

UNITED STATES OF AMERICA  
BEFORE THE  
FEDERAL ENERGY REGULATORY COMMISSION

**TRANSCANADA HYDRO NORTHEAST INC.**

**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)**

**Volume III.A**

**Study 13 – Tributary and Backwater Fish Access and Habitats**  
**Study Report**

**Updated Study Report**

**September 14, 2015**

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**TRANSCANADA HYDRO NORTHEAST INC.**

**ILP Study 13**  
**Tributary and Backwater Fish Access and Habitats**  
**Study**

***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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**September 14, 2015**

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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.

Twenty-three of the 37 study sites showed no project effect on fish access or habitat (e.g., water depth and water level fluctuation under the full range of TransCanada operating conditions. Water quality at all sites was generally within state water quality standards, and not discernably affected by project operations.

The 10 remaining sites underwent additional analysis. Four of these sites were also shown to have no project effect. Two sites were shown to have minimal project effects and two more have some potential for stranding under low tributary and mainstem conditions. The two sites located in the Vernon riverine section just below Vernon Dam are apparently more influenced by the downstream Turners Falls project impoundment elevation and operations than by Vernon operations.

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### 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
VTDEC	Vermont Department of Environmental Conservation
WSE	Water surface elevation

## 1.0 INTRODUCTION

This study report presents the initial findings of the 2014 Tributary and Backwater Area Fish Access and Habitats Study (Study 13) 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. Study Plan 13, 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.

This report provides results from Study 13 from data collected at the selected tributaries and backwater locations during the period July-November, 2014 and 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.

## 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). A total of 36 randomly selected sampling locations were identified and one additional site (Cold River, ID CT-BR-4.02) was added to the study at the request of NHFGD. The numbers of sample sites by sub-reach visited during 2014 were:

Upper Wilder Impoundment – 4 locations  
Middle Wilder Impoundment – 5 locations  
Lower Wilder Impoundment – 5 locations  
Upper Wilder Riverine – 2 locations  
Lower Wilder Riverine – 3 locations  
Bellows Falls Impoundment – 6 locations  
Bellows Falls Riverine – 3 locations  
Vernon Impoundment – 7 locations  
Vernon Riverine – 2 locations

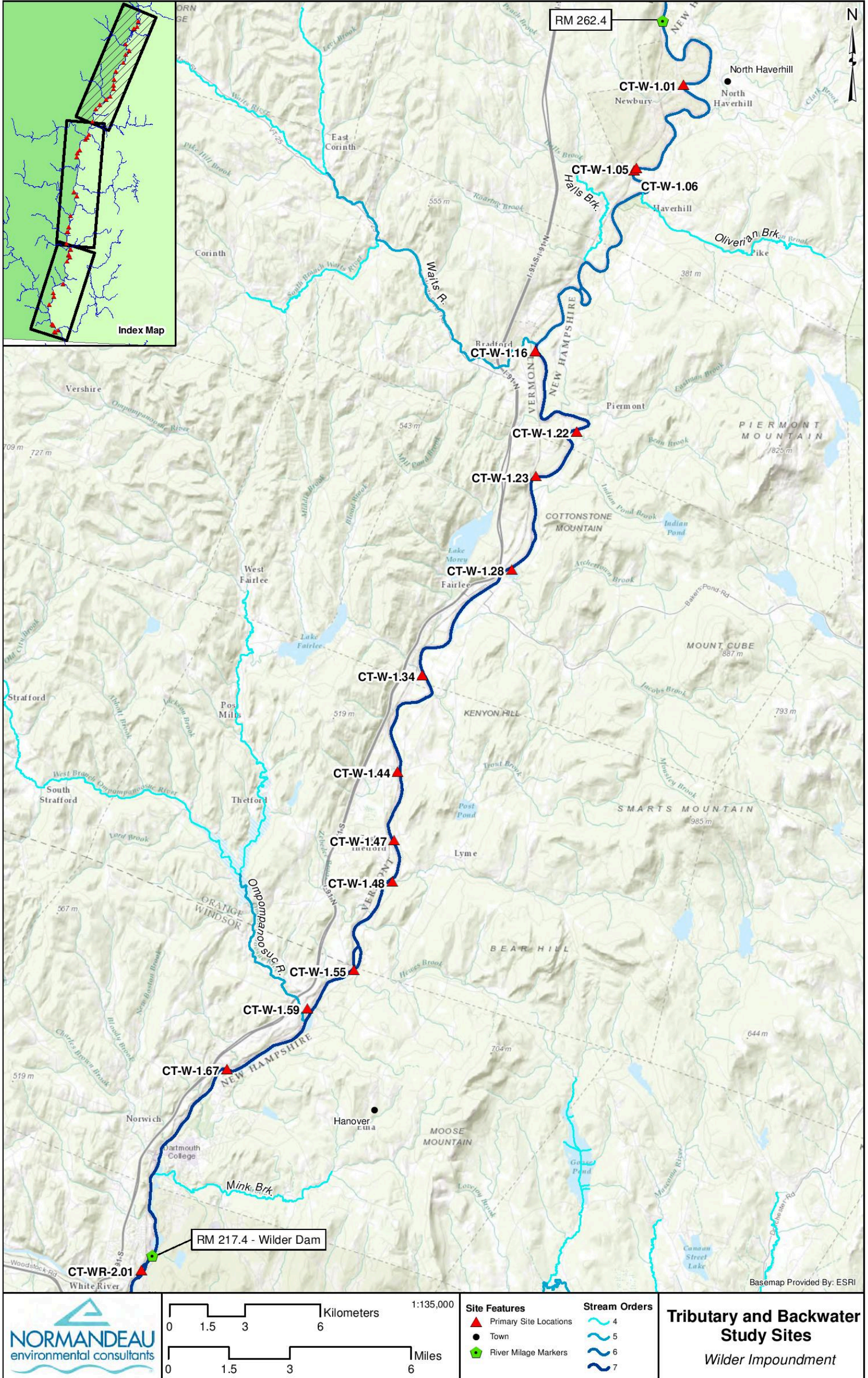
A full listing of the 37 study sites is presented in tabular format in Table 3-1 and graphically in Figure 3-1.

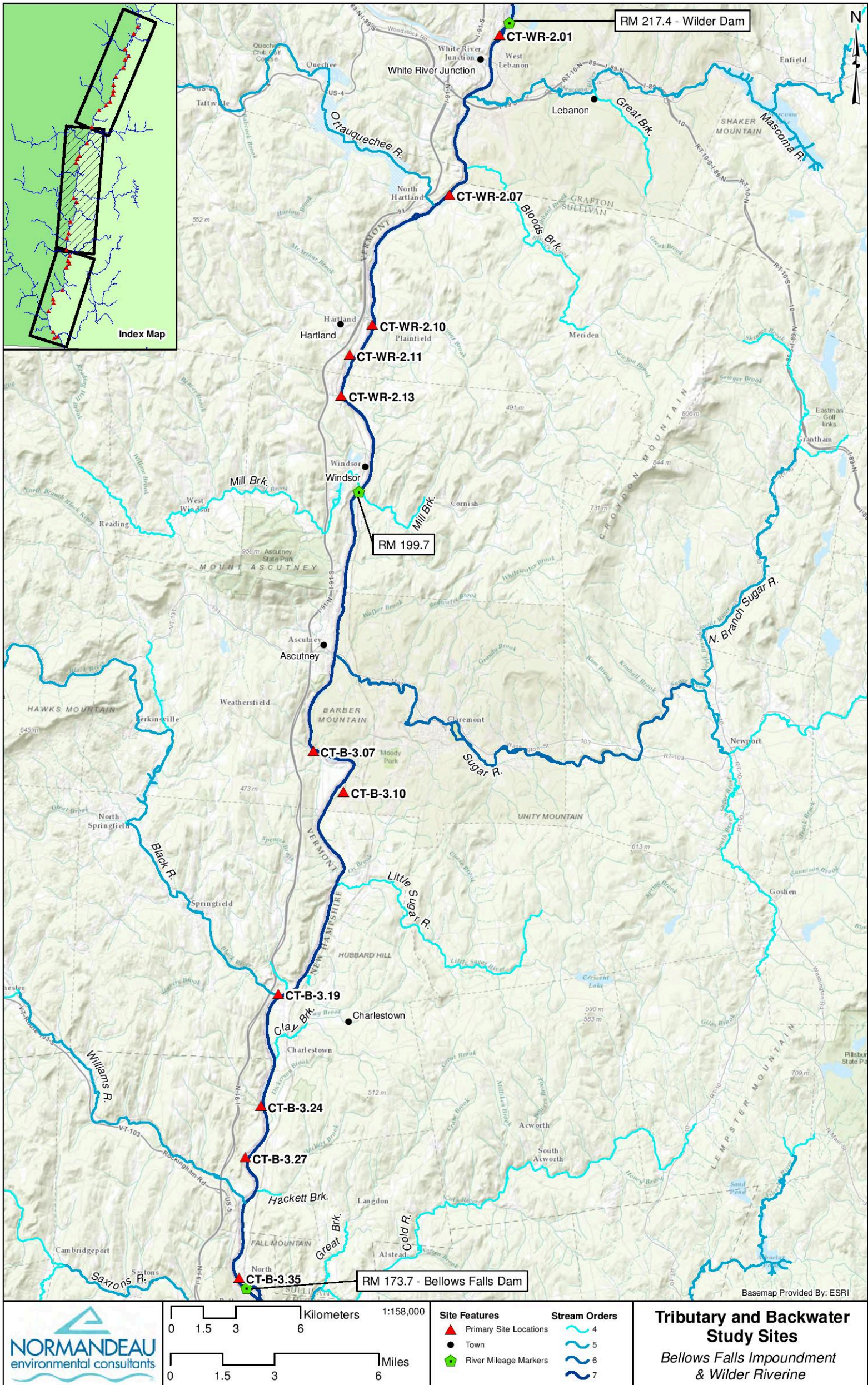
Table 3-1. Tributary and backwater study locations.

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		0	-72.067176	44.058021
CT-W-1.06	Upper Wilder	Minor Trib		2	-72.068263	44.057211
CT-W-1.16	Upper Wilder	Backwater		0	-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		0	-72.128038	43.913834
CT-W-1.34	Middle Wilder	Minor Trib		2	-72.171864	43.875890
CT-W-1.44	Middle Wilder	Backwater		0	-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		0	-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		0	-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

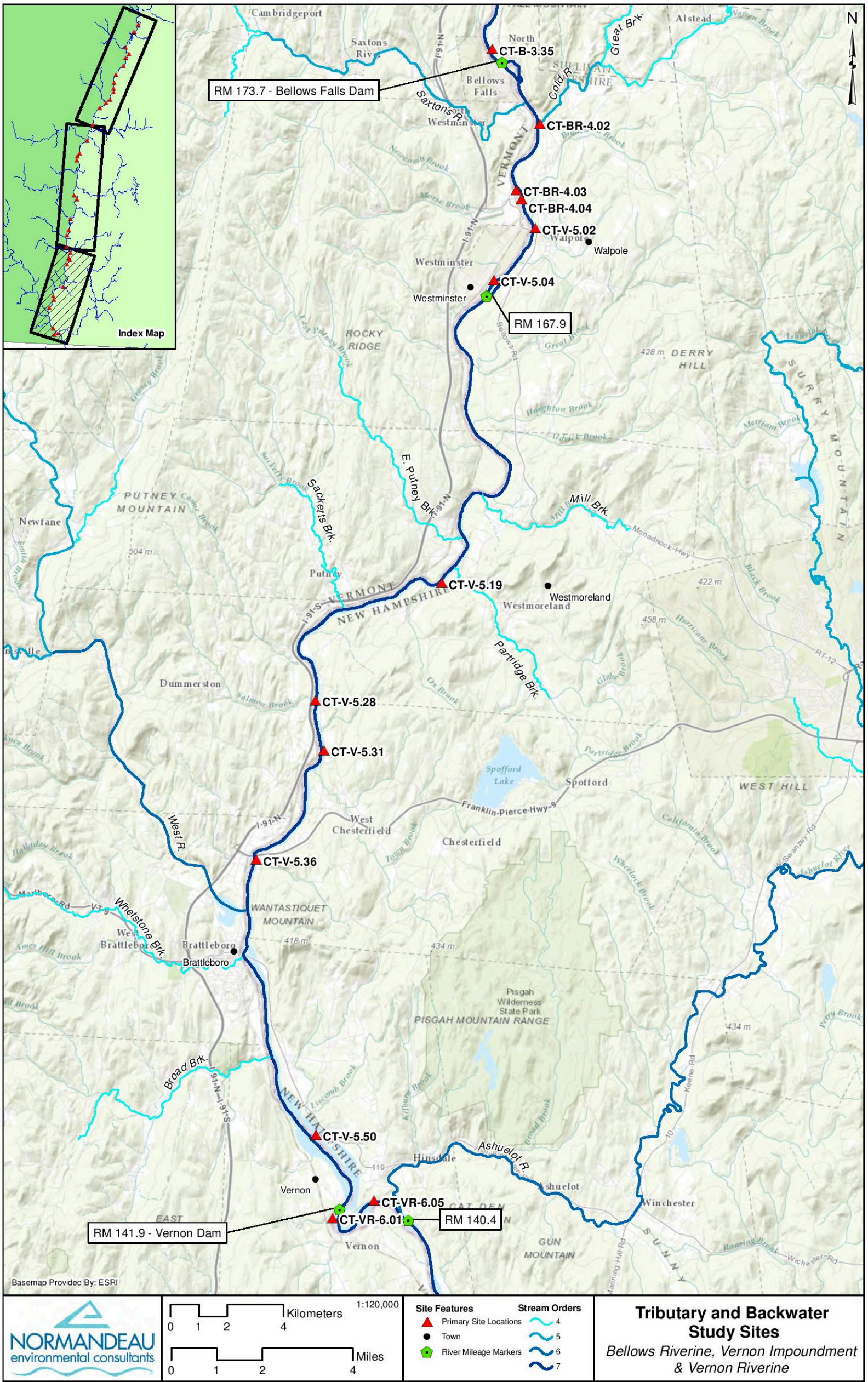
Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Coordinates	
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	-72.526038	42.933915
CT-V-5.31	Vernon	Minor Trib		2	-72.521983	42.918029
CT-V-5.36	Vernon	Minor Trib		2	-72.550993	42.882986
CT-V-5.50	Vernon	Backwater		0	-72.523771	42.795522
CT-VR-6.01	Vernon Riverine	Minor Trib		2	-72.516318	42.768916
CT-VR-6.05	Vernon Riverine	Minor Trib		1	-72.498398	42.774687

Figure 3-1. Tributary and backwater study locations.









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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  $\pm 0.1$  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  $\frac{3}{4}$ -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 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  $\geq 99\%$  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 HOBOWare 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 $\leq$	Reject if $\geq$
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. Only Rainbow Trout, a non-native salmonid stocked for recreational purposes, would potentially spawn during the fall. 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 also somewhat drier than normal. Monthly precipitation data is 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 remain some data gaps at some sites. For instance, at this time there is no mainstem level logger data associated with the Cold River (site CT-BR 4.02). Mainstem data for that site was to be collected from a water level logger that had been overwintered in 2013 to 2014. Divers were unable to search for and retrieve

that logger in early summer but presumed it to be in place and operational. When the level logger was searched by divers in October it was found to be missing and a replacement unit was installed. However, data from October 10 through the last site visit on November 10 may become available after 2015 spring high flows when divers will attempt to retrieve the level logger which is being overwintered again from 2014 to 2015.

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 site visits and level logger data notes.

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Initial Visit	2 <sup>nd</sup> Visit	3 <sup>rd</sup> 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		0	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		0	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		0	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		0	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		0	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	2 <sup>nd</sup> Visit	3 <sup>rd</sup> 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		0	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	2 <sup>nd</sup> Visit	3 <sup>rd</sup> 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 is being overwintered again in 2014/2015. Data after 10/09 will not be available until unit can be successfully retrieved and downloaded in spring 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		0	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 are summarized in Table 5.2-1. This information 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, and notes and observations related to tributary/backwater access limitations are presented.

Project-affected reach was estimated by extending the maximum mainstem WSE recorded during normal operating conditions (e.g., non-spill periods) up into the tributary or backwater to the thalweg point where that value was first reached. 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 (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. Further analysis to determine the primary driver for water surface elevations in the Upper Wilder impoundment is necessary and will require the hydraulic model (Study 4) and/or comparison of upstream USGS gage data and Wilder dam elevation data with site specific water level logger WSE data. Preliminary results from the hydraulic model suggest upstream inflow has a significant influence on WSE in the Upper Wilder reach.

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 outflows based on visual observations and/or tributary level logger data, and one of those sites (CT-WR-2.10, McArthur Brook) had no natural outflow on 2 of the 3 site visits.

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. 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.

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, 25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> 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, 25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> 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.

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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	Beaver dam present.
CT-W-1.05		backwater	2119	1.2 – 2.3	Downed trees and branches, sediment limit depth at access channel.
CT-W-1.06		2	136	0.5 – 1.0	Culvert present, limited suitable habitat observed.
CT-W-1.16		backwater	416	1.0 – 1.5	Shallow areas observed in backwater access channel.
CT-W-1.22	Indian Pond Brook	3	1114	1.5 – 4.2	Downed logs, scour hole observed.
CT-W-1.23		1	263	0.1 – 1.6	Shallow, shoaled area observed.
CT-W-1.28		backwater	1285	5.6 – 7.2	Shallow areas observed.
CT-W-1.34		2	322	0.5 – 1.9	Shallow margins observed (November visit)
CT-W-1.44		backwater	1391	8.8 – 9.8	Culvert present, upper feeder stream is limited to natural outflow.
CT-W-1.47		1	683	1.9 – 2.9	Scour hole observed near confluence.
CT-W-1.48	Grant Brook	3	3338	5.7 – 6.6	Thalweg bed elevation variable.
CT-W-1.55		1	402	1.5 – 3.1	Downed trees and branches, thalweg bed elevation variable.
CT-W-1.59		2	1689	2.1 – 2.9	Culvert present with debris loading on culvert's chain link fence.
CT-W-1.67		2	804	5.3 – 6.7	Culvert present, variable thalweg bed elevation. A farm water withdrawal is present.
CT-WR-2.01		2	45	0.2 – 0.7	Perched culvert observed.
CT-WR-2.07	Hanchetts Brook	1	-1 <sup>1</sup>	0.3 – 0.4	Downed trees and branches observed.
CT-WR-2.10	McArthur Brook	2	160	0 – 2.0	Intermittent stream, no outflow on 2 of 3 visits.
CT-WR-2.11	Lulls Brook	3	688	0.6 – 1.7	Variable thalweg profile, debris and scour/deposition present.
CT-WR-2.13	Bashan Brook	1	-9 <sup>2</sup>	0.1 – 0.4	Manmade blockages observed.

Site #	Waterbody Name	Stream Order	Project-affected Reach (ft)	Observed Max. Depth Range (ft) at Confluence	Site Observations
CT-B-3.07	Barkmill Brook	3	113	0.6 – 1.3	Culvert present, shoaled area observed.
CT-B-3.10		1	117	0.7 – 1.7	Debris, shallow areas observed.
CT-B-3.19		backwater	2252	2.9 – 5.3	Shallow littoral margins observed.
CT-B-3.24	Commissary Brook	3	455	1.0 – 2.1	Downed trees and branches, thalweg profile variable.
CT-B-3.27		2	2422	5.1 – 6.4	Thalweg profile variable.
CT-B-3.35		2	64	3.6 – 4.4	Culvert present, thalweg profile variable.
CT-BR-4.02	Cold River	5	900 <sup>3</sup>	0.8 – 2.9	Cobble observed to have shifted between visits.
CT-BR-4.03		2	254	0.1 – 2.6	Downed trees and branches observed.
CT-BR-4.04	Cobb Brook	3	535	1.4 – 2.2	Culvert, downed trees and branches present.
CT-V-5.02	Mad Brook	2	80 <sup>3</sup>	0.7 – 1.1	Perched culvert present.
CT-V-5.04		3	157	1.2 – 1.9	Downed trees and branches, shallow thalweg profile near confluence.
CT-V-5.19		1	99	0.1 – 0.8	Thalweg profile varies.
CT-V-5.28	Salmon Brook	3	169	1.2 – 1.7	Culvert present.
CT-V-5.31		2	78	0.3 – 1.0	Culvert present, thalweg profile varies.
CT-V-5.36		2	275	0.7 – 1.9	Culvert and retaining wall present.
CT-V-5.50		backwater	4989	6.3 – 10.3	Some shallow areas and shallow littoral margins observed, thalweg profile varies.
CT-VR-6.01		2	125	0.2 – 0.4	Downed trees and branches present.
CT-VR-6.05		1	165	0.1 – 0.3	Downed trees and branches present.

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

### 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 (°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. Table 5.4-1 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.

Table 5.4-2 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°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°C (50°F), all but 3 occurred in the November sampling round. Similarly, of the 41 temperature readings above 20°C (68°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 (highlighted in pink in Table 5.4-1). Approximately 59% of all pH measurements were within state standards. In 3 sampling instances (less than 2% and highlighted in blue in Table 5.4-1), 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 466 µS/cm. Twenty-eight percent of conductivity measurements were less than

100  $\mu\text{S}/\text{cm}$ ; 53% were between 100 and 200  $\mu\text{S}/\text{cm}$ ; and 19% were greater than 200  $\mu\text{S}/\text{cm}$ . 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). These data are highlighted in yellow in Table 5.4-1.

Table 5.4-1. Summary of water quality data collected in 2014 at tributary and backwater sites.

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH <sup>1</sup>	Conductivity (µS/cm)	Turbidity (NTU)	DO <sup>2</sup> (mg/L) instan.	DO <sup>2</sup> (%) instan.
CT-W-1.01	Wilder	Harriman Brook	2	4-Aug-14	Mid	1.2	18.9	6.2	149	7.3	8.8	95.3
				26-Aug-14	Mid	1.0	21.9	7.0	177	4.2	8.6	98.1
				25-Sep-14	Mid	0.6	11.4	6.0	262	6.5	10.2	93.3
				4-Nov-14	Mid	1.0	3.6	5.8	139	265.0	13.6	103.1
CT-W-1.05	Wilder	backwater	0	4-Aug-14	Mid	1.0	23.4	5.7	83	2.7	7.9	94.3
				26-Aug-14	Mid	1.0	22.4	6.8	85	2.1	7.1	82.2
				25-Sep-14	Mid	2.4	17.3	5.4	85	2.4	8.9	92.4
				4-Nov-14	Mid	1.6	7.3	5.6	81	2.5	10.6	87.8
CT-W-1.06	Wilder		2	4-Aug-14	Mid	0.7	19.2	6.1	146	6.4	9.0	97.2
				26-Aug-14	Mid	1.0	17.9	6.9	192	1.8	10.0	105.0
				25-Sep-14	Mid	0.7	10.0	7.5	225	3.2	10.9	96.5
				4-Nov-14	Mid	0.5	6.1	5.8	177	1.8	13.0	108.1
CT-W-1.16	Wilder	backwater	0	6-Aug-14	Mid	1.0	22.0	8.8	112	3.2	7.5	85.2
				26-Aug-14	Mid	1.0	22.5	7.2	90	2.0	6.5	74.4
				25-Sep-14	Mid	2.8	17.0	6.4	86	3.0	9.2	95.7
				4-Nov-14	Mid	0.9	6.7	5.8	95	2.1	12.1	98.7
CT-W-1.22 <sup>3</sup>	Wilder	Indian Pond Brook	3	6-Aug-14	Mid	1.5	18.8	5.9	51	3.4	9.0	97.5
				26-Aug-14	Mid	1.0	18.1	6.3	70	1.2	8.7	92.1
				25-Sep-14	Surface	1.0	16.5	6.4	92	6.9	9.2	94.4
				25-Sep-14	Mid	3.0	12.2	6.3	82	-	10.2	94.6
				25-Sep-14	Bottom	5.0	11.6	6.3	80	-	10.2	93.9
				5-Nov-14	Mid	0.8	7.0	5.7	54	1.9	12.4	101.9
CT-W-1.23	Wilder		1	5-Aug-14	Mid	0.6	18.3	5.9	135	21.1	9.4	98.5
				26-Aug-14	Mid	1.0	23.5	6.8	98	6.7	8.0	91.2
				25-Sep-14	Mid	0.8	16.8	6.6	96	5.4	9.4	96.6
				5-Nov-14	Mid	0.1	7.3	5.8	146	2.5	11.5	95.9

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH <sup>1</sup>	Conductivity (µS/cm)	Turbidity (NTU)	DO <sup>2</sup> (mg/L) instan.	DO <sup>2</sup> (%) instan.
CT-W-1.28	Wilder	backwater	0	5-Aug-14	Mid	1.9	24.3	5.6	97	54.9	7.3	86.9
				25-Aug-14	Mid	1.5	26.8	7.0	85	2.6	7.8	98.1
				25-Sep-14	Surface	1.0	16.5	6.7	95	3.6	9.2	93.9
				25-Sep-14	Mid	2.0	16.8	6.6	96	3.6	9.1	93.7
				25-Sep-14	Bottom	4.0	16.2	6.6	103	3.6	8.1	82.8
				5-Nov-14	Mid	1.2	5.7	5.8	81	3.1	10.9	87.0
CT-W-1.34	Wilder		2	5-Aug-14	Mid	1.1	16.1	6.3	255	5.8	8.9	90.1
				25-Aug-14	Mid	1.0	18.1	6.5	351	2.6	7.9	83.6
				25-Sep-14	Mid	1.0	16.4	6.4	192	2.4	9.0	91.8
				5-Nov-14	Mid	0.2	9.1	6.1	370	4.5	10.0	87.0
CT-W-1.44	Wilder	backwater	0	5-Aug-14	Surface	1.0	21.3	9.1	146	1.8	6.8	78.5
				5-Aug-14	Mid	2.0	21.2	-	146	-	6.8	77.3
				5-Aug-14	Bottom	3.0	21.0	-	62	-	6.1	70.2
				26-Aug-14	Surface	1.0	20.6	7.4	128	2.2	7.6	84.9
				26-Aug-14	Mid	2.0	20.5	7.5	126	2.2	7.5	82.3
				26-Aug-14	Bottom	3.0	20.4	7.6	132	2.2	6.7	74.4
				25-Sep-14	Surface	1.0	16.6	6.6	120	14.4	9.2	94.1
				25-Sep-14	Mid	5.0	16.7	6.7	126	14.4	8.7	89.4
				25-Sep-14	Bottom	10.0	16.4	6.6	143	14.4	8.5	86.7
				20-Oct-14	Surface	1.0	13.4	6.5	98	4.7	9.1	87.6
				20-Oct-14	Mid	4.0	13.5	6.5	98	4.7	9.2	88.7
20-Oct-14	Bottom	8.0	13.8	6.4	79	4.7	9.3	89.7				
CT-W-1.47	Wilder		1	24-Jul-14	Mid	2.0	21.8	5.9	96	4.5	7.7	87.2
				25-Aug-14	Mid	1.0	20.3	6.3	135	1.5	8.6	95.0
				25-Sep-14	Mid	1.5	16.6	6.9	106	3.4	9.2	94.1
				3-Nov-14	Mid	2.0	6.1	5.8	99	4.1	10.1	81.8

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH <sup>1</sup>	Conductivity (µS/cm)	Turbidity (NTU)	DO <sup>2</sup> (mg/L) instan.	DO <sup>2</sup> (%) instan.
CT-W-1.48 <sup>4</sup>	Wilder	Grant Brook	3	25-Jul-14	Mid	1.1	17.4	6.1	132	1.8	10.2	106.1
				26-Aug-14	Surface	1.0	18.8	7.1	120	-	7.1	76.1
				26-Aug-14	Mid	1.5	18.2	7.0	127	-	7.4	78.5
				26-Aug-14	Bottom	3.5	16.9	7.0	139	-	7.6	79.0
				25-Sep-14	Surface	1.0	16.7	6.5	119	3.0	8.9	91.7
				25-Sep-14	Mid	3.0	15.9	6.5	123	3.0	9.1	92.3
				25-Sep-14	Bottom	5.0	13.9	6.6	158	3.0	11.1	97.3
				6-Nov-14	Mid	1.3	5.6	6.1	127	2.4	12.5	99.0
CT-W-1.55	Wilder		1	24-Jul-14	Mid	2.3	19.1	6.5	172	2.6	8.3	89.5
				25-Aug-14	Mid	1.0	18.9	6.6	149	2.0	8.3	89.3
				24-Sep-14	Mid	1.2	16.6	7.3	103	1.8	9.1	92.9
				6-Nov-14	Mid	1.0	6.2	6.3	228	9.6	10.8	87.7
CT-W-1.59	Wilder	backwater	0	23-Jul-14	Mid	2.0	27.5	6.7	198	1.9	8.5	106.7
				26-Aug-14	Mid	1.0	21.3	7.7	192	1.4	8.0	89.5
				24-Sep-14	Mid	2.6	15.7	6.8	18	2.3	7.9	79.6
				20-Oct-14	Mid	1.7	12.5	6.3	267	2.5	8.1	76.1
CT-W-1.67	Wilder		2	22-Jul-14	Surface	1.0	23.8	6.1	142	2.7	9.1	107.4
				22-Jul-14	Mid	2.0	21.9	6.0	179	-	9.8	111.4
				22-Jul-14	Bottom	3.0	21.4	6.2	188	-	9.7	109.8
				25-Aug-14	Surface	1.0	22.3	6.2	172	2.1	7.8	89.4
				25-Aug-14	Mid	2.0	21.0	6.2	164	-	8.3	91.5
				25-Aug-14	Bottom	3.0	20.5	6.0	165	-	7.0	77.9
				24-Sep-14	Surface	1.0	15.7	7.0	124	-	8.7	87.1
				24-Sep-14	Mid	2.0	15.7	6.9	123	-	8.7	87.1
				24-Sep-14	Bottom	3.0	15.7	6.9	122	-	8.4	83.6
20-Oct-14	Mid	2.0	12.4	6.3	123	7.7	6.9	65.1				
CT-WR-2.01	Wilder Riverine		2	23-Jul-14	Mid	0.1	11.6	6.3	461	1.0	10.6	98.0
				28-Aug-14	Mid	0.8	11.0	6.7	462	1.1	11.0	99.6
				23-Sep-14	Mid	0.5	9.3	7.2	466	0.4	11.5	100.2
				6-Nov-14	Mid	0.6	8.7	6.6	462	29.0	11.6	100.2

