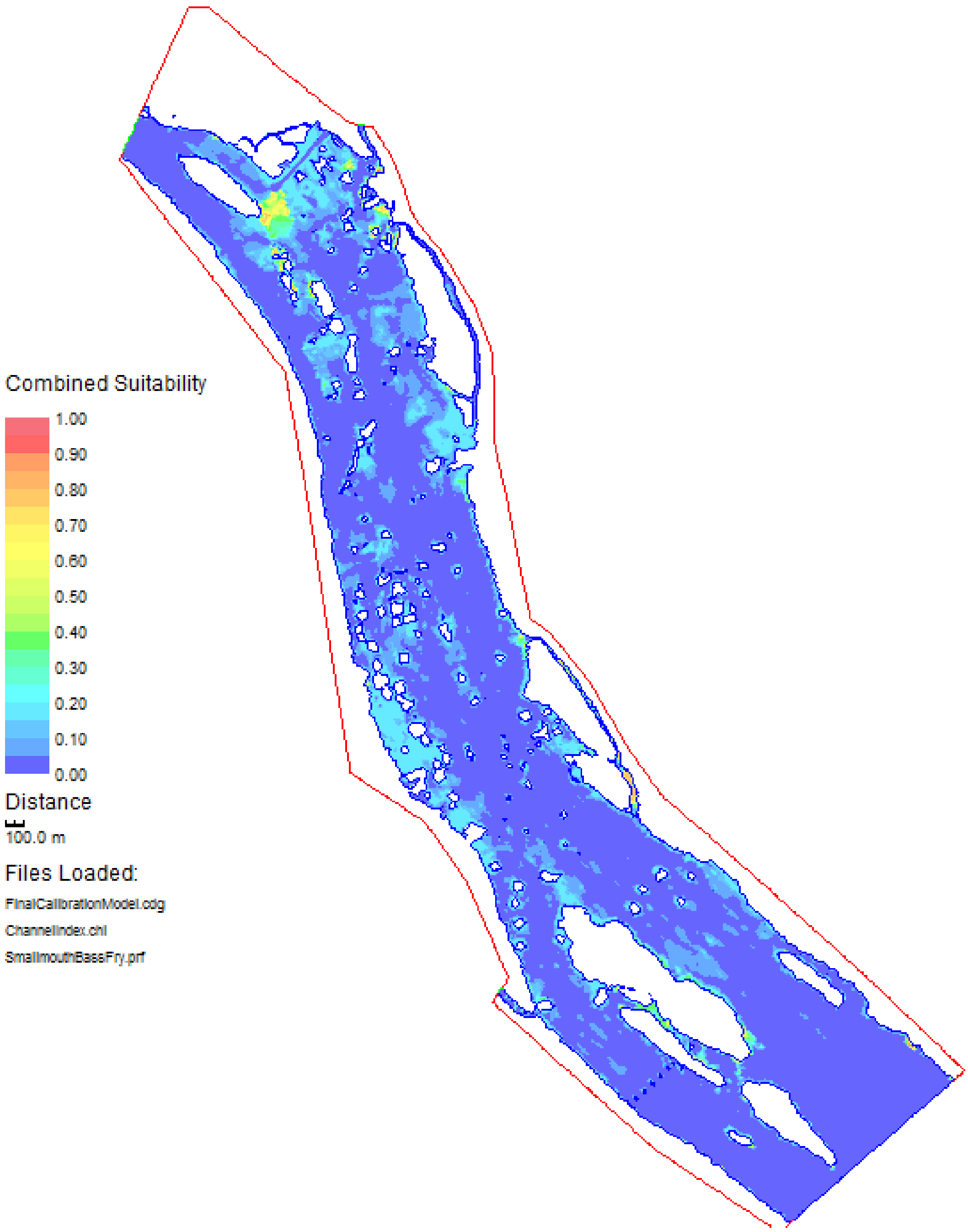
Smallmouth Bass Spawning – 70,000 cfs



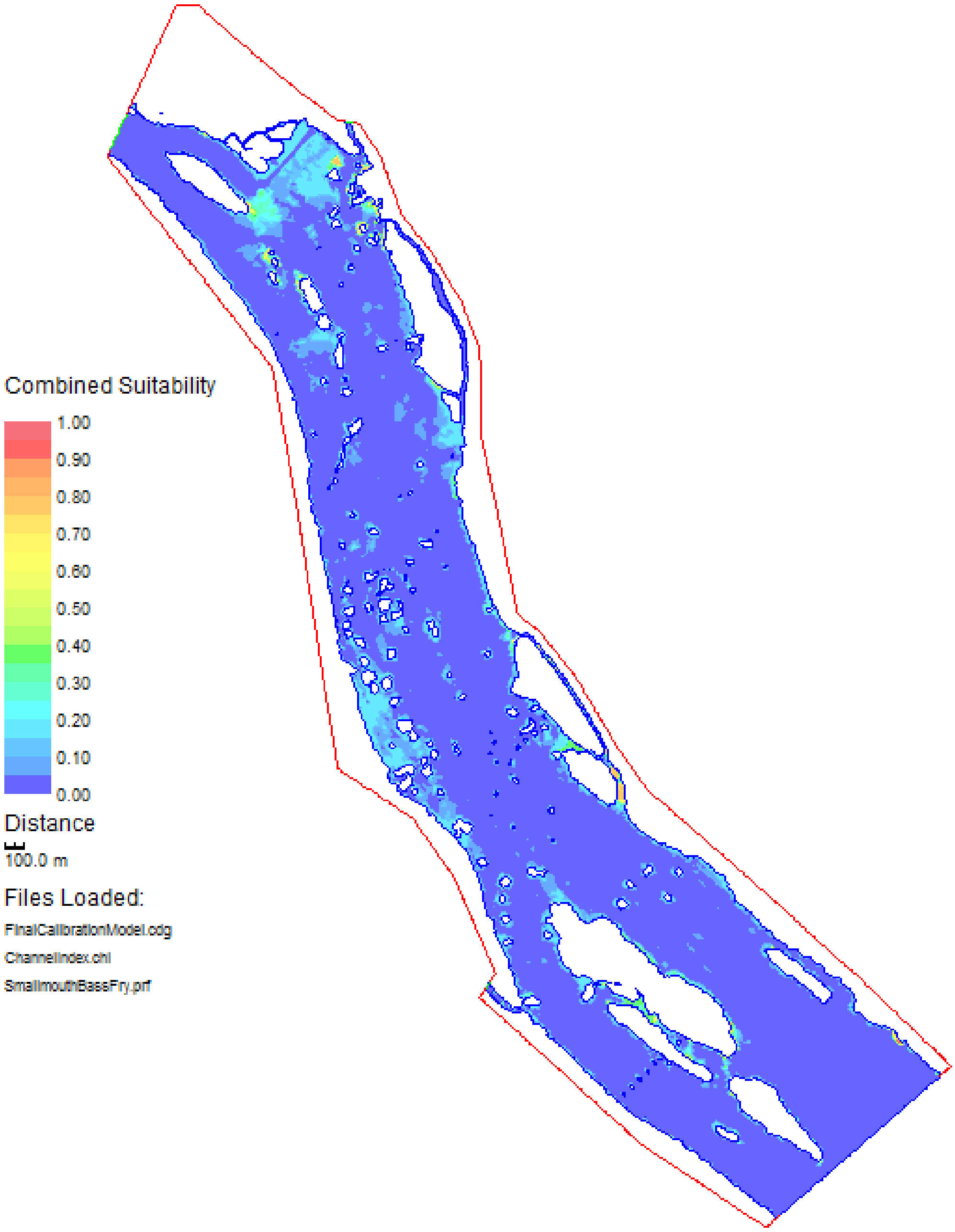
Smallmouth Bass Spawning – 80,000 cfs



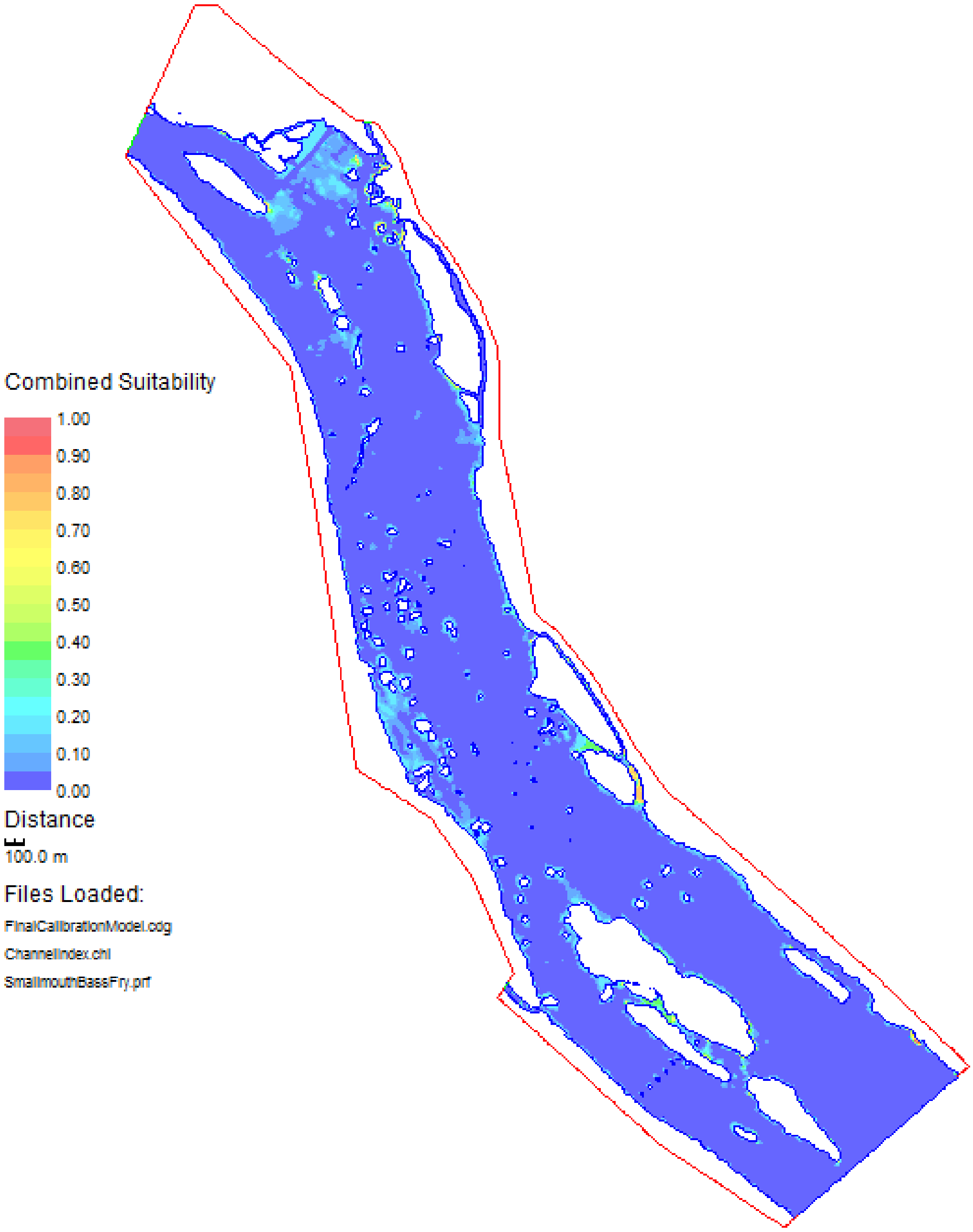
Smallmouth Bass Spawning – 86,000 cfs



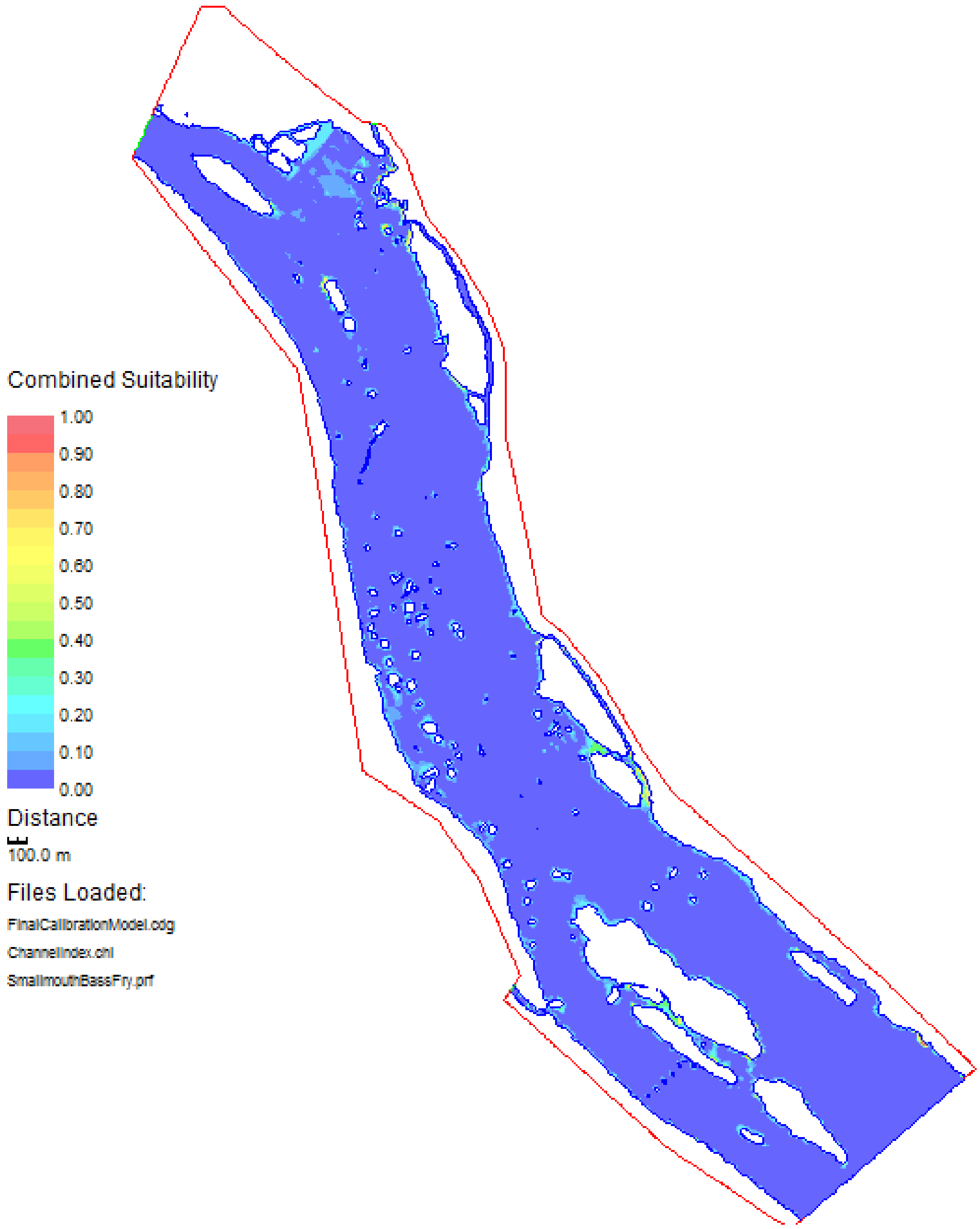
Smallmouth Bass Fry – 2,000 cfs



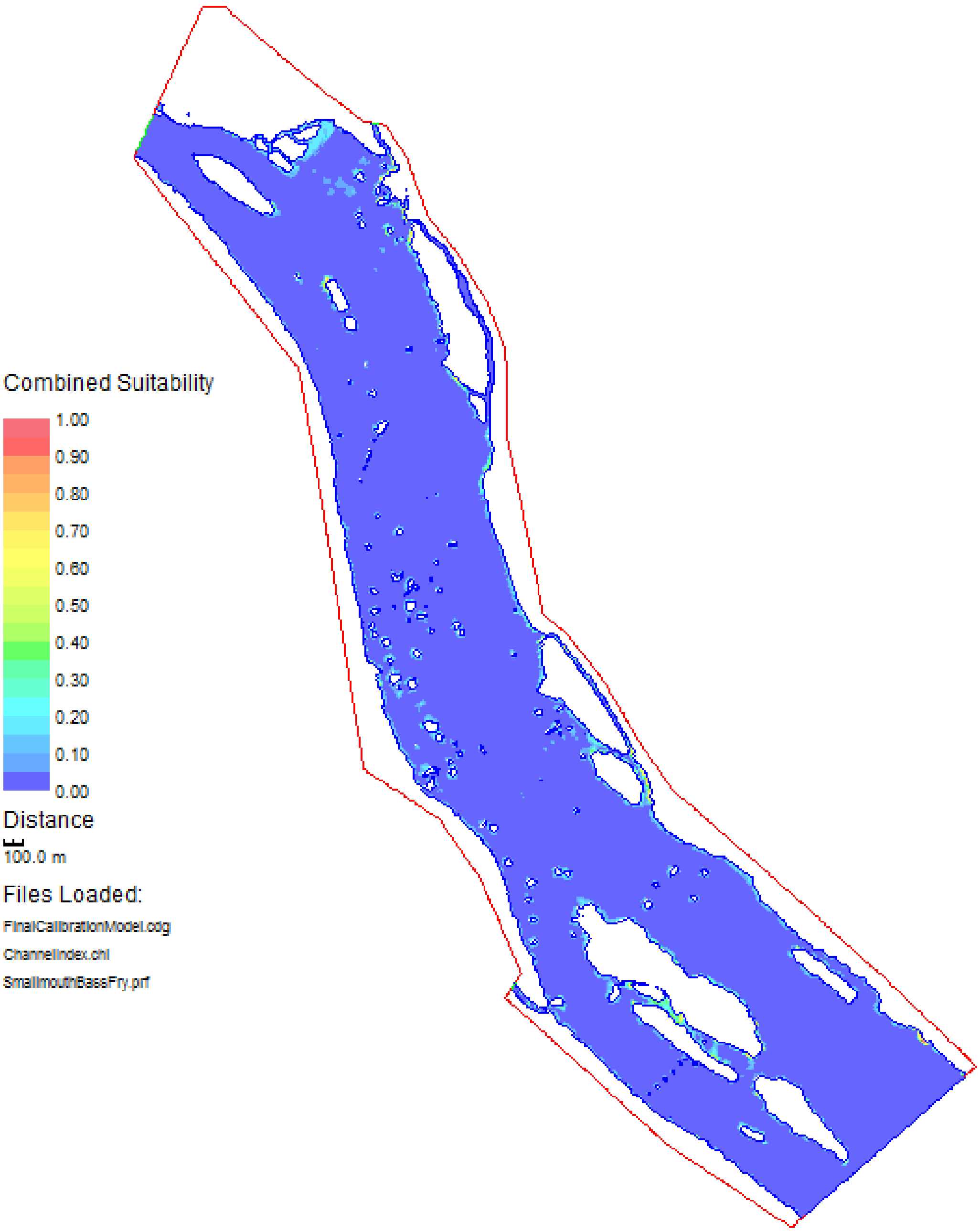
Smallmouth Bass Fry – 3,500 cfs



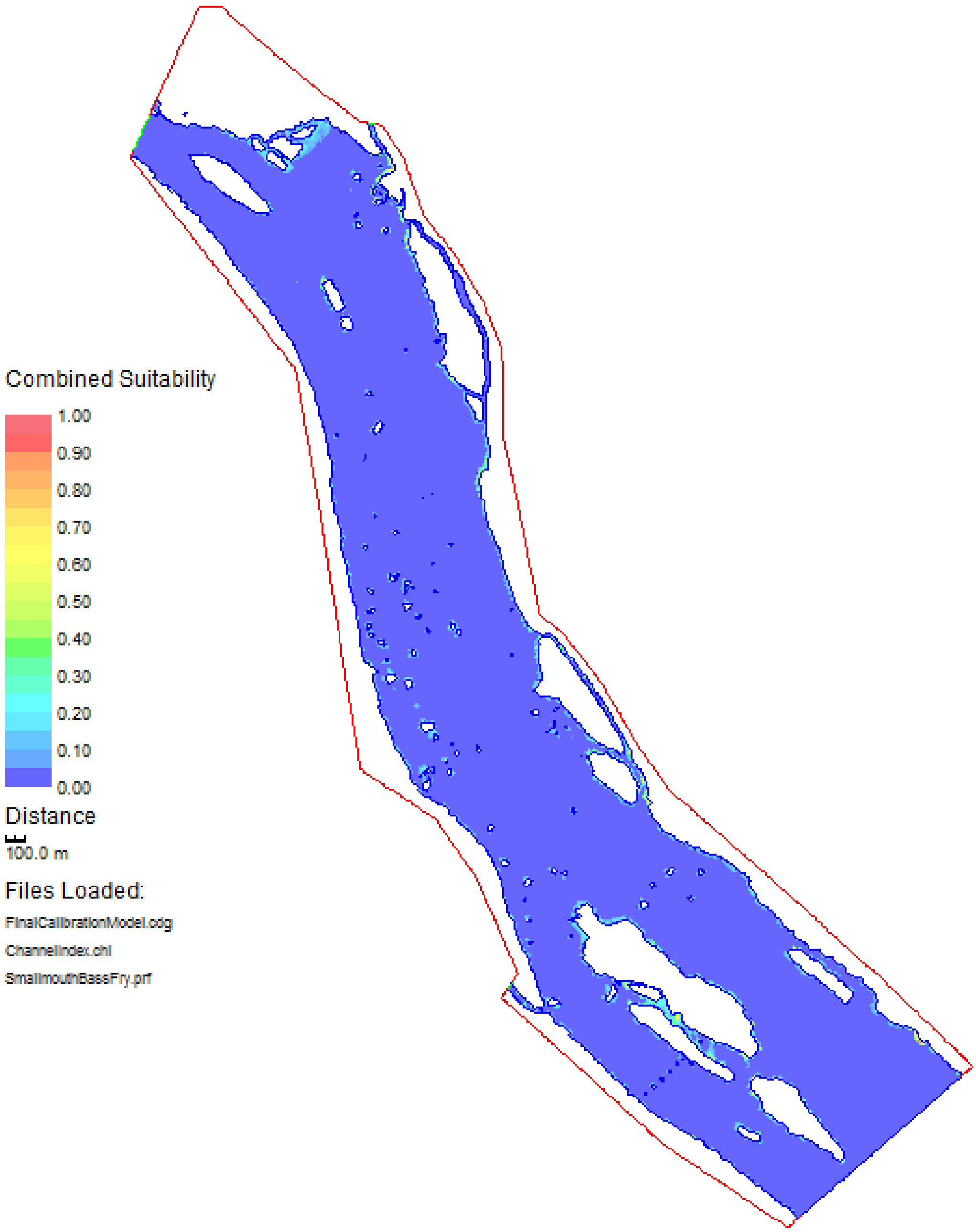
Smallmouth Bass Fry – 5,000 cfs



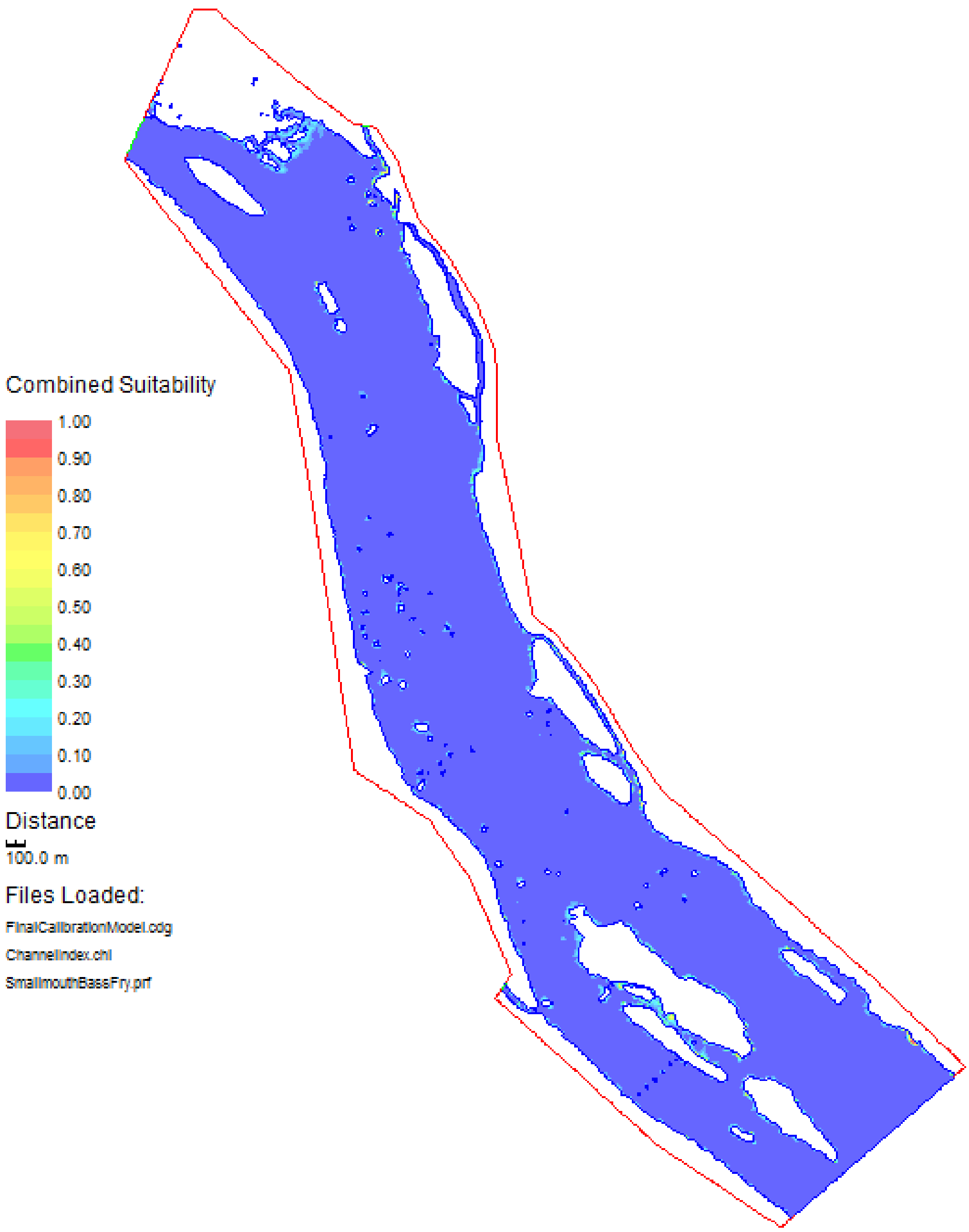
Smallmouth Bass Fry – 7,500 cfs



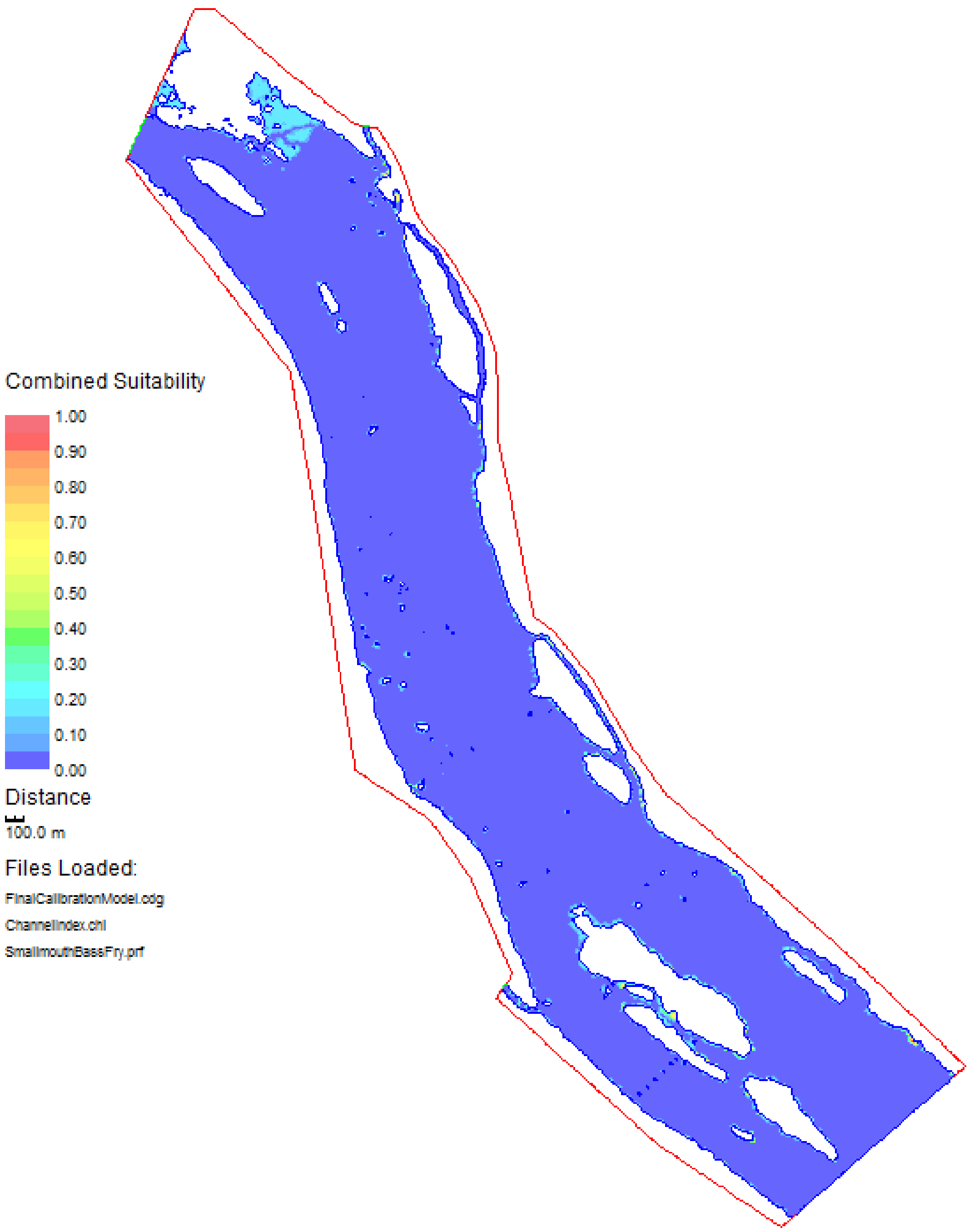
Smallmouth Bass Fry – 10,000 cfs



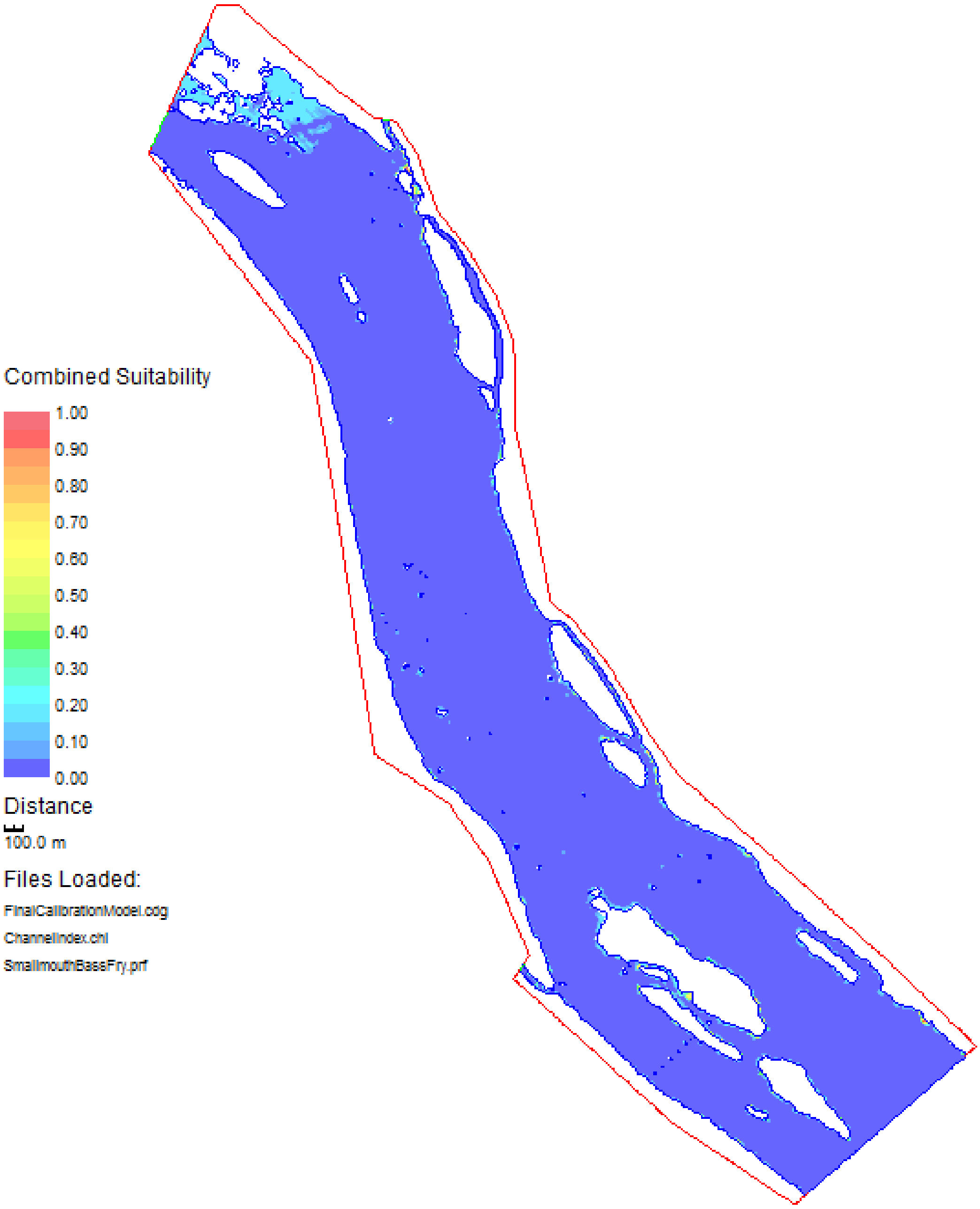
Smallmouth Bass Fry – 15,000 cfs



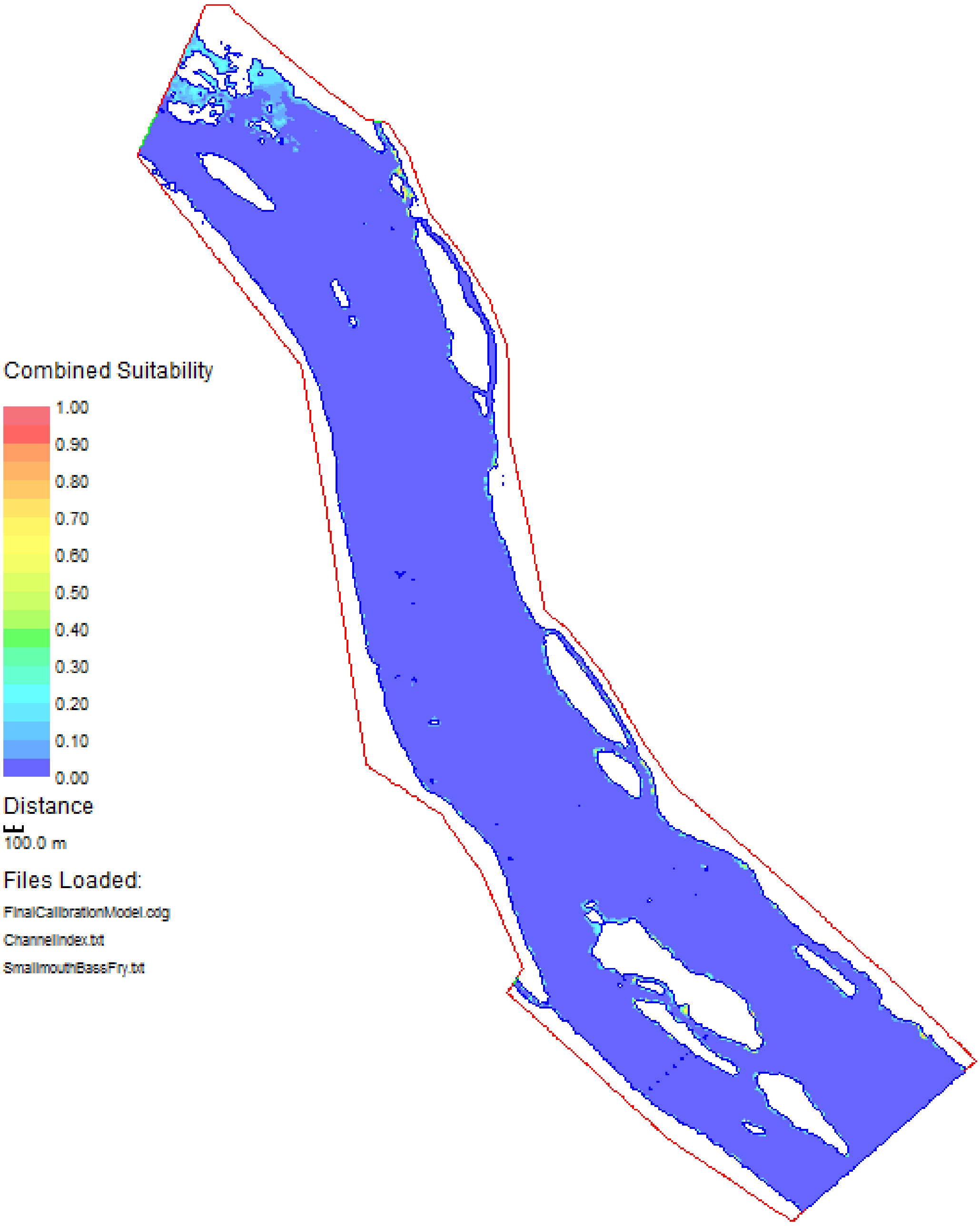
Smallmouth Bass Fry – 20,000 cfs



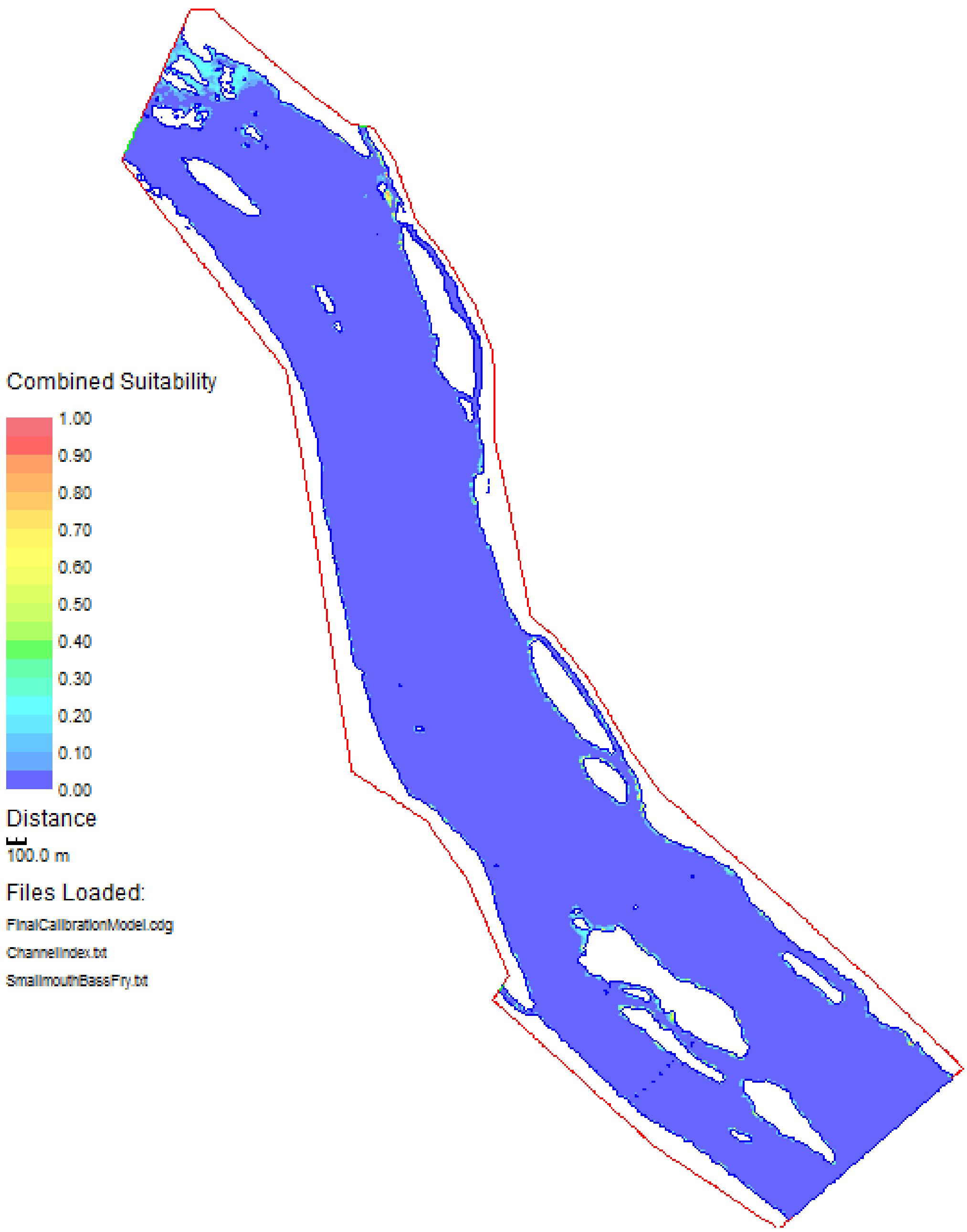
Smallmouth Bass Fry – 30,000 cfs



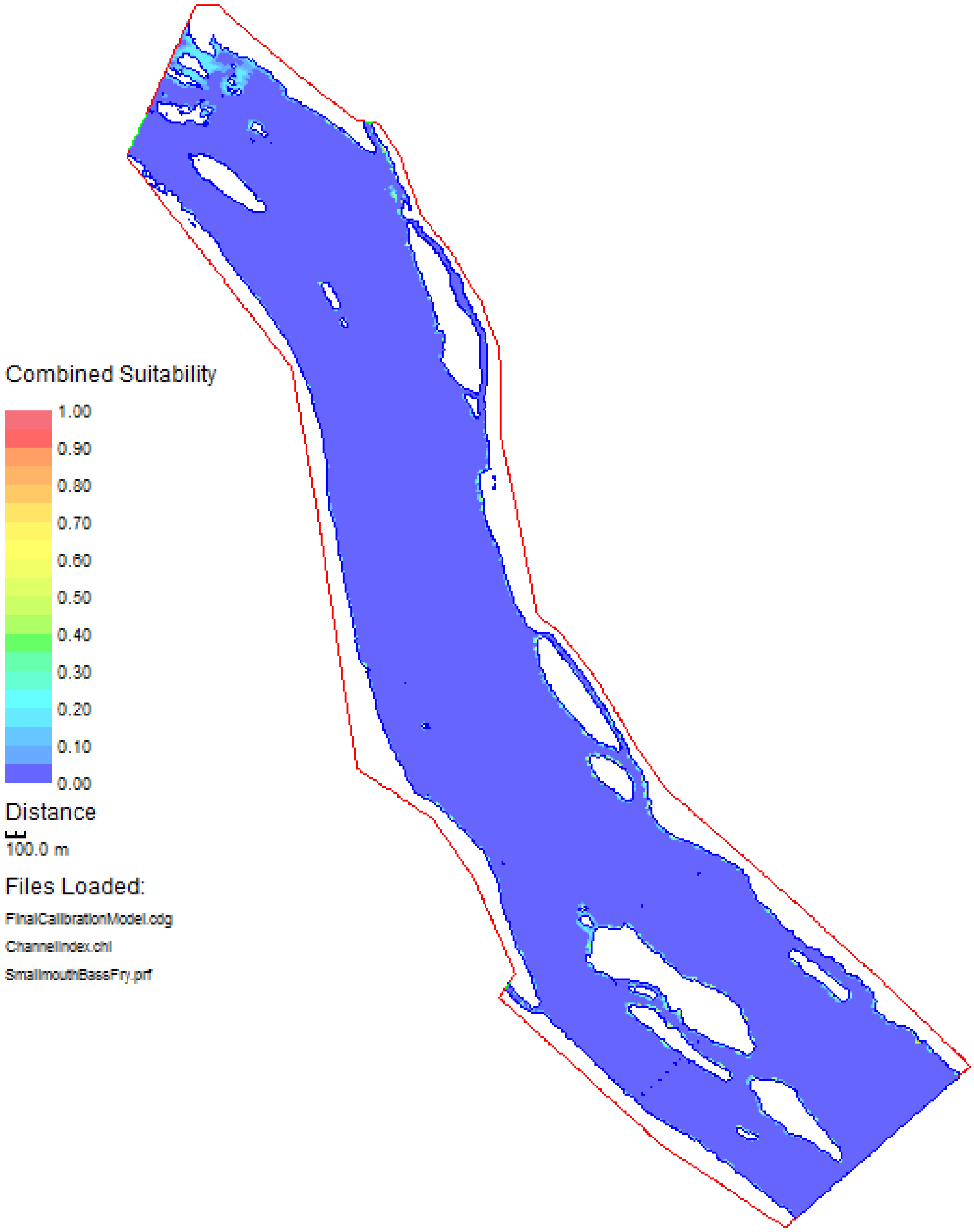
Smallmouth Bass Fry – 40,000 cfs



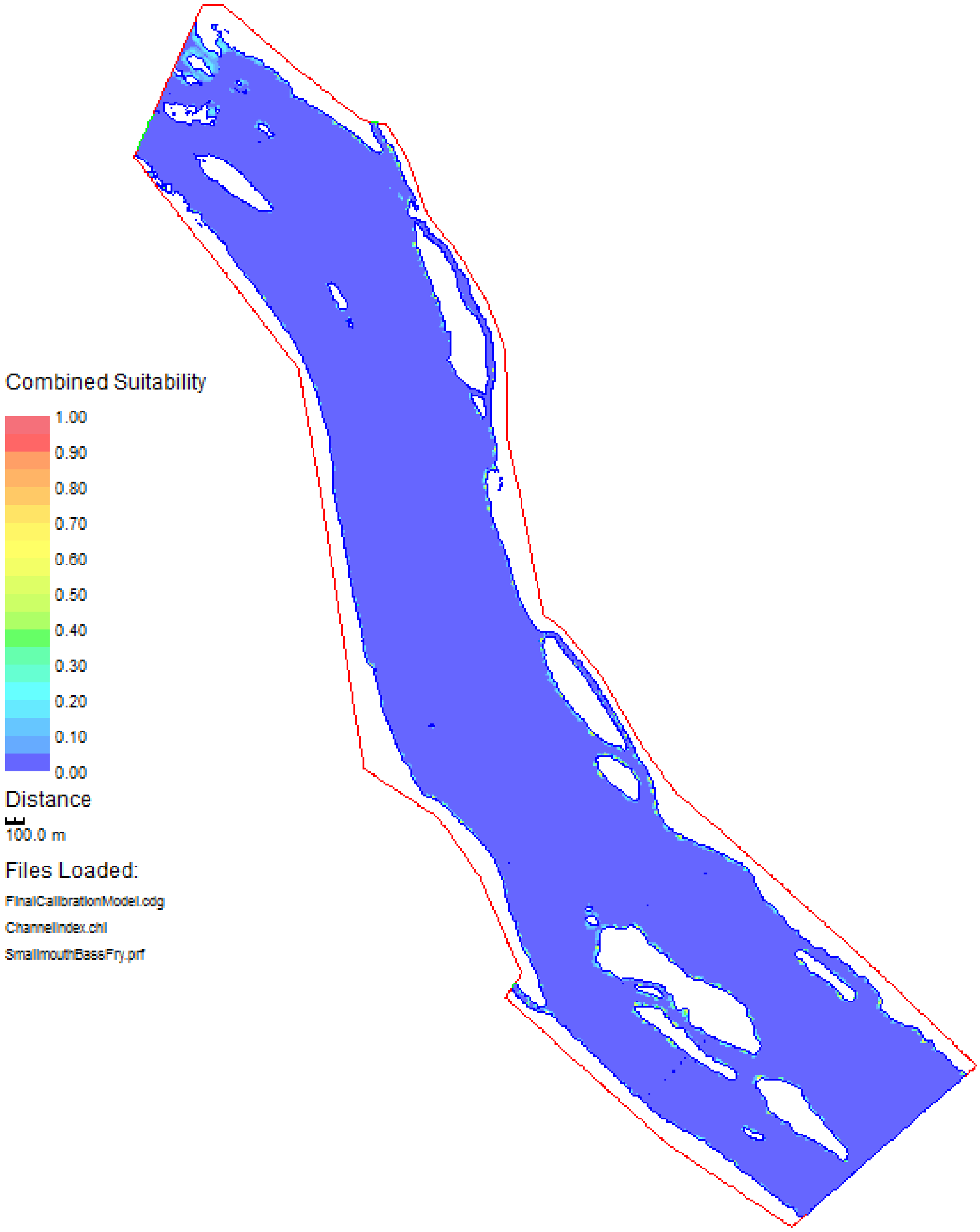
Smallmouth Bass Fry – 50,000 cfs



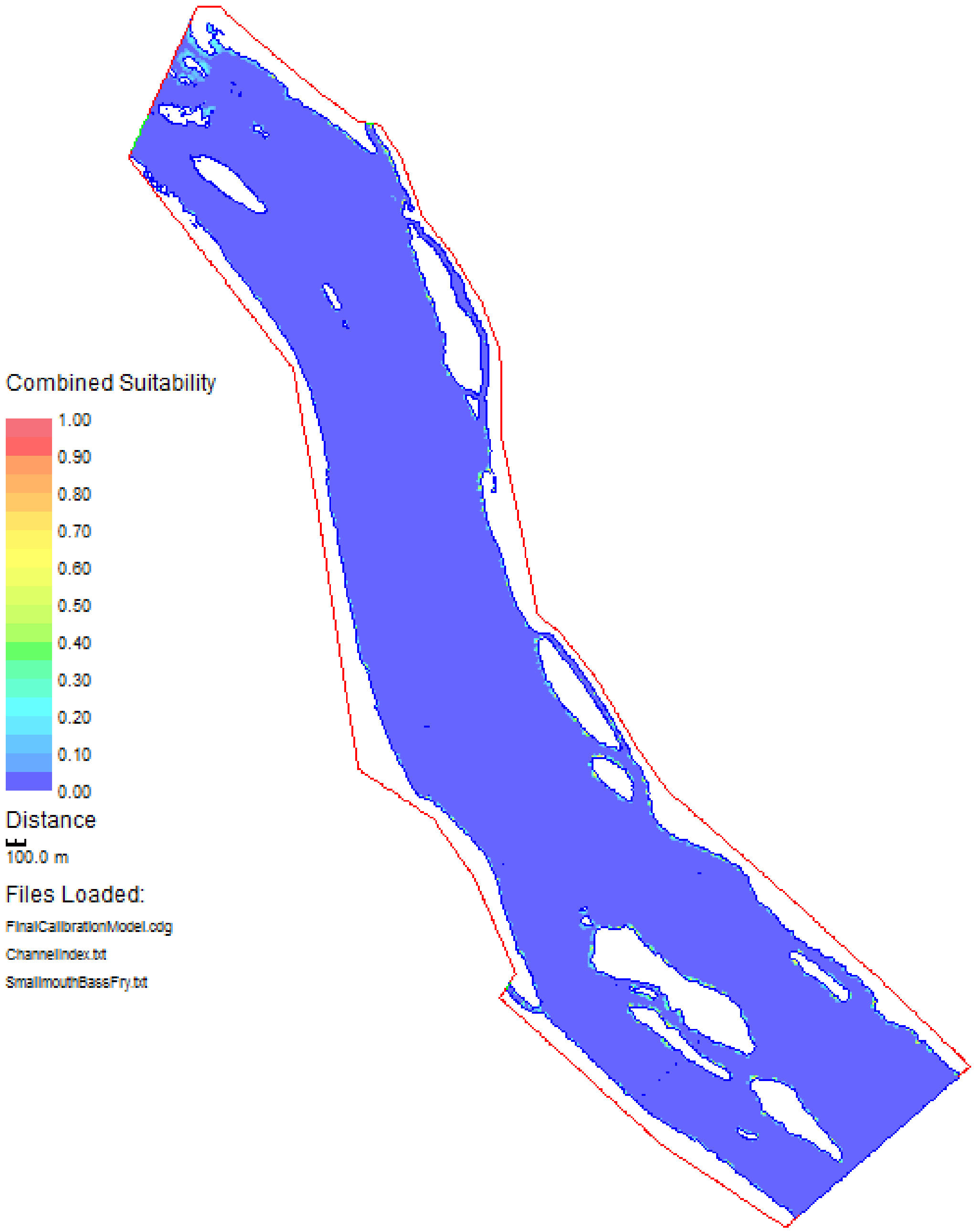
Smallmouth Bass Fry – 60,000 cfs



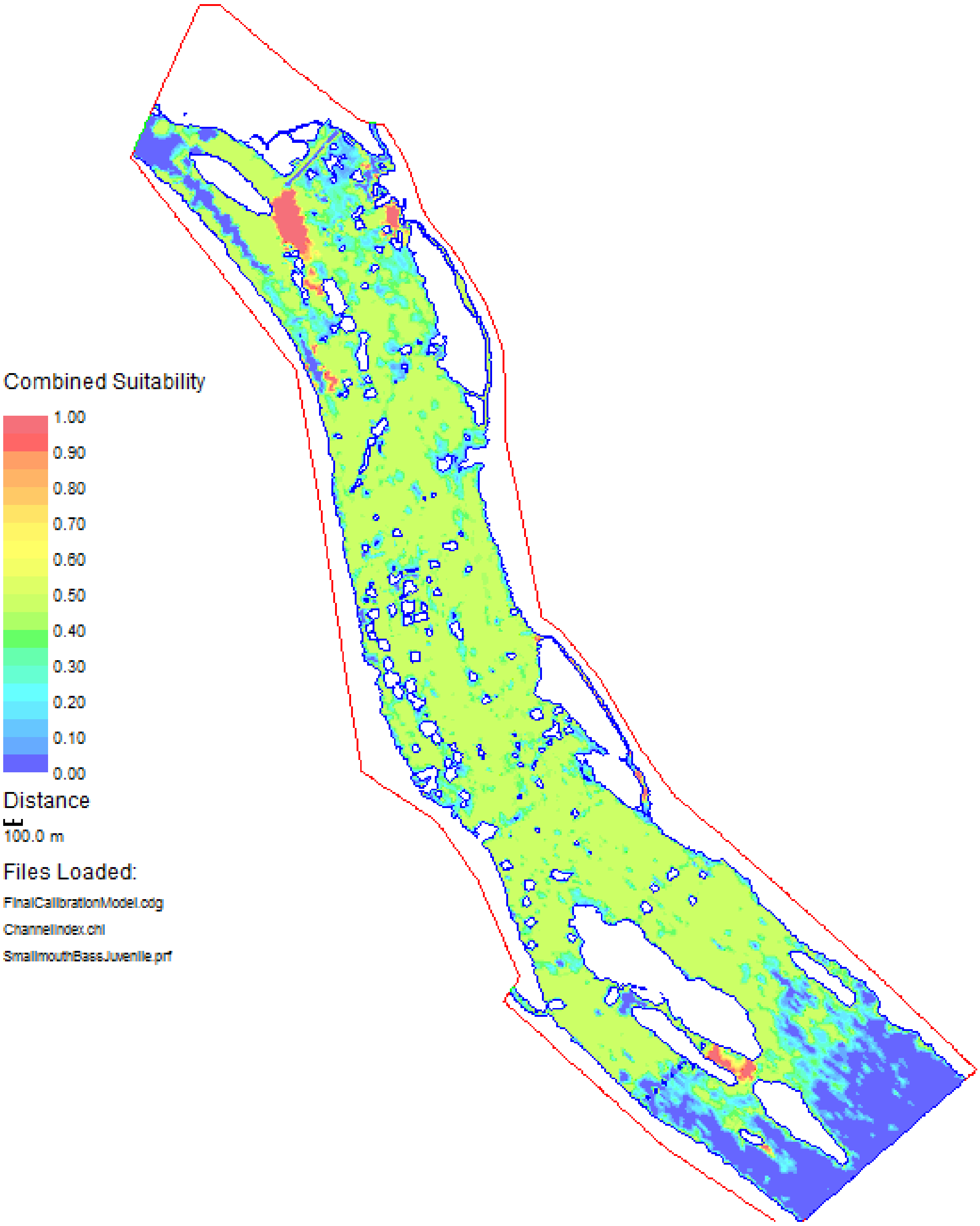
Smallmouth Bass Fry – 70,000 cfs



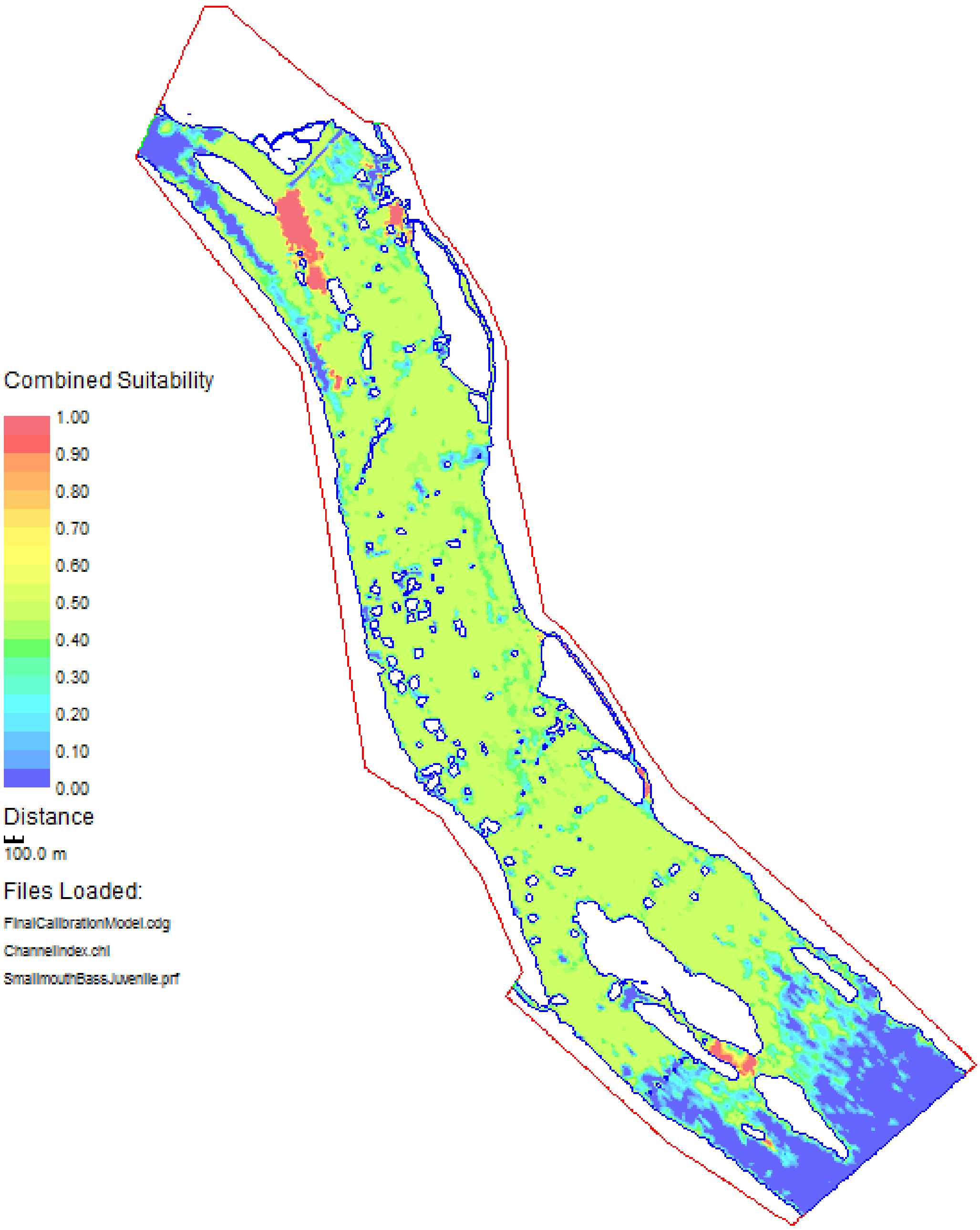
Smallmouth Bass Fry – 80,000 cfs



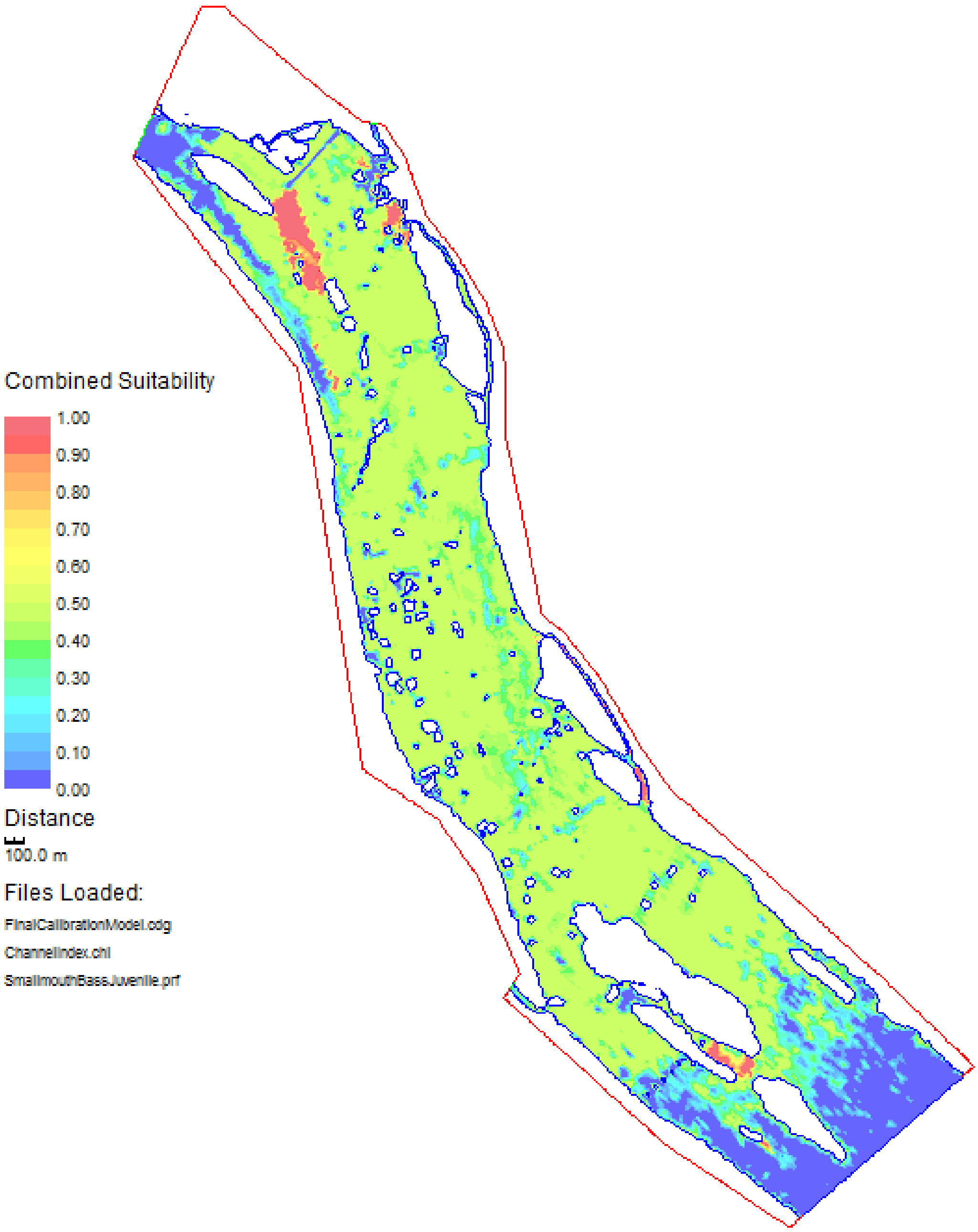
Smallmouth Bass Fry – 86,000 cfs



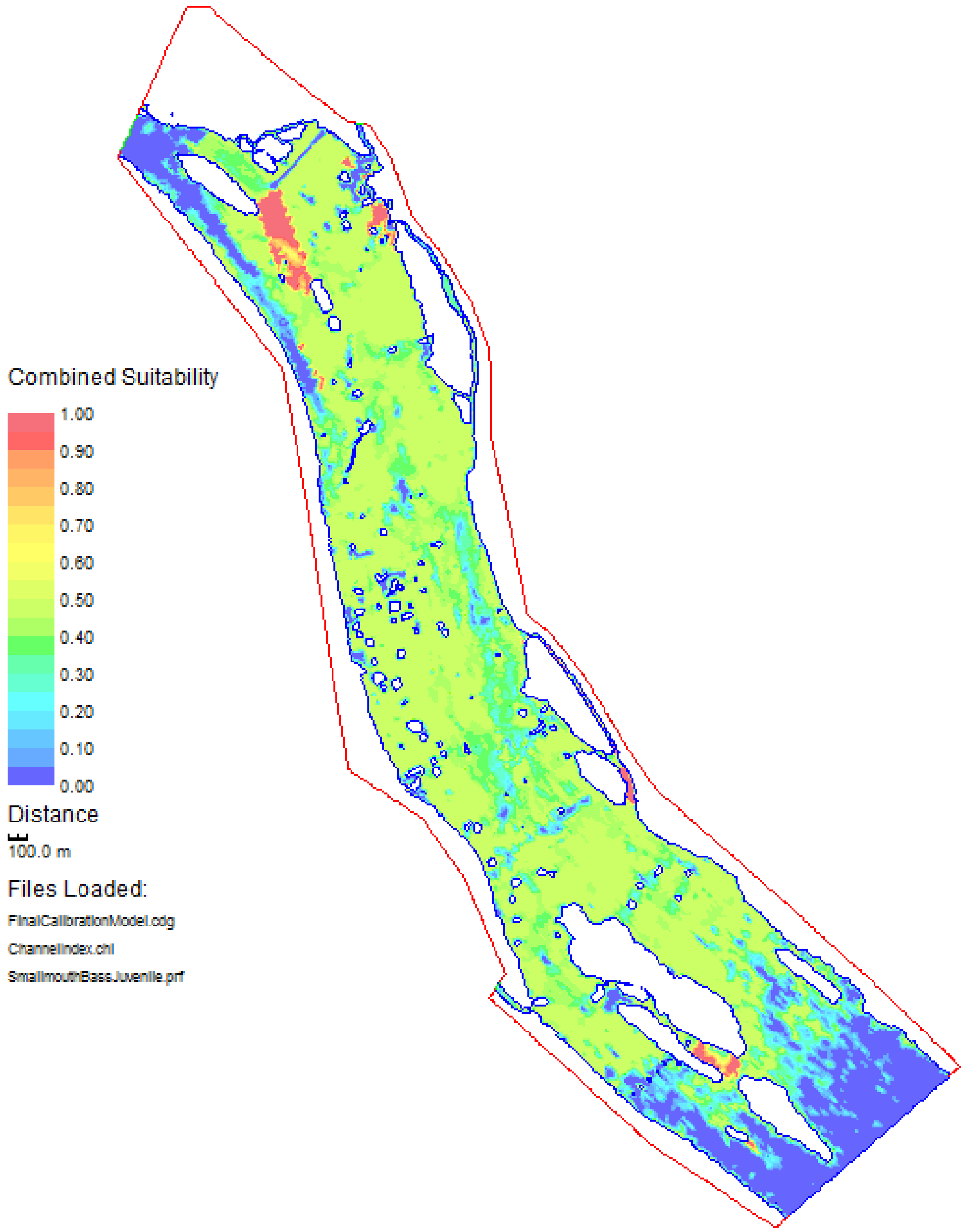
Smallmouth Bass Juvenile – 2,000 cfs



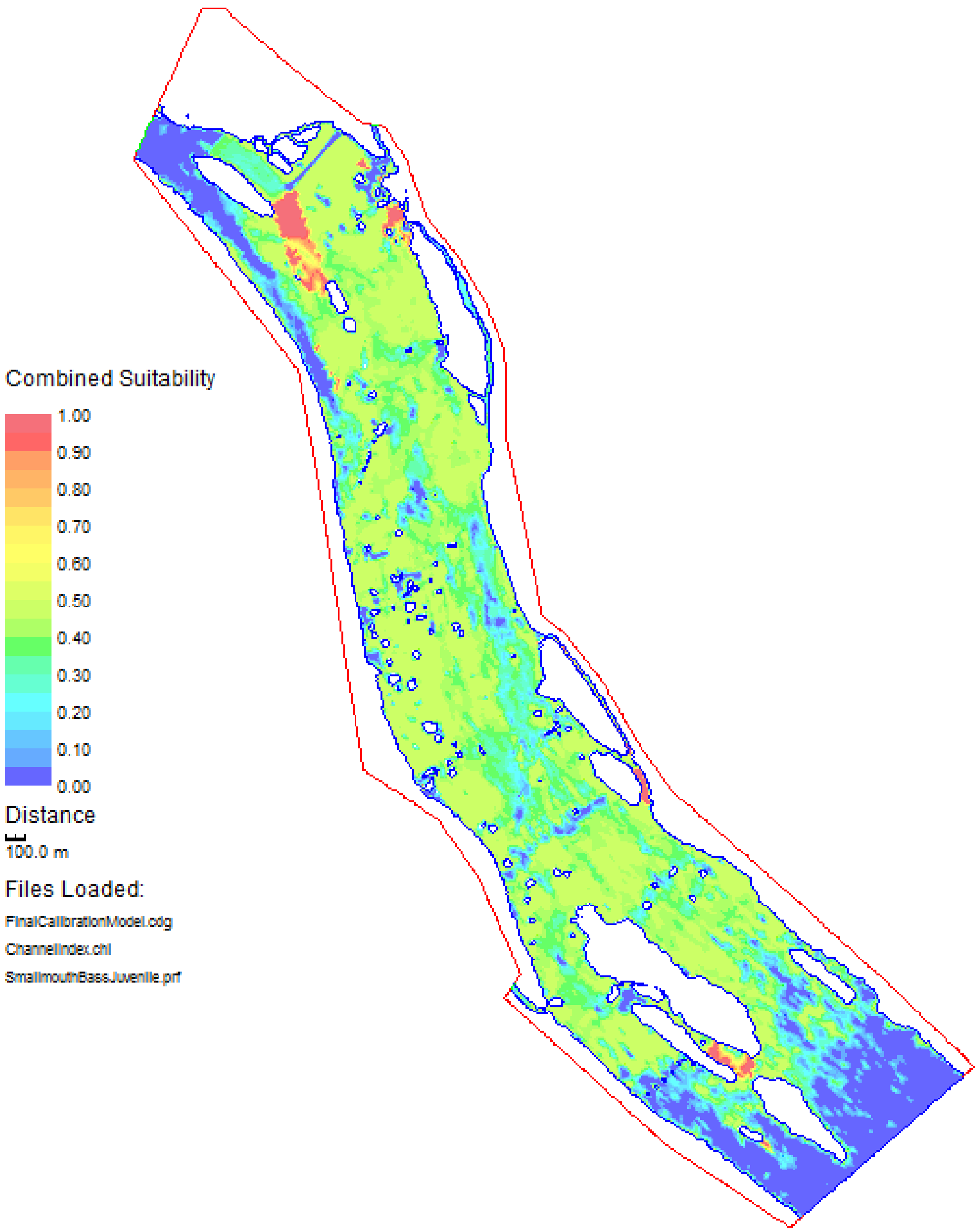
Smallmouth Bass Juvenile – 3,500 cfs



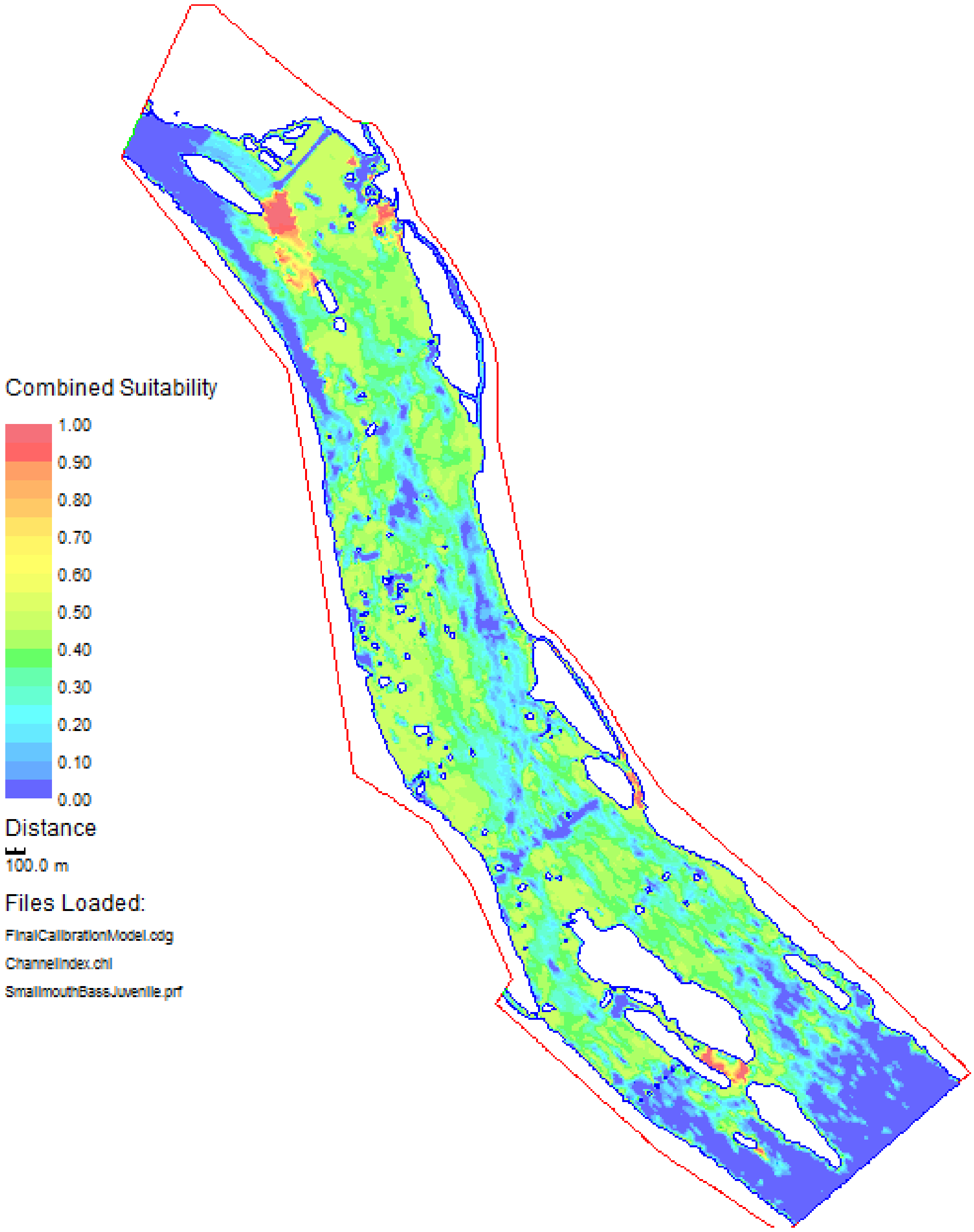
Smallmouth Bass Juvenile – 5,000 cfs



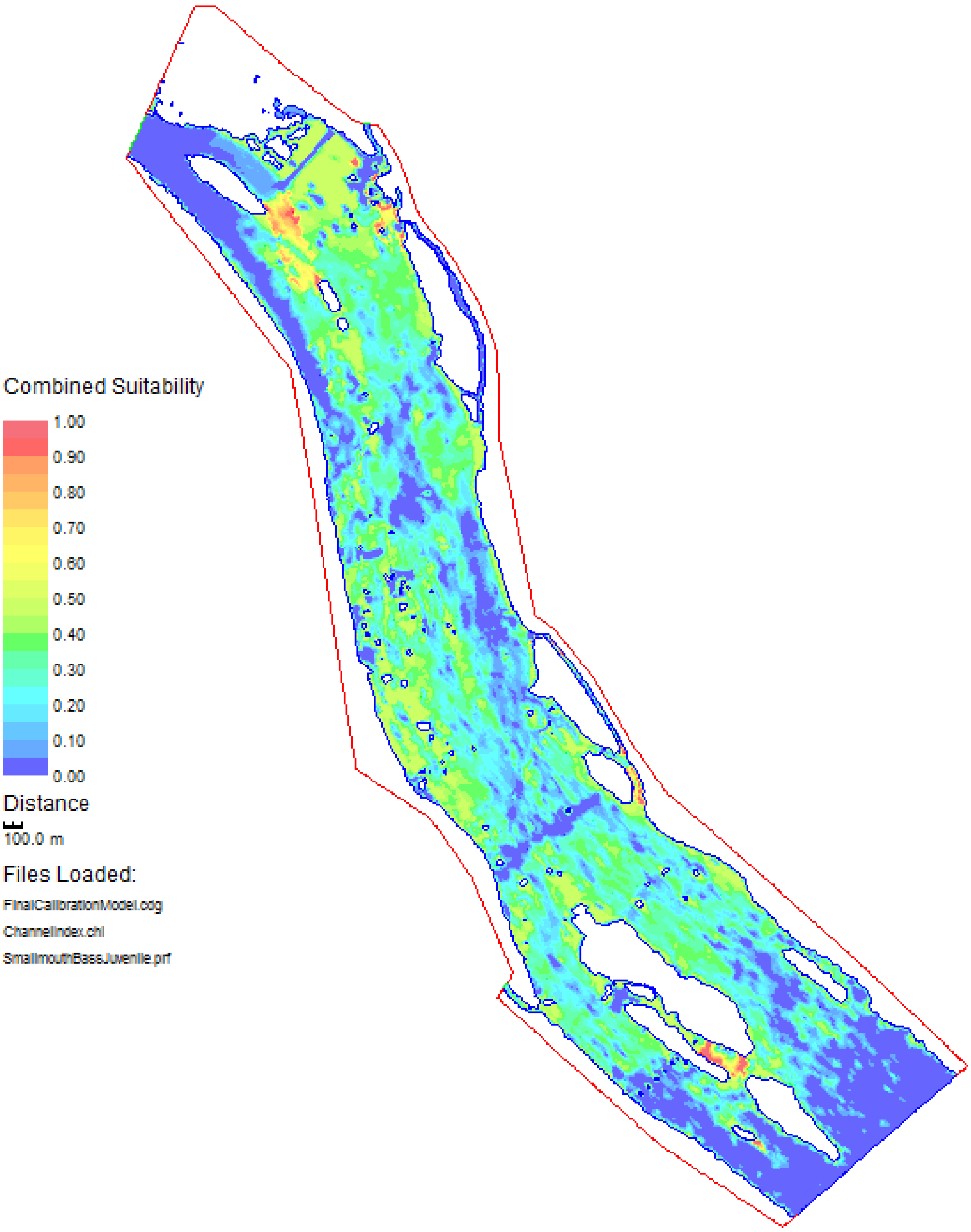
Smallmouth Bass Juvenile – 7,500 cfs



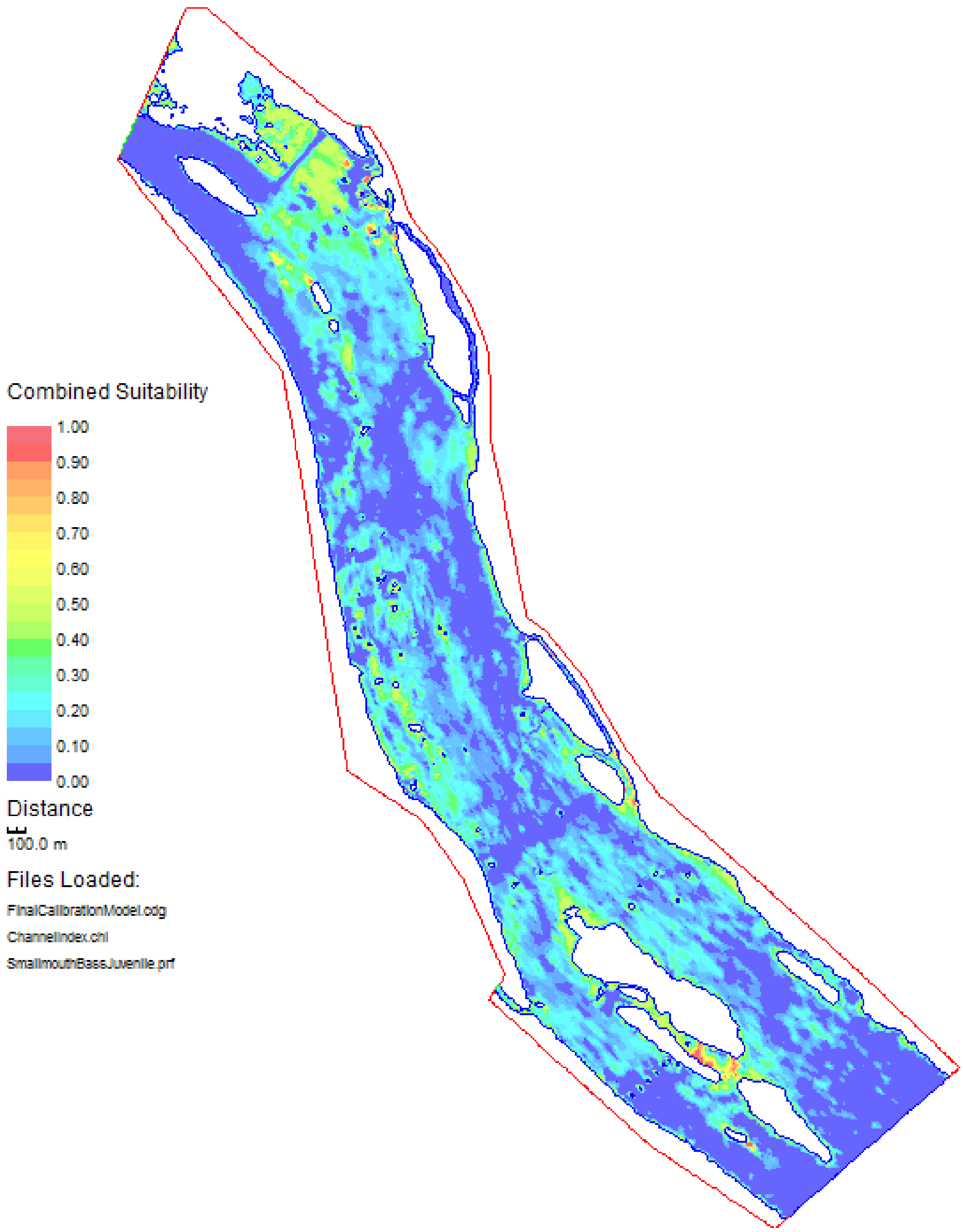
Smallmouth Bass Juvenile – 10,000 cfs



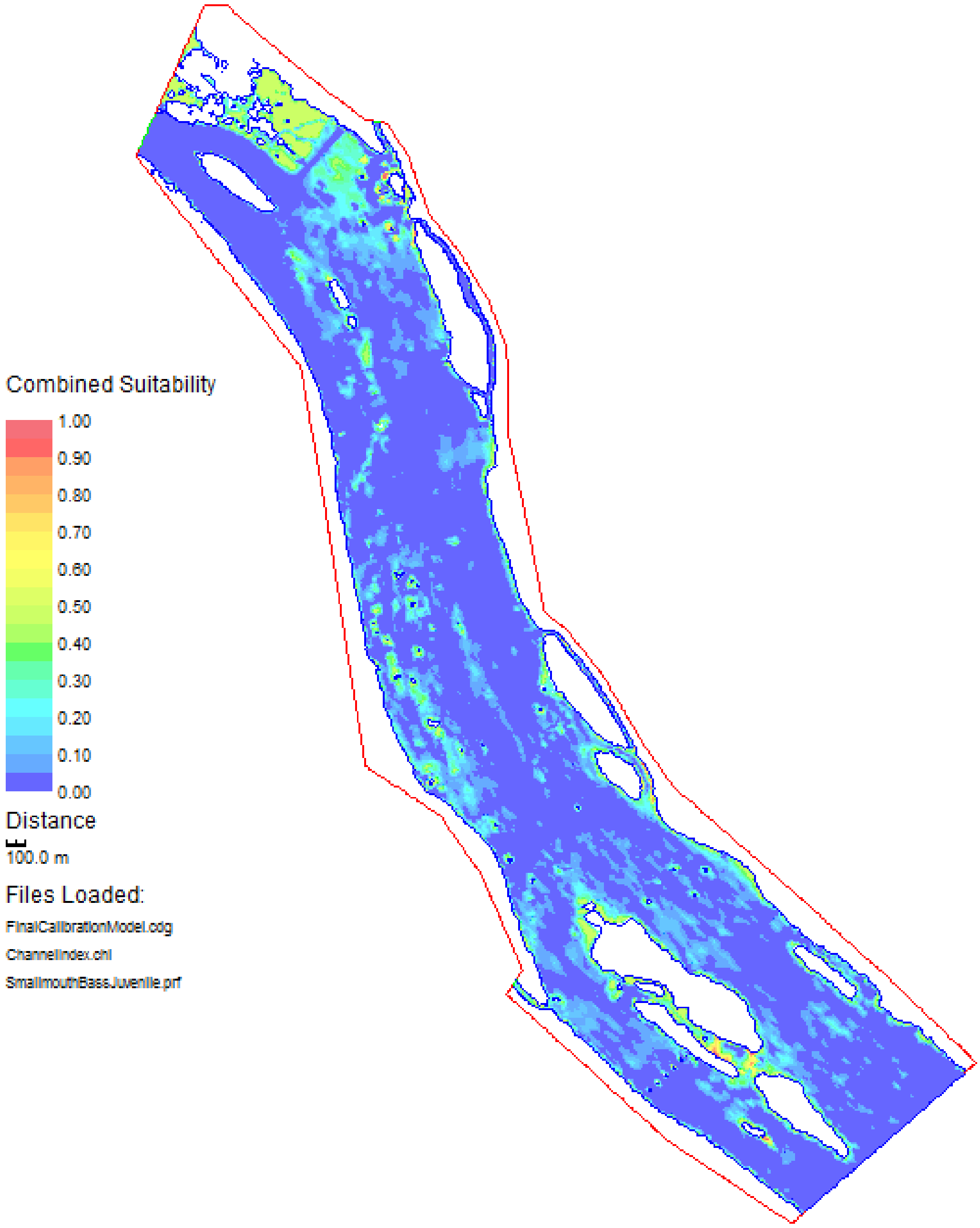
Smallmouth Bass Juvenile – 15,000 cfs



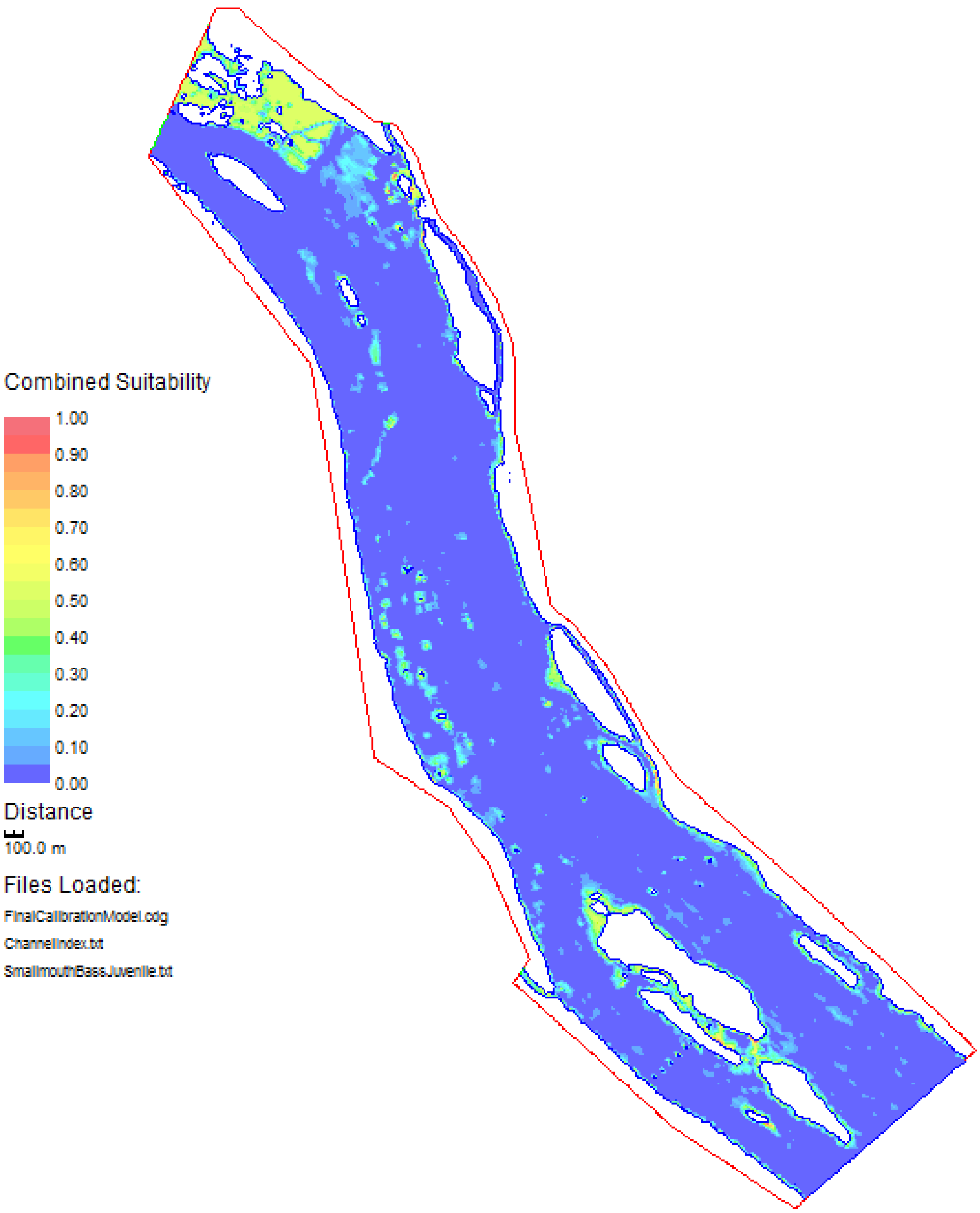
Smallmouth Bass Juvenile – 20,000 cfs



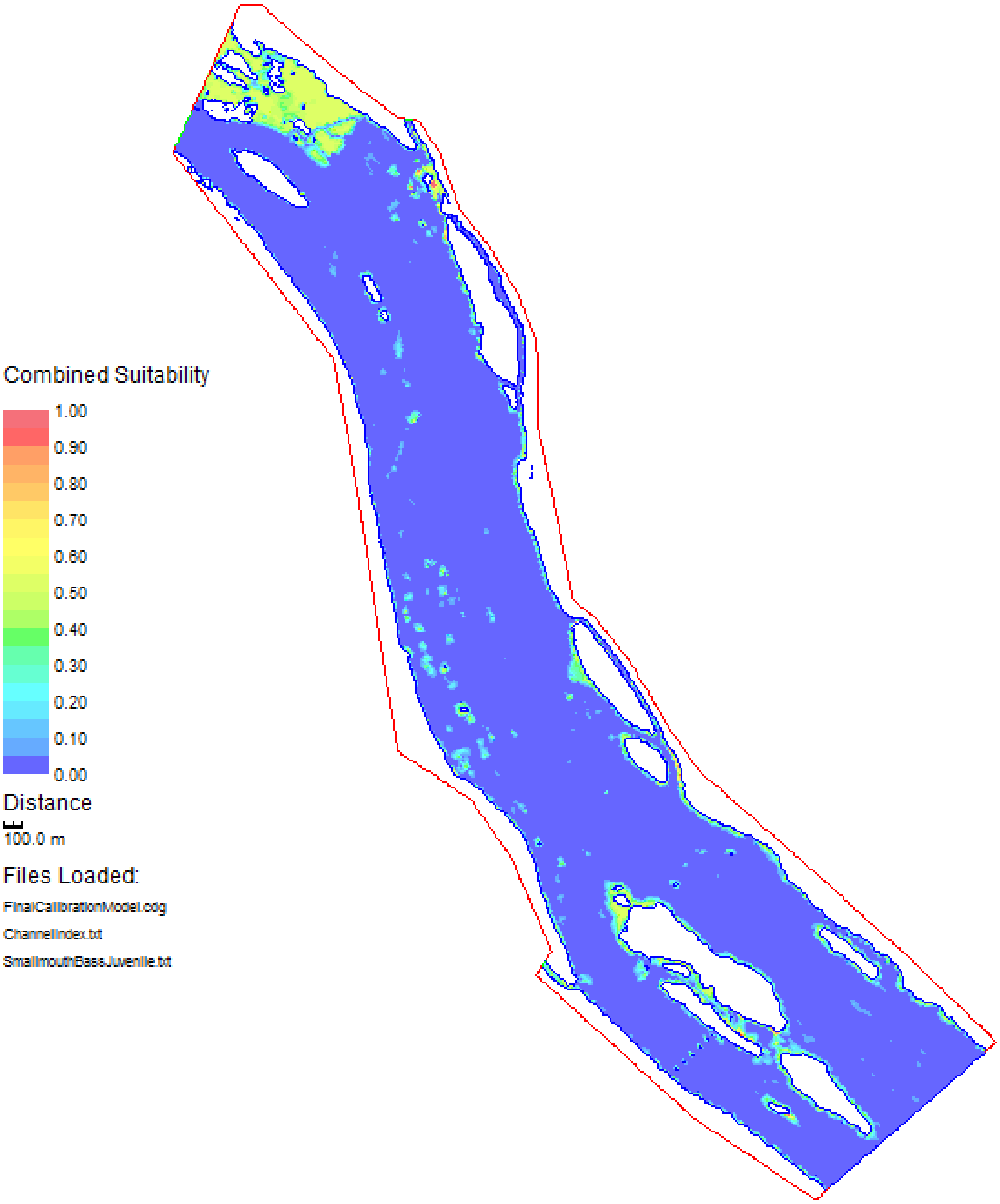
Smallmouth Bass Juvenile – 30,000 cfs



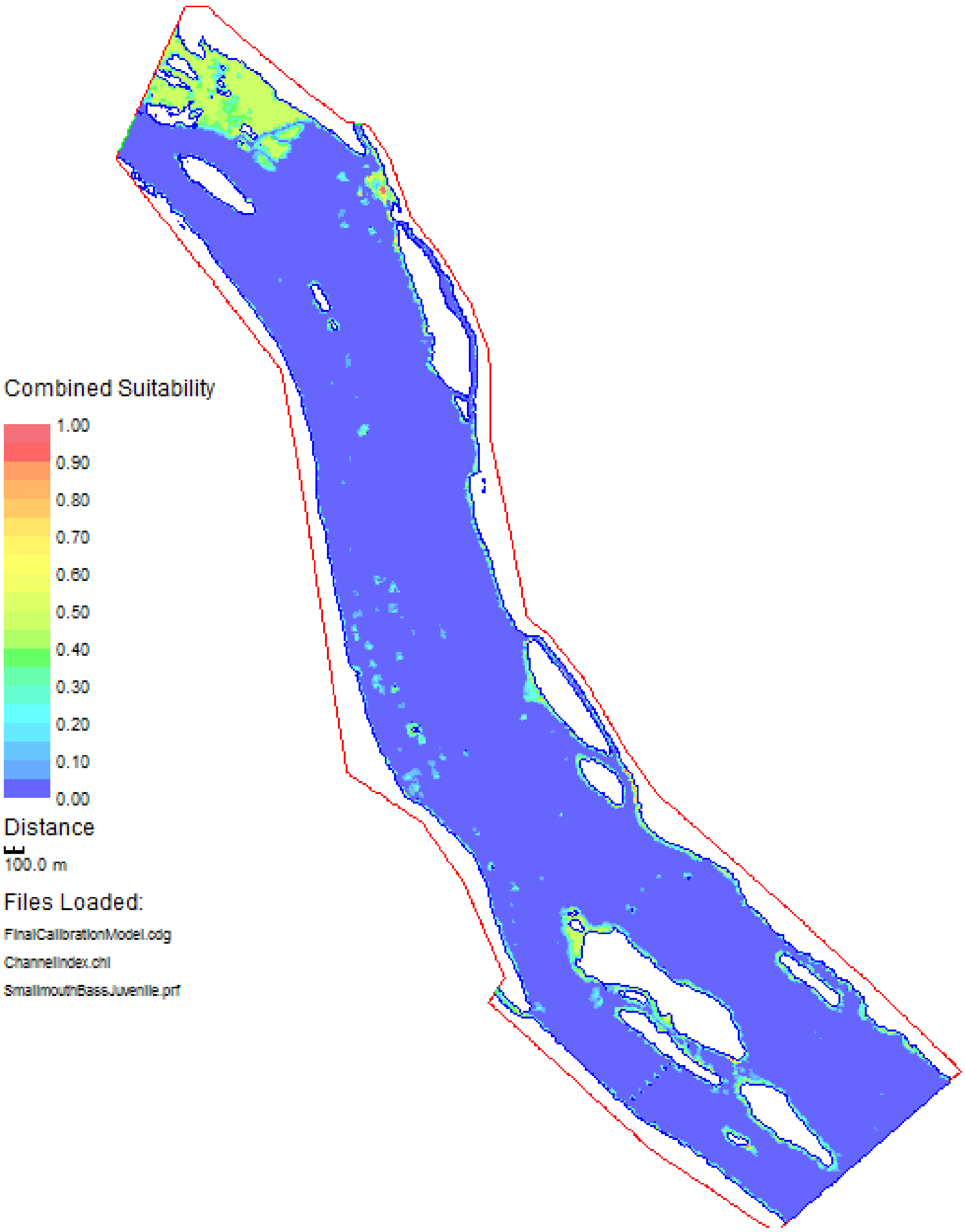
Smallmouth Bass Juvenile – 40,000 cfs



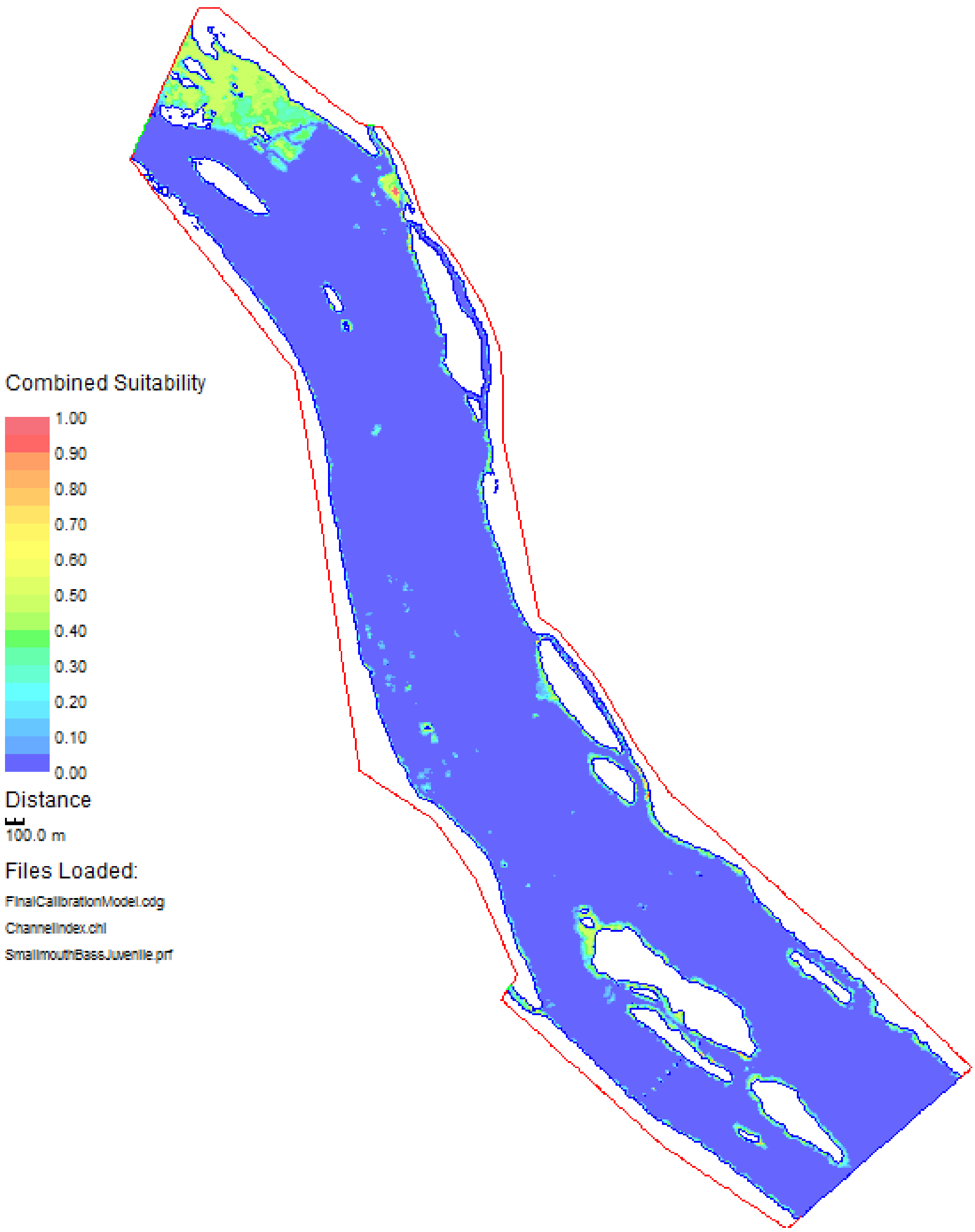
Smallmouth Bass Juvenile – 50,000 cfs



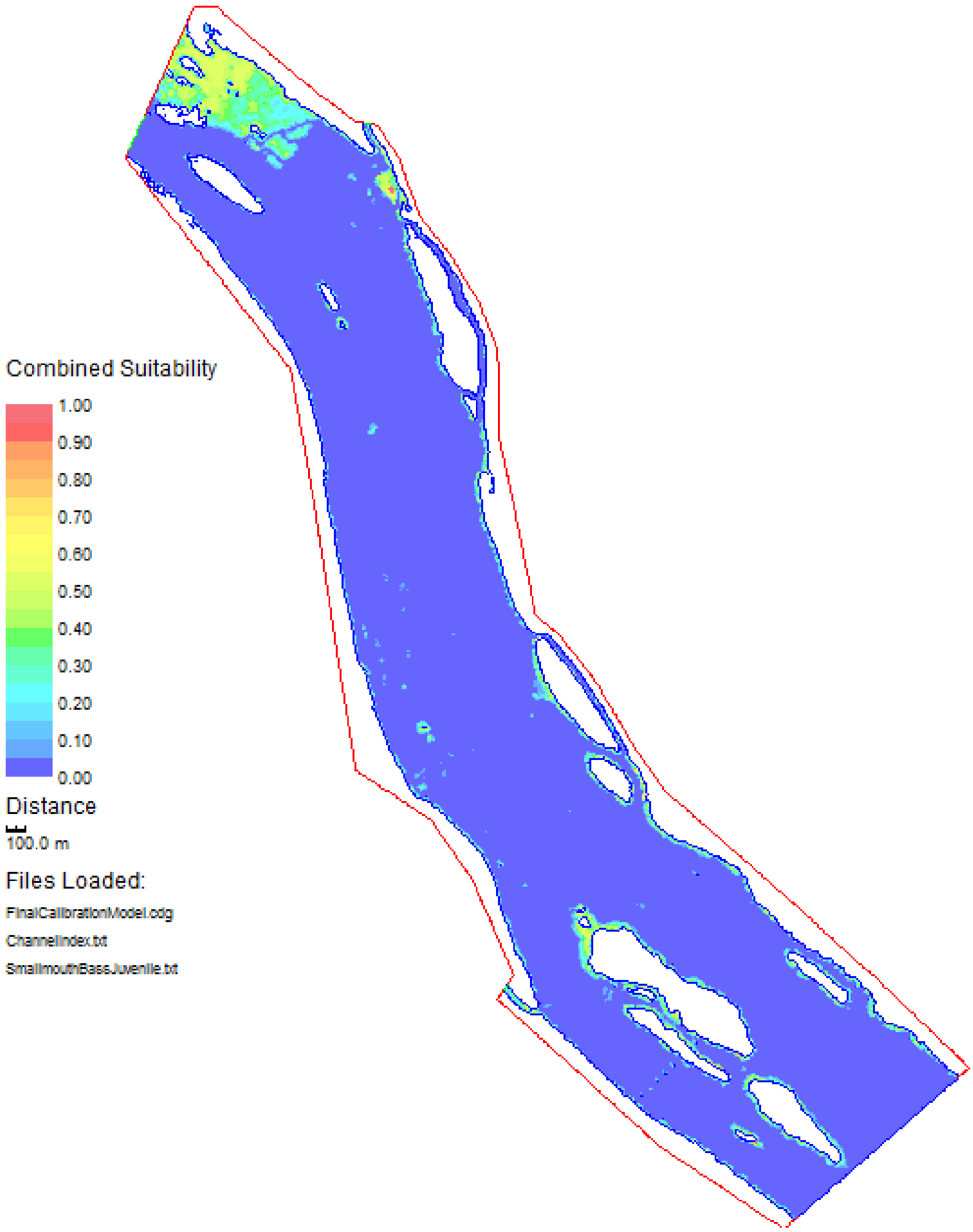
Smallmouth Bass Juvenile – 60,000 cfs



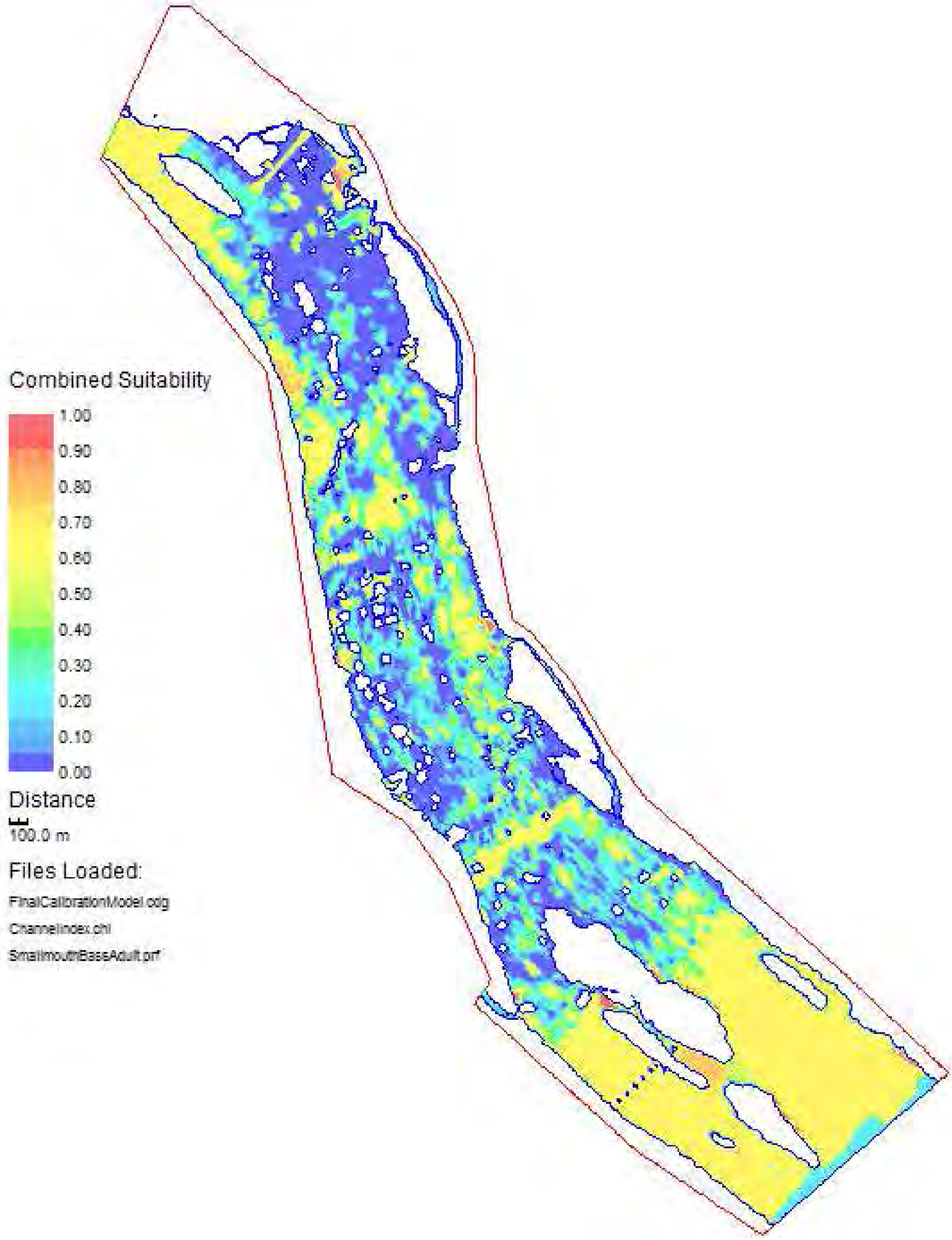
Smallmouth Bass Juvenile – 70,000 cfs



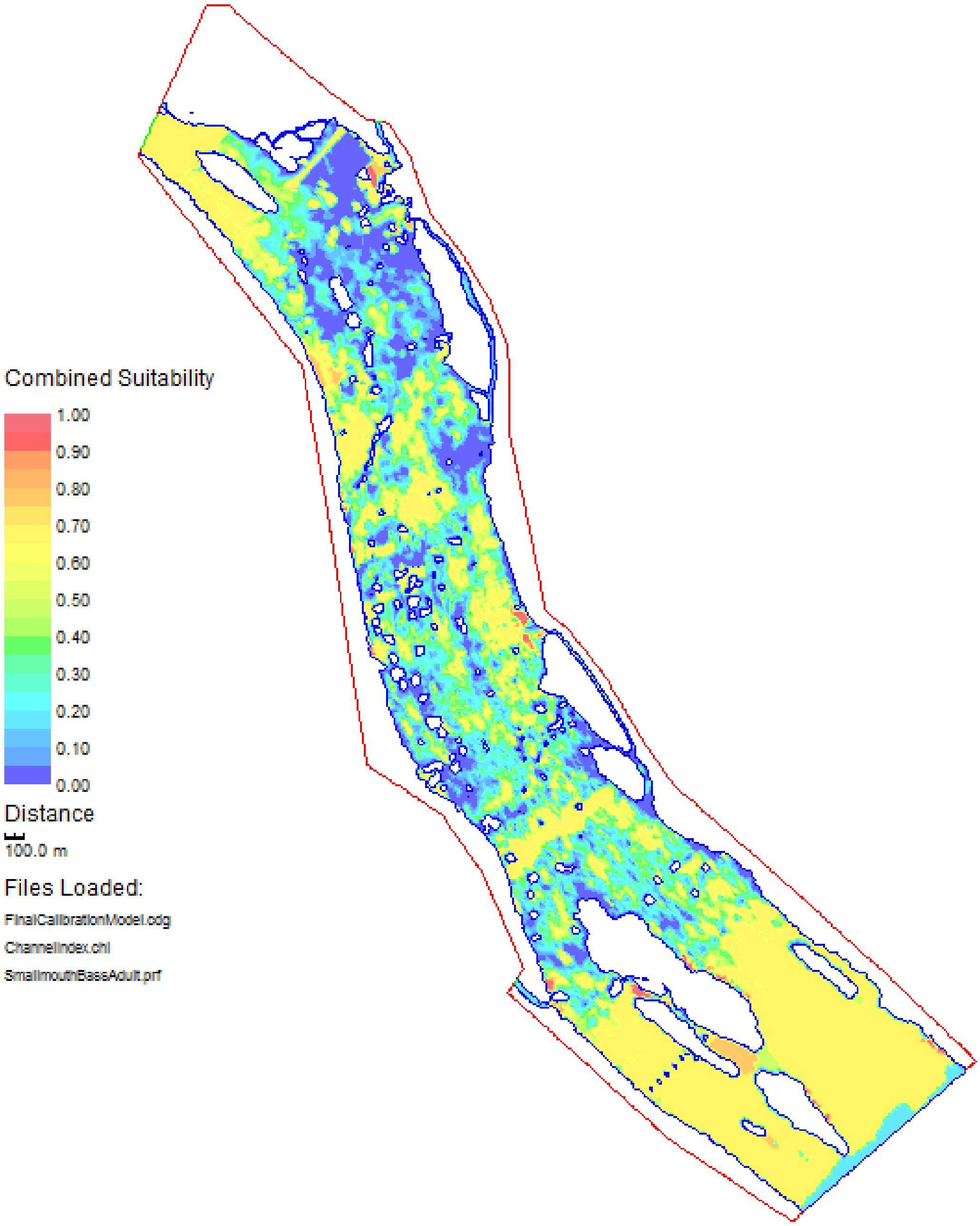
Smallmouth Bass Juvenile – 80,000 cfs



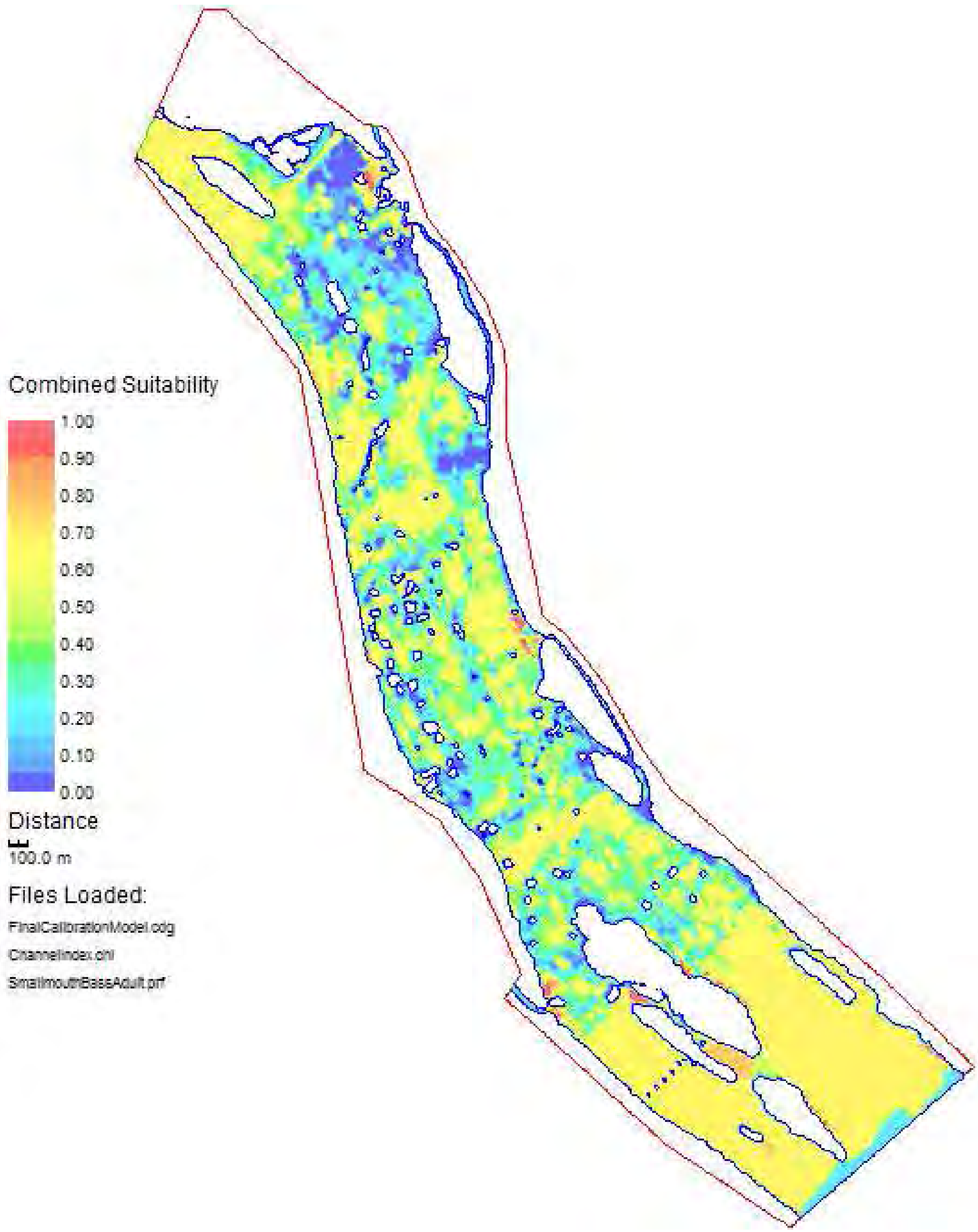
Smallmouth Bass Juvenile – 86,000 cfs



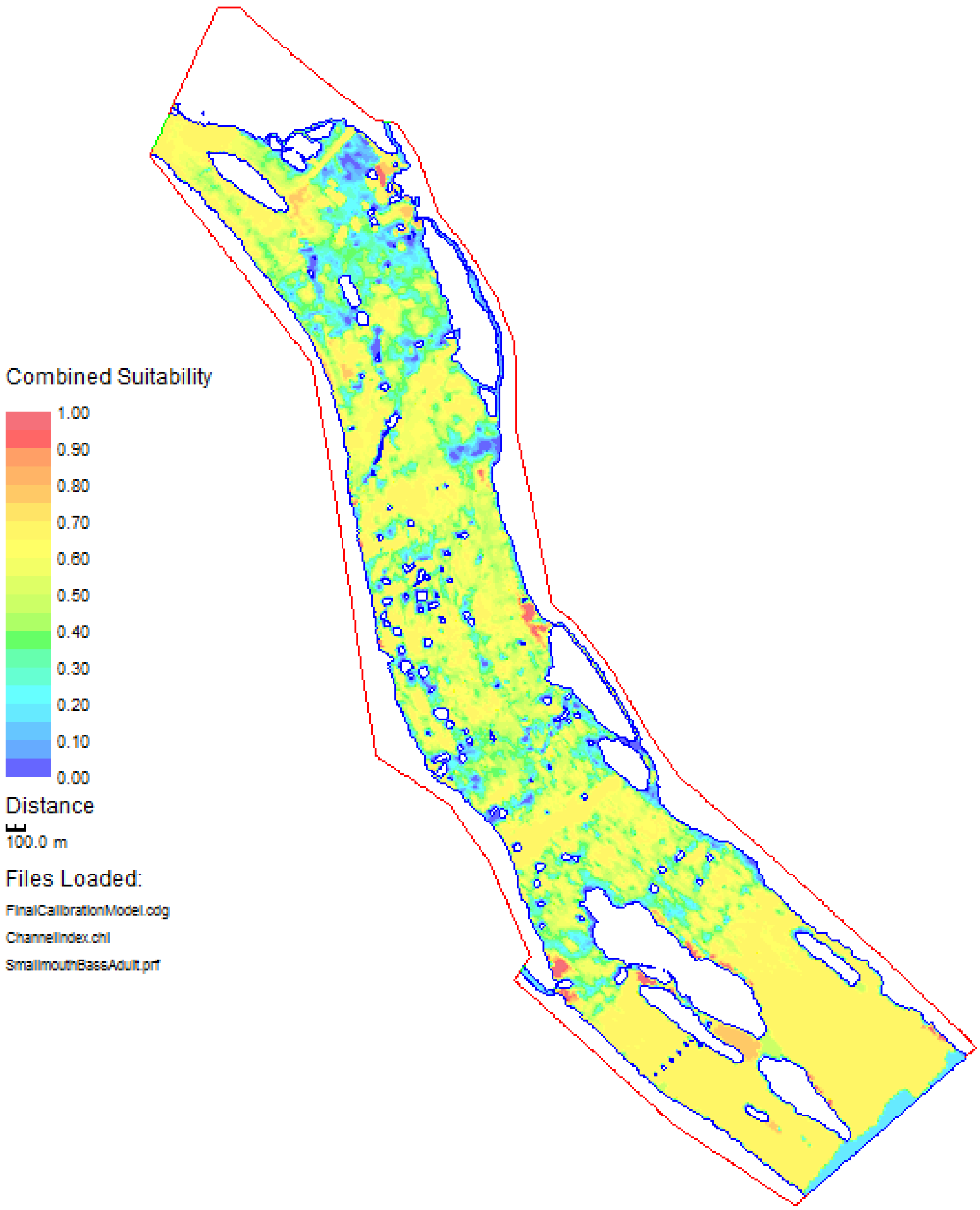
Smallmouth Bass Adult – 2,000 cfs



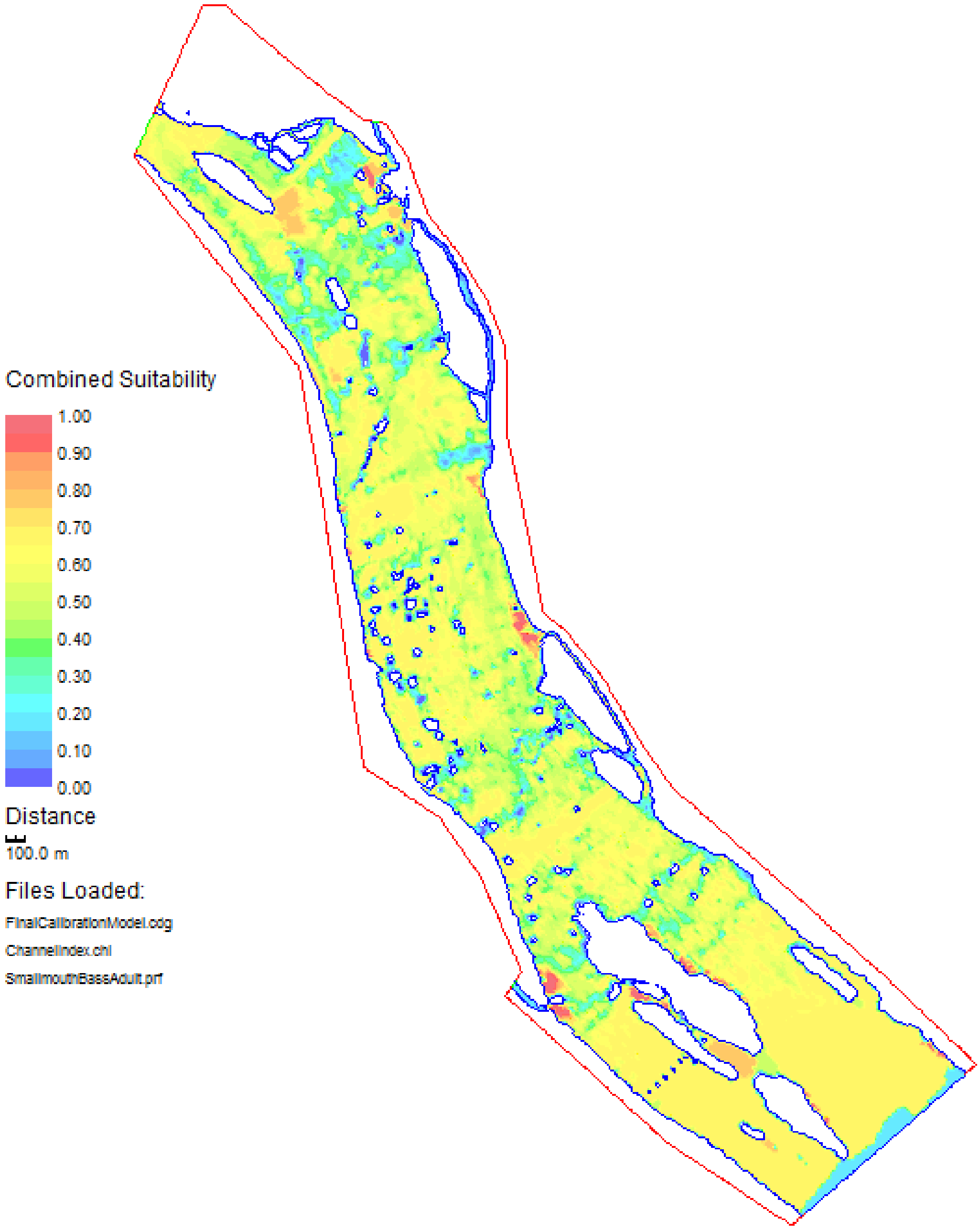
Smallmouth Bass Adult –3,500 cfs



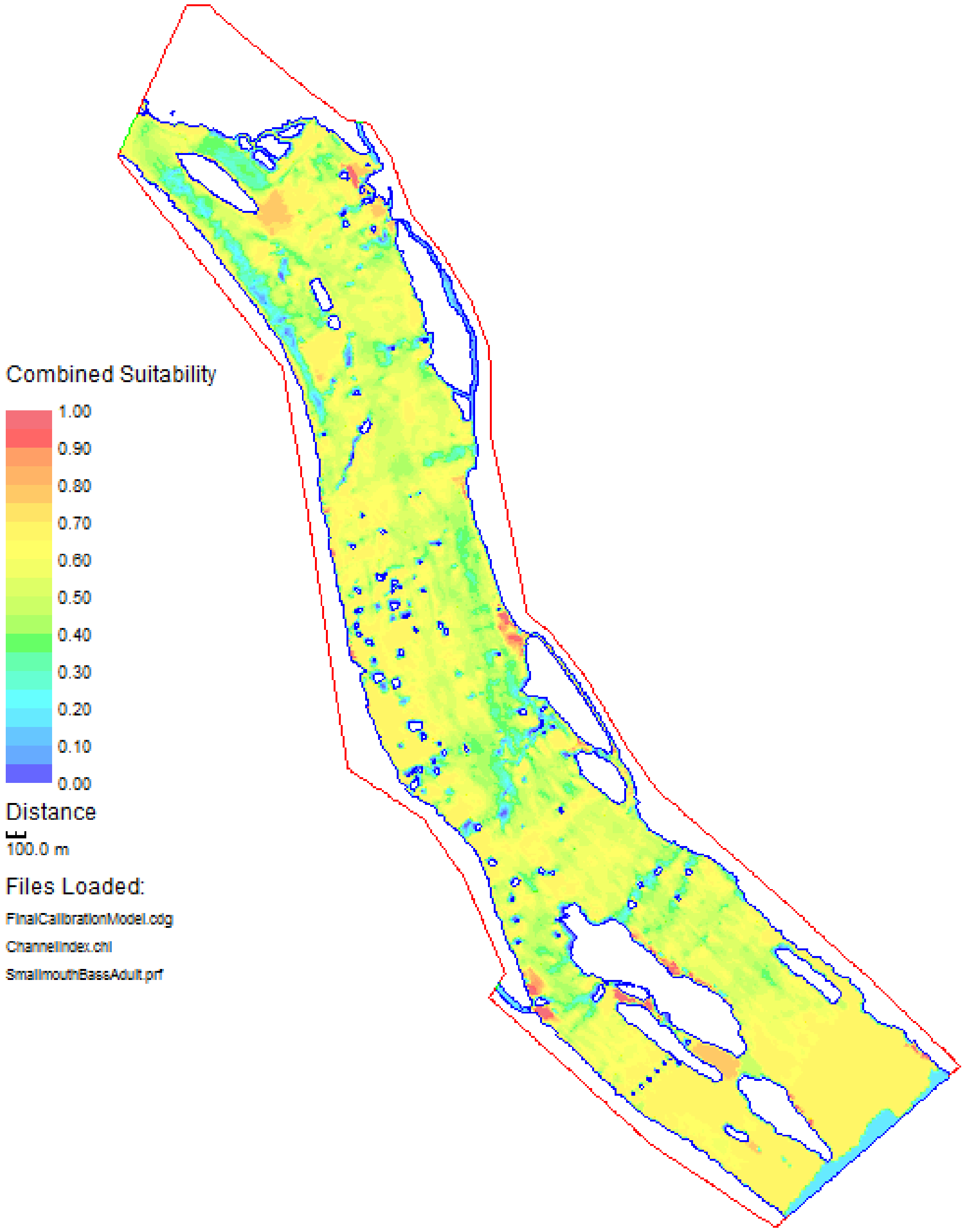
Smallmouth Bass Adult – 5,000 cfs



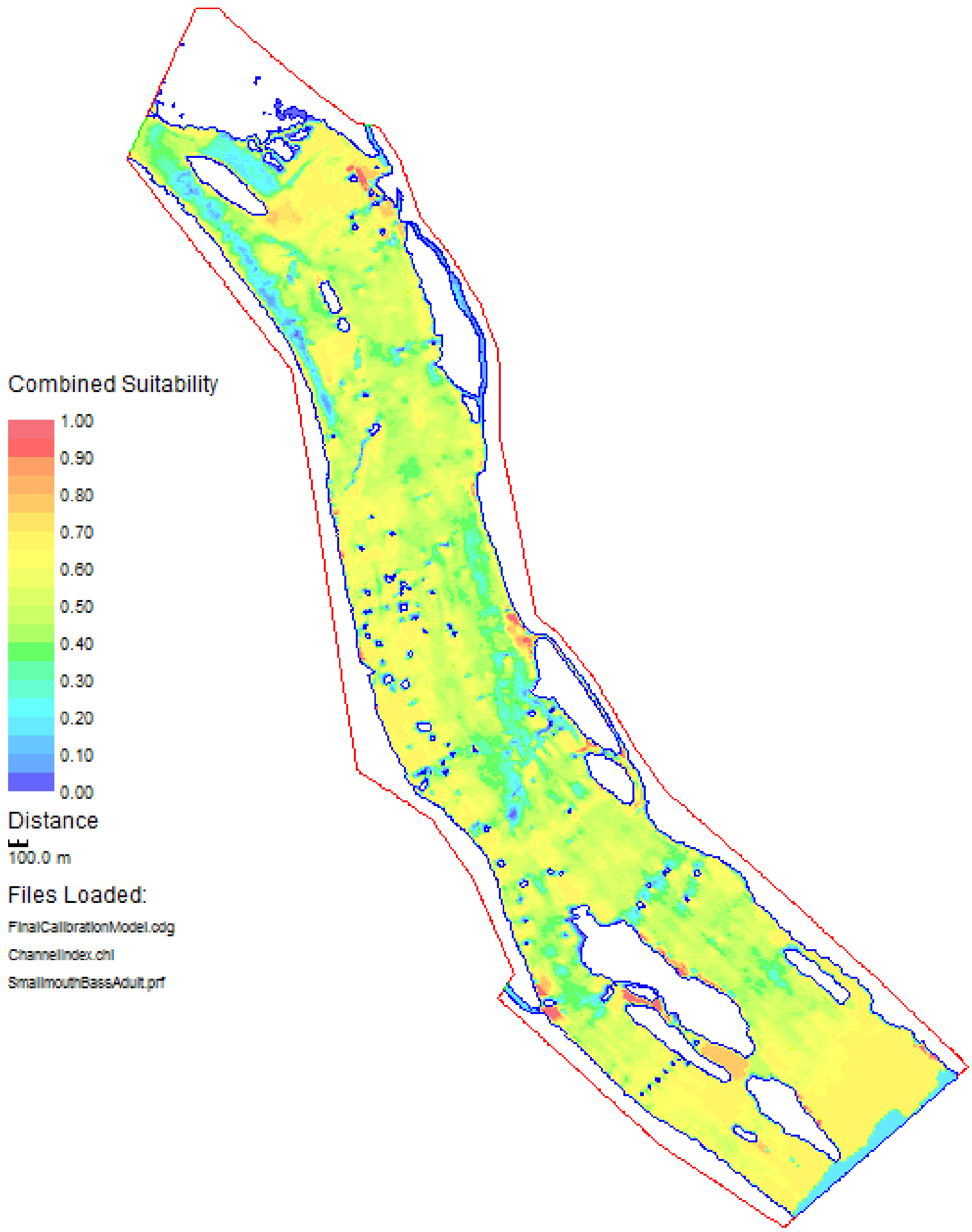
Smallmouth Bass Adult – 7,500 cfs



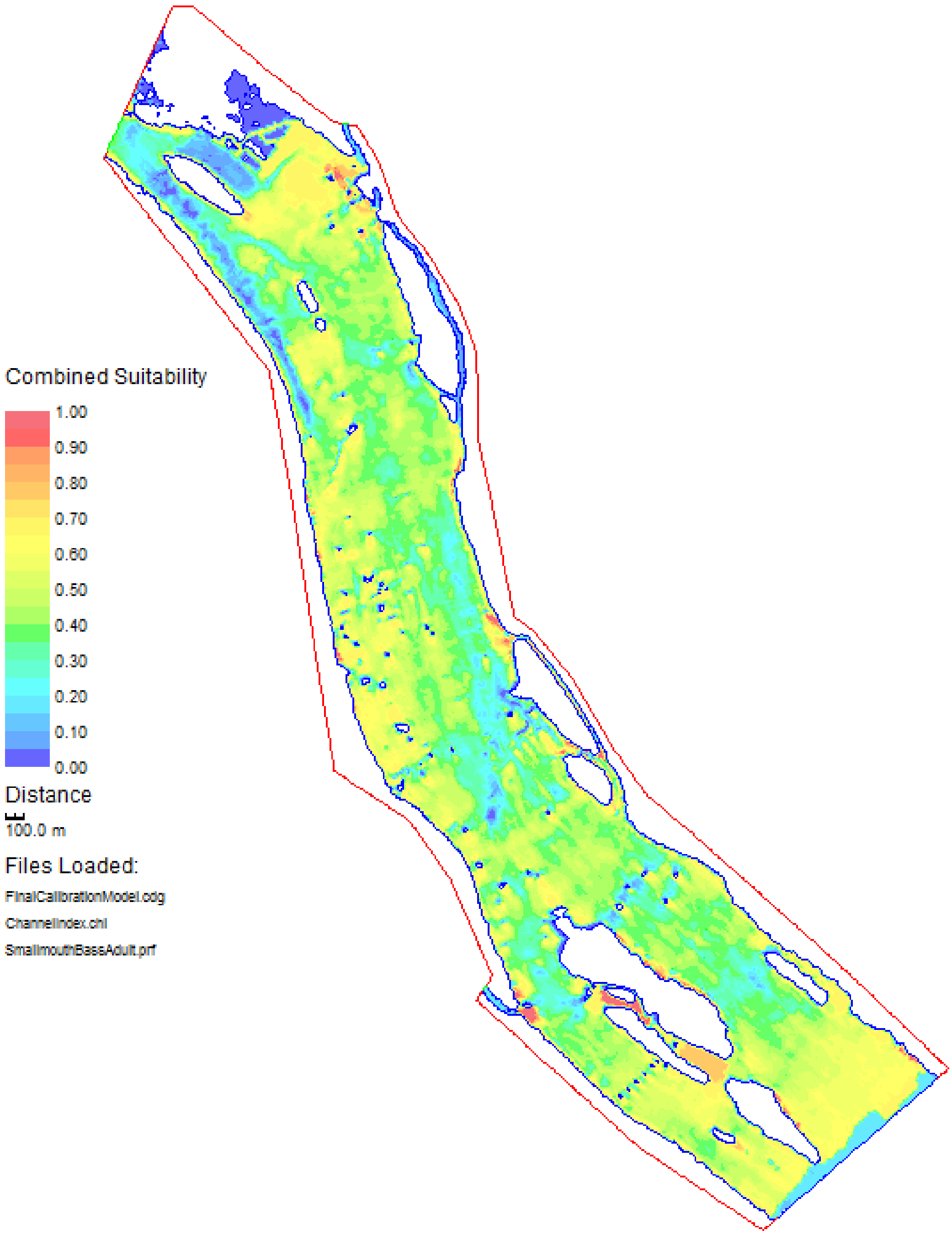
Smallmouth Bass Adult – 10,000 cfs



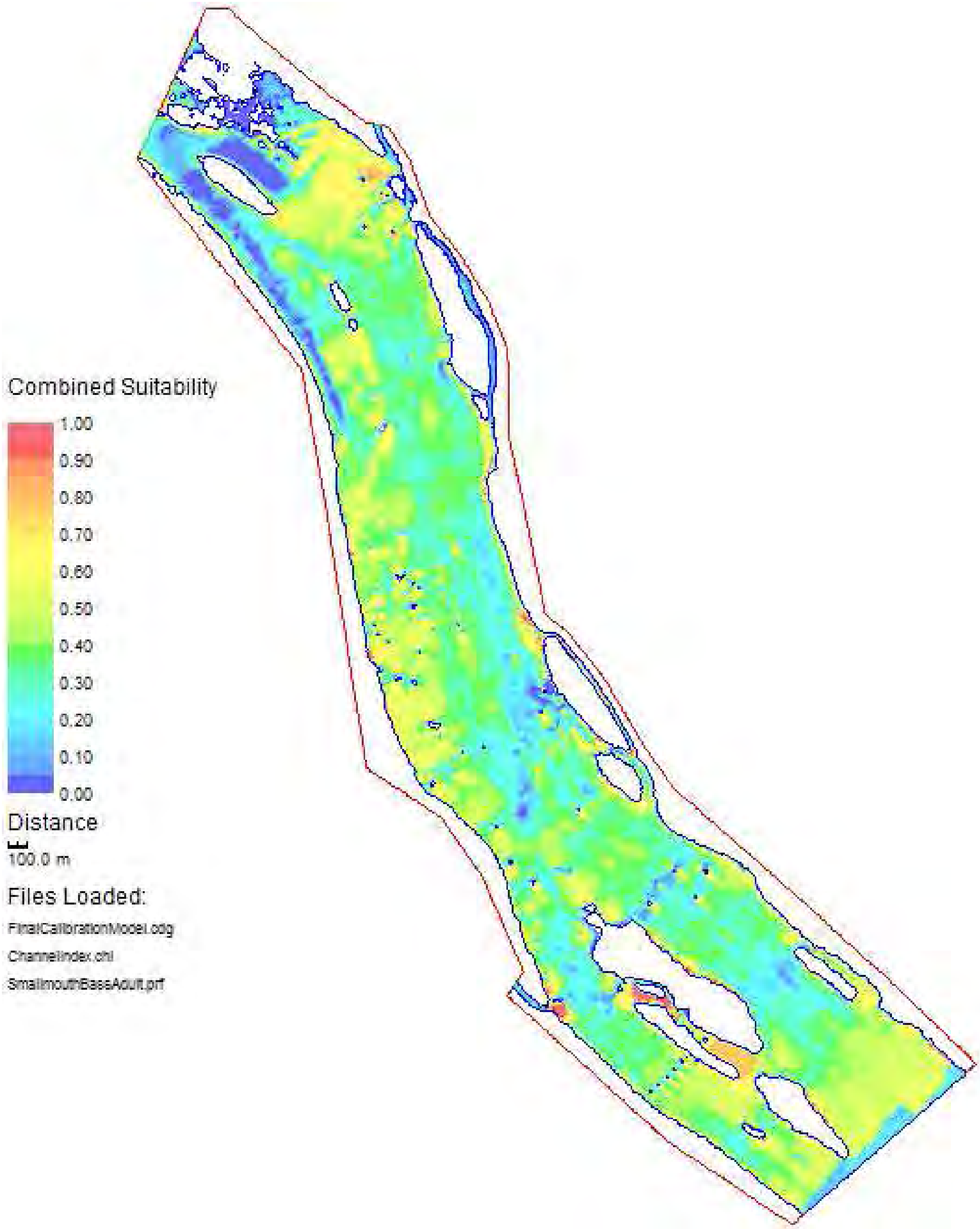
Smallmouth Bass Adult – 15,000 cfs



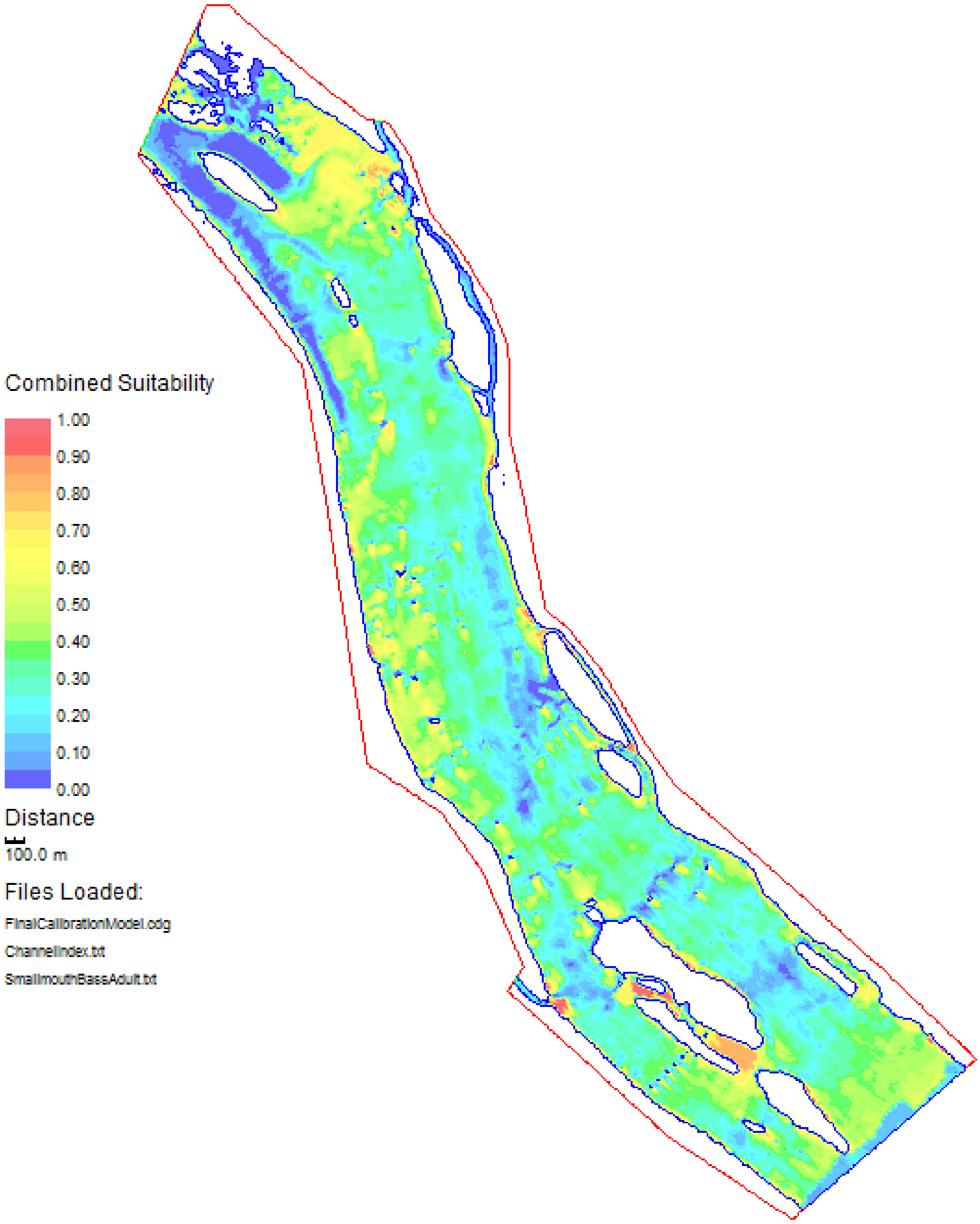
Smallmouth Bass Adult – 20,000 cfs



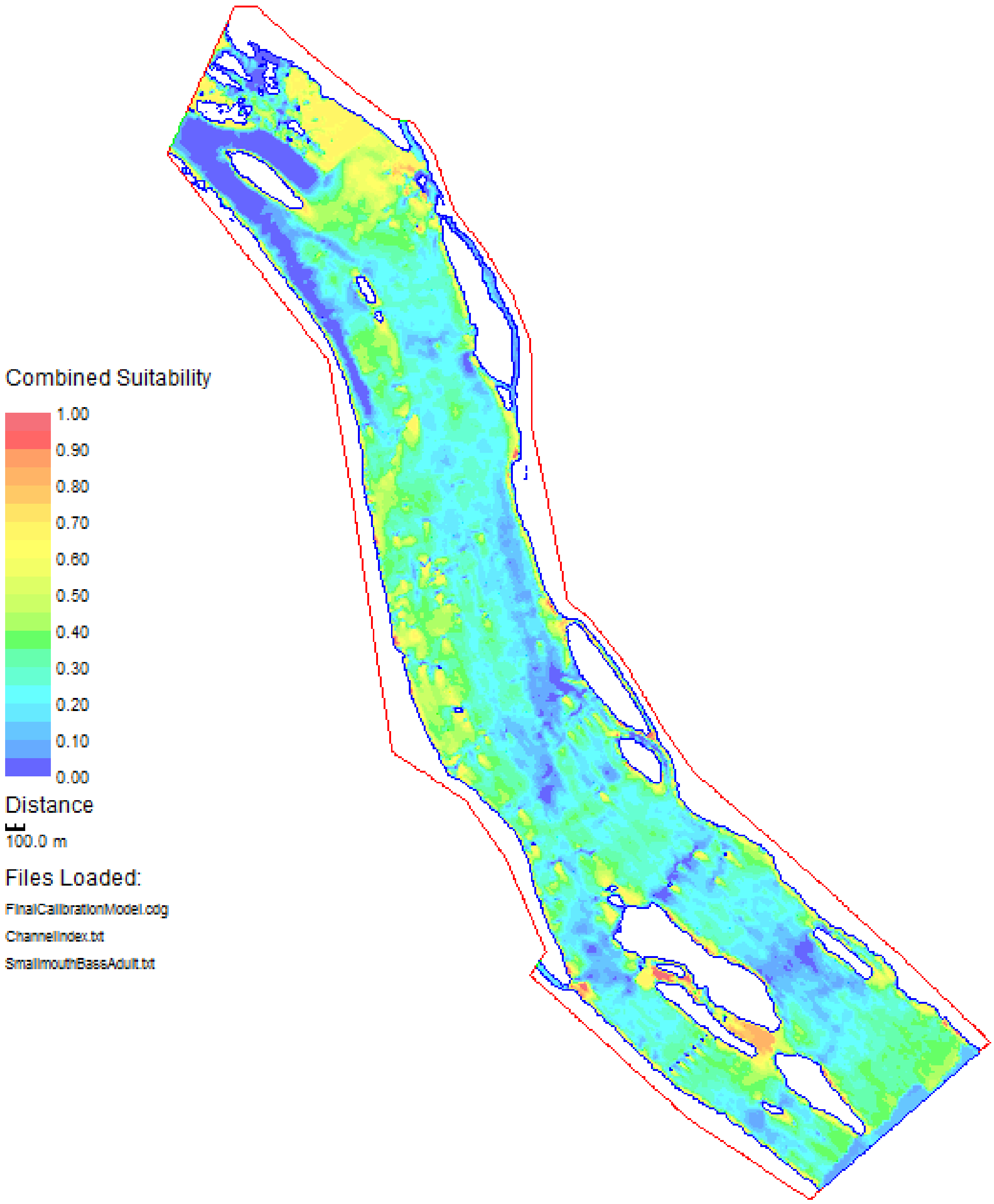
Smallmouth Bass Adult – 30,000 cfs



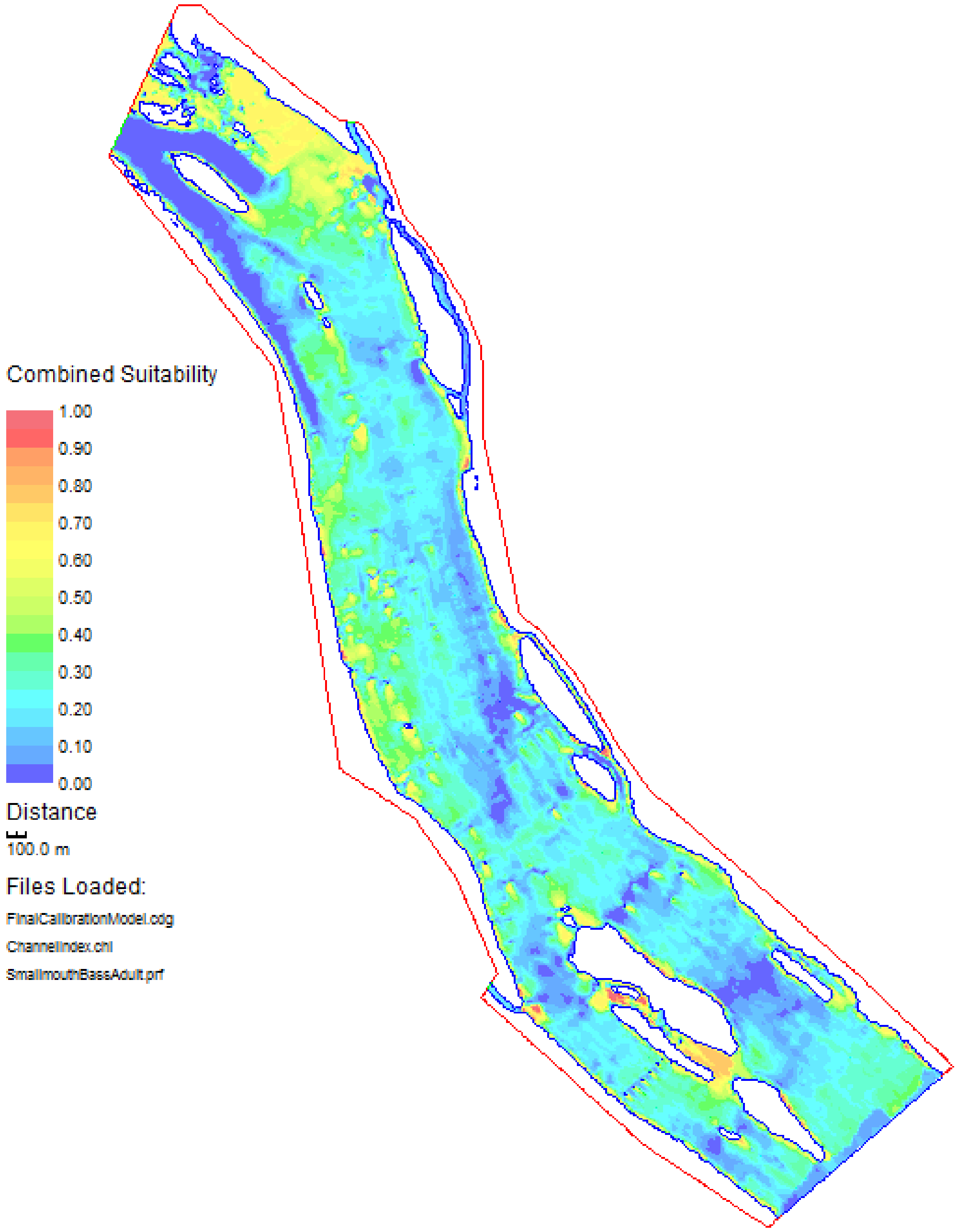
Smallmouth Bass Adult – 40,000 cfs



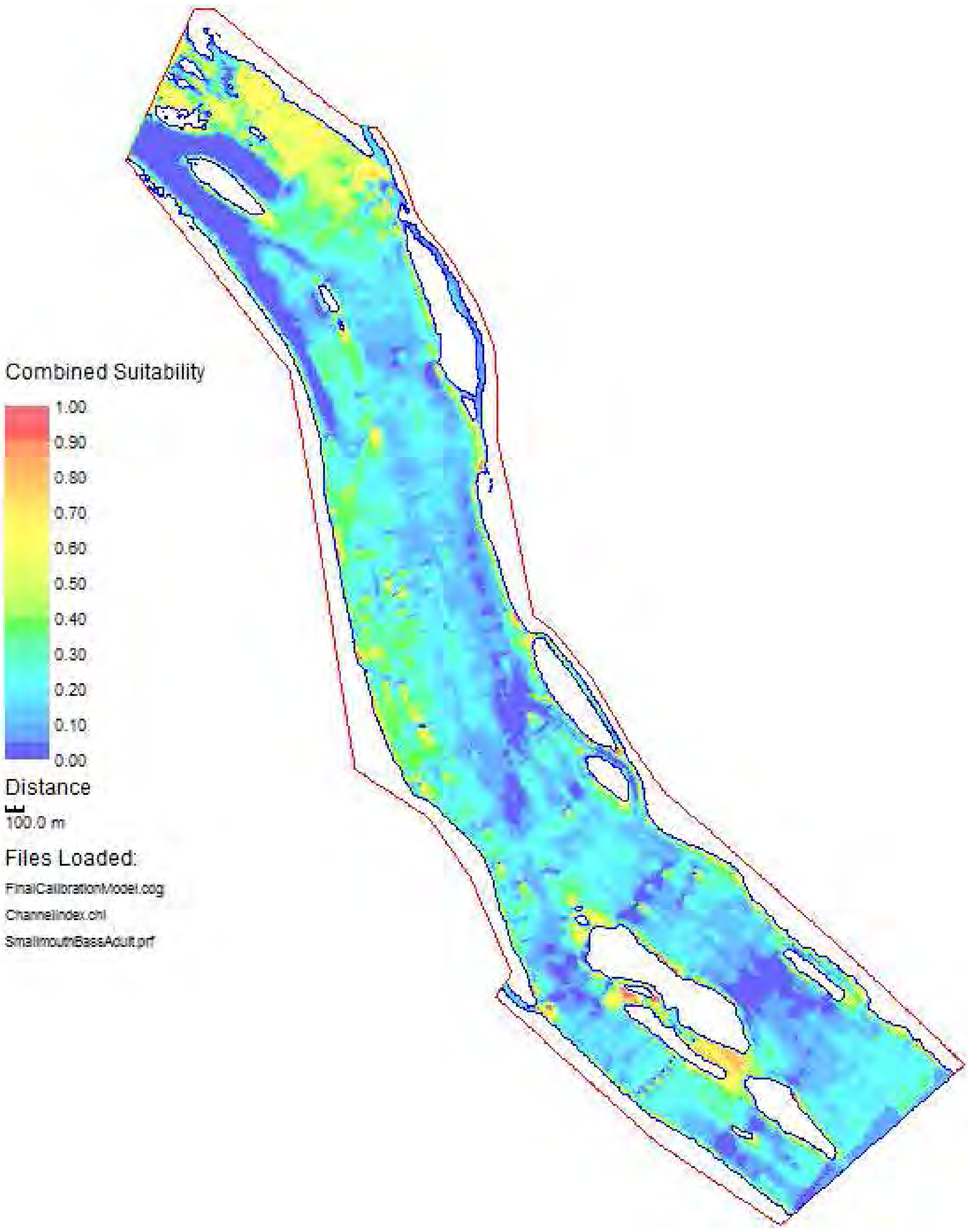
Smallmouth Bass Adult – 50,000 cfs



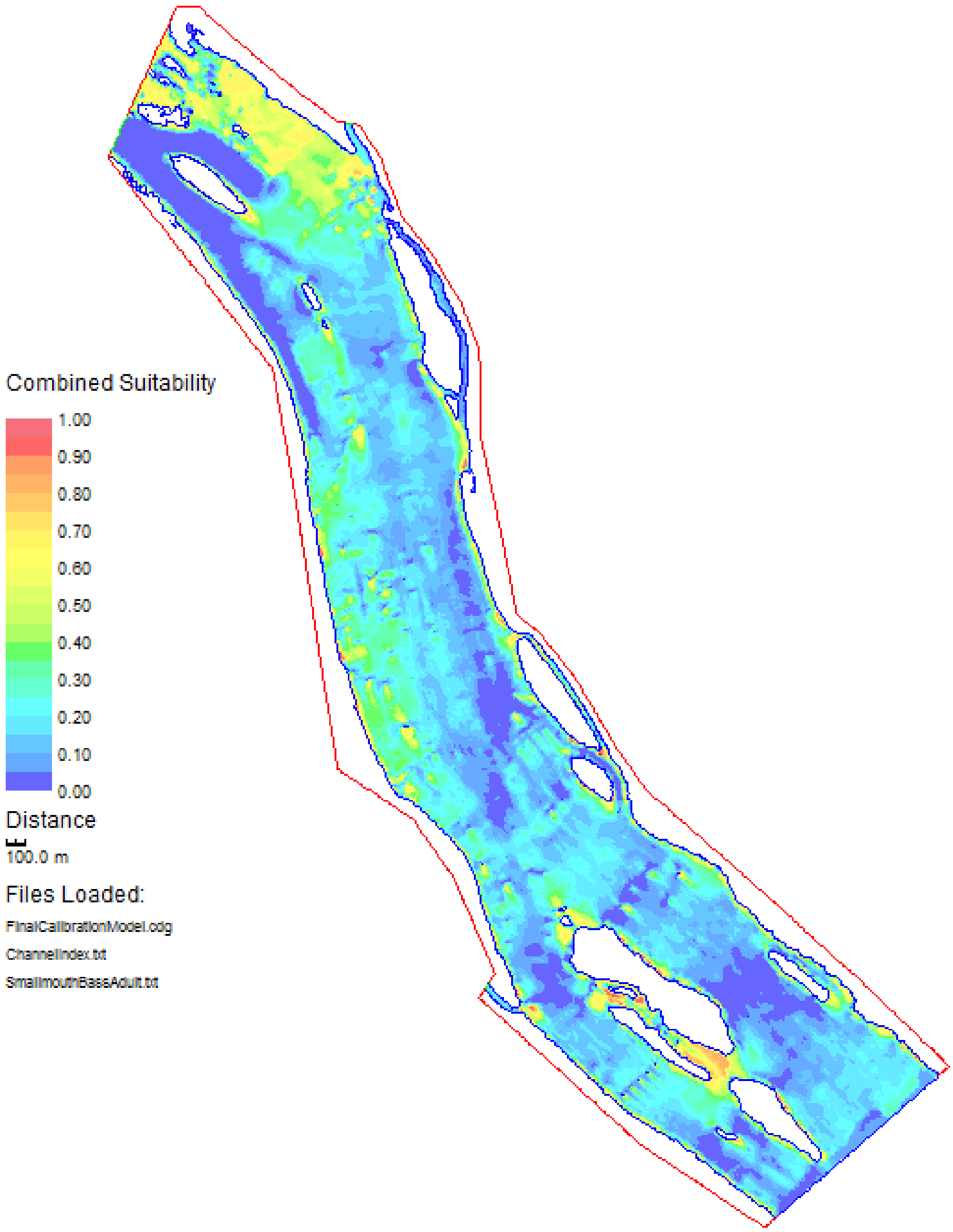
Smallmouth Bass Adult – 60,000 cfs



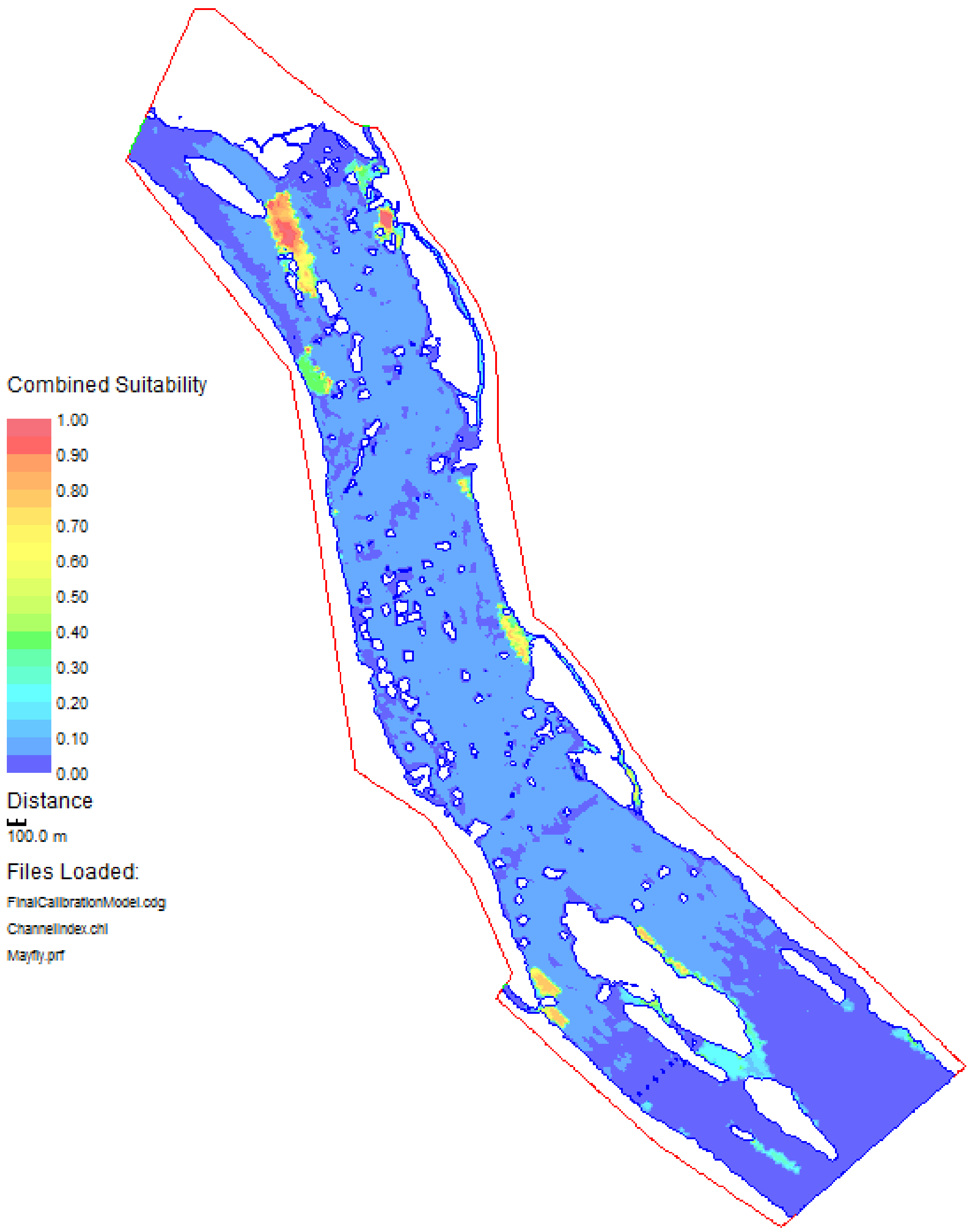
Smallmouth Bass Adult – 70,000 cfs



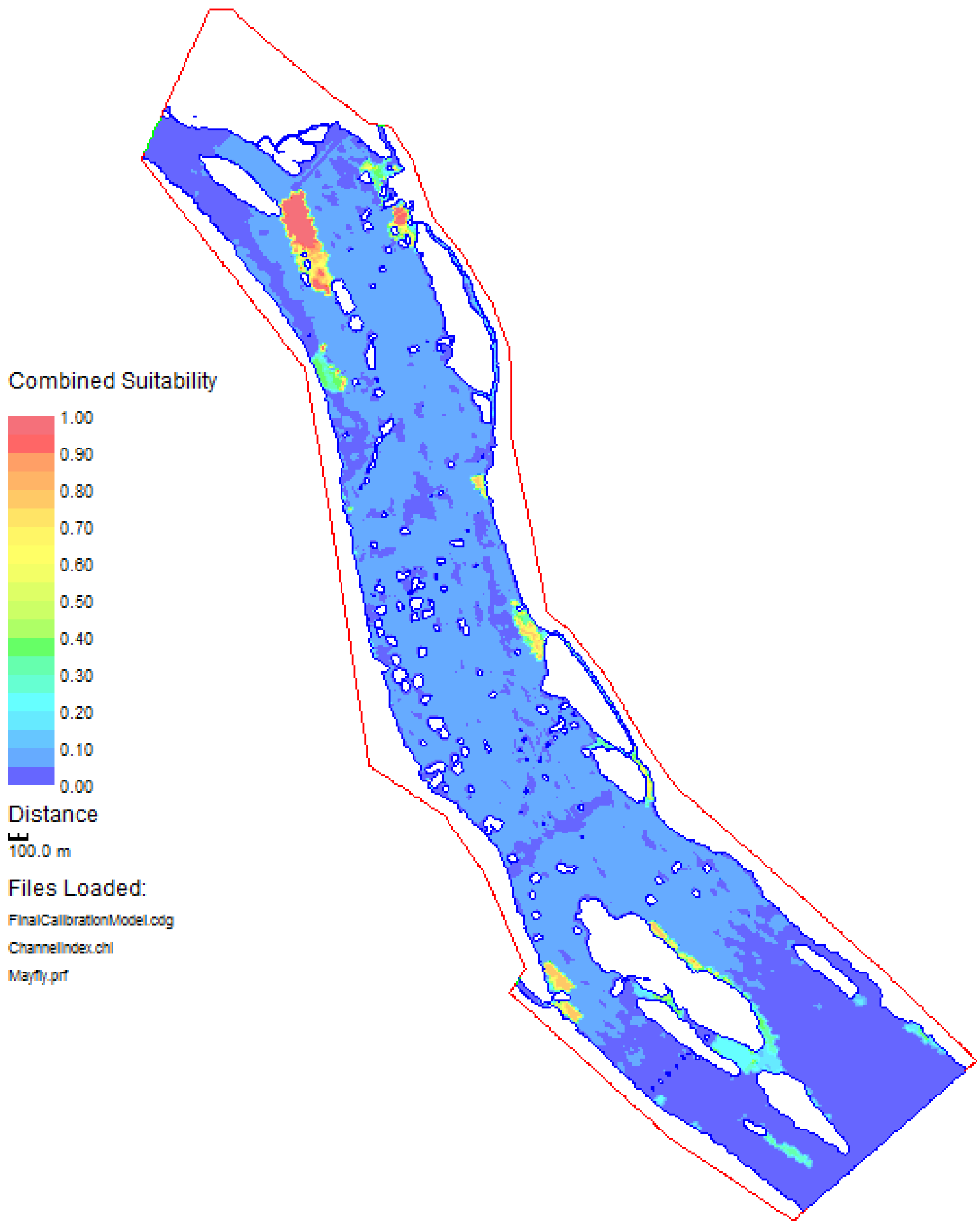
Smallmouth Bass Adult – 80,000 cfs



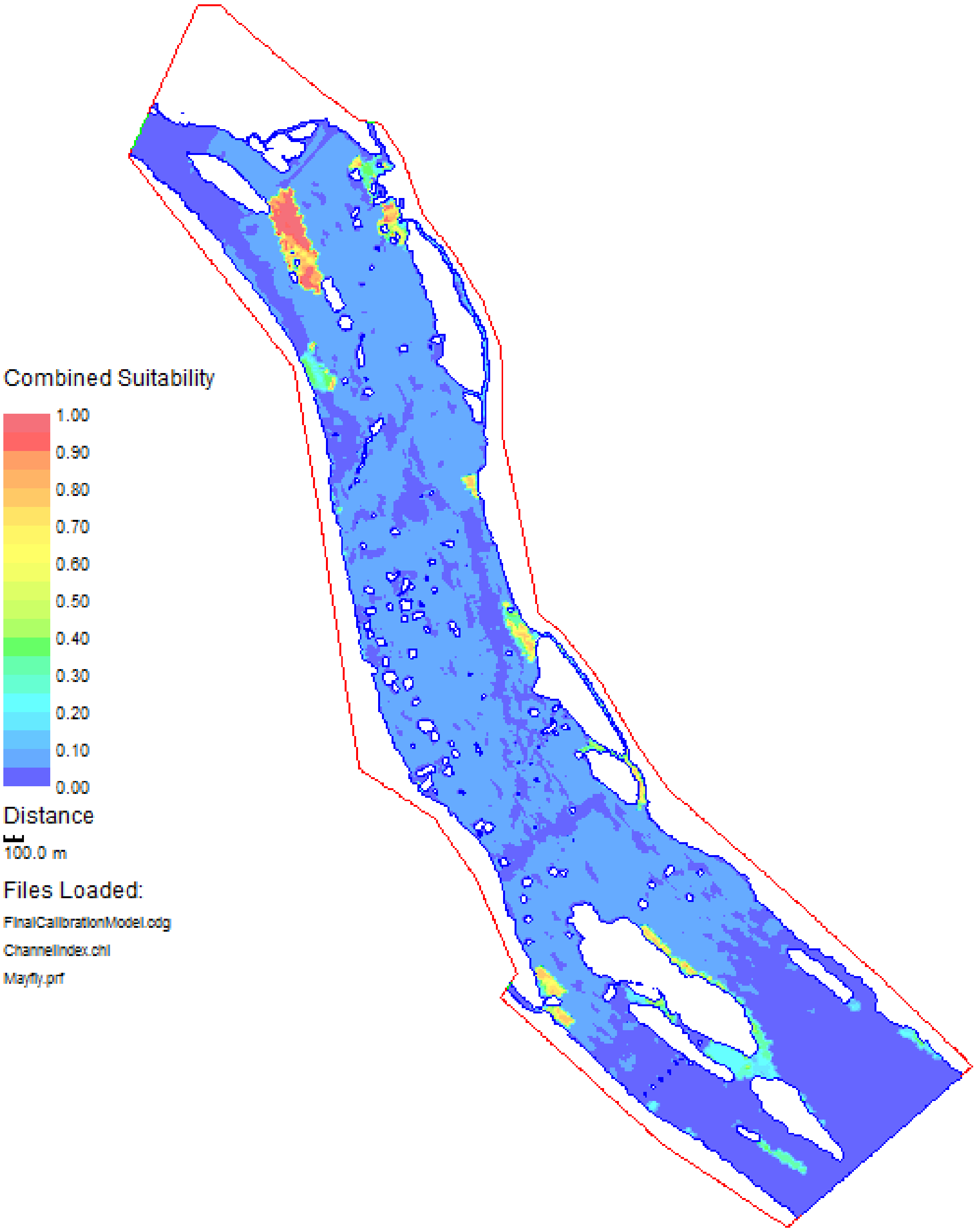
Smallmouth Bass Adult – 86,000 cfs



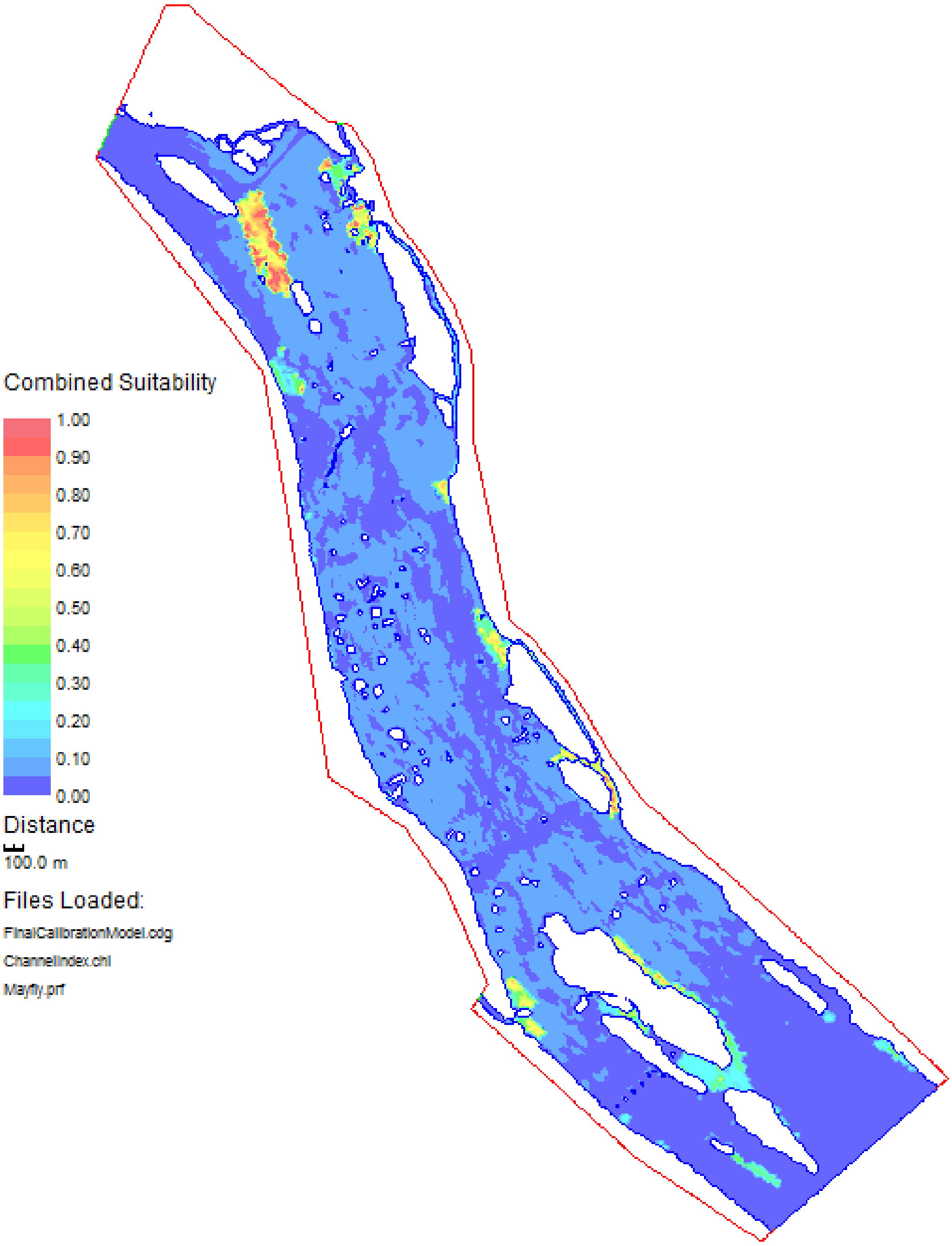
Mayfly – 2,000 cfs



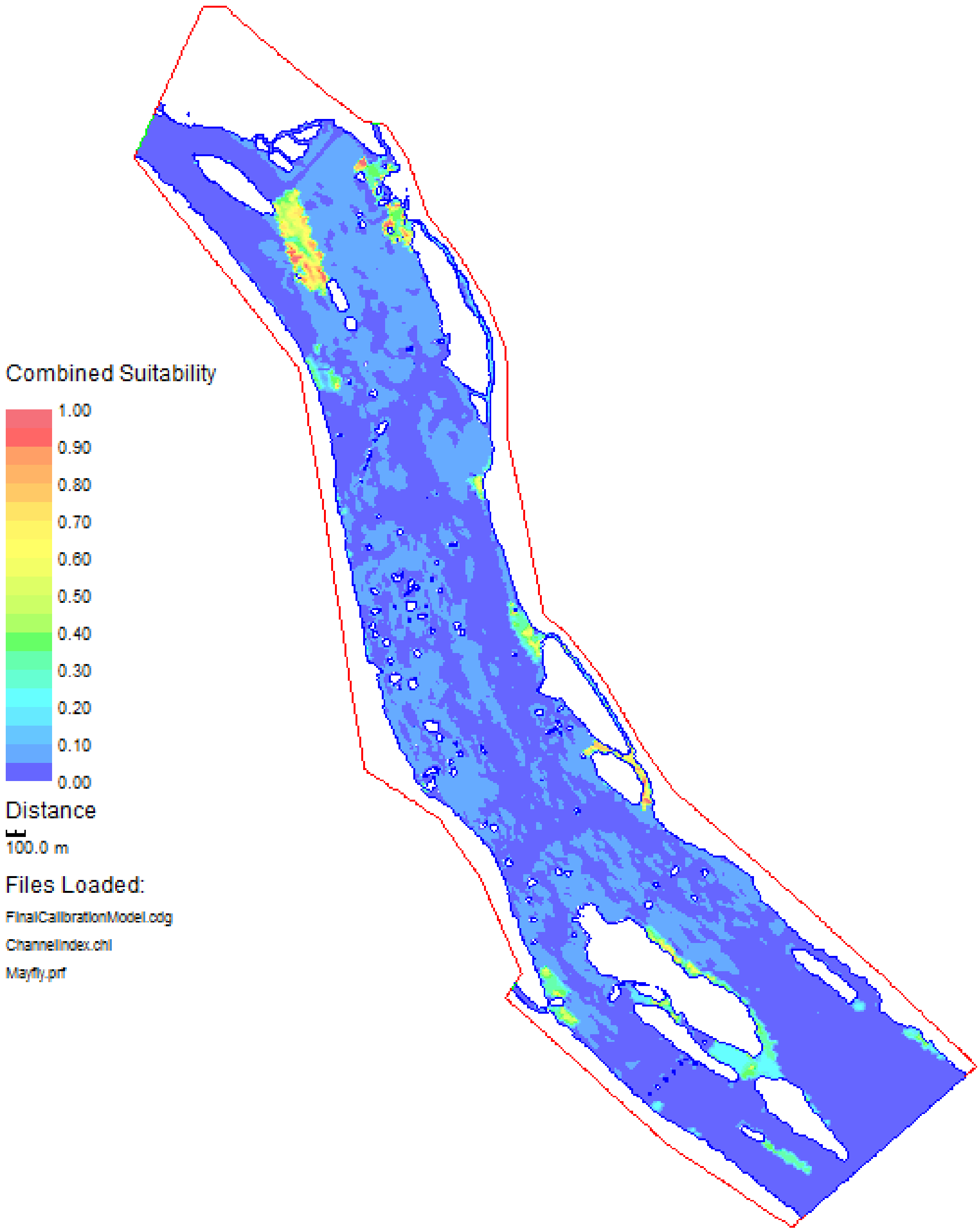
Mayfly – 3,500 cfs



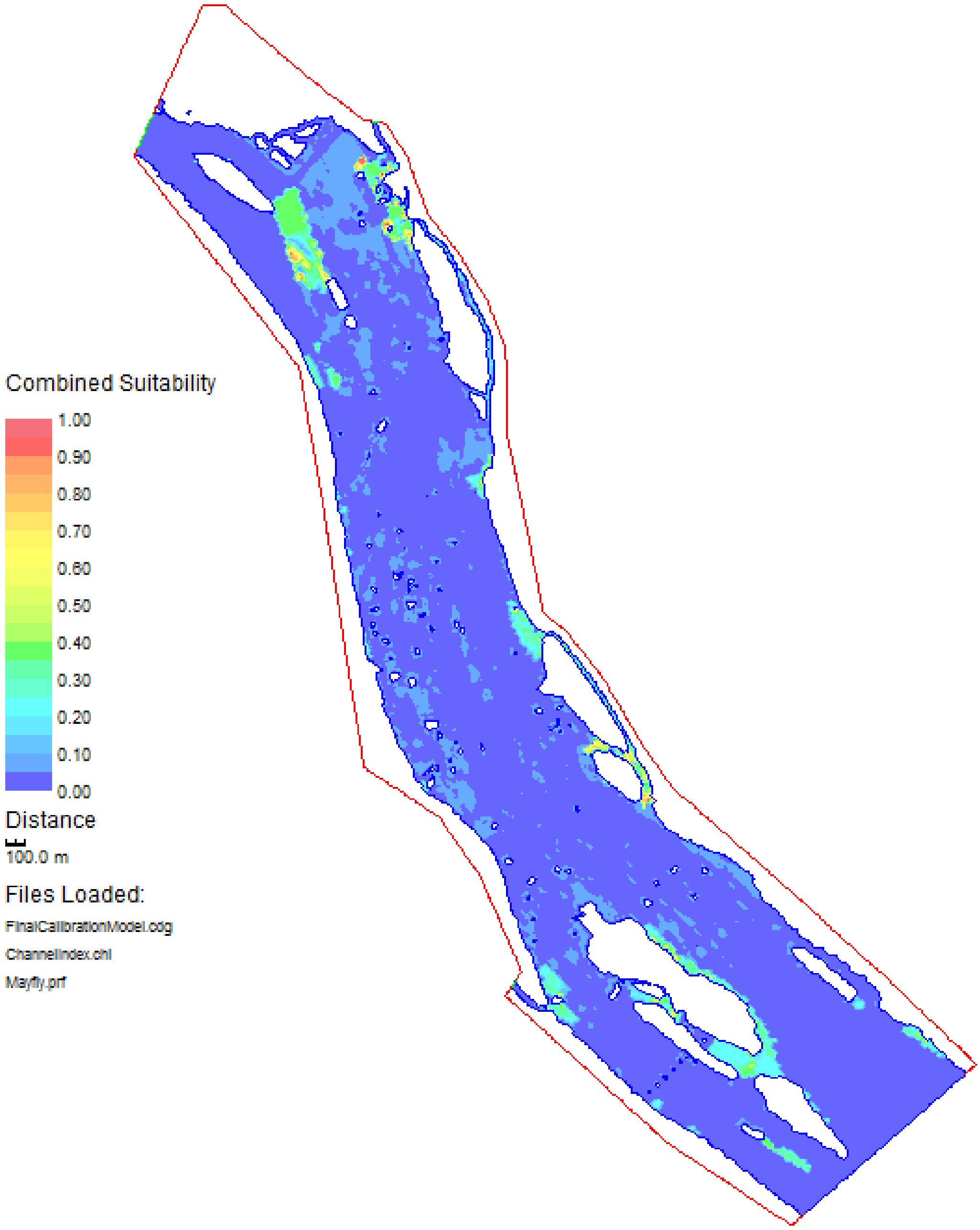
Mayfly – 5,000 cfs



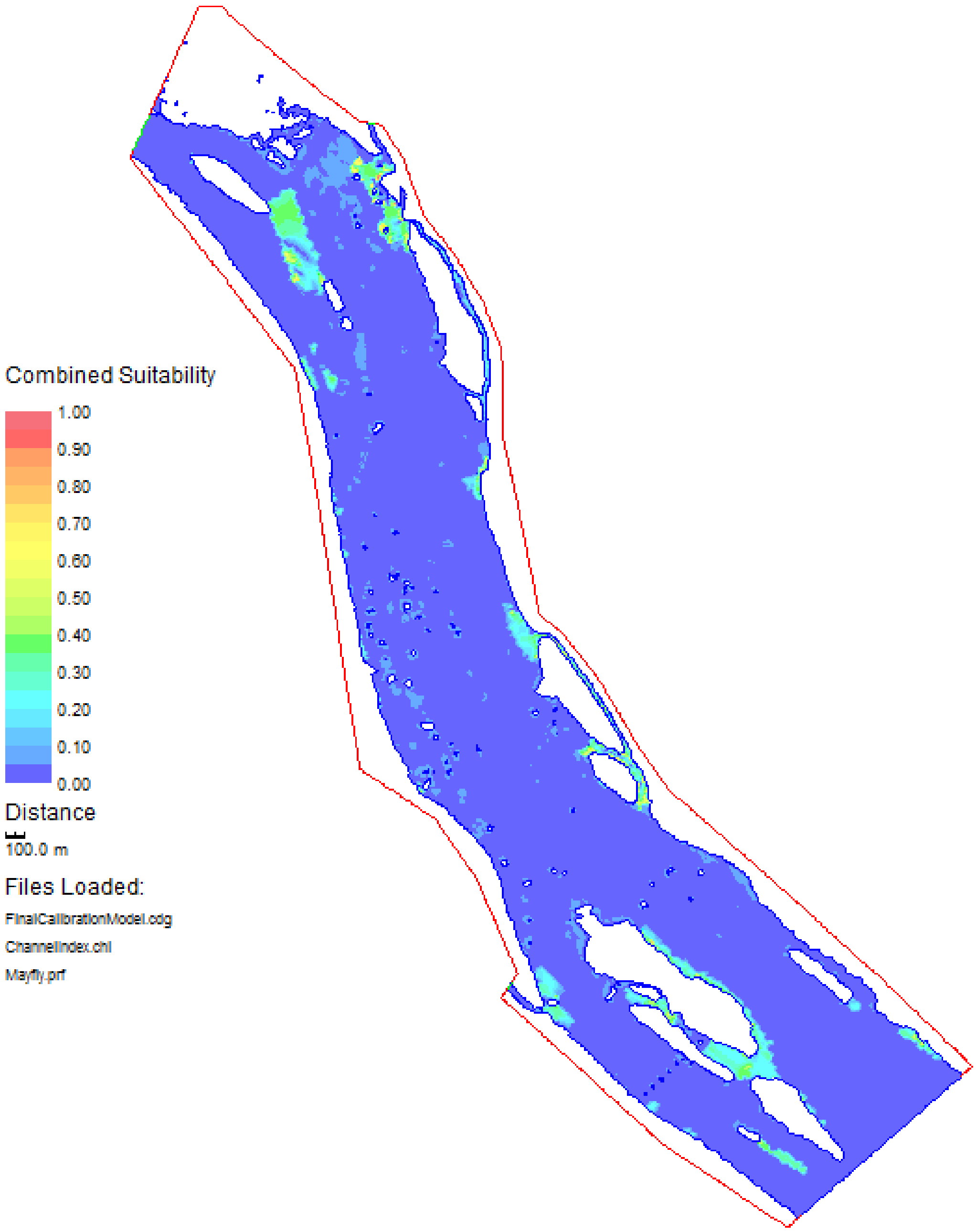
Mayfly – 7,500 cfs



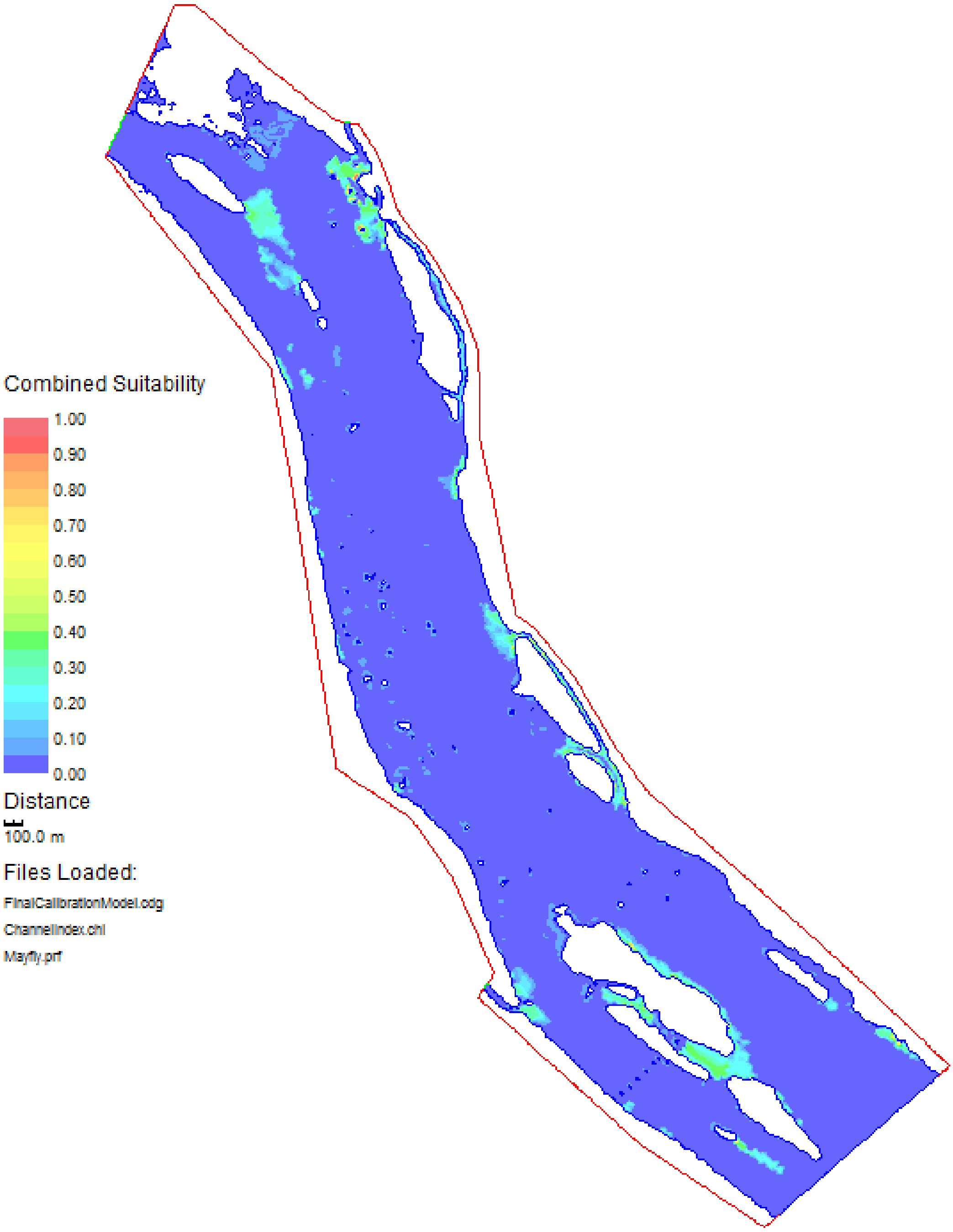
Mayfly – 10,000 cfs



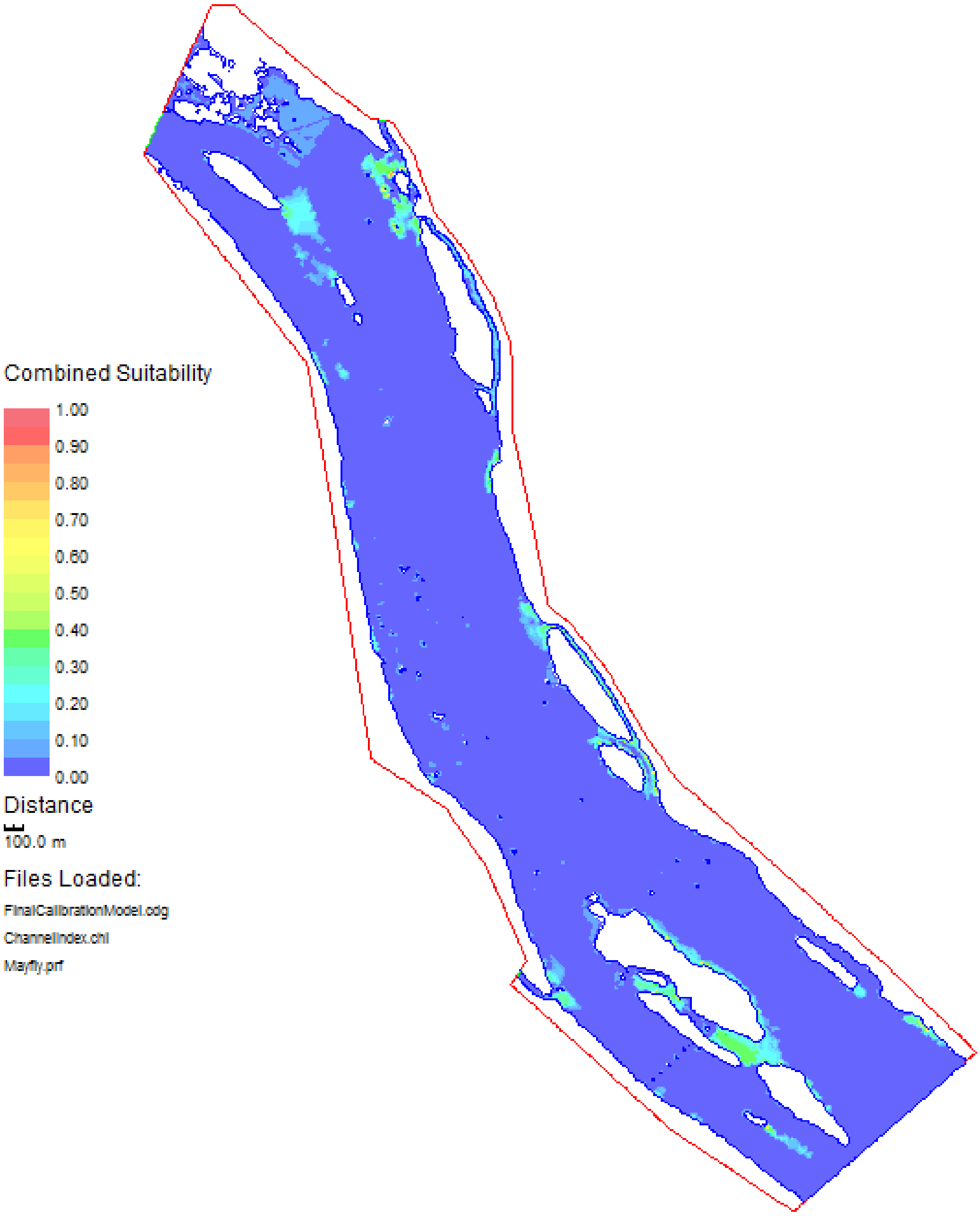
Mayfly – 15,000 cfs



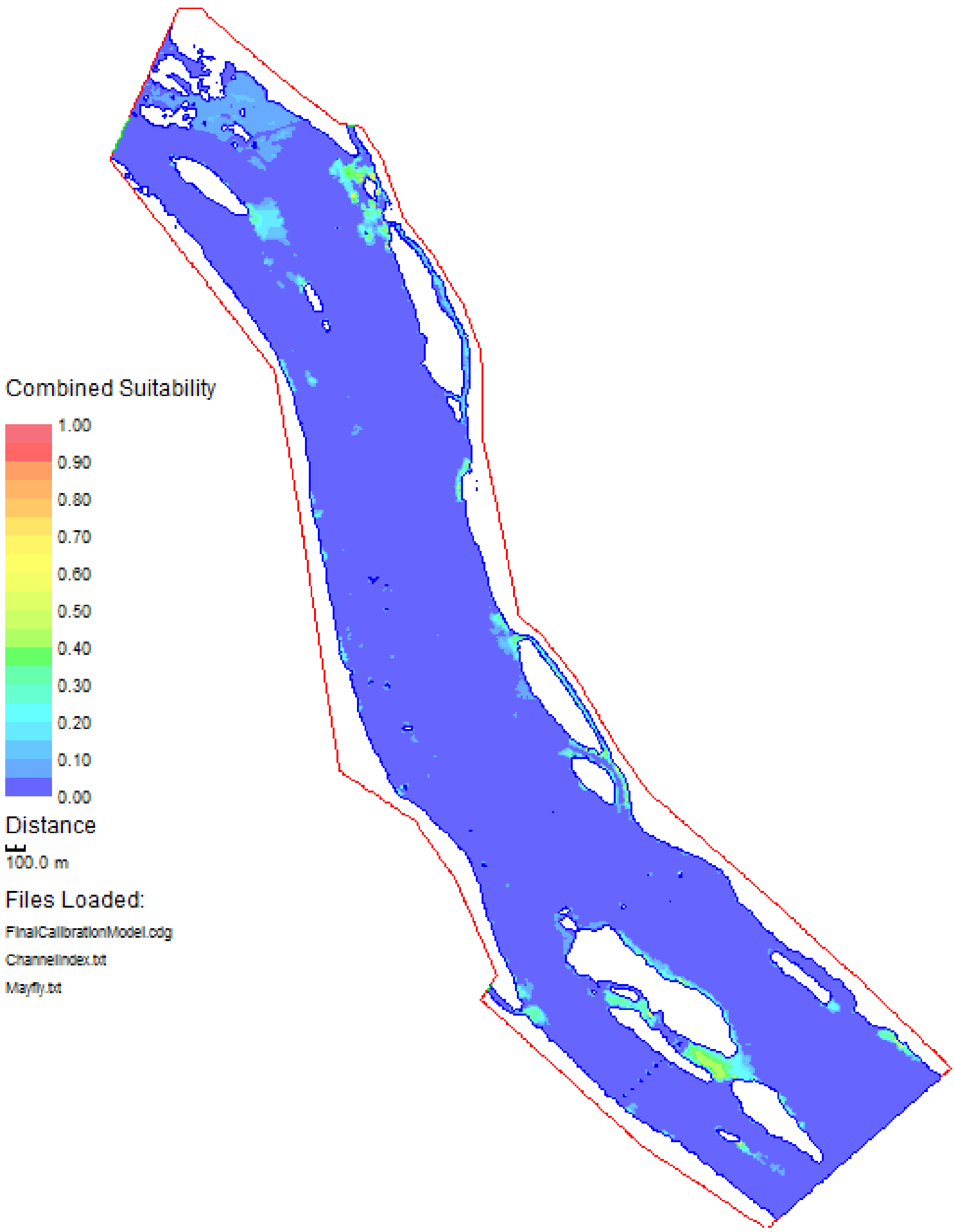
Mayfly – 20,000 cfs



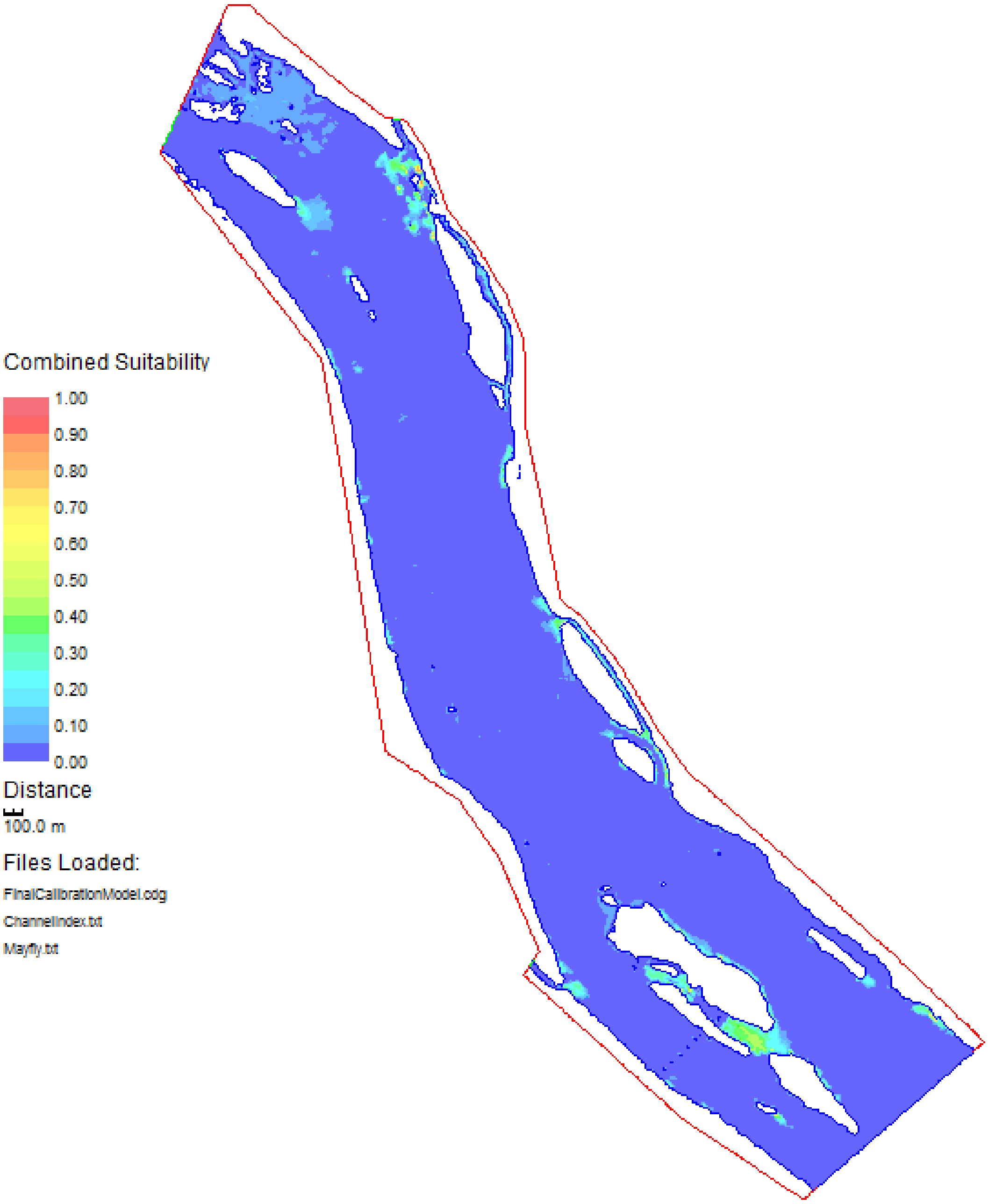
Mayfly – 30,000 cfs



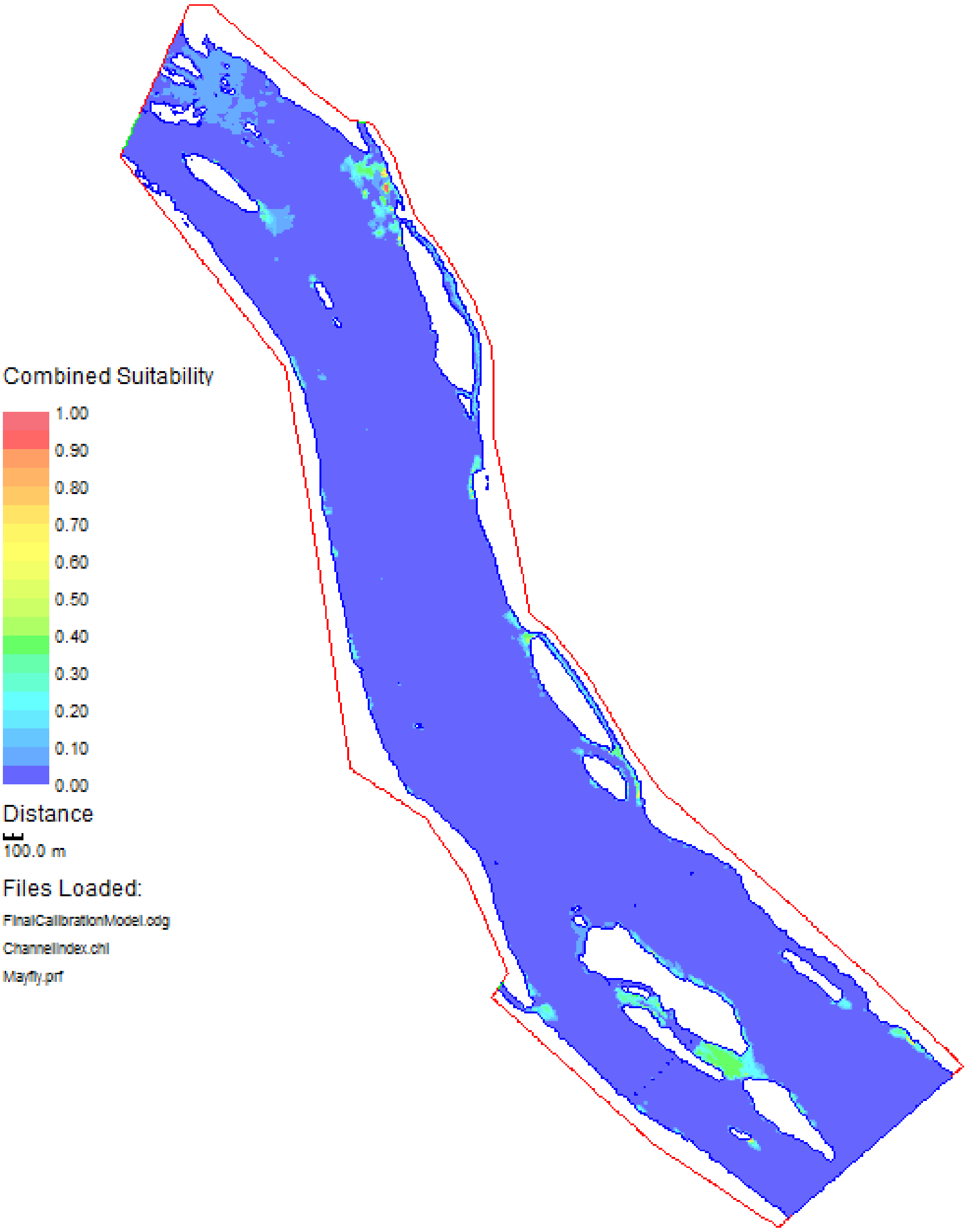
Mayfly – 40,000 cfs



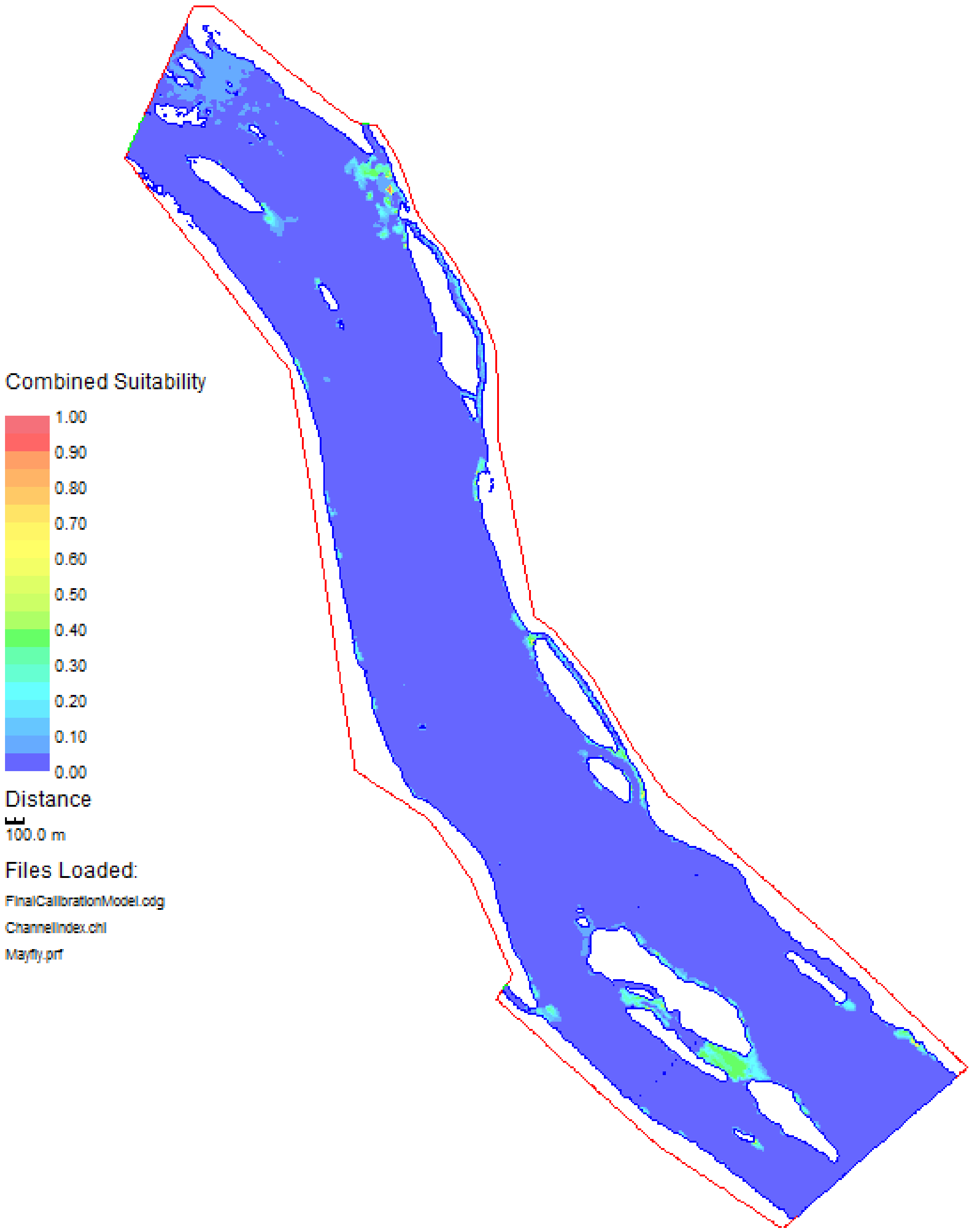
Mayfly – 50,000cfs



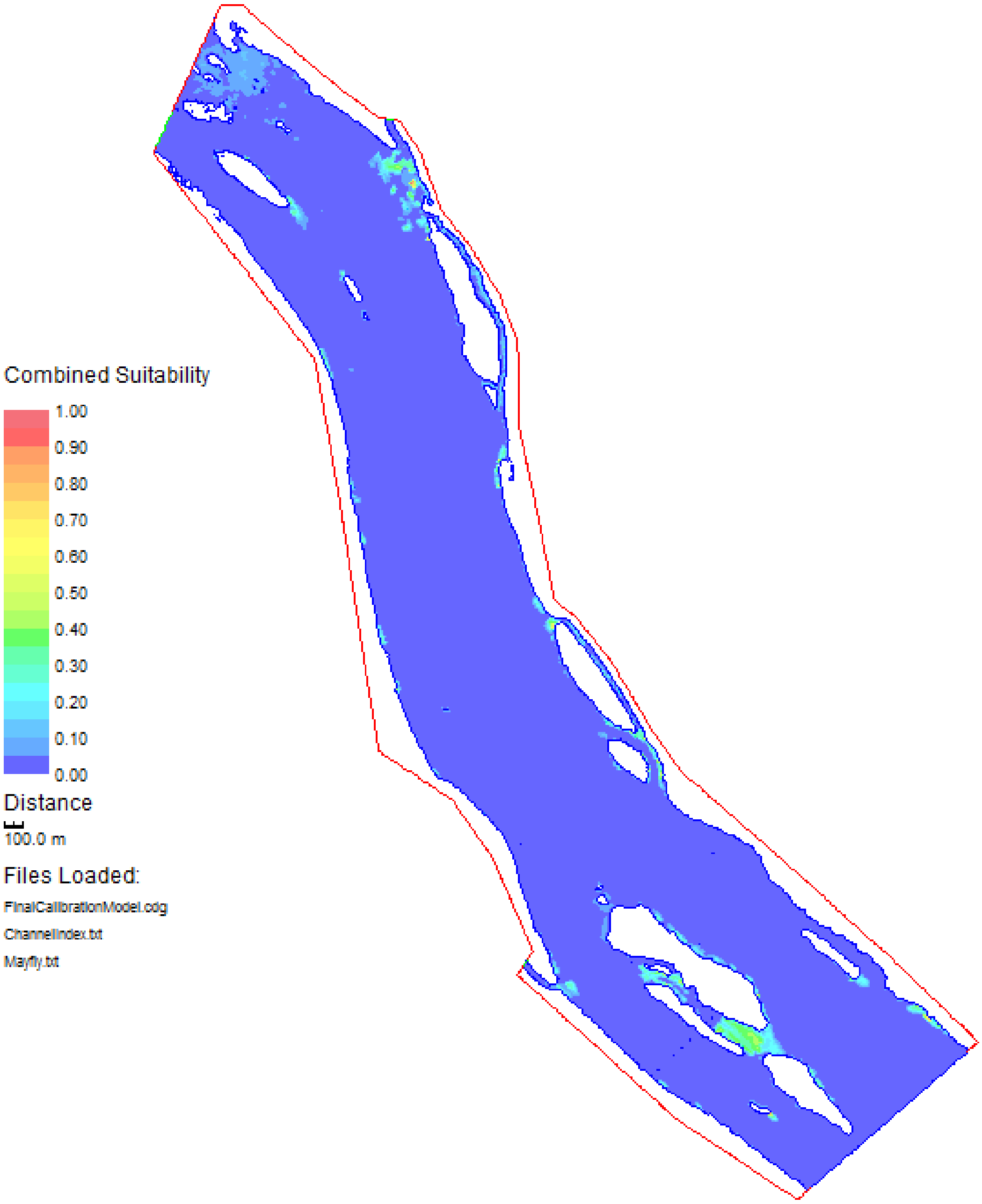
Mayfly – 60,000 cfs



