Relicensing Study 3.3.13

Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat Study Report

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

Prepared for:

FirstLight Power Resources

Prepared by:

Kleinschmidt

Gomez and Sullivan Engineers

JUNE 2016

EXECUTIVE SUMMARY

FirstLight Hydro Generating Company (FirstLight) is the current licensee of the Northfield Mountain Pumped Storage Project (Northfield Mountain Project, FERC No. 2485) and the Turners Falls Hydroelectric Project (Turners Falls Project, FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the Northfield Mountain and Turners Falls Projects using FERC's Integrated Licensing Process (ILP). The current licenses for the Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both set to expire on April 30, 2018. This report documents the results of Study No. 3.3.13 *Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat*. The study evaluates the impacts of the Turners Falls and Northfield Mountain Projects on littoral zone fish spawning and spawning habitats.

The study was conducted in the spring of 2015 in the Connecticut River from Vernon Dam in Vernon, VT, to the Turners Falls Dam in Gill and Turners Falls, MA. Prior to conducting the field investigation, a desktop literature review determined when resident species known to occur in the Project area typically spawn. The littoral zone was considered to extend from the edge of the water line[1] at the shore to a depth of approximately six feet to the extent that observable characteristics of the littoral zone could be viewed.

The littoral zone of the entire Turners Falls Impoundment (TFI) was traversed via boat and/or wading parallel to shore to visually identify fish nests, egg masses/deposits, and/or potential spawning habitat. Major tributaries (such as the Ashuelot and Millers Rivers, Pauchaug Brook, *etc.*) were investigated upstream to a point corresponding to the normal high water elevation[2]. At each spawning site, surveyors collected data, recorded observations, and to the extent possible, attempted to identify the spawning fish species. The position and elevation of nests were surveyed using a RTK-GPS unit.

With the use of the hydraulic model developed for the TFI as part of Study Report No. 3.2.2, an analysis was conducted to determine if the elevation of the spawning habitat or nest location could become exposed based on how the TFI could be operated[3] and how the TFI was historically[4] operated from 2000 to 2014. The hydraulic model simulated steady state conditions whereby flows through the TFI were held constant over a range of flows and downstream starting WSELs at the Turners Falls Dam varying from 176 feet to 185 ft (the licensed operating range of the TFI). In addition, the hydraulic model simulated unsteady state conditions whereby hourly flows (Vernon discharges, Northfield Mountain pump/generation flows) and hourly varying downstream starting WSELs at the Turners Falls Dam varied at it did historically between 2000 and 2014. From these steady and unsteady state hydraulic modeling scenarios, an analysis was conducted at each early and late spawning site to determine if the spawning habitat or nest location could have been exposed under the FERC licensed operating range of the TFI (176 to 185 feet at the dam, based on the steady state model) and under historical operations between 2000 and 2014. From the modeling results, the percentage of time during each early and late spring period that spawning habitat or nest site would be suitably inundated to support spawning was estimated based on hydraulic modeling results.

A total of 21 spawning sites were located, evidenced by extruded egg masses, cleared patches in submerged substrates or dug nests. In some cases potential for spawning was inferred by the abundance of suitable

[1] For purposes of this study, edge of the water line was identified via bankside indicators of inundation, such as a horizontal break in terrestrial vegetation and the adjacent shoreline of the impoundment.
[2] For purposes of this study, normal high water in tributaries was identified as the elevation corresponding to bankside indicators of inundation, such as a horizontal break in terrestrial vegetation along the adjacent shoreline of the impoundment. The study explored upstream from this point to the first riffle
[3]The license for the Turners Falls Project provides for the TFI to be operated between elevation 176 and 185 at the Turners Falls Dam.
[4] Historically refers to how the TFI was actually operated on an hourly basis.

emergent or submerged vegetation that could be used by percids or esocids. Some spawning sites were individual nests, but others, especially in late spring, had clusters of well-defined individual nests, so that multiple spawning bed elevations were obtained across all sites. Early spring spawning sites were distributed throughout the upper, middle, and lower sections of the TFI and consisted of unguarded egg extrusions, redds, or submerged suitable habitat where no evidence of spawning could be conclusively determined. Late spring spawning was concentrated in the upper and lower extremes of the TFI and was dominated by dug centrarchids nests with guardian adult males present. A few isolated nests occurred in tributaries, most notably lamprey redds in riffles upstream from the TFI.

Littoral zone spawning suitability showed a range of responses to modeled TFI water level fluctuations, depending on the species and locations. In general the WSEL duration analysis shows that most late spring spawning nests are suitably submerged about 85-100 % of the times, but that early spring spawners (such as yellow perch) relying on emergent riparian vegetation sites such as cattail benches were suitably submerged for shorter durations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

cfs	cubic feet per second
EAV	emergent aquatic vegetation
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
HSC	Habitat Suitability Criteria
ILP	Integrated Licensing Process
NGVD29	National Geodetic Vertical Datum of 1929
PAD	Pre-Application Document
PSP	Proposed Study Plan
RSP	Revised Study Plan
RTK-GPS	Real Time Kinematic- Global Positioning System
SAV	Submerge Aquatic Vegetation
SD1	Scoping Document 1
SD2	Scoping Document 2
SPDL	Study Plan Determination Letter
TFI	Turners Falls Impoundment
VY	Vermont Yankee Nuclear Power Plant
WSEL	water surface elevation

1 INTRODUCTION

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

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

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

On August 27, 2013 Entergy Corp. announced that the Vermont Yankee Nuclear Power Plant (VY), located on the downstream end of the Vernon Impoundment on the Connecticut River and upstream of the two Projects, will be closing no later than December 29, 2014. With the closure of VY, certain environmental baseline conditions will change during the relicensing study period. On September 13, 2013, FERC issued its first Study Plan Determination Letter (SPDL) in which many of the studies were approved or approved with FERC modification. However, due to the impending closure of VY, FERC did not act on 19 proposed or requested studies pertaining to aquatic resources. The SPDL for these 19 studies was deferred until after FERC held a technical meeting with stakeholders on November 25, 2013 regarding any necessary adjustments to the proposed and requested study designs and/or schedules due to the impending VY closure. FERC issued its second SPDL on the remaining 19 studies on February 21, 2014, approving the RSP with one modification as follows

- FirstLight should deploy water level loggers, set to record at 15-minute intervals, and correlate observed field measurements such as depth of fish nests, egg masses, and suitable habitat to reservoir elevation. During the 2015 study season, FirstLight should deploy water level loggers at the same locations utilized during the 2014 field season for Study No. 3.2.2 *Hydraulic study of the Turners Falls Impoundment, Bypass Reach, and below Cabot* to capture the entire spawning and egg development period of target fish species.

This report documents the results of Study No. 3.3.13 *Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat.*

Note that tables, figures and photo referenced in the sections below appear at the end of the section.

1.1 Study Goals and Objectives

The goal of this study is to collect information to determine if Project operations negatively impact fish species so that appropriate mitigation measures may be developed, if warranted, to protect and conserve the species utilizing project waters. The study objectives are to:

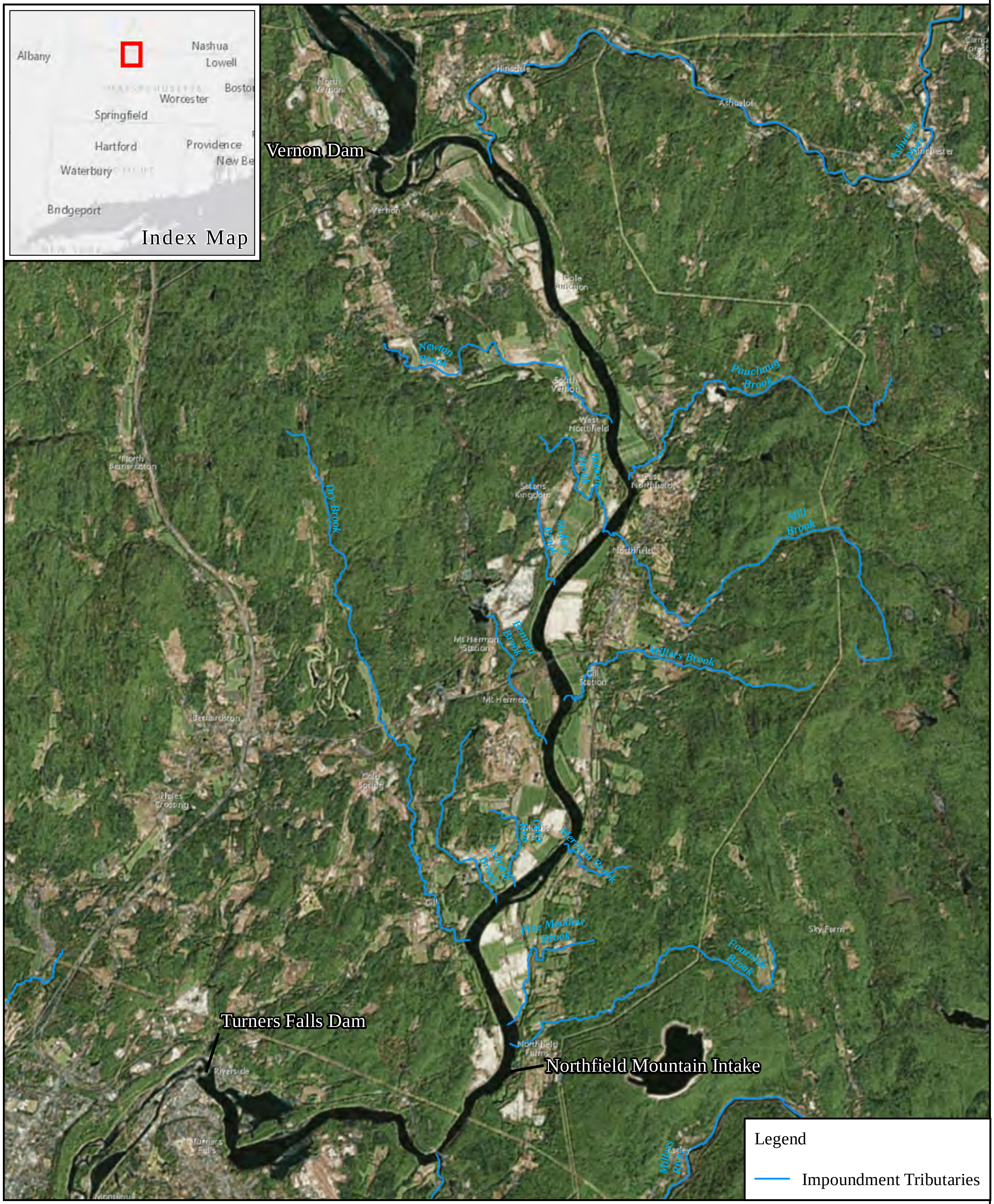
- Assess timing and location of fish spawning in the littoral zone.
- Delineate, qualitatively describe (*e.g.* substrate composition, vegetation type and relative abundance), and map shallow water habitat types subject to inundation and exposure due to project operations.
- Evaluate potential impacts of impoundment fluctuation on nest abandonment, spawning fish displacement and egg dewatering.

2 STUDY AREA

The study area included the Connecticut River from Vernon Dam in Vernon, VT, to the Turners Falls Dam in Gill and Turners Falls, MA (the Turners Falls Impoundment, TFI) - see Figure 2-1. The entire littoral zone was surveyed. To the extent practical, the surveys sought to document potential spawning habitat across the full range of licensed water surface elevations (WSEL) of 176.0 to 185.0 ft NGVD29[5] as measured at the Turners Fall Dam. The target survey zone was a general guideline, as the observable characteristics of the littoral zone can vary with water clarity, water level, time of day, and the prevailing weather conditions. The areas typically wetted when the TFI is at the upper range of its WSEL (185.0 ft were also observed to evaluate potential spawning habitat.

Major tributaries (such as the Ashuelot and Millers Rivers, Pauchaug Brook, *etc.*) were also investigated upstream to a point corresponding to the first riffle/area of gradient.

[5] All vertical elevations in this report are in relation to the National Geodetic Vertical Datum (NGVD) of 1929.



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

Relicensing Study No. 3.3.13
Impacts of the Turners Falls Project
and Northfield Mountain Project on
Littoral Zone Fish Habitat and Spawning Habitat

N

0 0.75 1.5 3 Miles

Figure 2-1: Overview of Littoral Zone Fish Spawning Survey Study Area

Path: W:\gis\studies\3_3_13\maps\Figure 2-1.mxd

3 FIELD METHODS AND HYDRAULIC MODEL

3.1 Field Methods

The study was conducted in the spring of 2015. Prior to conducting the field investigation, a desktop literature review determined when resident species known to occur in the Project area typically spawn. The early spawning survey targeted a period when water temperature ranged from approximately 7 to 14 °C to capture broadcast spawning species such as pike, yellow perch, and walleye. A second survey was scheduled to coincide with water temperatures ranging from approximately 18-22 °C to capture nest-building species. Field work was scheduled to occur during times when river flow through the TFI was less than 25,000 cfs for safety, and targeted water temperature prevailed. Because water temperature was a likely spawning event trigger, ambient water temperature was monitored on a daily basis to determine when to mobilize field surveys.

For the purpose of this investigation, the littoral zone was considered as a general guideline to be the area extending from the edge of the water line at the shore at the time of the survey, out to a depth of approximately six feet to the extent that observable characteristics of the littoral zone varies with water clarity, water level, time of day, and the prevailing weather conditions. Efforts were made to make observations on days with relatively clear observation conditions such as good daylight, minimal wind and reasonable water clarity. Survey periods were conducted between 08:00 and 17:00 to ensure good overhead lighting.

Field sampling was conducted by systematically traversing the littoral zone (depth < 6 feet) of the entire TFI via boat and/or foot (wading) parallel to shore, to visually identify any fish nests, egg masses/deposits, and/or spawning habitat. Equipment and data collection was aided by:

- a digital camera for photo-documentation of habitat types, egg deposits, and identified nests;
- a Real-Time Kinematic- Global Positioning System or RTK-GPS was used to geo-reference the locations and elevations *(all elevations are reported as NGVD29*) of identified habitats, egg deposits, and nests (Figures 3.1-1 and 3.1-2). Point elevations were collected on individual spawning sites; however, in some cases where several nests were clustered a series of representative elevations were obtained;
- a handheld water quality meter to measure *in situ* water temperature;
- a Marsh-McBirney flow meter to collect spot mean column velocity measurements at identified spawning habitats, egg deposits, and nests;
- a secchi disk to estimate water clarity;
- a stadia rod and/or depth meter for recording depth of identified spawning habitats, egg deposits, and nests; and
- data sheets for recording water quality parameters, general observations, weather conditions, and other relevant descriptive information (*e.g.*, substrate sizes associated with nests, approximate diameter of identified nests, presence of fish at nests, presence of aquatic vegetation, nest abandonment, *etc.*).

As required by FERC in its study plan modification, FirstLight installed water level loggers (Onset HOBO Water Level Logger Model U20) at the onset of the survey period at representative locations throughout the TFI. The water level logger monitoring sites are listed in Table 3.1-1 and shown in Figure 3.1-3. When installed, the elevation of each water level logger was surveyed using a RTK-GPS relative to NGVD29 datum. The loggers were set to record the WSEL every 15 minutes. Dates of installation and retrieval are shown in Table 3.1-1.

During the early spring, where the search was focused on areas where broadcasted adhesive eggs could occur, locations such as gravel shoals, point bars etc. were scrutinized by boat and also wading where safe and practical. At locations where eggs could be embedded in gravel interstices, substrates were inspected using underwater surveillance such as an Aquascope viewing tube. Aquatic and riparian vegetation was also examined for evidence of extruded egg masses. During the late spring when the search was focused on areas where nest construction could occur, the crew sought evidence of either nest construction, redd formation, or spawning aggregations of adult fish.

In most cases the species of fish was visually determined, but in some cases (centrarchids) where the spawning adults could not be identified precisely to species, an attempt was made to collect the guardian male through angling. If that was not possible, the fish were identified to the genus level based on body form or listed as "unknown."

At each spawning site, various field data were collected and spawning fish species identified, if possible. Species identification was conducted in some cases by direct observation, capture of guarding adult males (*e.g.* centrarchids), or by examination of extruded egg masses. In some cases where no nest guardianship was occurring such as a cleared gravel spawning site (redd), it was not possible to positively confirm the identity of the species that made a redd. The position and elevation of nests and/or potential habitat were surveyed to the NGVD29 datum using a RTK-GPS unit.

Data were recorded on waterproof field data sheets. Upon completion of the field survey, all data sheets were reviewed for quality assurance and then electronically transcribed. The field data sheets are included in Appendix A (note the elevation data on the data sheets is in NAVD88 datum; the elevations were converted to NGVD29 datum for this report).

3.2 Hydraulic Model

In addition to the water level data collected in 2015 for this study, FirstLight developed a hydraulic model of the TFI as part of Study No. 3.2.*2 Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot*. As explained in the Study No. 3.2.2 Report filed with FERC on 3/31/2015, several water level loggers installed specifically for the hydraulic modeling study were placed in the TFI from approximately April to mid-November 2014; WSELs were collected every 15-minutes. The hydraulic model was calibrated to the measured WSELs throughout the TFI over the study period. Model inputs needed to calibrate the hydraulic model during the period when the loggers were installed included:

- Known Vernon Hydroelectric Project discharges (including spill);
- Known Northfield Mountain Project flows used for pumping and generating;
- Known tributary inflows from the Ashuelot and Millers River; and,

Known WSEL at the Turners Falls Dam (this elevation is needed to set the downstream boundary condition in the hydraulic model).

As described in the Study 3.2.2 Report, the calibration was excellent as modeled WSELs closely matched observed WSELs. The calibrated hydraulic model was used to simulate steady state conditions, whereby the model inputs listed in the above bullets were held constant. In addition, the calibrated model was used to simulate unsteady state conditions, whereby the model inputs listed in the above bullets varied on an hourly time step for the period January 1, 2000 through September 30, 2014 (after filing the Study No. 3.2.2 Report, it was later updated to include up to September 30, 2015). Thus, hourly WSELs are available at transects in the hydraulic model for the period January 1, 2000 through September 30, 2015.

3.3 Use of Hydraulic Model in Littoral Zone Study

To supplement the WSEL data collected in 2015 for this study, the hydraulic model was used to evaluate how the operation of the Vernon Hydroelectric Project, Northfield Mountain Project and Turners Falls Hydroelectric Project could impact spawning locations. As noted above, the vertical elevation of each nesting site was surveyed as part of the littoral zone study. With that information, the hydraulic model was used in both steady (flow constant) and unsteady (flow varying over time) modes to determine the potential for exposing the spawning sites located in 2015 as described below.

Readers need to be mindful that the 2015 field assessment represents a snapshot in time. Essentially the spawning locations surveyed in 2015 are being evaluated using the WSEL data and the hydraulic model relative to: a) actual conditions during the spawning periods in 2015; b) how the Projects (Vernon, Northfield Mountain and Turners Falls) historically operated over the period January 1, 2000 to September 30, 2015 (focusing on the months of April-June); and c) how FirstLight could have operated the WSEL at the Turners Falls Dam under its FERC licensed operating range of 176 to 185 feet under a range of inflows (steady state model). There are many issues to consider as follows:

- Spawning locations (horizontal and vertical position) within the TFI may vary from year-to-year and are driven by many factors,

- One factor influencing where spawning occurs is the magnitude of flow and the WSEL of the TFI at the time of spawning. For example, if the water levels were high, the vertical position of the spawning location may have been higher. Alternatively, if the water levels were low, the vertical position of the spawning location may have been lower.

- The WSEL and flows that occurred in 2015 are impacted not only by the operation of the Vernon Hydroelectric Project, Northfield Mountain Project and Turners Falls Hydroelectric Project, but also by magnitude of flow and hydraulics in the TFI. As noted in Study Report No. 3.2.2, when flows exceed approximately 20,000 cfs (which is beyond the hydraulic capacity of Vernon, Northfield or Turners Falls), WSELs above the French King Gorge are controlled by the natural constriction at the gorge.

3.3.1 Unsteady State Model

The hydraulic model was used in an unsteady state whereby the model inputs -- known Vernon Hydroelectric Project discharge, the Ashuelot River flow, the amount of water used for pumping or generating at the Northfield Mountain Project, the Millers River flow and the WSEL at the Turners Falls Dam (to set the downstream boundary condition in the hydraulic model)—were used to simulate WSEL throughout the TFI on an hourly basis for the period January 1, 2000 to September 30, 2015. Again, as noted above, the location of each spawning site was matched with a transect from the hydraulic model. An analysis was subsequently conducted to determine if, under unsteady state conditions over the last 15 years, the spawning sites established in 2015 could have been dewatered.

3.3.2 Steady State Model

The steady state hydraulic model was also used to determine if the spawning locations identified in 2015 could have been exposed if FirstLight had operated the TFI over its FERC licensed operating range of 176 to 185 feet and under different flows. The steady state model runs were conducted under three different downstream boundary conditions at the Turners Falls Dam of 176, 181.3[6] and 185 feet.

For these steady state scenarios the flow through the TFI (referred to by FirstLight as the naturally routed flow) was held constant, but included intervening inflow from the Ashuelot and Millers Rivers. Hourly flow data from May 1-31 and June 1-30 were obtained for the Vernon discharge, Ashuelot River USGS Gage flow and Millers River USGS Gage flow for the years 2000-2015. From this, the 5, 15, 25, 50, 75, 85 and 95% exceedance flows for May and June were computed at each location. For example, the median May flow -- based on hourly data for the period 2000-2015 -- at Vernon, Ashuelot River and Millers River flows was 14,437, 885, and 738 cfs, respectively. Thus in the steady state model, the Vernon discharge would be set at 14,437 cfs, and additional inflow from the Ashuelot (885 cfs) and Millers (738 cfs) would be added for a total flow at the Turners Falls Dam of 16,060 cfs. If the spawning site was located just downstream of the confluence of the Ashuelot River the steady state flow would equal the Vernon discharge plus the Ashuelot River flow. If the spawning site was located downstream of the confluence of the Millers Rivers, the steady state flow would equal the Vernon discharge plus the Ashuelot River plus the Millers River flow.

To determine if spawning locations observed in 2015 could be dewatered by operating over the FERC licensed operating range and range of flows described above, several steady state model runs were simulated as described in Table 3.3.2-1. Note that for these steady state scenarios, the Northfield Mountain Project was held idle[7].

As shown in Figure 3.1-3, the location of each early and late spawning site was mapped and compared against the transects in the hydraulic model. Because of the density of transects, a transect was in very close proximity to each spawning location was used so an analysis could be conducted to determine if under steady state conditions, whether the spawning sites established in 2015 could have been dewatered.

[6] Elevation 181.3 feet is the median WSEL at the Turners Falls Dam based on observed hourly data for the period 2000-2009.

[7] As described in Section 3.3.2, the unsteady state hydraulic model runs were based on actual conditions that occurred from January 1, 2000 to September 30, 2015, which reflects Northfield Mountain pumping and generating flows.

Table 3.1-1: Water Level Logger Monitoring Locations and Names

Logger	Description	Monitoring Period
Stebbins Island SN 10486576	Located just below Stebbins Island	6/13/2015-7/24/2015
Mill Brook SN 10486588	Located at the confluence of Mill Brook near the Northfield Golf Club	5/4/2015-7/24/2015
Cattails SN 10486367	Located near the confluence of Merriam Brook, just upstream of Kidds Island	5/5/2015-7/24/2015
Kidds Island SN 10486366	Located on the east side of Kidds Island	5/5/2015-7/24/2015
French King Bridge SN 10486572	Located at the French King Bridge	6/12/2015-8/6/2015
Below French King Bridge SN 10486595	Located just downstream of the French King Bridge	5/6/2015-8/6/2015
Turners Falls Dam (permanent gage)	Located at the Turners Falls Dam	All of 2015

Table 3.3.2-1: Steady State Hydraulic Modeling Scenarios

Scenario	*TFI Elevation at the Turners Falls Dam	**Steady State Flow	***Northfield Mountain Project Operation
1-7	176 feet	5, 15, 25, 50, 75, 85 and 95% exceedance flow for May	Idle
8-14	176 feet	5, 15, 25, 50, 75, 85 and 95% exceedance flow for June	Idle
15-21	181.3 feet	5, 15, 25, 50, 75, 85 and 95% exceedance flow for May	Idle
22-28	181.3 feet	5, 15, 25, 50, 75, 85 and 95% exceedance flow for June	Idle
29-35	185 feet	5, 15, 25, 50, 75, 85 and 95% exceedance flow for May	Idle
36-42	185 feet	5, 15, 25, 50, 75, 85 and 95% exceedance flow for June	Idle

Notes:

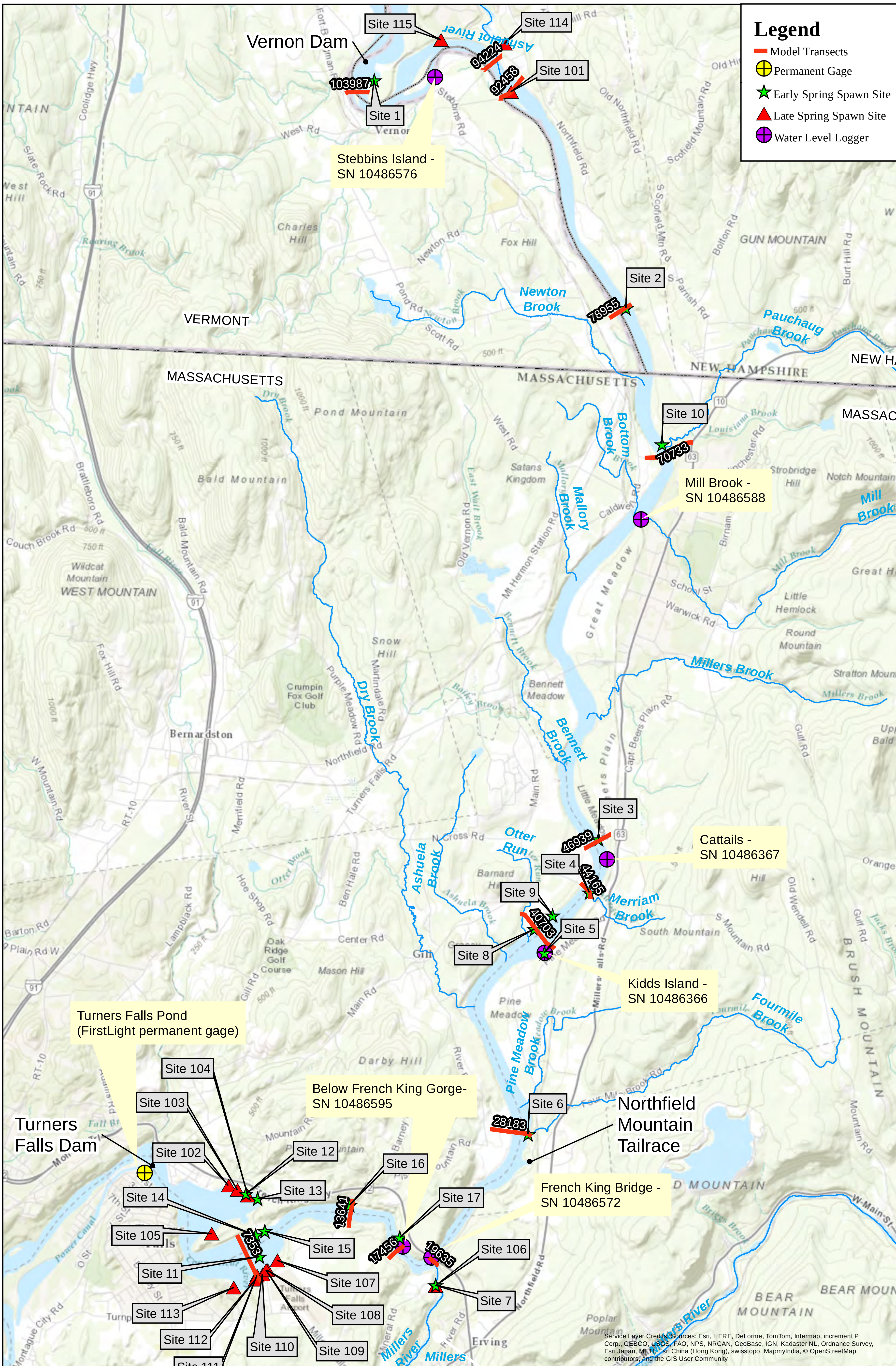
**This elevation was used to set the downstream boundary condition in the steady state hydraulic modeling runs.*

*** For these steady state scenarios the flow through the TFI (referred to by FirstLight as the naturally routed flow) was held constant, but included intervening inflow from the Ashuelot and Millers Rivers. Hourly flow data from May 1-31 and June 1-30 were obtained for the Vernon discharge, Ashuelot River USGS Gage flow and Millers River USGS Gage flow for the years 2000-2015. From this, the 5, 15, 25, 50, 75, 85 and 95% exceedance flows for May and June were computed at each location.*

****For purposes of this assessment, the Northfield Mountain Project was held idle. The unsteady state model runs simulated Northfield Mountain Project in a generating, pumping and idle mode.*

Figure 3.1-1: Typical Geo-positioning and Bed Elevation Data Collection

Figure 3.1-2: Centrarchid Spawning Site as Observed from Boat



FirstLight Power Resources

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

RELICENSING STUDY 3.3.13

N

0 0.5 1 2 Miles

Figure 3.1-3: Water Level Logger Locations Deployed in 2015 and Location of Selected Hydraulic Model Transects

Path: W:\gis\studies\3_3_13\maps\Figure 3.1-3.mxd

4 RESULTS

4.1 Literature Review

Literature indicated that most fish species spawning could be classified as early-mid-spring (*i.e.* generally ambient temperatures of 7-12 °C) and late spring (*i.e.*, ambient temperatures of 15-22 °C) (Table 4.1-1). Early-spawning fish were generally species that either broadcast spawn or those that deposited eggs on or in substrates with no guardianship; late spawning species generally spawned in well-prepared nests and typically guarded incubating eggs. Spawning strategies for common littoral zone fish species in the TFI are summarized in Table 4.1-2.

4.2 Field Survey

Early spring surveys were conducted from May 4-6, 2015, and late spring surveys were generally conducted from June 11-13, 2015. An initial attempt to commence the late spring survey on June 1 was aborted and delayed to mid-June due to the onset of heavy rain and unsafe high flows[8]. Water temperature and river flow were monitored daily to detect the onset of both suitable spawning thermal and safe boating conditions. Table 4.2-1 summarizes ambient daily water temperature-- the daily water temperatures were based on instantaneous spot measurements obtained at various locations in the TFI. The flow shown in Table 4.2-1 represents the mean Vernon discharge for the day based on averaging the 15 minute flow data. Water temperature during the early spring survey ranged from 10.0 to 14.1 °C, except in the lower reaches of tributaries such as Pauchaug Brook and Millers River which were warmer (16-16.7 °C). Water temperatures during the late spring survey ranged from 16.0 to 21.5 °C. Water clarity during survey dates generally exceeded 6 ft., although on a few occasions during June 11-13, water clarity decreased to 4 ft. Shown in Appendix A are the data sheets recorded during the early and late spring surveys.

Appendix B includes weekly plots of the WSELs recorded at the water level loggers listed in Table 3.1-1 along with the Vernon Hydroelectric Project discharge and the Northfield Mountain Project flows used for pumping and generating. To put the flows and WSELs experienced during the 2015 spawning surveys into perspective, it was compared to a longer period of record. Specifically, the hourly Vernon discharge and TFI WSEL as measured at the Turners Falls Dam were used to develop duration curves for two periods of record a) May and June of 2015 and b) May and June for the period 2000-2014. Shown in Figure 4.2-1 are the Vernon discharge duration curves. There are four duration curves representing May and June for the two periods (2015 and 2000-2014). The dashed lines represent 2015 while the solid lines represent 2000-2014. The flows in May 2015 were considerably lower than historically (2000-2014). The maximum Vernon discharge in May 2015 was 19,843 cfs, slightly higher than the hydraulic capacity of the Vernon Hydroelectric Project of 17,130 cfs. Similarly, the flows in June 2015 were also lower than historically (2000-2014). The maximum Vernon discharge in June 2015 was 26,956 cfs.

Shown in Figure 4.2-2 are the WSEL as measured at the Turners Falls Dam. There are four WSEL duration curves representing May and June for the two periods (2015 and 2000-2014). The dashed lines represent 2015 while the solid lines represent 2000-2014. The WSELs at the Turners Falls Dam in May and June 2015 were considerably lower than historically (2000-2014).

4.3 Littoral Zone Spawning

Shown in Figure 3.1-3 are the locations where spawning sites were located in the early and late spring. A total of 32 spawning sites (17 in the early spring and 15 in the late spring) were discovered throughout the survey; a site number was assigned to each location as shown in Figures 3.1-3. The majority of the late

[8] When naturally routed flows exceeded approximately 25,000 cfs, boating conditions were deemed unsafe for this study. In this case, the weather forecast was for increased rains—in fact flows exceeded 30,000 cfs days after June 1.

spring sites were located in Barton Cove. Note that within the 32 sites there were individual spawning nests or redds, and in other cases a multitude of nests. Thus, in total, 113 bed elevations were obtained across the 32 spawning sites.

4.3.1 Early Spring Spawners

Table 4.3.1-1 lists the spawning Site ID number[9], the hydraulic modeling transect at (or very close to) the spawning site, the identified species, the elevation and depth of the potential spawning habitat at the time of the field survey, and any comments. Spawning sites were evidenced by extruded egg masses, and by cleared patches in submerged substrates. In some cases there were no egg masses directly evident, but the potential for spawning was inferred, for example, by the abundance of suitable riparian vegetation that could be used by percids, such as partially submerged cattail stalks. During the course of the early spring survey, observed potential spawning bed depths were as deep as 4.5 ft. Several sites consisting of riparian cattail stalks that could provide potential spawning substrates were as much as 1.6 ft above the WSEL at the time of survey.

Most of the early spring sites were concentrated in three areas (see Figure 3.1-3):

- the upper TFI above Pauchaug Brook (*sites 001, 002, and 010*)
- middle TFI from Pauchaug Brook to the French King Gorge (*sites 003-006, 008, 009*)
- lower TFI from below the French King Gorge to Turners Falls Dam (*sites 011-017*)

The spring spawning sites can be further classified into three habitat types:

- gravel/cobble bars (*sites 001, 002, 004-007)*
- emergent vegetation on the edges of the TFI (*sites 003, 010, 012, 013, and 015-017*), and
- submerged aquatic vegetation (*sites 008, 009, 011 and 014*)

4.3.2 Hydraulic Modeling Analysis of Early Spring Spawners

Unsteady Flow Hydraulic Model

The unsteady state modeling is essentially presenting the historical conditions, as the WSELs at a given transect are based on the flows and operating conditions that occurred on an hourly basis during May and June for the years 2000 to 2015. Thus, each figure includes one WSEL plot along with the same horizontal lines to denote the spawning locations. Note that at sites where multiple bed elevations were collected, the highest and lowest elevations are shown on the figures.

Steady Flow Hydraulic Model

As described in Section 3.3.1, the hydraulic model simulated steady state conditions under three different downstream boundary conditions at the Turners Falls Dam of 176, 181.3 and 185 feet; whereby 176 to 185 feet represents the FERC licensed operating range of the TFI as measured at the Turners Falls Dam. In addition, various flows conditions were simulated as described in Table 3.3.2-1. The hydraulic model was simulated for each of the scenarios in Table 3.3.2-1 resulting in a WSEL at each transect in the TFI. The transect location relative to the spawning location is shown in Figure 3.1-1; the transect number associated with each spawning location is shown in Table 4.3.1-1. As Table 4.3.1-1 shows in some cases one transect

[9] Site IDs were given a number of 001-017 for the May survey and 101-115 for the June Survey.

was used to represent several spawning locations because they were clumped in close proximity. For example, Site Nos. 011, 012, 013 and 014 are represented by hydraulic model transect number 7353. The hydraulic model results were coupled with the early spring spawning sites to determine if the potential spawning locations could be exposed under various operating conditions.

Evaluation

Below are the figures developed for each spawning site.

Figure No.	Site No.	HEC-RAS Transect No.
Upper TFI		
4.3.2-1	001	103987
4.3.2-2	002	78954
4.3.2-3	010	70732
Middle TFI		
4.3.2-4	003	46939
4.3.2-5	004	44165
4.3.2-6	009	40702
4.3.2-7	008	40702
4.3.2-8	005	40702
4.3.2-9	006	28182
4.3.2-10	007	19634
Lower TFI		
4.3.2-11	017	7353
4.3.2-12	016	7353
4.3.2-13	015	7353
4.3.2-14	014	7353
4.3.2-15	011	7353
4.3.2-16	013	7353
4.3.2-17	012	7353

Each figure contains three plots. The top plot shows the spawning elevation (see spawning elevation is always shown as a horizontal line on all three plots and is shown in Table 4.3.1-1) along with the WSEL data either collected or modeled from the nearest transect April 15-May, 2015. The middle plot shows the unsteady state (historical from 2000-2015) WSELs for April and May in relation to the spawning elevation. The bottom plot shows the steady state (licensed range of TFI fluctuation) WSELs for April and May in relation to the spawning elevation. A description of potential early spring spawning habitat evaluated using the 2015 WSEL data and hydraulic model follows.

Upper TFI (Vernon Dam to Pauchaug Brook)

Site 001 is a riprap and cobble shoreline across from the tailwater of the Vernon Project. Although no spawning was detected it appears to have characteristics suitable for walleye spawning. Walleye broadcast fertilized eggs that are negatively buoyant, and become adhesive, settling into interstitial spaces of unembedded geologic material. The critical minimum depth was assumed to be that which begins to dewater the submerged substrate to which eggs could lodge within. Figure 4.3.2-1 (top plots) demonstrates that this elevation corresponds to 185.5 ft and was consistently submerged throughout April, but became inconsistently submerged throughout May 2015. Modeling of historic WSELs (middle plot) demonstrates that these substrate elevations would remain sufficiently submerged approximately 90% of the time in April and 60% of the time in May.

The steady state model analysis (lower plot) shows that the substrate at this site would remain wetted at flows of approximately >10,000 cfs when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows >9,000 cfs when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 002 is a submerged mid-channel gravel bar shoal suitable for walleye spawning. Although no spawning was detected, the site exhibited highly suitable characteristics. The critical minimum depth was assumed to be that which begins to dewater the submerged substrate to which eggs could adhere. Figure 4.3.2-2 (top plot) shows that this elevation corresponds to 180.9 ft. and was consistently submerged throughout April and most of May, but became briefly dewatered in late May. Modeling of historic TFI WSELs demonstrates that these substrate elevations would remain sufficiently submerged nearly 100% of the time in April and May.

The steady state model analysis (lower plot) shows that the substrate at this site would remain wetted at flows of approximately >13,000 cfs when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 010. A second significant spawning feature is an emergent stand of cattail stubs along the shoreline in the vicinity of Pauchaug Brook. Emergent vegetation substrate at this site has characteristics suitable for spawning. The vegetation provides a substrate to which eggs could adhere. Figure 4.3.2-3 demonstrates that these elevations correspond to 183.8 ft. and above. This elevation was consistently submerged during the first three weeks of April, but not thereafter. Modeling of historic TFI WSELs shows that the elevation (middle plot) was submerged 70% of the time on April and 40 % of the time in May.

The steady state model analysis (lower plot) shows that the emergent habitat at this site would remain wetted at flows of approximately >24,000 cfs when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows >17,500 cfs when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Mid TFI (Pauchaug Brook to French King Gorge)

Littoral zone spawning habitat in this area includes strips of emergent riparian vegetation along the river edge (Sites 003, 008 and 009) and also shoreline and submerged gravel bars potentially suitable for walleye spawning Sites 004, 005, and 006).

Site 003 is an emergent stand of cattail stubs along the shoreline just upstream of Kidds Island; although no spawning was detected, vegetative substrates have characteristics suitable for yellow perch spawning. The critical minimum depth was assumed to be that which dewaters the submerged vegetation to which eggs could adhere. Figure 4.3.2-4 demonstrates that this elevation corresponds to 182.1 ft and was consistently submerged throughout most of April; however during most of May was frequently dewatered. Modeling of historic TFI WSELs demonstrates that these substrate elevations would remain sufficiently submerged approximately 90% of the time in April and 75% in May.

The steady state model analysis (lower plot) shows that the emergent habitat at this site would remain wetted at flows of approximately >23,000 cfs when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows >11,000 cfs when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 004 is a gravel bar at the mouth of Merriam Brook, which appears to be potentially suitable for walleye spawning. Although no spawning was detected, substrates have characteristics suitable for spawning. The critical minimum depth was assumed to be that which dewaters the submerged substrate to which eggs could adhere. Figure 4.3.2-5 demonstrates that this elevation corresponds to 177.9 ft and was consistently submerged throughout April and May. Modeling of historic TFI WSELs demonstrates that these substrate elevations would remain sufficiently submerged 100% of the time in April and May.

The steady state model analysis shows that the substrate at this site would remain wetted at flows of approximately >9,000 cfs when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Sites 009 and 008 are strips of submerged aquatic vegetation that varies in depth but appears suitable for yellow perch spawning. Due to their close proximity, these two sites were analyzed together. The shallowest and deepest extreme elevations of vegetation were assumed to be that substrate to which eggs could adhere. Figures 4.3.2-6 and 4.3.2-7 demonstrate that these elevations range from to 182.0 to 182.3 ft. Both elevations were consistently submerged throughout most of April but only intermittently during May. Modeling of historic TFI WSELs demonstrates that the Site 008 elevation was submerged 90% of the time on April and 80 % of the time in May; Site 009 remains sufficiently submerged 90% of the time in April and 70% of the time May.

The steady state model analysis (lower plot) shows that the emergent habitat at Site 8 and 9 would remain wetted at flows of approximately >24,000 cfs and >25,500 cfs respectively when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows >10,000 cfs and >13,000 cfs respectively when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 005 contains shoreline rip-rap substrate that appears to be potentially suitable for walleye spawning. The critical minimum depth was assumed to be that which dewaters the submerged substrate to which eggs could adhere. Figure 4.3.2-8 demonstrates that this elevation corresponds to 177.0 ft. and was consistently submerged throughout April and May. Modeling of historic TFI WSELs demonstrates that these substrate elevations would remain sufficiently submerged 100% of the time in April and May.

The steady state model analysis shows that the substrate at this site would remain wetted at almost all flow and WSEL scenarios.

Site 006 is an extensive gravel bar at the mouth of Fourmile Brook; although no spawning was detected, this site appears to be potentially suitable for walleye spawning. The shallowest and deepest elevations were assumed to be that submerged substrate to which eggs could adhere. Figure 4.3.2-9 demonstrates that these elevations range from 179.4 to 181.6 ft. The highest substrate elevation was consistently submerged throughout most of April but only intermittently during May. The lower substrate elevation was submerged at all times. Modeling of historic TFI WSELs demonstrates that the upper substrate elevation was submerged 90% of the time on April and 80% of the time in May; the lower elevation remains sufficiently submerged 100% of the time in April and May.

The steady state model analysis shows that the lower elevation substrate at this site would remain wetted at flows of approximately >18,000 cfs when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows >6,000 cfs when the WSEL at the Turners Falls Dam is at its median of 181.3 ft. The upper substrate elevation remains wetted at most inflows when the WSEL at Turners Falls Dam is at its median.

Millers River

Site 007 consisted of a gravel bed in the riffles of the Millers River upstream from the TFI confluence; no spawning was detected but potential for walleye spawning was evident. The critical minimum depth occurs at elevation 182.0 ft. Figure 4.3.2-10 shows the WSELs at the nearest model transect in the TFI; however, because these nests were in the Millers River upstream from the TFI confluence, they would remain wetted regardless of the TFI elevation, assuming adequate inflow from the Millers River.

Lower TFI- Below French King Gorge to Barton Cove

This segment is the east-west reach below the sharp bend below the French King Bridge. Although most of the shoreline in this segment is vertical, bedrock controlled walls with little or no littoral zone, there are a few scattered pockets of littoral spawning habitat suitable for yellow perch, including a submerged aquatic vegetation (SAV) bed and emergent aquatic vegetation(EAV) cattail stubs (sites 011, 14-15).

Site 017 is also an emergent stand of cattails although at a higher elevation compared to Site 016. Figure 4.3.2-11 demonstrates that this elevation corresponds to 182.8 ft. This elevation was occasionally submerged, but frequently dewatered during the entire April through May monitoring period. Modeling of historic TFI WSELs demonstrates that the elevation was submerged about 25% of the time in April and about 17% of the time in May.

The steady state model analysis (lower plot) shows that the spawning habitat becomes exposed at the median TFI WSEL of 181.3 ft.

Site 016 is an emergent stand of cattails providing a substrate to which eggs could adhere Figure 4.3.2-12 demonstrates that this elevation corresponds to 180.6 ft. This elevation was mostly submerged, but occasionally dewatered at brief frequencies during the entire April through May monitoring period. Modeling of historic TFI WSELs demonstrates that the elevation was submerged about 85% of the time in April and in May.

The steady state model analysis (lower plot) shows that the emergent habitat at this site would be dewatered under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft. It would be wetted under all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Lower TFI-Barton Cove and Lower TFI

This segment is the most downstream segment of TFI. It is lacustrine, with extensive embayment dominated by fine sediments, and expansive littoral zone areas. During early spring, spawning was evidenced by scattered gelatinous strings of egg masses in the EAV and riparian vegetation fringing parts of the shoreline.

Site 015 is an emergent stand of cattail near which an extruded egg mass was found. Figure 4.3.2-13 demonstrates that this elevation corresponds to 181.0 ft. Similar to Site 014, this elevation was about equally submerged and dewatered at brief frequencies during the April through May monitoring period. Modeling of historic TFI WSELs demonstrates that the elevation was submerged about 60% of the time in April and 68% of the time in May.

The steady state model analysis (lower plot) shows that, at the median TFI WSEL of 181.3 ft, the emergent habitat remains wetted and below the median TFI WSEL, the habitat becomes exposed.

Site 014 contained a submerged bed of aquatic vegetation which may provide spawning habitat for yellow perch and some esocids. Figure 4.3.2-14 demonstrates that this elevation corresponds to 180.9 ft. This elevation was about equally submerged and dewatered at brief frequencies during the April through May monitoring period. Modeling of historic TFI WSELs demonstrates that the elevation was submerged about 70% of the time in April and 60% of the time in May.

The steady state model analysis (lower plot) shows that, at the median TFI WSEL of 181.3 ft, the spawning habitat remains wetted and at flows below that, the spawning habitat becomes exposed.

Site 011 contained a submerged bed of aquatic vegetation which may provide spawning habitat for yellow perch and some esocids. Figure 4.3.2-15 demonstrates that these elevations correspond to 180.4 ft. This elevation was intermittently dewatered for brief periods during the April through May 2015 period. Modeling of historic TFI operation demonstrates that the elevation was submerged about 80-82% of the time in April and May.

The steady state model analysis (lower plot) shows that, at the median TFI WSEL of 181.3 ft, the spawning habitat remains wetted, and at flows slightly below the median (less than a foot WSEL), the habitat becomes exposed.

Site 013 is an emergent stand of cattail and other vegetation near which an extruded egg mass was found. The lowest and highest elevations of vegetation were assumed to be substrate to which eggs could adhere. Figure 4.3.2-16 demonstrates that these elevations correspond to 181.1 to 182.2 ft. The higher elevation was infrequently submerged throughout the monitoring period, and the lower elevation was about equally submerged and dewatered at brief frequencies during the April through May monitoring period. Modeling of historic TFI WSELs demonstrates that the upper elevation was only submerged about 55% of the time in April and 65% of the time in May; the lower elevation was submerged about 80% of the time in April and in 85% in May.

The steady state model analysis (lower plot) shows that, at the median TFI WSEL of 181.3 ft, the emergent habitat remains partially inundated. At flows below the median, the spawning habitat becomes exposed.

Site 012 is an emergent stand of cattail and other vegetation near which and extruded egg mass was found. The lowest and highest elevations of vegetation were assumed to be substrate to which eggs could adhere. Figure 4.3.2-17 demonstrates that these elevations correspond to 180.4 to 182.4 ft. The higher elevation was infrequently submerged throughout the monitoring period, and the lower elevation was intermittently dewatered for brief periods during the April through May monitoring period. Modeling of historic TFI WSELs demonstrates that the upper elevation was only submerged about 20% of the time in April and 10% of the time in May; the lower elevation was submerged about 80-85% of the time in April and in May.

The steady state model analysis (lower plot) shows that, at the median TFI WSEL of 181.3 ft, the emergent habitat remains partially inundated. At flows below the median, the spawning habitat becomes exposed.

4.3.3 Late Spring Spawners

Shown in Table 4.3.3-1 are 15 spawning sites (91 bed elevations) located during late spring survey. The TFI elevations were recorded between 179.9 and 184.6 ft (at Stebbins Island) during the course of the late spring survey, resulting in observed spawning bed depths ranging as deep as 4.5 ft. One nest at a single site in Barton Cove was observed to be dewatered. All were nests (both guarded and unguarded). These were evidenced by cleared patches in submerged substrates and well-formed centrarchids nests. Such nests were located both singly and also in clusters.

Most late spring spawning locations were concentrated in two areas:

- The far upper reach of the TFI between Stebbins Island and the unnamed island below the mouth of the Ashuelot River, as well as the Ashuelot River (S*ite Nos. 101, and 114-115*)
- The far lower reach of the TFI between the French King Gorge and Turners Falls Dam, within or immediately upstream from Barton Cove (*Site Nos. 102-105 and 107-113*)

Ambient spawning substrate depths ranged from -0.1ft[10] to 4.5 ft submergence at the time of the survey. Figure 4.3.3-1 shows a histogram of centrarchid nest depths observed in Barton Cove-Lower TFI during the June 2015 survey.

4.3.4 Hydraulic Modeling Analysis of Late Spring Spawners

The same analysis described above for early spring spawners was repeated for the late spring spawners to evaluate if the late spring spawning locations identified in 2015 could be dewatered. During the late spring spawning surveys, the primary species identified included sunfish, smallmouth bass, largemouth bass, unknown centrarchid and either lamprey or sucker. All of these fish are nest builders and all but lamprey/sucker guard their nests. In the analysis of whether the nest elevation would be exposed, it was assumed that the nest would be abandoned if the WSEL dropped to less than 0.5 feet above the nest for all

[10] One nest site (at Site 015) was dewatered/abandoned on the date of the of field survey.

species except sea lamprey and white sucker (they do not guard nests). For example, if a sunfish nest was surveyed at elevation 179.4 feet, it was assumed that if the WSEL at site dropped to less than 179.9 feet (179.4 + 0.5 ft), the nest would no longer be guarded and hence would be considered "exposed".

Table 4.3.3-1 lists the site number, the hydraulic model closest to the spawning location, the species, the nest elevation, the depth at the time of survey and any comments. In addition, the nest elevation plus 0.5 feet was calculated for only those nests guarded; this elevation represents the critical point where abandonment may occur.

Again, the hydraulic model simulated steady state conditions under three different downstream boundary conditions at the Turners Falls Dam (176, 181.3 and 185 feet) and range of flows as described in Table 3.3.2-1. The hydraulic transect closest to each spawning site is shown in Figure 3.1-3 and listed in Table 4.3.3-1. A description of late spring spawning locations evaluated using the 2015 WSEL data and hydraulic model follows.

Evaluation

Below are the figures developed for each spawning site.

Figure No.	Site No.	HEC-RAS Transect No.
Upper TFI		
4.3.4-1	115	94223
4.3.4-2	114	94223
4.3.4-3	101	92458
Millers River		
4.3.4-4	106	19634
Lower TFI		
4.3.4-5	107	7353
4.3.4-6	108	7353
4.3.4-7	109	7353
4.3.4-8	110	7353
4.3.4-9	111	7353
4.3.4-10	112	7353
4.3.4-11	113	7353
4.3.4-12	105	7353
4.3.4-13	104	7353
4.3.4-14	103	7353
4.3.4-15	102	7353

Upper TFI (Stebbins Island to Ashuelot River)

Three types of nest spawning sites were observed in this reach. Site 115 was a smallmouth bass nest behind object cover near the shoreline, Site 114 was a pair of sunfish (species undetermined) nests in the lower reach of the Ashuelot River, and Site 101 was a cleared patch of gravel at the head of the un-named island just offshore of the mouth of the Ashuelot River.

Sites 115 and 114 consisted of three surveyed centrarchid nests with critical abandonment elevations (i.e. 6 inches or less water ranging from 182.5 to 182.7 ft. Figures 4.3.4-1 (Site 115) and 4.3.4-2 (Site 114) demonstrates that all nests were inadequately submerged during June 2015 for brief periods after the June 11-13, 2015 survey dates. Modeling of historic WSELs demonstrates that these nests elevations would remain sufficiently submerged approximately 70 to 75% of the time. Based on the steady state model analysis (lower plot) the WSELs at this site are driven by inflow conditions. The model shows that the nests at these two sites would remain suitably deep at flows of approximately >12,500 cfs when the WSEL at the

Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows >7,500 cfs when the WSEL at the Turners Falls Dam is at its median of 181.3 ft. Note that Site 114 was found in the Ashuelot River in a location that is influenced by the TFI, however, flows in the Ashuelot River will also influence this site, but these tributary influences are outside of the capabilities the hydraulic model for the TFI.

At **Site 101,** four bed elevations were collected, ranging from 181.8 to 182.2 ft. Figure 4.3.4-3 demonstrates that this potential site was not continuously submerged during June, but experienced brief periods when water levels dropped to a point that would dewater the substrate. It should be noted that no fish were observed at this site; spawning was inferred based on suitable velocity and substrate conditions found at the time of the survey. Modeling of historic WSELs (middle plot) demonstrates that the substrate at this site would remain sufficiently submerged approximately 80% of the time. The steady state model analysis (lower plot) shows that the substrate at this site would remain wetted at flows of approximately >11,000 cfs when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at flows >6,000 cfs when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Millers River

Site 106 consisted of two surveyed lamprey nests in the riffles of the Millers River upstream from the TFI confluence. These are unguarded redds, so rather than show the critical abandonment elevations (i.e. 6 inches or less water depth), the actual bed elevations of the nests are shown. Figure 4.3.4-4 demonstrates that, based on the nearest model transect and 2015 water level datalogger in the TFI, these redds were submerged during June 2015. Modeling of historic TFI WSELs demonstrates that the shallowest nest elevation at this site would remain sufficiently submerged approximately 95% of the time, and that the deepest nest remains adequately submerged approximately 99% of the time; however, because these nests were in the Millers River upstream from the TFI confluence, they would remain wetted regardless of the TFI elevation, assuming adequate inflow from the Millers River.

Barton Cove and Lower TFI

Spawning in this reach was entirely composed of largemouth bass, and centrarchid sunfish. Numerous nests were observed in littoral zone embayments, often in clusters but also individual and/or widely spaced nests. Bass nests were frequently associated with object cover such as submerged logs, boulders, or submerged or emergent vegetation clumps. Among these sites there were over 100 observed nests. At the time of the surveys, most of the nest depths generally ranged from 2.5-3.5 feet deep.