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH <sup>1</sup>	Conductivity (µS/cm)	Turbidity (NTU)	DO <sup>2</sup> (mg/L) instan.	DO <sup>2</sup> (%) instan.
CT-WR-2.07	Wilder Riverine	Hanchetts Brook	1	22-Jul-14	Mid	0.5	16.1	7.1	127	1.9	9.3	94.6
				28-Aug-14	Mid	0.4	18.3	6.6	136	1.1	9.0	96.2
				23-Sep-14	Mid	0.3	10.3	7.0	149	0.5	10.8	96.2
				6-Nov-14	Mid	0.5	6.5	6.0	125	0.5	12.2	99.1
CT-WR-2.10 <sup>5</sup>	Wilder Riverine	McArthur Brook	2	2-Sep-14	Mid	0.2	14.8	6.6	356	-	6.9	68.5
				7-Nov-14	Mid	1.1	6.9	6.2	309	0.3	12.4	102.5
CT-WR-2.11	Wilder Riverine	Lulls Brook	3	28-Aug-14	Mid	1.0	19.3	6.5	204	6.3	9.0	98.8
				24-Sep-14	Mid	1.2	12.4	7.6	288	0.9	11.8	110.8
				7-Nov-14	Mid	0.9	6.2	6.2	226	0.8	13.0	105.2
CT-WR-2.13	Wilder Riverine	Bashan Brook	1	22-Jul-14	Mid	0.5	18.0	7.1	297	4.3	9.5	100.4
				28-Aug-14	Mid	0.3	17.3	6.7	245	4.7	9.7	99.8
				24-Sep-14	Mid	0.2	13.3	7.2	388	1.2	11.1	106.3
				7-Nov-14	Mid	0.4	6.5	6.3	237	0.3	12.6	102.4
CT-B-3.07	Bellows Falls	Barkmill Brook	3	28-Jul-14	Mid	1.4	18.4	6.7	90	21.8	9.4	99.9
				27-Aug-14	Mid	1.0	16.8	7.5	158	0.7	7.9	81.1
				22-Sep-14	Mid	1.2	13.0	6.9	185	0.3	9.8	91.9
				7-Nov-14	Mid	0.3	5.9	6.1	127	0.6	12.9	103.4
CT-B-3.10	Bellows Falls		1	28-Jul-14	Mid	0.9	17.2	6.6	441	1.6	9.5	98.7
				27-Aug-14	Mid	1.0	14.5	7.1	241	0.5	8.5	82.4
				22-Sep-14	Mid	0.2	14.3	7.2	399	0.9	10.4	101.2
				7-Nov-14	Mid	1.3	6.9	6.3	404	0.3	11.7	96.0
CT-B-3.19	Bellows Falls	backwater	0	27-Jul-14	Mid	2.0	24.5	6.4	153	19.1	8.3	97.9
				27-Aug-14	Surface	1.0	22.4	7.5	131	3.1	7.5	85.5
				27-Aug-14	Mid	3.0	21.1	7.4	125	3.1	6.9	76.5
				27-Aug-14	Bottom	6.0	20.4	7.2	123	3.1	7.3	79.8
				23-Sep-14	Surface	1.0	17.4	7.3	158	4.0	8.9	92.5
				23-Sep-14	Mid	3.0	17.1	7.4	158	4.0	8.7	89.3
				23-Sep-14	Bottom	6.0	16.5	7.4	158	4.0	7.8	79.6
8-Nov-14	Mid	1.4	5.1	6.4	132	4.6	12.6	98.4				



Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH <sup>1</sup>	Conductivity (µS/cm)	Turbidity (NTU)	DO <sup>2</sup> (mg/L) instan.	DO <sup>2</sup> (%) instan.
CT-B-3.24 <sup>6</sup>	Bellows Falls	Commissary Brook	3	27-Jul-14	Mid	1.0	17.5	6.7	126	257.0	9.3	96.8
				27-Aug-14	Mid	1.0	18.4	7.5	172	2.0	8.9	95.2
				23-Sep-14	Mid	2.1	11.7	7.4	200	3.6	11.2	103.8
				8-Nov-14	Mid	0.8	5.2	6.5	147	1.1	13.7	109.0
CT-B-3.27	Bellows Falls		2	26-Jul-14	Mid	1.8	25.2	5.4	132	7.3	5.7	66.6
				27-Aug-14	Surface	1.0	24.1	6.7	129	16.3	5.7	67.7
				27-Aug-14	Mid	2.0	22.2	6.7	147	16.3	4.3	50.1
				27-Aug-14	Bottom	3.5	21.3	6.5	161	16.3	1.9	22.1
				23-Sep-14	Surface	1.0	18.8	7.4	140	4.7	8.3	89.1
				23-Sep-14	Mid	3.0	17.2	7.4	140	4.7	7.7	80.2
				23-Sep-14	Bottom	5.0	16.6	7.4	133	4.7	6.9	76.4
				8-Nov-14	Mid	1.2	6.7	6.5	108	12.7	10.1	82.0
CT-B-3.35	Bellows Falls		2	26-Jul-14	Mid	1.5	18.9	6.5	62	16.4	7.5	80.6
				27-Aug-14	Mid	1.0	22.8	7.0	84	3.9	8.0	93.5
				23-Sep-14	Mid	2.2	19.7	7.6	136	2.4	8.8	95.5
				8-Nov-14	Mid	1.6	7.3	6.0	55	4.8	11.6	96.6
CT-BR-4.02	Bellows Riverine	Cold River	5	21-Jul-14	Mid	1.0	21.9	5.7	70	1.1	11.2	127.4
				27-Aug-14	Mid	1.0	21.9	6.9	77	1.7	8.9	101.2
				22-Sep-14	Mid	1.1	15.7	6.3	91	1.7	10.1	101.6
				10-Nov-14	Mid	1.5	4.5	6.9	61	0.5	14.0	107.7
CT-BR-4.03	Bellows Riverine		2	11-Aug-14	Mid	0.7	14.9	5.0	320	31.3	2.1	20.8
				10-Sep-14	Mid	0.5	13.7	6.5	248	0.8	7.3	74.6
				9-Nov-14	Mid	0.8	7.0	6.4	206	9.7	9.2	76.3
CT-BR-4.04	Bellows Riverine	Cobb Brook	3	11-Aug-14	Mid	1.7	18.0	6.1	78	2.8	9.0	94.7
				10-Sep-14	Mid	1.9	14.7	7.2	91	3.1	9.8	96.9
				9-Nov-14	Mid	1.9	7.9	6.5	66	0.7	11.5	97.0
CT-V-5.02	Bellows Riverine/ Vernon	Mad Brook	2	8-Aug-14	Mid	1.6	18.4	-	188	3.9	8.2	87.0
				8-Sep-14	Mid	1.0	16.8	6.1	451	0.5	9.2	94.9
				8-Nov-14	Mid	1.5	6.8	6.5	279	1.3	12.3	101.1
CT-V-5.04	Vernon		3	7-Aug-14	Mid	1.5	18.8	6.0	278	9.0	8.1	87.6
				9-Sep-14	Mid	1.7	16.9	6.9	323	9.3	9.8	101.3
				11-Nov-14	Mid	1.4	6.3	7.6	279	4.2	11.8	96.0

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH <sup>1</sup>	Conductivity (µS/cm)	Turbidity (NTU)	DO <sup>2</sup> (mg/L) instan.	DO <sup>2</sup> (%) instan.
CT-V-5.19	Vernon		1	6-Aug-14	Mid	0.7	18.8	5.0	108	71.0	8.0	86.5
				9-Sep-14	Mid	0.6	16.5	6.2	145	2.1	6.5	64.5
				11-Nov-14	Mid	0.5	9.6	7.7	133	10.0	8.9	78.4
CT-V-5.28	Vernon	Salmon Brook	3	7-Aug-14	Mid	1.4	15.3	6.7	141	6.2	9.4	93.6
				9-Sep-14	Mid	1.2	15.3	6.7	146	0.6	10.7	107.1
				10-Nov-14	Mid	0.8	6.4	6.9	125	0.8	13.0	105.4
CT-V-5.31	Vernon		2	7-Aug-14	Mid	1.0	15.5	5.2	87	1.3	6.2	62.0
				9-Sep-14	Mid	0.9	16.7	5.8	82	0.7	6.9	70.8
				11-Nov-14	Mid	0.3	7.8	7.3	81	2.0	10.9	91.8
CT-V-5.36	Vernon		2	7-Aug-14	Mid	0.5	16.5	5.4	49	1.9	8.8	90.6
				9-Sep-14	Mid	0.4	15.6	6.3	60	0.7	10.3	103.5
				10-Nov-14	Mid	0.9	6.3	6.8	41	0.3	12.7	103.1
CT-V-5.50	Vernon	backwater	0	7-Aug-14	Surface	1.0	23.0	8.5	113	2.3	6.9	82.0
				7-Aug-14	Mid	2.5	22.5	-	115	-	6.8	81.5
				7-Aug-14	Bottom	5.0	22.0	-	119	-	6.4	75.0
				9-Sep-14	Surface	1.0	22.9	7.0	114	3.7	7.1	82.5
				9-Sep-14	Mid	4.0	22.4	6.7	117	3.7	7.1	81.4
				9-Sep-14	Bottom	8.0	22.1	6.7	125	3.7	5.9	67.1
				21-Oct-14	Surface	1.0	13.2	7.0	122	3.3	9.4	90.1
				21-Oct-14	Mid	3.0	13.2	6.9	120	3.3	9.1	87.2

1. Values of pH less than 6.5 are highlighted in pink; values greater than 8.0 are highlighted in blue.
2. Values for DO (mg/l) lower than 5.0 and values for DO (% saturation) lower than 70% are highlighted in yellow.
3. Site CT-W-1.22, Indian Pond Brook is the outlet of Indian Pond which is designated as impaired for pH (NHDES, 2012).
4. Site CT-W-1.48, Grant Brook has been identified as impaired based on fisheries bioassessments (NHDES, 2012).
5. Site CT-WR-2.10, McArthur Brook had no outflow on the 2 Sep site visit. Data was taken in a small standing pool in the stream channel.
6. Site CT-B-3.24, Commissary Brook has been identified as impaired for sediment due to bank failure and erosion from past clay mining (VTDEC, 2014).

Table 5.4-2. Summary of water quality data collected in 2014 and 2015 at tributary and backwater sites potentially affected by the closure of Vermont Yankee.

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH <sup>1</sup>	Conductivity (µS/cm)	Turbidity (NTU)	DO (mg/L) instan.	DO (%) instan.
CT-VR-6.01	Vernon Riverine		2	12-Aug-14	Mid	0.7	9.6	5.9	73	1.7	12.1	106.2
				9-Sep-14	Mid	0.8	9.1	6.4	74	0.4	12.9	111.9
				11-Nov-14	Mid	1.1	7.1	7.1	73	0.5	12.5	103.4
				17-Jun-15	Mid	1.5	16.8	7.2	96	n/a <sup>2</sup>	108.6	10.6
				29-Jul-15	Mid	0.4	13.7	7.0	108	n/a <sup>2</sup>	113.8	11.8
				26-Aug-15	Mid	1.5	17.7	7.3	105	2.1	111.3	10.6
CT-VR-6.05	Vernon Riverine		1	12-Aug-14	Mid	0.4	15.6	5.8	180	n/a <sup>2</sup>	10.2	102.3
				9-Sep-14	Mid	0.4	13.6	6.9	192	6.1	11.1	107.2
				11-Nov-14	Mid	0.9	8.4	7.3	194	7.8	11.8	100.9
				17-Jun-15	Mid	1.5	18.3	7.3	98	n/a <sup>2</sup>	113.6	10.7
				29-Jul-15	Mid	0.5	22.9	7.0	142	n/a <sup>2</sup>	105.9	9.1
				26-Aug-15	Mid	0.5	16.5	7.7	182	53	124.0	12.1

1. Values of pH less than 6.5 are highlighted in pink; values greater than 8.0 are highlighted in blue.
2. Turbidity meter did not calibrate in the field, recorded values were suspect.

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## **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, as well as by the operation of the Wilder, Bellows Falls and Vernon Projects. Assessment of project effects will rely 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. Hydraulic model derived water level elevations at these locations based upon project operations will provide critical information in the assessment.

### **6.1 Water Depth and Fluctuation**

Adequate access for fish to enter into tributaries and backwaters from the mainstem river was defined as water depths 0.5 ft or greater at the confluence cross section at least 75% of the time during the period of WSE data record (or conversely <0.5 ft less than 25% of the time). For sites that met these criteria, fish access was not considered to be adversely affected by project operations. As noted in Section 5.0, the observation period was limited for some sites due to missing or invalid level logger data; did not encompass the earlier spring season when most fish species would be likely to seek access to tributaries and backwaters for spawning and residency; and included the typically drier late summer/early fall months which in 2014 were drier than normal. Therefore, conditions at all study sites can reasonably be considered worst case.

#### **6.1.1 Initial Assessment**

The approximate percentage of time (occurrence of valid water level readings) < 0.5 ft of water depth at the confluence cross sections in the ranges of <25%, 25-49.9%, 50-74.9%, 75-99.9%, and 100% is summarized in Tables 6.1-1 (by study reach) and 6.1-2 (by stream order) and detailed for each site in Table 6.1-3. The majority of locations (27) had 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. Those sites met the initial assessment criteria, and it can be concluded that there is no likely adverse effect from water level fluctuations caused by project operations on fish access at those sites.

Occurrence of water depths < 0.5 feet or more at the confluence cross section more than 25% of the time (n = 8) were more predominant in smaller tributaries (i.e., stream order = 1 or 2) located within the riverine reaches. The 2 undetermined sites are CT-BR-4.02, Cold River and CT-V-5.02, Mad Brook and since there is no

mainstem data available for these sites, the initial assessment could not determine whether the sites are or are not affected by water fluctuations caused by project operations. Further analysis will require application of the hydraulic model and its specific cross-sections in the vicinity of these study sites.

Table 6.1-1. Percentage of occurrence of < 0.5 ft water depth at the confluence, by study reach.

Reach	Total # Sites	Percentage of occurrence of confluence cross section water depth less than 0.5 ft.					
		0%	0- <25%	25- <50%	50- <75%	>75%	Undetermined
Wilder Impoundment	14	8	6				
Wilder Riverine	5	1			2	2	
Bellows Falls Impoundment	6	3	2		1		
Bellows Falls Riverine	3		1	1			1
Vernon Impoundment	7	1	5				1
Vernon Riverine	2			1	1		
<b>All</b>	<b>37</b>	<b>13</b>	<b>14</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>2</b>

Table 6.1-2. Percentage of occurrence of < 0.5 ft water depth at the confluence, by stream order.

Stream Order	Total # Sites	Percentage of occurrence of confluence cross section water depth less than 0.5 ft.					
		0%	0- <25%	25- <50%	50- <75%	>75%	Undetermined
1	8	2	2	1	1	2	
2	14	4	6		3		1
3	8	3	4	1			
5	1						1
Backwater	6	4	2				
<b>All</b>	<b>37</b>	<b>13</b>	<b>14</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>2</b>

Table 6.1-3. Percentage of 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 at Confluence
CT-W-1.01	Upper Wilder	Minor Trib	Harriman Brook	2	0.02%
CT-W-1.05	Upper Wilder	Backwater		0	0.05%
CT-W-1.06	Upper Wilder	Minor Trib		2	13.6%
CT-W-1.16	Upper Wilder	Backwater		0	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		0	0%
CT-W-1.34	Middle Wilder	Minor Trib		2	0.4%
CT-W-1.44	Middle Wilder	Backwater		0	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		0	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		0	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



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

### 6.1.2 Potentially Affected Sites

The sites with confluence water depth <0.5 ft of water depth at least 25% of occurrences and the 2 sites with no mainstem WSE data 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 6.1-4 including the % 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. Sections 6.1.2.1 – 6.1.2.10 describe each site in more detail, and Tables 6.1-4 and 6.1-5 summarize relevant data.

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Table 6.1-4. Summary of conditions at potentially affected sites.

Site #	Sub Reach	Water Body Name	Stream Order	% of Time <0.5 ft Water Depth at Confluence	Project-Affected Reach Length (from confluence, ft)	Range of Water Depths at Confluence Measured on Site Visits (ft)	Range of Water Depths at Tributary Logger (ft)	Limited Data	Other Potential Factors
CT-WR-2.01	Upper Wilder Riverine		2	70.2%	45	0.2 – 0.7	0.0 – 3.8	Some tributary WSE data missing	Perched culvert.
CT-WR-2.07	Upper Wilder Riverine	Hanchetts Brook	1	95.8%	-1	0.3 – 0.4	0.5 – 2.2	Some tributary WSE and mainstem WSE data missing	Downed trees and branches present. Project-affect reach limited.
CT-WR-2.10	Lower Wilder Riverine	McArthur Brook	2	58.2%	16	0.0 – 2.0	0.4 – 4.7		Intermittent stream, no outflow on 2 of 3 visits.
CT-WR-2.13	Lower Wilder Riverine	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.
CT-B-3.10	Bellows Falls		1	68.3	117	0.7 – 1.7	0.9 – 2.2	Some mainstem WSE data missing	Debris, shallow areas observed.
CT-BR-4.02	Bellows Riverine	Cold River	5	Undetermined	~900	0.8 – 2.9	1.0 – 5.7	No mainstem WSE data available	Cobble observed to have shifted between site visits.
CT-BR-4.04	Bellows Riverine	Cobb Brook	3	40.5%	535	1.4 – 2.2	1.8 – 6.4		Culvert, downed trees and branches present.
CT-V-5.02	Vernon	Mad Brook	2	Undetermined	~ 80	0.7 – 1.1	0.8 – 4.8	No mainstem WSE data available	Perched culvert.
CT-VR-6.01	Vernon Riverine		2	58.6%	125	0.2 – 0.4	0.6 – 4.4		Downed trees and branches present.
CT-VR-6.05	Vernon Riverine		1	42.5%	165	0.1 – 0.3	0.1 – 3.6		Downed trees and branches present.

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Project operations data were reviewed for the period of available mainstem WSE data at each site. Table 6.1-5 summarizes minimum mainstem WSE needed to achieve 0.5 ft of water depth at the confluence cross section, along with maximum mainstem WSE values recorded during normal project operations, and maximum mainstem WSE values recorded over the entire period of record. There were occasional, mostly brief, periods of non-operational high water resulting in spillage at one or more of the projects that occurred during late July, in mid-August, and in late October 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. Wilder operations during that 7-day period ranged from minimum flow up to full or nearly full generation flow, providing a representative range of operations. 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. 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. For sites BR-4.02 (Cold River) and V-5.02 (Mad Brook), tributary WSE data were used as a proxy for mainstem WSE data which was unavailable for the entire study period.

Project operations during these time periods were plotted along with recorded site mainstem WSE data as well as the calculated site mainstem WSE needed to achieve 0.5 ft of water depth at the tributary confluence cross section. Figures 6.1-1 through Figure 6.1-12 in Sections 6.1.2.1 – 6.1.2.10 present these graphs for the 10 potentially affected sites. It should be noted that the two vertical scales on each graph (project discharge on the left and WSE on the right) are not correlated numerically, so that elevation data does not equate to specific project discharge levels, and vice versa at any point on the graphs.

Table 6.1-5. Mainstem WSE values recorded at potentially affected sites.

Site #	Minimum Mainstem WSE for 0.5 ft Confluence Water Depth (ft)	Maximum Project-Affected Mainstem WSE (ft)	Maximum Recorded Mainstem WSE (ft)
CT-WR-2.01	328.8	332.7	334.6
CT-WR-2.07	319.3	320.8	321.9
CT-WR-2.10	302.7	307.2	307.3
CT-WR-2.13	304.0	302.9	303.0
CT-B-3.10	289.8	290.4	290.9
CT-BR-4.02	223.7	No data	No data
CT-BR-4.04	220.2	224.5	225.7
CT-V-5.02	221.2	No data	No data
CT-VR-6.01	183.1	187.2	189.0
CT-VR-6.05	181.6	185.9	187.6

**6.1.2.1 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. Water depth at the confluence cross section was < 0.5 ft about 70% of the time during the period of record, and ranged from 0.2 to 0.7 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.0 to 3.8 ft based on limited tributary data. Figure 6.1-1 illustrates that mainstem water levels at the site closely track Wilder discharge flows. The thalweg profile within the project-affected reach is gradual without apparent stranding spots. It is likely that channel depths within the tributary are limited as part of its natural flow regime. As a result, potential access for fish into this small tributary is likely limited more by its own specific characteristics (i.e., limited outflow) than by TransCanada operations.

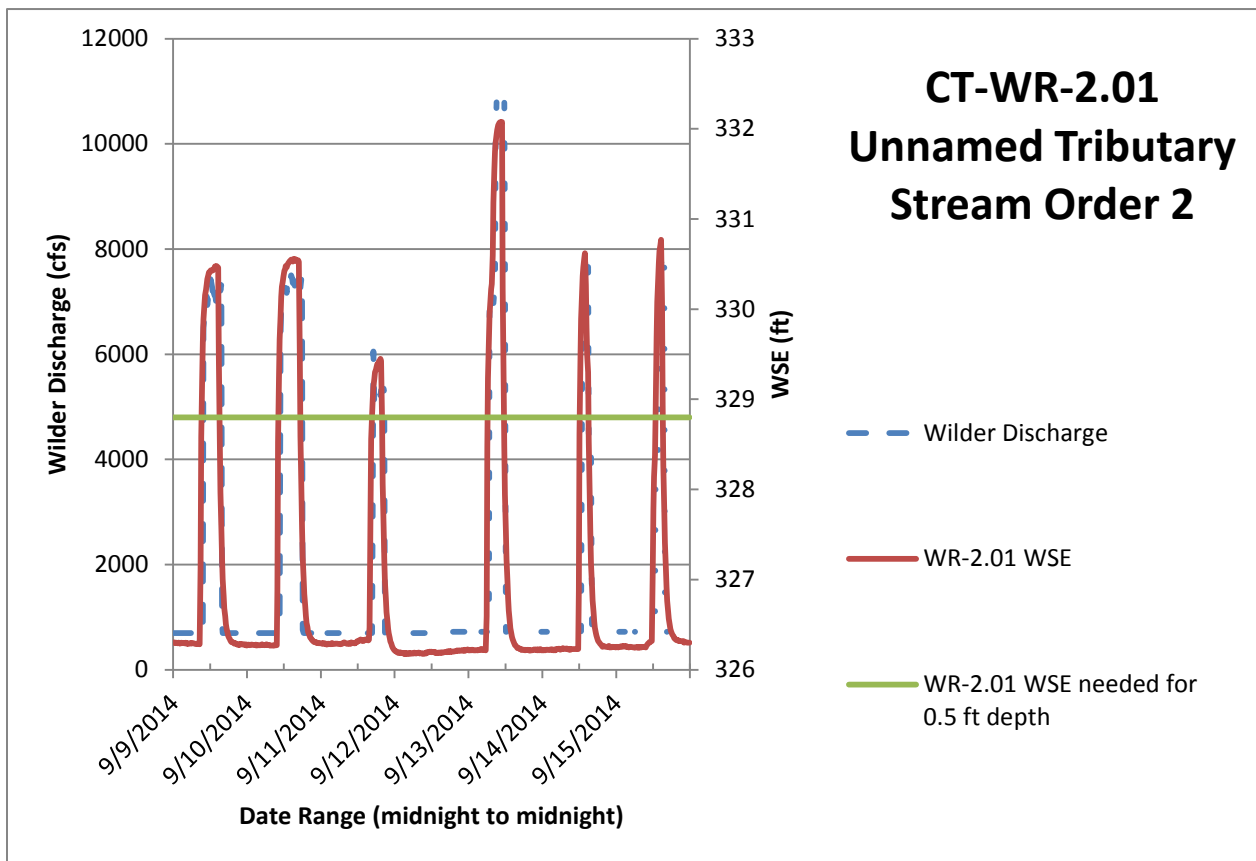


Figure 6.1-1. Representative operating conditions at Site CT-WR-2.01.

**6.1.2.2 Site CT-WR-2.07**

Site CT-WR-2.07, Hanchetts Brook, is a stream order 1 tributary located approximately 6 mi downstream from the Wilder Project. Downed trees and branches were observed that likely restrict mainstem flow into the tributary (see photographs in [Appendix A](#)). Water depth at the observed confluence cross section was less than 0.5 ft nearly 96% of the time based on limited mainstem data, and ranged from 0.3 to 0.4 ft as measured at site visits. The project-affected reach determined by WSE data, was calculated to be 1 ft closer to the mainstem than visually observed (e.g., at the tributary logger location). The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 319.3 ft and the maximum recorded project-affected WSE is 320.8 ft. Water depth at the tributary logger location ranged from 0.5 to 2.2 ft based on limited tributary data. Figure 6.1-2 illustrates that mainstem water levels at the site track Wilder discharge flows (with a slight time delay due to distance). The tributary thalweg profile changes in the vicinity of the project-affected reach which could create stranding under low mainstem and tributary 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 outflow).

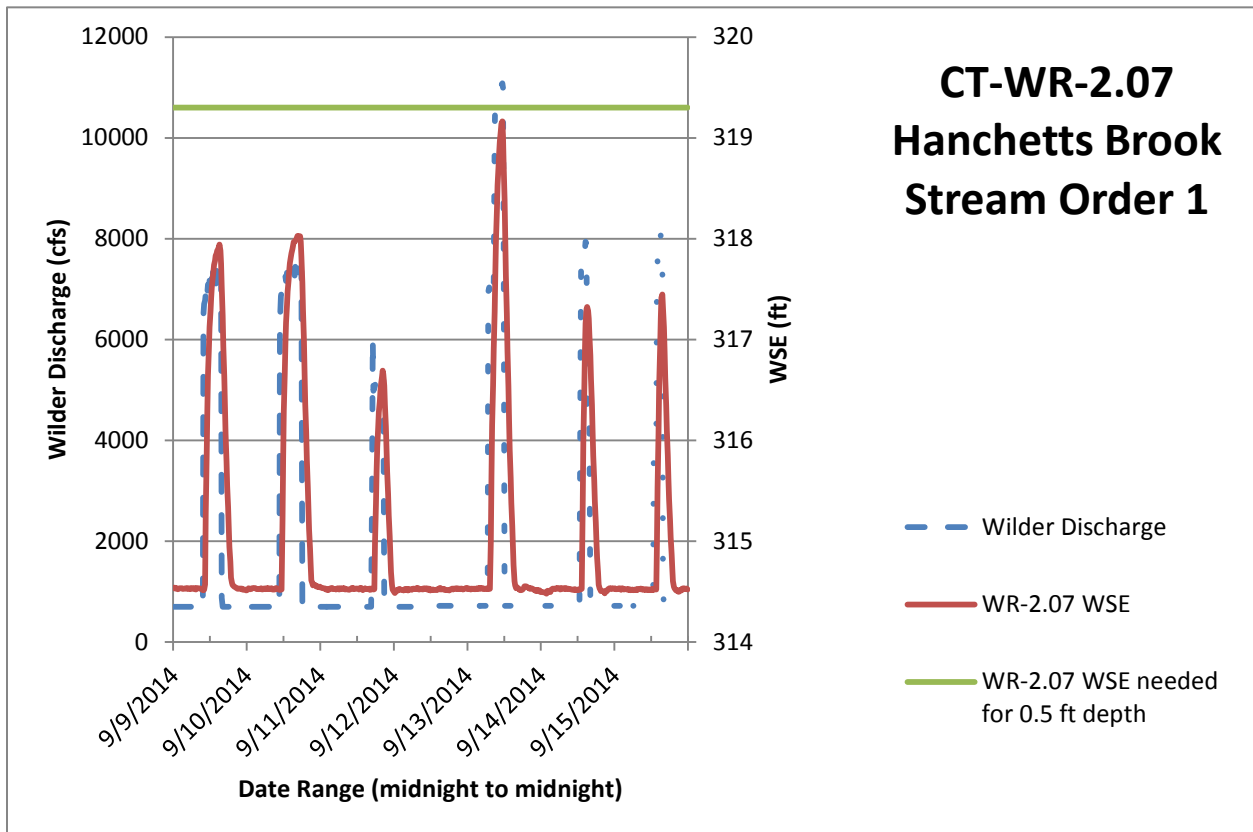


Figure 6.1-2. Representative operating conditions at Site CT-WR-2.07.

**6.1.2.3 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 outflow on 2 of 3 site visits. Even so, water depth at the confluence cross section was 0.5 ft or greater approximately 42% of the time during the study period. 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. Water depth at the confluence cross section ranged from 0.3 to 0.4 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 outflow which is unrelated to TransCanada operations.

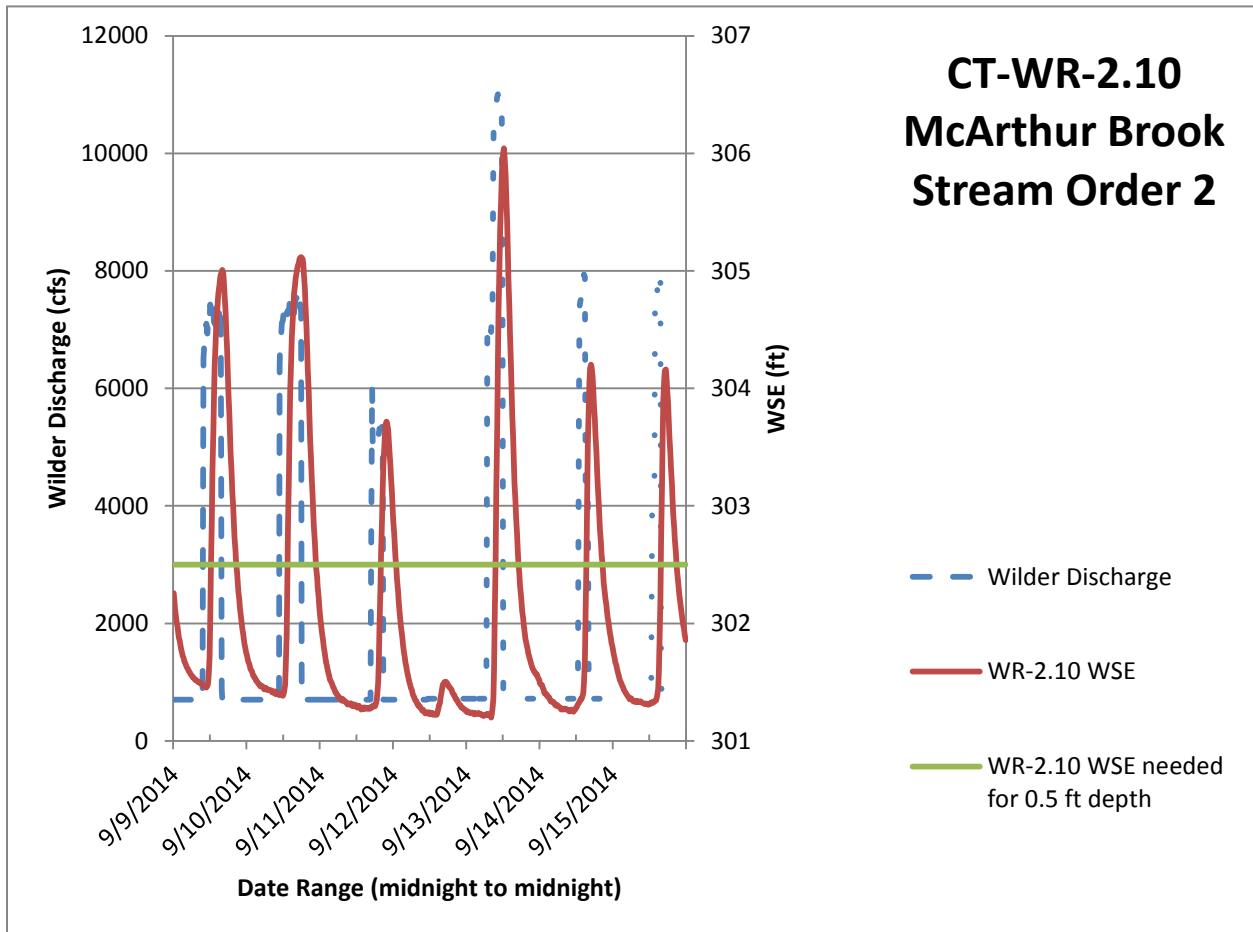


Figure 6.1-3. Representative operating conditions at Site CT-WR-2.10.