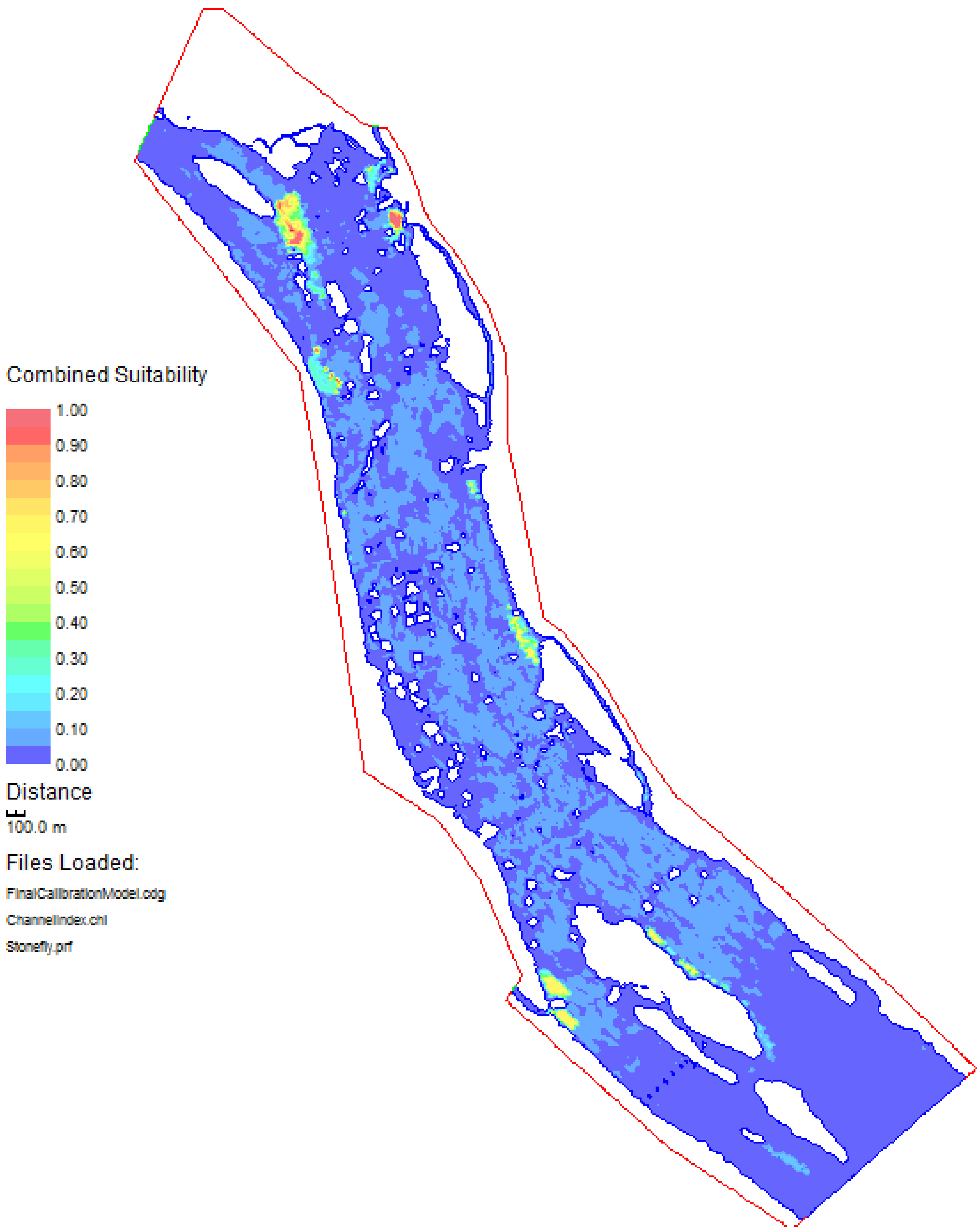
Mayfly – 70,000 cfs



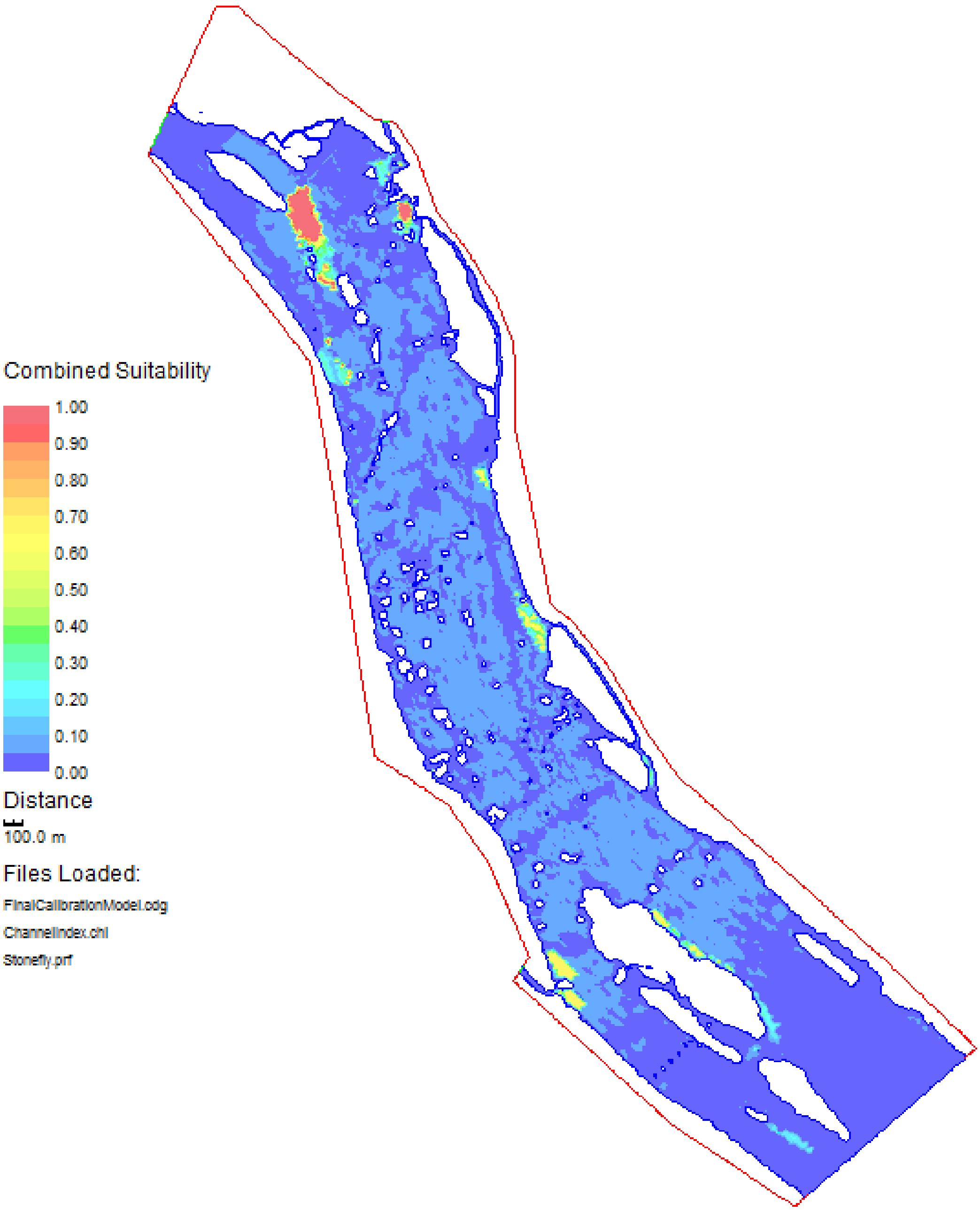
Mayfly – 80,000 cfs



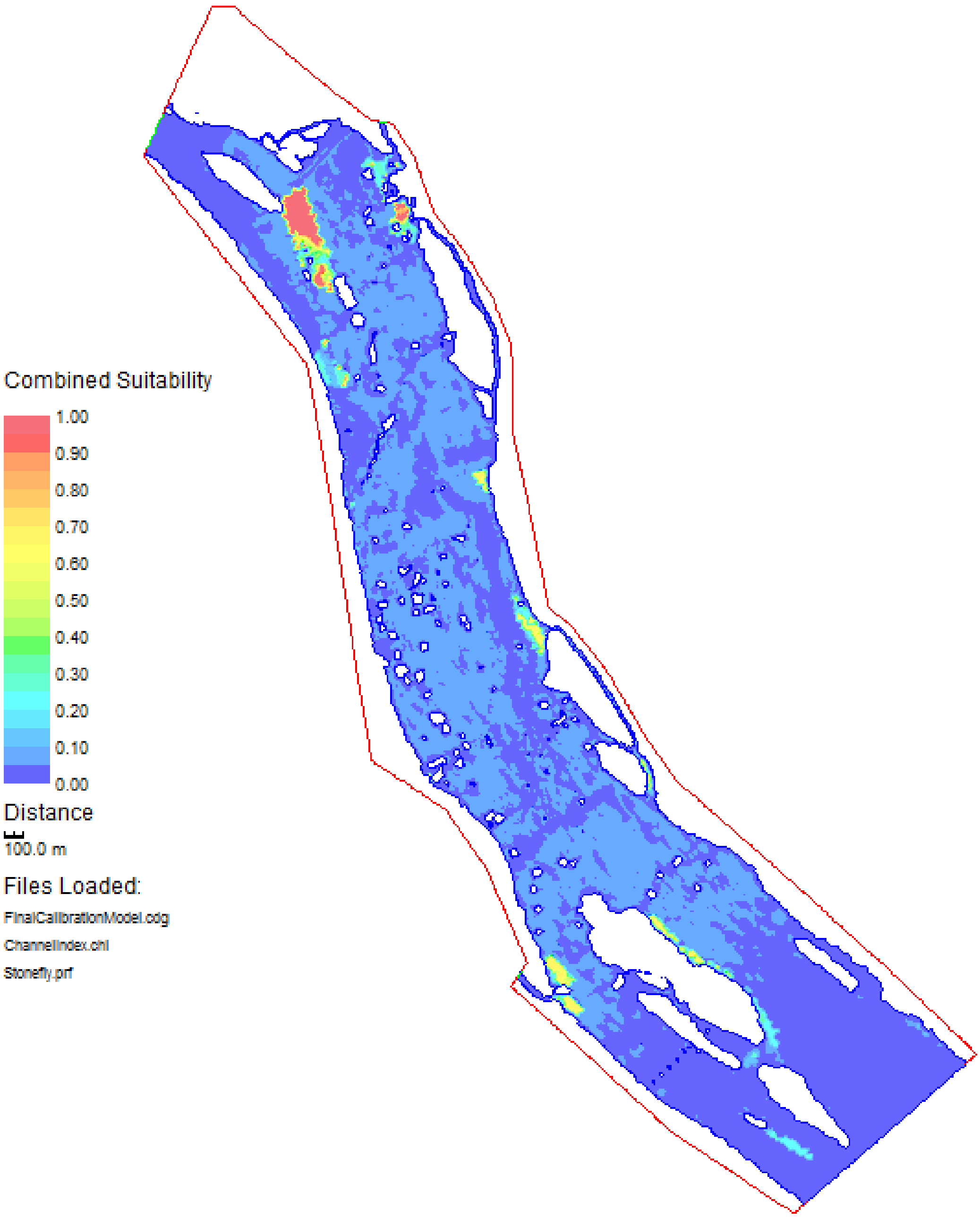
Mayfly – 86,000 cfs



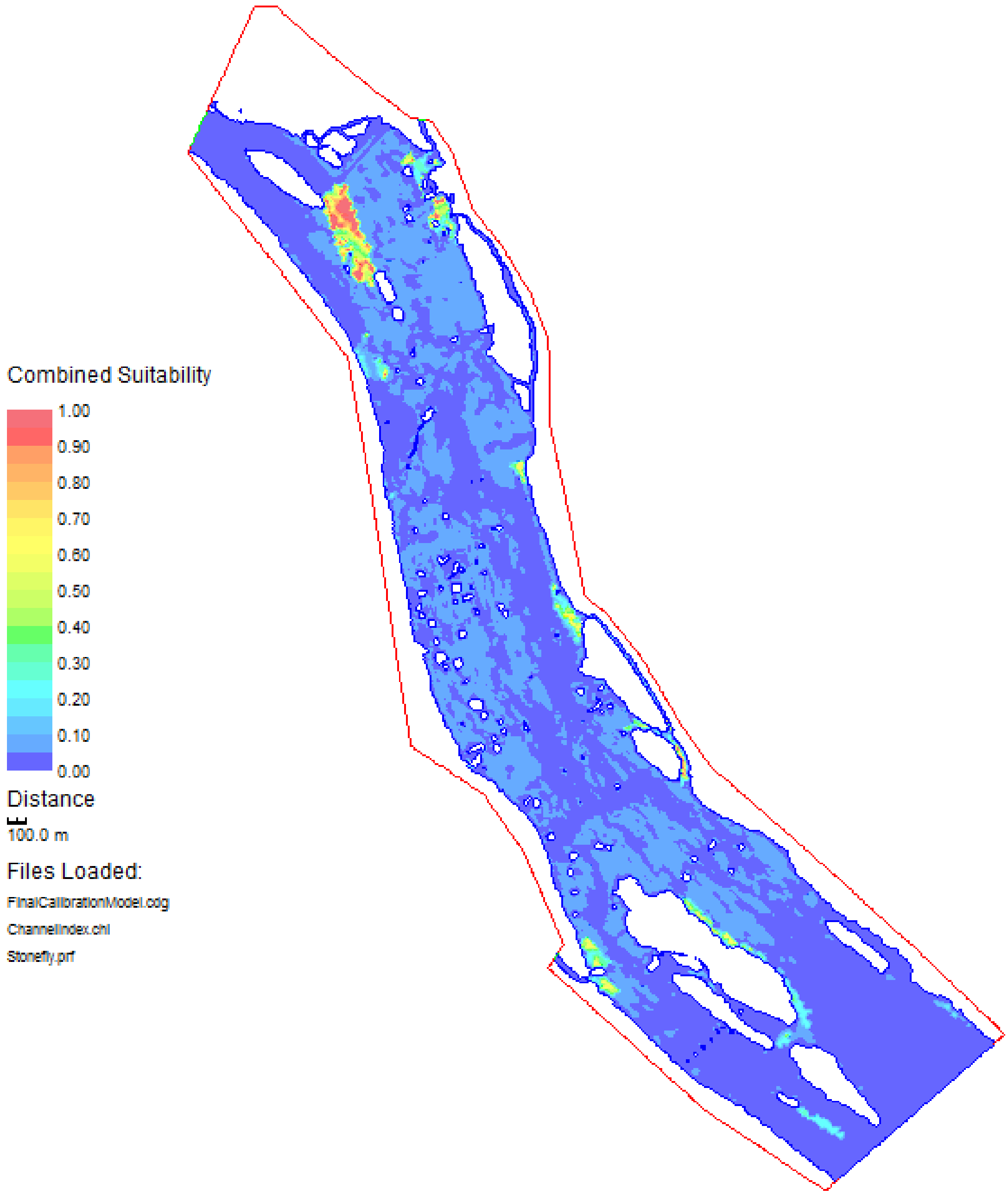
Stonefly – 2,000 cfs



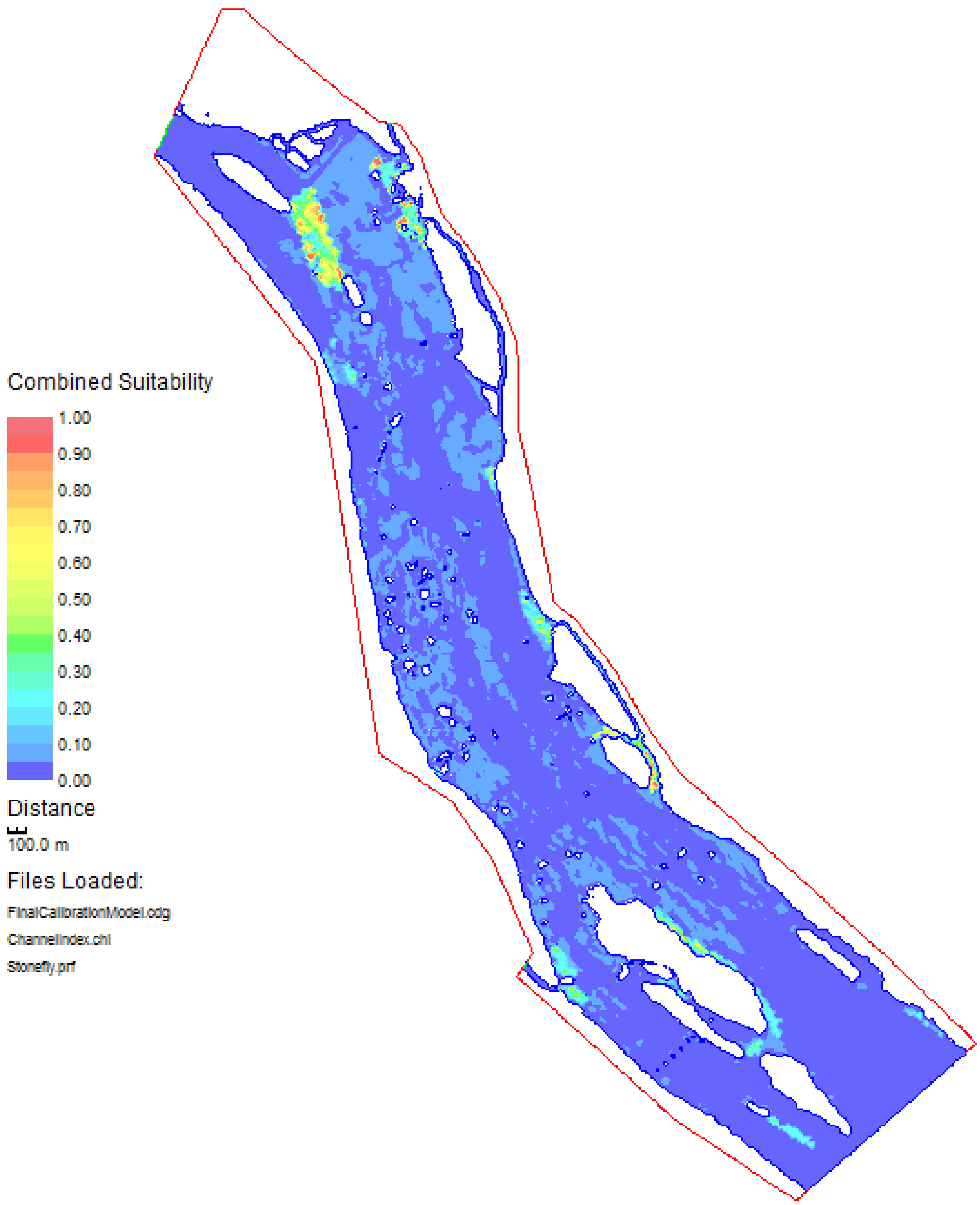
Stonefly – 3,500 cfs



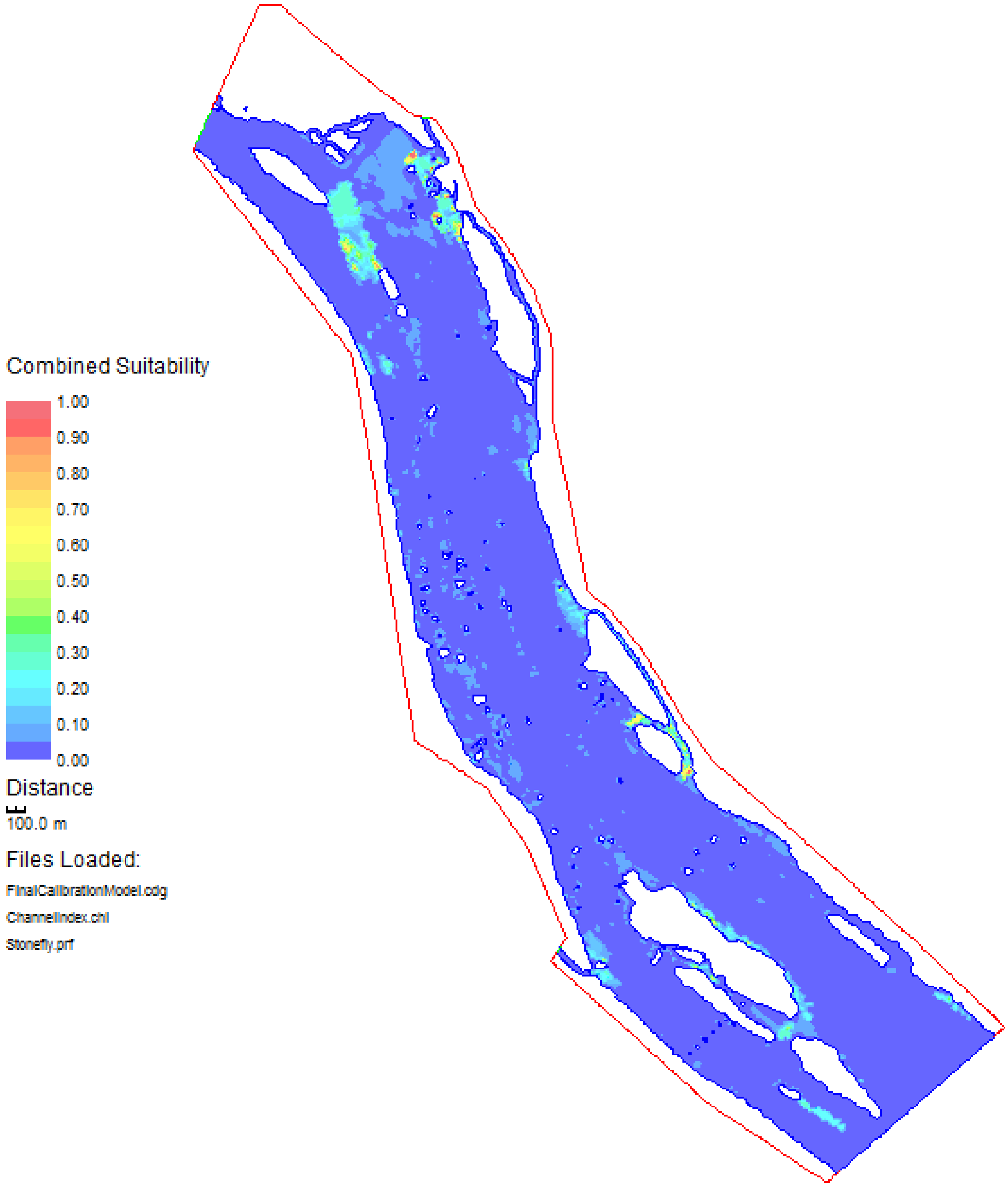
Stonefly – 5,000 cfs



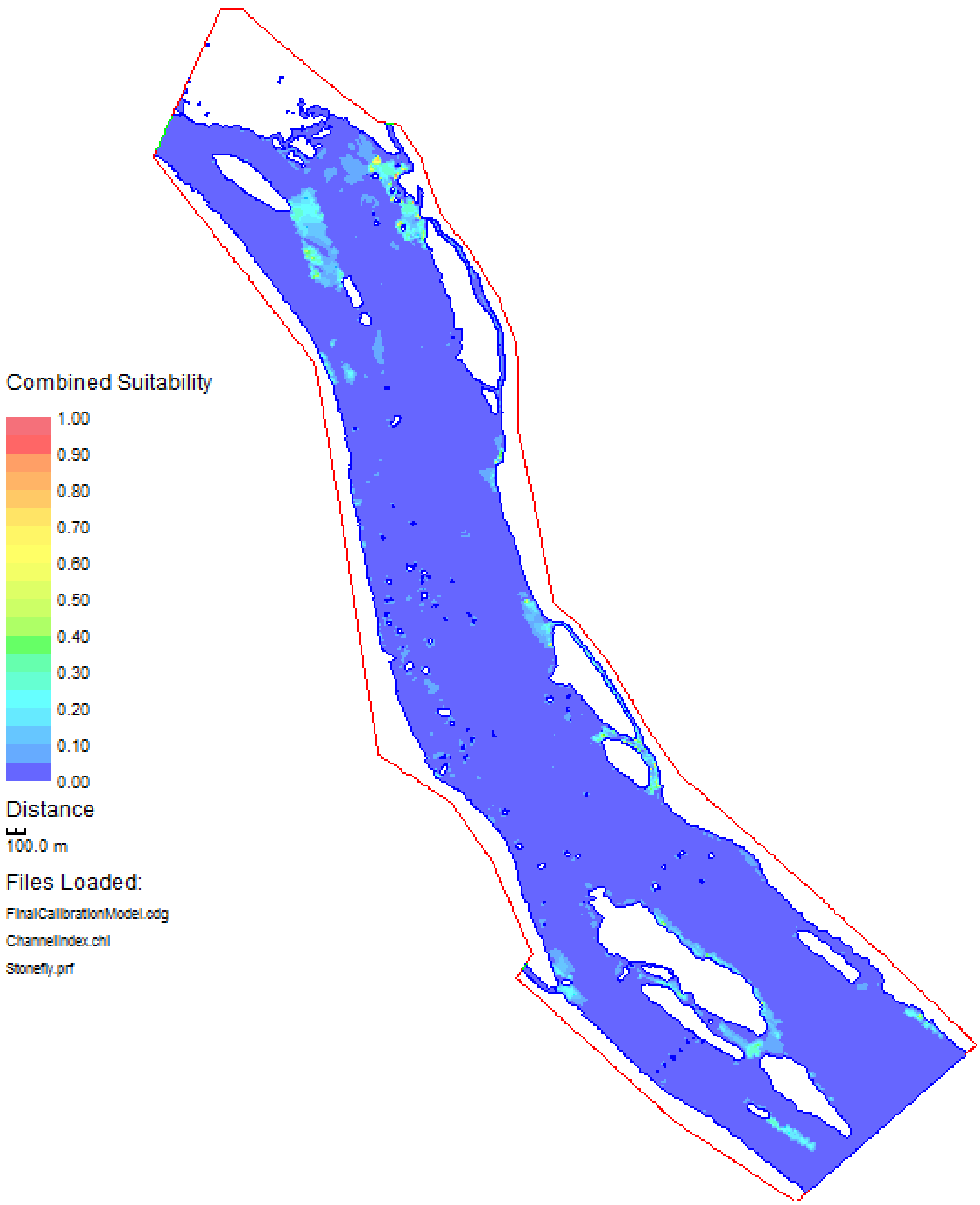
Stonefly – 7,500 cfs



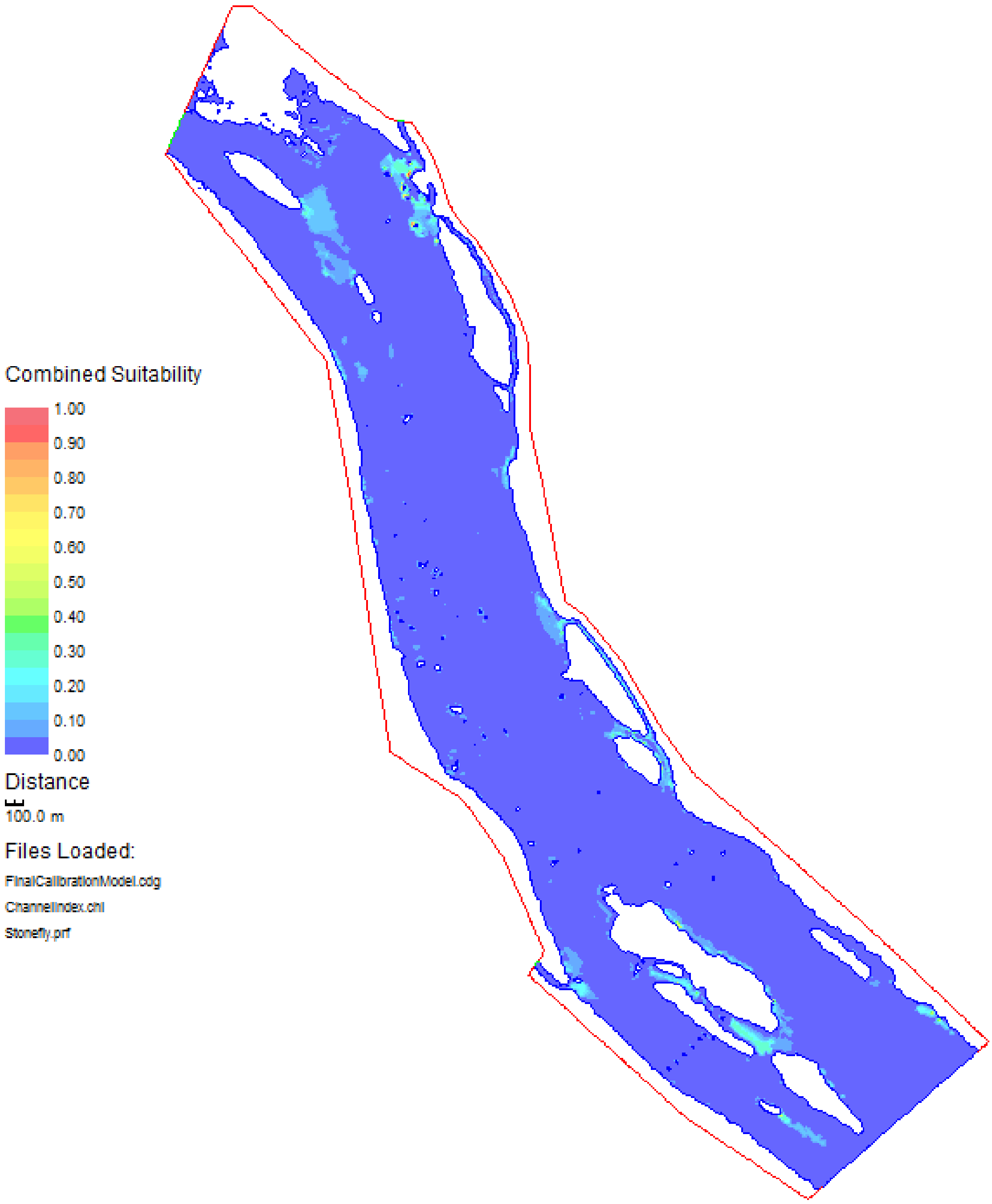
Stonefly – 10,000 cfs



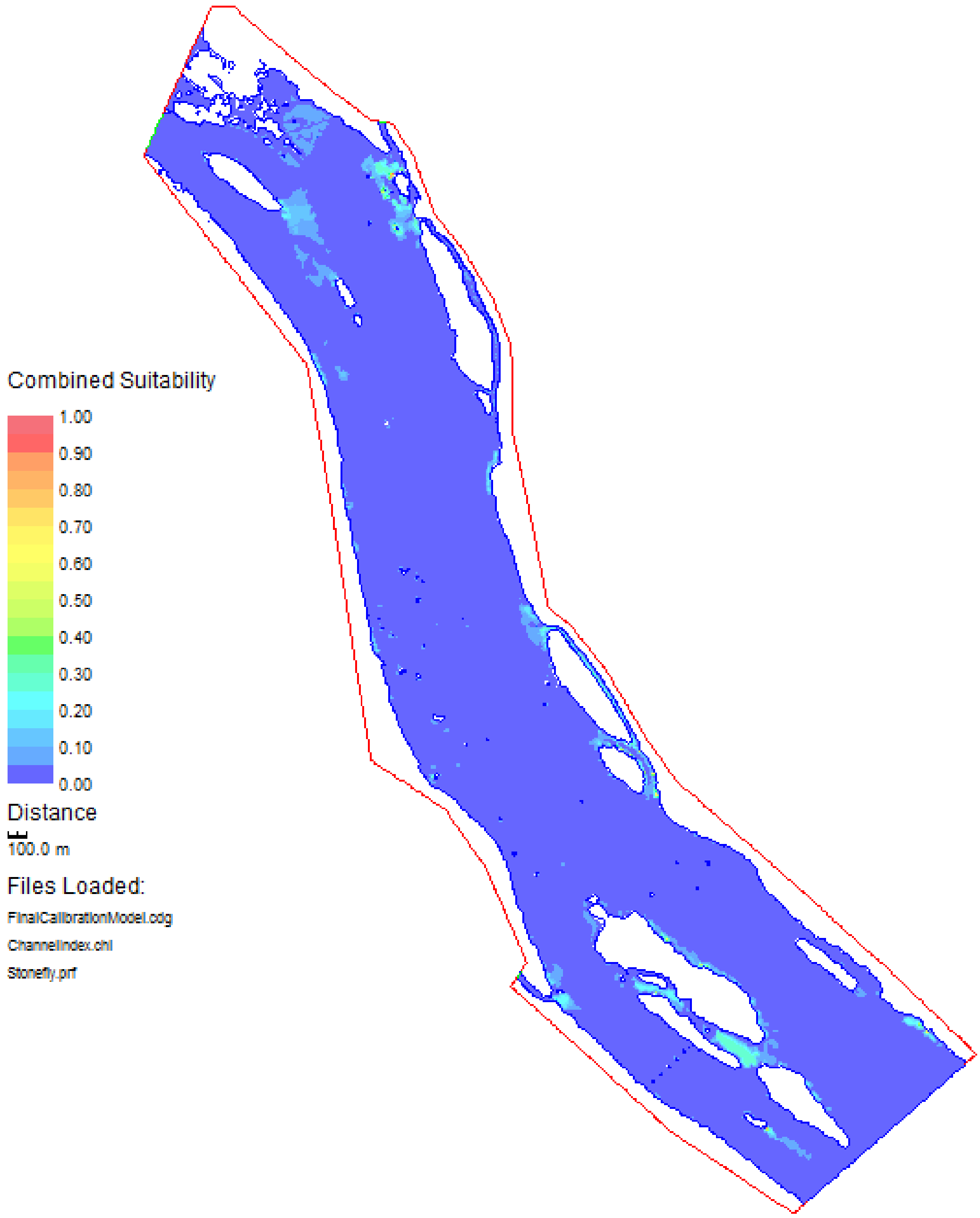
Stonefly – 15,000 cfs



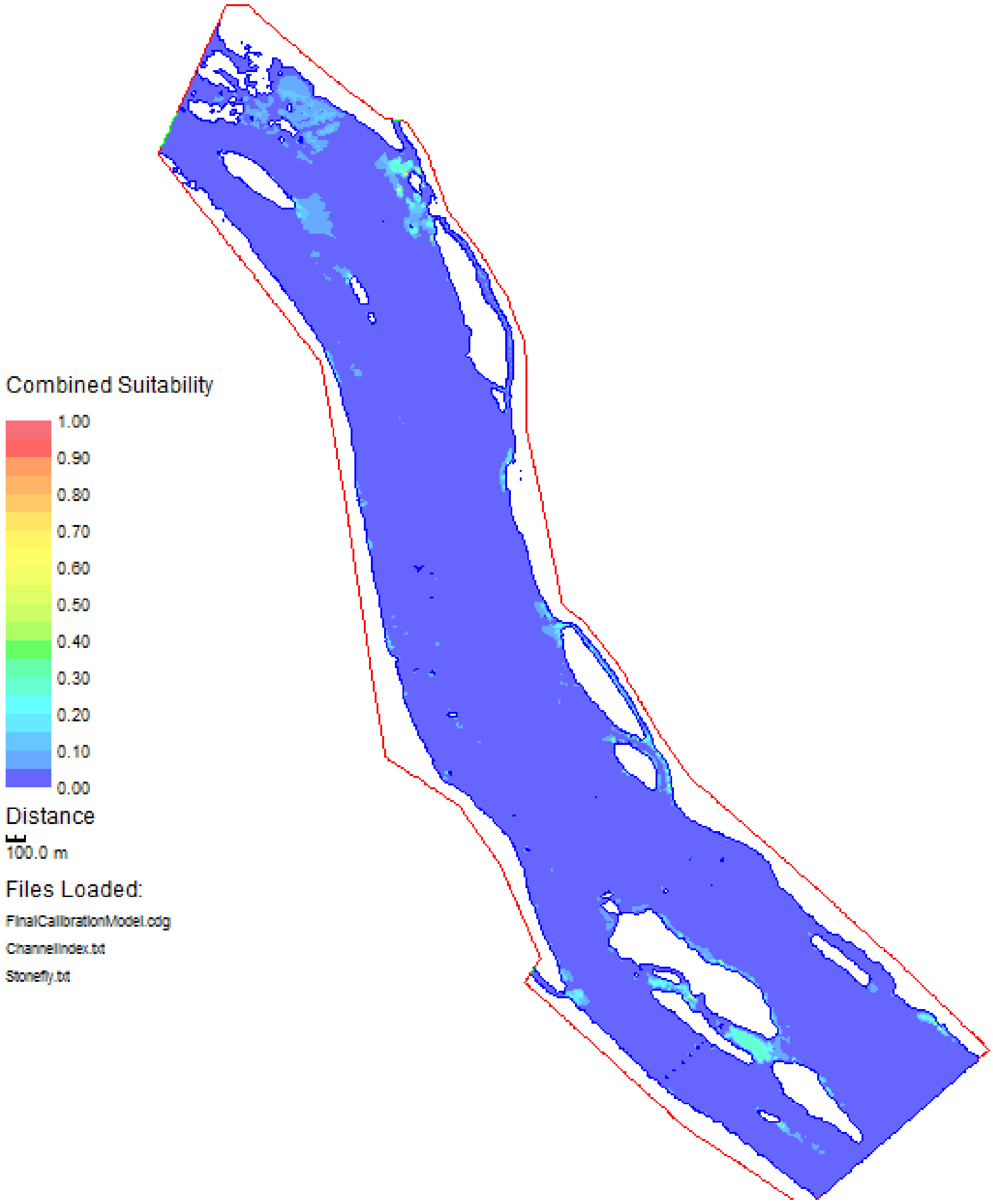
Stonefly – 20,000 cfs



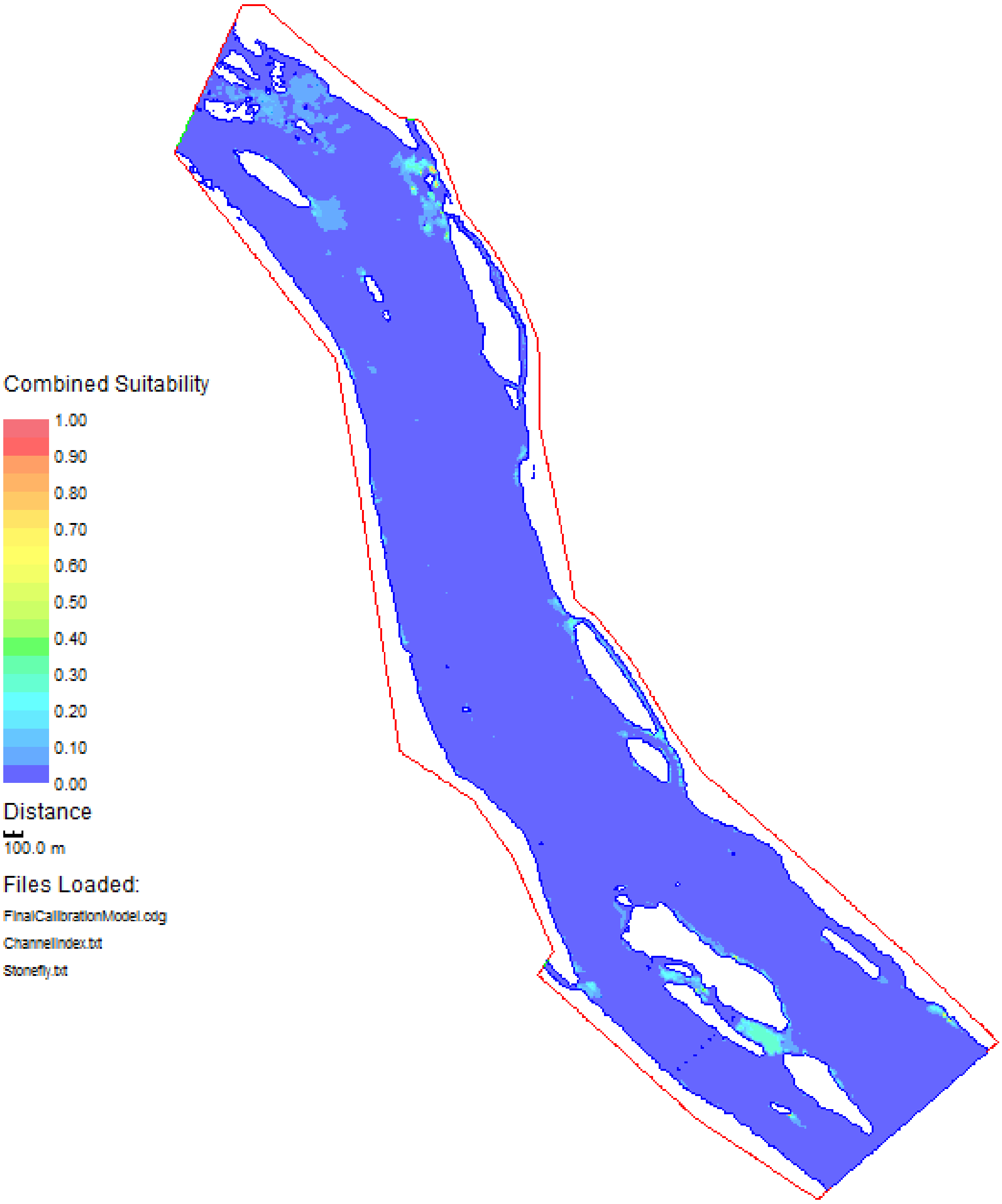
Stonefly – 30,000 cfs



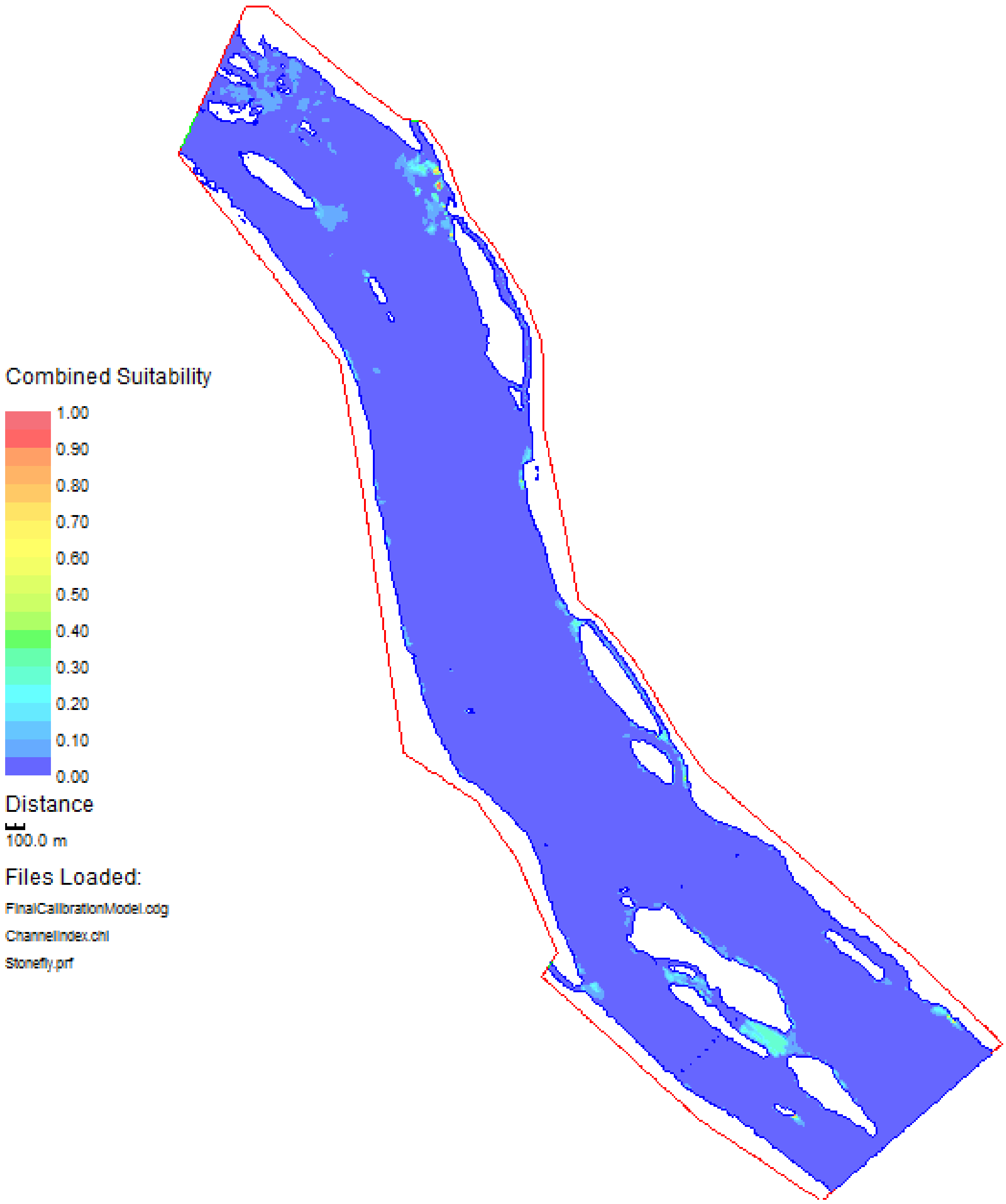
Stonefly – 40,000 cfs



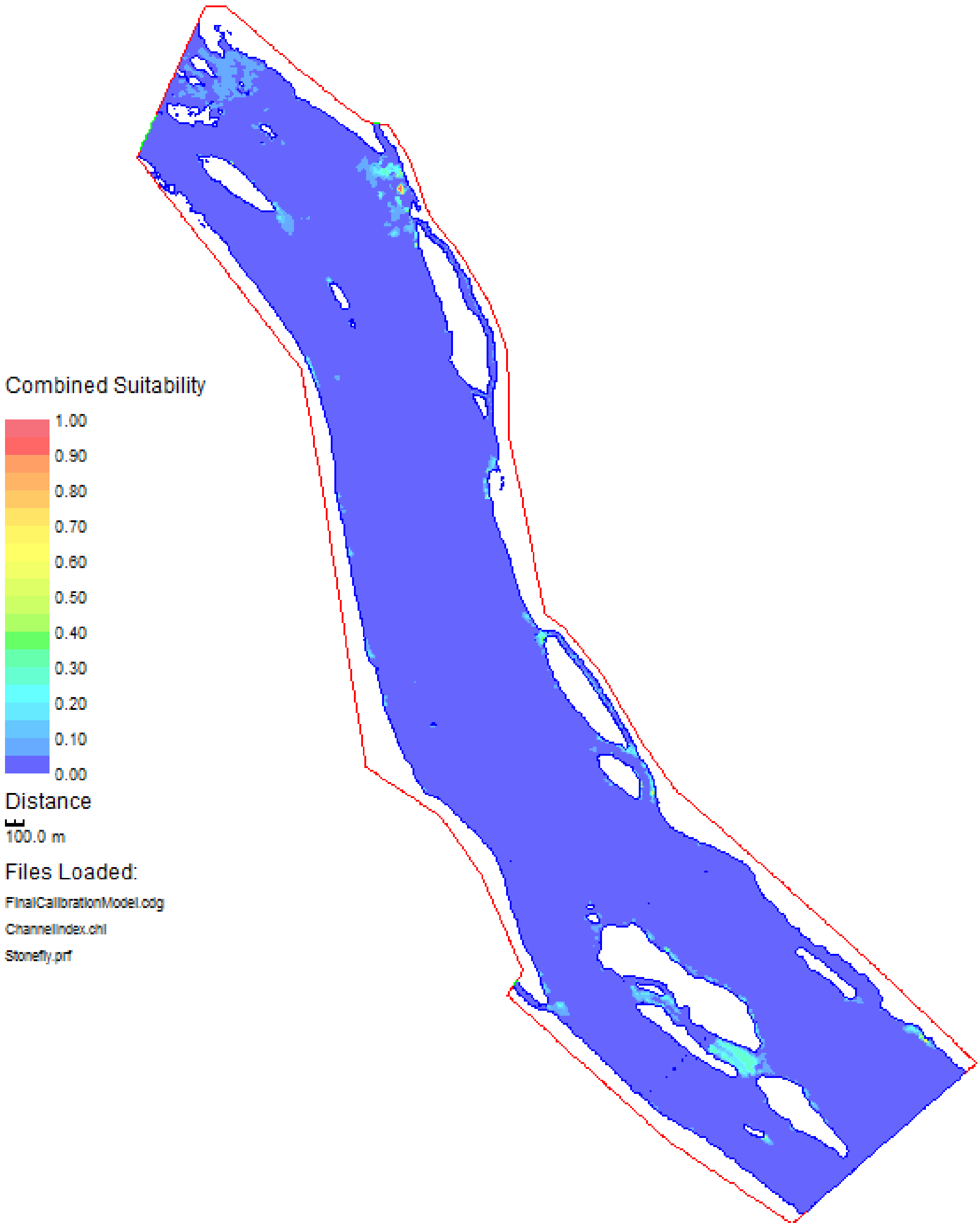
Stonefly – 50,000 cfs



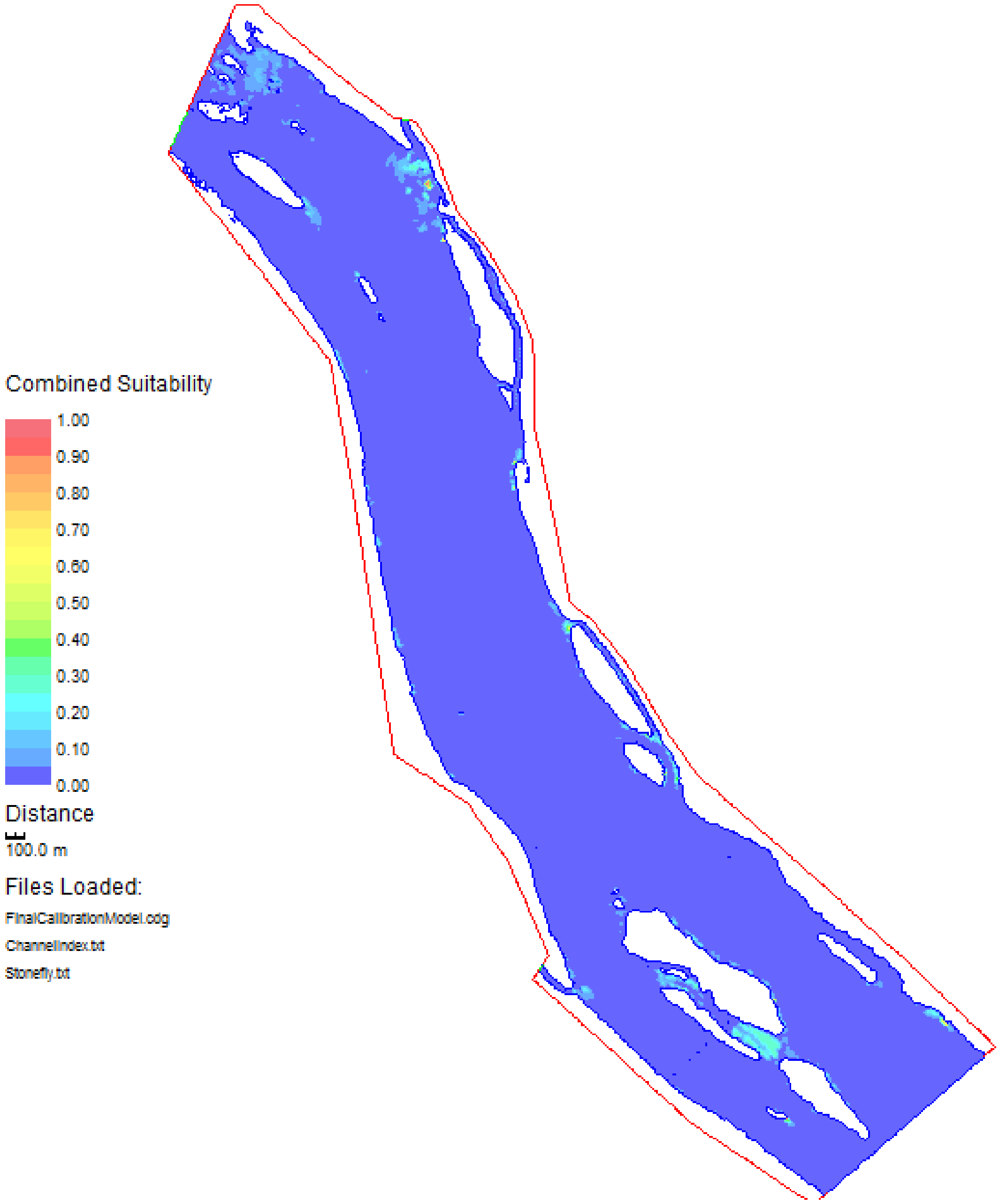
Stonefly – 60,000 cfs



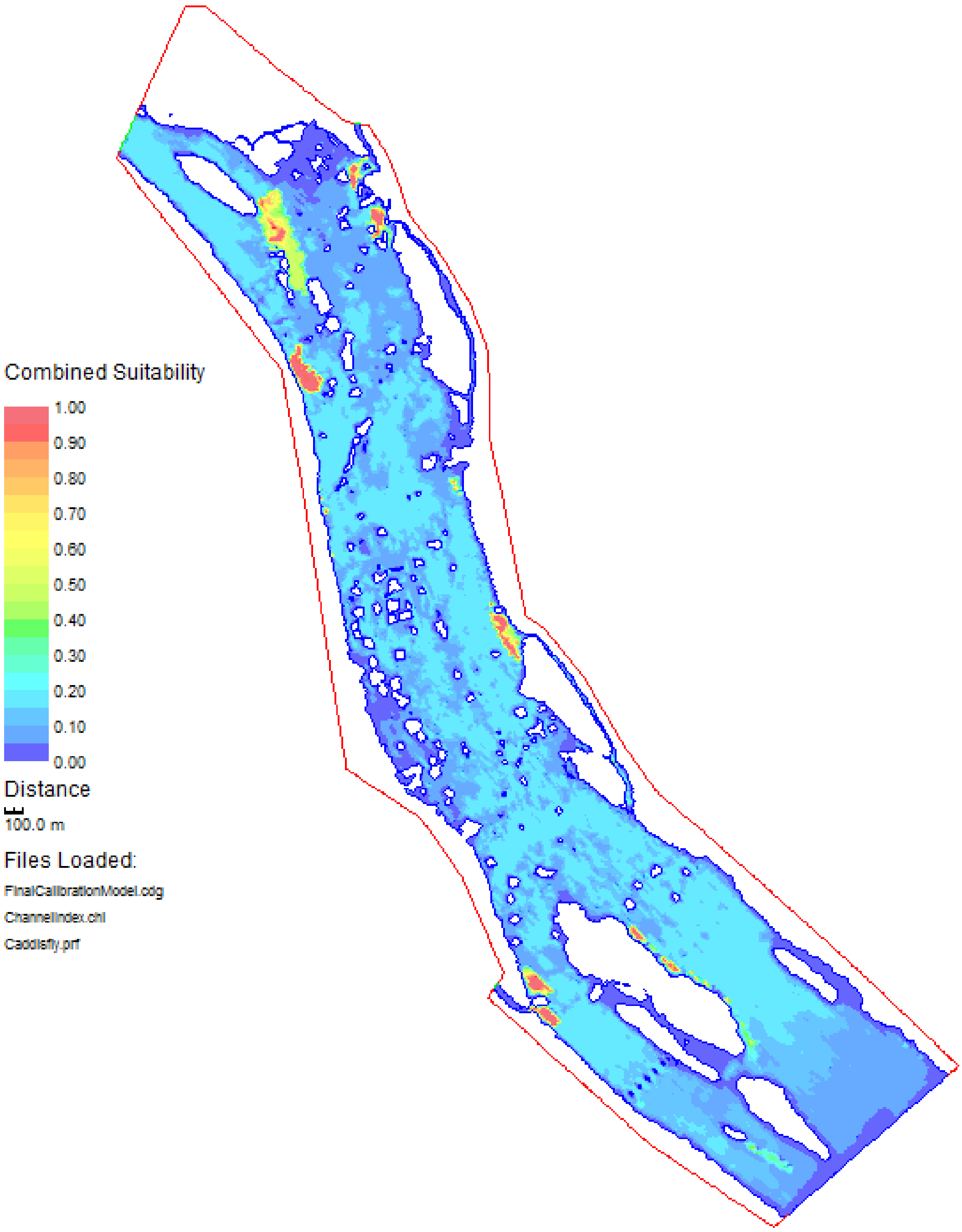
Stonefly – 70,000 cfs



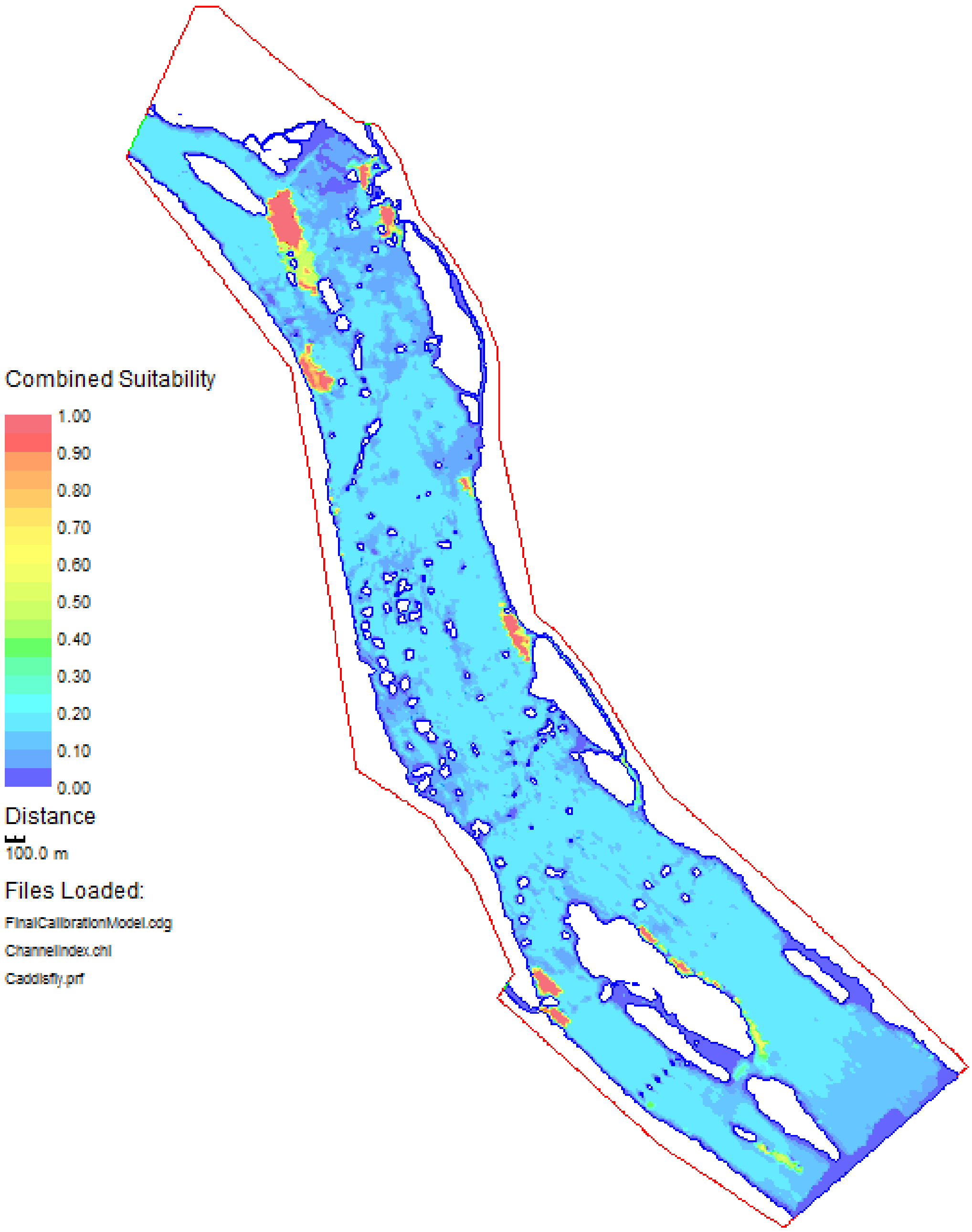
Stonefly – 80,000 cfs



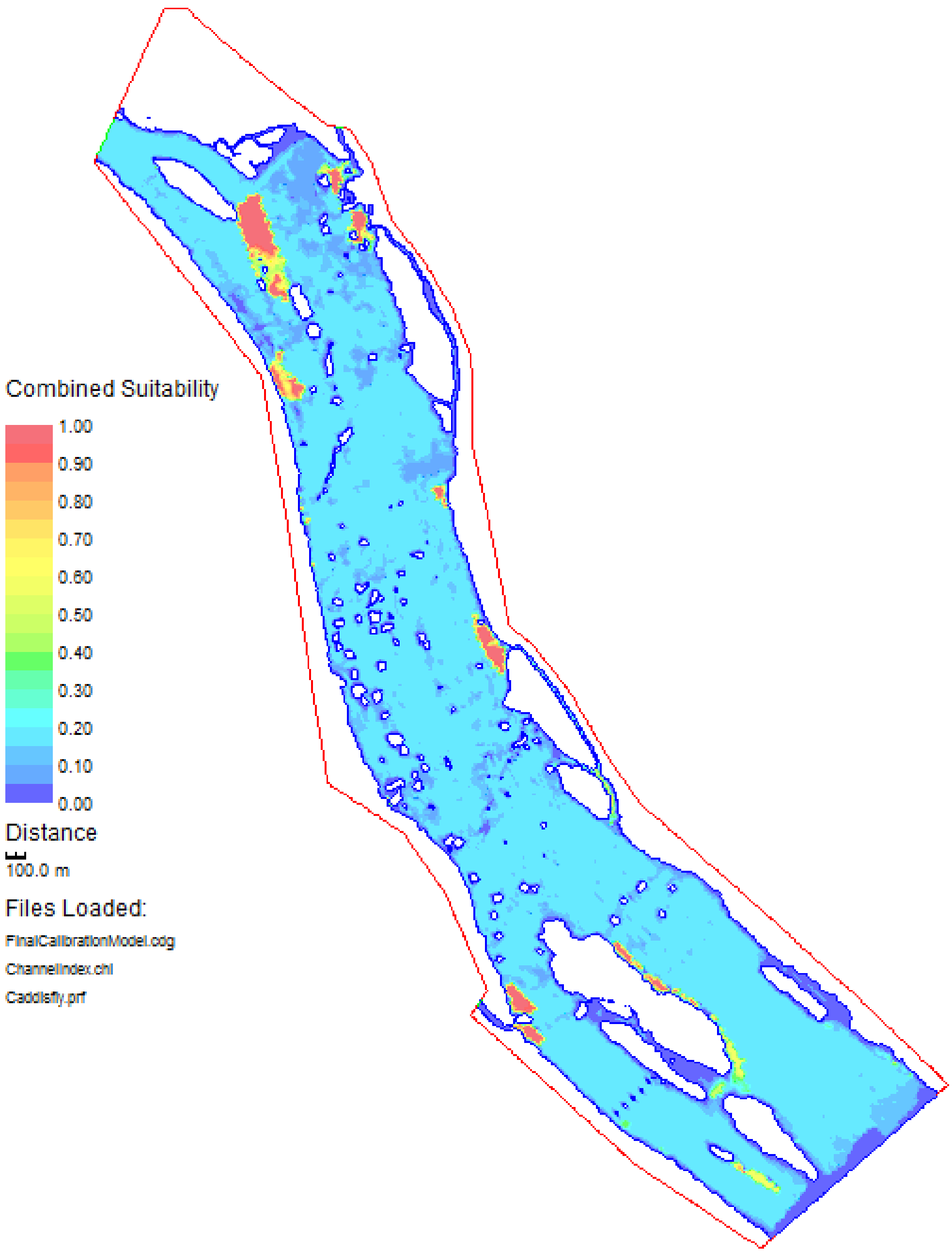
Stonefly – 86,000 cfs



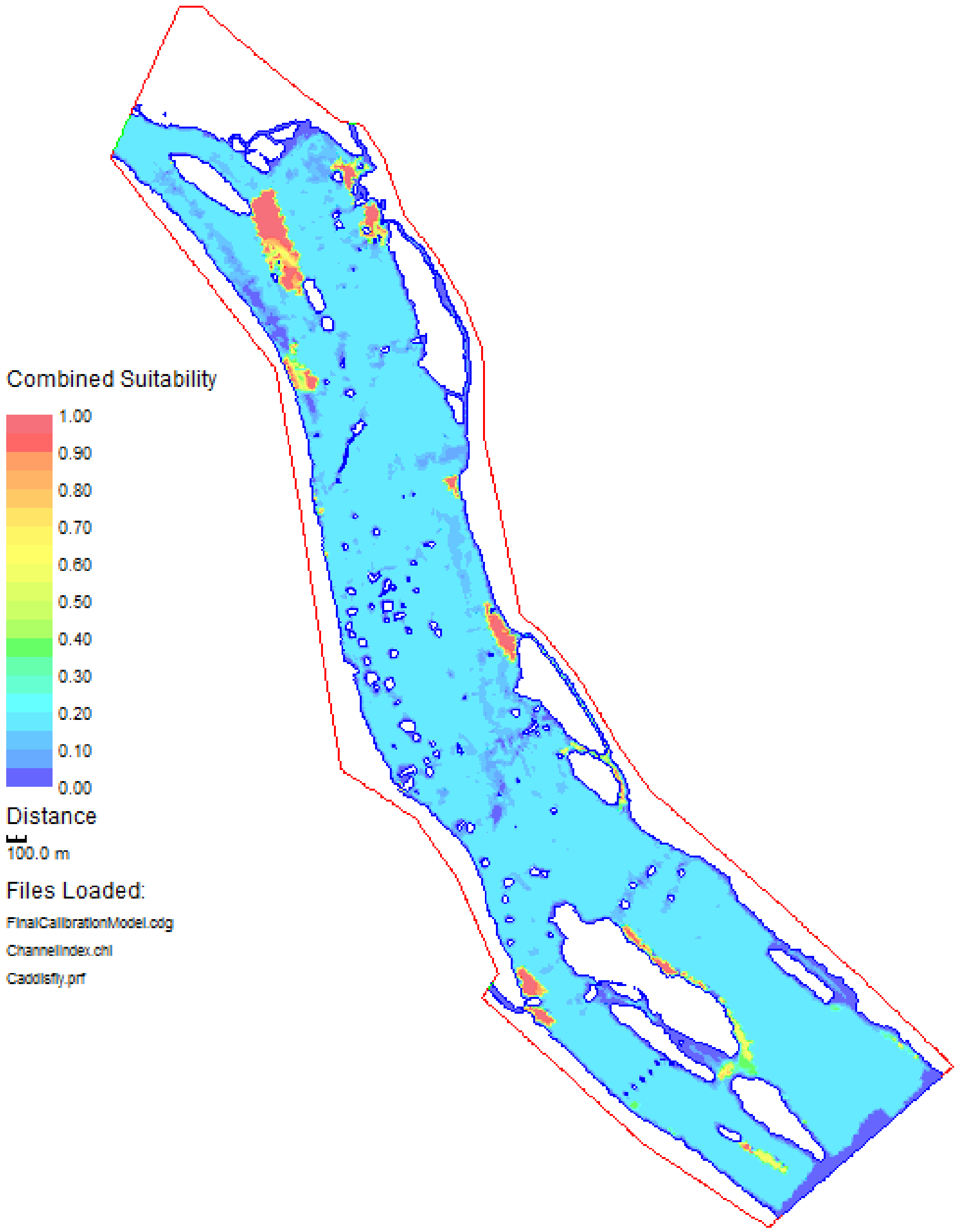
Caddisfly – 2,000 cfs



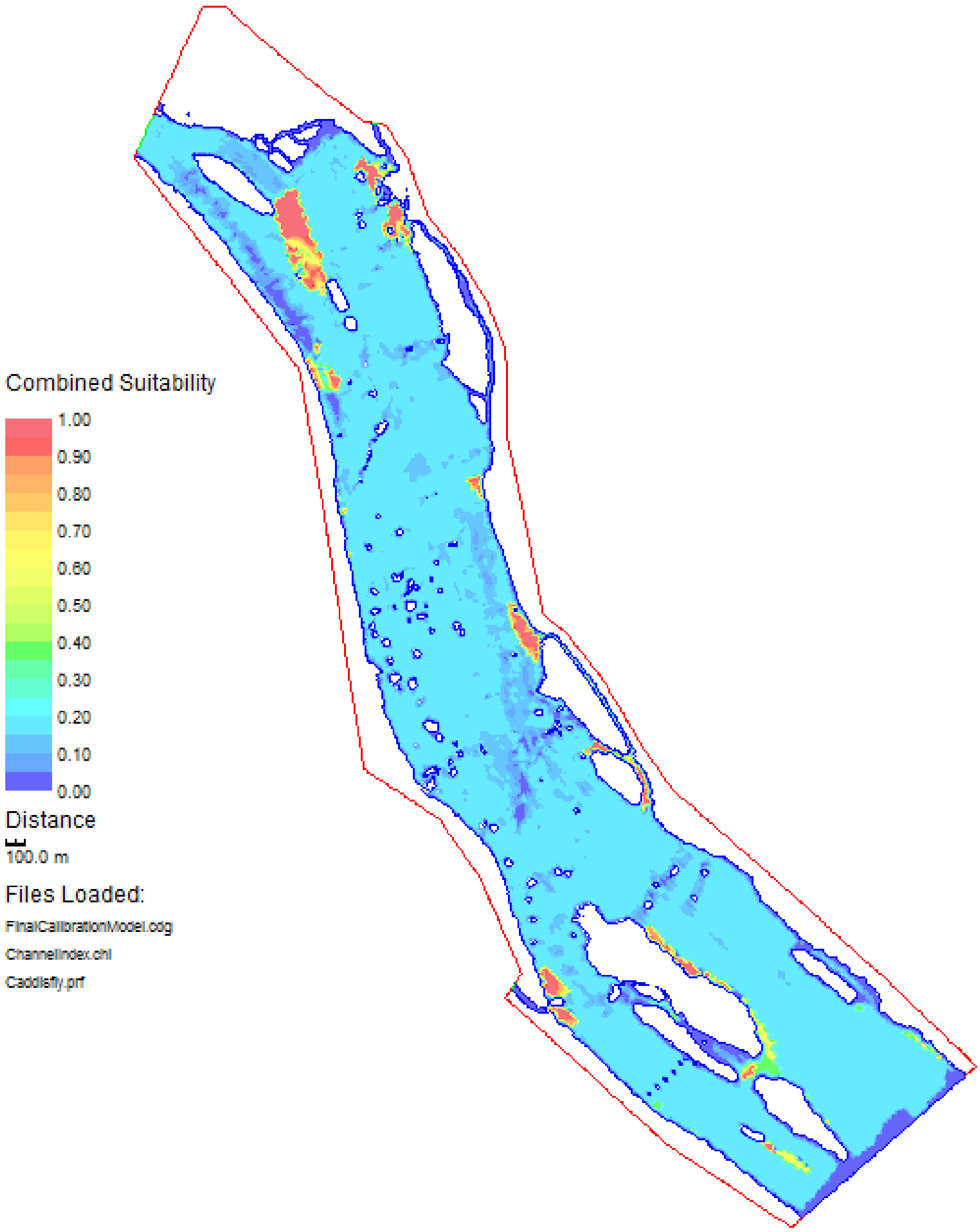
Caddisfly – 3,500 cfs



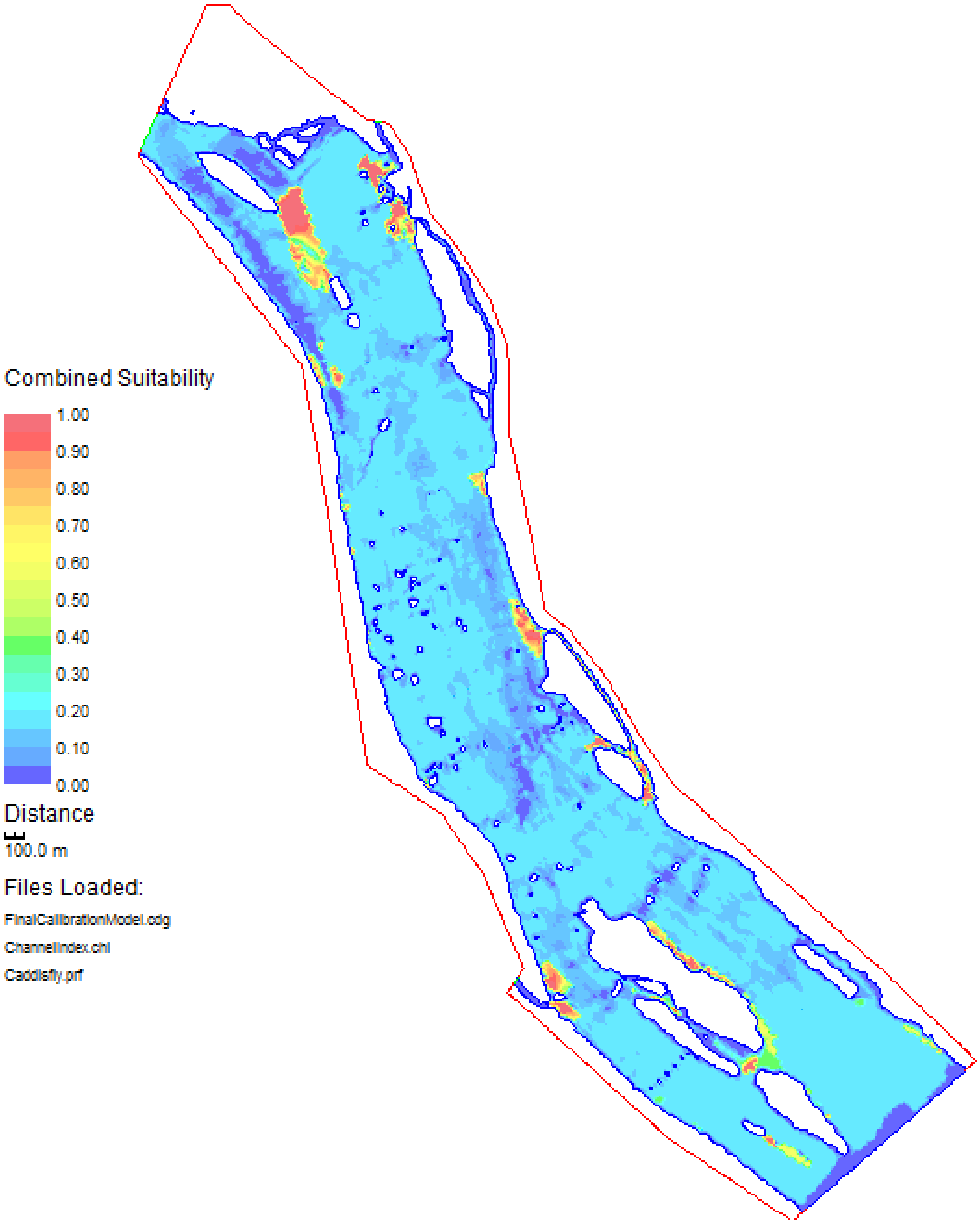
Caddisfly – 5,000 cfs



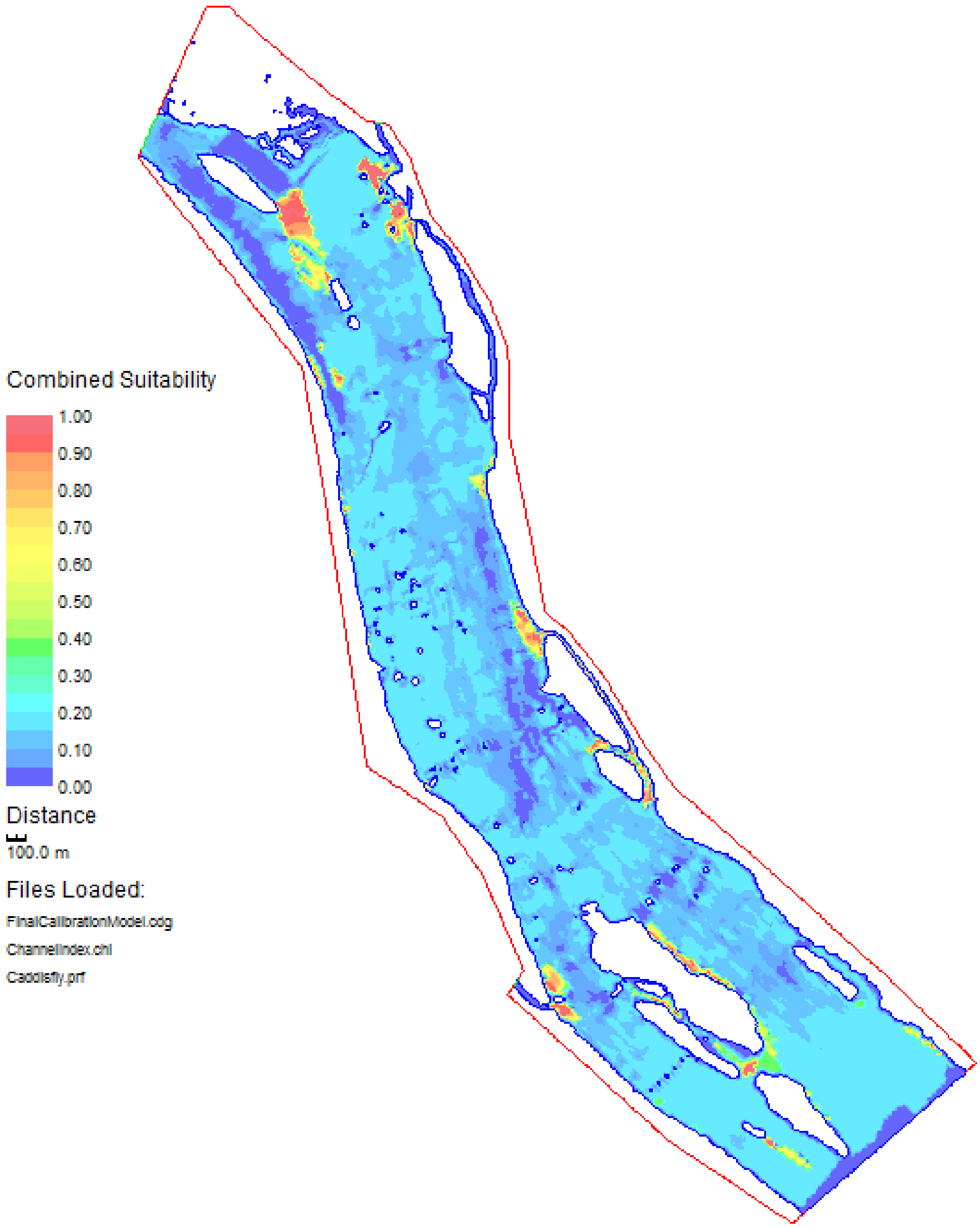
Caddisfly – 7,500 cfs



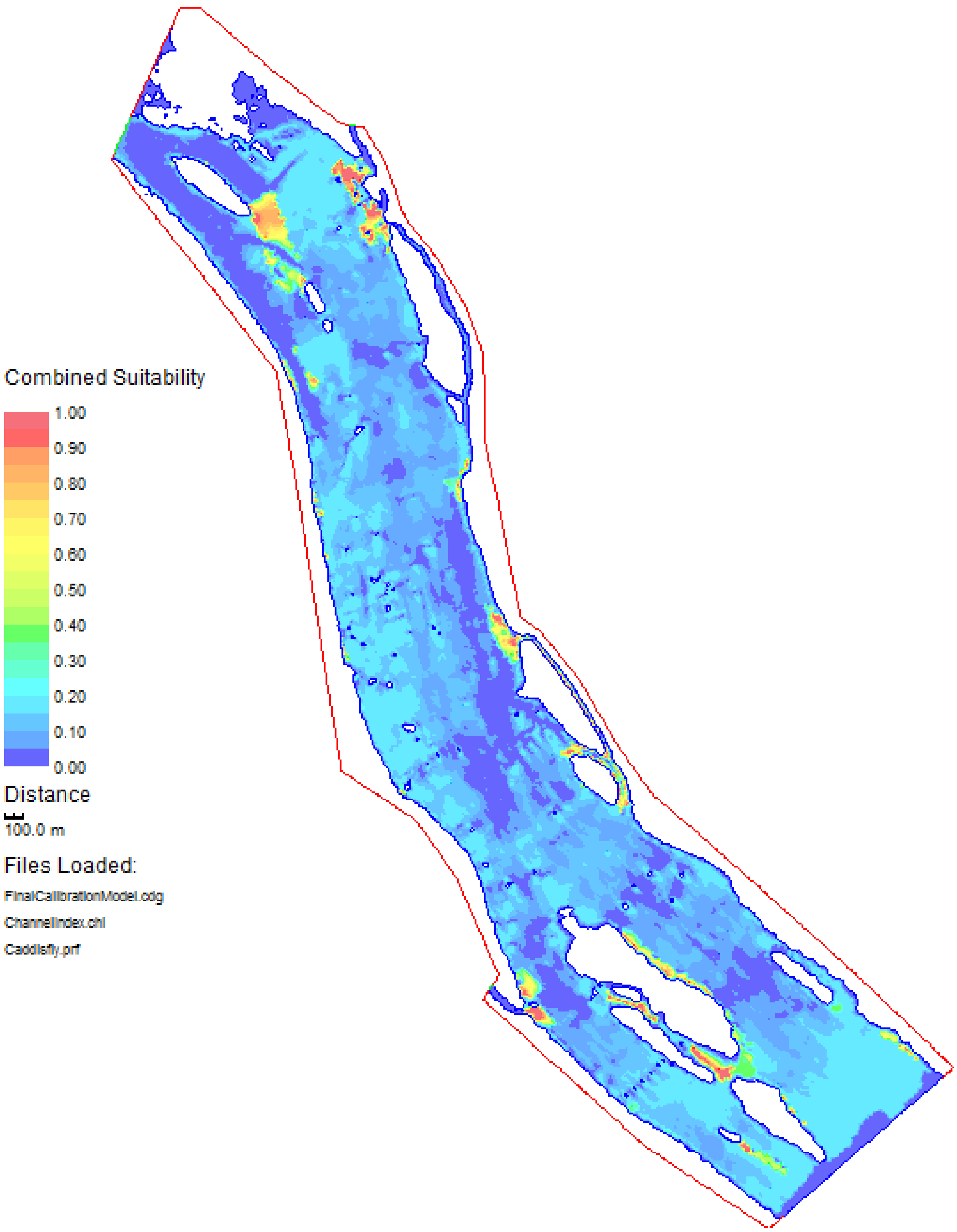
Caddisfly – 10,000 cfs



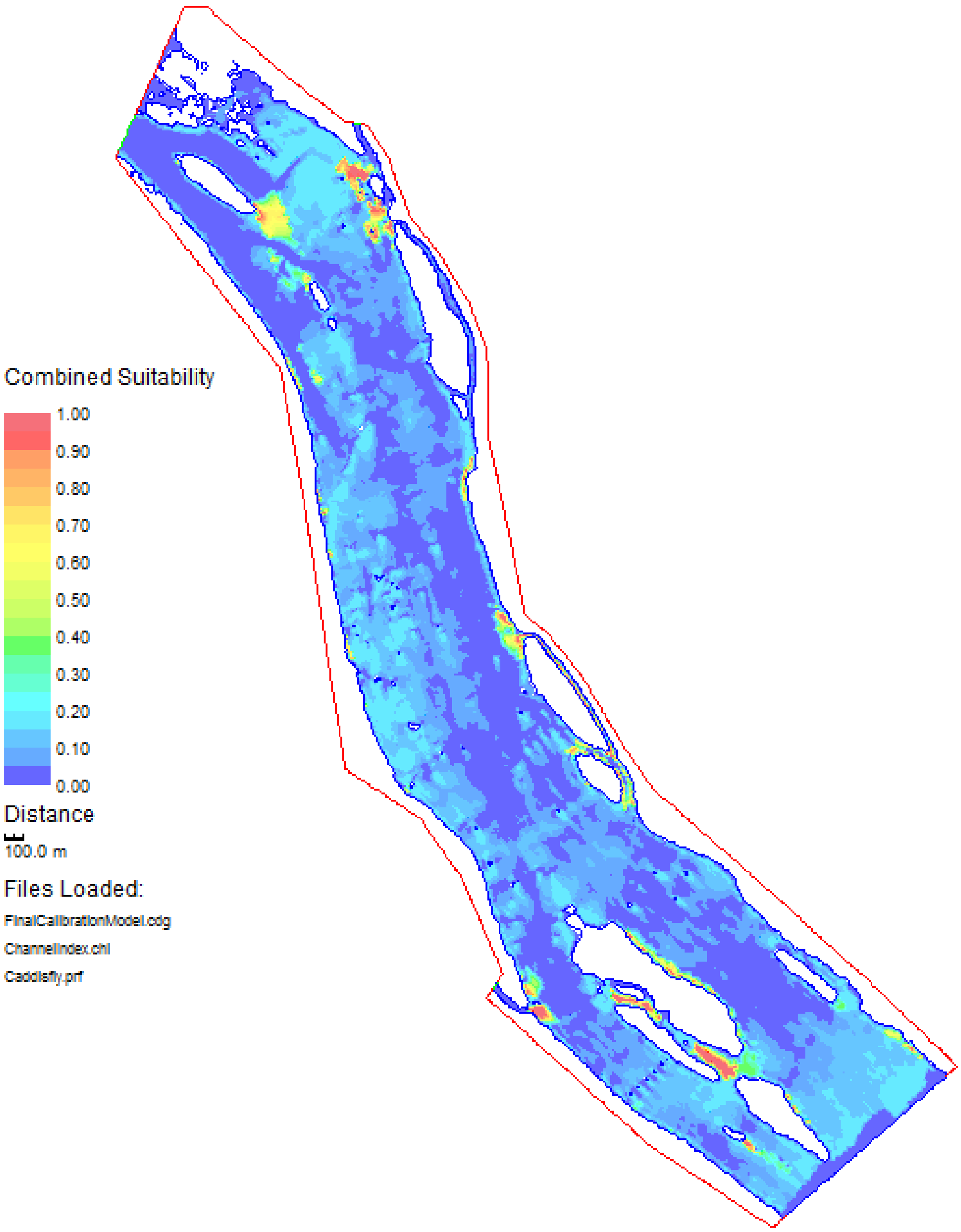
Caddisfly – 15,000 cfs



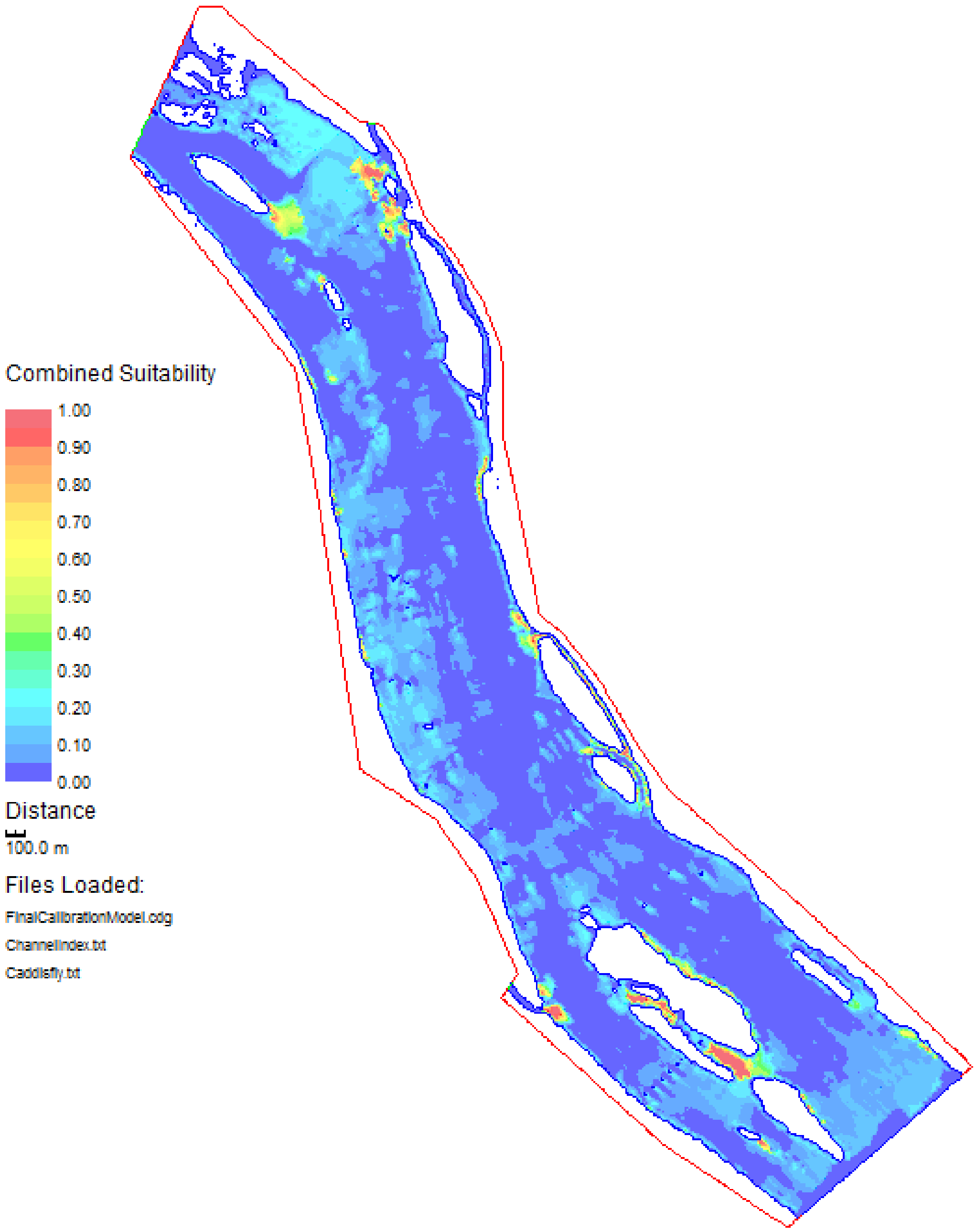
Caddisfly – 20,000 cfs



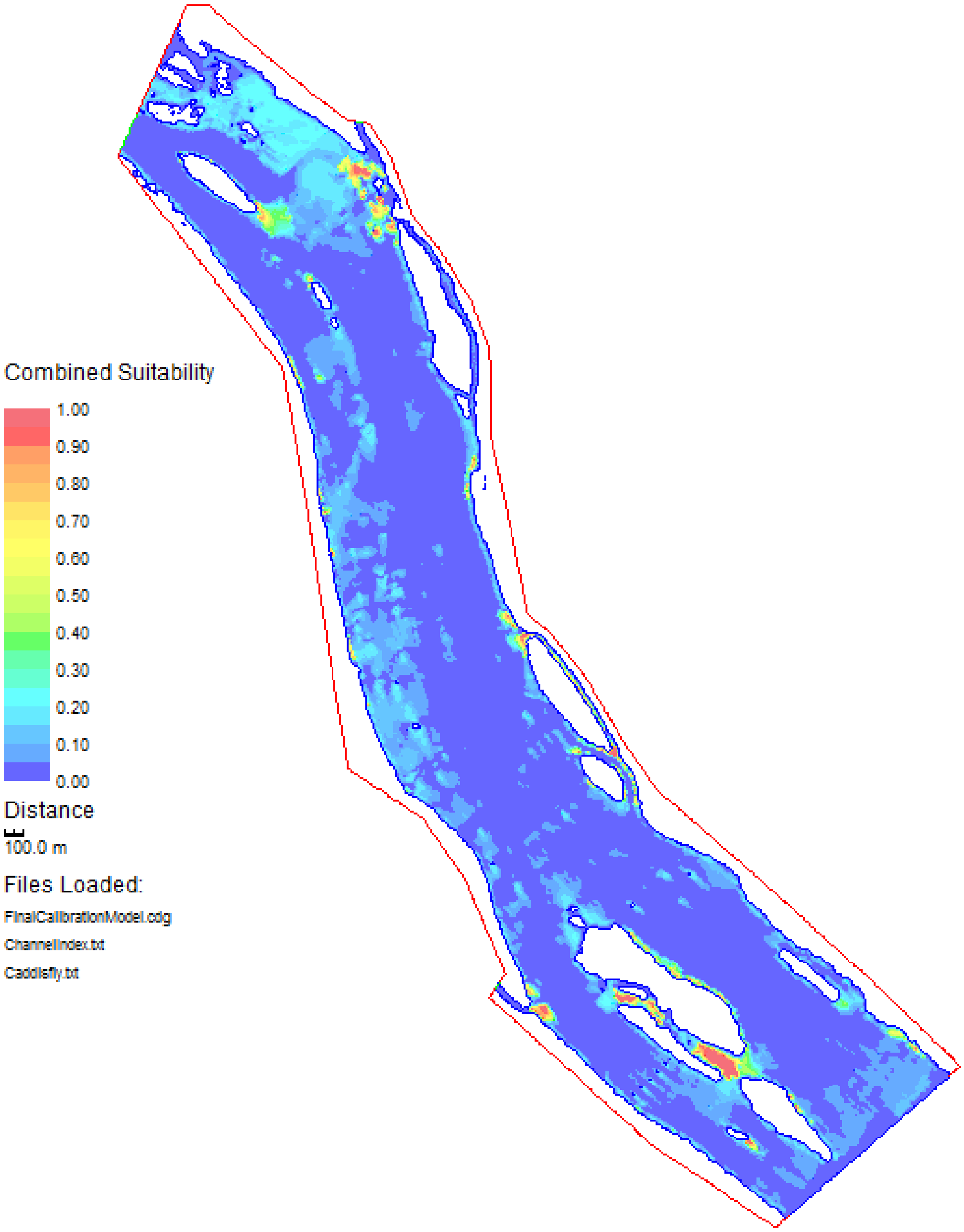
Caddisfly – 30,000 cfs



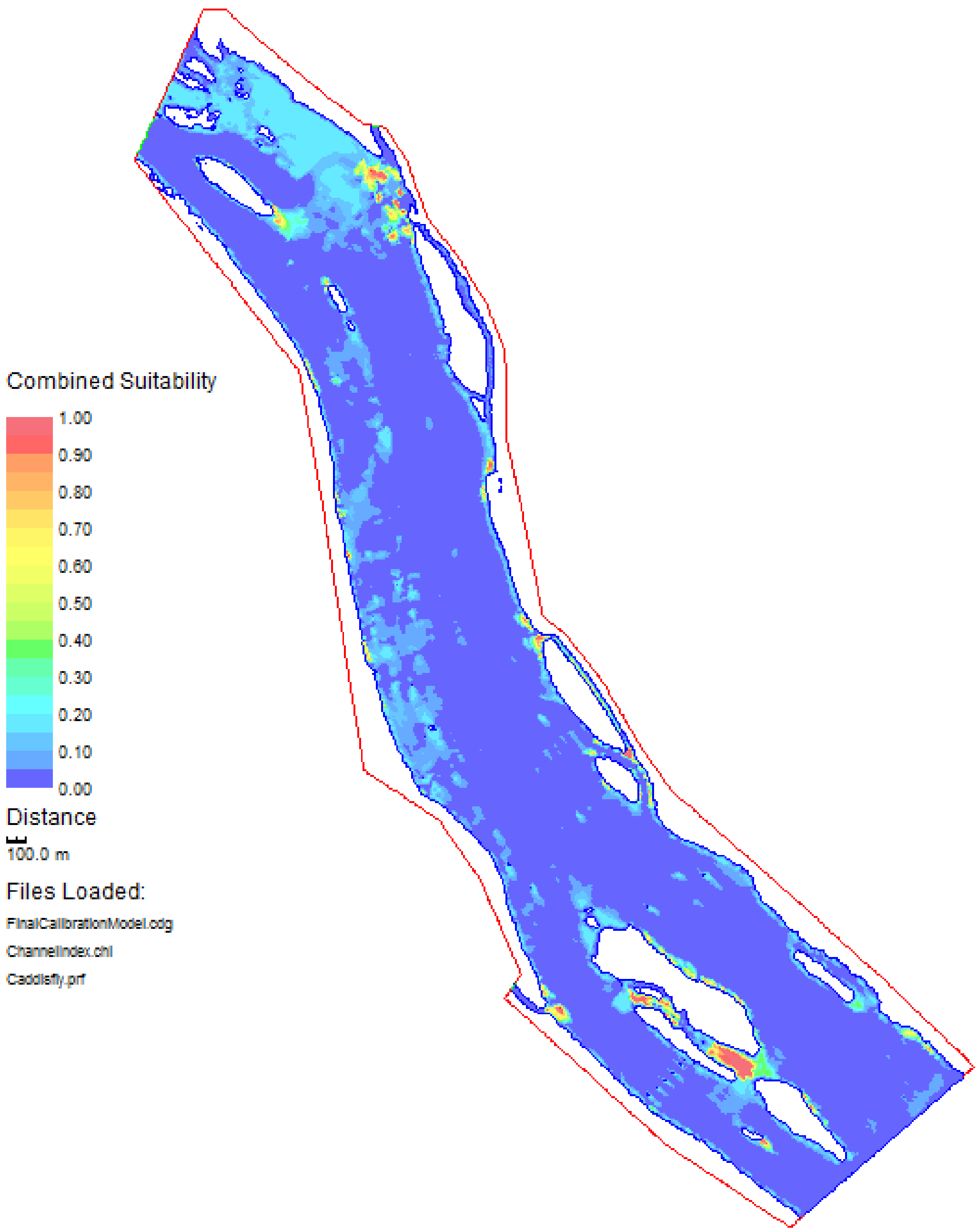
Caddisfly – 40,000 cfs



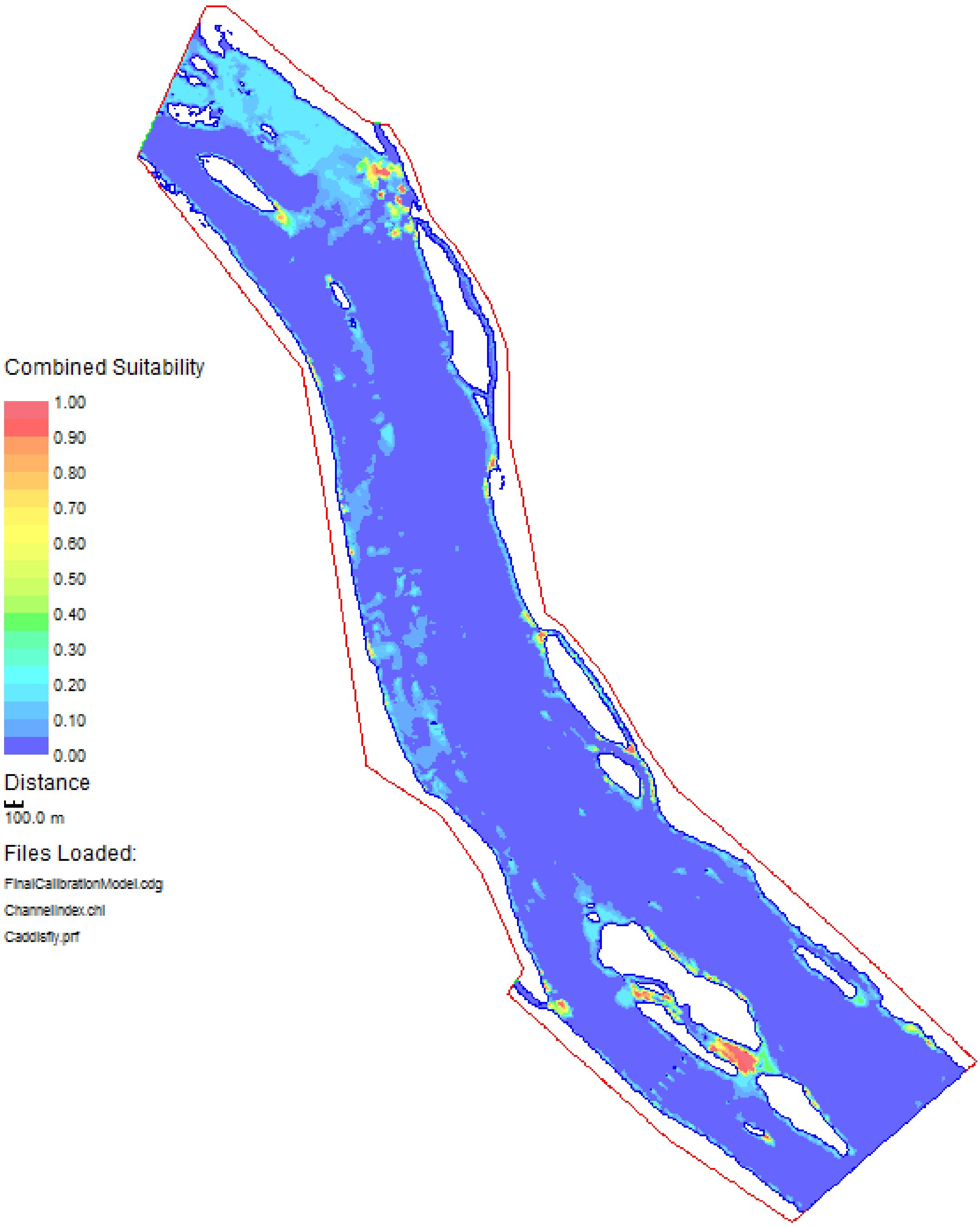
Caddisfly – 50,000 cfs



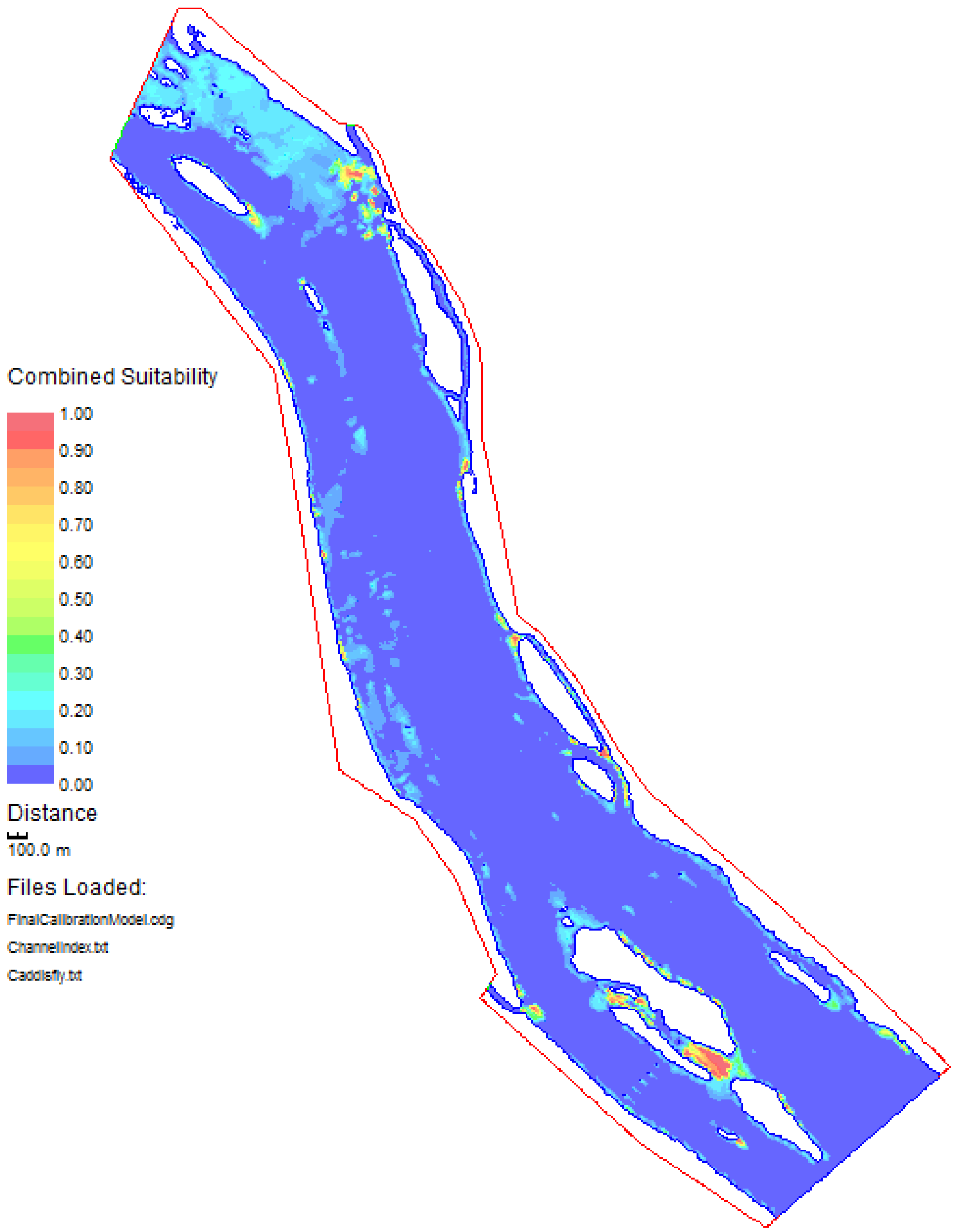
Caddisfly – 60,000 cfs



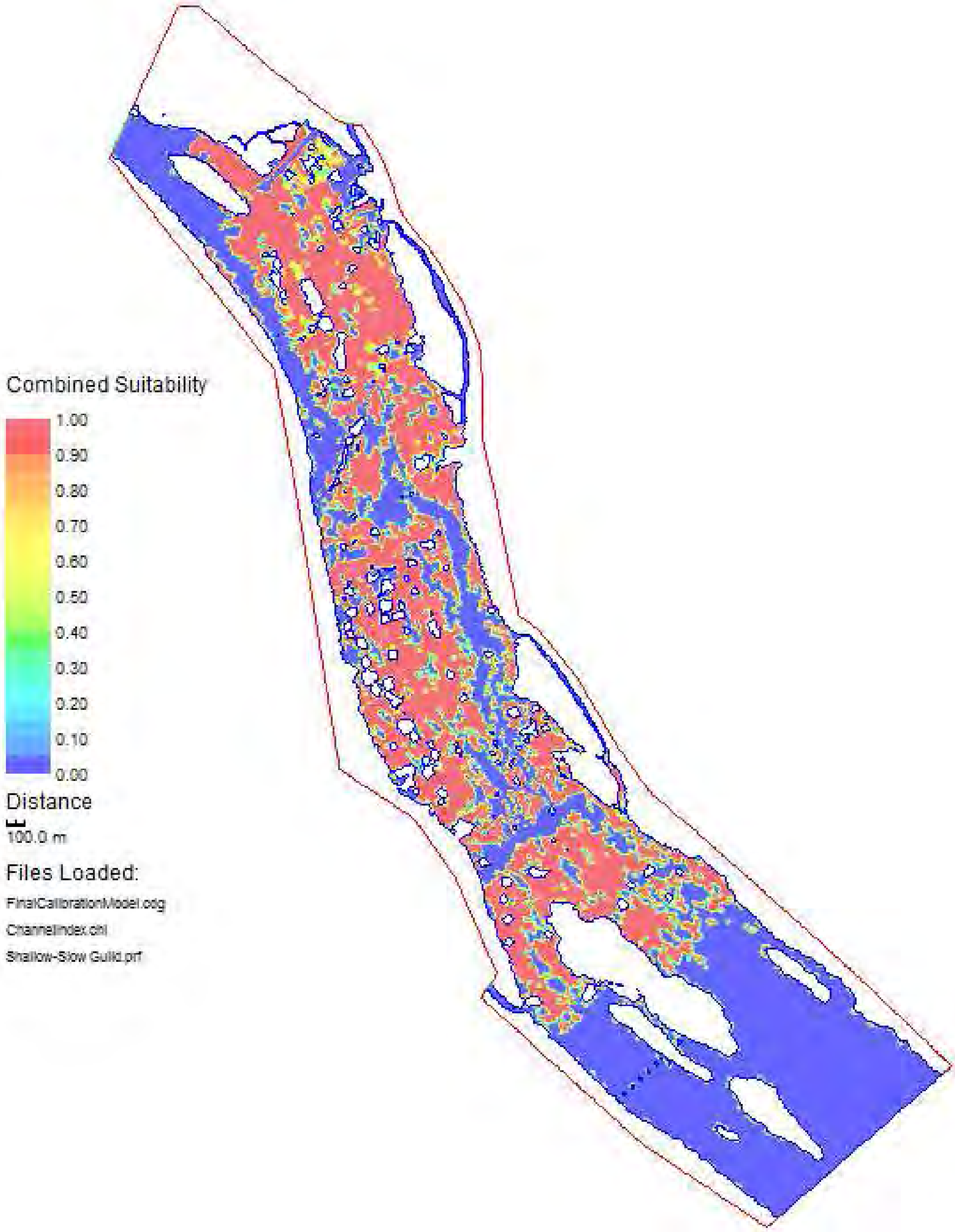
Caddisfly – 70,000 cfs



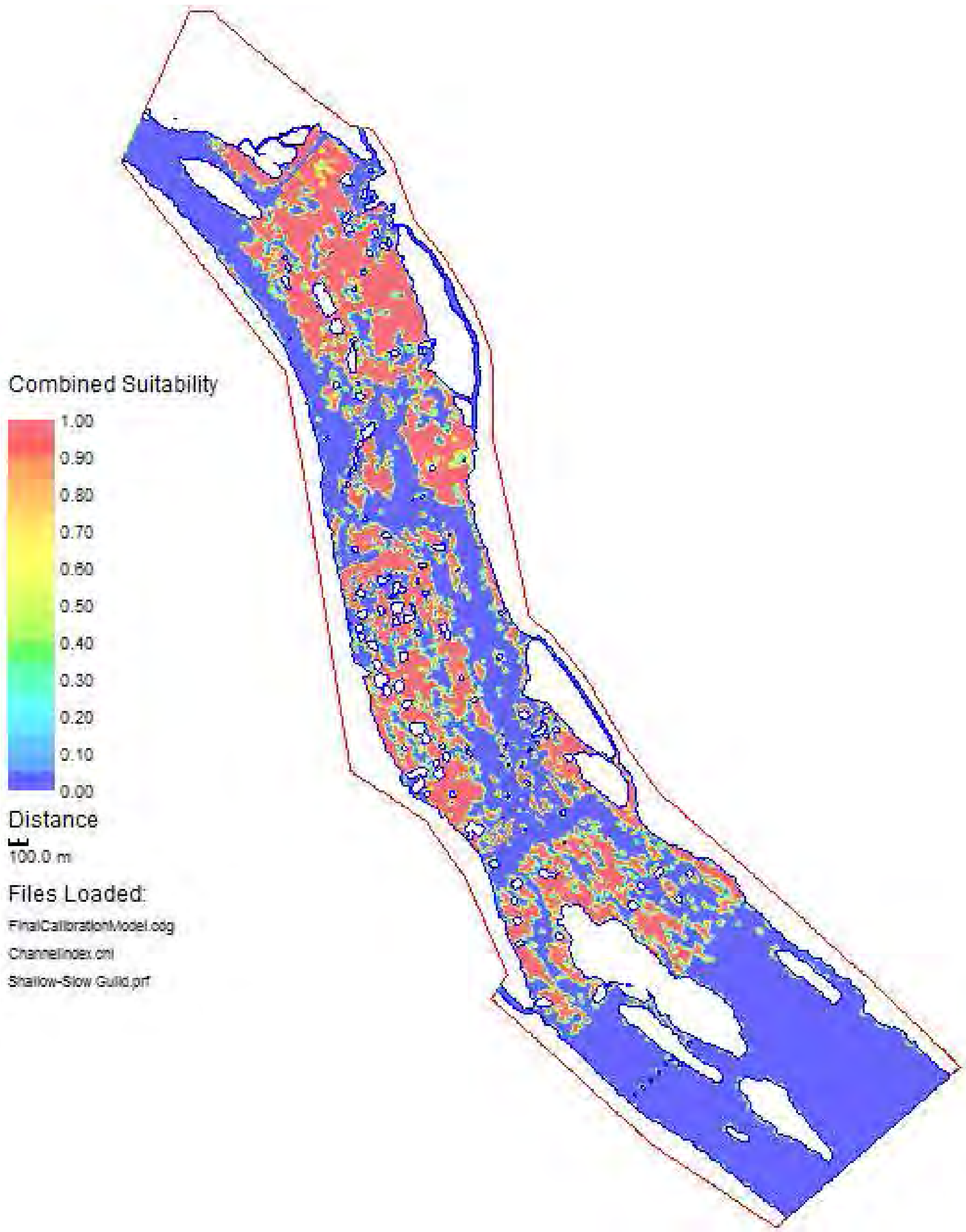
Caddisfly – 80,000 cfs



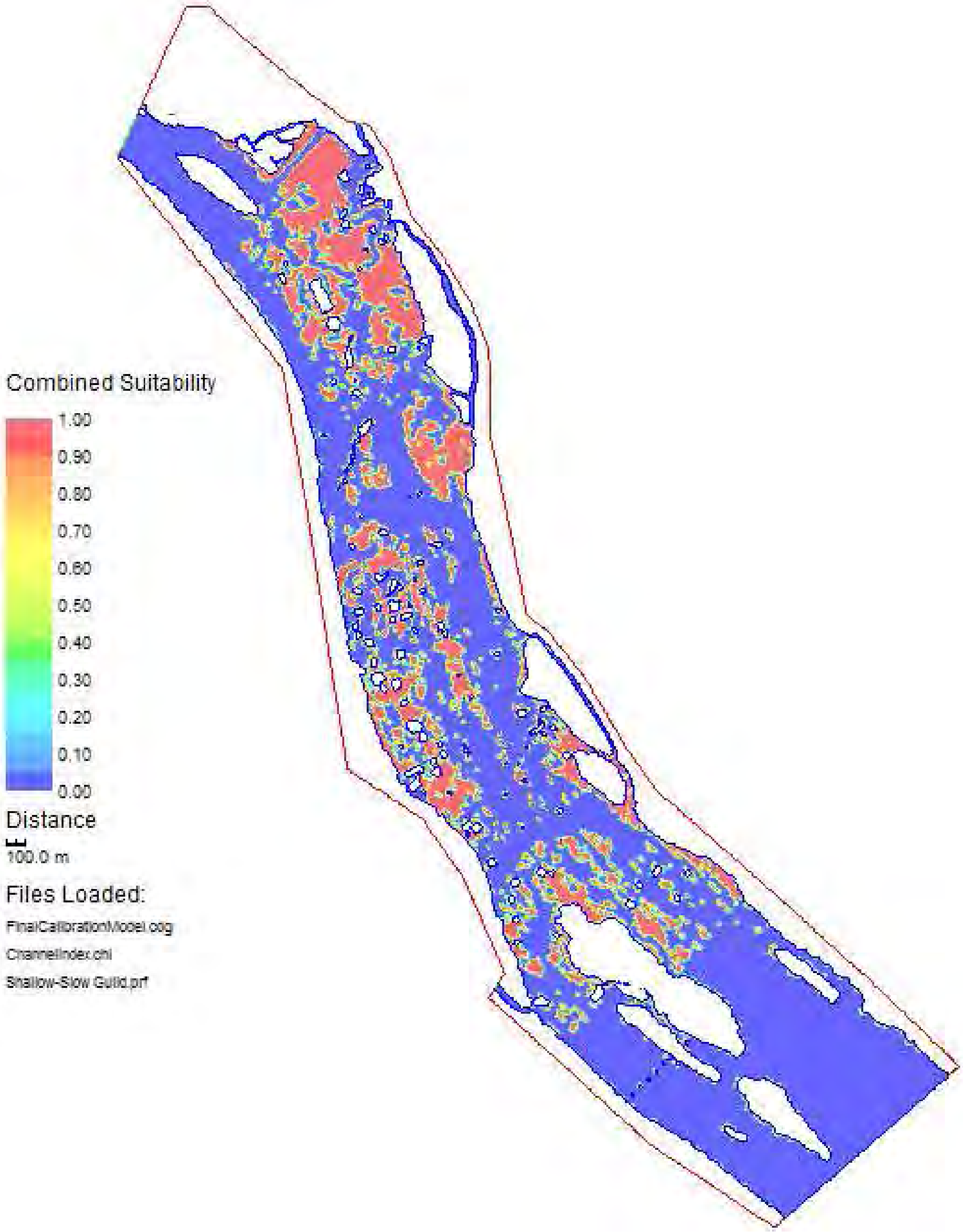
Caddisfly – 86,000 cfs



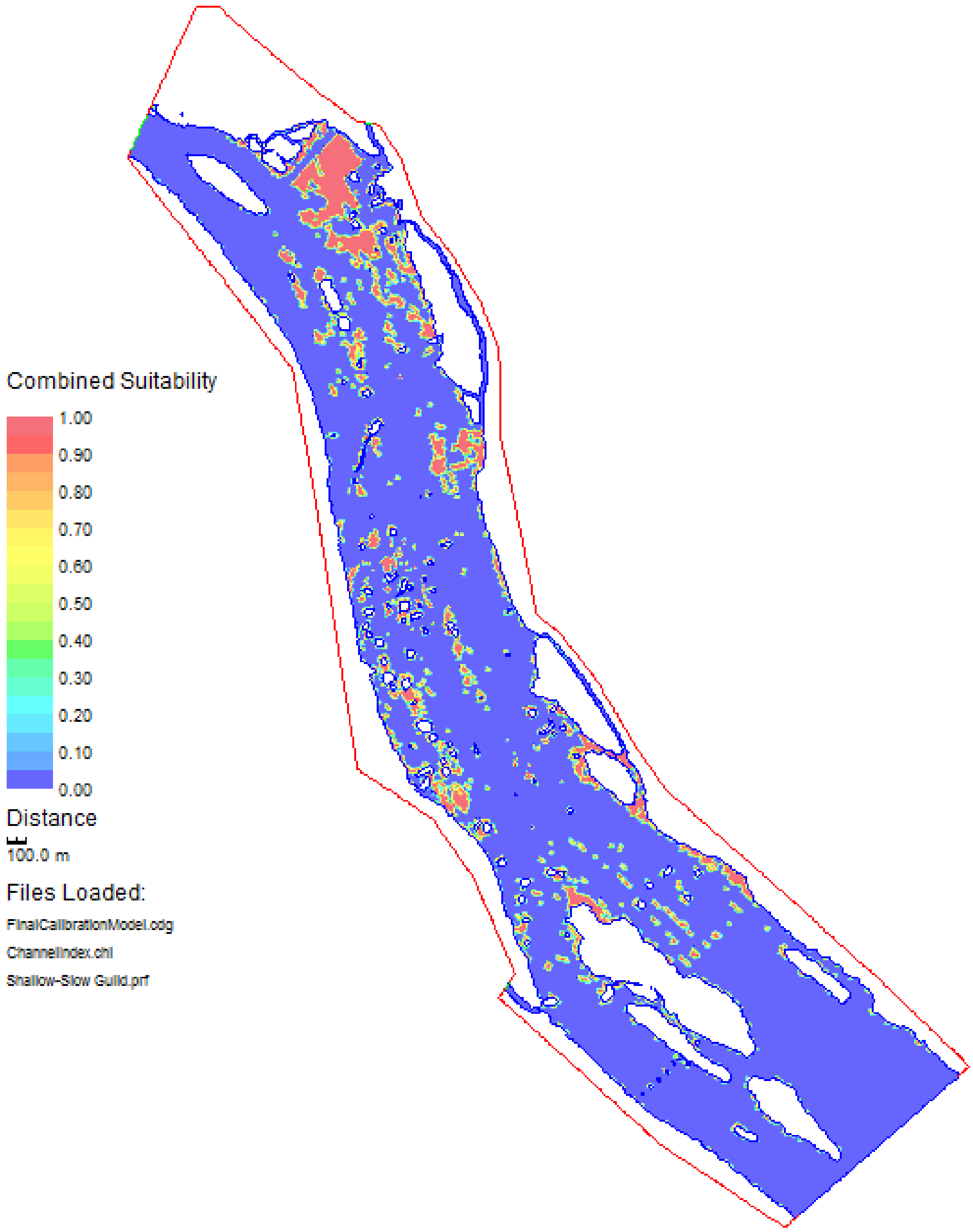
Shallow-Slow Guild – 2,000 cfs



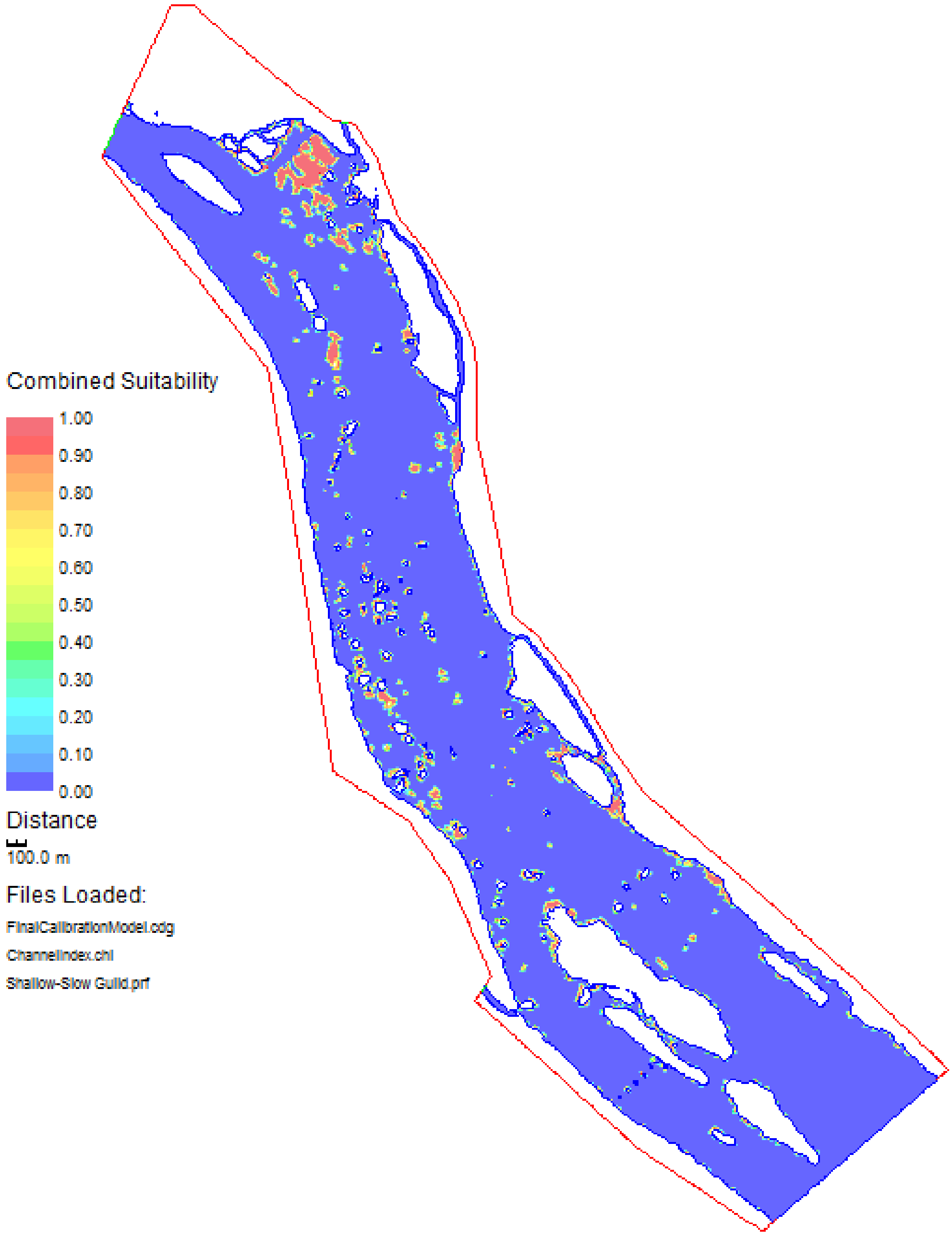
Shallow-Slow Guild – 3,500 cfs



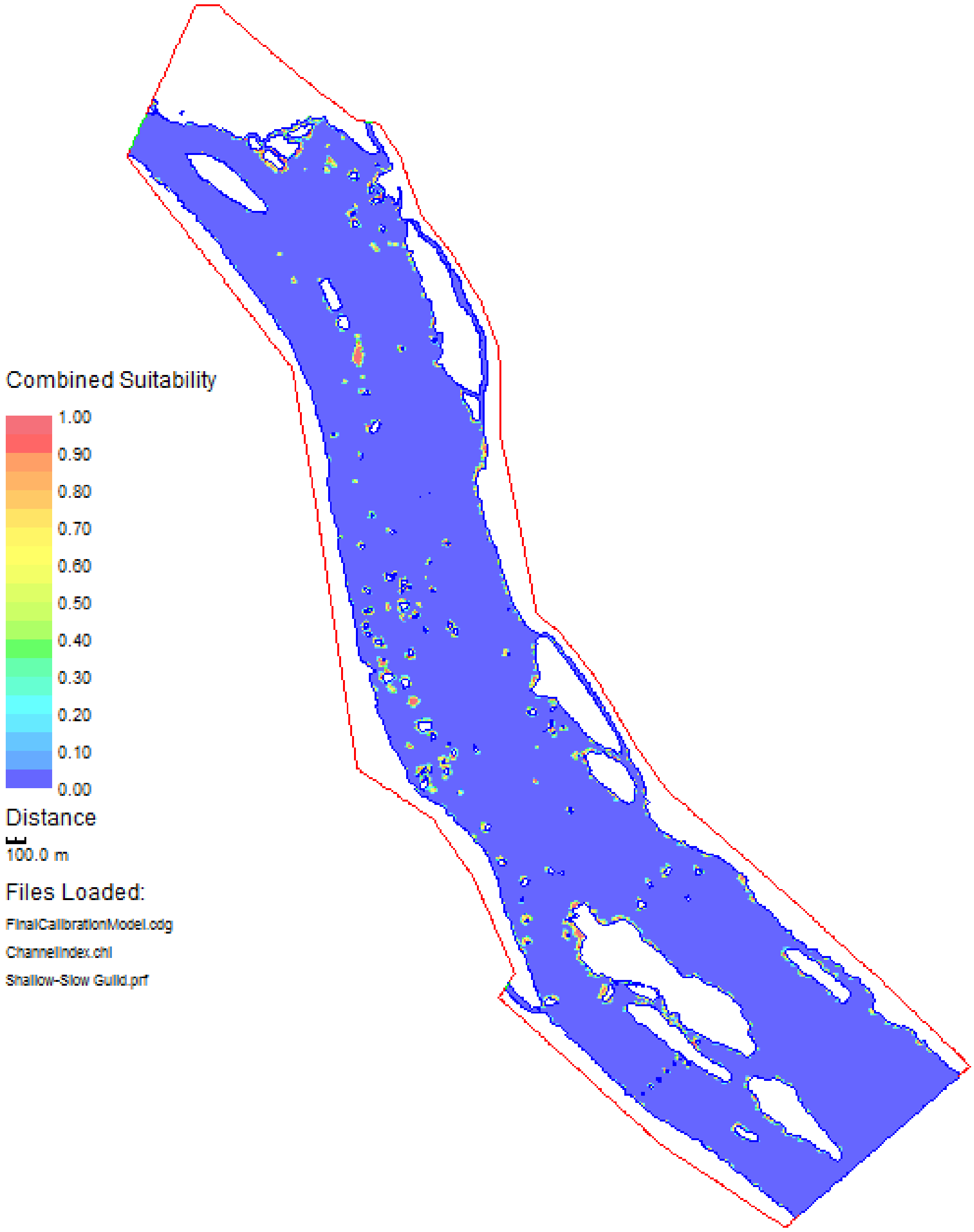
Shallow-Slow Guild – 5,000 cfs



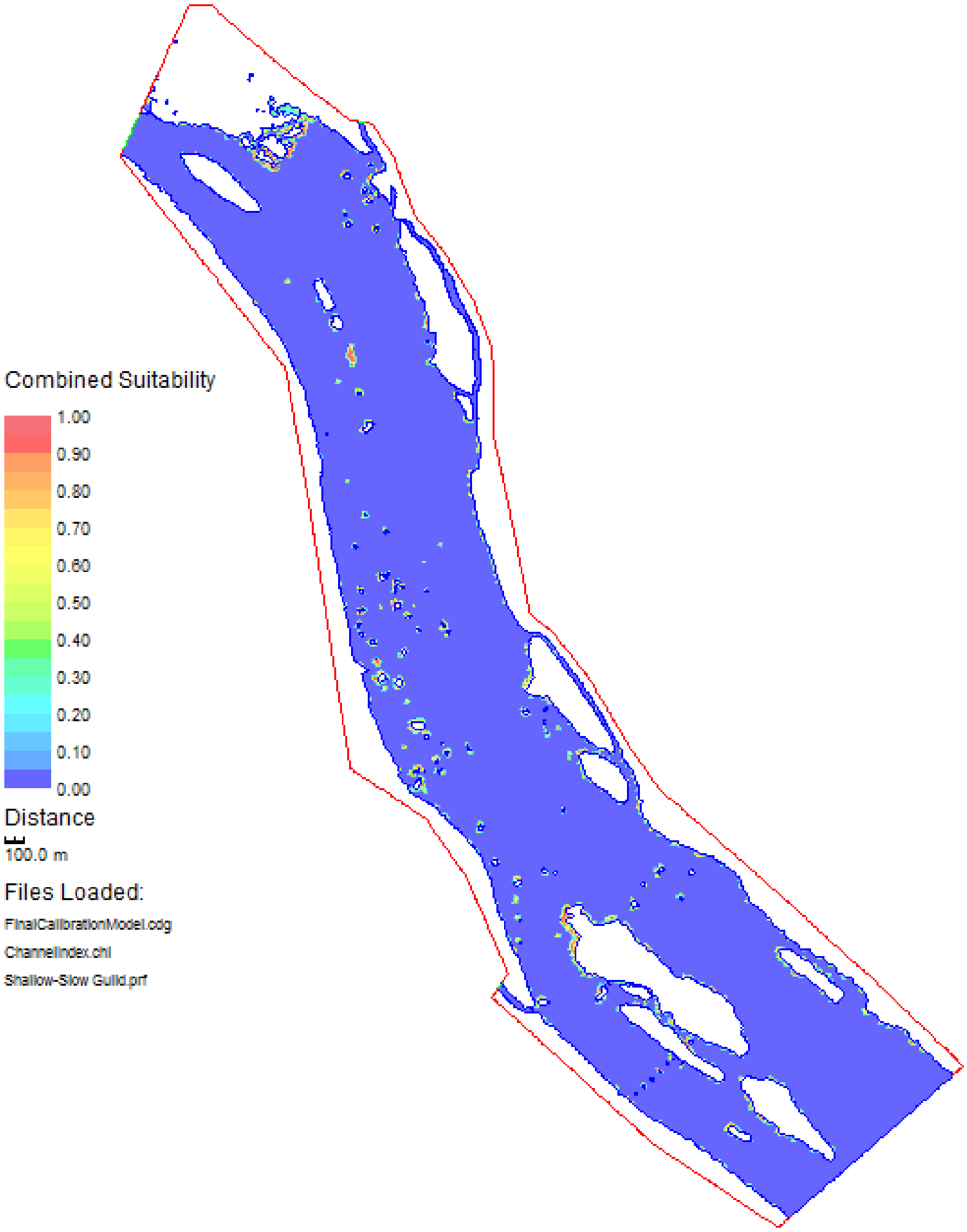
Shallow-Slow Guild – 7,500 cfs



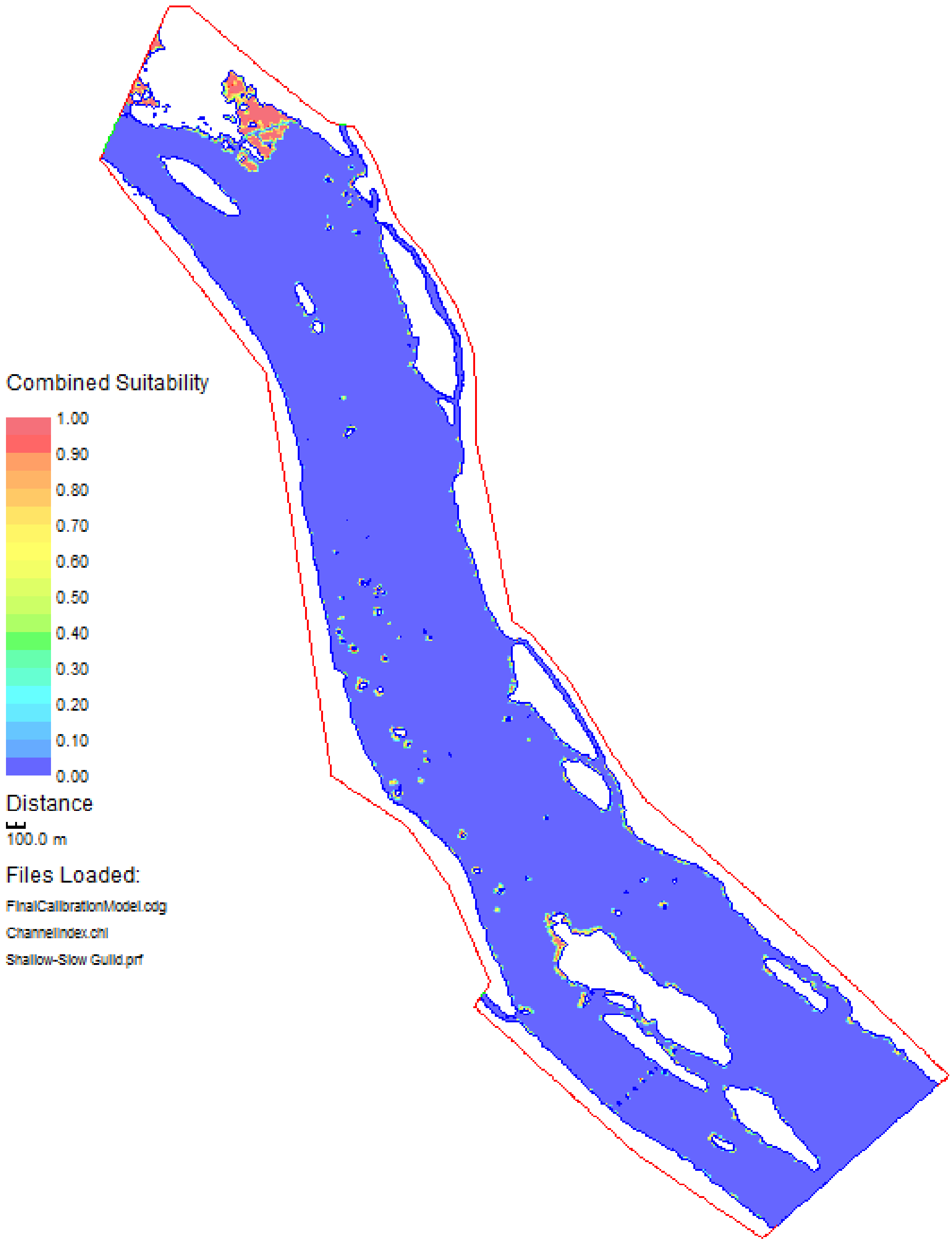
Shallow-Slow Guild – 10,000 cfs



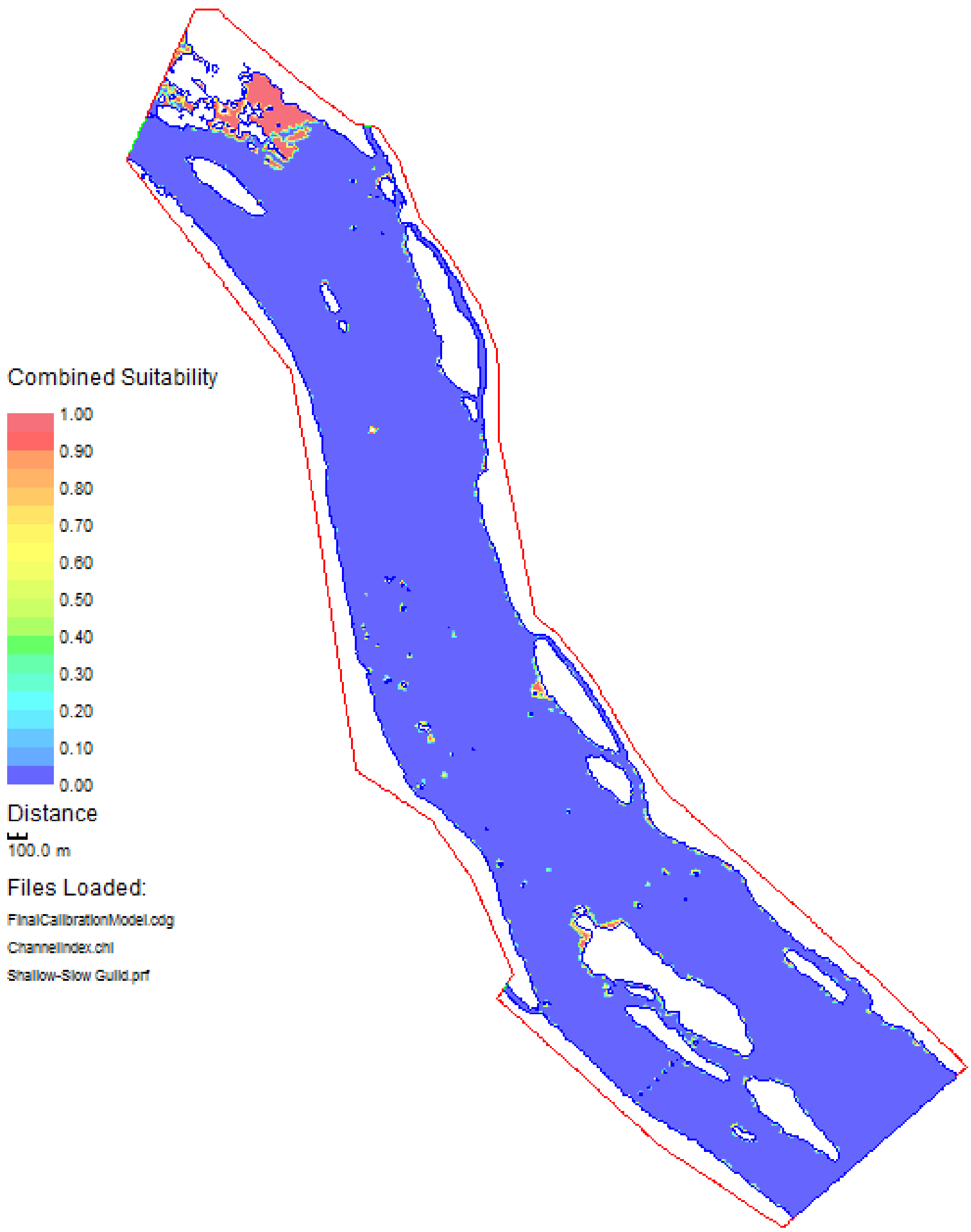
Shallow-Slow Guild – 15,000 cfs



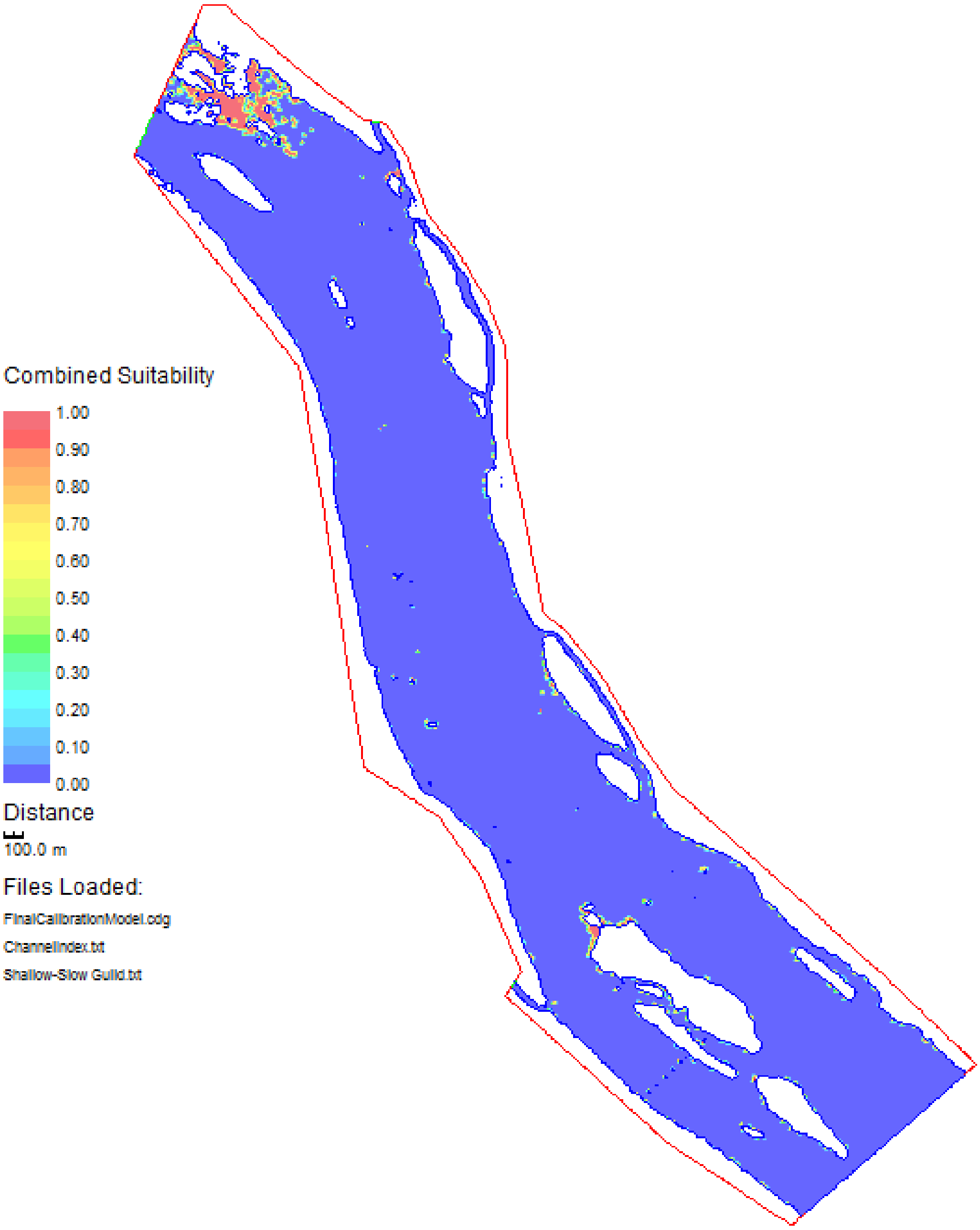
Shallow-Slow Guild – 20,000 cfs



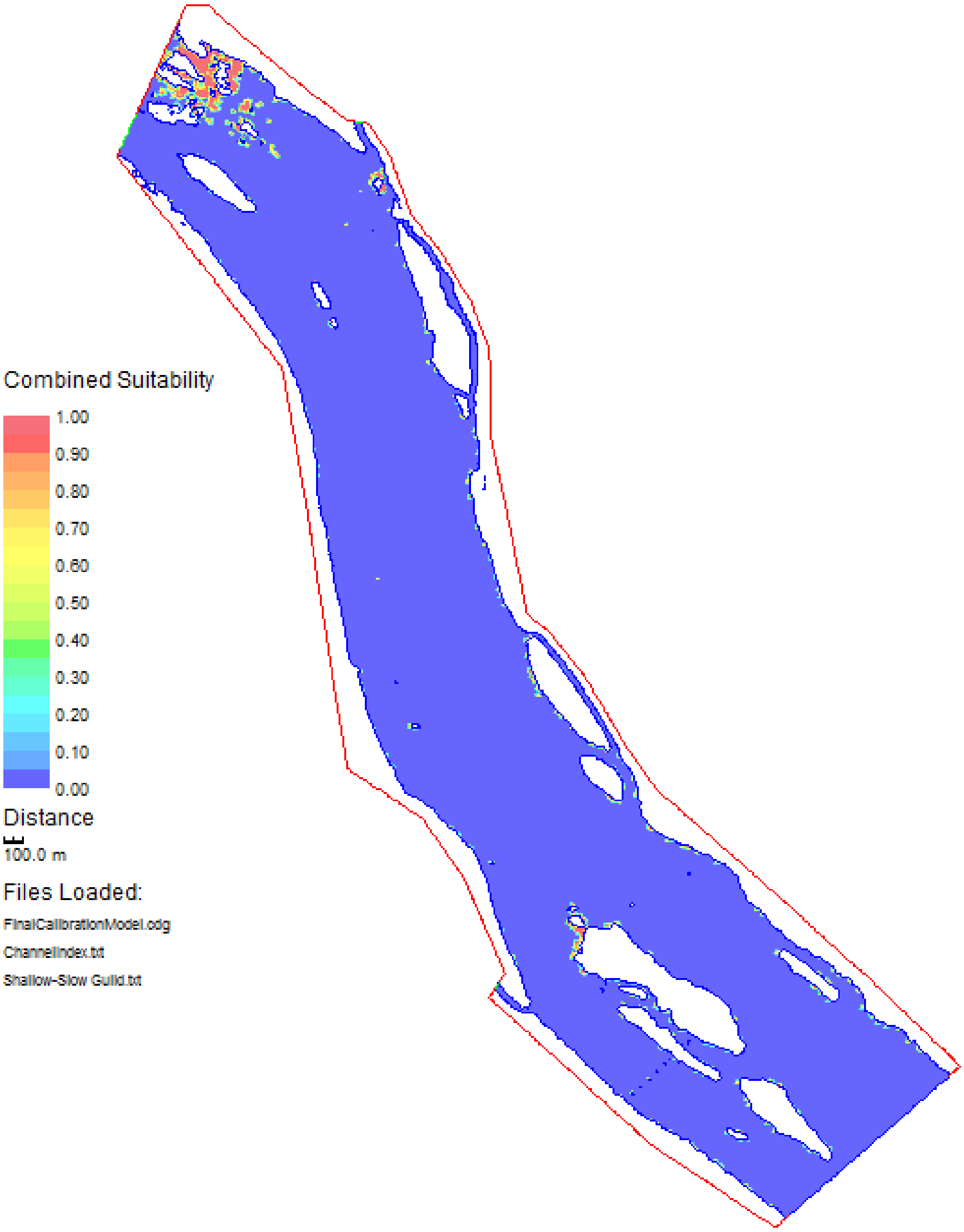
Shallow-Slow Guild – 30,000 cfs



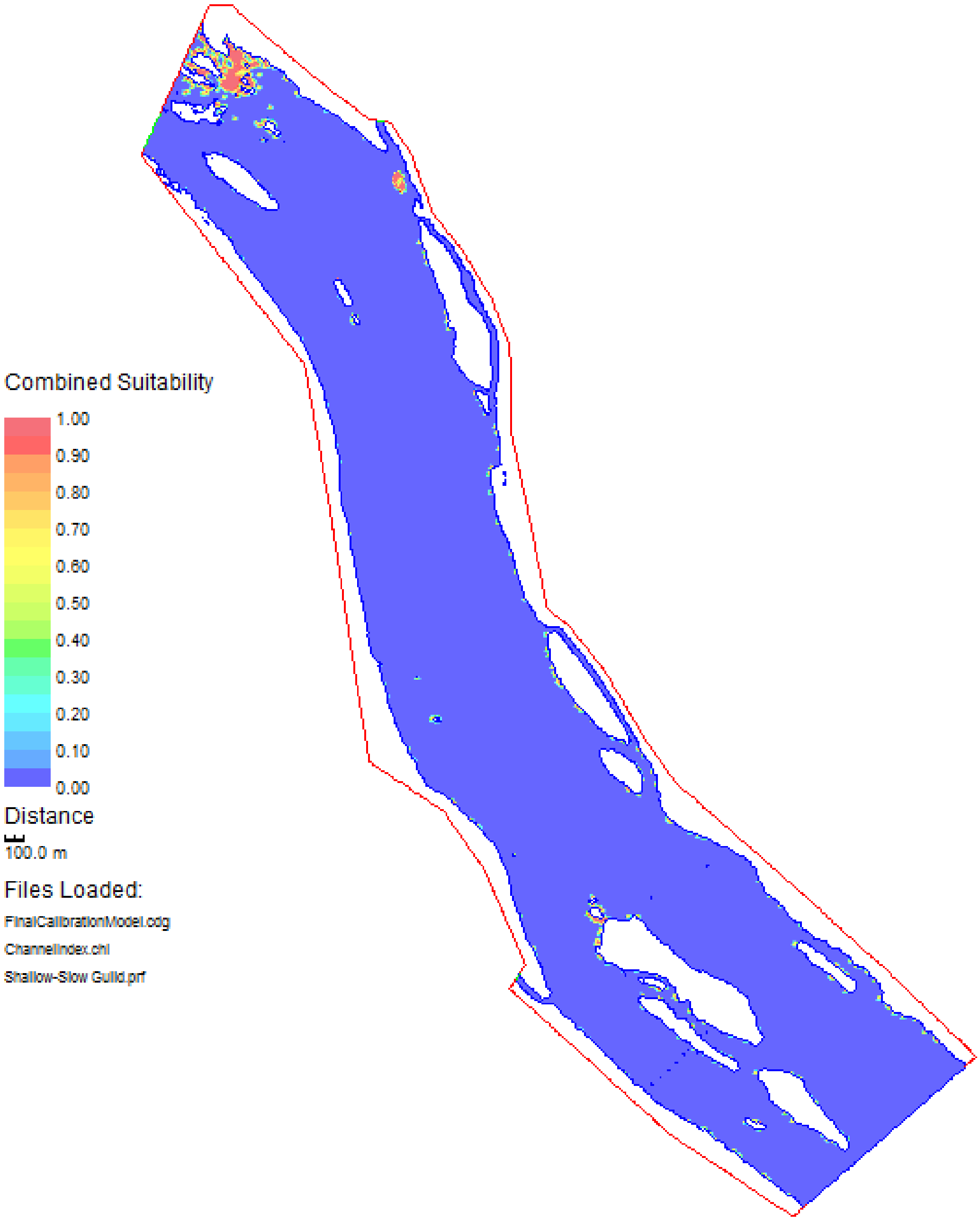
Shallow-Slow Guild – 40,000 cfs



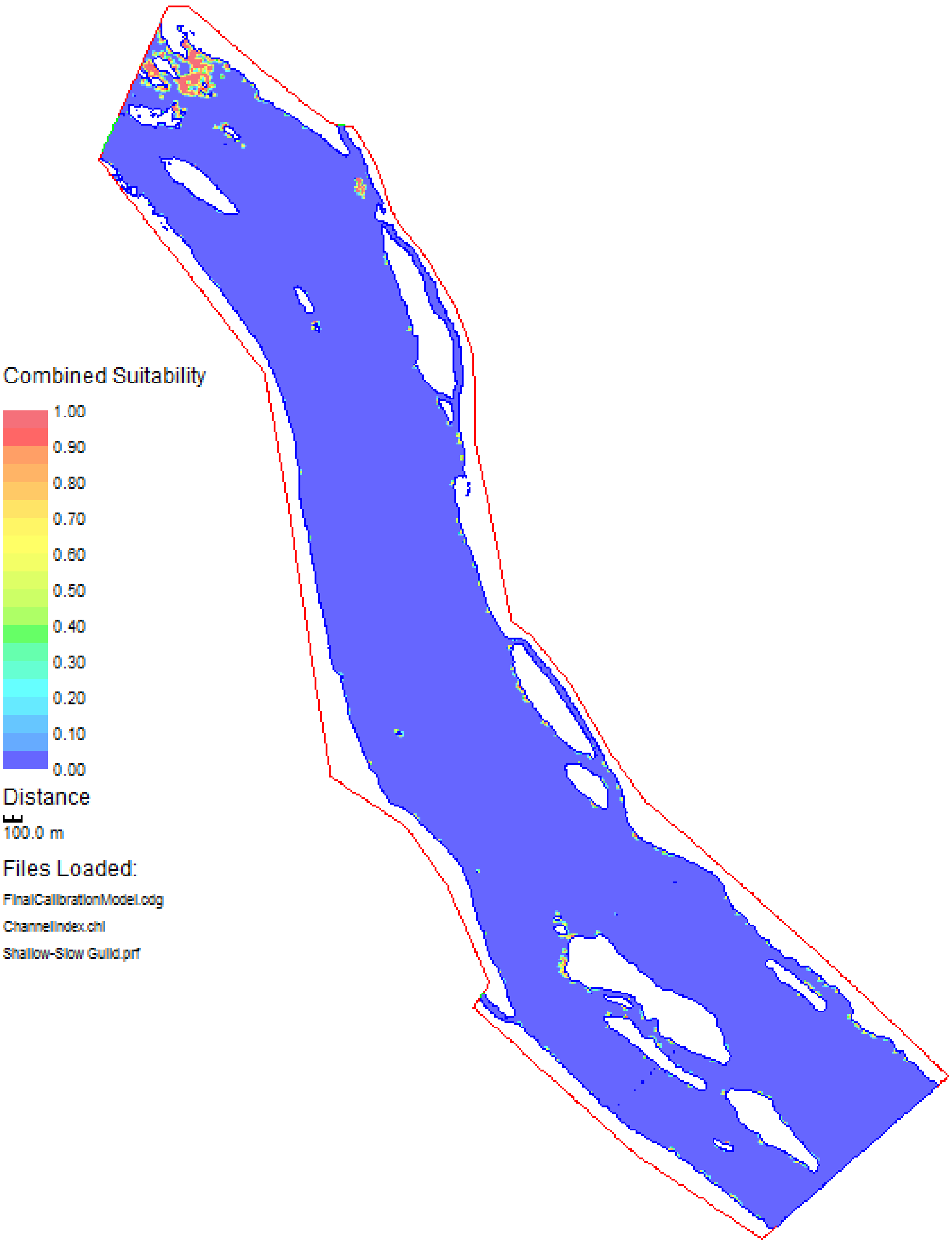
Shallow-Slow Guild – 50,000 cfs



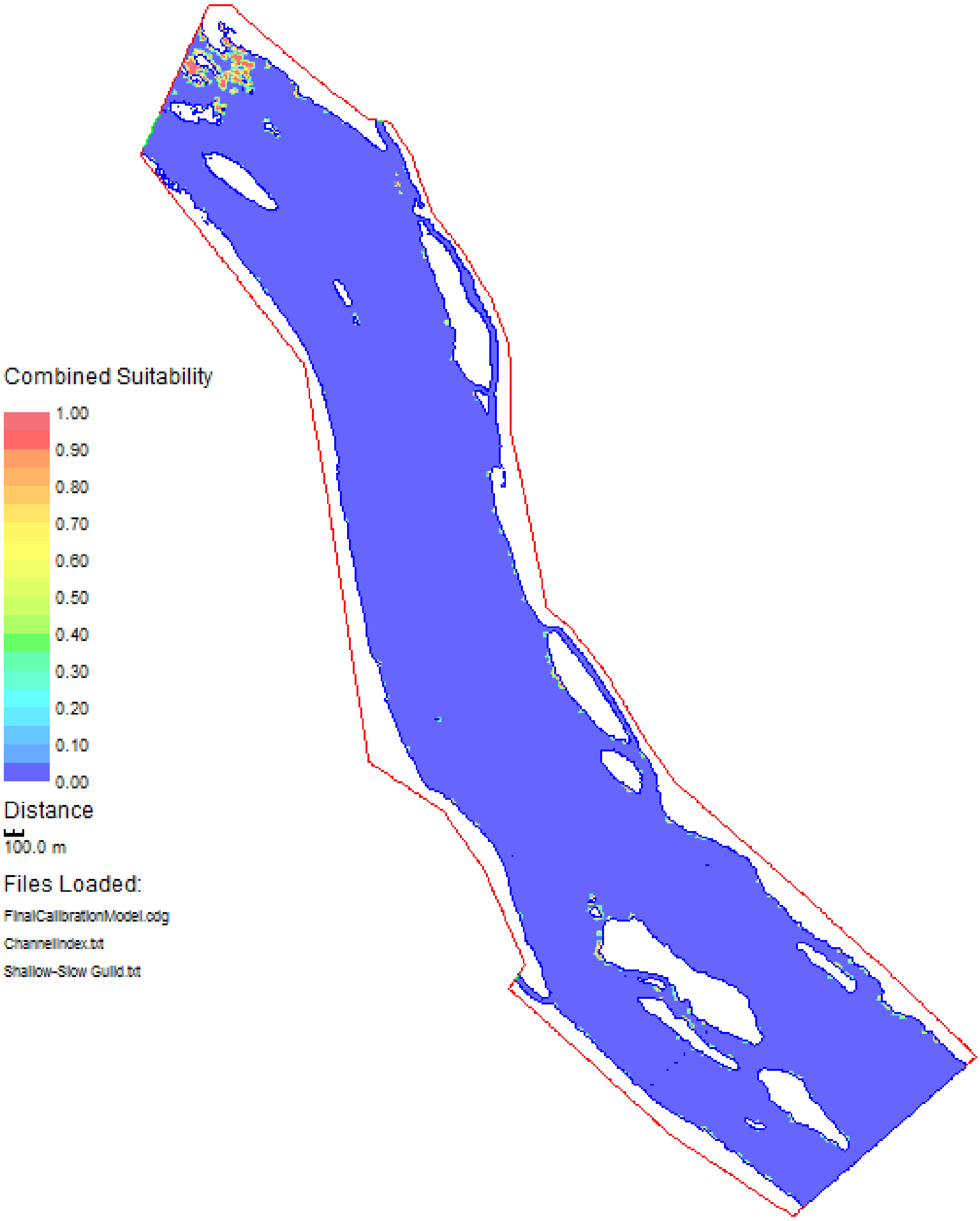
Shallow-Slow Guild – 60,000 cfs



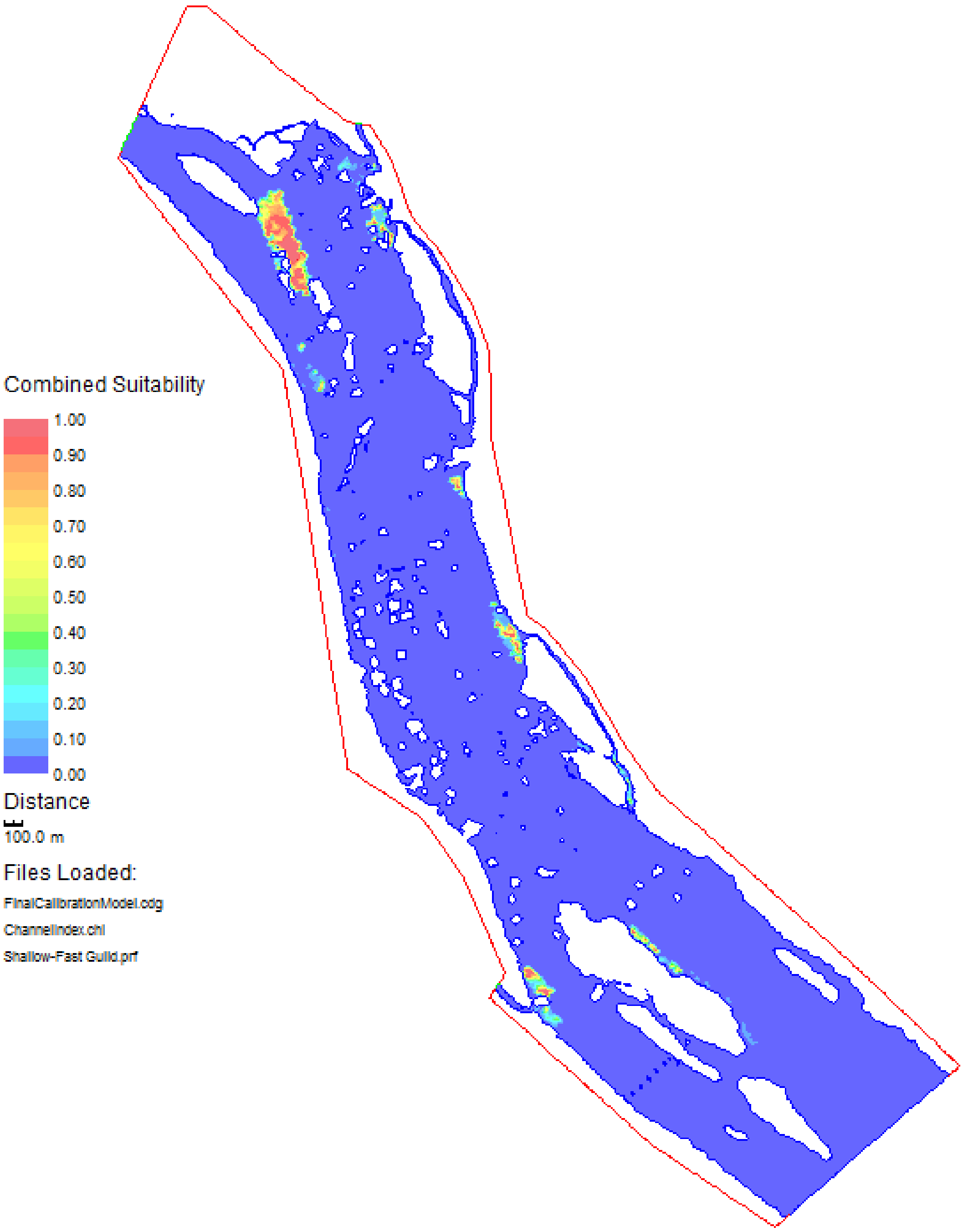
Shallow-Slow Guild – 70,000 cfs



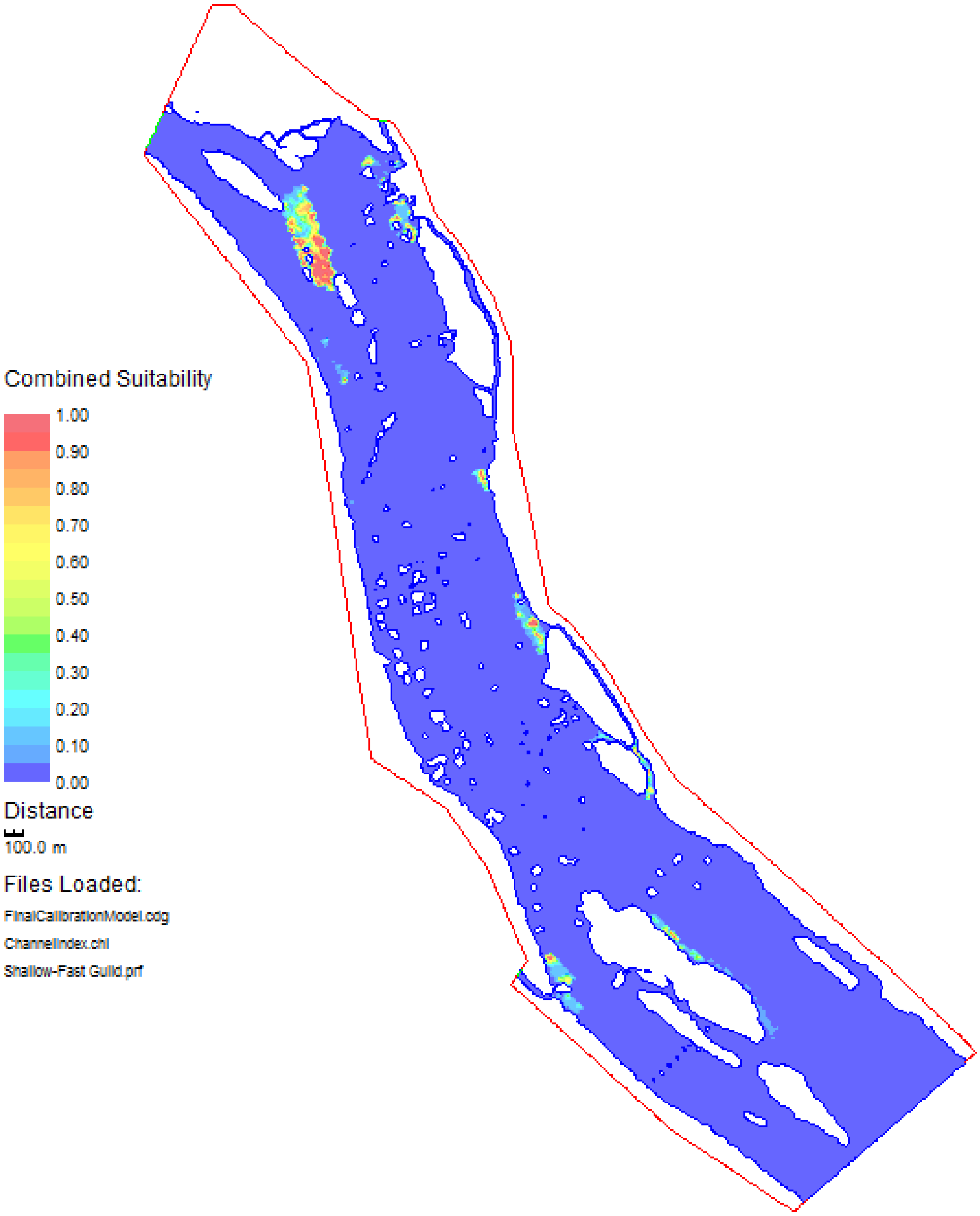
Shallow-Slow Guild – 80,000 cfs



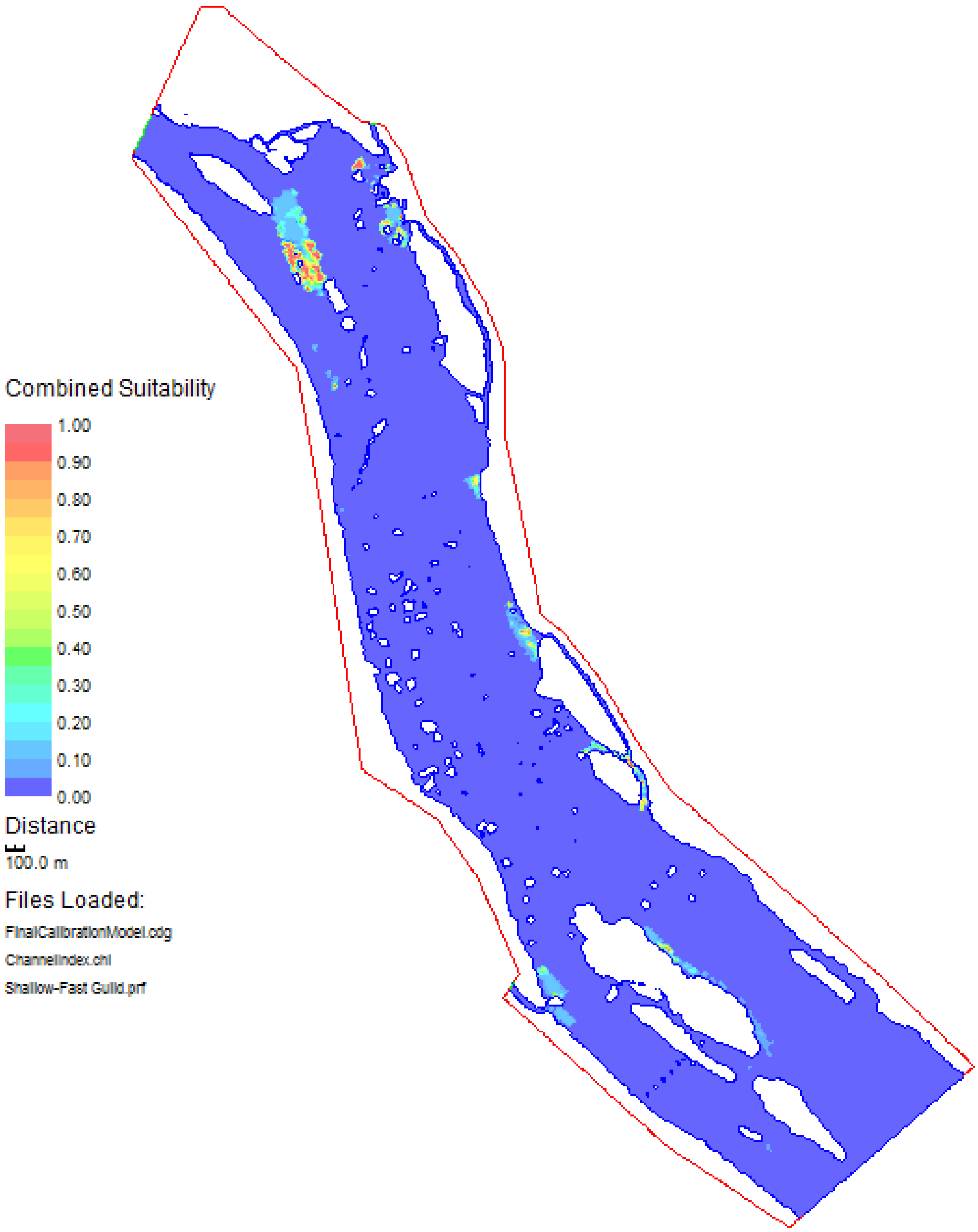
Shallow-Slow Guild – 86,000 cfs



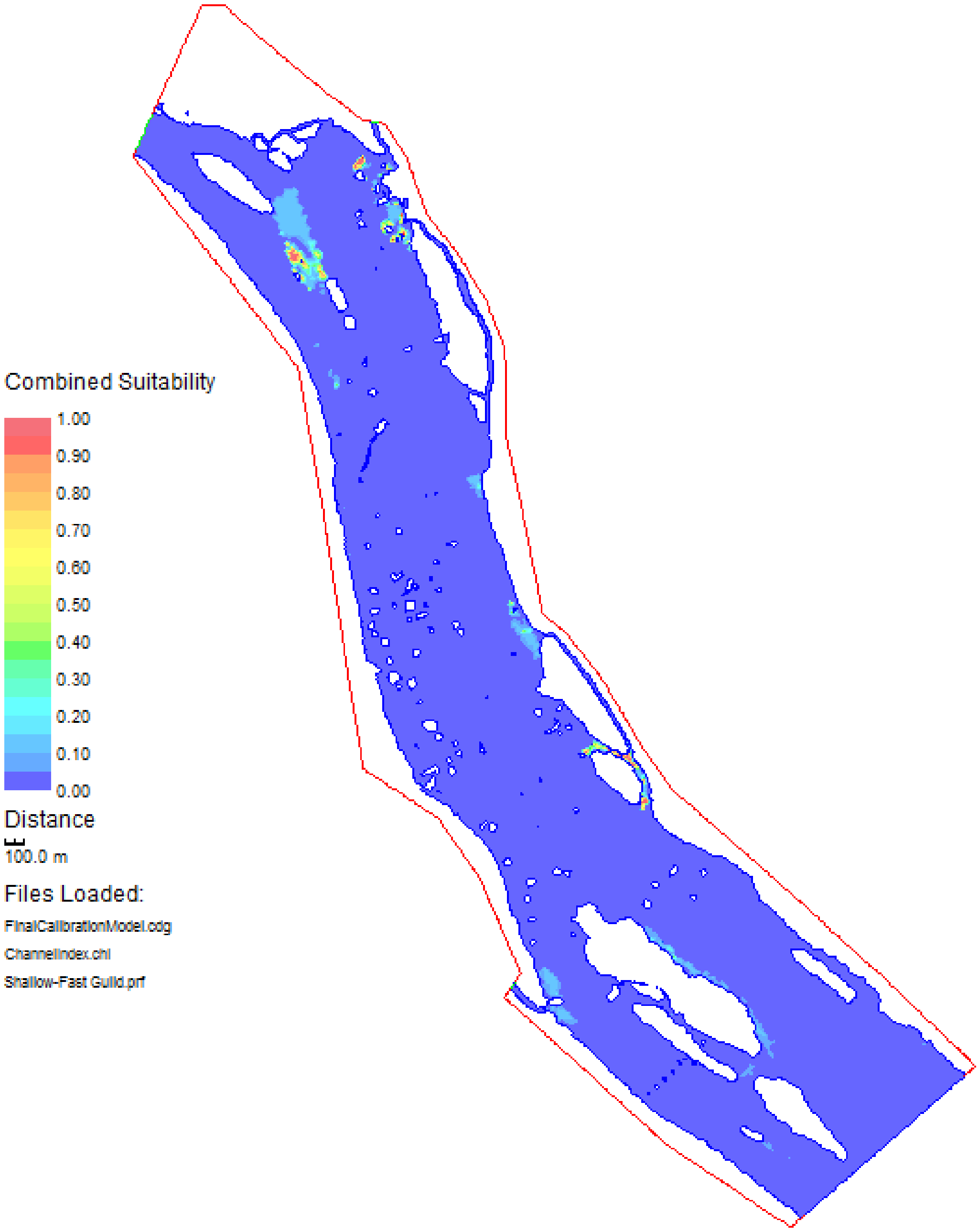
Shallow-Fast Guild – 2,000 cfs



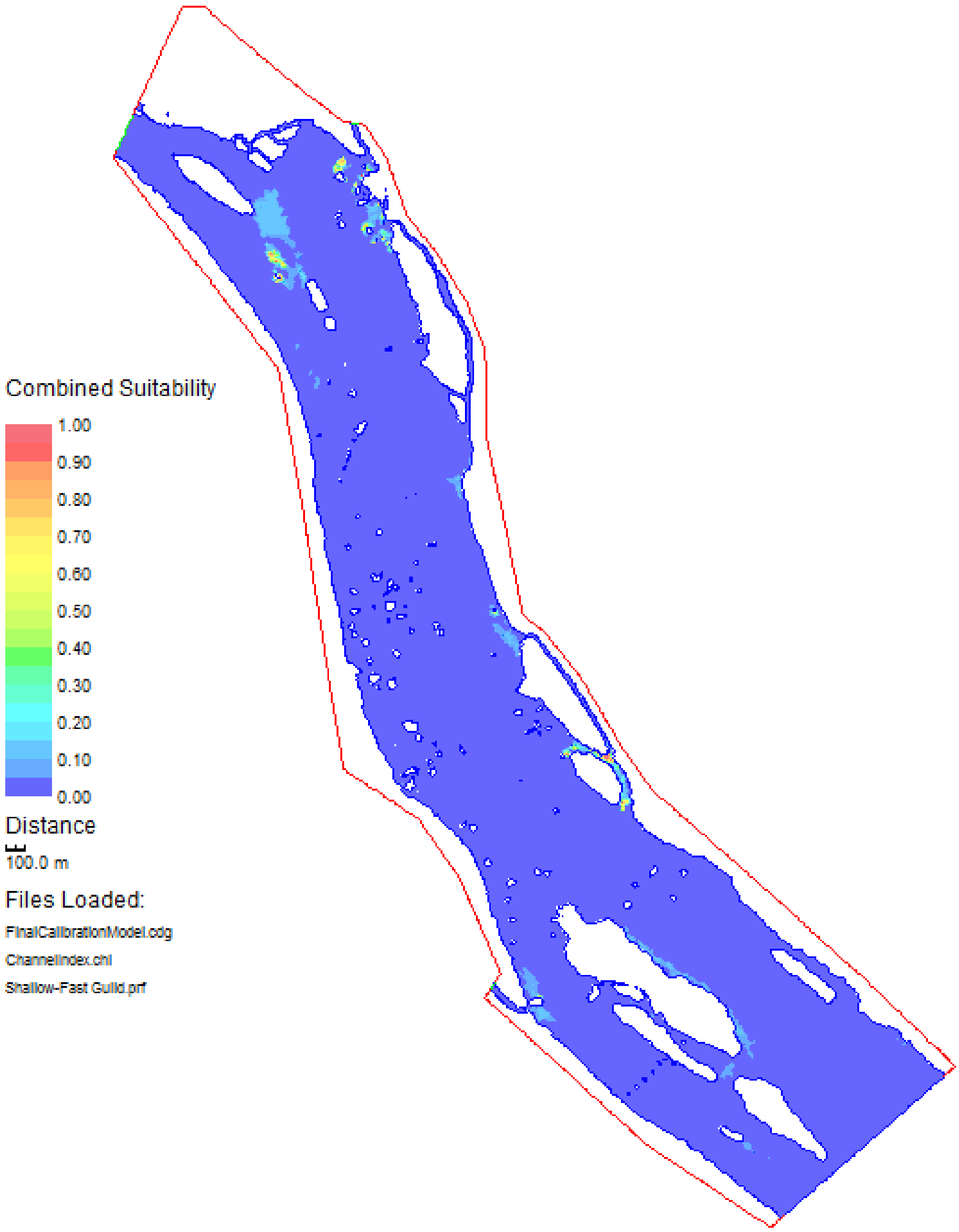
Shallow-Fast Guild – 3,500 cfs



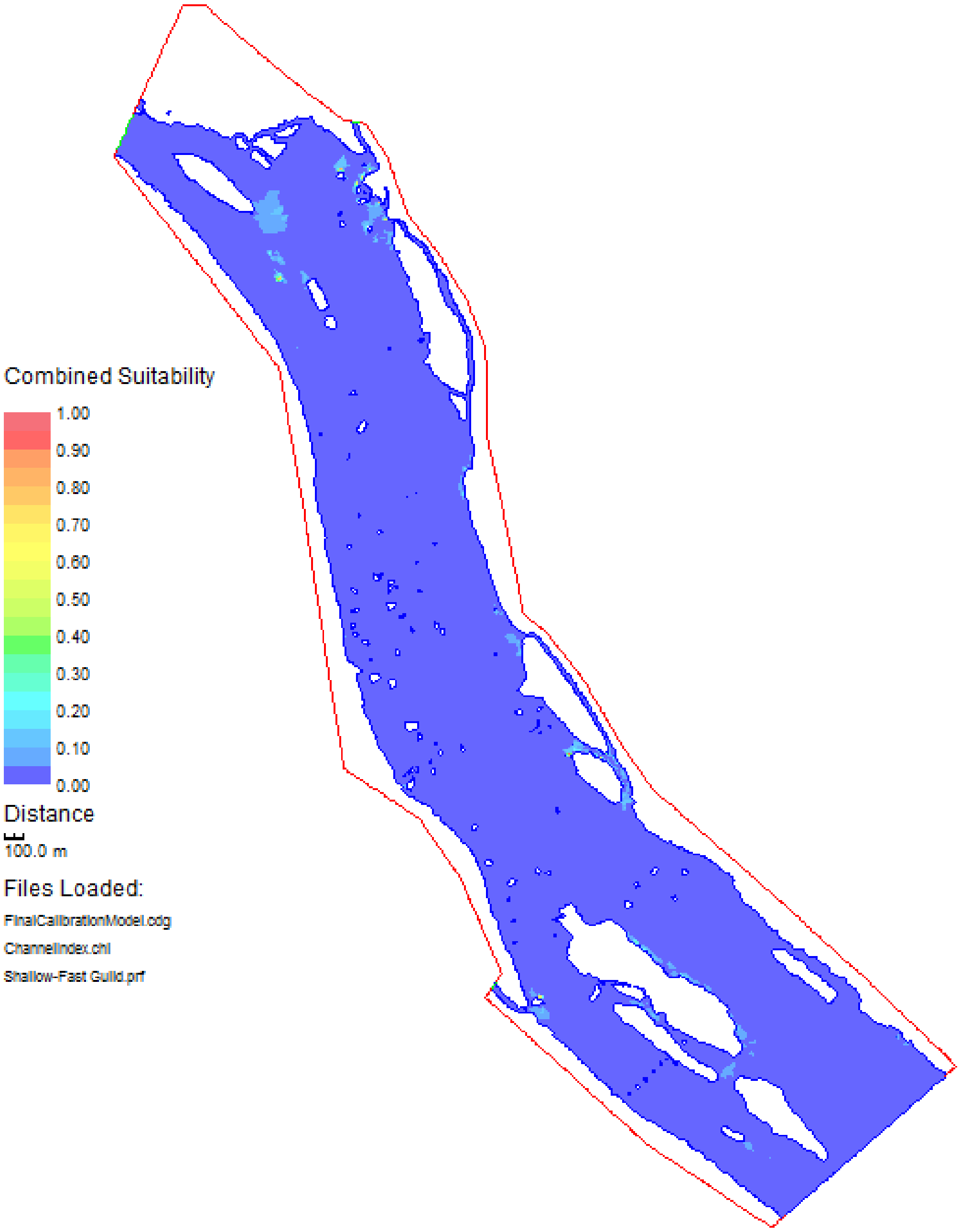
Shallow-Fast Guild – 5,000 cfs



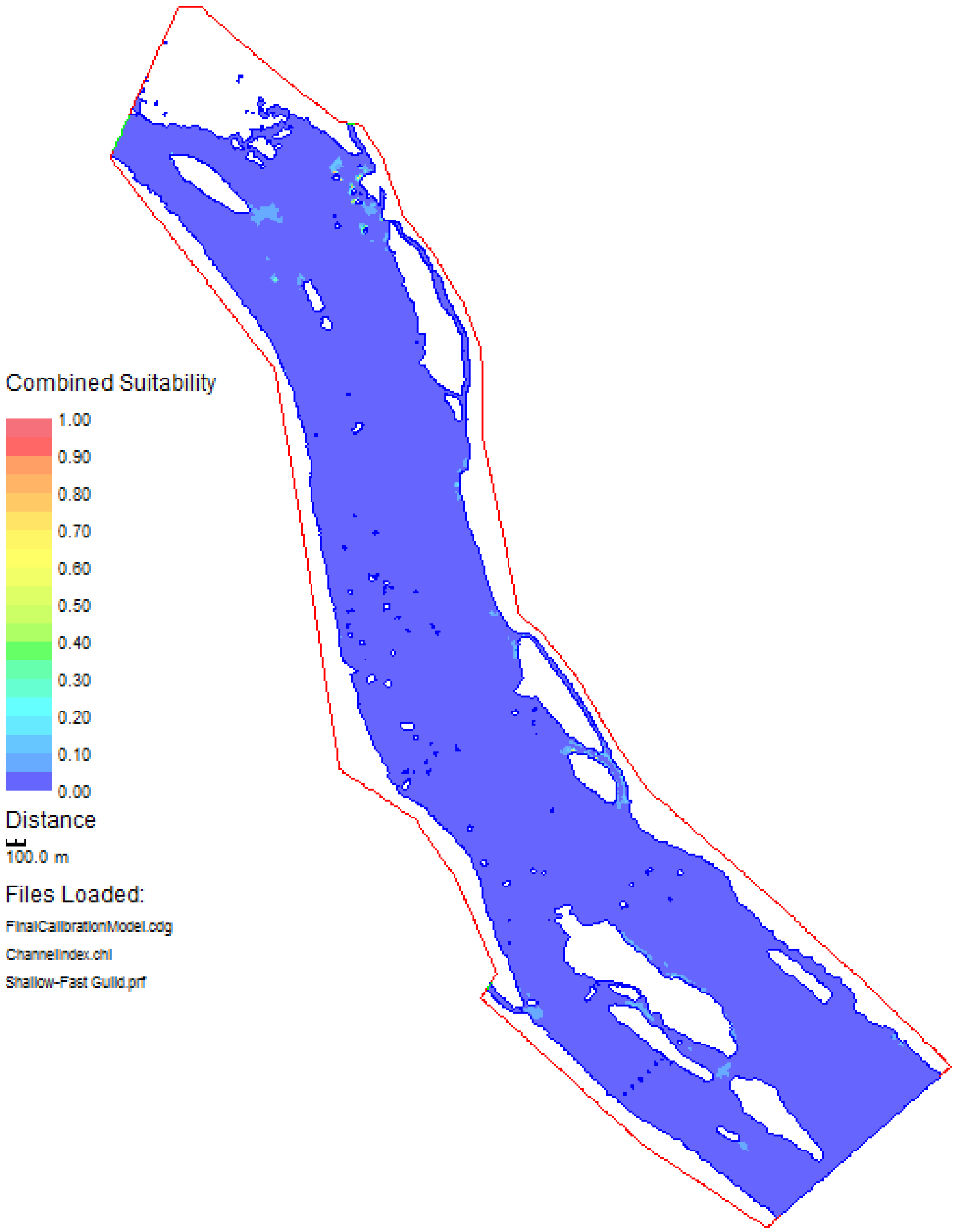
Shallow-Fast Guild – 7,500 cfs



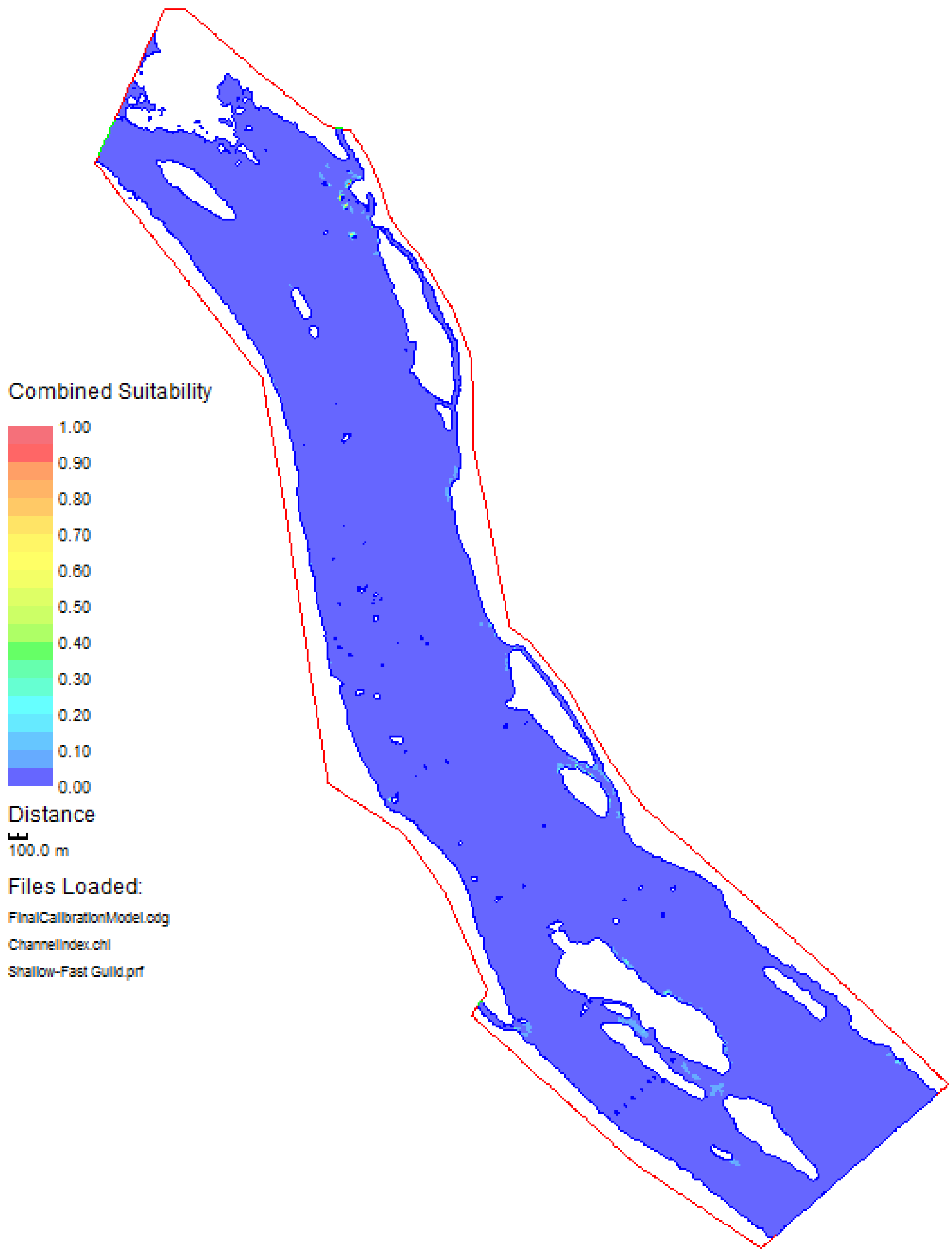
Shallow-Fast Guild – 10,000 cfs



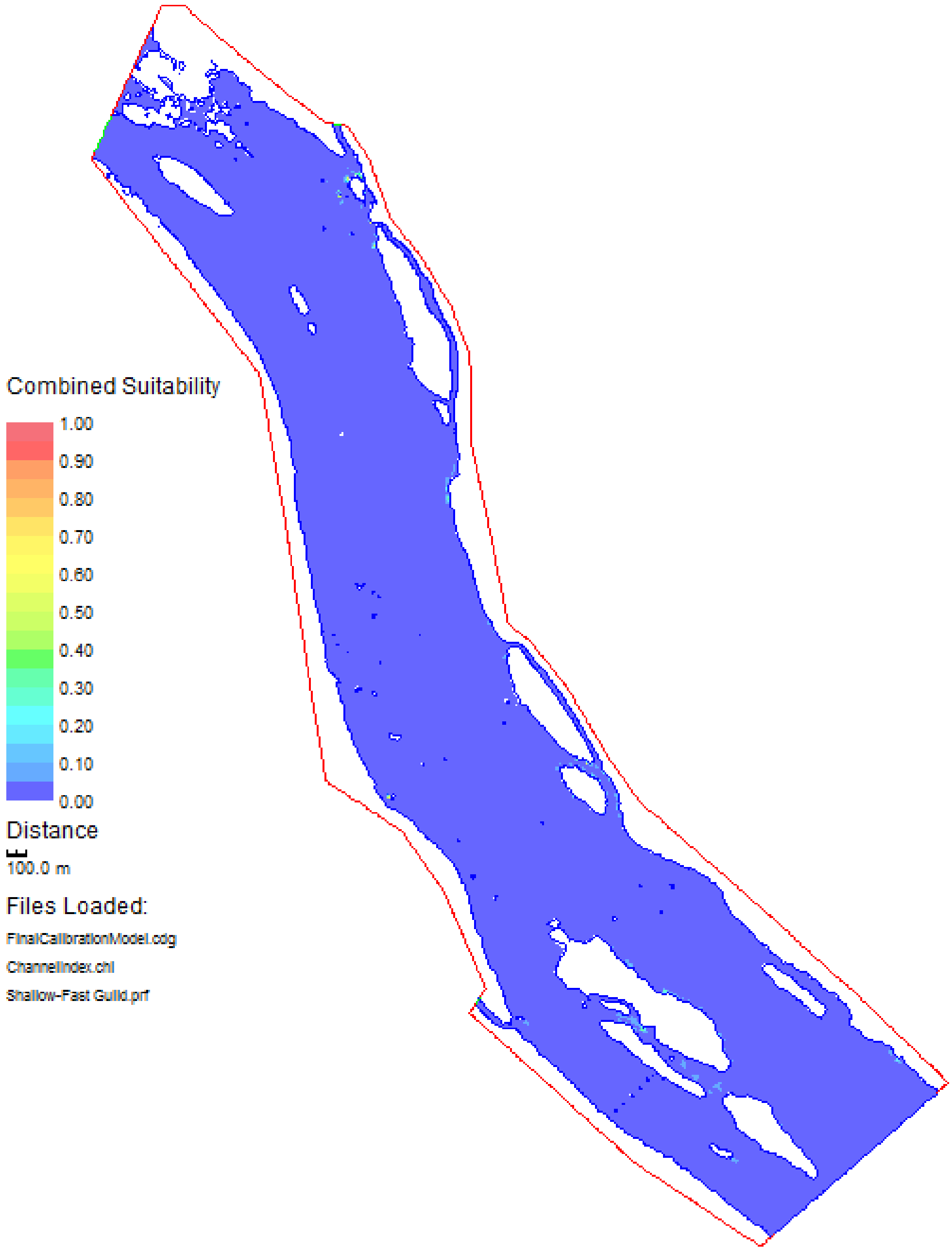
Shallow-Fast Guild – 15,000 cfs



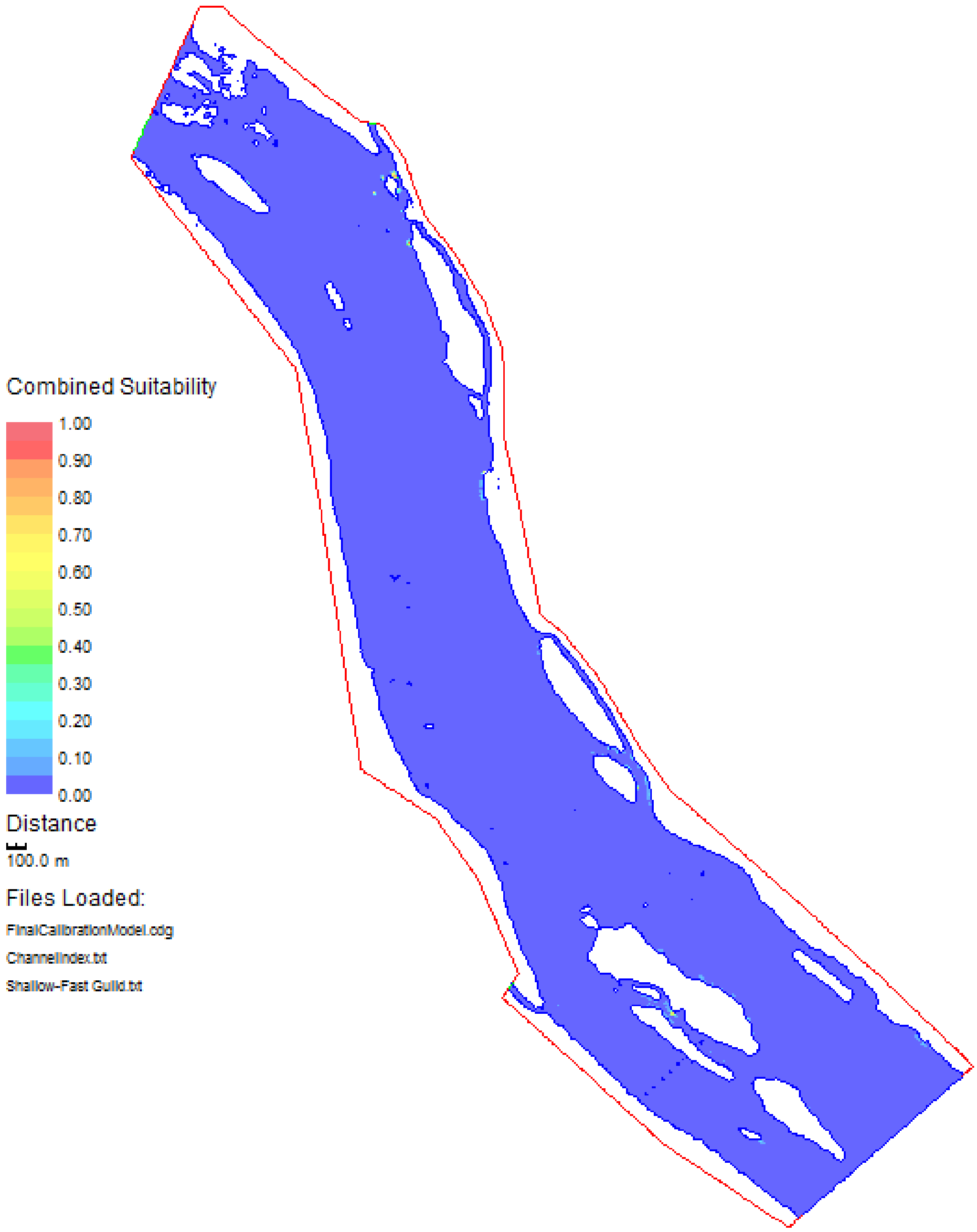
Shallow-Fast Guild – 20,000 cfs



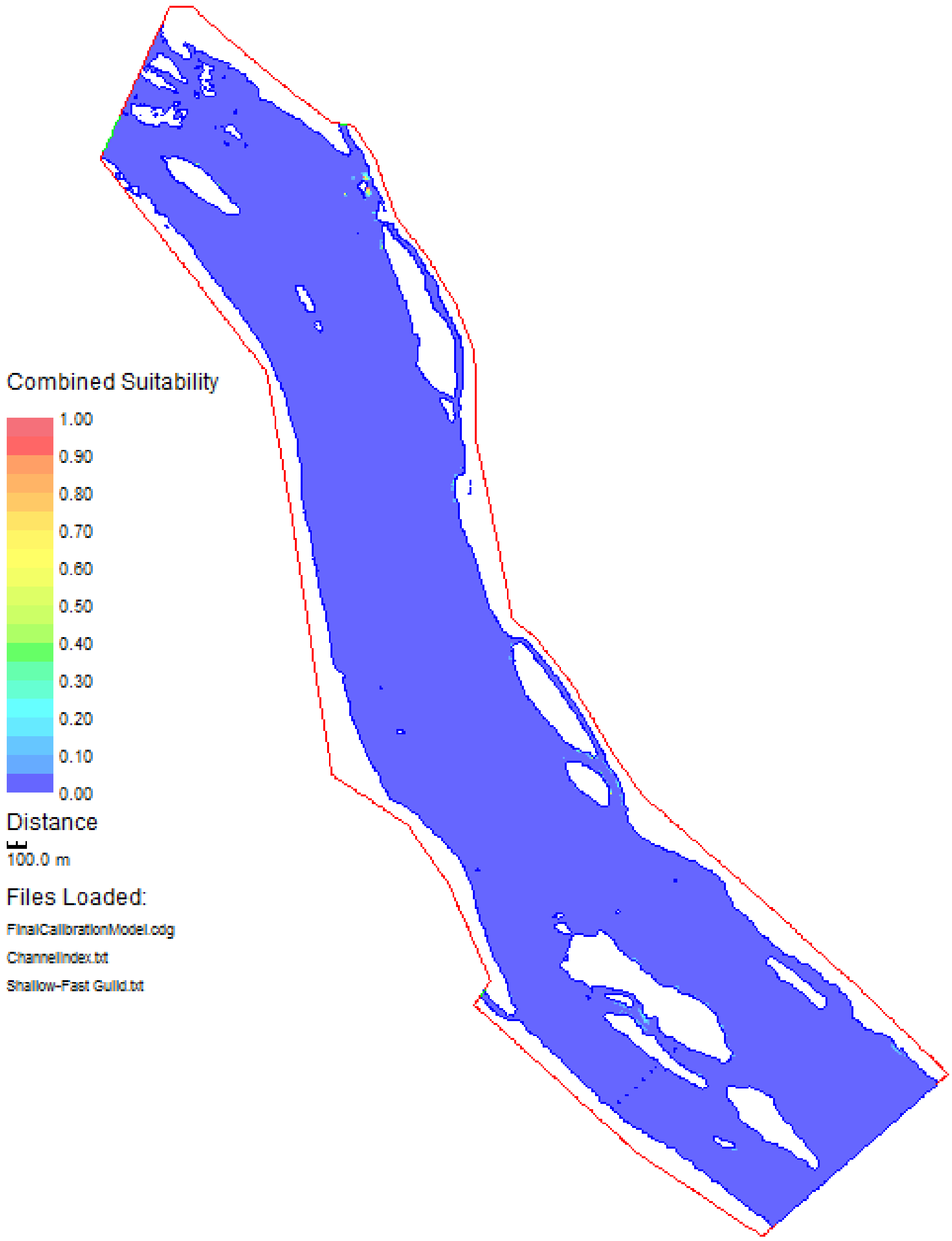
Shallow-Fast Guild – 30,000 cfs



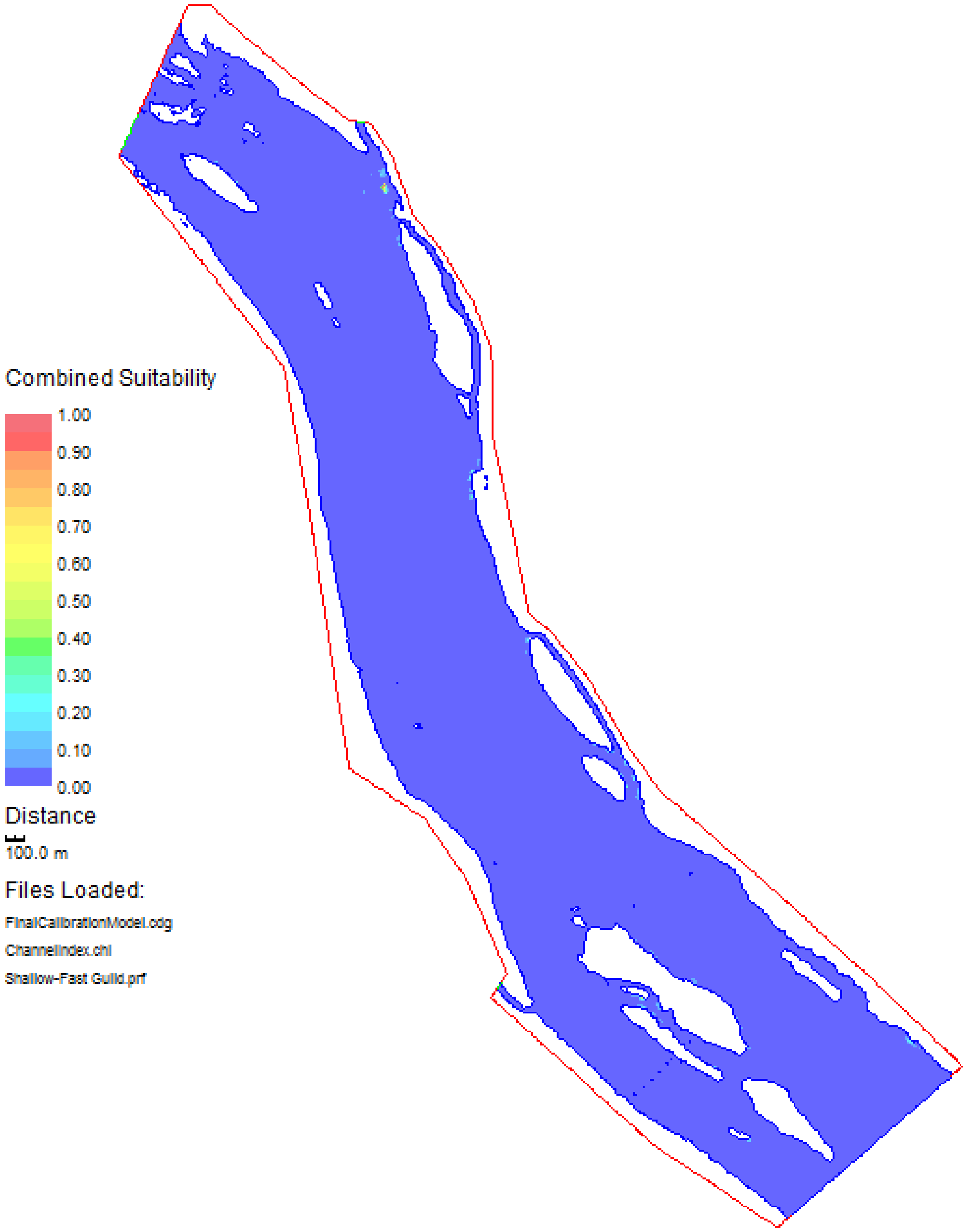
Shallow-Fast Guild – 40,000 cfs



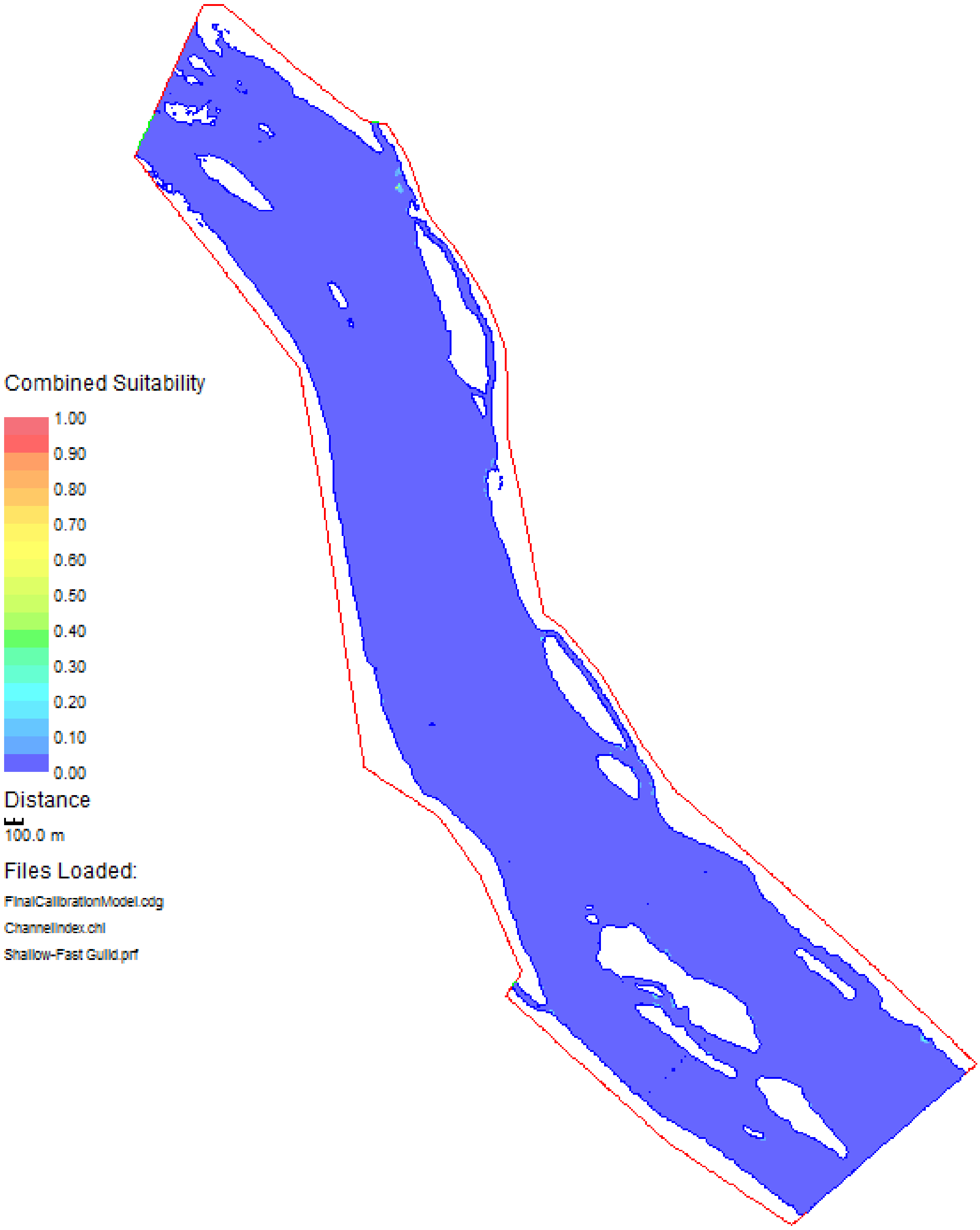
Shallow-Fast Guild – 50,000 cfs



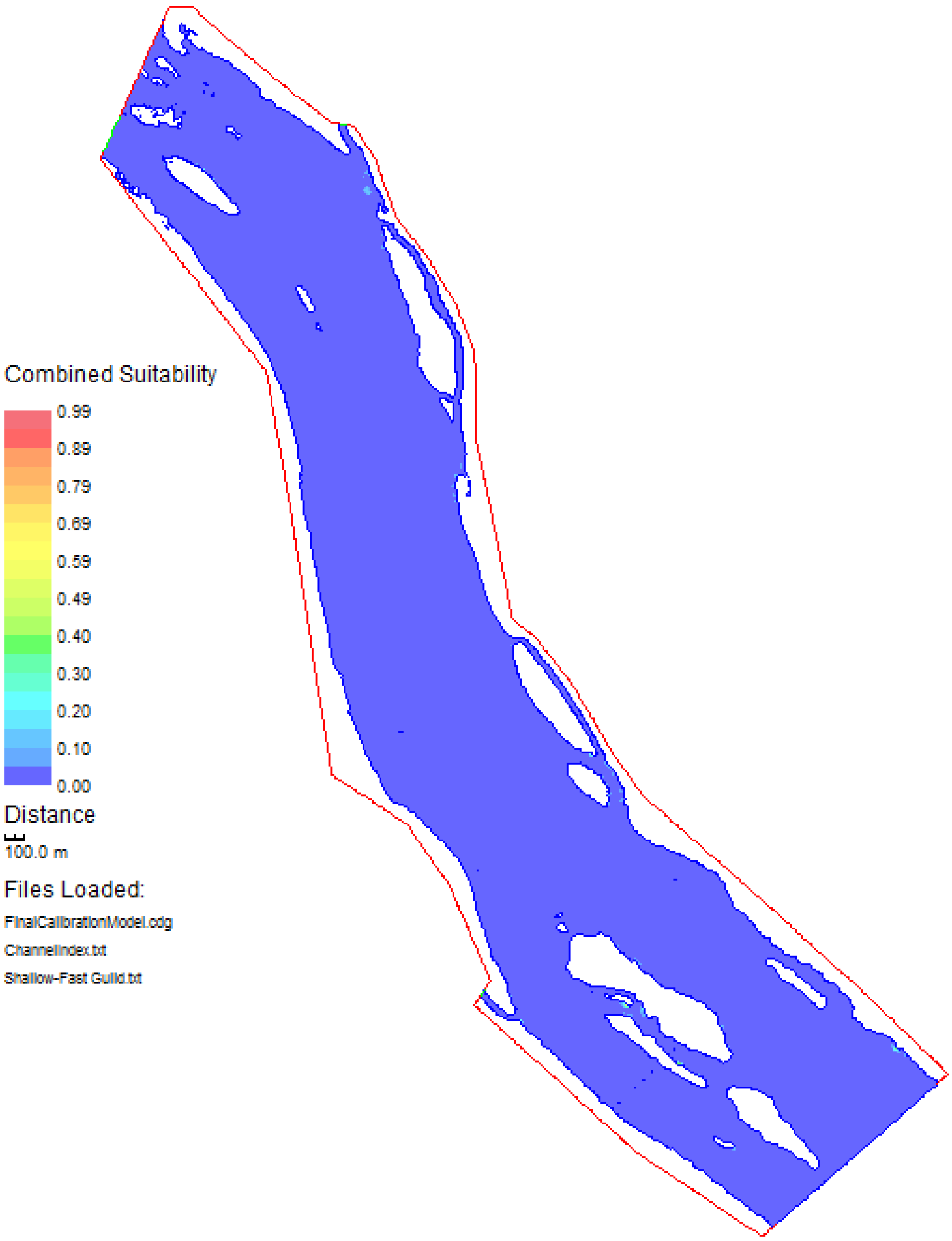
Shallow-Fast Guild – 60,000 cfs



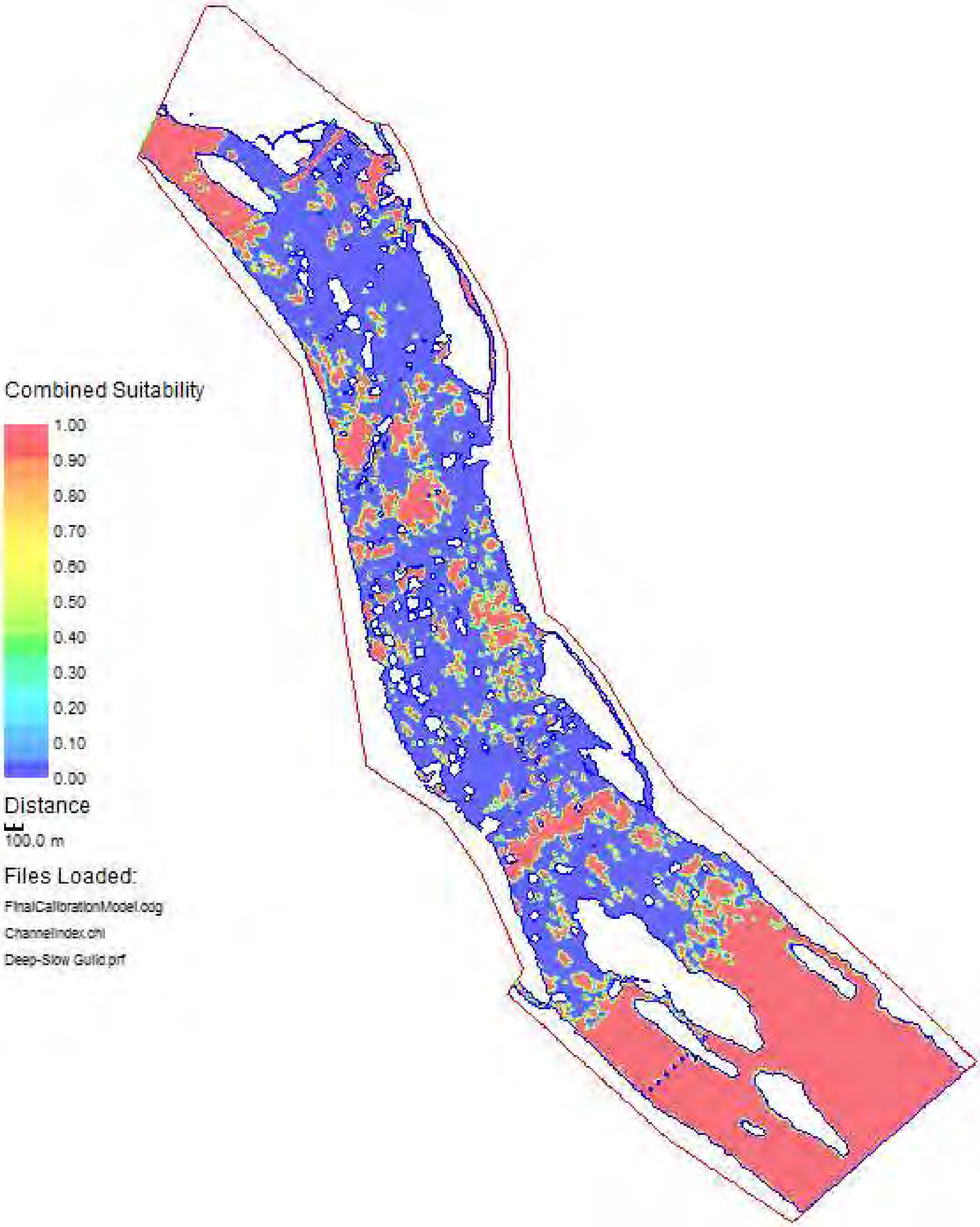
Shallow-Fast Guild – 70,000 cfs



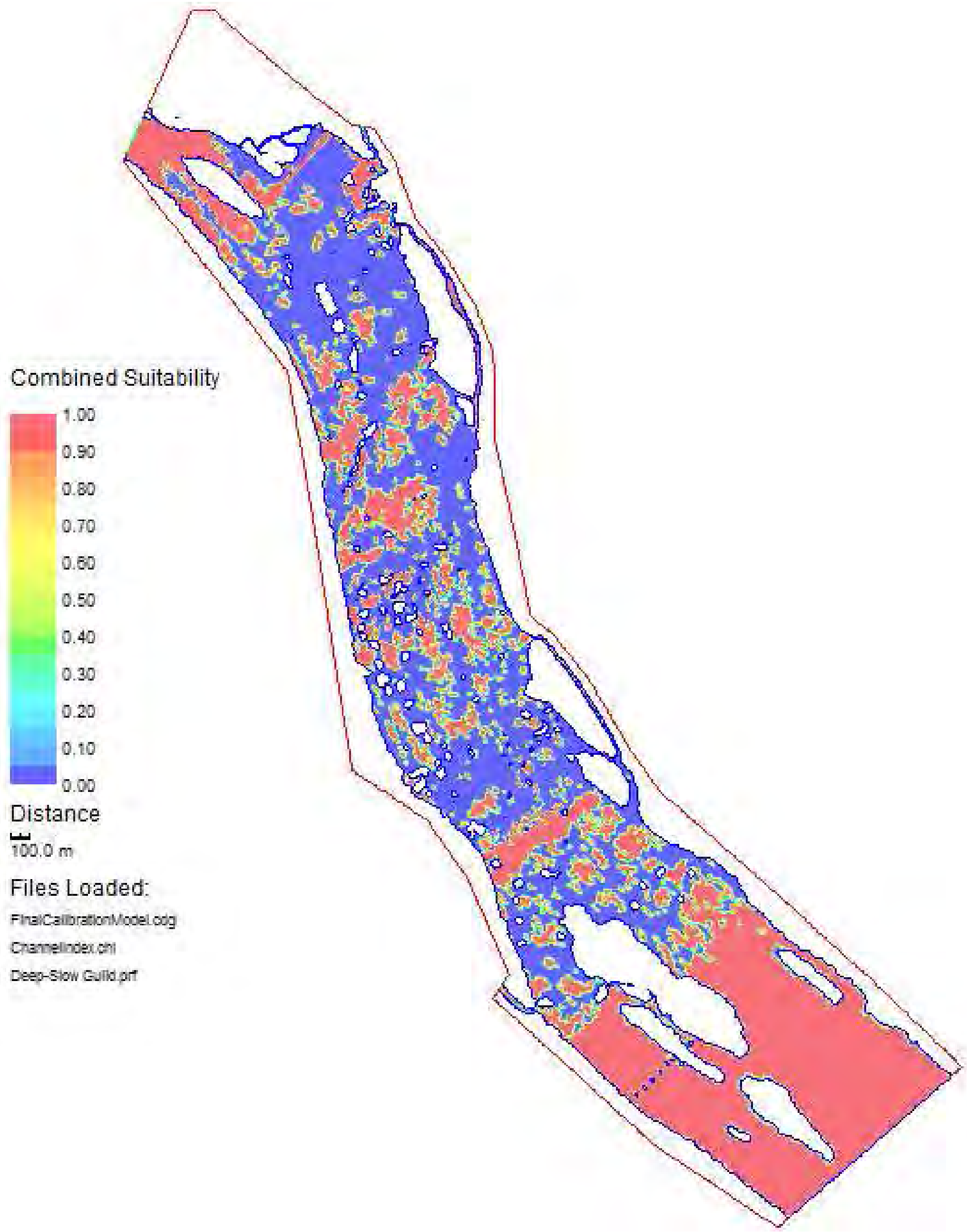
Shallow-Fast Guild – 80,000 cfs



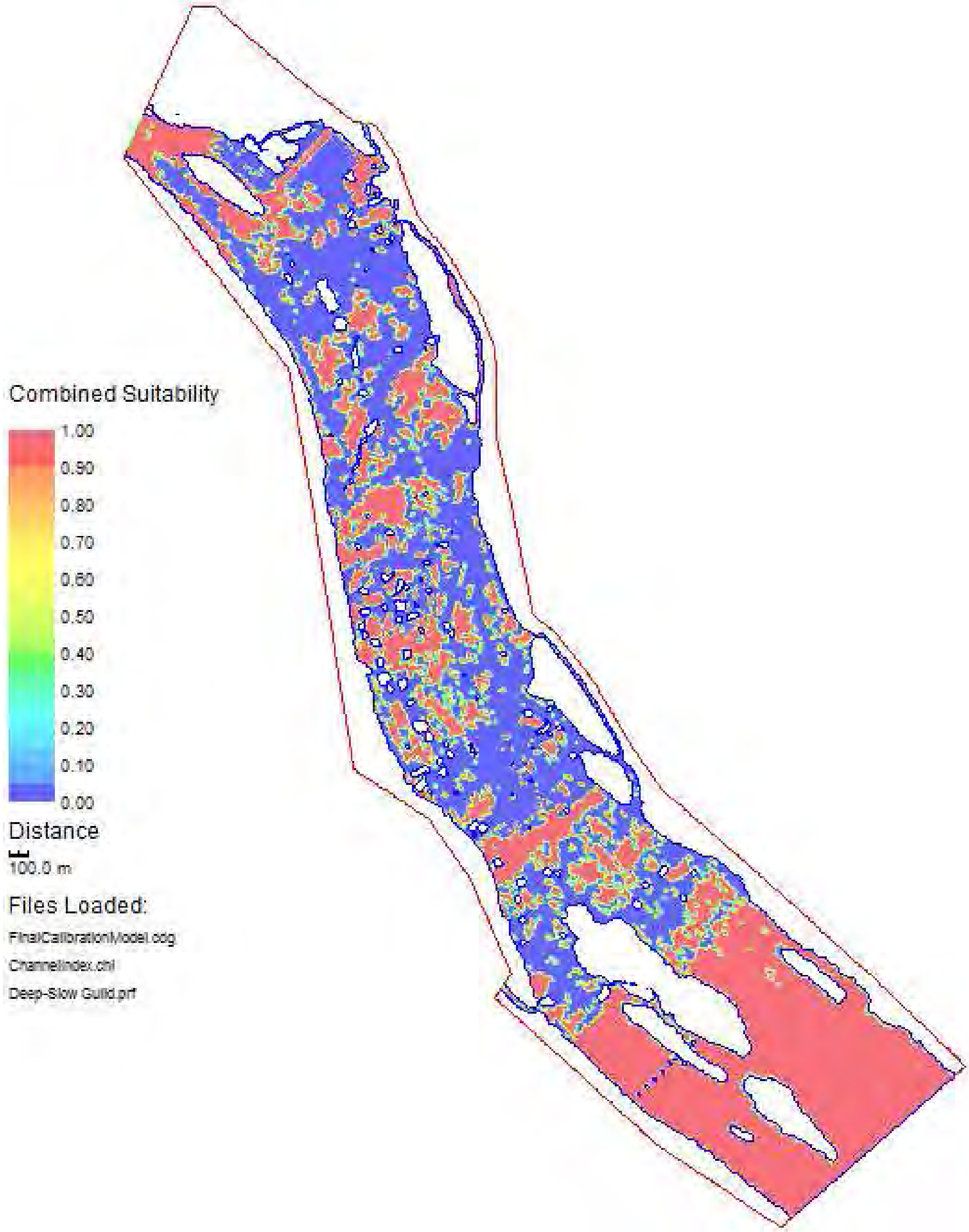
Shallow-Fast Guild – 86,000 cfs



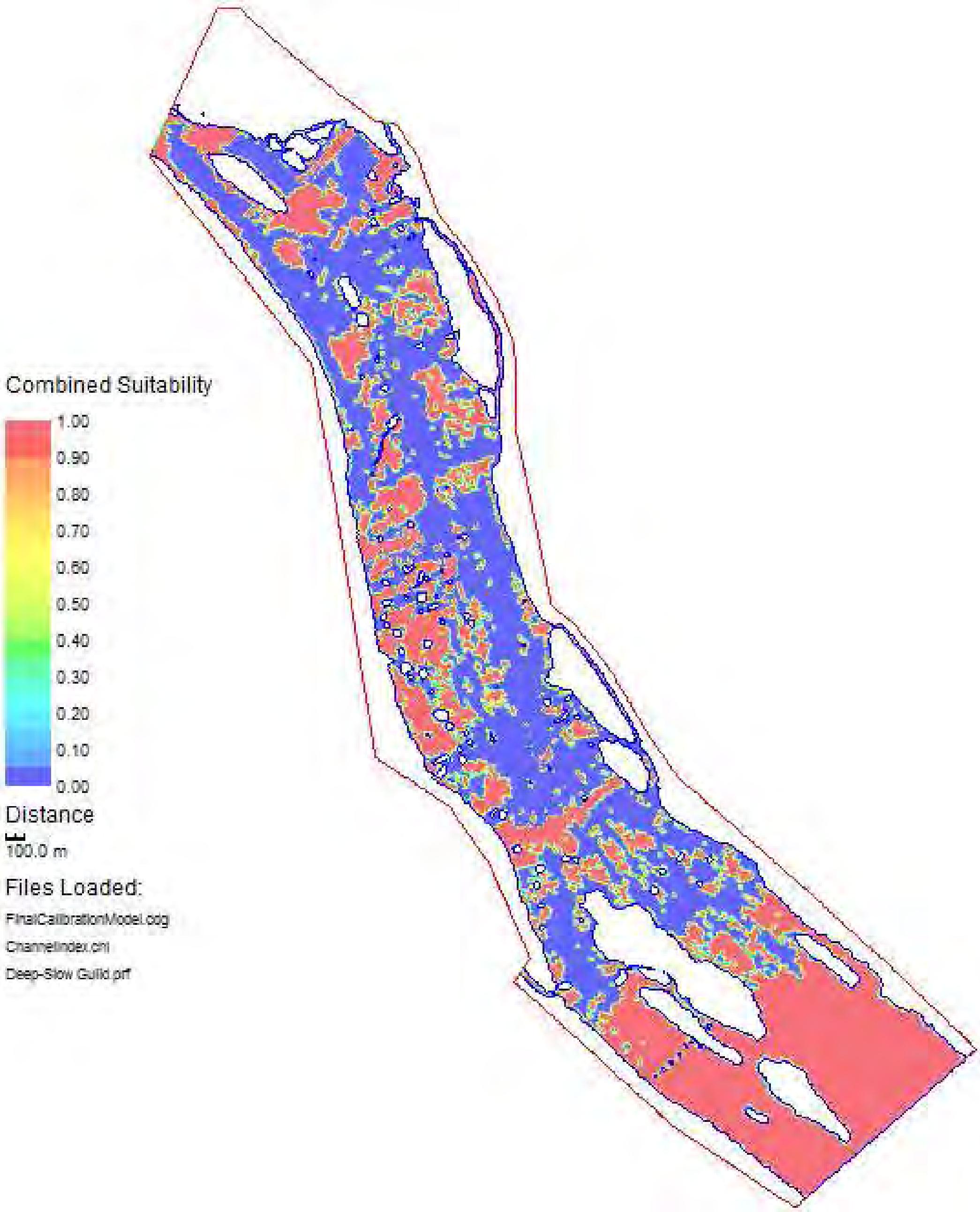
Deep-Slow Guild – 2,000 cfs