Site 107 consisted of four surveyed nests with critical abandonment elevations ranging from 177.8 to 179.4 ft. Figure 4.3.4-5 demonstrates that all nests were adequately submerged during June 2015. Modeling of historic TFI WSELs demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 96% of the time, and that the deepest nest would always remain adequately submerged. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 108 consisted of eight surveyed nests with critical abandonment elevations (i.e., 6 inches or less water depth) ranging from 179.1 to 180.0 ft. Figure 4.3.4-6 demonstrates that all but one nest was adequately submerged during June 2015; the shallowest net was briefly too shallow on two occasions in late June. Modeling of historic TFI WSELs demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 92% of the time, and that the deepest nest remains adequately submerged approximately 98% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 109 consisted of seven surveyed nests with critical abandonment elevations ranging from 178.5 to 179.7 ft. Figure 4.3.4-7 demonstrates that all nests, except one, were adequately submerged during June 2015. Modeling of historic TFI WSELs demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 95% of the time, and that the deepest nest remain adequately submerged approximately 99% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 110 consisted of six surveyed nests with critical abandonment elevations ranging from 178.4 to 179.7 ft. Figure 4.3.4-8 demonstrates that all nests, except one, were adequately submerged during June 2015. Modeling of historic TFI WSELs demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 95% of the time, and that the deepest nest remain adequately submerged approximately 99% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 111 consisted of approximately 35 centrarchid nests, with critical abandonment elevations ranging from 177.6 to 179.5 ft. Nest depths at this site ranged from 2.6-4.5 feet deep. Figure 4.3.4-9 shows the highest and lowest critical abandonment elevations and reveals that all nests at this site were adequately submerged during June 2015. Modeling of historic TFI WSELs demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 95% of the time, and that the deepest nest would remain adequately submerged approximately 100% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 112 consisted of nine surveyed nests with critical abandonment elevations ranging from 179.0 to 180.2 ft. Figure 4.3.4-10 demonstrates that all but the shallowest nest were adequately submerged during June 2015. Modeling of historic TFI operation demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 89% of the time, and that the deepest nest remains adequately submerged approximately 98% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 113 consisted of six surveyed nests with critical abandonment elevations ranging from 179.4 to 179.8 ft. Figure 4.3.4-11 demonstrates that all but two of the shallowest nest were adequately submerged during June 2015. The two shallowest nests were marginally too shallow for a brief period in late June. Modeling of historic TFI WSELs demonstrates that the nests at this site would remain sufficiently submerged approximately 95-96% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

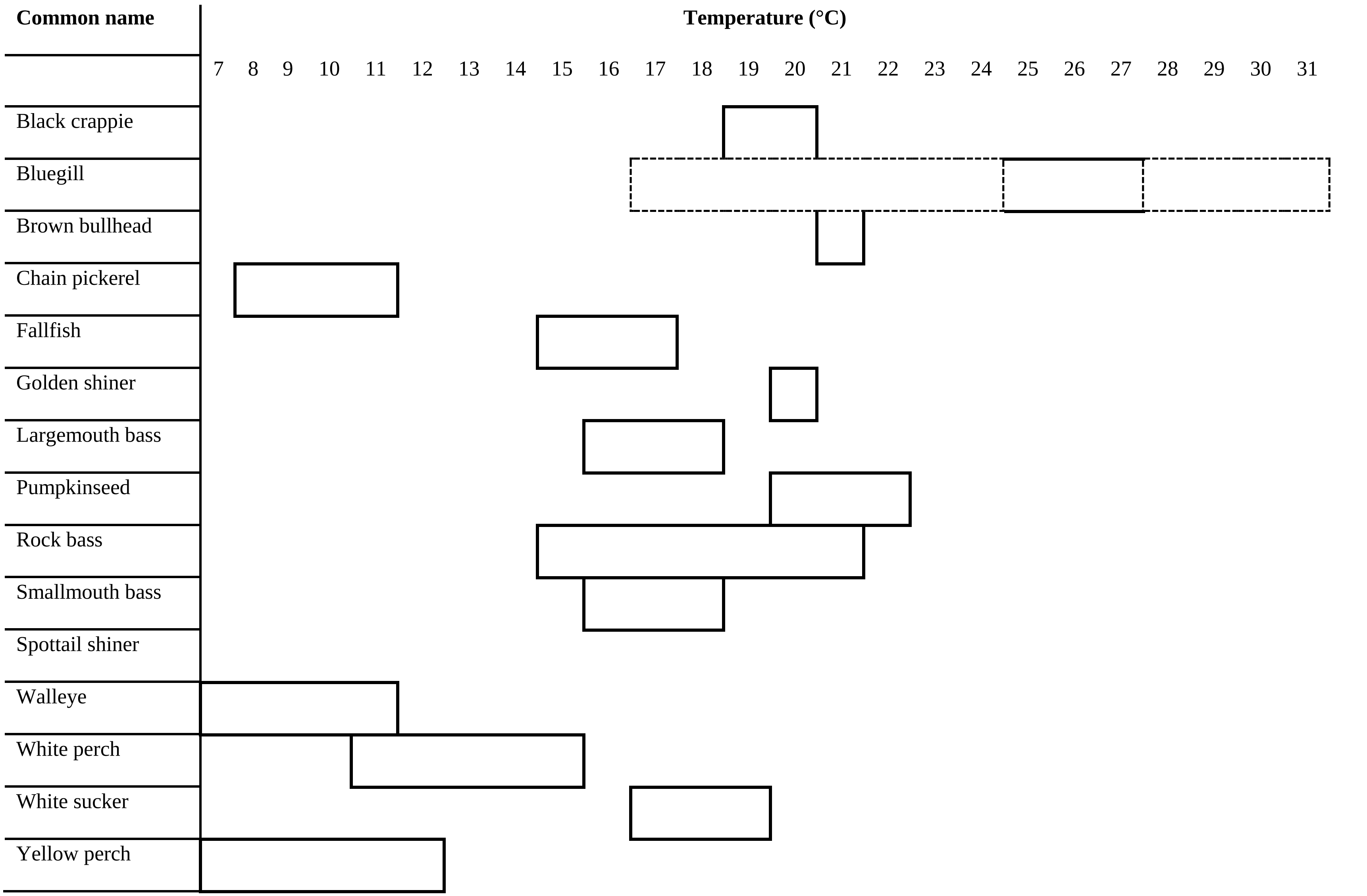
Site 105 consisted of four surveyed nests with critical abandonment elevations ranging from 179.7 to 181.6 ft. Figure 4.3.4-12 demonstrates that most nests were not consistently submerged during June 2015 with the exception of the deepest nest found at this site. Modeling of historic TFI WSELs shows that the shallowest nest at this site would not remain sufficiently submerged; in fact, this nest was observed to be abandoned/dewatered during the field survey. The deepest nest at this sites would remain adequately submerged approximately 95% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft. The upper nest elevation is exposed at the median TFI WSEL of 181.3 ft. The degree of exposure for all other nests vary at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 104 also exhibited a similar overall trend; it consisted of nine surveyed nests with critical abandonment elevations ranging from 178.7 to 179.8 ft. Figure 4.3.4-13 shows that most nests were adequately submerged continuously during June 2015 with the exception of the shallowest nest which was instantaneously too shallow on two dates in late June. Modeling of historic TFI WSELs demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 95% of the time, and that the deepest nest remain adequately submerged approximately 98% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 103 exhibited a similar overall trend; it consisted of three surveyed nests with critical abandonment elevations ranging from 178.6 to 180.1 ft. Figure 4.3.4-14 demonstrates that most nests were adequately submerged continuously during June 2015 with the exception of the shallowest nest which was marginally too shallow on several dates throughout June, likely long enough to induce nest failure. Modeling of historic TFI WSELs demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 90% of the time, and that the deepest nest remains adequately submerged approximately 98% of the time. The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Site 102 consisted of 18 surveyed nests with critical abandonment elevations (i.e. 6 inches or less water depth) ranging from 178.0 to 179.9 ft. Figure 4.3.4-15 demonstrates that most nests were adequately submerged continuously during June 2015 with the exception of the four shallowest nests, which may have been too shallow periodically on June 27-28. Modeling of historic TFI WSELs (middle plot) demonstrates that the shallowest nest at this site would remain sufficiently submerged approximately 95% of the time, and that the deepest nest remain adequately submerged at all times (based on June 2000-2015 data). The steady state model analysis (lower plot) shows that the nests would be exposed under all flows when the WSEL at the Turners Falls Dam is at its minimum of 176 ft, and would remain wetted at all flows when the WSEL at the Turners Falls Dam is at its median of 181.3 ft.

Table 4.1-1: Summary of Spawning Temperatures for Common Littoral Fish species of the Turners Falls Impoundment



Source: Scott, WB. and E.J. Crossman, 1973. Freshwater fishes of Canada. Fish. Res Bd. Canada, Ottawa CA. Bulletin 194. 966 pp.

Table 4.1-2. Spawning Strategies for Common Littoral Fish Species of the Turners Falls Impoundment.

Common Name	Strategy	Notes	Period
Yellow perch	Spawning in shallow weedy areas	Broadcast spawn, eggs are adhesive, no guardianship	April and May
Pumpkinseed	Nest scoured in sand/fines	Male adult guardianship	late spring to mid-summer
Smallmouth bass	Sand/gravel nest near object cover	Male adult guardianship	late spring to early summer
Largemouth bass	Sand/fines nest near object cover	Male adult guardianship	mid spring to early summer
Bluegill	Sand/fines nest	Male adult guardianship	mid May to mid-summer
Spottail shiner	Scatter eggs on sandy bottoms at mouths of streams	Broadcast spawn, no guardianship	May to mid-June
White sucker	Gravel bars in tributary or shoal areas	no guardianship	Mid-April to May
Walleye	Cobble riffle or shoals	Broadcast spawn, no guardianship	April
Golden shiner	Submerged vegetation in shallow water	Broadcast spawn, eggs are adhesive, no guardianship	May to August
Black crappie	Nest scoured in sand/fines	Male adult guardianship	mid spring to early summer
White perch	Broadcast spawn	Eggs are planktonic	Mid spring
Rock bass	Sand/gravel nest near object cover	Male adult guardianship	June
Brown bullhead	Sand/fines nest	Male adult guardianship	late May through June
Chain pickerel	Strings of eggs in marshy areas	Broadcast spawn, eggs are adhesive, no guardianship	March to May
Fallfish	Gravel in low velocity stream margins	nest builder, no guardianship	late April through May

Sources:

Scott, WB. and E.J. Crossman, 1973. Freshwater fishes of Canada. Fish. Res Bd. Canada, Ottawa CA. Bulletin 194. 966 pp;

Hartel, K.E., D.B. Halliwell and A.E. Launer. 2002. Inland Fishes of Massachusetts. Massachusetts Audubon Society. 328 pp.

Table 4.2-1: Summary of Ambient Field Conditions during Littoral Zone Spawning Surveys, May-June 2015

Date	Water Temperature (º C)	Weather	*Average Vernon Discharge (cfs)	Water Clarity	Notes
4-May-15	10.0	sunny breezy	13,873	clear	
4-May-15	10.0	sunny breezy	13,873	clear	
4-May-15	16	scattered clouds	13,873	clear	Pauchaug Brook
5-May-15	16.7	hazy sun	12,122	clear	Millers River
5-May-15	11.7	hazy sun	12,122	6 + ft	
5-May-15	11.3	hazy sun	12,122	6+ ft	
5-May-15	11.2	bright overcast	12,122	6+ ft	
5-May-15	14.1	sunny calm	12,122	7.5 ft	
5-May-15	10.1	sunny windy	12,122	6+ ft	
5-May-15	10.9	partly cloudy windy	12,122	6+ ft	
5-May-15	11.4	partly cloudy breezy	12,122	6+ ft	
6-May-15	11.5	sunny calm	11,175	7.5 ft	
6-May-15	11.4	sunny calm	11,175	7.5 ft	
6-May-15	11.3	sunny calm	11,175	7.5 ft	
6-May-15	14.1	sunny calm	11,175	7.5 ft	
6-May-15	11.3	sunny breezy	11,175	7.5 ft	
6-May-15	11.7	sunny breezy	11,175	7.5 ft	
**1-Jun-15	16	rain	***12,353	clear	
11-Jun-15	18.5	sunny	22,952	6 ft	
11-Jun-15	19	sunny calm	22,952	6 ft	
11-Jun-15	18	sunny breezy	22,952	6 ft	
11-Jun-15	21	sunny breezy	22,952	6 ft	
11-Jun-15	21	sunny windy	22,952	4 ft	
11-Jun-15	21	sunny windy	22,952	6 ft	
11-Jun-15	20.5	sunny	22,952	5.5 ft	
11-Jun-15	21	sunny windy	22,952	5 ft	
11-Jun-15	21	sunny breezy	22,952	4 ft	
11-Jun-15	21.5	sunny breezy	22,952	4 ft	
12-Jun-15	18.0	sunny	16,790	6 ft	
12-Jun-15	19.0	sunny	16,790	NA	
13-Jun-15	21.3	sunny	16,500	6 ft	
13-Jun-15	17	sunny breezy	13,383	5 ft	Stebbins Is. gravel bar
13-Jun-15	18.5	sunny breezy	13,383	6+ ft	

**The average Vernon discharge was computed from average the 15 minute discharge data over the day.*

*** The June 1 survey was aborted and delayed to mid-June due to the onset of heavy rain and unsafe high flows.*

****By late this day, Vernon discharges exceeded 25,000 cfs and continued to rise the next couple of days exceeding 30,000 cfs.*

Table 4.2-2: Minimum and Maximum Elevations Recorded at Water Level Loggers

Logger	Description	Monitoring Period	Min Elev.	Max Elev.
Stebbins Island SN 10486576	Located just below Stebbins Island	6/13/2015-7/24/2015	181.01 ft	190.03 ft
Mill Brook SN 10486588	Located at the confluence of Mill Brook near the Northfield Golf Club	5/4/2015-7/24/2015	179.26 ft	187.65 ft
Cattails SN 10486367	Located near the confluence of Merriam Brook, just upstream of Kidds Island	5/5/2015-7/24/2015	179.26 ft	186.62 ft
Kidds Island SN 10486366	Located on the east side of Kidds Island	5/5/2015-7/24/2015	179.13 ft	186.40 ft
French King Bridge SN 10486572	Located at the French King Bridge	6/12/2015-8/6/2015	178.96 ft	184.26 ft
Below French King Bridge SN 10486595	Located just downstream of the French King Bridge	5/6/2015-8/6/2015	178.82 ft	184.04 ft
Turners Falls Dam (permanent gage)	Located at the Turners Falls Dam	5/5/2015-7/24/2015	179.10 ft	183.94 ft

Table 4.3.1-1: Summary of Spawning/Habitat Observations in the TFI during May 2015

Site ID number	Hydraulic Model Transect No. near site location	Species	Spawning Elevation (ft)	*Depth at Time of Survey (ft)	Comments
Site 001 Below Vernon	103987	walleye	185.5	1.0	*potential for spawning was inferred from conditions*
Site 002 main channel gravel bar	78954	walleye	180.9	2.1	*potential for spawning was inferred from conditions*
Site 010 near Pauchaug Brook	70732	esocid	183.8	-0.6	*potential for spawning was inferred from conditions*
Site 003 Cattails	46939	yellow perch	182.1	-1.6	*potential for spawning was inferred from conditions*
Site 004 near Merriam Brook (gravel bar)	44165	walleye	177.9	3.7	*potential for spawning was inferred from conditions*
Site 005 Kidds Island	40702	walleye	177.0	4.4	*potential for spawning was inferred from conditions*
Site 006 near Fourmile Brook – bed 1	28182	walleye	180.6	1.1	*potential for spawning was inferred from conditions (gravel/cobble bar)*
Site 006 near Fourmile Brook – bed 2	28182	walleye	180.9	0.8	*potential for spawning was inferred from conditions (gravel/cobble bar)*
Site 006 near Fourmile Brook – bed 3	28182	walleye	181.6	0.1	*potential for spawning was inferred from conditions (gravel/cobble bar)*
Site 006 near Fourmile Brook – bed 4	28182	walleye	179.4	2.3	*potential for spawning was inferred from conditions (gravel/cobble bar)*
Site 008 SAV bed	40702	yellow perch	182.0	1.4	*potential for spawning was inferred from conditions*
Site 009 SAV bed	40702	yellow perch	182.3	0.5	*potential for spawning was inferred from conditions*
Site 007 Millers River gravel bar	19634	unknown spp.	182.0	0.5	*Upstream of TFI backwater* **observed redd formation;** *no species identification*
Site 011 SAV bed	7353	esocid	180.4	2.1	**extruded egg mass**
Site 012 emergent bed (high point)	7353		182.4	0.2	**extruded egg mass**
Site 012 emergent bed (low point)	7353	esocid	180.4	2.2	**extruded egg mass**
Site 013 emergent bed (low point)	7353	yellow perch	181.1	1.4	**extruded egg mass**
Site 013 emergent bed (high point)	7353	yellow perch	182.2	0.3	**extruded egg mass**
Site 014 SAV Bed	7353	yellow perch	180.9	1.7	**extruded egg mass**
Site 015 emergent bed.	7353	yellow perch	181.0	1.5	**extruded egg mass**
Site 016 emergent bed	13641	yellow perch	180.6	1.9	**extruded egg mass**
Site 017 emergent bed	17455	yellow perch	182.8	-0.2	*potential for spawning was inferred from conditions*

* Negative numbers indicate dewatered substrate (*ft above ambient water level at time of survey*).

- Upper Impoundment
- Middle Impoundment
- Lower Impoundmen

Table 4.3.3-1: Summary of Spawning Observations in the Turners Falls Impoundment during June 2015.

Site ID No.	Hydraulic Model Transect No. near spawning location	Species	Nest Elev. (ft)	Nest Elev. + 0.5 ft	Depth at Time of Survey (ft)	Comments
SITE 101 D	92458	lamprey or sucker	182.2	182.2	1.8	
SITE 101 A	92458	lamprey or sucker	182.2	182.2	1.8	
SITE 101 B	92458	lamprey or sucker	182.0	182.0	2.0	
SITE 101 C	92458	lamprey or sucker	181.8	181.8	2.2	
SITE114 A	94223	unkn. Centrarchid	182.2	182.7	1.6	Ashuelot River
SITE114 B	94223	unkn. Centrarchid	182.0	182.5	1.8	Ashuelot River
SITE 115	94223	Smallmouth bass	182.1	182.6	2.0	
SITE102L	7353	sunfish	179.4	179.9	1.0	
SITE102I SHALLOW	7353	sunfish	179.3	179.8	1.1	
SITE102H	7353	sunfish	179.1	179.6	1.3	
SITE102G	7353	sunfish	179.1	179.6	1.3	
SITE102B	7353	sunfish	178.8	179.3	1.6	
SITE102M	7353	sunfish	178.7	179.2	1.7	
SITE102C	7353	sunfish	178.6	179.1	1.8	
SITE102N	7353	sunfish	178.5	179.0	1.9	
SITE102A	7353	sunfish	178.4	178.9	2.0	
SITE102E	7353	sunfish	178.1	178.6	2.3	
SITE102D	7353	sunfish	178.1	178.6	2.3	
SITE102K	7353	sunfish	178.0	178.5	2.4	
SITE102F	7353	sunfish	178.0	178.5	2.4	
SITE102J	7353	sunfish	178.0	178.5	2.4	
SITE102P	7353	sunfish	177.8	178.3	2.6	
SITE102Q	7353	sunfish	177.6	178.1	2.8	
SITE102O	7353	sunfish	177.6	178.1	2.8	
SITE102I DEEP	7353	sunfish	177.5	178.0	2.9	
SITE103B SHALLOW	7353	sunfish	179.6	180.1	0.8	
SITE103B DEEP	7353	sunfish	178.8	179.3	1.6	
SITE103A	7353	sunfish	178.1	178.6	2.3	
SITE104A	7353	sunfish	179.3	179.8	1.8	
SITE104C	7353	sunfish	179.0	179.5	2.1	
SITE104F	7353	sunfish	178.8	179.3	2.3	
SITE104G	7353	sunfish	178.8	179.3	2.3	
SITE104B	7353	sunfish	178.8	179.3	2.3	
SITE104D	7353	sunfish	178.8	179.3	2.3	
SITE104 H INSHORE	7353	sunfish	178.7	179.2	2.4	
SITE104E	7353	sunfish	178.7	179.2	2.4	

Site ID No.	Hydraulic Model Transect No. near spawning location	Species	Nest Elev. (ft)	Nest Elev. + 0.5 ft	Depth at Time of Survey (ft)	Comments
SITE104H OFFSHORE	7353	sunfish	178.2	178.7	2.9	
SITE105C	7353	sunfish	181.1	181.6	-0.1	
SITE105D	7353	sunfish	180.8	181.3	0.2	
SITE105A	7353	sunfish	180.0	180.5	1.0	
SITE105B	7353	sunfish	179.2	179.7	1.8	
107A	7353	LM Bass	177.9	178.4	3.0	
107B	7353	LM Bass	178.4	178.9	2.5	
107C	7353	sunfish	177.9	178.4	3.0	
107D	7353	LM Bass	177.6	178.1	3.3	
107E	7353	LM Bass	177.9	178.4	3.0	
107F	7353	LM Bass	177.3	177.8	3.6	
107G	7353	sunfish	178.1	178.6	2.8	
107H	7353	sunfish	178.6	179.1	2.3	
107I	7353	sunfish	178.9	179.4	2.0	
107J	7353	sunfish	178.4	178.9	2.5	
108A	7353	LM Bass	179.1	179.6	2.4	
108B	7353	LM Bass	178.8	179.3	2.7	
108C	7353	sunfish	179.0	179.5	2.5	
108D	7353	sunfish	178.9	179.4	2.6	
108E	7353	LM Bass	179.0	179.5	2.5	
108F	7353	sunfish	179.2	179.7	2.3	
108G	7353	sunfish	179.5	180.0	2.0	
108H	7353	LMB and sunfish	178.6	179.1	2.9	
109A	7353	LM Bass	178.4	178.9	3.1	
109B	7353	LM Bass	178.5	179.0	3.0	
109C	7353	LMB and sunfish	178.7	179.2	2.8	
109 CLUSTER	7353	LMB and sunfish	178.0	178.5	3.5	
109D	7353	LM Bass	178.7	179.2	2.8	
109E	7353	sunfish	179.2	179.7	2.3	
109F	7353	sunfish	178.7	179.2	2.8	
SITE110A	7353	LM Bass	178.6	179.1	2.9	
SITE110D	7353	LM Bass	178.4	178.9	3.1	
SITE110C	7353	LM Bass	178.2	178.7	3.3	
SITE110B	7353	LM Bass	178.1	178.6	3.4	
SITE110E	7353	sunfish	177.9	178.4	3.6	
SITE110F	7353	sunfish	179.2	179.7	2.3	
Site111 shallowest	7353	LM bass	179.0	179.5	2.6	32 nests found at this site

Site ID No.	Hydraulic Model Transect No. near spawning location	Species	Nest Elev. (ft)	Nest Elev. + 0.5 ft	Depth at Time of Survey (ft)	Comments
Site111 deepest	7353	LM bass	177.1	177.6	4.5	
SITE 112 H	7353	sunfish	179.7	180.2	2.0	
SITE 112 G	7353	LM bass	179.2	179.7	2.5	
SITE 112 A	7353	LM bass	179.1	179.6	2.6	
SITE 112 F	7353	sunfish	179.1	179.6	2.6	
SITE 112 B	7353	LM bass	179.0	179.5	2.7	
SITE 112 E	7353	sunfish	178.9	179.4	2.8	
SITE 112 C	7353	LM bass	178.7	179.2	3.0	
SITE 112 D	7353	LM bass	178.6	179.1	3.1	
SITE 112 I	7353	sunfish	178.5	179.0	3.2	
SITE 113 B	7353	sunfish	179.3	179.8	2.4	
SITE 113 C	7353	undetermined	179.3	179.8	2.4	
SITE 113 D	7353	undetermined	179.3	179.8	2.4	
SITE 113 A	7353	LM bass	179.2	179.7	2.5	
SITE 113 E	7353	LM bass	179.2	179.7	2.5	
SITE 113 F	7353	LM bass	178.9	179.4	2.8	
SITE106A	19634	sucker or lamprey	179.9	179.9	1.0	Millers River
SITE106B	19634	sucker or lamprey	179.2	179.2	1.7	Millers River

Upper Impoundment

Lower Impoundment

Figure 4.2-1: Vernon Discharge Duration Curves for May and June in 2015 and for the period 2000-2014

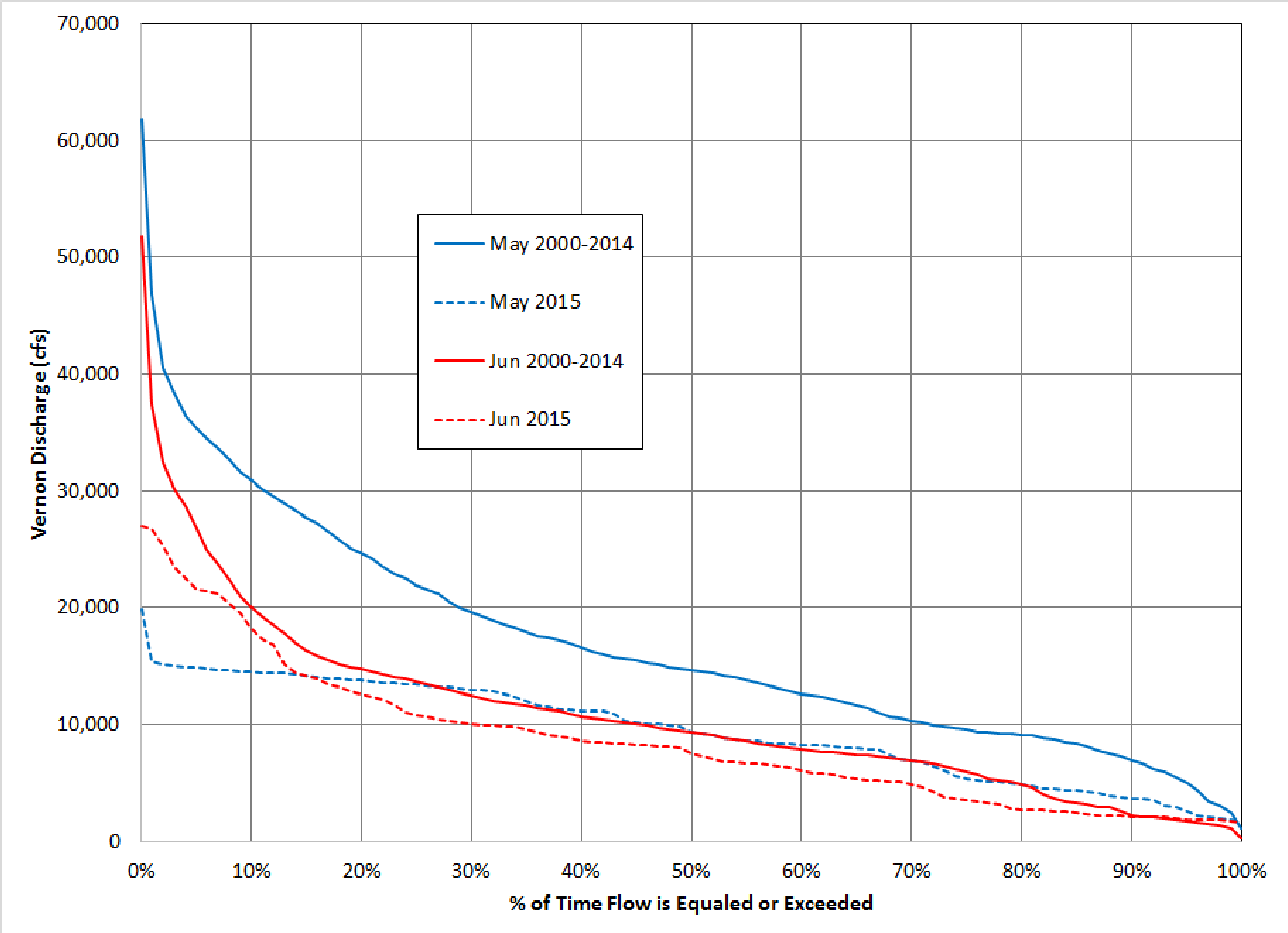


Figure 4.2-2: Turners Falls Impoundment Elevation Duration Curves as measured at Turners Falls for May and June in 2015 and the period 2000-2014

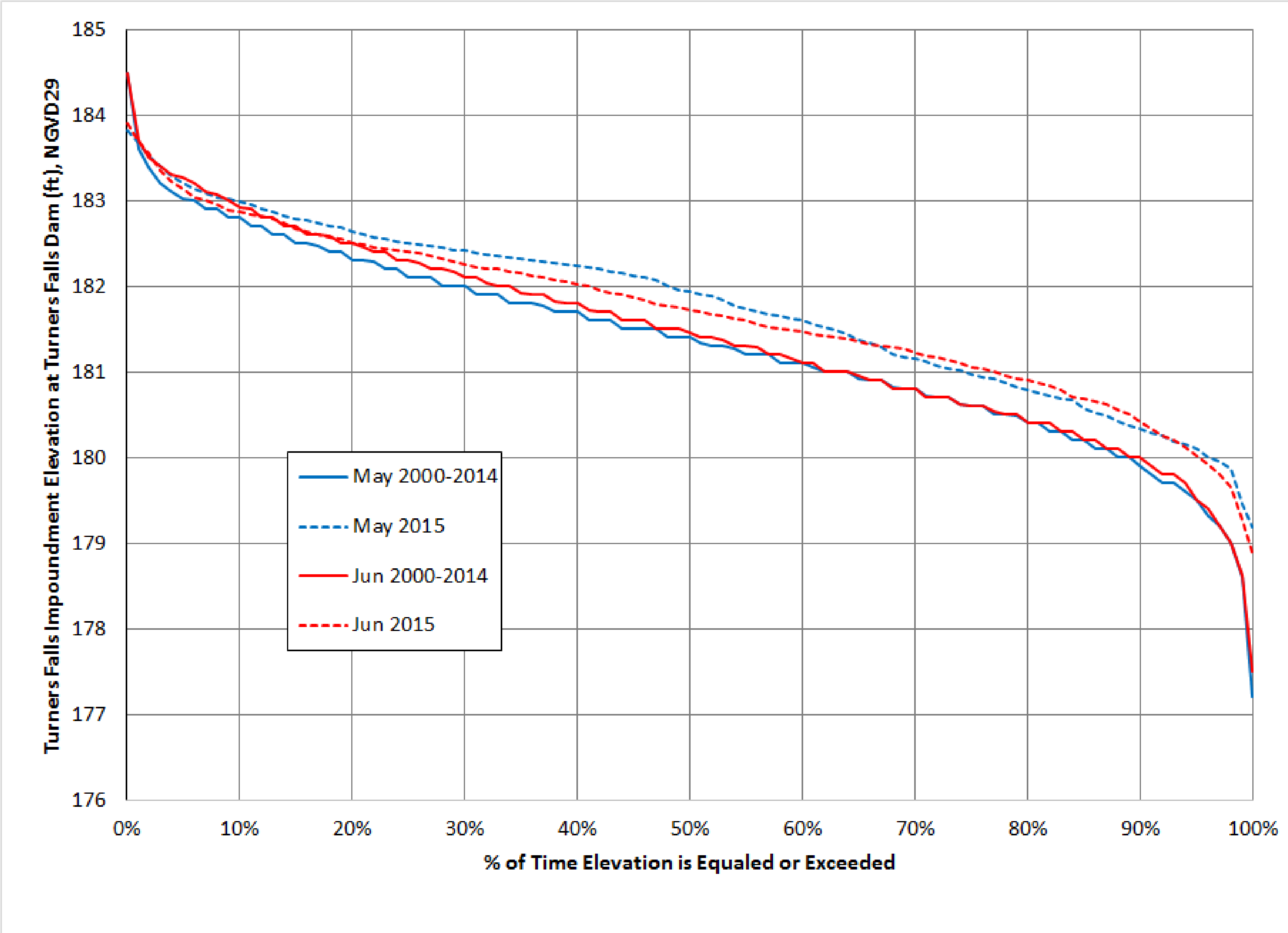
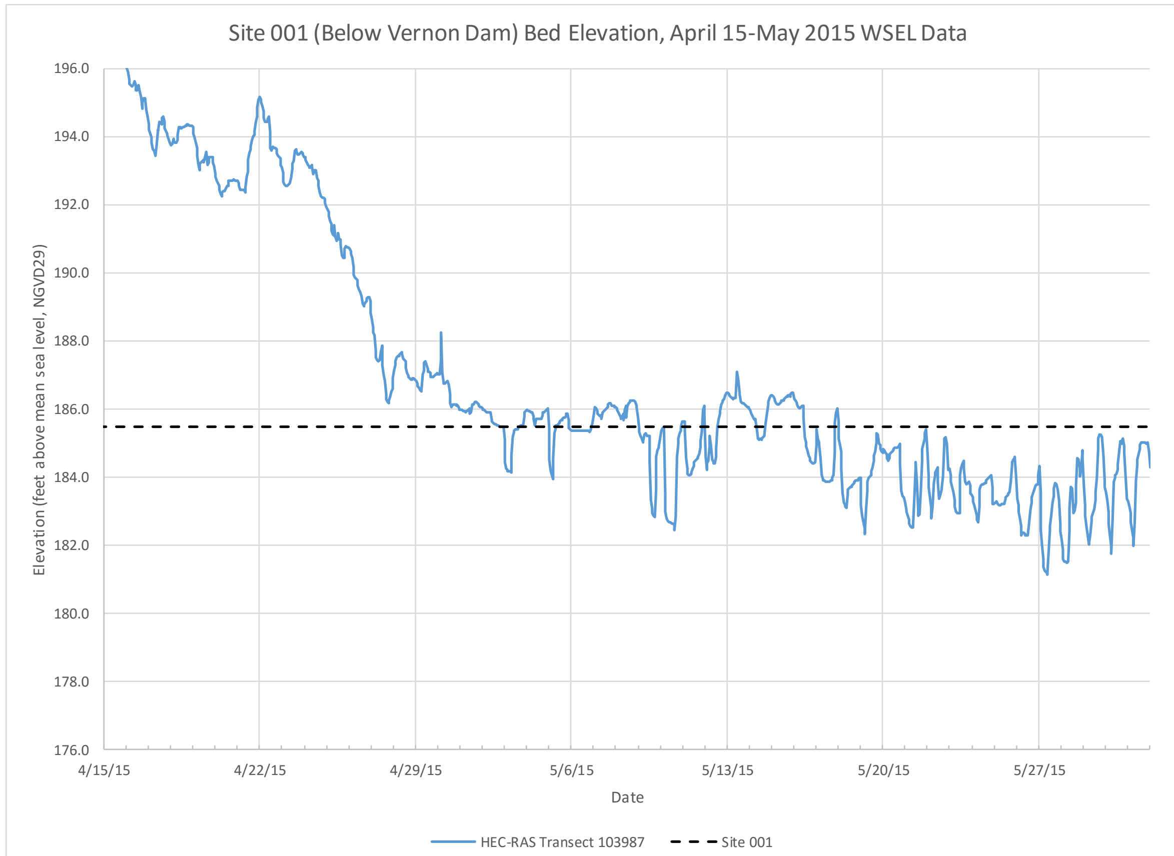
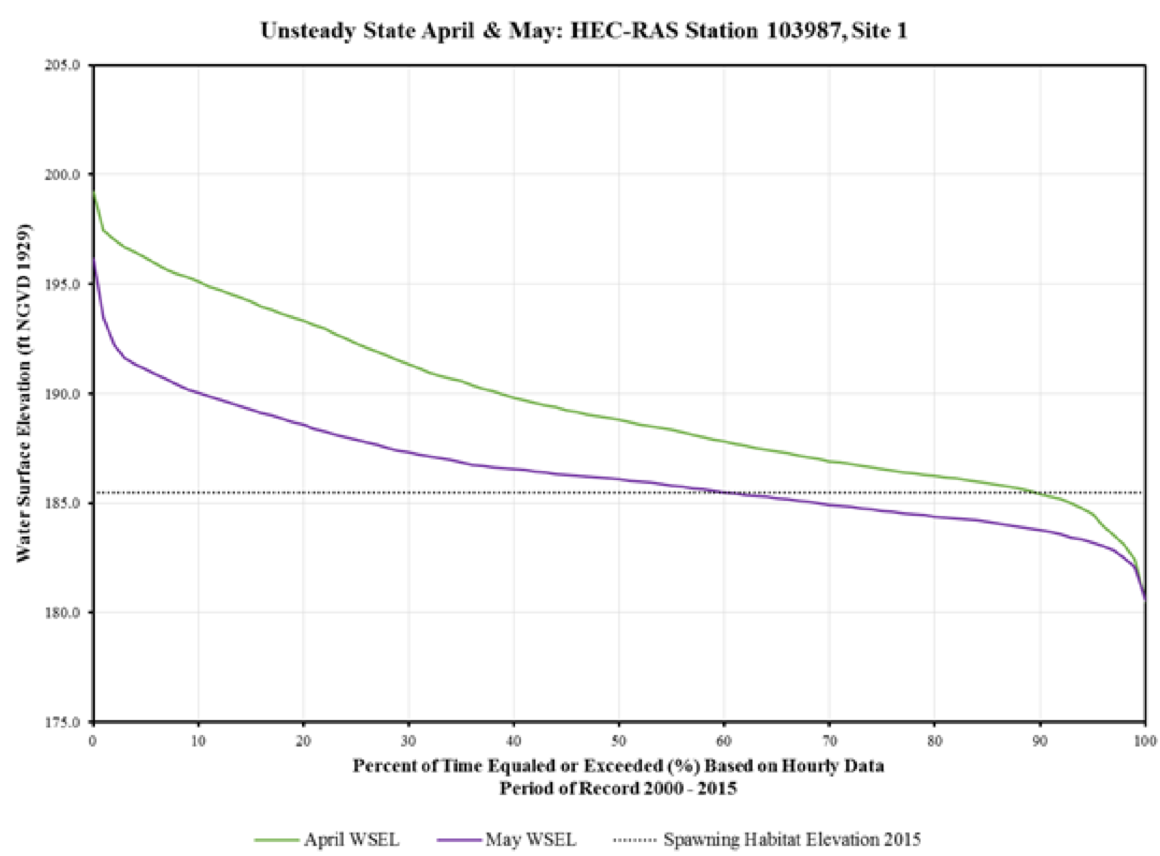


Figure 4.3.2-1: Early Spring Spawn WSEL Analysis at Site 001 (HEC-RAS Transect 103987)





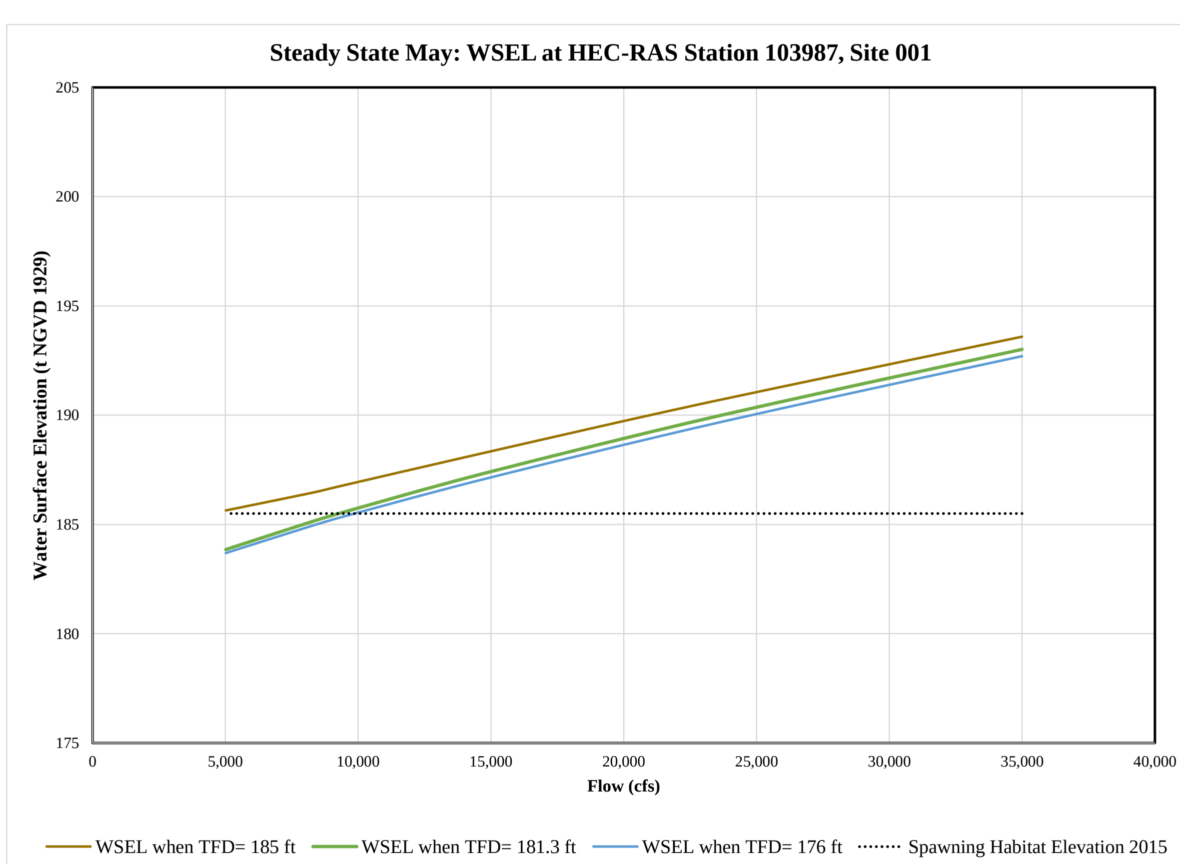
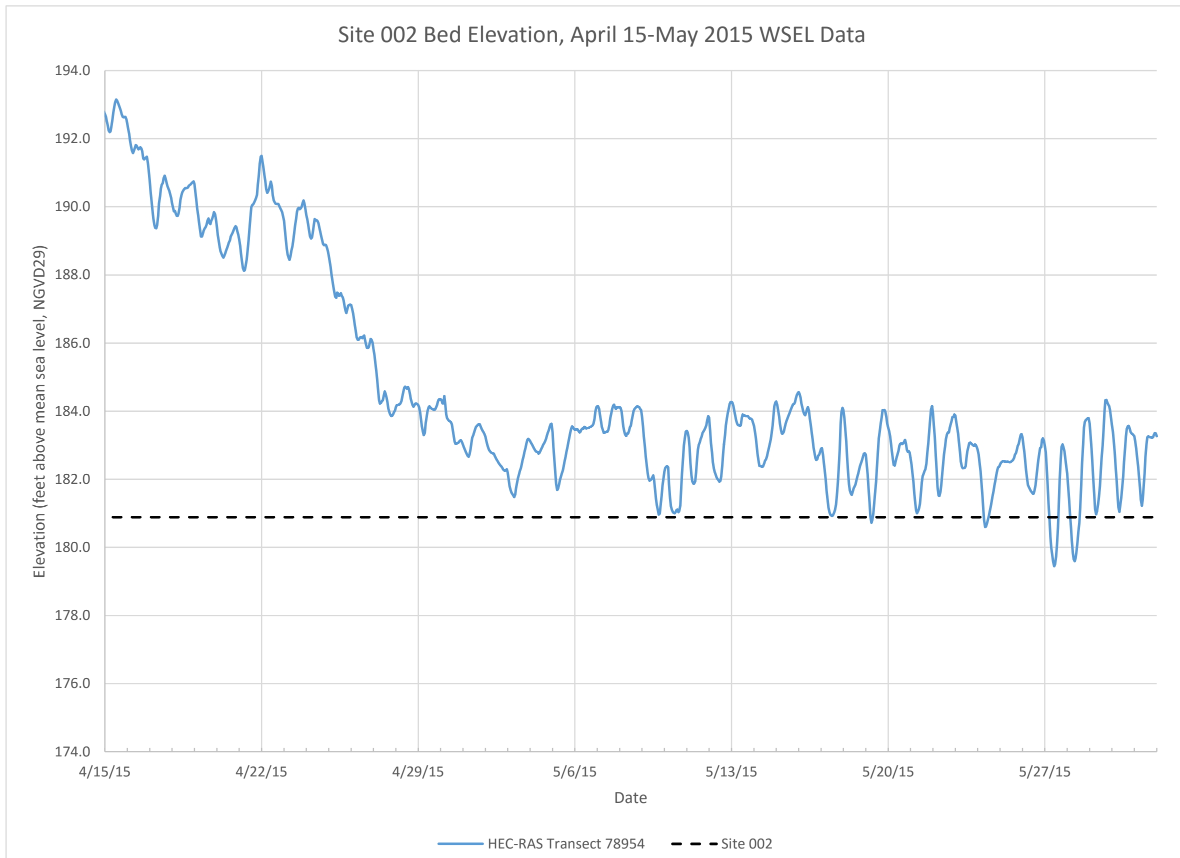
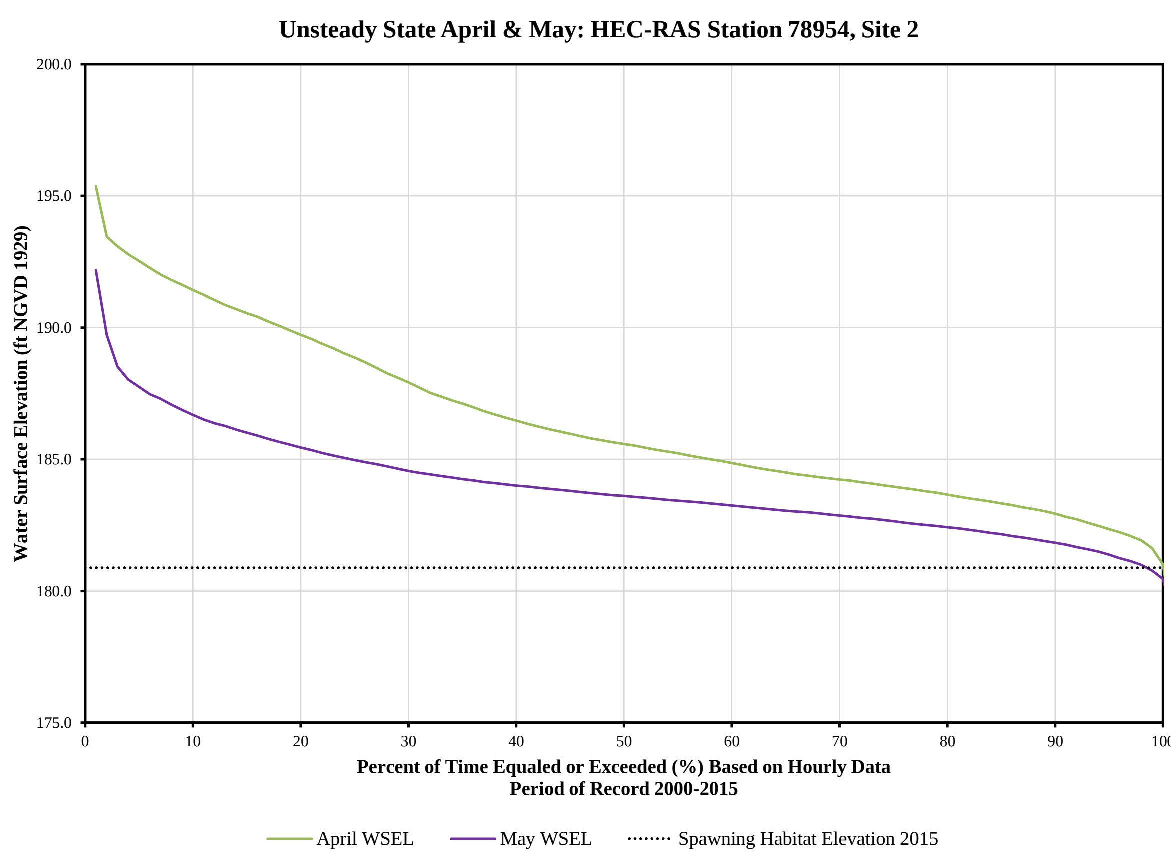


Figure 4.3.2-2: Early Spring Spawn WSEL Analysis at Site 002 (HEC-RAS Transect 78954)





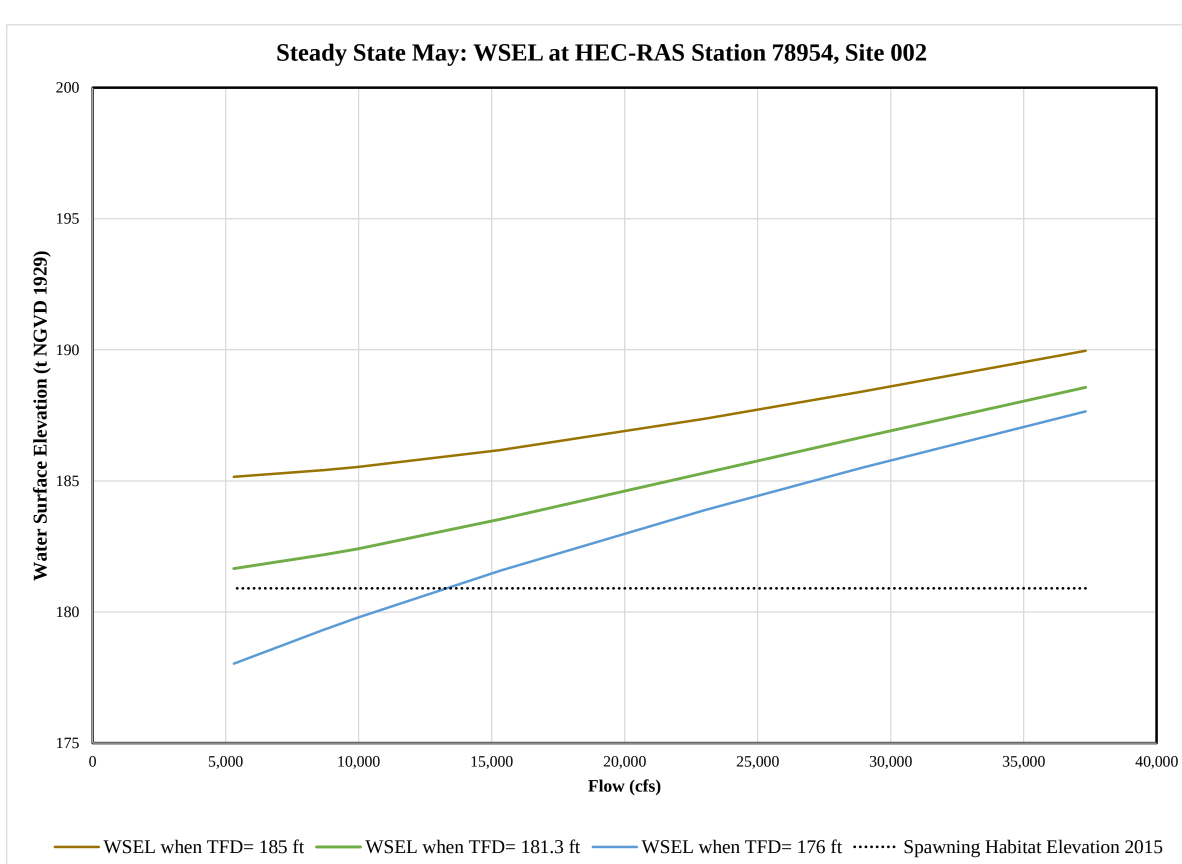
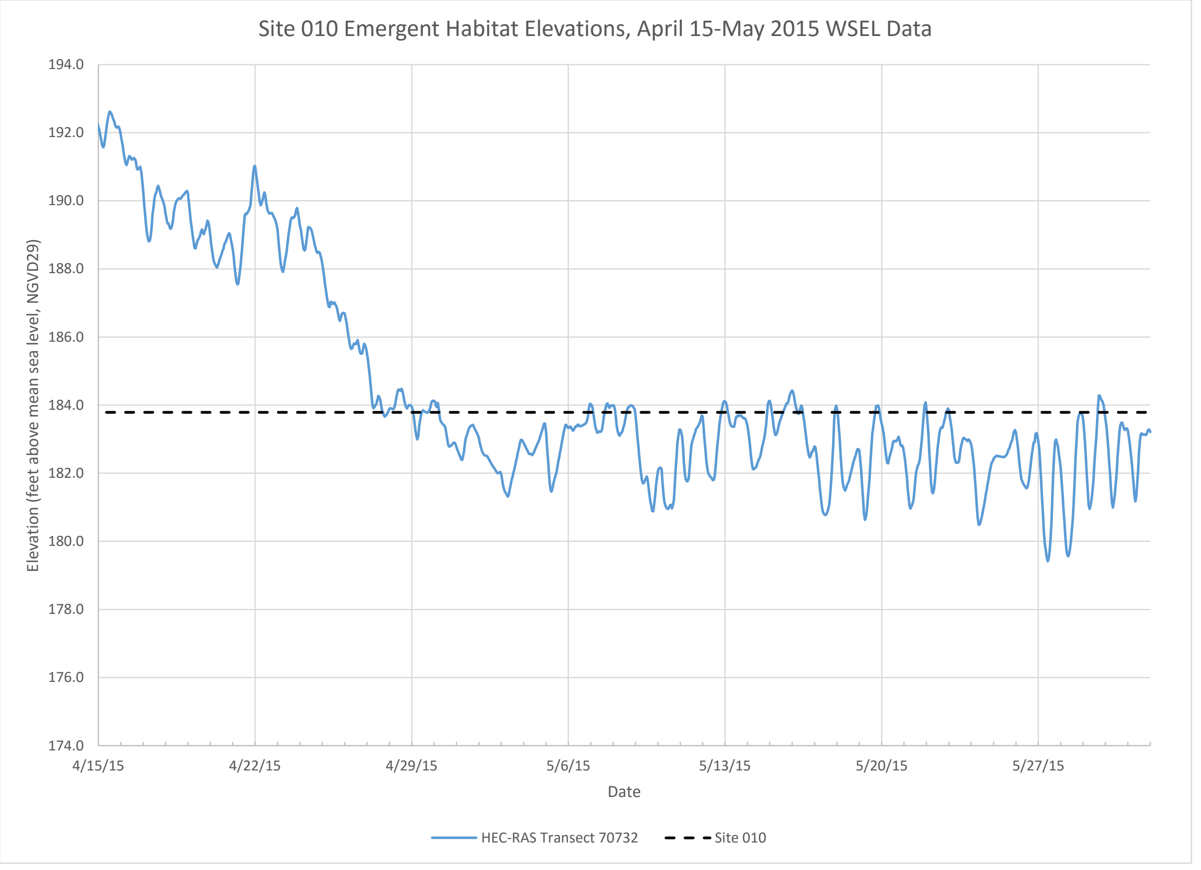
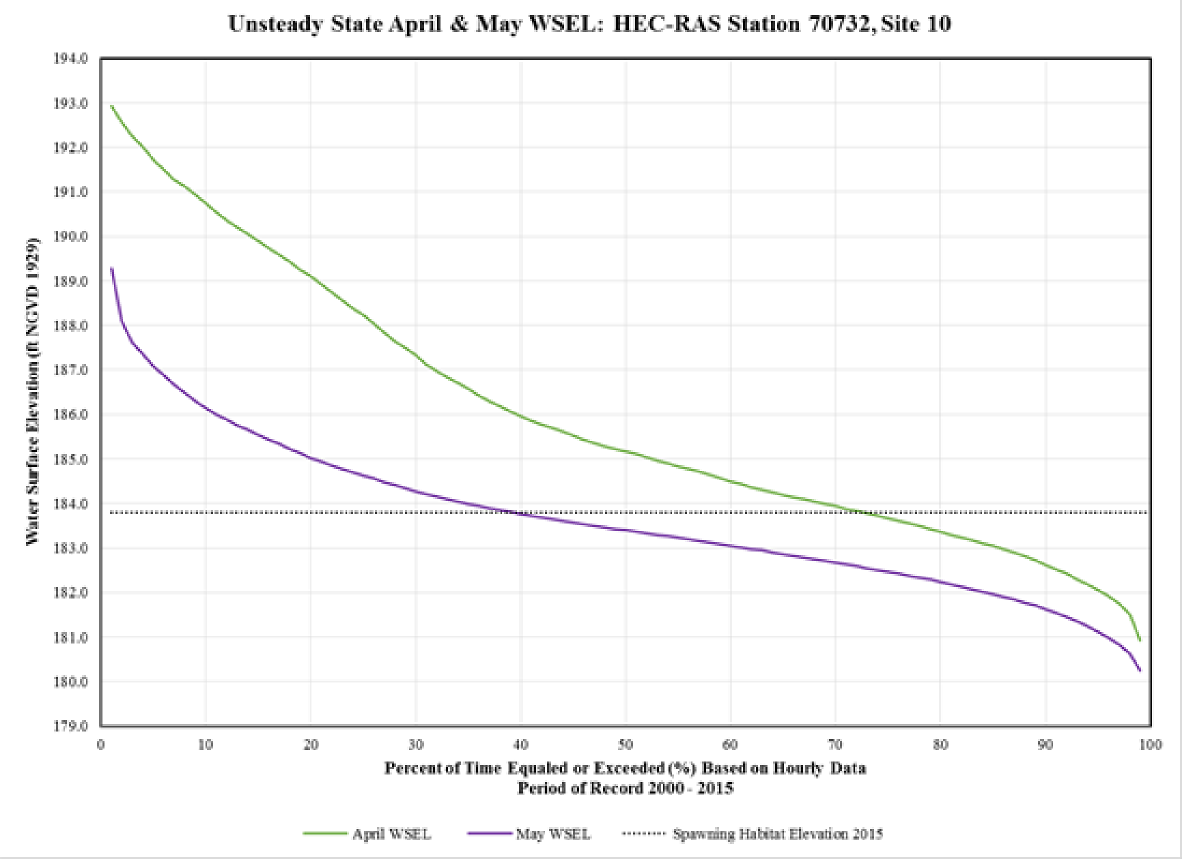


Figure 4.3.2-3: Early Spring Spawn WSEL Analysis at Site 010 (HEC-RAS Transect 70732)