**6.1.2.4 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 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 project-affected reach determined by WSE data, was calculated to be 9 ft closer (elevation 302.9) to the mainstem than visually observed (e.g., at the tributary logger location), and upstream into the tributary from the tributary logger location. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 304.0 ft. 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 outflow under low mainstem and 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 likely limited more by its own specific characteristics (i.e., limited outflow) and anthropogenic factors than by TransCanada operations.

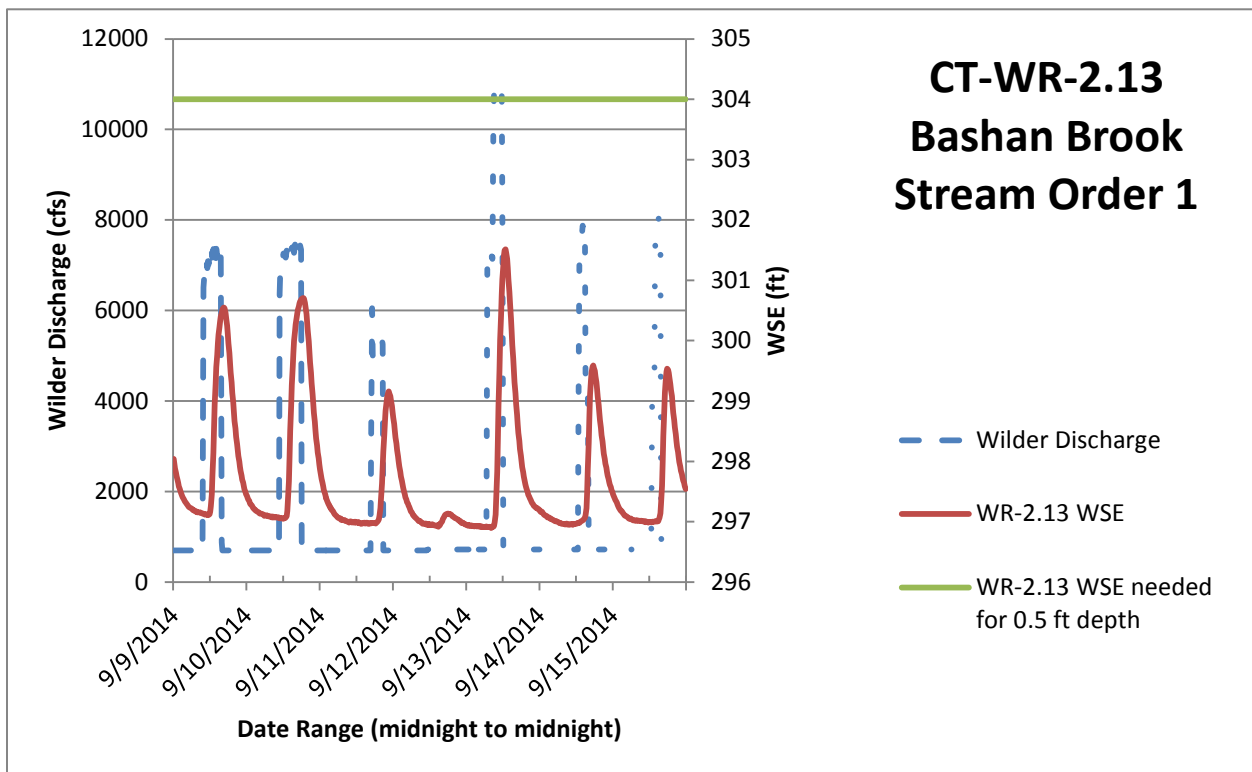


Figure 6.1-4. Representative operating conditions at Site CT-WR-2.13.

**6.1.2.5 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 WSE needed to achieve 0.5 ft depth at the confluence cross section is 289.8 ft. Water depth at the confluence cross section was less than 0.5 ft approximately 68.3% of the time based on limited mainstem water level logger data; however, water depths ranged from 0.7 to 1.7 ft as measured during the site visits. 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 (allowing for time differences due to distance from the project). The thalweg profile varies somewhat within the project-affected reach, and potential stranding spots are present. Therefore, access into this tributary may be limited by available water depths through shallower portions of the channel under low mainstem and tributary low flow conditions such as those observed during the November 7<sup>th</sup> site visit (see photographs in [Appendix A](#)).

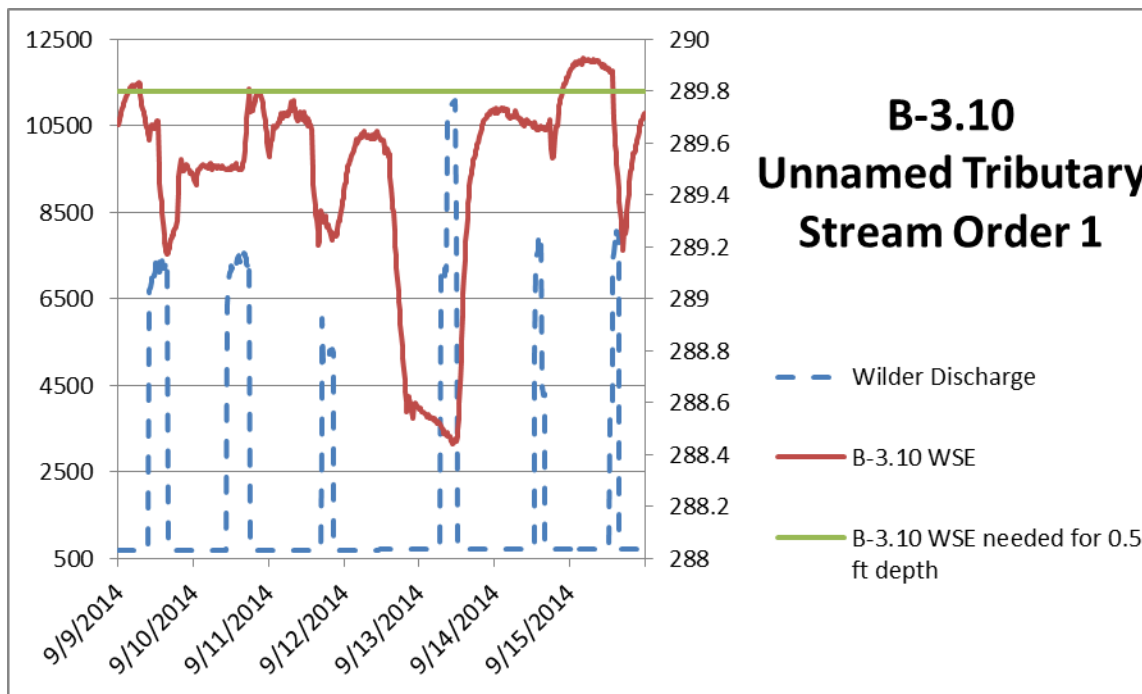


Figure 6.1-5. Representative operating conditions at Site CT-B-3.10.

**6.1.2.6 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. 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](#)). Since no mainstem data was available for the study period (see Section 5.1), the effects of fluctuations in mainstem WSE on the tributary are unknown at this time and in Figure 6.1-6, Cold River tributary WSE data was used as a proxy for the mainstem data. The figure illustrates that the minimum tributary water elevation recorded (224.6 ft) 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). The thalweg profile within the project-affected reach is slightly variable near the confluence, but not likely to create standing spots given the level of outflow from the Cold River which provides sufficient water depths for fish access under normal project operations.

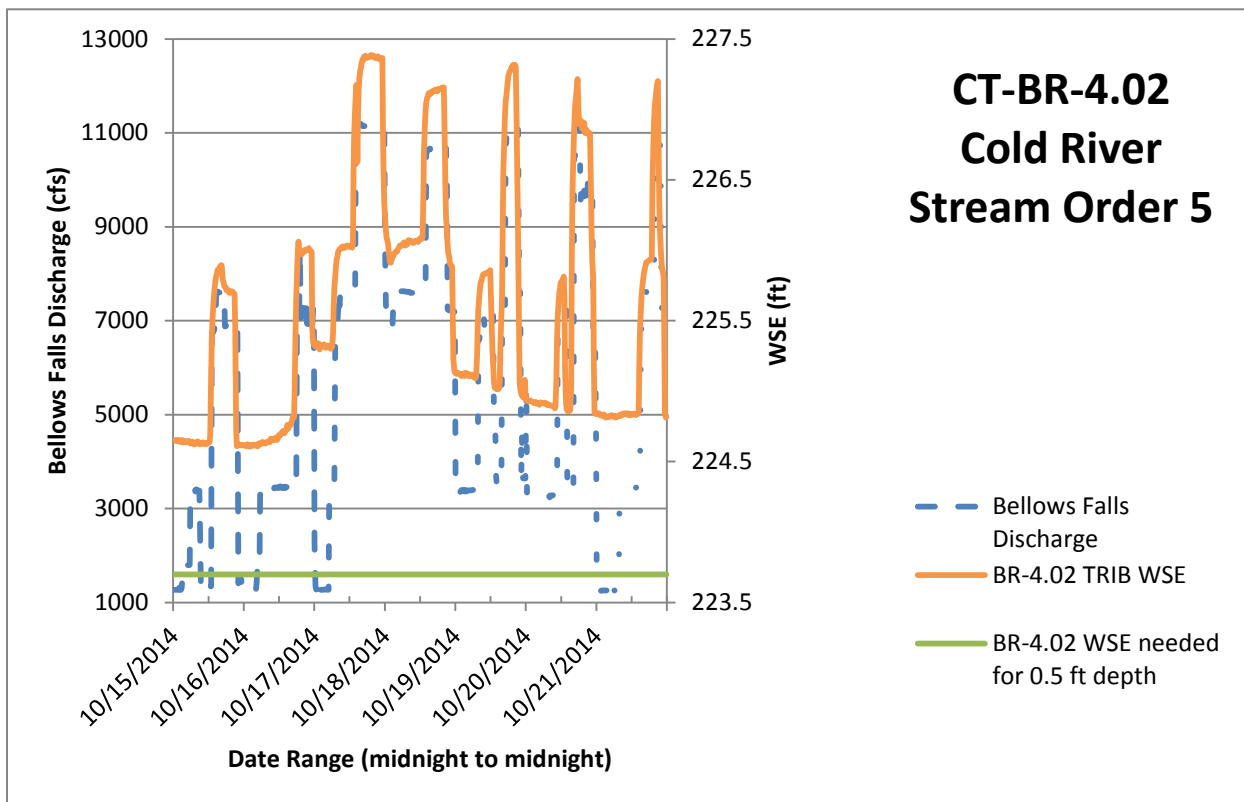


Figure 6.1-6. Representative operating conditions at Site CT-BR-4.02.

**6.1.2.7 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. 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 closely follow 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. Tributary outflow is generally sufficient to provide access, but could be limited for larger fish under low mainstem and tributary low flow conditions.

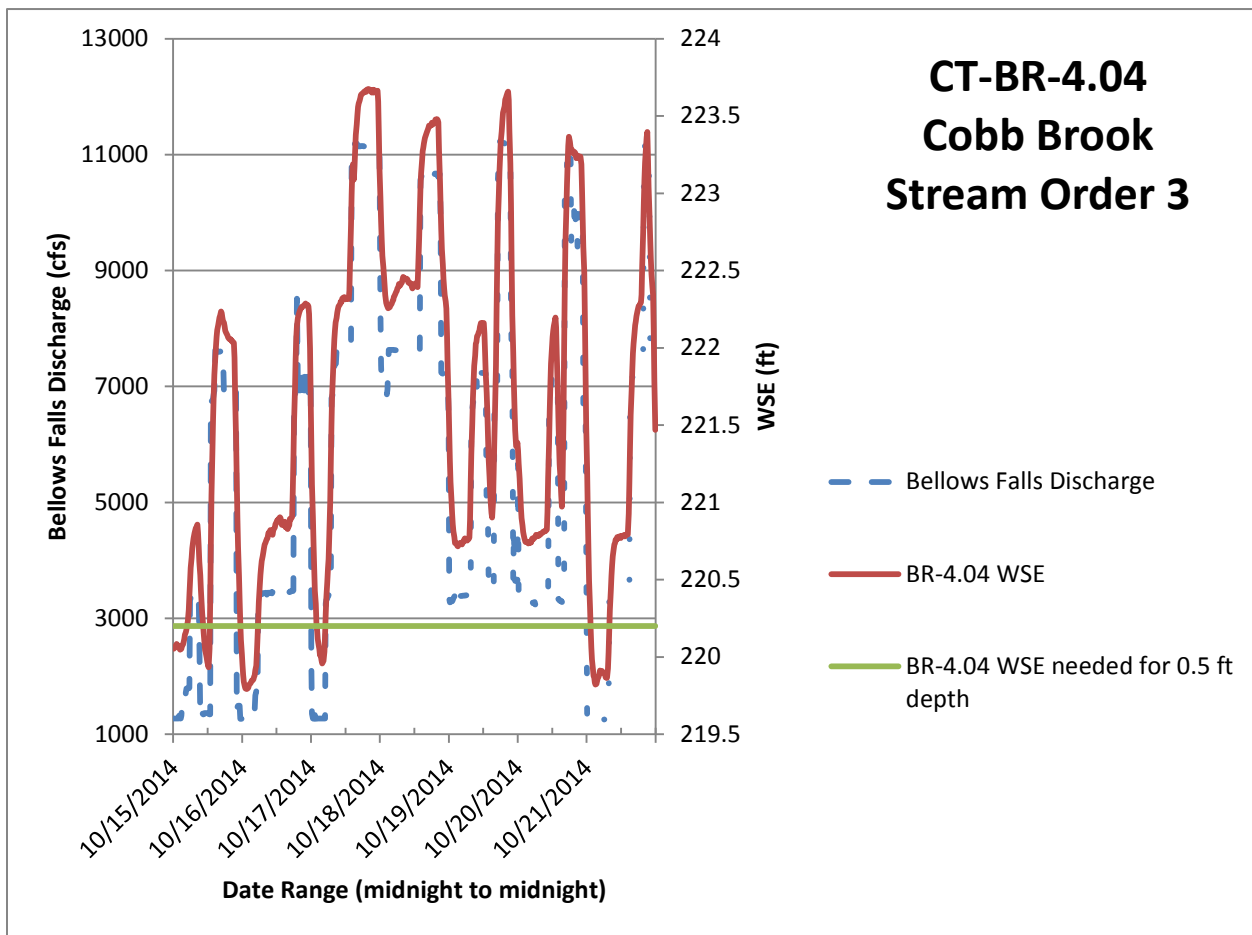


Figure 6.1-7. Representative operating conditions at Site CT-BR-4.04.

**6.1.2.8 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 and 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. Since no mainstem data was available for the study period, the effects of fluctuations in mainstem WSE on the tributary are unknown. In Figure 6.1-8, Mad Brook tributary WSE data was used as a proxy for the mainstem data. The figure illustrates that the minimum tributary water elevation recorded during the representative week (221.0 ft) and throughout the study period (220.9 ft, see [Appendix A](#)) were 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 under low mainstem and tributary conditions. Access into the tributary may be limited to the tributary’s natural outflow under low mainstem and tributary low flow conditions.

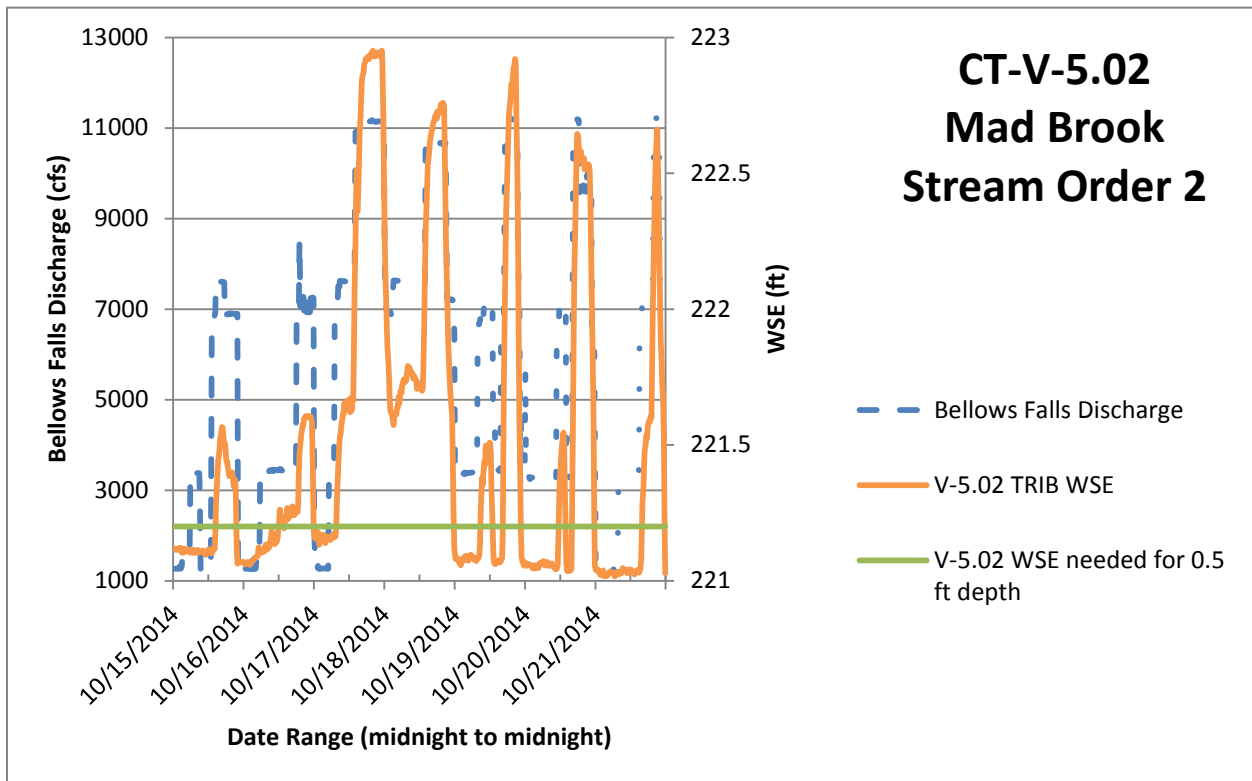


Figure 6.1-8. Representative operating conditions at Site CT-V-5.02.

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#### **6.1.2.9 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. 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. Figure 6.1-9 illustrates that mainstem water levels at the site closely track Vernon discharge flows.

This site is at the upper end of FirstLight's Turners Falls impoundment and therefore also influenced by FirstLight operations and impoundment elevation fluctuations. As a proxy for FirstLight operations, the figure includes Vernon tailwater elevations during the representative Vernon operating conditions (Figure 6.1-9), which may not be conditions representative of FirstLight's impoundment operations. 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 (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.

The thalweg profile varies slightly within the project-affected reach which could create stranding spots under low mainstem and tributary conditions. Therefore, access into this tributary by larger fish may be limited to the tributary's natural outflow under low mainstem and tributary low flow conditions.

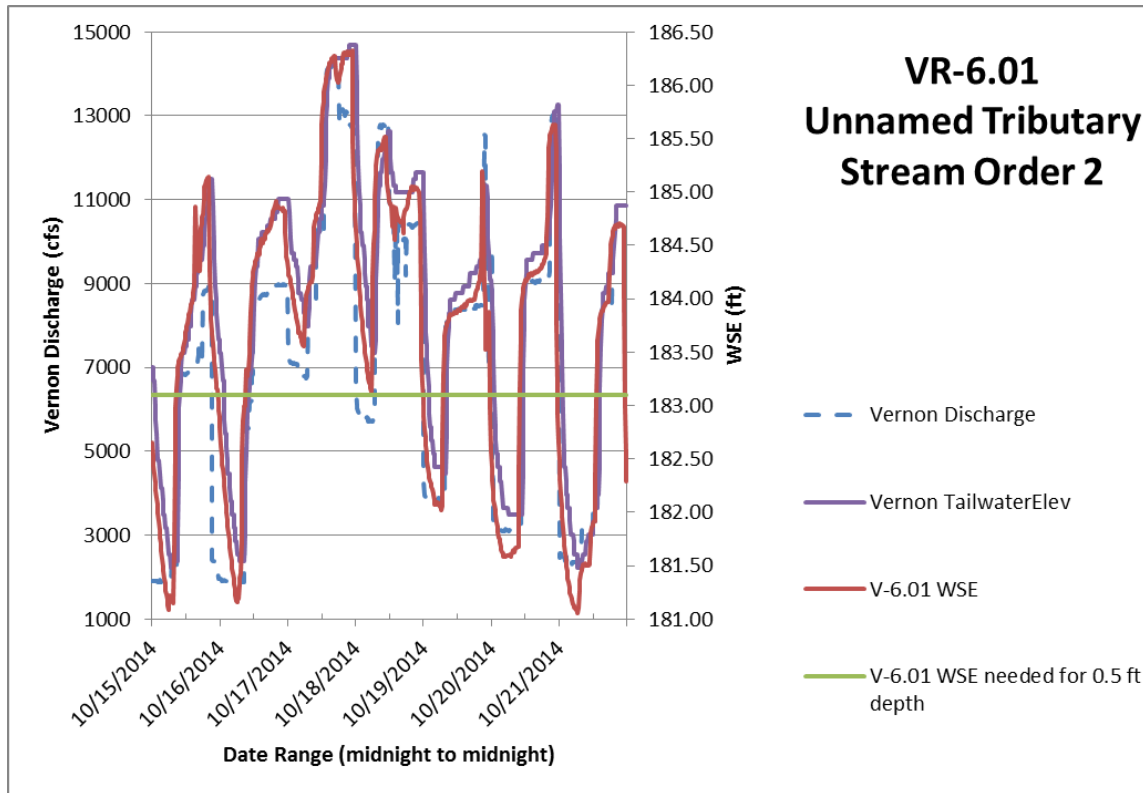


Figure 6.1-9. Representative operating conditions at Site CT-VR-6.01.

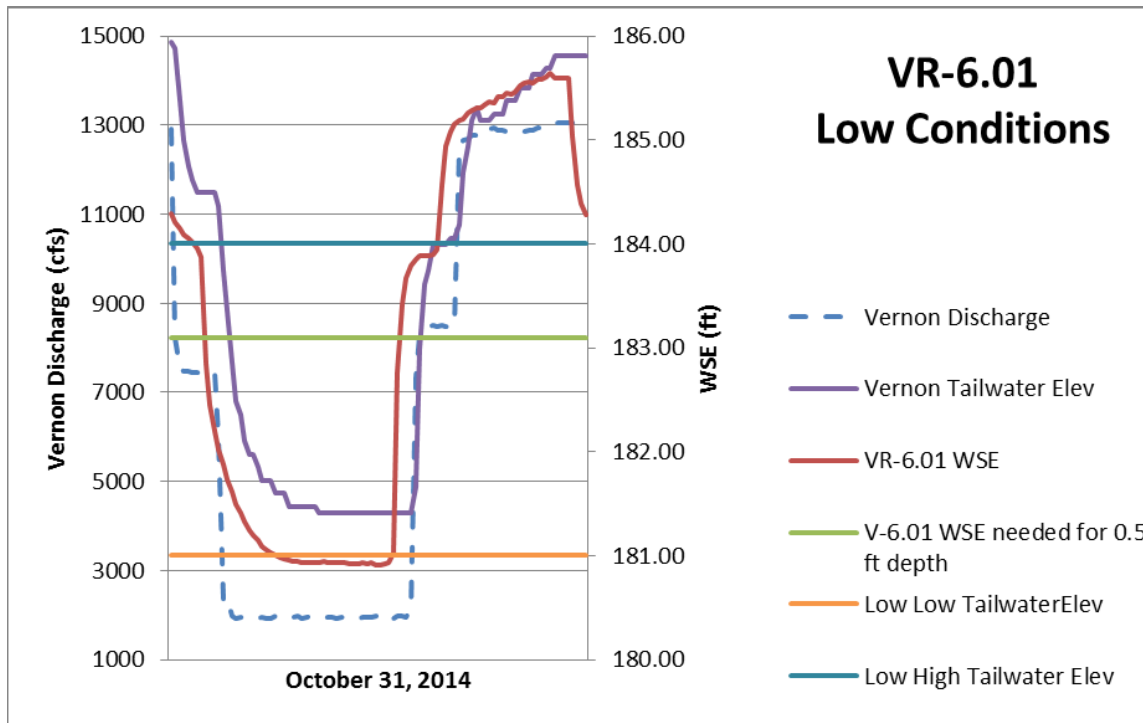


Figure 6.1-10. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.01.



#### **6.1.2.10 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 in a portion that is influenced by Vernon discharge and First Light's downstream projects. 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. 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. Figure 6.1-11 illustrates that mainstem water levels at the site closely follow Vernon discharge flows.

This site is at the upper end of FirstLight's Turners Falls impoundment and therefore also influenced by FirstLight operations and impoundment elevation fluctuations. As a proxy for FirstLight operations, the figure includes Vernon tailwater elevations during the representative Vernon operating conditions (Figure 6.1-11), which may not be conditions representative of FirstLight's impoundment operations. 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.

The thalweg profile varies slightly within the project-affected reach which could create stranding spots under low mainstem and tributary conditions. Access into this tributary is generally adequate, but may be limited to the tributary's natural under low mainstem and tributary low flow conditions.

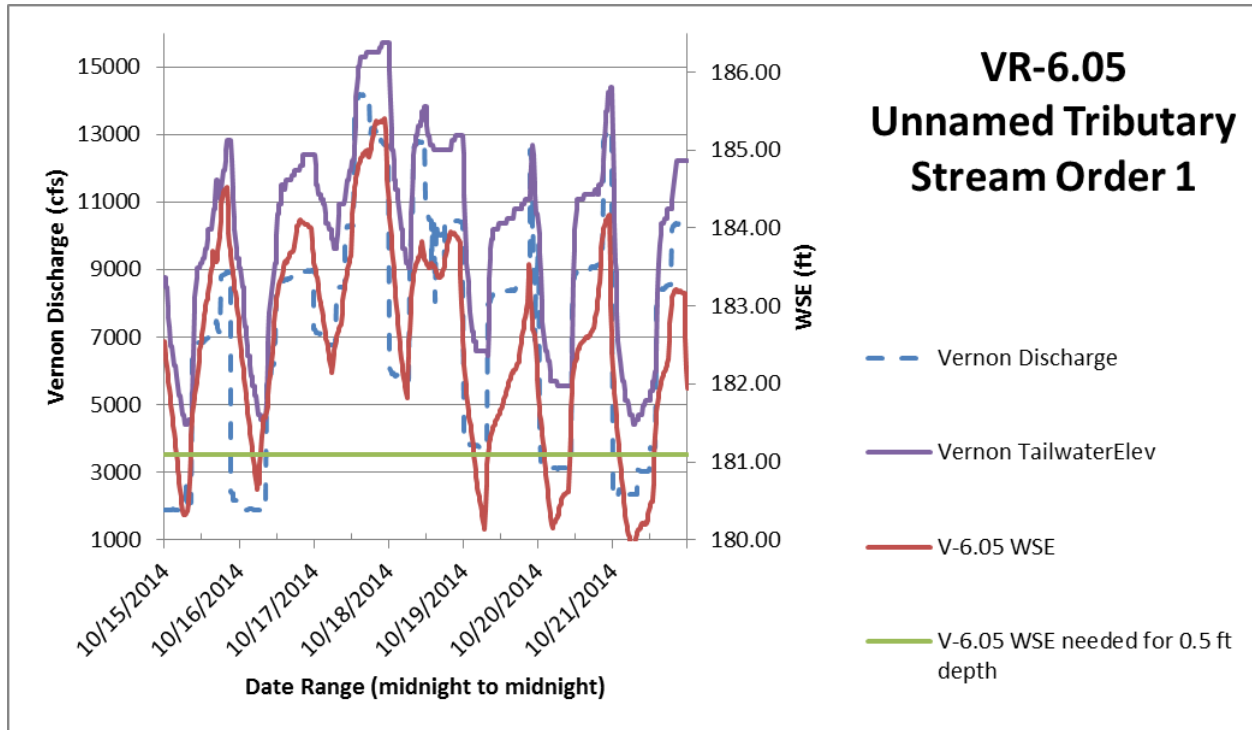


Figure 6.1-11. Representative operating conditions at Site CT-VR-6.05.