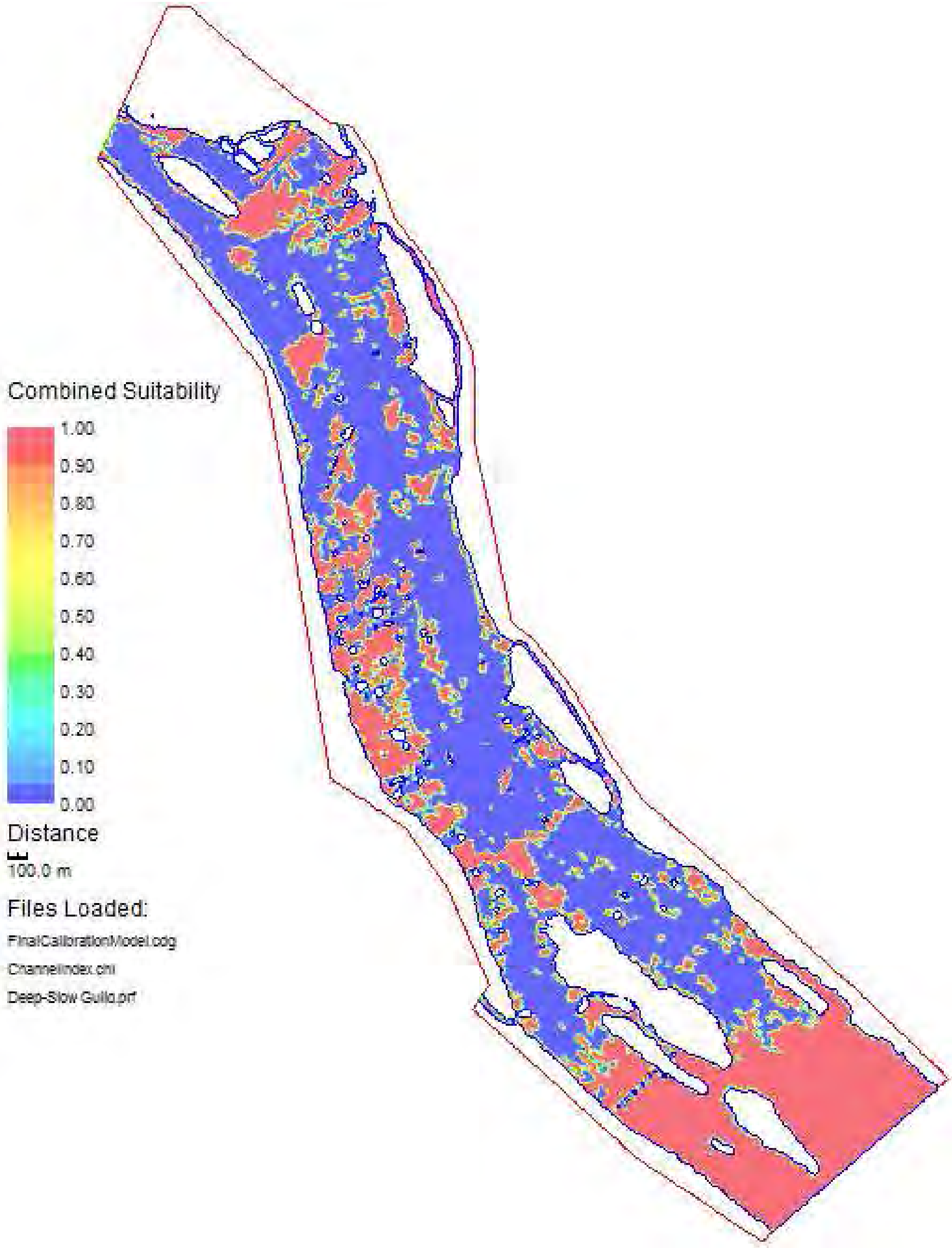
Deep-Slow Guild – 3,500 cfs



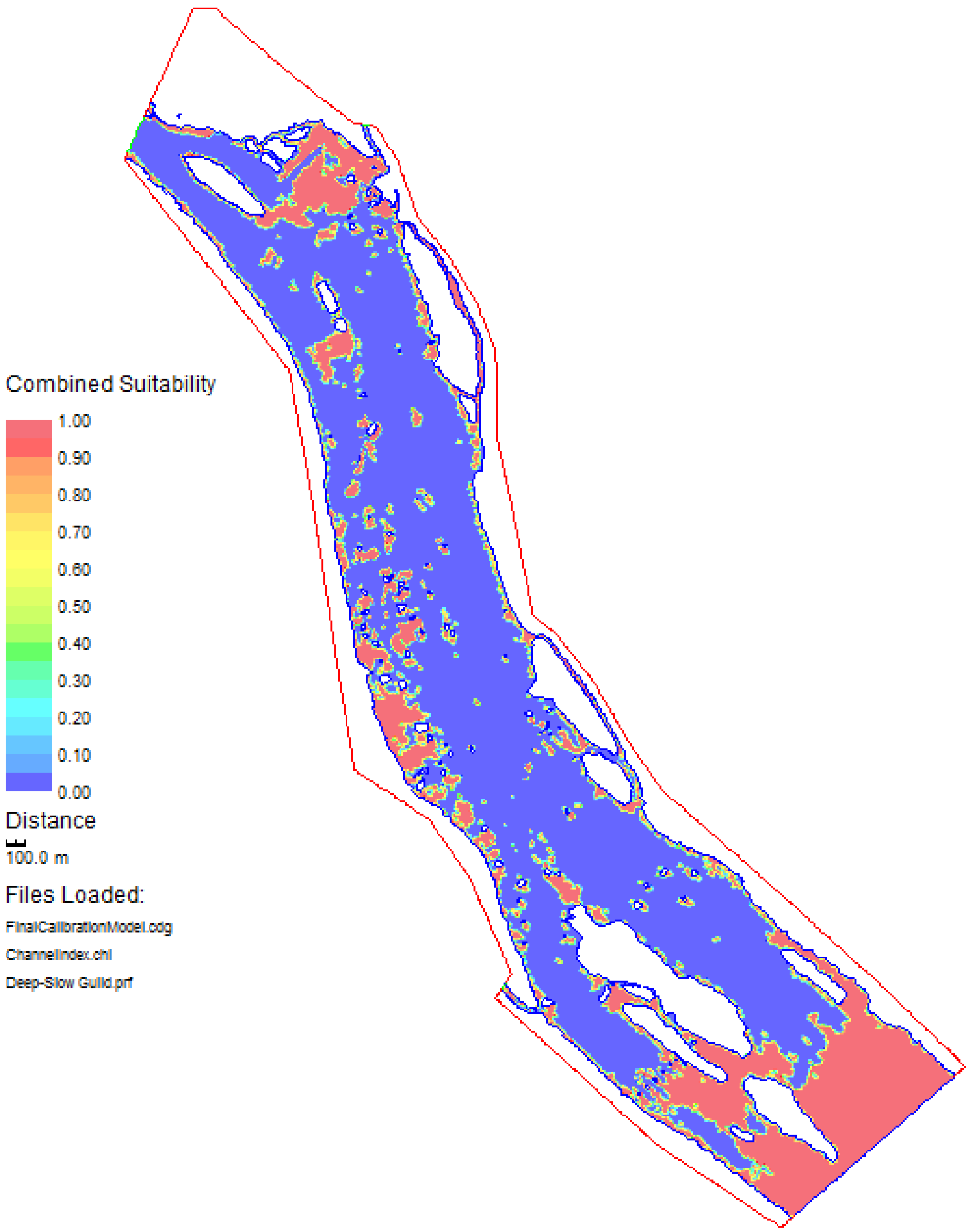
Deep-Slow Guild – 5,000 cfs



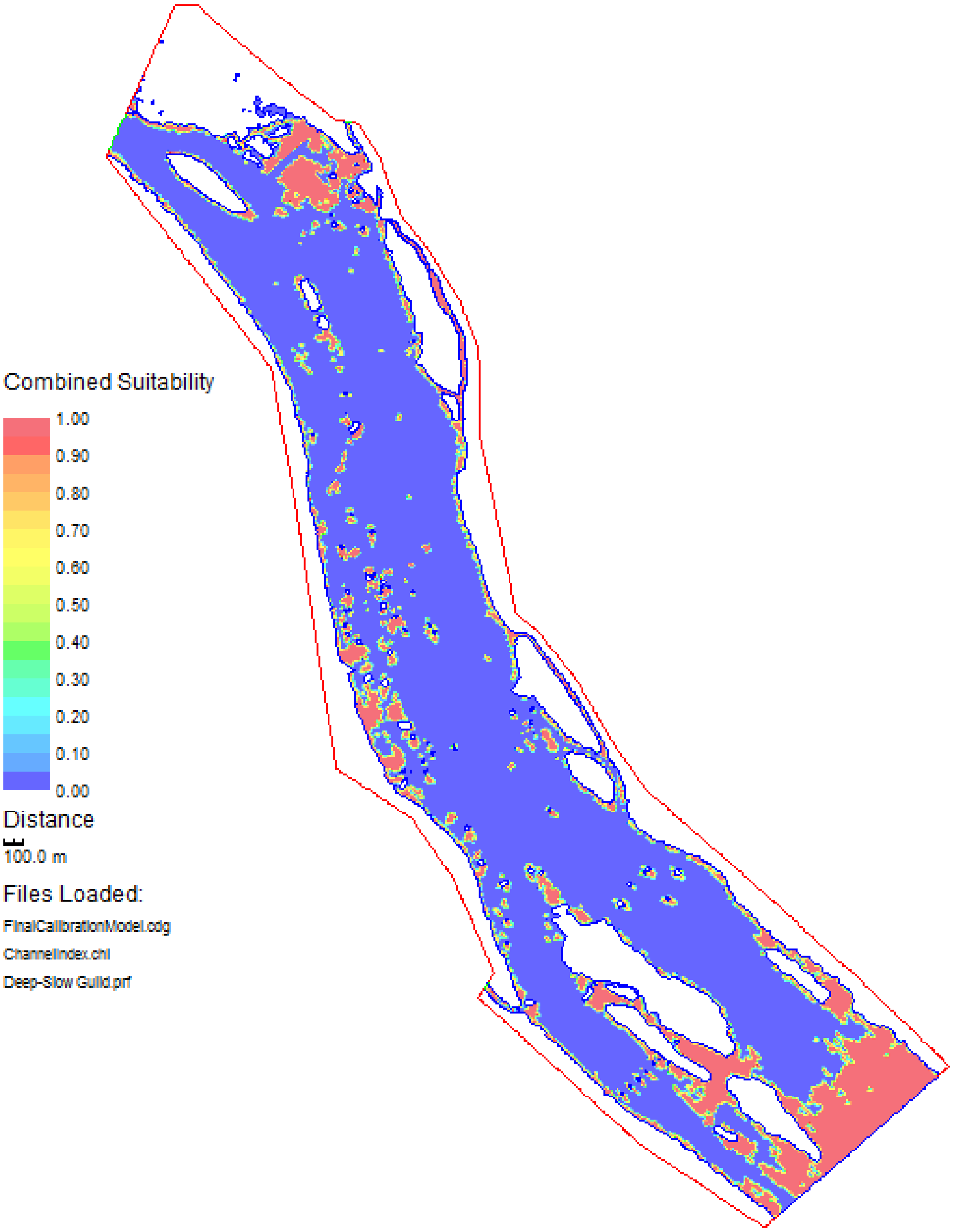
Deep-Slow Guild – 7,500 cfs



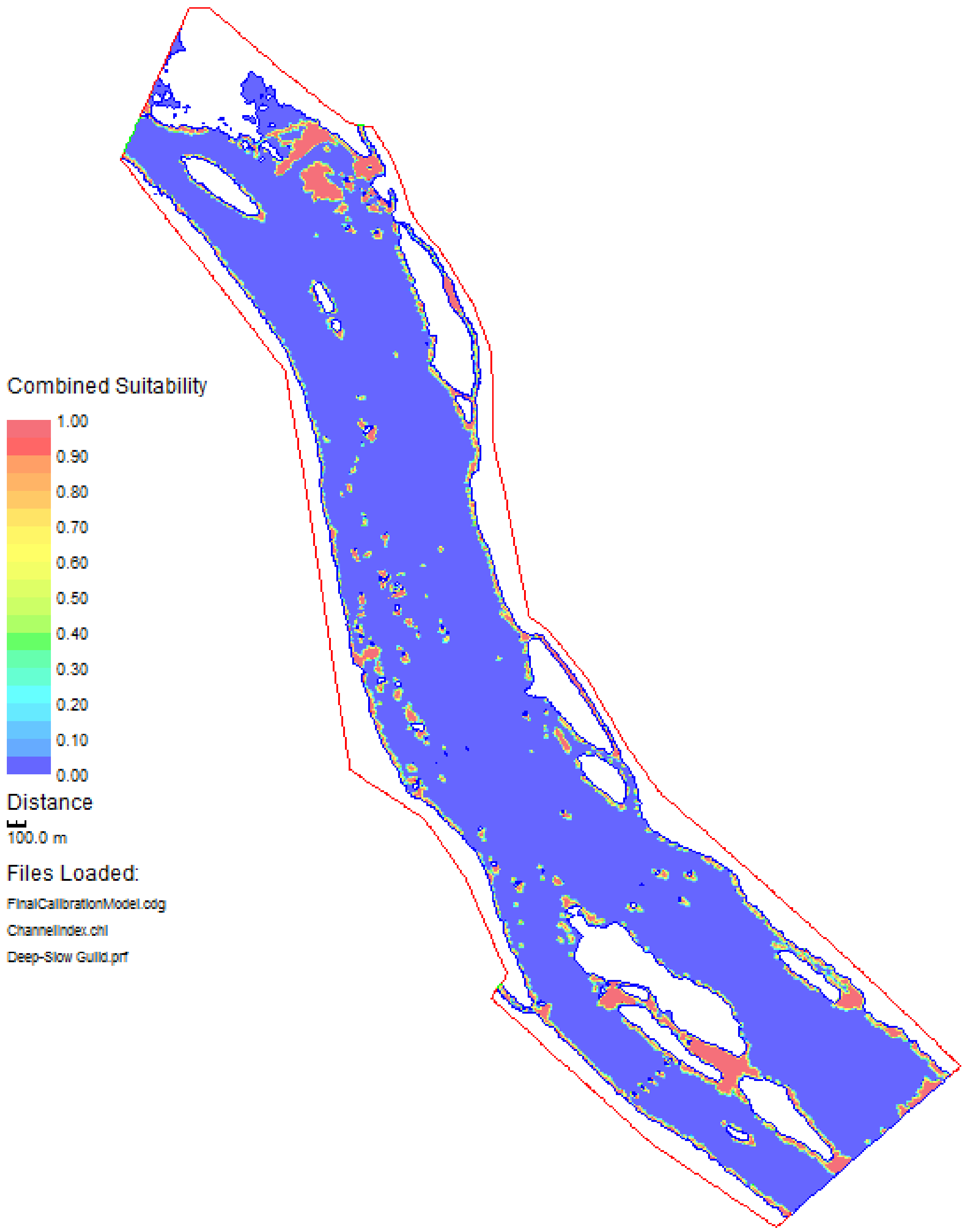
Deep-Slow Guild – 10,000 cfs



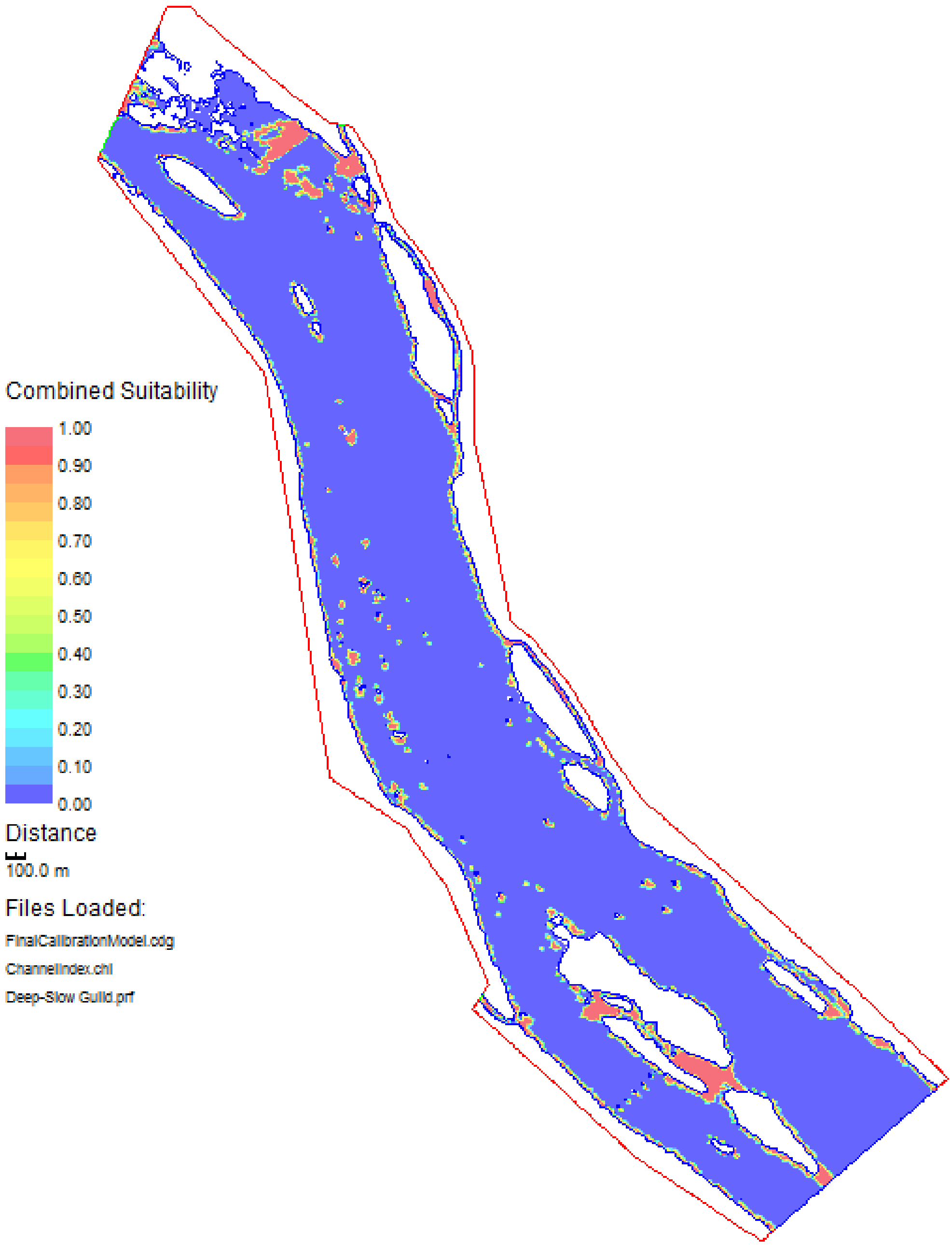
Deep-Slow Guild – 15,000 cfs



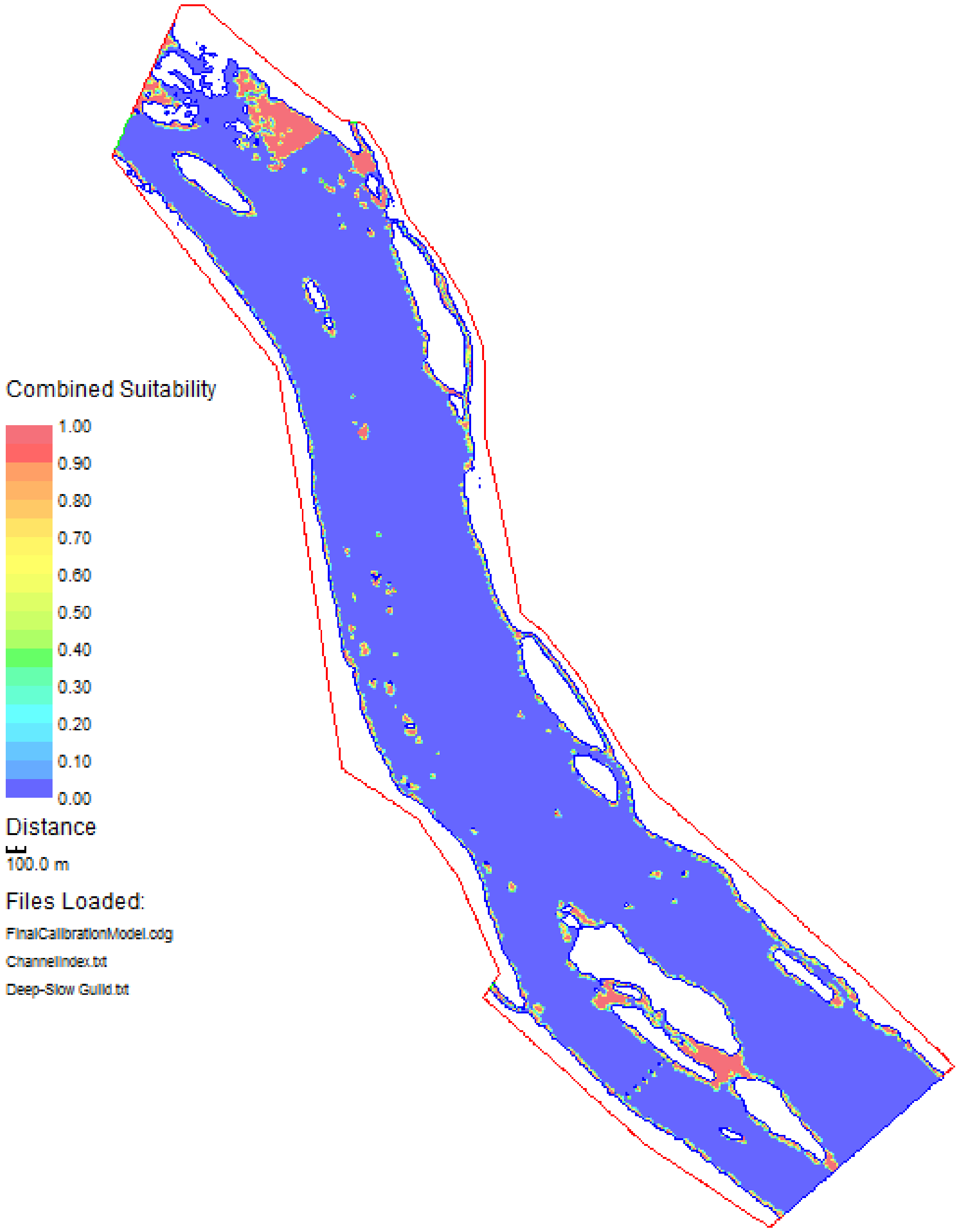
Deep-Slow Guild – 20,000 cfs



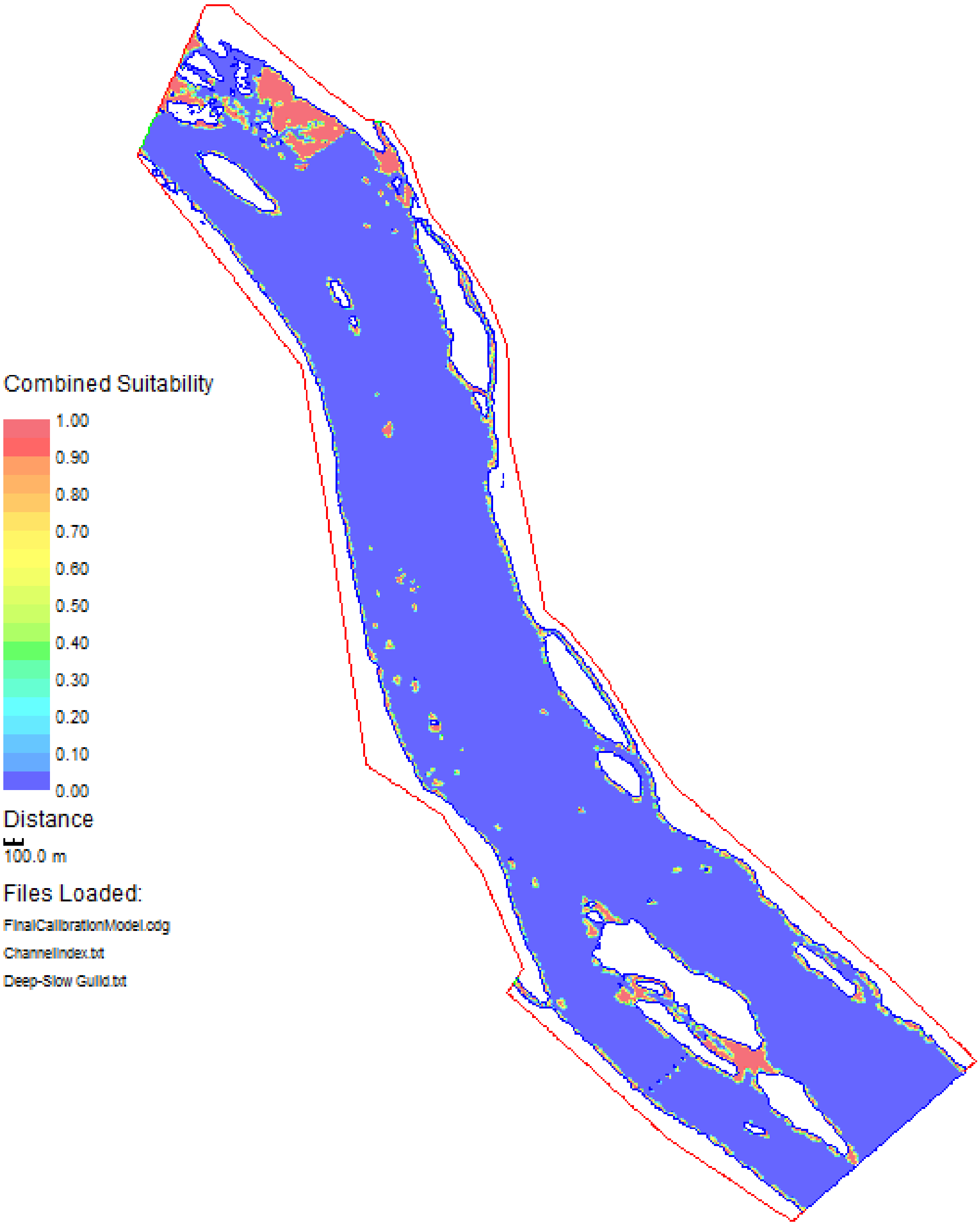
Deep-Slow Guild – 30,000 cfs



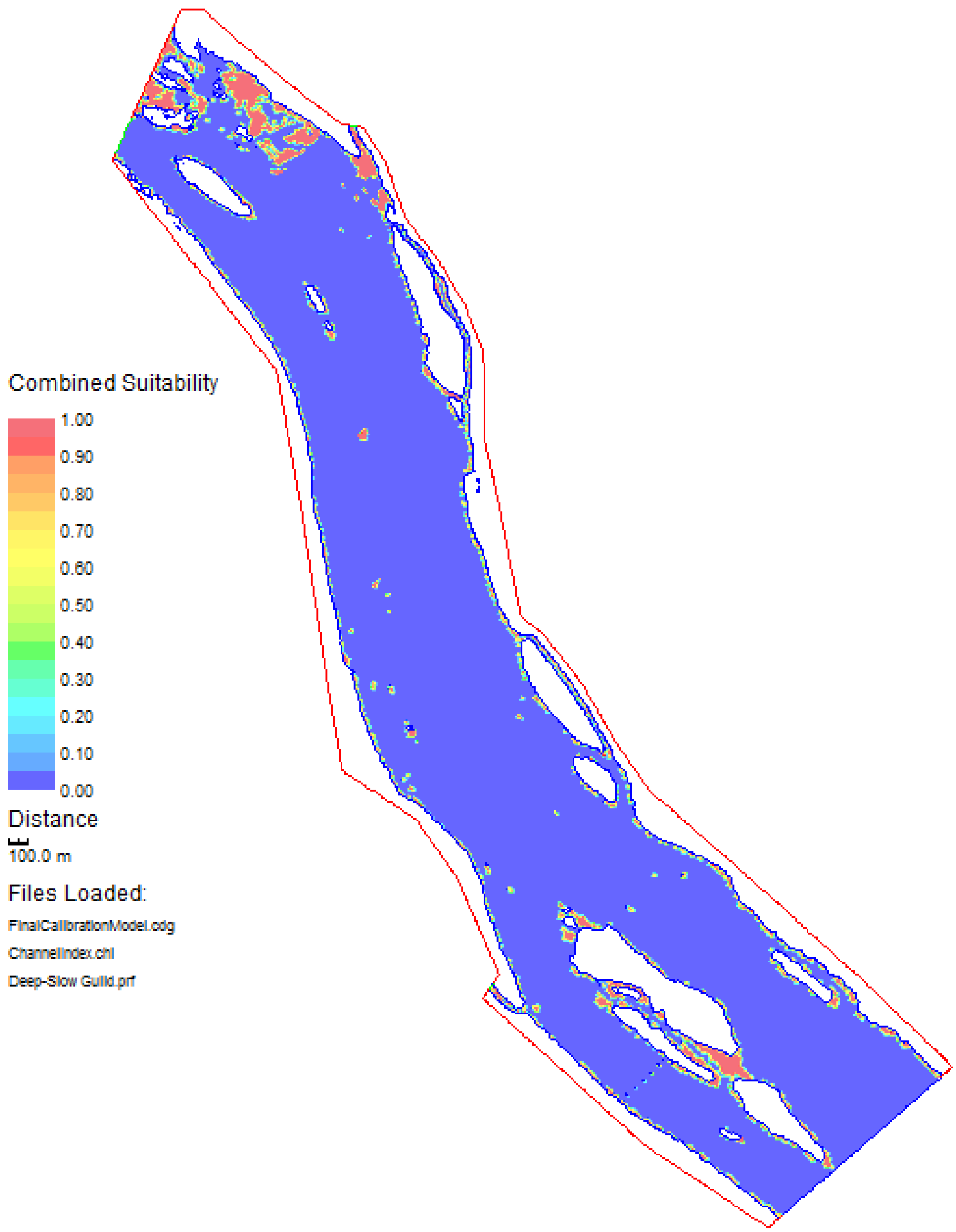
Deep-Slow Guild – 40,000 cfs



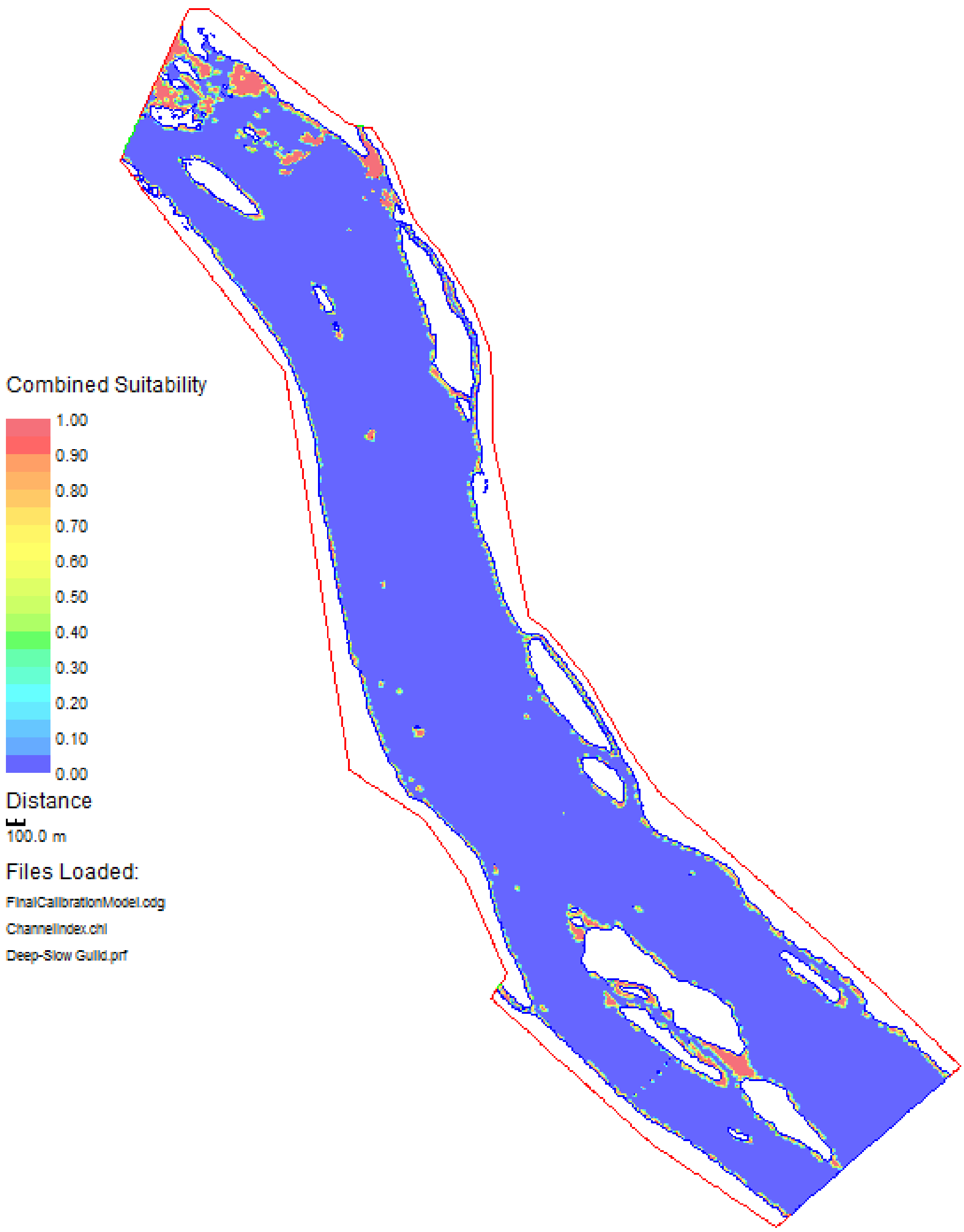
Deep-Slow Guild – 50,000 cfs



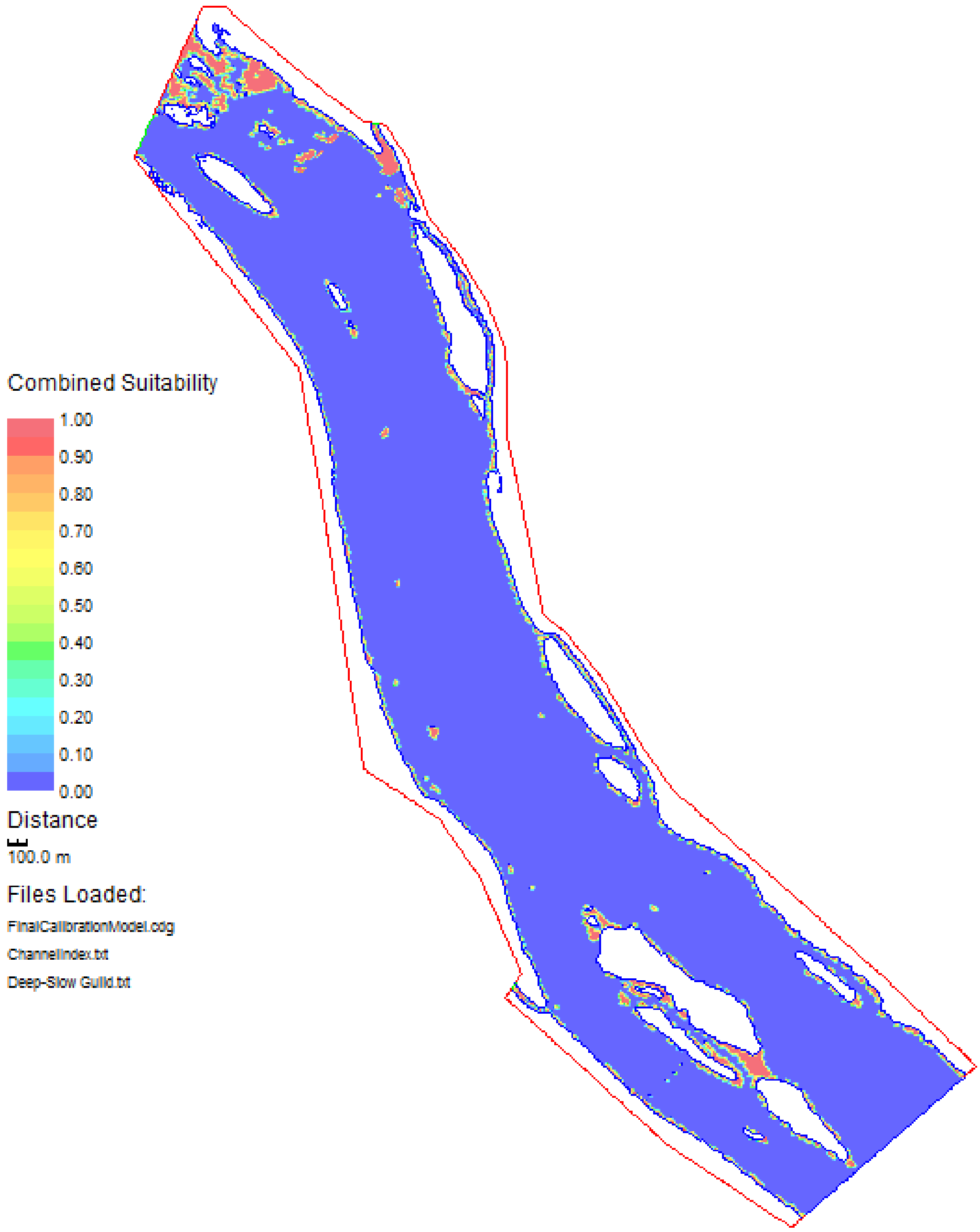
Deep-Slow Guild – 60,000 cfs



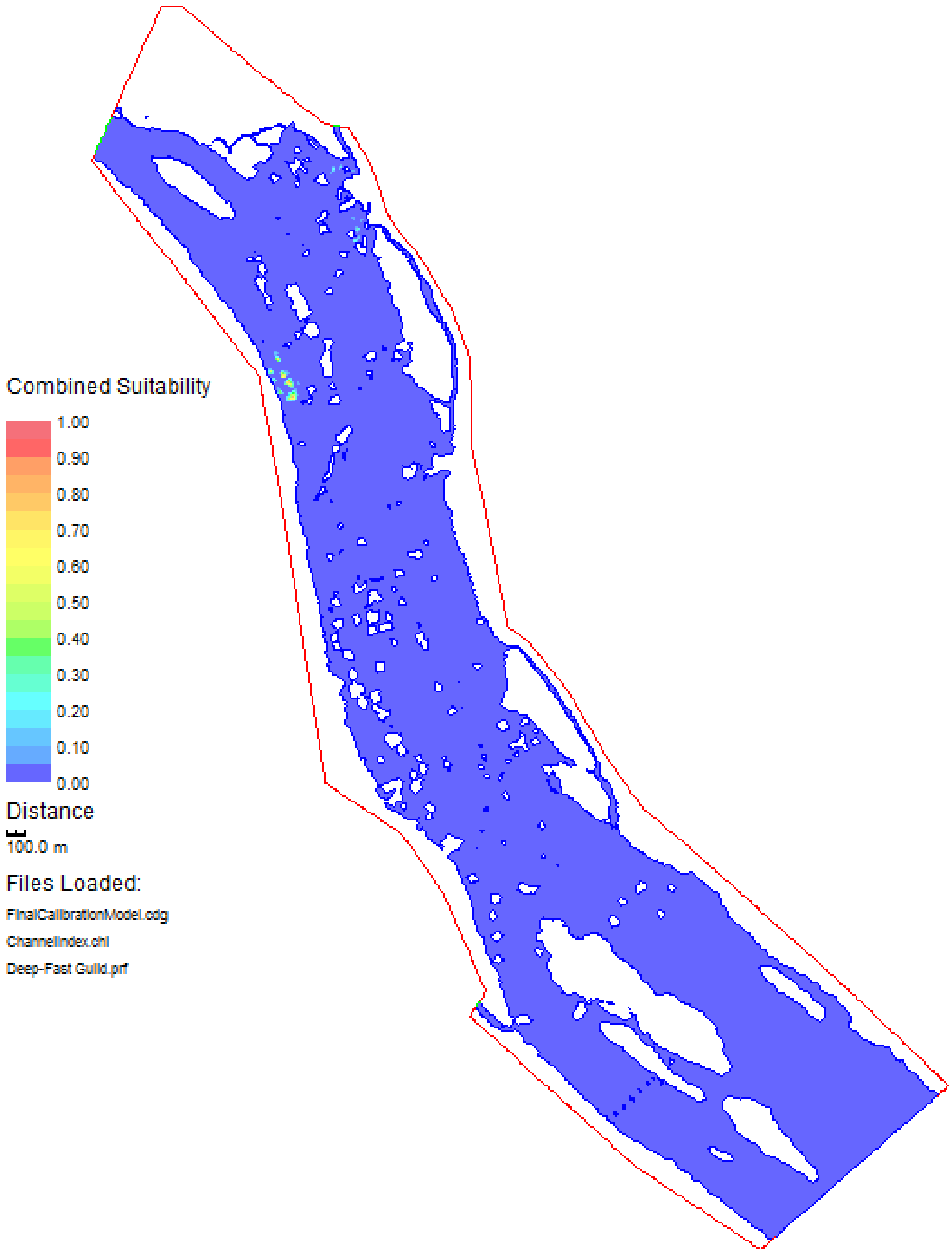
Deep-Slow Guild – 70,000 cfs



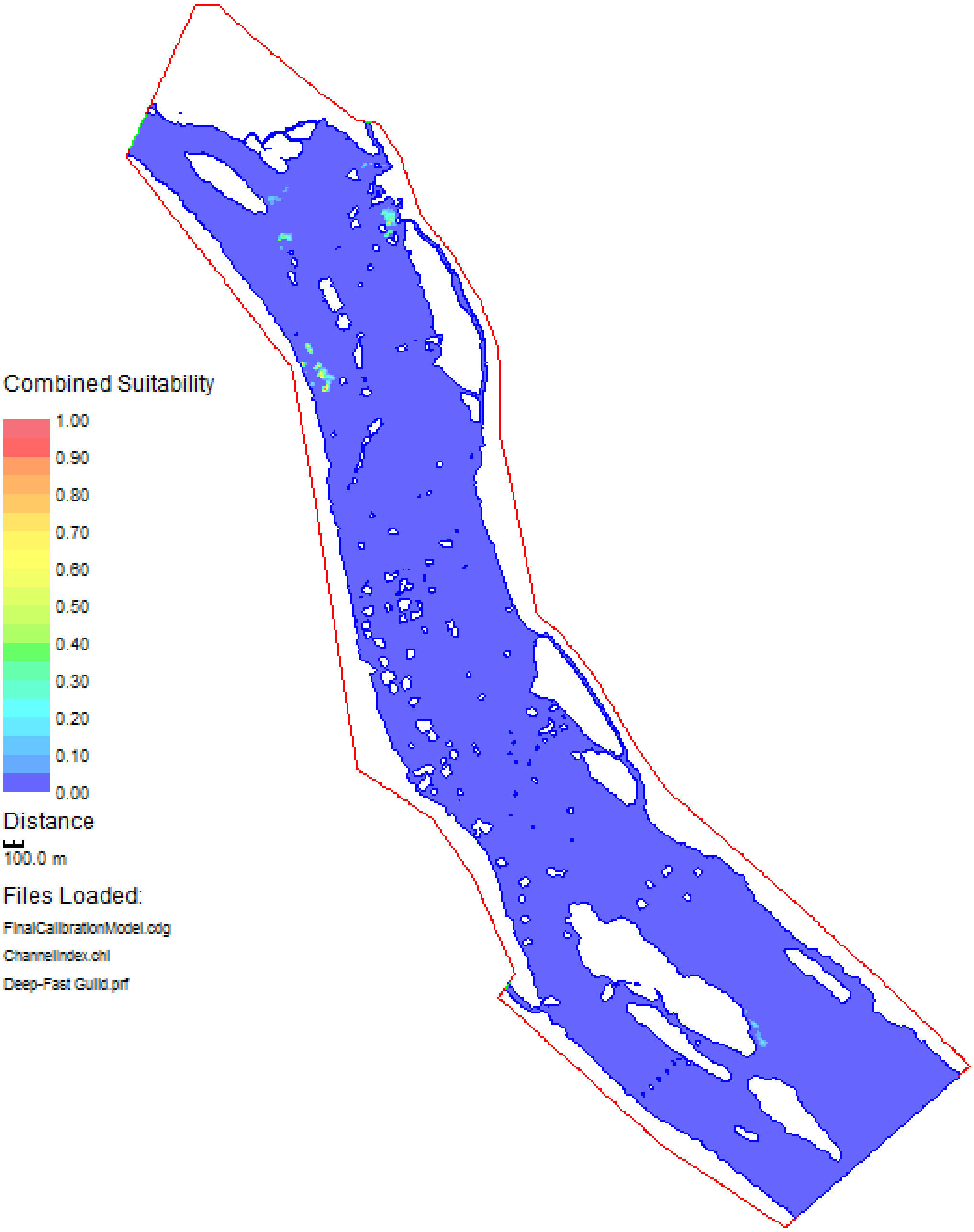
Deep-Slow Guild – 80,000 cfs



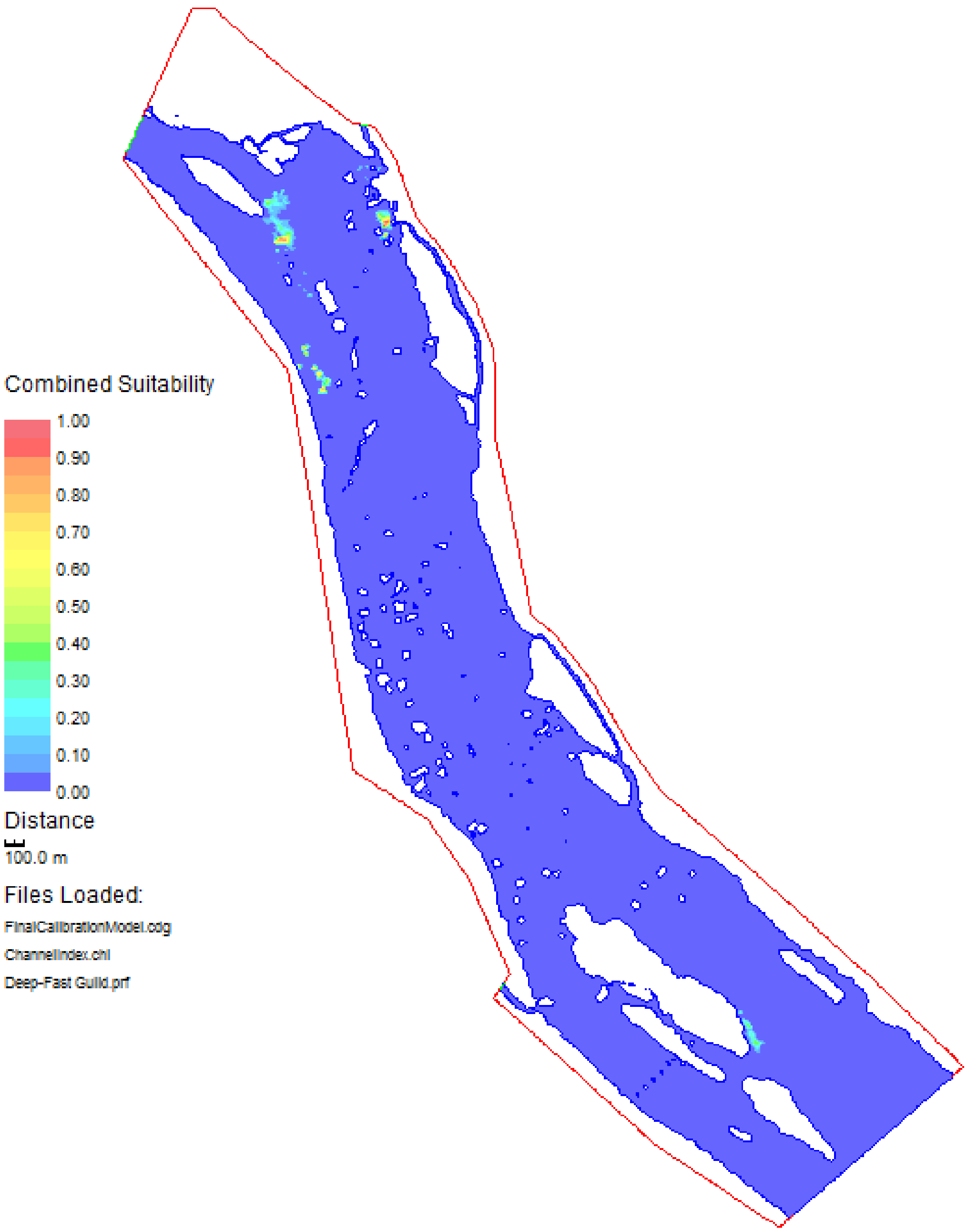
Deep-Slow Guild – 86,000 cfs



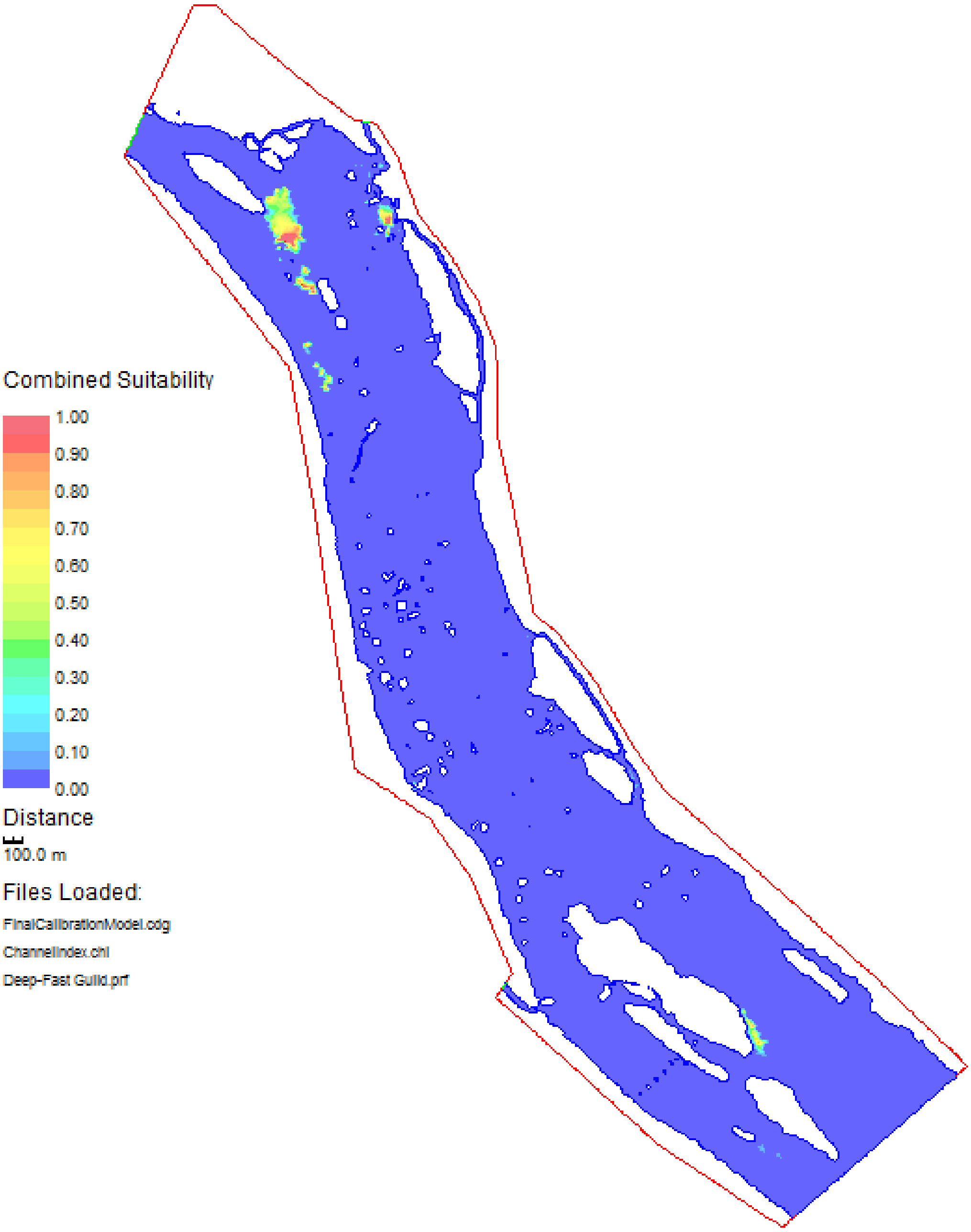
Deep-Fast Guild – 2,000 cfs



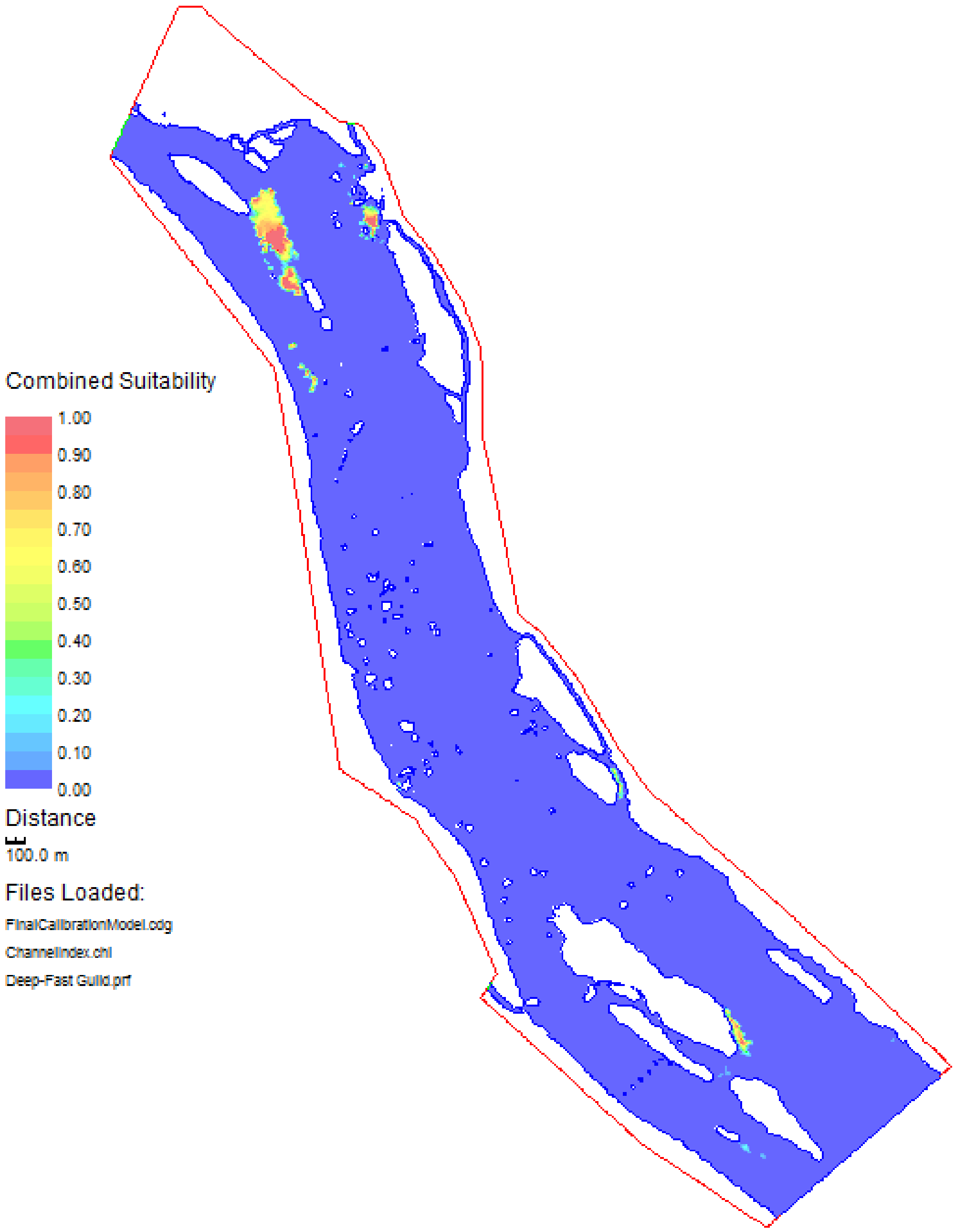
Deep-Fast Guild – 3,500 cfs



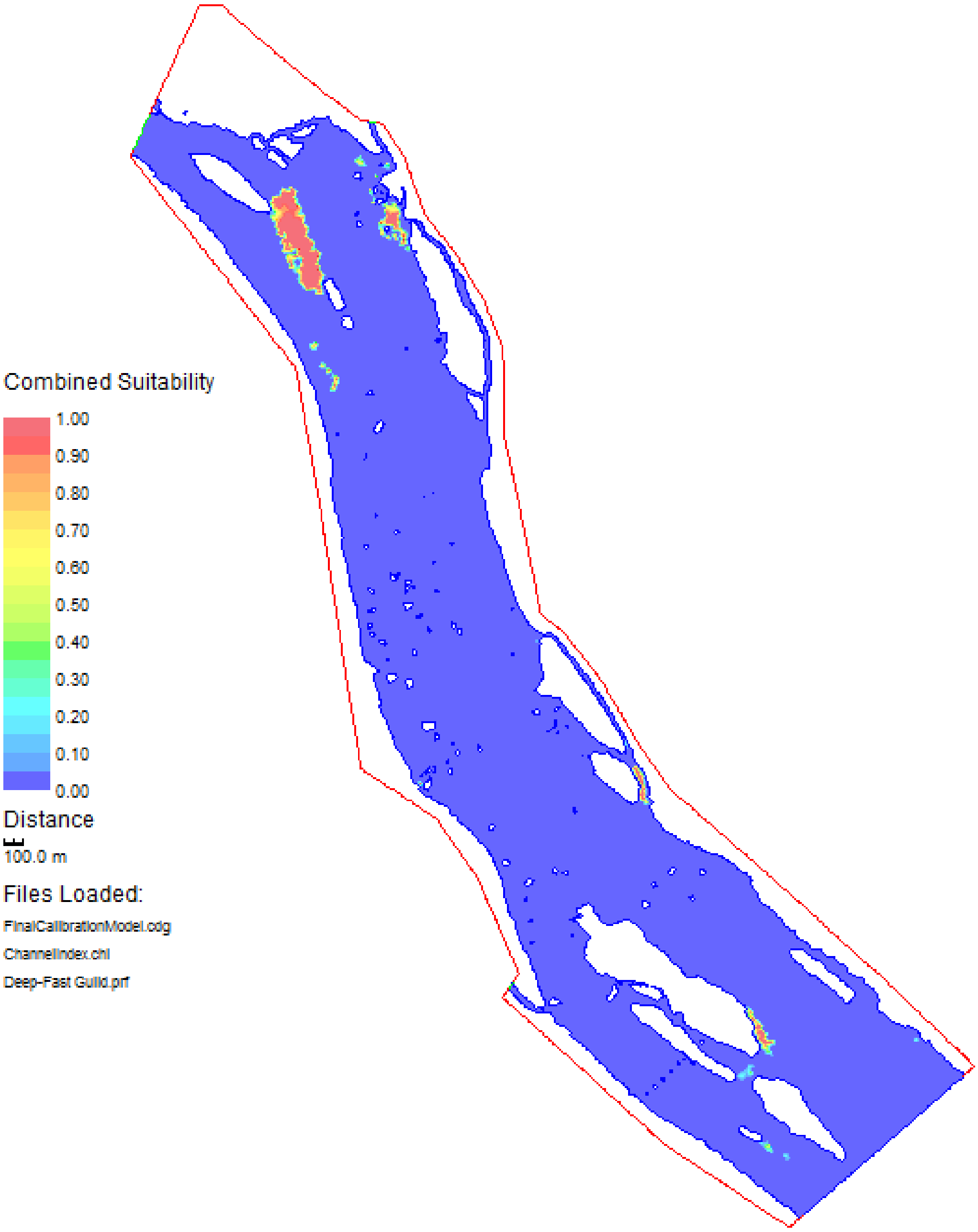
Deep-Fast Guild – 5,000 cfs



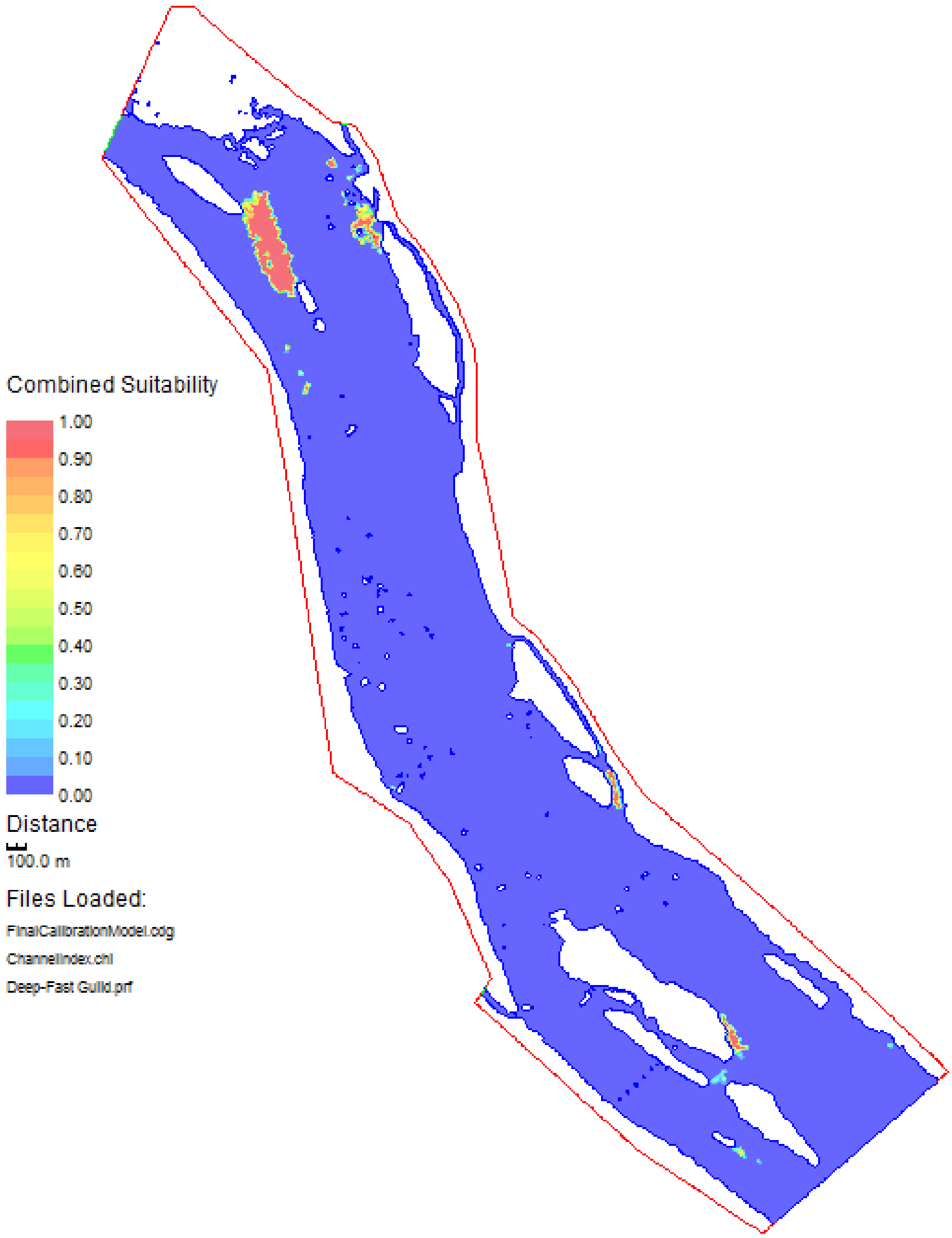
Deep-Fast Guild – 7,500 cfs



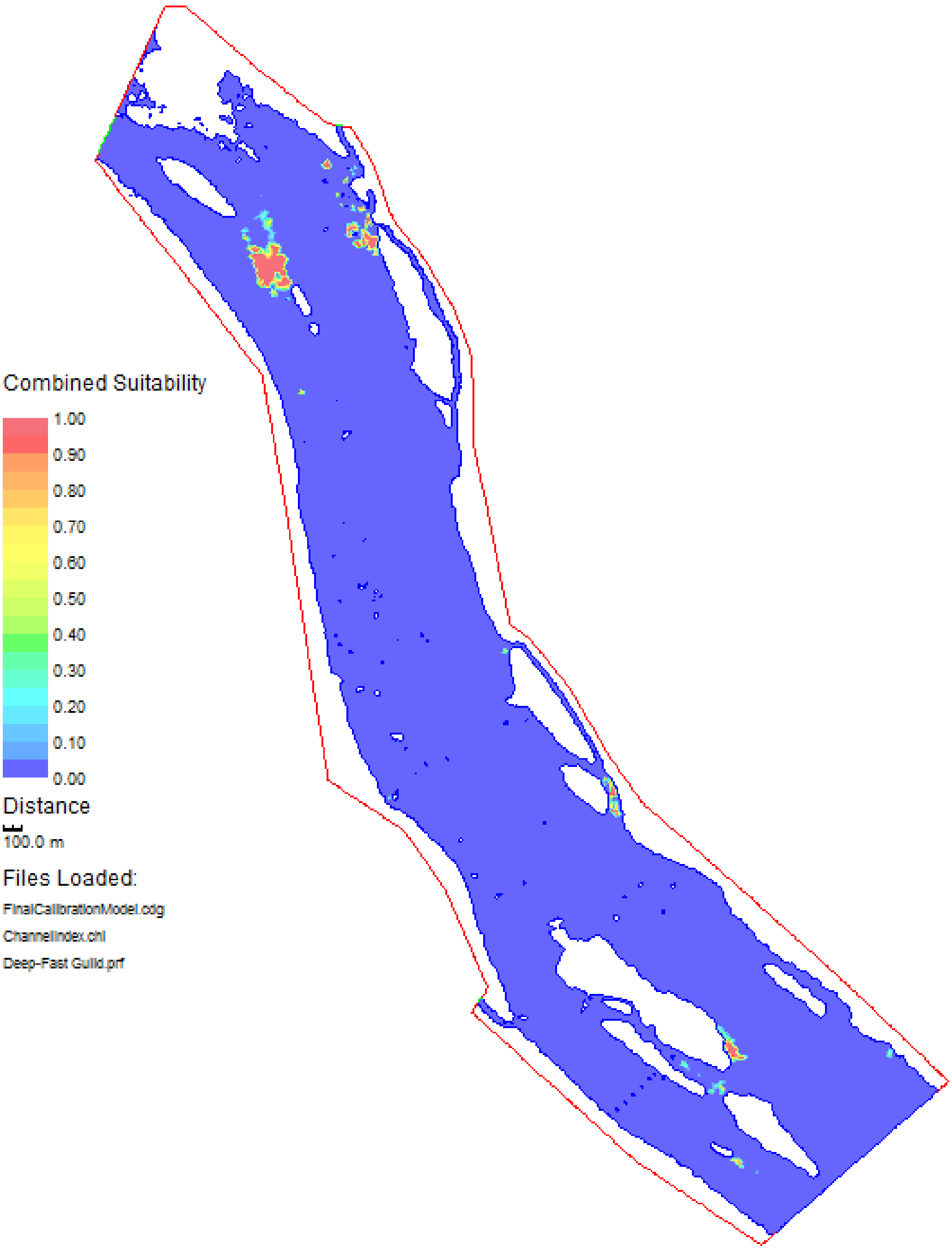
Deep-Fast Guild – 10,000 cfs



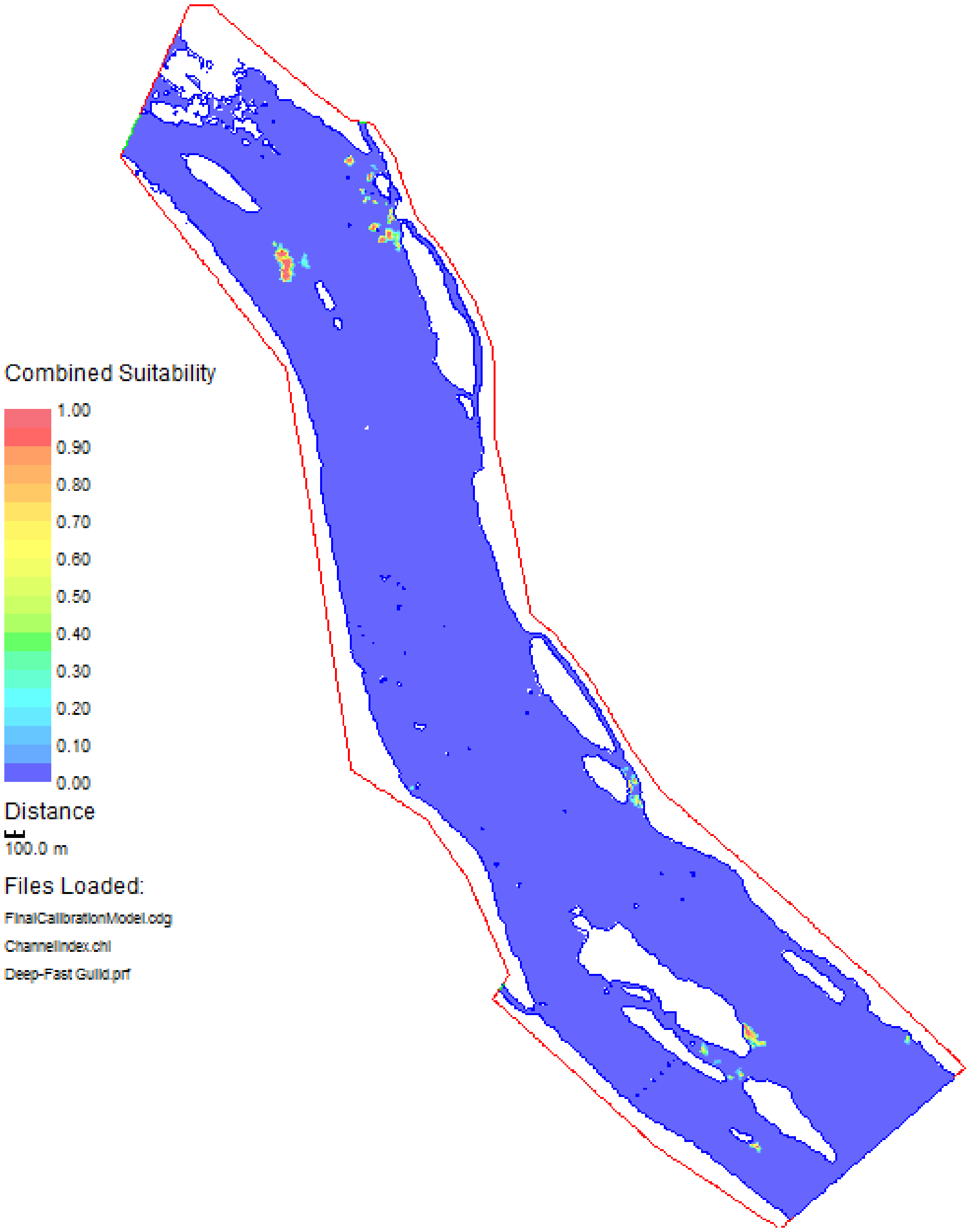
Deep-Fast Guild – 15,000 cfs



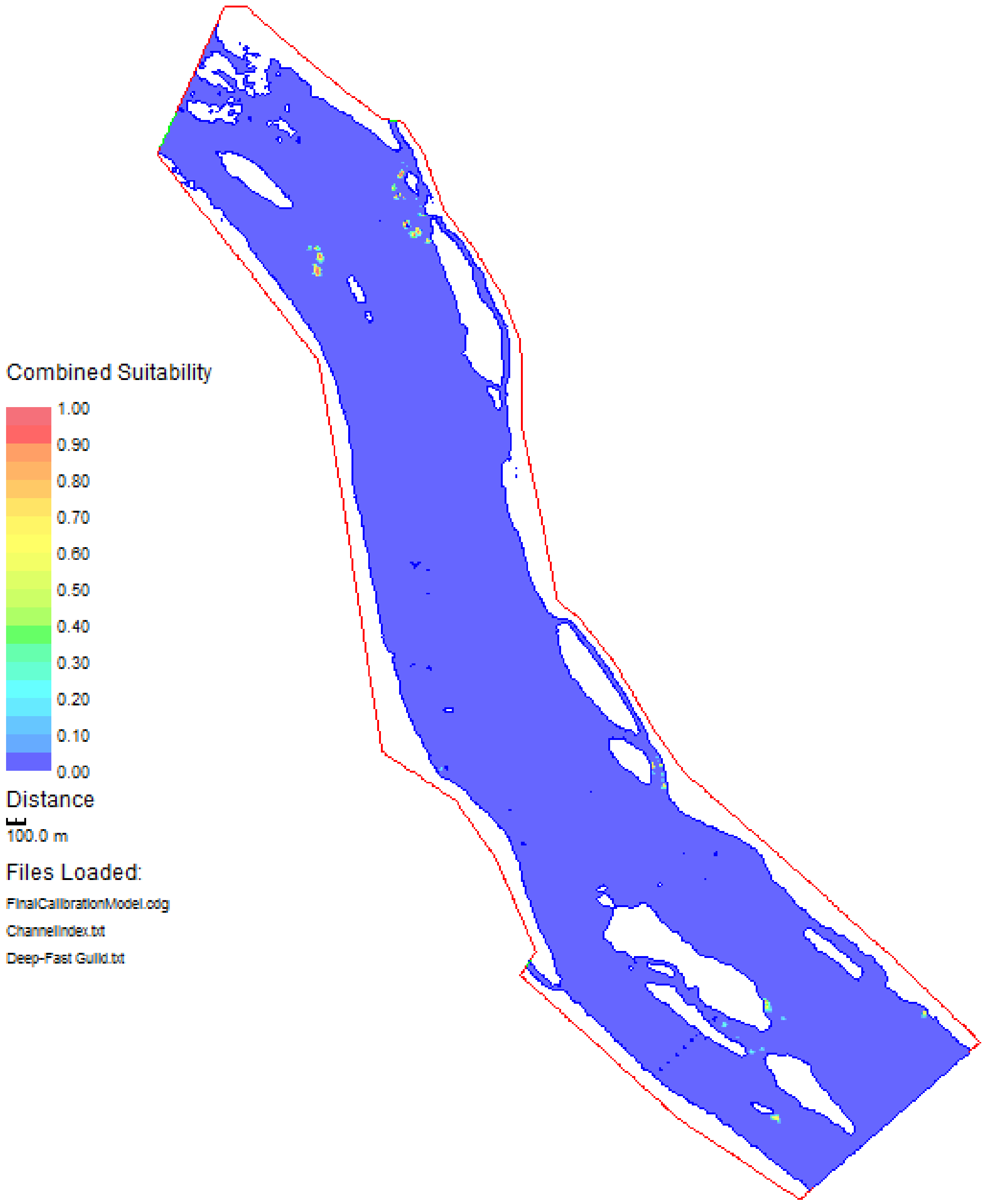
Deep-Fast Guild – 20,000 cfs



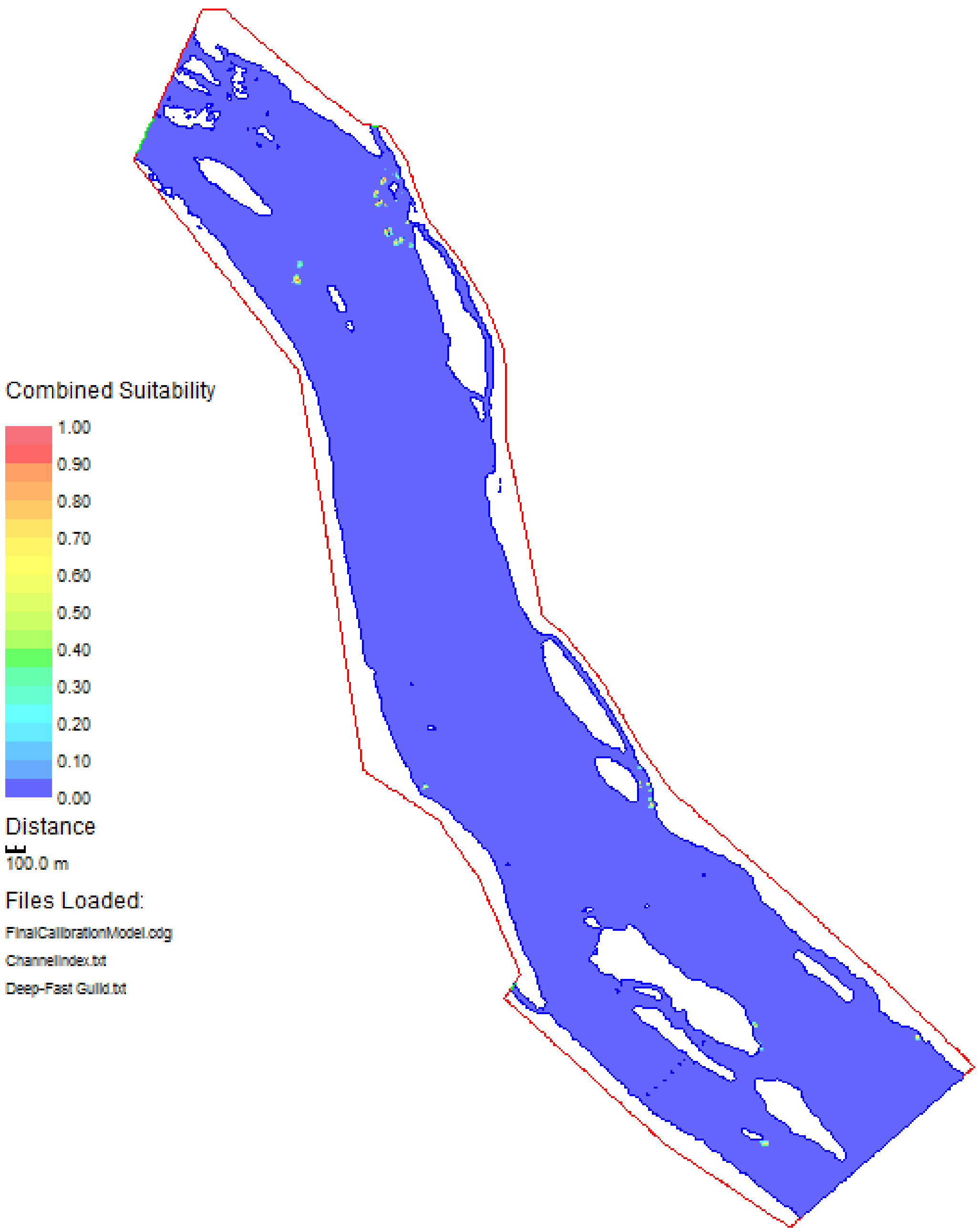
Deep-Fast Guild – 30,000 cfs



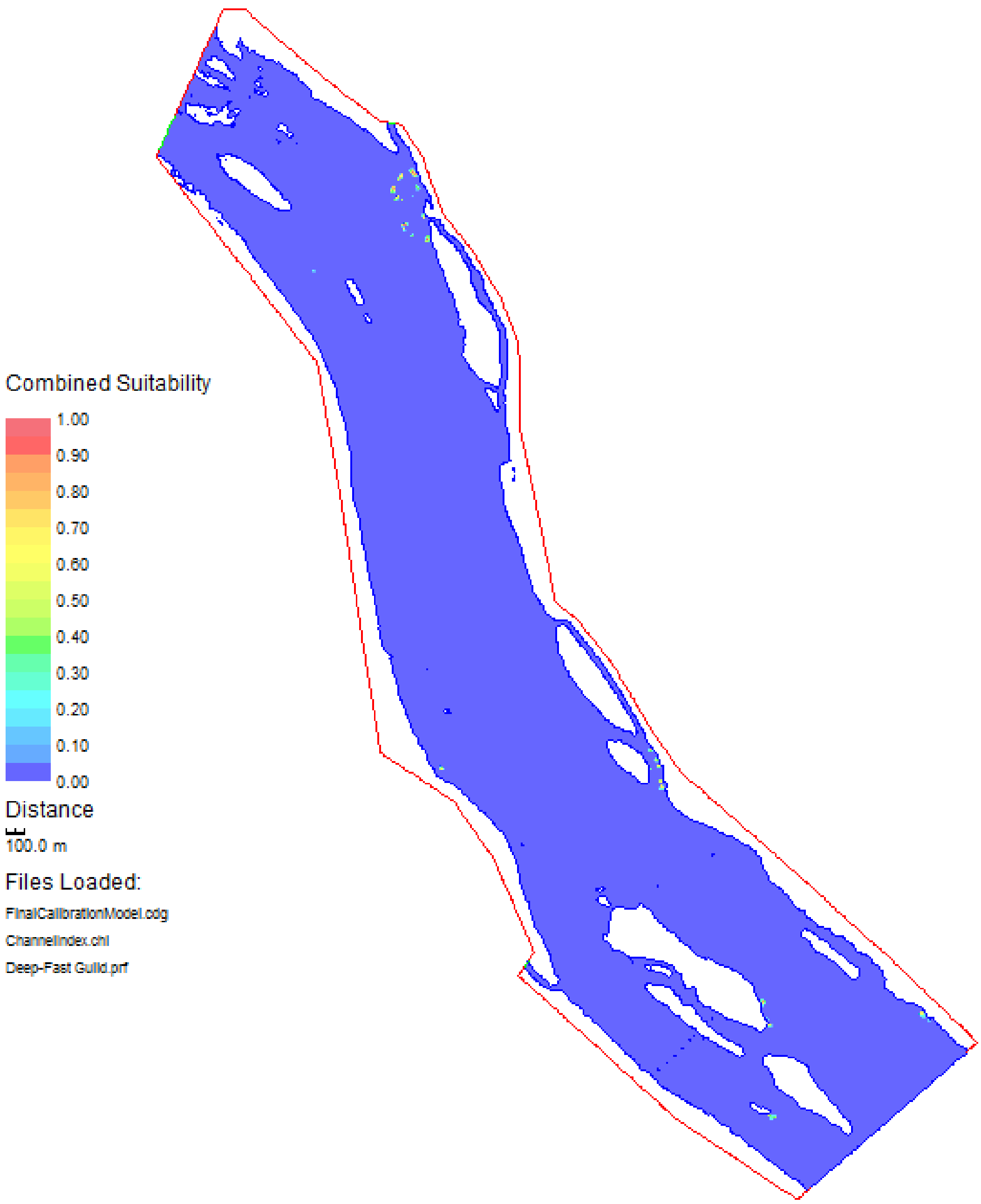
Deep-Fast Guild – 40,000 cfs



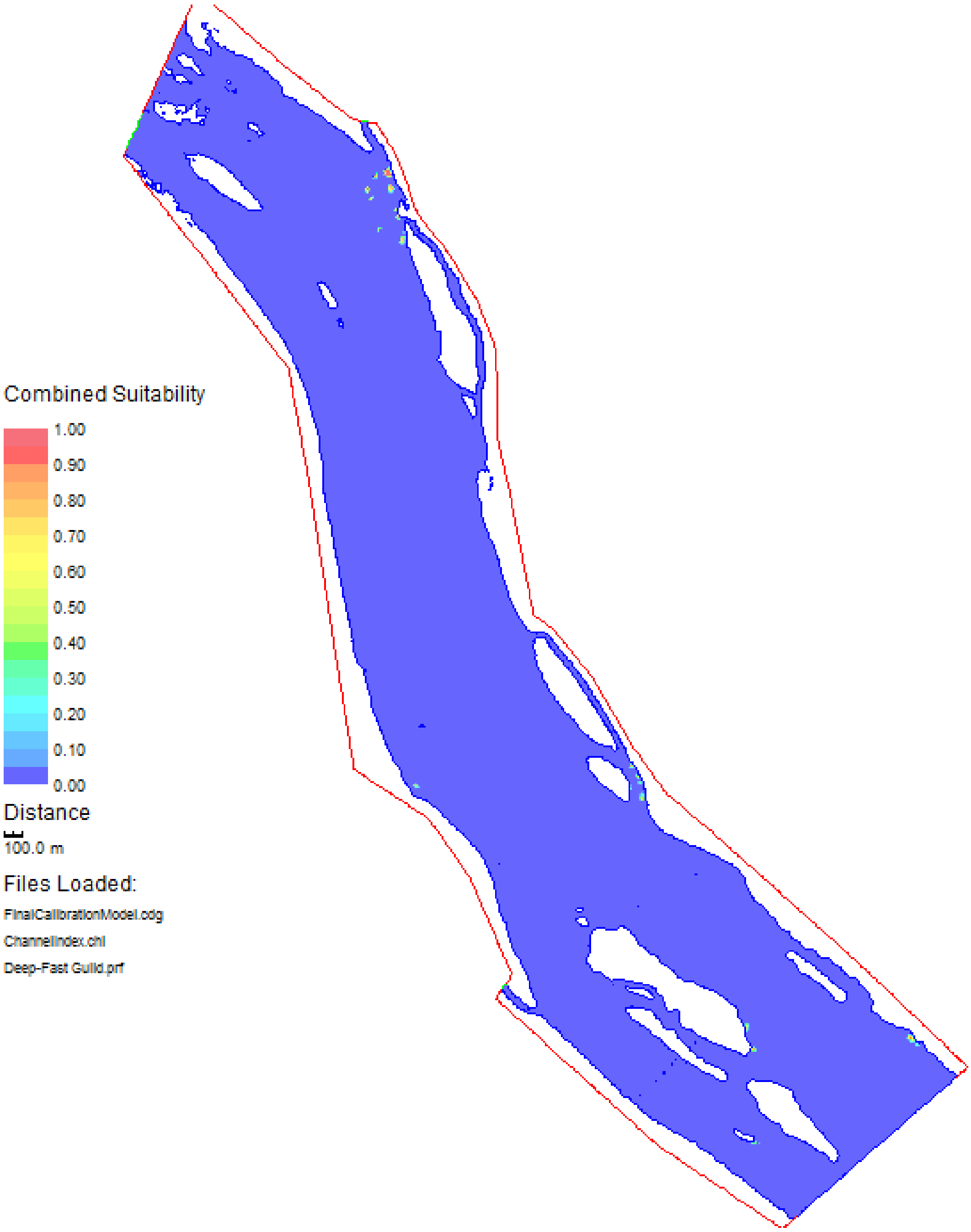
Deep-Fast Guild – 50,000 cfs



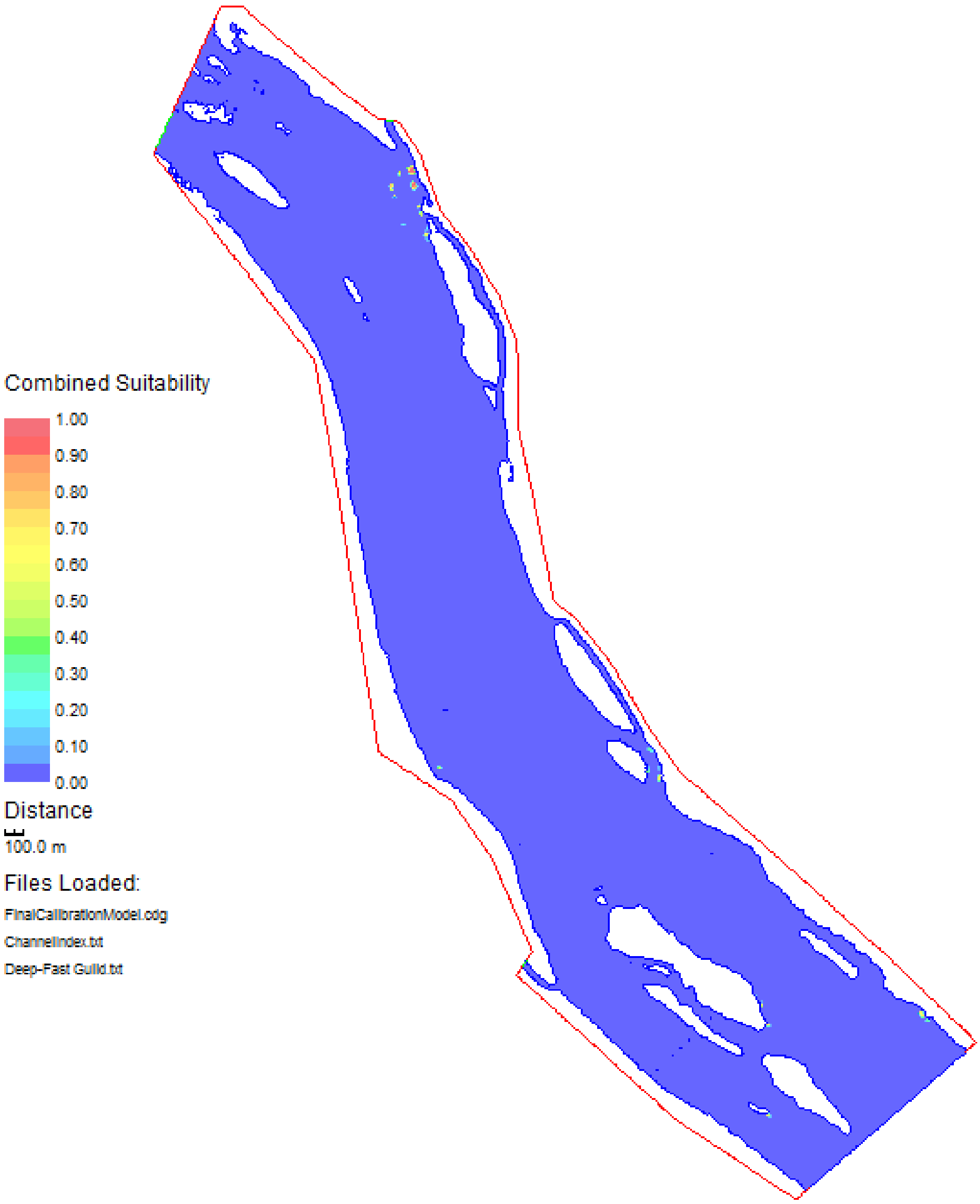
Deep-Fast Guild – 60,000 cfs



Deep-Fast Guild – 70,000 cfs

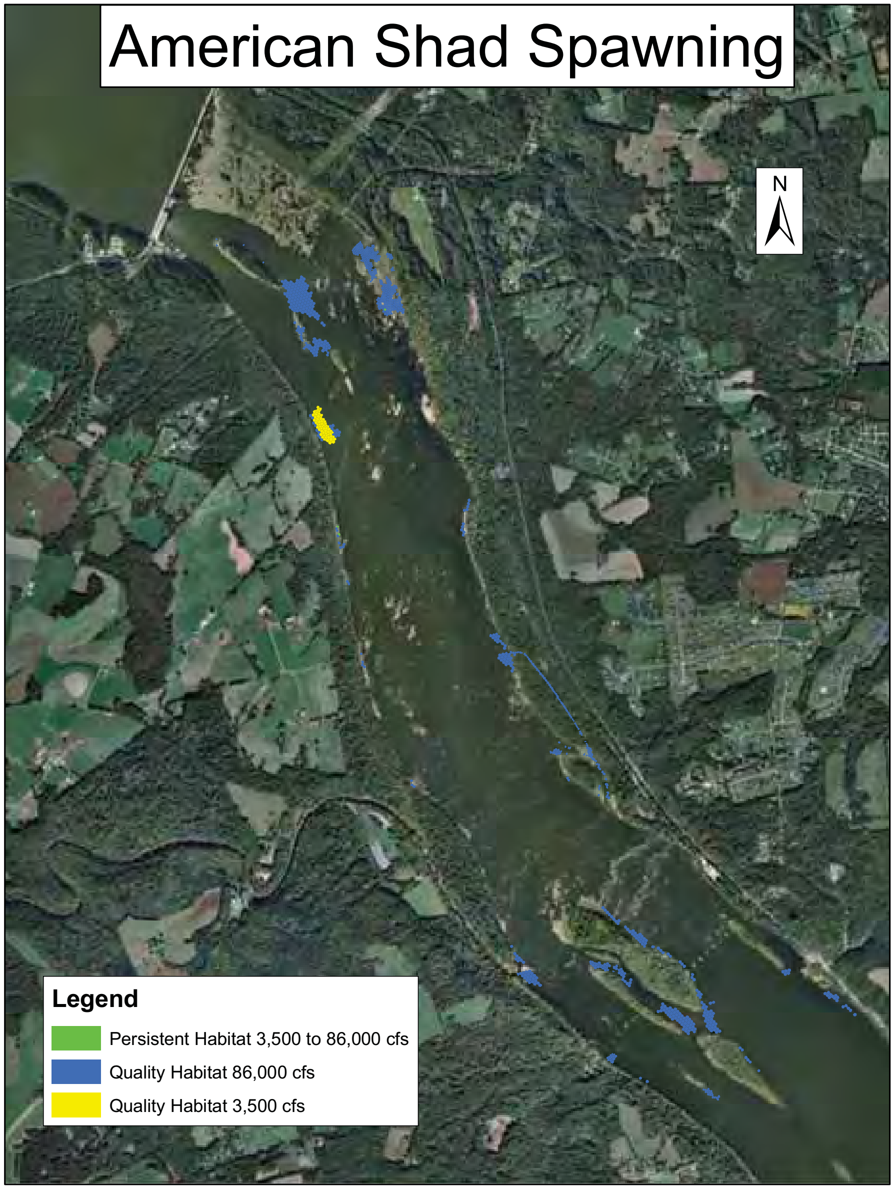


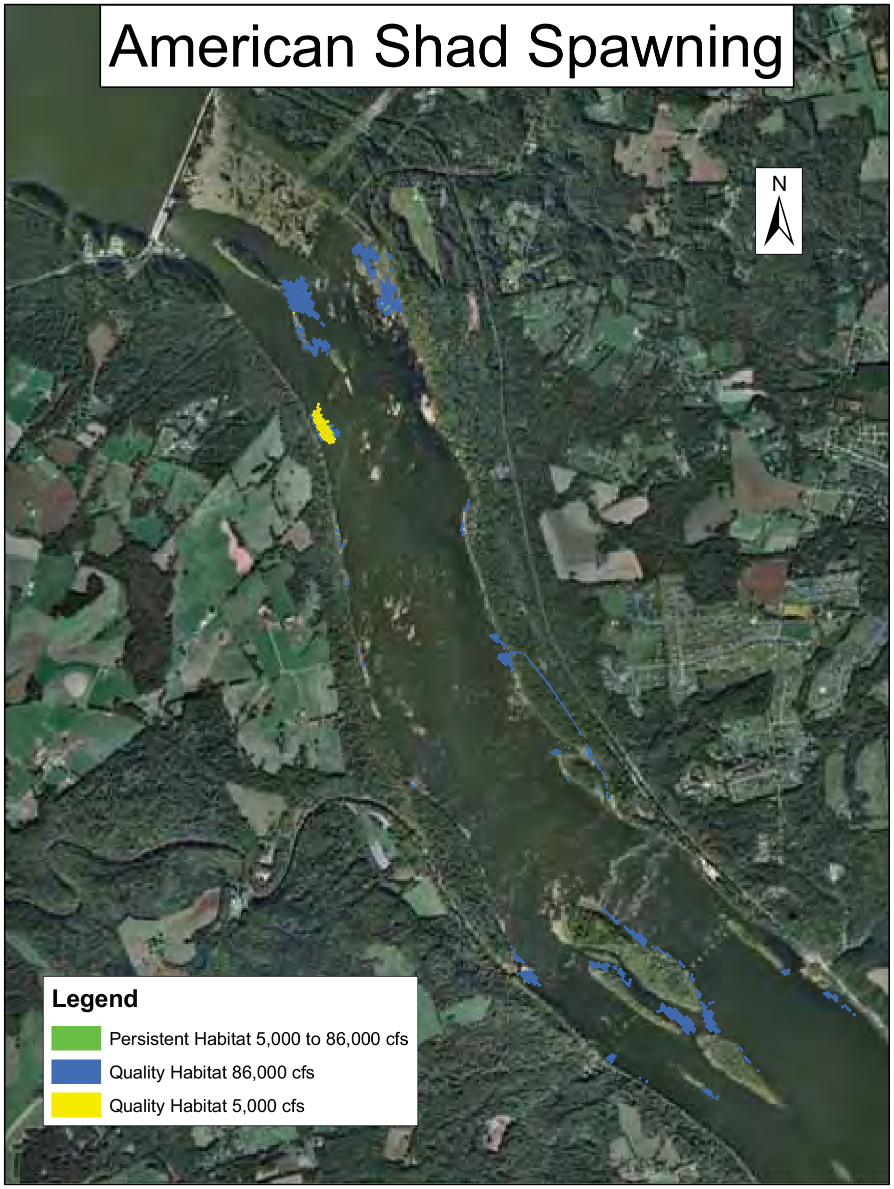
Deep-Fast Guild – 80,000 cfs

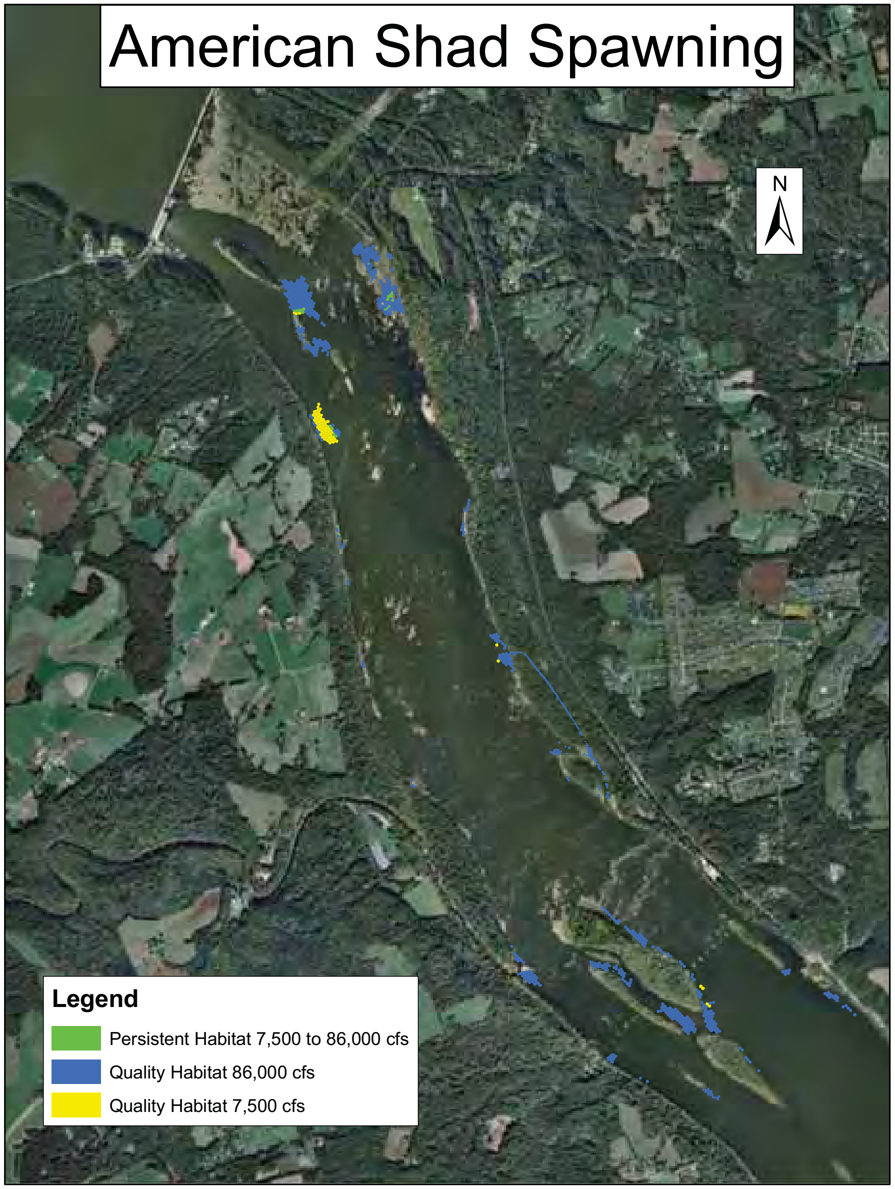


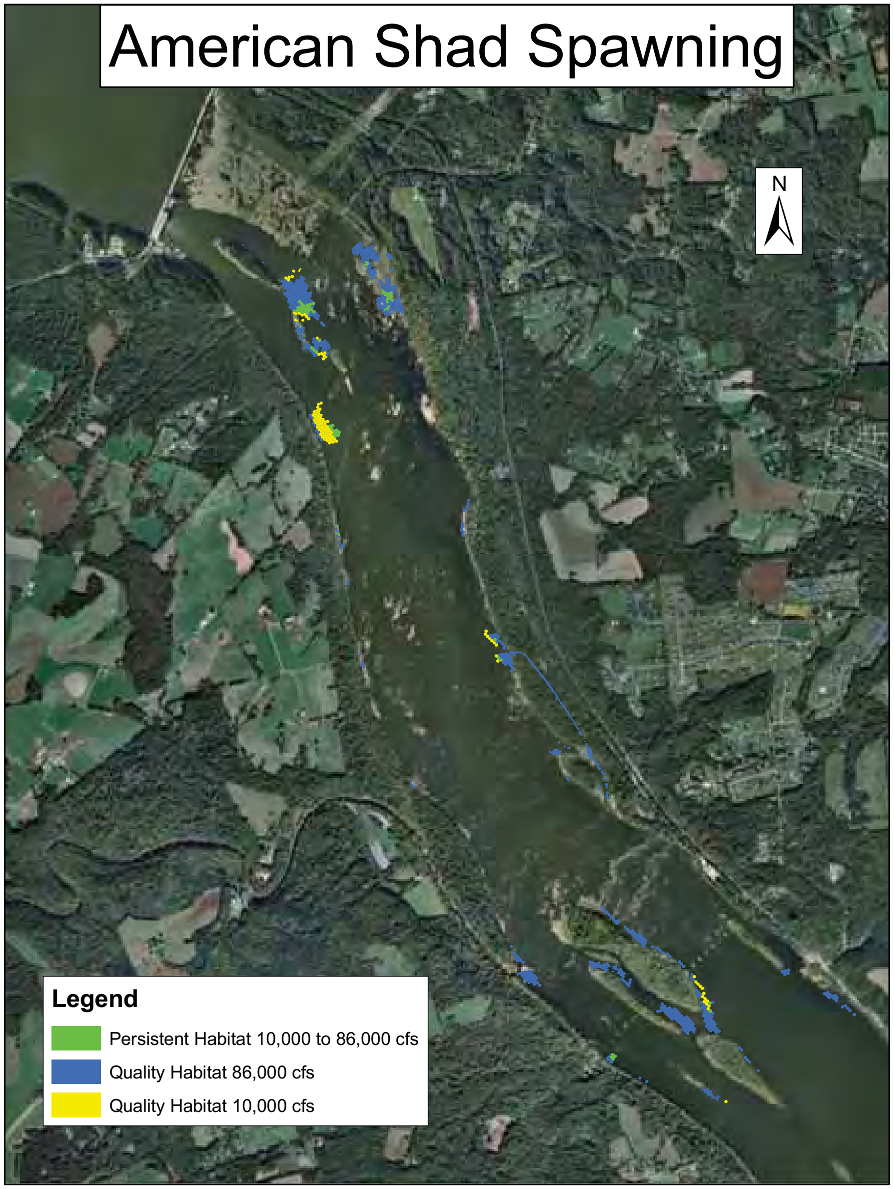
Deep-Fast Guild – 86,000 cfs

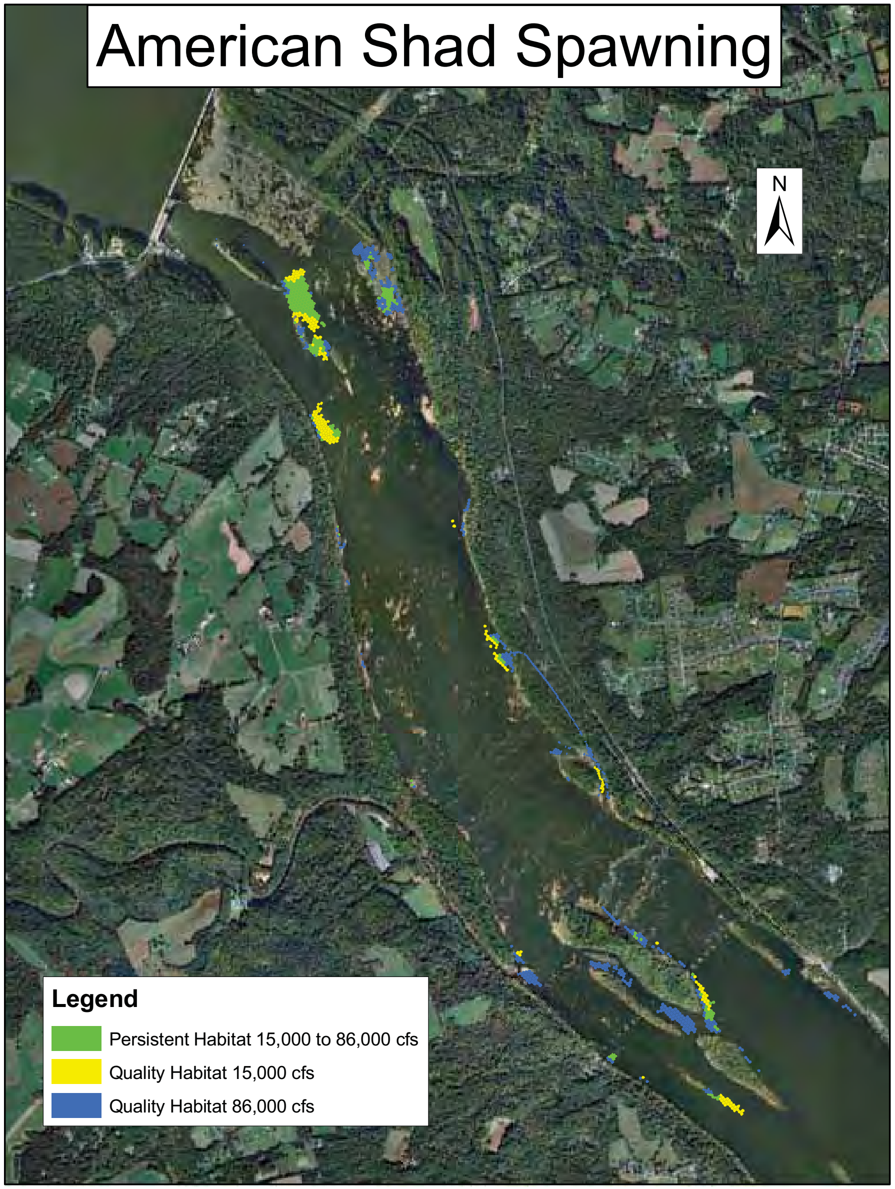
APPENDIX F-HABITAT PERSISTENCE MAPS

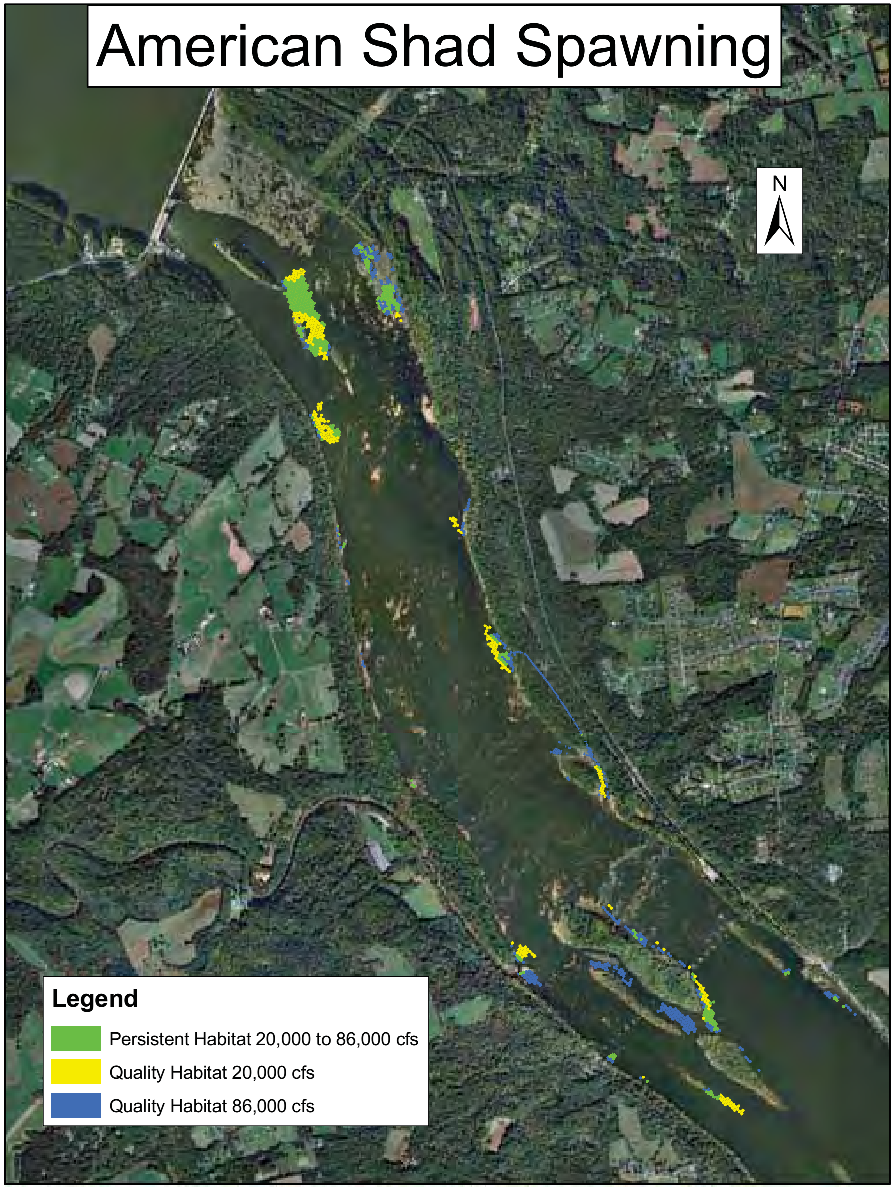

American Shad Spawning
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

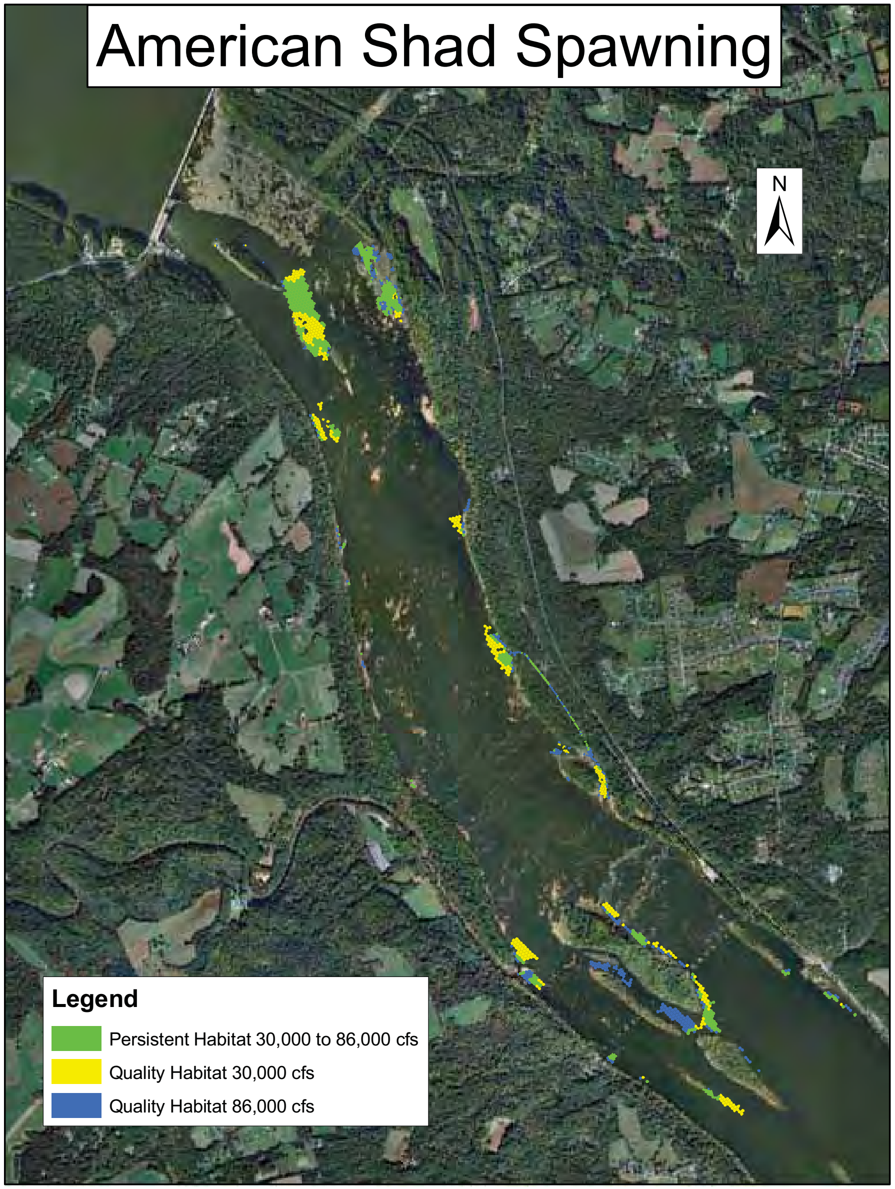

American Shad Spawning
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

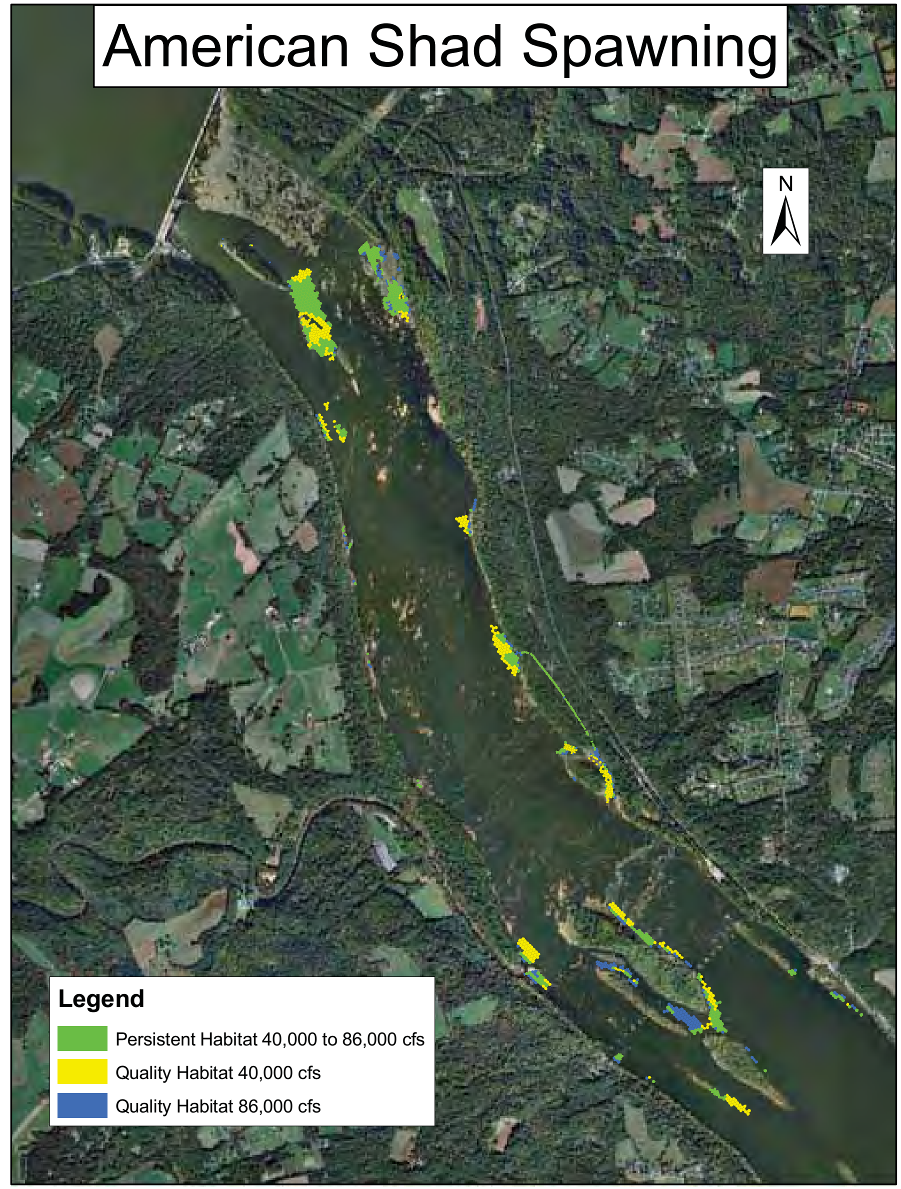

American Shad Spawning
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

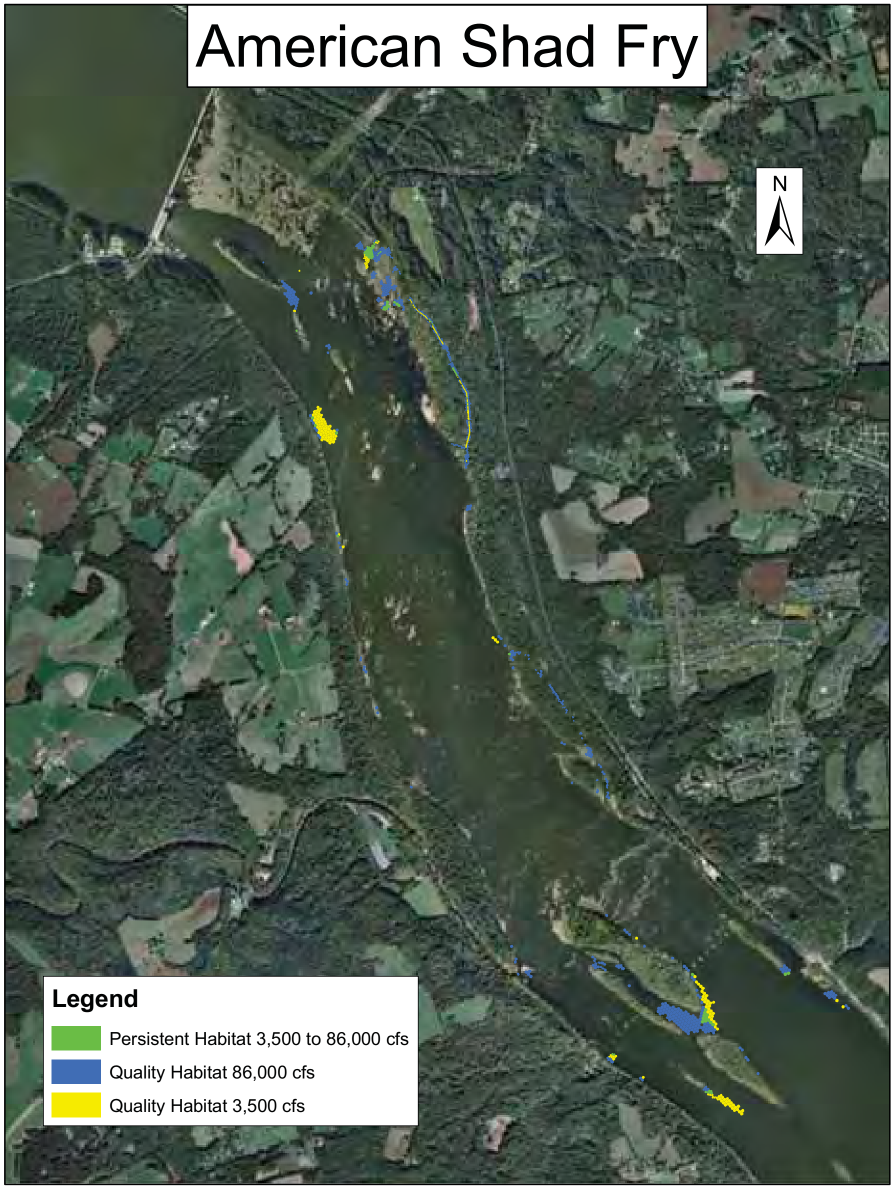

American Shad Spawning
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

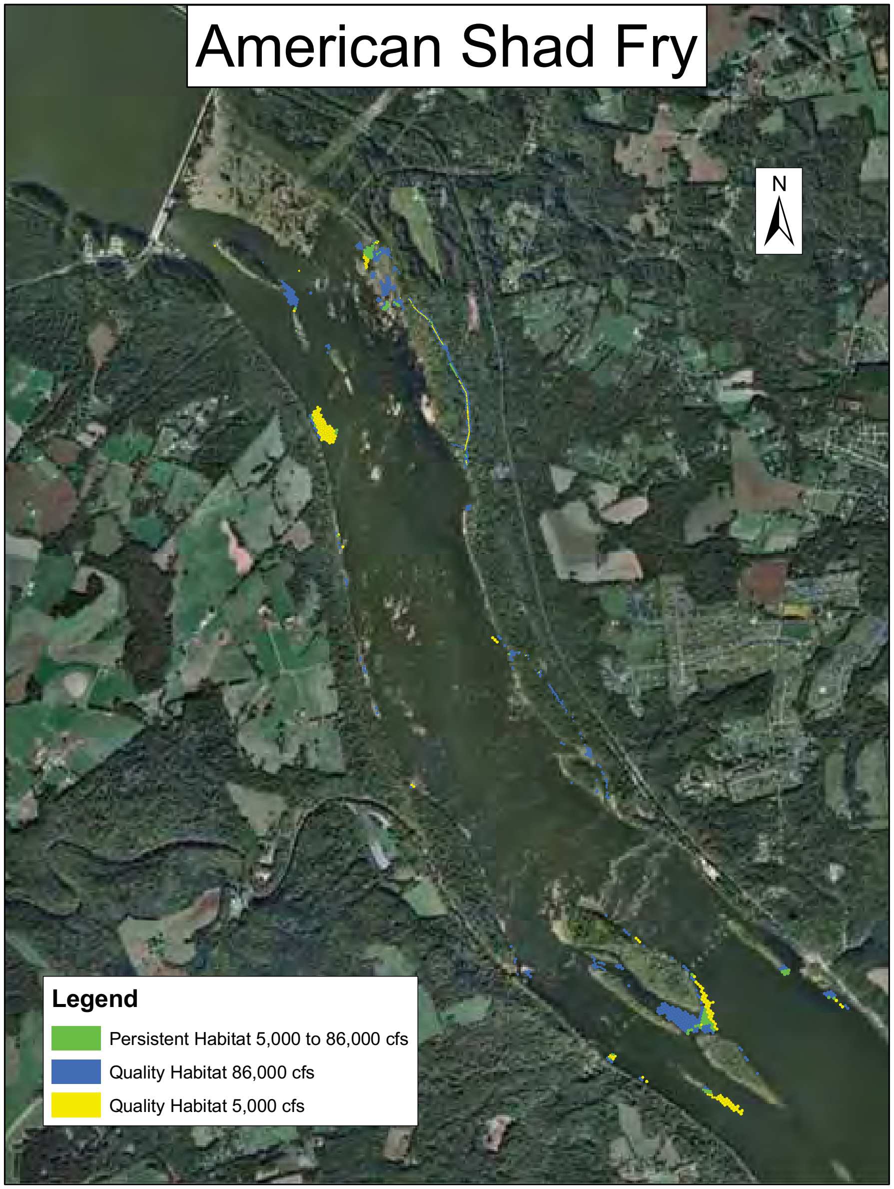

American Shad Spawning
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

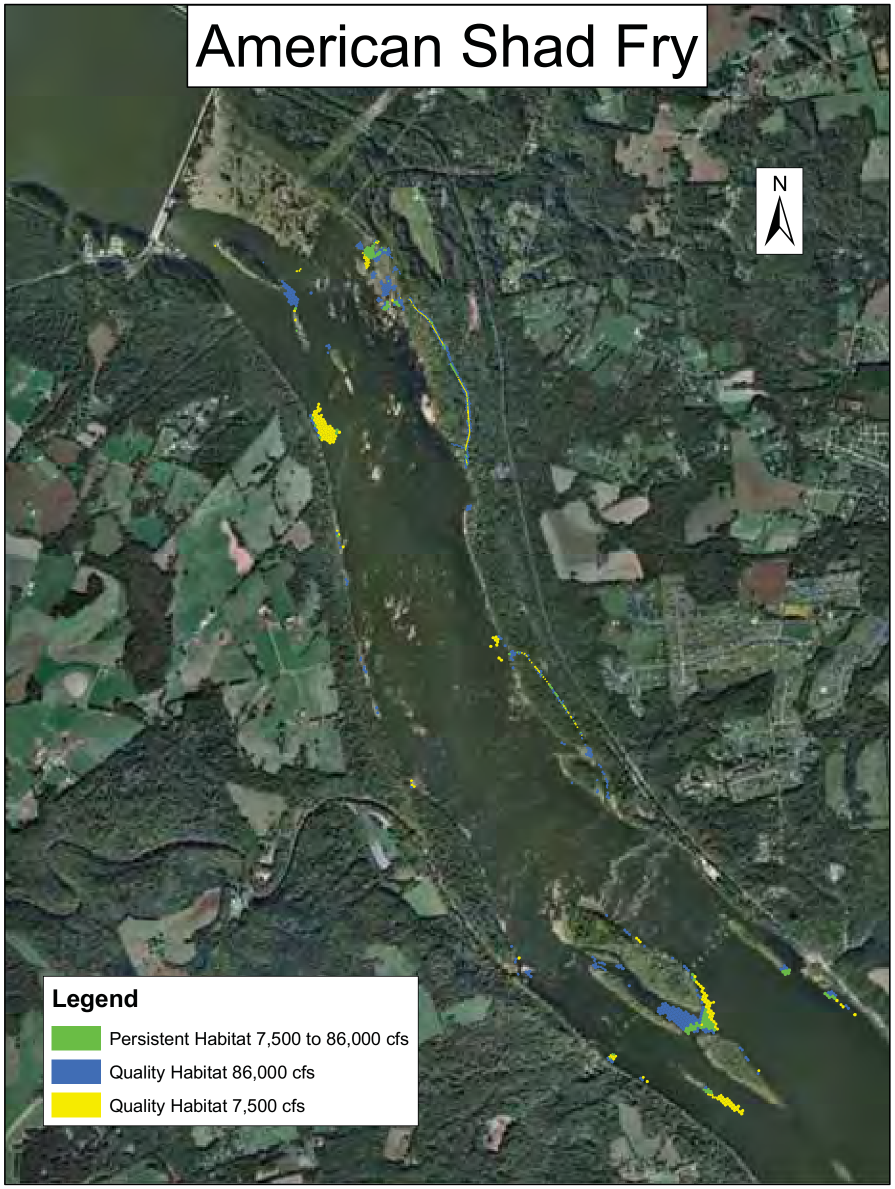

American Shad Spawning
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

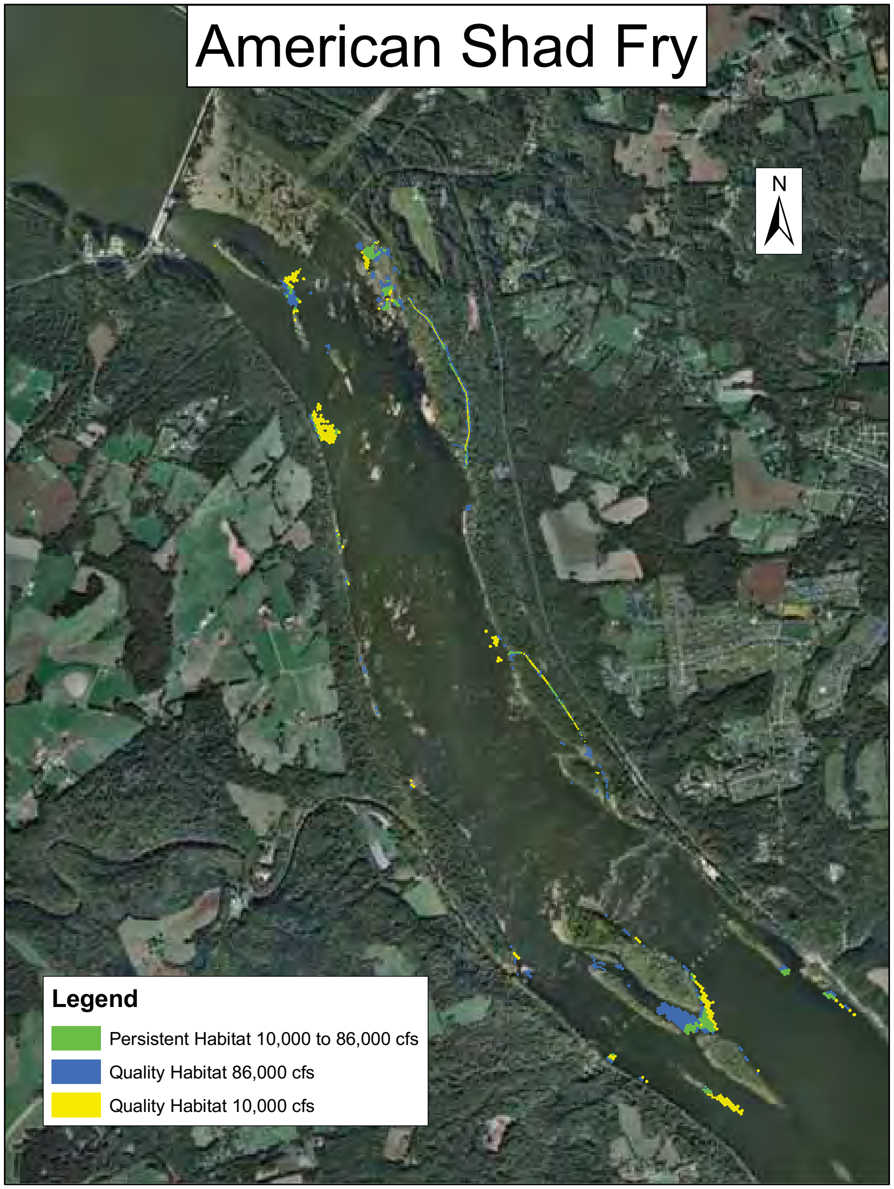

American Shad Spawning
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

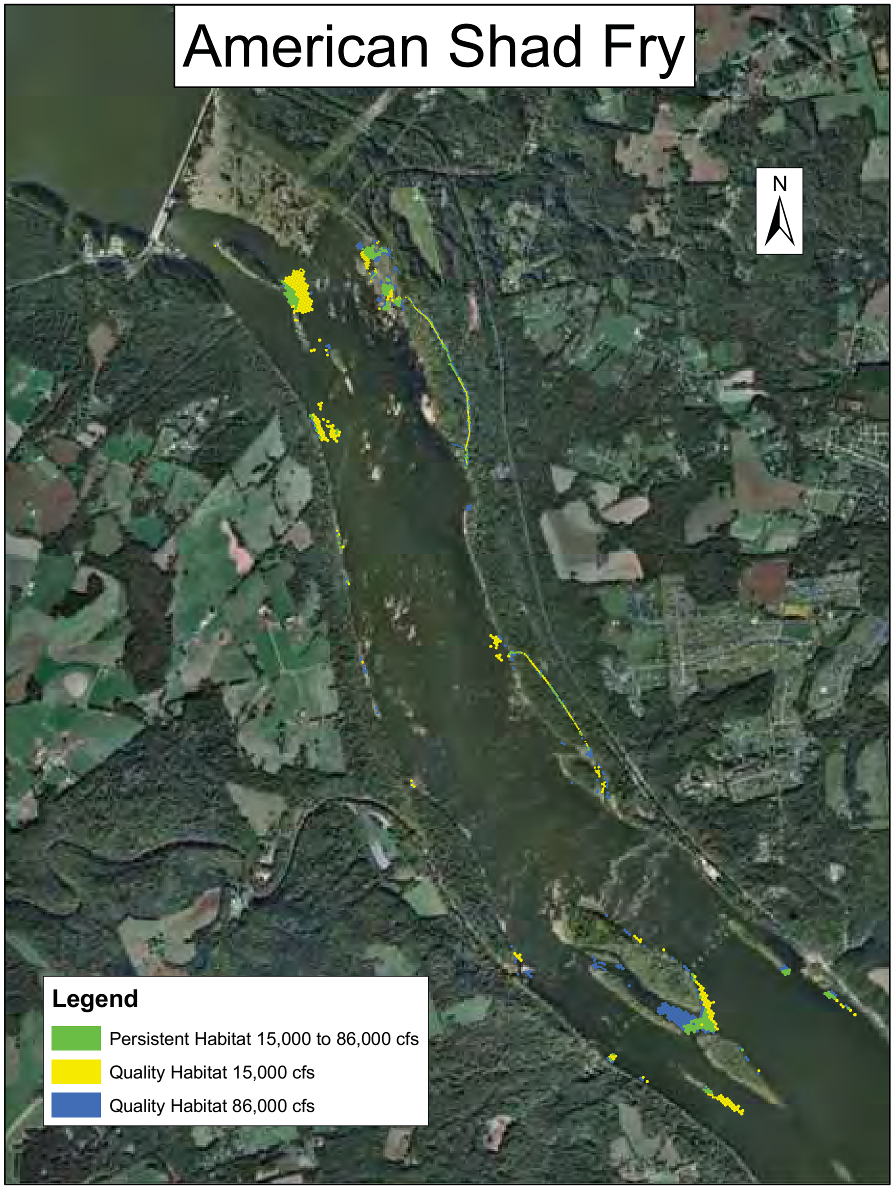

American Shad Spawning
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

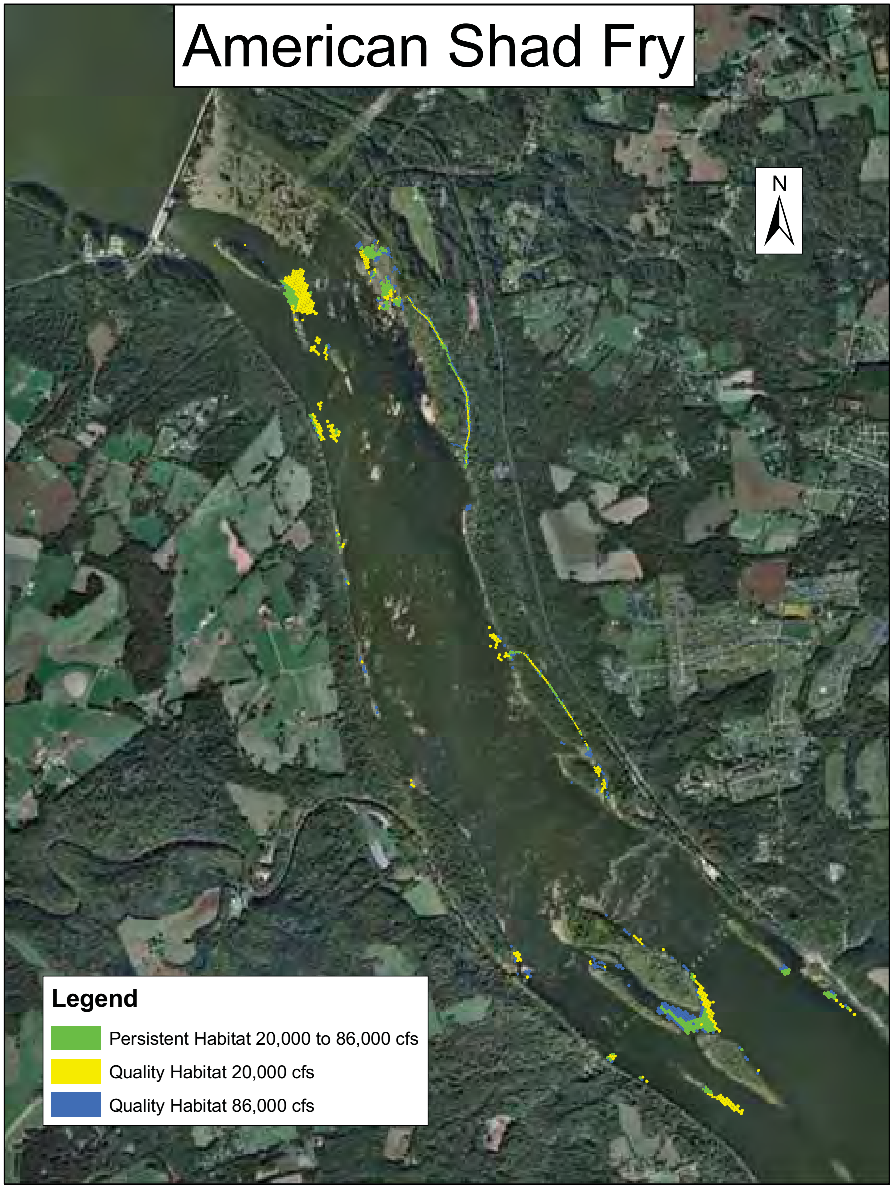

American Shad Fry
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

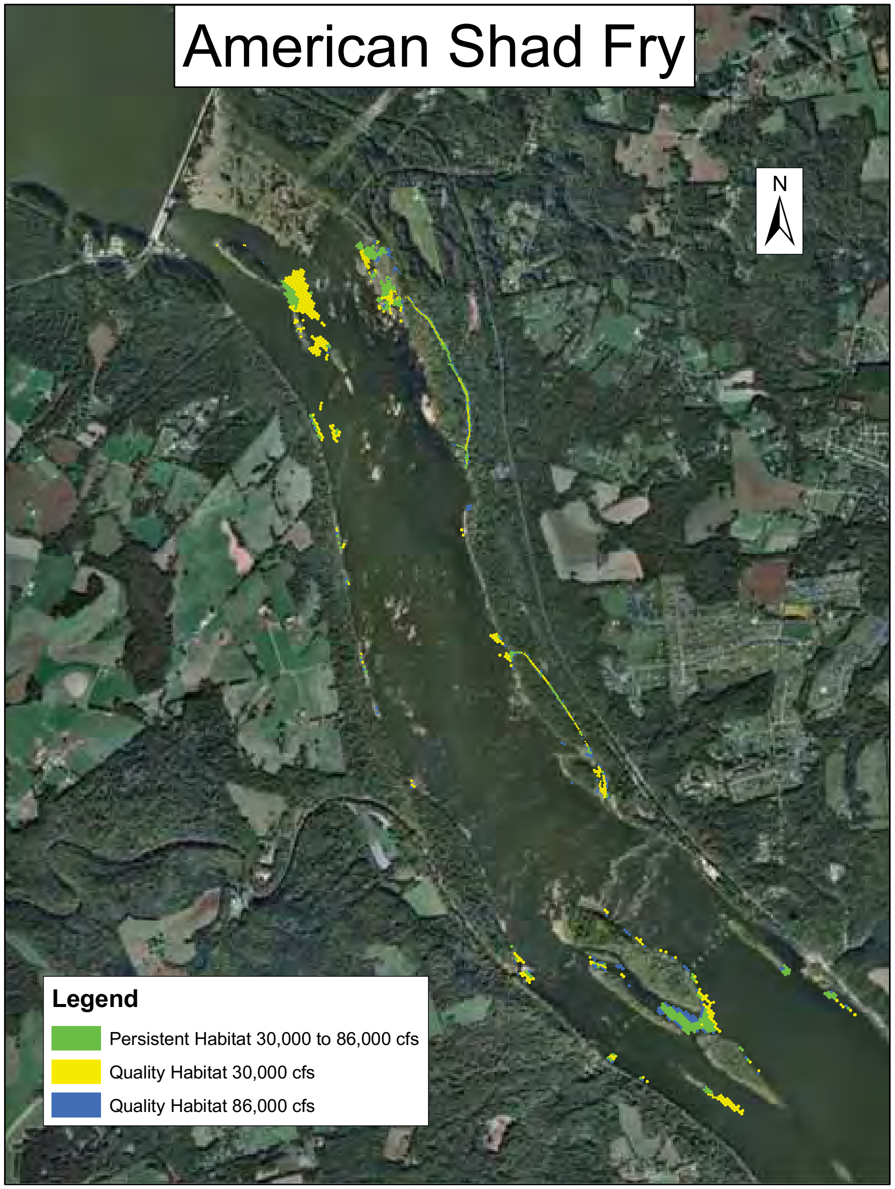

American Shad Fry
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

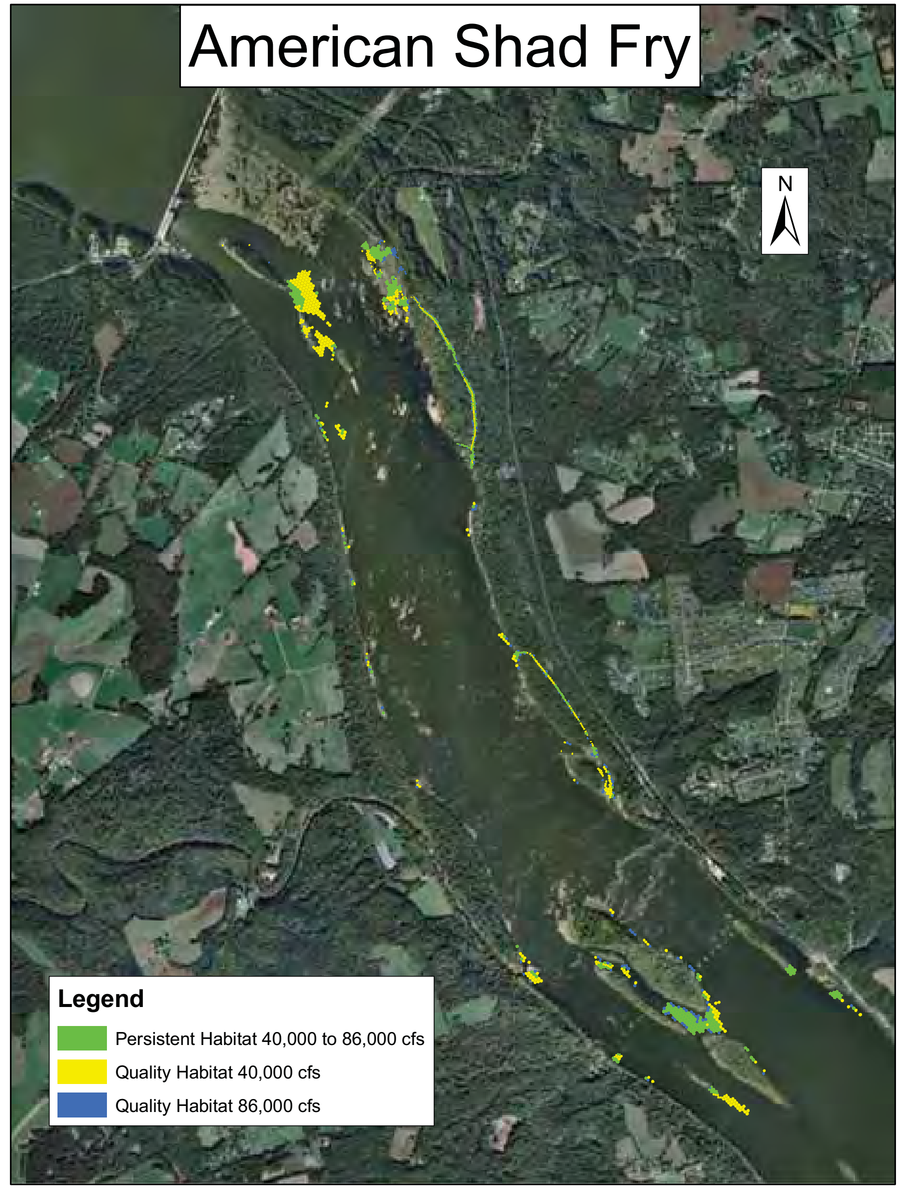

American Shad Fry
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

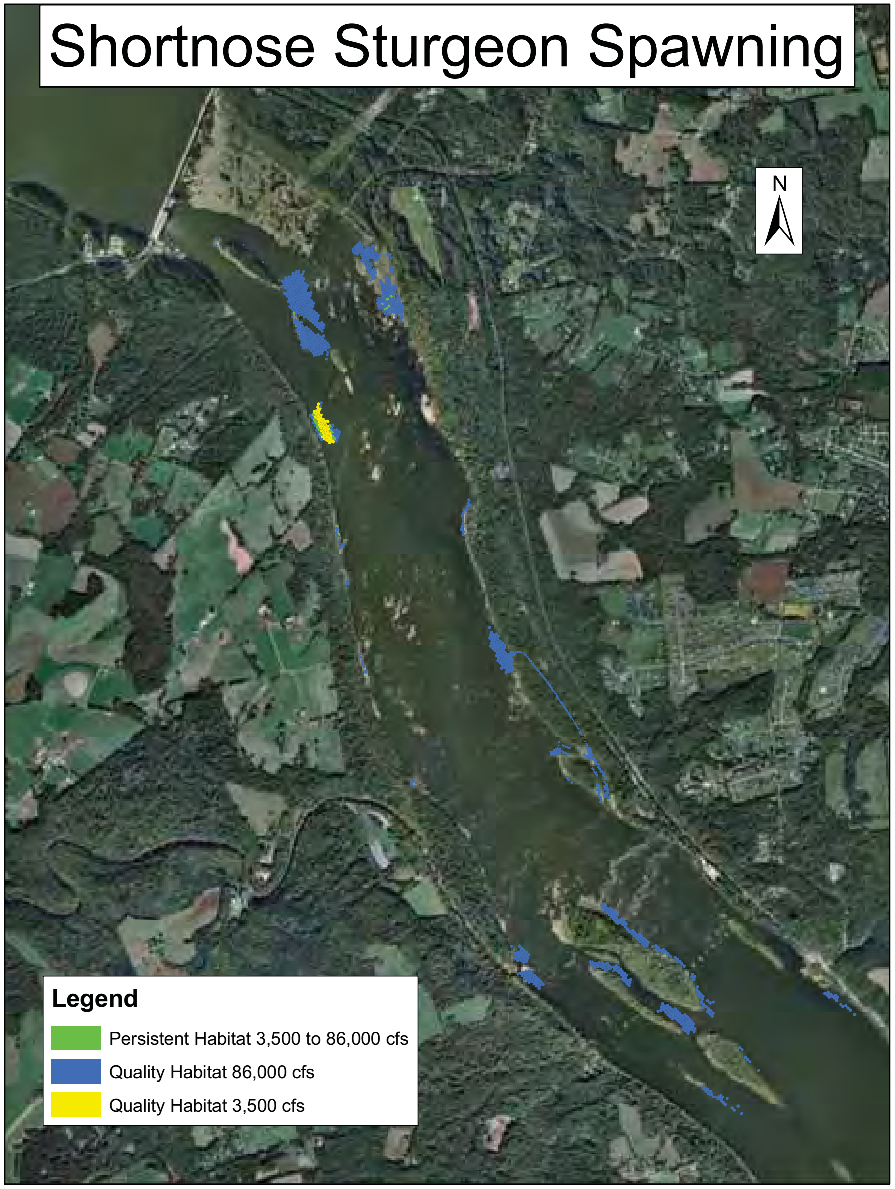

American Shad Fry
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

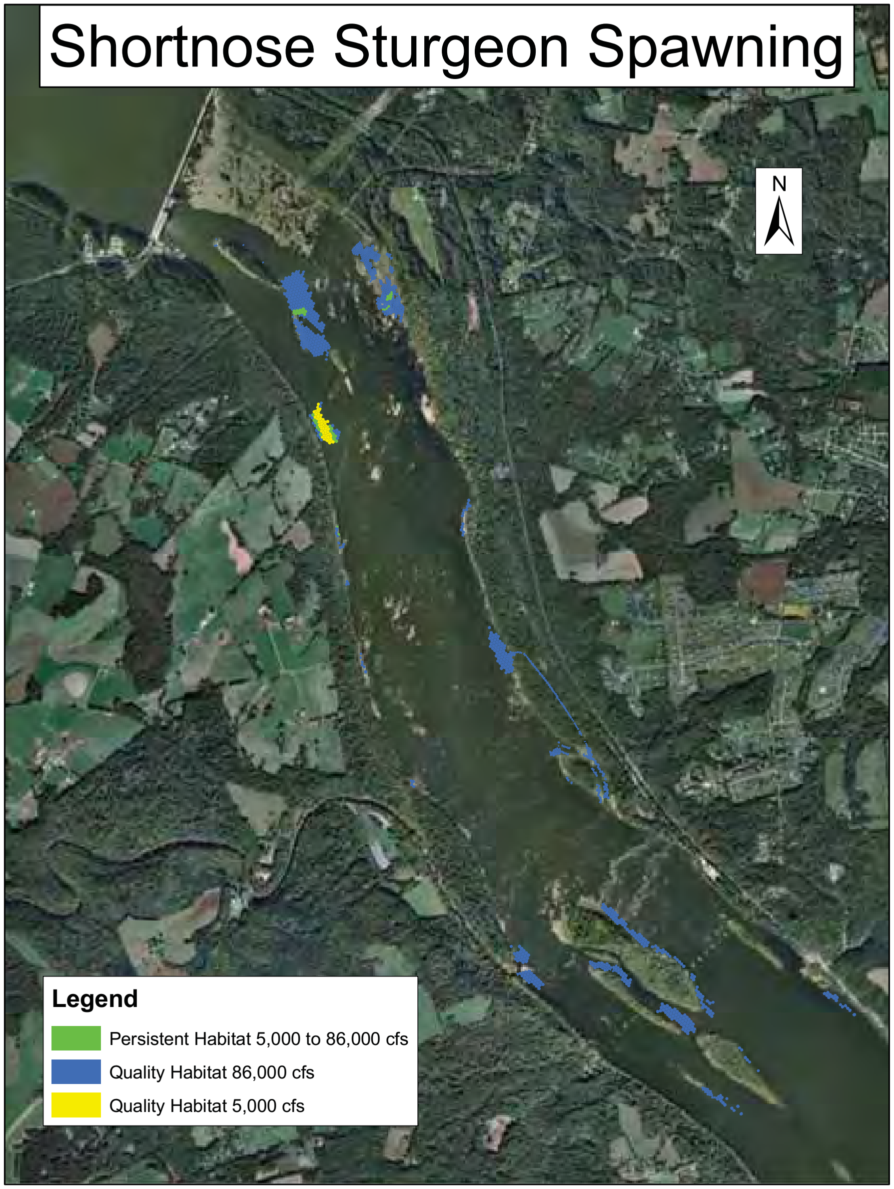

American Shad Fry
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

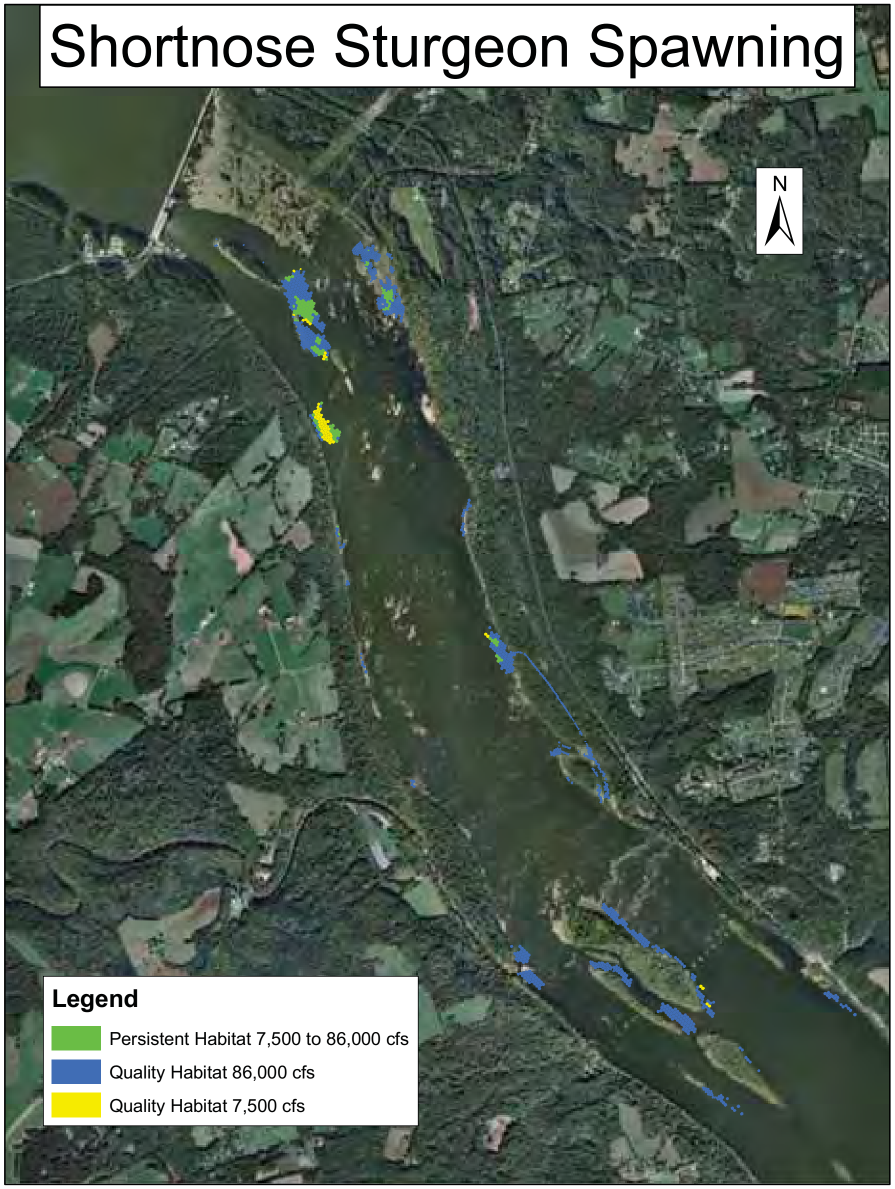

American Shad Fry
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

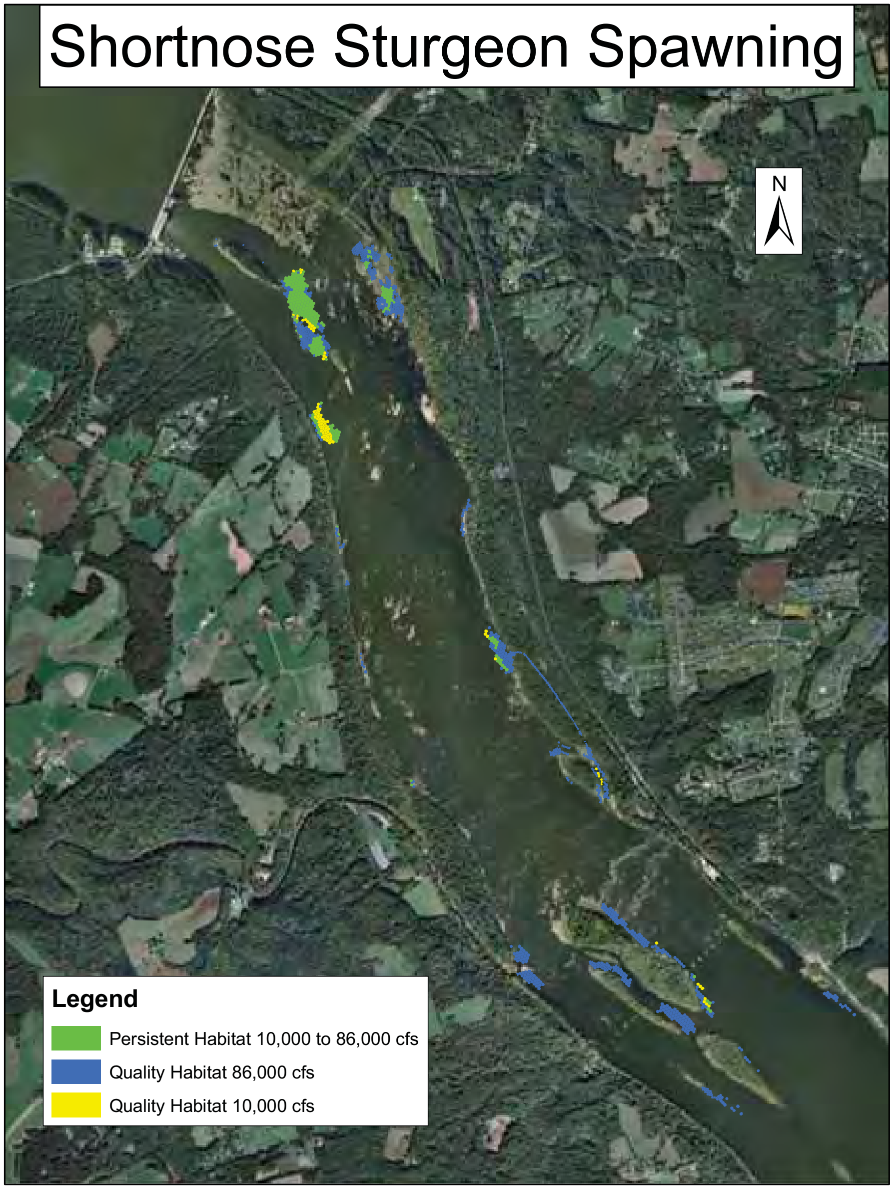

American Shad Fry
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

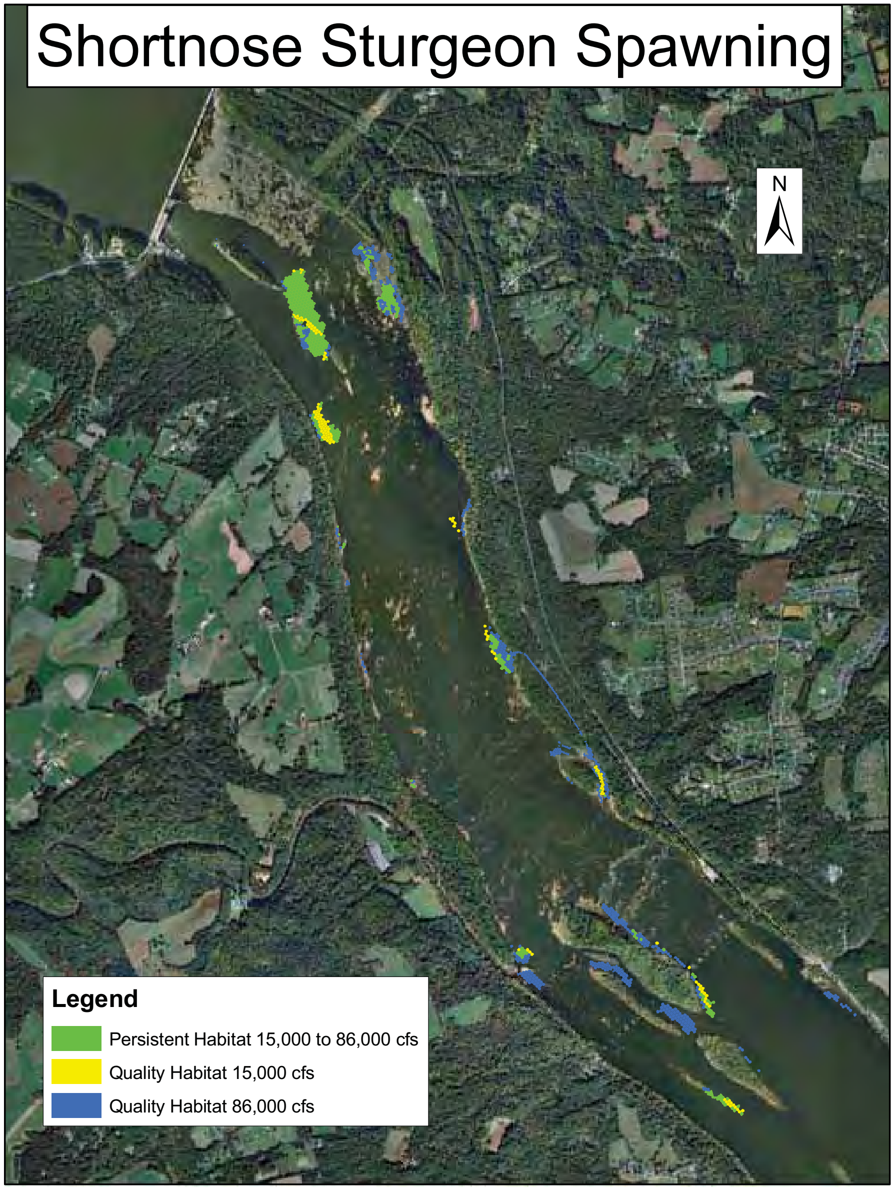

American Shad Fry
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

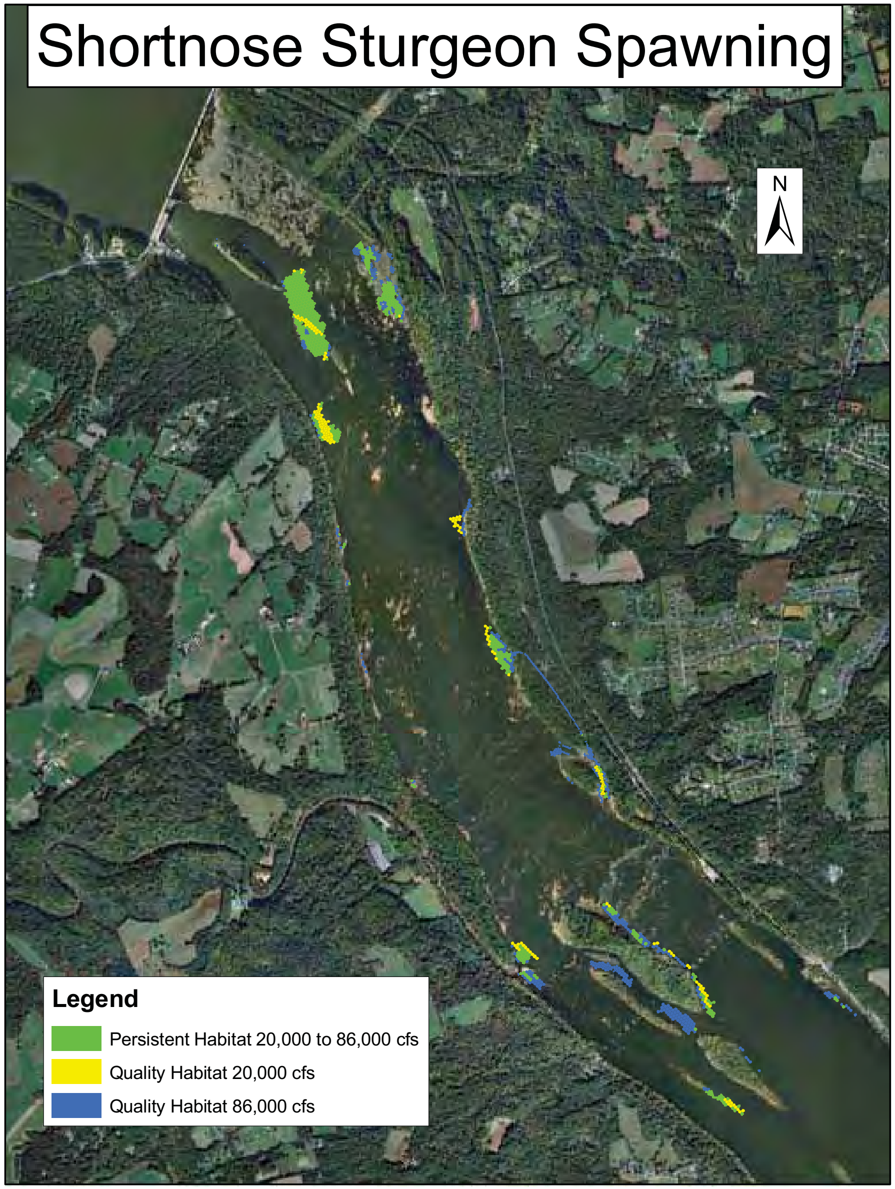

Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

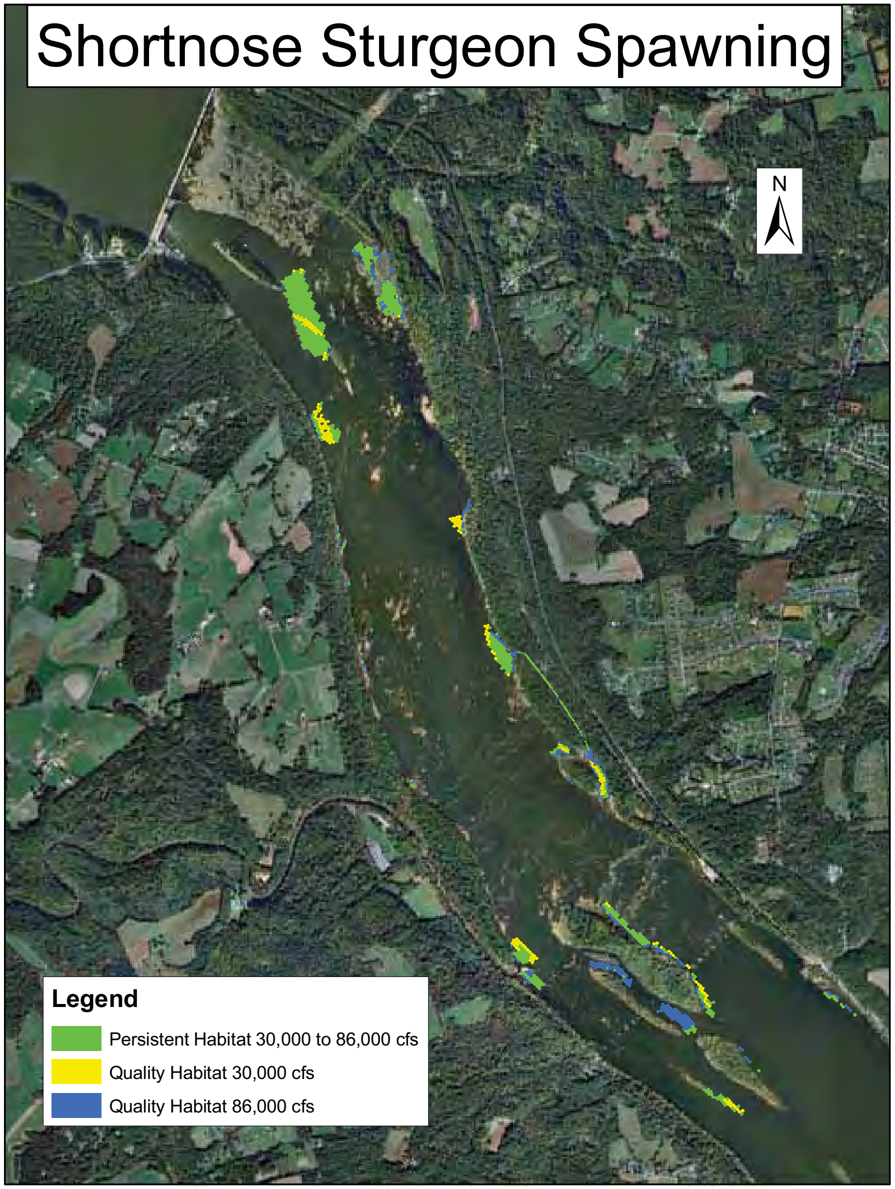

Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs


Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

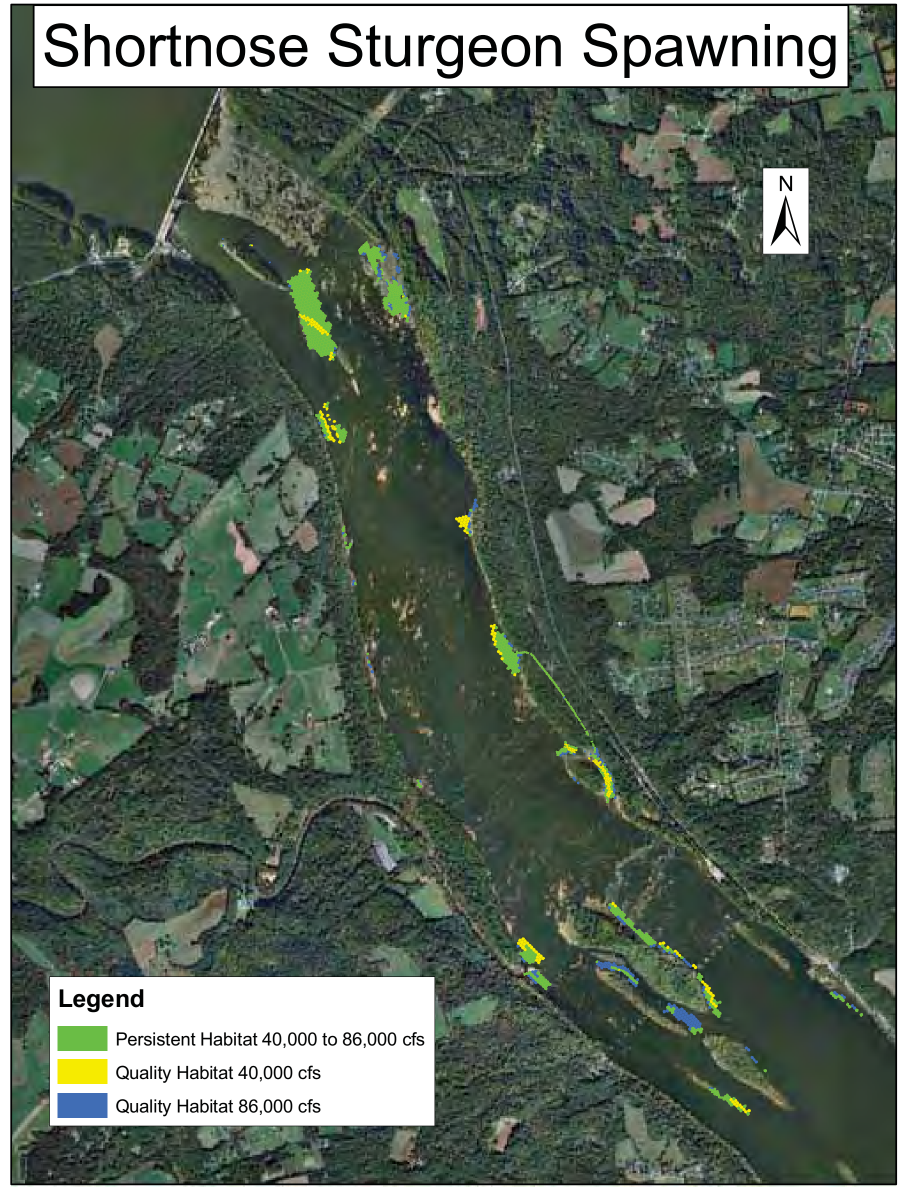

Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs


Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs


Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs



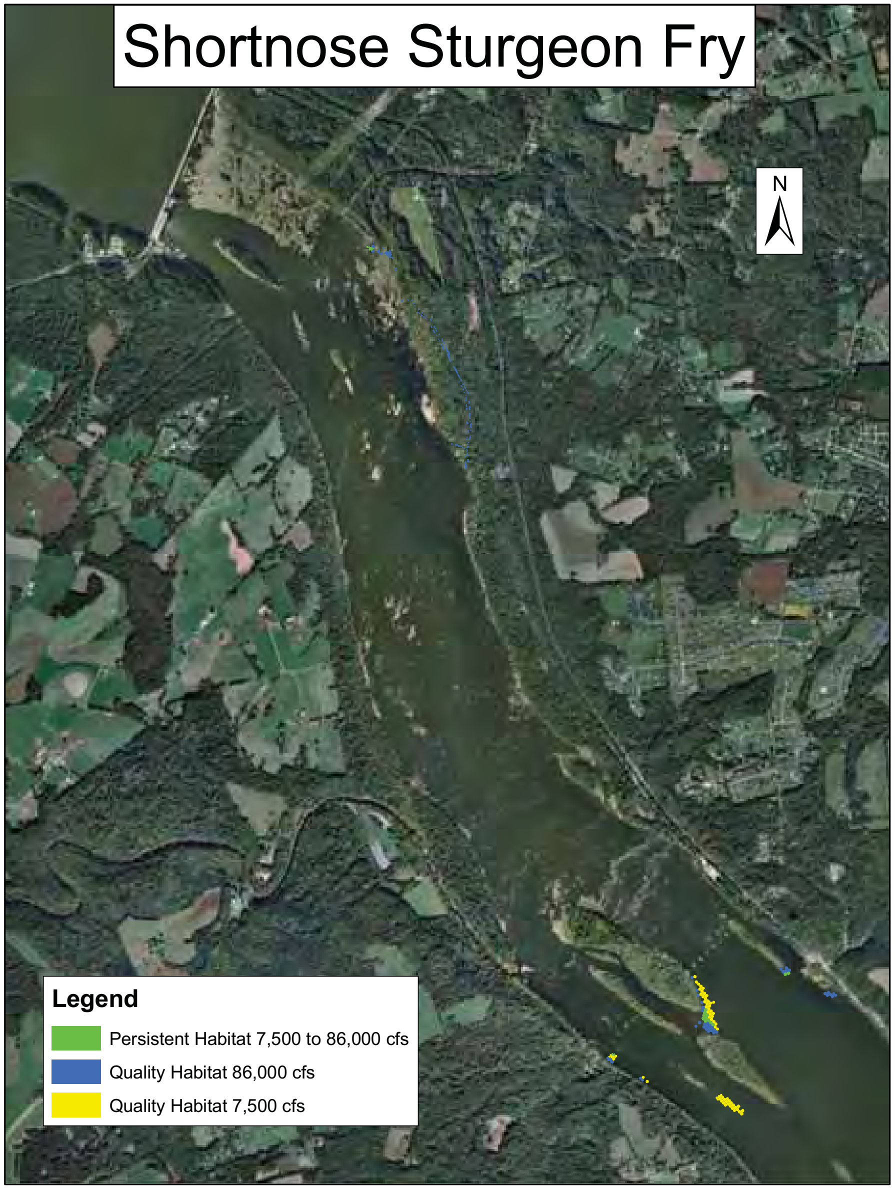
Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

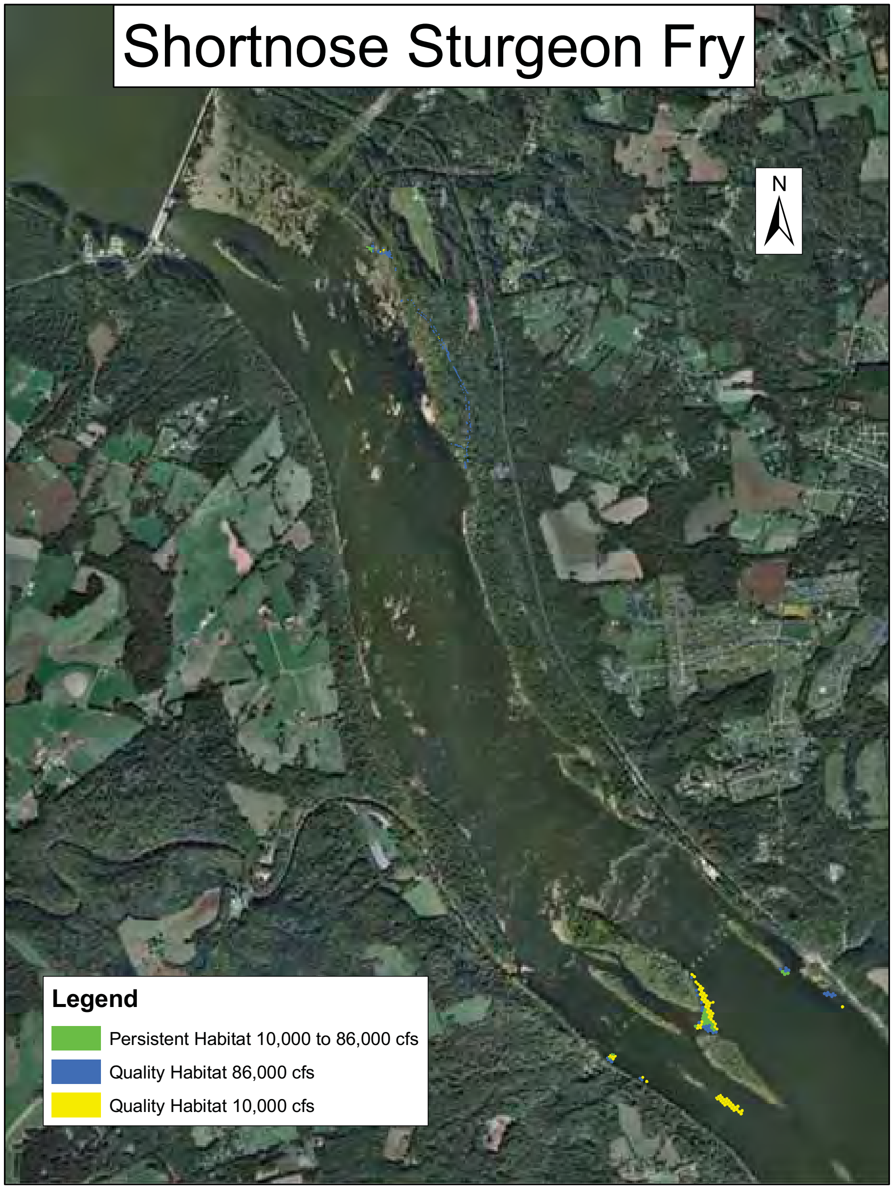


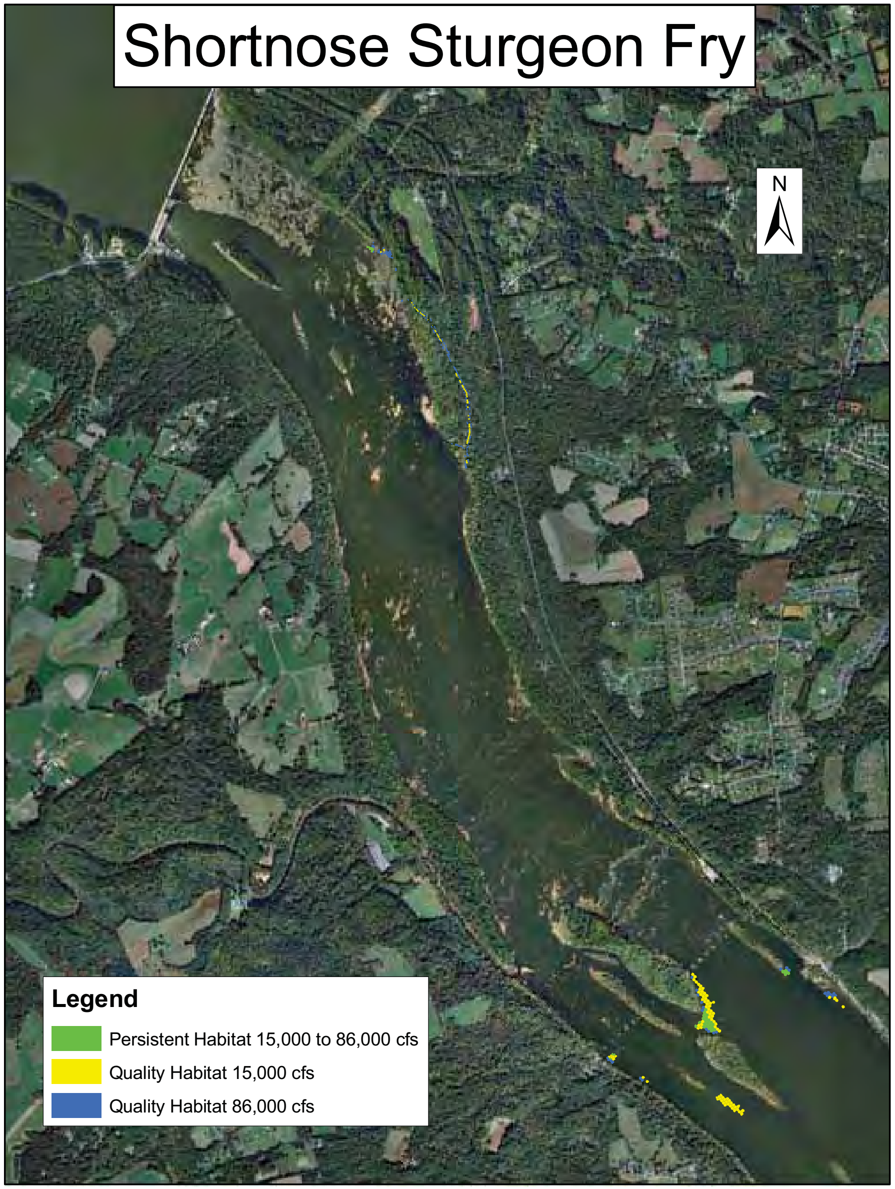
Shortnose Sturgeon Spawning
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

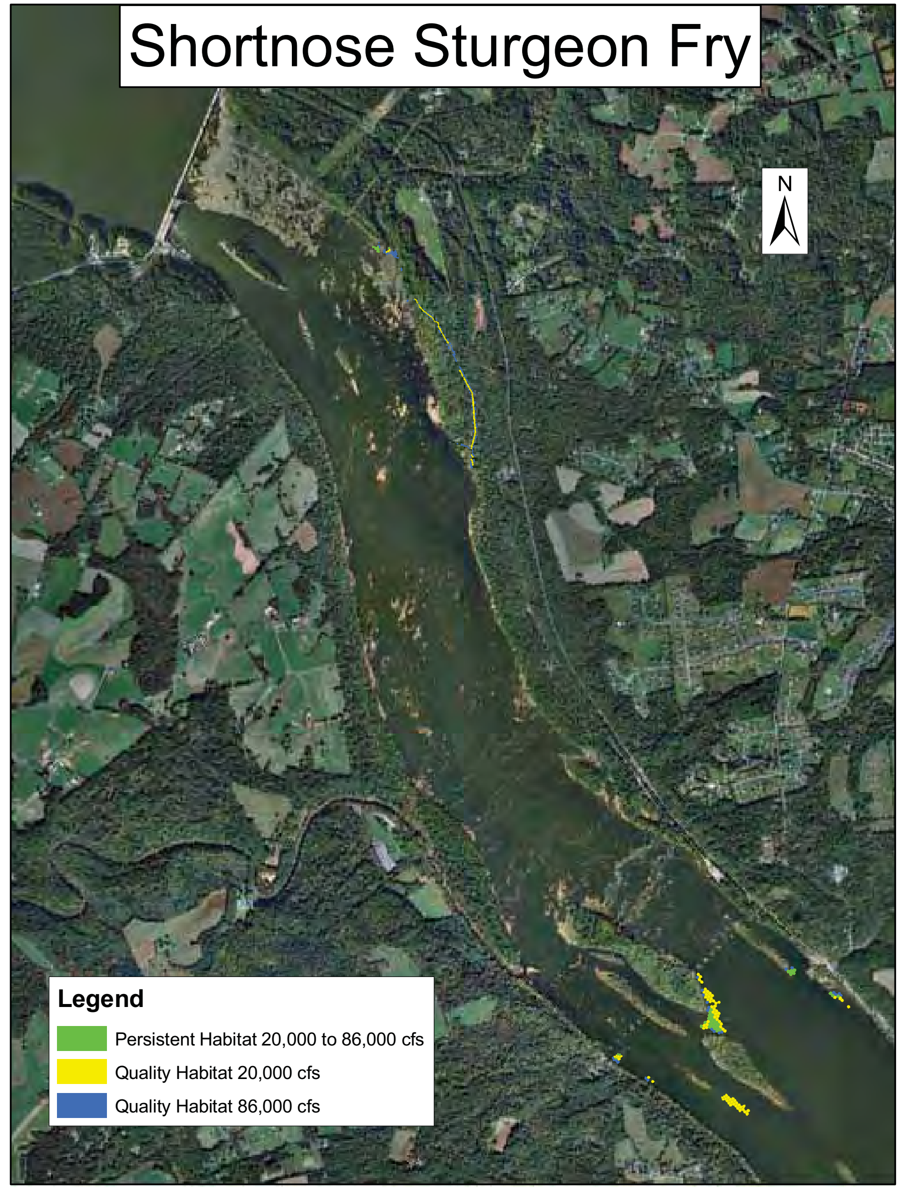
Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

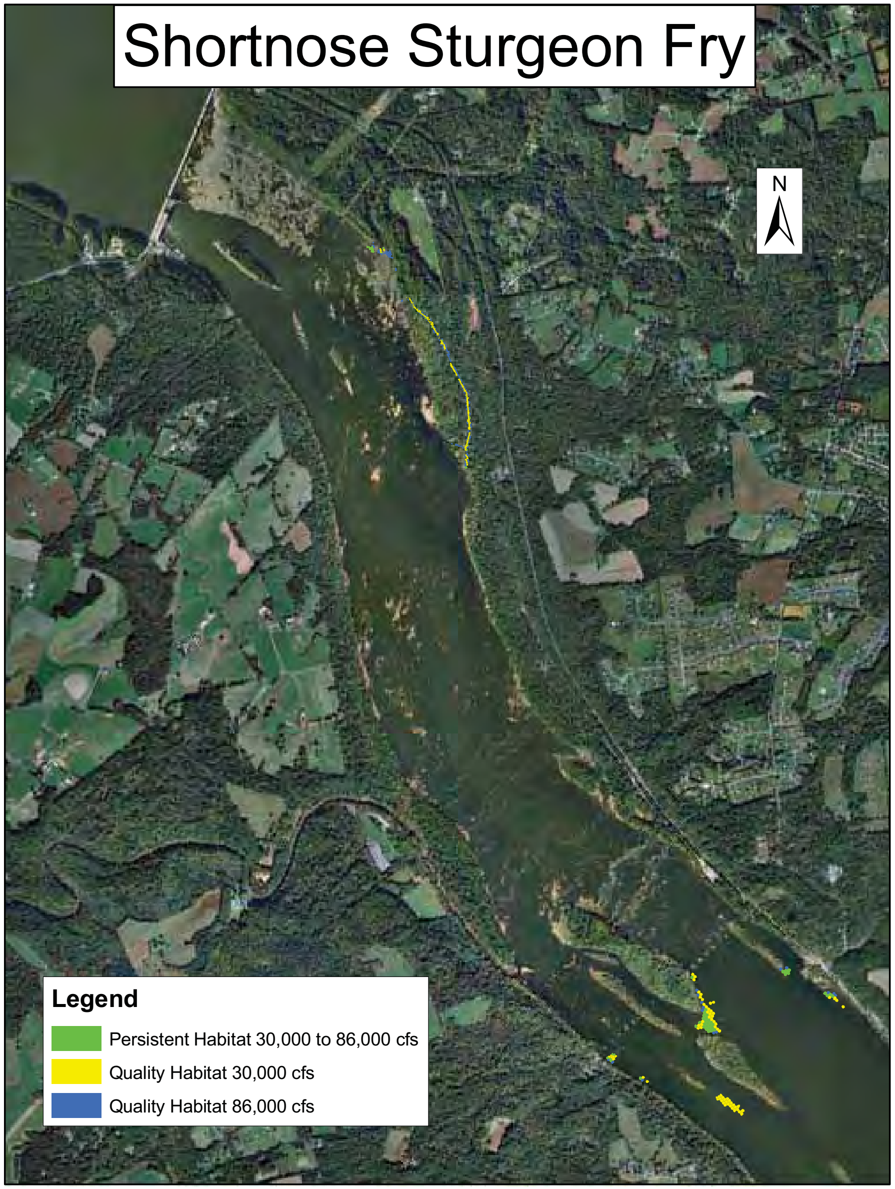
Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs


Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

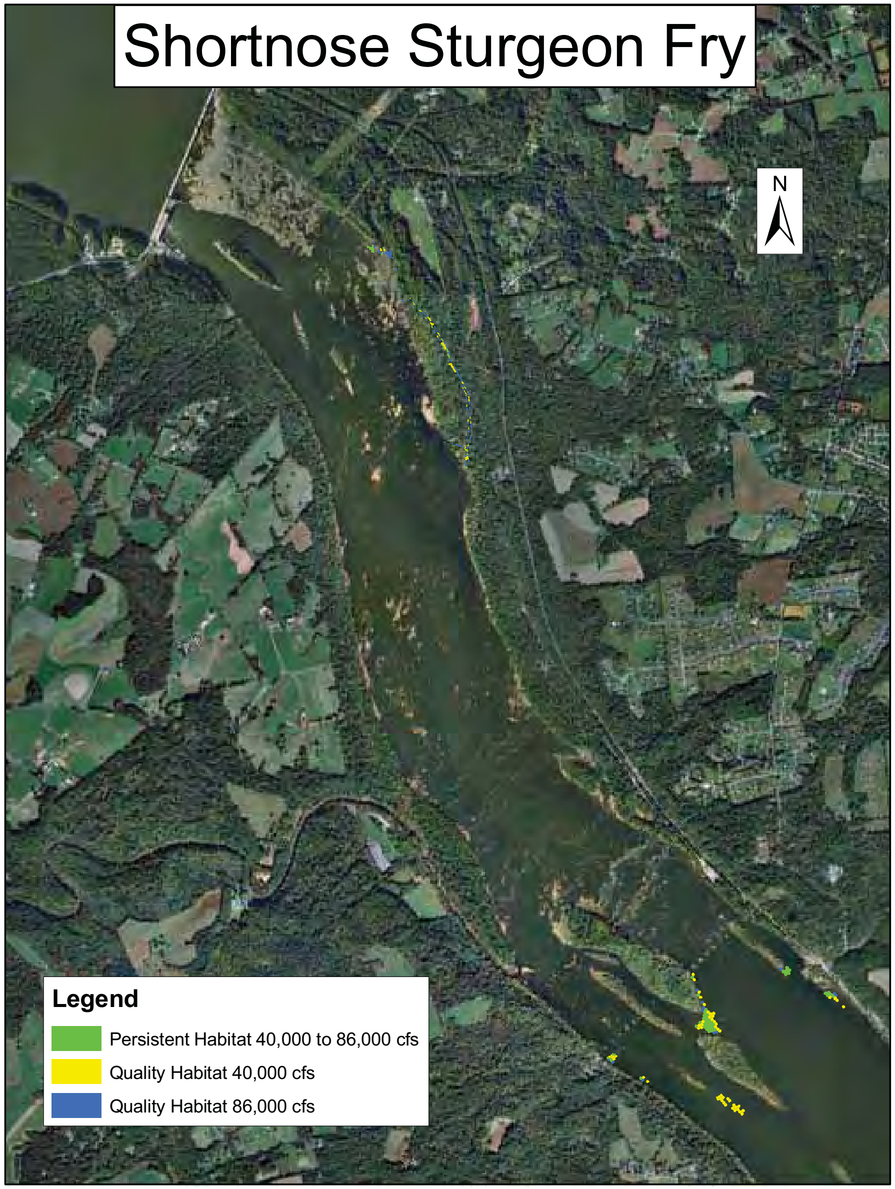

Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs


Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

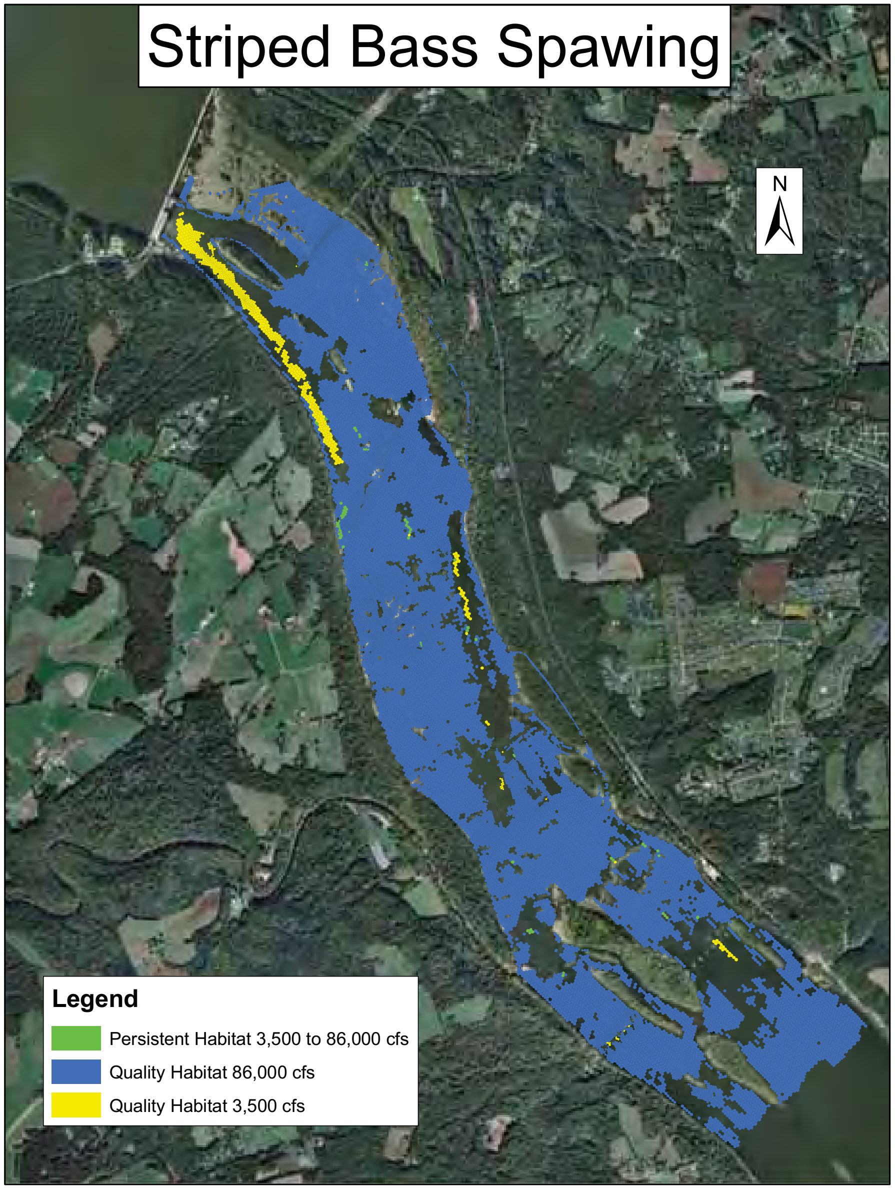

Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

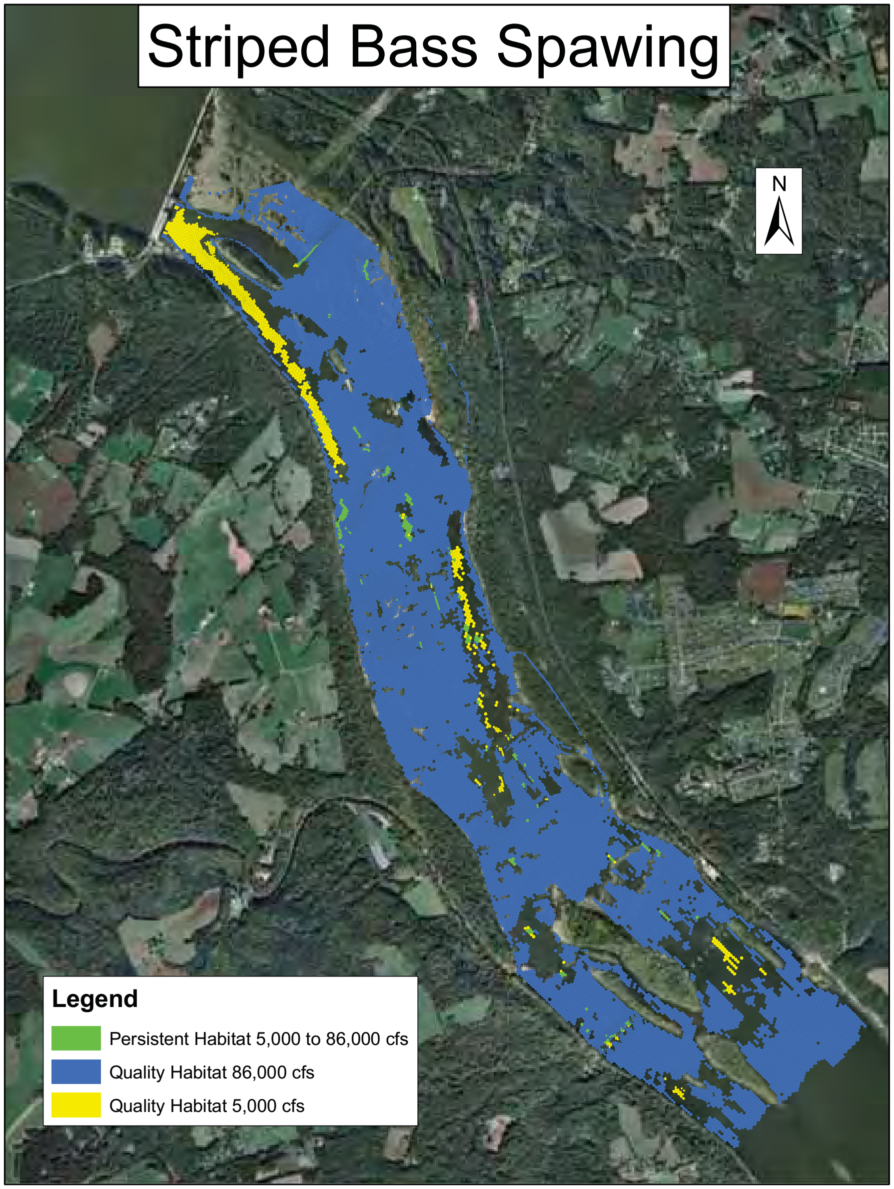


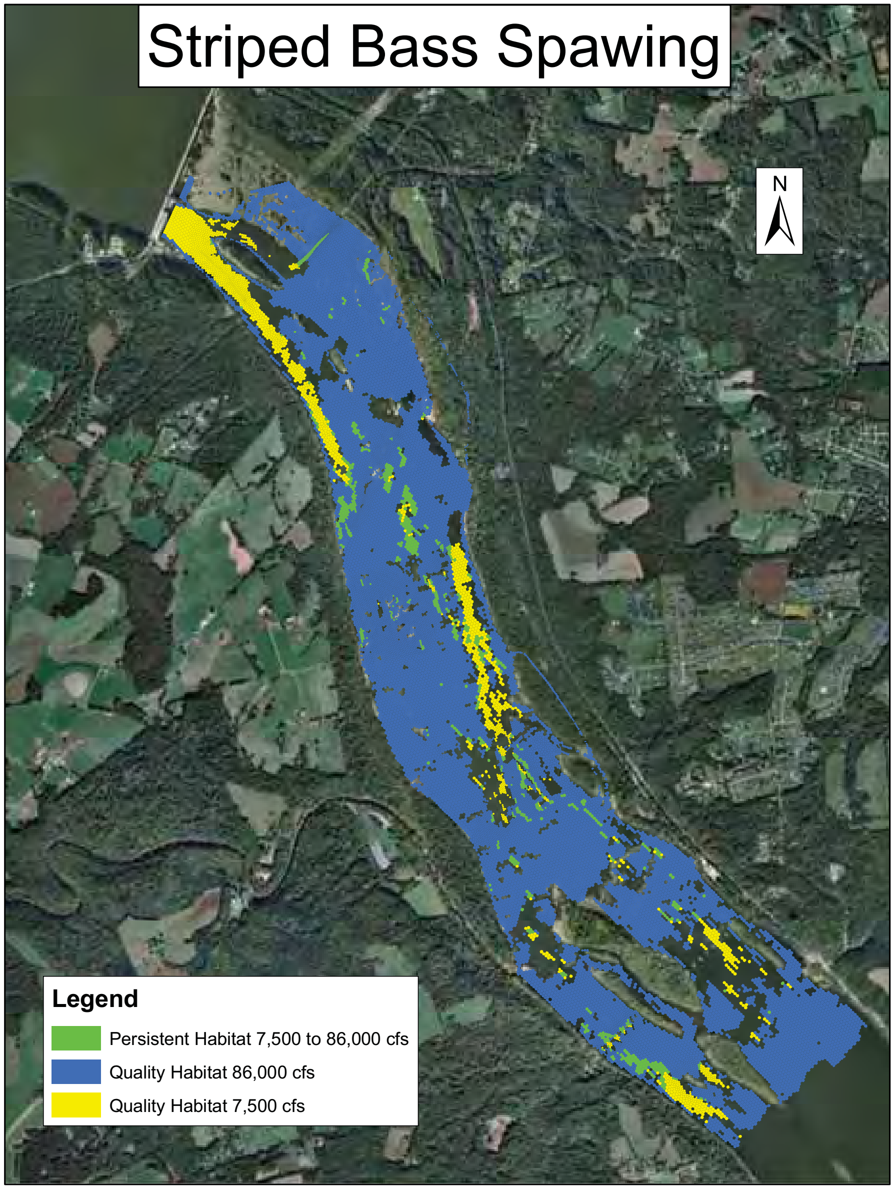
Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

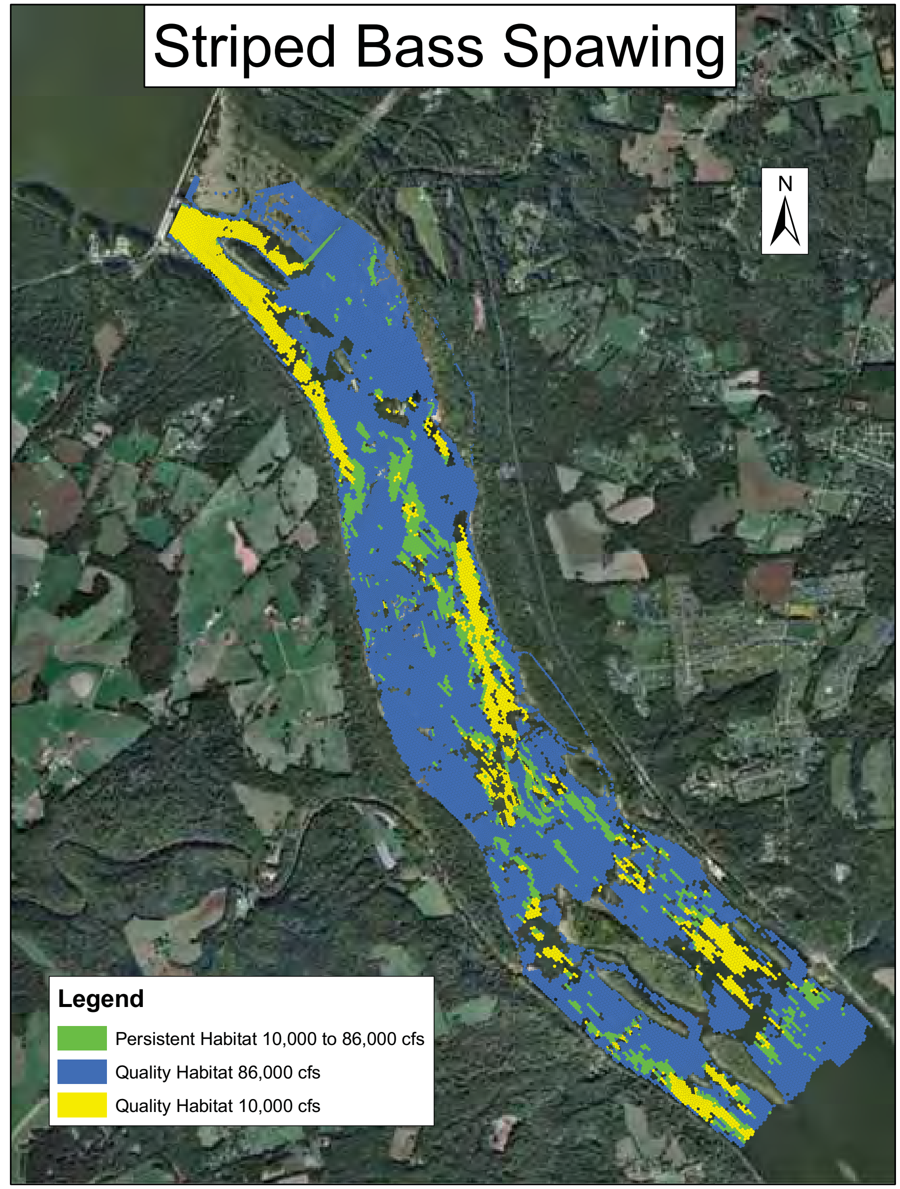


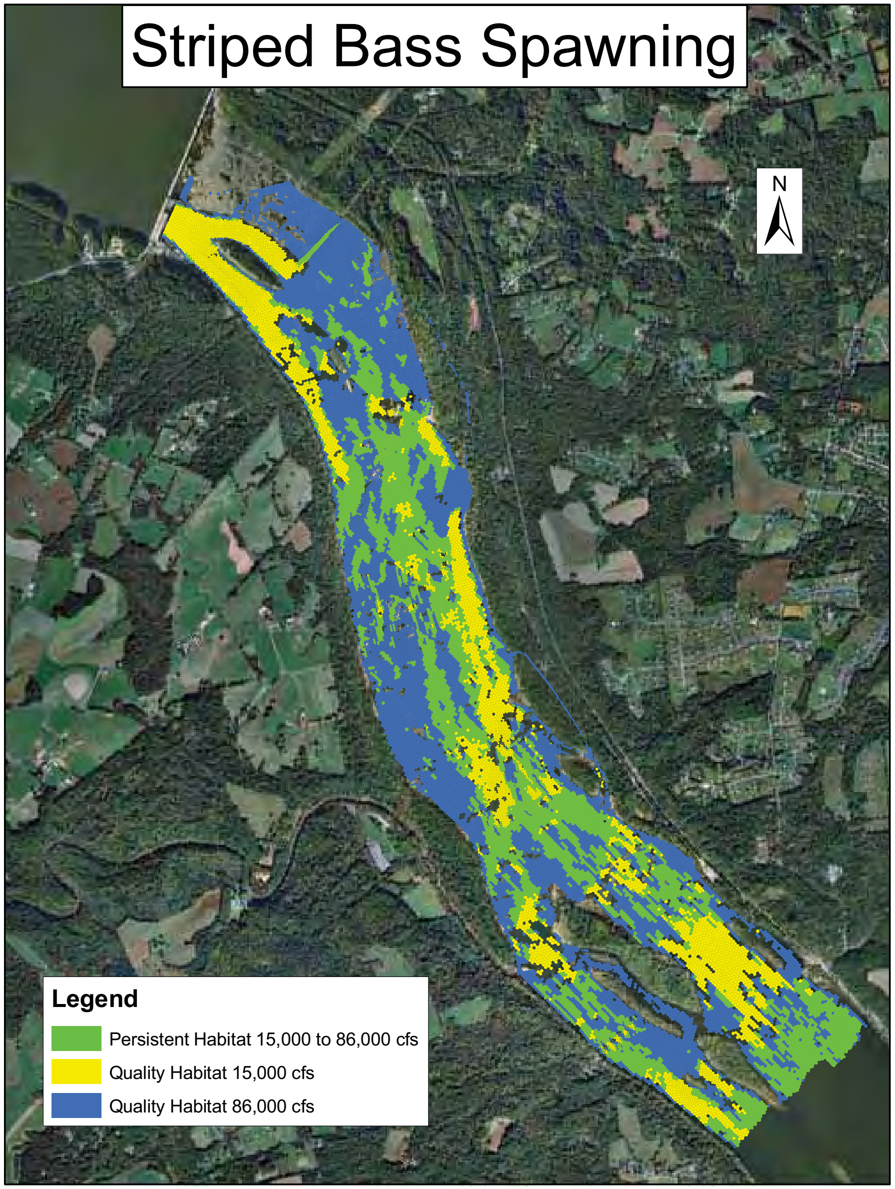
Shortnose Sturgeon Fry
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

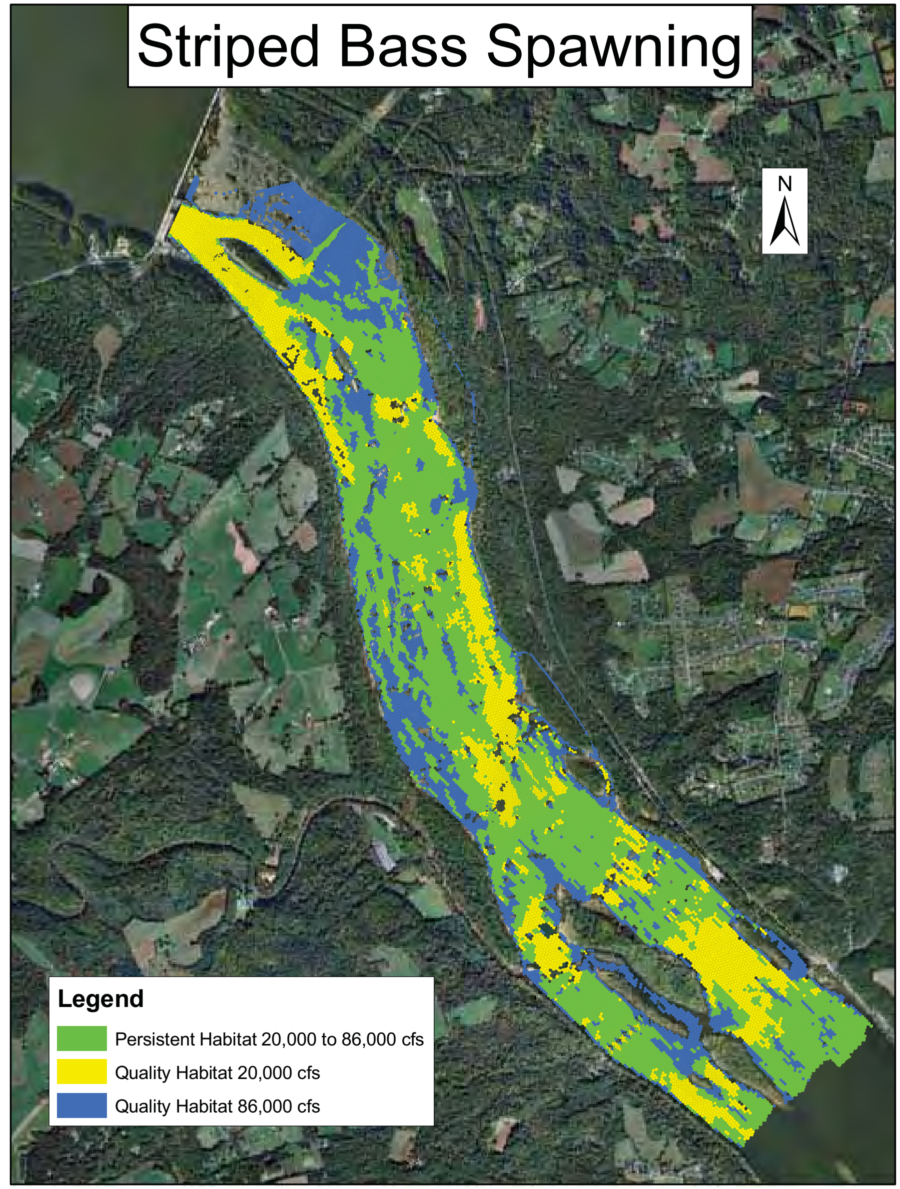

Striped Bass Spawing
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

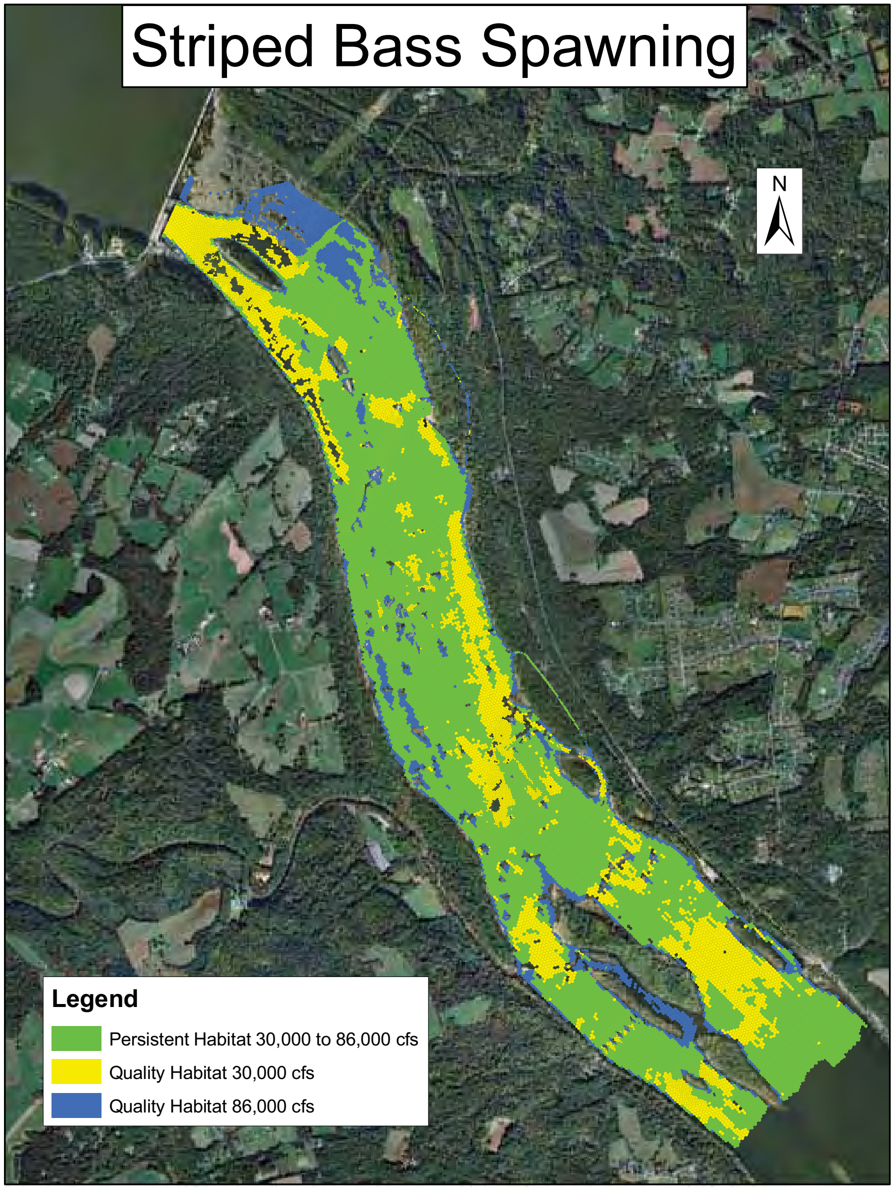

Striped Bass Spawing
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

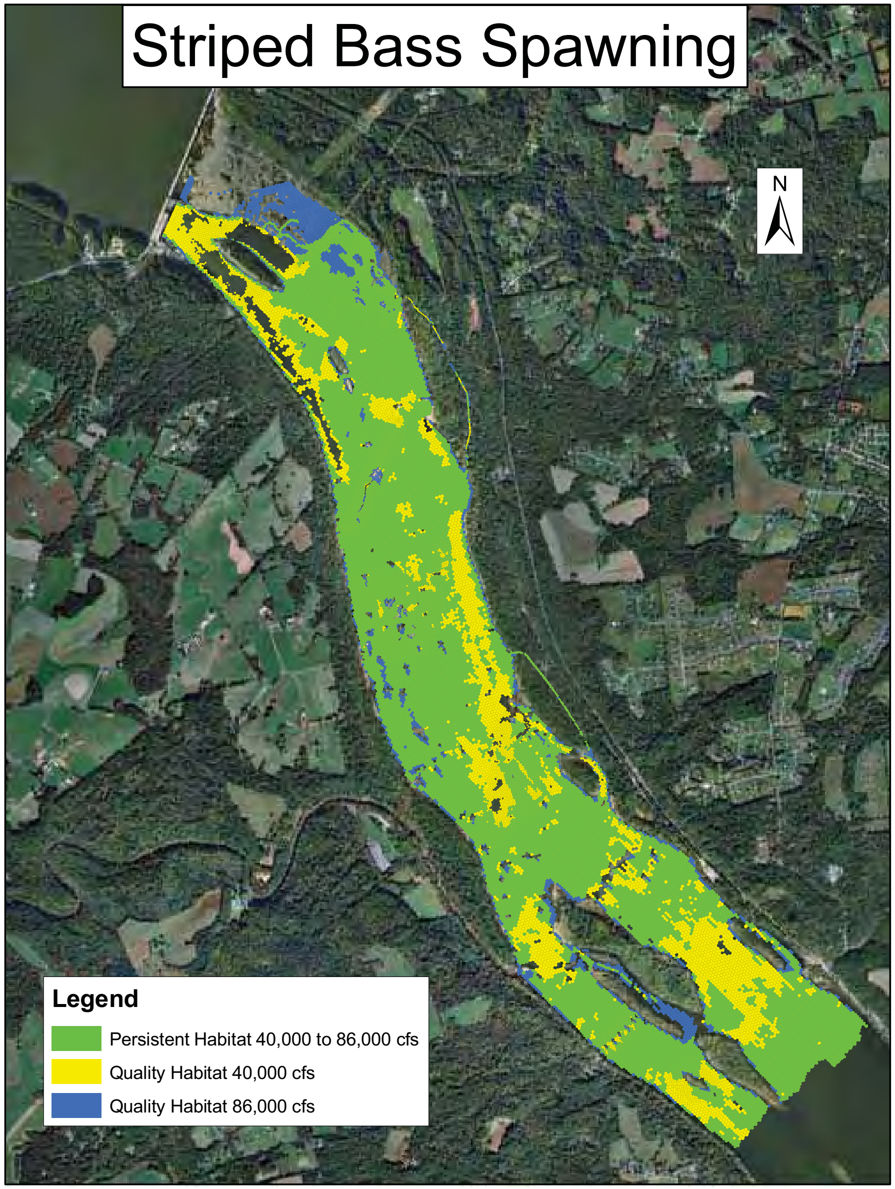

Striped Bass Spawing
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

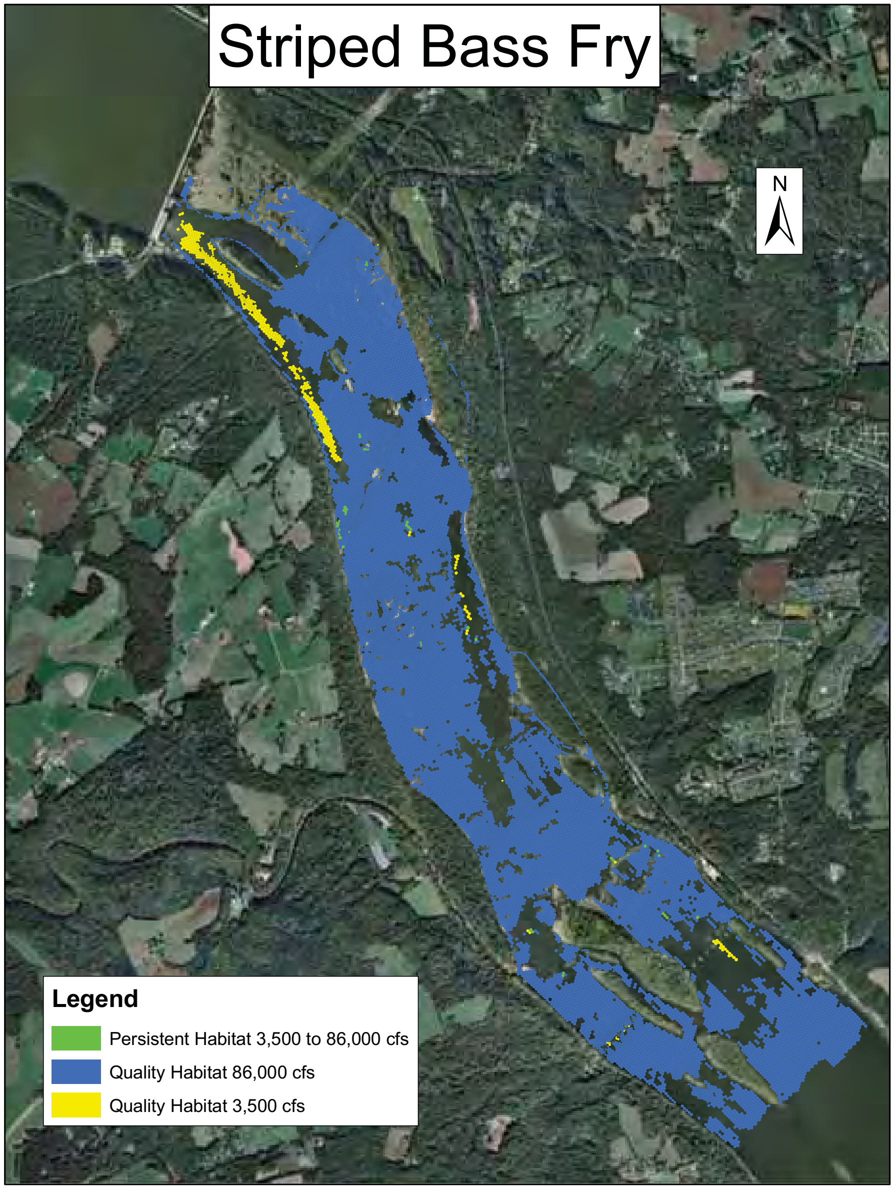

Striped Bass Spawing
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

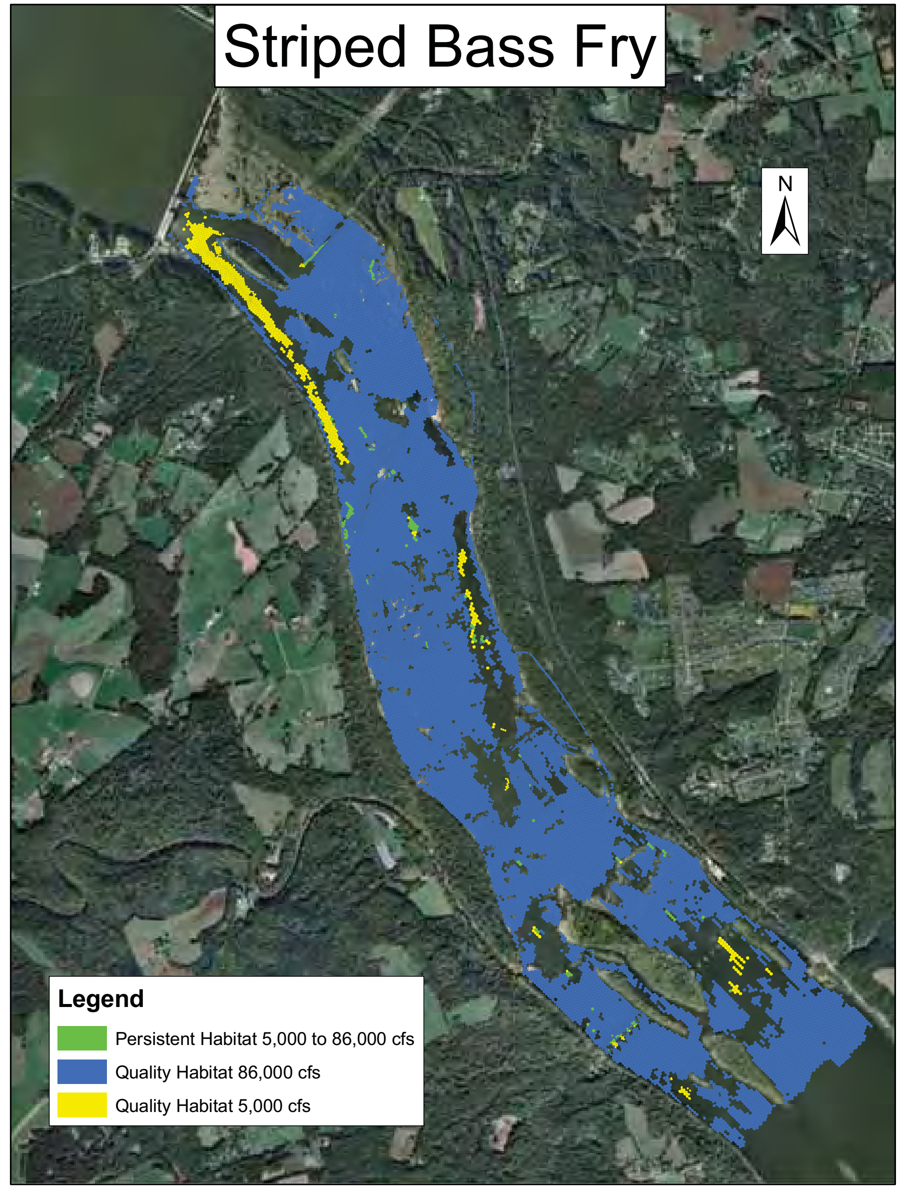

Striped Bass Spawning
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

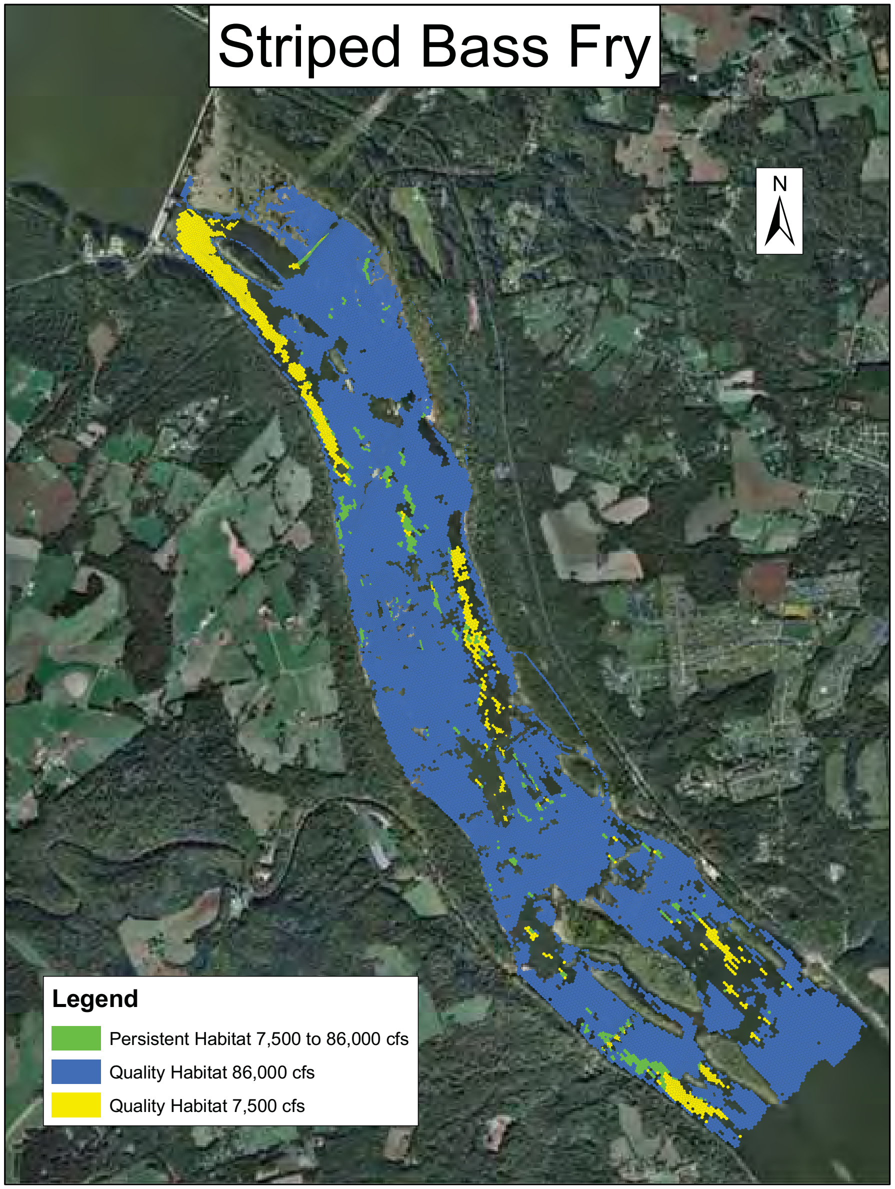

Striped Bass Spawning
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

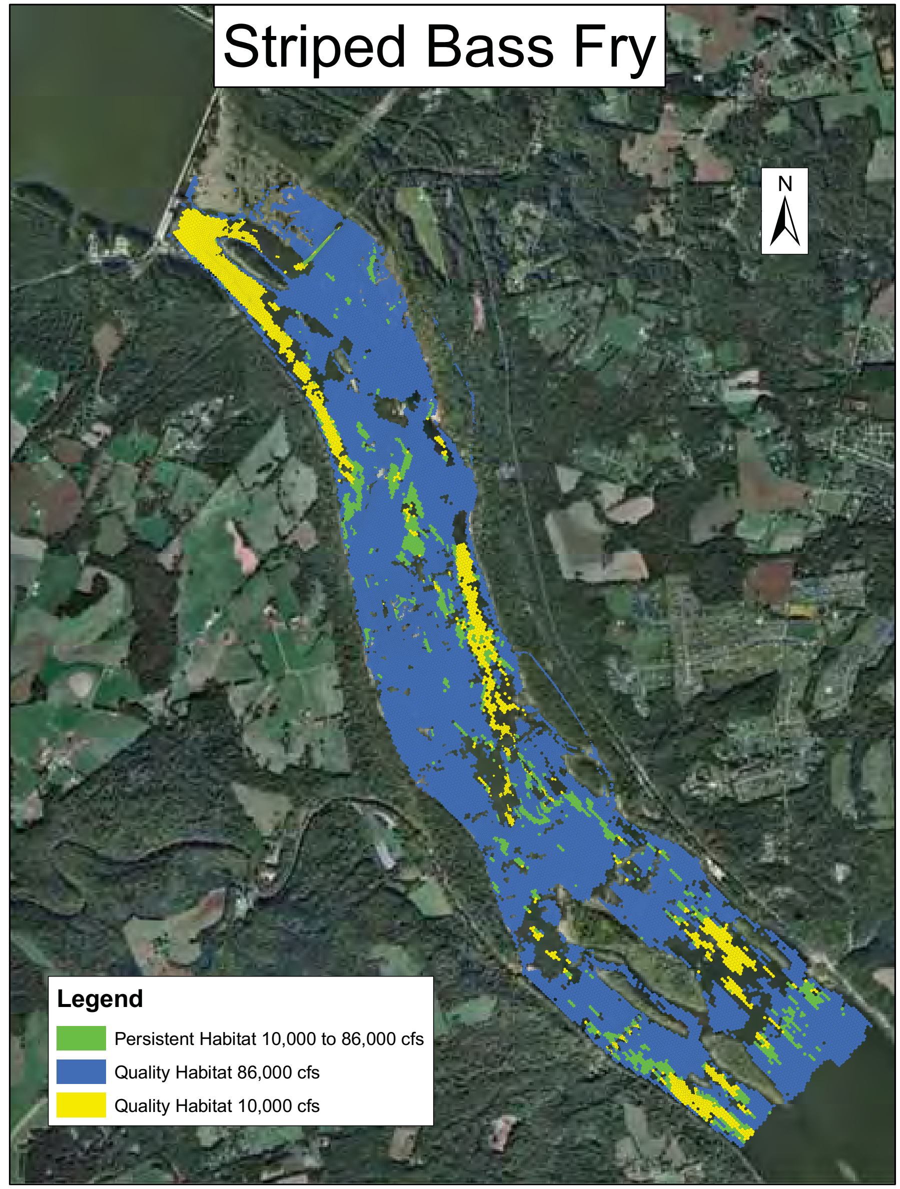

Striped Bass Spawning
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

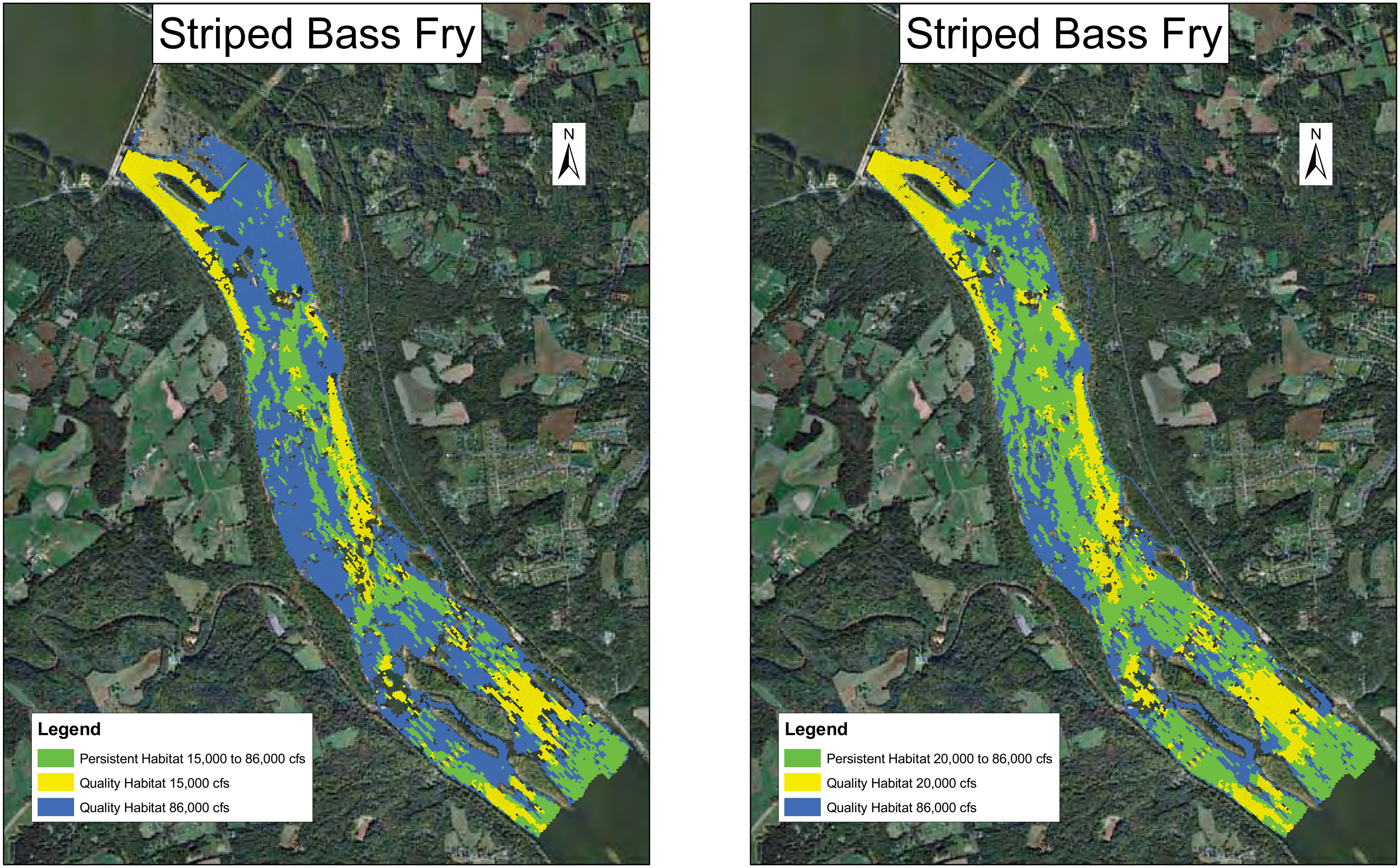

Striped Bass Spawning
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

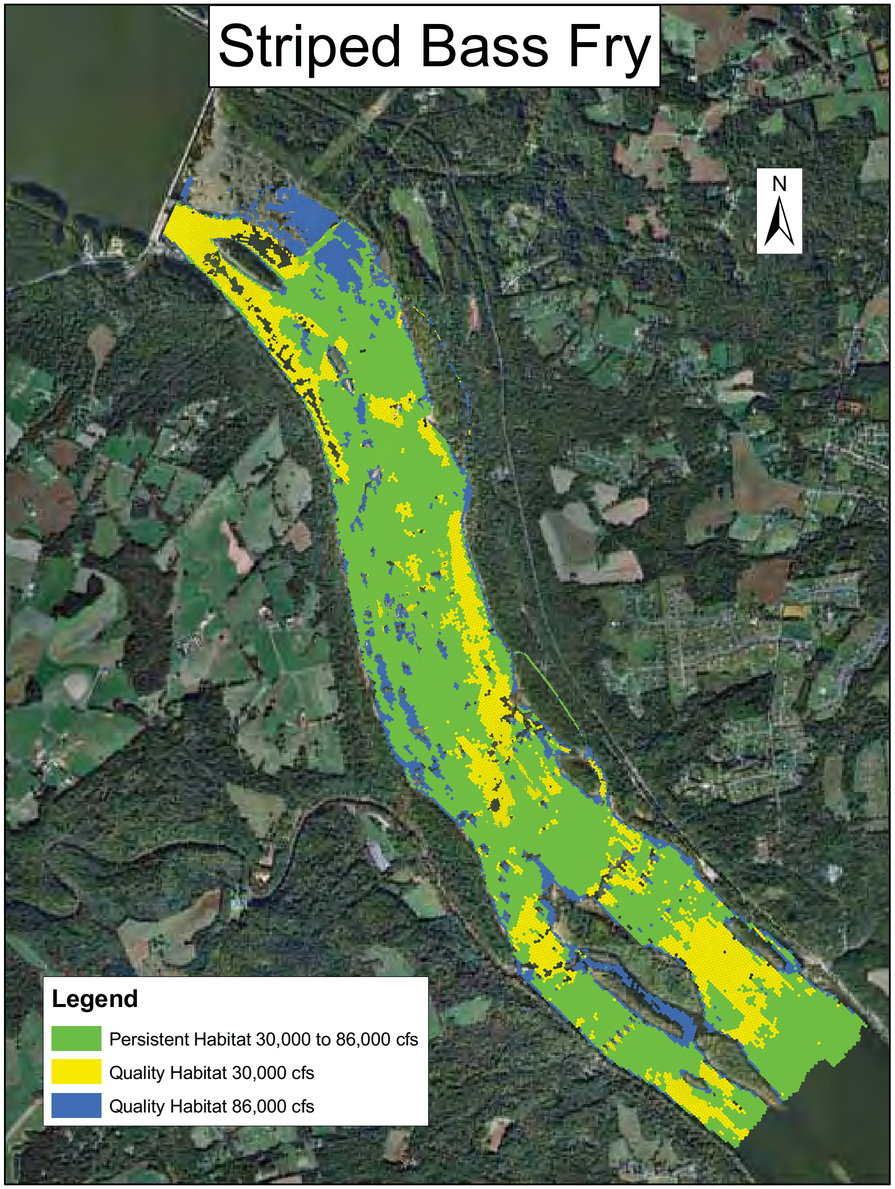

Striped Bass Fry
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

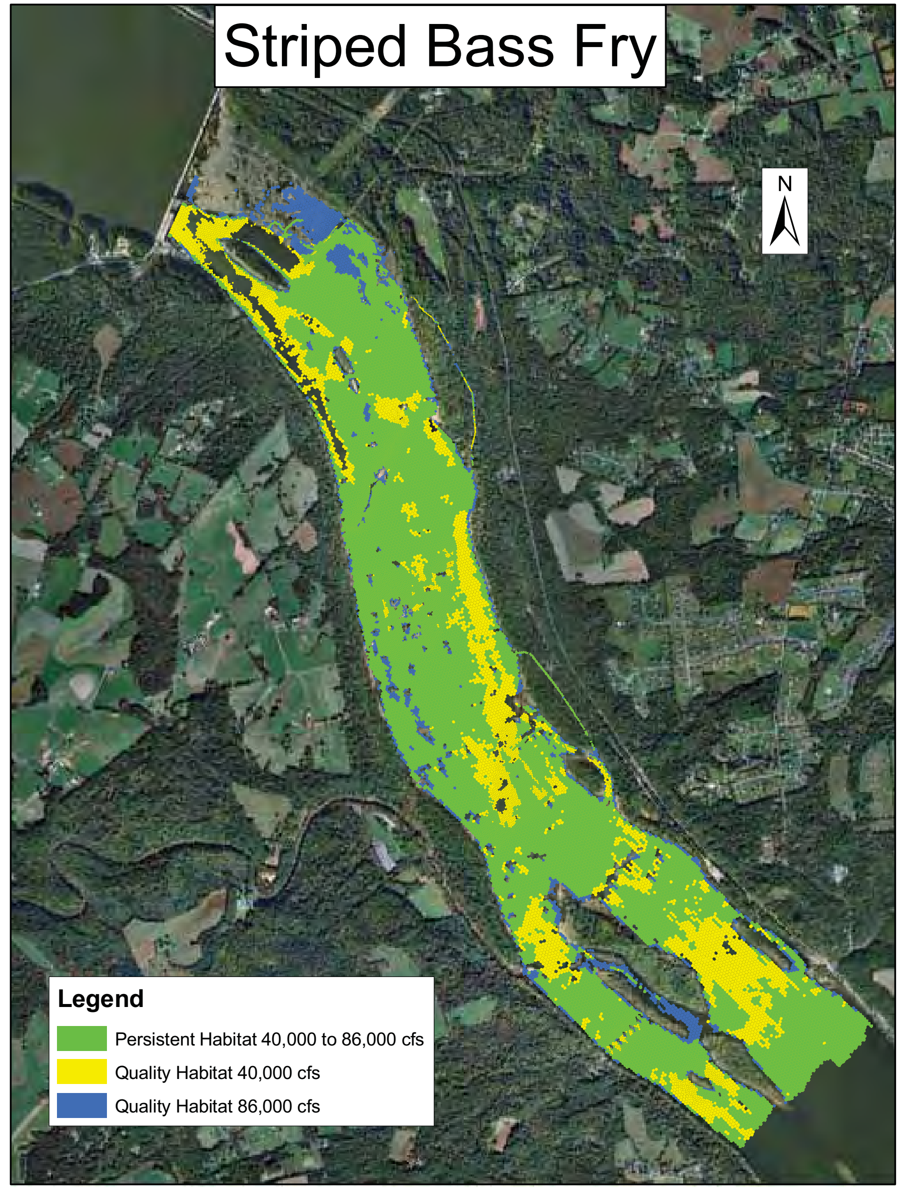

Striped Bass Fry
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

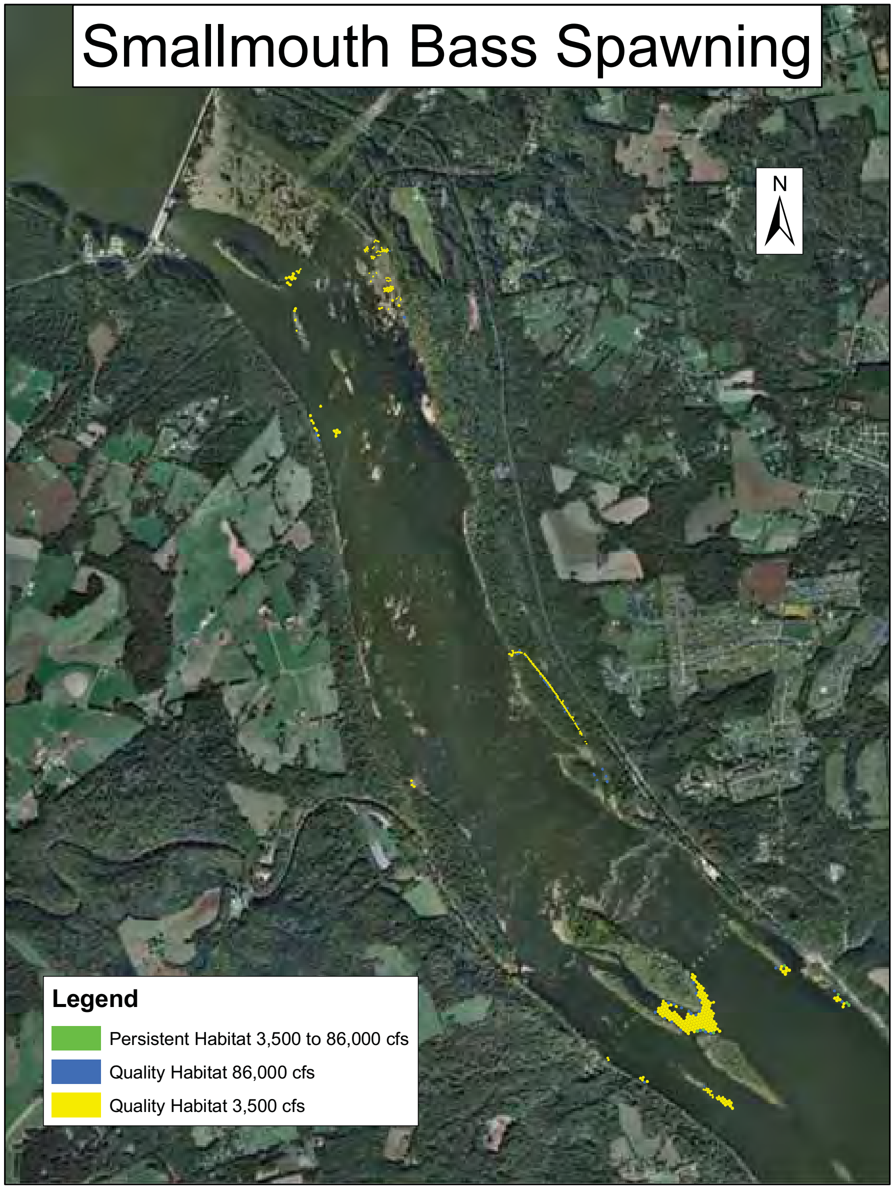

Striped Bass Fry
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

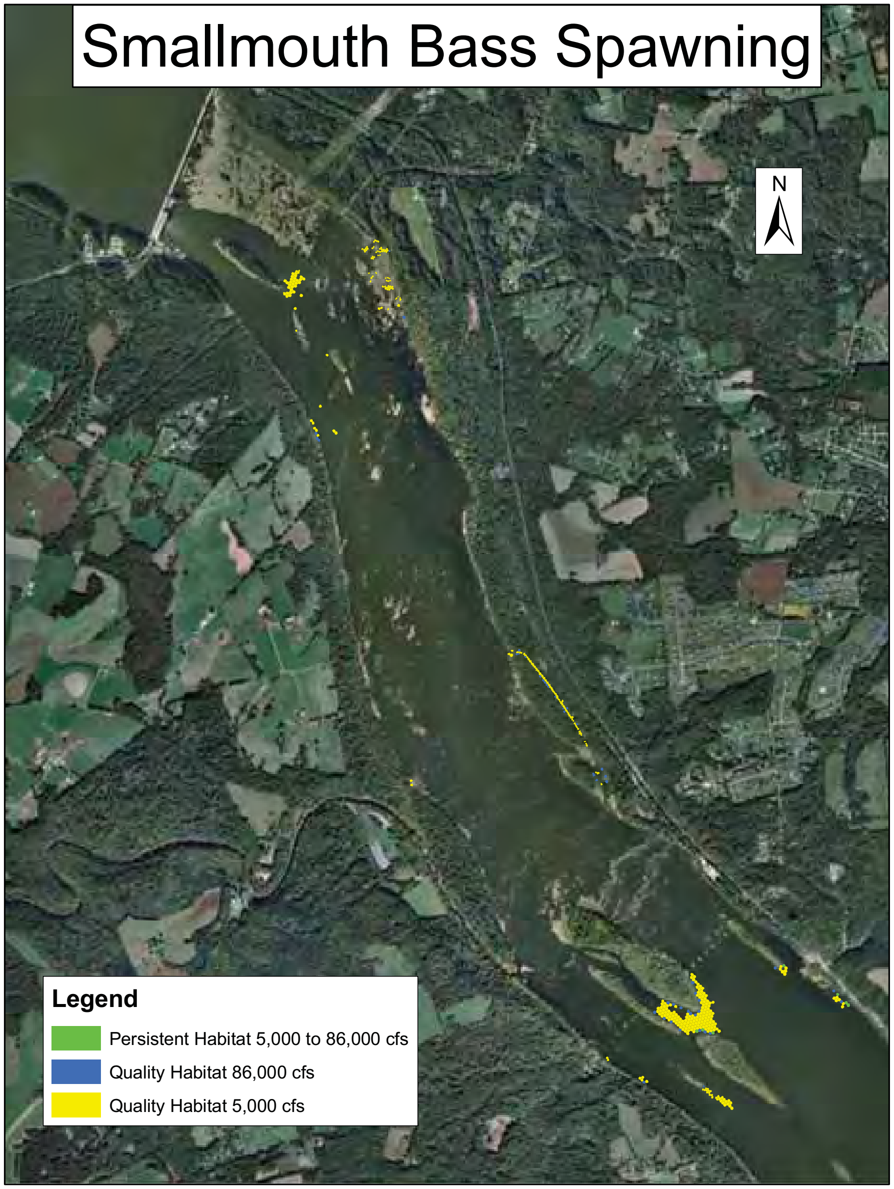

Striped Bass Fry
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

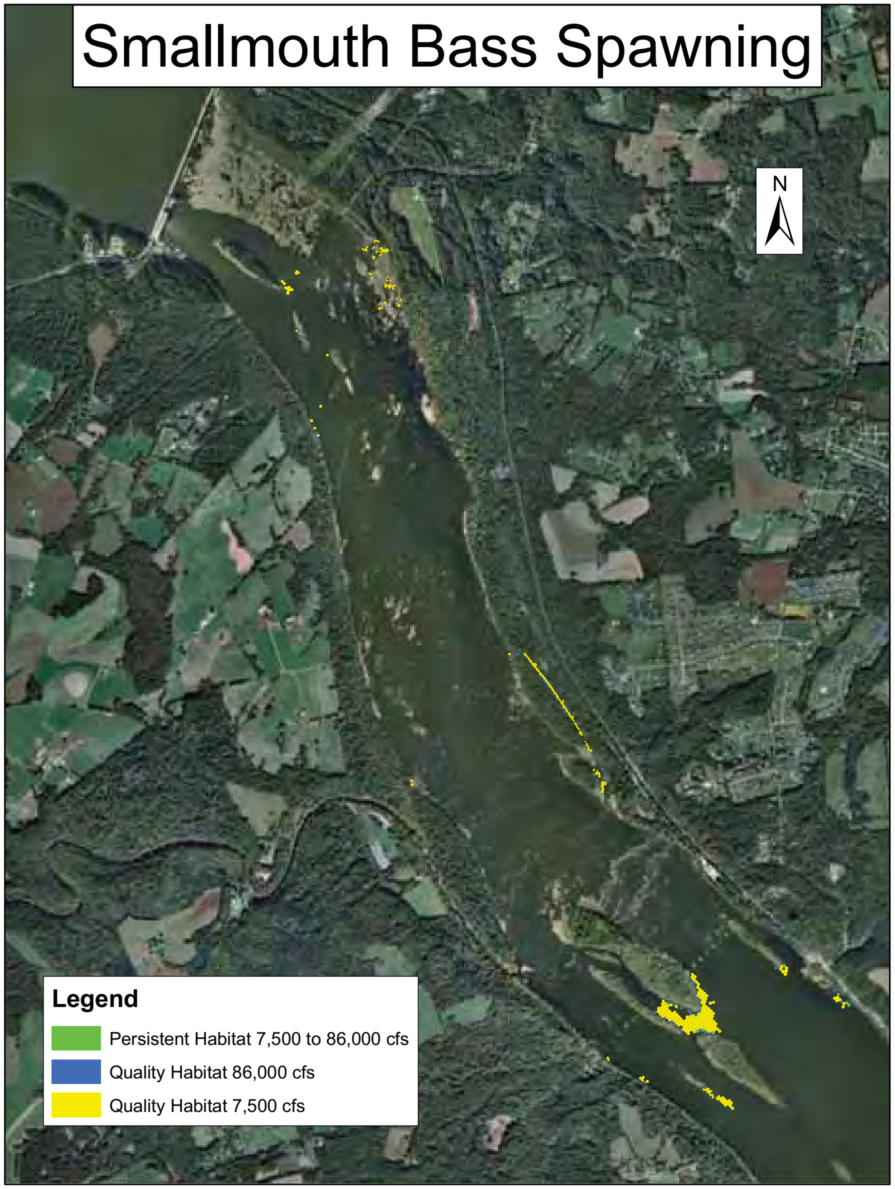

Striped Bass Fry
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs
Striped Bass Fry
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

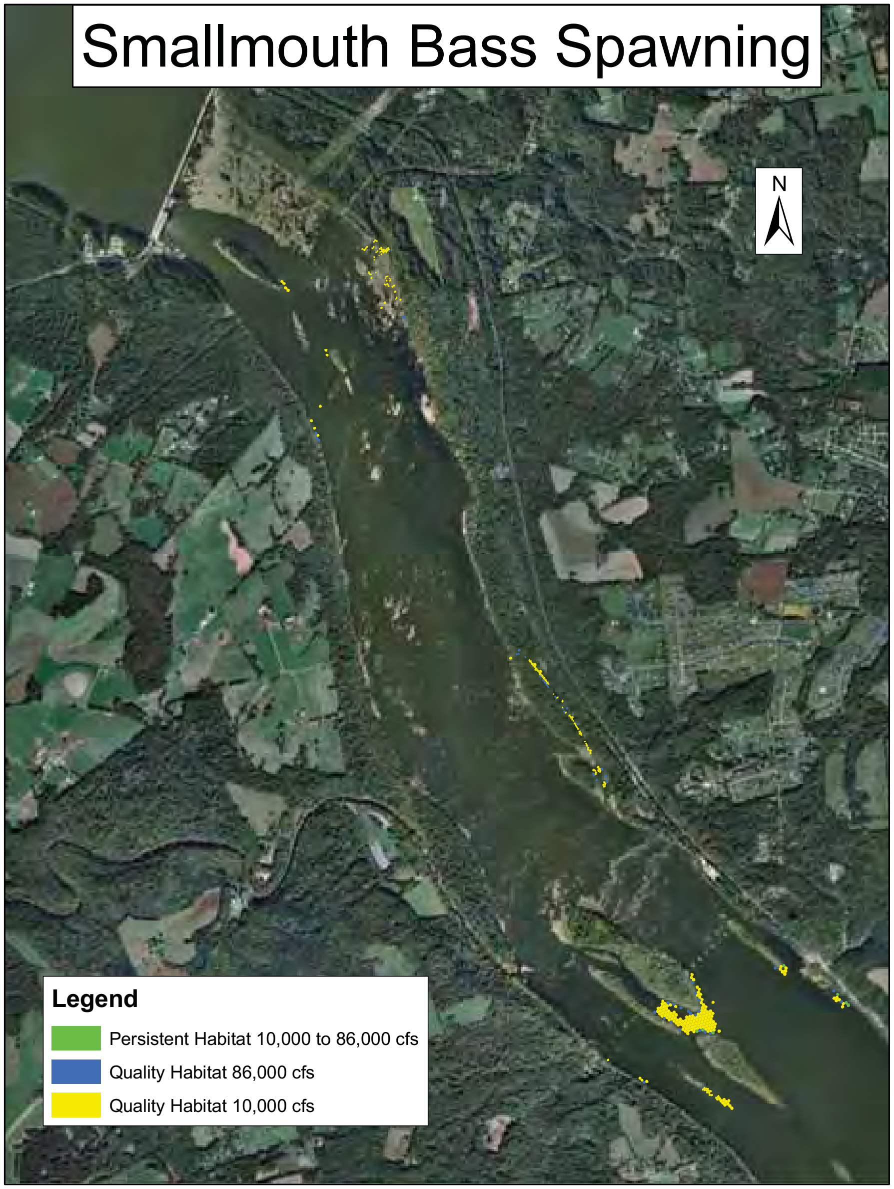

Striped Bass Fry
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs


Striped Bass Fry
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

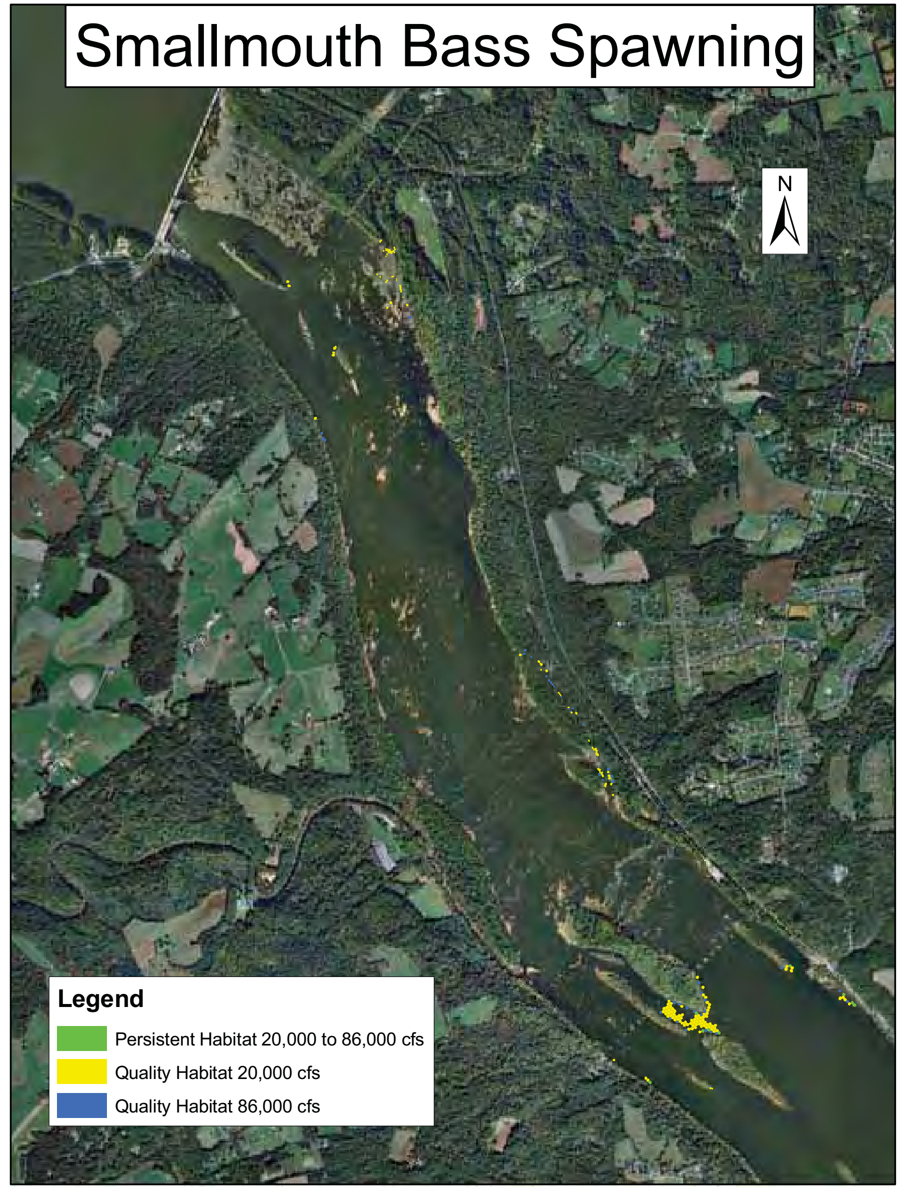

Smallmouth Bass Spawning
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs


Smallmouth Bass Spawning
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

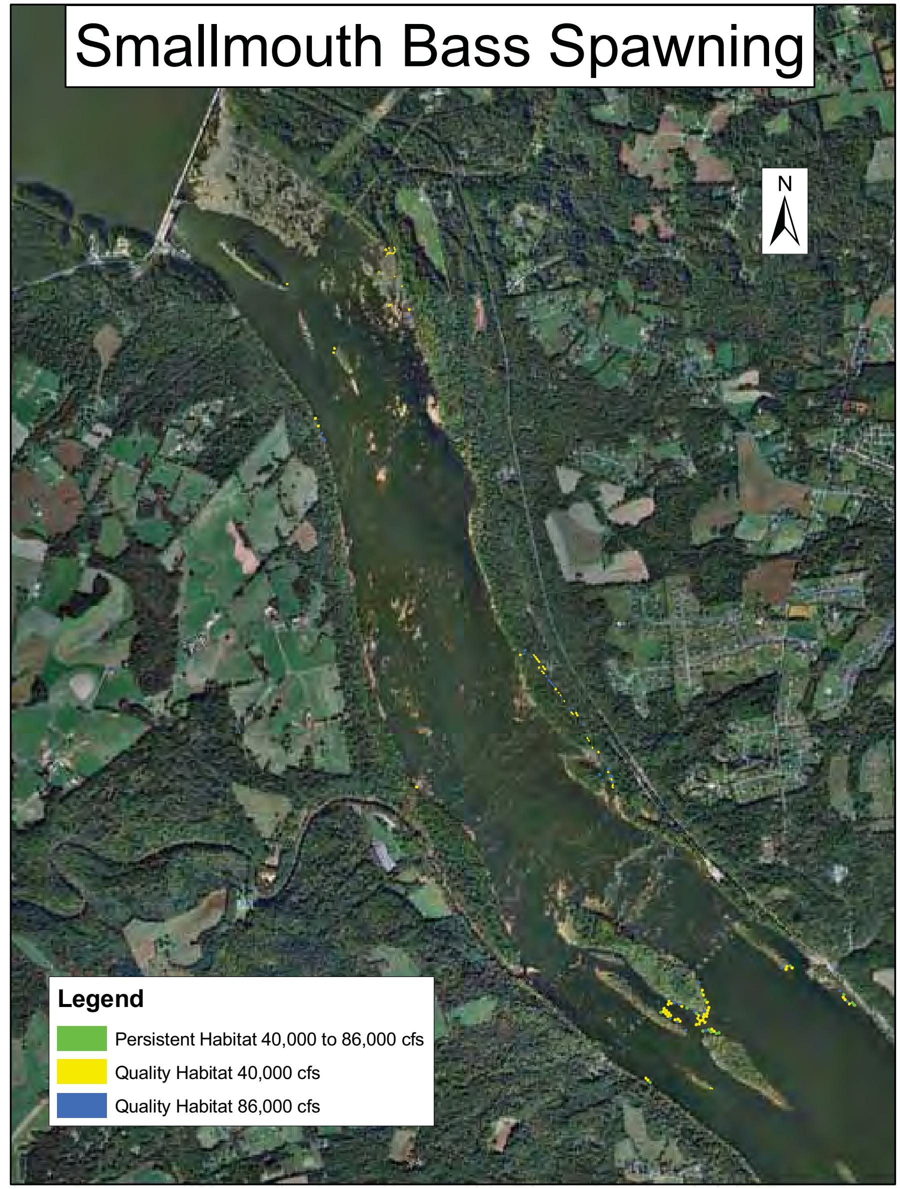

Smallmouth Bass Spawning
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

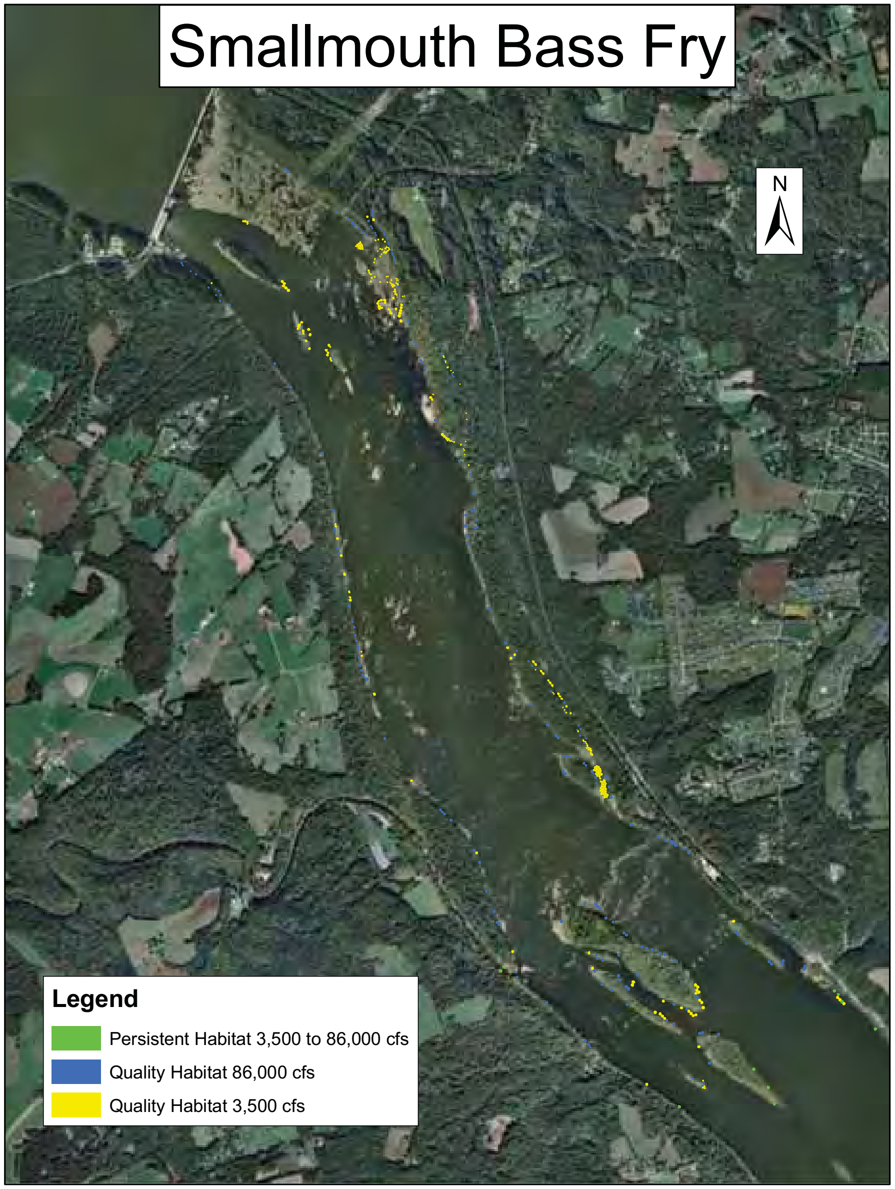

Smallmouth Bass Spawning
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

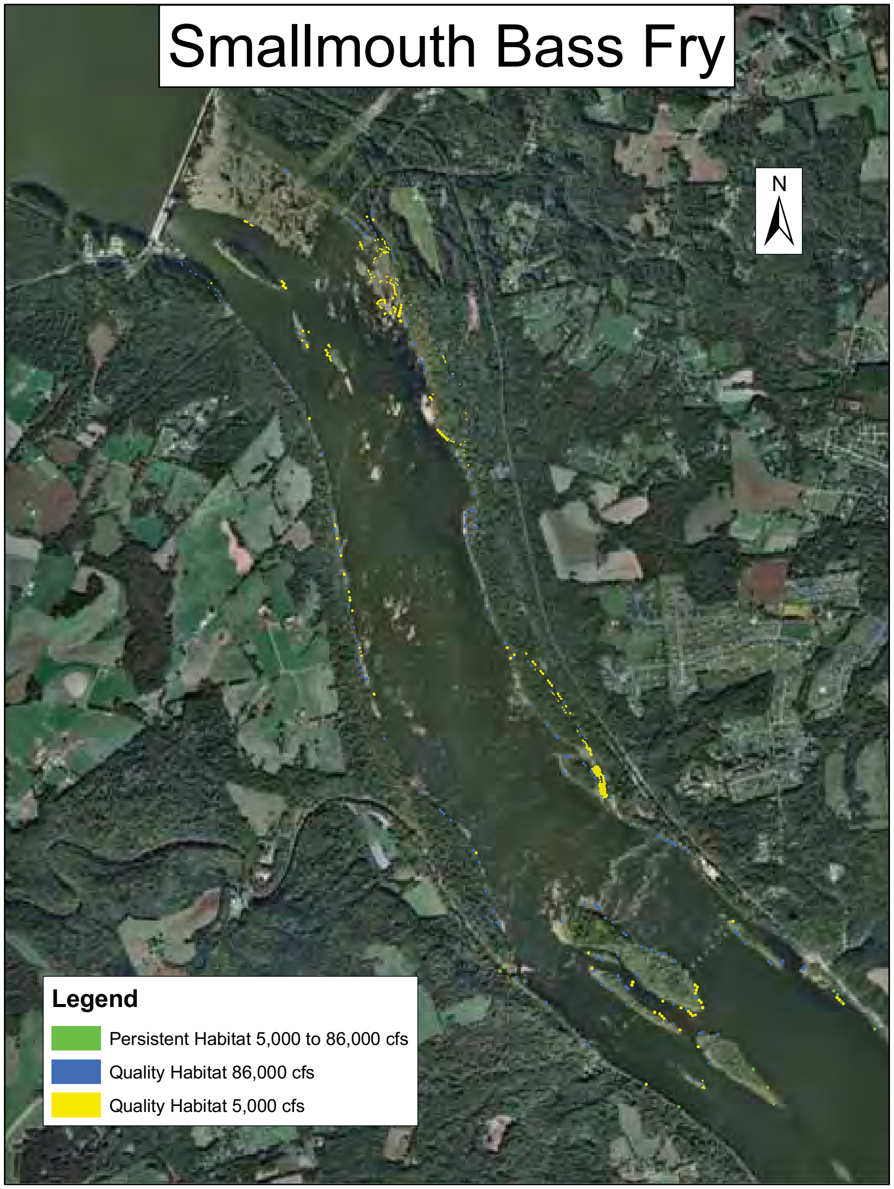

Smallmouth Bass Spawning
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

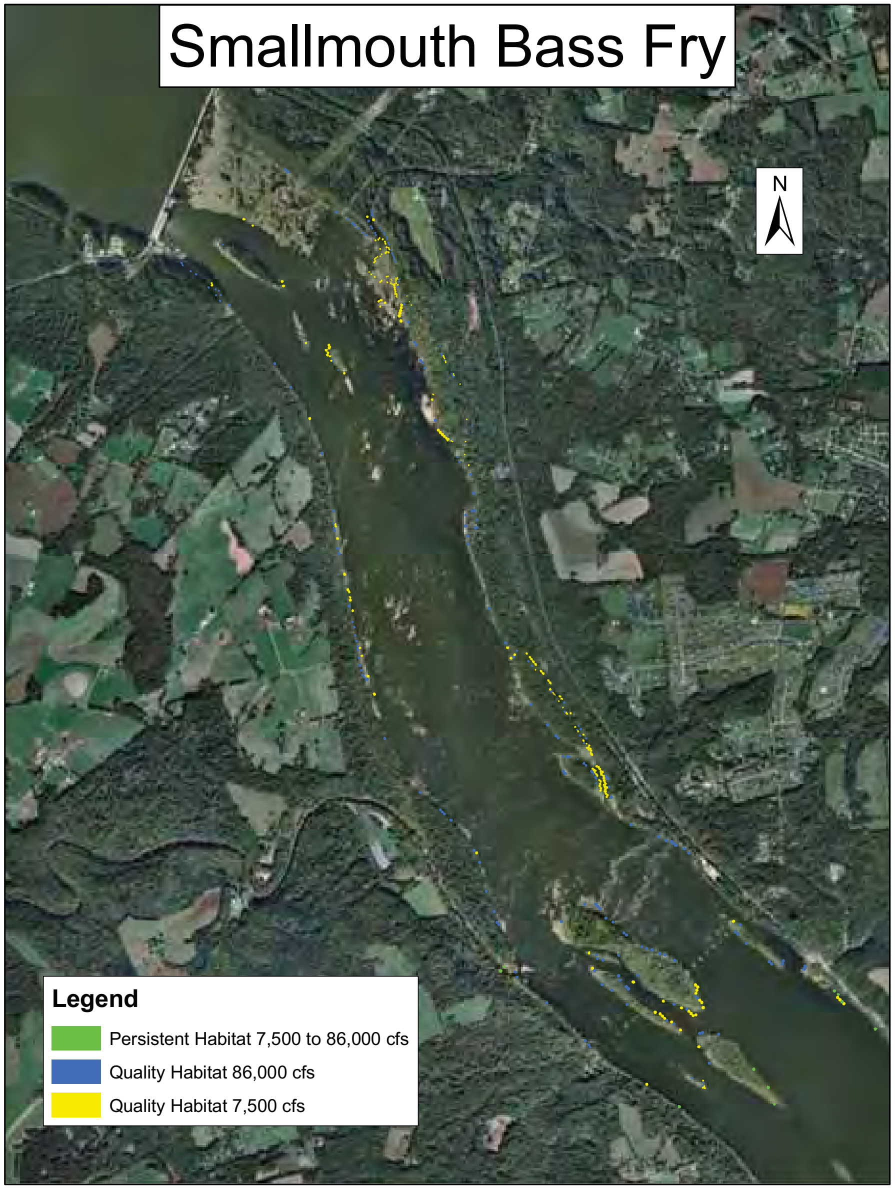

Smallmouth Bass Spawning
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs


Smallmouth Bass Spawning
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

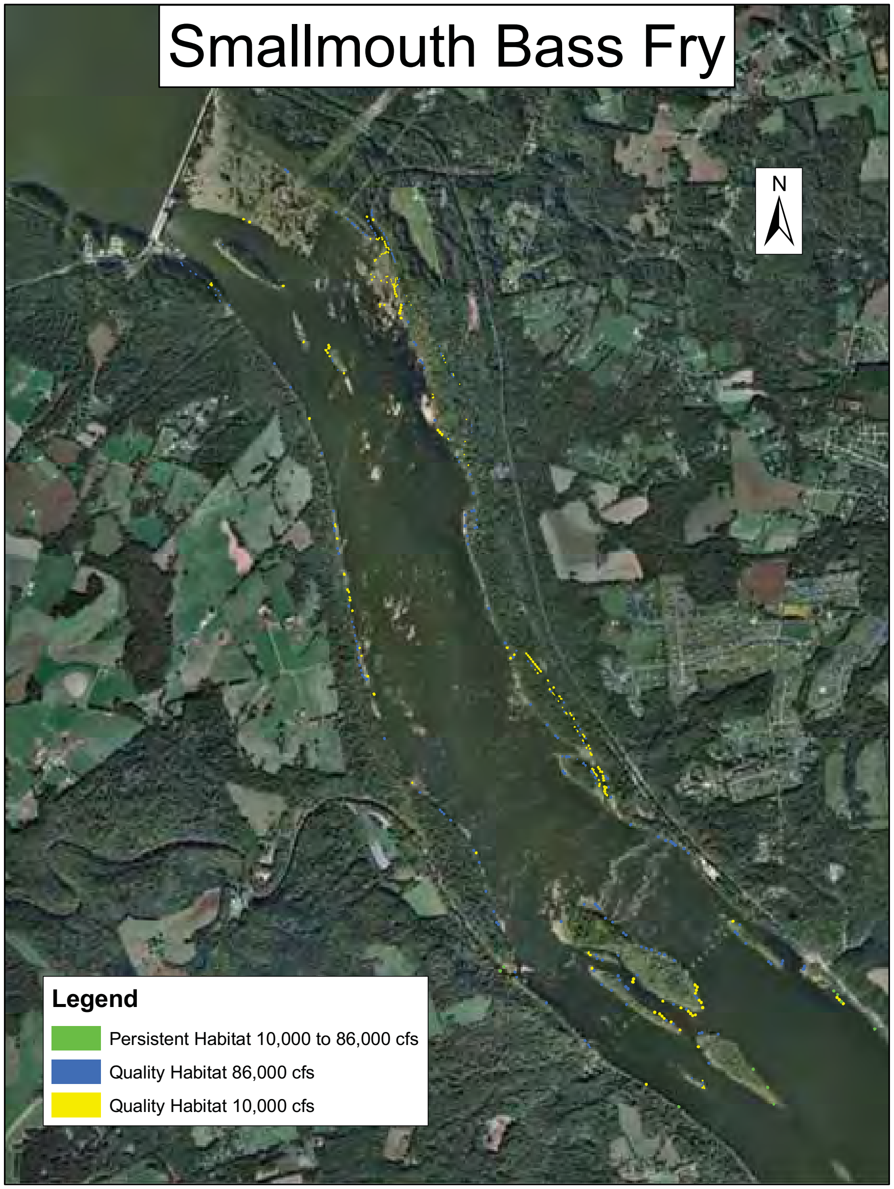

Smallmouth Bass Spawning
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs


Smallmouth Bass Fry
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs


Smallmouth Bass Fry
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs



Smallmouth Bass Fry
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs



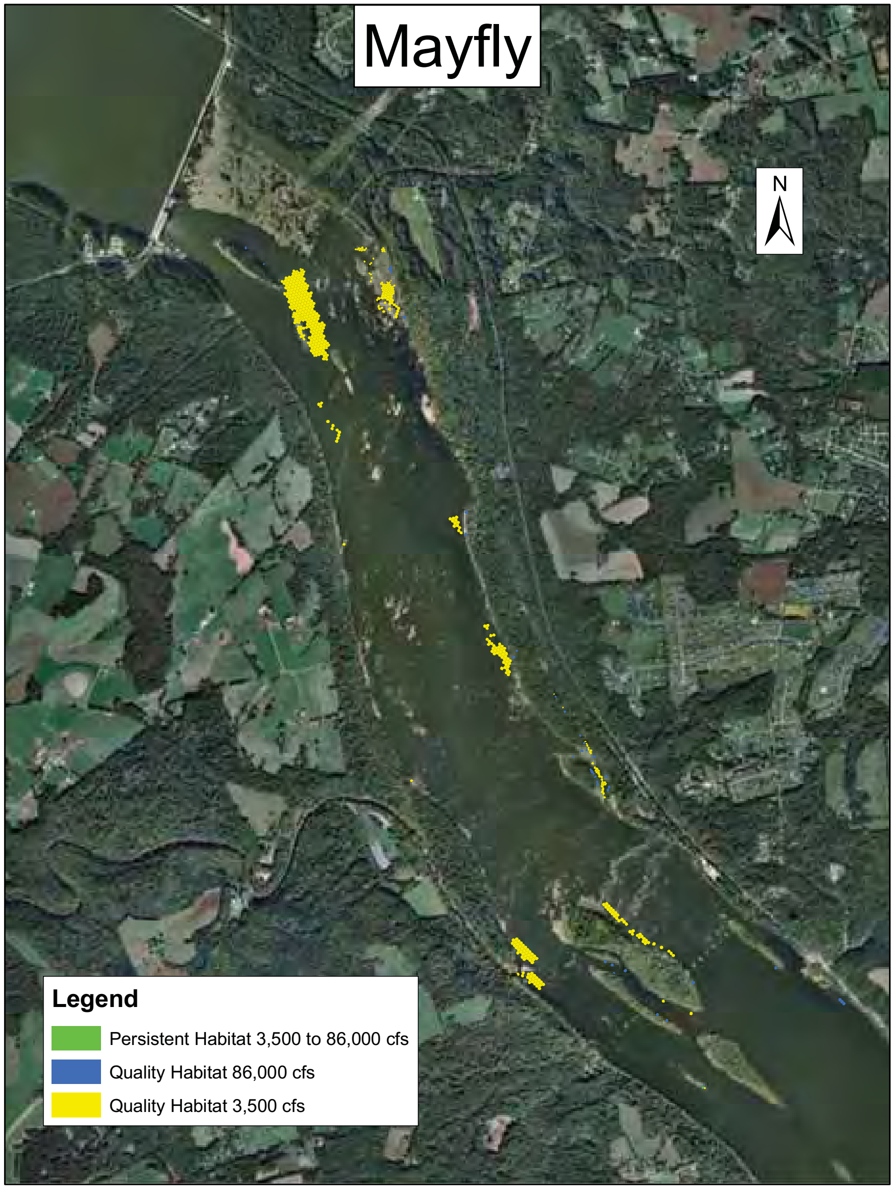
Smallmouth Bass Fry
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