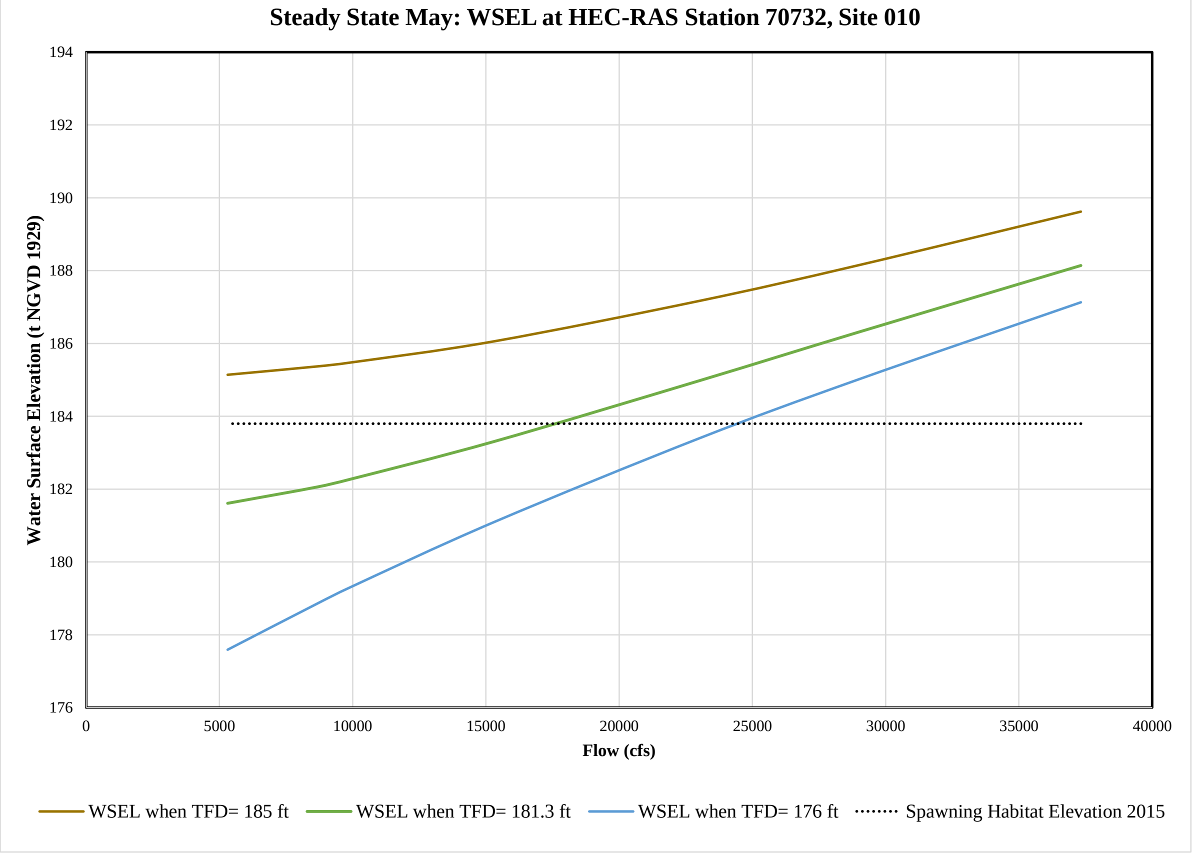
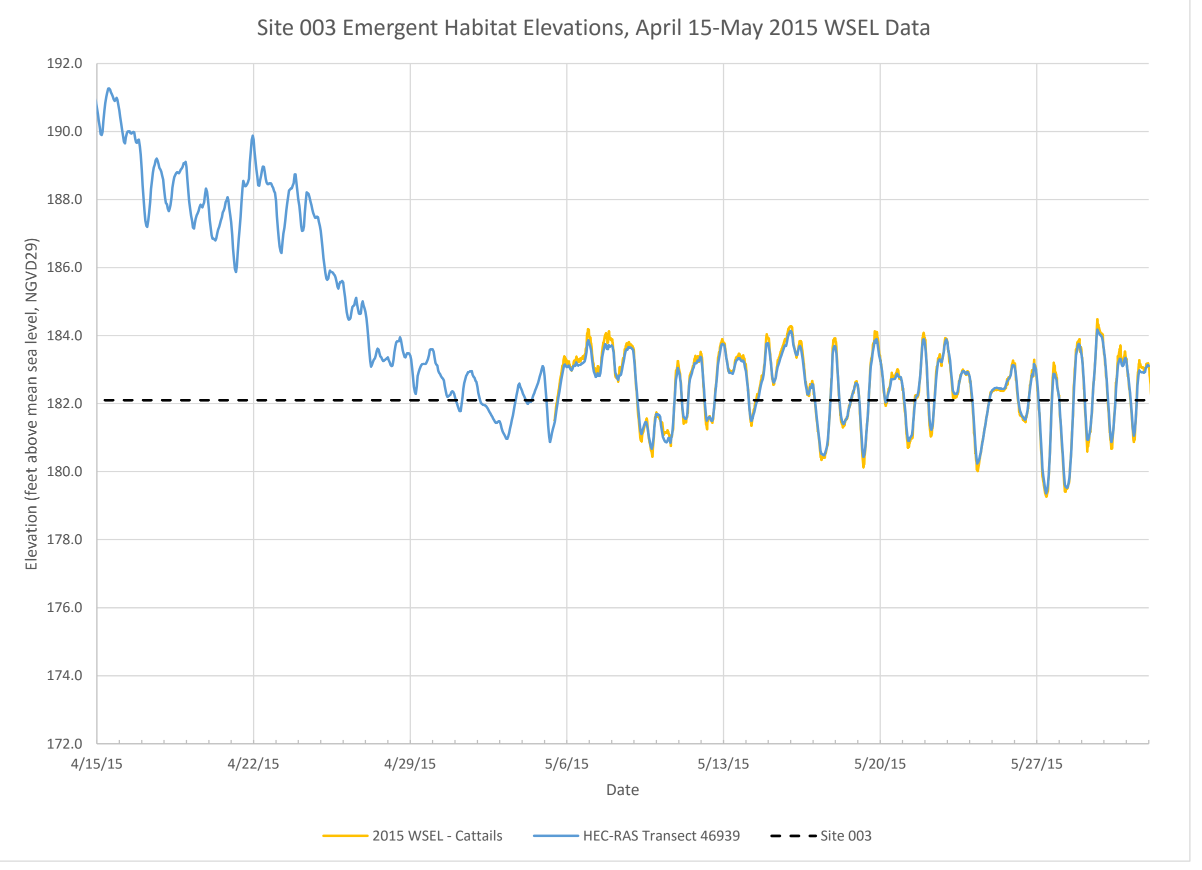
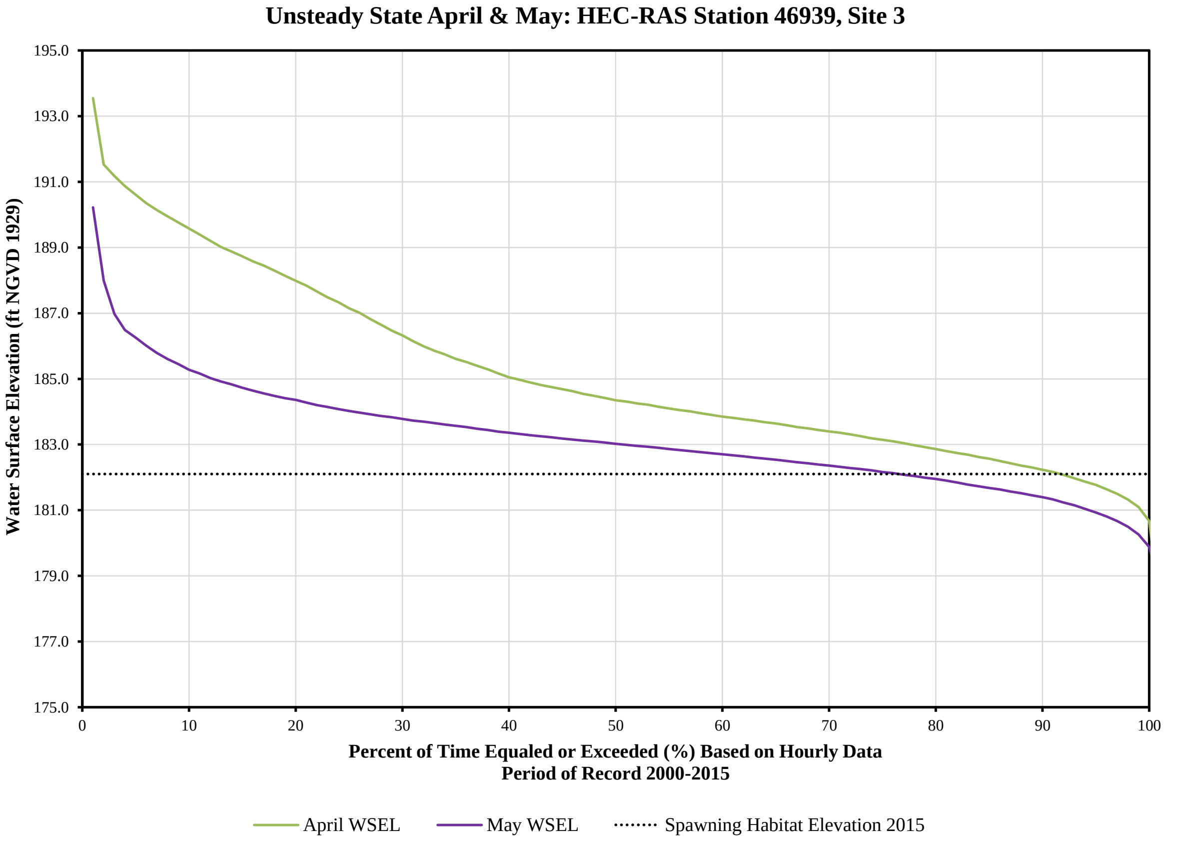


Figure 4.3.2-4: Early Spring Spawn WSEL Analysis at Site 003 (HEC-RAS Transect 46939)





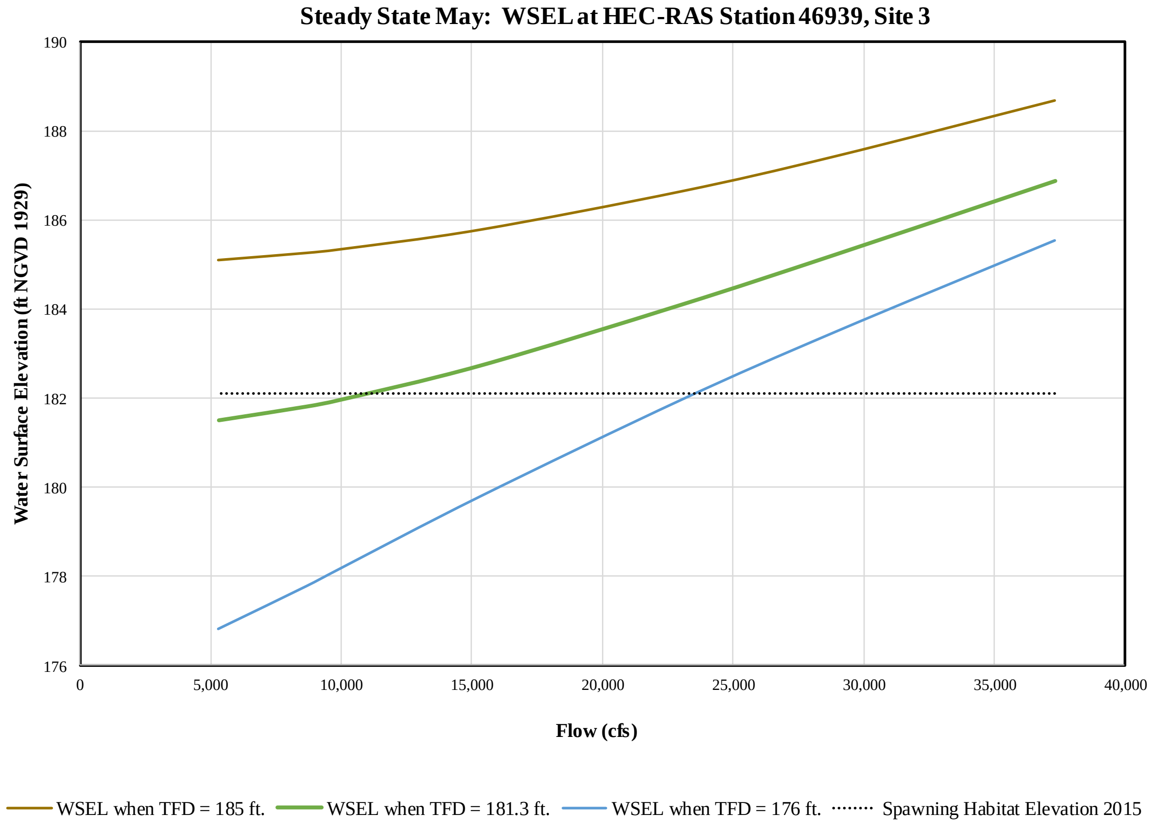
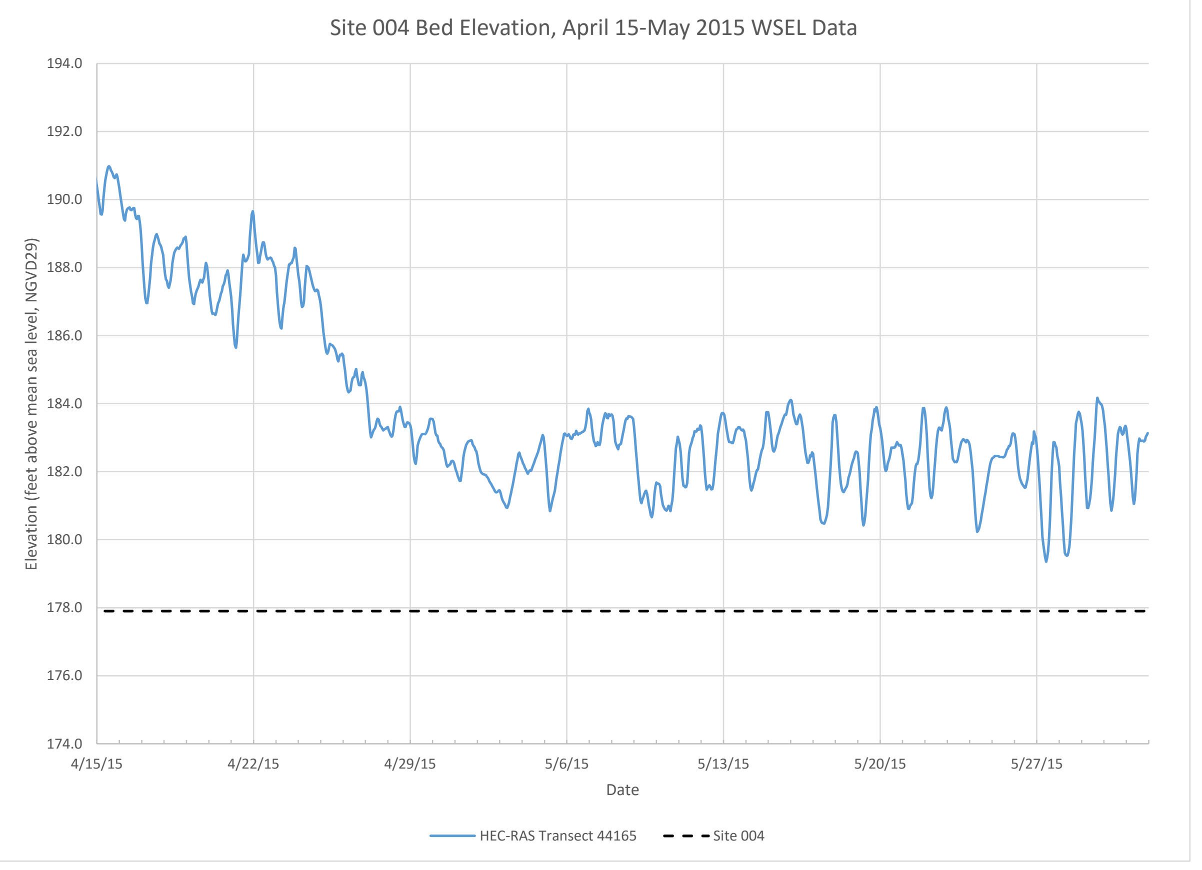
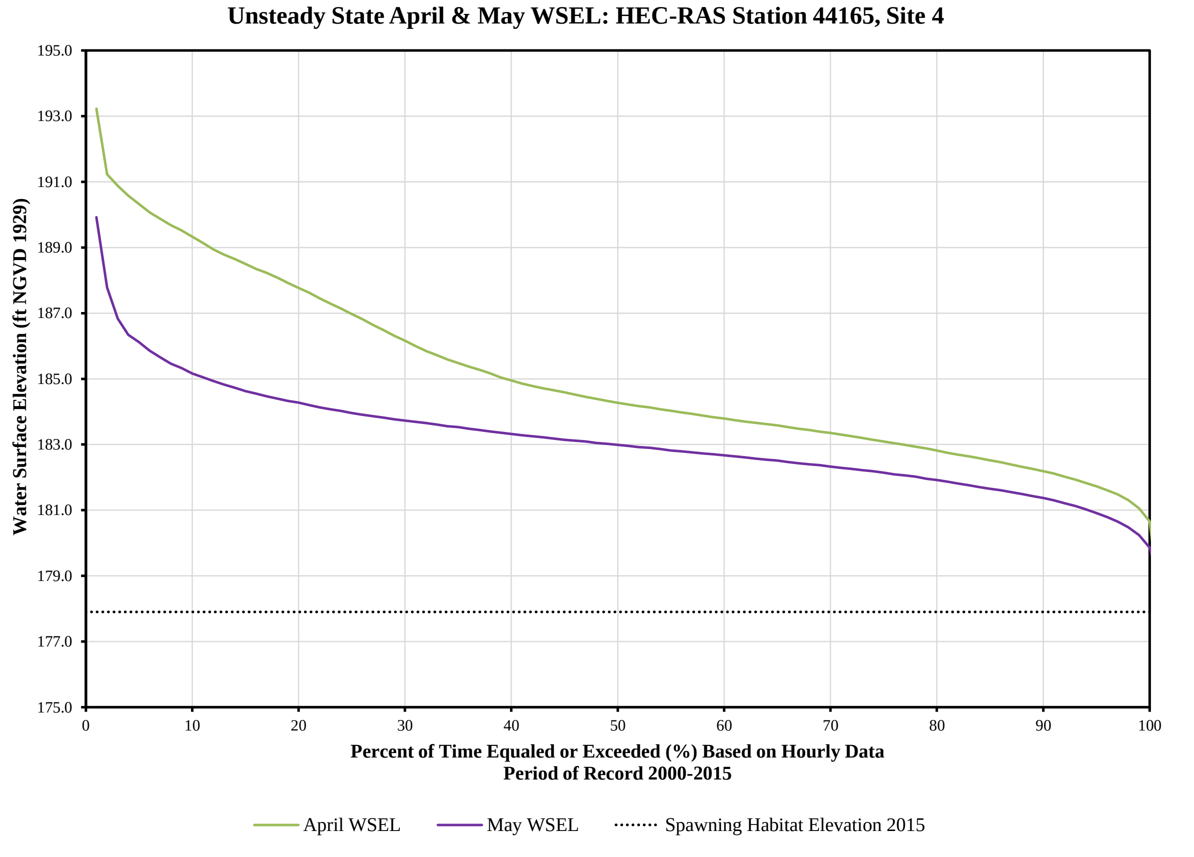


Figure 4.3.2-5: Early Spring Spawn WSEL Analysis at Site 004 (HEC-RAS Transect 44165)





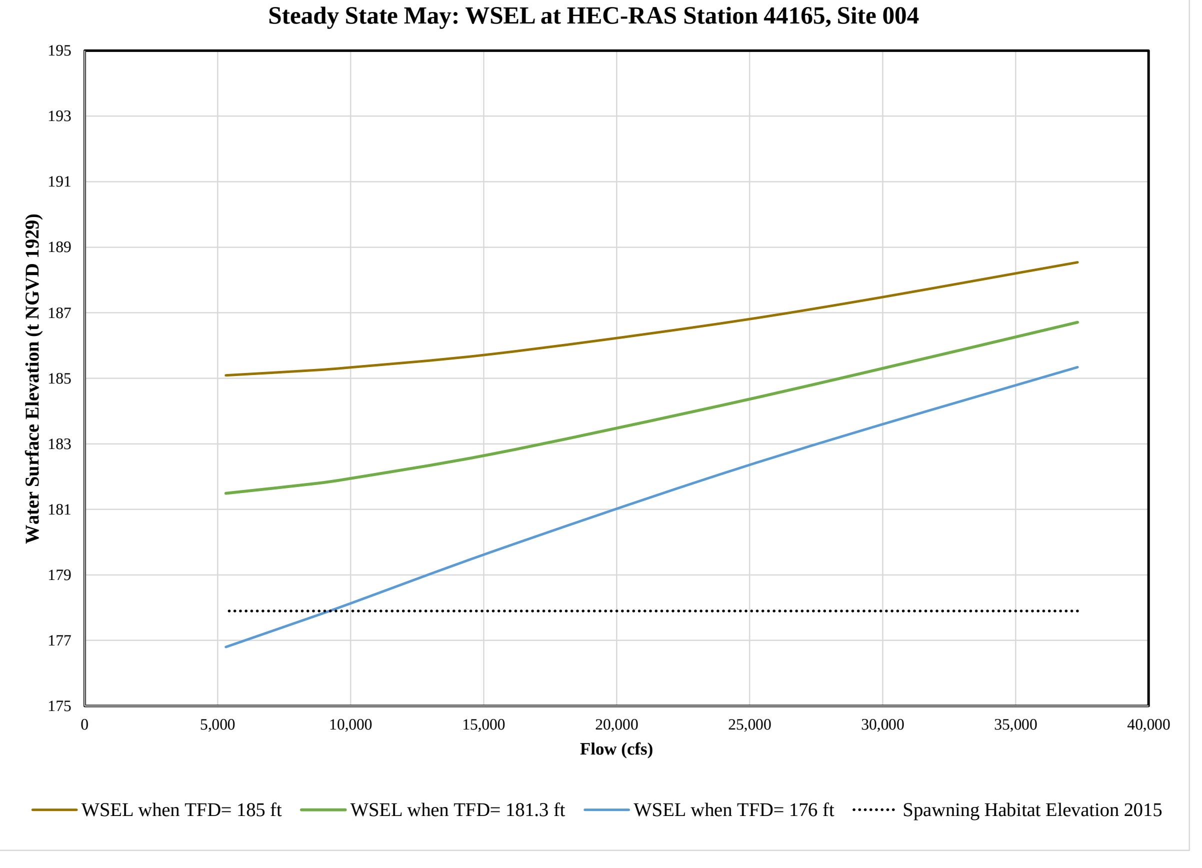
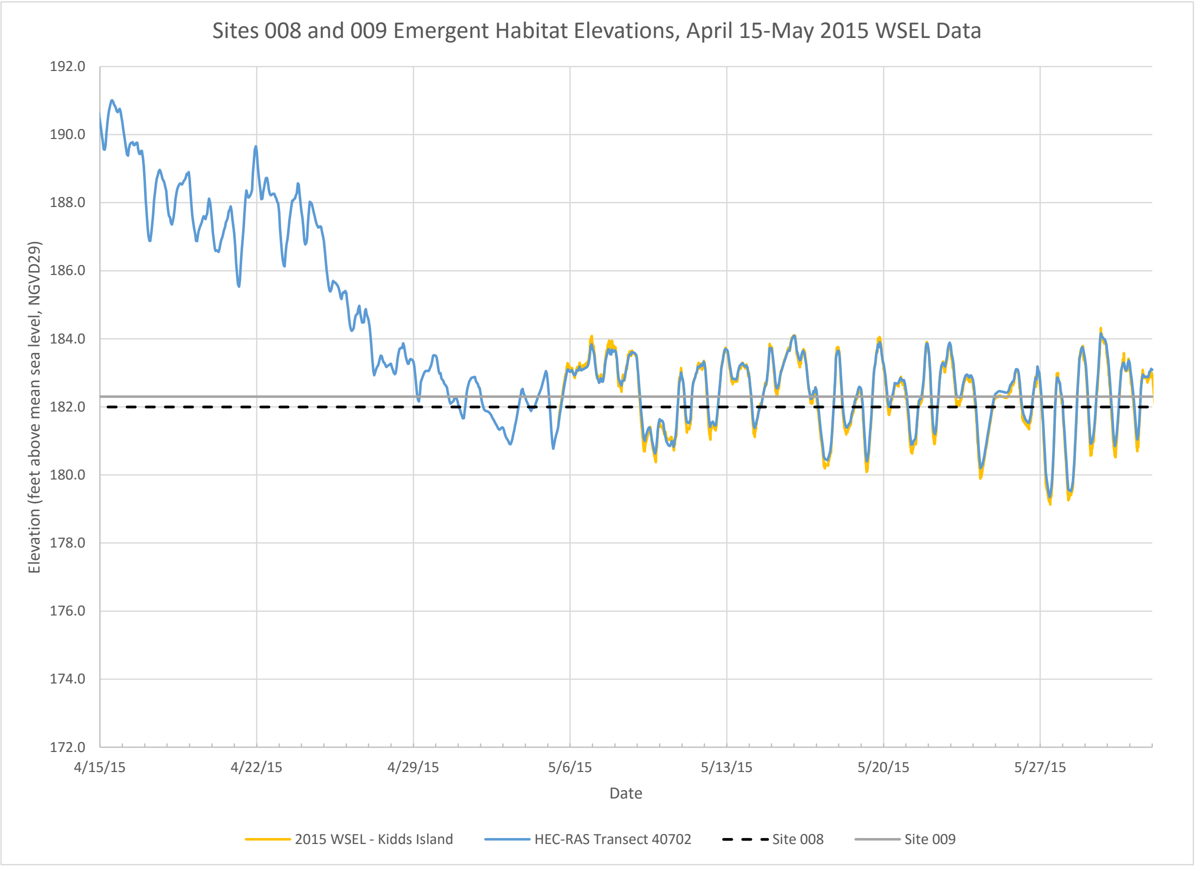
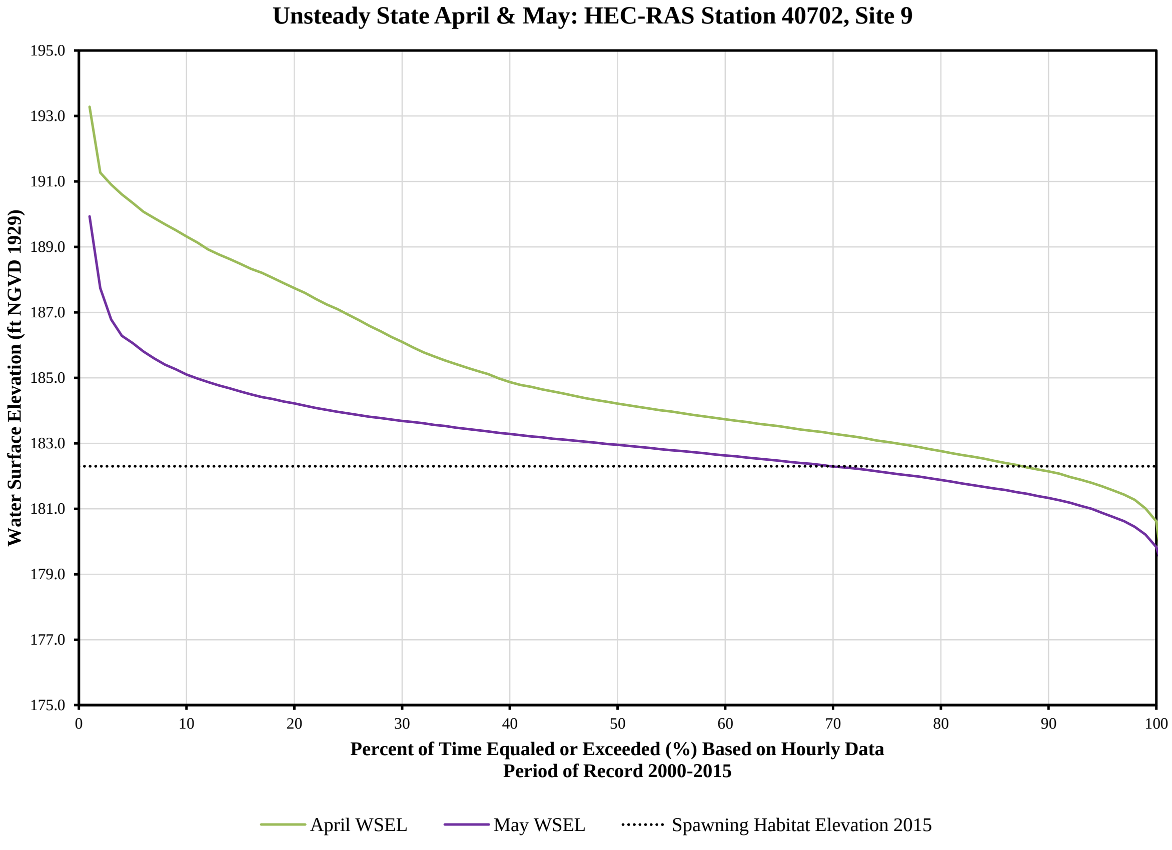


Figure 4.3.2-6: Early Spring Spawn WSEL Analysis at Site 009 (HEC-RAS Transect 40702)





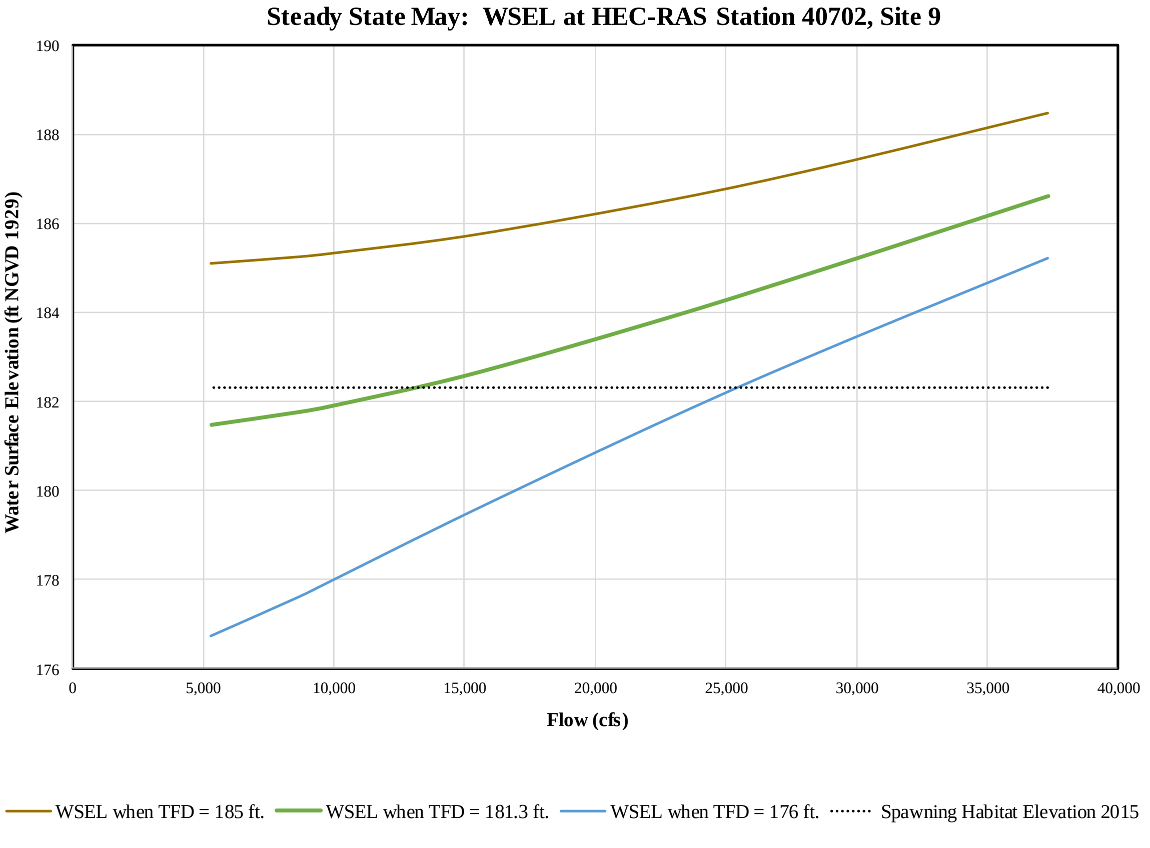
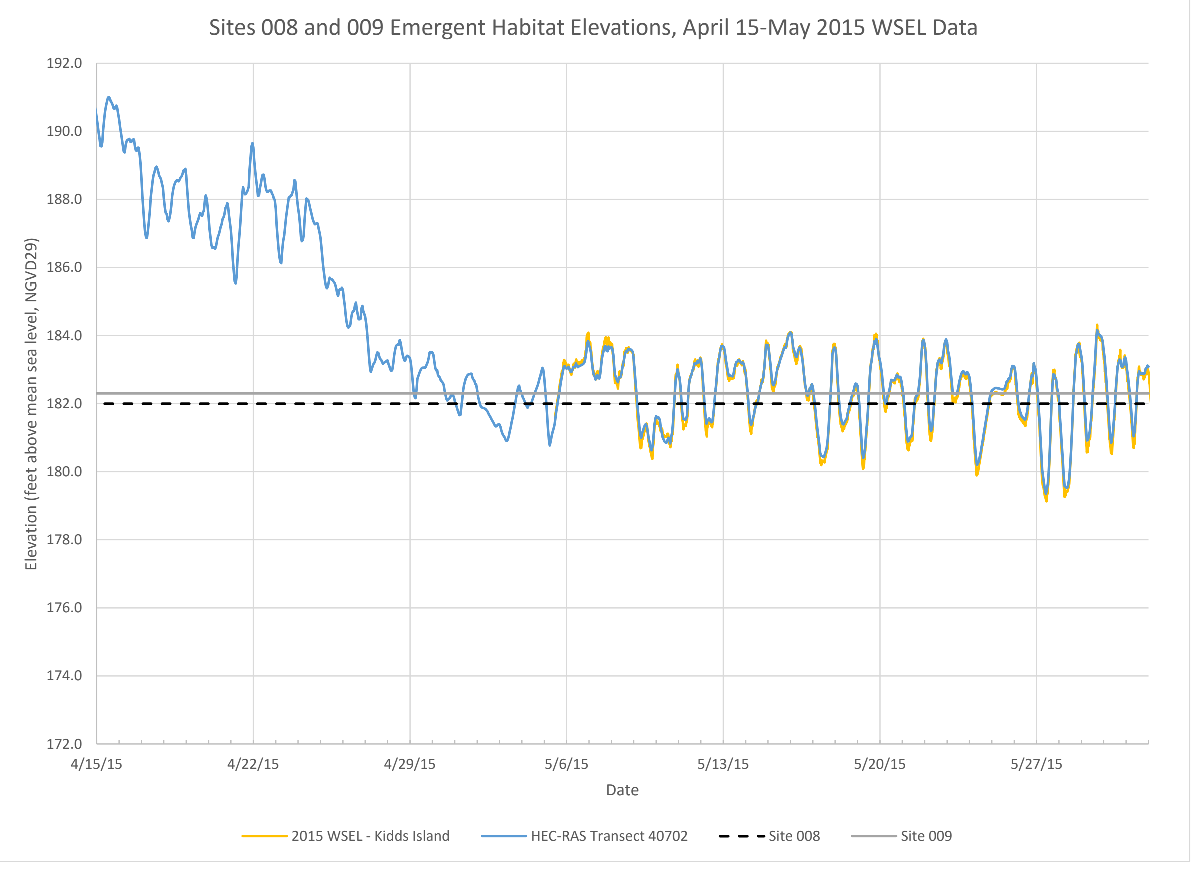
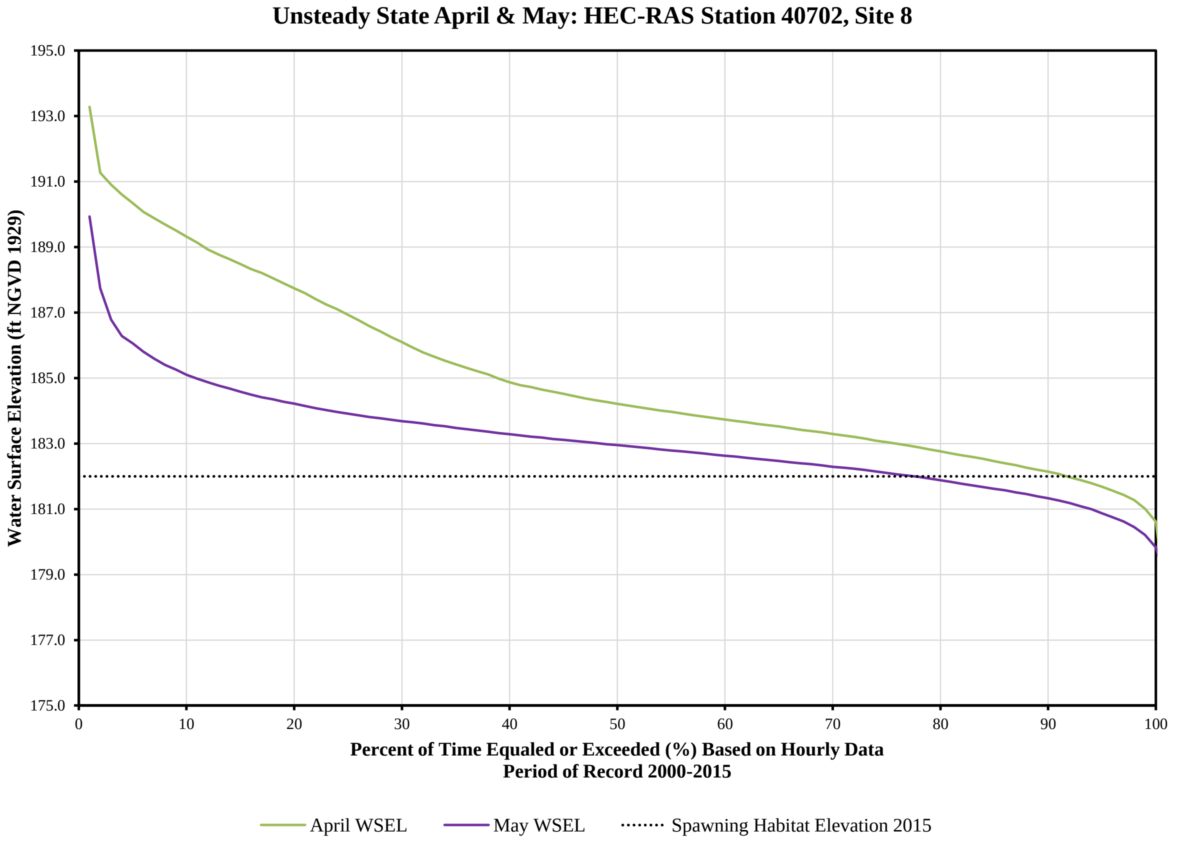


Figure 4.3.2-7: Early Spring Spawn WSEL Analysis at Site 008 (HEC-RAS Transect 40702)





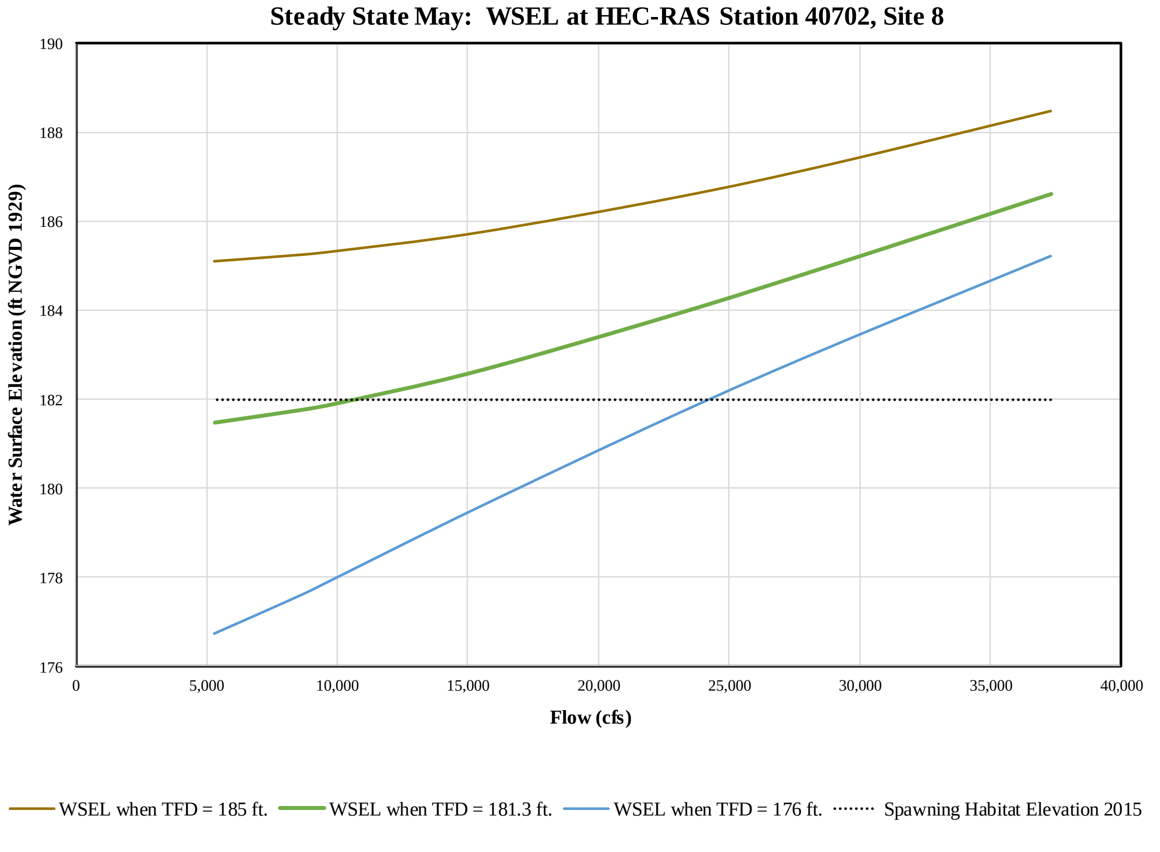
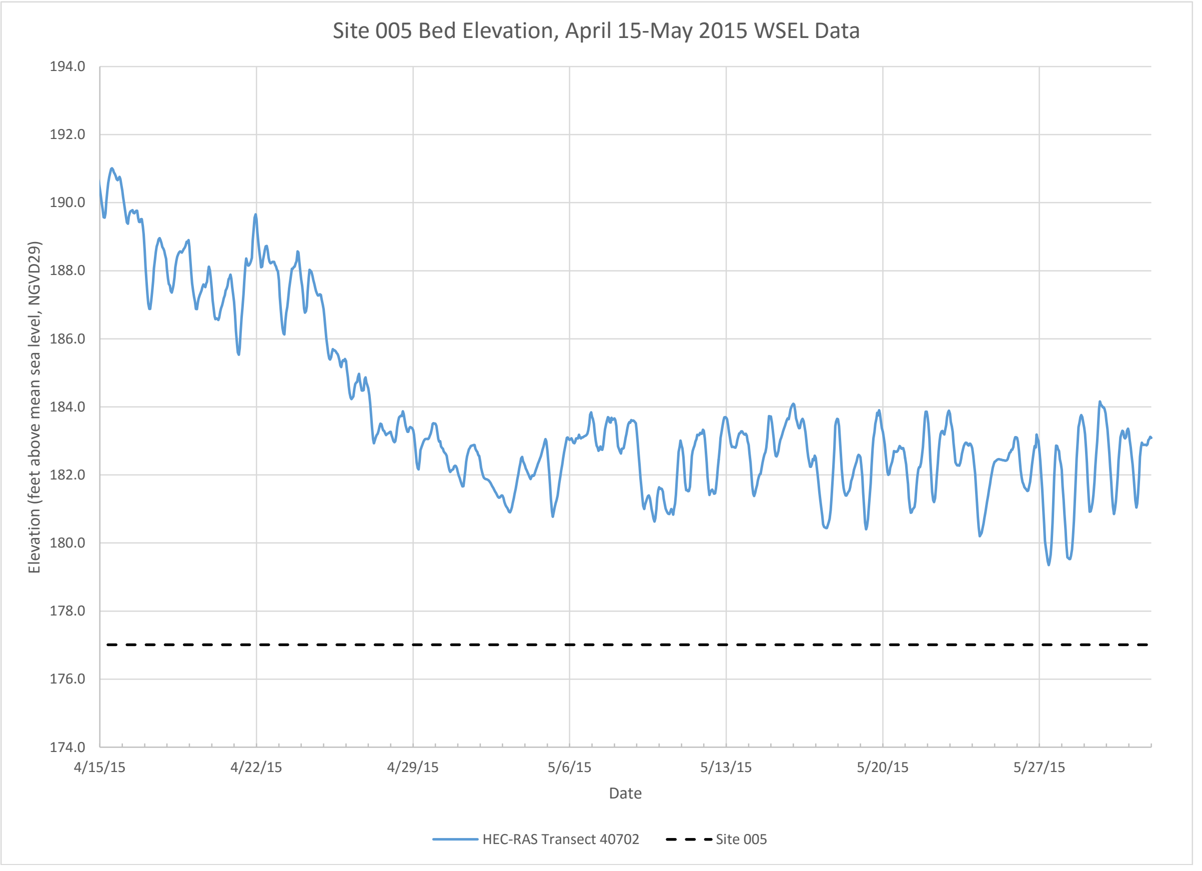
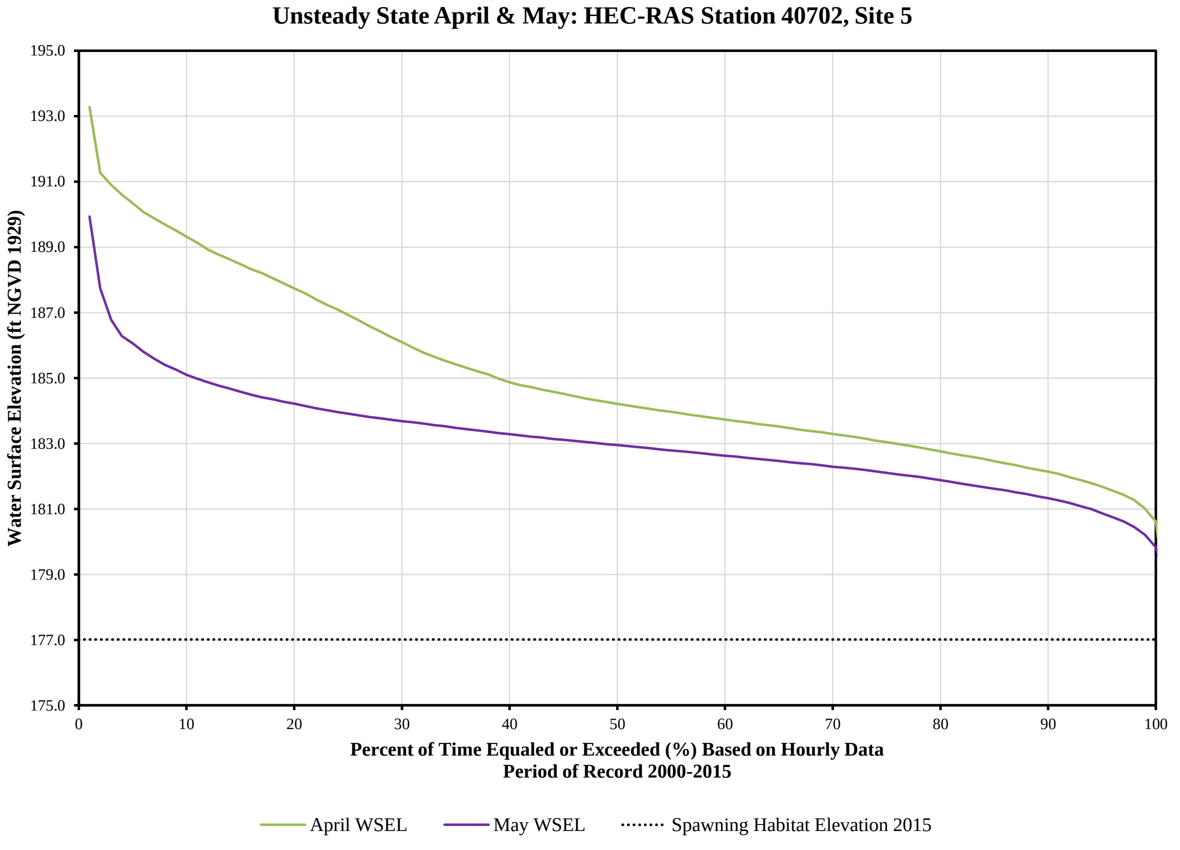


Figure 4.3.2-8: Early Spring Spawn WSEL Analysis at Site 005 (HEC-RAS Transect 40702)





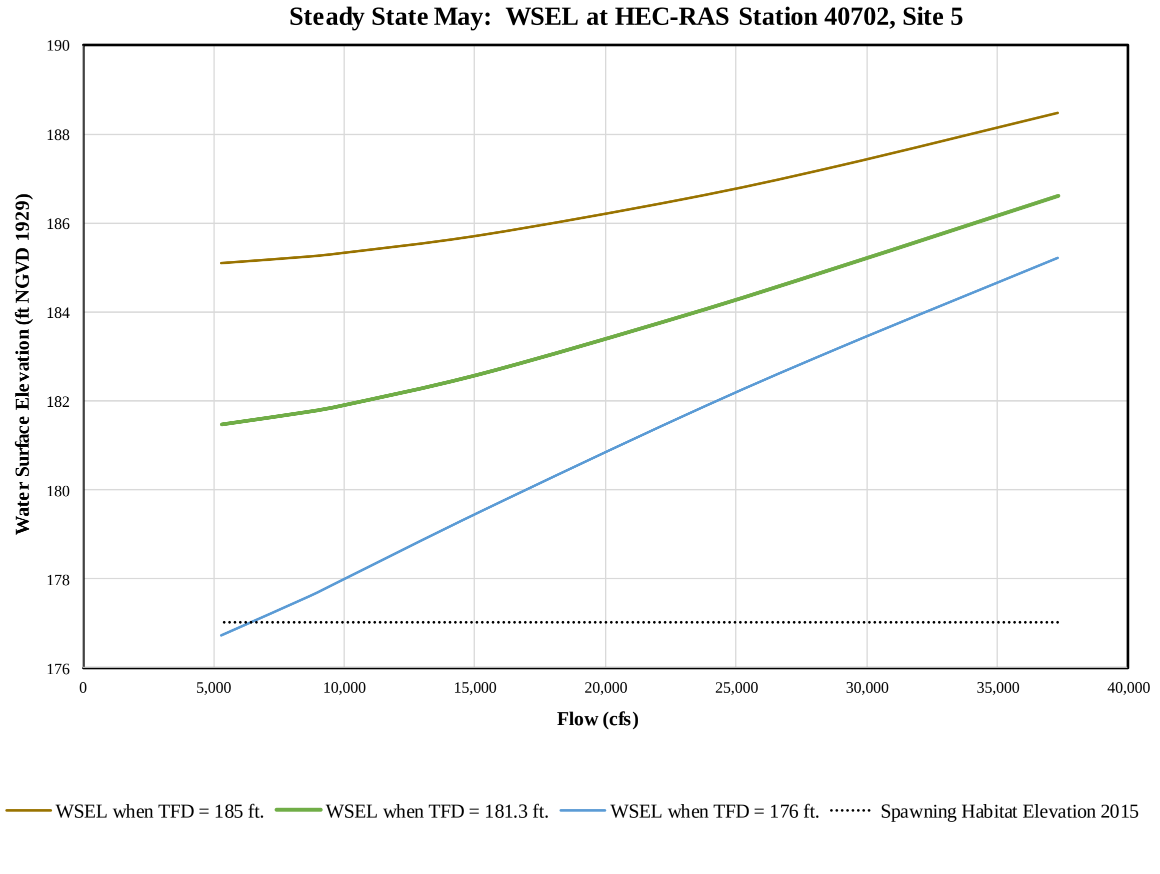
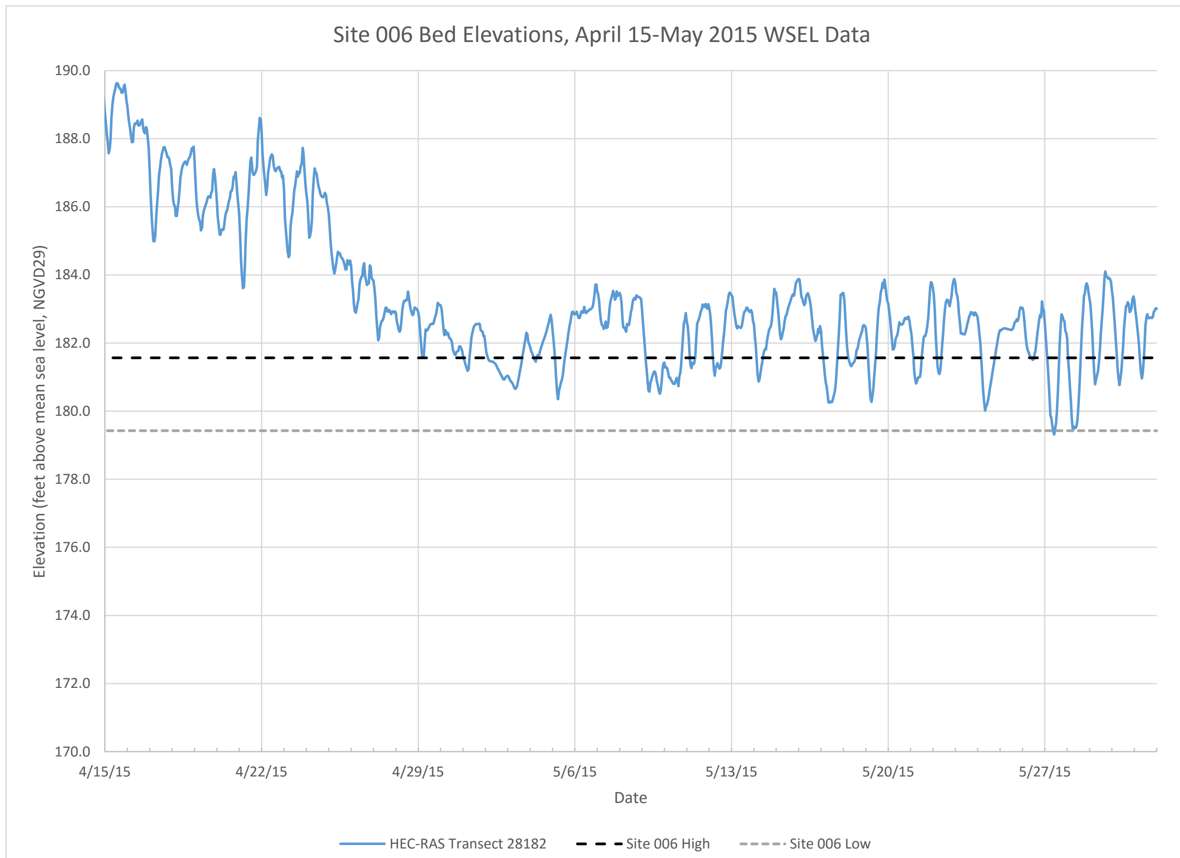
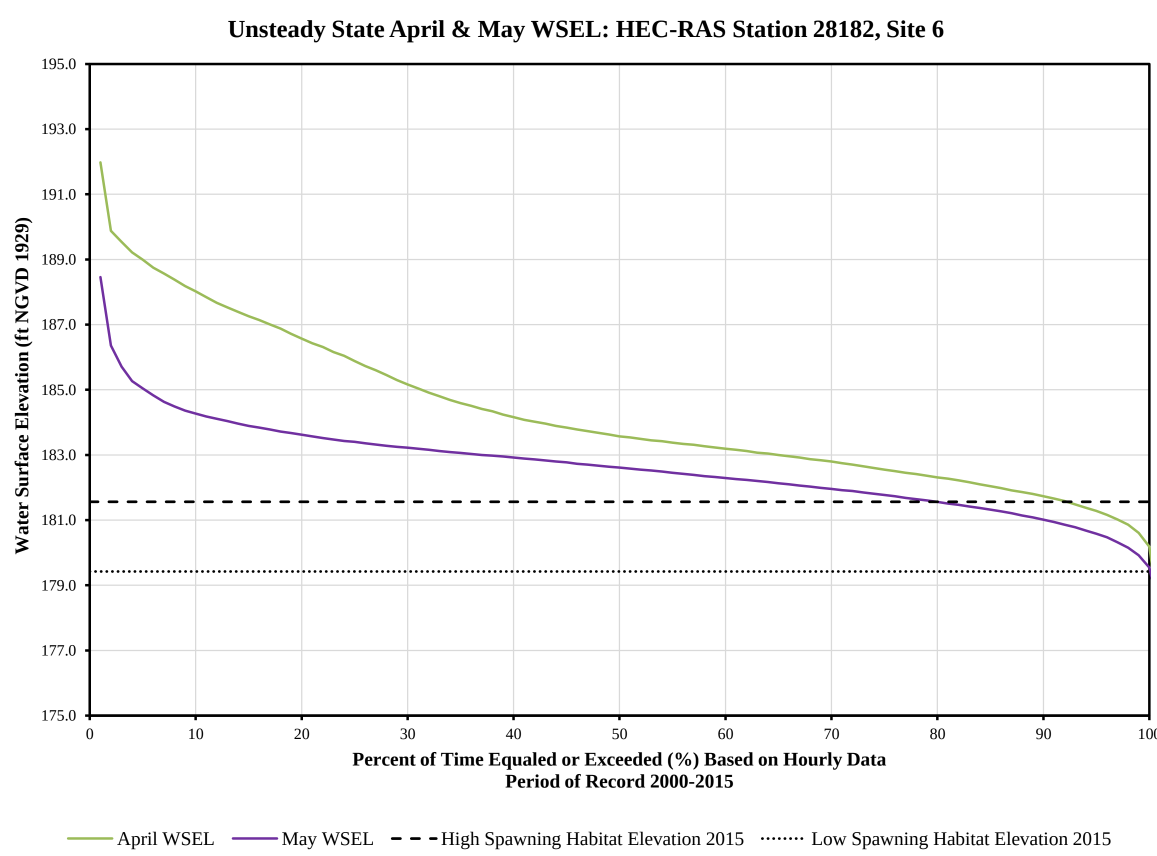


Figure 4.3.2-9: Early Spring Spawn WSEL Analysis at Site 006 (HEC-RAS Transect 28182)