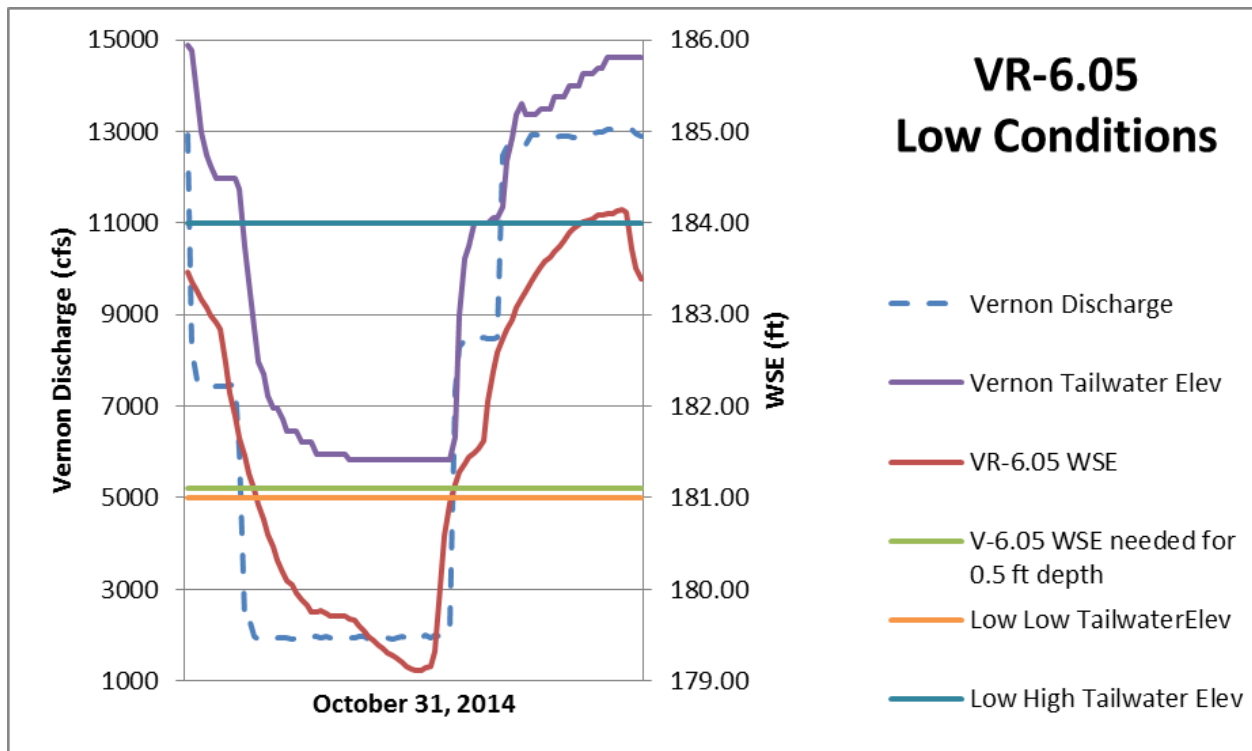


Figure 6.1-12. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.05

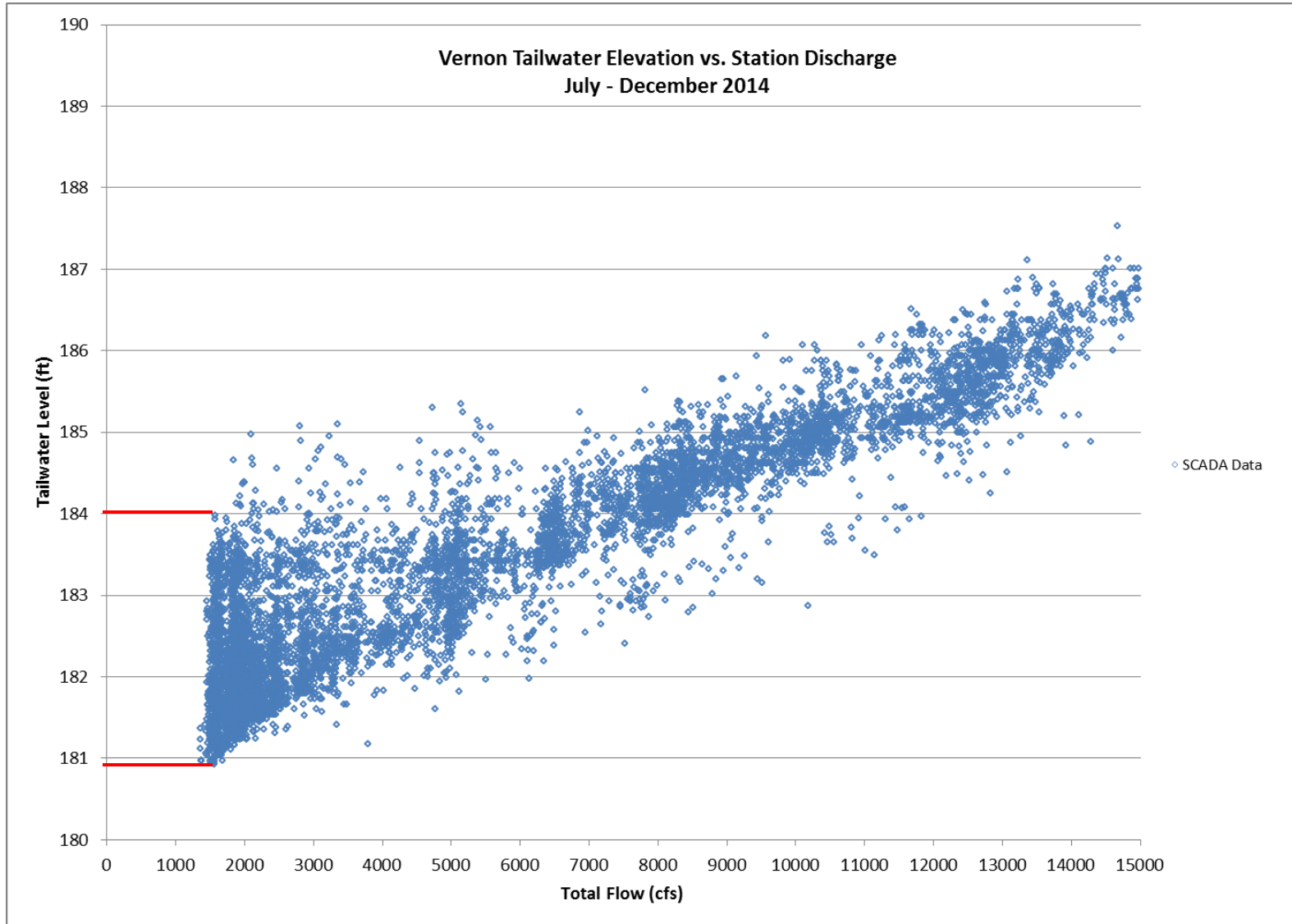


Figure 6.1-13. Vernon tailwater elevation at different station discharge levels.

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## 6.2 Water Quality

Water quality measurements taken within the tributaries and backwaters at the study sites generally met state water quality standards, except for pH at some sites (Section 5.2). Low pH is most likely due to naturally occurring causes. Similarly, temperature, conductivity, and turbidity are most likely to be functions of the tributaries and backwaters themselves rather than a function of project operations. Dissolved oxygen standards were met on most occasions at virtually all sites throughout the study period. Thus, the study data indicate that project operations do not have a discernable adverse effect on water quality in tributaries and backwaters.

The baseline water quality study conducted in 2012 (Normandeau, 2013) corroborates this conclusion. That study took place from June through September 2012 and was conducted under a wide range of flow and operating conditions including an extensive period of low flow/high temperature conditions. That study concluded that under ordinary hydroelectric operating conditions during summer high temperature/low flow periods, basic water quality parameters generally met applicable state standards; and irrespective of the effects of project operations, water quality in project waters supported all designated uses and met applicable criteria for the overwhelming majority of the study period throughout the entire study area.

## 6.3 Study Conclusions

The project effects assessment included herein should be considered preliminary for those sites identified as potentially affected by project operations. Results from other studies will be needed to better evaluate project effects for those sites. Relevant studies include the Hydraulic Modeling Study (Study 4), Operations Modeling Study (Study 5), and the Instream Flow Study (Study 9). None of these studies are complete at this time. Further assessment of the potential effects of project operations on specific tributary and backwater site access and habitats identified as potentially affected in this report will be included in a study report addendum and/or the Draft License Applications once results from the other studies are available.

Results of this study indicate that 27 of the 37 study sites including all backwater sites are not adversely affected by TransCanada project operations based on the conservative study criteria of sites having a confluence water depth < 0.5 ft for at least 25% of the time (based on each site's available 15-minute WSE data occurrences over the period of record).

Additional evaluation was conducted for the remaining 10 sites (Section 6.1). The relative level of overall potential project effects for those sites is summarized in Table 6.3-1. Factors including stream order, project-affected reach length, site conditions, thalweg profile, and natural outflow of the tributaries contribute to the relative importance of project operational changes (water depth and fluctuation) on fish access and habitat.

Only sites CT-B-3.10 (impoundment site) and CT-BR-4.04 (Cobb Brook) appear to have potential project effects of any significance that could limit fish access.

All other sites appear to have either no project effect or very minor effects under low mainstem and/or tributary conditions. The two sites downstream of Vernon (CT-VR-6.01 and CT-VR-6.05) are apparently more affected by Turners Falls impoundment elevations and operation of the Turners Falls/Northfield Mountain projects than by Vernon project operations.

Table 6.3-1. Summary of potential project effects.

Site #	Waterbody Name	Stream Order	Project-affected Reach Length (from confluence ft)	Contributing Site Factors	Potential Project Effect
CT-WR-2.01		2	45	Perched culvert.	None – low tributary outflow
CT-WR-2.07	Hanchetts Brook	1	-1	Downed trees and branches.	Minor - potential stranding under low tributary and mainstem conditions
CT-WR-2.10	McArthur Brook	2	160	Intermittent stream.	None – low tributary outflow
CT-WR-2.13	Bashan Brook	1	-9	Man-made blockages.	None – low tributary outflow
CT-B-3.10		1	117	Debris and shallow areas observed.	Potential stranding under low tributary and mainstem conditions
CT-BR-4.02	Cold River	5	~900	Shifting cobble. No mainstem WSE data.	None - sufficient natural outflow
CT-BR-4.04	Cobb Brook	3	535	Culvert. Downed trees and branches.	Potential stranding under low tributary and mainstem conditions, but generally sufficient natural outflow.
CT-V-5.02	Mad Brook	2	~80	Perched culvert. No mainstem WSE data.	Minor - potential stranding under low tributary and mainstem conditions
CT-VR-6.01		2	125	Downed trees and branches. Turners Falls impoundment levels.	Potential stranding under low tributary and mainstem conditions, attributable to Turners Falls operational effect.
CT-VR-6.05		1	165	Turners Falls impoundment levels.	Potential stranding under low tributary and mainstem conditions, attributable to Turners Falls operational effect.

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## 7.0 LITERATURE CITED

- ASQL (American Society for Quality Control). 1993. Sampling procedures and tables for inspection by attributes. ANSI/ASQC Z1.4-1993.
- 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.
- VTDEC (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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## 1.0 WILDER IMPOUNDMENT

### 1.1 Site CT-W-1.01 Harriman Brook

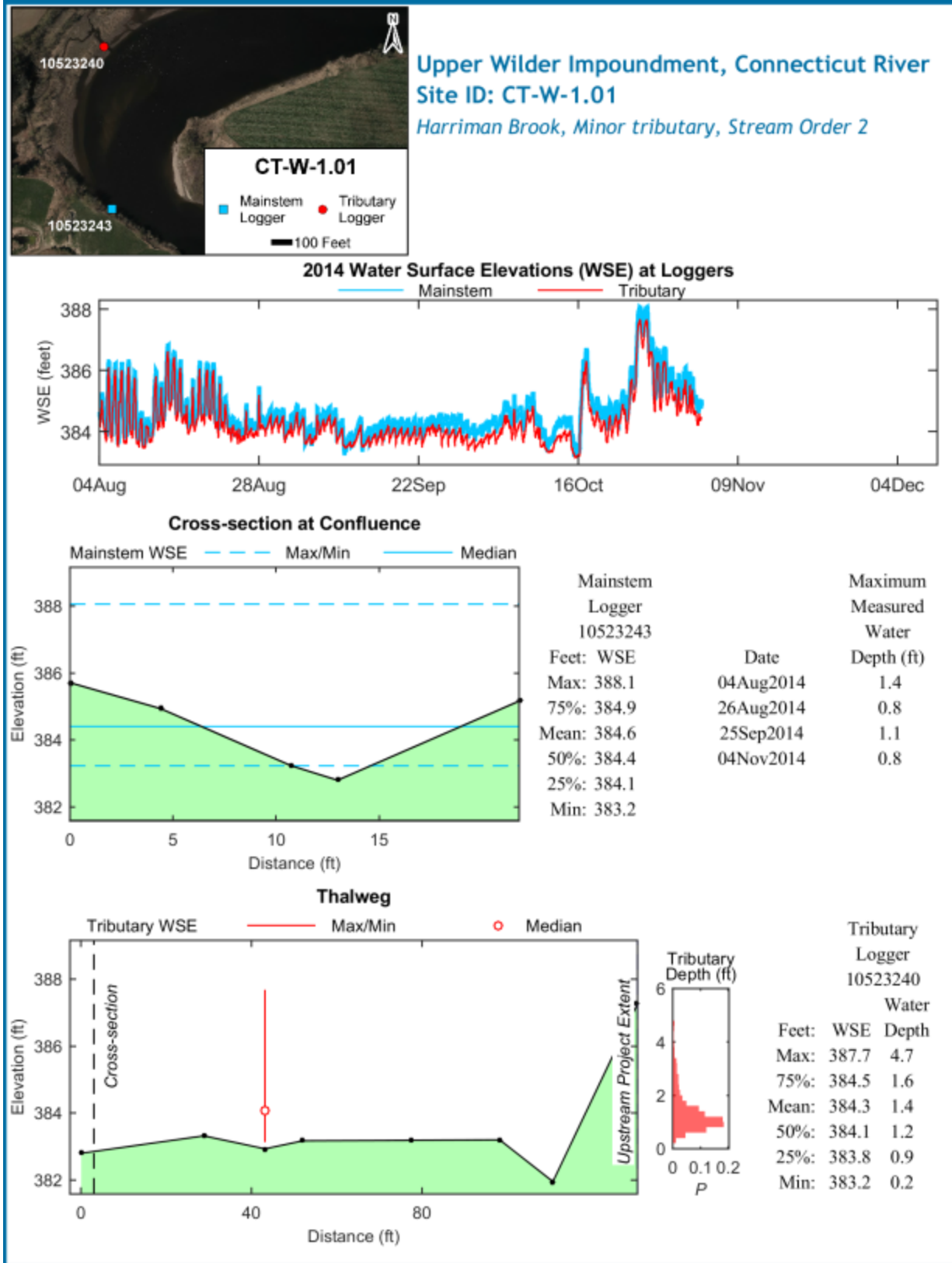
Site CT-W-1.01 Harriman Brook, is a stream order 2 tributary located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523240) and mainstem (SN 10523243) level loggers were installed on that date. Subsequent site visits were 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 4<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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.





**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

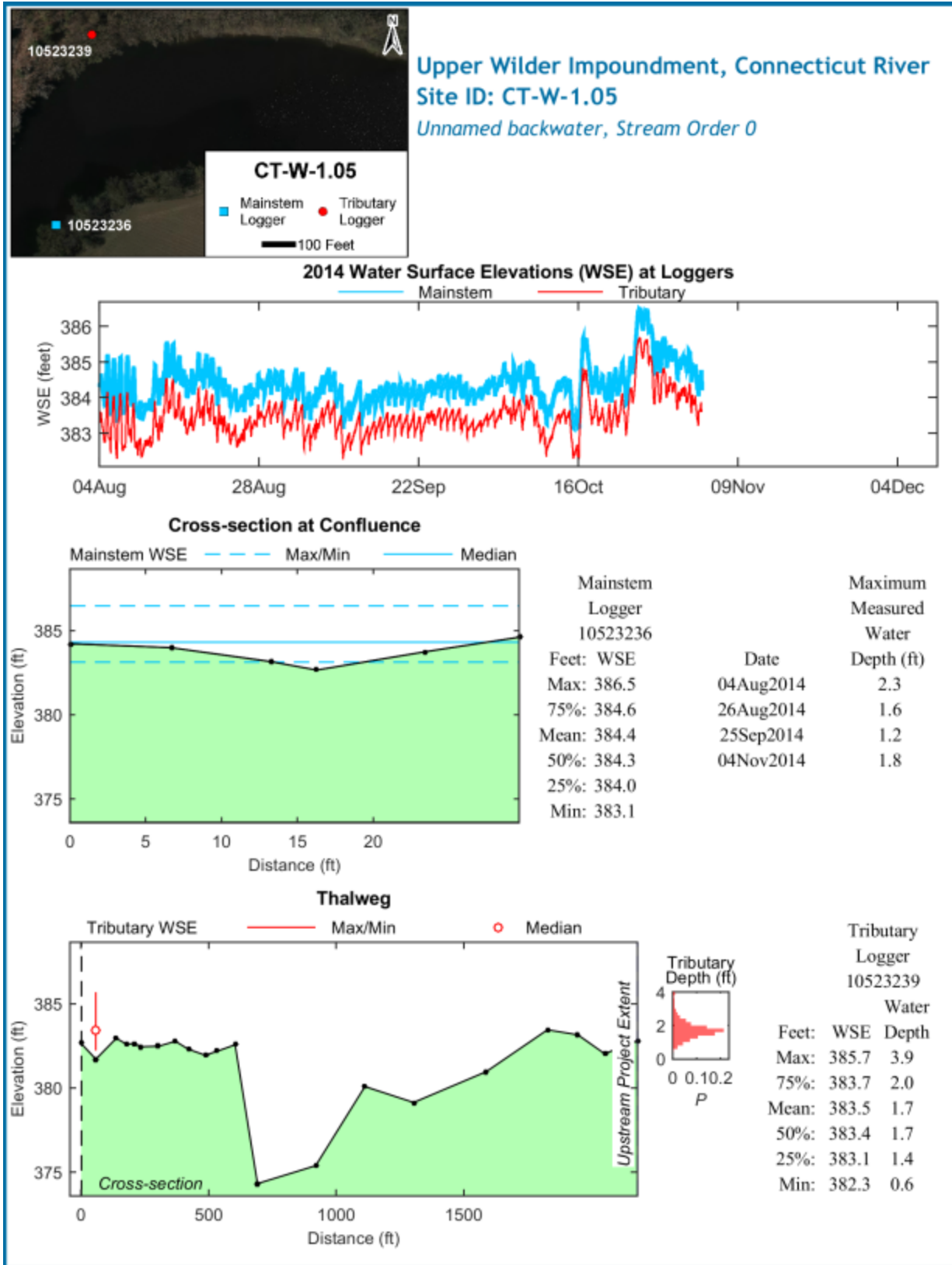
Site CT-W-1.05 is a backwater located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523239) and mainstem (SN 10523236) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 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., 25<sup>th</sup> through 75<sup>th</sup> 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.



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).

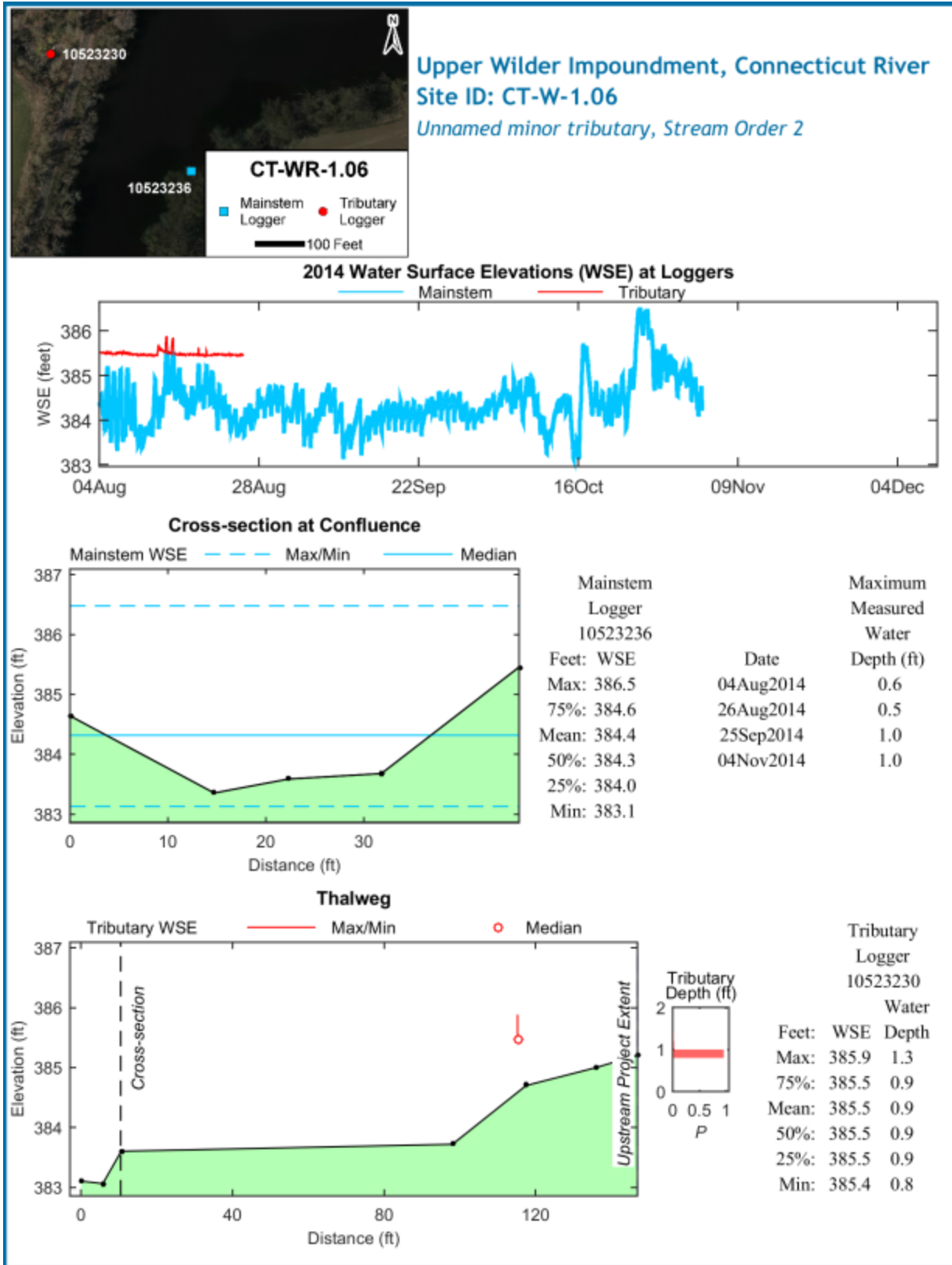


View of the end of project-affected reach within site CT-W-1.06.



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





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

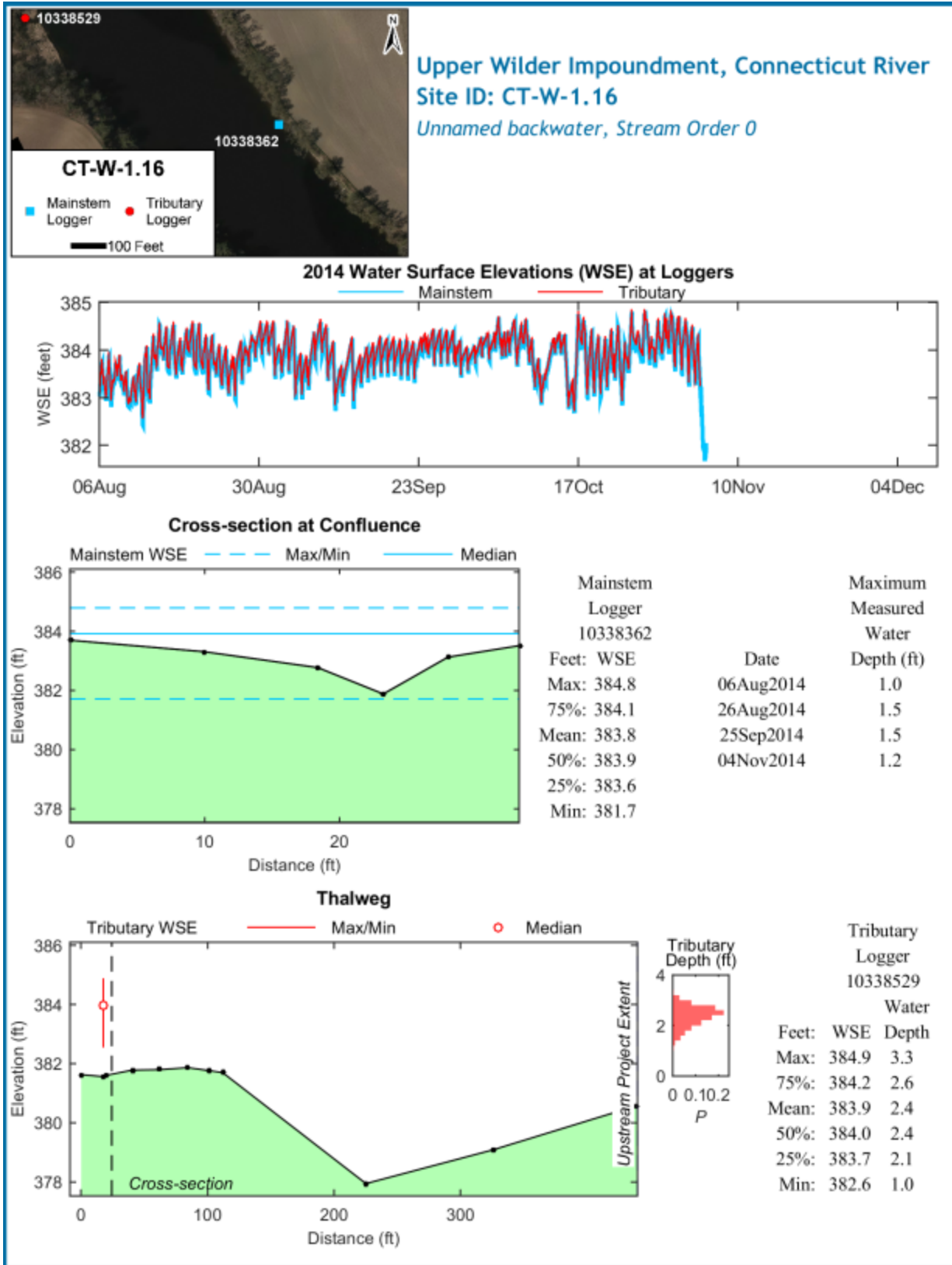


#### **1.4 Site CT-W-1.16 Backwater**

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<sup>th</sup> through 75<sup>th</sup> 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



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## 1.5 Site CT-W-1.22 Indian Pond Brook

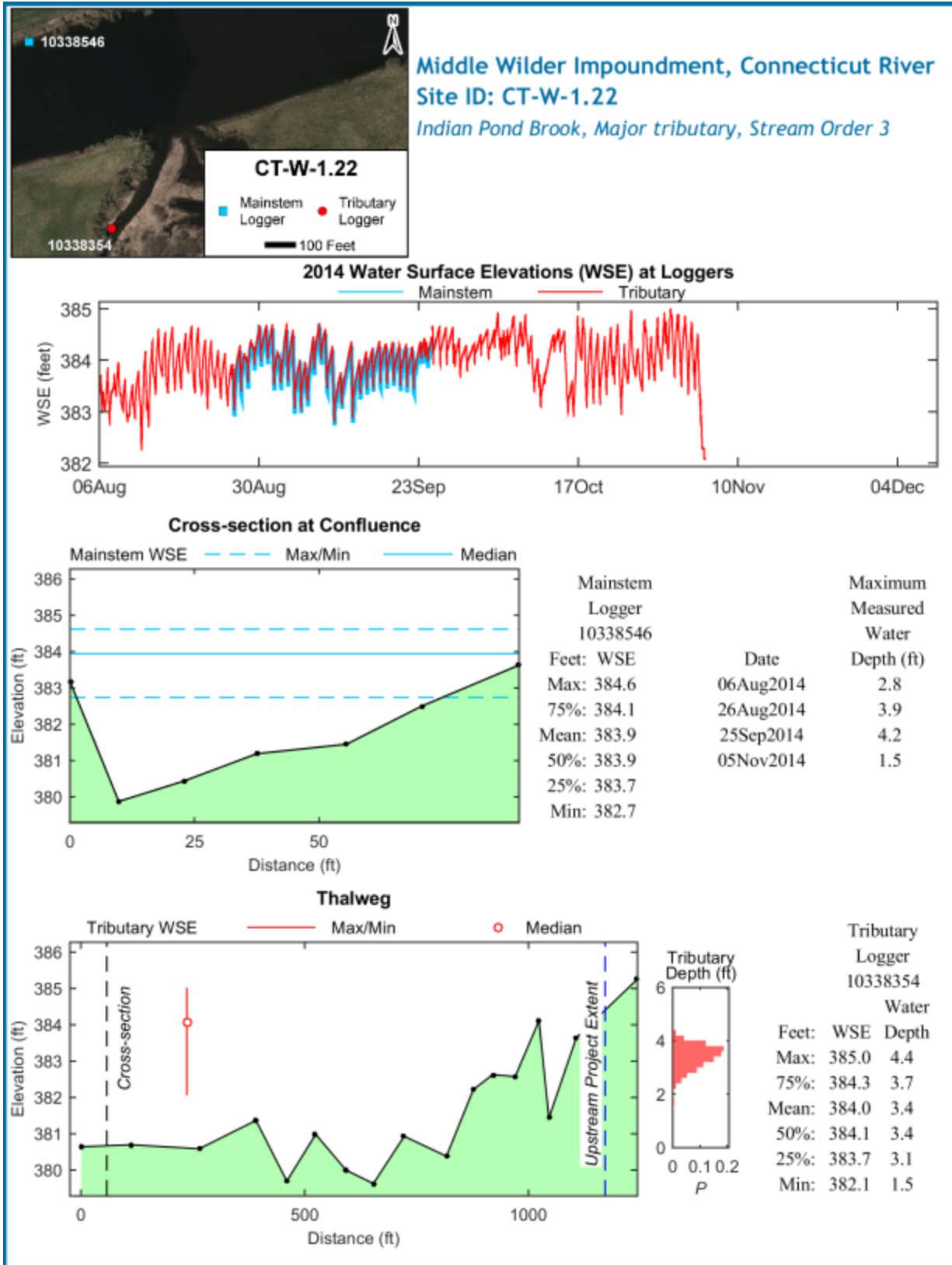
Site CT-W-1.22 Indian Pond Brook, is a stream order 3 tributary located on the New Hampshire side in the middle Wilder impoundment. This location was initially visited on August 6, 2014 and tributary (SN 10338354) and mainstem (SN 10338546) level loggers were installed on that date. Subsequent site visits 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 26<sup>th</sup>. 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 6<sup>th</sup> and ranged between 0.2 ft on the downstream side of an in-stream 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.





