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December 1, 2016

VIA ELECTRONIC FILING
Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Re: TransCanada Hydro Northeast Inc. Preliminary Licensing Proposal for Project Nos. 1892-026, 1855-045, and 1904-073

Dear Secretary Bose:

Pursuant to the regulations of the Federal Energy Regulatory Commission (Commission or FERC), Title 18 Code of Federal Regulations (18 C.F.R.) § 5.16, TransCanada Hydro Northeast Inc. ("TransCanada") hereby submits Preliminary Licensing Proposals (PLPs) for the Wilder, Bellows Falls, and Vernon Projects ("Projects") in a consolidated document. Verbal communication with FERC staff on October 14, 2016 authorized TransCanada's intent to file PLPs for the three licensed projects in a single document. The current licenses for the Projects expire on April 30, 2019.

TransCanada's Proposal in the PLP

The PLP includes a section on Proposed Actions and Alternatives that includes the no-action alternative and TransCanada's proposal. At this time, TransCanada is not proposing any changes to the Wilder, Bellows Falls or Vernon Project facilities, their operations or maintenance, or to existing environmental measures. As a result, TransCanada's proposal is identical to what would be referred to as the no-action alternative.

Since many of TransCanada's studies are not yet final, it would be premature at this time for TransCanada to develop a complete licensing proposal, reflecting other alternatives for operating the Projects in the new license term. Once TransCanada's studies and FirstLight's studies are complete and TransCanada has had an opportunity to discuss the study results with resource agencies and other stakeholders, TransCanada will be in a better position to develop comprehensive proposals for relicensing the Projects.

In the event that FERC, federal or state agencies, or the public provide proposals for alternatives to the Projects' facilities, operations, maintenance and/or environmental measures, TransCanada will evaluate those proposals or develop a modified proposal of its own in the Final License Applications (FLAs) or during the course of FERC's post-filing environmental analysis, as appropriate.

Review of the PLP and Filing of Comments

Pursuant to § 5.16(e), comments must be filed with the Commission no later than February 28, 2017 or 90 days from filing of the PLP. Given that TransCanada's proposal for relicensing the Project is incomplete; TransCanada expects that stakeholders may reserve their right to provide substantive comments until after more comprehensive proposals for relicensing the Projects are presented.

Status of FERC-Approved Studies

TransCanada filed a Proposed Study Plan on April 16, 2013 followed by an Updated Study Plan on July 9, 2013, and a Revised Study Plan on August 14, 2013. During 2013 and 2014, several studies were initiated, and TransCanada filed its Initial Study Report (ISR) on September 15, 2014. Studies continued in 2014 and 2015, and updated Study Reports (USRs) were filed on various dates with the first USR being filed on September 15, 2014 and additional USRs were filed as more studies were completed: on March 2, 2015, September 14, 2015, March 1, 2016, May 16, 2016, June 17, 2016, and August 1, 2016. Pursuant to 18 C.F.R. § 5.15, study results meetings were held and meeting summaries were filed in association with the ISR and each USR.

On November 30, 2016 TransCanada filed supplemental information or revised study reports for the following studies:

- Study 10 – Fish Assemblage Study - Final Report Supplement.
- Study 14-15 – Resident Fish Spawning in Impoundments and Riverine Sections Study – Revised Final Report.
- Study 17 – Upstream Passage of Riverine Fish Species Assessment – Final Report.
- Study 18 – American Eel Upstream Passage Assessment – Report Supplement.
- Study 23 – Fish Impingement, Entrainment, and Survival Study – Final Report.
- Study 27 – Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study – Final Report Supplement

Analysis and study report revisions for some studies remain in progress at this time. Results are included in this PLP to the extent they are available at this time. Supplemental information or revised study reports for the following studies are expected to be filed in December 2016 and January 2017. Final results from those studies will be reported in the Final License Applications for the Projects.

- Study 2-3 – Riverbank Transect and Riverbank Erosion Study, Final Study Report expected by January 31, 2017 (initial report was filed August 1, 2016).
- Study 6 – Water Quality Study, Revised Final Study Report expected by December 15, 2016 (initial report was filed March 1, 2016, final report was filed August 1, 2016).
- Study 19 – American Eel Downstream Passage Assessment, Final Study Report expected by January 15, 2017 (initial report was filed May 15, 2016).
- Study 21 – American Shad Telemetry Study, Final Study Report expected December 15, 2016 (initial report was filed August 1, 2016).
- Study 22 – Downstream Migration of Juvenile Shad at Vernon, Final Study Report expected January 15, 2017 (initial report was filed May 16, 2016).
- Study 25 – Dragonfly and Damselfly Inventory and Assessment, Final Study Report expected December 15, 2016 (initial report was filed June 17, 2016).

Three other studies depend on additional stakeholder consultation for completion and results from these studies will be filed when consultation and resulting analysis is completed.

- Study 9 – Instream Flow Study (interim report was filed March 1, 2016).
- Study 24 – Dwarf Wedgemussel and Co-Occurring Mussel Survey - HSC Report (Phase 1 and Phase 2 reports were filed September 15, 2014, and March 2, 2015, respectively; Delphi Panel Report was filed May 16, 2016).
- Study 33 – Traditional Cultural Properties Study (initial report was filed May 16, 2016).

Also being filed today is the Phase II Archaeological Site Evaluations, Wilder Hydroelectric Project (FERC No. 1892-026) and Vernon Hydroelectric Project (FERC No. 1904-073), Orange and Windham Counties, Vermont.

Availability of PLP

TransCanada is filing the PLP with the Commission electronically. To access the PLP on the Commission's website (http://www.ferc.gov), go to the "eLibrary" link, and enter one of the following docket numbers, P-1855 (Bellows Falls), P-1892 (Wilder) or P-1904 (Vernon). TransCanada is also making the PLP available for download at the following website http://www.transcanada-relicensing.com (click on link found under "Announcements").

If there are any questions regarding the information provided in this filing or the process, please contact John Ragonese at 603-498-2851 or by emailing john_ragonese@transcanada.com.

Sincerely,

John L. Ragonese
FERC License Manager

Attachment: Preliminary Licensing Proposal for TransCanada's Wilder, Bellows Falls, and Vernon Hydroelectric Projects.

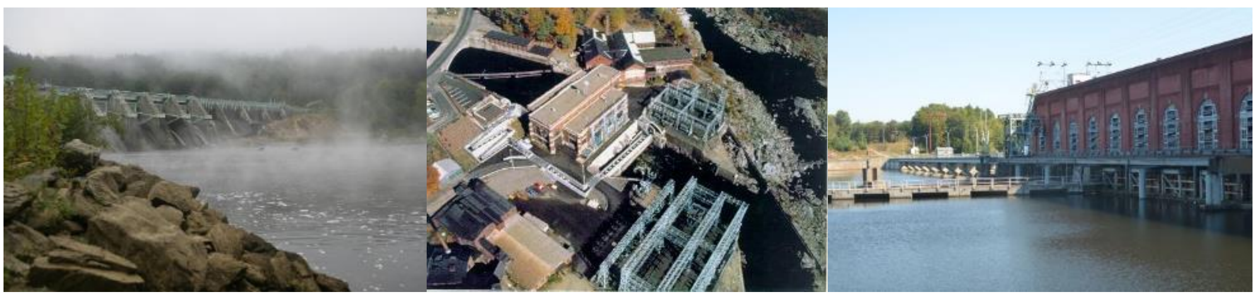
cc: Interested Parties List (distribution through email notification of availability and download from TransCanada's relicensing web site www.transcanada-relicensing.com).

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)



PRELIMINARY LICENSING PROPOSAL

December 1, 2016

TransCanada

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LIST OF FIGURES

LIST OF TABLES

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ACRONYMS AND ABBREVIATIONS

µS/cm	microsiemens per centimeter
1D	one-dimensional
2D	two-dimensional
acre-ft	acre-feet
ACHP	Advisory Council on Historic Preservation
A.D.	Anno Domini
APE	area of potential effects (as pertains to Section 106 of the National Historic Preservation Act)
ASMFC	Atlantic States Marine Fisheries Commission
B.C.	Before Christ
B.P.	Before Present
C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
CRASC	Connecticut River Atlantic Salmon Commission
CSO	combined sewer overflow
CTDEEP	Connecticut Department of Energy and Environmental Protection
CWA	Clean Water Act
°C	degrees Celsius
DA	drainage area
DO	dissolved oxygen
DOI	U.S. Department of the Interior
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
El.	elevation
EO	element occurrence
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
°F	degrees Fahrenheit
FCA	Forward Capacity Auction
FERC	Federal Energy Regulatory Commission

FirstLight	Power Resources
FLA	final license application
FPA	Federal Power Act
ft	foot or feet
ft/s	feet per second
FWS	U.S. Department of the Interior, Fish and Wildlife Service
HI-Z	HI-Z Turb'N
HPMP	Historic Properties Management Plan
ILP	Integrated Licensing Process
IPANE	Invasive Plant Atlas of New England
ISO-NE	New England Independent System Operator
ISR	Initial Study Report
KOP	key observation point
kV	kilovolt
kVA	kilovolt-ampere
kW	kilowatt
m^2	square meter
mgd	million gallons per day
mg/L	milligram(s) per liter
mg/m^3	milligrams per cubic meter
mL	milliliter
MW	megawatt
MWh	megawatt-hour
National Register	National Register of Historic Places
NEIWPCC	New England Interstate Water Pollution Control Commission
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
NHA	New Hampshire Audubon
NHDES	New Hampshire Department of Environmental Services
NHFGD	New Hampshire Fish and Game Department
NHNHB	New Hampshire Natural Heritage Bureau
NHPA	National Historic Preservation Act
NHSHPO	New Hampshire State Historic Preservation Officer

NITHPO	Narragansett Indian Tribal Historic Preservation Officer
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
NWI	National Wetlands Inventory
PAD	Pre-Application Document
PGA	peak ground acceleration
PHABSIM	Physical Habitat Simulation
PIT	passive integrated transponder
PLP	Preliminary Licensing Proposal
PM&E measures	protection, mitigation, and enhancement measures
Projects	Wilder (FERC No. 1892), Bellows Falls (FERC No. 1855), and Vernon (FERC No. 1904) Hydroelectric Projects
PSP	Proposed Study Plan
REC	Renewable Energy Credit
RPM	revolutions per minute
RM	river mile
RSP	Revised Study Plan
RTE	rare, threatened, or endangered
§	Section of a statute such as 18 C.F.R. § 5.6 (c)
SD1	Scoping Document 1
SD2	Scoping Document 2
SGCN	Species of Greatest Conservation Need
SHPO	State Historic Preservation Office
Sound	Long Island Sound
SPD	Study Plan Determination
sq. mi.	square mile(s)
TCP	Traditional Cultural Property
TMDL	total maximum daily load
TransCanada	TransCanada Hydro Northeast Inc.

USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USGS	U.S. Geological Survey
USR	Updated Study Report
VAR	volt-ampere-reactive
VANR	Vermont Agency of Natural Resources
VDEC	Vermont Department of Environmental Conservation
VFWD	Vermont Fish & Wildlife Department
VTNHI	Vermont Natural Heritage Inventory
VTSHPO	Vermont State Historic Preservation Officer
VY	Vermont Yankee Nuclear Power Plant
WAP	Wildlife Action Plan
WSE	water surface elevation

1. INTRODUCTION

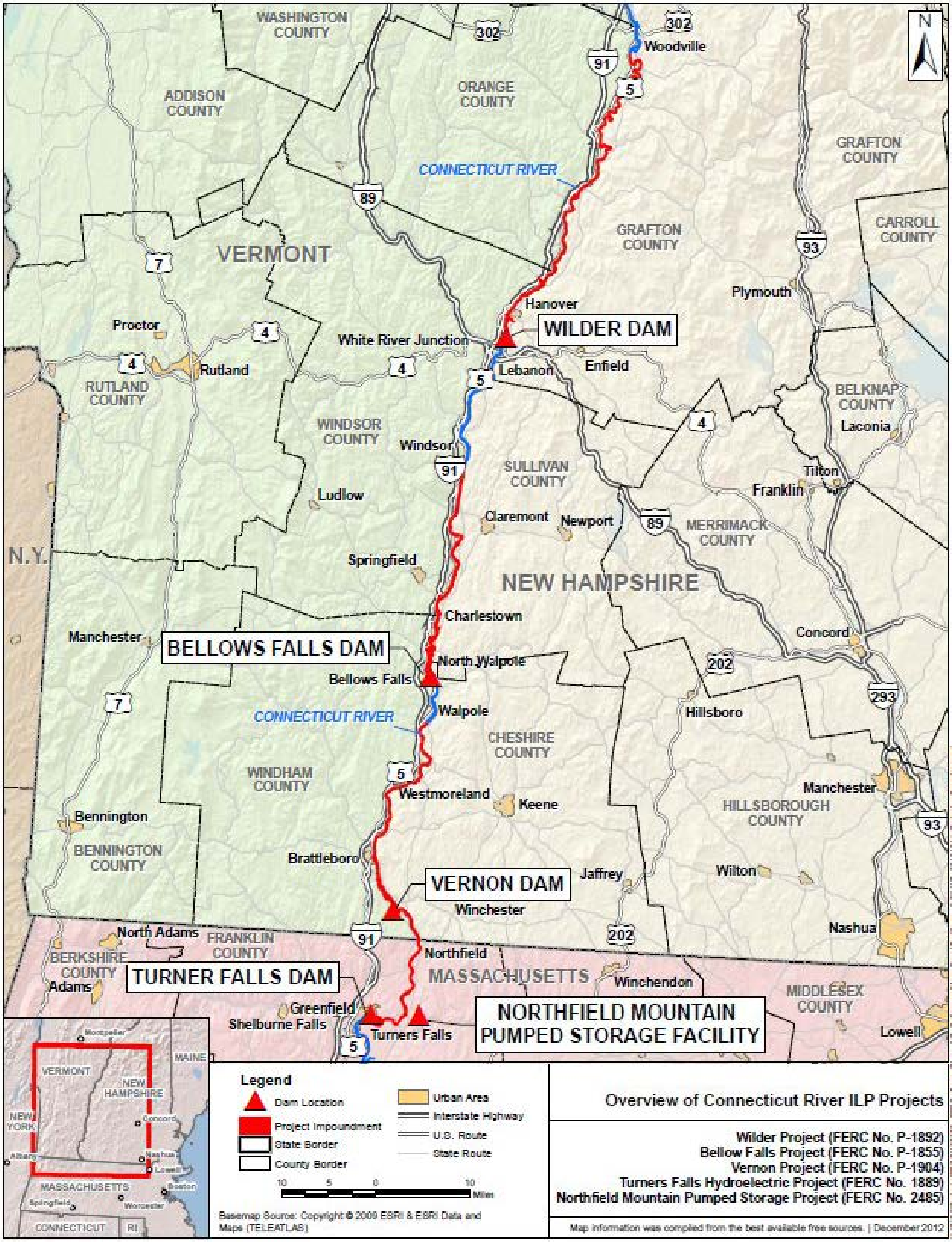
TransCanada Hydro Northeast Inc. (TransCanada) plans to file applications with the Federal Energy Regulatory Commission (FERC) by April 30, 2017, for new major licenses for the existing Wilder (FERC No. 1892), Bellows Falls (FERC No. 1855), and Vernon (FERC No. 1904) Hydroelectric Projects (Projects). TransCanada is following the Integrated Licensing Process (ILP) and on October 31, 2012, filed with FERC its Notices of Intent (NOIs) to seek new licenses for the Wilder, Bellows Falls, and Vernon Projects, along with a Pre-Application Document (PAD) for each Project.

Current licenses for the Projects were issued in 1979 and will expire on April 30, 2019.[1] The Projects are located on the Connecticut River in New Hampshire and Vermont (Figure 1.0-1). No federal lands are located within the Project boundaries. Table 1.0-1 summarizes general Project information.

Table 1.0-1. Summary of general Project information.

	Wilder	Bellows Falls	Vernon
FERC Project no.	1892	1855	1904
Current license term	12/10/1979–4/30/2019	08/03/1979–4/30/2019	06/25/1979–4/30/2019
Project location (state: town, county)	Vermont: Hartford, Windsor New Hampshire: Lebanon, Grafton	Vermont: Rockingham, Windham New Hampshire: Walpole, Cheshire	Vermont: Vernon, Windham New Hampshire: Hinsdale, Cheshire
Dam location (river mile [RM])	217.4	173.7	141.9
Authorized generating capacity (megawatt [MW])	35.6	40.8	32.4
Dependable capacity New England Independent System Operator's average summer-winter capacity supply obligation for the 10th Forward Capacity Auction (FCA #10) (kilowatt [kW])	43,400 kW	49,000 kW	32,000 kW
Annual energy production (gross megawatt-hour [MWh])	166,454 MWh/year	258,366 MWh/year	156,578 MWh/year

[1] On January 16, 2015, TransCanada filed a request with FERC to extend for 1 year the current terms of the licenses for Wilder, Bellows Falls, and Vernon Projects. On July 22, 2015, the Director granted the request, and Project licenses expire on April 30, 2019.



Source: FERC (2013)

Figure 1.0-1. Locations of Connecticut River Projects.

This Preliminary Licensing Proposal (PLP) presents TransCanada's proposal for the continued operation of the Wilder, Bellows Falls, and Vernon Projects under the terms of new licenses. TransCanada does not propose new capacity or new construction at the Projects at this time; however, as opportunities arise to examine upgrades and efficiency gains, TransCanada has and will continue to evaluate them in the ordinary course of its business.

The PLP is a consolidated document incorporating pertinent information for all three Projects. The purposes of this PLP as defined by 18 Code of Federal Regulations (C.F.R.) § 5.16 are to:

- Describe the existing and proposed facilities associated with the Projects including lands and waters;
- Describe the existing and proposed Project operations and maintenance plans to include measures for protection, mitigation, and enhancement measures (PM&E measures) with respect to each resource area affected by the Projects; and
- Provide TransCanada's draft environmental analysis of the continuing and incremental effects of the Projects by resource area, including the results of studies conducted under the approved study plans.

This PLP considers only TransCanada's proposed environmental measures as prescribed in 18 C.F.R. § 5.16(b)(3). Any preliminary environmental measures proposed by federal and state resource agencies, Indian Tribes, non-governmental organizations, or members of the public (see 18 C.F.R. § 5.18(b)(5)(ii)(C)) will be analyzed in Exhibit E of the license applications for the Projects to provide the foundation for FERC's National Environmental Policy Act (NEPA) analysis.

1.1 Purpose of Action and Need for Power

1.1.1 Purpose of Action

FERC must decide whether to issue licenses to TransCanada for the Projects and what conditions should be placed in any licenses issued. In deciding whether to issue a license for a hydroelectric project, FERC must determine that the project will be best adapted to a comprehensive plan for improving or developing a waterway. In addition to the power and developmental purposes for which licenses are issued (e.g., flood control, irrigation and water supply), FERC must give equal consideration to the purposes of energy conservation, the protection, mitigation of damage to, and enhancement of fish and wildlife (including related spawning grounds and habitat), the protection of recreational opportunities, and the preservation of other aspects of environmental quality.

Issuing new licenses for the Projects would allow TransCanada to continue to generate electricity at the Projects for the term of the new licenses, making electric power from a renewable resource available to serve regional demand and supporting other variable renewable energy resources (e.g., wind and solar) serving the region.

This PLP has been prepared in accordance with 18 C.F.R. § 5.16 and generally follows FERC's guidelines in *Preparing Environmental Documents* (FERC, 2008). In the PLP, TransCanada assesses the environmental and economic effects of continuing to operate the Projects as proposed. TransCanada also considers the effects of the no-action alternative. Important resource issues that are addressed herein include erosion, aquatic habitat, fish passage, recreation, rare, threatened, and endangered species, and cultural and historic resources.

1.1.2 Need for Power

The Projects are located in the regional electric system that is operated by the New England Independent System Operator (ISO-NE) and that supplies electric power to the New England states. ISO-NE is responsible for regional grid operation and dispatch of generation, wholesale market administration, and power system analysis and planning to ensure system reliability and adequate generation and transmission resources to meet regional needs. ISO-NE prepares both short- and long-term projections of electricity supply and demand. The 2016–2025 Forecast Report of Capacity, Energy, Loads, and Transmission projects annual increases of 0.9 percent in summer peak demand, 0.6 percent in winter peak demand, and 0.8 percent in annual energy use from 2016 to 2025 (ISO-NE, 2016).

Table 1.0-1 (above) summarizes the authorized capacity and annual energy production for the Projects. Combined, the Projects provide 124,400 kilowatts (kW) of dependable capacity and on average 581,398 annual megawatt-hours (MWh) to the regional power grid. Over the term of the new licenses, the Projects will continue to directly provide renewable power and can support variable energy resources through reserve capacity, both of which displace fossil-fired generation, reducing power plant emissions, creating an environmental benefit. The Projects also provide forward capacity, real-time reserves, voltage-ampere reactive (VAR) support[2] and Renewable Energy Credits (RECs) within the ISO-NE power pool.

1.2 Applicable Statutory and Regulatory Requirements

Issuance of new licenses for the Projects is subject to requirements under the Federal Power Act (FPA) and other federal statutes. Requirements applicable to this PLP are summarized below. Additional requirements such as FPA Section 18 fishway prescriptions and Section 10(j) recommendations may be issued by agencies with authority after filing of the final license applications (FLAs) for the Projects.

[2] Voltage is regulated through reactive power production and consumption, and resources on the grid may be compensated for providing this reactive power capability. Voltage-ampere reactive (VAR) is the unit of measurement for reactive power.

1.2.1 Clean Water Act

Section 401 of the Clean Water Act (CWA) requires TransCanada to obtain certification from the appropriate state pollution control agency verifying compliance with the CWA or to obtain a waiver of certification. The New Hampshire Department of Environmental Services (NHDES) and the Vermont Department of Environmental Conservation (VDEC) are the state agencies responsible for water quality certifications for the Projects. On April 1, 2016, the states of New Hampshire and Vermont informed TransCanada by letter of their decision not to issue joint Section 401 water quality certifications for the Projects and requiring TransCanada to submit state-specific certification applications for each of the Wilder, Bellows Falls, and Vernon Projects.

TransCanada will file requests for water quality certification with the two state agencies in accordance with 18 C.F.R. § 5.23(b) within 60 days of FERC's issuance of notice of acceptance of the FLAs and Ready for Environmental Analysis notice.

1.2.2 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) requires FERC to consult with the U.S. Department of the Interior, Fish and Wildlife Service (FWS), and the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) Fisheries (aka National Marine Fisheries Service or NMFS), to ensure that FERC's licensing actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of such species. TransCanada has been designated as FERC's non-federal representative for informal consultation under the ESA (in FERC's NOI to File License Application and Commencing Pre-filing Process issued on December 21, 2012).

TransCanada reviewed species lists obtained from FWS, NMFS, and the New Hampshire and Vermont Natural Heritage Bureaus. Endangered species listed under the ESA that occur or are likely to occur in the Wilder, Bellows Falls, and/or Vernon Projects include dwarf wedgemussel, Jesup's milk vetch, and northeastern bulrush. The bald eagle is present in the Project areas and is a protected species under the Bald and Golden Eagle Protection Act (16 United States Code [U.S.C.] § 668-688c). Currently, no federally designated critical habitats occur in New Hampshire or Vermont (FWS, 2016a).

The endangered Puritan tiger beetle was not observed in field surveys conducted in 2014. It was likely extirpated and last observed in the Project areas in 1932. The northern long-eared bat was newly listed as threatened on April 2, 2015. The species may occur within the Project boundaries, but the species was neither requested to be nor was evaluated in relicensing field studies,[3] and the species was not observed in any other relicensing studies.

1.2.3 Coastal Zone Management Act

Section 307(c)(3) of the Coastal Zone Management Act requires that all federally licensed and permitted activities be consistent with approved state Coastal Zone Management Programs. The Projects are not located within New Hampshire's designated Coastal Management Zone, defined by the state's 3-mile territorial sea, extending from the Maine-New Hampshire border to the Massachusetts-New Hampshire border and extending inland to include the lands and waters in all or part of 17 coastal towns in Rockingham and Strafford counties. Vermont does not have a Coastal Zone Management Program. The Wilder, Bellows Falls, and Vernon Projects are not located in a state-designated coastal zone management area and, therefore, are not subject to the New Hampshire coastal zone program review. Accordingly, TransCanada's assessment is that no coastal zone consistency certification is needed for the Projects.[4]

1.2.4 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires that every federal agency take into account how each of its undertakings could affect historic properties. Historic properties are any prehistoric or historic districts, sites, buildings, structures, Traditional Cultural Properties (TCPs), and objects significant in American history, architecture, engineering, and culture that are eligible for inclusion in the National Register of Historic Places (National Register).

TransCanada has been designated as FERC's non-federal representative for informal consultation under Section 106 (in FERC's NOI to File License Application and Commencing Pre-filing Process issued on December 21, 2012). TransCanada developed and implemented several studies to identify any adverse effects on historic properties resulting from continued operation of the Projects. Study plans were developed, and the New Hampshire and Vermont State Historic Preservation Offices (SHPOs), affected Indian Tribes, and other interested parties were given an opportunity to comment prior to FERC's final Study Plan Determination (SPD). The

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[3] The primary threat to the species is white-nose syndrome, a fungal disease that affects bats during hibernation in caves and mines, none of which are located within the Project boundaries. The species is state-listed as threatened in New Hampshire and as endangered in Vermont.

[4] The NHDES Coastal Program concurred via email dated November 10, 2016, from Christian Wilson, Federal Consistency Coordinator, that Project relicensing is not subject to the state's federal consistency review.

results of those studies are discussed in Section 3.10, *Cultural and Historic Resources*, and provide the basis for the Programmatic Agreement to be executed by the SHPOs, TransCanada, and other interested parties, which will likely direct TransCanada to develop Historic Properties Management Plans (HPMPs).

1.2.5 Wild and Scenic Rivers Act

Section 7(a) of the Wild and Scenic Rivers Act requires federal agencies to make a determination as to whether the operation of a project under a new license would invade the area or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the designated river corridor. No segments of the Connecticut River have been designated for inclusion in the Wild and Scenic Rivers System. However, two segments are listed in the Nationwide Rivers Inventory, which identifies potential candidates for inclusion in the Wild and Scenic Rivers System. The first segment is a 24-mile reach downstream of the Wilder Project from Windsor, Vermont, to the confluence of the Williams River in Rockingham, Vermont, in the Bellows Falls Project. *Hydrology* is the outstandingly remarkable value supporting this listing. The second segment is an 18-mile reach downstream of the Bellows Falls Project from the Route 123 Bridge in Walpole, New Hampshire, to the Route 9 Bridge in Brattleboro, Vermont, in the Vernon Project. *Hydrology*, *botanical*, and *historical* are the outstandingly remarkable values supporting this listing. Both segments were listed in 1982 (National Park Service, 2016). Federal agencies are required to assess whether a federal action could diminish the outstandingly remarkable values for which a segment is listed in the Nationwide Rivers Inventory. The Projects were constructed well before the listing of these two segments, and TransCanada proposes no change in the facilities and operations of the Projects. Consequently, relicensing of the Projects would not diminish the outstandingly remarkable values for which these segments of the Connecticut River were listed.

1.2.6 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act requires federal agencies to consult with NOAA Fisheries on all actions that may adversely affect Essential Fish Habitat (EFH). EFH was defined for Atlantic Salmon as all aquatic habitats in the watersheds of identified rivers including all tributaries, to the extent that they are currently or were historically accessible for salmon migration in Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut, including the entire Connecticut River watershed. The designation excludes only areas upstream of longstanding naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years) (NEFMC, 1998).

Beginning in 1967, the Connecticut River Atlantic Salmon Commission (CRASC) worked to restore Atlantic Salmon to the Connecticut River Basin by hatchery production and stocking, as well as other management and regulatory approaches. Upstream and downstream fish passage facilities at the Wilder, Bellows Falls, and Vernon Projects have provided Atlantic Salmon with passage through the Projects since the 1980s. Because of low adult returns over the years, FWS discontinued culturing salmon for restoration in the Connecticut River Basin in 2012. New Hampshire, Vermont, and Massachusetts also discontinued rearing and stocking programs, yet small numbers of adult salmon have continued to return to the basin. In 2016, however, no adult salmon returned to the Project-affected areas (see Section 3.5, *Fish and Aquatic Resources*). Therefore, TransCanada does not anticipate that relicensing of the Projects will adversely affect EFH for Atlantic Salmon.

1.3 Public Review and Comment

1.3.1 Scoping

On December 21, 2012, FERC issued its Notice of Commencement of Proceedings and Scoping Document 1 (SD1) for its NEPA analysis of the "Connecticut River Projects," which includes the Wilder, Bellows Falls, and Vernon Projects as well the Turners Falls (FERC No. 1889) and Northfield Mountain Pumped Storage (FERC No. 2485) Projects.[5] FERC staff indicated in SD1 its intent to prepare a single Environmental Impact Statement (EIS) for the five Connecticut River Projects to analyze both site-specific and cumulative environmental impacts and reasonable alternatives to the proposed actions. FERC also designated TransCanada as its non-federal representative for carrying out informal consultation, pursuant to Section 7 of the ESA and Section 106 of the NHPA for the Wilder, Bellows Falls, and Vernon Projects.

In January 2013, in various locations near the five Connecticut River Projects in New Hampshire, Vermont, and Massachusetts, FERC staff held six Project-specific scoping meetings and one additional scoping meeting to help identify the cumulative effects of licensing the five Projects. Site visits to the TransCanada Projects had been conducted on October 1–3, 2012, prior to the scoping meetings as a result of FERC's decision to avoid winter conditions that would limit access to the facilities under the normal scoping schedule.

On April 15, 2013, FERC issued its Scoping Document 2 (SD2), in response to verbal and written comments received at the scoping meetings as well as during the scoping process.

[5] FirstLight Power Resources (FirstLight) is the Licensee of the downstream Turners Falls Hydroelectric Project and the Northfield Mountain Pumped Storage Project. The current licenses for both the Turners Falls Project and the Northfield Mountain Project expire on April 30, 2018. On April 29, 2016, FirstLight filed with FERC a consolidated FLA for the two projects and is seeking to combine the projects into a single new license.

1.3.2 Study Plans and Studies

On April 16, 2013, TransCanada filed its Proposed Study Plan (PSP).[6] In the PSP, TransCanada responded to comments received on the PADs and to study requests for the Projects from state and federal agencies, local officials, non-governmental organizations, and other interested parties (collectively, stakeholders).

With its filing of the PSP, TransCanada included a study request responsiveness summary, identifying each study request, the Study Plan's responsiveness to the request, and the rationale for why any particular study request was not adopted. The April 16, 2013, filing also included TransCanada's schedule for Study Plan meetings. TransCanada recognized that a single meeting would not be adequate to clarify and discuss its PSP and, therefore, held a series of Study Plan meetings and discussions from May to July 2013 regarding its Study Plan proposals. TransCanada received extensive feedback and participation from many interested stakeholders within resource-specific working groups.

Comments on the PSP were due on July 15, 2013 (i.e., within 90 days of the filing of the PSP). During the consultation process, TransCanada received, discussed, and reviewed stakeholder comments on its PSP. In addition, in response to comments received and consultation with stakeholders through the Study Plan meetings, TransCanada filed with FERC an updated PSP on July 9, 2013.

TransCanada filed its Revised Study Plan (RSP) to address the effects of continued operation of the TransCanada Projects on August 14, 2013. The RSP included 33 individual studies and data collection efforts (Table 1.3-1). The RSP reflected comments received during the Study Plan meetings and working group discussions as well as formal comments filed by stakeholders with FERC.

On August 27, 2013, Entergy announced plans to decommission the Vermont Yankee Nuclear Power Plant (VY) during the fourth quarter of 2014. VY withdrew cooling water from, and discharged it back into, the Vernon Project impoundment. The effect of decommissioning VY thus changed the baseline conditions at the Vernon Project.

In a September 13, 2013, SPD, the Director delayed issuing determinations for 20 aquatic resource studies, pending a technical meeting on the issue of VY's decommissioning; however, determinations were issued for the remaining 13 studies unlikely to be affected by VY's continued operation or decommissioning. These studies were approved with, or without, modifications. In addition, 4 requested studies were determined to be not required. On September 24, 2014, TransCanada filed a request for clarification on specific aspects of the determination, and the Director provided clarification on those aspects in a letter dated October 22, 2013.

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[6] Delays on FERC's eFiling website prevented PSP filing on the due date of April 15, 2013.

Table 1.3-1. Summary of ILP studies filed prior to December 1, 2016.

Study No.	Study Title	Modified from RSP[a]	FERC Filing Date	Citation
1	Historical Riverbank Position and Erosion Study		03/01/2016	Field and Normandeau (2016a)
2–3	Riverbank Transect and Riverbank Erosion Studies	X	08/01/2016	Field and Normandeau (2016b)
4	Hydraulic Modeling Study	X	Initial Report 03/01/2016 Final Report 06/17/2016	GEI (2016)
5	Operations Modeling Study	X	08/01/2016	Hatch (2016)
6	Water Quality Study	X	Initial Report 03/01/2016 Final report 08/01/2016	Louis Berger and Normandeau (2016a)
7	Aquatic Habitat Mapping Study		Initial Report 09/15/2014 Final Report 03/02/2015	Normandeau (2015a)
8	Channel Morphology and Benthic Habitat Study		Initial report 03/02/2015 Final Report 05/16/2016 Supplemental data 08/31/2016	Stantec and Normandeau (2016)
9	Instream Flow Study		Interim Report 03/01/2016	Normandeau (2016a)
10	Fish Assemblage Study	X	Initial Report 03/01/2015 Final Report 08/01/2016 Report Supplement 11/30/2016	Normandeau (2016b)
11	American Eel Survey	X	03/01/2016	Normandeau (2016c)

Study No.	Study Title	Modified from RSP[a]	FERC Filing Date	Citation
12	Tessellated Darter Survey	X	Initial Report 03/01/2016 Final Report 08/01/2016	Normandeau (2016d)
13	Tributary and Backwater Fish Access and Habitats Study	X	Preliminary Report 09/14/2015 Final Report 06/17/2016	Normandeau (2016e)
14-15	Resident Fish Spawning in Impoundments and Riverine Sections Studies	X	Interim Report 03/01/2016 Final Report 08/01/2016 Revised Final Report 11/30/2016	Normandeau (2016f)
16	Sea Lamprey Spawning Assessment	X	Interim Report 03/01/2016 Final Report 08/01/2016	Normandeau (2016g)
17	Upstream Passage of Riverine Fish Species Assessment	X	Initial Report 05/16/2016 Final Report 11/30/2016	Normandeau (2016h)
18	American Eel Upstream Passage Assessment	X	Initial Report 03/01/2016 Report Supplement 11/30/2016	Normandeau (2016i)
19	American Eel Downstream Passage Assessment	X	05/16/2016 Supplemental data 08/31/2016	Normandeau (2016j)
20	American Eel Downstream Migration Timing Assessment	X	06/17/2016	Normandeau (2016k)
21	American Shad Telemetry Study - Vernon	X	Initial Report 08/01/2016	Normandeau (2016l)

Study No.	Study Title	Modified from RSP[a]	FERC Filing Date	Citation
22	Downstream Migration of Juvenile American Shad - Vernon	X	05/16/2016 Supplemental data 08/31/2016	Normandeau (2016m)
23	Fish Impingement, Entrainment, and Survival Study	X	Initial Report 05/16/16 Final Report 11/30/2016	Normandeau (2016n)
24	Dwarf Wedgemussel and Co-occurring Mussel Study		• Phase 1 Report 09/15/2014 • Phase 2 Report 03/02/2015 • Delphi Panel Report 05/16/2016	Biodrawversity and Louis Berger (2014) Biodrawversity and Louis Berger (2015) Normandeau (2016o)
25	Dragonfly and Damselfly Inventory and Assessment	X	06/17/2016	Normandeau (2016p)
26	Cobblestone and Puritan Tiger Beetle Survey		06/17/2016	Normandeau (2016q)
27	Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study		Preliminary Report 09/14/2015 Final Report 08/01/2016 Report Supplement 11/30/2016	Normandeau (2016r)
28	Fowler's Toad Survey		06/17/2016	Normandeau (2016s)
29	Northeastern Bulrush Survey		06/17/2016	Normandeau (2016t)
30	Recreation Facility Inventory and Use & Needs Assessment	X	03/01/2016	Louis Berger and Normandeau (2016b)

Study No.	Study Title	Modified from RSP[a]	FERC Filing Date	Citation
31	Whitewater Boating Flow Assessment - Bellows Falls and Sumner Falls	X	03/01/2016	Louis Berger and Normandeau (2016c)
32	Bellows Falls Aesthetic Flow Study		Initial Report 03/01/2016 Final Report 08/01/2016	Louis Berger and Normandeau (2016d)
33	Cultural and Historic Resources Study		• Phase 1A Archaeological Reconnaissance Survey Report for Vernon Project 04/10/2008 (filed with SHPOs only) • Phase 1A Archaeological Reconnaissance Survey Reports for Wilder and Bellows Falls Projects 07/01/2013 • Phase 1A Archaeological Reconnaissance Survey Update for Vernon Project 12/23/2014 • Phase IB Archaeological Identification Survey for Wilder, Bellows Falls, and Vernon Projects 03/23/2016 • Phase II Archaeological Determination of Eligibility Lampshire Meadow Site, Wilder Project 08/01/2016	Various, see Section 3.10.

Study No.	Study Title	Modified from RSP[a]	FERC Filing Date	Citation
			• Phase II Archaeological Site Evaluation Surveys Wilder and Vernon Projects 12/01/2016 • Traditional Cultural Properties (TCP) Initial Report 05/16/2016	

a. Modifications include study delays to 2015 due to VY closure, FERC SPDs, and/or TransCanada study plan revisions filed December 31, 2013.

A technical meeting was held on November 26, 2013, to discuss the effects of the planned VY closure and to identify aquatic resource studies that were: (1) not affected by operation of VY that could be implemented in 2014; (2) likely affected by operation of VY; and (3) might need modification due to the decommissioning of VY.

On December 31, 2013, TransCanada submitted revisions to 5 Study Plans based on the VY technical meeting and on follow-up discussions with agencies and stakeholders. Minor revisions were made to the following Study Plans: Study 6, *Water Quality*; Study 13, *Tributary and Backwater Area Fish Access and Habitat*s; Study 18, *American Eel Upstream Passage Assessment*; Study 21, *American Shad Telemetr*y; and Study 23, *Fish Impingement, Entrainment, and Survival*.

On February 21, 2014, the Director issued another SPD for those 20 aquatic resource studies and a "new" Vernon Hydroacoustic Study, that the SPD referred to as a "study requested but not adopted by TransCanada." Of those 20 proposed studies, 15 were deferred until 2015 to allow for the new post-VY baseline condition. Five studies were determined to be not affected by the VY decommissioning and were approved without modification for implementation in 2014. FERC also addressed TransCanada's December 31, 2013, Study Plan revisions in this SPD.

On March 24, 2014, TransCanada filed a request for rehearing arguing against the need to conduct the newly requested Vernon Hydroacoustic Study; however, stakeholder consultation was conducted and the Study Plan requested in the SPD was filed on September 15, 2014. A technical meeting was held on November 20, 2014, to discuss issues surrounding the potential use of hydroacoustics at the Vernon Project. Subsequently, on May 14, 2015, the Director issued an order eliminating the requirement to conduct the Vernon Hydroacoustic Study, and approving the updated RSP for Study 22, *Downstream Migration of Juvenile American Shad at Vernon*, that TransCanada had filed on February 3, 2015.

During 2013 and 2014, several studies were initiated. On September 15, 2014, TransCanada filed its Initial Study Report (ISR); held a meeting on September 29, 2014 to discuss initial results; and filed the meeting summary on October 14, 2014. At the meeting, TransCanada announced some expected study delays because of lack of water in 2014. Written comments on the ISR were received, and TransCanada filed a response to those comments on December 15, 2014.

In 2015, fishery and water quality studies, which were delayed by the VY closing, were initiated, and several incomplete studies that began in 2014 were continued.

TransCanada filed its Updated Study Report (USR) on September 14, 2015; held a meeting on October 1 and 2, 2015, to discuss the results; and filed the meeting summary on October 14, 2015. Written comments on the USR were received and TransCanada filed a response to those comments on December 14, 2015. The Director issued an SPD on January 15, 2016, withholding staff determinations on stakeholder-requested study modifications to Studies 3, 5, 13, 14, 15, and 18 pending completion of those studies.

Also on September 14, 2015, the Director issued a Revised Process Plan and Schedule for the Connecticut River Projects that identified March 1, 2016, as a “target” filing deadline for USRs on studies yet to be completed. Any remaining study reports that could not be filed by March 1, 2016, would be identified along with a respective filing date for each study.

TransCanada filed a second USR on March 1, 2016; held the associated results meeting on March 17 and 18, 2016; and filed the meeting summary on March 31, 2016. Written comments on the second USR were received, and TransCanada filed a response to those comments on June 14, 2016. The Director issued an SPD on the second USR on June 29, 2016.

On May 5, 2016, the Director issued a Revised Process Plan and Schedule for the Connecticut River Projects that identified May 15, 2016 (a Sunday, May 16 being the next business day) as the filing deadline for USRs on most studies not completed by the March 1, 2016, filing; and August 1, 2016 as the filing deadline for the remaining studies that are not yet complete.

Because of the need to conduct additional analysis of hydraulic and operations model data, not all reports listed in FERC’s current schedule for filing as part of the third USR on May 16, 2015, were filed at that time, although 7 study reports were filed. TransCanada held a meeting on June 1, 2016, to discuss the associated results and filed the meeting summary on June 14, 2016. Written comments on the May 16, 2016, USR were received, and TransCanada filed a response to those comments on August 15, 2016 (the business day following the August 13, 2016, Saturday due date). The Director issued an SPD on the third USR on September 12, 2016.

FERC staff was consulted about study reports that could not be filed by May 16, 2016, and TransCanada proposed a target date of June 17, 2016, for completion and distribution of those reports in order to provide the reports to stakeholders for review and consultation prior to the Final Study Report filing deadline of August 1, 2016.

On June 17, 2016, TransCanada filed the fourth USR that included 6 study reports and 1 revised report in response to comments on the USR filed on March 1, 2016. In consultation with FERC staff and stakeholders, TransCanada held a meeting on July 15, 2016 (after the 15-day due date), to discuss results and filed the meeting summary for the June 17, 2016, USR on August 1, 2016.

On August 1, 2016, TransCanada filed the fifth USR that included the 5 study reports that were incomplete for the May 16, 2016, USR filing; 2 final study reports for which interim reports were filed March 1, 2016; and 4 revised (final) study reports in response to comments received during the comment period for the March 1, 2016, USR. Two other study reports were initially to be included in the fifth USR, but further consultation with stakeholders and analysis was necessary to complete these studies. Those studies are Study 9, *Instream Flow Study* (interim report was filed March 1, 2016), and Study 24, *Dwarf Wedgemussel and Co-Occurring Mussel Survey – Habitat Suitability Criteria Report* (Study 24 Phase 1 and Phase 2 reports were filed September 15, 2014, and March 2, 2015, respectively; the Delphi Panel report was filed May 16, 2016). TransCanada held the associated USR meeting on August 25, 2016, and filed the meeting summary for the August 1, 2016, USR on August 31, 2016. In consultation with FERC staff, the comment period for the fourth (June 17, 2016) and fifth (August 1, 2016) USRs remained open until September 30, 2016, the deadline for study reports filed on or before the August 1, 2016, USR filing.

Also on August 31, 2016, TransCanada filed supplemental information requested by stakeholders for 3 studies filed on May 16, 2016 (Study 8, *Channel Morphology and Benthic Habitats Study*; Study 19, *American Eel Downstream Passage Assessment*; and Study 22, *Downstream Migration of Juvenile American Shad at Vernon*).

Written comments on the June 17 and August 1, 2016, USRs were received, and TransCanada filed a response to those comments on October 31, 2016 (the business day following the October 30, 2016, Sunday due date). In conjunction with those responses, TransCanada agreed to provide supplemental data or report revisions for some studies (Table 1.3-2). Additional revised study reports or report supplements were filed November 30, 2016 (see Table 1.3-1). Results from revised studies that are available at this time are identified and included in this PLP environmental analysis. Results not yet available will be identified and included in the FLA Exhibit E.

The Director issued an SPD on the fourth and fifth USRs on November 29, 2016, which is under review at this time.

Table 1.3-2. Status of ongoing studies.

Study No.	Study Title	Additional Effort Needed	Expected Filing Date
2-3	Riverbank Transect Study and Riverbank Erosion Study	Revised report to include additional analysis and revisions based on stakeholder comments.	January 31, 2017
6	Water Quality Study	Revised final report to include additional analysis and revisions based on stakeholder comments.	December 15, 2016
9	Instream Flow Study	Report addendum and additional model runs to follow receipt of stakeholder consultation on dual flow analysis.	TBD

Study No.	Study Title	Additional Effort Needed	Expected Filing Date
19	American Eel Downstream Passage Assessment	Final report to include re-analysis of downstream route selection and timing, and supplemental data per FERC's September 12, 2016, SPD.	January 15, 2017
21	American Shad Telemetry Study - Vernon	Final report to include all new analysis per stakeholder comments, and re-analysis of downstream passage route selection and timing.	January 15, 2017
22	Downstream Migration of Juvenile American Shad - Vernon	Final report to include re-analysis of downstream route selection and timing, and supplemental data per FERC's September 12, 2016, SPD.	January 15, 2017
23	Fish Impingement, Entrainment, and Survival Study	Report supplement to include revisions to total Project survival based on revised downstream passage results of studies 19 and 22.	January 15, 2017
24	Dwarf Wedgemussel and Co-occurring Mussel Study	Habitat Suitability Index finalization for dwarf wedgemussel and co-occurring species, stakeholder consultation, additional modeling, and final report.	TBD
25	Dragonfly and Damselfly Inventory and Assessment	Final report to include additional data presentation and analysis per stakeholder comments.	December 15, 2016
33	Cultural and Historic Resources Study	TCP report revision per stakeholder comments and tribal representative meetings and interviews.	TBD

1.3.3 Post PLP Filing

TransCanada is providing this PLP for public review and comment. As required by 18 C.F.R. § 5.16(e), comments must be filed no later than 90 days from the filing date of the PLP. TransCanada will address comments on this PLP submitted by FERC and others as it develops the FLAs and, in accordance with 18 C.F.R. § 5.1(d), will consult with appropriate federal and state agencies, Indian Tribes, and interested members of the public before filing the FLAs by April 30, 2017.

2. PROPOSED ACTION AND ALTERNATIVES

2.1 No-action Alternative

The no-action alternative is the baseline from which to compare the proposed action (i.e., relicensing of the Wilder, Bellows Falls, and Vernon Projects) and all action alternatives that are assessed. Under the no-action alternative, the Projects would continue to operate under the terms and conditions of the current licenses and current measures that are implemented voluntarily. Thus, the no-action alternative includes the existing facilities and current operations. The no-action alternative is described for each Project in the subsections below.

2.1.1 Wilder

2.1.1.1 Project History

On April 22, 1944, the original Wilder Project license was issued to the Bellows Falls Hydro-Electric Corporation by the Federal Power Commission (FERC's predecessor agency) with the intent to construct a new integrated powerhouse and concrete dam 0.5 mile downstream of an existing dam, powerhouse and paper mill complex known as the Olcott Falls Mill (see Section 3.10, *Cultural and Historic Resources*). After the July 28, 1948, license transfer to New England Power Company, reconstruction of the present-day Wilder Project began in March 1949 and commenced operations on December 1, 1950. The original license for the Project expired on June 30, 1970, and the Project operated under annual licenses until the license was renewed on December 10, 1979. A December 11, 1985, amendment authorized the construction of a fish ladder, powerhouse expansion, and a third 3.2 megawatt (MW) unit.

On October 5, 1978, FERC approved a Settlement Agreement concerning fish passage facilities for Atlantic Salmon at the Wilder and Bellows Falls Projects and for Atlantic Salmon and American Shad at the Vernon Project. The settlement was executed on December 30, 1977, among the Licensee; the states of Massachusetts, Connecticut, New Hampshire, and Vermont; FWS; and four non-governmental organizations (the Environmental Defense Fund; the Massachusetts Public Interest Research Group, Inc.; For Land's Sake; and Trout Unlimited). The settlement called for staged design, construction, and operation of passage facilities at the three Projects, with Wilder's construction and operation occurring after completion of the two fishways downstream. The installation of a new 3.2-MW unit harnessed the required minimum flow for additional generation while using the unit discharge for ladder entrance attraction water supply. Construction of the fish ladder and third generating unit was completed in 1987 (see Section 2.1.1.5, *Existing Environmental Measures*).

On July 26, 1990, the Licensee entered into a Memorandum of Agreement with CRASC for permanent downstream fish passage facilities for the Wilder, Bellows

Falls, and Vernon Projects. Downstream fish passage at the Wilder Project uses an existing surface gate adjacent to the fish ladder exit and powerhouse without structural modification or license amendments. Downstream passage at the Wilder Project began in 1988 (see Section 2.1.1.5, *Existing Environmental Measures*).

On February 27, 1998, FERC approved the transfer of the license from New England Power Company to USGen New England, Inc. Under a multi-license amendment dated November 19, 1998, regional electrical transmission facilities were removed from the Project, including step up transformers. At that time, the powerhouse was automated and began operations via remote control from the Connecticut River Control Center (now from the Renewable Operations Center) in Wilder, Vermont.

On January 24, 2005, FERC approved the transfer of the license to TransCanada Hydro Northeast Inc., the current Licensee.

2.1.1.2 Existing Project Facilities

The Wilder Project's dam and powerhouse are located on the Connecticut River at river mile (RM) 217.4, approximately 1.5 miles upstream of the White River confluence and 7 miles downstream of the Ompompanoosuc River in the town of Hartford, Windsor County, Vermont, and in the city of Lebanon, Grafton County, New Hampshire (Figure 2.1-1). Primary Project facilities include the dam and spillway; the powerhouse, garage/service building and switchyard; and the non-Project Renewable Operations Center, Wilder Hydro Office, and Connecticut River Office. Fish passage facilities (see Section 2.1.1.5, *Existing Environmental Measures*) and recreation areas and facilities include a boat launch, portage, picnic areas, hiking trail, fish ladder viewing area, and fishing access (see Section 3.8, *Recreation Resources and Land Use*).

The Project impoundment extends upstream about 45 miles to a point about 4.0 miles below the Wells River-Woodsville Bridge. The Project has limited storage capacity because of the relatively flat terrain from McIndoes dam, one of three developments in the Fifteen Mile Falls Project (FERC No. 2077), downstream to the Wilder Project. The impoundment has a surface area of 3,100 acres and about 105 miles of shoreline and a total volume of 34,600 acre-feet (acre-ft) at elevation (El.) 385.0[7] feet (ft) at the top of the stanchion boards. The usable storage amounts to about 13,350 acre-ft in 5 ft of drawdown to El. 380 ft; however, the typical impoundment operating range is 2.5 ft, between El. 382.0 and El. 384.5 ft under non-spill conditions.

[7] All elevations in Chapter 2 are stated in National Geodetic Vertical Datum of 1929 (NGVD29).

Figure 2.1-1. Primary Wilder Project facilities.

The dam is a concrete gravity structure extending across the Connecticut River from Hartford, Vermont, to Lebanon, New Hampshire. The dam structures include an earthen embankment that is about 400 ft long, a non-overflow gravity concrete bulkhead wall that is 232 ft long, a concrete forebay intake that is 208 ft long, a gravity concrete spillway that is about 526 ft long and 59 ft in maximum height, and another earthen embankment that is about 180 ft long. The south embankment is 13 ft in maximum height and the north embankment is primarily a natural bank to which protection has been added. The spillway portion of the dam is divided into four sections: skimmer gate, six tainter gates, four stanchion flashboards, and another skimmer gate. The various bays are separated by concrete piers supporting a steel and concrete bridge. The non-overflow section crest is at El. 393 ft (Table 2.1-1).

Table 2.1-1. Wilder spillway facilities.

Gate Type	Number	Size (height or width, by length in ft)	Elevation (NGVD29)
Tainter gates	6	30 x 36	355.0 (sill)
Stanchion bays	4	17 x 50	368.0 (crest)
Skimmer gate	1	15 x 20	365.0 (sill)
Skimmer gate	1	10 x 10	375.0 (sill)

The powerhouse superstructure is 181 ft by 50 ft by about 50 ft high and is constructed of steel frame and brick. The powerhouse contains three turbine generator units, electrical equipment, a control room (used as a backup to the Renewable Operations Center for local operations), machine shop, excitation equipment, emergency generator, air compressor, an overhead crane, offices, storage rooms, battery room, and ancillary equipment. The state boundary line between New Hampshire and Vermont lies between Unit Nos. 1 and 2.

The concrete gravity intake is integral with the powerhouse structure with separate water passages for each of the three turbine generating units. Water enters directly from the forebay intake and into the turbine scroll or wheel cases. The draft tubes discharge into a short tailrace excavated partly in the bank and partly in the bed of the river. The scroll cases and draft tubes are formed in the concrete of the substructure, which was poured on rock. The water passages for Unit Nos. 1 and 2 have trashracks (5-inch clear spacing) and head gates consisting of one flat steel sliding panel and one wheel-type gate for each unit. Each head gate is equipped with an electrically driven fixed hoist. Unit No. 3 has a trashrack (1.625-inch clear spacing) and an 8-ft-diameter butterfly valve. A hydraulic trashrack rake is used to pull river debris away from the unit intakes. It is manually operated and is driven to the trashracks in front of each unit on a set of tracks that are located on top of the dam. The rake head is lowered to the bottom of the racks and is then retracted upward along the rack to remove debris. The debris is then conveyed into a trailer for removal. The powerhouse substructure is of reinforced concrete construction. The original generating unit draft tube gates are operated by electric hoists mounted on an external catwalk on the downstream face of the powerhouse. The Unit No. 3 draft tube slide gate is operated by motor-driven screw stem hoists in the powerhouse. Unit Nos. 1 and 2 each have direct connected main and pilot exciters as well as spare motor-generator excitation for the plant. Table 2.1-2 provides turbine and generator specifications.

Project electrical facilities include the generators, generator terminals that extend from the powerhouse to the 13.8-kilovolt (kV) bus of the outdoor substation, and station service transformers located inside the substation. The high-voltage transmission lines, switchyards, and substation transformers and equipment located inside a fenced area adjacent to the powerhouse lie within the Project boundary but are not Project facilities. Instead, this equipment is owned and operated by a regional transmission company, New England Power Company, doing business as National Grid. The controls for the 13.8-kV, 46-kV, and 115-kV lines and for the outdoor substation, also owned by New England Power Company, are located inside the powerhouse.

Table 2.1-2. Wilder turbines and generators.

Turbine Units	**Nos. 1 and 2**	**No. 3**
Type	Kaplan adjustable blade propeller type	Francis vertical runner
Design head (ft)	49	58
Horsepower rating at design head	23,750	4,470
Maximum hydraulic capacity (cfs)	5,650[a]	825[b]
Minimum hydraulic capacity (cfs)	400	400
Revolutions per minute (rpm)	112.5	212
Intake trashrack clear spacing (inches)	5.0	1.625
Generators		
Nameplate capacity (kilovolt-ampere ([kVA])	18,000	3,555
Power factor	0.9	0.9
Nameplate capacity (kW)	16,200	3,200
Phase/frequency	3/60	3/60
Voltage	13,800	13,800

a. Flow at 52 ft of head.

b. Flow at 58 ft of head.

2.1.1.3 Project Safety

The Project has been operating for more than 37 years under the existing license and during this time, FERC staff have conducted operational inspections focusing on the continued safety of the structures, identification of unauthorized modifications, efficiency and safety of operations, compliance with the terms of the license, and proper maintenance. In addition, the Project has been inspected and evaluated every 5 years by an independent consultant and a consultant's safety report has been submitted for FERC review under 18 C.F.R. Part 12.

2.1.1.4 Existing Project Operations

Operations at the Project are coordinated with other TransCanada hydroelectric generating facilities on the Connecticut River, taking into consideration variations in demand for electricity and natural flow variations. TransCanada typically operates the Projects in a load-following or peaking mode in an attempt, within license limitations and available inflow, to maximize electrical power generation when the price of power is high and reduce generation when the price of power is low. When inflows are less than maximum generating capacity, TransCanada uses the limited impoundment storage at the Project to dispatch generation as required to meet the generation schedule managed by ISO-NE. Generation can vary during the course of any day between the required minimum flow and full generating capacity, if higher flows are available. Over the course of a day, the Project generally passes the average daily inflow. During periods of sustained high flows, TransCanada dispatches Project generation in a must-run status to use available water for generation. Once flows exceed powerhouse capacity, it operates the Projects in a "river profile" manner (see Section 3.4.1.1, *Water Quantity*).

2.1.1.5 Existing Environmental Measures

Water Level and Flow Management

The licensed minimum flow (Article 35) at the Wilder Project is 675 cubic ft per second (cfs) or a discharge flow equal to the inflow if less. Minimum flow is provided primarily by generation from Unit No. 3 at an efficient operating flow of about 700 cfs. Discharge from Unit No. 3 also serves as the attraction flow for the fish ladder. Additional non-generation flows have been provided seasonally for Atlantic Salmon upstream and downstream fish passage on a schedule provided annually by CRASC based on fish counts at downstream projects (see below). For the past several years, the number of Atlantic Salmon returning to the Connecticut River has been low and therefore upstream and downstream passage flows have not occurred.

Reservoir elevation at the dam is typically within a 2.5-ft range between El. 382.0 and 384.5 ft above mean sea level under normal operation (non-spill conditions). The overall operating range is between El. 380 ft and 385 ft, but this range is only be exercised during high water events that require spill through tainter gates only as specified in the Operating Procedures, which were developed as required under

Article 32. In extreme flood events, where flood flows increase beyond the capacity of tainter gates, stanchion bays would be removed, which would require the elevation be just below the concrete crest at 365 ft in order to reinstall the beams and boards. Such an event has never occurred since the Wilder Project has been in operation. Under Article 32 of the license, TransCanada and the U.S. Army Corps of Engineers (USACE) developed a Coordination Agreement that specifies how the Wilder Project is operated during high flow events. Operating Procedures also restrict impoundment drawdown rates to typically 0.1 to 0.2 ft per hour and to not exceed 0.3 ft per hour. There is approximately 3,000 cfs per hour per 0.1 ft of elevation.

During the summer recreation season, beginning on the Friday before Memorial Day, through the last weekend in September, TransCanada maintains a self-imposed minimum impoundment level at El. 382.5 ft from Fridays at 4:00 p.m. through Sundays at midnight, unless experiencing high flows above generating capacity. TransCanada maintains similar elevations for holidays during this period.

Recreation

The Project includes the following formal recreation areas and facilities: (1) the Hartford (Wilder) picnic area at Kilowatt Park (North); (2) Wilder dam (Olcott Falls) boat launch at Kilowatt Park (South); (3) Wilder dam fish ladder and angler parking; (4) Lebanon (Wilder dam) picnic area, vista, and hiking trails; (5) Wilder dam portage and downstream natural areas; and (6) Gilman Island including primitive campsites and Titcomb Cabin (see Section 3.8, *Recreation Resources and Land Use*).

Upstream Fish Passage

TransCanada operates upstream fish passage facilities in accordance with the 1978 Settlement Agreement as described in Section 2.1.1.1, *Project History*, above. CRASC provides an annual *Fish Passage Notification Schedule*, which sets the dates for upstream passage for all dams on the Connecticut River. Typically, the upstream fish ladder operates from May 15 through July 15 and in fall from September 15 through November 15 for Atlantic Salmon; however, in recent years fish ladder operation has been suspended because of low returns and abandonment of the program by FWS and the states.

The Wilder fish ladder is a reinforced concrete structure with accessory electrical, mechanical, and pneumatic equipment that is designed to provide passage past the dam for migrating Atlantic Salmon. Upstream migrating fish are guided to the ladder entrance by attraction water supplied from the discharge of the Unit No. 3 generator and collection channel weirs. When Unit No. 3 is not available, a Unit No. 3 bypass supplies the attraction water. Upstream migrating fish enter the tailrace area where fish are attracted to the main entrance weir at the northwest end of the powerhouse. A spillway entrance weir and a turbine entrance weir are incorporated into the southeast and southwest walls of the attraction water channel for use under varying tailwater conditions. The spillway entrance weir is a gated entrance slot used for fish attraction from the spillway area, where fish may congregate during high-water spill conditions. The tailrace entrance weir is a gated entrance slot that is used for fish attraction during minimum flow operation of the "continuous-flow" turbine (Unit No. 3). The attraction water weirs, when used, open fully; they are not adjustable.

Fish travel through the 6-ft-wide entrance channel along the powerhouse to the attraction water floor diffuser in the southeast half of a spare turbine bay between the powerhouse and the concrete dam. From the attraction water diffuser, fish enter a 6-ft-wide fish ladder entrance channel and "climb" to the forebay by swimming through a series of 58 pools created by a sequence of overflow weirs with each succeeding weir spaced 10 ft apart and 12 inches higher than the last. After passing 28 pools, the fish enter the counting/trapping area, guided by flow and crowder screens, travel through a 3-ft-wide flume, and pass an underwater viewing window, where they may be observed and counted. At this location, they can be trapped and diverted to a holding pool by means of manually activated pneumatic trapping gates. From the counting/trapping area, fish continue to swim through an additional 30 overflow weirs and pools to the 5-ft-wide fish ladder exit channel in the spillway adjacent to the powerhouse. The exit channel (the last pool) includes a motor driven headgate, widely spaced trashracks (sufficient to pass adult salmon) with 12-inch spacing, and slots for wooden stop logs. The headgate is either open or closed. The last five weirs in the vertical slot section contain adjustable weir gates that can be lowered (opened) to provide a nearly constant flow when the forebay elevation drops through its normal operating range. As the impoundment water surface elevation (WSE) rises and falls, these gates are programmed to maintain a nearly constant water level of 12 inches over the first fixed weir downstream of the five adjustable weirs by means of a water level monitor and control system.

An outdoor public viewing area with an observation deck and underwater window is located at the northwest end of the fish ladder on the Vermont shore adjacent to the powerhouse parking lot.

Downstream Fish Passage

As of February 11, 2016, CRASC no longer requires downstream passage operations at Wilder for Atlantic Salmon smolts (see Section 3.5, *Fish and Aquatic Resources*). TransCanada has operated downstream fish passage facilities in accordance with the 1990 Memorandum of Agreement as previously described in Section 2.1.1.1, *Project History*. CRASC's annual *Fish Passage Notification Schedule* set the dates for downstream passage for all dams on the Connecticut River. Downstream passage flows were provided for adult Atlantic Salmon from October 15 to December 31 if 50 or more adults were documented as having passed upstream. Downstream fish passage was provided by the existing log sluiceway located between Unit No. 3 and the fish ladder entrance gallery bay and spillway. The existing sluice gate is motorized and operated locally as needed. A flow of 512 cfs was maintained continuously through the skimmer gate for downstream passage.

Existing License Requirements

In addition to Standard Articles 1 through 28 set forth in Form L-3 (Revised October 1975) titled "Terms and Conditions of License for Constructed Major Project Affecting Navigable Waters of the United States," the Wilder Project license includes the requirements summarized in Table 2.1-3.

Table 2.1-3. Summary of Wilder Project license and amendment requirements.

License Article	Summary of Requirement
29	Requires establishment and maintenance of amortization reserves based on a specified reasonable rate of return upon the net investment in the Project.
30 (December 11, 1985, amendment)	Requires payment of annual charges to FERC for the cost of administration of the license, based on the authorized installed capacity (including the 1985 addition of Unit No. 3) for that purpose of 47,500 horsepower.
31	Requires implementing and modifying when appropriate, the Emergency Action Plan on file with FERC designed to provide an early warning to upstream and downstream inhabitants and property owners if an impending or actual sudden release of water is caused by an accident to, or failure of, Project works.
32	Requires entering into an agreement with USACE to provide for the coordinated operation of the Project in the interest of flood control and navigation on the Connecticut River.
33	Requires installation and operation of signs, light, sirens, barriers, or other devices that may be reasonably needed to warn the public of fluctuations in flow from the Project and to protect the public in its recreational use of Project lands and waters.
34 (December 15, 1980, amendment)	Gives authority to the Licensee to grant permission for certain types of use and occupancy of Project lands and waters and to convey certain interests in project lands and waters for certain types of use and occupancy, without prior FERC approval.
35	Requires the Licensee to maintain a continuous minimum flow of 675 cfs (approximately 0.20 cfs per square mile (sq. mi.) of drainage basin) or a discharge flow equal to the inflow of the impoundment, whichever is less, from the Project into the Connecticut River. These flows may be modified temporarily: (1) during and to the extent required by operating emergencies beyond the control of the Licensee; and (2) in the interest of recreation and protection of the fisheries resources upon mutual agreement between the Licensee and the Fish and Game Departments of New Hampshire and Vermont.
36	Requires undertaking consultation and cooperation with the appropriate SHPO(s) prior to the commencement of any construction or development of any Project works or other facilities at the Project.

License Article	Summary of Requirement
37	Requires filing with FERC a feasibility analysis of installing additional generating capacity at the Project.
38	Required filing revised Exhibit K drawings clearly delineating the limits of the lands over which the Licensee holds flowage rights for the Project.

2.1.1.6 Project Boundary

The Wilder Project boundary includes the powerhouse and dam, the impounded portion of the river (approximately 45 miles from the dam upstream), a limited amount of TransCanada fee-owned Project land, and a significant amount of private lands adjacent to the river upon which TransCanada retains sufficient flowage rights to operate the Project.

The Project boundary encompasses the areas necessary to operate and the Project. The extent to which lands with flowage rights retained by TransCanada are affected by water due to Project operation or natural inflow is largely determined by the elevation of the land in relation to the elevation of the river water surface. Surface water elevation can be affected by three considerations: (1) surface water elevation at the dam; (2) the quantity of inflow from upstream and intermittent sources; and (3) the distance upstream of the dam.

TransCanada owns 123 acres of land in the Wilder Project. Of this, 43 acres are used for the Project facility area, 59 acres are used for public outdoor recreational use, 10 acres are currently under agreement to Dartmouth College for recreational use, and 11 acres remain as undeveloped scattered parcels. More than 30 acres of the recreational land is also undeveloped except for hiking and nature trails. Minor portions of the Project area are subject to the rights of the general public to use public streets and walkways within the area.

2.1.2 Bellows Falls

2.1.2.1 Project History

The Project was originally constructed in 1927 (see Section 3.10, *Cultural and Historic Resources*). The original license for the Bellows Falls Project was issued jointly to New England Power Company, Bellows Falls Hydro-Electric Corporation, and the Connecticut River Power Company on October 13, 1943. New England Power Company subsequently purchased all of the physical properties and franchise of Bellows Falls Hydro-Electric Corporation and became the Licensee, as authorized by the Federal Power Commission under its Order dated July 9, 1948. The original license expired on June 30, 1970. The Project operated under annual licenses until the license was renewed on August 3, 1979.

On October 5, 1978, FERC approved a Settlement Agreement concerning fish passage facilities for Atlantic Salmon at the Wilder and Bellows Falls Projects, and for Atlantic Salmon and American Shad at the Vernon Project. The settlement was executed on December 30, 1977, among the Licensee; the states of Massachusetts, Connecticut, New Hampshire, and Vermont; FWS; and four non-governmental organizations (the Environmental Defense Fund; the Massachusetts Public Interest Research Group, Inc.; For Land's Sake; and Trout Unlimited). The settlement called for staged design, construction and operation of passage facilities at the three Projects, with Bellows Falls' construction schedule dependent upon a trigger number of 30 returning adult Salmon to the downstream Holyoke Project (FERC No. 2004). The upstream fish ladder was subsequently completed and commenced operation in 1984 (see Section 2.1.2.5, *Existing Environmental Measures*).

On July 26, 1990, the Licensee entered into a Memorandum of Agreement with CRASC for permanent downstream fish passage facilities for the Wilder, Bellows Falls, and Vernon Projects. A downstream fish diversion boom was installed in 1996, and downstream passage is provided via the forebay sluiceway/skimmer gate, and by a supplemental sluice pipe (see Section 2.1.2.5, *Existing Environmental Measures*).

On February 27, 1998, FERC approved the transfer of the license from New England Power Company to USGen New England, Inc. Under a multi-license amendment dated November 19, 1998, regional electrical transmission facilities were removed from the Project including three step-up transformers. At that time, the powerhouse was automated and began operations via remote control from the Connecticut River Control Center in Wilder, Vermont.

On January 21, 2005, FERC approved a change in the Bellows Falls Project boundary to remove a small piece of land with an office building (presently the TransCanada North Walpole office) from the Project.

On January 24, 2005, FERC approved the transfer of the license to TransCanada Hydro Northeast Inc.

On February 5, 2005, FERC approved another Project boundary change to removed 8.8 acres and historic structures from the Project boundary to facilitate subsequent transfer to the Bellows Falls Historical Society.

2.1.2.2 Existing Project Facilities

The Bellows Falls Project dam is located on the Connecticut River at RM 173.7, about 1 mile upstream of the confluence of Saxtons River and 3 miles downstream of the Williams River at the upper end of a sharp bend of the Connecticut River at Bellows Falls, Vermont, in the town of Rockingham, Vermont, and in the town of Walpole, New Hampshire (Figure 2.1-2). The powerhouse is located downstream of the dam. Primary Project facilities include the dam, spillway, and bypassed reach; a power canal and powerhouse; a substation; an office building located near the dam; a line garage and storage building located near the powerhouse; fish passage facilities (see Section 2.1.2.5, *Existing Environmental Measures*); and recreation areas and facilities including three boat launches and picnic areas, a portage, and a visitor center with a fish ladder viewing window (see Section 3.8, *Recreation Resources and Land Use*).

The Project impoundment extends upstream about 26 miles to Chase Island at Windsor, Vermont, about 1 mile below the Windsor Bridge. The impoundment has a surface area of 2,804 acres, about 74 miles of shoreline, and a total volume of 26,900 acre-ft of El. 291.63 ft (normal impoundment elevation) at the top of the stanchion boards, providing a storage volume of 7,476 acre-ft in the maximum 3-ft drawdown to El. 288.63 ft. Under non-spill conditions the reservoir operating range is typically between El. 289.6 and 291.4 ft, which equates to 4,642 acre-feet of usable storage. The dam is a concrete gravity structure extending across the Connecticut River between Rockingham, Vermont, and Walpole, New Hampshire. Virtually all of the dam structure is located in New Hampshire. It is 643 ft long with a maximum height of about 30 ft and is divided by concrete piers into five bays. Two bays contain steel, roller-type flood gates and the three other bays contain stanchion flashboards (Table 2.1-4). A steel bridge runs the length of the dam for access and for operation of flashboards. A 25-ton gantry crane sits atop the bridge.

A power canal connects the impoundment to the powerhouse. The canal is lined with paving stones stabilized by a grid of concrete grade beams and walls. The downstream end of the canal is a concrete walled forebay. The canal is 100 ft wide at the upstream end, about 36 ft wide at the downstream end, about 29 ft deep, and approximately 1,700 ft long including the length of the powerhouse forebay. The canal creates a natural bypassed reach between the dam and the outlet of the powerhouse tailrace. The reach is about 3,500 ft (0.7 mile) long and receives minimal water from leakage and, when conditions dictate, from spill at the dam.

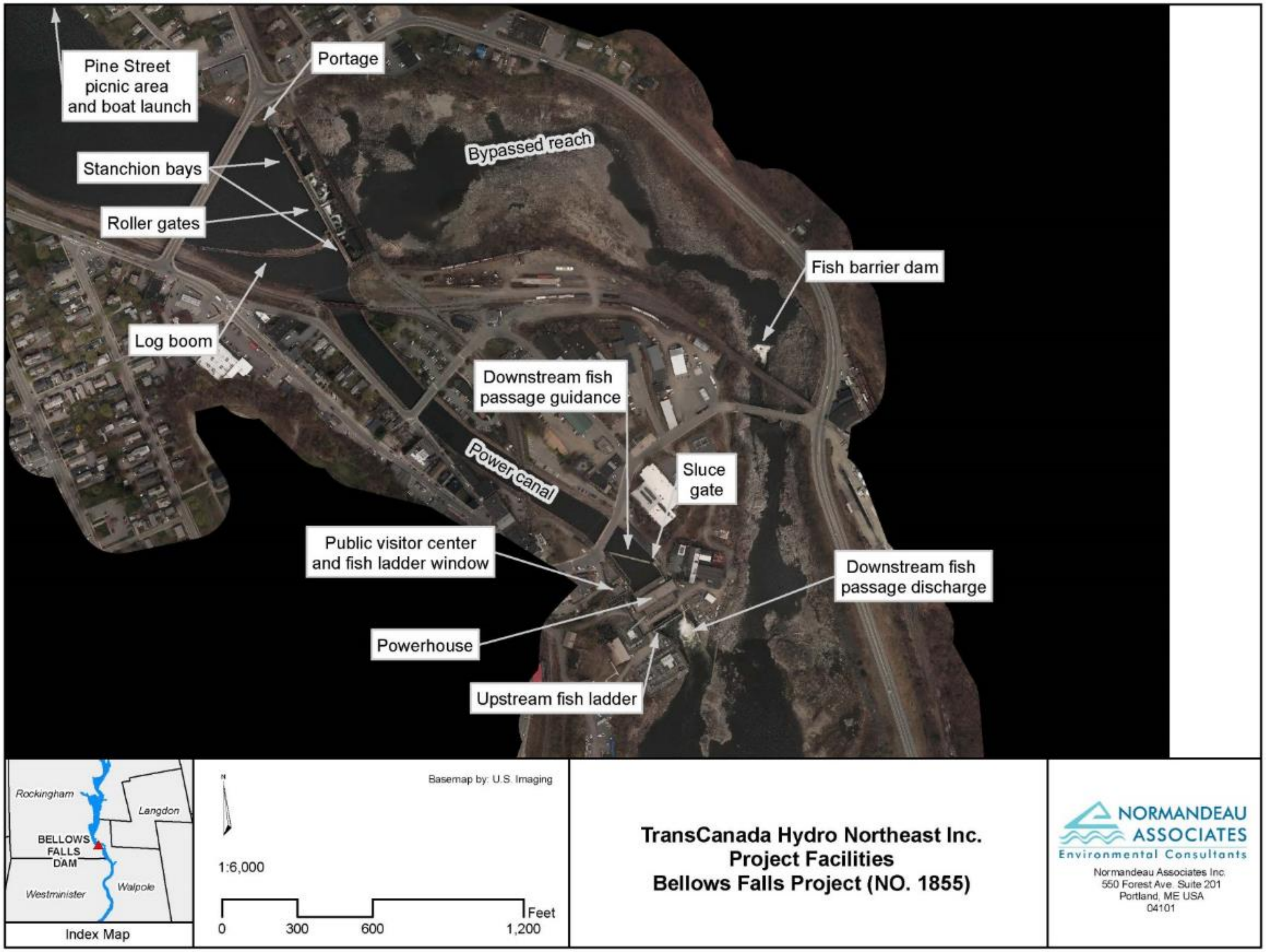

Figure 2.1-2. Primary Bellows Falls Project facilities.

Table 2.1-4. Bellows Falls spillway features.

Gate Type	Number	Size (height or width, by length in ft)	Elevation (NGVD29)
Roller gates	2	18 x 115	273.63 (crest)
Stanchion bays	2	13 x 121 with flashboards	273.63 (crest)
Stanchion bays	1	13 x 100 with flashboards	278.63 (crest)

The powerhouse superstructure is 186 ft by 106 ft by 52 ft, and constructed of steel frame and brick, and the substructure is constructed of reinforced concrete excavated into bedrock. The powerhouse contains three turbine/generators, electrical equipment, a switchboard (used as a backup facility to the Renewable Operations Center located at the Wilder Project), a machine shop, excitation equipment, emergency generator, air compressor, an overhead crane, offices, storage rooms, battery room, and ancillary equipment. Table 2.1-5 provides turbine and generator specifications.

The concrete gravity intake is integral with the powerhouse structure with two water passages for each of the three generating units. Water enters directly from the canal intake and into the scroll or wheel cases. The draft tubes discharge into the tailrace excavated partly in the bank and partly in the bed of the river. The generating units do not have draft tube gates. The scroll cases and draft tubes are formed in the substructure's concrete, which was poured on rock. The water passages for the three generating units have trashracks (4-inch clear spacing) and two headgates that can be used in any one of the three units. The headgates are equipped with an electrically driven hoist that can be moved along a track system to any of the three units as needed. A hydraulic trashrack rake is used to pull river debris away from the unit intakes. It is manually operated and is driven to the trashracks in front of each unit on a set of tracks that are located on top of the forebay intake structure. The rake head is lowered to the bottom of the racks and retracted upward along the rack to remove debris. The debris is conveyed into a trailer for removal. An ice sluice/skimmer gate is located on the east side of the forebay and is 12 ft wide by 10 ft high. The tailrace is about 900 ft long, of which 500 ft is through rock.

Project electrical facilities include the generators, generator terminals that extend from the powerhouse to a new outdoor substation located west of the powerhouse, switchgear, bus work, and two step-up transformers located in the substation. A 115-kV interconnection provides power to two switchyards and associated equipment located inside separately fenced areas adjacent to the powerhouse. These two switchyards lie within the Project boundary but are not Project facilities because this equipment is owned and operated by a regional transmission company, New England Power Company, doing business as National Grid.

Table 2.1-5. Bellows Falls turbines and generators.

Turbine Units	**Unit Nos. 1, 2, and 3**
Type	Vertical Francis
Design head (ft)	57
Horsepower rating at design head	18,000
Maximum hydraulic capacity at 62 ft of head (cfs)	3,850
Minimum hydraulic capacity (cfs)	700
rpm	85.7
Intake trashrack clear spacing (inches)	4.0
Generators	
Nameplate capacity (kVA)	17,000
Power factor	0.8
Nameplate capacity (kW)	13,600
Phase/frequency	3/60
Voltage	6,600

2.1.2.3 Project Safety

The Project has been operating for more than 37 years under the existing license, and during this time, FERC staff have conducted operational inspections focusing on the continued safety of the structures, identification of unauthorized modifications, efficiency and safety of operations, compliance with the terms of the license, and proper maintenance.

2.1.2.4 Existing Project Operations

Operations at the Project are coordinated with other TransCanada hydroelectric generating facilities on the Connecticut River, taking into consideration variations in demand for electricity and natural flow variations. TransCanada typically operates the Projects in a load-following or peaking mode in an attempt, within license limitations and available inflow, to maximize electrical power generation when the price of power is high and reduce generation when the price of power is low. When inflows are less than maximum generating capacity, TransCanada uses the limited impoundment storage at the Project to dispatch generation as required to meet the generation schedule managed by ISO-NE. Generation can vary during the course of any day between the required minimum flow and full generating capacity, if higher flows are available. Over the course of a day, the Project generally passes the average daily inflow. During periods of sustained high flows, TransCanada dispatches Project generation in a must-run status to use available water for generation. Once flows exceed powerhouse capacity, it operates the Projects in a “river profile” manner (see Section 3.4.1.1, *Water Quantity*). Figure 2.1-2 (Section 2.1.1.4, *Existing Project Operations*, above) illustrates the relationship between the TransCanada hydroelectric facilities on the Connecticut River.

2.1.2.5 Existing Environmental Measures

Water Level and Flow Management

The licensed minimum flow (Article 33) provides for a constant 1,083 cfs or a discharge flow equal to the inflow if less, through the powerhouse. Minimum flow is provided primarily through generation at a minimum efficient operating flow of about 1,300 cfs. There is no minimum flow requirement through the dam but leakage provides some flow in the bypassed reach (flows range between 125–300 cfs as calculated or estimated over the course of various studies). Additional non-generation flows are provided seasonally on a schedule provided annually by CRASC based on fish counts at downstream projects (see below).

Under non-spill conditions the reservoir typically fluctuates within a 1.8-ft range between El. 289.6 and 291.4 ft at the dam. The operating range, when considering most high water situations, is between El. 288.63 ft and 291.63 ft, but this range is only be exercised during high water events that do not require tripping of the stanchion bays as specified in the Operating Procedures, which were developed as required under Article 32. In extreme flood events, where flood flows increase beyond the capacity of the roller gates requiring stanchion bays be removed, the elevation would drop to just below the concrete crest at 278.6 ft in order to reinstall the beams and boards. Whenever possible, if flows exceed 50,000 cfs (maximum roller gate capacity plus station flow), top portions of stanchion boards are removed rather than trip the beams and removing all boards down to the concrete crest. The most recent event in which stanchion beams were removed was during Tropical Storm Irene in late August 2011. Under Article 32 of the license, TransCanada and USACE developed a Coordination Agreement that specifies how the Bellows Falls Project is operated during high flow events. Operating Procedures also restrict impoundment drawdown rates to typically 0.1 to 0.2 ft per hour and to not exceed 0.3 ft per hour. There is approximately 3,000 cfs per hour per 0.1 ft of elevation.

During the summer recreation season, beginning the Friday before Memorial Day, through the last weekend in September, TransCanada maintains a self-imposed minimum impoundment level of El. 289.6 ft from Fridays at 4:00 p.m. through Sundays at midnight, unless experiencing high flows above generating capacity. TransCanada maintains similar elevations for holidays during this period.

Recreation

The Project includes the following formal recreation areas and facilities: (1) Charlestown boat launch and picnic area; (2) Herrick's Cove boat launch and picnic area; (3) Pine Street boat launch and portage trail take-out; (4) Bellows Falls fish ladder visitor center; and (5) the informal boat-in campsite at Lower Meadow in Charlestown, New Hampshire (see Section 3.8, *Recreation Resources and Land Use*).

Upstream Fish Passage

TransCanada operates upstream fish passage facilities in accordance with the 1978 Settlement Agreement as described in Section 2.1.1.1, *Project History*, above. CRASC provides an annual *Fish Passage Notification Schedule*, which sets the dates for upstream passage for all dams on the Connecticut River. Typically, the upstream fish ladder operates from May 15 through July 15 and in fall from September 15 through November 15 for Atlantic Salmon; however, in recent years, fish ladder operation has been suspended because of low returns and abandonment of the program by FWS and the states.