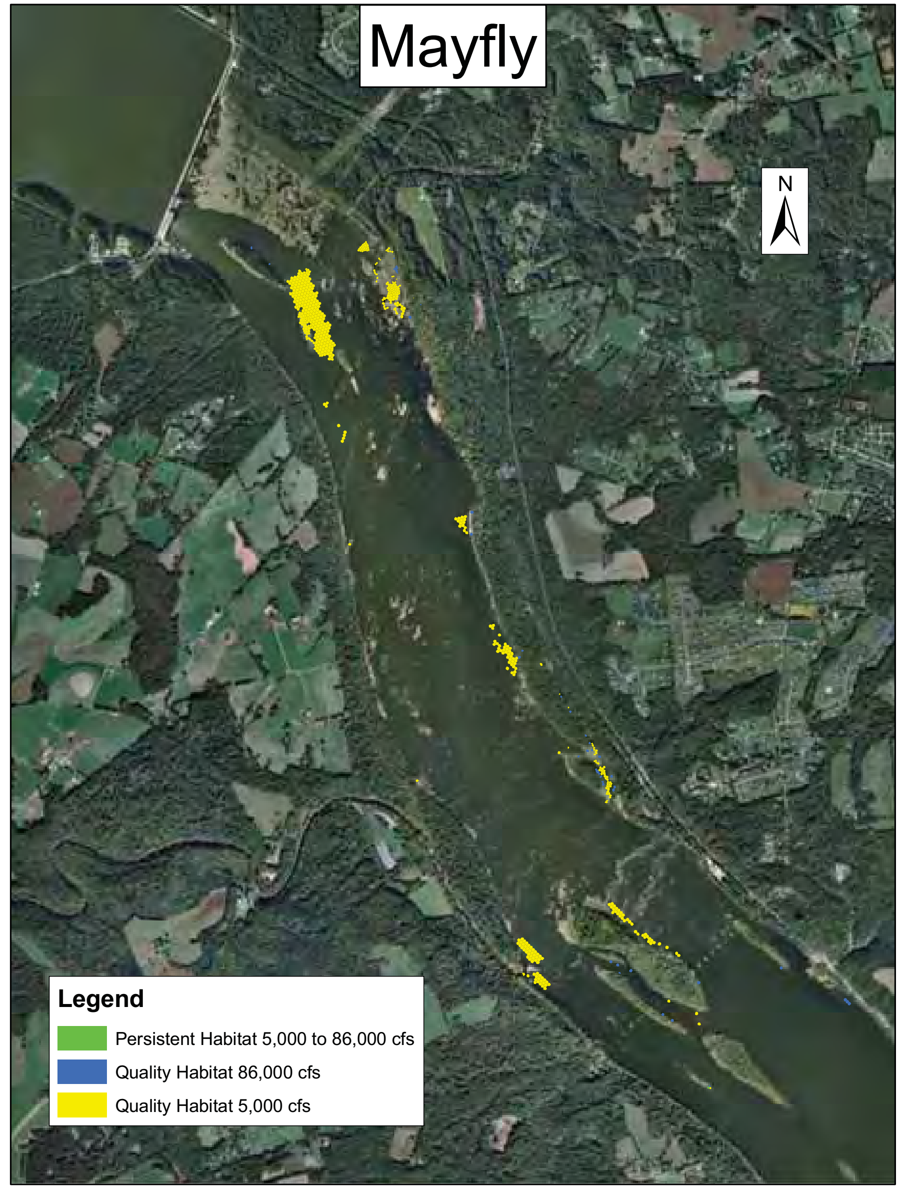

Smallmouth Bass Fry
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

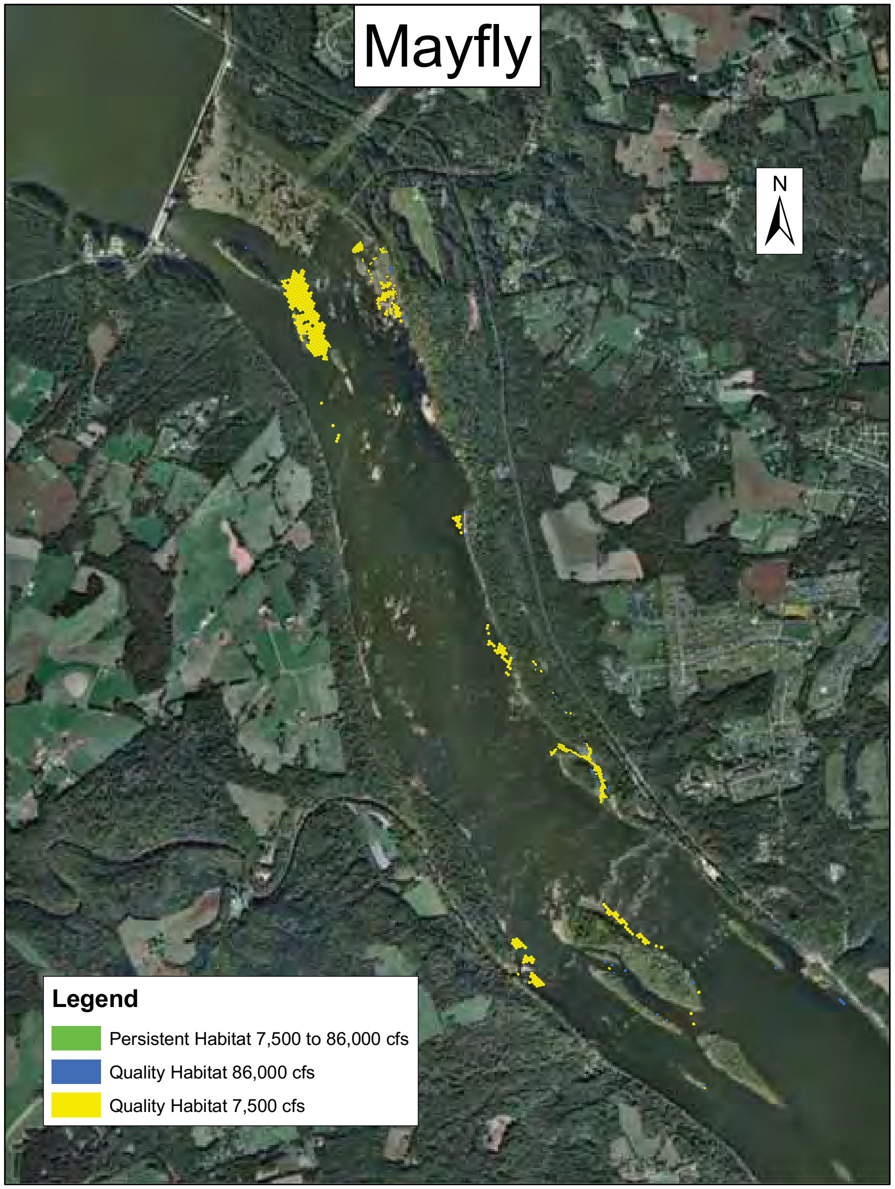

Smallmouth Bass Fry
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

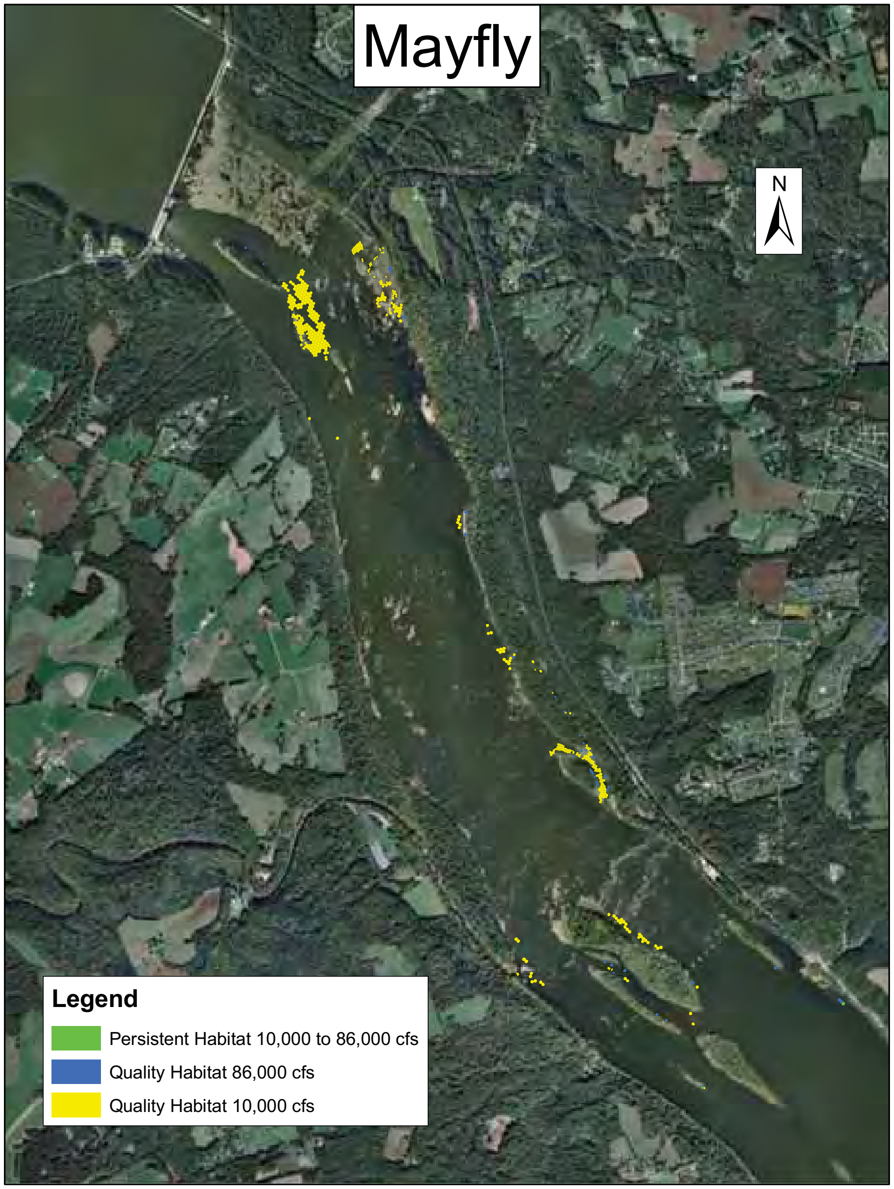

Smallmouth Bass Fry
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

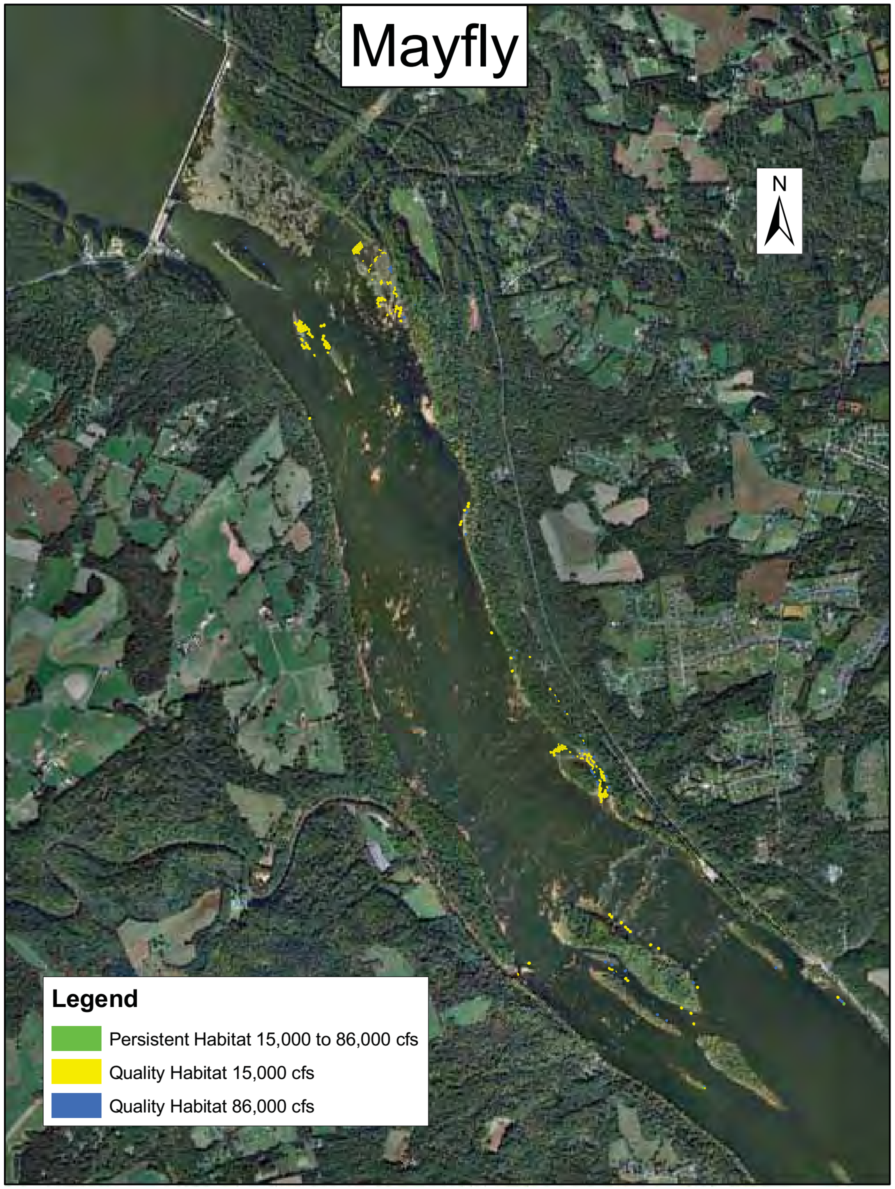

Smallmouth Bass Fry
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

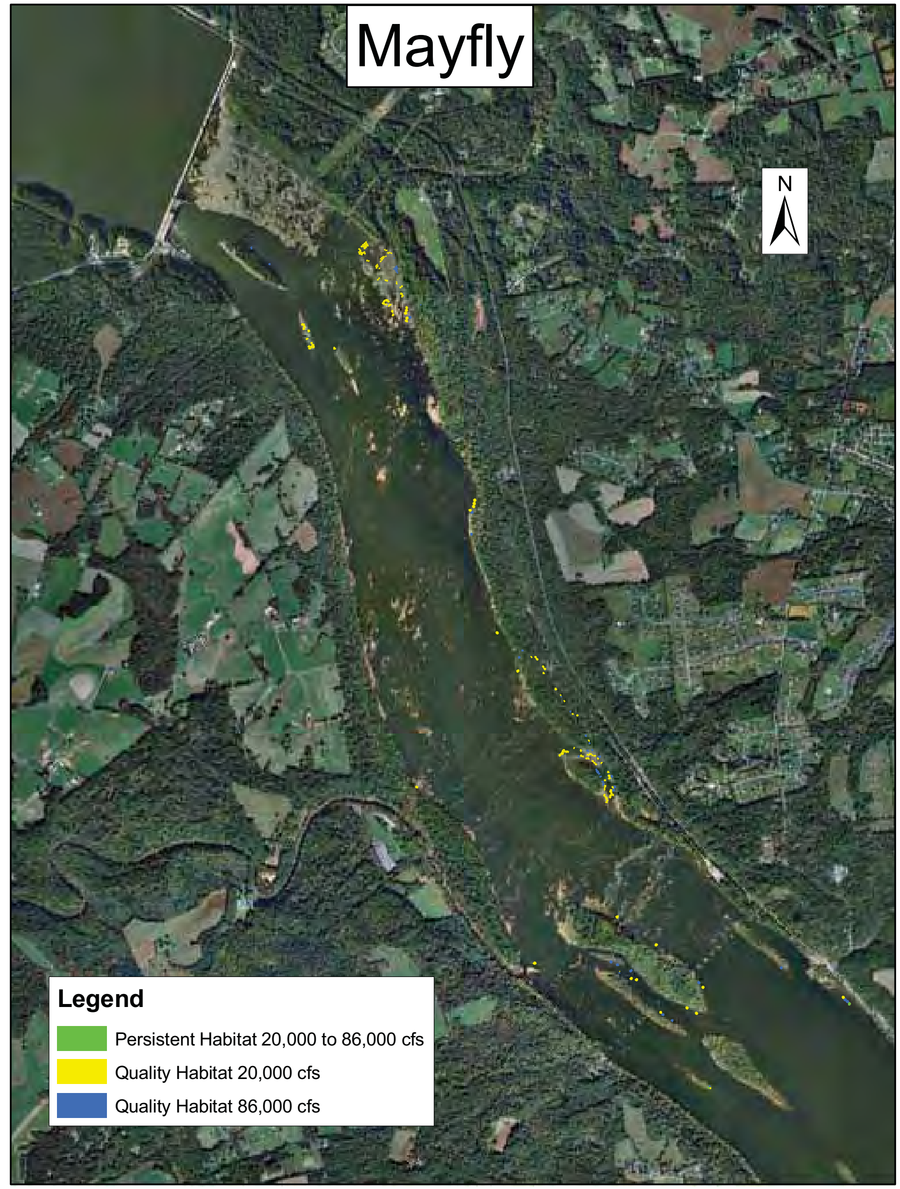

Mayfly
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs


Mayfly
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs


Mayfly
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

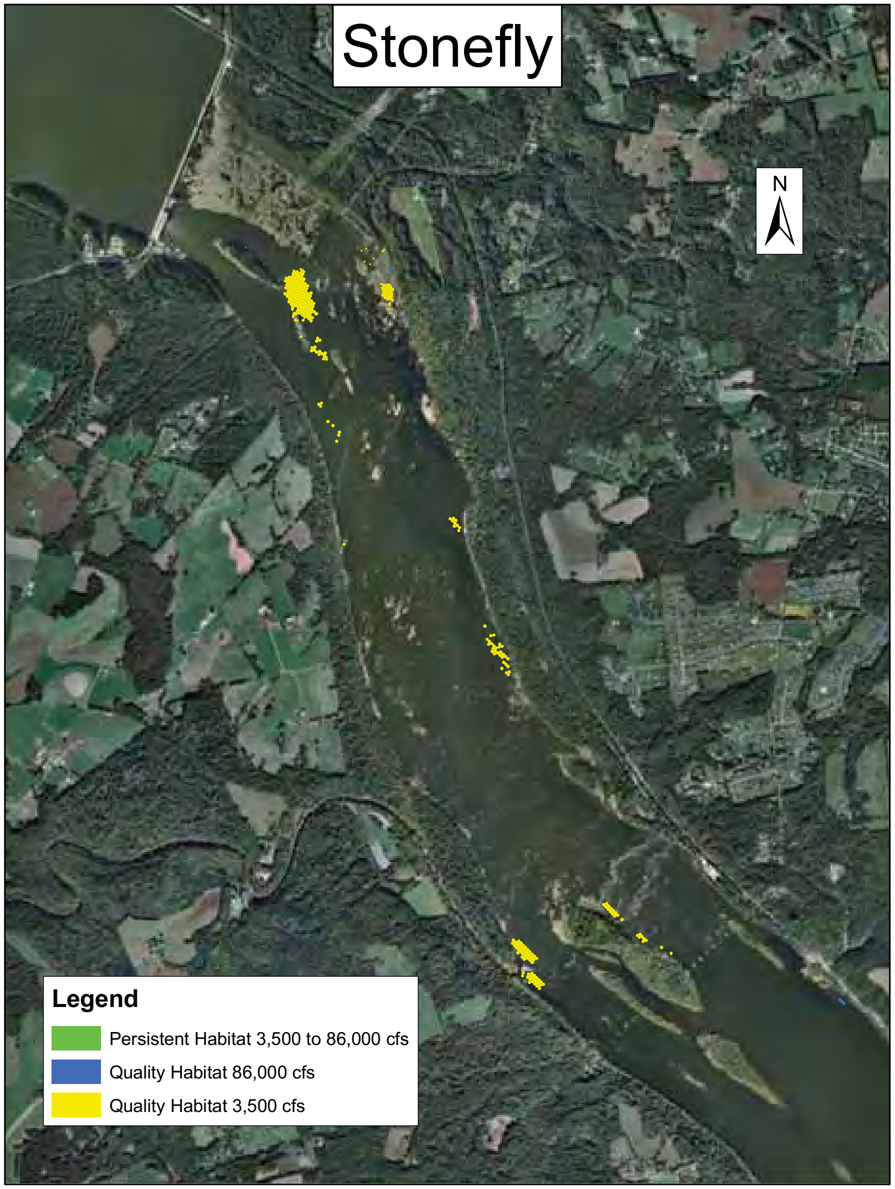

Mayfly
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

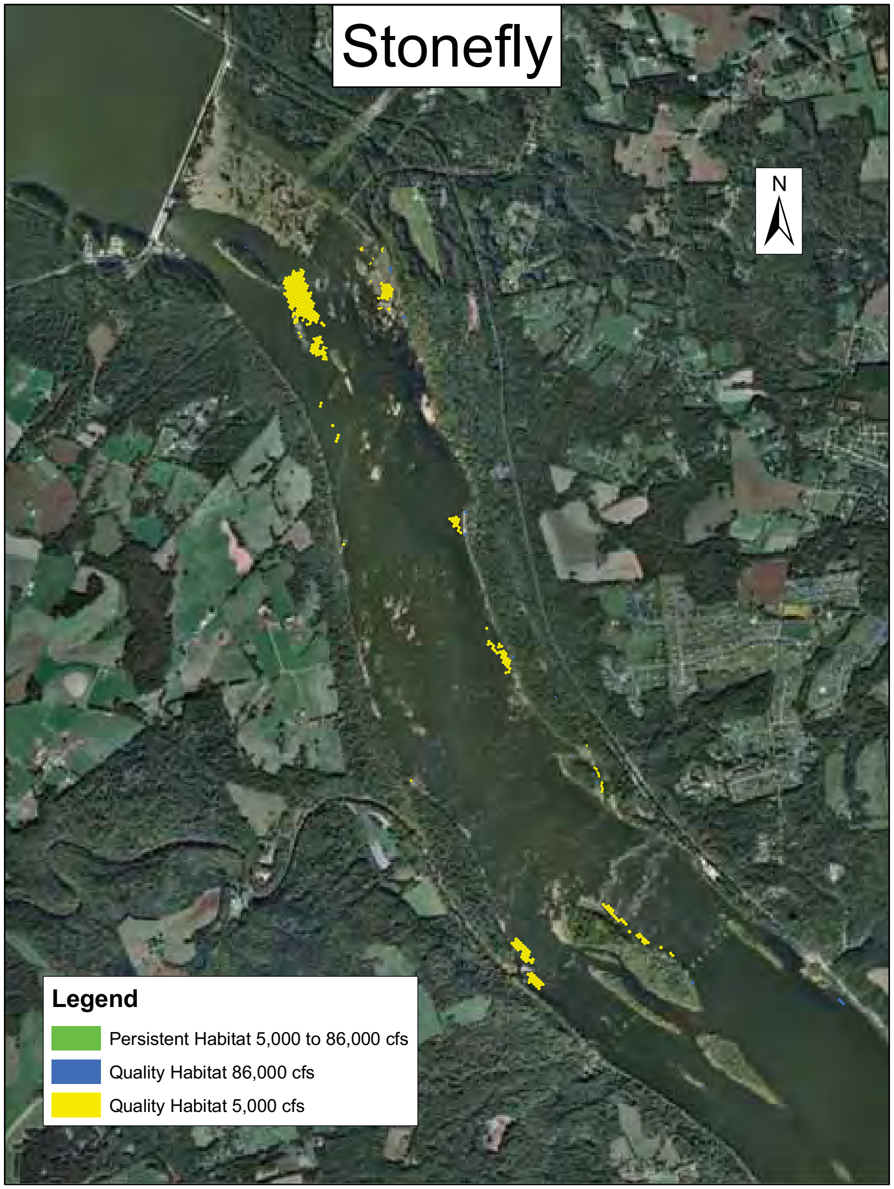

Mayfly
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

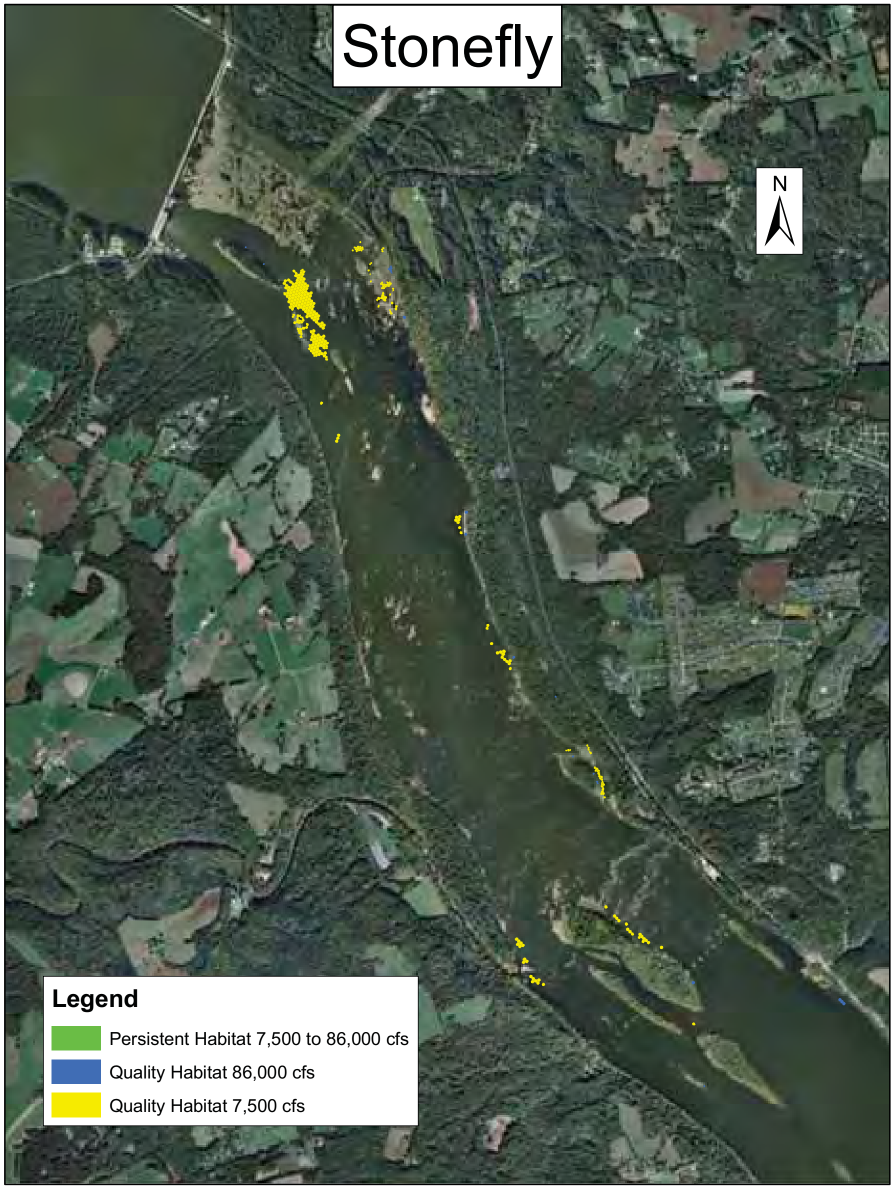

Mayfly
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

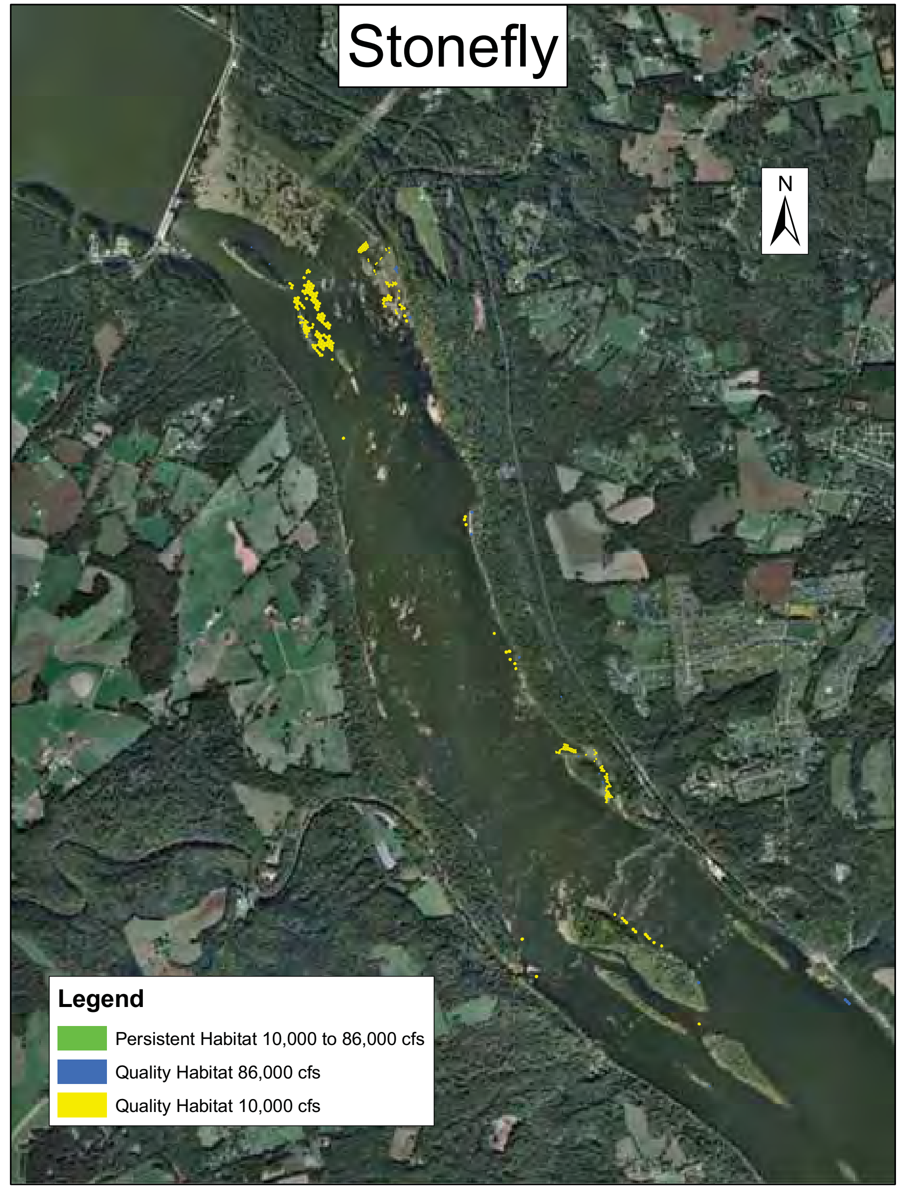

Mayfly
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

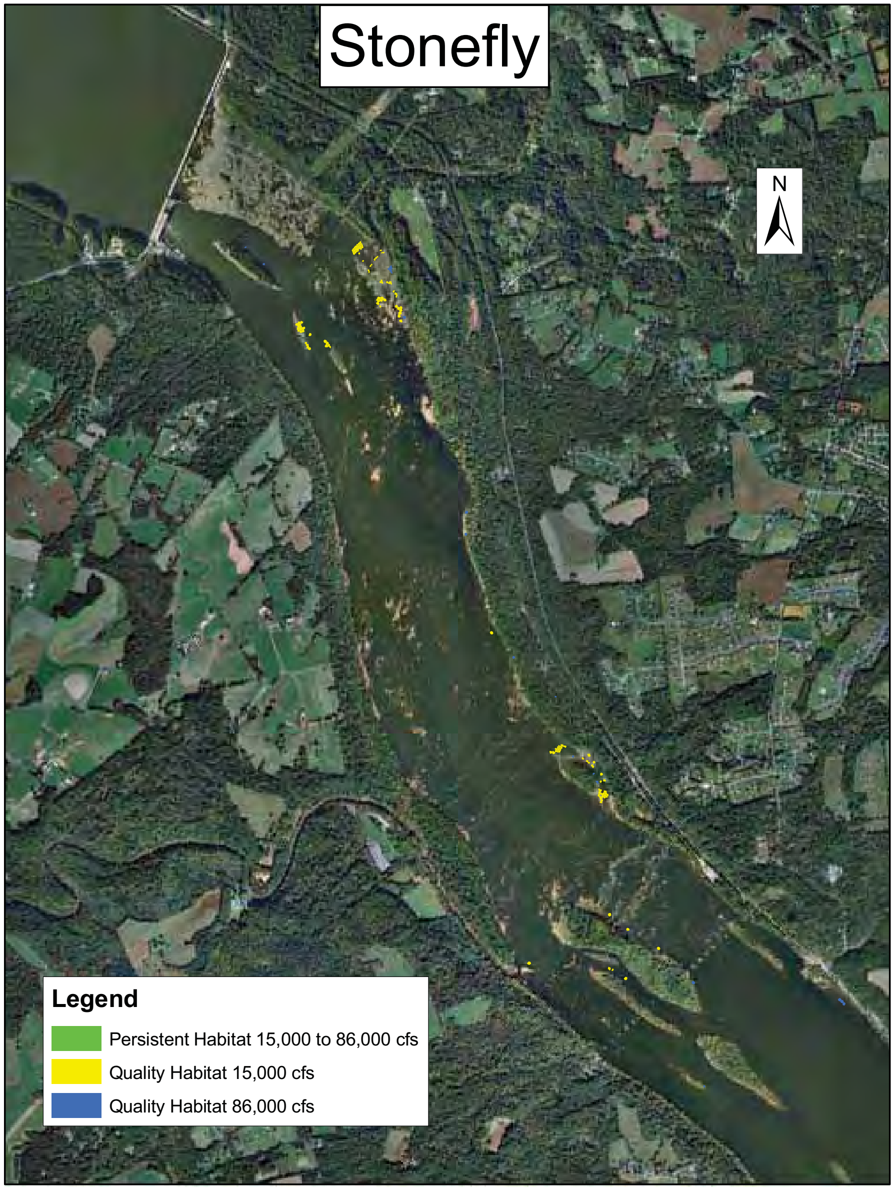

Mayfly
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs


Stonefly
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs


Stonefly
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

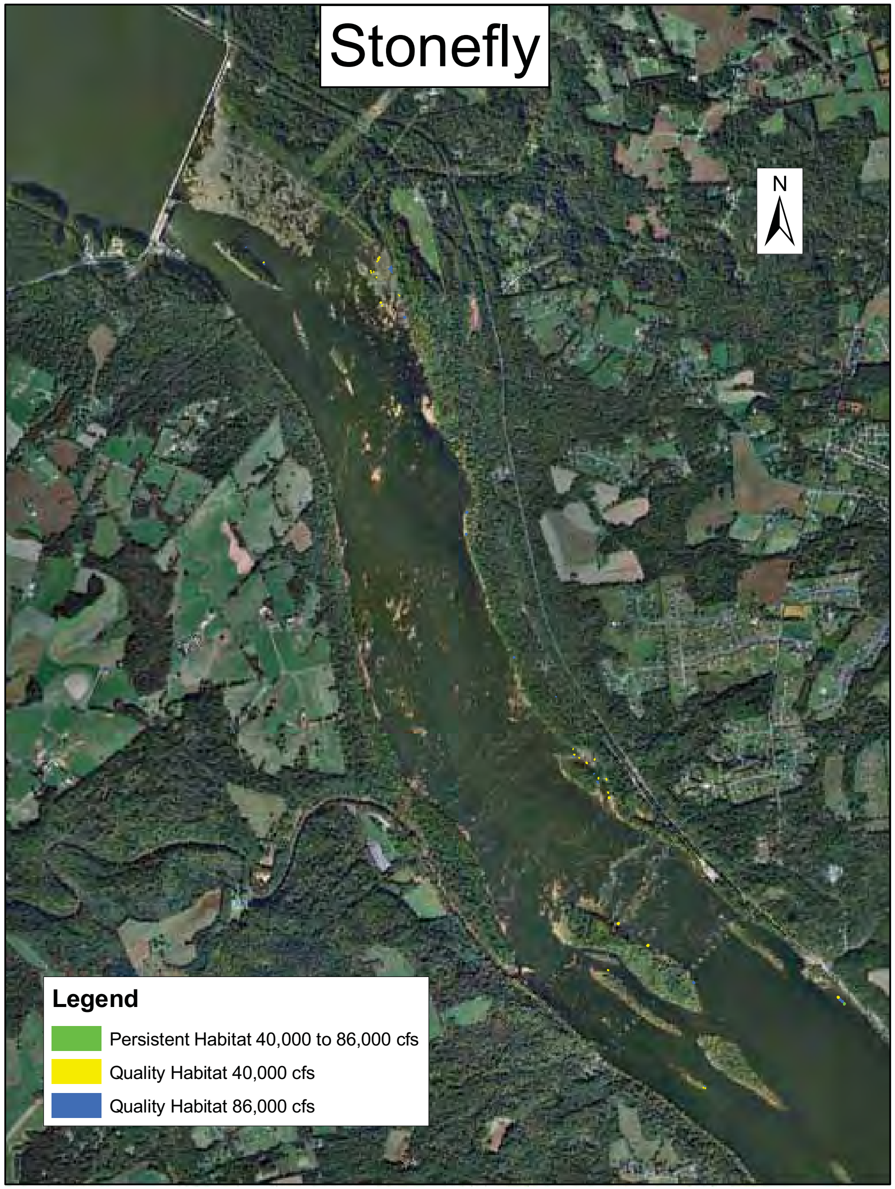

Stonefly
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

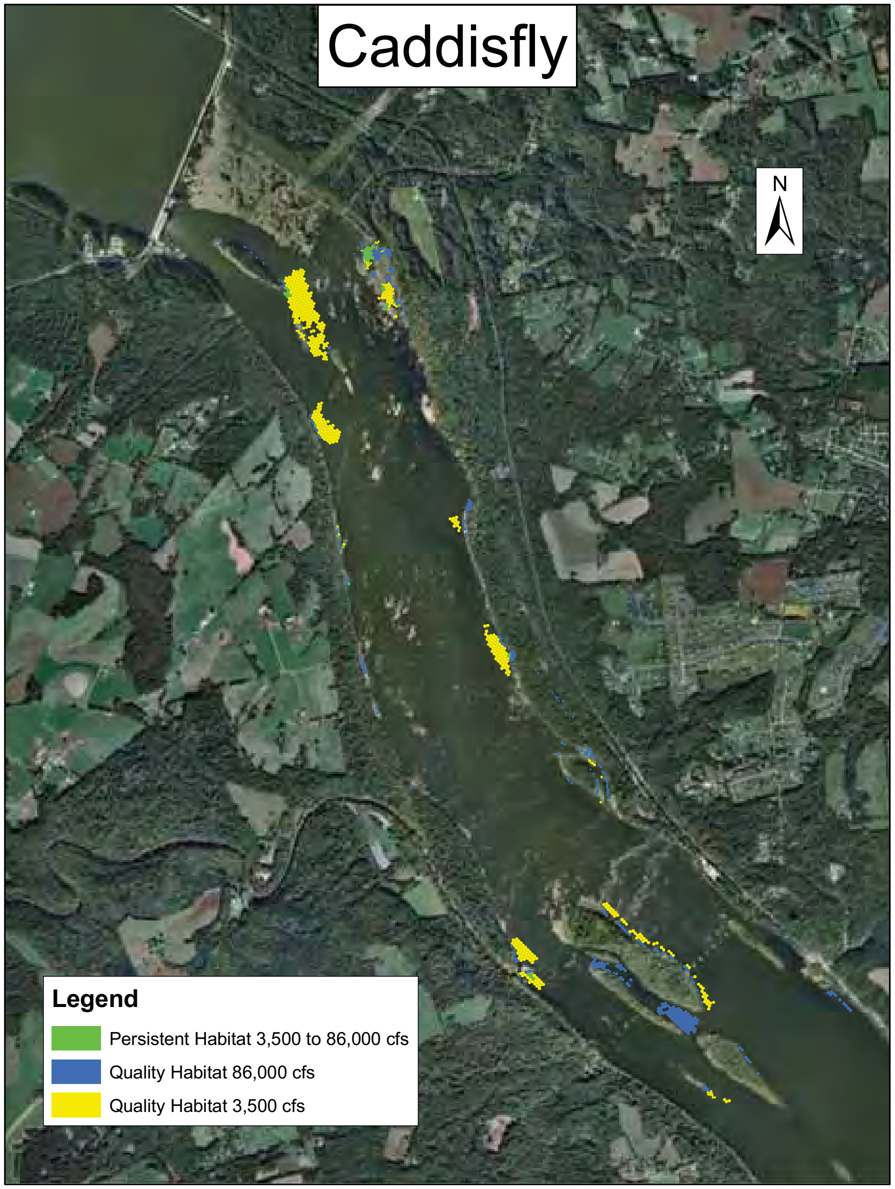

Stonefly
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

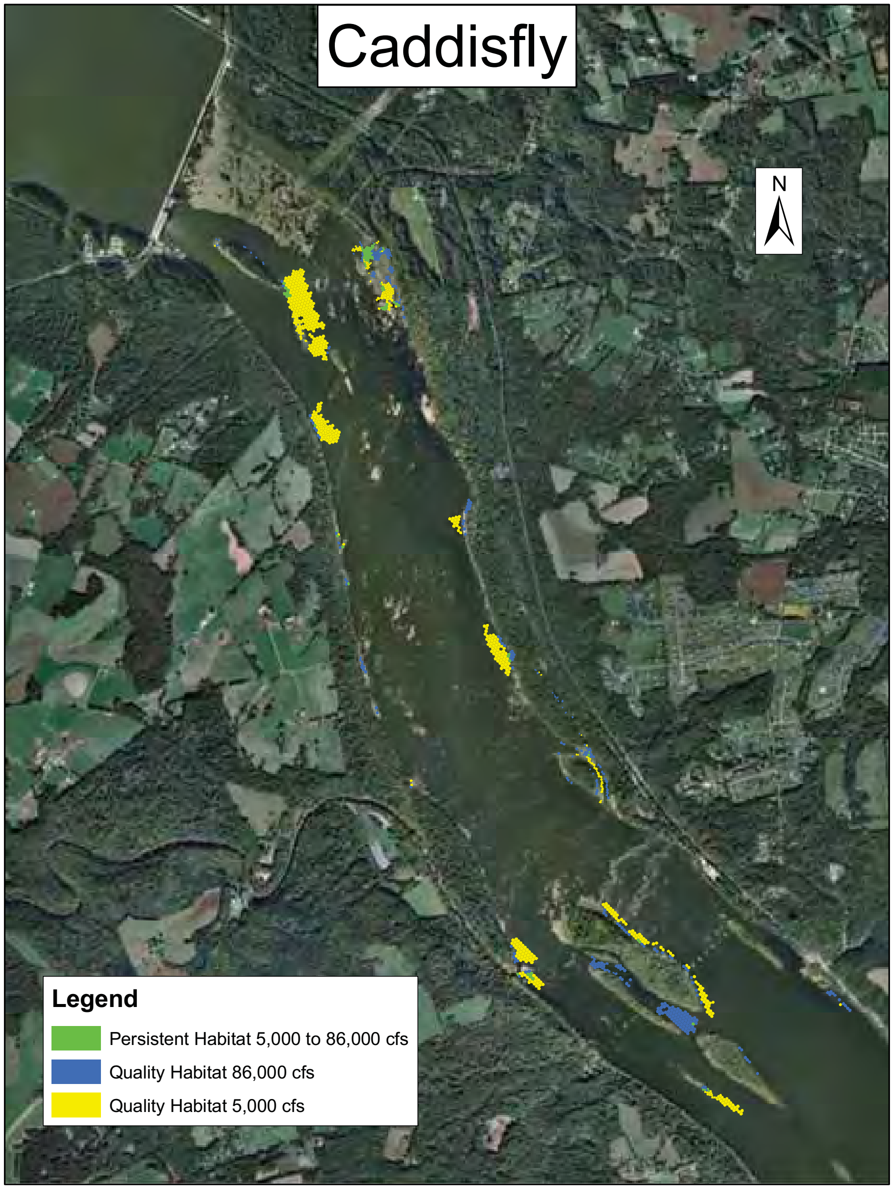

Stonefly
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

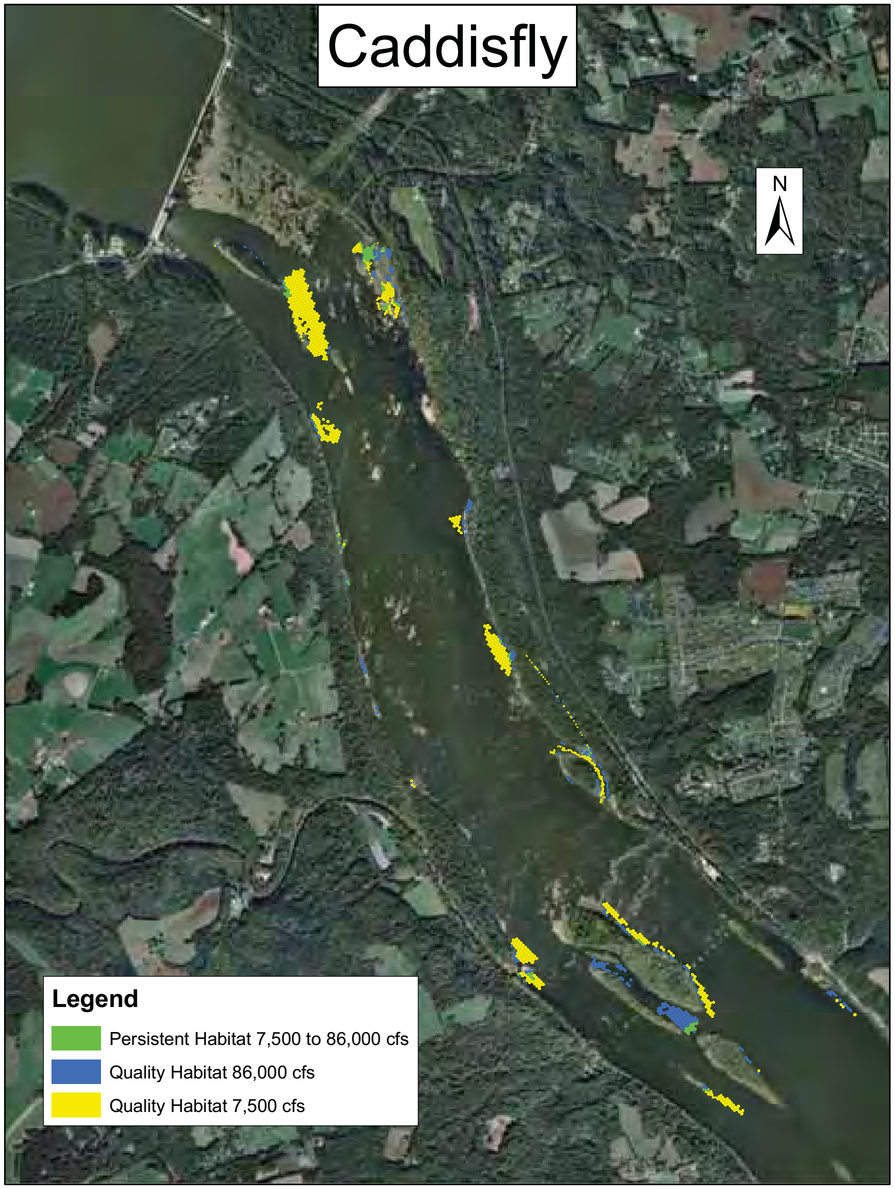

Stonefly
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

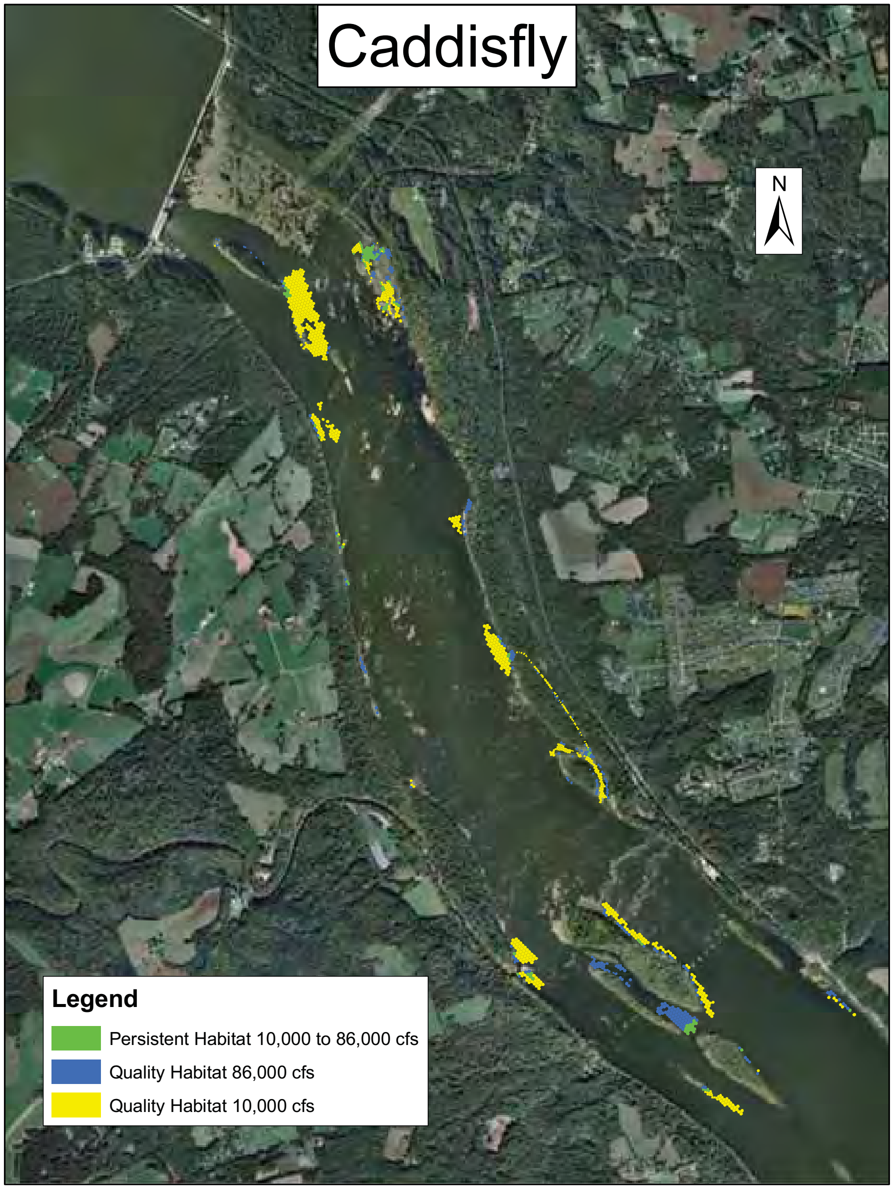

Stonefly
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

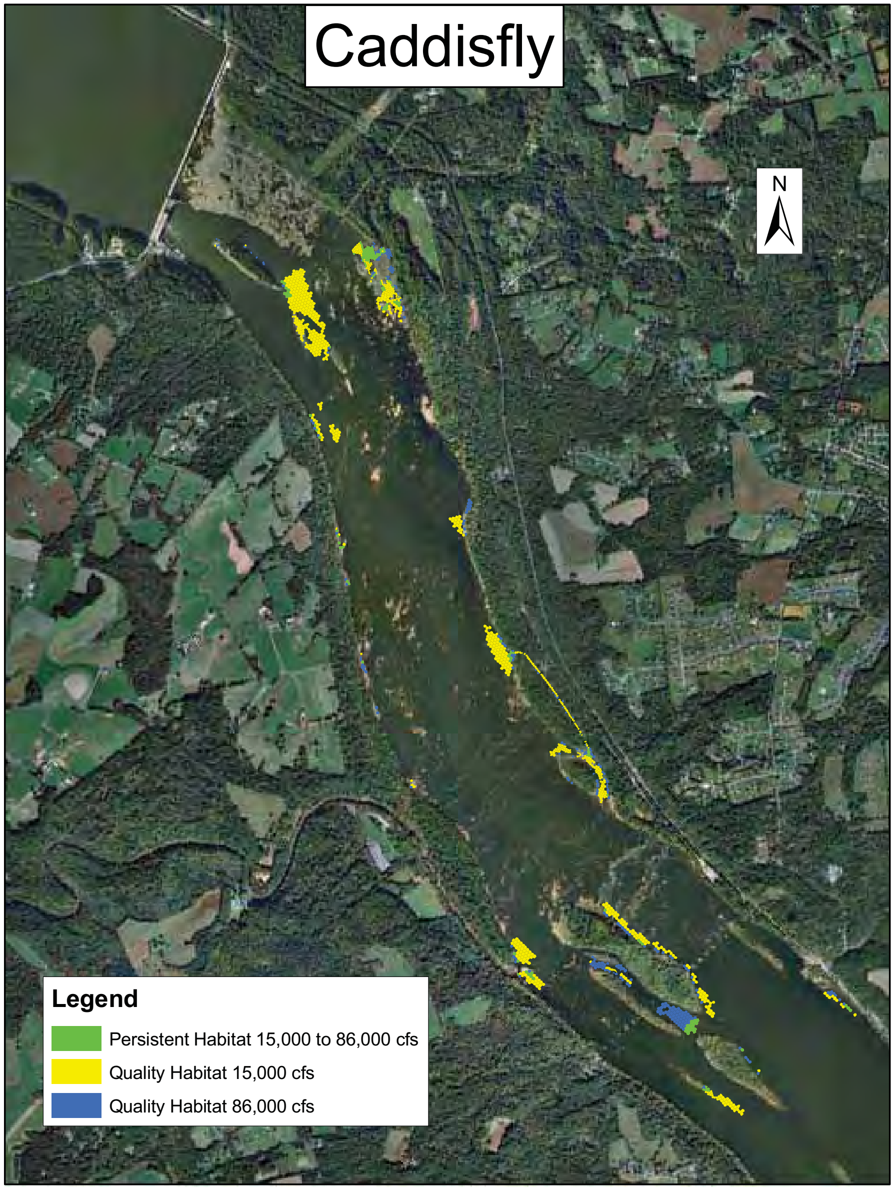

Stonefly
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

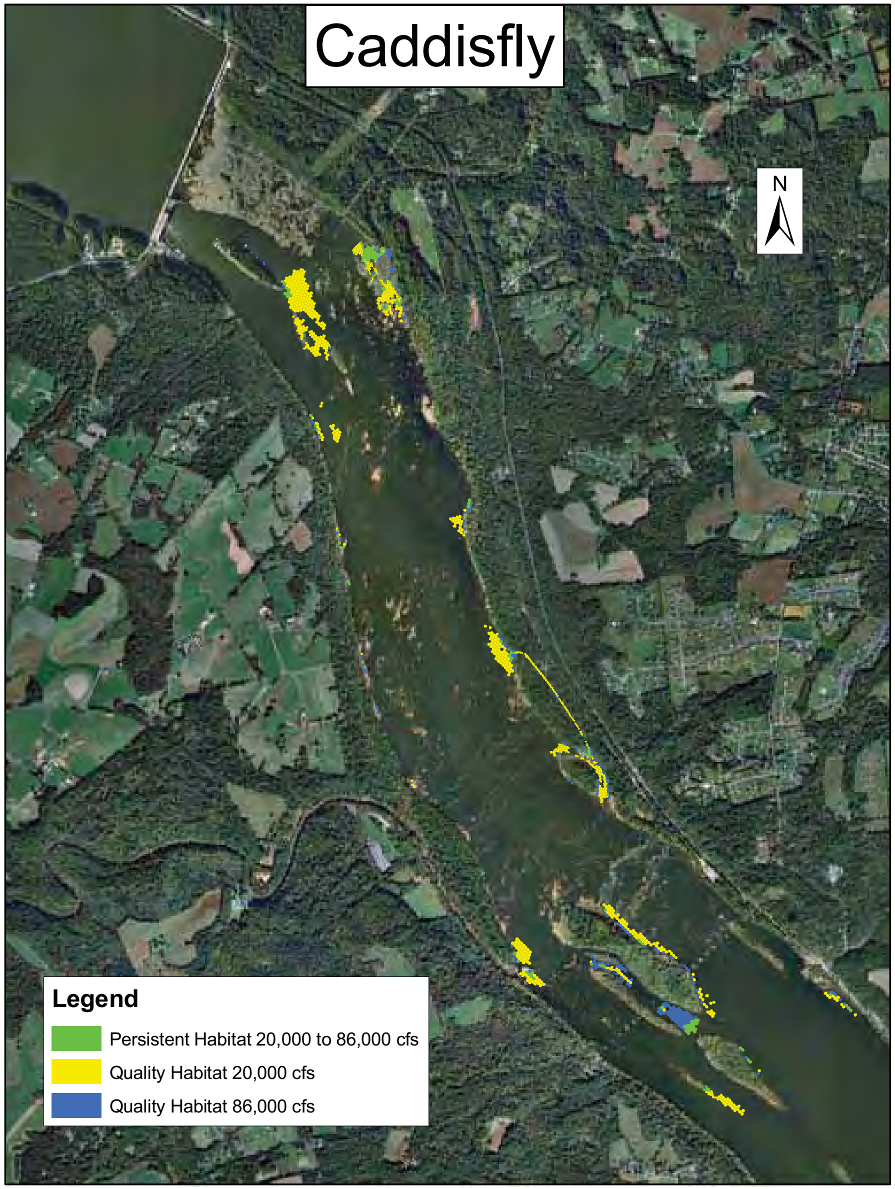

Caddisfly
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

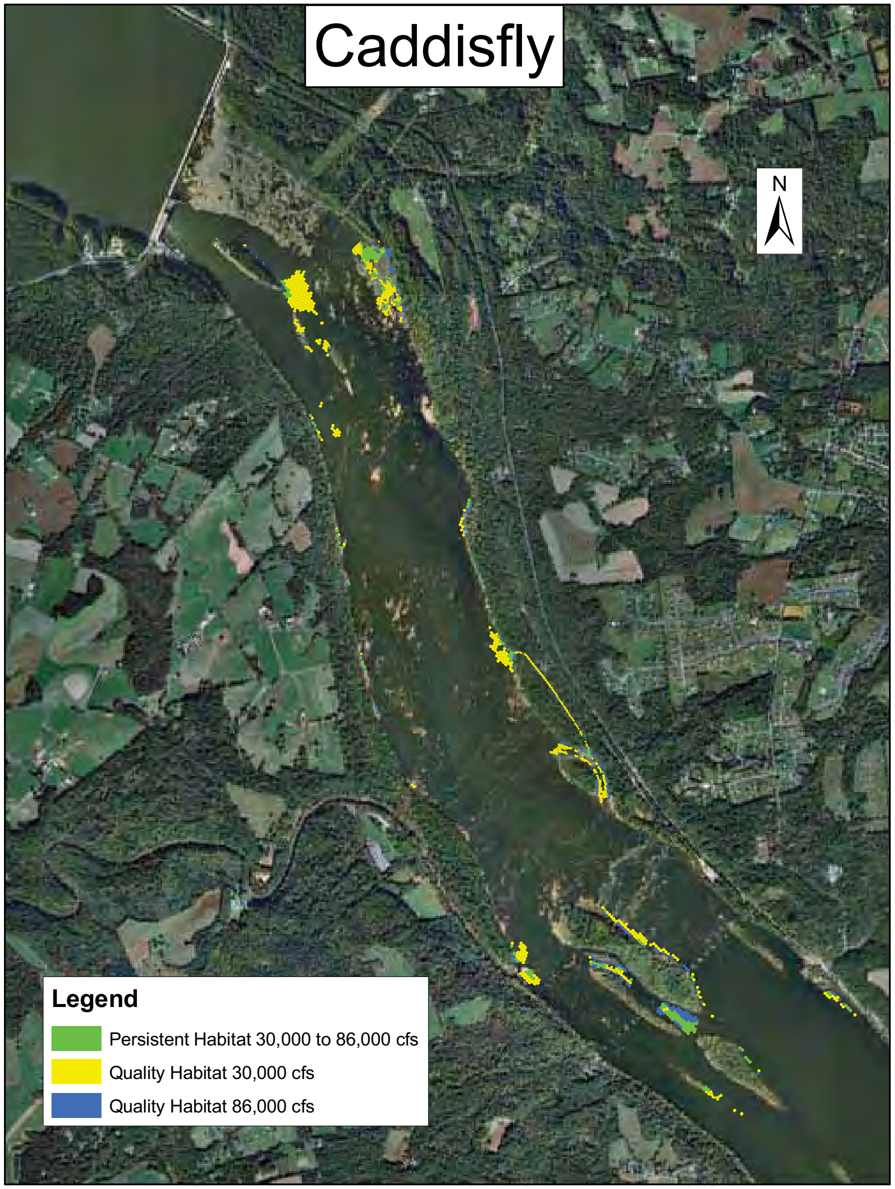

Caddisfly
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

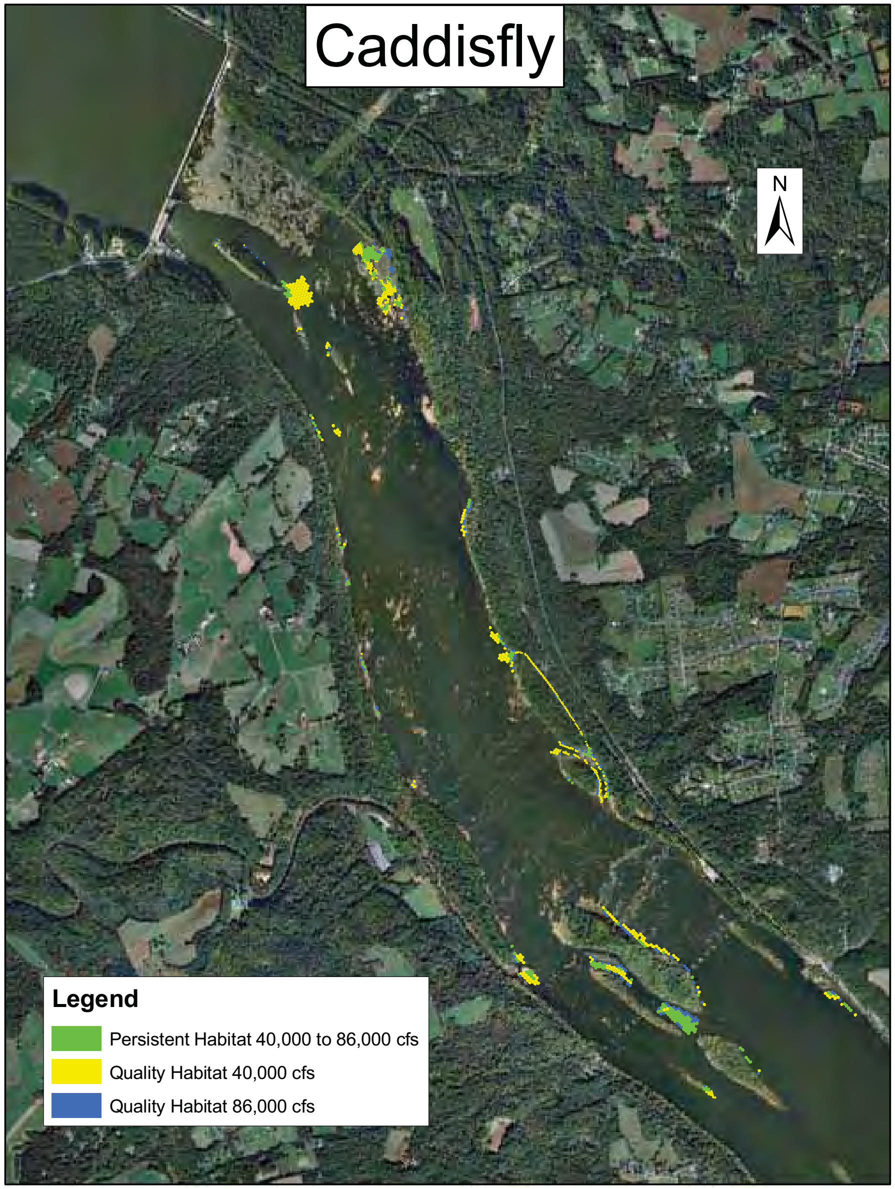

Caddisfly
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

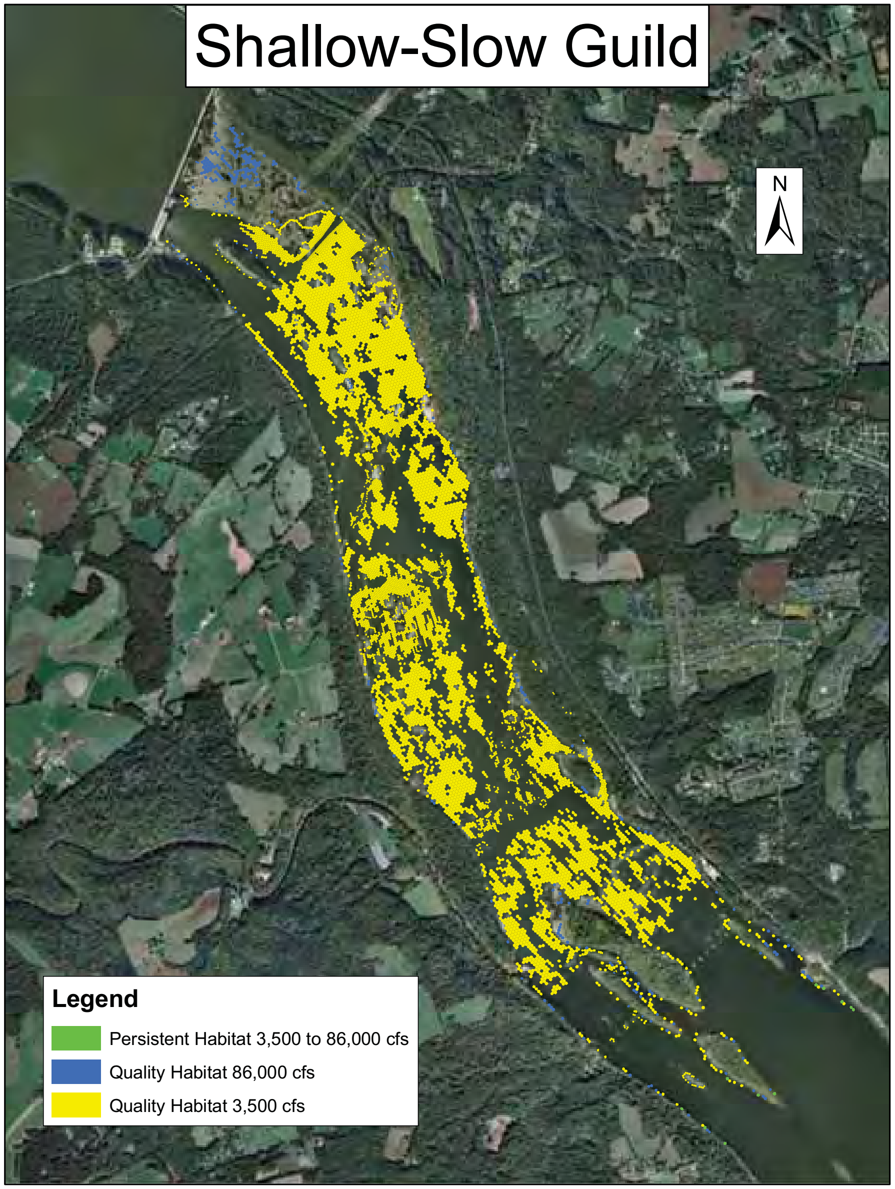

Caddisfly
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

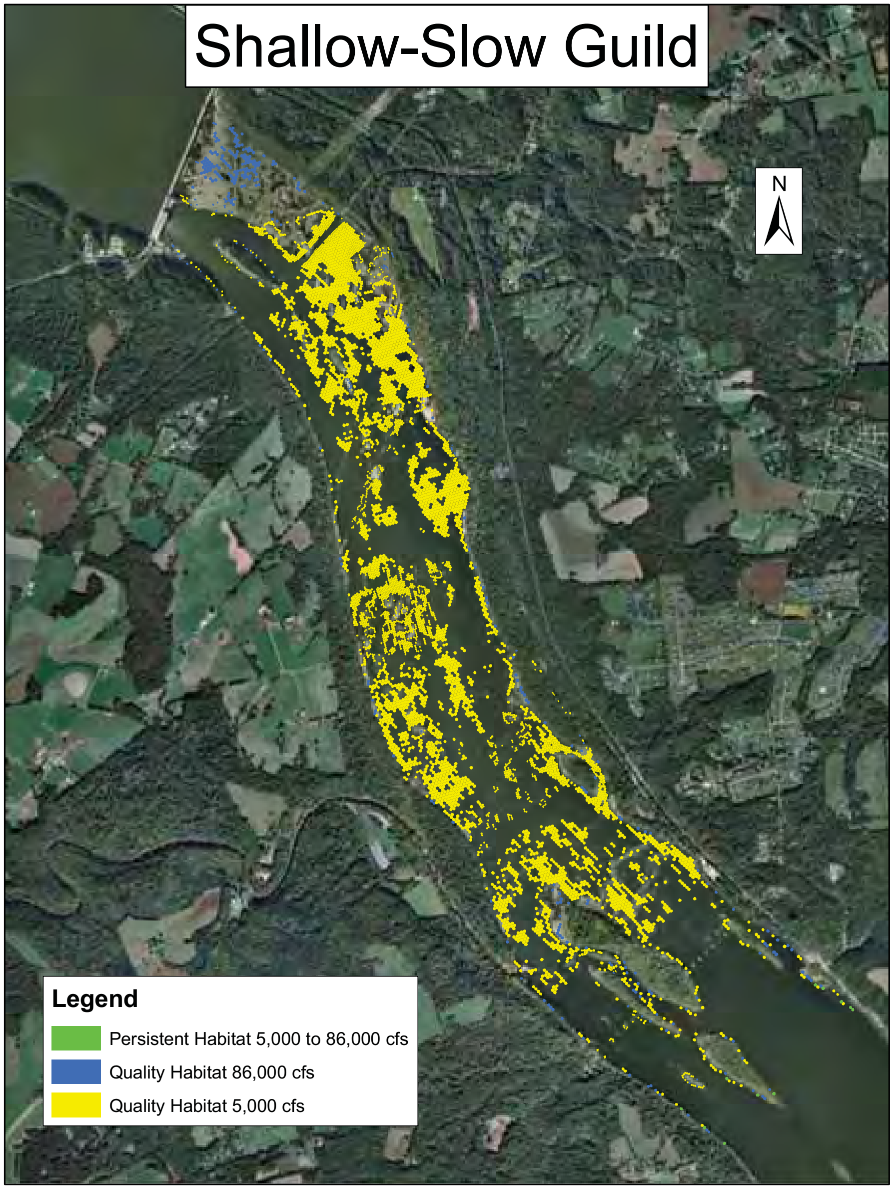

Caddisfly
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

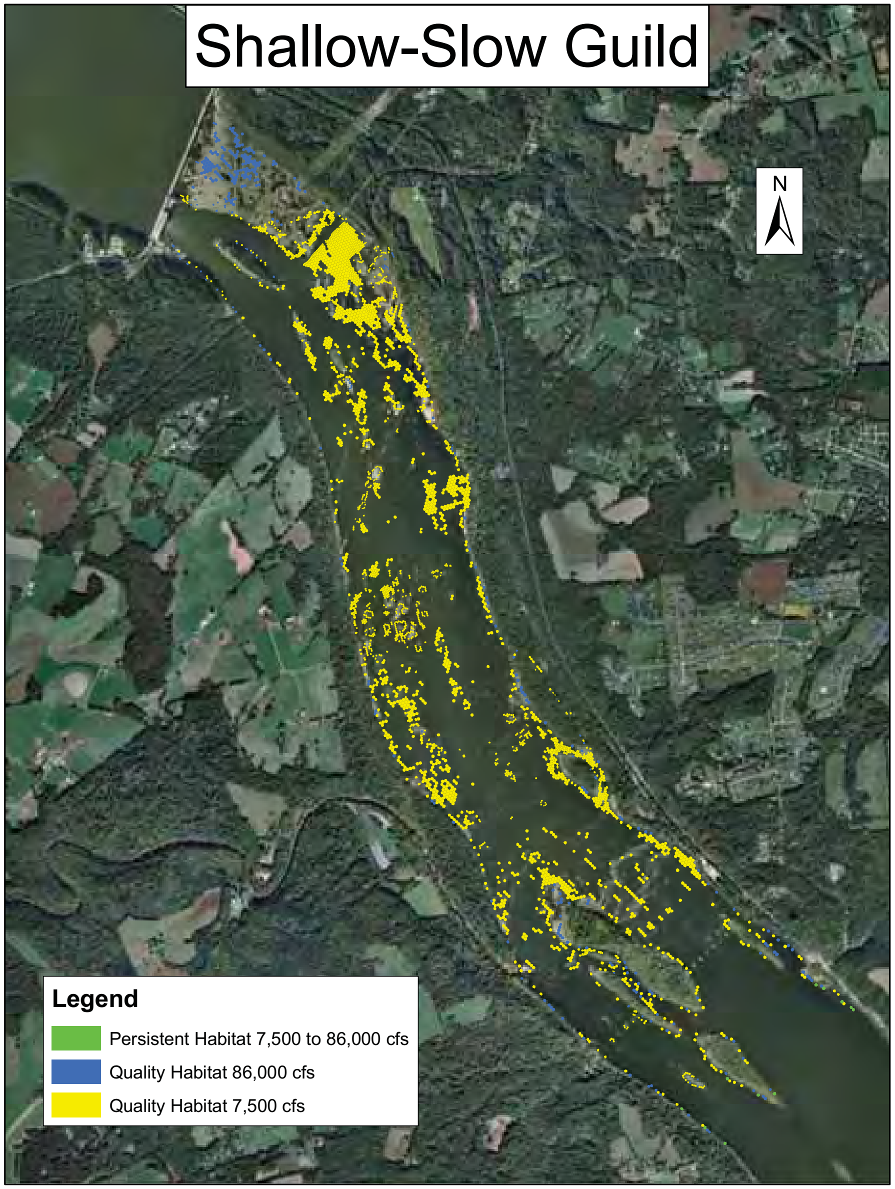

Caddisfly
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

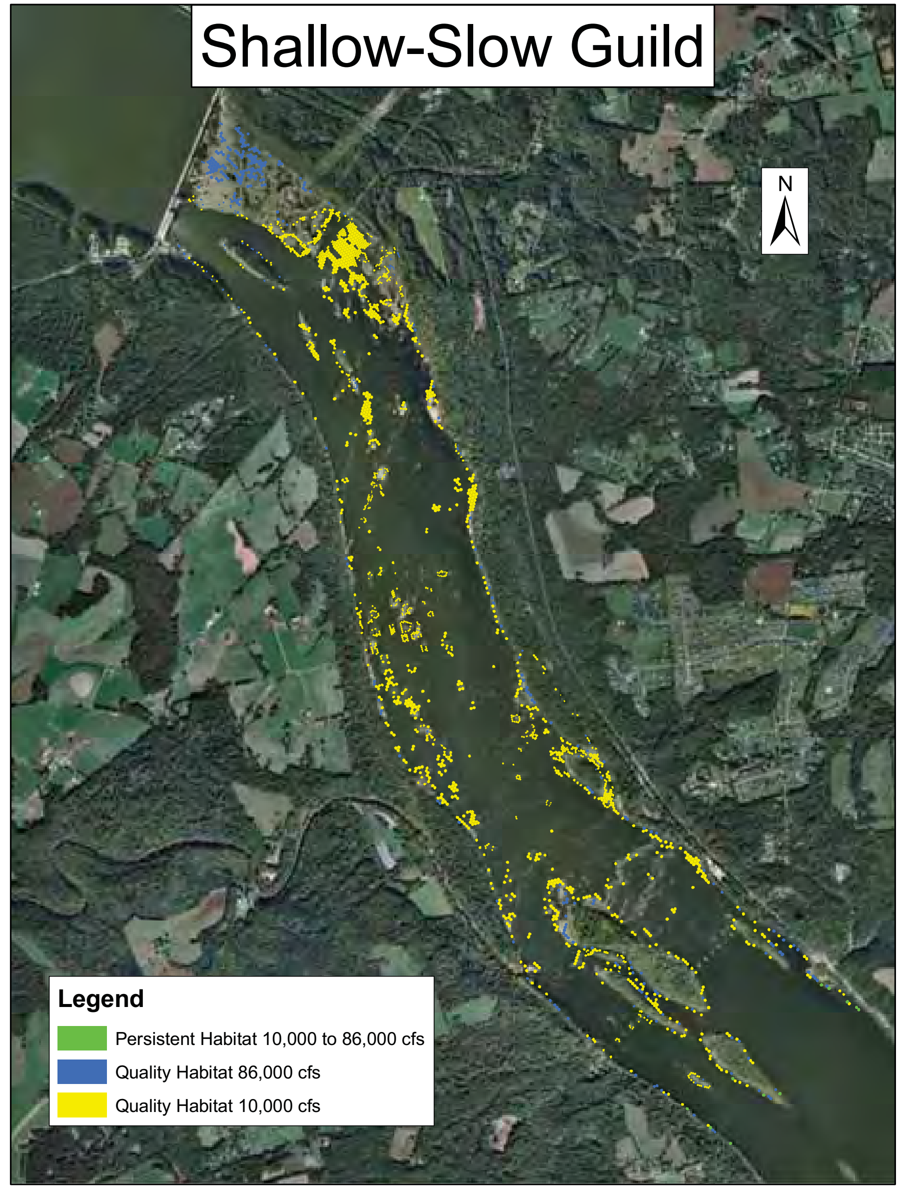

Caddisfly
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

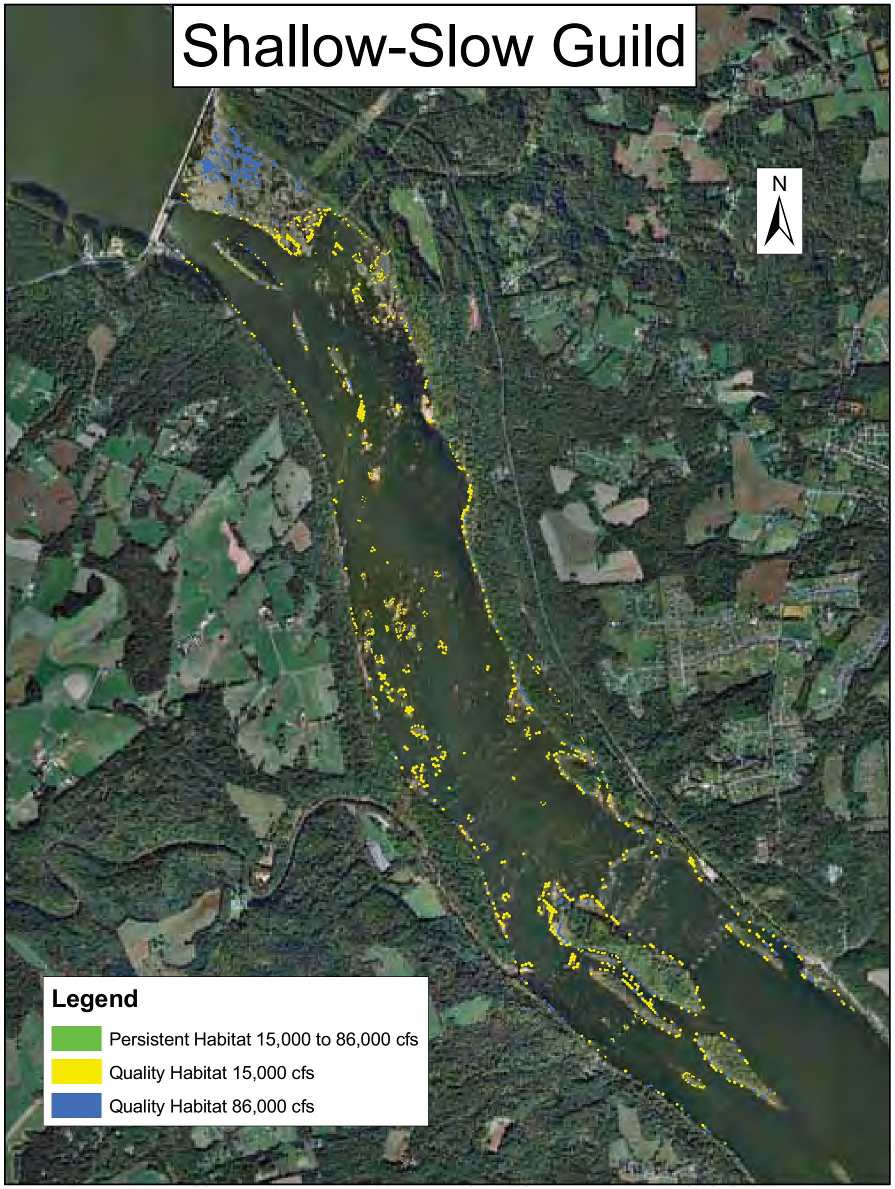

Caddisfly
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

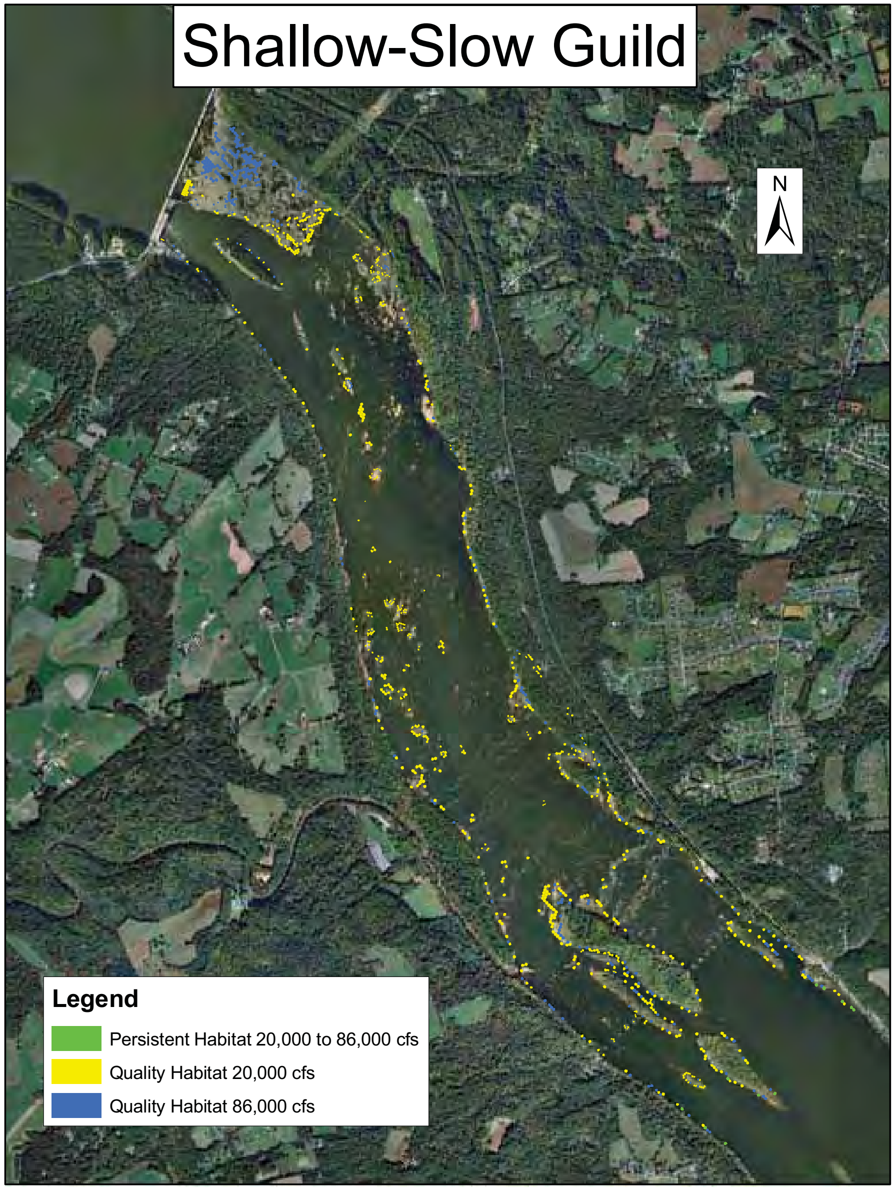

Shallow-Slow Guild
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

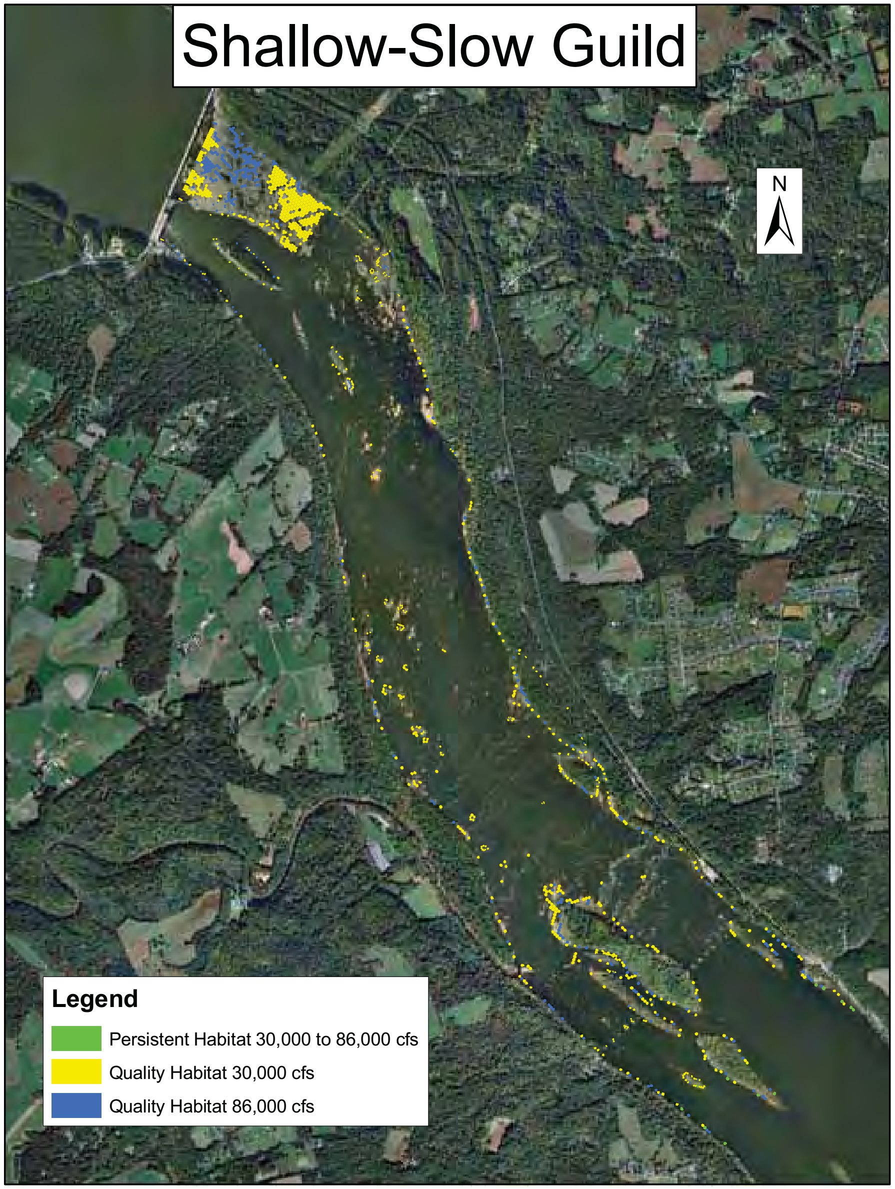

Shallow-Slow Guild
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs

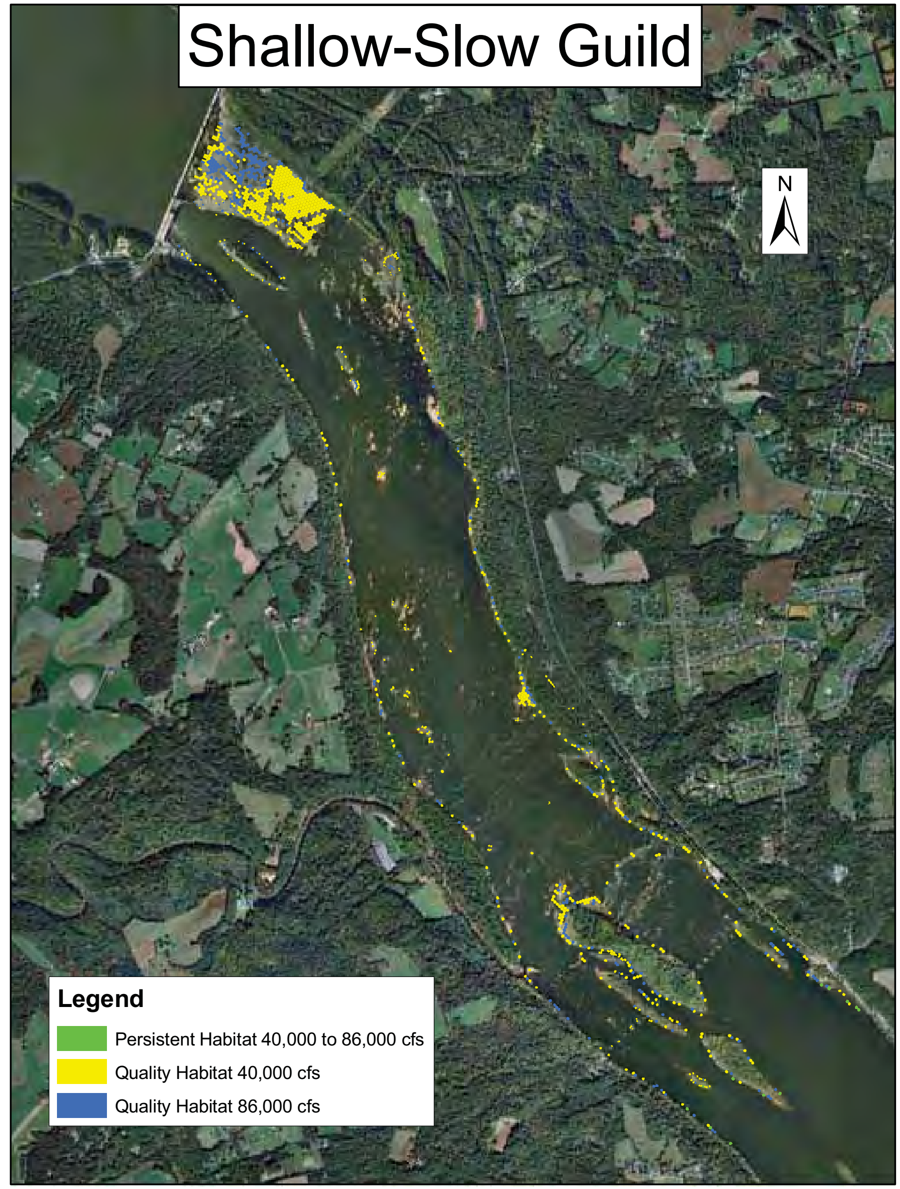

Shallow-Slow Guild
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

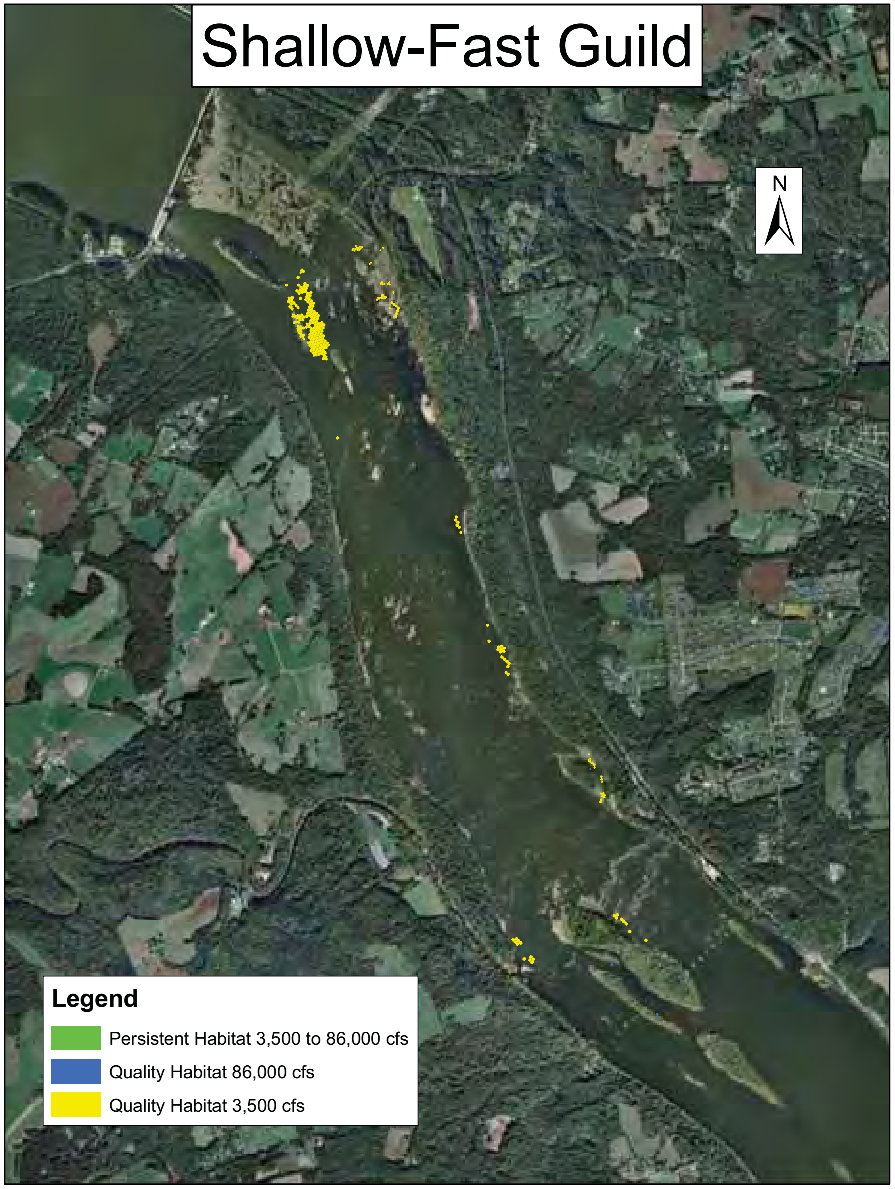

Shallow-Slow Guild
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs


Shallow-Slow Guild
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

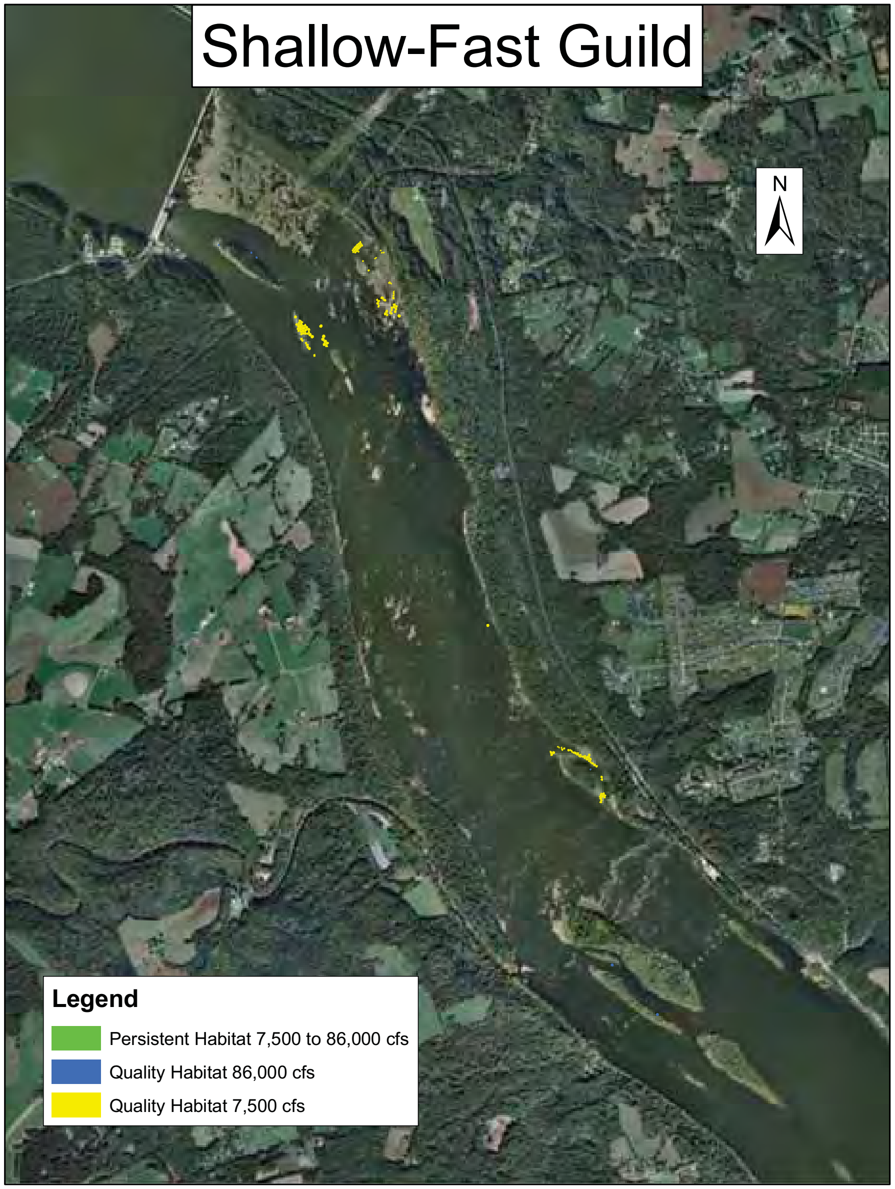

Shallow-Slow Guild
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs


Shallow-Slow Guild
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

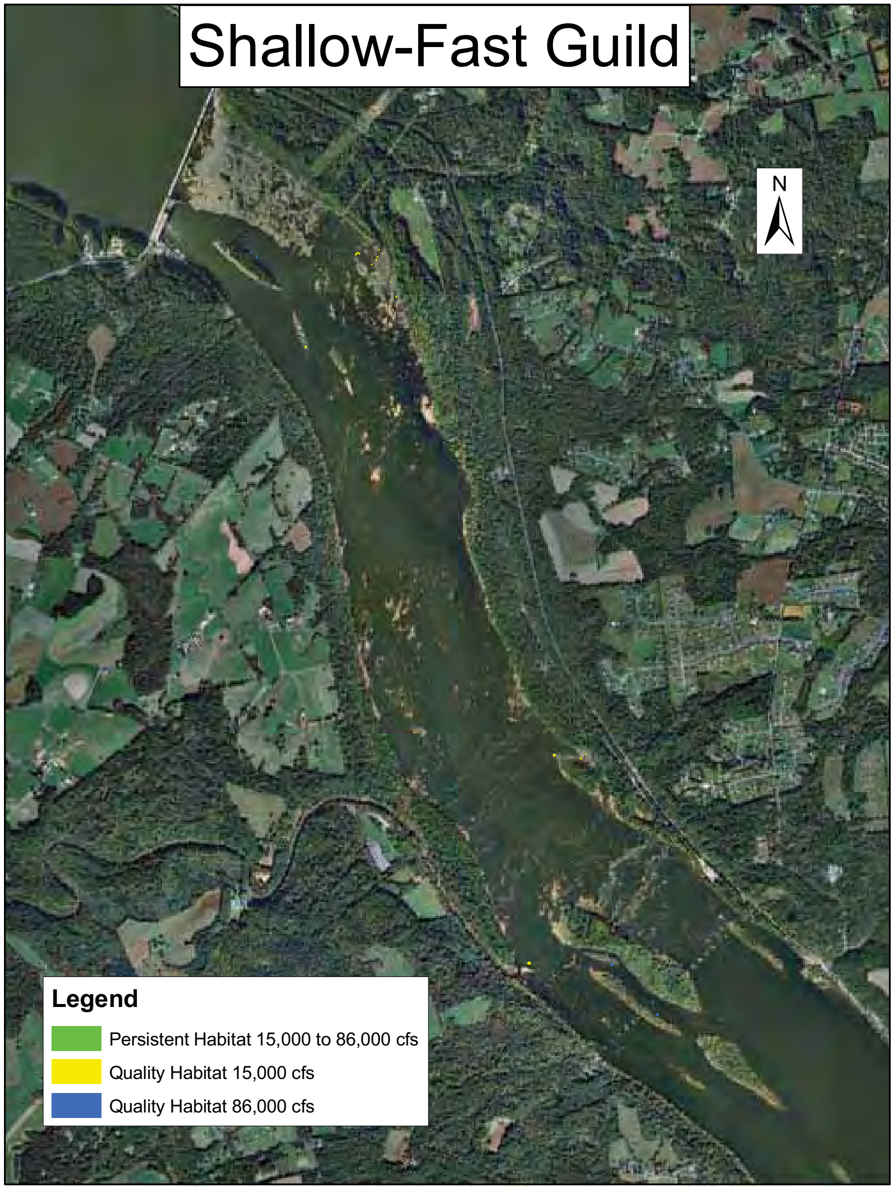

Shallow-Slow Guild
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs


Shallow-Fast Guild
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

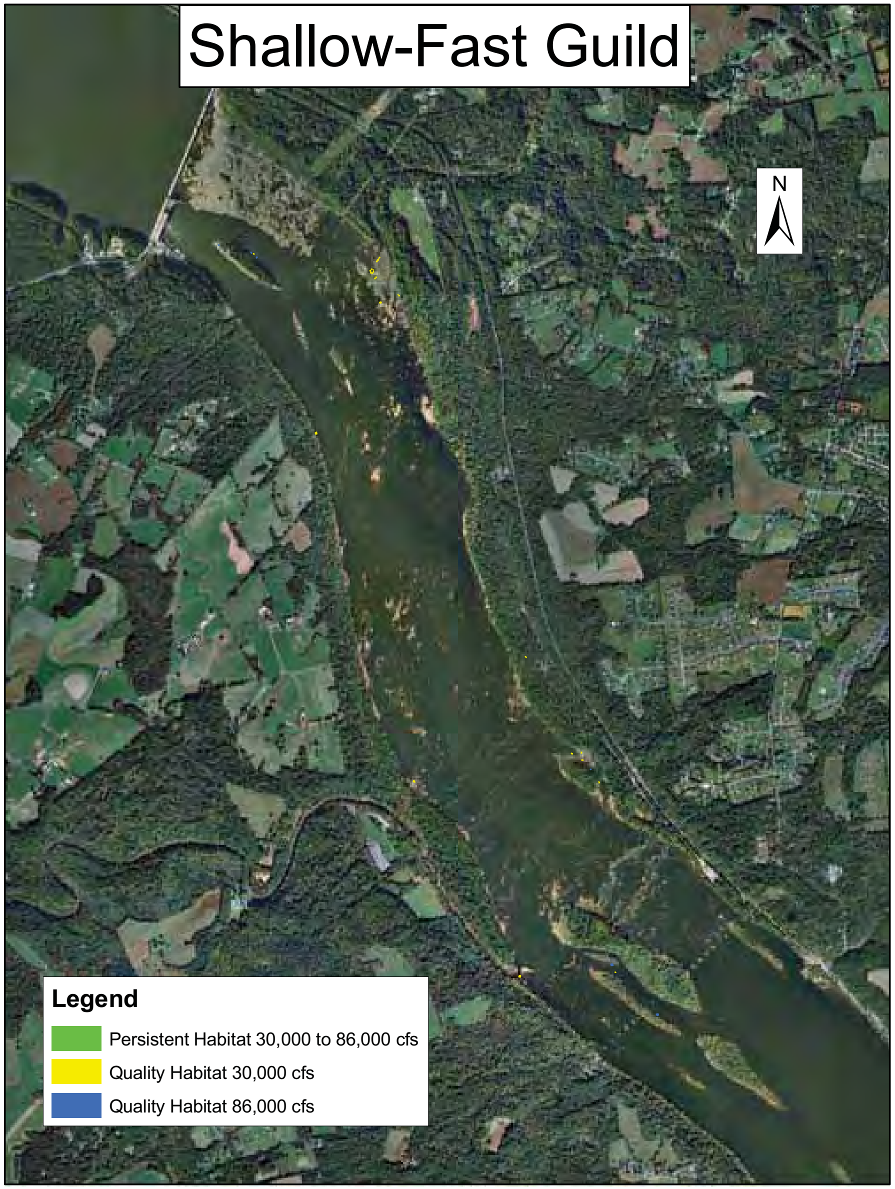

Shallow-Fast Guild
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs


Shallow-Fast Guild
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

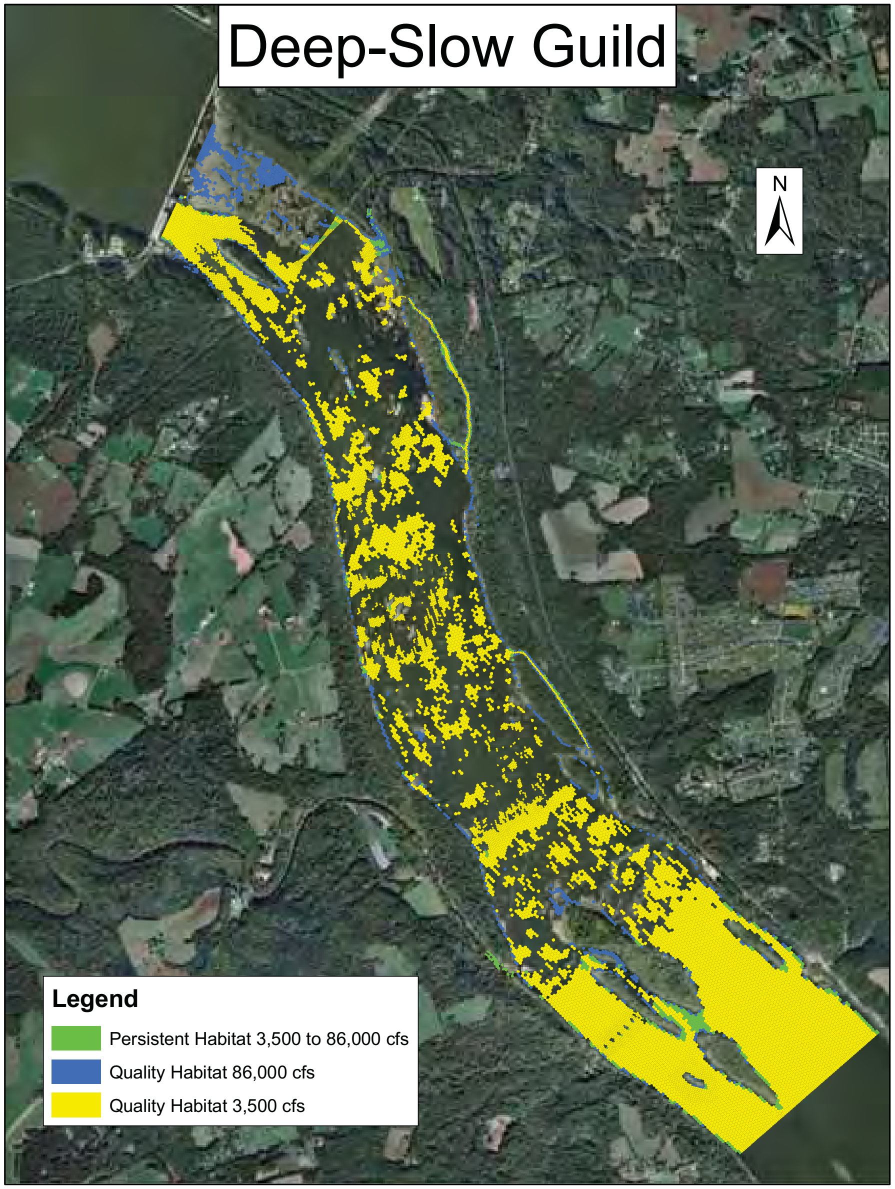

Shallow-Fast Guild
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs


Shallow-Fast Guild
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

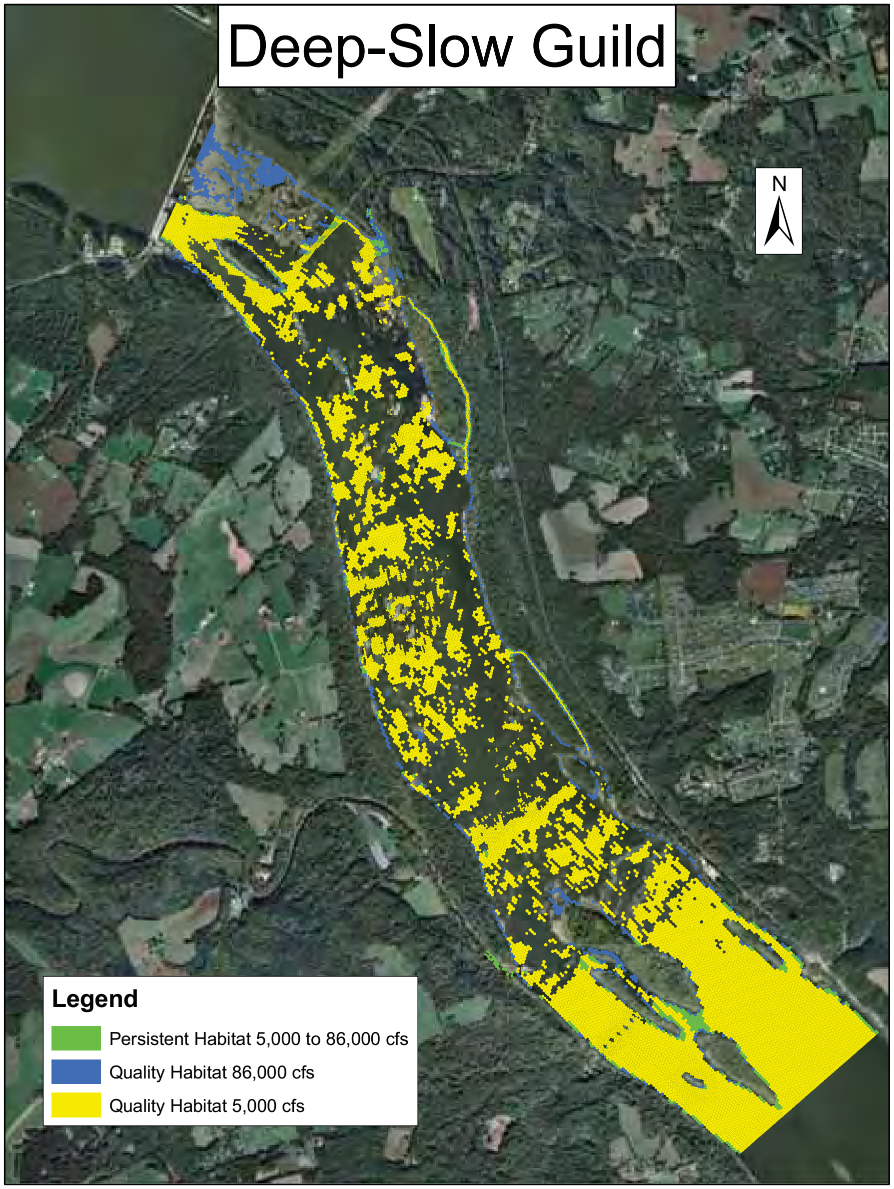

Shallow-Fast Guild
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs


Shallow-Fast Guild
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

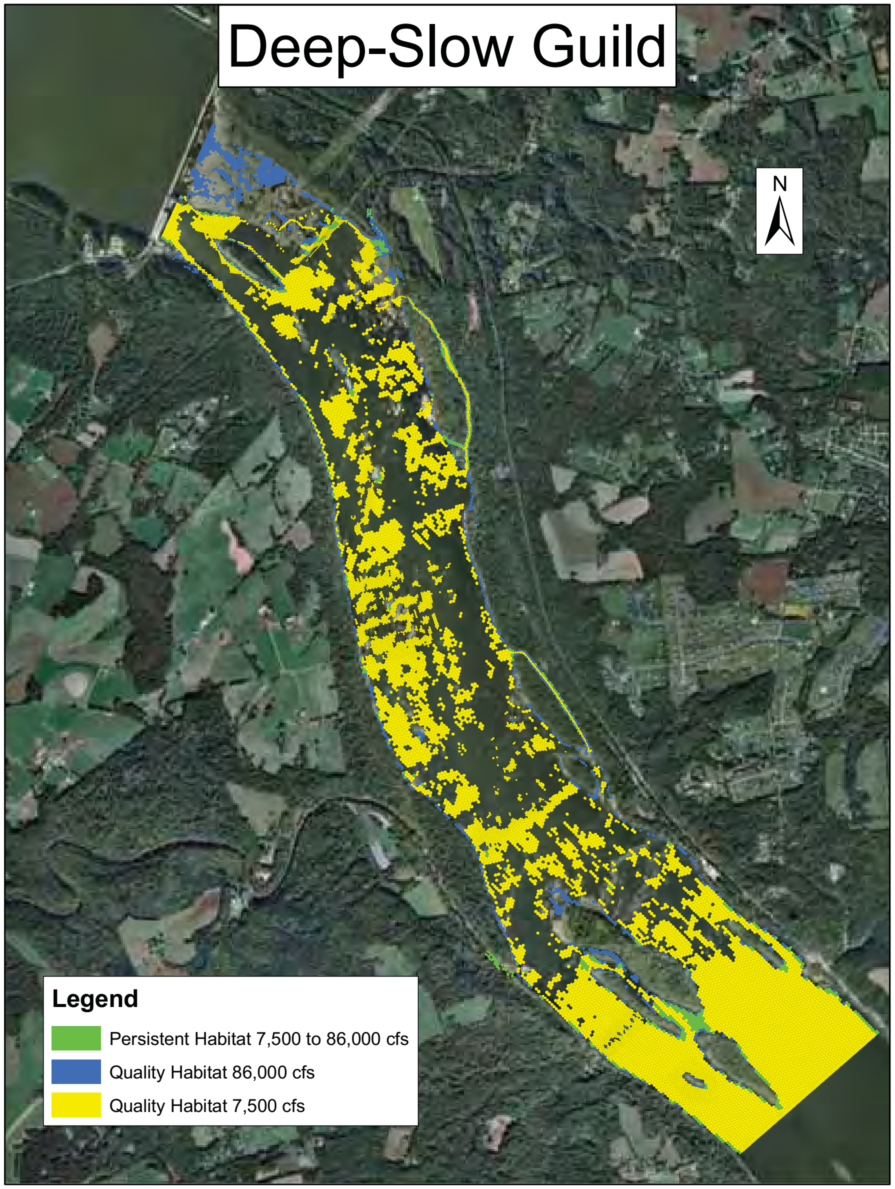

Shallow-Fast Guild
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

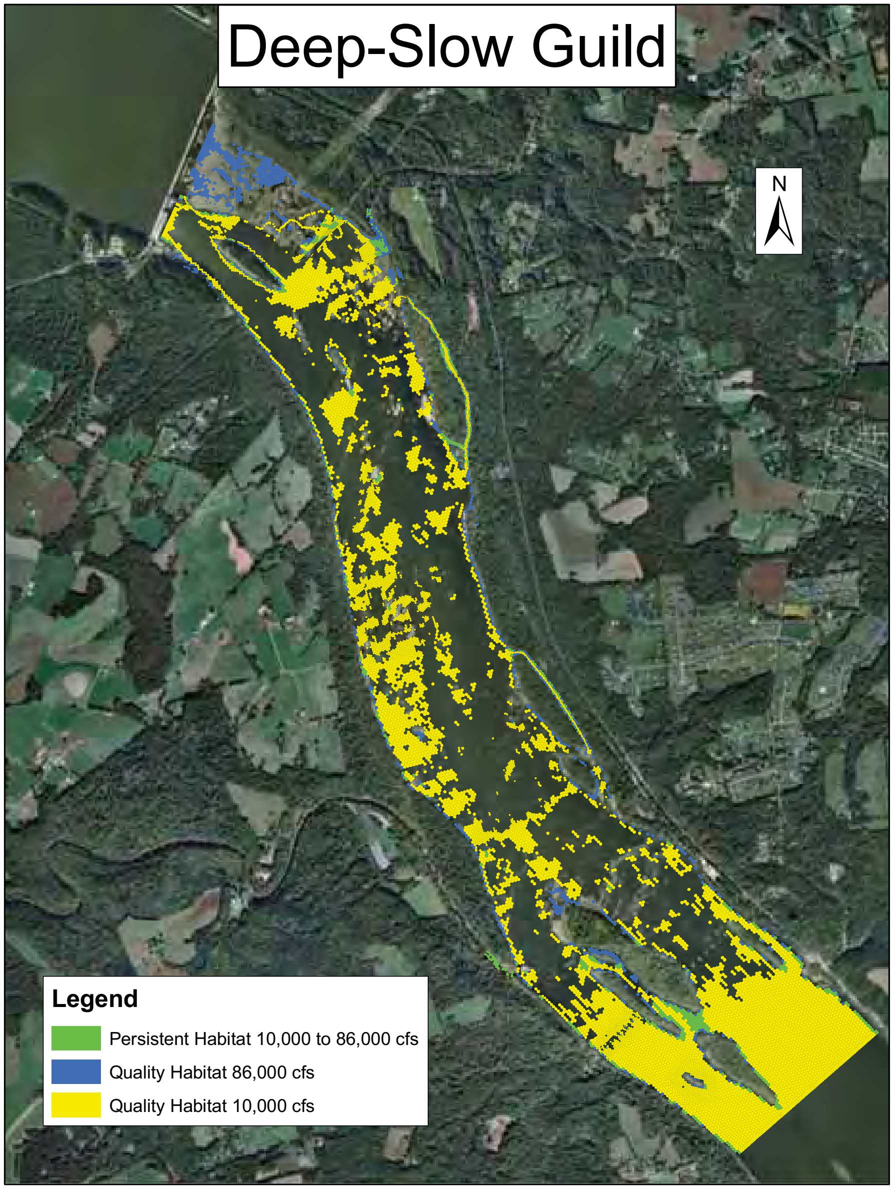


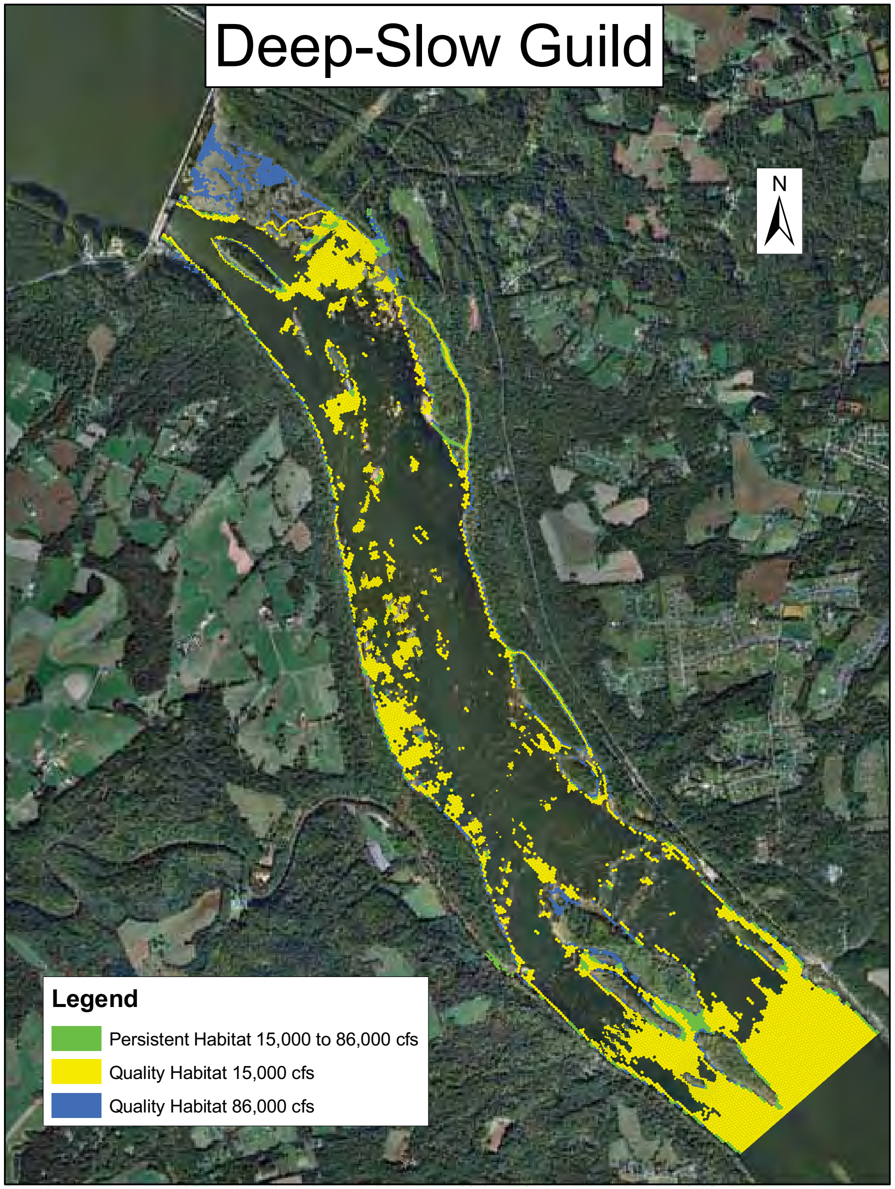
Deep-Slow Guild
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs



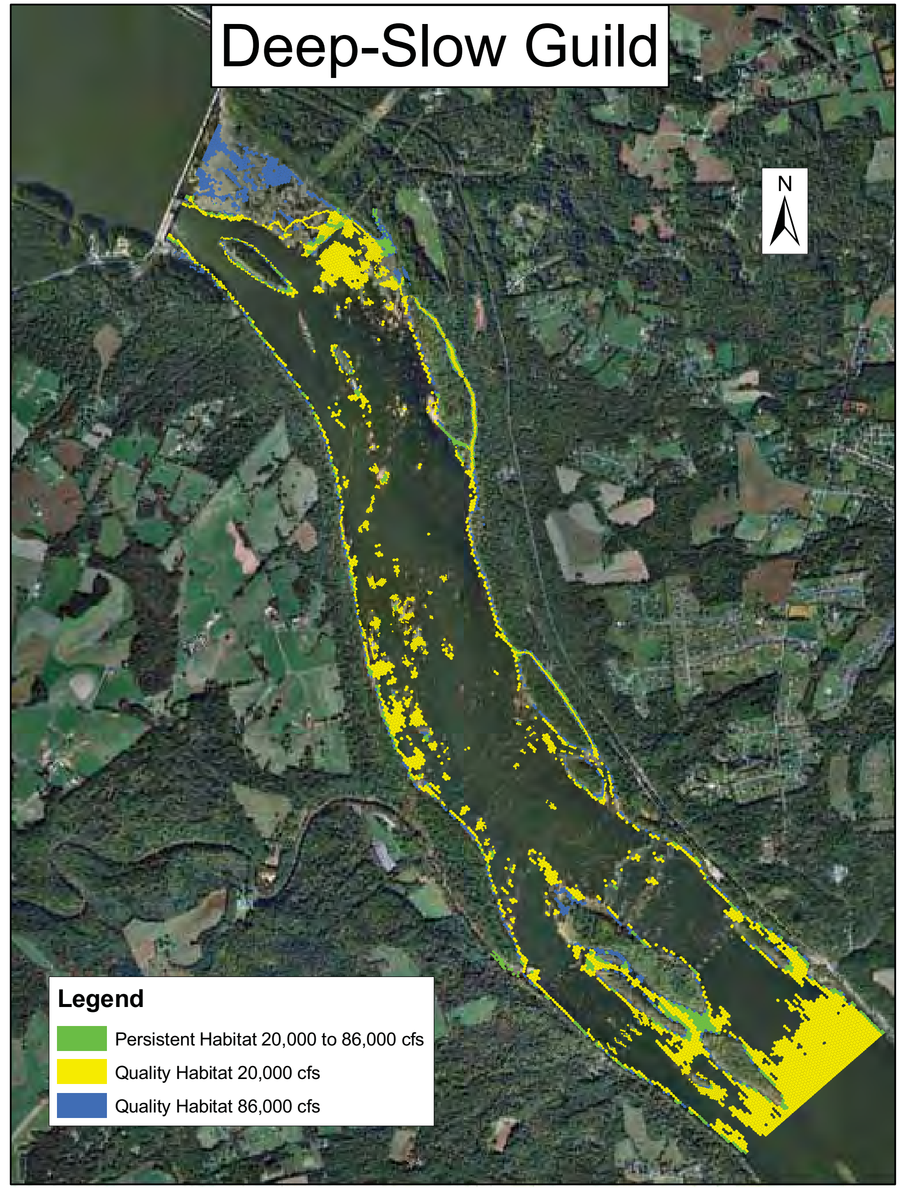
Deep-Slow Guild
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs


Deep-Slow Guild
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

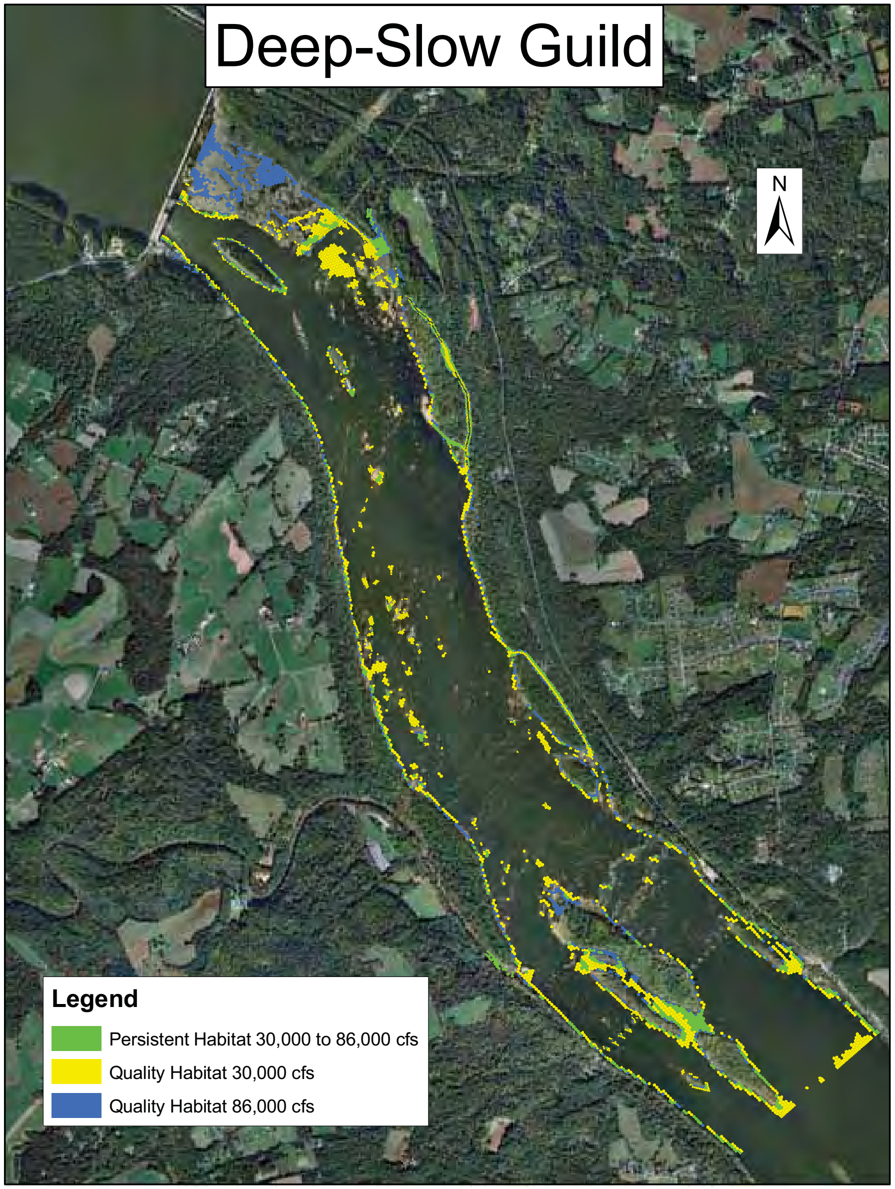

Deep-Slow Guild
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs

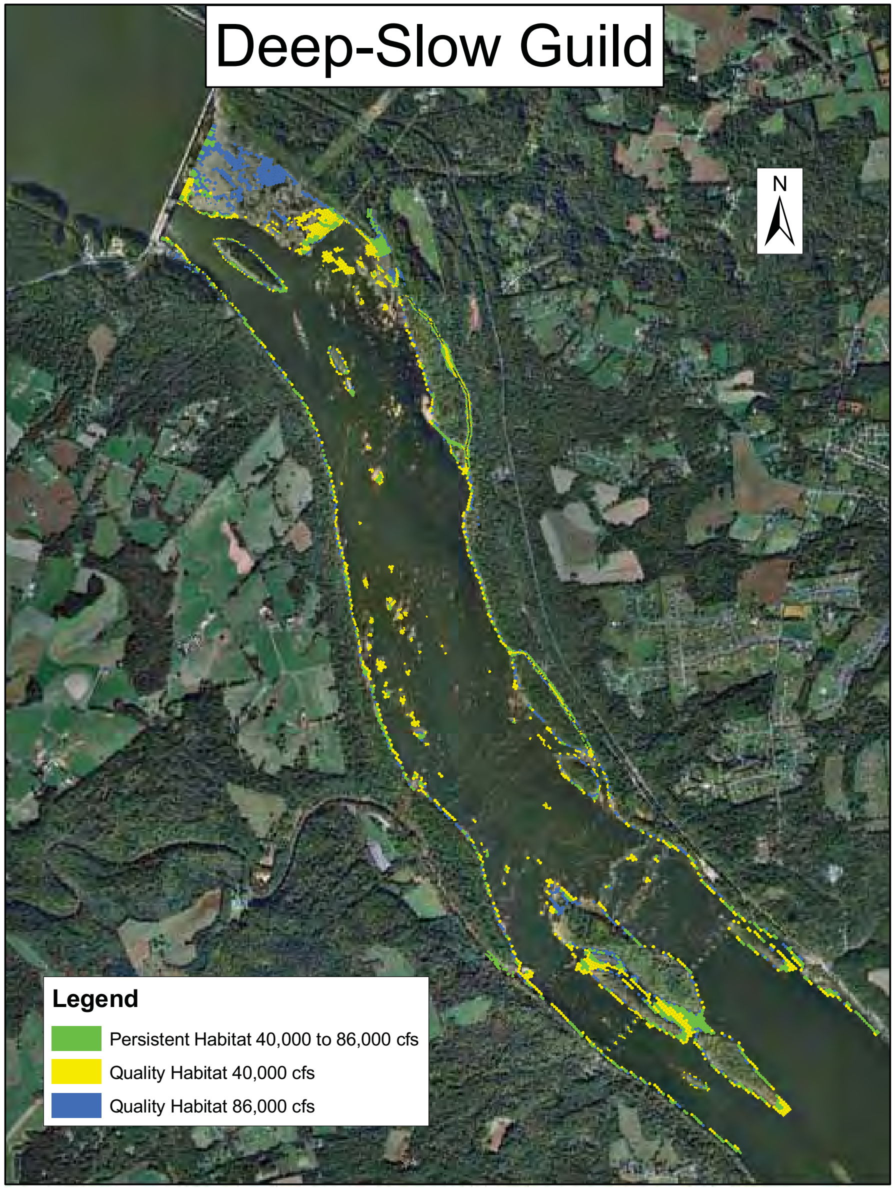


Deep-Slow Guild
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs

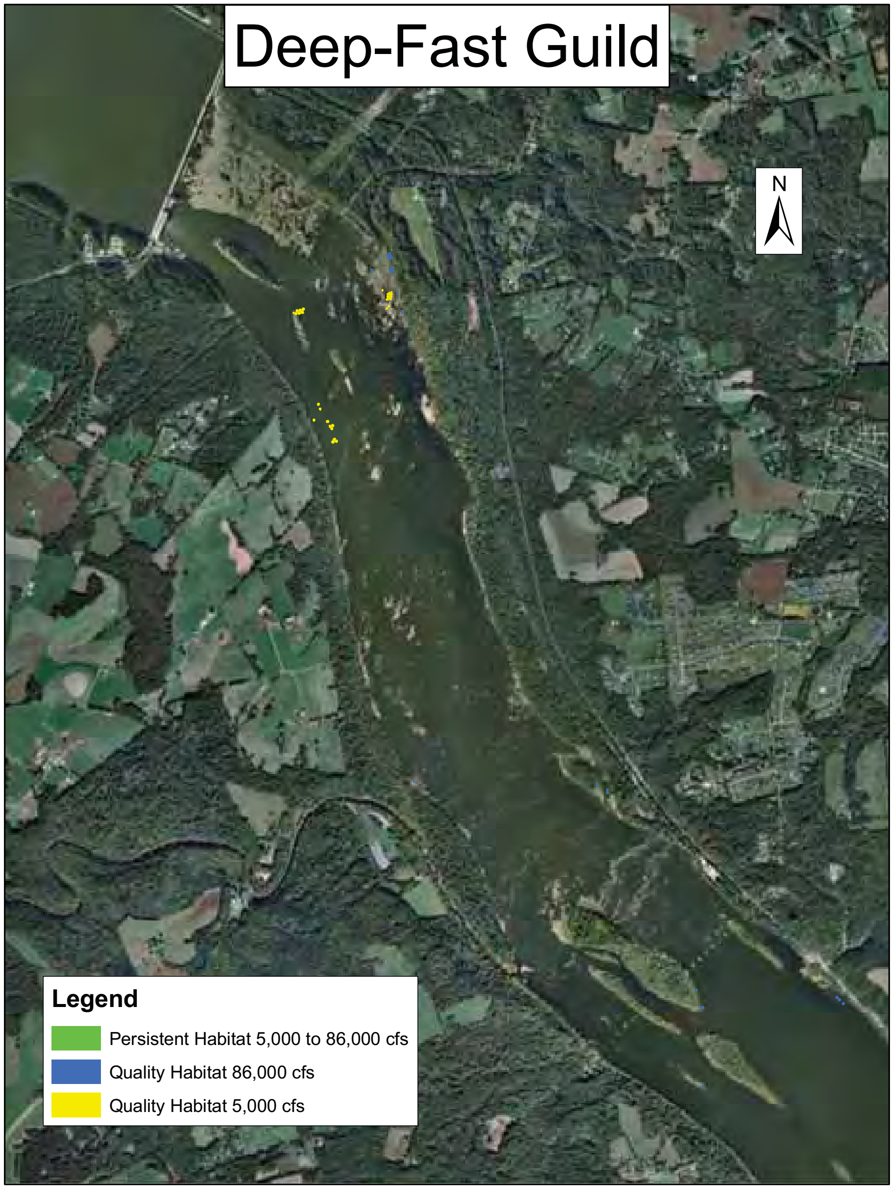


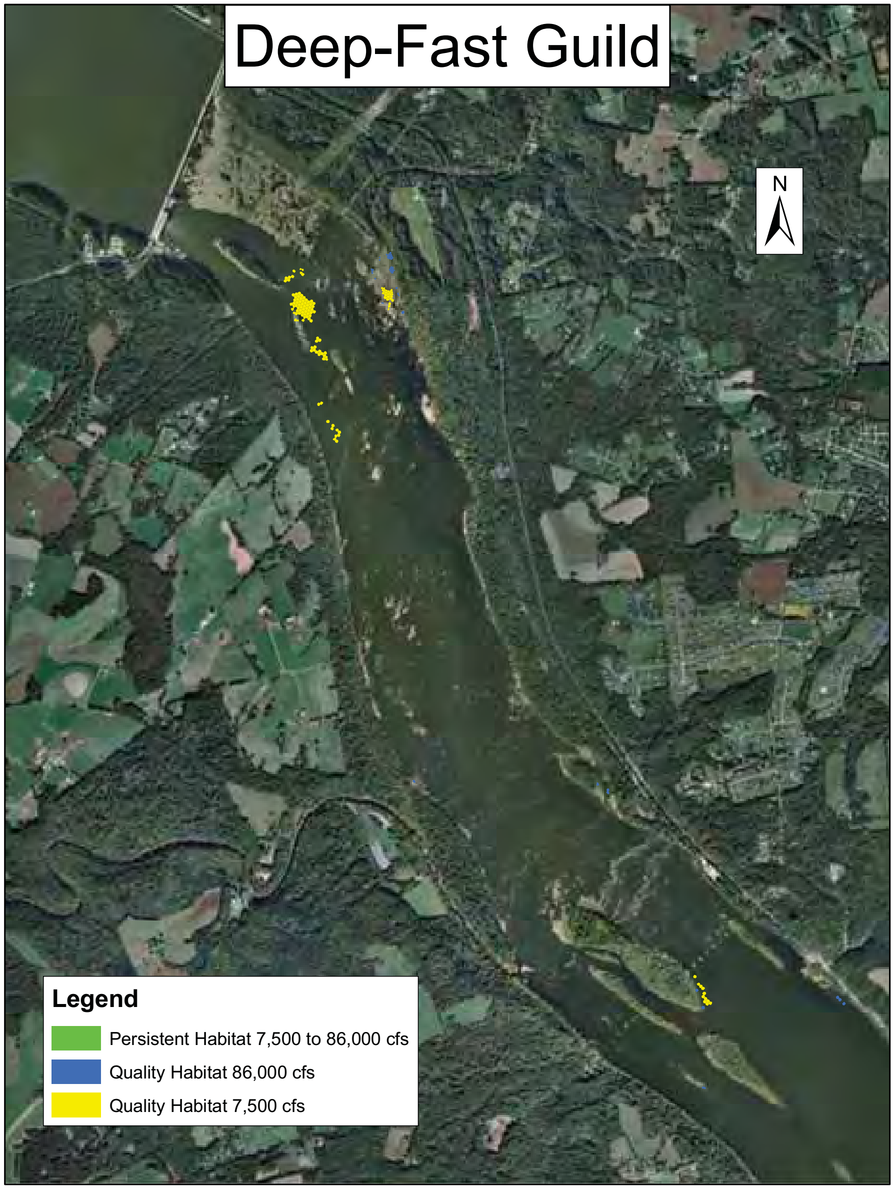
Deep-Slow Guild
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs

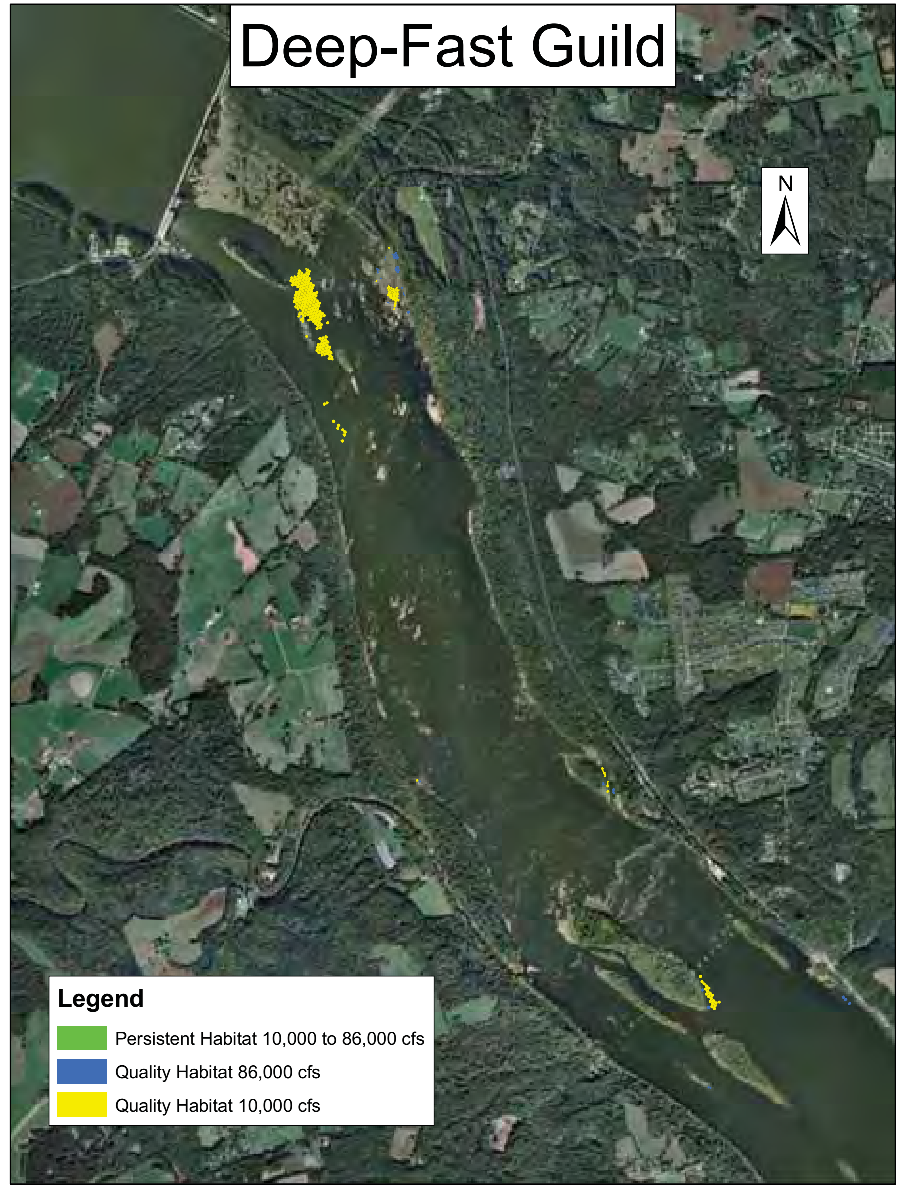

Deep-Slow Guild
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs

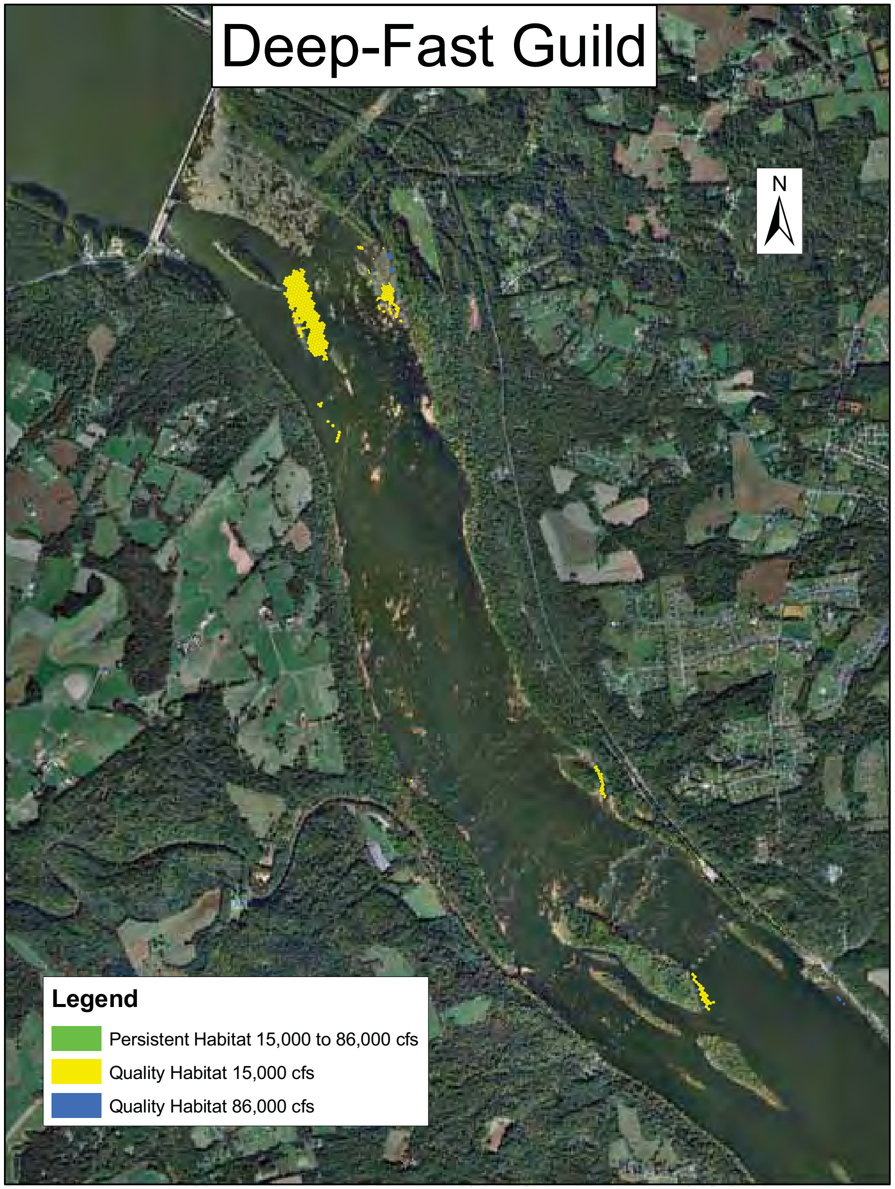

Deep-Slow Guild
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

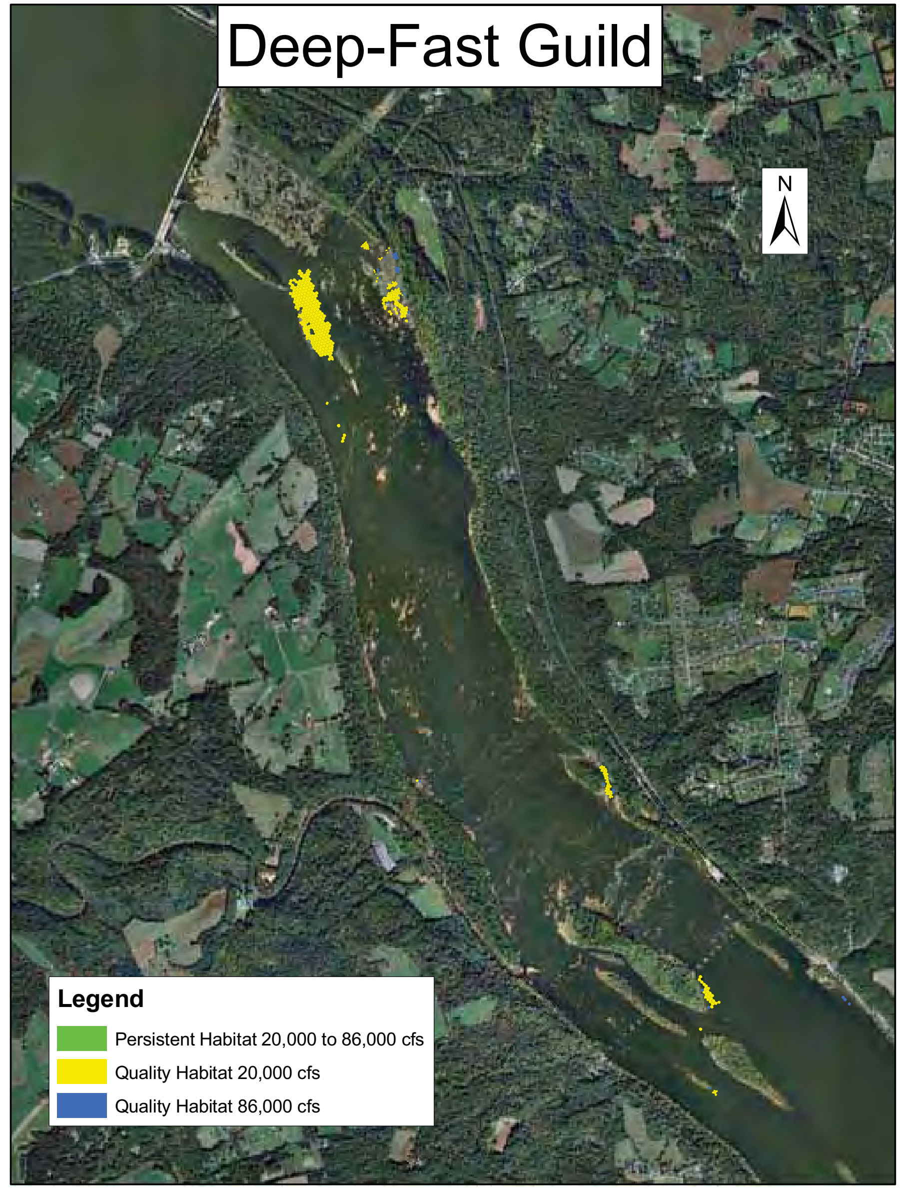

Deep-Fast Guild
N
Legend
Persistent Habitat 3,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 3,500 cfs

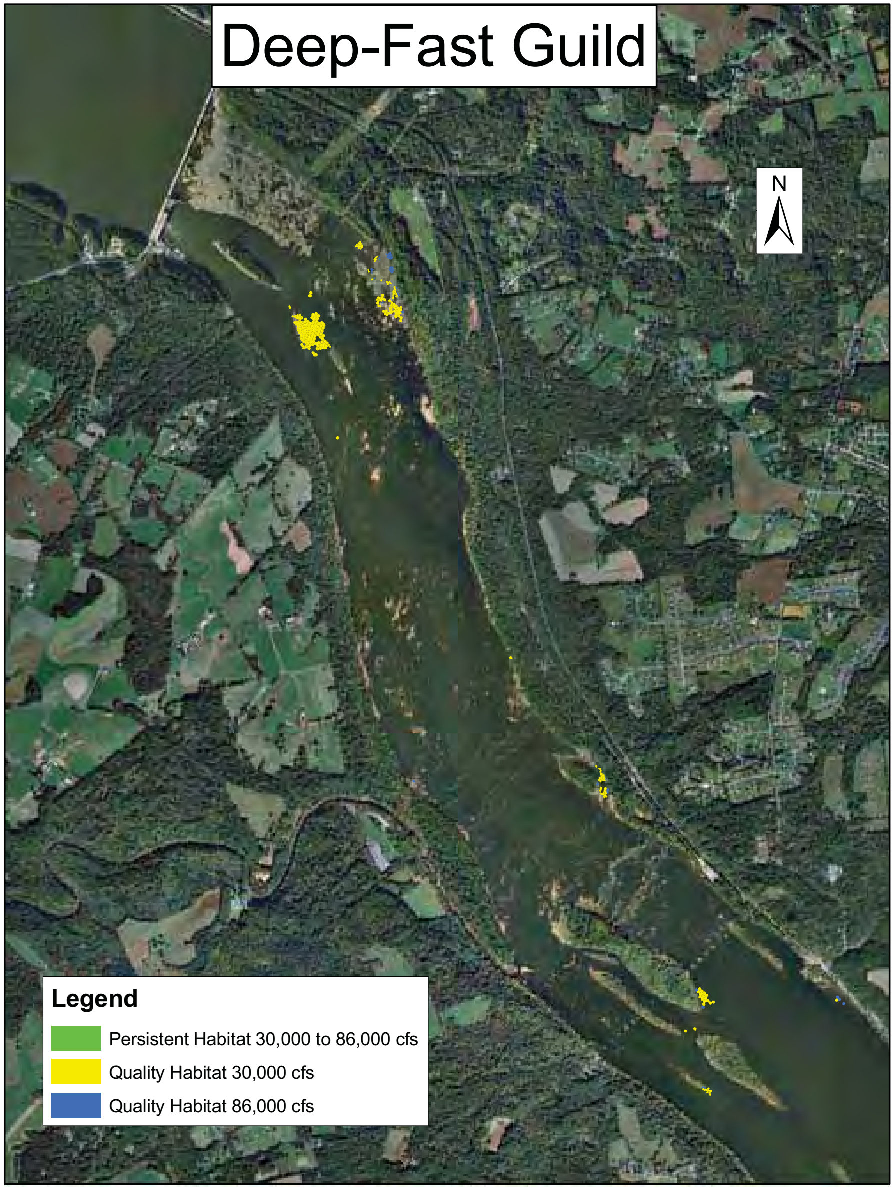

Deep-Fast Guild
N
Legend
Persistent Habitat 5,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 5,000 cfs


Deep-Fast Guild
N
Legend
Persistent Habitat 7,500 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 7,500 cfs

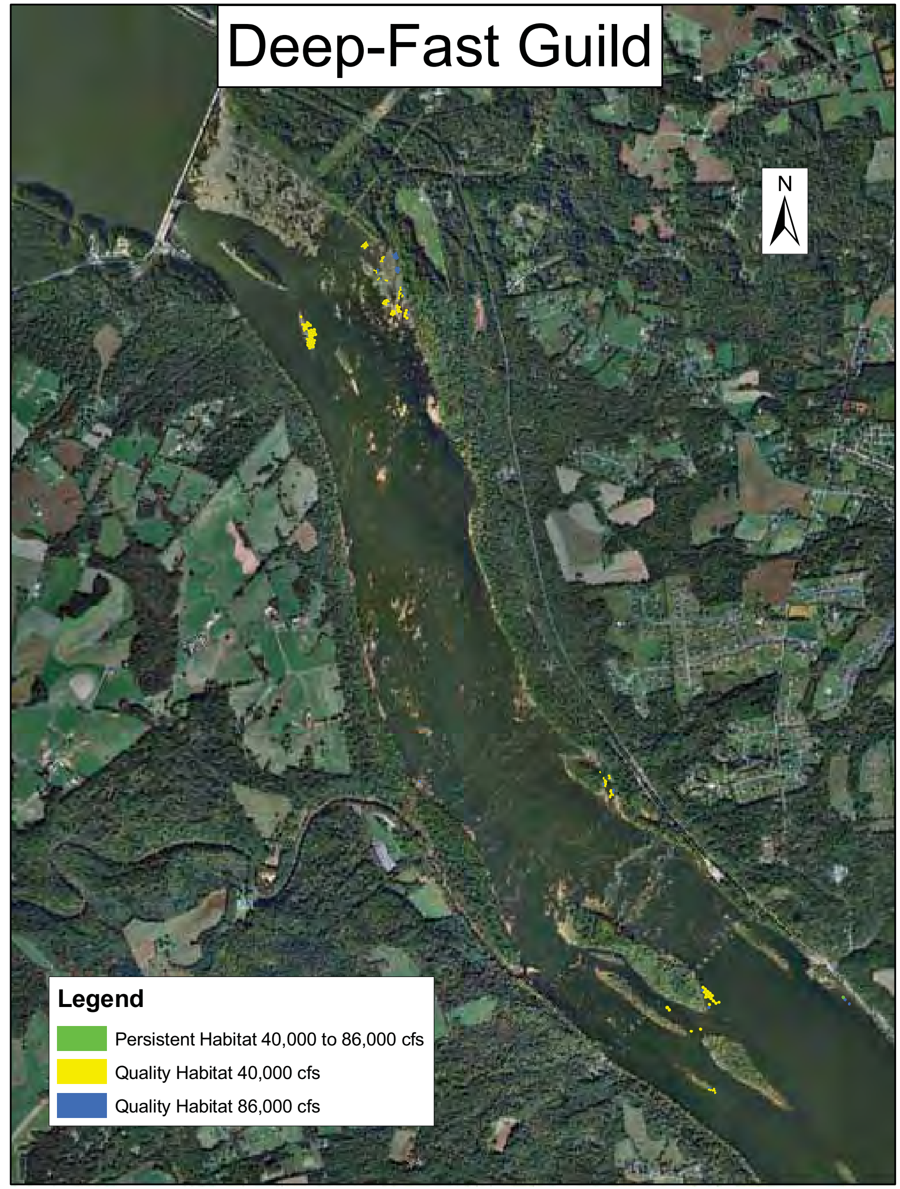

Deep-Fast Guild
N
Legend
Persistent Habitat 10,000 to 86,000 cfs
Quality Habitat 86,000 cfs
Quality Habitat 10,000 cfs


Deep-Fast Guild
N
Legend
Persistent Habitat 15,000 to 86,000 cfs
Quality Habitat 15,000 cfs
Quality Habitat 86,000 cfs


Deep-Fast Guild
N
Legend
Persistent Habitat 20,000 to 86,000 cfs
Quality Habitat 20,000 cfs
Quality Habitat 86,000 cfs



Deep-Fast Guild
N
Legend
Persistent Habitat 30,000 to 86,000 cfs
Quality Habitat 30,000 cfs
Quality Habitat 86,000 cfs



Deep-Fast Guild
N
Legend
Persistent Habitat 40,000 to 86,000 cfs
Quality Habitat 40,000 cfs
Quality Habitat 86,000 cfs

APPENDIX G-HABITAT PERSISTENCE TABLES

American Shad Spawning Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**144,797**	144,797	144,797	144,797	144,797	141,917	123,412	51,975	22,024	9,953	2,244	2,244	2,244	2,244
3,500		**185,653**	185,653	185,653	185,653	182,772	164,268	90,944	60,993	50,809	36,878	12,923	8,355	5,797
5,000			**205,330**	205,330	205,330	202,449	183,944	110,621	80,670	67,350	49,507	23,477	18,908	16,351
7,500				**282,747**	282,747	279,867	261,362	188,038	154,263	129,637	107,840	78,039	65,696	59,689
10,000					**577,085**	574,204	555,699	482,376	441,548	395,558	358,637	286,794	237,594	218,426
15,000						**1,465,467**	1,446,962	1,371,294	1,304,578	1,214,177	1,127,012	1,011,489	835,362	775,405
20,000							**2,022,046**	1,941,371	1,864,518	1,724,558	1,577,015	1,399,627	1,138,275	1,060,982
30,000								**2,649,183**	2,560,652	2,374,400	2,144,559	1,901,348	1,562,157	1,444,265
40,000									**2,973,742**	2,774,018	2,528,802	2,245,387	1,867,061	1,717,777
50,000										**3,030,923**	2,777,884	2,481,909	2,097,652	1,936,262
60,000											**2,949,583**	2,650,148	2,255,762	2,094,373
70,000												**2,822,902**	2,417,072	2,252,212
80,000													**2,521,060**	2,352,468
86,000														**2,428,418**

American Shad Fry Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**777,325**	498,460	498,460	496,595	476,681	406,498	377,363	333,429	279,597	244,141	139,585	104,876	98,139	87,704
3,500		**728,506**	728,506	725,625	705,711	635,528	606,393	550,468	475,584	421,668	283,816	220,876	191,528	169,829
5,000			**849,534**	846,654	826,739	756,556	727,422	669,974	591,703	537,418	394,962	320,270	278,311	255,179
7,500				**1,041,500**	1,021,586	951,403	922,269	844,507	763,055	695,182	536,764	459,586	407,483	362,549
10,000					**1,294,769**	1,217,019	1,184,019	1,098,860	1,003,959	915,246	725,605	630,819	558,090	485,719
15,000						**1,782,716**	1,742,814	1,627,930	1,499,061	1,380,637	1,159,137	976,364	783,883	683,040
20,000							**2,022,937**	1,892,622	1,735,982	1,592,407	1,334,634	1,137,435	923,572	811,462
30,000								**2,430,199**	2,248,323	2,010,837	1,667,028	1,414,608	1,171,041	1,037,298
40,000									**2,525,376**	2,233,046	1,863,024	1,586,409	1,330,746	1,185,350
50,000										**2,386,872**	2,006,611	1,713,862	1,447,049	1,299,900
60,000											**2,132,116**	1,829,621	1,553,819	1,400,029
70,000												**1,941,054**	1,660,877	1,501,242
80,000													**1,739,412**	1,571,189
86,000														**1,628,941**

Shortnose Sturgeon Spawning Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**168,802**	168,802	168,802	168,802	168,802	168,802	168,802	155,531	107,118	75,979	57,777	39,639	33,958	25,206
3,500		**208,169**	208,169	208,169	208,169	208,169	208,169	194,898	144,599	115,346	97,145	79,007	70,190	57,526
5,000			**268,281**	268,281	266,552	266,552	266,552	253,281	204,712	175,459	157,257	139,119	130,302	117,638
7,500				**630,269**	628,540	628,540	627,326	614,055	565,486	533,622	504,561	467,830	449,950	422,667
10,000					**1,135,971**	1,134,863	1,134,757	1,121,486	1,071,187	1,036,857	988,796	944,496	910,120	862,389
15,000						**1,811,743**	1,809,394	1,797,258	1,746,959	1,705,891	1,648,231	1,561,985	1,461,087	1,354,399
20,000							**2,277,424**	2,264,153	2,213,855	2,167,936	2,098,932	1,970,357	1,848,975	1,707,051
30,000								**2,852,779**	2,798,831	2,739,335	2,659,087	2,511,288	2,352,246	2,196,514
40,000									**3,074,321**	3,009,832	2,920,244	2,771,289	2,601,292	2,439,662
50,000										**3,267,368**	3,172,129	3,023,174	2,851,436	2,685,941
60,000											**3,323,283**	3,173,260	2,998,574	2,829,824
70,000												**3,324,084**	3,148,241	2,978,114
80,000													**3,264,273**	3,094,147
86,000														**3,161,551**

Shortnose Sturgeon Fry Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**4,347**	3,237	2,110	0	0	0	0	0	0	1,110	2,110	2,110	2,110	2,110
3,500		**19,259**	17,022	16,022	16,022	16,022	16,022	16,022	16,022	16,022	11,454	11,454	9,458	6,617
5,000			**72,289**	70,179	70,179	70,179	54,779	46,728	34,919	32,406	24,539	17,592	15,595	12,755
7,500				**285,504**	285,504	285,504	270,104	230,058	184,435	103,743	87,086	80,138	66,514	56,576
10,000					**343,620**	343,620	328,221	287,430	237,265	155,142	134,833	109,803	92,406	82,468
15,000						**441,902**	426,502	382,068	287,344	201,427	177,320	144,910	120,059	110,240
20,000							**492,843**	445,665	316,086	226,256	199,869	163,888	139,037	129,218
30,000								**509,888**	379,097	282,412	250,406	201,452	171,560	159,654
40,000									**420,786**	323,514	288,658	234,981	202,374	187,930
50,000										**382,912**	337,423	280,883	244,596	217,822
60,000											**390,651**	329,397	288,492	254,206
70,000												**364,366**	322,782	283,983
80,000													**348,005**	305,524
86,000														**341,974**

Striped Bass Spawning Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**837,992**	836,890	836,890	835,732	829,216	821,788	787,981	548,243	295,640	113,658	70,359	57,073	52,111	44,245
3,500		**1,723,802**	1,723,802	1,722,643	1,716,128	1,701,735	1,662,150	1,352,845	934,478	527,229	356,542	269,385	212,089	185,771
5,000			**2,973,203**	2,972,045	2,965,529	2,947,961	2,903,039	2,555,610	2,030,220	1,501,606	1,098,242	817,041	622,881	523,621
7,500				**7,257,979**	7,249,735	7,221,439	7,165,705	6,728,376	6,048,260	5,211,822	4,346,503	3,547,520	2,708,386	2,249,435
10,000					**14,563,959**	14,528,719	14,460,108	13,872,414	12,925,832	11,817,599	10,549,790	9,064,298	7,349,210	6,180,334
15,000						**32,755,354**	32,649,488	31,890,688	30,826,516	29,437,094	27,566,566	25,151,850	22,074,972	19,717,134
20,000							**47,114,451**	46,320,714	45,178,650	43,684,096	41,637,367	38,908,405	35,268,631	32,250,889
30,000								**56,121,710**	54,931,890	53,372,679	51,232,255	48,355,681	44,431,878	41,228,249
40,000									**57,852,856**	56,279,617	54,102,524	51,181,672	47,194,832	43,933,884
50,000										**58,137,814**	55,925,537	52,980,465	48,977,033	45,696,271
60,000											**56,966,799**	54,011,285	49,982,784	46,666,793
70,000												**54,915,913**	50,867,768	47,531,207
80,000													**52,828,545**	48,602,169
86,000														**49,295,125**

Striped Bass Fry Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**635,575**	626,080	634,473	633,315	633,315	629,743	607,154	405,289	230,780	100,160	64,634	53,093	43,003	36,620
3,500		**1,373,941**	1,361,434	1,372,783	1,368,926	1,365,354	1,331,412	1,017,326	659,937	342,464	251,431	185,515	140,759	121,915
5,000			**2,246,107**	2,240,676	2,241,092	2,234,274	2,200,331	1,839,769	1,350,812	918,425	723,717	560,085	414,101	359,367
7,500				**5,272,089**	5,266,504	5,252,931	5,215,436	4,824,027	4,156,128	3,464,316	3,007,794	2,398,180	1,793,199	1,465,970
10,000					**10,178,854**	10,159,863	10,108,176	9,646,415	8,880,269	7,965,033	7,161,220	6,121,364	4,956,273	4,234,143
15,000						**24,673,853**	24,584,801	23,916,221	22,950,061	21,722,937	20,271,587	18,339,360	15,943,031	14,200,858
20,000							**39,702,499**	38,884,762	37,863,793	36,462,739	34,685,483	32,239,302	28,993,195	26,382,494
30,000								**54,396,077**	53,267,143	51,720,944	49,716,780	46,893,266	43,026,073	39,843,007
40,000									**56,930,432**	55,331,715	53,262,082	50,373,793	46,385,181	43,133,321
50,000										**57,447,303**	55,338,861	52,413,478	48,407,718	45,123,491
60,000											**56,520,666**	53,558,095	49,531,568	46,226,030
70,000												**54,423,084**	50,357,930	47,036,894
80,000													**51,340,646**	47,997,061
86,000														**48,652,889**

Smallmouth Bass Spawning Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**965,602**	935,388	900,783	828,447	704,149	466,328	349,382	250,317	163,334	100,220	66,922	52,090	20,395	20,395
3,500		**1,001,643**	946,040	847,423	715,979	474,856	356,830	255,438	167,045	103,931	66,922	52,090	24,105	24,105
5,000			**1,049,421**	877,745	726,708	480,531	362,039	256,572	168,179	103,931	66,922	52,090	24,105	24,105
7,500				**937,519**	768,238	506,749	385,227	262,861	168,858	103,931	66,922	52,090	24,105	24,105
10,000					**805,333**	535,976	400,443	276,022	175,295	108,936	68,323	52,090	24,105	24,105
15,000						**599,897**	436,737	310,020	194,184	115,771	72,740	55,314	27,329	27,329
20,000							**468,765**	331,818	208,709	121,782	76,365	55,521	30,954	30,954
30,000								**376,417**	252,176	163,836	107,240	65,648	36,979	35,693
40,000									**290,844**	200,063	142,759	98,469	53,680	52,394
50,000										**238,531**	171,216	122,087	77,299	67,568
60,000											**207,370**	151,608	101,943	88,365
70,000												**189,642**	128,686	113,520
80,000													**156,313**	139,663
86,000														**149,553**

Smallmouth Bass Fry Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**694,082**	466,984	416,509	317,670	249,938	167,205	121,270	95,417	84,041	67,206	52,088	42,728	32,850	32,850
3,500		**569,096**	491,928	375,882	300,396	197,420	126,541	95,417	84,041	67,206	52,088	42,728	32,850	32,850
5,000			**556,566**	421,781	343,589	236,766	145,596	98,644	87,268	70,433	55,315	45,955	32,850	32,850
7,500				**469,250**	387,625	279,999	180,138	108,906	90,474	73,640	58,521	49,161	32,850	32,850
10,000					**440,880**	328,203	221,845	134,783	96,215	73,640	58,521	49,161	32,850	32,850
15,000						**408,111**	299,111	201,201	124,348	78,405	61,996	52,636	36,325	36,325
20,000							**364,906**	254,737	165,720	87,884	65,705	56,345	40,034	36,325
30,000								**404,325**	306,009	203,281	111,691	70,888	47,333	39,832
40,000									**464,128**	344,304	237,434	153,674	76,408	54,040
50,000										**485,040**	372,497	273,543	145,594	73,105
60,000											**572,089**	462,242	316,711	232,574
70,000												**608,065**	458,327	374,190
80,000													**599,578**	515,358
86,000														**611,893**

Stonefly Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**719,626**	667,825	572,880	292,603	42,504	0	0	0	0	0	0	0	0	0
3,500		**1,102,714**	988,611	609,355	234,731	0	0	0	0	0	0	0	0	0
5,000			**1,237,177**	826,049	402,405	11,142	0	0	0	0	0	0	0	0
7,500				**1,018,931**	569,309	80,333	4,274	0	0	0	0	0	0	0
10,000					**735,284**	188,973	24,871	0	0	0	0	0	0	0
15,000						**272,455**	63,438	0	0	0	0	0	0	0
20,000							**118,644**	10,364	3,642	0	0	0	0	0
30,000								**60,890**	22,926	6,311	4,911	4,911	4,911	3,450
40,000									**54,646**	15,291	4,911	4,911	4,911	3,450
50,000										**50,348**	26,520	10,202	10,202	8,740
60,000											**50,628**	25,456	15,098	10,046
70,000												**56,465**	33,633	19,401
80,000													**55,229**	39,407
86,000														**47,528**

Mayfly Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**1,508,906**	1,463,477	1,389,154	1,147,909	680,445	45,484	6,487	2,862	2,862	2,862	2,862	1,461	1,461	1,461
3,500		**1,678,709**	1,597,387	1,331,427	835,375	123,538	14,251	2,862	2,862	2,862	2,862	1,461	1,461	1,461
5,000			**1,738,130**	1,463,834	952,678	211,102	48,712	2,862	2,862	2,862	2,862	1,461	1,461	1,461
7,500				**1,682,263**	1,146,094	341,832	88,181	2,862	2,862	2,862	2,862	1,461	1,461	1,461
10,000					**1,240,598**	417,463	134,332	10,513	6,311	6,311	6,311	4,911	4,911	4,911
15,000						**533,413**	226,211	25,671	9,953	6,311	6,311	4,911	4,911	4,911
20,000							**294,469**	62,668	19,132	7,670	6,311	4,911	4,911	4,911
30,000								**157,452**	75,856	27,726	11,914	9,804	8,792	8,792
40,000									**154,252**	80,694	29,043	12,245	10,202	10,202
50,000										**155,949**	91,359	38,444	17,972	12,631
60,000											**142,372**	81,857	49,350	36,401
70,000												**138,200**	94,820	73,242
80,000													**111,579**	90,002
86,000														**105,964**

Caddisfly Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**1,623,818**	1,560,814	1,564,401	1,547,574	1,493,155	1,339,292	1,207,079	821,027	542,172	335,428	243,297	200,235	144,307	122,918
3,500		**1,999,767**	1,935,556	1,913,160	1,866,110	1,721,589	1,526,343	1,039,575	735,022	477,704	309,739	241,487	182,898	156,106
5,000			**2,299,204**	2,215,438	2,155,555	2,013,717	1,816,734	1,183,939	830,843	549,300	369,959	284,618	217,426	190,635
7,500				**2,562,903**	2,461,256	2,294,079	2,067,338	1,398,127	1,008,429	695,856	502,302	381,193	299,064	262,822
10,000					**2,673,519**	2,481,693	2,243,734	1,555,062	1,130,648	797,585	585,729	444,716	339,848	304,589
15,000						**2,771,663**	2,516,258	1,798,226	1,345,663	990,941	733,892	550,536	431,352	382,369
20,000							**2,680,057**	1,950,780	1,489,780	1,113,825	837,017	632,886	505,656	446,006
30,000								**2,249,785**	1,782,183	1,376,212	1,065,580	845,348	693,606	616,146
40,000									**1,957,893**	1,540,865	1,213,505	990,712	817,148	729,161
50,000										**1,680,757**	1,344,339	1,106,460	933,476	834,865
60,000											**1,464,095**	1,216,366	1,030,605	926,297
70,000												**1,352,242**	1,155,672	1,041,920
80,000													**1,251,439**	1,136,328
86,000														**1,186,154**

Shallow-Slow Guild Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**29,340,897**	21,211,551	13,679,571	5,116,534	1,528,548	478,999	374,064	232,692	169,167	120,394	90,032	64,179	52,078	39,391
3,500		**23,167,636**	15,539,608	6,712,280	2,765,326	530,279	375,684	232,692	169,167	120,394	90,032	64,179	52,078	39,391
5,000			**16,333,140**	7,410,604	3,367,053	776,767	386,638	235,080	169,167	120,394	90,032	64,179	52,078	39,391
7,500				**8,081,234**	3,999,812	1,294,130	530,949	242,155	172,451	123,679	90,032	64,179	52,078	39,391
10,000					**4,560,830**	1,769,249	902,892	264,139	172,451	123,679	90,032	64,179	52,078	39,391
15,000						**2,419,666**	1,499,413	511,865	193,879	136,883	99,289	65,553	53,452	39,391
20,000							**2,025,313**	956,928	301,582	150,037	109,946	69,012	53,452	39,391
30,000								**2,565,353**	1,644,746	467,736	151,950	84,460	59,047	40,891
40,000									**2,835,537**	1,503,331	538,878	113,038	69,588	40,891
50,000										**2,331,274**	1,267,620	532,870	141,243	63,810
60,000											**1,908,299**	1,137,822	669,442	382,763
70,000												**1,566,741**	1,061,739	725,521
80,000													**1,333,080**	971,624
86,000														**1,119,543**

Shallow-Fast Guild Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**1,041,153**	642,712	255,571	42,344	2,065	0	0	0	0	0	0	0	0	0
3,500		**816,102**	413,613	130,530	39,454	0	0	0	0	0	0	0	0	0
5,000			**514,632**	203,042	79,198	0	0	0	0	0	0	0	0	0
7,500				**294,116**	127,825	0	0	0	0	0	0	0	0	0
10,000					**165,002**	12,454	0	0	0	0	0	0	0	0
15,000						**22,348**	5,985	0	0	0	0	0	0	0
20,000							**22,823**	1,359	0	0	0	0	0	0
30,000								**34,456**	7,023	0	0	0	0	0
40,000									**19,918**	10,776	0	0	0	0
50,000										**28,881**	10,738	1,432	0	0
60,000											**28,063**	5,948	1,148	0
70,000												**16,176**	5,323	3,272
80,000													**6,637**	1,314
86,000														**12,103**

Deep-Slow Guild Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**29,173,856**	27,238,220	25,109,097	21,539,241	17,975,395	12,955,292	9,141,618	3,864,922	2,850,084	2,266,757	1,878,717	1,576,723	1,355,319	1,252,463
3,500		**32,671,145**	29,375,538	24,360,989	19,835,429	13,832,916	9,582,343	4,085,124	3,014,339	2,390,027	1,978,600	1,657,767	1,422,587	1,317,848
5,000			**34,237,116**	27,641,847	22,050,462	14,929,654	10,177,404	4,374,218	3,224,572	2,556,017	2,108,291	1,757,263	1,494,585	1,385,655
7,500				**32,875,712**	25,578,241	16,824,517	11,330,504	5,002,421	3,680,643	2,881,451	2,374,777	1,987,009	1,680,975	1,543,662
10,000					**28,075,993**	18,211,071	12,266,750	5,537,789	4,047,968	3,147,236	2,588,605	2,145,460	1,810,750	1,663,823
15,000						**20,065,376**	13,630,055	6,383,371	4,622,721	3,515,702	2,896,410	2,385,100	2,006,625	1,834,838
20,000							**14,329,296**	6,936,507	5,066,243	3,848,281	3,173,321	2,604,180	2,181,809	1,988,003
30,000								**7,672,733**	5,667,978	4,344,558	3,611,226	2,959,014	2,503,513	2,277,004
40,000									**6,478,344**	5,060,021	4,228,195	3,477,257	2,918,084	2,650,419
50,000										**6,243,614**	5,351,771	4,332,643	3,522,905	3,182,429
60,000											**6,222,656**	5,038,321	4,096,508	3,722,850
70,000												**5,760,875**	4,755,218	4,327,629
80,000													**5,299,677**	4,843,003
86,000														**5,192,284**

Deep-Fast Guild Persistent Quality Habitat Area (FT^2), by Flow Pairs (cfs).