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



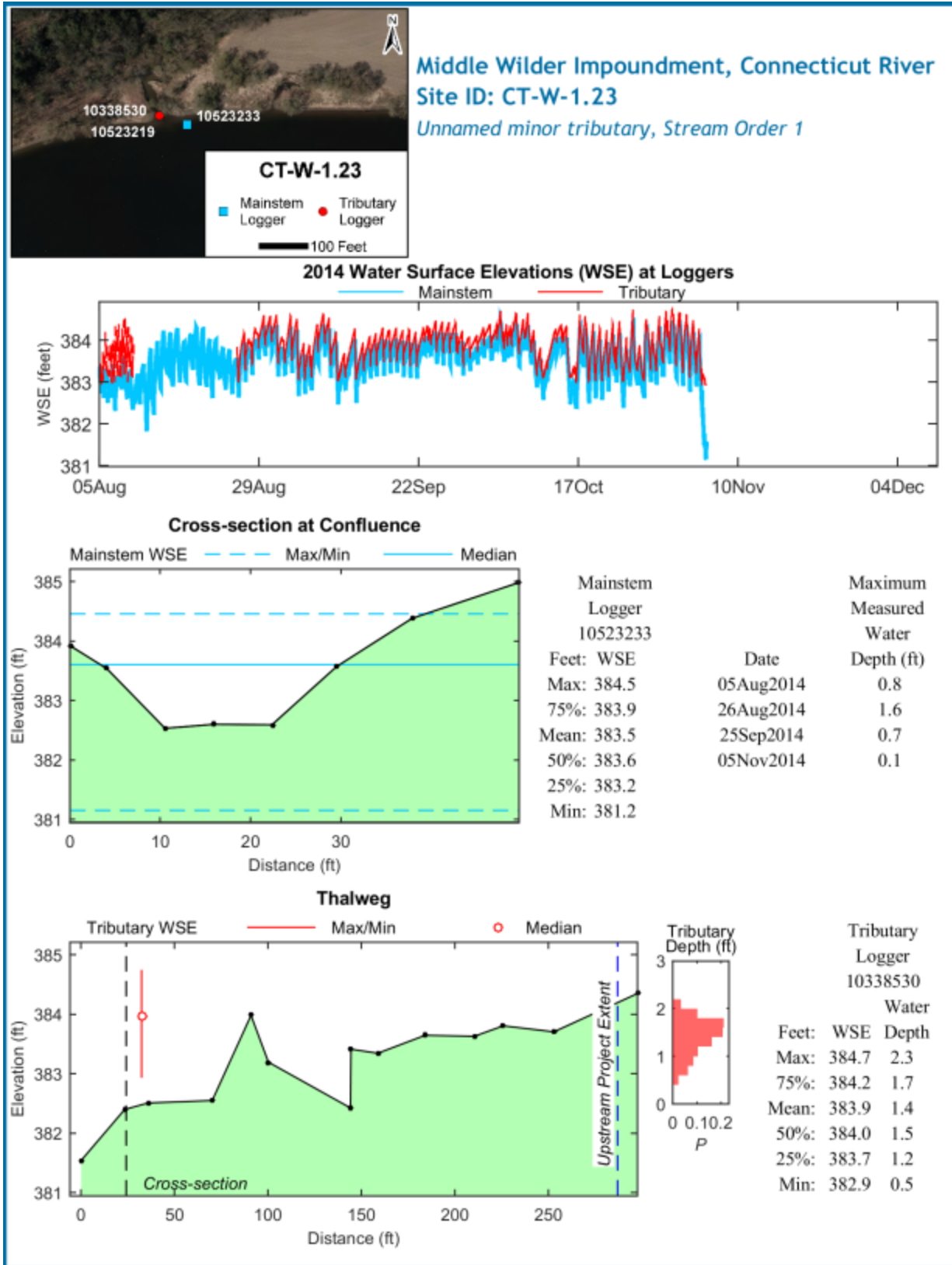
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## 1.6 Site CT-W-1.23

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., 25<sup>th</sup> through 75<sup>th</sup> 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 25<sup>th</sup> 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 5<sup>th</sup> 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*



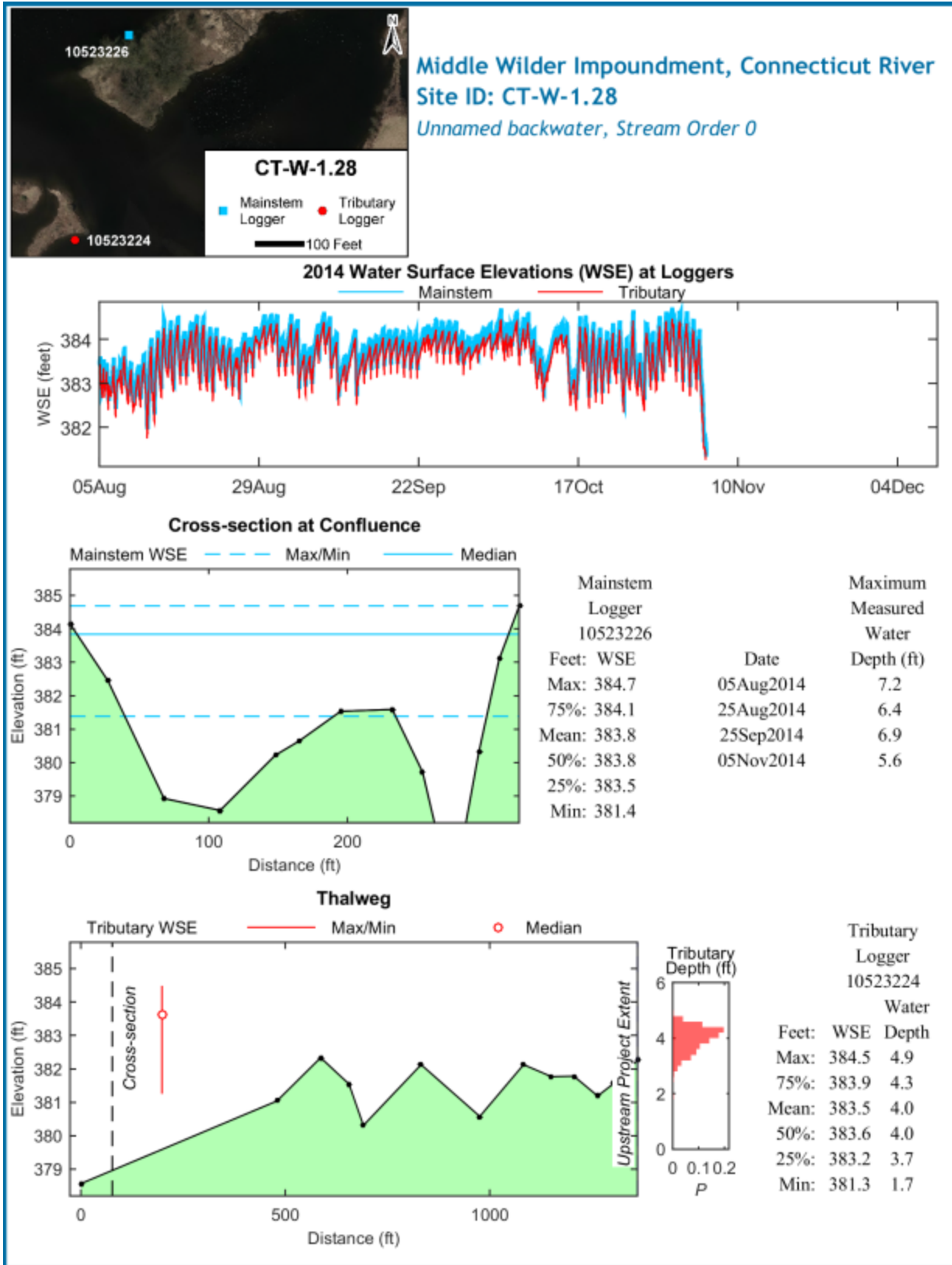
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## 1.7 Site CT-W-1.28 Backwater

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., 25<sup>th</sup> through 75<sup>th</sup> 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.





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



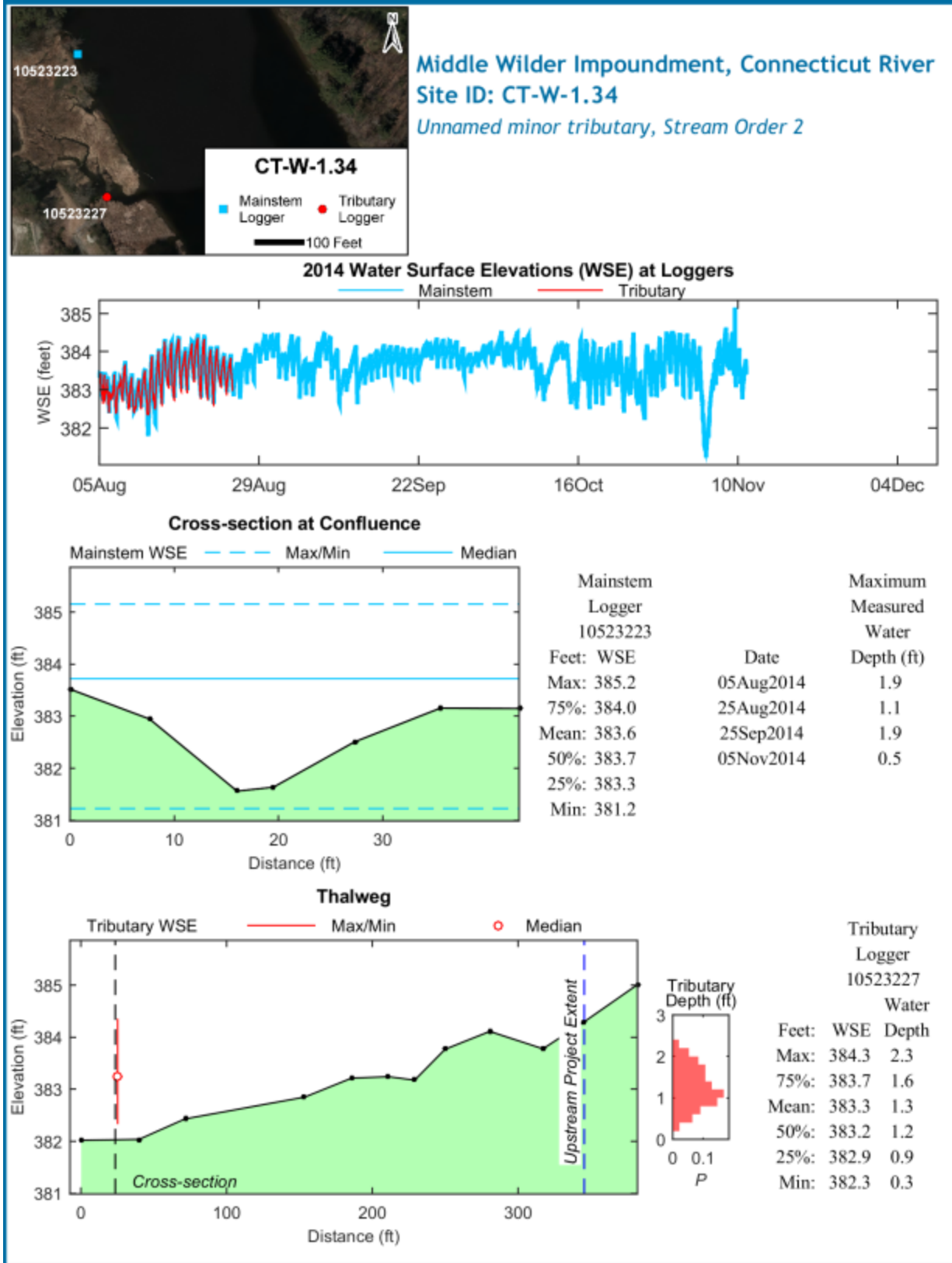
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## 1.8 Site CT-W-1.34

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 5<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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*



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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).

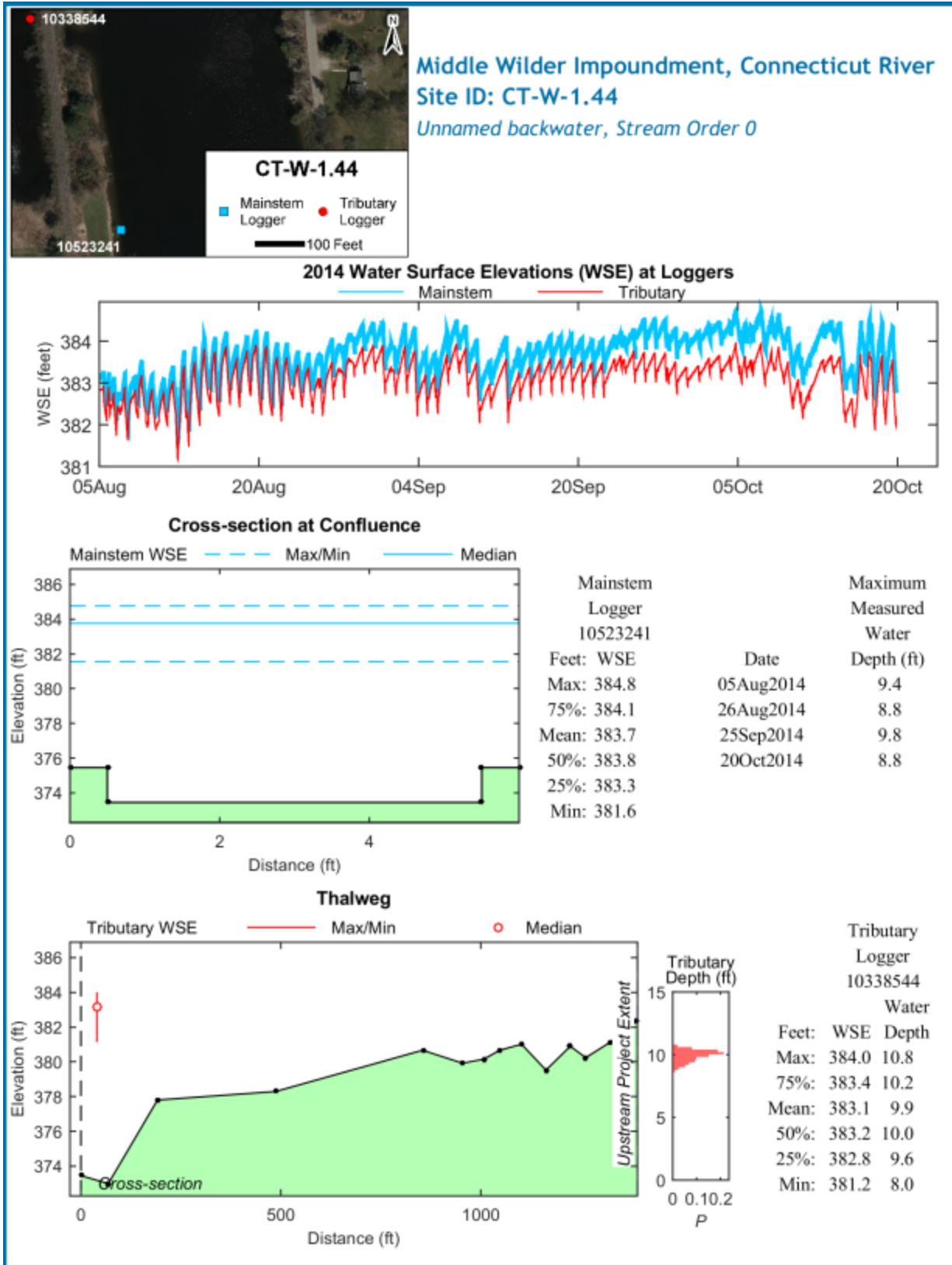
The small feeder stream covered the upper 400 ft of the project-affected reach. Water was present within backwater Site CT-W-1.44 during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 8.8 to 9.8 ft. Water depths were measured during 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., 25<sup>th</sup> through 75<sup>th</sup> 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.





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



### 1.10 Site CT-W-1.47

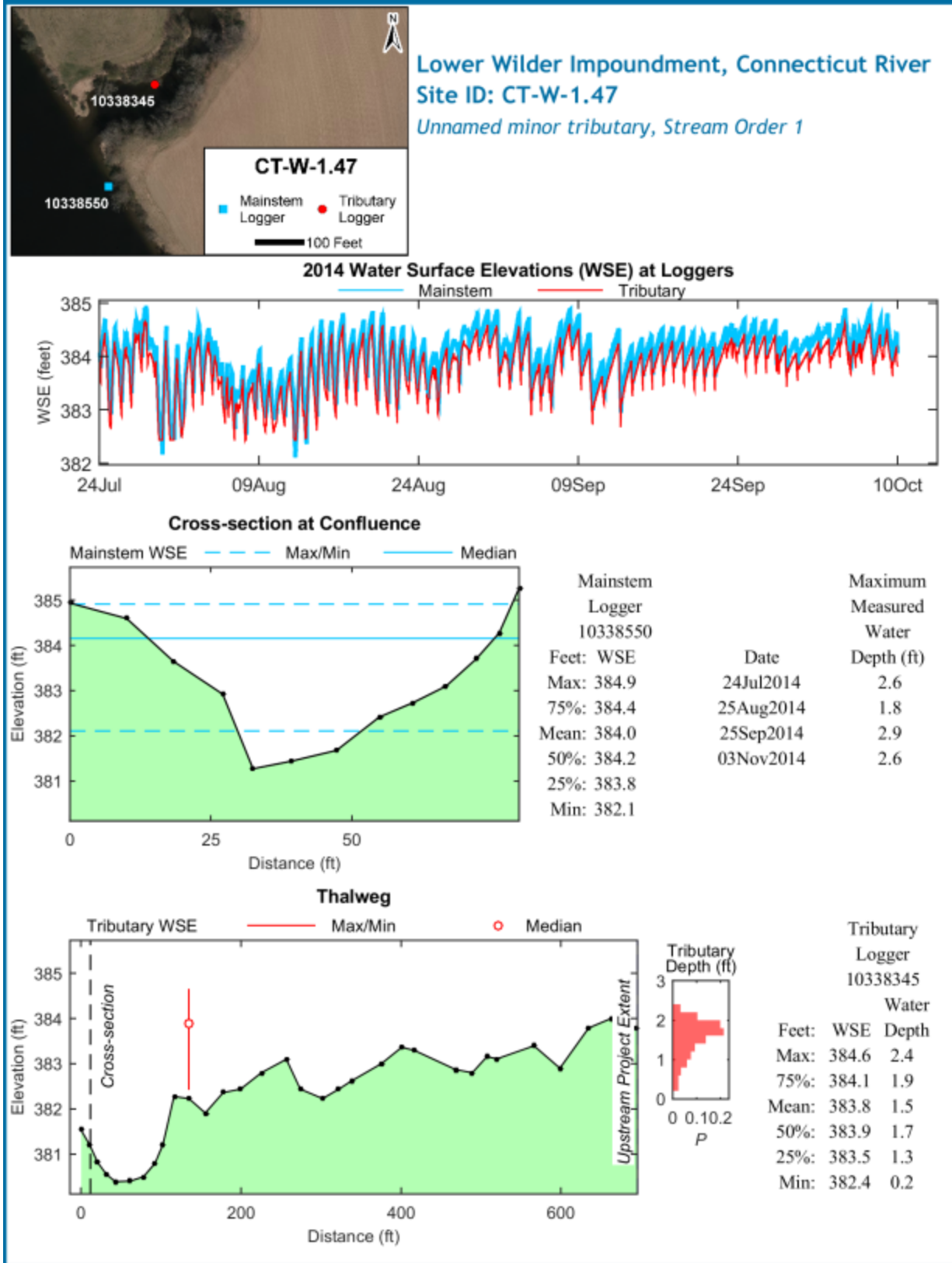
Site CT-W-1.47 is an unnamed stream order 1 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 24, 2014 and tributary (SN 10338345) and mainstem (SN 10338550) level loggers were installed on that date. Subsequent site visits were conducted 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 24<sup>th</sup> site visit and ranged between 0.3 and 3.9 ft (mean = 1.8 ft). Thalweg water depths of  $\leq 0.5$  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., 25<sup>th</sup> through 75<sup>th</sup> 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



### 1.11 Site CT-W-1.48 Grant Brook

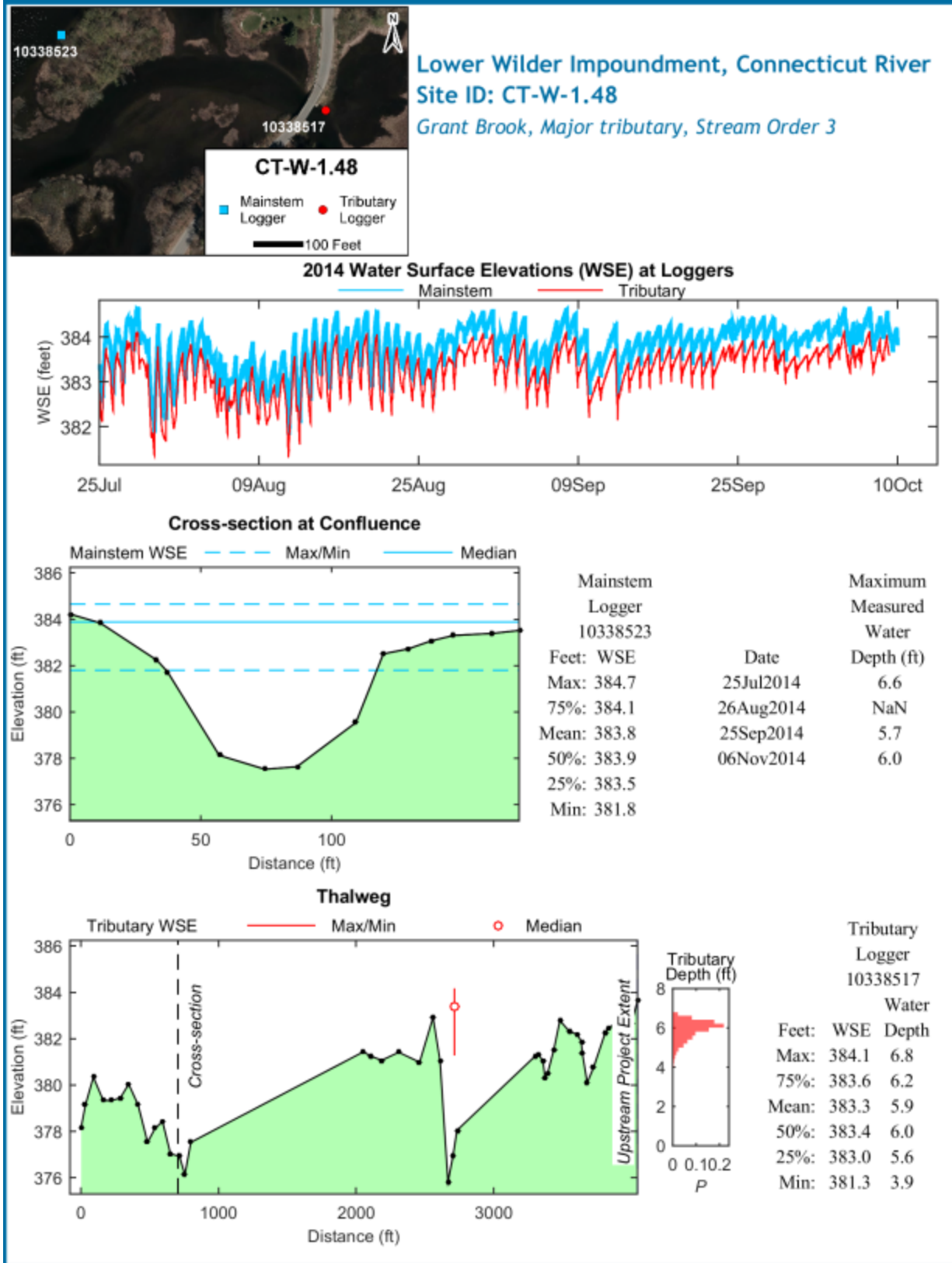
Site CT-W-1.48 Grant Brook, is a stream order 3 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 25, 2014 and tributary (SN 10338517) and mainstem (SN 10338523) level loggers were installed on that date. Subsequent site visits were 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 25<sup>th</sup> 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.





**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

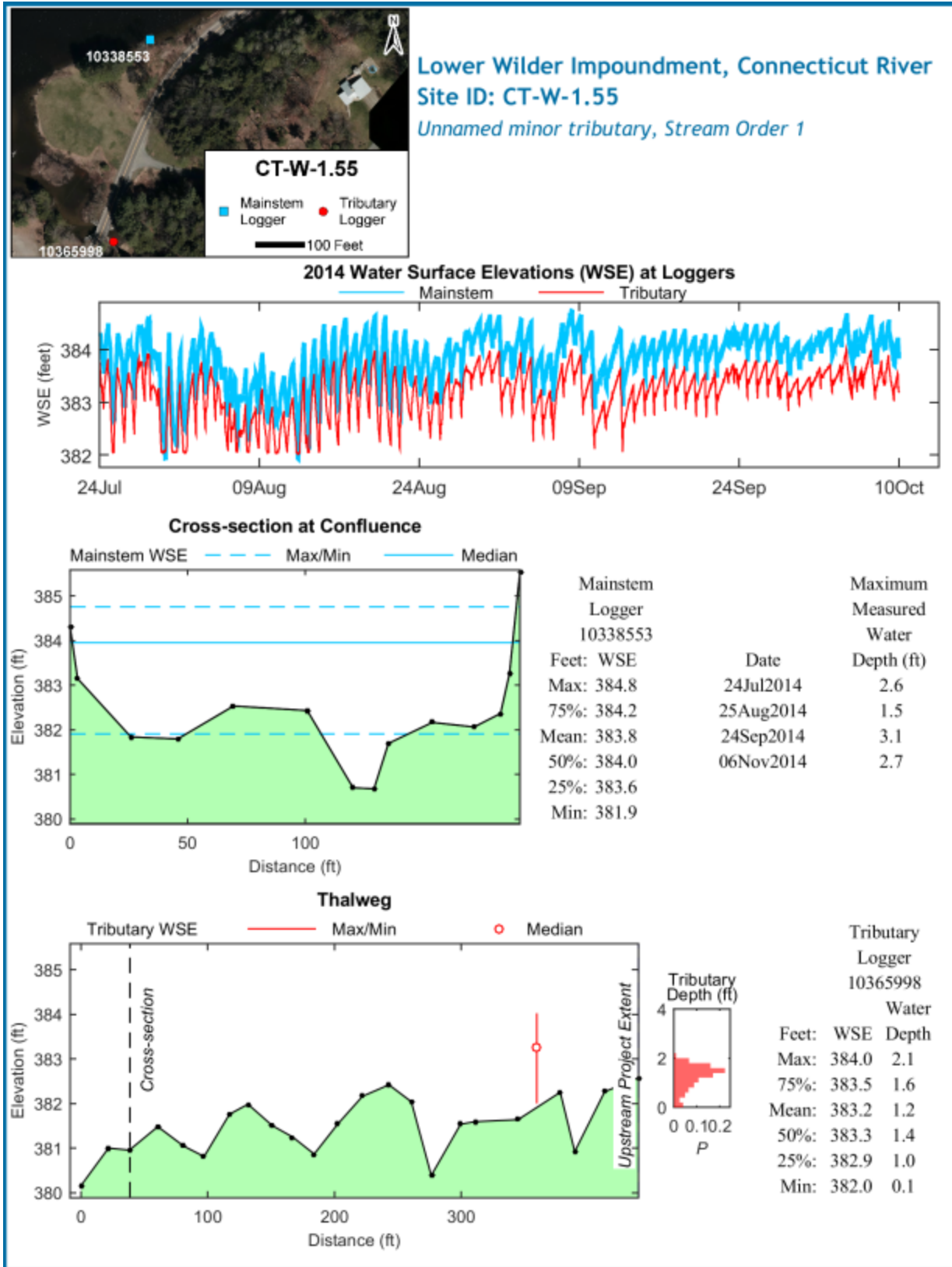
Site CT-W-1.55 is an unnamed stream order 1 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 24, 2014 and tributary (SN 10365998) and mainstem (SN 10338553) level loggers were installed on that date. Subsequent site visits were conducted 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 24<sup>th</sup> 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.



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



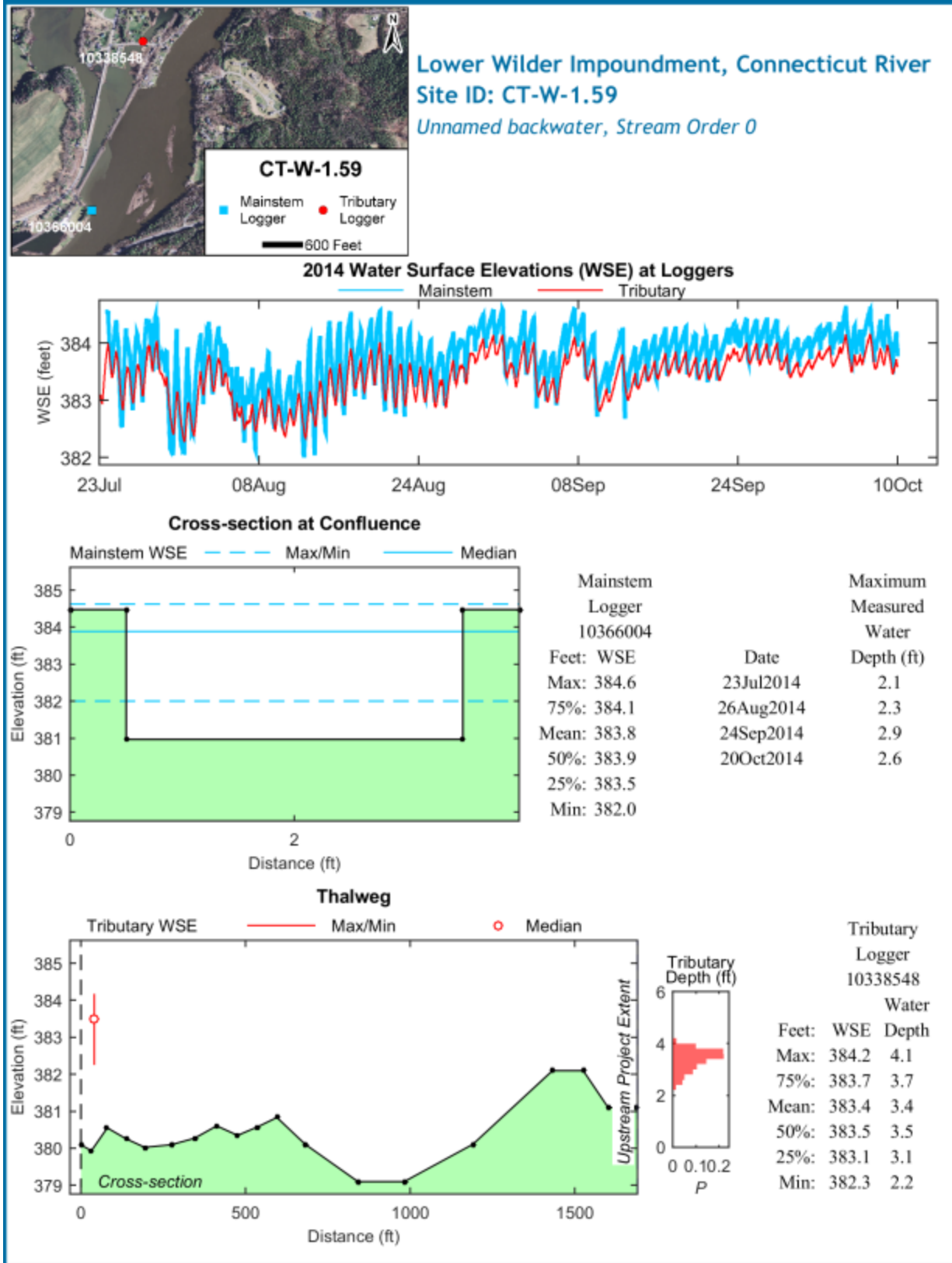
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### 1.13 Site CT-W-1.59