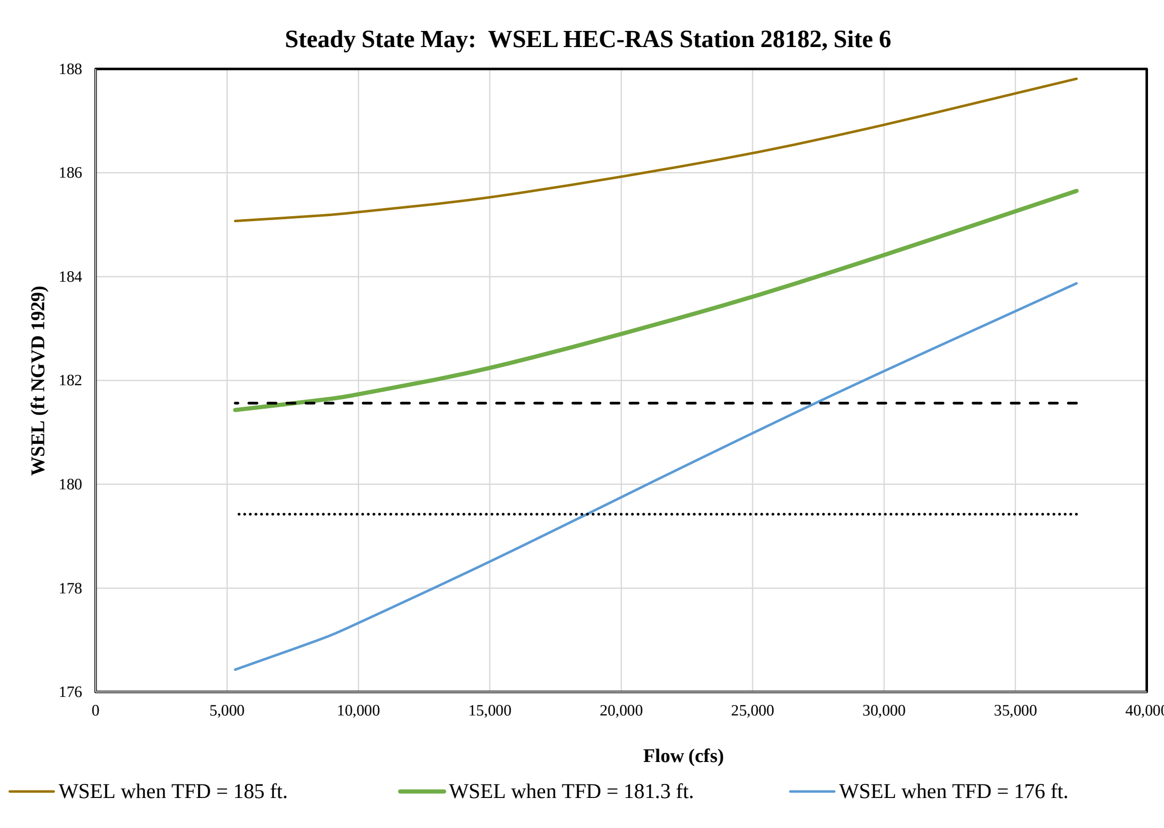
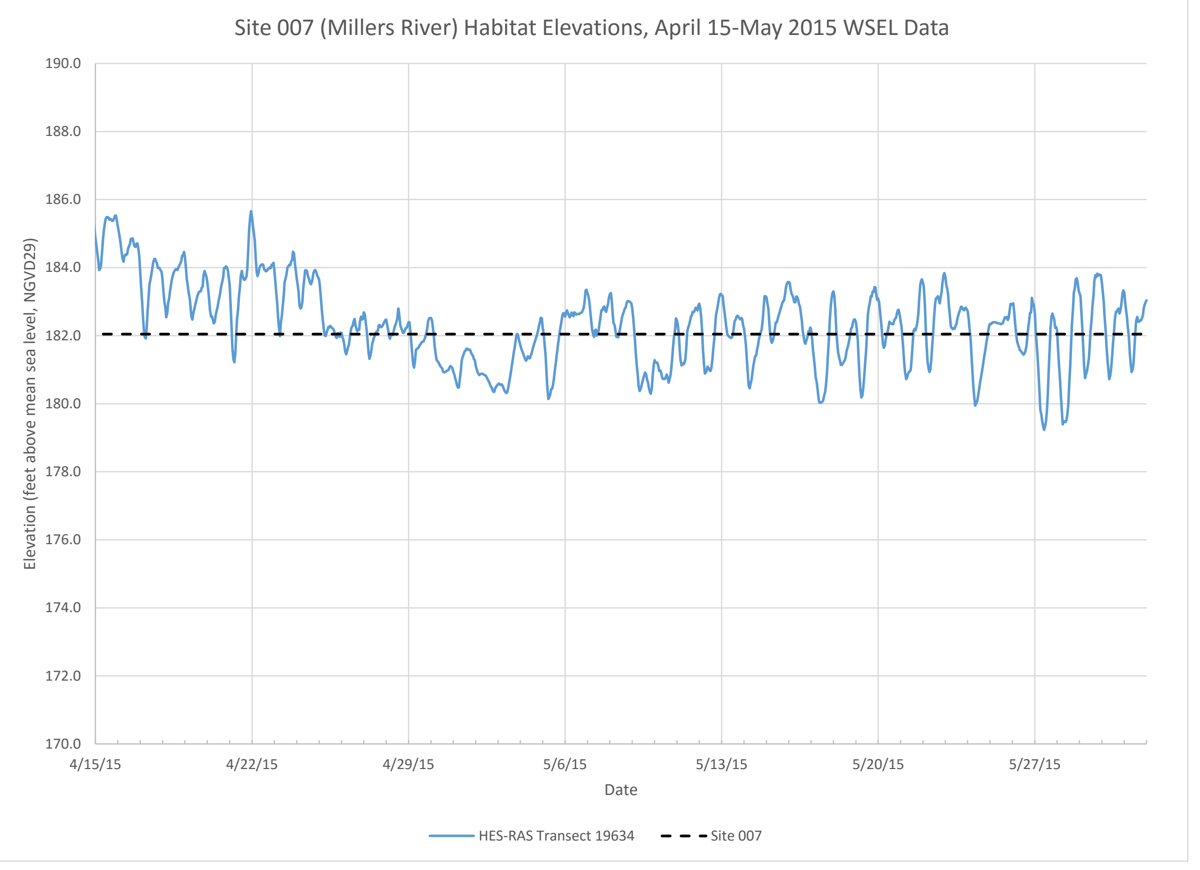
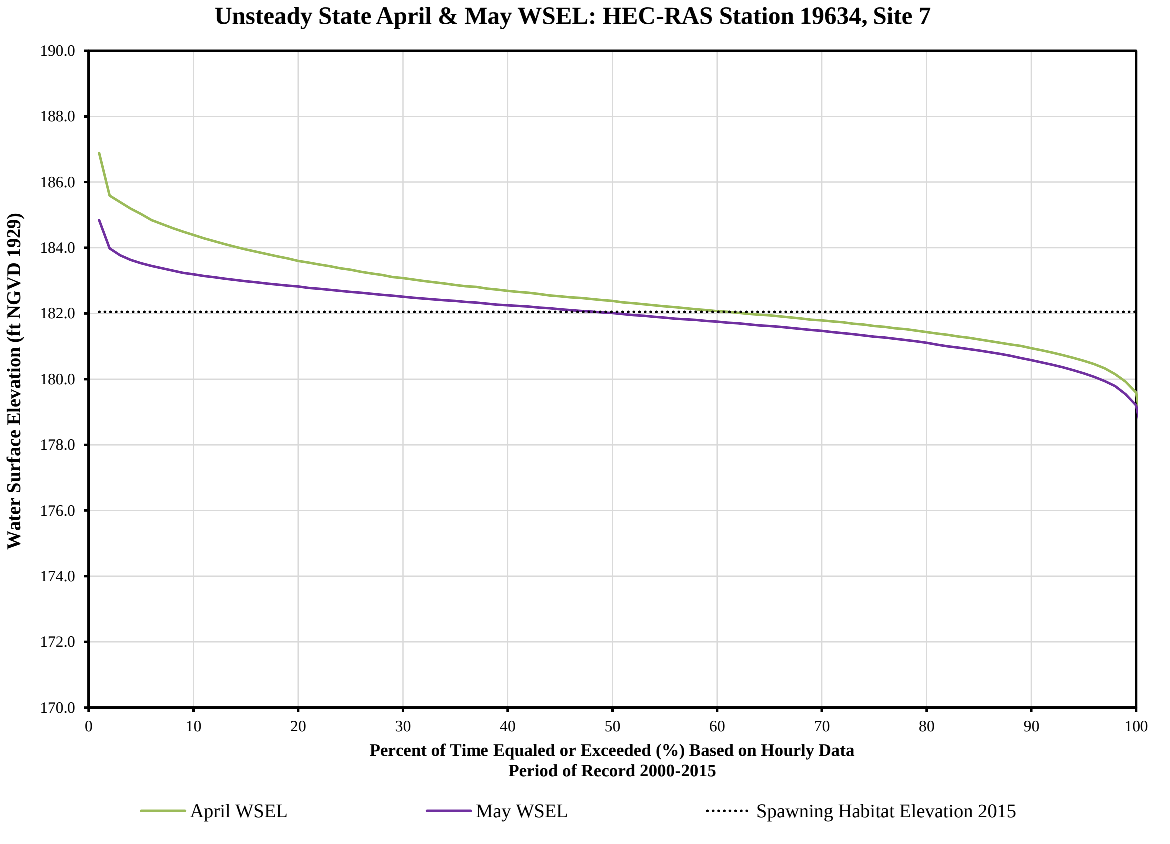


Figure 4.3.2-10: Early Spring Spawn WSEL Analysis at Site 007 (HEC-RAS Transect 19634)





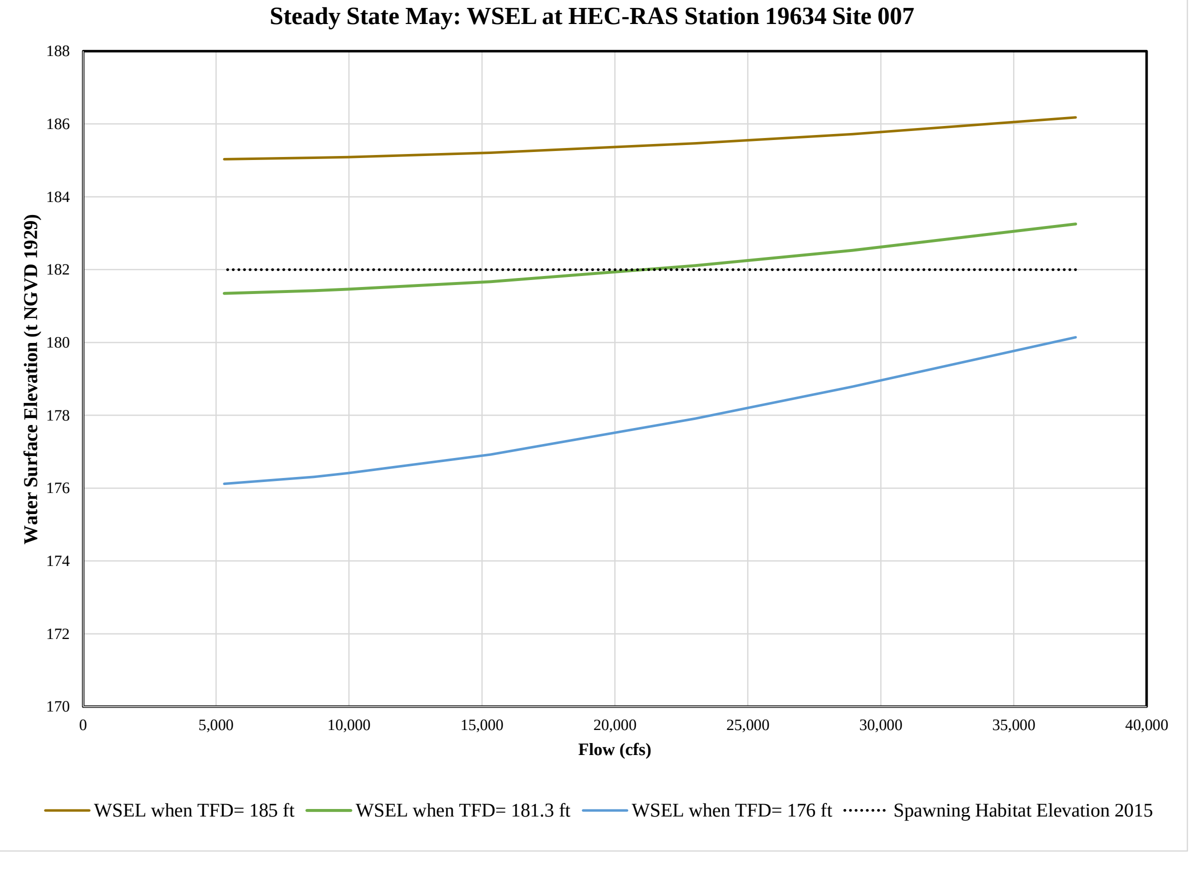
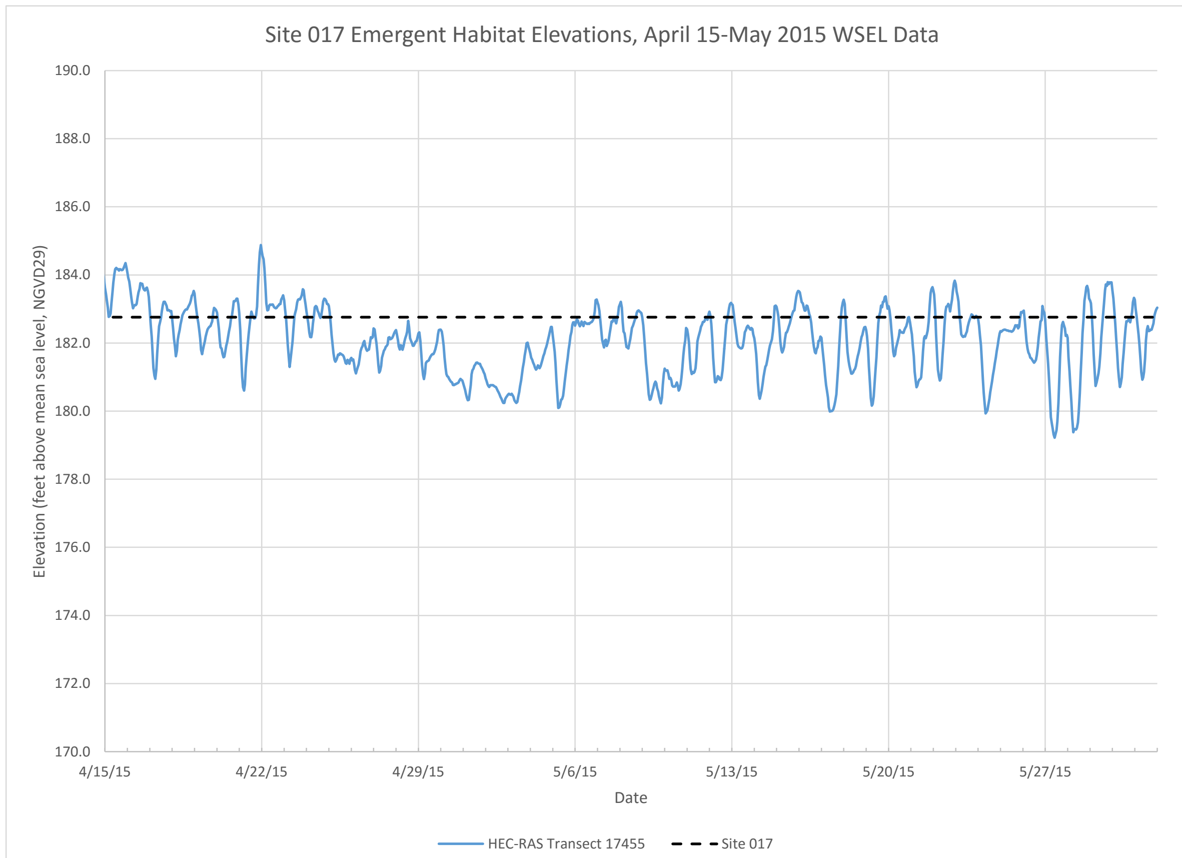
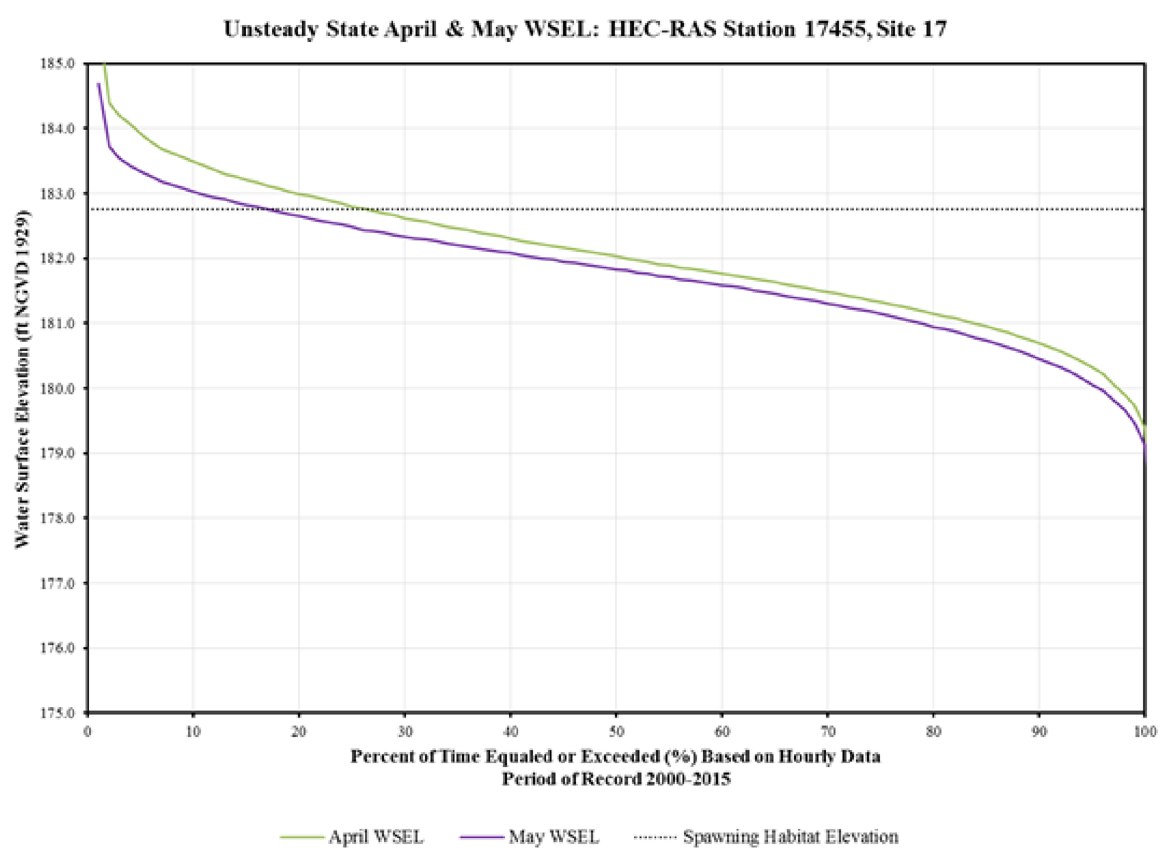


Figure 4.3.2-11: Early Spring Spawn WSEL Analysis at Site 017 (HEC-RAS Transect 17455)





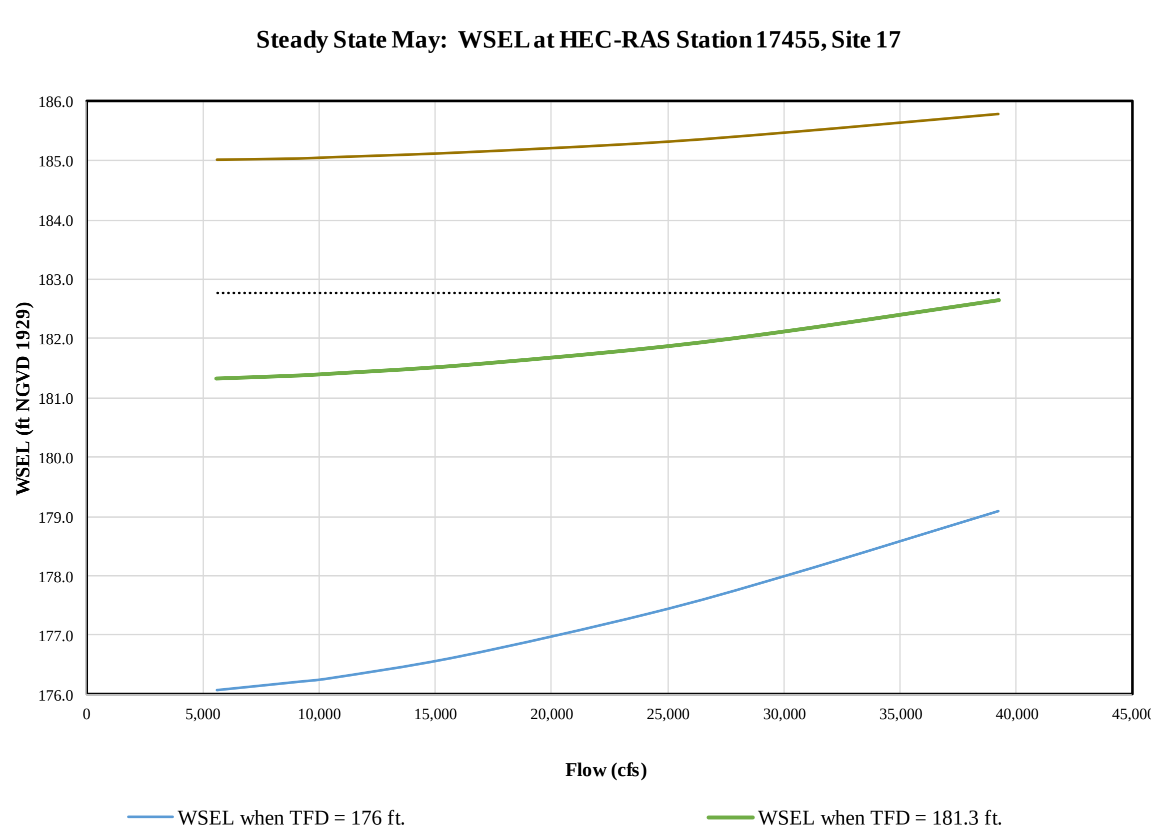
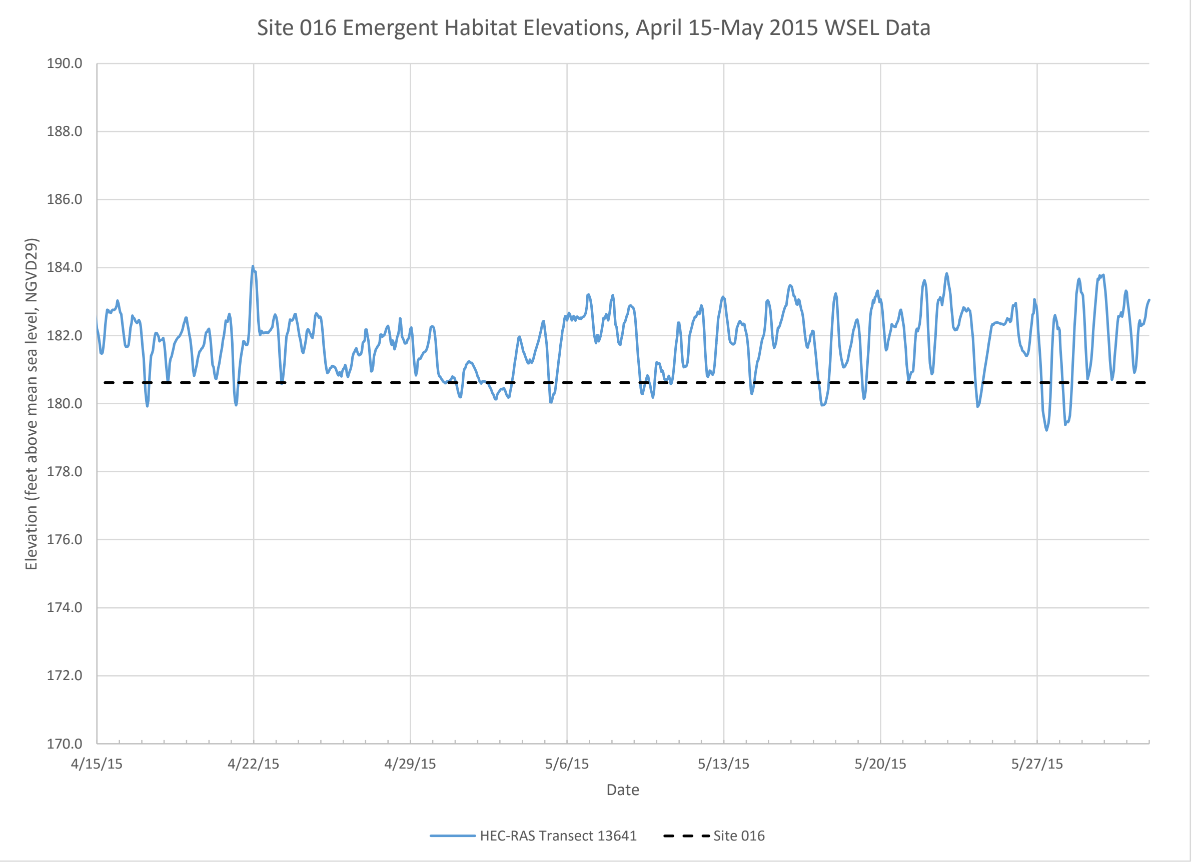
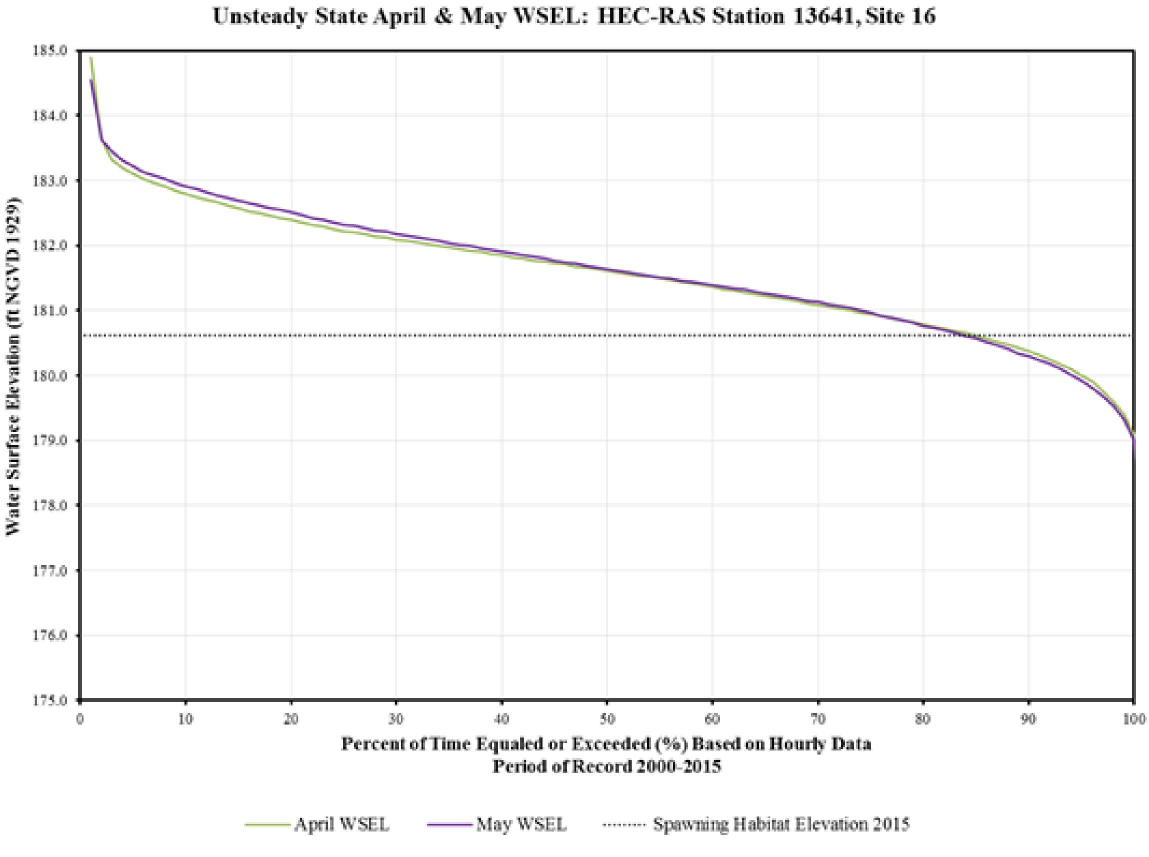


Figure 4.3.2-12: Early Spring Spawn WSEL Analysis at Site 016 (HEC-RAS Transect 13641)





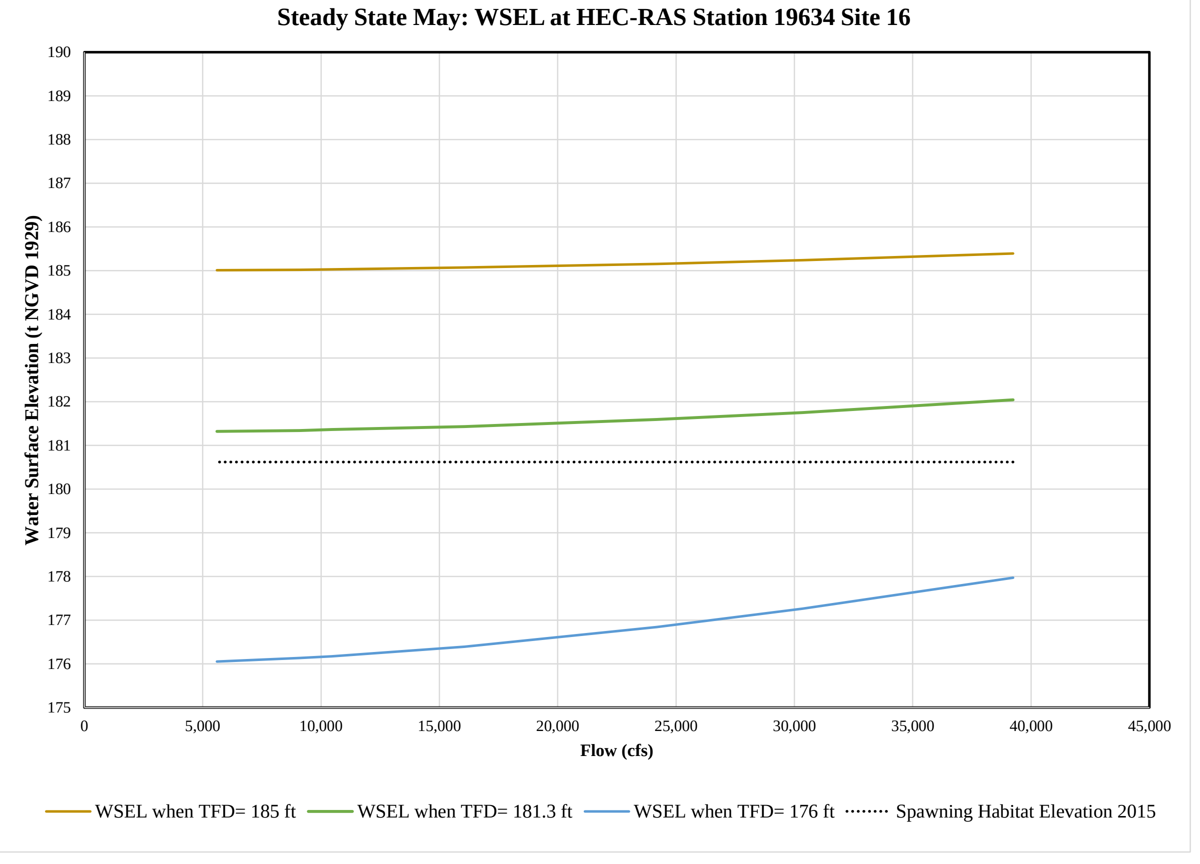
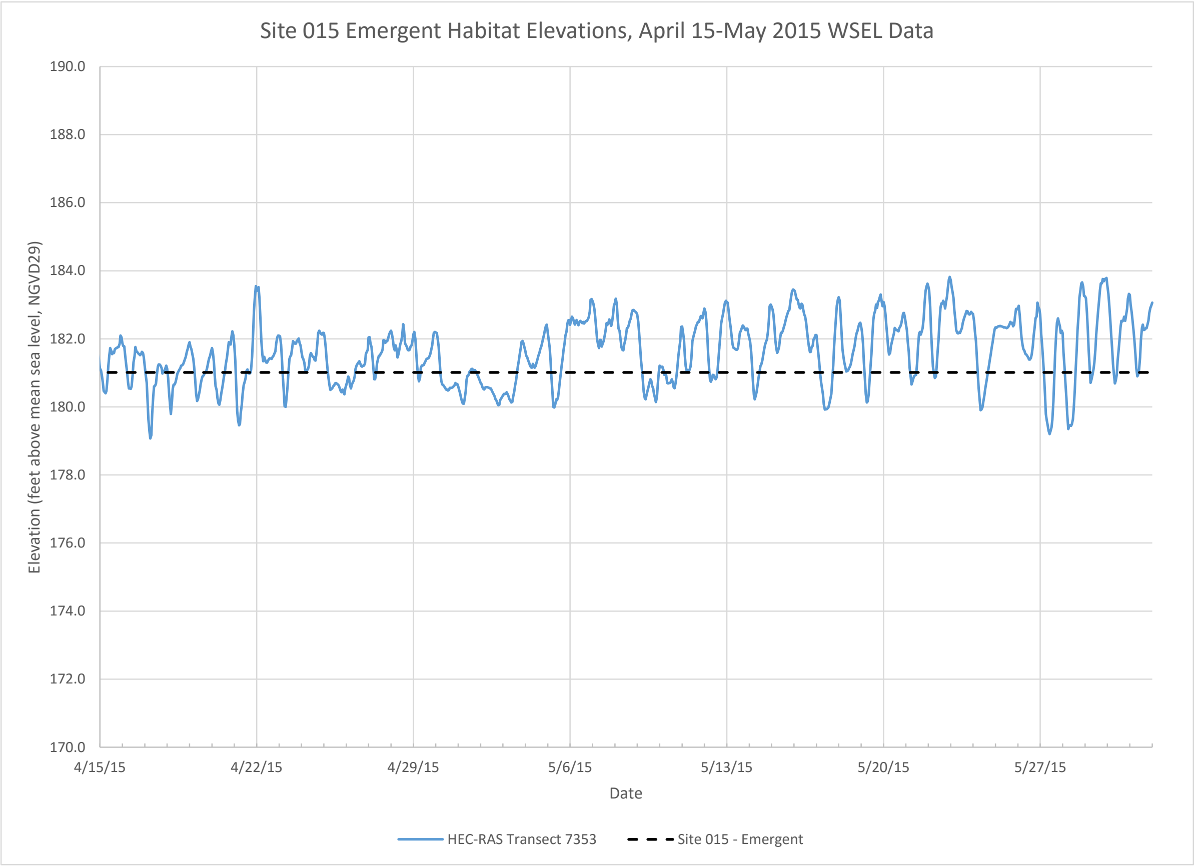
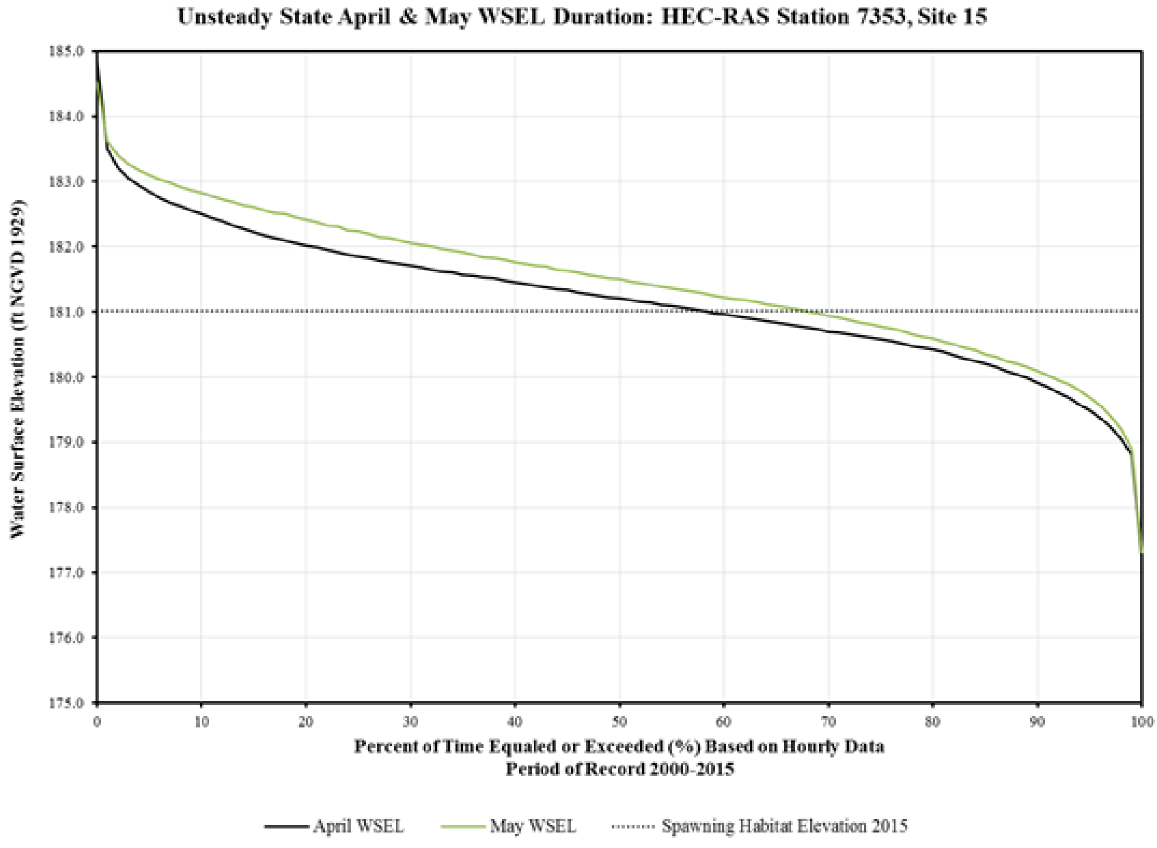


Figure 4.3.2-13: Early Spring Spawn WSEL Analysis at Sites 015 (HEC-RAS Transect 7353)





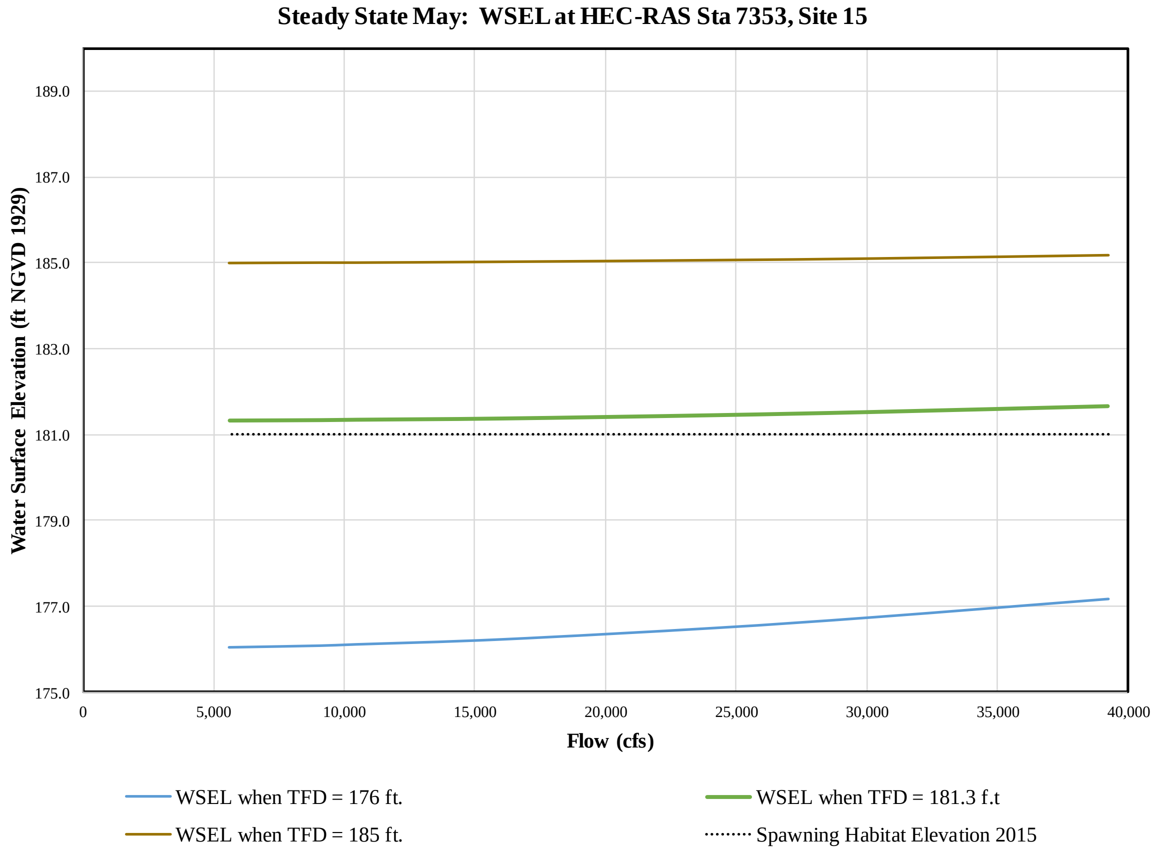


Figure 4.3.2-14: Early Spring Spawn WSEL Analysis at Sites 014 (HEC-RAS Transect 7353)

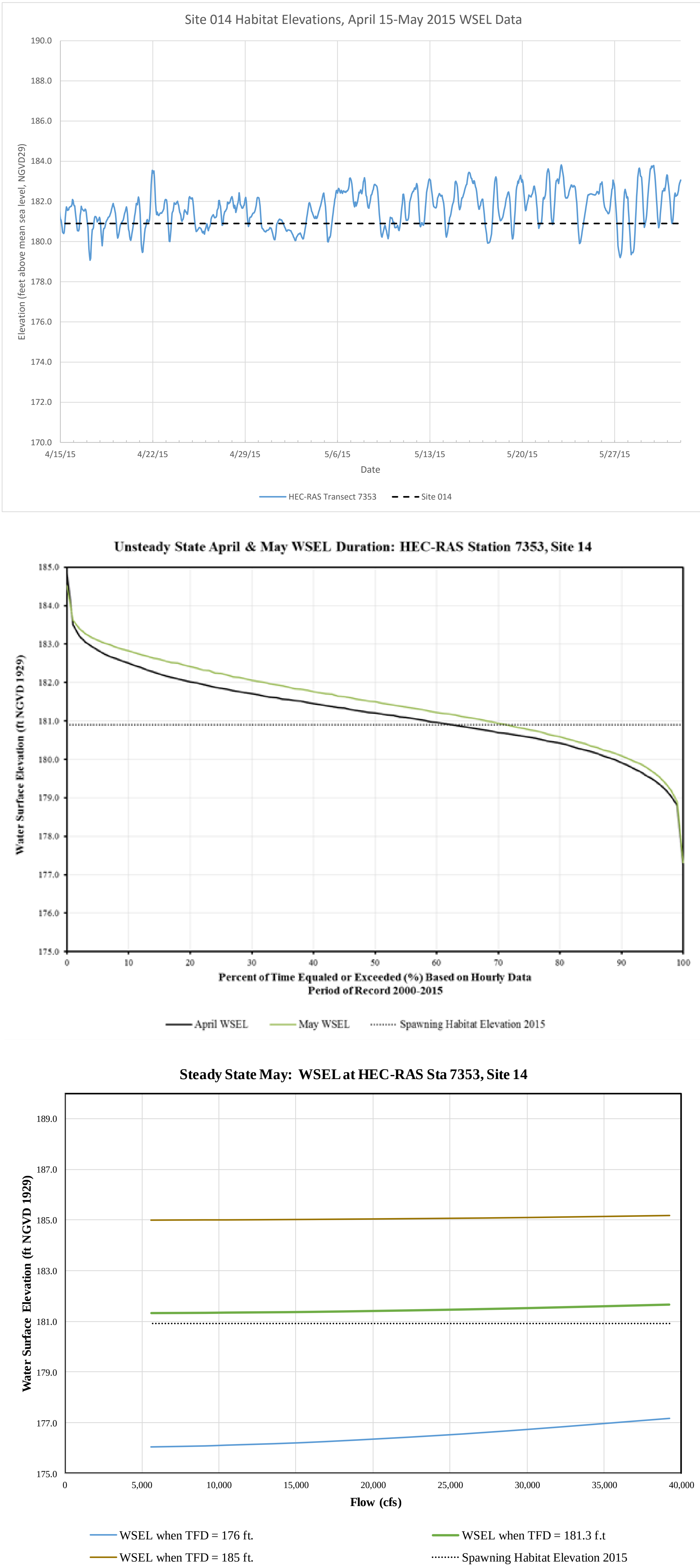
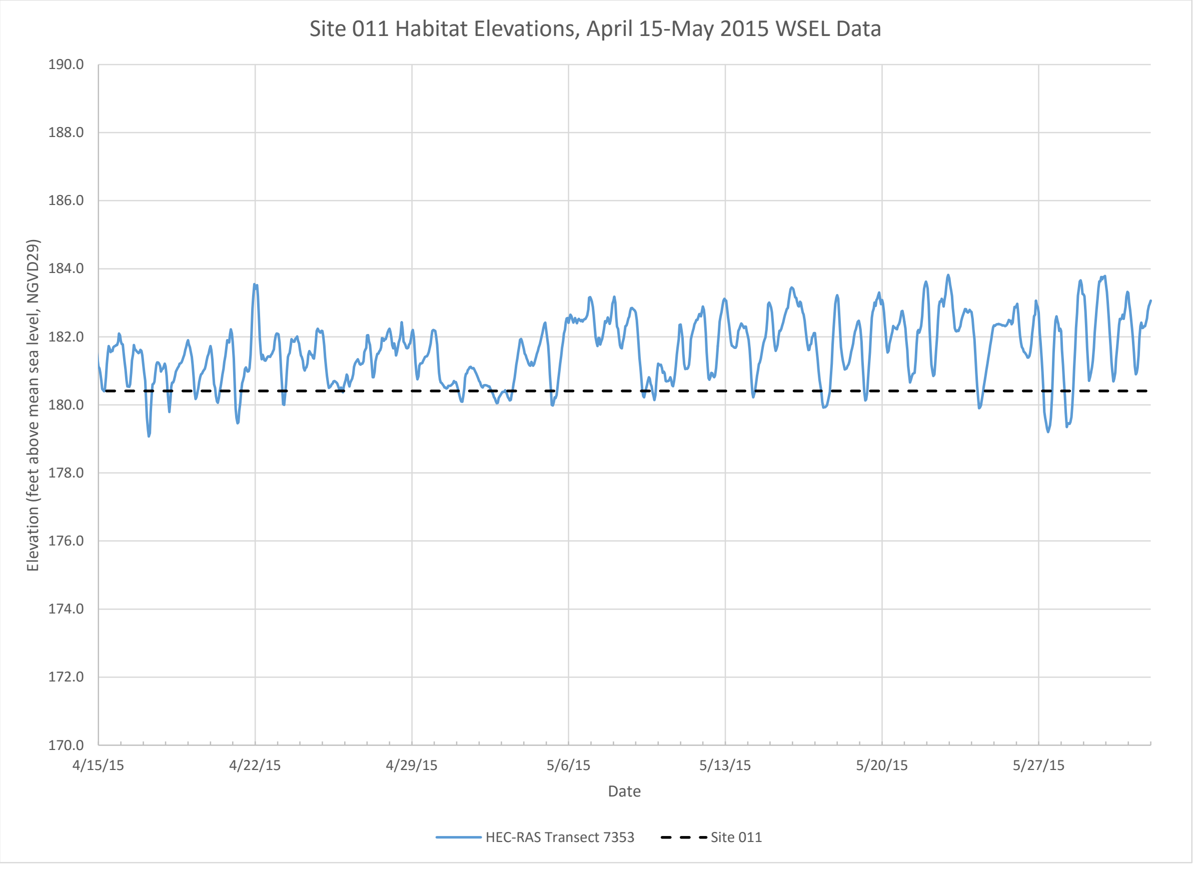
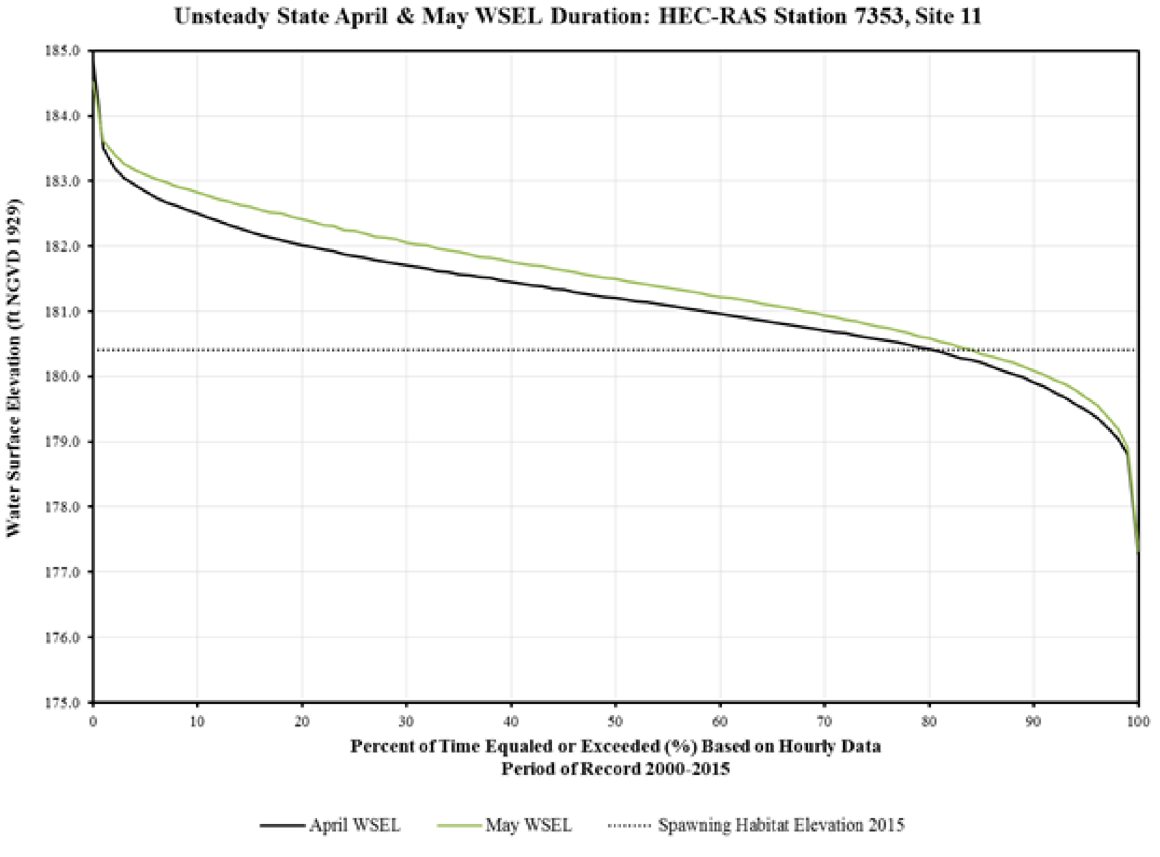


Figure 4.3.2-15: Early Spring Spawn WSEL Analysis at Site 011 (HEC-RAS Transect 7353)





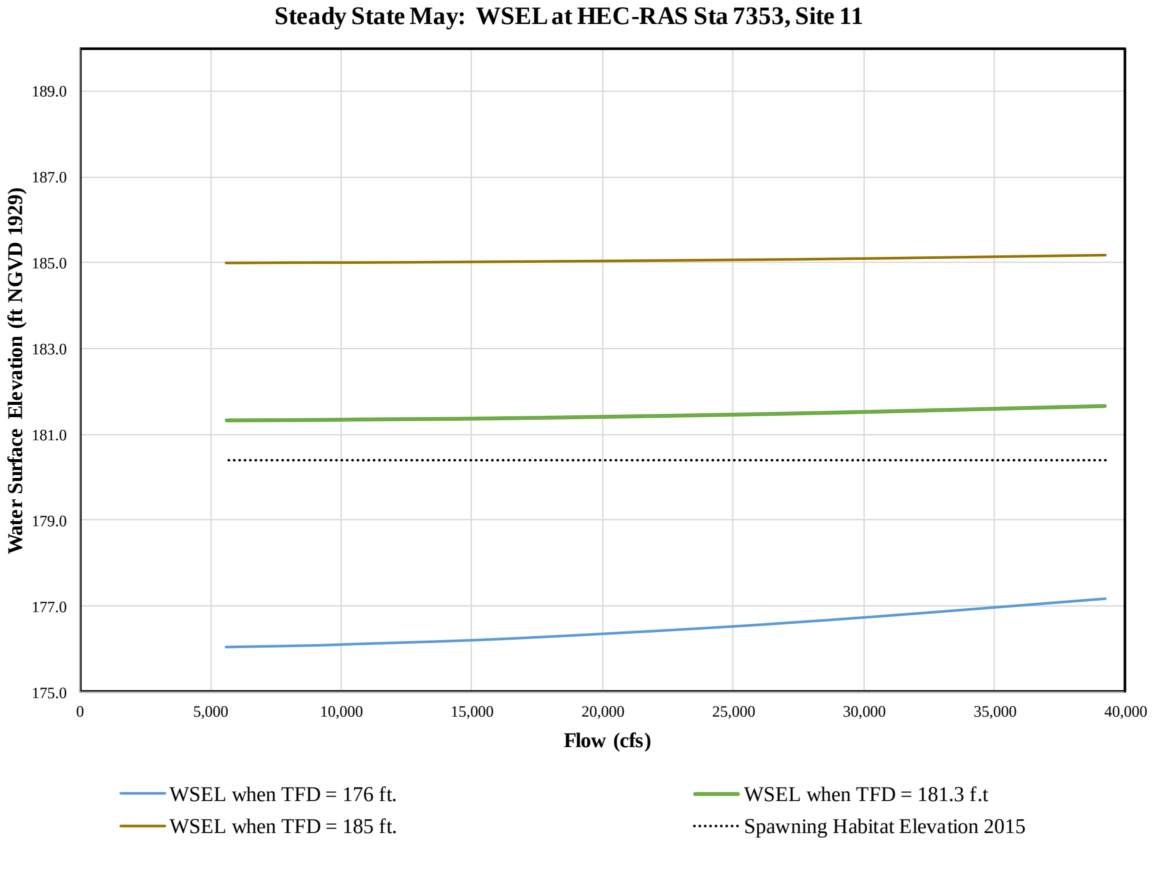


Figure 4.3.2-16: Early Spring Spawn WSEL Analysis at Sites 013 (HEC-RAS Transect 7353)

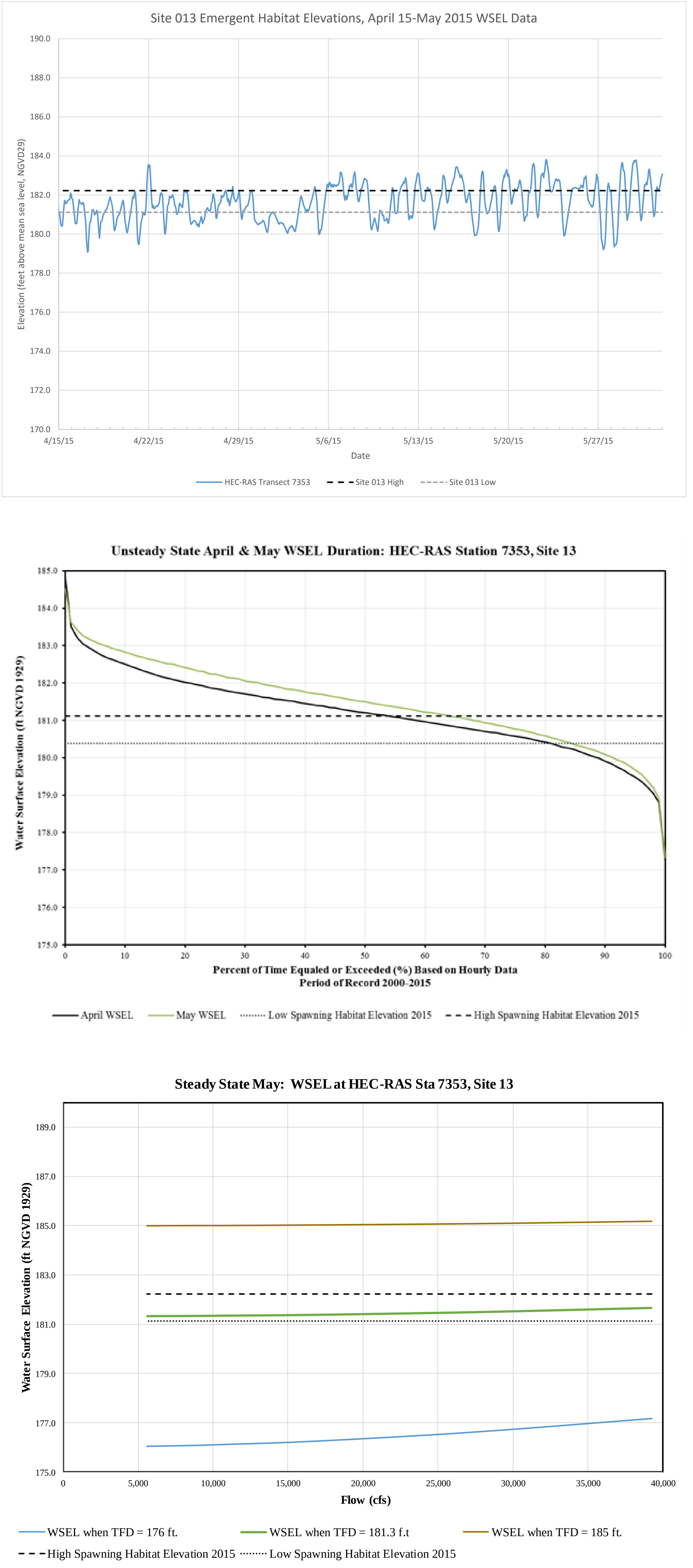


Figure 4.3.2-17: Early Spring Spawn WSEL Analysis at Site 012 (HEC-RAS Transect 7353)

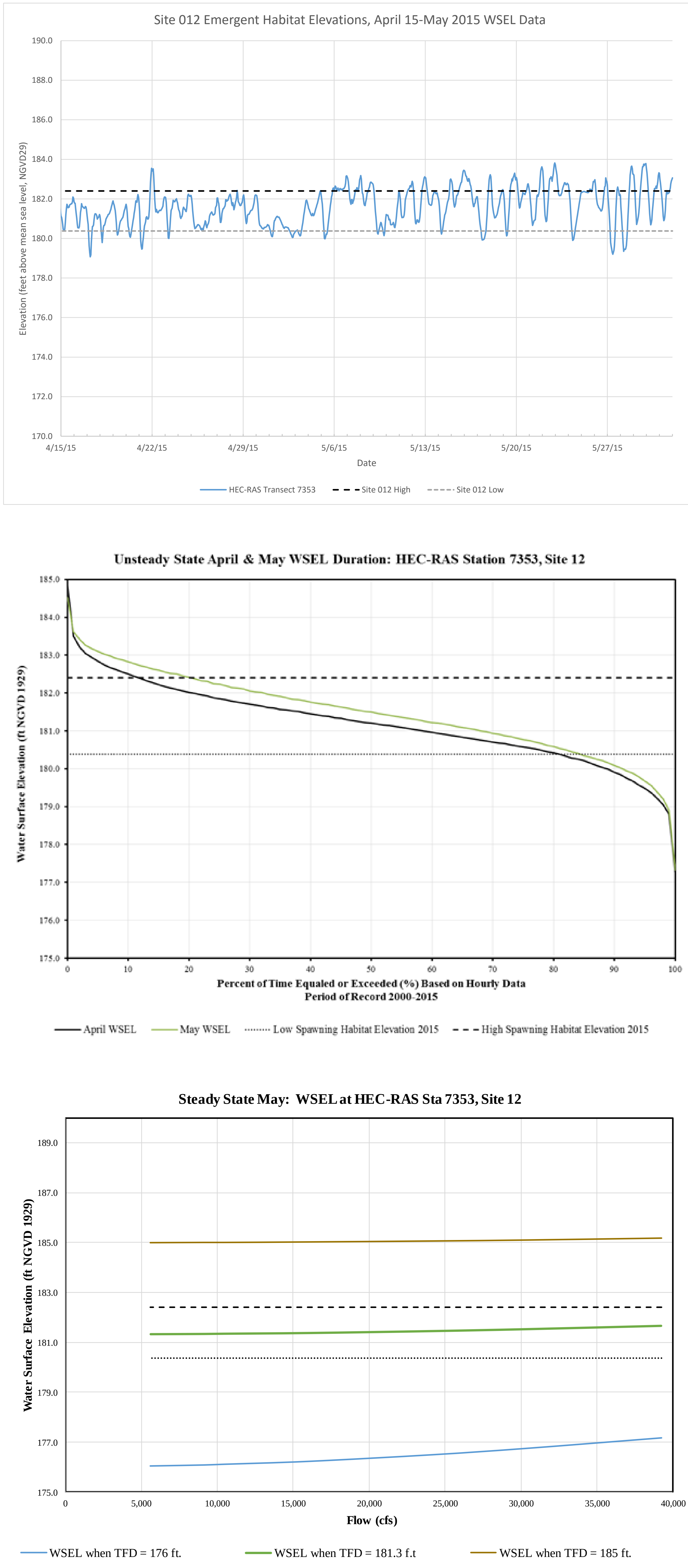


Figure 4.3.3-1: Distribution of Observed Nest Depths in the Barton Cove-Lower TFI Reach During 2015 Survey

