TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 13
Tributary and Backwater Fish Access and Habitats Study

Final Study Report

In support of Federal Energy Regulatory Commission Relicensing of:

Wilder Hydroelectric Project (FERC Project No. 1892-026)
Bellows Falls Hydroelectric Project (FERC Project No. 1855-045)
Vernon Hydroelectric Project (FERC Project No. 1904-073)

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EXECUTIVE SUMMARY

The goals of this study were to assess whether water-level fluctuations from project operations impede fish movement into and out of tributaries and backwater areas within the project-affected areas; and affect available fish habitat and water quality in the tributaries and backwater areas within the study area. The objectives of this study were to conduct a field study of a subset of tributaries and backwaters to identify and assess the potential effects of project related water-level fluctuations on fish access, available habitat, and water quality. The study area included 37 tributary and backwater sites within the area from the uppermost extent of the Wilder impoundment to the area downstream of Vernon Dam, including the Wilder, Bellows Falls, and Vernon impoundments and the riverine sections downstream of Wilder and Bellows Falls dams, and extending approximately 1.5 miles below Vernon dam.

The study was conducted from the period between late July and mid-November 2014 during which time each site was visited multiple times. Water level loggers were installed within the tributaries and backwaters along with a comparison water level logger installed in the Connecticut River mainstem near the confluence with the tributary/backwater. Bed profiles were measured and the length of the project-affected reach was estimated for each study site. Water quality data was collected and photographs were during each site visit.

Analysis based on summer/fall 2014 observations and water level logger data, and based on hydraulic and operations model (Studies 4 and 5) data for spring time (April 1 – June 30) indicate that normal project operations have little to no effect on fish ability to access tributaries on most days. Site-specific factors that may limit access include low or intermittent tributary flow and water depth, debris l accumulation from the tributaries themselves, and culverts, all of which are unrelated to normal project operations. Water quality at all sites is also not discernably affected by project operations.

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TABLE OF CONTENTS

List of Figures ..... **ii**

List of Tables ..... **iii**

List of Abbreviations ..... **iv**

1.0 INTRODUCTION **1**

2.0 STUDY GOALS AND OBJECTIVES **2**

3.0 STUDY AREA **2**

4.0 METHODOLOGY **9**

4.1 Field Sampling 9

4.2 Data Processing 10

5.0 RESULTS AND DISCUSSION **12**

5.1 Water Level Logger Data 12

5.2 Summary of Site Conditions 19

5.3 Water Quality 23

6.0 ASSESSMENT OF PROJECT EFFECTS **25**

6.1 Assessment of Project Effects on Water Depth and Fluctuation 25

7.0 Study Conclusions **55**

8.0 LITERATURE CITED **57**

APPENDIX A: TRIBUTARY AND BACKWATER STUDY SITE DETAIL

APPENDIX B1 AND B2: 2014 WATER QUALITY DATA (FILED SEPARATELY IN EXCEL FORMAT)

APPENDIX C: COMPARISON OF 2014 FIELD DATA WITH MODEL DATA (FILED SEPARATELY IN EXCEL FORMAT)

APPENDIX D: DAILY PERCENT OF ACCESS TIME WSE PLOTS BASED ON MODEL DATA

List of Figures

Figure 3.0-1. Tributary and backwater study locations. 5
Figure 4.1-1. Installation set-up used for HOBO water level loggers. 10
Figure 6.1-1. Representative operating conditions at Site CT-WR-2.01, 2014 (discharge and WSE vertical scales are not correlated)..... 32
Figure 6.1-2. Representative operating conditions at Site CT-WR-2.07, 2014 (discharge and WSE vertical scales are not correlated)..... 33
Figure 6.1-3. Representative operating conditions at Site CT-WR-2.10, 2014 (discharge and WSE vertical scales are not correlated)..... 34
Figure 6.1-4. Representative operating conditions at Site CT-WR-2.1, 2014 (discharge and WSE vertical scales are not correlated)..... 35
Figure 6.1-5. Representative operating conditions at Site CT-B-3.10, 2014 (discharge and WSE vertical scales are not correlated)..... 37
Figure 6.1-6. Representative operating conditions at Site CT-BR-4.02, 2014 (discharge and WSE vertical scales are not correlated)..... 38
Figure 6.1-7. Representative operating conditions at Site CT-BR-4.04, 2014 (discharge and WSE vertical scales are not correlated)..... 39
Figure 6.1-8. Representative operating conditions at Site CT-V-5.02, 2014 (discharge and WSE vertical scales are not correlated)..... 40
Figure 6.1-9. Representative operating conditions at Site CT-VR-6.01, 2014 (discharge and WSE vertical scales are not correlated)..... 42
Figure 6.1-10. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.01 (discharge and WSE vertical scales are not correlated). 42
Figure 6.1-11. Representative operating conditions at Site CT-VR-6.05, 2014 (discharge and WSE vertical scales are not correlated)..... 44
Figure 6.1-12. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.05 (discharge and WSE vertical scales are not correlated). 44
Figure 6.1-13. Vernon tailwater elevation at different station discharge levels, 2014, illustrating effect of Turner's Falls impoundment on elevation. 45

List of Tables

Table 3.0-1. Tributary and backwater study locations. 3
Table 4.2-1. Use code definitions for HOBO water level logger data. 11
Table 4.2-2. Lot sampling plan for QC inspection at less than 1% AOQL. 11
Table 5.1-1. Summary of 2014 site visits and level logger data notes. 15
Table 5.2-1. Project-affected reach length, confluence cross-section water depth, notes and observations from site visits..... 21
Table 6.1.1-1. Percent occurrence of < 0.5 ft water depth at the confluence of each study site. 25
Table 6.1.1-2. Summary of 2014 conditions at potentially affected sites based on water level logger data. 29
Table 6.1.1-3. Mainstem WSE values recorded at potentially affected sites based on water level logger data, 2014 and Hydraulic Model. 31
Table 6.1.2-1. Criteria for categorization of spring time access restrictions. 47
Table 6.1.2-2. Summary of modeled access restrictions to study sites under normal project operations for 50% and 100%-of-day criteria. 48
Table 6.1.2-3. Comparison of access restrictions in 2014 and under normal project operations with modeled 50% and 100%-of-date criteria. 50
Table 6.1.2-4. Summary of non-project factors limiting access for sites characterized as frequently or occasionally restricted in spring time based on model data (50%-of-day criterion). 52
Table 6.1.2-5. Comparison of measured tributary water depth and USGS[a] daily mean discharge data for the Cold River, 2014. 54
Table 7.0-1. Comparison of study sites to available sites, by stream order. 56

List of Abbreviations

AOQL	Average Outgoing Quality Limit
CRWC	Connecticut River Watershed Council
DO	Dissolved oxygen
FERC	Federal Energy Regulatory Commission
FWS	U.S. Department of the Interior – Fish and Wildlife Service
µS/cm	Micro-siemens per centimeter
NHDES	New Hampshire Department of Environmental Services
NHFGD	New Hampshire Fish and Game Department
NTU	Nephelometric Turbidity Units
RTK	Real Time Kinematic Unit
SN	Serial number
su	Standard units
TransCanada	TransCanada Hydro Northeast Inc.
VANR	Vermont Agency of Natural Resources
VDEC	Vermont Department of Environmental Conservation
WSE	Water surface elevation

1.0 INTRODUCTION

This study was conducted in support of Federal Energy Regulatory Commission (FERC) relicensing efforts by TransCanada Hydro Northeast Inc. (TransCanada) for the Wilder Hydroelectric Project (FERC Project No. 1892), Bellows Falls Hydroelectric Project (FERC No. 1855) and the Vernon Hydroelectric Project (FERC No. 1904).

Operations at TransCanada's Wilder, Bellows Falls, and Vernon hydroelectric projects (projects) may impede fish movement into and out of tributary and backwater areas in the impoundments and riverine reaches. In their study requests, U.S. Department of the Interior-Fish and Wildlife Service (FWS), New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish and Game Department (NHFGD), Vermont Agency of Natural Resources (VANR), and Connecticut River Watershed Council (CRWC) expressed concern that water-level fluctuations due to project operations have the potential to create conditions that could impede the movement of fish between the Connecticut River and its tributaries and backwaters. These conditions, if present, could limit access to spawning habitat and growth opportunities. Additionally, project-related, water-level changes have the potential to alter water quality in these areas, which could decrease productivity.

The Study 13 Revised Study Plan (RSP) as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of project-affected tributaries and backwaters would be evaluated for potential effects of water-level fluctuations on fish access, habitat and water quality. An initial site selection report was posted on TransCanada's relicensing website on May 8, 2014 and comments were received during an aquatics working group meeting held on May 23, 2014; during a follow up conference call on July 1, 2014; and in email communications from FWS and NHFGD (July 2, July 8, and July 9, 2014). The final sampling locations were randomly selected in the Updated Revised Site Selection Report (Normandeau 2014a) which included modifications that addressed all working group discussion and comments. The Final Site Selection Report was filed with FERC on September 15, 2014 in Volume III.C of TransCanada's Initial Study Report.

The initial study report was filed on September 14, 2015 and was based on preliminary assessment of project effects based on field observations and water level logger data collected in 2014. This final study report provides water quality data collected at two sites downstream of Vermont Yankee (VY) in 2015. Collection of this additional water quality data after the closure of VY was requested by stakeholders in a technical meeting held November 26, 2013; discussed as part of a December 18, 2013 aquatics working group conference call; and included in TransCanada's December 31, 2013 study plan modification letter to FERC.

This final report also incorporates revisions based on stakeholder comments on the initial study report and on a TransCanada proposed approach to assessing spring

time fish access restrictions (as requested by and provided to the working group on April 6, 2016). Sections 6.1.2 – 6.1.3 of this final report describe the new analysis and provide results based on modeled data in the spring time.

2.0 STUDY GOALS AND OBJECTIVES

As stated in the Revised Study Plan (RSP), the goals of this study were to assess whether water-level fluctuations from project operations:

- impede fish movement into and out of tributaries and backwater areas within the project-affected areas; and;
- Affect available fish habitat and water quality in the tributaries and backwater areas within the project-affected areas.

Specific objectives for this study were to conduct a field study:

- of a subset of tributaries and backwaters in the project-affected areas to assess potential effects of water-level fluctuations on fish access to these areas in the impoundments and riverine reaches below the projects; and
- to examine potential effects of water level fluctuations on available habitat and water quality in a subset of project-affected tributaries and backwaters.

3.0 STUDY AREA

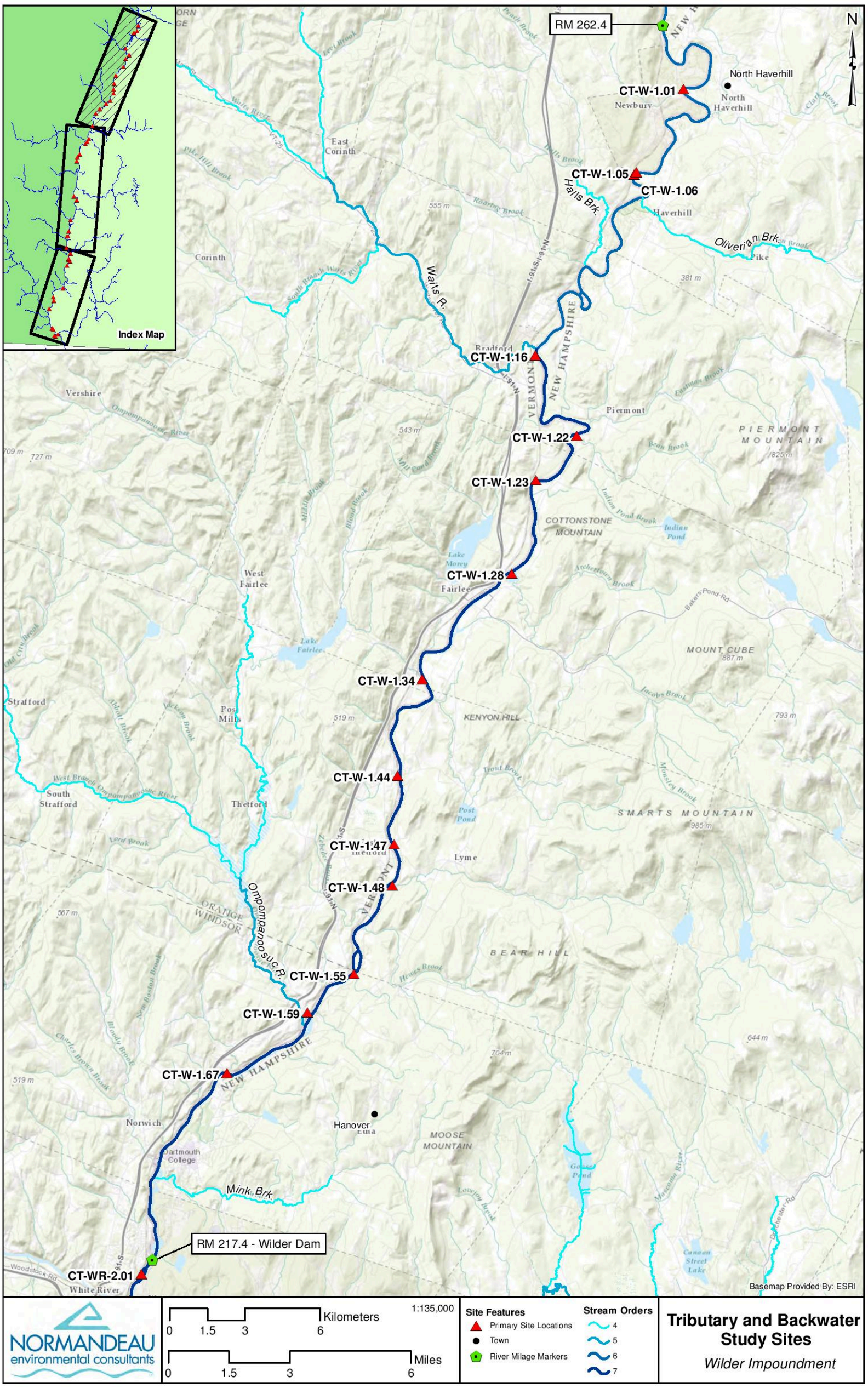
Locations for the assessment of tributary and backwater access were randomly selected within nine sub-reaches defined by project structures, naturally occurring river breaks, and the magnitude of daily water surface elevation (WSE) fluctuations occurring within the project area from the upper extent of Wilder impoundment (RM 262.4) to the downstream extent of Stebbins Island below Vernon Dam (RM 141.9). These sub-reaches were defined during the selection process detailed in the Updated Revised Site Selection Report (Normandeau 2014a). Thirty-six randomly selected sampling locations were identified and one site (Cold River, ID CT-BR-4.02) was added to the study at the request of NHFGD. A full listing of the 37 study sites is presented in tabular format in Table 3.0-1 and graphically in Figure 3.0-1.

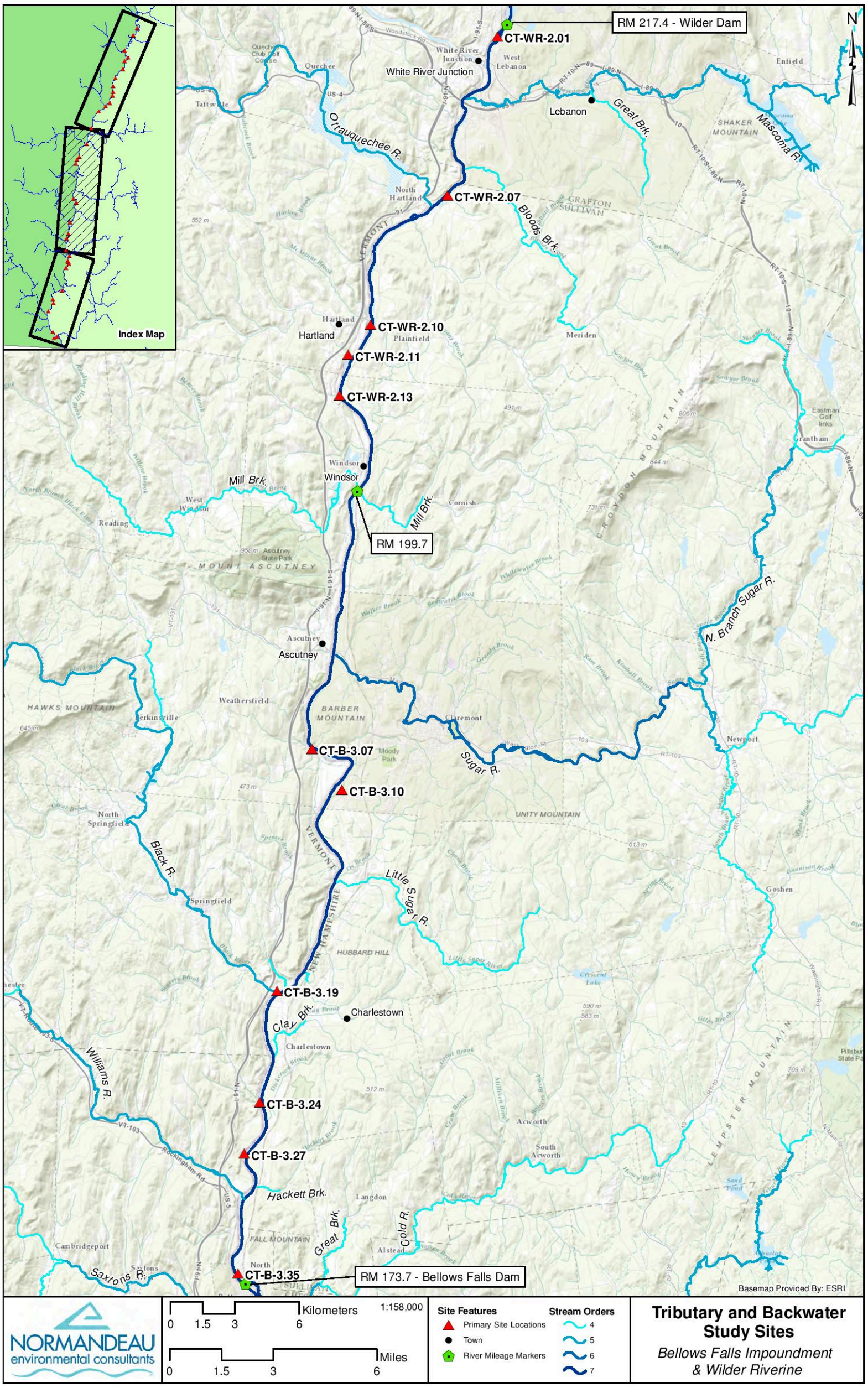
Table 3.0-1. Tributary and backwater study locations.

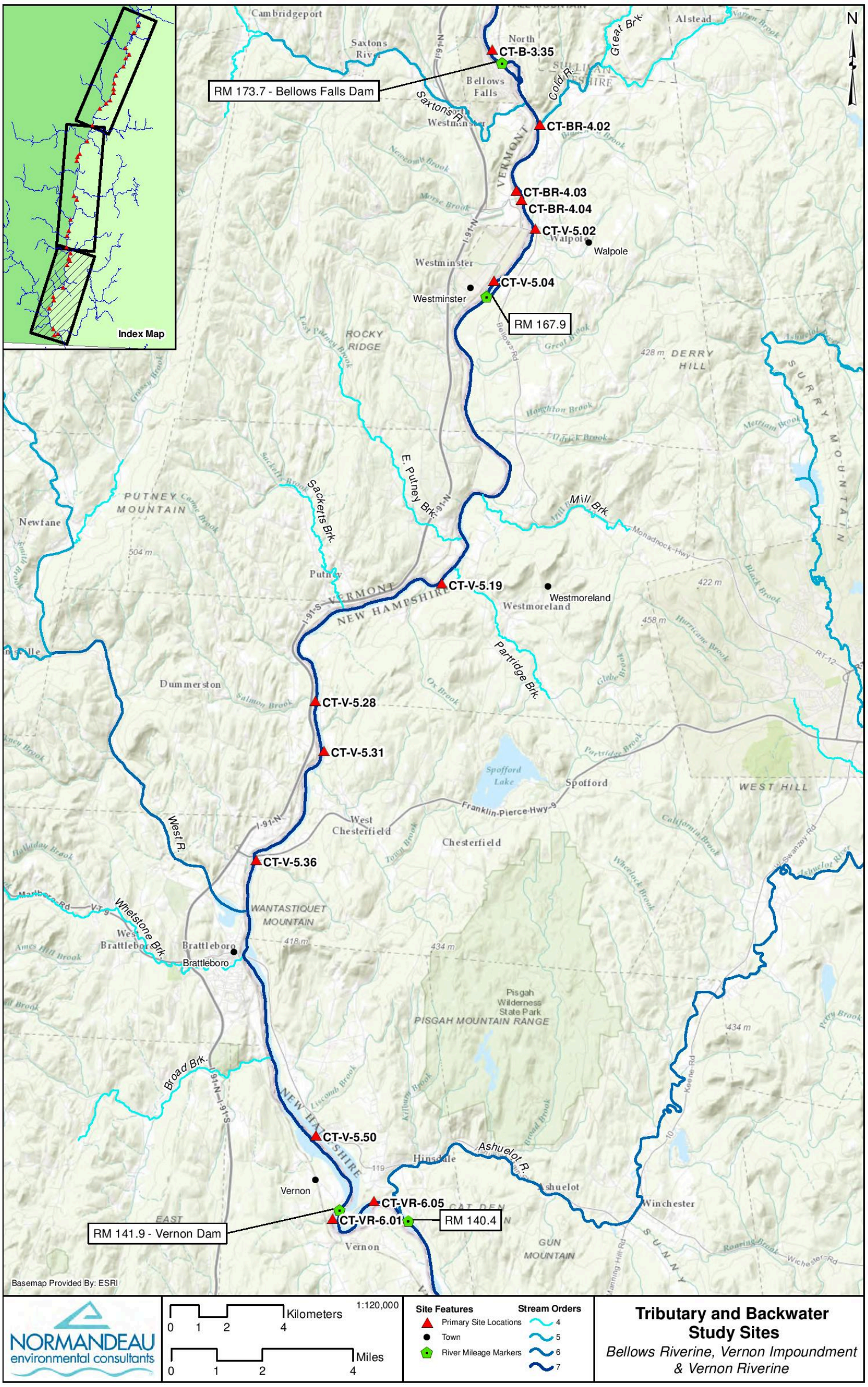
Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Coordinates	
CT-W-1.01	Upper Wilder	Minor Trib	Harriman Brook	2	-72.043789	44.087891
CT-W-1.05	Upper Wilder	Backwater		n/a	-72.067176	44.058021
CT-W-1.06	Upper Wilder	Minor Trib		2	-72.068263	44.057211
CT-W-1.16	Upper Wilder	Backwater		n/a	-72.116927	43.992195
CT-W-1.22	Middle Wilder	Major Trib	Indian Pond Brook	3	-72.096067	43.963445
CT-W-1.23	Middle Wilder	Minor Trib		1	-72.116113	43.947391
CT-W-1.28	Middle Wilder	Backwater		n/a	-72.128038	43.913834
CT-W-1.34	Middle Wilder	Minor Trib		2	-72.171864	43.875890
CT-W-1.44	Middle Wilder	Backwater		n/a	-72.183827	43.841237
CT-W-1.47	Lower Wilder	Minor Trib		1	-72.185333	43.816672
CT-W-1.48	Lower Wilder	Major Trib	Grant Brook	3	-72.186158	43.801778
CT-W-1.55	Lower Wilder	Minor Trib		1	-72.204879	43.770009
CT-W-1.59	Lower Wilder	Backwater		n/a	-72.227711	43.756159
CT-W-1.67	Lower Wilder	Minor Trib		2	-72.267375	43.734246
CT-WR-2.01	Upper Wilder Riverine	Minor Trib		2	-72.308929	43.661900
CT-WR-2.07	Upper Wilder Riverine	Minor Trib	Hanchetts Brook	1	-72.337180	43.595029
CT-WR-2.10	Lower Wilder Riverine	Minor Trib	McArthur Brook	2	-72.380636	43.540433
CT-WR-2.11	Lower Wilder Riverine	Major Trib	Lulls Brook	3	-72.393608	43.527828
CT-WR-2.13	Lower Wilder Riverine	Minor Trib	Bashan Brook	1	-72.398248	43.510763
CT-B-3.07	Bellows	Major Trib	Barkmill Brook	3	-72.412279	43.362394
CT-B-3.10	Bellows	Minor Trib		1	-72.394886	43.345417
CT-B-3.19	Bellows	Backwater		n/a	-72.431303	43.260732
CT-B-3.24	Bellows	Major Trib	Commissary Brook	3	-72.440597	43.213887
CT-B-3.27	Bellows	Minor Trib		2	-72.449136	43.192375
CT-B-3.35	Bellows	Minor Trib		2	-72.452103	43.142063
CT-BR-4.02	Bellows Riverine	Major Trib	Cold River	5	-72.431083	43.118314
CT-BR-4.03	Bellows Riverine	Minor Trib		2	-72.440915	43.097277
CT-BR-4.04	Bellows Riverine	Major Trib	Cobb Brook	3	-72.438781	43.094376
CT-V-5.02	Vernon	Minor Trib	Mad Brook	2	-72.432666	43.085102
CT-V-5.04	Vernon	Major Trib		3	-72.450288	43.068487
CT-V-5.19	Vernon	Minor Trib		1	-72.471748	42.971787

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Coordinates	
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	-72.526038	42.933915
CT-V-5.31	Vernon	Minor Trib		2	-72.521983	42.918029
CT-V-5.36	Vernon	Minor Trib		2	-72.550993	42.882986
CT-V-5.50	Vernon	Backwater		n/a	-72.523771	42.795522
CT-VR-6.01	Vernon Riverine	Minor Trib		2	-72.516318	42.768916
CT-VR-6.05	Vernon Riverine	Minor Trib		1	-72.498398	42.774687

Figure 3.0-1. Tributary and backwater study locations.




RM 217.4 - Wilder Dam
CT-WR-2.01
White River Junction
West Lebanon
Lebanon
Enfield
Ottauquechee R.
Great Brk.
Mascoma R.
SHAKER MOUNTAIN
CT-WR-2.07
North Hartland
Bloods Brk.
GRAFTON
SULLIVAN
VERMONT
Hartland
CT-WR-2.10
Plainfield
Meriden
CT-WR-2.11
CT-WR-2.13
Eastman Golf links
Grantham
Windsor
Mill Brk.
West Windsor
Reading
Cornish
RM 199.7
MOUNT ASCUTNEY
Ascutney State Park
N. Branch Sugar R.
Ascutney
Weathersfield
BARBER MOUNTAIN
HAWKS MOUNTAIN
Perkinsville
Claremont
Newport
CT-B-3.07
CT-B-3.10
Moody Park
Sugar R.
UNITY MOUNTAIN
North Springfield
Black R.
Springfield
Little Sugar R.
Goshen
NEW HAMPSHIRE
HUBBARD HILL
CT-B-3.19
Charlestown
Clay Brk.
Williams R.
CT-B-3.24
CT-B-3.27
Rockingham Rd
Acworth
South Acworth
Hackett Brk.
Langdon
Great Brk.
Cold R.
FALL MOUNTAIN
Cambridgeport
Saxtons R.
North Saxtons
CT-B-3.35
RM 173.7 - Bellows Falls Dam
Index Map
N
Basemap Provided By: ESRI
NORMANDEAU environmental consultants
0 1.5 3 6 Kilometers
0 1.5 3 6 Miles
1:158,000
Site Features
Primary Site Locations
Town
River Mileage Markers
Stream Orders
4
5
6
7
Tributary and Backwater Study Sites
Bellows Falls Impoundment & Wilder Riverine


Index Map
N
CT-B-3.35
RM 173.7 - Bellows Falls Dam
CT-BR-4.02
CT-BR-4.03
CT-BR-4.04
CT-V-5.02
CT-V-5.04
RM 167.9
CT-V-5.19
CT-V-5.28
CT-V-5.31
CT-V-5.36
CT-V-5.50
CT-VR-6.05
CT-VR-6.01
RM 140.4
RM 141.9 - Vernon Dam
Cambridgeport
Saxtons River
North Walpole
Bellows Falls
Westminster
Walpole
Alstead
Great Brk.
Cold R.
Saxtons R.
I-91-N
VERMONT
NEW HAMPSHIRE
Newfane
PUTNEY MOUNTAIN
Putney
Westmoreland
Dummerston
Spofford
Spofford Lake
WEST HILL
West Chesterfield
Chesterfield
Brattleboro
WANTASTIQUET MOUNTAIN
Pisgah Wilderness State Park
PISGAH MOUNTAIN RANGE
Hinsdale
Ashuelot
Winchester
Vernon
GUN MOUNTAIN
ROCKY RIDGE
DERRY HILL
Sackets Brk.
E. Putney Brk.
Mill Brk.
Partridge Brk.
West R.
Whetstone Brk.
Broad Brk.
Ashuelot R.
Basemap Provided By: ESRI
1:120,000
Kilometers
0 1 2 4
Miles
0 1 2 4
Site Features
Primary Site Locations
Town
River Mileage Markers
Stream Orders
4
5
6
7
NORMANDEAU environmental consultants
Tributary and Backwater Study Sites
Bellows Riverine, Vernon Impoundment & Vernon Riverine

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4.0 METHODOLOGY

4.1 Field Sampling

Each site was first visited during July or August 2014. During the initial site visit, two HOBO level loggers (vertical accuracy of ±0.1 inch) were installed at each selected location and programmed to collect temperature and pressure information at 15-minute intervals. One level logger was installed within the tributary or backwater of interest and the second was located in the mainstem river, adjacent to the study site of interest. During installation, the exact position of each unit (latitude, longitude and elevation relative to the project structures) was recorded using a Leica GS-14 Real Time Kinematic (RTK) unit. Level loggers were maintained at their set elevations by being placed inside a perforated well pipe structure affixed to a piece of ¾-inch rebar and set vertically into the bottom substrate (Figure 4.1-1). Barometric reference loggers were installed over the study reach for use in processing water level logger data collected at the mainstem, tributary, and backwater locations.

Bed elevation information was collected at each site during the initial site visit at (1) a single cross section placed at the apparent confluence of the tributary or backwater and the mainstem river, and (2) along the thalweg of the tributary/backwater within the apparent project-affected area. The approximate extent of the project-affected area was determined visually by the survey crew during the initial visit. The visual examinations looked for areas that were obviously subjected to wetting due to fluctuations as well as water lines on tributary or backwater bankings or abutments, culvert pipes, large boulders, bank vegetation, and the like that indicated the predominant water surface elevation.

Bed elevation points were collected using the Leica RTK unit where coverage was available and by the use of a Topcon level and stadia rod referenced to a bench mark with a known elevation in areas where RTK coverage was unavailable (i.e., beneath heavy tree canopy). Water quality data was collected at locations generally near the midpoint of the project-affected reach and included temperature, dissolved oxygen, pH, conductivity and turbidity, using handheld meters which were calibrated at the beginning of each day. At locations with a water depth of greater than three feet, water quality data were collected in the form of vertical profiles (surface, mid, bottom). At locations with less than three feet of water depth, a single water quality measurement was made at approximate mid-depth. A series of geo-referenced photographs was taken at each location during the initial visit.

Each site was then visited once monthly during August and September, with a final visit during October or November 2014. Following each download, the level logger was returned to the well pipe. The “pull” and “set” times bracketing the period of time the level logger was out of water were recorded. The same suite of parameters recorded during the initial site visit was also collected (i.e., date-time of visit, cross section water depths at the confluence with mainstem, water quality parameters, and condition photographs). During the final visits, level loggers were

removed from the well pipe holding structure and data were downloaded to a laptop computer loaded with HOBOware Pro Software.

4.2 Data Processing

Level logger data files were downloaded and imported into HOBOware Pro Software for air pressure compensation. Sensor depths at each 15-minute interval were determined based on the relationship between recorded pressure values at the in-water level logger and in-air barometric reference location. Following determination of water depth values, each individual record was assigned a use code that defines its collection status and subsequent use in analytical tasks (Table 4.2-1). Water level logger data in Excel format and updated geodata files (in ArcGIS and kmz format) are included as part of this study report.

Data sheets containing all field recorded parameters (e.g., water quality, level logger pull and set information, bed elevations, etc.) were collected and data was keypunched and then subjected to a QC inspection to assure a 1% AOQL (Average Outgoing Quality Limit) according to a lot sampling plan (ASQL 1993). This procedure ensures that ≥99% of the observations in a data file agree with the original data sheets. The number of observations to be checked, and the number of those that must be within tolerance are presented in Table 4.2-2. If more than the acceptable number of failures is found then the data set must be inspected 100%.

Figure 4.1-1. Installation set-up used for HOBO water level loggers.

Table 4.2-1. Use code definitions for HOBO water level logger data.

Use Code	Description
1	Valid for all analytical tasks
2	Logger out of water (act of downloading)
3	Logger out of water (not yet deployed)
4	Sensor potentially out of water (based on depth readings)
5	Sensor depth exceeds reported instrument range
6	Manually flagged during data review: bad pressure data due to malfunction
7	Manually flagged during data review: ice formation in sensor
8	Manually flagged during data review: ice formation in barometer
9	Manually flagged after time series review

Table 4.2-2. Lot sampling plan for QC inspection at less than 1% AOQL.

Lot Size	Sample Size	Number of Failures	
		Accept if ≤	Reject if ≥
1-32	ALL	0	1
33-500	32	0	1
501-3,200	125	1	2
3,201-10,000	200	2	3
10,001-35,000	315	3	4
35,001-150,000	500	5	6
150,001-500,000	800	7	8
500,001 and over	1,250	10	11

5.0 RESULTS AND DISCUSSION

All 37 study sites were visited 3 or 4 times from late July to late October or mid-November, 2014. During each site visit, water quality data was collected, water depth was measured, and representative photographs were taken. Water level loggers were downloaded and replaced if found to be missing or apparently malfunctioning.

This study was conducted from late July to mid-November 2014, encompassing the late summer-early fall time period when natural tributary flows are typically lower than levels encountered during the spring. The majority of movement for fish present in the mainstem Connecticut River into tributary and backwater habitats is likely to occur during the spring spawning period (April-June). This includes backwater spawning species such as Northern Pike, Chain Pickerel, Largemouth Bass, and Pumpkinseed, tributary confluence spawners such as White Sucker, Walleye, and Smallmouth Bass, and anadromous migrants such as Sea Lamprey which may move upstream into larger tributaries. Juvenile American Shad are likely to use backwater habitat as nursery areas prior to fall outmigration. American Eels may move into (mostly larger) tributaries for their freshwater life stage, but can access tributaries in very low water levels.

Portions of the 2014 study season were somewhat drier than normal. Monthly precipitation data was collected by TransCanada at Comerford Station (at the Fifteen Mile Falls project located about 58 river miles upstream of Wilder Station) and at Bellows Falls Station. July was wetter than the 10-year average at both locations. August and September had much lower precipitation than the 10-year average as recorded at Comerford (43.6% and 84.3%, respectively), while October and November were well above average there. At Bellows Falls, August had slightly above average precipitation (102.5%), while September, October, and November were all below the 10-year average for precipitation (40.4%, 88.3%, and 66.8%, respectively).

5.1 Water Level Logger Data

Table 5.1-1 provides a summary of the installation, site visitation, and removal dates for level loggers at all 37 study sites, as well as notes on water level logger data associated with the sites. During the course of the study, there were fourteen instances of missing data from mainstem or tributary/backwater level loggers. The majority of those instances were due to either vandalism or missing equipment. Two level loggers stopped recording for unknown reasons following their initialization and deployment in the field. All units that malfunctioned, were found missing, or were vandalized were replaced immediately upon discovery. However, there remained some data gaps at some sites.

Three level loggers had bad data discovered during post-season data processing. In these cases, following correction of recorded air pressure values, data was plotted and the results were visually examined for potential outliers. In some instances, air pressure values recorded by these level loggers resulted in plotted

sensor water depths far exceeding the expected normal range for a particular location, and as a result the data was assigned a Use Code of 9 (in Table 4.2-1).

Because missing or invalid WSE data from mainstem and/or tributary/backwater site limited the period of analysis at some sites, the WSE-based data presented herein for those sites may not be truly representative of site conditions over the entire study season. WSE data from mainstem level loggers located in the vicinity of the site of interest (e.g., related to other nearby study sites) was reviewed for use as surrogate data. In all cases, the distances and the change in longitudinal gradient of the mainstem between sites precluded the reasonable use of surrogate data.

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Table 5.1-1. Summary of 2014 site visits and level logger data notes.

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Initial Visit	2nd Visit	3rd Visit	Last Visit	Level Logger Notes
CT-W-1.01	Upper Wilder	Minor Trib	Harriman Brook	2	08/04	08/26	09/25	11/04	
CT-W-1.05	Upper Wilder	Backwater		n/a	08/04	08/26	09/25	11/04	
CT-W-1.06	Upper Wilder	Minor Trib		2	08/04	08/26	09/25	11/04	Site logger post-processing found bad data. Data available from 08/04 – 08/26. Mainstem logger found missing on 11/04. Data available from 08/04 – 09/25.
CT-W-1.16	Upper Wilder	Backwater		n/a	08/06	08/26	09/25	11/04	
CT-W-1.22	Middle Wilder	Major Trib	Indian Pond Brook	3	08/06	08/26	09/25	11/04	Site logger malfunction, data available from 08/26 – 11/04. Mainstem logger found missing on 11/04. Data available from 08/04 – 09/25.
CT-W-1.23	Middle Wilder	Minor Trib		1	08/05	08/26	09/25	11/05	Site logger malfunction, data available from 08/10 – 11/05.
CT-W-1.28	Middle Wilder	Backwater		n/a	08/05	08/25	09/25	11/05	
CT-W-1.34	Middle Wilder	Minor Trib		2	08/05	08/25	09/25	11/05	Site logger post-processing found bad data. Data available from 08/05 – 08/26.
CT-W-1.44	Middle Wilder	Backwater		n/a	08/05	08/26	09/25	10/10	
CT-W-1.47	Lower Wilder	Minor Trib		1	07/24	08/25	09/25	11/03	
CT-W-1.48	Lower Wilder	Major Trib	Grant Brook	3	07/25	08/26	09/25	11/06	
CT-W-1.55	Lower Wilder	Minor Trib		1	07/24	08/25	09/24	11/06	Mainstem logger removed 10/20
CT-W-1.59	Lower Wilder	Backwater		n/a	07/23	08/26	09/24	10/20	Mainstem logger installed 07/24
CT-W-1.67	Lower Wilder	Minor Trib		2	07/22	08/25	09/24	10/20	

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Initial Visit	2nd Visit	3rd Visit	Last Visit	Level Logger Notes
CT-WR-2.01	Upper Wilder Riverine	Minor Trib		2	07/23	08/28	09/23	11/06	Site logger missing, replaced 08/28, data available from 08/28 – 11/06.
CT-WR-2.07	Upper Wilder Riverine	Minor Trib	Hanchetts Brook	1	07/22	08/28	09/23	11/06	Site logger missing, replaced 08/28, data available 08/28 – 11/06. Mainstem logger found missing on 11/06, data available from 07/22 – 09/23.
CT-WR-2.10	Lower Wilder Riverine	Minor Trib	McArthur Brook	2	09/02	09/24	n/a	11/07	
CT-WR-2.11	Lower Wilder Riverine	Major Trib	Lulls Brook	3	08/28	09/24	n/a	11/07	
CT-WR-2.13	Lower Wilder Riverine	Minor Trib	Bashan Brook	1	07/22	08/28	09/24	11/07	Site logger found out of stream flow due to site tampering on 08/28, data available 08/28 – 11/07
CT-B-3.07	Bellows	Major Trib	Barkmill Brook	3	07/28	08/27	09/22	11/07	
CT-B-3.10	Bellows	Minor Trib		1	08/03	08/27	09/22	11/07	Mainstem logger missing on 08/27, replaced. Data available 08/27- 11/07
CT-B-3.19	Bellows	Backwater		n/a	07/27	08/27	09/23	11/08	
CT-B-3.24	Bellows	Major Trib	Commissary Brook	3	07/27	08/27	09/23	11/08	
CT-B-3.27	Bellows	Minor Trib		2	07/26	08/27	09/23	11/08	
CT-B-3.35	Bellows	Minor Trib		2	07/26	08/27	09/23	11/08	

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Initial Visit	2nd Visit	3rd Visit	Last Visit	Level Logger Notes
CT-BR-4.02	Bellows Riverine	Major Trib	Cold River	5	07/21	08/27	09/22	11/10	The existing mainstem logger which had been overwintered in 2013/2014 was not searched for by divers in early July, due to increased flows which cut short overwintered logger retrieval. However, it was presumed to be still in place. The logger was searched for by divers on 10/09/2014 and found to be missing at that time. It was replaced and was overwintered again in 2014/2015.
CT-BR-4.03	Bellows Riverine	Minor Trib		2	08/11	09/10	n/a	11/09	
CT-BR-4.04	Bellows Riverine	Major Trib	Cobb Brook	3	08/11	09/10	n/a	11/09	
CT-V-5.02	Bellows Riverine/ Vernon	Minor Trib	Mad Brook	2	08/08	09/08	n/a	11/08	Site logger post-processing found some bad data. No mainstem data available.
CT-V-5.04	Vernon	Major Trib		3	08/07	09/09	n/a	11/11	Mainstem logger removed by vandalism and retrieved by police dept. Replaced on 09/22. Data available 08/07 – 09/09 and 09/22 – 11/11.
CT-V-5.19	Vernon	Minor Trib		1	08/06	09/09	n/a	11/11	
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	08/07	09/09	n/a	11/10	
CT-V-5.31	Vernon	Minor Trib		2	08/07	09/09	n/a	11/11	
CT-V-5.36	Vernon	Minor Trib		2	08/07	09/09	n/a	11/10	
CT-V-5.50	Vernon	Backwater		n/a	08/07	09/09	n/a	10/21	
CT-VR-6.01	Vernon Riverine	Minor Trib		2	08/12	09/09	n/a	11/11	
CT-VR-6.05	Vernon Riverine	Minor Trib		1	08/12	09/09	n/a	11/11	

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5.2 Summary of Site Conditions

Site conditions and key observations made during the 2014 field visits are summarized in Table 5.2-1. Information gathered during the field visits is further described in Section 5.3 and detailed for each site in Appendix A. The range of water depths measured during site visits at the deepest point in the confluence cross-section, water depths in the tributaries and backwaters, water level logger data, thalweg profiles, and photographs, notes and observations related to tributary/backwater access limitations are presented.

Water surface elevation at the confluence cross section in conjunction with thalweg bed elevation data determine if, how often, and how far up into the tributary or backwater the mainstem river influence is present. The project-affected reach was first determined in the field based on visual evidence. At some small tributaries, the project-affected reach is very short, less than 200 feet. At numerous sites, regardless of length, the project-affected reach and/or water access may be restricted by culverts, debris, blockages, or naturally shallow areas that may limit mainstem water inundation within the tributaries or backwaters. Some of the smaller order tributaries had low naturally occurring stream flows based on visual observations and/or tributary level logger data, and one of those sites (CT-WR-2.10, McArthur Brook) had no natural stream flow on two of the three site visits.

The extent of project effects was later estimated by extending the maximum WSE value recorded under normal (non-spill) operations by the mainstem level logger upstream to the point along the tributary thalweg profile where that elevation was first achieved. In some cases, WSE data later showed that the project-affected reach length was different (either longer or shorter) than visually estimated and upon which the tributary or backwater thalweg bed elevation was determined. There were occasional periods of non-operational high water during the study period that resulted in spillage at one or more of the projects, including over short periods in late July, mid-August, and late October. WSE data recorded during those time periods is outside the range of TransCanada's project operations. The maximum mainstem WSE recorded by loggers (as described in Appendix A) includes such high flow periods (where applicable for the period of data record at each site) and these data were excluded from the determination of project-affected reach length.

Summaries, WSE and bed elevation plots, and photographs of the available data recorded at each study site are presented in Appendix A. Summary figures (two pages including photographs) for each site consist of the following:

- **Plot map**: Presents the geo-referenced location of the mainstem and tributary/backwater level loggers, each identified by serial number, installed at each sampling location.
- **Water Surface Elevation Time Series**: Presents a time series plot for calculated WSE as recorded by mainstem and study site level loggers (i.e., "tributary"). WSE values were calculated as the sum of the measured level

logger bed elevation at the pressure sensor and the sensor depth values compensated for atmospheric pressure near ground level.

- **Cross-section Elevation Plot**: Presents bed elevation data for a cross-section located across the tributary/backwater of interest in the vicinity of the confluence with the mainstem. The minimum and maximum WSE values calculated from level logger depths recorded during the period of record by the mainstem level logger are overlaid (dashed blue line). Likewise, the median (solid blue line) WSE value is also displayed. The plot is drawn at scale for readability.
- **Mainstem Logger WSE Summary**: tabular presentation of the average, minimum, maximum, 25th, 50th, and 75th percentile of WSE values calculated based on sensor depth information collected by the mainstem level logger (may include non-project related high flow periods).
- **Thalweg Elevation Plot**: Presents bed elevation data along the thalweg from the vicinity of the visually-determined confluence upstream and through the project-affected reach. In some cases the thalweg plot extends further into the mainstem than the location of the cross section, based on the actual mainstem water's edge observed on the initial site visit. The location of the cross section and approximate extent of the project-affected reach are indicated. The minimum, maximum (vertical red line) and median (red open circle) WSE values calculated based on compensated sensor depth readings from the tributary/backwater level logger are displayed at the level logger location. The distance along the thalweg (i.e., distance in feet from confluence) was estimated from the cumulative sum of point-to-point distances between bed elevation readings. The plot is drawn at scale for readability.
- **Tributary Depth Frequency Distribution**: Presents the frequency distribution of calculated water depth values (ft) at the location of the tributary/backwater level logger data.
- **Tributary Logger WSE Summary**: tabular presentation of the average, minimum, maximum, 25th, 50th, and 75th percentile of WSE values calculated based on sensor depth information collected by the tributary/backwater level logger.
- **Water Depths**: Maximum measured water depths at the confluence cross section from field measurements taken during site visits, and tributary/backwater water depths calculated from sensor depth information collected at the tributary/backwater level logger are displayed next to the cross section and thalweg plots.
- **Site Photographs**: Presents a series of representative time-stamped photographs from the site confluence cross section and at culverts upstream from the confluence taken during each of the monthly site visits. With the exception of photographs presented to highlight instream features (e.g., culverts, downed trees, etc.) the majority of photographs presented were taken at or near the confluence of the tributary or backwater with the mainstem Connecticut River.

Table 5.2-1. Project-affected reach length, confluence cross-section water depth, notes and observations from site visits.

Site #	Waterbody Name	Stream Order	Project-affected Reach (ft)	Observed Max. Depth Range (ft) at Confluence	Site Observations
CT-W-1.01	Harriman Brook	2	128	0.8 – 1.4	Variable tributary thalweg profile, beaver dam present.
CT-W-1.05		backwater	2119	1.2 – 2.3	Variable backwater bed profile, downed trees and branches, sediment limit depth at access channel.
CT-W-1.06		2	136	0.5 – 1.0	Gradually rising tributary thalweg bed elevation, culvert present, limited suitable habitat observed.
CT-W-1.16		backwater	416	1.0 – 1.5	Variable backwater bed profile, shallow areas observed in backwater access channel.
CT-W-1.22	Indian Pond Brook	3	1114	1.5 – 4.2	Variable tributary thalweg profile, downed logs, scour hole observed.
CT-W-1.23		1	263	0.1 – 1.6	Variable tributary thalweg profile, shallow, shoaled area observed.
CT-W-1.28		backwater	1285	5.6 – 7.2	Variable backwater bed profile, shallow areas observed.
CT-W-1.34		2	322	0.5 – 1.9	Tributary thalweg profile varies near the upper project extent. Shallow margins observed (November visit)
CT-W-1.44		backwater	1391	8.8 – 9.8	Culvert present but appeared not to be a barrier, upper feeder stream is limited to natural flow.
CT-W-1.47		1	683	1.9 – 2.9	Variable tributary thalweg profile, scour hole observed near confluence.
CT-W-1.48	Grant Brook	3	3338	5.7 – 6.6	Variable tributary thalweg profile.
CT-W-1.55		1	402	1.5 – 3.1	Variable tributary thalweg profile, downed trees and branches, thalweg bed elevation variable.
CT-W-1.59		2	1689	2.1 – 2.9	Variable tributary thalweg profile, culvert present with debris loading on culvert's chain link fence.
CT-W-1.67		2	804	5.3 – 6.7	Variable tributary thalweg profile, culvert present. A farm water withdrawal is present.
CT-WR-2.01		2	45	0.2 – 0.7	Gradually rising tributary thalweg bed elevation, perched culvert observed.
CT-WR-2.07	Hanchetts Brook	1	-1[a]	0.3 – 0.4	Tributary thalweg bed elevation increases approximately 2 ft just upstream of project-affected extent. Downed trees, branches, and cobbles, boulders observed.
CT-WR-2.10	McArthur Brook	2	160	0 – 2.0	Gradually rising tributary thalweg bed elevation. Intermittent stream, no flow on 2 of 3 visits.
CT-WR-2.11	Lulls Brook	3	688	0.6 – 1.7	Variable tributary thalweg profile, debris and scour/ deposition present.
CT-WR-2.13	Bashan Brook	1	-9[b]	0.1 – 0.4	Gradually rising tributary thalweg bed elevation, manmade blockages observed.
CT-B-3.07	Barkmill Brook	3	113	0.6 – 1.3	Variable tributary thalweg profile, culvert present, shoaled area observed.

Site #	Waterbody Name	Stream Order	Project-affected Reach (ft)	Observed Max. Depth Range (ft) at Confluence	Site Observations
CT-B-3.10		1	117	0.7 – 1.7	Variable thalweg profile, debris, shallow areas observed.
CT-B-3.19		backwater	2252	2.9 – 5.3	Variable backwater bed profile, shallow littoral margins observed.
CT-B-3.24	Commissary Brook	3	455	1.0 – 2.1	Variable tributary thalweg profile, downed trees and branches, thalweg profile variable.
CT-B-3.27		2	2422	5.1 – 6.4	Variable tributary thalweg profile,
CT-B-3.35		2	64	3.6 – 4.4	Variable tributary thalweg profile, culvert present
CT-BR-4.02	Cold River	5	900[c]	0.8 – 2.9	Gradually rising tributary thalweg bed elevation, large areas of cobble, observed to have shifted between visits.
CT-BR-4.03		2	254	0.1 – 2.6	Tributary thalweg bed elevation rises approximately 1 ft just upstream of confluence cross section. Downed trees and branches observed.
CT-BR-4.04	Cobb Brook	3	535	1.4 – 2.2	Variable tributary thalweg profile, culvert, downed trees and branches present.
CT-V-5.02	Mad Brook	2	80[3]	0.7 – 1.1	Variable tributary thalweg profile, perched culvert present.
CT-V-5.04		3	157	1.2 – 1.9	Variable tributary thalweg profile, downed trees and branches, shallow thalweg profile near confluence.
CT-V-5.19		1	99	0.1 – 0.8	Variable tributary thalweg profile.
CT-V-5.28	Salmon Brook	3	169	1.2 – 1.7	Variable tributary thalweg profile, culvert present.
CT-V-5.31		2	78	0.3 – 1.0	Variable tributary thalweg profile, culvert present.
CT-V-5.36		2	275	0.7 – 1.9	Variable tributary thalweg profile, culvert and retaining wall present.
CT-V-5.50		backwater	4989	6.3 – 10.3	Variable backwater bed profile, some shallow areas and shallow littoral margins observed, thalweg profile varies.
CT-VR-6.01		2	125	0.2 – 0.4	Gradually rising tributary thalweg profile, with small depressions, downed trees and branches present.
CT-VR-6.05		1	165	0.1 – 0.3	Gradually rising tributary thalweg profile, with small depressions, downed trees and branches present.

a. CT-WR-2.07 project-affected reach determined by WSE data to be 1 ft closer to mainstem than the visually determined confluence location.
b. CT-WR-2.13 project-affected reach determined by WSE data to be 9 ft closer to mainstem than the visually determined confluence location.
c. Sites CT-BR-4.02 and CT-V-5.02 project-affected reaches are based on visual determination only, not WSE data since mainstem WSE data was not available.

5.3 Water Quality

Water quality parameters were collected at each study site in a location approximately mid-way in the visually determined project-affected reach (rather than at the confluence cross section location) to better reflect the tributary/backwater conditions. Water quality data included temperature (^{o}C), pH, conductivity (µS/cm), turbidity (NTU), DO (mg/L), and DO saturation (%). All measurements were taken with handheld field meters and data represent instantaneous readings. Appendix B-1 (filed separately in Excel format, and formerly Table 5.4-1 in the initial study report) presents the results of water quality sampling conducted at each site on each visit date. Table notes indicate the tributaries identified by each state as being water quality impaired in the most recent Section 303(d) List of Impaired Waters state submittals to the US Environmental Protection Agency. Both states have numeric water quality standards for pH and DO, but only narrative criteria for the other parameters measured. Appendix B-2 (formerly Table 5.4-2 in the initial study report) presents water quality data at the two sites (VR-6.01 and VR-6.02) that had been potentially affected by VY operations. Data was collected in 2014 while VY was still operating, and in 2015 after VY's closure, as requested by stakeholders during the final study plan modification process in late 2013 (see Section 1.0).

Temperature

Temperature in all tributaries and backwaters ranged from 3.6 to 27.5^{o}C over the course of the study (late July to mid-November). In keeping with naturally occurring seasonal temperature differences, of the 36 temperature readings below 10^{o}C (50^{o}F), all but 3 occurred in the November sampling round. Similarly, of the 41 temperature readings above 20^{o}C (68^{o}F), all but 3 occurred from July 21 – August 22.

pH

Approximately 39% of all pH measurements in tributaries and/or backwaters were lower than then New Hampshire and Vermont state standards of 6.5 standard units (su) for Class B waters. Approximately 59% of all pH measurements were within state standards. In 3 sampling instances (less than 2% of samples), pH readings were higher than the New Hampshire standard of 8.0 su, with 2 of those instances also higher than the Vermont standard of 8.5 su. There were no apparent trends related to the few high pH values. All of the pH measurements at site CT-W-1.22 (Indian Pond Brook) were below 6.5 su. Several sites had pH measurements less than 6.5 su in the majority of sampling rounds. Chronic low pH is common throughout New Hampshire and Vermont in smaller streams whose watersheds are dominated by wetlands and organic material. Episodic low pH is also quite common in New Hampshire and Vermont and is usually associated with acidic precipitations event or period of snowmelt. High pH is usually associated with algal growth.

Conductivity

Conductivity measurements across all sites and sampling rounds ranged from 18 to 6 µS/cm. Twenty-eight percent of conductivity measurements were less than 100

µS/cm; 53% were between 100 and 200 µS/cm; and 19% were greater than 200 µS/cm. Sites CT-WR-2.01 and CT-B-3.10 had the highest conductivity readings and some other sites had consistently higher readings than other sites, but no other general trends were apparent. Conductivity is generally related to the type of bedrock and associated soils that are found in the watershed. Relatively higher conductivity is often associated with calcareous bedrock and soils while lower conductivity is commonly found in granitic bedrock and soils. In streams closely associated with highways or in urban settings, elevated conductivity is often associated with sodium chloride.

Turbidity

Turbidity measurements across all sites and sampling rounds ranged from less than 1 to 265 NTU, with 134 readings (88%) less than 10 NTU. Four turbidity readings (approximately 3% of the total) were greater than 50 NTU, with 2 of those readings greater than 250 NTU. Elevated turbidity levels are generally related to precipitation events and associated sediment movement. Instream construction or logging activities can also lead to short-term increases in turbidity.

Dissolved Oxygen

Dissolved oxygen remained within New Hampshire and Vermont Class B water quality standards at most sites and in most sampling rounds with only a few instances of measurements outside of one or both state standards. In 3 sampling instances, instantaneous DO measured in mg/l was lower than New Hampshire's 5.0 mg/l instantaneous standard and in 3 more sampling instances, lower than Vermont's 6.0 mg/l standard. In all 6 instances (3.5% of all samples), DO % saturation was also lower than the Vermont standard of 70% for cold water habitat. New Hampshire's 75% DO saturation standard is a daily average numerical standard, while the data collected in this study was instantaneous, so the New Hampshire DO % saturation standard is not applicable for this study. There was one additional sampling instance where DO measured in mg/l met both state standards, but the % saturation measurement was below the Vermont standard for cold water habitat. Four of the six low DO readings occurred at a single site (CT-B-3.27, a stream order 2 tributary), with 3 instances on the same day (surface, mid and bottom samples).

6.0 ASSESSMENT OF PROJECT EFFECTS

Water-level fluctuations have the potential to create conditions that could impede the movement of fish between the Connecticut River and its tributaries and backwaters. These conditions, if present, could limit access to spawning and rearing habitat. Additionally, project-related, water-level changes could potentially alter water quality in these areas, which could decrease productivity. Water level changes in the project-affected areas occur as a result of changes in natural flows, changes in flow and water levels due to upstream flow management at TransCanada projects, US Army Corps of Engineer Flood Control dams and other public and private dams on tributaries, as well as by the operation of the Wilder, Bellows Falls and Vernon projects.

Assessment of project effects relied upon associating observed changes in water levels at the study sites and specific project operations that are not otherwise caused by the influences stated above. Observed site conditions and water level logger data collected in 2014 along with Hydraulic and Operations model (Studies 4 and 5) derived water level elevations (WSE) at these locations also provided critical information in the assessment. For the purposes of this report, adequate access for fish to enter into tributaries and backwaters from the mainstem river was conservatively estimated as water depths 0.5 ft or greater at the tributary confluence cross section.

6.1 Assessment of Project Effects on Water Depth and Fluctuation

6.1.1 Preliminary Assessment Based on Field Evaluation

Preliminary assessment of project effects was conducted using 2014 field evaluations and actual WSEs between the mainstem confluence and tributary locations, and later compared to modeled WSEs under normal project operations at each mainstem location, when model data became available after issuance of the initial study report. The approximate percentage of time (occurrence of valid water level readings) < 0.5 ft of water depth at the confluence cross sections based on water level logger data collected in the summer and fall of 2014 is summarized for each site in Table 6.1.1-1. The majority of study sites (27 or 73%) had summer/fall water depths less than 0.5 ft in the confluence cross section thalweg 25% or less of the time during the period of record (or greater than 0.5 ft. 75% of the time or more), including all backwater sites.

Table 6.1.1-1. Percent occurrence of < 0.5 ft water depth at the confluence of each study site.

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	% Occurrence of WSE < 0.5 ft Depth
CT-W-1.01	Upper Wilder	Minor Trib	Harriman Brook	2	0.02%
CT-W-1.05	Upper Wilder	Backwater		n/a	0.05%
CT-W-1.06	Upper Wilder	Minor Trib		2	13.6%

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	% Occurrence of WSE < 0.5 ft Depth
CT-W-1.16	Upper Wilder	Backwater		n/a	0.5%
CT-W-1.22	Middle Wilder	Major Trib	Indian Pond Brook	3	0%
CT-W-1.23	Middle Wilder	Minor Trib		1	11.0%
CT-W-1.28	Middle Wilder	Backwater		n/a	0%
CT-W-1.34	Middle Wilder	Minor Trib		2	0.4%
CT-W-1.44	Middle Wilder	Backwater		n/a	0%
CT-W-1.47	Lower Wilder	Minor Trib		1	0%
CT-W-1.48	Lower Wilder	Major Trib	Grant Brook	3	0%
CT-W-1.55	Lower Wilder	Minor Trib		1	0%
CT-W-1.59	Lower Wilder	Backwater		n/a	0%
CT-W-1.67	Lower Wilder	Minor Trib		2	0%
CT-WR-2.01	Upper Wilder Riverine	Minor Trib		2	70.2%
CT-WR-2.07	Upper Wilder Riverine	Minor Trib	Hanchetts Brook	1	95.8%
CT-WR-2.10	Lower Wilder Riverine	Minor Trib	McArthur Brook	2	58.2%
CT-WR-2.11	Lower Wilder Riverine	Major Trib	Lulls Brook	3	0%
CT-WR-2.13	Lower Wilder Riverine	Minor Trib	Bashan Brook	1	100%
CT-B-3.07	Bellows	Major Trib	Barkmill Brook	3	13.9%
CT-B-3.10	Bellows	Minor Trib		1	68.3%
CT-B-3.19	Bellows	Backwater		n/a	0%
CT-B-3.24	Bellows	Major Trib	Commissary Brook	3	0.9%
CT-B-3.27	Bellows	Minor Trib		2	0%
CT-B-3.35	Bellows	Minor Trib		2	0%
CT-BR-4.02	Bellows Riverine	Major Trib	Cold River	5	Undetermined
CT-BR-4.03	Bellows Riverine	Minor Trib		2	11.7%
CT-BR-4.04	Bellows Riverine	Major Trib	Cobb Brook	3	40.5%
CT-V-5.02	Bellows Riverine/Vernon	Minor Trib	Mad Brook	2	Undetermined
CT-V-5.04	Vernon	Major Trib		3	2.2%
CT-V-5.19	Vernon	Minor Trib		1	1.1%
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	21.1%
CT-V-5.31	Vernon	Minor Trib		2	24.0%

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	% Occurrence of WSE < 0.5 ft Depth
CT-V-5.36	Vernon	Minor Trib		2	0.3%
CT-V-5.50	Vernon	Backwater		n/a	0%
CT-VR-6.01	Vernon Riverine	Minor Trib		2	58.6%
CT-VR-6.05	Vernon Riverine	Minor Trib		1	42.5%

The eight sites with confluence water depth <0.5 ft at least 25% of occurrences and the two sites with no mainstem WSE data (BR-4.02 (Cold River) and V-5.02 (Mad Brook) warranted additional evaluation of site-specific factors to better understand and assess potential project effects. Conditions at those "potentially affected" sites are summarized in Table 6.1.1-2 including the percent of occurrences with water depth <0.5 ft at the confluence cross section, the range of water depths measured at the confluence cross section during site visits, the overall range of water depths at the tributary water level logger location (during the period of logger record), and other site factors that could limit access for fish. Sites with limited water level logger data in the tributary and/or mainstem are identified and data from those sites may not be fully representative of overall site conditions during the entire study period. Occurrence of water depths < 0.5 feet at the confluence cross section more than 25% of the time were more predominant in smaller tributaries (i.e., stream order = 1 or 2) located within the riverine reaches.

Project discharge data were reviewed for the initial set of potentially affected sites for period of available mainstem WSE data at each site. This information was supplemented with normal project operations WSE data from the Hydraulic Model (Study 4), summarized in Table 6.1.1-3. There were occasional, mostly brief, periods of naturally occurring high water resulting in spillage at one or more of the projects that occurred during late July, in mid-August, and in late October, 2014 and WSE data recorded during those time periods is outside of the range of project operations, and outside of TransCanada's control. WSE data was available for all sites in the Wilder riverine section during the week of September 9 – September 15, 2014. Wilder operations during that 7-day period ranged from minimum flow up to full or nearly full generation flow, providing a representative range of normal project operations. A similar set of WSE data was available for all sites in the Bellows Falls and Vernon projects (except at sites BR-4.02 and V-5.02) during the 7-day period from October 15 to October 21, 2014. Both projects operated between minimum flows and full or nearly full generation, providing a representative range of operations for sites in the Bellows Falls and Vernon project areas. ,model data only since mainstem WSE data was unavailable for the entire study period.

The sections below describe each of the ten sites in more detail and it is important to note that the vertical scales for project discharge and WSE are not correlated (WSE on the right scale does not equate to discharge cfs on the left scale)

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Table 6.1.1-2. Summary of 2014 conditions at potentially affected sites based on water level logger data.