The upstream fish passage system consists of a conventional vertical slotted weir fish ladder at the powerhouse and an upstream concrete barrier dam in the bypassed reach. The barrier dam prevents upstream migrating fish from being attracted by spillway discharge into the reach and later becoming trapped in isolated pools after spill ends. The barrier is located just upstream of the Boston and Maine Railroad Bridge. The fish ladder is a 920-ft-long, reinforced concrete structure with accessory electrical, mechanical, and pneumatic equipment that is designed to provide passage for migrating Atlantic Salmon past the dam by way of the forebay and canal, a vertical distance of about 60 ft. Upstream migrating fish are attracted to the tailrace channel by flow from the turbines. Once in the tailrace area, fish are attracted to the main entrance weir at the east end of the powerhouse. Attraction water is provided by the upper three weirs containing slide gates, which open and close depending on the forebay elevation to maintain the required fish ladder flow. A skimmer gate/sluiceway is located in the forebay and is used for additional fish ladder attraction water. Water from this channel enters two diffuser openings at the fish ladder entrance. Fish enter the 8-ft-wide fish ladder entrance channel and "climb" to the forebay by swimming through a series of 67 slots and cascading pools with each succeeding weir spaced 8 ft apart and 12 inches higher than the last. After passing 34 pools, the fish enter a level turning section and pass through another 10 pools to the counting/trapping area. There, fish are guided by flow and crowder screens, travel through a 3-ft-wide flume, and pass an underwater viewing window where they may be observed and counted. From the counting/trapping area, fish continue to climb through an additional 22 pools to the ladder’s 8-ft-wide exit channel into the forebay and canal. The exit channel (i.e., the last pool) includes a motor driven headgate, widely spaced trashracks (sufficient to pass adult salmon), and slots for wooden stop logs. The last three weirs contain adjustable weir gates that can be lowered (opened) to provide a nearly constant 25 ft cfs fish ladder flow when the forebay elevation drops through its 3-ft operating range.

The fish ladder visitor center is located adjacent to the upper two pools and exit channel. The building’s basement serves as a public viewing gallery with two underwater windows. The upper floor provides informational displays on hydro generation, recreation, archaeology, and anadromous fish restoration and has a picture window view of the fish ladder to the south (downstream).

Downstream Fish Passage

As of February 11, 2016, CRASC no longer requires downstream passage operations at Bellows Falls for Atlantic Salmon smolts (see Section 3.5, *Fish and Aquatic Resources*). TransCanada has operated downstream fish passage facilities in accordance with the 1990 Memorandum of Agreement as previously described in Section 2.1.1.1, *Project History*. CRASC's annual *Fish Passage Notification Schedule* set the dates for downstream passage for all dams on the Connecticut River. Downstream passage flows were provided for adult Atlantic Salmon from October 15 to December 31 if 50 or more adults were documented as having passed upstream. Downstream migrating fish are attracted to the forebay sluiceway/skimmer gate by a solid, partial depth diversion boom across the canal. A small auxiliary gate located on the east side of the powerhouse is opened to direct fish that may get under the diversion boom to the sluiceway.

Existing License Requirements

In addition to Standard Articles 1 through 28 set forth in Form L-3 (Revised October 1975) titled "Terms and Conditions of License for Constructed Major Project Affecting Navigable Waters of the United States," the Bellows Falls Project license includes the requirements summarized in Table 2.1-6.

Table 2.1-6. Summary of Bellows Falls Project license and amendment requirements.

License Article	Summary of Requirement
29	Requires establishment and maintenance of amortization reserves based on a specified reasonable rate of return upon the net investment in the Project.
30	Requires payment of annual charges to FERC for the cost of administration of the license, based on the authorized installed capacity for that purpose of 54,400 horsepower.
31	Requires implementing and modifying when appropriate, the Emergency Action Plan on file with FERC designed to provide an early warning to upstream and downstream inhabitants and property owners if an impending or actual sudden release of water is caused by an accident to, or failure of, Project works.
32	Requires entering into an agreement with USACE to provide for the coordinated operation of the Project in the interest of flood control and navigation on the Connecticut River.
33	Requires the Licensee to maintain a continuous minimum flow of 1,083 cfs (0.20 cfs per sq. mi. of drainage basin) or a discharge flow equal to the inflow of the impoundment, whichever is less, from the Project into the Connecticut River. This flow may be modified temporarily: (1) during and to the extent required by operating emergencies beyond the control of the Licensee, or (2) in the interest of recreation and protection of the fisheries resources upon mutual agreement between the Licensee and the Fish and Game Departments of New Hampshire and Vermont.

License Article	Summary of Requirement
34	Requires undertaking consultation and cooperation with the appropriate SHPO(s) prior to the commencement of any construction or development of any Project works or other facilities at the Project.
35	Requires installation and operation of signs, light, sirens, barriers, or other devices that may be reasonably needed to warn the public of fluctuations in flow from the Project and to protect the public in its recreational use of Project lands and waters.
36 (December 15, 1980 amendment)	Gives authority to the Licensee to grant permission for certain types of use and occupancy of Project lands and waters and to convey certain interests in project lands and waters for certain types of use and occupancy, without prior FERC approval.
37	Requires filing with FERC a feasibility analysis of installing additional generating capacity at the Project.

2.1.2.6 Project Boundary

The Project boundary includes the powerhouse, canal and dam, the impounded portion of the river (approximately 26 miles upstream from the dam), a limited amount of fee-owned project land, and a significant quantity of private lands adjacent to the river upon which TransCanada retains sufficient flowage rights to operate the Project. The Project boundary encompasses the areas necessary to operate and the Project. The extent to which lands with flowage rights retained by TransCanada are affected by water due to project operation or natural inflow is largely determined by the elevation the elevation of the land in relation to the elevation of the river water surface. Surface water elevation can be affected by three considerations: 1) surface water elevation at the dam; 2) the quantity of inflow from upstream and intermittent sources; and 3) the distance upstream of the dam.

TransCanada owns 835 acres of land in the Project. Of this, 62 acres are used for plant and related facilities; 86 acres for public outdoor recreational use; 60 acres have been set aside as natural lands; and the remaining 627 acres support local agriculture, farming, and wildlife management.

2.1.3 Vernon

2.1.3.1 Project History

The Project was originally constructed in 1909 (see Section 3.10, *Cultural and Historic Resources*). The original license for the Project was issued by the Federal Power Commission (FERC's predecessor agency) on March 26, 1945, and in 1955, the Project was purchased by New England Power Company. The original license expired on June 30, 1970, and the Project operated under annual licenses until the license was renewed on June 25, 1979. The license had been amended on July 31, 1970, for the use of the Project as a cooling water source for VY located just upstream.

On October 5, 1978, FERC approved a Settlement Agreement concerning fish passage facilities for American Shad and Atlantic Salmon at the Project, and at the Wilder and Bellows Falls Project for Atlantic Salmon. The settlement was executed on December 30, 1977, among the Licensee, the states of Massachusetts, Connecticut, New Hampshire and Vermont, FWS, and four non-governmental organizations (the Environmental Defense Fund; the Massachusetts Public Interest Research Group, Inc.; For Land's Sake; and Trout Unlimited). The settlement called for staged design, construction and operation of passage facilities at the three Projects, with Vernon's construction being the first in the series. The upstream fish ladder was subsequently completed and commenced operation in 1981 (see Section 2.1.3.5, *Existing Environmental Measures*).

In 1986, a major reconstruction of the spillway crest water control mechanisms was completed and included the addition of a trash sluice (skimmer) gate, six tainter gates, and two 50-ft bays of hydraulic panels in the spillway section. A new trashrack raking system was constructed along the powerhouse forebay at that time.

On July 26, 1990, the Licensee entered into a Memorandum of Agreement with CRASC for permanent downstream fish passage facilities for the Wilder, Bellows Falls, and Vernon Projects. Downstream passage facilities were constructed in 1995 and consist of a 250-cfs "fish pipe" and louver array, as well as a 40-cfs "fish bypass" (also known as a "fish tube") (see Section 2.1.3.5, *Existing Environmental Measures*).

On June 12, 1992, FERC issued an order amending the license for the proposed replacement of four existing 2.0-MW turbine/generator units (Units Nos. 5 through 8) with two 14.0-MW turbine/generator units (Unit Nos. 11 and 12). As required by Article 403 of the 1992 license amendment, downstream fish passage facilities at the Project were completed in 1995. However, after several time extensions, the replacement of the four existing generating units never occurred. The license was subsequently amended on July 28, 2006, for the proposed replacement of the same four existing units with four new 4.0-MW units. That replacement did occur and the new units became operational in 2008.

On February 27, 1998, FERC approved the transfer of the license from New England Power Company to USGen New England, Inc. At that time, the powerhouse was automated and began operations via remote control from the Connecticut River Control Center in Wilder, Vermont. On January 24, 2005, FERC approved the transfer of the license to TransCanada Hydro Northeast Inc., the current Licensee.

2.1.3.2 Existing Project Facilities

The Vernon Project's dam and powerhouse are located on the Connecticut River at RM 141.9, about 2 miles upstream of the confluence of the Ashuelot River and

7.4 miles downstream of the West River, in the town of Vernon, Vermont, and the town of Hinsdale, New Hampshire (Figure 2.1-3). Primary Project facilities include the powerhouse, dam, and spillway; the former Superintendent's house; a storage/maintenance building and yard; fish passage facilities (see Section 2.1.3.5, *Existing Environmental Measures*); and recreation areas and facilities including a boat launch, portage, picnic areas, fishing access, fish ladder viewing area, and an open space areas (see Section 3.8, *Recreation Resources and Land Use*).

The Vernon impoundment is approximately 26 miles long and extends upstream approximately to the Walpole Bridge (Route 123 Bridge) at Westminster Station, Vermont. The impoundment has a surface area of 2,550 acres with a shoreline of approximately 69 miles and a total volume of about 40,000 acre-ft at a full impoundment El. of 220.13 ft at the top of the stanchions. Backwater effects raise the full impoundment level to about El. 227 ft at the upstream end of the impoundment. The maximum drawdown is 8 ft to El. 212.13 ft at the spillway crest, for a maximum usable storage capacity of 18,300 acre-ft. The more typical impoundment operating range under non-spill conditions is between El. 218.3 and El. 220.1 for usable storage capacity of 4,489 acre-ft.

The dam is a composite overflow and non-overflow ogee-type, concrete gravity structure extending across the Connecticut River between Hinsdale, New Hampshire, and Vernon, Vermont. Backwater forming the impoundment of the Turners Falls Project located about 20 miles downstream reaches up to Vernon dam. The Vernon dam is 956 ft long with a maximum height of 58 ft. It consists of the integral powerhouse with a sluice gate block section that is about 356 ft long and a concrete overflow spillway section about 600 ft long. The maximum dam height is 58 ft. The spillway portion of the dam is divided into 12 containing, from west to east, a trash sluice, 4 tainter gates, 2 hydraulic flashboard bays, 3 stanchion bays, and 2 tainter gates (Table 2.1-7). The various bays are separated by concrete piers supporting a steel and concrete bridge that runs the length of the dam for access and for operation of flashboards. The trash sluice is a skimmer gate that passes logs and other debris deflected away from the powerhouse by a log and ice boom in the powerhouse forebay.

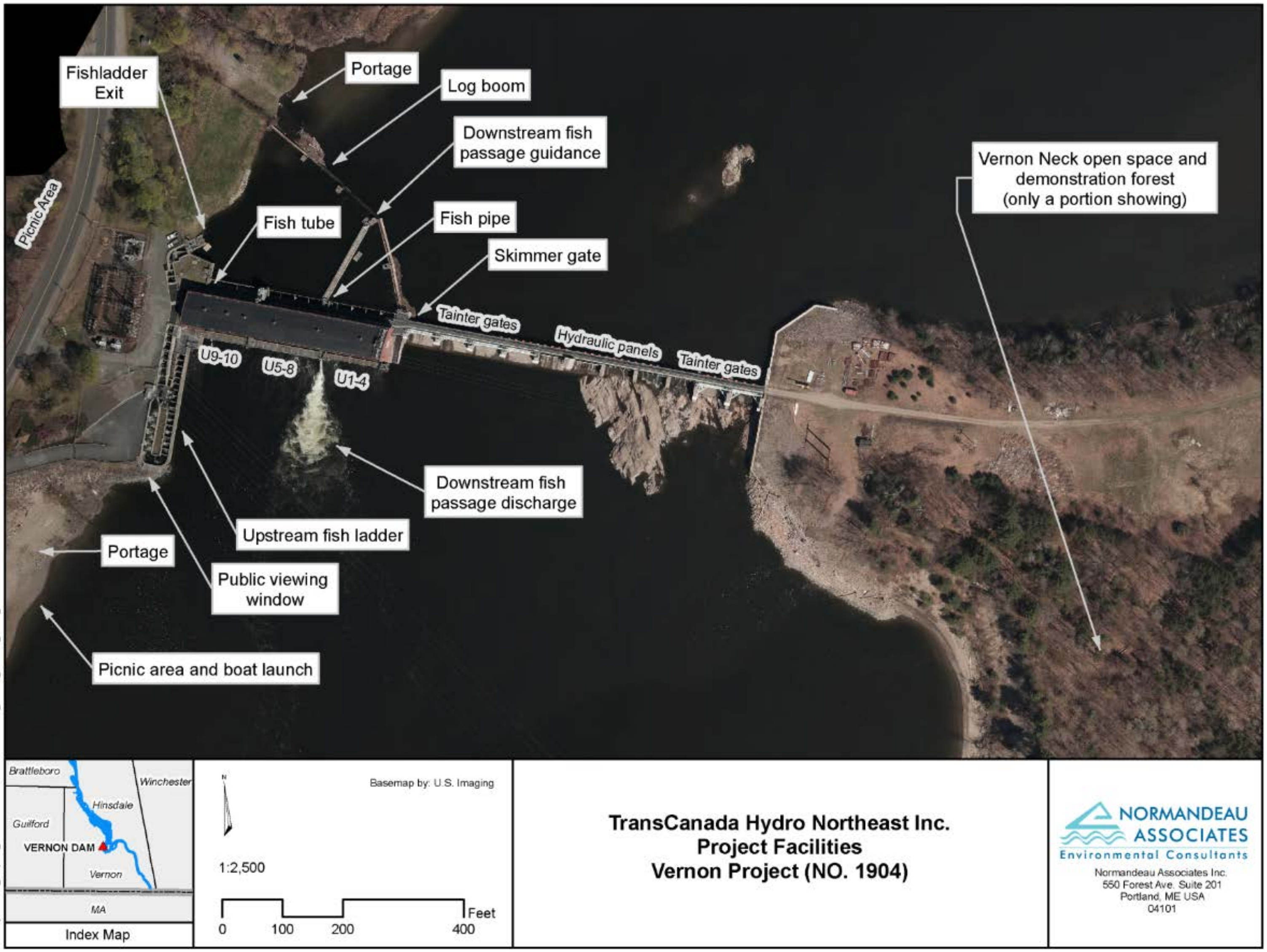

Figure 2.1-3. Primary Vernon Project facilities.

Table 2.1-7. Vernon spillway features.

Gate Type	Number	Size (height or width, by length in ft)	Elevation (NGVD29)
Fishway sluice	1	9 x 6 (inlet end) 4 x 5 (discharge end)	210.13 194.33
Trash sluice	1	13 x 13	209.13 (sill)
Tainter gates	2	20 x 50	202.13 (crest)
Tainter gates	4	10 x 50	212.13 (crest)
Hydraulic panel bays	2	10 x 50	212.13 (crest)
Stanchion bays	2	10 x 50	212.13 (crest)
Stanchion bay	1	10 x 42.5	212.13 (crest)
Hydraulic floodgates	8	7 x 9 (invert)	173.13 (sill)

The powerhouse is integral to the dam and is approximately 356 ft long by 55 ft wide by 45 ft high; it is a reinforced concrete substructure with a structural steel and brick superstructure. It contains 10 turbine/generators, electrical equipment, switchboard (used as a backup facility to the Renewable Operations Center located at the Wilder Project), machine shop, excitation equipment, emergency generator, air compressor, an overhead crane, offices, storage rooms, and ancillary equipment. Table 2.1-8 provides turbine and generator specifications.

The concrete gravity intake is integral with the powerhouse structure with two water passages for Unit Nos. 9 and 10, and a single water passage for Unit No. 1 through No. 8. Water enters directly from the forebay intake and into the scroll or wheel cases. The draft tubes discharge into a short tailrace excavated partly in the bank (for Unit Nos. 9 and No. 10) and partly in the bed of the river. The scroll cases and draft tubes are formed in the concrete of the substructure which was poured on bedrock. The only units that have draft tube gates are Units No. 5 through No. 8. These gates are operated with a common electrical hoist that can be positioned in any bay via an overhead monorail.

The water passages for Unit No. 9 and No. 10 have trashracks with 3.625-inch clear spacing and head gates consisting of two concrete gates with an electrically driven fixed hoist. Units No. 1 through No. 8 have trashrack clear spacing of 1.75-inches. Unit No. 1 through No. 4 head gates consist of a single steel-hinge gate, one for each unit. Units No. 5 through No. 8 have one steel slide gate for each unit equipped with an electrically driven fixed hoist. A hydraulic trashrack rake is used to pull river debris away from the unit intakes. It is manually operated and is driven to the trashracks in front of each unit on a set of tracks that are located on top of the forebay intake structure. The rake head is lowered to the bottom of the racks and is then retracted riding up the rack removing the debris. The debris is then conveyed into a trailer for removal.

Project electrical facilities include the generators, four step-up transformers, bus structures, switching equipment and switchboard, generator terminals and a 13.8-kV interconnection that runs underneath the station to two outdoor 13.8- to 69-kV step-up transformers located in an outdoor substation west of the powerhouse.

Non-Project facilities located within the Project boundary include switchgear, bus work, and a 69-kV interconnection owned by the regional transmission company, New England Power Company, doing business as National Grid.

Table 2.1-8. Vernon turbines and generators.

Unit Nos.	**Nos. 1–4**	**Nos. 5–8**	**Nos. 9–10**
Turbines			
Type	Single runner vertical Francis	Vertical axial flow Kaplan	Single runner vertical Francis
Design head (ft)	35	32	34
Horsepower rating at design head	4,190	5,898	6,000
Maximum hydraulic capacity (cfs)	1,092[a]	1,860[b]	2,060[c]
Minimum hydraulic capacity (cfs)	400	300	500
rpm	133.3	144	75
Intake trashrack clear spacing (inches)	1.75	1.75	3.625
Generators			
Nameplate KVA	2,500	5,000	6,000
Power factor	0.8	0.9	0.7
Nameplate KW	2,000	4,000	4,200
Phase/frequency	3/60	3/60	3/60
Voltage	2,300	13,800	13,800

a. Flow at 35.4 ft of head
b. Flow at 32 ft of head
c. Flow at 36.6 ft of head

2.1.3.3 Project Safety

The Project has been operating for more than 37 years under the existing license and during this time, Commission staff have conducted operational inspections focusing on the continued safety of the structures, identification of unauthorized modifications, efficiency and safety of operations, compliance with the terms of the license, and proper maintenance.

2.1.3.4 Existing Project Operations

Operations at the Project are coordinated with other TransCanada hydroelectric generating facilities on the Connecticut River, taking into consideration variations in demand for electricity and natural flow variations. TransCanada typically operates the Projects in a load-following or peaking mode in an attempt, within license limitations and available inflow, to maximize electrical power generation when the price of power is high and reduce generation when the price of power is low. When inflows are less than maximum generating capacity, TransCanada uses the limited impoundment storage at the Project to dispatch generation as required to meet the generation schedule managed by ISO-NE. Generation can vary during the course of any day between the required minimum flow and full generating capacity, if higher flows are available. Over the course of a day, the Project generally passes the average daily inflow. During periods of sustained high flows, TransCanada dispatches Project generation in a must-run status to use available water for generation. Once flows exceed powerhouse capacity, it operates the Projects in a "river profile" manner (see Section 3.4.1.1, *Water Quantity*). Figure 2.1-2 (Section 2.1.1.4, *Existing Project Operations*, above) illustrates the relationship between the TransCanada hydroelectric facilities on the Connecticut River.

2.1.3.5 Existing Environmental Measures

Water Level and Flow Management

The licensed minimum flow (Article 34) at Vernon is 1,250 cfs or a discharge flow equal to the inflow if less, and is provided primarily through generation at an efficient operating flow of about 1,600 cfs. Additional non-generation flows are provided seasonally on a schedule provided annually by CRASC based on fish counts at downstream projects (see below).

Normal reservoir operation is typically within a 1.8-ft range between El. 218.3 and 220.1 ft. The overall operating range is between El. 212.13 ft and 220.13 ft, but this range would only be exercised during high water events that do not require tripping of the stanchion bays as specified in the Operating Procedures, which were developed as required under Article 32. In extreme flood events, where flood flows increase beyond the capacity of the tainter gates, hydraulic floodgates and hydraulic flashboards requiring stanchion bays would be removed, the elevation would drop to just below the concrete crest at 212.6 ft in order to reinstall the beams and boards. Whenever possible, if flows exceed approximately 80,000 cfs, top portions of stanchion boards are removed rather than tripping the beams and removing all boards down to the concrete crest. The most recent event in which stanchion beams were removed was during Tropical Storm Irene in late August 2011. Under Article 32 of the license, TransCanada and USACE developed a Coordination Agreement, which specifies how the Vernon Project is operated during high flow events. Operating Procedures also restrict impoundment drawdown rates to typically 0.1 to 0.2 ft per hour and to not exceed 0.3 ft per hour. There is approximately 3,000 cfs per hour per 0.1 ft of elevation.

During the summer recreation season, beginning the Friday before Memorial Day, through the last weekend in September, TransCanada maintains a self-imposed minimum impoundment level at El. 218.6 ft from Fridays at 4:00 p.m. through Sundays at midnight, unless experiencing high flows above generating capacity. TransCanada maintains similar elevations for holidays during this period.

Recreation

The Project includes the following formal recreation areas and facilities: (1) Vernon Glen picnic area; (2) Governor Hunt Recreation Area and boat launch including fishing access, and a fish ladder viewing area; (3) boat portage; (4) Vernon Neck open space; and (5) informal boat-in campsites in Hinsdale, New Hampshire, and on Stebbins Island (see Section 3.8, *Recreation Resources and Land Use*).

Upstream Fish Passage

TransCanada operates upstream fish passage facilities in accordance with the 1978 Settlement Agreement as described in Section 2.1.1.1, *Project History*, above. CRASC provides an annual *Fish Passage Notification Schedule*, which sets the dates for upstream passage for all dams on the Connecticut River. As of 2016 and if required, upstream passage is provided in spring from April 15 through July 15 for Atlantic Salmon and American Shad (and for Blueback Herring, although none have passed since 2000; See Section 3.5, *Fish and Aquatic Resources*) and in fall from September 15 through November 15 for Atlantic Salmon.

The fish ladder is a reinforced concrete structure (Ice Harbor and vertical slot design) that is 984 ft long and has accessory electrical, mechanical, and pneumatic equipment that is designed to provide passage for migrating Atlantic Salmon and American Shad past the dam, a vertical distance of about 35 ft. Upstream migrating fish enter the tailrace area where they are attracted to entrance weirs at the west end of the powerhouse. Fish are attracted into the fish ladder and "climb" by swimming through a series of 51 pools created by a sequence of overflow weirs in the lower section and by a series of vertical slot pools in the upper section. After passing the first 26 overflow weir pools, each 15 ft wide by 10 ft long, and 12 inches higher than the last, fish enter the counting/trapping area and a regulating pool. A constant WSE of about 208 ft is maintained in the regulating pool and a steady flow is provided. Flow in the regulating pool can be supplemented as needed by a floor diffuser from the attraction water intake at the fish ladder exit. Fish are guided by flow and crowder screens through a narrow opening, passing an underwater viewing window where they can be observed and counted. They can also be trapped and diverted to a holding pool by means of manually activated pneumatic trapping gates. From the counting/trapping area, fish continue to climb through the vertical slot section of the fish ladder, consisting of an additional 25 pools each about 6 inches higher than the last. At the upper end of the fish ladder, fish pass through a flume, past screens protecting the attraction water intake, through a 12-ft-wide exit channel, and into the forebay. The exit channel is divided by a concrete center pier and includes pairs of motor-driven headgates, widely-spaced trashracks (sufficient to pass adult salmon), and slots for wooden stop logs. A public viewing area and underwater window are located just south of the powerhouse parking lot.

Downstream Fish Passage

TransCanada operates downstream fish passage facilities at Vernon in accordance with the 1990 Memorandum of Agreement as previously described in Section 2.1.1.1, *Project History*. CRASC's an annual *Fish Passage Notification Schedule*, which sets the dates for downstream passage for all dams on the Connecticut River.

Downstream fish passage facilities consist of a "fish pipe" that discharges about 350 cfs through the powerhouse, and a 156-ft-long louver array that extends from the forebay to the fish pipe entrance. The angled louver array consists of stainless steel panels with 3/8-inch x 2-inch louver vanes placed 3 inches on center and angled 60 degrees from the direction of the panels. Panels extend to a depth of 12–14 ft below the normal operation impoundment WSE. The louver intercepts and directs downstream-migrating fish that enter the forebay from mid-river and from the east (New Hampshire) shoreline into the fish pipe. A second smaller "fish bypass" (or "fish tube") is located near Unit No. 10. It discharges about 40 cfs and functions as a secondary passage route for fish that are not intercepted by the louver array and are able to enter the western end of the forebay. Downstream passage is provided for:

- Adult American Shad from April 15 through July 31;
- Juvenile American Shad from August 1 through November 15;
- Adult American Eels from September 1 through November 15 through the fish pipe; and
- Adult Atlantic salmon from October 15 through December 31, if 50 or more adults are documented passing upstream.

As of February 11, 2016, CRASC no longer requires downstream passage operations at Vernon for Atlantic Salmon smolts (see Section 3.5, *Fish and Aquatic Resources*).

Existing License Requirements

In addition to Standard Articles 1 through 28 set forth in Form L-3 (Revised October 1975) titled "Terms and Conditions of License for Constructed Major Project Affecting Navigable Waters of the United States," the Vernon Project license includes the requirements summarized in Table 2.1-9.

Table 2.1-9. Summary of Vernon license and amendment requirements.

License Article	Summary of Requirement
29	Requires establishment and maintenance of amortization reserves based on a specified reasonable rate of return upon the net investment in the Project.
30	As revised June 16, 2007, requires payment of annual charges to FERC for the cost of administration of the license, based on the authorized installed capacity for that purpose of 32.4 MW.
31	Requires implementing and modifying when appropriate, the Emergency Action Plan on file with FERC designed to provide an early warning to upstream and downstream inhabitants and property owners if an impending or actual sudden release of water is caused by an accident to, or failure of, Project works.
32	Requires entering into an agreement with USACE to provide for the coordinated operation of the Project in the interest of flood control and navigation on the Connecticut River.
33	Required providing potable water at Vernon Glen and the Governor Hunt picnic area, and completing all improvements to the Governor Hunt boat launch area and all recreation facilities detailed in the license Exhibit R. The Vernon Neck Demonstration Forest Area shall be designated as a natural area, with only limited public use. The northern portion of the Vernon Glen may continue in existing agriculture use, subject to its reservation for future recreational development that may be determined necessary during the license period.
34	Requirement to maintain a continuous minimum flow of 1,250 cfs (0.20 cfs per sq. mi. of drainage basin) or a discharge flow equal to the inflow of the impoundment, whichever is less, from the Project into the Connecticut River. This flow may be modified temporarily: (1) during and to the extent required by operating emergencies beyond the control of the Licensee; and (2) in the interest of recreation and protection of the fisheries resources upon mutual agreement between the Licensee and the Fish and Game Departments of New Hampshire and Vermont.
35	Requires undertaking consultation and cooperation with the appropriate SHPO(s) prior to the commencement of any construction or development of any Project works or other facilities at the Project.
36	Requires installation and operation of signs, light, sirens, barriers, or other devices that may be reasonably needed to warn the public of fluctuations in flow from the Project and to protect the public in its recreational use of Project lands and waters.
37 (December 15, 1980, amendment)	Giving authority to the Licensee to grant permission for certain types of use and occupancy of Project lands and waters and to convey certain interests in Project lands and waters for certain types of use and occupancy, without prior FERC approval.

License Article	Summary of Requirement
38	Required filing for approval a revised Exhibit K and (1) clearly delineating its flowage rights for Project lands, as well as fee ownership, and (2) incorporating all information denoted on Exhibit Drawing K-2, Sheet 3A of 14, which was a part of the application for amendment of license filed May 31, 1968.
39	Required filing with FERC a feasibility analysis of installing additional generating capacity at the Project.
40	Required filing a copy of a report with FERC within 30 days after USACE issues its final report on its study of erosion on the Connecticut River.
301, 302, 303 (June 12, 1992, amendment)	Required commencing construction of the revised Project works within 2 years, and completing construction of the project within 4 years from the date of amendment; revising and submitting drawings, specifications and exhibits.
304 (June 12, 1992, amendment)	Requires continuing to allow the New England Power Pool's regional central dispatching system (NEPEX) to coordinate operation of the Vernon Project with the Northfield Mountain Project (Project No. 2485) and Turners Falls Project for generation output. In the event that NEPEX will no longer continue to adequately coordinate the Projects' operation, the Licensee must enter into a reasonable agreement with Northeast Utilities Service Company (NUSCO, then owner of Northfield Mountain and Turners Falls) to coordinate the operation of the three Projects.
401 (June 12, 1992, and July 28, 2006, amendments)	Required preparing and filing for Commission approval at least 90 days before commencing construction, a final plan and schedule to control erosion, slope stability, and fugitive dust and to minimize the quantity of sediment resulting from project construction and operation. Further, the Licensee must implement its plan and schedule for minimizing impacts on migrating anadromous fish during excavation and construction.
402 (June 12, 1992, and July 28, 2006, amendments)	Required preparing and filing for FERC approval at least 90 days before commencing construction, a final plan and schedule for upstream fish passage and for monitoring the effectiveness of the passage of Atlantic Salmon, American Shad, and other anadromous fishes.
404 (June 12, 1992, amendment)	Required preparing National Register registration forms consistent with the Secretary of the Interior's Standards and Guidelines for Historic Preservation for the Vernon powerhouse; and documenting the components proposed for replacement according to the standards of the Historic American Engineering Records of the National Park Service, prior to commencing any Project-related construction activities, that would affect the characteristics of the Vernon powerhouse that make it eligible for the National Register.

License Article	Summary of Requirement
405 (July 28, 2006, amendment)	Requirement to comply with the conditions of the water quality certificate, issued by NHDES, pursuant to Section 401 of the CWA. Those provisions included developing and implementing the following plans: Operations Plan, Flow Release Monitoring Plan, Dissolved Oxygen and Temperature Monitoring Plan, Erosion Monitoring Plan, and Debris Removal Plan.
Additional Provision	An additional provision of the July 28, 2006, license amendment required the Licensee to implement the "Memorandum of Agreement Regarding the Proposed Amendment to the License of the Vernon Hydroelectric Project Vernon, Vermont and Hinsdale, New Hampshire" Memorandum of Agreement. The Memorandum of Agreement included filing of the HPMP for the Project and the following provisions: (1) conduct photographic documentation of the powerhouse; (2) conduct digital video documentation at key stages of the Project to record the removal of the original equipment and installation of the new equipment; (3) conduct archaeological investigations to identify known archaeological sites and areas within project boundaries that have a likelihood of containing archaeological deposits; (4) prepare an HPMP for the Project; and (5) offer, and if accepted, donate generating and electrical equipment removed from the powerhouse to museums and educational organizations.

2.1.3.6 Project Boundary

The Project boundary includes the powerhouse and dam, the impounded portion of the river (approximately 26 miles upstream from the dam), a limited amount of fee-owned project land, and a significant quantity of private lands adjacent to the river upon which TransCanada retains sufficient flowage rights to operate the Project. The Project boundary encompasses the areas necessary to operate and the Project. The extent to which lands with flowage rights retained by TransCanada are affected by water due to Project operation or natural inflow is largely determined by the elevation of the land in relation to the elevation of the river water surface. Surface water elevation can be affected by three considerations: (1) surface water elevation at the dam; (2) the quantity of inflow from upstream and intermittent sources; and (3) the distance upstream of the dam.

TransCanada owns 287 acres of land in the Vernon Project. Of this, 16 acres are used for plant and related facilities, 34 acres are for public outdoor recreational use, 14 acres have been leased for agricultural and other uses, 223 acres have been set aside as natural lands.

2.2 TransCanada's Proposal

At this time, TransCanada is not proposing any changes to the Wilder, Bellows Falls, or Vernon Project facilities, their operations or maintenance, or to existing environmental measures (described in Section 2.1 and Sections 3.3 through 3.11). As a result, TransCanada's proposal is identical to the no-action alternative. If FERC, federal or state agencies, or the public provide proposals for alternatives to the Projects' facilities, operations, maintenance and/or environmental measures, TransCanada will evaluate those proposals in Exhibit E of the FLAs or during the course of FERC's post-filing environmental analysis, as appropriate.

2.3 Alternatives Considered but Eliminated from Further Analysis

TransCanada considered several action alternatives but eliminated them from further analysis because they are not reasonable in the circumstances of the Wilder, Bellows Falls, and Vernon Projects. Those alternatives are: (1) issuing a non-power license; (2) federal government takeover of the Projects; and (3) retiring the Projects. Each is discussed below.

2.3.1 Non-Power License

A non-power license is a temporary license that FERC issues when it determines that a project should no longer be used to generate power. In SD2, FERC stated that this is not an appropriate alternative for the Wilder, Bellows Falls, and Vernon Projects.

> A non-power license is a temporary license the Commission would terminate whenever it determines that another governmental agency is authorized and willing to assume regulatory authority and supervision over the lands and facilities covered by the non-power license. At this time, no governmental agency has suggested a willingness or ability to take over any of these five projects. No party has sought a non-power license, and we have no basis for concluding that the TransCanada and FirstLight projects should no longer be used to produce power. Thus, we do not consider a non-power license a reasonable alternative to relicensing the projects.

In addition, power from the three TransCanada Projects is needed (see Section 1.1.2, *Need for Power*) and new licenses can be issued that satisfy the requirements of Sections 4(e) and 10(a)[8] of the FPA, which require FERC to give equal consideration to all uses of the waterway on which a project is located. Therefore, TransCanada concurs with FERC that this alternative is not a reasonable one.

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[8] 16 U.S.C. § 797(e) (2000), and 16 U.S.C. § 803(a)(1) (2000), respectively

2.3.2 Federal Government Takeover

TransCanada has not analyzed federal government takeover of the Wilder, Bellows Falls, and/or Vernon Projects and concurs with FERC's perspective stated in SD2:

> In accordance with § 16.14 of the Commission's regulations, a federal department or agency may file a recommendation that the United States exercise its right to take over a hydroelectric power project with a license that is subject to sections 14 and 15 of the FPA.[9] We do not consider federal takeover to be a reasonable alternative. Federal takeover of the project would require congressional approval. While that fact alone would not preclude further consideration of this alternative, there is currently no evidence showing that federal takeover should be recommended to Congress. No party has suggested that federal takeover would be appropriate, and no federal agency has expressed interest in operating any of these five projects (the three TransCanada Projects and two FirstLight Projects).

2.3.3 Retiring the Project

TransCanada has not analyzed retiring (decommissioning) the Wilder, Bellows Falls, and/or Vernon Projects and concurs with FERC's perspective on potentially retiring these projects as summarized in SD2. Several commenters to FERC's SD1 recommended that FERC include decommissioning as an alternative action. As summarized in SD2, FWS, The Nature Conservancy and Two Rivers-Ottauquechee suggested that "eliminating project decommissioning from further review, prior to scoping is pre-mature. Two Rivers-Ottauquechee requests that decommissioning of the Wilder Project is considered in the Commission's NEPA document, and FWS states, in general, that decommissioning should be evaluated for the Connecticut River projects." FERC's response to these comments in SD2 states:

> Decommissioning some or all of [the] Connecticut River projects would require denying the relicense applications and surrender or termination of the existing licenses with appropriate conditions. There would be significant costs involved with decommissioning the projects and/or removing project facilities. The projects provide a viable, safe, and clean renewable source of power to the region. Based on the 17 factors (to be considered when determining whether a more thorough analysis of decommissioning is warranted), outlined in The Interagency Task Force Report on NEPA Procedures in FERC Hydroelectric Licensing,[10] we do not consider decommissioning to be a reasonable alternative for the Connecticut River projects, at this time.

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[9] 16 U.S.C. §§ 791(a)-825(r).

[10] http://www.ferc.gov/industries/hydropower/indus-act/itf/nepa_final.pdf.

3. ENVIRONMENTAL ANALYSIS

3.1 General Setting

3.1.1 Overview of the Basin

The Connecticut River originates in the Fourth Connecticut Lake in Pittsburg, New Hampshire, near the Canadian border. It flows in a southerly direction for about 407 miles to Long Island Sound (the Sound) at Old Saybrook, Connecticut. The river flows 255 miles between New Hampshire and Vermont and forms the state border from Stewartstown, New Hampshire, and Canaan, Vermont, to the Massachusetts border at Hinsdale, New Hampshire, and Vernon, Vermont. The New Hampshire-Vermont state border is designated as the ordinary low-water mark on the western (Vermont) shore, without reference to extreme droughts[11] and prior to inundation by impoundments of dams after 1933 when the US Supreme Court issued its decision on the state boundary location as a result of boundary lawsuit filed by Vermont against New Hampshire in 1915.

The river has a drainage area (DA) of 11,250 square miles (sq. mi.). The upper Connecticut River Basin[12] (Figure 3.1-1) has a DA of 7,751 sq. mi. and is about 271 miles long. It includes the Wilder, Bellows Falls, and Vernon Project areas and the area downstream to the Turners Falls Project.

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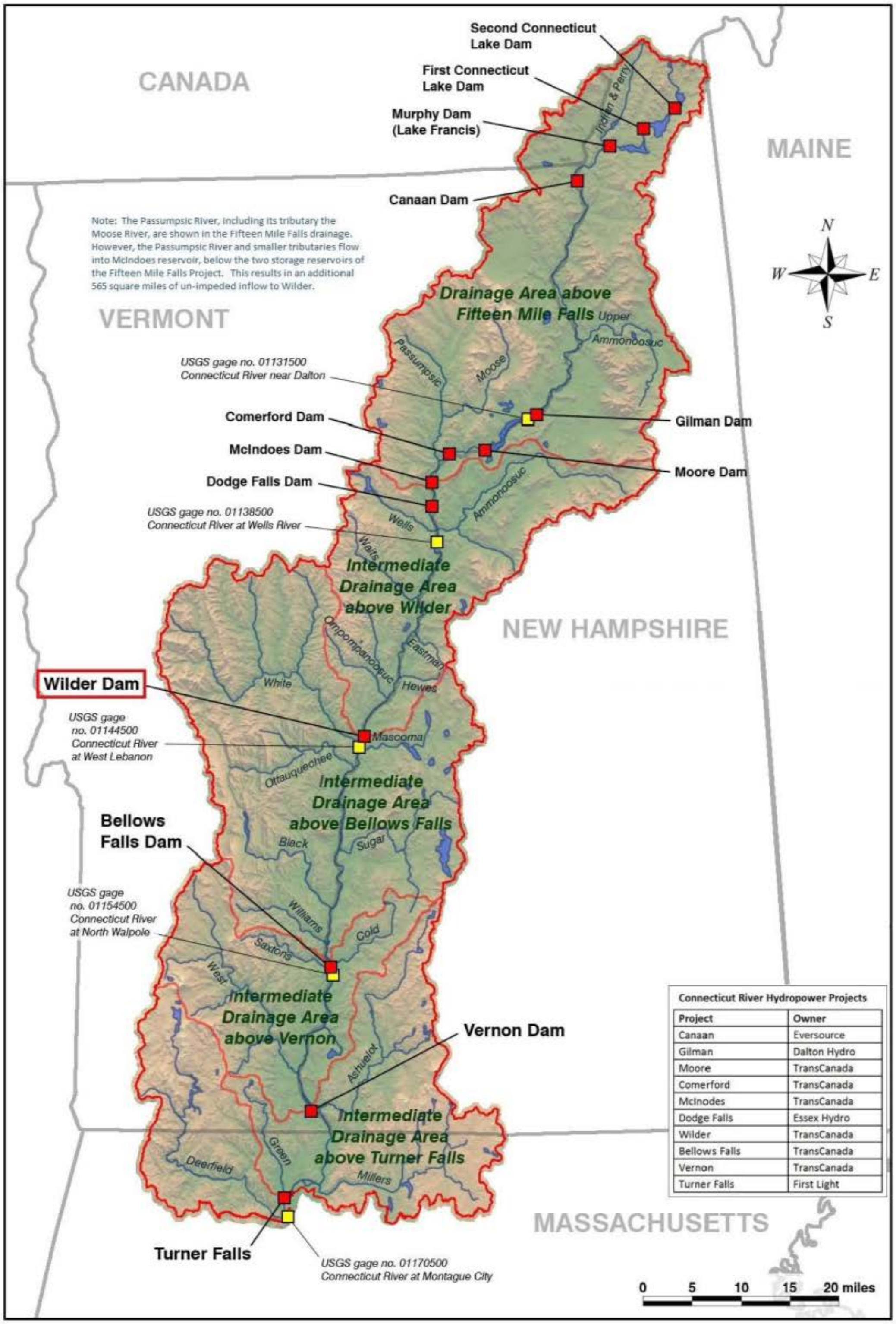
[11] Vermont v. New Hampshire. 1933. State of Vermont v. State of New Hampshire 289 U.S. 593. May 29, 1933. Available at: https://www.law.cornell.edu/supremecourt/text/289/593#writing-type-1-STONE. Accessed September 19, 2016.

[12] The upper Connecticut River Basin is defined as the northern part of the watershed from the headwaters to the confluence of the Deerfield River, near Greenfield, Massachusetts.



Project	Owner
Canaan	Eversource
Gilman	Dalton Hydro
Moore	TransCanada
Comerford	TransCanada
McInodes	TransCanada
Dodge Falls	Essex Hydro
Wilder	TransCanada
Bellows Falls	TransCanada
Vernon	TransCanada
Turner Falls	First Light

Source: EPA (2012, as modified by TransCanada)

Figure 3.1-1. The upper Connecticut River basin.

3.1.1.1 Tributaries

Twelve major tributaries (stream order 5 or greater) enter the Connecticut River and provide direct inflow to the Projects (Table 3.1-1) as described below.[13] More than 140 smaller tributaries (stream order 4 or less) also enter the Connecticut River within the approximate 122-mile length encompassing the Project areas (Figures 3.1-2 through 3.1-4).

Table 3.1-1. Major tributaries (fifth order stream or higher) draining to the Wilder, Bellows Falls, and Vernon Project areas.

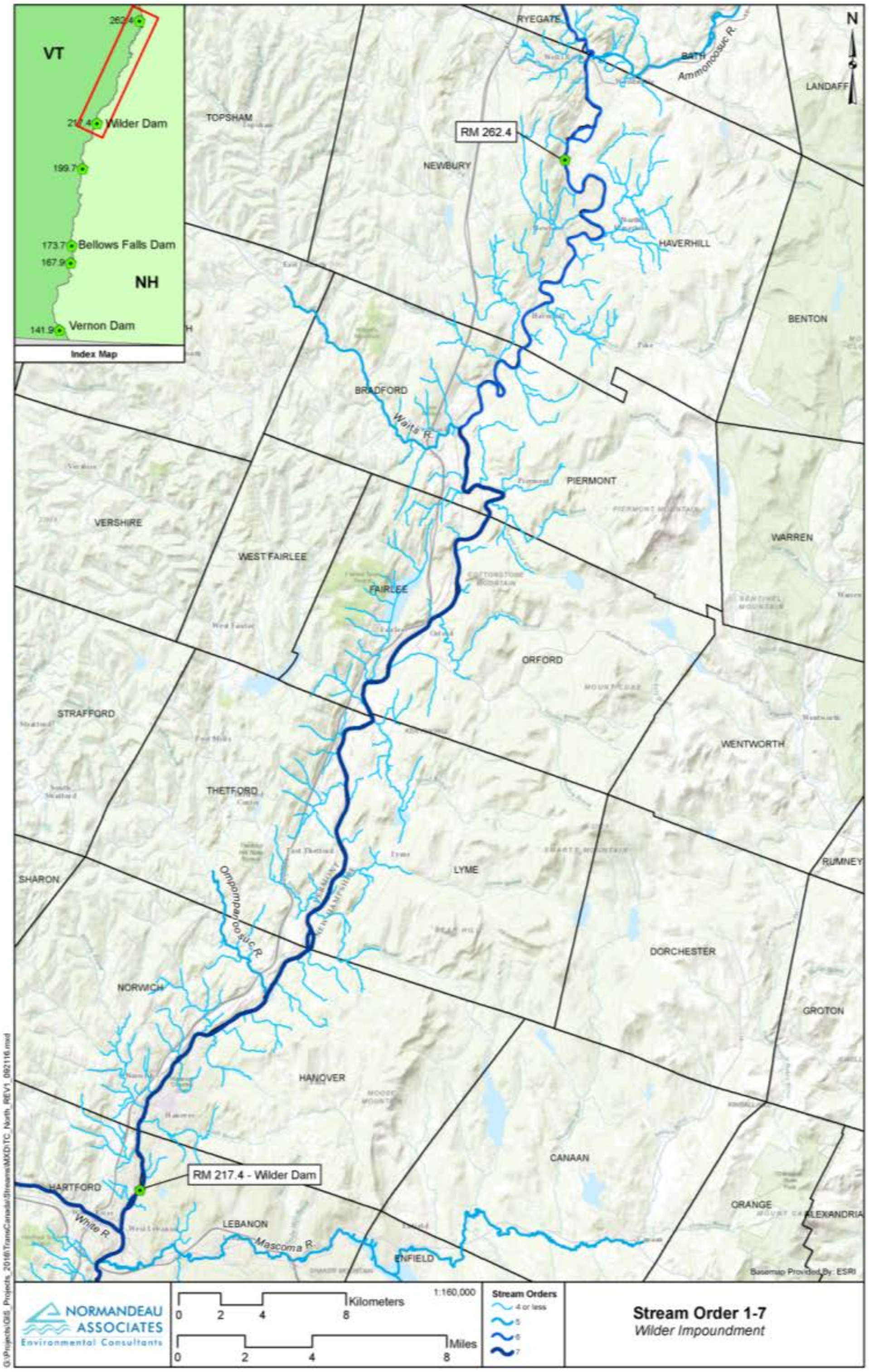
Tributary	Connecticut River Confluence Location	Stream Order	Drainage Area (sq. mi.)	Enters Mainstem at River Mile
Between Dodge Falls and Wilder Dams				
Ammonoosuc River[a]	Woodsville (Haverhill), NH	5	395	266.3
Waits River	Bradford, VT	5	158	246.8
Ompompanoosuc River	Pompanoosuc, VT	5	136	224.3
Between Wilder and Bellows Falls Dams				
White River	White River Junction, VT	7	710	215.1
Mascoma River	West Lebanon, NH	5	194	214.2
Ottauquechee River	North Hartland, VT	5	222	210.2
Sugar River	West Claremont, NH	6	275	195.2
Black River	Springfield/Gould Mill, VT	5	204	183.1
Williams River	Rockingham, VT	5	118	176.4
Between Bellows Falls and Vernon Dams				
Saxtons River	North Westminster, VT	5	78	172.5
Cold River	Cold River, NH	5	100	171.9
West River	Brattleboro, VT	6	423	149.3
Downstream of Vernon Dam				
Ashuelot River[b]	Hinsdale, NH	6	421	139.6

Source: USGS (2016a, 2016b)

a. The Ammonoosuc River enters the mainstem upstream of the Wilder impoundment and just upstream of the Wells River (fourth order stream tributary and not listed here).

b. The Ashuelot River enters the mainstem just downstream of the Vernon Project-affected riverine reach.

[13] Stream order is a hierarchical ordering of streams based on the degree of branching. A first order stream is an unbranched stream and combines with another first order stream to form a second order stream, two second order streams combine to form a third order stream, etc. (Armantrout, 1998).

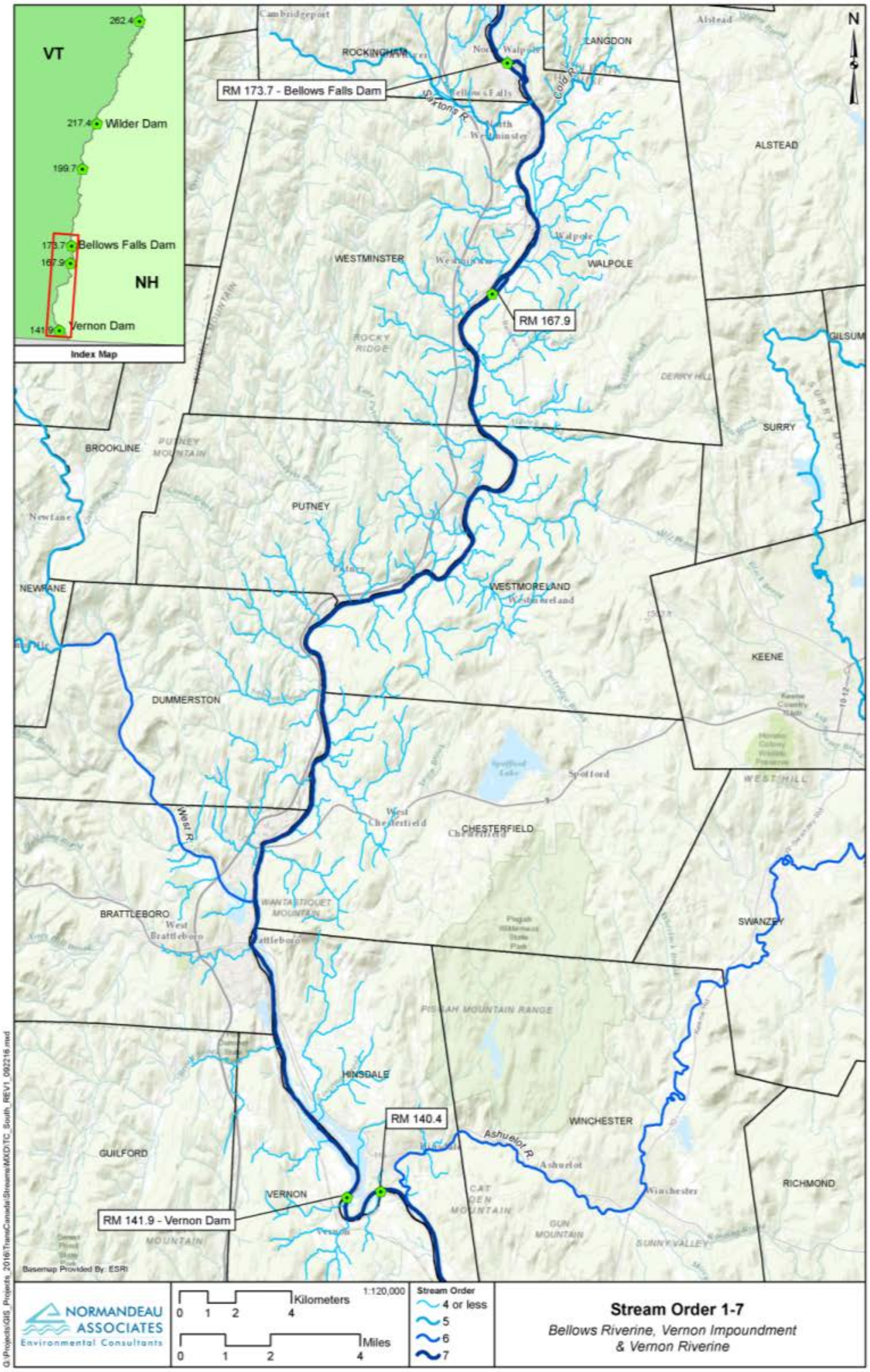


Source: USGS (2016b, as modified by TransCanada)

Figure 3.1-2. Tributaries to the Wilder Project.

Source: USGS (2016b, as modified by TransCanada)

Figure 3.1-3. Tributaries to the Bellows Falls Project.



Source: USGS (2016b, as modified by TransCanada)

Figure 3.1-4. Tributaries to the Vernon Project.

3.1.1.2 Major Water Uses

The river was used as a means of log conveyance mostly in the spring for the timber industry from the mid-1800s until 1915 when the last major log drives occurred; however, pulpwood was floated down the river until 1949 (Brown, 2009). Similarly, dams constructed for industrial mill power and transportation also pre-dated large-scale hydroelectric development. The Connecticut River has long been used for recreational purposes including power boating, canoeing, kayaking, rowing, sport fishing, and ice fishing.

Both surface water from tributaries and groundwater in the vicinity of the Connecticut River and tributaries within the Wilder, Bellows Falls, and Vernon Project areas are used for drinking water, irrigation, mining, and industrial purposes. Based on available information, there is little use of surface water from the Connecticut River for non-power purposes within the Project areas. Three New Hampshire-registered withdrawals[14] taken directly from the Connecticut River in Hanover, Plainfield, and Westmoreland are used for irrigation or institutional purposes. The only major withdrawal from Vermont waters of the Connecticut River was for cooling water for VY, which ceased operation in 2014. Treated wastewater from private, commercial, municipal, and industrial sources in New Hampshire and Vermont discharges to both the Connecticut River and its tributaries and is permitted under CWA § 402 implementing regulations at 40 C.F.R. 122.

3.1.1.3 Dams

Dams on the mainstem of the Connecticut River include Second Connecticut Lake, First Connecticut Lake, Murphy dam without hydropower production, and 12 hydroelectric developments. The Canaan and Gilman Projects, the Fifteen Mile Falls Project (Moore, Comerford, and McIndoes developments), and Dodge Falls Project (FERC No. 8011) are located upstream of the Wilder, Bellows Falls, and Vernon Projects. Downstream are the Turners Falls, Northfield Mountain Pumped Storage, and Holyoke Projects all located in Massachusetts (Table 3.1-2). Numerous small licensed and exempt hydropower projects and hundreds of small non-powered dams are located on tributaries to the Connecticut River in New Hampshire and Vermont. Information about the Project dams and impoundments follows:

- Wilder dam is located at RM 217.4, and the impoundment extends upstream approximately 45 river miles to Haverhill, New Hampshire, and Newbury, Vermont. The downstream Project-affected riverine reach is approximately 17.7 miles long.
- Bellows Falls dam is located at RM 173.7, and the impoundment extends upstream approximately 26 river miles to Cornish, New Hampshire, and

[14] New Hampshire requires registration of water withdrawals more than 20,000 gallons per day averaged over 7 days or a total of more than 600,000 gallons per day in a 30-day period. Vermont requires permits for water withdrawals from in-state waters but does not have a system for tracking permitted withdrawals.

Windsor, Vermont. The downstream Project-affected riverine reach is approximately 5.8 miles long.

- Vernon dam is located at RM 141.9, and the impoundment extends upstream approximately 26 river miles to Walpole, New Hampshire, and Westminster, Vermont. The downstream Project-affected riverine reach is approximately 1.5 miles long to the downstream end of Stebbins Island.

Building of the large mainstem hydroelectric dams on the Connecticut River in New Hampshire and Vermont started with the completion of the Vernon Project in 1909, followed by the Bellows Falls Project in 1928. The upstream Fifteen Mile Falls Project, consisting of McIndoes, Comerford, and Moore dams, was constructed between the 1930s and 1950s. The Wilder Project, constructed in 1950, was a redevelopment of a site occupied by a paper mill and hydroelectric plant.

Table 3.1-2. Mainstem Connecticut River dams and hydropower projects.

Project Name	Owner	FERC No.	River Mile	Storage Capacity (acre-ft)
Second Connecticut Lake	TransCanada	NA	389.5	11,613
First Connecticut Lake	TransCanada	NA	382.2	73,493
Murphy Dam (Lake Francis)	State of NH	NA	374.2	99,306
Canaan	Eversource	P-7528	370	200
Gilman	Dalton Hydro	P-2392	300	705
Moore	TransCanada	P-2077	283.5	223,722
Comerford	TransCanada	P-2077	275.2	32,270
McIndoes	TransCanada	P-2077	268.6	5,988
Dodge Falls [a]	Essex Hydro	P-8011	264.6	Run of river
Wilder	TransCanada	P-1892	217.4	13,350 (at 5-ft drawdown)
Bellows Falls	TransCanada	P-1855	173.7	7,476 (at 3-ft drawdown)
Vernon	TransCanada	P-1904	141.9	18,300 (at 8-ft drawdown)
Northfield Mountain	FirstLight	P-2485	127	12,318
Turners Falls	FirstLight	P-1899	122	16,150
Holyoke	Holyoke Gas and Electric	P-2004	87	Run of river

Source: TransCanada Operations Department; FirstLight (2016a); NHDES (2016); VDEC (2016)

a. Exempt project.

USACE operates flood control dams on four of the major tributaries to the Wilder, Bellows Falls, or Vernon Project areas (Table 3.1-3). In accordance with FERC License Article 32 of each Project license, TransCanada maintains an agreement with USACE that provides for the coordinated operation of the Projects in the interest of flood control and navigation on the Connecticut River. Under the agreement, TransCanada lowers the WSE at the dams in anticipation of inflows greater than maximum generating capacity at each Project. These high water operations are initiated to manage upstream water elevations within certain flowage rights and to reduce the potential for river flows to spill outside of the normal bank full conditions (see Section 3.4.1.1, *Water Quantity*).

Table 3.1-3. USACE dams in the vicinity of the Wilder, Bellows Falls, and Vernon Projects[a]

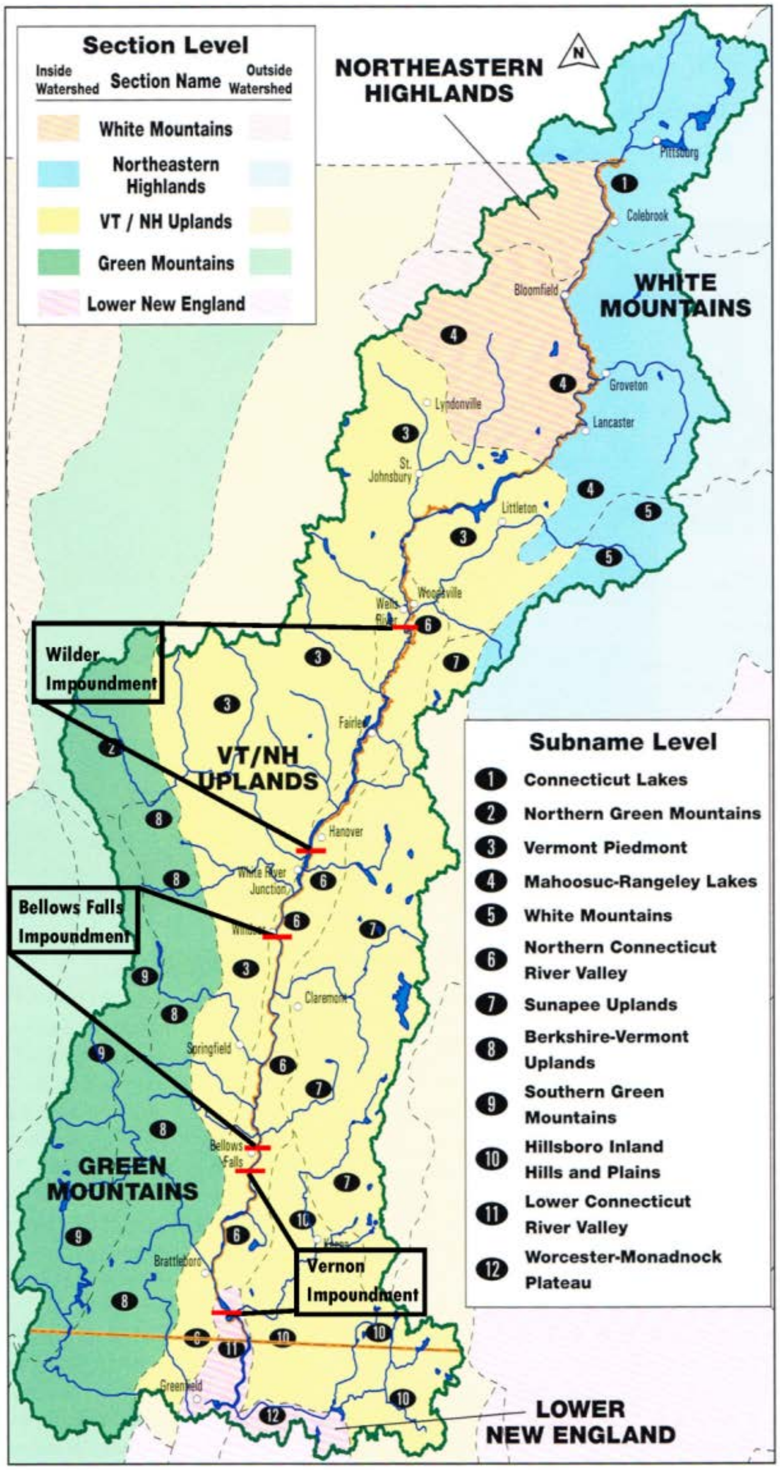
USACE Project Name	Tributary	Discharges to Connecticut River Impoundment	Flood Storage Capacity (acre-ft)
Union Village	Ompompanoosuc	Wilder	7,365
North Hartland	Ottauquechee	Bellows Falls	71,198
North Springfield	Black	Bellows Falls	51,250
Ball Mountain	West	Vernon	54,626
Townshend	West	Vernon	33,757

Source: USACE (2016)

a. USACE operates two additional flood control dams in New Hampshire on the Ashuelot River, which enters the Connecticut River 2.1 river miles downstream of Vernon dam.

3.1.2 Topography

The Projects are located primarily within the Vermont/New Hampshire Uplands section of the New England Physiographic Province, although the lower portion of the Vernon impoundment is located in the Lower New England region (Figure 3.1-5). Within the smaller biophysical regions of eastern Vermont and western New Hampshire, the Projects lie in the Southern Vermont Piedmont. The region comprises low rolling foothills dissected by many rivers and streams draining to the Connecticut River. The lowlands comprise fertile farmland and the hills are covered with hardwood forests (Thompson and Sorenson, 2000).



Source: Brown (2009, as modified by TransCanada)

Figure 3.1-5. Physiographic regions of New Hampshire and Vermont encompassing the Wilder, Bellows Falls, and Vernon Projects.

The word piedmont, which means "at the foot of the mountains," is used to describe an area of foothills, and this area comprises rolling hills and valleys at the foot of the Green Mountains that extend into western New Hampshire, and at the foot of the White Mountains in New Hampshire to the east. The most notable feature of the piedmont landscape is a number of mountains that rise above the surrounding landscape. These isolated mountains are called monadnocks, a word believed to originate in Abenaki that means "island mountain place" (Vermont Geographic Alliance, 2016) and consist of resilient granite outcrops. Mount Ascutney in Windsor and Weathersfield, Vermont, is such a monadnock and was formed by plutonic activity that resulted from the Alleghenian Orogeny, when subsurface magma was melted and reformed (see Section 3.3, *Geologic and Soil Resources*). This magma cooled and became very hard rock, and it has resisted the erosion that has lowered the softer sedimentary rocks that surround it. Elevations in the Southern Vermont Piedmont range from less than 300 ft at Vernon to 3,144 ft at the top of Mount Ascutney (Thompson and Sorenson, 2000).

3.1.3 Climate

The climate within the Wilder, Bellows Falls, and Vernon Project areas consists of mild and humid summers and cold winters. Average temperatures tend to be slightly warmer, and precipitation somewhat higher (although snowfall tends to be lower) at the southern end of the area near Vernon, Vermont, than at the northerly upstream end of the Wilder impoundment at Haverhill, New Hampshire. Precipitation is relatively evenly distributed throughout the year. Table 3.1-4 provides a summary of average climate data throughout the approximate 122-mile area that encompasses the Projects.

Table 3.1-4. Average annual climate data for the Wilder, Bellows Falls, and Vernon Project areas.

		Wilder Top of Impoundment Haverhill, NH	Wilder Dam Hanover, NH	Bellows Falls Dam Walpole, NH	Vernon Dam Vernon, VT
Temp. (°F)	January low	6	10	11	11
	January high	26	28	29	32
	July low	55	59	59	59
	July high	77	82	80	84
Ave. annual (inches)	Precipitation	40.0	40.1	44.9	47.0
	Snowfall	71	61	57	55[a]

Source: U.S. Climate Data (2016)

a. Snowfall data from Keene, New Hampshire.

3.1.4 Major Land Uses

Land use in the Connecticut River Valley is predominantly rural and agricultural, and a considerable portion of the land is undeveloped and forested. Much of the land in the valley has been preserved by property owners using various conservation easements for agriculture, open space, and habitat protection. Bottomland agriculture in the area is used for dairy, vegetable, and hay farming. Along the New Hampshire and Vermont sides of the Connecticut River, most of the land is zoned for limited residential use with infrequent commercial and industrial sites (NHDES, 1991). This development pattern was established in early settlement days and consisted of mosaic villages and small cities surrounded by rural areas that continues today. The juxtaposition of dense villages with working forestlands and agricultural fields defines the character of the Connecticut River Valley. While industrial land use is rare near the river, railroad tracks are commonly found along the banks of both sides of the river and in proximity to the Projects. The primary land uses adjacent to the Project boundaries are recreation, agriculture, and wildlife habitat.

See Section 3.8, *Recreation Resources and Land Use*, for additional information about the recreation resources and land uses within the Wilder, Bellows Falls, and Vernon Project areas.

3.1.5 Major Economic Activities

The primary industry sector in each of the six counties within the Project areas is the educational services/healthcare/social assistance market, accounting for between 29 and 34 percent of total jobs in each of the counties in the area. The next largest industries in each of these counties are manufacturing and retail trade, making up between 9 and 19 percent of total jobs in each county (U.S. Census Bureau, 2014a). The Cheshire Medical Center and Dartmouth Hitchcock Clinic-Keene in Cheshire County employs 1,200 persons, while the Dartmouth Hitchcock Medical Center/Hitchcock Clinic employs 6,900 people in Grafton County. Dartmouth College employs 3,200 people in Grafton County as well. In Sullivan County, the largest employer is Sturm Ruger & Co., a sporting firearms company, which employs 1,455 people (NHES, 2016). In Vermont, the Veterans Demonstration Hospital, Franklin Pierce College, and the Community College of Vermont also support a number of jobs (Hartford Chamber 2016). VY formerly employed approximately 600 people; however, since commercial operation of the facility ended in December 2014 and as it is currently being decommissioned, employment at VY has decreased substantially.

See Section 3.11, *Socioeconomics*, for additional information about the economy with the Wilder, Bellows Falls, and Vernon Project areas.

3.2 Scope of Cumulative Effects Analysis

3.2.1 Cumulatively Affected Resources

According to the Council on Environmental Quality's regulations for implementing NEPA (40 C.F.R. 1508.7), a cumulative effect is the effect on the environment that results from the incremental effect of the action when added to other past, present and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower and other land and water development activities.

FERC issued SD2 on April 15, 2013, which included the cumulative effects of the Wilder, Bellows Falls, and Vernon Projects as well as FirstLight's Turners Falls and Northfield Mountain (Project No. 2485) Projects located downstream of the TransCanada Projects on the Connecticut River.

> Based on information in the Pre-Application Documents and staff analysis of the written comments submitted from agencies and other stakeholders on the SD1 document and comments from the January 2013 public scoping meetings, we identified the following resources that may be cumulatively affected by the proposed operation and maintenance of the five Connecticut River Projects: water quality and quantity[15] (including power generation), fishery resources (including anadromous and catadromous fish and fish passage), floodplain communities, freshwater mussels, sediment movement, recreational uses, and rare, threatened, and endangered species (FERC, 2013).

The geographic and temporal scope of the cumulative effects analysis including past, present and reasonably foreseeable future actions considered in the analysis for these resources is summarized below.

3.2.2 Geographic Scope of Analysis for Cumulatively Affected Resources

The geographic scope of analysis for cumulatively affected resources defines the physical limits or boundaries of the proposed Project operations and maintenance under new licenses. Because the proposed actions (e.g., continued operation of the Projects) would affect the resources differently, the geographic scope for each resource may vary.

In SD2, FERC describes the geographic scope for cumulatively affected resources and TransCanada has included this geographic area in the cumulative effects analysis for these resources as applicable to the TransCanada Projects. In addition

[15] From FERC SD2: Water quantity is defined as flow magnitude, flow frequency, flow duration, flow timing, and rate of change.

to the three TransCanada Projects and the two FirstLight Projects that are the subject of FERC's cumulative effects analysis, 10 additional mainstem dams on the Connecticut River and tributary dams are located throughout the watershed (Section 3.1.1.3, *Dams*). Collectively, all of these dams cumulatively affect the resource areas identified by FERC.

3.2.2.1 Water Quantity and Water Quality

Because of the extensive seasonal storage capacity at Moore impoundment (part of the Fifteen Mile Falls Project located upstream of the Wilder Project), FERC identified the geographical extent of cumulative effects on water quantity and water quality to include the Connecticut River from the base of Moore dam to the mouth of the Connecticut River at the Sound. FERC chose this geographic area to "recognize the cumulative operational influences of the upstream water storage, and the operations of the five Connecticut River projects on water quantity throughout this area and subsequently on water quality that could occur downstream to mouth of the Connecticut River at Long Island Sound."

Section 3.4.3 discusses cumulative effects of the Wilder, Bellows Falls, and Vernon Projects on water quantity and water quality within the Project areas.

3.2.2.2 Migratory Fish Species

Because hydroelectric dams influence both upstream and downstream fish migration within river systems, FERC identified the geographical extent of potential cumulative effects on anadromous, catadromous, and diadromous fish species to include the Connecticut River from the Sound upstream to each species' historical habitat range.

Section 3.5.3 discusses cumulative effects of the Wilder, Bellows Falls, and Vernon Projects on migratory fish species that occur within the Project areas.

3.2.2.3 Resident Fish Species, Freshwater Mussels, and Sediment Movement

FERC identified the geographical extent of cumulative effects on resident fish species, freshwater mussels, and sediment movement to include the upper extent of the Wilder impoundment downstream to the Route 116 Bridge in Sunderland,[16] Massachusetts. FERC chose this geographic area because "the operation of the five projects (TransCanada and FirstLight projects) could be a contributing factor to sediment movement within the river and cumulative effects on resident fisheries and freshwater mussel habitat in this area."

[16] From FERC SD2: The Route 116 Bridge is located at the approximate upstream extent of the Holyoke Project impoundment.

Section 3.5.3 discusses cumulative effects of the Wilder, Bellows Falls, and Vernon Projects on resident fish species and freshwater mussels that occur within the Project areas. Section 3.7.3 discusses the cumulative effects of the Projects on the federally endangered dwarf wedgemussel, and Section 3.3.3 discusses cumulative effects of the Projects on sediment movement.

3.2.2.4 Terrestrial and Floodplain Communities

FERC identified the geographic scope of cumulative effects on terrestrial and floodplain communities to include the 100-year floodplain (as defined by the Federal Emergency Management Agency) adjacent to the Project-affected areas from the upstream extent of the Wilder impoundment downstream to the Route 116 Bridge in Sunderland, Massachusetts. FERC chose this geographic area because the operation of the TransCanada and FirstLight projects, "in combination with other land uses in the Connecticut River Basin, may cumulatively affect floodplain communities adjacent to project impoundments and downstream riverine reaches in this area."

Section 3.6.3 discusses cumulative effects of the Wilder, Bellows Falls, and Vernon Projects on terrestrial and floodplain communities that occur within the Project areas.

3.2.2.5 Recreation (Multi-day Paddle Trips)

The presence of multiple dams on the Connecticut River may cumulatively affect multi-day paddle trips. In its SD2, FERC identified the geographic scope of the cumulative effects on recreation for multi-day paddling trips on the Connecticut River as extending possibly as far upstream as Murphy dam (RM 383) in Pittsburg, New Hampshire, where the natural riverine reaches become navigable (CRWC, 2007; American Whitewater, 2013) and downstream to the Holyoke dam, the most downstream dam, in Holyoke, Massachusetts.

Section 3.8.3 discusses the cumulative effects of the Wilder, Bellows Falls, and Vernon Projects on multi-day paddling trips on the Connecticut River.

3.2.3 Temporal Scope of Analysis for Cumulatively Affected Resources

The temporal scope of the cumulative effects analysis includes past, present, and reasonably foreseeable future actions and their effects on each cumulatively affected resource. Because the term of new licenses for the Wilder, Bellows Falls, and Vernon Projects is expected to range from 30 to 50 years, the temporal scope of analysis includes reasonably foreseeable actions over that timeframe. Because TransCanada is not proposing changes to current Project operations or maintenance, future effects due to Project operation, are not expected to change from present conditions over the term of new licenses.

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3.3 Geologic and Soil Resources

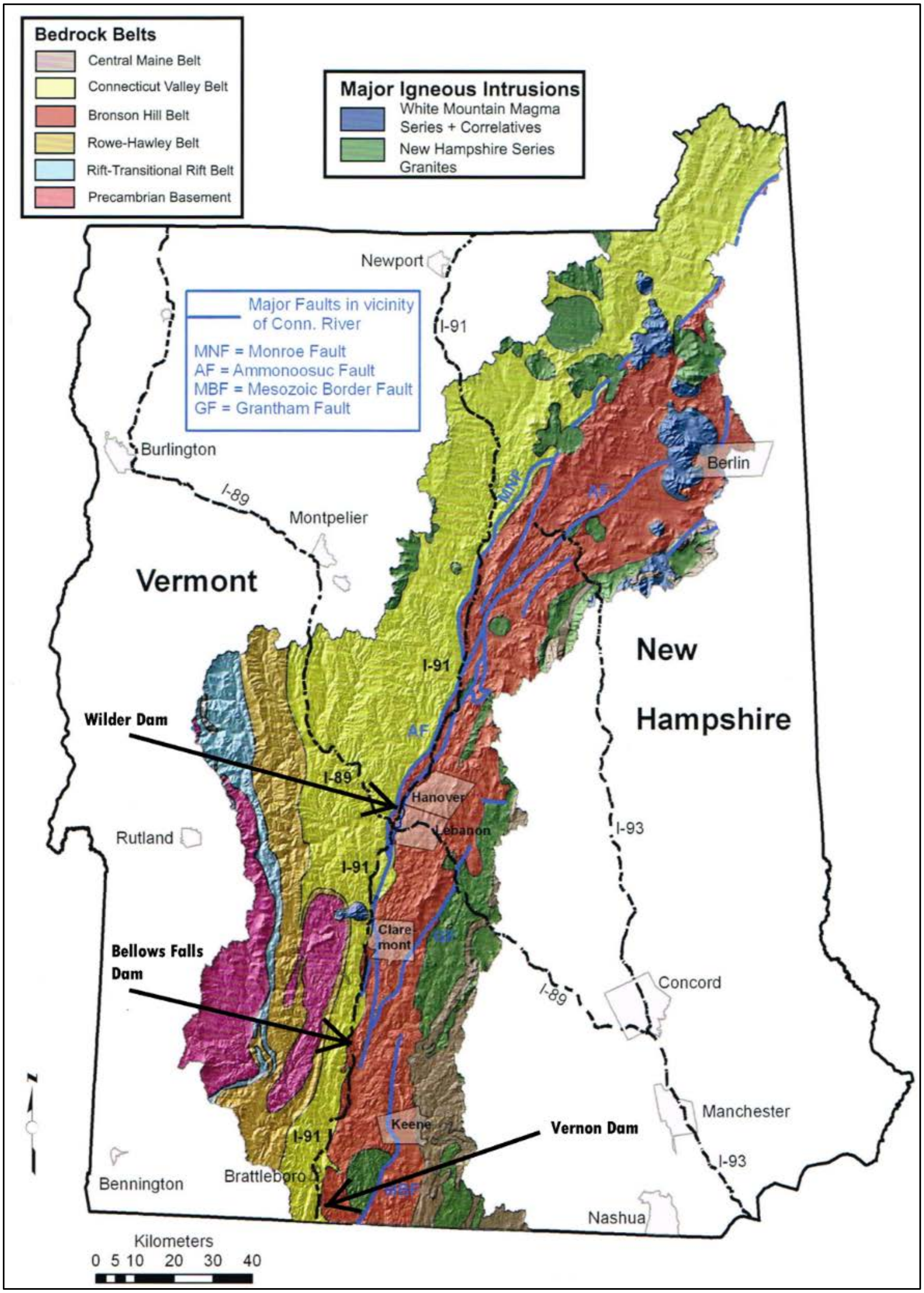
3.3.1 Affected Environment

3.3.1.1 Regional Geology

Bedrock Geology

The bedrock geology in the vicinity of the Wilder, Bellows Falls, and Vernon Projects is broadly similar. The Connecticut River Valley runs along a major tectonic boundary that results in starkly contrasting bedrock geology on either side of the valley (Figure 3.3-1). In the westernmost portion of the watershed in Vermont's Green Mountains are gneisses, marbles, and quartzites that are more than 1 billion years old (i.e., Precambrian Basement) and were originally sediments deposited along the edge of the proto-North American continent known as Laurentia (Van Diver, 1987). This ancient continent began to rift apart (much like the Red Sea rift system today) around 650 million years ago to form a proto-Atlantic Ocean (known as the Iapetus Ocean) into which sediments were deposited to ultimately form the rocks of the Rift-Transitional Rift Belt and Rowe-Hawley Belt in Vermont.

In a reversal of tectonic plate motions around 450 million years ago, the Iapetus Ocean began to close through subduction of the oceanic crust that was formed and attached to the Laurentian continent as a result of the preceding rifting cycle. Similar to the setting of present-day Japan, the partial melting of this subducting Iapetus Ocean crust led to the formation of a volcanic arc now represented by the Bronson Hill Belt in New Hampshire composed of metamorphosed volcanics and granites. Ultimately, through continued subduction, the volcanic arc accreted onto the Laurentian continent at the end of the Taconian Orogeny (i.e., mountain building event) resulting in faulting and metamorphism of both the rocks in the Bronson Hill Belt of New Hampshire and the older rocks to the west in Vermont. Subsequent erosion of the large mountains formed as a result of the Taconian Orogeny shed sediment both to the east and west with the westward directed sediments eventually forming the currently metamorphosed sandstones, shales, and limestones of the Connecticut Valley Belt (Kim and Wunsch, 2009). After almost 50 million years of tectonic quiescence following the Taconian Orogeny, the collision of the Laurentian continent with Avalonia, another ancient continent whose remnants are now primarily found in western Europe, resulted in the Acadian Orogeny that emplaced the granite intrusions of the New Hampshire Series and further faulted, folded, and metamorphosed the preexisting rocks that are now found in the Connecticut River watershed. Further continental collisions between Laurentia and Gondwanaland, an ancient continent whose remnants are now found primarily in Africa, South America, and Antarctica, resulted in the Alleghenian Orogeny from 280 to 300 million years ago and the formation of a single super continent known as Pangea. No rocks from this period are found in the Connecticut River watershed in Vermont and New Hampshire, but the Alleghenian Orogeny did further deform and metamorphose the preexisting rocks.



Source: Brown (2009)

Figure 3.3-1. Bedrock geology in the Project areas.

The breakup of Pangea and ultimate formation of the present day Atlantic Ocean through rifting began approximately 200 million years ago. The White Mountain Series granites formed at this time with the rifting also responsible for the formation of the north-south trending Ammonoosuc Fault that exerts a strong control on the orientation of the Connecticut River Valley from north of the Wilder impoundment to south of Bellows Falls dam. Faults and other fractures in the bedrock formed during the earlier orogenies also control drainage trends in the watershed, especially the rectilinear drainage networks characteristic of many of the river's tributaries in Vermont.

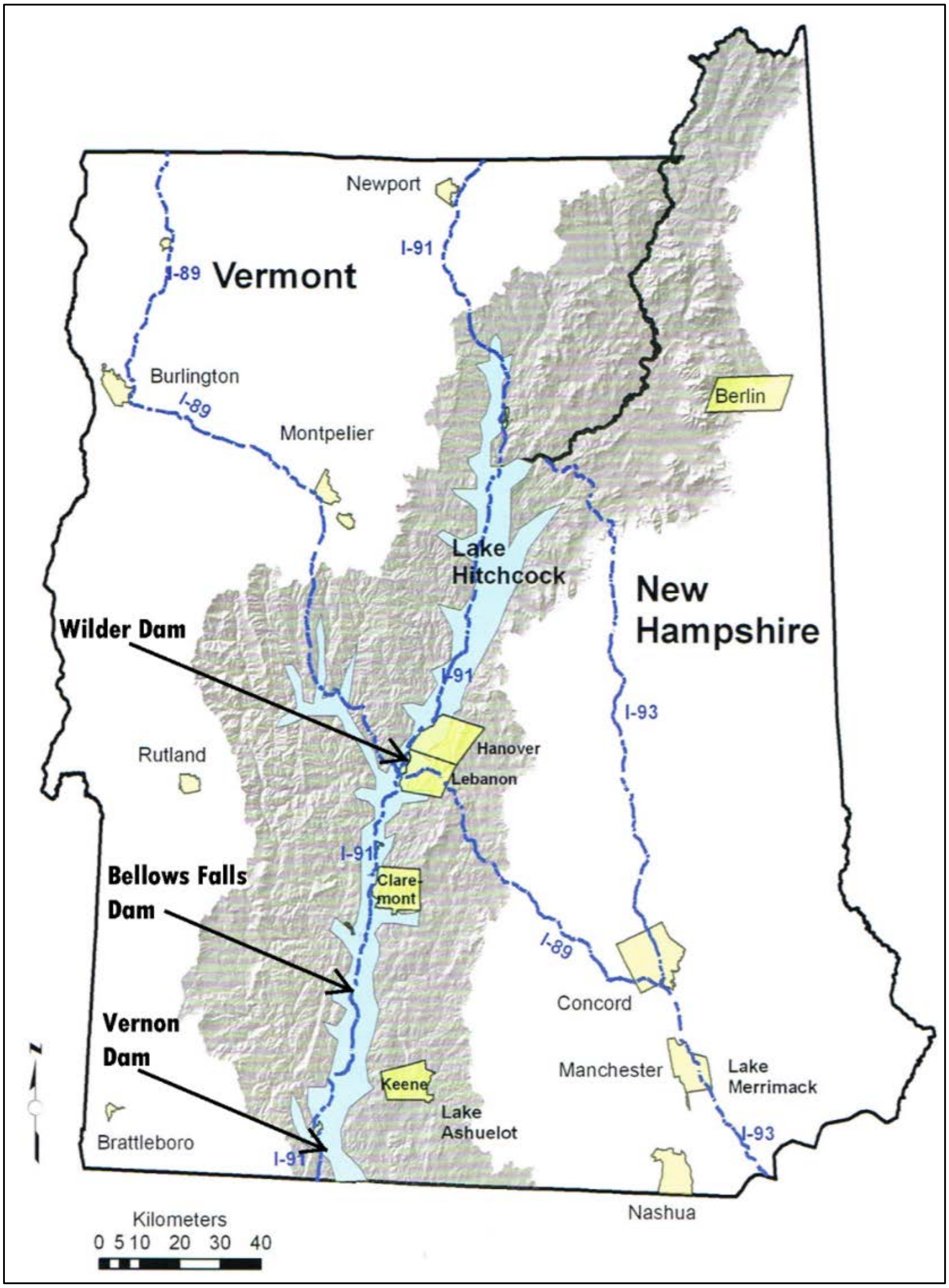
Surficial Geology

The bedrock geology and tectonic processes described above exert a strong control on the topography and physiography of the Connecticut River watershed. The generally north-northeast trending mountain ridges and intervening valleys reflect the underlying orientation of the rock formations and the folds and faults that have deformed them. The ridges are composed of rock types more resistant to erosion with the valleys underlain by less resistant rocks, and the highest peaks of the Green Mountains in Vermont are largely composed of the most erosion-resistant and oldest Precambrian Basement rocks (Kim and Wunsch, 2009). The less resistant rock types found in the Connecticut Valley Belt and Bronson Hill Belt have formed more rolling hills and short ridges compared to the higher more pronounced ridges in the center of the Green Mountains. Isolated dome shaped hills in the watershed such as Mount Ascutney in Windsor, Vermont, are typically underlain by circular granite intrusions of the New Hampshire and White Mountain magma series with radial drainage patterns developed by streams flowing off of the circular peaks in all directions. The upland areas of the watershed are at times draped with a relatively thin veneer of glacial till, but it is only in the Connecticut River and tributary valleys where the effects of glacial action are more pronounced.