	Generation Flow (cfs)													
Minimum Flow (cfs)	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
2,000	**26,023**	17,087	10,729	0	0	0	0	0	0	0	0	0	0	0
3,500		**42,565**	36,207	22,353	18,755	16,181	7,057	0	0	0	0	0	0	0
5,000			**87,601**	71,933	68,335	62,100	51,230	0	0	0	0	0	0	0
7,500				**432,421**	425,512	415,546	380,848	24,222	20,389	0	0	0	0	0
10,000					**824,557**	807,476	749,295	181,626	39,905	0	0	0	0	0
15,000						**1,147,771**	1,073,457	450,498	76,006	0	0	0	0	0
20,000							**1,229,743**	589,498	187,862	7,256	0	0	0	0
30,000								**684,917**	265,554	59,033	20,719	1,527	0	0
40,000									**314,843**	91,922	49,655	19,116	7,221	3,642
50,000										**103,436**	60,183	29,644	13,605	4,280
60,000											**74,380**	40,209	24,170	14,845
70,000												**69,597**	51,727	33,990
80,000													**78,660**	60,922
86,000														**74,469**

APPENDIX H-MUSSEL HABITAT HYDRAULIC PARAMETERS

Table H-1: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 2,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	0.50	0.11	0.05	2.70	0.00
D-12	264	Absent	8b	16707	0.59	0.12	0.05	9.40	0.00
D-38	257	Present	6	5336	0.53	0.06	0.02	1.10	0.00
D-26	235	Present	8a	18621	0.35	0.00	0.00	0.00	0.00
D-13	225	Present	8b	16707	0.58	0.10	0.04	6.10	0.00
D-27	164	Present	8a	18621	1.18	0.18	0.05	12.70	0.00
D-16	145	Present	8b	16707	1.55	0.05	0.01	0.60	0.00
W-12	100	Absent	8a	18621	1.31	0.00	0.00	0.00	0.00
D-25	98	Present	8a	18621	0.98	0.23	0.07	**51.80**	0.00
W-27	92	Present	8a	18621	0.39	0.00	0.00	0.00	0.00
W-16	91	Present	8b	16707	1.45	0.00	0.00	0.00	0.00
D-40	85	Present	8a	18621	0.83	0.30	0.11	**32.10**	0.00
D-22	80	Present	8b	16707	0.80	0.01	0.00	0.10	0.00
D-35	80	Absent	8a	18621	1.34	0.16	0.04	3.20	0.00
D-18	79	Present	8b	16707	1.98	0.06	0.01	0.70	0.00
D-24	78	Present	8a	18621	0.39	0.15	0.08	**21.40**	0.00
W-14	67	Present	8b	21856	0.37	0.00	0.00	0.02	0.00
W-6	58	Absent	6	6.50	0.00	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	0.48	0.00	0.00	0.00	0.00
D-1	49	Absent	8a	18621	0.09	0.03	0.03	2.40	0.00
W-15	48	Absent	8b	18621	1.49	0.00	0.00	0.00	0.00
W-20	46	Present	6	5336	0.41	0.00	0.00	0.00	0.00
D-28	44	Present	8a	18621	0.85	0.09	0.03	11.70	0.00
D-15	43	Present	5	126.3	0.94	0.04	0.01	0.30	0.00
D-14	40	Present	8b	16707	1.48	0.10	0.03	2.10	0.00
W-13	29	Absent	8b	16707	0.20	0.06	0.04	16.60	0.00
D-29	26	Absent	8a	18621	1.20	0.10	0.03	7.50	0.00
D-36	26	Absent	8a	18621	0.52	0.13	0.06	2.40	0.00
D-31	25	Absent	8a	18621	1.33	0.38	0.11	**51.50**	0.00
W-21	22	Absent	3	5336	0.62	0.01	0.00	0.03	0.00
D-2	20	Absent	8a	18621	1.13	0.00	0.00	0.00	0.00
W-18	19	Absent	8b	18621	0.58	0.00	0.00	0.00	0.00
W-19	19	Absent	8b	16707	0.50	0.19	0.09	17.30	0.00
W-28	19	Present	8a	18621	0.13	0.07	0.06	**49.10**	0.00
D-19	19	Absent	8b	21856	0.47	0.00	0.00	0.01	0.00
D-11	18	Absent	8a	18621	1.81	0.02	0.00	0.10	0.00
D-34	18	Absent	8a	18621	0.50	0.25	0.11	**30.10**	0.00
W-24	16	Present	8a	18621	0.25	0.01	0.01	2.50	0.00
D-17	15	Absent	8b	16707	1.98	0.07	0.02	0.90	0.00
W-23	14	Absent	8a	18621	0.91	0.36	0.12	**192.40**	0.01
W-25	13	Absent	8a	18621	0.11	0.05	0.05	**197.30**	0.01
D-21	13	Absent	8b	16707	0.14	0.18	0.15	**450.50**	0.03
D-41	13	Absent	8a	18621	0.10	0.00	0.00	0.00	0.00
D-43	13	Absent	8a	18621	0.57	0.21	0.09	18.50	0.00
D-37	12	Present	6	5336	1.22	0.01	0.00	0.00	0.00
W-22	11	Absent	8a	18621	0.57	0.23	0.10	**161.60**	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	0.21	0.06	0.04	**61.00**	0.00
D-5	11	Absent	8a	18621	0.23	0.03	0.02	**23.20**	0.00
D-10	11	Absent	8a	18621	0.34	0.16	0.09	**39.10**	0.00
D-33	11	Present	8a	18621	0.96	0.16	0.05	6.20	0.00
D-44	10	Absent	8a	18621	0.43	0.18	0.09	**22.90**	0.00
D-3	8	Absent	8a	16707	0.18	0.01	0.01	0.36	0.00
W-7	7	Absent	3	6.50	1.22	0.00	0.00	0.00	0.00
D-9	7	Absent	8a	18621	0.35	0.22	0.12	**286.90**	0.02
D-7	6	Absent	8a	16707	0.37	0.01	0.00	0.04	0.00
W-8	5	Absent	3	6.50	0.10	0.04	0.04	0.60	0.09
D-6	5	Absent	8a	18621	0.28	0.23	0.14	**173.90**	0.01
W-17	4	Absent	8b	16707	0.67	0.12	0.05	9.50	0.00
W-3	4	Absent	7	21856	1.95	0.12	0.03	1.80	0.00
W-11	4	Absent	8a	18621	0.18	0.09	0.06	**153.60**	0.01
D-42	4	Present	8a	18621	0.63	0.39	0.16	**144.00**	0.01
D-8	3	Absent	8a	18621	0.16	0.18	0.14	**238.20**	0.01
W-26	3	Absent	3	6.50	1.11	0.04	0.01	0.10	0.02
W-5	3	Absent	8a	18621	1.38	0.03	0.01	0.10	0.00
D-30	3	Absent	8a	18621	0.55	0.20	0.09	16.30	0.00
W-10	1	Absent	8a	18621	0.18	0.08	0.06	**126.20**	0.01
W-9	1	Absent	6	5336.1	0.18	0.06	0.05	0.20	0.00
W-1	1	Absent	5	126.3	2.31	0.01	0.00	0.00	0.00
D-20	0	Absent	8b	16707	0.41	0.15	0.07	**39.90**	0.00
D-32	0	Absent	6	5336	0.48	0.09	0.04	14.20	0.00
W-2	0	Absent	5	126.3	2.04	0.05	0.01	0.30	0.00
W-4	0	Absent	6	5336	0.63	0.15	0.06	5.60	0.00

Table H-2: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 3,500 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	0.63	0.16	0.06	4.80	0.00
D-12	264	Absent	8b	16707	0.64	0.17	0.07	17.50	0.00
D-38	257	Present	6	5336	0.67	0.10	0.04	3.00	0.00
D-26	235	Present	8a	18621	0.48	0.02	0.01	0.10	0.00
D-13	225	Present	8b	16707	0.65	0.13	0.05	10.20	0.00
D-27	164	Present	8a	18621	1.31	0.20	0.06	14.50	0.00
D-16	145	Present	8b	16707	1.55	0.07	0.02	1.30	0.00
W-12	100	Absent	8a	18621	1.39	0.00	0.00	0.00	0.00
D-25	98	Present	8a	18621	1.11	0.28	0.08	63.50	0.00
W-27	92	Present	8a	18621	0.53	0.00	0.00	0.00	0.00
W-16	91	Present	8b	16707	1.46	0.00	0.00	0.00	0.00
D-40	85	Present	8a	18621	0.99	0.37	0.12	40.60	0.00
D-22	80	Present	8b	16707	0.93	0.06	0.02	1.40	0.00
D-35	80	Absent	8a	18621	1.47	0.20	0.05	4.70	0.00
D-18	79	Present	8b	16707	1.98	0.09	0.02	1.80	0.00
D-24	78	Present	8a	18621	0.52	0.20	0.09	24.80	0.00
W-14	67	Present	8b	21856	0.43	0.01	0.00	0.12	0.00
W-6	58	Absent	1	6.50	0.00	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	0.63	0.01	0.00	0.01	0.00
D-1	49	Absent	8a	18621	0.17	0.05	0.04	2.10	0.00
W-15	48	Absent	8b	18621	1.50	0.00	0.00	0.00	0.00
W-20	46	Present	6	5336	0.46	0.00	0.00	0.00	0.00
D-28	44	Present	8a	18621	0.99	0.13	0.04	16.90	0.00
D-15	43	Present	5	126.3	0.95	0.07	0.02	1.00	0.01
D-14	40	Present	8b	16707	1.50	0.15	0.04	5.10	0.00
W-13	29	Absent	8b	16707	0.25	0.09	0.06	26.30	0.00
D-29	26	Absent	8a	18621	1.34	0.13	0.04	11.80	0.00
D-36	26	Absent	8a	18621	0.65	0.16	0.06	2.90	0.00
D-31	25	Absent	8a	18621	1.47	0.45	0.12	67.70	0.00
W-21	22	Absent	3	5336	0.68	0.02	0.01	0.09	0.00
D-2	20	Absent	8a	18621	1.27	0.04	0.01	0.10	0.00
W-18	19	Absent	8b	18621	0.70	0.00	0.00	0.00	0.00
W-19	19	Absent	8b	16707	0.63	0.27	0.11	27.40	0.00
W-28	19	Present	8a	18621	0.28	0.05	0.03	5.40	0.00
D-19	19	Absent	8b	21856	0.59	0.01	0.00	0.05	0.00
D-11	18	Absent	8a	18621	1.93	0.05	0.01	0.60	0.00
D-34	18	Absent	8a	18621	0.62	0.30	0.12	33.80	0.00
W-24	16	Present	8a	18621	0.35	0.06	0.03	35.30	0.00
D-17	15	Absent	8b	16707	1.98	0.10	0.02	2.10	0.00
W-23	14	Absent	8a	18621	1.00	0.40	0.13	192.90	0.01
W-25	13	Absent	8a	18621	0.21	0.12	0.09	369.60	0.02
D-21	13	Absent	8b	16707	0.24	0.23	0.15	233.60	0.01
D-41	13	Absent	8a	18621	0.25	0.00	0.00	0.00	0.00
D-43	13	Absent	8a	18621	0.72	0.27	0.10	25.30	0.00
D-37	12	Present	6	5336	1.36	0.01	0.00	0.00	0.00
W-22	11	Absent	8a	18621	0.68	0.29	0.11	170.20	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	0.35	0.11	0.06	**78.90**	0.00
D-5	11	Absent	8a	18621	0.35	0.06	0.03	**28.50**	0.00
D-10	11	Absent	8a	18621	0.44	0.30	0.14	**90.70**	0.00
D-33	11	Present	8a	18621	1.08	0.20	0.06	9.30	0.00
D-44	10	Absent	8a	18621	0.59	0.26	0.11	**31.80**	0.00
D-3	8	Absent	8a	16707	0.32	0.05	0.03	4.28	0.00
W-7	7	Absent	3	6.50	1.30	0.00	0.00	0.00	0.00
D-9	7	Absent	8a	18621	0.47	0.28	0.13	**257.80**	0.01
D-7	6	Absent	8a	16707	0.48	0.01	0.01	0.12	0.00
W-8	5	Absent	3	6.50	0.18	0.02	0.02	0.12	0.02
D-6	5	Absent	8a	18621	0.40	0.29	0.15	**139.90**	0.01
W-17	4	Absent	8b	16707	0.70	0.16	0.06	17.20	0.00
W-3	4	Absent	7	21856	2.02	0.13	0.03	2.20	0.00
W-11	4	Absent	8a	18621	0.27	0.12	0.07	**142.80**	0.01
D-42	4	Present	8a	18621	0.77	0.44	0.16	**135.50**	0.01
D-8	3	Absent	8a	18621	0.27	0.24	0.15	**164.60**	0.01
W-26	3	Absent	3	6.50	1.20	0.04	0.01	0.10	0.02
W-5	3	Absent	8a	18621	1.46	0.01	0.00	0.00	0.00
D-30	3	Absent	8a	18621	0.70	0.30	0.12	**29.50**	0.00
W-10	1	Absent	8a	18621	0.27	0.13	0.08	**163.60**	0.01
W-9	1	Absent	6	5336.1	0.25	0.25	0.16	2.97	0.00
W-1	1	Absent	5	126.3	2.38	0.02	0.00	0.00	0.00
D-20	0	Absent	8b	16707	0.53	0.20	0.09	**46.70**	0.00
D-32	0	Absent	6	5336	0.62	0.13	0.05	18.00	0.00
W-2	0	Absent	5	126.3	2.11	0.06	0.01	0.40	0.00
W-4	0	Absent	6	5336	0.71	0.20	0.08	8.50	0.00

Table H-3: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 5,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	0.73	0.20	0.07	6.80	0.00
D-12	264	Absent	8b	16707	0.71	0.22	0.08	24.50	0.00
D-38	257	Present	6	5336	0.78	0.14	0.05	5.00	0.00
D-26	235	Present	8a	18621	0.59	0.07	0.03	1.30	0.00
D-13	225	Present	8b	16707	0.71	0.16	0.06	13.00	0.00
D-27	164	Present	8a	18621	1.42	0.22	0.06	15.80	0.00
D-16	145	Present	8b	16707	1.56	0.09	0.02	2.30	0.00
W-12	100	Absent	8a	18621	1.48	0.01	0.00	0.00	0.00
D-25	98	Present	8a	18621	1.21	0.32	0.09	73.30	0.00
W-27	92	Present	8a	18621	0.64	0.02	0.01	0.10	0.00
W-16	91	Present	8b	16707	1.46	0.00	0.00	0.00	0.00
D-40	85	Present	8a	18621	1.11	0.41	0.13	46.90	0.00
D-22	80	Present	8b	16707	1.03	0.11	0.03	4.00	0.00
D-35	80	Absent	8a	18621	1.57	0.23	0.06	6.00	0.00
D-18	79	Present	8b	16707	1.98	0.13	0.03	3.30	0.00
D-24	78	Present	8a	18621	0.62	0.24	0.10	28.70	0.00
W-14	67	Present	8b	21856	0.50	0.02	0.01	0.44	0.00
W-6	58	Absent	1	6.50	0.00	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	0.75	0.02	0.01	0.03	0.00
D-1	49	Absent	8a	18621	0.26	0.10	0.06	4.30	0.00
W-15	48	Absent	8b	18621	1.50	0.00	0.00	0.00	0.00
W-20	46	Present	6	5336	0.55	0.00	0.00	0.00	0.00
D-28	44	Present	8a	18621	1.10	0.16	0.05	21.80	0.00
D-15	43	Present	5	126.3	0.95	0.10	0.03	2.10	0.02
D-14	40	Present	8b	16707	1.52	0.20	0.05	9.10	0.00
W-13	29	Absent	8b	16707	0.31	0.12	0.07	32.00	0.00
D-29	26	Absent	8a	18621	1.45	0.16	0.04	16.20	0.00
D-36	26	Absent	8a	18621	0.76	0.19	0.07	3.80	0.00
D-31	25	Absent	8a	18621	1.57	0.52	0.13	81.70	0.00
W-21	22	Absent	3	5336	0.73	0.03	0.01	0.18	0.00
D-2	20	Absent	8a	18621	1.38	0.11	0.03	0.70	0.00
W-18	19	Absent	8b	18621	0.80	0.00	0.00	0.01	0.00
W-19	19	Absent	8b	16707	0.73	0.33	0.12	36.00	0.00
W-28	19	Present	8a	18621	0.40	0.04	0.02	1.60	0.00
D-19	19	Absent	8b	21856	0.69	0.02	0.01	0.33	0.00
D-11	18	Absent	8a	18621	2.03	0.08	0.02	1.50	0.00
D-34	18	Absent	8a	18621	0.73	0.30	0.11	30.60	0.00
W-24	16	Present	8a	18621	0.44	0.11	0.05	71.00	0.00
D-17	15	Absent	8b	16707	1.98	0.13	0.03	3.70	0.00
W-23	14	Absent	8a	18621	1.08	0.40	0.12	174.90	0.01
W-25	13	Absent	8a	18621	0.30	0.17	0.10	332.10	0.02
D-21	13	Absent	8b	16707	0.33	0.27	0.15	170.80	0.01
D-41	13	Absent	8a	18621	0.36	0.01	0.00	0.10	0.00
D-43	13	Absent	8a	18621	0.83	0.32	0.11	30.60	0.00
D-37	12	Present	6	5336	1.47	0.02	0.00	0.00	0.00
W-22	11	Absent	8a	18621	0.76	0.33	0.12	177.30	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	0.45	0.14	0.07	**78.90**	0.00
D-5	11	Absent	8a	18621	0.45	0.07	0.04	**29.50**	0.00
D-10	11	Absent	8a	18621	0.53	0.37	0.16	**103.80**	0.01
D-33	11	Present	8a	18621	1.19	0.24	0.07	12.70	0.00
D-44	10	Absent	8a	18621	0.71	0.33	0.12	**40.40**	0.00
D-3	8	Absent	8a	16707	0.42	0.09	0.04	6.99	0.00
W-7	7	Absent	3	6.50	1.38	0.00	0.00	0.00	0.00
D-9	7	Absent	8a	18621	0.57	0.33	0.14	**242.80**	0.01
D-7	6	Absent	8a	16707	0.59	0.02	0.01	0.25	0.00
W-8	5	Absent	3	6.50	0.26	0.02	0.01	0.04	0.01
D-6	5	Absent	8a	18621	0.50	0.35	0.16	**132.30**	0.01
W-17	4	Absent	8b	16707	0.75	0.21	0.08	**25.40**	0.00
W-3	4	Absent	7	21856	2.11	0.16	0.03	3.00	0.00
W-11	4	Absent	8a	18621	0.35	0.15	0.08	**133.70**	0.01
D-42	4	Present	8a	18621	0.89	0.49	0.17	**139.90**	0.01
D-8	3	Absent	8a	18621	0.37	0.29	0.15	**127.80**	0.01
W-26	3	Absent	3	6.50	1.28	0.05	0.01	0.10	0.02
W-5	3	Absent	8a	18621	1.54	0.03	0.01	0.10	0.00
D-30	3	Absent	8a	18621	0.81	0.39	0.14	**42.70**	0.00
W-10	1	Absent	8a	18621	0.36	0.17	0.09	**155.30**	0.01
W-9	1	Absent	6	5336.1	0.33	0.37	0.21	6.08	0.00
W-1	1	Absent	5	126.3	2.47	0.03	0.01	0.10	0.00
D-20	0	Absent	8b	16707	0.62	0.25	0.10	**53.20**	0.00
D-32	0	Absent	6	5336	0.72	0.16	0.06	**22.40**	0.00
W-2	0	Absent	5	126.3	2.20	0.07	0.02	0.70	0.01
W-4	0	Absent	6	5336	0.79	0.24	0.09	11.30	0.00

Table H-4: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 7,500 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	0.87	0.25	0.09	9.80	0.00
D-12	264	Absent	8b	16707	0.81	0.27	0.10	34.20	0.00
D-38	257	Present	6	5336	0.93	0.18	0.06	7.50	0.00
D-26	235	Present	8a	18621	0.73	0.18	0.07	6.70	0.00
D-13	225	Present	8b	16707	0.82	0.19	0.07	15.50	0.00
D-27	164	Present	8a	18621	1.57	0.25	0.06	18.60	0.00
D-16	145	Present	8b	16707	1.57	0.13	0.03	4.50	0.00
W-12	100	Absent	8a	18621	1.61	0.04	0.01	0.20	0.00
D-25	98	Present	8a	18621	1.35	0.37	0.10	88.10	0.00
W-27	92	Present	8a	18621	0.79	0.07	0.02	1.60	0.00
W-16	91	Present	8b	16707	1.47	0.00	0.00	0.00	0.00
D-40	85	Present	8a	18621	1.27	0.48	0.13	55.60	0.00
D-22	80	Present	8b	16707	1.16	0.17	0.05	8.70	0.00
D-35	80	Absent	8a	18621	1.73	0.27	0.07	8.10	0.00
D-18	79	Present	8b	16707	1.99	0.19	0.04	6.80	0.00
D-24	78	Present	8a	18621	0.76	0.29	0.11	35.20	0.00
W-14	67	Present	8b	21856	0.61	0.05	0.02	2.35	0.00
W-6	58	Absent	1	6.50	0.11	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	0.91	0.05	0.02	0.15	0.00
D-1	49	Absent	8a	18621	0.39	0.15	0.08	7.30	0.00
W-15	48	Absent	8b	18621	1.52	0.01	0.00	0.01	0.00
W-20	46	Present	6	5336	0.69	0.00	0.00	0.00	0.00
D-28	44	Present	8a	18621	1.25	0.20	0.06	29.60	0.00
D-15	43	Present	5	126.3	0.97	0.16	0.05	4.80	0.04
D-14	40	Present	8b	16707	1.56	0.28	0.07	16.90	0.00
W-13	29	Absent	8b	16707	0.41	0.17	0.08	36.10	0.00
D-29	26	Absent	8a	18621	1.61	0.21	0.05	23.80	0.00
D-36	26	Absent	8a	18621	0.91	0.23	0.08	5.10	0.00
D-31	25	Absent	8a	18621	1.71	0.60	0.15	102.80	0.01
W-21	22	Absent	3	5336	0.83	0.04	0.02	0.43	0.00
D-2	20	Absent	8a	18621	1.52	0.22	0.06	2.40	0.00
W-18	19	Absent	8b	18621	0.93	0.01	0.00	0.05	0.00
W-19	19	Absent	8b	16707	0.86	0.41	0.14	47.60	0.00
W-28	19	Present	8a	18621	0.57	0.07	0.03	3.10	0.00
D-19	19	Absent	8b	21856	0.82	0.08	0.03	4.12	0.00
D-11	18	Absent	8a	18621	2.16	0.13	0.03	3.30	0.00
D-34	18	Absent	8a	18621	0.88	0.29	0.10	23.70	0.00
W-24	16	Present	8a	18621	0.58	0.17	0.07	98.20	0.01
D-17	15	Absent	8b	16707	1.99	0.19	0.04	7.40	0.00
W-23	14	Absent	8a	18621	1.21	0.39	0.11	139.50	0.01
W-25	13	Absent	8a	18621	0.43	0.23	0.11	298.10	0.02
D-21	13	Absent	8b	16707	0.46	0.33	0.15	134.80	0.01
D-41	13	Absent	8a	18621	0.52	0.09	0.04	3.80	0.00
D-43	13	Absent	8a	18621	0.99	0.38	0.12	37.80	0.00
D-37	12	Present	6	5336	1.62	0.03	0.01	0.10	0.00
W-22	11	Absent	8a	18621	0.86	0.38	0.13	186.40	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	0.59	0.18	0.08	76.10	0.00
D-5	11	Absent	8a	18621	0.59	0.10	0.04	30.00	0.00
D-10	11	Absent	8a	18621	0.67	0.42	0.16	98.20	0.01
D-33	11	Present	8a	18621	1.35	0.34	0.09	22.30	0.00
D-44	10	Absent	8a	18621	0.87	0.41	0.14	51.80	0.00
D-3	8	Absent	8a	16707	0.56	0.14	0.06	11.87	0.00
W-7	7	Absent	3	6.50	1.51	0.00	0.00	0.00	0.00
D-9	7	Absent	8a	18621	0.71	0.40	0.15	225.80	0.01
D-7	6	Absent	8a	16707	0.73	0.04	0.02	0.76	0.00
W-8	5	Absent	3	6.50	0.39	0.02	0.01	0.04	0.01
D-6	5	Absent	8a	18621	0.64	0.43	0.17	139.50	0.01
W-17	4	Absent	8b	16707	0.82	0.27	0.10	38.30	0.00
W-3	4	Absent	7	21856	2.24	0.19	0.04	4.50	0.00
W-11	4	Absent	8a	18621	0.48	0.21	0.09	127.40	0.01
D-42	4	Present	8a	18621	1.05	0.56	0.17	149.00	0.01
D-8	3	Absent	8a	18621	0.52	0.37	0.16	114.50	0.01
W-26	3	Absent	3	6.50	1.42	0.06	0.02	0.20	0.03
W-5	3	Absent	8a	18621	1.67	0.08	0.02	0.40	0.00
D-30	3	Absent	8a	18621	0.96	0.51	0.17	64.10	0.00
W-10	1	Absent	8a	18621	0.49	0.22	0.10	143.50	0.01
W-9	1	Absent	6	5336.1	0.45	0.39	0.18	5.98	0.00
W-1	1	Absent	5	126.3	2.60	0.04	0.01	0.20	0.00
D-20	0	Absent	8b	16707	0.76	0.31	0.11	62.90	0.00
D-32	0	Absent	6	5336	0.86	0.21	0.07	30.30	0.01
W-2	0	Absent	5	126.3	2.33	0.09	0.02	1.00	0.01
W-4	0	Absent	6	5336	0.91	0.29	0.10	15.10	0.00

Table H-5: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 10,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	0.99	0.29	0.09	12.70	0.00
D-12	264	Absent	8b	16707	0.90	0.32	0.11	42.30	0.00
D-38	257	Present	6	5336	1.05	0.21	0.07	9.30	0.00
D-26	235	Present	8a	18621	0.86	0.23	0.08	9.20	0.00
D-13	225	Present	8b	16707	0.92	0.21	0.07	16.80	0.00
D-27	164	Present	8a	18621	1.69	0.28	0.07	21.60	0.00
D-16	145	Present	8b	16707	1.58	0.17	0.04	7.40	0.00
W-12	100	Absent	8a	18621	1.72	0.07	0.02	0.70	0.00
D-25	98	Present	8a	18621	1.46	0.42	0.11	101.60	0.01
W-27	92	Present	8a	18621	0.92	0.13	0.04	4.70	0.00
W-16	91	Present	8b	16707	1.47	0.01	0.00	0.00	0.00
D-40	85	Present	8a	18621	1.40	0.53	0.14	62.70	0.00
D-22	80	Present	8b	16707	1.27	0.24	0.07	15.40	0.00
D-35	80	Absent	8a	18621	1.86	0.31	0.07	10.50	0.00
D-18	79	Present	8b	16707	1.99	0.24	0.05	11.60	0.00
D-24	78	Present	8a	18621	0.87	0.34	0.12	41.30	0.00
W-14	67	Present	8b	21856	0.71	0.09	0.03	7.36	0.00
W-6	58	Absent	1	6.50	0.22	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	1.04	0.10	0.03	0.63	0.00
D-1	49	Absent	8a	18621	0.51	0.19	0.09	9.30	0.00
W-15	48	Absent	8b	18621	1.54	0.01	0.00	0.02	0.00
W-20	46	Present	6	5336	0.83	0.00	0.00	0.00	0.00
D-28	44	Present	8a	18621	1.38	0.24	0.07	37.20	0.00
D-15	43	Present	5	126.3	0.98	0.21	0.07	8.60	0.07
D-14	40	Present	8b	16707	1.61	0.35	0.09	25.60	0.00
W-13	29	Absent	8b	16707	0.51	0.21	0.09	38.40	0.00
D-29	26	Absent	8a	18621	1.73	0.25	0.06	31.40	0.00
D-36	26	Absent	8a	18621	1.03	0.26	0.08	6.30	0.00
D-31	25	Absent	8a	18621	1.82	0.67	0.16	122.30	0.01
W-21	22	Absent	3	5336	0.95	0.06	0.02	0.83	0.00
D-2	20	Absent	8a	18621	1.63	0.30	0.07	4.40	0.00
W-18	19	Absent	8b	18621	1.05	0.02	0.01	0.17	0.00
W-19	19	Absent	8b	16707	0.97	0.47	0.15	57.50	0.00
W-28	19	Present	8a	18621	0.70	0.11	0.04	6.10	0.00
D-19	19	Absent	8b	21856	0.93	0.16	0.05	14.08	0.00
D-11	18	Absent	8a	18621	2.28	0.16	0.03	5.30	0.00
D-34	18	Absent	8a	18621	1.01	0.28	0.09	19.10	0.00
W-24	16	Present	8a	18621	0.70	0.21	0.08	107.40	0.01
D-17	15	Absent	8b	16707	2.01	0.24	0.05	12.00	0.00
W-23	14	Absent	8a	18621	1.32	0.37	0.10	110.90	0.01
W-25	13	Absent	8a	18621	0.55	0.28	0.12	274.30	0.01
D-21	13	Absent	8b	16707	0.57	0.38	0.16	128.90	0.01
D-41	13	Absent	8a	18621	0.65	0.24	0.10	22.60	0.00
D-43	13	Absent	8a	18621	1.12	0.43	0.13	43.60	0.00
D-37	12	Present	6	5336	1.74	0.04	0.01	0.20	0.00
W-22	11	Absent	8a	18621	0.94	0.42	0.14	192.40	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	0.70	0.22	0.08	74.00	0.00
D-5	11	Absent	8a	18621	0.71	0.12	0.04	30.50	0.00
D-10	11	Absent	8a	18621	0.79	0.45	0.16	97.00	0.01
D-33	11	Present	8a	18621	1.48	0.43	0.11	33.90	0.00
D-44	10	Absent	8a	18621	1.01	0.46	0.15	59.60	0.00
D-3	8	Absent	8a	16707	0.67	0.19	0.07	17.70	0.00
W-7	7	Absent	3	6.50	1.63	0.00	0.00	0.00	0.00
D-9	7	Absent	8a	18621	0.83	0.45	0.16	220.80	0.01
D-7	6	Absent	8a	16707	0.85	0.07	0.03	2.06	0.00
W-8	5	Absent	3	6.50	0.51	0.04	0.02	0.14	0.02
D-6	5	Absent	8a	18621	0.76	0.50	0.18	150.90	0.01
W-17	4	Absent	8b	16707	0.89	0.32	0.11	50.20	0.00
W-3	4	Absent	7	21856	2.35	0.23	0.05	5.90	0.00
W-11	4	Absent	8a	18621	0.59	0.26	0.11	135.30	0.01
D-42	4	Present	8a	18621	1.18	0.61	0.18	158.30	0.01
D-8	3	Absent	8a	18621	0.65	0.43	0.17	114.70	0.01
W-26	3	Absent	3	6.50	1.55	0.07	0.02	0.30	0.05
W-5	3	Absent	8a	18621	1.78	0.13	0.03	0.90	0.00
D-30	3	Absent	8a	18621	1.08	0.62	0.19	84.90	0.00
W-10	1	Absent	8a	18621	0.60	0.27	0.11	137.60	0.01
W-9	1	Absent	6	5336.1	0.56	0.36	0.15	4.74	0.00
W-1	1	Absent	5	126.3	2.71	0.05	0.01	0.30	0.00
D-20	0	Absent	8b	16707	0.87	0.36	0.12	72.10	0.00
D-32	0	Absent	6	5336	0.98	0.26	0.08	38.20	0.01
W-2	0	Absent	5	126.3	2.45	0.12	0.02	1.60	0.01
W-4	0	Absent	6	5336	1.02	0.34	0.11	19.20	0.00

Table H-6: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 15,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	1.18	0.38	0.11	18.60	0.00
D-12	264	Absent	8b	16707	1.07	0.40	0.12	54.40	0.00
D-38	257	Present	6	5336	1.25	0.26	0.07	12.10	0.00
D-26	235	Present	8a	18621	1.06	0.29	0.09	13.30	0.00
D-13	225	Present	8b	16707	1.09	0.23	0.07	18.00	0.00
D-27	164	Present	8a	18621	1.90	0.33	0.08	27.70	0.00
D-16	145	Present	8b	16707	1.61	0.24	0.06	14.50	0.00
W-12	100	Absent	8a	18621	1.91	0.12	0.03	1.70	0.00
D-25	98	Present	8a	18621	1.65	0.50	0.13	125.10	0.01
W-27	92	Present	8a	18621	1.14	0.19	0.06	8.60	0.00
W-16	91	Present	8b	16707	1.49	0.01	0.00	0.10	0.00
D-40	85	Present	8a	18621	1.61	0.61	0.15	75.90	0.00
D-22	80	Present	8b	16707	1.44	0.35	0.09	30.30	0.00
D-35	80	Absent	8a	18621	2.08	0.40	0.09	16.20	0.00
D-18	79	Present	8b	16707	2.01	0.35	0.08	24.60	0.00
D-24	78	Present	8a	18621	1.06	0.42	0.13	52.70	0.00
W-14	67	Present	8b	21856	0.88	0.23	0.08	34.23	0.00
W-6	58	Absent	1	6.50	0.32	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	1.25	0.23	0.06	3.07	0.00
D-1	49	Absent	8a	18621	0.70	0.25	0.10	12.60	0.00
W-15	48	Absent	8b	18621	1.58	0.02	0.00	0.07	0.00
W-20	46	Present	6	5336	1.07	0.01	0.00	0.00	0.00
D-28	44	Present	8a	18621	1.58	0.31	0.08	51.80	0.00
D-15	43	Present	5	126.3	1.03	0.32	0.10	18.00	0.14
D-14	40	Present	8b	16707	1.72	0.46	0.11	42.90	0.00
W-13	29	Absent	8b	16707	0.67	0.27	0.11	45.60	0.00
D-29	26	Absent	8a	18621	1.94	0.33	0.08	46.90	0.00
D-36	26	Absent	8a	18621	1.25	0.34	0.10	9.50	0.00
D-31	25	Absent	8a	18621	2.02	0.80	0.18	158.80	0.01
W-21	22	Absent	3	5336	1.17	0.11	0.03	2.06	0.00
D-2	20	Absent	8a	18621	1.83	0.41	0.10	8.00	0.00
W-18	19	Absent	8b	18621	1.23	0.06	0.02	1.19	0.00
W-19	19	Absent	8b	16707	1.16	0.57	0.17	73.80	0.00
W-28	19	Present	8a	18621	0.93	0.16	0.05	10.30	0.00
D-19	19	Absent	8b	21856	1.11	0.24	0.07	25.99	0.00
D-11	18	Absent	8a	18621	2.47	0.22	0.05	9.50	0.00
D-34	18	Absent	8a	18621	1.23	0.28	0.08	16.90	0.00
W-24	16	Present	8a	18621	0.90	0.28	0.10	116.90	0.01
D-17	15	Absent	8b	16707	2.05	0.34	0.08	23.80	0.00
W-23	14	Absent	8a	18621	1.52	0.35	0.09	81.90	0.00
W-25	13	Absent	8a	18621	0.75	0.35	0.13	227.30	0.01
D-21	13	Absent	8b	16707	0.75	0.47	0.17	133.20	0.01
D-41	13	Absent	8a	18621	0.85	0.38	0.13	42.80	0.00
D-43	13	Absent	8a	18621	1.35	0.51	0.14	53.20	0.00
D-37	12	Present	6	5336	1.95	0.06	0.01	0.40	0.00
W-22	11	Absent	8a	18621	1.08	0.47	0.15	199.30	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	0.90	0.28	0.09	**77.80**	0.00
D-5	11	Absent	8a	18621	0.90	0.15	0.05	**31.60**	0.00
D-10	11	Absent	8a	18621	1.00	0.52	0.17	**100.40**	0.01
D-33	11	Present	8a	18621	1.70	0.57	0.14	**54.20**	0.00
D-44	10	Absent	8a	18621	1.23	0.55	0.16	**70.60**	0.00
D-3	8	Absent	8a	16707	0.86	0.28	0.10	**30.30**	0.00
W-7	7	Absent	3	6.50	1.86	0.01	0.00	0.00	0.00
D-9	7	Absent	8a	18621	1.03	0.54	0.17	**225.20**	0.01
D-7	6	Absent	8a	16707	1.05	0.17	0.05	9.24	0.00
W-8	5	Absent	3	6.50	0.74	0.09	0.03	0.78	0.12
D-6	5	Absent	8a	18621	0.96	0.61	0.20	**171.00**	0.01
W-17	4	Absent	8b	16707	1.03	0.42	0.13	**71.50**	0.00
W-3	4	Absent	7	21856	2.55	0.27	0.05	8.30	0.00
W-11	4	Absent	8a	18621	0.78	0.35	0.13	**146.30**	0.01
D-42	4	Present	8a	18621	1.40	0.70	0.19	**177.50**	0.01
D-8	3	Absent	8a	18621	0.86	0.51	0.18	**118.80**	0.01
W-26	3	Absent	3	6.50	1.78	0.10	0.02	0.60	0.09
W-5	3	Absent	8a	18621	1.97	0.24	0.05	3.00	0.00
D-30	3	Absent	8a	18621	1.29	0.80	0.22	**123.40**	0.01
W-10	1	Absent	8a	18621	0.80	0.34	0.12	**129.80**	0.01
W-9	1	Absent	6	5336.1	0.76	0.64	0.23	13.63	0.00
W-1	1	Absent	5	126.3	2.91	0.08	0.02	0.70	0.01
D-20	0	Absent	8b	16707	1.05	0.45	0.14	**91.30**	0.01
D-32	0	Absent	6	5336	1.18	0.34	0.10	**53.10**	0.01
W-2	0	Absent	5	126.3	2.64	0.16	0.03	2.90	0.02
W-4	0	Absent	6	5336	1.22	0.42	0.12	**26.40**	0.00

Table H-7: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 20,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	1.34	0.44	0.12	24.20	0.00
D-12	264	Absent	8b	16707	1.22	0.45	0.13	62.70	0.00
D-38	257	Present	6	5336	1.42	0.29	0.08	14.00	0.00
D-26	235	Present	8a	18621	1.22	0.34	0.10	16.50	0.00
D-13	225	Present	8b	16707	1.23	0.25	0.07	18.50	0.00
D-27	164	Present	8a	18621	2.06	0.38	0.08	34.90	0.00
D-16	145	Present	8b	16707	1.65	0.31	0.08	23.40	0.00
W-12	100	Absent	8a	18621	2.08	0.15	0.03	2.50	0.00
D-25	98	Present	8a	18621	1.80	0.57	0.14	144.90	0.01
W-27	92	Present	8a	18621	1.33	0.22	0.06	10.80	0.00
W-16	91	Present	8b	16707	1.52	0.03	0.01	0.10	0.00
D-40	85	Present	8a	18621	1.79	0.68	0.16	88.10	0.00
D-22	80	Present	8b	16707	1.59	0.45	0.11	46.10	0.00
D-35	80	Absent	8a	18621	2.26	0.45	0.10	19.40	0.00
D-18	79	Present	8b	16707	2.03	0.46	0.10	41.40	0.00
D-24	78	Present	8a	18621	1.22	0.48	0.14	63.20	0.00
W-14	67	Present	8b	21856	1.02	0.38	0.12	78.33	0.00
W-6	58	Absent	1	6.50	0.59	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	1.43	0.34	0.09	6.68	0.00
D-1	49	Absent	8a	18621	0.86	0.31	0.11	16.20	0.00
W-15	48	Absent	8b	18621	1.64	0.03	0.01	0.18	0.00
W-20	46	Present	6	5336	1.26	0.02	0.00	0.00	0.00
D-28	44	Present	8a	18621	1.74	0.37	0.09	66.40	0.00
D-15	43	Present	5	126.3	1.08	0.40	0.12	27.90	0.22
D-14	40	Present	8b	16707	1.84	0.55	0.13	59.00	0.00
W-13	29	Absent	8b	16707	0.82	0.34	0.12	54.50	0.00
D-29	26	Absent	8a	18621	2.10	0.40	0.09	63.20	0.00
D-36	26	Absent	8a	18621	1.43	0.41	0.11	13.40	0.00
D-31	25	Absent	8a	18621	2.18	0.90	0.20	191.30	0.01
W-21	22	Absent	3	5336	1.34	0.16	0.04	3.96	0.00
D-2	20	Absent	8a	18621	1.99	0.47	0.11	10.60	0.00
W-18	19	Absent	8b	18621	1.38	0.12	0.03	3.88	0.00
W-19	19	Absent	8b	16707	1.31	0.65	0.18	85.10	0.01
W-28	19	Present	8a	18621	1.13	0.19	0.06	11.90	0.00
D-19	19	Absent	8b	21856	1.27	0.31	0.09	35.63	0.00
D-11	18	Absent	8a	18621	2.63	0.27	0.05	13.60	0.00
D-34	18	Absent	8a	18621	1.41	0.43	0.11	35.60	0.00
W-24	16	Present	8a	18621	1.07	0.35	0.11	127.80	0.01
D-17	15	Absent	8b	16707	2.09	0.44	0.10	37.90	0.00
W-23	14	Absent	8a	18621	1.70	0.36	0.09	73.30	0.00
W-25	13	Absent	8a	18621	0.92	0.39	0.13	191.50	0.01
D-21	13	Absent	8b	16707	0.90	0.55	0.18	146.60	0.01
D-41	13	Absent	8a	18621	1.03	0.49	0.15	59.80	0.00
D-43	13	Absent	8a	18621	1.54	0.57	0.15	62.10	0.00
D-37	12	Present	6	5336	2.11	0.09	0.02	0.90	0.00
W-22	11	Absent	8a	18621	1.21	0.52	0.15	206.90	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	1.07	0.34	0.10	**90.90**	0.00
D-5	11	Absent	8a	18621	1.07	0.18	0.06	**34.30**	0.00
D-10	11	Absent	8a	18621	1.17	0.58	0.17	**105.60**	0.01
D-33	11	Present	8a	18621	1.88	0.58	0.14	**53.50**	0.00
D-44	10	Absent	8a	18621	1.42	0.61	0.16	**79.00**	0.00
D-3	8	Absent	8a	16707	1.03	0.36	0.11	**41.53**	0.00
W-7	7	Absent	3	6.50	2.06	0.00	0.00	0.00	0.00
D-9	7	Absent	8a	18621	1.20	0.61	0.18	**234.80**	0.01
D-7	6	Absent	8a	16707	1.22	0.26	0.08	18.80	0.00
W-8	5	Absent	3	6.50	0.94	0.17	0.06	2.35	0.36
D-6	5	Absent	8a	18621	1.13	0.69	0.21	**183.90**	0.01
W-17	4	Absent	8b	16707	1.16	0.50	0.15	**90.70**	0.01
W-3	4	Absent	7	21856	2.71	0.32	0.06	11.10	0.00
W-11	4	Absent	8a	18621	0.95	0.43	0.14	**156.60**	0.01
D-42	4	Present	8a	18621	1.58	0.77	0.20	**191.00**	0.01
D-8	3	Absent	8a	18621	1.04	0.59	0.18	**127.80**	0.01
W-26	3	Absent	3	6.50	1.98	0.14	0.03	1.00	0.15
W-5	3	Absent	8a	18621	2.14	0.31	0.07	5.20	0.00
D-30	3	Absent	8a	18621	1.47	0.94	0.25	**158.10**	0.01
W-10	1	Absent	8a	18621	0.97	0.39	0.13	**129.20**	0.01
W-9	1	Absent	6	5336.1	0.93	0.72	0.24	16.23	0.00
W-1	1	Absent	5	126.3	3.07	0.11	0.02	1.30	0.01
D-20	0	Absent	8b	16707	1.20	0.53	0.15	**110.50**	0.01
D-32	0	Absent	6	5336	1.34	0.41	0.11	**66.90**	0.01
W-2	0	Absent	5	126.3	2.80	0.20	0.04	4.20	0.03
W-4	0	Absent	6	5336	1.39	0.48	0.13	**31.60**	0.01

Table H-8: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 30,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	1.60	0.54	0.14	32.00	0.00
D-12	264	Absent	8b	16707	1.47	0.54	0.14	75.70	0.00
D-38	257	Present	6	5336	1.70	0.33	0.08	15.80	0.00
D-26	235	Present	8a	18621	1.49	0.42	0.11	22.00	0.00
D-13	225	Present	8b	16707	1.49	0.29	0.08	21.80	0.00
D-27	164	Present	8a	18621	2.33	0.49	0.10	52.80	0.00
D-16	145	Present	8b	16707	1.76	0.43	0.10	43.30	0.00
W-12	100	Absent	8a	18621	2.36	0.18	0.04	3.60	0.00
D-25	98	Present	8a	18621	2.06	0.68	0.15	181.80	0.01
W-27	92	Present	8a	18621	1.65	0.27	0.07	14.00	0.00
W-16	91	Present	8b	16707	1.59	0.06	0.01	0.70	0.00
D-40	85	Present	8a	18621	2.08	0.80	0.18	110.90	0.01
D-22	80	Present	8b	16707	1.85	0.61	0.14	77.60	0.00
D-35	80	Absent	8a	18621	2.56	0.56	0.11	28.70	0.00
D-18	79	Present	8b	16707	2.09	0.66	0.15	83.10	0.00
D-24	78	Present	8a	18621	1.48	0.60	0.16	81.70	0.00
W-14	67	Present	8b	21856	1.27	0.57	0.16	138.31	0.01
W-6	58	Absent	1	6.50	0.90	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	1.71	0.49	0.12	12.77	0.00
D-1	49	Absent	8a	18621	1.15	0.42	0.13	25.60	0.00
W-15	48	Absent	8b	18621	1.78	0.06	0.01	0.81	0.00
W-20	46	Present	6	5336	1.53	0.03	0.01	0.10	0.00
D-28	44	Present	8a	18621	2.02	0.48	0.11	95.50	0.01
D-15	43	Present	5	126.3	1.21	0.53	0.15	45.70	0.36
D-14	40	Present	8b	16707	2.05	0.70	0.16	88.30	0.01
W-13	29	Absent	8b	16707	1.07	0.45	0.14	73.00	0.00
D-29	26	Absent	8a	18621	2.38	0.52	0.11	97.00	0.01
D-36	26	Absent	8a	18621	1.73	0.53	0.13	20.40	0.00
D-31	25	Absent	8a	18621	2.46	1.07	0.22	245.30	0.01
W-21	22	Absent	3	5336	1.60	0.27	0.07	10.29	0.00
D-2	20	Absent	8a	18621	2.27	0.51	0.11	11.80	0.00
W-18	19	Absent	8b	18621	1.64	0.20	0.05	9.66	0.00
W-19	19	Absent	8b	16707	1.57	0.76	0.20	105.20	0.01
W-28	19	Present	8a	18621	1.45	0.22	0.06	12.60	0.00
D-19	19	Absent	8b	21856	1.51	0.39	0.10	49.96	0.00
D-11	18	Absent	8a	18621	2.92	0.36	0.07	21.60	0.00
D-34	18	Absent	8a	18621	1.72	0.55	0.13	52.50	0.00
W-24	16	Present	8a	18621	1.36	0.45	0.12	152.90	0.01
D-17	15	Absent	8b	16707	2.21	0.60	0.13	68.20	0.00
W-23	14	Absent	8a	18621	1.99	0.41	0.09	80.30	0.00
W-25	13	Absent	8a	18621	1.20	0.49	0.14	196.20	0.01
D-21	13	Absent	8b	16707	1.14	0.69	0.21	183.10	0.01
D-41	13	Absent	8a	18621	1.31	0.64	0.18	85.50	0.00
D-43	13	Absent	8a	18621	1.85	0.69	0.16	79.20	0.00
D-37	12	Present	6	5336	2.39	0.15	0.03	2.50	0.00
W-22	11	Absent	8a	18621	1.48	0.61	0.16	219.60	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	1.36	0.47	0.13	128.70	0.01
D-5	11	Absent	8a	18621	1.35	0.25	0.07	44.40	0.00
D-10	11	Absent	8a	18621	1.47	0.68	0.18	119.20	0.01
D-33	11	Present	8a	18621	2.19	0.67	0.14	63.80	0.00
D-44	10	Absent	8a	18621	1.74	0.71	0.17	93.20	0.01
D-3	8	Absent	8a	16707	1.31	0.51	0.14	66.06	0.00
W-7	7	Absent	3	6.50	2.43	0.03	0.01	0.10	0.02
D-9	7	Absent	8a	18621	1.50	0.73	0.19	257.50	0.01
D-7	6	Absent	8a	16707	1.53	0.41	0.11	38.77	0.00
W-8	5	Absent	3	6.50	1.30	0.37	0.10	9.79	1.51
D-6	5	Absent	8a	18621	1.42	0.80	0.21	199.00	0.01
W-17	4	Absent	8b	16707	1.39	0.63	0.17	122.10	0.01
W-3	4	Absent	7	21856	2.99	0.38	0.07	15.00	0.00
W-11	4	Absent	8a	18621	1.24	0.54	0.15	174.70	0.01
D-42	4	Present	8a	18621	1.88	0.88	0.20	213.20	0.01
D-8	3	Absent	8a	18621	1.35	0.72	0.20	153.10	0.01
W-26	3	Absent	3	6.50	2.34	0.19	0.04	1.90	0.29
W-5	3	Absent	8a	18621	2.42	0.38	0.08	7.30	0.00
D-30	3	Absent	8a	18621	1.76	1.17	0.28	217.30	0.01
W-10	1	Absent	8a	18621	1.26	0.47	0.13	128.30	0.01
W-9	1	Absent	6	5336.1	1.23	0.61	0.18	11.13	0.00
W-1	1	Absent	5	126.3	3.36	0.15	0.03	2.20	0.02
D-20	0	Absent	8b	16707	1.45	0.67	0.18	148.00	0.01
D-32	0	Absent	6	5336	1.63	0.52	0.13	89.80	0.02
W-2	0	Absent	5	126.3	3.09	0.24	0.04	5.60	0.04
W-4	0	Absent	6	5336	1.68	0.56	0.14	38.40	0.01

Table H-9: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 40,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	1.82	0.61	0.14	38.60	0.00
D-12	264	Absent	8b	16707	1.69	0.62	0.15	88.60	0.01
D-38	257	Present	6	5336	1.93	0.36	0.08	17.30	0.00
D-26	235	Present	8a	18621	1.72	0.48	0.12	27.00	0.00
D-13	225	Present	8b	16707	1.71	0.37	0.09	31.60	0.00
D-27	164	Present	8a	18621	2.56	0.59	0.12	72.00	0.00
D-16	145	Present	8b	16707	1.87	0.53	0.12	63.70	0.00
W-12	100	Absent	8a	18621	2.61	0.24	0.05	5.70	0.00
D-25	98	Present	8a	18621	2.28	0.78	0.16	215.50	0.01
W-27	92	Present	8a	18621	1.91	0.34	0.08	19.60	0.00
W-16	91	Present	8b	16707	1.67	0.11	0.03	2.40	0.00
D-40	85	Present	8a	18621	2.33	0.91	0.19	131.40	0.01
D-22	80	Present	8b	16707	2.07	0.73	0.16	103.00	0.01
D-35	80	Absent	8a	18621	2.81	0.67	0.13	38.40	0.00
D-18	79	Present	8b	16707	2.17	0.84	0.18	130.70	0.01
D-24	78	Present	8a	18621	1.69	0.69	0.17	97.60	0.01
W-14	67	Present	8b	21856	1.48	0.70	0.18	179.13	0.01
W-6	58	Absent	1	6.50	1.18	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	1.95	0.63	0.14	20.02	0.00
D-1	49	Absent	8a	18621	1.40	0.51	0.14	33.50	0.00
W-15	48	Absent	8b	18621	1.92	0.11	0.03	2.54	0.00
W-20	46	Present	6	5336	1.77	0.19	0.04	2.20	0.00
D-28	44	Present	8a	18621	2.25	0.58	0.12	122.90	0.01
D-15	43	Present	5	126.3	1.34	0.63	0.17	60.20	0.48
D-14	40	Present	8b	16707	2.25	0.83	0.18	114.70	0.01
W-13	29	Absent	8b	16707	1.29	0.54	0.15	89.60	0.01
D-29	26	Absent	8a	18621	2.61	0.63	0.13	130.50	0.01
D-36	26	Absent	8a	18621	1.98	0.61	0.14	25.70	0.00
D-31	25	Absent	8a	18621	2.70	1.20	0.23	287.90	0.02
W-21	22	Absent	3	5336	1.83	0.39	0.09	20.02	0.00
D-2	20	Absent	8a	18621	2.52	0.47	0.10	9.70	0.00
W-18	19	Absent	8b	18621	1.85	0.25	0.06	13.49	0.00
W-19	19	Absent	8b	16707	1.78	0.86	0.21	122.70	0.01
W-28	19	Present	8a	18621	1.72	0.23	0.06	11.90	0.00
D-19	19	Absent	8b	21856	1.71	0.47	0.11	62.72	0.00
D-11	18	Absent	8a	18621	3.16	0.42	0.08	28.80	0.00
D-34	18	Absent	8a	18621	1.97	0.66	0.15	68.20	0.00
W-24	16	Present	8a	18621	1.60	0.57	0.14	192.40	0.01
D-17	15	Absent	8b	16707	2.33	0.73	0.15	97.20	0.01
W-23	14	Absent	8a	18621	2.24	0.48	0.10	95.70	0.01
W-25	13	Absent	8a	18621	1.44	0.59	0.16	222.30	0.01
D-21	13	Absent	8b	16707	1.35	0.82	0.23	220.20	0.01
D-41	13	Absent	8a	18621	1.55	0.70	0.18	90.50	0.00
D-43	13	Absent	8a	18621	2.11	0.79	0.17	96.00	0.01
D-37	12	Present	6	5336	2.62	0.23	0.05	5.30	0.00
W-22	11	Absent	8a	18621	1.71	0.67	0.16	217.90	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	1.61	0.60	0.15	171.00	0.01
D-5	11	Absent	8a	18621	1.60	0.32	0.08	59.90	0.00
D-10	11	Absent	8a	18621	1.73	0.77	0.19	136.50	0.01
D-33	11	Present	8a	18621	2.44	0.75	0.15	76.10	0.00
D-44	10	Absent	8a	18621	2.01	0.80	0.18	105.20	0.01
D-3	8	Absent	8a	16707	1.56	0.63	0.16	90.69	0.01
W-7	7	Absent	3	6.50	2.74	0.10	0.02	0.60	0.09
D-9	7	Absent	8a	18621	1.75	0.82	0.20	279.60	0.02
D-7	6	Absent	8a	16707	1.79	0.56	0.13	63.19	0.00
W-8	5	Absent	3	6.50	1.60	0.49	0.12	15.60	2.40
D-6	5	Absent	8a	18621	1.66	0.88	0.22	210.90	0.01
W-17	4	Absent	8b	16707	1.59	0.73	0.19	146.60	0.01
W-3	4	Absent	7	21856	3.23	0.45	0.08	19.80	0.00
W-11	4	Absent	8a	18621	1.50	0.63	0.16	191.50	0.01
D-42	4	Present	8a	18621	2.13	0.96	0.21	230.60	0.01
D-8	3	Absent	8a	18621	1.60	0.82	0.21	171.30	0.01
W-26	3	Absent	3	6.50	2.64	0.28	0.06	3.90	0.60
W-5	3	Absent	8a	18621	2.66	0.42	0.08	8.80	0.00
D-30	3	Absent	8a	18621	2.00	1.35	0.30	266.80	0.01
W-10	1	Absent	8a	18621	1.51	0.51	0.13	126.00	0.01
W-9	1	Absent	6	5336.1	1.49	0.60	0.16	10.16	0.00
W-1	1	Absent	5	126.3	3.60	0.18	0.03	3.10	0.02
D-20	0	Absent	8b	16707	1.65	0.79	0.20	182.10	0.01
D-32	0	Absent	6	5336	1.88	0.60	0.14	107.20	0.02
W-2	0	Absent	5	126.3	3.34	0.26	0.05	6.80	0.05
W-4	0	Absent	6	5336	1.94	0.60	0.14	40.60	0.01

Table H-10: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 50,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	2.02	0.68	0.15	45.70	0.00
D-12	264	Absent	8b	16707	1.89	0.69	0.16	101.20	0.01
D-38	257	Present	6	5336	2.14	0.40	0.09	20.70	0.00
D-26	235	Present	8a	18621	1.91	0.54	0.12	31.30	0.00
D-13	225	Present	8b	16707	1.91	0.49	0.11	50.80	0.00
D-27	164	Present	8a	18621	2.77	0.69	0.13	91.60	0.00
D-16	145	Present	8b	16707	1.99	0.62	0.14	82.90	0.00
W-12	100	Absent	8a	18621	2.83	0.32	0.06	9.80	0.00
D-25	98	Present	8a	18621	2.47	0.87	0.18	246.80	0.01
W-27	92	Present	8a	18621	2.14	0.44	0.10	31.00	0.00
W-16	91	Present	8b	16707	1.76	0.17	0.04	6.30	0.00
D-40	85	Present	8a	18621	2.54	1.00	0.20	150.20	0.01
D-22	80	Present	8b	16707	2.27	0.83	0.18	124.90	0.01
D-35	80	Absent	8a	18621	3.04	0.76	0.14	47.70	0.00
D-18	79	Present	8b	16707	2.25	0.99	0.21	179.10	0.01
D-24	78	Present	8a	18621	1.89	0.76	0.18	112.40	0.01
W-14	67	Present	8b	21856	1.67	0.81	0.20	214.66	0.01
W-6	58	Absent	1	6.50	1.33	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	2.16	0.76	0.17	28.47	0.00
D-1	49	Absent	8a	18621	1.62	0.53	0.13	32.30	0.00
W-15	48	Absent	8b	18621	2.06	0.18	0.04	6.83	0.00
W-20	46	Present	6	5336	1.97	0.42	0.10	10.50	0.00
D-28	44	Present	8a	18621	2.45	0.66	0.13	148.30	0.01
D-15	43	Present	5	126.3	1.47	0.73	0.19	76.10	0.60
D-14	40	Present	8b	16707	2.42	0.93	0.19	139.20	0.01
W-13	29	Absent	8b	16707	1.49	0.62	0.16	103.60	0.01
D-29	26	Absent	8a	18621	2.82	0.73	0.14	162.80	0.01
D-36	26	Absent	8a	18621	2.21	0.68	0.15	30.20	0.00
D-31	25	Absent	8a	18621	2.91	1.30	0.24	322.10	0.02
W-21	22	Absent	3	5336	2.05	0.52	0.12	33.31	0.01
D-2	20	Absent	8a	18621	2.74	0.42	0.08	7.40	0.00
W-18	19	Absent	8b	18621	2.04	0.30	0.07	18.29	0.00
W-19	19	Absent	8b	16707	1.97	0.95	0.22	139.00	0.01
W-28	19	Present	8a	18621	1.95	0.24	0.05	11.50	0.00
D-19	19	Absent	8b	21856	1.89	0.55	0.13	80.80	0.00
D-11	18	Absent	8a	18621	3.38	0.49	0.08	36.50	0.00
D-34	18	Absent	8a	18621	2.19	0.75	0.16	82.90	0.00
W-24	16	Present	8a	18621	1.81	0.68	0.16	237.00	0.01
D-17	15	Absent	8b	16707	2.46	0.83	0.17	122.70	0.01
W-23	14	Absent	8a	18621	2.46	0.54	0.11	112.40	0.01
W-25	13	Absent	8a	18621	1.65	0.68	0.17	250.60	0.01
D-21	13	Absent	8b	16707	1.53	0.94	0.24	258.10	0.02
D-41	13	Absent	8a	18621	1.76	0.79	0.19	105.40	0.01
D-43	13	Absent	8a	18621	2.34	0.89	0.18	112.60	0.01
D-37	12	Present	6	5336	2.82	0.32	0.06	9.70	0.00
W-22	11	Absent	8a	18621	1.93	0.71	0.16	220.20	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	1.83	0.72	0.17	**214.70**	0.01
D-5	11	Absent	8a	18621	1.82	0.40	0.09	**78.20**	0.00
D-10	11	Absent	8a	18621	1.95	0.86	0.20	**153.60**	0.01
D-33	11	Present	8a	18621	2.67	0.83	0.16	**88.40**	0.00
D-44	10	Absent	8a	18621	2.24	0.87	0.19	**116.60**	0.01
D-3	8	Absent	8a	16707	1.78	0.71	0.17	**104.37**	0.01
W-7	7	Absent	3	6.50	3.02	0.14	0.03	1.30	0.20
D-9	7	Absent	8a	18621	1.97	0.90	0.21	**298.40**	0.02
D-7	6	Absent	8a	16707	2.01	0.63	0.14	**74.01**	0.00
W-8	5	Absent	3	6.50	1.87	0.56	0.13	19.06	**2.93**
D-6	5	Absent	8a	18621	1.88	0.95	0.22	**220.50**	0.01
W-17	4	Absent	8b	16707	1.76	0.82	0.20	**169.20**	0.01
W-3	4	Absent	7	21856	3.46	0.51	0.09	**24.30**	0.00
W-11	4	Absent	8a	18621	1.72	0.71	0.17	**209.50**	0.01
D-42	4	Present	8a	18621	2.35	1.03	0.22	**246.20**	0.01
D-8	3	Absent	8a	18621	1.83	0.91	0.21	**189.10**	0.01
W-26	3	Absent	3	6.50	2.91	0.45	0.08	9.50	**1.46**
W-5	3	Absent	8a	18621	2.88	0.45	0.09	9.70	0.00
D-30	3	Absent	8a	18621	2.22	1.49	0.32	**307.40**	0.02
W-10	1	Absent	8a	18621	1.74	0.54	0.13	**121.20**	0.01
W-9	1	Absent	6	5336.1	1.72	0.64	0.16	11.00	0.00
W-1	1	Absent	5	126.3	3.83	0.22	0.04	4.20	0.03
D-20	0	Absent	8b	16707	1.83	0.89	0.21	**214.90**	0.01
D-32	0	Absent	6	5336	2.10	0.67	0.15	**120.30**	0.02
W-2	0	Absent	5	126.3	3.56	0.30	0.05	8.50	0.07
W-4	0	Absent	6	5336	2.18	0.63	0.14	**42.20**	0.01

Table H-11: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 60,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	2.19	0.74	0.16	52.20	0.00
D-12	264	Absent	8b	16707	2.07	0.75	0.17	113.30	0.01
D-38	257	Present	6	5336	2.32	0.47	0.10	27.30	0.01
D-26	235	Present	8a	18621	2.09	0.58	0.13	34.60	0.00
D-13	225	Present	8b	16707	2.09	0.62	0.14	74.00	0.00
D-27	164	Present	8a	18621	2.95	0.77	0.14	110.90	0.01
D-16	145	Present	8b	16707	2.11	0.70	0.15	101.20	0.01
W-12	100	Absent	8a	18621	3.04	0.39	0.07	14.60	0.00
D-25	98	Present	8a	18621	2.64	0.95	0.19	277.30	0.01
W-27	92	Present	8a	18621	2.35	0.49	0.10	36.20	0.00
W-16	91	Present	8b	16707	1.86	0.26	0.06	13.80	0.00
D-40	85	Present	8a	18621	2.74	1.08	0.21	167.40	0.01
D-22	80	Present	8b	16707	2.44	0.92	0.19	144.20	0.01
D-35	80	Absent	8a	18621	3.23	0.84	0.15	56.80	0.00
D-18	79	Present	8b	16707	2.34	1.13	0.24	225.50	0.01
D-24	78	Present	8a	18621	2.06	0.84	0.19	126.20	0.01
W-14	67	Present	8b	21856	1.85	0.91	0.21	245.27	0.01
W-6	58	Absent	1	6.50	1.65	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	2.34	0.88	0.18	37.43	0.00
D-1	49	Absent	8a	18621	1.83	0.53	0.12	30.20	0.00
W-15	48	Absent	8b	18621	2.20	0.29	0.06	16.07	0.00
W-20	46	Present	6	5336	2.16	0.58	0.13	19.70	0.00
D-28	44	Present	8a	18621	2.64	0.73	0.14	170.50	0.01
D-15	43	Present	5	126.3	1.59	0.83	0.21	93.40	0.74
D-14	40	Present	8b	16707	2.58	1.03	0.20	162.30	0.01
W-13	29	Absent	8b	16707	1.67	0.68	0.17	114.70	0.01
D-29	26	Absent	8a	18621	3.00	0.82	0.15	194.00	0.01
D-36	26	Absent	8a	18621	2.41	0.73	0.15	34.20	0.00
D-31	25	Absent	8a	18621	3.11	1.39	0.25	351.50	0.02
W-21	22	Absent	3	5336	2.26	0.66	0.14	51.09	0.01
D-2	20	Absent	8a	18621	2.94	0.38	0.07	6.00	0.00
W-18	19	Absent	8b	18621	2.22	0.36	0.08	24.30	0.00
W-19	19	Absent	8b	16707	2.14	1.02	0.22	154.60	0.01
W-28	19	Present	8a	18621	2.16	0.23	0.05	10.60	0.00
D-19	19	Absent	8b	21856	2.04	0.64	0.14	101.96	0.00
D-11	18	Absent	8a	18621	3.59	0.55	0.09	44.40	0.00
D-34	18	Absent	8a	18621	2.39	0.84	0.17	97.40	0.01
W-24	16	Present	8a	18621	2.00	0.76	0.17	266.80	0.01
D-17	15	Absent	8b	16707	2.59	0.92	0.18	144.90	0.01
W-23	14	Absent	8a	18621	2.66	0.61	0.12	129.40	0.01
W-25	13	Absent	8a	18621	1.84	0.75	0.18	274.00	0.01
D-21	13	Absent	8b	16707	1.69	1.05	0.26	294.30	0.02
D-41	13	Absent	8a	18621	1.95	0.87	0.20	120.50	0.01
D-43	13	Absent	8a	18621	2.54	0.97	0.19	128.30	0.01
D-37	12	Present	6	5336	3.00	0.41	0.08	15.90	0.00
W-22	11	Absent	8a	18621	2.12	0.78	0.17	238.50	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	2.04	0.83	0.19	**256.60**	0.01
D-5	11	Absent	8a	18621	2.03	0.47	0.11	**97.00**	0.01
D-10	11	Absent	8a	18621	2.16	0.93	0.20	**169.70**	0.01
D-33	11	Present	8a	18621	2.87	0.91	0.17	**101.00**	0.01
D-44	10	Absent	8a	18621	2.45	0.94	0.19	**128.00**	0.01
D-3	8	Absent	8a	16707	1.99	0.72	0.16	**97.61**	0.01
W-7	7	Absent	3	6.50	3.27	0.17	0.03	1.70	0.26
D-9	7	Absent	8a	18621	2.18	0.97	0.21	**311.20**	0.02
D-7	6	Absent	8a	16707	2.22	0.67	0.14	**77.45**	0.00
W-8	5	Absent	3	6.50	2.12	0.68	0.15	**26.91**	**4.14**
D-6	5	Absent	8a	18621	2.08	1.00	0.22	**227.60**	0.01
W-17	4	Absent	8b	16707	1.92	0.90	0.21	**189.90**	0.01
W-3	4	Absent	7	21856	3.66	0.55	0.09	**27.30**	0.00
W-11	4	Absent	8a	18621	1.93	0.77	0.18	**221.10**	0.01
D-42	4	Present	8a	18621	2.55	1.10	0.22	**260.40**	0.01
D-8	3	Absent	8a	18621	2.03	0.99	0.22	**206.00**	0.01
W-26	3	Absent	3	6.50	3.14	0.60	0.11	16.50	**2.54**
W-5	3	Absent	8a	18621	3.09	0.47	0.09	10.20	0.00
D-30	3	Absent	8a	18621	2.42	1.61	0.33	**340.90**	0.02
W-10	1	Absent	8a	18621	1.95	0.59	0.13	**127.10**	0.01
W-9	1	Absent	6	5336.1	1.93	0.68	0.16	11.94	0.00
W-1	1	Absent	5	126.3	4.03	0.26	0.04	6.00	0.05
D-20	0	Absent	8b	16707	1.98	0.99	0.22	**246.80**	0.01
D-32	0	Absent	6	5336	2.30	0.72	0.15	**130.30**	0.02
W-2	0	Absent	5	126.3	3.76	0.34	0.06	10.60	0.08
W-4	0	Absent	6	5336	2.39	0.68	0.14	**47.30**	0.01

Table H-12: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 70,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	2.36	0.80	0.17	58.60	0.00
D-12	264	Absent	8b	16707	2.23	0.81	0.17	124.50	0.01
D-38	257	Present	6	5336	2.49	0.56	0.11	36.60	0.01
D-26	235	Present	8a	18621	2.26	0.62	0.13	38.40	0.00
D-13	225	Present	8b	16707	2.25	0.73	0.16	99.00	0.01
D-27	164	Present	8a	18621	3.12	0.85	0.15	129.80	0.01
D-16	145	Present	8b	16707	2.23	0.77	0.16	118.10	0.01
W-12	100	Absent	8a	18621	3.23	0.46	0.08	19.80	0.00
D-25	98	Present	8a	18621	2.80	1.02	0.19	305.60	0.02
W-27	92	Present	8a	18621	2.55	0.53	0.11	39.30	0.00
W-16	91	Present	8b	16707	1.96	0.37	0.09	26.80	0.00
D-40	85	Present	8a	18621	2.91	1.15	0.22	183.70	0.01
D-22	80	Present	8b	16707	2.60	0.99	0.20	162.10	0.01
D-35	80	Absent	8a	18621	3.42	0.91	0.16	65.40	0.00
D-18	79	Present	8b	16707	2.43	1.25	0.26	269.40	0.02
D-24	78	Present	8a	18621	2.22	0.90	0.19	139.20	0.01
W-14	67	Present	8b	21856	2.01	0.98	0.22	267.78	0.01
W-6	58	Absent	1	6.50	1.85	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	2.52	0.99	0.20	46.25	0.00
D-1	49	Absent	8a	18621	2.02	0.54	0.12	30.50	0.00
W-15	48	Absent	8b	18621	2.34	0.42	0.09	32.97	0.00
W-20	46	Present	6	5336	2.33	0.75	0.16	31.50	0.01
D-28	44	Present	8a	18621	2.80	0.79	0.15	191.00	0.01
D-15	43	Present	5	126.3	1.71	0.92	0.22	110.10	0.87
D-14	40	Present	8b	16707	2.73	1.11	0.22	183.70	0.01
W-13	29	Absent	8b	16707	1.84	0.73	0.17	122.90	0.01
D-29	26	Absent	8a	18621	3.17	0.90	0.16	223.40	0.01
D-36	26	Absent	8a	18621	2.59	0.79	0.16	38.30	0.00
D-31	25	Absent	8a	18621	3.29	1.47	0.26	377.60	0.02
W-21	22	Absent	3	5336	2.43	0.82	0.17	74.69	0.01
D-2	20	Absent	8a	18621	3.13	0.33	0.06	4.50	0.00
W-18	19	Absent	8b	18621	2.37	0.43	0.09	32.40	0.00
W-19	19	Absent	8b	16707	2.29	1.09	0.23	168.70	0.01
W-28	19	Present	8a	18621	2.36	0.21	0.04	8.10	0.00
D-19	19	Absent	8b	21856	2.19	0.73	0.16	126.02	0.01
D-11	18	Absent	8a	18621	3.77	0.60	0.10	52.70	0.00
D-34	18	Absent	8a	18621	2.57	0.91	0.18	111.60	0.01
W-24	16	Present	8a	18621	2.18	0.81	0.18	280.60	0.02
D-17	15	Absent	8b	16707	2.71	1.00	0.19	165.10	0.01
W-23	14	Absent	8a	18621	2.85	0.67	0.13	147.30	0.01
W-25	13	Absent	8a	18621	2.02	0.82	0.18	294.70	0.02
D-21	13	Absent	8b	16707	1.84	1.15	0.27	328.90	0.02
D-41	13	Absent	8a	18621	2.12	0.94	0.21	134.80	0.01
D-43	13	Absent	8a	18621	2.73	1.05	0.20	143.20	0.01
D-37	12	Present	6	5336	3.17	0.51	0.09	24.00	0.00
W-22	11	Absent	8a	18621	2.29	0.85	0.18	261.00	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	2.23	0.93	0.20	**295.00**	0.02
D-5	11	Absent	8a	18621	2.22	0.53	0.11	**115.40**	0.01
D-10	11	Absent	8a	18621	2.35	1.00	0.21	**183.90**	0.01
D-33	11	Present	8a	18621	3.05	0.98	0.18	**113.30**	0.01
D-44	10	Absent	8a	18621	2.64	1.00	0.20	**139.50**	0.01
D-3	8	Absent	8a	16707	2.18	0.64	0.14	**73.50**	0.00
W-7	7	Absent	3	6.50	3.49	0.19	0.03	2.10	0.32
D-9	7	Absent	8a	18621	2.37	1.02	0.21	**319.30**	0.02
D-7	6	Absent	8a	16707	2.40	0.71	0.15	**82.59**	0.00
W-8	5	Absent	3	6.50	2.35	0.86	0.18	**41.15**	**6.33**
D-6	5	Absent	8a	18621	2.27	1.05	0.22	**232.70**	0.01
W-17	4	Absent	8b	16707	2.07	0.97	0.22	**209.20**	0.01
W-3	4	Absent	7	21856	3.85	0.58	0.10	**30.60**	0.00
W-11	4	Absent	8a	18621	2.13	0.82	0.18	**229.70**	0.01
D-42	4	Present	8a	18621	2.73	1.15	0.22	**274.60**	0.01
D-8	3	Absent	8a	18621	2.22	1.06	0.23	**221.70**	0.01
W-26	3	Absent	3	6.50	3.34	0.69	0.12	**21.30**	**3.28**
W-5	3	Absent	8a	18621	3.28	0.50	0.09	11.30	0.00
D-30	3	Absent	8a	18621	2.60	1.71	0.34	**369.20**	0.02
W-10	1	Absent	8a	18621	2.14	0.65	0.14	**141.80**	0.01
W-9	1	Absent	6	5336.1	2.13	0.71	0.16	12.91	0.00
W-1	1	Absent	5	126.3	4.22	0.31	0.05	8.20	0.06
D-20	0	Absent	8b	16707	2.13	1.08	0.24	**277.60**	0.02
D-32	0	Absent	6	5336	2.49	0.76	0.15	**137.60**	0.03
W-2	0	Absent	5	126.3	3.96	0.38	0.06	12.80	0.10
W-4	0	Absent	6	5336	2.58	0.76	0.15	**56.30**	0.01

Table H-13: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 80,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	2.51	0.85	0.17	64.60	0.00
D-12	264	Absent	8b	16707	2.39	0.86	0.18	134.40	0.01
D-38	257	Present	6	5336	2.65	0.65	0.13	47.50	0.01
D-26	235	Present	8a	18621	2.41	0.67	0.14	43.10	0.00
D-13	225	Present	8b	16707	2.40	0.83	0.17	123.60	0.01
D-27	164	Present	8a	18621	3.28	0.92	0.16	148.50	0.01
D-16	145	Present	8b	16707	2.35	0.83	0.17	134.40	0.01
W-12	100	Absent	8a	18621	3.41	0.53	0.09	25.10	0.00
D-25	98	Present	8a	18621	2.95	1.09	0.20	332.50	0.02
W-27	92	Present	8a	18621	2.73	0.56	0.11	43.20	0.00
W-16	91	Present	8b	16707	2.06	0.50	0.11	47.30	0.00
D-40	85	Present	8a	18621	3.08	1.22	0.22	198.70	0.01
D-22	80	Present	8b	16707	2.75	1.06	0.20	178.10	0.01
D-35	80	Absent	8a	18621	3.59	0.98	0.16	73.80	0.00
D-18	79	Present	8b	16707	2.53	1.36	0.27	310.90	0.02
D-24	78	Present	8a	18621	2.37	0.96	0.20	151.40	0.01
W-14	67	Present	8b	21856	2.16	1.03	0.22	279.90	0.01
W-6	58	Absent	1	6.50	2.04	0.00	0.00	0.00	0.00
D-39	57	Present	7	21856	2.67	1.09	0.21	54.25	0.00
D-1	49	Absent	8a	18621	2.20	0.57	0.12	32.40	0.00
W-15	48	Absent	8b	18621	2.48	0.50	0.10	43.34	0.00
W-20	46	Present	6	5336	2.50	1.00	0.20	55.40	0.01
D-28	44	Present	8a	18621	2.96	0.86	0.16	211.50	0.01
D-15	43	Present	5	126.3	1.82	1.00	0.24	126.70	1.00
D-14	40	Present	8b	16707	2.87	1.19	0.22	204.10	0.01
W-13	29	Absent	8b	16707	1.99	0.77	0.17	128.00	0.01
D-29	26	Absent	8a	18621	3.32	0.97	0.17	251.50	0.01
D-36	26	Absent	8a	18621	2.76	0.84	0.16	42.30	0.00
D-31	25	Absent	8a	18621	3.46	1.54	0.26	400.70	0.02
W-21	22	Absent	3	5336	2.59	0.99	0.20	104.98	0.02
D-2	20	Absent	8a	18621	3.31	0.37	0.07	5.50	0.00
W-18	19	Absent	8b	18621	2.52	0.50	0.10	42.17	0.00
W-19	19	Absent	8b	16707	2.44	1.15	0.24	180.70	0.01
W-28	19	Present	8a	18621	2.53	0.16	0.03	4.40	0.00
D-19	19	Absent	8b	21856	2.32	0.82	0.17	151.66	0.01
D-11	18	Absent	8a	18621	3.95	0.66	0.11	61.00	0.00
D-34	18	Absent	8a	18621	2.74	0.99	0.19	125.60	0.01
W-24	16	Present	8a	18621	2.34	0.85	0.18	286.20	0.02
D-17	15	Absent	8b	16707	2.83	1.07	0.20	183.10	0.01
W-23	14	Absent	8a	18621	3.02	0.72	0.13	165.40	0.01
W-25	13	Absent	8a	18621	2.18	0.88	0.19	311.60	0.02
D-21	13	Absent	8b	16707	1.98	1.24	0.28	362.00	0.02
D-41	13	Absent	8a	18621	2.29	1.01	0.21	148.70	0.01
D-43	13	Absent	8a	18621	2.91	1.12	0.21	157.30	0.01
D-37	12	Present	6	5336	3.32	0.62	0.11	34.30	0.01
W-22	11	Absent	8a	18621	2.46	0.92	0.19	284.20	0.02

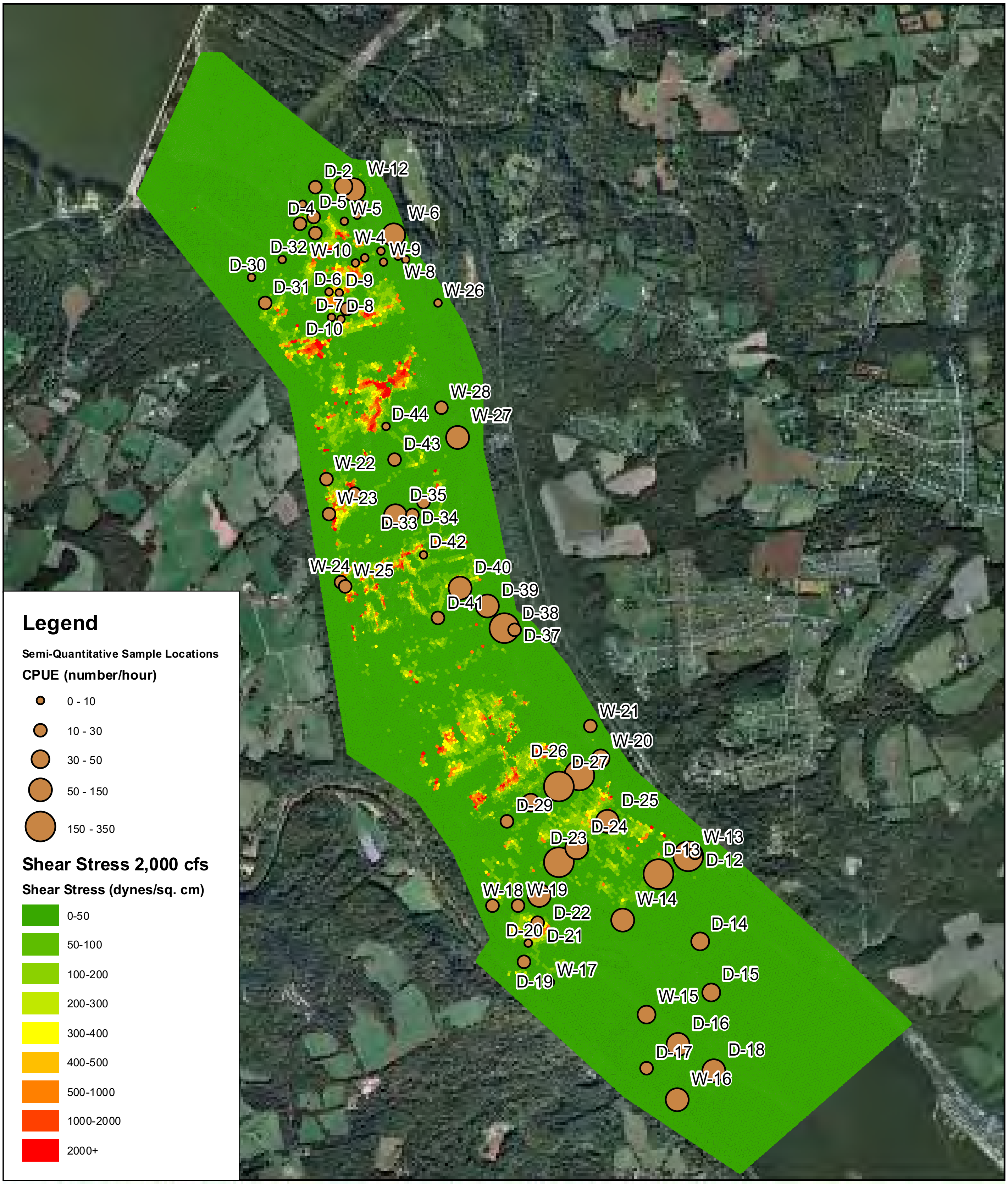
Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-4	11	Absent	8a	18621	2.40	1.02	0.21	**330.00**	0.02
D-5	11	Absent	8a	18621	2.40	0.59	0.12	**131.60**	0.01
D-10	11	Absent	8a	18621	2.53	1.06	0.21	**197.10**	0.01
D-33	11	Present	8a	18621	3.22	1.05	0.19	**125.60**	0.01
D-44	10	Absent	8a	18621	2.82	1.06	0.20	**150.40**	0.01
D-3	8	Absent	8a	16707	2.36	0.55	0.11	**51.09**	0.00
W-7	7	Absent	3	6.50	3.68	0.21	0.03	2.40	0.37
D-9	7	Absent	8a	18621	2.55	1.06	0.21	**325.70**	0.02
D-7	6	Absent	8a	16707	2.58	0.77	0.15	**92.78**	0.01
W-8	5	Absent	3	6.50	2.54	1.03	0.21	**56.75**	**8.73**
D-6	5	Absent	8a	18621	2.45	1.09	0.22	**237.90**	0.01
W-17	4	Absent	8b	16707	2.21	1.04	0.22	**230.00**	0.01
W-3	4	Absent	7	21856	4.03	0.62	0.10	**33.50**	0.00
W-11	4	Absent	8a	18621	2.31	0.87	0.18	**237.00**	0.01
D-42	4	Present	8a	18621	2.89	1.21	0.23	**288.20**	0.02
D-8	3	Absent	8a	18621	2.40	1.13	0.23	**237.90**	0.01
W-26	3	Absent	3	6.50	3.53	0.76	0.13	**25.20**	**3.88**
W-5	3	Absent	8a	18621	3.45	0.53	0.09	12.70	0.00
D-30	3	Absent	8a	18621	2.77	1.80	0.35	**393.60**	0.02
W-10	1	Absent	8a	18621	2.32	0.71	0.15	**157.60**	0.01
W-9	1	Absent	6	5336.1	2.31	0.76	0.16	14.30	0.00
W-1	1	Absent	5	126.3	4.40	0.35	0.05	10.40	0.08
D-20	0	Absent	8b	16707	2.27	1.16	0.25	**308.10**	0.02
D-32	0	Absent	6	5336	2.66	0.80	0.16	**143.50**	0.03
W-2	0	Absent	5	126.3	4.13	0.41	0.06	14.60	0.12
W-4	0	Absent	6	5336	2.76	0.85	0.16	**68.20**	0.01

Table H-14: Hydraulic Parameters at Semi-Quantitative Mussel Sampling Locations for 86,000 cfs. Orange Numbers Indicate Low Flow Threshold Exceedences (20 dynes/cm^2), While Red Numbers Indicate High Flow Threshold Exceedences (150 dynes/cm^2)

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
D-23	318	Present	8b	16707	2.59	0.88	0.18	68.00	0.00
D-12	264	Absent	8b	16707	2.47	0.89	0.18	140.40	0.01
D-38	257	Present	6	5336	2.74	0.69	0.13	53.80	0.01
D-26	235	Present	8a	18621	2.50	0.69	0.14	46.00	0.00
D-13	225	Present	8b	16707	2.49	0.89	0.18	137.60	0.01
D-27	164	Present	8a	18621	3.36	0.97	0.17	159.80	0.01
D-16	145	Present	8b	16707	2.42	0.87	0.18	143.50	0.01
W-12	100	Absent	8a	18621	3.51	0.57	0.10	28.30	0.00
D-25	98	Present	8a	18621	3.04	1.13	0.21	347.80	0.02
W-27	92	Present	8a	18621	2.83	0.59	0.11	46.40	0.00
W-16	91	Present	8b	16707	2.11	0.59	0.13	64.50	0.00
D-40	85	Present	8a	18621	3.17	1.25	0.22	207.50	0.01
D-22	80	Present	8b	16707	2.84	1.10	0.21	187.20	0.01
D-35	80	Absent	8a	18621	3.69	1.01	0.17	78.90	0.00
D-18	79	Present	8b	16707	2.58	1.42	0.28	333.60	0.02
D-24	78	Present	8a	18621	2.46	0.99	0.20	158.80	0.01
W-14	67	Present	8b	21856	2.25	1.06	0.22	282.55	0.01
W-6	58	Absent	1	6.50	2.15	0.01	0.00	0.00	0.00
D-39	57	Present	7	21856	2.77	1.14	0.22	58.56	0.00
D-1	49	Absent	8a	18621	2.30	0.59	0.12	33.70	0.00
W-15	48	Absent	8b	18621	2.55	0.57	0.11	55.57	0.00
W-20	46	Present	6	5336	2.59	1.18	0.23	75.40	0.01
D-28	44	Present	8a	18621	3.05	0.89	0.16	223.20	0.01
D-15	43	Present	5	126.3	1.89	1.05	0.24	137.40	1.09
D-14	40	Present	8b	16707	2.95	1.24	0.23	216.10	0.01
W-13	29	Absent	8b	16707	2.08	0.79	0.17	130.30	0.01
D-29	26	Absent	8a	18621	3.41	1.02	0.18	267.80	0.01
D-36	26	Absent	8a	18621	2.86	0.87	0.16	44.90	0.00
D-31	25	Absent	8a	18621	3.56	1.58	0.27	413.50	0.02
W-21	22	Absent	3	5336	2.68	1.09	0.21	124.91	0.02
D-2	20	Absent	8a	18621	3.42	0.42	0.07	6.90	0.00
W-18	19	Absent	8b	18621	2.61	0.54	0.11	48.16	0.00
W-19	19	Absent	8b	16707	2.52	1.19	0.24	187.40	0.01
W-28	19	Present	8a	18621	2.63	0.12	0.02	2.30	0.00
D-19	19	Absent	8b	21856	2.40	0.87	0.18	167.15	0.01
D-11	18	Absent	8a	18621	4.05	0.69	0.11	66.20	0.00
D-34	18	Absent	8a	18621	2.84	1.03	0.20	133.70	0.01
W-24	16	Present	8a	18621	2.44	0.87	0.18	288.20	0.02
D-17	15	Absent	8b	16707	2.90	1.10	0.21	193.20	0.01
W-23	14	Absent	8a	18621	3.11	0.76	0.14	175.70	0.01
W-25	13	Absent	8a	18621	2.28	0.91	0.19	320.70	0.02
D-21	13	Absent	8b	16707	2.06	1.29	0.29	380.70	0.02
D-41	13	Absent	8a	18621	2.38	1.05	0.22	156.60	0.01
D-43	13	Absent	8a	18621	3.01	1.15	0.21	165.40	0.01
D-37	12	Present	6	5336	3.41	0.68	0.12	41.20	0.01

Station	Catch Per Unit Effort (number/hour)	Alewife Floater	Substrate	Critical Shear Stress (dynes/cm^2)	Depth (ft)	Water Velocity (ft/s)	Froude Number	Shear Stress (dynes/cm2)	Relative Shear Stress
W-22	11	Absent	8a	18621	2.56	0.96	0.19	298.80	0.02
D-4	11	Absent	8a	18621	2.51	1.07	0.22	349.30	0.02
D-5	11	Absent	8a	18621	2.50	0.63	0.13	140.20	0.01
D-10	11	Absent	8a	18621	2.64	1.10	0.22	204.60	0.01
D-33	11	Present	8a	18621	3.32	1.08	0.19	132.80	0.01
D-44	10	Absent	8a	18621	2.92	1.09	0.20	157.10	0.01
D-3	8	Absent	8a	16707	2.46	0.53	0.11	46.39	0.00
W-7	7	Absent	3	6.50	3.80	0.22	0.04	2.70	0.42
D-9	7	Absent	8a	18621	2.65	1.08	0.21	329.60	0.02
D-7	6	Absent	8a	16707	2.68	0.81	0.16	101.36	0.01
W-8	5	Absent	3	6.50	2.65	1.09	0.21	63.19	9.72
D-6	5	Absent	8a	18621	2.55	1.11	0.22	240.90	0.01
W-17	4	Absent	8b	16707	2.29	1.08	0.23	243.10	0.01
W-3	4	Absent	7	21856	4.13	0.64	0.10	35.20	0.00
W-11	4	Absent	8a	18621	2.41	0.89	0.18	241.30	0.01
D-42	4	Present	8a	18621	2.99	1.24	0.23	296.40	0.02
D-8	3	Absent	8a	18621	2.50	1.17	0.24	248.40	0.01
W-26	3	Absent	3	6.50	3.64	0.79	0.13	27.40	4.22
W-5	3	Absent	8a	18621	3.55	0.55	0.09	13.60	0.00
D-30	3	Absent	8a	18621	2.86	1.85	0.35	407.00	0.02
W-10	1	Absent	8a	18621	2.42	0.74	0.15	166.10	0.01
W-9	1	Absent	6	5336.1	2.42	0.79	0.16	15.37	0.00
W-1	1	Absent	5	126.3	4.51	0.37	0.06	11.50	0.09
D-20	0	Absent	8b	16707	2.34	1.21	0.25	326.40	0.02
D-32	0	Absent	6	5336	2.76	0.82	0.16	146.30	0.03
W-2	0	Absent	5	126.3	4.24	0.42	0.07	15.50	0.12
W-4	0	Absent	6	5336	2.87	0.90	0.17	75.20	0.01

APPENDIX I-SHEAR STRESS MAPS PLOTTED WITH SEMI-QUANTITATIVE MUSSEL SURVEY LOCATIONS



N

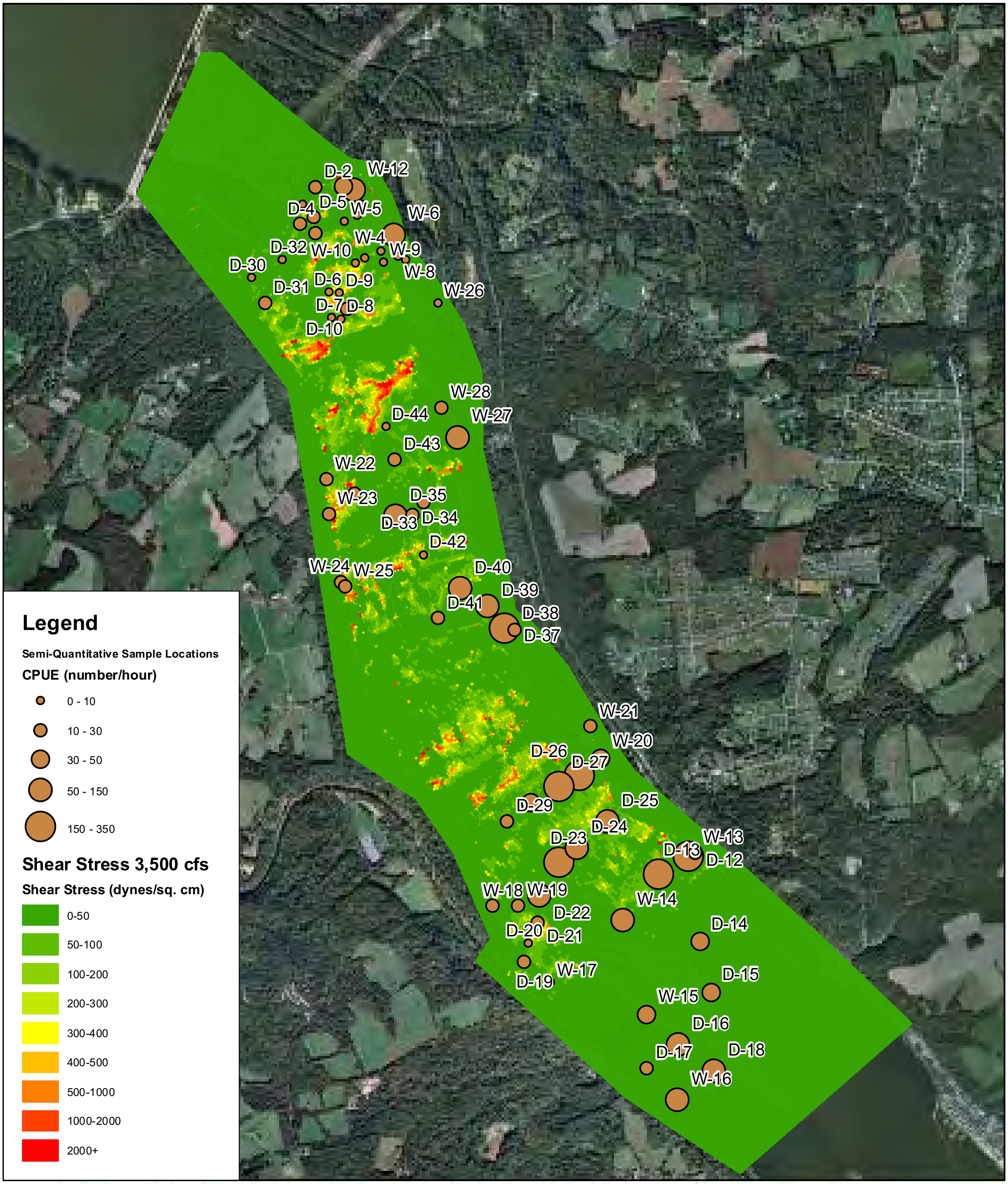
1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure I-1
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 2,000 cfs.



Exelon.

N

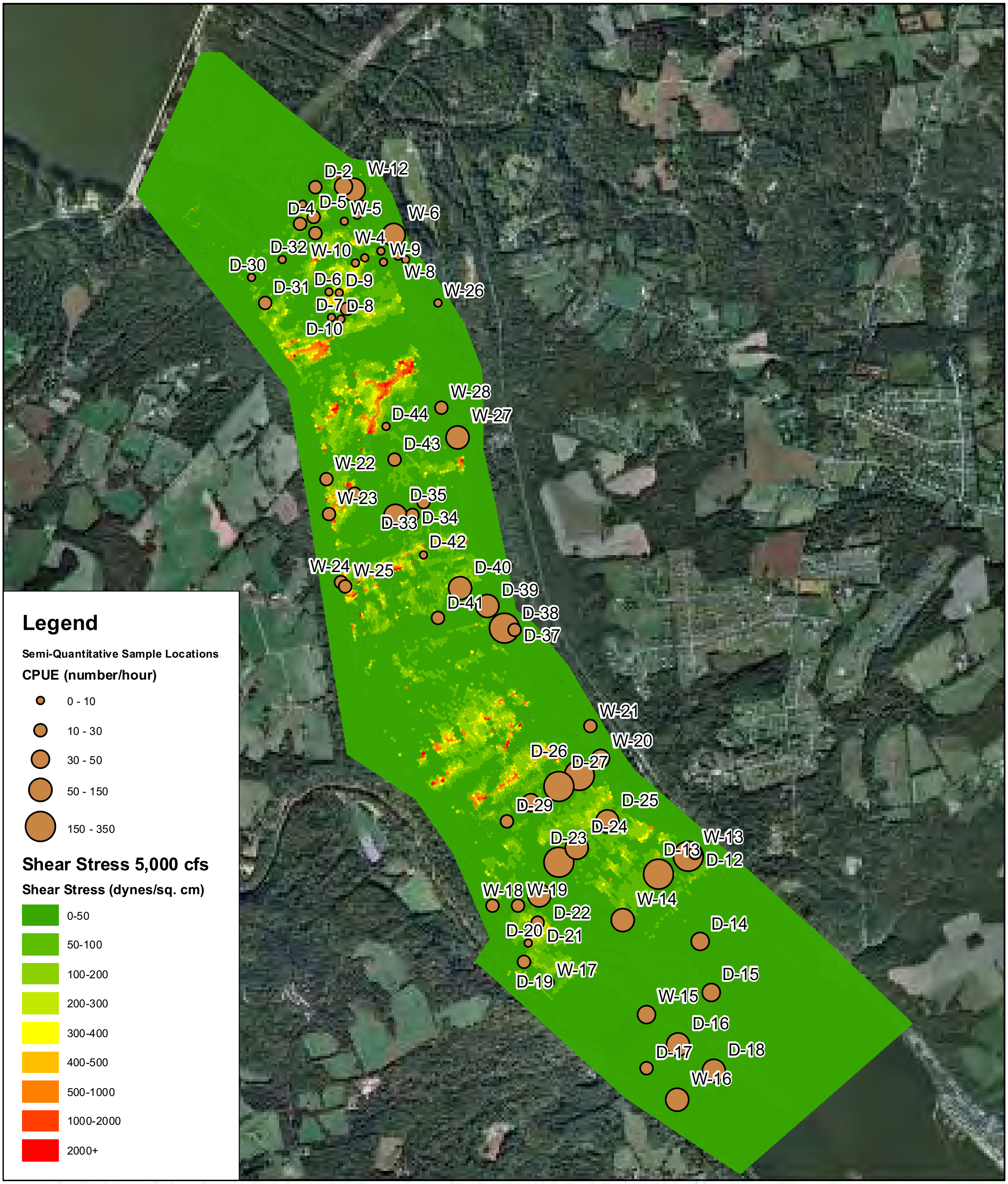
1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure I-2
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 3,500 cfs.



N

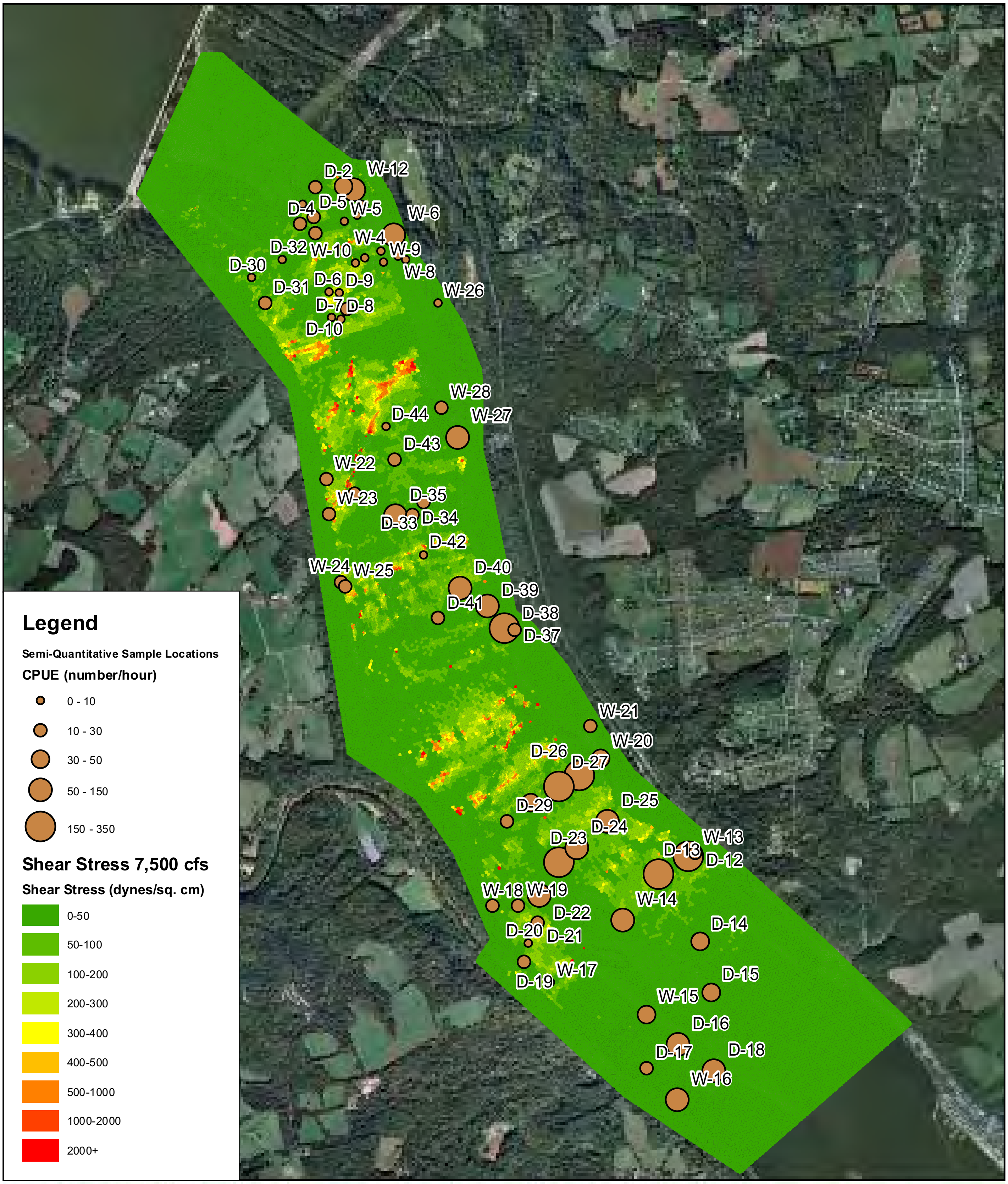
1 inch = 0.52 miles

0 | 1,900 | 3,800 | 7,600 | 11,400 Feet

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure I-3
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 5,000 cfs.



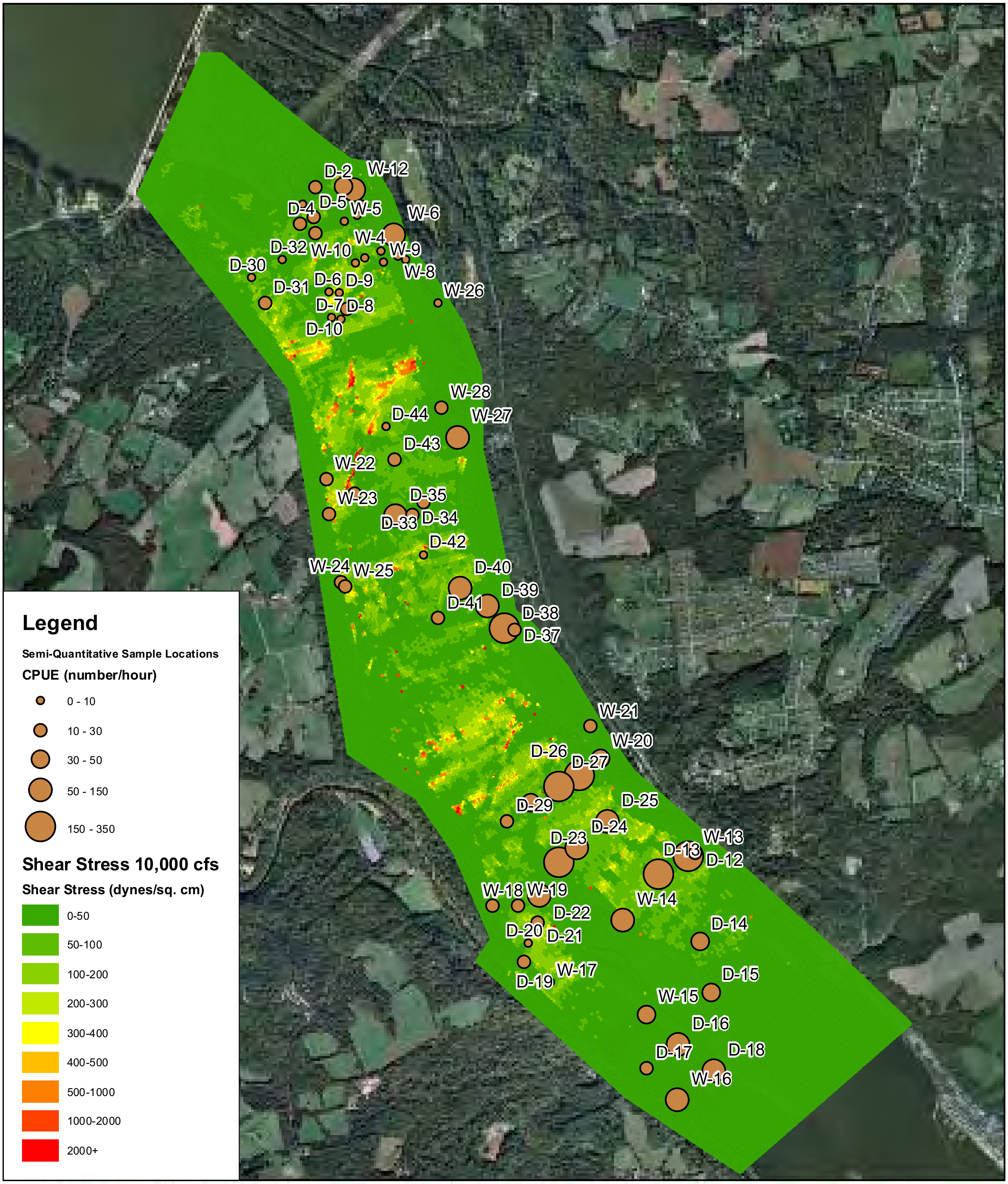
N

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

EXELON GENERATION COMPANY, LLC
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure I-4
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 7,500 cfs.



Exelon.

N

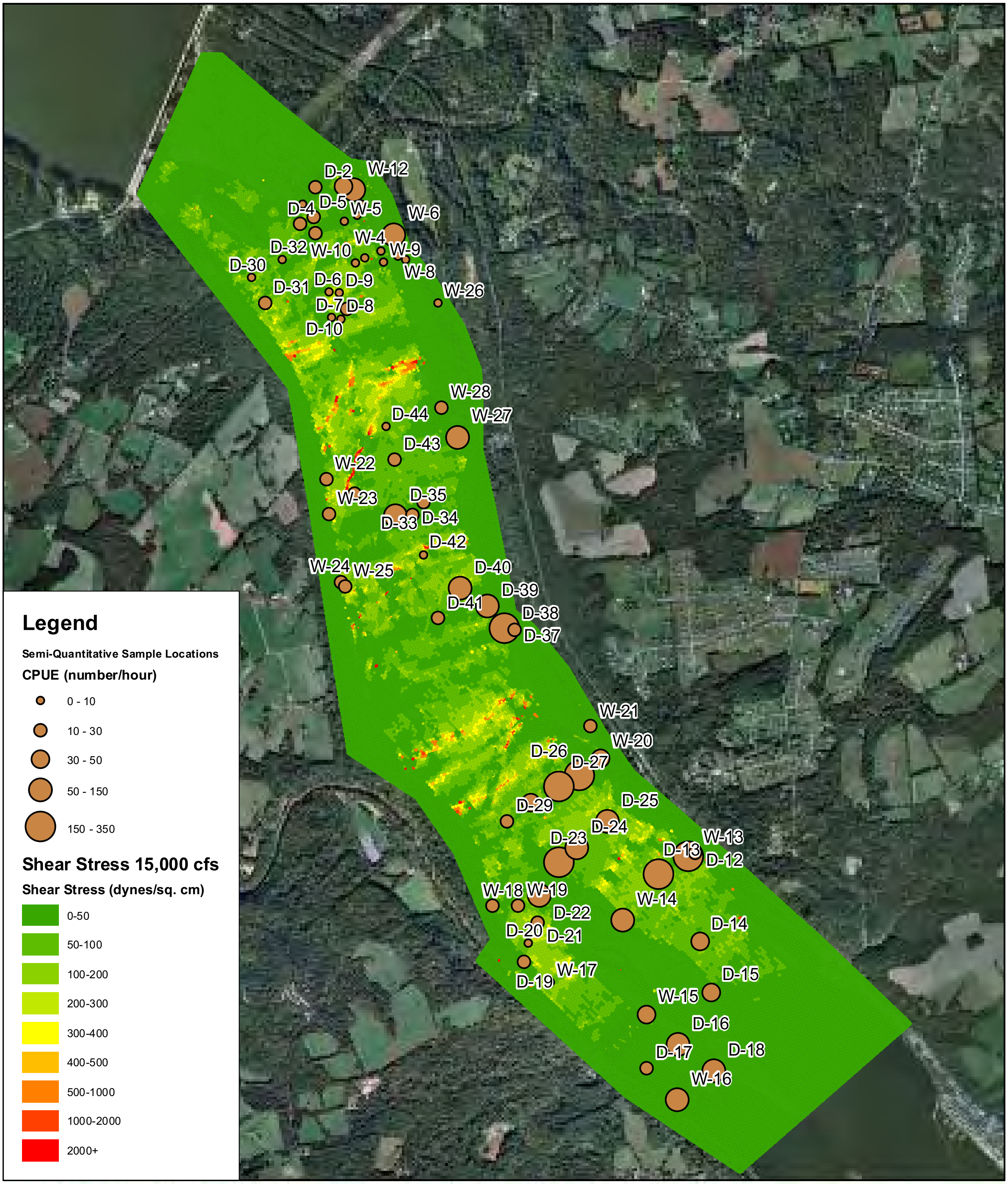
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

Figure I-5
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 10,000 cfs.



N

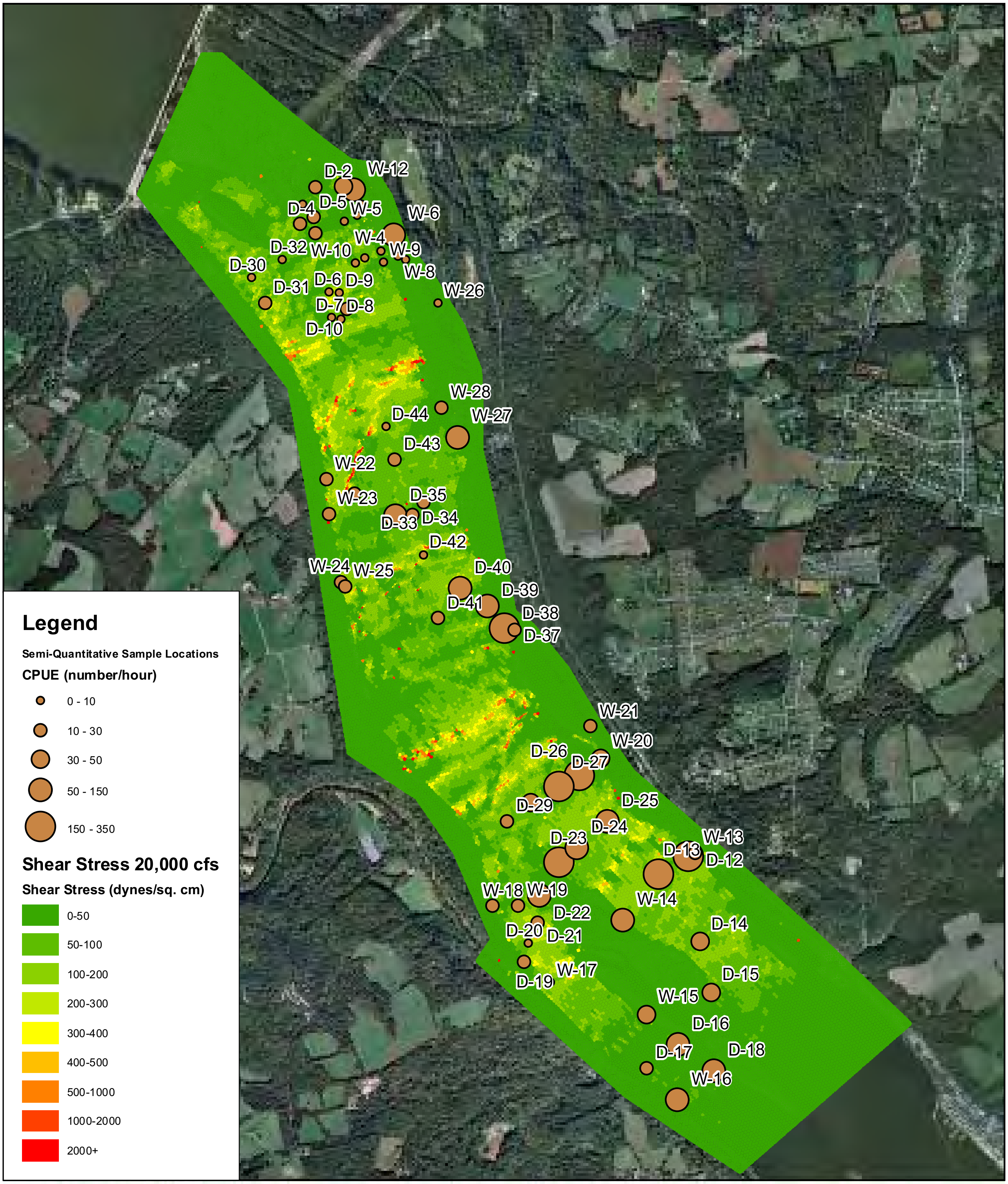
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

Figure I-6
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 15,000 cfs.



N

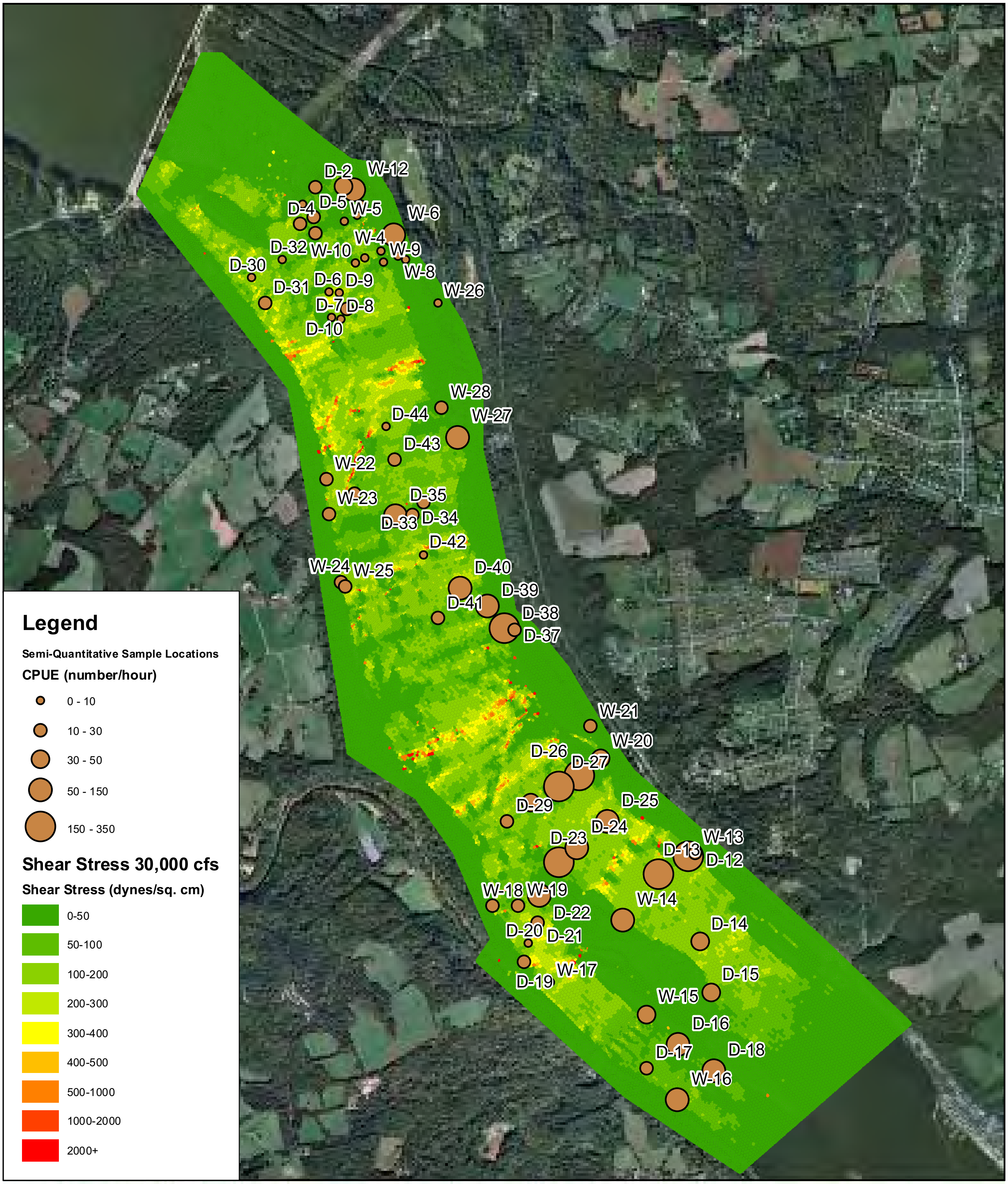
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

Figure I-7
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 20,000 cfs.



Exelon.

N

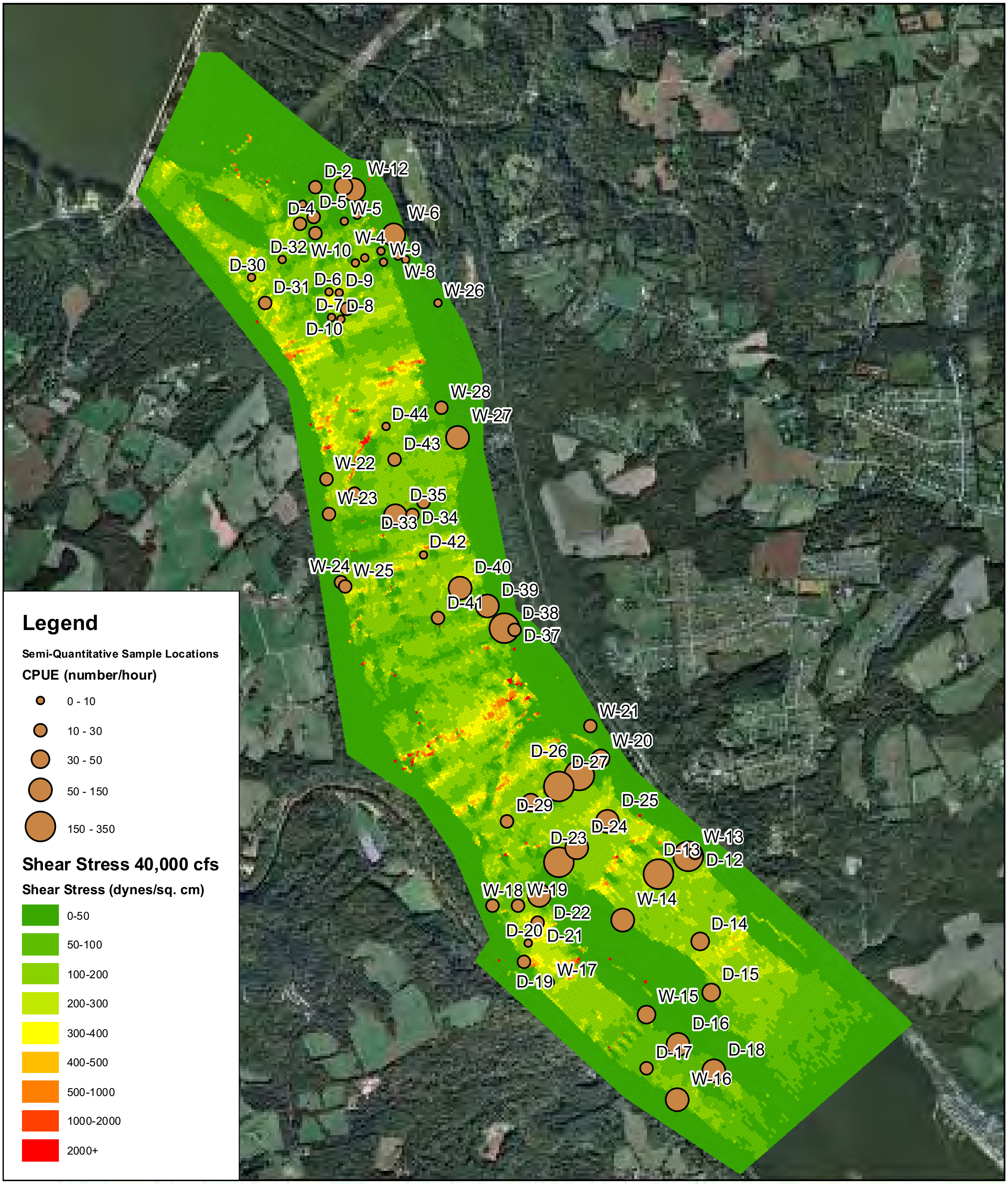
1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure I-8
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 30,000 cfs.



Exelon.

N

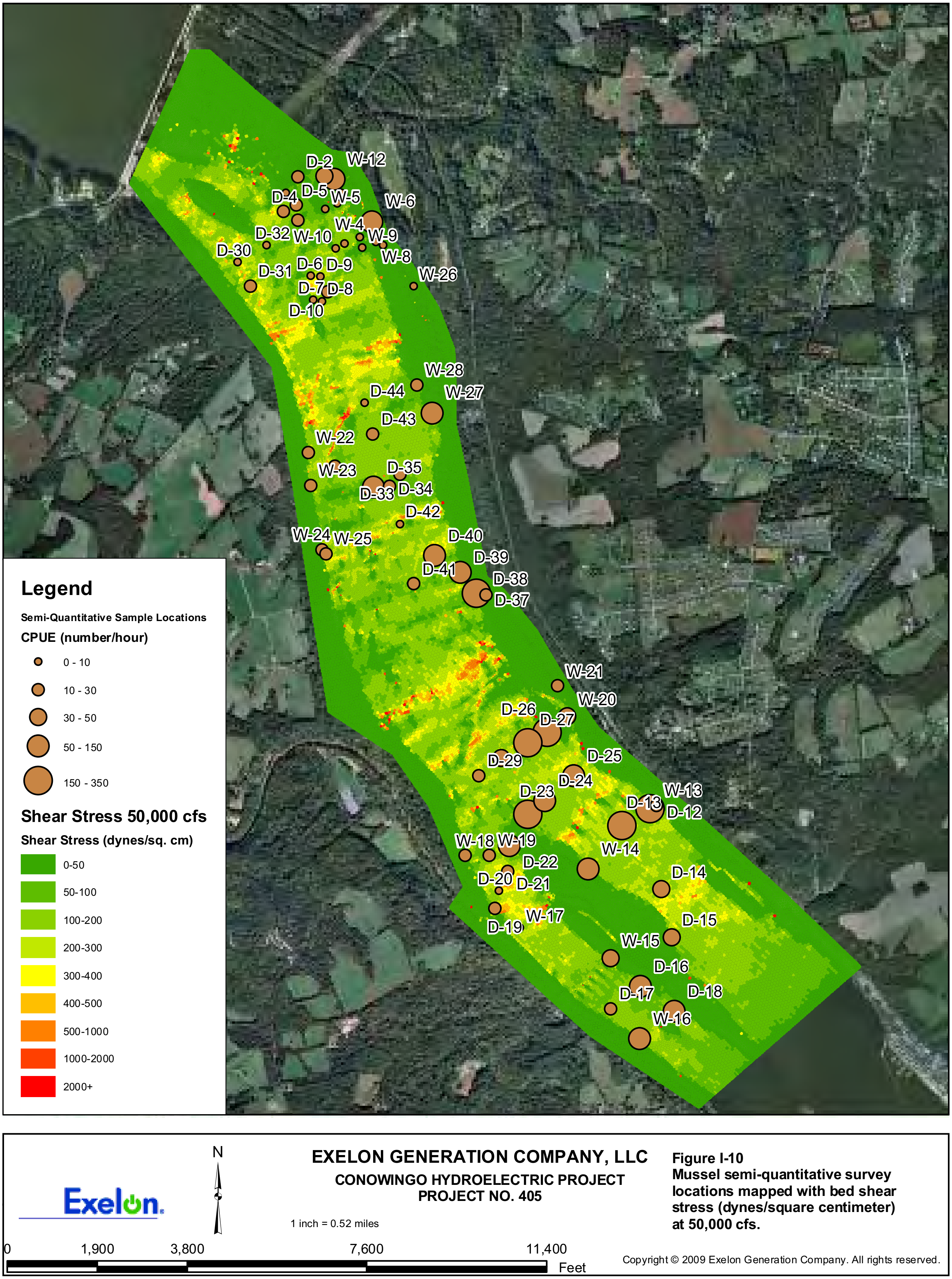
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

Figure I-9
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 40,000 cfs.

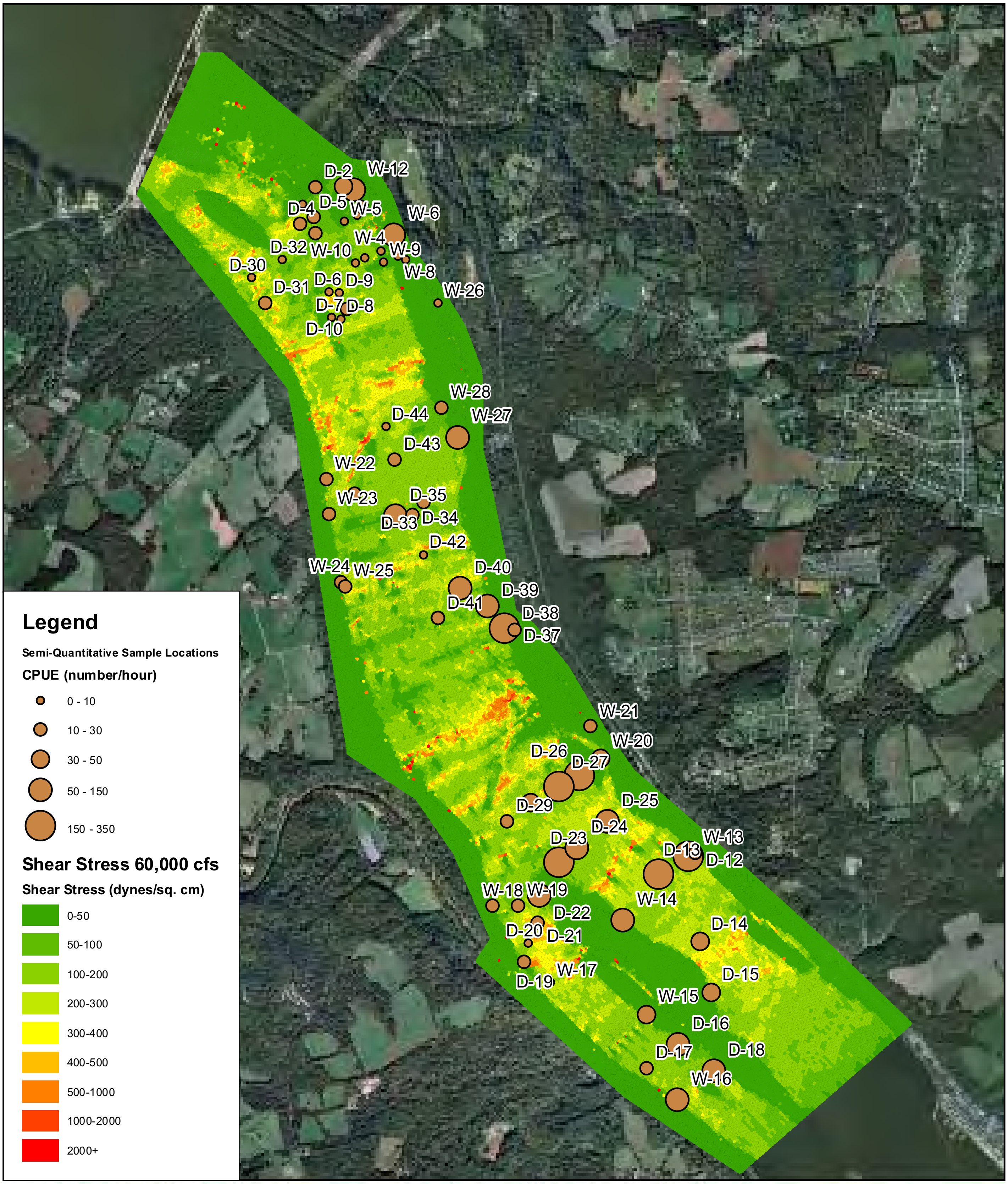


Exelon.

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure I-10
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 50,000 cfs.



N

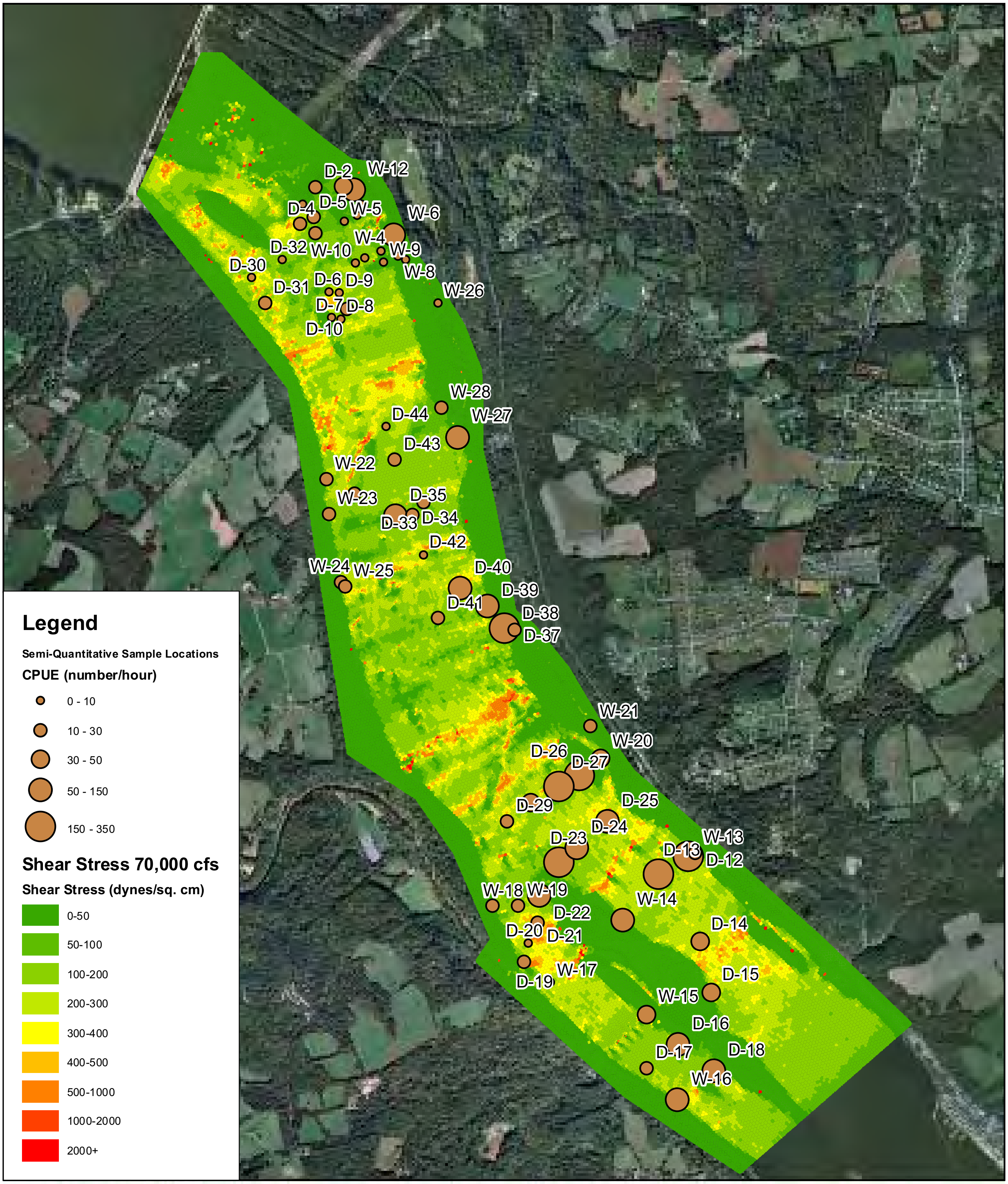
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

Figure I-11
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 60,000 cfs.



Exelon.

N

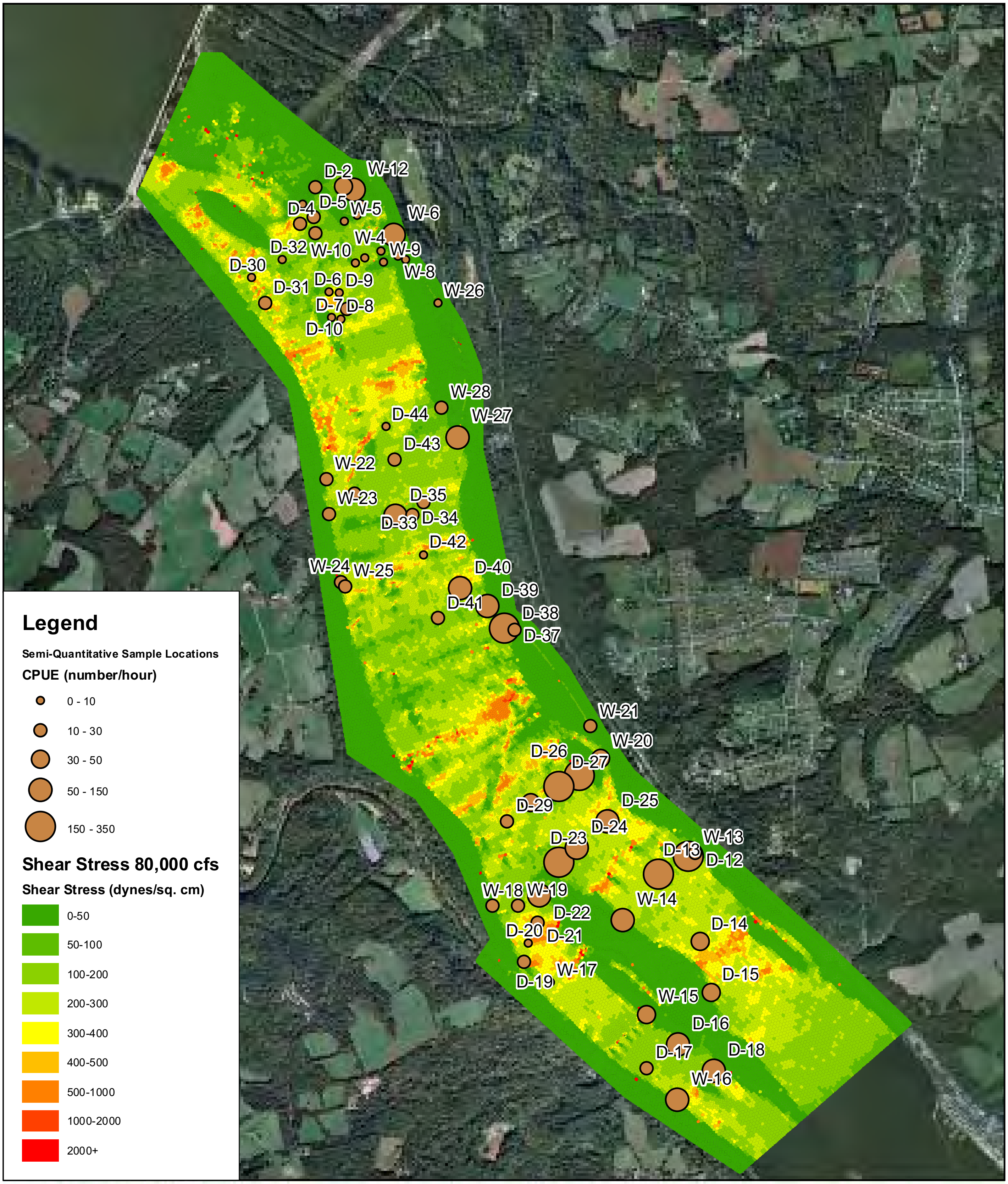
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

Figure I-12
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 70,000 cfs.



Exelon.

N

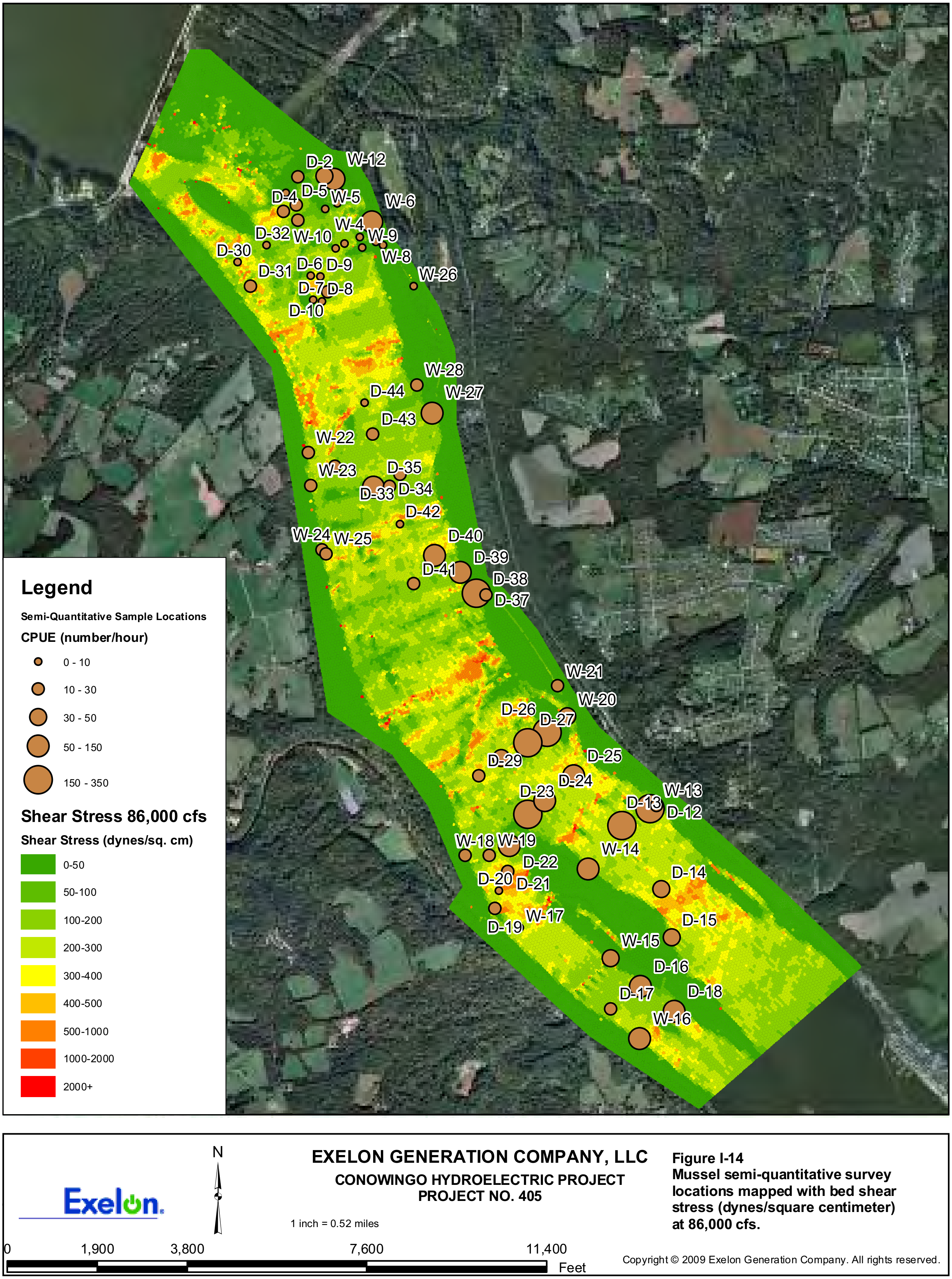
EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

1 inch = 0.52 miles

0 1,900 3,800 7,600 11,400 Feet

Figure I-13
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 80,000 cfs.



Exelon.

EXELON GENERATION COMPANY, LLC

CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure I-14
Mussel semi-quantitative survey locations mapped with bed shear stress (dynes/square centimeter) at 86,000 cfs.

INSTREAM FLOW HABITAT ASSESSMENT BELOW CONOWINGO DAM

RSP 3.16

ADDENDUM-HABITAT TIME SERIES REPORT

CONOWINGO HYDROELECTRIC PROJECT
FERC PROJECT NUMBER 405

Prepared for:

Exelon

Prepared by:

Gomez and Sullivan Engineers, P.C.

January 2012

EXECUTIVE SUMMARY

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project (Conowingo Project). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. FERC issued the final study plan determination for the Conowingo Project on February 4, 2010, approving the revised study plan with certain modifications.

The final study plan determination required Exelon to conduct an Instream Flow Assessment below Conowingo Dam. The study's revised study plan (RSP) methodology specified several tasks. One of the tasks was to complete a habitat time series analysis as part of Conowingo RSP 3.16: Instream Flow Habitat Assessment below Conowingo Dam (C3.16). The goal of the habitat time series analysis was to merge the habitat versus flow relationship developed in C3.16 with the hourly operations model data developed in Conowingo RSP 3.11: Hydrologic Study of the Lower Susquehanna River (C3.11), which was provided in an addendum to the 3.11 study report titled "Operations Modeling Baseline Report." The purpose of this addendum is to provide the results of the habitat time series analysis below Conowingo Dam.

The habitat time series analyses translated the Baseline model run's hourly Conowingo Dam outflow time series (Jan 1930 – Dec 2007) into twenty-three individual habitat time series – one time series for each species/life stage investigated in the Conowingo 3.16 study report.

The analyses were compiled into monthly and seasonal periods, with only mobile species defined as potentially present in the stakeholder-derived periodicity table shown for each month/season. Species-by-species habitat duration graphs are the primary reported output. Additionally, commentary and explanatory time series plots showing habitat changes over time are presented. These results will be used as a common frame of reference to compare all alternative operating scenarios examined with the operations model.

Statistics similar to those presented in this report will be generated as alternative operating scenarios are developed by Exelon in consultation with stakeholders. Those results will then be compared on a relative basis to these "Baseline" run results.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

FERC	Federal Energy Regulatory Commission
ILP	Integrated Licensing Process
ISR	Initial Study Report
MW	Megawatt
NGO	Non-Government Organization
NOI	Notice of Intent
OASIS	Operational Analysis and Simulation of Integrated Systems
PAD	Pre-Application Document
PSP	Proposed Study Plan
RSP	Revised Study Plan
USGS	United States Geological Survey
WSE	Water Surface Elevation
WUA	Weighted Usable Area
WY	Water Year

1. INTRODUCTION

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt (MW) Conowingo Hydroelectric Project (Project). Exelon is applying for a new license using the FERC's Integrated Licensing Process (ILP). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014.

Exelon filed its Pre-Application Document (PAD) and Notice of Intent with FERC on March 12, 2009. On June 11 and 12, 2009, a site visit and two scoping meetings were held at the Project for resource agencies and interested members of the public. Following these meetings, formal study requests were filed with FERC by several resource agencies. Many of these study requests were included in Exelon's Proposed Study Plan (PSP), which was filed on August 24, 2009. On September 22 and 23, 2009, Exelon held a meeting with resource agencies and interested members of the public to discuss the PSP.

Formal comments on the PSP were filed with FERC on November 22, 2009 by Commission staff, and several resource agencies. Exelon filed a Revised Study Plan (RSP) for the Project on December 22, 2009. FERC issued the final study plan determination for the Project on February 4, 2010, approving the RSP with certain modifications.

The final study plan determination required Exelon to conduct an Instream Flow Assessment below Conowingo Dam. The study's RSP methodology specified several tasks. One of the tasks was to complete a habitat time series analysis, as part of Conowingo study 3.16: Instream Flow Habitat Assessment below Conowingo Dam (C3.16). The goal of the habitat time series analysis was to merge the habitat versus flow relationship developed in C3.16 with the hourly operations model data developed in Conowingo study 3.11: Hydrologic Study of the Lower Susquehanna River (C3.11), which was provided in an addendum to the 3.11 study report titled "Operations Modeling Baseline Report." The purpose of this addendum to the Conowingo 3.16 report is to provide the results of the habitat time series analysis below Conowingo Dam.

2. BACKGROUND

This addendum combines the results of two studies: Conowingo Study 3.16: Instream Flow Habitat Assessment below Conowingo Dam; and the Conowingo Study 3.11: Hydrologic Study of the Lower Susquehanna River addendum titled "Operations Modeling Baseline Report." Detailed background and analysis of both studies' results are described in the previously mentioned study reports. However, this section will briefly review study results relevant to the habitat time series analysis, which is the subject of this report.

2.1 Habitat versus Flow Relationships

The Conowingo Study 3.16: Instream Flow Habitat Assessment below Conowingo Dam report presented 23 unique habitat versus flow relationships for several species and lifestages of special concern[1], three macroinvertebrate species (Ephemeroptera [Mayfly], Plecoptera [Stonefly], Trichoptera [Caddisfly]) and four "habitat guilds" (shallow-slow, shallow-fast, deep-slow, deep-fast). Table 2.1-1 lists the monthly periodicity of each target species and life stage. Table 2.1-2 provides each species and life stages' available habitat, as predicted by a hydraulic/habitat model, for a range of flows. Appendix A shows the modeled habitat versus flow curves.

2.2 OASIS Operations Model Results

Exelon developed an operations model to better understand how operational changes at the lower Susquehanna River's four hydroelectric facilities affect the timing of river flows and energy generation. The model calibration procedure involved adjusting several model parameters and constraints to match historic (2004-2007) Project data (flow, stage, generation), and then using the parameters and constraints from the final calibrated model to predict Project operations over a longer-term period (1930-2007) to establish a "Baseline" model. The Baseline model will serve as a basis of comparison to analyze alternative hydropower operation scenarios, developed in consultation with stakeholders, in the future.

The operations model's details and computational methods were described in an addendum to Conowingo Study Report 3.11 and Muddy Run Study Report 3.2, titled "Operations Modeling Calibration Report", while the Baseline model's details and results were summarized in an addendum to Conowingo Study Report 3.11 and Muddy Run Study Report 3.2 titled "Operations Modeling Baseline Report."

[1] Analyses conducted reflect the updated juvenile American shad habitat suitability criteria discussed at the September 2011 relicensing meeting.

The model takes into account each Project's (Safe Harbor, Holtwood, Muddy Run, and Conowingo) engineering data and operational constraints, such as Conowingo's minimum flow requirement (Table 2.2-1). The Baseline production run was simulated using hydrologic data from Jan 1930 through Dec 2007[2]. All other production runs with be simulated over this same period.

[2] The Baseline production run contains information to run from Jan 1930 through March 2008, but in order to prevent partial-year records skewing any month-by-month analyses, analyses are limited to Jan 1930 – Dec 2007.

3. METHODS

This analysis followed the habitat time series methodology described in Bovee et al. (1998). A habitat time series analysis uses habitat/weighted usable area (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 a habitat time series requires 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 value from the habitat versus discharge relationship. Thus, the habitat time series was produced by translating hourly discharges from the Conowingo Project into associated WUA values and recording the translated values back to the hourly time step. The translation process is shown in Figure 3-1.

The habitat versus discharge relationships for all target species and life stages analyzed in the Conowingo Study 3.16: Instream Flow Habitat Assessment below Conowingo Dam report were merged with the hourly operations model hydrology data reported in the Conowingo Study 3.11 addendum titled "Operations Modeling Baseline Report" to yield habitat time series. Select habitat time series plots (WUA versus time) are presented for each species, along with explanatory text for each species/life stage.

The aggregated habitat time series were presented in the form of monthly habitat duration curves for all target species and life stages. Using habitat time series duration curves allows habitat to be depicted over time for the entire analysis period. Additionally, the percent of time the study reach was at or above habitat thresholds from the Conowingo RSP 3.16 study (Table 3-1) report were computed. The habitat time series results may be used to compare alternative flow management scenarios.

4. RESULTS AND DISCUSSION

The habitat time series analyses translated the Baseline model run's hourly Conowingo Dam outflow time series (Jan 1930 – Dec 2007) into twenty-three individual habitat time series – one hourly time series for each species/lifestage investigated in the Conowingo 3.16 study report. This section shows habitat time series results for select mobile[3] species for several seasonal periods. Habitat time series plots were not presented for immobile species, as we believe the persistent habitat maps and tables presented in the Conowingo RSP 3.16 study report, when compared to seasonal minimum and maximum flows, are a more effective tool for assessing immobile species' habitat. Additionally, habitat guilds have been excluded from the time series plots. Aggregated results for all species are presented in the form of monthly habitat duration tables and curves.

Monthly habitat duration analyses were completed for all species considered potentially present for that period (Table 2.1-1). Species-by-species habitat duration tables showing the percent of time a given species' habitat was at or above a certain value are in Appendix B, while habitat duration figures (habitat plotted versus percent of time equaled or exceeded) are in Appendix C. These results will be used as a common frame of reference to compare all alternative operating scenarios examined with the operations model.

The following sections presents select habitat time series by grouped months. The select habitat time series plots presented are for the same select species/life stages identified in section 5 of the Conowingo RSP 3.16 study report. Months with similar sets of select species were grouped together (e.g., January, February, March).

4.1 January, February, March

January, February and March had the following set of select mobile species identified in the Conowingo RSP 3.16 study report:

- Striped bass adults;
- Smallmouth bass adults;

[3] Mobile species/life stages are all of the species that were not specifically designated as immobile in Table 2.1-1. The immobile species included all spawning/incubation and fry life stages, as well as all of the macroinvertebrate species.

A one-week habitat time series plot is shown in Figure 4.1-1. Habitat in these months was generally good for adult striped bass habitat and adult smallmouth bass habitat, with adult striped bass habitat varying more than adult smallmouth bass habitat. Generally, most species/life stages' habitat in these months had a roughly bimodal distribution, with significant time at or near the habitat associated with 86,000 cfs and significant time at the habitat associated with the seasonal minimum flow (1,750 cfs in January and February or 3,500 cfs in March).

4.2 April, May and June

April, May and June had the following set of select mobile species identified in the Conowingo 3.16 report:

- American shad adults;
- Striped bass juvenile (June only);
- Striped bass adults;
- Smallmouth bass adults;

Sample one-week habitat time series plots are shown in Figure 4.2-1 and Figure 4.2-2. Habitat in these months was generally good for adult striped bass habitat and adult smallmouth bass habitat, with adult striped bass habitat varying more than adult smallmouth bass habitat. Generally, species/life stages that prefer higher flows (American shad, striped bass) had high amounts of habitat, which was a function of the season's high water availability and the relatively high minimum flows (10,000 cfs in April and 7,500 cfs in May). Habitat availability was generally less in June because of the lower minimum flows and general flow availability.

4.3 July, August, September

July, August and September had the following set of select mobile species identified in the Conowingo 3.16 report:

- American shad juveniles;
- Striped bass juveniles;
- Striped bass adults;

- Smallmouth bass juveniles (August/September only);
- Smallmouth bass adults;

Sample one-week habitat time series plots are shown in Figure 4.3-1 and Figure 4.3-2. Habitat in these months was generally poor for species/life stages that preferred high flows (striped bass, all life stages), and was generally good for species/life stages that prefer lower flows (juvenile American shad, caddisfly). Smallmouth bass adults also had high habitat values during these months.

4.4 October, November, December

October, November and December had the following set of select mobile species identified in the Conowingo 3.16 report:

- American shad juveniles (October/November only);
- Striped bass juveniles;
- Striped bass adults;
- Smallmouth bass juveniles;
- Smallmouth bass adults;

Sample one-week habitat time series plots are shown in Figure 4.4-1 and Figure 4.4-2. Like January, February and March, most species/life stages' habitat in these months had a roughly bimodal distribution, with significant time at or near the habitat associated with 86,000 cfs and significant time at the habitat associated with the seasonal minimum flow (3,500 cfs in October and November and 1,750 cfs in December). Smallmouth bass adults also had high habitat values during these months.

5. CONCLUSIONS

This report presented the results of a habitat time series analysis conducted for the “Baseline” model run. The results were described in several methods. The first presentation method was showing weekly time series plots for select species/life stages. Secondly, monthly habitat duration curves and tables were created for all species/life stages. Habitat time series plots were not presented for immobile life stages, as we believe the habitat persistence maps and tables included in the Conowingo RSP 3.16 study report are a better tool for analyzing immobile species’ habitat. All analyses were grouped into seasons with similar species/life stages and hydrology.

As new alternative operating scenarios are considered in consultation with stakeholders, summary statistics similar to those presented in this report will be generated for the operational alternatives. Operational alternatives’ habitat time series results can then be compared relative to these “Baseline” run results.

6. REFERENCES

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.

TABLE 2.1-1: TARGET SPECIES' SEASONAL PERIODICITY BELOW CONOWINGO DAM[4].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
American Shad												
Spawning				■	■	■						
Fry					■	■	■					
Juveniles							■	■	■	■	■	
Adults				■	■	■						
Hickory Shad												
Spawning (Deep-Slow)			■	■	■							
Fry(Shallow-Slow)				■	■	■						
Juveniles (Deep-Slow)						■						
Adults (Deep-Fast)			■	■	■							
Blueback Herring												
Spawning (Deep-Slow)				■	■	■						
Fry (Shallow-Slow)					■	■						
Juveniles (Shallow-Slow)							■	■	■	■		
Adults (Deep-Slow)				■	■	■						
Alewife												
Spawning (Deep-Slow)			■	■	■							
Fry (Shallow-Slow)			■	■	■							
Juveniles (Deep-Slow)						■	■	■	■	■		
Adults (Shallow-Slow)				■	■							
White Perch												
Spawning (Shallow-Fast, Deep-Fast)				■	■	■						
Fry (Shallow-Slow)				■	■	■	■					
Juveniles (Shallow-Slow, Deep-Slow)					■	■	■	■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Yellow Perch												
Spawning (Deep-Slow)			■	■								
Fry (Shallow-Slow)				■	■							
Juveniles (Deep-Slow)						■	■	■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Striped Bass												
Spawning				■	■	■						
Fry				■	■	■	■					
Juveniles						■	■	■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■

[4] Italicized life stages are considered immobile, and habitat guilds associated with species/life stages are shown in parentheses.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Largemouth Bass												
Spawning (Shallow-Slow, Deep-Slow)					■	■						
Fry (Shallow-Slow, Deep-Slow)						■	■					
Juveniles (Shallow-Slow, Deep-Slow)								■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Smallmouth Bass												
Spawning					■	■						
Fry						■	■					
Juveniles								■	■	■	■	■
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Walleye												
Spawning (Deep-Fast)			■	■								
Fry (Deep-Slow)				■	■	■						
Juveniles (Deep-Slow)						■	■	■	■	■	■	■
Adults (Deep-Slow)	■	■	■	■	■	■	■	■	■	■	■	■
Shortnose sturgeon												
Spawning				■	■							
Fry					■	■	■					
Juveniles/Adults	■	■	■	■	■	■	■	■	■	■	■	■
Atlantic sturgeon												
Spawning (Deep-Fast)				■	■							
Fry (Deep-Slow, Deep-Fast)					■	■	■					
Juveniles/Adults (Deep-Slow, Deep-Fast)	■	■	■	■	■	■	■	■	■	■	■	■
American eel												
Elver (Shallow-Slow, Deep-Slow, Deep-Fast)				■	■	■	■	■	■	■		
Yellow (Shallow-Slow,Deep-Slow,Deep-Fast)	■	■	■	■	■	■	■	■	■	■	■	■
Silver (Deep-Slow)									■	■	■	■
Alewife floater												
Adults/juveniles	■	■	■	■	■	■	■	■	■	■	■	■
Spawning										■	■	■
Larvae			■	■	■							
Eastern elliptio												
Adults/juveniles	■	■	■	■	■	■	■	■	■	■	■	■
Spawning	■	■	■									
Larvae				■	■	■	■	■				
Fingernail clams												
Adults	■	■	■	■	■	■	■	■	■	■	■	■
Spawning/larvae	■	■	■	■	■	■	■	■	■	■	■	■
Ephemeroptera-Plecoptera-Trichoptera												
all life stages	■	■	■	■	■	■	■	■	■	■	■	■

TABLE 2.1-2: FLOW VERSUS HABITAT RELATIONSHIPS[5].

		Flow (cfs)													
Species	Stage	2,000	3,500	5,000	7,500	10,000	15,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	86,000
American Shad	Spawning	2,085	4,133	6,315	9,811	12,809	17,312	20,382	23,395	24,053	23,371	21,914	19,904	17,511	16,044
	Fry	6,847	8,796	10,371	12,433	14,077	16,319	17,547	17,990	16,803	15,182	13,603	12,166	10,836	10,096
	Juvenile	15,952	19,019	20,392	21,316	21,652	21,591	21,072	19,429	17,853	15,623	13,857	12,274	10,797	9,970
	Adult	7,575	9,218	10,860	13,391	15,605	19,151	21,871	25,237	26,205	25,880	24,913	23,513	21,816	20,731
Shortnose Sturgeon	Spawning	1,875	3,386	4,817	6,883	8,512	10,709	12,035	13,472	13,983	14,048	13,905	13,578	13,089	12,729
	Fry	248	353	442	559	642	742	798	849	839	809	774	725	674	654
	Juvenile	611	813	933	1,074	1,177	1,314	1,385	1,432	1,385	1,321	1,255	1,194	1,126	1,096
	Adult	611	813	933	1,074	1,177	1,314	1,385	1,432	1,385	1,321	1,255	1,194	1,126	1,096
Striped Bass	Spawning	7,157	10,753	13,999	18,988	23,687	31,969	38,894	49,065	54,669	56,217	55,057	52,467	49,988	47,196
	Fry	4,436	7,310	10,195	14,928	19,566	28,061	35,485	46,895	53,476	55,546	54,597	52,113	48,968	47,000
	Juvenile	11,000	14,966	17,676	20,657	22,653	25,130	26,820	29,018	30,036	29,752	28,204	25,809	23,022	21,340
	Adult	7,426	11,986	16,339	22,817	28,243	36,762	43,177	52,101	58,016	61,283	62,763	63,369	63,531	63,445
Smallmouth Bass	Spawning	1,037	1,124	1,142	1,061	951	730	600	479	423	374	336	299	272	255
	Fry	3,611	2,636	2,051	1,531	1,277	998	868	943	1,035	944	926	873	801	797
	Juvenile	24,392	25,873	26,005	25,144	23,770	20,455	16,765	10,152	6,054	4,277	3,658	3,429	3,184	3,033
	Adult	22,322	26,500	29,972	33,951	35,972	36,374	34,707	30,358	26,785	23,838	21,366	19,079	16,993	15,853
Macroinvertebrates	Stonefly	3,257	4,180	4,432	4,083	3,353	2,281	1,739	1,303	1,111	974	833	720	637	593
	Mayfly	5,508	6,016	6,053	5,600	4,929	3,853	3,248	2,630	2,210	1,885	1,612	1,396	1,237	1,163
	Caddisfly	8,711	10,866	12,027	12,752	12,738	12,032	11,026	8,903	7,010	5,529	4,418	3,655	3,170	2,947
Guilds	Shallow-Slow	29,172	23,143	16,319	8,092	4,541	2,408	2,060	2,557	2,855	2,346	1,902	1,570	1,317	1,102
	Shallow-Fast	1,079	938	718	527	366	206	162	126	92	85	79	60	45	45
	Deep-Slow	29,192	32,691	34,258	32,896	28,093	20,078	14,338	7,677	6,482	6,247	6,226	5,764	5,303	5,195
	Deep-Fast	40	73	175	465	744	1,148	1,219	716	326	123	80	71	73	72

[5] Habitat area reported in thousands of square feet.

TABLE 2.2-1: CONOWINGO DAM'S SEASONAL MINIMUM FLOW REQUIREMENTS.

Date Range	Continuous Minimum Flow Release (cfs)
December 1 – February 28	3,500 cfs intermittent[6] or inflow[7], whichever is less
March 1 – March 31	3,500 cfs or inflow, whichever is less
April 1 – April 30	10,000 cfs or inflow, whichever is less
May 1 – May 31	7,500 cfs or inflow, whichever is less
June 1 – September 14	5,000 cfs or inflow, whichever is less
September 14 – November 30	3,500 cfs or inflow, whichever is less

[6] Intermittent refers to 6 hours at 3,500 cfs, followed by 6 hours with no required release. This was modeled in the Baseline model as a continuous 1,750 cfs release.

[7] Inflow refers to the flow at the Marietta USGS gage #01576000.

TABLE 3-1: FLOWS PROVIDING PERCENTAGES OF MAXIMUM WEIGHTED USABLE AREA (WUA)

Species/Life Stage	Months Present	Flow at Maximum WUA (cfs)	Flow Range Providing 90% of Maximum WUA (cfs)	Flow Range Providing 80% of Maximum WUA (cfs)	Flow Range Providing 70% of Maximum WUA (cfs)	Flow Range Providing 60% of Maximum WUA (cfs)
American Shad:						
Spawning & Inc.	Apr-Jun	40,000	24,200 – 61,325	18,144 – 72,765	14,472 – 82,757	11,801 – 86,000*
Fry	May-Jul	30,000	14,716 – 43,771	10,703 – 55,000	7,744 – 67,028	5,513 – 80,335
Juvenile	Jul-Nov	10,000	4,011 – 29,652	2,670 – 42,383	2,000* – 52,641	2,000* – 65,469
Adult	Apr-Jun	40,000	25,090 – 69,495	18,332 – 84,715	13,861 – 86,000*	10,166 – 86,000*
Shortnose Sturgeon:						
Spawning & Inc.	Apr-May	50,000	24,234 – 86,000*	16,997 – 86,000*	13,008 – 86,000*	9,872 – 86,000*
Fry	May-Jul	30,000	16,917 – 62,164	11,835 – 79,017	8,546 – 86,000*	6,424 – 86,000*
Juvenile	All	30,000	14,068 – 54,906	9,240 – 77,199	6,228 – 86,000*	4,078 – 86,000*
Adult	All	30,000	14,068 – 54,906	9,240 – 77,199	6,228 – 86,000*	4,078 – 86,000*
Striped Bass:						
Spawning & Inc.	Apr-Jun	50,000	32,730 – 77,550	25,977 – 86,000*	20,450 – 86,000*	16,272 – 86,000*
Fry	Apr-Jul	50,000	34,705 – 76,746	27,846 – 86,000*	22,977 – 86,000*	18,547 – 86,000*
Juvenile	Jun-Dec	40,000	20,968 – 64,890	12,777 – 76,387	7,961 – 86,000*	5,290 – 86,000*
Adult	All	80,000	38,584 – 86,000*	28,570 – 86,000*	21,450 – 86,000*	16,057 – 86,000*
Smallmouth Bass:						
Spawning & Inc.	May-Jun	5,000	2,000* – 8,262	2,000* – 10,853	2,000* – 13,430	2,000* – 16,725
Fry	Jun-Jul	2,000*	2,000* – 2,556	2,000* – 3,111	2,000* – 3,778	2,000* – 4,703
Juvenile	Aug-Dec	5,000	2,000* – 10,552	2,000* – 14,474	2,000* – 18,051	2,000* – 21,757
Adult	All	15,000	6,737 – 24,531	4,623 – 33,522	3,127 – 44,491	2,000* – 58,145
Macroinvertebrates						
Ephemeroptera (Mayfly)	All	5,000	3,190 – 7,823	2,469 – 9,340	2,000* – 11,168	2,000* – 13,235
Plecoptera (Stonefly)	All	5,000	2,000* – 8,067	2,000* – 10,404	2,000* – 13,217	2,000* – 16,828
Trichoptera (Caddisfly)	All	10,000	4,289 – 17,762	3,038 – 23,884	2,000* – 29,890	2,000* – 36,612
Habitat Guilds						
Shallow Slow	All	2,000*	2,000* – 2,726	2,000* – 3,452	2,000* – 4,098	2,000* – 4,740
Shallow Fast	Apr-Jun	2,000*	2,000* – 3,143	2,000* – 4,007	2,000* – 4,743	2,000* – 5,921
Deep Slow	All	5,000	2,703 – 8,574	2,000* – 10,428	2,000* – 12,565	2,000* – 14,702
Deep Fast	All	20,000	14,376 – 22,424	12,866 – 24,848	11,355 – 27,271	9,888 – 26,695

*Indicates that the flow range was limited by the lowest or highest production run flow, thus the true flow range providing this habitat falls outside of the modeled flows and is greater than shown.