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



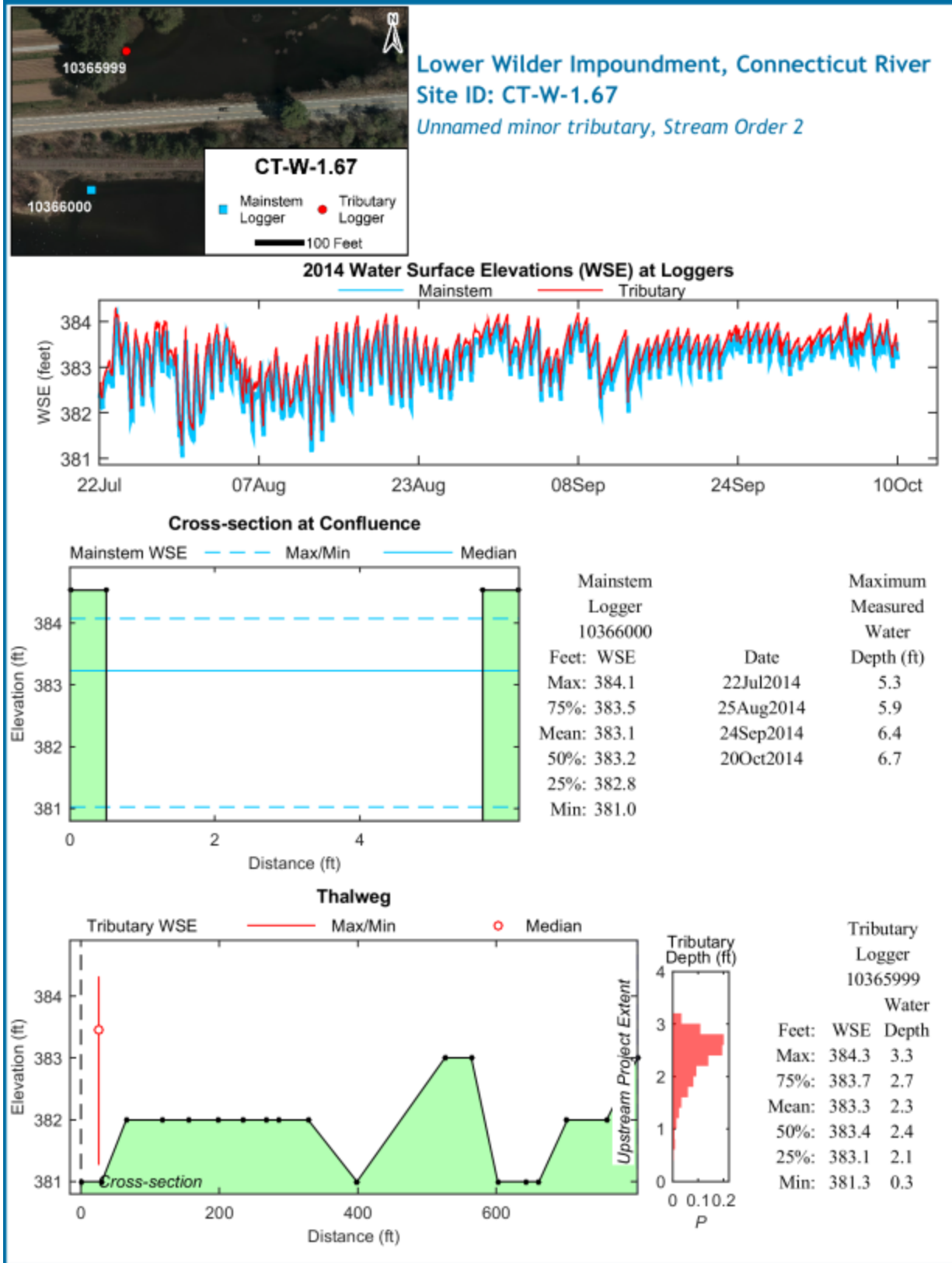
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#### 1.14 Site CT-W-1.67

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



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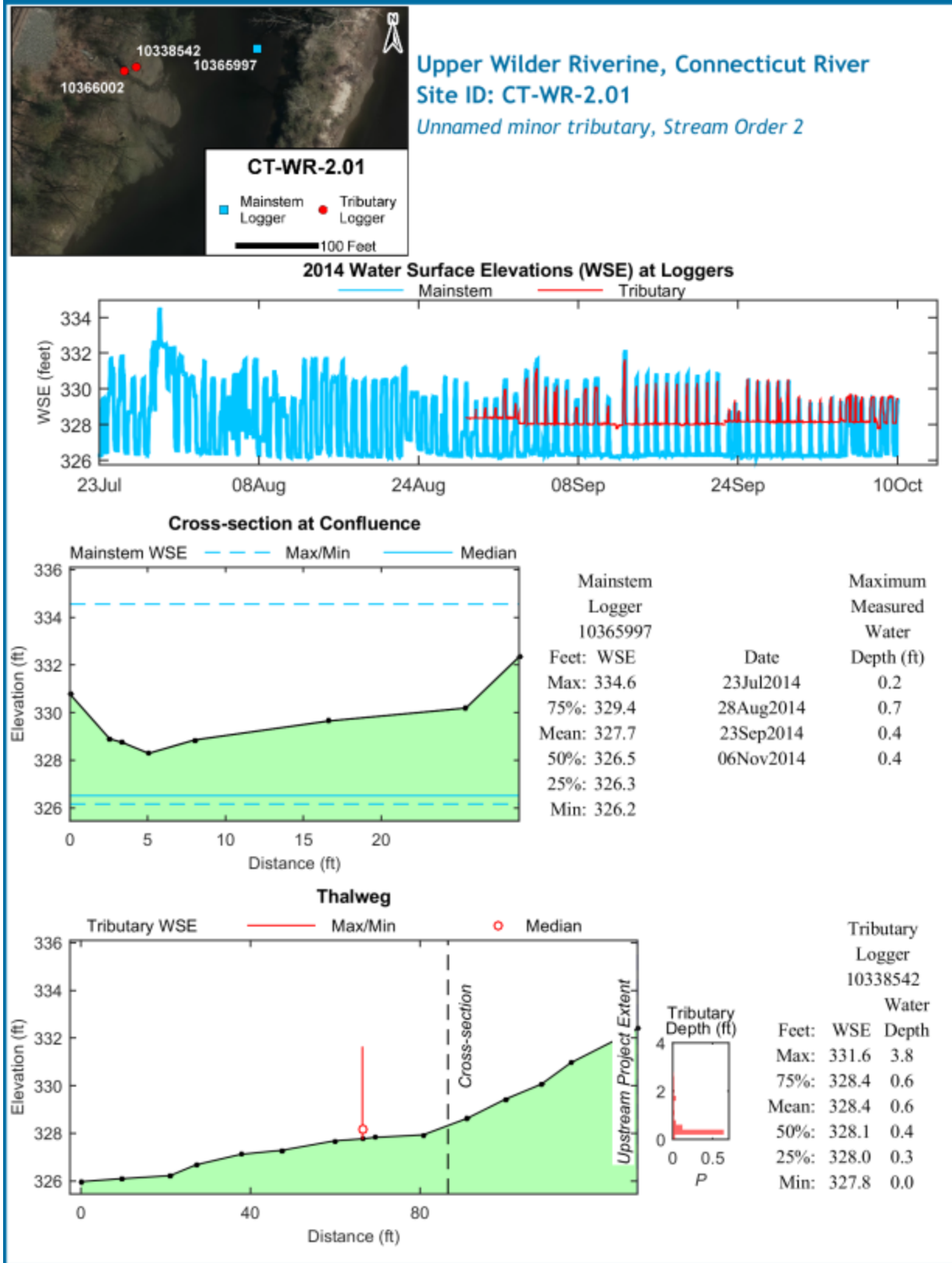
## 2.0 WILDER RIVERINE SECTION

### 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 23<sup>rd</sup> 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).





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



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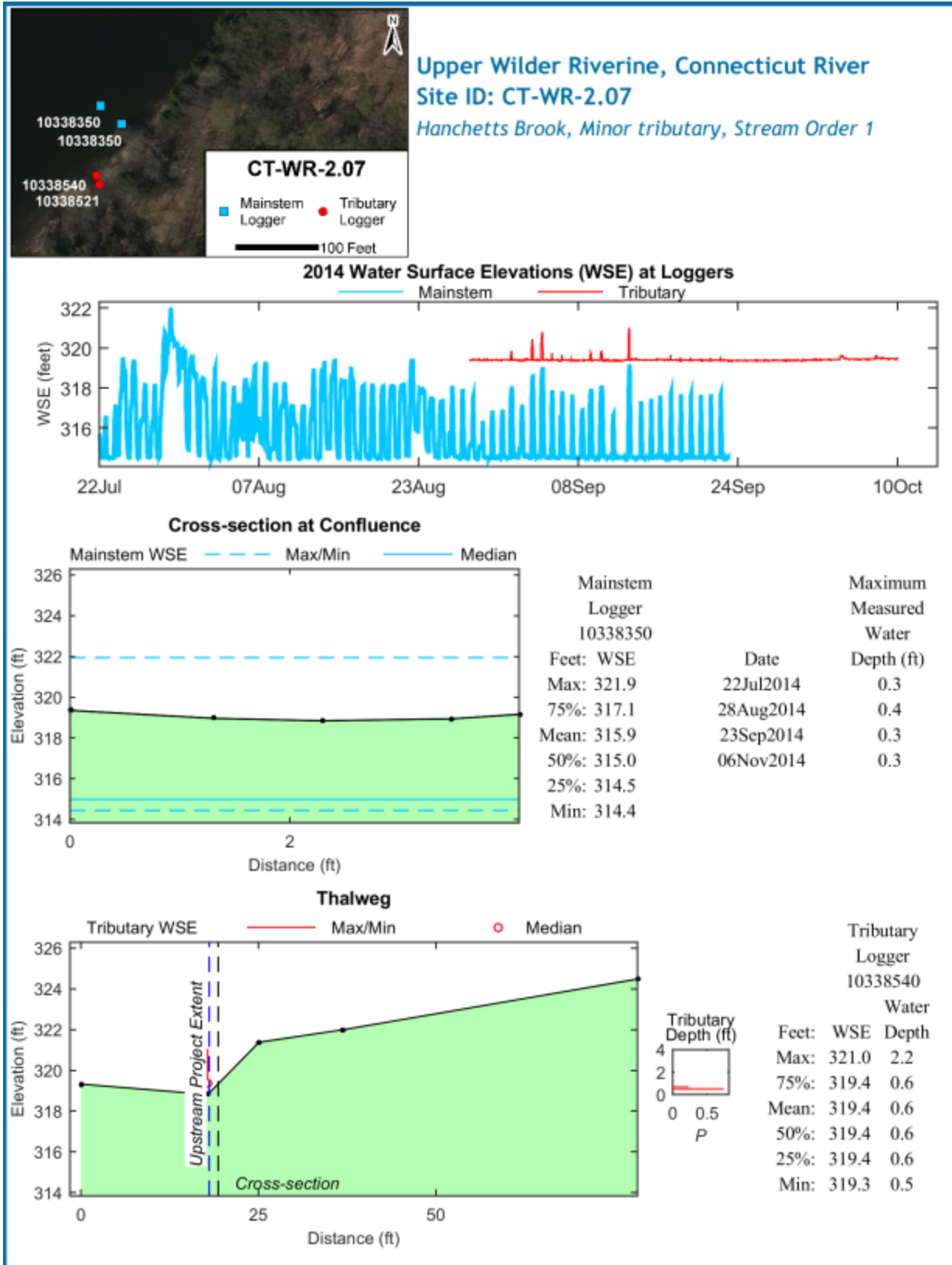
## 2.2 Site CT-WR-2.07 Hanchetts Brook

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 6<sup>th</sup> 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



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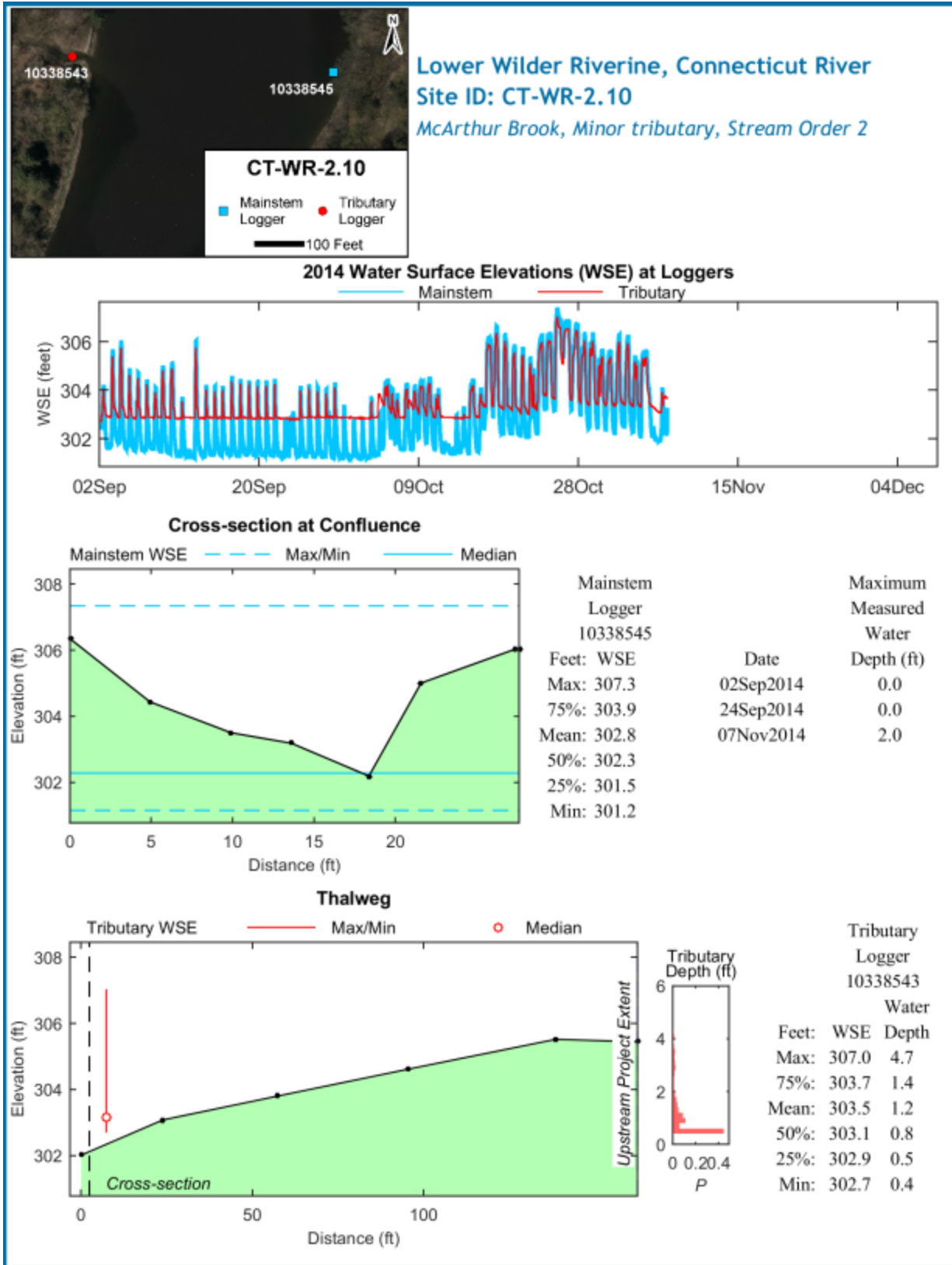
### 2.3 Site CT-WR-2.10 McArthur Brook

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 7<sup>th</sup> visit and was 2.0 ft at its deepest point. Bed elevations were recorded from the dry channel bed during the September 24<sup>th</sup> 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.





**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

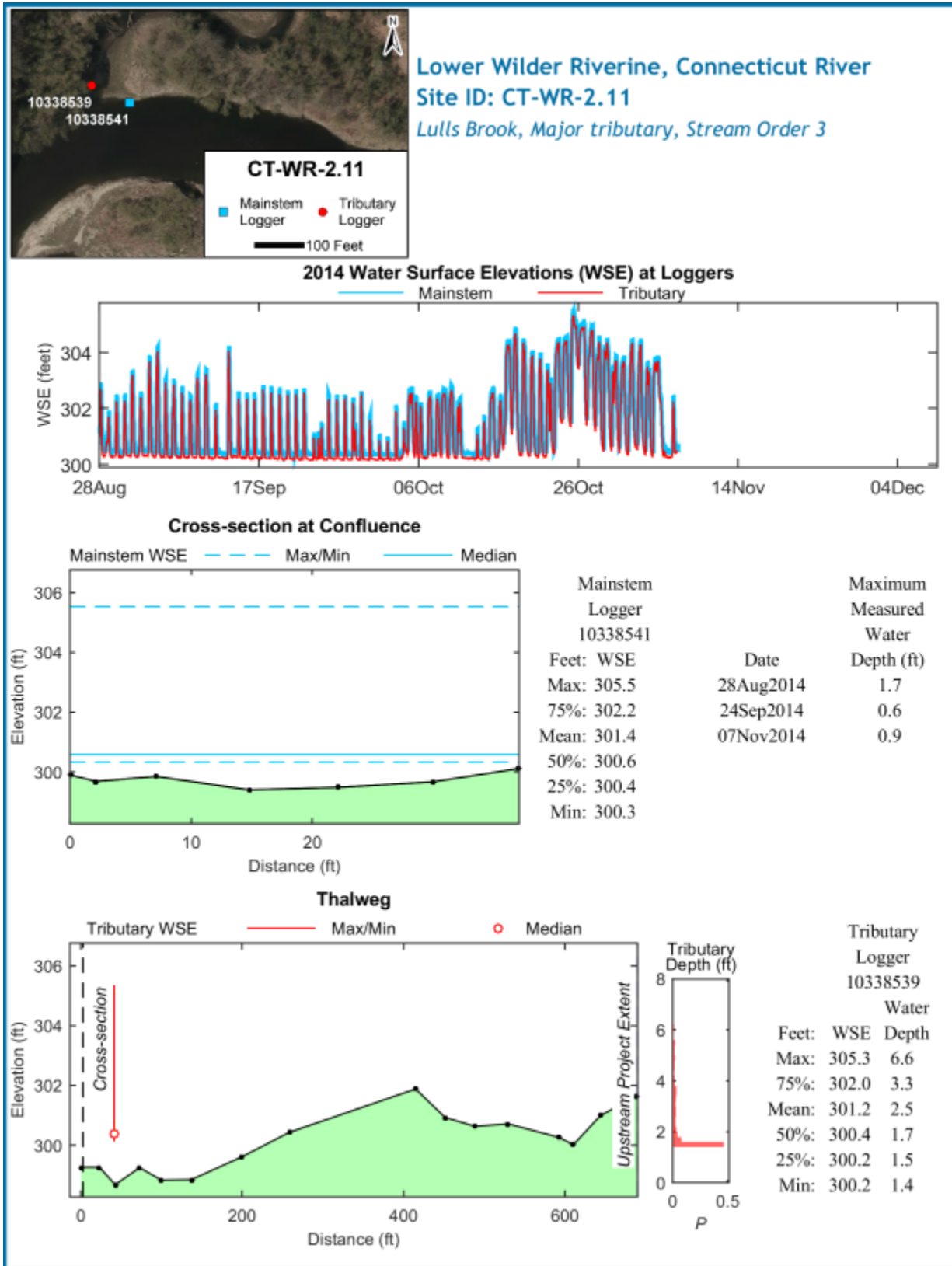
Site CT-WR-2.11 Lulls Brook, is a stream order 3 tributary located on the Vermont side in the lower Wilder riverine reach. This location was initially visited on August 28, 2014 and tributary (SN 10338539) and mainstem (SN 10338541) level loggers were installed on that date. An additional site visit 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 24<sup>th</sup> 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*



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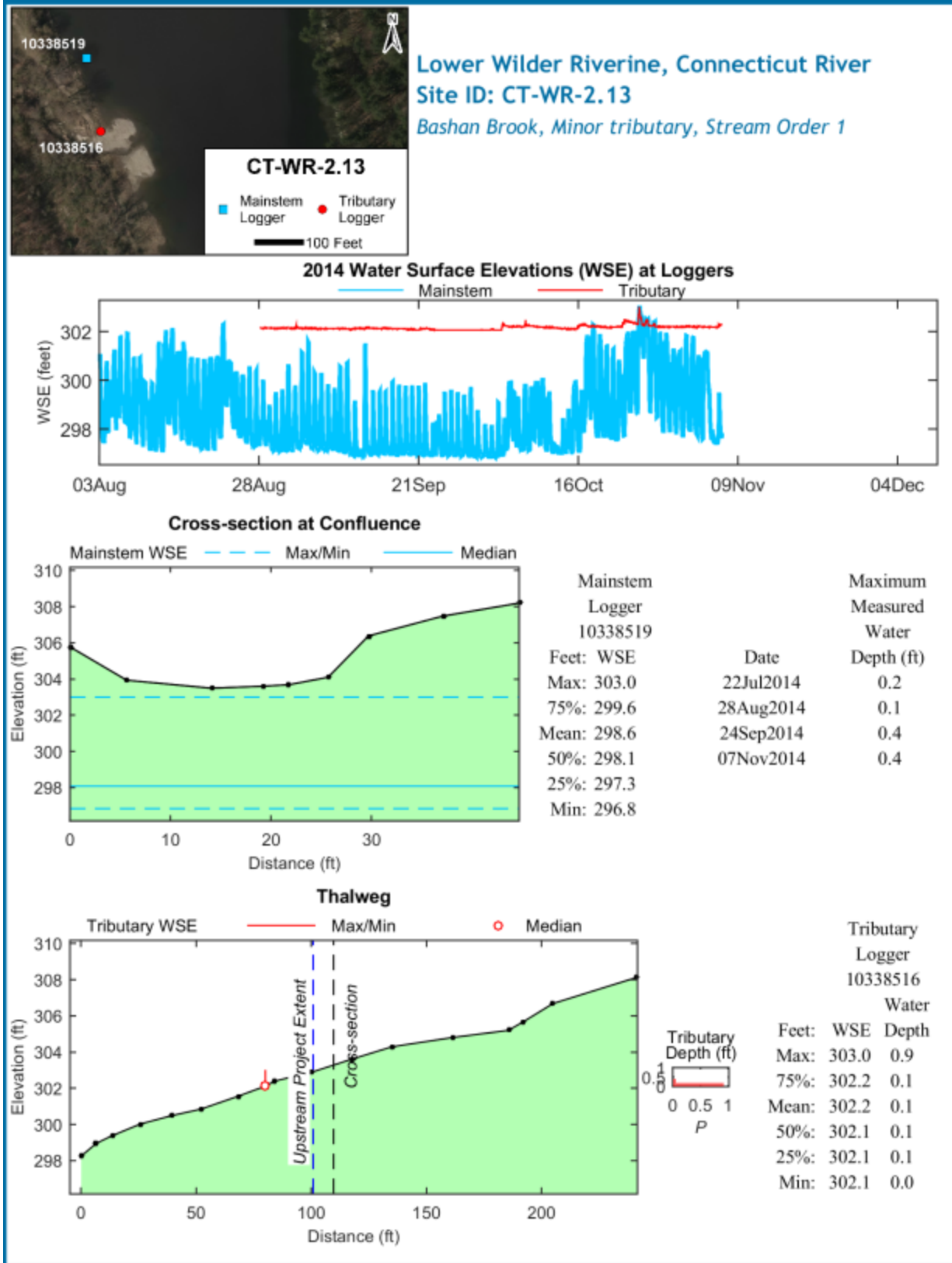
## 2.5 Site CT-WR-2.13 Bashan Brook

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 22<sup>nd</sup> 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*



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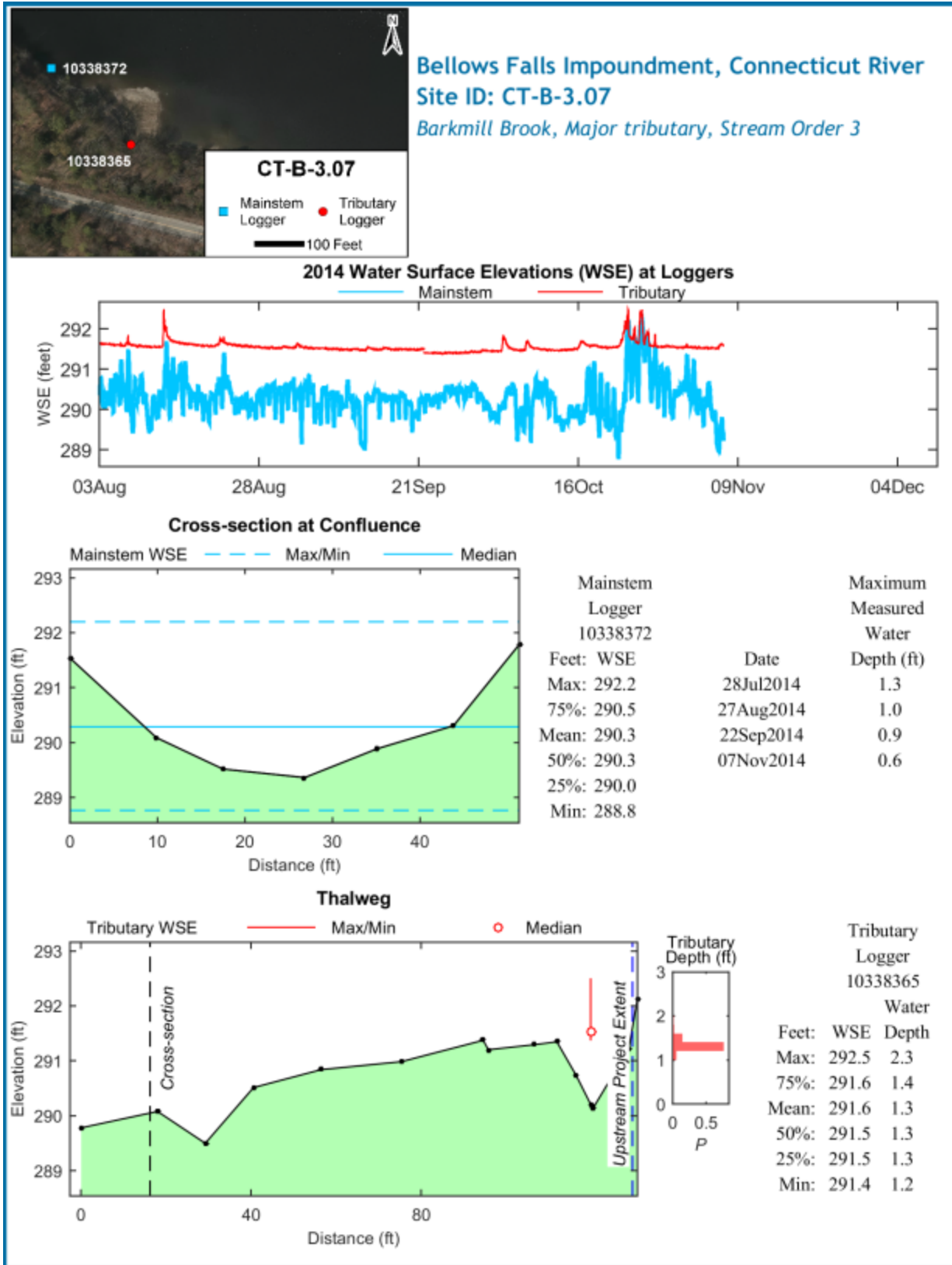
### 3.0 BELLOWS FALLS IMPOUNDMENT

#### 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 28<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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 25<sup>th</sup> 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 7<sup>th</sup> 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.



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



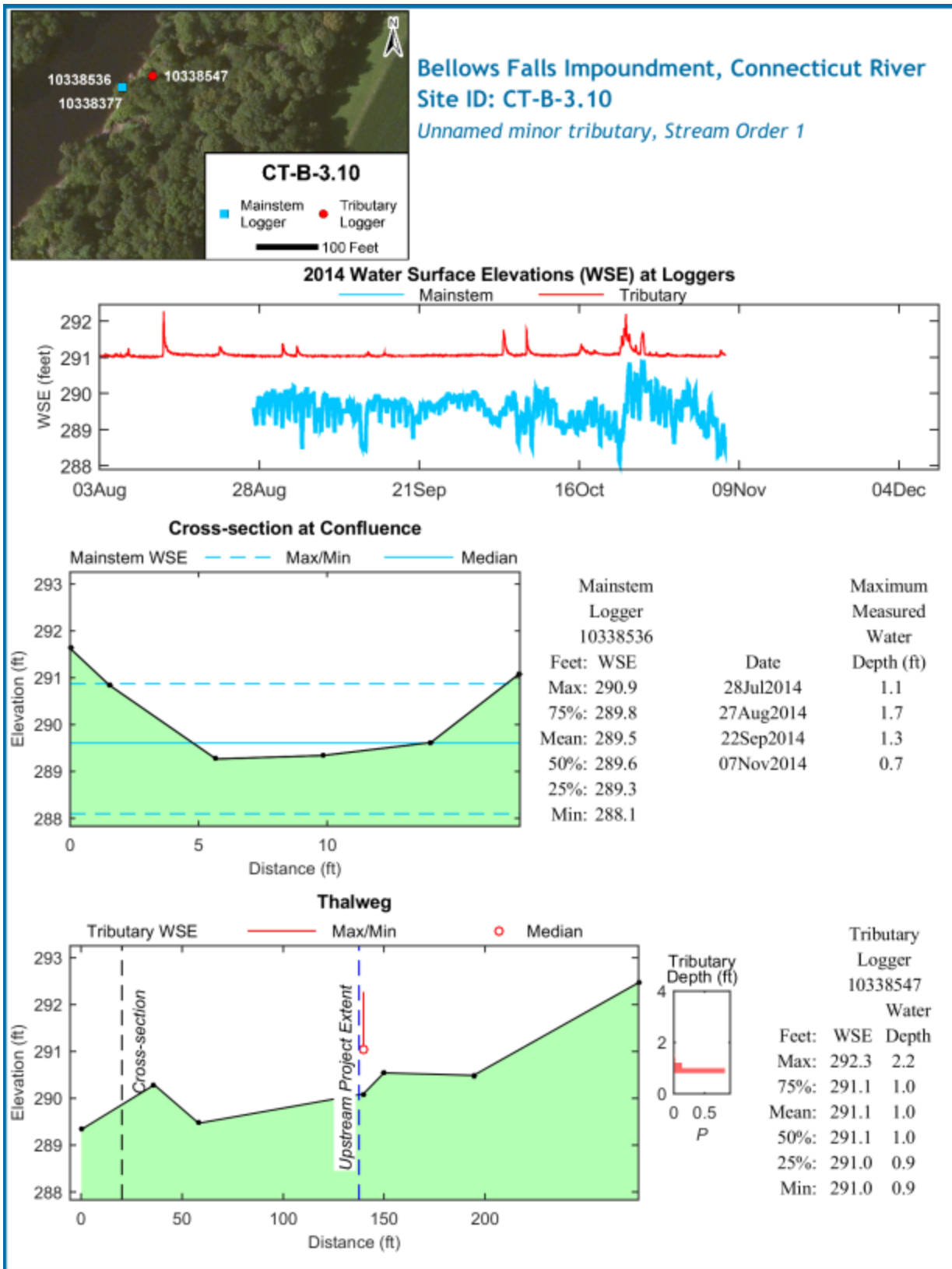
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### 3.2 Site CT-B-3.10

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 7<sup>th</sup> 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 25<sup>th</sup> 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 7<sup>th</sup> 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).