The surficial geology of the Wilder, Bellows Falls, and Vernon Project areas is in large part attributable to glacial processes. Although the position of the Connecticut River Valley and watershed more broadly were already well established prior to glaciation, the final Pleistocene advance and retreat of the continental ice mass during the Wisconsin Period eroded and picked up bedrock; realigned some drainages; and deposited till, erratics, and glacial moraines. The retreat of ice from New Hampshire and Vermont about 13,500 years ago left widespread glacial deposits and glacial erosional surfaces. An important part of the deglaciation in this area was the formation of temporary lakes along the margins of the ice fronts. The Connecticut River Valley is situated within the boundaries of Glacial Lake Hitchcock. Glacial Lake Hitchcock formed as glacial meltwaters released from the ice sheet were dammed behind a natural sand, gravel, and till barrier deposited in the area of Rocky Hill, Connecticut, to the south. Continued ice melt resulted in a massive natural lake impoundment north of the Rocky Hill dam, which at its maximum stretched 200 miles from Rocky Hill to St. Johnsbury, Vermont, and reached 20 miles in width (Figure 3.3-2). Glacial Lake Hitchcock persisted in the upper Connecticut River Valley until about 12,300 years ago. The Connecticut River appears to have essentially continued along the same pre-glacial course following the drainage of Glacial Lake Hitchcock.

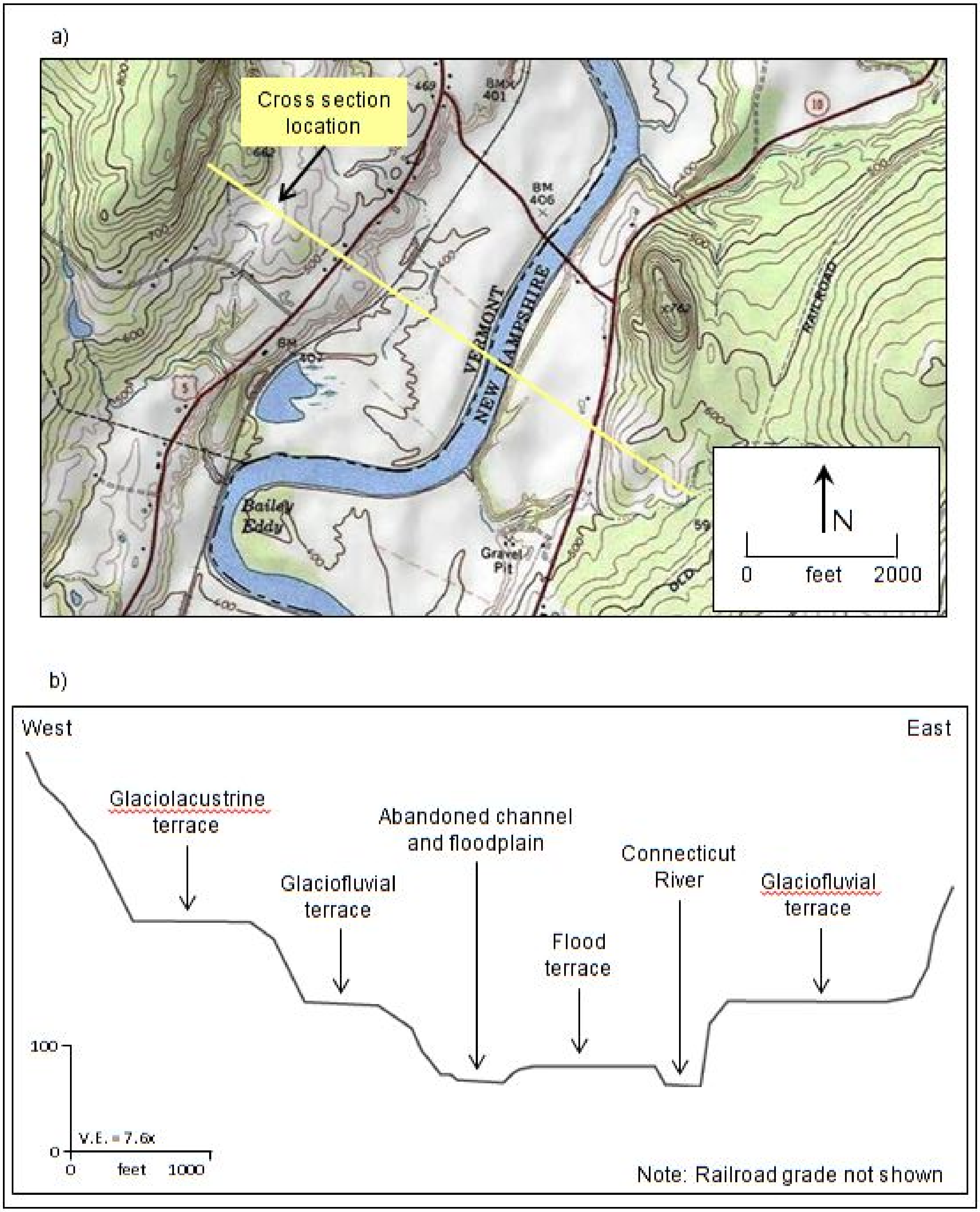
Sandy deltas built out into Glacial Lake Hitchcock at the mouths of tributaries with the tops of these deltaic sediments serving as indicators of the surface elevation of the lake (Brigham-Grett and Rittenour, 2001). While Glacial Lake Hitchcock sediments might be expected along the river given that the lake extended across the valley (Tufts University, 2016), non-glacial lakes at lower elevations persisted after the draining of Glacial Lake Hitchcock (Ridge and Larsen, 1990), so the presence of varved clays or sandy deltaic sediments in the Project areas cannot be immediately attributed to Glacial Lake Hitchcock. In addition, fluvial sediments, inset into the lake and delta terraces, were deposited as the river became fully established from northern New Hampshire to the Sound.

The resulting surficial geology of the Connecticut River Valley consists of a series of terraces stepping up from the river. The river channel's position relative to the various geomorphic surfaces determines the bank heights and bank composition along the length of the river with higher banks encountered where the river flows against older and higher terraces. These terrace and floodplain surfaces, among others, are seen throughout the Project areas. The greatest number, extent, and complexity of surfaces occur where the valley is wide. Much of the Connecticut River Valley in the Project areas is quite narrow such as between Putney and Brattleboro, Vermont, in the Vernon impoundment, but several wider sections exist where a complex assortment of geomorphic surfaces are present (Figure 3.3-3). The widest portion of the valley in the Project areas is in the upper Wilder impoundment upstream of Orford, New Hampshire, with other wide, but much shorter, portions of the valley present in the Bellows Falls impoundment upstream of the Williams River and in the Vernon impoundment between the Cold River confluence and East Putney, Vermont. Surficial geological deposits along the Project areas consist of glaciofluvial, glaciolacustrine, postglacial fluvial sands and gravels, and recent alluvium along the banks of the Connecticut River and glacial till and moraines in the adjacent upland areas.



Source: Brown (2009)

Figure 3.3-2. Extent of Glacial Lake Hitchcock.



Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Study

Figure 3.3-3. Example terrace and floodplain cross section in the Connecticut River Valley.

3.3.1.2 Seismicity

Seismographs and recording stations are located throughout the Northeast with two stations in the Connecticut River Valley within about 50 miles of the Projects (Figure 3.3-4). The Wilder, Bellows Falls, and Vernon Projects are in an area of relatively low seismicity in the Connecticut River Valley. Seismic activity in the Project areas, typical of the Northeast region of North America, is characterized by a low rate of earthquake occurrence. Specific causes of earthquake activity in the Connecticut River Valley are not known.

Historical records of earthquakes in the Northeast date back to the 1500s. Early records indicate several significant earthquakes in New England with some occurring prior to the establishment of seismographs and recording stations. The earliest damaging seismic event is documented to have occurred in 1638 in central New Hampshire, although the damage levels and location of the earthquake are uncertain (Weston Observatory, 2016). In 1755, an earthquake with an estimated magnitude of 6.2 occurred off the coast of Massachusetts. Beginning in the early 1900s, a number of seismographs was operating, although routine reporting of instrumental data on earthquakes in this region did not begin until the late 1930s. The strongest damaging earthquake with an epicenter in the state of New Hampshire occurred at Tamworth on December 20 and 24, 1940, with a measured magnitude of about 5.5 on both dates. The number of seismic stations in the Northeast increased significantly between 1970 and 1974; by 1974, area seismologists were operating a regional seismic network (Figure 3.3-4).

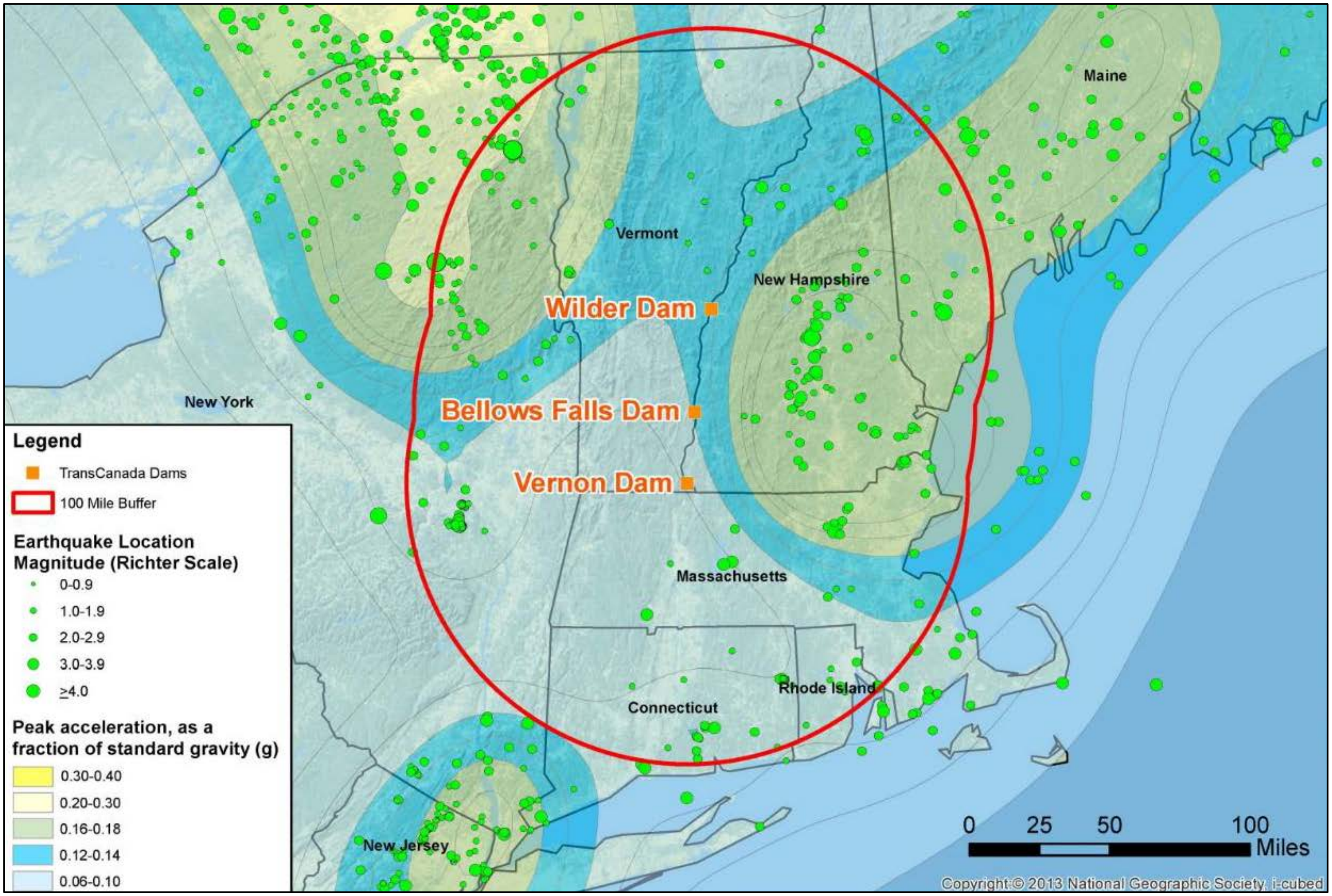
The amount of direct physical damage from an earthquake depends on several factors including the earthquake intensity, stability of underlying geologic materials, and construction features of structures exposed to seismic vibration, which vary from site to site. To show probabilistic expectations for damaging shaking from earthquakes, the U.S. Geological Survey (USGS) has developed Seismic Hazard Maps, which indicate the earthquake motions that have a certain probability of occurring across the entire United States. The hazard map for the New England vicinity (Figure 3.3-5) indicates a peak horizontal ground acceleration[17] at the Projects of 0.10 to 0.14 g (gravitational force) for a 2 percent probability of exceedance in 50 years (USGS, 2014). Most earthquakes in the vicinity of the Projects are of small magnitude (Figure 3.3-6). Earthquakes with a magnitude lower than 2.5 on the Richter scale[18] are typically not felt by humans.

[17] Peak ground acceleration (PGA) is the maximum ground acceleration that occurs during earthquake shaking at a location. The horizontal PGA component is generally larger than the vertical component and is the most commonly used type of ground acceleration in engineering applications. A horizontal PGA of 0.10 to 0.14 g is equal to 3.2 to 4.5 feet/second. The perceived shaking at this PGA level is strong, but the potential damage is light (USGS, 2016c).

[18] The magnitude of earthquakes is described using the Richter scale, which is determined from the logarithm of the amplitude of waves recorded by seismographs.

Source: Weston Observatory (2016)

Figure 3.3-4. Seismic stations in the Northeast.

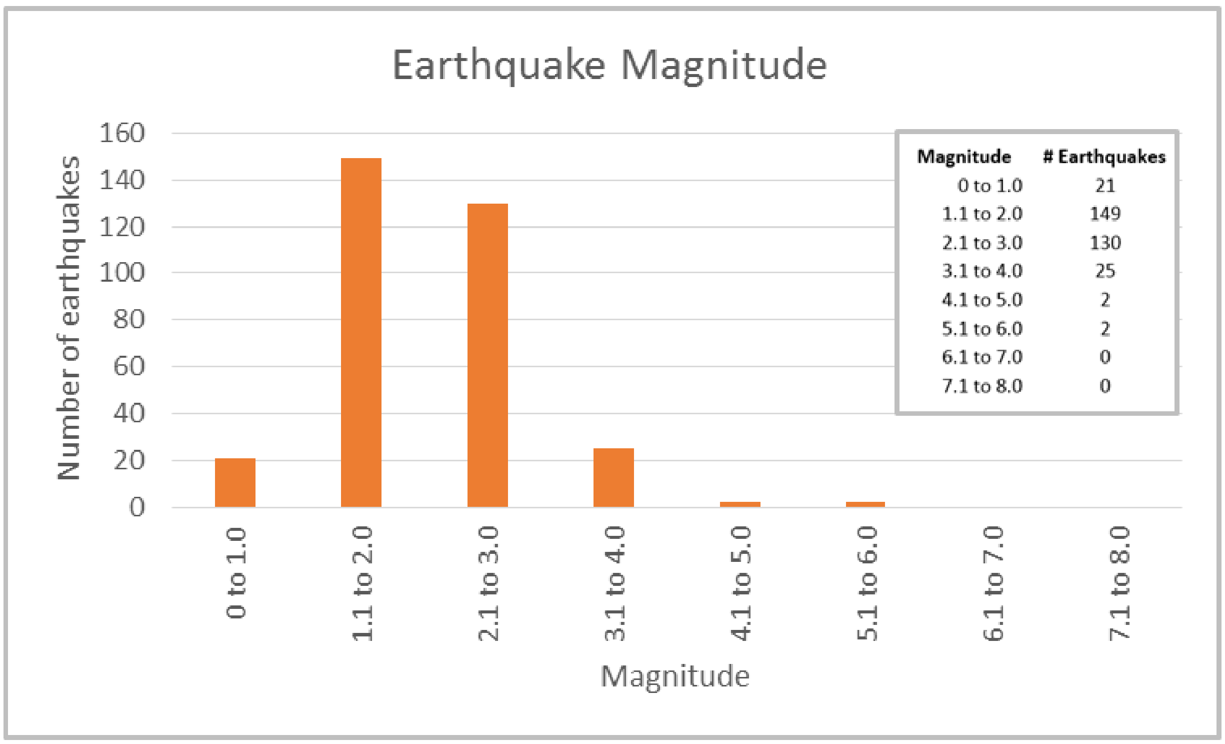


Source: USGS (2014)

Figure 3.3-5. Earthquake locations, 100-mile buffer, and peak acceleration.

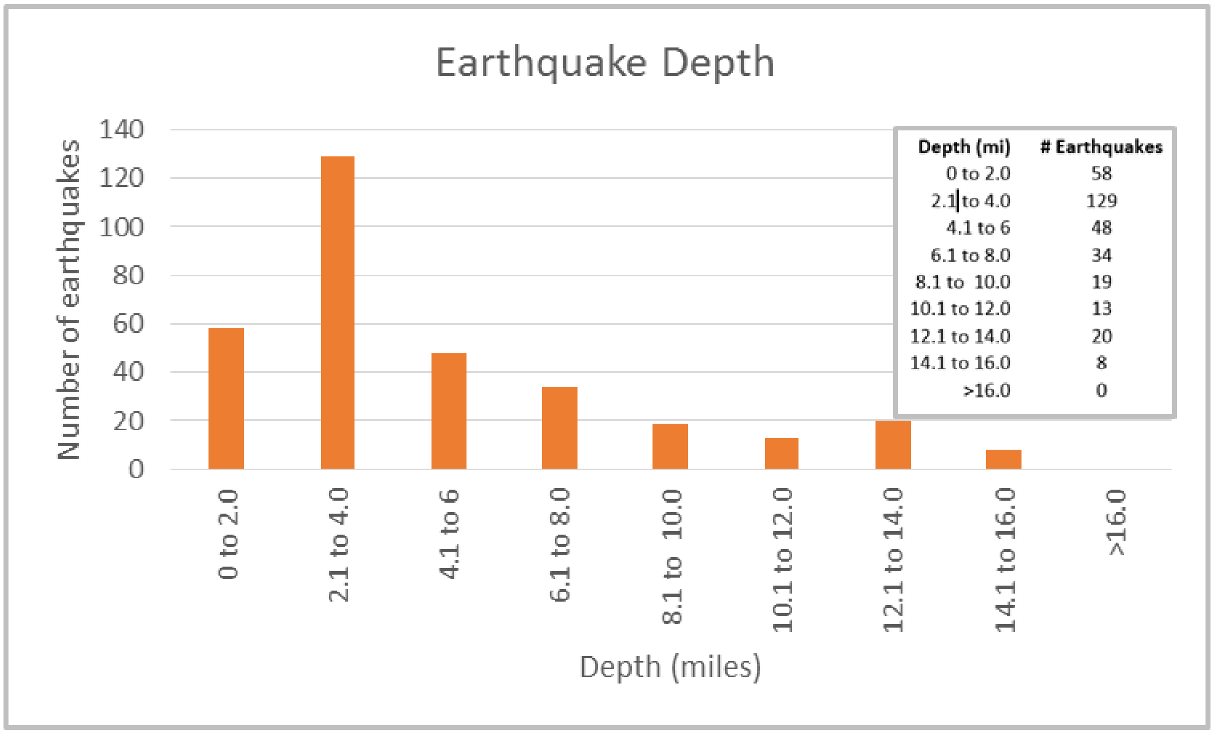
The USGS Earthquake Catalog (USGS, 2016d), a compilation of monitoring station data, indicates that 329 earthquakes are known to have occurred within 100 miles of the Projects since the establishment of a seismic monitoring network in the region in 1974. The largest seismic event since 1974 (magnitude 5.3) occurred on April 20, 2002, in the Adirondack State Park about 91 miles northwest of Wilder dam and 14.6 miles west of Chesterfield, New York. Only 4 of the 329 recorded earthquakes (1 percent) since 1974 had a magnitude higher than 4.0 (Figure 3.3-6), while 300 of 329 recorded earthquakes (91 percent) had a magnitude of 3.0 or lower.

Monitoring stations in the Northeast indicate that seismicity occurs at relatively shallow depths in the upper crust. For earthquakes evaluated within 100 miles of the Projects since 1974, recorded depths ranged from ground surface to a maximum depth of 14.7 miles with an average depth of 4.8 miles. About 80 percent of the earthquakes were recorded occurring at depths of 8.0 miles, or shallower (Figure 3.3-7).



Source: USGS (2016d)

Figure 3.3-6. Frequency of earthquake magnitude within 100 miles of the Wilder, Bellows Falls, and Vernon Projects.



Source: USGS (2016d)

Figure 3.3-7. Frequency of earthquake depth within 100 miles of the Wilder, Bellows Falls, and Vernon Projects.

The spatial and vertical distributions of recorded earthquakes within 100 miles of the Projects suggest a lack of a predominant factor responsible for the seismicity. Earthquakes may be caused by human activity (hydraulic fracturing and nuclear detonations) and by natural sources of crustal deformation such as faulting, magma migration, or by geologic intrusions where deformable material is forced into brittle overlying rocks. With volcanic activity not occurring in the eastern United States, and regular hydraulic fracturing activities being only a recent development and furthermore not occurring in the region, crustal rupture is the principal source of crustal deformation in the northeastern United States.

Several faults are mapped in the Connecticut River Valley in New Hampshire and Vermont (Figure 3.3-1); however, no earthquake focus can be directly related to faults (NHDES, 1994) and no active faults are mapped in New Hampshire or Vermont (USGS, 2014). The bedrock underlying the Project areas ranges from about 1.4 billion to 100 million years of age and is characterized by north-northeast trending belts of metamorphosed sedimentary and igneous rocks (Brown, 2009). Observations of faults in the region near the Projects indicate the faults are healed and have not been active in 90 million years or longer (NHDES, 1994).

3.3.1.3 Soils

Table 3.3-1 summarizes the soil types[19] found in each of the Project areas and the sections below provide more detail for each Project (ILP Study 33, *Cultural and Historic Resources Study, Phase 1A Reports*).

Wilder Project

Numerous soil types are present in the Wilder Project area. Soil types situated on terrace formations along the Connecticut River include loamy sands and sandy loams associated with the Quonset, Windsor, Agawam, Merrimac, and Ninigret series. These soils formed from deposits laid down as glacial outwash. Silt loams associated with the Hitchcock, Belgrade, and Hartland soil series are also present, and formed in glaciolacustrine deposits most likely associated with Glacial Lake Hitchcock. Other terrace soil types consist of units classified as Urban land-Windsor-Agawam complex and pits, sand and pits. The Urban land-Windsor-Agawam complex represents areas where anthropogenically disturbed soils are intermixed with small areas of undisturbed sandy loam Windsor and Agawam series soils. Pits, sand and pits, and gravel represent areas of gravel and sand quarrying or borrow pits.

Soil types along floodplains include moderately erodible sandy loams associated with the Podunk, Rumney, Hadley, and Ondawa soil series, and highly erodible silt loams associated with the Winooski and Limerick soil series. Adjacent upland areas contain sandy loams associated with the Tunbridge, Woodstock, and Colrain soil series, Buckland loam series, and silt loams associated with the Bernardson, Cardigan, and Pittstown soil series. Other soil types present in upland area include the Glover-Vershire complex. These soils can often consist of a rocky to very rocky shallow mantle overlying bedrock and are frequently interspersed with bedrock outcrops. Udorthent and Udipsamment soil types are also present along the Project area and consist of human-transported fill deposits.

Bellows Falls Project

Soil types situated on terrace formations along the Connecticut River include loamy sands and sandy loams associated with the Quonset, Windsor, Agawam, Ninigret series and Warwick series gravelly loam. These soils formed from deposits laid down as glacial outwash. Silt loams associated with the Hitchcock, Belgrade, and Unadilla Variant soil series are also present and formed in glaciolacustrine deposits likely associated with Glacial Lake Hitchcock. Other terrace soil types consist of units classified as Urban land-Windsor-Agawam complex and pits, sand and pits, gravel. The Urban land-Windsor-Agawam complex represents areas where anthropogenically disturbed soils are intermixed with small areas of undisturbed

[19] Detailed soil maps for the Project areas can be generated at http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

sandy loam Windsor and Agawam series soils. Pits, sand and pits, gravel soil types represent areas of gravel and sand quarrying or borrow pits.

Soil types along floodplains include moderately erodible sandy loams associated with the Podunk, Rumney, Hadley, and Ondawa soil series and highly erodible silt loams associated with the Winooski and Limerick soil series. Adjacent upland areas contain sandy loams associated with the Tunbridge, Marlow, Lyman, and Monadnock soil series and silt loams associated with the Dummerston, Macomber, Bernardson, Cardigan, Kearsarge, and Dutchess soil series. Taconic channery loam soils are also present in upland areas. These upland soils can be rocky to very rocky. Other soil types present in upland areas include the Glover-Vershire complex, Lyman-Rock outcrop complex, Macomber-Taconic complex and Vershire-Dummerston complex. These soils can often consist of a shallow mantle overlying bedrock and are frequently interspersed with bedrock outcrops. Udorthent and Udipsamment soil types are also present and consist of human-transported fill deposits.

Vernon Project

The portion of the Vernon Project located in the southeastern part of Windham County, Vermont, is covered by Dummerston-Macomber-Taconic association soils, derived primarily from bedrock-controlled loamy glacial till. These soils are very deep to shallow, gently sloping to very steep, somewhat excessively drained and well-drained soils that formed in loamy glacial till on hills and mountains and have moderate erodibility. The only exception to this soil association is in the vicinity of Vernon dam and the islands just below the dam, which contain Tunbridge-Marlow-Lyman soils. These soils are also very deep to shallow, gently sloping to very steep, somewhat excessively drained to well-drained soils that have formed in loamy glacial till on hills and mountains. Tunbridge soils have low erodibility and Marlow and Lyman soils have moderate erodibility.

The majority of the Project area in Cheshire County, New Hampshire, is made up of Windsor-Agawam-Hoosic soils, which are very deep, on nearly level to very steep land that is excessively drained, well-drained, and somewhat excessively drained. Windsor and Hoosic soils have low erodibility and Agawam soils have moderate erodibility. The soils are loamy and formed in glacial outwash deposits. The only exception to this is in the vicinity of Wantastiquet Mountain State Park in Hinsdale and Chesterfield, New Hampshire, which contains Bernardston-Cardigan-Kearsarge-Dutchess soils. These soils are also very deep, moderately deep, and shallow on gently sloping to very steep land that is well drained to excessively drained and consists of loamy soils that formed in glacial till and have moderate erodibility.

Table 3.3-1. Summary of soil types present in the Wilder, Bellows Falls, and Vernon Project areas.

Associated Land Form/Context	Soil Type	Parent Material	Wilder	Bellows Falls	Vernon
Terraces	Quonset fine sandy loam	Formed in glaciofluvial deposits	X	X	
	Windsor loamy sand or loamy fine sand		X	X	X
	Warwick gravelly loam			X	
	Agawam fine sandy loam		X	X	X
	Hoosic sandy loam				X
	Merrimac sandy loam		X		
	Ninigret fine sandy loam		X	X	
	Hinckley sandy loam				
	Urban land-Windsor-Agawam complex		X	X	
	Pits, sand, and pits, gravel		X	X	
	Hitchcock silt loam	Formed in glaciolacustrine deposits	X	X	
	Belgrade silt loam		X	X	
	Hartland silt loam		X		
	Unadilla Variant silt loam			X	
Floodplains	Podunk fine sandy loam	Formed in alluvium	X	X	
	Rumney fine sandy loam		X	X	
	Hadley very fine sandy loam		X	X	
	Winooski silt loam (highly erodible)		X	X	
	Limerick silt loam (highly erodible)		X	X	
	Ondawa fine sandy loam		X	X	
Uplands (hill, ridges, mountains)	Tunbridge fine sandy loam	Formed in glacial till	X	X	X
	Marlow fine sandy loam			X	X
	Lyman fine sandy loam			X	X
	Buckland sandy loam		X		
	Colrain sandy loam		X		

Associated Land Form/Context	Soil Type	Parent Material	Wilder	Bellows Falls	Vernon
Uplands (hill, ridges, mountains) (cont.)	Dummerston silt loam	Formed in glacial till		X	X
	Macomber silt loam			X	X
	Woodstock sandy loam		X		
	Taconic channery loam			X	X
	Bernardston silt loam		X	X	X
	Cardigan silt loam		X	X	X
	Pittstown silt loam		X		
	Kearsarge silt loam			X	X
	Dutchess silt loam			X	X
	Monadnock fine sandy loam			X	
	Glover-Vershire complex (very rocky fine sandy loams)		X	X	
	Lyman-Rock outcrop complex (very stony fine sandy loam and bedrock outcrops)			X	
	Macomber-Taconic complex (very rocky channery silt loams)			X	
	Vershire-Dummerston complex (rocky fine sandy loams)			X	
Various (infilled contexts)	Udorthents and Udipsamments	Human transported soils	X	X	

Source: ILP Study 33, *Cultural and Historic Resources Study, Phase 1A Reports*

3.3.1.4 Riverbank Composition and Conditions

The position of the Connecticut River channel relative to the soils described in Section 3.3.1.3 largely determines riverbank composition throughout the Project areas. TransCanada conducted three relicensing studies related to soils and erosion:

- ILP Study 1, Historical Riverbank Position and Erosion Study;
- ILP Study 2, Riverbank Transect Study; and
- ILP Study 3, Riverbank Erosion Study.

Reports for Studies 2 and 3 were combined into a single document, ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies.*

The preponderance of sandy soils (including loam with admixtures of silt and clay), whether of glacial or alluvial origin, is reflected in the riverbank composition throughout the Project areas with 76 percent of the banks mapped as sand in Studies 2-3 (Table 3.3-2). However, the complex glacial and post-glacial history of the valley with advancing and retreating glaciers, lakes impounded behind natural dams, and the formation of multiple floodplain levels as the modern river reached its current position has given rise to a heterogeneous stratigraphy in the sediments that fill the valley such that the composition at the base of the riverbank is often different than the upper bank in the same location, especially where the banks are high. In such instances, the mapped soils, generally reflecting conditions within a few feet of the surface, are not an accurate indication of the bank composition at the bank toe where riverine action is most effective. A typical heterogeneity observed in the banks is sandy glacial outwash or alluvial soils overlaying varved glaciolacustrine clay at the base of the bank. Groundwater seeps are often observed emanating along such contacts where well-draining sands and loams are found above less permeable clay and silt. A more detailed breakdown of bank composition within each Project area is provided below.

Bank heights largely depend on the geomorphic surface along which the river is flowing; bank heights are low where the river flows across the modern floodplain and are higher where the river encounters older glacial surfaces, generally closer to the valley's edge. In the impoundments, bank heights are generally lower closer to the dams because of the backwatering upstream of the dams. Bank heights immediately upstream of Vernon dam, for example, are less than 1 foot in places because of the inundation of the modern floodplain. In contrast, bank heights of greater than 50 feet are present where the river flows against glacial till along the valley's edge. The highest bank in the Project areas is greater than 90 feet in Charlestown, New Hampshire, and is composed of glacial outwash sands. A more detailed breakdown of bank heights within each Project area is provided below and summarized in Table 3.3-2.

Table 3.3-2. Percentage of bank characteristics by Project area.

	Project Areas Combined	Wilder Imp.	Wilder Riverine	Bellows Falls Imp.	Bellows Falls Riverine	Vernon Imp.	Vernon Riverine
Bank Height (ft)							
< 1	3.0	5.4	0.4	1.2	0.5	3.2	0.6
1-4.9	9.0	9.6	0.5	16.3	1.0	9.8	0.0
5-7.9	7.1	13.6	1.2	3.3	4.2	5.4	0.3
8-9.9	7.5	9.0	3.8	8.4	1.0	8.4	1.3
10-14.9	19.9	24.0	15.2	20.1	23.6	15.3	30.0
15-19.9	17.2	15.5	30.6	8.8	16.9	17.6	25.2
20-29.9	15.6	15.8	12.3	15.9	16.5	17.2	16.9
30-50	12.6	6.0	17.6	16.7	36.3	11.3	9.9
> 50	8.1	1.2	18.4	9.4	0.0	11.7	15.7
Bank Texture							
Bedrock	4.4	2.1	8.3	3.6	0.9	5.6	17.1
Boulder / fractured	1.3	0.4	0.2	0.9	17.9	0.1	5.5
Cobble	6.3	0.4	24.5	1.6	29.3	2.9	0.0
Glacial clay	2.1	1.2	2.0	3.8	0.0	1.5	19.9
Gravel	10.2	2.0	38.6	12.6	5.6	2.8	0.0
Sand	75.7	93.9	26.4	77.5	46.4	87.1	57.5

	Project Areas Combined	Wilder Imp.	Wilder Riverine	Bellows Falls Imp.	Bellows Falls Riverine	Vernon Imp.	Vernon Riverine
Bank Stability							
Eroding	11.3	13.7	9.5	13.9	4.6	7.9	14.4
Vegetated eroding	22.1	20.9	21.6	20.0	22.5	25.2	33.7
Failing armor	6.4	6.7	8.8	5.9	4.9	5.2	6.1
Unstable banks	***39.8***	***41.3***	***39.9***	***39.8***	***32.0***	***38.2***	***54.2***
Armored	14.4	15.2	7.6	14.8	31.0	14.6	5.1
Stable	41.9	39.4	49.9	39.0	37.0	44.5	35.7
Healed erosion	3.8	4.1	2.6	6.5	0.0	2.7	5.0
Stable banks	***60.2***	***58.7***	***60.1***	***60.2***	***68.0***	***61.8***	***45.8***
Riparian Vegetation							
Present	77.3	69.0	85.1	74.2	80.1	88.1	63.2
Absent	22.7	31.0	14.9	25.8	19.9	11.9	36.8

Source: ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies*

Bank erosion occurs when the sum of the forces driving erosion exceeds the resisting strength of the bank (Parker et al., 2008; Easterbrook, 1993). For these reasons, bank composition and bank height are important controls on the distribution of erosion because the bank's composition is an important determinant of its strength to resist erosion, while gravitational forces, an important driver of erosion, increase with increasing bank height. The bank's resistance to erosion depends on bank material properties (such as grain size and cohesion), vegetation (type and amount), and other bank characteristics such as form roughness (i.e., topographic surface irregularities). The driving forces acting on a bank, regardless of bank height, can also be increased by the removal of the underlying support (e.g., overhanging banks), an increase in the surcharge (i.e., weight) on the bank slope accompanying precipitation, or the addition of failed material from upslope, or an increase of lateral stresses that can accompany the formation of ice in cracks or water added to pore spaces.

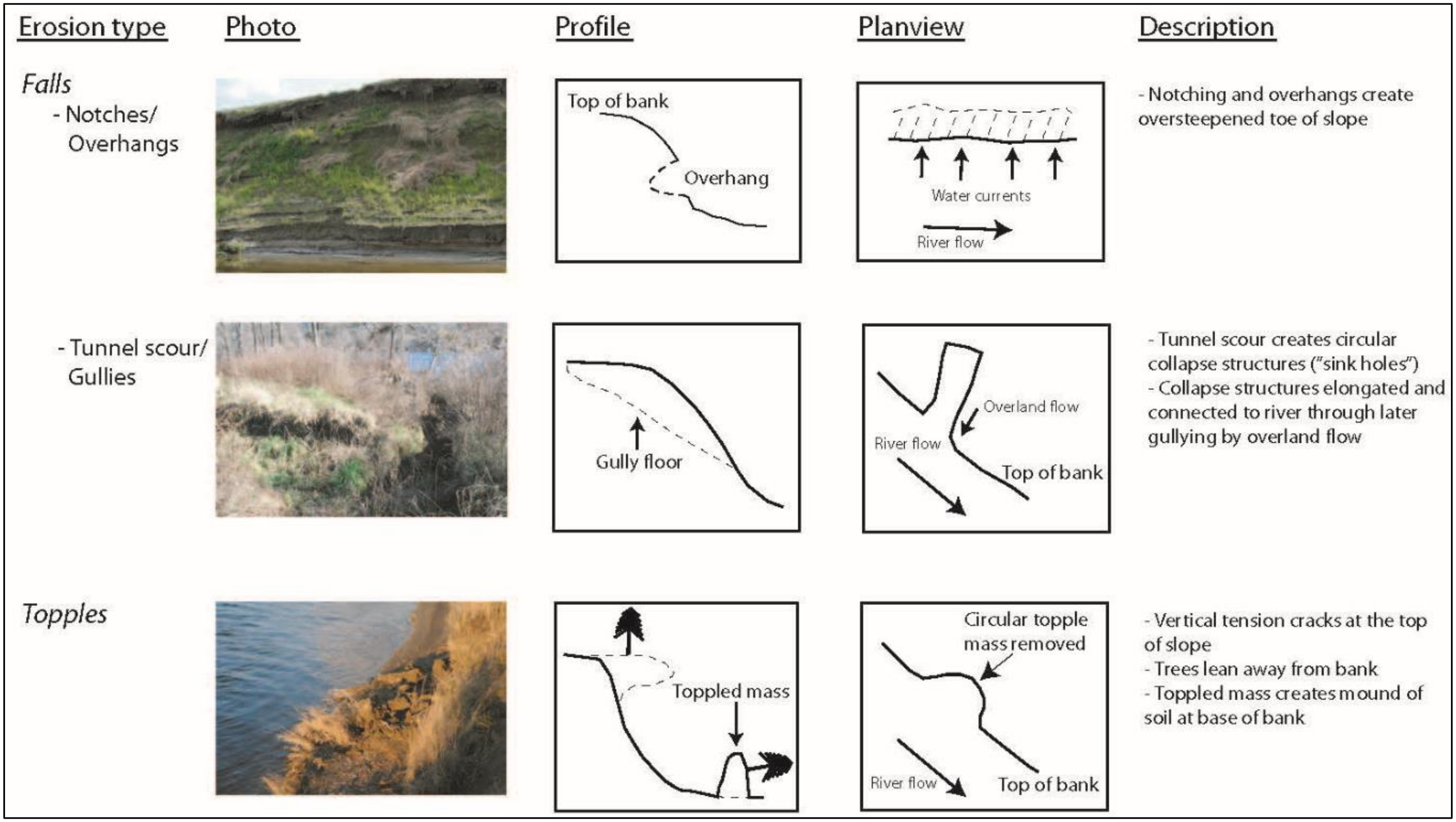
Riparian vegetation can increase a bank's resistance to erosion because roots help to bind soil particles together (Micheli and Kirchner, 2002). While 82 percent of the banks within the Project areas have riparian vegetation, the height of the riverbanks in many locations may limit the stabilizing influence of the roots. On high riverbanks, the roots of the vegetation may penetrate into the soil only a small fraction of the bank's total height while the greatest erosive forces are acting at the base where the river is flowing against the bank. In these instances, the stabilizing influence of the vegetation may result after the tree has been undermined by erosion, fallen to the base of the bank, and in that position protect the bank from further erosion until completely dislodged from the bank and washed downstream. The stabilizing influence of even dead trees at the base of the bank may persist for several years (Figure 3.3-8).

Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

Figure 3.3-8. Example of riparian vegetation on bank.

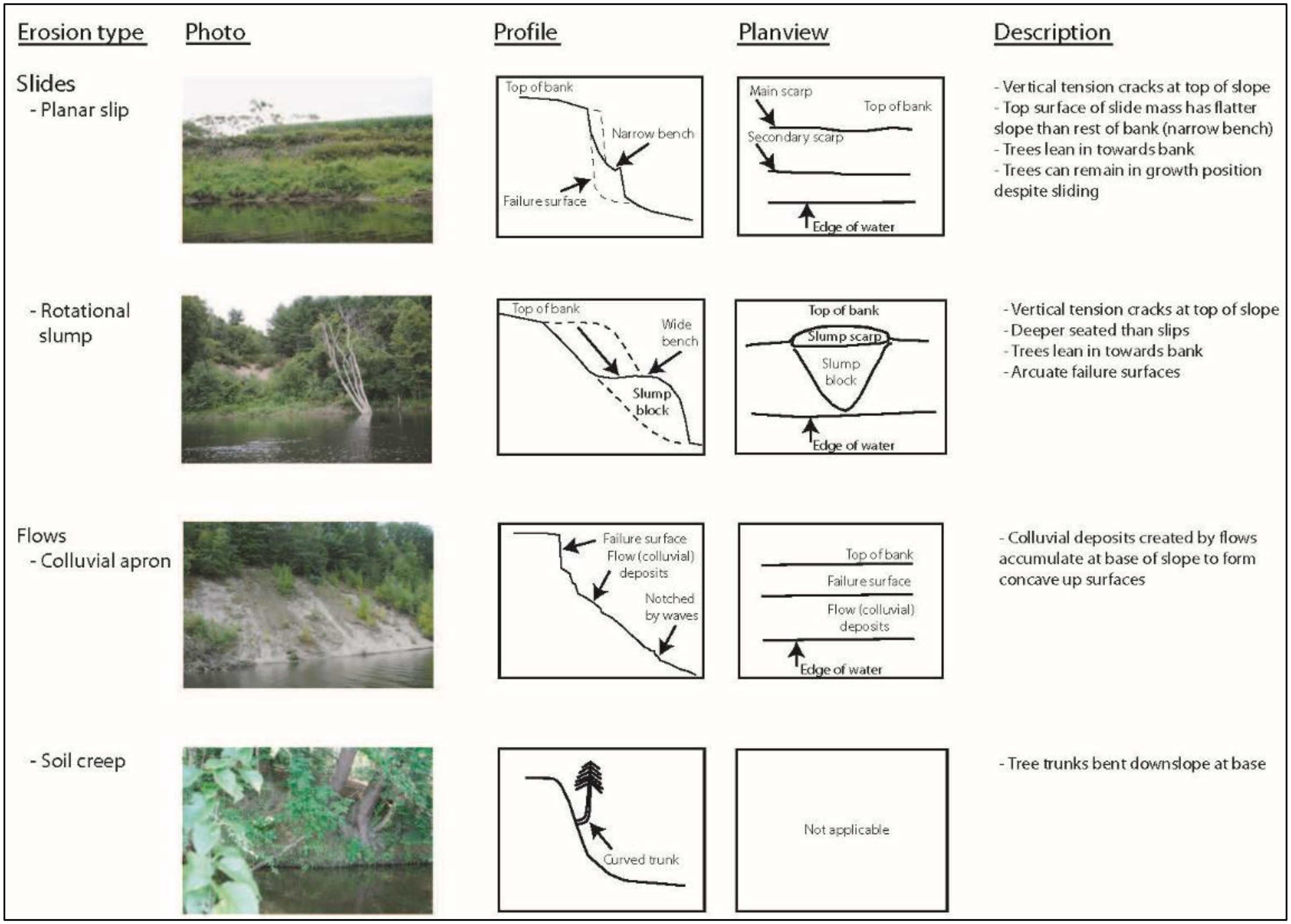
When the driving forces exceed the resisting forces of the banks in the three Project areas, the resulting erosion occurs by four primary processes: falls, topples, slides, and flows (Figure 3.3-9). All four erosion processes often occur at the same place over a period of time in a "cycle of erosion" that leads to the removal of material from the bank and a continuation of the erosion process (Figure 3.3-10).

While falls might typically be considered to involve masses of sediment free falling through the air to the base of the bank, the removal of individual particles by water currents are also categorized as falls because these particles are first dislodged then rolled or carried in suspension away from the bank. Water currents strong enough to erode and transport sediment in the three Project areas are potentially generated by at least five different mechanisms: waves, water level fluctuations, overland flow, groundwater seeps, and tractive forces generated by river flow (particularly during higher flows). Currents, by whichever mechanism, acting at the base of the bank over prolonged (although not necessarily continuous) periods can create the notches and overhangs seen along 37 percent of the river's banks over the three Project areas (Studies 2-3).



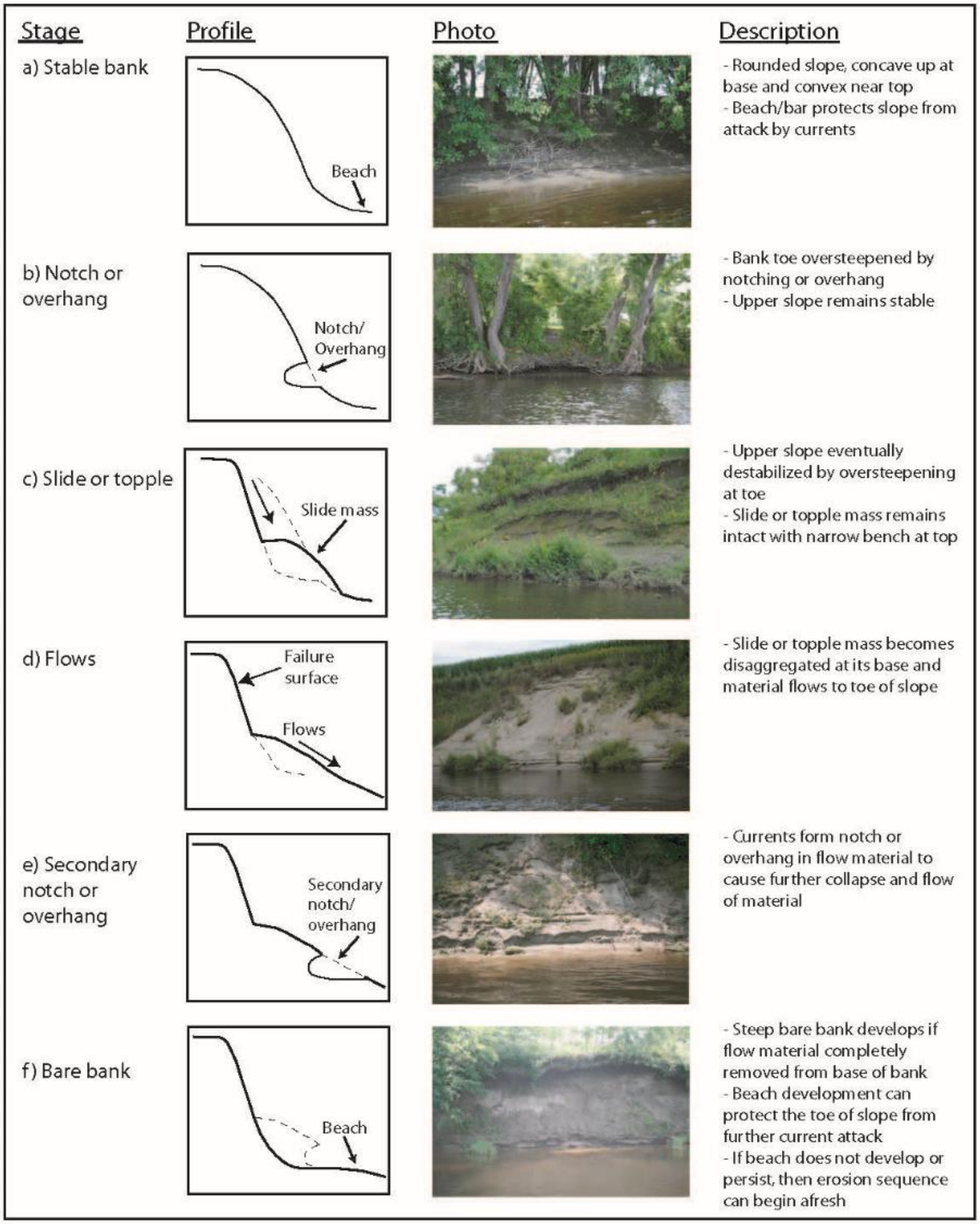
Source: Adapted from Field, 2007, in ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies*

Figure 3.3-9. Types of erosion occurring in the Project areas and their characteristics.



Source: Adapted from Field, 2007, in ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies*

Figure 3.3-9. Types of erosion occurring in the Project areas and their characteristics.



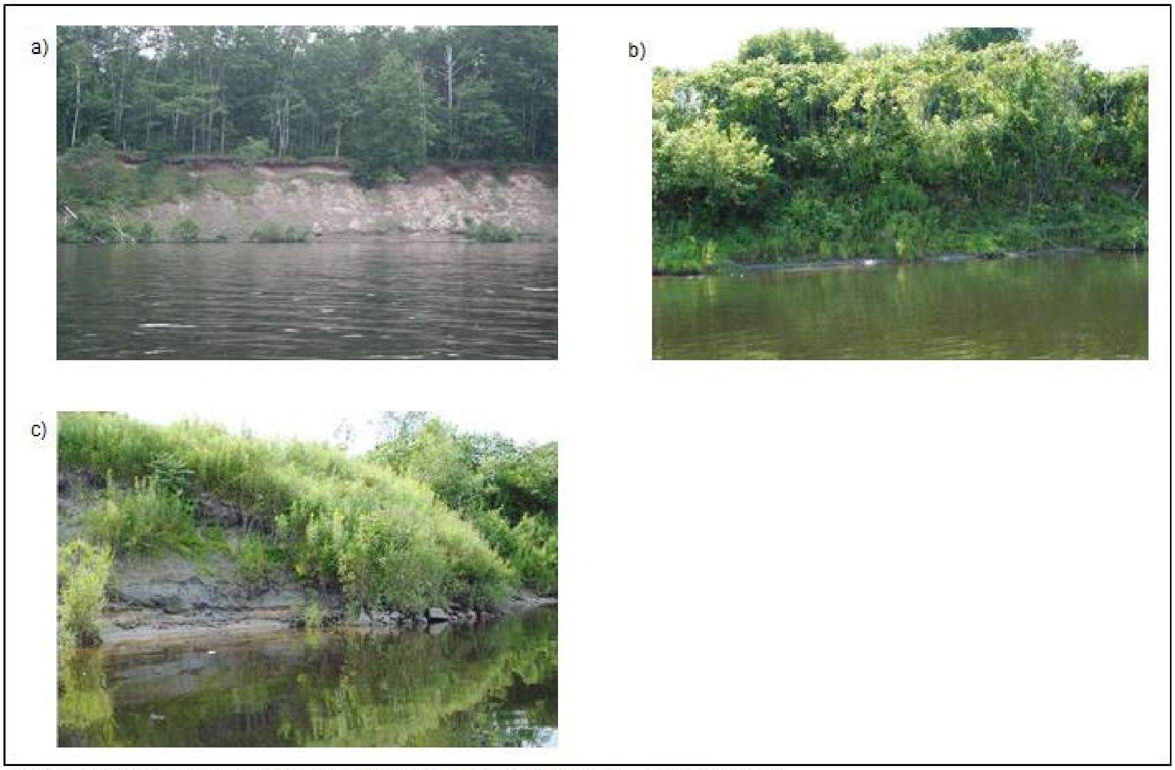
Source: Adapted from Field, 2007, in ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies*
Note: Different stages of erosion can be occurring adjacent to each other along a long, continuously eroding bank.

Figure 3.3-10. Model idealizing steps in the cycle of erosion.

Slides are large blocks of the bank that slide along failure surfaces that are either relatively shallow and parallel to the bank line (i.e., planar slips) or deeper seated, arcuate-shaped in planform, and have a concave-up profile (i.e., rotational slumps). Planar slips are the most dominant form of erosion observed other than overhangs created by falls. Topples develop when vertical tension cracks parallel to the top edge of the bank widen to a point where the top portion of cohesive blocks of soil rotate forward about a pivot point near the base of the soil mass. Topples also occur when soil attached to an undermined root system of trees or other vegetation leans over and collapses over the bank. Topples form from either pristine bank material or as larger planar slips and rotational slumps break apart into smaller blocks of soil. Flows form at the base of planar slips, rotational slumps, and topple blocks as the material becomes disaggregated into individual particles at the time of the initial sliding or toppling or at some later point. Dry grain flows or liquefied flows can occur at the same time as the initial sliding/toppling or for some time after an event if the material remains loose, especially on the over-steepened base of the slide masses. Flows are an important mechanism for delivering eroded soil to the base of the bank. If the material accumulating at the base of the bank remains for an extended period, the upper portion of the bank can restabilize; however, if flood flows ultimately carry the accumulated material away from the bank, new overhangs can develop at the base of the bank and the cycle of erosion restarted afresh to continue the erosion.

The current amount and distribution of erosion in the three Project areas were established by mapping bank stability as part of Studies 2-3. The 250 miles of bank length that were mapped were subdivided into six stability categories: stable, armored, eroding, vegetated eroding, failing armor, and healed erosion. Banks mapped as eroding, vegetated eroding, and failing armor are all unstable banks equally prone to erosion. The reason for discriminating between the three is because of differences in the visual appearance of the banks. Eroding banks are largely devoid of vegetation and have well-exposed bare scarps created where the bank material has slid or toppled downslope (Figure 3.3-11, Photo a). Vegetated eroding banks also have bare scarps—an indicator that erosion is occurring—but such scarps are obscured by vegetation and the evidence for erosion easily missed without careful observation (Figure 3.3-11, Photo b). Past armoring efforts to protect the riverbanks have failed in many locations with erosion once again occurring. The failing armor category was established to reflect this past armoring history, although only barely visible remnants of the armoring remain in some cases (Figure 3.3-11, Photo c).

Banks mapped as vegetated eroding and failing armor were likely not mapped as eroding in earlier efforts that extend back to the 1950s because the typical bare bank face usually associated with erosion is not often present in these locations. Taken together, the three bank stability types representing unstable banks represent 40 percent of the bank length through the three Project areas. A more detailed breakdown of erosion within each Project area is provided below and summarized in Table 3.3-3.



Photos of the unstable bank categories: a) eroding, b) vegetated eroding, c) failing armor.

Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

Figure 3.3-11. Unstable bank examples of eroding, vegetated eroding, and failing armor categories.

Table 3.3-3. Percentage of bank erosion in 1958, 1978, and 2014.

River Reach	Time period	Bank length (miles)	Stable (miles)	%	Eroding (miles)	%
Entire Project Areas	1958	218.4	190.3	87.1	28.2	12.9
Wilder Impoundment	1958	93.3	88.5	94.8	4.8	5.2
Bellows Falls Impoundment	1958	52.6	37.9	71.9	14.8	28.1
Vernon Impoundment	1958	59.9	53.2	88.8	6.7	11.2
Entire Project Areas	1978	218.4	186.3	85.3	32.1	14.7
Wilder Impoundment	1978	93.3	76.1	81.6	17.2	18.4
Bellows Falls Impoundment	1978	52.6	48.8	92.8	3.8	7.2
Vernon Impoundment	1978	60.0	50.2	83.8	9.7	16.2

River Reach	Time period	Bank length (miles)	Stable (miles)	%	Eroding (miles)	%
Entire Project Areas	2014	251.8	223.3	88.7	28.5	11.3
Wilder Impoundment	2014	90.2	77.9	86.3	12.4	13.7
Bellows Falls Impoundment	2014	49.5	42.6	86.1	6.9	13.9
Vernon Impoundment	2014	57.8	53.2	92.1	4.6	7.9

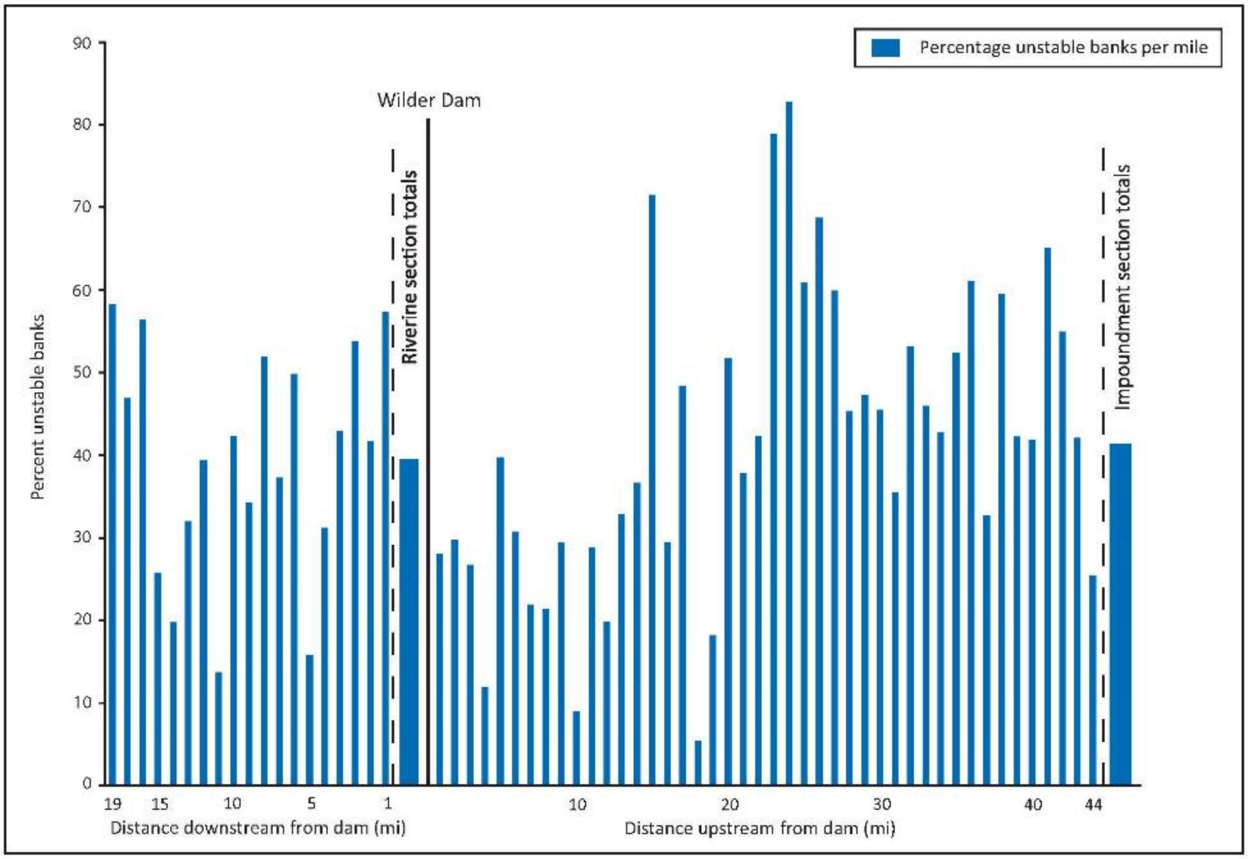
Source: ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies*

Wilder Project

The height, composition, and stability of the banks vary considerably throughout the Wilder impoundment. The upper impoundment flows across wide floodplain areas, so bank heights are generally limited to less than 15 feet north of Bradford, Vermont, and Piermont, New Hampshire. Bank heights exceed 50 feet in portions of the lower impoundment where the river more frequently encounters glacial surfaces. Very low banks of less than 5 feet make up 15 percent of the Wilder impoundment and are typically found at tributary confluences and where old abandoned oxbows intersect the river.

Banks of the upper Wilder impoundment are composed (almost exclusively) of sand (Table 3.3-1), but gravel is present at the base of the banks in some locations. While loam and sand banks are also prevalent in the lower impoundment, gravel and clay banks are more frequently observed. Bedrock is uncommon in the Wilder impoundment, although bedrock outcrops along 8 percent of the banks in the riverine section downstream of the dam with most of this concentrated in the Sumner Falls area. The large percentage of cobble banks in the Wilder riverine reach compared to the impoundment is consistent with bank heights greater than 15 feet for nearly 80 percent of the bank length.

Slightly greater than 40 percent of the banks in the Wilder impoundment are unstable (i.e., banks designated as eroding, vegetated eroding, or failing armor). Although significant variation exists, bank instability in Wilder impoundment is generally greater with increasing distance from Wilder dam (Figure 3.3-12). The lower levels of erosion closer to the dam may be the result of higher levels of armoring on the riverbanks in the lower impoundment. The highest levels of erosion in the Wilder riverine reach are found in the most downstream portions of the reach but are nearly as high at the upstream end just below the dam. Erosion rates are lowest in the middle portion of the riverine reach where the greatest amount of bedrock is present along the banks. Overall, the percentage of unstable banks in Wilder impoundment is similar to that documented in the Wilder riverine reach.

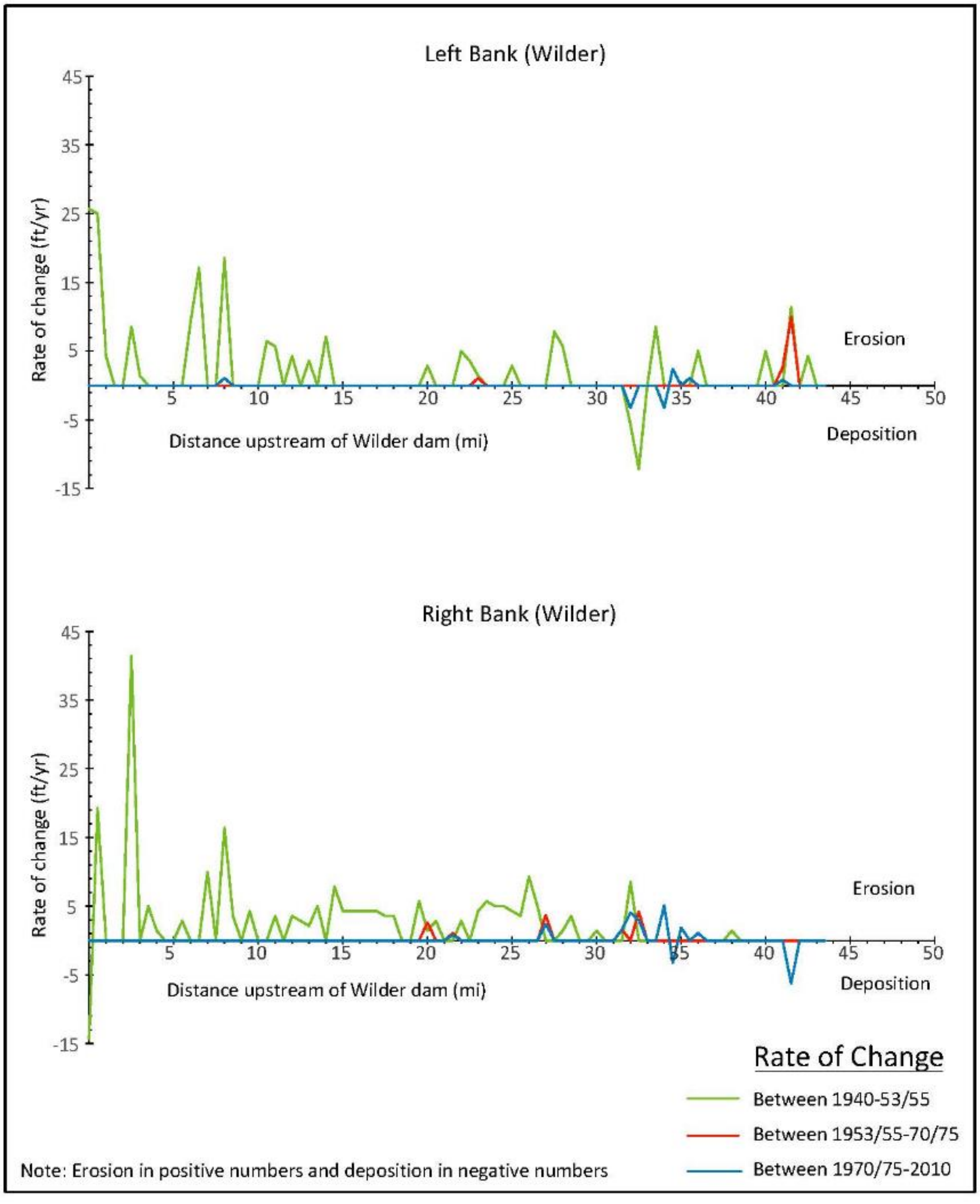


Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

Figure 3.3-12. Variation in amounts of erosion with distance from Wilder dam.

The amount of erosion in the Wilder impoundment appears to have increased through time as determined by comparing maps of erosion completed in 1958, 1978, and 2014 (Table 3.3-3). For the historical comparison, only those banks categorized as eroding in 2014 were used because vegetated eroding and failing armor banks were not likely considered eroding in the earlier mapping efforts. Between 1958 and 2014, the percentage of bank length that was eroding increased from 5 to 14 percent. Given that a greater percentage of the lower impoundment is armored, the increase in erosion primarily occurred in the upper impoundment where Project operations (i.e., impoundment elevation fluctuations) have little influence on flow conditions. An analysis of georeferenced historical aerial photographs indicates that the rate of erosion has increased slightly at some locations in upper Wilder impoundment with very little change occurring in the lower impoundment after an initial inundation of the banks after the opening of Wilder dam in 1950. In addition to temporal variations in the rate of erosion, the rate of erosion in Wilder impoundment varies spatially as well (Figure 3.3-13). Available data sources compiled in Studies 2-3 enabled the establishment of erosion rates at only a few isolated locations but demonstrate that erosion rates in Wilder impoundment vary from approximately 10 ft per year to less than 1.0 ft per year.

Two years of erosion monitoring at six sites in the impoundment as part of Studies 2-3 recorded recession at the top of the bank at one site and no erosion at the other five locations in the Wilder impoundment.



Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

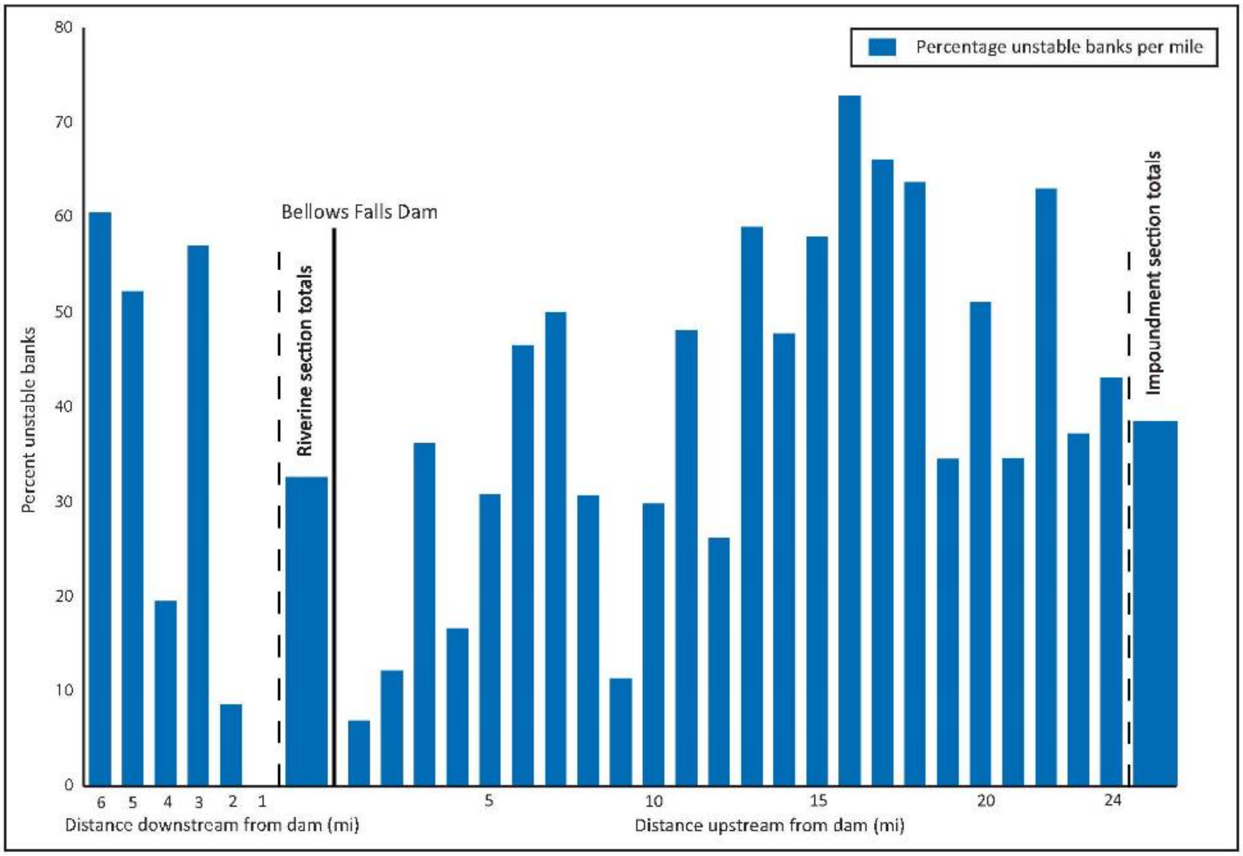
Figure 3.3-13. Rates of erosion in Wilder impoundment with distance upstream of the dam (left and right banks looking downstream).

Bellows Falls Project

The height, composition, and stability of the banks also vary considerably throughout the Bellows Falls impoundment. Higher banks resulting from the river flowing against old river terraces or glacial surfaces are present throughout most of the impoundment but are generally found only along one bank at any given location with a lower floodplain on the opposite bank. In general, banks are less than 15 feet high when the river flows against active floodplains or tributary deltas and greater than 15 feet where the river encounters glacial surfaces or terraces. The nearly 20 percent of the banks less than 5 feet high are concentrated in the lower impoundment, where a number of low floodplain meadows have formed upstream of the Williams River delta that constricts the valley and causes backwatering upstream during floods. The low banks also result from the opening of Bellows Falls dam in 1928 that raised water levels and inundated the lower portions of once higher banks.

Bank composition in the Bellows Falls impoundment is nearly 80 percent sand (Table 3.3-1). Gravel and cobble are present along less than 15 percent of the bank, largely along portions of the nearly 10 percent of banks that are more than 50 feet high. Bedrock occurs along only 4 percent of banks in the impoundment. While less than 1 percent of the banks have exposed bedrock in the Bellows Falls riverine reach downstream of the dam, nearly 20 percent of the banks are composed of boulders, suggesting bedrock may be present just below the surface. The large percentage of cobble banks in the riverine reach compared to the impoundment is consistent with bank heights greater than 15 feet for 70 percent of the bank length.

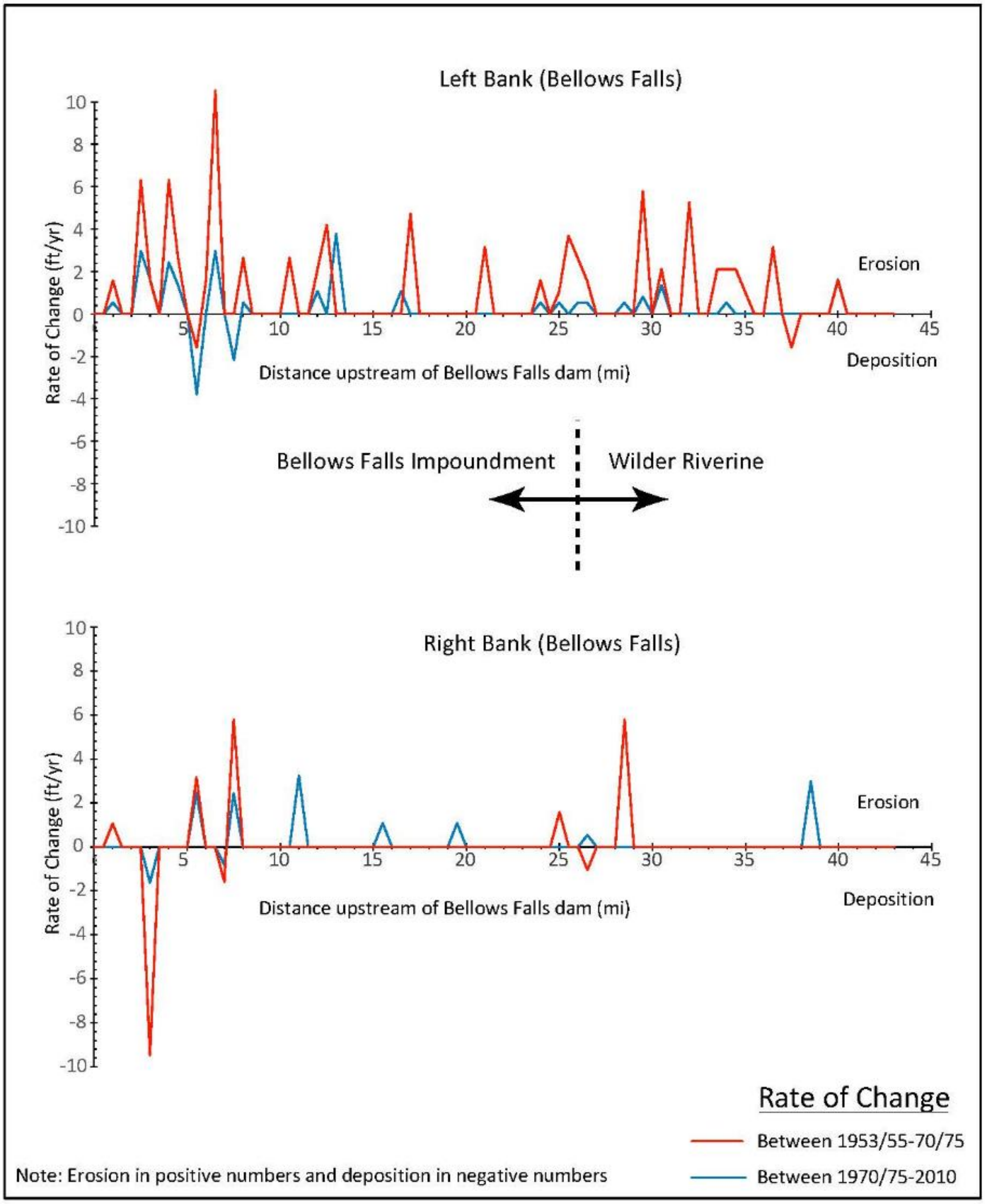
Forty percent of the banks in the Bellows Falls impoundment are unstable (Studies 2-3). Although significant variation exists, bank instability in the impoundment is generally greater with increasing distance from the dam (Figure 3.3-14). The lower levels of erosion closer to the dam may be due to the presence of armoring along the higher banks on the Vermont shore and the low banks on the New Hampshire side. Lower banks have limited gravitational force to drive erosion. The highest levels of erosion in the Bellows Falls riverine reach are found in the most downstream portions of the reach. The percentage of unstable banks in the Bellows Falls riverine reach is approximately 7 percent lower than in the Bellows Falls impoundment, largely because no unstable banks are present in the first mile downstream of Bellows Falls dam where bedrock, boulders, and armoring are prevalent.



Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

Figure 3.3-14. Variation in amounts of erosion with distance from Bellows Falls dam.

The amount of erosion in the Bellows Falls impoundment appears to have decreased through time as determined by comparing maps of erosion completed in 1958, 1978, and 2014 (Table 3.3-3). For the historical comparison, only those banks categorized as eroding in 2014 were used because vegetated eroding and failing armor banks were not likely considered eroding in the earlier mapping efforts. Between 1958 and 2014, the percentage of eroding banks decreased from 28 to 14 percent. An analysis of georeferenced historical aerial photographs indicates that the rate of erosion has decreased significantly at many locations, particularly in the lower Bellows Falls impoundment (Figure 3.3-15). In addition to temporal variations in the rate of erosion, the rate of erosion in the impoundment varies spatially as well. Two years of erosion monitoring at four sites in the impoundment as part of Studies 2-3 recorded recession at the top of the bank at two sites and no erosion at the other two locations. With 7 feet of bank recession at a monitoring site in Charlestown, New Hampshire, in the lower impoundment, current erosion rates in the Bellows Falls impoundment range from 0 ft per year to as high as 3.5 ft per year.



Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

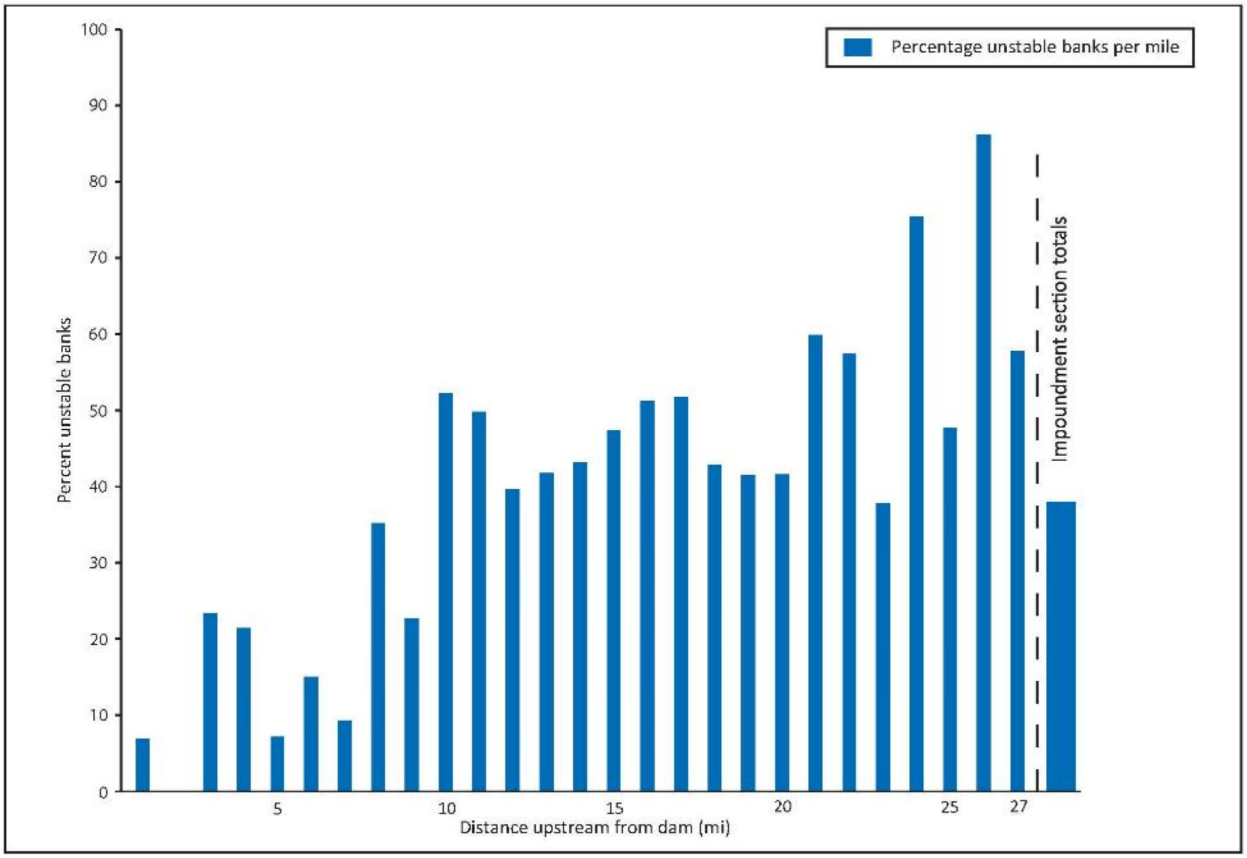
Figure 3.3-15. Rates of erosion in Bellows Falls impoundment with distance upstream of the dam (left and right banks looking downstream).

Vernon Project

Like the Wilder and Bellows Falls impoundments, the height, composition, and stability of the banks vary throughout the Vernon impoundment. Nearly 60 percent of the banks in the impoundment are greater than 15 feet high as more than 10 miles of the impoundment between Putney and Brattleboro, Vermont, pass through a narrow portion of the Connecticut River Valley where very little floodplain is present. Greater than 10 percent of the bank length is less than 5 feet high in large part because of backwater areas inundated upstream of Vernon dam.

Banks in the Vernon impoundment are composed of nearly 90 percent sand (Table 3.3-1). However, more areas of bedrock outcrop occur along the banks of the Vernon impoundment than in the Wilder or Bellows Falls impoundments, reflecting the long narrow valley between Putney and Brattleboro. While most of the Vernon riverine reach downstream of the dam is composed of sand (58 percent), a considerable percentage of the banks are composed of bedrock (17 percent), and glacial clay (20 percent) as the river flows through the relatively confined valley for the approximate 1.5 miles of river considered part of the Vernon riverine reach for Studies 2-3.

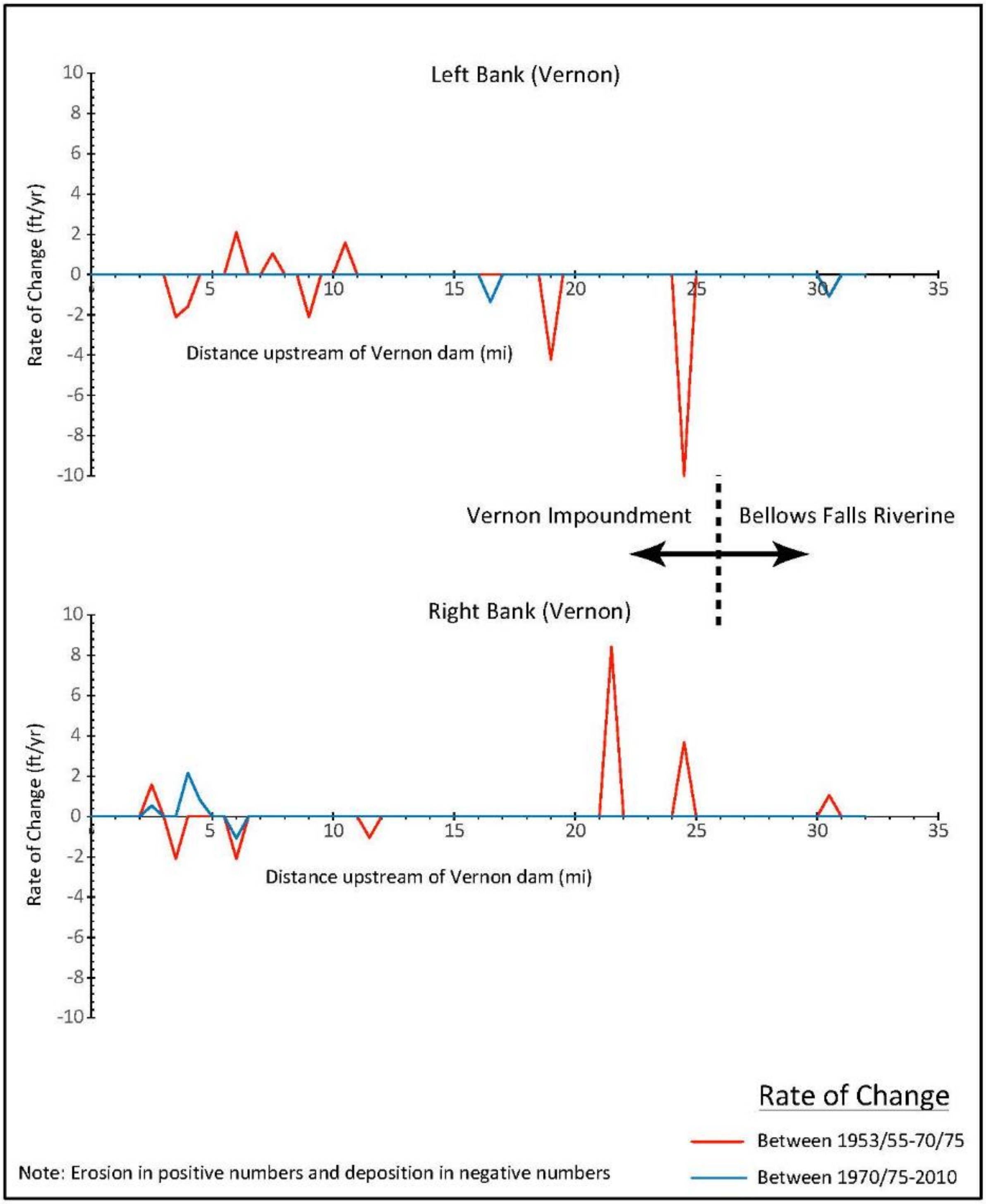
Nearly 40 percent of the banks in the Vernon impoundment are unstable (Studies 2-3). Although some variation exists, bank instability in the impoundment is generally greater with increasing distance from the dam (Figure 3.3-16). The presence of very low banks associated with the raising of Vernon dam in 1909 best explains the lower levels of erosion closer to the dam. Two years of erosion monitoring at three sites in the impoundment as part of Studies 2-3 recorded no recession at the top of the bank at those sites. More than half of the banks in the Vernon riverine reach are unstable with greater amounts of instability in the second mile downstream of the dam compared to the first mile closest to the dam, but comparisons of erosion levels between the Vernon impoundment and the Vernon riverine reach are unwarranted given the great disparity in length (i.e., only two data points are available from the riverine reach, and data is not shown in Figure 3.3-16).



Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

Figure 3.3-16. Variation in amounts of erosion with distance from Vernon dam.

The amount of erosion in the Vernon impoundment appears to have decreased slightly through time as determined by comparing maps of erosion completed in 1958, 1978, and 2014 (Table 3.3-3). For the historical comparison, only those banks categorized as eroding in 2014 were used because vegetated eroding and failing armor banks were not likely considered eroding in the earlier mapping efforts. Between 1958 and 2014, the percentage of eroding banks decreased from 11 to 8 percent. An analysis of georeferenced historical aerial photographs indicates that the rate of erosion has decreased at many locations and increased at others with most of these changes occurring in lower Vernon impoundment (Figure 3.3.17). Few data are available to determine rates of erosion in the Vernon impoundment. Two years of erosion monitoring at three sites in Vernon impoundment as part of Studies 2-3 recorded no bank recession, suggesting the rate of erosion is very slow for at least parts of the impoundment.

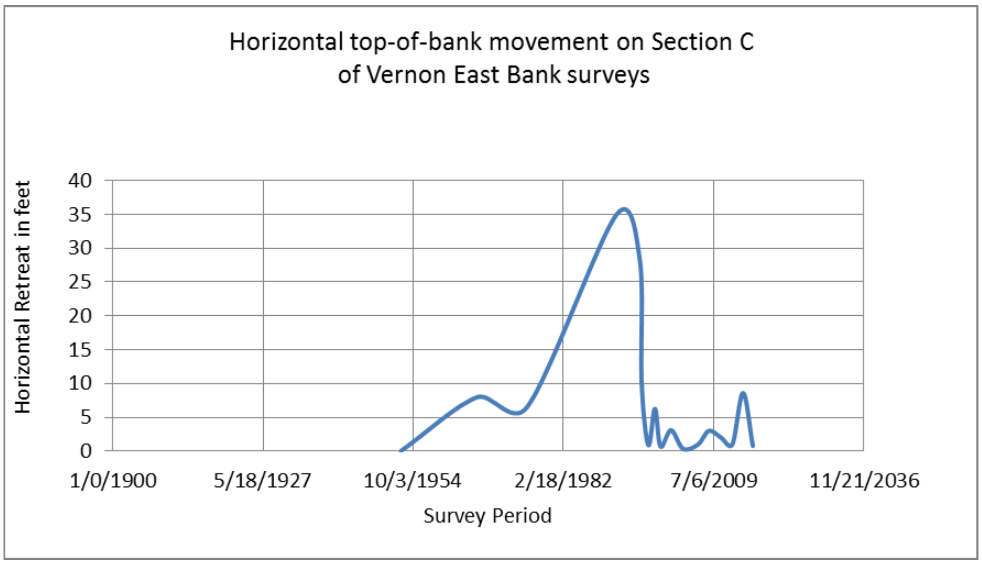


Source: ILP Studies 2-3, Riverbank Transect and Riverbank Erosion Studies

Figure 3.3-17. Rates of erosion in Vernon impoundment with distance upstream of the dam (left and right banks looking downstream).

Vernon Neck East Bank Erosion

Twenty-five years of monitoring on a 73-ft high bank immediately downstream of Vernon dam on the left bank (of Vernon Neck so-called) documents an average erosion rate of approximately 2.6 ft per year. Based on aerial photographic evidence indicating the top of bank in 1952, 1966, and 1975 and survey monitoring from 1991 until present, it is apparent that rates of erosion have varied over the 61-year period (Figure 3.3.18). The greatest rate of top-of-bank retreat corresponds with the period between 1975 and 1991. It was at the start of this time frame that the Northfield Mountain Pumped Storage Project commenced operation which included increasing the Turners Falls impoundment WSE by 5.4 ft. This change in turn, resulted in an increase of WSE at the base of Vernon dam and the Vernon Neck east bank, causing a higher WSE-bank interface.



Source: TransCanada

Figure 3.3.18. Vernon East Bank historical top-of-bank movement.

High water events, combined with the higher WSE acting on the high bank are largely responsible for the increased rate of erosion. In 1986, as part of the Vernon Project's spillway crest control and gate modifications, bedrock was removed below the tainter gates on the left bank to re-direct flow into the center river channel and reduce the whirlpool effect in the pool below the Vernon Neck east bank. This action may be in part supportive of the development of the beach at the base of the steep bank. Monitoring of the east bank included hydrographic monitoring of the submerged pool below and confirmed the gradual development of a submerged bench and beach at the base. Since 2006, despite annual high flow events with the exception of Tropical Storm Irene in 2011 causing a slight increase in slope failure immediately following that event, biennial surveys indicate little change in the top-of-bank and erosion has remained uniform and slight along the entire length of the bank. The toe-of-slope also shows little change along the entire length of the base of the bank and only minor and normal settling, a common phenomenon in open sloped areas composed primarily of sandy soils.

3.3.2 Environmental Effects

Analysis of bank erosion data compiled as part of Studies 2-3 indicates that continued erosion in the Project areas is the result of high flows that exceed the applicable Project's maximum operational flow. Multiple forces act on the riverbanks through time to move the cycle of erosion forward as illustrated in Figure 3.3-10. The continuation of erosion, however, ultimately depends on the removal of sediment that accumulates at the base of the bank from upslope erosion.

3.3.2.1 Effects of Project Operations on Sediment Transport

Evaluations of coarse-grained sediment stability using information collected as part of Study 8 and Study 4 indicate that most coarse-grained substrates are stable at flows within the applicable Project's maximum station discharge. Study 8 concludes that mainstem flows at or greater than the Projects' maximum operational flows and tributary inflows are the dominant factors that lead to transport of coarse-grained sediments in the Project areas. Sediment available for transport is supplied to the river from tributary inputs and bank erosion. Deltas are building out into the Connecticut River at the mouths of numerous tributaries (e.g., the Cold River) and supply fine-grained sediment as well as coarse-grained gravel, cobble, and boulders.

Threshold Velocity for Sediment Entrainment

As part of study report revisions in progress at this time, comparisons were made between flow velocities generated at various flow levels and the minimum threshold velocity necessary to transport (or entrain) sediment in the Project areas. The threshold velocity depends on a variety of parameters such as grain size, cohesion between the sediment grains, stratification, turbulence in the water, existing turbidity in the water, and vegetative cover. The predominant soils in the Project area consist of fine sandy loam and fine silty loams (Table 3.3-4). In a publication on thresholds for small channel design, the Natural Resources Conservation Service (NRCS) (2007) recommended a maximum permissible velocity of 1.5 feet per second (ft/s) for fine sand in clear water without any detritus, and 2.5 ft/s in water carrying colloidal silts. For sandy loam, NRCS (2007) recommended a maximum permissible velocity of 1.75 ft/s for clear water and 2.5 ft/s for water carrying colloidal silts. Finally, for silty loam, NRCS (2007) recommended a maximum permissible velocity of 2.0 ft/s for clear water and 3.0 ft/s for water carrying colloidal silts. Because these values are design parameters, they contain a factor of safety. USACE (1991) used an allowable mean velocity for non-scouring flood control channels of 2.0 ft/s for fine sand. Considering these values, a reasonably conservative minimum threshold for sediment entrainment along the Connecticut River is considered to be 2.0 ft/s. Considering that the river carries sediment and material accumulating at the base of the banks from upslope erosion is sometimes vegetated (thus reducing entrainment potential), a reasonable range for sediment entrainment is estimated at 2.0 to 3.0 ft/s based on velocities provided by the NRCS (2007) and USACE (1991).

Table 3.3-4. Flow velocities measured at corresponding impoundment erosion monitoring sites.[a]

Parameter	Units	Study 2-3 Site ID and Name		
		02-W03	02-W09	02-B07
		Bellavance	Mudge	Charlestown
Project area		Wilder Impoundment	Wilder Impoundment	Bellows Falls Impoundment
Town		Bradford, VT	Lyme, NH	Charlestown, NH
Latitude		44.014852	43.822787	43.220017
Longitude		-72.09461	-72.187887	-72.437683
Streamflow Velocity Measurements in the field				
Date		August 6, 2015		
Measured velocity (mean)	ft/s	0.6	0.7	0.7
River flow at measured velocity	cfs	2,690	4,990	8,560
Max. station discharge	cfs	10,700	10,700	11,400
Percent of total generation		25%	47%	75%
Additional contribution from spill		0%	0%	0%
Modeled Streamflow Velocities				
Velocity at measured flow[b]	ft/s	0.3–0.4	0.7	0.4–0.6
Velocity at minimum flow	ft/s	0.1	0.1	0.1
Velocity at maximum generating flow[b]	ft/s	0.7–0.9	1.3–1.4	0.6–0.7
Minimum flow needed for threshold velocity[c]	cfs	100,000	17,000	28,000
Modeled velocity at 30,000 cfs	ft/s	1.7	3.3	2.3
Modeled velocity at 60,000 cfs	ft/s	1.8	5.0	3.4
Modeled velocity at 100,000 cfs	ft/s	2.0	6.6	4.2
Threshold velocity for erosion[c]	ft/s	2.0–3.0		

Source: ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies* (report revision in progress)

a. Data were not included in filed study report, but will be included in the revised study report.

b. Ranges indicate variations due to the range of normal operations WSEs at the downstream dam.

c. Threshold velocity data from NRCS (2007) and USACE (1991). Reasonable range is 2.0–3.0 ft/s.

Flow Velocities

Flow velocities were measured at three impoundment monitoring sites and three riverine monitoring sites for Studies 2–3 and to compare with the hydraulic model (Study 4) calculated average velocities at those locations, with good agreement between field measurements and calculated velocities.

At the Studies 2–3 impoundment monitoring sites (Bellavance, Mudge, and Charlestown) velocities were measured in August 2015 when river flows were at 25 percent, 47 percent, and 75 percent, respectively, of the applicable Project maximum station discharge. Velocities were also modeled for Project minimum flow and maximum station discharge, and for flood flows (30,000, 60,000, and 100,000 cfs) during Study 4 (Table 3.3-4). Both the measured and modeled velocities at the impoundment sites were well below the 2.0 ft/s velocity minimum threshold for sediment entrainment under normal Project operations, indicating that the sediment accumulating at the base of the riverbanks would generally require higher flows and higher velocities to be entrained and removed. In addition, aside from fine sand, silt and clay, some of the sediments at the base of these banks include coarser materials that would have a higher threshold for entrainment. Note that this analysis did not consider localized shear stress on the banks, but rather the considered the overall likelihood of normal Project operations within the impoundments to remove beach or submerged material or lead to channel scour based on average velocities

Flow velocities were also measured at Studies 2–3 monitoring sites in the riverine reaches downstream of the Projects (Hartford, Malnati, and Stebbins Island sites) and at the North Walpole USGS gage (no. 01154500) in May 2015. Flows at Wilder and Bellows Falls represented Project discharges plus natural inflow at that time and Vernon flows were 64 percent of maximum station discharge (Table 3.3-5). Velocities were also modeled for each Project's minimum flow and maximum station discharge, and for flood flows (30,000, 60,000, and 100,000 cfs) during Study 4 (Table 3.3-5). Results indicate that the threshold entrainment velocity is not reached at the Hartford and North Walpole gage sites under the range of normal Project operating discharges but is reached at the Malnati and Stebbins Island sites at higher flows within the normal Project operating ranges.

Table 3.3-5. Flow velocities measured at corresponding riverine erosion monitoring sites and the North Walpole USGS gage[a].

Parameter	Units	Study 2-3 Site ID and Name			
		02-WR01	NA	02-BR05	02-VR02
		Hartford	USGS Gage N. Walpole	Malnati	Stebbins Island
Project Area		Wilder Riverine	Bellows Falls Riverine	Bellows Falls Riverine	Vernon Riverine
Town		Hartford, VT	Walpole, NH	Walpole, NH	Hinsdale, NH

Parameter	Units	Study 2-3 Site ID and Name			
		02-WR01	NA	02-BR05	02-VR02
		Hartford	USGS Gage N. Walpole	Malnati	Stebbins Island
Latitude		43.6638	43.125964	43.095957	42.770815
Longitude		-72.30636	-72.4 37676	-72.438574	-72.504831
Streamflow Velocity Measurements in the field					
Date		May 9, 2015	May 13, 2015		May 14, 2015
Measured velocity (mean)	ft/s	1.3	2.0	2.6	2.3 [b]
River flow at measured velocity	cfs	11,540	11,970	12,040	11,848 [b]
Max. station discharge	cfs	10,700	11,400	11,400	17,100
Percentage of total generation		100%	100%	100%	69% [b]
Additional contribution from spill		14%	5%	6%	0%
Modeled Streamflow Velocities					
Velocity at measured flow[c]	ft/s	1.9	1.9	2.5–2.6	1.9–2.1
Velocity at minimum flow[c]	ft/s	0.3	0.5	0.5–0.6	0.4–0.7
Velocity at maximum generating flow[c]	ft/s	1.8	1.8	2.4–2.5	2.1–2.3
Minimum flow needed for threshold velocity[c]	cfs	13,000	13,000	8,000	11,000–14,000
Modeled velocity at 30,000 cfs	ft/s	3.1	3.5	4.0	2.7
Modeled velocity at 60,000 cfs	ft/s	4.3	4.8	5.2	3.1
Modeled velocity at 100,000 cfs	ft/s	5.4	6.0	6.1	3.4
Threshold velocity for erosion[d]	ft/s	2.0–3.0			

Source: ILP Studies 2-3, *Riverbank Transect and Riverbank Erosion Studies* (report revision in progress)

a. Data were not included in filed study report, but will be included in the revised study report.

b. Velocity and flow was measured in the left (New Hampshire side) channel at 8,290 cfs, while Vernon total discharge was 11,848 cfs. Modeled values are based on whole river flows including both left and right (Vermont side) channels.

c. Ranges indicate variations due to the range of normal operations WSEs at the downstream dam.

d. Threshold velocity data from NRCS (2007) and USACE (1991). Reasonable range is 2.0–3.0 ft/s.

The Malnati site is located in the Bellows Falls riverine reach and receives inflow from Bellows Falls as well as from the Saxtons and Cold rivers, both large tributaries (fifth order stream). Threshold entrainment velocity of 2.0 ft/s is reached at 8,000 cfs of flow at that site which occurs most often during the spring freshet and fall rain events. Based on flow exceedance curves (see Section 3.4.1.1, *Water Quantity*), the occurrence of 8,000 cfs flows from Bellows Falls and excluding tributary flows is 95 percent in April and 14 percent overall from July through September (average = 43 percent on an annual basis). As noted above, an overall reasonable range for sediment entrainment is estimated at 2.0 to 3.0 ft/s. The flow at the Malnati site required for sediment entrainment based on a 3.0 ft/s entrainment velocity rather than the more conservative 2.0 ft/s used in this analysis is approximately 17,000 cfs, well above the maximum station discharge of 11,400 cfs.

At the Stebbins Island site, flow at the time of field measurement was 68 percent of the maximum station discharge, but since the field measurements were taken only in the left channel (New Hampshire side) around Stebbins Island, the measured flow in that channel amounted to approximately 70 percent of total Vernon discharge at that time, and 48 percent of the Project's maximum generating flow of 17,100 cfs. Flows in the Vernon riverine reach required to reach the threshold entrainment velocity are influenced by WSEs at the downstream Turners Falls dam and range from 11,000 to 14,000 cfs within Turners Falls normal operating range (Table 3.3-5), and between 12,000 and 13,000 cfs at the Turners Falls dam median WSE of 181.3 ft (NGVD29). Flows within the range of 11,000 to 14,000 cfs occur primarily during the spring freshet and fall rain events. Based on flow exceedance curves (see Section 3.4.1.1, *Water Quantity*), the occurrence of these flows are 85 and 91 percent respectively, in April, but only 7 and 12 percent respectively, overall from July through September (average = 26 and 36 percent respectively, on an annual basis).

Measured and modeled velocities are difficult to compare at the Stebbins Island site where total river flow is split around the island (modeled velocities are based on average velocity across both channels). The left channel accounted for 70 percent of total discharge from Vernon at the time of field measurement, but that channel is wider and shallower than the right channel so direct proportioning of flow and velocity cannot be made with modeled data. As noted above, the overall reasonable range for sediment entrainment is estimated at 2.0 to 3.0 ft/s. The flow required for sediment entrainment based on a 3.0 ft/s entrainment velocity rather than the more conservative 2.0 ft/s used in this analysis, and based on full river flow is nearly 60,000 cfs (Table 3.3-5).

While multiple factors affect sediment entrainment thresholds, these data demonstrate that removal of the material accumulating at the base of the banks along the shore of the impoundments is attributable to high flow events outside of normal Project operations. Along the riverine reaches, removal of material at the base of the banks is attributable mostly to high flow events, but may also occur locally to some extent during higher generating flows depending on local bank composition and particle size. As discussed in Section 3.3.1.4, *Riverbank Composition and Conditions*, flow velocities at or above the threshold entrainment value do not necessarily mean that erosion is continuously occurring at a given site. Preferential removal of the most easily moved particles (i.e., fine sand) will lead to armoring with coarser particles that are not entrained, and over time, will reduce erosion of finer particles at a given flow velocity. Furthermore, removal of any material accumulating at the base of the riverbanks from upslope erosion caused by the processes described in Figure 3.3-10 must occur before further erosion of the bank itself can continue.

3.3.2.2 Effects of Project Operations on Bank Erosion

The erosion data were analyzed with GIS to identify potential causes of erosion (Studies 2-3). Specifically, bank instability was compared with bank height (and geomorphic surface), position on meander bends, presence of riparian vegetation, and fluctuations in WSEs associated with normal Project operations. The following discussion summarizes the results of the analysis (see the Studies 2-3 report for details).

Bank Height and Composition

The stability of the banks is related to their height and composition. Nine bank height categories were selected to represent the range of geomorphic surfaces the river encounters throughout the Project areas: <1 ft (representing backwater areas inundated by the dams), 1-5 ft (tributary deltas, point bars), 5-8 ft (floodplain), 8–10 ft (floodplain), 10–15 ft (floodplain), 15–20 ft (flood terrace), 20–30 ft (flood terrace), 30–50 ft (glacial terrace), and >50 ft (glacial terrace). Among the various categories, banks that are 15–30 ft high are typically the least stable; these banks are composed of sand and sandy loam. Sand and sandy loam are also characteristic of floodplains, point bars, and many tributary deltas, but these bank height categories are more stable due to their lower height. Banks higher than 30 ft (glacial terraces) are more stable as well, because they are often composed of indurated (i.e., compacted) clay, gravel and cobbles, or bedrock; these materials are less prone to erosion.

Meanders and Armoring

Along unaltered meandering alluvial rivers, erosion rates are typically higher on the outside bends of meanders than on the inside bends due to higher shear stresses. However, analysis of unstable banks along both sides of meanders (as well as straight reaches) in the Project areas shows a slight preference for unstable banks on the inside bends as opposed to the outside bends. This finding is likely a result of bank armor that is almost twice as likely to exist along the outside bends of meanders (and along straight reaches) compared to the inside bends.

Riparian Vegetation

Bank and riparian vegetation is considered to have a stabilizing influence on riverbanks given that roots tend to bind soil particles together and increase bank resistance to erosion (Micheli and Kirchner, 2002). However, field observations show that erosion in the Project areas is only slightly more likely to occur where vegetation is absent compared to where it is present. The generally weak link between erosion and the absence of vegetation is likely the result of high banks; trees growing on the top of high banks generally do not have root systems that extend down to the base of the bank where they would be most effective at stabilizing the bank. Plant species with different root characteristics (i.e., shallow versus deep or tap rooting) as well as soil type characteristics (compaction, depth, and layer types) can affect the beneficial extent a riparian vegetative provides. Vegetation growing on the bank slope itself could also have a stabilizing influence all the way to the toe of the bank. Ultimately, such vegetation increases the resisting force of erosion, but erosion can still occur of the driving forces are greater even where vegetation is present.

Water Surface Elevations

The effect of the magnitude of water level fluctuations on erosion was assessed for normal Project operations. For this analysis, the median WSE fluctuation (i.e., 50th percentile exceedance interval) under no spill conditions was established for each of the more than 1,100 cross sections used in hydraulic modeling (Study 4) and operations modeling (Study 5) of the Project areas. Overall, the magnitude of the median WSE fluctuations does not correlate well with the location of unstable banks. In some instances high rates of erosion are associated with higher WSE fluctuation ranges, such as in the Bellows Falls impoundment while the Bellows Falls riverine reach also shows a tendency for erosion to be concentrated where the WSE fluctuation range is low. In the impoundments, more than 75 percent of the bank length experiences a median WSE fluctuation of less than 1.5 ft, a range considered ineffective at causing erosion because of the limited hydraulic gradient that would develop between the lowering river level and groundwater that seeps into the bank when the river is at the upper limit of the WSE fluctuation range. Although the range of WSE fluctuations is greater in the riverine reaches, the low correlation between erosion and the magnitude of WSE fluctuations indicates that other factors, such as bank height, exert a stronger control on the distribution of erosion than the magnitude of WSE fluctuations (see Section 3.3.2.1, *Effects of Project Operations on Sediment Transport*). TransCanada's impoundment drawdown rate restrictions (no more than 0.3 ft per hour and typically 0.1–0.2 ft per hour) also serve to limit the rate of impoundment fluctuations and the potential for sudden spill events downstream of the dams which might otherwise lead to entrainment threshold velocities in the riverine reaches.

Summary of Effects

In summary, erosion in the Project areas is most clearly influenced by bank height and associated geomorphic surface. Erosion preferentially occurs where bank heights are between 15 and 30 ft high. These bank heights generate sufficient gravitational forces to drive erosion and are typically associated with sandy banks that provide limited resistance to erosion. WSE fluctuations associated with normal Project operations are one of several factors along with waves, groundwater seepage, and high flows that can create notching and overhangs that characterize the initial stages in the cycle of erosion. Based on direct observations and calculated WSE fluctuation associated with normal Project operations, there does not appear to be a correlation between project related WSE fluctuation and erosion occurrence in both riverine and impounded reaches. Most importantly, continued erosion in the Project areas depends on high flows to entrain and remove eroding material accumulating at the base of the banks, as described in Section 3.3.2.1, *Effects of Project Operations on Sediment Transport*. Water velocities generated at flows near or above the maximum station discharges are the only flows capable of entraining enough accumulated sediment to sustain the cycle of erosion. Additional statistical analysis is being conducted as part of study report revisions (in progress at this time) in an attempt to better quantify these effects, and those results will be reported in the FLAs.

Vernon Project operations and maintenance do not appear to cause any adverse effects on the narrow neck of land known as the Vernon Neck, which separates the Vernon impoundment from the tailwater.[20] This was a natural ridge that has been armored at various times on the upstream and downstream slopes to prevent erosion. A vegetation management plan is in place to limit the growth of potentially dangerous trees and allow regular inspection of this area. No erosion is evident. Surveys have been conducted periodically showing minor changes to the toe of the downstream slope.

3.3.3 Cumulative Effects

As described in Section 3.2.2, *Scope of Cumulative Effects Analysis*, FERC identified the geographical extent of cumulative effects on sediment movement to include the upper extent of the Wilder impoundment downstream to the Route 116 Bridge in Sunderland, Massachusetts, the approximate upstream extent of the Holyoke Project impoundment. The environmental analysis discussed in Section 3.3.2, *Environmental Effects*, *Geologic and Soils Resources*, indicates that normal Project operations do not affect fine sediment movement or transport within the impoundments. Flow velocities in the riverine reaches downstream of each Project within the range of normal generating discharges can entrain fine sediments which could lead to increased levels of suspended sediment and subsequent deposition within those reaches and potentially within the upper portion of the next downstream impoundment. However, as discussed in Section 3.3.2.1, *Effects of Project Operations on Sediment Transport*, flow velocities above the threshold value do not necessarily mean that erosion is continuously occurring at a given site. Where erosion does take place, preferential removal of the most easily moved

[20] FERC SD2 specifically included this location and potential Project effects on stability.

particles (i.e., fine sand) will lead to armoring with coarser particles that will over time reduce erosion at a given flow velocity.

3.3.4 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures for geology and soils. Normal Project maintenance, including recreation area maintenance activities occur from time to time along the river banks. These activities are conducted in accordance with state and federal wetlands regulations and related stormwater pollution prevention measures and best management practices to avoid compromising riverbank integrity or creating shoreline erosion that might otherwise lead to localized sediment transport or adverse effects on riparian and wetland vegetation. TransCanada is proposing to maintain current voluntary limits on impoundment drawdown rates (no more than 0.3 ft/hour and typically 0.1–0.2 ft per hour), which serve to limit the rate of impoundment fluctuations and the potential for sudden spill events downstream of the dams which might otherwise lead to entrainment threshold velocities in the riverine reaches.

3.3.5 Unavoidable Adverse Effects

The normal Project operations that contribute to notching and overhangs that characterize the initial stages in the cycle of erosion are unavoidable, but contribute only a small fraction of the total sediment transported and deposited by the Connecticut River within the impoundments. High natural flows that cannot be controlled or managed by Project operations do affect sedimentation and/or sediment transport in the impoundments play a much larger role in causing unavoidable adverse effects on other resources such as protected species, aquatic and wetland habitats, or cultural resources discussed in Sections 3.4–3.10. However, as discussed in those sections the effects caused by project operational flows and impoundment fluctuations appear to be minimal to none in most cases.

There do not appear to be any adverse effects caused by Vernon Project operations and maintenance on the narrow neck of land known as the Vernon Neck which separates the Vernon impoundment from the tailwater. There is a vegetation management plan in place that limits the growth of potentially dangerous trees and allows regular inspection of this area. No erosion is evident. Surveys have been conducted periodically showing minor changes to the toe of the downstream slope.

3.4 Water Resources

3.4.1 Affected Environment

3.4.1.1 Water Quantity

Hydrology and Stream Flow

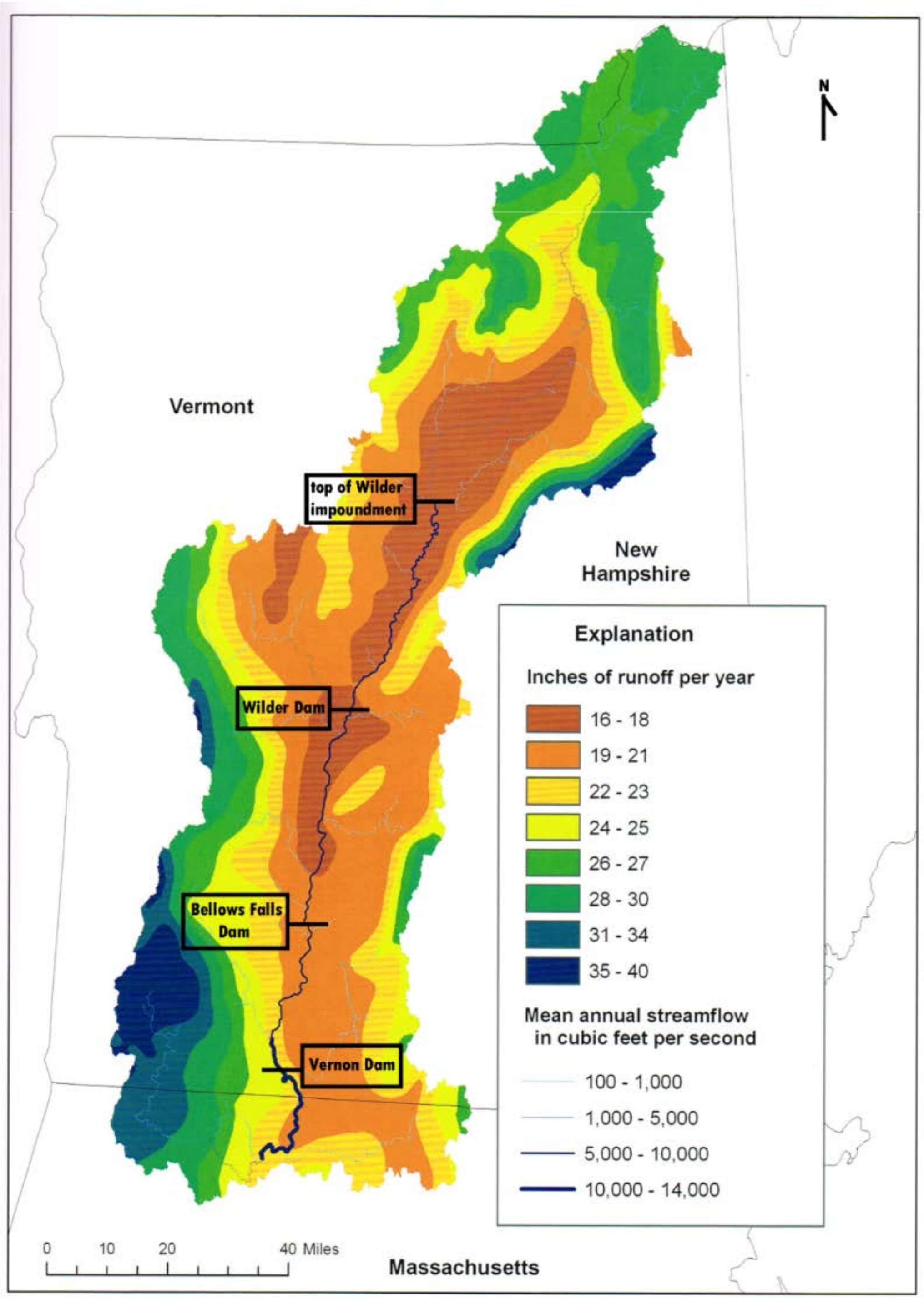
Flows into the Wilder, Bellows Falls, and Vernon Projects are regulated by managed flows from upstream dams and supplemented by tributary inflows including releases from tributary USACE dams (see Section 3.1.1 for basin description). Flows in the Connecticut River and in some major tributaries are measured at USGS gages for the DAs shown in Table 3.4-1, listed from upstream to downstream. In addition, TransCanada records impoundment water levels, generation, and discharges continuously at its Projects.

Table 3.4-1. Active USGS gages in the Project areas.

Location	Drainage Area (sq. mi.)	Gaged Drainage Area (sq. mi.)	USGS Gage No.
McIndoes Dam	2200	---	
Tributary – Ammonoosuc River, NH	395	88	01137500
Connecticut River at Wells River	2,644	2,644	01138500
Tributary - Wells River, VT	100	98	01139000
Tributary - Ompompanoosuc River	136	130	01141500
Wilder Dam	3,375	---	
Tributary - White River, VT	710	690	01144000
Tributary - Ottauquechee River, VT	222	221	01151500
Connecticut River at West Lebanon	4,092	4,092	01144500
Tributary - Sugar River, NH	275	269	01152500
Tributary - Williams River, VT	118	112	01153550
Bellows Falls Dam	5,414	---	
Connecticut River at North Walpole	5,493	5,493	01154500
Tributary - Saxtons River, VT	78	72	01154000
Tributary - Cold River, NH	100	75	01154950
Vernon Dam	6,266	---	
Tributary - Ashuelot River, NH	421	420	01161000

Source: USGS (2016a, 2016e)

Estimated annual runoff varies across the Connecticut River watershed because of topography, regional weather patterns, influences of the Green and White mountains located on either side of the river valley, and annual precipitation variations resulting from latitude and mountain effects. The amount of estimated effective runoff into the Connecticut River (less evapotranspiration estimates and correlated to measured runoff where that data were available) ranges from approximately 16 to 25 inches in the Project areas, increasing from upstream to downstream (Brown, 2009; Figure 3.4-1).



Source: Brown (2009, as modified by TransCanada)

Figure 3.4-1. Average annual runoff in the Project areas.

Project Inflows and Outflows

Wilder Project

The Wilder Project has a total DA of 3,375 sq. mi. Inflow is both unregulated (51 percent of DA) and regulated (49 percent of DA). Storage operations associated with the Fifteen Mile Falls Project reservoirs (58 miles upstream of Wilder dam) and headwater storage reservoirs (163 miles upstream of Wilder dam) owned by the State of New Hampshire and TransCanada are responsible for flow regulation and augmentation throughout the year. Within the 1,740 sq. mi. of the unregulated portion of the DA below these reservoirs, one USACE flood control project on the Ompompanoosuc River regulates flow during and immediately following precipitation or high runoff periods. All other dams and impoundments located within the DA generally operate in a non-storage, river-of-river mode (see Section 3.1.1, *Overview of the Basin*).

The Wilder impoundment is approximately 45 miles long and extends to Newbury, Vermont, and Haverhill, New Hampshire, about 4 miles downstream of the Wells River-Woodsville Bridge. The impoundment is riverine in character and ranges in depths from several feet to about 60 ft near the dam. Bathymetry in the impoundment changes rapidly as the result of underlying bedrock, channel constriction, deposition, and scour primarily associated with high flows.

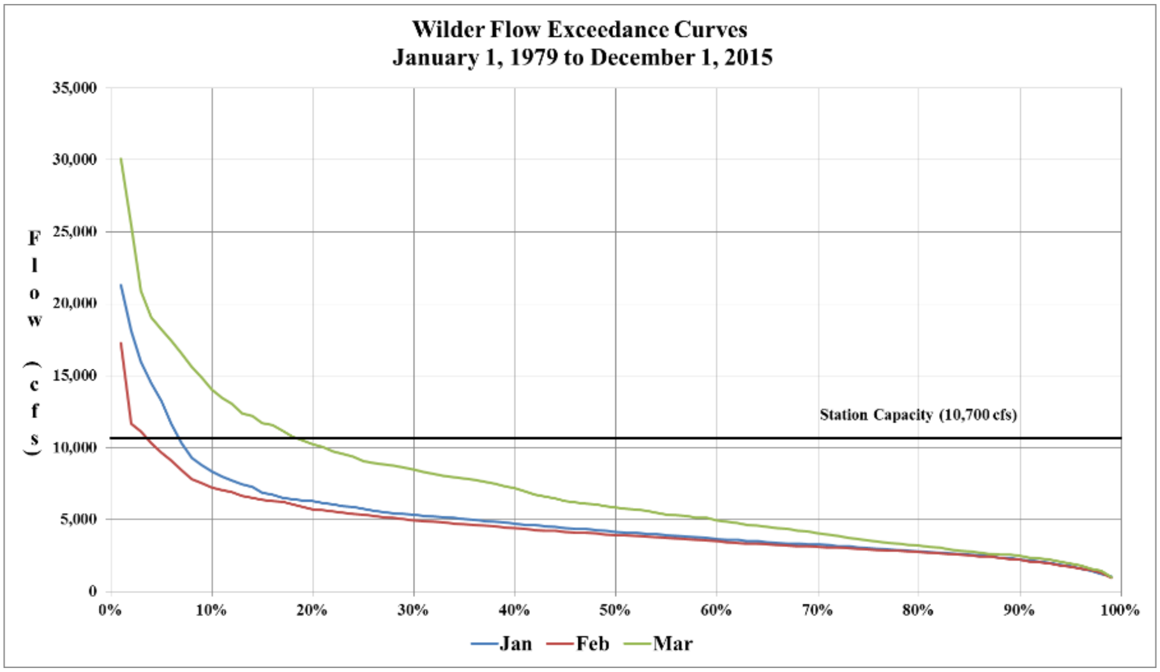
Because of the relatively flat terrain from McIndoes dam downstream to the Project, the Project has limited storage capacity, which is primarily a function of impoundment length and a limited normal range of WSE. Under normal generation conditions, regulated flow from McIndoes dam reach Wilder dam on average in about 8 hours. The small run-of-river Dodge Falls Project is located about 51 river miles above Wilder dam and has limited effect on travel times from McIndoes dam.

The Wilder impoundment has a surface area of 3,100 acres and a maximum total volume of 34,600 acre-ft at El. 385 ft NGVD29[21] at the top of the stanchion boards. The overall operating range of the Project, accounting for both low inflow and most high inflows conditions is typically between El. 380.0 ft and 385.0 ft, providing about 13,350 acre-ft of storage in the 5-ft range. The storage volume associated with the typical operating range, under non-spill conditions, between El. 382.0 ft and 384.5 ft is 7,350 acre-ft, or 55 percent of the overall usable storage.

Figures 3.4-2 through 3.4-5 provide monthly flow exceedance curves for the Wilder Project from January 1, 1979, to December 31, 2015, the range of full calendar years encompassing the current license term. Data are based on two USGS gages in the project vicinity — USGS gage no. 01144500, Connecticut River at West Lebanon, New Hampshire (subsequently referred to as the West Lebanon gage), located downstream of the confluence with the White River, and USGS gage no. 01144000, White River at West Hartford, Vermont (subsequently referred to as the

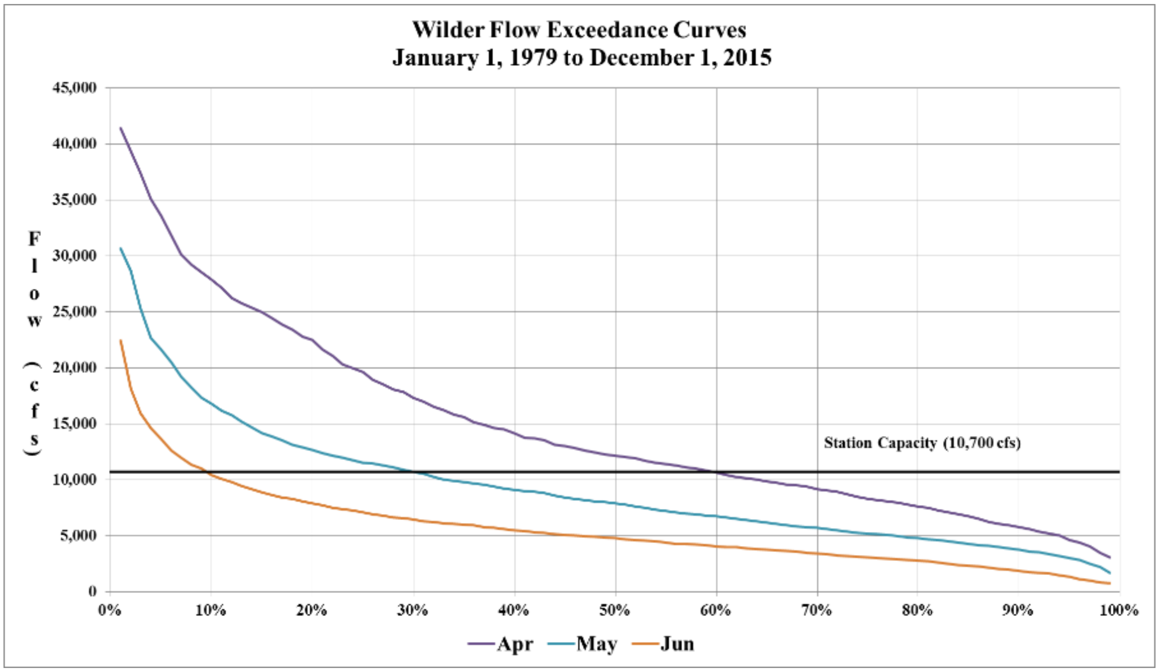
[21] All vertical elevations in Section 3.4 are stated in National Geodetic Vertical Datum of 1929 (NGVD29).

White River gage), located a short distance upstream on the White River. To estimate flow at only the Wilder Project, the daily flow data from the White River gage were prorated by 1.039 based on gaged DAs. These daily prorated flow values were used to account for the small amount of the White River DA that is not captured by the White River gage and for the small tributaries that enter the Connecticut River above the West Lebanon gage. For each day, the daily average flows from the prorated values from the White River gage were then subtracted from the daily West Lebanon gage to estimate flows from the Wilder Project. Table 3.4-2 summarizes the minimum, mean, and maximum values of average monthly flows for the same data set as the exceedance curves.



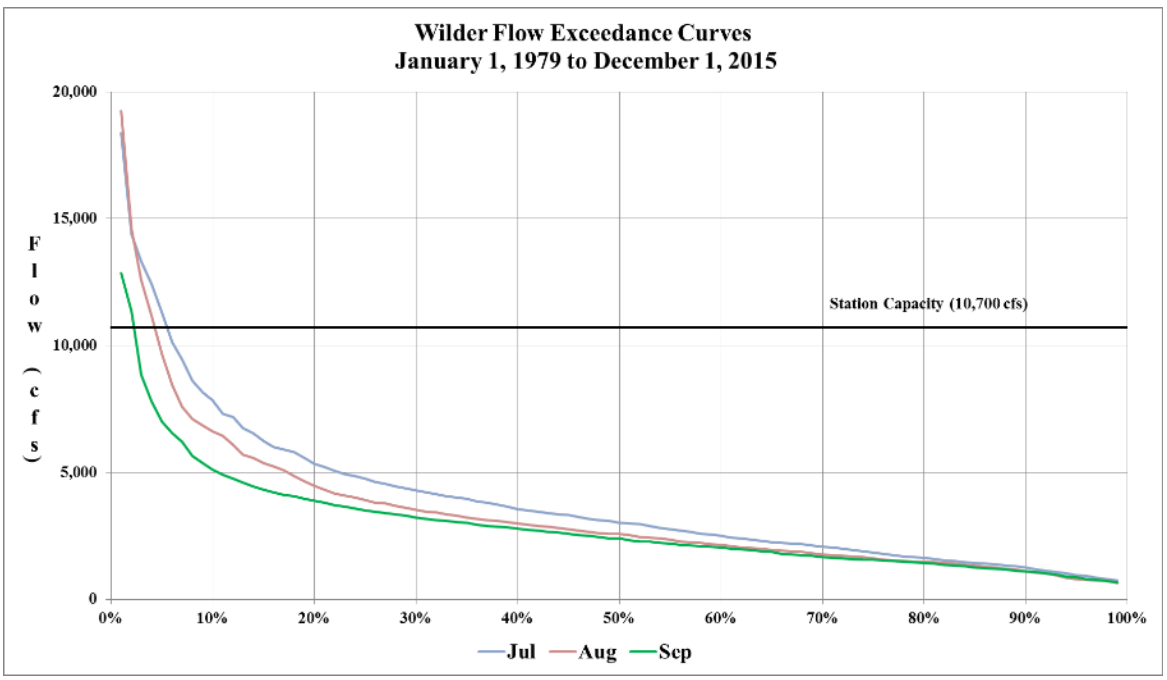
Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-2. Wilder flow exceedance curves, January–March.



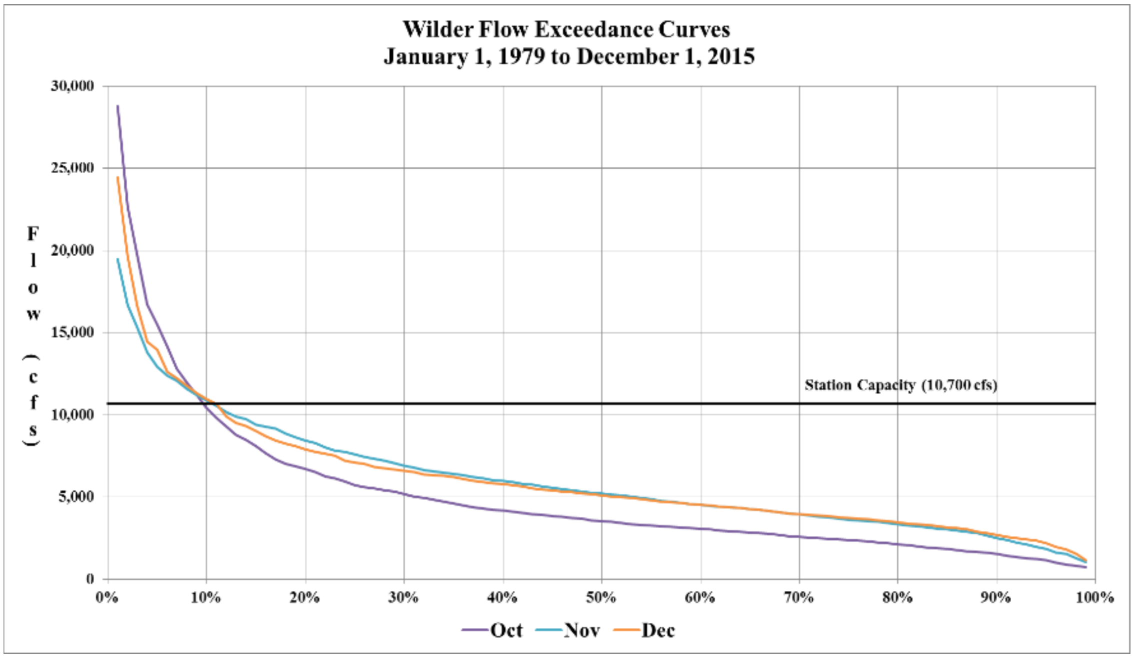
Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-3. Wilder flow exceedance curves, April–June.



Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-4. Wilder flow exceedance curves, July–September.



Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-5. Wilder flow exceedance curves, October–December.

Table 3.4-2. Wilder estimated minimum, mean, and maximum average monthly flow values (cfs), January 1979—December 2015.

Month	Minimum	Year	Mean	Maximum	Year
January	2,004	1981	5,111	11,319	2006
February	1,797	1980	4,613	14,011	1981
March	2,733	2015	7,381	18,135	1979
April	4,360	1995	14,824	23,140	2008
May	3,710	1987	9,328	18,428	1996
June	1,991	1999	5,778	12,966	1984
July	1,474	1995	3,996	10,466	1996
August	1,233	2001	3,508	12,949	2008
September	1,131	2001	2,970	7,004	2011
October	1,299	2001	5,176	15,260	2005
November	2,229	2001	6,109	13,416	2005
December	2,555	2001	6,192	13,578	1983

Source: USGS (2016e, as modified by TransCanada)

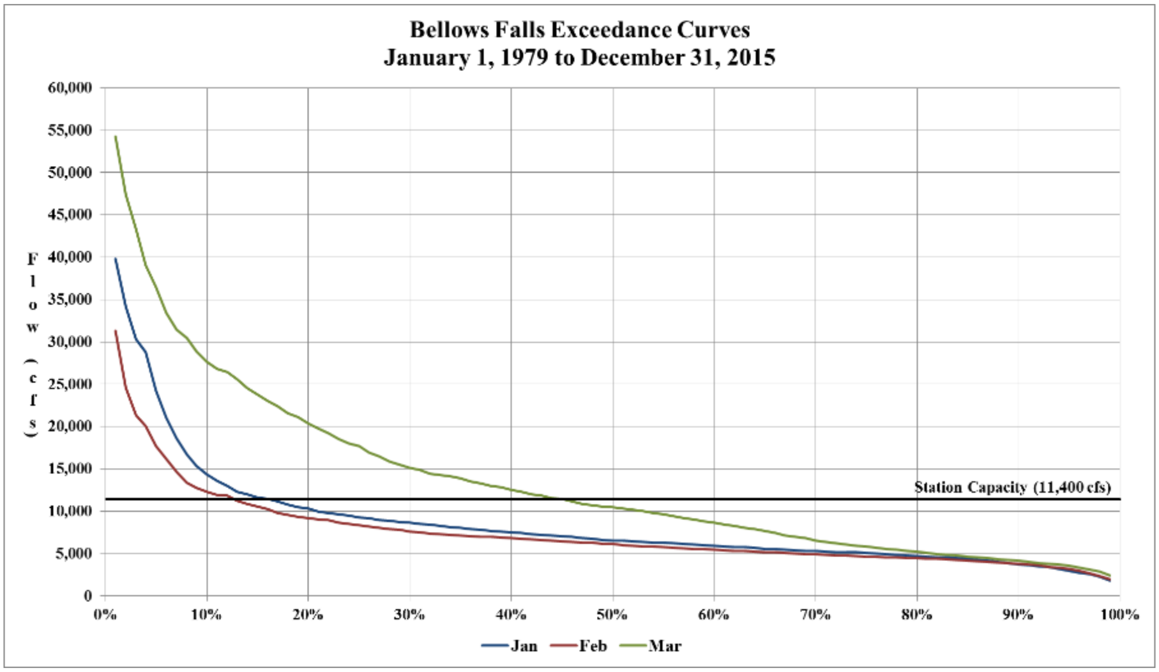
Bellows Falls Project

The Bellows Falls Project has a total DA of 5,414 sq. mi. Inflow is from discharge from the Wilder Project and natural inflow from the 2,039 sq. mi. of intermediate DA downstream of the Wilder Project. More than 42 percent of the total enters as unmanaged flow below the Wilder Project, except under flood flow conditions when the USACE dams on the Ottauquechee and Black rivers store water temporarily (see Section 3.1.1, *Overview of the Basin*).

The Bellows Falls impoundment is approximately 26 miles long and extends upstream to Chase Island at Windsor, Vermont, about 1 mile downstream of the Windsor Bridge. The impoundment is riverine in character and ranges in depths of several feet to about 30 ft near the dam. Bathymetry in the impoundment changes rapidly as the result of underlying bedrock, channel constriction, deposition, and scour primarily associated with high flows, such as those that occurred with Tropical Storm Irene in late August 2011.

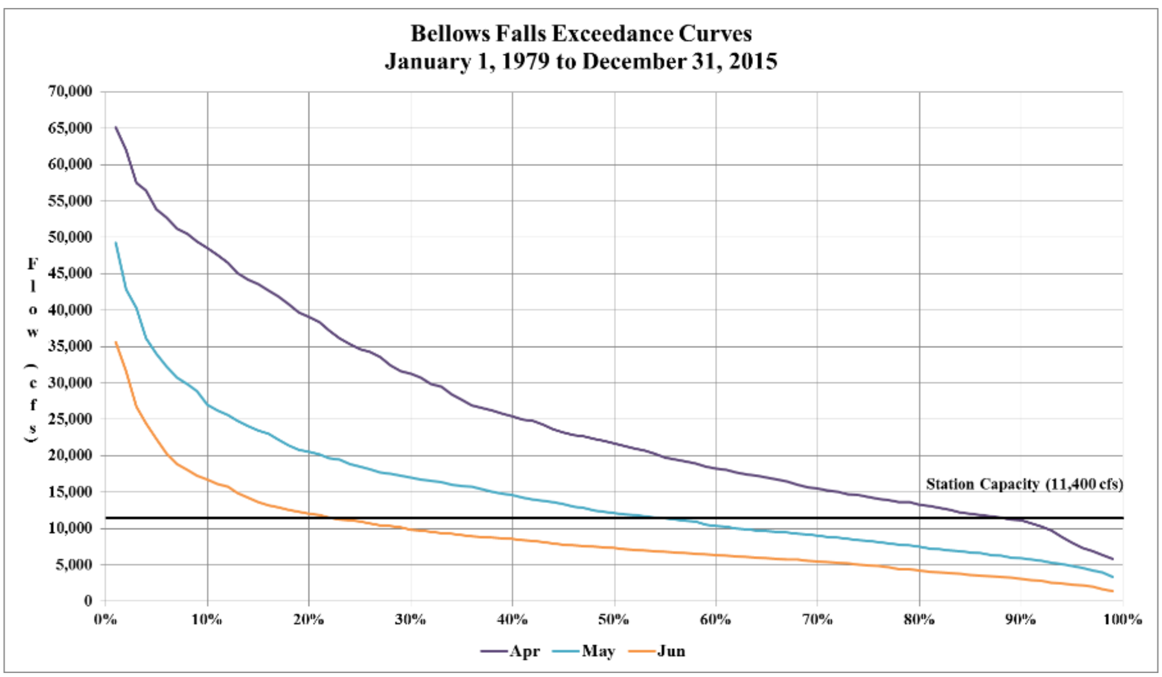
Under normal generation conditions, it takes about 8 hours for flow from Wilder to reach Bellows Falls dam. The impoundment has a surface area of 2,804 at El. 291.63 ft at the top of the stanchion boards. The overall operating range of the Project, accounting for both low inflow and most high inflows conditions, is typically between El. 288.63 ft and 291.63 ft, providing about 7,476 acre-ft of storage in the 3-ft. range. The storage volume associated with the typical operating range, under non-spill conditions, between El. 289.6 ft and 291.4 ft is 4,642 acre-ft, or 62 percent of the overall usable storage.

Figures 3.4-6 through 3.4-9 provide monthly flow exceedance curves for the Bellows Falls Project from January 1, 1979, to December 31, 2015, the range of full calendar years encompassing the current license term. Data are based on the North Walpole gage, located downstream of the confluence with Saxtons River (about 2 miles from Bellows Falls dam). To estimate flow at only the Bellows Falls Project, the daily flow data from the North Walpole gage were prorated by 0.986 based on gaged DA to remove the small effect of inflow from the Saxtons River under most circumstances. Table 3.4-3 summarizes the minimum, mean, and maximum values of average monthly flows for the same data set as the exceedance curves.



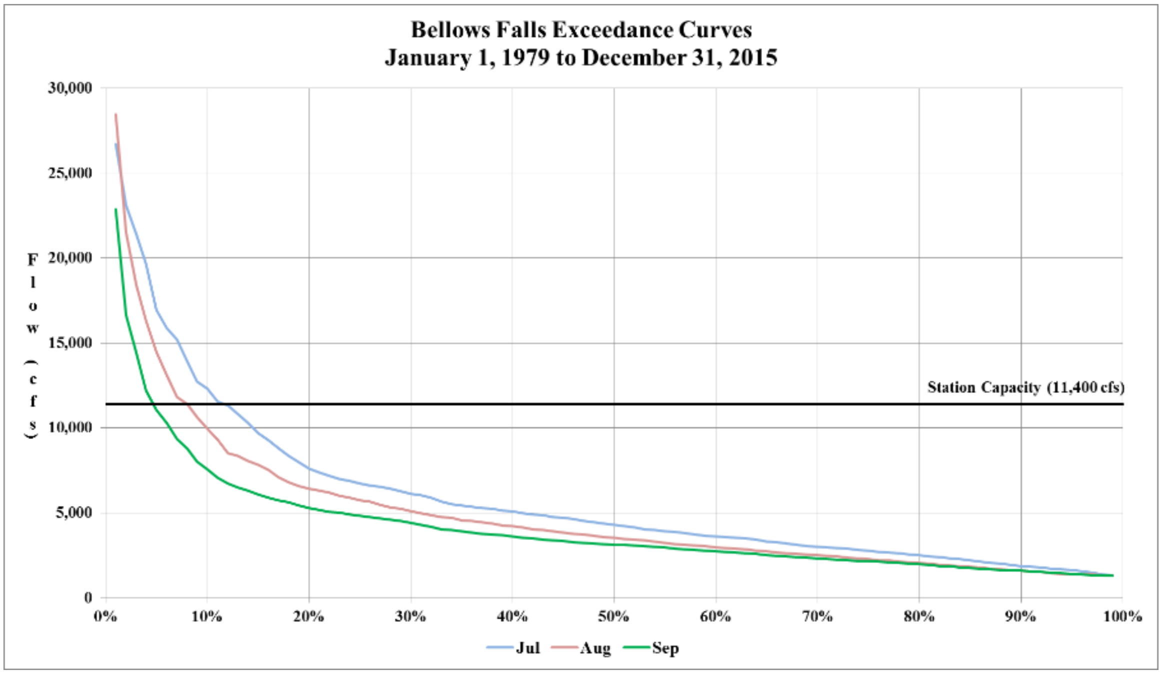
Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-6. Bellows Falls flow exceedance curves, January–March.



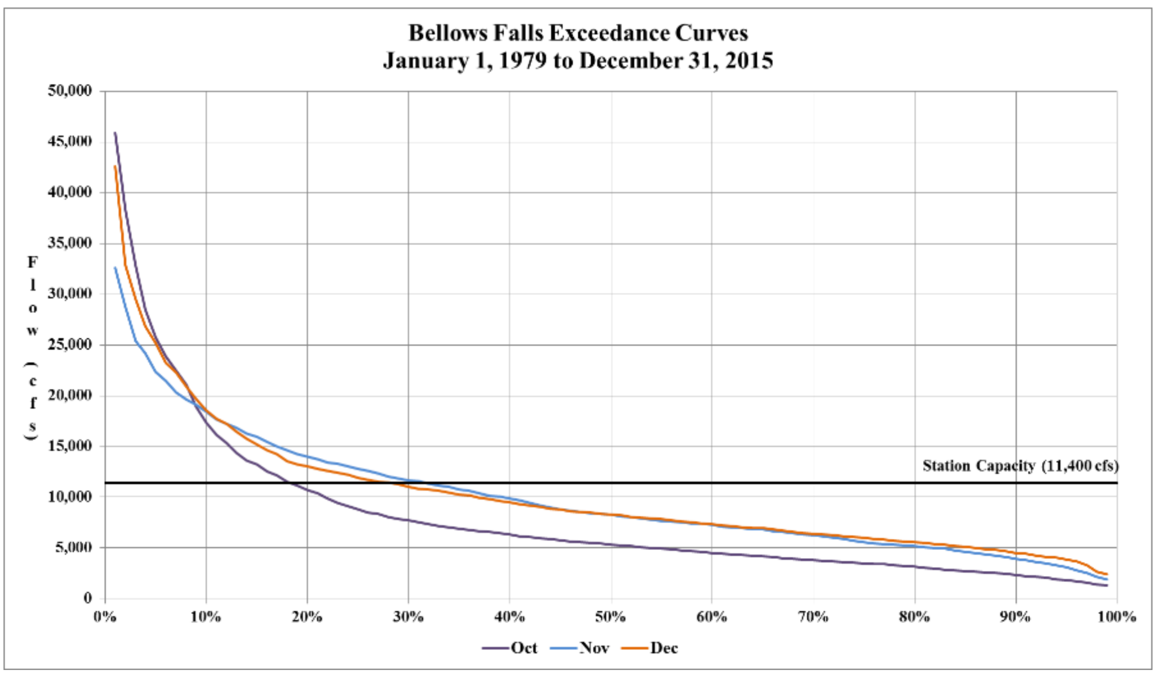
Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-7. Bellows Falls flow exceedance curves, April–June.



Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-8. Bellows Falls flow exceedance curves, July–September.



Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-9. Bellows Falls flow exceedance curves, October–December.

Table 3.4-3. Bellows Falls estimated minimum, mean, and maximum average monthly flow values (cfs), January 1979–December 2015.

Month	Minimum	Year	Average	Maximum	Year
January	2,588	1981	8,666	20,573	2006
February	2,697	1980	7,584	21,499	1981
March	4,405	2015	13,729	33,660	1979
April	7,690	1995	25,776	40,676	2008
May	7,137	1995	14,924	29,404	1996
June	3,038	1999	9,104	20,972	2006
July	1,896	1991	6,011	16,880	2013
August	1,631	2001	5,132	17,803	2008
September	1,533	1995	4,270	13,056	2011
October	1,810	2001	8,167	25,550	2005
November	2,771	2001	10,048	22,794	2005
December	3,558	2001	10,423	22,440	2003

Source: USGS (2016e, as modified by TransCanada)

Vernon Project

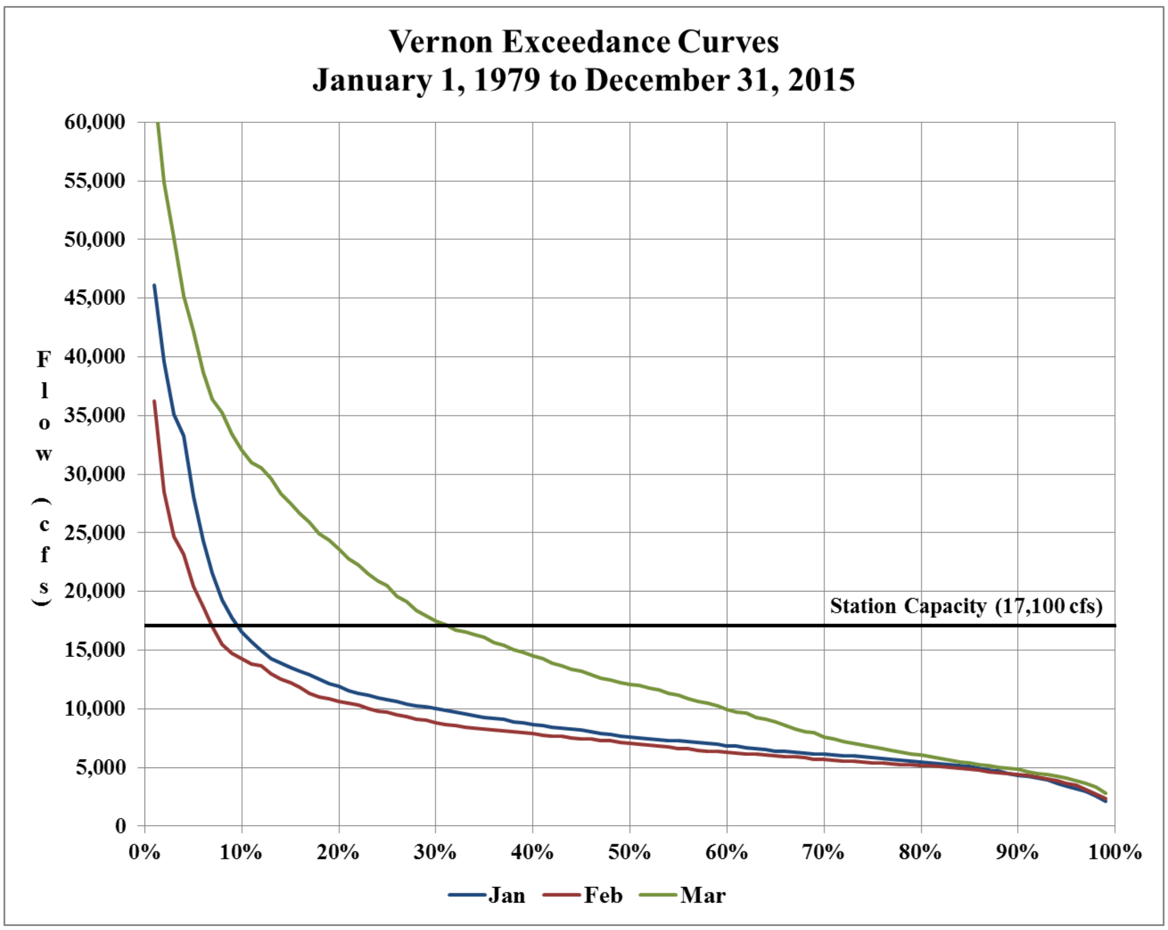
The Vernon Project has a total DA of 6,266 sq. mi. Inflow is from discharge from the Wilder and Bellows Falls Projects and natural inflow from the 852 sq. mi. of intermediate DA downstream of the Bellows Falls Project. Only 13.5 percent of inflow enters as unmanaged flow below the Bellows Falls Project, except under flood flow conditions when the USACE dams on the West River store water temporarily (see Section 3.1.1, *Overview of the Basin*).

The Vernon impoundment is approximately 26 miles long and extends upstream approximately to Dunshee Island, located downstream of the Walpole Bridge (Route 123) at Westminster Station, Vermont. The impoundment is riverine in character and ranges in depths of several feet to about 50 ft near the dam. Bathymetry in the impoundment changes rapidly as the result of underlying bedrock, channel constriction, deposition, and scour primarily associated with high flows, such as those that occurred with Tropical Storm Irene in late August 2011.

Under normal generating conditions, it takes about 4 hours for flow releases from the Bellows Falls Project to reach Vernon dam. The impoundment has a surface area of 2,550 acres and a total volume of about 40,000 acre-ft at El. 220.13 ft at the top of the stanchion boards. The overall operating range of the Project is from El. 212.13 ft (top of concrete crest) to El. 220.13 ft (8 ft). Maximum drawdown to the spillway crest if hydraulic and stanchion flashboards are lowered or removed under high flow, equates to a maximum storage capacity of 18,300 acre-ft. The more typical impoundment operating range under non-spill conditions is between

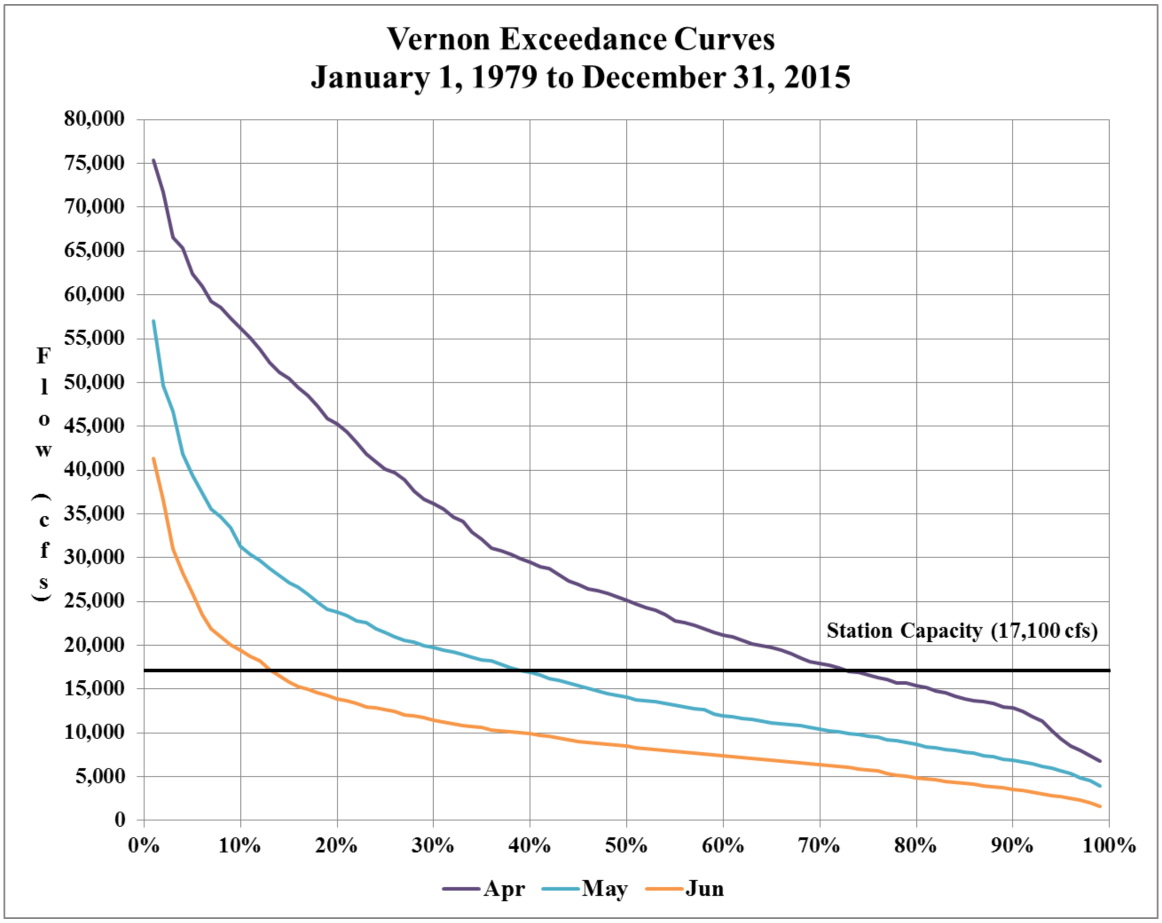
El. 218.3 and El. 220.1 for usable storage capacity of 4,489 acre-ft or 24.5 percent of the overall usable storage.

Figures 3.4-10 through 3.4-13 provide monthly flow exceedance curves for the Vernon Project from January 1, 1979, to December 31, 2015, the range of full calendar years encompassing the current license term. To provide monthly data representative of flow at the Vernon Project, daily flow data from the North Walpole gage were prorated by 1.141 based on gaged DA to produce the monthly flow exceedance curves. This proration was used to account for the normally small amount of inflow from the Cold and West rivers and smaller tributaries that flow into the North Walpole gage. Table 3.4-4 summarizes the minimum, mean, and maximum values of average monthly flows for the same data set as the exceedance curves.



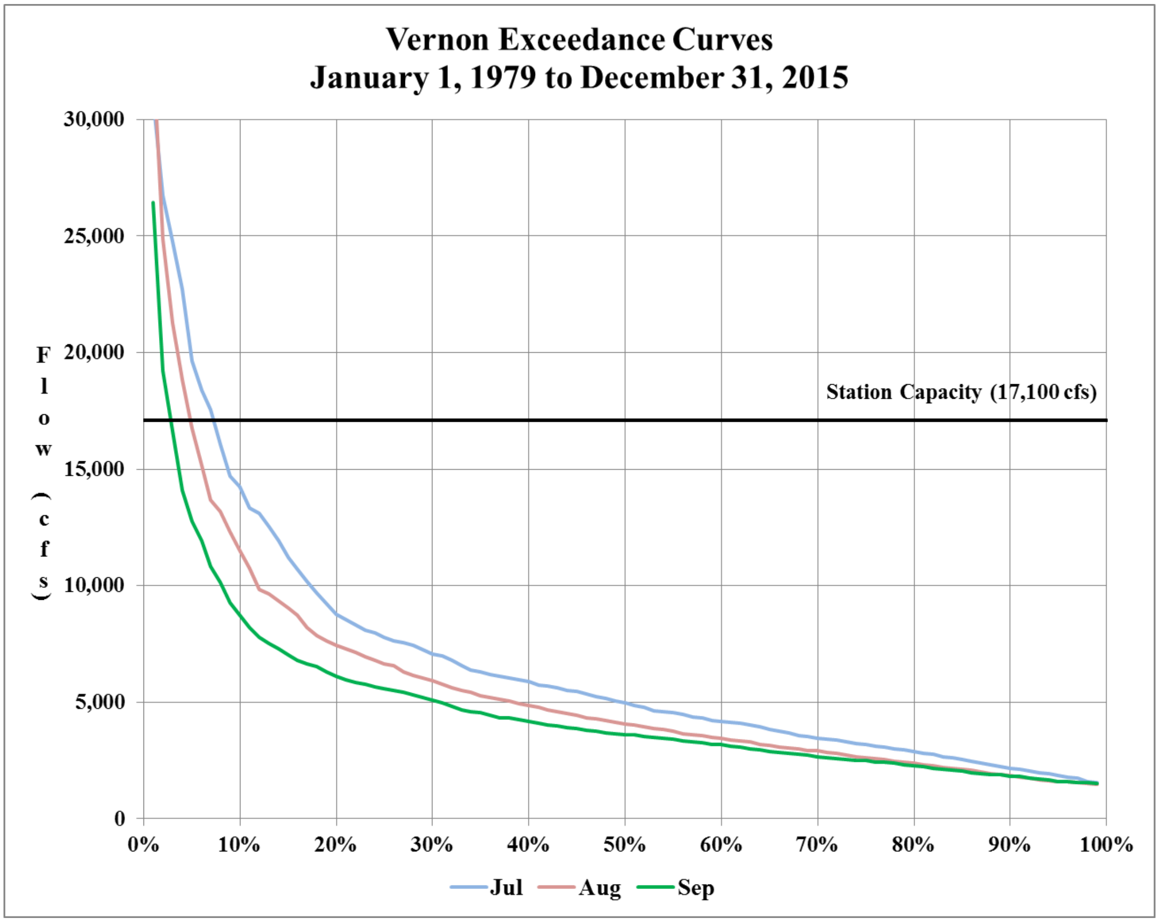
Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-10. Vernon flow exceedance curves, January–March.



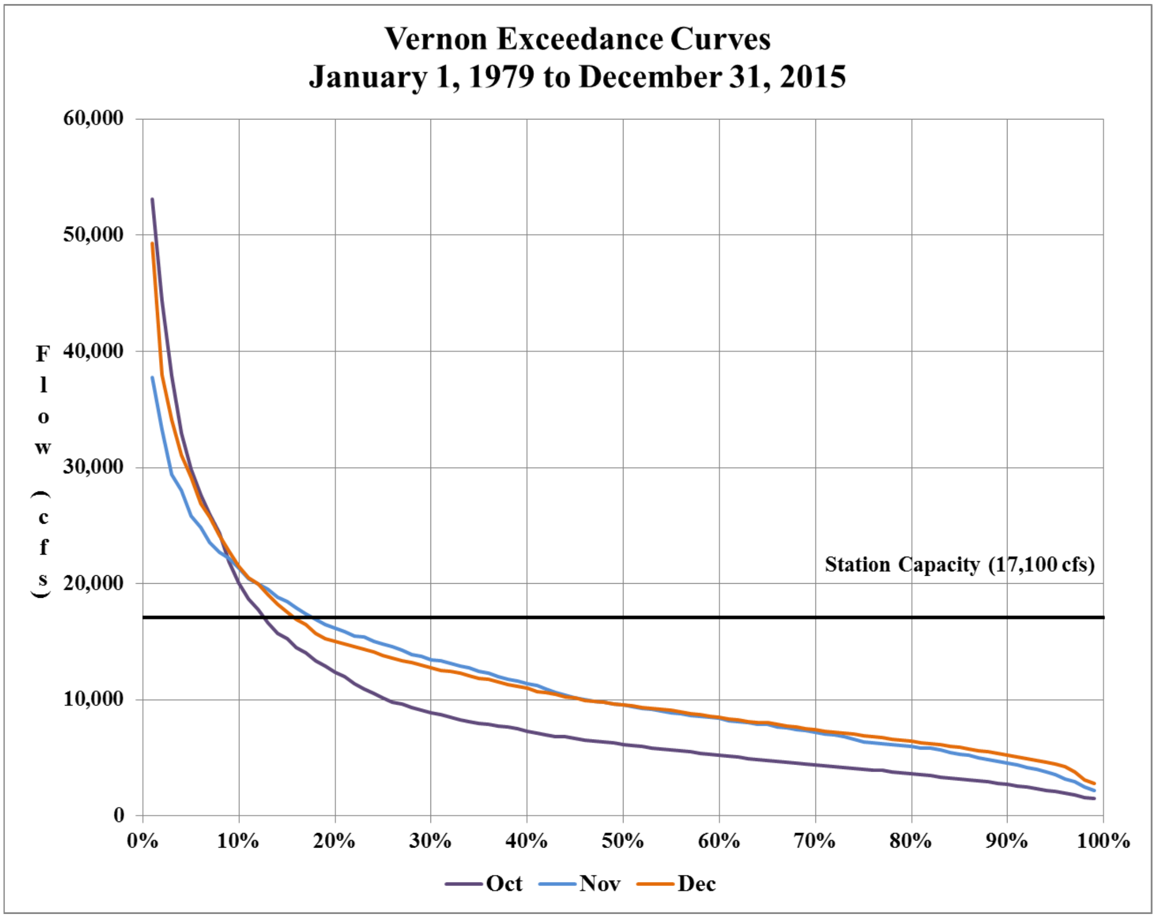
Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-11. Vernon flow exceedance curves, April–June.



Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-12. Vernon flow exceedance curves, July–September.



Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-13. Vernon flow exceedance curves, October–December.

Table 3.4-4. Vernon estimated minimum, mean, and maximum average monthly flow values (cfs), January 1979–December 2015.

Month	Minimum	Year	Average	Maximum	Year
January	2,995	1981	10,029	23,811	2006
February	3,121	1980	8,775	24,882	1981
March	5,123	2015	15,918	38,958	1979
April	8,901	1995	29,832	47,078	2008
May	8,260	1995	17,272	34,032	1996
June	3,516	1999	10,537	24,273	2006
July	2,194	1991	6,957	19,536	2013
August	1,888	2001	5,939	20,604	2008
September	1,774	1995	4,942	15,111	2011
October	2,095	2001	9,453	29,571	2005
November	3,207	2001	11,629	26,381	2005
December	4,118	2001	12,063	25,972	1983

Source: USGS (2016e, as modified by TransCanada)

Normal Project Operations

Operations at the Projects are coordinated with other TransCanada hydroelectric generating facilities on the Connecticut River, taking into consideration variations in demand for electricity and natural flow variations. TransCanada typically operates the Projects in a load-following or peaking mode in an attempt, within license limitations and available inflow, to maximize electrical power generation when the price of power is high and reduce generation when the price of power is low. When inflows are less than maximum generating capacity, TransCanada uses the limited impoundment storage at the Projects to coordinate flows between Projects and dispatch generation as required to meet the generation schedule set by ISO-NE through the day ahead or real time markets. Generation can vary during the course of any day between the required minimum flow and full generating capacity, if higher flows are available. Over the course of a day, the Projects generally pass the average daily inflow. During periods of sustained high flows, TransCanada dispatches Project generation in a must-run status to use available water for generation. Once flows exceed powerhouse capacity, TransCanada operates the Projects in a “river profile” manner, slowly reducing the WSE at the dam as inflows increase (see High Flow Operations section below).

At each Project, estimated and anticipated inflow forms the basis for bidding into the day-ahead energy market. Day-ahead hourly bids reflect must-run generation periods associated with minimum flow periods, periods when sustained higher flows are anticipated and opportunistic generation when inflow and available storage allows and demand is anticipated to be high. Anticipated inflow calculations predict impoundment elevations and determine whether spill gates must be operated to pass flow in excess of Project generating capacities. Estimated inflow is calculated using discharge from the Project plus/minus changes in impoundment elevation measured at the dam on an hourly basis, averaged over a rolling 6-hour period. Impoundment drawdown rates at each Project are typically less than 0.1 to 0.2 ft per hour and do not exceed 0.3 ft per hour based on TransCanada's established Operating Procedures. There is approximately 3,000 cfs per hour per 0.1 ft of elevation and 0.3 ft per hour represents a maximum station output. Restricting drawdown under spill conditions to the same maximum as the station prevents higher than typical drawdown rates or downstream flow increases.

Wilder Project

The maximum station discharge with all three units operating is approximately 11,700 cfs, although 98% of the time flows are between 10,700 cfs and 700 cfs. The Project itself has a maximum discharge (generation plus spill) capacity of 157,600 cfs, and the flood of record at this site, which occurred in March 1936, was 91,000 cfs. Since then, a USACE flood control structure on the Ompompanoosuc River s has been built, the Wilder Project redeveloped, and the Moore dam, which has some flood control capacity, was constructed. All of these facilities have helped to decrease the peak flow at the Wilder Project during flood events. Since the Moore dam began operating in the late 1950s, the highest flow recorded at the Wilder Project has been less than 65,000 cfs.

The licensed minimum flow at the Wilder Project is 675 cfs (or inflow if less) and is provided primarily by generation from Unit No. 3 at an efficient operating flow of about 700 cfs. Additional non-generation flows are provided seasonally on a schedule provided annually by CRASC based on fish counts at downstream projects. If required, fish passage flows are provided in spring (May 15–July 15) and in fall (September 15–November 15) for upstream fish passage (25 cfs fishway flow plus Unit No. 3 generation flow for attraction water) and for downstream fish passage (512 cfs) from October 15 to December 31. As of 2016, CRASC no longer requires downstream passage operations at Wilder for Atlantic Salmon smolts in spring, and only requires fall downstream passage operations if 50 or more adult salmon are documented passing upstream (see Section 3.5, *Fish and Aquatic Resources*).

During the summer recreation season, beginning on the Friday before Memorial Day, through the last weekend in September, TransCanada maintains a self-imposed minimum impoundment level at El. 382.5 ft from Fridays at 4:00 p.m. through Sundays at midnight. TransCanada maintains similar elevations for holidays during this period.

Bellows Falls Project

The maximum station discharge with all three units operating is approximately 11,400 cfs, although 98% of the time flows are between 11,235 cfs and 1,220 cfs. The Project itself has a maximum discharge (generation plus spill) capacity of 119,785 cfs, and the flood of record, occurred in March 1936, was 156,000 cfs. Since then, three upstream USACE flood control structures have been built (Union

Village, Ompompanoosuc River; North Hartland, Ottauquechee River; and North Springfield, Black River) and the Moore dam, which has some flood control capability, was constructed. These facilities have helped to decrease the peak flow during flood events. Since the Moore dam began operating in the late 1950s, the highest flow recorded at the Bellows Falls Project (as measured at the dam by TransCanada) was 103,397 cfs during Tropical Storm Irene on August 29, 2011.

The licensed minimum flow at the Bellows Falls powerhouse is 1,083 cfs (or inflow if less) and is provided primarily through generation, typically at least 1,200 cfs. There is no minimum flow requirement through the dam into the bypassed reach, but leakage provides some flow in the bypassed reach (flows range between 125-300 cfs as calculated or estimated over the course of various studies. Additional non-generation flows are provided seasonally at the powerhouse on a schedule provided annually by CRASC based on fish counts at downstream projects. If required, fish passage flows are provided in spring (May 15–July 15) and in fall (September 15–November 15) for upstream fish passage (25 cfs fishway flow and 55 cfs attraction flow) and for downstream fish passage (225 cfs). As of 2016, CRASC no longer requires downstream passage operations at Bellows Falls for Atlantic Salmon smolts in spring, and it only requires fall downstream passage operations if 50 or more adults are documented passing upstream (see Section 3.5, *Fish and Aquatic Resources*).

During the summer recreation season, beginning the Friday before Memorial Day, through the last weekend in September, TransCanada maintains a self-imposed minimum impoundment level of El. 289.6 from Fridays at 4:00 p.m. through Sundays at midnight and similar hours for holidays during this period.

Vernon Project

The maximum station discharge with all ten units operating under ideal or optimum conditions is considered to be about 17,100 cfs. However, actual operating data suggests that total station discharge is rarely, if ever, greater than 15,500 cfs, and 98 percent of the time flows are between 14,500 cfs and 1,530 cfs. The Project itself has a maximum discharge (generation plus spill) capacity of 127,600 cfs, and the flood of record, which occurred in March 1936, was 176,000 cfs. Five USACE flood control structures (Union Village, Ompompanoosuc River; North Hartland, Ottauquechee River; North Springfield, Black River; Ball Mountain and Townsend, West River) along with Moore dam which has some flood control capability have helped to decrease the peak flow during flood events. Since Moore dam began operating in the late 1950s and USACE dams were constructed in the 1960s, the highest flow recorded at Vernon dam has been less than 110,000 cfs. The peak discharge from Vernon dam during Tropical Storm Irene reached 102,626 cfs.