Site #	Water Body Name	Stream Order	% of Time <0.5 ft Water Depth at Confluence	Project-Affected Reach Length from Confluence (ft)[a]	Range of Water Depths at Confluence Measured on Site Visits (ft)	Range of Water Depths at Tributary Logger (ft)	Data Limitations	Other Limiting Factors
CT-WR-2.01		2	70.2%	45	0.2 – 0.7	0.0 – 3.8	Some tributary WSE data missing	Perched culvert; periods of low tributary streamflow
CT-WR-2.07	Hanchetts Brook	1	95.8%	-1	0.3 – 0.4	0.5 – 2.2	Some tributary WSE and mainstem WSE data missing	Tributary thalweg bed elevation increases approximately 2 ft just upstream of project-affected extent. Downed trees, branches and cobbles, boulders present. Project-affect reach limited.
CT-WR-2.10	McArthur Brook	2	58.2%	16	0.0 – 2.0	0.4 – 4.7		Intermittent stream, no flow on 2 of 3 visits; periods of low tributary streamflow.
CT-WR-2.13	Bashan Brook	1	100%	-9	0.1 – 0.4	0.0 – 0.9	Some tributary WSE data missing	Man-made blockages. Project-affected reach limited; periods of low tributary streamflow
CT-B-3.10		1	68.3	117	0.7 – 1.7	0.9 – 2.2	Some mainstem WSE data missing	Variable thalweg profile, debris, shallow areas observed.
CT-BR-4.02	Cold River	5	n/a	~900	0.8 – 2.9	1.0 – 5.7	No mainstem WSE data available	Large areas of cobble, observed to have shifted between visits.
CT-BR-4.04	Cobb Brook	3	40.5%	535	1.4 – 2.2	1.8 – 6.4		Variable tributary thalweg profile, culvert, downed trees and branches present.
CT-V-5.02	Mad Brook	2	n/a	~ 80	0.7 – 1.1	0.8 – 4.8	No mainstem WSE data available	Variable tributary thalweg profile, perched culvert present.
CT-VR-6.01		2	58.6%	125	0.2 – 0.4	0.6 – 4.4		Downed trees and branches present.
CT-VR-6.05		1	42.5%	165	0.1 – 0.3	0.1 – 3.6		Downed trees and branches present ; periods of low tributary streamflow

a. Negative values indicate that project-affect reach determined by available mainstem WSE data was closer to the mainstem than the visually determined confluence location.

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Table 6.1.1-3. Mainstem WSE values[1] recorded at potentially affected sites based on water level logger data, 2014 and Hydraulic Model.

Site #	Min Mainstem WSE for 0.5 ft Confluence Water Depth ft)	Min Recorded Mainstem WSE (ft)	Max Recorded Mainstem WSE (ft)	Min Model WSE (ft)[a]	Max Model WSE (ft)[a]	Normal Project Operations Min Model Flow (cfs) needed for 0.5 ft Confluence Water Depth
CT-WR-2.01	328.8	326.2	334.6	324.9	331.6	5,000
CT-WR-2.07	319.3	314.4	321.9	313.6	320.9	7,400
CT-WR-2.10	302.7	301.2	307.3	298.8	306.5	4,450
CT-WR-2.13	304.0	296.8	303.0	296.2	303.5	> 12,000 (above Wilder max generating capacity)
CT-B-3.10	289.8	288.1	290.9	289.2	292.2	Min flow to 6,500 depending on Bellows Falls dam WSE
CT-BR-4.02	223.7	No data	No data	220.5	227.7	4,000
CT-BR-4.04	220.2	219.4	225.7	218.5	224.3	2,750
CT-V-5.02	221.2	No data	No data	218.4	225.7	5,000 to 6,000 depending on Bellows Falls dam WSE
CT-VR-6.01	183.1	180.7	189.0	180.2[b]	186.8[b]	6,750 to 7,250 depending on Vernon dam WSE
CT-VR-6.05	181.6	178.9	187.6	180.0[b]	185.4[b]	1,200 to 7,000 depending on Turners Falls dam WSE

a. Hydraulic model WSE elevation at the site under normal project operations (min flow to max nominal generating capacity and normal operating dam WSE).
b. Hydraulic model WSE elevation at the site under Vernon generating capacity range (min flow to max nominal capacity) and Turners Falls dam normal operating dam WSE range.

[1] All WSE values are reported in the North American Vertical Datum of 1988 (NAVD 88).

Site CT-WR-2.01

Site CT-WR-2.01 is a stream order 2 tributary located approximately 0.4 mi downstream from the Wilder Project. A perched culvert is present (see photographs in Appendix A) and the project-affected reach extends approximately 45 ft into the tributary from the cross section to an elevation of 332.7 ft, slightly above the culvert bottom sill elevation (at elevation 332.4). The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 328.8 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the tributary logger location ranged from 0.0 to 3.8 ft The thalweg profile within the project-affected reach is gradual without apparent stranding spots and therefore channel depths within the tributary are limited as part of the natural flow regime of the stream itself. As a result, potential access for fish into this small tributary is likely limited more by its own specific characteristics (i.e., limited stream flow) than by TransCanada operations. Project operations simply inundate the most downstream a portion of the tributary at times (at flows in excess of 5000 cfs measured at the cross section) and at other times exposes the natural stream channel which has no evidence of potential barriers to access other than the stream flow itself.

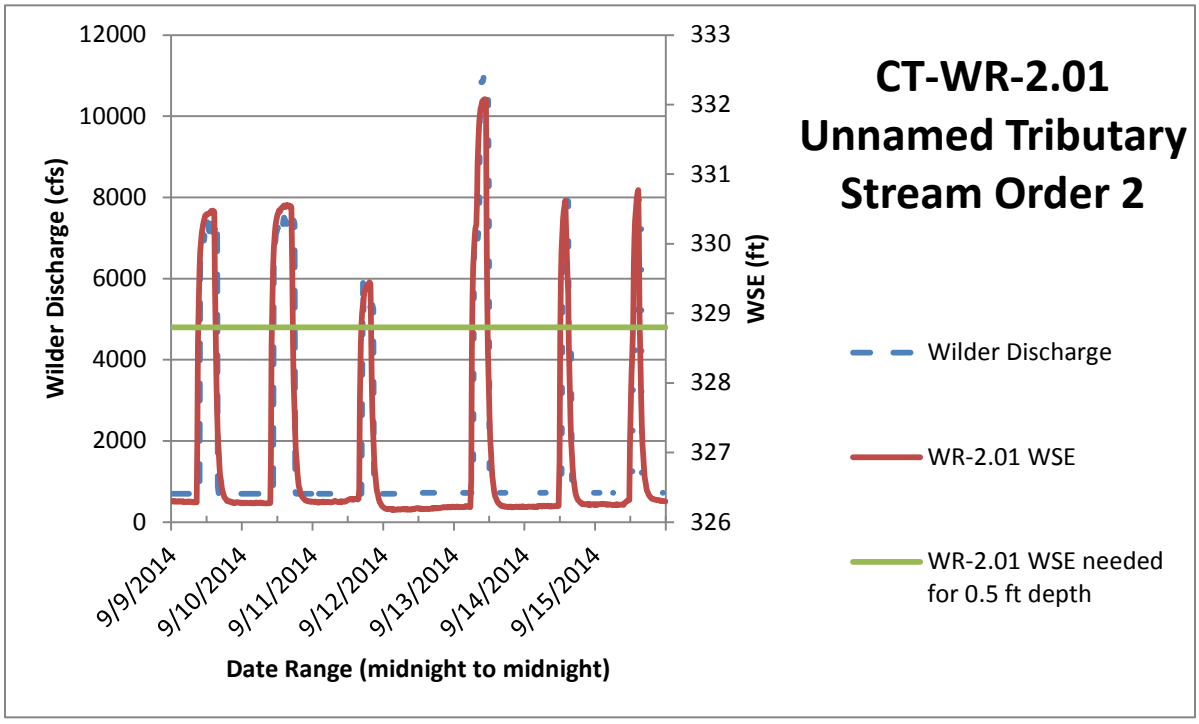

Figure 6.1-1. Representative operating conditions at Site CT-WR-2.01, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-WR-2.07

Site CT-WR-2.07, Hanchetts Brook, is a stream order 1 tributary located approximately 6 miles downstream from the Wilder Project. Downed trees and branches and large cobble and boulders were observed at the approximate extent of the project-affected reach that likely restrict mainstem flow into the tributary (see photographs in Appendix A). Photos also indicate periods of very low flow in this stream. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 319.3 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the tributary logger location ranged from 0.1 to 0.3 ft based on limited tributary data. Water depth at the observed confluence cross section was less than 0.5 ft nearly 96% of the time based on limited mainstem WSE data, and ranged from 0.3 to 0.4 ft as measured at site visits. The tributary thalweg profile changes in the vicinity of the project-affected reach which could create stranding under combined low mainstem elevation and tributary low flow conditions. It is likely that channel depths within the tributary are limited as part of its natural flow regime under virtually all operational project discharge levels. As a result, potential access for fish into this small tributary is limited by its own specific characteristics (i.e., limited stream flow and blockages). Figure 6.1-2 illustrates that mainstem water levels at the site track Wilder discharge flows (with a slight time delay due to distance). Therefore based upon all the information we conclude that access can be impaired but as a result of natural stream features rather than flows and project operations which generally do not alter that condition and may improve access when mainstem flows are above 7,400 cfs.

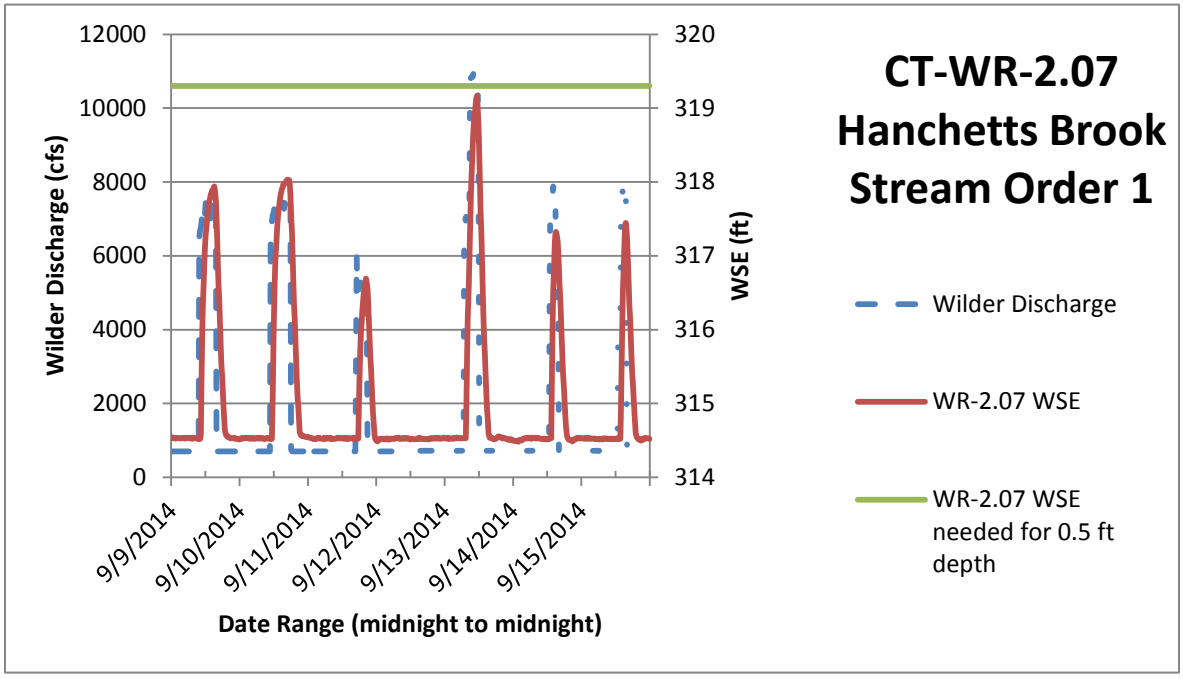

Figure 6.1-2. Representative operating conditions at Site CT-WR-2.07, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-WR-2.10

Site CT-WR-2.10, McArthur Brook, is an intermittent stream located approximately 10.9 miles downstream from the Wilder Project. The stream had no natural flow on 2 of 3 site visits (see photographs in Appendix A). Photos also indicate periods of very low flow in this stream. The project-affected reach extends approximately 160 ft into the tributary from the cross section to an elevation of 307.2 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 302.7 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the confluence cross section ranged from 0.0 to 2.0 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.4 to 4.7 ft. Figure 6.1-3 illustrates that mainstem water levels at the site track Wilder discharge flows (with a time delay due to distance).

The thalweg profile within the project-affected reach is gradual without apparent stranding spots. Based on its intermittent nature, channel depths within the tributary are limited as part of its natural flow regime. Access to additional aquatic habitat within this tributary will be limited by the seasonal presence of stream flow although access is potentially improved as flows exceed 4,450 cfs. Water depth at the confluence cross section was 0.5 ft or greater approximately 42% of the time during the study period in large part due to periodic mainstem inundation when flows exceed 4,450 cfs at the site.

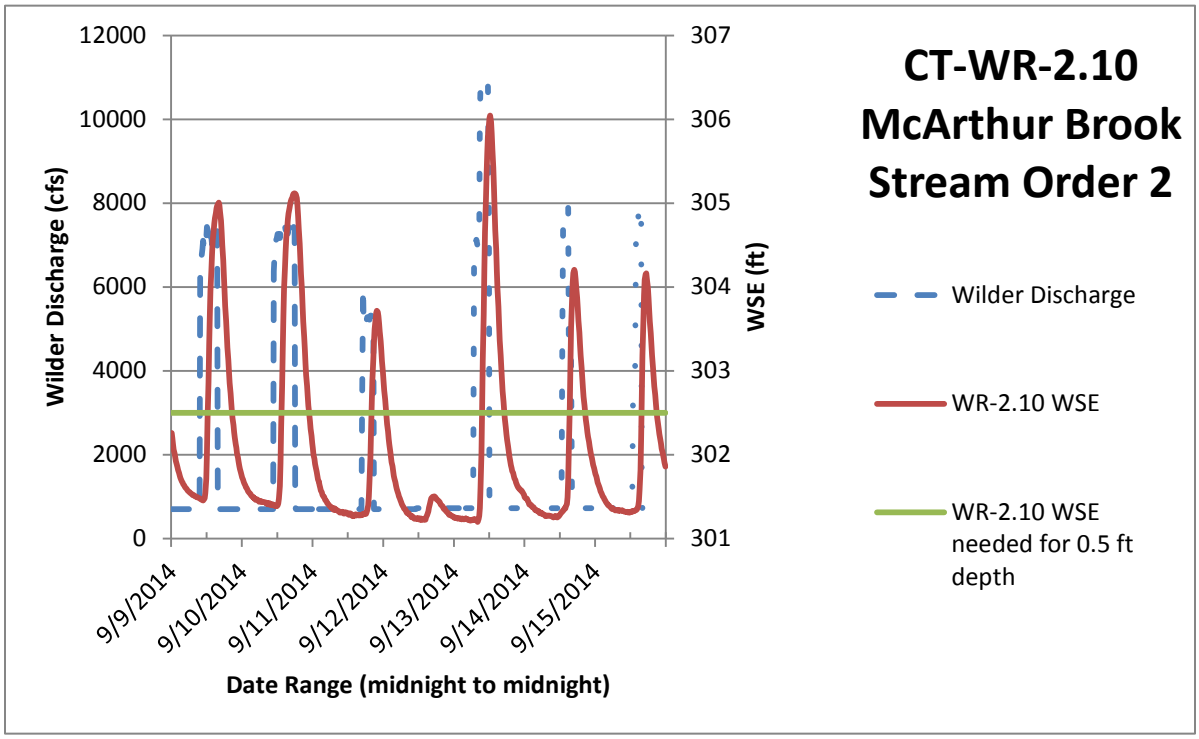

Figure 6.1-3. Representative operating conditions at Site CT-WR-2.10, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-WR-2.13

Site CT-WR-2.13, Bashan Brook is a stream order 1 tributary located approximately 13.1 miles downstream from the Wilder Project. The tributary is located in a high-traffic put-in/take-out for recreational boaters associated with Great River Outfitters and subject to repeated construction of rock blockages, apparently to create pools in the stream (see photographs in Appendix A). These blockages contributed to mainstem inflow and confluence depth less than 0.5 ft under all recorded conditions (100% of occurrences). The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 304.0 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth measured at the cross section during sites visits ranged from 0.1 to 0.4 ft. Water depth at the tributary logger location ranged from 0.0 to 0.9 ft based on limited tributary data. Figure 6.1-4 illustrates that mainstem water levels at the site follow Wilder discharge flows (with a time delay due to distance).

The thalweg profile within the project-affected reach is gradual without apparent stranding spots. Channel depths within the tributary are limited to natural stream flow under essentially all mainstem flows within Wilder's normal project operations (including full generation flows) and low tributary conditions, and mainstem water inflow is restricted due to manmade blockages under all operational project discharge levels during the period of record. As a result, potential access for fish into this small tributary is limited by its own specific characteristics (i.e., limited stream flow) and anthropogenic factors rather than by TransCanada operations.

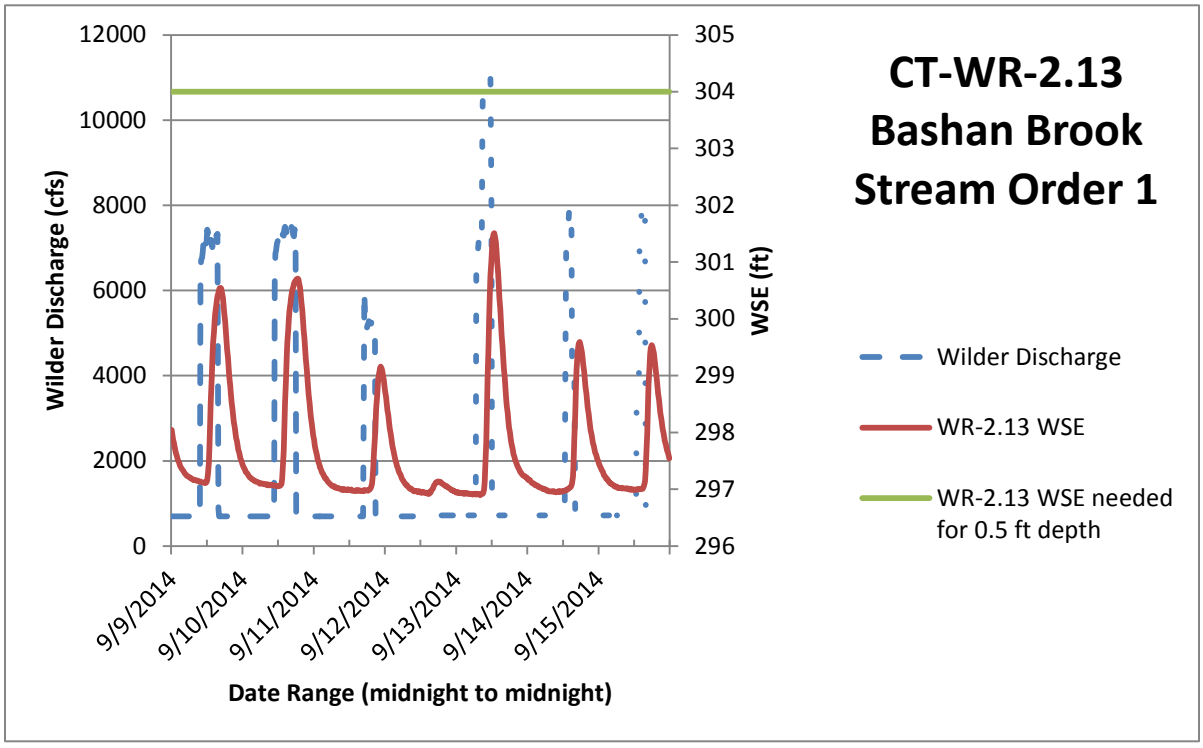

Figure 6.1-4. Representative operating conditions at Site CT-WR-2.1, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-B-3.10

Site CT-B-3.10 is a stream order 1 tributary located approximately 16 miles upstream of the Bellows Falls Project. Based on its location, this impoundment tributary is potentially affected by both Wilder and Bellows Falls project operations. The project-affected reach extends approximately 117 ft into the tributary from the confluence cross section to an elevation of 290.4 ft. The thalweg profile varies within the project-affected reach, and potential stranding spots are present, as is debris. The WSE needed to achieve 0.5 ft depth at the confluence cross section is 289.8 ft. and water depths ranged from 0.7 to 1.7 ft as measured during the site visits as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the confluence cross section was 0.5 ft or greater approximately 32% of the time during the study period based (on limited mainstem water level logger data) in large part due to periodic inundation at all project flows except when Bellows Falls dam WSE is at its lowest operating elevation of 289.2 ft when flows 6,500 cfs or higher would be needed to inundate the stream. It is likely that channel depths within the tributary are limited as part of its natural flow regime under virtually all operational project discharge levels. As a result, potential access for fish into this small tributary is limited by its own specific characteristics (i.e., limited stream flow). Water depth at the tributary logger location ranged from 0.9 to 2.2 ft based on water level logger data.

Figure 6.1-5 illustrates that mainstem water levels at the site fluctuate with changes in the upstream Wilder discharge flows (with a slight time delay due to distance). Therefore, access into this tributary may be limited by available water depths through shallower portions of the channel under virtually all mainstem conditions and low tributary flow conditions such as those observed during the November 7th site visit (see photographs in Appendix A). Therefore, based upon all the information we conclude that access can be impaired but as a result of natural stream features and flows and project operations do not alter that condition.

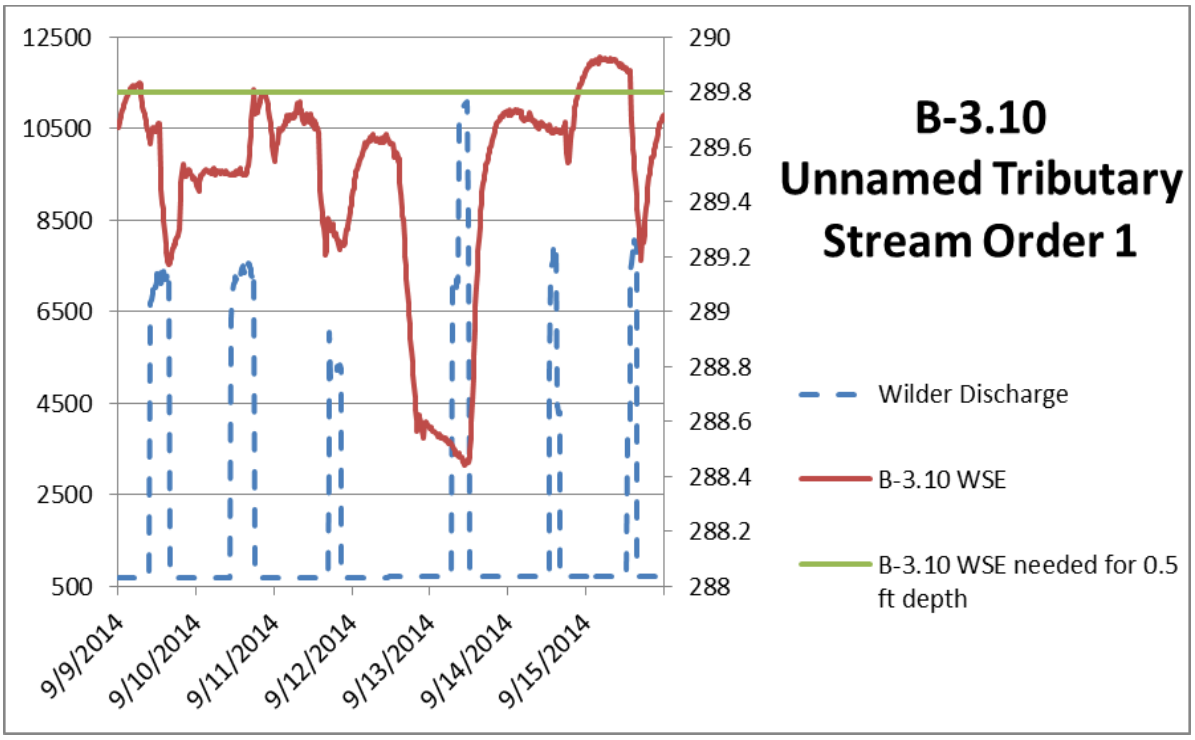

Figure 6.1-5. Representative operating conditions at Site CT-B-3.10, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-BR-4.02

Site CT-BR-4.02, the Cold River, is a stream order 5 tributary located approximately 1.2 miles downstream from the Bellows Falls Project. Based on visual evidence, the project-affected reach was estimated based on visual observation (not verified due to missing mainstem WSE data) to extend approximately 900 ft into the tributary from the confluence cross section to a point just upstream of the Route 12 Bridge. Water depths in the confluence cross section ranged from 0.8 – 2.9 feet as measured at site visits as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the tributary logger location ranged from 1.0 – 5.7 feet. The cobble substrate over which the Cold River flows at its confluence with the mainstem is dynamic and changes in location and quantity of cobble were evident from one site visit to the next (see photographs in Appendix A).

Mainstem WSE ranges from 220.5 to 227.7 under normal project operations based on the hydraulic model which would inundate the confluence at flows of 4,000 cfs or more. However, as Figure 6.1-6 illustrates, the minimum tributary water elevation recorded (224.6 ft) used as a proxy for missing mainstem WSE data, during the representative week and throughout the study period (224.4 ft) remained above the minimum mainstem WSE needed to achieve 0.5 ft of depth at the confluence cross section (223.7 ft).

While the tributary channel may be affected to some extent by project operations, based upon the observed tributary depths (1 foot or greater), and sufficient flows in this large tributary, there do not appear to be adverse project effects to access.

The thalweg profile within the project-affected reach is slightly variable near the confluence, but not likely to create stranding spots unless the cobble substrate shifts dramatically (e.g., as a result of storm events).

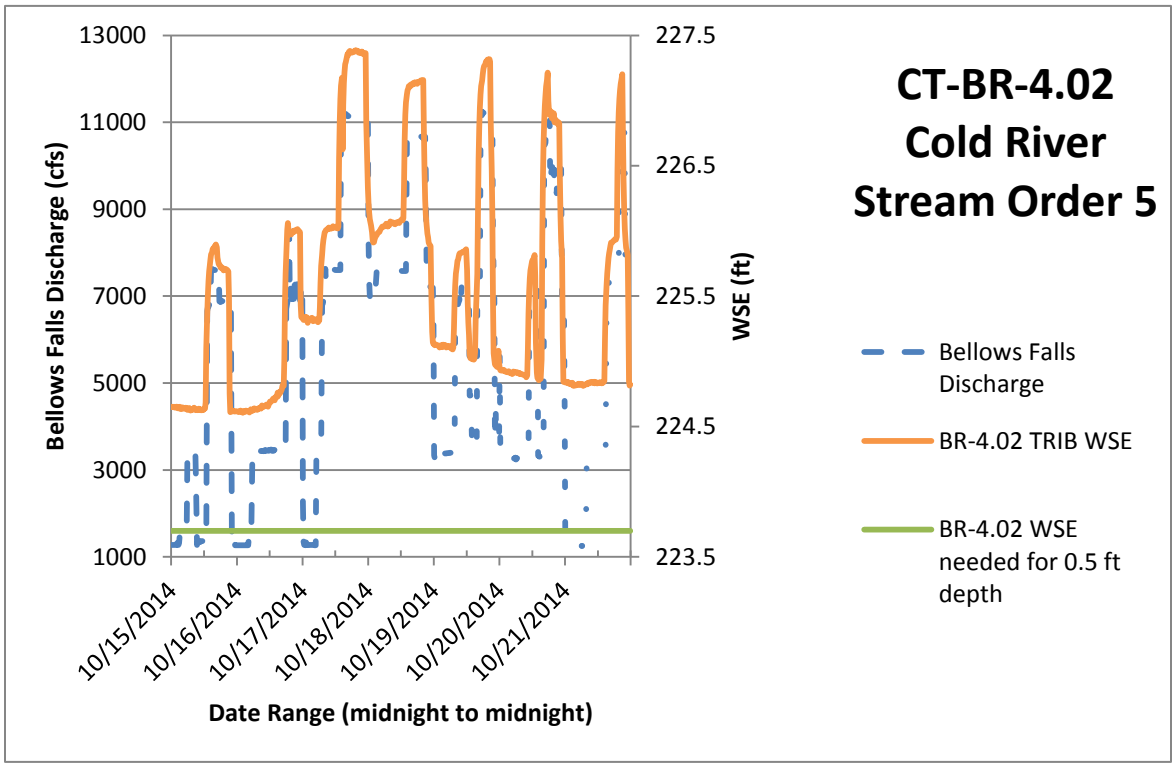

Figure 6.1-6. Representative operating conditions at Site CT-BR-4.02, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-BR-4.04

Site CT-BR-4.04, Cobb Brook is a stream order 3 tributary located approximately 3 miles downstream from the Bellows Falls Project. Downed trees and branches were observed that likely limit mainstem inflow at the upper extent of the reach. The project-affected reach extends approximately 535 ft from the confluence cross section to a railroad culvert (see photographs in Appendix A) with a bottom sill elevation of 225.85 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 220.2 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the confluence cross section was < 0.5 ft about 41% of the time during the period of record, and ranged from 1.4 to 2.2 ft as measured at site visits. Water depth at the tributary logger location ranged from 1.8 to 6.4 ft

as measured during site visits. Figure 6.1-7 illustrates that mainstem water levels at the site follows Bellows Falls generation and discharge flows (with a slight time delay due to distance). The thalweg profile is variable within the project-affected reach and as a result, stranding is possible; however tributary flow is generally sufficient to provide access, but could be limited for larger fish under mainstem flows less than 2,750 cfs and tributary low flow conditions. Therefore, based upon the observed tributary depths of 1.8 feet or more, there do not appear to be adverse effects to tributary access.

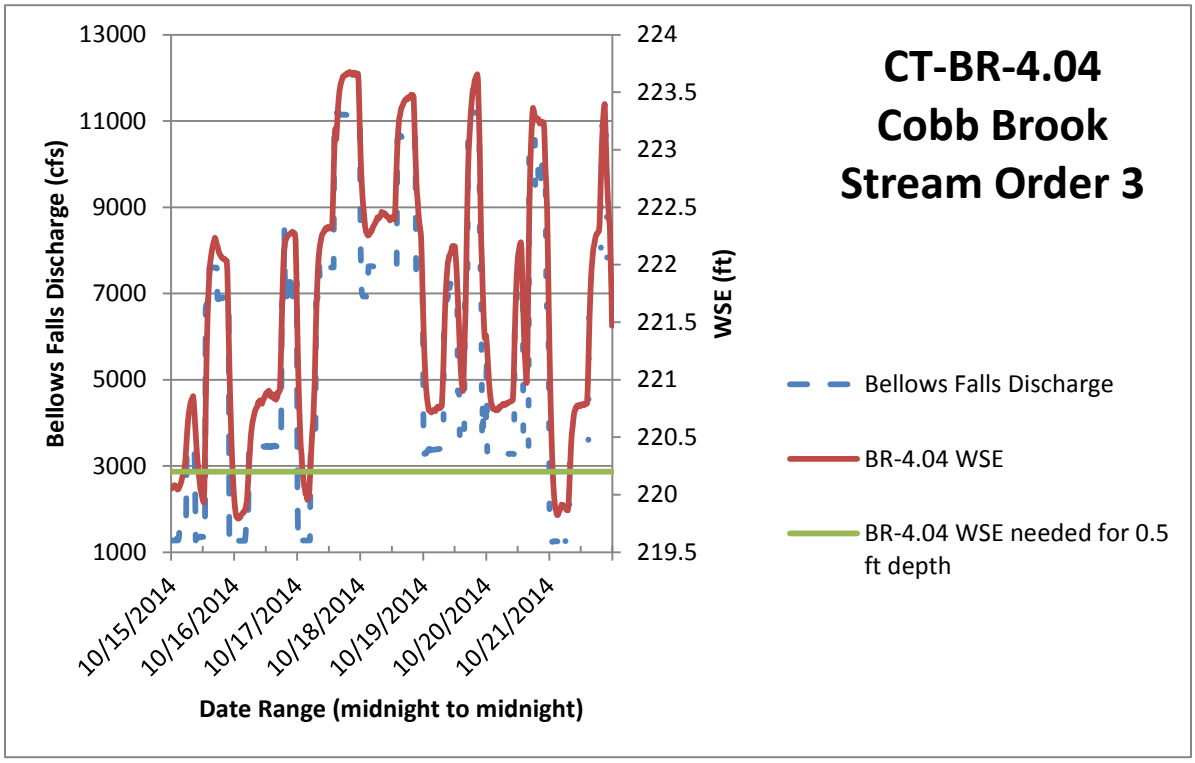

Figure 6.1-7. Representative operating conditions at Site CT-BR-4.04, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-V-5.02

Site CT-V-5.02, Mad Brook, is a stream order 2 tributary located just upstream of Walpole Bridge, so can be considered part of the Bellows Falls riverine reach, rather than the Vernon impoundment as the site was first identified. Based on visual evidence, the project-affected reach was estimated based on visual observation (not verified due to missing mainstem WSE data) to extend approximately 80 ft into the tributary to a culvert with a bottom sill elevation of 223.8 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 221.2 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depths in the

confluence cross section ranged from 0.7 – 1.1 feet as measured at site visits. Water depth at the tributary logger location ranged from 0.8 – 4.8 feet.

Mainstem WSE ranges from 218.4 to 225.7 under normal project operations based on the hydraulic model, would inundate the confluence at flows of 5,000 to 6,000 cfs depending on the Vernon dam WSE. However, Figure 6.1-8 illustrates that the minimum tributary WSE (used as a proxy for missing mainstem WSE data) recorded during the representative week (221.0 ft) and throughout the study period (220.9 ft, see Appendix A) were slightly less than the minimum mainstem WSE needed to achieve 0.5 ft of depth at the confluence cross section (221.2 ft).

The thalweg profile varies slightly within the estimated project-affected reach, and some areas of stranding are possible and access into the tributary may be limited to the tributary's natural stream flow under some mainstem and tributary low flow conditions. However, with a minimum of 0.8 feet of measured depth in the tributary and the presence of a potential perched culvert, project operations appears to cause non-adverse effects.

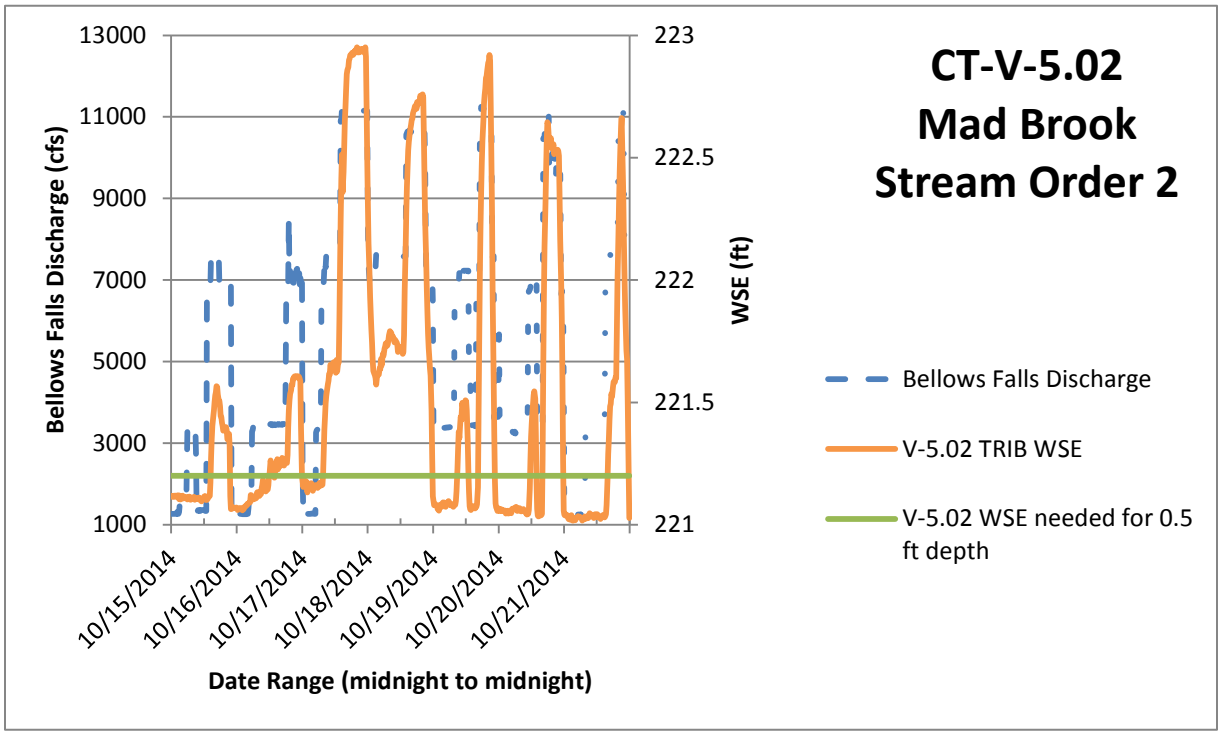

Figure 6.1-8. Representative operating conditions at Site CT-V-5.02, 2014 (discharge and WSE vertical scales are not correlated).

Site CT-VR-6.01

Site CT-VR-6.01 is a stream order 2 tributary located 0.2 miles downstream from the Vernon Project. Downed trees and branches were observed that likely limit mainstem inflow at the upper extent of the reach (see photographs in Appendix A). The project-affected reach extends approximately 125 ft from the confluence cross section to an elevation of 187.2. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 183.1 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the confluence cross section was < 0.5 ft about 59% of the time during the period of record, and ranged from 0.2 - 0.4 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.6 – 4.4 ft.

This site is at the upper end of FirstLight's Turners Falls impoundment and therefore influenced by Vernon discharge and FirstLight operations that can independently cause impoundment elevation fluctuations of several feet under normal operations. Mainstem WSE ranges from 180.2 to 186.8 under Vernon's normal project discharges and under the range of Turners Falls dam normal operating WSEs based on the hydraulic model, would inundate the confluence at flows of 6,750 at Turners Falls dam low normal operating WSE to 7,250 cfs at Turners Falls dam high normal operating WSE.

As a proxy for FirstLight operations, Figure 6.1-9 includes Vernon tailwater elevations during the representative Vernon operating conditions. Under Vernon minimum flow discharge, the tailwater elevation can range between approximately 181.0 ("low low tailwater elevation") and 184.0 ft ("low high tailwater elevation") largely due to operation of the FirstLight projects (see Figure 6.1-13 below). Figure 6.1-10 presents data for October 31, 2014. This was a day in which TransCanada restricted Vernon discharge to minimum flows and FirstLight lowered the Turners Falls impoundment during a portion of the day to facilitate low mainstem conditions needed for Study 8 – Channel Morphology and Benthic Habitat Study. Data for this date therefore represents extremely low mainstem conditions.

Access into this tributary is generally adequate based on measured tributary water depth but may be limited by tributary low flow conditions or low Turners Falls impoundment WSE. Mainstem (TF impoundment) WSEs in this reach are affected by both FirstLight operations and Vernon project discharge.

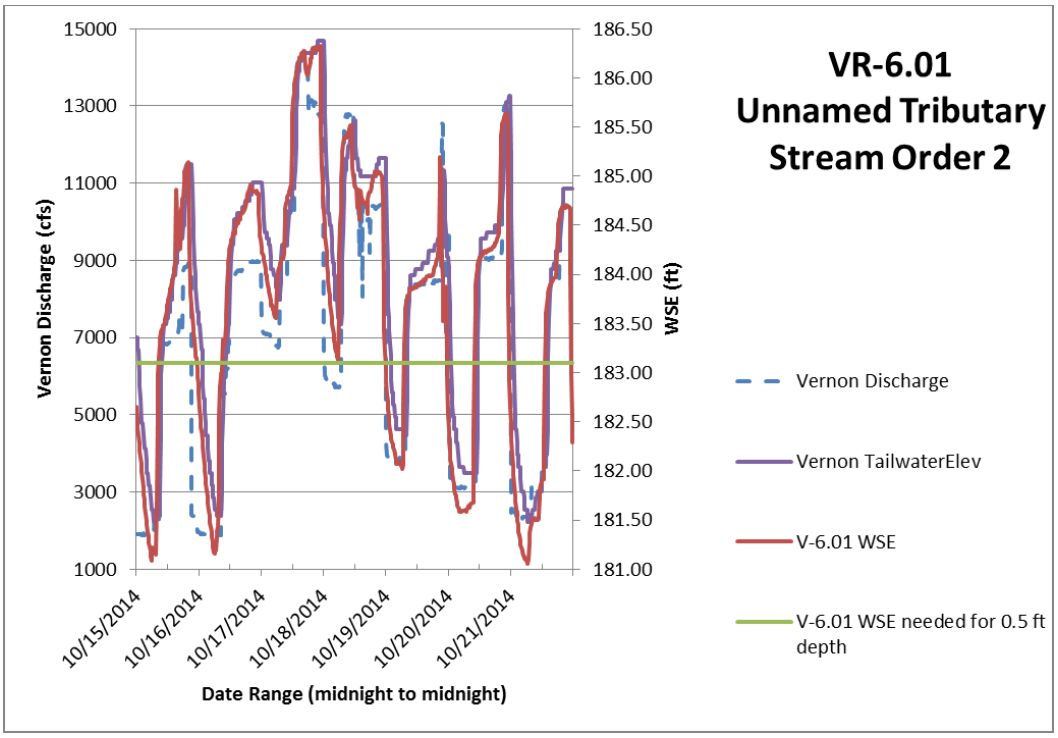

Figure 6.1-9. Representative operating conditions at Site CT-VR-6.01, 2014 (discharge and WSE vertical scales are not correlated).

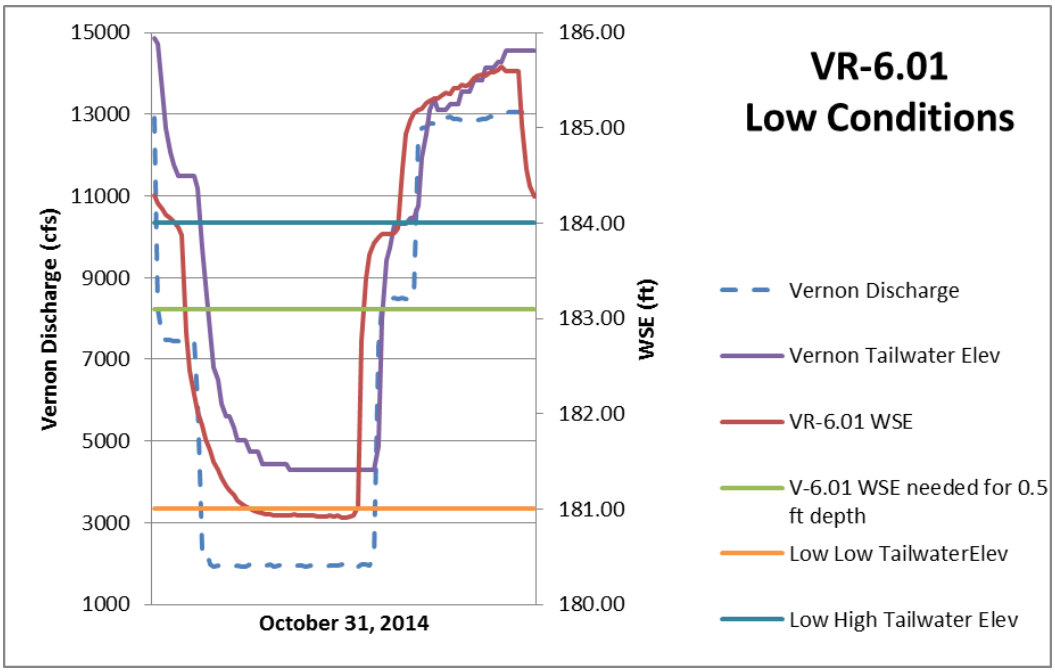

Figure 6.1-10. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.01 (discharge and WSE vertical scales are not correlated).

Site CT-VR-6.05

Site CT-VR-6.05 is a stream order 1 tributary located approximately 1.5 miles downstream from the Vernon Project. Downed trees and branches were observed that likely limit mainstem inflow at the upper extent of the reach. The project-affected reach extends approximately 165 ft from the confluence cross section to an elevation of 185.9 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 181.6 ft as measured at the lowest thalweg point in the cross section and without consideration of tributary flow or tributary water depth. Water depth at the confluence cross section was < 0.5 ft about 43% of the time during the period of record, and ranged from 0.1 – 0.3 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.1 – 3.6 ft.

This site is at the upper end of FirstLight's Turners Falls impoundment and therefore influenced by Vernon discharge and FirstLight operations that can independently cause impoundment elevation fluctuations of several feet under normal operations. Mainstem WSE ranges from 180.0 to 185.4 under Vernon's normal project discharges and under the range of Turners Falls dam normal operating WSEs based on the hydraulic model, would inundate the confluence at flows from minimum flow at Turners Fall dam low operating WSE to 7,000 cfs at Turners Falls dam high operating WSE. As a proxy for FirstLight operations, Figure 6.1-11 includes Vernon tailwater elevations during the representative Vernon operating conditions Under Vernon minimum flow periods, the tailwater elevation can range between approximately 181.0 ("low low tailwater elevation") and 184.0 ft ("low high tailwater elevation") largely due to operation of the FirstLight projects (Figure 6.1-13). Figure 6.1-12 presents data for October 31, 2014. This was a day in which TransCanada restricted Vernon discharge to minimum flows and FirstLight lowered the Turners Falls impoundment during a portion of the day to facilitate low mainstem conditions needed for Study 8 – Channel Morphology and Benthic Habitat Study. Data for this date therefore represents extremely low mainstem conditions.

Access into this tributary is generally adequate based on measured tributary water depth but may be limited by tributary low flow conditions or low Turners Falls impoundment WSE. Mainstem (TF impoundment) WSE in this reach are affected by both FirstLight operations and Vernon project discharge.

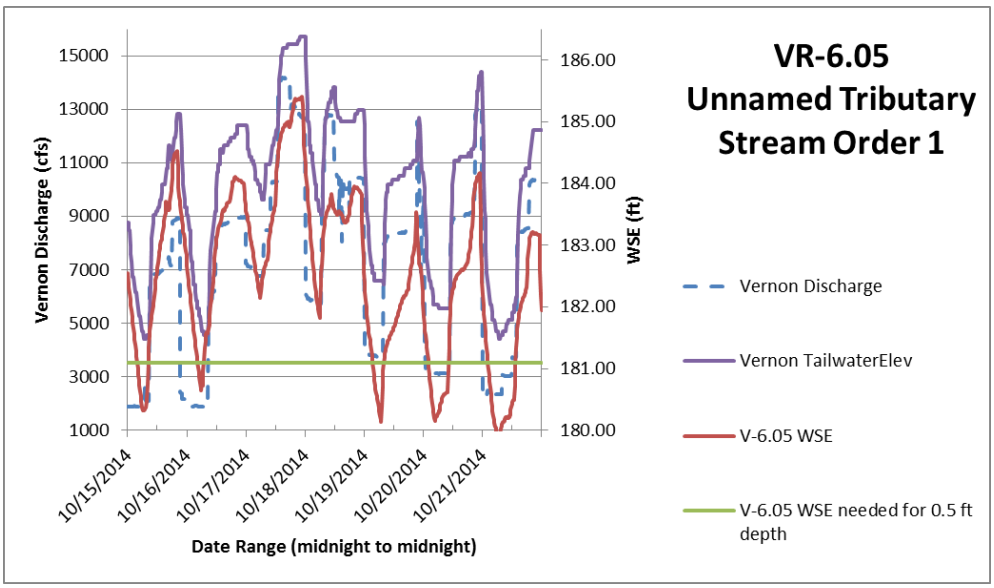

Figure 6.1-11. Representative operating conditions at Site CT-VR-6.05, 2014 (discharge and WSE vertical scales are not correlated).

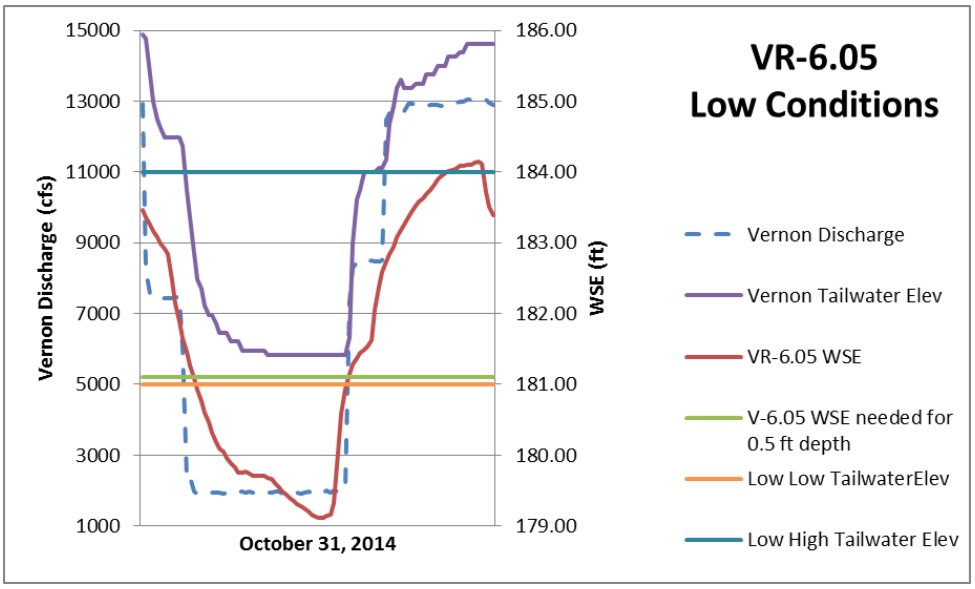

Figure 6.1-12. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.05 (discharge and WSE vertical scales are not correlated).

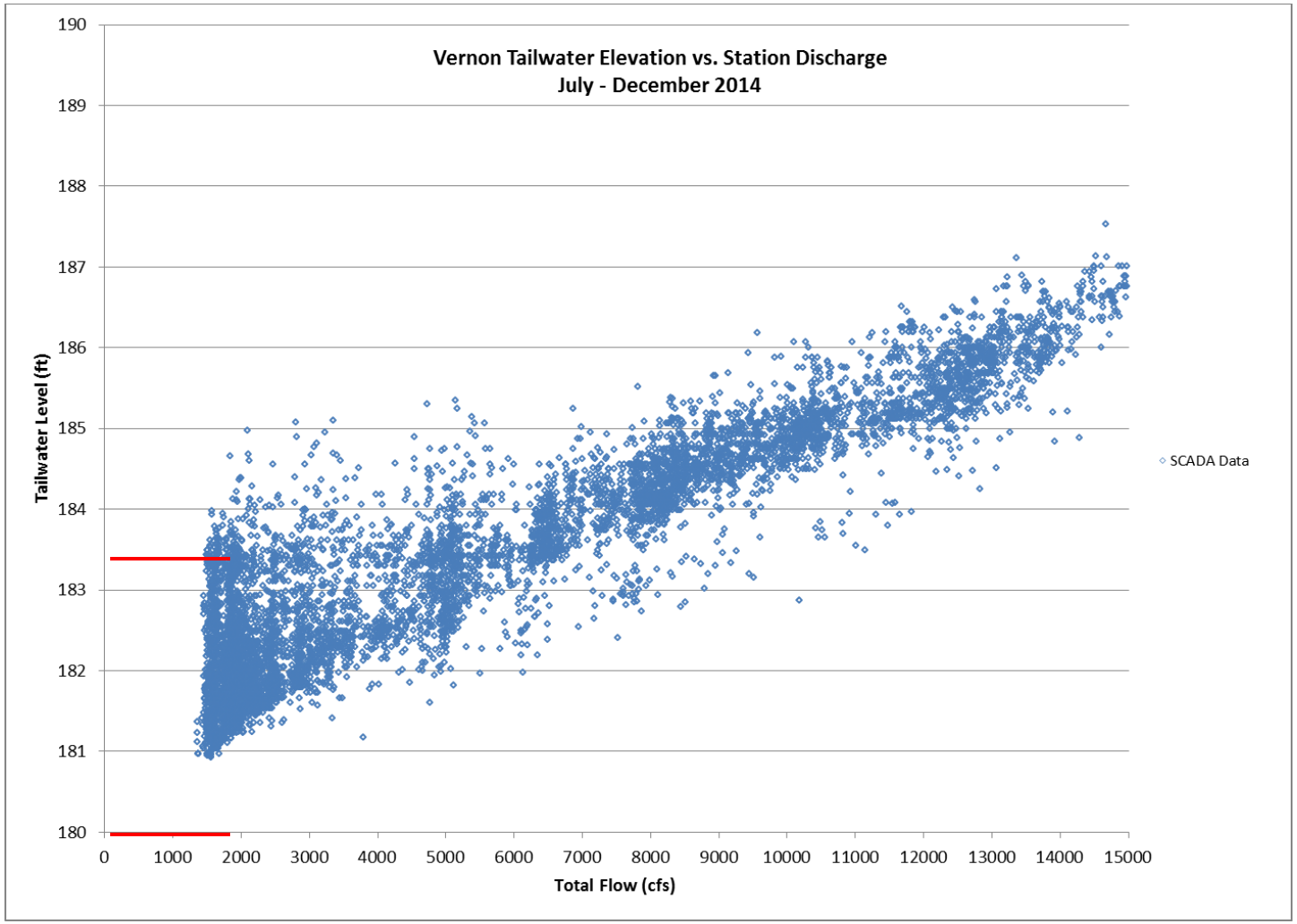

Figure 6.1-13. Variation in actual Vernon tailwater elevation reading at station discharge levels, 2014, illustrating effect of Turner's Falls operations on WSE independent of Vernon discharge.

6.1.2 Assessment of Project Effects on WSE

The initial study report recognized that results based on 2014 field observations and water level logger data were preliminary since Hydraulic and Operations model (Studies 4 and 5) data were not available at the time of report filing on September 14, 2015. Stakeholders provided comments on the initial study report and TransCanada filed its response to those comments on December 14, 2015. TransCanada developed a proposed methodology for the second evaluation to be based on modeled data and presented it at the March 17-18, 2016 study meeting, and in an email to the aquatics working group on April 6, 2016. Stakeholders submitted additional comments by May 2, 2016 as part of their comments on the March 16, 2016 filing of other study reports. TransCanada responded to those comments in its May 31, 2016 response-to-comments filing.

This revised report includes the requested evaluation of study sites during the spring spawning period to identify periods of time with < 0.5 ft of water depth for one hour or more (the minimum model time step) as well as for 12 hours or more as originally proposed. The 12-hour criterion was retained simply to create a breakpoint for analysis purposes, but is also considered reasonable for quantifying adverse project effects as fish approaching from the mainstem would have adequate access under this criterion for no less than 50% of the total time on any un-flagged date while the < 0.5 ft of access at any time is considered the most conservative condition.

6.1.2.1 Model-Based Assessment Approach and Criteria Used

Minimum mainstem WSE values for all 37 study sites were evaluated relative to output from Studies 4 and 5 which provided predicted WSE values at fixed locations. The Operations model used a representative subset of 5 of the available 30 historical years of hydrological and operational data to predict the frequency and duration of occurrence of < 0.5 ft of water depth at each study site on a daily basis. For each modeled hydrology, output used in this study consisted of daily cumulative hour totals where the predicted mainstem WSE at a study site confluence location was less than the minimum WSE value required for access (i.e., 0.5 ft of water depth or greater).

Tributary access at each study site was evaluated using modeled output for the spring spawning period (April 1 – June 30). To accomplish this, all spring dates in each of the five modeled annual hydrologies where at least 0.5 ft of water was present at the confluence cross section (indicating adequate access) for:

a. 12+ hours of a particular date (“50% criterion”); and

b. during any of the 24 hours of a particular date (“100% criterion”).

The number of such dates at each site in proportion to the total number of spring dates (91 total) was then determined. All model years were flagged where the proportion in (b) above was ≥ 10% of spring time dates in that model year, as described in the analysis proposal. This equates to approximately less than one day per week (10% of dates, 9 days over the 91 total spring days, or on average

less than one day per week) and is very conservative since fish approaching from the mainstem would otherwise have access over 90% of spring time days. The criteria used to categorize project effects based on model data are summarized in Table 6.1.2-1.

Table 6.1.2-1. Criteria for categorization of spring time access restrictions.

Category of Access Restriction (based on <0.5 ft of water depth)	% of Dates (April-June) with <0.5 ft Water Depth	During this Number of Model Years
"None"	0	All 5 years
"Negligible"	<10%	1, 2 or 3
"Infrequent"	<10%	4 or 5
"Occasional"	≥10%	1, 2 or 3
"Frequent"	≥10%	4 or 5

The percentage of dates where the modeled WSE is less than the WSE value required to provide access at the confluence of 0.5 ft of depth or more for 12+ hours per day and for 24 hours per day was calculated for all 37 sites in each of the five model years. These data were then restricted to periods of normal project operations.

As part of its operating procedure for high flow management, TransCanada lowers WSE at the dams in anticipation of inflows greater than maximum generating capacity at each project. This is done under Article 32 of the existing project licenses and in accordance with the coordination agreement with the US Army Corps of Engineers which operates flood control dams in the Connecticut River basin. These high water operations are initiated in order to manage upstream water elevations within certain flowage rights and to reduce the potential for river flows to spill outside of the normal bank full conditions. These conditions and operating protocols are not considered normal project operations but occur each spring during the spring freshet coinciding with the time frame (April 1- June 30) requested by stakeholders to be included in this assessment of project effects and any other times when anticipated flows exceed downstream station capacities.

To account for this condition at each study site and limit the assessment to potential effects of normal project operations, model data was evaluated based on the total number of hours on each date with WSE equal to or greater than the lowest WSE associated with normal project operations. Then access was calculated as the number of those hours where WSE was less than that determined to provide access (i.e., 0.5 ft of water depth or greater). Study sites were examined for periods where access is restricted (< 0.5 ft of water depth based on the measured confluence cross section and absent consideration of tributary flow) for 50% or more hours on a particular date based on the total number of normal operations hours of that date; and for any hours (100% criterion) of that date as requested by stakeholders. Model years where those proportions were ≥10% of all spring dates were also flagged and results were categorized as described in Table 6.1.2-1 above.

This approach is very conservative and is likely to significantly overestimate potential impacts on fish seeking access to tributaries.

It is important also to note that the hydraulic model accurately describes mainstem WSE's at model cross-sections based upon mainstem flows and downstream elevation at the dam. The model was not developed to evaluate tributaries or tributary flows and cannot predict or estimate tributary inflows on any given day.

6.1.2.2 Model-Based Assessment Results

Data based on the model analysis are summarized by study reach in Table 6.1.2-2. Not surprisingly, the number of study sites categorized as having more frequent access restrictions increases when the more conservative 100%-of-date criterion is used rather than the 50%-of-date criterion (e.g., up to 12 hours/day with adequate access). The discussion of model results that follows is limited to the 50%-of-date model criterion, since it is reasonable to assume that access for up to half of each day is sufficient for fish desiring to enter a tributary. The 100%-of-date criterion as requested by stakeholders is included for completeness in Appendix C but constitutes a worst-case scenario. Detailed data for each site based on the model analysis are included in Appendix C (filed separately in Excel format); and graphically for each site in Appendix D which shows percent of hours with at least 0.5 ft of depth in each 24-hour spring time day, including during times of river profile reservoir operations outside of normal project operations.

Table 6.1.2-2. Summary of modeled access restrictions to study sites under normal project operations for 50% and 100%-of-day criteria.

50% Daily Access Restriction (April 1 – June 30)					
Reach	**None**	**Negligible**	**Infrequent**	**Occasional**	**Frequent**
Wilder	8	3	1	2	0
Wilder Riverine	0	0	0	2	3
Bellows	5	1	0	0	0
Bellows Riverine	0	1	0	3	0
Vernon	4	0	0	1	1
Vernon Riverine	0	1	0	1	0
All Reaches	**17**	**6**	**1**	**9**	**4**
100% Daily Access Restriction (April 1 – June 30)					
Reach	**None**	**Negligible**	**Infrequent**	**Occasional**	**Frequent**
Wilder	7	1	1	3	2
Wilder Riverine	0	0	0	0	5
Bellows	4	0	0	2	0
Bellows Riverine	0	0	0	0	4
Vernon	2	1	1	0	2
Vernon Riverine	0	0	0	0	2
All Reaches	**13**	**2**	**2**	**5**	**15**

6.1.2.3 Model Comparison with 2014 Field Observations and Data

Table 6.1.2-3 and Appendix C provide a comparison of 2014 summer/fall access restrictions with spring time modeled conditions (including the 100%-of-day criterion not discussed below). It should be noted that 2014 access restrictions were calculated based on the percent of time over the water level logger period of record during typically drier conditions. The spring time model analysis results are based on the percent of hours during each day under normal project operations with access restrictions and the number of days in each modeled year where those restrictions occur more than 10% of the time. Neither the spring time analysis nor the 2014 field-based analysis considered any affect associated with tributary flows and tributary flow-related depth.

- Twenty-three of the 37 sites (62%) including all seven backwater sites were characterized by the model as having no restriction or negligible access restrictions in the spring time. Eleven of those sites also had 0% occurrence of access restriction in 2014, and ten sites had less than 25% occurrence in 2014 (the access threshold considered in Section 6.1.). The remaining two sites (CT-B-3.10 and CT-VR-6.05, both stream order 1 tributaries) had 68.3% and 42.5% occurrences of access restriction in 2014, respectively but were still characterized as negligible in spring time.
- One site (CT-W-1.07 a stream order 1tributary) was characterized by the model with infrequent spring time access restrictions although it had 0% occurrences in 2014.
- Nine sites were characterized as occasionally restricted in spring time and of those, four were below the 25% of occurrence threshold in 2014; three had 2014 access restrictions between 40.5% and 58.6% of occurrences. The remaining two were undetermined in 2014 (Cold River CT-BR-4.02 and Mad Brook CT-V-5.02) due to a lack of mainstem water level logger data. As mentioned in the summer/fall 2014 analysis, the Cold River in particular is a stream order 5 tributary and generally has sufficient inflow and depth even in the summer/fall to maintain access (see Section 6.1.1 and Appendix A for more discussion of the site conditions).
- The remaining four sites (all stream order 1 or 2) were characterized as frequently restricted in spring time and were also restricted from 24.0% to 100% of occurrences in 2014. Three of these sites are in the Wilder riverine section of the river and one (CT-V-5.31) is located in the Vernon impoundment. Although not as seemingly evident as in the Cold River site, access at these remaining four sites are largely affected and determined by the amount of flow in the tributaries themselves rather than mainstem elevations.

As discussed above, modeled data alone does not fully characterize site conditions and cannot account for site-specific conditions that are limiting factors to access and unrelated to project operational WSE levels. Table 6.1.2-4 summarizes site conditions discussed in Section 6.1.1 and detailed in Appendix A for sites characterized as frequently or occasionally restricted in spring time based on model data.

Table 6.1.2-3. Comparison of access restrictions in 2014 and under normal project operations with modeled 50% and 100%-of-date criteria.

Site ID	Reach	Type	Waterbody Name	Stream Order	WSE < 0.5 ft Depth at Confluence		
					2014 % Occurrence	Modeled 50% of Date	Modeled 100% of Date
CT-W-1.01	Wilder	Minor Trib	Harriman Brook	2	0.02%	None	Negligible
CT-W-1.05	Wilder	Backwater		n/a	0.05%	Negligible	Occasional
CT-W-1.06	Wilder	Minor Trib		2	13.6%	Occasional	Frequent
CT-W-1.16	Wilder	Backwater		n/a	0.5%	Negligible	Occasional
CT-W-1.22	Wilder	Major Trib	Indian Pond Brook	3	0%	None	None
CT-W-1.23	Wilder	Minor Trib		1	11.0%	Occasional	Frequent
CT-W-1.28	Wilder	Backwater		n/a	0%	None	None
CT-W-1.34	Wilder	Minor Trib		2	0.4%	Negligible	Infrequent
CT-W-1.44	Wilder	Backwater		n/a	0%	None	None
CT-W-1.47	Wilder	Minor Trib		1	0%	Infrequent	Occasional
CT-W-1.48	Wilder	Major Trib	Grant Brook	3	0%	None	None
CT-W-1.55	Wilder	Minor Trib		1	0%	None	None
CT-W-1.59	Wilder	Backwater		n/a	0%	None	None
CT-W-1.67	Wilder	Minor Trib		2	0%	None	None
CT-WR-2.01	Wilder Riverine	Minor Trib		2	70.2%	Frequent	Frequent
CT-WR-2.07	Wilder Riverine	Minor Trib	Hanchetts Brook	1	95.8%	Frequent	Frequent
CT-WR-2.10	Wilder Riverine	Minor Trib	McArthur Brook	2	58.2%	Occasional	Frequent
CT-WR-2.11	Wilder Riverine	Major Trib	Lulls Brook	3	0%	Occasional	Frequent
CT-WR-2.13	Wilder Riverine	Minor Trib	Bashan Brook	1	100%	Frequent	Frequent
CT-B-3.07	Bellows Falls	Major Trib	Barkmill Brook	3	13.9%	None	Occasional

Site ID	Reach	Type	Waterbody Name	Stream Order	WSE < 0.5 ft Depth at Confluence		
					2014 % Occurrence	Modeled 50% of Date	Modeled 100% of Date
CT-B-3.10	Bellows Falls	Minor Trib		1	68.3%	Negligible	Occasional
CT-B-3.19	Bellows Falls	Backwater		n/a	0%	None	None
CT-B-3.24	Bellows Falls	Major Trib	Commissary Brook	3	0.9%	None	None
CT-B-3.27	Bellows Falls	Minor Trib		2	0%	None	None
CT-B-3.35	Bellows Falls	Minor Trib		2	0%	None	None
CT-BR-4.02	Bellows Falls Riverine	Major Trib	Cold River	5	Undetermined	Occasional	Frequent
CT-BR-4.03	Bellows Falls Riverine	Minor Trib		2	11.7%	Negligible	Frequent
CT-BR-4.04	Bellows Falls Riverine	Major Trib	Cobb Brook	3	40.5%	Occasional	Frequent
CT-V-5.02	Bellows Falls Riverine /Vernon	Minor Trib	Mad Brook	2	Undetermined	Occasional	Frequent
CT-V-5.04	Vernon	Major Trib		3	2.2%	None	Negligible
CT-V-5.19	Vernon	Minor Trib		1	1.1%	None	Infrequent
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	21.1%	Occasional	Frequent
CT-V-5.31	Vernon	Minor Trib		2	24.0%	Frequent	Frequent
CT-V-5.36	Vernon	Minor Trib		2	0.3%	None	None
CT-V-5.50	Vernon	Backwater		n/a	0%	None	None
CT-VR-6.01	Vernon Riverine	Minor Trib		2	58.6%	Occasional	Frequent
CT-VR-6.05	Vernon Riverine	Minor Trib		1	42.5%	Negligible	Frequent

Table 6.1.2-4. Summary of non-project factors limiting access for sites characterized as frequently or occasionally restricted in spring time based on model data (50%-of-day criterion).