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



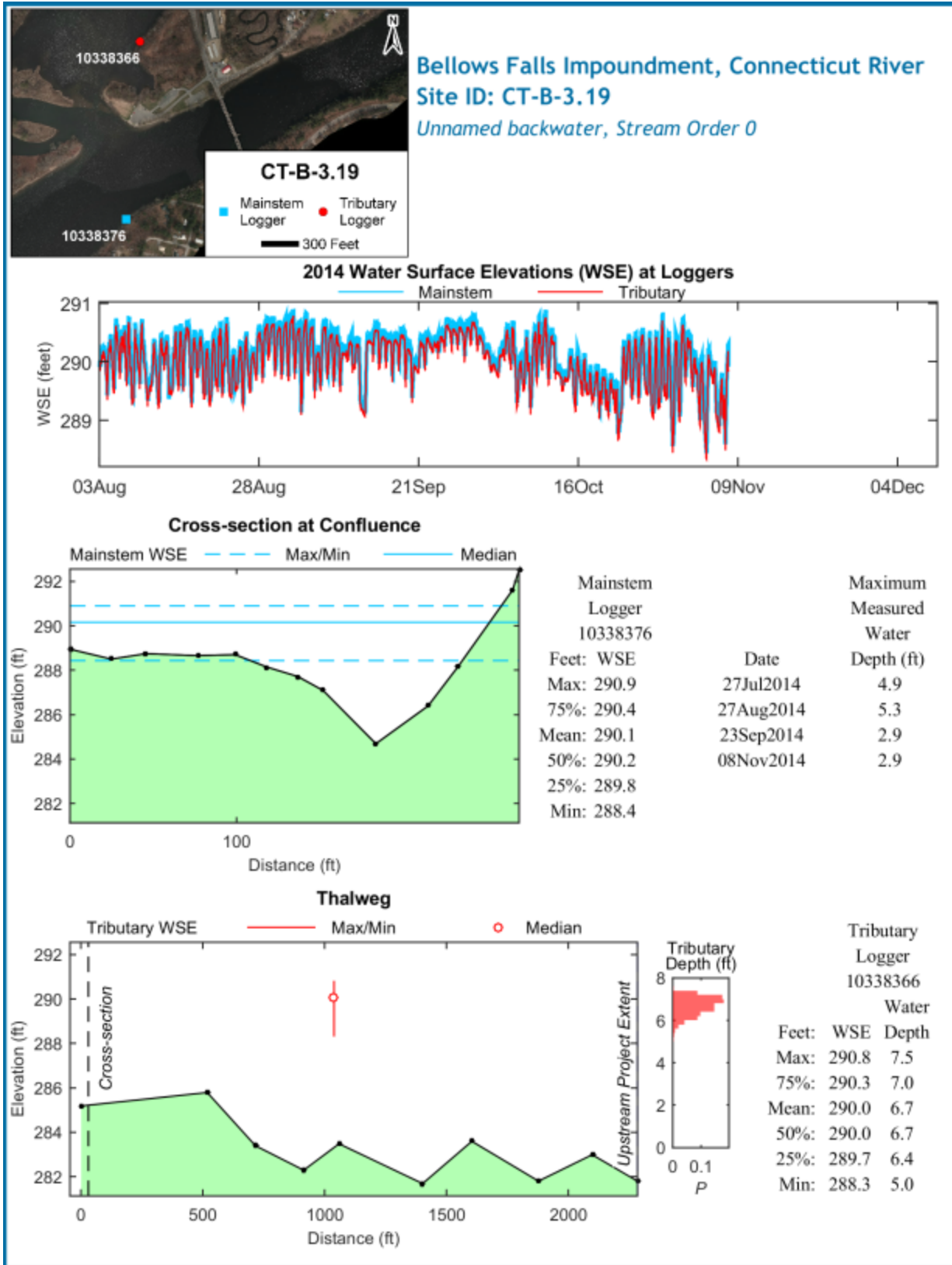
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### 3.3 Site CT-B-3.19 Backwater

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.



**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.

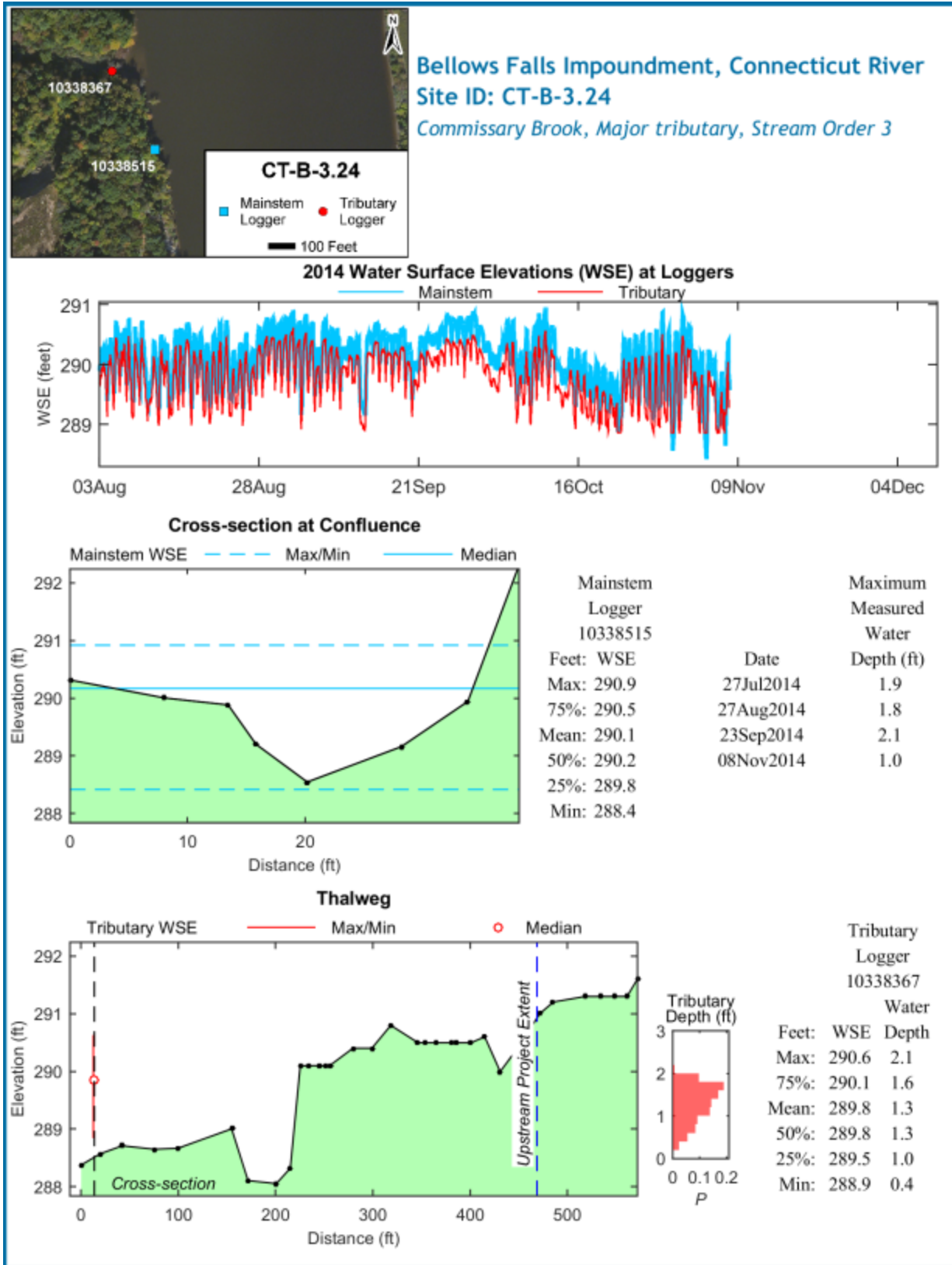
The tributary level logger was installed in the immediate vicinity of the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 200 ft upstream to a point where the tributary narrowed greatly and had dense canopy cover (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 27<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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 27<sup>th</sup> 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*

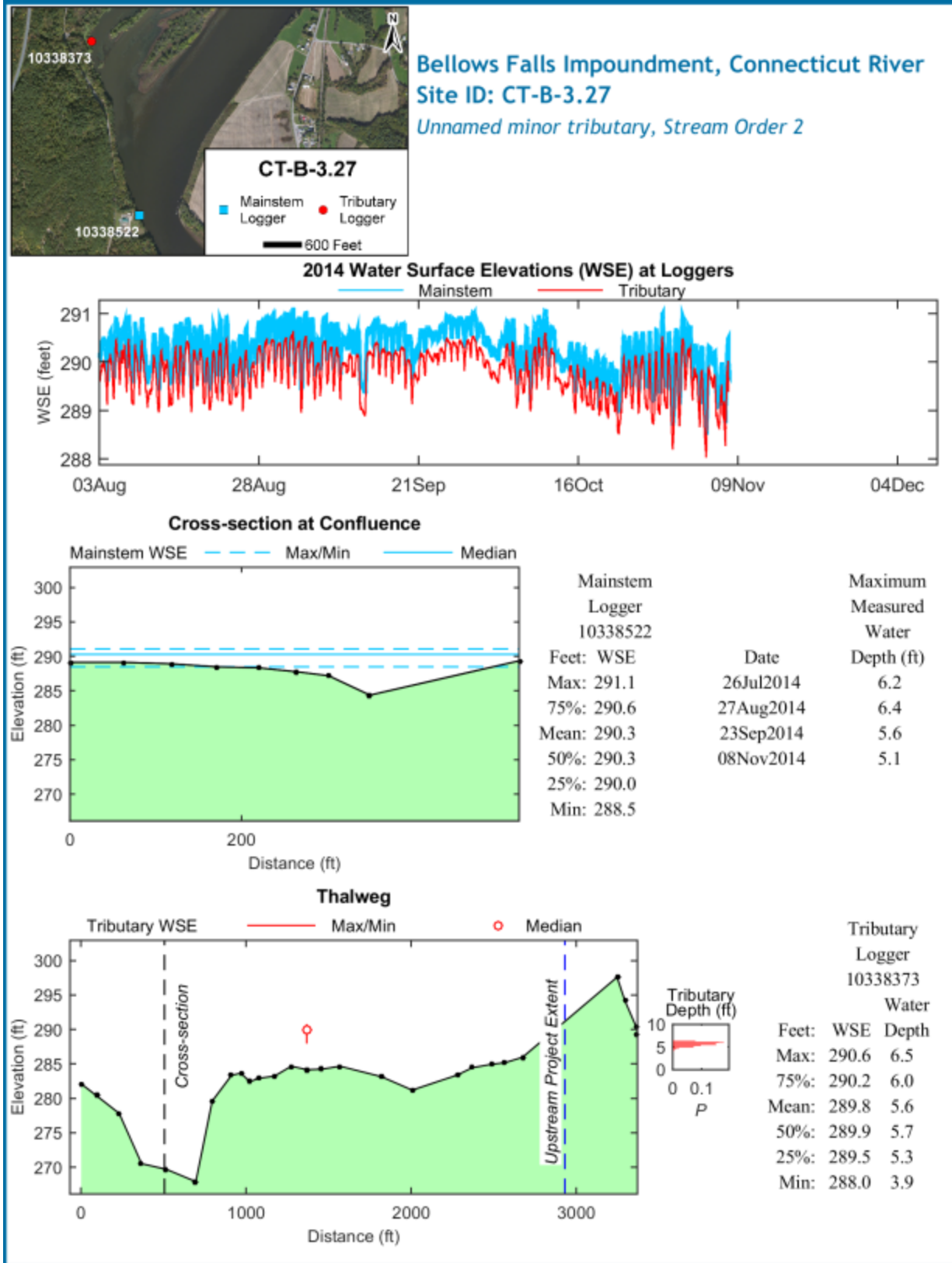


### 3.5 Site CT-B-3.27

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 26<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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).



**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

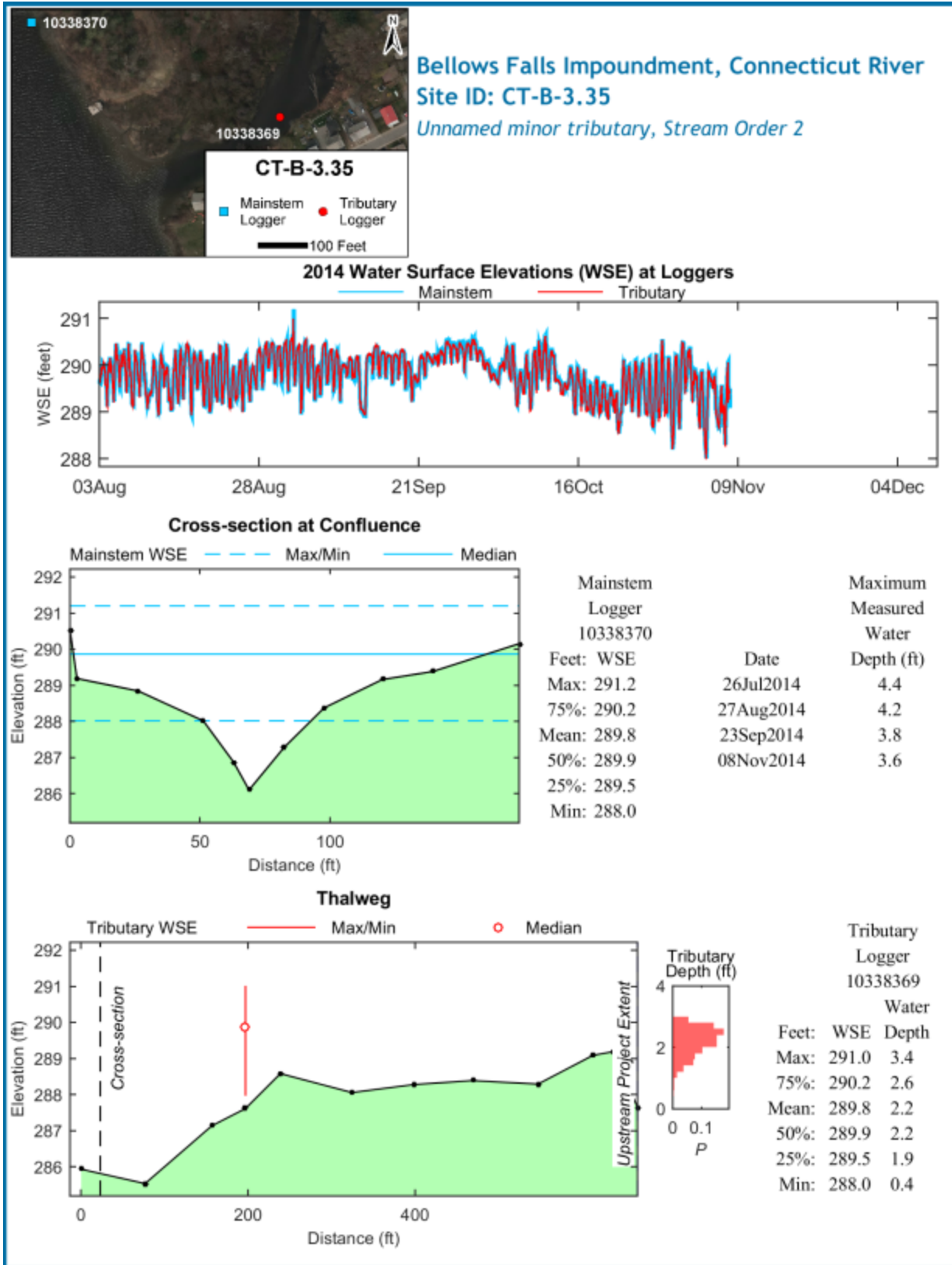
Site CT-B-3.35 is an unnamed stream order 2 tributary located on the New Hampshire side in the Bellows Falls impoundment. This location was initially visited on July 26, 2014 and tributary (SN 10338369) and mainstem (SN 10338370) level loggers were installed on that date. Subsequent site visits were 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., 25<sup>th</sup> through 75<sup>th</sup> 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.





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

26Jul14 07:08



26Jul14 08:49



27Aug14 11:55



23Sep14 14:31



08Nov14 13:55



08Nov14 14:03



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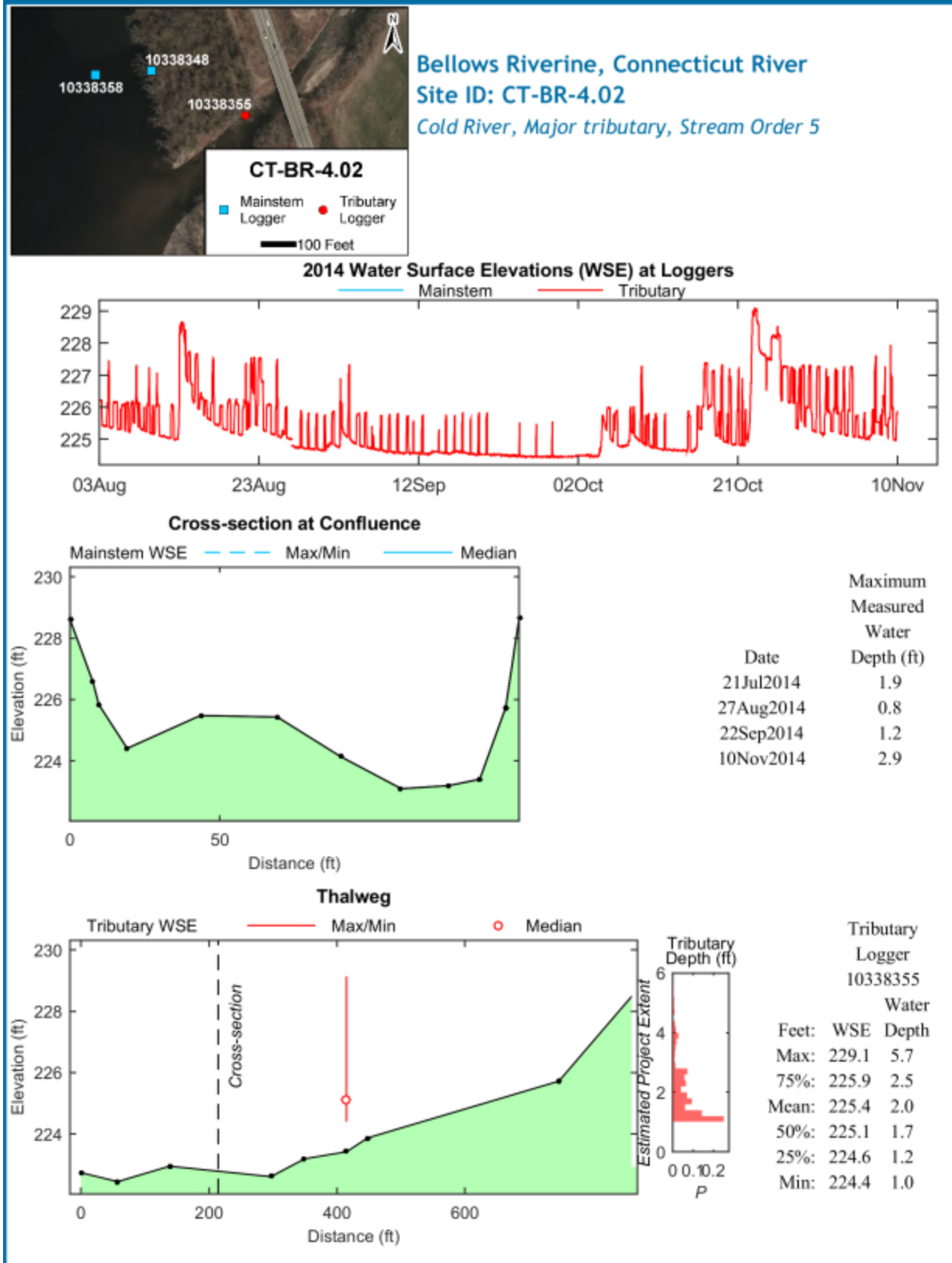
## 4.0 BELLOWS FALLS RIVERINE SECTION

### 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 21<sup>st</sup> (min = 1.2 ft; max = 2.2 ft; mean = 1.5 ft), August 27<sup>th</sup> (min = 0.7 ft; max = 1.7 ft; mean = 1.2 ft), and November 10<sup>th</sup> (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).



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



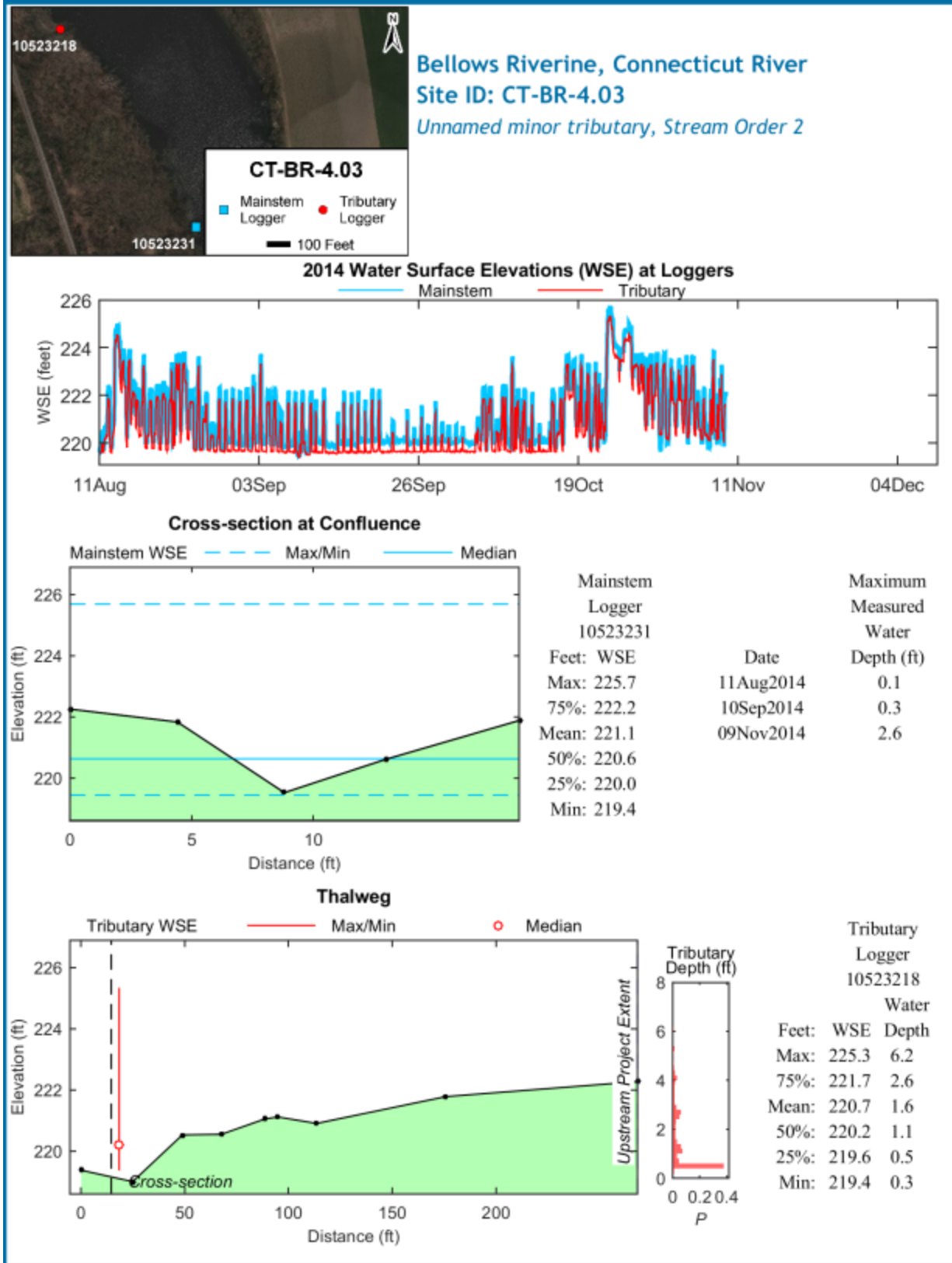
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## 4.2 Site CT-BR-4.03

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 8<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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).





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



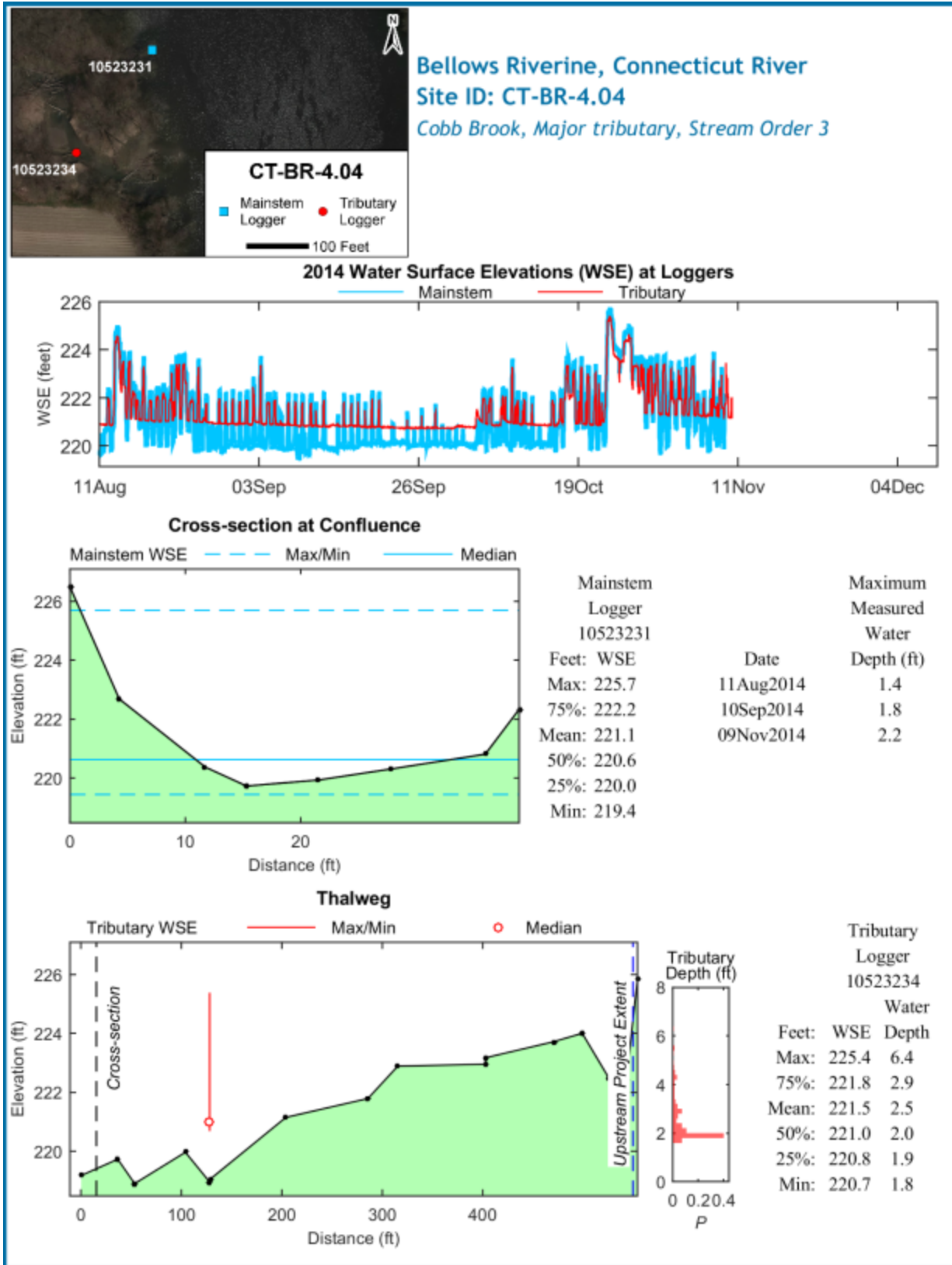
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### **4.3 Site CT-BR-4.04 Cobb Brook**

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 11<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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.



**Bellows Riverine, Connecticut River**  
**Site ID: CT-BR-4.04**

*Cobb Brook, Major tributary, Stream Order 3*



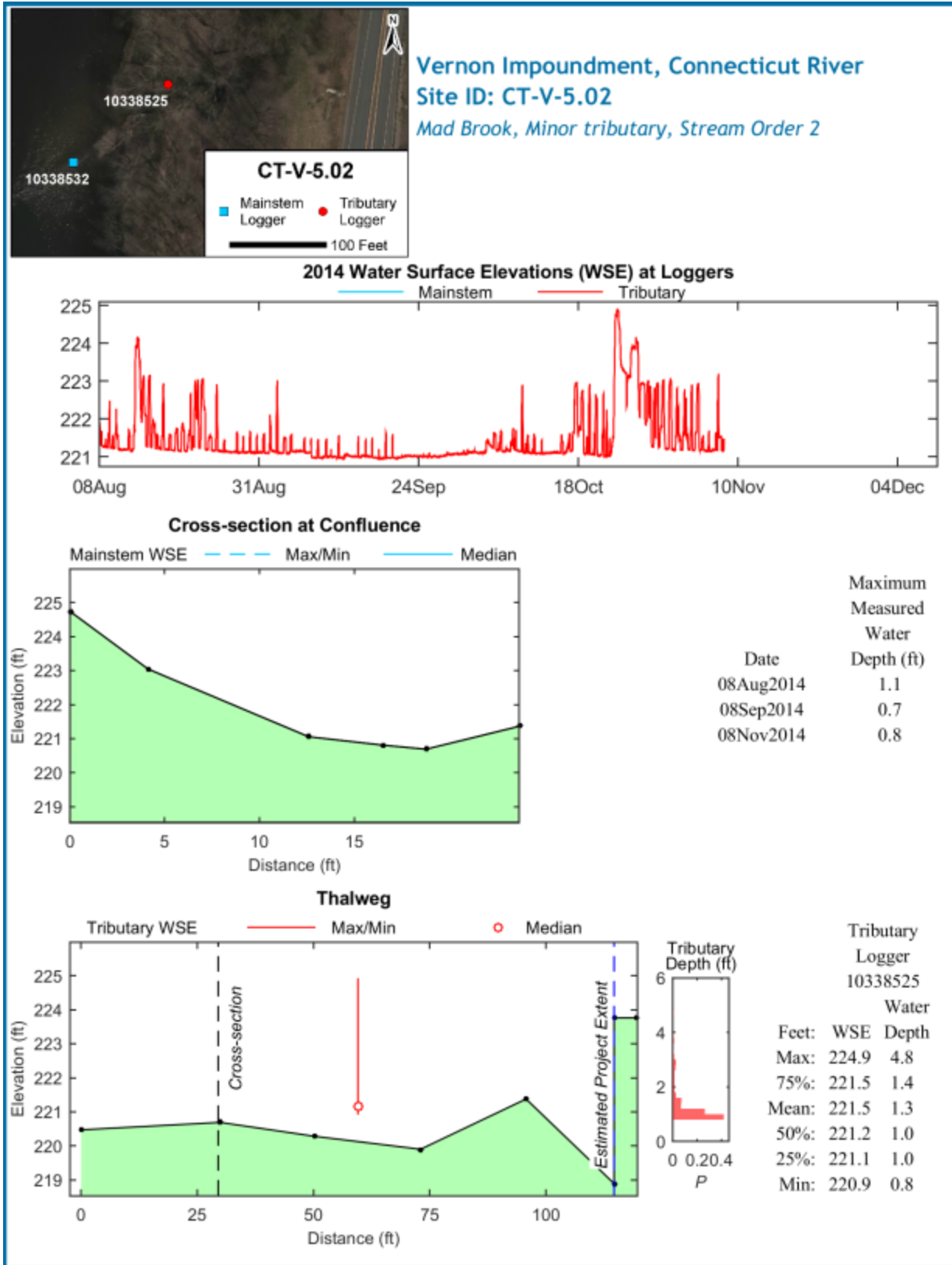
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#### 4.4 Site CT-V-5.02 Mad Brook

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 8<sup>th</sup> 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



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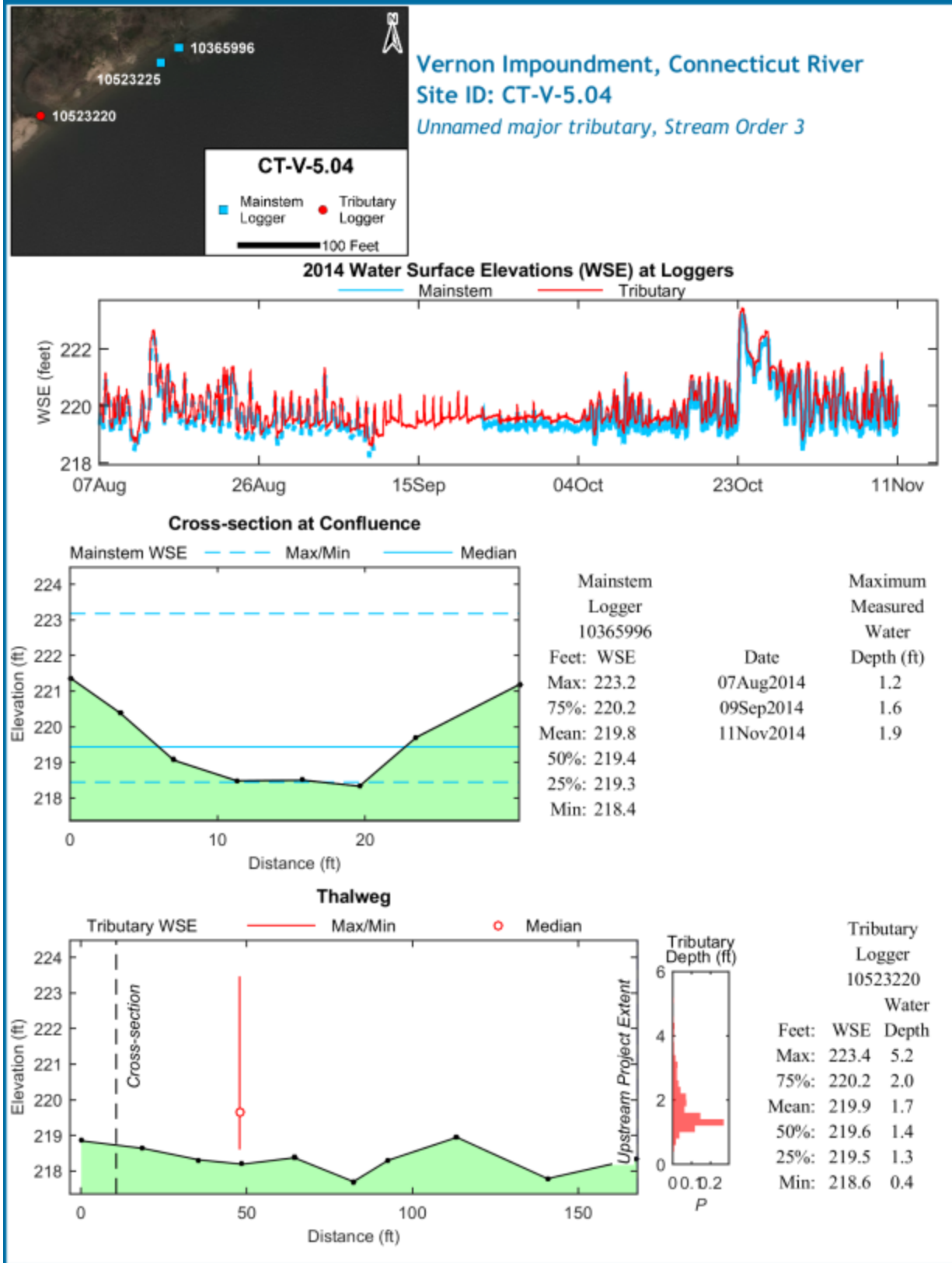
## 5.0 VERNON IMPOUNDMENT

### 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 9<sup>th</sup> 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 11<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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.