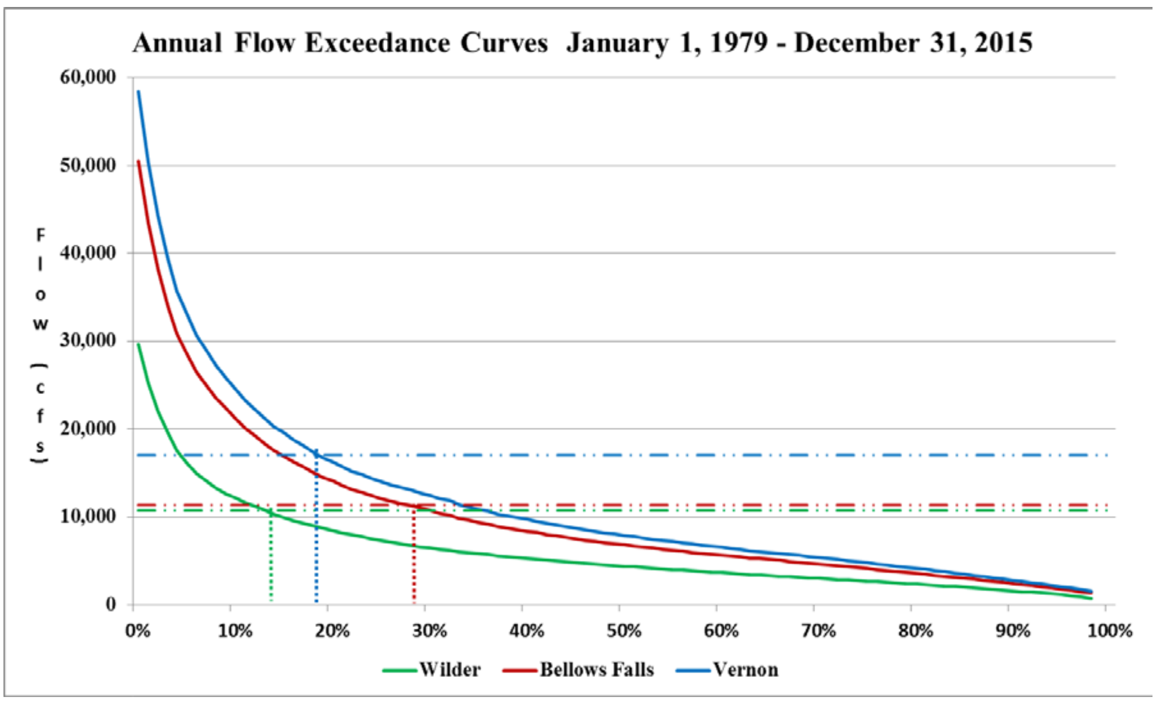
The licensed minimum flow at Vernon is 1,250 cfs (or inflow if less) and is provided primarily through generation and is typically at least 1,500 cfs and above 1,600 cfs approximately 99 percent of the time. Additional non-generation flows are provided seasonally on a schedule provided annually by CRASC based on fish counts at downstream projects. If required, fish passage flows are provided in spring (April

15–July 15) and in fall (September 15–November 15) for upstream fish passage for adult Atlantic Salmon and adult American Shad (65-cfs fishway flow and 200-cfs attraction flow) and for downstream fish passage of several species from April 1–December 31 (350 cfs from the fish pipe and 40 cfs from the fish tube) (see Section 3.5, *Fish and Aquatic Resources*).

During the summer recreation season, beginning the Friday before Memorial Day, through the last weekend in September, TransCanada maintains a self-imposed minimum impoundment level at El. 218.6 ft from Fridays at 4:00 p.m. through Sundays at midnight and similar hours for holidays during this period.

High Flow Operations

High flows occur routinely throughout the year at each Project, most often during the spring freshet and the fall rainy season. Annually flows at the dams exceed Project capacity approximately 14 percent of the time at the Wilder Project, approximately 29 percent of the time at the Bellows Falls Project, and approximately 19 percent of the time at the Vernon Project (Figure 3.4-14, see also monthly flow exceedance curves above).



Source: USGS (2016e, as modified by TransCanada)

Figure 3.4-14. Wilder, Bellows Falls, and Vernon annual flow exceedance curves.

Spring runoff on the Connecticut River typically occurs in phases based on latitude. For example, normal spring runoff at the Vernon Project occurs distinctly earlier than runoff above Bellows Falls and Wilder dams but below the Fifteen Mile Falls Project. The spring runoff from the Connecticut Lakes down to the Fifteen Mile Falls Project occurs even later in the season. The seasonal storage capability of the Fifteen Mile Falls Project is limited in comparison to the total amount of inflow it receives. However, the storage capacity at the Fifteen Mile Falls Project is used during spring runoff to "shave" the maximum anticipated peak flows downstream and refill the impoundments). This operation reduces potential downstream high water conditions at the Wilder, Bellows Falls, and Vernon Projects, which are typically spilling, and in the case of Bellows Falls and Vernon, often prevents the need to trip stanchions.

During periods of ice movement in the spring, frequent upstream observations and river elevation checks are made within the impoundments. When an ice jam occurs upstream of a dam, an increased or artificial inflow condition is created by a large swell of water in front of the jam as the water behind the jam pushes the ice and water in front of it. When this condition is observed, TransCanada must increase generation or spill gate discharges to pass this temporary situation and to keep the impoundment elevation within its operating pond limits.

When anticipated inflows to each Project impoundment increase above Project generating capacity, TransCanada initiates "river profile" operations by lowering the impoundment elevation at each dam. In the case of the Wilder Project, this operations guideline is the result of the engineering design consideration that went into the final Wilder dam re-development when the present day Project was first conceived. The primary consideration for selecting a maximum operating elevation of 385 ft and the high flow "river profile operation" was to limit the extent of tillable agricultural land that would be inundated, and under high water conditions, the extent of flooding would not increase beyond what had been flooded prior to the re-development. The February 1949 Indenture and Flowage Easement with the Boston and Maine Railroad and from testimony given before the Federal Power Commission (predecessor of FERC) license hearings prior to the redevelopment of the Wilder Project specified those design and operating criteria. The purpose of this operation is to ensure that for flood flows up to the magnitude of those previously experienced (11,000 to 100,000 cfs), the backwater elevations with the current Wilder dam with the pond pre-drawn to El. 380 ft will not exceed those that would have occurred with the old dam.

Once calculated anticipated inflows exceed Project generating capacity, various combinations of spill gates (see Section 2.1, *No-action Alternative*) are operated and impoundment elevations are maintained at certain set-points until flows exceed the total spill capacity of the Project, at which point would surcharge WSE at the dam. Table 3.4-5 lists maximum impoundment elevations that are maintained based on different anticipated inflow levels at each Project.

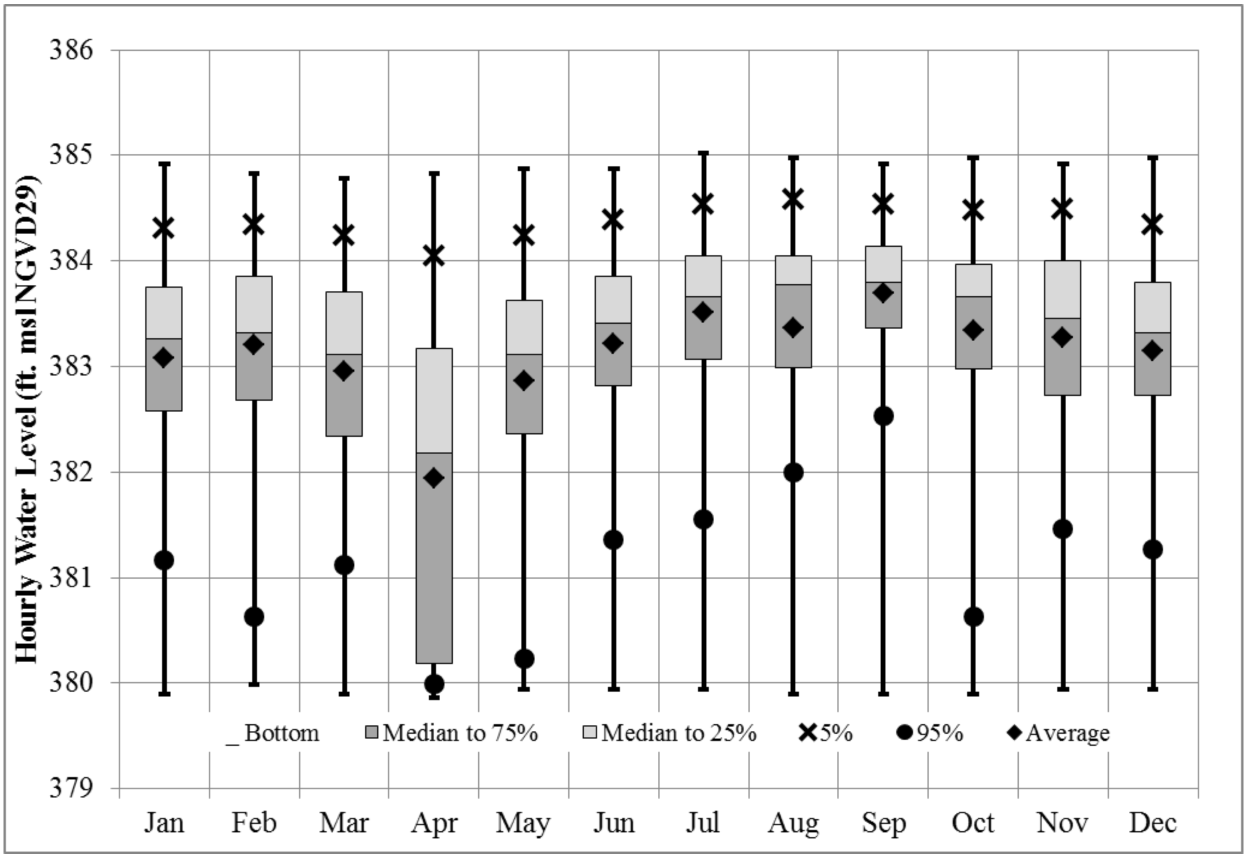
Table 3.4-5. River profile and high flow operations inflows and impoundment elevations.

Project	Anticipated Inflow (cfs)	Maximum Elevation at the Dam (NGVD29)
Wilder	<10,000	385.0
	10,000	384.5
	12,000	384.0
	14,000	383.0
	16,000	382.0
	18,000	381.0
	20,000–85,000	380.0
	85,000–145,000	Impoundment elevation rises from 380.0 and is maintained at 384.0 as long as possible. Stanchion board removal at 145,000 cfs
	> 145,000	All gates are opened and all stanchion bays removed, impoundment elevation increases dependent upon inflow increases
Bellows Falls	< 11,000	291.6
	11,000–20,000	291.1
	20,000–50,000	290.1 (289.6 if ice is present)
	50,000–90,000	289.6 and partial stanchion board removal @ 52,000 cfs
	>90,000	All gates are opened and all stanchion bays removed, impoundment elevation increases dependent upon inflow increases; impoundment elevation rises from 289.6 and is maintained at 290.6. as long as possible before elevation surcharges as inflow increases
Vernon	< 17,000	220.13
	17,000–45,000	219.6
	45,000–70,100	218.6
	70,100 < 105,000	Impoundment elevation rises from 218.5 and is maintained at 220.1 as long as possible, including partial to full stanchion board removal as needed
	>105,000	All gates, flashboard panels are opened and all stanchion bays removed, impoundment elevation increases dependent upon inflow increases

Source: TransCanada

Wilder Project

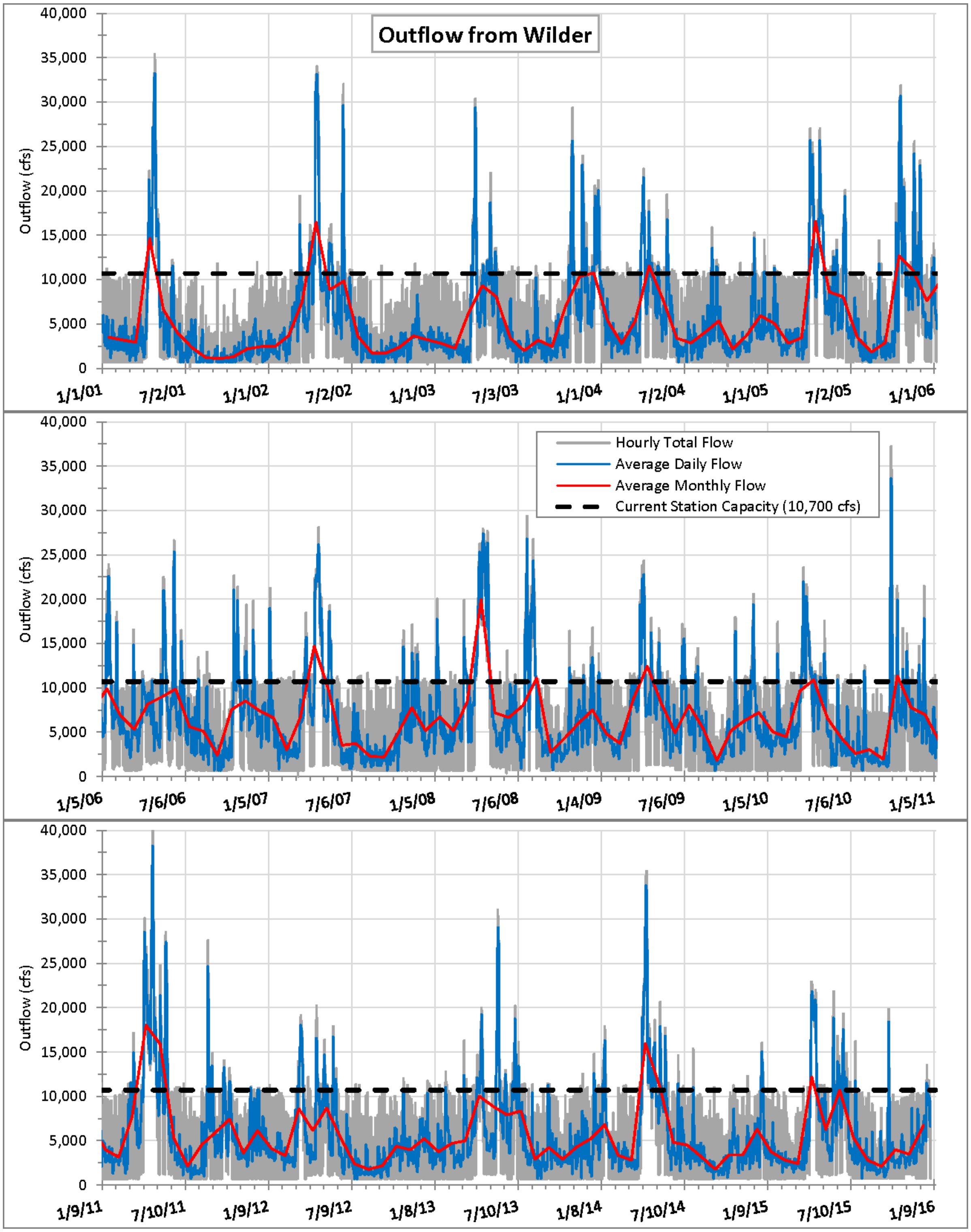
Figure 3.4-15 presents hourly median, average, minimum, and maximum values and the 5, 25, 75, and 95 percent exceedance values for WSEs at Wilder dam from January 1, 2001, to December 31, 2015. This figure illustrates the operational range and high flow operations when the impoundment WSE is lowered at the dam in April when flows in excess of 10,000 cfs are common.



Source: TransCanada

Figure 3.4-15. Wilder hourly impoundment water surface elevations January 1, 2001–December 31, 2015.

Figure 3.4-16 graphs hourly outflow as compared to the daily and monthly average outflow from January 1, 2001, to December 31, 2015. The figure shows that outflows from the Project are normally between minimum flow and the maximum station discharge of 11,700 cfs under non-spill conditions.

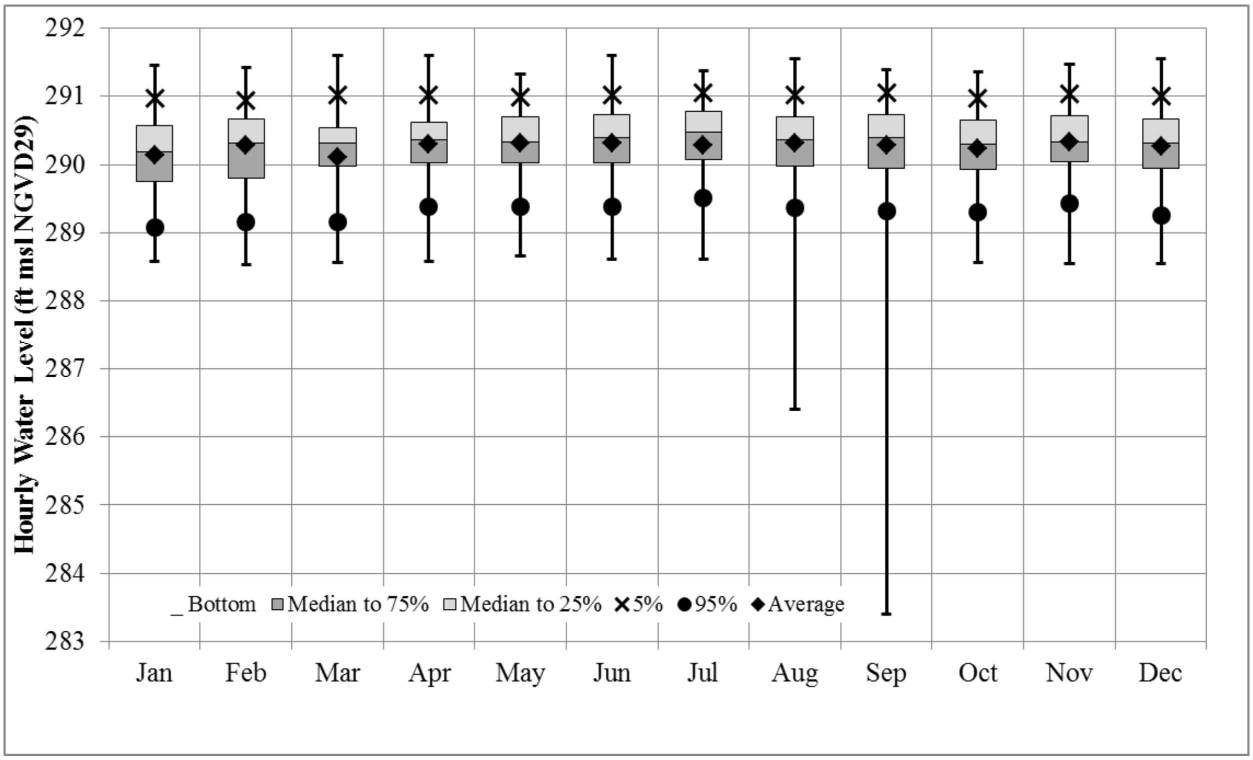


Source: TransCanada

Figure 3.4-16. Hourly, average daily, and average monthly outflow from the Wilder Project (January 1, 2001–December 31, 2015).

Bellows Falls Project

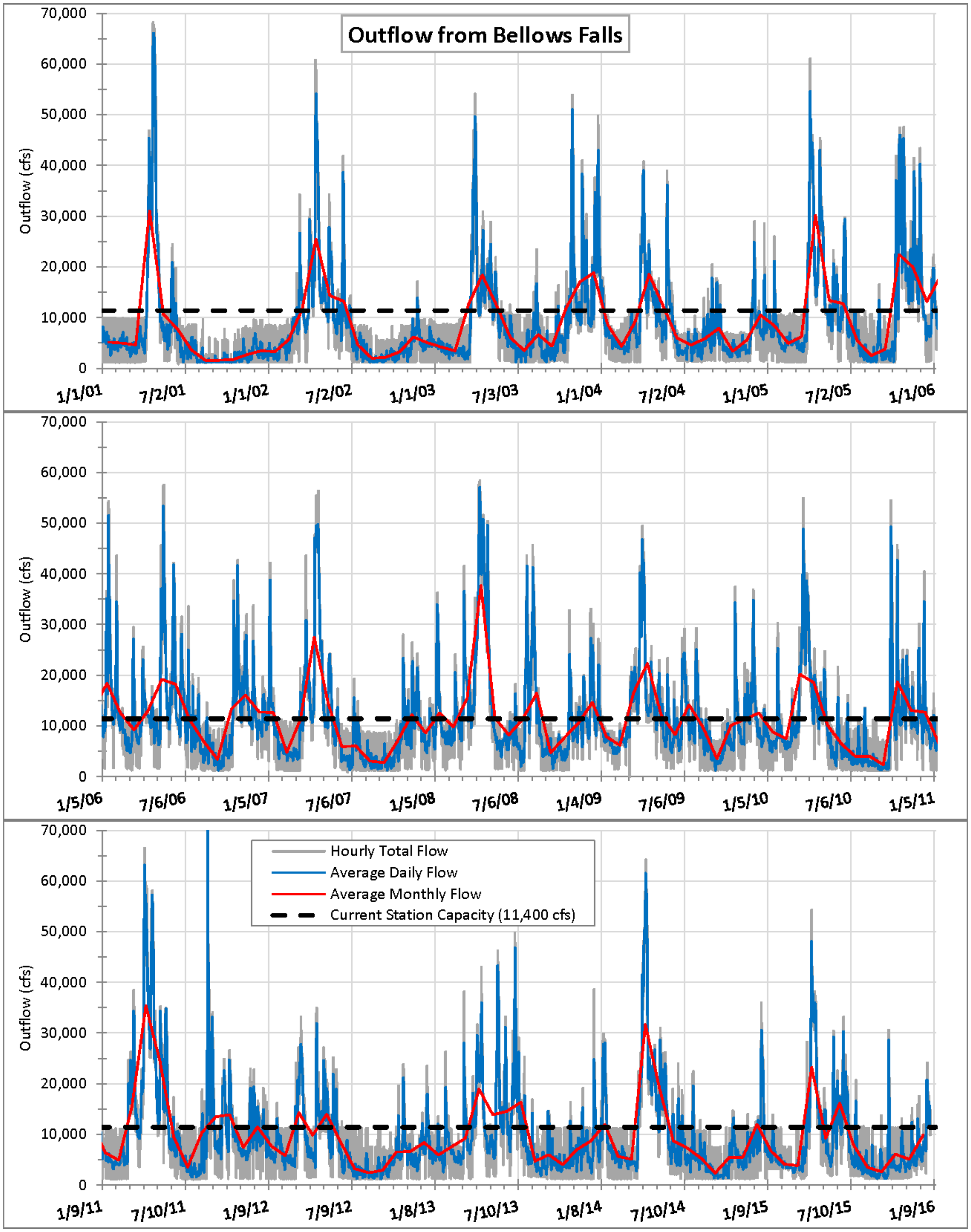
Figure 3.4-17 presents the average hourly median, average, minimum, and maximum values and the 5, 25, 75, and 95 percent exceedance values for impoundment WSEs from January 1, 2001, to December 31, 2015. This figure illustrates the operating range including periods when the WSE dropped below the minimum operational impoundment level in late August and early September 2011 after Tropical Storm Irene which had peak flows of 103,397 cfs that necessitated pulling two bays of stanchion boards and a portion of a third bay (between the concrete piers).



Source: TransCanada

Figure 3.4-17. Bellows Falls hourly impoundment water surface elevations January 1, 2001–December 31, 2015.

Figure 3.4-18 graphs hourly outflow as compared to the daily and monthly average outflow from January 1, 2001, to December 31, 2015. The figure shows that outflows from the Project are normally between minimum flow and the maximum station discharge of 11,400 cfs under non-spill conditions.

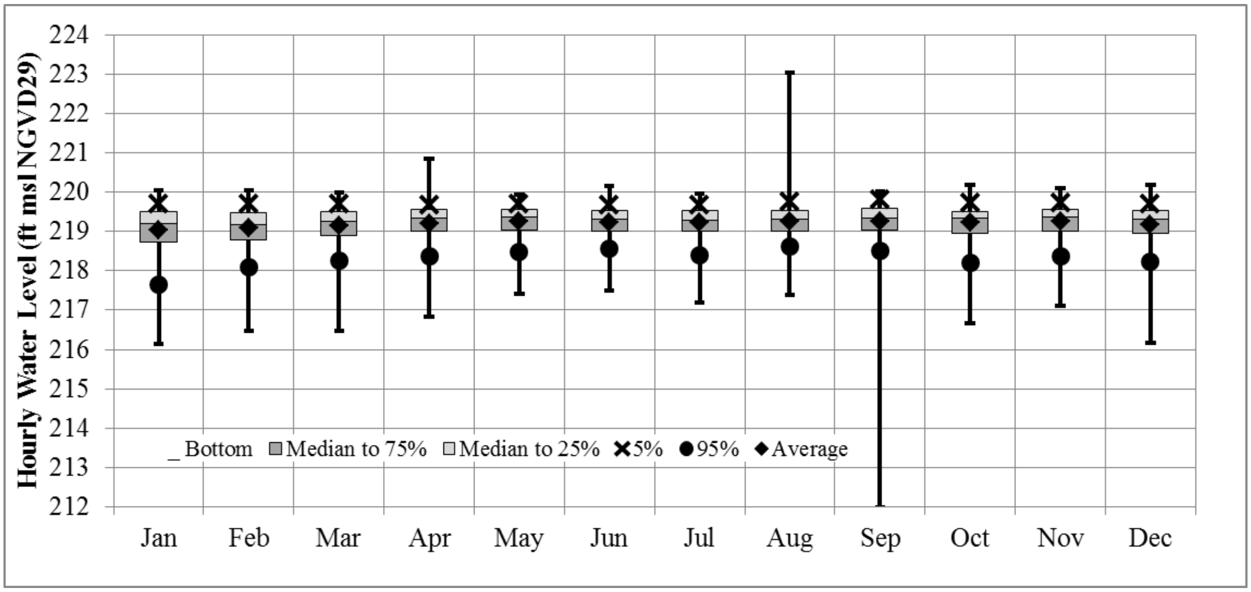


Source: TransCanada

Figure 3.4-18. Hourly, average daily, and average monthly outflow from the Bellows Falls Project (January 1, 2001–December 31, 2015).

Vernon Project

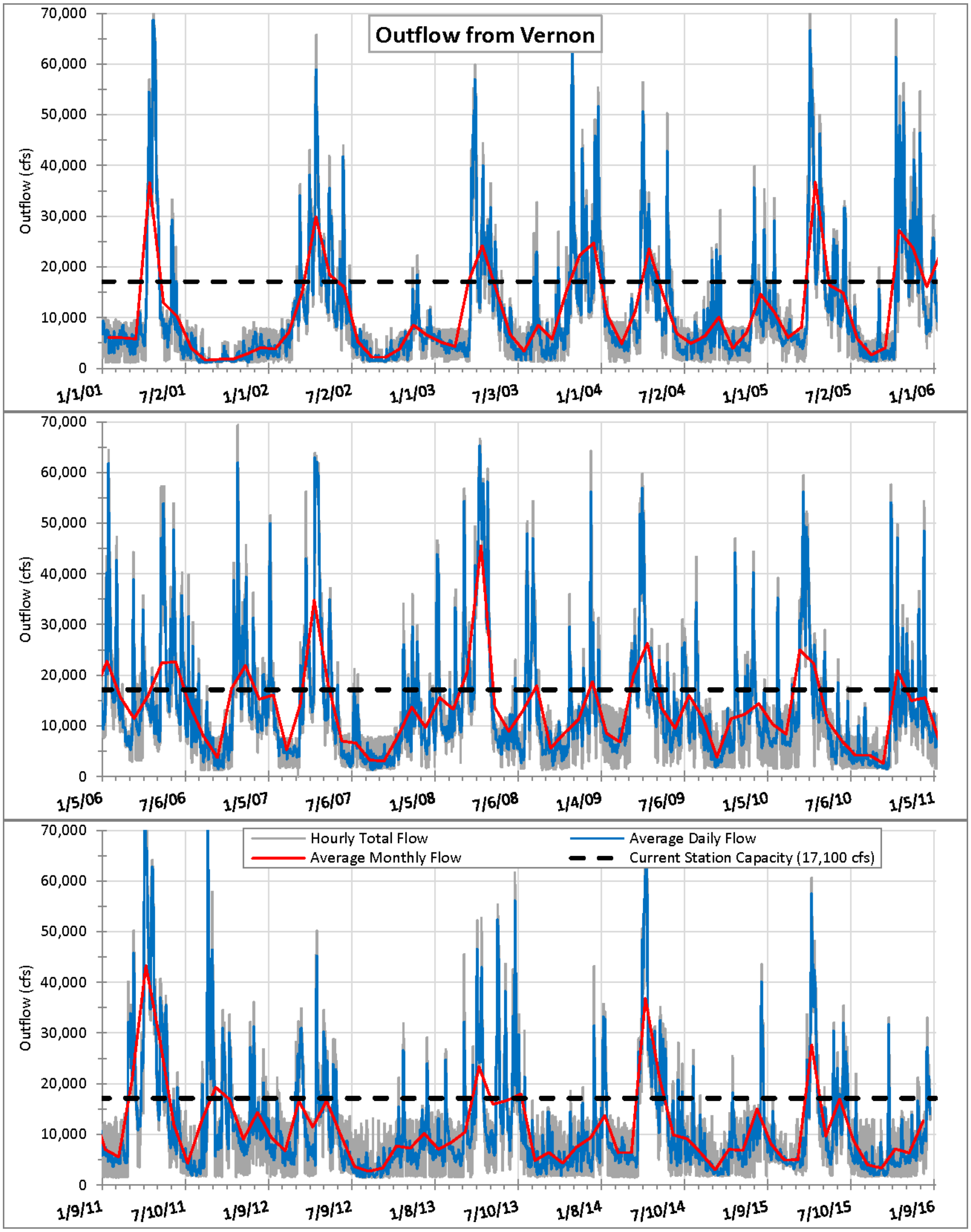
Figure 3.4-19 presents hourly median, average, minimum, and maximum values and the 5, 25, 75, and 95 percent exceedance values for impoundment WSEs from January 1, 2001, to December 31, 2015, and illustrates the operating rage. However, the impoundment reached a peak elevation of 223.04 ft on August 29, 2011, during Tropical Storm Irene and discharge reached a peak flow of 102,626 cfs. The minimum impoundment level during the period shown was El. 212.0 ft on September 14, 2011, also as a result of Tropical Storm Irene.



Source: TransCanada

Figure 3.4-19. Vernon hourly impoundment elevations January 1, 2001–December 31, 2015.

Figure 3.4-20 graphs hourly outflow as compared to the daily and monthly average outflow from January 1, 2001 to December 31, 2015. The figure shows that outflows from the Project are normally between minimum flow and the optimum station discharge of 17,100 cfs under non-spill conditions.



Source: TransCanada

Figure 3.4-20. Hourly, average daily, and average monthly outflow from the Vernon Project (January 1, 2001–December 31, 2015).

3.4.1.2 Water Quality

Surface Water Quality Standards and Designated Uses

The Connecticut River within the Wilder, Bellows Falls, and Vernon Projects is subject to both New Hampshire and Vermont surface water quality standards and designated uses relevant to their respective waterbody classification.

New Hampshire

Through its NH-Env-Wq 1700 Surface Water Quality Regulations (readopted with amendments in 2016), New Hampshire established water quality standards for the state's surface water uses. These water quality standards are intended to protect public health and welfare, enhance the quality of water, and serve the purposes of the CWA and Revised Statute Annotated 485-A. In addition, the surface water quality standards consist of numerical and narrative criteria for the protection and propagation of fish, shellfish, and wildlife and provide for such designated uses as recreation, public water supply, agriculture, and industry and navigation. Criteria are established by statute Title L Water Management and Protection, Chapter 485-A, *Water Pollution and Waste Disposal*, and by administrative rules Env-Wq 1700.

Surface waters in New Hampshire are classified as either Class A or Class B. Class A waters are of the highest quality and are managed to be potentially acceptable for water supply uses after adequate treatment. Class B waters are of the second highest quality and are managed to achieve and maintain certain designated uses. The New Hampshire General Court has designated the Connecticut River in the vicinity of the Wilder, Bellows Falls, and Vernon Projects as Class B waters. Tables 3.4-6 and 3.4-7, respectively, present and describe applicable water quality standards and the designated uses for Class B waters in New Hampshire.

Table 3.4-6. Applicable New Hampshire Class B surface water quality standards.

Parameter	Administrative Code	Numeric or Narrative Standard
Temperature	Env-Wq 1703.13	Any increase shall not be such as to appreciably interfere with the uses assigned to this class.
Dissolved oxygen (DO)	Env-Wq 1702.07	Daily average at least 75 percent saturation; instantaneous minimum of 5.0 milligrams per liter (mg/L).
pH	Env-Wq 1703.18	6.5 to 8.0, unless due to natural causes.
Turbidity	Env-Wq 1703.11	Not exceed naturally occurring conditions by more than 10 nephelometric turbidity units (NTU). If a discharge causes or contributes to an increase equal to or more than 10 NTU of receiving water upstream of the discharge or otherwise outside of the visible discharge, a violation of the turbidity standard shall be deemed to have occurred.
Nutrients	Env-Wq 1703.14	Nitrogen—none in such concentrations that would impair any existing or designated uses, unless naturally occurring. Phosphorus—none in such concentrations that would impair any existing or designated uses, unless naturally occurring.
Bacteria (Escherichia coli)	Env-Wq 1703.06	Geometric mean of three samples over 60-day period shall not contain more than 126 *E-coli* bacteria per 100 milliliters (mL), or no greater than 406 per 100 mL in one sample. For designated beach areas, the geometric mean based on at least three samples over a 60-day period shall not exceed 47 *E-coli* bacteria per 100 mL or 88 per 100 mL in a single sample, unless naturally occurring.

Sources: NHCAR (2008) and NHGC (1998)

Table 3.4-7. Designated uses for Class B New Hampshire surface waters.

Designated Use	NHDES Definition
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers
Drinking Water Supply after Adequate Treatment	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.
Primary Contact Recreation	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.

Source: NHDES (2015a)

Vermont

Vermont water quality standards serve as the foundation to protect and enhance the quality of Vermont's surface waters (VDEC, 2014a). The current water quality standards became effective December 30, 2014. Surface waters in Vermont are classified as Class A(1), Class A(2), or Class B based on numerical and/or narrative criteria to protect the designated uses. Waters designated as Class A(1) are Ecological Waters that are managed to maintain an essentially natural condition. Class A(2) waters are Public Water Supply waters managed for the natural condition with the exception of withdrawals for public water supplies. Class B waters are managed to achieve and maintain a level of quality that fully supports certain designated uses. The Connecticut River in the vicinity of the three Projects is designated as Class B water in Vermont and as coldwater fish habitat (VDEC, 2014a).[22] Applicable Vermont surface water quality standards and designated uses for the Wilder, Bellows Falls, and Vernon Projects are presented in Table 3.4-8 and Table 3.4-9, respectively.

[22] Within the mainstem Project areas, the Connecticut River is not explicitly listed as either Class B warmwater fish habitat or Class B coldwater fish habitat; therefore, it is assumed the Connecticut River is a Class B coldwater fishery (see VDEC, 2014a, Appendix A). However, see discussion under Table 3.4-9, note b.

Table 3.4-8. Applicable Vermont Class B surface water quality standards for coldwater fish habitat.[a]

Parameter	Chapter and Section	Numeric or Narrative Standard
Temperature	3-01 B.1a and b	Change or rate of change in temperature, either upward or downward, shall be controlled to ensure full support of aquatic biota, wildlife, and aquatic habitat uses. The total increase from ambient temperature due to all discharges and activities shall not exceed 1 degree Fahrenheit (°F) (0.56 degrees Celsius [°C]) from ambient temperatures, except for the assimilation of thermal waste as permitted by the Secretary.
DO	3-04 B.2a	Not less than 6 mg/L and 70% saturation at all times in all other waters designated as a coldwater fish habitat.
pH	3.01 B.9	pH values shall be maintained within the range of 6.5 and 8.5. Both the change and the rate of change in pH values shall be controlled to ensure the full support of the aquatic biota, wildlife, and aquatic habitat uses.
Turbidity	3-04 B.1a	None in such amounts or concentrations that would prevent the full support of uses, and not to exceed 10 NTU as an annual average under dry weather base-flow conditions.
Nutrients	3.01 B.3c(3) and 3.01 B.2a	Nitrates not to exceed 5.0 mg/L as nitrogen (NO_3-N) at flows exceeding low median monthly. Phosphorus is to be limited so that it will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.
Bacteria (*Escherichia coli*)	3-04 B.3	Not to exceed a geometric mean of 126 organisms per 100 mL obtained over a representative period of 60 days, and no more than 10% of samples above 235 organisms/100 mL. In waters receiving combined sewer overflows, the representative period shall be 30 days.

Source: VDEC (2014a)

a. Waters in which one or more applicable water quality criteria are not met because of natural influences shall not be considered in noncompliance with respect to such criteria. In such waters, activities may be specifically authorized by a permit, provided that those activities do not further reduce the quality of the receiving waters and comply with all other applicable criteria.

Table 3.4-9. Designated uses for Vermont Class B surface waters.

Designated Use	Numeric or Narrative Standard[a]
Aquatic Biota, Wildlife, and Aquatic Habitat	Aquatic biota and wildlife sustained by high quality aquatic habitat with additional protection in those waters where these uses were sustainable at a higher level based on Water Management Type designation.[b]
Aesthetics	Water character, flows, water level, bed and channel characteristics, exhibiting good aesthetic value and, where attainable, excellent aesthetic value based on Water Management Type designation.
Public Water Supply	Suitable for use as a source for public water supply with filtration and disinfection.
Irrigation of Crops and Other Agricultural Uses	Suitable, without treatment, for irrigation of crops used for human consumption without cooking and suitable for other agricultural uses.
Swimming and Other Primary Contact Recreation	Suitable for swimming and other forms of water based recreation where sustained direct contact with the water occurs and, where attainable, suitable for these uses at very low risk of illness based on Water Management Type designation.
Boating, Fishing and Other Recreational Uses	Suitable for these uses with additional protection in those waters where these uses are sustainable at a higher level based on Water Management Type designation.

Source: VDEC (2014a)

a. All Class B waters shall eventually be designated as being either Water Management Type 1, Type 2 or Type 3. The Connecticut River encompassing the Wilder, Bellows Falls and Vernon Projects has no such water management-type designation; therefore, according to Section 3-06 of the Vermont Water Quality Standards, the criteria based on a water management type shall not apply.

b. The Vermont temperature standard stated is for Class B coldwater habitat including the Connecticut River. The Waits, Ottauquechee, and Black rivers are classified as warmwater fish habitat at the confluence with the Connecticut River, but only from June 1 through September 30. The *Water Quality Standards Revisions – 2016 Fact Sheet & Questions and Answers*, dated July 14, 2016, indicates Class B waters would be independently reclassified as either Class B(1) or Class B(2) and that the temperature criteria would change for coldwater fish habitat based on the reclassification (http://dec.vermont.gov/sites/dec/files/wsm/Laws-Regulations-Rules/2016_07_16%3B_FAQ_for_VWQS.pdf).

According to the FAQ, the temperature criteria will not change for Class B(2) waters. However, the temperature criteria will change for waters classified as Class B(1). The FAQ states: "[f]or waters that are classified B(1) for fishing, the 1 degrees °F increase criterion will apply to waters with a seven-day mean maximum daily temperature between June 1 and September 30 of less than 68°F. For B(1) waters over 68°F, there shall be no increase in temperature due to all discharges and activities. The 68°F criterion was developed using a large Agency database from Vermont streams supporting wild Brook, Brown, or Rainbow trout populations."

It has not been explicitly published whether the Connecticut River that encompasses the three Projects would be reclassified as either warmwater or coldwater fish habitat and whether the temperature criteria would change. Results from Study 10, *Fish Assemblage Study*, indicate the percent composition of fish species within the Connecticut River in the vicinity of the three Projects substantially consists of more warmwater species than coldwater species (http://www.vtfishandwildlife.com/common/pages/DisplayFile.aspx?itemId=111999). In fact, the percent composition of trout species within Connecticut River that encompasses the three Projects is less than 0.1 percent (see Figure 5.4-3 of Study 10). Therefore, the Connecticut River in the vicinity of the three Projects can be considered to be more warmwater fish habitat than coldwater fish habitat.

Section 303(d) Listing and Total Maximum Daily Load

Under Section 303(d) of the federal CWA, and in adherence with federal water quality planning and management regulations (40 C.F.R. Part 130), all states are required to develop lists of impaired or "Category 5" waters; commonly referred to as the 303(d) list. The list includes lakes, ponds, rivers, and streams whose water quality does not meet state-defined water quality standards. Each state's list must be updated every 2 years and submitted to the U.S. Environmental Protection Agency (EPA) for approval. The CWA requires the development of total maximum daily loads (TMDLs) for waters on the list and the provision of a schedule indicative of TMDL completion priority.

In 2014, NHDES prepared a draft list of impaired waterbodies for the state (NHDES, 2015b). Likewise, in 2014, VDEC prepared a final 303(d) list of impaired waterbodies for which a TMDL is required to be developed (Part A), a list of impaired waterbodies with other pollution control measures in place other than a TMDL (Part B), a list of impaired waterbodies that have a completed TMDL approved by EPA (Part D), a list of waterbodies that are altered aquatic habitats or designated uses are affected by invasive species (Part E), waterbodies affected by flow alteration (Part F), and other stressed waterbodies that are prevented from attaining higher water quality. Each assessment unit and associated water quality impairments and stresses are discussed below from upstream to downstream by Project for New Hampshire and Vermont.[23] Table 3.4-10 presents the NHDES and VDEC 303(d) listing of impaired or threatened waters in the Wilder, Bellows Falls, and Vernon Project areas for which a TMDL is needed (NHDES, 2015b; VDEC, 2014b), tributaries to the Connecticut River are included only if they are impaired at the mouth, adjacent to Project waters.[24] Table 3.4-10 also presents the length of river and designated uses that are impaired, the type of impairment, the TMDL priority, and the source of the impairment.

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[23] An assessment unit is the basic unit of record for conducting and reporting water quality assessments.

[24] Defined as within 100 ft of the river.

Table 3.4-10. NHDES and VDEC 303(d) listing of impaired or threatened waterbodies in the Wilder, Bellows Falls, and Vernon Project vicinity for which a TMDL is needed.

Waterbody (Unit ID)	Primary Town, State[a]	Project Vicinity	Size	Designated Uses[b]	Impairment Type	TMDL Priority	Pollutant Source[c]
Wilder							
Clark Brook (NHRIV801030703-02)	Haverhill, NH	Impoundment	22.4 miles	AL	Aluminum, fishes bioassessments	Low	Unknown
Grant Brook (NHRIV801040204-02)	Lyme, NH	Impoundment	9.8 miles	AL	Fishes bioassessments	Low	Unknown
Hewes Brook (NHRIV801040402-04)	Lyme, NH	Impoundment	16.1 miles	AL	Benthic macroinvertebrates, fishes bioassessments	Low	Unknown
Mink Brook (NHRIV801040401-05)	Hanover, NH	Impoundment	13.7 miles	AL	Fishes bioassessments	Low	Unknown
Mascoma River (NHRIV801060106-20)	Lebanon, NH	Downstream of dam riverine	1.4 miles	AL	Aluminum	Low	Unknown
Blow-Me-Down Brook (NHRIV801060303-11)	Cornish, NH	Downstream of dam riverine	0.3 mile	AL	Aluminum	Low	Unknown
Bellows Falls							
Sugar River (NHRIV801060407-16)	Claremont, NH	Impoundment	1.7 miles	AL	pH, Aluminum	Low	Unknown
Black River (VT10-11)	Springfield, VT	Impoundment	4.6 miles	1CR	*E. coli*	Low	CSO
Connecticut River, Bellows Falls Impoundment (NHIMP801060703-05)	Charlestown, NH	Impoundment	1,720 acres	AL	pH	Low	Atmospheric deposition (acidity)
Clay Brook (NHRIV801060703-06)	Charlestown, NH	Impoundment	2.4 miles	AL	Fishes bioassessments	Low	Unknown
Commissary Brook (VT13-10)	Rockingham, VT	Impoundment	0.2 mile	AL, AES	Sediment	Low	Erosion

Waterbody (Unit ID)	Primary Town, State[a]	Project Vicinity	Size	Designated Uses[b]	Impairment Type	TMDL Priority	Pollutant Source[c]
Connecticut River, Bellows Falls Bypassed Reach (NHRIV801070501-10-01)	Walpole, NH	Bypassed reach	0.9 mile	AL	pH	Low	Unknown
Cold River (NHRIV801070203-12)	Walpole, NH	Downstream of dam riverine	1.2 miles	AL	pH	Low	Unknown
Vernon							
Partridge Brook (NHRIV801070503-03)	Westmoreland, NH	Impoundment	28.3 miles	AL	pH, Fishes bioassessments	Low	Unknown
Connecticut River, Partridge Brook to West River Confluence (NHRIV801070505-10)	Westmoreland, NH	Impoundment	13.1 miles	AL	pH	Low	Unknown
Crosby Brook (VT13-13)	Brattleboro, VT	Impoundment	0.7 mile	AL	Sediment	Medium	Sedimentation, channelization, buffer loss
Ash Swamp Brook (NHRIV801070507-01)	Hinsdale, NH	Impoundment	14.7 miles	AL	Benthic macro-invertebrate bioassessments	Low	Unknown
Connecticut River, Downstream of Vernon Dam to MA Border (NHRIV802010501-05)	Hinsdale, NH	Downstream of dam riverine	7.6 miles	AL	pH, Aluminum, Copper	Low	Unknown

Source: NHDES (2015b); VDEC (2014b)

a. For Vermont, there is no needed and required TMDL for the mainstem Connecticut River that encompasses the Wilder Project vicinity (VDEC, 2014b, 2014e).

b. AL – aquatic life; AES – aesthetics; 1CR – primary contact recreation

c. CSO – combined sewer overflow

New Hampshire

Fifteen New Hampshire assessment units encompass the Wilder, Bellows Falls and Vernon Project areas on the mainstem. The assessment units are discussed below in an upstream to downstream direction.

NHRIV801030703-04—Extends 22.2 river miles from the confluence of the Ammonoosuc River in Haverhill and Bath, New Hampshire, just upstream of the Wilder impoundment to the Waits River confluence located in Bradford, Vermont. This segment generally supports aquatic life and drinking water after treatment, but data are lacking to determine whether it supports primary and secondary contact recreation based on Escherichia coli bacteria levels.

NHRIV801040205-06—Extends 7.1 river miles from the Waits River confluence to the Orford and Lyme, New Hampshire, town border. In this assessment unit, drinking water after adequate treatment is fully supported, but data are lacking to determine whether aquatic life, primary and secondary contact recreation, and wildlife designated uses are supported.

NHLAK801040402-03—Extends 21.7 river miles from the Orford and Lyme, New Hampshire, border to Wilder dam and is referred to by NHDES as Wilder Lake. This stretch of river generally supports aquatic life, drinking water after adequate treatment, primary and secondary contact recreation designated uses, but data are lacking to determine whether wildlife uses are met.

NHRIV801040402-13—Extends 2.0 river miles from Wilder dam downstream to the White River confluence in White River Junction, Vermont. This assessment unit supports aquatic life and drinking water after adequate treatment designated uses. Information is lacking to determine whether primary and secondary contact recreation and wildlife designated uses are supported in this reach.

NHRIV801060302-01—Extends from the White River confluence to the Mascoma River confluence in Lebanon, New Hampshire, about 1.4 river miles. In this reach of the mainstem river, aquatic life, drinking water after adequate treatment, and secondary contact recreation are supported; primary contact recreation is impaired because of E. coli bacteria from combined sewer overflows (CSO), but a statewide bacteria TMDL is in place (NHDES, 2010; VDEC, 2011).[25,26] No data are available to determine whether wildlife uses are supported.

NHRIV801060302-05—Extends 14.5 river miles from the Mascoma River confluence to Blow-me-down Brook in Cornish, New Hampshire, and supports drinking water after adequate treatment and secondary contact recreation uses but is impaired for primary contact recreation because of E. coli from CSOs. No data are available to determine whether aquatic life uses are supported.

NHRIV801060305-12—Extends 7.5 river miles from the Connecticut River's confluence with Blow-me-down Brook to its confluence with the Sugar River. This reach of river supports drinking water after adequate treatment and both primary and secondary contact recreation. Aquatic and wildlife uses need data to determine whether they are supported.

NHRIV801060702-12—Extends from the Sugar River confluence 15.4 river miles to the Black River confluence in Springfield, Vermont. This assessment unit supports drinking water after adequate treatment and primary and secondary contact recreation, but aquatic life uses are impaired and wildlife uses cannot be determined. Aquatic life uses are impaired because of invasive aquatic algae and non-native aquatic plants.

NHIMP801060703-05—Encompasses a portion of the Bellows Falls impoundment and extends 12.8 river miles from the Black River confluence to the Bellows Falls dam and powerhouse. This assessment unit supports drinking water after adequate treatment and potentially supports primary contact recreation, but it is undetermined whether this assessment unit supports secondary contact recreation or wildlife uses because of insufficient information. In addition, this assessment unit is marginally impaired for aquatic life uses due to pH from atmospheric deposition and a TMDL is needed (NHDES, 2015b).

NHRIV801070501-10-01—Encompasses the Bellows Falls bypassed reach. In the bypassed reach, aquatic life uses are marginally impaired by pH from atmospheric deposition and a TMDL is needed (NHDES, 2015b). Drinking water uses are supported after adequate treatment, while primary and secondary contact

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[25] Combined sewers are pipes that collect both stormwater and municipal wastewater or sewage. If the sewer pipe capacity is exceeded during heavy rain events, the sewer overflows.

[26] Each statewide TMDL for bacteria-impaired waters applies to all waters impaired by bacteria in Vermont and New Hampshire. However, Assessment Units NHRIV801060302-01 and NHRIV801060302-05 are the only areas of the mainstem Connecticut River in the Project areas where these TMDLs apply based on the 2014 303(d) lists.

recreation as well as wildlife uses are not determined because of insufficient information.

NHRIV801070501-10-02—Extends 10.6 river miles from the Bellows Falls powerhouse to the Houghton Brook confluence in Walpole, New Hampshire. This assessment unit includes a portion of the downstream Bellows Falls riverine and Vernon impoundment areas. The unit supports aquatic life and drinking water uses; however, insufficient information is available to determine whether primary and secondary contact recreation uses and wildlife uses are supported.

NHRIV801070502-06—Extends 5.1 river miles from the Houghton Brook confluence to Partridge Brook in Westmoreland, New Hampshire. The unit supports drinking water uses after adequate treatment, but it is unknown whether aquatic life, primary and secondary contact recreation, and wildlife uses are supported because of insufficient information.

NHRIV801070505-10—Extends 13.1 river miles from the Partridge Brook confluence to the West River confluence in Brattleboro, Vermont. The unit supports drinking water uses after adequate treatment, but it is unknown whether primary and secondary contact recreation and wildlife uses are supported because of insufficient information. Aquatic life is impaired and a TMDL is needed because of pH exceedances. The source of the impairment due to pH is unknown.

NHIMP801070507-01—Extends 11.0 river miles from the West River confluence to Vernon dam (NHIMP801070507-01). The unit supports drinking water after adequate treatment and aquatic life and primary contact recreation. It is unknown whether secondary contact recreation and wildlife uses are supported because of insufficient information.

NHRIV802010501-05—Encompasses Project-affected waters that extend downstream from Vernon dam 7.6 river miles to the New Hampshire/Massachusetts border. This segment supports primary and secondary contact recreation and drinking water uses after adequate treatment; however, the segment is marginally and severely impaired for aquatic life because of aluminum and copper concentrations, respectively, and a TMDL is needed. It is also unknown whether wildlife uses in this reach are met because of insufficient information.

The entire portion of the Connecticut River that encompasses the assessment units above for the Wilder, Bellows Falls, and Vernon Projects is impaired for fish consumption because of mercury from atmospheric deposition (New Hampshire only). A Northeast–wide TMDL was completed for mercury and approved by EPA in 2007 for the entire Northeastern United States, which includes these New Hampshire assessment units (NEIWPCC, 2007).

Vermont

Six Vermont waterbody segments encompass the Wilder, Bellows Falls, and Vernon Project areas. The waterbody segments are discussed below in an upstream to downstream direction.

VT16-07—Extends 48.9 river miles from the Connecticut River confluence with the Wells River to Wilder dam. Vermont's 2014 303(d) list of impaired waterbodies and associated parts identifies a portion of this segment that extends from Wilder dam to Bradford, Vermont as impaired because of fluctuating flows and water levels associated with hydropower generation. The only uses affected in these reaches because of fluctuating flows and water levels are aquatic life support uses (VDEC, 2014c). In addition, VDEC (2014d) reports segment VT13-02 as, "CT RIVER, HOYTS LNDNG, WILDER DAM, TRANSCANADA LAUNCH." However, Hoyts Landing is located in Springfield, Vermont, at the Connecticut River's confluence with the Black River in Springfield, Vermont, within the Bellows Falls impoundment and is managed by the Vermont Fish & Wildlife Department (VFWD). Segment VT16-07 is the river segment that encompasses Wilder dam. No other impairments are identified within this waterbody segment.

VT13-01—Extends 21.4 river miles from Wilder dam to the Connecticut River's confluence with the Sugar River. Vermont's 2014 303(d) list of impaired waterbodies and associated parts lists a portion of this segment that ranges from Wilder dam downstream 20.5 miles to Ascutney Village, Vermont, as impaired because of fluctuating flows and water levels associated with hydropower generation. No other impairments are identified within this waterbody segment.

VT13-02—Extends 21.6 river miles from the confluence with Sugar River downstream to Bellows Falls dam. This segment of the Connecticut River is impaired because of fluctuating flows and water levels associated with hydropower generation (VDEC, 2014c). Flow regulation within this segment impacts aquatic life support and aesthetics (VDEC, 2014c). In addition, the area near and around the Hoyts Landing boat ramp [as identified by the state, see VT16-07 above] is stressed because of abundant Eurasian milfoil (VT13-02) (VDEC, 2014d). The presence of Eurasian milfoil impacts aesthetics, aquatic life support, and both primary and secondary contact recreation. No other impairments are identified within this waterbody segment.

VT13-03—Extends from Bellows Falls dam downstream about 25.0 miles to the confluence with the West River in Brattleboro, Vermont, is Waterbody Segment VT13-03. This segment encompasses riverine reaches downstream of Bellows Falls dam as well as the Vernon impoundment. VDEC (2014c) lists VT13-03 from Bellows Falls dam 24 miles downstream (including much of the Vernon impoundment) as altered by flow regulation from hydroelectric generation, which impacts aquatic life support. No other impairments are identified within this waterbody segment.

VT13-04—Vermont's 2014 303(d) list of impaired waterbodies and associated parts identifies Waterbody Segment VT13-04, which extends 7.4 river miles from the Connecticut River confluence with the West River to Vernon dam, as impaired because of fluctuating flows and water levels associated with hydropower generation affecting aquatic life support (VDEC, 2014c). No other impairments are identified within this waterbody segment.

VT13-05—Includes riverine reaches downstream of Vernon dam as well as impoundment areas of the Turner's Falls Project. This waterbody segment also serves as the lower reservoir for the Northfield Mountain Pumped Storage Project. This waterbody segment extends 5.7 river miles downstream of Vernon dam, but only 5.5 river miles from Vernon dam downstream is listed as impaired because of fluctuating flows and water levels associated with hydropower generation affected aquatic life support (VDEC, 2014c). In addition, tritium has been identified has a possible pollutant within segment VT13-05 as a result of underground leakage from the now decommissioned VY (VDEC, 2014f).[27] No other impairments are identified within this waterbody segment.

Vermont does not have a specific needed, required, or completed and approved TMDL on the mainstem Connecticut River that encompasses the Wilder, Bellows Falls, or Vernon Project areas (VDEC, 2014b, 2014e). However, waters of the Connecticut Rive are included in the Northeast-wide TMDL for mercury (NEIWPCC, 2007).

Long Island Sound TMDL

The Sound has a DA of about 16,000 sq. mi. The largest source is the Connecticut River, contributing 70 percent of the total freshwater entering the Sound annually. Nitrogen is the primary limiting nutrient for algal growth in the Sound. Increased nitrogen loading from point and non-point sources has led to hypoxic dissolved oxygen (DO) levels and subsequent loss of designated uses and severe effects on wildlife in the Sound. The Long Island Sound TMDL was developed by the New York Department of Environmental Conservation and Connecticut Department of Environmental Protection and was approved by EPA with the goal of reducing nitrogen loading into the Sound from both point and non-point sources to improve DO levels (NYSDEC and CDEP, 2000).

National Pollutant Discharge Elimination System Permits

Wilder Project

The Wilder Project was issued a National Pollutant Discharge Elimination System (NPDES) permit in the mid-1990s, and the Project has held a valid discharge permit since then. NPDES #VT0000787, permit #3-1393, allows the Project to discharge minor, non-generation related wastewaters, including noncontact cooling water from Units 1, 2, and 3, internal facility drainage, and sump pit waters associated

[27] Tritium is a radioactive isotope of the hydrogen atom.

with the generating units. TransCanada is required to conduct quarterly sampling of its wastewaters and report the results of the sampling to VDEC, the permitting authority. Permit parameters and limits for temperature, pH, and oil/grease are the same for all discharge outfalls as listed below:

- Temperature (<90°F);
- pH (6.5–8.5); and
- Oil/grease (<20 milligrams per liter [mg/L], not required for non-contact cooling water).

All sources of wastewater from the Wilder Project combine into a single outfall. TransCanada applied for a 5-year renewal permit in December 2015 (pending at this time) with a daily maximum flow limitation for outfall S/N 001 of 3.13 million gallons per day (mgd), a discharge level only required over a few days for annual dewatering of generating units, average daily discharge is approximately 0.8 mgd.

Bellows Falls Project

The Bellows Falls Project was issued an NPDES permit in the mid-1990s and has held a valid discharge permit since then (NPDES #VT0000795). This permit allows the Project to discharge minor, non-generation-related wastewaters, including non-contact cooling water from turbine bearings and air compressors and internal leakage in wheelpits and sumps. TransCanada is required to conduct quarterly sampling of its wastewaters and report the results of the sampling to VDEC, the permitting authority. Permit parameters and limits for temperature, pH, and oil/grease are the same for all discharge outfalls as listed below:

- Temperature (<90°F);
- pH (6.5-8.5); and
- Oil/grease (<20 mg/L, not required for non-contact cooling water).

TransCanada applied for a 5-year renewal permit in December 2015 (pending at this time) with the following daily maximum flow limits that vary by discharge outfall as noted below:

- 0.023 mgd for S/N 002, S/N 009 and S/N 010: Bearing unit cooling water;
- 0.152 mgd for S/N 003: Air compressor cooling water, sump waters, and other internal drainage waters after treatment via and oil water separator; and
- 1.296 mgd for S/N 004: Wheel pit drainage waters during extremely high river flows.

Vernon Project

The Project was issued an NPDES permit in the mid-1990s and has held a valid discharge permit since then (NPDES No. VT0000868). This permit allows the Project to discharge minor, non-generation-related wastewaters, including non-contact cooling water from turbine bearings and air compressors and internal leakage in wheelpits and sumps. TransCanada is conducting quarterly sampling of its wastewaters and reporting results to VDEC. Permit parameters and limits for temperature, pH, and oil/grease are the same for all discharge outfalls as listed below:

- Temperature (<90°F);
- pH (6.5-8.5); and
- Oil/grease (<20 mg/L, not required for non-contact cooling water).

TransCanada applied for a 5-year renewal permit in December 2015 (pending at this time) with daily maximum flow limits that vary by discharge outfall as noted below:

- 0.144 mgd for S/N 001: Bearing cooling water, sump waters, and other internal drainage water;
- "as necessary" for S/N 002: Uncontaminated water during draft tube dewatering of Units 5 through 8; and
- 0.336 mgd for S/N 003: Non-contact bearing cooling water and auto-strainer backwash from Units 5 through 10.

TransCanada has never measured a permit exceedance at the Wilder, Bellows Falls, or Vernon Projects.

Other Wastewater Treatment Facilities

Sixty-four wastewater treatment facilities are located in the Connecticut River watershed upstream of the Projects. Table 3.4-11 lists the locations of these facilities.

Table 3.4-11. New Hampshire and Vermont towns in the Connecticut River watershed with wastewater treatment facilities upstream of each Project dam.

New Hampshire		Vermont	
Town	**Number of Facilities**	**Town**	**Number of Facilities**
Upstream of Wilder Dam			
Bethlehem	2	Barnet	1
Colebrook	1	Bradford	1
Groveton	2	Canaan	2
Hanover	1	Danville	1
Lancaster	2	Fairlee	1
Lisbon	1	Lunenburg	1
Littleton	1	Lyndon	2

New Hampshire		Vermont	
Town	**Number of Facilities**	**Town**	**Number of Facilities**
N. Stratford	2	Newbury	1
Northumberland	1	St. Johnsbury	1
Piermont	1		
Whitefield	1		
Woodsville	1		
Between Wilder and Bellows Falls Dams			
Charlestown	1	Bethel	1
Claremont	1	Cavendish	1
Guild	1	Chelsea	1
Lebanon	1	Hartford	3
Meriden	1	Ludlow	1
Newport	1	Windsor	2
Springfield	1		
Sunapee	1		
West Lebanon	2		
Between Bellows Falls and Vernon Dams			
Westmoreland	1	Brattleboro	3
		Dummerston	1
		Londonderry	1
		Rockingham	1
		Vernon	2

Fish Tissue Contamination and Consumption Advisories

In 2000, a joint federal and state screening level survey was performed to provide baseline fish tissue contaminant data for several fish species present in the Connecticut River (Hellyer, 2006). The study objectives were to better understand the risk to human health from eating Connecticut River fish and to learn what threat eating these fish poses to other mammals, birds, and fishes. For this study, fillet and composite samples of smallmouth bass, white sucker, and yellow perch were collected from three reaches that encompass each Project area: (1) above Turners Falls dam, Massachusetts, to Vernon dam (Reach 4); (2) above Vernon dam to Wilder dam (Reach 5); and (3) above Wilder dam to Moore dam, New Hampshire (Reach 6) were analyzed for total mercury, polychlorinated biphenyls, organochlorine pesticides (e.g., dichlorodiphenyltrichloroethane), and dioxins. The study determined that: (1) total mercury concentrations in all three species were significantly higher in fish collected from the upstream reaches in higher elevation drainage basins that experience greater air deposition than in downstream reaches; and (2) mercury contamination, attributed mainly from atmospheric deposition, posed a risk to recreational and subsistence fishers and to fish-eating wildlife. The study also concluded that polychlorinated biphenyls, organochlorine pesticides, and dioxins levels in fish tissues could pose a potential risk to human health. Both the states of New Hampshire and Vermont have freshwater fish consumption advisories, and as discussed above, a TMDL is in place for the entire Northeast United States to reduce mercury concentration in fish resulting from atmospheric deposition (NHFGD, 2016a; Vermont Department of Health, 2016; NEIWPCC, 2007).

Historical Water Quality

In 2004, NHDES and EPA conducted a water quality study on the 275 miles of the river between the Canadian and Massachusetts borders in anticipation of the 2005 update of the Connecticut River Management Plan (Connecticut River Joint Commissions, 2008). Samples were collected from June through August, and in some cases, September. Data relevant to the Wilder, Bellows Falls, and Vernon Projects are summarized in Tables 3.4-12, 3.4-13, and 3.4-14, respectively. All sites sampled in the Wilder and Vernon Project areas were found to fully support the designated uses of aquatic life and primary and secondary contact recreation. For the Bellows Falls Project area, most sites sampled were found to be fully supporting the designated uses of aquatic life, and primary and secondary contact recreation; however, the Route 11 Bridge in Charlestown, New Hampshire, Assessment Unit (NHRIV801060702-12) was found not to support aquatic life because of the presence of invasive species, and the Interstate 89 bridge and railroad bridge sites located in Lebanon and West Lebanon, New Hampshire, respectively, were determined not to support primary contact recreation because of impairments from CSOs.

Table 3.4-12. 2004 NHDES Connecticut River water quality assessment data for the Wilder Project area.

Site (Assessment Unit)	Dissolved Oxygen		pH min/max	Temp. (°C) min/max	Bacteria Geometric Mean (#/100 mL)
	(mg/L) min/max	(% Sat.) min/max			
Newbury Road Bridge, Haverhill, NH (NHRIV801030703-04)	7.5 / 8.6	85 / 94	6.9 /7.6	18.5 / 22.0	53
Route 25A Bridge, Orford, NH (NHRIV801040205-06)	7.3 / 8.5	84 / 92	6.6 / 7.6	19.1 / 23.0	43
Wilder Impoundment, West Wheelock Street Bridge, Hanover, NH (NHLAK801040402-03)	7.8 / 8.2	83 / 94	6.8 / 7.7	19.6 / 22.0	17
Route 4 Bridge, West Lebanon, NH (NHRIV801040402-13)	6.8 / 8.3	84 / 95	6.8 / 7.5	19.0 / 21.0	21
Route 89 Bridge, Lebanon, NH (NHRIV801060302-01)	6.6 / 9.4	85 / 97	6.6 / 7.7	16.7 / 23.0	21
Railroad Bridge at Blue Seal, West Lebanon, NH (NHRIV801060302-01)	6.7 / 8.7	85 / 92	6.7 / 7.6	18.0 / 22.0	67
Sumner Falls, Plainfield, NH (NHRIV801060302-05)	7.3 / 8.5	82 / 96	6.5 / 7.8	19.7 / 22.0	66

Source: TransCanada (2012a, 2012b)

Table 3.4-13. 2004 NHDES Connecticut River water quality assessment data for the Bellows Falls Project area.

Site (Assessment Unit)	Dissolved Oxygen		pH min/max[a]	Temp. (°C) min/max	Bacteria Geometric Mean (#/100 mL)
	(mg/L) min/max	(% Sat.) min/max			
Route 12/103 Bridge, Claremont, NH (NHRIV801060305-12)	7.9 / 8.5	86 / 96	6.8 / 7.7	18.3 / 23.0	28
Route 11 Bridge, Charlestown, NH (NHRIV801060702-12)	7.7 / 9.7	89 / 97	7.4 / 7.7	15.5 / 25.0	18
Arch Street Bridge, Walpole, NH (NHIMP801060703-05)	7.2 / 9.5	88 / 97	6.7 / 7.6	15.5 / 25.0	20
Bellows Falls Dam Bypass Reach (NHRIV801070501-10-01)	7.9 / 9.8	90 / 106	7.1 / 8.01	15.2 / 24.0	40

Source: TransCanada (2012b)

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-14. 2004 NHDES Connecticut River water quality assessment data for the Vernon Project area.

Site (Assessment Unit)	Dissolved Oxygen		pH min/max[a]	Temp. (°C) min/max	Bacteria Geometric Mean (#/100 mL)
	(mg/L) min/max	(%Sat.) min/max			
Route 123/Walpole Bridge (NHRIV801070501-10-02)	7.9 / 9.7	91 / 101	6.6 / 7.7	15.4 / 24.0	18
Immediately upstream of confluence with Partridge Brook (NHRIV801070502-06)	6.8 / 9.1	79 / 93	7.0 / 7.6	14.9 / 24.0	19
Route 9 Bridge, Chesterfield (NHRIV801070505-10)	7.5 / 9.7	88 / 96	6.49 / 7.6	15.5 / 23.0	15
Route 119 Bridge Hinsdale (NHIMP801070507-01)	7.8 / 10.3	92 / 106	6.49 / 7.6	15.2 / 23.0	34

Source: TransCanada (2012c)

a. Values with two digits after the decimal point are those that exceeded state standard(s).

In 2008 and 2009, the University of Massachusetts, in cooperation with the Targeted Watershed Initiative, sampled a 14-mile stretch of the Connecticut River for bacteria twice a week during high-use recreation summer months. Ten sampling stations were located between the Hartford (Wilder) picnic area at Kilowatt Park (North) in Hartford, Vermont (0.8 mile upstream of Wilder dam), to the Wilgus State Park in Weathersfield, Vermont (21 miles upstream of Bellows dam). The sites were designated to document the effectiveness of the CSO reductions in Lebanon, New Hampshire, and the elimination of the six CSOs in Hartford, Vermont, in 2007. The geometric means for the 14-mile stretch of water sampled during this study were below the bacterial water quality standard for primary contact recreation of 126 per 100 milliliters (mL), although the water quality standard was exceeded for a single sample at two locations in 2008 and at two locations in 2009 under wet conditions. For all sampling sites except one, wet weather bacterial counts were higher than dry weather counts. At three locations, 1 sample of 27 samples exceeded the New Hampshire water quality standards single sample maximum of 400 per 100 mL: East Wilder boat launch, West Lebanon, New Hampshire (520 per 100 mL); Lyman Point Park launch, Hartford, Vermont (480 per 100 mL); and Blood's Brook launch (Lebanon launch), New Hampshire (416 per 100 mL). No site reported more than one exceedance.

Water quality has also been occasionally measured at three USGS streamflow gages in the Project areas. These gages include the Connecticut River at Wells River, Vermont, (USGS gage no. 01138500), and the West Lebanon and North Walpole gages. The water quality data collected or measured at these gages include temperature (degrees Celsius [°C]), specific conductivity (microsiemens per centimeter [µS/cm]), DO (mg/L; percent saturation), pH (standard units), and various nutrient metrics (Tables 3.4-15, 3.4-16, and 3.4-17).

USGS, in cooperation with the New England Interstate Water Pollution Control Commission (NEIWPCC), also performed a study examining total nitrogen concentrations and nitrogen loading in the Upper Connecticut River basin from December 2002 through September 2005. The study estimated the mean annual load and yield of total nitrogen of the Connecticut River at Wells River, Vermont, was 4.5 million pounds/year and 1,690 (pounds/sq. mi.)/year, respectively. In addition, at North Walpole, New Hampshire, the mean annual load and yield of total nitrogen in the Connecticut River was estimated to be 9.6 million pounds/year and 1,750 (pounds/sq. mi.)/year, respectively (Deacon et al., 2006). .

Table 3.4-15. Water quality data collected or measured at the Connecticut River at Wells River, Vermont, USGS gage no. 01138500 from 2005 through 2007.

Date/Time	Discharge (cfs)	Temperature (°C)	Dissolved Oxygen (mg/L; % saturation)		Specific Conductivity (µS/cm)	pH (standard units)	Total Nitrogen (unfiltered; mg/L)	Nitrite (filtered; mg/L)	Nitrate (filtered; mg/L)	Phosphorus (mg/L)
1/4/2005 12:30 p.m.	6,450	1.8	13.2	92	86	7.0	0.39	0.005[a]	0.187[a]	0.009
2/1/2005 2.00 p.m.	2,060	0.1	13.7	94	92	6.8	0.48	< 0.008	0.261	0.036
3/2/2005 3:15 p.m.	5,930	0.7	13.4	94	77	6.7	0.48	< 0.008	0.266	0.011
3/31/2005 1:45 p.m.	4,510 [a]	2.3	15.2	110	119	6.9	0.66	< 0.008	0.261	0.109
4/6/2005 1:45 p.m.	19,100	2.3	13.2	96	84	7.1	0.70	< 0.008	0.242	0.087
4/11/2005 11:45 a.m.	17,300	2.2	13.6	99	63	7.1	0.49 [a]	< 0.008	0.196	0.041
4/18/2005 3:45 p.m.	11,900	5.7	11.5	94	85	7.4	0.46	< 0.008	0.203	0.032
5/4/2005 10:00 a.m.	11,200	6.5	12.2	99	58	6.9	0.34	< 0.008	0.148	0.023
6/14/2005 10:15 a.m.	2,280	16.8	9.1	94	71	6.6	0.35	< 0.008	0.112	0.013
7/6/2005 1:15 p.m.	5,090	19.0	8.9	96	90	6.9	0.39	< 0.008	0.116	0.015
7/26/20053:00 p.m.	1,640	23.0	8.4	99	112	7.5	0.36	< 0.008	0.118	0.010
8/8/20053:00 p.m.	2,850	23.2	7.7	91	84	7.2	0.39	< 0.008	0.131	0.007
10/25/2006 10:45 a.m.	10,300	10.3	9.6	86	73	7.0	0.44	< 0.002	0.167	0.015
12/14/2006 9:30 a.m.	5,080	3.6	11.9	90	76	6.8	0.39	0.001[a]	0.202[a]	0.010
2/7/2007 9:30 a.m.	4,480	0.0	---	---	---	6.6	---	0.001[a]	0.271[a]	---
3/28/2007 10:00 a.m.	12,400	---	---	---	79	7.0	0.62	< 0.002	0.344	0.038
4/19/2007 10:15 a.m.	19,900	---	---	---	70	7.0	0.59	< 0.002	0.250	0.051
5/2/2007 10:15 a.m.	17,600	---	---	---	47	6.8	0.48	0.002[a]	0.214[a]	0.026
5/16/2007 10:00 a.m.	4,020	11.0	10.7	101	57	6.6	0.43	0.001[a]	0.203[a]	0.012
6/27/2007 10:30 a.m.	1,590	19.4	7.4	80	102	7.4	0.36	0.002[a]	0.166[a]	0.013
8/1/2007 10:00 a.m.	1,340	22.2	7.4	85	107	7.4	0.39	0.002	0.189	0.006[a]
9/5/2007 9:45 a.m.	1,220	18.8	13.2	92	100	7.4	0.35	0.002[a]	0.164[a]	0.006[a]

Source: USGS (2016f)
Note: "---" indicates no data are available.
a. Value reported is estimated.

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Table 3.4-16. Water quality data collected or measured at the Connecticut River at West Lebanon, New Hampshire, USGS gage no. 01144500 from 2005 through 2007.

Date/Time	Discharge (cfs)	Temperature (°C)	Dissolved Oxygen (mg/L; % saturation)		Specific Conductivity (µS/cm)	pH (standard units)	Total Nitrogen (unfiltered; mg/L)	Nitrite (filtered; mg/L)	Nitrate (filtered; mg/L)	Phosphorus (mg/L)
4/12/2005 7:30 a.m.	23,200	3.0	14.1	105	76	7.3	0.57 [a]	< 0.008	0.206	0.059
8/8/2005 8:00 a.m.	1,460	24.0	7.7	92	160	7.6	0.41	< 0.008	0.167	0.006
10/25/2006 2:00 p.m.	14,900	10.8	11.8	104	82	7.2	0.43	< 0.002	0.185	0.015
12/14/2006 11:30 a.m.	9,670	2.8	12.6	94	106	7.4	0.45	0.001[a]	0.257[a]	0.012
2/7/2007 1:00 p.m.	2,740	0.0	---	---	---	7.0	0.54	0.001[a]	0.400[a]	0.011
3/28/2007 1:15 p.m.	22,700	---	---	---	84	7.1	0.78	< 0.002	0.420	0.133
4/19/2007 2:00 p.m.	31,600	---	---	---	81	7.2	0.61	< 0.002	0.286	0.089
5/2/2007 1:00 p.m.	23,400	---	---	---	67	7.1	0.51	0.002[a]	0.252[a]	0.036
5/16/2007 12:45 p.m.	10,600	13.7	10.2	98	84	6.9	0.46	0.001[a]	0.232[a]	0.013
6/27/2007 1:30 p.m.	6,350	22.4	7.1	82	129	7.5	0.42	0.003	0.217	0.008[a]
8/1/2007 1:00 p.m.	1,380	24.8	8.3	100	134	7.6	0.38	0.002	0.188	0.009
9/5/2007 12:15 p.m.	762	22.8	---	---	145	7.2	0.38	0.003	0.198	0.006[a]

Source: USGS (2016g)

Note: "---" indicates no data are available.

a. Value reported is estimated.

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Table 3.4-17. Water quality data collected or measured at the Connecticut River at North Walpole, New Hampshire, USGS gage no. 01154500 from 2005 through 2007.

Date/Time	Discharge (cfs)	Temperature (°C)	Dissolved Oxygen (mg/L; % saturation)		Specific Conductivity (µS/cm)	pH (standard units)	Total Nitrogen (unfiltered; mg/L)	Nitrite (filtered; mg/L)	Nitrate (filtered; mg/L)	Phosphorus (mg/L)
1/5/2005 2:00 p.m.	11,400	0.1	13.4	92	112	7.1	0.39	0.005[a]	0.240[a]	0.010
1/31/2005 12:00 p.m.	10,200 [a]	0.1	13.4	92	111	7.0	0.47	< 0.008	0.302	0.011
2/28/2005 11:00 a.m.	10,300	0.2	13.6	98	149	6.9	0.52	< 0.008	0.337	0.013
3/31/2005 5:30 p.m.	26,500	0.2	12.8	89	118	6.9	0.57	< 0.008	0.240	0.078
4/7/2005 2:15 p.m.	46,700	3.9	13.9	106	88	7.2	0.56	< 0.008	0.214	0.121
4/12/2005 7:00 p.m.	30,100	---	---	---	83	7.1	1.40	< 0.008	0.208	0.048
4/18/2005 8:00 a.m.	15,200	7.2	11.9	98	108	7.2	0.41	< 0.008	0.236	0.019
5/3/2005 2:30 p.m.	24,400	7.9	11.4	96	85	7.5	0.33	< 0.008	0.168	0.022
6/7/2005 5:00 p.m.	10,300	---	---	---	101	7.3	0.36	< 0.008	0.142	0.009
7/5/2005 4:00 p.m.	7,340	---	---	---	125	7.5	0.38	< 0.008	0.159	0.015
7/25/2005 11:30 a.m.	3,350	25.7	7.0	86	120	7.5	0.34	< 0.008	0.147	0.011
8/10/2005 1:30 p.m.	1,630	26.4	7.8	97	151	7.8	0.39	< 0.008	0.167	0.009
8/11/2005 3:45 p.m.	6,400	26.7	6.9	86	141	7.4	0.36	< 0.008	0.161	0.006
10/25/2006 5:15 p.m.	22,200	9.5	9.8	84	87	7.0	0.44	< 0.002	0.194	0.018
12/14/2006 3:00 p.m.	10,700	2.6	13.1	97	116	6.9	0.47	0.001[a]	0.281[a]	0.010
2/7/2007 4:30 p.m.	9,090	0.0	---	---	---	7.0	0.57	0.002[a]	0.408[a]	0.012
3/28/2007 4:30 p.m.	35,500	---	---	---	86	7.0	0.84	0.001[a]	0.371[a]	0.152
4/19/2007 5:00 p.m.	49,900	---	---	---	81	6.6	0.64	< 0.002	0.267	0.194
5/2/2007 4:30 p.m.	30,400	---	---	---	73	6.8	0.49	0.002[a]	0.262[a]	0.028
5/16/2007 4:15 p.m.	11,300	14.5	9.5	93	96	6.9	0.44	0.002[a]	0.252[a]	0.011
6/27/2007 4:30 p.m.	8,710	23.5	---	---	142	7.4	0.42	0.003	0.203	0.011
8/1/2007 4:30 p.m.	8,360	25.9	8.0	98	125	7.2	0.38	0.001[a]	0.169[a]	0.007[a]
9/5/2007 2:45 p.m.	1,390	22.3	---	---	136	7.7	0.42	0.003	0.178	0.009

Source: USGS (2016h)

Note: "---" indicates no data are available.

a. Value reported is estimated.

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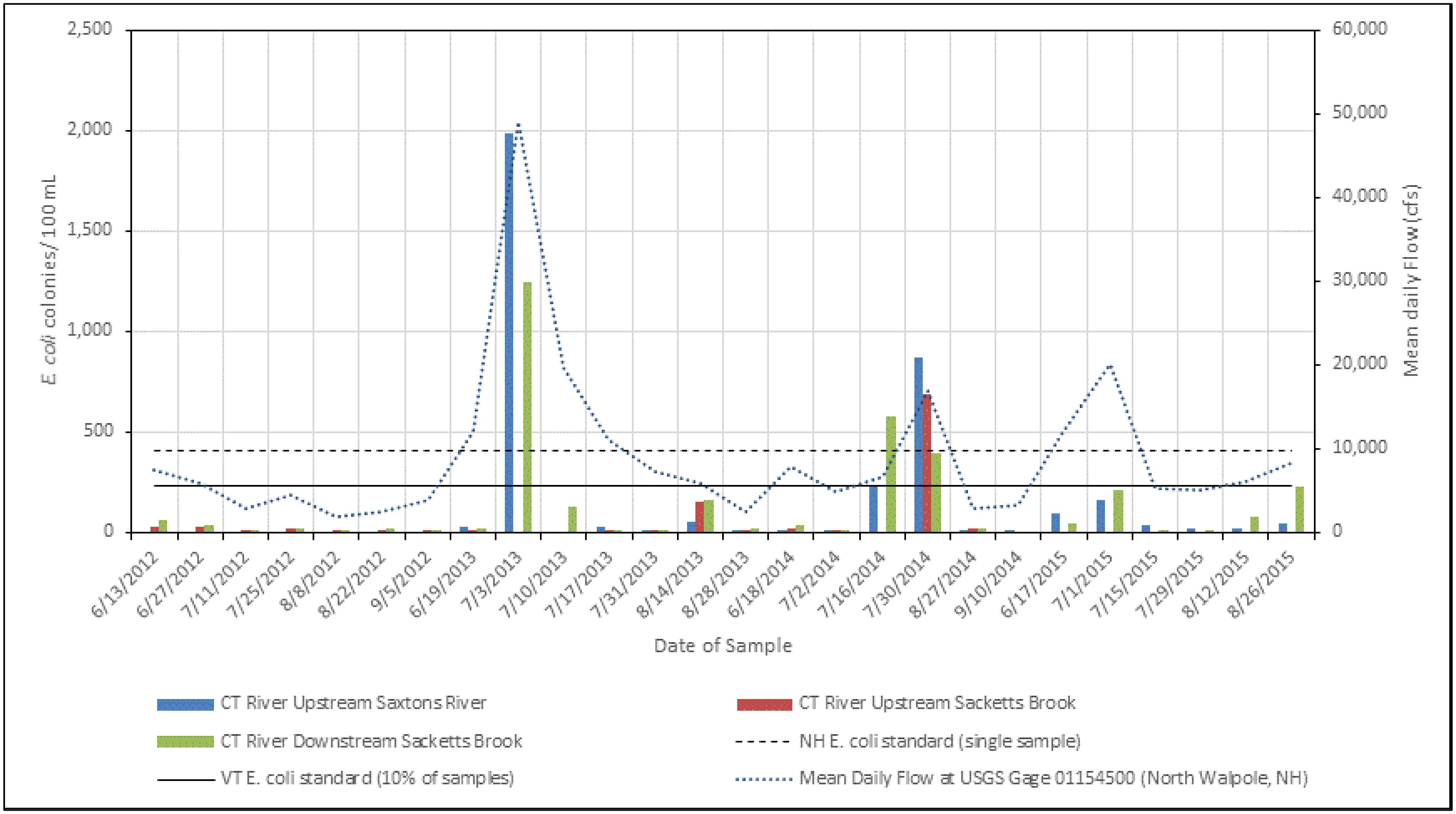
Escherichia coli

The Connecticut River Watershed Council in cooperation with the Pioneer Valley Planning Commission conducts volunteer bacteria monitoring throughout the Connecticut River basin (Connecticut River Watershed Council and Pioneer Valley Planning Commission, 2016). Throughout the Wilder, Bellows Falls and Vernon Project areas, Connecticut River Watershed Council and its volunteers collected water samples from only the Vernon Project area for bacteria analyses. Water samples were collected upstream and downstream of the Sacketts Brook confluence in Putney, Vermont, and upstream of the Saxtons River confluence. Figure 3.4-21 presents the results of the analyses for 2012 through 2015. Water samples for bacteria analysis were also collected from several main tributaries, including the White, Ottauquechee, Black, Williams, Saxtons, and West rivers.