Site ID	Sub Reach	Waterbody Name	Stream Order	Project-affected Reach (ft)[a]	2014 % Occurrence < 0.5 ft at Confluence	Measured Trib. Water Depth (ft)	Spring Time Modeled Restriction	Additional Factors Limiting Access
CT-WR-2.01	Upper Wilder Riverine		2	45	70.2%	0.1 – 0.3	Frequent	Perched culvert observed, short project-affected reach.
CT-WR-2.07	Upper Wilder Riverine	Hanchetts Brook	1	-1	95.8%	0.1 – 0.3	Frequent	Tributary thalweg bed elevation increases approximately 2 ft just upstream of project-affected extent. Downed trees, branches and cobbles, boulders present. Short project-affect reach
CT-WR-2.13	Lower Wilder Riverine	Bashan Brook	1	-9	100%	0.1 – 0.6	Frequent	Man-made blockages. Short project-affected reach.
CT-V-5.31	Vernon		2	78	24.0%	0.2 – 1.4	Frequent	Thalweg profile varies, culvert present. Short project-affected reach.
CT-W-1.06	Upper Wilder		2	136	13.60%	0.3 – 1.0	Occasional	Culvert present which may limit depth to outflow, limited suitable habitat observed. Short project-affect reach.
CT-W-1.23	Middle Wilder		1	263	11.00%	0.1 – 0.7	Occasional	Thalweg profile varies, some periods of limited stream flow, shallow, shoaled area observed.
CT-WR-2.10	Lower Wilder Riverine	McArthur Brook	2	160	58.20%	No inflow on 2 visits	Occasional	Intermittent stream, no flow on 2 of 3 visits. Short project-affect reach.
CT-WR-2.11	Lower Wilder Riverine	Lulls Brook	3	688	0%	0.5 – 2.4	Occasional	Variable thalweg profile, significant debris and scour/ deposition present.
CT-BR-4.02	Bellows Riverine	Cold River	5	900	Undetermined	0.7 – 3.0	Occasional	Thalweg profile varies due to cobble, which was observed to have shifted between visits and may move frequently in storms.
CT-BR-4.04	Bellows Riverine	Cobb Brook	3	535	40.50%	0.4 – 1.9	Occasional	Thalweg profile varies, depth limited to natural stream flow due to culvert, downed trees and branches present.
CT-V-5.02	Bellows Riverine/ Vernon	Mad Brook	2	80	Undetermined	0.6 – 3.1	Occasional	Thalweg profile varies, depth limited to natural stream flow due to perched culvert present.

Site ID	Sub Reach	Waterbody Name	Stream Order	Project-affected Reach (ft)[a]	2014 % Occurrence < 0.5 ft at Confluence	Measured Trib. Water Depth (ft)	Spring Time Modeled Restriction	Additional Factors Limiting Access
CT-V-5.28	Vernon	Salmon Brook	3	169	21.10%	0.3 – 1.1	Occasional	Thalweg profile varies, depth limited to natural stream flow due to culvert present.
CT-VR-6.01	Vernon Riverine		2	125	58.60%	0.3 – 1.2	Occasional	Affected by Turners Falls operation, downed trees and branches present.

a. Negative values indicate that project-affect reach determined by available mainstem WSE data was closer to the mainstem than the visually determined confluence location.

Potentially project-affected sites include the 13 sites listed Table 6.1.2-4 based on the model criteria of 50% of hours during spring time dates that have less than 0.5 feet of water depth at the mainstem confluence 10% or more of springtime dates in four or five modeled years (e.g., categorized as frequently or occasionally restricted). As noted above, the 2014 field-based analysis did not consider tributary flow or flow-related depth and the model cannot predict tributary inflows at any given site which is likely to skew estimates of project effects at any given site. The photographs and thalweg profiles in Appendix A help to illustrate clearly the observed conditions at these sites. Appendix D also illustrates that for most sites at least some periods of access (at least 0.5 ft of depth at the confluence) based on model data are available on most days during spring time.

- One site (CT-VR-6.01) is primarily affected by operations of the Turners Falls Project and not by Vernon project operations.
- Ten additional sites have less than 300 feet of project affected reach, limited outflow providing little mainstem-connected habitat, culverts that limit connectivity under some conditions, and/or blockages due to debris accumulation or man-made causes.
- One site (CT-WR-2.11) has a variable thalweg which can limit connectivity under low outflow and low mainstem WSE, along with significant debris accumulation that is likely to limit access.
- The Cold River, a stream order 5 tributary, has a broad delta bar at the mainstem confluence with coarse-grained substrate (gravel/cobble) contributed primarily by outflow from the tributary itself (Stantec and Normandeau, 2016). This condition also exists within the tributary itself as observed in 2014 (illustrated in the Appendix A photographs). As cobble is deposited at the confluence with tributary outflow, broad shallow areas are created which can limit the extent and depth of mainstem WSE into portions of the tributary. A comparison of tributary depths measured in 2014 with USGS gage daily mean discharge data (Gage #01154950, Alstead NH) on the same dates illustrates the relationship between stream flows and water depth. Even at low stream flows there is sufficient water depth along the thalweg (Table 6.1.2-5).

Table 6.1.2-5. Comparison of measured tributary water depth and USGS[a] daily mean discharge data for the Cold River, 2014.

Date	Measured Water Depth (ft)			Daily Mean Discharge (cfs)
	Min.	Max.	Mean	
7/21/2014	1.2	2.2	1.5	90
8/27/2014	0.7	1.7	1.2	40
11/10/2014	1.0	3.0	2.1	71

a. USGS gage station # 01154950 (Alstead, NH)

7.0 STUDY CONCLUSIONS

The four study sites showing frequent limited access are located in riverine or upper impoundment areas and are minor tributaries (stream order 1 or 2) and, as noted during field observations, do not have significant natural outflow. Although impedances to passage at these four locations may exist during the spring (based on modeled data) and during the normally lower flow summer/fall period, opportunities for fish passage at these sites are limited beyond streamflow and water depth by several non-project related impacts including downed woody debris, culverts, and introduction of artificial blockages due to human activities. In addition to those field observations, the project-affected reach length estimated for each of these sites during the 2014 field evaluations is relatively short.

The nine sites showing occasional access limitations are also primarily small streams (6 sites including one intermittent stream) and five of those also have short project-affected reaches. All of these tributaries are subject to access limitations based natural streamflow, presence of debris, shifting cobble, and/or culverts which are non-project related causes and are likely to be the primary drivers behind occasional access limitations rather than normal project operations.

Project operations do not appear to alter water quality in tributaries and backwaters based on water quality data collected in 2014 which generally met state water quality standards. Results of the 2012 and 2015 water quality studies (Normandeau, 2013; Louis Berger and Normandeau, 2016) also indicate that water quality in the mainstem is supportive of fish productivity.

Lastly, this study was conducted at a small subset of all tributaries and backwaters to the Connecticut River within the study area (Table 7.0-1). While some study sites showed occasional or frequent project effects, these sites comprise a small fraction of all available fish habitat in tributaries and backwaters within the basin, and this study focused on the smallest tributaries (stream orders 1, 2, and 3) which would be most likely to have limited stream flow. It is extremely likely that adequate access exists at the many other larger tributaries and backwaters throughout the project-affected areas.

Table 7.0-1. Comparison of study sites to available sites, by stream order.

Stream Order	Study 13 Selected Sites	Number of Available Tributaries	Study 13 % of Available Tributaries
0	0	41	0.0%
1	8	31	25.8%
2	13	53	24.5%
3	8	36	22.2%
4	0	17	0.0%
5	1	8	12.5%
6	0	3	0.0%
backwaters	7	41	17.1%
TOTAL	37	230	16.1%

8.0 LITERATURE CITED

ASQL (American Society for Quality Control). 1993. Sampling procedures and tables for inspection by attributes. ANSI/ASQC Z1.4-1993.

Louis Berger and Normandeau Associates, Inc. 2016. ILP Study 6 - Water Quality Monitoring and Continuous Temperature Monitoring Study Report. Prepared for TransCanada Hydro Northeast Inc. March 1, 2016.

NHDES (New Hampshire Department of Environmental Services). 2012. Final 2012 Section 303(d) Surface Water Quality List Submitted to EPA for Approval. February 12, 2014.

Normandeau (Normandeau Associates, Inc.). 2013. 2012 Baseline Water Quality Study Final Report. Prepared for TransCanada Hydro Northeast Inc. August 23, 2013.

Normandeau 2014a. ILP Study 13 -Tributary and Backwater Fish Access and Habitats Study - Updated Revised Site Selection Report. Prepared for TransCanada Hydro Northeast Inc. July 17, 2014.

Normandeau 2014b. ILP Study 7 - Aquatic Habitat Mapping Study Final Report. Prepared for TransCanada Hydro Northeast Inc. March 2, 2015.

Stantec Consulting Services Inc. and Normandeau Associates, Inc, 2016. ILP – Study 8 – Channel Morphology and Benthic Habitat Study Final Study Report. Prepared for TransCanada Hydro Northeast Inc. May 16, 2016.

VDEC (Vermont Department of Environmental Conservation). 2014. State of Vermont 2014 303(d) List of Impaired Waters. September 2014.

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Appendix A

Tributary and Backwater Study Site Detail

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APPENDIX A – TABLE OF CONTENTS

1.0 Wilder Impoundment 1
1.1 Site CT-W-1.01 Harriman Brook 1
1.2 Site CT-W-1.05 Backwater 5
1.3 Site CT-W-1.06 9
1.4 Site CT-W-1.16 Backwater 13
1.5 Site CT-W-1.22 Indian Pond Brook 17
1.6 Site CT-W-1.23 21
1.7 Site CT-W-1.28 Backwater 25
1.8 Site CT-W-1.34 29
1.9 Site CT-W-1.44 Backwater 33
1.10 Site CT-W-1.47 37
1.11 Site CT-W-1.48 Grant Brook 41
1.12 Site CT-W-1.55 45
1.13 Site CT-W-1.59 49
1.14 Site CT-W-1.67 53
2.0 Wilder Riverine section 57
2.1 Site CT-WR-2.01 57
2.2 Site CT-WR-2.07 Hanchetts Brook 61
2.3 Site CT-WR-2.10 McArthur Brook 65
2.4 Site CT-WR-2.11 Lulls Brook 69
2.5 Site CT-WR-2.13 Bashan Brook 73
3.0 Bellows Falls Impoundment 77
3.1 Site CT-B-3.07 Barkmill Brook 77
3.2 Site CT-B-3.10 81
3.3 Site CT-B-3.19 Backwater 85
3.4 Site CT-B-3.24 Commissary Brook 89
3.5 Site CT-B-3.27 93
3.6 Site CT-B-3.35 97

APPENDIX A – TABLE OF CONTENTS - CONTINUED

4.0 Bellows Falls Riverine section 101

4.1 Site CT-BR-4.02 Cold River 101

4.2 Site CT-BR-4.03 105

4.3 Site CT-BR-4.04 Cobb Brook 109

4.4 Site CT-V-5.02 Mad Brook.....113

5.0 Vernon Impoundment 117

5.1 Site CT-V-5.04 117

5.2 Site T-V-5.19 121

5.3 Site CT-V-5.28 Salmon Brook.....125

5.4 Site CT-V-5.31 129

5.5 Site CT-V-5.36 133

5.6 Site CT-V-5.50 Backwater.....135

6.0 Vernon Riverine section 139

6.1 Site CT-VR-6.01 139

6.2 Site CT-VR-6.05 143

1.0 WILDER IMPOUNDMENT

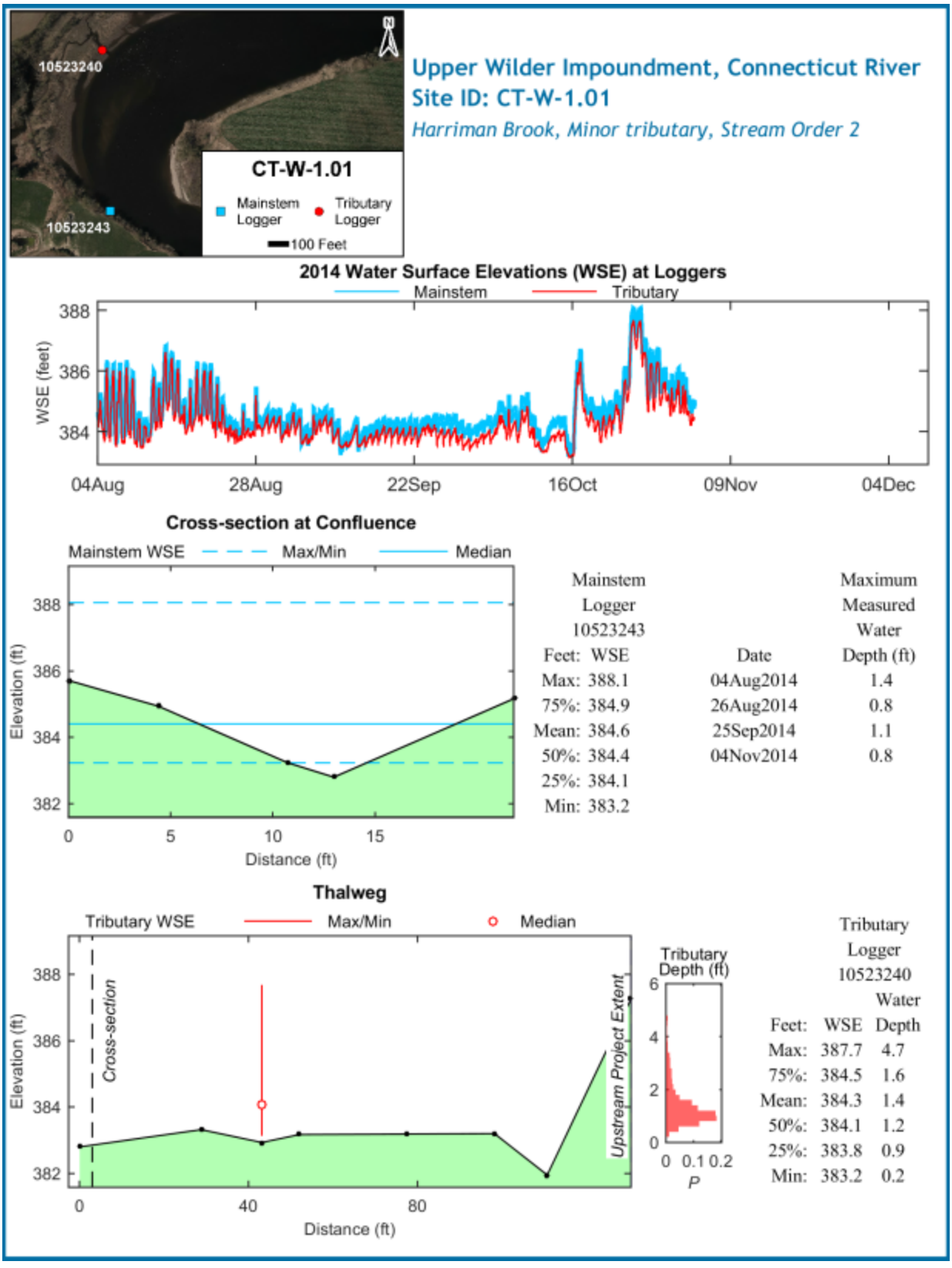
1.1 Site CT-W-1.01 Harriman Brook

Site CT-W-1.01 Harriman Brook, is a stream order 2 tributary located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523240) and mainstem (SN 10523243) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 40 feet upstream from the visually determined confluence with the mainstem. During the initial site visit, the field crew visually determined that the project-affected reach extends approximately 128 ft up into Harriman Brook to a beaver dam with a crest elevation of 387.3 ft. Review of the WSE values recorded by the mainstem level logger indicates that a minimum of 75% of the time, water levels remain below the beaver dam crest elevation (75% occurrence = 384.9 ft / beaver dam crest = 387.3 ft). However, the maximum operational WSE (388.1 ft) recorded by the mainstem level logger indicates that the project-affected reach extends farther up the tributary on occasion. Flow was present in Harriman Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.8 to 1.4 ft. Water depths were measured along the channel thalweg during the initial site visit on August 4th and ranged between 1.2 and 2.3 ft (mean = 1.5 ft). Water depths at the tributary logger location ranged from 0.2 to 4.7 ft (mean = 1.4 ft).

Review of the frequency distribution of tributary water depth recorded by the tributary level logger (Figure 5.1-1), indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 0.9 and 1.6 ft. As indicated by the minimum water depth recorded by the tributary level logger (0.2 ft), access may be reduced under low flow mainstem and tributary conditions (0.02% of data occurrences < 0.5 ft of depth at the confluence).

Beaver dam at Harriman Brook, site CT-W-1.01.


10523240
10523243
N
CT-W-1.01
Mainstem Logger
Tributary Logger
100 Feet
Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.01
Harriman Brook, Minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
388
386
384
04Aug
28Aug
22Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
388
386
384
382
0
5
10
15
Distance (ft)
Mainstem Logger 10523243
Feet: WSE
Max: 388.1
75%: 384.9
Mean: 384.6
50%: 384.4
25%: 384.1
Min: 383.2
Date
04Aug2014
26Aug2014
25Sep2014
04Nov2014
Maximum Measured Water Depth (ft)
1.4
0.8
1.1
0.8
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Elevation (ft)
388
386
384
382
0
40
80
Distance (ft)
Tributary Depth (ft)
6
4
2
0
0 0.1 0.2
P
Tributary Logger 10523240
Feet: WSE Water Depth
Max: 387.7 4.7
75%: 384.5 1.6
Mean: 384.3 1.4
50%: 384.1 1.2
25%: 383.8 0.9
Min: 383.2 0.2

Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.01
Harriman Brook, Minor tributary, Stream Order 2

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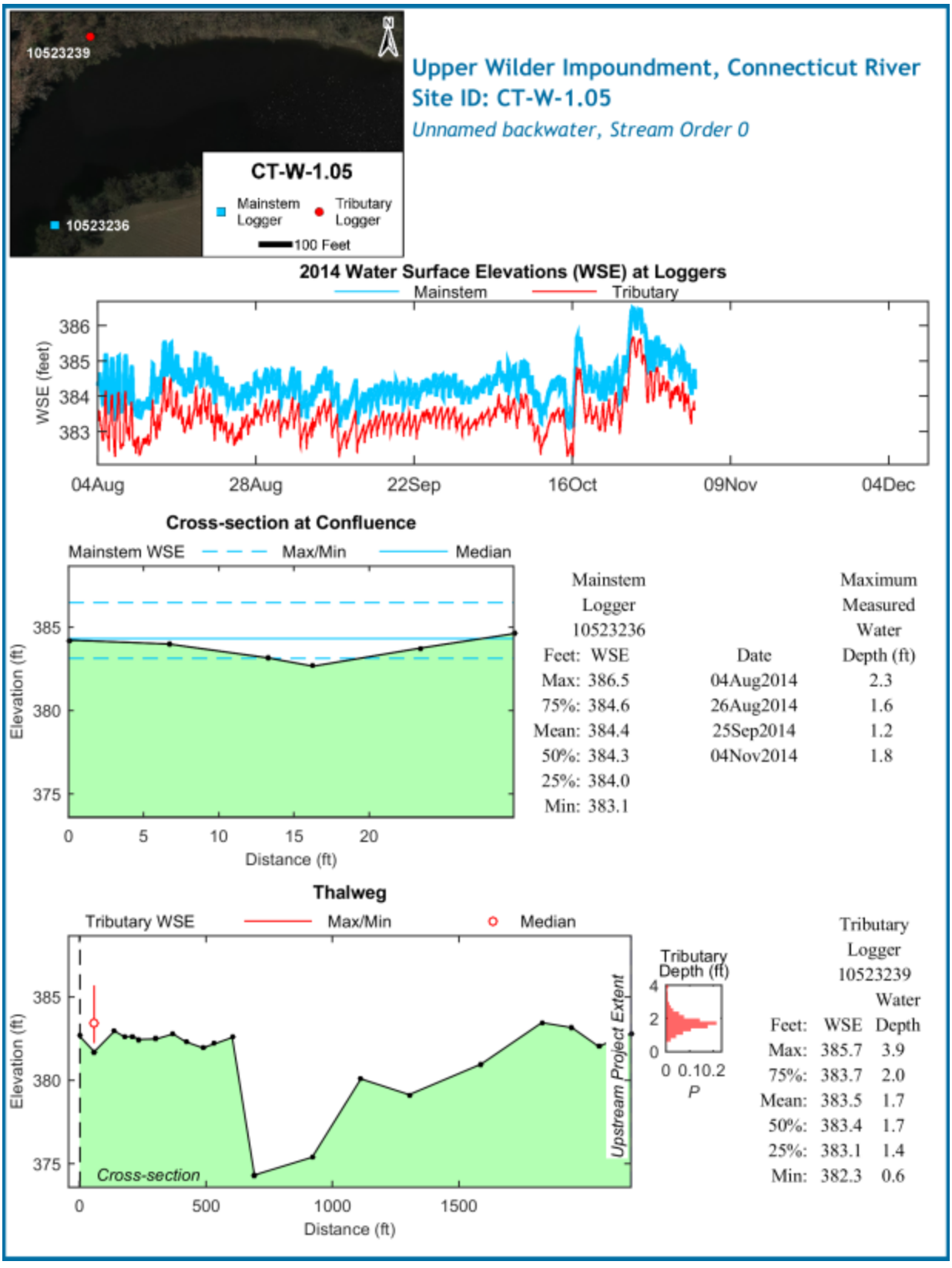
1.2 Site CT-W-1.05 Backwater

Site CT-W-1.05 is a backwater located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523239) and mainstem (SN 10523236) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed.

The site is connected to the mainstem via an approximately 700-foot-long stream-like access channel (see access channel confluence with mainstem in photograph dated 25Sep14 below). The backwater level logger was installed within the access channel at a location approximately 60 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of the mainstem influenced area as the entire length of the access channel, and across the ponded backwater area (a linear distance of approximately 2,180 ft). The project-affected reach was later determined from WSE data to extend to approximately 2,119 ft. Sedimentation in the vicinity of large downed tree trunks/branches was apparent (see photo below). Water was present within the access channel and backwater section of Site CT-W-1.05 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged between 1.2 and 2.3 ft.

Water depths along the access channel thalweg ranged between 1.3 and 2.4 ft (mean = 1.9 ft). Review of the frequency distribution of water depth recorded by the tributary level logger in the access channel indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 1.4 and 2.0 ft and is adequate for access. Water depths measured within the ponded backwater area primarily ranged from 1-4 ft with deeper areas up to 8-9 ft. However, as indicated by the minimum water depth recorded at the backwater level logger location (0.6 ft), access may be reduced at higher elevation thalweg locations upstream of the level logger location under low mainstem conditions (0.05% of data occurrences < 0.5 ft of depth at the confluence).

View within the access channel connecting mainstem to backwater at Site CT-W-1.05 showing numerous downed logs creating potential blockage during low flow conditions.


10523239
10523236
CT-W-1.05
Mainstem Logger
Tributary Logger
100 Feet
Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.05
Unnamed backwater, Stream Order 0
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
386
385
384
383
04Aug
28Aug
22Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
385
380
375
0
5
10
15
20
Distance (ft)
Mainstem Logger 10523236
Feet: WSE
Max: 386.5
75%: 384.6
Mean: 384.4
50%: 384.3
25%: 384.0
Min: 383.1
Date
04Aug2014
26Aug2014
25Sep2014
04Nov2014
Maximum Measured Water Depth (ft)
2.3
1.6
1.2
1.8
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
385
380
375
Cross-section
Upstream Project Extent
0
500
1000
1500
Distance (ft)
Tributary Depth (ft)
4
2
0
0 0.10.2
P
Tributary Logger 10523239
Feet: WSE Water Depth
Max: 385.7 3.9
75%: 383.7 2.0
Mean: 383.5 1.7
50%: 383.4 1.7
25%: 383.1 1.4
Min: 382.3 0.6

Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.05
Unnamed backwater, Stream Order 0

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1.3 Site CT-W-1.06

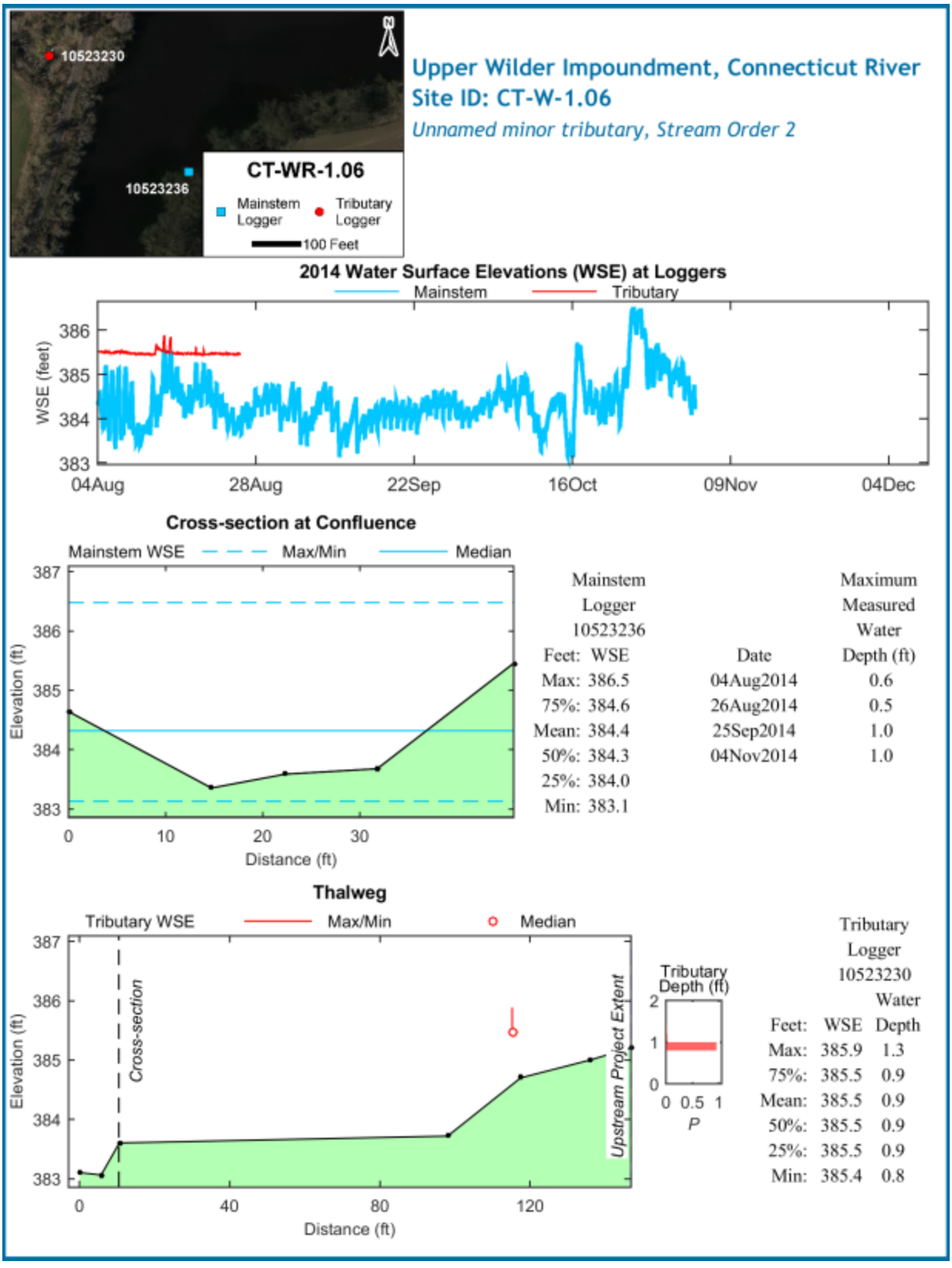
Site CT-W-1.06 is an unnamed stream order 2 tributary located on the Vermont side in upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523230) and mainstem (SN 10523236) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed. During the manual data review portion of post-processing, it was discovered that pressure readings recorded by the tributary level logger were impacted by a logger malfunction. This malfunction resulted in plotted sensor depths far exceeding the range expected for this particular location and data from this location was assigned a Use Code = 9 (Table 4.2-1). As a result sensor depth information for the tributary logger is limited to the period August 4 to August 26, 2014. The mainstem logger was found to be missing from its installation location during the final site visit and as a result sensor depth information for the mainstem logger is limited to the period August 4 to September 25, 2014.

Tributary CT-W-1.06 converges with the mainstem Connecticut River just downstream of an approximately 90-ft-long tunnel underneath the railroad (see photo section below). The tributary level logger was installed on the upstream side of the tunnel, approximately 100 ft above the confluence. During the initial site visit, the field crew visually determined that the mainstem influence extends approximately 137 ft up into tributary to a large blockage with a crest elevation of 385.3 ft. A minimum of 75% of the time, project-affected water levels remain below the project-affected elevation (75% occurrence = 384.6 ft /project extent = 385.3 ft). However, the maximum operational WSE (386.5 ft) recorded by the mainstem level logger indicates that the project-affected extends farther up into the tributary on occasion. Flow was present in the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.5-1.0 ft. Water depths were measured along the channel thalweg and ranged between 1.0 and 0.3 ft (mean = 0.6 ft) with shallow depths present towards the upstream end of the suspected project-affected reach.

The project-affected portion of tributary CT-W-1.06 is relatively short (136 ft) with the majority of the reach lying within a culvert tunnel and offering limited aquatic habitat (see photo below). The downstream edge of the culvert is located at an elevation of 383.6 ft, and based on the recorded range of mainstem WSE values is submerged 0.4 ft at least 75% of the time. As indicated by the minimum WSE recorded at the mainstem level logger location (383.1 ft), water depth at the downstream edge of the culvert may be limited to only natural stream outflow under low mainstem and tributary conditions (13.6% of data occurrences < 0.5 ft of depth at the confluence).

View of the end of project-affected reach within site CT-W-1.06.

View looking upstream through tunnel at site CT-W-1.06.


10523230
10523236
CT-WR-1.06
Mainstem Logger
Tributary Logger
100 Feet
N
Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.06
Unnamed minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
386
385
384
383
04Aug
28Aug
22Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
387
386
385
384
383
0
10
20
30
Distance (ft)
Mainstem Logger 10523236
Feet: WSE
Max: 386.5
75%: 384.6
Mean: 384.4
50%: 384.3
25%: 384.0
Min: 383.1
Date
04Aug2014
26Aug2014
25Sep2014
04Nov2014
Maximum Measured Water Depth (ft)
0.6
0.5
1.0
1.0
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
387
386
385
384
383
Cross-section
Upstream Project Extent
0
40
80
120
Distance (ft)
Tributary Depth (ft)
2
1
0
0 0.5 1
P
Tributary Logger 10523230
Feet: WSE Water Depth
Max: 385.9 1.3
75%: 385.5 0.9
Mean: 385.5 0.9
50%: 385.5 0.9
25%: 385.5 0.9
Min: 385.4 0.8

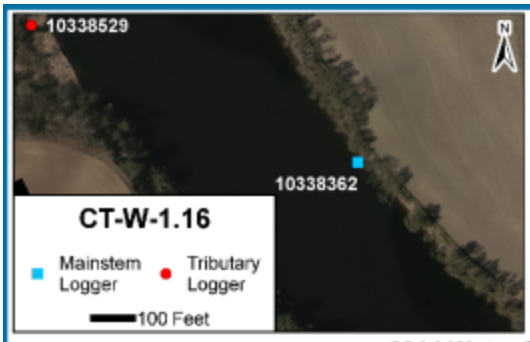
Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.06
Unnamed minor tributary, Stream Order 2

1.4 Site CT-W-1.16 Backwater

Site CT-W-1.16 is a backwater located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 6, 2014 and tributary (SN 10338529) and mainstem (SN 10338362) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed.

Site CT-W-1.16 is connected to the mainstem via an approximately 125-ft-long stream-like access channel (see access channel confluence with mainstem in photograph dated 06Aug14). The backwater level logger was installed within the access channel at a location near the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of the project influence as the entire length of the access channel, and across the ponded backwater area (a linear distance of 415 ft), later determined by evaluation of WSE data to be 416 ft. Water was present within the access channel and backwater section during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 1.0 to 1.5 ft. Water depths were measured along the access channel thalweg and within the ponded backwater area during the initial site visit and ranged between 1.2 and 1.5 ft (mean = 1.3 ft) in the thalweg. Water depths measured within the ponded backwater area primarily ranged from 1-2 ft with deeper areas up to 4-5 ft.

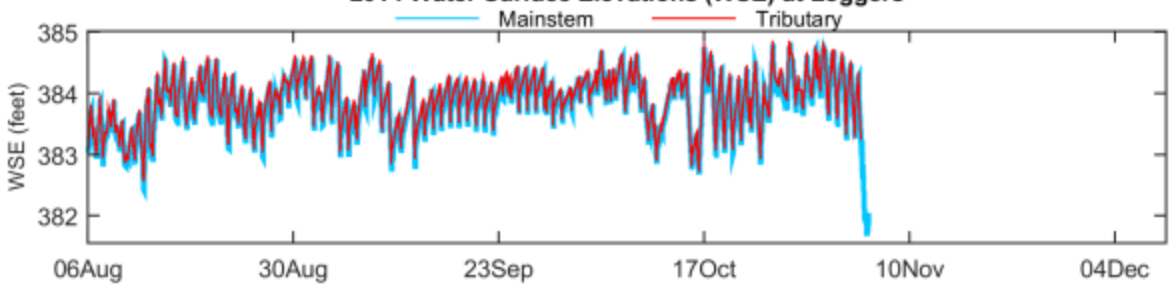
Based on the measured water depths, it is most likely that any access restrictions at the site (if present) would be located in the access channel based on its shallower bathymetry than was observed in the ponded backwater area. However, review of the frequency distribution of water depth recorded by the tributary level logger in the access channel, indicates that under most conditions (i.e., 25^{th} through 75^{th} percentiles) water depth at that location ranged between 2.1 and 2.6 ft with a minimum recorded water depth of 1.0 ft which will provide adequate access under virtually all conditions (0.5% of data occurrences < 0.5 ft of depth at the confluence).



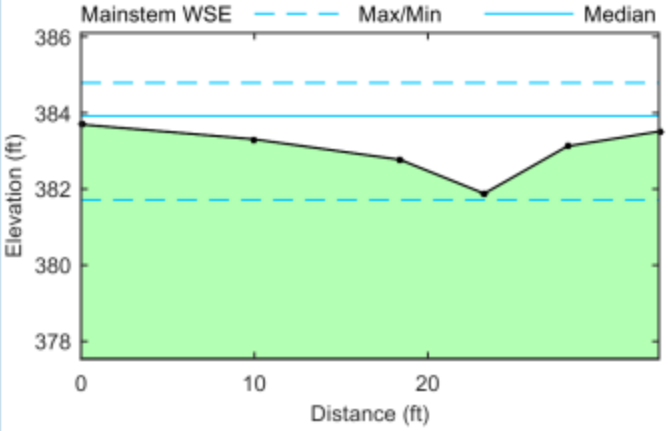
Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.16

Unnamed backwater, Stream Order 0

2014 Water Surface Elevations (WSE) at Loggers

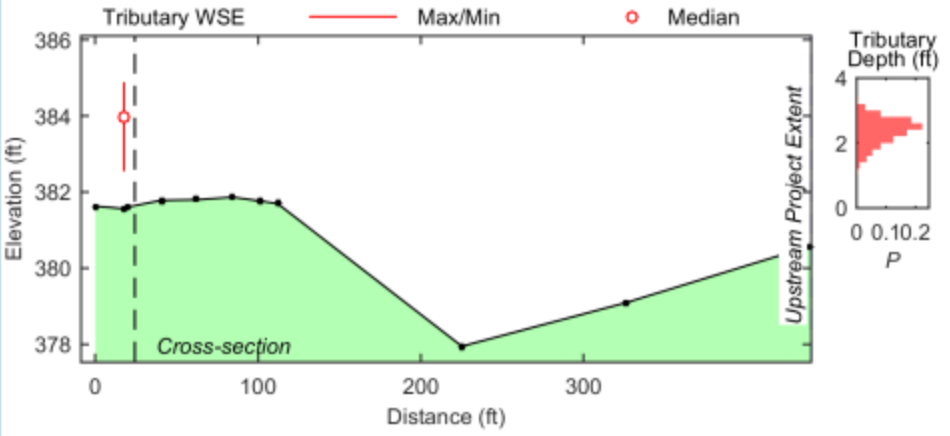


Cross-section at Confluence



Mainstem Logger 10338362 Feet: WSE		Date	Maximum Measured Water Depth (ft)
Max:	384.8	06Aug2014	1.0
75%:	384.1	26Aug2014	1.5
Mean:	383.8	25Sep2014	1.5
50%:	383.9	04Nov2014	1.2
25%:	383.6		
Min:	381.7		

Thalweg



Tributary Logger 10338529 Feet:	WSE	Water Depth
Max:	384.9	3.3
75%:	384.2	2.6
Mean:	383.9	2.4
50%:	384.0	2.4
25%:	383.7	2.1
Min:	382.6	1.0

Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.16
Unnamed backwater, Stream Order 0

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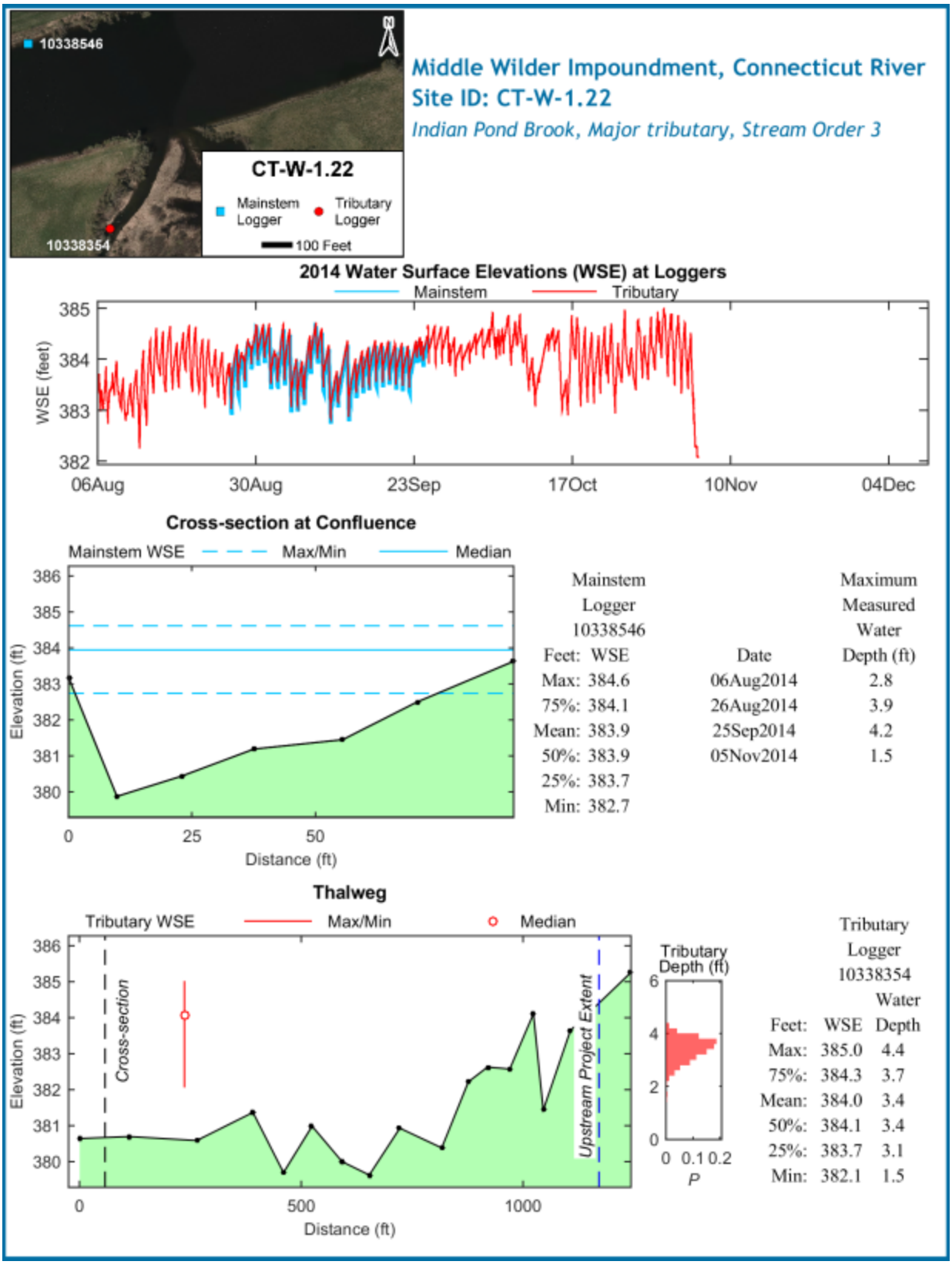
1.5 Site CT-W-1.22 Indian Pond Brook

Site CT-W-1.22 Indian Pond Brook, is a stream order 3 tributary located on the New Hampshire side in the middle Wilder impoundment. This location was initially visited on August 6, 2014 and tributary (SN 10338354) and mainstem (SN 10338546) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed. The level logger initially installed in the mainstem suffered a launch failure after installation and did not record from the time it was initially installed until the first check on August 26th. The unit was reprogrammed on that date. The mainstem level logger was also found to be missing during the final site visit. As a result mainstem sensor depth information is limited to the period August 26 to September 25, 2014.

The tributary level logger was installed approximately 180 feet upstream from the confluence with the mainstem. The extent of project influence was estimated by extending the maximum operational WSE value recorded by the mainstem level logger (384.4 feet) upstream to the point along the tributary thalweg profile where that elevation was first achieved. Mainstem data collected at this site was limited to a one month period and based on that limitation, the project-influenced reach was estimated at 1,114 ft up into the tributary. The maximum mainstem WSE elevation (384.6) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach. Flow was present in Indian Pond Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.5 to 4.2 ft. Water depths were measured along the channel thalweg during the initial site visit on August 6th and ranged between 0.2 ft on the downstream side of an instream obstruction (see photo below) and 3.4 ft (mean = 1.9 ft).

There is a single shallow water area located approximately 1,000 ft upstream of the confluence with the mainstem. The presence of this shallow water area can be attributed to downed logs with a deeper scour hole on the upstream side and area of deposition on the downstream side (see thalweg plot and photographs). However, under all recorded conditions access appears adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

View looking from upstream to downstream of in-stream obstruction creating shallow-water shoal area within the project-affected portion of Indian Pond Brook approximately 1,000 ft upstream from the confluence with mainstem river during 2014.


10338546
10338354
N
CT-W-1.22
Mainstem Logger
Tributary Logger
100 Feet
Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.22
Indian Pond Brook, Major tributary, Stream Order 3
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
385
384
383
382
06Aug
30Aug
23Sep
17Oct
10Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
386
385
384
383
382
381
380
0
25
50
Distance (ft)
Mainstem Logger 10338546
Feet: WSE
Max: 384.6
75%: 384.1
Mean: 383.9
50%: 383.9
25%: 383.7
Min: 382.7
Date
06Aug2014
26Aug2014
25Sep2014
05Nov2014
Maximum Measured Water Depth (ft)
2.8
3.9
4.2
1.5
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Elevation (ft)
386
385
384
383
382
381
380
0
500
1000
Distance (ft)
Tributary Depth (ft)
6
4
2
0
0 0.1 0.2
P
Tributary Logger 10338354
Feet: WSE Water Depth
Max: 385.0 4.4
75%: 384.3 3.7
Mean: 384.0 3.4
50%: 384.1 3.4
25%: 383.7 3.1
Min: 382.1 1.5

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.22
Indian Pond Brook, Major tributary, Stream Order 3

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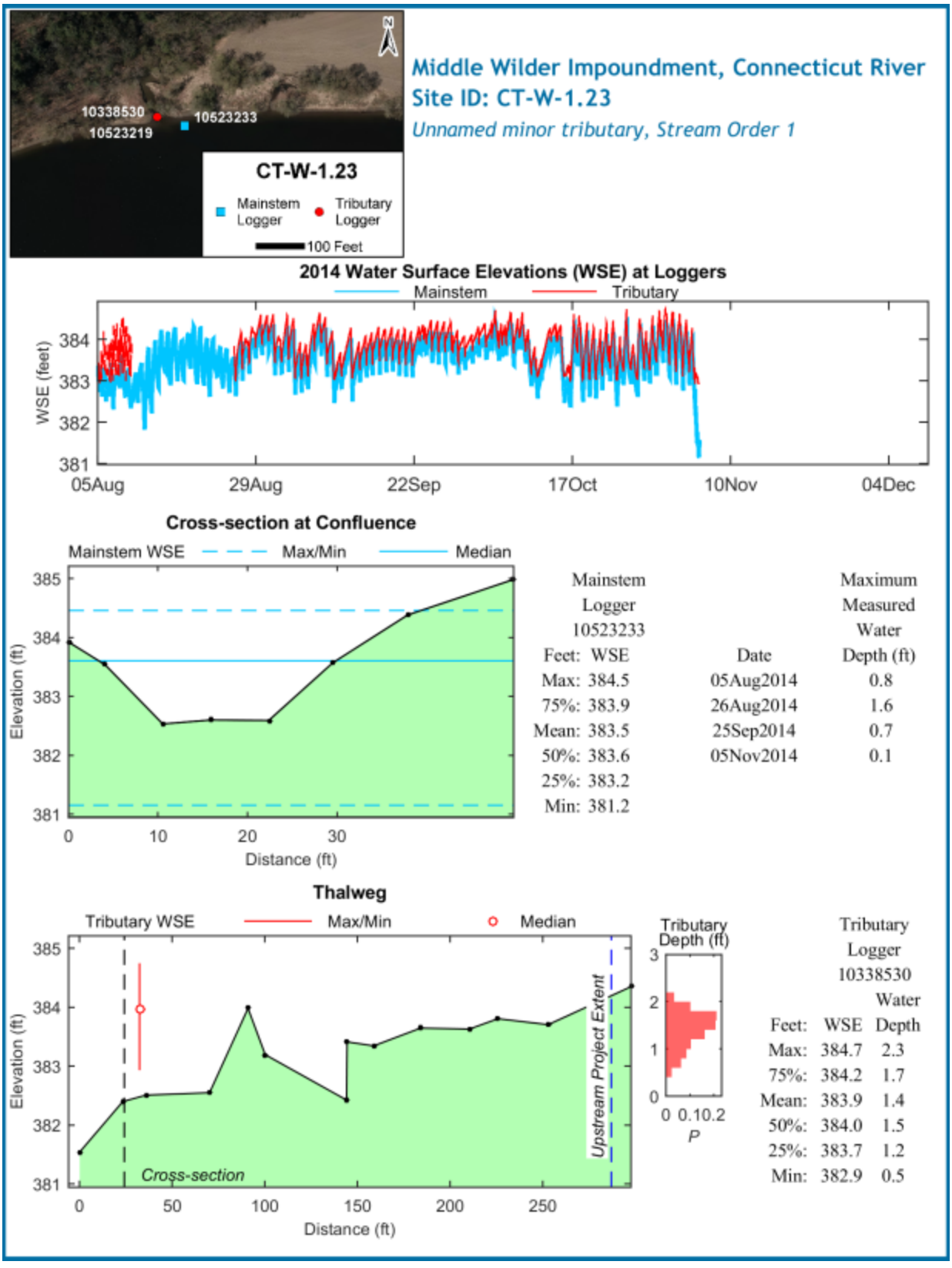
1.6 Site CT-W-1.23

Site CT-W-1.23 is an unnamed stream order 1 tributary located on the Vermont side in the middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary (SN 10523219) and mainstem (SN 10523233) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 5, 2014 at which time the level loggers were removed. The level logger initially installed in the tributary was determined to have stopped working five days after installation in the field. The field crew replaced that unit with a new logger (SN 10338530). As a result data sensor depth information for the tributary is limited to the period August 10 to November 5, 2014.

The tributary level logger was installed approximately 9 feet upstream from the confluence with the mainstem. The extent of project effects was estimated by extending the maximum operational WSE value recorded by the mainstem level logger (384.2 feet) upstream to the point along the tributary thalweg profile where that elevation was first achieved and the project-affected reach was determined to be 263 ft. The maximum mainstem WSE (384.5) indicates that the mainstem influence extends farther up in to the tributary than the project-affected reach. Flow was present in tributary CT-W-1.23 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 1.6 ft. Water depths were measured along the channel thalweg during the November 5th site visit and ranged between 0.1 and 0.7 ft (mean = 0.2 ft).

Site CT-W-1.23 is a small, stream order 1 tributary. Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 1.2 and 1.7 ft and should provide adequate upstream access. However, access will likely be hindered at a shallow, shoaled area (elevation = 383.9 ft) located approximately 100 ft upstream from the confluence (see photo taken at 0939 on 05Nov14 below). Only WSE values in the upper 25th percentile of those recorded by the mainstem level logger indicated that mainstem inflow would be available to provide access over the shoaled area. Access into this tributary is limited under low flow mainstem and tributary conditions such as those observed during the November 5th site visit (11.0% of data occurrences < 0.5 ft of depth at the confluence).


Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.23
Unnamed minor tributary, Stream Order 1
10338530
10523233
10523219
CT-W-1.23
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
05Aug
29Aug
22Sep
17Oct
10Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
Distance (ft)
Mainstem Logger 10523233
Feet: WSE
Max: 384.5
75%: 383.9
Mean: 383.5
50%: 383.6
25%: 383.2
Min: 381.2
Date
05Aug2014
26Aug2014
25Sep2014
05Nov2014
Maximum Measured Water Depth (ft)
0.8
1.6
0.7
0.1
Thalweg
Tributary WSE
Max/Min
Median
Tributary Depth (ft)
Upstream Project Extent
Cross-section
Tributary Logger 10338530
Feet: WSE Water Depth
Max: 384.7 2.3
75%: 384.2 1.7
Mean: 383.9 1.4
50%: 384.0 1.5
25%: 383.7 1.2
Min: 382.9 0.5

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.23
Unnamed minor tributary, Stream Order 1

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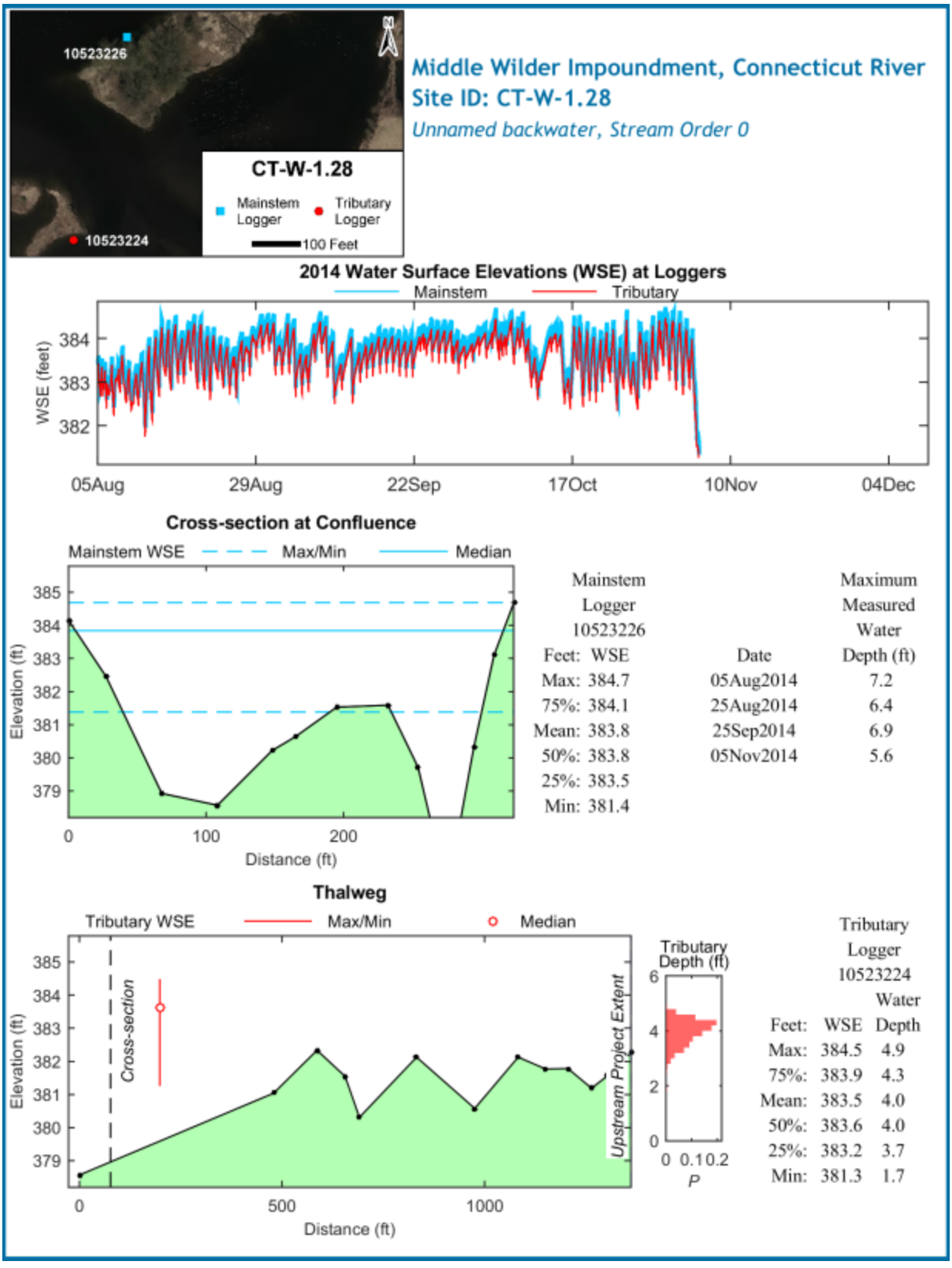
1.7 Site CT-W-1.28 Backwater

Site CT-W-1.28 is a backwater located on the New Hampshire side in the middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary (SN 10523224) and mainstem (SN 10523226) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 25, 2014. The final site visit occurred on November 5, 2014 at which time the level loggers were removed.

Backwater Site CT-W-1.28 is connected to the mainstem via a wide opening (see confluence with mainstem in photograph section below). The backwater level logger was installed approximately 120 ft from the confluence. During the initial site visit, the field crew visually determined the extent of the project-affected area (elevation 384.5 ft) as running across the ponded backwater area (a linear distance of 1,285 ft), verified later by evaluation of WSE data. The maximum mainstem WSE (384.7) indicates that the mainstem influence extends farther than the project-affected reach. Water was present within the backwater during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 5.6 to 7.2 ft. Water depths were measured across the ponded backwater area during the initial site visit and ranged between 1.0 and 3.0 ft (mean = 1.9 ft).

Review of range of WSE values recorded by the mainstem level logger, indicates that under all observed conditions (i.e., min through max values) water depth at thalweg within the immediate confluence area ranged between 5.4 and 8.7 ft, and will provide adequate upstream access. As evidenced by the thalweg profile, bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the backwater level logger is considered, under most conditions (i.e., 25th through 75th percentiles) WSE ranged between 383.2 ft and 383.9 ft. This range of WSE values would provide greater than 1 foot of water over all of the higher elevation locations in the thalweg (with 0% of data occurrences < 0.5 ft of depth at the confluence). However, as indicated by the minimum WSE values recorded at the mainstem and backwater level logger locations (381.4 and 381.3 ft, respectively), available habitat area within the backwater may be reduced somewhat under low mainstem conditions.


10523226
10523224
CT-W-1.28
Mainstem Logger
Tributary Logger
100 Feet
Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.28
Unnamed backwater, Stream Order 0
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
384
383
382
05Aug
29Aug
22Sep
17Oct
10Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
380
379
0
100
200
Distance (ft)
Mainstem Logger 10523226
Feet: WSE
Max: 384.7
75%: 384.1
Mean: 383.8
50%: 383.8
25%: 383.5
Min: 381.4
Date
05Aug2014
25Aug2014
25Sep2014
05Nov2014
Maximum Measured Water Depth (ft)
7.2
6.4
6.9
5.6
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
380
379
Cross-section
Upstream Project Extent
0
500
1000
Distance (ft)
Tributary Depth (ft)
6
4
2
0
0 0.10.2
P
Tributary Logger 10523224
Feet: WSE Water Depth
Max: 384.5 4.9
75%: 383.9 4.3
Mean: 383.5 4.0
50%: 383.6 4.0
25%: 383.2 3.7
Min: 381.3 1.7

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.28
Unnamed backwater, Stream Order 0

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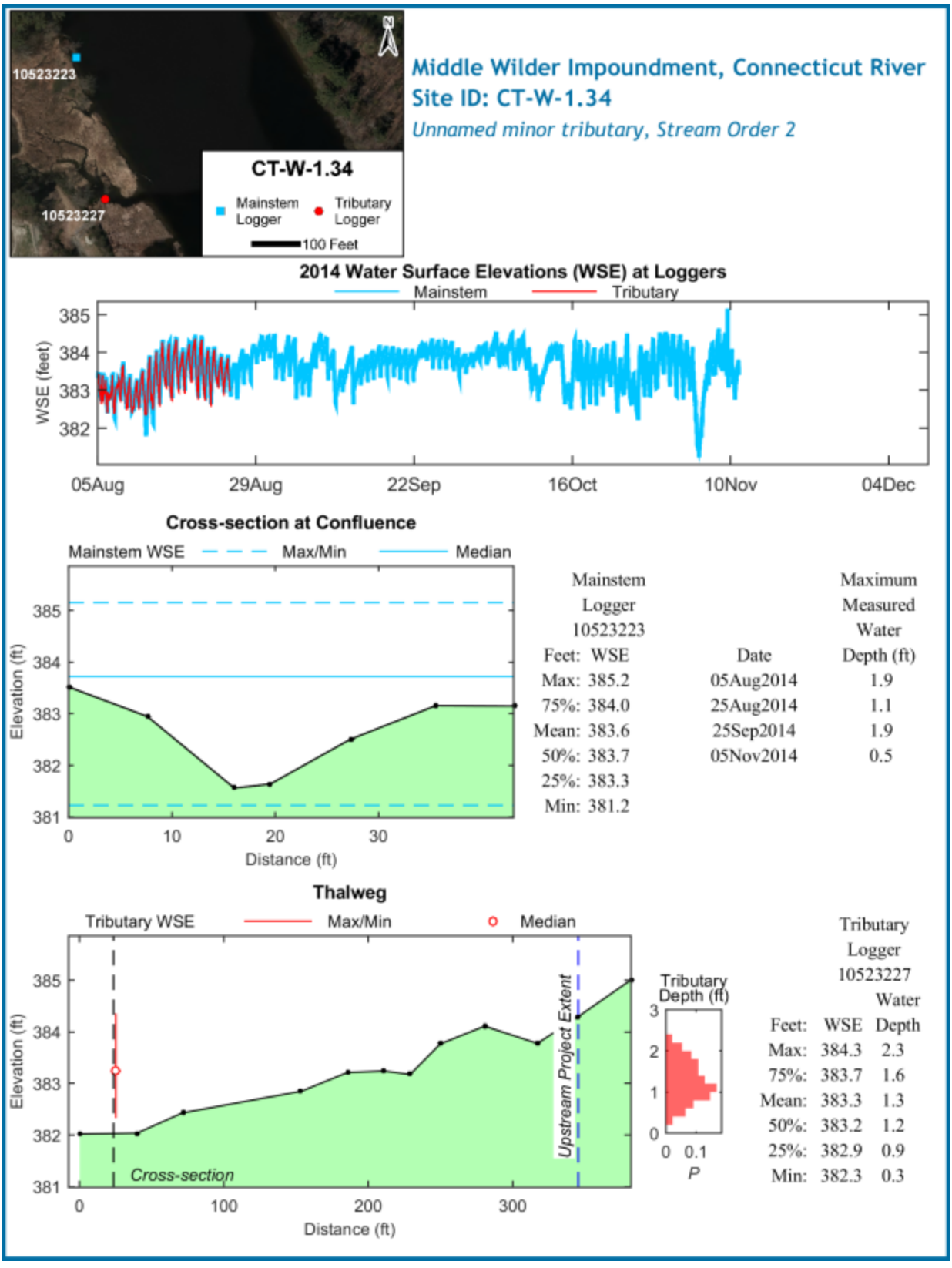
1.8 Site CT-W-1.34

Site CT-W-1.34 is an unnamed stream order 2 tributary located on the Vermont side in middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary (SN 10523227) and mainstem (SN 10523223) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 25, 2014. The final site visit occurred on November 5, 2014 at which time the tributary level logger was removed. The mainstem level logger at site CT-W-1.34 was removed six days later (November 11, 2014). During the manual data review portion of post-processing, it was discovered that pressure readings recorded by the tributary level logger were impacted by a logger malfunction. This malfunction resulted in plotted sensor depths far exceeding the range expected for this particular location and data from this location was assigned a Use Code = 9 (Table 4.2-1). As a result sensor depth information for the tributary is limited to the period August 5 to August 26, 2014.

The tributary level logger was installed in the immediate vicinity of the confluence with the mainstem. The extent of project effects was estimated by extending the maximum operational WSE value recorded by the mainstem level logger upstream to the point along the tributary thalweg profile where that elevation was first achieved, approximately 322 ft up into the tributary. The maximum mainstem WSE (385.2 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (384.3 ft elevation). Flow was present in tributary CT-W-1.34 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.5 to 1.9 ft. Water depths were measured along the channel thalweg during the August 5th site visit and ranged between 0.2 and 1.2 ft (mean = 0.6 ft).

Site CT-W-1.34 is a small, stream order 2 tributary. Review of the frequency distribution of water depth recorded by the tributary level logger over the limited period of logger data indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 0.9 and 1.6 ft and should provide adequate access. Under median conditions (WSE = 383.6 ft; mainstem level logger), the tributary will be inundated by mainstem water approximately 250 ft upstream from the confluence. Under low mainstem WSE conditions (minimum value recorded = 381.2 ft), the tributary is no longer inundated by mainstem water and is limited to its own natural outflow. Under those conditions, access would be limited as evidenced by the minimum water depth recorded by the tributary logger (water depth = 0.3 ft, see Nov 5 photos) and may be limited (0.4% of data occurrences < 0.5 ft of depth at the confluence).


Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.34
Unnamed minor tributary, Stream Order 2
10523223
10523227
CT-W-1.34
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
385
384
383
382
05Aug
29Aug
22Sep
16Oct
10Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
0
10
20
30
Distance (ft)
Mainstem Logger 10523223
Feet: WSE
Max: 385.2
75%: 384.0
Mean: 383.6
50%: 383.7
25%: 383.3
Min: 381.2
Date
05Aug2014
25Aug2014
25Sep2014
05Nov2014
Maximum Measured Water Depth (ft)
1.9
1.1
1.9
0.5
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
0
100
200
300
Distance (ft)
Cross-section
Upstream Project Extent
Tributary Depth (ft)
3
2
1
0
0
0.1
P
Tributary Logger 10523227
Feet: WSE Water Depth
Max: 384.3 2.3
75%: 383.7 1.6
Mean: 383.3 1.3
50%: 383.2 1.2
25%: 382.9 0.9
Min: 382.3 0.3

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.34
Unnamed minor tributary, Stream Order 2

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1.9 Site CT-W-1.44 Backwater

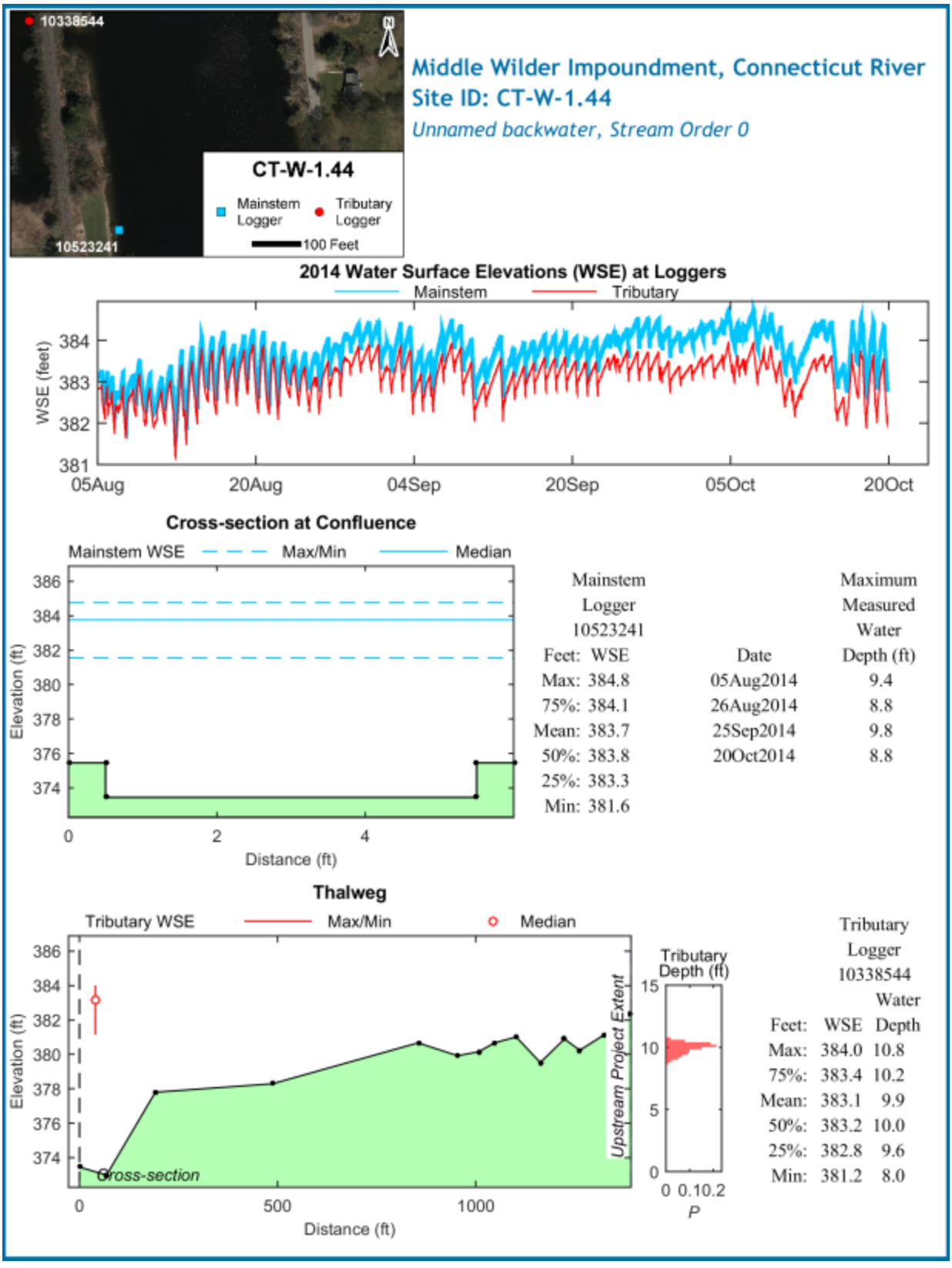
Site CT-W-1.44 is a backwater located on the Vermont side in the middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary and mainstem level loggers were installed on that date. Subsequent site visits were conducted on August 25/26 and September 25, 2014. The final site visit occurred on October 20, 2014 at which time the level loggers were removed.

The site is connected to the mainstem via a large culvert approximately 5 ft wide and 13 ft deep which runs for approximately 50 ft underneath the railroad. The backwater level logger was installed adjacent to the culvert entrance on the backwater side. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area and up a small feeder stream to a point where visible bank scour was absent (see photo below). The project-affected area was estimated to cover a linear distance of 1,391 ft, later confirmed by evaluation of WSE data. The maximum mainstem WSE (384.8 ft) indicates that the mainstem influence extends farther into the backwater than the project-affected reach (384.5 ft elevation).

The small feeder stream covered the upper 400 ft of the project-affected reach. Water was present within backwater Site CT-W-1.44 during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 8.8 to 9.8 ft. Water depths were measured during the initial site visit across the ponded backwater area and up the small feeder stream located along the western bank of the backwater. Water depths within the feeder stream ranged between 0.3 and 3.2 ft (mean = 1.9 ft) with shallower readings at the upper extent of the project-affected area. Water depths measured within the ponded backwater area primarily ranged from 1-3 ft with deeper areas up to 4-5 ft.

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth within the culvert located at the confluence ranged between 8.3 and 11.1 ft and will provide adequate upstream access. As evidenced by the thalweg profile bottom elevations vary from the confluence across the backwater and up the feeder stream. When the range of WSE values recorded by the backwater level logger is considered, under all observed conditions (i.e., min through max values) WSEs were sufficient to cover the thalweg point within the ponded backwater area with the greatest elevation (380.7 ft) with 0.5 ft of water depth. When the bed elevation at the upstream extent of the feeder stream was compared to the range of WSE values recorded by the backwater level logger, that location was inundated with at least 0.4 ft of water under most conditions (i.e., 25th through 75th percentiles; WSE values of 382.8 ft and 383.4 ft (with 0% of data occurrences < 0.5 ft of depth at the confluence). As indicated by the minimum WSE recorded at the backwater level logger location (381.2 ft), water depth at the upstream end of the feeder stream may be limited to natural stream outflow under low mainstem conditions.

Upstream extent of project-affected area associated with backwater Site CT-W-1.44 as determined by visual observations, August 2014.


10338544
10523241
N
CT-W-1.44
Mainstem Logger
Tributary Logger
100 Feet
Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.44
Unnamed backwater, Stream Order 0
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
384
383
382
381
05Aug
20Aug
04Sep
20Sep
05Oct
20Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
386
384
382
380
378
376
374
0
2
4
Distance (ft)
Mainstem Logger 10523241
Feet: WSE
Max: 384.8
75%: 384.1
Mean: 383.7
50%: 383.8
25%: 383.3
Min: 381.6
Date
05Aug2014
26Aug2014
25Sep2014
20Oct2014
Maximum Measured Water Depth (ft)
9.4
8.8
9.8
8.8
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
386
384
382
380
378
376
374
Cross-section
Upstream Project Extent
0
500
1000
Distance (ft)
Tributary Depth (ft)
15
10
5
0
0 0.10.2
P
Tributary Logger 10338544
Feet: WSE Water Depth
Max: 384.0 10.8
75%: 383.4 10.2
Mean: 383.1 9.9
50%: 383.2 10.0
25%: 382.8 9.6
Min: 381.2 8.0

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.44
Unnamed backwater, Stream Order 0

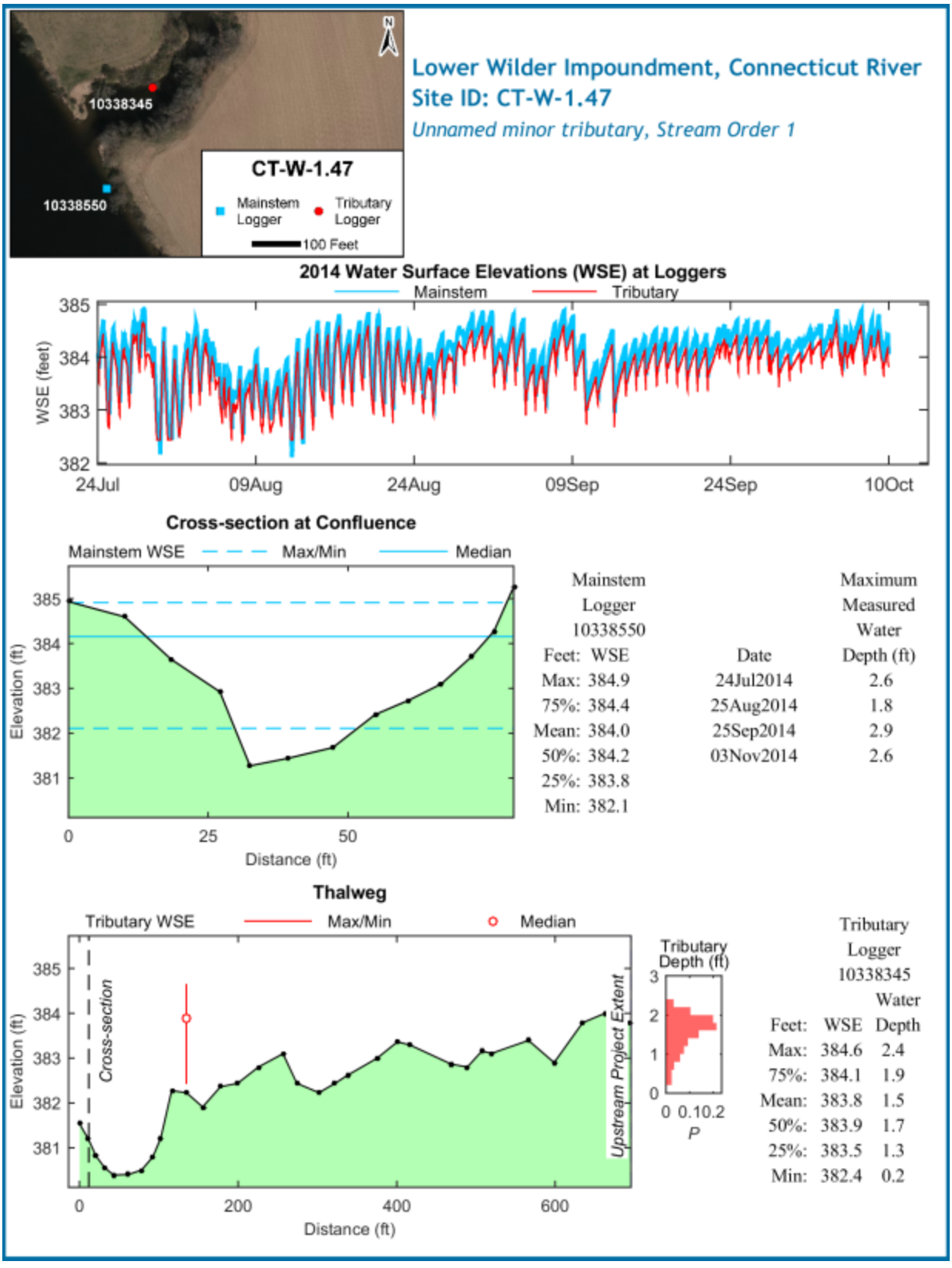
1.10 Site CT-W-1.47

Site CT-W-1.47 is an unnamed stream order 1 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 24, 2014 and tributary (SN 10338345) and mainstem (SN 10338550) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 25, 2014. The final site visit occurred on November 3, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 123 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 683 ft, later confirmed by evaluation of WSE data, up into the tributary to a section where bank vegetation did not indicate significant fluctuating water levels (see photo below). The maximum mainstem WSE (384.9 ft)indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (384.7 ft elevation). Flow was present in the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.8 to 2.9 ft. Water depths were measured along the channel thalweg during the July 24th site visit and ranged between 0.3 and 3.9 ft (mean = 1.8 ft). Thalweg water depths of ≤ 0.5 ft were limited to the upper 40-50 ft of the project-affected reach.

Site CT-W-1.47 is a small, stream order 1 tributary. Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 1.1 and 1.7 ft with deeper conditions present in the 123 ft stretch between the tributary level logger and the mainstem confluence. Under median mainstem conditions (WSE = 384.2 ft; mainstem level logger), the tributary is inundated by mainstem water to the upstream end of the project-affected reach. Under low mainstem WSE conditions (minimum value recorded = 382.1 ft), the tributary is inundated by project-affected water approximately 100 ft upstream and above that, at and beyond a deep thalweg hole, is limited to only its own natural outflow but access should still be adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

Upstream extent of project-affected area associated with
Site CT-W-1.47 as determined by visual observations, July 2014.


Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.47
Unnamed minor tributary, Stream Order 1
10338345
10338550
CT-W-1.47
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
385
384
383
382
24Jul
09Aug
24Aug
09Sep
24Sep
10Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
0
25
50
Distance (ft)
Mainstem Logger 10338550
Feet: WSE
Max: 384.9
75%: 384.4
Mean: 384.0
50%: 384.2
25%: 383.8
Min: 382.1
Date
24Jul2014
25Aug2014
25Sep2014
03Nov2014
Maximum Measured Water Depth (ft)
2.6
1.8
2.9
2.6
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
Cross-section
Upstream Project Extent
0
200
400
600
Distance (ft)
Tributary Depth (ft)
3
2
1
0
0 0.10.2
P
Tributary Logger 10338345
Feet: WSE Water Depth
Max: 384.6 2.4
75%: 384.1 1.9
Mean: 383.8 1.5
50%: 383.9 1.7
25%: 383.5 1.3
Min: 382.4 0.2

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.47
Unnamed minor tributary, Stream Order 1

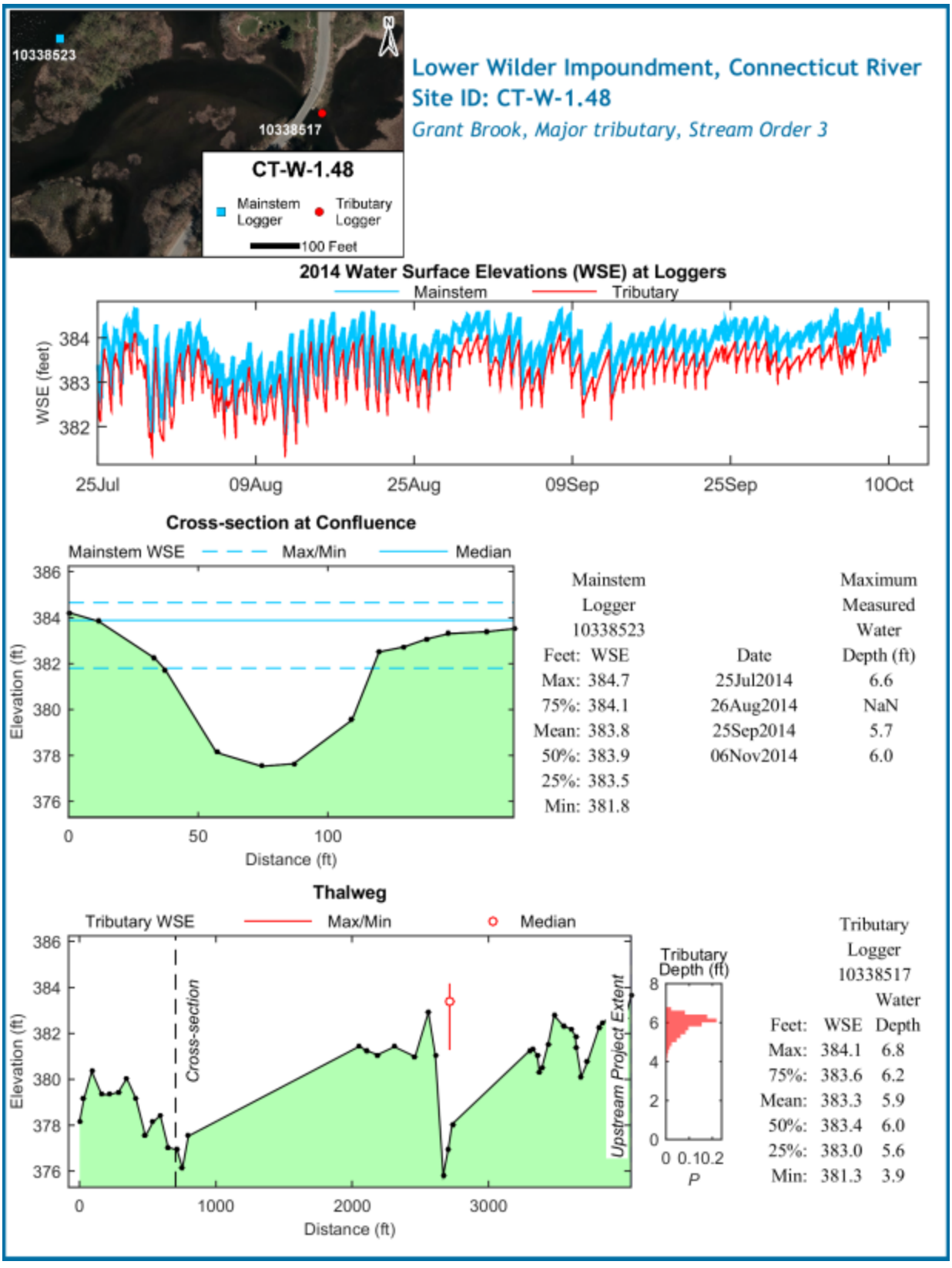
1.11 Site CT-W-1.48 Grant Brook

Site CT-W-1.48 Grant Brook, is a stream order 3 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 25, 2014 and tributary (SN 10338517) and mainstem (SN 10338523) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 6, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 810 feet upstream from the confluence with the mainstem and just on the upstream side of the River Road bridge. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 2,284 ft up into Grant Brook to a section of the tributary where bank vegetation did not indicate significant fluctuating water levels (see photo below). Review of the WSE values recorded by the mainstem level logger indicates that the project-affected reach extends to approximately 3,338 ft, and the maximum mainstem WSE (384.7 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (384.5 ft). Project-affected water levels remain below the end of project elevation (383.6 ft) between 25-50 percent of the time (25% occurrence = 383.5 ft / 50% occurrence = 383.9 ft).

Flow was present in Grant Brook during each of the four visits. Water depth at the confluence cross section was measured during three of the four visits and the maximum water depth ranged from 5.7 to 6.6 ft. Water depths were measured along the channel thalweg during the initial site visit on July 25th and ranged between 0.6 ft and 8.3 ft (mean = 3.9 ft). The shallowest water depth on the date of measurement was located at the upstream extent of the project-affected reach and access should be adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

Upstream extent of project-affected area associated with Site CT-W-1.48 as determined by visual observations, July 2014.


10338523
10338517
N
CT-W-1.48
Mainstem Logger
Tributary Logger
100 Feet
Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.48
Grant Brook, Major tributary, Stream Order 3
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
384
383
382
25Jul
09Aug
25Aug
09Sep
25Sep
10Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
386
384
382
380
378
376
0
50
100
Distance (ft)
Mainstem Logger 10338523
Feet: WSE
Max: 384.7
75%: 384.1
Mean: 383.8
50%: 383.9
25%: 383.5
Min: 381.8
Date
25Jul2014
26Aug2014
25Sep2014
06Nov2014
Maximum Measured Water Depth (ft)
6.6
NaN
5.7
6.0
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
386
384
382
380
378
376
Cross-section
Upstream Project Extent
0
1000
2000
3000
Distance (ft)
Tributary Depth (ft)
8
6
4
2
0
0 0.10.2
P
Tributary Logger 10338517
Feet: WSE Water Depth
Max: 384.1 6.8
75%: 383.6 6.2
Mean: 383.3 5.9
50%: 383.4 6.0
25%: 383.0 5.6
Min: 381.3 3.9

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.48
Grant Brook, Major tributary, Stream Order 3

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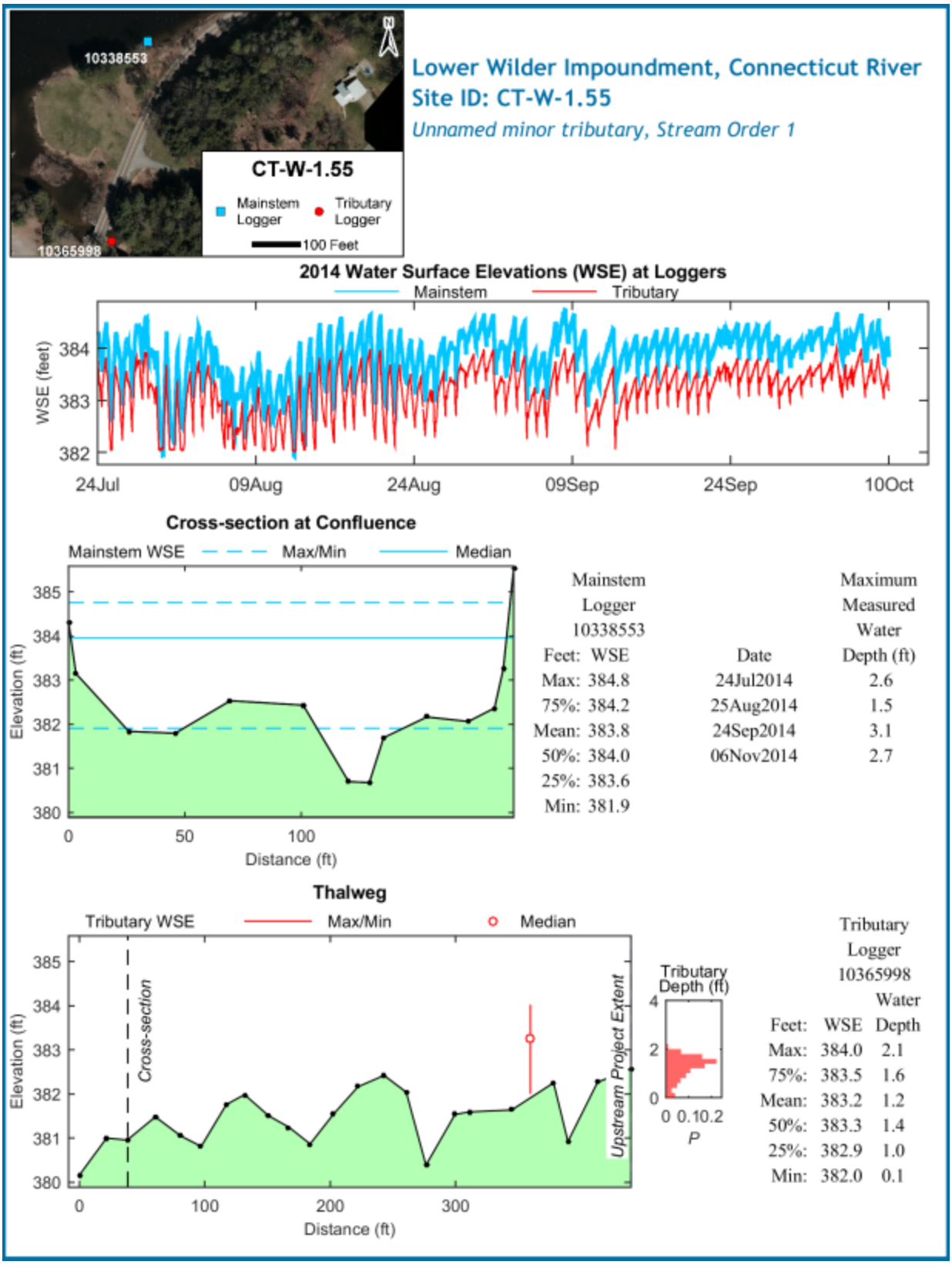
1.12 Site CT-W-1.55

Site CT-W-1.55 is an unnamed stream order 1 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 24, 2014 and tributary (SN 10365998) and mainstem (SN 10338553) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 24, 2014. The final site visit was initiated late in the day on October 20, 2014 and the mainstem level logger was removed on that date. Due to high flows associated with a rain event, the remainder of the final site visit was conducted on November 6, 2014 at which time the tributary logger was removed.

The tributary level logger was installed approximately 321 feet upstream from the confluence with the mainstem and just on the upstream side of the River Road bridge. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 402 ft up into the tributary (later confirmed by evaluation of WSE data) to a section where bank vegetation did not indicate significant fluctuating water levels (see photo below). The maximum mainstem WSE (384.8 ft) indicates that the mainstem influence extends slightly farther upstream than the project-affected reach (384.5 ft). Flow was present in tributary CT-W-1.55 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.5 to 3.1 ft. Water depths were measured along the channel thalweg during the initial site visit on July 24th and ranged between 1.2 ft and 4.6 ft (mean = 2.6 ft).

Review of the frequency distribution of tributary water depth recorded by the level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 0.9 and 1.5 ft. As indicated by the minimum water depth recorded at the tributary level logger location (0.1 ft), access may be reduced within some sections of the channel downstream of the level logger location under low mainstem conditions and access could be limited, but 0% of data occurrences were < 0.5 ft of depth at the confluence.

Upstream extent of project-affected area associated with Site CT-W-1.55 as determined by visual observations, 2014.


10338553
10365998
N
CT-W-1.55
Mainstem Logger
Tributary Logger
100 Feet
Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.55
Unnamed minor tributary, Stream Order 1
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
384
383
382
24Jul
09Aug
24Aug
09Sep
24Sep
10Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
380
0
50
100
Distance (ft)
Mainstem Logger 10338553
Feet: WSE
Max: 384.8
75%: 384.2
Mean: 383.8
50%: 384.0
25%: 383.6
Min: 381.9
Date
24Jul2014
25Aug2014
24Sep2014
06Nov2014
Maximum Measured Water Depth (ft)
2.6
1.5
3.1
2.7
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
380
Cross-section
Upstream Project Extent
0
100
200
300
Distance (ft)
Tributary Depth (ft)
4
2
0
0 0.10.2
P
Tributary Logger 10365998
Feet: WSE Water Depth
Max: 384.0 2.1
75%: 383.5 1.6
Mean: 383.2 1.2
50%: 383.3 1.4
25%: 382.9 1.0
Min: 382.0 0.1

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.55
Unnamed minor tributary, Stream Order 1

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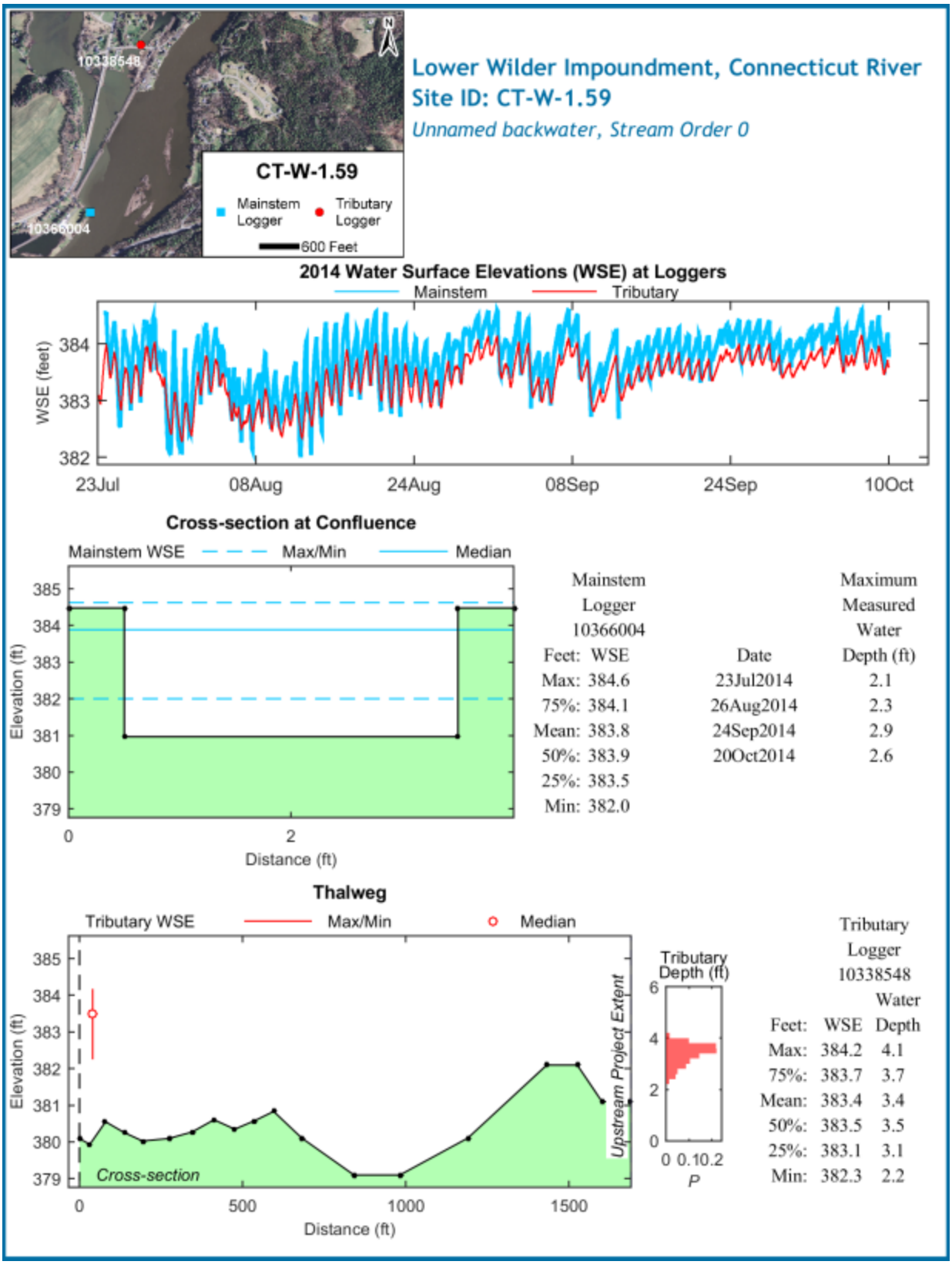
1.13 Site CT-W-1.59

Site CT-W-1.59 is a backwater located on the Vermont side in the lower Wilder impoundment. This location was initially visited on July 23, 2014. The tributary level logger (SN 10338548) was installed on that date and the mainstem level logger (SN 10366004) was installed the following day (July 24, 2014). Subsequent site visits were conducted on August 26 and September 24, 2014. The final site visit occurred on October 20, 2014 at which time the level loggers were removed.

Backwater Site CT-W-1.59 is connected to the mainstem via a culvert approximately 3 ft wide and 2.9 ft deep which runs for approximately 70 ft underneath Kendall Station Road. The backwater level logger was installed adjacent to the culvert entrance on the backwater side. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area (see photograph time stamped 15:16 20Oct14). The project-affected area was estimated to cover a linear distance of 1,689 ft, later confirmed by evaluation of WSE data. The maximum mainstem WSE (384.6 ft) indicates that the mainstem influence extends slightly farther into the backwater than the project affected reach (384.5). Water was present within the backwater during each of the four visits. Water depth at the access culvert was measured during each visit and ranged from 2.1 to 2.9 ft. Water depths were measured across the ponded backwater area during the initial site visit and ranged between 1.4 and 4.4 ft (mean = 3.1 ft) with shallower readings at the upper extent of the project-affected area. Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth within the culvert located at the confluence ranged between 1.0 and 3.6 ft and will provide adequate upstream access. The culvert entrance into the backwater is covered with a section of chain link fencing which was regularly clogged with woody debris (see photographs below).

As evidenced by the thalweg profile , bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the backwater level logger is considered, under the majority of observed conditions (i.e., 25% occurrence and greater) WSEs were sufficient to cover the thalweg point with the greatest elevation (382.1 ft) with 1.0 ft of water depth. Although unrelated to TransCanada operations, fish access may be periodically hindered by the occurrence of debris loading on the section of chain link fencing installed over the backwater side of the access culvert. Access into the backwater is adequate (0% of data occurrences < 0.5 ft of depth at the confluence).


Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.59
Unnamed backwater, Stream Order 0
10338548
10366004
CT-W-1.59
Mainstem Logger
Tributary Logger
600 Feet
N
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
384
383
382
23Jul
08Aug
24Aug
08Sep
24Sep
10Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
380
379
0
2
Distance (ft)
Mainstem Logger 10366004
Feet: WSE
Max: 384.6
75%: 384.1
Mean: 383.8
50%: 383.9
25%: 383.5
Min: 382.0
Date
23Jul2014
26Aug2014
24Sep2014
20Oct2014
Maximum Measured Water Depth (ft)
2.1
2.3
2.9
2.6
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
385
384
383
382
381
380
379
Cross-section
Upstream Project Extent
0
500
1000
1500
Distance (ft)
Tributary Depth (ft)
6
4
2
0
0 0.10.2
P
Tributary Logger 10338548
Feet: WSE Water Depth
Max: 384.2 4.1
75%: 383.7 3.7
Mean: 383.4 3.4
50%: 383.5 3.5
25%: 383.1 3.1
Min: 382.3 2.2

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.59
Unnamed backwater, Stream Order 0

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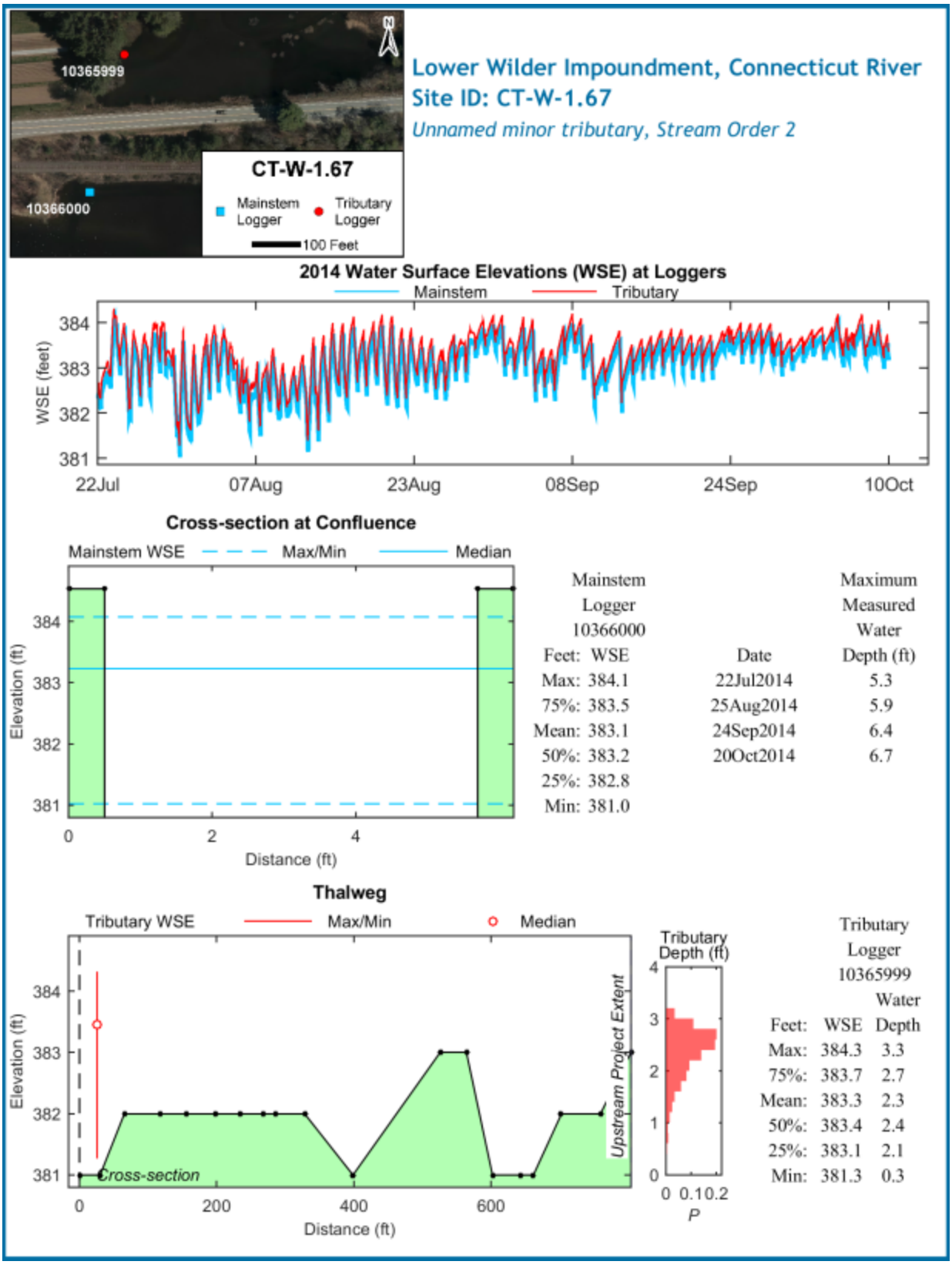
1.14 Site CT-W-1.67

Site CT-W-1.67 is an unnamed stream order 2 tributary located on the Vermont side in the lower Wilder impoundment. This location was initially visited on July 22, 2014 and tributary and mainstem level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 24, 2014. The final site visit occurred on October 20, 2014 at which time the level loggers were removed.

The tributary is connected to the mainstem via a culvert approximately 5 ft wide and 8 ft deep which runs for approximately 150 ft underneath the railroad and Route 5. There is a pump withdrawal for an adjacent farm operation located along the western bank just upstream from the culvert entrance. The tributary functions more as a backwater than as a tributary due to the presence of the culvert and can be characterized by a large ponded area (see photos and site map below). The tributary level logger was installed approximately 25 feet upstream of the culvert entrance on the backwater side. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area (see photo time stamped 0959 20Oct14 below). The project-affected area was estimated to cover a linear distance of 804 ft, later confirmed by evaluation of WSE data. The maximum mainstem WSE (384.1 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (383.8 ft). Water was present within the backwater during each of the four visits. Water depth at the access culvert was measured during each visit and ranged from 5.3 to 6.7 ft. Water depths across the ponded backwater area were calculated as the difference between the measured WSE during the initial site visit and measured bed elevation information collected during Study 7 (Normandeau 2014b) and ranged between 0 and 1.9 ft (mean = 1.1 ft) with non-wetted areas towards the upper extent of the project-affected reach.

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth within the culvert located at the confluence ranged between 3.9 and 7.0 ft and will provide adequate upstream access. As evidenced by the thalweg profile , bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the tributary/backwater level logger is considered, under the majority of observed conditions (i.e., 25% occurrence and greater) WSEs were sufficient to wet each surveyed thalweg point. Thalweg points with the greatest elevation (383.0 ft; located a linear distance of 550-600 ft from culvert exit into backwater) would be minimally wetted (0.1 ft to dry) under low water conditions (i.e., WSE values occurring 25% of the time or less). Due to shallow bed elevations present within the ponded, backwater area, wetted area available to fish will likely be reduced during periods of low mainstem flow. However, access at the confluence is adequate (0% of data occurrences < 0.5 ft of depth at the confluence).


Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.67
Unnamed minor tributary, Stream Order 2
10365999
10366000
CT-W-1.67
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
384
383
382
381
22Jul
07Aug
23Aug
08Sep
24Sep
10Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
Distance (ft)
Mainstem Logger 10366000
Feet: WSE
Max: 384.1
75%: 383.5
Mean: 383.1
50%: 383.2
25%: 382.8
Min: 381.0
Date
22Jul2014
25Aug2014
24Sep2014
20Oct2014
Maximum Measured Water Depth (ft)
5.3
5.9
6.4
6.7
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
P
Distance (ft)
Tributary Logger 10365999
Feet: WSE Water Depth
Max: 384.3 3.3
75%: 383.7 2.7
Mean: 383.3 2.3
50%: 383.4 2.4
25%: 383.1 2.1
Min: 381.3 0.3

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.67
Unnamed minor tributary, Stream Order 2

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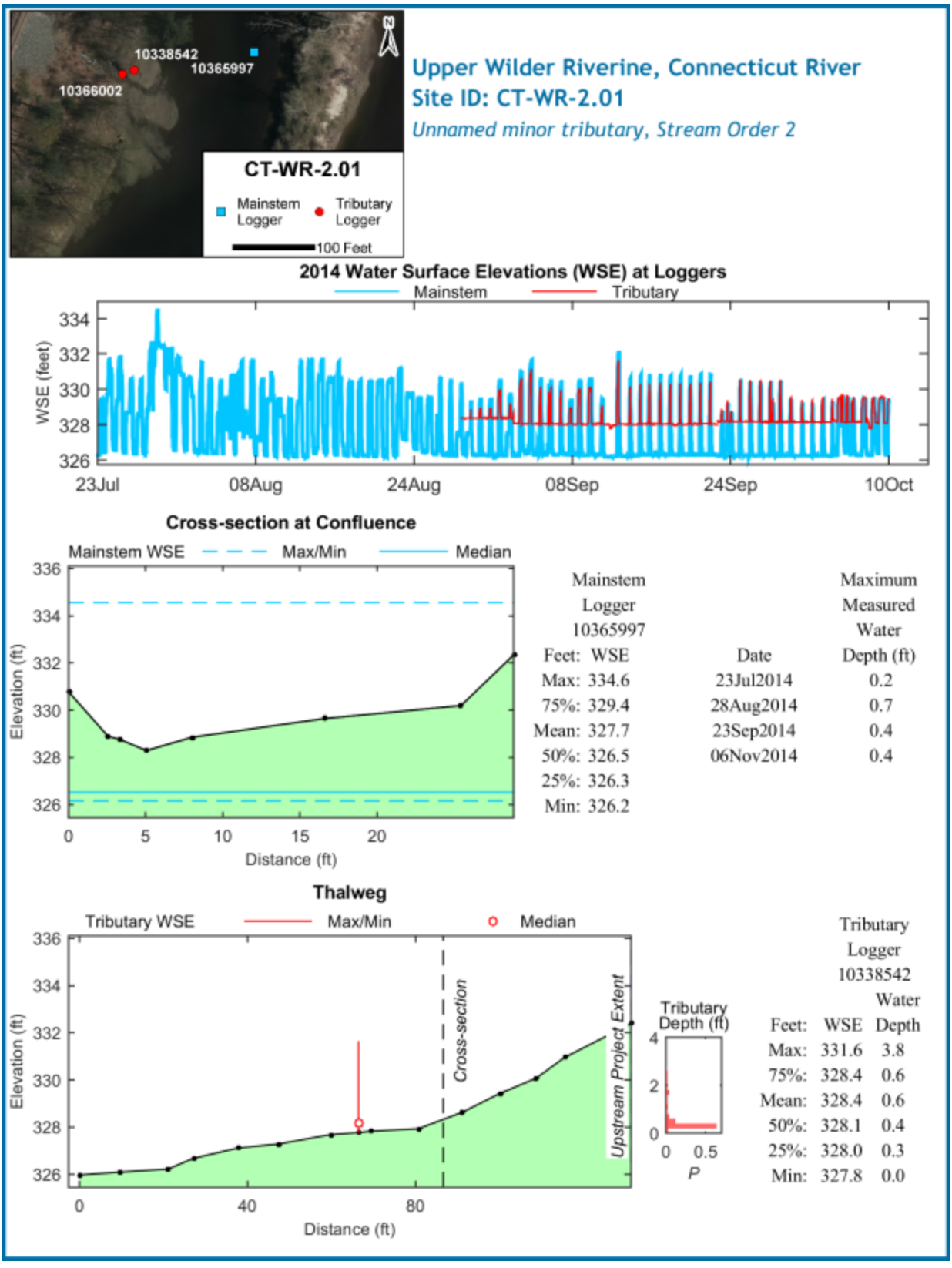
2.0 WILDER RIVERINE SECTION

2.1 Site CT-WR-2.01

Site CT-WR-2.01 is an unnamed stream order 2 tributary located on the Vermont side in the upper Wilder riverine reach. This location was initially visited on July 23, 2014 and tributary (SN 10366002) and mainstem (SN 10365997) level loggers were installed on that date. Subsequent site visits were conducted on August 28 and September 23, 2014. The final site visit occurred on November 6, 2014 at which time the level loggers were removed. The level logger initially installed in the tributary was found to be missing during the subsequent download visit and it was replaced with a new logger (SN 10338542). As a result, data sensor depth information for the tributary is limited to the period August 28 to November 6, 2014.

The tributary level logger was installed in the immediate vicinity of the apparent confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 45 ft upstream from the cross section location to the base of a perched culvert passing underneath the railroad (see photo time stamped 0829 06Nov14 below). Review of the WSE values recorded by the mainstem level logger indicates that a minimum of 75% of the time, mainstem water levels remain below the lower sill of the perched pipe culvert (75% occurrence = 329.4 ft / culvert sill = 332.4 ft). However, the maximum operational mainstem WSE (332.7 ft) slightly inundates the culvert entrance and project effects may extend further upstream. The maximum mainstem WSE (334.6 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach.

Water was present at the site during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.2 to 0.7 ft with 70.2% of data occurrences < 0.5 ft of depth. Water depths were measured along the channel thalweg during the initial site visit on July 23rd and ranged between 0.1 ft and 0.3 ft (mean = 0.2 ft). Site CT-WR-2.01 is a small, stream order 2 tributary with a relatively short reach. Based on visual evaluation of the site on four dates during 2014, it does not appear that the tributary provides a significant flow contribution to the mainstem reach. Channel depths within the site are limited as part of the stream's natural flow regime and as a result, access may be limited during low mainstem and tributary conditions (70.2% of data occurrences < 0.5 ft of depth at the confluence).


10338542
10365997
10366002
CT-WR-2.01
Mainstem Logger
Tributary Logger
100 Feet
Upper Wilder Riverine, Connecticut River
Site ID: CT-WR-2.01
Unnamed minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
23Jul
08Aug
24Aug
08Sep
24Sep
10Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
Distance (ft)
Mainstem Logger 10365997
Feet: WSE
Max: 334.6
75%: 329.4
Mean: 327.7
50%: 326.5
25%: 326.3
Min: 326.2
Date
23Jul2014
28Aug2014
23Sep2014
06Nov2014
Maximum Measured Water Depth (ft)
0.2
0.7
0.4
0.4
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
P
Tributary Logger 10338542
Feet: WSE Water Depth
Max: 331.6 3.8
75%: 328.4 0.6
Mean: 328.4 0.6
50%: 328.1 0.4
25%: 328.0 0.3
Min: 327.8 0.0

Upper Wilder Riverine, Connecticut River
Site ID: CT-WR-2.01
Unnamed minor tributary, Stream Order 2

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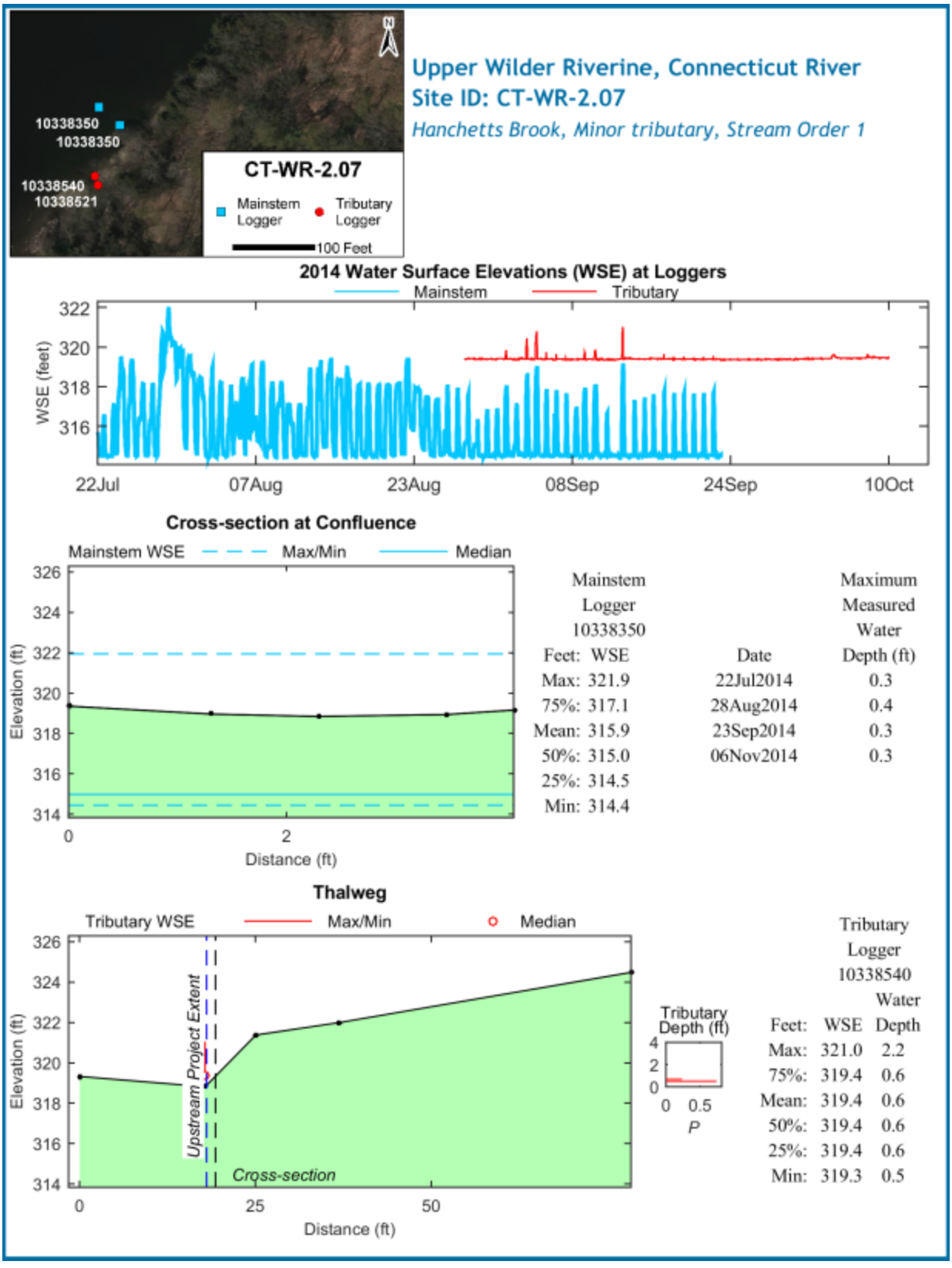
2.2 Site CT-WR-2.07 Hanchetts Brook

Site CT-WR-2.07 Hanchetts Brook, is a stream order 1 tributary located on the New Hampshire side in the upper Wilder riverine reach. This location was initially visited on July 22, 2014 and tributary (SN 10338521) and mainstem (SN 10338350) level loggers were installed on that date. Subsequent site visits were conducted on August 28 and September 23, 2014. The final site visit occurred on November 6, 2014 at which time the tributary level logger was removed and the mainstem logger was found to be missing. The level logger initially installed in the tributary was found to be missing during the August 28 download visit and a new logger (SN 10338540) was installed in its place. As a result, tributary data sensor depth information is limited to the period August 28 to November 6 and mainstem information is limited to the period July 22 to September 23, 2014.

The tributary level logger was installed in the vicinity of the confluence with the mainstem. The project-affected reach was estimated at approximately 35 ft; however, the maximum operational WSE value recorded by the mainstem level logger (320.8 feet) indicates that the project-affected reach ends approximately 1 ft downstream of the visually determined confluence cross section. The maximum mainstem WSE (321.9 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach. Flow was present in Site CT-WR-2.07 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.3 to 0.4 ft (see photo below). Water depths were measured along the channel thalweg during the final site visit on November 6th and ranged between 0.1 and 0.3 ft. Channel depths within the tributary are limited as part of the stream's natural flow regime and access can be limited under virtually all mainstem and tributary conditions (95.8% of data occurrences < 0.5 ft at the originally presumed confluence).

Site CT-WR-2.07 flow through lower end of tributary.


Upper Wilder Riverine, Connecticut River
Site ID: CT-WR-2.07
Hanchetts Brook, Minor tributary, Stream Order 1
10338350
10338350
10338540
10338521
CT-WR-2.07
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
322
320
318
316
22Jul
07Aug
23Aug
08Sep
24Sep
10Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
326
324
322
320
318
316
314
0
2
Distance (ft)
Mainstem Logger 10338350
Feet: WSE
Max: 321.9
75%: 317.1
Mean: 315.9
50%: 315.0
25%: 314.5
Min: 314.4
Date
22Jul2014
28Aug2014
23Sep2014
06Nov2014
Maximum Measured Water Depth (ft)
0.3
0.4
0.3
0.3
Thalweg
Tributary WSE
Max/Min
Median
Upstream Project Extent
Cross-section
0
25
50
Distance (ft)
Tributary Depth (ft)
4
2
0
0 0.5
P
Tributary Logger 10338540
Feet: WSE Water Depth
Max: 321.0 2.2
75%: 319.4 0.6
Mean: 319.4 0.6
50%: 319.4 0.6
25%: 319.4 0.6
Min: 319.3 0.5

Upper Wilder Riverine, Connecticut River
Site ID: CT-WR-2.07
Hanchetts Brook, Minor tributary, Stream Order 1

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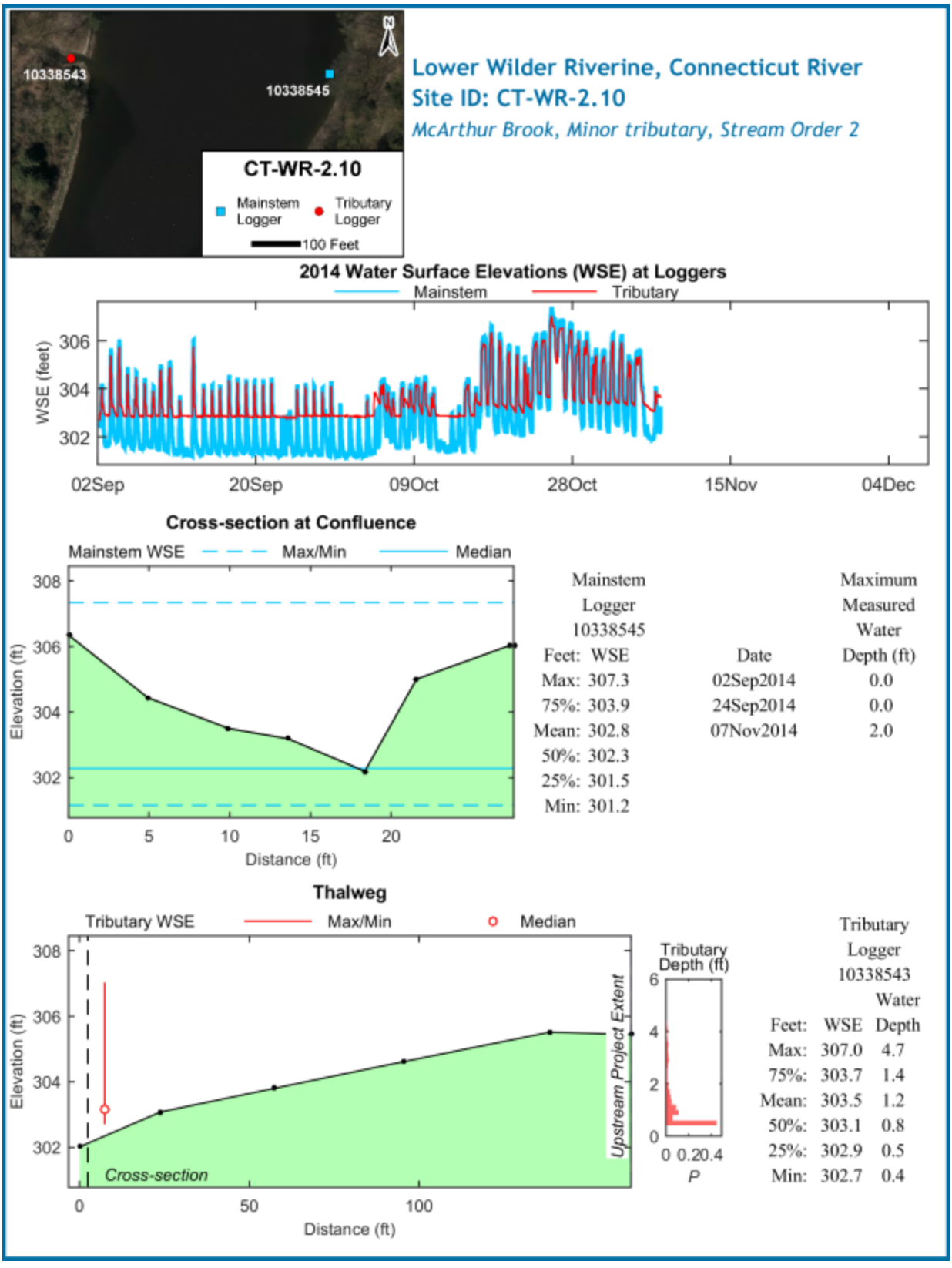
2.3 Site CT-WR-2.10 McArthur Brook

Site CT-WR-2.10 McArthur Brook, is a stream order 2 tributary located on the Vermont side in the lower Wilder riverine reach, downstream of Sumner Falls. This location was initially visited on September 2, 2014 and tributary (SN 10338543) and mainstem (SN 10338545) level loggers were installed on that date. On the date of level logger installation, McArthur Brook was mostly dry and the tributary logger was installed in the apparent 'thalweg' of the stream bed. An additional site visit was conducted on September 24, 2014 during which the brook was completely dry. The final site visit occurred on November 7, 2014 at which time flow was present and the level loggers were removed.

The tributary level logger was installed in the vicinity of the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 160 ft up into McArthur Brook to a section of the tributary where bank vegetation did not indicate significant fluctuating water levels, later confirmed by evaluation of WSE data (see photo below). Review of the WSE values recorded by the mainstem level logger indicates that a minimum of 75% of the time, project-affected water levels remain below the suspected extent of project effects (75% occurrence = 303.9 ft / suspected upper extent = 305.5 ft). The maximum mainstem WSE (307.3 ft) indicates that the mainstem influence extends slightly farther up into the tributary than the project-affected reach elevation (307.2 ft). Flow was present in McArthur Brook during one of the three visits. Water depth at the confluence cross section was measured during the November 7th visit and was 2.0 ft at its deepest point. Bed elevations were recorded from the dry channel bed during the September 24th site visit. It appears that McArthur Brook only seasonally provides a flow contribution to the mainstem river. Based on its intermittent nature, channel depths within McArthur Brook are limited as part of the natural flow regime in that tributary. However, access is adequate under some conditions (58.2% of data occurrences < 0.5 ft at the confluence).

Upstream extent of project-affected area associated with McArthur Brook as determined by visual observations, 2014.


10338543
10338545
N
CT-WR-2.10
Mainstem Logger
Tributary Logger
100 Feet
Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.10
McArthur Brook, Minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
306
304
302
02Sep
20Sep
09Oct
28Oct
15Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
308
306
304
302
0
5
10
15
20
Distance (ft)
Mainstem Logger 10338545
Feet: WSE
Max: 307.3
75%: 303.9
Mean: 302.8
50%: 302.3
25%: 301.5
Min: 301.2
Date
02Sep2014
24Sep2014
07Nov2014
Maximum Measured Water Depth (ft)
0.0
0.0
2.0
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
308
306
304
302
Cross-section
Upstream Project Extent
0
50
100
Distance (ft)
Tributary Depth (ft)
6
4
2
0
0 0.20.4
P
Tributary Logger 10338543
Feet: WSE Water Depth
Max: 307.0 4.7
75%: 303.7 1.4
Mean: 303.5 1.2
50%: 303.1 0.8
25%: 302.9 0.5
Min: 302.7 0.4

Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.10
McArthur Brook, Minor tributary, Stream Order 2

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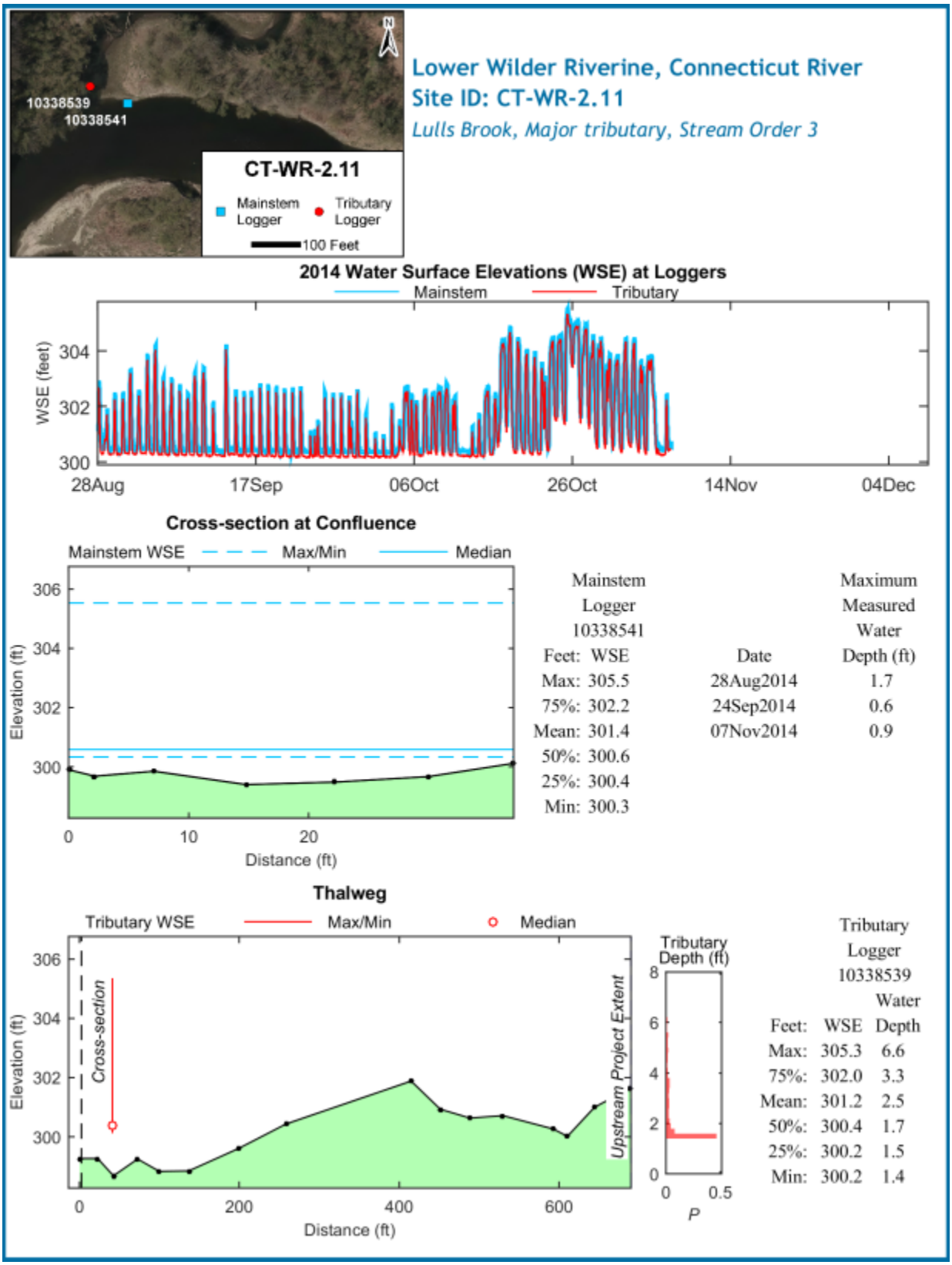
2.4 Site CT-WR-2.11 Lulls Brook

Site CT-WR-2.11 Lulls Brook, is a stream order 3 tributary located on the Vermont side in the lower Wilder riverine reach. This location was initially visited on August 28, 2014 and tributary (SN 10338539) and mainstem (SN 10338541) level loggers were installed on that date. An additional site visit was conducted on September 24, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed. Lulls Brook has a significant amount of woody debris present in it creating areas of scour and deposition (see photos below).

The tributary level logger was installed approximately 40 ft upstream of the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 690 ft upstream (elevation 301.6 ft), later confirmed at 688 ft from evaluation of WSE data. Review of the WSE values recorded by the mainstem level logger indicates that between 50 and 75% of the time, project-affected water levels remain below the suspected upper end of the project-affected portion of Lulls Brook (50% occurrence = 300.6 ft / 75% occurrence = 302.2 ft). The maximum mainstem WSE (305.5 ft) indicates the mainstem influence extends slightly farther upstream than the project-affected reach (305.3 ft elevation). Water was present within Lulls Brook during each of the three visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.6 to 1.7 ft. Water depths were measured along the channel thalweg during the September 24th site visit and ranged between 0.5 ft and 2.4 ft (mean = 1.3 ft).

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth at the thalweg within the immediate confluence area ranged between 0.9 and 6.1 ft and will provide adequate upstream access. As evidenced by the thalweg profile , bottom elevations show an increase-decrease pattern with distance moved upstream. It is possible that under low mainstem and tributary flow conditions, areas of significant woody debris may hinder upstream movement; however there were no data occurrences of < 0.5 ft depth at the confluence.

Examples of scour and depositional areas associated with the abundant woody debris present in Lulls Brook.


Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.11
Lulls Brook, Major tributary, Stream Order 3
10338539
10338541
CT-WR-2.11
Mainstem Logger
Tributary Logger
100 Feet
N
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
304
302
300
28Aug
17Sep
06Oct
26Oct
14Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
306
304
302
300
0
10
20
Distance (ft)
Mainstem Logger 10338541
Feet: WSE
Max: 305.5
75%: 302.2
Mean: 301.4
50%: 300.6
25%: 300.4
Min: 300.3
Date
28Aug2014
24Sep2014
07Nov2014
Maximum Measured Water Depth (ft)
1.7
0.6
0.9
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
306
304
302
300
Cross-section
Upstream Project Extent
0
200
400
600
Distance (ft)
Tributary Depth (ft)
8
6
4
2
0
0
0.5
P
Tributary Logger 10338539
Feet: WSE Water Depth
Max: 305.3 6.6
75%: 302.0 3.3
Mean: 301.2 2.5
50%: 300.4 1.7
25%: 300.2 1.5
Min: 300.2 1.4

Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.11
Lulls Brook, Major tributary, Stream Order 3

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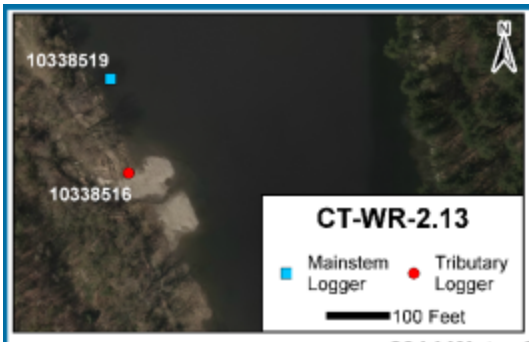
2.5 Site CT-WR-2.13 Bashan Brook

Site CT-WR-2.13 Bashan Brook, is a stream order 1 tributary located on the Vermont side in the lower Wilder riverine reach. This location was initially visited on July 22, 2014 and tributary (SN 10338516) and mainstem (SN 10338519) level loggers were installed on that date. Subsequent site visits were conducted on August 28 and September 24, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed.

Bashan Brook enters the lower Wilder riverine reach in the vicinity of a high-traffic put-in/take-out for recreational boaters. As seen in site photographs below, man-made rock blockages were frequently built in the stream creating small pool areas in this tributary as it flowed through cobble/gravel substrate between the water's edge and vegetated shoreline. One of these blockages rerouted the stream away from the tributary logger during the initial period of deployment (July 22- August 28) and as a result, tributary information is limited to the period August 28 to November 7, 2014.

During the initial site visit, the field crew established a cross section at a point in Bashan Brook near the vegetated shoreline (photograph time stamped 09:47 22Jul14). The field crew visually estimated that project effects extend approximately 250 ft upstream from the cross section to an elevation of 308.1 ft. However, later evaluation of WSE data showed that the project-affected reach does not enter the tributary (located 9 feet downstream of the visually determined confluence cross section at 302.9 ft elevation). Similarly, the extent of the mainstem influence lies approximately 7 ft below the confluence cross section (303.0 ft elevation). Water was present within Bashan Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.1 to 0.4 ft. Water depths were measured along the channel thalweg during the initial July 22nd site visit and ranged between 0.1 ft and 0.6 ft (mean = 0.3 ft). There were no data occurrences with confluence water depths of 0.5 ft or greater.

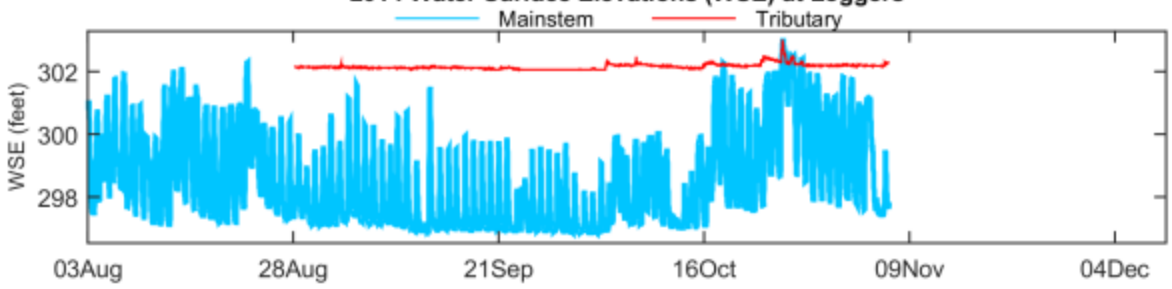
Bashan Brook is a small, stream order 1 tributary. Based on visual evaluation of the project-affected reach on four dates during 2014, it does not appear that Bashan Brook provides a significant flow contribution to the mainstem reach downstream of Wilder dam. Channel depths within Bashan Brook are limited as part of the stream's natural flow regime and access is modified and/or limited by manmade obstructions.



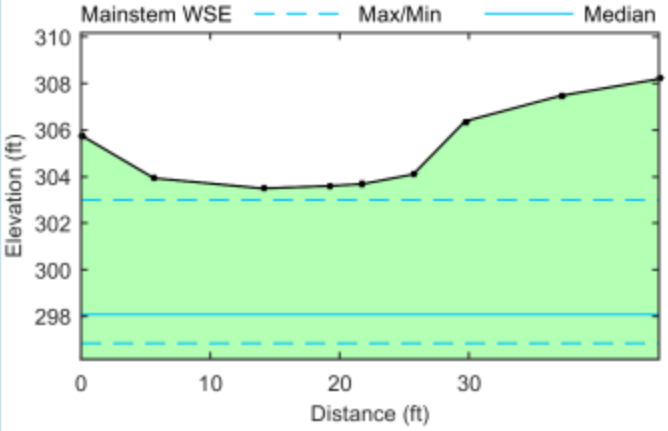
Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.13

Bashan Brook, Minor tributary, Stream Order 1

2014 Water Surface Elevations (WSE) at Loggers

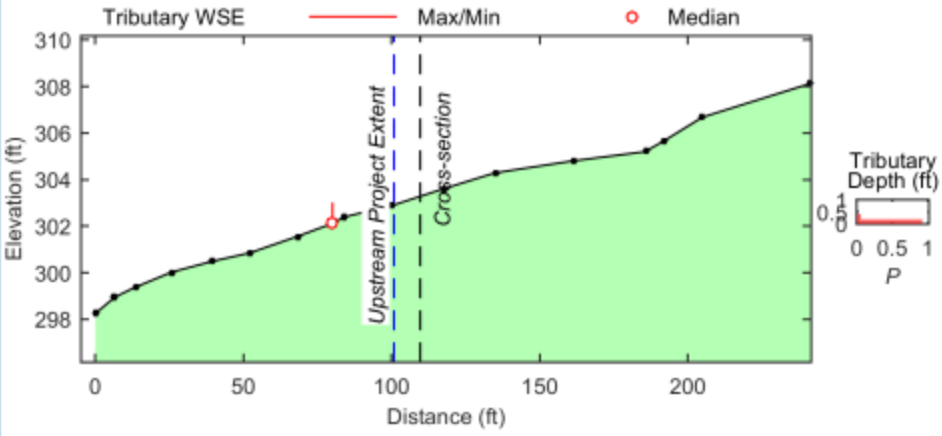


Cross-section at Confluence



Mainstem Logger 10338519		Maximum Measured Water Depth (ft)
Feet: WSE	Date	
Max: 303.0	22Jul2014	0.2
75%: 299.6	28Aug2014	0.1
Mean: 298.6	24Sep2014	0.4
50%: 298.1	07Nov2014	0.4
25%: 297.3		
Min: 296.8		

Thalweg



Tributary Logger 10338516		Water Depth
Feet:	WSE	
Max:	303.0	0.9
75%:	302.2	0.1
Mean:	302.2	0.1
50%:	302.1	0.1
25%:	302.1	0.1
Min:	302.1	0.0

Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.13
Bashan Brook, Minor tributary, Stream Order 1

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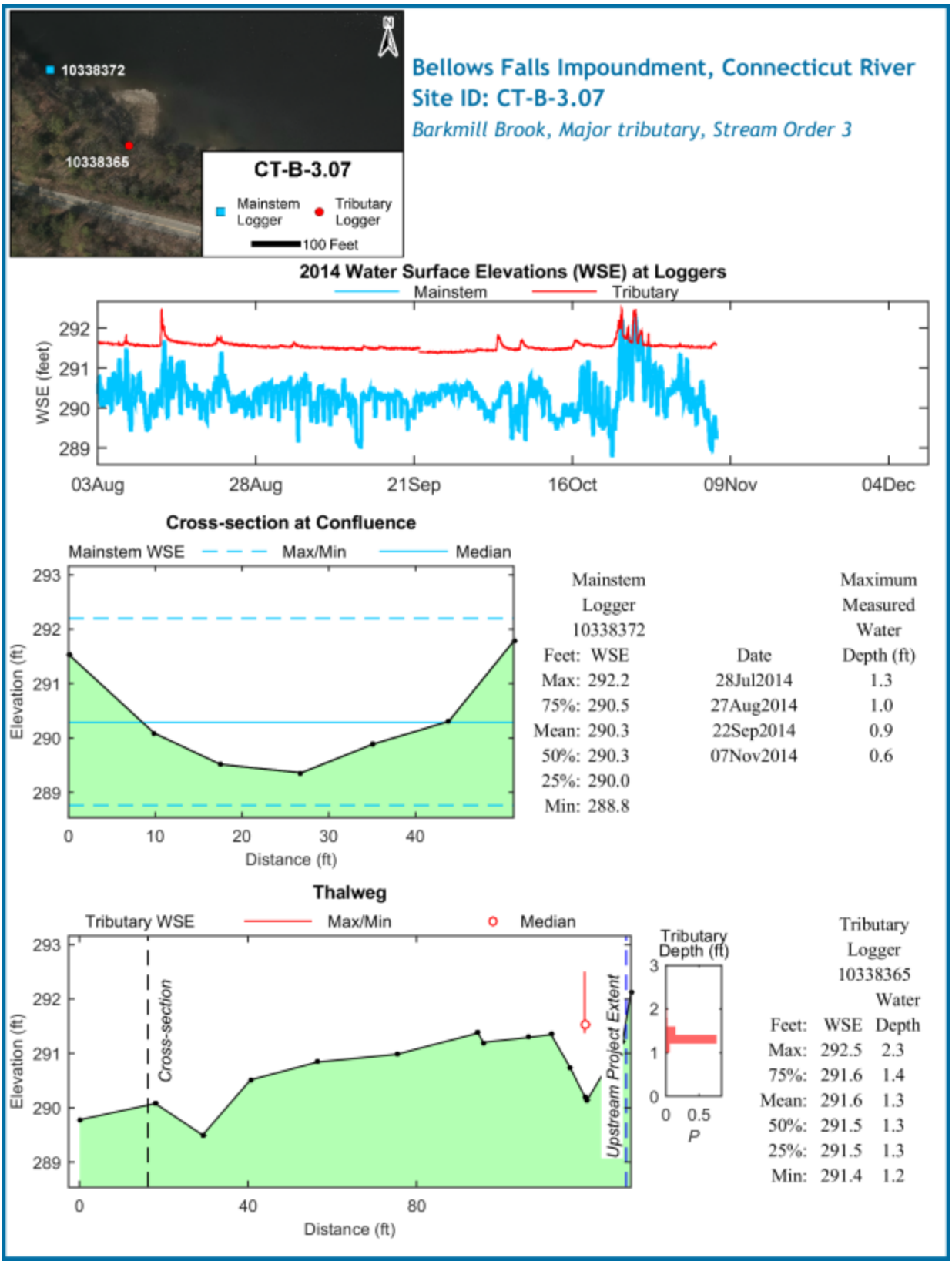
3.0 BELLOWS FALLS IMPOUNDMENT

3.1 Site CT-B-3.07 Barkmill Brook

Site CT-B-3.07 Barkmill Brook, is a stream order 3 tributary located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 28, 2014 and tributary (SN 10338365) and mainstem (SN 10338372) level loggers were installed at that time. Subsequent site visits were conducted on August 27 and September 22, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 104 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 115 ft up into Barkmill Brook to the base of a large culvert extending under Route 5 later confirmed by WSE data to be 113 ft (see photo time stamped 11:24 28Jul14). The maximum mainstem WSE (292.2 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (291.6 ft elevation). Water was present within Barkmill Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.6 to 1.3 ft. Water depths were measured along the channel thalweg during the initial July 28th site visit and ranged between 0.2 ft and 2.0 ft (mean = 0.9 ft). The shallowest depth was located at the upstream extent of the project-affected reach (i.e., culvert lip).

Review of the frequency distribution of water depth recorded by the mainstem level logger, indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 0.6 and 1.1 ft and should provide adequate upstream access. However, access may be limited under low mainstem and tributary conditions through a shallow, spread-out section of stream located between 40 and 100 ft upstream of the cross section having thalweg elevations between 290.5 and 291.3 ft. Only WSE values in the upper 25th percentile of those recorded by the mainstem level logger indicated that mainstem water would be available to provide access over the shoaled area. Access into this tributary may be limited by available water depths over the shoaled portion of the channel under low mainstem and tributary conditions such as those observed during the November 7th site visit (see photograph time stamped 14:20 07Nov14 below). However, access is generally adequate with only 13.9% of data occurrences < 0.5 ft depth at the confluence.


10338372
10338365
CT-B-3.07
Mainstem Logger
Tributary Logger
100 Feet
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.07
Barkmill Brook, Major tributary, Stream Order 3
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
292
291
290
289
03Aug
28Aug
21Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
293
292
291
290
289
0
10
20
30
40
Distance (ft)
Mainstem Logger 10338372
Feet: WSE
Max: 292.2
75%: 290.5
Mean: 290.3
50%: 290.3
25%: 290.0
Min: 288.8
Date
28Jul2014
27Aug2014
22Sep2014
07Nov2014
Maximum Measured Water Depth (ft)
1.3
1.0
0.9
0.6
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
293
292
291
290
289
Cross-section
Upstream Project Extent
0
40
80
Distance (ft)
Tributary Depth (ft)
3
2
1
0
0
0.5
P
Tributary Logger 10338365
Feet: WSE Water Depth
Max: 292.5 2.3
75%: 291.6 1.4
Mean: 291.6 1.3
50%: 291.5 1.3
25%: 291.5 1.3
Min: 291.4 1.2

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.07
Barkmill Brook, Major tributary, Stream Order 3

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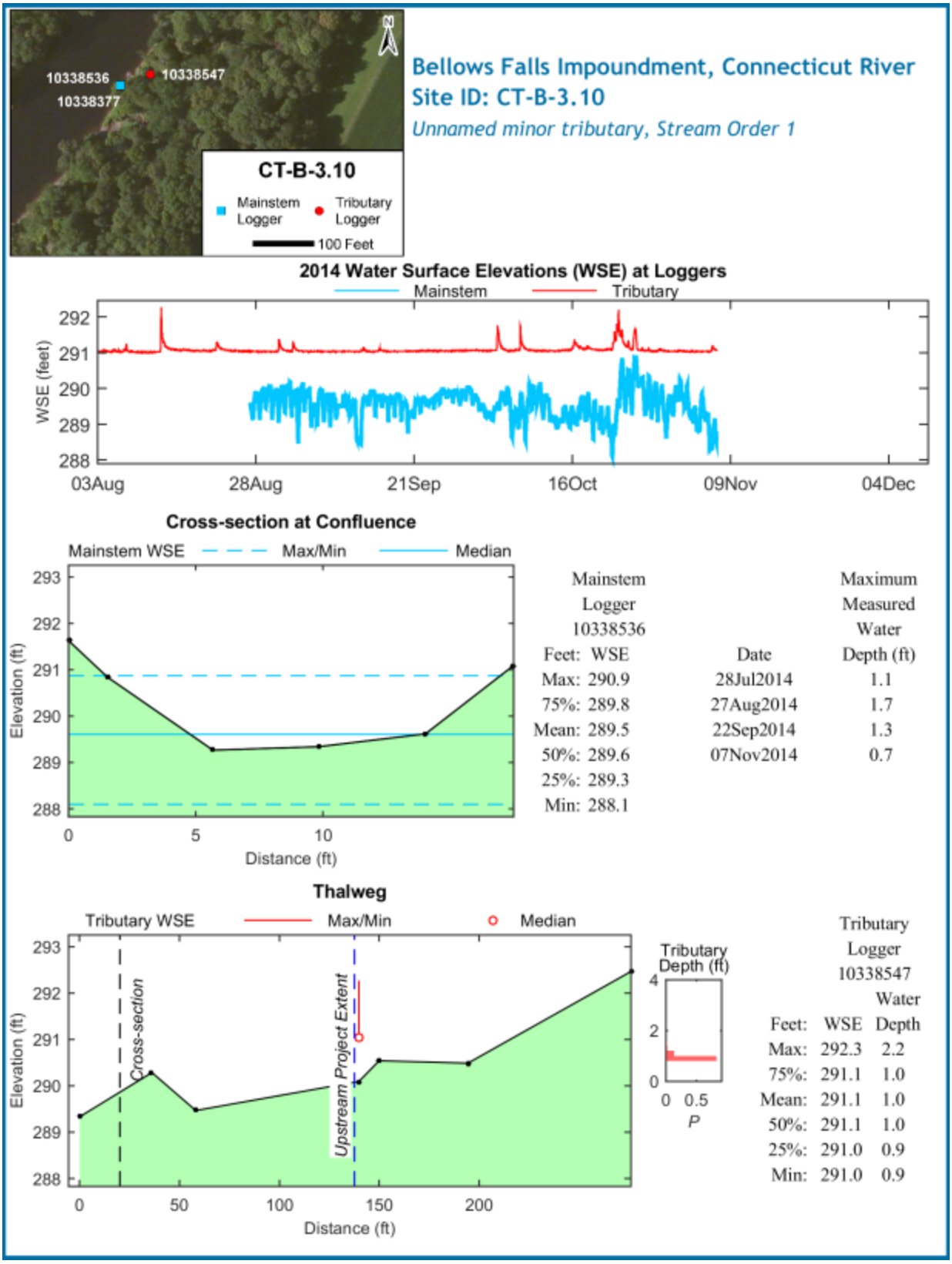
3.2 Site CT-B-3.10

Site CT-B-3.10 is an unnamed stream order 1 tributary located on the New Hampshire side in the Bellows Falls impoundment. This location was initially visited on July 28, 2014. Cross sectional and channel thalweg bed elevation information and water quality readings were collected on that date. Tributary (SN 10338547) and mainstem (SN 10338377) level loggers were installed at this location on August 3, 2014. Subsequent site visits were conducted on August 27 and September 22, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed. The level logger initially installed in the mainstem was found to be missing during the subsequent download visit and a new logger was installed at that site (SN10338536). As a result, mainstem sensor depth information is limited to the period August 27 to November 7, 2014.

The tributary level logger was installed approximately 120 feet upstream from the confluence with the mainstem, later confirmed by WSE data to be 117 ft. The maximum WSE value recorded by the mainstem level logger (290.9 ft) indicates that the mainstem influence can extend farther up into the tributary than the project-affected reach (290.4 ft elevation). Flow was present in the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.7 to 1.7 ft. Water depths were measured along the channel thalweg during the November 7th site visit and ranged between 0.4 and 1.0 ft (mean = 0.6 ft).

Site CT-B-3.10 is a small, stream order 1 tributary. Review of the percentiles for WSE values recorded by the mainstem level logger indicate that under conditions at or below the 25th percentile, mainstem water provides no additional inundation at the confluence and depth there is determined by natural stream outflow under those conditions. Access into this tributary may be limited by available water depths through shallower portions of the channel under low tributary flow conditions such as those observed during the November 7th site visit (see photograph time stamped 15:30 07Nov14 below). Access is limited a majority of the time (68.3% of data occurrences < 0.5 ft depth at the confluence).


10338536
10338547
10338377
CT-B-3.10
Mainstem Logger
Tributary Logger
100 Feet
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.10
Unnamed minor tributary, Stream Order 1
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
292
291
290
289
288
03Aug
28Aug
21Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
293
292
291
290
289
288
0
5
10
Distance (ft)
Mainstem Logger 10338536
Feet: WSE
Max: 290.9
75%: 289.8
Mean: 289.5
50%: 289.6
25%: 289.3
Min: 288.1
Date
28Jul2014
27Aug2014
22Sep2014
07Nov2014
Maximum Measured Water Depth (ft)
1.1
1.7
1.3
0.7
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
293
292
291
290
289
288
Cross-section
Upstream Project Extent
0
50
100
150
200
Distance (ft)
Tributary Depth (ft)
4
2
0
0
0.5
P
Tributary Logger 10338547
Feet: WSE Water Depth
Max: 292.3 2.2
75%: 291.1 1.0
Mean: 291.1 1.0
50%: 291.1 1.0
25%: 291.0 0.9
Min: 291.0 0.9

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.10
Unnamed minor tributary, Stream Order 1

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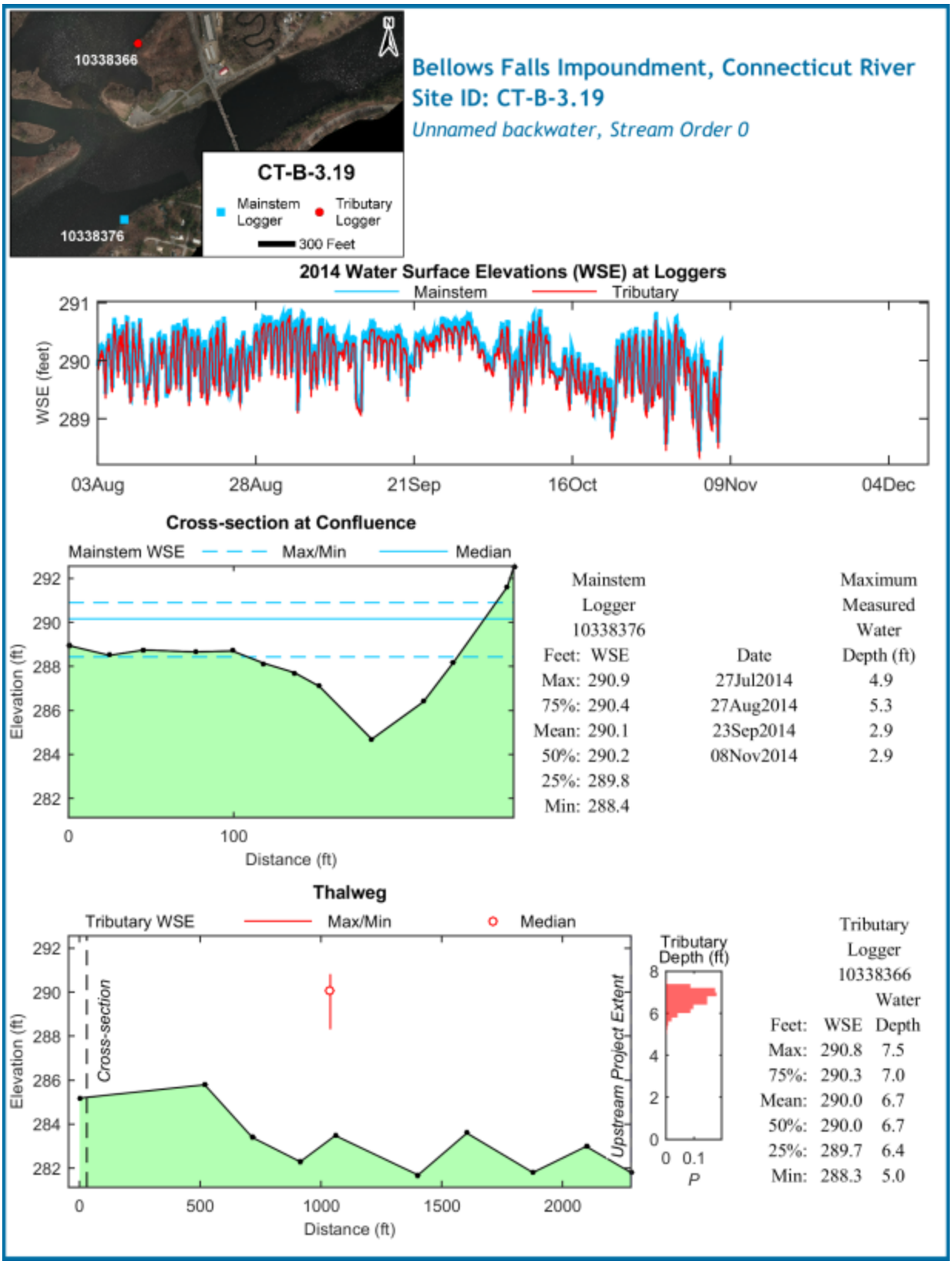
3.3 Site CT-B-3.19 Backwater

Site CT-B-3.19 is a backwater located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 27, 2014 and tributary (SN 10338366) and mainstem (SN 10338376) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

The backwater is connected to the mainstem via the Black River near the Hoyts Landing in Springfield, Vermont. The backwater level logger was installed approximately 1,000 feet away from the confluence. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area (see photo time stamped 13:07 27Jul14 below). The project-affected area was estimated to cover a linear distance of 2,252 ft, later confirmed by evaluation of WSE data. Water was present within the backwater during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 2.9 to 5.3 ft. Water depths across the ponded backwater area were measured during the initial site visit and ranged between 3.8 and 7.9 ft (mean = 6.4 ft).

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth at the confluence ranged between 3.7 and 6.2 ft and will provide adequate upstream access. As evidenced by the thalweg profile , bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the backwater level logger is considered (290.8-288.3 ft), WSEs under all observed conditions were sufficient to wet each surveyed thalweg point by a minimum of 2.5 ft. Due to shallow bed elevations present along the littoral margins of the ponded, backwater area, wetted area available to fish will likely be reduced in those margins during periods of low mainstem flow; however there were no data occurrences < 0.5 ft of depth at the confluence.


10338366
10338376
CT-B-3.19
Mainstem Logger
Tributary Logger
300 Feet
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.19
Unnamed backwater, Stream Order 0
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
291
290
289
03Aug
28Aug
21Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
292
290
288
286
284
282
0
100
Distance (ft)
Mainstem Logger 10338376
Feet: WSE
Max: 290.9
75%: 290.4
Mean: 290.1
50%: 290.2
25%: 289.8
Min: 288.4
Date
27Jul2014
27Aug2014
23Sep2014
08Nov2014
Maximum Measured Water Depth (ft)
4.9
5.3
2.9
2.9
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Elevation (ft)
292
290
288
286
284
282
0
500
1000
1500
2000
Distance (ft)
Tributary Depth (ft)
8
6
4
2
0
0
0.1
P
Tributary Logger 10338366
Feet: WSE Water Depth
Max: 290.8 7.5
75%: 290.3 7.0
Mean: 290.0 6.7
50%: 290.0 6.7
25%: 289.7 6.4
Min: 288.3 5.0

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.19
Unnamed backwater, Stream Order 0

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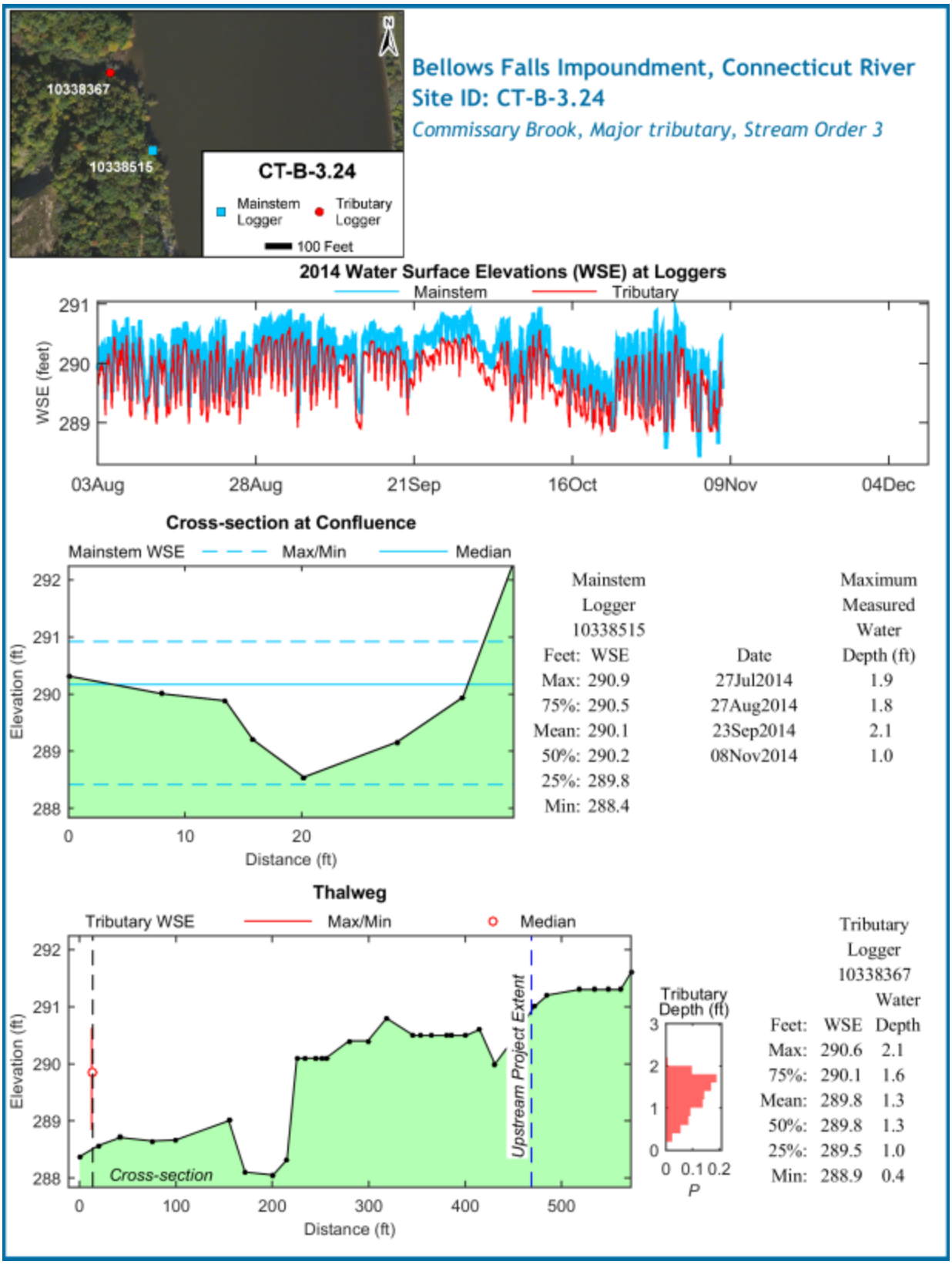
3.4 Site CT-B-3.24 Commissary Brook

Site CT-B-3.24 Commissary Brook, is a stream order 3 tributary located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 27, 2014 and tributary (SN 10338367) and mainstem (SN 10338515) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

The tributary level logger was installed in the immediate vicinity of the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 200 ft upstream to a point where the tributary narrowed greatly and had dense canopy cover see photo below). Additional bed elevation data for this location was collected in association with Study 7 during 2013 and upon review of that data for this report and WSE data the thalweg profile was extended to a point approximately 455 ft upstream of the confluence (290.9 ft elevation). Flow was present in Commissary Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.0 to 2.1 ft. Water depths were measured along the lowermost 200 ft of the channel thalweg during the initial site visit on July 27th and ranged between 1.4 ft and 2.3 ft (mean = 1.9 ft).

Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 1.0 and 1.6 ft and should provide adequate upstream access. Under median conditions (WSE = 290.2 ft; mainstem level logger), Commissary Brook is inundated by mainstem water to the point approximately 200 ft upstream from the confluence that was visually determined to be the extend of project effects during the initial July 27th site visit. Under low mainstem WSE conditions (minimum value recorded = 288.4 ft, Commissary Brook is no longer inundated by mainstem water and is limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.4 ft); however under most conditions access is adequate (0.9% of data occurrences < 0.5 ft of depth at the confluence).

Upstream extent of mainstem influenced area associated with Commissary Brook as determined by visual observations, 2014.


Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.24
Commissary Brook, Major tributary, Stream Order 3
10338367
10338515
CT-B-3.24
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
291
290
289
03Aug
28Aug
21Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
292
291
290
289
288
0
10
20
Distance (ft)
Mainstem Logger 10338515
Feet: WSE
Max: 290.9
75%: 290.5
Mean: 290.1
50%: 290.2
25%: 289.8
Min: 288.4
Date
27Jul2014
27Aug2014
23Sep2014
08Nov2014
Maximum Measured Water Depth (ft)
1.9
1.8
2.1
1.0
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
292
291
290
289
288
Cross-section
Upstream Project Extent
0
100
200
300
400
500
Distance (ft)
Tributary Depth (ft)
3
2
1
0
0 0.1 0.2
P
Tributary Logger 10338367
Feet: WSE Water Depth
Max: 290.6 2.1
75%: 290.1 1.6
Mean: 289.8 1.3
50%: 289.8 1.3
25%: 289.5 1.0
Min: 288.9 0.4

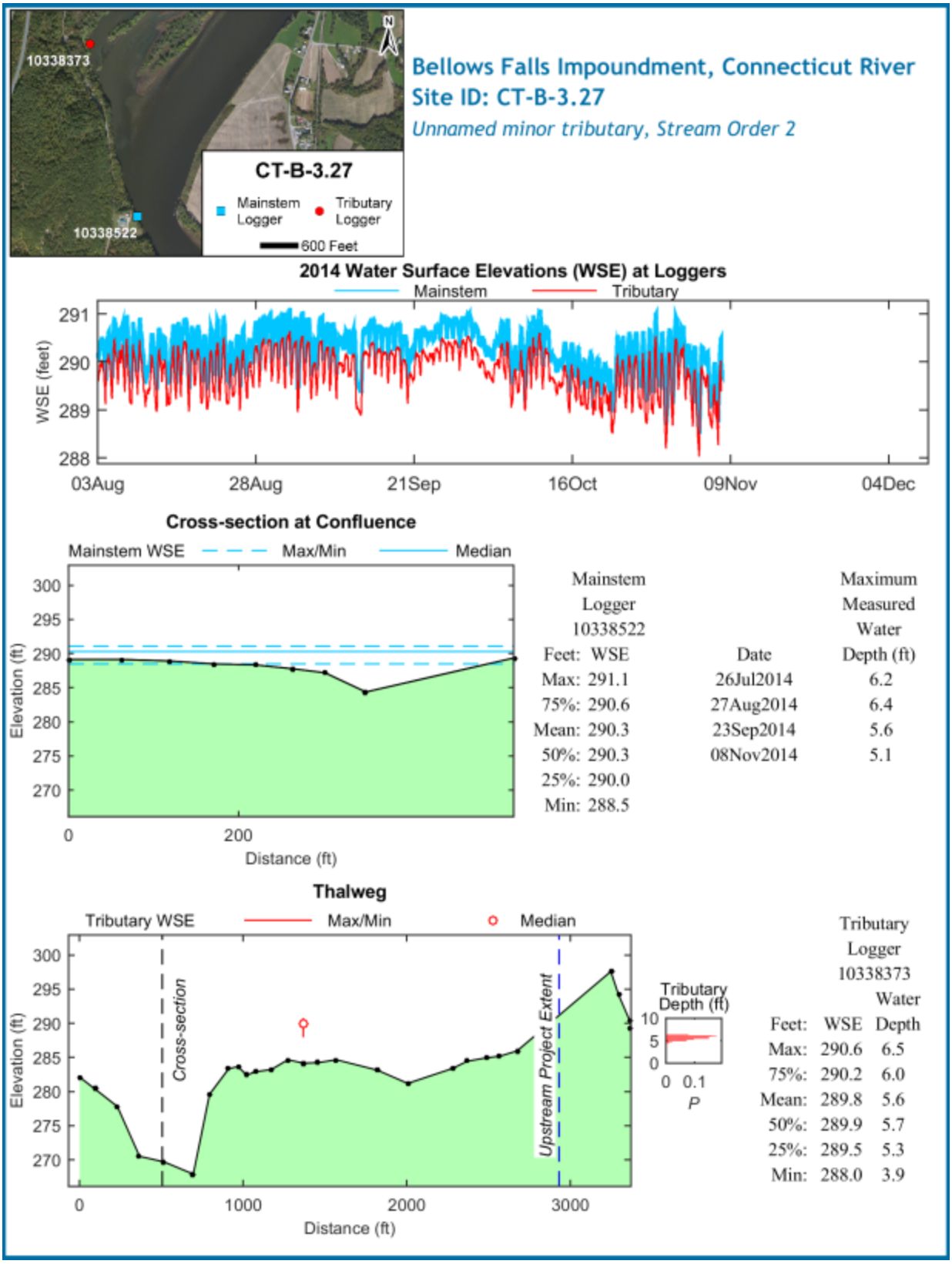
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.24
Commissary Brook, Major tributary, Stream Order 3

3.5 Site CT-B-3.27

Site CT-B-3.27 is an unnamed stream order 2 tributary located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 26, 2014 and tributary (SN 10338373) and mainstem (10338522) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 860 feet upstream from the confluence with the mainstem. The extent of project effects was estimated at 2,422 ft up into the tributary, later confirmed by evaluation of WSE data (291.1 ft elevation). Flow was present at Site CT-B-3.27 during each of the four visits. Water depth at the confluence cross section was measured during each of the four visits and the maximum water depth ranged from 5.1 to 6.4 ft. Water depths were measured along the channel thalweg during the initial site visit on July 26th and ranged between 1.2 ft and 19.2 ft (mean = 6.8 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger, indicates that under all observed conditions (i.e., min through max WSE values) water depth at the immediate confluence area maintained a minimum value of 4.1 ft. Review of the frequency distribution of tributary water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 5.3 and 6.0 ft and adequate access is available and access is adequate (0% of data occurrences <0.5 ft depth at the confluence).


10338373
10338522
N
CT-B-3.27
Mainstem Logger
Tributary Logger
600 Feet
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.27
Unnamed minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
291
290
289
288
03Aug
28Aug
21Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
300
295
290
285
280
275
270
0
200
Distance (ft)
Mainstem Logger 10338522
Feet: WSE
Max: 291.1
75%: 290.6
Mean: 290.3
50%: 290.3
25%: 290.0
Min: 288.5
Date
26Jul2014
27Aug2014
23Sep2014
08Nov2014
Maximum Measured Water Depth (ft)
6.2
6.4
5.6
5.1
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
300
295
290
285
280
275
270
Cross-section
Upstream Project Extent
0
1000
2000
3000
Distance (ft)
Tributary Depth (ft)
10
5
0
0 0.1
P
Tributary Logger 10338373
Feet: WSE Water Depth
Max: 290.6 6.5
75%: 290.2 6.0
Mean: 289.8 5.6
50%: 289.9 5.7
25%: 289.5 5.3
Min: 288.0 3.9

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.27
Unnamed minor tributary, Stream Order 2

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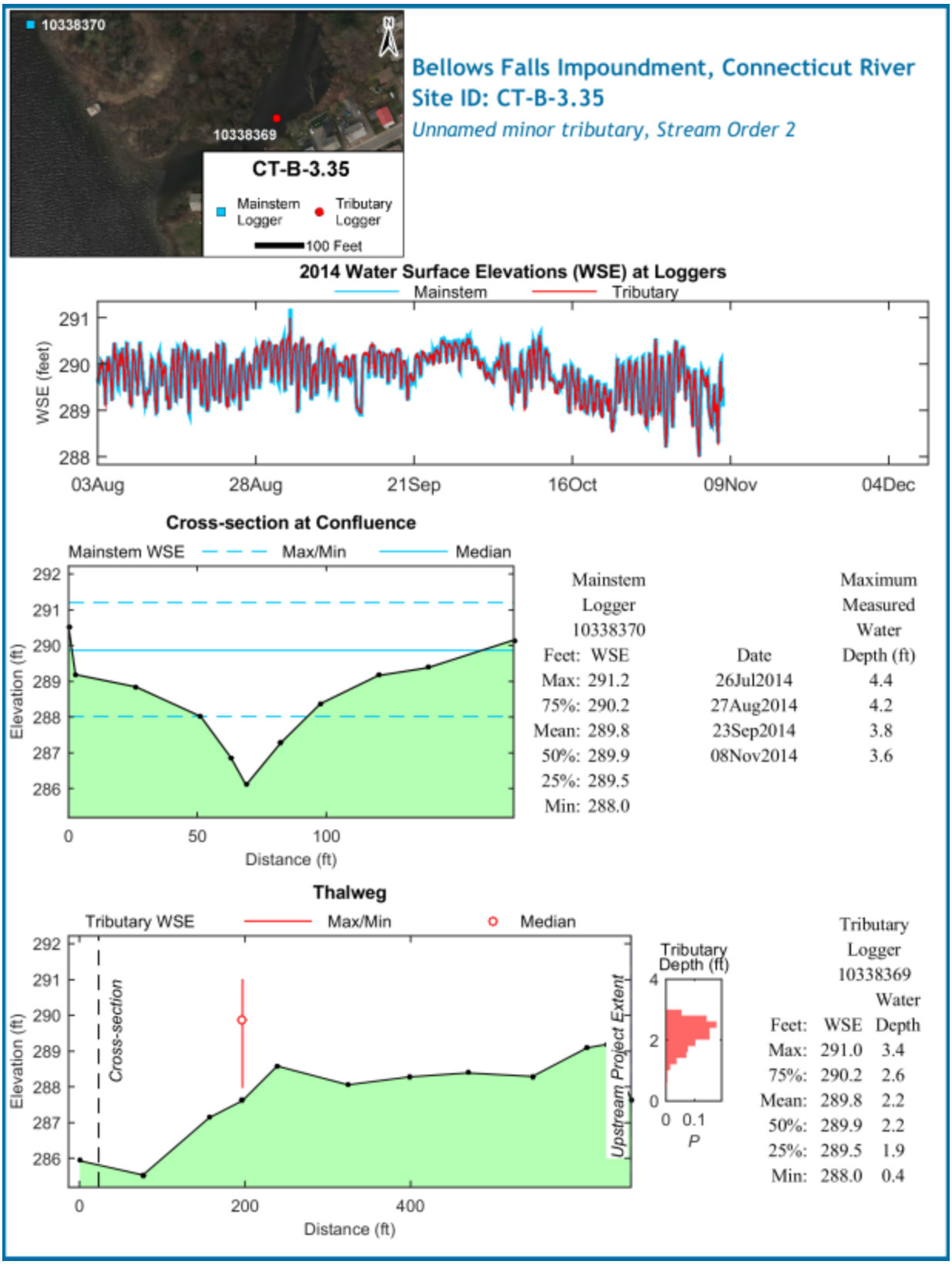
3.6 Site CT-B-3.35

Site CT-B-3.35 is an unnamed stream order 2 tributary located on the New Hampshire side in the Bellows Falls impoundment. This location was initially visited on July 26, 2014 and tributary (SN 10338369) and mainstem (SN 10338370) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 173 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 643 ft up into the tributary to the base of a 5-ft diameter culvert extending approximately 125 ft under Route 12 (see photo below). The sill elevation of the culvert was at 289.6 ft and was visually determined to be the upper end of the project-affected reach. Later evaluation of WSE data indicates that the project-affected reach extends beyond the culvert (291.2 ft elevation) and the culvert sill is inundated by mainstem water nearly 75% of the time. Water was present within the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 3.6 to 4.4 ft. Water depths were measured along the channel thalweg during the initial July 28th site visit and ranged between 0.9 ft and 4.8 ft (mean = 2.4 ft).

Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 1.9 and 2.6 ft and should provide adequate upstream access (0% of data occurrence < 0.5 ft depth at the confluence).

Culvert near upstream extent of project-affected area associated with Site CT-B-3.35 as determined by visual observations, 2014.


10338370
10338369
CT-B-3.35
Mainstem Logger
Tributary Logger
100 Feet
N
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.35
Unnamed minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
291
290
289
288
03Aug
28Aug
21Sep
16Oct
09Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
292
291
290
289
288
287
286
0
50
100
Distance (ft)
Mainstem Logger 10338370
Feet: WSE
Max: 291.2
75%: 290.2
Mean: 289.8
50%: 289.9
25%: 289.5
Min: 288.0
Date
26Jul2014
27Aug2014
23Sep2014
08Nov2014
Maximum Measured Water Depth (ft)
4.4
4.2
3.8
3.6
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
292
291
290
289
288
287
286
Cross-section
Upstream Project Extent
0
200
400
Distance (ft)
Tributary Depth (ft)
4
2
0
0
0.1
P
Tributary Logger 10338369
Feet: WSE Water Depth
Max: 291.0 3.4
75%: 290.2 2.6
Mean: 289.8 2.2
50%: 289.9 2.2
25%: 289.5 1.9
Min: 288.0 0.4

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.35
Unnamed minor tributary, Stream Order 2

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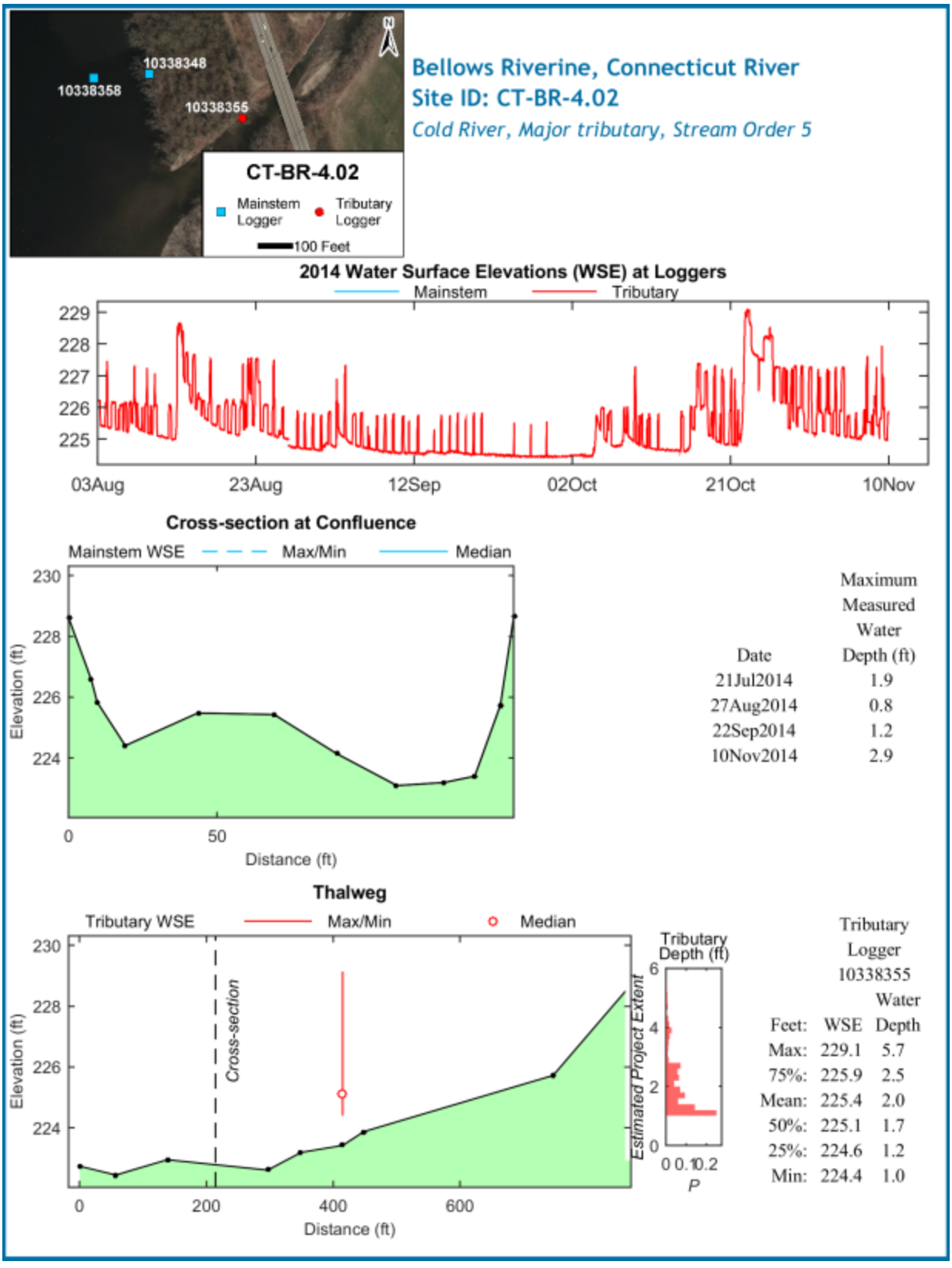
4.0 BELLOWS FALLS RIVERINE SECTION

4.1 Site CT-BR-4.02 Cold River

Site CT-BR-4.02 Cold River, is a stream order 5 tributary located on the New Hampshire side in the Bellows Falls riverine reach. This location was initially visited on July 21, 2014 and a tributary level logger (SN 10338355) was installed on that date. A mainstem logger was not installed during the initial site visit as one was presumed to be already present at a location adjacent to the confluence (SN 10338348; over-winter logger site associated with Study 7). Subsequent site visits were conducted on August 27 and September 22, 2014. The final site visit occurred on November 10, 2014 at which time the tributary level logger was removed. The Study 7 overwinter mainstem logger at site CT-BR-4.02 was determined to be missing on October 9, 2014 during dive sampling. A new logger (SN 10338358) was installed at that time. Mainstem logger 10338358 is still deployed and is scheduled for download once divers can safely access that area following spring 2015 high flows.

The tributary level logger was installed approximately 200 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 900 ft up into the Cold River to a point just upstream of the Route 12 Bridge. Water was present within the Cold River during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.8 to 2.9 ft. Water depths were measured along the channel thalweg during the July 21st (min = 1.2 ft; max = 2.2 ft; mean = 1.5 ft), August 27th (min = 0.7 ft; max = 1.7 ft; mean = 1.2 ft), and November 10th (min = 1.0 ft; max = 3.0 ft; mean = 2.1 ft) site visits.

The Cold River is a large, stream order 5 tributary. Based on visual observations of the project-affected reach on four dates during 2014, it appears that natural outflow from the Cold River provides sufficient water depths for access. An adequate thalweg was present on the date of each site visit. The cobble substrate over which the Cold River flows at its confluence with the mainstem is very dynamic and changes in location and quantity were evident from one site visit to the next (see photograph time stamped 14:30 21Jul14 below).


10338348
10338358
10338355
N
CT-BR-4.02
Mainstem Logger
Tributary Logger
100 Feet
Bellows Riverine, Connecticut River
Site ID: CT-BR-4.02
Cold River, Major tributary, Stream Order 5
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
229
228
227
226
225
03Aug
23Aug
12Sep
02Oct
21Oct
10Nov
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
230
228
226
224
0
50
Distance (ft)
Date
Maximum Measured Water Depth (ft)
21Jul2014 1.9
27Aug2014 0.8
22Sep2014 1.2
10Nov2014 2.9
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
230
228
226
224
Cross-section
Estimated Project Extent
Tributary Depth (ft)
6
4
2
0
0 0.1 0.2
P
0
200
400
600
Distance (ft)
Tributary Logger 10338355
Feet: WSE Water Depth
Max: 229.1 5.7
75%: 225.9 2.5
Mean: 225.4 2.0
50%: 225.1 1.7
25%: 224.6 1.2
Min: 224.4 1.0

Bellows Riverine, Connecticut River
Site ID: CT-BR-4.02
Cold River, Major tributary, Stream Order 5

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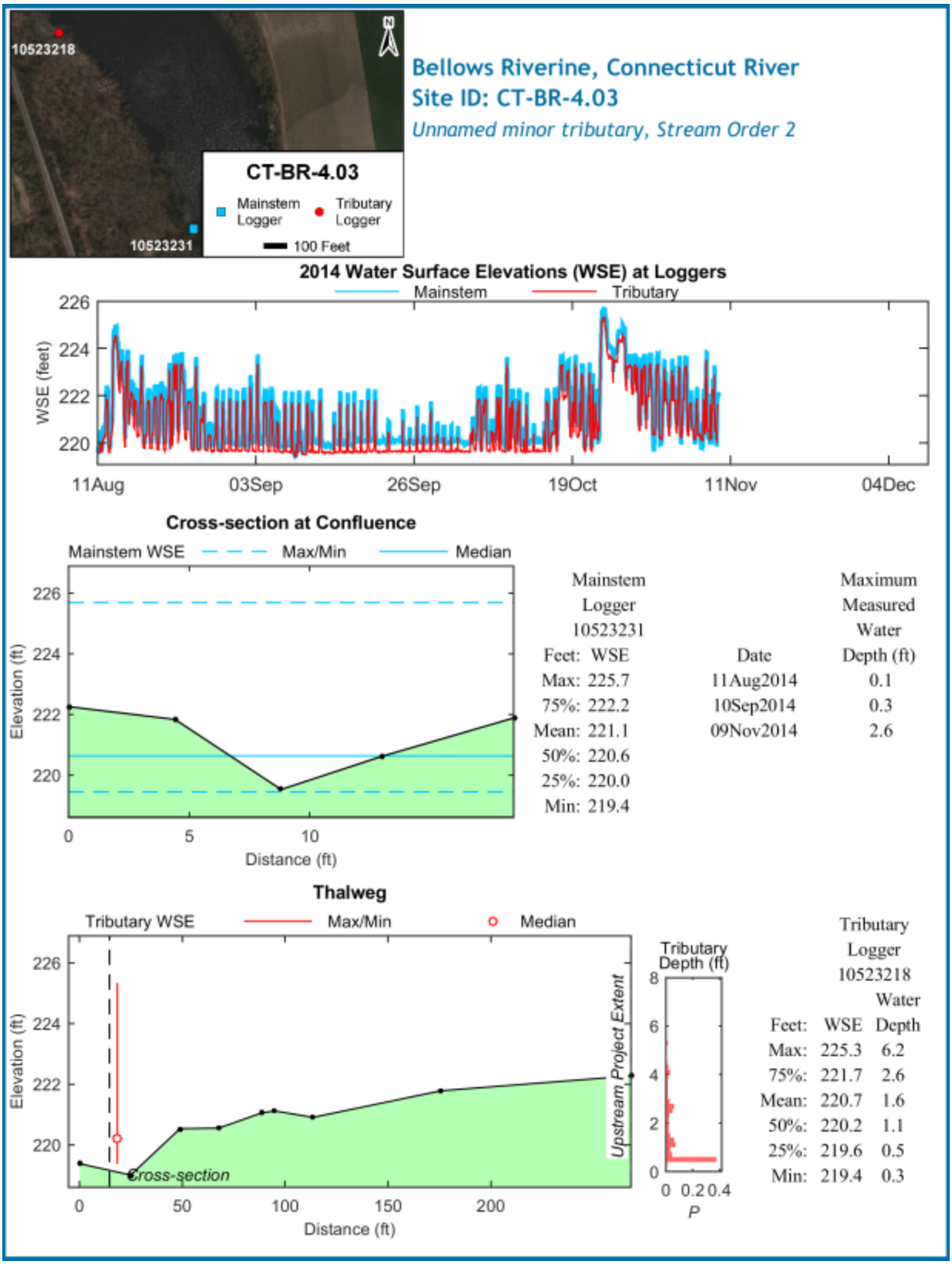
4.2 Site CT-BR-4.03

Site CT-BR-4.03 is an unnamed stream order 2 tributary located on the Vermont side in the Bellows Falls riverine reach. This location was initially visited on August 11, 2014 and tributary (SN 10523218) and mainstem (SN 10523218) level loggers were installed on that date. A subsequent site visit was conducted on September 10, 2014. The final site visit occurred on November 9, 2014 at which time the level loggers were removed.

The tributary level logger was installed in the immediate vicinity of the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 254 ft (later confirmed by evaluation of WSE data) up into the tributary to a section where bank vegetation did not appear to indicate significant fluctuating water levels (bed elevation = 222.3 ft). Review of the WSE values recorded by the mainstem level logger indicates that under nearly all conditions observed, mainstem water levels remained below the suspected end of the project-affected reach (75% occurrence = 222.2 ft). However, the maximum mainstem WSE (225.7 ft) indicated that the mainstem influence extends farther upstream than the project-affected reach (224.5 ft elevation). Flow was present in tributary CT-BR-4.03 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 2.6 ft. Water depths were measured along the channel thalweg during the August 8th site visit and ranged between 0.1 and 0.6 ft (mean = 0.2 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (elevation = 217.9 ft) ranged between 0.5 and 2.7 ft. Under low mainstem WSE conditions (minimum value recorded = 219.4 ft), Site CT-BR-4.03 is not inundated by mainstem water (see photograph time stamped 07:37 10Sep14 below) and is limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger (water depth = 0.3 ft); however, only 11.7% of all data occurrences were < 0.5 ft depth at the confluence).


10523218
10523231
N
CT-BR-4.03
Mainstem Logger
Tributary Logger
100 Feet
Bellows Riverine, Connecticut River
Site ID: CT-BR-4.03
Unnamed minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
226
224
222
220
11Aug
03Sep
26Sep
19Oct
11Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
226
224
222
220
0
5
10
Distance (ft)
Mainstem Logger 10523231
Feet: WSE
Max: 225.7
75%: 222.2
Mean: 221.1
50%: 220.6
25%: 220.0
Min: 219.4
Date
11Aug2014
10Sep2014
09Nov2014
Maximum Measured Water Depth (ft)
0.1
0.3
2.6
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
226
224
222
220
Cross-section
Upstream Project Extent
0
50
100
150
200
Distance (ft)
Tributary Depth (ft)
8
6
4
2
0
0 0.2 0.4
P
Tributary Logger 10523218
Feet: WSE Water Depth
Max: 225.3 6.2
75%: 221.7 2.6
Mean: 220.7 1.6
50%: 220.2 1.1
25%: 219.6 0.5
Min: 219.4 0.3

Bellows Riverine, Connecticut River
Site ID: CT-BR-4.03
Unnamed minor tributary, Stream Order 2

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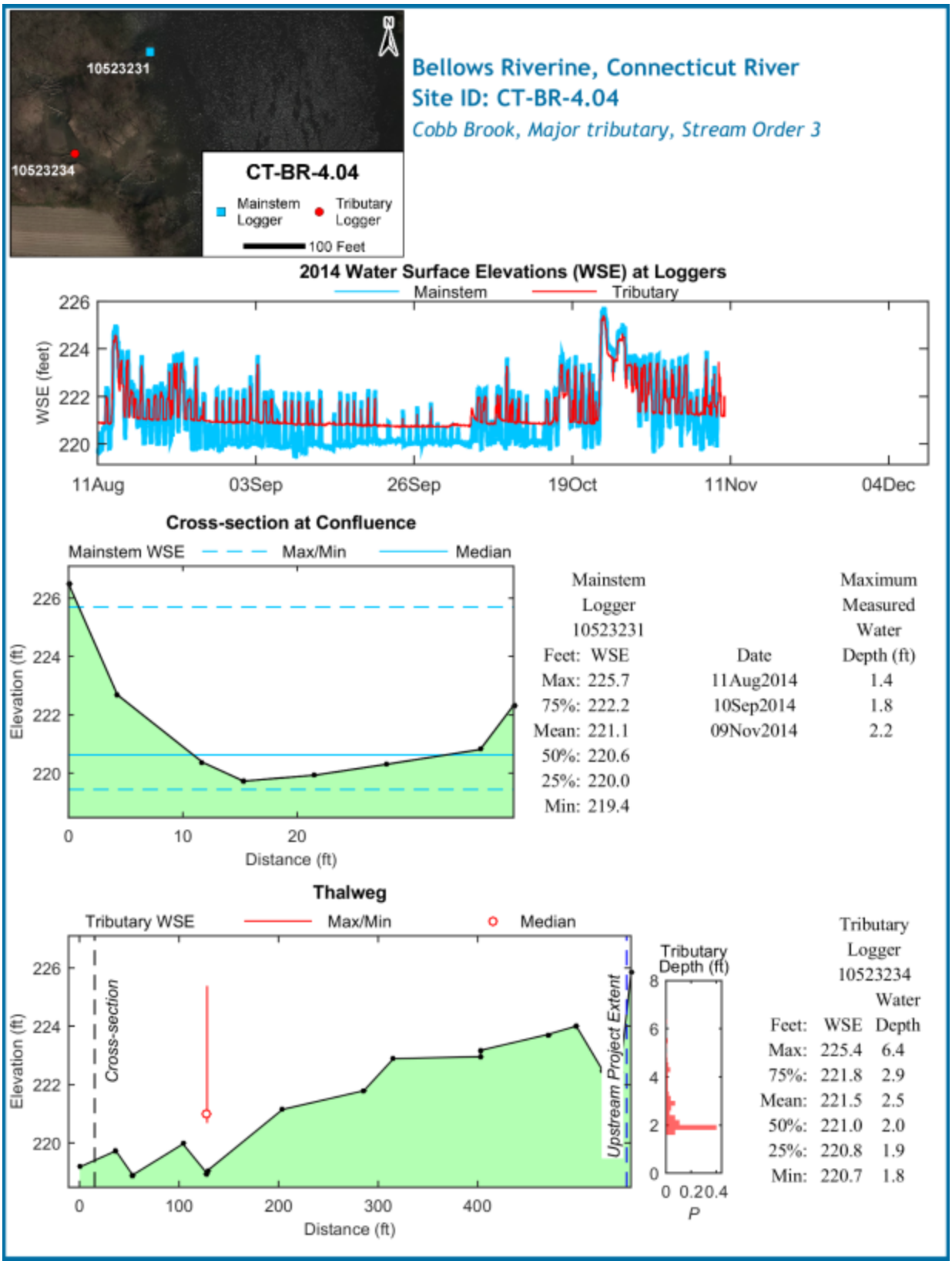
4.3 Site CT-BR-4.04 Cobb Brook

Site CT-BR-4.03 Cobb Brook, is a stream order 3 tributary located on the Vermont side in the Bellows Falls riverine reach. This location was initially visited on August 11, 2014 and tributary (SN 10523234) and mainstem (SN 10523231) level loggers were installed on that date. A subsequent site visit was conducted on September 10, 2014. The final site visit occurred on November 9, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 113 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 540 ft up into Cobb Brook to the base of a railroad culvert (later confirmed by evaluation of WSE data to be 535 ft, see photograph time stamped 10:58 11Aug14). Review of the WSE values recorded by the mainstem level logger indicates that under all conditions, both the project-affected elevation (224.5 ft) and the maximum mainstem influence (225.7 ft) remained just below the culvert bottom sill elevation of 225.85 ft). Flow was present in Cobb Brook during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.4 to 2.2 ft. Water depths were measured along a 189 ft section of the channel thalweg during the initial site visit on August 11th and ranged between 0.4 and 1.9 ft (mean = 1.0 ft).

Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the tributary logger ranged between 1.9 and 2.9 ft and should provide adequate access. Under low mainstem conditions (minimum value recorded = 219.4 ft), Cobb Brook is no longer inundated by mainstem water and is limited to only its own natural outflow which is generally adequate for access; however, 40.5% of data occurrences were < 0.5 ft depth at the confluence indicating that under both mainstem and tributary low conditions, access could be limited for larger fish.


10523231
10523234
CT-BR-4.04
Mainstem Logger
Tributary Logger
100 Feet
Bellows Riverine, Connecticut River
Site ID: CT-BR-4.04
Cobb Brook, Major tributary, Stream Order 3
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
11Aug
03Sep
26Sep
19Oct
11Nov
04Dec
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
Distance (ft)
Mainstem Logger 10523231
Feet: WSE
Max: 225.7
75%: 222.2
Mean: 221.1
50%: 220.6
25%: 220.0
Min: 219.4
Date
11Aug2014
10Sep2014
09Nov2014
Maximum Measured Water Depth (ft)
1.4
1.8
2.2
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
P
Tributary Logger 10523234
Feet: WSE Water Depth
Max: 225.4 6.4
75%: 221.8 2.9
Mean: 221.5 2.5
50%: 221.0 2.0
25%: 220.8 1.9
Min: 220.7 1.8

Bellows Riverine, Connecticut River
Site ID: CT-BR-4.04
Cobb Brook, Major tributary, Stream Order 3

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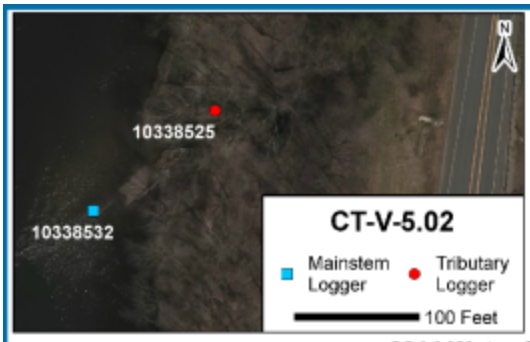
4.4 Site CT-V-5.02 Mad Brook

Site CT-V-5.02 Mad Brook, is a stream order 2 tributary located on the New Hampshire side at the lower end of the Bellows Falls riverine section/at the just upstream of the upper end of the Vernon impoundment. This location was initially visited on August 8, 2014 and tributary (SN 10338525) and mainstem (SN 10338532) level loggers were installed on that date. A subsequent site visit was conducted on September 8, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed. During the manual data review portion of post-processing, it was discovered that pressure readings recorded by the mainstem level logger were impacted by a logger malfunction. This malfunction resulted in plotted sensor depths exceeding the range expected for this particular location and data from this location was assigned a Use Code = 9 (Table 4.2-1). As a result, no mainstem level logger data is available.