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.

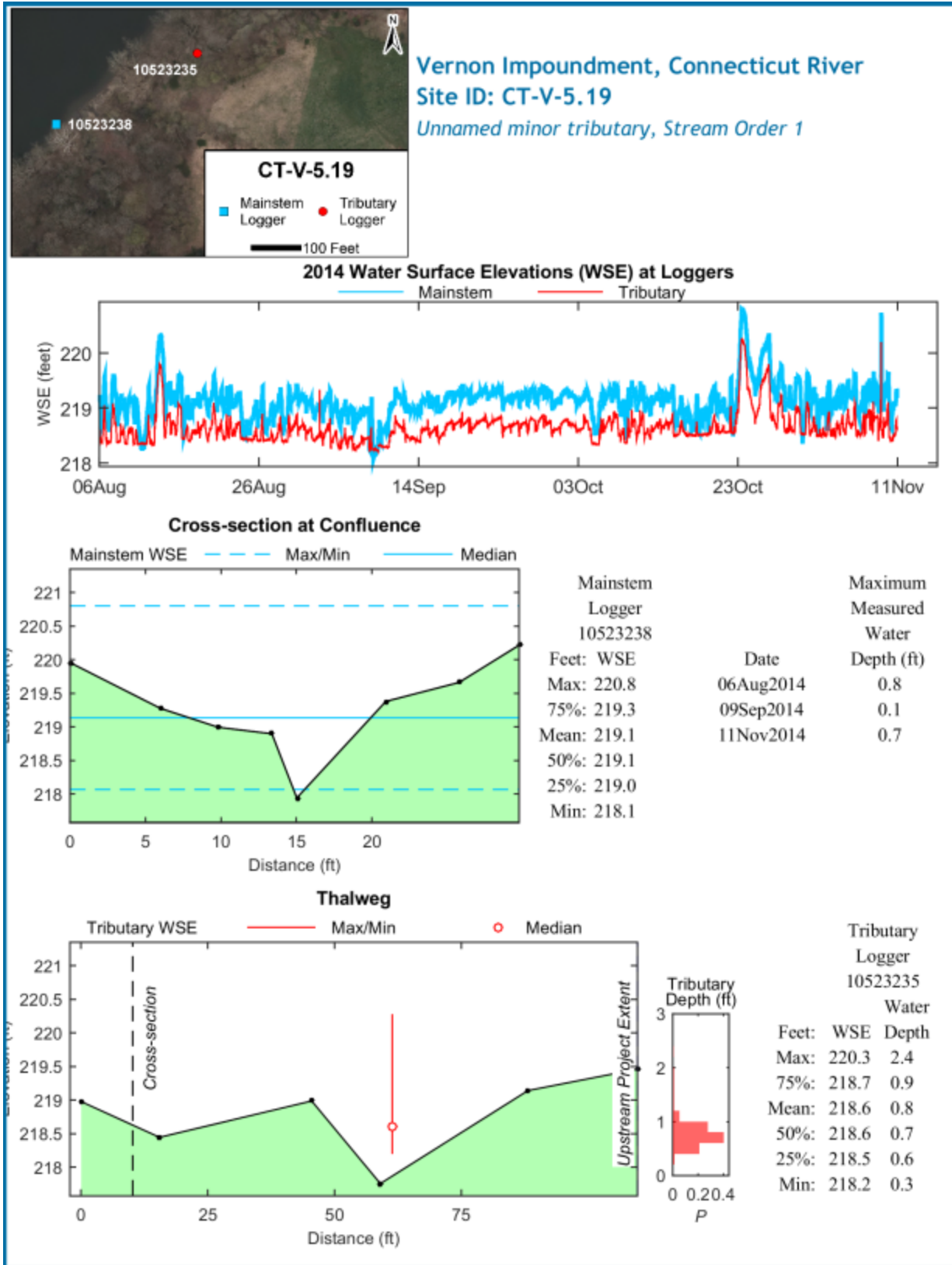
The tributary level logger was installed approximately 51 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 100 ft up into the tributary to a section where bank vegetation did not appear to indicate 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 11<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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.





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

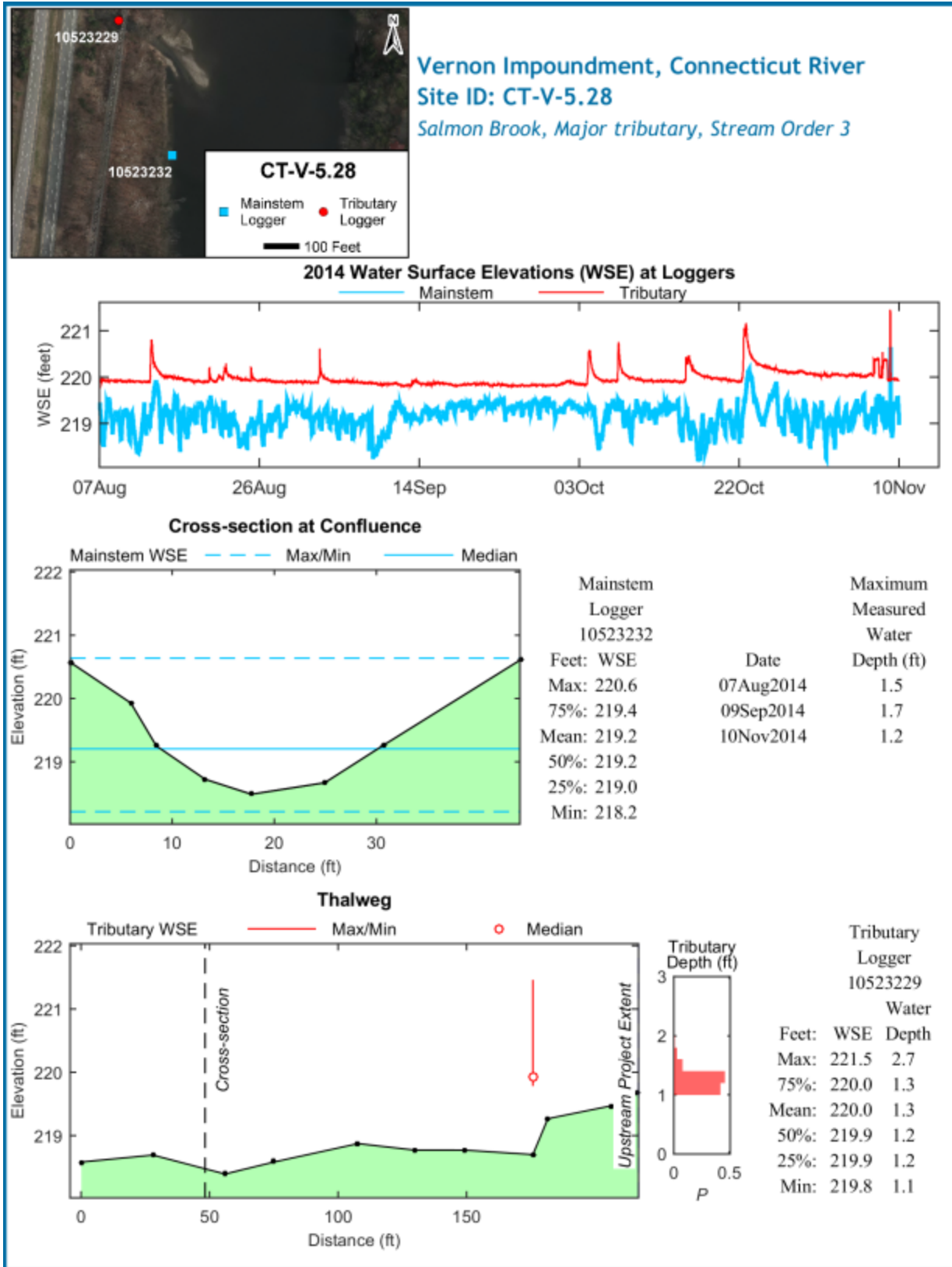


### 5.3 Site CT-V-5.28 Salmon Brook

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 7<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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).



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



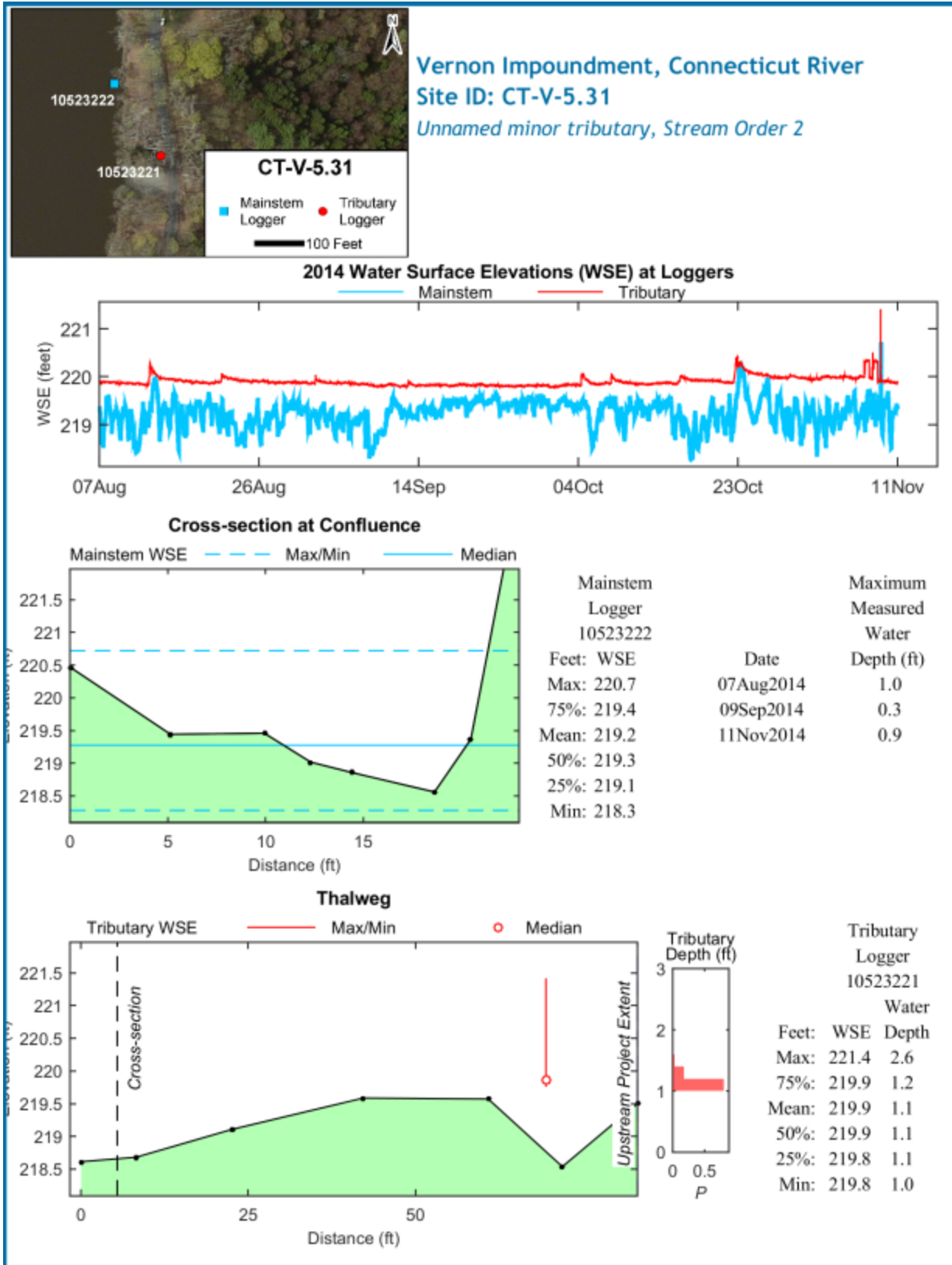
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#### 5.4 Site CT-V-5.31

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 11<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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



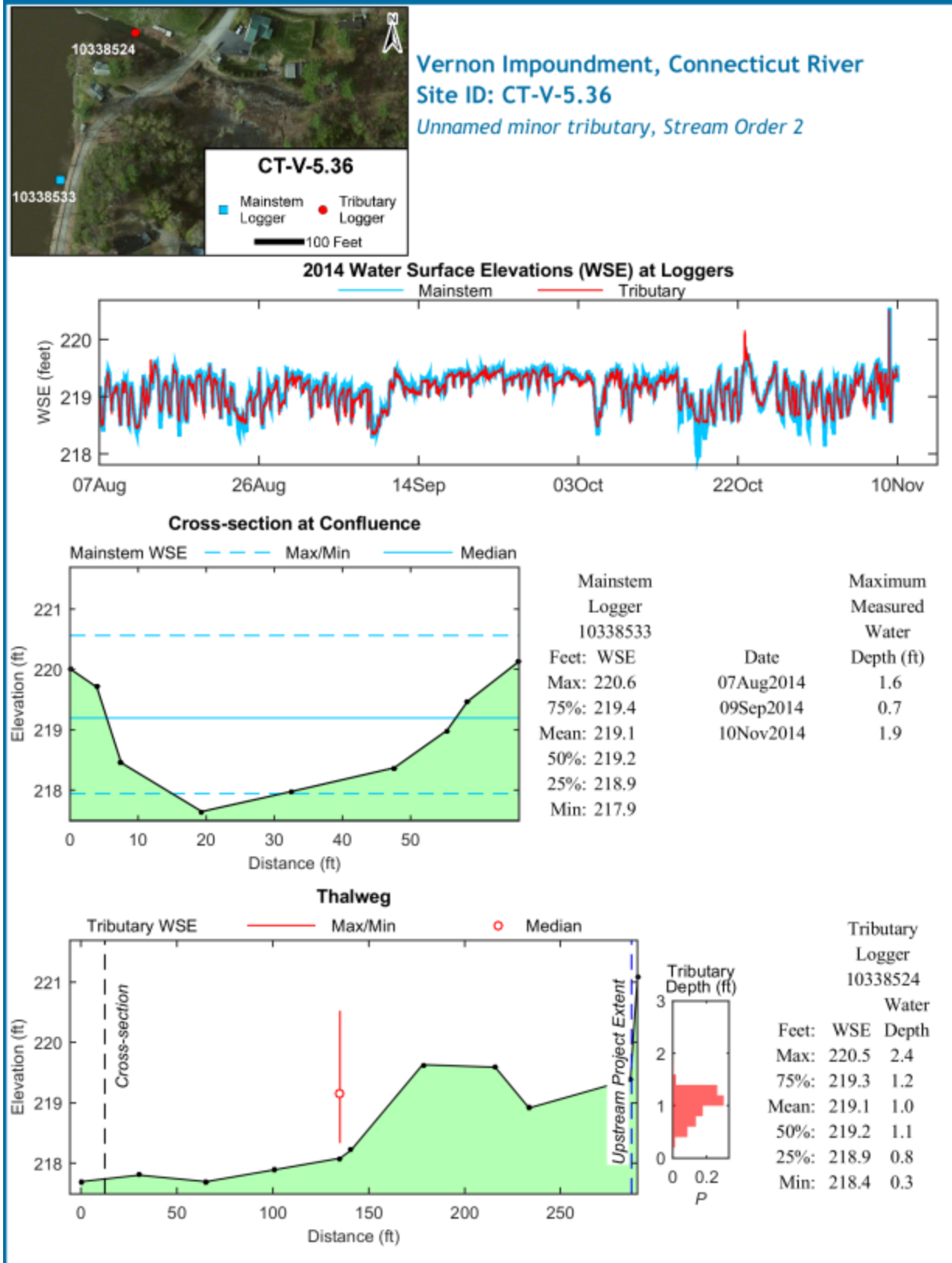
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## 5.5 Site CT-V-5.36

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 7<sup>th</sup> 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., 25<sup>th</sup> through 75<sup>th</sup> 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.

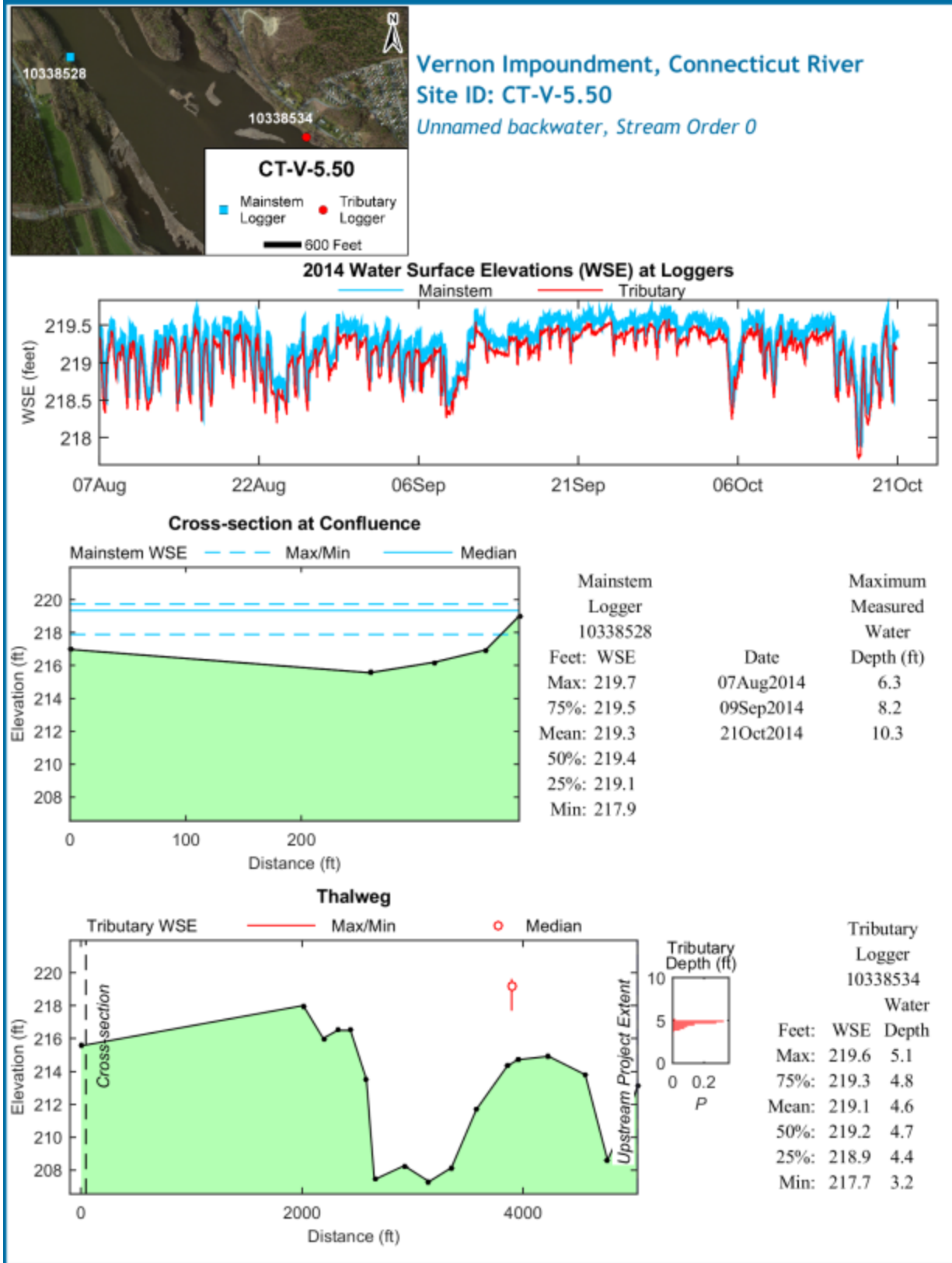


## 5.6 Site CT-V-5.50 Backwater

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., 25<sup>th</sup> to 75<sup>th</sup> 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



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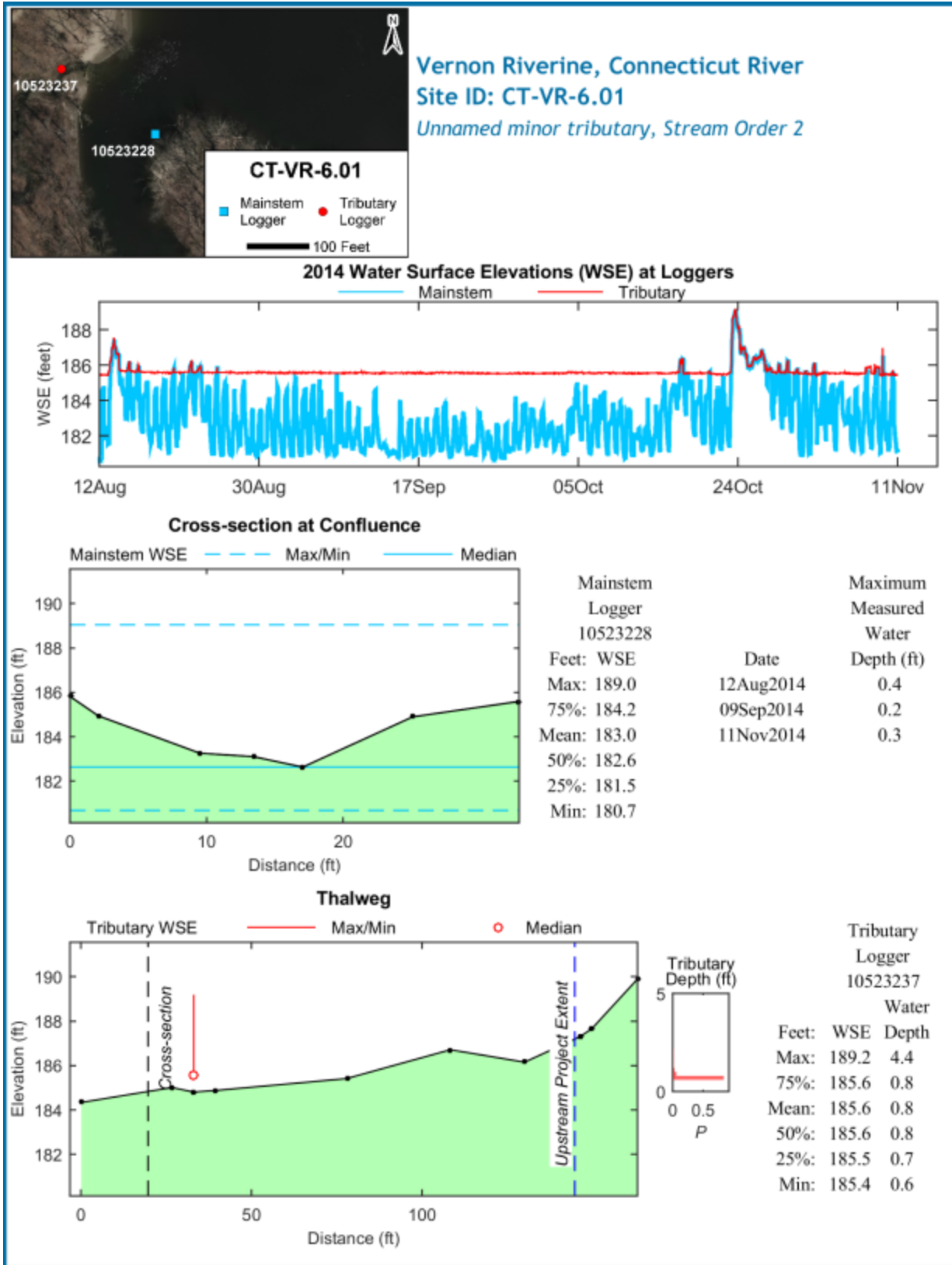
## 6.0 VERNON RIVERINE SECTION

### 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 12<sup>th</sup> 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., 75<sup>th</sup> 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



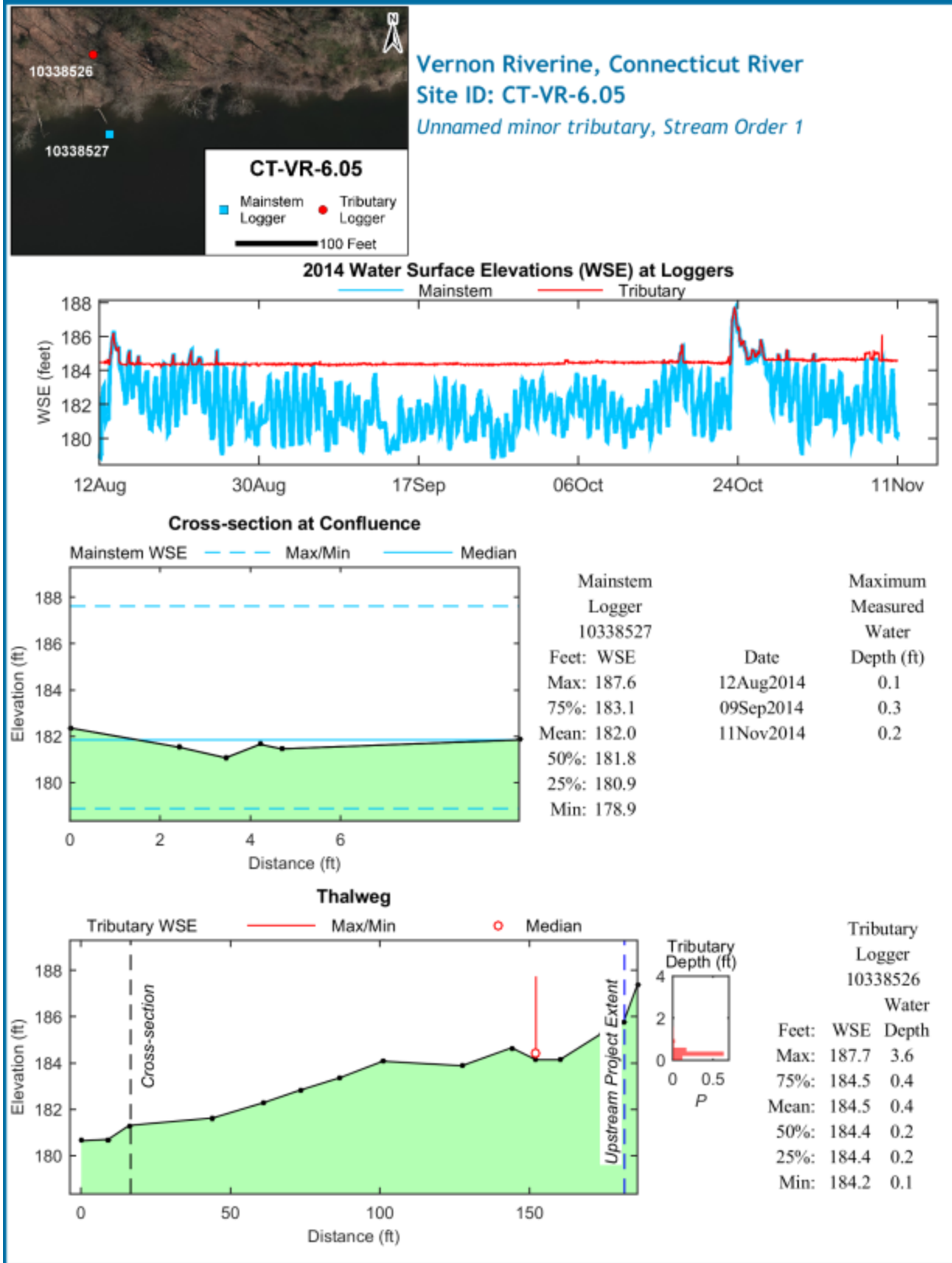
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## 6.2 Site CT-VR-6.05

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 11<sup>th</sup> 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., 50<sup>th</sup> 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 (25<sup>th</sup> 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