FIGURE 3-1: HABITAT TIME SERIES EXAMPLE

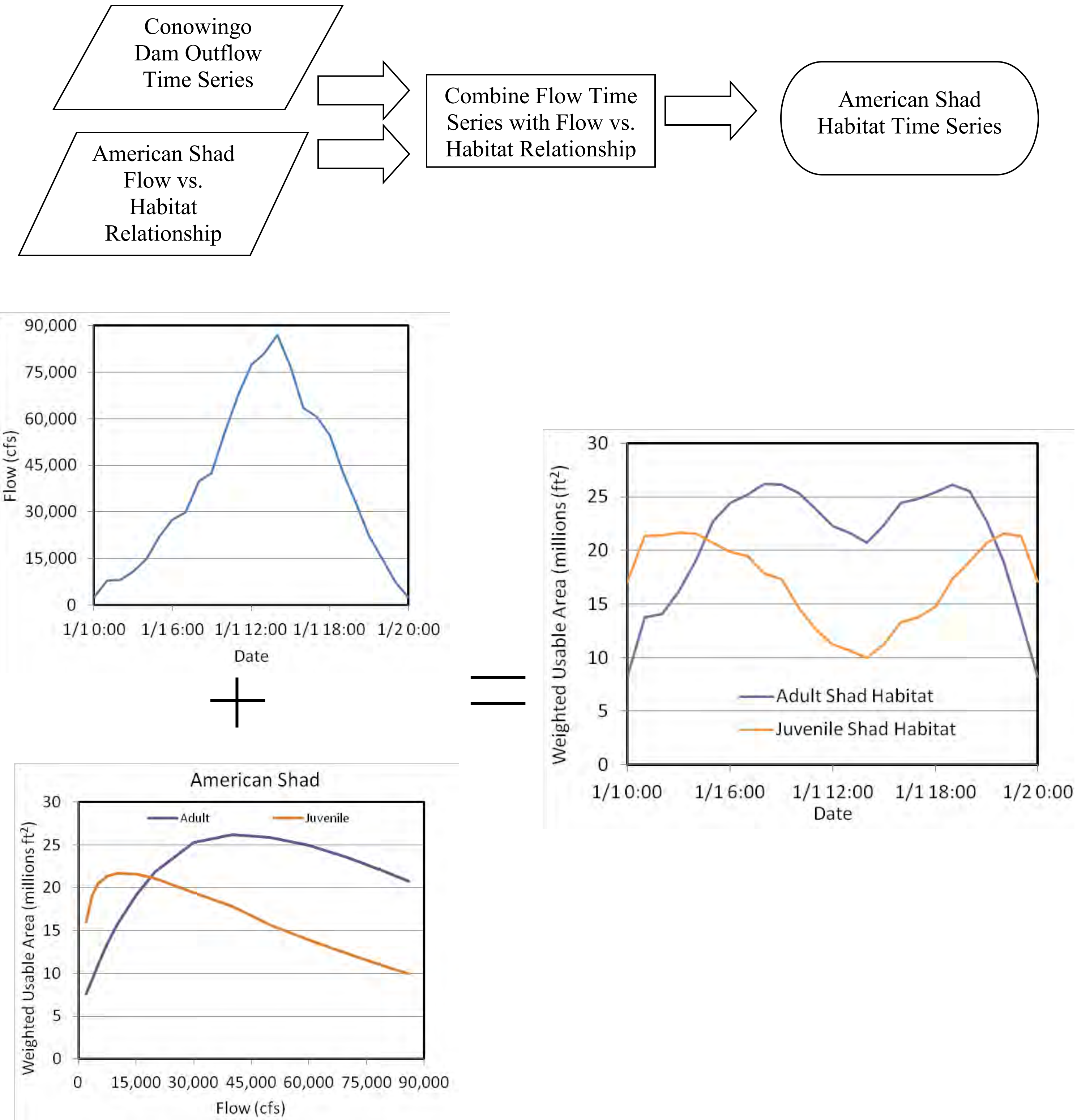


FIGURE 4.1-1: EXAMPLE WEEKLY HABITAT TIME SERIES PLOT FOR SELECT SPECIES/LIFE STAGES PRESENT IN JANUARY, FEBRUARY AND MARCH

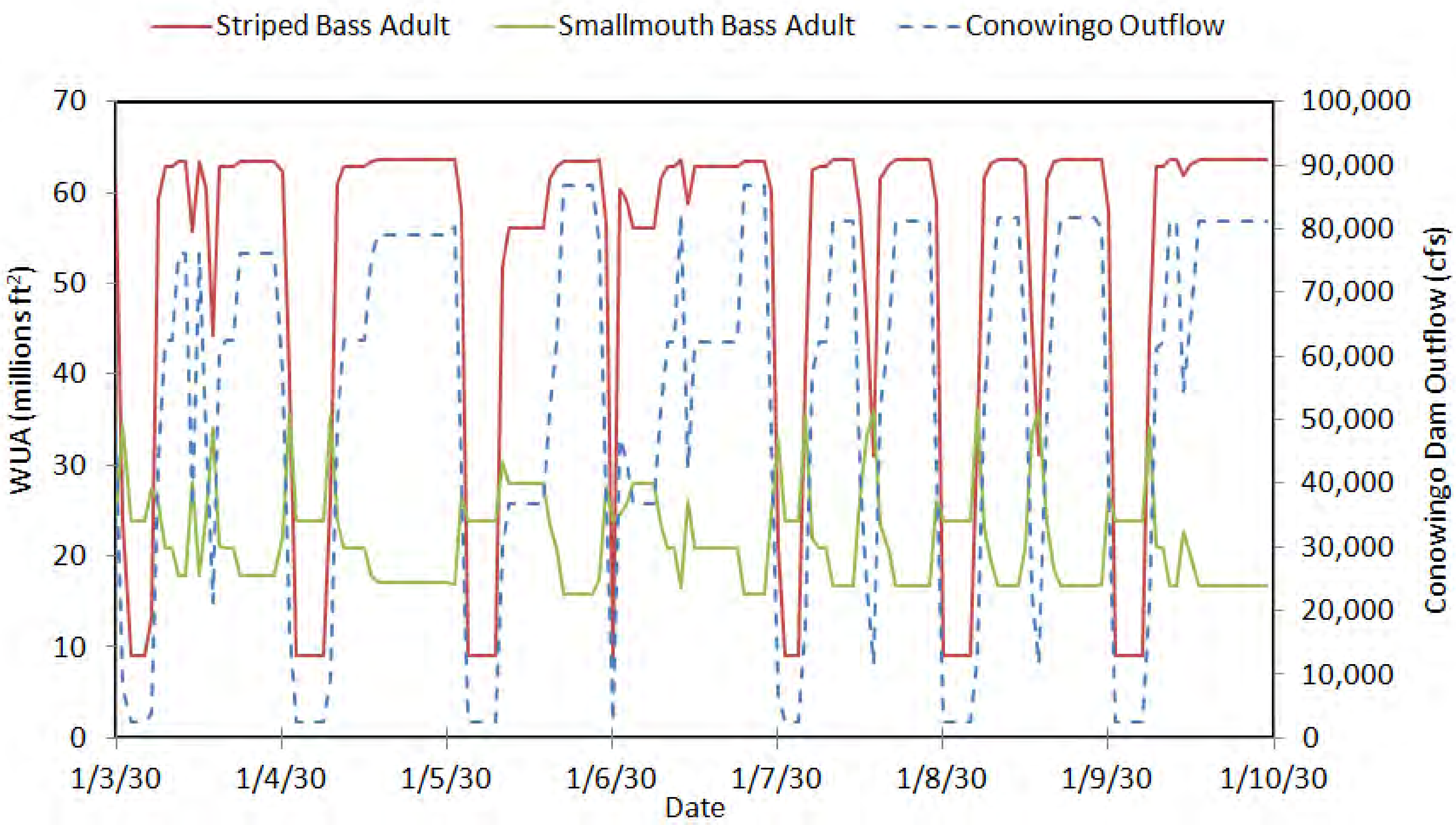
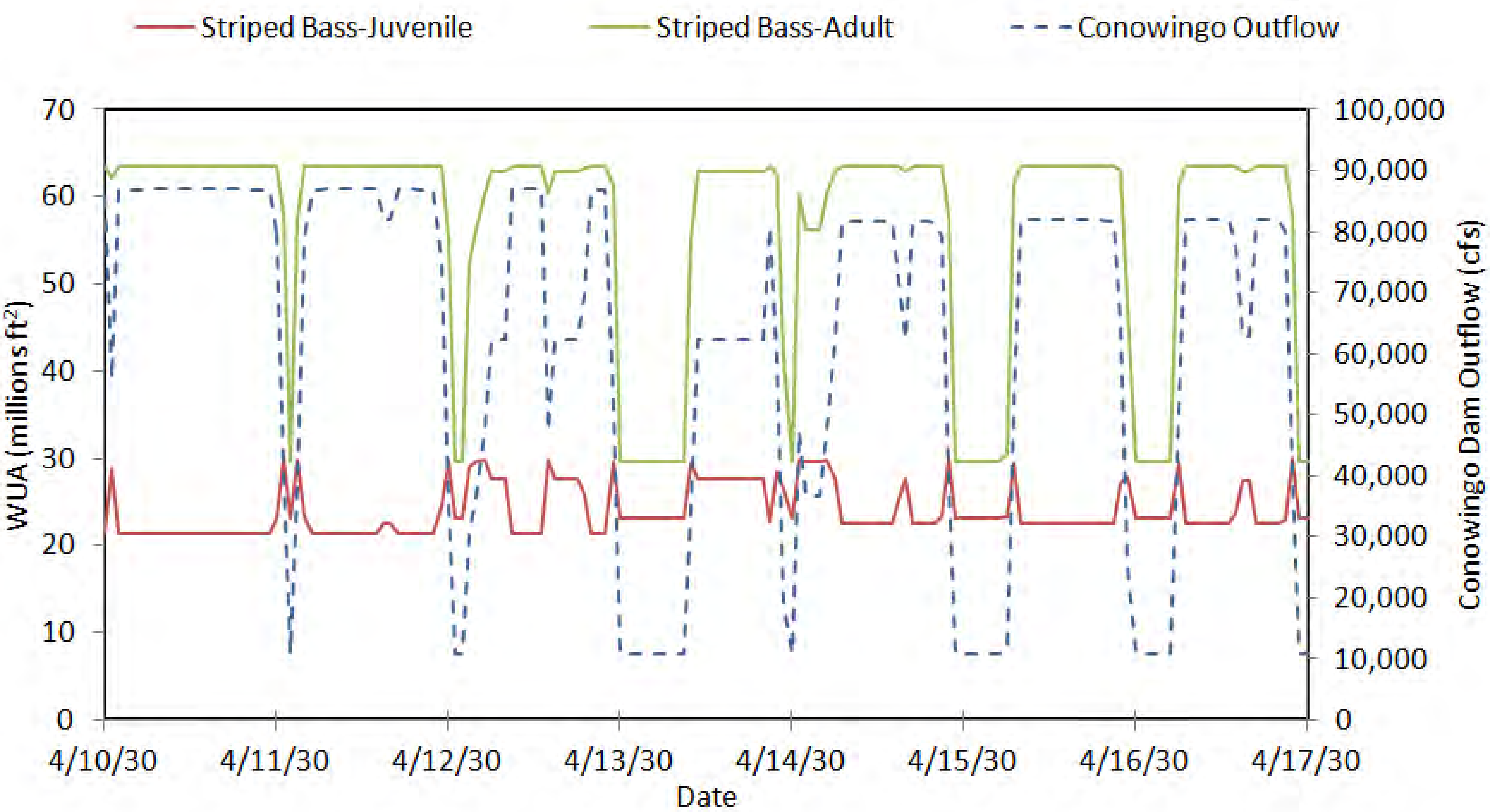


FIGURE 4.2-1: EXAMPLE WEEKLY HABITAT TIME SERIES PLOT FOR SELECT MOBILE STRIPED BASS LIFE STAGES PRESENT IN APRIL, MAY AND JUNE[8].



[8] Striped bass juveniles are not present in April or May, but are included in this time series plot for display purposes, since the flow/habitat relationship does not change with season.

FIGURE 4.2-2: EXAMPLE WEEKLY HABITAT TIME SERIES PLOT FOR SELECT MOBILE AMERICAN SHAD AND SMALLMOUTH BASS LIFE STAGES PRESENT IN APRIL, MAY AND JUNE.

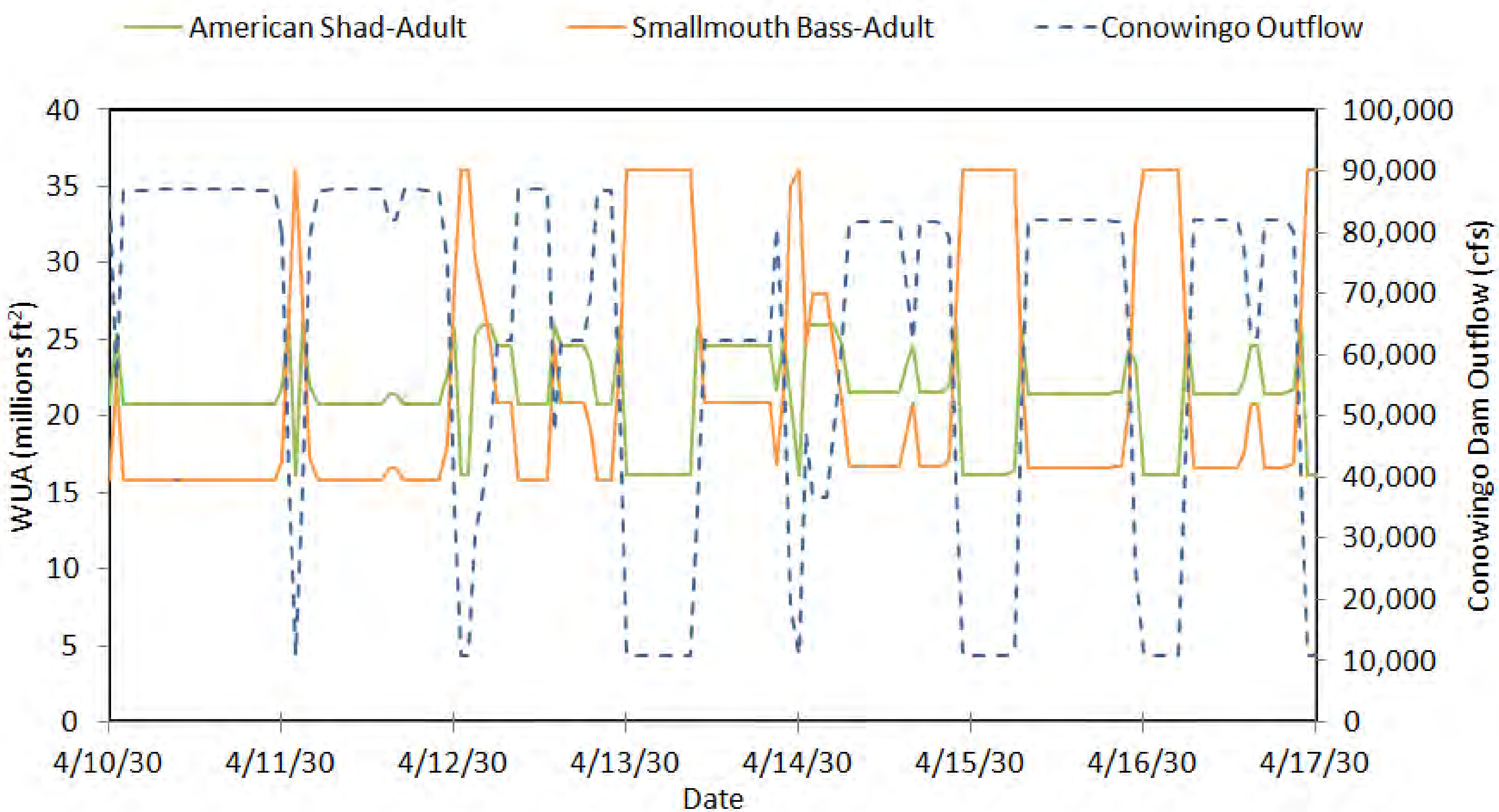


FIGURE 4.3-1: EXAMPLE WEEKLY HABITAT TIME SERIES PLOT FOR SELECT MOBILE AMERICAN SHAD AND STRIPED BASS LIFE STAGES PRESENT IN JULY, AUGUST AND SEPTEMBER.

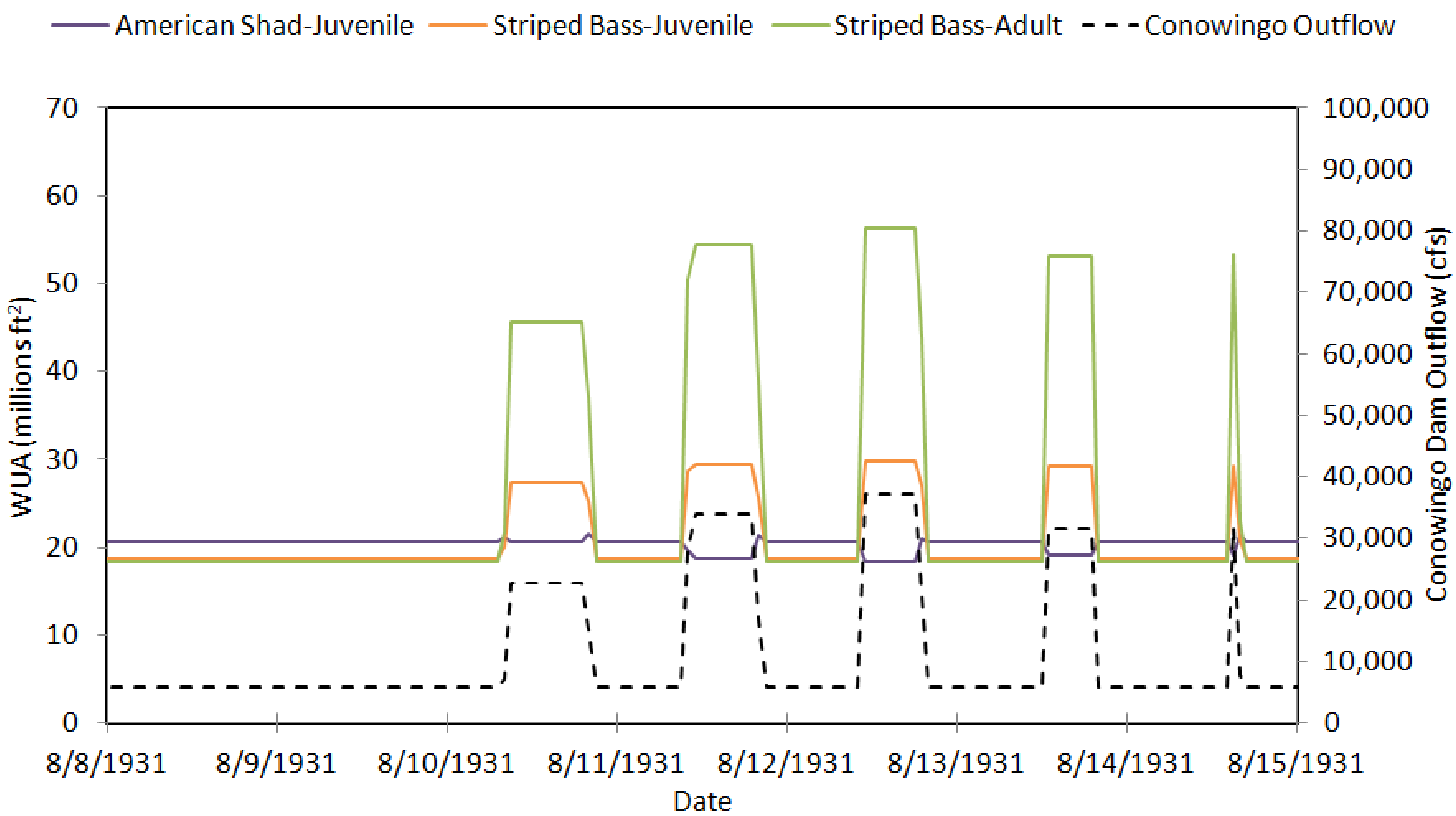
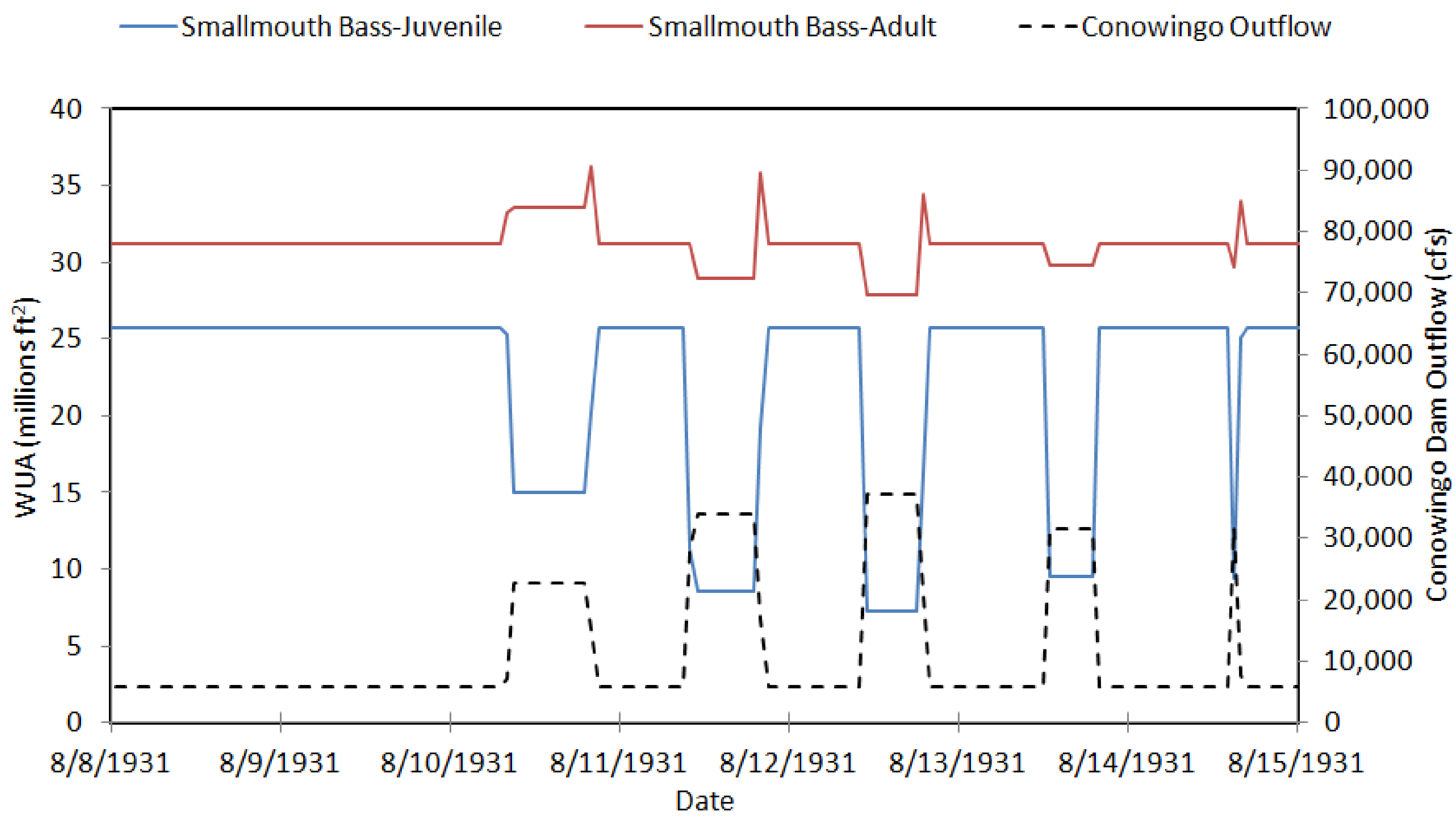


FIGURE 4.3-2: EXAMPLE WEEKLY HABITAT TIME SERIES PLOT FOR SELECT MOBILE SMALLMOUTH BASS LIFE STAGES[9] PRESENT IN JULY, AUGUST AND SEPTEMBER.



[9] Juvenile smallmouth bass are not present in July, but are included in this time series plot for display purposes, since the flow/habitat relationship does not change with season.

FIGURE 4.4-1: EXAMPLE WEEKLY HABITAT TIME SERIES PLOT FOR SELECT MOBILE STRIPED BASS LIFE STAGES PRESENT IN OCTOBER, NOVEMBER AND DECEMBER.

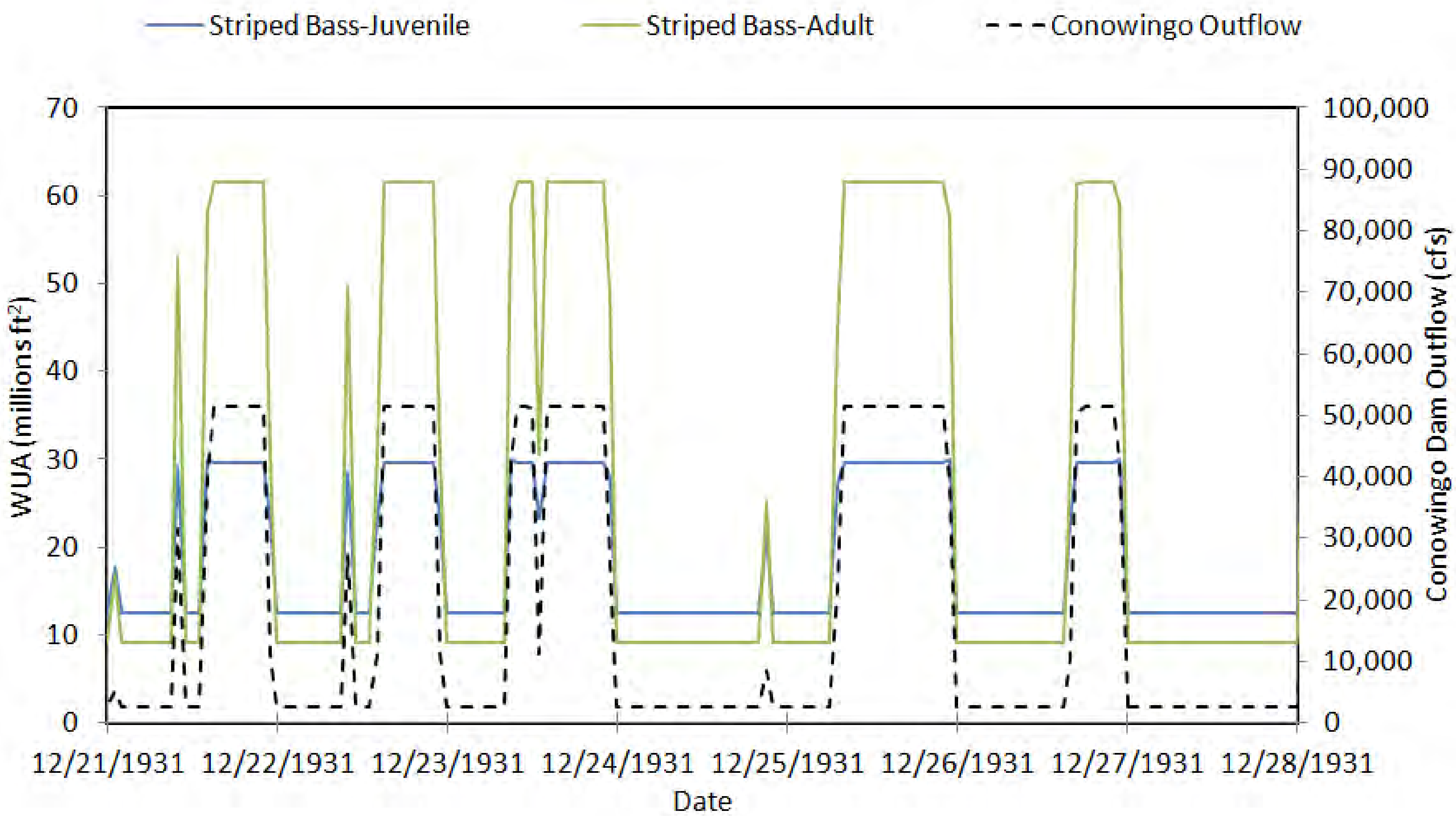
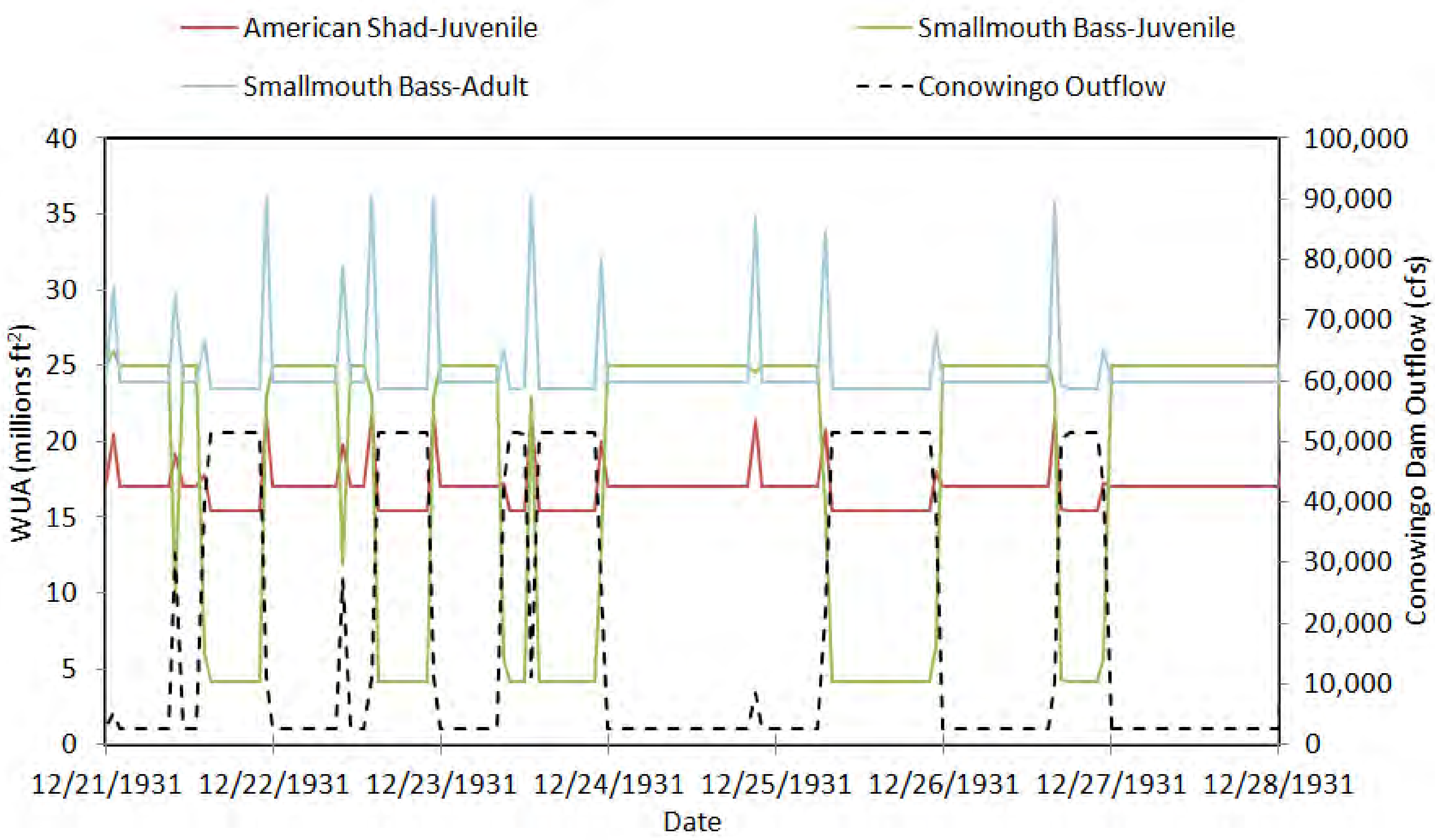


FIGURE 4.4-2: EXAMPLE WEEKLY HABITAT TIME SERIES PLOT FOR SELECT MOBILE AMERICAN SHAD AND SMALLMOUTH BASS LIFE STAGES PRESENT IN OCTOBER, NOVEMBER AND DECEMBER[10].



[10] Juvenile American shad are not present in December, but are included in this time series plot for display purposes, since the flow/habitat relationship does not change with season.

APPENDIX A: HABITAT (WEIGHTED USABLE AREA) VERSUS FLOW CURVES

Figure A-1: American shad flow vs. habitat relationship

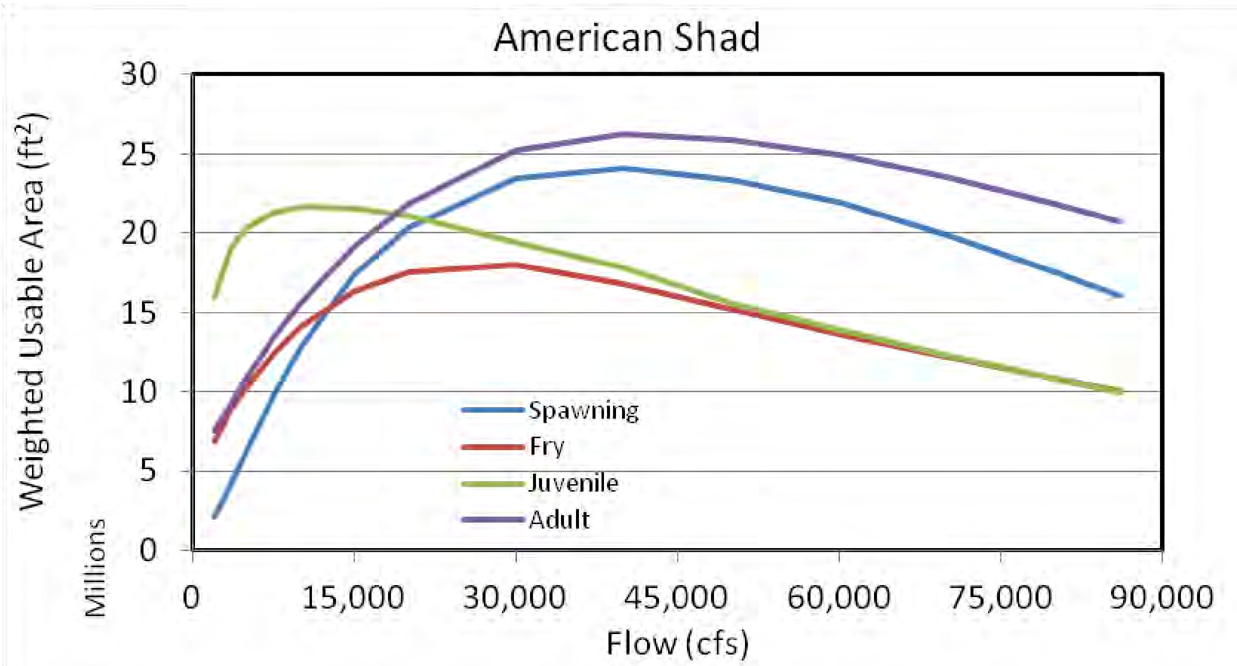
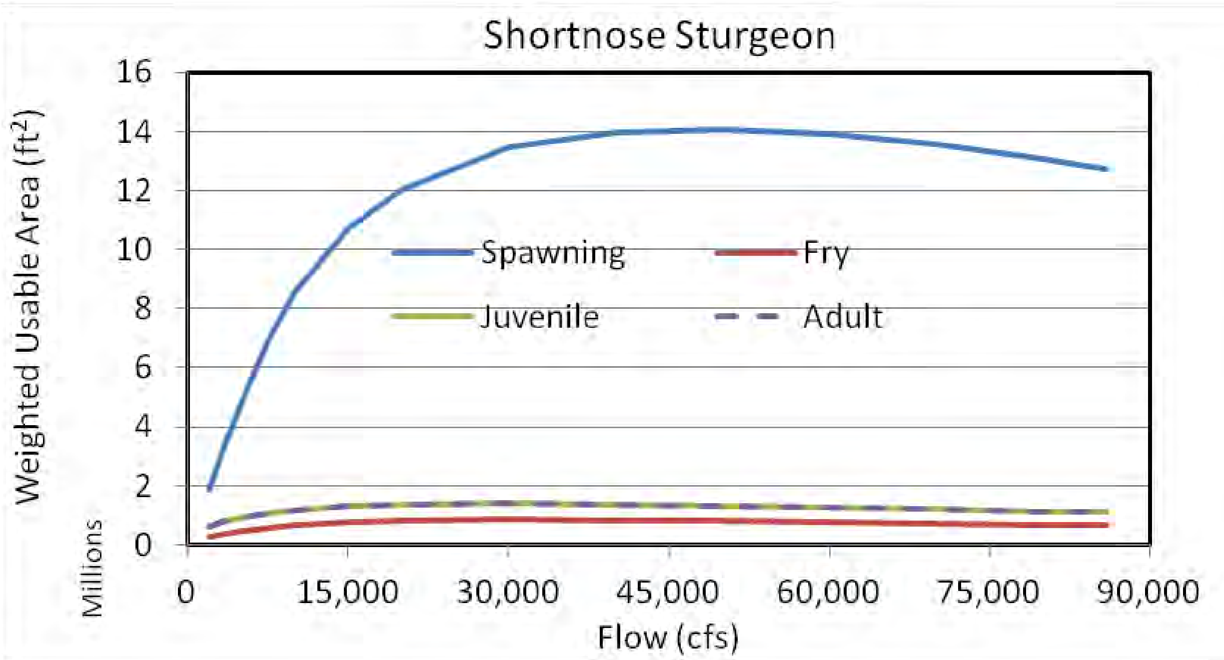


Figure A-2: Shortnose sturgeon flow vs. habitat relationship



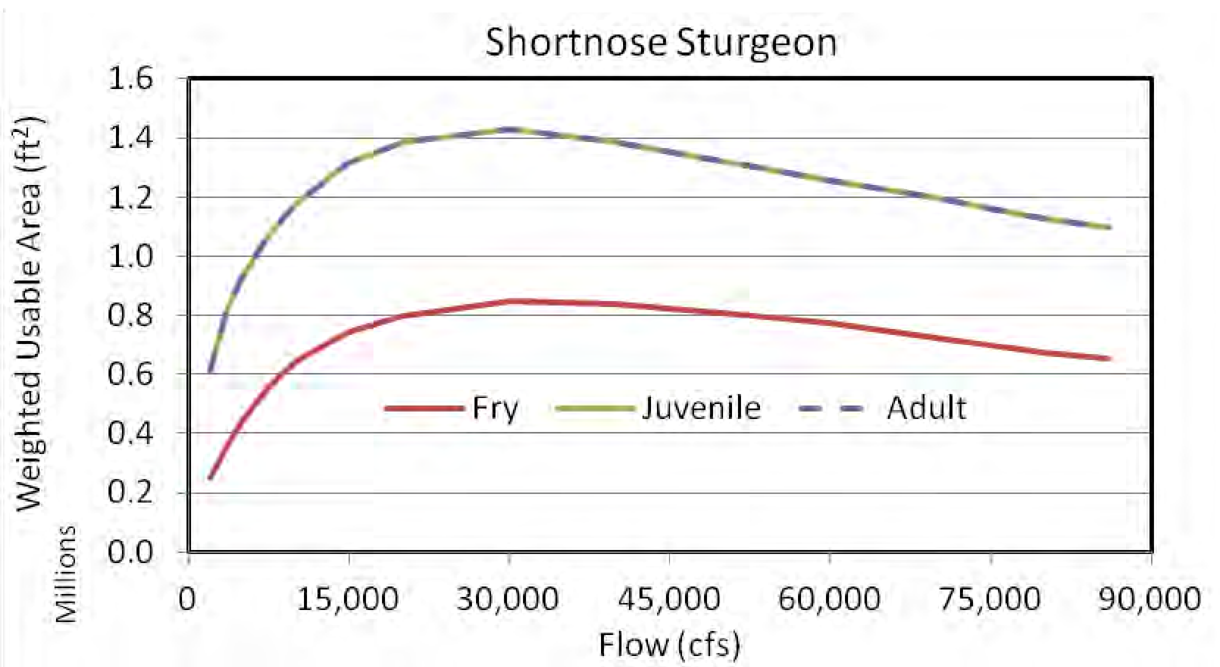


Figure A-3: Striped bass flow vs. habitat relationship

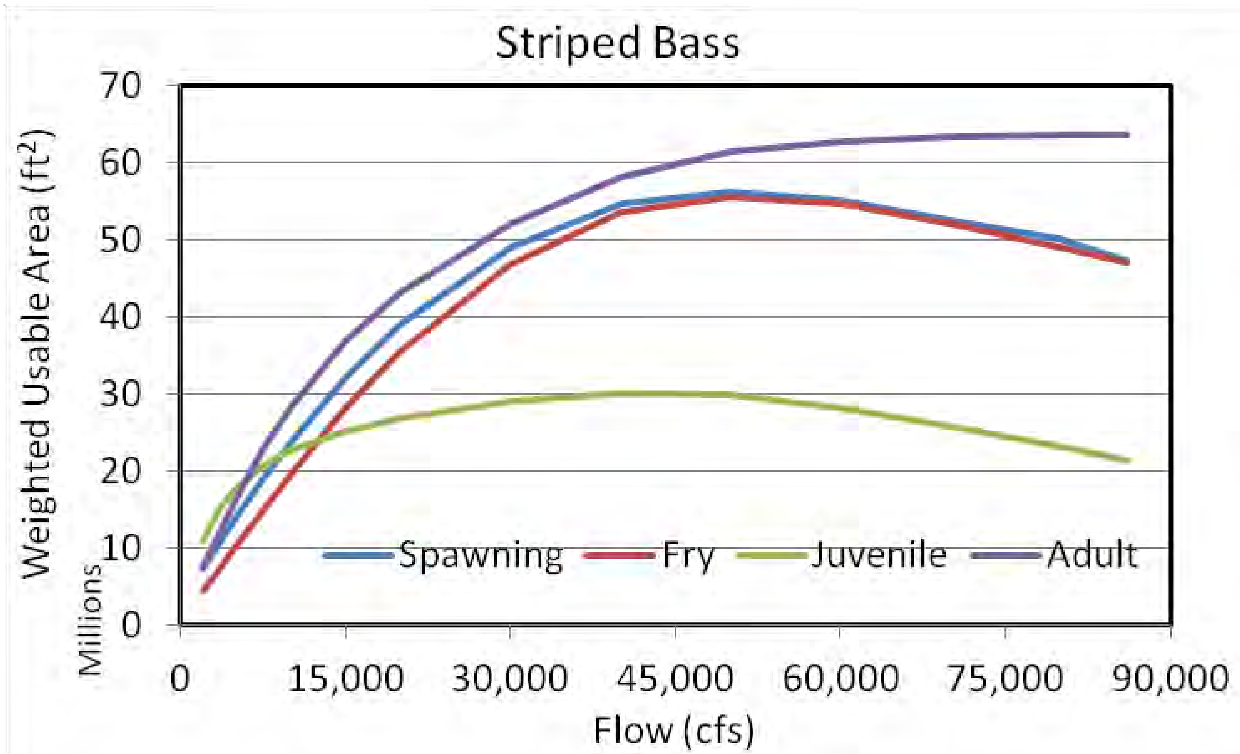
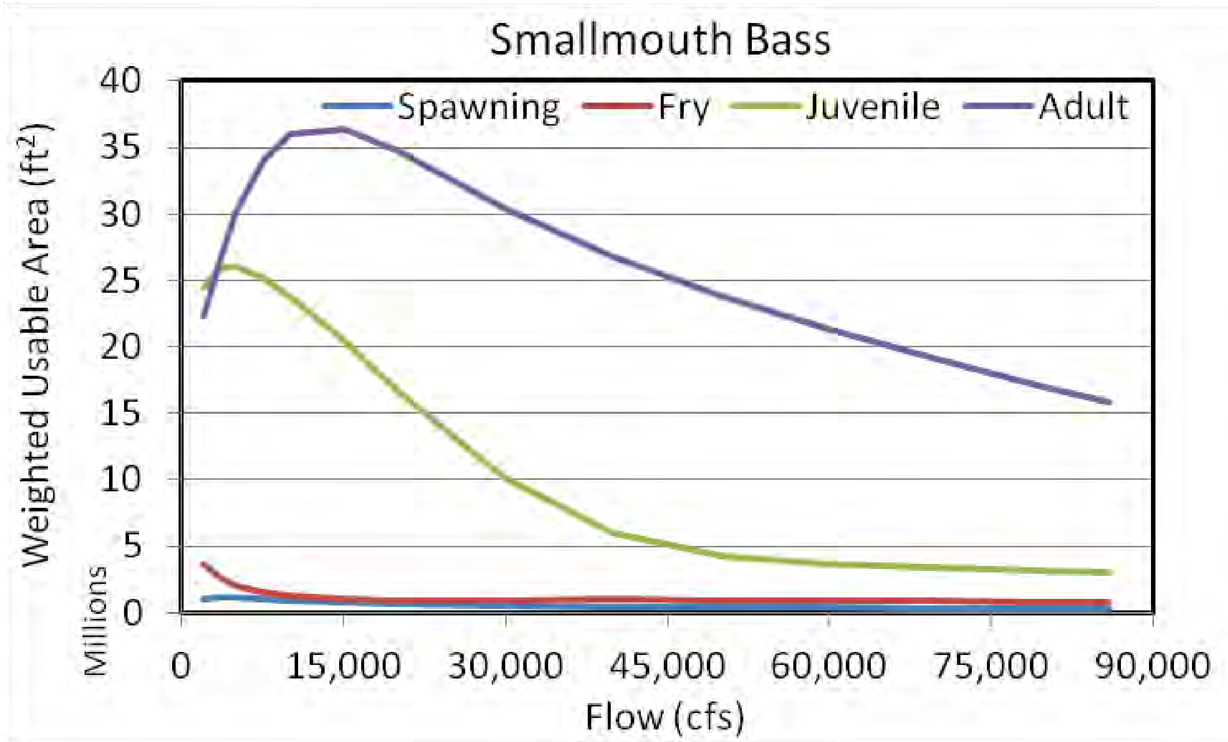


Figure A-4: Smallmouth bass flow vs. habitat relationship



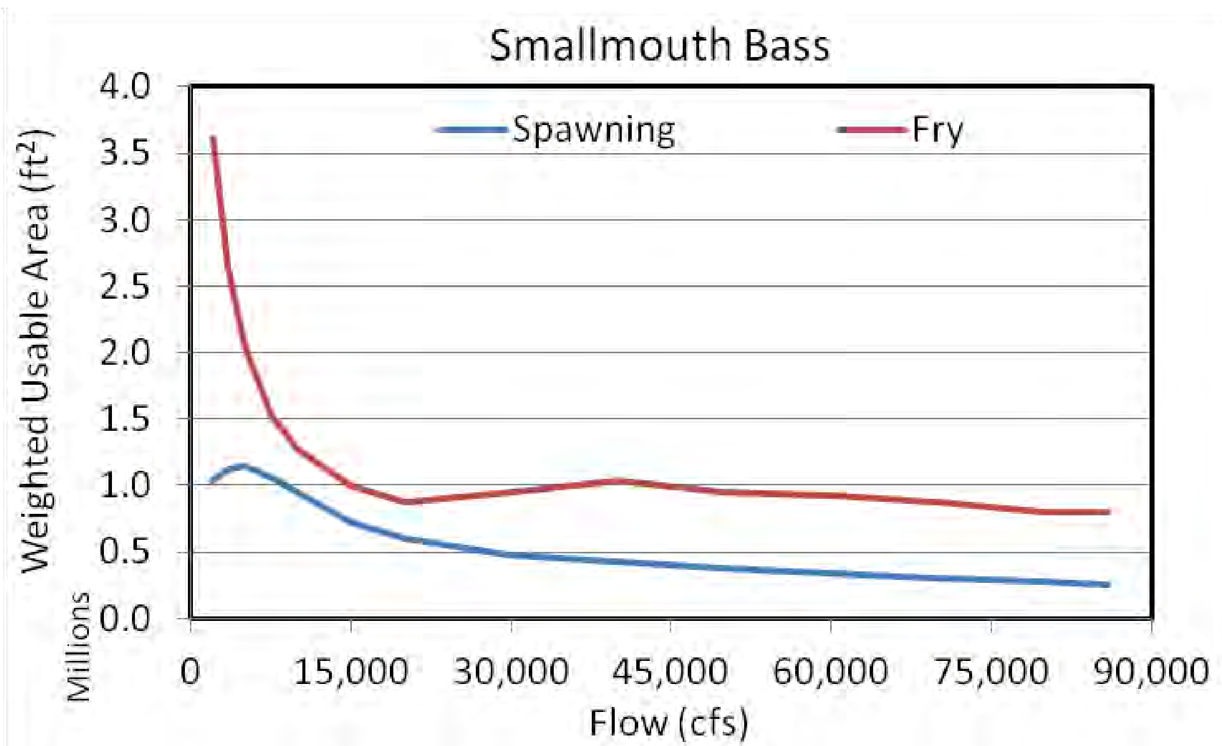


Figure A-5: Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies) flow vs. habitat relationship

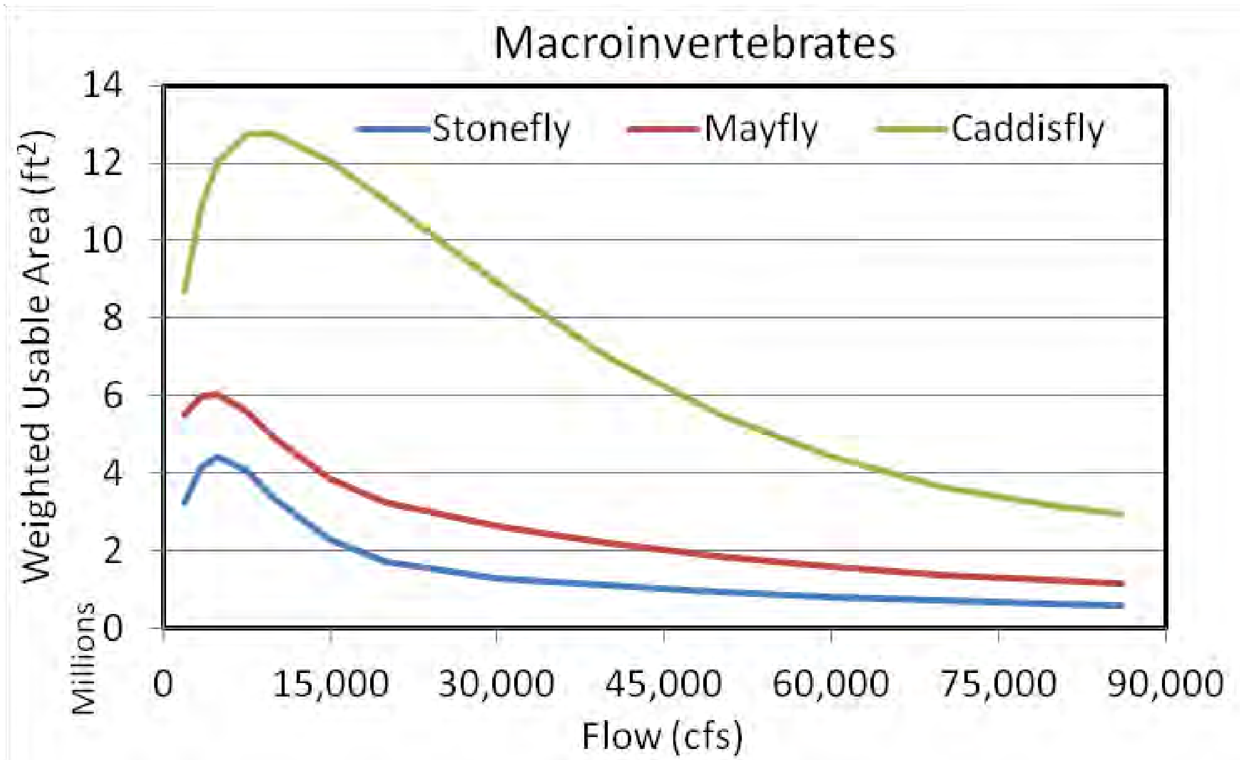
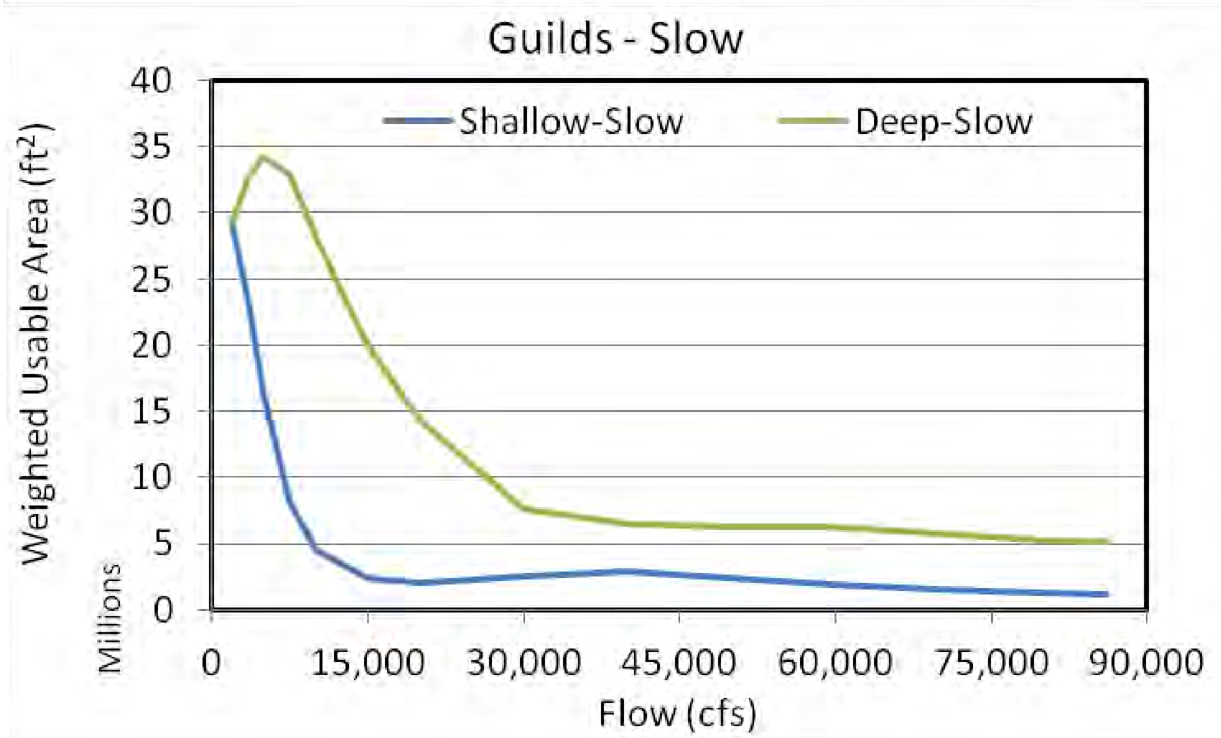
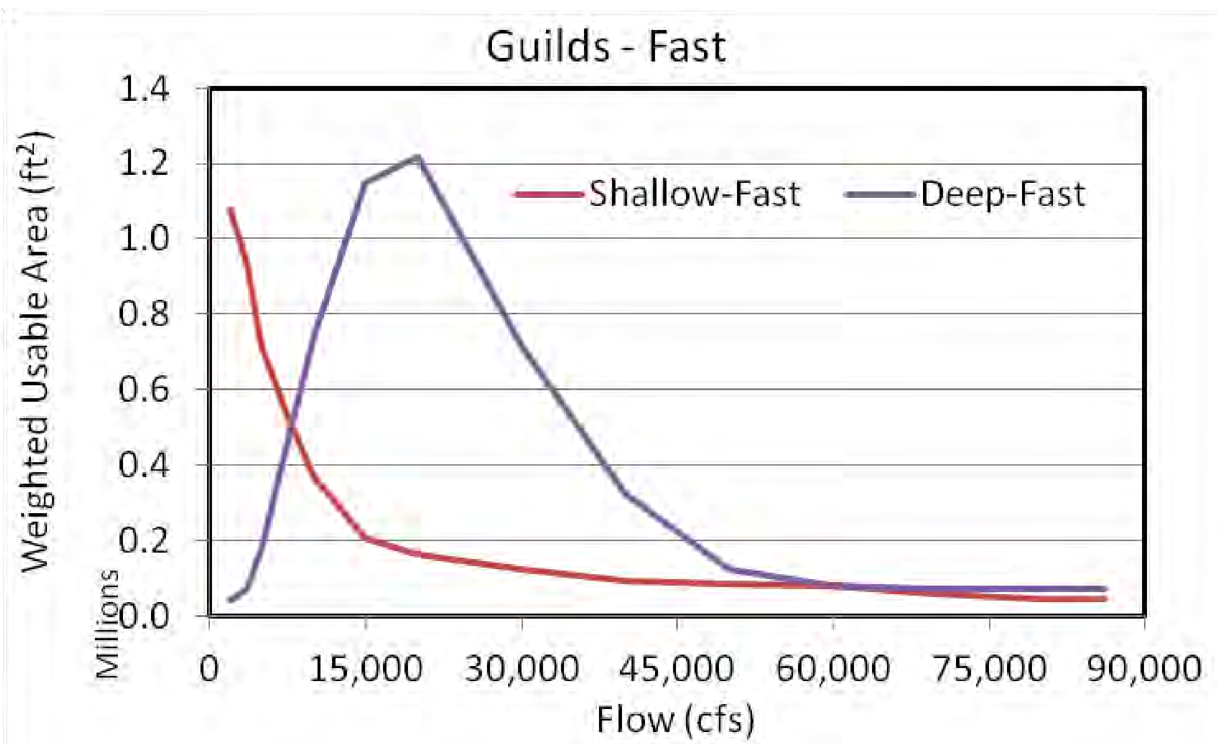


Figure A-6: Shallow-slow, shallow-fast, deep-slow, and deep-fast habitat guilds' flow vs. habitat relationship





APPENDIX B: MONTHLY HABITAT DURATION TABLES – PERIOD OF RECORD JAN 1930 TO DEC 2007

Table B-1: January Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Adult	Smallmouth Bass-Adult	Macroinvertebrates-Stonefly	Macroinvertebrates-Mayfly	Macroinvertebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	1,431,613	1,431,613	63,530,962	36,373,606	4,429,632	6,052,606	12,751,664	26,961,058	34,247,643	1,219,233
5	1,400,286	1,400,286	63,508,307	33,290,844	3,595,462	5,694,125	10,924,163	26,961,058	30,474,769	834,251
10	1,368,579	1,368,579	63,445,446	28,416,903	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	452,541
15	1,339,400	1,339,400	63,445,446	26,033,500	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	273,984
20	1,290,710	1,290,710	63,445,446	24,288,891	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	138,571
25	1,240,711	1,240,711	63,445,446	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	85,901
30	1,202,410	1,202,410	62,950,855	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	77,702
35	1,133,292	1,133,292	62,587,938	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	72,845
40	1,118,198	1,118,198	61,030,491	23,853,989	3,595,462	5,694,125	9,500,975	21,194,605	30,474,769	72,485
45	1,095,959	1,095,959	58,848,652	23,853,989	1,705,603	3,200,163	9,500,975	2,784,941	13,826,499	72,485
50	1,095,959	1,095,959	55,134,035	23,853,989	1,204,276	2,414,536	7,932,081	2,667,498	7,064,556	72,485
55	1,095,959	1,095,959	43,862,655	23,853,989	1,075,699	2,127,085	6,632,179	2,464,664	6,422,402	72,485
60	846,949	846,949	13,228,733	23,853,989	984,178	1,910,378	5,643,523	2,241,948	6,265,554	71,387
65	684,999	684,999	9,098,087	21,657,967	849,387	1,644,053	4,548,968	1,954,187	6,228,929	51,978
70	684,999	684,999	9,098,087	20,657,006	797,659	1,544,867	4,181,298	1,798,826	6,083,258	51,978
75	684,999	684,999	9,098,087	17,624,739	662,216	1,285,201	3,316,944	1,393,399	5,442,737	51,978
80	684,999	684,999	9,098,087	16,765,345	628,402	1,222,309	3,125,370	1,273,842	5,281,471	51,978
85	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
90	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
95	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
100	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978

Table B-2: February Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Adult	Smallmouth Bass-Adult	Macroinvertebrates-Stonefly	Macroinvertebrates-Mayfly	Macroinvertebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	1,431,613	1,431,613	63,530,962	36,373,284	4,430,602	6,052,752	12,751,799	26,961,058	34,249,822	1,219,276
5	1,397,257	1,397,257	63,508,906	33,308,934	3,595,462	5,694,125	10,821,250	26,961,058	30,474,769	824,014
10	1,368,579	1,368,579	63,445,446	28,023,518	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	409,394
15	1,325,726	1,325,726	63,445,446	25,734,953	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	236,268
20	1,267,554	1,267,554	63,445,446	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	112,570
25	1,239,966	1,239,966	63,445,446	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	78,474
30	1,222,509	1,222,509	63,203,698	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	77,811
35	1,158,819	1,158,819	62,915,428	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	72,871
40	1,121,593	1,121,593	62,540,692	23,853,989	2,413,978	3,986,798	9,500,975	2,848,609	21,072,176	72,745
45	1,095,959	1,095,959	60,955,933	23,853,989	1,286,128	2,593,490	8,738,445	2,710,160	7,573,581	72,485
50	1,095,959	1,095,959	58,848,652	23,853,989	1,075,699	2,127,085	6,632,179	2,481,358	6,422,402	72,485
55	1,095,959	1,095,959	52,614,987	23,853,989	987,305	1,917,783	5,677,307	2,243,667	6,270,914	72,485
60	1,095,959	1,095,959	35,705,302	21,736,890	853,883	1,652,787	4,584,451	1,968,355	6,229,599	72,203
65	684,999	684,999	9,098,087	20,790,570	804,270	1,557,465	4,225,827	1,818,218	6,110,242	51,978
70	684,999	684,999	9,098,087	19,703,763	750,475	1,454,955	3,863,490	1,660,422	5,890,670	51,978
75	684,999	684,999	9,098,087	17,460,776	655,752	1,272,706	3,278,810	1,373,522	5,406,465	51,978
80	684,999	684,999	9,098,087	16,712,930	626,350	1,218,913	3,115,094	1,263,944	5,276,528	51,978
85	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
90	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
95	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
100	684,999	684,999	9,098,087	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978

Table B-3: March Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Adult	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	1,431,603	1,431,603	63,530,977	36,372,562	4,431,612	6,052,899	12,751,836	19,503,178	34,253,817	1,219,276
5	1,380,028	1,380,028	63,511,529	29,264,630	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	469,921
10	1,312,063	1,312,063	63,487,369	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	187,804
15	1,240,772	1,240,772	63,445,446	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
20	1,235,536	1,235,536	63,445,446	28,351,869	4,314,472	6,026,160	11,485,220	15,831,652	33,526,764	127,684
25	1,158,375	1,158,375	63,445,446	28,351,869	1,235,399	2,482,581	8,238,689	2,664,808	7,258,106	127,684
30	1,122,133	1,122,133	63,445,446	24,781,205	1,017,453	1,989,169	6,002,981	2,331,304	6,322,581	127,684
35	1,117,669	1,117,669	63,445,446	20,878,392	808,617	1,565,748	4,255,107	1,830,969	6,127,985	78,469
40	1,095,959	1,095,959	63,445,446	20,760,152	802,764	1,554,596	4,215,686	1,813,802	6,104,097	77,998
45	1,095,959	1,095,959	63,445,446	18,477,765	695,845	1,350,204	3,515,335	1,496,814	5,631,445	72,884
50	1,095,959	1,095,959	63,445,446	16,896,003	633,514	1,230,773	3,150,988	1,298,517	5,293,793	72,805
55	1,095,959	1,095,959	63,416,015	16,675,139	624,872	1,216,465	3,107,684	1,256,807	5,272,964	72,485
60	1,095,959	1,095,959	62,923,496	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
65	1,095,959	1,095,959	62,892,133	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
70	1,095,959	1,095,959	60,237,214	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
75	1,095,959	1,095,959	54,176,203	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
80	941,241	941,241	16,722,149	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
85	876,765	876,765	14,307,543	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
90	876,765	876,765	14,307,543	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
95	876,765	876,765	14,307,543	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,485
100	876,765	876,765	14,307,543	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	71,305

Table B-4: April Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	American Shad-Spawning	American Shad-Adult	Shortnose Sturgeon-Spawning	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Spawning	Striped Bass-Fry	Striped Bass-Adult	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Shallow-Fast	Guilds-Deep-Slow	Guilds-Deep-Fast
0	24,052,112	26,203,751	14,047,970	1,431,594	1,431,594	56,214,461	55,543,968	63,530,905	36,373,686	3,181,597	4,757,207	12,625,419	4,199,891	340,261	26,810,635	1,219,139
5	23,410,362	25,774,044	13,919,278	1,361,976	1,361,976	54,881,944	54,085,603	63,511,691	36,036,667	3,181,597	4,757,207	12,625,419	4,199,891	340,261	26,810,635	808,658
10	21,446,590	24,575,721	13,815,842	1,259,999	1,259,999	54,264,928	53,789,775	63,501,264	36,036,667	3,181,597	4,757,207	12,625,419	4,199,891	340,261	26,810,635	808,658
15	20,821,112	23,873,374	13,556,353	1,236,662	1,236,662	51,995,594	51,207,477	63,445,446	36,036,667	3,181,597	4,757,207	12,625,419	4,199,891	340,261	26,810,635	808,658
20	17,973,577	22,008,800	13,098,389	1,198,546	1,198,546	49,934,838	48,930,432	63,445,446	36,036,667	3,181,597	4,757,207	12,625,419	4,199,891	340,261	26,810,635	808,658
25	17,215,676	21,572,605	12,995,082	1,198,546	1,198,546	49,211,800	48,407,765	63,445,446	27,825,324	1,166,614	2,332,196	7,561,055	2,494,920	101,828	6,830,343	439,429
30	17,019,628	21,311,766	12,729,222	1,198,546	1,198,546	47,196,225	47,000,432	63,445,446	22,155,244	877,716	1,699,081	4,772,540	2,043,455	80,783	6,233,147	93,982
35	16,044,034	20,731,411	12,729,222	1,198,546	1,198,546	47,196,225	47,000,432	63,445,446	20,700,688	799,821	1,548,987	4,195,861	1,805,168	73,518	6,092,083	77,761
40	16,044,034	20,731,411	12,729,222	1,149,000	1,149,000	47,196,225	47,000,432	63,445,446	17,690,449	664,806	1,290,208	3,332,226	1,401,366	49,870	5,457,274	72,863
45	16,044,034	20,731,411	12,729,222	1,121,472	1,121,472	47,196,225	47,000,432	63,445,446	16,813,772	630,297	1,225,446	3,134,865	1,282,988	45,268	5,286,038	72,789
50	16,044,034	20,731,411	12,729,222	1,116,312	1,116,312	47,196,225	47,000,432	63,445,446	16,619,495	622,694	1,212,861	3,096,774	1,246,299	45,268	5,267,717	72,485
55	16,044,034	20,731,411	12,729,222	1,095,959	1,095,959	47,196,225	47,000,432	63,445,446	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
60	16,044,034	20,731,411	12,729,222	1,095,959	1,095,959	47,196,225	47,000,432	63,445,446	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
65	16,044,034	20,731,411	12,729,222	1,095,959	1,095,959	47,196,225	47,000,432	62,939,269	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
70	16,044,034	20,731,411	12,729,222	1,095,959	1,095,959	47,196,225	47,000,432	62,290,252	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
75	16,044,034	20,731,411	12,729,222	1,095,959	1,095,959	47,196,225	47,000,432	56,293,103	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
80	13,529,767	16,172,307	8,863,738	1,095,959	1,095,959	25,012,497	20,925,139	29,605,944	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
85	13,529,767	16,172,307	8,863,738	1,095,959	1,095,959	25,012,497	20,925,139	29,605,944	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
90	13,529,767	16,172,307	8,863,738	1,095,959	1,095,959	25,012,497	20,925,139	29,605,944	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
95	13,529,767	16,172,307	8,863,738	1,095,959	1,095,959	25,012,497	20,925,139	29,605,944	15,853,210	592,708	1,163,221	2,946,532	1,101,587	44,742	5,195,451	72,485
100	13,529,767	16,172,307	8,863,738	1,095,959	1,095,959	25,012,497	20,925,139	29,605,944	15,853,210	592,708	1,163,221	2,946,532	1,101,587	44,548	5,195,451	71,306

Table B-5: May Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	American Shad-Spawning	American Shad-Fry	American Shad-Adult	Shortnose Sturgeon-Spawning	Shortnose Sturgeon-Fry	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Spawning	Striped Bass-Fry	Striped Bass-Adult	Smallmouth Bass-Spawning	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Shallow-Fast	Guilds-Deep-Slow	Guilds-Deep-Fast
0	24,052,441	17,989,106	26,204,235	14,048,237	848,524	1,431,557	1,431,557	56,216,434	55,545,580	63,530,926	1,025,945	36,372,562	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	1,219,162
5	23,487,417	16,667,179	25,887,502	13,995,636	821,968	1,370,889	1,370,889	55,465,520	54,810,182	63,513,397	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
10	22,239,364	14,948,663	24,988,129	13,821,612	792,507	1,303,756	1,303,756	54,357,803	53,879,417	63,503,146	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
15	21,153,495	13,246,916	24,169,647	13,653,830	760,490	1,238,869	1,238,869	52,565,050	51,681,137	63,445,446	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
20	18,969,641	12,958,968	22,614,643	13,226,068	712,791	1,188,010	1,188,010	50,467,321	49,487,014	63,445,446	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
25	17,523,050	12,958,968	21,778,156	13,045,519	675,931	1,133,128	1,133,128	49,563,548	48,637,948	63,445,446	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
30	17,142,341	12,958,968	21,516,549	12,980,209	669,307	1,119,999	1,119,999	49,108,043	48,333,004	63,445,446	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
35	16,044,034	12,958,968	20,731,411	12,729,222	663,506	1,116,095	1,116,095	47,196,225	47,000,432	63,445,446	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
40	16,044,034	12,958,968	20,731,411	12,729,222	654,034	1,106,672	1,106,672	47,196,225	47,000,432	63,179,190	1,025,945	34,598,154	3,849,647	5,385,192	12,747,524	6,955,753	475,441	31,358,915	554,488
45	16,044,034	12,958,968	20,731,411	12,729,222	654,034	1,106,672	1,106,672	47,196,225	47,000,432	62,740,511	469,075	29,721,567	1,268,615	2,555,201	8,565,915	2,665,818	119,744	7,464,670	554,488
50	16,044,034	12,958,968	20,731,411	12,729,222	654,034	1,106,672	1,106,672	47,196,225	47,000,432	60,727,294	382,615	24,339,218	996,896	1,940,492	5,780,910	2,295,478	86,071	6,287,350	157,388
55	16,044,034	12,958,968	20,731,411	12,729,222	654,034	1,106,672	1,106,672	47,196,225	47,000,432	53,153,963	336,258	21,403,098	834,868	1,615,850	4,434,380	1,908,434	78,963	6,226,768	81,051
60	10,770,758	12,616,968	14,099,348	7,404,318	585,873	1,106,672	1,106,672	20,491,952	16,412,029	24,552,989	310,545	19,796,160	755,049	1,463,670	3,894,295	1,673,837	66,235	5,909,337	74,160
65	10,770,758	11,122,716	14,099,348	7,404,318	585,873	1,106,672	1,106,672	20,491,952	16,412,029	24,552,989	277,790	17,442,836	655,044	1,271,339	3,274,638	1,371,347	47,981	5,402,496	72,836
70	10,770,758	10,719,404	14,099,348	7,404,318	585,873	1,106,672	1,106,672	20,491,952	16,412,029	24,552,989	269,321	16,813,772	630,297	1,225,446	3,134,865	1,282,988	45,268	5,286,038	72,780
75	10,770,758	10,597,849	14,099,348	7,404,318	585,873	1,106,672	1,106,672	20,491,952	16,412,029	24,552,989	266,583	16,626,522	622,969	1,213,316	3,098,152	1,247,626	45,268	5,268,379	72,485
80	10,770,758	10,095,846	14,099,348	7,404,318	585,873	1,095,959	1,095,959	20,491,952	16,412,029	24,552,989	255,275	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
85	10,770,758	10,095,846	14,099,348	7,404,318	585,873	1,095,959	1,095,959	20,491,952	16,412,029	24,552,989	255,275	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,268	5,195,451	72,485
90	10,770,758	10,095,846	14,099,348	7,404,318	585,873	1,095,959	1,095,959	20,491,952	16,412,029	24,552,989	255,275	15,853,210	592,708	1,163,221	2,946,532	1,101,587	45,201	5,195,451	72,485
95	10,770,758	10,095,846	14,099,348	7,404,318	585,873	1,095,959	1,095,959	20,491,952	16,412,029	24,552,989	255,275	15,853,210	592,708	1,163,221	2,946,532	1,101,587	44,728	5,195,451	72,485
100	10,770,758	10,095,846	14,099,348	7,404,318	585,873	1,095,959	1,095,959	20,491,952	16,412,029	24,552,989	255,275	15,853,210	592,708	1,163,221	2,946,532	1,101,587	44,549	5,195,451	71,306

Table B-6: June Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	American Shad-Spawning	American Shad-Fry	American Shad-Adult	Shortnose Sturgeon-Fry	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Spawning	Striped Bass-Fry	Striped Bass-Juvenile	Striped Bass-Adult	Smallmouth Bass-Spawning	Smallmouth Bass-Fry	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Shallow-Fast	Guilds-Deep-Slow	Guilds-Deep-Fast
0	24,052,567	17,990,214	26,204,557	848,513	1,431,598	1,431,598	56,216,898	55,545,960	30,036,088	63,530,962	1,141,787	2,247,502	36,372,642	4,432,285	6,052,996	12,751,750	18,611,517	791,769	34,257,996	1,219,247
5	23,715,396	17,341,934	25,979,248	838,153	1,397,257	1,397,257	55,576,539	54,914,189	29,832,961	63,507,081	1,115,969	1,884,459	31,259,080	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	694,135
10	23,336,915	16,205,454	25,595,782	817,736	1,354,537	1,354,537	54,840,136	53,972,535	29,343,790	63,445,446	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	319,223
15	22,193,555	14,915,160	24,848,022	792,818	1,303,233	1,303,233	52,984,699	52,154,949	28,333,392	63,445,446	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
20	20,503,061	13,433,674	23,473,515	753,070	1,238,696	1,238,696	50,825,538	49,745,332	26,740,503	62,844,319	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
25	18,182,027	11,682,039	22,019,152	694,333	1,160,873	1,160,873	49,450,486	48,514,659	24,090,786	61,386,033	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
30	17,142,341	11,030,696	21,513,114	669,862	1,121,452	1,121,452	47,196,225	47,000,432	22,692,507	58,477,498	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
35	16,044,034	11,030,696	20,731,411	654,034	1,095,959	1,095,959	47,196,225	47,000,432	21,339,712	52,309,332	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
40	11,909,474	11,030,696	14,940,358	617,202	1,095,959	1,095,959	22,276,947	18,173,727	21,339,712	26,614,078	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
45	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
50	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
55	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	1,115,969	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	656,821	33,822,081	268,075
60	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	984,209	1,353,432	31,245,476	3,572,310	5,130,584	12,258,995	5,607,064	414,269	29,534,678	268,075
65	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	477,022	999,011	29,992,053	1,296,060	2,615,203	8,836,288	2,704,617	124,564	7,635,344	268,075
70	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	416,399	958,321	26,368,231	1,091,268	2,163,950	6,800,360	2,481,358	90,988	6,449,084	268,075
75	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	371,580	932,208	23,665,717	963,766	1,866,228	5,451,639	2,210,441	84,439	6,245,958	119,950
80	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	330,758	901,604	21,058,658	817,540	1,582,751	4,315,207	1,857,143	76,400	6,164,405	79,187
85	7,433,616	11,030,696	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	285,991	838,287	18,073,656	679,914	1,319,410	3,421,350	1,447,823	52,793	5,542,047	72,851
90	7,433,616	10,687,968	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	269,145	800,737	16,801,732	629,825	1,224,666	3,132,504	1,280,714	45,268	5,284,903	72,485
95	7,433,616	10,095,846	11,669,625	479,924	977,987	977,987	15,595,435	11,709,213	18,630,144	18,411,598	255,275	797,300	15,853,210	592,708	1,163,221	2,946,532	1,101,587	44,783	5,195,451	72,485
100	5,581,479	9,841,684	10,307,936	412,570	892,483	892,483	12,908,271	9,225,403	16,765,771	14,876,254	255,275	797,300	15,853,210	592,708	1,163,221	2,946,532	1,101,587	44,547	5,195,451	71,309

Table B-7: July Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	American Shad-Fry	American Shad-Juvenile	Shortnose Sturgeon-Fry	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Fry	Striped Bass-Juvenile	Striped Bass-Adult	Smallmouth Bass-Fry	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	17,989,859	21,651,751	848,524	1,431,561	1,431,561	55,538,095	30,036,002	63,530,962	4,391,296	36,373,846	4,432,285	6,052,996	12,751,750	33,995,037	34,257,996	1,219,290
5	17,565,220	20,687,296	839,270	1,402,995	1,402,995	54,676,688	29,795,419	63,445,446	2,390,372	32,141,704	4,362,102	6,042,834	12,258,995	20,276,557	33,822,390	812,129
10	16,497,989	20,687,296	818,193	1,361,456	1,361,456	52,609,570	29,091,064	61,742,303	2,050,764	31,245,476	4,320,607	5,986,247	12,258,995	16,318,673	33,822,081	396,732
15	14,939,980	20,687,296	787,623	1,300,321	1,300,321	49,092,675	27,727,734	58,376,215	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
20	12,723,563	20,687,296	706,315	1,195,987	1,195,987	46,842,257	24,552,604	52,060,275	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
25	11,030,696	20,687,296	654,034	1,095,959	1,095,959	27,025,715	21,339,712	35,723,875	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
30	11,030,696	20,687,296	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
35	11,030,696	20,687,296	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
40	11,030,696	20,687,296	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
45	11,030,696	20,687,296	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
50	11,030,696	20,687,296	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
55	11,030,696	20,687,296	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
60	11,030,696	20,687,296	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
65	11,030,696	20,543,095	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	31,245,476	4,320,607	5,907,938	12,027,069	13,686,128	33,822,081	268,075
70	11,030,696	20,174,093	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,884,459	29,972,086	4,223,756	5,907,938	11,450,223	13,686,128	32,973,116	268,075
75	11,030,696	19,533,051	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	1,034,973	28,729,118	2,411,640	3,984,452	10,589,839	2,852,624	21,054,702	202,348
80	11,030,696	18,665,734	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	987,935	27,247,806	1,304,823	2,632,821	8,766,806	2,656,042	7,707,918	159,502
85	10,678,228	17,407,567	479,924	977,987	977,987	11,709,213	18,630,144	18,411,598	941,012	25,558,806	1,095,517	2,174,009	6,846,255	2,400,437	6,456,365	111,503
90	10,146,190	14,853,565	442,487	932,900	932,900	10,194,552	17,676,314	16,338,654	915,389	22,745,093	929,861	1,800,370	5,184,068	2,126,612	6,240,910	78,234
95	9,457,378	11,520,693	390,845	863,132	863,132	8,521,616	16,104,543	13,814,274	836,292	18,015,163	677,608	1,314,952	3,407,746	1,440,732	5,529,108	72,485
100	5,287,746	9,969,840	163,765	449,926	449,926	2,136,988	7,827,598	3,777,742	797,300	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	12,711

Table B-8: August Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	American Shad-Juvenile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Juvenile	Striped Bass-Adult	Smallmouth Bass-Juvenile	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	21,651,751	1,431,542	1,431,542	30,036,088	63,530,962	26,005,058	36,373,525	4,432,285	6,052,996	12,751,825	33,995,037	34,257,996	1,219,290
5	20,687,296	1,395,978	1,395,978	29,554,142	62,163,699	26,005,058	33,336,079	4,432,285	6,052,996	12,258,995	24,276,087	34,257,996	876,684
10	20,687,296	1,336,327	1,336,327	27,727,734	56,617,358	25,992,557	31,245,476	4,408,890	6,049,536	12,258,995	21,887,007	34,112,794	375,603
15	20,687,296	1,207,954	1,207,954	24,500,553	45,446,637	25,947,922	31,245,476	4,323,156	6,037,181	12,258,995	19,475,882	33,822,081	268,075
20	20,687,296	977,987	977,987	18,630,144	18,411,598	25,900,471	31,245,476	4,320,607	6,024,046	12,258,995	17,142,095	33,822,081	268,075
25	20,687,296	977,987	977,987	18,630,144	18,411,598	25,729,644	31,245,476	4,320,607	5,943,497	12,258,995	16,318,673	33,822,081	268,075
30	20,687,296	977,987	977,987	18,630,144	18,411,598	25,729,644	31,245,476	4,320,607	5,907,938	12,258,995	16,318,673	33,822,081	268,075
35	20,687,296	977,987	977,987	18,630,144	18,411,598	25,729,644	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
40	20,687,296	977,987	977,987	18,630,144	18,411,598	25,729,644	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
45	20,687,296	977,987	977,987	18,630,144	18,411,598	25,729,644	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
50	20,687,296	977,987	977,987	18,630,144	18,411,598	25,729,644	31,245,476	4,320,607	5,907,938	12,258,995	13,686,128	33,822,081	268,075
55	20,486,085	977,987	977,987	18,630,144	18,411,598	25,729,644	31,245,476	4,320,607	5,907,938	12,027,069	13,686,128	33,822,081	268,075
60	20,391,614	977,987	977,987	18,630,144	18,411,598	25,729,644	29,972,086	4,320,607	5,907,938	12,027,069	13,686,128	33,822,081	268,075
65	20,285,438	977,987	977,987	18,630,144	18,411,598	25,729,644	29,972,086	4,316,996	5,907,938	11,735,245	13,686,128	33,551,834	175,275
70	19,910,160	932,900	932,900	17,676,314	16,338,654	25,729,644	29,226,786	4,228,973	5,907,938	11,374,750	13,686,128	33,011,767	175,275
75	19,479,963	932,900	932,900	17,676,314	16,338,654	25,618,200	28,226,880	4,041,426	5,907,938	11,003,021	13,686,128	32,189,486	152,846
80	19,105,600	918,385	918,385	17,349,313	15,813,467	23,834,007	27,196,885	3,351,736	5,100,381	10,473,709	13,686,128	28,266,779	121,148
85	18,354,178	877,246	877,246	16,422,511	14,324,953	15,083,349	26,113,011	1,628,162	3,090,539	9,780,887	2,681,623	12,644,239	92,467
90	17,433,624	834,744	834,744	15,464,995	12,787,112	7,023,179	24,970,965	1,156,078	2,309,161	7,001,556	2,380,530	6,764,821	72,808
95	13,542,310	774,730	774,730	14,220,760	11,128,938	3,908,250	20,911,326	889,759	1,722,474	4,867,585	2,066,783	6,234,940	66,967
100	9,969,840	449,926	449,926	7,827,598	3,777,742	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	12,711

Table B-9: September Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	American Shad-Juvenile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Juvenile	Striped Bass-Adult	Smallmouth Bass-Juvenile	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	21,651,763	1,431,542	1,431,542	30,034,582	63,530,119	26,005,058	36,371,679	4,432,285	6,052,996	12,751,723	33,995,037	34,257,996	1,219,290
5	21,083,995	1,395,615	1,395,615	29,271,209	63,429,745	25,991,060	34,595,697	4,408,217	6,049,121	12,258,995	25,988,359	34,108,615	971,236
10	20,687,296	1,332,618	1,332,618	27,443,543	58,963,984	25,943,432	31,245,476	4,320,607	6,035,938	12,258,995	24,215,796	33,822,081	538,228
15	20,687,296	1,217,819	1,217,819	24,518,602	47,787,361	25,943,432	31,245,476	4,320,607	6,035,938	12,258,995	23,142,612	33,822,081	268,075
20	20,687,296	1,095,959	1,095,959	21,339,712	33,656,166	25,943,432	31,245,476	4,320,607	6,035,938	12,258,995	23,142,612	33,822,081	268,075
25	20,687,296	977,987	977,987	18,630,144	18,411,598	25,943,432	31,245,476	4,320,607	6,035,938	12,027,069	19,503,178	33,822,081	268,075
30	20,391,614	977,987	977,987	18,630,144	18,411,598	25,943,432	29,992,053	4,314,472	6,035,938	11,801,041	19,503,178	33,526,764	268,075
35	20,011,760	977,987	977,987	18,630,144	18,411,598	25,897,566	29,731,368	4,314,472	6,023,242	11,485,220	19,503,178	33,526,764	175,275
40	19,750,895	977,987	977,987	18,630,144	18,411,598	25,873,004	28,351,869	4,314,472	6,016,443	11,485,220	19,503,178	33,526,764	157,191
45	19,750,895	932,900	932,900	17,676,314	16,338,654	25,779,181	28,351,869	4,314,472	5,984,211	11,485,220	19,503,178	33,526,764	127,684
50	19,750,895	891,280	891,280	16,738,672	14,832,730	25,729,644	28,351,869	4,314,472	5,907,938	11,485,220	18,679,756	33,526,764	127,684
55	19,750,895	876,765	876,765	16,411,671	14,307,543	25,729,644	28,351,869	4,247,992	5,907,938	11,485,220	16,318,673	33,150,701	127,684
60	19,750,895	876,765	876,765	16,411,671	14,307,543	25,729,644	28,351,869	4,179,828	5,907,938	11,167,047	13,686,128	32,691,070	127,684
65	19,268,086	876,765	876,765	16,411,671	14,307,543	25,729,644	28,023,518	4,168,141	5,907,938	10,865,964	13,686,128	32,691,070	127,684
70	19,018,645	876,765	876,765	16,411,671	14,307,543	25,354,508	26,500,192	3,871,652	5,836,963	10,865,964	13,686,128	31,522,263	101,297
75	18,939,243	876,765	876,765	16,411,671	14,307,543	24,963,414	26,500,192	3,637,905	5,702,946	10,358,496	13,686,128	30,635,743	73,294
80	18,194,706	812,610	812,610	14,966,365	11,986,274	21,663,837	25,775,968	2,566,447	4,245,624	9,863,056	3,185,504	23,000,065	73,294
85	17,546,594	812,610	812,610	14,966,365	11,986,274	13,348,866	24,692,417	1,513,725	2,928,542	9,258,150	2,496,164	10,897,157	72,485
90	16,557,924	776,745	776,745	14,260,420	11,174,541	5,538,409	23,600,510	1,070,862	2,115,630	6,579,919	2,214,662	6,414,111	67,303
95	11,722,623	717,506	717,506	13,094,421	9,833,814	3,337,848	18,300,409	688,853	1,336,689	3,474,087	1,475,313	5,592,210	57,408
100	9,969,840	449,926	449,926	7,827,598	3,777,742	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	12,711

Table B-10: October Habitat Exceedance Percentiles. Areas listed in ft^2.

Exceedance Percentile	American Shad-Juvenile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Juvenile	Striped Bass-Adult	Smallmouth Bass-Juvenile	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	21,651,726	1,431,557	1,431,557	30,034,951	63,530,878	26,004,794	36,372,562	4,431,780	6,052,923	12,751,718	30,051,989	34,254,862	1,218,604
5	21,144,843	1,405,043	1,405,043	29,535,518	63,445,446	25,943,432	34,852,357	4,314,472	6,035,938	11,485,220	25,301,038	33,526,764	1,020,787
10	19,750,895	1,367,950	1,367,950	28,389,401	62,915,149	25,943,432	30,852,075	4,314,472	6,035,938	11,485,220	23,142,612	33,526,764	703,664
15	19,750,895	1,301,027	1,301,027	27,131,847	59,537,379	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	261,738
20	19,750,895	1,210,875	1,210,875	24,395,997	52,563,650	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
25	19,750,895	1,117,936	1,117,936	22,551,760	43,830,530	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
30	19,750,895	1,095,959	1,095,959	21,339,712	29,679,213	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
35	19,750,895	876,765	876,765	16,411,671	14,307,543	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
40	19,750,895	876,765	876,765	16,411,671	14,307,543	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
45	19,750,895	876,765	876,765	16,411,671	14,307,543	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
50	19,750,895	876,765	876,765	16,411,671	14,307,543	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
55	19,750,895	876,765	876,765	16,411,671	14,307,543	25,873,004	28,351,869	4,307,352	6,016,443	11,485,220	19,503,178	33,526,764	127,684
60	19,750,895	876,765	876,765	16,411,671	14,307,543	25,828,561	28,351,869	4,168,948	6,000,836	11,191,601	19,503,178	32,674,739	127,684
65	19,585,268	876,765	876,765	16,411,671	14,307,543	25,285,375	28,351,869	3,835,819	5,809,141	10,865,964	19,503,178	31,377,620	127,684
70	19,018,645	876,765	876,765	16,411,671	14,307,543	23,211,322	26,500,192	3,172,376	4,747,953	10,370,257	4,181,541	26,741,702	127,684
75	18,493,205	876,765	876,765	16,411,671	14,307,543	16,280,890	26,266,212	1,707,173	3,202,386	9,865,930	2,675,990	13,850,478	78,600
80	17,712,200	876,765	876,765	16,411,671	14,307,543	9,831,882	25,082,384	1,287,796	2,597,137	8,709,252	2,427,845	7,583,954	73,294
85	16,648,989	876,765	876,765	16,411,671	14,307,543	5,226,448	24,342,135	1,046,809	2,058,679	6,320,097	2,178,209	6,372,891	72,485
90	13,459,439	812,610	812,610	14,966,365	11,986,274	3,600,217	20,791,622	804,322	1,557,564	4,226,178	1,818,371	6,110,455	72,240
95	10,491,836	740,476	740,476	13,546,543	10,353,688	3,128,716	16,572,416	620,852	1,209,811	3,087,544	1,237,408	5,263,277	61,245
100	9,969,840	581,701	581,701	10,421,350	6,760,175	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	34,723

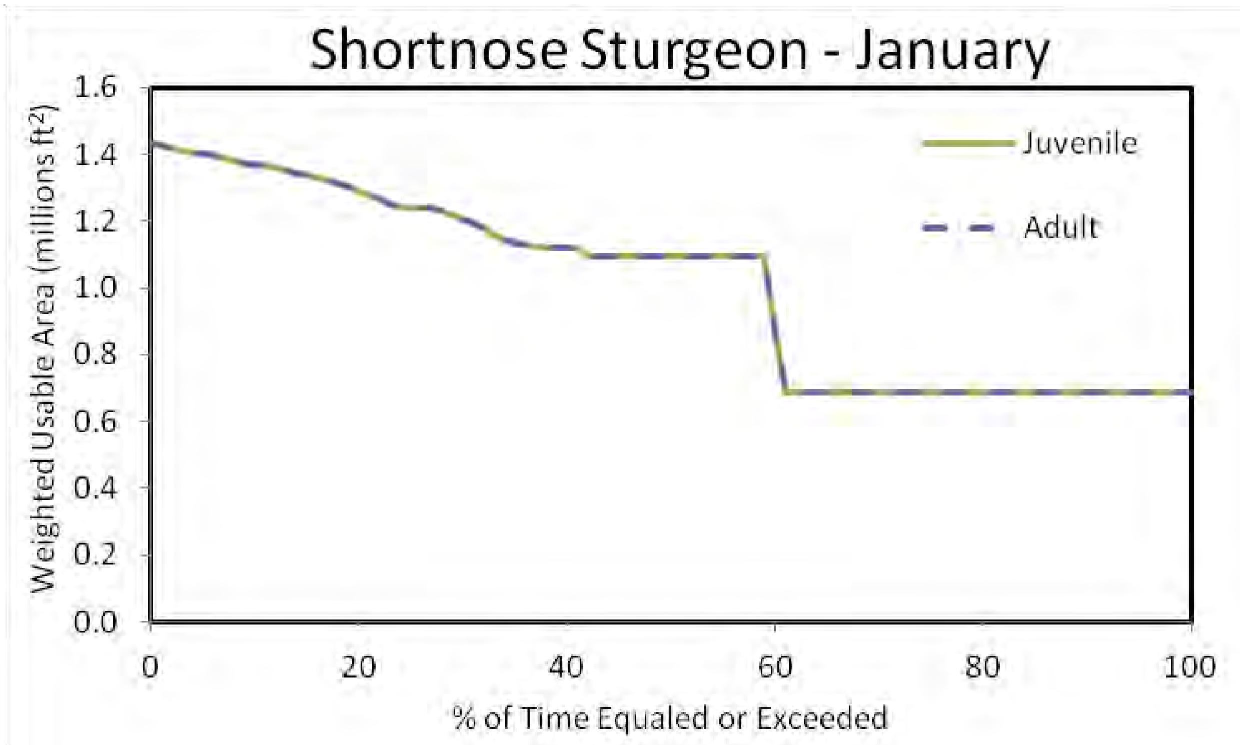
Table B-11: November Habitat Exceedance Percentiles. Areas listed in ft^2.

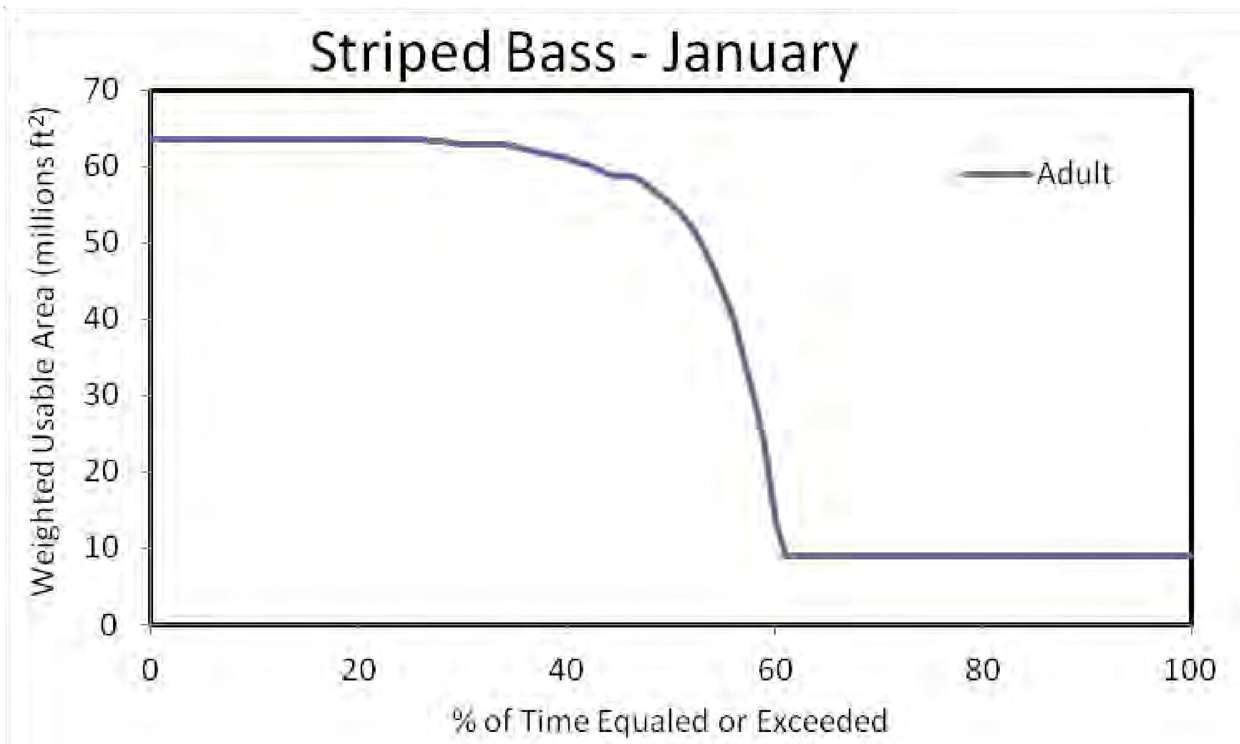
Exceedance Percentile	American Shad-Juvenile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Juvenile	Striped Bass-Adult	Smallmouth Bass-Juvenile	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	21,651,567	1,431,575	1,431,575	30,036,145	63,530,962	26,004,529	36,372,513	4,431,275	6,052,850	12,751,728	28,701,465	34,253,636	1,219,290
5	20,719,821	1,399,988	1,399,988	29,808,396	63,506,685	25,943,432	33,394,237	4,314,472	6,035,938	11,485,220	23,142,612	33,526,764	890,083
10	19,750,895	1,357,349	1,357,349	29,168,079	63,445,446	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	457,536
15	19,750,895	1,310,688	1,310,688	27,836,790	63,445,446	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	206,298
20	19,750,895	1,242,208	1,242,208	27,349,375	63,004,178	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
25	19,750,895	1,216,237	1,216,237	25,563,197	62,784,821	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
30	19,750,895	1,144,077	1,144,077	23,407,396	60,255,837	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
35	19,750,895	1,117,971	1,117,971	22,554,003	56,129,423	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
40	19,750,895	1,095,959	1,095,959	21,339,712	46,196,954	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
45	19,750,895	1,095,959	1,095,959	21,141,749	24,134,520	25,943,432	28,351,869	4,314,472	6,035,938	11,485,220	19,503,178	33,526,764	127,684
50	19,750,895	876,765	876,765	16,411,671	14,307,543	25,873,004	28,351,869	4,179,828	6,016,443	11,485,220	19,503,178	32,691,070	127,684
55	19,750,895	876,765	876,765	16,411,671	14,307,543	24,557,505	28,351,869	3,454,599	5,436,886	10,865,964	7,229,582	29,632,575	127,684
60	19,018,645	876,765	876,765	16,411,671	14,307,543	14,527,362	27,337,924	1,591,479	3,038,611	9,804,146	2,709,772	12,084,214	127,684
65	17,736,734	876,765	876,765	16,411,671	14,307,543	7,361,256	25,789,895	1,171,932	2,343,824	7,613,450	2,505,830	6,863,418	127,684
70	16,295,351	876,765	876,765	16,411,671	14,307,543	4,835,563	24,342,754	1,016,672	1,987,319	5,994,542	2,252,807	6,321,242	78,607
75	13,799,599	876,765	876,765	16,411,671	14,307,543	3,649,278	21,282,971	828,643	1,603,909	4,389,992	1,889,712	6,209,724	75,187
80	13,227,071	876,765	876,765	16,411,671	14,307,543	3,566,702	20,455,974	787,708	1,525,905	4,114,274	1,769,637	6,042,642	72,860
85	11,234,795	876,765	876,765	16,411,671	14,307,543	3,256,981	17,611,305	661,686	1,284,177	3,313,819	1,391,771	5,439,765	72,485
90	10,572,731	876,765	876,765	16,411,671	14,307,543	3,143,480	16,683,874	625,213	1,217,031	3,109,397	1,258,457	5,273,788	72,485
95	9,969,840	812,610	812,610	14,966,365	11,986,274	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	72,055
100	9,969,840	626,835	626,835	11,309,730	7,781,682	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	42,262

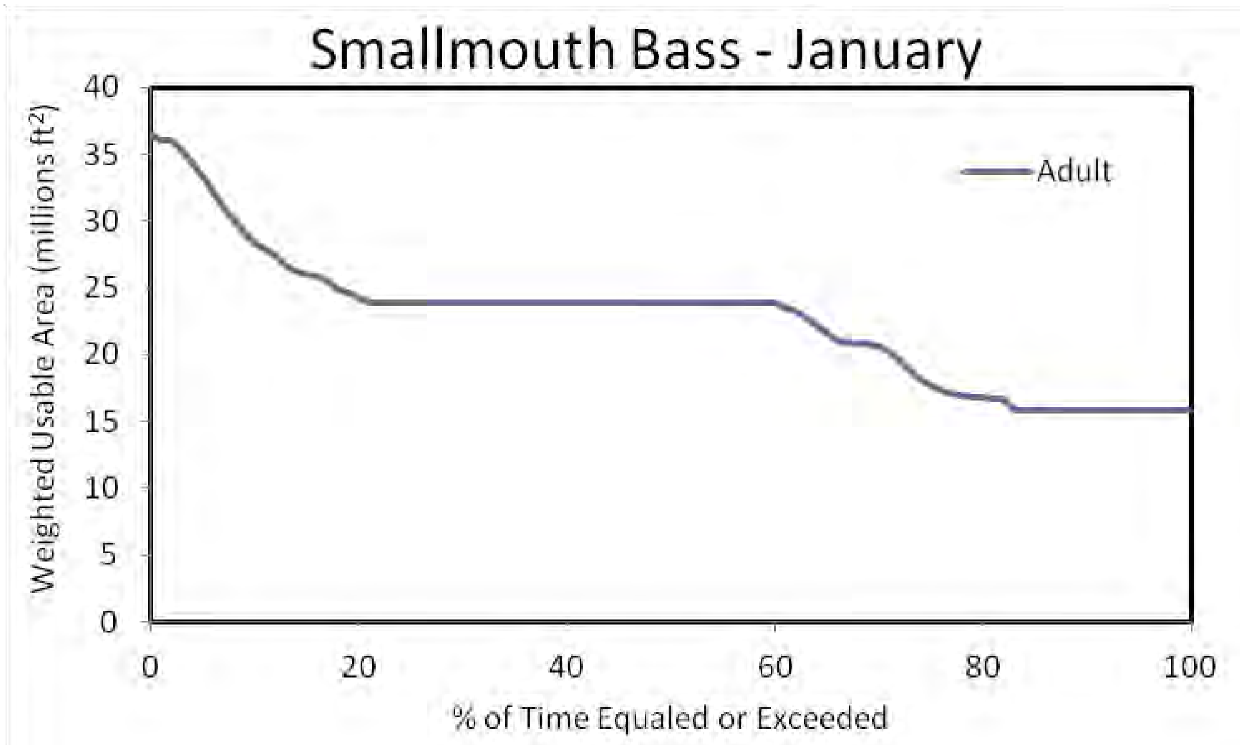
Table B-12: December Habitat Exceedance Percentiles. Areas listed in ft^2.

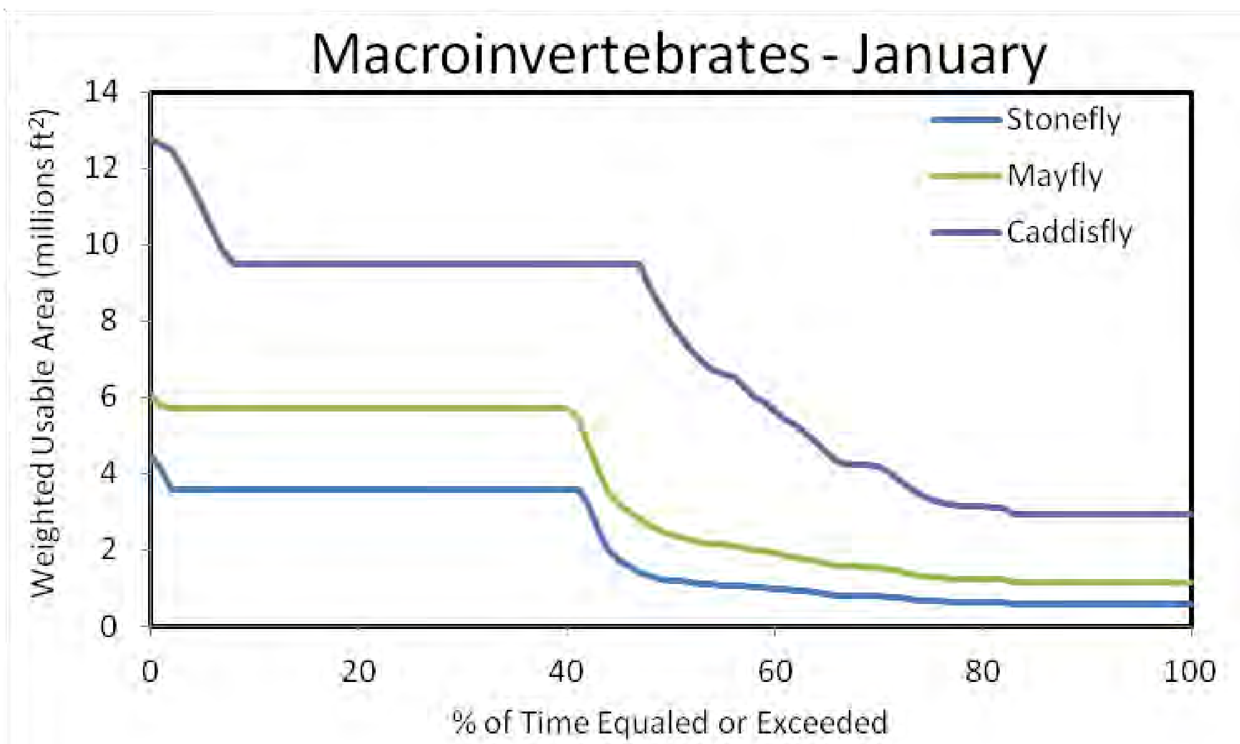
Exceedance Percentile	Shortnose Sturgeon-Juvenile	Shortnose Sturgeon-Adult	Striped Bass-Juvenile	Striped Bass-Adult	Smallmouth Bass-Juvenile	Smallmouth Bass-Adult	Macroinver-tebrates-Stonefly	Macroinver-tebrates-Mayfly	Macroinver-tebrates-Caddisfly	Guilds-Shallow-Slow	Guilds-Deep-Slow	Guilds-Deep-Fast
0	1,431,589	1,431,589	30,036,088	63,530,962	26,004,529	36,372,160	4,432,006	6,052,850	12,751,669	30,176,591	34,256,906	1,219,219
5	1,398,753	1,398,753	29,841,318	63,511,287	24,934,773	32,842,279	3,595,462	5,694,125	11,485,220	26,961,058	30,474,769	812,129
10	1,367,327	1,367,327	29,527,060	63,450,014	24,934,773	28,351,869	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	418,376
15	1,321,246	1,321,246	28,781,769	63,445,446	24,934,773	26,033,500	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	219,905
20	1,272,613	1,272,613	27,672,899	63,445,446	24,934,773	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	117,374
25	1,239,826	1,239,826	26,827,405	63,445,446	24,934,773	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	81,971
30	1,181,187	1,181,187	24,438,266	63,087,225	24,934,773	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	76,429
35	1,127,626	1,127,626	23,036,994	62,797,257	24,934,773	23,853,989	3,595,462	5,694,125	9,500,975	26,961,058	30,474,769	72,842
40	1,118,471	1,118,471	22,575,872	61,509,329	24,934,773	23,853,989	3,595,462	5,694,125	9,500,975	19,503,178	30,474,769	72,563
45	1,095,959	1,095,959	21,339,712	58,945,361	17,566,559	23,853,989	1,856,811	3,379,167	9,500,975	2,784,142	15,584,844	72,485
50	1,095,959	1,095,959	21,339,712	55,302,003	7,934,553	23,853,989	1,198,818	2,402,604	7,878,313	2,647,395	7,030,615	72,485
55	1,095,959	1,095,959	21,339,712	41,783,798	5,548,541	23,853,989	1,071,643	2,117,480	6,588,357	2,389,071	6,415,450	72,485
60	876,765	876,765	16,411,671	14,307,543	4,182,057	23,459,755	952,032	1,843,436	5,359,039	2,192,512	6,244,211	71,508
65	684,999	684,999	12,454,576	9,098,087	3,644,597	21,236,087	826,322	1,599,487	4,374,361	1,882,904	6,200,252	51,978
70	684,999	684,999	12,454,576	9,098,087	3,535,440	20,142,877	772,211	1,496,373	4,009,889	1,724,178	5,979,386	51,978
75	684,999	684,999	12,454,576	9,098,087	3,237,902	17,448,729	655,277	1,271,788	3,276,008	1,372,061	5,403,800	51,978
80	684,999	684,999	12,454,576	9,098,087	3,155,051	16,771,233	628,632	1,222,690	3,126,525	1,274,954	5,282,026	51,978
85	684,999	684,999	12,454,576	9,098,087	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
90	684,999	684,999	12,454,576	9,098,087	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
95	684,999	684,999	12,454,576	9,098,087	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	51,978
100	577,537	577,537	10,339,386	6,665,929	3,033,449	15,853,210	592,708	1,163,221	2,946,532	1,101,587	5,195,451	34,027

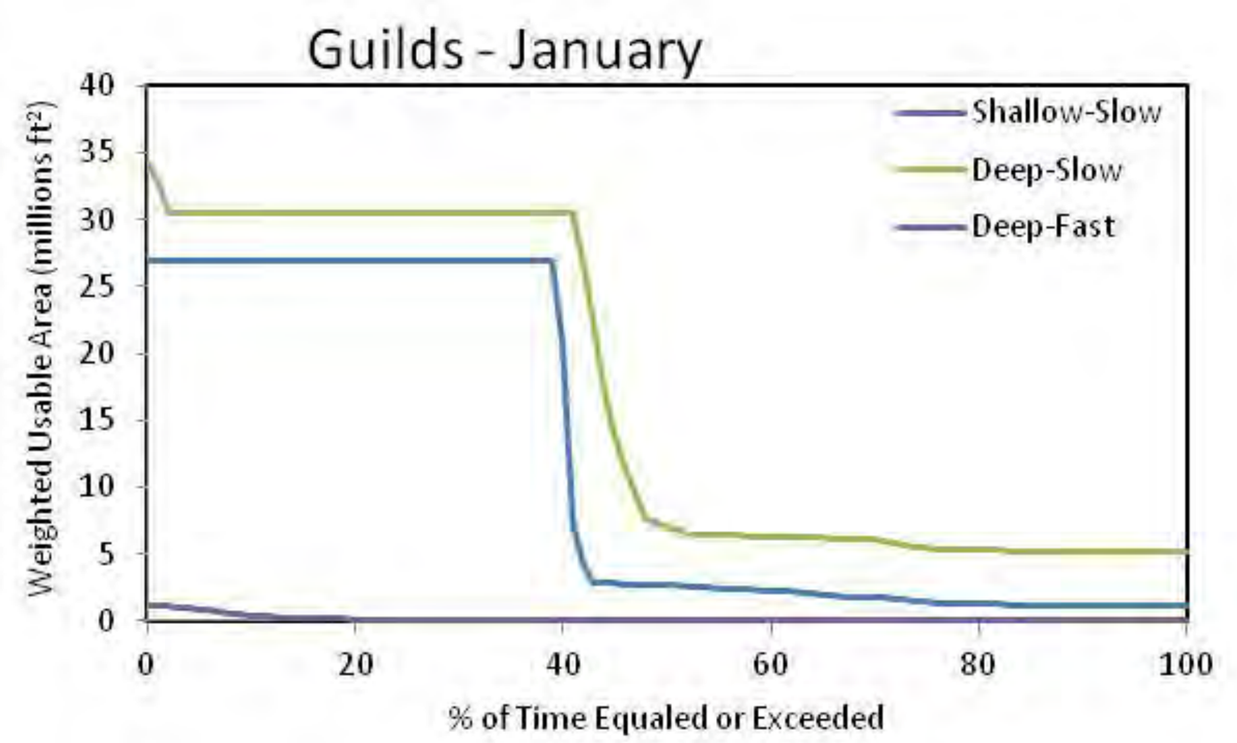
APPENDIX C: MONTHLY HABITAT DURATION CURVES – PERIOD OF RECORD JAN 1930 TO DEC 2007.

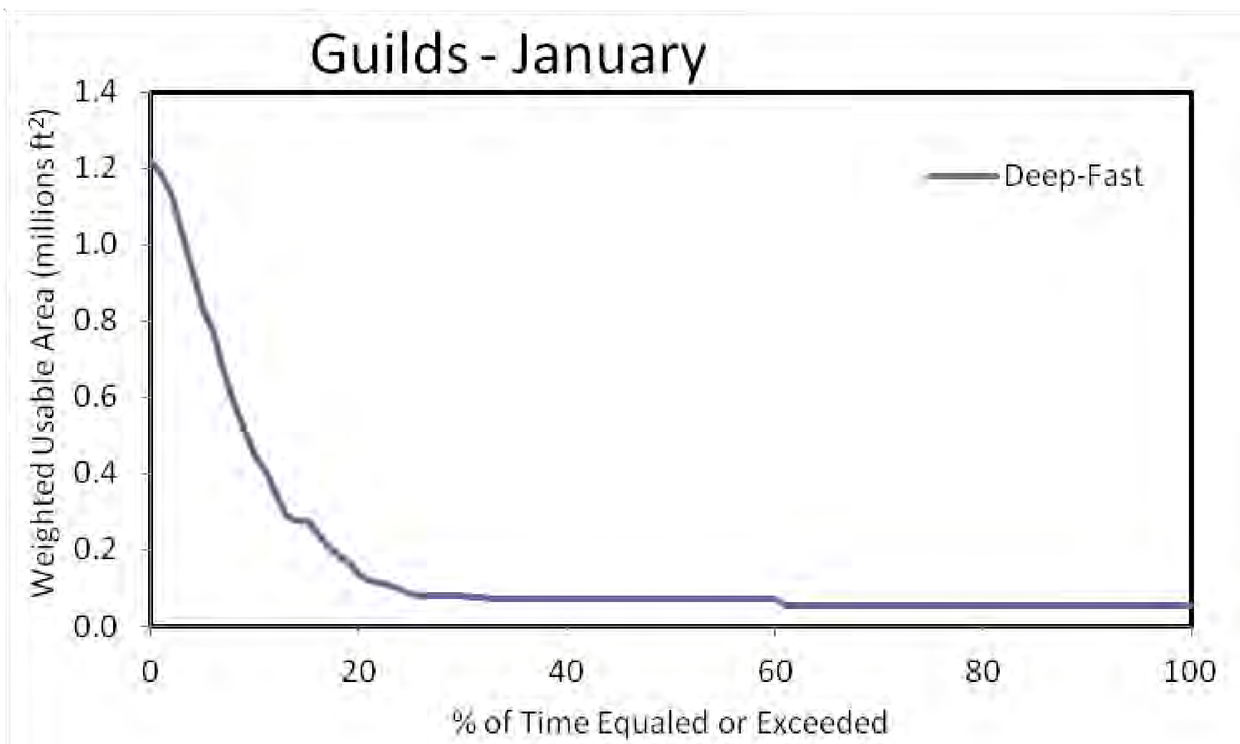

Shortnose Sturgeon - January
Juvenile
Adult
Weighted Usable Area (millions ft²)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded

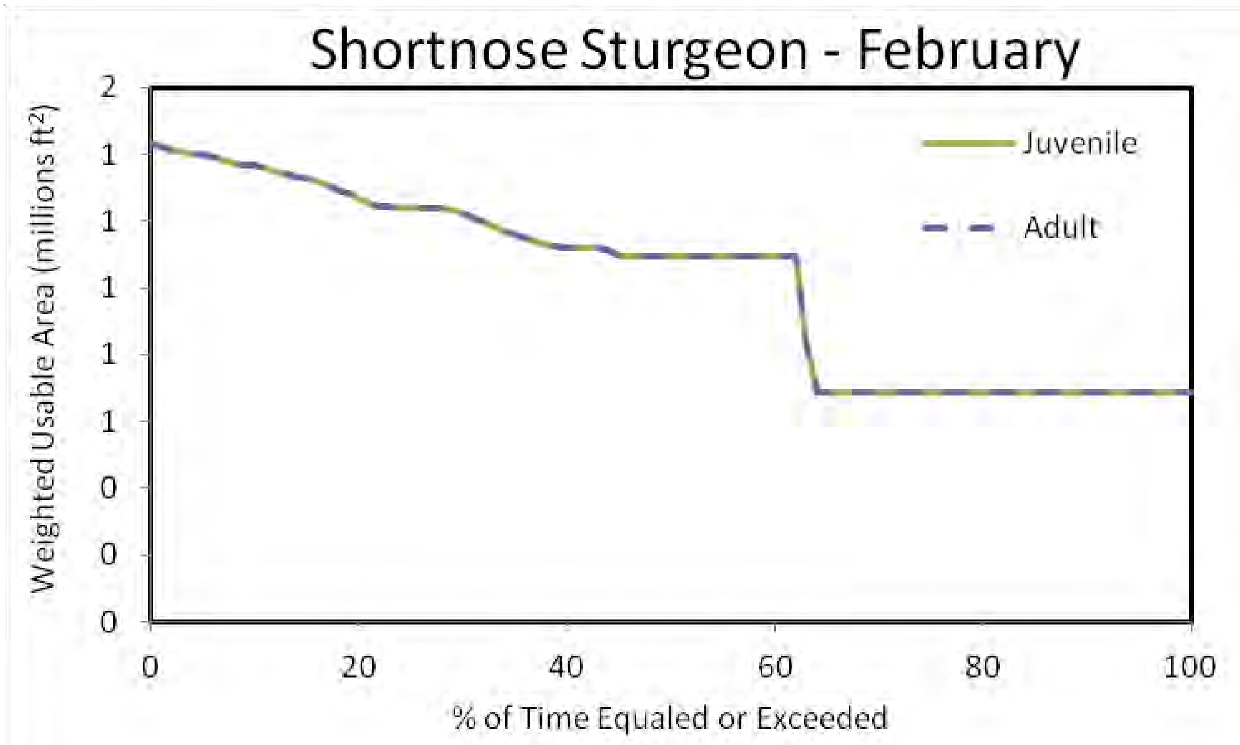

Striped Bass - January
Adult
Weighted Usable Area (millions ft²)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded

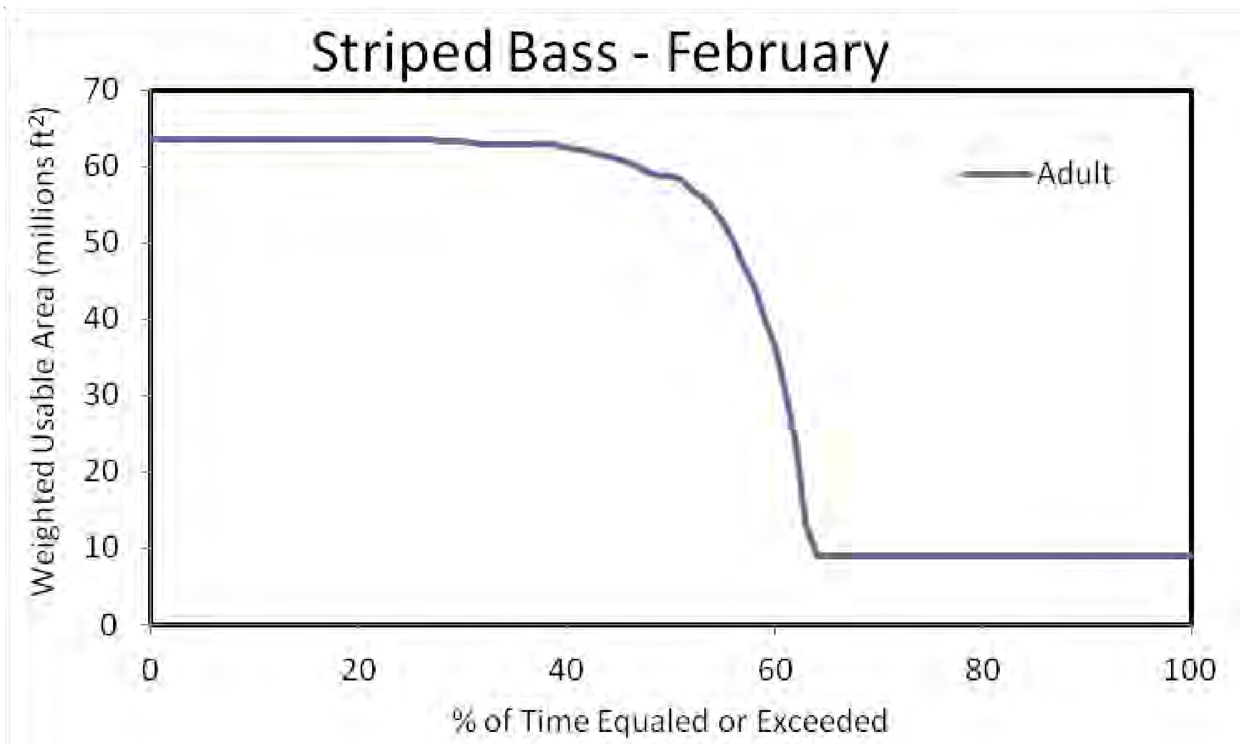

Smallmouth Bass - January
Adult
Weighted Usable Area (millions ft2)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
% of Time Equaled or Exceeded

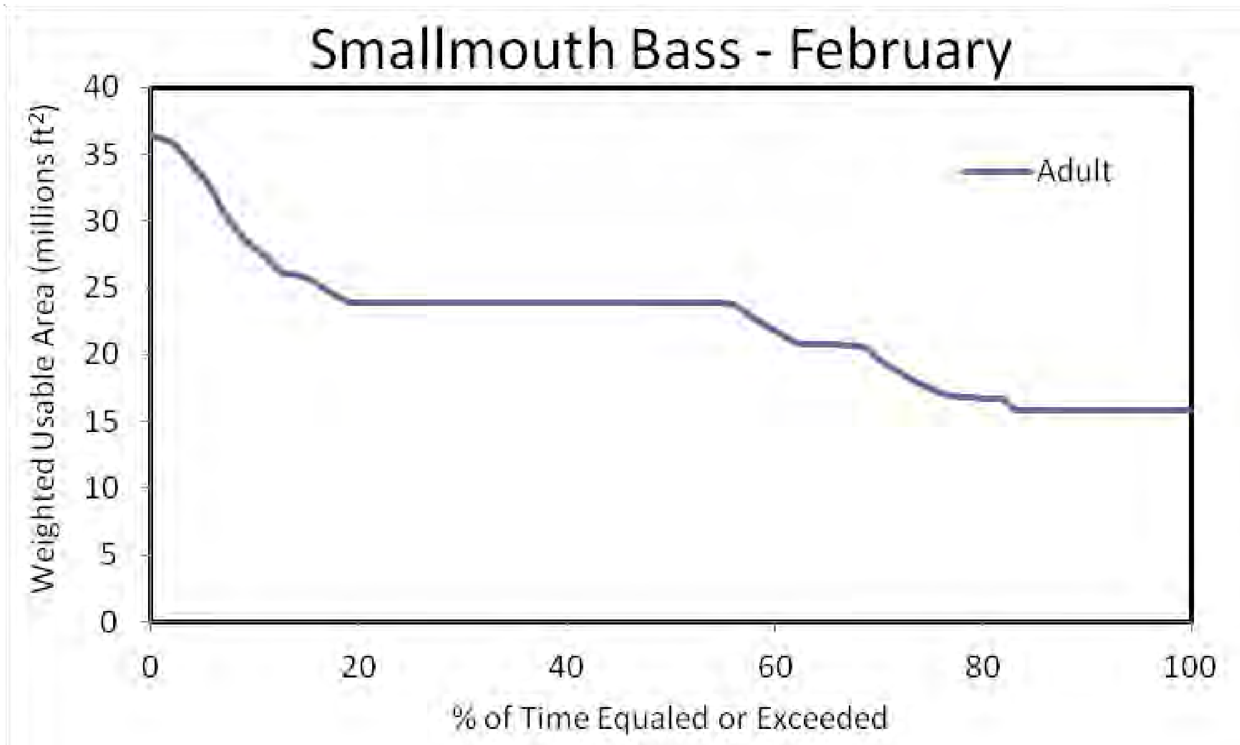

Macroinvertebrates - January
Stonefly
Mayfly
Caddisfly
Weighted Usable Area (millions ft2)
0
2
4
6
8
10
12
14
0
20
40
60
80
100
% of Time Equaled or Exceeded

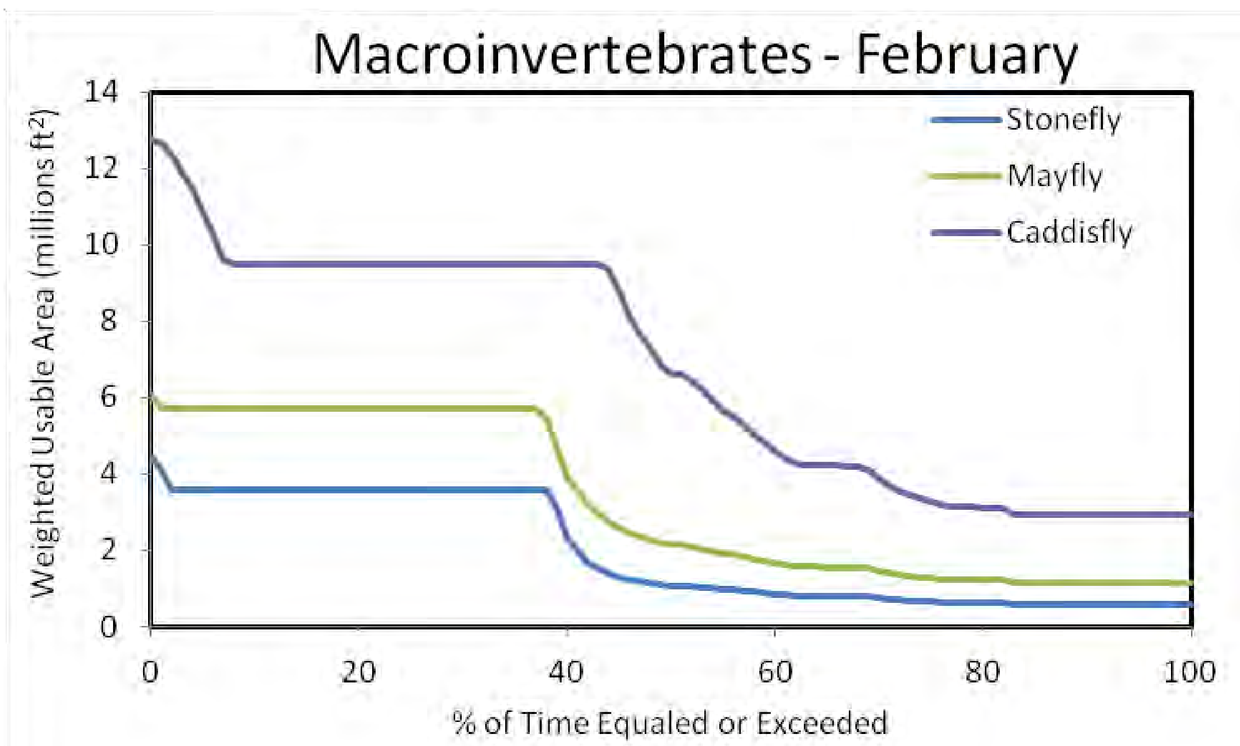

Guilds - January
Weighted Usable Area (millions ft²)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast

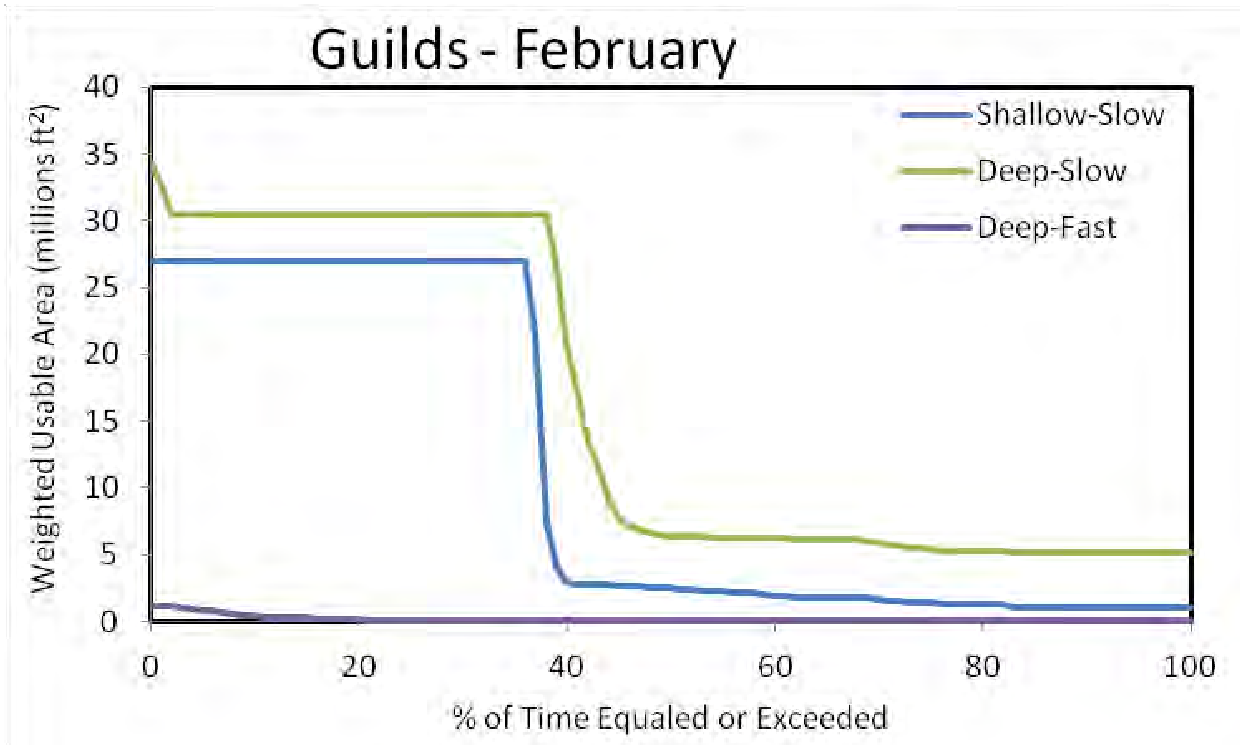

Guilds - January
Weighted Usable Area (millions ft²)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Deep-Fast

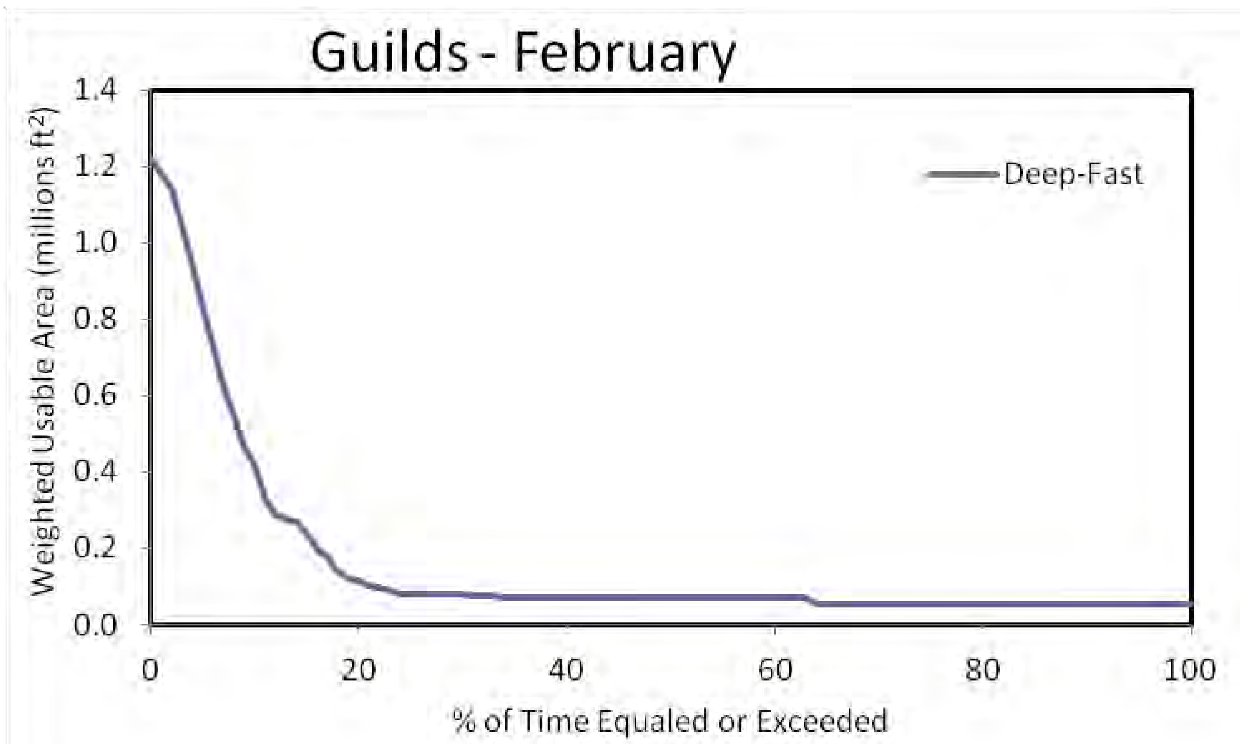

Shortnose Sturgeon - February
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
Juvenile
Adult
2
1
1
1
1
1
0
0
0
0
20
40
60
80
100

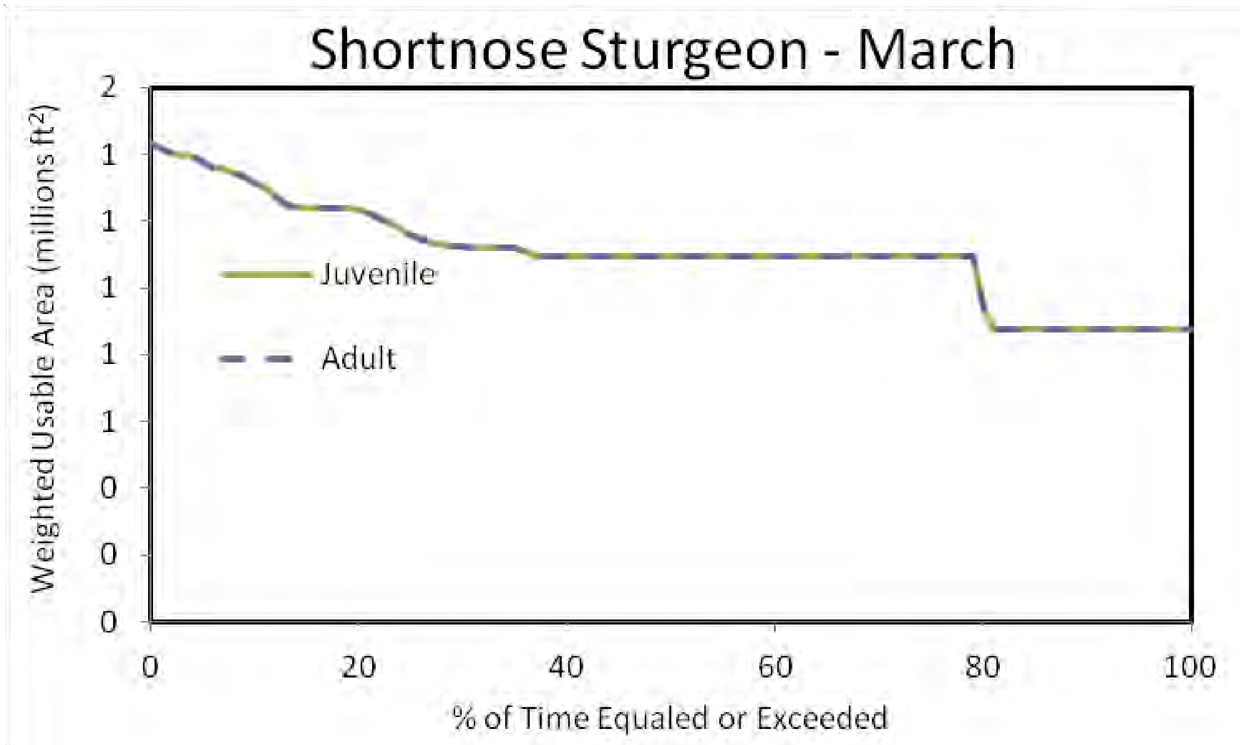

Striped Bass - February
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
Adult
70
60
50
40
30
20
10
0
0
20
40
60
80
100


Smallmouth Bass - February
Adult
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100

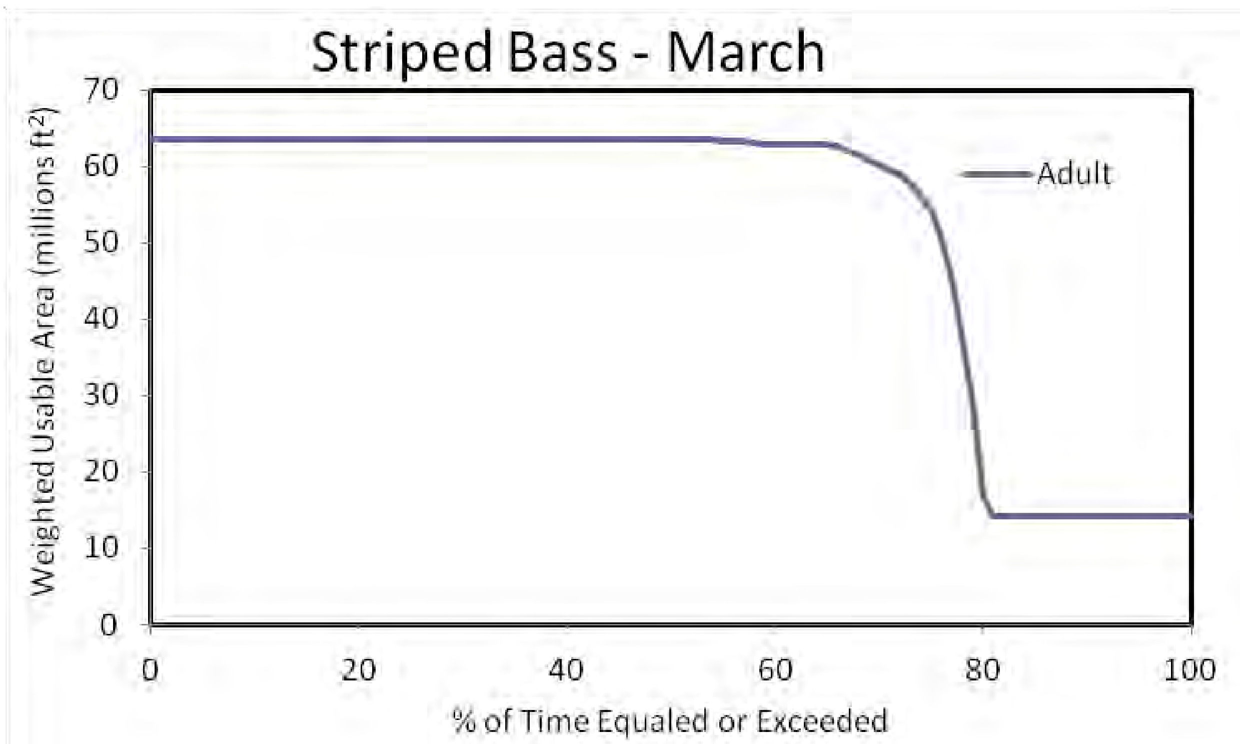

Macroinvertebrates - February
Stonefly
Mayfly
Caddisfly
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0
2
4
6
8
10
12
14
0
20
40
60
80
100


Guilds - February
Weighted Usable Area (millions ft2)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast

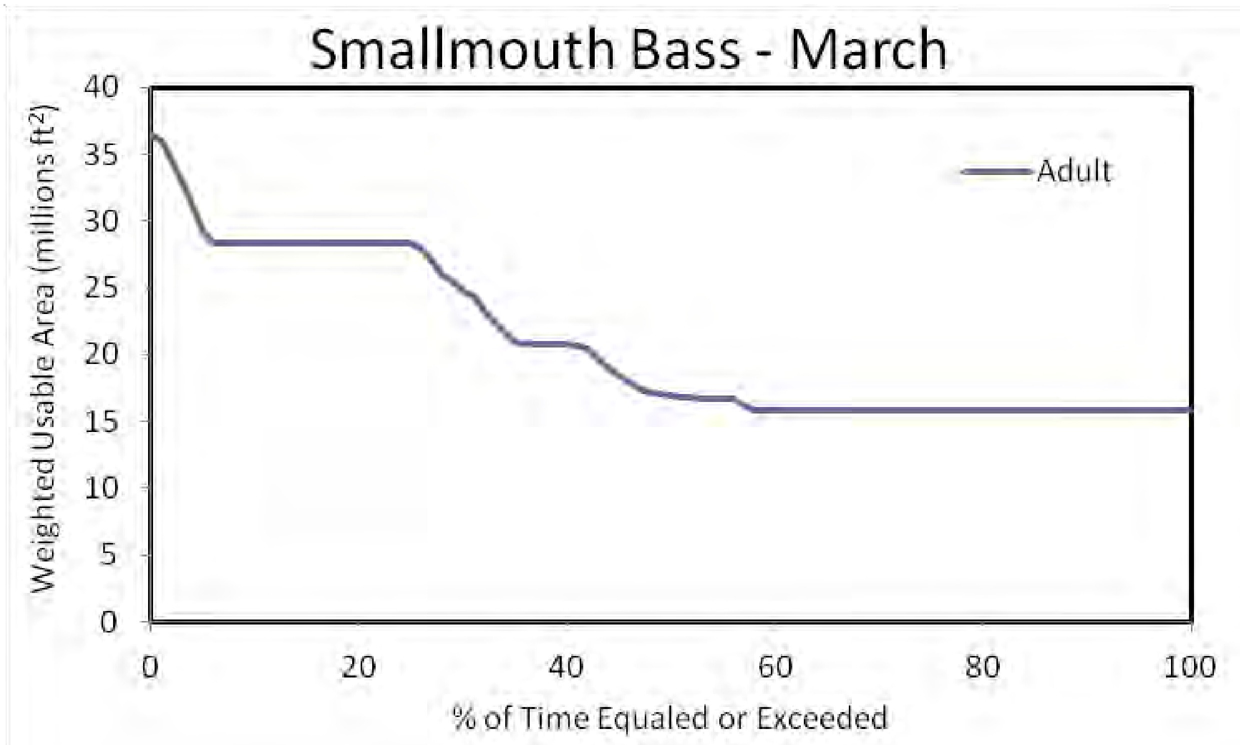

Guilds - February
Weighted Usable Area (millions ft2)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Deep-Fast



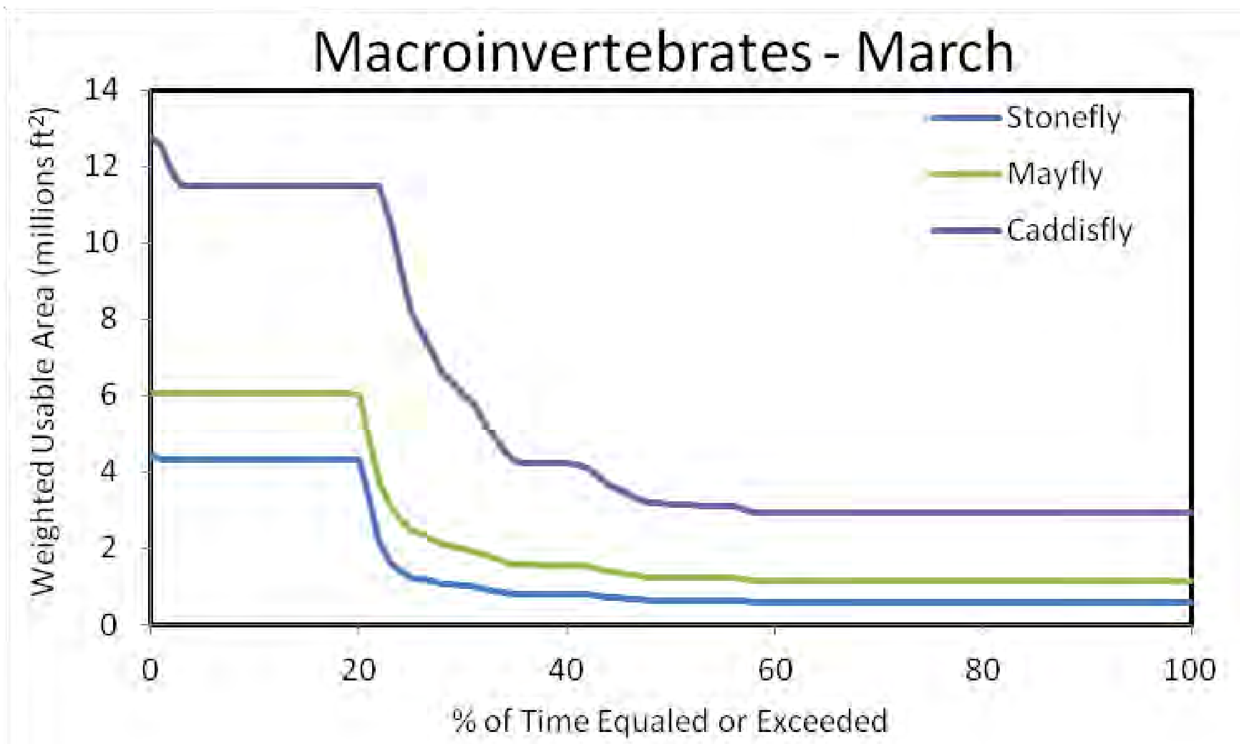
Shortnose Sturgeon - March
Weighted Usable Area (millions ft2)
2
1
1
1
1
1
0
0
0
Juvenile
Adult
0
20
40
60
80
100
% of Time Equaled or Exceeded



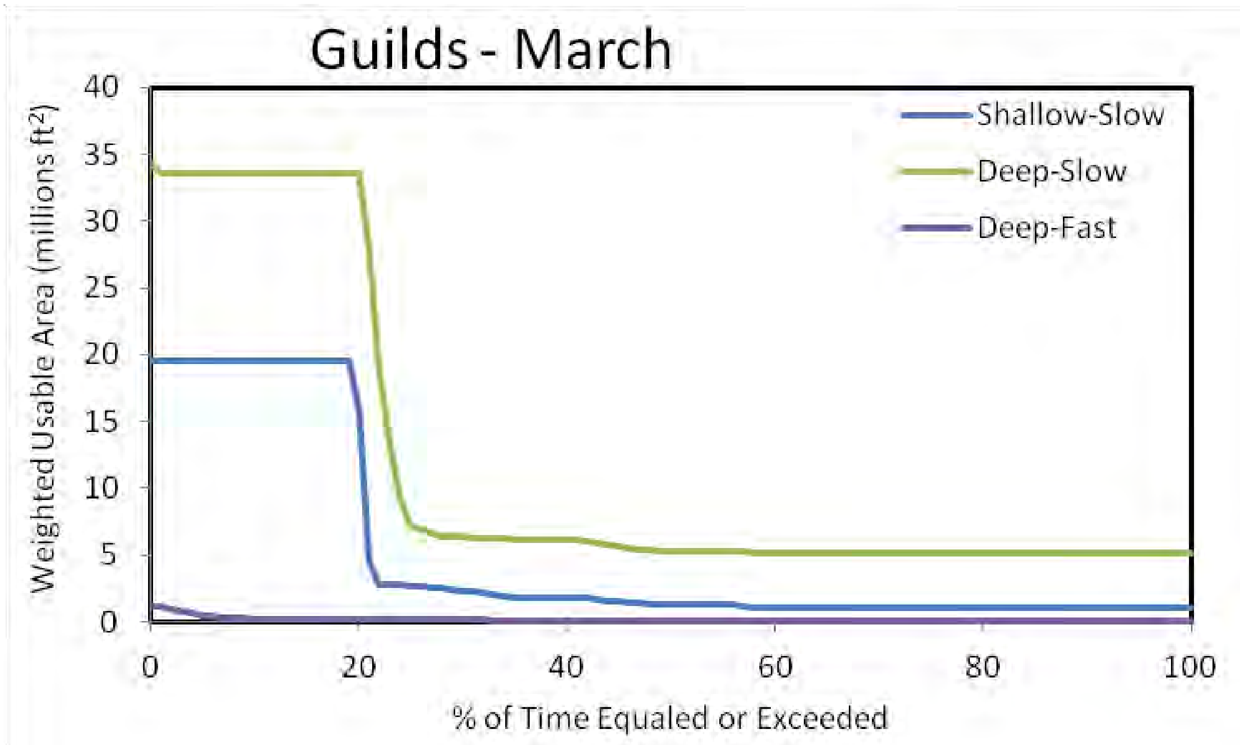
Striped Bass - March
Weighted Usable Area (millions ft2)
70
60
50
40
30
20
10
0
Adult
0
20
40
60
80
100
% of Time Equaled or Exceeded

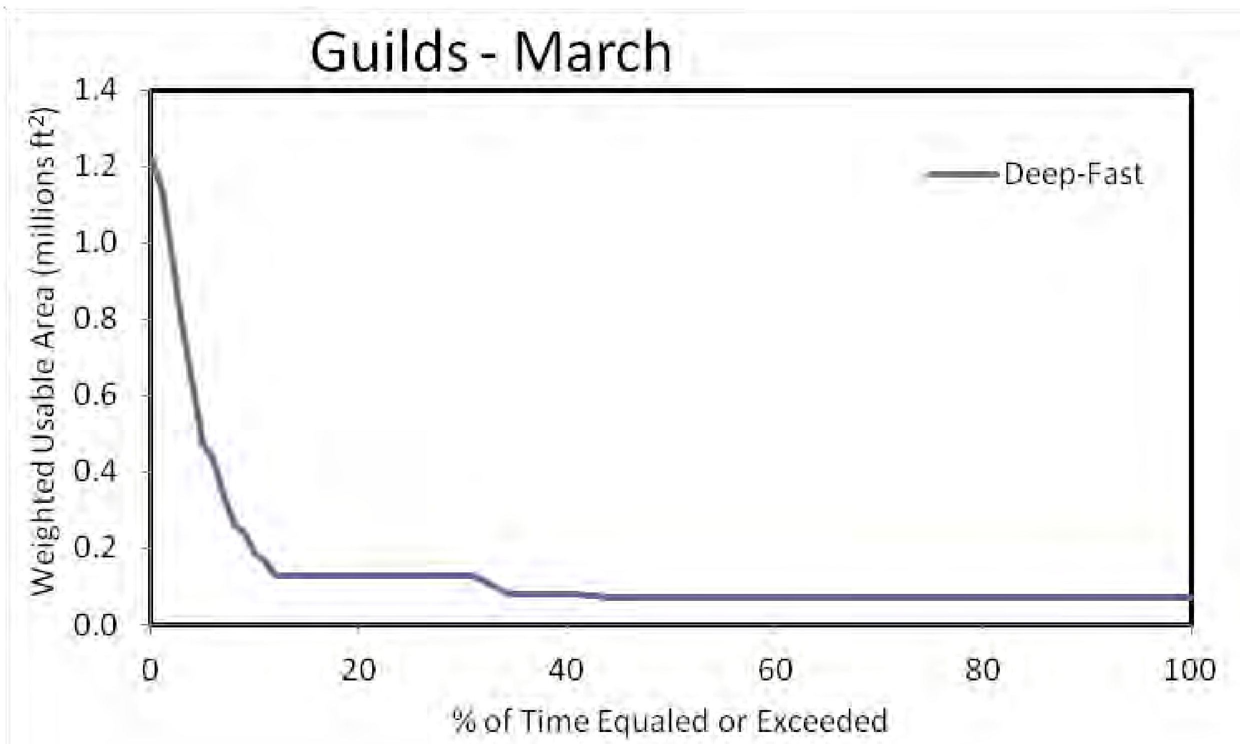


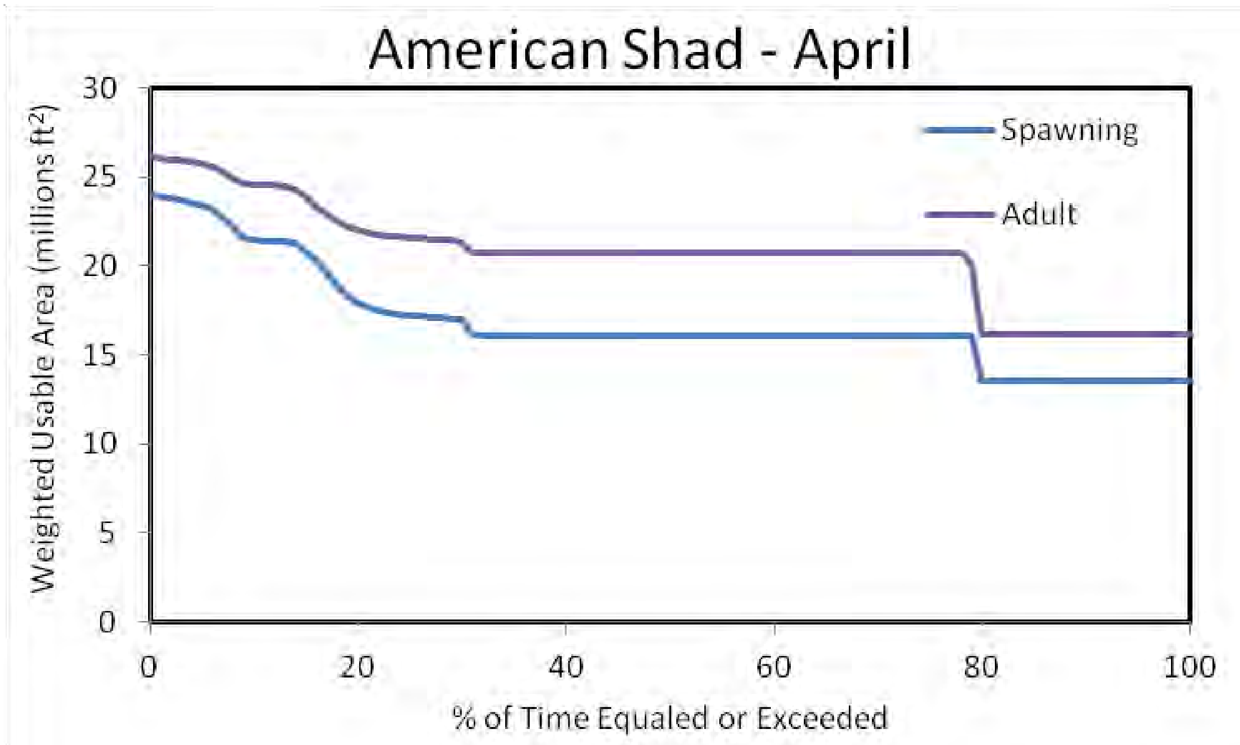
Smallmouth Bass - March
Weighted Usable Area (millions ft²)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Adult

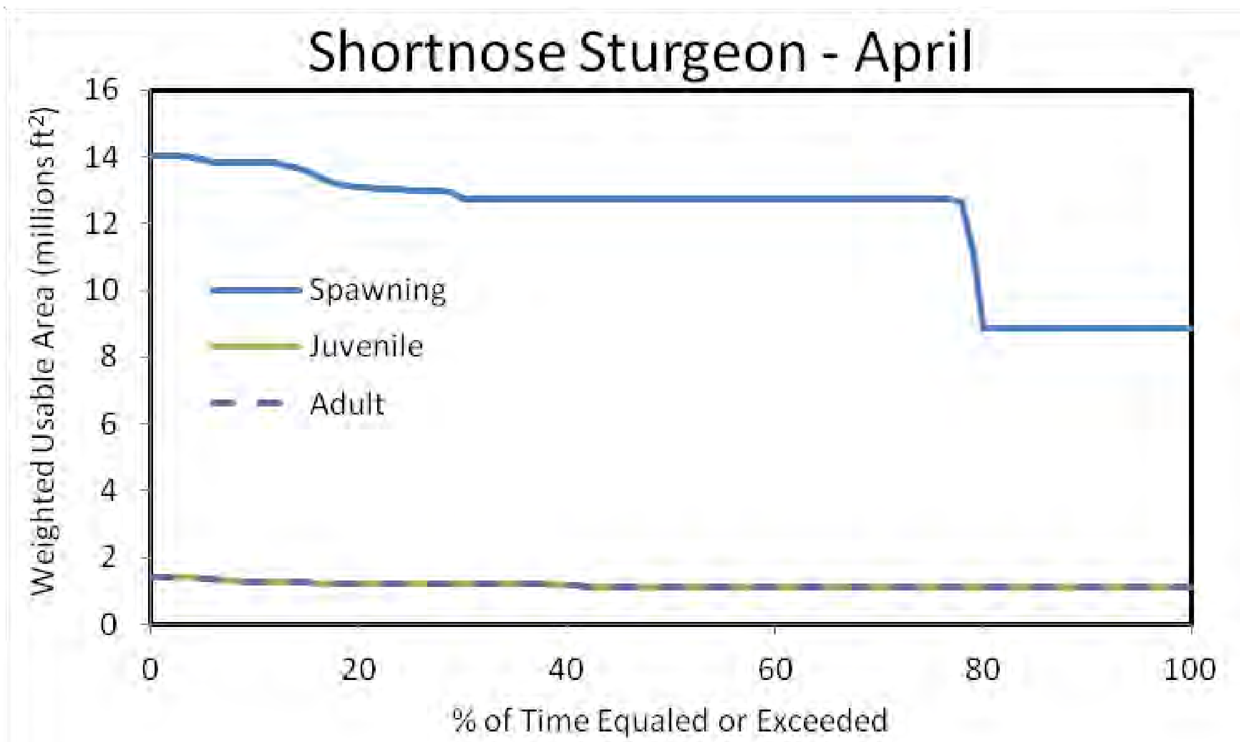


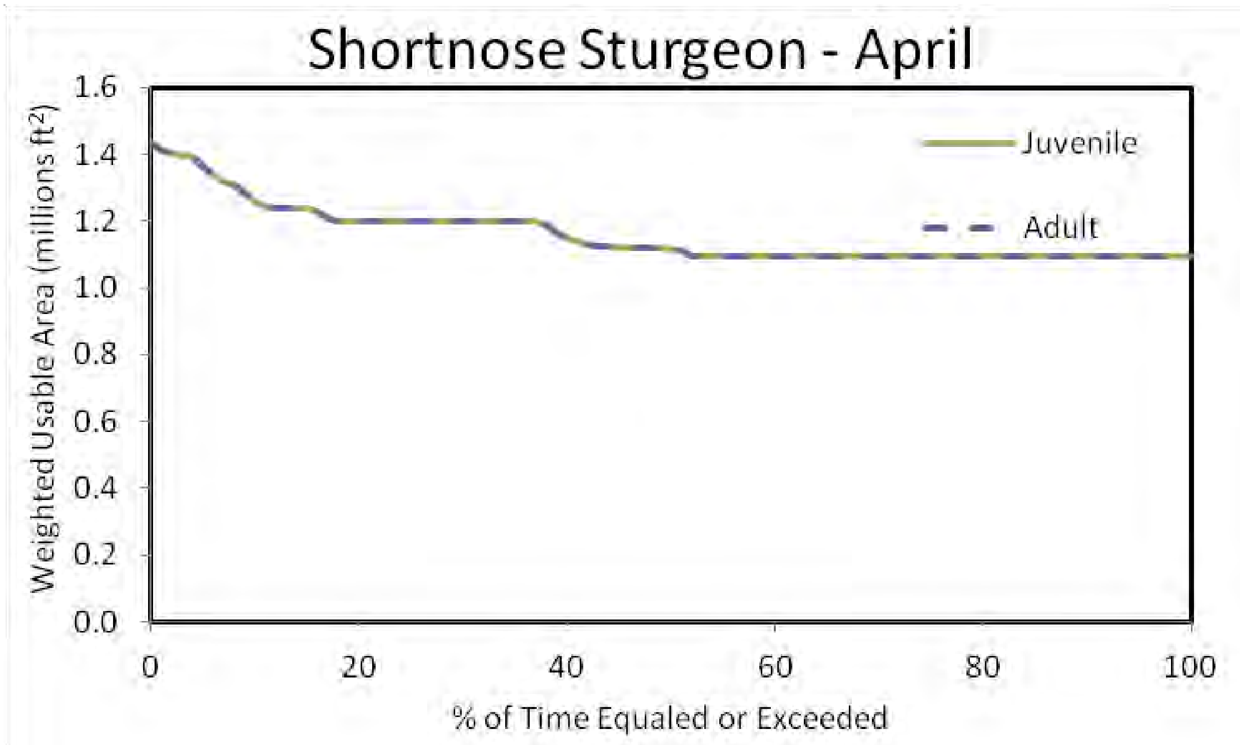
Macroinvertebrates - March
Weighted Usable Area (millions ft²)
14
12
10
8
6
4
2
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Stonefly
Mayfly
Caddisfly

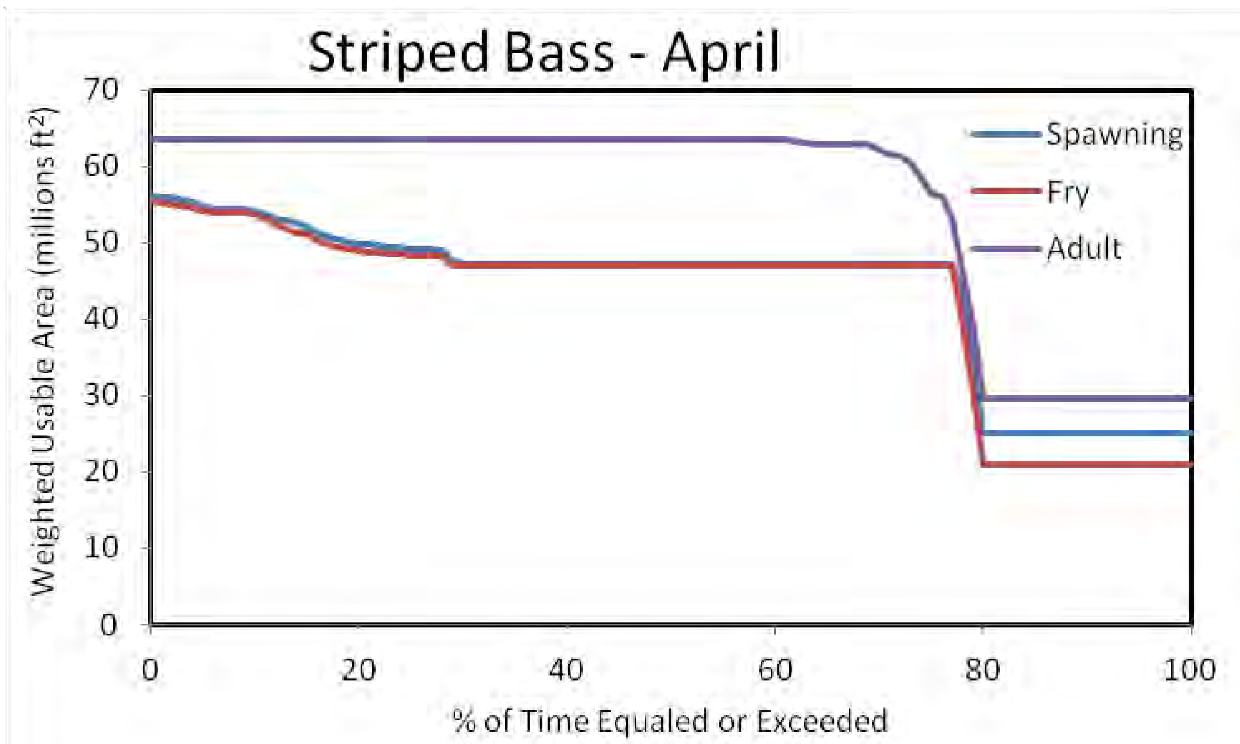

Guilds - March
Weighted Usable Area (millions ft^2)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast

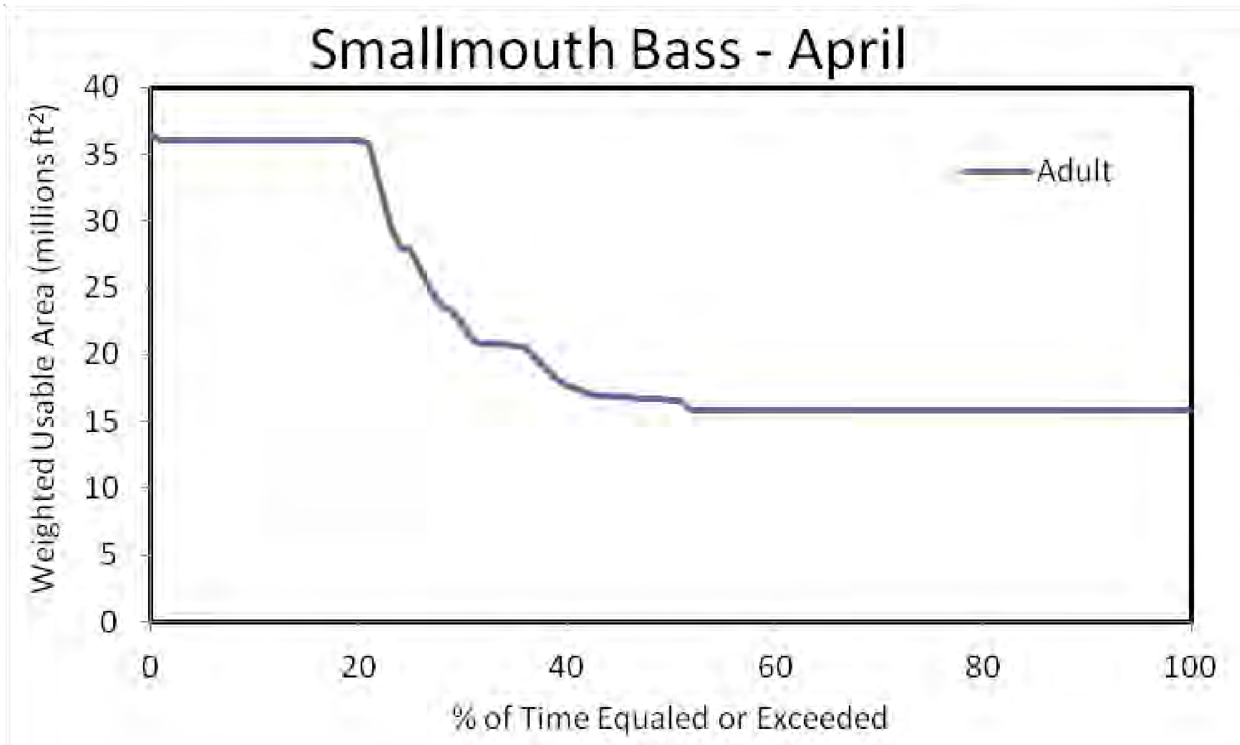

Guilds - March
Weighted Usable Area (millions ft^2)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Deep-Fast

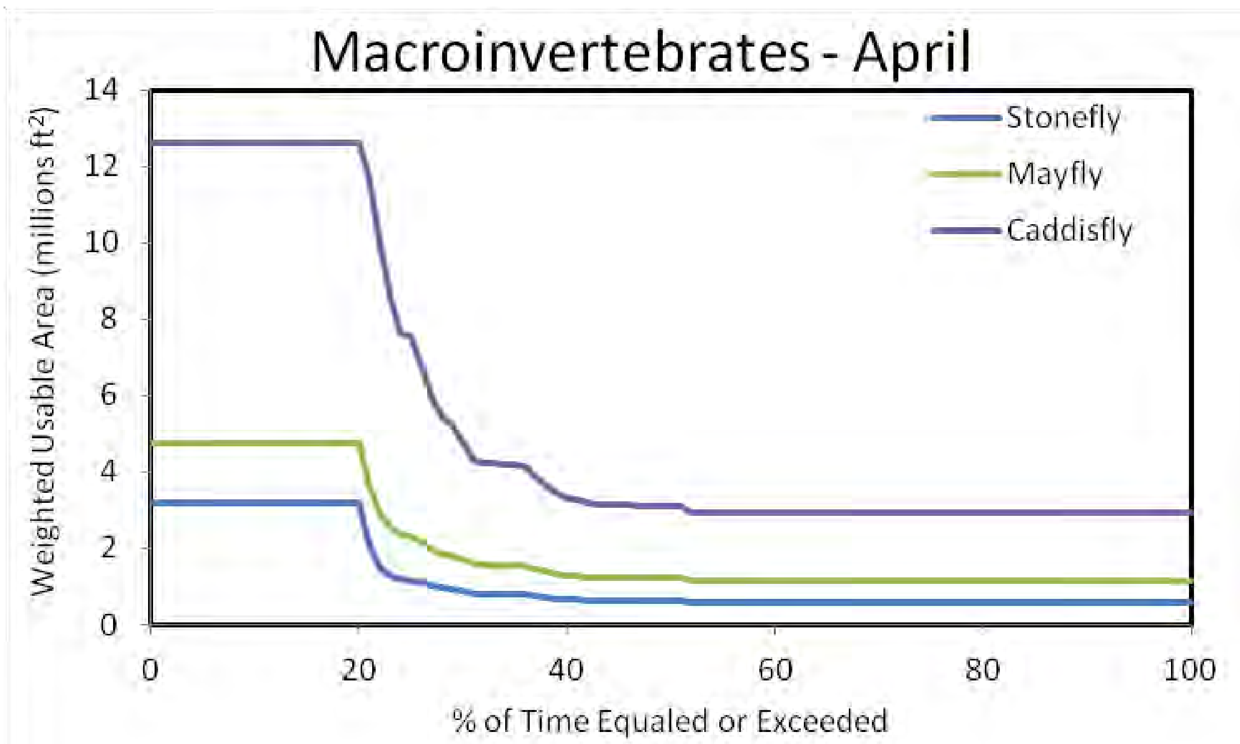

American Shad - April
Spawning
Adult
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
30
25
20
15
10
5
0
0
20
40
60
80
100

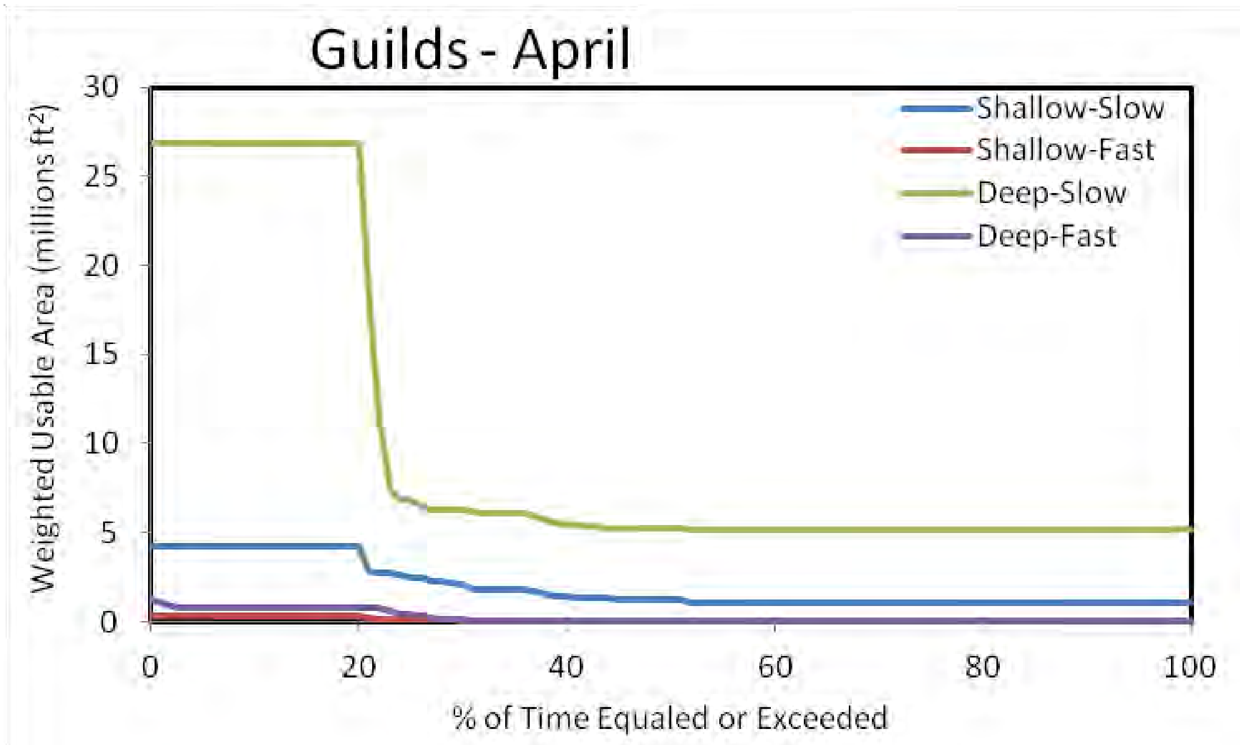

Shortnose Sturgeon - April
Spawning
Juvenile
Adult
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100

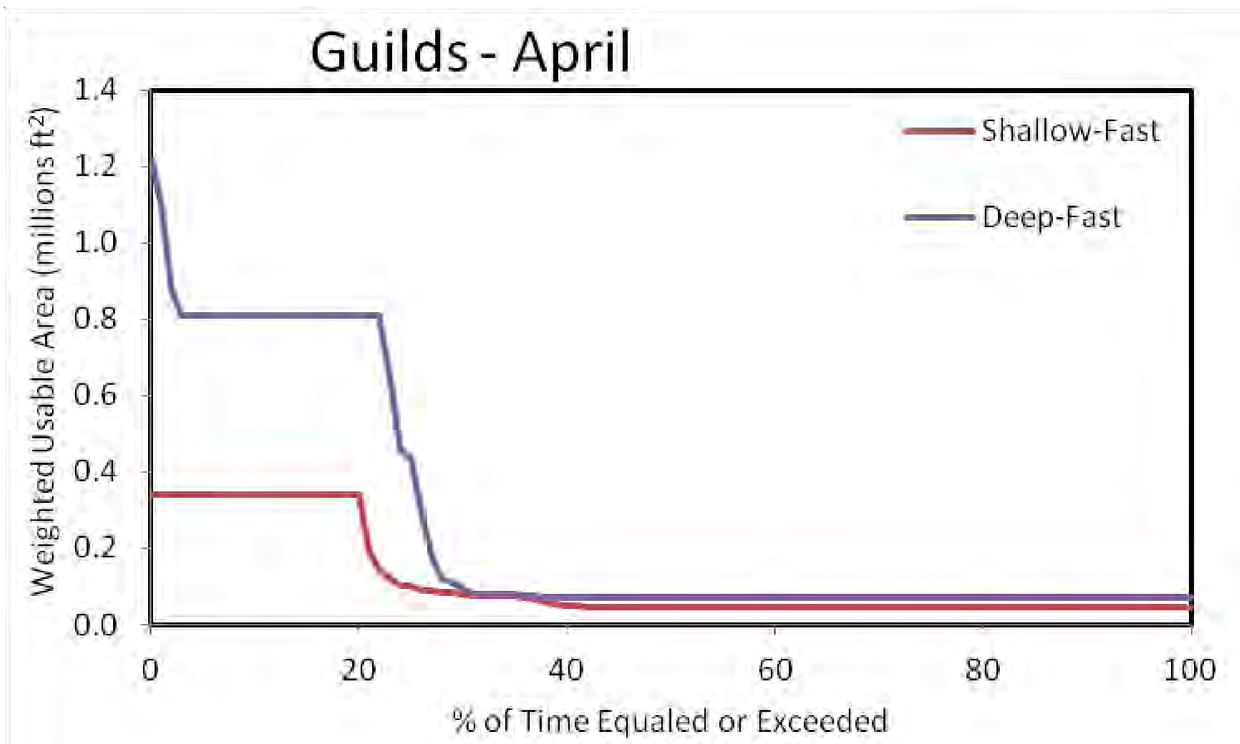

Shortnose Sturgeon - April
Weighted Usable Area (millions ft²)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult

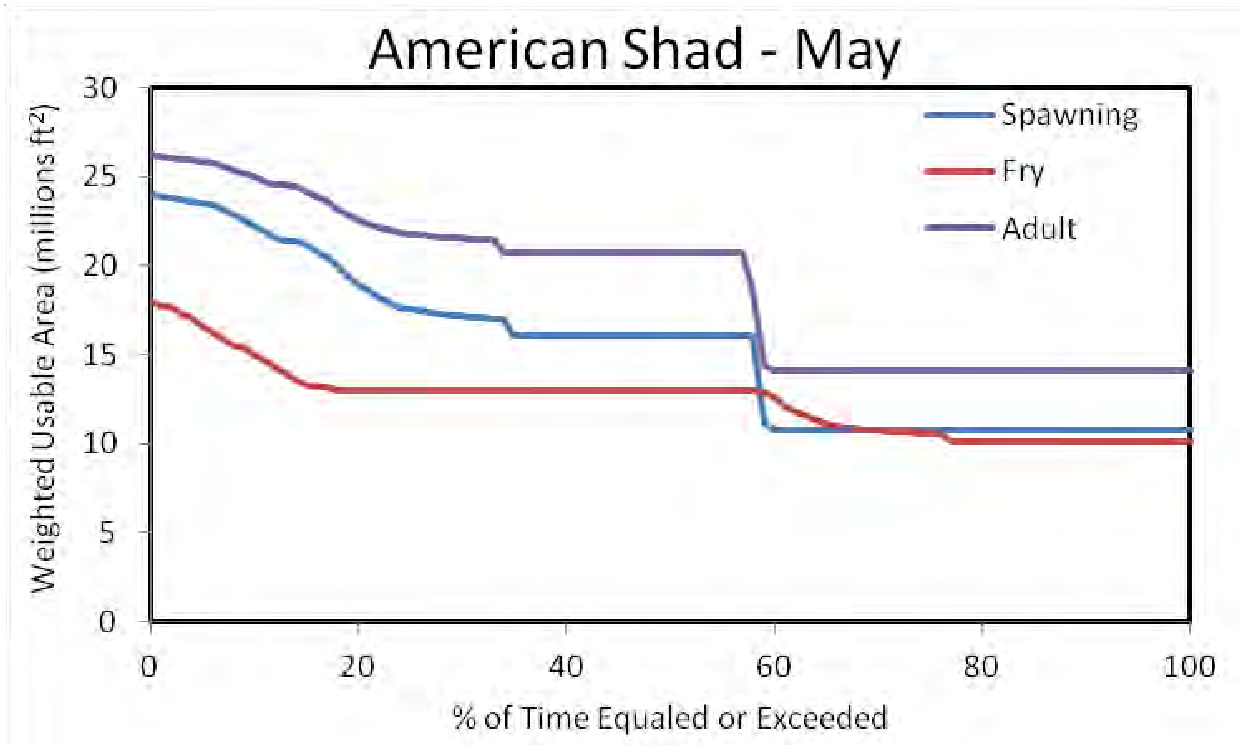

Striped Bass - April
Weighted Usable Area (millions ft²)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Spawning
Fry
Adult