TransCanada Water Quality Studies

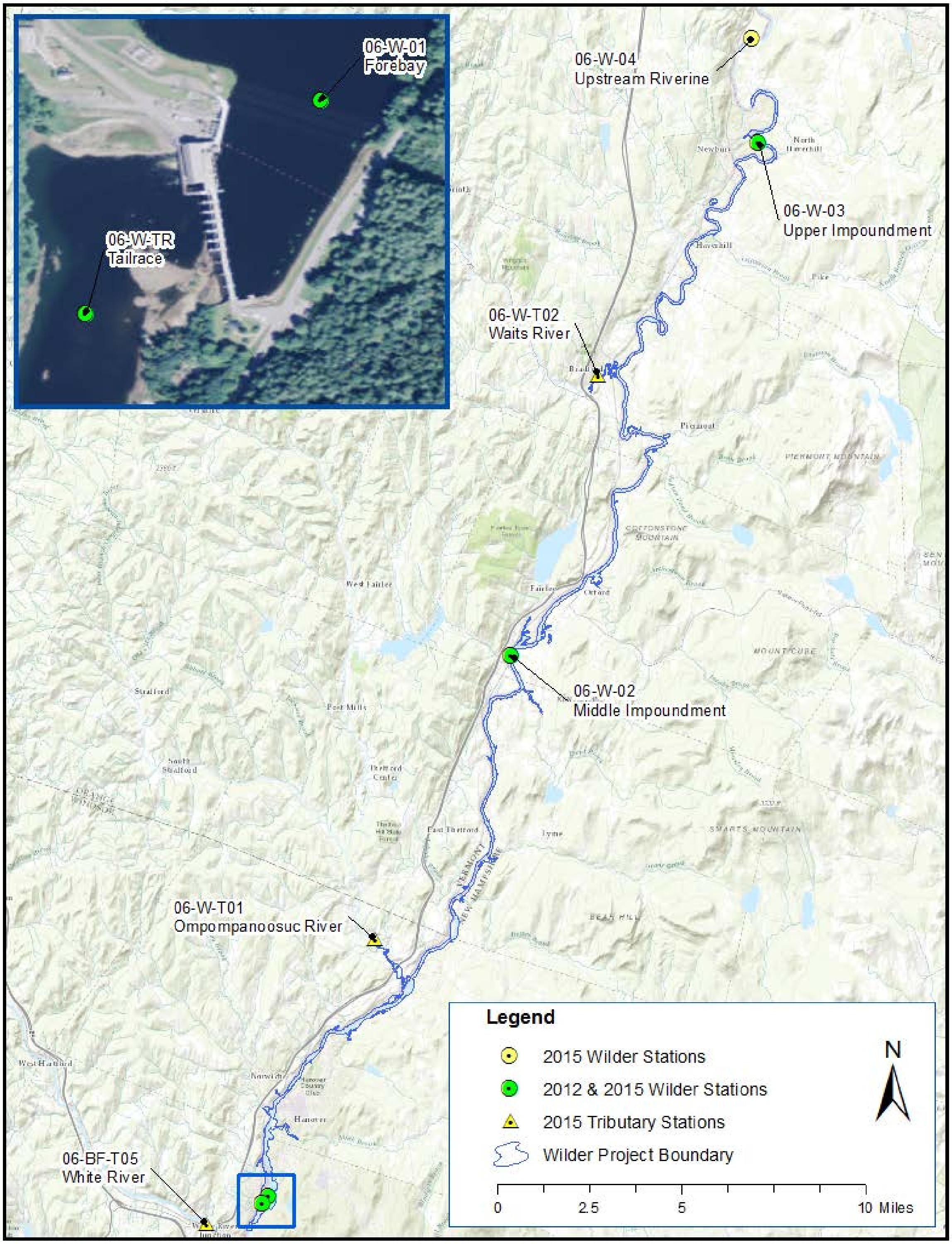
In 2012 and 2015, TransCanada conducted two baseline water quality studies in support of the Wilder, Bellows Falls, and Vernon Project relicensing proceedings (Normandeau, 2013a; ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring*). Water quality data collected during the 2012 Baseline Water Quality Study were collected during the summer of 2012 and are representative of conditions during a low-flow, warm-weather period. Measured parameters during the 2012 study consisted of temperature (°C), DO (mg/L, percent saturation), specific conductivity (µS/cm), pH (standard units), nutrients, and chlorophyll-*a*. Data were collected at various locations throughout the Project areas and included stations in the upper impoundments, middle impoundments, forebays, tailraces, and the Bellows Falls bypassed reach (Figures 3.4-22 through 3.4-24). Temperature, DO, specific conductivity, and pH were continuously measured in each Project forebay and tailrace, as well as the Bellows Falls bypassed reach. Vertical profiles were collected at all impoundment stations. Nutrients and chlorophyll-*a* were only collected at each Project forebay from water column composite samples.

As a part of the ILP, TransCanada conducted additional water quality monitoring (Study 6) during spring, summer, and fall 2015 using similar methods as the 2012 study, but with the following additions: (1) turbidity monitoring, (2) continuous recording of water temperature at all stations, (3) addition of a riverine station upriver of the upper extent of each Project’s impoundment, (4) continuous water temperature monitoring in the 10 largest tributaries, and (5) all water quality parameters were continuously recorded, except for nutrient and chlorophyll-*a*, over a 10-day, low-flow period during the summer (Figures 3.4-22 through 3.4-24). The 2015 study, conducted between April 1 and November 15, was performed under representative flow and weather conditions. Grab samples of water quality parameters, such as temperature, DO, pH, turbidity, and specific conductivity, were also collected at specific study sites in most fisheries studies. Results of those sampling events are included in applicable study reports (i.e., Studies 10 through 16 and Study 21).



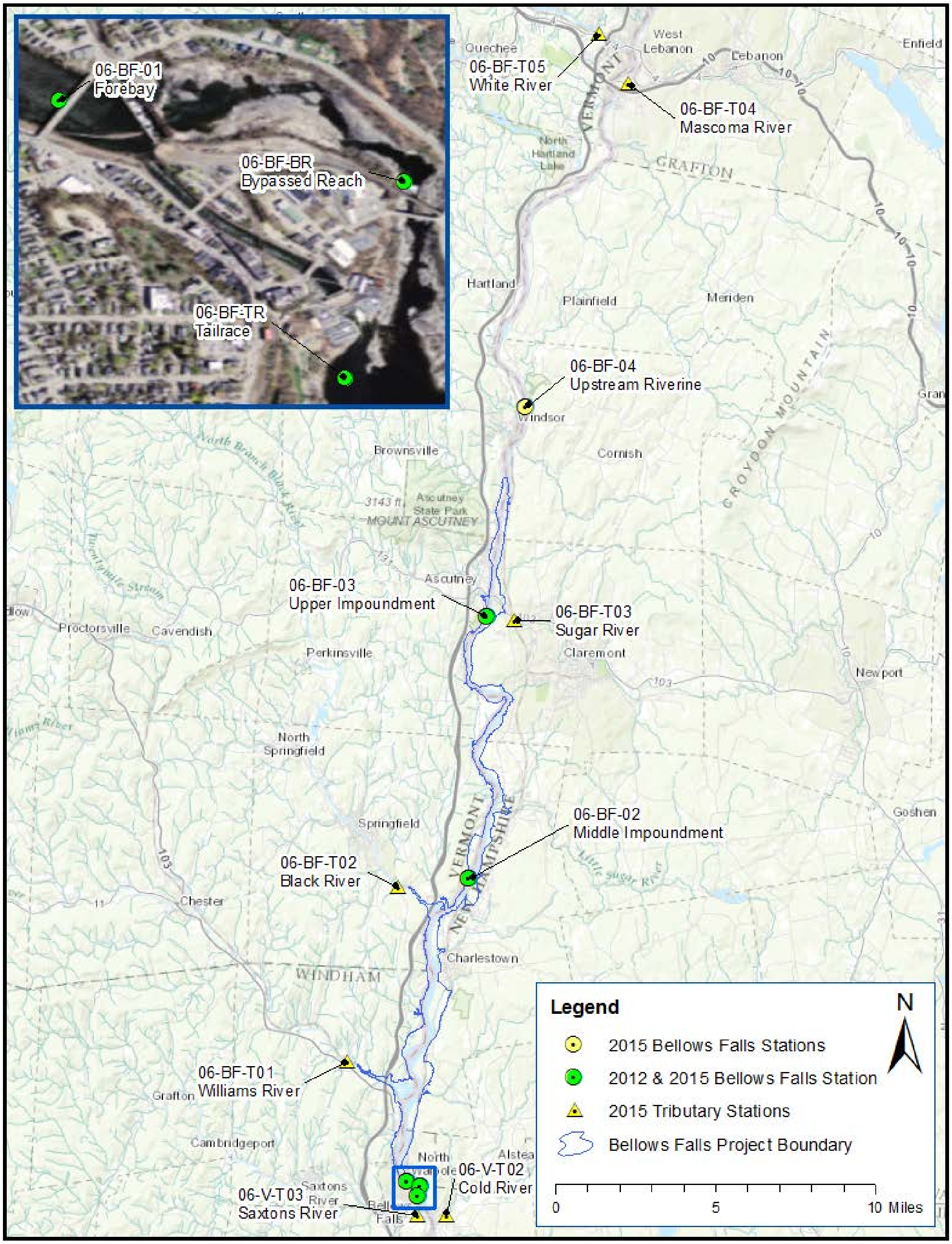
Source: Connecticut River Watershed Council and Pioneer Valley Planning Commission (2016, as modified by TransCanada)

Figure 3.4-21. *E. coli* colony bacteria counts in the Vernon Project area.



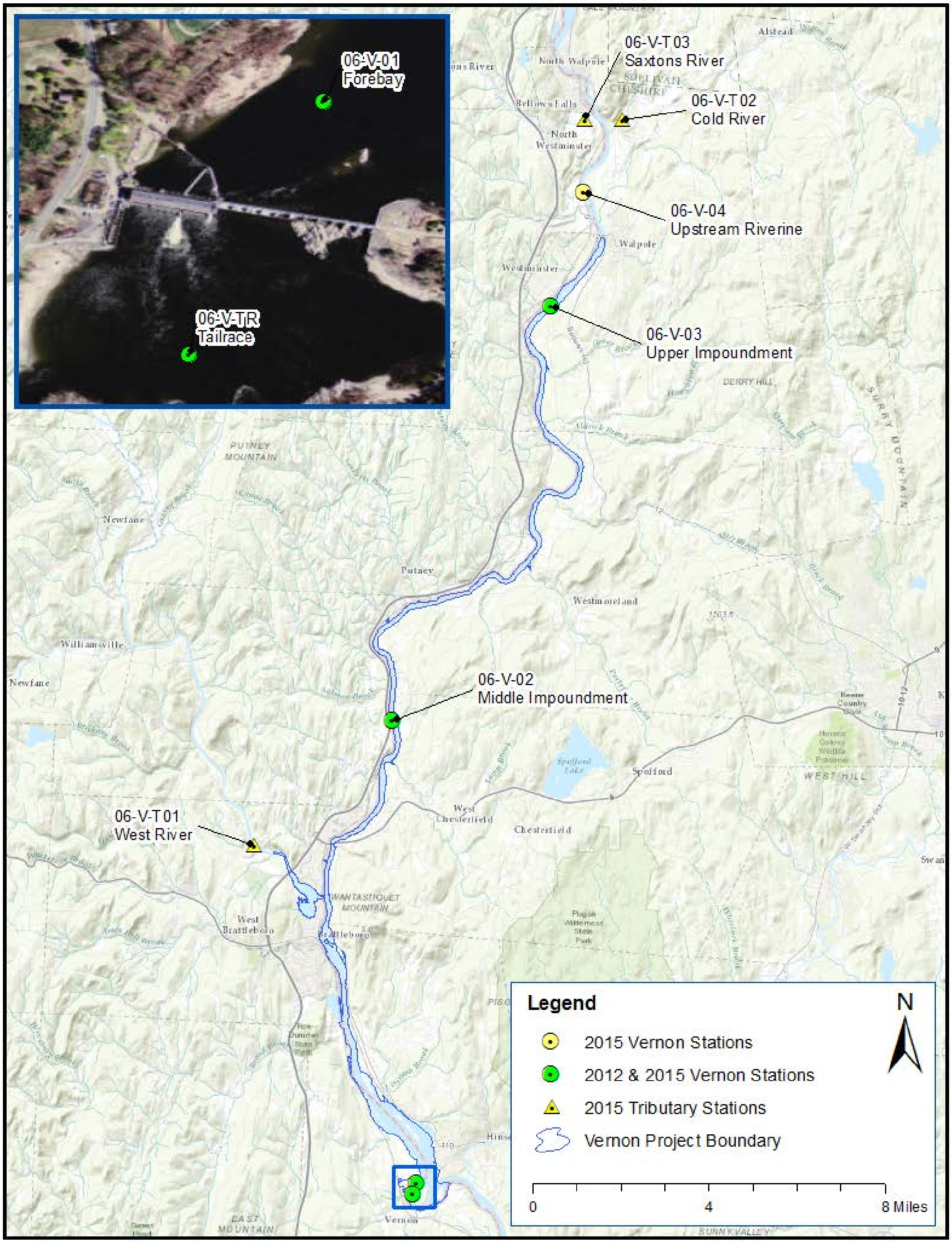
Source: modified from ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-22. 2012 and 2015 Wilder water quality monitoring stations.



Source: modified from ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-23. 2012 and 2015 Bellows Falls water quality monitoring stations.



Source: modified from ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-24. 2012 and 2015 Vernon water quality monitoring stations.

Wilder Project

Temperature and Dissolved Oxygen

Continuous water temperature and DO data were recorded at the Wilder forebay and tailrace, and vertical profiles of water temperature and DO were collected at all Wilder impoundment stations in 2012 from June through September (Normandeau, 2013a). Overall, water temperatures gradually warmed, peaked in early August, and then began to cool. Over the study period, temperatures ranged from 17.3°C (upper impoundment) to 26.5°C (forebay) (Table 3.4-18). DO concentrations (continuous measurements and vertical profiles) in the forebay and tailrace ranged from 5.7 to 9.7 mg/L and 6.5 to 9.3 mg/L, respectively (Table 3.4-18). The low DO level of 5.7 mg/L, which corresponds to 69 percent saturation, occurred during a period of weak stratification in the water column.

In 2015, water temperature, measured continuously throughout the Wilder study area, exhibited seasonal warming and cooling. As the weather warmed in the spring, water temperatures increased rapidly, followed by a steady increase through the summer until late-summer when water temperatures reached their maximum and began to gradually decrease through the fall (Figure 3.4-25). Throughout the Wilder Project area, continuous water temperature readings ranged from 6.4 to 25.8°C. The coolest temperatures were observed at the upper impoundment and upstream riverine stations during the spring and fall, and the warmest temperatures were observed at the middle impoundment and forebay stations in late-August, suggesting a gradual warming over the 46-river mile study area from the upstream riverine area to the Project dam and tailrace (Table 3.4-19). Diel temperature fluctuations occurred at all stations but were more prominent at the shallower upstream and upper impoundment areas than the deeper lower impoundment area and the tailrace where water temperatures were similar between the stations and diel fluctuation were attenuated. The 2015 seasonal trend in the DO concentrations and saturation levels over the study period was as follows (Figures 3.4-26 and Figure 3.4-27): DO levels were relatively high in June, then decreased through the summer because of lower oxygen solubility at higher water temperatures. DO reached its lowest level in mid-September of 6.6 mg/L (78 percent saturation) in the Wilder forebay subsequently increasing with falling water temperatures in early fall. Overall, DO concentrations measured continuously in the Wilder forebay ranged between 6.6 and 10.2 mg/L and percent saturation ranged between 78 and 111 percent. The DO concentrations continuously monitored in the Wilder tailrace ranged from 6.9 to 9.8 mg/L and 81 to 106 percent saturation (Tables 3.4-20 and 3.4-21).

Vertical profiles of water temperature and DO measured at all mainstem Wilder stations indicate that the water column was generally thermally uniform with some surface warming during the summer and was well oxygenated throughout the study period (see Study 6, Appendix H). DO levels based on instantaneous vertical profile measurements ranged from 7.2 mg/L (forebay) to 10.4 mg/L (upper impoundment), and 82 (forebay) to 102 (upper impoundment) percent saturation (Table 3.4-22).

Table 3.4-18. Water temperature, dissolved oxygen, specific conductivity, and pH statistics for the Wilder Project in 2012.

Statistic	Station				
	Upper Impound. 06-W-03 (profile)	Middle Impound. 06-W-02 (profile)	Forebay 06-W-01 (profile)	Forebay 06-W-01 (cont.)	Tailrace 06-W-TR (cont.)
Water Temperature (°C)					
Maximum	22.6	24.1	26.0	26.5	25.4
Minimum	17.3	19.8	19.8	21.1	19.2
Median	20.7	21.8	22.8	24.1	23.6
Mean	20.3	21.9	22.7	24.0	23.2
Dissolved Oxygen (mg/L)					
Maximum	9.1	8.8	9.0	9.7	9.3
Minimum	7.9	7.4	6.0	5.7	6.5
Median	8.7	7.9	7.8	7.6	7.3
Mean	8.5	8.1	7.7	7.6	7.5
Dissolved Oxygen (% saturation)					
Maximum	103	102	108	119	110
Minimum	89	85	71	69	76
Median	94	91	89	91	87
Mean	94	92	90	92	89
Minimum 24-hour mean	---	---	---	78	79
Specific Conductivity (μS/cm)					
Maximum	106	141	137	132	134
Minimum	88	81	85	88	80
Median	93	95	103	109	109
Mean	94	100	108	110	109
pH (standard units)[a]					
Maximum	7.7	7.6	7.5	7.8	7.7
Minimum	5.72	6.37	6.6	7.0	7.1
Median	7.0	7.2	7.2	7.2	7.3
Mean	6.9	7.2	7.2	7.2	7.3

Source: TransCanada (2012a)

Note: "---" indicates no data are available.

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Intensive continuous water temperature and continuous DO monitoring occurred at all Wilder impoundment and upstream riverine stations during a 10-day, high-temperature, low-flow monitoring event (Study 6). During this intensive sampling event, temperature was continuously recorded at three different locations across the river channel at each station (referred to as river left, mid-channel, and river right) and at up to three different depths.[28] Table 3.4-23 presents statistics for each station and deployment depth. Mean temperatures among all stations and deployment depths ranged between 22.1°C at the upstream riverine station and 24.0°C at the Wilder forebay station. Mean temperatures at river left, mid-channel, and river right locations at both upstream and upper impoundment stations were similar. At the middle impoundment, station temperatures were similar among deployment depths (1.0 meter below the water surface, mid-depth, and 1.0 meter above river bottom) and among the river left, mid-channel, and river right locations; mean bottom temperatures were 0.4°C cooler than those on the surface. The Wilder forebay station showed the greatest temperature difference of 0.9 to 1.0°C between surface and bottom temperatures where depths ranged from 6.9 meters at river left to 13.0 meters at river right. Mean DO levels were higher at the upstream and upper impoundment stations than at the middle and forebay stations (Table 3.4-24). Mean DO concentrations at the upstream and upper impoundment stations were both 8.4 mg/L, and percent DO saturation levels were 96 and 97 percent, respectively. The minimum daily mean ranged from 94 to 95 percent DO saturation. Mean DO concentrations at the middle impoundment and forebay stations were slightly lower, ranging from 7.9 to 8.1 mg/L. Mean percent DO saturation levels were 93 percent and 94 percent, and minimum daily mean percent DO saturation levels ranged between 87 to 98 percent at the forebay station, and 92 to 96 percent at the middle impoundment station.

[28] River left and river right are the left-hand or right-hand sides of the river, respectively, as viewed facing downstream.

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-25. Wilder continuous water temperatures observed during spring, summer, and fall 2015 with Wilder discharge.

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Table 3.4-19. Monthly water temperatures for Wilder Project in 2015.

Temperature (°C)	May	Jun	Jul	Aug	Sep	Oct	Nov	All
Upstream Riverine (06-W-04)								
Maximum	18.3	18.4	22.9	24.1	23.9	17.5	11.3	24.1
Minimum	6.6	12.2	16.6	18.9	15.9	7.8	6.8	6.6
Median	11.5	16.3	19.7	21.3	20.7	12.9	8.8	17.3
Mean	11.8	16.0	19.6	21.4	20.5	12.6	9.2	16.4
Upper Impoundment (06-W-03)								
Maximum	18.5	18.4	23.5	25.1	24.4	17.3	11.2	25.1
Minimum	6.4	12.1	16.8	19.1	16.3	7.8	6.6	6.4
Median	11.7	16.3	19.8	21.4	20.8	13.0	8.9	17.3
Mean	12.0	16.0	19.7	21.5	20.6	12.6	9.2	16.5
Middle Impoundment (06-W-02)								
Maximum	19.6	18.8	23.4	25.8	24.6	17.5	10.8	25.8
Minimum	7.1	12.4	17.4	20.7	17.2	9.1	7.6	7.1
Median	12.5	16.7	20.4	22.1	21.2	13.1	8.9	17.8
Mean	12.7	16.4	20.4	22.4	21.2	12.6	9.2	16.9
Forebay (06-W-01)								
Maximum	18.9	19.0	23.8	25.8	25.2	17.7	10.2	25.8
Minimum	10.1	12.4	16.8	21.7	17.7	9.2	7.9	7.9
Median	14.1	16.8	20.9	23.2	22.2	13.3	9.4	18.2
Mean	13.9	16.7	20.7	23.2	22.0	13.0	9.3	17.7
Tailrace (06-W-TR)								
Maximum	18.8	19.0	23.5	25.1	24.3	17.7	9.8	25.1
Minimum	10.1	12.5	16.8	21.7	17.7	9.1	7.9	7.9
Median	14.0	16.9	20.9	23.1	22.2	13.2	9.3	18.2
Mean	13.8	16.8	20.8	23.1	21.8	12.9	9.2	17.6

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

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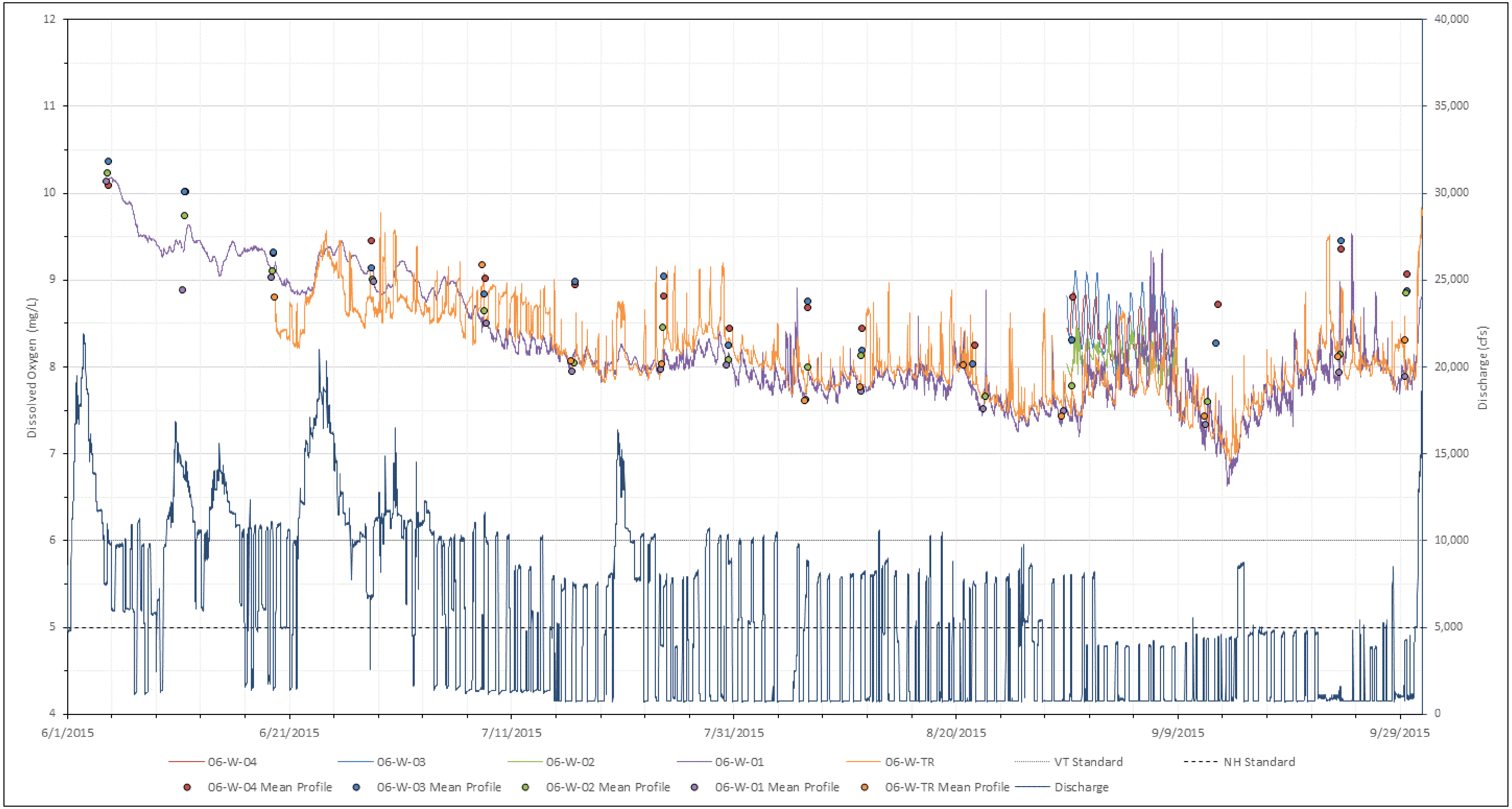

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-26. 2015 DO concentrations continuously measured in the Wilder forebay and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Wilder discharge.

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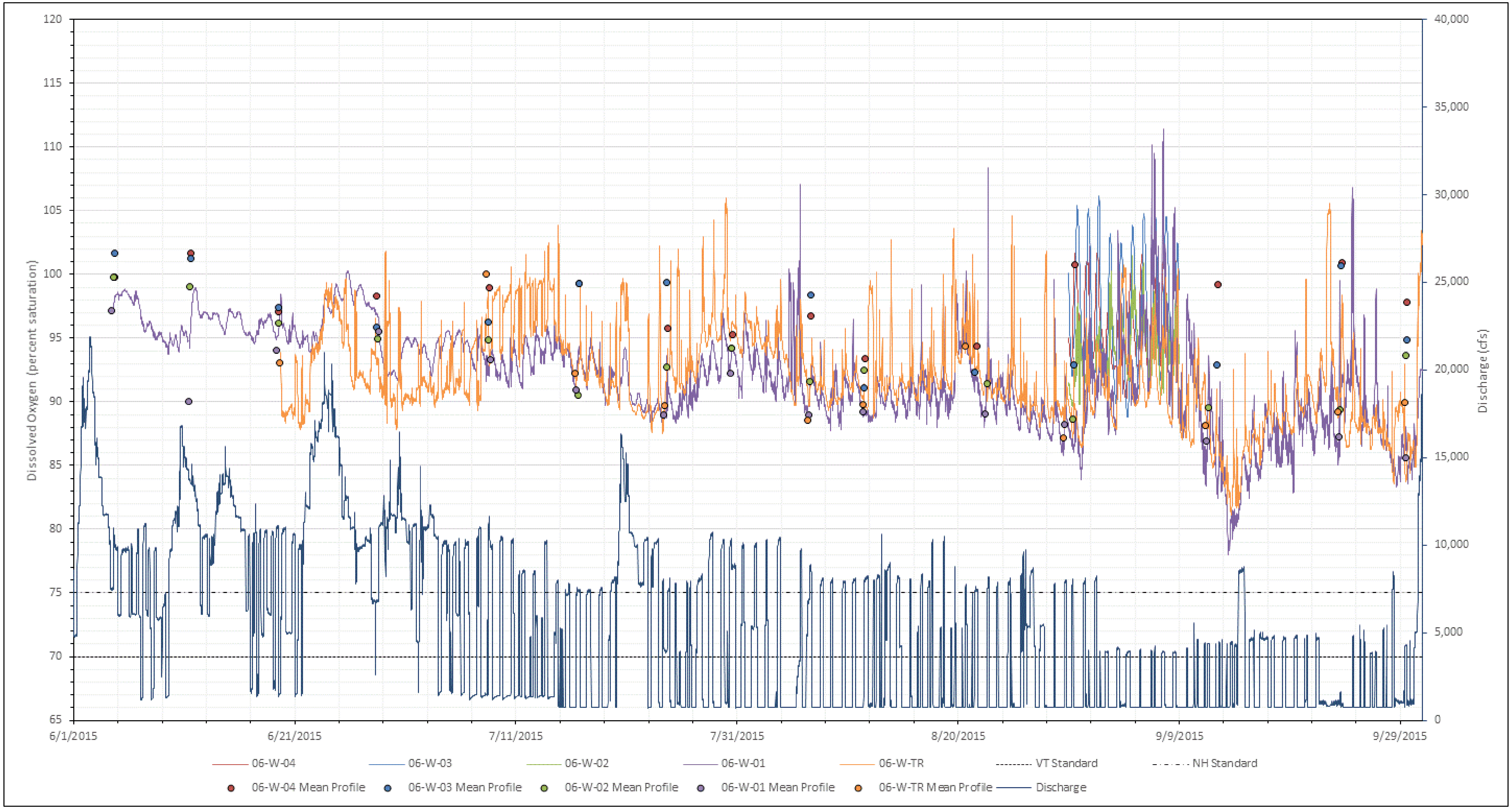

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-27. 2015 DO percent saturation continuously measured in the Wilder forebay and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Wilder discharge.

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Table 3.4-20. Monthly statistics for continuously monitored temperature, specific conductivity, dissolved oxygen, pH, and turbidity in the Wilder forebay in 2015.

Statistic	Jun	Jul	Aug	Sep	All
Temperature (°C)					
Maximum	19.0	23.8	25.8	25.2	25.8
Minimum	13.4	16.8	21.7	17.7	13.4
Median	17.0	20.9	23.2	22.2	21.7
Mean	17.0	20.7	23.2	22.0	20.9
Specific Conductivity (µS/cm)					
Maximum	107	142	142	163	163
Minimum	69	83	105	115	69
Median	78	104	118	134	114
Mean	81	104	120	136	111
Dissolved Oxygen (mg/L)					
Maximum	10.2	9.2	8.9	9.5	10.2
Minimum	8.8	7.8	7.2	6.6	6.6
Median	9.3	8.2	7.8	7.9	8.1
Mean	9.3	8.3	7.8	7.8	8.3
Dissolved Oxygen (% saturation)					
Maximum	100	97	108	111	111
Minimum	92	88	84	78	78
Median	96	93	91	89	92
Mean	96	93	91	90	92
Maximum daily mean	100	95	96	98	100
Min daily mean	92	89	87	81	81
pH (standard units)[a]					
Maximum	7.5	7.6	7.8	8.02	8.02
Minimum	7.3	7.3	7.2	7.4	7.2
Median	7.4	7.4	7.4	7.5	7.4
Mean	7.4	7.4	7.4	7.5	7.4
Turbidity (NTU)					
Maximum	28.3	25.3	7.6	12.1	28.3
Minimum	0.0	0.7	0.3	0.0	0.0
Median	1.9	1.4	0.7	0.6	0.9
Mean	3.4	3.0	0.9	0.6	1.9

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-21. Monthly statistics for continuously monitored temperature, specific conductivity, dissolved oxygen, pH, and turbidity collected in the Wilder tailrace in 2015.

Statistic	Jun	Jul	Aug	Sep	All
Temperature (°C)					
Maximum	19.0	23.5	25.1	24.3	25.1
Minimum	16.3	16.8	21.7	17.7	16.3
Median	18.3	20.9	23.1	22.2	22.1
Mean	18.1	20.8	23.1	21.8	21.5
Specific Conductivity (µS/cm)					
Maximum	102	145	145	161	161
Minimum	70	82	105	117	70
Median	84	106	117	131	116
Mean	83	105	119	133	115
Dissolved Oxygen (mg/L)					
Maximum	9.8	9.4	9.0	9.8	9.8
Minimum	8.2	7.8	7.4	6.9	6.9
Median	8.7	8.4	7.9	7.9	8.0
Mean	8.8	8.4	7.9	7.9	8.1
Dissolved Oxygen (% saturation)					
Maximum	102	106	105	106	106
Minimum	88	88	86	81	81
Median	92	94	91	89	91
Mean	93	94	92	90	92
Maximum daily mean	98	98	96	97	98
Minimum daily mean	89	90	89	84	84
pH (standard units)					
Maximum	7.5	7.6	7.6	7.7	7.7
Minimum	7.2	7.2	7.3	7.3	7.2
Median	7.4	7.4	7.4	7.4	7.4
Mean	7.4	7.4	7.4	7.4	7.4
Turbidity (NTU)					
Maximum	64.0	23.8	8.3	14.8	64.0
Minimum	0.3	0.3	0.8	0.1	0.1
Median	3.6	1.6	1.4	1.2	1.3
Mean	7.8	2.8	1.6	1.3	2.5

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Table 3.4-22. Vertical profile statistics for temperature, dissolved oxygen, specific conductivity, pH, and turbidity for Wilder Project in 2015.

Statistic	Upstream Riverine 06-W-04	Upper Impound. 06-W-03	Middle Impound. 06-W-02	Forebay 06-W-01	Tailrace 06-W-TR
Mean water depth (meters)[a]	0.8	2.2	7.2	10.6	8.6
Temperature (°C)					
Maximum	22.1	22.2	25.7	24.7	23.8
Minimum	14.9	14.5	14.2	13.4	18.0
Median	20.1	19.9	20.9	20.7	22.5
Mean	19.2	19.2	20.3	20.4	21.9
Dissolved Oxygen (mg/L)					
Maximum	10.1	10.4	10.3	10.2	9.2
Minimum	8.3	8.0	7.5	7.2	7.4
Median	8.9	8.9	8.1	8.0	8.0
Mean	9.0	8.9	8.5	8.2	7.9
Dissolved Oxygen (% saturation)					
Maximum	102	102	100	101	100
Minimum	93	91	88	82	86
Median	98	96	93	90	89
Mean	98	97	93	91	90
Specific Conductivity (µS/cm)					
Maximum	121	121	126	139	138
Minimum	62	63	68	74	94
Median	96	95	106	111	130
Mean	96	93	104	109	123
pH (standard units)					
Maximum	7.6	7.5	7.5	7.5	7.5
Minimum	7.2	7.2	7.3	7.3	7.3
Median	7.4	7.3	7.4	7.4	7.4
Mean	7.4	7.4	7.5	7.4	7.4
Turbidity (NTU)					
Maximum	2.7	2.9	5.0	59.3	2.7
Minimum	0.0	0.0	0.0	0.0	0.1
Median	0.9	0.7	0.5	1.2	1.2
Mean	1.0	0.8	0.9	3.1	1.3

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Average of individual depths recorded during each station visit.

Table 3.4-23. Water temperatures for Wilder Project during 10-day, high-temperature, low-flow monitoring period in 2015.

Logger Location	Statistic	Temperature (°C)		
		River Left	Mid-channel	River Right
Upstream Riverine (06-W-04)				
Mid-depth	Maximum	24.8	24.3	23.6
	Minimum	20.3	20.3	20.4
	Mean	22.3	22.3	22.1
Depth to bottom (at first deployment, meters)		0.2	0.3	1.0
Upper Impoundment (06-W-03)				
Mid-depth	Maximum	24.2	24.2	24.2
	Minimum	20.8	20.8	20.7
	Mean	22.4	22.4	22.4
Depth to bottom (at first deployment, meters)		1.5	1.8	2.7
Middle Impoundment (06-W-02)				
1m below surface	Maximum	25.0	24.6	24.9
	Minimum	21.7	21.7	21.8
	Mean	23.1	23.0	23.2
Mid-depth	Maximum	NA	23.6	24.1
	Minimum		21.6	21.7
	Mean		22.7	22.8
1m above bottom	Maximum	23.9	23.4	23.6
	Minimum	21.7	21.6	21.7
	Mean	22.7	22.6	22.8
Depth to bottom (at first deployment, meters)		3.9	6.3	6.2
Forebay (06-W-01)				
1m below surface	Maximum	26.5	26.2	26.3
	Minimum	22.9	22.9	22.9
	Mean	24.0	23.9	23.9
Mid-depth	Maximum	24.4	24.2	23.8
	Minimum	22.7	22.7	22.7
	Mean	23.3	23.2	23.1
1m above bottom	Maximum	23.9	23.5	23.5
	Minimum	22.7	22.7	22.7
	Mean	23.0	23.0	23.0
Depth to bottom (at first deployment, meters)		6.9	10.1	13

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Note: NA – no logger was deployed because of shallow water depths.

Table 3.4-24. Statistics of temperature, specific conductivity, dissolved oxygen, pH, and turbidity for the Wilder Project during 10-day, high-temperature, low-flow monitoring period in 2015.

Statistic	Station			
	Upstream Riverine 06-W-04	Upper Impound. 06-W-03	Middle Impound. 06-W-02	Forebay 06-W-01
Temperature (°C)				
Maximum	23.6	23.9	24.3	24.8
Minimum	20.4	20.5	21.6	22.6
Median	22.1	22.1	22.8	23.3
Mean	22.1	22.1	22.8	23.4
Specific Conductivity (µS/cm)				
Maximum	120	125	164	151
Minimum	96	101	119	112
Median	112	114	131	132
Mean	111	115	133	133
Dissolved Oxygen (mg/L)				
Maximum	8.9	9.1	8.5	9.4
Minimum	8.0	7.9	7.8	7.2
Median	8.4	8.4	8.1	7.9
Mean	8.4	8.4	8.1	7.9
Dissolved Oxygen (% saturation)				
Maximum	103	106	102	111
Minimum	90	89	90	84
Median	96	96	94	93
Mean	96	97	94	93
Maximum daily mean	99	99	96	98
Minimum daily mean	94	95	92	87
pH (standard units)[a]				
Maximum	7.7	7.7	7.5	8.02
Minimum	7.4	7.3	7.1	7.4
Median	7.5	7.5	7.3	7.6
Mean	7.5	7.5	7.3	7.6
Turbidity (NTU)				
Maximum	3.9	4.2	2.5	1.2
Minimum	1.4	0.7	0.3	0.1
Median	1.8	1.1	0.7	0.6
Mean	1.7	1.0	0.6	0.5

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Specific Conductivity

Specific conductivity data collected in 2012 and 2015 typically ranged between 80 and 141 µS/cm and 62 and 163 µS/cm, respectively (Table 3.4-18, Table 3.4-22, and Table 3.4-20). During both studies, specific conductivity was observed to generally increase from upstream areas through the impoundment to the forebay and tailrace, where specific conductivities were generally similar between the two stations. Seasonally, specific conductivity was variable throughout both studies, and was generally lower in late spring and early summer and higher in mid to late summer. No vertical stratification of specific conductivity was observed in either 2012 or 2015, and there was no daily trend in specific conductivity among all stations during the 10-day, high-temperature, low-flow monitoring period in 2015 (Normandeau, 2013a; Study 6).

pH

In 2012, pH was continuously measured in the Wilder forebay and tailrace from June through September and instantaneously measured through the water column during the collection of vertical profiles at the upper impoundment, middle impoundment, and forebay stations. In 2012, pH levels in the Wilder forebay and tailrace ranged between 6.6 and 7.8, and pH through the remainder of the impoundment ranged from 5.7 to 7.7 (Table 3.4-18). Instances when pH levels fell below the lower state surface water quality standard occurred on June 26, 2012, and July 10, 2012. On June 26, 2012, vertical profile pH measurements that exceeded the lower limit were 6.4 at the middle impoundment station and 5.7 to 6.1 at the upper impoundment station. On July 10, 2012, pH ranged from 5.8 to 6.0 at the Wilder upper impoundment station (Normandeau, 2013a; Study 6).

In 2015, pH was also continuously measured in the Wilder forebay and tailrace, and instantaneously measured during the collection of vertical profiles at all impoundment stations and the upstream riverine station. In the Wilder forebay, pH levels ranged from 7.2 to 7.8 from June through August, and the same mean monthly pH level of 7.4, was measured for June, July, and August (Table 3.4-20). In September, the mean pH value increased slightly to 7.5, and the highest pH value of 8.02 was recorded at the forebay station, exceeding the New Hampshire pH standard by 0.02 standard units. In the Wilder tailrace, pH ranged from 7.2 to 7.7 with minor fluctuations, and it did not rise above or fall below the Vermont or New Hampshire surface water quality standards (Table 3.4-21). Vertical profiles indicate that pH throughout the water column was uniform at all Wilder monitoring stations, and ranged from 7.2 to 7.6 (Table 3.4-22). During the 10-day, high-temperature, low-flow monitoring period pH was continuously monitored at all mainstem Wilder stations, and exhibited strong diurnal fluctuations at the upstream and upper impoundment stations, but the fluctuations attenuated at the middle impoundment station and forebay and were absent in the tailrace (see Study 6, Appendix J). The lowest pH recorded during the 10-day, high-temperature, low-flow monitoring period was 7.1 at the middle impoundment station and the highest pH recorded was 8.02 at the forebay station, as described above (Table 3.4-24). At no point during the 2015 study was pH observed to exceed the Vermont surface water quality standard.

Turbidity

Turbidity was monitored on a continuous basis from June through September 2015 at the Wilder forebay and tailrace stations (Study 6). Turbidity at the forebay and tailrace stations was generally very low but increased in response to precipitation events that often resulted in spill at the Project dam (Figure 3.4-28). Turbidity at the forebay station ranged from 0.0 to 28.3 nephelometric turbidity units (NTU) with an overall median and mean of 0.9 and 1.9 NTU, respectively (Table 3.4-20). Turbidity at the tailrace station ranged from 0.1 NTU to 64.0 NTU with an overall median and mean of 1.3 and 2.5 NTU, respectively (Table 3.4-21). Vertical profiles of turbidity also depicted a range of values that reflect weather conditions, but overall mean and median turbidity values throughout the Project area ranged from 0.8 to 3.1 NTU and 0.5 to 1.2 NTU, respectively (Table 3.4-22). During low-flow conditions, turbidity was very low in upstream areas and throughout the Wilder impoundment, and generally decreased downstream. Median turbidity values recorded during this period ranged from 1.8 NTU at the upstream riverine station to 0.6 NTU at the forebay with a maximum of 4.2 NTU recorded at the upper impoundment station (Table 3.4-24).

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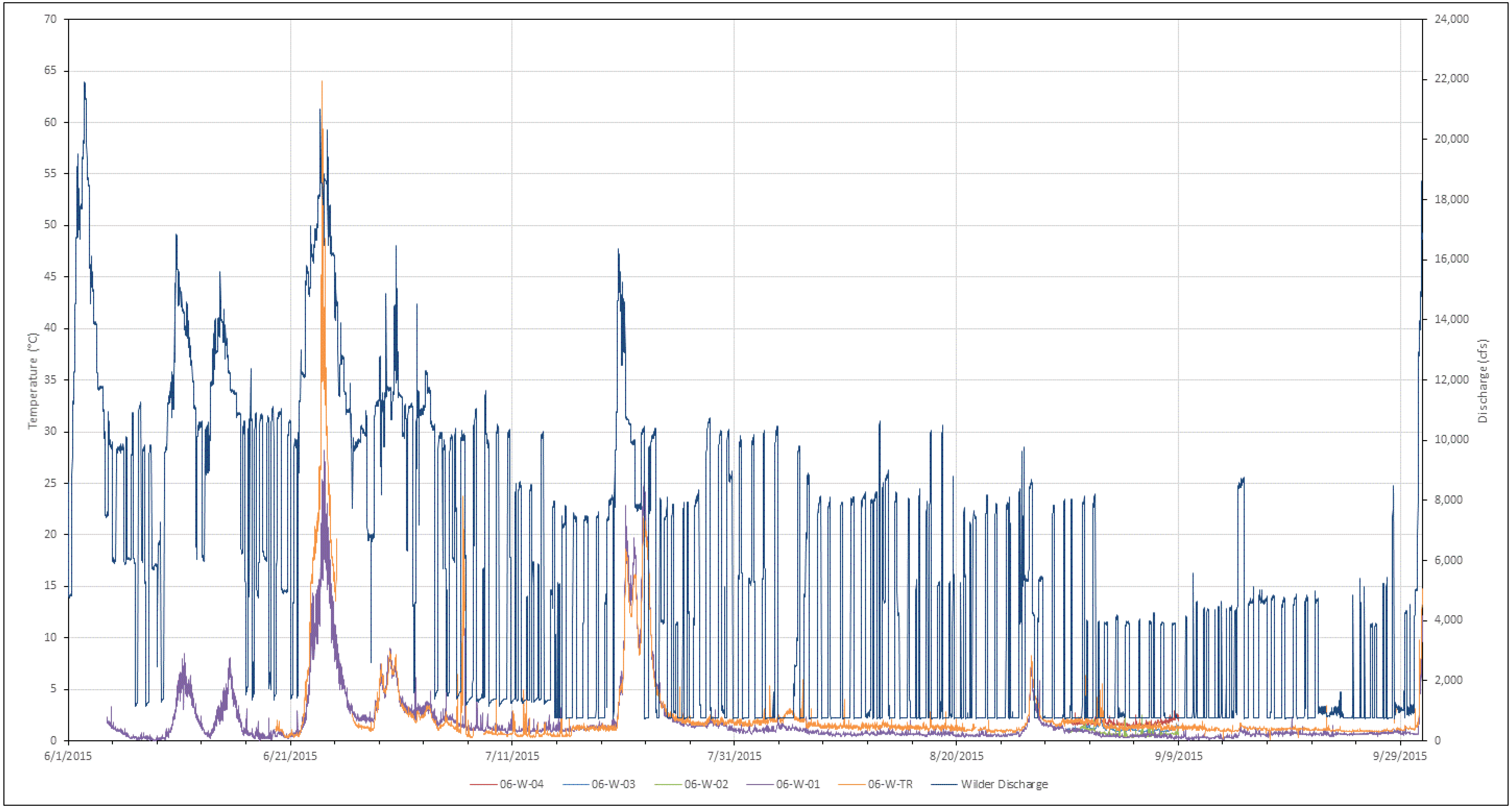

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-28. 2015 turbidity measured in the Wilder forebay and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Wilder discharge.

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Nutrients and Chlorophyll-a

In 2012 and 2015, total nitrogen, total phosphorus, nitrate/nitrite, total Kjeldahl nitrogen, and chlorophyll-*a* concentrations were measured in a water column composite sample in the Wilder forebay (Table 3.4-25 and Table 3.4-26). Nutrients and chlorophyll-*a* generally did not show a seasonal pattern. In 2012, mean nitrate/nitrite and total phosphorus concentrations were 0.19 and 0.019 mg/L, respectively (Table 3.4-25). Chlorophyll-*a* concentrations ranged from 1.6 to 5.8 milligrams per cubic meter (mg/m^3) with a mean of 3.5 mg/m^3. In 2015, concentrations were similar. Mean nitrate/nitrite and total phosphorus concentrations were 0.16 and 0.013 mg/L, respectively (Table 3.4-26). Chlorophyll-*a* concentrations ranged from 0.6 to 4.7 mg/m^3 with a mean of 2.2 mg/m^3.

Table 3.4-25. Nutrient and chlorophyll-*a* concentrations in the Wilder forebay in 2012.

Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Nitrate/Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-*a* (mg/m^3)
7/10/2012	0.76	0.032	0.16	0.60	4.3
7/17/2012	0.54	0.018	0.17	0.37	5.1
7/24/2012	0.68	0.039	0.21	0.47	5.8
7/31/2012	0.60	0.015	0.22	0.38	3.1
8/7/2012	0.72	0.009	0.22	0.50	2.7
8/14/2012	0.55	0.016	0.18	0.37	4.2
8/22/2012	0.62	0.012	0.18	0.44	2.2
8/28/2012	0.59	0.019	0.19	0.40	3.3
9/4/2012	0.59	0.021	0.20	0.39	2.4
9/11/2012	0.64	0.010	0.17	0.47	1.6
Maximum	0.76	0.039	0.22	0.60	5.8
Minimum	0.54	0.009	0.16	0.37	1.6
Median	0.61	0.017	0.19	0.42	3.2
Mean	0.63	0.019	0.19	0.44	3.5

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Table 3.4-26. Nutrient and chlorophyll-*a* concentrations in the Wilder forebay in 2015.

Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Nitrate/Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-*a* (mg/m^3)
6/4/2015	<0.50	0.012	0.14	<0.50	0.7
6/11/2015	<0.50	0.026	0.14	<0.50	1.1
6/19/2015	<0.50	0.011	0.09	<0.50	1.5
6/28/2015	<0.50	0.018	0.09	<0.50	1.5
7/8/2015	<0.50	0.014	0.12	<0.50	1.1
7/16/2015	<0.50	0.009	0.30	<0.50	1.5
7/24/2015	<0.50	0.014	0.11	<0.50	0.6
7/30/2015	0.74	0.022	0.14	0.60	2.8
8/6/2015	<0.50	0.008	0.15	<0.50	3.1
8/11/2015	<0.50	0.009	0.17	<0.50	2.5
8/22/2015	0.77	0.012	0.27	0.50	2.4
8/29/2015	1.50	0.009	0.26	1.20	4.7
9/11/2015	<0.5	0.011	0.16	<0.50	2.5
9/23/2015	<0.5	0.009	0.14	<0.50	3.5
9/29/2015	1.15	0.008	0.15	1.00	3.9
Maximum	1.50	0.026	0.30	1.20	4.7
Minimum	<0.50	0.008	0.09	<0.50	0.6
Median	<0.50	0.011	0.14	<0.50	2.4
Mean[a]	0.46	0.013	0.16	0.40	2.2

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. For values below the detection limit of 0.5 mg/L, a concentration of 0.25 mg/L was assumed for calculations of the mean for the associated analyte.

Bellows Falls Project

Temperature and Dissolved Oxygen

In 2012, continuous temperature and DO levels were measured in the Bellows Falls forebay, bypassed reach, and tailrace (Normandeau, 2013a). Vertical profiles of temperature and DO levels were also collected in the Bellows Falls impoundment. Water temperatures gradually increased until mid-August before slowly declining. Strong daily fluctuations in temperature were observed in the shallow, riverine Bellows Falls bypassed reach. Diel fluctuations in temperature were less pronounced in the forebay and tailrace. Temperatures in the forebay, bypassed reach, and tailrace ranged from 21.0 to 27.0°C, 20.9 to 27.2°C, and 21.0 to 26.3°C, respectively, over the summer study period (Table 3.4-27). Overall temperatures in the mainstem (excluding the bypassed reach) ranged from 18.7°C (upper impoundment) to 27.0°C (forebay). Continuous measurements of DO in the forebay, bypassed reach, and tailrace indicated that waters were generally well oxygenated over the study season but fell below state standards in several instances in the forebay and bypassed reach. In the forebay and bypassed reach, DO levels fell below the Vermont surface water quality standard when DO concentrations briefly fell to 5.97 mg/L on July 16, 2012, and to 5.94 mg/L on July 23, 2012, respectively. As measured by vertical profiles, DO levels in the forebay were below state surface water quality standards and ranged between 5.9 mg/L (71 percent saturation) to 3.3 mg/L (39 percent saturation) at depths of 8.0 to 11.7 meters on July 18, 2012. These observations coincided with periods of stratification during high water temperature and low flow and were brief in duration (observed only on 1 day on July 18, 2012; Normandeau, 2013a). DO levels throughout the middle and upper impoundment remained above both Vermont and New Hampshire surface water quality standards throughout the 2012 study.

Table 3.4-27. Water temperature, DO, specific conductivity, and pH statistics for Bellows Falls Project in 2012.

Statistic	Station					
	Upper Impound. 06-BF-03 (profile)	Middle Impound. 06-BF-02 (profile)	Forebay 06-BF-01 (profile)	Forebay 06-BF-01 (cont.)	Bypassed Reach 06-BF-BR (cont.)	Tailrace 06-BF-TR (cont.)
Water Temperature (°C)						
Maximum	24.7	25.6	26.5	27.0	27.2	26.3
Minimum	18.7	19.4	21.0	21.3	20.9	21.0
Median	22.4	23.7	24.1	24.9	25.0	24.4
Mean	22.3	23.1	23.7	24.7	24.8	24.2
Dissolved Oxygen (mg/L)						
Maximum	9.3	9.4	10.6	10.3	9.7	10.7
Minimum	7.4	7.1	3.3[a]	5.9[b]	6.0	6.5
Median	8.1	8.2	8.1	7.9	8.5	8.8
Mean	8.2	8.2	7.9	7.8	8.5	8.8
Dissolved Oxygen (% saturation)						
Maximum	102	103	120	124	121	130
Minimum	88	86	39.0[a]	72.8[b]	74	79
Median	93	96	96	96	103	106
Mean	94	96	94	95	104	106
Minimum 24-hour mean	NA	NA	NA	83	84	93
Specific Conductivity (µS/cm)						
Maximum	183	165	162	168	167	170
Minimum	107	111	118	114	115	118
Median	132	136	141	142	144	145
Mean	133	136	142	142	143	144
pH (standard units)[c]						
Maximum	7.8	7.8	7.7	8.53	8.06	7.6
Minimum	6.08	6.9	6.45	7.2	7.5	7.1
Median	7.2	7.6	7.5	7.7	7.7	7.3
Mean	7.2	7.5	7.4	7.7	7.7	7.3

Source: TransCanada (2012b)

Note: NA — not applicable.

a. Recorded on July 18, 2012, in the hypolimnion.

b. Recorded on July 23, 2013, at 25% depth from surface.

c. Values with two digits after the decimal point are those that exceeded state standard(s).

In 2015, water temperature was continuously monitored from late April through November 15 in the Bellows Falls upstream riverine reach, impoundment, forebay bypassed reach, and tailrace, and along transects and different depth stratum at the impoundment and upstream riverine stations during a 10-day, high-temperature, low-flow monitoring period (Figure 3.4-23). Throughout the Bellows Falls Project area, all stations showed a similar seasonal pattern of warming during the spring and summer and cooling during the fall (Figure 3.4-29). Temperatures ranged from 5.8 to 26.3°C, and were on average cooler at the upstream riverine stations and warmest at the forebay and tailrace (Table 3.4-28). At the shallower upstream riverine, upper impoundment, and bypassed reach stations, water temperatures had larger diurnal fluctuations whereas at the forebay and tailrace diurnal fluctuations were smaller or sometimes absent.

DO was continuously measured in the forebay, bypassed reach, and tailrace. During the 10-day, high-temperature, low-flow monitoring period, DO was continuously monitored at all mainstem stations. DO levels were relatively high in June then decreased through the summer and began to increase again in September (Figure 3.4-30 and Figure 3.4-31). DO levels ranged from 7.1 to 10.7 mg/L and 84 to 118 percent saturation with the lowest DO levels being observed in August and September (Tables 3.4-29, 3.4-30, and 3.4-31).

Temperature and DO vertical profiles collected throughout the Bellows Falls study area from June to October indicated the water column was generally uniform with some surface warming during the summer but was well oxygenated (see Study 6, Appendix H). Unlike in 2012, no instances of stratification were observed in the forebay; however, weak and very brief stratification was observed at the middle impoundment station when a thermal discontinuity was observed at the surface resulting in a temperature difference between the surface and 1.0 meter depth of about 2.8°C (July 29, 2015). Below the 1.0-meter-depth interval, temperatures were uniform and about 24°C. No other instances of stratification occurred and DO levels never fell below state surface water quality standards (Table 3.4-32).

Intensive continuous water temperature and continuous DO monitoring occurred at all Bellows Falls impoundment and upstream riverine stations during the 10-day, high-temperature, low-flow monitoring period. During this intensive sampling event, temperature was continuously recorded at three different locations across the river channel at each station (referred to as river left, mid-channel, and river right) and at up to three different depths. Mean temperatures at each deployment depth among deployment locations were similar (Table 3.4-33). Locations shallower than 4.5 meters generally had a difference between surface and bottom temperatures of 0.3°C; for locations deeper than 7.9 meters (forebay river right and mid-channel), this difference was greater than or equal to 0.5°C. Mean DO concentrations at the upstream, upper, and middle impoundment stations ranged from 8.6 to 8.7 mg/L, and the mean daily percent DO saturation levels ranged from 97 to 109 percent (Table 3.4-34). The mean DO concentration observed at the Bellows Falls forebay was 8.3 mg/L and the mean daily percent DO saturation ranged from 95 to 109 percent.

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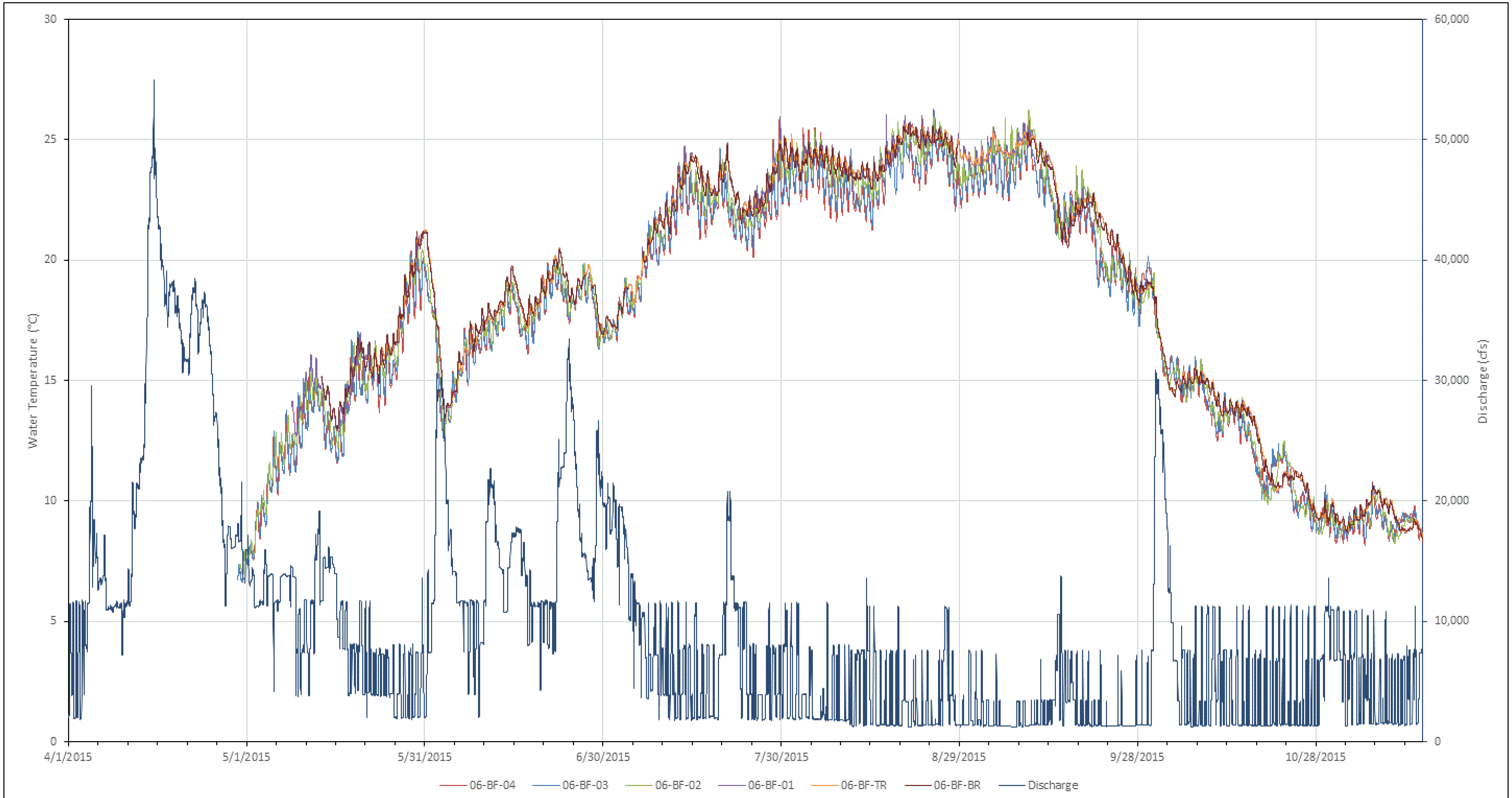

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-29. Bellows Falls continuous water temperatures observed during spring, summer, and fall 2015 with Bellows Falls discharge.

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Table 3.4-28. Monthly water temperatures for Bellows Falls Project in 2015.

Temperature (°C)	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	All
Upstream Riverine (06-BF-04)									
Maximum	7.9	20.4	19.9	25.9	26.3	25.9	17.5	10.3	26.3
Min	6.7	7.3	12.5	16.6	21.3	17.6	8.2	5.8	5.8
Median	7.2	14.0	17.4	21.7	23.4	22.2	12.6	8.9	18.0
Mean	7.3	13.9	17.8	21.3	23.5	21.8	12.5	8.7	17.3
Upper Impoundment (06-BF-03)									
Maximum	8.0	20.4	19.8	25.7	26.3	25.8	17.8	10.6	26.3
Minimum	6.6	7.3	12.5	16.7	21.4	17.3	8.4	6.1	6.1
Median	7.2	14.1	17.5	21.8	23.6	22.3	12.8	9.0	18.2
Mean	7.2	14.0	17.2	21.4	23.6	21.8	12.5	8.7	17.5
Middle Impoundment (06-BF-02)									
Maximum	8.15	20.9	20.1	25.2	26.0	26.2	18.1	10.5	26.2
Minimum	6.9	7.6	12.8	16.7	22.3	18.0	8.6	6.1	6.1
Median	7.3	14.4	17.7	22.1	24.1	22.6	12.9	9.0	18.3
Mean	7.4	14.3	17.5	21.7	24.1	22.2	12.5	8.8	17.8
Forebay (06-BF-01)									
Maximum	ND	21.3	20.5	26.	26.1	25.7	18.5	10.4	26.1
Minimum	ND	12.7	13.3	17.1	23.3	18.1	9.0	6.8	6.8
Median	ND	15.7	18.1	22.5	24.3	22.5	13.7	9.1	18.9
Mean	ND	16.0	17.8	22.0	24.4	22.5	12.8	9.1	18.4
Bypassed Reach (06-BF-BR)									
Maximum	ND	21.2	20.5	25.2	25.7	25.3	18.5	10.8	25.7
Minimum	ND	13.0	13.5	17.2	23.0	18.1	9.0	6.8	6.8
Median	ND	16.2	18.2	22.7	24.3	21.5	13.6	9.1	18.8
Mean	ND	16.6	17.9	22.3	24.4	21.5	12.8	9.1	18.2
Tailrace (06-BF-TR)									
Maximum	ND	21.3	20.5	25.4	25.7	25.3	18.4	10.5	25.7
Minimum	ND	15.3	13.4	17.1	23.3	18.1	9.0	6.9	6.9
Median	ND	17.2	18.1	22.5	24.4	22.5	13.7	9.2	19.3
Mean	ND	17.9	17.8	22.0	24.4	22.5	12.8	9.1	18.8

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Note: ND – no data; high flows and spill conditions in April precluded data collection until May.

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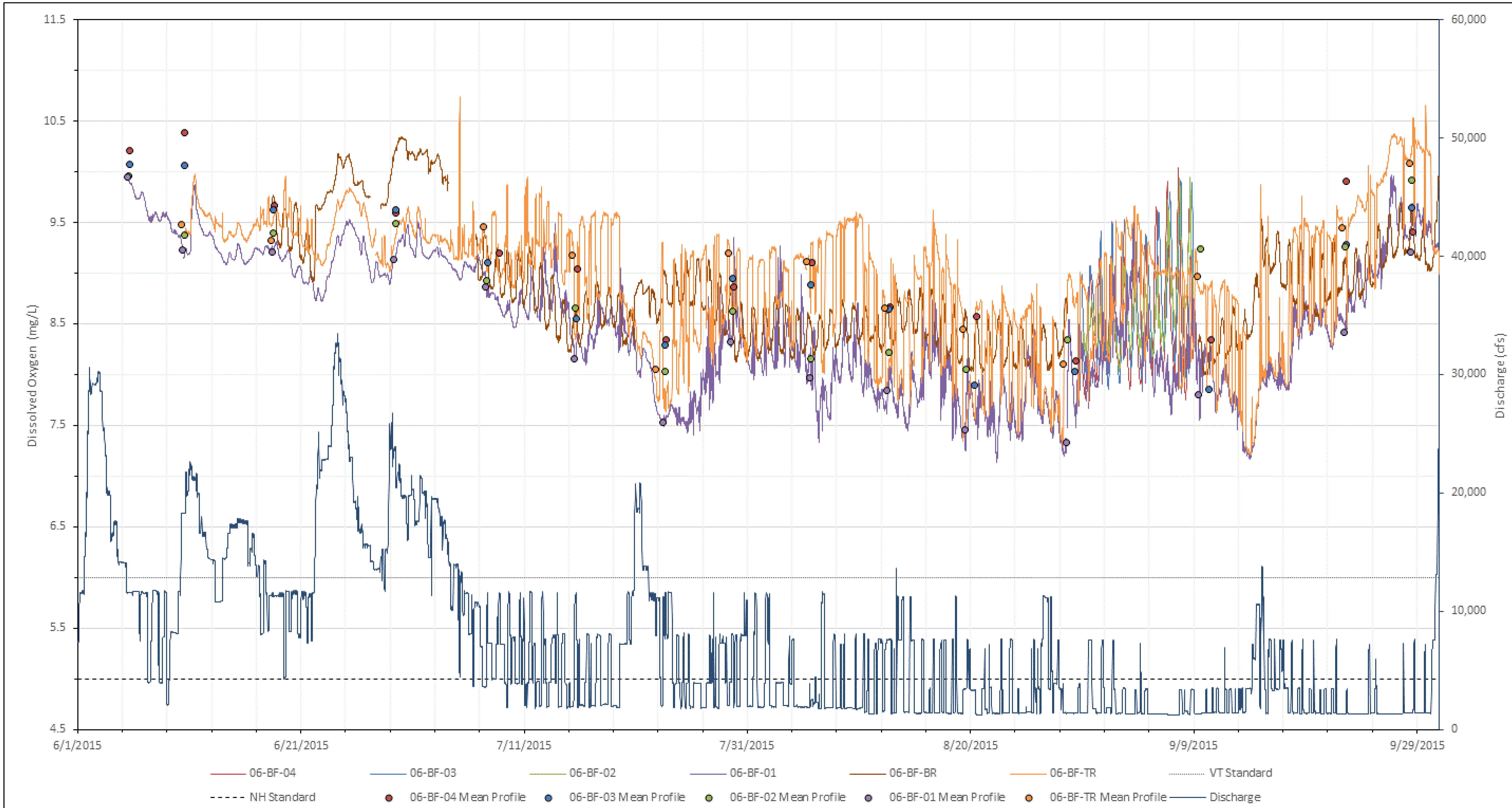

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-30. 2015 DO concentrations measured in the Bellows Falls forebay, tailrace, and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Bellows Falls discharge.

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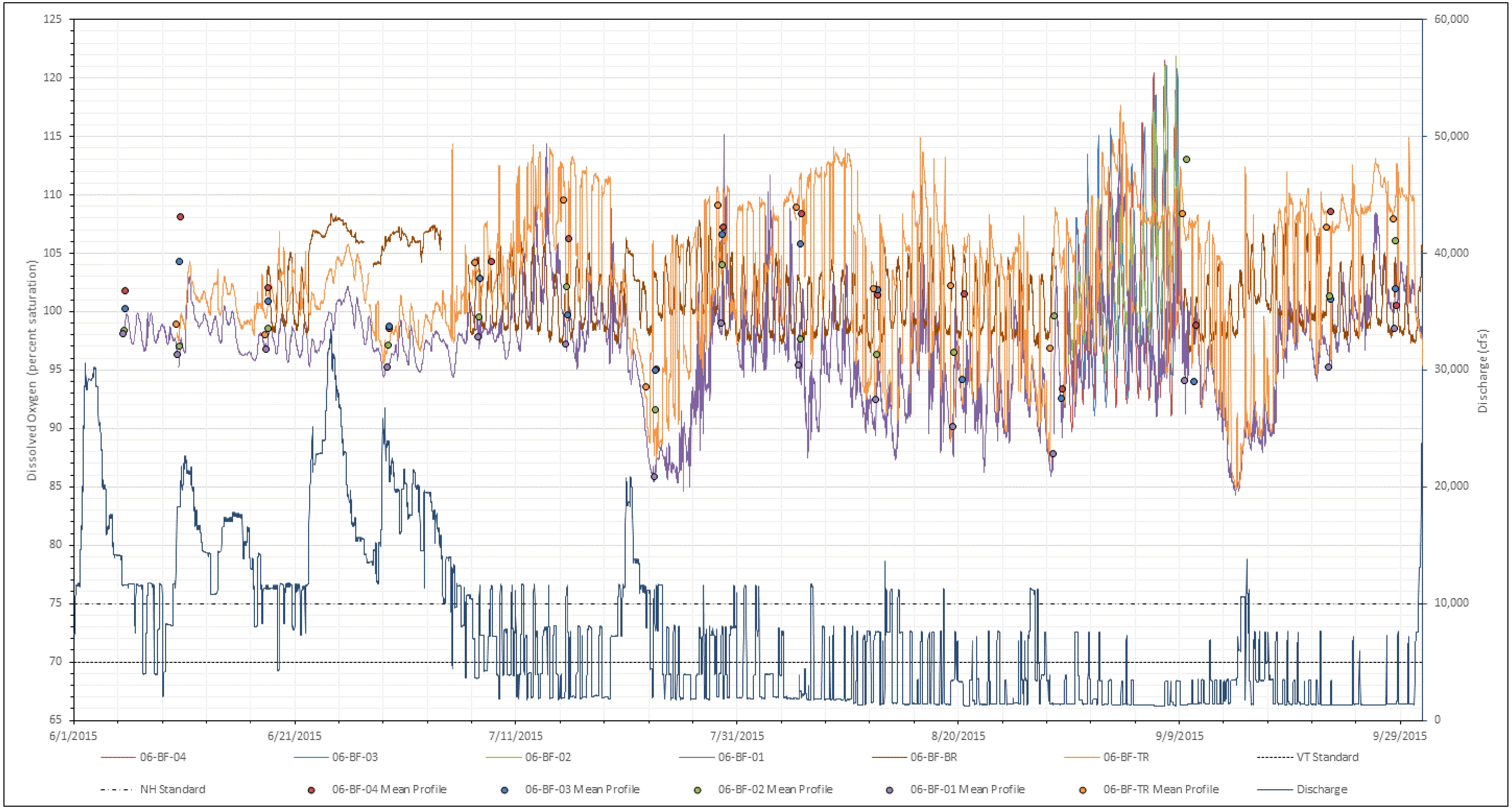

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-31. 2015 DO percent saturation measured in the Bellows Falls forebay, bypassed reach, and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Bellows Falls discharge.

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Table 3.4-29. Monthly statistics for continuously monitored temperature, specific conductivity, dissolved oxygen, pH, and turbidity in the Bellows Falls forebay in 2015.

Statistic	Jun	Jul	Aug	Sep	All
Temperature (°C)					
Maximum	20.5	26.0	26.1	25.7	26.1
Minimum	14.8	17.1	23.8	18.1	14.8
Median	18.2	22.5	24.3	22.5	22.7
Mean	18.2	22.0	24.4	22.5	21.9
Specific Conductivity (µS/cm)					
Maximum	119	158	169	176	176
Minimum	78	95	122	137	78
Median	94	129	146	157	141
Mean	95	127	146	157	133
Dissolved Oxygen (mg/L)					
Maximum	9.9	9.5	9.3	10.0	10.0
Minimum	8.7	7.4	7.1	7.2	7.1
Median	9.2	8.6	7.9	8.4	8.5
Mean	9.3	8.5	7.9	8.5	8.5
Dissolved Oxygen (% saturation)					
Maximum	103	115	112	115	115
Minimum	94	85	86	84	84
Median	98	98	95	98	98
Mean	98	97	95	98	97
Maximum daily mean	101	104	102	109	109
Minimum daily mean	96	87	91	87	87
pH (standard units)[a]					
Maximum	7.7	8.12	8.08	8.28	8.28
Minimum	7.4	7.4	7.5	7.6	7.4
Median	7.5	7.6	7.7	7.8	7.7
Mean	7.5	7.6	7.7	7.8	7.7
Turbidity (NTU)					
Maximum	66.7	9.5	2.4	13.4	66.7
Minimum	0.0	1.0	0.8	0.9	0.0
Median	1.7	1.8	1.2	1.5	1.5
Mean	4.9	2.6	1.2	1.6	2.5

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-30. Monthly statistics for continuously monitored temperature, specific conductivity, dissolved oxygen, pH, and turbidity in the Bellows Falls bypassed reach in 2015.

Statistic	Jun	Jul	Aug	Sep	All
Temperature (°C)					
Maximum	20.5	25.2	25.7	25.3	25.7
Minimum	16.9	17.2	23.0	18.1	16.9
Median	18.9	22.7	24.3	21.5	22.9
Mean	18.8	22.3	24.4	21.5	22.3
Specific Conductivity (µS/cm)					
Maximum	118	154	170	174	174
Minimum	51	89	121	146	51
Median	97	130	148	157	143
Mean	94	128	147	159	137
Dissolved Oxygen (mg/L)					
Maximum	10.3	10.2	8.9	10.0	10.3
Minimum	8.9	8.1	8.0	8.0	8.0
Median	9.8	8.8	8.4	8.9	8.7
Mean	9.8	8.9	8.4	8.9	8.9
Dissolved Oxygen (% saturation)					
Maximum	108	108	106	108	108
Minimum	98	97	97	97	97
Median	106	102	100	100	101
Mean	105	102	100	101	102
Maximum daily mean	108	107	102	103	108
Minimum daily mean	100	100	99	99	99
pH (standard units)[a]					
Maximum	7.9	8.07	7.96	8.0	8.07
Minimum	7.5	7.6	7.5	7.5	7.5
Median	7.6	7.8	7.7	7.7	7.7
Mean	7.6	7.8	7.7	7.7	7.7
Turbidity (NTU)					
Maximum	82.3	18.7	8.0	19.8	82.3
Minimum	0.5	0.0	1.4	0.3	0.0
Median	8.2	2.1	1.8	2.0	2.0
Mean	12.5	2.9	1.8	2.1	3.7

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-31. Monthly statistics for continuously monitored temperature, specific conductivity, dissolved oxygen, pH, and turbidity in the Bellows Falls tailrace in 2015.

Statistic	Jun	Jul	Aug	Sep	All
Temperature (°C)					
Maximum	20.5	25.2	25.7	25.3	25.7
Minimum	17.0	17.1	23.3	18.1	16.9
Median	18.6	22.5	24.4	22.5	23.0
Mean	18.6	22.0	24.4	22.5	22.2
Specific Conductivity (µS/cm)					
Maximum	117	155	168	175	175
Minimum	77	96	121	135	77
Median	92	127	146	154	140
Mean	93	126	147	154	133
Dissolved Oxygen (mg/L)					
Maximum	10.0	10.7	9.6	10.7	10.7
Minimum	9.0	7.6	7.3	7.2	7.2
Median	9.5	9.2	8.7	9.1	9.1
Mean	9.5	9.0	8.6	9.1	9.0
Dissolved Oxygen (% saturation)					
Maximum	107	114	145	118	118
Minimum	96	87	87	85	85
Median	101	102	104	108	103
Mean	101	103	103	104	103
Maximum daily mean	105	110	112	113	113
Minimum daily mean	97	92	93	88	88
pH (standard units)[a]					
Maximum	7.6	8.0	7.9	8.10	8.10
Minimum	7.5	7.2	7.4	7.6	7.2
Median	7.5	7.6	7.6	7.8	7.7
Mean	7.5	7.6	7.6	7.8	7.7
Turbidity (NTU)					
Maximum	42.6	34.9	21.0	22.8	42.6
Minimum	0.0	0.0	0.0	0.1	0.0
Median	3.3	1.7	0.9	0.9	1.2
Mean	6.1	2.7	1.1	1.2	2.5

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-32. Vertical profile statistics for Bellows Falls Project in 2015.

Statistic	Upstream Riverine 06-BF-04	Upper Impound. 06-BF-03	Middle Impound. 06-BF-02	Forebay 06-BF-01	Tailrace 06-BF-TR
Mean water depth (meters)[a]	2.1	3.1	3.2	11.0	4.9
Temperature (°C)					
Maximum	25.0	24.4	27.4	25.5	25.0
Minimum	15.2	15.1	14.8	14.7	17.4
Median	21.8	22.0	21.9	21.8	23.6
Mean	21.1	20.7	21.2	21.4	22.3
Dissolved Oxygen (mg/L)					
Maximum	10.4	10.1	10.1	10.0	10.1
Minimum	8.1	7.9	7.9	7.1	8.0
Median	9.1	9.0	8.9	8.3	9.1
Mean	9.1	9.0	8.9	8.4	9.0
Dissolved Oxygen (% saturation)					
Maximum	109	107	117	111	110
Minimum	93	92	91	85	93
Median	102	101	99	96	103
Mean	102	100	100	95	104
Specific Conductivity (µS/cm)					
Maximum	178	182	172	160	160
Minimum	85	58	62	87	92
Median	141	149	129	135	143
Mean	134	139	131	130	137
pH (standard units)[b]					
Maximum	8.19	8.05	8.44	8.0	7.9
Minimum	7.4	7.5	7.4	7.4	7.3
Median	7.8	7.7	7.7	7.6	7.6
Mean	7.8	7.7	7.7	7.6	7.7
Turbidity (NTU)					
Maximum	13.1	17.7	24.9	14.1	13.8
Minimum	0.0	0.0	0.0	0.0	0.0
Median	0.9	0.7	0.5	0.7	0.8
Mean	3.2	3.2	2.5	1.6	1.2

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*
a. Average of individual depths recorded during each station visit.
b. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-33. Water temperatures for Bellows Falls during the 10-day, high-temperature, low-flow monitoring period in 2015.

Deployment Depth	Statistic	Temperature (°C)		
		River Left	Mid-channel	River Right
Upstream Riverine (06-BF-04)				
Mid-depth	Maximum	25.7	25.5	26.3
	Minimum	22.4	22.4	21.8
	Mean	23.8	23.6	23.6
Depth to bottom (at first deployment, meter)		0.8	1.3	0.6
Upper Impoundment (06-BF-03)				
Mid-depth	Maximum	25.6	26.0	25.6
	Minimum	22.5	22.7	22.8
	Mean	23.8	24.1	24.0
Depth to bottom (at first deployment, meter)		2.1	0.8	2.9
Middle Impoundment (06-BF-02)				
1 meter below surface	Maximum	26.4	25.5	26.1
	Minimum	23.3	23.4	23.4
	Mean	24.4	24.3	24.4
1 meter above bottom	Maximum	25.2	25.0	25.2
	Minimum	23.3	23.3	23.3
	Mean	24.2	24.1	24.2
Depth to bottom (at first deployment, meter)		3.1	3.3	4.0
Forebay (06-BF-01)				
1 meter below surface	Maximum	26.5	26.2	26.8
	Minimum	25.9	23.9	24.1
	Mean	24.8	24.9	24.9
Mid-depth	Maximum	25.9	25.1	25.3
	Minimum	23.8	23.9	23.9
	Mean	24.6	24.4	24.9
1 meter above bottom	Maximum	25.7	24.7	25.0
	Minimum	23.8	23.8	23.9
	Mean	24.5	24.3	24.4
Depth to bottom (at first deployment, meter)		4.5	10.3	7.9

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Table 3.4-34. Statistics of temperature, specific conductivity, dissolved oxygen, pH and turbidity for Bellows Falls Project during the 10-day, high-temperature, low-flow monitoring period in 2015.