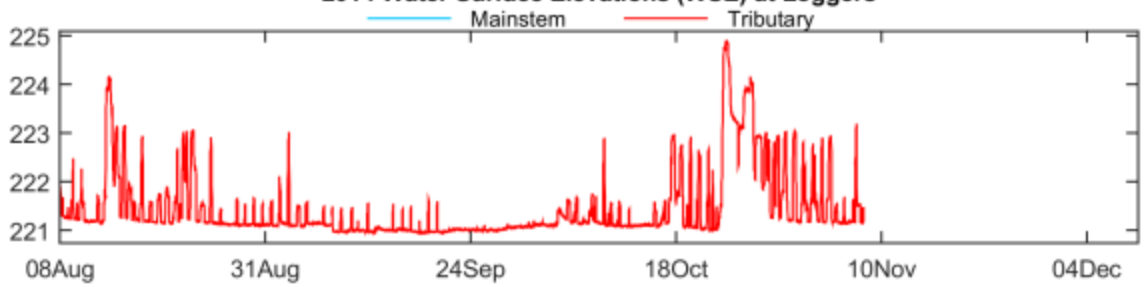
The tributary level logger was installed approximately 30 feet upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 80 ft up into Mad Brook to culvert with a lower sill elevation of 223.8 ft, later confirmed by evaluation of WSE data (see photograph time stamped 14:28 08Sep14 below). Review of the WSE values recorded by the mainstem level logger indicates that mainstem water levels remained below the lower sill elevation of the culvert for the period of record. Flow was present in Mad Brook during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.7 to 1.1 ft. Water depths were measured along the channel thalweg during the final site visit on November 8th and ranged between 0.6 and 3.1 ft (mean = 1.6 ft).

Based on visual evaluation of the project-affected reach on three dates during 2014 as well as recorded water depths along the channel thalweg and at the confluence cross section (and given the lack of mainstem data) access could be limited under low mainstem and tributary conditions.

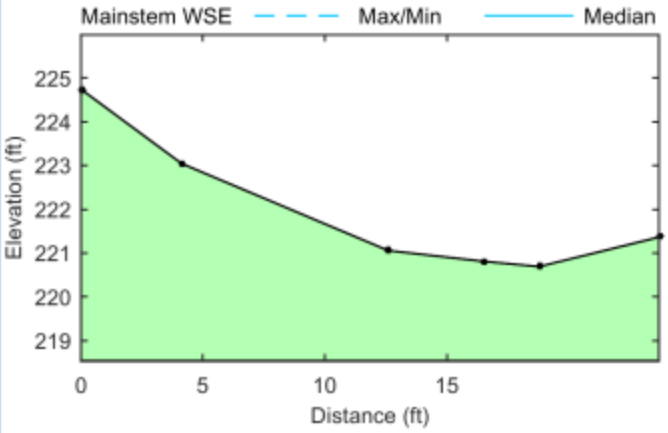


Vernon Impoundment, Connecticut River
Site ID: CT-V-5.02
Mad Brook, Minor tributary, Stream Order 2

2014 Water Surface Elevations (WSE) at Loggers

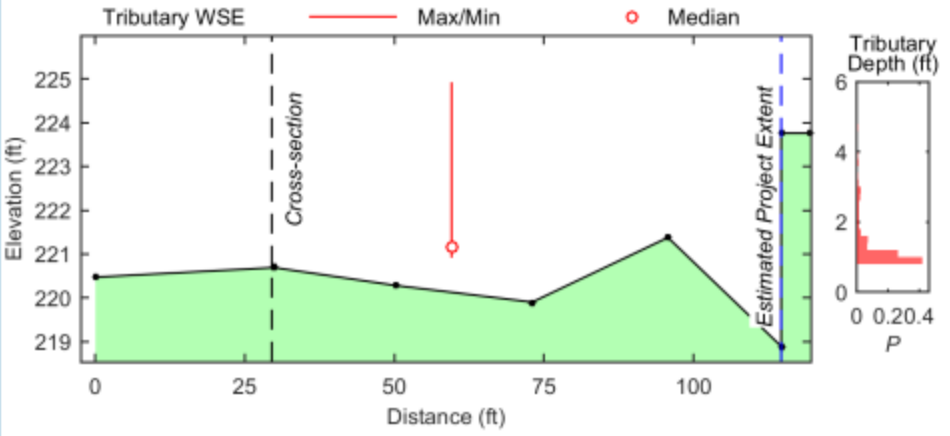


Cross-section at Confluence



Date	Maximum Measured Water Depth (ft)
08Aug2014	1.1
08Sep2014	0.7
08Nov2014	0.8

Thalweg



	Tributary Logger 10338525	
Feet:	WSE	Water Depth
Max:	224.9	4.8
75%:	221.5	1.4
Mean:	221.5	1.3
50%:	221.2	1.0
25%:	221.1	1.0
Min:	220.9	0.8

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.02
Mad Brook, Minor tributary, Stream Order 2

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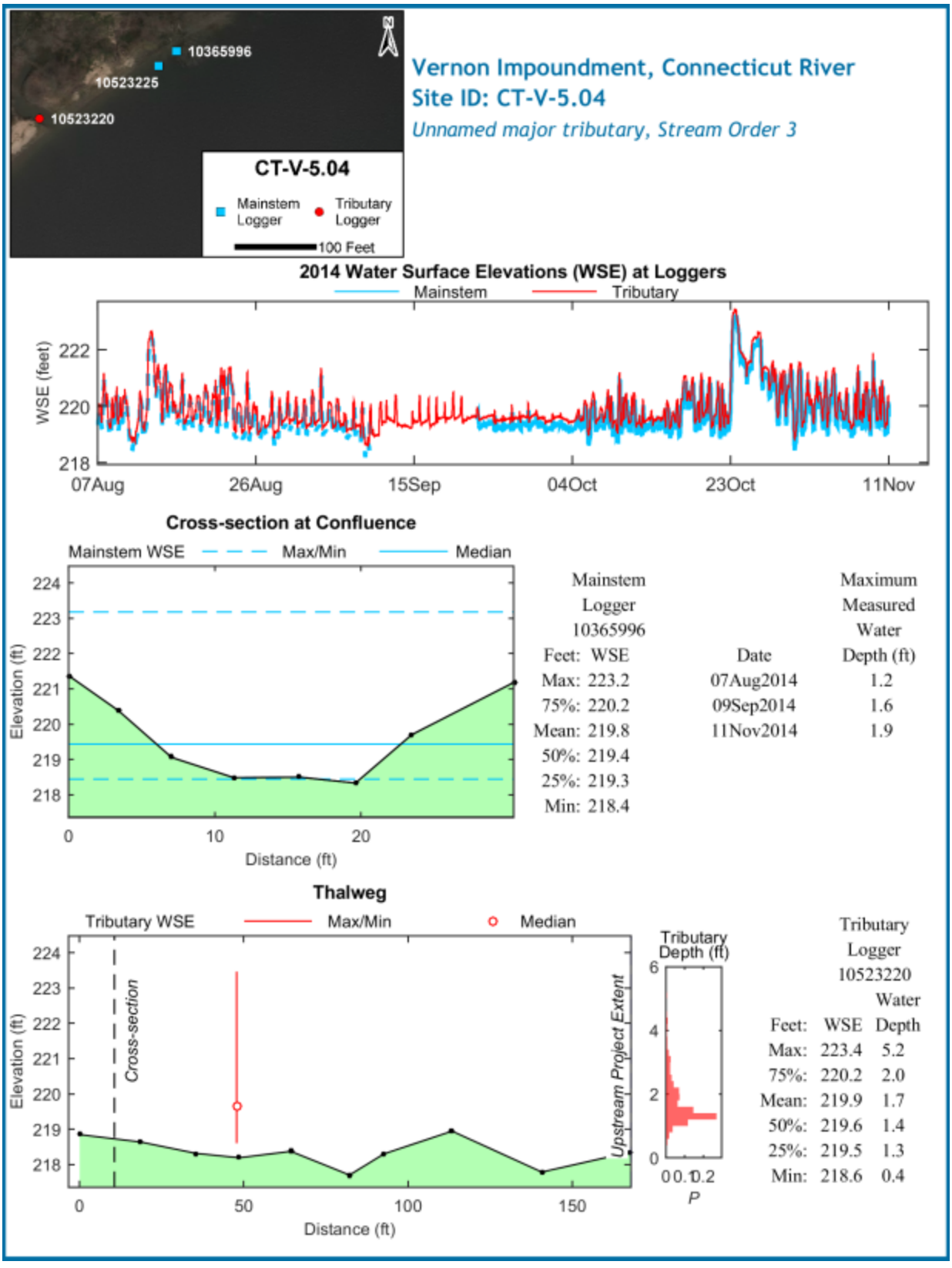
5.0 VERNON IMPOUNDMENT

5.1 Site CT-V-5.04

Site CT-V-5.04 is an unnamed stream order 3 tributary located on the Vermont side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10523220) and mainstem (SN 10523225) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed. Following the September 9th download, Normandeau was notified by the Bellows Falls police department that level logger SN 10523225 had been turned in at their station. A new unit was installed (SN 10365996) immediately upon notification to Normandeau on September 22. As a result, sensor depth information for the mainstem site is available for the periods August 7 to September 9 and September 22 to October 11.

The tributary level logger was installed approximately 37 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 257 ft up into the tributary to a section where bank vegetation did not appear to indicate significant fluctuating water levels. Later evaluation of WSE data indicated that the mainstem WSE (223.2) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (222.5 ft elevation). Flow was present in the tributary during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.2 to 1.9 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 1.6 and 2.1 ft (mean = 1.8 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (218.3 ft) ranged between 1.0 and 1.9 ft. Under low mainstem and tributary conditions, the site is minimally inundated by mainstem water and is primarily limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.4 ft); however, only 2.2% of data occurrences were <0.5 ft of depth at the confluence.


10365996
10523225
10523220
CT-V-5.04
Mainstem Logger
Tributary Logger
100 Feet
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.04
Unnamed major tributary, Stream Order 3
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
07Aug
26Aug
15Sep
04Oct
23Oct
11Nov
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
Distance (ft)
Mainstem Logger 10365996
Feet: WSE
Max: 223.2
75%: 220.2
Mean: 219.8
50%: 219.4
25%: 219.3
Min: 218.4
Date
07Aug2014
09Sep2014
11Nov2014
Maximum Measured Water Depth (ft)
1.2
1.6
1.9
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
P
Tributary Logger 10523220
Feet: WSE Water Depth
Max: 223.4 5.2
75%: 220.2 2.0
Mean: 219.9 1.7
50%: 219.6 1.4
25%: 219.5 1.3
Min: 218.6 0.4

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.04
Unnamed major tributary, Stream Order 3

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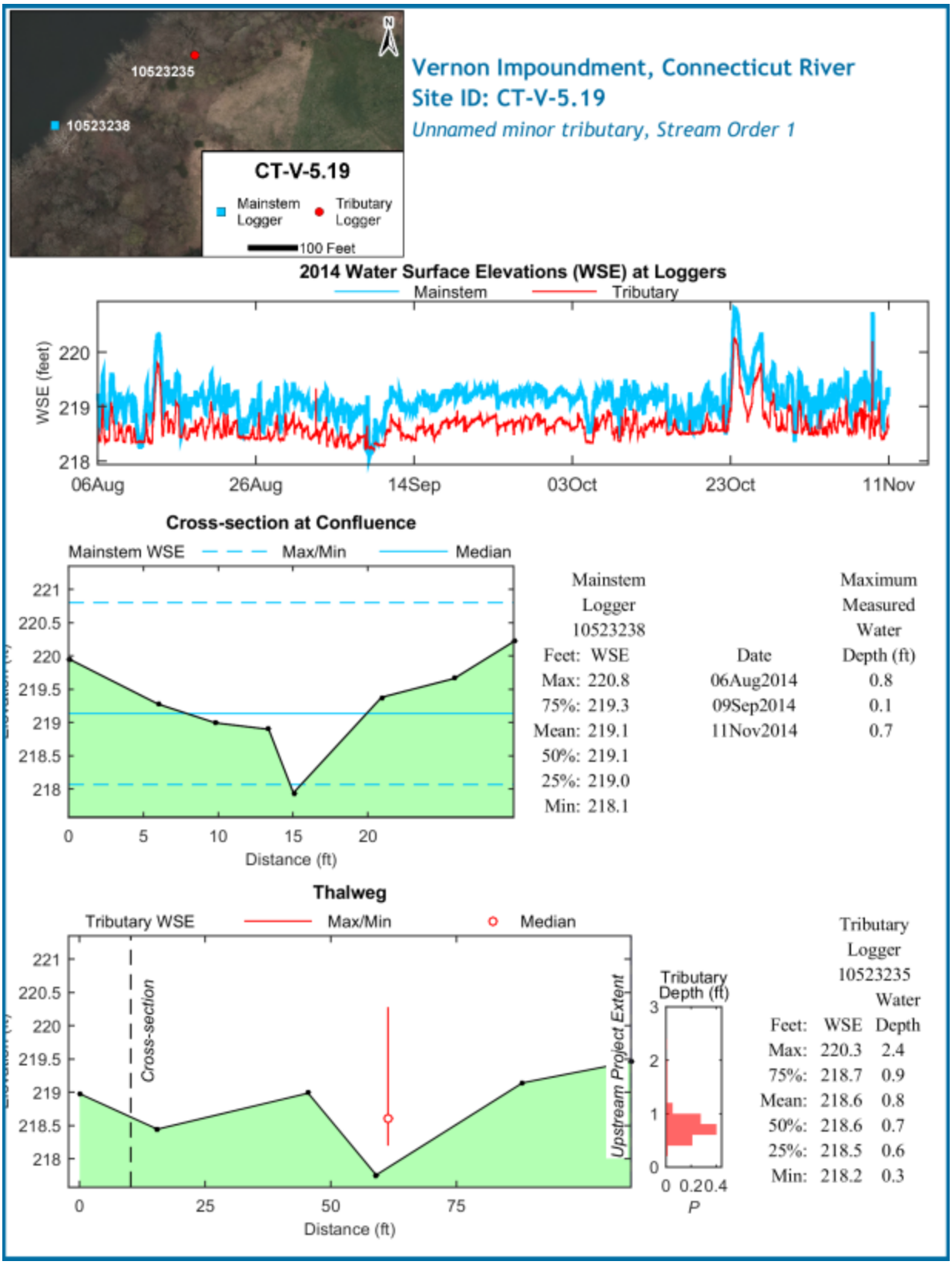
5.2 Site T-V-5.19

Site CT-V-5.19 is an unnamed stream order 1 tributary located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 6, 2014 and tributary (SN 10523235) and mainstem (SN 10523238) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 51 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 100 ft up into the tributary to a section where bank vegetation did not appear to indicate significant fluctuating water levels, later confirmed by evaluation of WSE data to be 99 ft (see photo below). The maximum mainstem WSE (220.8 ft) indicated that the mainstem influence extends farther up into the tributary than the project-affected reach (220.4 ft elevation). Flow was present in tributary CT-V-5.19 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 0.8 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 0.2 and 1.1 ft (mean = 0.7 ft) with shallower depths located towards the upstream end of the project-affected reach.

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (217.9 ft) ranged between 1.1 and 1.4 ft. Under low mainstem WSE conditions (minimum value recorded = 218.1 ft), the tributary is minimally inundated by mainstem water (see photograph time stamped 14:35 09Sep14 below) and is primarily limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.3 ft); however, only 1.1% of data occurrences were < 0.5 ft of depth at the confluence.

Upstream extent of project-affected area associated with Site CT-V-5.19 as determined by visual observations, 2014.


10523235
10523238
CT-V-5.19
Mainstem Logger
Tributary Logger
100 Feet
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.19
Unnamed minor tributary, Stream Order 1
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
220
219
218
06Aug
26Aug
14Sep
03Oct
23Oct
11Nov
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
221
220.5
220
219.5
219
218.5
218
0
5
10
15
20
Distance (ft)
Mainstem Logger 10523238
Feet: WSE
Max: 220.8
75%: 219.3
Mean: 219.1
50%: 219.1
25%: 219.0
Min: 218.1
Date
06Aug2014
09Sep2014
11Nov2014
Maximum Measured Water Depth (ft)
0.8
0.1
0.7
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
3
2
1
0
0 0.20.4
P
0
25
50
75
Distance (ft)
Tributary Logger 10523235
Feet: WSE Water Depth
Max: 220.3 2.4
75%: 218.7 0.9
Mean: 218.6 0.8
50%: 218.6 0.7
25%: 218.5 0.6
Min: 218.2 0.3

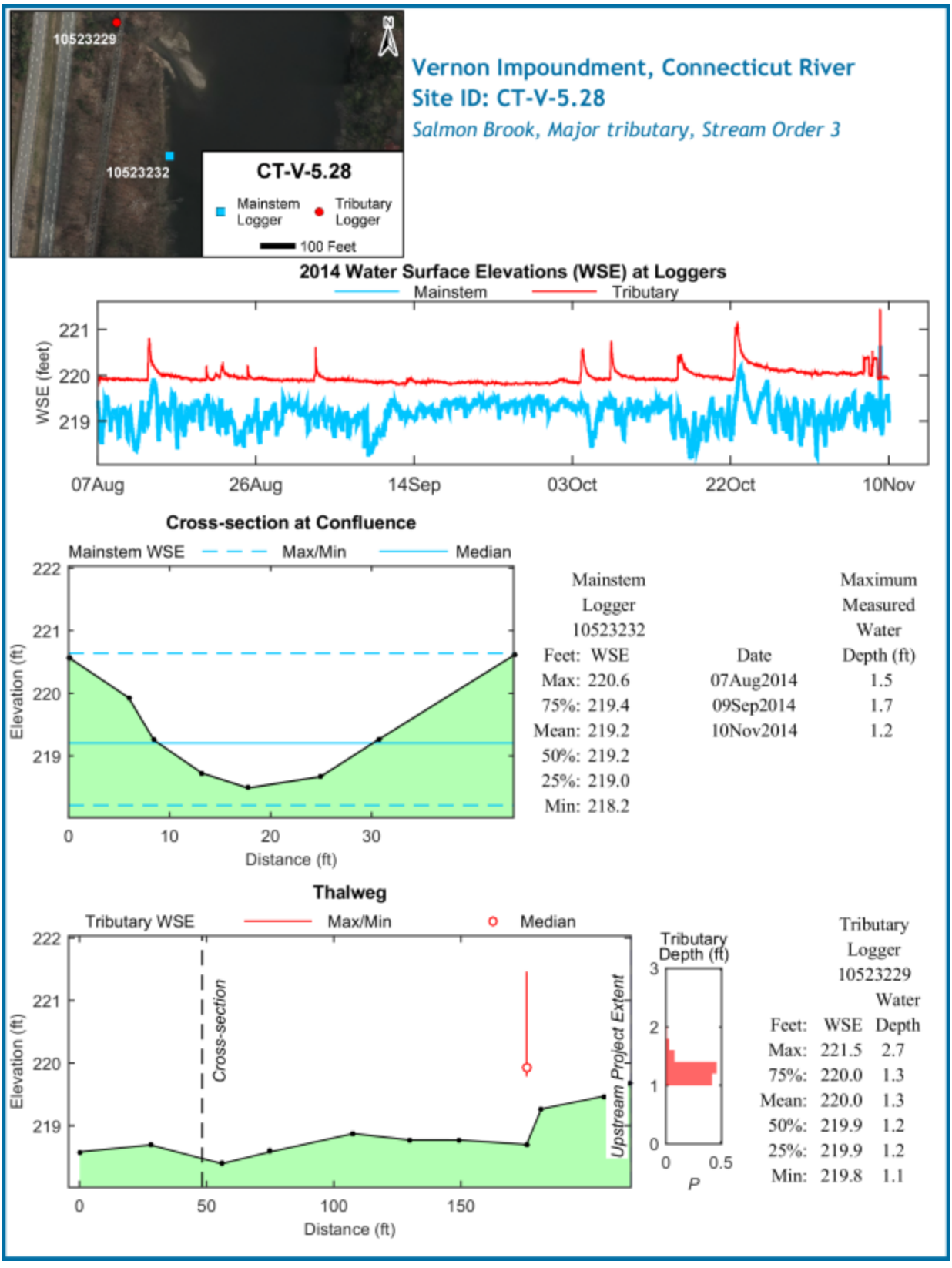
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.19
Unnamed minor tributary, Stream Order 1

5.3 Site CT-V-5.28 Salmon Brook

Site CT-V-5.28 Salmon Brook, is a stream order 3 tributary located on the Vermont side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10523229) and mainstem (10523232) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 10, 2014 at which time the level loggers were removed.

The tributary level logger was installed under a railroad bridge at a point approximately 127 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 170 ft up into Salmon Brook to the base of a large culvert running under Interstate 91, later confirmed by evaluation of WSE data to be 169 ft (see photograph time stamped 07:37 07Aug14 below). The maximum mainstem WSE (220.6 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (220.0 ft elevation). Flow was present in tributary CT-V-5.28 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.2 to 1.7 ft. Water depths were measured along the channel thalweg during the August 7th site visit and ranged between 0.3 and 1.1 ft (mean = 0.7 ft) with shallower depths located towards the upstream end of the project-affected reach.

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (218.5 ft) ranged between 0.5 and 0.8 ft. Under low mainstem WSE conditions (minimum value recorded = 218.2 ft), the tributary is not inundated by mainstem water and is limited to only its own natural outflow. Under those conditions, access should still be adequate as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 1.1 ft), and only limited under some low mainstem (21.1% of data occurrences < 0.5 ft of depth at the confluence).


10523229
10523232
CT-V-5.28
Mainstem Logger
Tributary Logger
100 Feet
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.28
Salmon Brook, Major tributary, Stream Order 3
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
221
220
219
07Aug
26Aug
14Sep
03Oct
22Oct
10Nov
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
222
221
220
219
0
10
20
30
Distance (ft)
Mainstem Logger 10523232
Feet: WSE
Max: 220.6
75%: 219.4
Mean: 219.2
50%: 219.2
25%: 219.0
Min: 218.2
Date
07Aug2014
09Sep2014
10Nov2014
Maximum Measured Water Depth (ft)
1.5
1.7
1.2
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
3
2
1
0
0
0.5
P
0
50
100
150
Distance (ft)
Tributary Logger 10523229
Feet: WSE Water Depth
Max: 221.5 2.7
75%: 220.0 1.3
Mean: 220.0 1.3
50%: 219.9 1.2
25%: 219.9 1.2
Min: 219.8 1.1

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.28
Salmon Brook, Major tributary, Stream Order 3

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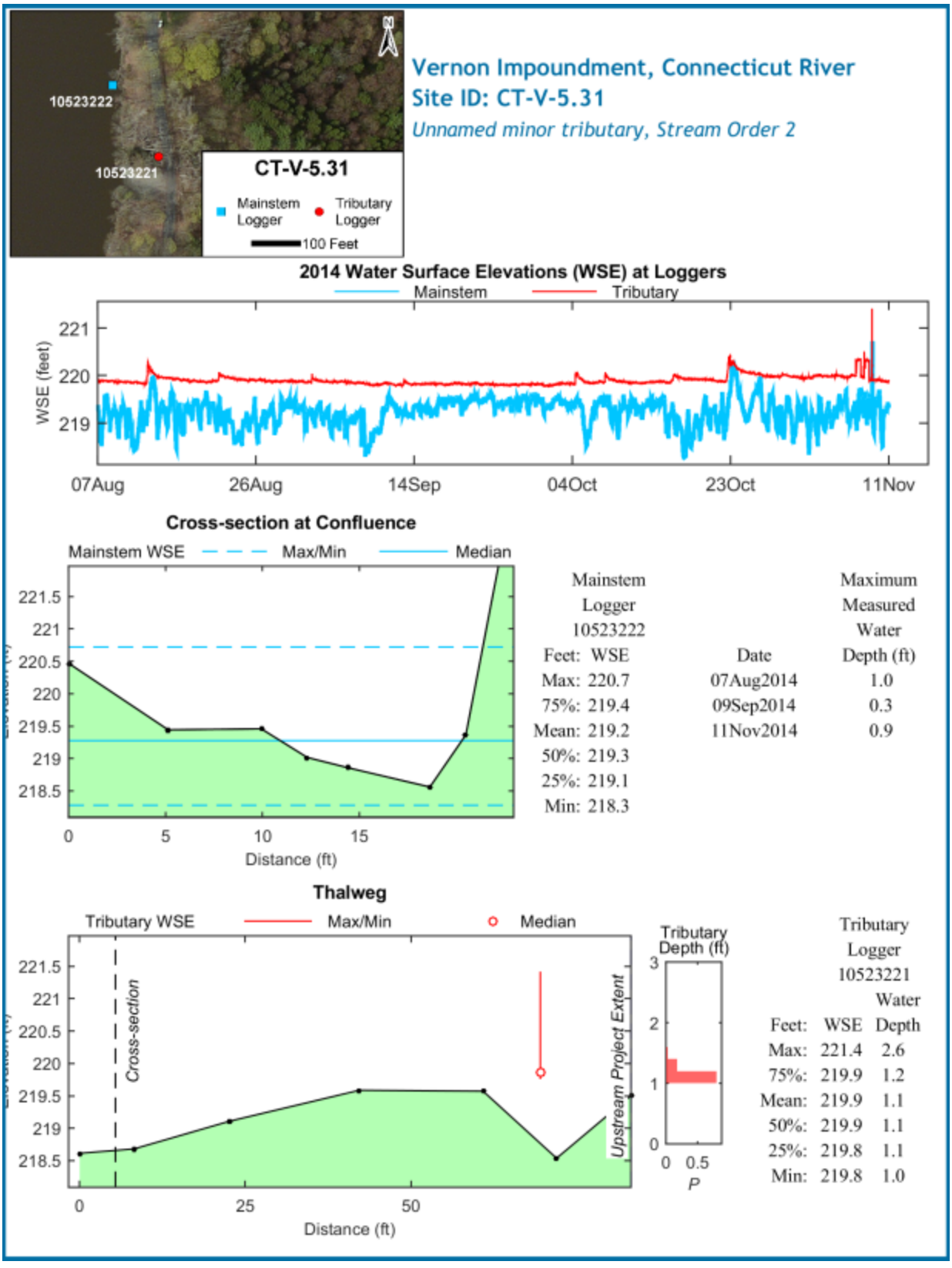
5.4 Site CT-V-5.31

Site CT-V-5.31 is an unnamed stream order 2 tributary located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10523221) and mainstem (SN 10523222) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

The tributary level logger was installed at a point approximately 64 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 78 ft up into the tributary to the base of a culvert running under River Road, later confirmed by evaluation of WSE data (see photograph time stamped 16:09 11Nov14 below).
The maximum mainstem WSE (220.7 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (220.0 ft elevation). Flow was present in the tributary during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.3 to 1.0 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 0.2 and 1.4 ft (mean = 0.6 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (218.6 ft) ranged between 0.5 and 0.8 ft. Under low mainstem WSE conditions (minimum value recorded = 218.3 ft), the tributary is not inundated by mainstem water and is limited to only its own natural outflow. Under those conditions, access should still be adequate as evidenced by the presence of higher thalweg bed elevations located downstream of the tributary logger location with its minimum recorded water depth (1.0 ft), and only limited under some low mainstem (24% of data occurrences < 0.5 ft of depth at the confluence)..


Vernon Impoundment, Connecticut River
Site ID: CT-V-5.31
Unnamed minor tributary, Stream Order 2
10523222
10523221
CT-V-5.31
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
221
220
219
07Aug
26Aug
14Sep
04Oct
23Oct
11Nov
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
221.5
221
220.5
220
219.5
219
218.5
0
5
10
15
Distance (ft)
Mainstem Logger 10523222
Feet: WSE
Max: 220.7
75%: 219.4
Mean: 219.2
50%: 219.3
25%: 219.1
Min: 218.3
Date
07Aug2014
09Sep2014
11Nov2014
Maximum Measured Water Depth (ft)
1.0
0.3
0.9
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
0
25
50
Distance (ft)
Tributary Depth (ft)
3
2
1
0
0 0.5
P
Tributary Logger 10523221
Feet: WSE Water Depth
Max: 221.4 2.6
75%: 219.9 1.2
Mean: 219.9 1.1
50%: 219.9 1.1
25%: 219.8 1.1
Min: 219.8 1.0

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.31
Unnamed minor tributary, Stream Order 2

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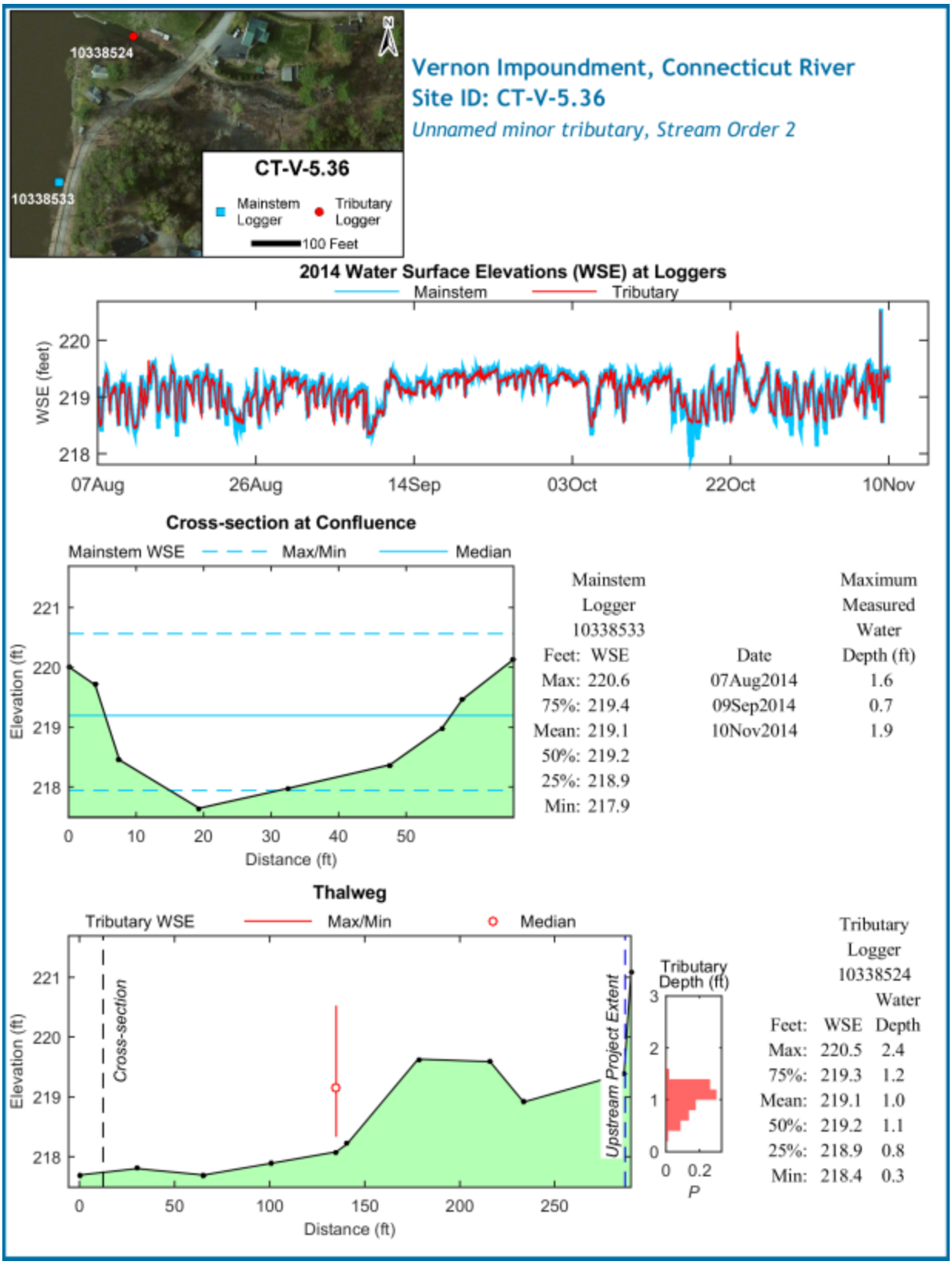
5.5 Site CT-V-5.36

Site CT-V-5.36 is an unnamed stream order 2 tributary located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10338524) and mainstem (SN 10338533) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 10, 2014 at which time the level loggers were removed.

The tributary level logger was installed at a point approximately 122 ft upstream from the confluence with the mainstem and just downstream of the Mountain Road bridge. During the initial site visit, the field crew visually determined that project effects extend approximately 276 ft (bed elevation = 219.4 ft) up into the tributary to a point upstream of the bridge, later confirmed by evaluation of WSE data to be 275 ft. The maximum mainstem WSE (220.6 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (219.7 ft elevation). Flow was present in the tributary during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.7 to 1.9 ft. Water depths were measured along the channel thalweg during the August 7th site visit and ranged between 0.2 and 1.6 ft (mean = 1.0 ft) with shallower depths towards the upper end of the project-affected reach. Bed elevations (and resulting water depths) were shallower in the portion of the project-affected reach located immediately under and upstream of the Mountain Road bridge.

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (217.6 ft) ranged between 1.3 and 1.8 ft. Under low mainstem conditions (minimum WSE value recorded = 217.9 ft), the tributary is minimally inundated by mainstem water and is regulated by the stream's own natural outflow. Under low tributary conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.3 ft); however, only 0.3% of data occurrences were < 0.5 ft of depth at the confluence.

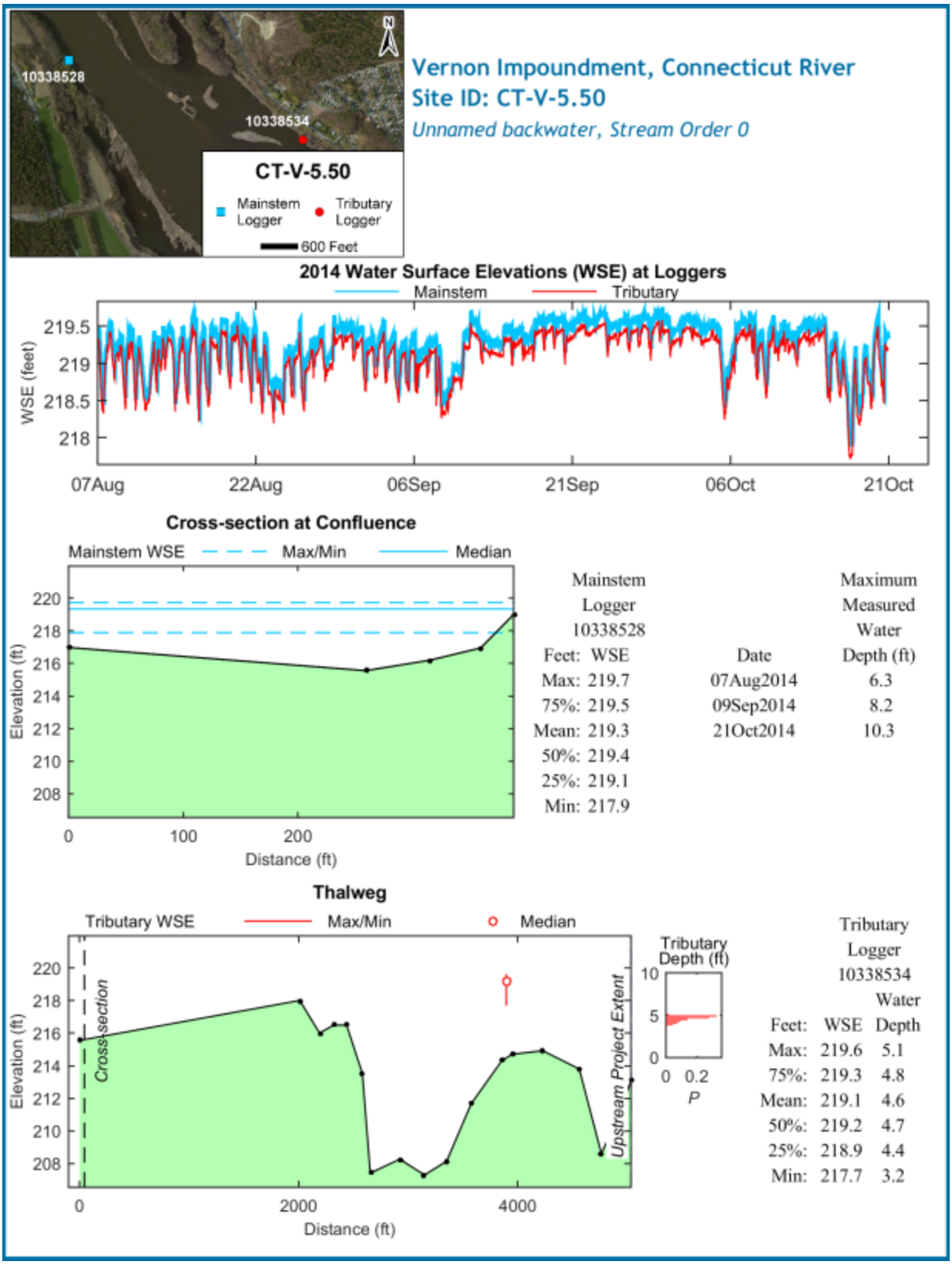

10338524
10338533
CT-V-5.36
Mainstem Logger
Tributary Logger
100 Feet
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.36
Unnamed minor tributary, Stream Order 2
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
220
219
218
07Aug
26Aug
14Sep
03Oct
22Oct
10Nov
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
221
220
219
218
0
10
20
30
40
50
Distance (ft)
Mainstem Logger 10338533
Feet: WSE
Max: 220.6
75%: 219.4
Mean: 219.1
50%: 219.2
25%: 218.9
Min: 217.9
Date
07Aug2014
09Sep2014
10Nov2014
Maximum Measured Water Depth (ft)
1.6
0.7
1.9
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
3
2
1
0
0
0.2
P
Elevation (ft)
221
220
219
218
0
50
100
150
200
250
Distance (ft)
Tributary Logger 10338524
Feet: WSE Water Depth
Max: 220.5 2.4
75%: 219.3 1.2
Mean: 219.1 1.0
50%: 219.2 1.1
25%: 218.9 0.8
Min: 218.4 0.3

5.6 Site CT-V-5.50 Backwater

Site CT-V-5.50 is a backwater located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10338534) and mainstem (SN 10338528) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on October 21, 2014 at which time the level loggers were removed.

The backwater is connected directly to the mainstem via a large open access area (see photograph time stamped 09:04 07Aug14 below). The backwater level logger was installed approximately 3,800 feet away from the confluence. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area, covering a linear distance of 4,988 ft, later confirmed by evaluation of WSE data to be 4,989 ft. Water was present within the backwater during each of the three visits. Water depth at the confluence cross section was measured during each visit and ranged from 6.2 to 10.3 ft. Water depths across the ponded backwater area were calculated as the difference between the measured WSE during the initial site visit and measured bed elevation information collected during Study 7 (Normandeau 2014b) and ranged between 1.3 and 12.0 ft (mean = 6.7 ft).

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth at the confluence ranged between 2.3 and 4.1 ft and will provide adequate access. As evidenced by the thalweg profile, bottom elevations vary from the confluence across the backwater. When the majority of the range of WSE values recorded by the backwater level logger is considered (i.e., 25th to 75th percentiles; 219.1-219.5 ft), water depth over each surveyed thalweg point was a minimum of 1.1 ft and access is adequate under most conditions. Due to shallow bed elevations present along the littoral margins and at some locations within the ponded, backwater area, wetted area available to fish will likely be reduced during periods of low mainstem flow (e.g., minimum WSE value recorded at backwater level logger; 217.7 ft); however, there were no data occurrences < 0.5 ft of depth at the confluence.


Vernon Impoundment, Connecticut River
Site ID: CT-V-5.50
Unnamed backwater, Stream Order 0
10338528
10338534
CT-V-5.50
Mainstem Logger
Tributary Logger
600 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
219.5
219
218.5
218
07Aug
22Aug
06Sep
21Sep
06Oct
21Oct
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
220
218
216
214
212
210
208
0
100
200
Distance (ft)
Mainstem Logger 10338528
Feet: WSE
Max: 219.7
75%: 219.5
Mean: 219.3
50%: 219.4
25%: 219.1
Min: 217.9
Date
07Aug2014
09Sep2014
21Oct2014
Maximum Measured Water Depth (ft)
6.3
8.2
10.3
Thalweg
Tributary WSE
Max/Min
Median
Cross-section
Upstream Project Extent
Tributary Depth (ft)
10
5
0
0 0.2
P
Elevation (ft)
220
218
216
214
212
210
208
0
2000
4000
Distance (ft)
Tributary Logger 10338534
Feet: WSE Water Depth
Max: 219.6 5.1
75%: 219.3 4.8
Mean: 219.1 4.6
50%: 219.2 4.7
25%: 218.9 4.4
Min: 217.7 3.2

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.50
Unnamed backwater, Stream Order 0

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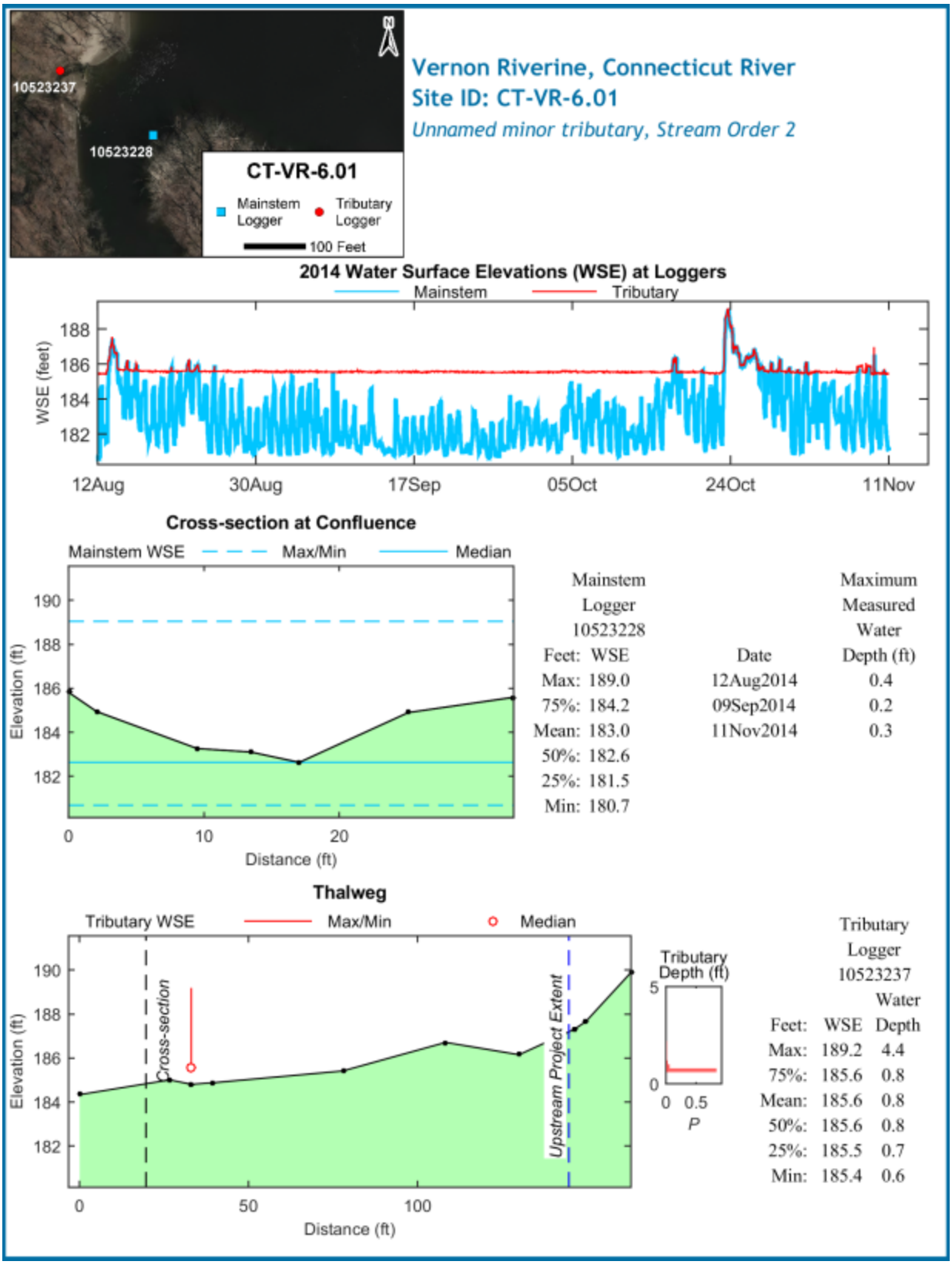
6.0 VERNON RIVERINE SECTION

6.1 Site CT-VR-6.01

Site CT-VR-6.01 is an unnamed stream order 2 tributary located on the Vermont side in the Vernon riverine reach. This location was initially visited on August 12, 2014 and tributary (SN 10523237) and mainstem (SN 10523228) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

The tributary level logger was installed in the vicinity of the confluence with the mainstem. The project-affected reach was visually estimated at 138 ft up into the tributary, later confirmed by evaluation of mainstem WSE data to be 135 ft. The maximum mainstem WSE (189.0 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (187.2 ft elevation). Flow was present in tributary CT-VR-6.01 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.2 to 0.4 ft. Water depths were measured along the channel thalweg during the August 12th site visit and ranged between 0.3 and 1.2 ft (mean = 0.7 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under elevated conditions (i.e., 75th percentile) water depth at the thalweg elevation of the cross section confluence (bed elevation = 182.6 ft) was 1.6 ft. Under median mainstem WSE conditions (median = 182.6 ft), the tributary is not inundated by mainstem water and access is regulated by the stream's own natural outflow. Access may be limited for larger fish under low mainstem and tributary conditions (58.6% of data occurrences <0.5 ft of depth at the confluence). It is important to note that the site is located within the Turners Falls impoundment and subject to water level fluctuations as a result of impoundment operations, beyond the control of TransCanada operations.


Vernon Riverine, Connecticut River
Site ID: CT-VR-6.01
Unnamed minor tributary, Stream Order 2
10523237
10523228
CT-VR-6.01
Mainstem Logger
Tributary Logger
100 Feet
2014 Water Surface Elevations (WSE) at Loggers
Mainstem
Tributary
WSE (feet)
188
186
184
182
12Aug
30Aug
17Sep
05Oct
24Oct
11Nov
Cross-section at Confluence
Mainstem WSE
Max/Min
Median
Elevation (ft)
190
188
186
184
182
0
10
20
Distance (ft)
Mainstem Logger 10523228
Feet: WSE
Max: 189.0
75%: 184.2
Mean: 183.0
50%: 182.6
25%: 181.5
Min: 180.7
Date
12Aug2014
09Sep2014
11Nov2014
Maximum Measured Water Depth (ft)
0.4
0.2
0.3
Thalweg
Tributary WSE
Max/Min
Median
Elevation (ft)
190
188
186
184
182
Cross-section
Upstream Project Extent
0
50
100
Distance (ft)
Tributary Depth (ft)
5
0
0 0.5
P
Tributary Logger 10523237
Feet: WSE Water Depth
Max: 189.2 4.4
75%: 185.6 0.8
Mean: 185.6 0.8
50%: 185.6 0.8
25%: 185.5 0.7
Min: 185.4 0.6

Vernon Riverine, Connecticut River
Site ID: CT-VR-6.01
Unnamed minor tributary, Stream Order 2

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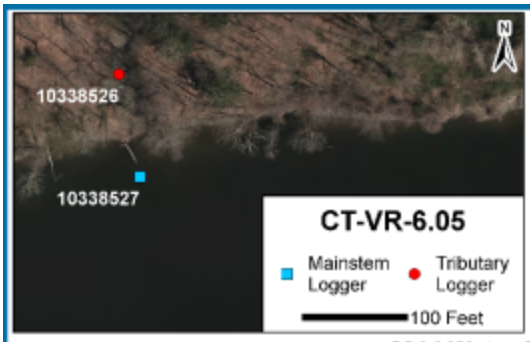
6.2 Site CT-VR-6.05

Site CT-VR-6.05 is an unnamed stream order 1 tributary located on the New Hampshire side in the Vernon riverine reach. This location was initially visited on August 12, 2014 and tributary (SN 10338526) and mainstem (SN 10338527) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

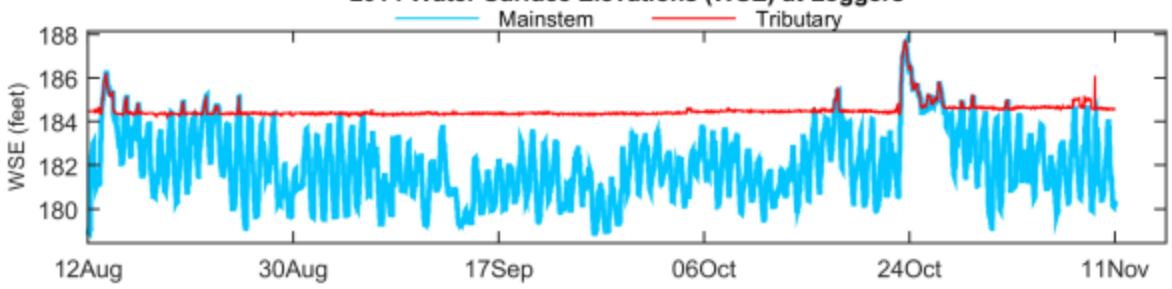
The tributary level logger was installed approximately 135 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 170 ft up into the tributary (bed elevation = 187.4 ft). Evaluation of WSE data later indicated that the project-affected reach extends to 165 ft. The maximum mainstem WSE (187.6 ft) indicates mainstem influence extends farther up into the tributary than the project-affected reach (185.9 ft elevation). Flow was present in tributary CT-VR-6.05 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 0.3 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 0.2 and 0.9 ft (mean = 0.3 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under median conditions (i.e., 50th percentile) water depth at the thalweg elevation of the cross section confluence (bed elevation = 181.1 ft) was 0.7 ft. Under lower mainstem WSE conditions (25th percentile = 180.9 ft, the tributary is not inundated by project-affected water and access is regulated by the stream's own natural outflow. Access may be limited for larger fish under low mainstem and tributary conditions (42.5% of data occurrences < 0.5 ft of depth at the confluence). It is important to note that the site is located within the Turners Falls impoundment and subject to water level fluctuations as a result of impoundment operations, beyond the control of TransCanada operations.

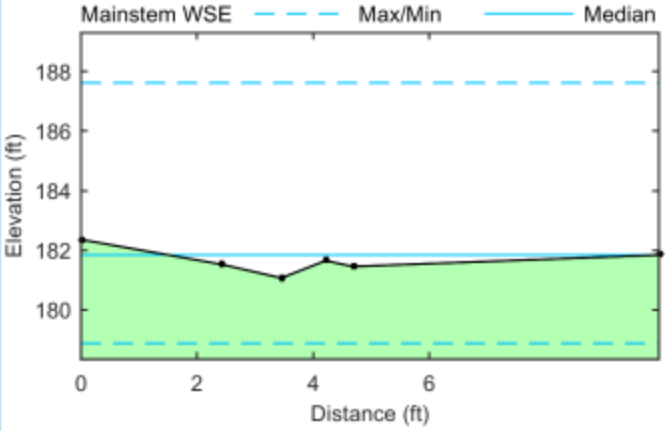


Vernon Riverine, Connecticut River
Site ID: CT-VR-6.05
Unnamed minor tributary, Stream Order 1

2014 Water Surface Elevations (WSE) at Loggers

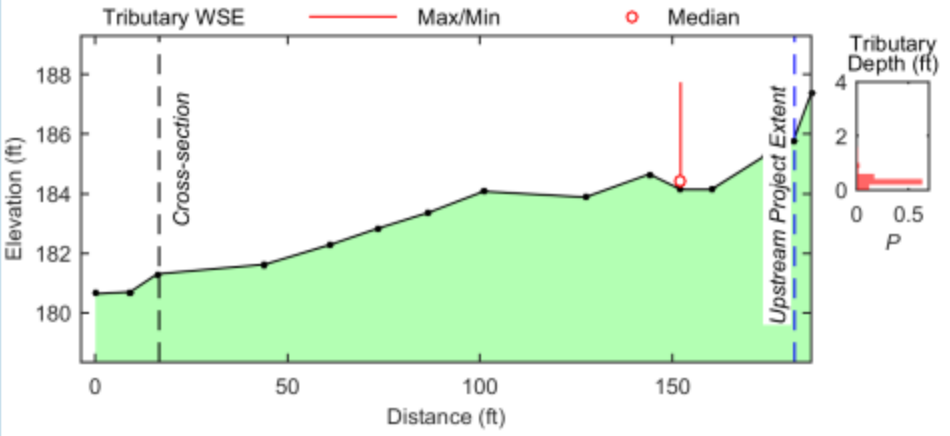


Cross-section at Confluence



Mainstem Logger 10338527		Maximum Measured Water Depth (ft)
Feet: WSE	Date	
Max: 187.6	12Aug2014	0.1
75%: 183.1	09Sep2014	0.3
Mean: 182.0	11Nov2014	0.2
50%: 181.8		
25%: 180.9		
Min: 178.9		

Thalweg



Tributary Logger 10338526		
		Water
Feet:	WSE	Depth
Max:	187.7	3.6
75%:	184.5	0.4
Mean:	184.5	0.4
50%:	184.4	0.2
25%:	184.4	0.2
Min:	184.2	0.1

Vernon Riverine, Connecticut River
Site ID: CT-VR-6.05
Unnamed minor tributary, Stream Order 1

Appendices B1, B2, and C

2014 Water Quality Data

Comparison of 2014 Field Data with Model Data

(filed separately in Excel format)

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Appendix D

Daily Percent of Access Time

WSE Plots Based on Model Data

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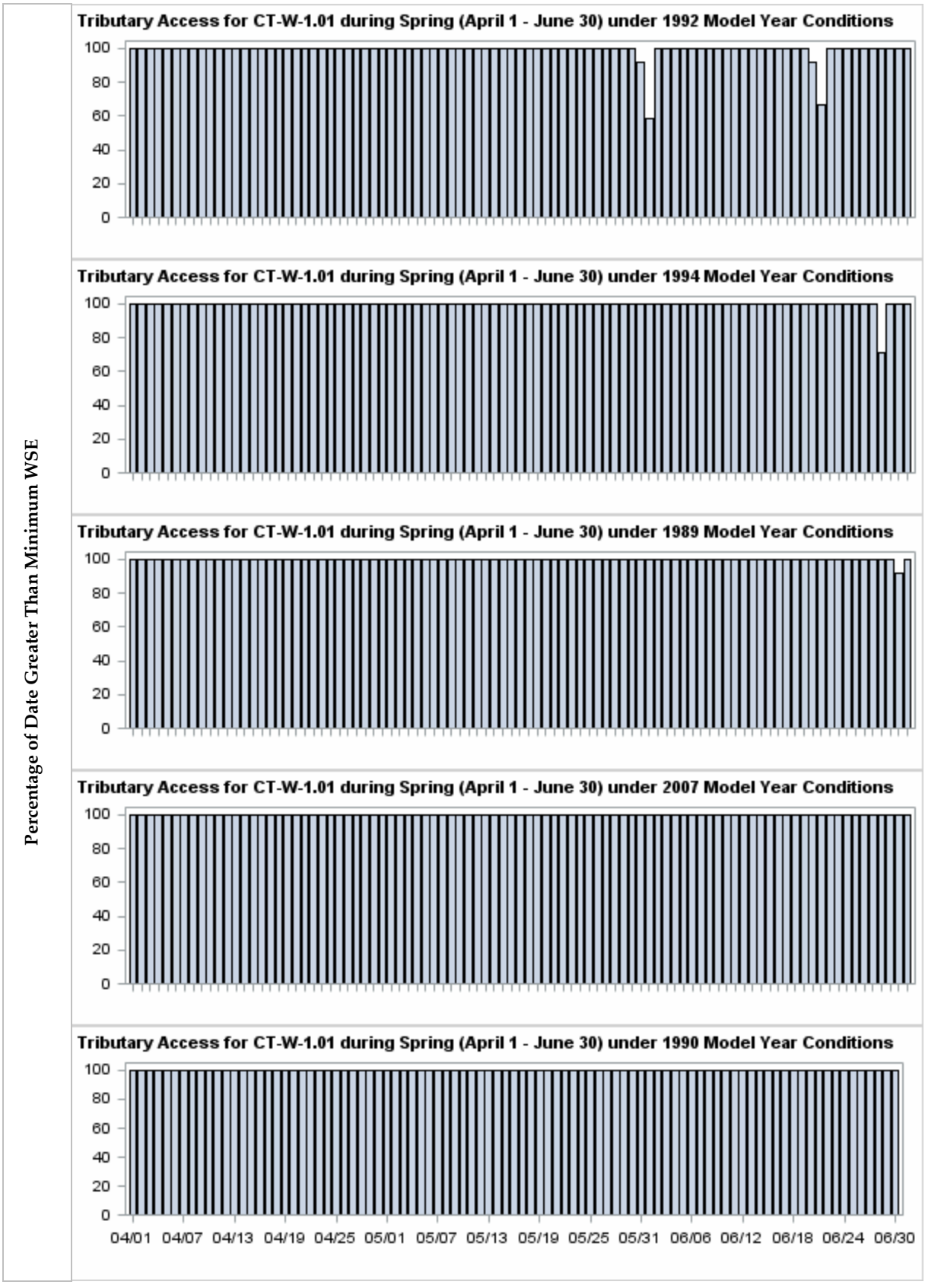

Figure 1. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.01.

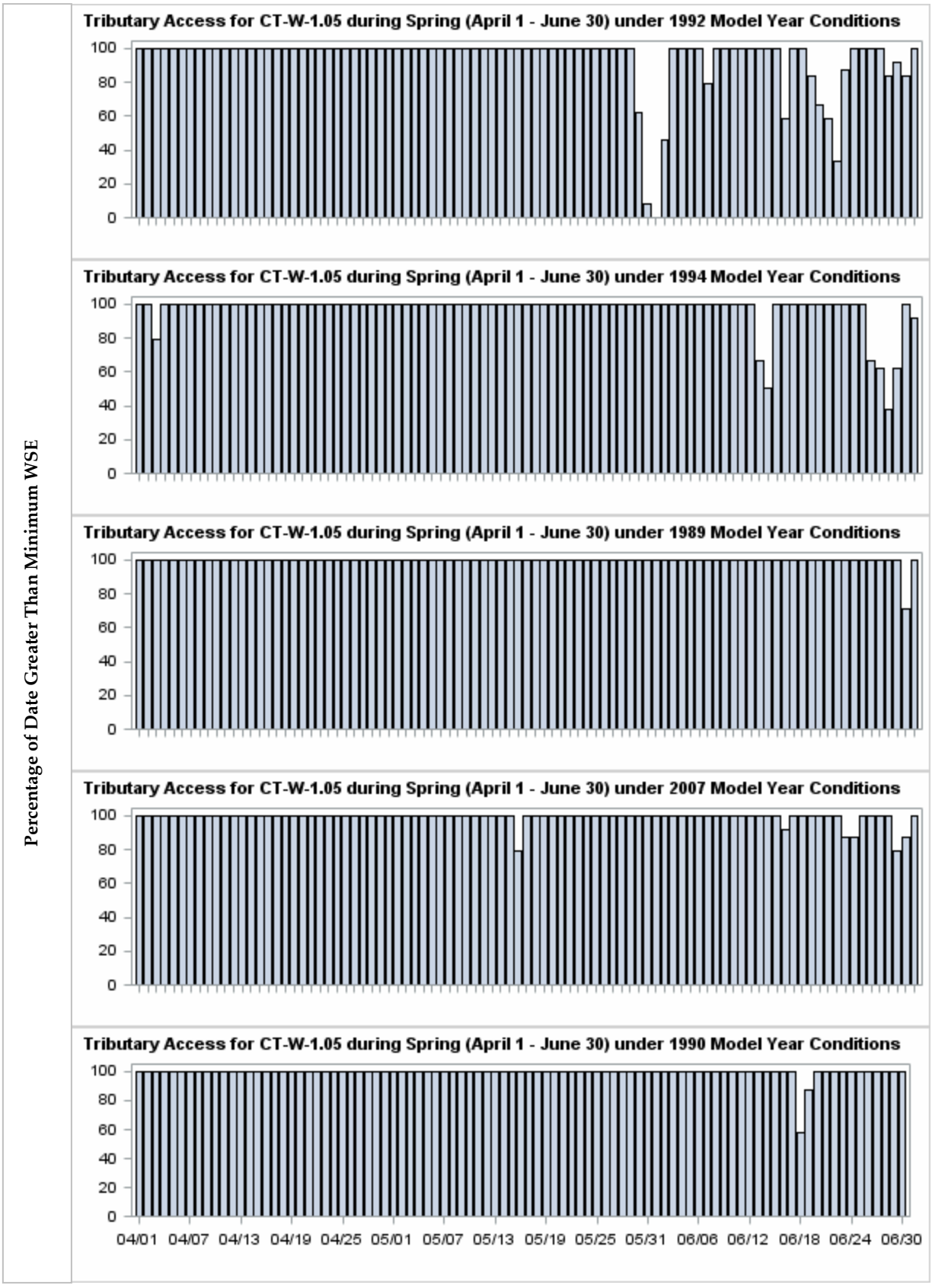

Figure 2. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.05.

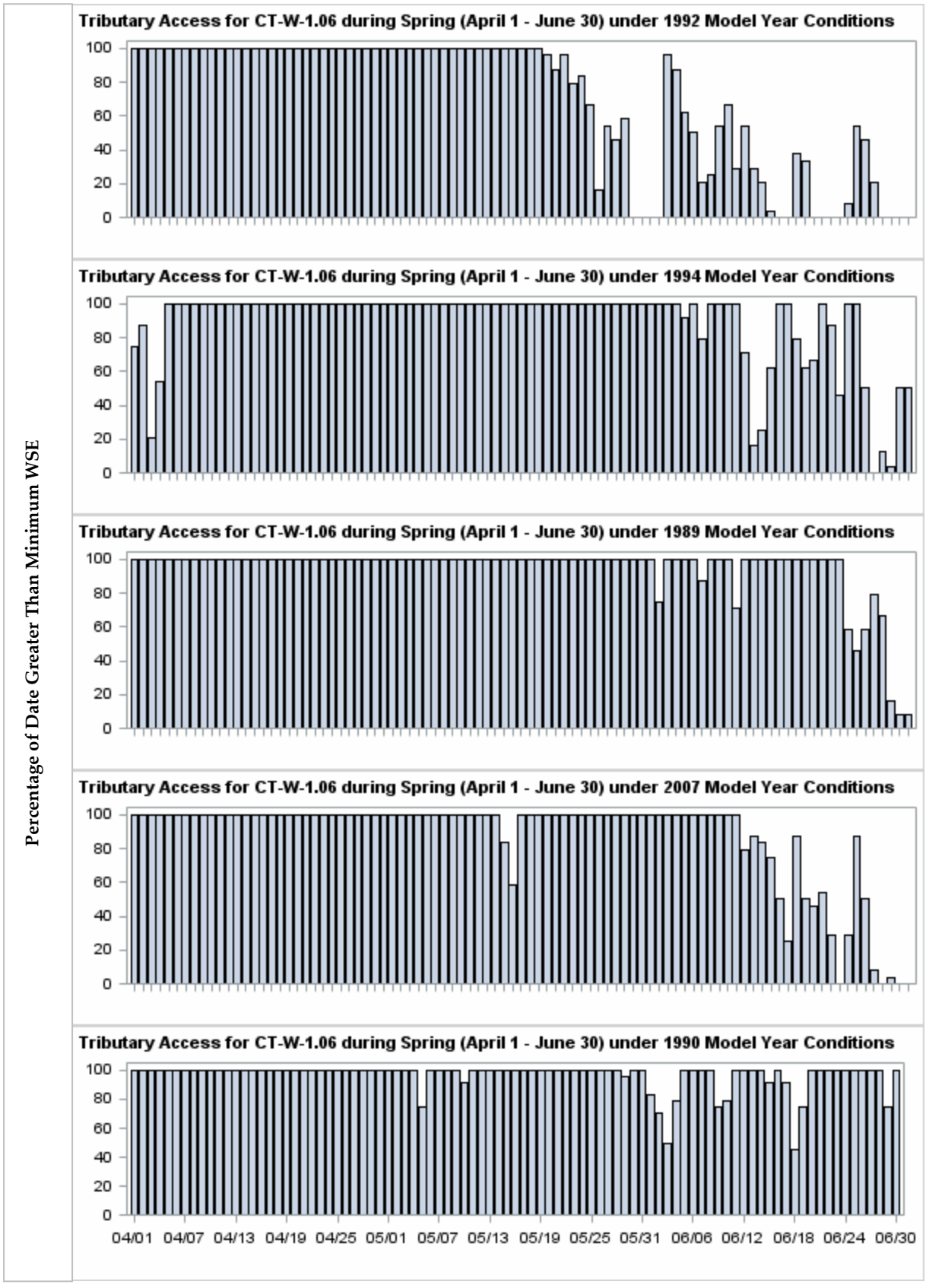

Figure 3. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.06.