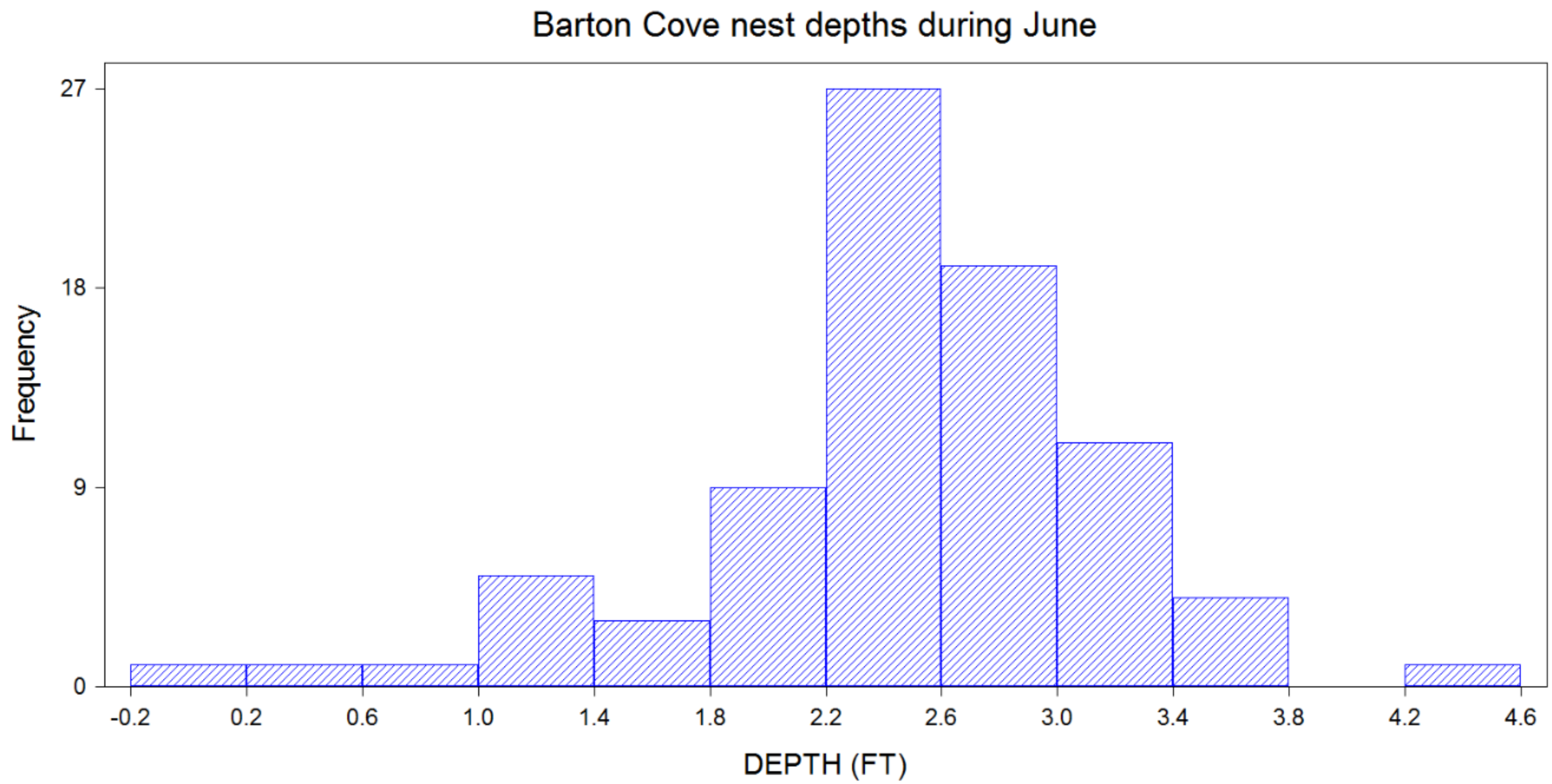
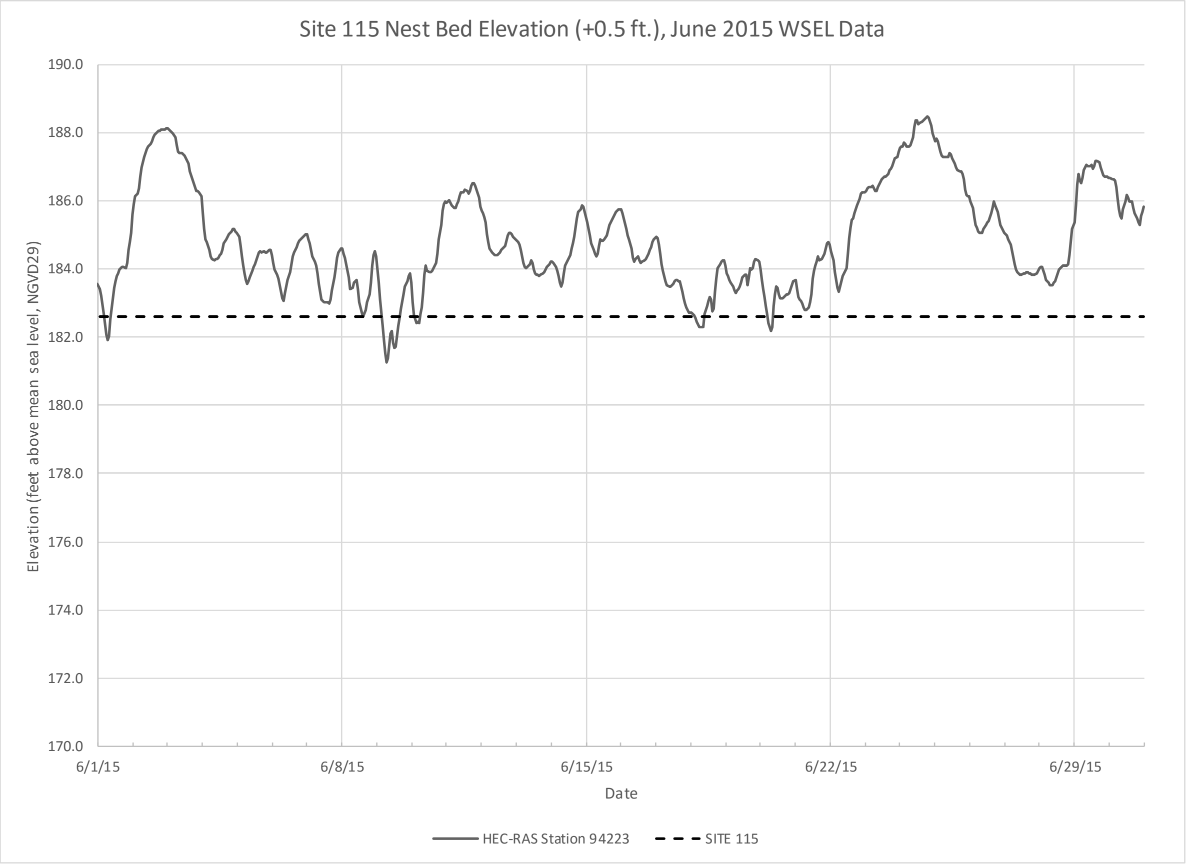
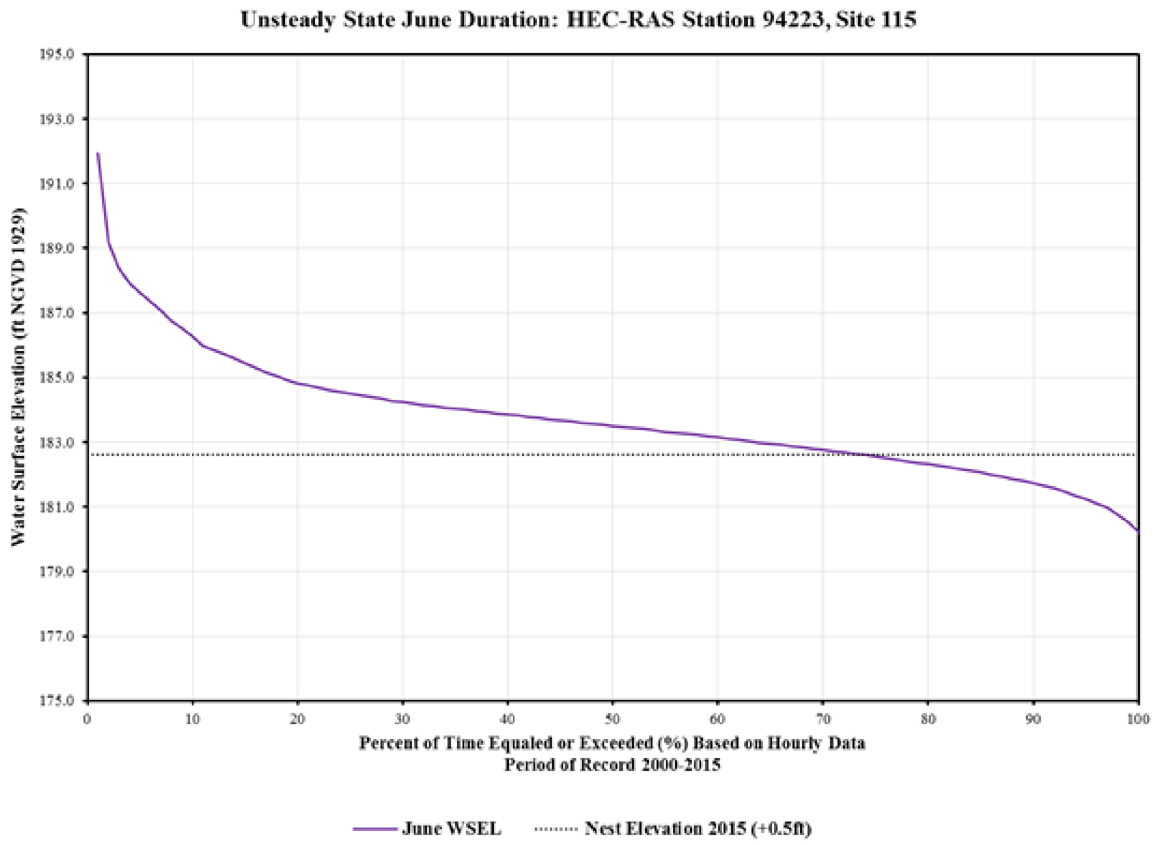


Figure 4.3.4-1: Late Spring Spawn WSEL Analysis at Site 115 (HEC-RAS Transect 94223)





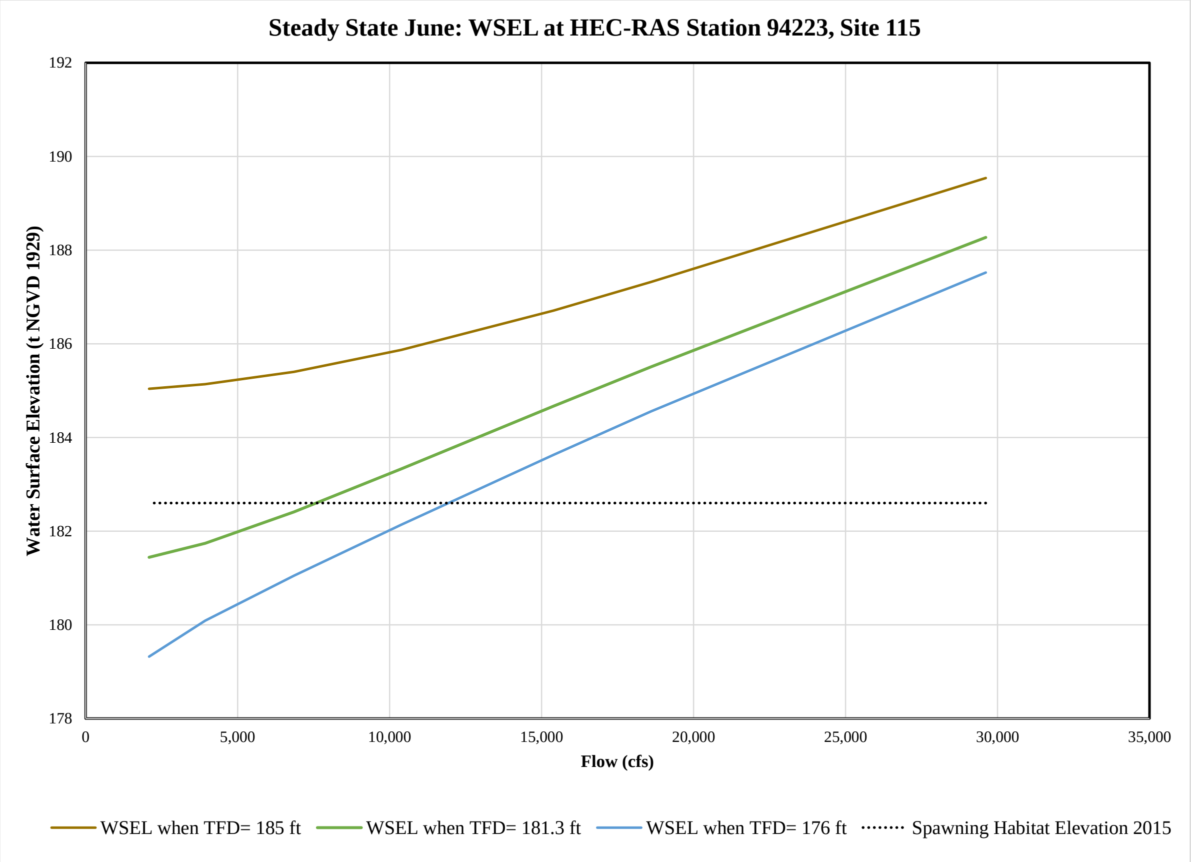
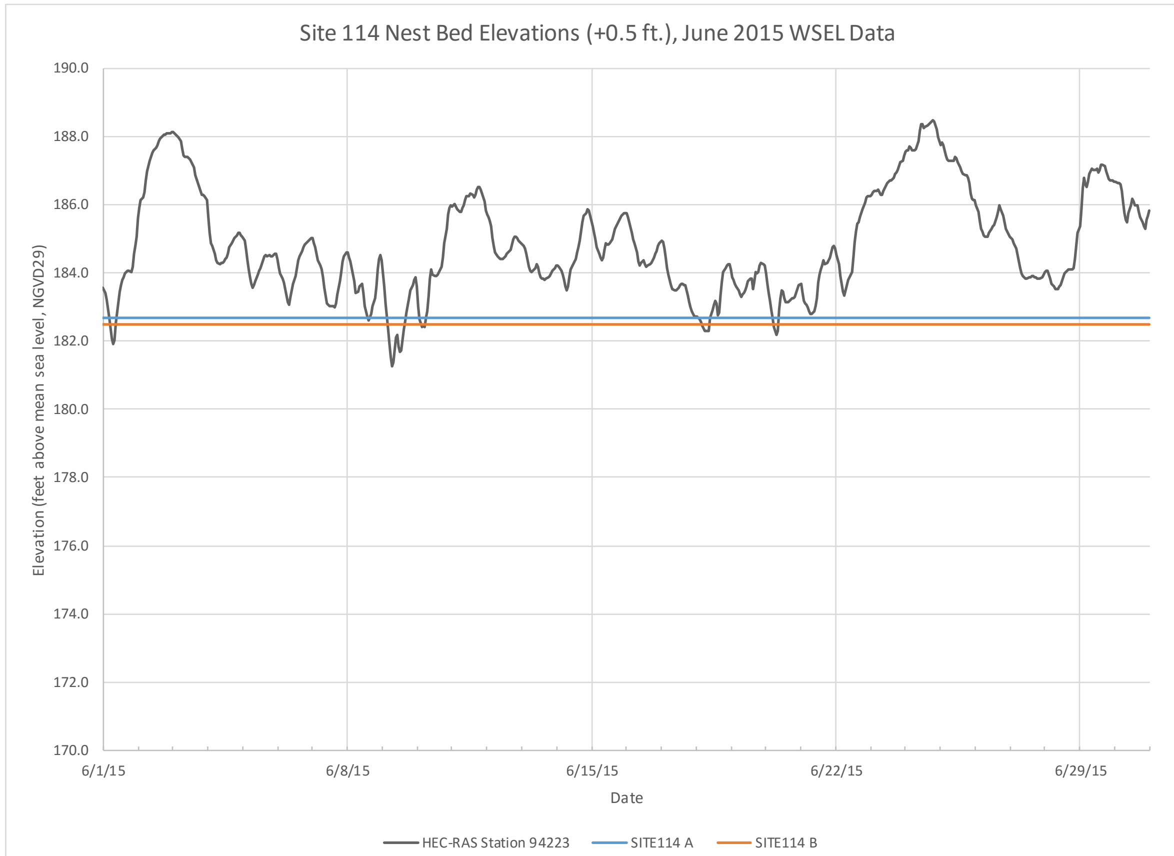
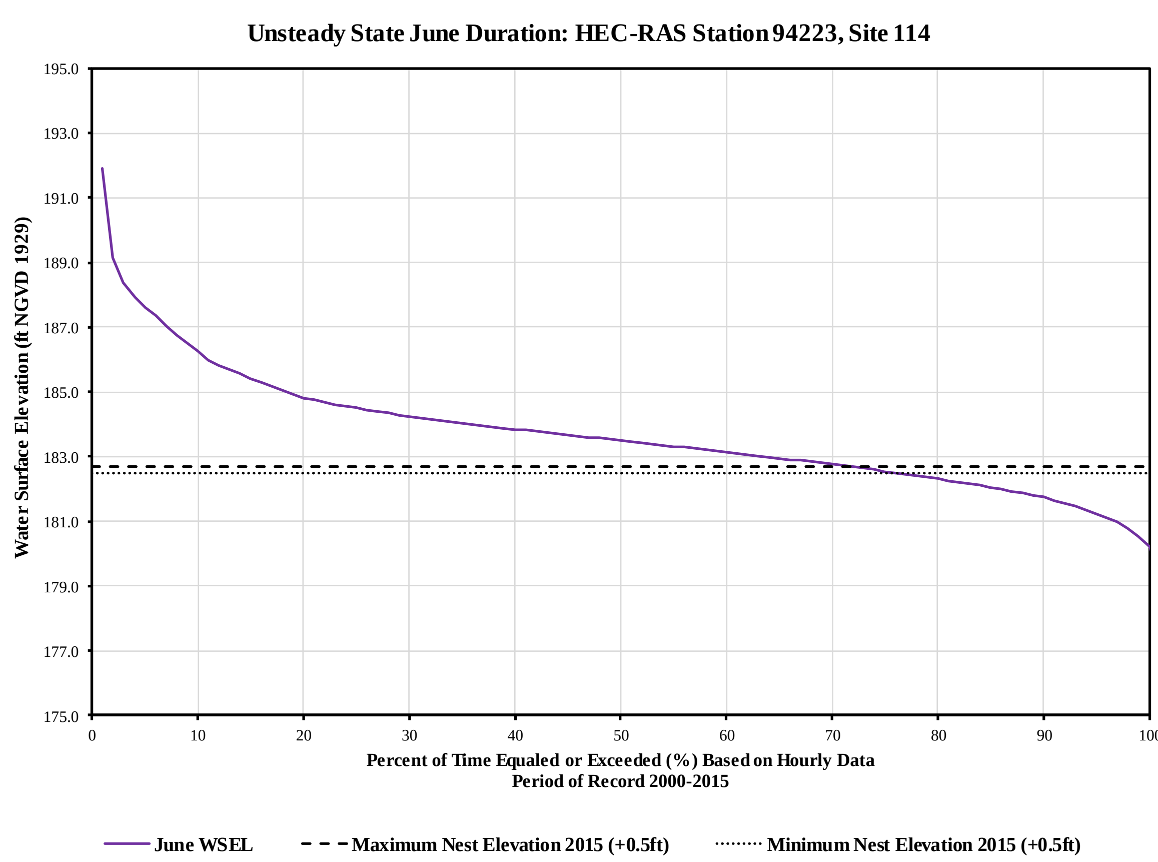


Figure 4.3.4-2: Late Spring Spawn WSEL Analysis at Site 114 (HEC-RAS Transect 94223)





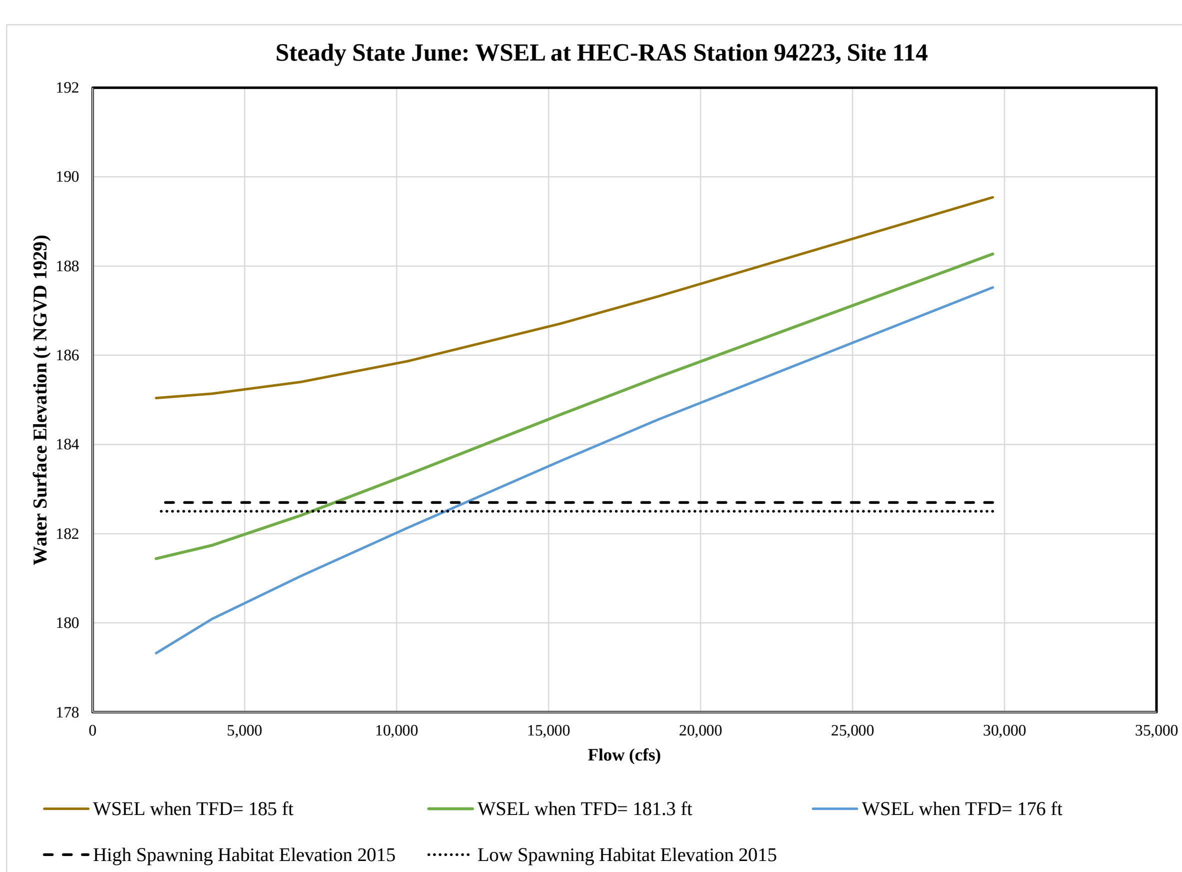
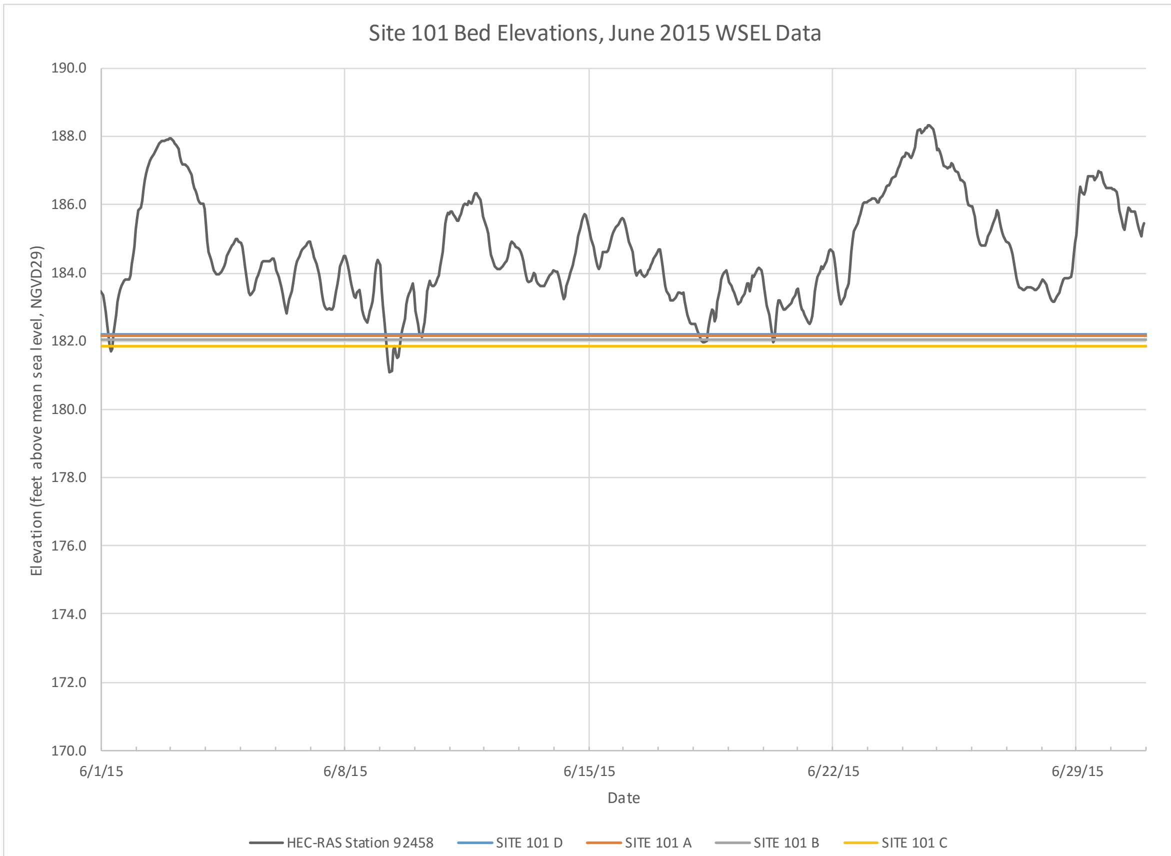
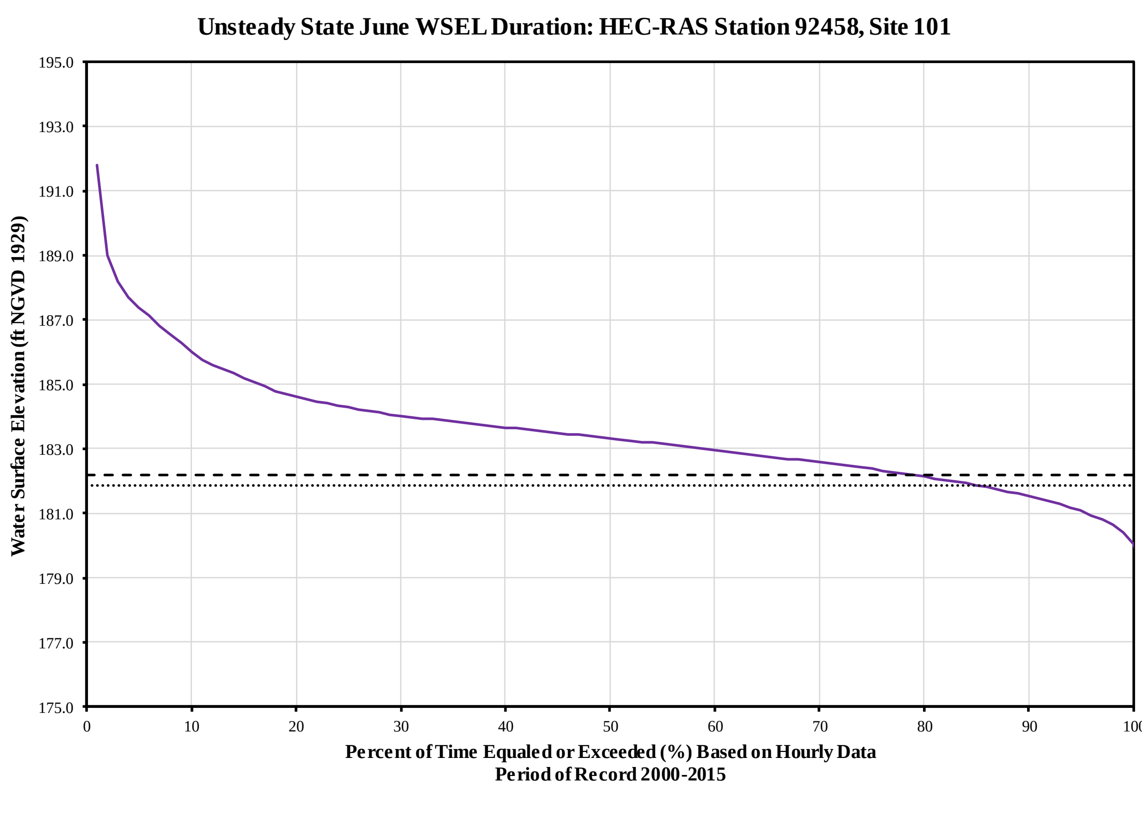


Figure 4.3.4-3: Late Spring Spawn WSEL Analysis at Site 101 (HEC-RAS Transect 92458)





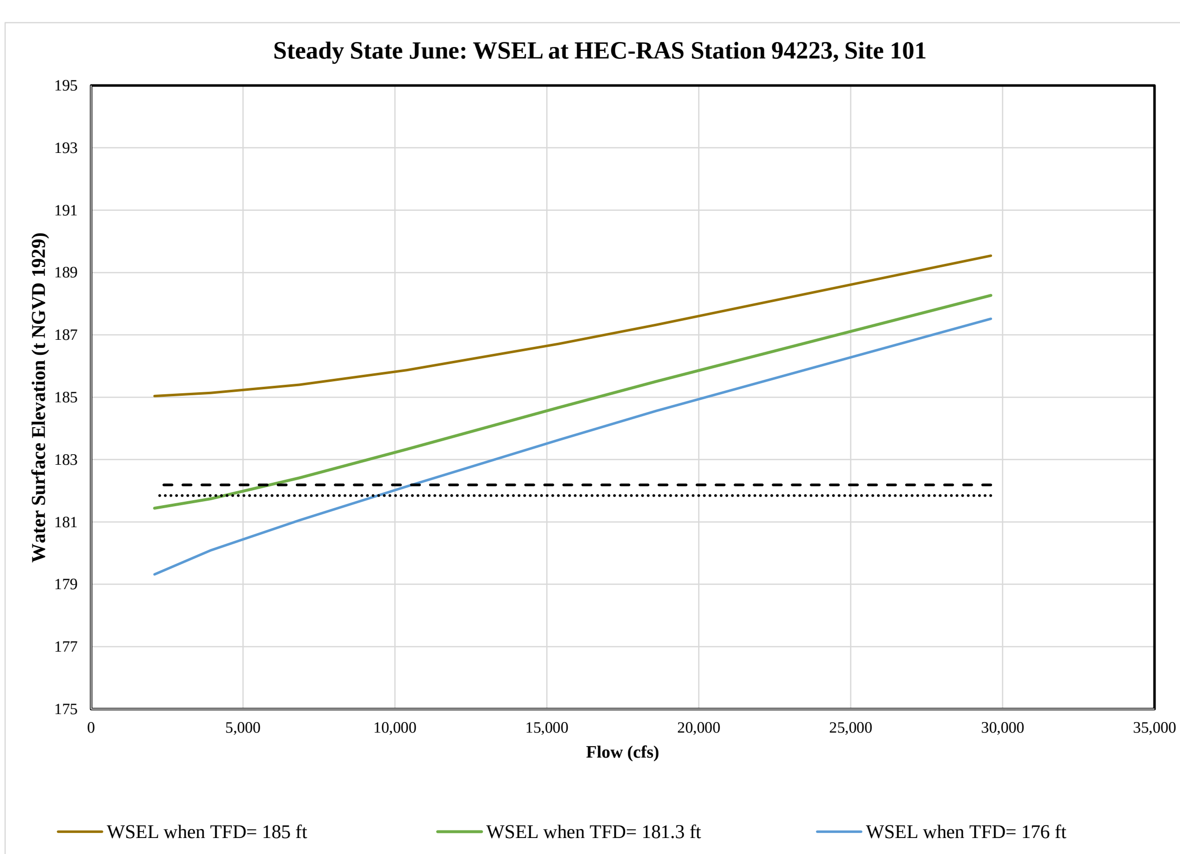
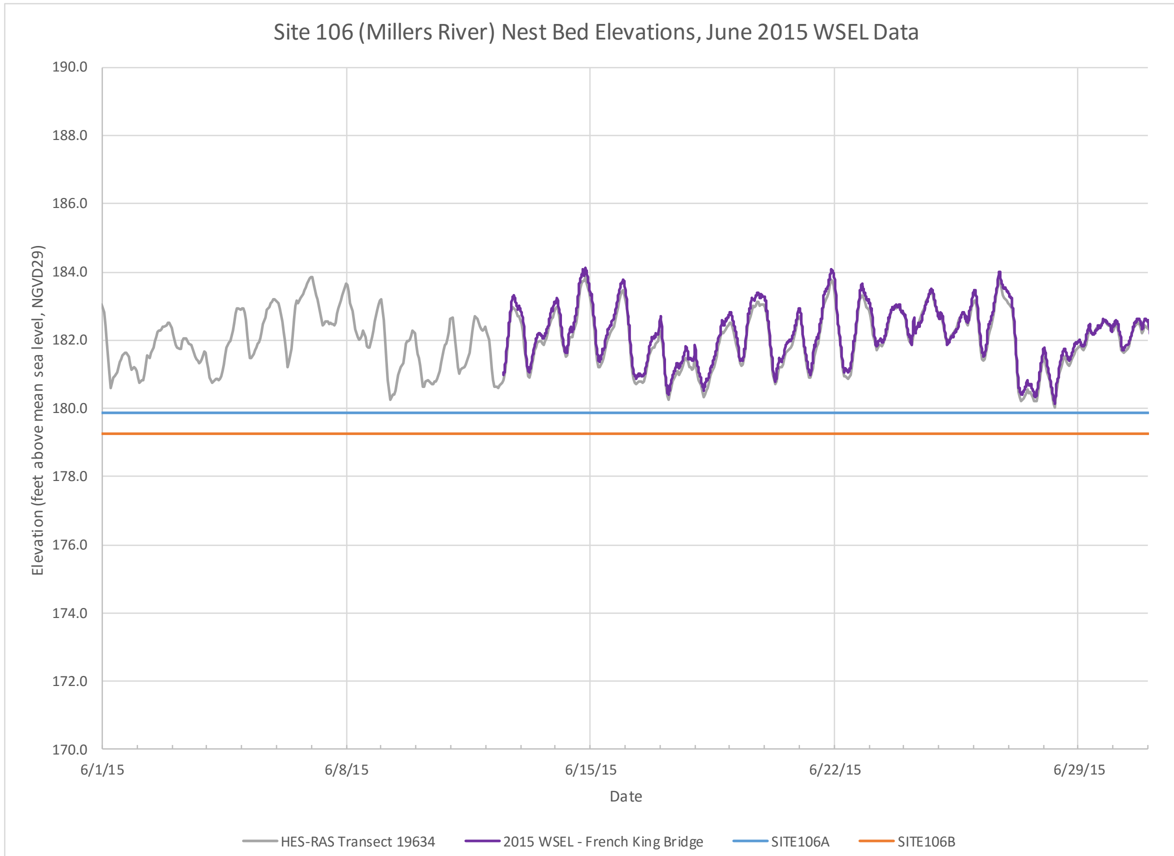
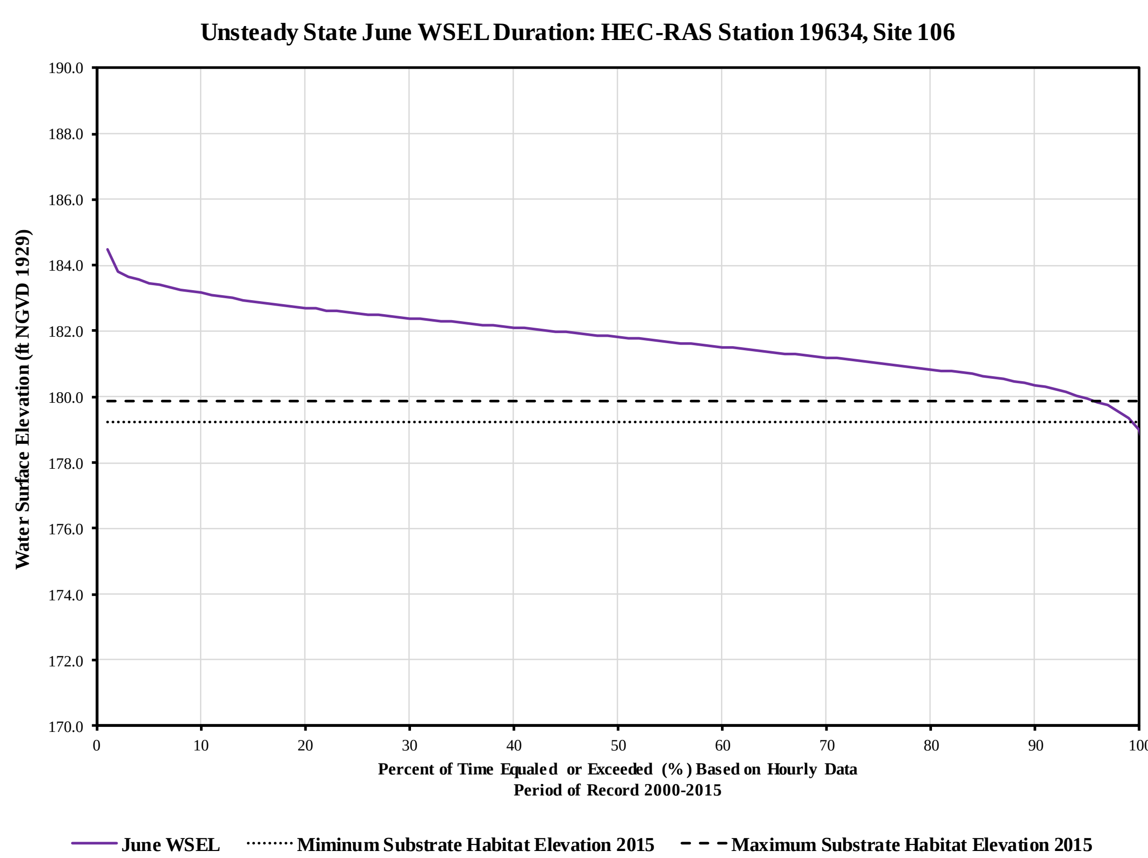


Figure 4.3.4-4: Late Spring Spawn WSEL Analysis at Site 106 (HEC-RAS Transect 19634)





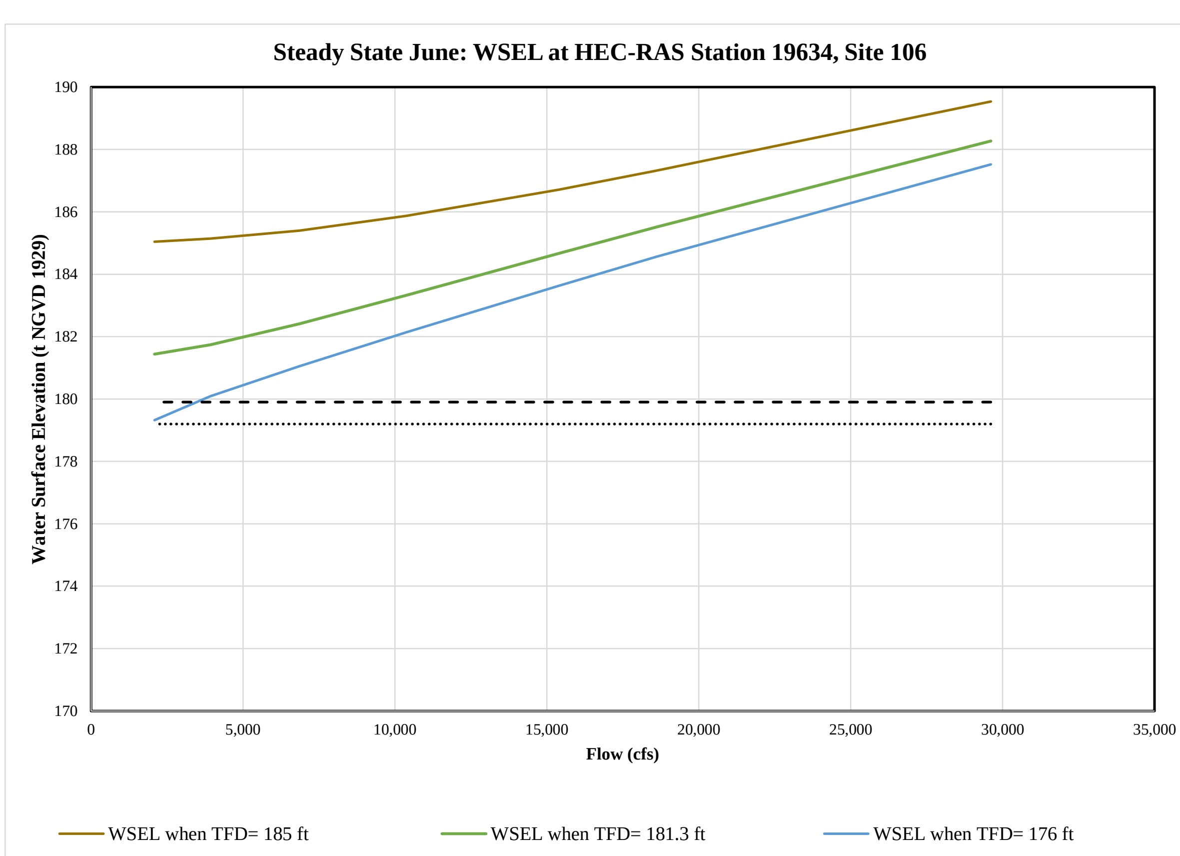
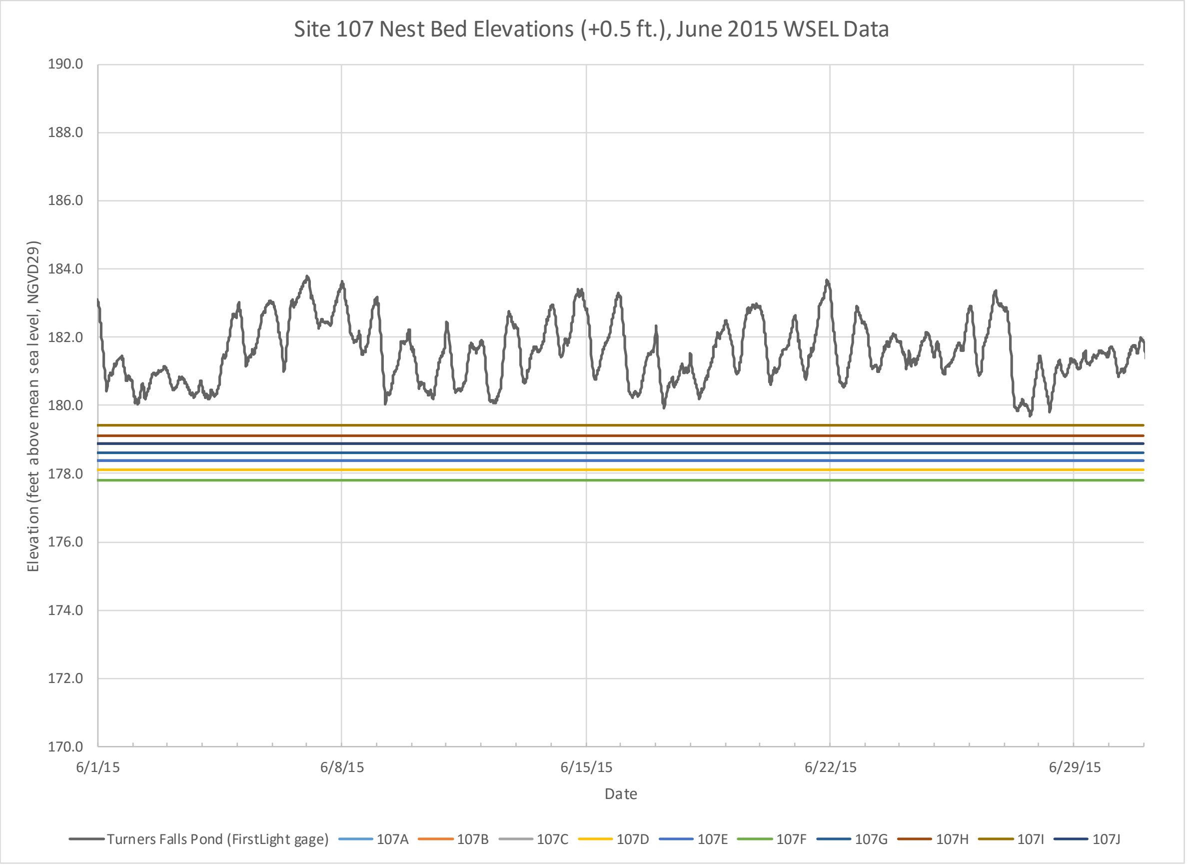
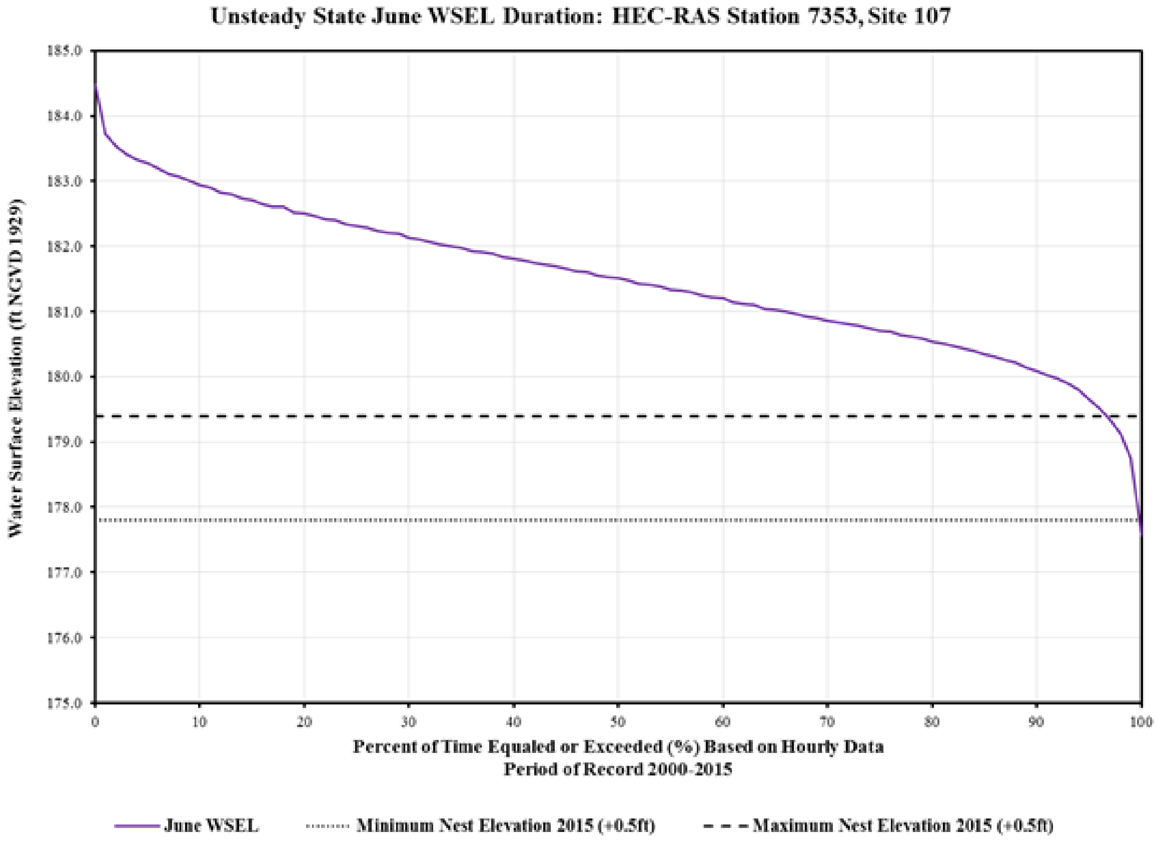


Figure 4.3.4-5: Late Spring Spawn WSEL Analysis at Site 107 (HEC-RAS Transect 7353)





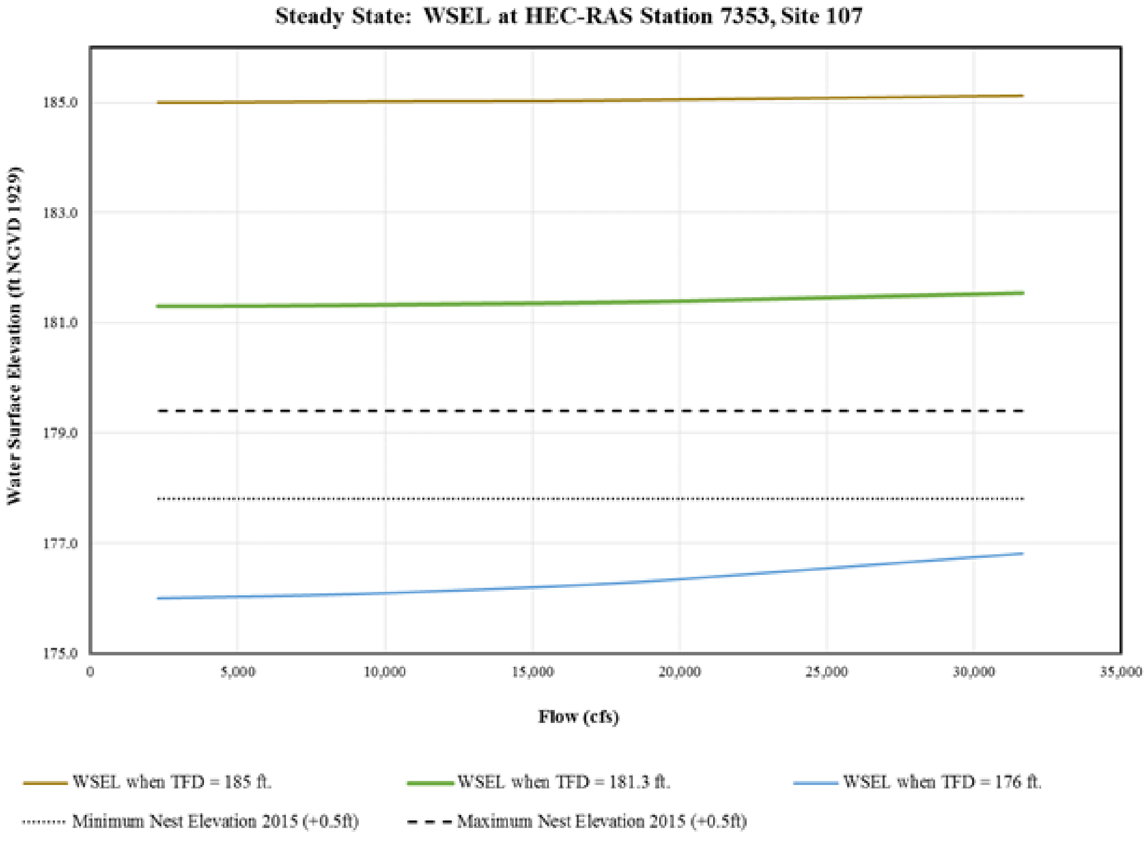
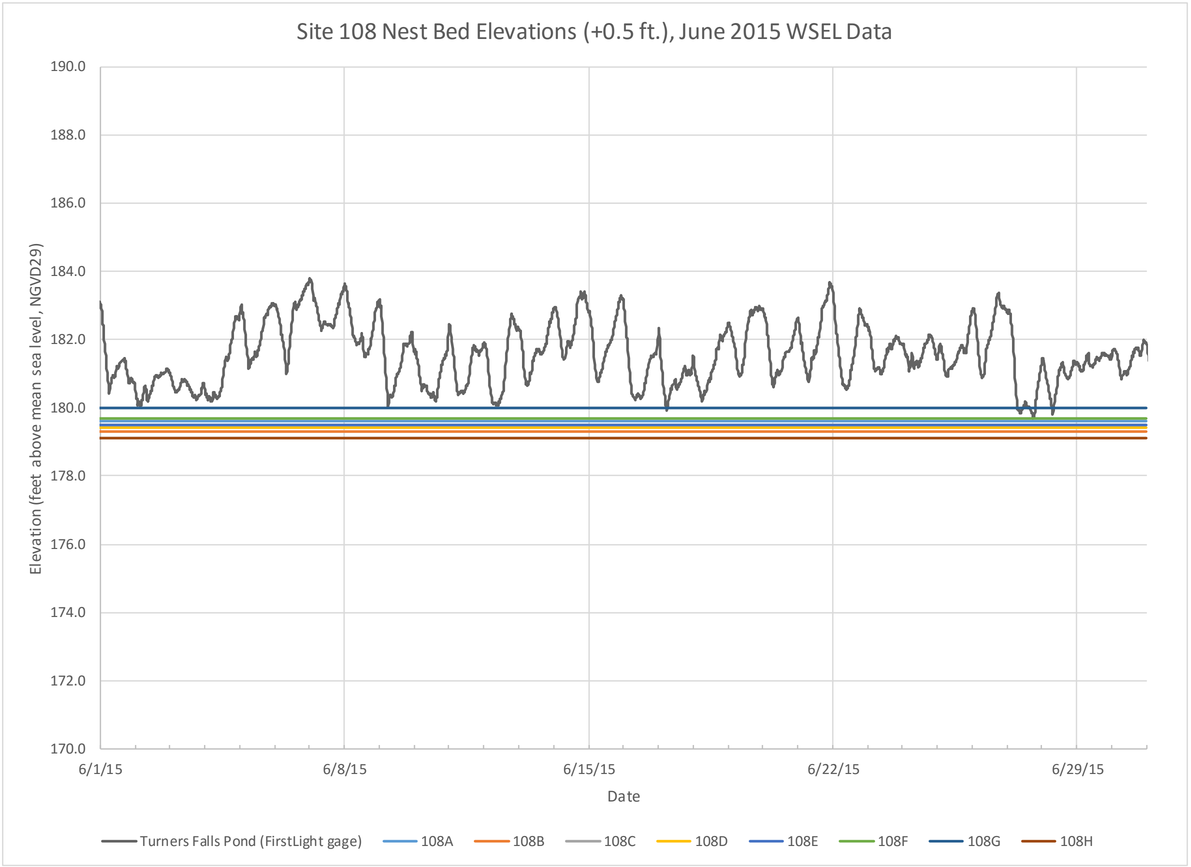
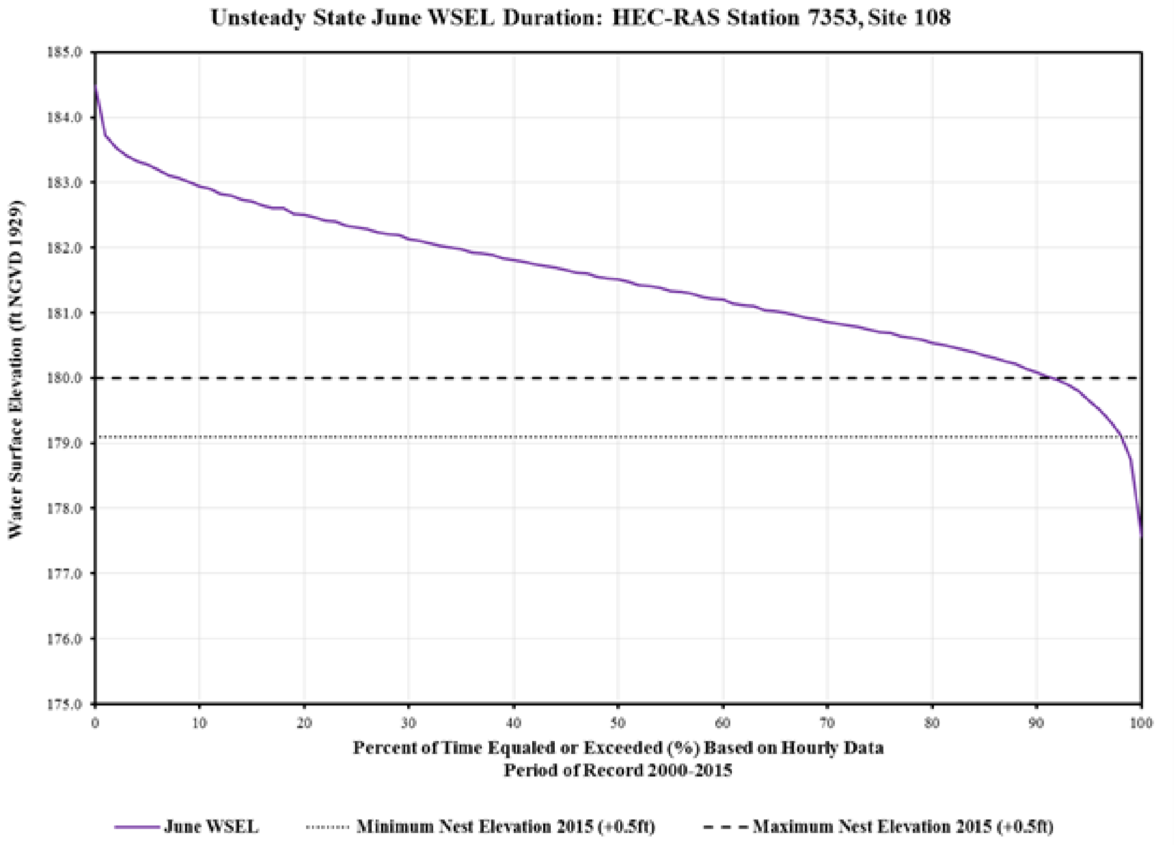


Figure 4.3.4-6: Late Spring Spawn WSEL Analysis at Site 108 (HEC-RAS Transect 7353)