Statistic	Station			
	Upstream Riverine 06-BF-04	Upper Impound. 06-BF-03	Middle Impound. 06-BF-02	Forebay 06-BF-01
Temperature (°C)				
Maximum	25.5	25.5	25.9	25.7
Minimum	22.4	22.6	23.3	23.8
Median	23.4	23.7	24.3	24.5
Mean	23.6	23.8	24.2	24.5
Specific Conductivity (µS/cm)				
Maximum	185	182	173	160
Minimum	121	127	133	135
Median	153	152	151	148
Mean	153	155	153	148
Dissolved Oxygen (mg/L)				
Maximum	10.0	9.9	10.0	9.5
Minimum	7.8	7.9	8.0	7.6
Median	8.5	8.6	8.6	8.2
Mean	8.6	8.7	8.6	8.3
Dissolved Oxygen (% saturation)				
Maximum	122	121	122	115
Minimum	90	91	95	91
Median	100	101	102	99
Mean	101	103	103	99
Maximum daily mean	104	106	109	109
Minimum daily mean	97	100	99	95
pH (standard units)[a]				
Maximum	8.42	8.30	8.56	8.28
Minimum	7.6	7.5	7.9	7.6
Median	7.9	7.8	8.02	7.7
Mean	7.9	7.8	8.05	7.7

Statistic	Station			
	Upstream Riverine 06-BF-04	Upper Impound. 06-BF-03	Middle Impound. 06-BF-02	Forebay 06-BF-01
Turbidity (NTU)				
Maximum	9.9	3.3	3.2	2.1
Minimum	0.2	0.6	0.5	1.1
Median	1.0	1.0	0.7	1.5
Mean	1.2	1.2	0.8	1.5

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

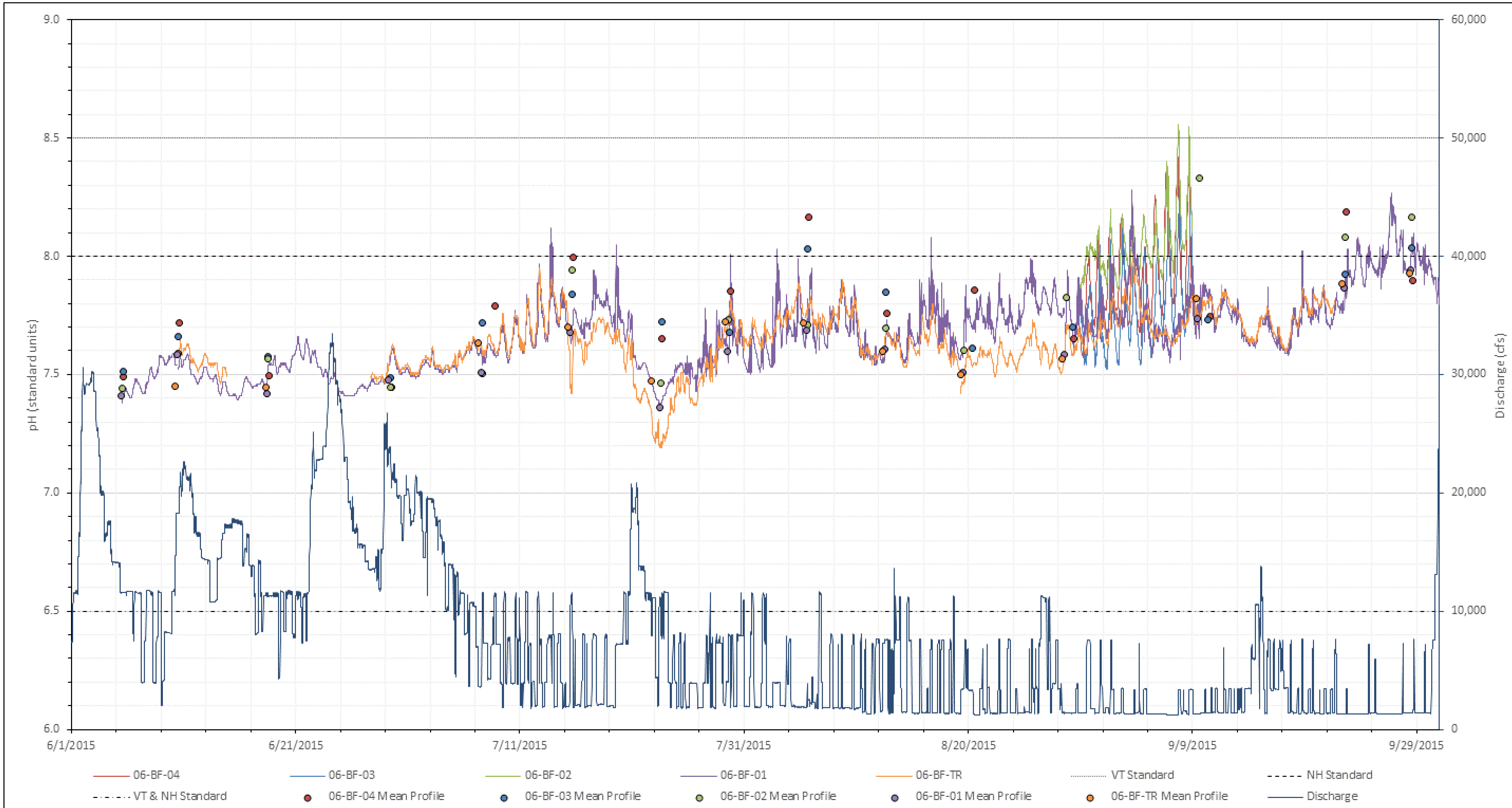
Specific Conductivity

In 2012, specific conductivity ranged between 107 to 183 µS/cm, while during 2015, specific conductivity ranged between 51 to 182 µS/cm. In both study years, specific conductivity readings throughout the Project area were fairly consistent and did not exhibit a spatial trend. Seasonally, however, specific conductivity was variable throughout the study period, but was generally higher in the middle and latter half of this period than the beginning and exhibited no stratification (Normandeau, 2013a; Study 6). In 2015, during the 10-day, high-temperature, low-flow monitoring period specific conductivity exhibited diurnal fluctuations in the shallower upstream riverine station and upper impoundment station, but the diurnal fluctuations attenuated in the deeper middle impoundment and forebay areas.

pH

In 2012, pH was continuously measured in the Bellows Falls forebay, bypassed reach, and tailrace from June through September and instantaneously measured through the water column during vertical profiles at the Bellows Falls upper impoundment, middle impoundment, and forebay stations. As shown in Table 3.4-27, pH ranged between 6.45 and 8.53 in the forebay, between 7.5 and 8.06 in the bypassed reach, and between 7.1 and 7.6 in the tailrace. At the middle impoundment and upper impoundment stations, pH ranged from 6.9 to 7.8 and 6.08 to 7.8, respectively. In the forebay, pH also corresponded well with DO levels and gradually increased from mid-July to mid-September following a decrease in early July (Normandeau, 2013a), and pH levels were uniform throughout the water column. In the bypassed reach, pH exhibited diurnal fluctuations between 7.0 and 8.0, which corresponded well with DO level fluctuations. In the tailrace, pH was relative high in mid-June, then decreased to about 7.0, and fluctuated between 7.0 and 7.5 from July to mid-September. During the 2012 study, pH occasionally exceeded both New Hampshire and Vermont upper and lower water quality standards (Normandeau, 2013a). The continuous pH data for the forebay indicated exceedances of the upper New Hampshire and Vermont state surface water quality standards that occurred throughout the study. The upper limit of one or both standards was exceeded within the bypassed reach and tailrace forebay, n = 337, range = 8.01 to 8.53 standard units; bypassed reach, n = 35, range = 8.01 to 8.06 standard units; tailrace, n = 72 range = 8.01 to 8.16 standard units.

In 2015, pH was also continuously monitored in the Bellows Falls forebay, bypassed reach, and tailrace from June through September as well as during the 10-day, high-temperature, low-flow monitoring period in late August and early September. In the forebay, pH levels ranged from 7.4 to 8.28, and monthly mean pH levels ranged from 7.5 to 7.8 (Figure 3.4-32; Table 3.4-29). Instances when pH levels in the forebay exceeded the upper limit of the New Hampshire standard but not the Vermont standard were infrequent in July and August but became more frequent in late September. In the bypassed reach, pH levels ranged from 7.5 to 8.07, and July was the only month in which pH levels at that monitoring station were greater than 8.0 (Table 3.4-30). Mean monthly pH levels in the tailrace increased from June through September and pH levels ranged from 7.2 to 8.10; pH levels only exceeded 8.0 in September (Table 3.4-31). Vertical profiles indicate that mean pH levels were slightly higher at the upstream riverine, upper impoundment, and middle impoundment areas than at the forebay or tailrace (Table 3.4-32). The maximum instantaneous pH measurements greater than 8.0 (the New Hampshire standard) but less than 8.5 (the Vermont standard) occurred at the upstream, upper impoundment, and middle impoundment stations; pH levels never were observed to fall below 7.3 at any monitoring stations and were uniform throughout the water column at all mainstem stations during the study period. During the 10-day, high-temperature, low-flow monitoring period all the upstream riverine, impoundment, and forebay stations recorded pH levels greater than 8.0 exceeding the New Hampshire standard, but only the middle impoundment station recorded pH levels greater than 8.5, exceeding also the Vermont standard (Table 3.4-34). The upstream, upper, and middle impoundment stations exhibited strong diel fluctuations, and the peaks of the fluctuations generally occurred during late afternoon; no strong or apparent diel pH trends were observed at the forebay or tailrace stations nor was there evidence of pH stratification among stations (see Study 6, Appendix J).



Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-32. 2015 pH measured in the Bellows Falls forebay, bypassed reach, and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Bellows Falls discharge.

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Turbidity

In 2015, turbidity was monitored continuously in the Bellows Falls forebay, bypassed reach, tailrace, and at all impoundment and upstream riverine stations during the 10-day, high-temperature, low-flow monitoring period. In addition, turbidity was also measured throughout the water column at each station (except the bypassed reach) (Study 6). Turbidity at the forebay and tailrace stations was generally very low but increased in response to high flows resulting from precipitation events that often resulted in spill at the Project dam (Figure 3.4-33). At the forebay station, turbidity levels ranged from 0.0 to 67 NTU with an overall median and mean of 1.5 and 2.5 NTU, respectively (Table 3.4-29). Turbidity ranged from 0.0 to 82 NTU in the bypassed reach, but the overall median and mean levels were 2.0 and 3.7 NTU, respectively (Table 3.4-30). Turbidity in the tailrace ranged from 0.0 to 43 NTU and had an overall median of 1.2 NTU and mean of 2.5 NTU (Table 3.4-31). Turbidity levels for each profile were low and uniform throughout the water column, except during or shortly after high flows and precipitation events. Overall, median and mean turbidity levels were all below 1 NTU and 4 NTU, respectively (Table 3.4-32). During the 10-day, high-temperature, low-flow monitoring period, turbidity was generally low; mean and median values were all below 2 NTU, with a maximum of 9.9 NTU at the upstream station (Table 3.4-34).

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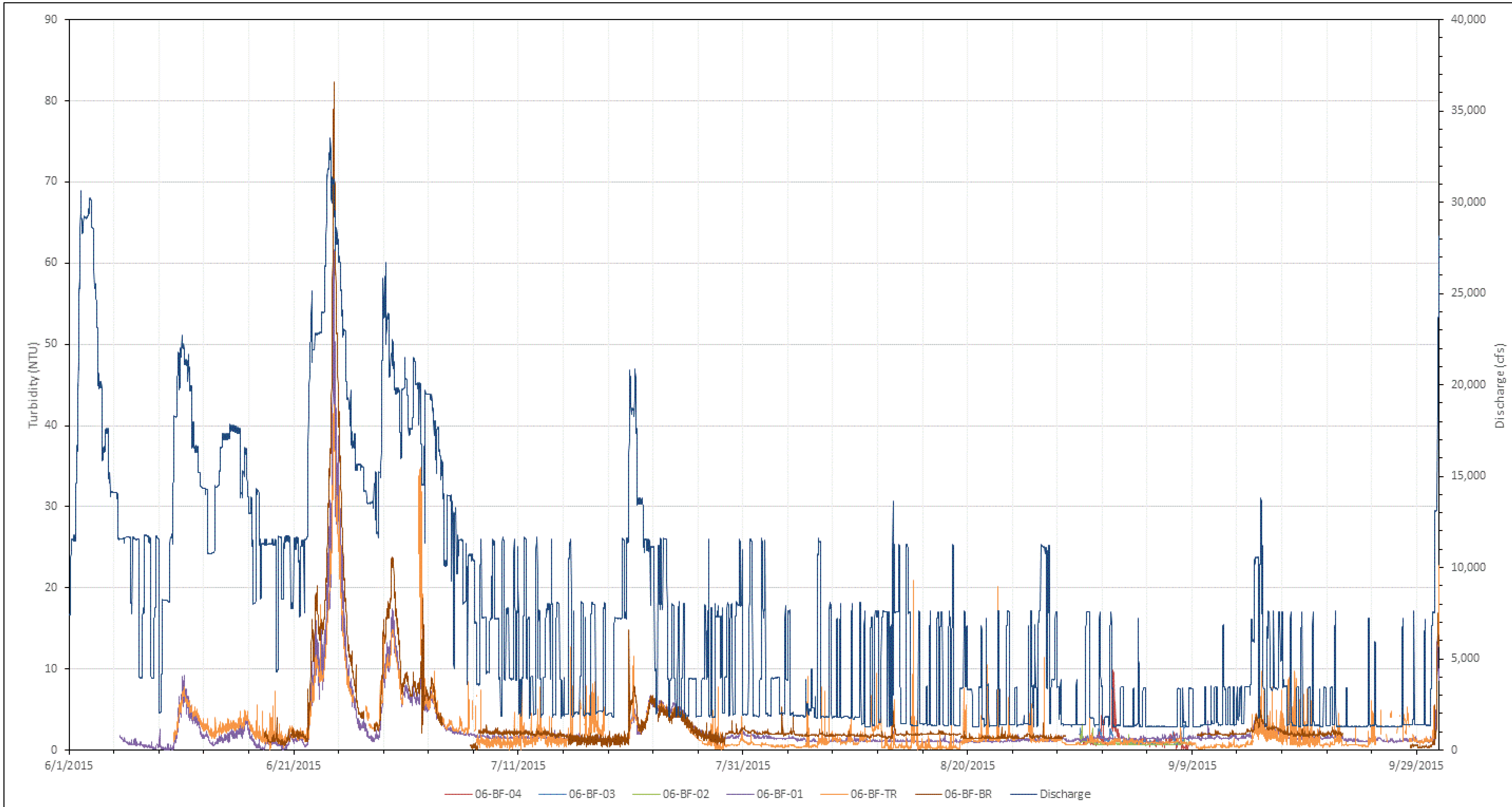

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-33. 2015 turbidity measured in the Bellows Falls forebay, bypassed reach, and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Bellows Falls discharge.

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Nutrients and Chlorophyll-a

In 2012 and 2015, total nitrogen, total phosphorus, nitrate/nitrite, total Kjeldahl nitrogen, and chlorophyll-*a* concentrations were measured in a water column composite sample in the Bellows Falls forebay. The concentrations did not show a strong seasonal pattern. In 2012, the mean nitrate/nitrite and total phosphorus concentrations were 0.19 and 0.020 mg/L, respectively (Table 3.4-35). Chlorophyll-*a* concentrations ranged from 2.7 to 6.6 mg/m^3 with a mean of 3.9 mg/m^3. Concentrations were similar in 2015 with the mean nitrate/nitrite and total phosphorus concentrations of 0.15 and 0.014 mg/L, respectively (Table 3.4-36). Chlorophyll-*a* concentrations ranged from less than 0.5 to 6.8 mg/m^3 with a mean of 3.2 mg/m^3.

Table 3.4-35. Nutrient and chlorophyll-*a* concentrations in the Bellows Falls forebay in 2012.

Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Nitrate/ Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-*a* (mg/m^3)
7/11/2012	0.53	0.012	0.16	0.37	3.8
7/18/2012	0.66	0.024	0.17	0.49	6.6
7/25/2012	0.61	0.010	0.20	0.41	2.7
8/1/2012	0.66	0.028	0.22	0.44	4.4
8/8/2012	0.83	0.039	0.21	0.62	3.5
8/15/2012	0.69	0.048	0.21	0.48	4.0
8/23/2012	0.58	0.009	0.15	0.43	2.9
8/29/2012	0.59	0.010	0.18	0.41	4.2
9/5/2012	0.56	0.012	0.16	0.40	3.1
9/12/2012	0.61	0.011	0.19	0.42	3.8
Maximum	0.83	0.048	0.22	0.62	6.6
Minimum	0.53	0.009	0.15	0.37	2.7
Median	0.61	0.012	0.19	0.43	3.8
Mean	0.63	0.020	0.19	0.45	3.9

Source: Normandeau (2013a)

Table 3.4-36. Nutrient and chlorophyll-*a* concentrations in the Bellows Falls forebay in 2015.

Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Nitrate/ Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-*a* (mg/m^3)
6/5/2015	<0.50	0.011	0.14	<0.50	0.7
6/10/2015	1.47	0.012	0.17	1.30	1.4
6/18/2015	<0.50	0.012	0.10	<0.50	2.2
6/29/2015	<0.50	0.036	0.13	<0.50	1.5
7/7/2015	0.73	0.014	0.13	0.60	<0.5
7/15/2015	<0.50	0.009	0.30	<0.50	2.9
7/23/2015	<0.50	0.019	0.14	<0.50	3.6
7/29/2015	<0.50	0.009	0.13	<0.50	4.6
8/5/2015	0.63	0.006	0.13	0.50	3.9
8/12/2015	<0.50	0.012	0.16	<0.50	3.2
8/19/2015	0.69	0.009	0.19	0.50	4.2
8/28/2015	<0.50	0.012	0.17	<0.50	3.1
9/9/2015	0.8	0.024	0.12	0.70	6.8
9/22/2015	<0.50	0.009	0.11	<0.50	4.3
9/28/2015	0.78	0.009	0.08	0.70	5.0
Maximum	1.47	0.036	0.30	1.30	6.8
Minimum	<0.50	0.006	0.08	<0.50	<0.5
Median	<0.50	0.012	0.13	<0.50	3.2
Mean[a]	0.49	0.014	0.15	0.44	3.2

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. For values below the detection limit of 0.5 mg/L, a concentration of 0.25 mg/L was assumed for mean calculations for the associated analyte.

Vernon Project

Temperature and Dissolved Oxygen

Continuous temperature and DO levels were recorded in the Vernon forebay and tailrace, and vertical profiles of temperature and DO levels were collected from the Vernon upper impoundment, middle impoundment, and forebay during summer 2012 (Normandeau, 2013a). Surface water temperatures in 2012 demonstrated a typical seasonal pattern of warming in early summer, relatively consistent temperature during mid-summer, and cooling in late-summer and early fall. Overall temperatures ranged from 20.2 to 29.3°C (Table 3.4-37). Based on vertical profile measurements, mean temperatures were cooler at the upper impoundment station and increased toward Vernon dam (Table 3.4-37). The highest temperatures were observed during mid-summer and ranged from about 26 to 29°C. DO was continuously measured in the Vernon forebay and tailrace, and readings were fairly consistent throughout the deployment period ranging from 6.3 to 9.1 mg/L (81 to 115 percent saturation) and 7.4 to 9.8 mg/L (94 to 118 percent saturation) (Table 3.4-37). Based on vertical profiles, mean DO levels decreased from the upper impoundment station toward Vernon dam, but never fell below Vermont or New Hampshire surface water quality standards, despite very weak stratification being observed in late June in the forebay.

In 2015, water temperature was continuously monitored in the Vernon upstream riverine reach, impoundment, forebay, and tailrace. Data from all stations reflect a similar seasonal pattern of warming during the spring and summer, and cooling during the fall (Figure 3.4-34). Over the entire study area, temperatures ranged from 7.2 to 27.2°C and were on average cooler at the upstream riverine site and warmest at the forebay and tailrace (Table 3.4-38). Water temperatures throughout the water column were generally uniform and exhibited only mild surface warming from late-July to mid-September, but no stratification (the maximum decrease in temperature between depth intervals ranged from 0.2 to 0.9°C) (see Study 6, Appendix H).

Intensive continuous water temperature monitoring occurred at the upstream and impoundment stations during the 10-day, high-temperature, low-flow monitoring period at three different locations at each station and up to three different depths (Table 3.4-39). Mean water temperatures ranged from 24.5 to 25.5°C. At the upstream and upper impoundment stations mean water temperatures were similar across the channel (river left, mid-channel, river right) and at the various deployment depths. At the middle impoundment station, temperatures recorded 1 meter above the river bottom and at mid-depth were similar across the channel, but during the afternoon, maximum surface temperatures were warmer by up to about 1°C compared to maximum temperatures recorded at mid-depth. At the forebay, mean temperatures were similar at 1 meter above bottom and mid-depth, but maximum surface temperatures were about 2.0°C warmer than bottom temperatures.

DO was also continuously monitored in the forebay and tailrace areas and at all stations during the 10-day, high-temperature, low-flow monitoring period in late-August and early-September 2015. In the forebay, DO levels initially were at their highest levels in June and gradually decreased to their lowest levels at the beginning of September (Figure 3.4-35 and Figure 3.4-36). DO concentrations measured continuously at the forebay ranged from 6.9 to 10.0 mg/L and percent saturation levels ranged from 82 to 119 percent (Table 3.4-39). In the tailrace, DO levels were fairly consistent throughout the study period and ranged from 7.3 to 10.1 mg/L and 86 to 111 percent, respectively (Table 3.4-40). Even during the 10-day, high-temperature, low-flow monitoring period, DO levels were never observed to decline below state surface water quality standards (Figures 3.4-35 and 3.4-36; Table 3.4-41). DO vertical profiles collected at all study stations showed that the water column was well oxygenated (Table 3.4-42).

Table 3.4-37. Water temperature, DO, specific conductivity, and pH statistics for Vernon Project in 2012.

Statistic	Station				
	Upper Impound. V-03 (Profile)	Middle Impound. V-02 (Profile)	Forebay V-01 (Profile)	Forebay V-01 (Continuous)	Tailrace V-TR (Continuous)
Water Temperature (°C)					
Maximum	25.1	27.4	28.3	29.3	28.6
Minimum	20.2	21.4	21.6	22.9	22.8
Median	23.8	24.5	25.1	26.7	26.4
Mean	23.5	24.2	24.9	26.6	26.1
Dissolved Oxygen (mg/L)					
Maximum	10.2	9.8	9.6	9.1	9.8
Minimum	7.2	7.0	6.4	6.3	7.4
Median	8.6	8.1	7.8	7.9	8.7
Mean	8.5	8.1	7.9	7.8	8.7
Dissolved Oxygen (% saturation)					
Maximum	120	115	115	115	118
Minimum	87	86	79	81	94
Median	99	95	94	98	107
Mean	100	96	95	98	108
Minimum 24-hour Mean	NA	NA	NA	87	100
Specific Conductivity (µS/cm)					
Maximum	161	164	158	162	163
Minimum	122	113	123	115	116
Median	146	138	141	143	142
Mean	142	139	141	142	141
pH (standard units)[a]					
Maximum	7.6	7.6	7.9	7.8	8.01
Minimum	6.6	7.1	6.7	7.1	7.2
Median	7.2	7.4	7.4	7.4	7.6
Mean	7.2	7.4	7.4	7.4	7.6

Source: TransCanada (2012c)

Note: NA — not applicable.

a. Values with two digits after the decimal point are those that exceeded state standard(s).

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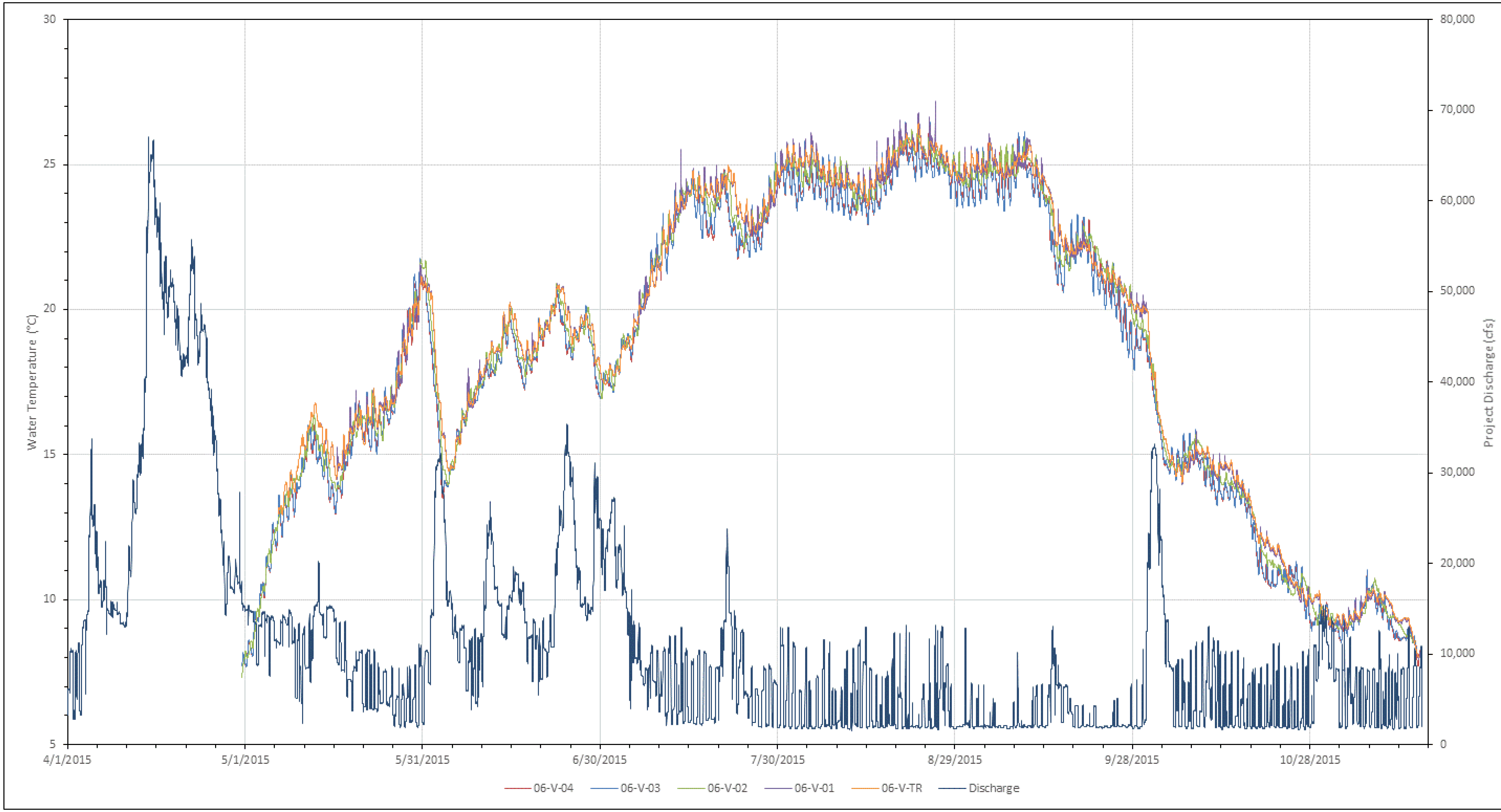

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-34. Vernon continuous water temperatures observed during spring, summer, and fall 2015 with Vernon discharge.

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Table 3.4-38. Monthly water temperatures for Vernon Project in 2015.

Temperature (°C)	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	All
Upstream Riverine (06-V-04)									
Maximum	8.1	21.3	20.6	25.2	26.2	25.9	18.3	10.8	26.2
Min	7.9	7.7	13.5	17.1	22.9	18.0	8.9	7.2	7.2
Median	8.0	14.9	18.3	22.4	24.4	22.3	13.4	9.0	18.7
Mean	8.0	14.8	17.9	21.9	24.5	22.4	12.7	9.1	18.1
Upper Impoundment (06-V-03)									
Maximum	8.2	21.8	20.7	25.4	26.5	26.1	18.3	11.1	26.5
Min	7.7	7.7	13.7	17.2	22.9	17.9	8.9	7.2	7.2
Median	8.1	15.1	18.2	22.7	24.5	22.3	13.4	9.0	18.8
Mean	8.0	14.9	18.0	22.2	24.5	22.4	12.7	9.1	18.2
Middle Impoundment (06-V-02)									
Maximum	8.1	21.6	20.9	25.6	26.6	25.9	18.3	10.7	26.6
Min	7.3	8.0	14.0	17.2	23.4	18.4	9.1	7.9	7.3
Median	7.8	15.3	18.5	23.1	24.8	22.5	13.6	9.3	19.1
Mean	7.7	15.1	18.1	22.4	24.8	22.8	12.9	9.2	18.5
Forebay (06-V-01)									
Maximum	ND	21.6	20.9	25.8	27.2	26.1	18.3	10.4	27.2
Min	ND	14.2	14.5	17.4	23.5	18.4	9.0	7.7	7.7
Median	ND	16.5	18.7	23.2	24.9	22.4	13.9	9.3	19.7
Mean	ND	16.9	18.4	22.4	24.9	22.9	13.0	9.3	19.0
Tailrace (06-V-TR)									
Maximum	ND	21.2	20.8	25.7	26.4	25.8	18.4	10.4	26.4
Min	ND	12.9	14.4	17.4	23.6	18.4	9.1	7.7	7.7
Median	ND	16.1	18.7	23.4	25.0	22.3	14.0	9.4	19.5
Mean	ND	16.4	18.4	22.5	25.0	22.9	13.1	9.4	18.9

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Note: ND – no data; high flows and spill conditions in April precluded data collection until May.

Table 3.4-39. Water temperatures for Vernon Project during the 10-day, high-temperature, low-flow period monitoring period in 2015.

Logger Location	Statistic	Temperature (°C)		
		River Left	Mid-channel	River Right
Upstream Riverine (06-V-04)				
1 meter below surface	Maximum	ND	ND	25.9
	Minimum			23.7
	Mean			24.5
Mid-depth	Maximum	27.1	25.9	ND
	Minimum	23.0	23.8	
	Mean	24.6	24.5	
1 meter above bottom	Maximum	ND	ND	26.0
	Minimum			23.8
	Mean			24.6
Depth to bottom (at first deployment, meter)		0.8	2.3	4.1
Upper Impoundment (06-V-03)				
1 meter below surface	Maximum	26.3	ND	ND
	Minimum	22.2		
	Mean	24.5		
Mid-depth	Maximum	ND	26.3	25.9
	Minimum		23.5	23.8
	Mean		24.6	24.7
1 meter above bottom	Maximum	26.2	ND	ND
	Minimum	23.4		
	Mean	24.6		
Depth to bottom (at first deployment, meter)		3.4	2.7	2.1
Middle Impoundment (06-V-02)				
1 meter below surface	Maximum	26.3	26.1	26.1
	Minimum	24.4	24.4	24.4
	Mean	25.0	25.0	25.0
Mid-depth	Maximum	25.3	25.3	25.2
	Minimum	24.4	24.4	24.3
	Mean	24.8	24.8	24.8
1 meter above bottom	Maximum	25.1	25.2	25.3
	Minimum	24.4	24.4	24.4
	Mean	24.7	24.8	24.8
Depth to bottom (at first deployment, meter)		4.8	5.6	6.3

Logger Location	**Statistic**	**Temperature (°C)**		
		River Left	**Mid-channel**	**River Right**
Logger Location	**Statistic**	**Temperature (°C)**		
		River Left	**Mid-channel**	**River Right**
Forebay (06-V-01)				
1 meter below surface	Maximum	28.1	27.8	27.9
	Min	24.6	24.6	24.7
	Mean	25.5	25.4	25.5
Mid-depth	Maximum	26.0	26.6	25.6
	Min	24.4	24.6	24.5
	Mean	24.9	25.1	24.9
1 meter above bottom	Maximum	25.3	26.0	25.2
	Min	24.2	24.5	24.4
	Mean	24.6	24.9	24.7
Depth to bottom (at first deployment, meter)		6.9	5.4	17.2

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Note: ND – no data; no logger was deployed due to shallow water depths.

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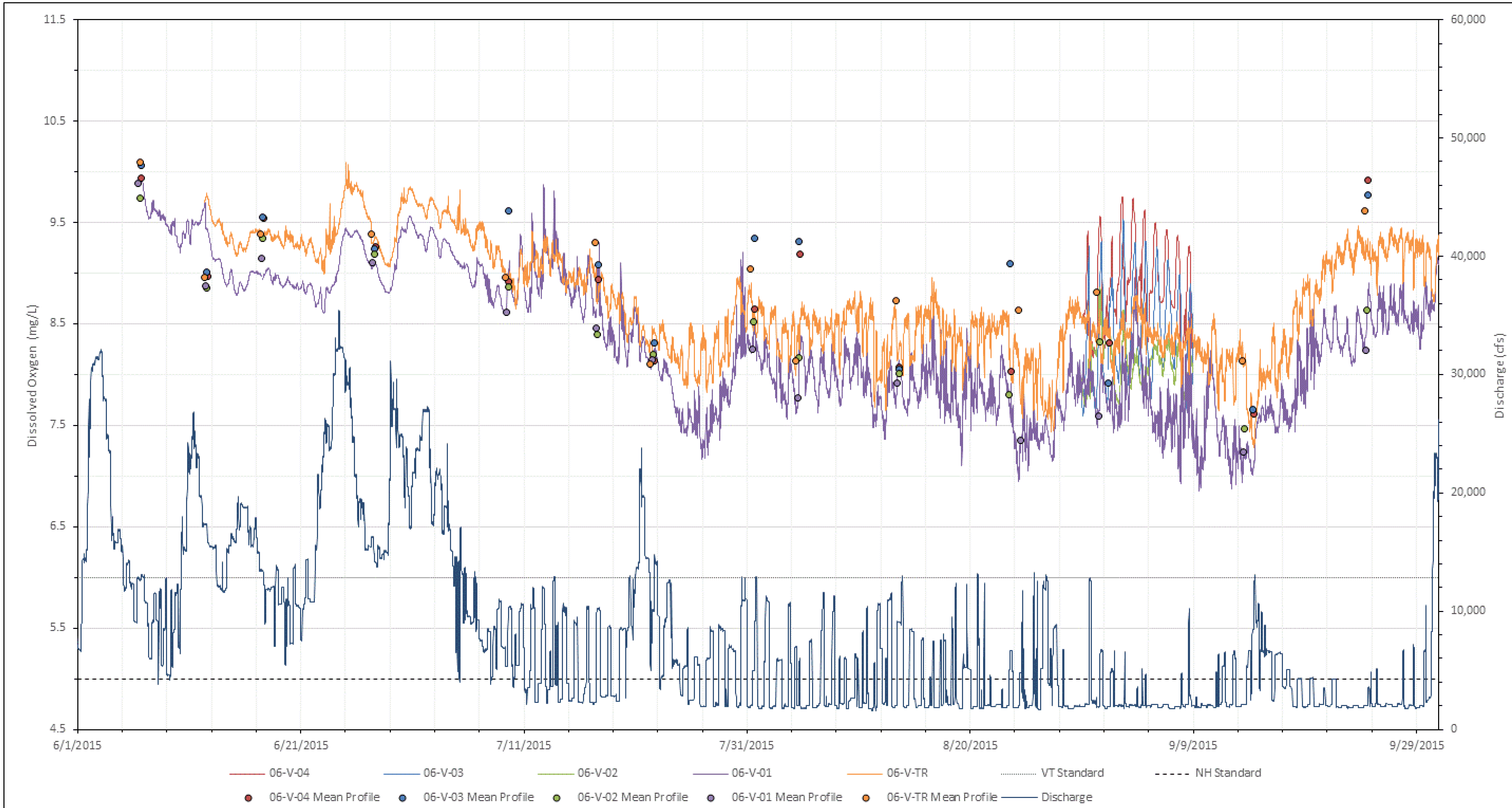

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-35. 2015 DO concentrations continuously measured in the Vernon forebay and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Vernon discharge.

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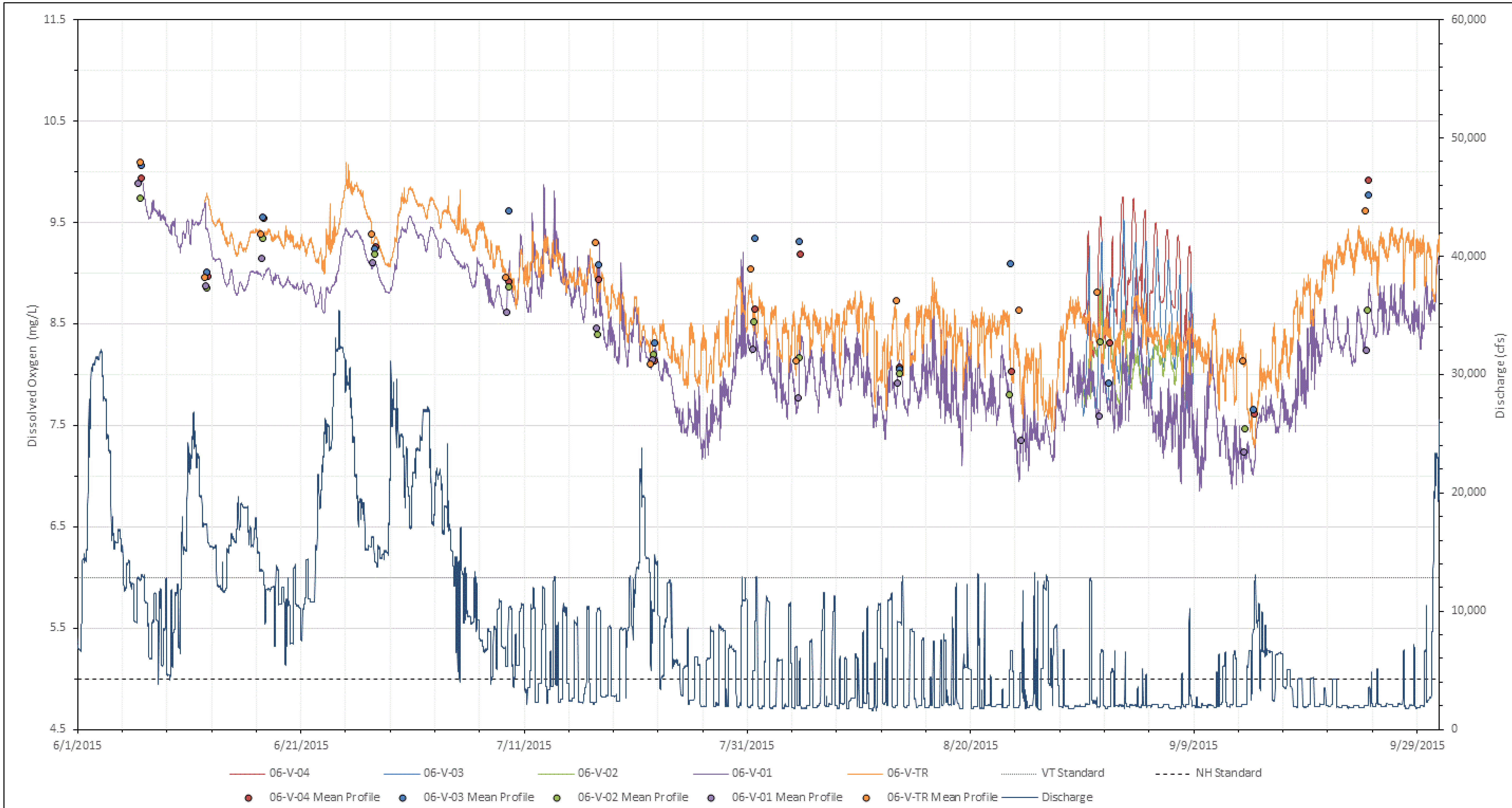

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-36. 2015 DO saturation continuously measured in the Vernon forebay and tailrace, and at all stations during a 10-day, high-temperature low-flow period with Vernon discharge.

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Table 3.4-40. Monthly statistics of continuously monitored temperature, specific conductivity, dissolved oxygen, pH, and turbidity in the Vernon forebay in 2015.

Statistic	Jun	Jul	Aug	Sep	All
Temperature (°C)					
Maximum	20.9	25.8	27.2	26.1	27.2
Minimum	15.5	17.4	23.5	18.4	15.5
Median	18.9	23.2	24.9	22.4	23.5
Mean	18.8	22.4	24.9	22.9	22.5
Specific Conductivity (µS/cm)					
Maximum	115	151	159	170	170
Minimum	80	93	129	132	80
Median	96	129	145	152	139
Mean	96	125	145	152	131
Dissolved Oxygen (mg/L)					
Maximum	10.0	9.9	8.7	9.2	10.0
Minimum	8.6	7.2	7.0	6.9	6.9
Median	9.1	8.7	7.9	7.9	8.3
Mean	9.2	8.6	7.9	8.0	8.3
Dissolved Oxygen (% saturation)					
Maximum	104	120	105	111	120
Minimum	94	83	84	82	82
Median	98	99	95	93	96
Mean	98	99	95	93	96
Maximum daily mean	102	109	99	101	109
Minimum daily mean	96	87	89	86	86
pH (standard units)[a]					
Maximum	7.6	8.05	7.9	7.9	8.05
Minimum	7.4	7.3	7.3	7.3	7.3
Median	7.5	7.5	7.6	7.6	7.5
Mean	7.5	7.5	7.6	7.6	7.5
Turbidity (NTU)					
Maximum	32.2	13.9	3.6	22.1	32.2
Minimum	0.0	0.7	0.3	0.2	0.0
Median	1.4	1.9	1.2	1.0	1.4
Mean	3.8	2.5	1.2	1.4	2.1

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-41. Monthly statistics for continuously monitored temperature, specific conductivity, dissolved oxygen, pH, and turbidity in the Vernon tailrace in 2015.

Statistic	Jun	Jul	Aug	Sep	All
Temperature (°C)					
Maximum	20.8	25.7	26.4	25.8	26.4
Minimum	17.4	17.4	23.6	18.4	17.4
Median	19.3	23.4	25.0	22.3	23.8
Mean	19.2	22.5	25.0	22.9	22.7
Specific Conductivity (µS/cm)					
Maximum	106	153	156	170	170
Minimum	81	92	127	130	81
Median	91	129	145	153	142
Mean	91	125	144	154	134
Dissolved Oxygen (mg/L)					
Maximum	10.1	9.8	9.0	9.5	10.1
Minimum	9.0	7.8	7.4	7.3	7.3
Median	9.4	8.9	8.4	8.5	8.6
Mean	9.4	8.9	8.4	8.6	8.7
Dissolved Oxygen (% saturation)					
Maximum	110	111	108	108	111
Minimum	98	91	90	86	86
Median	102	103	102	101	102
Mean	102	102	101	100	101
Maximum daily mean	107	109	104	104	109
Minimum daily mean	99	94	94	89	89
pH (standard units)					
Maximum	7.6	7.8	7.7	7.9	7.9
Minimum	7.4	7.4	7.4	7.5	7.4
Median	7.5	7.5	7.5	7.6	7.5
Mean	7.5	7.6	7.6	7.6	7.6
Turbidity (NTU)					
Maximum	35.4	16.3	4.9	19.9	35.4
Minimum	0.0	0.9	0.4	0.1	0.0
Median	1.8	1.8	1.3	1.0	1.4
Mean	5.4	2.6	1.3	1.3	2.4

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Table 3.4-42. Statistics of temperature, specific conductivity, dissolved oxygen, pH, and turbidity for Vernon Project during the 10-day, high-temperature, low-flow monitoring period in 2015.

Statistic	Station			
	Upstream Riverine 06-V-04	Upper Impound. 06-V-03	Middle Impound. 06-V-02	Forebay 06-V-01
Temperature (°C)				
Maximum	25.9	26.1	25.7	26.1
Minimum	23.8	23.4	24.2	24.4
Median	24.5	24.4	24.7	24.8
Mean	24.5	24.5	24.7	24.9
Specific Conductivity (µS/cm)				
Maximum	184	163	163	152
Minimum	150	136	145	141
Median	165	150	154	146
Mean	166	150	154	146
Dissolved Oxygen (mg/L)				
Maximum	9.8	9.5	8.9	9.0
Minimum	7.9	7.4	7.7	6.9
Median	8.8	8.4	8.1	7.7
Mean	8.7	8.4	8.1	7.8
Dissolved Oxygen (% saturation)				
Maximum	118	117	108	111
Minimum	94	89	92	83
Median	104	100	99	94
Mean	105	101	98	94
Maximum daily mean	109	104	101	101
Minimum daily mean	99	95	95	91
pH (standard units)[a]				
Maximum	8.03	8.01	7.8	7.9
Minimum	7.6	7.6	7.6	7.4
Median	7.7	7.7	7.6	7.6
Mean	7.7	7.8	7.6	7.6
Turbidity (NTU)				
Maximum	7.8	1.8	1.2	2.8
Minimum	0.2	0.4	0.4	0.4
Median	1.2	0.8	0.6	0.9
Mean	1.1	0.7	0.6	0.9

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Values with two digits after the decimal point are those that exceeded state standard(s).

Table 3.4-43. Vertical profile statistics for Vernon Project in 2015.

Statistic	Upstream Riverine 06-V-04	Upper Impound. 06-V-03	Middle Impound. 06-V-02	Forebay 06-V-01	Tailrace 06-V-TR
Mean Water Depth (meters)[a]	2.4	3.3	5.6	16.2	7.4
Temperature (°C)					
Maximum	24.9	25.4	25.9	26.3	25.2
Minimum	16.0	16.1	16.3	15.4	15.9
Median	22.5	22.3	23.1	23.7	24.0
Mean	21.4	21.3	21.7	21.8	23.0
Dissolved Oxygen (mg/L)					
Maximum	10.2	10.3	10.0	9.9	10.1
Minimum	7.6	7.6	7.4	7.1	7.9
Median	8.9	9.3	8.4	8.3	8.9
Mean	8.9	9.2	8.6	8.4	8.9
Dissolved Oxygen (% saturation)					
Maximum	112	114	106	105	112
Minimum	88	88	87	85	95
Median	102	104	98	97	104
Mean	101	103	98	95	103
Specific Conductivity (µS/cm)					
Maximum	167	162	157	157	156
Minimum	86	60	95	84	83
Median	128	130	128	131	138
Mean	126	126	126	127	133
pH (standard units)[b]					
Maximum	8.06	8.0	7.7	7.7	7.8
Minimum	7.4	7.5	7.4	7.3	7.3
Median	7.6	7.6	7.5	7.5	7.6
Mean	7.7	7.6	7.5	7.5	7.6
Turbidity (NTU)					
Maximum	23.0	25.2	27.2	21.3	4.1
Minimum	0.0	0.0	0.0	0.0	0.0
Median	1.5	1.3	0.8	1.3	1.6
Mean	4.0	4.3	2.3	2.0	1.4

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. Average of individual depths recorded during each station visit.

b. Values with two digits after the decimal point are those that exceeded state standard(s).

Specific Conductivity

Specific conductivity ranged from 113 to 164 µS/cm in 2012 and from 60 to 184 µS/cm in 2015 (Tables 3.4-37, 3.4-40, 3.4-41, and 3.4-42). In both study years, specific conductivity throughout the Vernon Project area was fairly consistent, although in 2015 specific conductivity levels in the forebay and tailrace generally increased over the monitoring period. In addition, specific conductivity was uniform throughout the water column in both 2012 and 2015 and increased over the deployment period in 2015 (Normandeau, 2103; ILP Study 6).

pH

In 2012, pH was continuously monitored in the forebay and tailrace and instantaneously during vertical profiles throughout the impoundment (Normandeau, 2013a). In the forebay, pH ranged between 6.7 and 7.9, and in the tailrace, pH ranged between 7.2 and 8.01. At the middle impoundment and upper impoundment stations, pH ranged between 7.1 and 7.6 and between 6.6 and 7.6, respectively (Table 3.4-37). Throughout the water column, pH values were consistent. Over the duration of the 2012 study, pH only exceeded the New Hampshire upper water quality standard in the tailrace for 1.5 hours (range 8.01 to 8.04) on June 21, 2012 (Normandeau, 2013a).

During 2015, pH was also continuously monitored in the forebay and tailrace, measured in vertical profiles, and continuously monitored during the 10-day, high-temperature, low-flow monitoring period throughout the Vernon Project area (Study 6). At the forebay and tailrace stations, pH levels were generally similar and ranged from 7.3 to 8.05 (Tables 3.4-40, 3.4-41, and 3.4-43). At the middle and upper impoundment and upstream stations, pH ranged from 7.4 to 8.06. As in 2012, pH values were consistent throughout the water column. The pH time-series for all stations during the 10-day, high-temperature, low-flow monitoring period showed well-defined diel fluctuations in pH levels at the upstream and upper impoundment stations, and less pronounced or no diel fluctuations in pH at the middle impoundment and forebay stations, respectively (see Study 6, Appendix J).

Turbidity

In 2015, turbidity was monitored continuously in the Vernon forebay and tailrace and at all impoundment and upstream riverine stations during the 10-day, high-temperature, low-flow monitoring period. In addition, turbidity was also measured during the collection of vertical profiles. Turbidity was generally low, but increased during precipitation events (Figure 3.4-37). Turbidity ranged from 0.0 to 32 NTU in the forebay, and from 0.0 to 35 NTU in the tailrace (Tables 3.4-40, 3.4-41, and 3.4-43). Turbidity levels were uniform throughout the water column, except during or shortly after high flow and precipitation events, when turbidity varied throughout the water column. At the middle impoundment and upper impoundment stations, turbidity levels ranged between 0.0 and 27 NTU and 0.0 and 25 NTU, respectively (Table 3.4-43). At the upstream riverine station, turbidity ranged between 0.0 and 23 NTU (Table 3.4-43).

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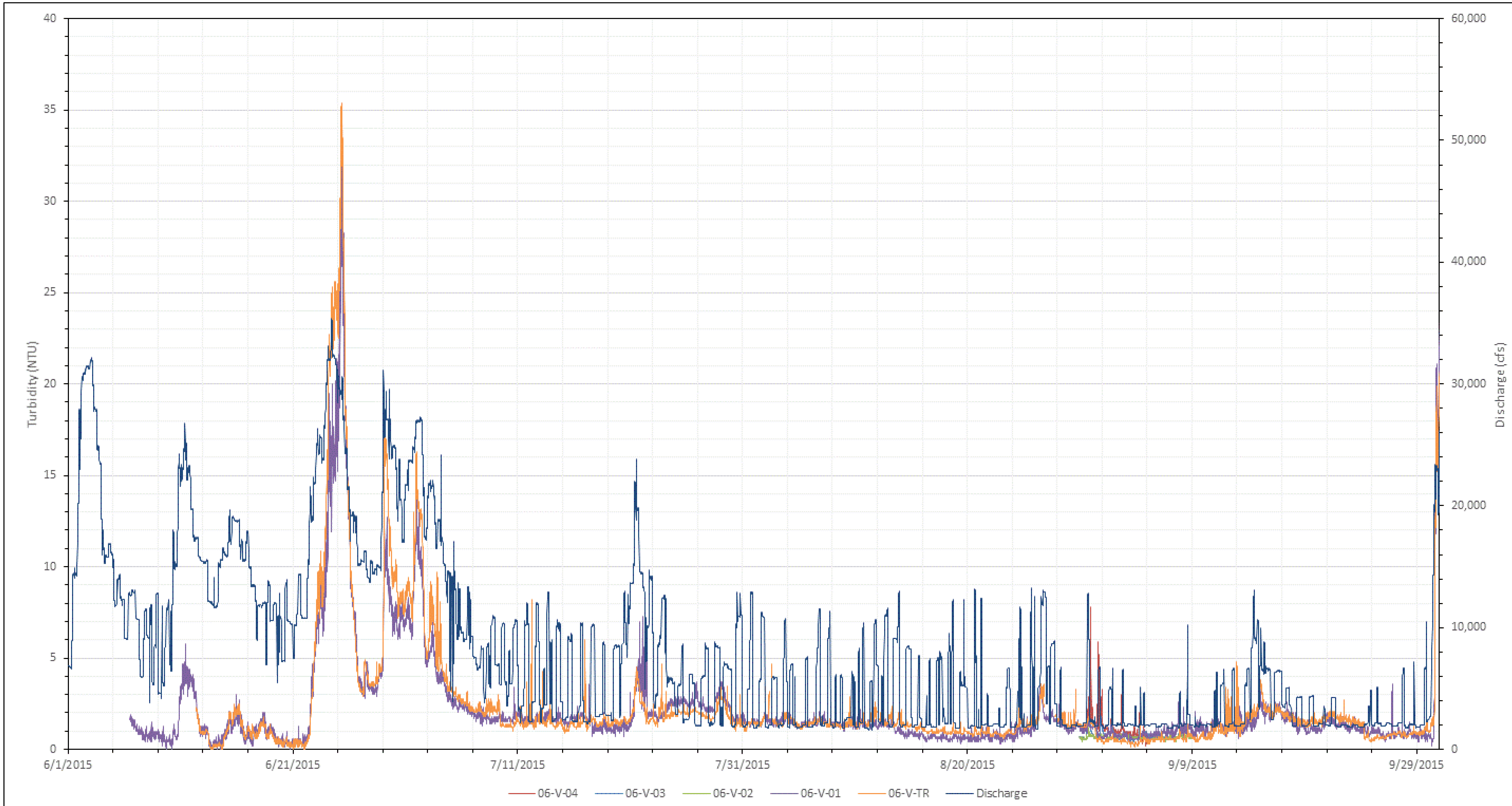

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-37. 2015 turbidity measured in the Vernon forebay and tailrace, and at all stations during a 10-day, high-temperature, low-flow period with Vernon discharge.

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Nutrients and Chlorophyll-a

In 2012 and 2015, total nitrogen, total phosphorus, nitrate/nitrite, total Kjeldahl nitrogen, and chlorophyll-*a* concentrations were measured in a water column composite sample in the Vernon forebay. As was observed for the Wilder and Bellows Falls Projects, concentrations did not show a pronounced seasonal pattern at the Vernon Project. In 2012, mean nitrate/nitrite and total phosphorus concentrations were 0.20 and 0.020 mg/L, respectively (Table 3.4-44). Chlorophyll-*a* concentrations ranged from 2.0 to 5.9 mg/m^3 with a mean of 3.5 mg/m^3. In 2015, concentrations were similar. Mean nitrate/nitrite and total phosphorus concentrations were 0.13 and 0.019 mg/L, respectively (Table 3.4-45). Chlorophyll-*a* concentrations ranged from 0.7 to 9.0 mg/m^3 with a mean of 2.9 mg/m^3.

Table 3.4-44. Nutrient and chlorophyll-*a* concentrations in the Vernon forebay in 2012.

Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Nitrate/Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-*a* (mg/m^3)
7/12/2012	0.55	0.013	0.16	0.39	5.9
7/19/2012	0.75	0.058	0.20	0.55	4.2
7/26/2012	0.62	0.013	0.21	0.41	2.7
8/2/2012	0.63	0.010	0.23	0.40	2.2
8/9/2012	0.66	0.009	0.24	0.42	4.4
8/16/2012	0.69	0.038	0.18	0.51	3.8
8/24/2012	0.67	0.014	0.20	0.47	3.5
8/30/2012	0.58	0.013	0.20	0.38	3.6
9/6/2012	0.72	0.019	0.20	0.52	2.0
9/13/2012	0.68	0.013	0.21	0.47	3.1
Maximum	0.75	0.058	0.24	0.55	5.9
Minimum	0.55	0.009	0.16	0.38	2.0
Median	0.67	0.013	0.20	0.45	3.6
Mean	0.66	0.020	0.20	0.45	3.5

Source: Normandeau (2013a)

Table 3.4-45. Nutrients and chlorophyll-*a* concentrations in the Vernon forebay in 2015.

Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Nitrate/ Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Chlorophyll-*a* (mg/m³)
6/6/2015	<0.50	0.013	0.12	<0.50	0.7
6/12/2015	<0.50	0.021	0.13	<0.50	0.8
6/17/2015	<0.50	0.018	0.13	<0.50	1.1
6/27/2015	<0.50	0.019	0.09	<0.50	1.1
7/9/2015	<0.50	0.012	0.13	<0.50	1.1
7/17/2015	<0.50	0.009	0.14	<0.50	2.9
7/22/2015	1.04	0.011	0.14	0.90	1.1
7/31/2015	0.82	0.009	0.12	0.70	2.4
8/4/2015	0.72	0.009	0.12	0.60	4.6
8/13/2015	<0.50	0.023	0.14	<0.50	4.3
8/24/2015	0.88	0.009	0.18	0.70	3.2
8/31/2015	<0.50	0.010	0.14	<0.50	3.2
9/13/2015	<0.50	0.019	0.18	<0.50	4.0
9/24/2015	<0.50	0.008	0.13	<0.50	4.6
10/2/2015	0.81	0.096	0.11	0.70	9.0
Maximum	1.04	0.096	0.18	0.90	9.0
Minimum	<0.50	0.008	0.09	<0.50	0.7
Median	<0.50	0.012	0.13	<0.50	2.9
Mean[a]	0.45	0.019	0.13	0.41	2.9

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

a. For values below the detection limit of 0.5 mg/L, a concentration of 0.25 mg/L was assumed for mean calculations for the associated analyte.

Tributaries

In 2015, water temperature was also continuously monitored in the 10 largest tributaries to the Connecticut River in the Project areas (Study 6). These tributaries were the Waits, Ompompanoosuc, White, Mascoma, Sugar, Black, Williams, Saxtons, Cold, and the West rivers. Water temperature trends were similar among the 10 tributaries; slightly cooler temperatures were observed in northern tributaries and warmer temperatures observed in southern tributaries (Table 3.4-46). The mean temperature in the two coldest tributaries—the Waits and Ompompanoosuc rivers—was 13.5 and 14.4°C, respectively. The mean temperature in the southernmost tributary, the West River, was 18.2°C.

Table 3.4-46. Monthly water temperatures in tributaries in 2015.

Temperature (°C)	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	All
Waits River (06-W-T02)									
Maximum	11.9	22.7	21.3	25.0	25.7	24.9	13.8	11.2	25.7
Minimum	0.0	5.4	9.7	12.8	15.4	11.6	2.3	2.7	0.0
Median	3.1	14.5	15.4	18.5	19.9	18.0	8.8	6.6	14.9
Mean	3.2	14.6	15.4	18.6	20.0	17.8	8.6	6.5	13.5
Ompompanoosuc River (06-W-T01)									
Maximum	9.7	23.2	21.7	25.8	26.4	24.6	14.7	11.4	26.4
Minimum	0.6	7.6	11.0	14.1	15.9	10.3	3.0	3.1	0.6
Median	4.8	14.2	16.3	19.3	20.4	17.8	9.5	7.1	15.5
Mean	4.8	14.3	16.1	19.4	20.5	17.8	9.1	7.0	14.4
White River (06-BF-T05)									
Maximum	10.2	27.4	22.6	28.6	29.2	29.4	15.4	11.2	29.4
Minimum	1.2	8.7	10.8	15.2	19.4	14.5	5.1	4.4	1.2
Median	5.4	15.3	17.2	21.7	23.5	21.2	10.6	7.7	16.9
Mean	5.3	15.5	16.9	21.4	23.5	21.2	10.4	7.8	16.1
Mascoma River (06-BF-T04)									
Maximum	9.3	25.3	24.0	28.6	28.3	27.3	17.8	12.1	28.6
Minimum	0.2	6.9	14.3	18.5	19.7	13.5	7.2	6.0	0.2
Median	3.8	15.0	19.2	22.6	23.4	21.0	12.2	8.9	17.6
Mean	3.8	15.0	19.2	22.7	23.4	20.4	12.3	9.0	16.1
Sugar River (06-BF-T03)									
Maximum	11.3	24.8	24.4	29.1	28.0	28.0	16.0	11.9	29.1
Minimum	0.5	9.0	12.6	16.9	20.7	14.3	5.0	4.4	0.5
Median	5.8	16.9	20.3	23.0	23.7	20.1	11.3	8.2	18.0
Mean	5.5	17.3	19.6	22.9	23.8	20.2	10.7	8.1	16.9
Black River (06-BF-T02)									
Maximum	10.4	25.0	24.0	28.4	27.5	25.6	15.8	11.3	28.4
Minimum	0.3	8.7	13.3	16.7	19.7	13.6	6.3	2.9	0.3
Median	5.1	16.9	19.4	23.1	23.1	23.4	20.2	11.0	17.7
Mean	4.7	17.1	19.3	22.8	23.4	20.0	10.6	7.9	16.2

Temperature (°C)	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	All
Williams River (06-BF-T01)									
Maximum	11.6	25.0	23.5	28.8	27.8	26.2	14.9	12.3	27.8
Minimum	0.2	7.5	11.2	14.6	17.4	11.7	4.7	3.8	0.2
Median	4.7	16.0	18.1	21.3	21.9	18.7	10.3	7.8	16.4
Mean	4.7	16.0	17.9	21.1	21.9	18.7	9.8	7.6	15.2
Saxtons River (06-V-T03)									
Maximum	12.5	24.9	25.3	26.9	26.3	25.2	15.1	13.2	26.9
Minimum	0.1	7.5	11.3	14.9	17.1	11.6	3.6	3.1	0.1
Median	5.0	16.2	18.5	21.2	21.7	18.8	10.2	7.8	16.3
Mean	4.9	16.2	18.3	20.9	21.7	18.6	9.8	7.7	15.0
Cold River (06-V-T02)									
Maximum	11.1	24.9	25.0	28.0	27.4	25.8	15.7	13.1	28.0
Minimum	-0.1	6.7	11.0	15.1	16.3	10.8	4.6	3.0	-0.1
Median	4.4	15.5	17.8	20.8	21.2	18.3	10.2	7.6	16.6
Mean	4.3	15.4	17.9	20.8	21.3	18.4	10.1	7.6	15.0
West River (06-V-T01)									
Maximum	12.0	27.3	27.4	31.4	30.1	29.6	16.9	12.9	31.4
Minimum	3.5	8.6	11.9	15.9	19.0	13.5	4.7	3.4	3.4
Median	7.2	18.1	20.0	23.6	24.2	20.6	10.8	8.1	19.4
Mean	7.6	18.0	19.8	23.3	24.2	21.0	10.7	8.0	18.2

Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

3.4.2 Environmental Effects

3.4.2.1 Water Quantity

Normal Operating Ranges

Continued operation of the Wilder, Bellows Falls, and Vernon Projects will result in daily and sub-daily fluctuations in impoundment WSEs and discharge flows that have the potential to have short-term effects on water quantity in the impoundments and Project-affected riverine reaches downstream of each Project dam as defined in Section 3.1, *General Setting*. Water quantity effects (defined as flow magnitude, flow frequency, flow duration, flow timing, and rate of change in FERC's SD2) from Project operations are related to and dependent on current license limitations, available inflows from upstream projects, additional inflows resulting from precipitation events within the watershed, generating capacity, regional demand, and energy prices. Fluctuations in impoundment water levels are associated primarily with changes in daily and sub-daily inflows because the Projects have limited impoundment storage capacity. TransCanada is not proposing to change current operations and will continue to operate within existing license constraints and the narrower, voluntary operational parameters that collectively include normal and recreation-related impoundment water level fluctuation limits, limits on rates of impoundment level change, higher than licensed minimum flows, and supplemental flows for upstream and downstream fish passage. Therefore, existing water quantity effects will continue under the proposed Projects.

3.4.2.2 Water Quality

Evaluation of Project effects on water quality was based on data from deployed temperature loggers and multiparameter sondes, vertical profile measurements, and nutrient and chlorophyll-*a* analyses as a part of Study 6, as well as other relevant information as appropriate.

Project Operations Effects on Temperature and Dissolved Oxygen

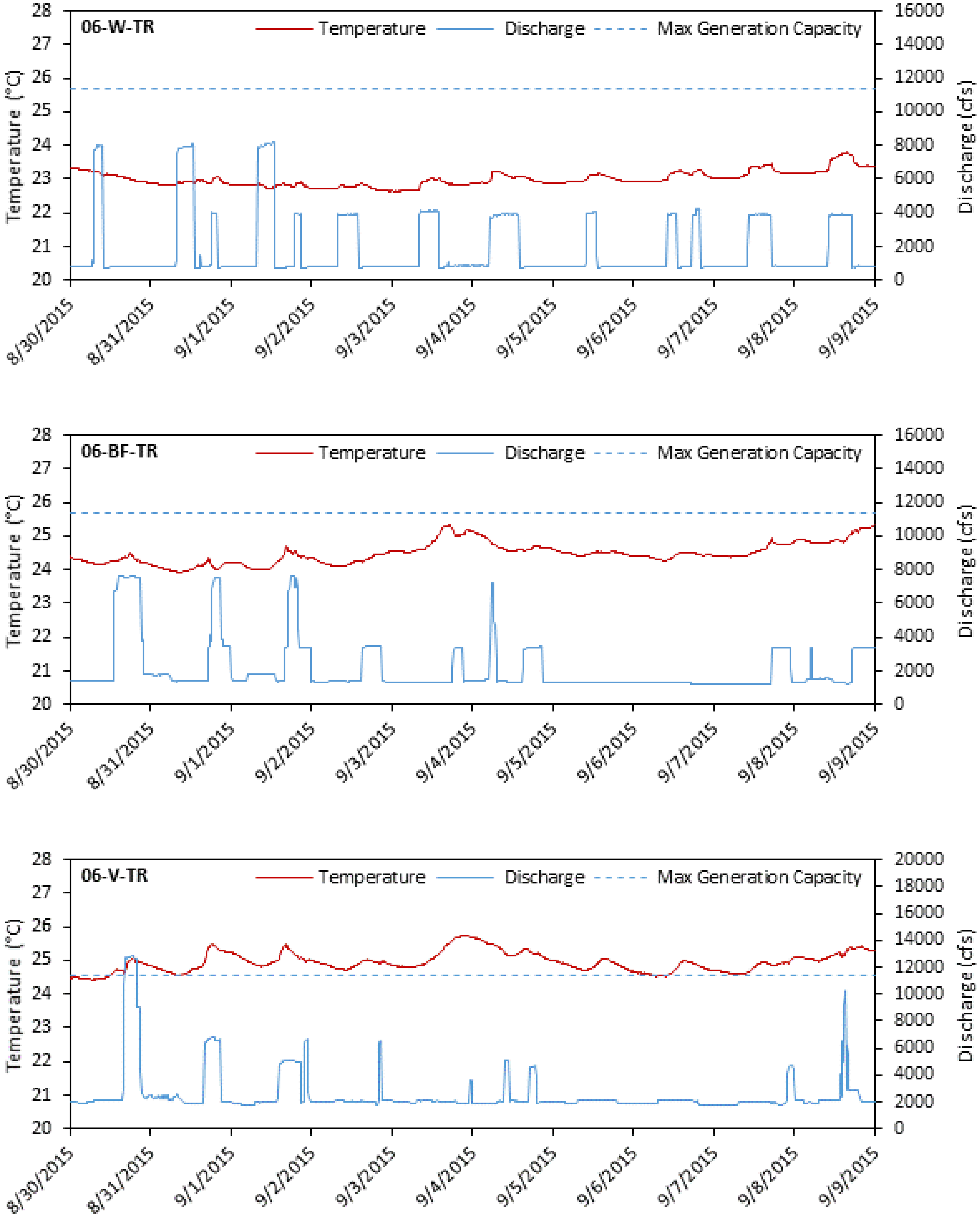
Temperature

New Hampshire surface water quality standards require that any increase in temperature shall not be such to appreciably interfere with the designated uses of Class B waters. Vermont surface water quality standards state the change or rate of change in temperature, either upward or downward, shall be controlled to ensure full support of aquatic biota, wildlife, and aquatic habitat uses and the total increase from ambient temperature due to all discharges and activities shall not exceed 1°F (0.56°C) from ambient temperatures, except for the assimilation of thermal waste as permitted by the Secretary (see Section 3.4.1.2, *Water Quality*, *Surface Water Quality Standards and Designated Uses*).

Continuous water temperature monitoring conducted for Study 6 demonstrated that water temperatures generally and gradually increase from the upstream riverine areas to the Project dams and tailraces. This progressive, gradual downstream warming often is observed over large spatial scales in river systems (Wetzel, 2001); however, it is unknown to what magnitude the gradual warming may be attributed to effects of the impoundments, effects of latitude, weather, and tributary contributions. For example, river temperatures vary in relationship to air temperatures and often exhibit a strong linear relationship with some time lag (Wetzel, 2001). The continuous mainstem temperature data show that upstream riverine stations respond more quickly to changes in air temperature than lower impoundment and tailrace stations (Study 6) because the upstream riverine areas are shallower with swift currents that facilitate the addition and loss of heat energy through convection and conduction with the atmosphere, streambed, and banks, resulting in downstream impoundment and tailrace stations being either warmer or cooler relative to the respective upstream riverine area at any given time. Subsequently, the larger daily swings in water temperatures that closely follow air temperatures and weather at the shallow upstream riverine areas result in occasional exceedance of the Vermont surface water quality standard for temperature, especially over the long longitudinal distances between the upstream riverine areas and the Project dams. When air temperatures are consistent for a long period or gradually warm and cool, mainstem water temperatures throughout the Project impoundments and tailraces become similar and the Vermont surface water quality standard is attained under existing Project operations (Study 6, Appendix P, report revision in progress).

The continuous water temperature loggers and continuous water quality multiparameter sondes deployed in the forebays and tailraces allow for the assessment of Project effects on water temperature as water is passed through the powerhouse for generation and discharged into the tailrace. Between the Project forebays and tailraces water temperatures were generally similar (Figures 3.4-25, 3.4-29, and 3.4-34), and overall mean water temperatures differed by −0.07°C at Wilder, −0.31°C at Bellows Falls, and 0.10°C at Vernon (Tables 3.4-19, 3.4-28, and 3.4-38). Any effects of Project generation on water temperature were generally indistinguishable from daily water temperature fluctuations (see Study 6, Appendix F). During the 10-day, high-temperature, low-low monitoring period, effects of Project generation and minimum flow operations on water temperature became more apparent; water temperatures generally increased very slightly during high generation flows and decreased very slightly when only minimum flows were being passed (Figure 3.4-38).

The effect of Project operations on water temperature in the tailraces partly depends on temperatures throughout the water column in the forebay, the depth of the water column from which water is being withdrawn for generation, and whether the water column is thermally stratified. Thermal stratification occurs when surface waters are heated more rapidly than the heat is distributed by mixing, which typically occurs during warm, calm periods of several days or more. In 2015, the Wilder, Bellows Falls, and Vernon Project areas were generally well mixed with some surfacing warming and weak, brief stratification at the Bellows Falls middle impoundment station (Study 6, Appendix H). With a well-mixed water column, water temperatures in the tailraces will reflect forebay temperatures. However, in 2012, short and temporary periods of thermal stratification (over a period of 7 days in mid-July at Wilder forebay, and 1 day each in the same period at Bellows Falls, and Vernon forebays), resulted in slightly cooler temperatures in the Project tailraces (see Study 6, Appendix L; Normandeau, 2013a). Therefore, when the impoundments are thermally stratified in the vicinity of the forebays, slightly cooler temperatures are expected to be discharged into the tailraces via generation; otherwise, tailrace temperatures will reflect temperatures of the forebays.



Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-38. Tailrace water temperatures and discharges at the Wilder, Bellows Falls, and Vernon Projects in 2015.

Overall, continued Project operations as proposed will support and maintain both states' designated uses for Class B waters as any increase in temperature from upstream riverine areas to the Project dams will be gradual over the 46-, 29-, and 30-river mile Project areas for the Wilder, Bellows Falls, and Vernon Projects, respectively. Temperature increases of more than 1 degree Fahrenheit (°F) (0.56°C) can occur when weather and climate conditions are conducive, such as those observed during 2015 (Study 6). Thermal stratification can occur in each Project forebay during an atypical warm year such as 2012, but will likely be intermittent and short in duration, and will likely result in slightly cooler temperatures in the Project tailraces from cool hypolimnetic waters.

Dissolved Oxygen

New Hampshire surface water quality standards for Class B waters require that DO concentrations do not fall below 5.0 mg/L, have a daily average of at least 75 percent saturation, and support all designated uses (Table 3.4-6). Vermont regulations specify that Class B coldwater habitat DO levels are not less than 6 mg/L and 70 percent saturation at all times and support designated uses (Table 3.4-7).

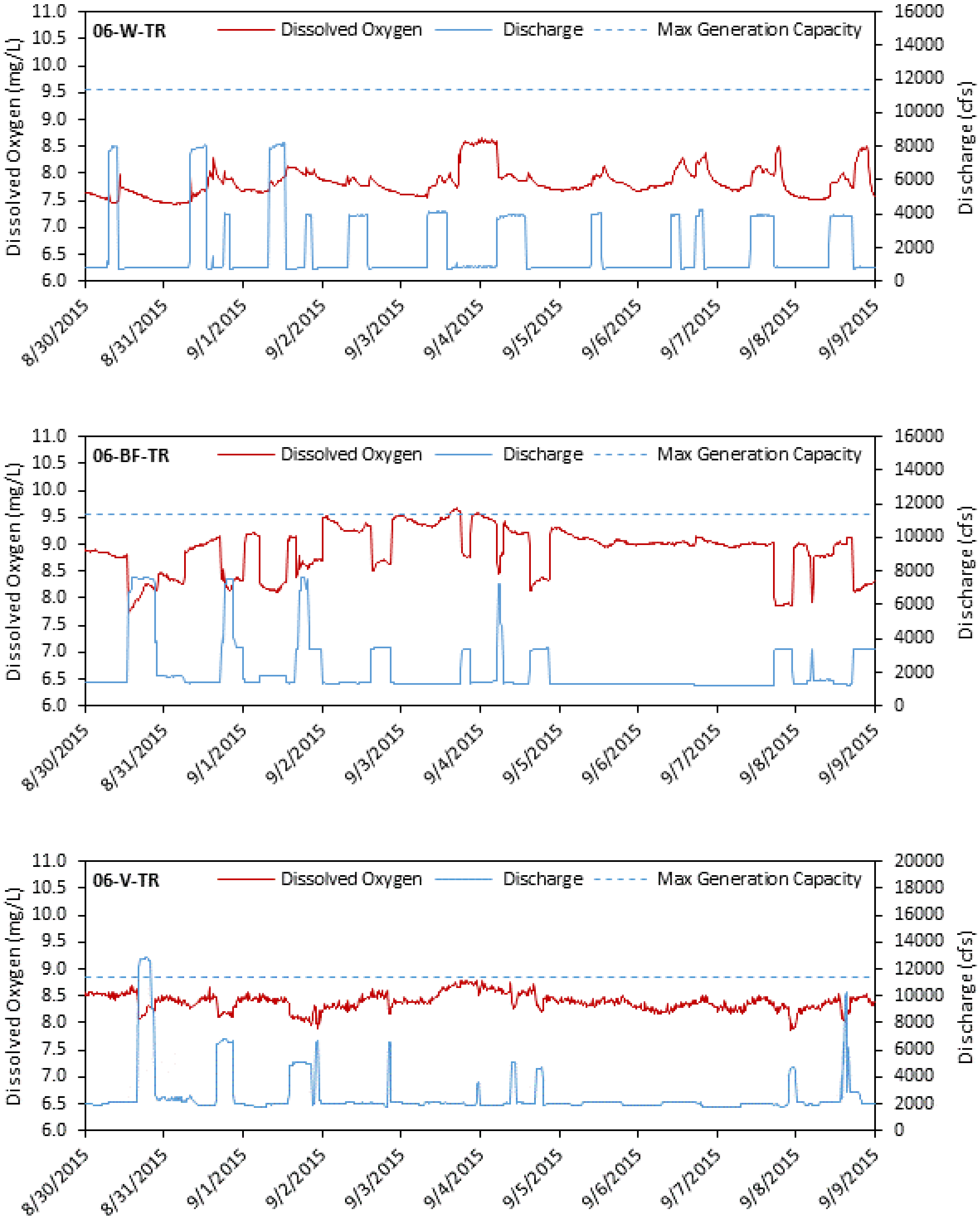
Among the three Projects, DO demonstrated seasonal trends over the 2015 study period, starting relatively high in June and decreasing through the summer because of lower oxygen solubility at higher water temperatures. DO levels reached their lowest point in mid-September prior to increasing again with decreasing water temperatures. DO levels were also observed to slightly decrease as waters flow from upstream areas through the Project impoundments. In 2015, DO levels throughout the water column and study area were above both New Hampshire and Vermont water quality standards at all times. However, in 2012, DO levels in the Wilder and Bellows Falls forebays fell below surface water quality standards (Normandeau, 2013a; Study 6). In the Wilder forebay, the minimum instantaneous DO concentration recorded was 5.7 mg/L and occurred on August 12, 2012; no other exceedances were observed. The instantaneous DO concentrations recorded in the hypolimnion of the Bellows Falls forebay that exceed state standards ranged from 3.3 to 5.9 mg/L, which occurred on a single day of July 18, 2012. Also, within the Bellows Falls forebay DO concentrations fell below state standards briefly on July 23, 2012 where a single value of 5.9 mg/L was measured.

In 2015, DO levels were slightly lower in the Bellows Falls and Vernon forebays than in the tailraces, but they were slightly higher at Wilder in the forebay than in the tailrace. The overall mean decreases in DO levels between the Wilder forebay and tailrace were 0.2 mg/L and 0.2 percent saturation at Wilder (Tables 3.4-20 and 3.4-21), 0.5 mg/L and 6.0 percent saturation at Bellows Falls (Tables 3.4-29 and 3.4-31), and 0.4 mg/L and 5.2 percent saturation at Vernon (Tables 3.4-40 and 3.4-41). In 2012 and 2015, it was observed that during periods of high generation flows and no spill, DO levels abruptly decreased coincident with increasing discharge, but they also abruptly increased when discharges decreased quickly (Figure 3.4-39; also see Study 6, Appendix F; Normandeau, 2013a). In 2015, this effect was observed in the tailraces of all three Projects but was most prominent in the Bellows Falls tailrace where DO levels generally decreased by about 1.0 mg/L when generation discharges increased, and DO levels increased quickly by about 1.0 mg/L when discharges decreased. In the instances in 2012 when DO levels fell below state surface water quality standards in the forebay hypolimnion at Wilder (Vermont standard only) and at Bellows Falls (New Hampshire and Vermont standards), Project discharges remained well oxygenated regardless of increasing or decreasing Project discharges (Normandeau, 2013a; Study 6). This suggests that low DO levels occurring during brief periods of stratification become re-oxygenated when passed through the powerhouses for generation and that designated uses and state surface water quality standards will be maintained downstream with continued Project operations.

Overall, under existing Project operating conditions, DO levels in Project-affected areas are generally above surface water quality standards of both New Hampshire and Vermont. The 2012 data suggest that only under atypical, low-flow, warm-weather conditions, as was observed in 2012, thermal stratification can occur resulting in potential low-DO levels below state surface water quality standards in hypolimnetic waters of the forebay. This can result in more frequent exceedances of the more stringent Vermont surface water quality standard (6 mg/L) than of the New Hampshire surface water quality standard (5 mg/L). However, as water is passed through the Project powerhouses, it becomes re-oxygenated and state surface water quality standards will be maintained in downstream reaches of the Connecticut River.

Project Operations Effects on Specific Conductivity

Neither New Hampshire nor Vermont has a state surface water quality standard for specific conductivity. In the 2012 and 2015 study years, when specific conductivity was continuously recorded and measured during the collection of vertical profiles, specific conductivities throughout the Project areas ranged from 62 to 184 µS/cm. Both studies determined that specific conductivity levels did not vary in response to changes in levels of generation between the Project forebays and tailraces (Normandeau, 2013a; Study 6). Therefore, levels of specific conductivity will likely reflect existing conditions with continued Project operations.



Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-39. Tailrace dissolved oxygen and discharges at Wilder, Bellows Falls, and Vernon Projects in 2015.

Project Operations Effects on pH

New Hampshire surface water quality standards for Class B waters require that pH levels remain between 6.5 and 8.0 standard units, unless due to natural causes, and that pH does not affect any designated uses. Similarly, the Vermont surface water quality standard for pH in Class B waters requires pH levels to remain between 6.5 and 8.5 standard units, and the change and the rate of change in pH must be controlled so as to not affect designated uses (see Section 3.4.1.2, *Water Quality*, *Surface Water Quality Standards and Designated Uses*).

At the Wilder and Vernon forebays, pH infrequently exceeded the more stringent upper New Hampshire pH standard, and at the Bellows Falls upstream riverine and impoundment stations, pH in 2015 most frequently exceeded the New Hampshire standard in August and September but was never observed to fall below the lower pH standard of 6.5. Most of the observed exceedances occurred during the 10-day, high-temperature, low-flow monitoring period at the upstream riverine and upper impoundment areas where pH exhibited large diel fluctuations relative to lower impoundment and forebay areas (see Study 6, Appendix J). At the Bellows Falls middle impoundment station, pH barely exceeded the upper Vermont surface water quality standard of 8.5 on September 7 and September 8, 2015. Specifically, on September 7, the highest pH value was 8.56 for a few hours in late afternoon; on September 8, the highest pH value was 8.55.

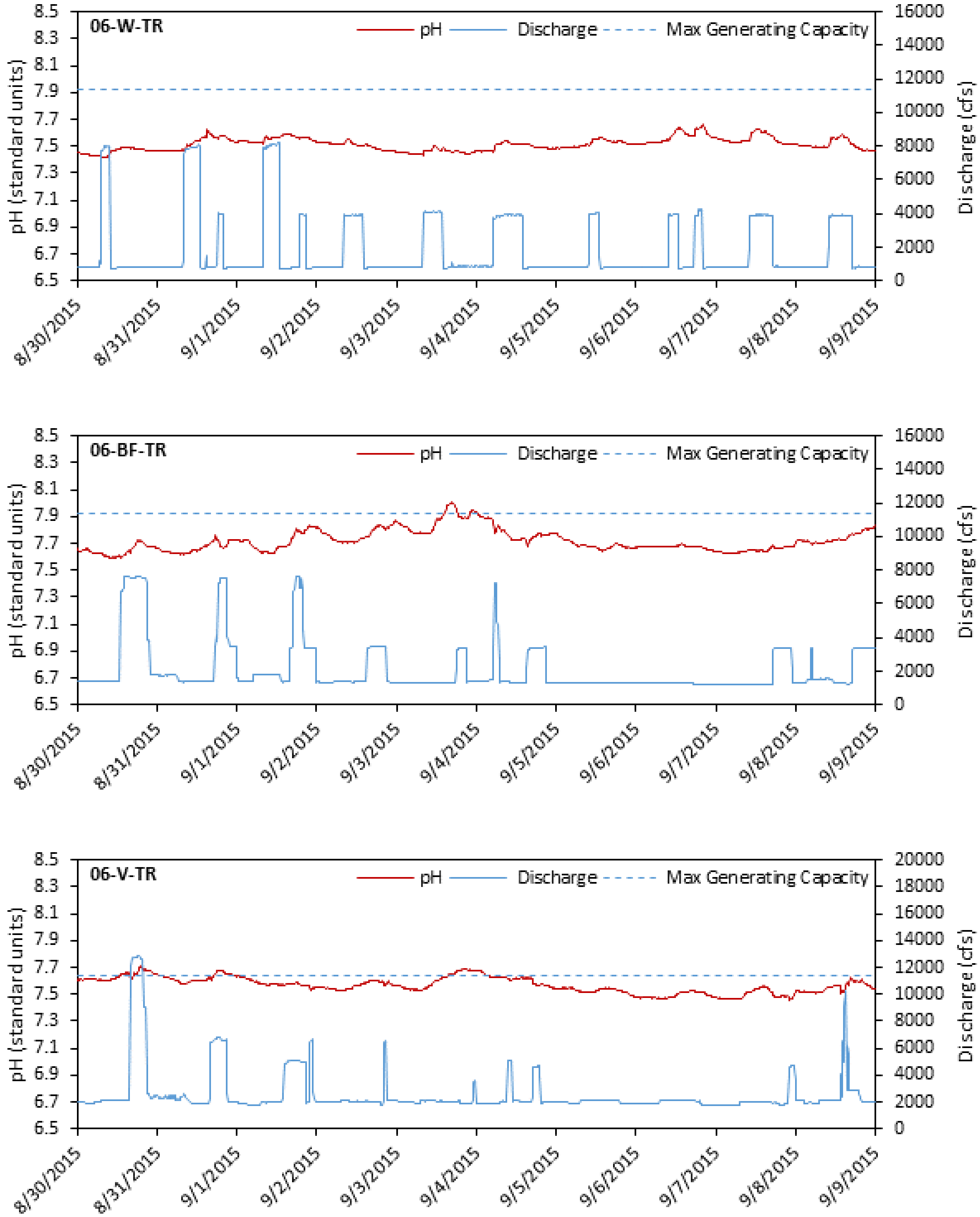
In 2012, pH values were observed to fall below both the Vermont and New Hampshire state surface water quality standards on June 26 in the Wilder upper and middle impoundment, and again on July 10 in the upper impoundment. The exceedances measured on June 26 and July 10 at the Wilder upper impoundment were measured instantaneously during the collection of a vertical profile and ranged from 5.7 to 6.1 and 5.8 to 6.0, respectively. At the Wilder middle impoundment station, only one exceedance, measuring 6.4 during the collection of a vertical profile, occurred on June 26. At the Bellows Falls upper impoundment station, pH fell below both state standards on July 11 and September 5. On July 11, pH exceedances, measured during the collection of a vertical profile, ranged from 6.1 to 6.3. However, on September 5, only one exceedance of 6.4 was measured during the collection of a vertical profile at the Bellows Falls upper impoundment station. The decrease in pH below state surface water quality standards in the Wilder and Bellows Falls impoundments was attributed to atmospheric deposition because these areas were listed as impaired for pH due to atmospheric deposition in 2012 (Normandeau, 2013a).