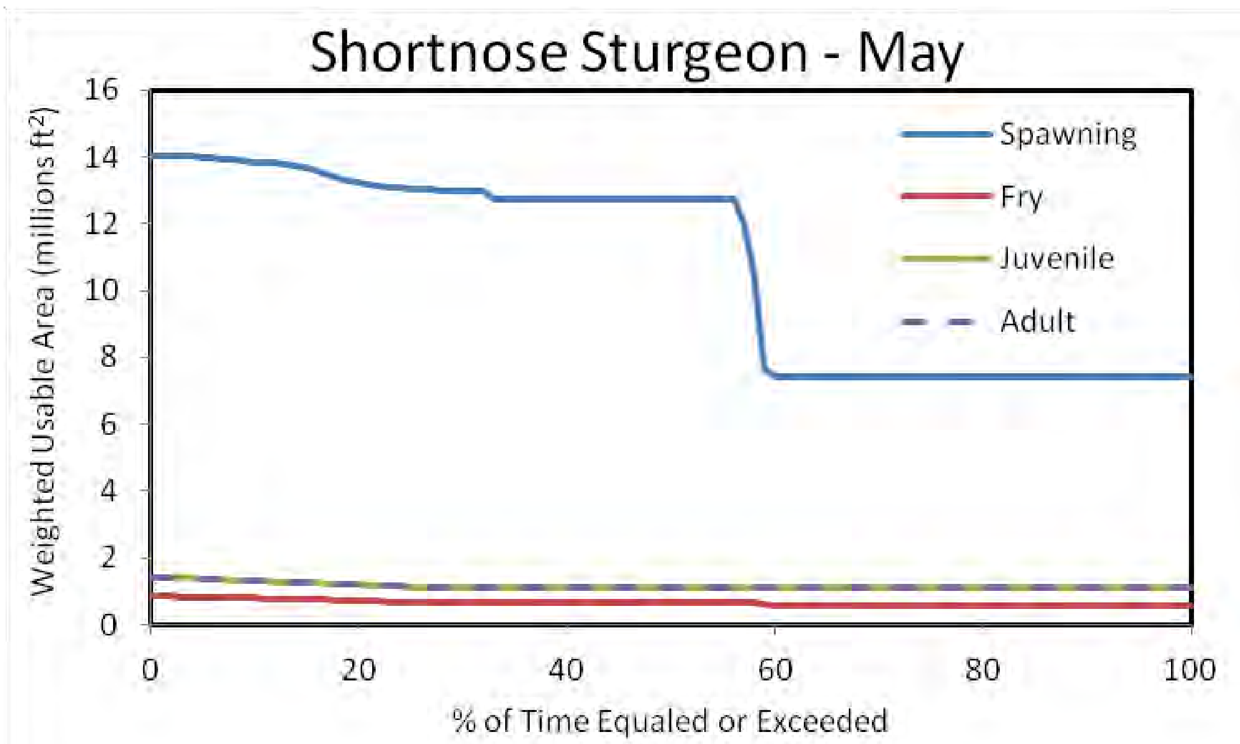

Smallmouth Bass - April
Adult
Weighted Usable Area (millions ft²)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded

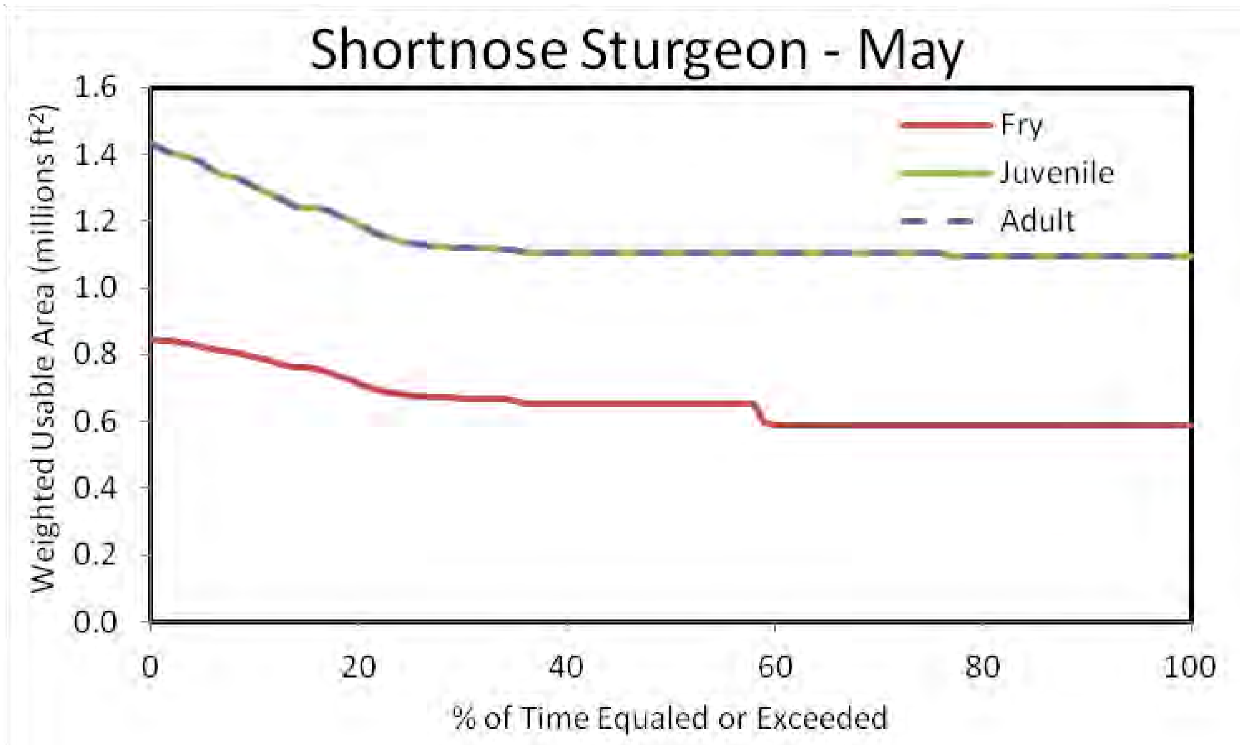

Macroinvertebrates - April
Stonefly
Mayfly
Caddisfly
Weighted Usable Area (millions ft²)
14
12
10
8
6
4
2
0
0
20
40
60
80
100
% of Time Equaled or Exceeded


Guilds - April
Weighted Usable Area (millions ft²)
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast

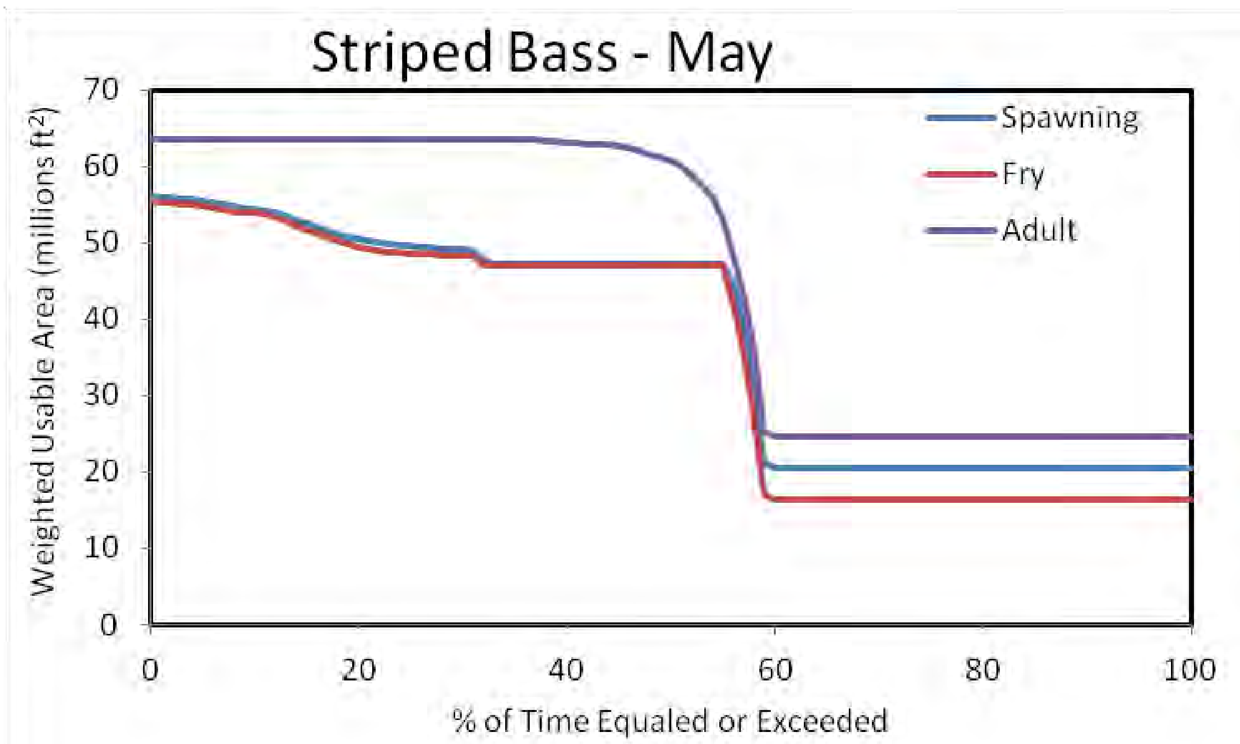

Guilds - April
Weighted Usable Area (millions ft²)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Fast
Deep-Fast


American Shad - May
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
Spawning
Fry
Adult
0
5
10
15
20
25
30
0
20
40
60
80
100

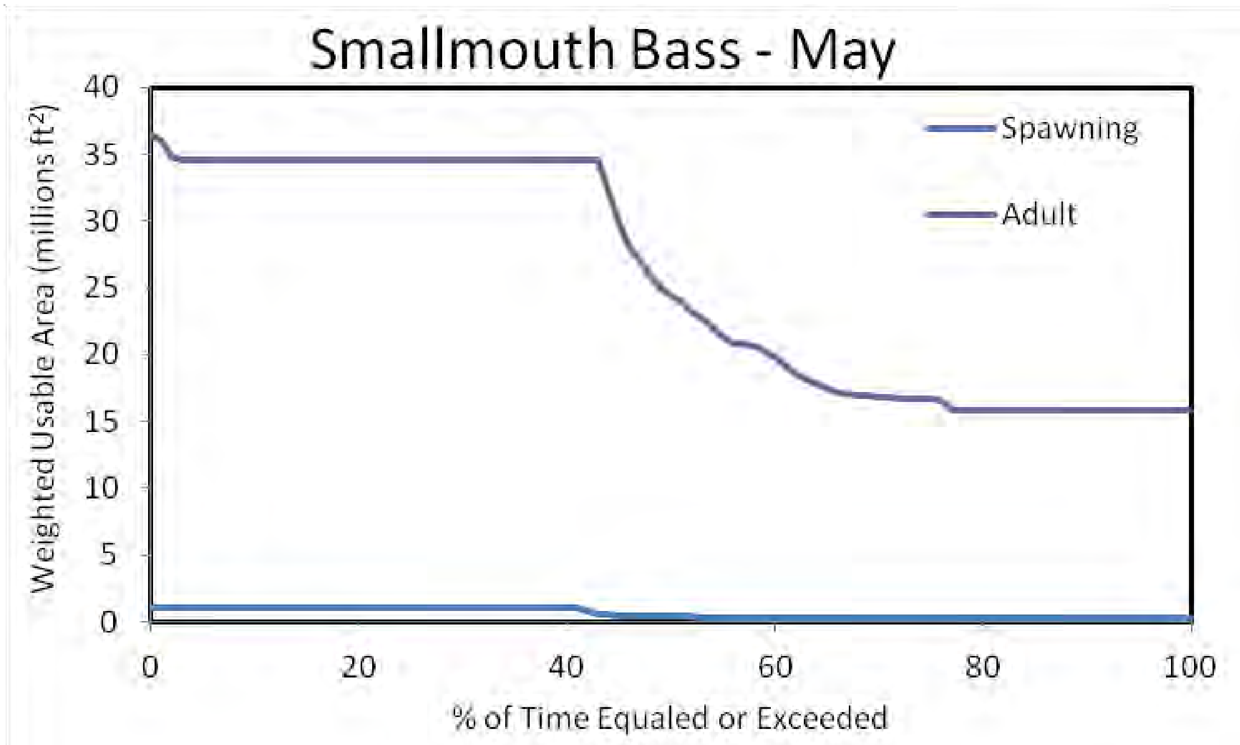

Shortnose Sturgeon - May
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
Spawning
Fry
Juvenile
Adult
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100

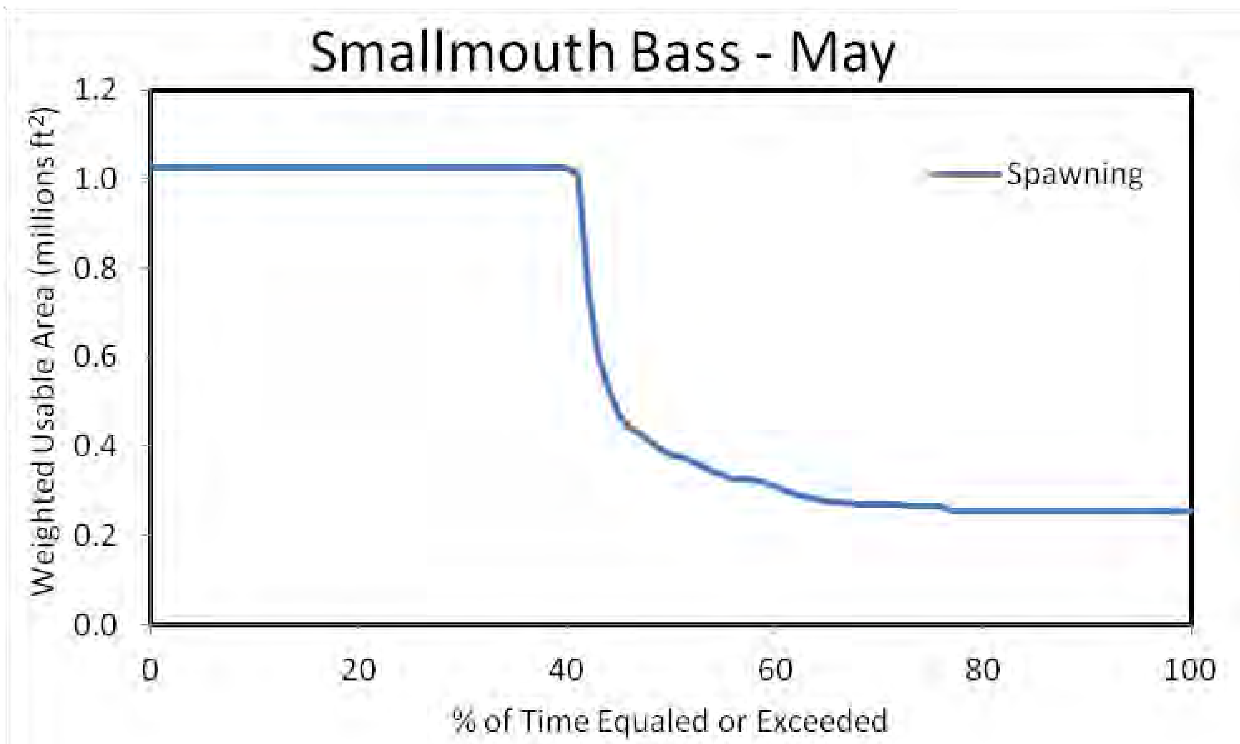


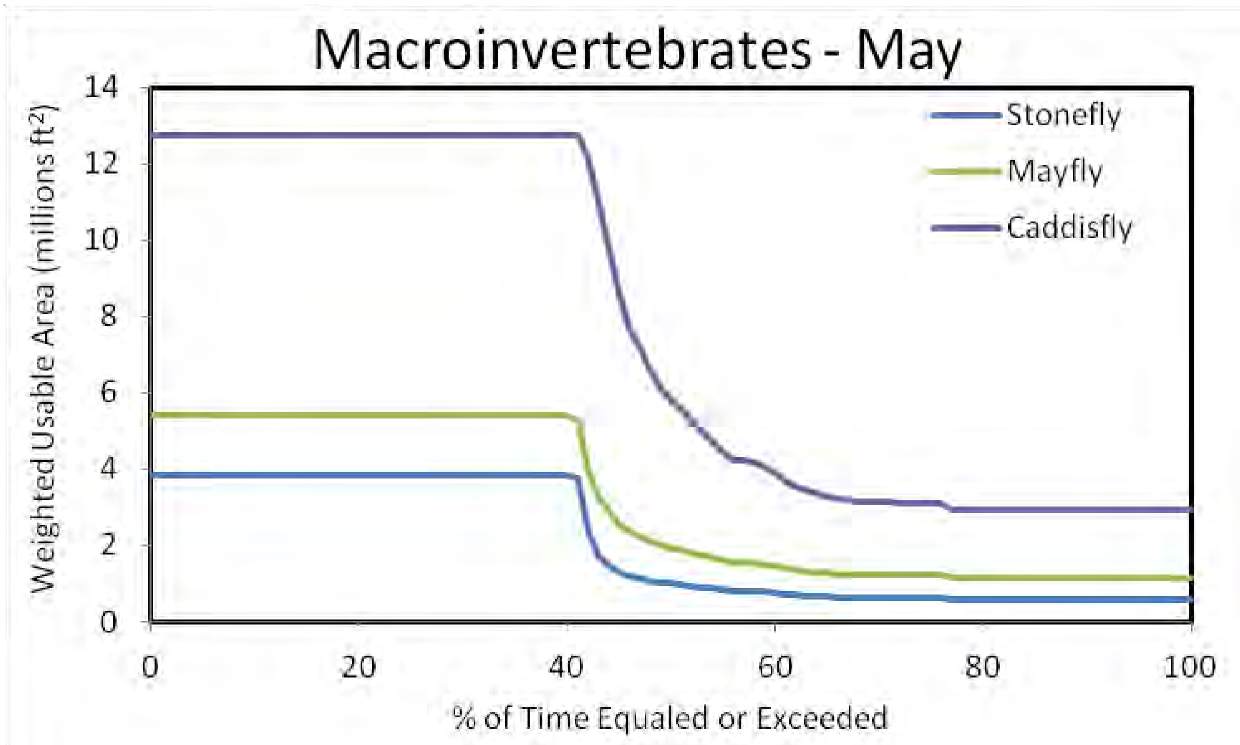
Shortnose Sturgeon - May
Fry
Juvenile
Adult
Weighted Usable Area (millions ft²)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded

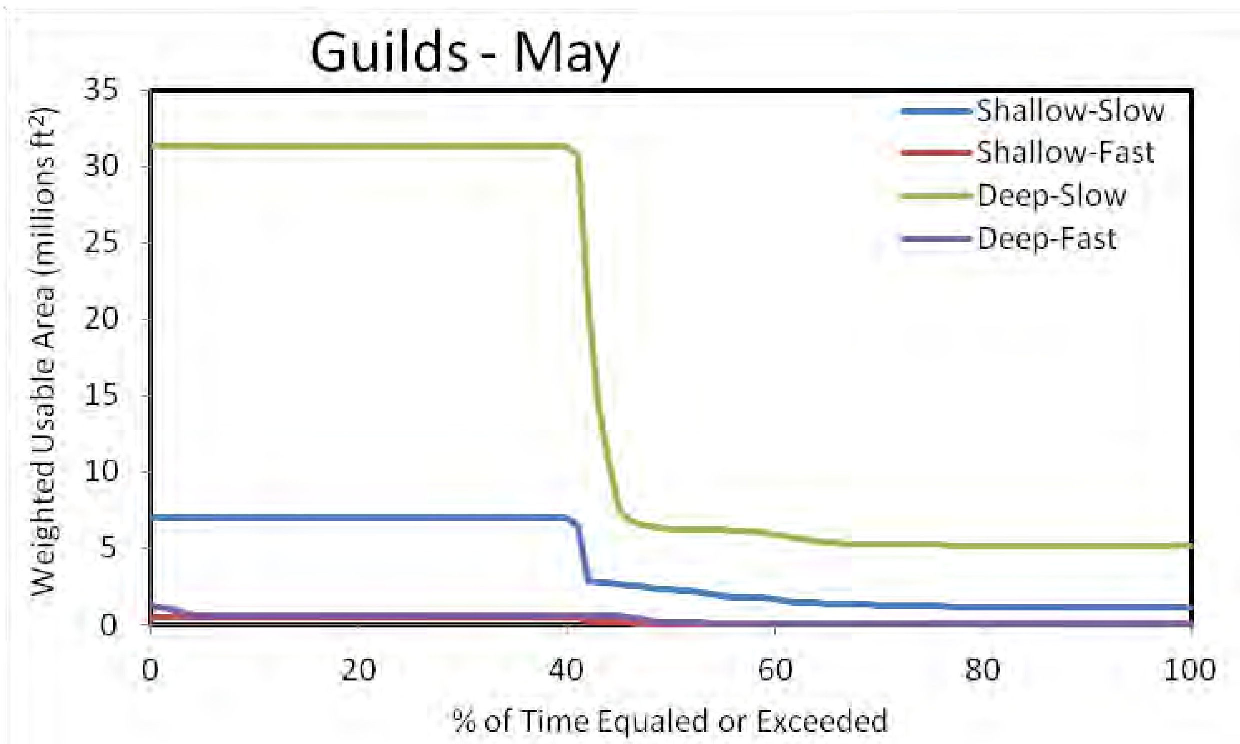


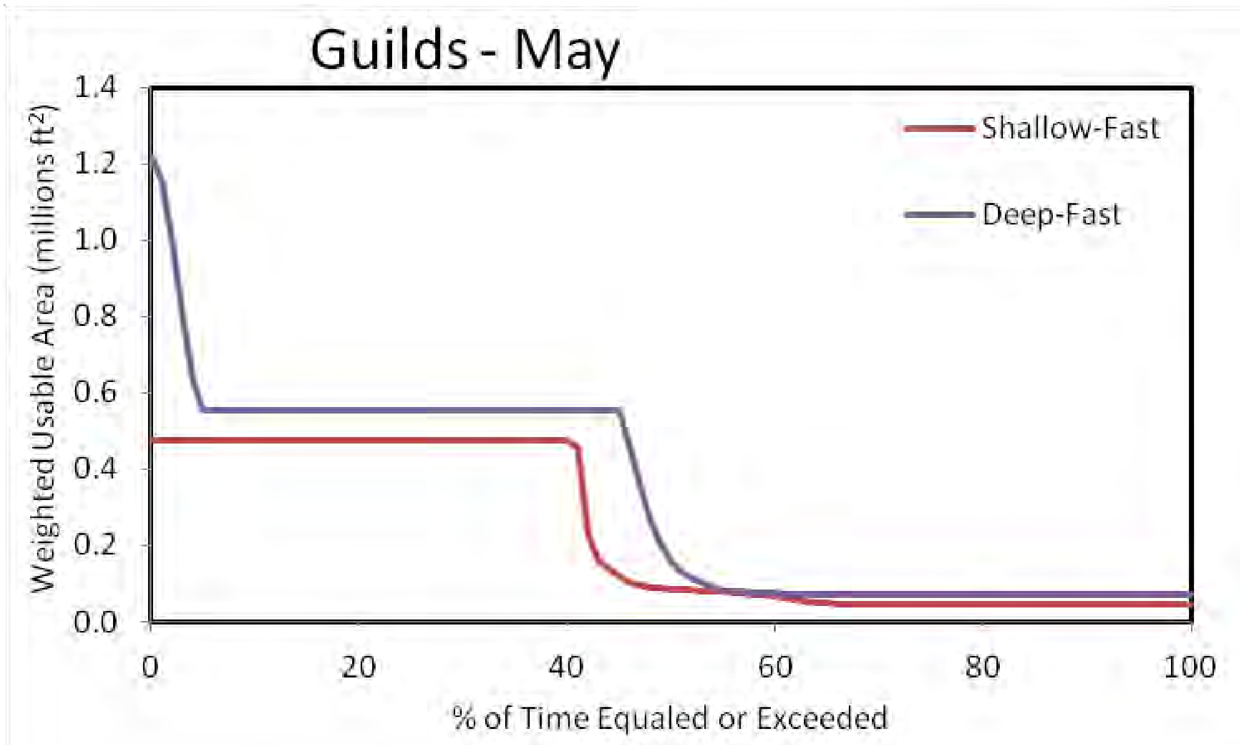
Striped Bass - May
Spawning
Fry
Adult
Weighted Usable Area (millions ft²)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded

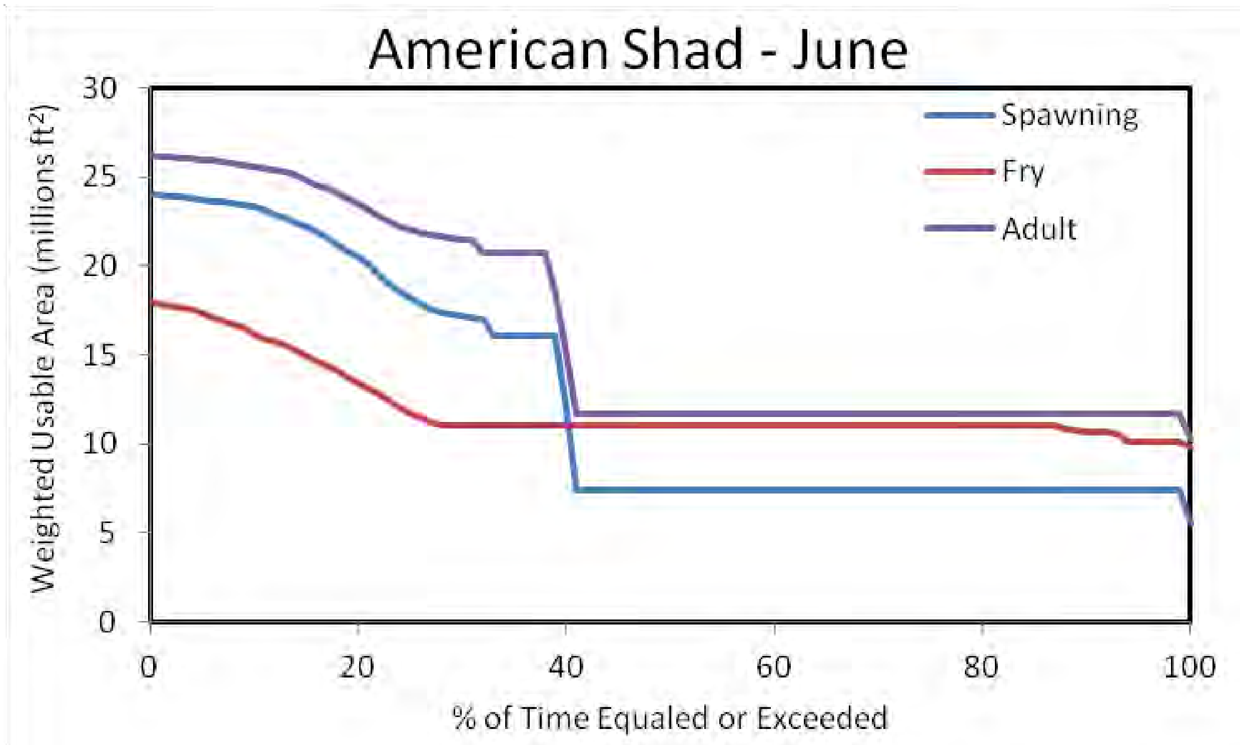

Smallmouth Bass - May
Spawning
Adult
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100

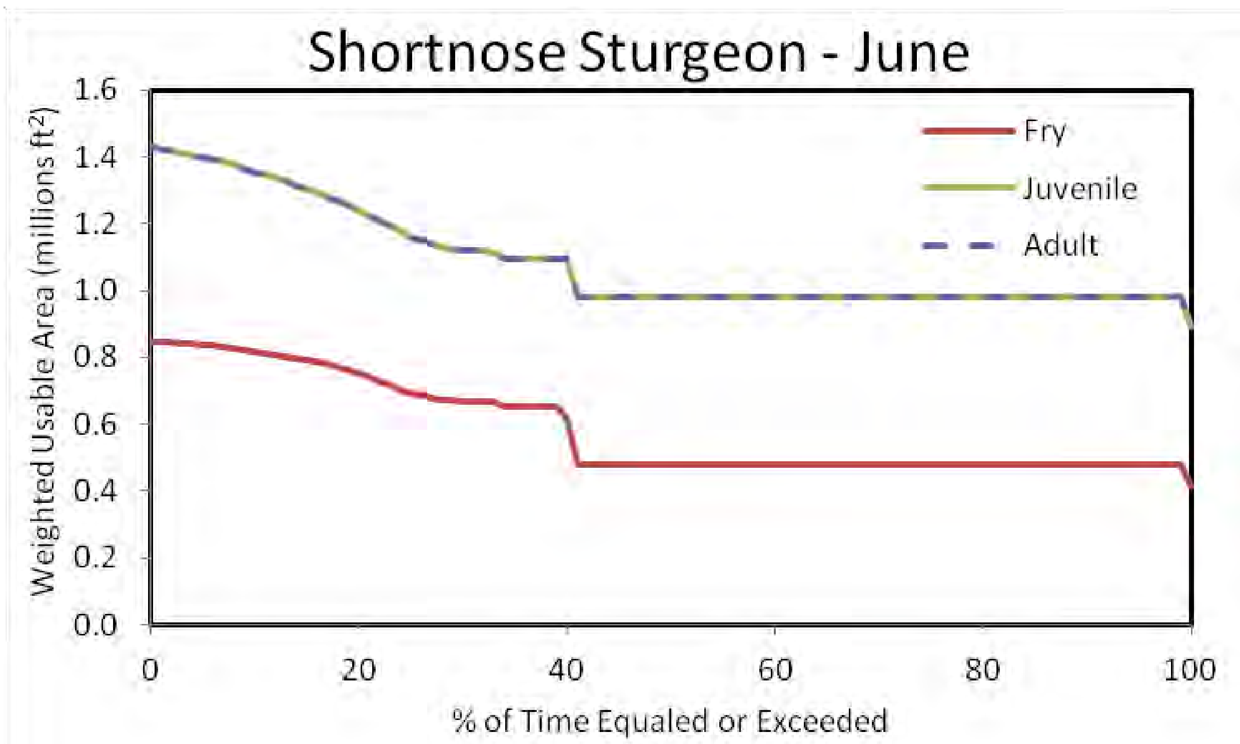

Smallmouth Bass - May
Spawning
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
20
40
60
80
100

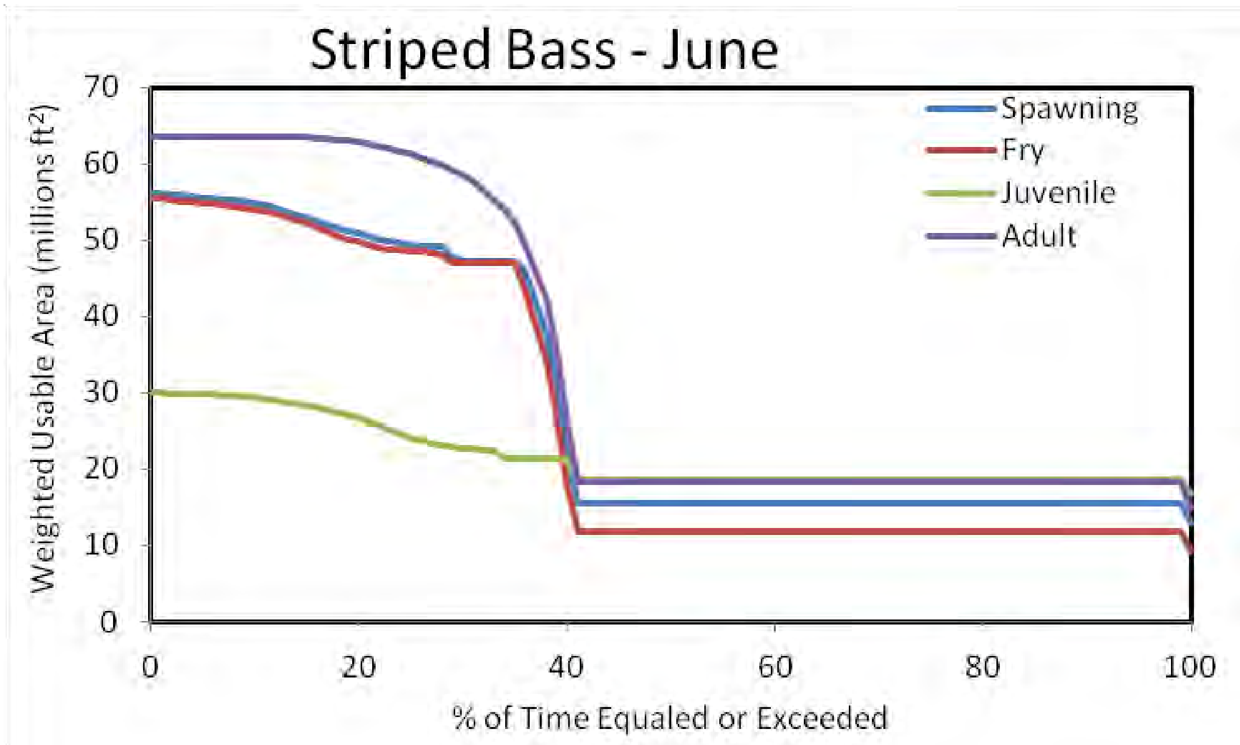

Macroinvertebrates - May
Weighted Usable Area (millions ft²)
Stonefly
Mayfly
Caddisfly
% of Time Equaled or Exceeded
0
2
4
6
8
10
12
14
0
20
40
60
80
100

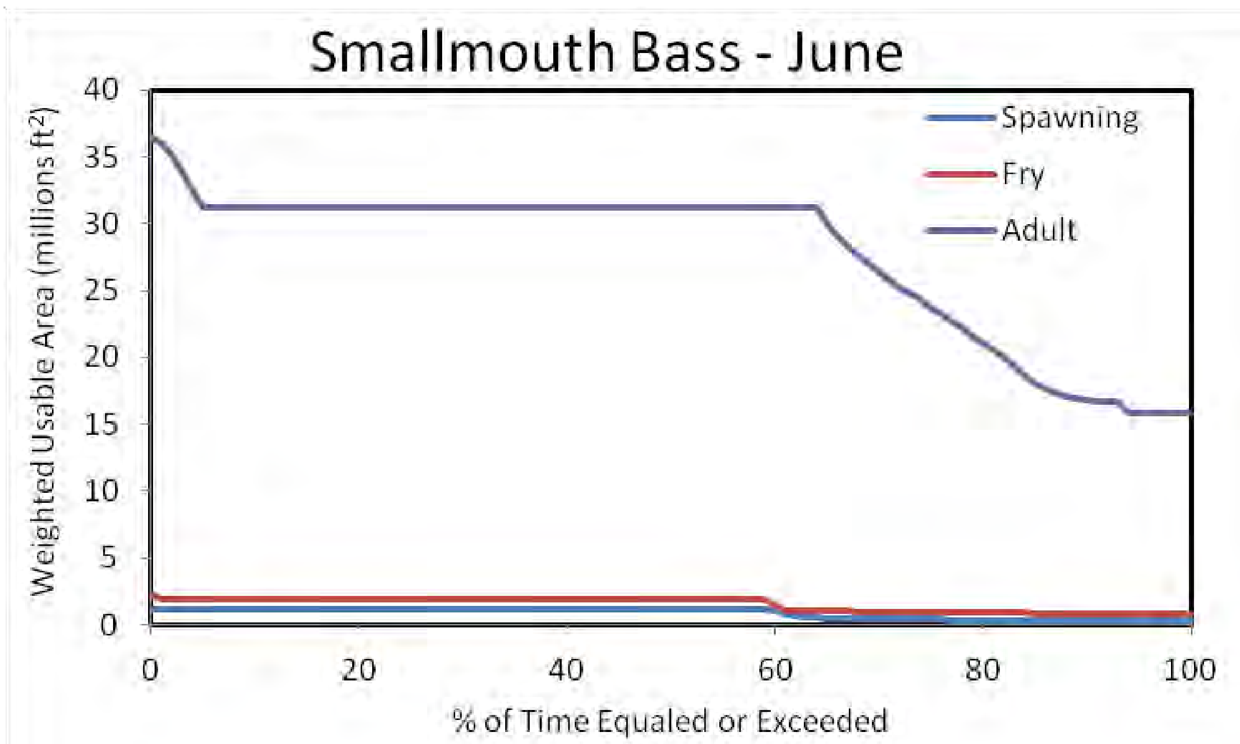

Guilds - May
Weighted Usable Area (millions ft²)
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast
% of Time Equaled or Exceeded
0
5
10
15
20
25
30
35
0
20
40
60
80
100

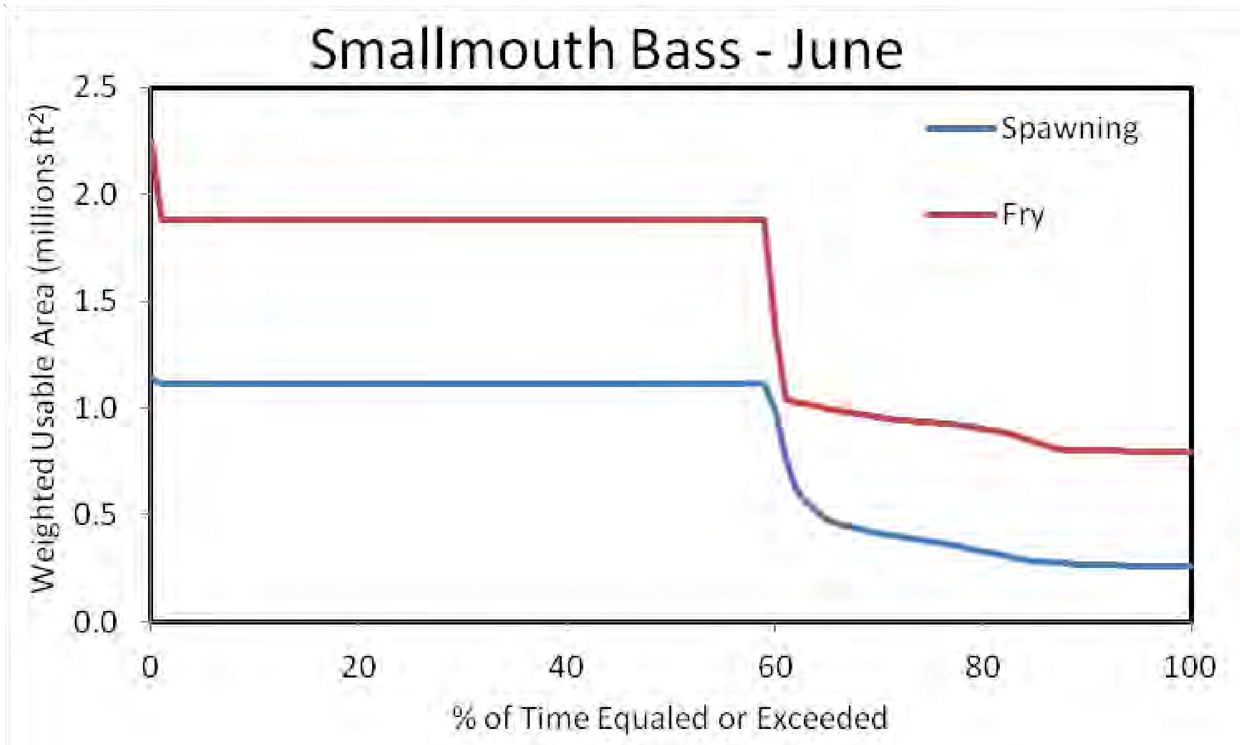

Guilds - May
Shallow-Fast
Deep-Fast
Weighted Usable Area (millions ft²)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded

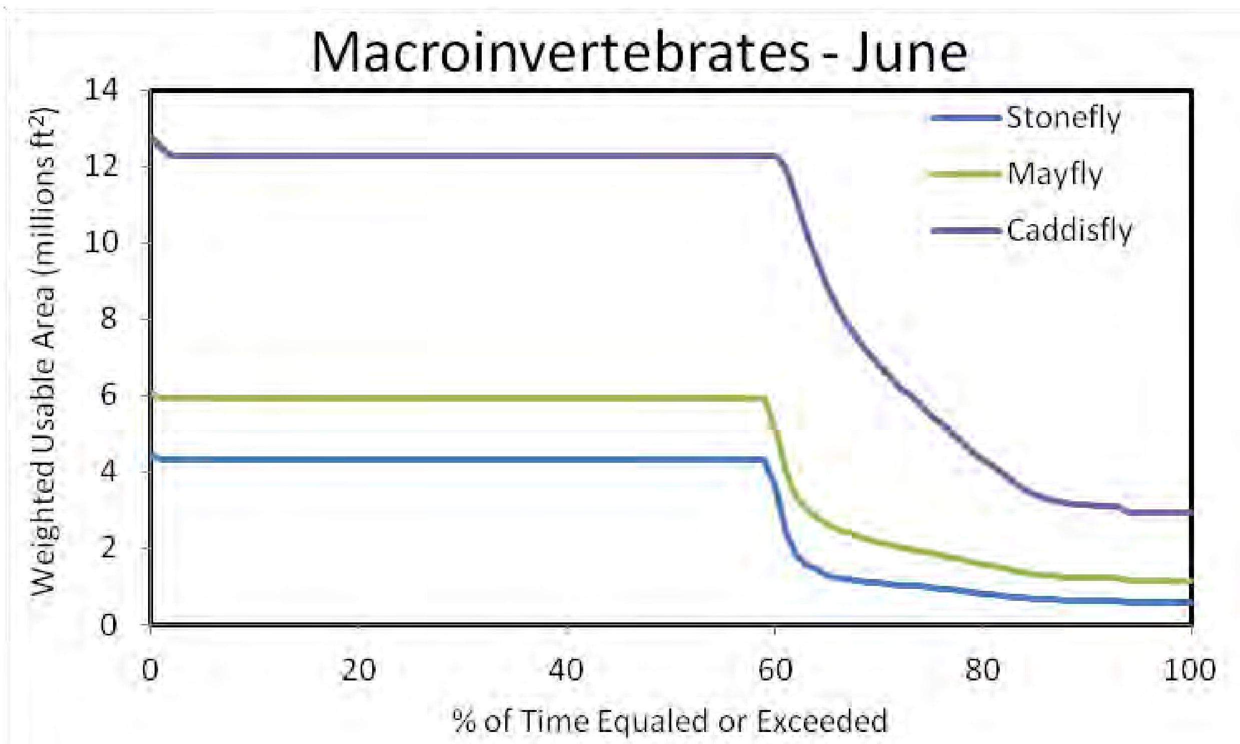

American Shad - June
Spawning
Fry
Adult
Weighted Usable Area (millions ft2)
0
5
10
15
20
25
30
0
20
40
60
80
100
% of Time Equaled or Exceeded

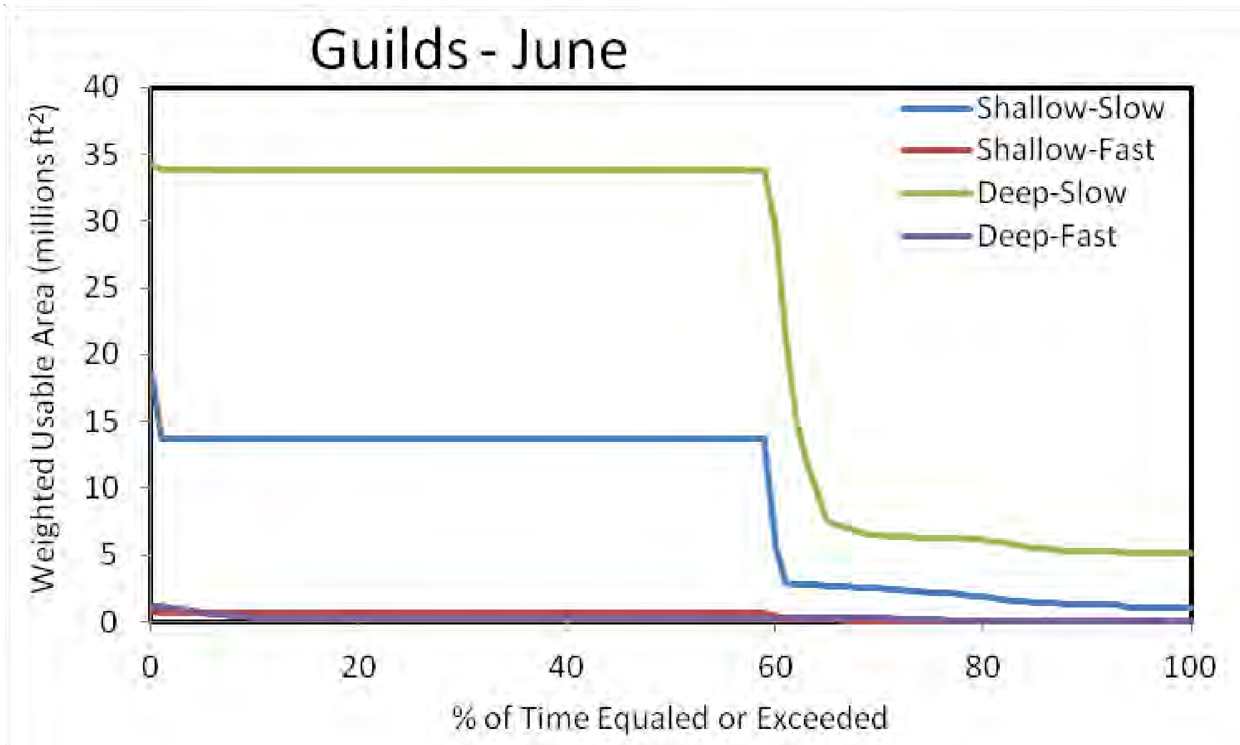

Shortnose Sturgeon - June
Fry
Juvenile
Adult
Weighted Usable Area (millions ft2)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
20
40
60
80
100
% of Time Equaled or Exceeded


Striped Bass - June
Weighted Usable Area (millions ft^2)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Spawning
Fry
Juvenile
Adult

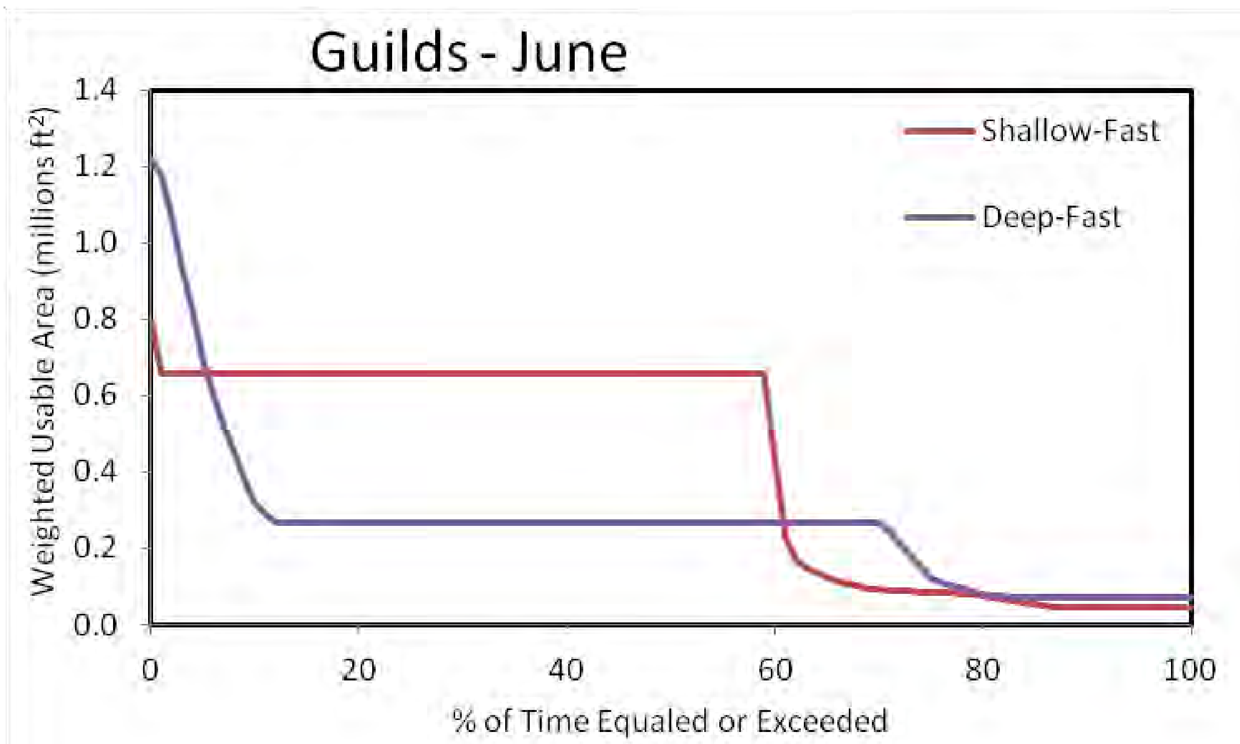

Smallmouth Bass - June
Weighted Usable Area (millions ft^2)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Spawning
Fry
Adult


Smallmouth Bass - June
Weighted Usable Area (millions ft²)
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Spawning
Fry

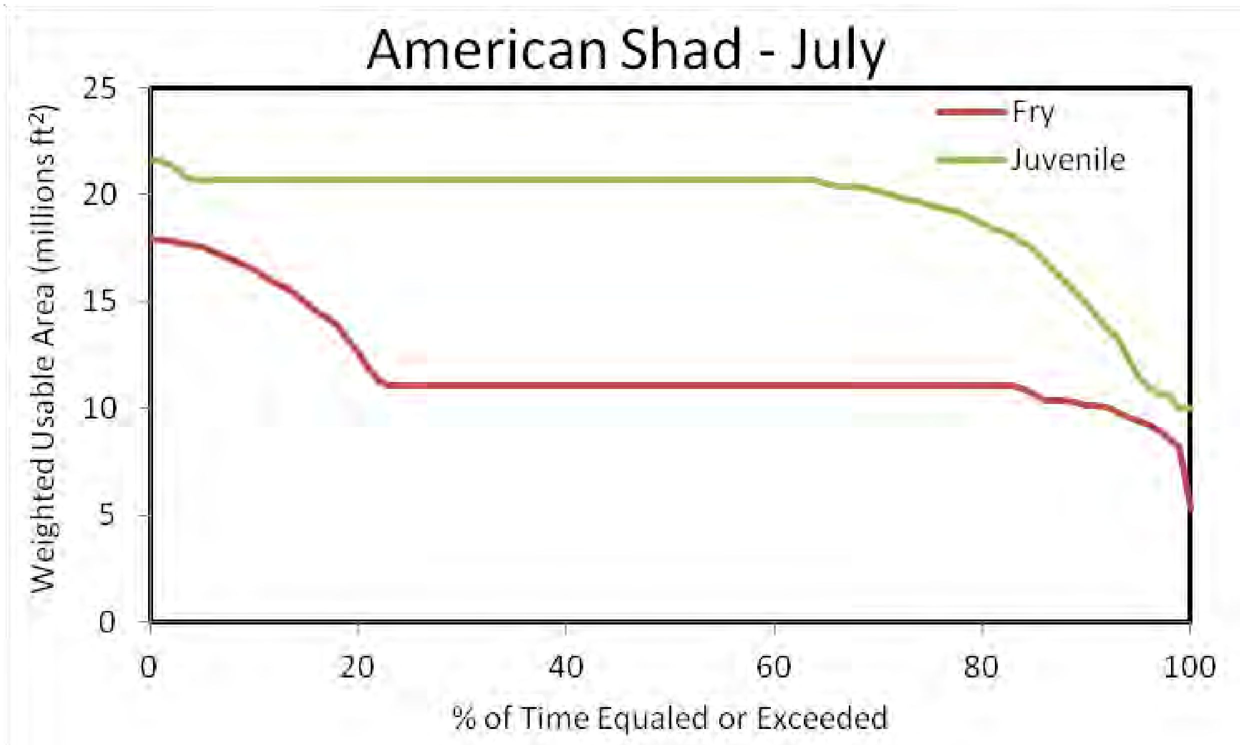

Macroinvertebrates - June
Weighted Usable Area (millions ft²)
14
12
10
8
6
4
2
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Stonefly
Mayfly
Caddisfly



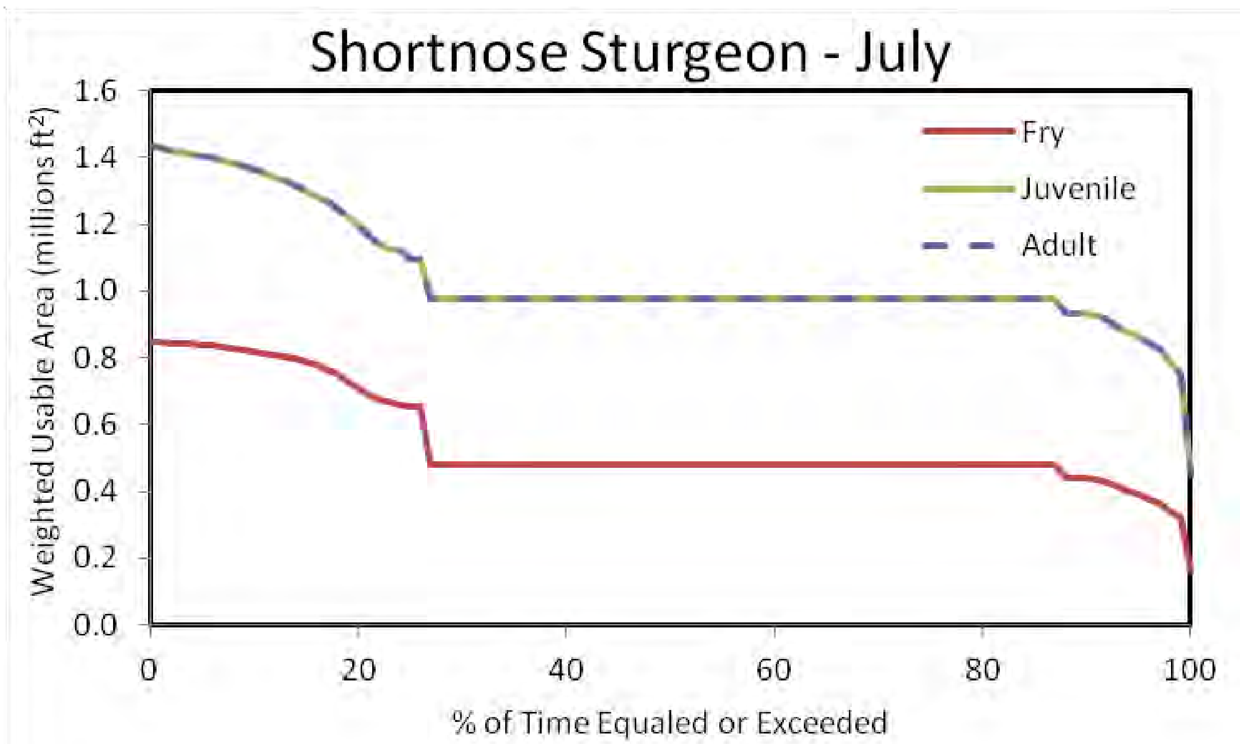
Guilds - June
Weighted Usable Area (millions ft^2)
% of Time Equaled or Exceeded
Shallow-Slow
Shallow-Fast
Deep-Slow
Deep-Fast
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100



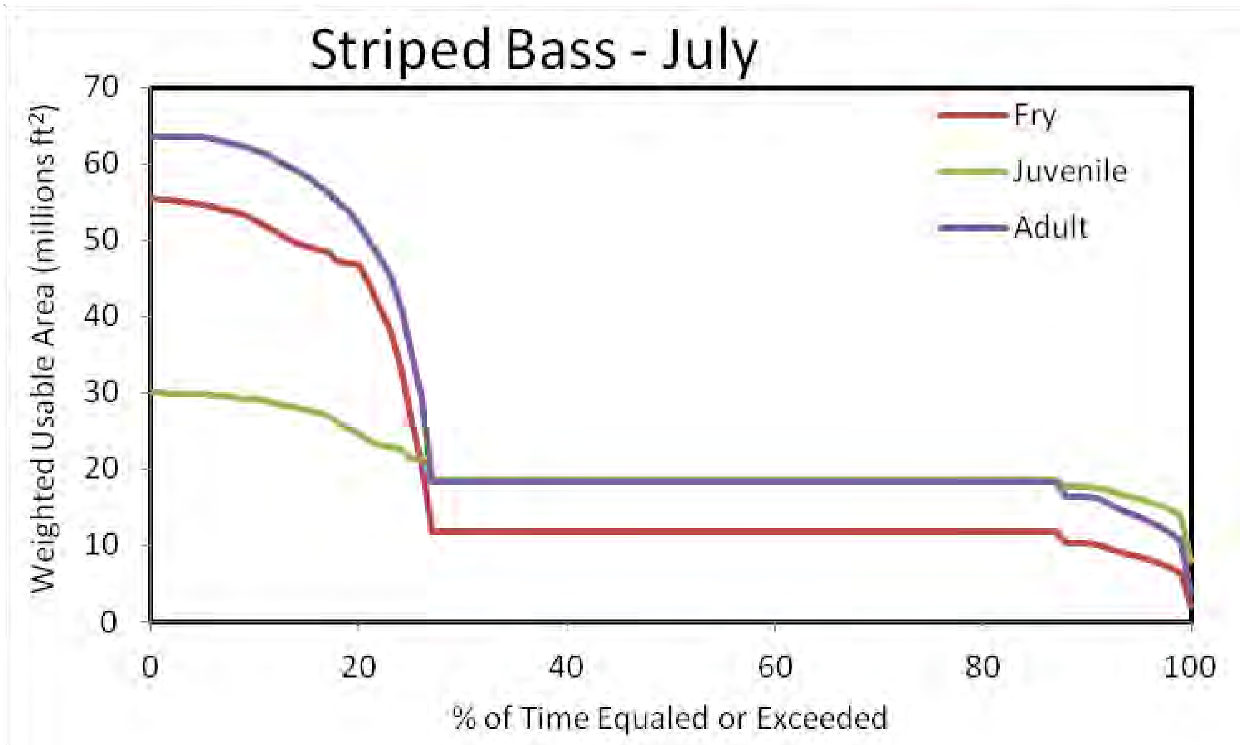
Guilds - June
Weighted Usable Area (millions ft^2)
% of Time Equaled or Exceeded
Shallow-Fast
Deep-Fast
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
20
40
60
80
100

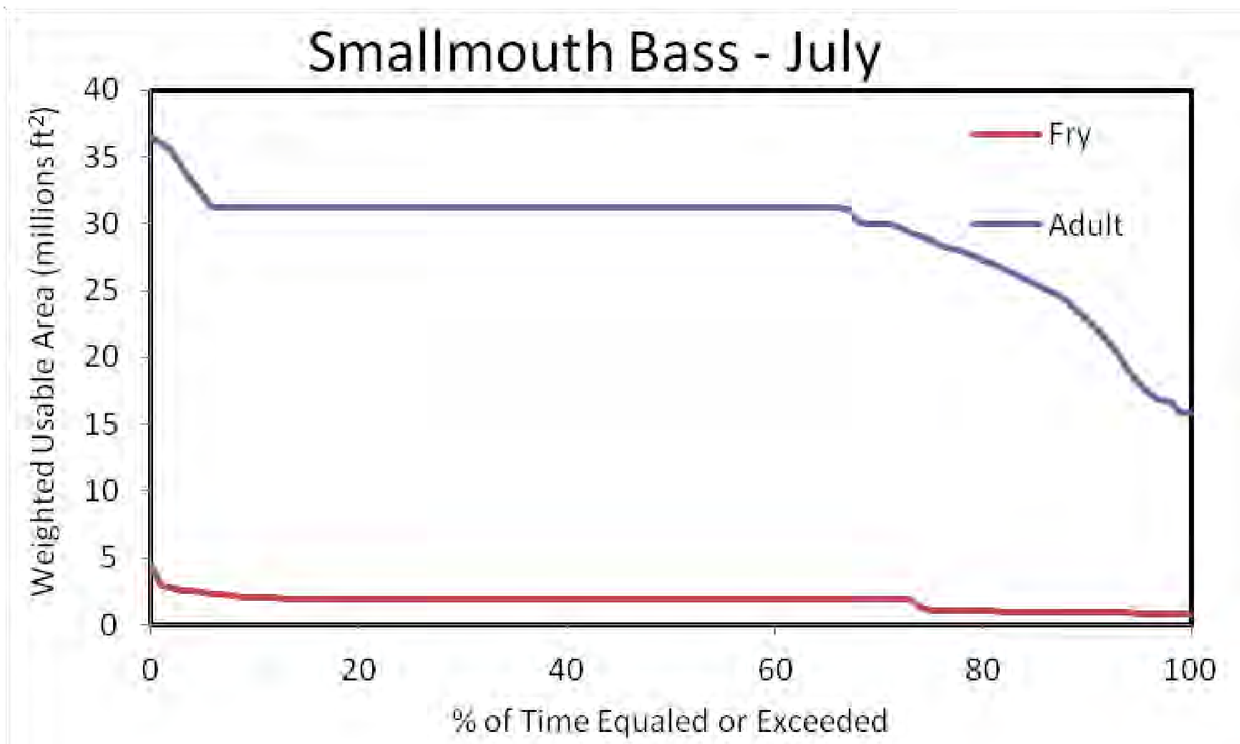


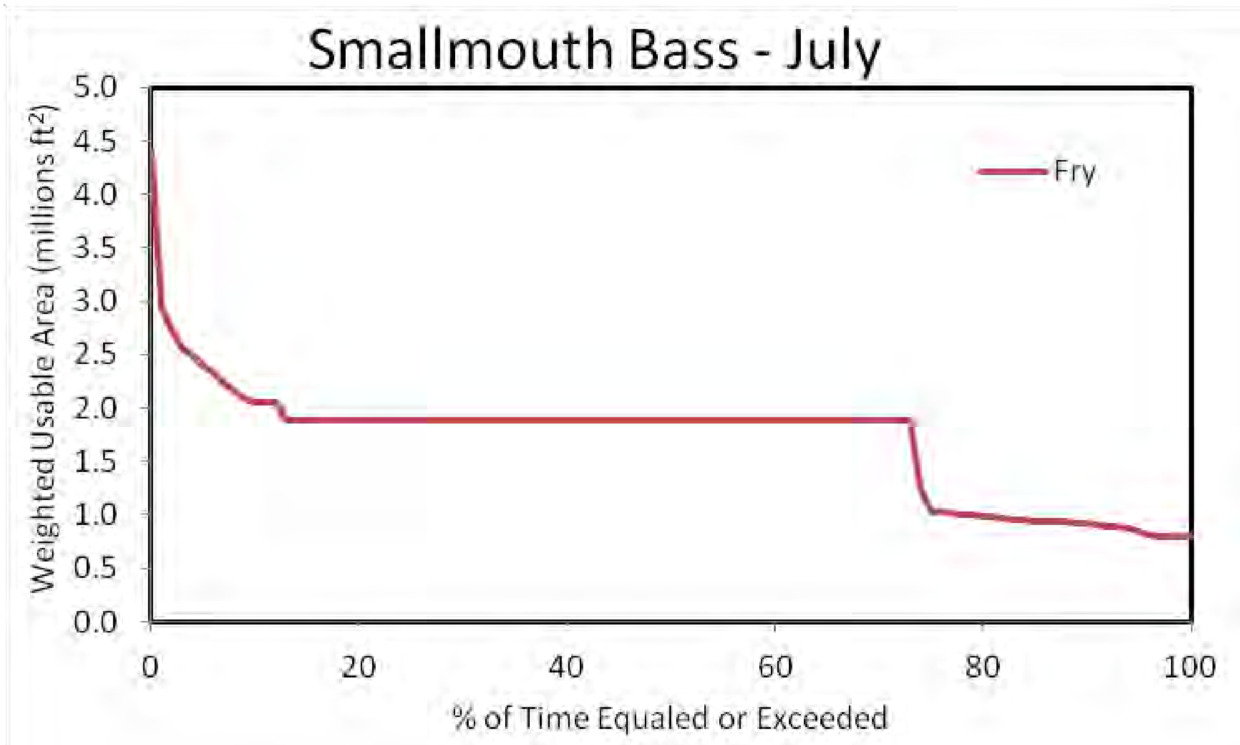
American Shad - July
Weighted Usable Area (millions ft2)
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Fry
Juvenile

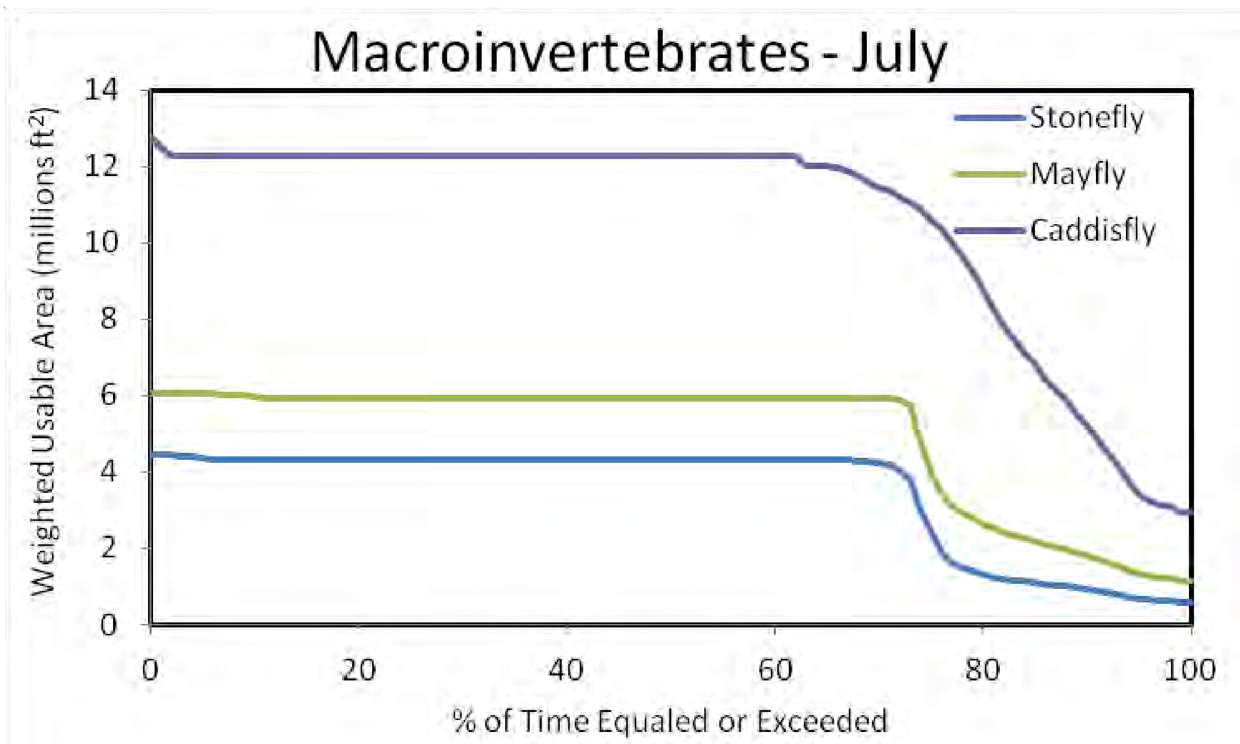


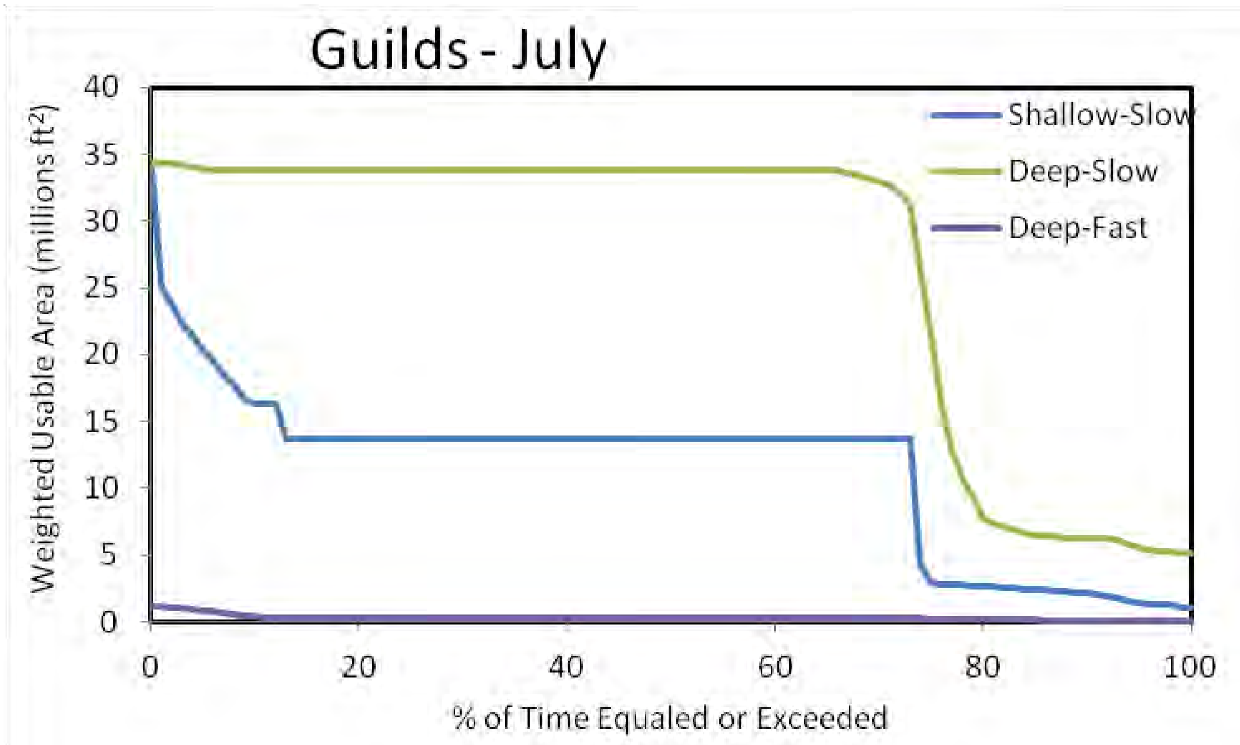
Shortnose Sturgeon - July
Weighted Usable Area (millions ft2)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Fry
Juvenile
Adult

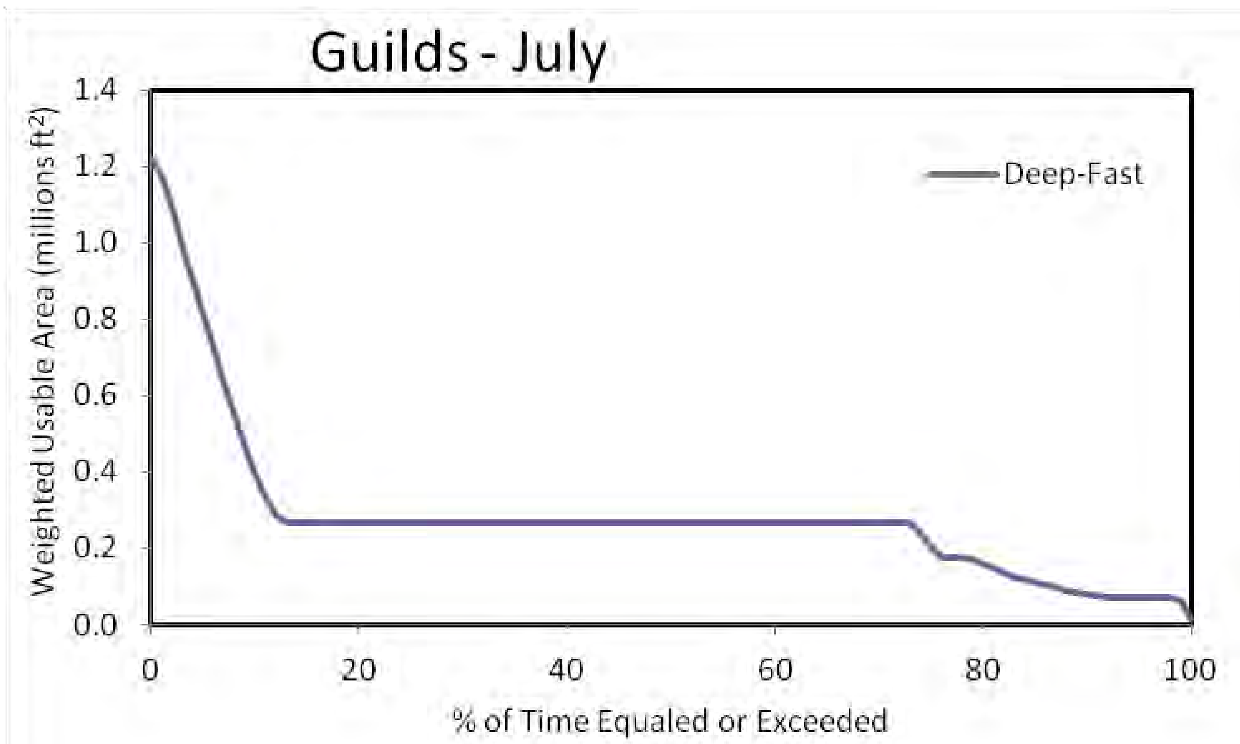

Striped Bass - July
Fry
Juvenile
Adult
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
0
10
20
30
40
50
60
70
0
20
40
60
80
100

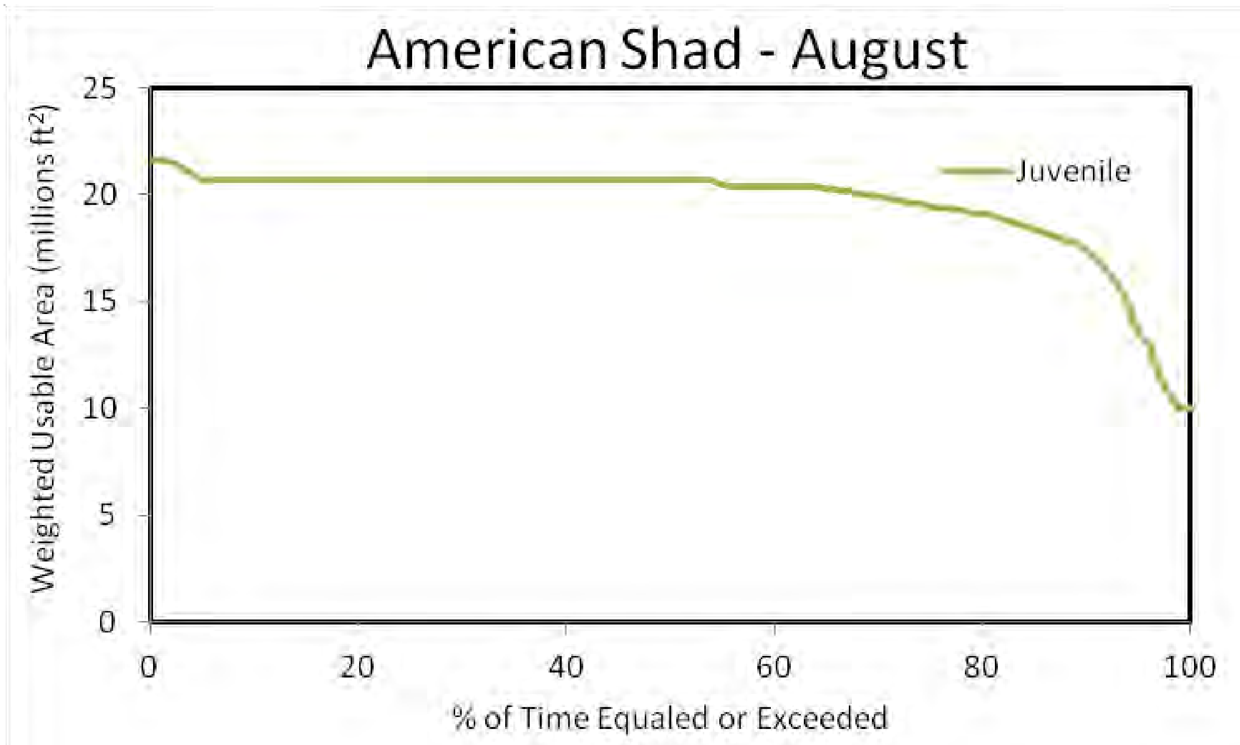

Smallmouth Bass - July
Fry
Adult
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100


Smallmouth Bass - July
Weighted Usable Area (millions ft²)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Fry
0
20
40
60
80
100
% of Time Equaled or Exceeded

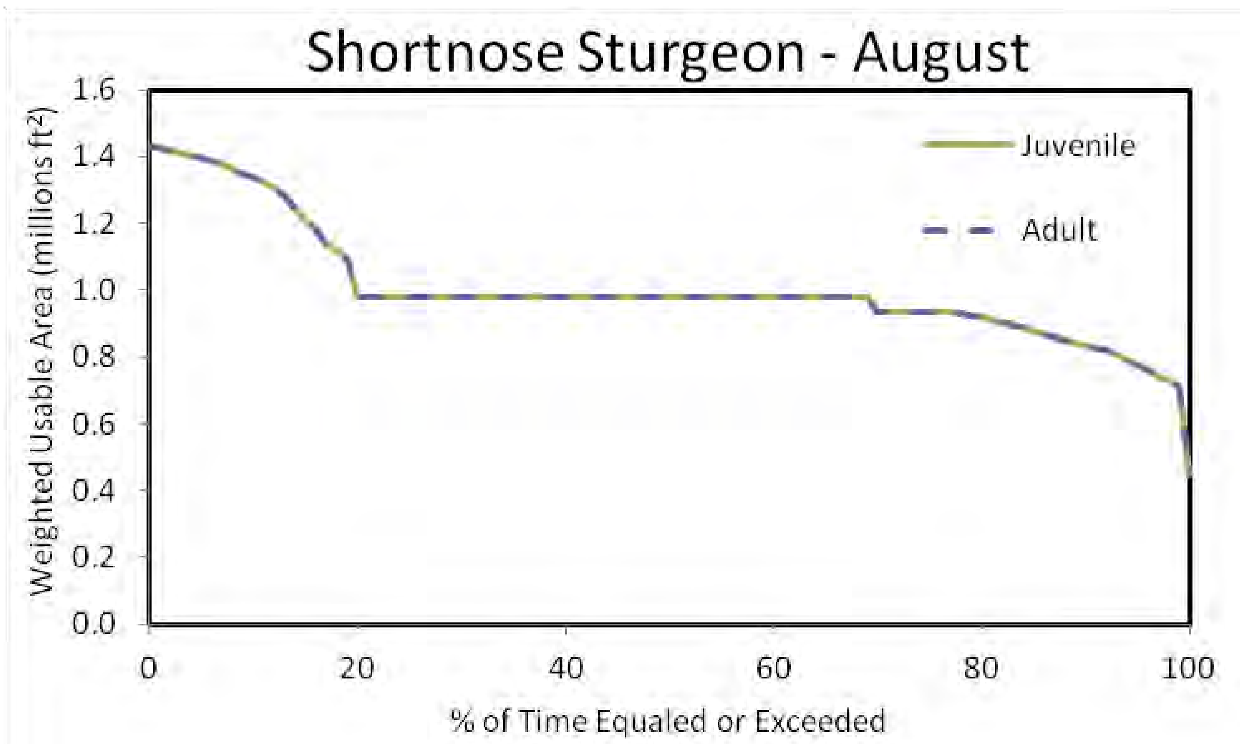

Macroinvertebrates - July
Weighted Usable Area (millions ft²)
14
12
10
8
6
4
2
0
Stonefly
Mayfly
Caddisfly
0
20
40
60
80
100
% of Time Equaled or Exceeded


Guilds - July
Weighted Usable Area (millions ft^2)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast

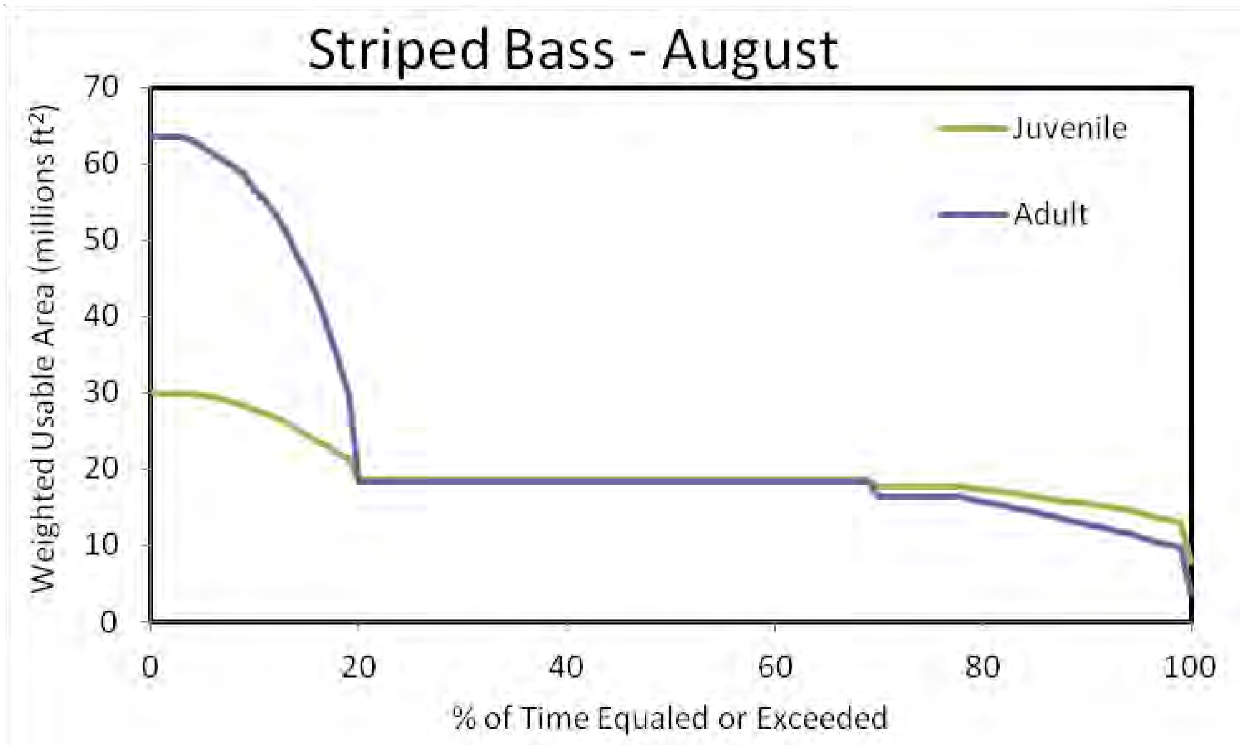

Guilds - July
Weighted Usable Area (millions ft^2)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Deep-Fast

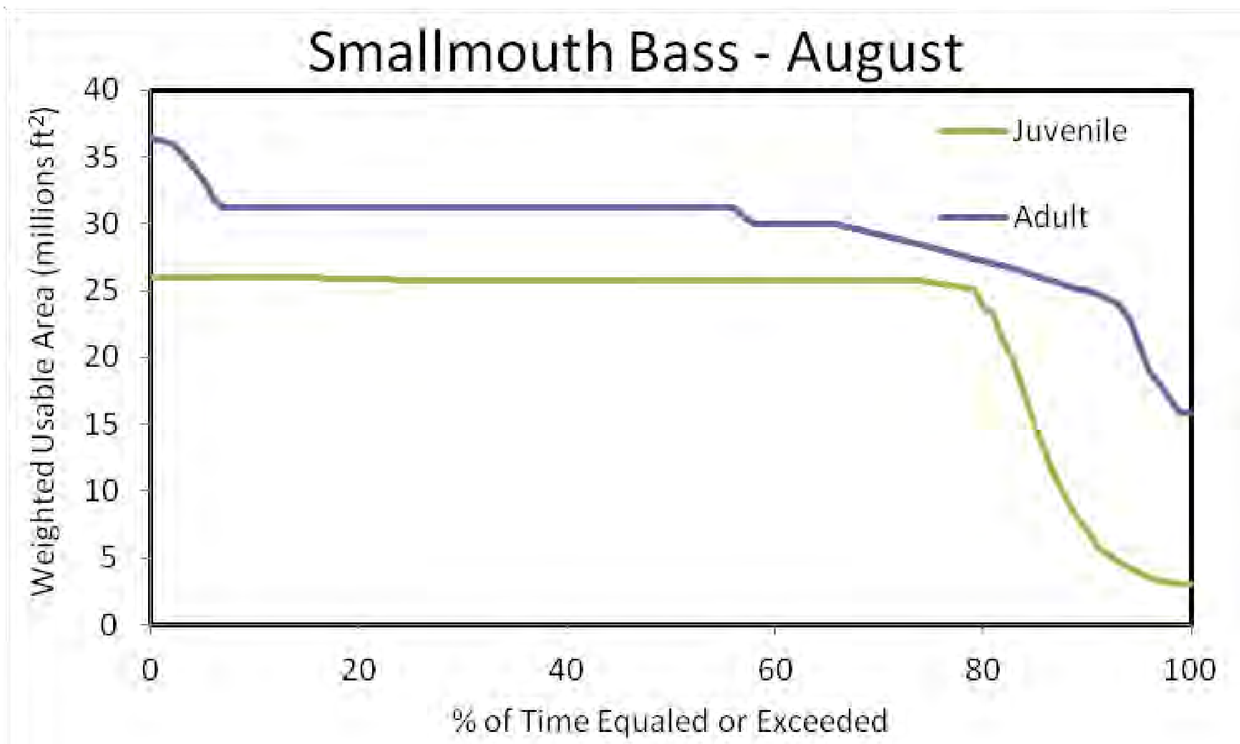


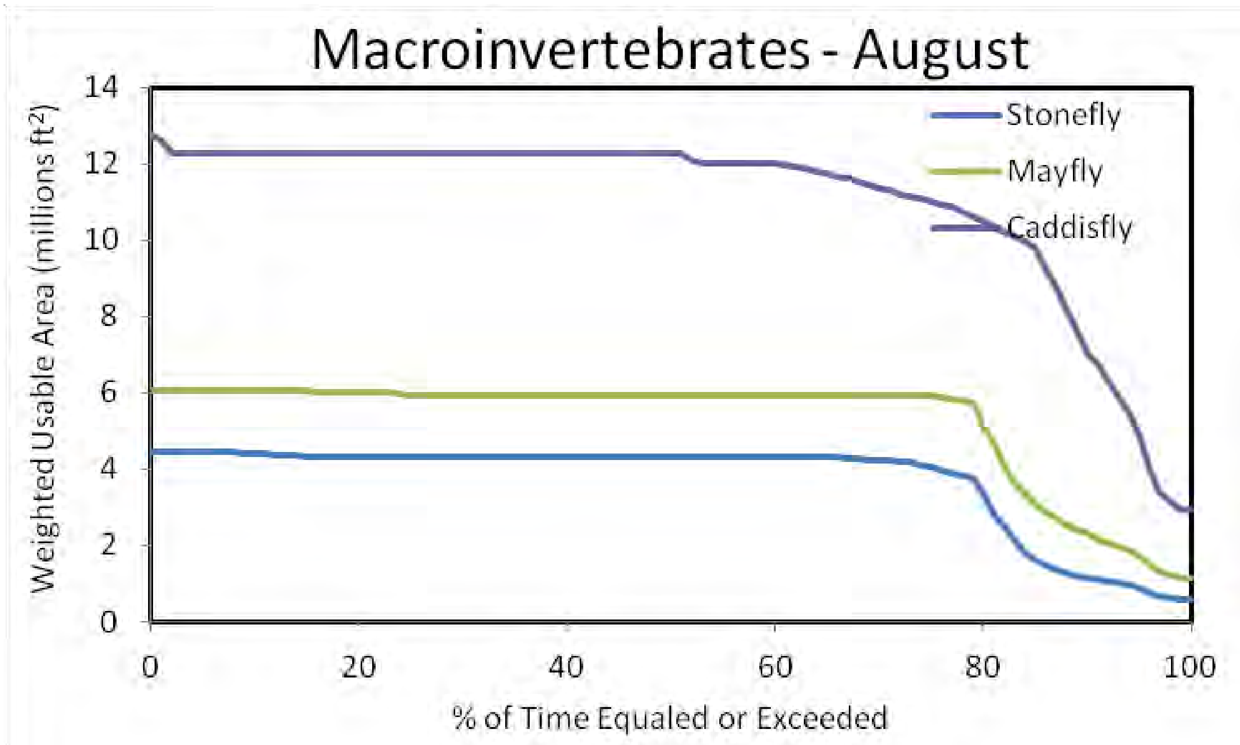
American Shad - August
Weighted Usable Area (millions ft2)
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile



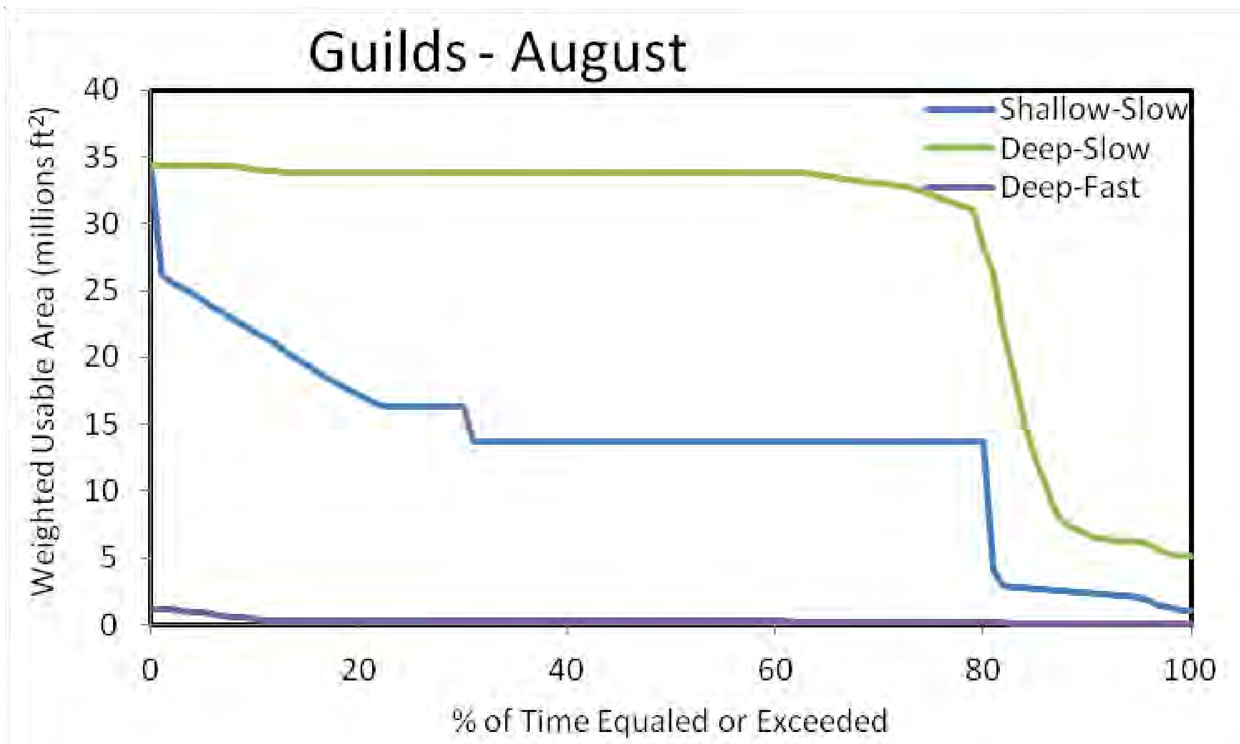
Shortnose Sturgeon - August
Weighted Usable Area (millions ft2)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult


Striped Bass - August
Weighted Usable Area (millions ft2)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult

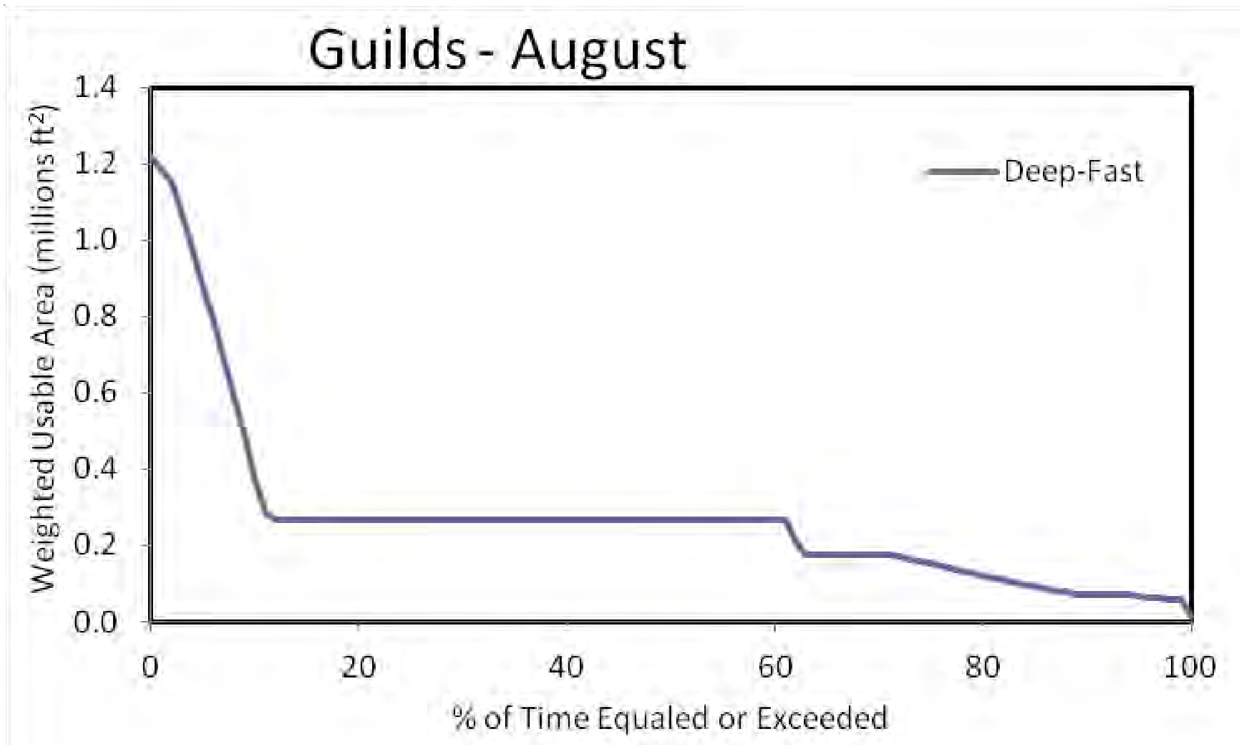

Smallmouth Bass - August
Weighted Usable Area (millions ft2)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult

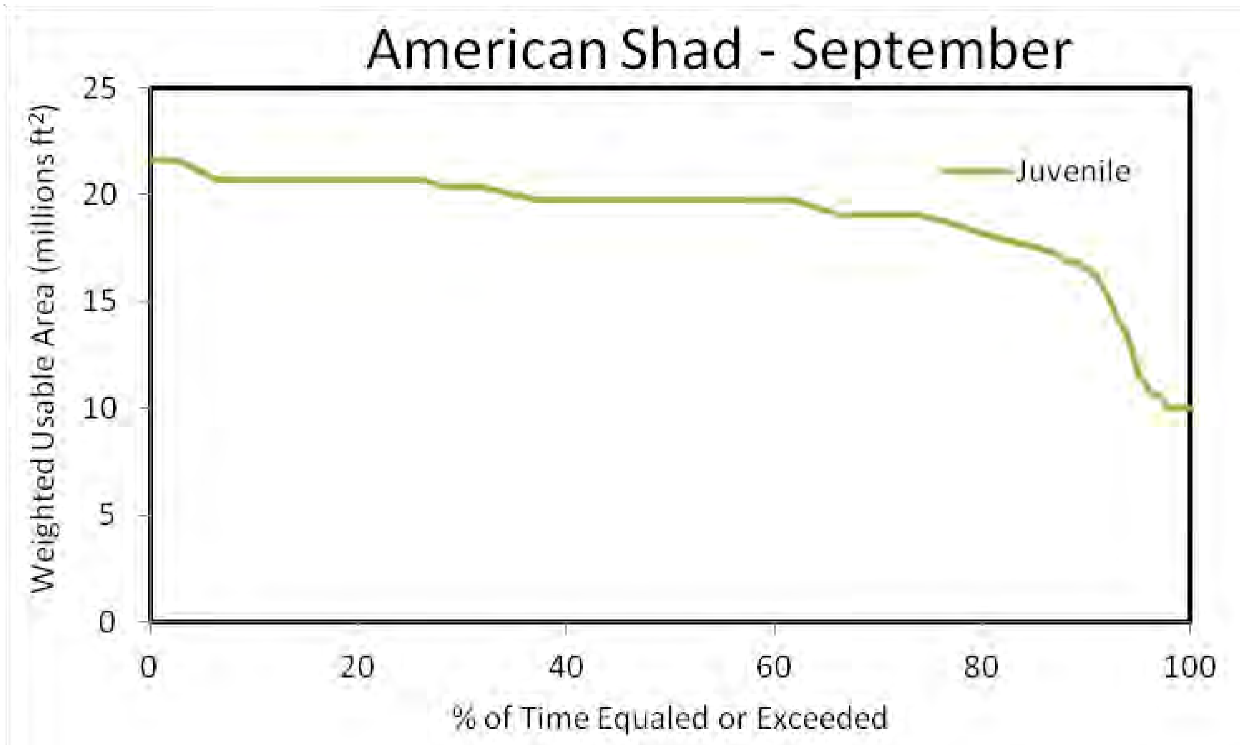


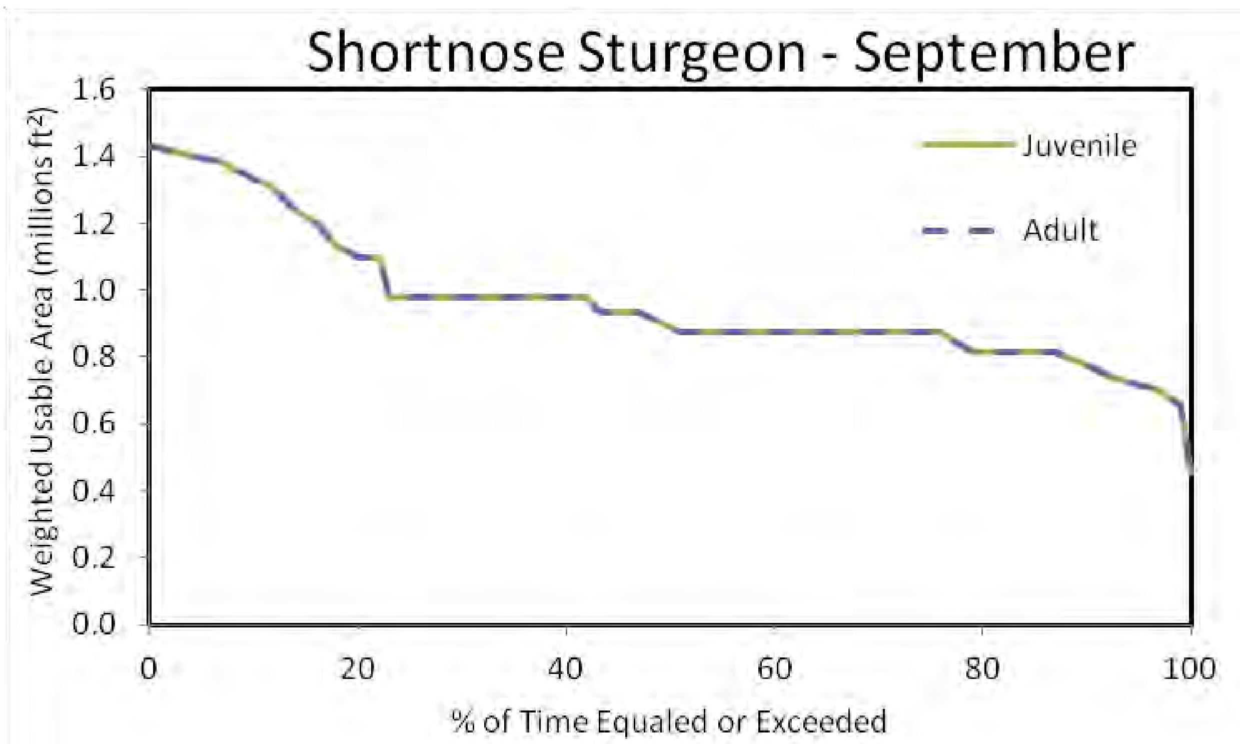
Macroinvertebrates - August
Weighted Usable Area (millions ft2)
14
12
10
8
6
4
2
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Stonefly
Mayfly
Caddisfly

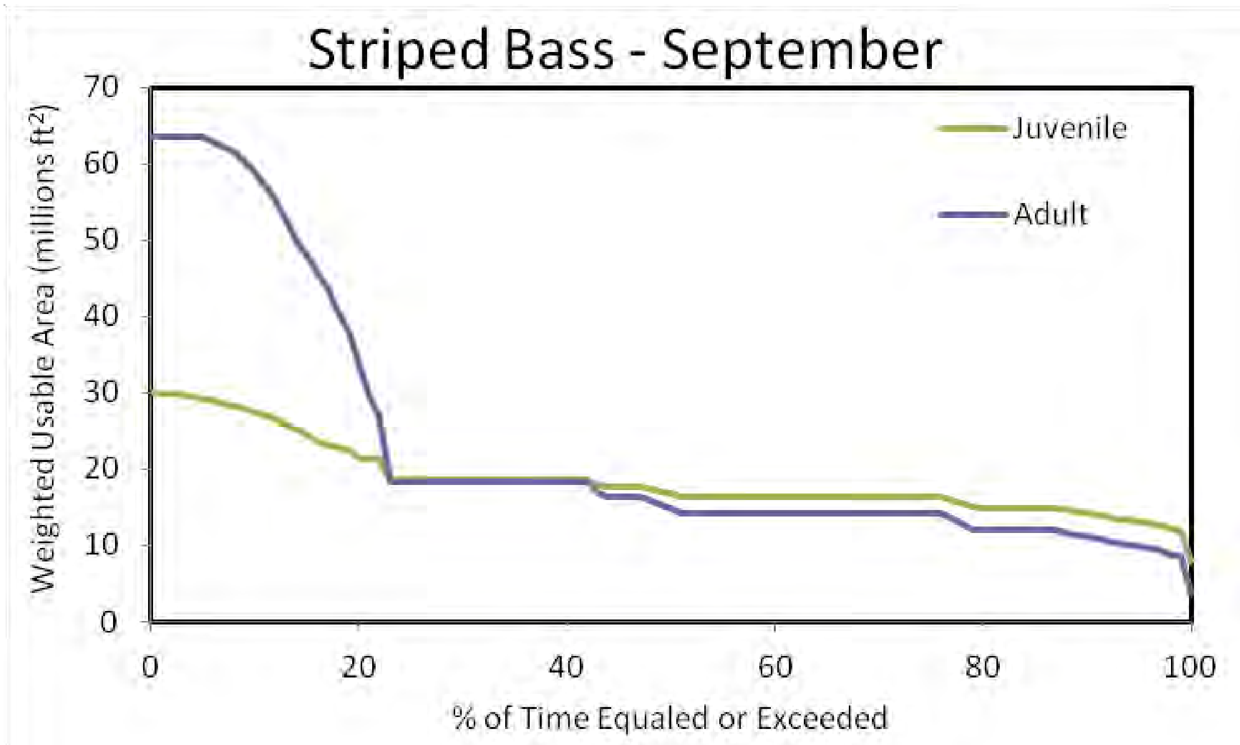


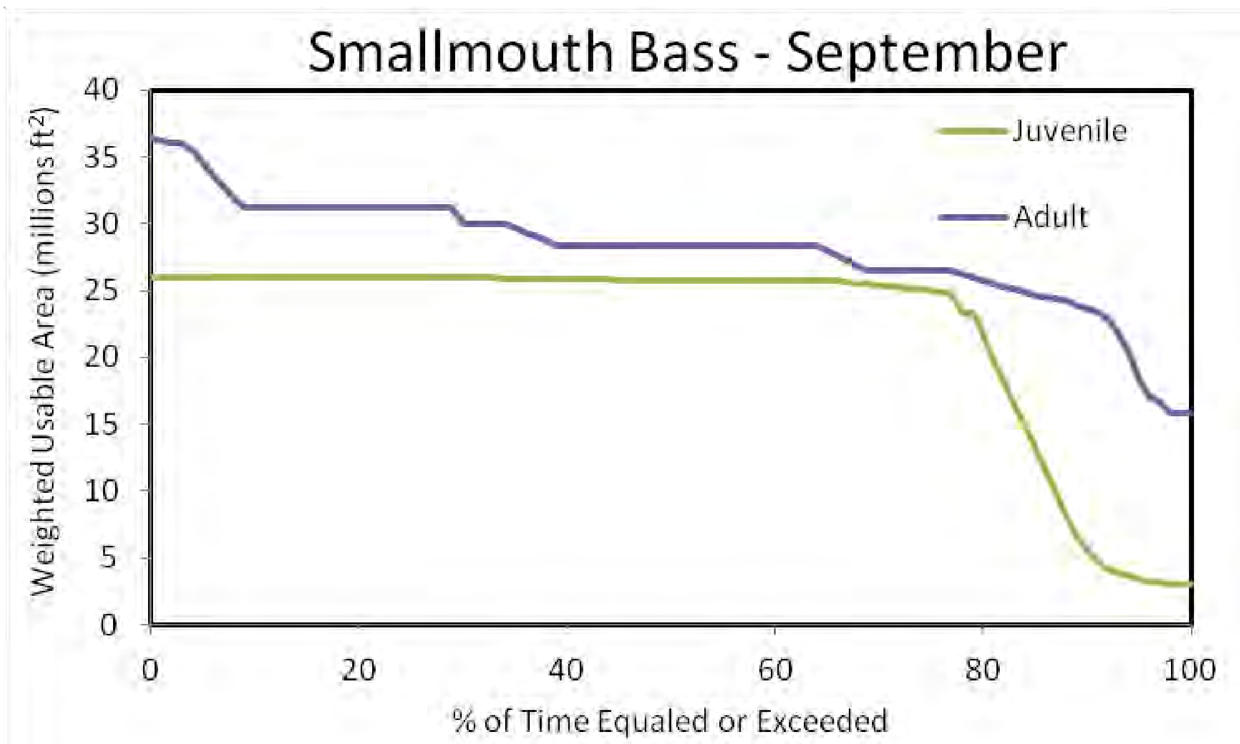
Guilds - August
Weighted Usable Area (millions ft2)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast

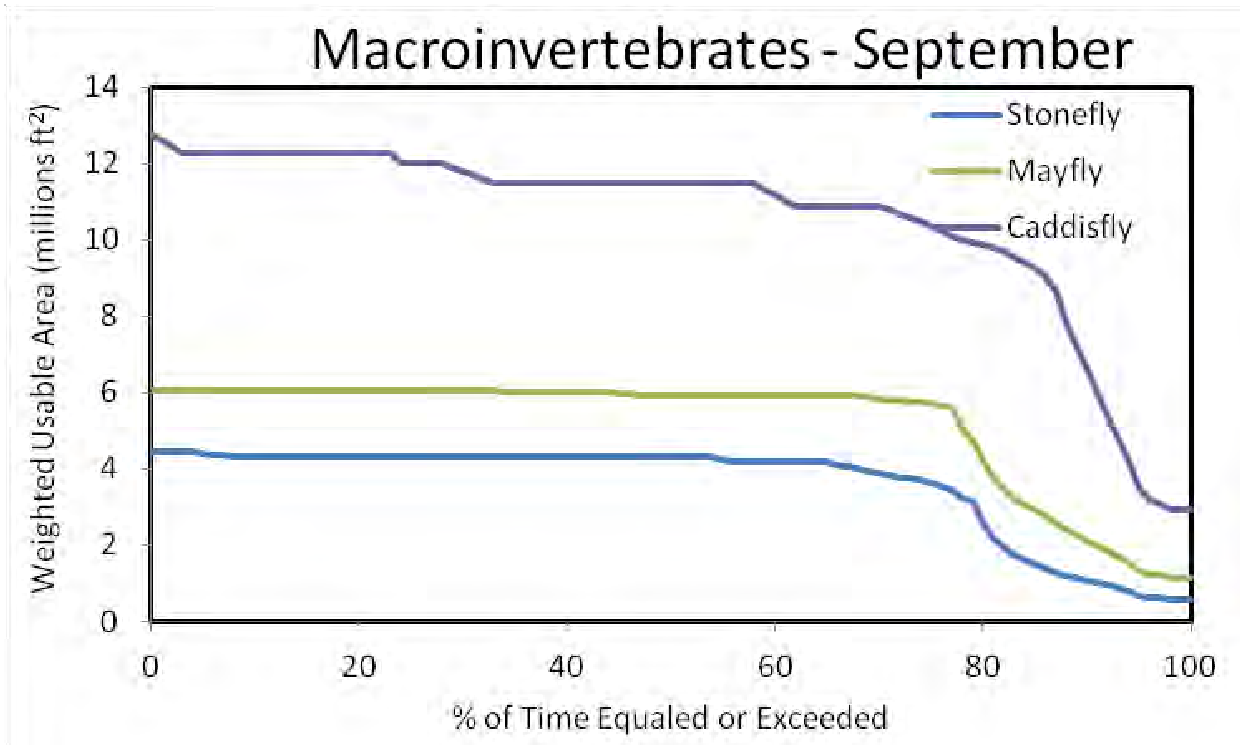

Guilds - August
Weighted Usable Area (millions ft²)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Deep-Fast
0
20
40
60
80
100
% of Time Equaled or Exceeded

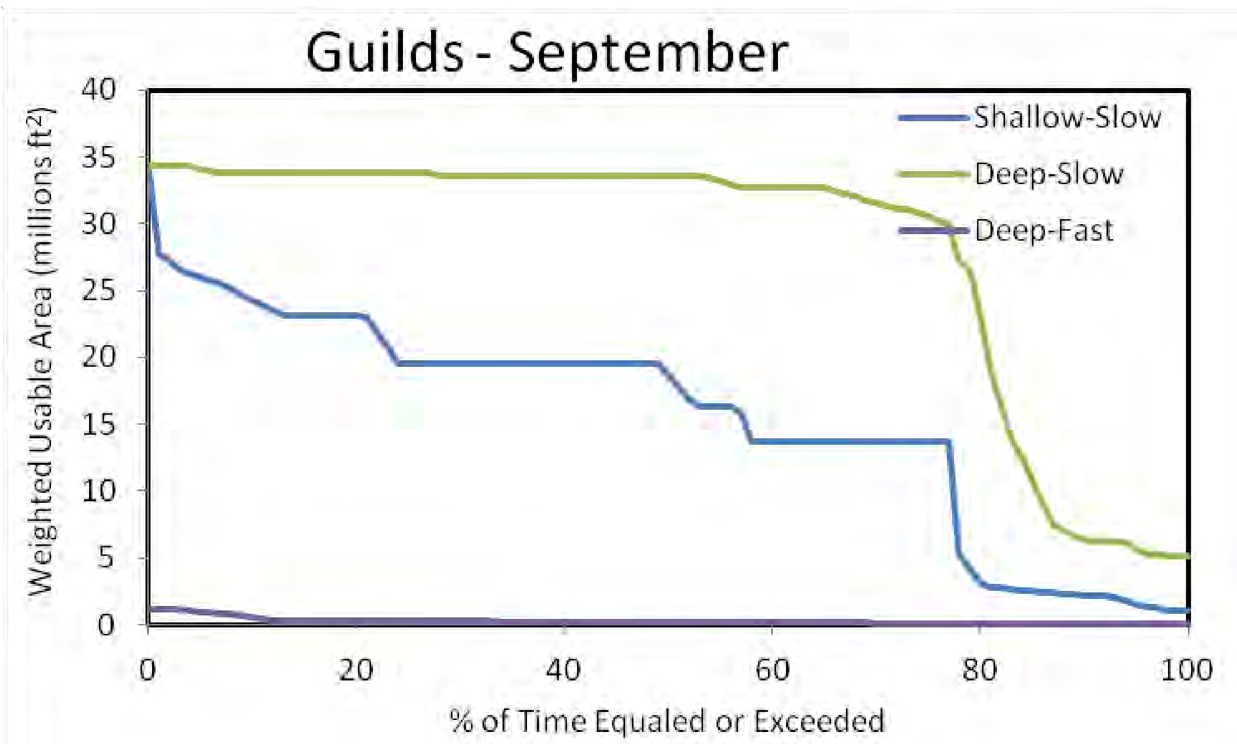

American Shad - September
Juvenile
Weighted Usable Area (millions ft²)
0
5
10
15
20
25
0
20
40
60
80
100
% of Time Equaled or Exceeded

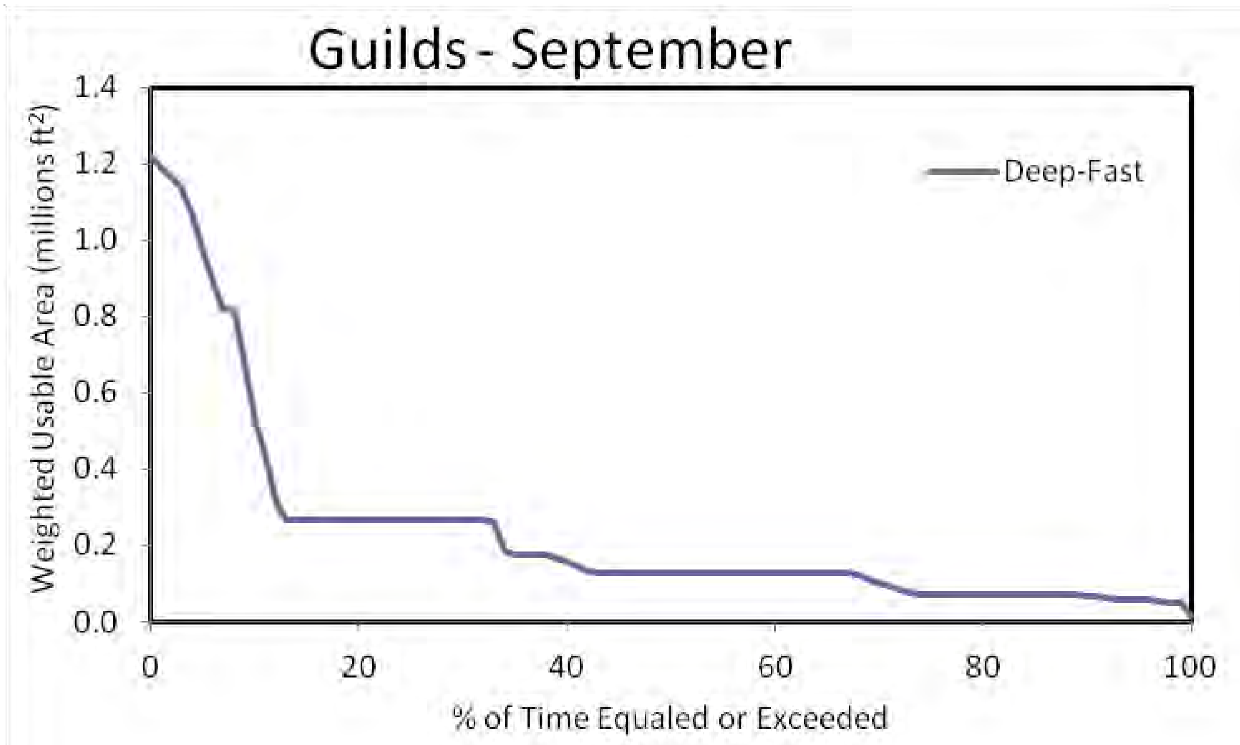

Shortnose Sturgeon - September
Juvenile
Adult
Weighted Usable Area (millions ft²)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
20
40
60
80
100
% of Time Equaled or Exceeded


Striped Bass - September
Weighted Usable Area (millions ft²)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult

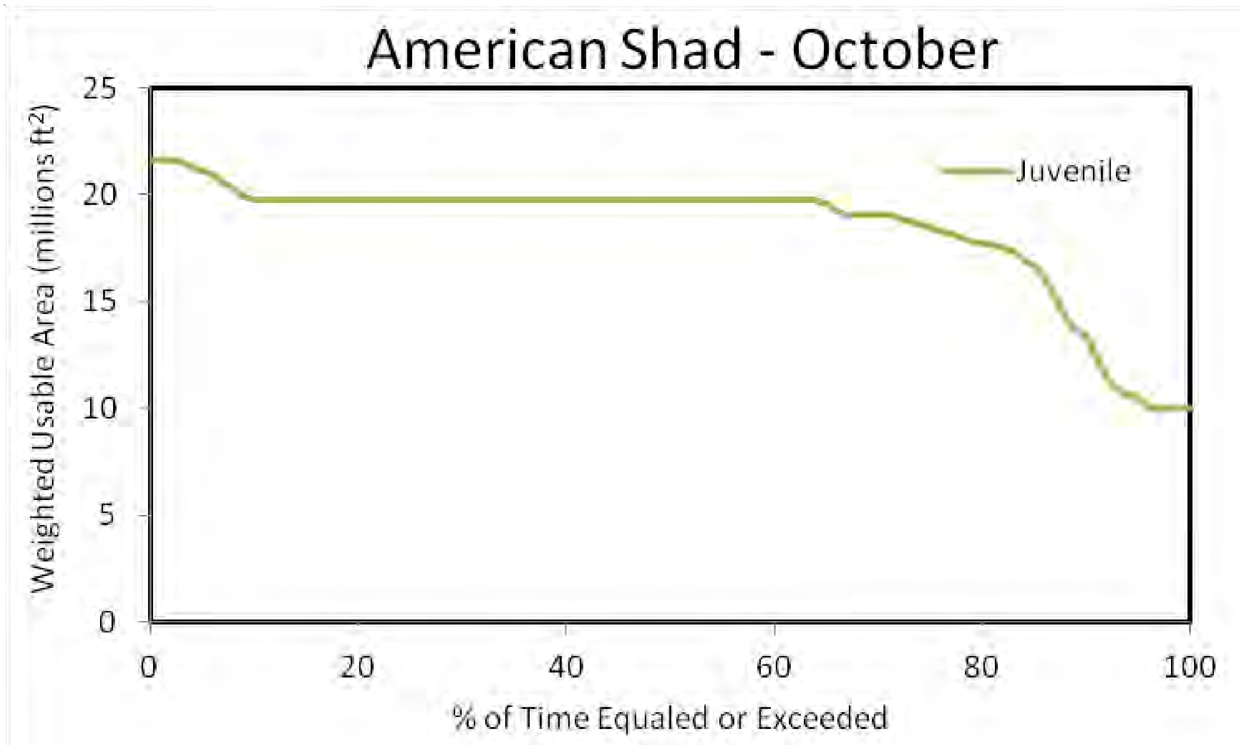

Smallmouth Bass - September
Weighted Usable Area (millions ft²)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult

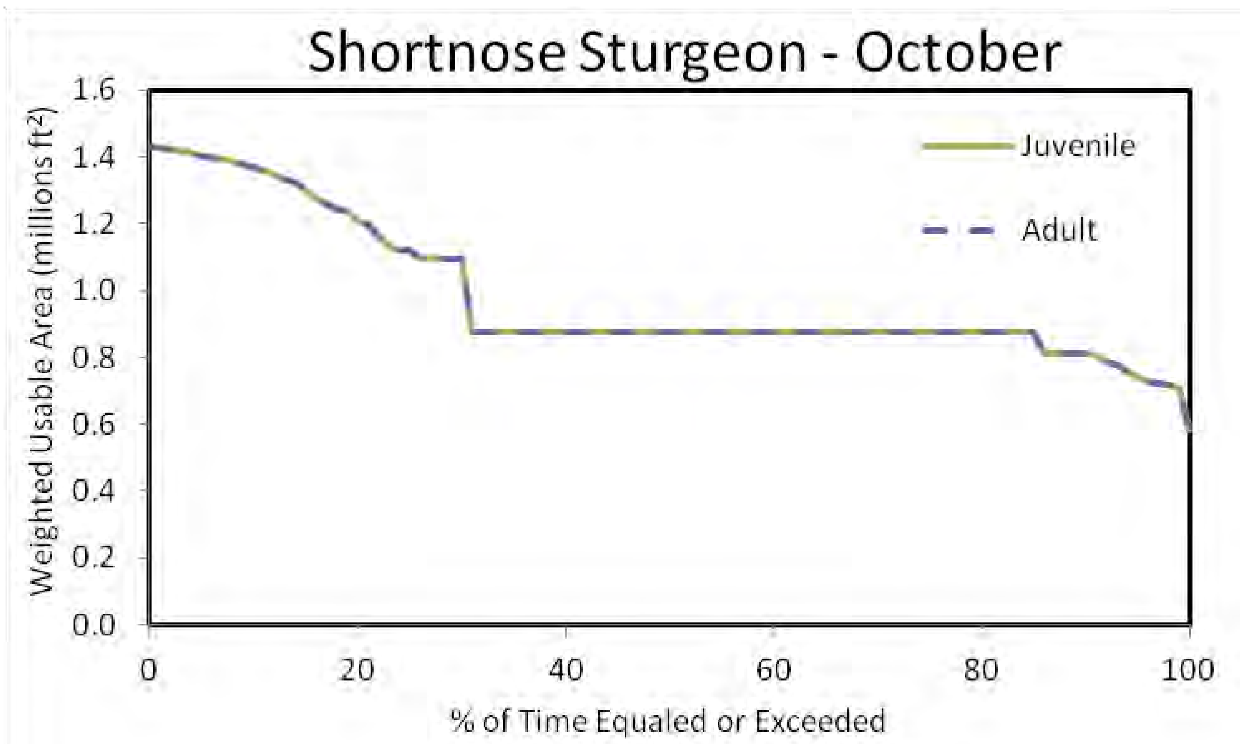

Macroinvertebrates - September
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
Stonefly
Mayfly
Caddisfly
0
2
4
6
8
10
12
14
0
20
40
60
80
100

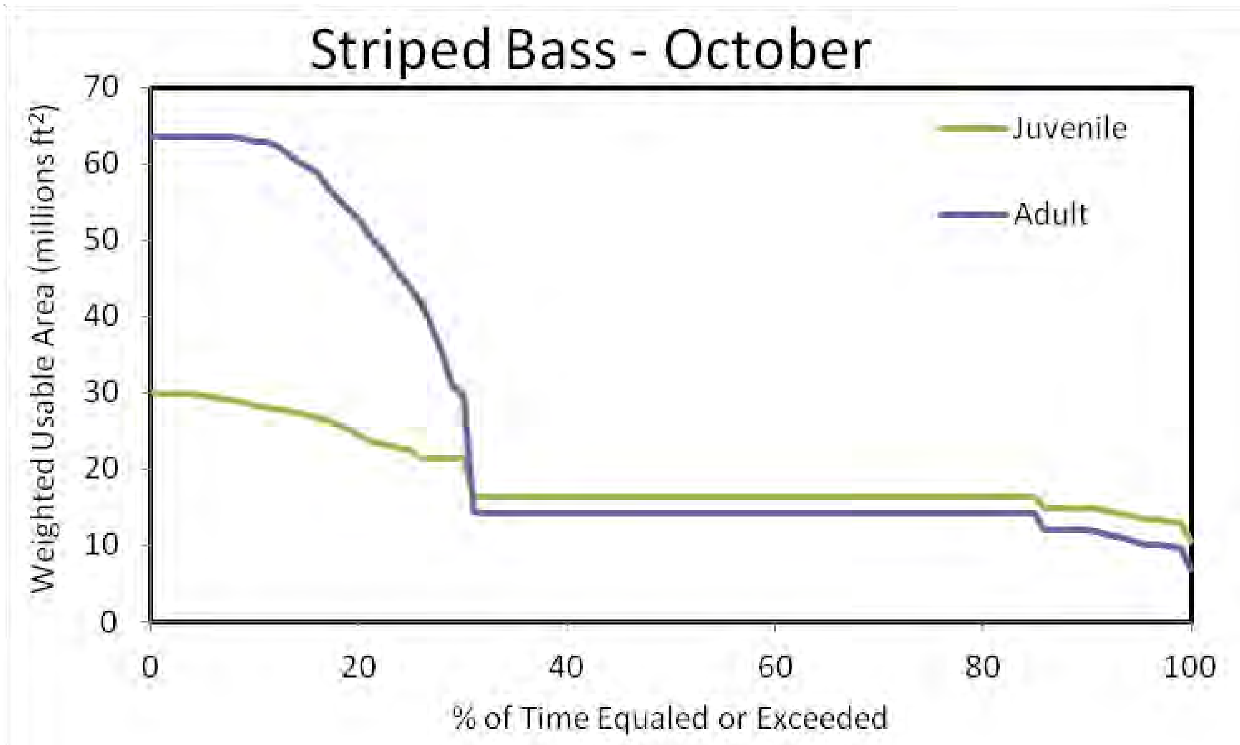

Guilds - September
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100

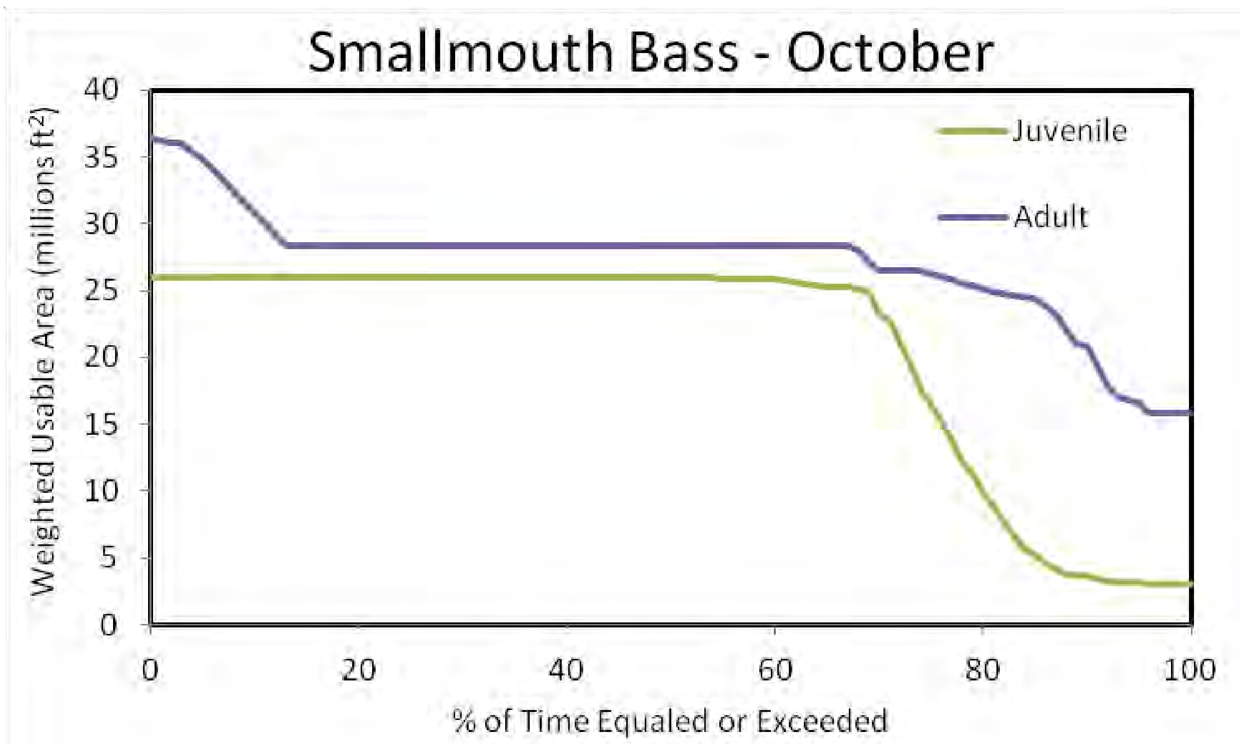


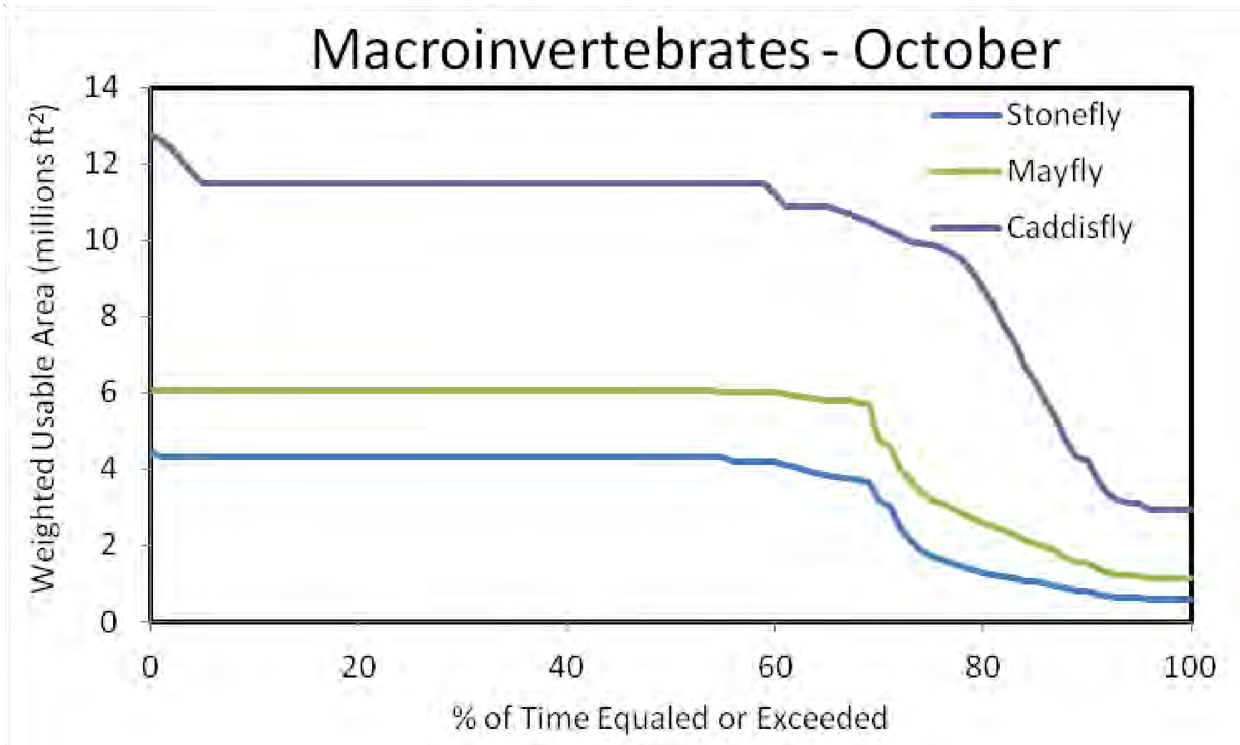
Guilds - September
Weighted Usable Area (millions ft2)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Deep-Fast
0
20
40
60
80
100
% of Time Equaled or Exceeded

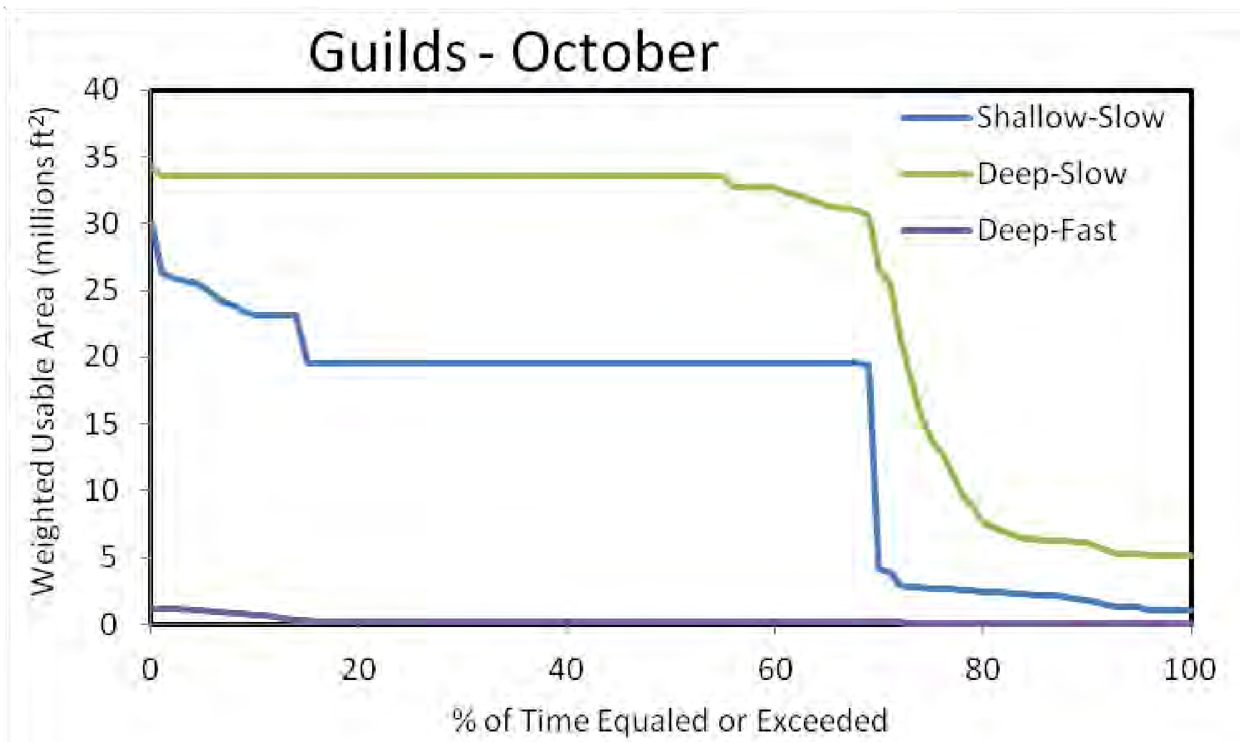

American Shad - October
Juvenile
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0
5
10
15
20
25
0
20
40
60
80
100

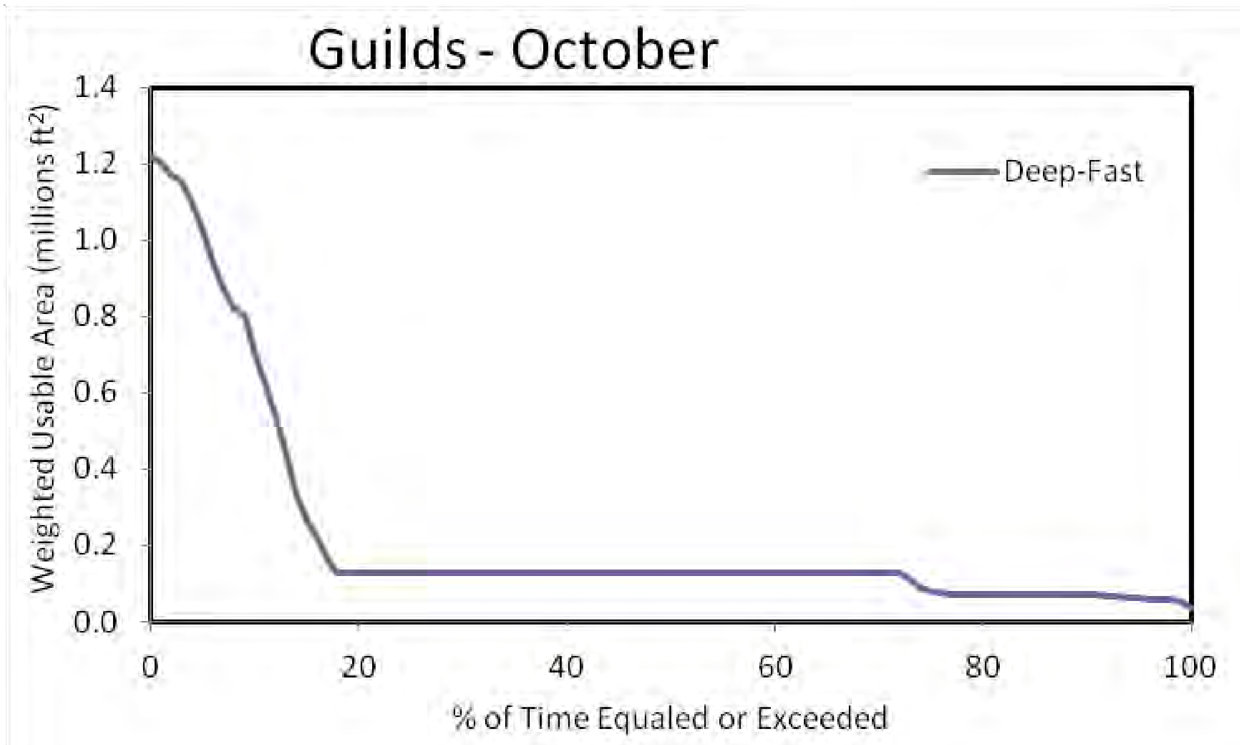

Shortnose Sturgeon - October
Juvenile
Adult
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
20
40
60
80
100

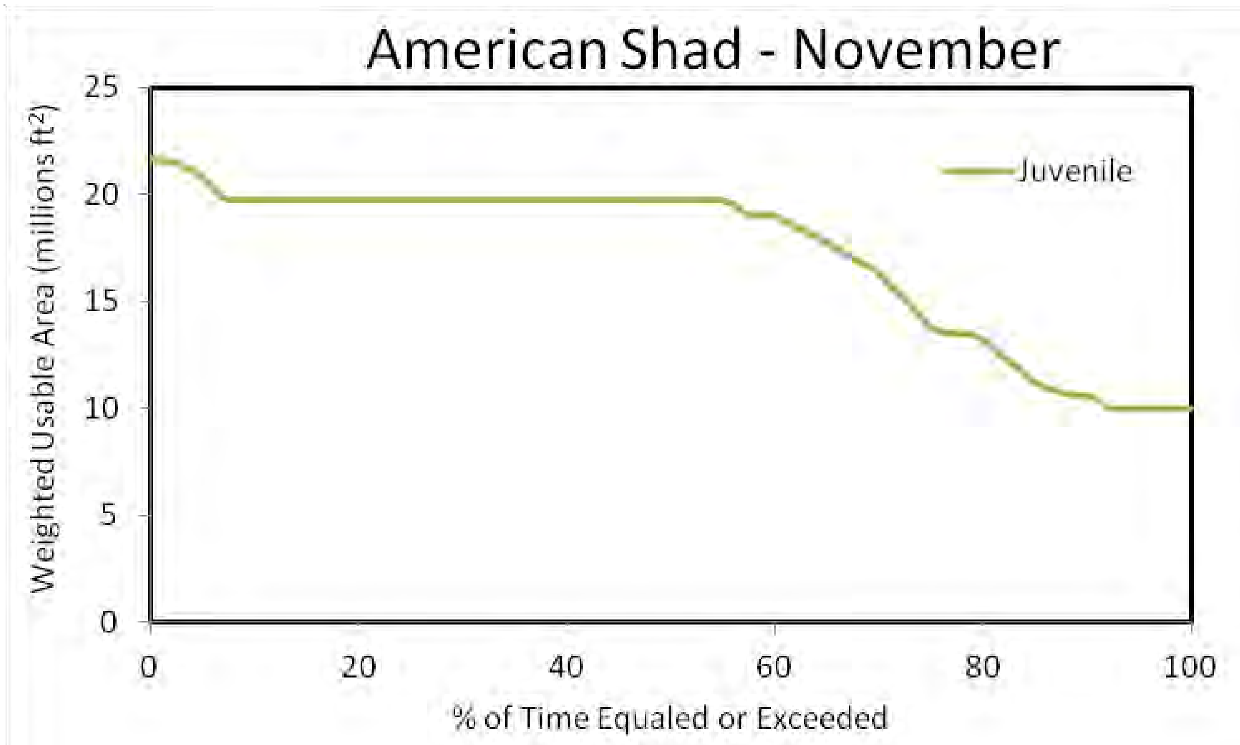

Striped Bass - October
Weighted Usable Area (millions ft2)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult

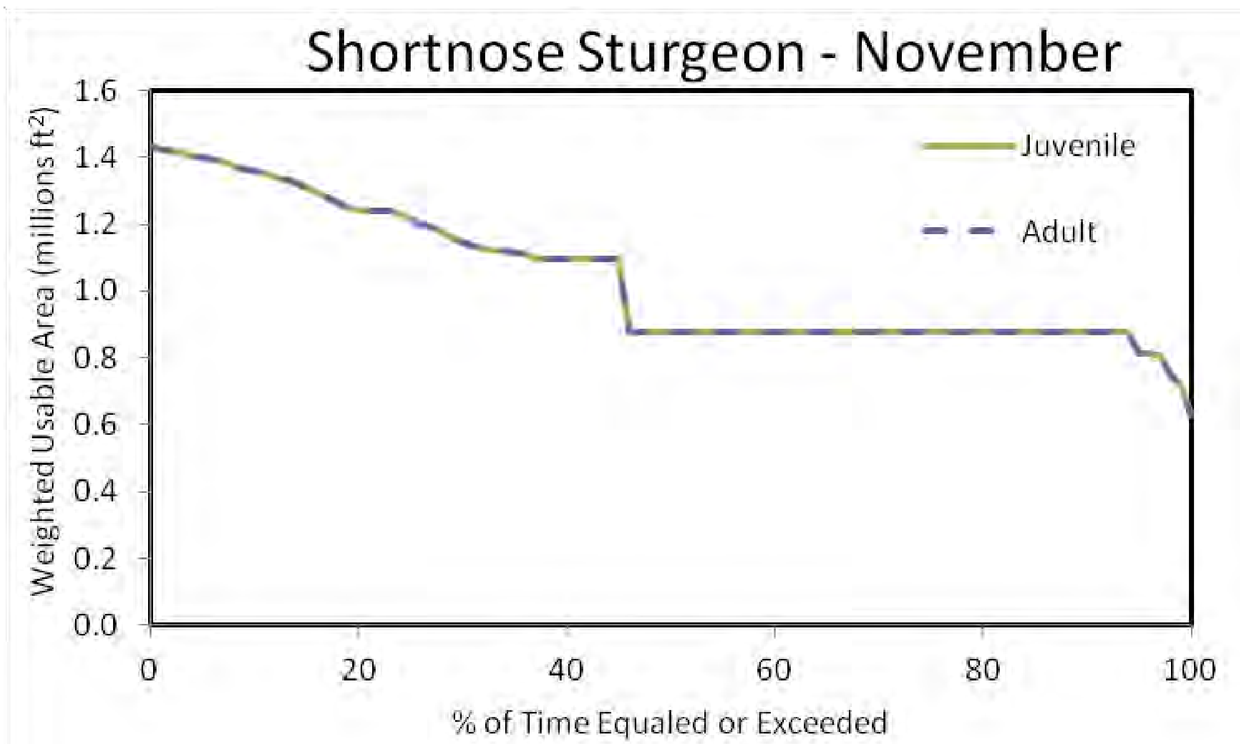

Smallmouth Bass - October
Weighted Usable Area (millions ft2)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult

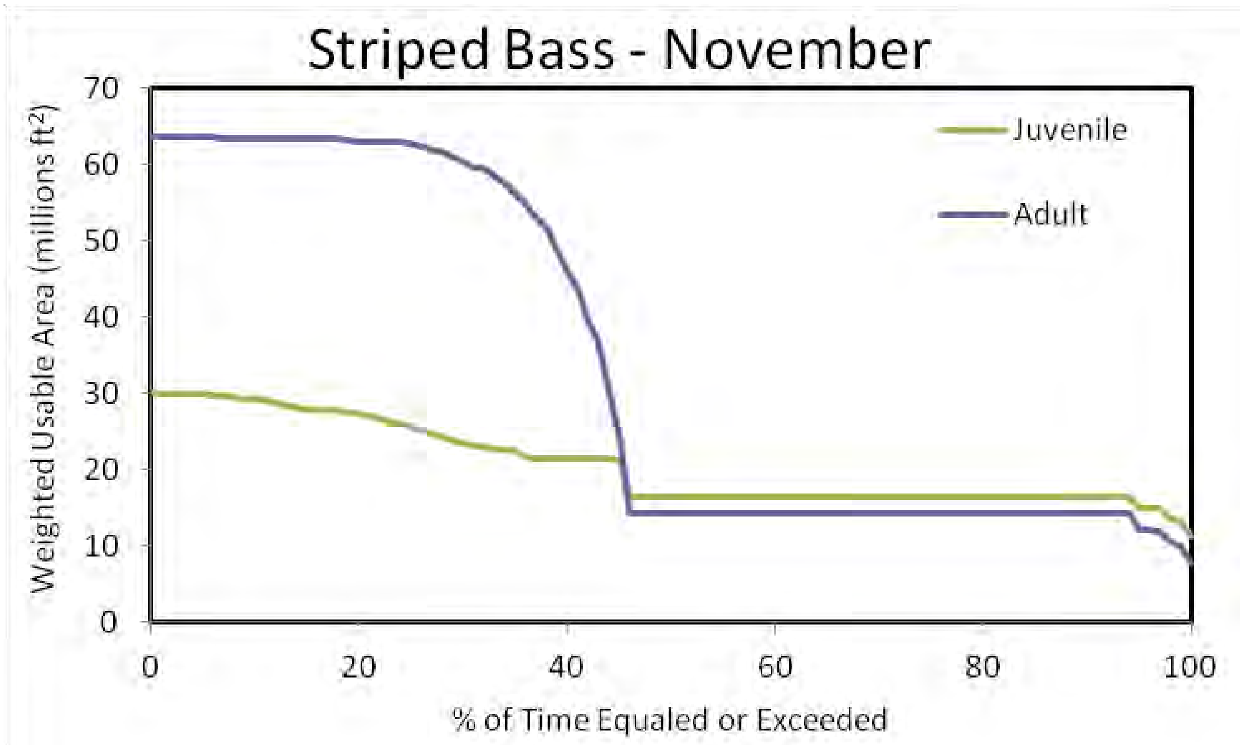

Macroinvertebrates - October
Weighted Usable Area (millions ft²)
14
12
10
8
6
4
2
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Stonefly
Mayfly
Caddisfly

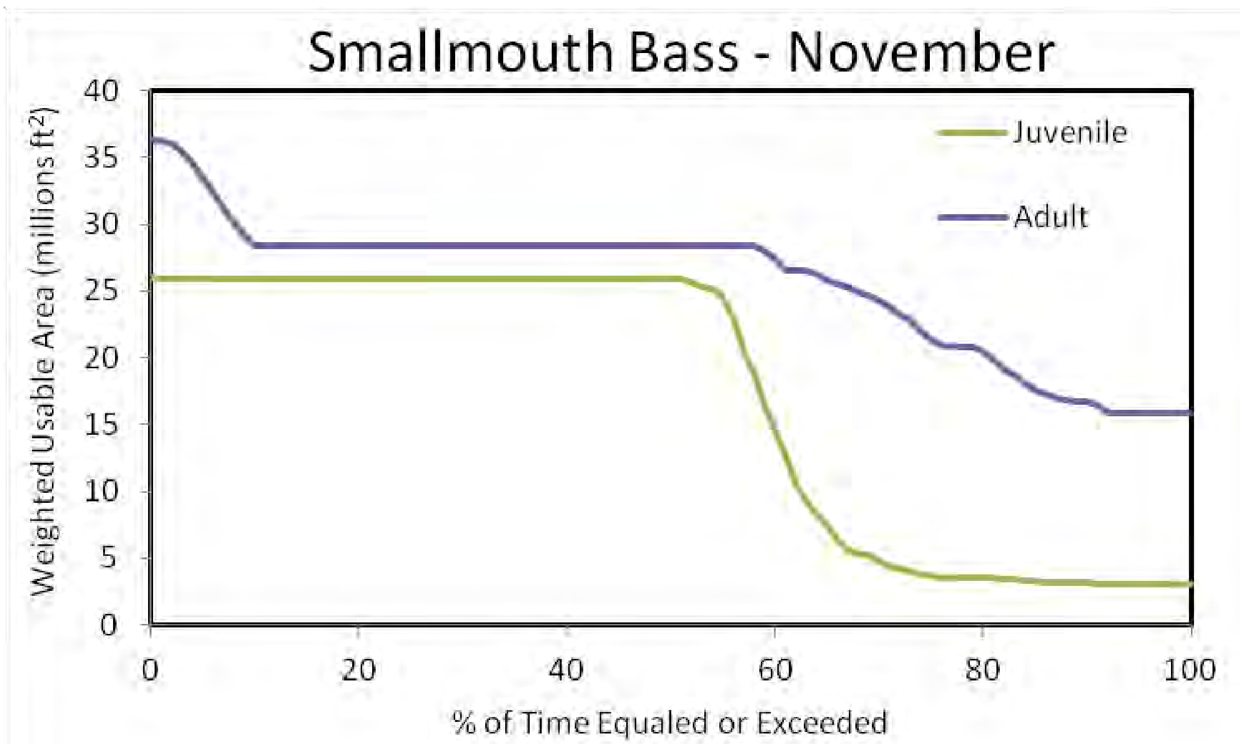

Guilds - October
Weighted Usable Area (millions ft²)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast

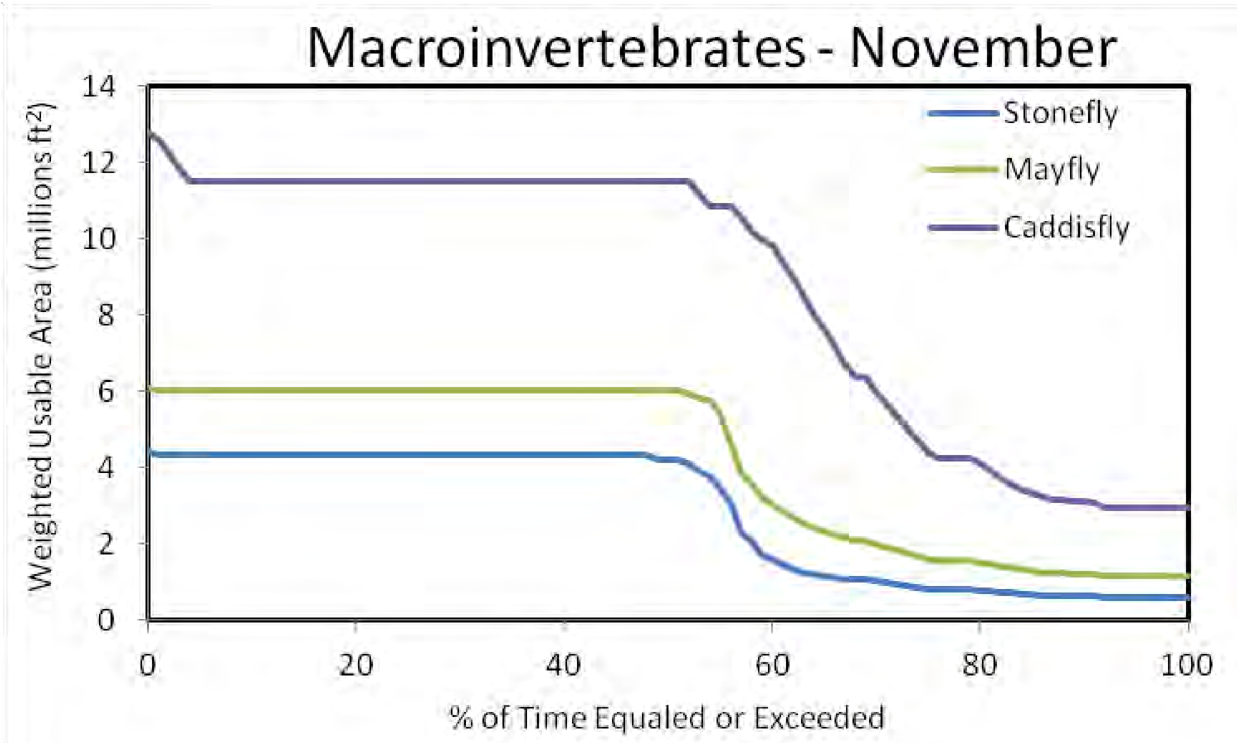

Guilds - October
Weighted Usable Area (millions ft²)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Deep-Fast

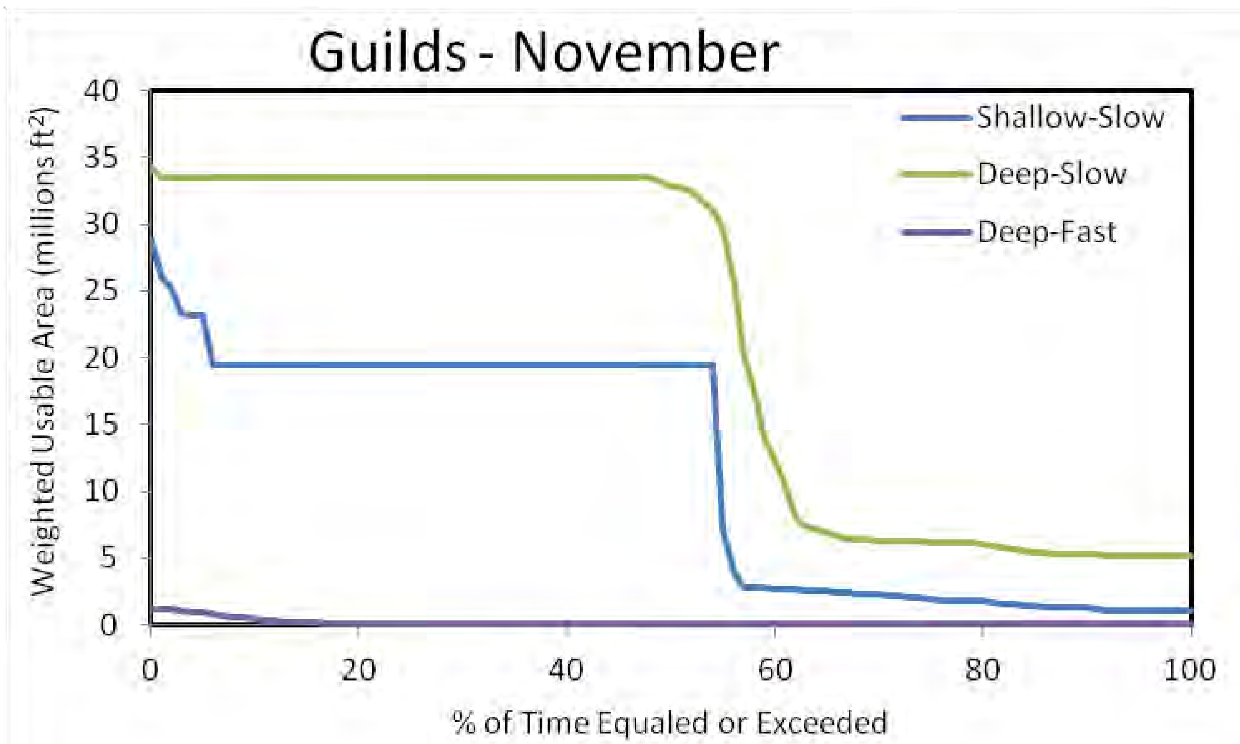

American Shad - November
Juvenile
Weighted Usable Area (millions ft2)
25
20
15
10
5
0
0
20
40
60
80
100
% of Time Equaled or Exceeded

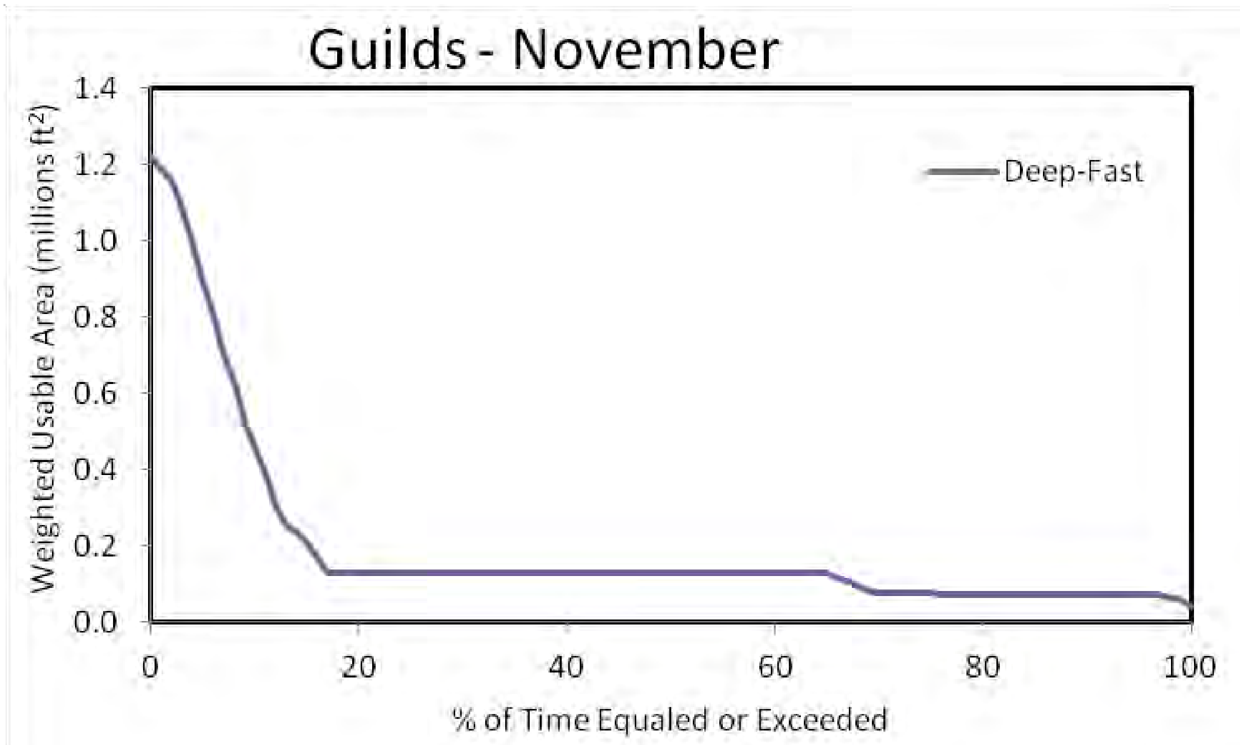

Shortnose Sturgeon - November
Juvenile
Adult
Weighted Usable Area (millions ft2)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded

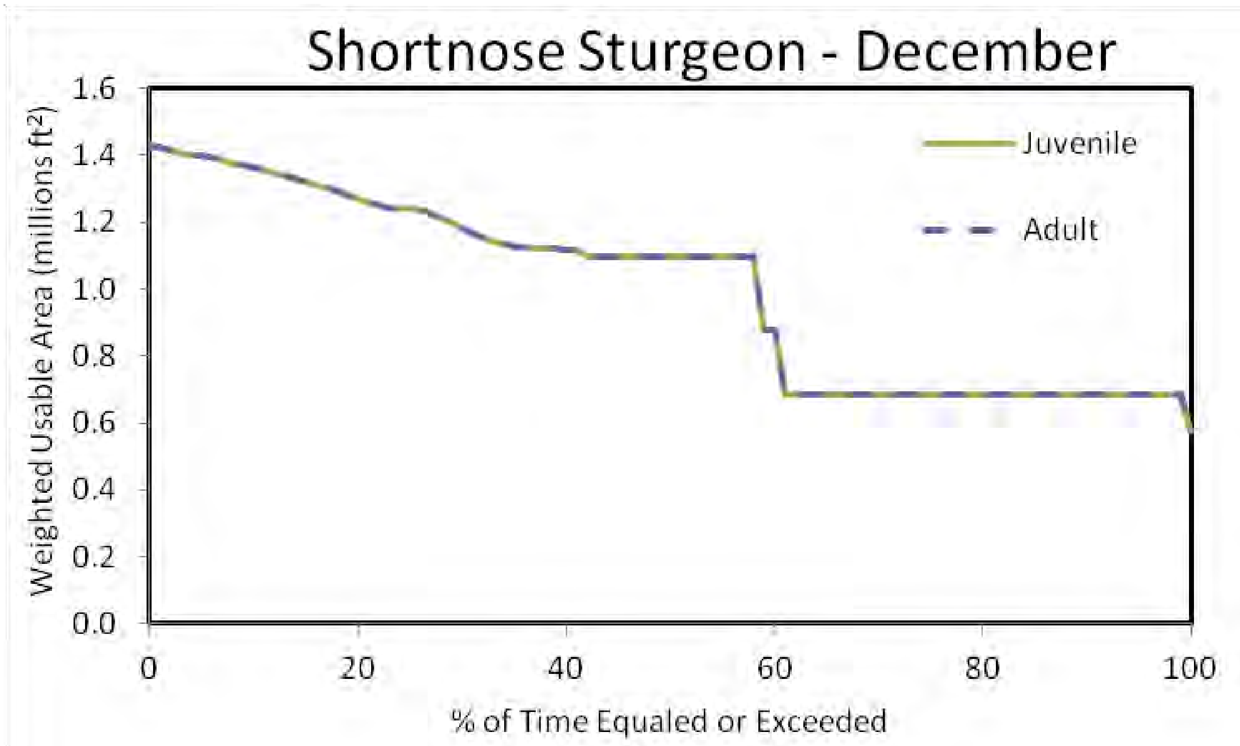

Striped Bass - November
Juvenile
Adult
Weighted Usable Area (millions ft²)
0
10
20
30
40
50
60
70
0
20
40
60
80
100
% of Time Equaled or Exceeded

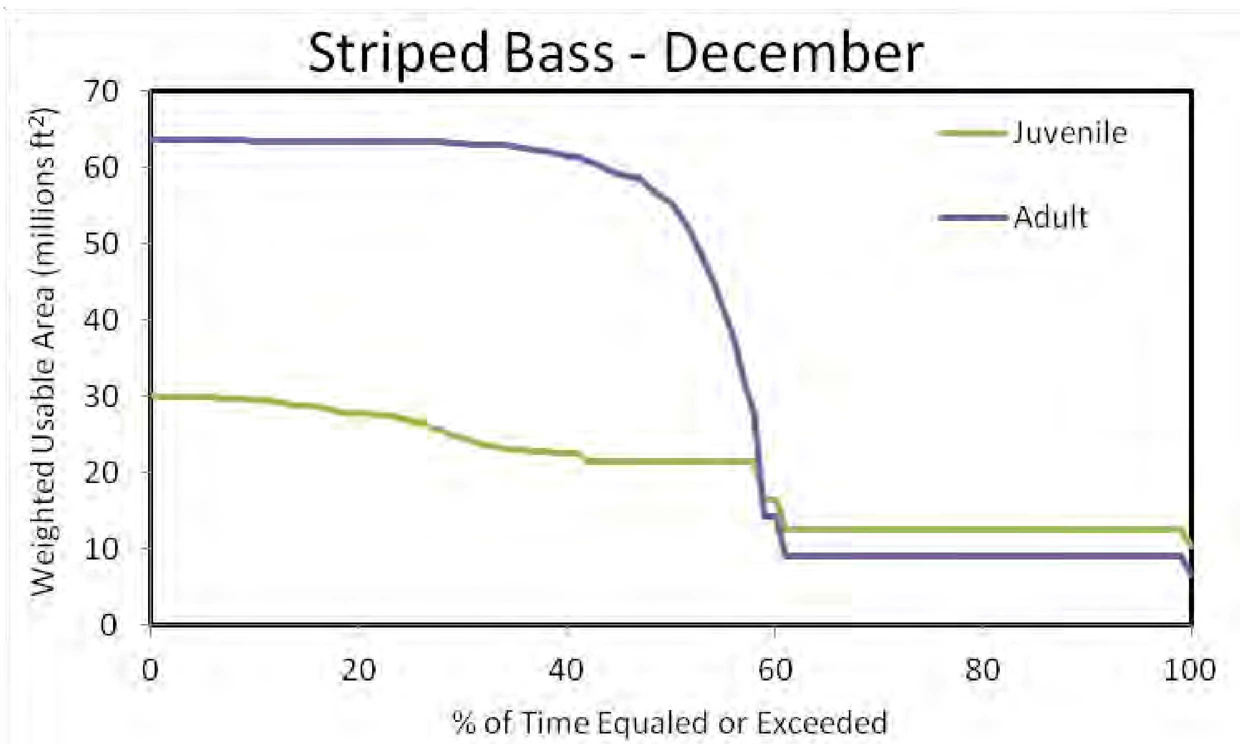

Smallmouth Bass - November
Juvenile
Adult
Weighted Usable Area (millions ft²)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
% of Time Equaled or Exceeded

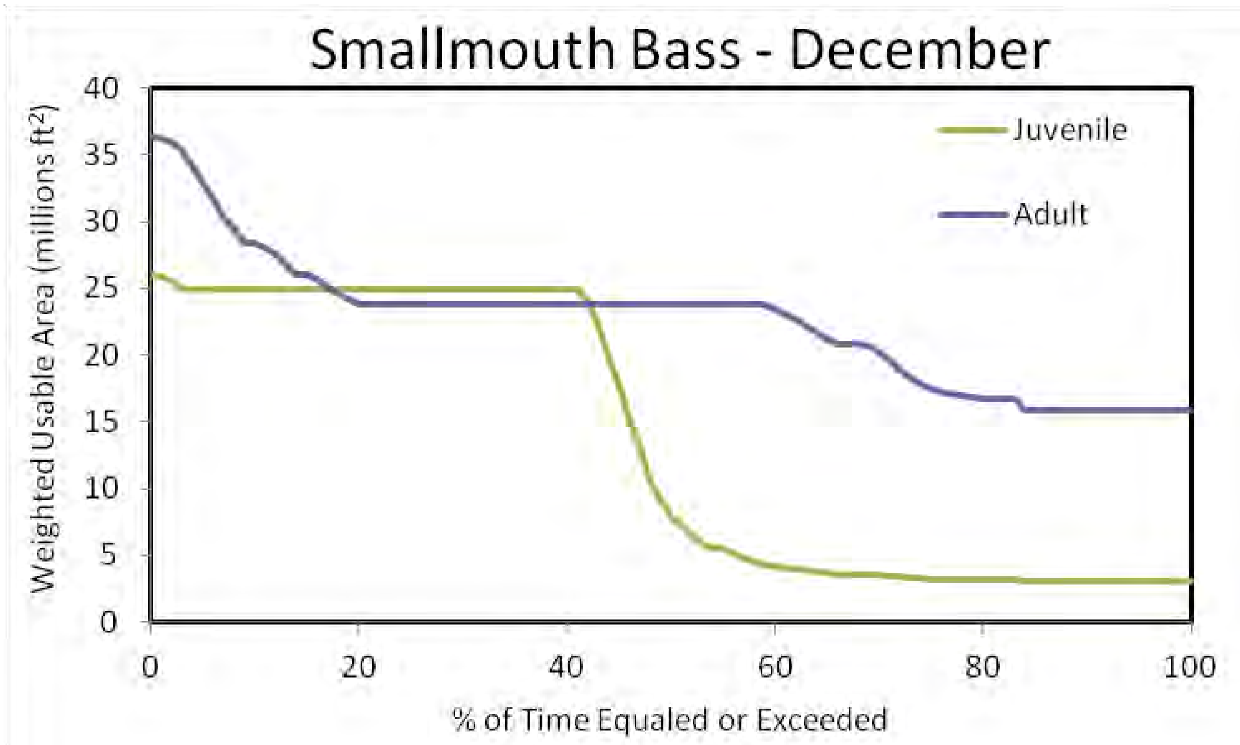

Macroinvertebrates - November
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
Stonefly
Mayfly
Caddisfly
0
2
4
6
8
10
12
14
0
20
40
60
80
100

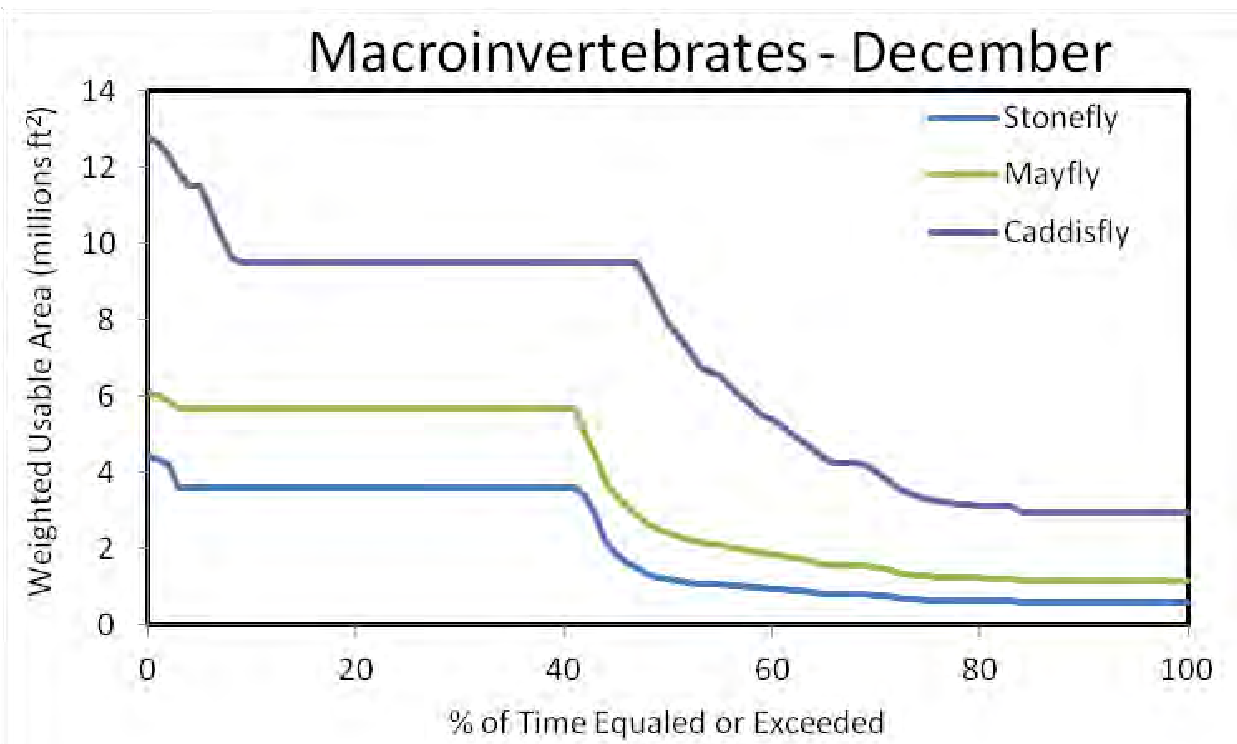

Guilds - November
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
Shallow-Slow
Deep-Slow
Deep-Fast
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100

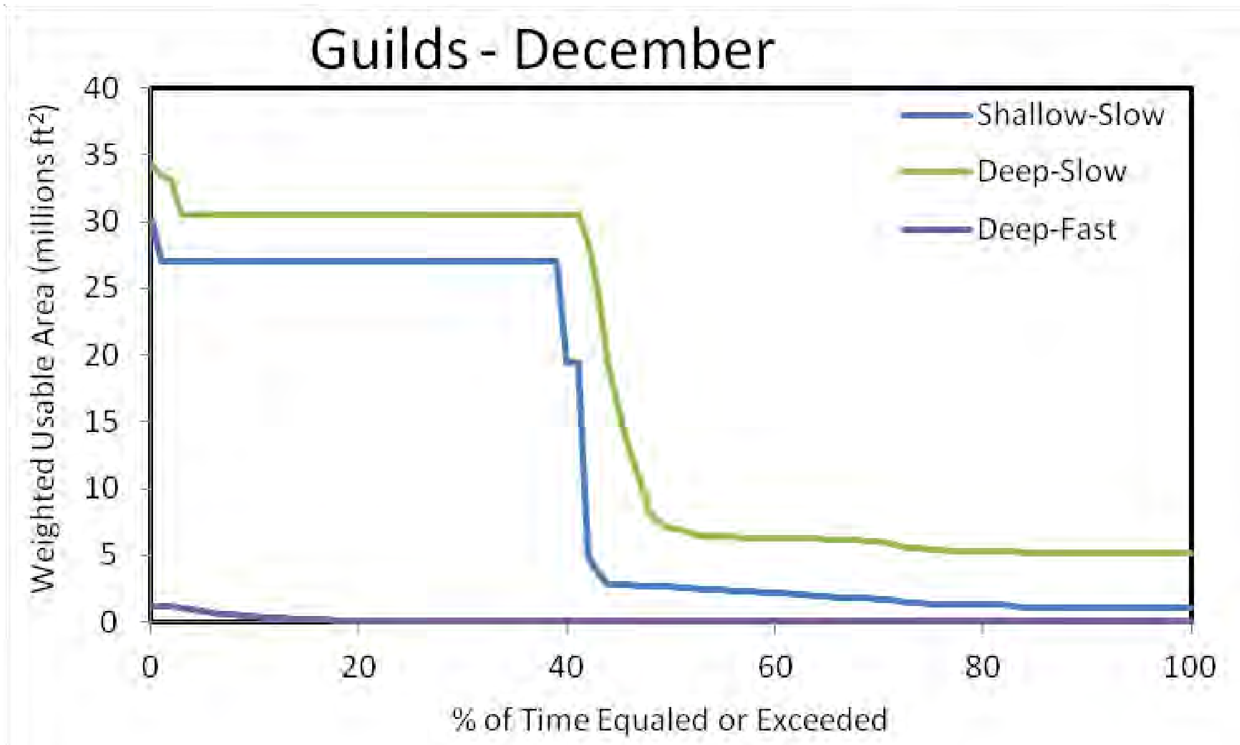

Guilds - November
Deep-Fast
Weighted Usable Area (millions ft²)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded

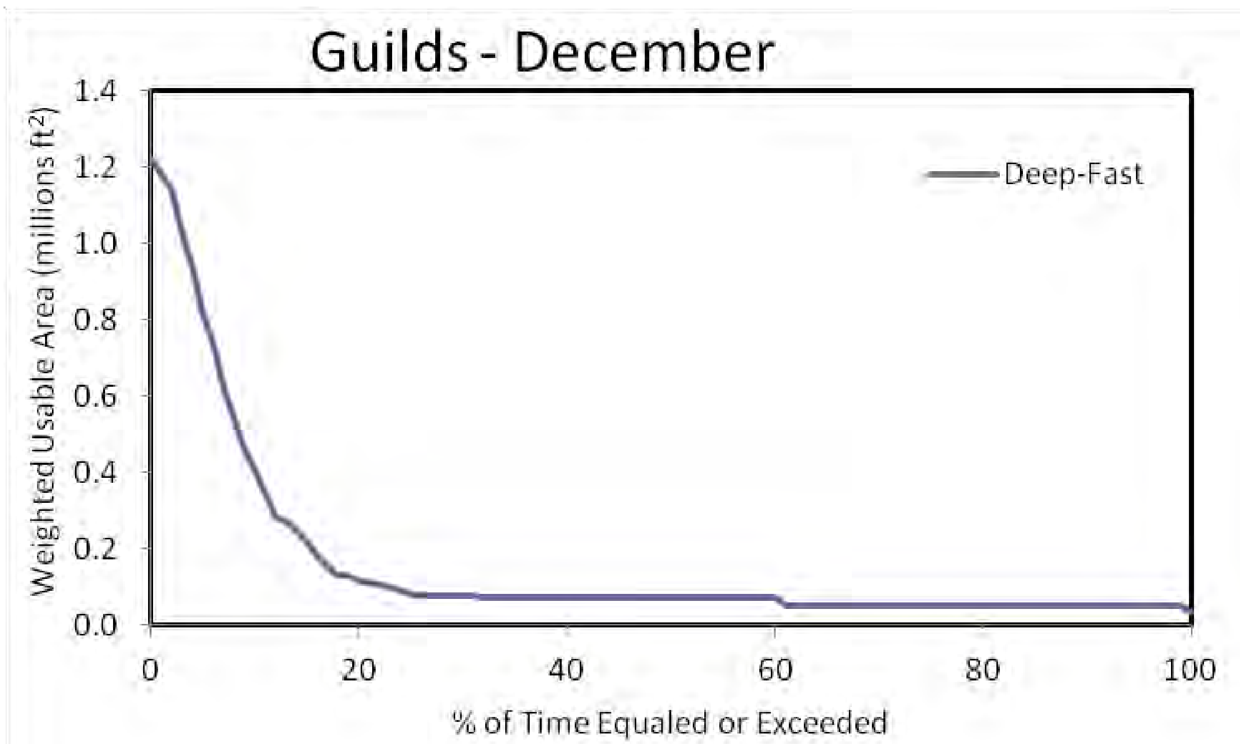

Shortnose Sturgeon - December
Weighted Usable Area (millions ft2)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult


Striped Bass - December
Weighted Usable Area (millions ft2)
70
60
50
40
30
20
10
0
0
20
40
60
80
100
% of Time Equaled or Exceeded
Juvenile
Adult


Smallmouth Bass - December
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
Juvenile
Adult
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100


Macroinvertebrates - December
Weighted Usable Area (millions ft²)
% of Time Equaled or Exceeded
Stonefly
Mayfly
Caddisfly
0
2
4
6
8
10
12
14
0
20
40
60
80
100


Guilds - December
Shallow-Slow
Deep-Slow
Deep-Fast
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100


Guilds - December
Deep-Fast
Weighted Usable Area (millions ft2)
% of Time Equaled or Exceeded
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
20
40
60
80
100