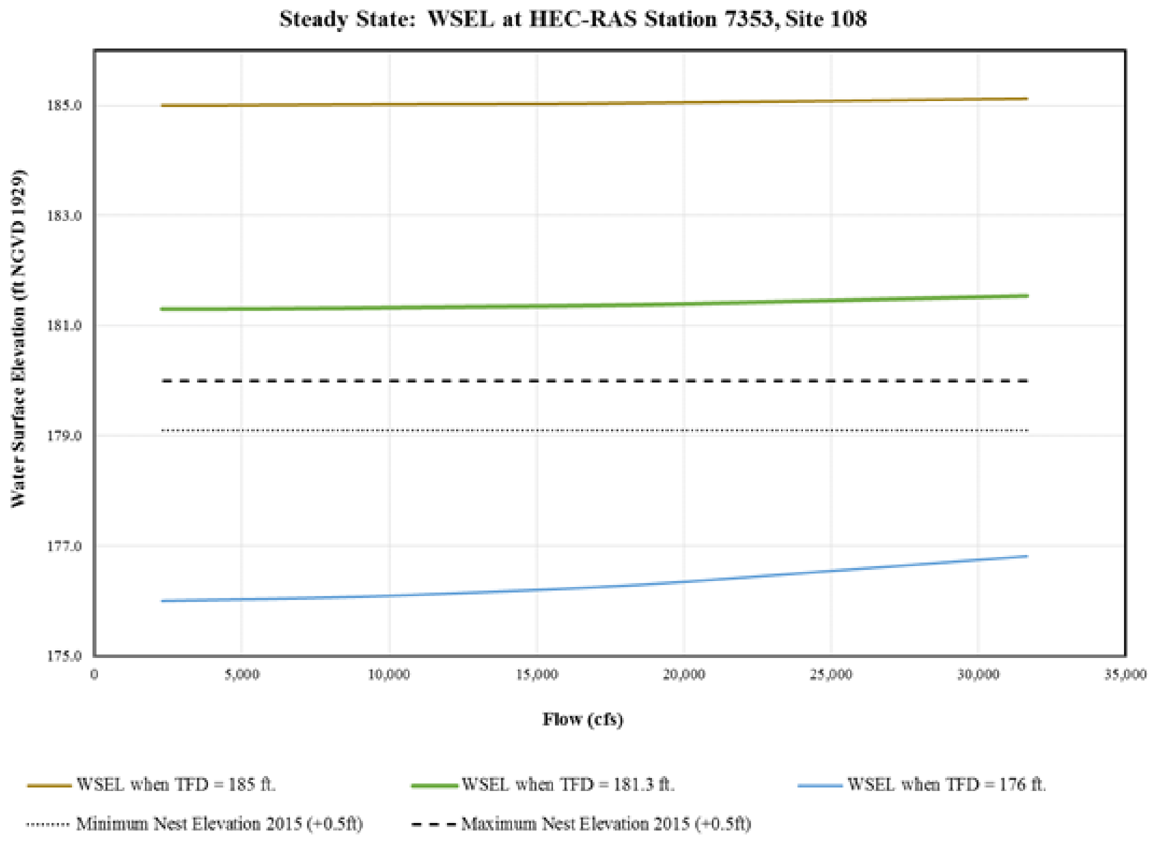
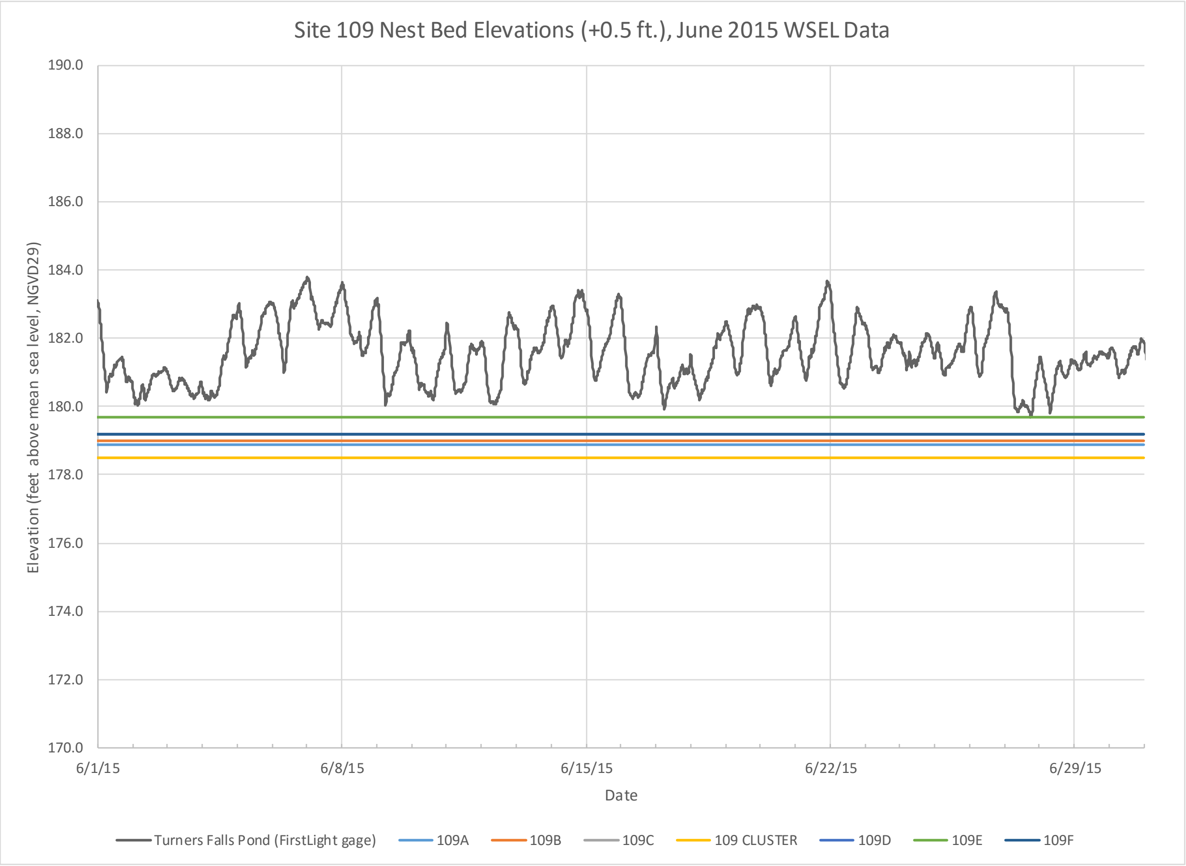
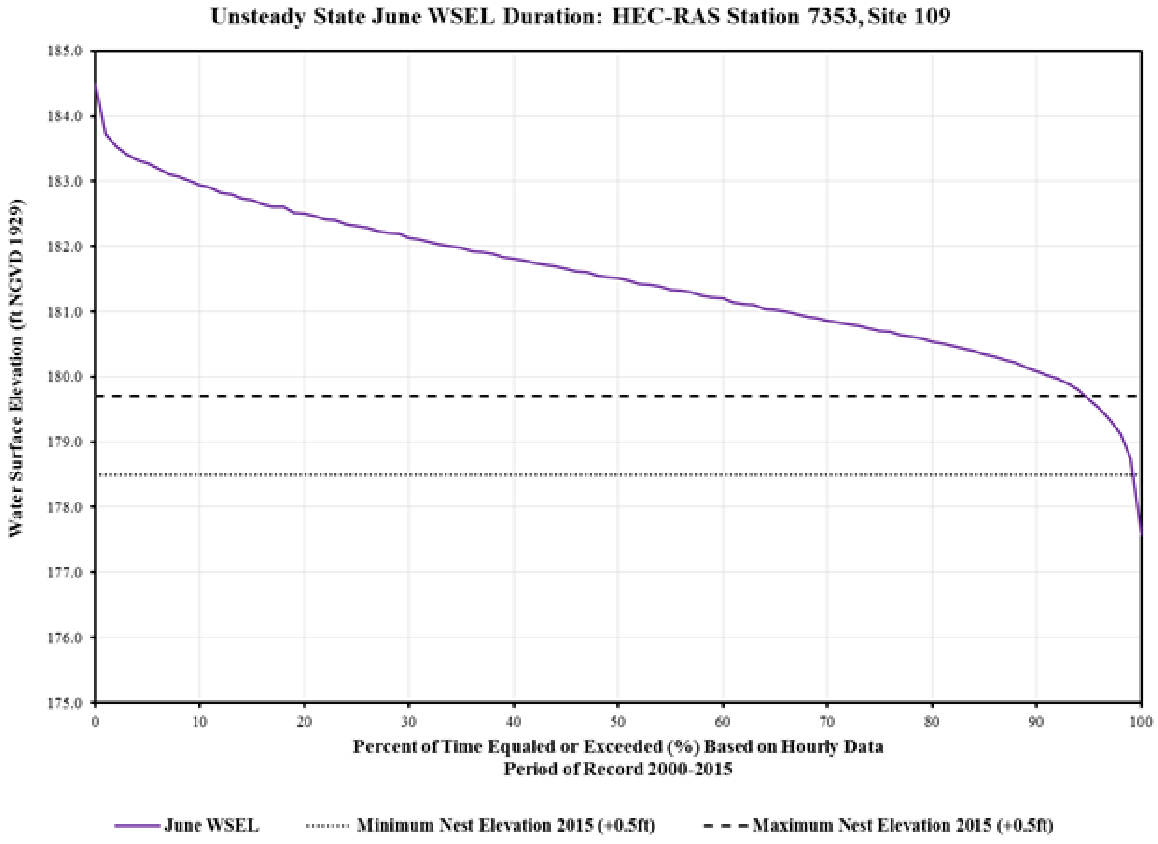


Figure 4.3.4-7: Late Spring Spawn WSEL Analysis at Site 109 (HEC-RAS Transect 7353)





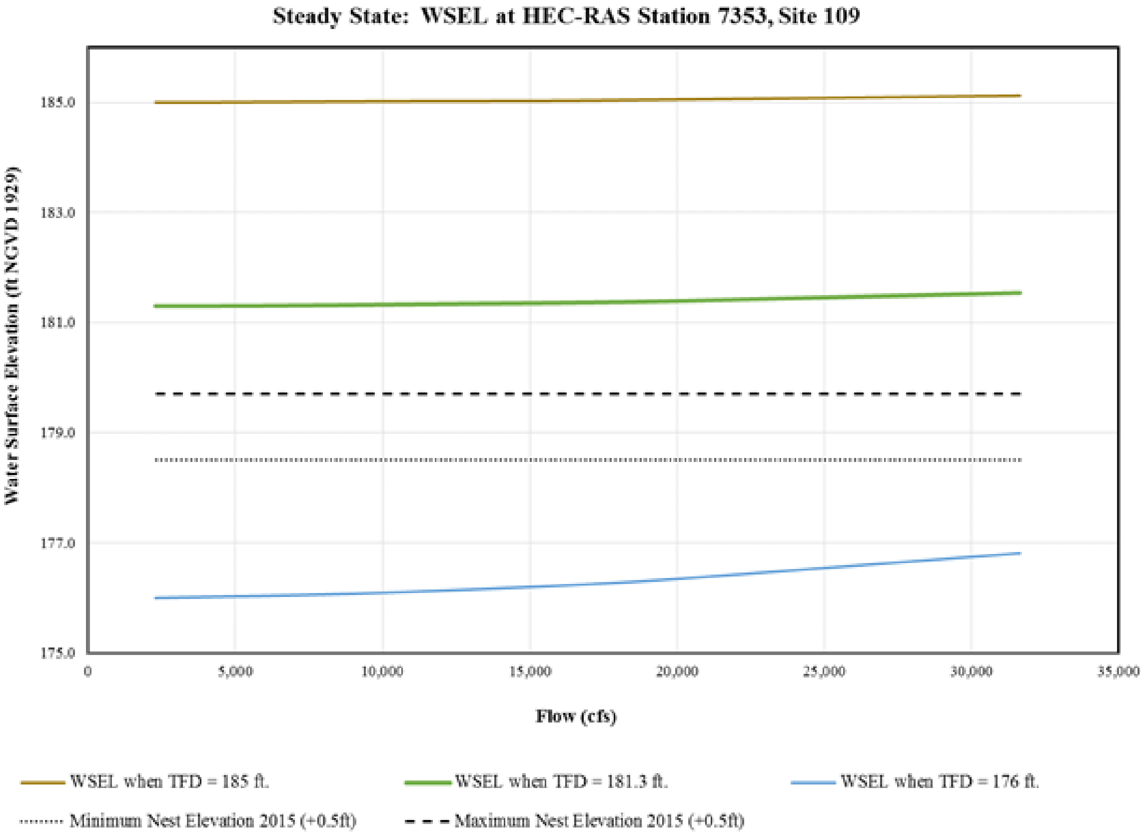
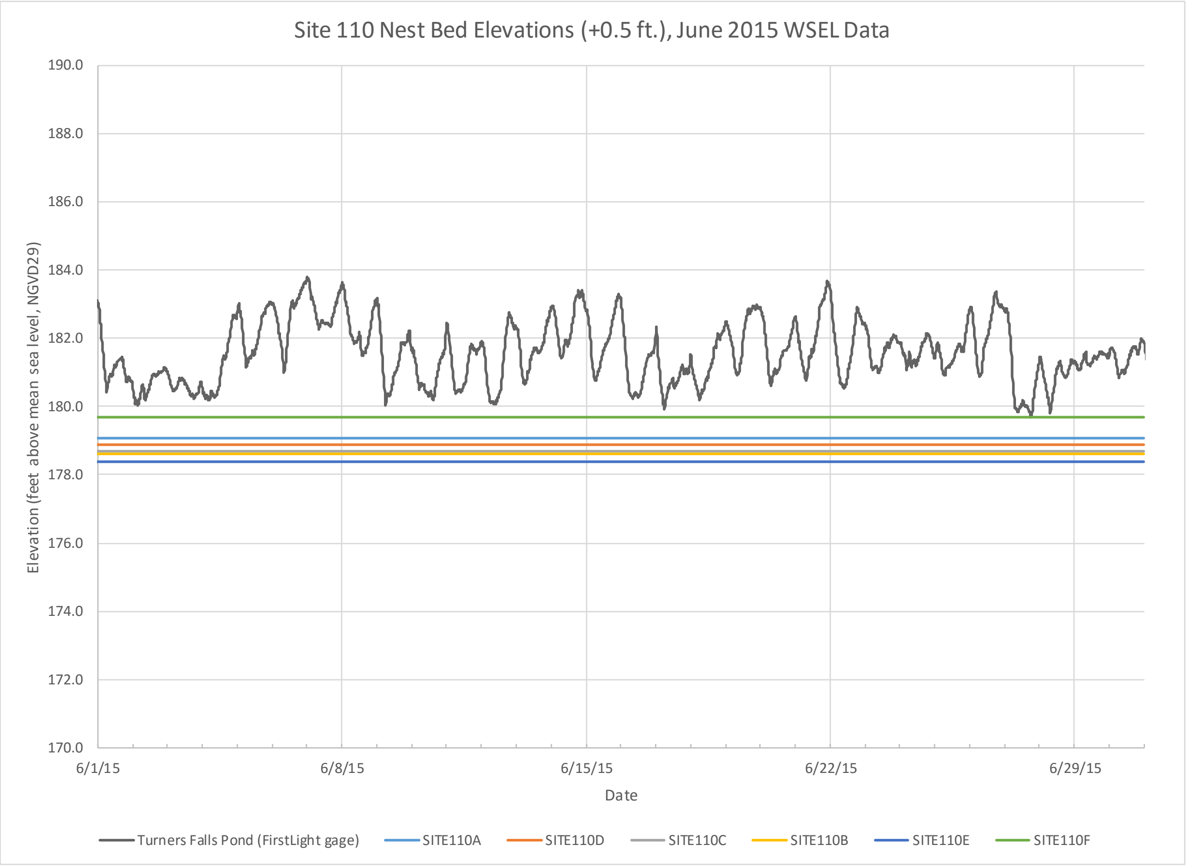
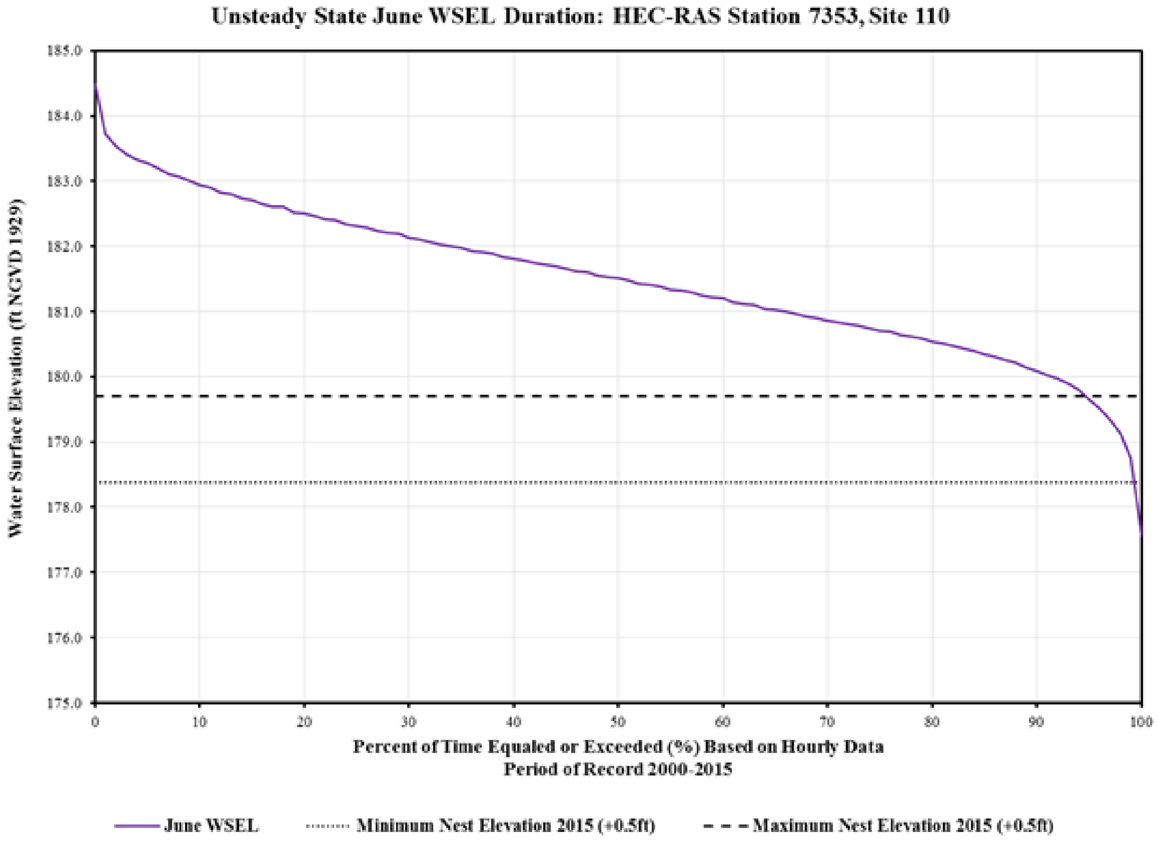


Figure 4.3.4-8: Late Spring Spawn WSEL Analysis at Site 110 (HEC-RAS Transect 7353)





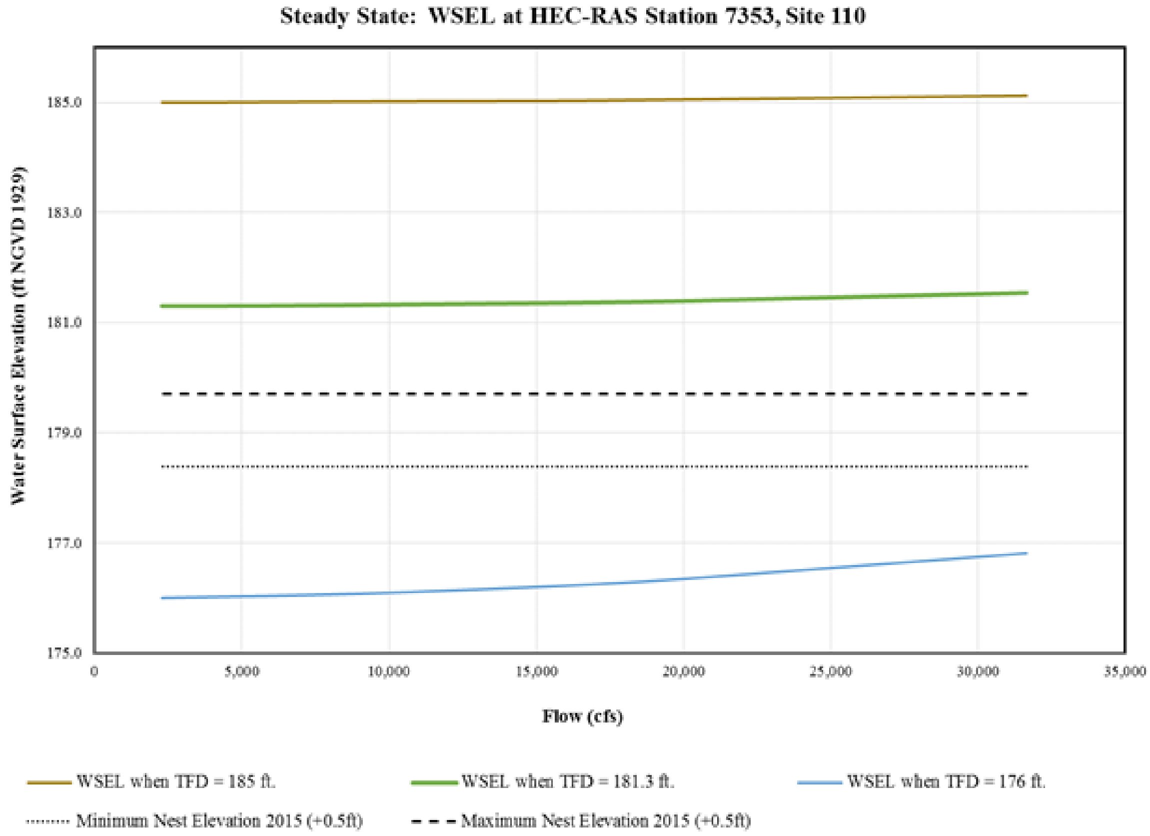
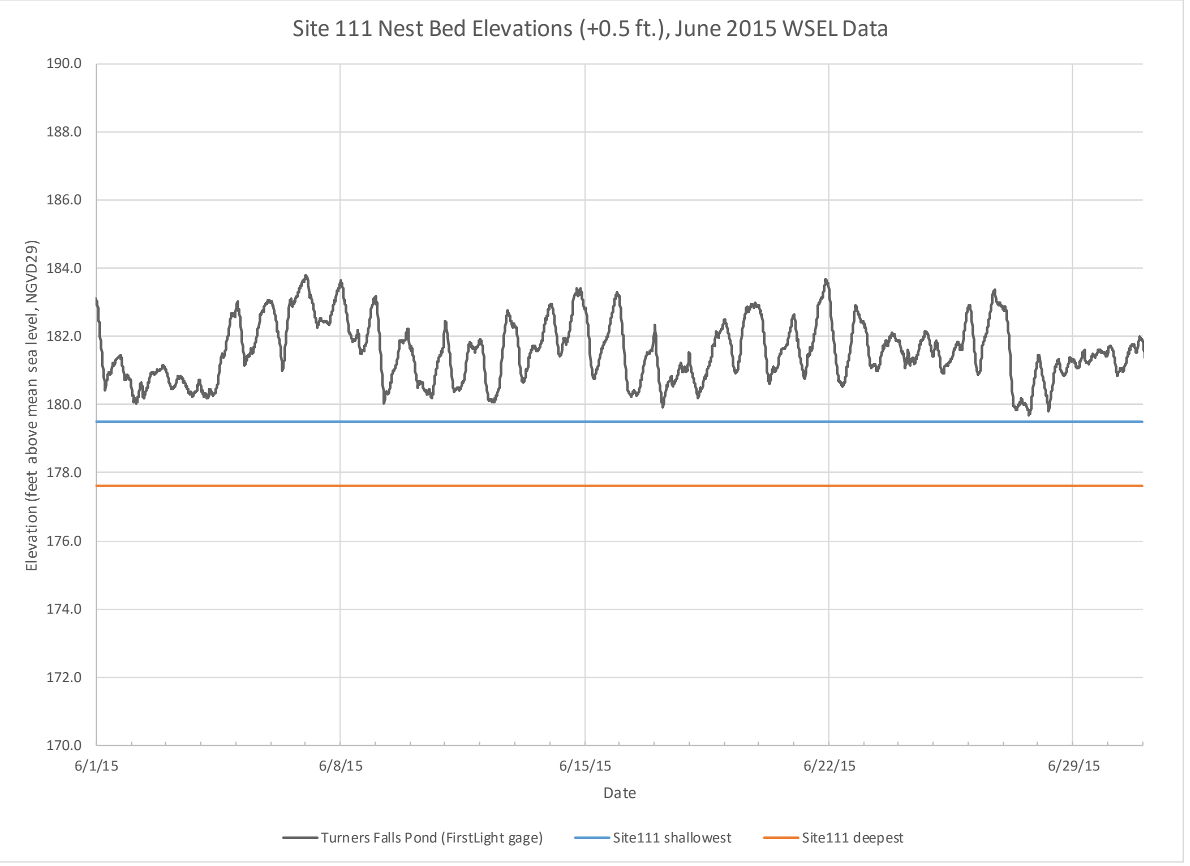
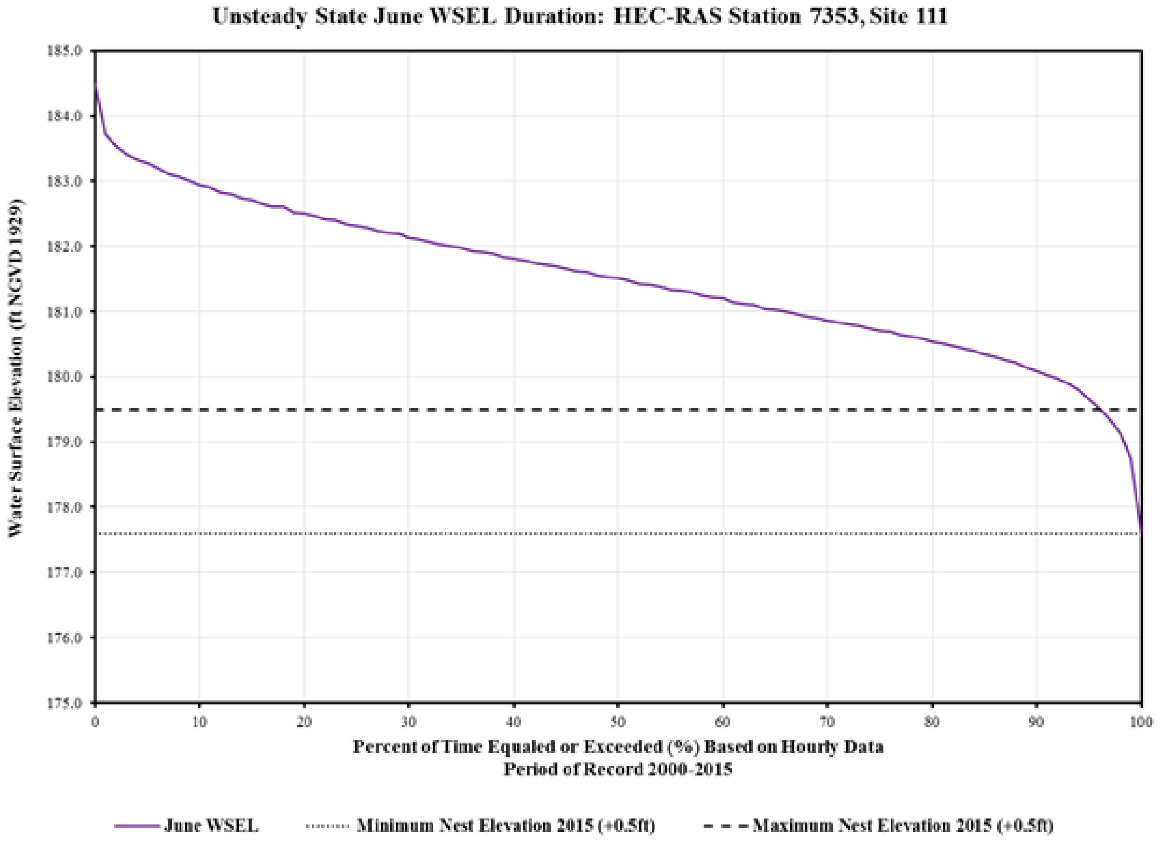


Figure 4.3.4-9: Late Spring Spawn WSEL Analysis at Site 111 (HEC-RAS Transect 7353)





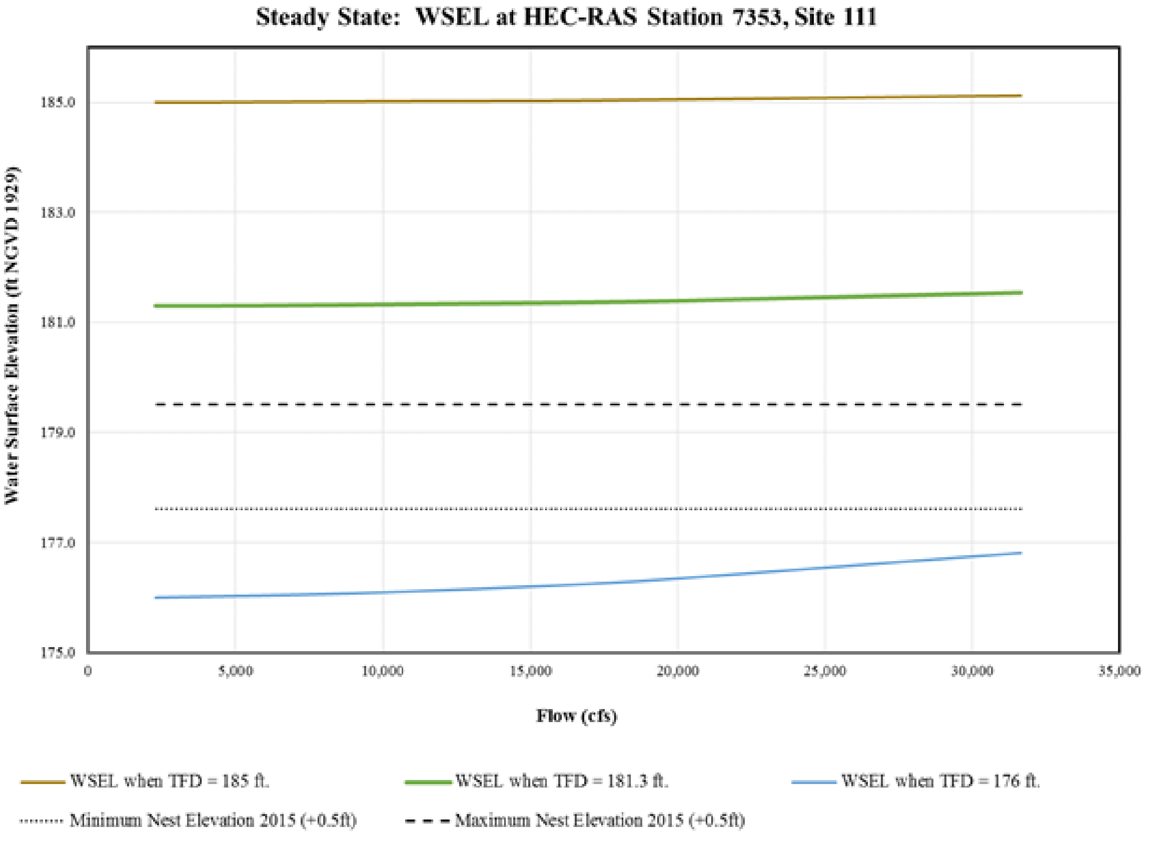
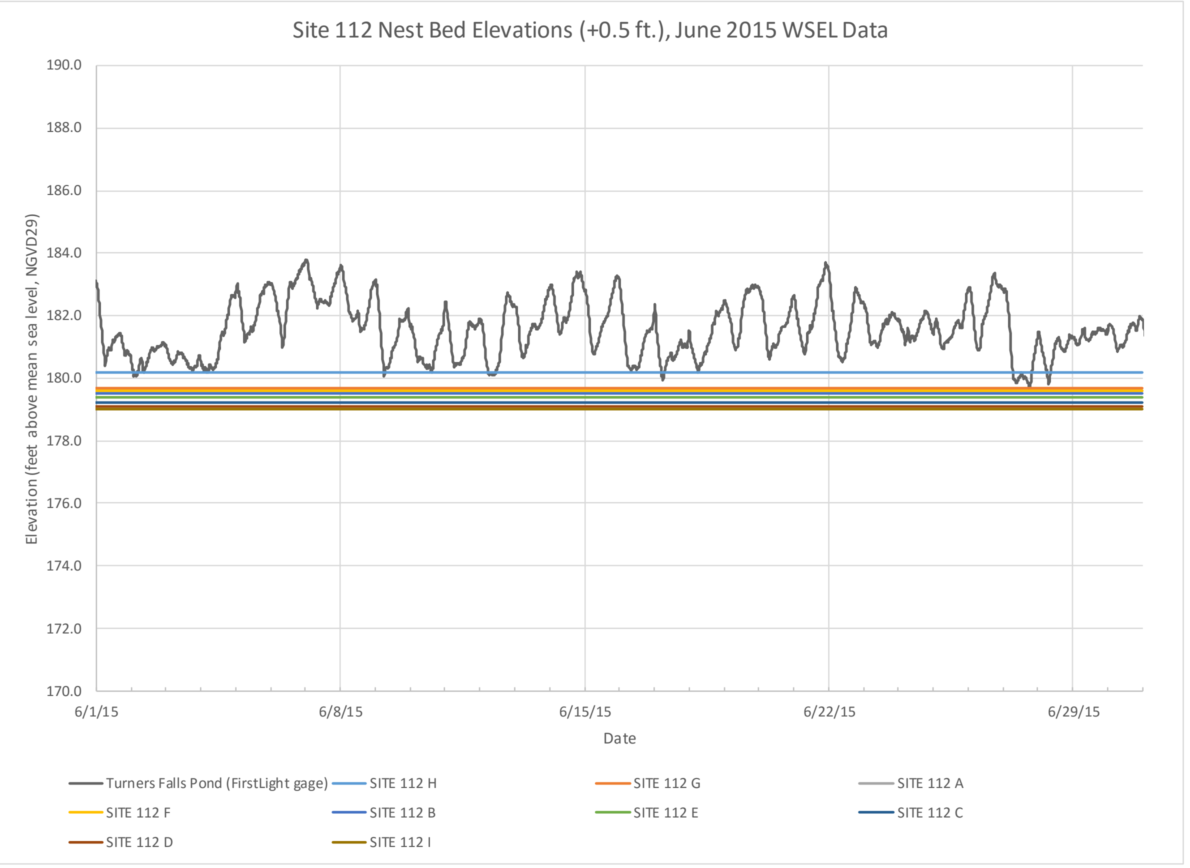
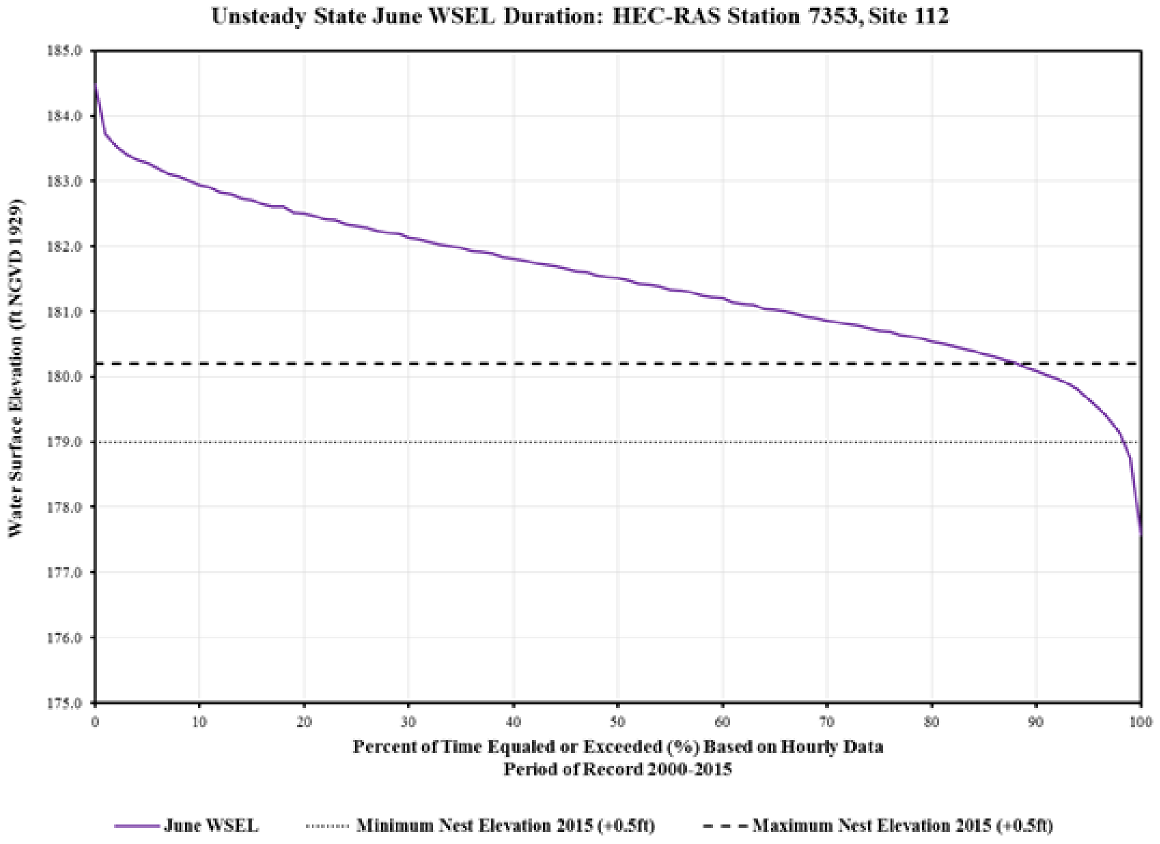


Figure 4.3.4-10: Late Spring Spawn WSEL Analysis at Site 112 (HEC-RAS Transect 7353)





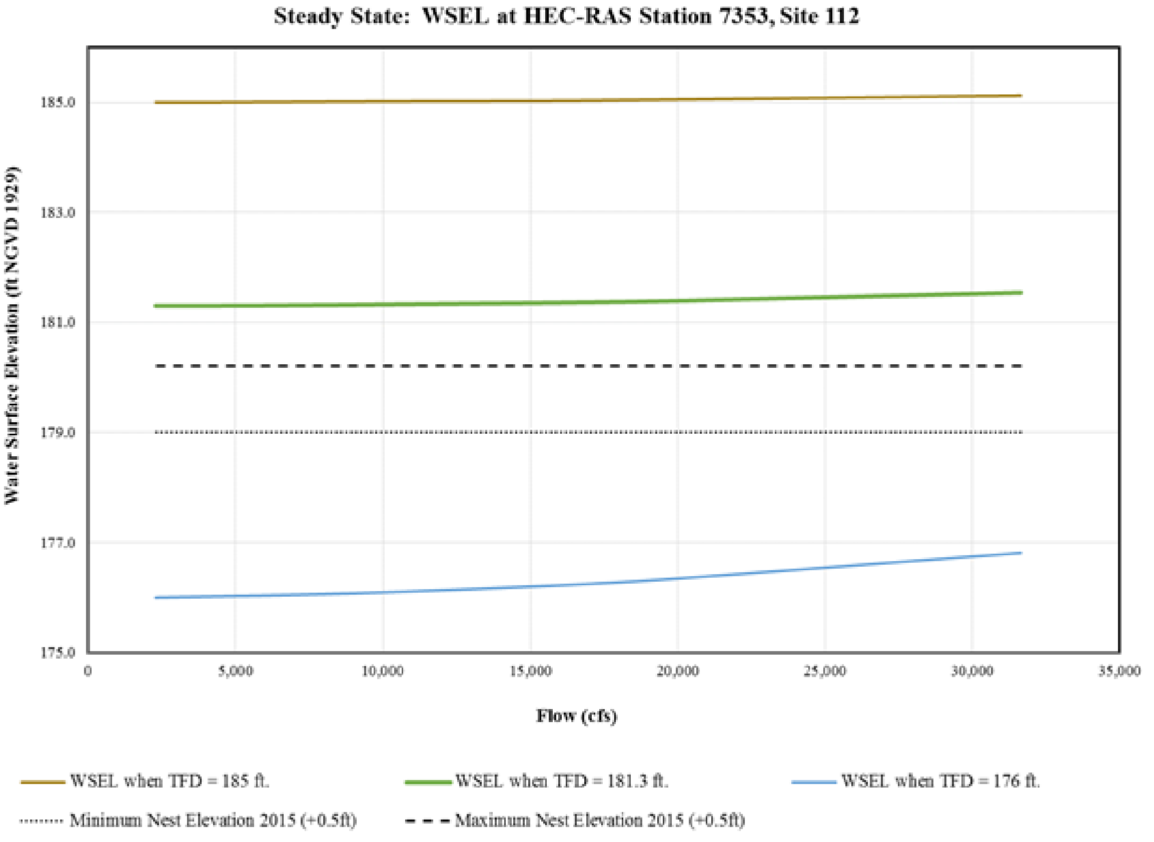
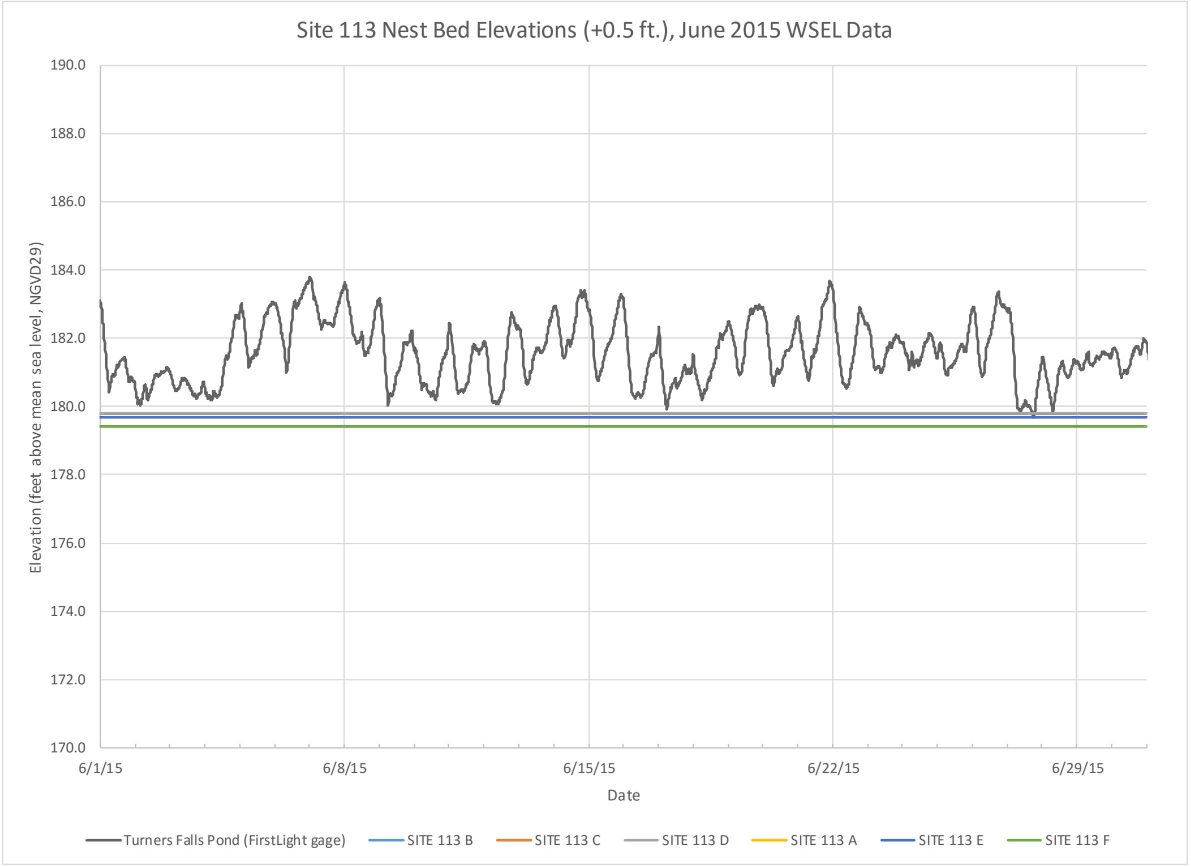
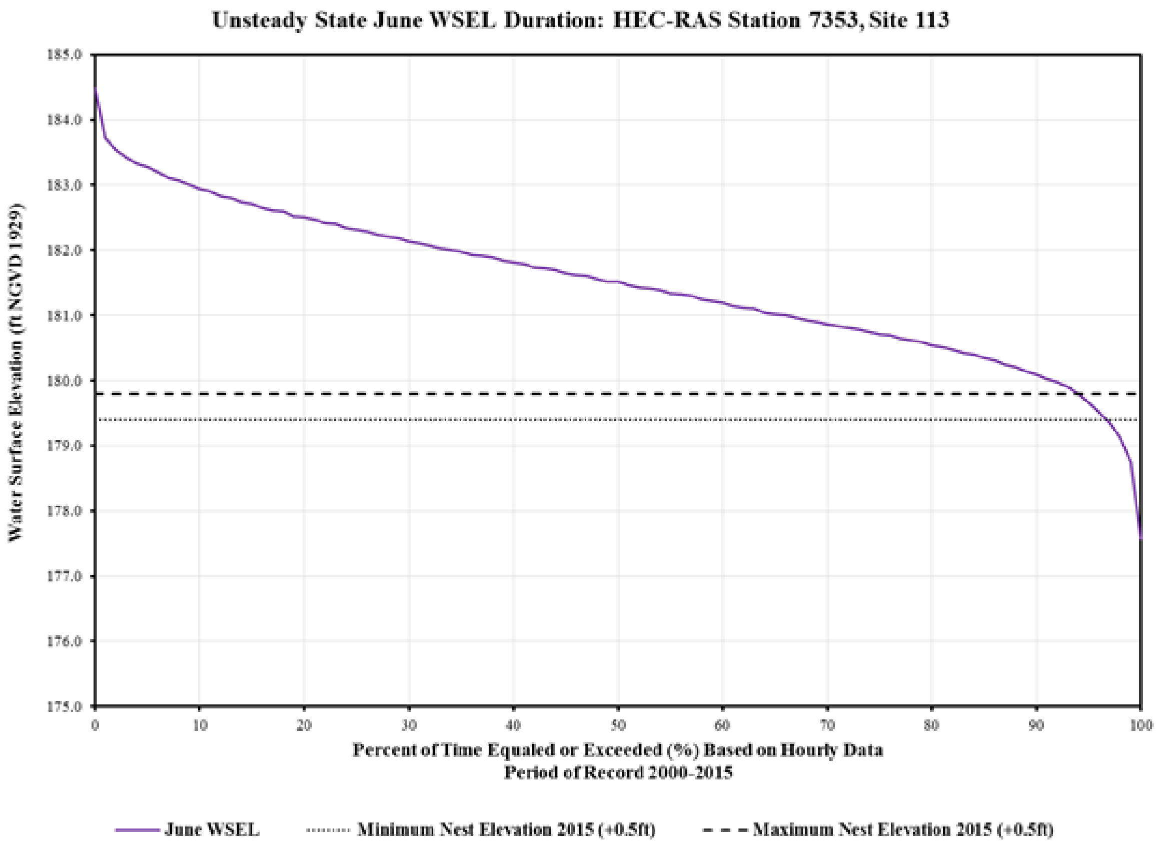


Figure 4.3.4-11: Late Spring Spawn WSEL Analysis at Site 113 (HEC-RAS Transect 7353)





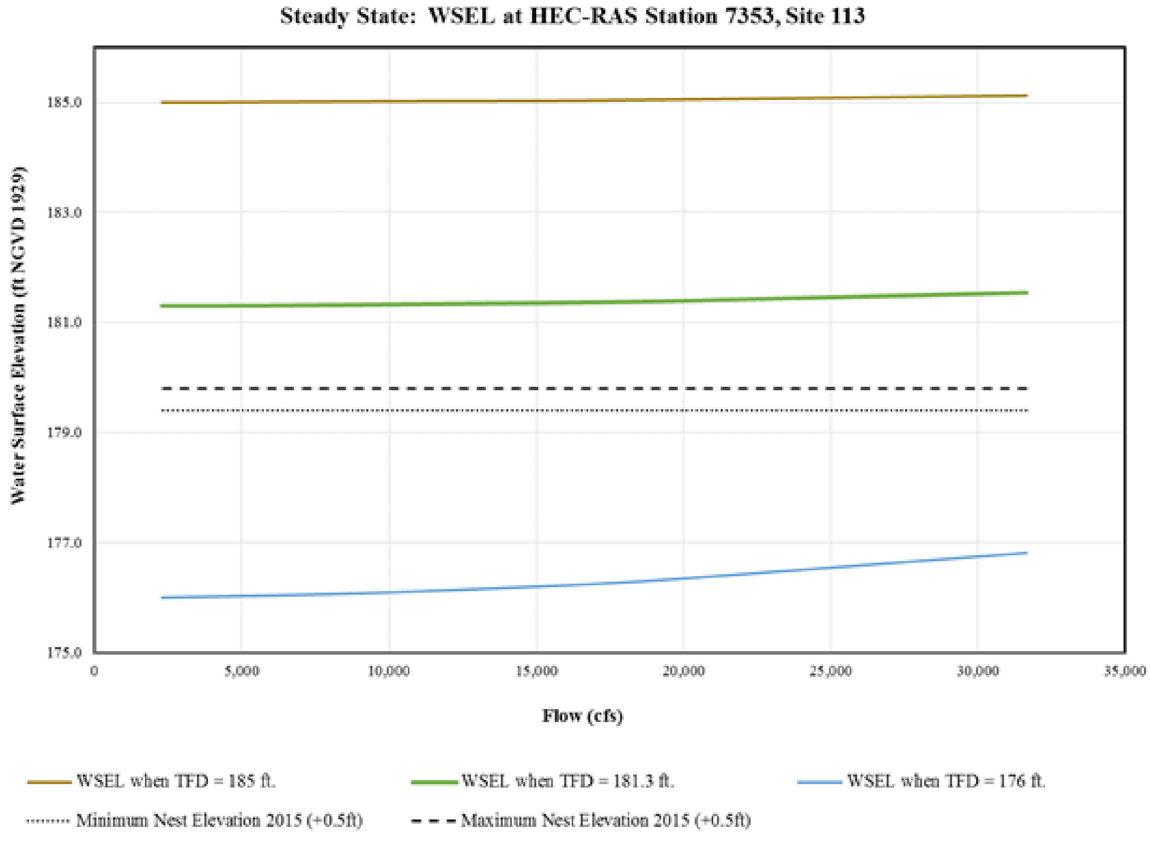
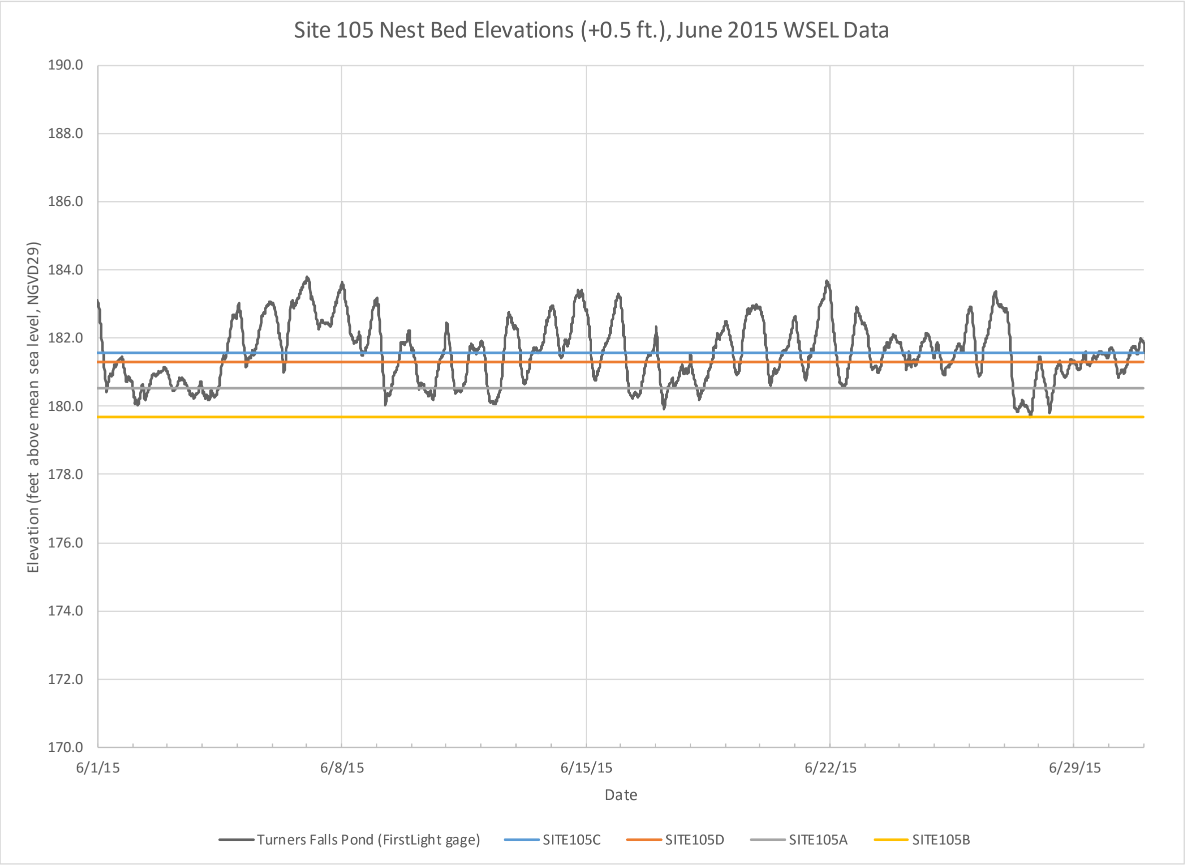
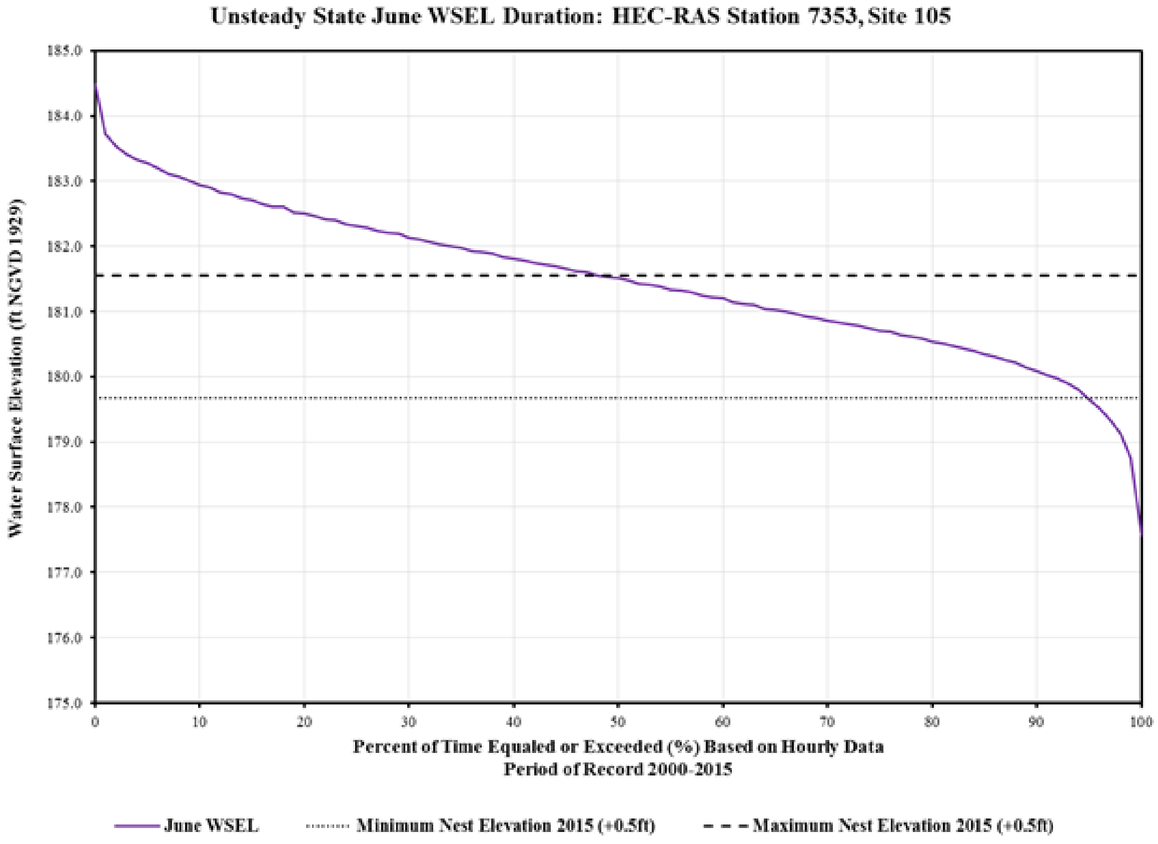


Figure 4.3.4-12: Late Spring Spawn WSEL Analysis at Site 105 (HEC-RAS Transect 7353)