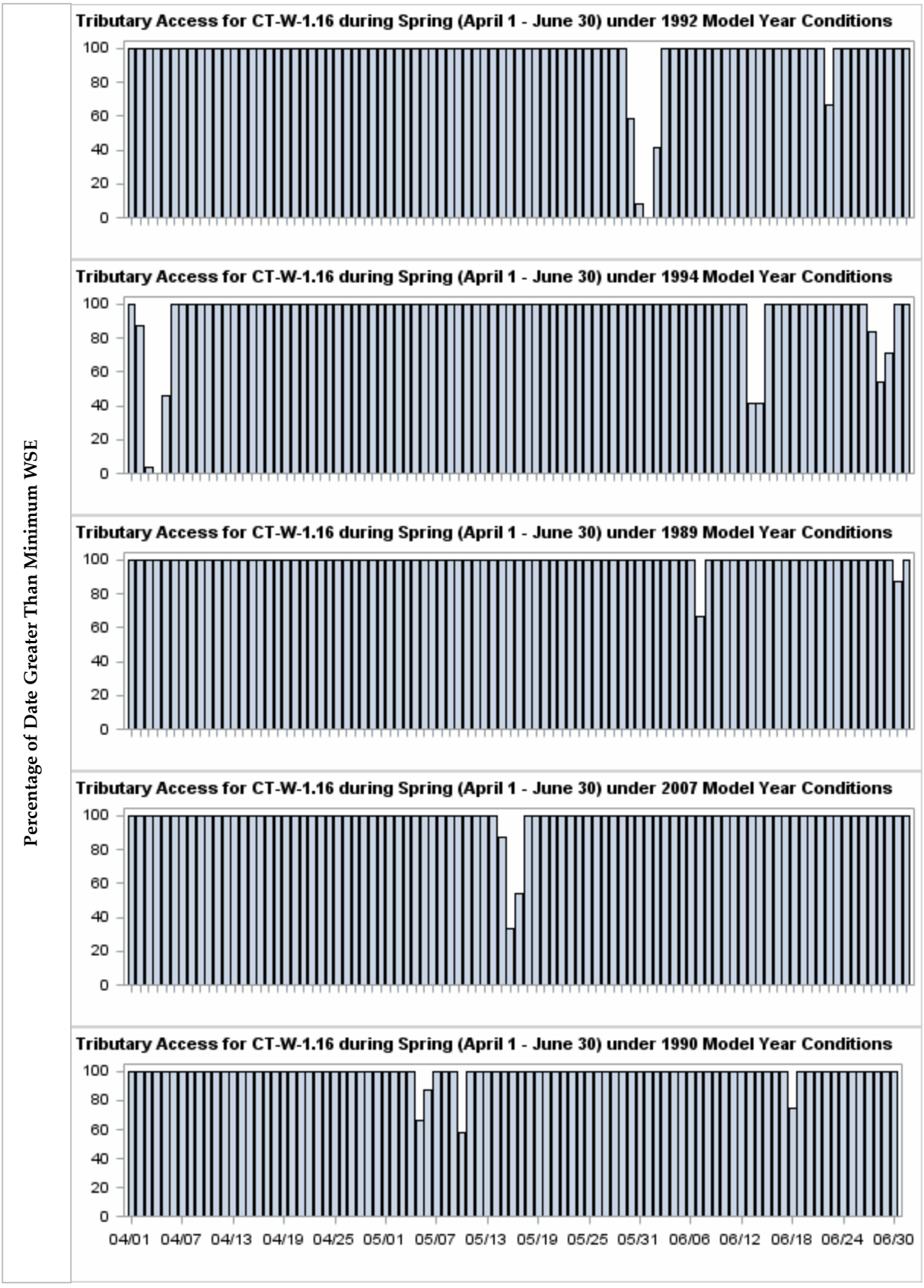

Figure 4. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.16.

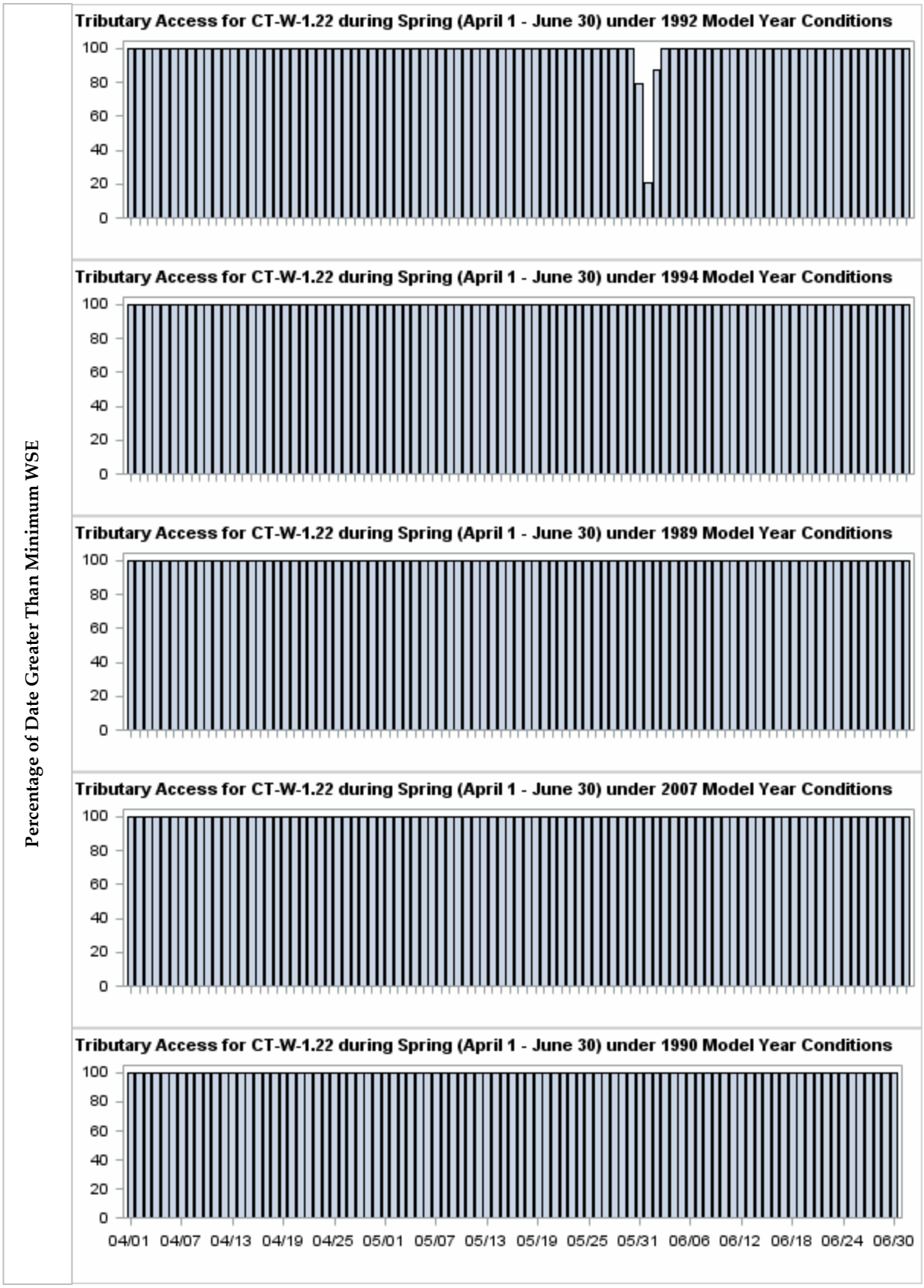

Figure 5. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.22.

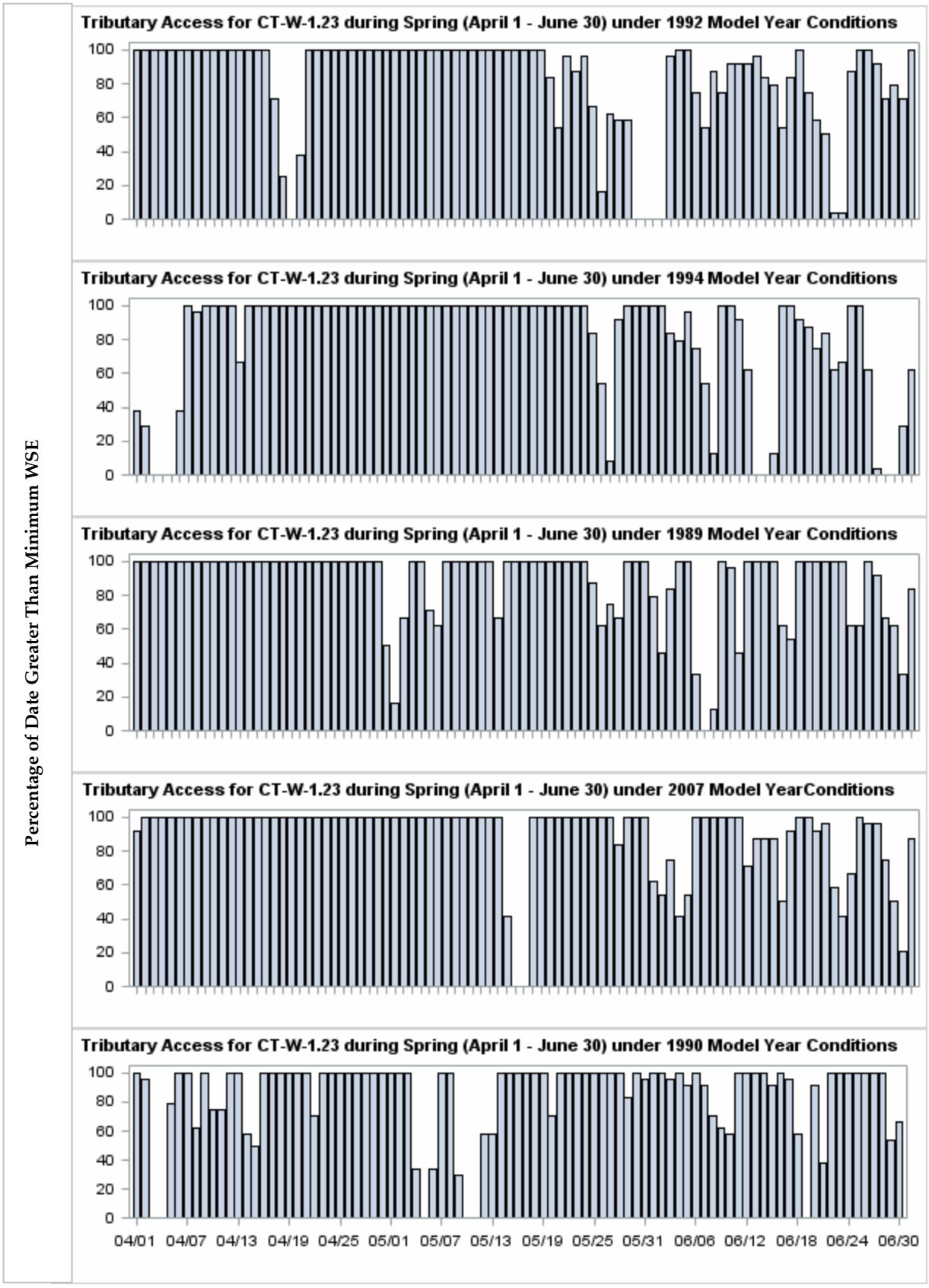

Figure 6. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.23.

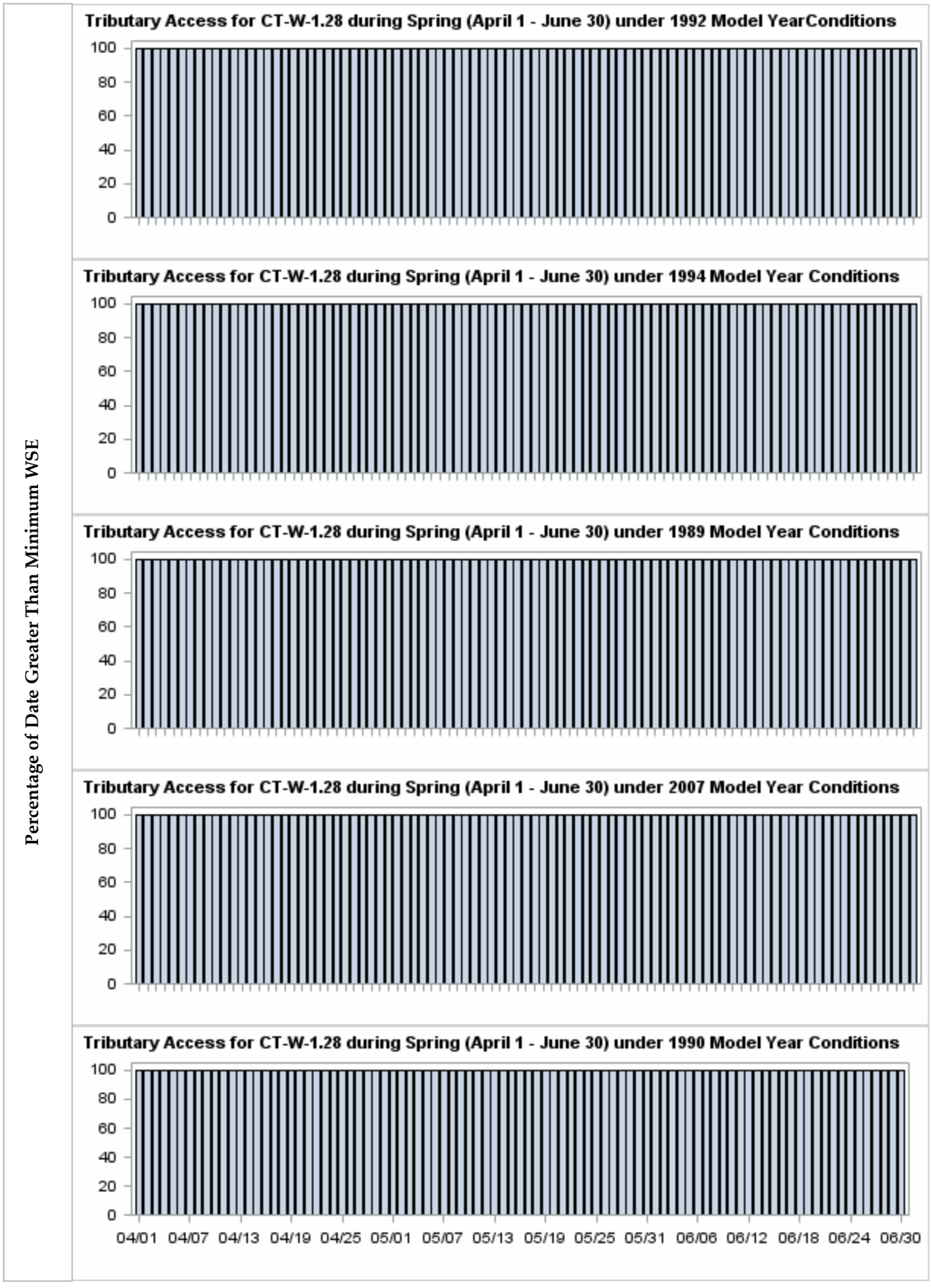

Figure 7. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.28.

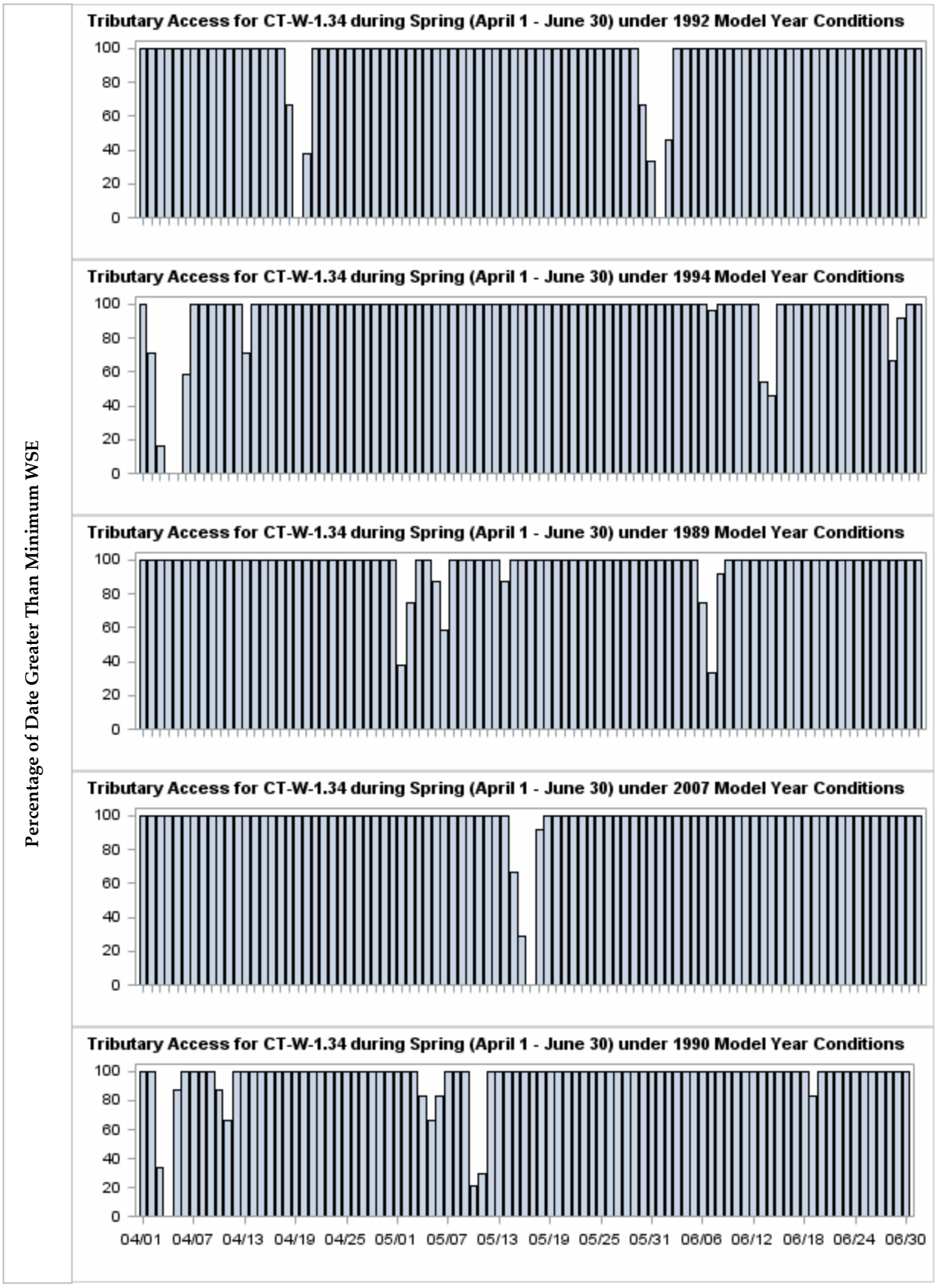

Figure 8. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.34.

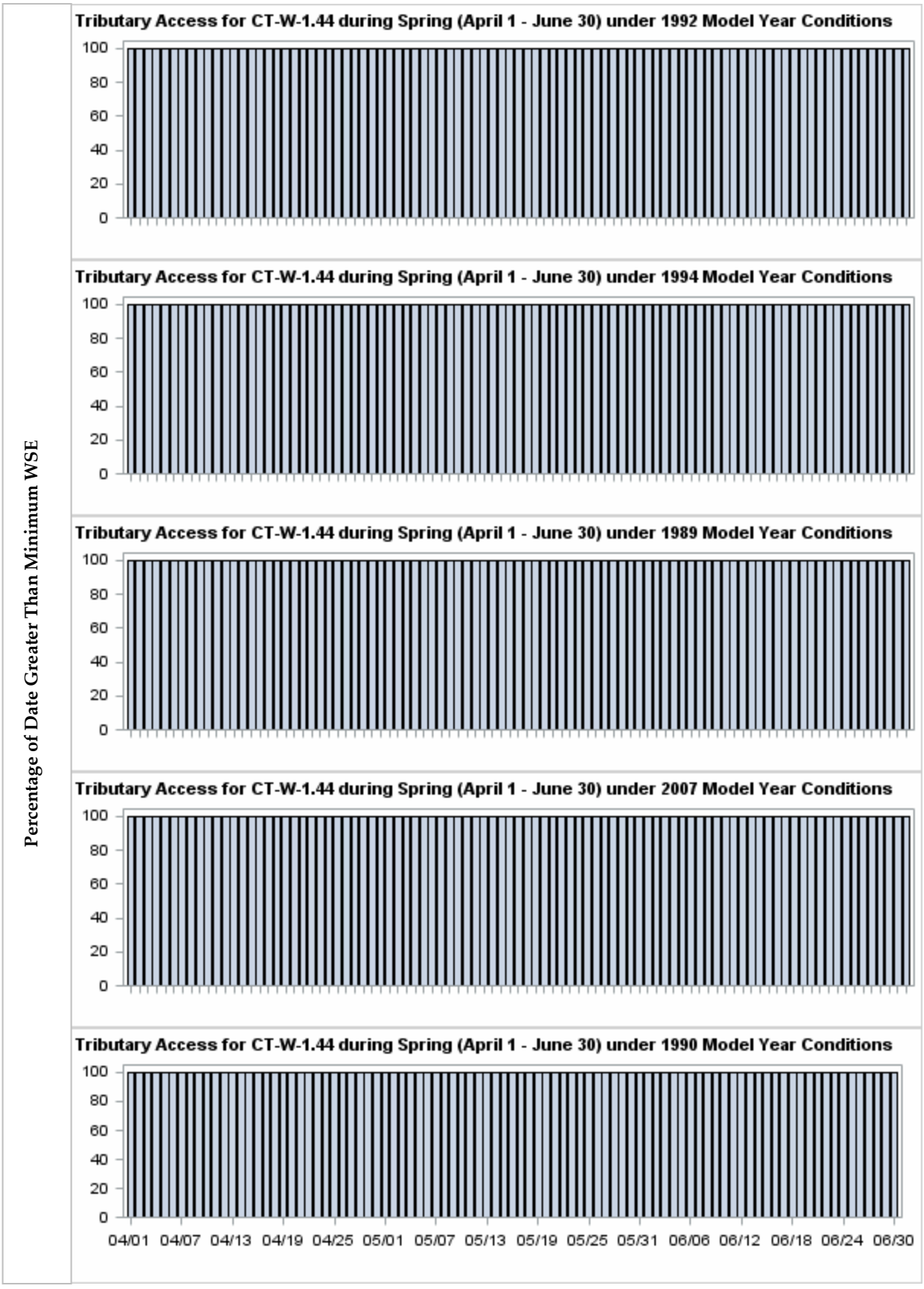

Figure 9. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.44.

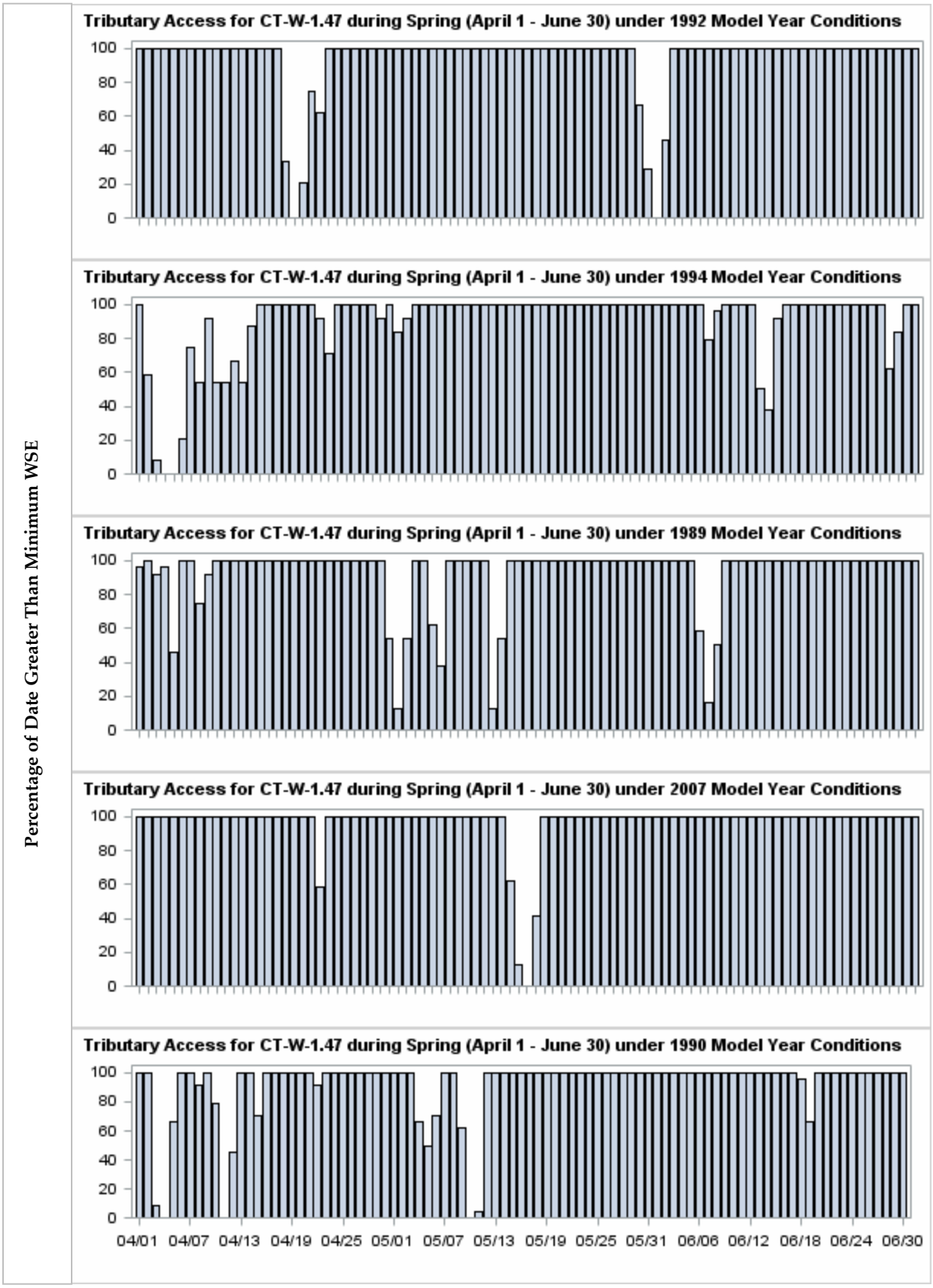

Figure 10. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.47.

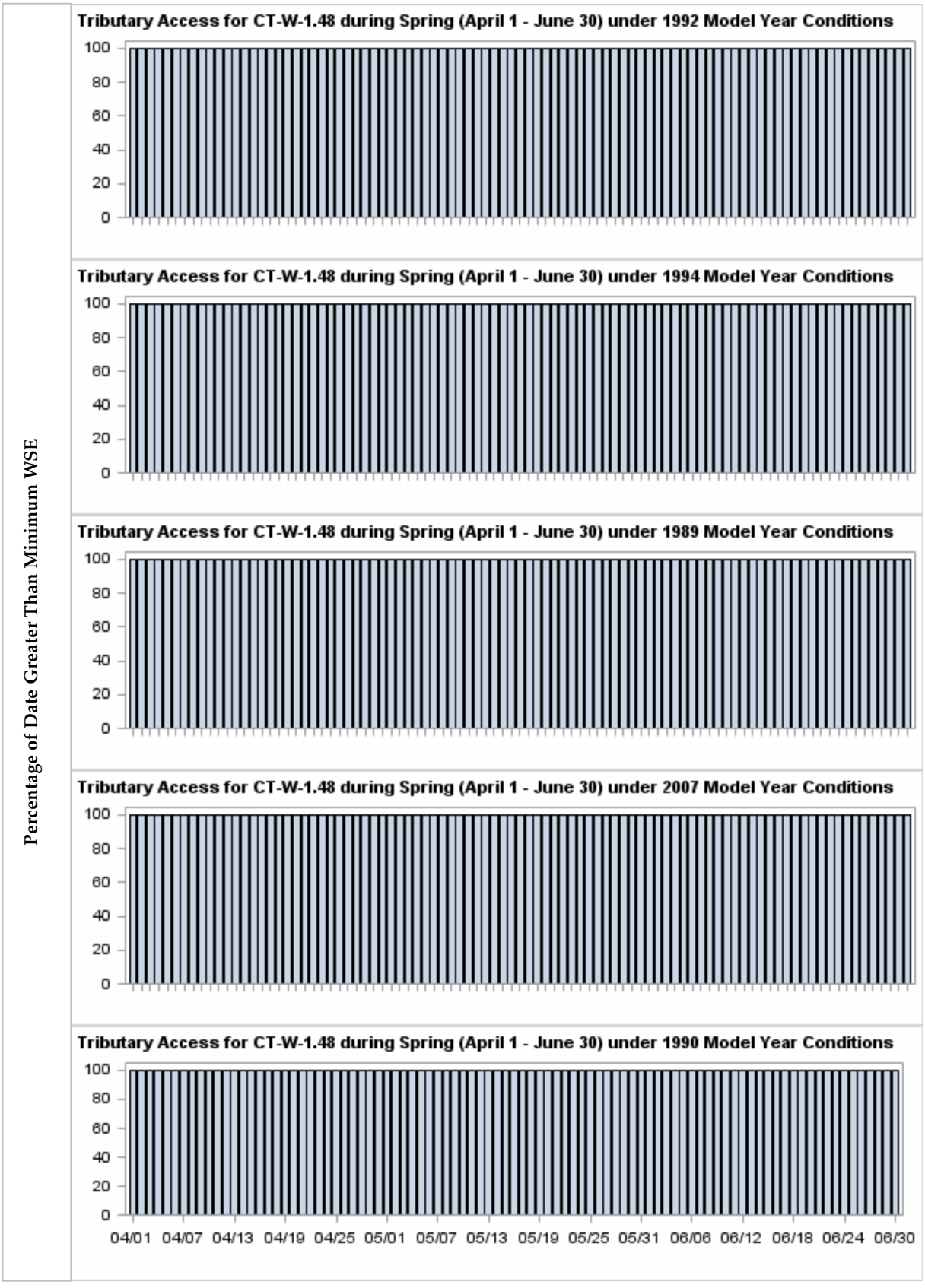

Figure 11. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.48.

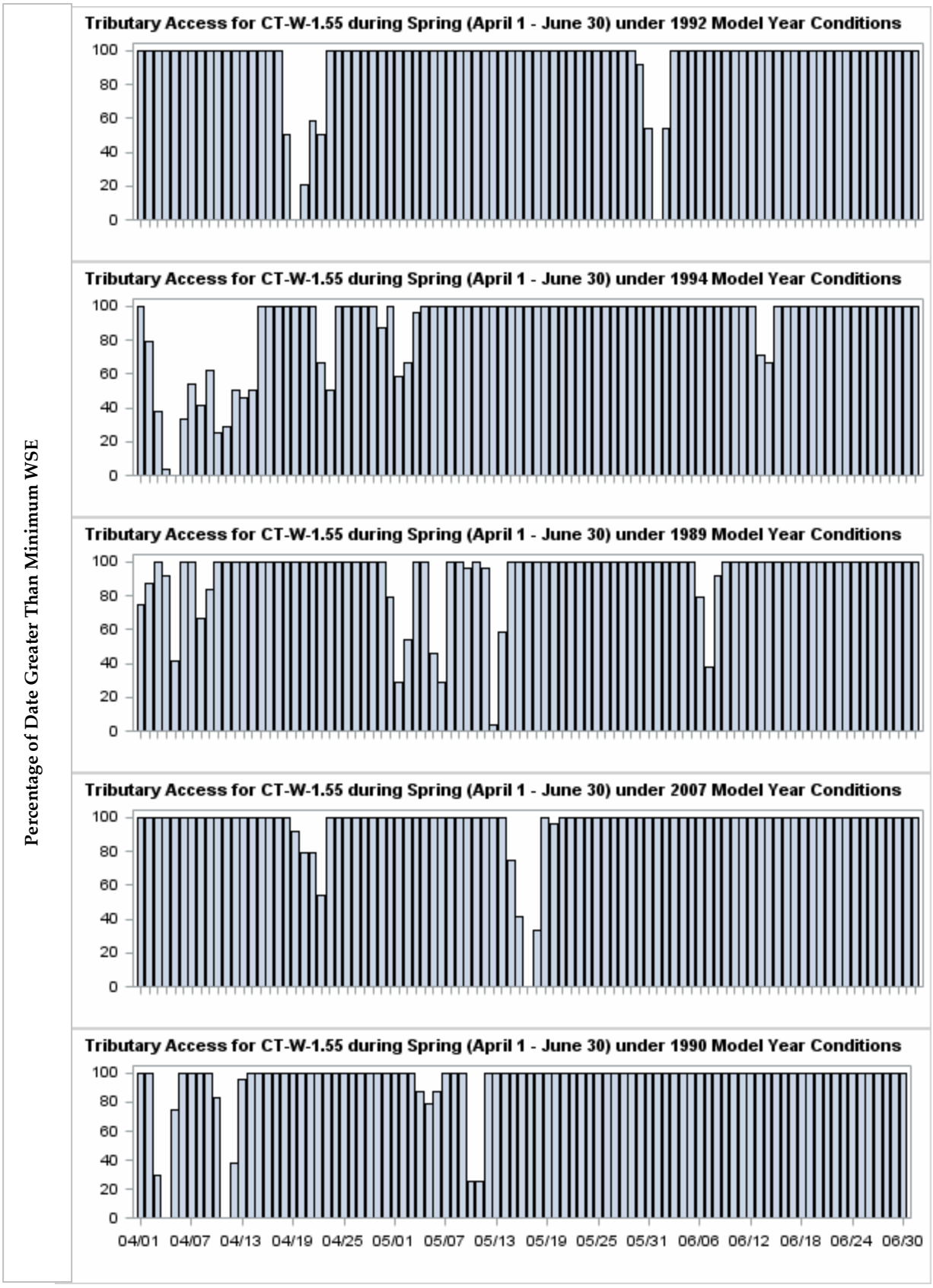

Figure 12. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.55.

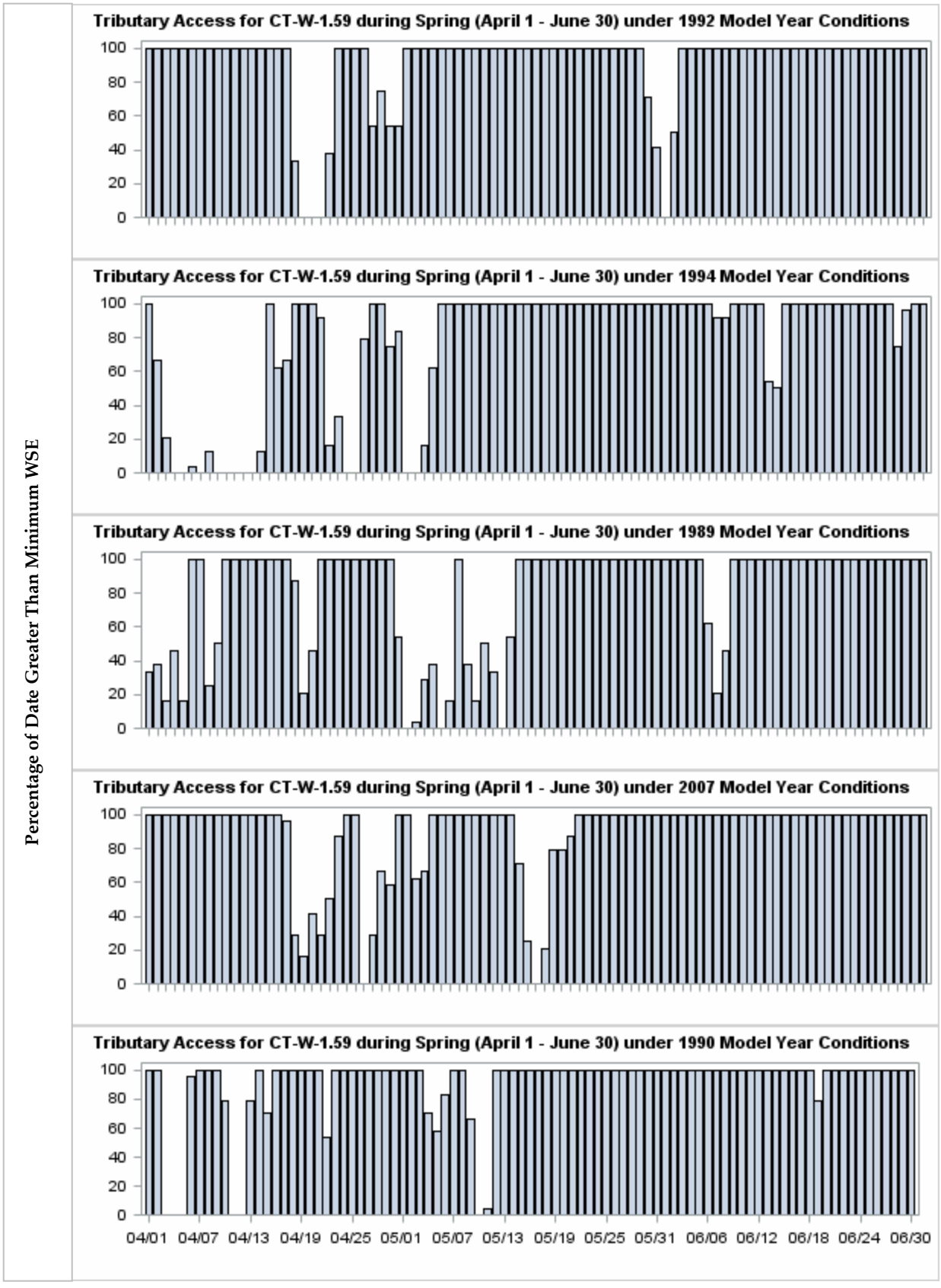

Figure 13. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.59.

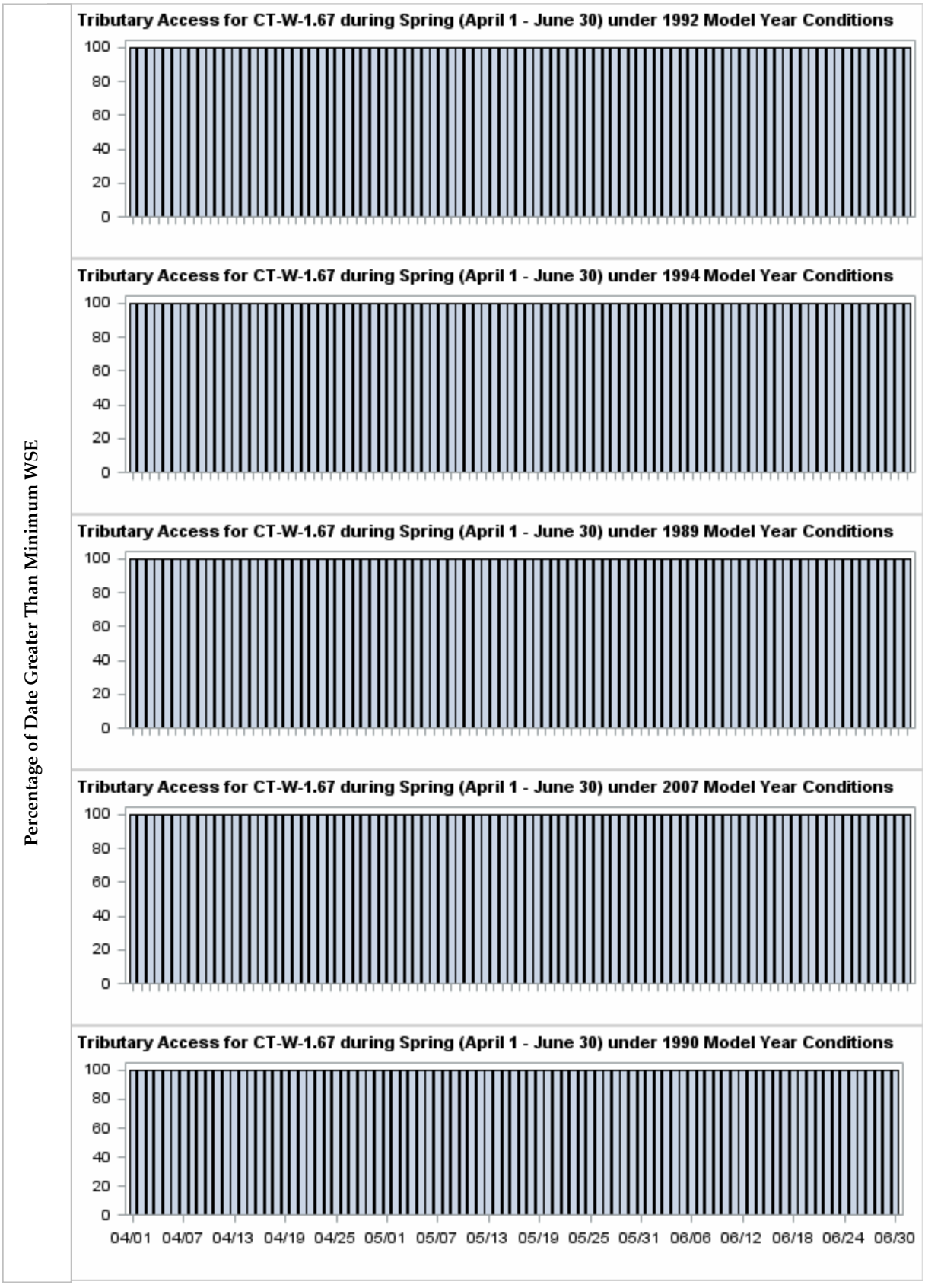

Figure 14. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-W-1.67.

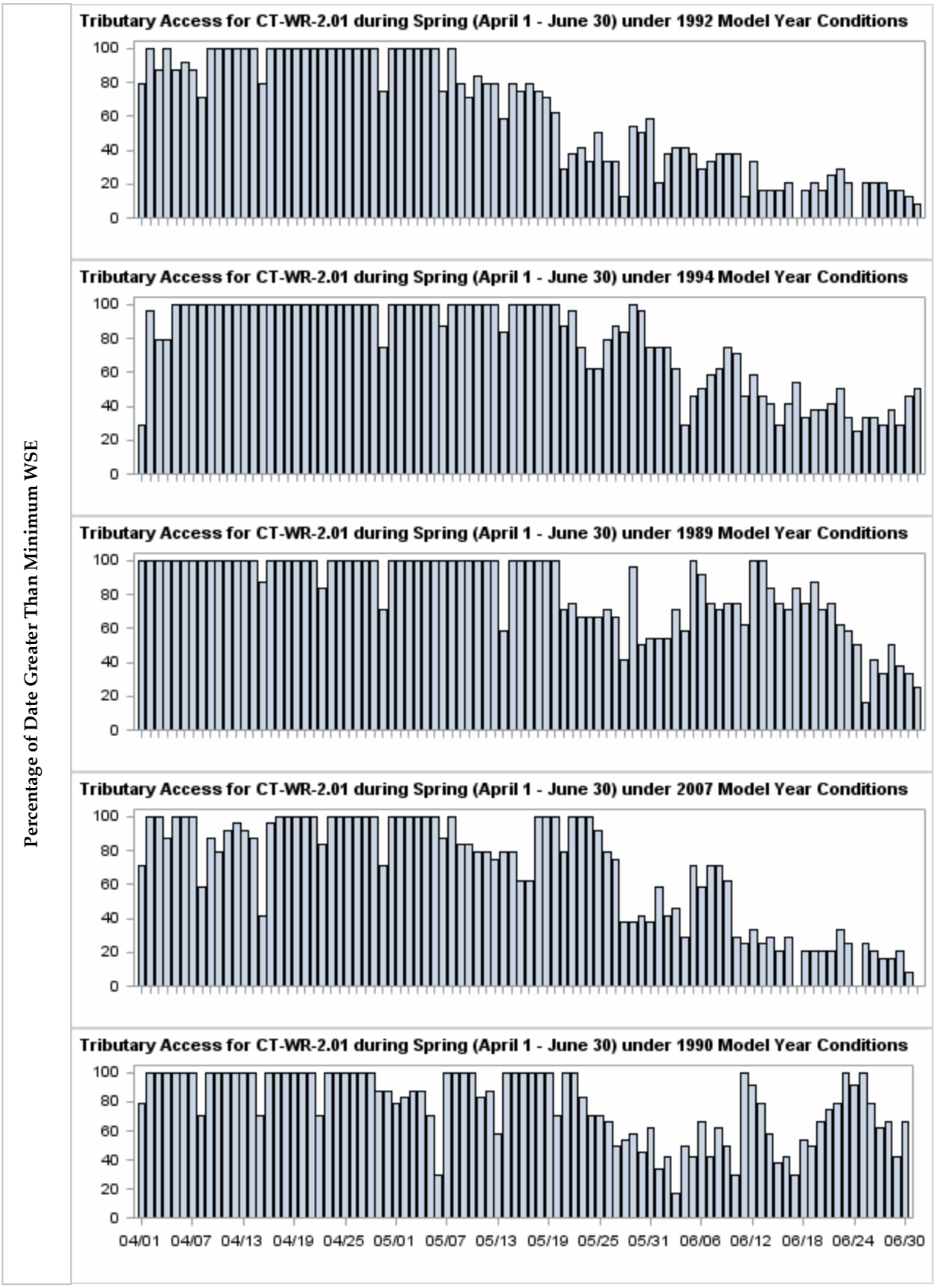

Figure 15. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-WR-2.01.

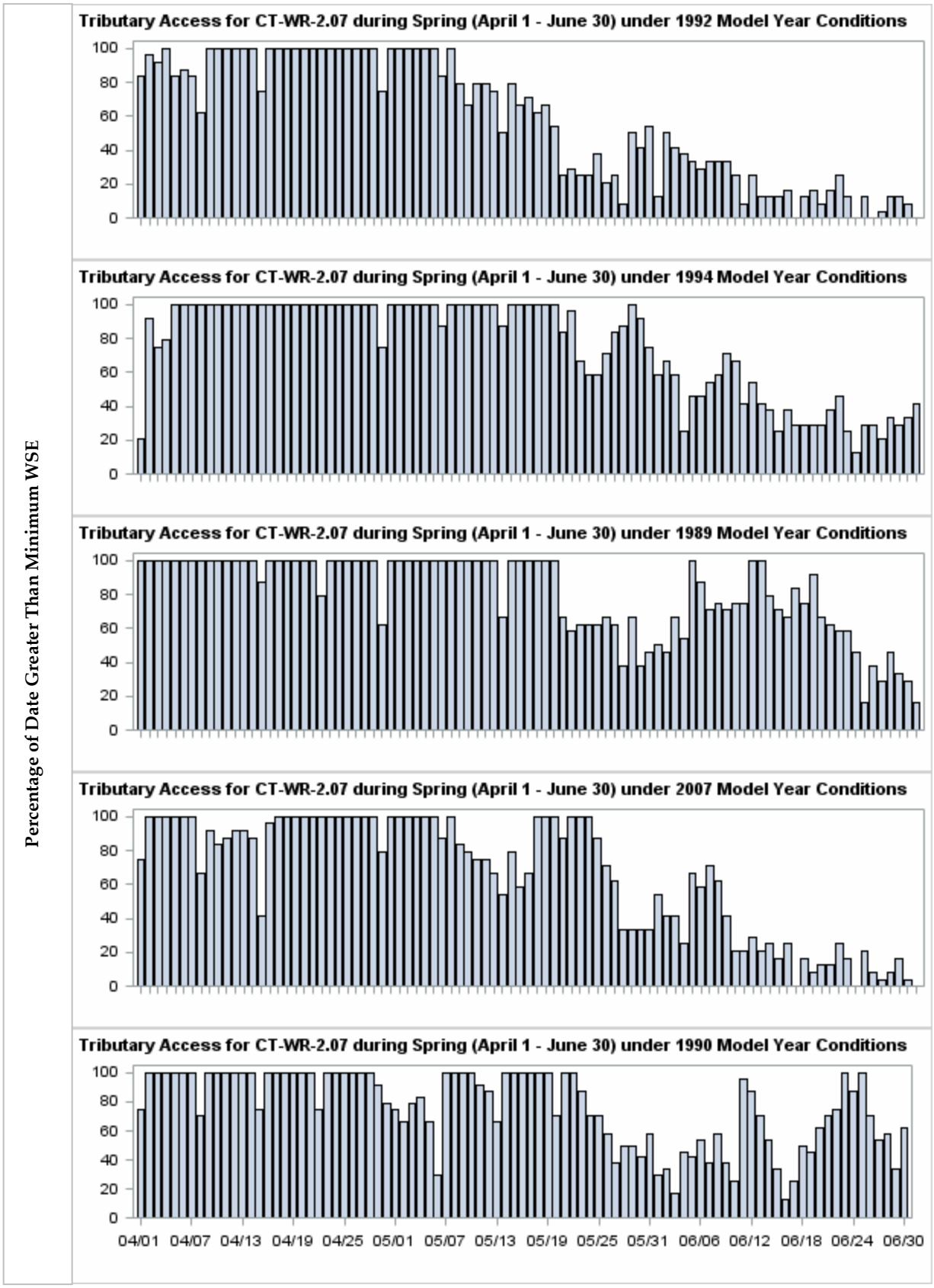

Figure 16. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-WR-2.07.

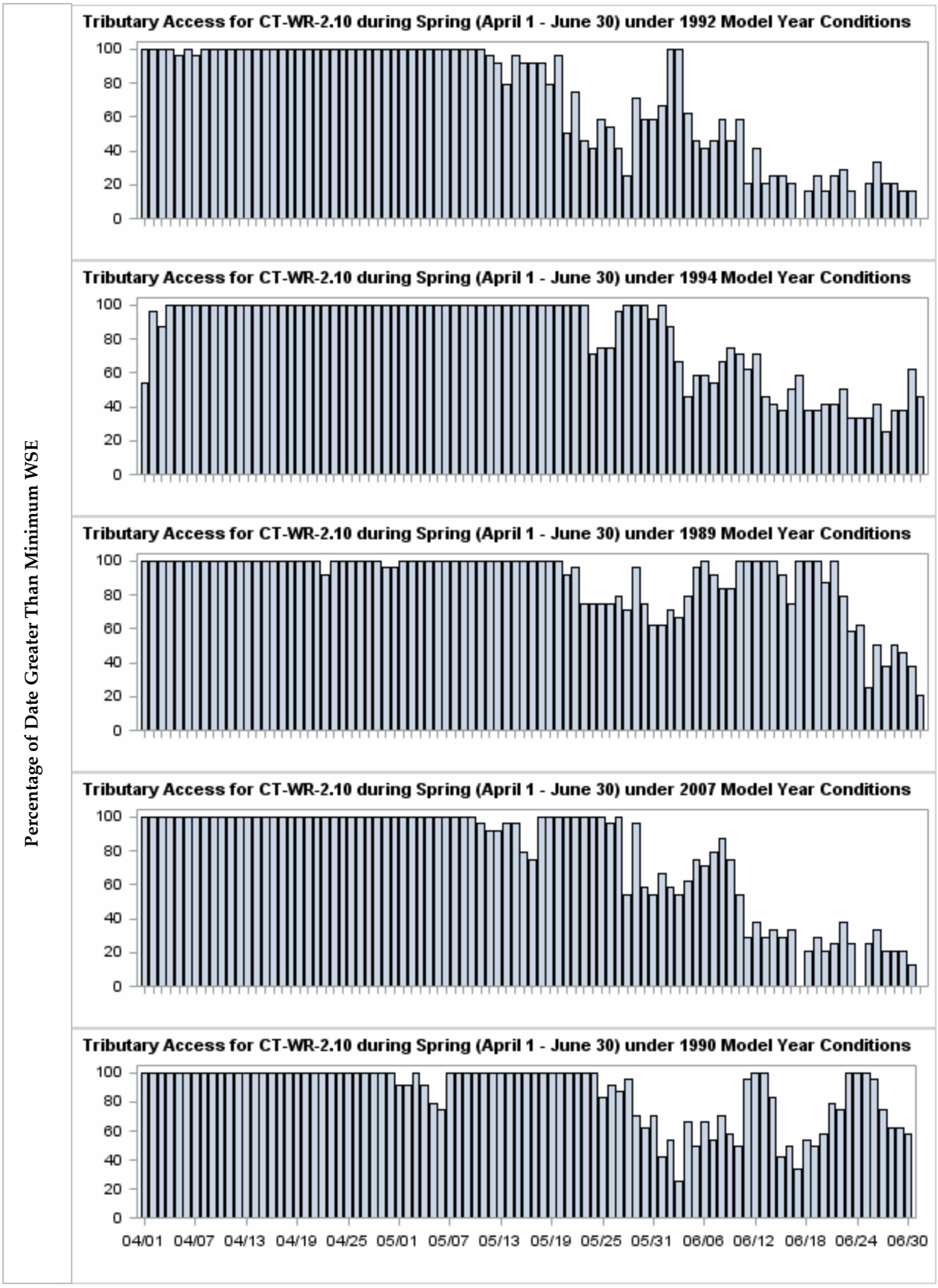

Figure 17. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-WR-2.10.

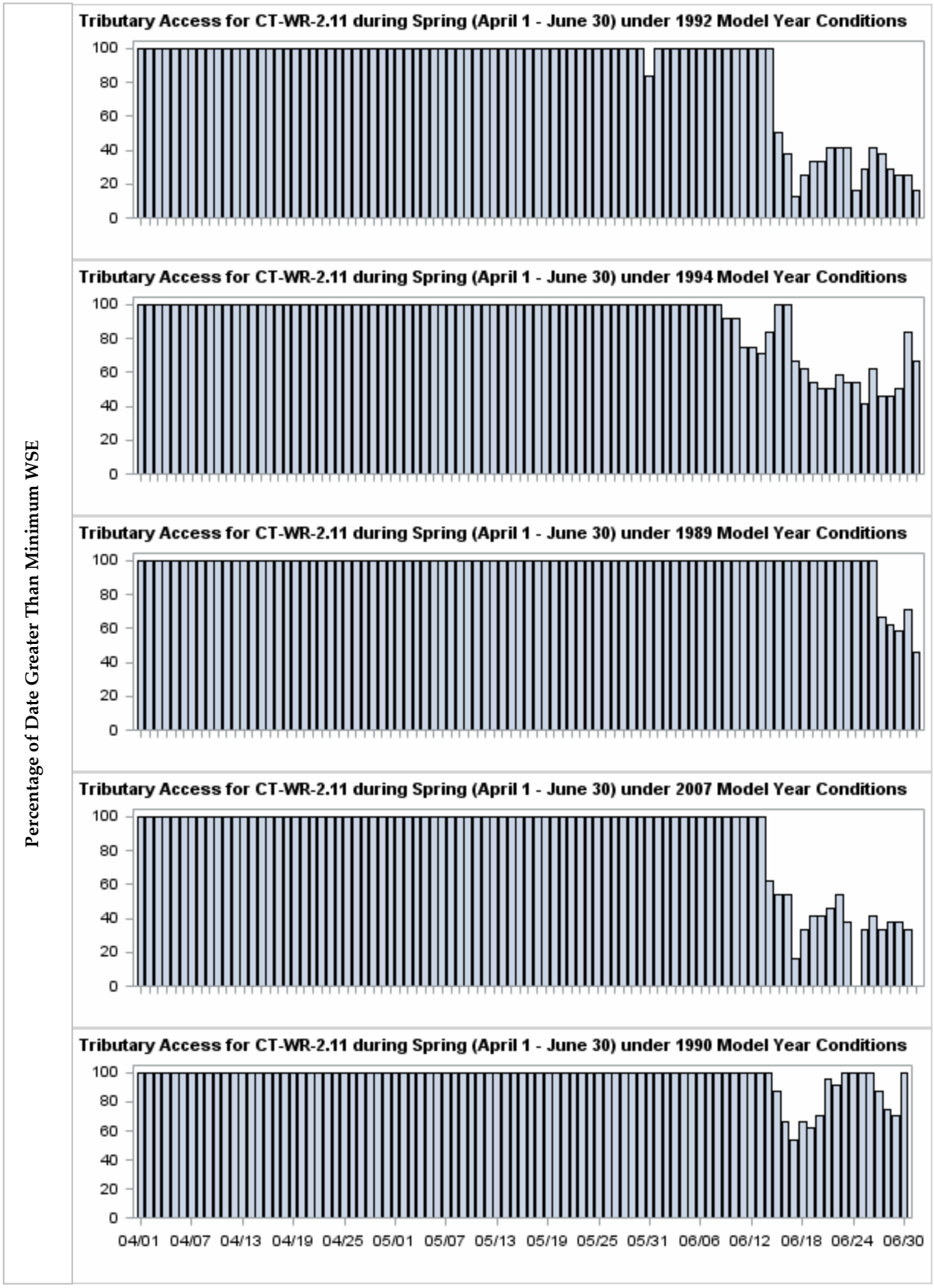

Figure 18. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-WR-2.11.

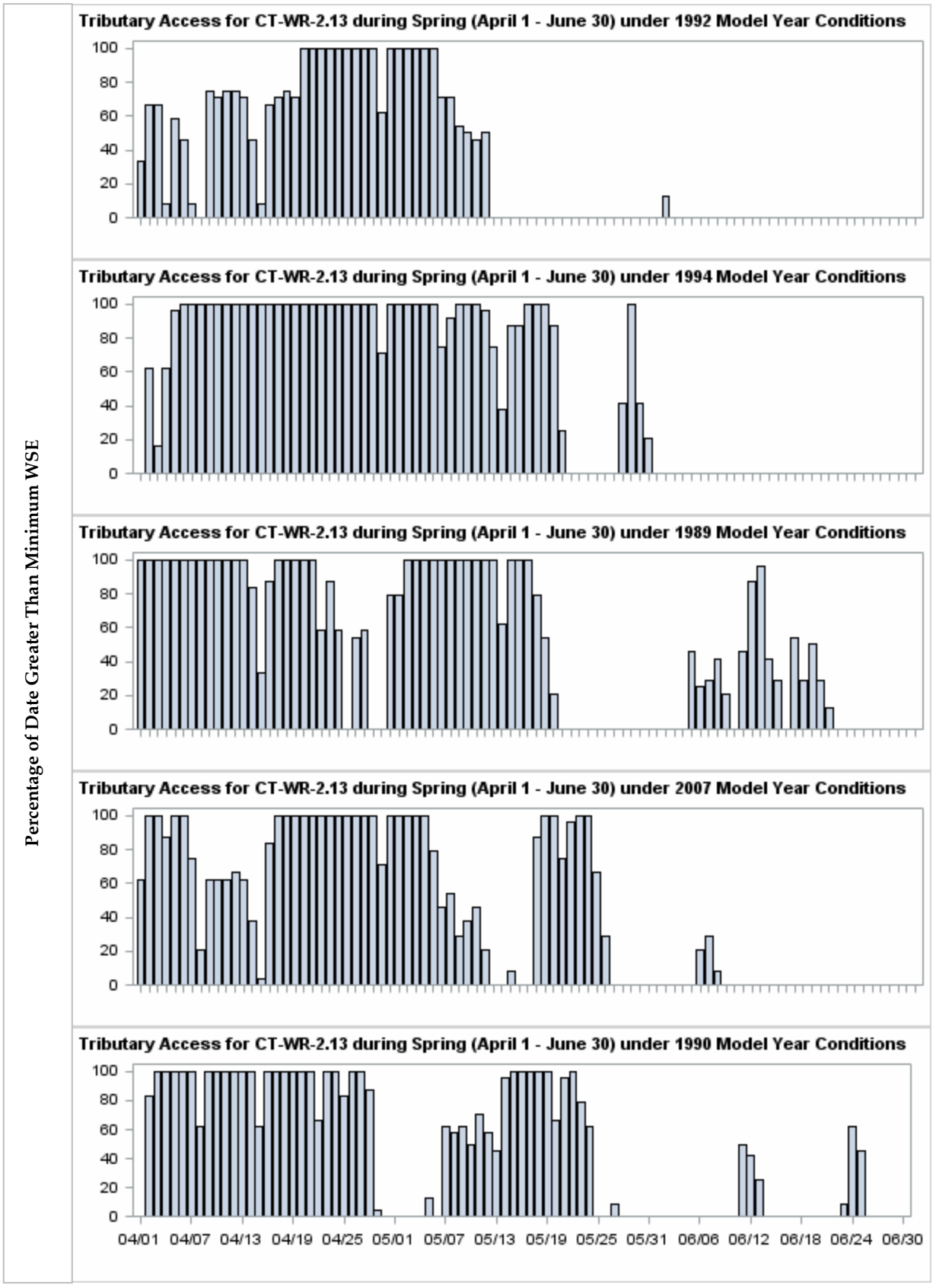

Figure 19. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-WR-2.13.

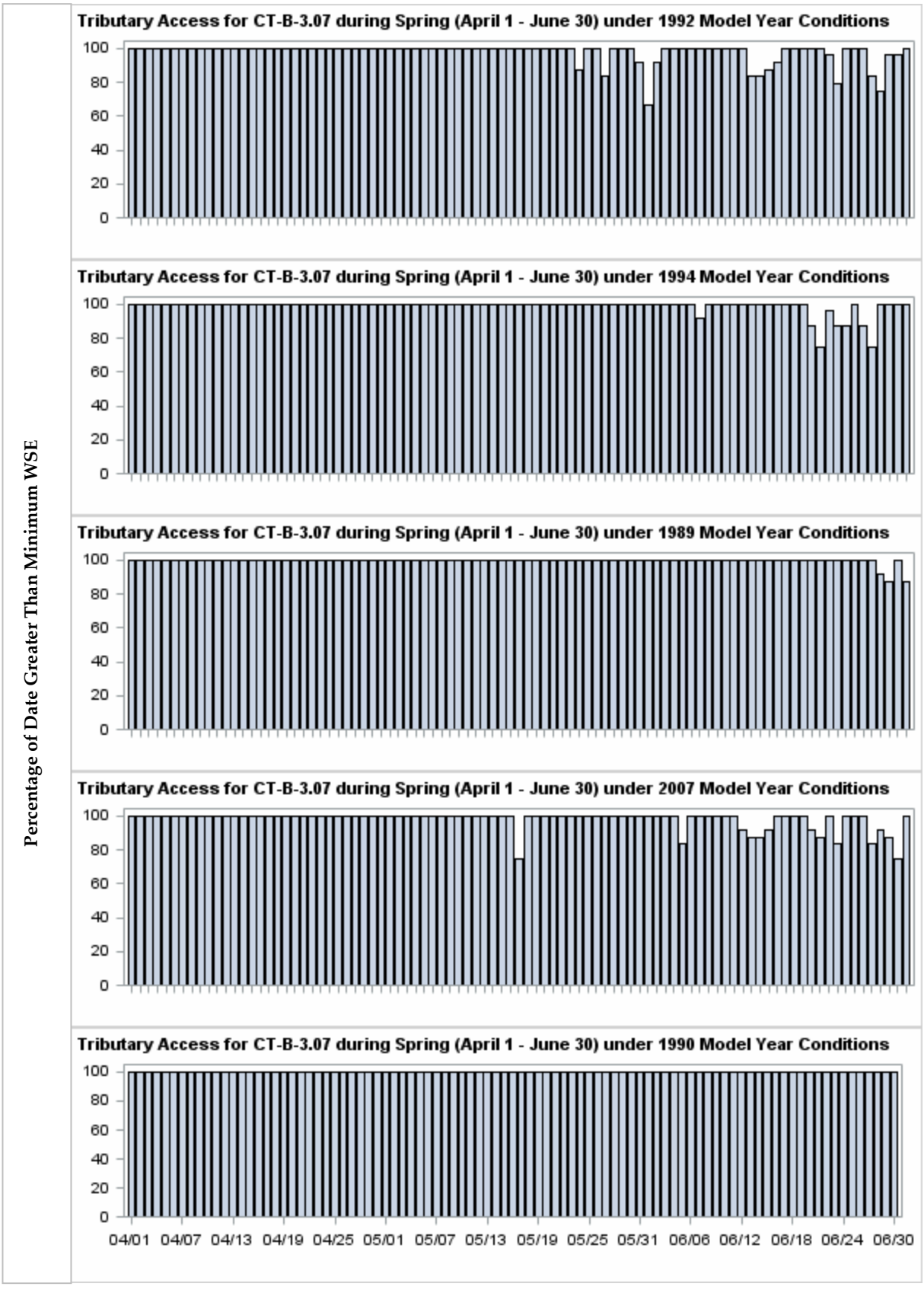

Figure 20. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-B-3.07.