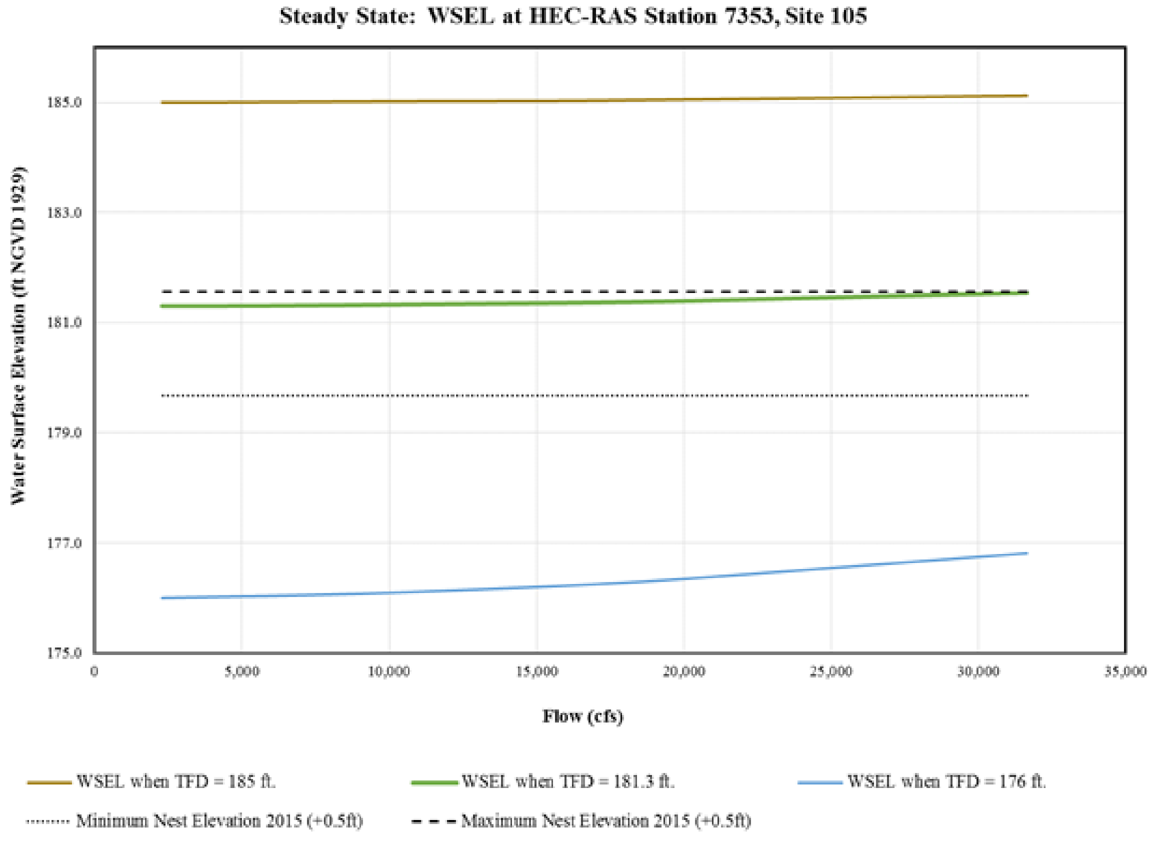
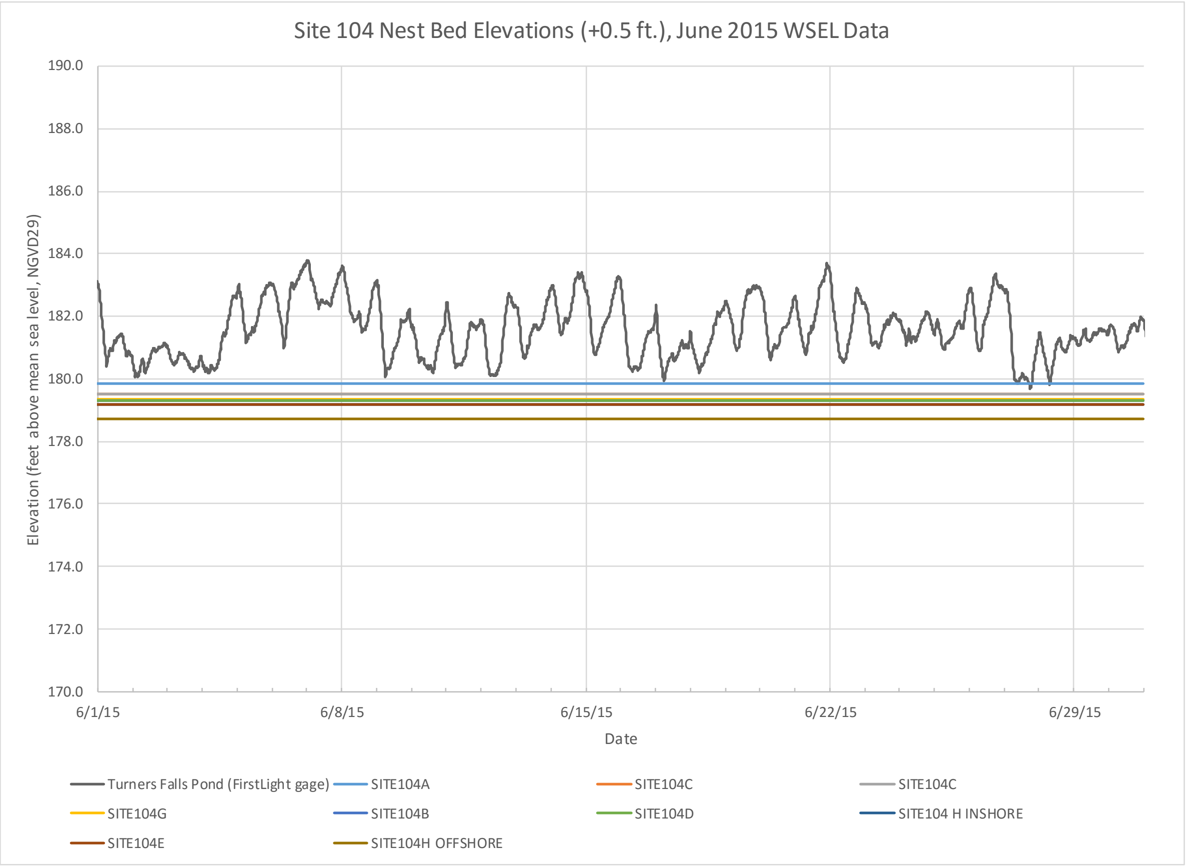
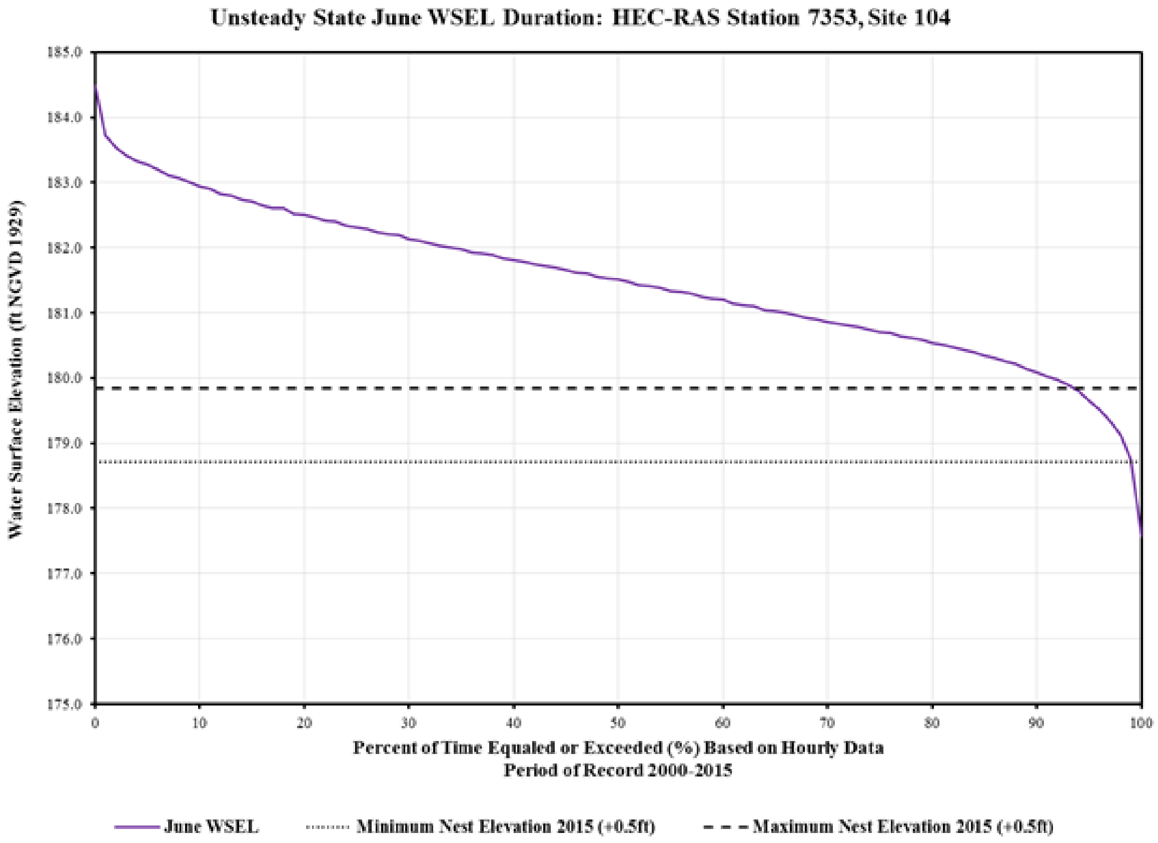


Figure 4.3.4-13: Late Spring Spawn WSEL Analysis at Site 104 (HEC-RAS Transect 7353)





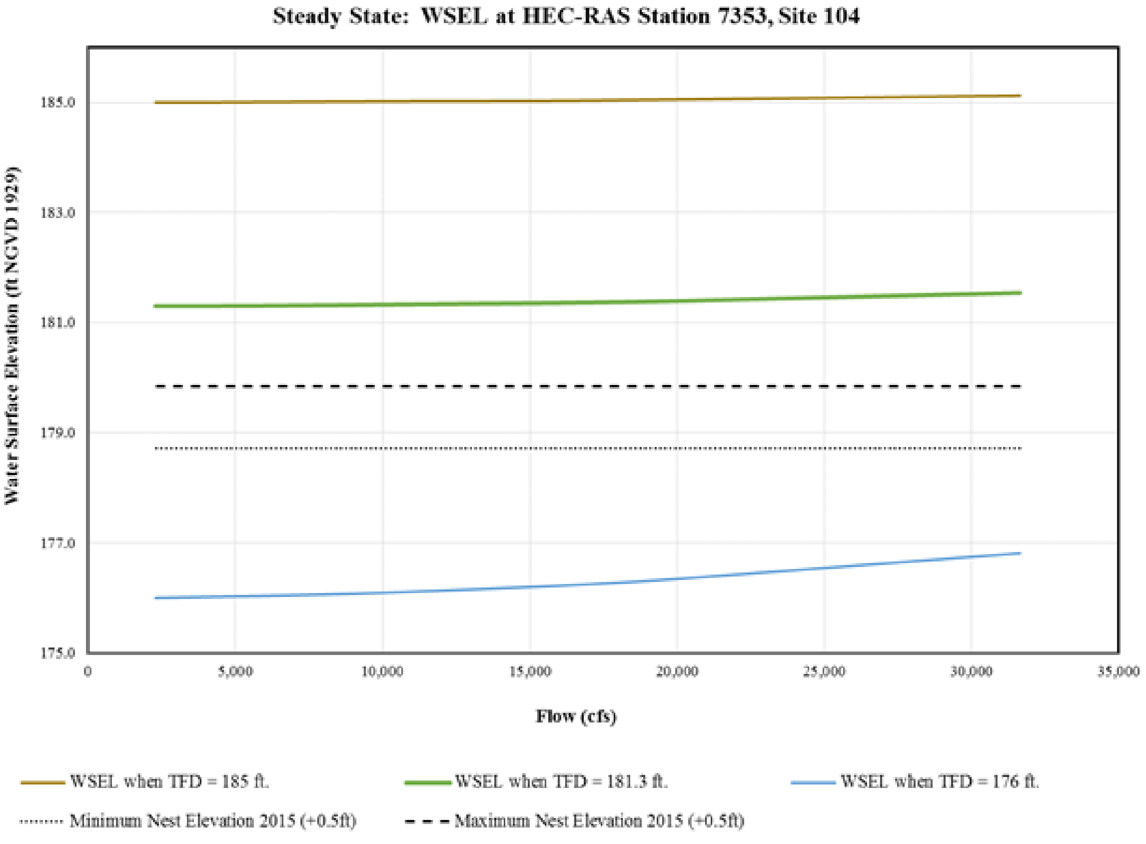
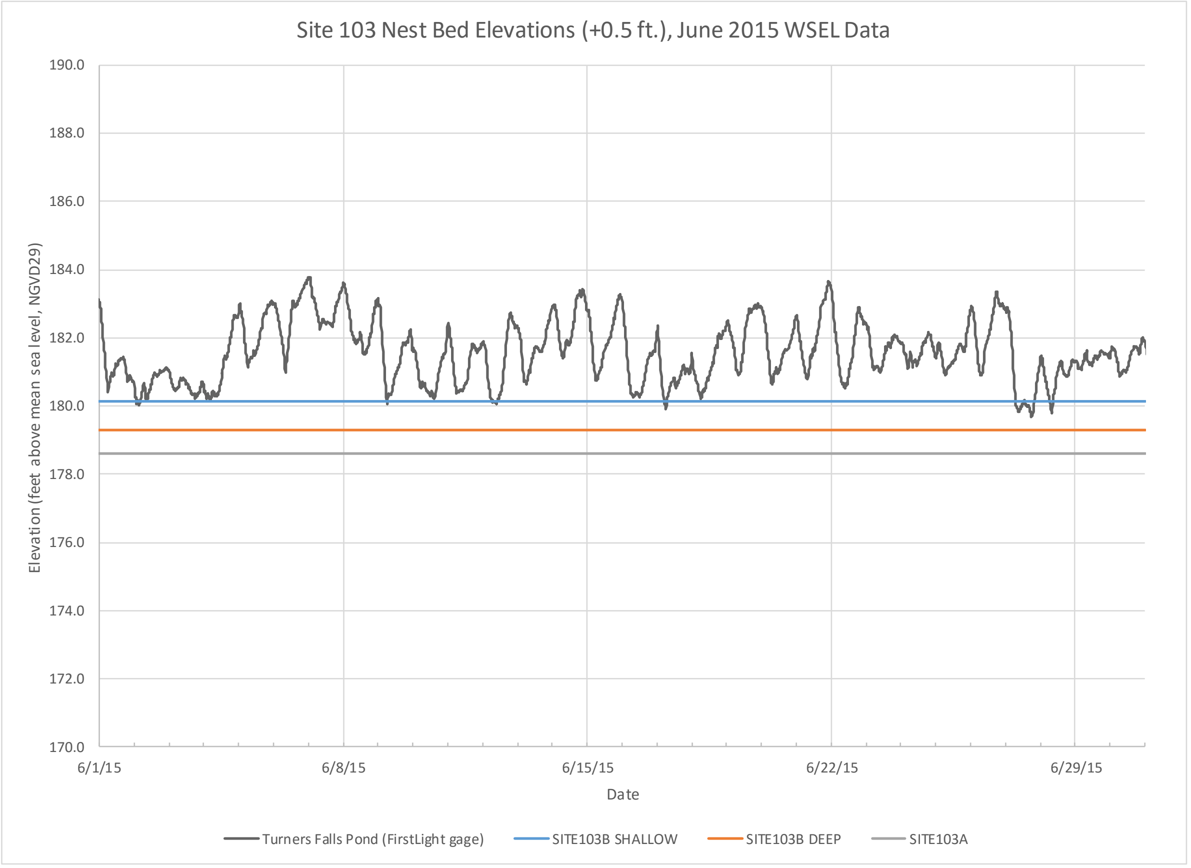
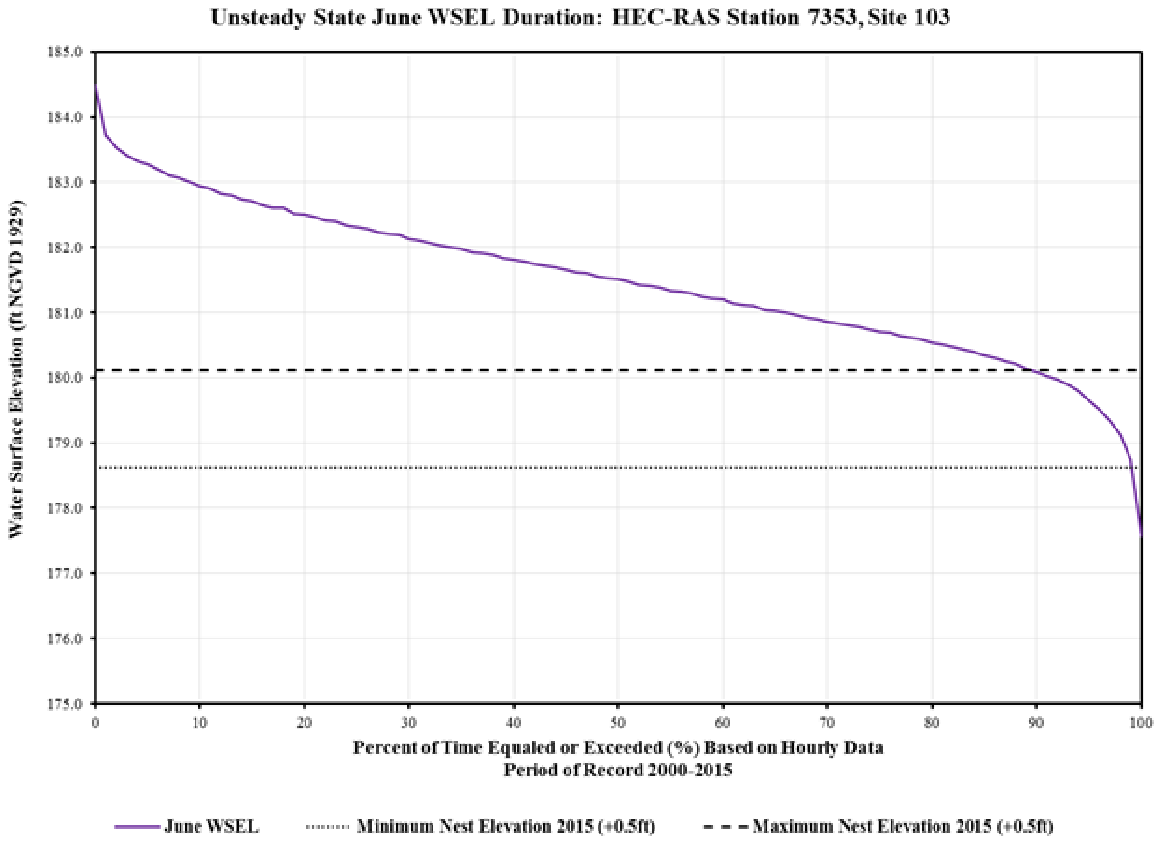


Figure 4.3.4-14: Late Spring Spawn WSEL Analysis at Site 103 (HEC-RAS Transect 7353)





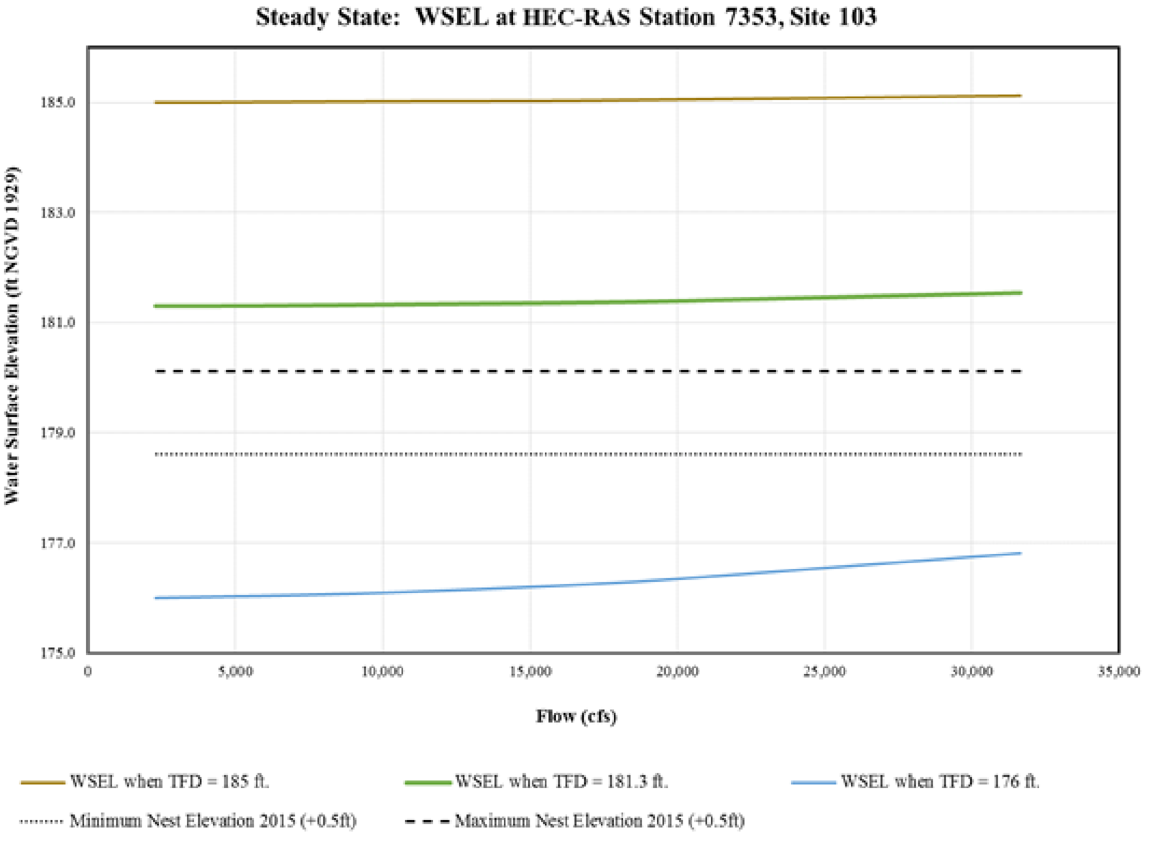
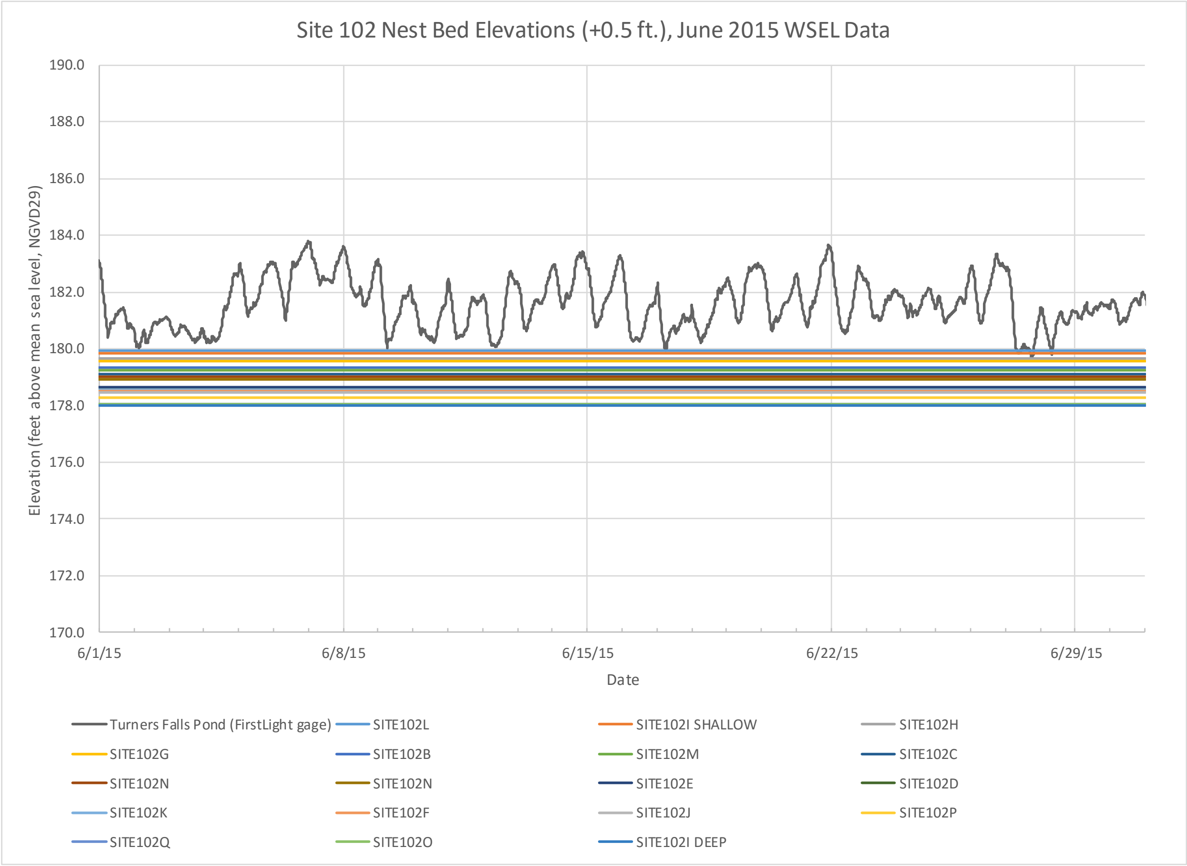
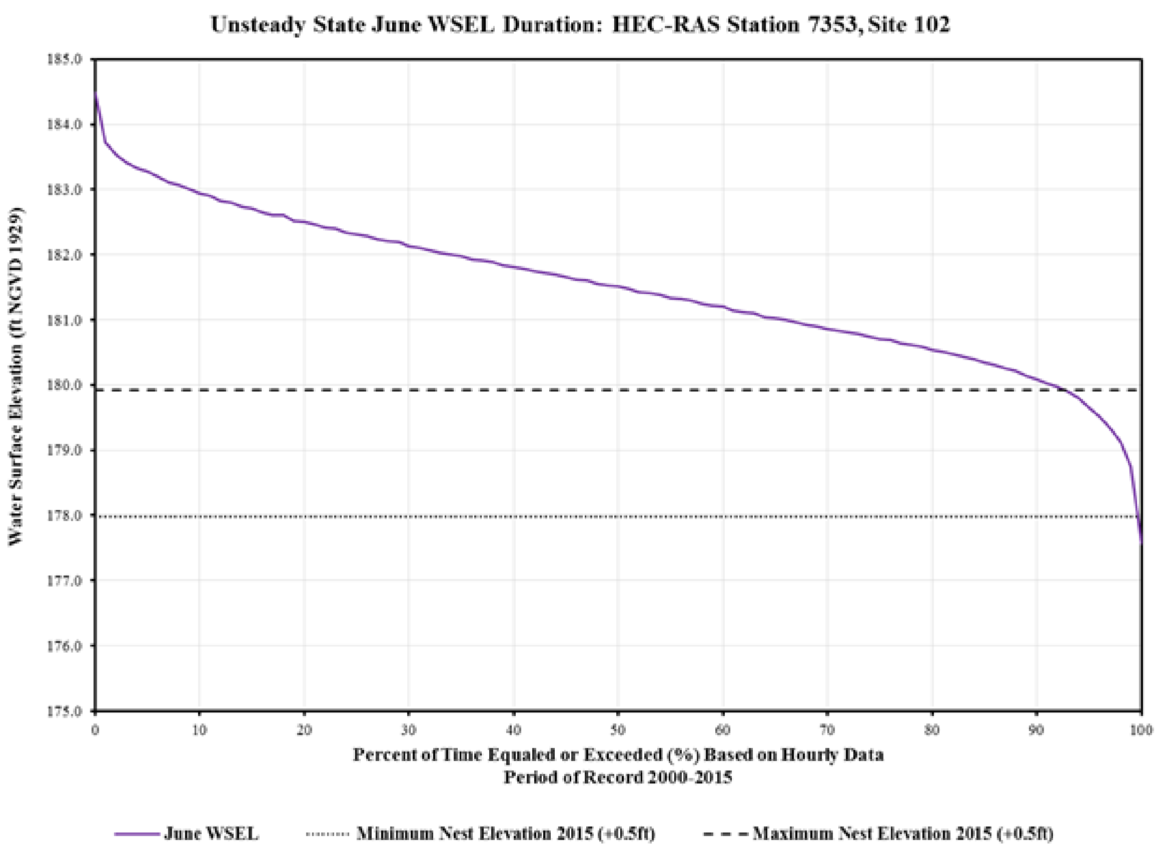
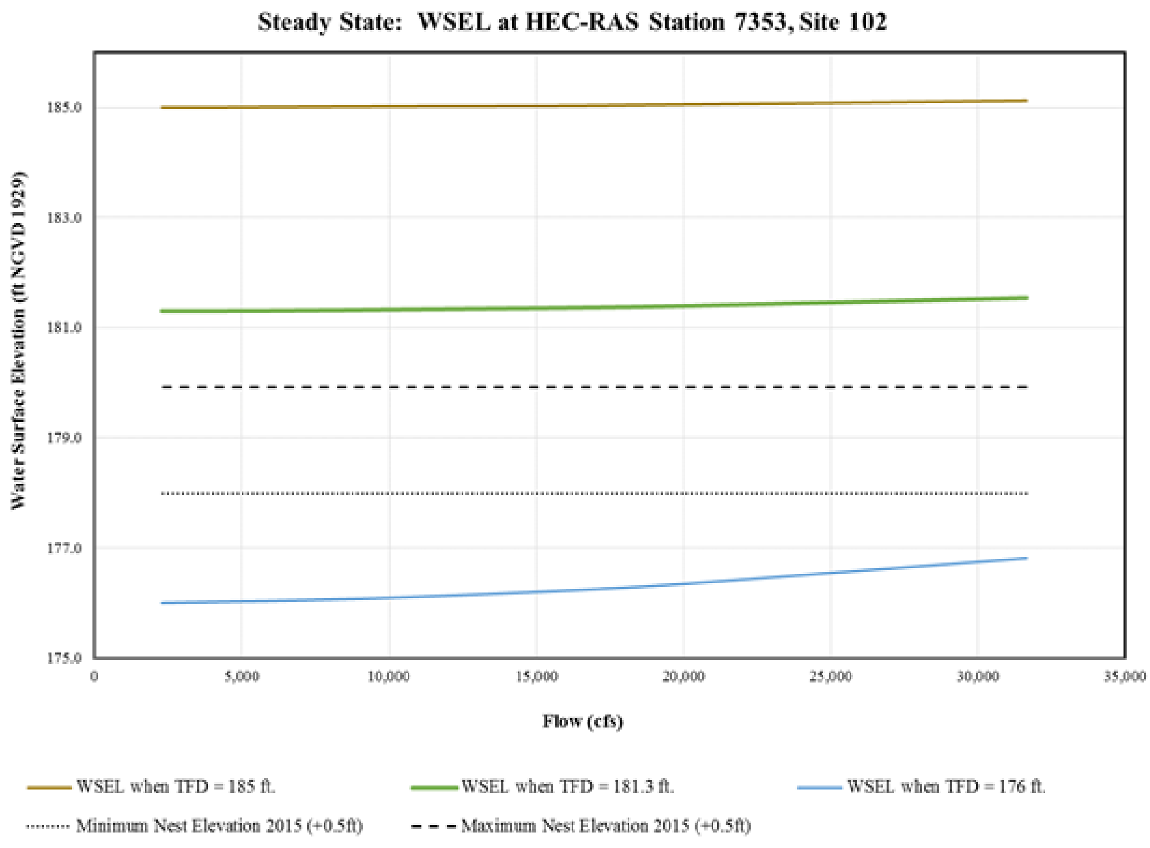


Figure 4.3.4-15: Late Spring Spawn WSEL Analysis at Site 102 (HEC-RAS Transect 7353)







5 DISCUSSION

5.1 Timing and location of fish spawning in the littoral zone

Early Spring Spawning

Although the exact dates of spawning in the TFI may vary slightly from year to year due to variable climatic conditions (and therefore water temperature), early spring spawning typically commences in late-April and continues through early to mid-May. This period coincides with relatively high flow resulting from basin-wide snowmelt and spring run-off. Availability of specific substrates is important, as fish spawning at this time are dominated by species that either bury their eggs in unguarded gravels or redds (*e.g.*, white sucker), broadcast spawn adhesive eggs that lodge in cobble or gravel interstices (*e.g.*, walleye), or extrude gelatinous egg masses that adhere to SAV or emergent riparian vegetation (*e.g.*, chain pickerel, northern pike, yellow perch).

Northern pike spawning is most successful over dense, and stable mats of short-stalked submerged vegetation (Mccarraher & Thomas, 1972). Yellow perch also utilize submerged plants and debris in slow moving or quiet water, and are relatively unspecialized about substrate selection (Collette *et al*., 1977). In this study, perch egg masses were observed adhered to the base of stalks of dead cattail plants and low hanging woody branches of riparian vegetation. Walleye spawning occurs over gravel and rubble in areas where sufficient water movement occurs to provide ventilating water circulation during incubation (Collette *et al*., 1977).

To some extent, prevailing water levels at the time of spawning may influence where fish elect to spawn. Since rivers and impoundments are hydraulically dynamic this may vary from year to year depending on hydrology and Project operations (which can include Vernon, Northfield and Turners Falls Project operation). In 2015, the TFI WSELs recorded between 180.9 and 182.3 ft as measured at the Turners Falls Dam during the course of early spring surveys were relatively close to the long-term median (181.3 ft) rather than either the upper or lower allowable elevations. Thus it appears that fish selected spawning sites under relatively "typical" TFI water levels in 2015.

Areas where either evidence of spawning was observed, or habitat and substrates suitable to such spawning, were limited to isolated patches in the TFI. Several gravel-rubble beds in the upper TFI appear to provide suitable spawning conditions for walleye; however, it was not practical to directly observe evidence of spawning due to relatively high flows and turbid water that occurred during the spawning period. In such cases, it was assumed that spawning could occur at these sites given the availability of suitable substrates. Small areas with SAV or emergent vegetation beds were scattered throughout the middle and lower reaches of the TFI, but most concentrated in the section below French King Gorge to Barton Cove. All life stages (including young of year, YOY) of walleye and yellow perch were detected in the fish assemblage study (Study No. 3.3.11), indicating that reproduction using these habitats was successful in 2015 and earlier years.

Late Spring Spawning

In this study, late spring spawning commenced in early June, coinciding with applicable water temperatures. However, the exact dates could vary from year to year, depending on prevailing climatic and water temperature conditions. Species that spawn during this period were dominated by nest-building guardians such as smallmouth bass, largemouth bass, and sunfishes.

To some extent, prevailing water levels at the time of nest building may influence where fish elect to spawn. Since rivers and impoundments are hydraulically dynamic this may vary from year to year depending on hydrology and Project operations (which can include Vernon, Northfield and Turners Falls Project operation). In 2015, the TFI WSEL recorded between 180.5 and 181.1(in Barton Cove) A localized elevation of 184.6 ft was recorded at the upstream extent of the TFI near Stebbins Island with the RTK instrument during the course of late spring surveys; most values therefore were relatively close to the long term median (181.3 ft at Barton Cove) rather than either the maximum or minimum allowable elevations. Thus, fish selected spawning sites under relatively "typical" TFI water levels.

Male centrarchids characteristically excavate a circular concave pit where the eggs are deposited, fertilized and guarded from incubation through the larval life stage. There is some variation among species, such as substrate selection; smallmouth bass prefer granular substrates such as sand, gravel, or rubble, and usually select nesting sites adjacent to object cover such as logs or boulders (Coble, 1975). Nests can be in flowing water if there is sufficient cover or in placid water. Both largemouth bass and bluegill generally prefer finer substrates and build nests in protected areas in coves (Heidinger, 1975). Largemouth are generally more territorial and thus nests are spaced 6 ft or more apart whereas bluegill nests may be clumped as little as inches apart (Heidinger, 1975).

Sea lamprey construct elongated nests of gravel and small rocks in riffles, and use body motions to create a silt free nest that may be up to 0.8 ft deep and 3.2 ft long (Kircheis, 2004).

Spawning was observed in the upper TFI between Stebbins Island and the vicinity of the Ashuelot River mouth, and also in the lower TFI within and immediately upstream from Barton Cove. The vicinity of Barton Cove, and the shoreline in the vicinity of the boat club, had the greatest concentrations of nests as these areas are the most lentic of all reaches of the TFI. Sea lamprey spawning was observed in areas such as riffles in the Millers River, and is discussed in detail in the report for Study No. 3.3.15 (*Assessment of Adult Sea Lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area*). Spawning nests were not detected in the middle reaches of the TFI, although YOY centrarchids were collected in all reaches of the TFI during the late summer fish assemblage survey (Study No. 3.3.11- *Fish Assemblage*). This suggests that some scattered spawning occurred in that area, but was not detected by this survey. Although suitable substrates can be found in the middle reaches of the TFI, one reason that spawning may have been limited in that reach was the relatively low abundance of object cover which bass in particular rely on. YOY lifestages of lamprey and centrarchids were detected in the fish assemblage study (Study No. 3.3.11), in reasonably close proximity to where nesting was observed, indicating that reproduction using these habitats was successful in 2015.

5.2 Qualitative Description of Shallow Water Habitat Types subject to Inundation and Exposure due to Project Operations

Shallow water habitat types were mapped and profiled in detail in the report for Study No. 3.3.14 (*Aquatic Habitat Mapping of Turners Falls Impoundment*). These littoral areas were characterized by lotic riverine areas flanking the channel in the upstream most two-thirds of the TFI, and a lacustrine embayed section of the TFI downstream from French King Gorge. The reach of TFI between the Northfield Mountain tailwater downstream through the gorge is comprised of steep, vertical bedrock walls and lacks any significant shallow water habitat.

The upstream reach extends a distance of approximately 13 miles, from a point about 1 mile below the Vernon Dam tailrace area downstream to the vicinity of the Northfield Mountain tailwater. This reach is relatively uniform and located within a broad floodplain. There are a few narrow islands comprised of alluvial materials such as gravel, cobble and fines. The *downstream reach* extends from the outlet of French King Gorge to the Turners Falls Dam. The lower reach TFI geometry is complex, and alternately defined by both bedrock and depositional features, and includes a complex of embayment, points, coves, islands and a wide range of substrates, and features shallow lacustrine littoral habitat.

Littoral zone substrates composed of fines and cobble collectively accounted for about 50% of all littoral substrate. Coarser materials are more common in the upper reach, and fines, muck and organic sediments are common in the lower reach. Bedrock and gravel were the next most common substrates. Wetlands occurred as isolated pockets in the upstream reach and as larger fringes in the lower reach particularly in areas of embayments where fine substrates tend to accumulate. SAV beds are present in scattered areas of the TFI, but are most abundant below French King Gorge as is woody debris and other forms of cover.

5.3 Potential Impacts of Project Operations on Nest Abandonment, Spawning Fish Displacement and Egg Dewatering

Early Spring Spawning

Spawning in the upper two-thirds of the TFI occurs in gravel-rubble beds (*e.g.* walleye, white sucker), SAV beds (*e.g.* northern pike), and riparian emergent vegetation such as remnants of cattails stalks (*e.g.* yellow perch). Areas within the TFI with substrates suitable for either walleye or white sucker spawning were documented. These areas were generally 1 to 2 ft deep at the time of the survey (Table 4.3.1-1). Depths greater than 1 ft up to 9.8 ft provide at least a suitability rating of 0.5 or greater for white sucker; and depths from approximately 1.2 ft up to 6 ft also meet or exceed a habitat suitability rating of 0.5 (Habitat Suitability Index Curves are included in Appendix C). It may be concluded that these TFI WSELs are frequently met at Site 2; however, Site 1 and Site 10 are only submerged about 50% or less of the time during April and May. Site 1 is directly in the Vernon tailwater and, at times, is directly influenced by Vernon discharges; Site 10 is a cattail bank near the edge of the riparian zone and is the inherently shallow. Although walleye may use shoals such as that at Site 2, they also undergo migrations to find suitable riffles for spawning (McMahon, 1984) and it is possible that additional spawning areas exist in tributaries outside of the study area.

SAV bed spawning sites for pike were very limited in the upper TFI. Suitable spawning depths range from 8 inches to 20 inches and pike will often elect quiet backwaters in tributaries (Inskip, 1982). Site 10 (in Pauchaug Brook) is submerged about 60% of the time in April (the month most likely for pike spawning), therefore not consistently usable. Inskip (1982) indicates that WSEL drops of up to 0.25m (10 inches) would maintain a suitability of 0.5 or greater for egg incubation and early post-hatch fry stage, and a drop of up to approximately 0.75m (30 inches) would maintain suitability during the later fry stage. Yellow perch spawning also would potentially occur on cattail stubs and other emergent vegetation submerged from approximately 3 to 12 ft in areas of extremely low velocity (less than .075 ft/sec) (Kreiger *et al*, 1983). Spawning suitability conditions in the upper TFI would therefore be marginally available under any circumstances.

Spawning habitat in the TFI below French King Gorge occurs in SAV beds (*e.g.* northern pike), and riparian emergent vegetation (*e.g.* yellow perch). These areas (Sites 11 and 12) were generally 2 ft deep at the time of the survey (Table 4.3.1-1) although the high point was shallower (approximately 0.2 ft), and are submerged adequately for spawning about 75% of the time during the April-May period. Median operating conditions are generally favorable for providing suitable spawning conditions at most, but not all, SAV beds. Suitable SAV spawning depths for yellow perch are generally (other than Site 17) available about 50-70% of the time (Sites 13-17).

Late Spring Spawning

Late spring spawning was dominated by nest building species such as centrarchids, and was confined to the uppermost and lowermost extremities of the TFI. Based on qualitative observations, there also was evidence of spawning in tributaries such as the Ashuelot and Millers River in riffle and shallow pool areas upstream from the TFI.

Spawning in the upper TFI was observed to consist of nests constructed adjacent to the bank areas (smallmouth bass and centrarchid), and a cleared gravel area adjacent to an unnamed island near the mouth of the Ashuelot (site 101). Although it was not possible to confirm the species that had cleared the gravel area, the redd did not appear to be consistent with typical sea lamprey construction; therefore, it was judged to be a white sucker nest. The greatest effect to spawning suitability in this littoral area would be induced by high inflows which could deepen spawning sites to the point of reducing suitability. The observed redd is 2.5 to 3.1 ft deep under median conditions, and is unsuitably deep for white sucker spawning regardless of TFI operation. Higher flows such as the 25% exceedance flow deepen this site further. This site may be unsuitable for spawning under significantly high inflow conditions. Under median flow and TFI operating conditions, the depths of centrarchid spawning nests appeared to be optimal, and would remain near optimal about 60% of the time at Site 114 and 65 % of the time at Site 115.

Spawning in the lower TFI occurs in embayment's and coves below French King Gorge and throughout the Barton Cove area and consists of excavated nests produced by various centrarchid species such as largemouth bass, bluegill and pumpkinseed sunfish. Centrarchid reproductive success depends upon guardianship of the nest by a male adult during the incubation and embryo life stage of the young. Although incubation may extend for a few days to a week, the total rearing period for the population may extend up to three weeks depending on the timing of spawning and ambient water temperatures at the time that govern hatching and development of young.

At the observed TFI elevation, few nests were shallower than 1.8 ft and the model depth was 2.4-2.7 ft (Figure 4.3.3-1). Habitat suitability for spawning under these conditions was predominantly near-optimal with a minority of sub-optimal nest depth sites. According to Struber *et al.* (1982a), most bluegill spawn in approximately 3-9 ft of depth and for bass the range is 0.5 ft to 24 ft. (Struber *et al.*, 1982b). This was considered as the "optimal" range for purposes of this analysis. Struber *et al.* (1982b) also indicates that water level drawdowns of up to -4m (13 ft) provide at least a spawning of 0.5 or better for bass. A drawdown of up to 2m (approximately 6.5 ft) maintains a suitability of 0.5 or better for bluegill (Struber *et al.*, 1982a). Under median flow conditions most nest depths ranged between 2 and 4 ft and would be considered optimal. Adult centrarchids may abandon nests if water gets too shallow, even though the nest itself may not become dewatered. Given that bass will maintain nests in as little as 0.5 ft of water it may be reasonable to select that depth as a threshold at which abandonment may occur. Thus, if nests are constructed under approximately median TFI water elevation conditions, nest abandonment may begin to occur at sites that are at 1.8 ft depth or shallower when the TFI WSEL falls below 179.8 ft. Nests built at the shallowest observed elevations generally remain adequately deep 90-95% of the time at most spawning locations and nests built at the deeper elevations remain adequately submerged nearly 100% of the time. (Only one nest site was observed to be at an elevation that was dewatered and would become too shallow more than 5% of the time). Should TFI elevation rise following nest construction, the increased depth did not appear to prohibit spawning and nesting success was not affected.

6 LITERATURE CITED

Coble, D.W. (1975). Smallmouth Bass. In R.H. and H. Clepper (Eds.) Black bass biology and management: National Symposium on the Biology and Mangement of the Centrarchid Basses, Tulsa, Oklahoma (pp. 21-33). Washington DC: Sport Fishing Inst.

Collette, B.B, Ali, M., Hokanson, K.E.F., Nagiec, M. Smirnov, S.A., Thorpe, J.E., Weatherly A.H., & Willemsen, J.. (1977). Biology of the percids. J. Fish. Res. Bd. Can. 34: 1890-1899.

Hartel, K.E., Halliwell, D.B., & Launer, A.E. (2002). Inland Fishes of Massachusetts, Massachusetts Audubon Society, Lincoln, MA.

Heidinger, R.C. (1975). Life history and biology of the largemouth bass. In R.H. and H. Clepper (Eds.), Black bass biology and management: National Symposium on the Biology and Management of the Centrarchid Basses, Tulsa, Oklahoma (pp. 11-20). Washington DC: Sport Fishing Inst.

Inskip, P.D. (1982). Habitat suitability models: northern pike. U.S. Dept. Fish and Wildl. Office of Biol. Serv. FWS/OBS/82-10.17. 40 pp.

Kircheis, F.W. (2004). Sea Lamprey *Petromyzon marinus*. Lynneaus 1758. F.W. Kirchies, LLC, Carmel, ME.

Kreiger, D.A., Terrell, J.W., & Nelson, P.C. (1983). Habitat suitability information: Yellow perch. U.S. Dept. Fish and Wildl. Serv. FWS/OBS-83/0.55. 37 pp.

Mccarraher D.B. & R.E. Thomas, (1972). Ecological significance of to northern pike, *Esox lucius*, spawning. Trans. Am. Fish. Soc. 101:3. 560-563.

McMahon, T.E., Terrell, J.W., & Nelson, P.C. (1984). Habitat suitability models: yellow perch. U.S. Dept. Fish and Wildl. Office of Biol. Serv. FWS/OBS/84-10.56. 43 pp.

Scott, W.B. & Crossman, E.J. (1973). Freshwater fishes of Canada, Bull. 184, Fish. Res. Board Can., Ottawa, CA. 966 pp.

Struber R.J., Gebhart, G., & Maughn, O.E. (1982a). Habitat suitability models: Bluegill. U.S. Dept. Fish and Wildl. Office of Biol. Serv. FWS/OBS/82-10.8. 26 pp.

Struber, R.J., Gebhart, G., & Maughn, O.E. (1982b). Habitat suitability models: largemouth bass. U.S. Dept. Fish and Wildl. Office of Biol. Serv. FWS/OBS/82-10.16. 32 pp.

APPENDIX A – RAW DATA SHEETS

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 5/4/15 TIME:________ STATION I.D. 001 FIELD CREW: BHK / JPG

WEATHER: Sunny breezy RIVER FLOW:________ WATER TEMPEATURE: 10.02

TURBIDITY: LOW IMPOUNDMENT STAGE (FT MSL) 181.1

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
001	NOT ACTIVE	0.5-1	N/A	COBBLE	LOW	0.18	NONE	NO	WALLEYE *

NOTES

* - POSSIBLE walleye spawning site in Vernon tailrace

photo 1 of shoreline at site 1.

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 5/4/15 TIME: 14:40 STATION I.D. 002 FIELD CREW: BHK | JPG

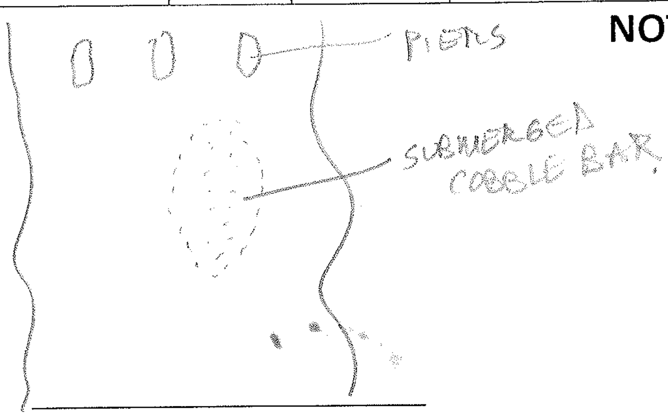
WEATHER: SCATTERED CLOUDS RIVER FLOW: ______ WATER TEMPEATURE: 10.0

TURBIDITY: LOW IMPOUNDMENT STAGE (FT MSL) 181.1

POSSIBLE WALLEYE SPAWNING SITE
COBBLE BAR D.S. OF OLD BRIDGE PIERS - MID CHANNEL SHOAL

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
002	N/A	0.5-3	N/A	COBBLE	CLEAN	3+ ft/sec	N/A	N/A	POSSIBLE WALLEYE

NOTES



[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation
[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 05/04/15 TIME: 15:30 STATION I.D. 003 FIELD CREW: BHK JPG

WEATHER: sunny some clouds RIVER FLOW: ______ WATER TEMPEATURE: 16°

TURBIDITY: ______ IMPOUNDMENT STAGE (FT MSL) 181.1

PACHAUG BROOK – NO EVIDENCE OF SPAWNING

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
—	—	—	—	some emergence	HIGH	0.0-0.3	—	pike	pike

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 5/5/15 TIME: 10:48 STATION I.D. 004 FIELD CREW: BHK KTPG

WEATHER: sunny, windy RIVER FLOW: 15,000 WATER TEMPEATURE: 10.58

TURBIDITY: +6 ft IMPOUNDMENT STAGE (FT MSL) 181.1 (RTK)

NO EVIDENCE OF SPAWNING

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
N/A	N/A	3.7'	N/A	BOULDER/COBBLE scattered veg.	LOW	1.0	N/A	—	possible walleye

NOTES

Potential walleye spawning shoal at mouth of Merriam Brook.

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 5/5/15 TIME: 11:15 STATION I.D. 005 FIELD CREW: BHK, JPG

WEATHER: partly cloudy breeze RIVER FLOW: 15,000 WATER TEMPEATURE: 10.88

TURBIDITY: +6 IMPOUNDMENT STAGE (FT MSL) 180.9 from RTK

no evidence of spawning

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
005	—	—	—	gravel rip rap	moderate		—	—	potential walleye

NOTES

River-Left channel near Kidds Island

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation
[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 5/5/15 TIME: 12:19 STATION I.D. 006 FIELD CREW: BHK JPG
WEATHER: Partly cloudy lght brz RIVER FLOW: 18,000 WATER TEMPEATURE: 11.36
TURBIDITY: +6 secchi IMPOUNDMENT STAGE (FT MSL) 181.2 RTK

mouth OF 4 mILE BROOK
no evidence of spawning

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
/	/	/	/	cobble	low	0.3-0.6	/	/	potential walleye

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation
[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 9:05 STATION I.D. 102 FIELD CREW: BHK JPG

WEATHER: sunny RIVER FLOW: ~25,000 WATER TEMPEATURE: 18.5

TURBIDITY: 6 ft secchi IMPOUNDMENT STAGE (FT MSL) 180.5 (control room)
RTK WSEL - 179.75 (DATUM 88)

BARTON COVE, U.S. of Boat launch

NEST I.D.	Active/ abandoned	RTK DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	177.9	15 inches	Gravel	LOW	0.0	yes	yes	SUNFISH
B	"	178.3	24 inch	"	"	"	"	UNK	"
C	"	178.2	24 inch	COBBLE	"	"	"	yes	"
D	"	177.5	26 in.	SAND	"	"	"	yes	"
E	"	177.6	24 in	Gravel	"	"	"	"	"
F	"	177.5	24 "	"	"	"	"	"	
G	"	178.5	12 "	"	"	"	"	NO	UNK
H	"	178.5	18 "	"	"	"	"	yes	SUNFISH
SHALL I	1 DOZEN CLUSTER	178.8	18 "	"	"	"	"	yes	"
DEEP "	"	176.9	"	"	"	"	"	"	"
J	SINGLE ACT.	177.4	24 IN	"	"	"	"	"	"
K	" "	177.5	24 "	SAND	"	"	"	"	"
L	" "	178.9	12 "	gravel	"	"	"	"	"
M	"	178.2	15 "	"	"	"	"	"	"
N		177.9	30	sand	"	"	"	"	"
O	CLUSTER of 4	177.0	30	"	"	"	"	"	"
P	SINGLE	177.3	18	"	"	"	"	"	"
Q	"	177.0	24	"	"	"	"	"	"

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation
[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 10:10 STATION I.D. 103 FIELD CREW: RHK JPG

WEATHER: sunny calm RIVER FLOW: ~25,000 WATER TEMPEATURE: 19 -

TURBIDITY: 6 ft IMPOUNDMENT STAGE (FT MSL) 180.5 NFD
179.9 RTK (NVG 88)

NEST I.D.	Active/ abandoned	DEPTH (ft) RTK elev.	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	177.5	15	sand	NO	0	yes	yes	sunfish
B (CLUSTER)	SHALLOW	178.8	15	"	"	"	"	"	CLUSTER OF ~10
B	DEEP	178.2	15	"	"	"	"	"	SUNFISH

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 10:45 STATION I.D. 104 FIELD CREW: BHK JPG

WEATHER: Sunny slight breeze RIVER FLOW: ~25,000 WATER TEMPEATURE: 18.0

TURBIDITY: 6 ft IMPOUNDMENT STAGE (FT MSL) 180.5 NFA CONTROL RTK

RTK WSEL 180.5

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	178.8	18-	sand	NO	0.0	Y	Y	SUNFISH
B	"	178.3	15	"	"	"	"	"	"
C	"	178.5	12	"	"	"	"	"	"
D	"	178.3	18	"	"	"	"	"	"
E	"	178.1	18	"	"	"	"	"	"
F	"	178.3	18	"	"	"	"	"	"
G	"	178.3	18	"	"	"	"	"	"
OFFSH H	CLUSTER OF 7	177.7	18	"	"	"	"	"	"
INSHORE		178.1	12	"	"	"	"	"	"

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 11:30 STATION I.D. 105 FIELD CREW: BHK JPG

WEATHER: sunny breezy RIVER FLOW: ~25,000 WATER TEMPEATURE: 18.0

TURBIDITY: 6 ft IMPOUNDMENT STAGE (FT MSL) 180.5 CONTROL ROOM
180.4 RTK 1

RTK EL. ~~180.8~~

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	179.5	22"	sand	~~[illegible]~~ MOD	0.0	UNK	UNK	SUNFISH
B	ABAND.	178.6	15"	"	MOD	"	"	"	"
C	DEWATERED	180.3	18"	" / SILT	"				on exp. bar
D	"	180.2							

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/[illegible]/15 TIME: 14:45 STATION I.D. 107 FIELD CREW: BHK JPG

WEATHER: sunny windy RIVER FLOW: ~25,000 WATER TEMPEATURE: 21°

TURBIDITY: 4 ft IMPOUNDMENT STAGE (FT MSL) ~~180.3~~ RTK #1 ~~180.0~~ 180.6 180.5

ROD EL.

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
107 A	ACTIVE	3	28	sand / LOG COVER	NONE	0.0	UNK	Y	LMB
107 B	"	2.5	24	" "	NONE	0.0	UNK	Y	LMB
107 C	"	3.0	30	" "				Y	SFish
D	"	3.3	32						LMB
E	"	3.0	36						LMB
F	"	3.6	36						LMB
G	"	2.8	20						SFSH
H	"	2.3	26						SFSH
I	"	2.0	18						sunfish
J	"	2.5	19						"

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 13:20 STATION I.D. 106 FIELD CREW: BHK JAG

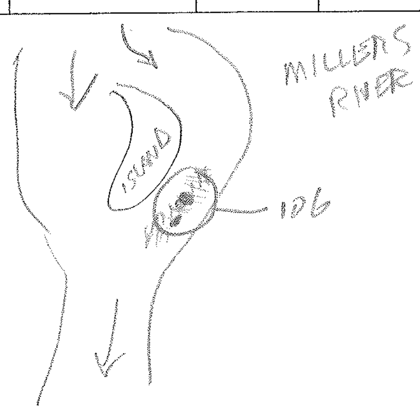
WEATHER: Sunny light wind RIVER FLOW: 25,000 WATER TEMPEATURE: 21°C

TURBIDITY: CLEAR IMPOUNDMENT STAGE (FT MSL) 180.35 RTK

Gravel bar at first riffle of Miller's River

NEST I.D.	Active/ abandoned	DEPTH (ft) RTK el.	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
00A	ACTIVE	179.3	18" L	COBB/GRAVEL	NO	1,33 / 0.12	UNK	NO	POSS LAMPREY or SUCKER
00B	"	178.7	18" L	COBB/GRAV	NO		UNK	NO	poss lamprey or sucker

NOTES



[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 15:23 STATION I.D. 108 FIELD CREW: BHK JPG

WEATHER: sunny windy RIVER FLOW: 25,000 WATER TEMPEATURE: 21

TURBIDITY: 4 ft IMPOUNDMENT STAGE (FT MSL) 180.6 RJK

SURVEY ROD

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	Active	2.4	44	fine sand	none	0.0	Yes	Yes	LM Bass
B	"	2.7	36	"	"	"	"	"	"
C	"	2.5	15	"	"	"	"	"	sunfish
D	"	2.6	30	"	"	"	"	"	"
E	"	2.5	48	"	"	"	"	"	LMB
F	"	2.3	36	"	"	"	"	"	SFSH
G	"	2.0	36	"	"	"	"	"	"
H.		2.9	24	"	"	"	"	UNK	CENTRARCHID

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11 TIME: 1534 STATION I.D. 109 FIELD CREW: AHK JPG

WEATHER: SUNNY WINDY RIVER FLOW: 25,000 WATER TEMPEATURE: 21

TURBIDITY: 6' secchi IMPOUNDMENT STAGE (FT MSL) 180.6 RTK

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	3.1	34	SAND & log	NONE	0	UNK	Y	LMB
B		3.0	38	" "		0	UNK	Y	LMB
C	11-nest	2.8	22	" "		0	UNK	Y	LMB/SFSH
D	CLUSTER	3.5	38	" "		0	UNK	Y	LMB/SFSH
D		2.8	36					Y	LMB
E		2.3	20					Y	SFSH
F		2.8	26						

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 15:46 STATION I.D. 110 FIELD CREW: BK / JG

WEATHER: Sunny RIVER FLOW: ~25,000 WATER TEMPEATURE: 20.5

TURBIDITY: 5.5' secchi IMPOUNDMENT STAGE (FT MSL) 180.4 RTK

NEST I.D.	Active/ abandoned	DEPTH (ft) RTK EL	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	177.5	36	SAND	NO	0	UNK	YES	LMB
B	}	177.5	40	SAND	}	0	"	"	LMB
C	}	177.5	36	SAND	}	0	"	"	LMB
D	}	177.5	38	"	}	0	"	"	"
E	}	177.7	36	"	}	0	"	"	SFSH
F	}	2.3*	28	"	}	0			

NOTES

* STADIA ROD

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/1/15 TIME: 1600 STATION I.D. 111 FIELD CREW: BK JG

WEATHER: Sunny WINDY RIVER FLOW: 25,000 WATER TEMPEATURE: 21

TURBIDITY: 5 ft secchi IMPOUNDMENT STAGE (FT MSL) ~~180.6~~ 181.1

LARGE FIELD OF NESTS at POINT OFF GREEN Camp.