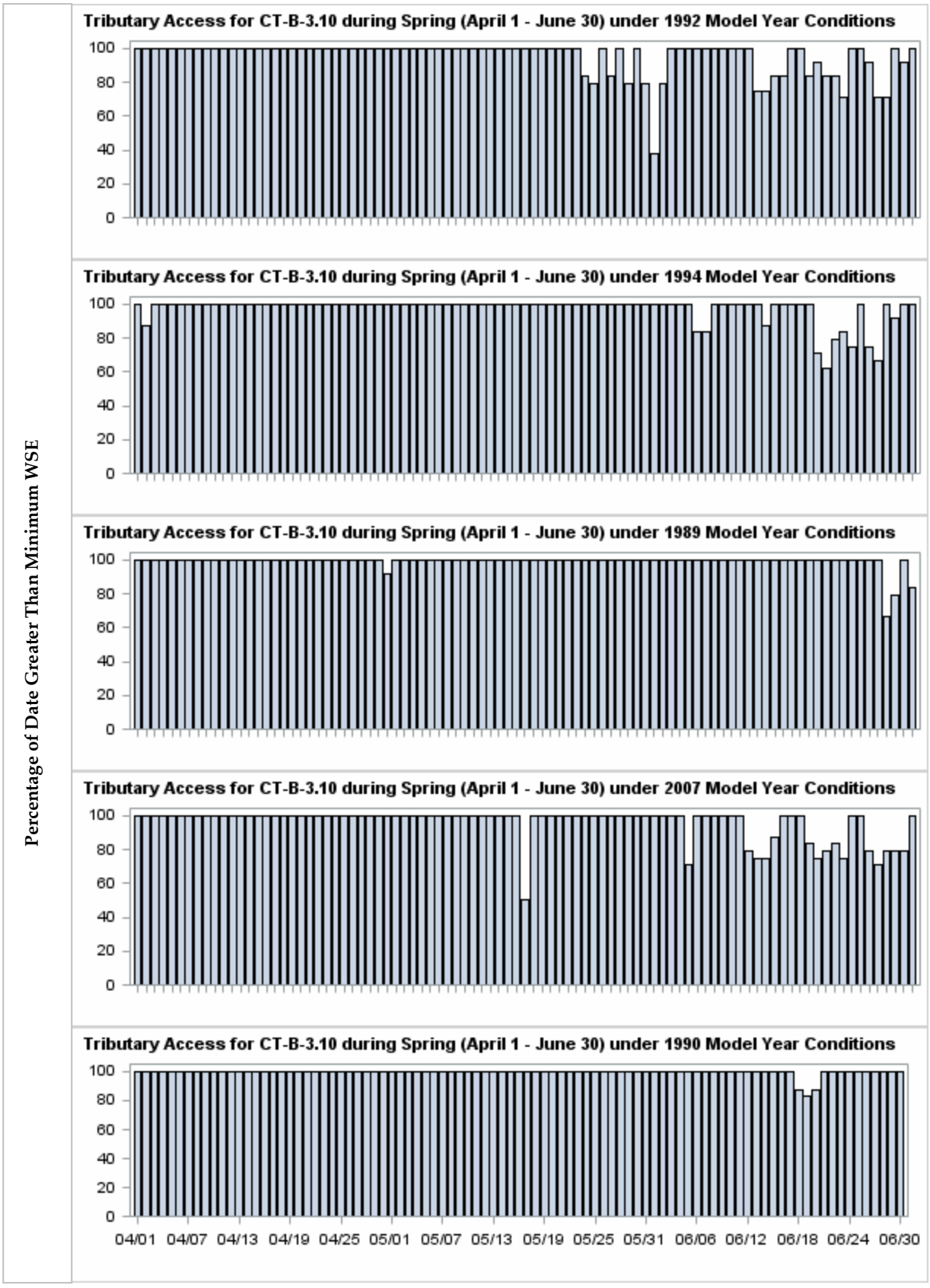

Figure 21. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-B-3.10.

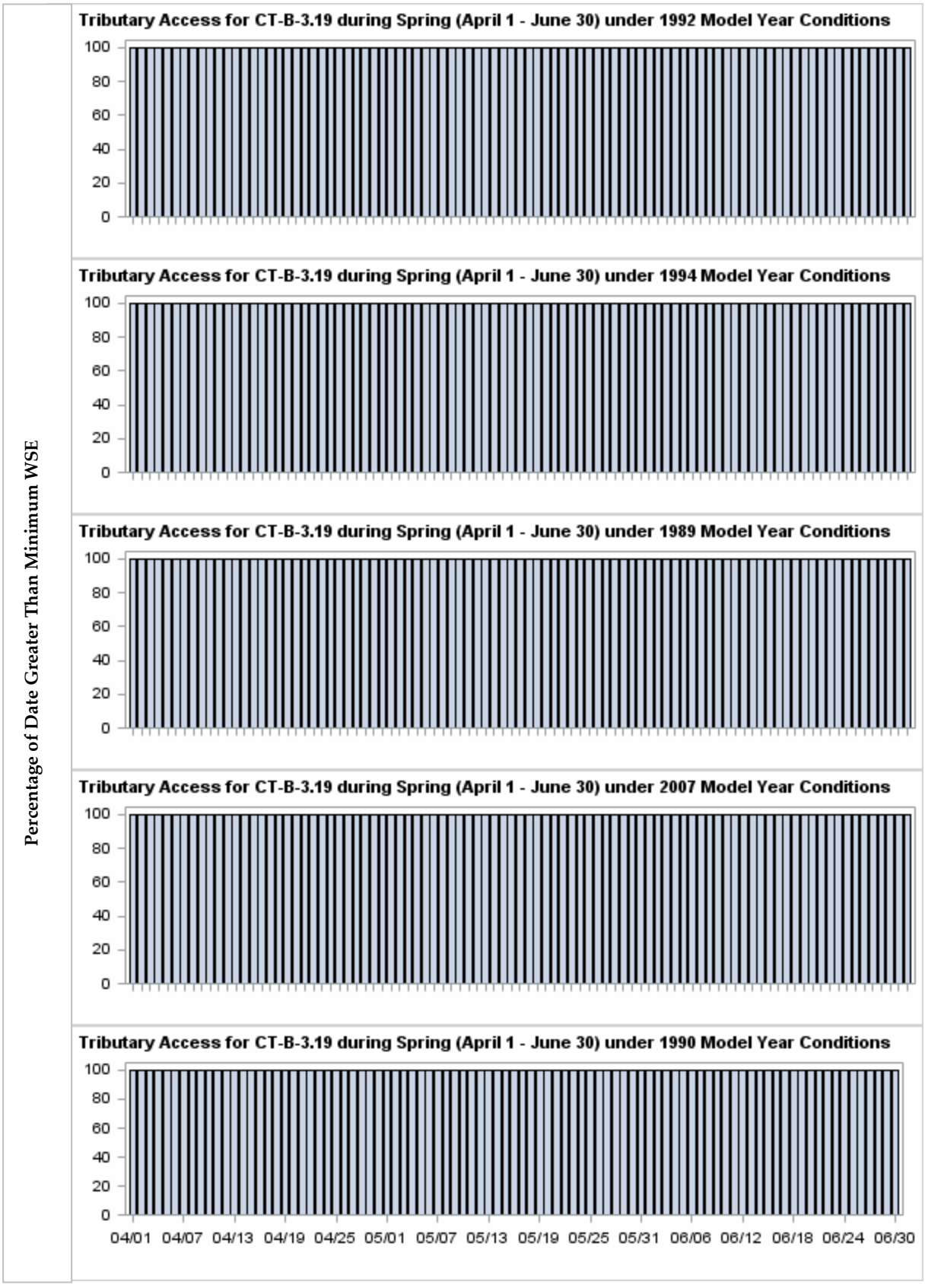

Figure 22. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-B-3.19.

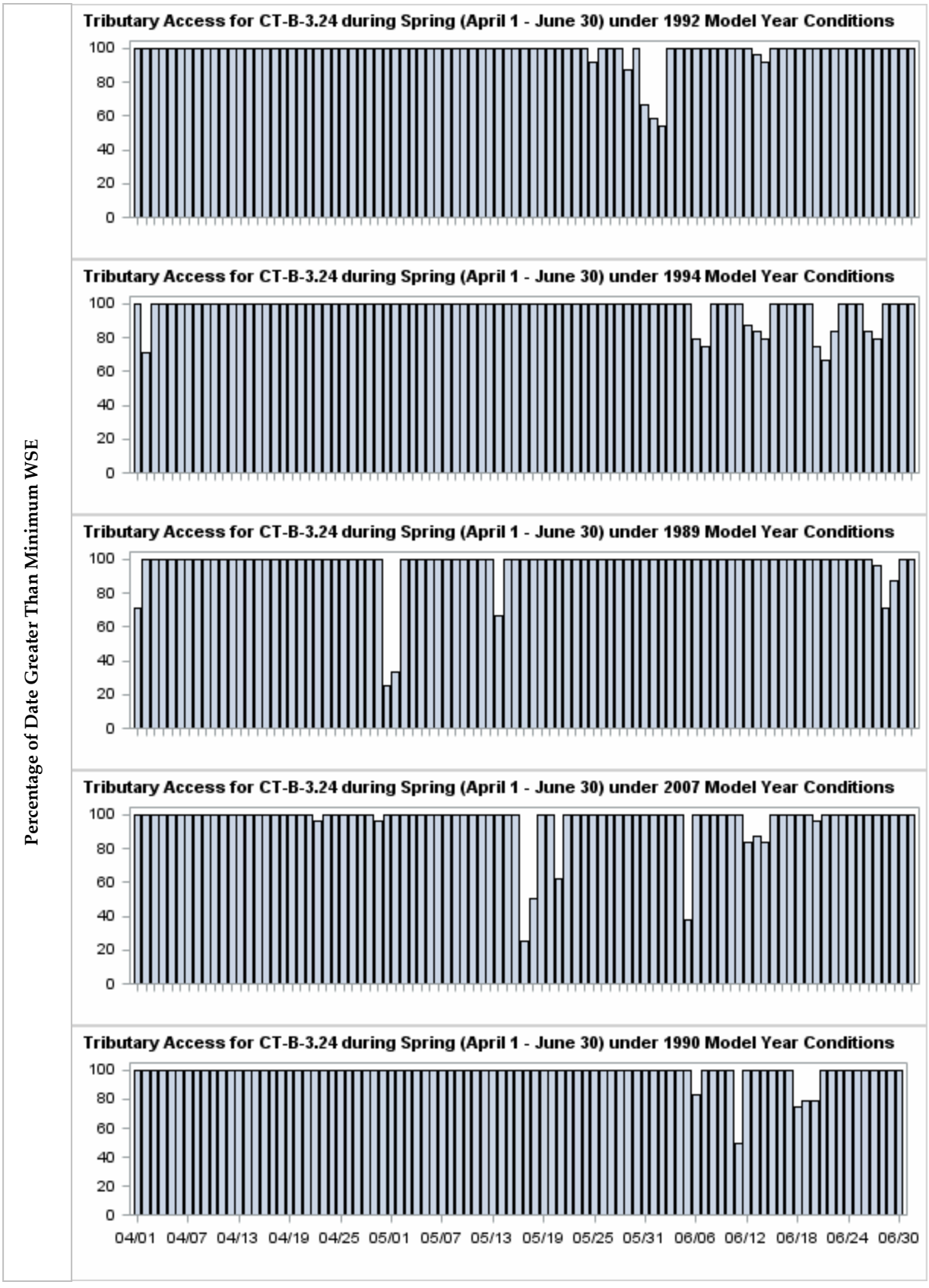

Figure 23. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-B-3.24.

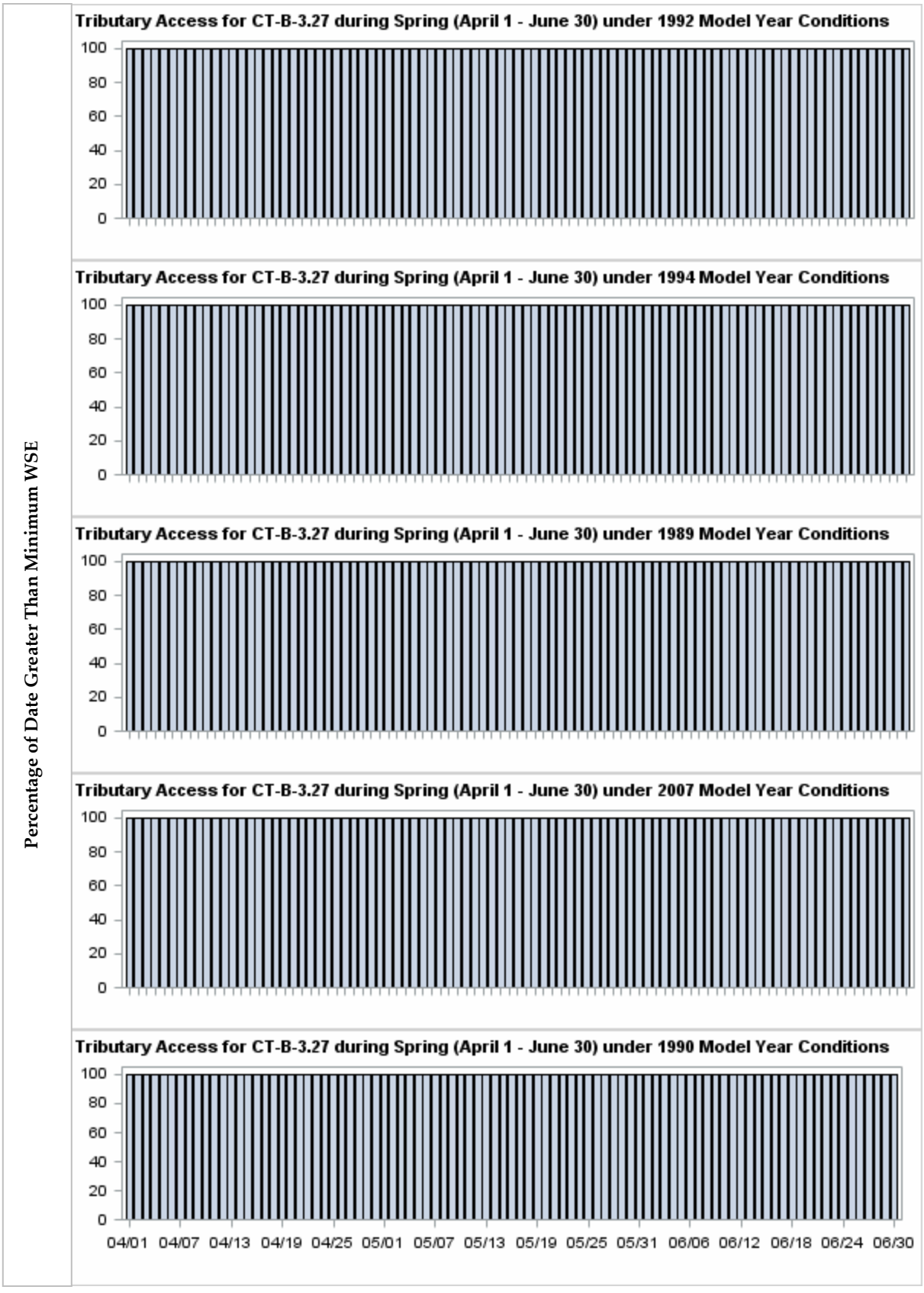

Figure 24. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-B-3.27.

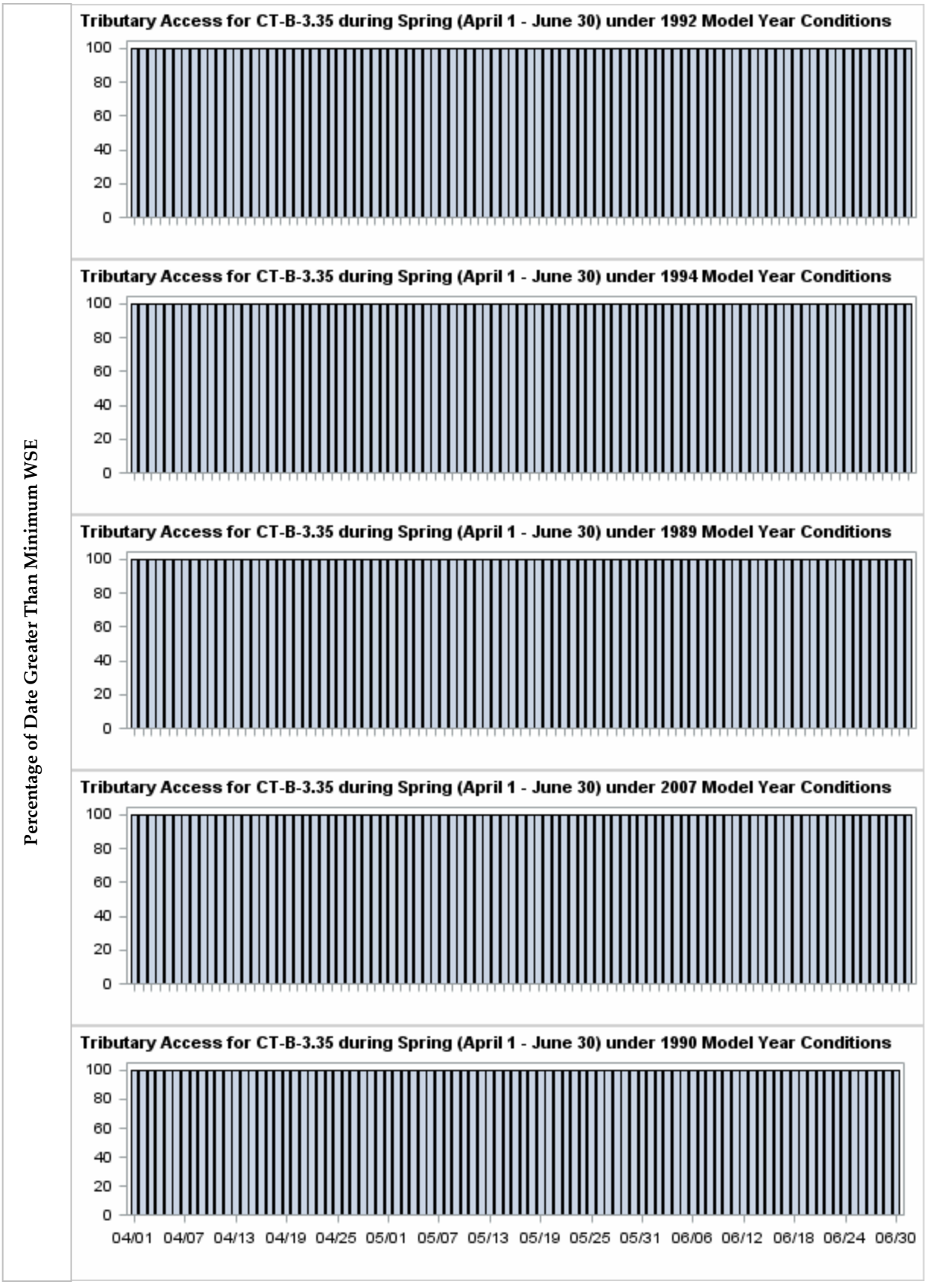

Figure 25. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-B-3.35.

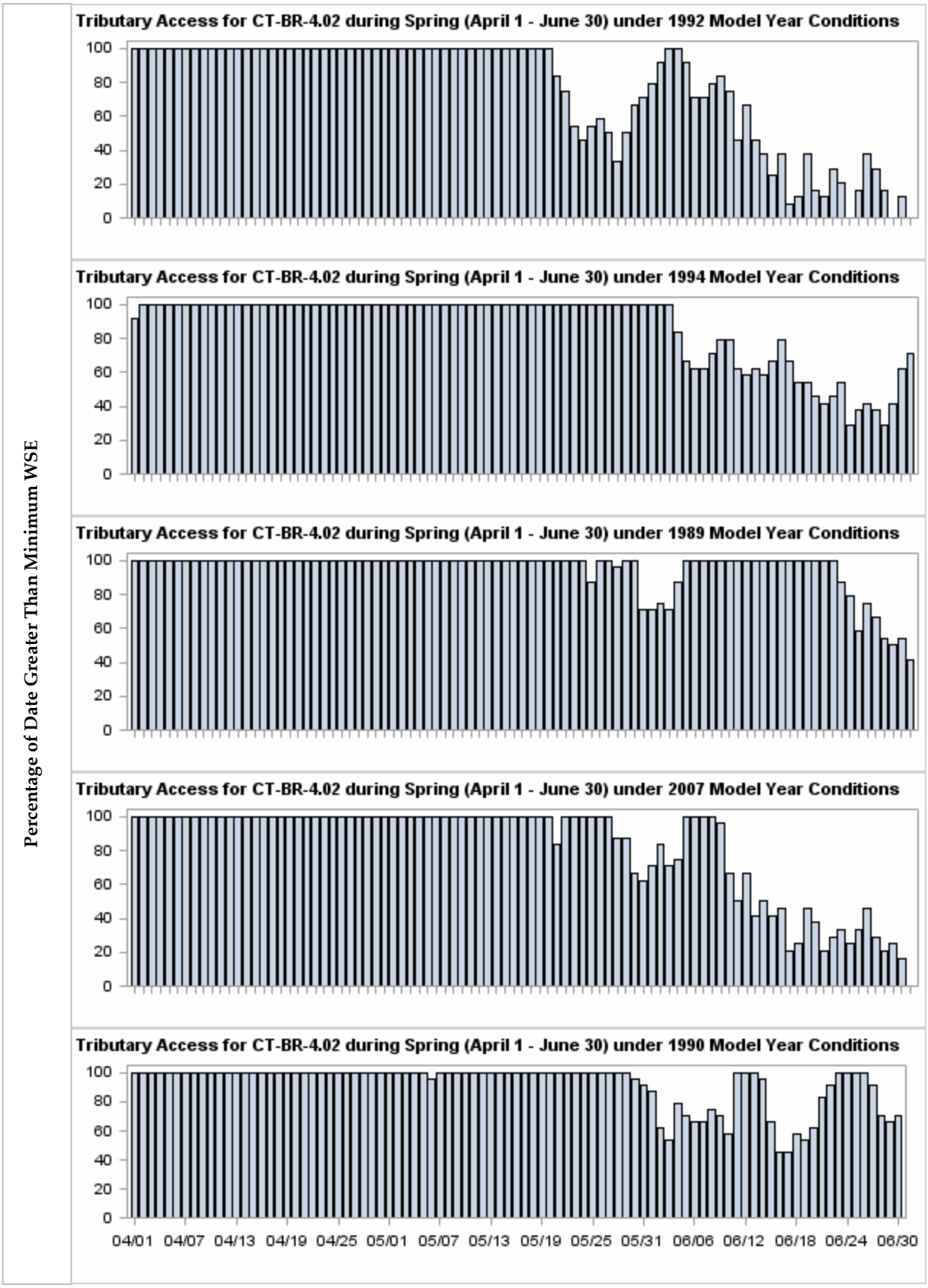

Figure 26. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-BR-4.02.

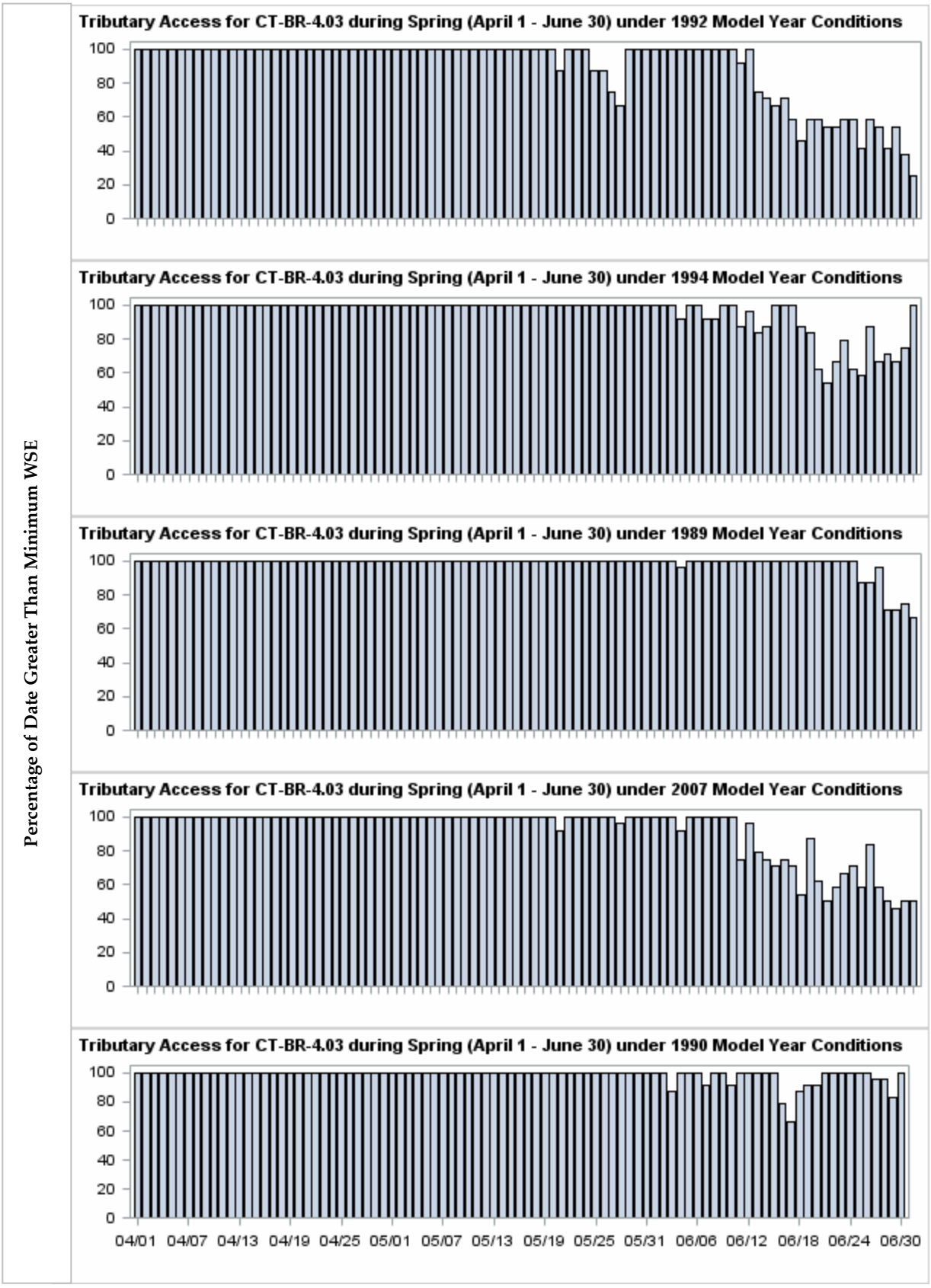

Figure 27. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-BR-4.03.

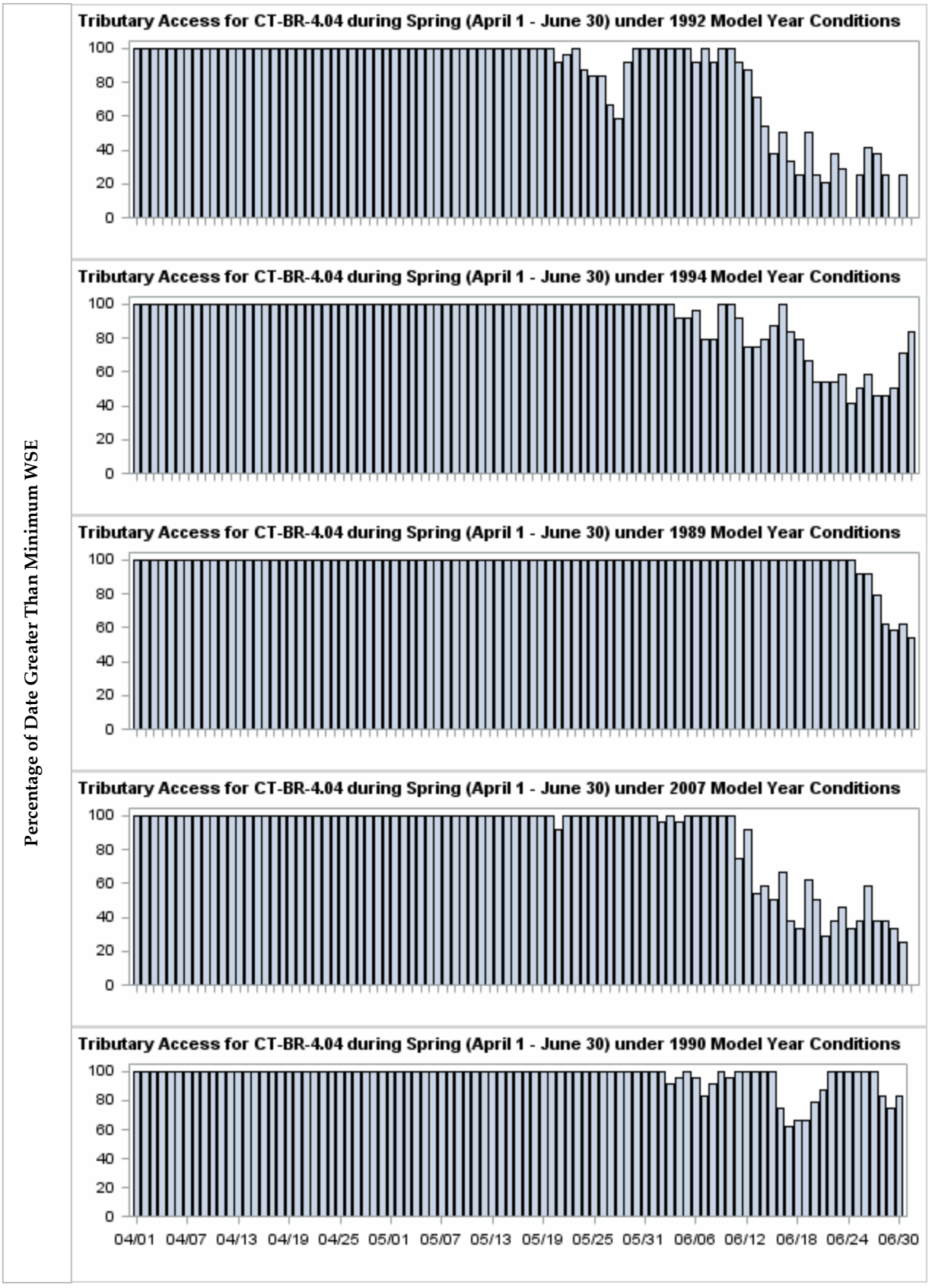

Figure 28. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-BR-4.04.

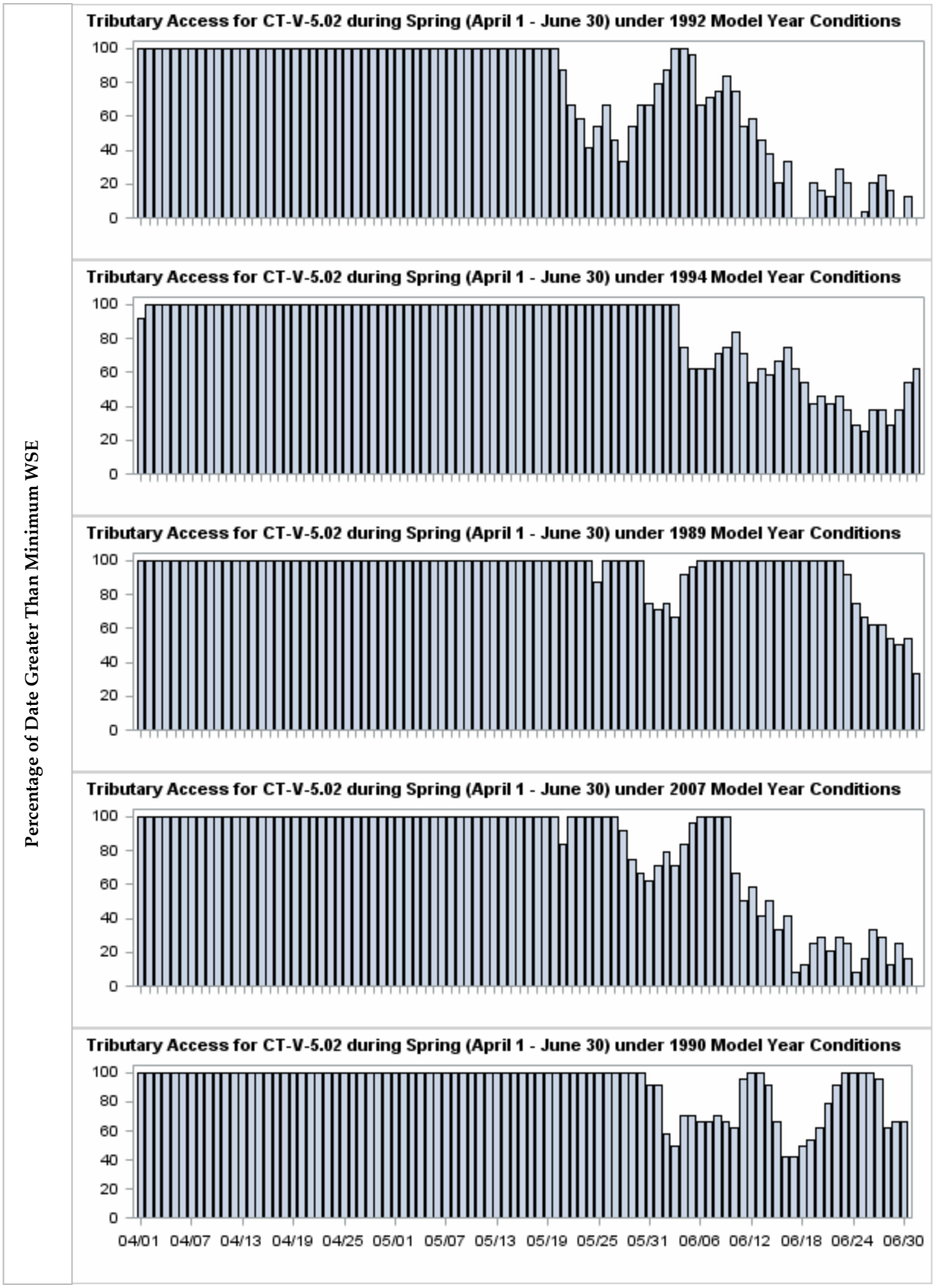

Figure 29. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-V-5.02.

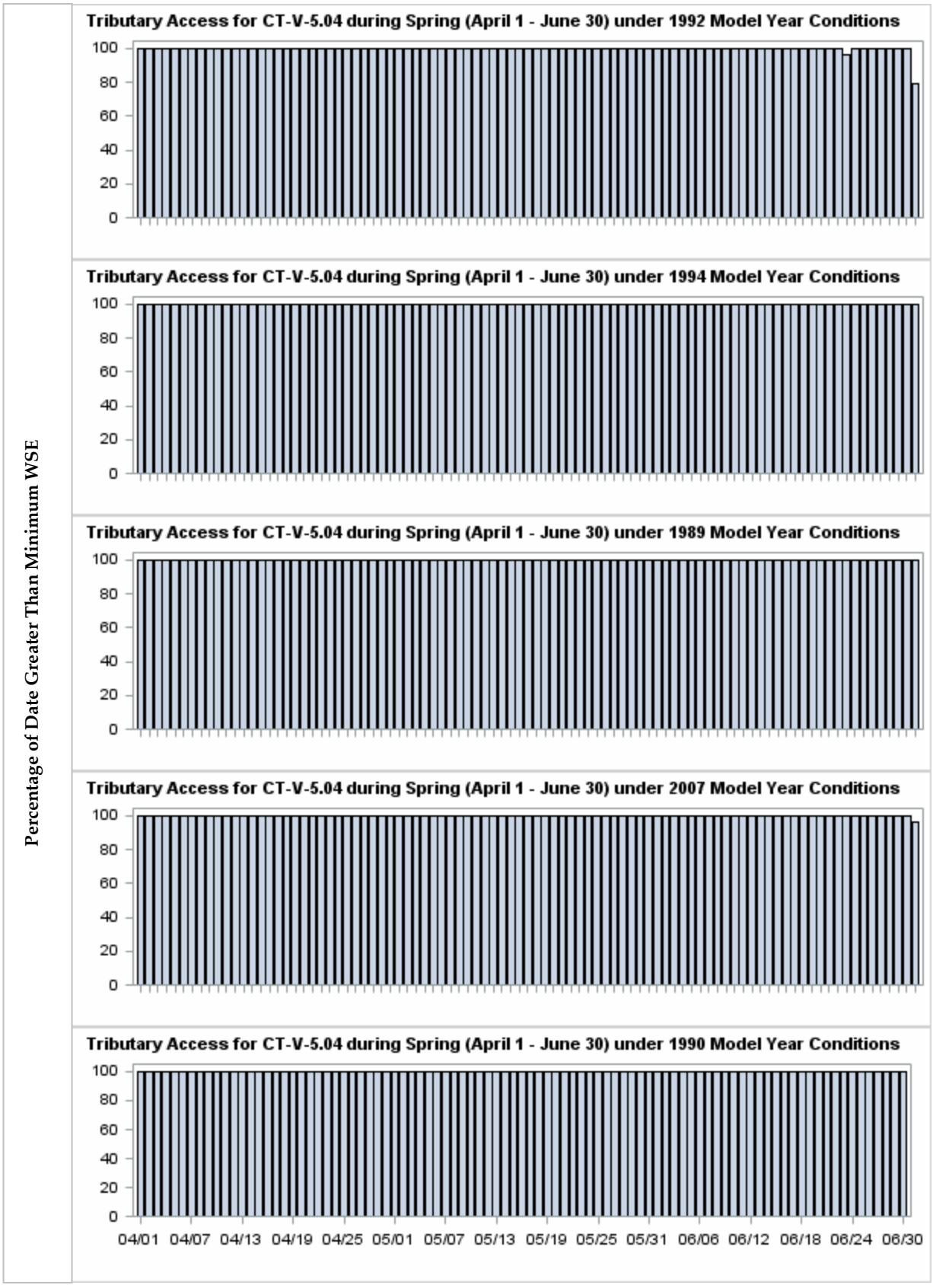

Figure 30. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-V-5.04.

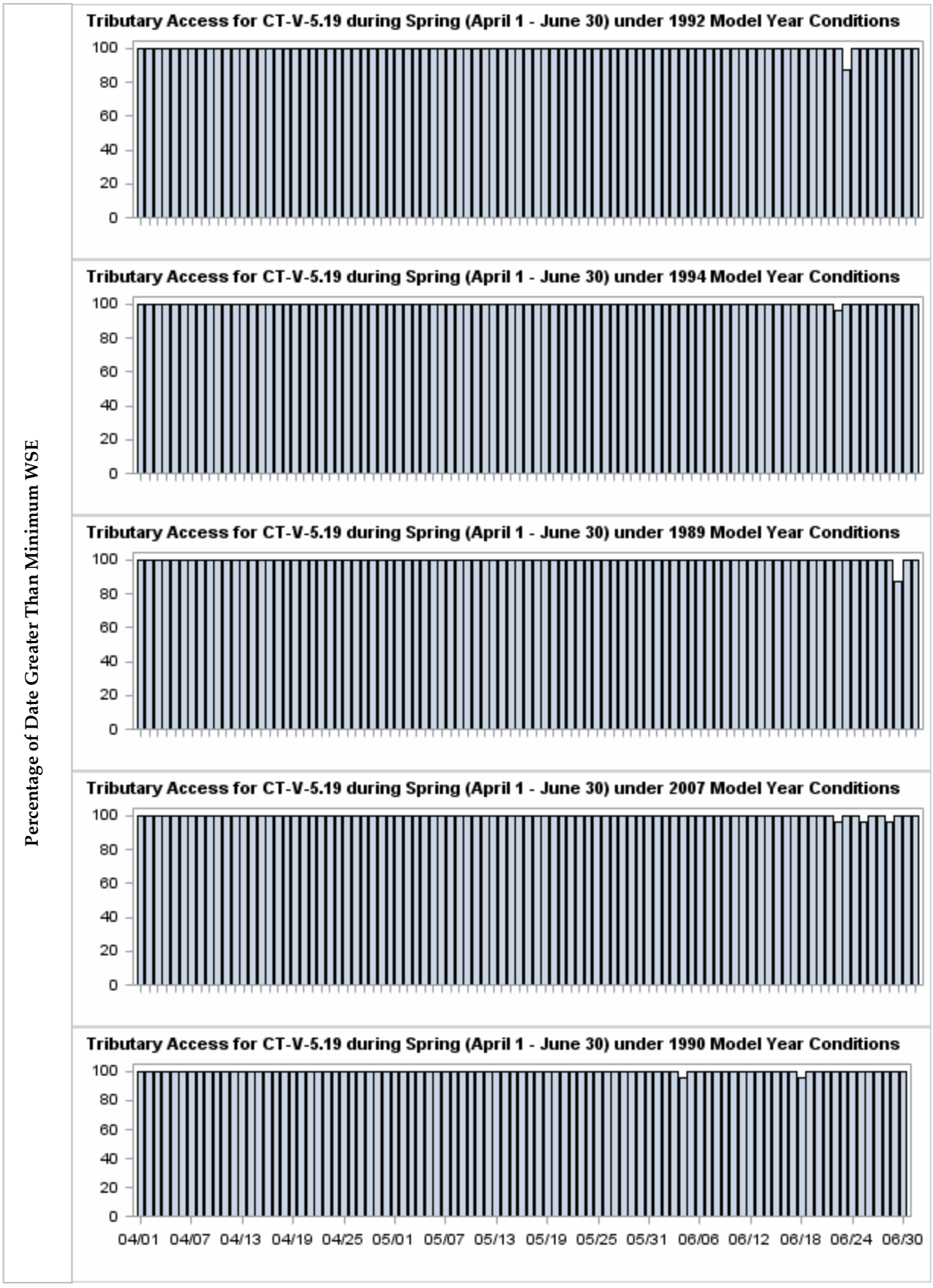

Figure 31. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-V-5.19.

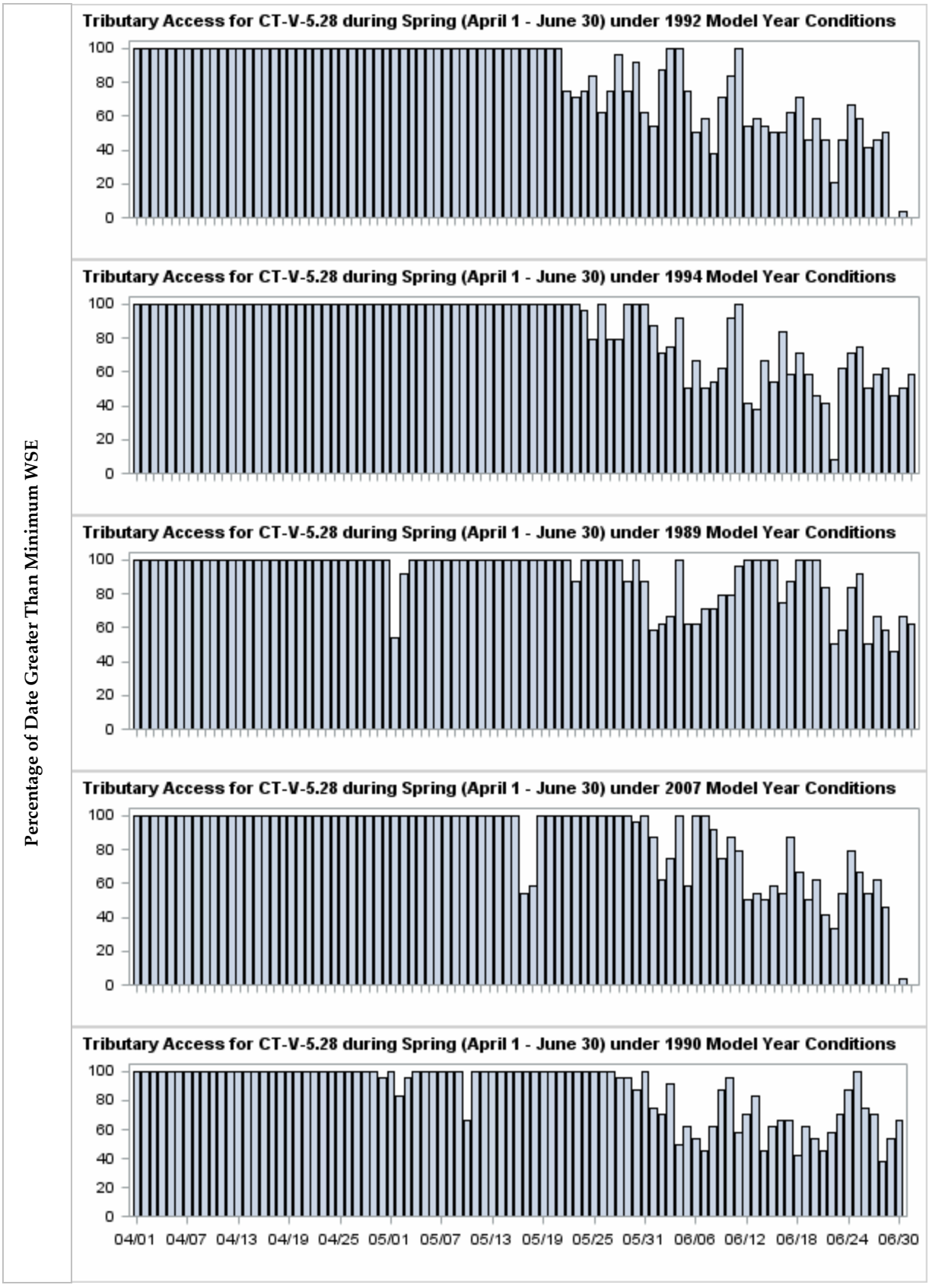

Figure 32. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-V-5.28.

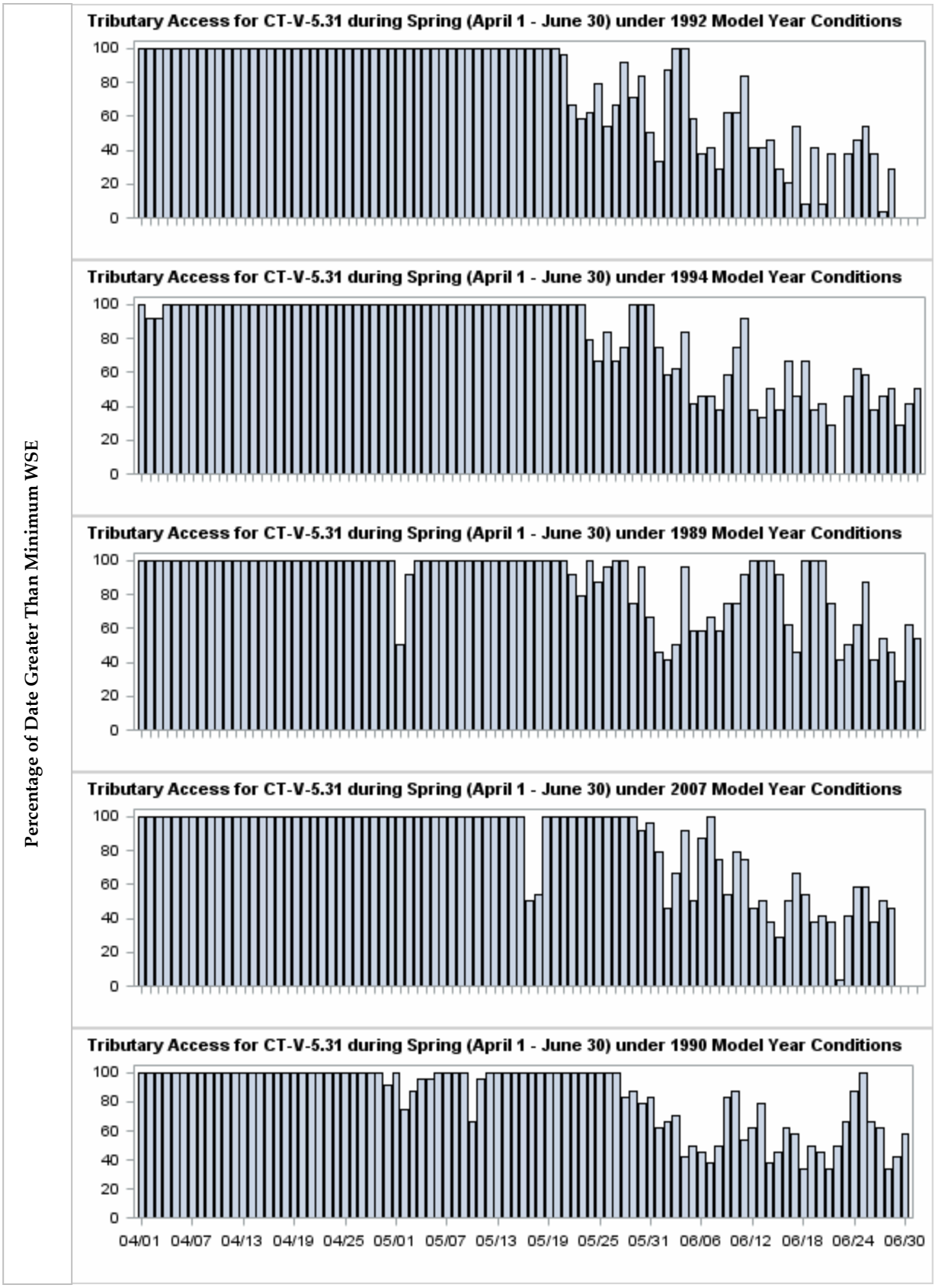

Figure 33. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-V-5.31.

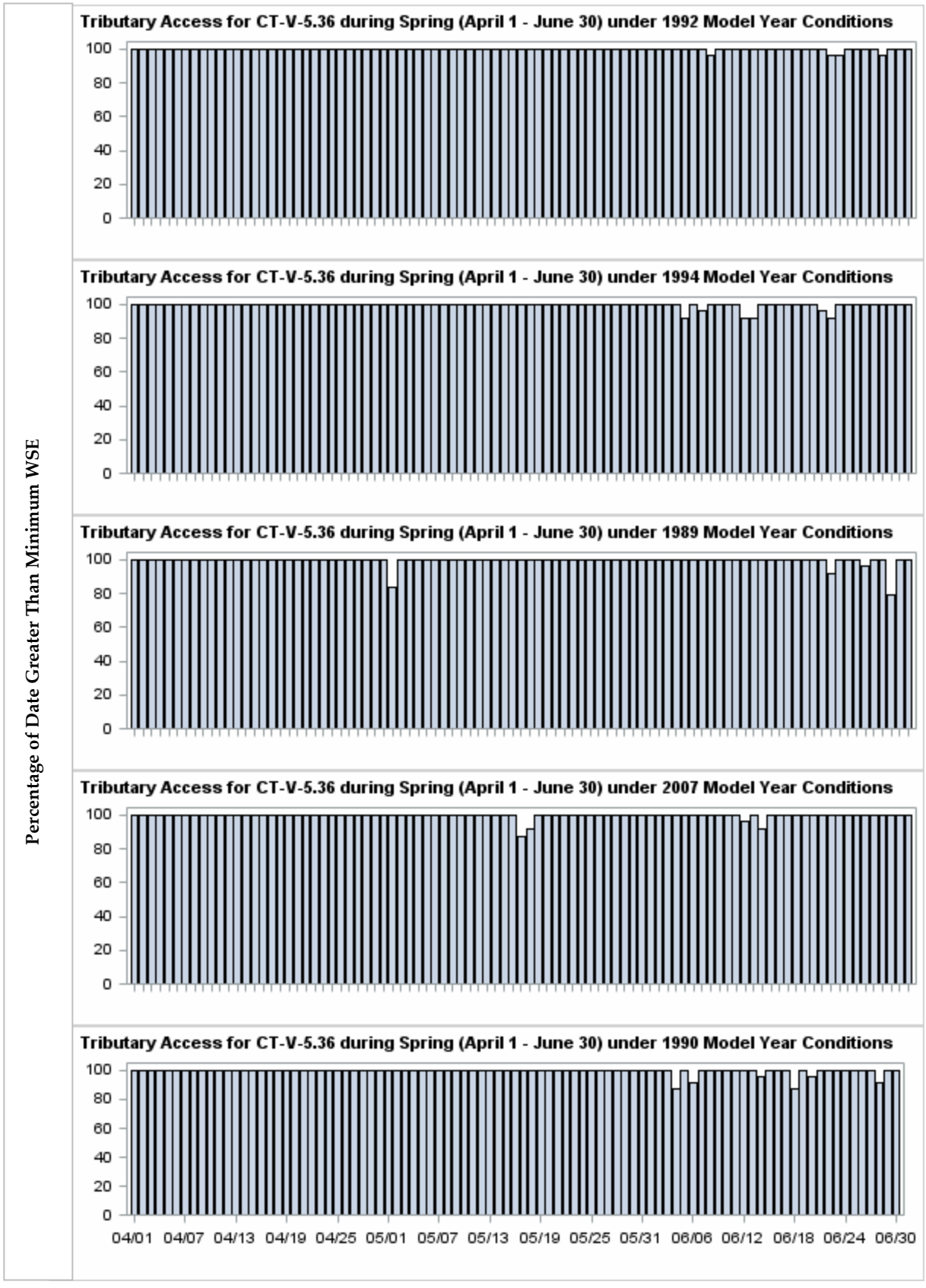

Figure 34. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-V-5.36.

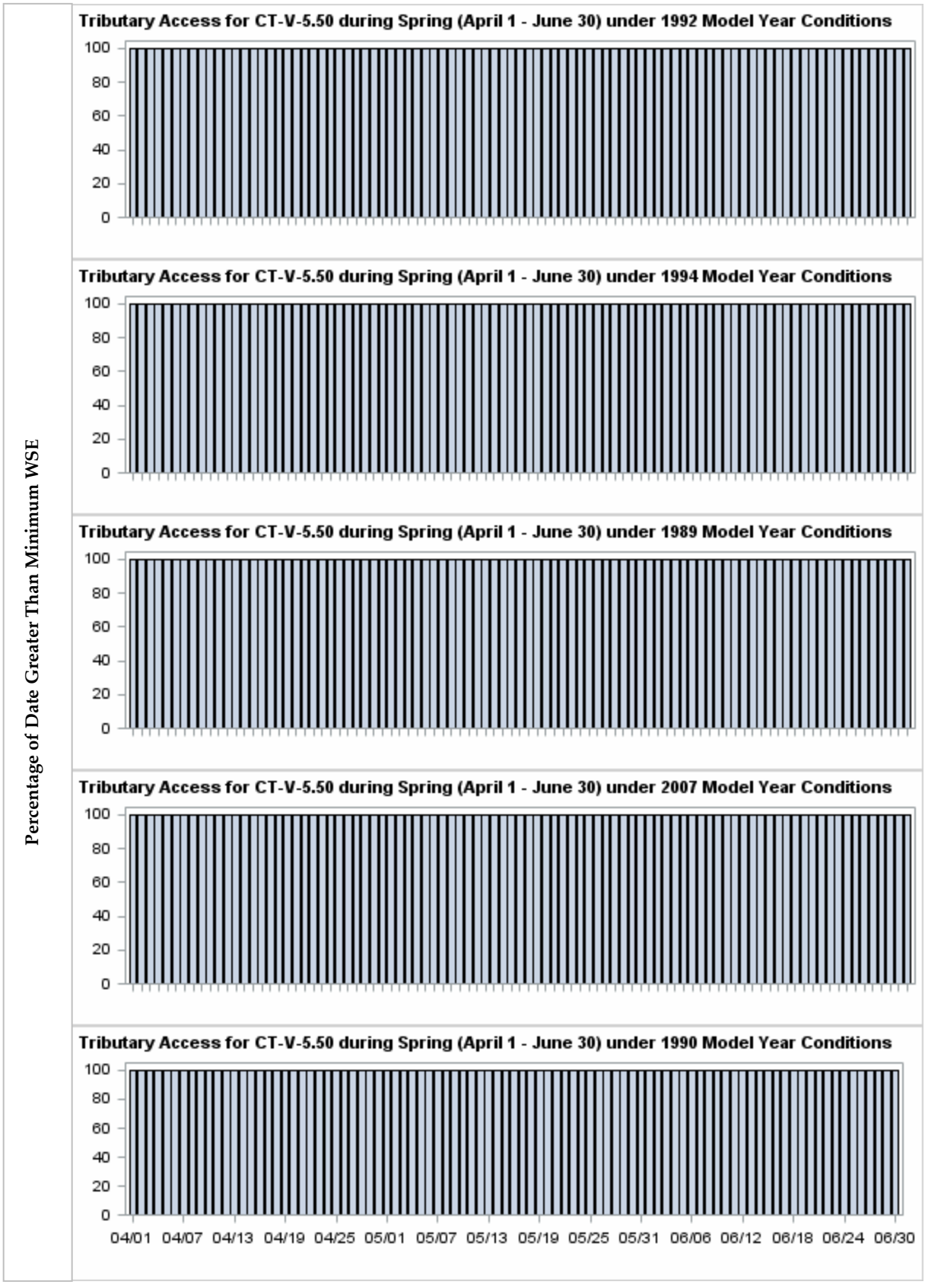

Figure 35. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-V-5.50.

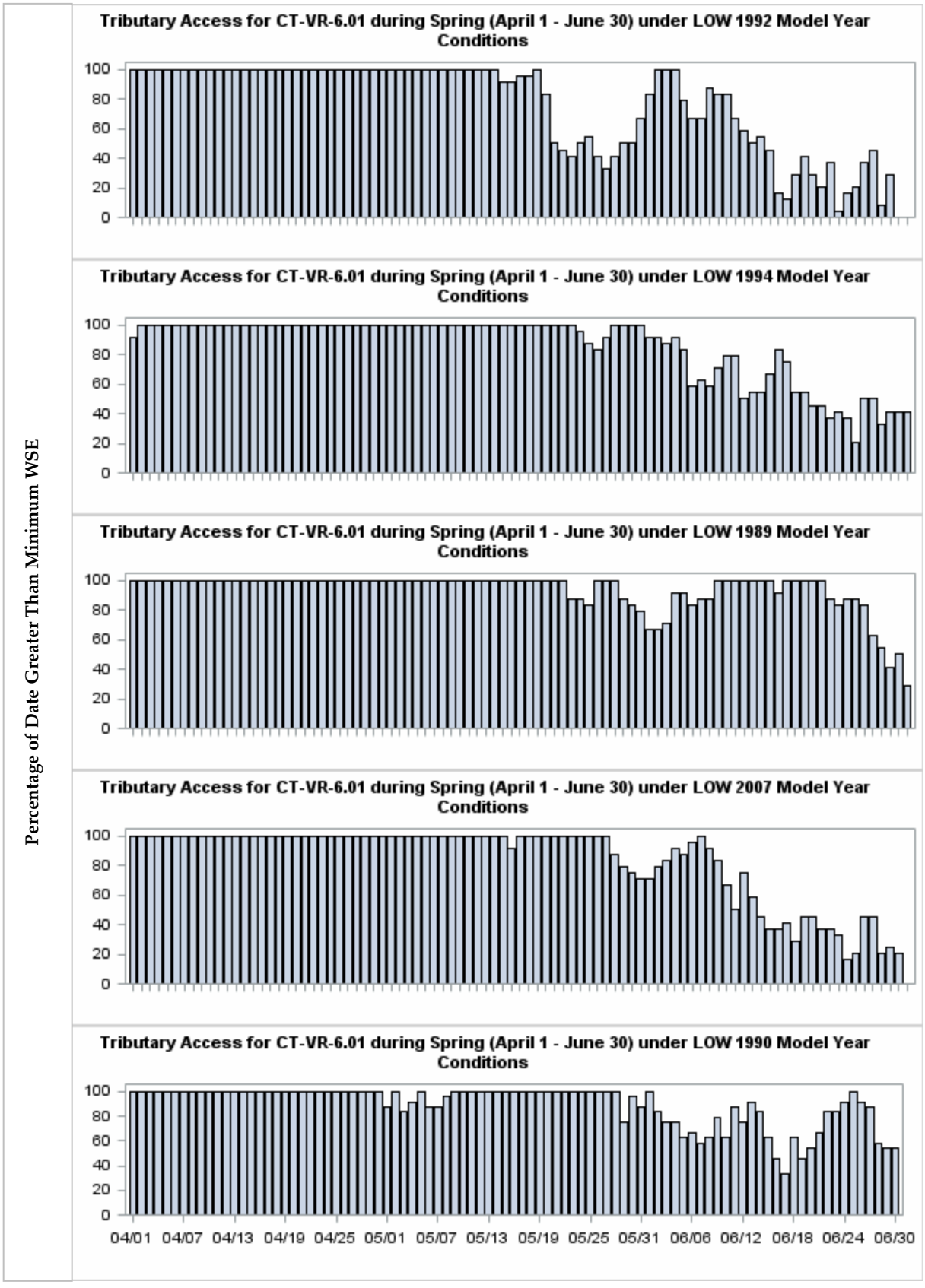

Figure 36. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-VR-6.01 (Turners Falls elevation = low).

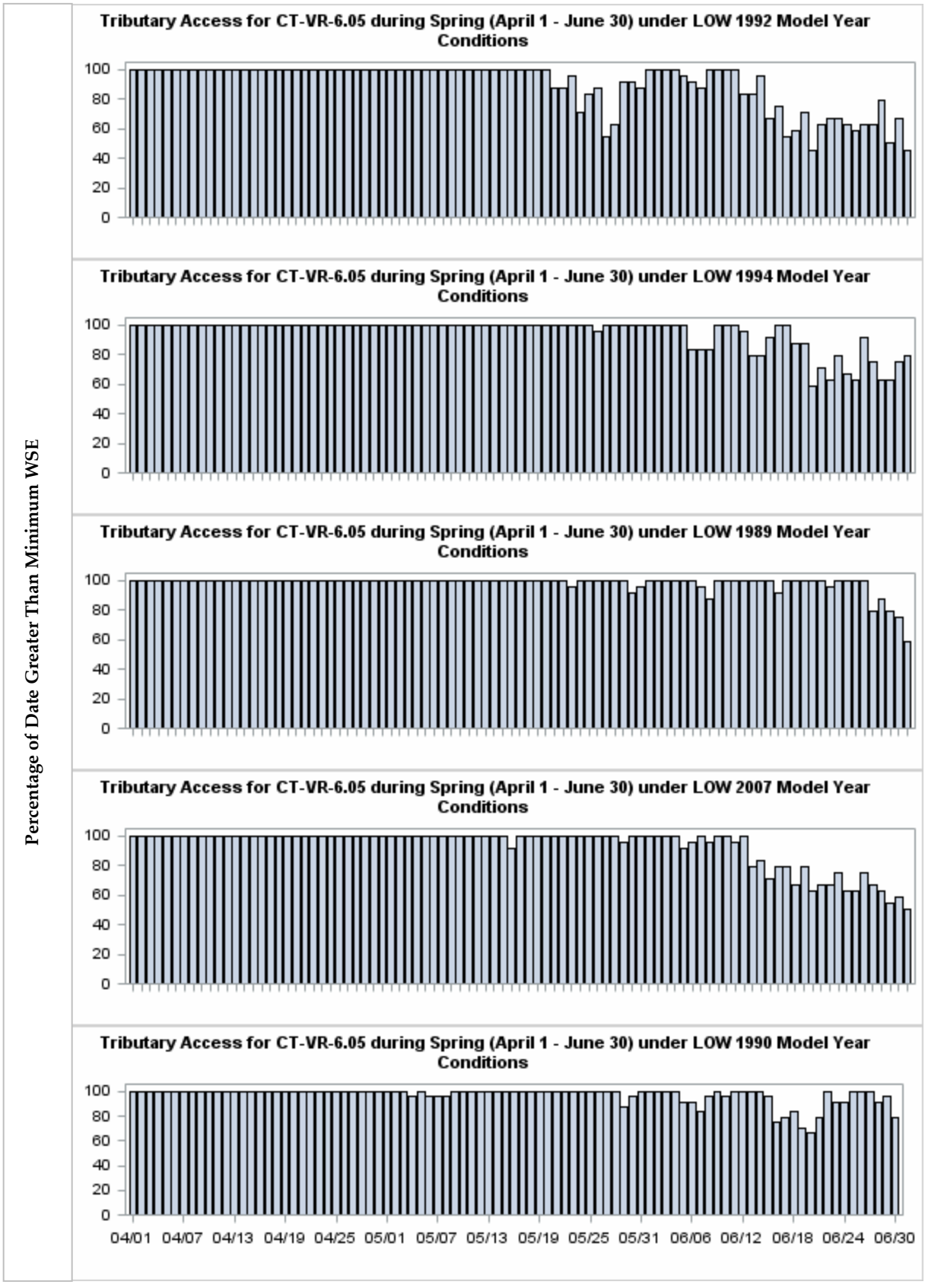

Figure 37. Percentage of spring dates (April 1 – June 30) where mainstem WSE provides adequate fish access during five model years at Site CT-VR-6.05 (Turners Falls elevation = low).