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
CLUSTER	ACTIVE		30 - 36	SAND GRAVEL	NONE	0.0	UNK	Y	LMB
OF		2.6							
~36		-4.5							
NESTS									

NOTES

- SITE IS comprised of a cluster of ~36 nests
STRIP IS ~ 25 WIDE x ~100 Ft long

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 16:20 STATION I.D. 112 FIELD CREW: BK JG

WEATHER: sunny breezy RIVER FLOW: 25,000 WATER TEMPEATURE: 21

TURBIDITY: 4 ft Sechi IMPOUNDMENT STAGE (FT MSL) 181.1 RTK

STA DPH

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	2.6	36	SAND SCATTERED LOGS	NONE	0.0	UNK	Y	LMB
B		2.7	30	" "					"
C		3.0	32	"					"
D		3.1	31	"					"
E		2.8	18	" "					SUNFISH
F		2.6	21	"					"
G		2.5	28	" "					LMB
H		2.0	18	"					SF
I		3.2	16	"					SF

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6-13-15 TIME: 0640 STATION I.D. 114 FIELD CREW: BHK JPG

WEATHER: sunny RIVER FLOW: ~16,500 WATER TEMPEATURE: 21.3

TURBIDITY: Low / 6ft sd IMPOUNDMENT STAGE (FT MSL) 180.9 CONTROL ROOM 7:30

lower ASHUELOT, backwater below RIFFLE BUT ABOVE TRESTLE

RTK EL 183.8 2 abandoned (?) sunfish nests

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ABANDONED	1.6	12"	SAND & PEBBLE	NONE	0.0	NO	NONE	UNK - CENTRARCHID
B	"	1.8	"	"	"	"	"	"	"

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/13/15 TIME: 9:45 STATION I.D. STEBBINS GRVL BAR FIELD CREW: BHK JPG

WEATHER: sunny breezy RIVER FLOW: ~16,000 WATER TEMPEATURE: 17°

TURBIDITY: 5' Sechi IMPOUNDMENT STAGE (FT MSL) 184.6 RTK

OVERALL GRAVEL BAR LIKELY GOOD FOR white sucker, possibly walleye

DELINEATED PERIMETER; NO SPECIFIC NESTING SITES

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
N/A	N/A	~3 ft	N/A	medium gravel	NONE	3-4 ft/sec	—	—	—

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/13/15 TIME: 11:45 STATION I.D. 115 FIELD CREW: BHK JPG

WEATHER: Sunny breezy RIVER FLOW: ~16,000 WATER TEMPEATURE: 18.5

TURBIDITY: Low 6' [illegible] IMPOUNDMENT STAGE (FT MSL) 183.5 RTK

NEST I.D.	Active/ abandoned	DEPTH (ft) (STADIA ROD)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	2 ft	12 in	sand/pea gravel below log	none	0.0 nose	UNK.	yes	male SMB
						0.8 mcv			

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/11/15 TIME: 16:38 STATION I.D. 113 FIELD CREW: BK JFG

WEATHER: sunny breezy RIVER FLOW: ~25,000 WATER TEMPEATURE: 21.5

TURBIDITY: 4 ft secchi IMPOUNDMENT STAGE (FT MSL) 181.1

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
A	ACTIVE	2.5	30	sand	NONE	0.0	UNK	yes	LMB
B	(	2.4	24	"	(	(	"	yes	SFSH
C	(	2.4	30	"	(	(	"	UNK	UNK CENTR
D	(	2.4	24	GRAVEL	(	(	"	"	" "
E	(	2.5	36	PEBBLE SAND/LOG	(	(	"	yes	LMB
F	(	2.8	32	" "	(	(	"	"	"

NOTES

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation
[2] High, Moderate, Low, Undetermined

3.3.13 FIRST LIGHT TURNERS FALLS IMPOUNDMENT LITTORAL ZONE SPAWNING SURVEY

DATE 6/1/15 TIME: 16:49 STATION I.D. 101 FIELD CREW: BHK JAG

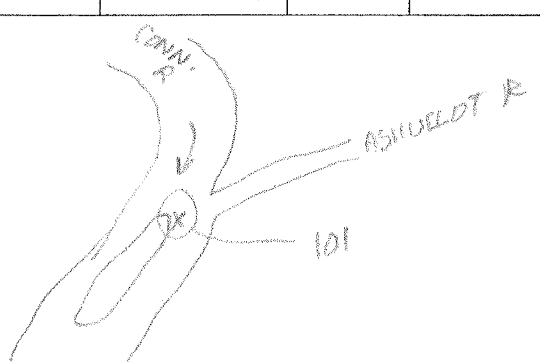
WEATHER: OVERCAST / RAIN RIVER FLOW: 14,000 WATER TEMPEATURE: 16

TURBIDITY: CLEAR IMPOUNDMENT STAGE (FT MSL)

Submerged gravel bar at upstream tip of island near the Ashuelot River.

NEST I.D.	Active/ abandoned	DEPTH (ft)	Diameter (inches)	SUBSTRATE/ vegetation[1]	SILTATION[2]	VELOCITY (ft/sec)	EGGS	Fish presence	SPECIES
001	ACTIVE	1.5	1 m.	LG GRAVEL SM COBBLE	NONE	3.1		NONE	W sucker
									poss. lamprey

NOTES



NOTE:
Revisited on 6/12/15 @ ~20,000 cfs.
Gravel bar was under ~3 ft. water depth
vel = ~6 ft/sec

[1] BR =bedrock BL =boulder CB = cobble GR =Gravel SD=sand FS=fines/sediment AV = Aquatic vegetation

[2] High, Moderate, Low, Undetermined

APPENDIX B – WEEKLY WATER SURFACE ELEVATION CHARTS (MAY – JULY 2015)

Figure B-1: WSEL Data from May 4-May 10, 2015

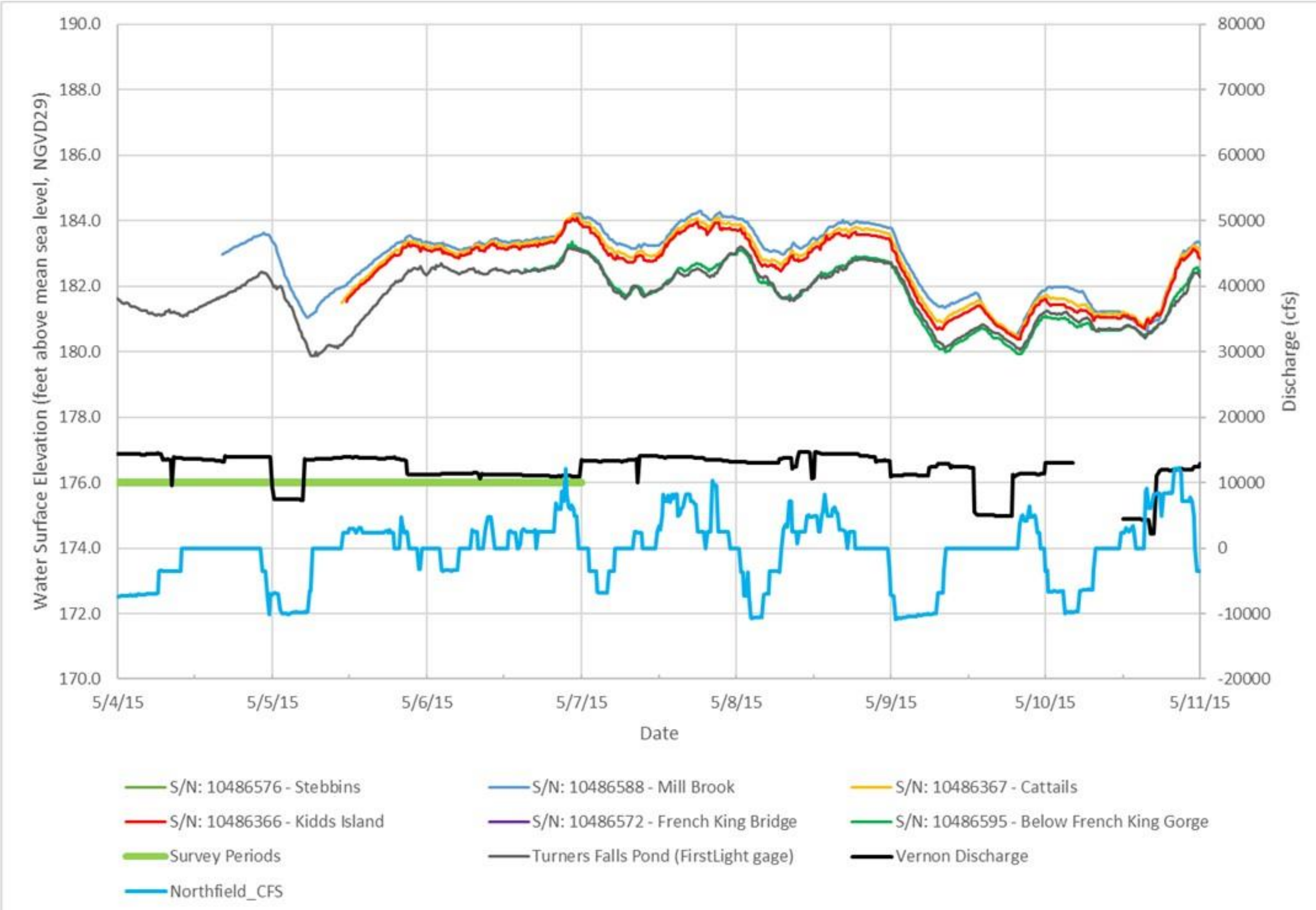


Figure B-2: WSEL Data from May 10-May 17, 2015

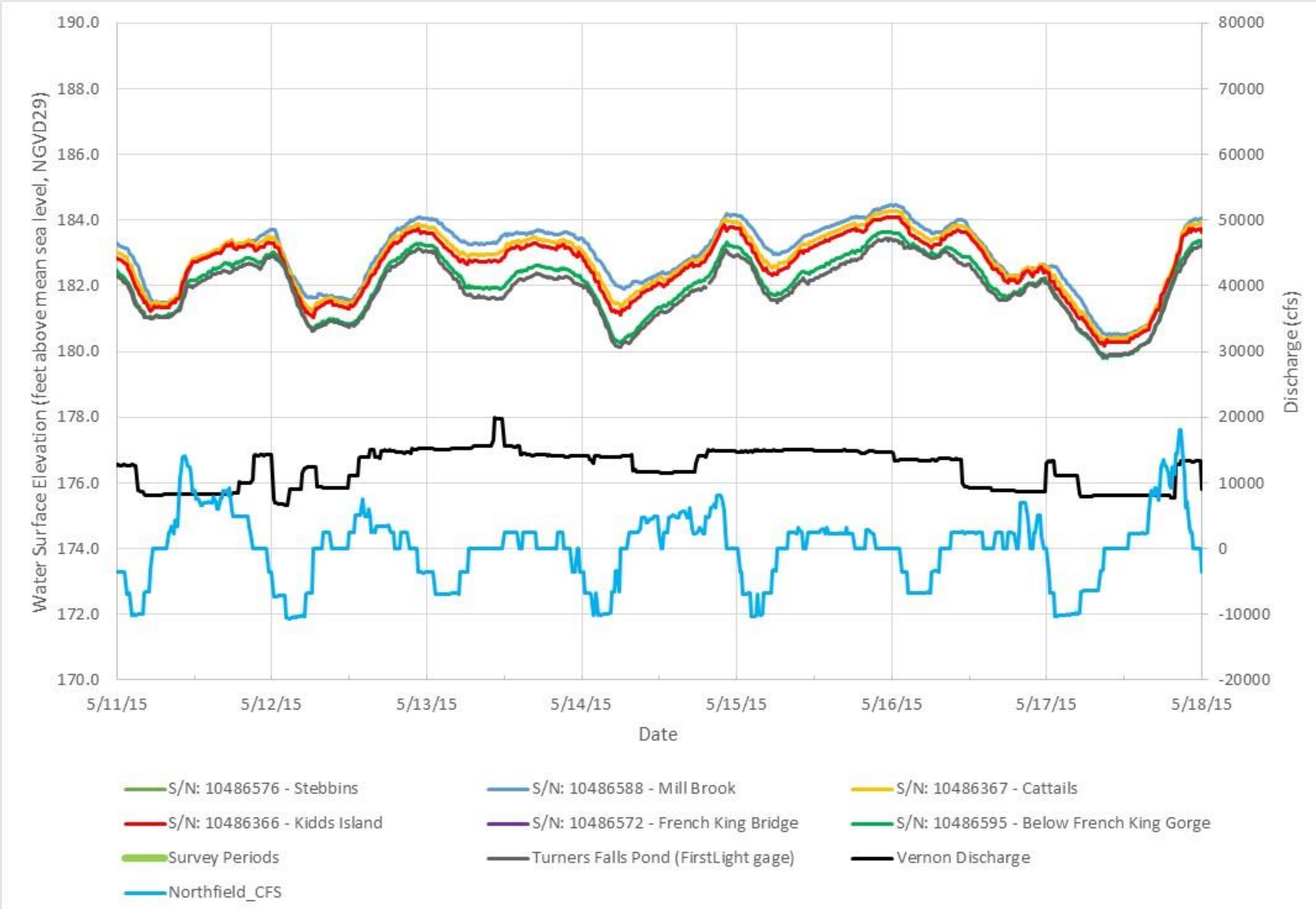


Figure B-3: WSEL Data from May 18-May 24, 2015

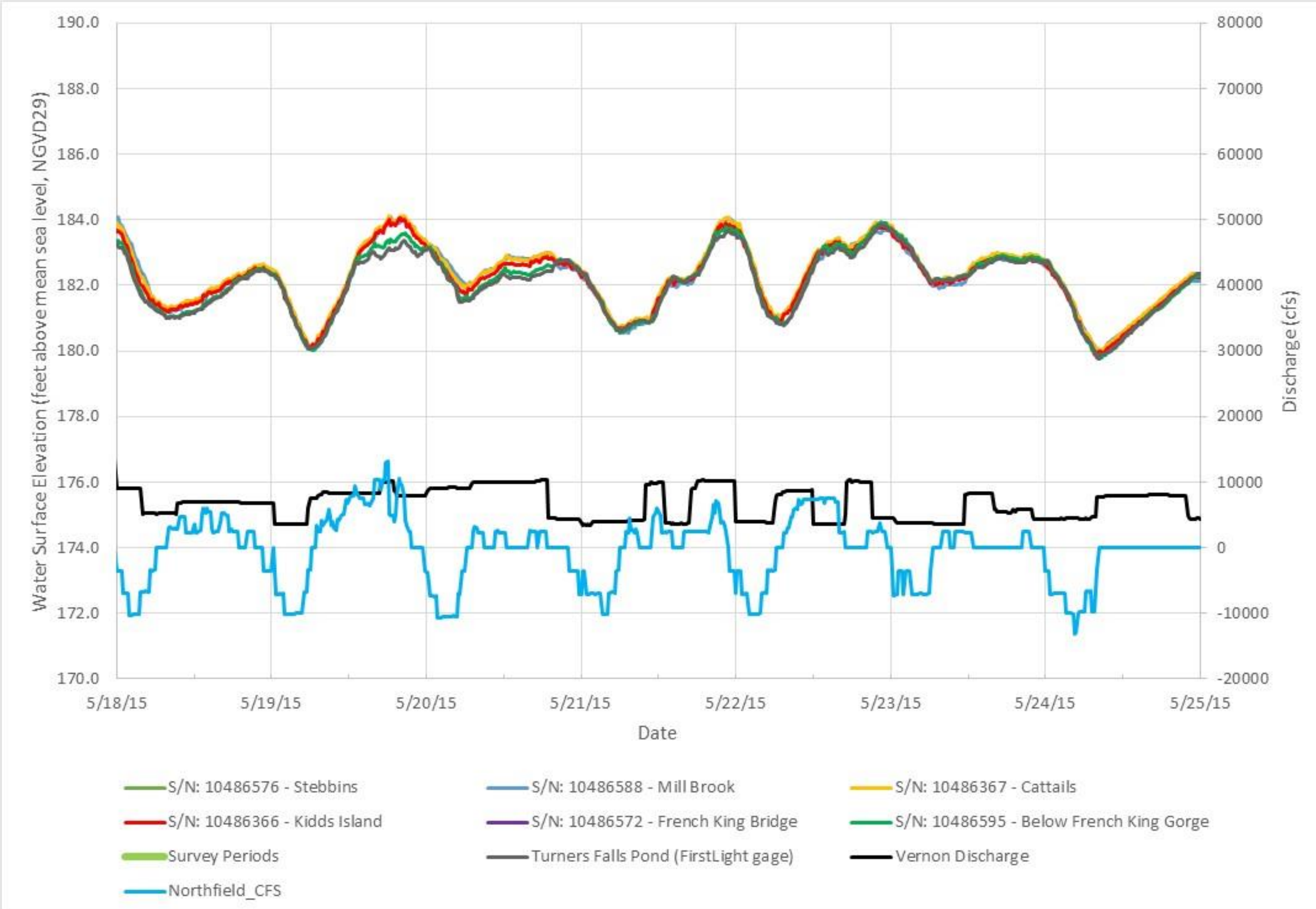


Figure B-4: WSEL Data from May 25-May 31, 2015

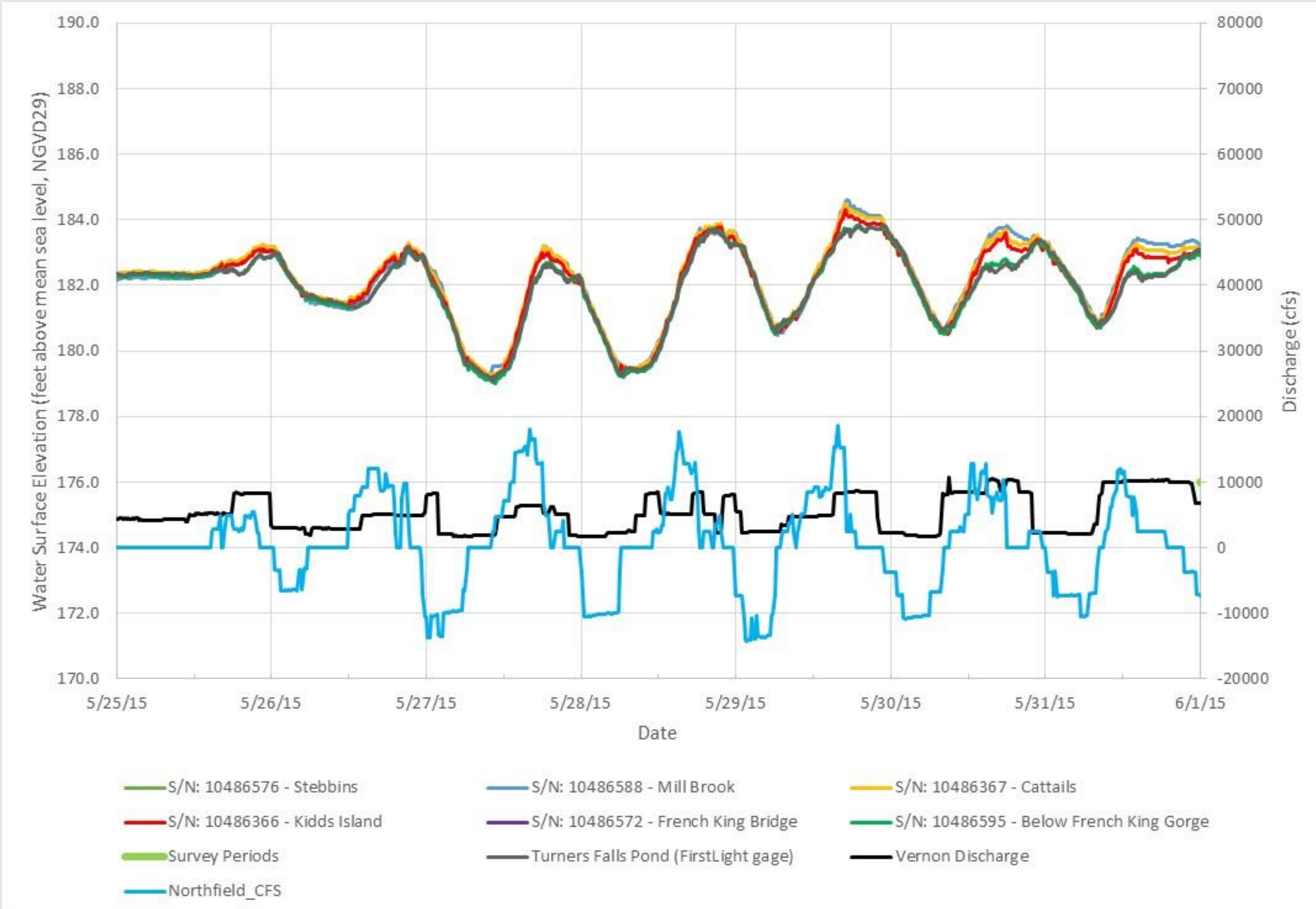


Figure B-5: WSEL Data from June 1-June 7, 2015

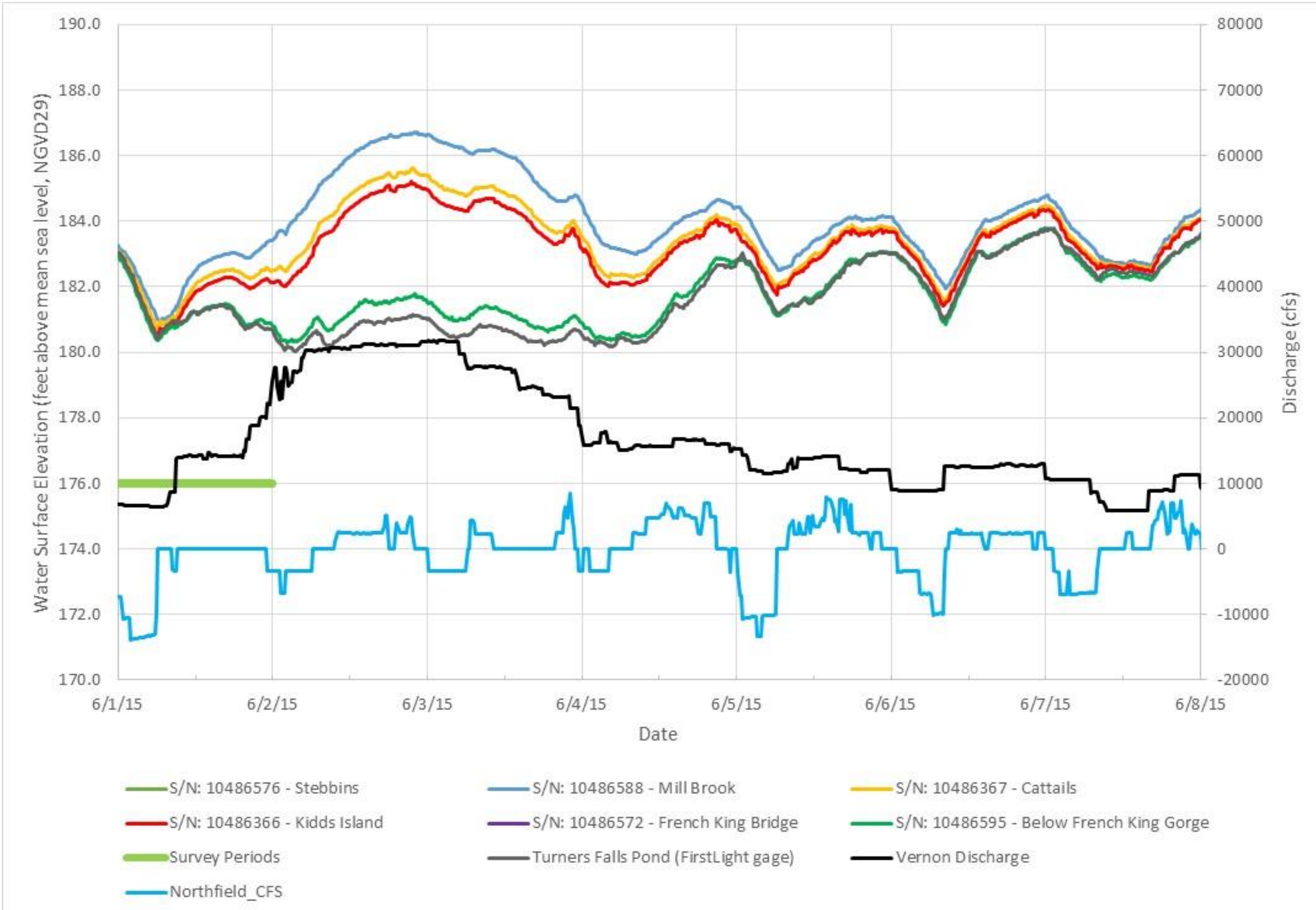


Figure B-6: WSEL Data from June 8-June 14, 2015

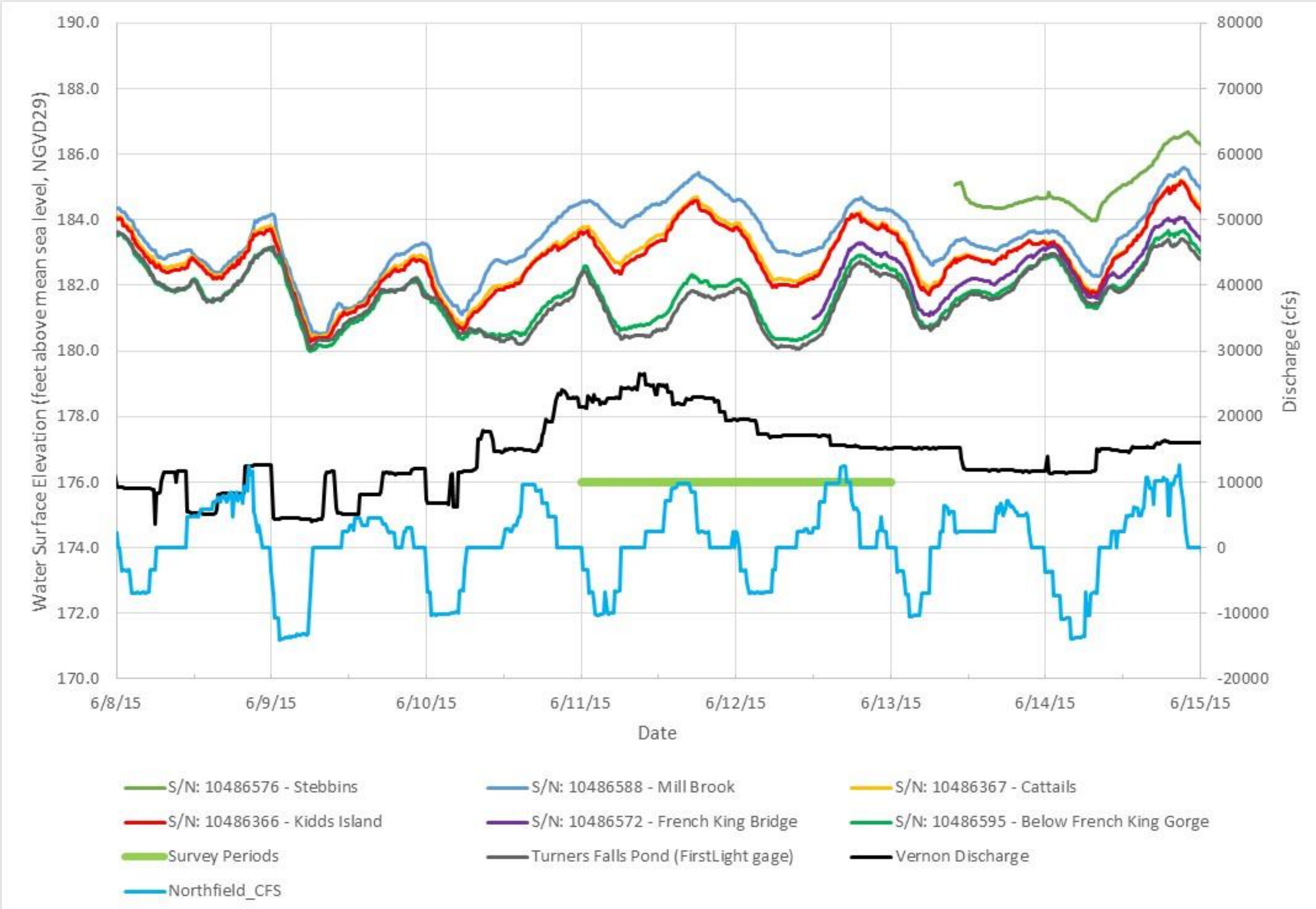


Figure B-7: WSEL Data from June 15-June 21, 2015

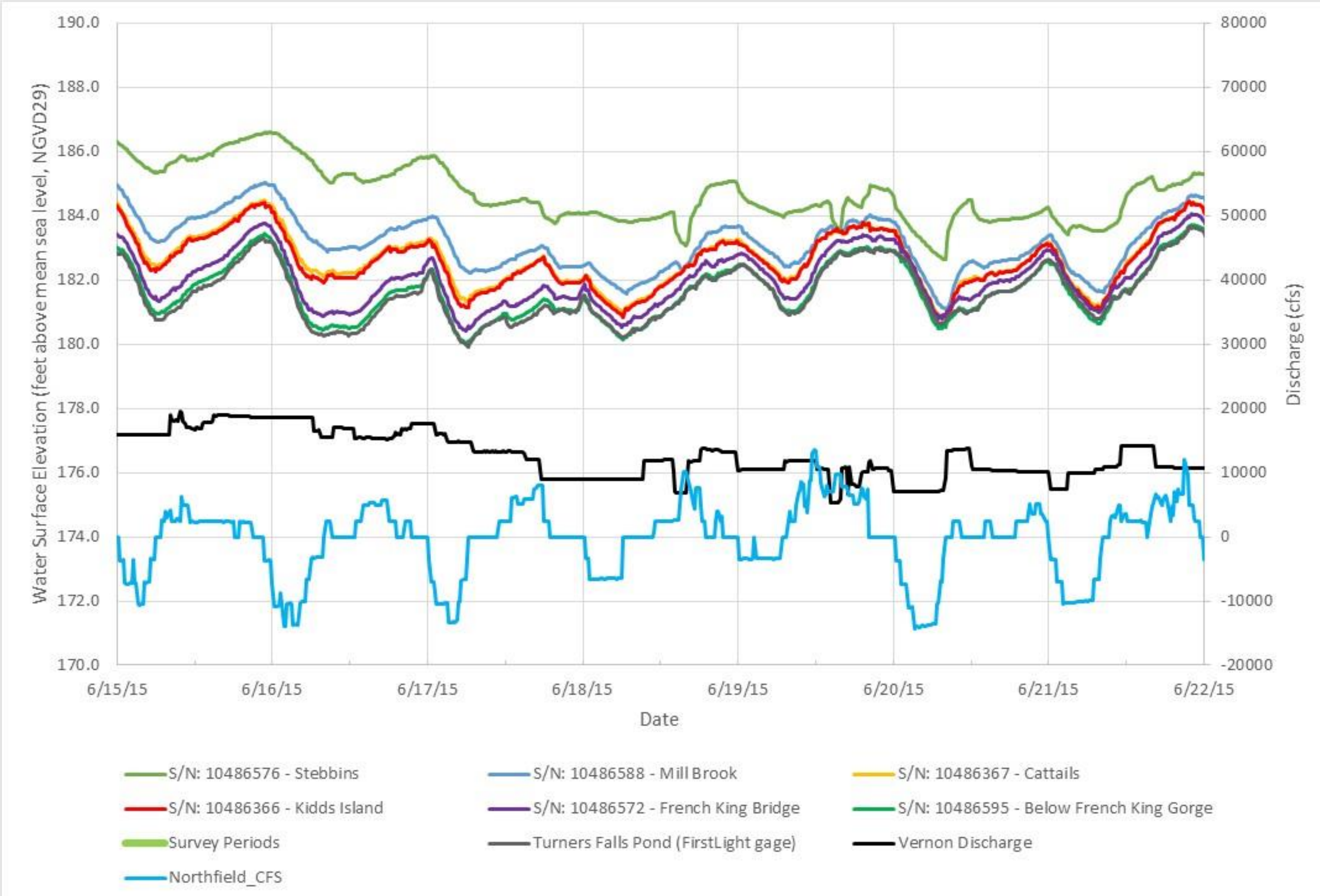


Figure B-8: WSEL Data from June 22-June 28, 2015

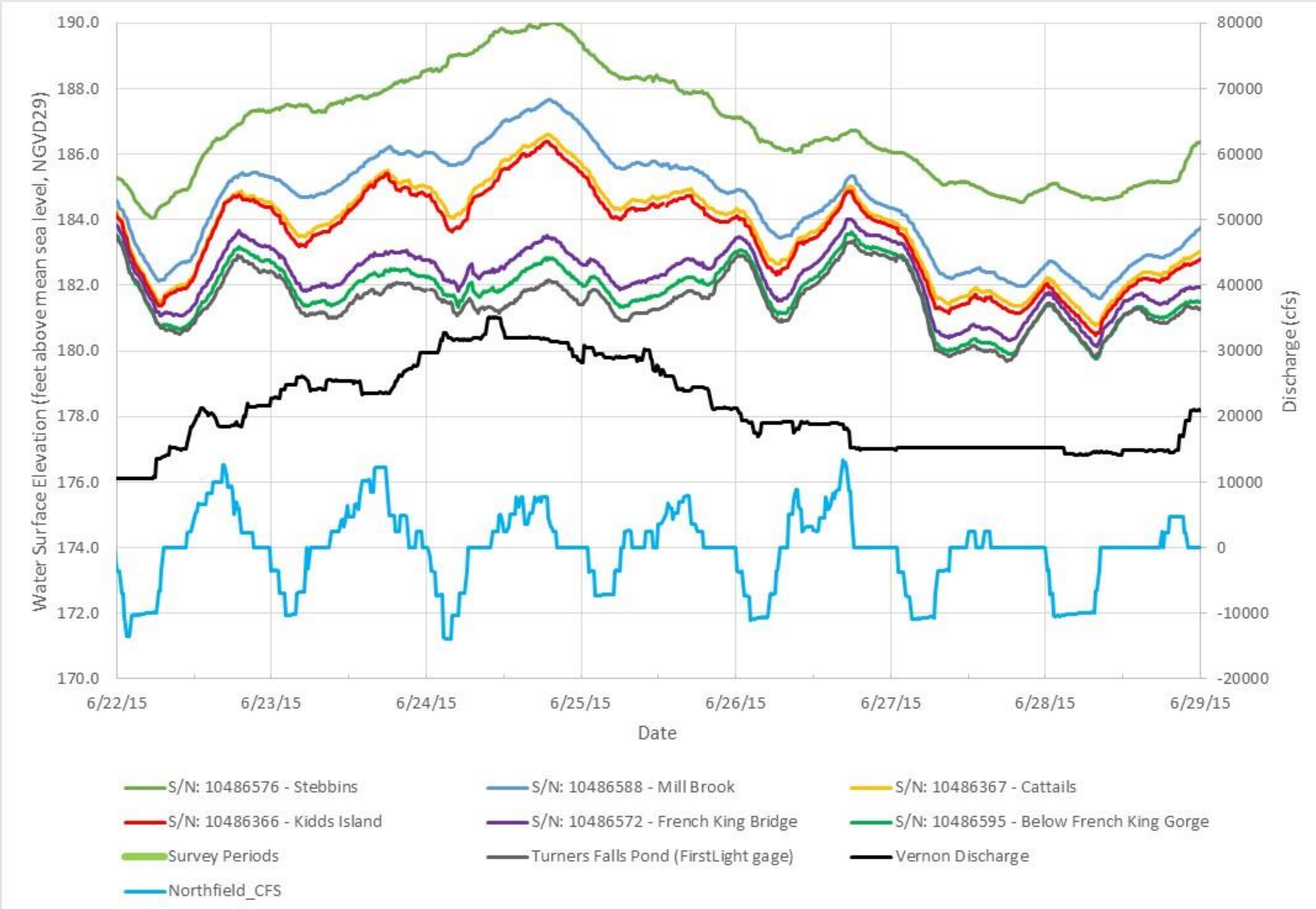


Figure B-9: WSEL Data from June 29-July 5, 2015

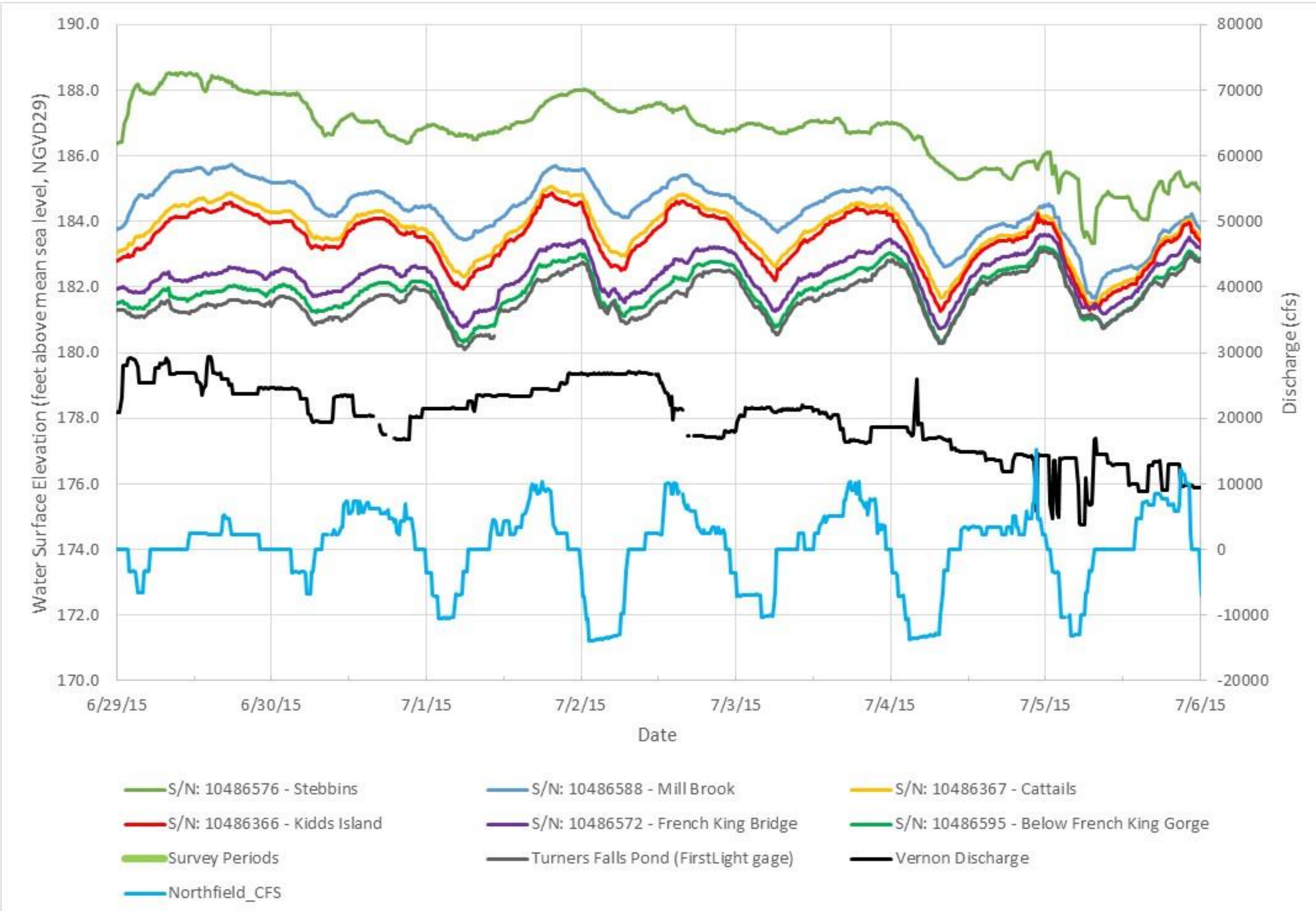


Figure B-10: WSEL Data from July 6-July 12, 2015

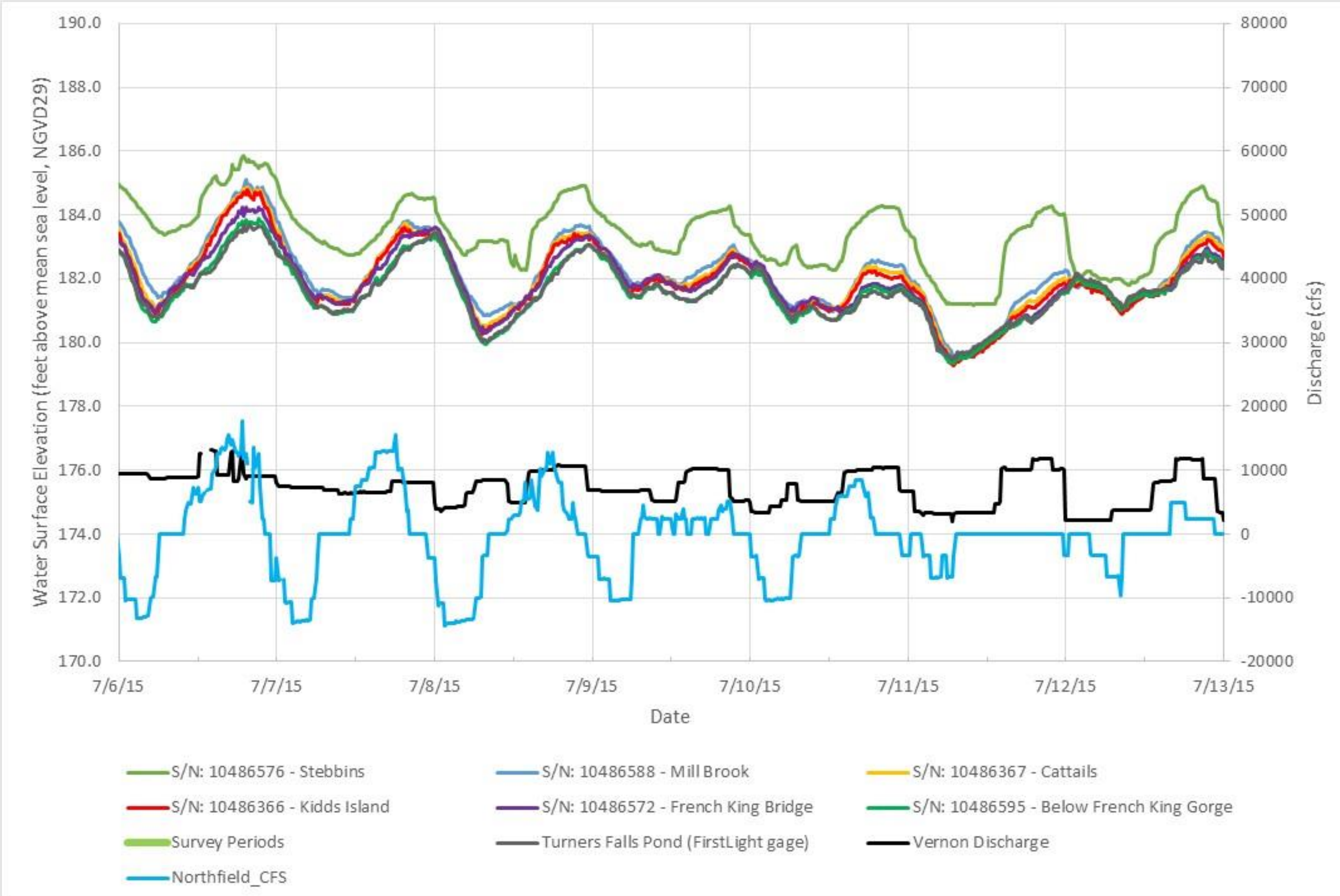


Figure B-11: WSEL Data from July 13-July 19, 2015

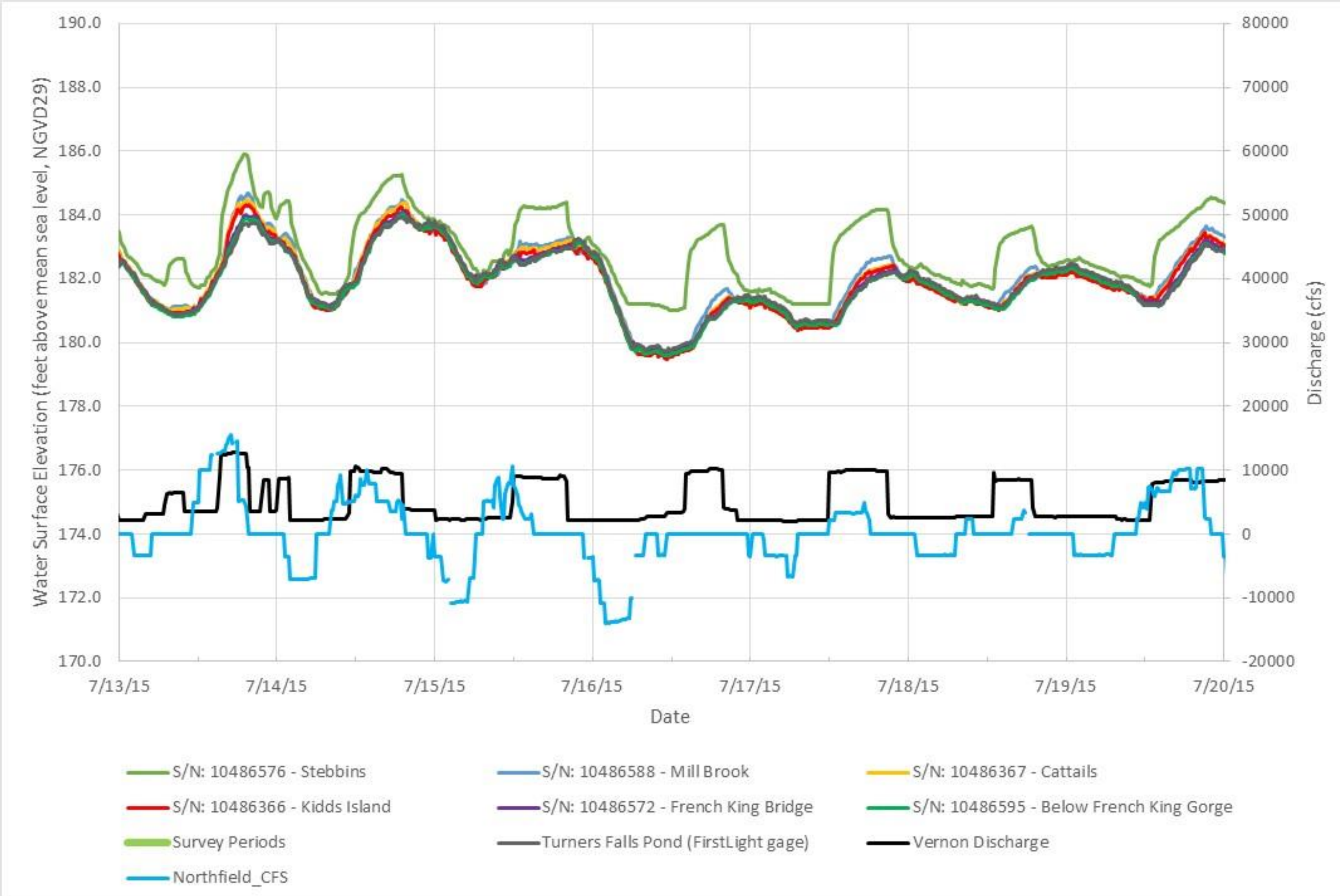
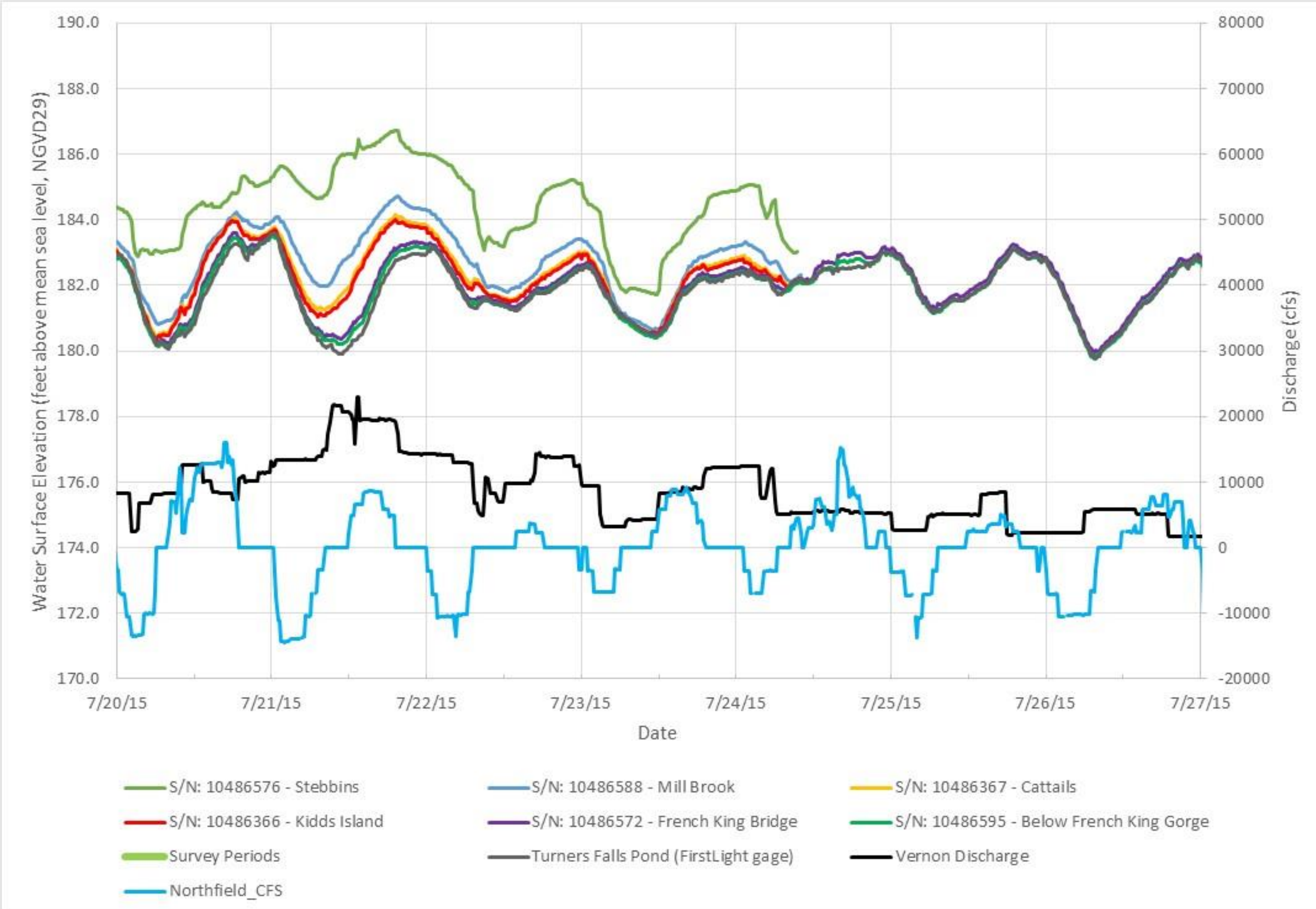


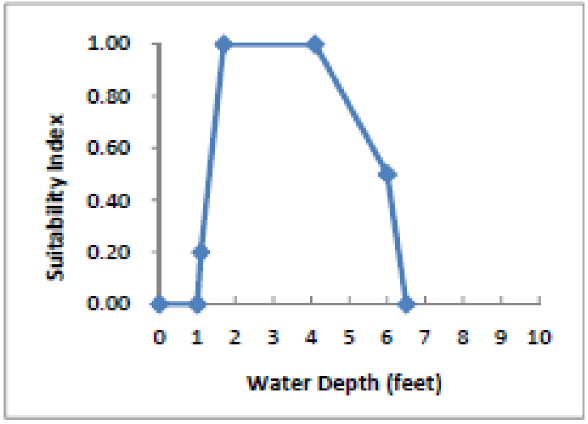
Figure B-12: WSEL Data from July 20-July 26, 2015



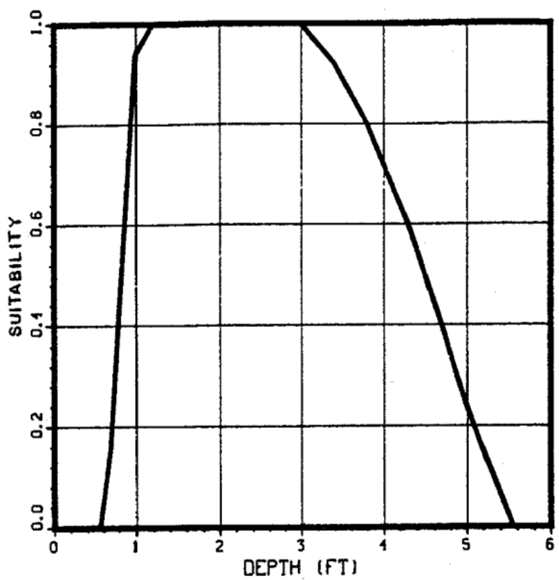
APPENDIX C – HABITAT SUITABILITY INDEX CURVES FOR DEPTH FOR VARIOUS FISH

Depth Suitability Criteria

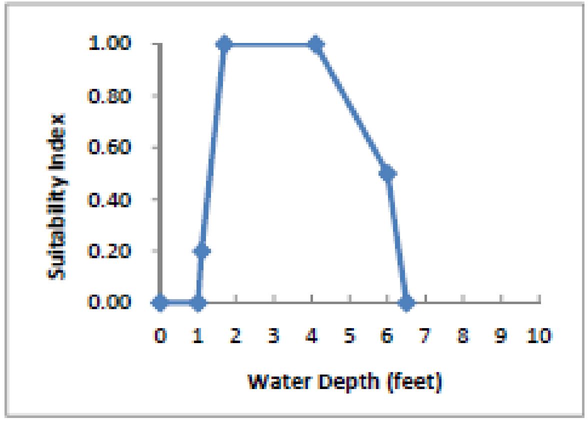
WALLEYE *(source: Turners Falls IFIM study)*



YELLOW PERCH
McMahon, *et. al*,, 1984.

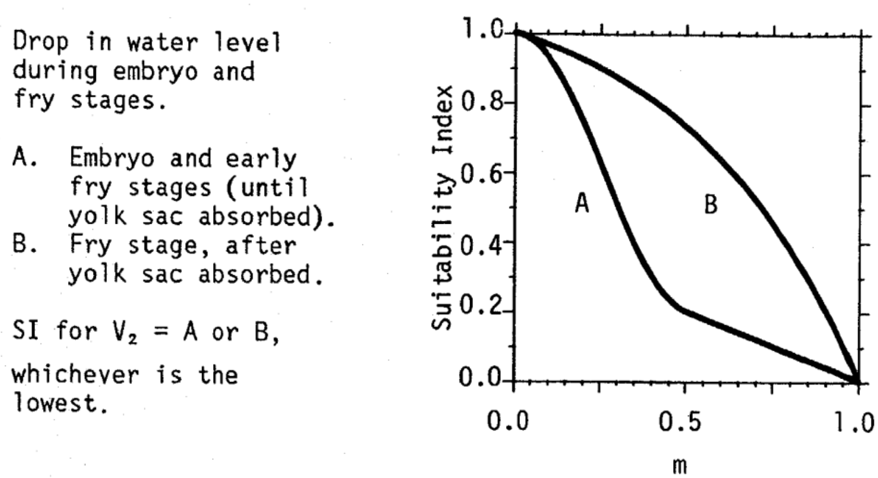


WHITE SUCKER *(source: Turners Falls IFIM study)*



NORTHERN PIKE

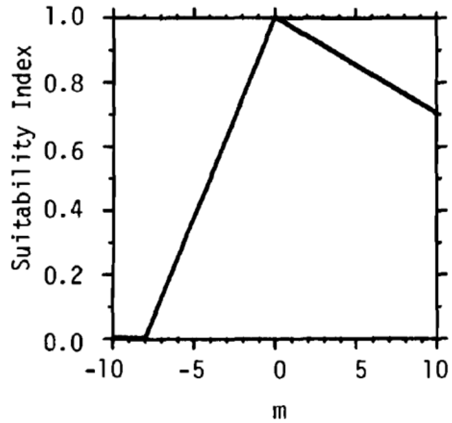
Pike rely on submerged vegetation (*Inskip, 1982; Maccahar and Thomas, 1972*). No specific depths are preferred, however Inskip (1982) provides some general guidance on post-spawning suitability (embryo and fry lifestages) of drop in water level.



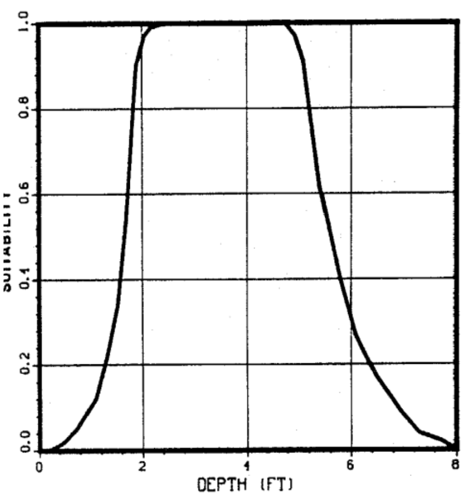
LARGEMOUTH BASS (source: Struber *et al.*, 1982b)

substrates, including vegetation, roots, sand, mud, and cobble (Harlan and Speaker 1956; Mraz and Cooper 1957; Mraz et al. 1961). Nests are constructed by the male at water depths averaging 0.3-0.9 m, with depths ranging from about 0.15 m to 7.5 m (Swingle and Smith 1950; Harlan and Speaker 1956; Mraz 1964; Clugston 1966; Allan and Romero 1975). Nests have been found as deep as 8.23 m in a reservoir where depth increased during the spawning period (Miller and Kramer 1971).

Maximum water level fluctuation during spawning. (Embryo)



SMALLMOUTH BASS (source: Edwards, *et al*., 1983)



SUNFISH (BLUEGILL) (source: Struber *et al.*, 1982a)

Reproduction

Bluegills are repeat spawners and the spawning season may extend from spring through summer (Anderson, pers. comm.). Spawning occurs from 17 to 31° C, with peak spawning at 24-27° C (Clugston 1966; Emig 1966; Scott and Crossman 1973; Kitchell et al. 1974; Pflieger 1975). Bluegills are guarding, nest building lithophils (Balon 1975). Nests are usually found in quiet, shallow (1-3 m) water (Swingle and Smith 1943). Although spawning will occur over almost any substrate, fine gravel or sand is preferred (Stevenson et al. 1969; Pflieger 1975). Incubation time ranges from 1.5 to 5 days, depending on ambient water temperature (Morgan 1951; Childers 1967; Heckman 1969; Hall et al. 1970; Merriner 1971).

Reservoir drawdown during spawning (embryo).