Also in 2012, pH was observed to exceed the more stringent upper New Hampshire surface water quality standard throughout the Bellows Falls and Vernon Project areas. Most exceedances, however, occurred in the Bellows Falls forebay and ranged from 8.01 to 8.53 (Study 6). In 2012, exceedances were observed in the forebay on July 11 and 12, August 21 through 25, and September 9 through 12. In the bypassed reach and tailrace, 2012 pH exceedances were shorter in duration and lasted from August 23 to 24 and from June 21 to 23, respectively. The high pH levels coincided with higher levels of chlorophyll-*a* and diurnal fluctuations of temperature and DO during the 10-day, high-temperature, low-flow monitoring period, suggesting that the pH exceedances are partly related to photosynthesis of algae and aquatic respiration.

The residence time of water flowing through any hydroelectric project impoundment can facilitate increased algal and vegetation growth and subsequently affect pH levels. However, because all three Projects are essentially operated as daily run-of-river projects, they typically do not store most inflow longer than 1 day, and the gross storage capacity in the Wilder and Vernon impoundments is 29 percent and 49 percent larger than in the Bellows Falls impoundment, respectively. Further, considering the differences in flow (median daily discharge in cfs),[29] the average residence times in the Wilder and Vernon impoundments are about 33 percent and 45 percent longer, respectively, than for Bellows Falls; yet pH exceedances in the Wilder and Vernon impoundments were rare in both the 2012 and 2015 study seasons, indicating that other potential cause of pH exceedances, such as nutrient loading from the watershed or atmospheric deposition, likely affect pH levels and thus compliance with state surface water quality standards.

Over the course of Study 6, potential effects of generation on pH were generally indistinguishable from daily pH fluctuations. However, pH increased very slightly (0.05 to 0.1) in the tailraces when discharges increased, and pH decreased slightly when discharges decreased (Figure 3.4-40). Because TransCanada is not proposing any changes to Project operations, continued Project operations will result in pH levels that reflect existing conditions, generally comply with state water quality standards, and will likely continue to support and maintain designated uses.

[29] From USGS water data based on 74-year record at North Walpole USGS gage no. 01144500; 102-year record at West Lebanon USGS gage no. 01154500.



Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

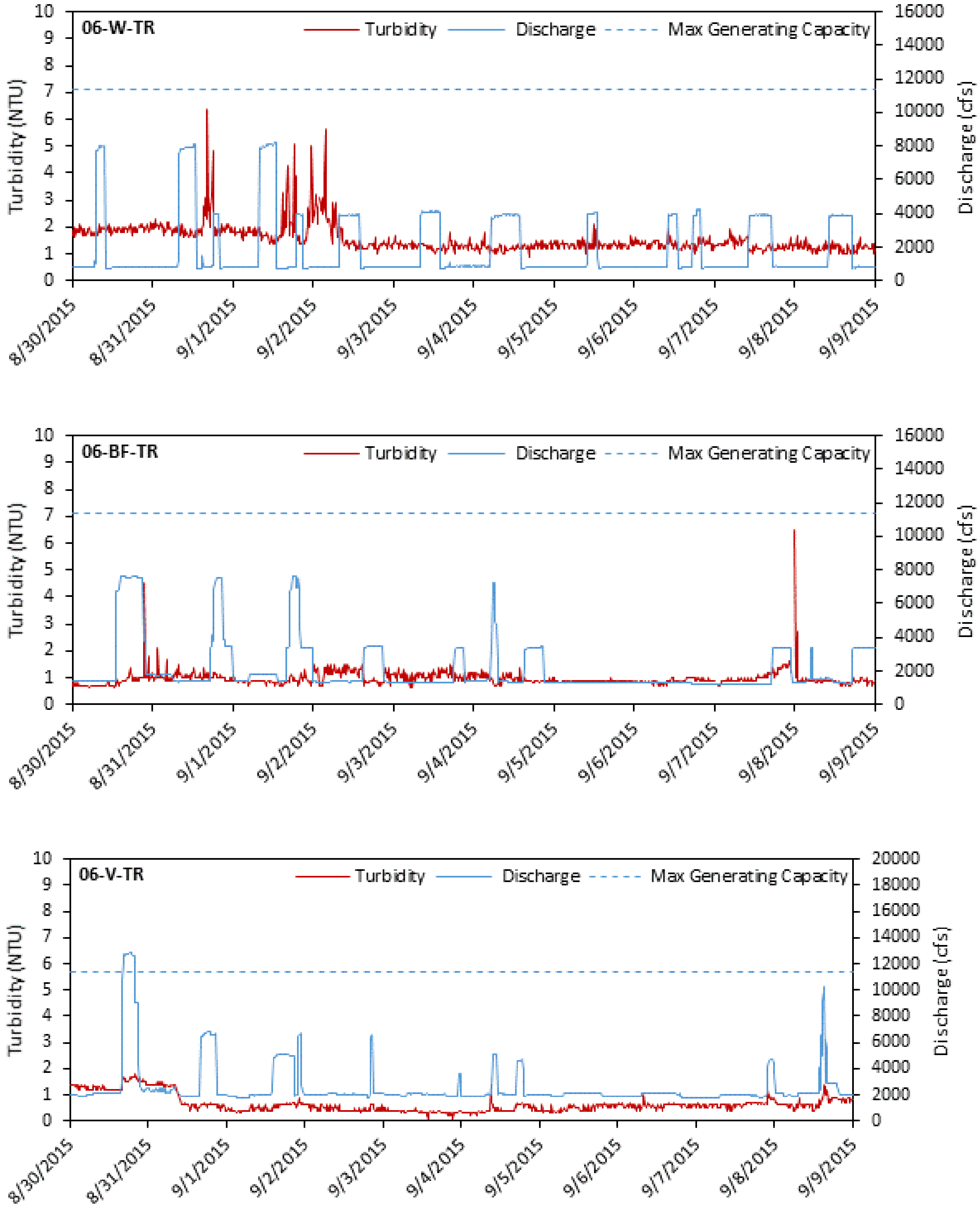
Figure 3.4-40. Tailrace pH and discharges at the Wilder, Bellows Falls, and Vernon Projects in 2015.

Project Operations Effects on Turbidity

New Hampshire surface water quality standards for Class B waters require turbidity not to exceed 10 NTU greater than natural conditions to maintain designated uses. Similarly, the Vermont surface water quality standard for turbidity for Class B waters requires turbidity not be in such amount or concentration that prevents full support of uses, and not to exceed 10 NTU as an annual average under dry weather base-flow conditions (see Section 3.4.1.2, *Water Quality*, *Surface Water Quality Standards and Designated Uses*).

Turbidity levels recorded during the course of Study 6 were very low among all mainstem study sites (not measured at tributary sites), and mean and median turbidities were less than 5 NTU for the majority of the study period. Turbidity increased during precipitation events that often result in high flows and spill conditions (Figures 3.4-28, 3.4-24, and 3.4-37; also see Study 6, Appendix F). Under low-flow conditions and throughout the study period, turbidity did not exceed 10 NTU above turbidity levels measured at the upstream riverine stations; only during periods of precipitation that resulted in high flow did turbidity levels throughout the study area differ by more than 10 NTU. Mean and median turbidity value differences were negligible between the forebay and tailrace stations at all three Projects, ranging between 0.6 and 0.3 NTU (forebay) and between 0.4 and 0.3 NTU (tailrace). When the three Projects were generating above minimum flows, turbidity was low in the tailrace and did not change with increasing or decreasing discharges (Figure 3.4-41).

The continuous and vertical profile turbidity data collected at all mainstem monitoring stations indicate that turbidity on very rare occasions exceeded the New Hampshire surface water quality standard of 10 NTU beyond upstream receiving waters and that under low-flow conditions turbidity in the Project areas did not exceed the Vermont surface water quality standard. The New Hampshire turbidity standard was exceeded on June 4, 2015, in the Wilder forebay; this exceedance was attributed to sampling through a debris field. In addition, periodic turbidity spikes occurred at the continuous monitoring stations but most notably within each Project tailrace. These spikes were attributed to debris drifting in front of the turbidity sensor. Because TransCanada is not proposing any changes to Project operations, turbidity levels will likely reflect those observed during the course of Study 6 and will likely comply with state surface water quality standards, and support and maintain designated uses.



Source: ILP Study 6, *Water Quality Monitoring and Continuous Temperature Monitoring Study*

Figure 3.4-41. Tailrace turbidity and discharges at Wilder, Bellows Falls, and Vernon Projects in 2015.

Project Operations Effects on Nutrients and Chlorophyll-*a*

New Hampshire surface water quality standards for nutrients in Class B waters require nitrogen to occur in no such concentrations that impair any existing or designated uses, unless naturally occurring. In addition, New Hampshire nutrient surface water quality standards require phosphorus levels to occur in no such concentrations that impair any existing or designated uses unless naturally occurring. Vermont state surface water quality standards for nutrients in Class B waters require nitrates not to exceed 5.0 mg/L (as NO_3-N) at flows exceeding low median monthly flow, and phosphorus is to be limited so that concentrations do not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses (see Section 3.4.1.2, *Water Quality*, *Surface Water Quality Standards and Designated Uses*).

Sources of nutrient loadings and enrichment in the watersheds for the three Projects include point and non-point sources, such as wastewater treatment facilities, CSOs, septic systems, and agricultural runoff. These discharges can affect attainment of surface water quality standards in the Wilder, Bellows Falls, and Vernon Project areas. Nutrient and chlorophyll-*a* analyses in 2012 and 2015 and field observations of no evidence of visual impairments (e.g., algal blooms) indicated that Project-affected waters are in compliance with state surface water quality standards and that designated uses are maintained and supported. These data and observations further indicate that Project-affected waters in the Wilder, Bellows Falls, and Vernon forebays are, on average, mesotrophic to oligotrophic under existing conditions (Tables 3.4-26, 3.4-36, and 3.4-46; Dodds et al., 1998; NHDES, 1997a; VDEC, 2000). Continued Projects will not alter these conditions.

3.4.3 Cumulative Effects

3.4.3.1 Water Quantity

The cumulative impacts of the Projects' continued operations on water quantity occurs within the larger context of water management in the Connecticut River System. River hydrology has been altered for more than 200 years since construction of the first canal at South Hadley, Massachusetts, in 1795. This was followed by construction of additional locks, canals, and dams on the mainstem during the early to mid-1800s from Wilder, Vermont, downstream to Windsor Locks, Connecticut (CRWC, 2013). Additional dams were built during the 1800s and 1900s on the mainstem and tributaries thoughout the watershed including several USACE flood control dams built on tributaries during the 1960s.

Hydroelectric operations on the Connecticut River are coordinated among projects and licensees and with USACE for purposes of flood control and navigation (Section 3.1.1.3, Dams). The Wilder, Bellows Falls, and Vernon Projects do contribute to alteration of the river's hydrology through fluctuations in impoundment water levels and discharge flows, which are highly regulated by upstream hydroelectric projects and depend on inflows from upstream and from tributaries because of limited impoundment storage capacity. Generation capacity along with licensed and voluntary operating constraints (Section 3.4.1) further limit the Projects' effects on water quantity to localized, short-term effects that are most apparent close to the dams and in the downstream reaches occuring as a result of normal (and high flow) operations of the Projects. Because these Projects pass all inflow on a daily or near-daily basis, they do not contribute substantially to water quantity effects farther downstream and they have no effect relative to water quantity effects from the base of Moore dam to the upstream extent of the Wilder impoundment. TransCanada does not propose to change Project operations; therefore, these existing conditions are not expected to change over the term of new licenses.

3.4.3.2 Water Quality

The Wilder, Bellows Falls, and Vernon Projects, as well as other hydroelectric projects and discharges from wastewater treatment facilities, operation of USACE flood control dams in the basin, irrigation and other water withdrawals, tributary contributions, and surface runoff on the Connecticut River both upstream and downstream, can cumulatively affect water quality—particularly temperature and DO. Baseline continuous and discrete water temperature data indicate that water temperatures slightly increase in the downstream direction from the upstream riverine reaches and upper impoundments toward the Project dams. This warming effect is very gradual and depends on ambient atmospheric conditions, latitude, and changes in elevation over the 122-mile Project areas because the three Projects pass all inflow on a daily or near daily basis and the impoundments have limited storage capacity. Therefore, over the large spatial extent from the base of Moore dam to Long Island, gradual warming of water temperatures is expected. Moreover, the existing thermal regime is not expected to change from existing conditions because TransCanada is not proposing any change in Project operations.

DO levels in the Project area follow a typical annual pattern with higher concentrations in late spring and early fall than during the summer. DO levels were observed to gradually decrease from upstream areas toward the Project dams, and change in response to generation and minimum flow operations as water is passed through the powerhouses, but DO typically does not fall below either state's surface water quality standards. The exception occurred during 2012, a low water year, when DO levels were observed to briefly fall below state surface water quality standards within the hypolimnion of the Wilder (Vermont standard only) and Bellows Falls (New Hampshire and Vermont standard) Project forebays, but increased above state surface water quality standards as water was passed through the powerhouses. Therefore, DO levels can be locally affected, but because water becomes re-oxygenated as it passes through the powerhouses, the Projects will not adversely and cumulatively affect DO levels of downstream reaches. Because TransCanada is not proposing any change in Project operations, existing DO levels throughout the entire Project area are not expected to change.

Data collected as a part of the 2012 and 2015 baseline water quality studies indicate that pH infrequently falls outside one or both state surface water quality standards, but these exceedances were attributed to atmospheric deposition and increased rates of photosynthesis, not to Project operations effects, such as impoundment residence time. Because TransCanada is not proposing any change in Project operations, existing pH levels throughout the Project area are not expected to change because of Project operations. Furthermore, because pH exceedances were attributed to factors other than Project operations, continued operation of the Projects as proposed will not cumulatively affect pH levels throughout the river.

Baseline turbidity data collected during Study 6 demonstrated that turbidity levels throughout the three Project areas were very low for the majority of the time, but increased in response to precipitation events and high flows that often resulted in spill at the Project dams. Because TransCanada is not proposing any changes to Project operations, turbidity levels will continue to reflect those observed throughout Study 6 and will very likely comply with state surface water quality standards. Therefore, continued operation of the Projects as proposed will not cumulatively affect turbidity levels throughout the river.

Nutrient and chlorophyll-a concentrations measured during in 2012 and 2015 indicate that state surface water quality standards and designated uses are supported. Because TransCanada is not proposing any changes in Project operations, attainment of state surface water quality standards relative to nutrients will not be affected because the Projects do not contribute to nutrient loading in the river. Therefore, nutrients and chlorophyll-*a* levels throughout the river will not be adversely, cumulatively affected by continued Project operations.

3.4.4 Proposed Protection, Mitigation, and Enhancement Measures

3.4.4.1 Water Quantity

TransCanada is not proposing any new PM&E measures related to water quantity. The voluntarily imposed operating limits and current license conditions provide water quantity environmental benefits related to fish, aquatic, terrestrial, recreational, and cultural and historic resources by:

- Limiting the magnitude and rate of change in impoundment water levels;
- Limiting impoundment water level reductions during the summer recreation season; and
- Providing instream flows greater than licensed minimums.

3.4.4.2 Water Quality

TransCanada is not proposing any new PM&E measures related to water quality beyond continuing to release current minimum flows higher than the licensed minimums. Because most inflows are passed on sub-daily to daily basis under current Project operations, these measures are sufficient to maintain water quality within the Project areas.

3.4.5 Unavoidable Adverse Effects

3.4.5.1 Water Quantity

Project operations will continue to alter flows in the Connecticut River, resulting in unavoidable adverse effects on some fish and aquatic resources (see Section 3.5, *Fish and Aquatic Resources*), some terrestrial resources (see Section 3.6, *Terrestrial Resources*), and potentially cultural and historic resources (see Section 3.10, *Historic and Cultural Resources*). Several factors constrain TransCanada's ability to significantly alter water quantity over the existing and proposed operational regime. These factors include:

- The amount and timing of water available as a function of upstream inflow and intermediate drainage flow. A portion of this inflow is subject to regulation and can be limited or currently augmented above natural flows during low flow periods, from upstream storage reservoirs.
- Limited generation flow capacity above which spill must occur;
- Safety and flood control operations, which are required during periods of high flows;
- Normal operations, which use only a portion of the overall impoundment storage capacity; and
- Limited impoundment storage, which necessitates spilling rather than storage of available inflows that exceed Project generating capacities.

3.4.5.2 Water Quality

The amount of warming (water temperature increases) that will occur as water flows from upstream areas to the Project dams will depend primarily on natural prevailing weather conditions and latitudinal variation. At times, the amount of warming can exceed Vermont's temperature standard (>1°F), especially over the long longitudinal distance from the upstream riverine area to each Project dam and due to larger diurnal temperature changes at the upstream riverine reaches. This effect will reflect existing conditions, i.e., be short term and have limited or negligible impacts.

Stratification of the Project impoundments will occur if weather conditions are conducive, as they were in 2012. Stratification of the Project impoundment can result in depleted DO levels in the hypolimnion, particularly in the forebay, and can fall below state surface water quality standards. Depressed DO levels in the forebays of the Projects will stress aquatic life. However, waters will become oxygenated above state standards as water passes through the Project powerhouses; therefore, the effect of low DO will be confined in the forebay and not affect downstream reaches. Any unavoidable adverse effects related to lower DO in the hypolimnion will be brief, confined to forebay areas, and have limited or negligible impacts.

3.5 Fish and Aquatic Resources

3.5.1 Affected Environment

The Connecticut River within the Wilder, Bellows Falls, and Vernon Project areas provide aquatic habitat for a variety of fish, freshwater mussels, and macroinvertebrates. Aquatic species depend on suitable physical habitat for migration, reproduction, and rearing. Parameters of physical habitat used by aquatic species include large-scale features such as substrate and mesohabitat type, tributary confluences, backwater/setback habitats, islands, bedrock falls, as well as smaller scale, submerged habitat attributes such as aquatic vegetation, bottom substrate materials, and large woody debris.

3.5.1.1 Fisheries Overview

The Connecticut River within the Wilder, Bellows Falls, and Vernon Project areas provides habitat for a diverse assemblage of fishes ranging from coldwater to warmwater species, both resident and migratory (Brown, 2009). Coldwater species such as trout[30] reside or migrate seasonally, and coolwater and warmwater species, reside year-round. The makeup of the resident fish population changes as the Connecticut flows south; coldwater trout give way to coolwater Smallmouth Bass and Chain Pickerel, then warmwater species like Walleye and Largemouth Bass. Introduced species include Largemouth and Smallmouth Bass, Rainbow and Brown Trout, Walleye, and Northern Pike (CRWC, 2015).

TransCanada conducted numerous relicensing studies to evaluate fisheries resources within the Project areas and are discussed in detail in Sections 3.5.1.2 and 3.5.1.3. Those fisheries-related studies are:

- ILP Study 10, Fish Assemblage Study;
- ILP Study 11, American Eel Survey;
- ILP Study 12, Tessellated Darter Survey;
- ILP Study 13, Tributary and Backwater Fish Access and Habitats Study;
- ILP Study 14 and ILP Study 15, Resident Fish Spawning in Impoundments and Riverine Sections Studies;
- ILP Study 16, Sea Lamprey Spawning Assessment;
- ILP Study 17, Upstream Passage of Riverine Fish Species Assessment;
- ILP Study 18, American Eel Upstream Passage Assessment;
- ILP Study 19, American Eel Downstream Passage Assessment (revision in progress);

[30] Naming conventions for common names of fishes follow the style guidelines in Chapter 9 of the American Fisheries Society (2013).

- ILP Study 20, American Eel Downstream Migration Timing Assessment;
- ILP Study 21, American Shad Telemetry Study – Vernon (revision in progress);
- ILP Study 22, Downstream Migration of Juvenile American Shad – Vernon (revision in progress); and
- ILP Study 23, Fish Impingement, Entrainment, and Survival Study (revision in progress).

Study 22 and sampling in 2015 for Study 10 indicate that more than 40 resident and migratory fish species occur in the Project areas. According to the 2015 field sampling, the Project impoundments are dominated (50 to 60 percent by number) by 3 species (Spottail Shiner, Yellow Perch, and Fallfish), whereas 50 percent of the fish community in the Wilder and Bellows Falls riverine reaches are composed of Smallmouth Bass, Tesselated Darter, and Fallfish (Study 10 and Study 12). Diadromous species that occur in portions of the Project areas include American Eel, American Shad, Sea Lamprey, and Atlantic Salmon, which require upstream and downstream passage through portions of the Project areas to use their native ranges to complete their life cycle (see Sections 3.5.1.2, *Aquatic Habitat*, and 3.5.1.3, *Resident Fish Populations*).

Threatened and Endangered Fish Species

No fish species present in the Project areas are listed as threatened or endangered under the federal ESA. Shortnose Sturgeon, which is a federally listed endangered species, is found as far upstream in the Connecticut River as Turners Falls dam downstream of the Vernon Project. Both American Eel and Blueback Herring were the subject of ESA-listing petitions, but NMFS determined after species status reviews in 2007 and in 2013 for eel, and in 2013 for herring, that listing was not warranted (FWS, 2016b). The Connecticut River Blueback Herring population has declined to the point where none have been recorded passing Vernon dam since 2000 (VT WAP Team, 2015), so presently no Blueback Herring use habitats in the Project areas. However, access to those habitats is provided by fish passage facilities at the Projects, so future population restoration would presumably result in the reintroduction of the species to the Project areas.

Essential Fish Habitat

Pursuant to the Magnuson-Stevens Fishery Conservation and Management Act, amended in 1996 (Public Law 94-265), habitats essential to federally managed commercial fish species are to be identified, and measures taken to conserve and enhance that habitat. EFH is defined as “all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut” (NEFMC, 1998), which includes the entire Connecticut River.

Beginning in 1967, CRASC worked to restore Atlantic Salmon to the river basin by hatchery production and stocking and other management and regulatory approaches. Upstream and downstream fish passage facilities at the Projects have provided Atlantic Salmon access through the Projects since the 1980s. However, because of low adult returns over the years, FWS discontinued culturing salmon for restoration in the Connecticut River Basin in 2012. New Hampshire, Vermont, and Massachusetts also discontinued rearing and stocking programs; however, small numbers of adult salmon have continued to return to the basin. In 2016, no adult salmon returned to the Project areas (see Section 3.5.1.3).

State-Listed Fish Species

Several sensitive fish species were found in the Project areas during field work for Study 10 conducted in 2015. These species are state-listed in New Hampshire (NHFGD, 2015) and/or Vermont (VT WAP Team, 2015) under each state's updated Wildlife Action Plan (WAP) as threatened (Bridle Shiner) or as Species of Greatest Conservation Need (SGCN) in each state's latest revision to WAPs. Table 3.5-1 summarizes the sensitive fish species found during Study 10; collectively, they constituted only 2.1 percent of the total catch in that study (see Sections 3.5.1.2 and 3.5.1.3 for detailed discussions). Additional state-listed sensitive species not found in Study 10 and not included in Table 3.5-1, but either previously documented, known to use, expected to use, or with potential to be restored to habitats within the Project areas include: Redbreast Sunfish (all three Projects), Blueback Herring (Bellows Falls and Vernon), and Rainbow Smelt (Vernon). In addition, Study 11 collected 3 American Eel in the Bellows Falls impoundment (not included in Table 3.5-1).

Table 3.5-1. Numbers of state-listed sensitive fish species found in Study 10 in the Wilder, Bellows Falls, and Vernon Project areas, 2015.

Species	NH Status[a]	VT Status[a]	Wilder		Bellows Falls			Vernon		Total
			I[b]	R[b]	I[b]	BP[b]	R[b]	I[b]	R[b]	
American Eel[c]	SC	SGCN-M	1	0	0	0	0	0	2	3
American Shad[c]	SC	SGCN-M	0	0	0	0	41	16	22	79
Blacknose Shiner		SGCN-H	50	0	0	0	0	0	0	50
Bridle Shiner	Threatened	SGCN-H	9	0	4	0	0	0	0	13
Brook Trout	SC	SGCN-M	0	7	0	0	0	5	5	17
Burbot	SC		0	0	0	0	3	0	0	3
Finescale Dace	SC		0	2	0	0	0	0	0	2
Sea Lamprey[c]	SC		0	15	8	0	13	23	3	62
Total			**60**	**24**	**12**	**0**	**57**	**44**	**32**	**229**

Source: ILP Study 10, *Fish Assemblage Study*

a. SC – species of concern, SCGN-H – high priority, SGCN-M – medium priority.
b. I – impoundment, R – downstream riverine reach, BP – Bellows Falls bypassed reach.
c. Migratory species.

Fishery Management Plans

The management of resident fishery species is addressed through state WAPs (NHFGD, 2015; Vermont WAP Team, 2015). The WAPs serve to identify species in greatest need of conservation, habitats that are at the greatest risk, and land uses and activities that present the greatest threats to wildlife and habitat. Both Vermont and New Hampshire's 2015 WAPs are currently under review. The WAPs include characterization of habitat and non-habitat threats as well as identified research and monitoring needs for several resident species identified as SGCN by either state and that were collected in the Project areas, including Brook Trout, Blacknose Shiner, Bridle Shiner, and Finescale Dace.

The WAPs also identified diadromous SGCN, including American Shad, American Eel, Blueback Herring, and Sea Lamprey. Fishery management plans have been published for Connecticut River diadromous species, including Atlantic Salmon, American Shad, American Eel, and river herring (Blueback Herring and Alewife, not present within the Project areas).

American Eel

The Atlantic States Marine Fisheries Commission (ASMFC) published its fishery management plans for American Eel (ASMFC, 2008, 2006, 2000). The initial management plan presented primary objectives pertaining to an increased understanding of eel life history and population dynamics and sources of mortality through fishery dependent data collection, research, and monitoring; protection and enhancement of eels in currently used habitats; and restoration to historically used habitats where practical. The 2008 addendum was published, in part, due to evidence that the American Eel stocks had declined and are at or near low levels, and ASMFC strongly recommended that member states and FWS request special consideration for American Eel in the FERC relicensing process, including improving upstream and downstream passage and collecting data on both (ASMFC, 2008). A Benchmark Stock Assessment (ASMFC, 2012) concluded that the American Eel population in U.S. waters is depleted and at or near historically low levels because of a combination of historical overfishing, habitat loss and alteration, productivity and food web alterations, predation, turbine mortality, changing climatic and oceanic conditions, toxins and contaminants, and disease. As a result, ASMFC approved Addendum 3 (ASMFC, 2013) with the goal of reducing mortality and increasing conservation of American Eel stocks across all lifestages. The addendum focused on the establishment of new management measures for commercial and recreational eel fisheries and the implementation of fishery independent and fishery dependent monitoring. Addendum 4 (ASMFC, 2014) followed and modified management of commercial fisheries.

American Shad

ASMFC published its fishery management plan for American Shad and river herring (Blueback Herring and Alewife) in 1985 (ASMFC, 1985) in response to low commercial landings. Objectives of the plan included regulating fishing mortality to ensure survival and enhancement of depressed stocks; improving habitat accessibility through improved or new fish passage facilities; improving water quality; ensuring that river flow allocation decisions consider flow needs of alosine fishes; ensuring that water withdrawal effects, including turbine mortalities, do not result in stock declines; initiating and expanding stock restoration programs (larval and adult stocking); and supporting research programs relevant to development of management recommendations.

Amendment 3 to the ASMFC fishery management plan (ASMFC, 2010), specific to American Shad, was published because a 2007 stock assessment found that stocks were at all-time lows and did not appear to be recovering to acceptable levels. Amendment 3 identified the primary causes for continued declines as excessive total mortality, habitat loss and degradation, and migration and habitat access impediments. The objectives of Amendment 3 included maximizing juvenile emigration from freshwater complexes; restoring and maintaining spawning stock biomass and age structure to achieve maximum juvenile recruitment; and managing harvest so that objectives 1 and 2 will not be compromised. A strategy to achieve those objectives included ensuring that adequate monitoring techniques are implemented to measure migratory success (i.e., upstream and downstream fish passage at barriers). The plan identified issues for state and federal agencies to address. A number of these issues are specific to dams, and some may be pertinent to the Project areas, including the following (paraphrased):

- Work to identify hydropower dams that pose significant impediment to diadromous fish migration and target them for appropriate recommendations during FERC relicensing;
- Evaluate the effectiveness of upstream and downstream passage; when passage is inadequate, improve facilities;
- Where appropriate, improve upstream fish passage effectiveness through operational or structural modifications at impediments to migration;
- Guide/route fish that have ascended the passage facility to an appropriate area so that they can continue upstream migration and avoid being swept back downstream below the obstruction;
- Evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities) and implement measures to pass fish via the route with the best survival rate;
- To mitigate hydrological changes from dams, consider operational changes such as turbine venting, aerating reservoirs upstream of hydroelectric plants, aerating flows downstream, and adjusting in-stream flows;
- Consider natural river discharge when altering instream flow to a river (flow regulation);
- Ensure that decisions on river flow allocation take into account American shad instream flow needs and minimize deviation from natural flow regimes; and

- Study the impacts and possible alteration of dam-related operations to enhance river habitat.

CRASC (1992) produced a management plan for American Shad in the Connecticut River basin with the overarching goal "to restore and maintain a spawning shad population to its historic range in the Connecticut River basin and to provide and maintain sport and the traditional in-river commercial fisheries for the species." The primary management objectives include achieving and sustaining an adult population of 1.5 to 2 million entering the mouth of the Connecticut River annually and achieving 40 to 60 percent passage at Holyoke dam, Massachusetts (the first barrier to upstream migration on the mainstem Connecticut River), and each successive upstream dam (Turners Falls and Vernon). In combination with a management objective of a maximum exploitation (fishing) rate of 40 percent, those objectives equate to an annual upstream passage objective of 144,000 to 432,000 American Shad at Vernon, thus making available the Project area between Bellows Falls and Vernon dams. Other pertinent management objectives include:

- Enhancing and promoting the recreational opportunities throughout the species' historical range;
- Establishing and maintaining a permanent population monitoring program on the Connecticut River; and
- Establishing an annual research program to address management programs associated with shad restoration goals and objectives.

In 2014, ASMFC approved the Connecticut Department of Energy and Environmental Protection's *American Shad Habitat Plan for the Connecticut River* (CTDEEP et al., 2014), prepared to fulfill requirements of Amendment 3 to the ASMFC Fishery Management Plan for American Shad, and supported the CRASC Management Plan for American Shad.

In 2015, CRASC prepared a species status report for Connecticut River American Shad (CRASC, 2015). It noted that while the objective of 1.5 to 2 million shad entering the Connecticut River has not been observed since the estimated 1983 and 1992 runs, using the lowest range of the population goal (1.5 million) and the lowest target passage rate (40 percent), CRASC determined that the target passage count for a restored population at the Vernon fish ladder would be >96,000 passed annually. Although achieving numeric passage targets at Vernon depends on passage at downstream dams, CRASC notes that the Vernon passage rate relative to Turners Falls passage 53 percent, within the management plan objective, from 2012 to 2014. In 2015 and 2016, that ratio was 68 percent and 66 percent, respectively (CRASC, 2016), exceeding the management plan objective.

Atlantic Salmon

Atlantic Salmon management in the Connecticut River Basin is supported by state and federal legislation that created CRASC. The Connecticut River distinct population segment of Atlantic Salmon was extirpated by the early 1800s with the loss of stocks indigenous to the Connecticut River (Fay et al., 2006; NMFS, 1999).

Connecticut River restoration efforts have been conducted following the 1998 *Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River* (CRASC, 1998). CRASC developed a cooperative effort that includes habitat protection, fisheries management, research, regulation, hatchery production and stocking. The strategic plan seeks to accomplish the program mission to: "protect, conserve, restore and enhance the Atlantic salmon population in the Connecticut River Basin for the public benefit, including recreational fishing." However, during July 2012, FWS announced that it would no longer produce hatchery-reared stock for the effort to restore Atlantic Salmon to the Connecticut River Basin because of the continued costs for low numbers of returns (see Section 3.5.1.3).

Blueback Herring

Amendment 2 to the ASMFC fishery management plan (ASMFC, 2009), specific to river herring was published because stock assessments determined that many populations of river herring were in decline or depressed. The objectives of the amendment included preventing further declines in river herring abundance; improving the understanding of commercial fishery bycatch mortality; increasing understanding of fisheries, stock dynamics, and population health to evaluate management performance; retaining existing or making more conservative regulations; and promoting improvements in degraded critical habitat. Recommendations pursuant to habitat access that could be pertinent to the Project areas, assuming restoration of the migratory river herring population to the Connecticut River above Vernon dam, include (paraphrased):

- Evaluating effectiveness of existing fish passage facilities and where inadequate, improving them;
- Evaluating passage survival of post-spawn and juvenile fish passing by available routes (e.g., turbines, spillage, bypass) and optimizing passage for the route with the best survival rate;
- Preventing entrainment in hydropower intakes with behavioral barrier devices;
- Ensuring that decisions on river flow allocation consider the flow needs of alosine fishes and minimize deviation from natural flow regimes;
- Ensuring that water withdrawal effects do not affect alosine stocks by impingement/entrainment; employing intake screens or deterrent devices as needed to prevent egg and larval mortality; and altering water intake velocities, if necessary, to reduce mortality;
- To mitigate hydrological changes from dams, considering operational changes such as turbine venting, aerating reservoirs upstream of hydroelectric plants, aerating flows downstream and adjusting in-stream flows;
- When considering options for restoring alosine habitat, including study of, and possible adjustment to, dam-related altered river flows; and

- Documenting the impact of power plants and other water intakes on larval, postlarval, and juvenile mortality in spawning areas and calculating the resultant impact to adult population size.

CRASC (2004) produced an amended management plan for river herring in the Connecticut River basin with the goal to "restore and maintain a spawning river herring population within its historic range in the Connecticut River basin." The primary management objectives pertinent to achieving and sustaining annual passage of 300,000 to 500,000 adults at Holyoke include:

- Achieving annual passage of 40 to 60 percent of the spawning run at each successive upstream barrier on the Connecticut River from Holyoke to Bellows Falls [equating to an annual passage objective of 48,000 to 180,000 Blueback Herring at Vernon dam];
- Maximizing outmigrant survival for juveniles and spent adult river herring; and
- Enhancing, restoring, and maintaining river herring habitat in the Connecticut River Basin.

3.5.1.2 Aquatic Habitat

TransCanada conducted 3 relicensing studies that focused on aquatic habitat including:

- ILP Study 7, Aquatic Habitat Mapping Study;
- ILP Study 8, Channel Morphology and Benthic Habitat Study; and
- ILP Study 9, Instream Flow Study.

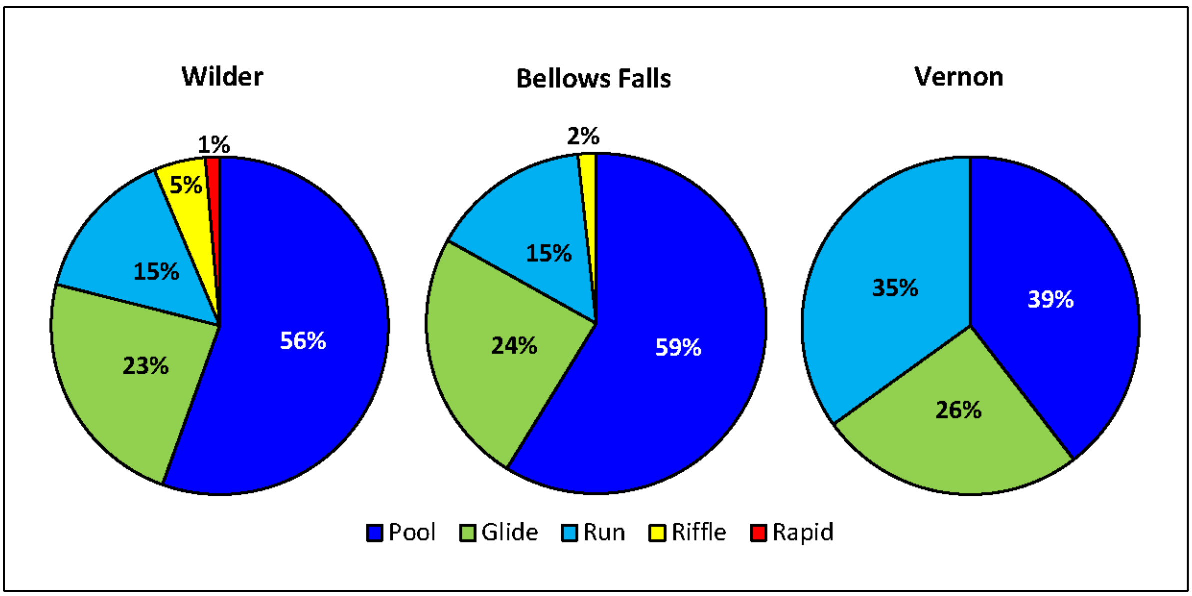
Several wildlife and botanical studies were also conducted that included evaluation of aquatic habitats relevant to those studies (see Section 3.6 and Section 3.7).

Habitat Types

The Project impoundments are generally classified as lentic (lake-like) habitat, although the upper portions of each impoundment possess more lotic (riverine) characteristics and the lower portions can also be more lotic at higher river flows. Overall, shallower depths, higher water velocities, and greater proportions of coarse substrate types (gravels, cobbles, and boulders) are present in the upper several miles of each impoundment (see below for substrate descriptions). The majority of aquatic habitat in each impoundment is characterized as placid and deep with steeply sloped banks and largely composed of fine substrate materials (e.g., silt, sand). Because of this basic homogeneity of habitat in the impoundments, the habitat in these reaches was predominantly classified according to dominant substrate composition (see Substrate Types below).

In contrast to the impoundment reaches, the 3 riverine reaches possess alternating lengths of different mesohabitat types. Mapping of riverine mesohabitat types, conducted as part of Study 7, used a classification system largely based on the attributes of depth and velocity, with the associated mixture of substrate types. Individual mesohabitat units were defined as pools, glides, runs, riffles, or rapids, and all split or side-channels were mapped separately. Study 7 includes a description of all mapping methodologies and mesohabitat type definitions.

The relative percentages of mesohabitat types were very similar in the Wilder and Bellows Falls riverine reaches; pool habitats dominate each reach at 56 to 59 percent by length, 23 to 24 percent glide habitats, 15 percent run habitats, and 2 to 5 percent riffle habitats (Figure 3.5-1). The Wilder reach also had a single rapid habitat at Sumner Falls (discussed below). Mesohabitat type proportions in the Vernon riverine reach were more evenly split at 39, 26, and 35 percent of pool, glide, and run habitats, respectively. Note that the Vernon riverine reach is only 1.5 miles long, so the total number of mesohabitat units (10) is far fewer than in the 17.7-mile Wilder and the approximate 6-mile Bellows Falls riverine reaches, which contained 101 and 28 mesohabitat units, respectively.



Source: ILP Study 7, *Aquatic Habitat Mapping Study*

Figure 3.5-1. Percentage by length of mesohabitat types in the 3 riverine reaches.

The riverine mesohabitat mapping was conducted mostly at low release levels, e.g., 900 cfs in the Wilder riverine reach and 2,000 to 3,000 cfs in the Bellows Falls riverine reach, under which flows the character of individual mesohabitat units are more distinct and easier to identify. In contrast, the short riverine reach below Vernon dam was mapped at flows 3,500 cfs just prior to mapping, increasing to approximately 9,600 cfs during the time mapping occurred and at a median tailrace elevation.

The Bellows Falls bypassed reach, a 0.7-mile channel immediately below Bellows Falls dam, was mapped as part of Study 7 and under conditions at that time; approximately 400 cfs was being discharged from the dam. This flow is somewhat higher than the typical leakage flow of approximately 125 cfs. The reach is a rock-dominated channel consisting of these mapped mesohabitats: pool (73 percent), run (16 percent), riffle (8 percent), and rapid/cascade (3 percent).

Tributaries

Tributaries are an important component of aquatic habitat associated with both the impoundment and riverine reaches. More than 150 named and unnamed tributaries enter Project waters. Most are small (first or second order streams) with steeper gradients that result in relatively minor interaction with the mainstem reaches in comparison to medium (third and fourth order streams) or large (fifth or higher order) tributaries, some of which are influenced by Project operations for several miles upstream of their mouths. Tributaries contribute flow, cool water temperatures, coarse sediments, woody debris, and other important habitat attributes to the mainstem reaches. Medium and large tributaries also provide additional rearing and spawning habitat for many fish species, including Walleye, White Sucker, Sea Lamprey, and Fallfish. Smallmouth Bass were noted to spawn in the lower reaches of larger tributaries, and the gravel-dominated deltas formed by small and medium tributaries at their confluence with impoundment reaches were found to support substantial spawning activity by both Smallmouth Bass and Fallfish (Studies 14-15). Colder tributaries likely provide a source of recruitment of salmonid species that are sought after by some anglers. Tributaries of all sizes can also serve as temporary refuge habitats for small and large fish species during times when the main channels are experiencing flood flows. Table 3.5-2 lists the medium and larger tributaries in the Project areas and the reaches into which they drain.

Table 3.5-2. List of medium and large (≥third order) tributaries in the Project areas.

Project Area	Tributary Name (listed from upstream to downstream)	Stream Order
Wilder Impoundment	Clark Brook	3
	Oliverian Brook	4
	Halls Brook	4
	Waits River	5
	Eastman Brook	3
	Indian Pond Brook	3
	Jacobs Brook	3
	NA	3
	Clay Brook	3
	NA	3
	Grant Brook	3

Project Area	**Tributary Name (listed from upstream to downstream)**	**Stream Order**
	Hewes Brook	3
	Ompompanoosuc River	5
	Bloody Brook	3
	Mink Brook	4
	Dothan Brook	3
Wilder Riverine	White River	7
	Mascoma River	5
	Kilburn Brook	3
	Bloods Brook	4
	Ottauquechee River	5
	Lulls Brook	3
	Blow-me-down Brook	3
	Hubbard Brook	3
	Mill Brook VT	4
	Mill Brook NH	4
Bellows Falls Impoundment	Sugar River	6
	Mill Brook	3
	Barkmill Brook	3
	Meadow Brook	3
	NA	3
	Ox Brook	3
	Little Sugar River	4
	Beaver Brook	4
	Spencer Brook	4
	Black River	5
	Clay Brook	4
	Commissary Brook	3
	Williams River	5
	Jabes Hackett Brook	4
	NA	3
Bellows Falls Riverine	Saxtons River	5
	Cold River	5
	Cobb Brook	3
	Blanchard Brook	3
	NA	3
Vernon Impoundment	NA	3
	Great Brook	3
	Houghton Brook	3

Project Area	Tributary Name (listed from upstream to downstream)	Stream Order
	Aldrick Brook	3
	Mill Brook	4
	East Putney Brook	4
	Partridge Brook	4
	Ox Brook	3
	Sacketts Brook	4
	Canoe Brook	3
	Salmon Brook	3
	Catsbane Brook	3
	NA	3
	West River	6
	Whetstone Brook	4
	Broad Brook	4
	Ash Swamp Brook	3
Vernon Riverine	NA	3

Source: USGS (2016b)

Backwater/Setback Habitats

Like the tributaries discussed above, backwater or setback habitats provide unique opportunities for spawning and rearing by many aquatic species. Forty-one backwaters are identified in the Project areas based on the National Hydrography Dataset (USGS, 2016b). However, the species that use backwaters are typically different than tributary-associated species. Yellow Perch, Northern Pike, Chain Pickerel, Largemouth Bass, Bluegill, Pumpkinseed, Black Crappie, and Golden Shiner frequent the shallow, vegetated habitats that are characteristic of many backwater habitats (Studies 14-15). With the exception of backwaters connected by a narrow channel (e.g., culverts under a railroad track), changes in WSEs in most backwaters closely mirror changes in the adjacent mainstem. The shallow waters typical of backwater habitats also tend to warm up more quickly in the spring and produce wider fluctuations in diel water temperatures with higher daily maxima during both spring and summer in comparison to mainstem temperatures. Exceptions to these rules were evident for backwaters associated with medium or larger tributaries (e.g., the backwater at the mouth of the Williams River in the Bellows Falls impoundment), which were influenced by cooler inflows.

Island Habitats

Eighteen permanent islands occur in the Project areas—8 in impoundment reaches and 10 in riverine reaches. Island habitats were targeted for sampling in the Studies 14–15 riverine and impoundment spawning studies because of the added complexity of habitat produced by the deposition zones associated with islands.

Project segments containing islands have double the amount of margin-related habitat per length of channel, which includes shallow shoal habitat and large woody debris. Islands in riverine reaches provide additional eddy habitat that is heavily used for spawning by Smallmouth Bass, and gravel/cobble bars present at the heads of islands were frequently selected for spawning by Sea Lamprey and Fallfish. Chase Island near the lower boundary of the Wilder riverine reach was 1 of few known locations in the Project areas to harbor the endangered dwarf wedgemussel, discussed in Section 3.7, *Threatened and Endangered Species* (ILP Study 24, *Dwarf Wedgemussel and Co-occurring Mussel Study*).

Bedrock Falls

Prominent bedrock-formed rapids and falls are rare in the Project areas; consequently, the rapids at Sumner Falls in the Wilder riverine reach represents a unique habitat unit that was assessed independently from the other more common mesohabitat types in Study 9. The rapids themselves offer relatively little habitat for fish on the Vermont side, which is composed of smooth bedrock bottom affording little protection from currents during high flows and a deep, bedrock slot possessing rapid velocities at all flows. The New Hampshire side contains more diversity of bedrock ridges, small slots, and some relatively large eddy areas at all but the highest project flows. A deep but moderately flowing slot occurs along a portion of the New Hampshire bank. Although habitat for aquatic species is limited within the rapids themselves, the habitat immediately downstream of the falls outlet is a very popular angling location that appears to produce high catch rates of gamefish, including Walleye, Smallmouth Bass, and Northern Pike.

The Bellows Falls bypassed reach also contains a bedrock-dominated channel with riffle and rapid habitat, although the upper, lower gradient portion of the 0.7-mile reach is not accessible to upstream migrating fish because of a fish barrier dam that is located 0.3 mile upstream from the bypass outlet.

Large Woody Debris

The presence and relative abundance of woody debris were assessed in the impoundment reaches using side-scanning sonar and visual surface observations. Although the overall percentage of woody debris was small in each reach, ranging from 1 percent by area in the Bellows Falls impoundment to a maximum of 3 percent in both the Wilder and Vernon impoundments, woody debris provides an important source of instream cover for both spawning and rearing for many fish species, particularly the piscivorous (i.e., fish eating), cover-oriented ambush predators such as Black Crappie, Largemouth and Smallmouth Bass, Northern Pike, and Chain Pickerel. Woody branches, whether dead or alive, were also heavily used by spawning Yellow Perch, which seemed to prefer draping their egg masses over branches rather than dropping them to the substrate (Figure 3.5-2, left). Woody debris was also uncommon in the riverine reaches, but where it did occur, it was frequently used by spawning Smallmouth Bass, which used the logs and branches as current breaks to protect the eggs and fry from excessive velocities and potential displacement from the nest (Figure 3.5-2, right).

Source: ILP Studies 14-15, *Resident Fish Spawning in Impoundments* and R*iverine Sections Study*

Figure 3.5-2. Use of woody vegetation and debris for spawning by Yellow Perch (left) and Smallmouth Bass (right).

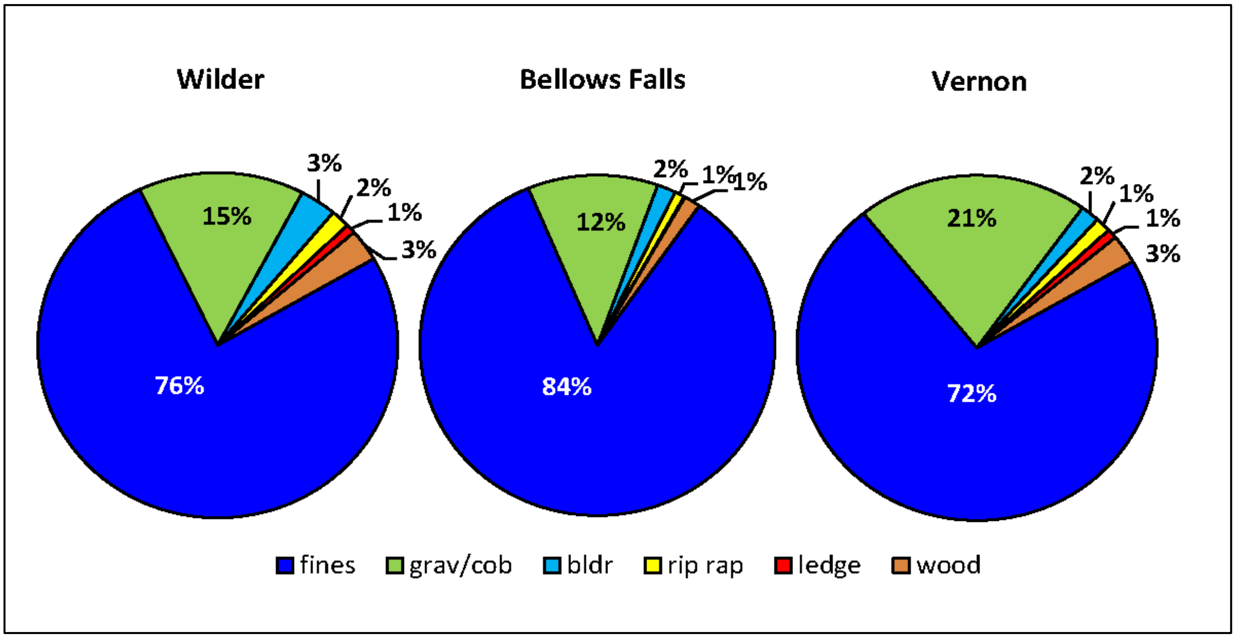
Substrate Types

Substrate composition in lakes and rivers has a significant influence on the suitability of habitat for fish spawning, feeding, and rearing (especially benthic fish); mussel colonization; invertebrate productivity; vegetation establishment; and the like. Many of the fish species assessed in Studies 14-15 and 16 have specific substrate requirements for spawning, such as aquatic vegetation for Northern Pike and Chain Pickerel spawning, clean (free of fine sediments) gravel and cobble particles for Sea Lamprey and Fallfish nest construction, and clean rock substrate for sucker and Walleye egg development. Although Smallmouth Bass can sweep thin layers of fine sediments to expose suitable substrate for egg incubation, heavy deposition of fines also will limit spawning success for this species.

Side-scan sonar and surficial observations were used to broadly characterize substrate composition within 3,000 acres of habitat in each of the 3 impoundment reaches (Study 7). A combination of surficial observations and underwater video was used in riverine reaches to assess detailed substrate composition across 71 one-dimensional (1D) transects and throughout both two-dimensional (2D) hydraulic modeling study locations for assessing flow/habitat relationships (Study 9). Substrate composition was also an important component of Study 8.

Impoundments

The side-scan sonar data collected for Study 7 within the Project impoundments classified substrate into 6 categories: (1) sand/silt/clay, (2) gravel/cobble, (3) boulder, (4) riprap, (5) ledge, and (6) woody debris. Substrate patches down to 100 square ft (and often smaller) were delineated in Geographic Information Systems to produce a separate layer for further assessment. As noted above, fines (sand, silt, and clay) dominated the substrate in each impoundment, representing from 72 percent of habitat in the Vernon impoundment to 84 percent in the Bellows Falls impoundment (Figure 3.5-3). Gravel/cobble substrate was the only other type that occurred in abundance in the Project impoundments, representing 15, 12, and 21 percent of the total substrate in the Wilder, Bellows Falls, and Vernon impoundments, respectively. Boulder, riprap, bedrock ledge, and woody debris composed between 1 and 3 percent of habitat in each reach. Overall, the Bellows Falls impoundment contained the most homogeneous habitat within the main channel, although all 3 impoundments contained rocky substrates in their upper reaches as well as along most major channel bends and at tributary mouths.



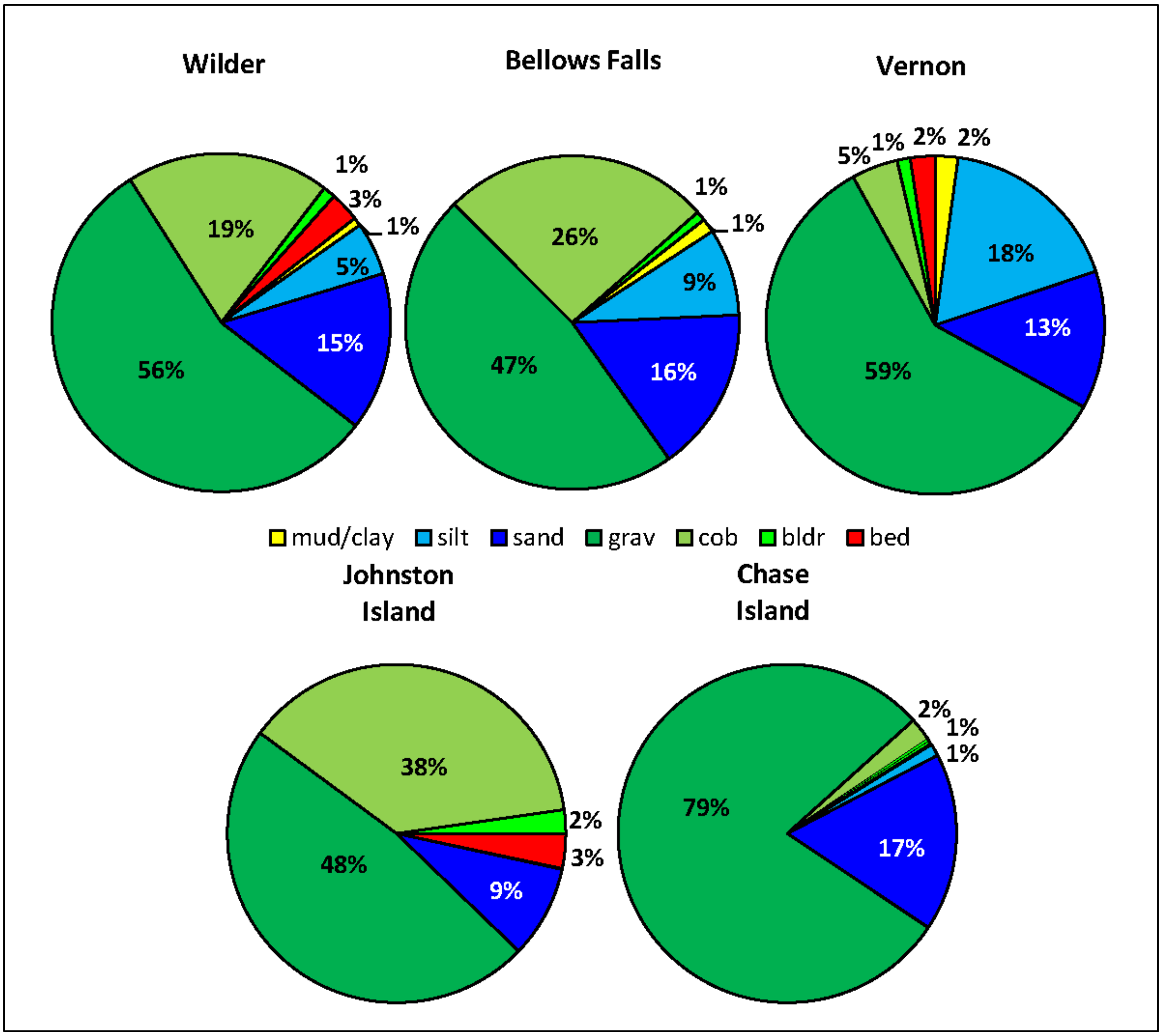
Source: ILP Study 7, *Aquatic Habitat Mapping Study*

Figure 3.5-3. Percentage by area of substrate types in the 3 impoundment reaches.

Riverine Reaches

As expected, the proportion of larger, rocky substrate types was higher in the riverine reaches than in the impoundment reaches. Combined together, gravel, cobble, and boulder made up 65 to 76 percent of dominant substrate along the 1D transects in the 3 riverine reaches (Figure 3.5-4). The proportion of fines (mud/clay, silt, and sand) ranged from 21 percent in the Wilder reach to 33 percent in the Vernon reach; the principal difference between reaches was the lower percentage of cobble and the higher percentage of silt in the Vernon riverine reach.

As noted above, the island habitats were frequently associated with large expanses of shallow bar and riffle habitats. Both of the island-based 2D study sites contained 80 to 90 percent rocky substrate with gravel dominating at the Chase Island study site versus a gravel/cobble mixture at the Johnston Island study site (Figure 3.5-4). Fines were relatively uncommon at Johnston Island, whereas the longer Chase Island study site (which extended well upstream of the actual island) contained 17 percent sandy substrate.



Source: ILP Study 7, *Aquatic Habitat Mapping Study*

Figure 3.5-4. Percentage by length of dominant substrate types along 1D transects in the 3 riverine reaches, and by area in the 2D study sites (Johnson and Chase Islands) in the Wilder riverine reach.

3.5.1.3 Resident Fish Populations

Abundance and Distribution

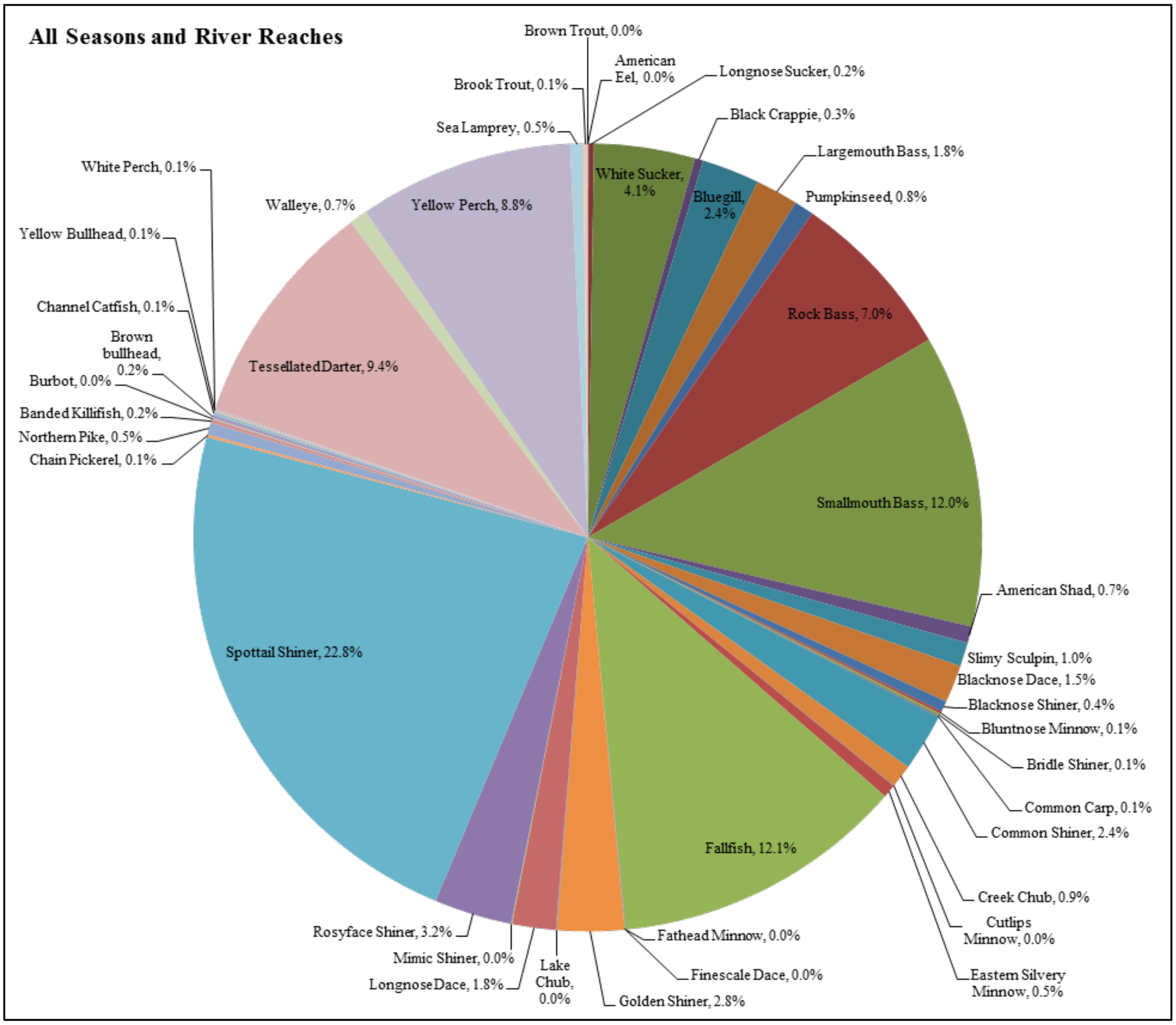
All Projects

The Connecticut River within the Wilder, Bellows Falls, and Vernon Project areas contains a diversity of habitats supporting a variety of resident fish species. Both intentional and accidental introductions have altered native fish communities within the basin (FWS, 2013a). The states of New Hampshire and Vermont annually stock Brook Trout, Brown Trout, and Rainbow Trout into the mainstem Connecticut River (New Hampshire) and in numerous tributaries upstream of, or within the Project areas, and formerly stocked Atlantic Salmon until 2013 (see Section 3.5.1.3). In 2016, the states collectively stocked approximately 33,000 Brook Trout, 28,000 Brown Trout, and 43,000 Rainbow Trout (NHFGD, 2016b; VFWD, 2016). Results from both historical surveys and sampling in 2015 (Study 10) indicate that more than 40 resident and migratory fish species occur in the Project areas.

Study 10 was conducted to characterize the occurrence, distribution, and relative abundance of both resident and migratory fish species present in the Project areas. Sixty-nine sites including impounded regions, riverine and bypassed reaches, tributaries, and backwaters within the Project-affected area were randomly selected during 3 seasonal periods (spring, summer, and fall) for sampling. Impoundment sites were sampled by 1,640-ft (500-meter) boat electrofishing transects as well as 2-hour experimental gillnet sets, while riverine and bypassed reaches, tributaries and backwater sites were sampled by up to 1,640-ft (500-meter) portable electrofishing transects and either a 100-ft beach seine sample (riverine sites) or 24-hour trapnet set (backwater sites).

A total of 11,551 fish representing 43 species and 14 families was collected over the Project areas (Figure 3.5-5 and Table 3.5-3)—40 resident species representing 11 families and 3 diadromous species representing 3 families (see Section 3.5.1.4, *Migratory Species*). Overall, Spottail Shiner, Fallfish, and Smallmouth Bass were the most abundant species collected across all river reaches and seasons combined. In addition to those 3 species, Tessellated Darter, Yellow Perch, and Rock Bass were the only other species to account for more than 5 percent each of the total number of individuals collected. The catch by specific gear type, season, and study reach is presented in the Study 10.

Six species of the Centrarchidae family were collected for Study 10—Largemouth Bass, Smallmouth Bass, Pumpkinseed, Bluegill, Rock Bass and Black Crappie. Centrachids are typically found in habitats with protective cover for feeding and nesting, generally in the littoral zone (along the shoreline to a depth of about 6 to 20 ft) in backwaters and other off-channel habitats. Spawning occurs from spring, when water temperatures are near 60˚F, into summer and early fall. Males typically construct nests in shallow water by sweeping a depression into sand or gravel, usually around brush, rocks, and logs.



Source: ILP Study 10, *Fish Assemblage Study*

Figure 3.5-5. Percent composition by species for all seasons, sampling gears, in all Project areas, 2015.

Table 3.5-3. Total catch (N) and percent composition for fish species collected in 2015 in the Project areas.

Family / Common Name	REACH														ALL	
	Wilder Impoundment		Wilder Riverine		Bellows Falls Impoundment		Bellows Falls Bypassed Reach		Bellows Falls Riverine		Vernon Impoundment		Vernon Riverine			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Anguillidae																
American Eel	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.6	3	<0.1
Catostomidae																
Longnose Sucker	0	0.0	26	1.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	26	0.2
White Sucker	88	4.1	163	6.9	74	2.8	8	3.9	52	3.0	62	3.0	31	8.7	478	4.1
Centrarchidae																
Black Crappie	0	0.0	0	0.0	16	0.6	1	0.5	0	0.0	20	1.0	2	0.6	39	0.3
Bluegill	20	0.9	5	0.2	25	0.9	0	0.0	19	1.1	154	7.4	49	13.7	272	2.4
Largemouth Bass	50	2.3	3	0.1	37	1.4	1	0.5	24	1.4	87	4.2	1	0.3	203	1.8
Pumpkinseed	10	0.5	0	0.0	40	1.5	0	0.0	3	0.2	38	1.8	1	0.3	92	0.8
Rock Bass	261	12.2	186	7.8	154	5.8	3	1.5	99	5.7	80	3.8	26	7.3	809	7.0
Smallmouth Bass	145	6.8	395	16.6	238	9.0	43	21.0	379	21.9	79	3.8	107	30.0	1386	12.0
Clupeidae																
American Shad	0	0.0	0	0.0	0	0.0	0	0.0	41	2.4	16	0.8	22	6.2	79	0.7
Cottidae																
Slimy Sculpin	7	0.3	73	3.1	1	<0.1	0	0.0	1	0.1	13	0.6	18	5.0	113	1.0
Cyprinidae																
Blacknose Dace	2	0.1	25	1.1	118	4.4	0	0.0	32	1.8	1	<0.1	0	0.0	178	1.5
Blacknose Shiner	50	2.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	50	0.4
Bluntnose Minnow	9	0.4	3	0.1	0	0.0	0	0.0	1	0.1	0	0.0	0	0.0	13	0.1
Bridle Shiner	9	0.4	0	0.0	4	0.2	0	0.0	0	0.0	0	0.0	0	0.0	13	0.1
Common Carp	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	0.2	2	0.6	6	0.1
Common Shiner	5	0.2	131	5.5	1	<0.1	1	0.5	134	7.7	0	0.0	0	0.0	272	2.4

Family / Common Name	REACH														ALL	
	Wilder Impoundment		Wilder Riverine		Bellows Falls Impoundment		Bellows Falls Bypassed Reach		Bellows Falls Riverine		Vernon Impoundment		Vernon Riverine			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Creek Chub	21	1.0	31	1.3	33	1.2	0	0.0	19	1.1	5	0.2	0	0.0	109	0.9
Cutlips Minnow	0	0.0	1	<0.1	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	2	<0.1
Eastern Silvery Minnow	3	0.1	0	0.0	0	0.0	1	0.5	25	1.4	34	1.6	0	0.0	63	0.5
Fallfish	358	16.7	375	15.8	200	7.5	2	1.0	254	14.7	192	9.2	12	3.4	1393	12.1
Fathead Minnow	0	0.0	2	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	<0.1
Finescale Dace	0	0.0	2	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	<0.1
Golden Shiner	95	4.4	2	0.1	102	3.8	0	0.0	22	1.3	96	4.6	1	0.3	318	2.8
Lake Chub	0	0.0	1	<0.1	0	0.0	0	0.0	3	0.2	0	0.0	0	0.0	4	<0.1
Longnose Dace	2	0.1	32	1.3	16	0.6	127	62.0	30	1.7	0	0.0	0	0.0	207	1.8
Mimic Shiner	0	0.0	0	0.0	0	0.0	0	0.0	4	0.2	0	0.0	0	0.0	4	<0.1
Rosyface Shiner	0	0.0	313	13.2	20	0.9	0	0.0	34	2.0	1	<0.1	1	0.3	369	3.2
Spottail Shiner	302	14.1	174	7.3	1163	43.8	0	0.0	216	12.5	755	36.3	22	6.2	2632	22.8
Esocidae																
Chain Pickerel	6	0.3	0	0.0	5	0.2	0	0.0	1	0.1	1	<0.1	0	0.0	13	0.1
Northern Pike	28	1.3	0	0.0	12	0.5	0	0.0	1	0.1	12	0.6	3	0.8	56	0.5
Fundulidae																
Banded Killifish	3	0.1	1	<0.1	0	0.0	1	0.5	7	0.4	1	<0.1	6	1.7	19	0.2
Gadidae																
Burbot	0	0.0	0	0.0	0	0.0	0	0.0	3	0.2	0	0.0	0	0.0	3	<0.1
Ictaluridae																
Brown bullhead	1	<0.1	0	0.0	11	0.4	2	1.0	3	0.2	2	0.1	0	0.0	19	0.2
Channel Catfish	0	0.0	0	0.0	1	<0.1	0	0.0	2	0.1	2	0.1	9	2.5	14	0.1
Yellow Bullhead	0	0.0	0	0.0	1	<0.1	0	0.0	6	0.3	0	0.0	0	0.0	7	0.1
Moronidae																
White Perch	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	0.3	0	0.0	7	0.1

Family / Common Name	REACH														ALL	
	Wilder Impoundment		Wilder Riverine		Bellows Falls Impoundment		Bellows Falls Bypassed Reach		Bellows Falls Riverine		Vernon Impoundment		Vernon Riverine			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Percidae																
Tessellated Darter	231	10.8	397	16.7	50	1.9	15	7.3	282	16.3	114	5.5	2	0.6	1091	9.4
Walleye	68	3.2	0	0.0	10	0.4	0	0.0	0	0.0	4	0.2	3	0.8	85	0.7
Yellow Perch	371	17.3	8	0.3	316	11.9	0	0.0	20	1.2	273	13.1	29	8.1	1017	8.8
Petromyzontidae																
Sea Lamprey	0	0.0	15	0.6	8	0.3	0	0.0	13	0.8	23	1.1	3	0.8	62	0.5
Salmonidae																
Brook Trout	0	0.0	7	0.3	0	0.0	0	0.0	0	0.0	5	0.2	5	1.4	17	0.1
Brown Trout	0	0.0	2	0.1	1	<0.1	0	0.0	1	0.1	0	0.0	0	0.0	4	<0.1
Total Individuals	**2146**		**2373**		**2658**		**205**		**1731**		**2081**		**357**		**11551**	
Total Families	**9**		**8**		**9**		**6**		**12**		**12**		**12**		**14**	
Taxa Richness	**26**		**26**		**28**		**12**		**31**		**28**		**23**		**43**	

Source: ILP Study 10, *Fish Assemblage Study*

Three species collected for Study 10 belong to the family Percidae, including 2 that fall within the subfamily Percinae (Walleye and Yellow Perch) and 1 within the subfamily Etheostomatinae (Tessellated Darter). Walleye and Yellow Perch commonly occur in lakes and rivers, occupying a variety of habitats and depths, while Tessellated Darter can be found in habitats ranging from small streams to large rivers and lakes, typically over mud or sand bottom in areas of little to no current (Langdon et al., 2006). Spawning for Yellow Perch and Walleye occurs at night during early spring after ice out. Tessellated Darter spawn in late April to May when water temperatures are between 50°F and 59°F, creating nests under rocks (Langdon et al., 2006).

Two species of the family Esocidae—Northern Pike and Chain Pickerel—were collected for Study 10. Not native to the Connecticut River, Northern Pike were introduced and are now naturalized within the Project impoundments. Esocid species prefer warm to cool lakes and rivers with slow current and large amount of aquatic vegetation. Spawning occurs during spring just after ice out, typically when waters reach 40°F in the Connecticut River. Esocids move into the shallow water of marshes and backwaters where adhesive eggs are broadcast onto vegetation (Langdon et al., 2006).

White Sucker and Longnose Sucker, representing the family Catostomidae, were collected for Study 10. White Sucker are found in a variety of habitats and environmental conditions including lakes and large rivers as well as small ponds and streams. It can be found in high and low gradient habitats and is generally tolerant of degraded environmental conditions including pollutants and siltation (Langdon et al., 2006). Longnose Sucker are commonly found in colder waters than White Sucker, which are often associated with gravel bottomed streams, rivers, and lakes (Scarola, 1973). Spawning occurs when water temperatures reach 40°F for Longnose Sucker and 50°F for White Sucker, typically between late April and June in the upper Connecticut River (Langdon et al., 2006). Adults migrate up tributaries to higher gradient riverine sections or even along windswept regions of lakes where they use rocky, shallow areas with moderate current (Langdon et al., 2006). No nests are prepared and no parental care is provided for the eggs, which are scattered along the bottom of these spawning areas.

Eighteen species from the family Cyprinidae were collected for Study 10 including Blacknose Dace, Blacknose Shiner, Bluntnose Minnow, Bridle Shiner, Common Carp, Common Shiner, Creek Chub, Cutlips Minnow, Eastern Silvery Minnow, Fallfish, Fathead Minnow, Finescale Dace, Golden Shiner, Lake Chub, Longnose Dace, Mimic Shiner, Rosyface Shiner, and Spottail Shiner. Cyprinids favor a variety of habitats, depths, temperatures, and water quality conditions, and at least 1 representative of this family can most likely be found within almost any reach of the Project areas. Three of the most commonly found species are Fallfish, Golden Shiner, and Spottail Shiner. While all 3 species inhabit lakes and large rivers, their habitat preferences distinguish them. Fallfish prefer clear water lakes and rivers with gravel bottoms, while Golden Shiner and Spottail Shiner are associated more with slower currents and modest to high concentrations of aquatic vegetation. Spawning periods for the

3 most common cyprinids range from spring through mid-summer with Fallfish initiating spawning the earliest (late April to May) followed by Golden Shiner and Spottail Shiner (May to August). Fallfish spawn over piles of stones or gravel bottoms in flowing water, which then are covered by mounds of additional stones (Scott and Crossman, 1973). Golden Shiner broadcast spawn over beds of vegetation, while Spottail Shiner are reported to aggregate for spawning at tributary mouths where they broadcast spawn over gravel bottoms (Becker, 1983).

Brown Bullhead, Yellow Bullhead and Channel Catfish are species of the family Ictaluridae collected for Study 10. Bullheads prefer warm water and usually inhabit regions near or on the bottom in shallow ponds, lakes, and slow moving rivers with abundant aquatic vegetation and soft bottoms. Channel Catfish also inhabit lakes and rivers but prefer clearer water associated with gravel (Scott and Crossman, 1973). Spawning for bullheads and Channel Catfish typically occurs from late spring to late summer when water temperatures range between 69°F and 85°F in nests with newly hatched young guarded by adult males (Becker 1983; Scott and Crossman, 1973).

Brook Trout and Brown Trout represent the members of the family Salmonidae collected for Study 10 (no Rainbow Trout were collected). Brook Trout, native to the region, can be found in a variety of habitats from deep lakes and large rivers to small headwater streams provided that a steady supply of cold, well-oxygenated water is present year-round. Brown Trout, introduced from Europe, are more tolerant of warmer temperatures than Brook Trout but tend to thrive under similar cold, well-oxygenated conditions. Spawning occurs in autumn over redds created by females for both species (Scarola, 1973; Scott and Crossman, 1973).

Banded Killifish, Burbot, Slimy Sculpin and White Perch are the sole species collected for Study 10 that represent the families Fundulidae, Gadidae, Cottidae, and Moronidae, respectively. Banded Killifish are a hardy species found in shallow reaches of lakes and streams throughout the eastern coastal plain of North America. Burbot are most often found in cold, deep lakes across northern North America but also can be found in streams and rivers. These fish migrate to shallow reaches of lakes or up rivers and streams to spawn under the ice in December through March. Slimy Sculpin occur widely throughout northern North America, typically in small gravel and cobble streams, although they have been found in larger lakes and rivers (Scarola, 1973). White Perch are not native to the upper Connecticut River but has been successfully introduced to many inland waters in New Hampshire and Vermont. These fish prefer shallow, warmer waters in lakes and rivers, spawning in shallow coves and tributaries in the spring (Scarola, 1973).

Wilder Project

A total of 2,146 fish was captured in the Wilder impoundment, of which Yellow Perch, Fallfish, and Spottail Shiner made up 48.1 percent of the total catch. The Wilder riverine reach (2,146 total fish captured) was dominated by Smallmouth Bass, Fallfish and Tessellated Darter (49.1 percent of the total catch) (Table 3.5-3).

Bellows Falls Project

In the Bellows Falls impoundment (2,658 total fish captured), Spottail Shiner accounted for 43.8 percent of the total catch followed by Yellow Perch (11.9 percent) and Smallmouth Bass (9.0 percent). The Bellows Falls bypassed reach catch included only 205 fish captured of which 62.0 percent were Longnose Dace, making this the only reach where this species accounted for greater than 2.0 percent of the total species composition. The Bellows Falls riverine reach (1,731 total fish captured) was similar to the Wilder riverine reach in that Smallmouth Bass, Fallfish, and Tessellated Darter were the dominant species, accounting for 52.9 percent of the total catch (Table 3.5-3).

Vernon Project

The Vernon impoundment (2,081 total fish captured), similar to the Bellows Falls impoundment, was dominated by Spottail Shiner (36.3 percent) as well as Yellow Perch (13.1 percent). The Vernon riverine reach (357 fish captured) was dominated by Smallmouth Bass, Bluegill and White Sucker, that together accounted for 52.4 percent of the total catch (Table 3.5-3).

Tessellated Darter Study

Study 12 was conducted in 2015 to characterize the distribution and relative abundance of this species through habitat-based field surveys. As 1 of 3 known hosts for the glochidia stage of federally endangered dwarf wedgemussel, (discussed in detail in Section 3.7, *Threatened and Endangered Species*), the Tessellated Darter is important to the life cycle of that species. Sampling in September 2015 was conducted at 45 randomly selected 1,640-ft (500-meter) map units within the Project areas and within each map unit; 3 cross-river transects were randomly placed. A 3-meter radius ring count circle was then placed at 5 count locations along each transect at which darters were quantified. From 675 count circles, 263 darters were observed (Table 3.5-4), 80 percent of which were determined to be juveniles based on estimated body length of less than 2.5 inches.

The majority of darters were observed in the Wilder impoundment followed by the Bellows Falls impoundment, while the fewest observations occurred in the southern-most reaches (Vernon impoundment and Vernon riverine reach).

Table 3.5-4. Summary statistics for Tessellated Darter observations by river reach, 2015.

Description	Total Count of Darters	Mean Number of Darters/ 25 square meters (m^2)	Standard Deviation	Min Number of Darters / 25 m^2	Max Number of Darters / 25 m^2
Wilder impoundment	208	1	4.4	0	40
Wilder riverine	9	0.1	0.3	0	1
Bellows Falls impoundment	37	0.3	1.1	0	9
Bellows Falls riverine	6	0.1	0.4	0	3
Vernon impoundment	2	<0.1	0.1	0	1
Vernon riverine	1	<0.1	0.2	0	1
Total	**263**	**0.4**	**2.5**	**0**	**40**

Source: ILP Study 12, *Tessellated Darter Survey*

No dwarf wedgemussels were identified among the 5 species of freshwater mussels found during Study 12 sampling. However, Tessellated Darters found during Study 12 and Study 10 were distributed within the mussel survey reaches and were found nearby or in the general vicinity (within 1 to 2 miles up or downstream) of most locations where dwarf wedgemussels were found during Study 24. Darters were also present near some mussel survey sites where no dwarf wedgemussels were found (e.g., near Sumner Falls).

Upstream Passage

Study 17 was conducted in 2015 to evaluate fish ladder use by resident species at the three Projects. The study used digital video fish passage monitoring systems consisting of a closed-circuit video camera; a laptop computer capable of running Salmonsoft's FishCap/FishRev, version 2.6.3.0[31] software; an uninterruptable power source battery backup; and accessories as recommended by the Vermont Agency of Natural Resources (VANR). Movements of 15 species/genera past the viewing areas at each Project fish ladder were tabulated by the direction of movement (upstream or downstream) and net passage counts were calculated (upstream counts – downstream counts) on an hourly basis.

The Projects' fish ladders are normally operated on an as-needed seasonal basis for migratory species based on passage counts at downstream projects (see Sections 2.1.1.5, 2.1.2.5, and 2.1.3.5, *Existing Environmental Measures*, for each Project). For purposes of this study of resident species fish passage, video recording was

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conducted from as early as possible in spring 2015 until ice-in in early January 2016.

High numbers of upstream and downstream movements relative to the net upstream passage counts suggests milling of fish in the fish ladder counting windows, resulting in multiple recordings of the same fish. That conclusion is supported by anecdotal observations made by fisheries technicians of fish resting and/or moving in and out of the field of view, indicating a pattern of occupancy rather than passage (Study 17). Alternatively, the occurrence of multiple counts of individuals could result from fallback and unsuccessful upstream passage. In either case, the number of both upstream and downstream movements likely highly overestimates the actual number of individuals using the fish ladders. Therefore, net passage is the best metric for estimating actual passage, particularly in the context of monitoring for upstream passage, which was the purpose of Study 17.

Wilder Project

The fish ladder operated from April 17, 2015, to January 7, 2016. Resident species were recorded to have low fish ladder usage and minimal net passage. Five of the 11 target resident species/genera were recorded with only net downstream passage recorded for sunfish (Table 3.5-5). The majority of net passage for all species except trout, and for all species combined, occurred during the fish ladder's normal operating season (from opening in spring through July 15, note that the Wilder fish ladder is only operated if there has been passage of adult Atlantic Salmon at Bellows Falls). Cumulative net passage reached 80 percent for bass on July 22, for Walleye on August 2, and for sunfish on August 25. The single net passage for White Sucker occurred on June 8.

Trout were recorded most frequently in the ladder and throughout the extended 2015 study season, with only 50 percent cumulative net passage by July 15, yet 80 percent of trout cumulative net passage had occurred by July 30. Bass were also recorded frequently throughout the extended season, but net passage was low.

Table 3.5-5. Wilder fish ladder total recorded movements and net passage by operating period, 2015.

Species/ Genera	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed[a]
	First Date	Last Date	Obser-vations	Net No. Passed[a]	First Date	Last Date	Obser-vations	Net No. Passed[a]		
Bass	May 21	July 8	548	28	July 20	Dec 21	321	11	July 22	39
White Sucker	May 12	June 8	19	1	NA	NA	0	0	May 12	1
Walleye	May 12	July 15	111	13	July 22	Oct 16	210	8	Aug 2	21
Trout	May 16	July 15	267	37	July 16	Jan 7	1,887	37	Jul 30	74
Sunfish	May 21	July 5	3	-1	July 24	Sep 15	48	-4	Aug 25	-5
Bullhead	No observations									
Crappie	No observations									
Pike/Pickerel	No observations									
Yellow Perch	No observations									
Carp	No observations									
Other	No observations									

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative net passage value indicates overall net downstream movement.

Bellows Falls Project

The fish ladder operated from April 15, 2015, to January 6, 2016. Overall fish ladder usage was very low. Five of 11 target resident species/genera were recorded with bass being the most common species recorded (Table 3.5-6).

The majority of net passage for all species but sunfish and for all species combined occurred during the fish ladder's normal operating season (from opening in spring through July 15, note that the Bellows Falls fish ladder is only operated if there has been passage of adult salmon or sufficient numbers of Sea Lamprey at the Vernon Project). Cumulative net passage reached 80 percent for bass on May 25, for White Sucker on May 5, for Walleye on May 14, and for trout on July 8. For sunfish, 80 percent net passage occurred on September 3. Bass were recorded most frequently in the ladder and from May 12 to November 3. However, no net upstream passage occurred after May 21 (80 percent of cumulative net downstream passage occurred by May 25).

Table 3.5-6. Bellows Falls fish ladder total recorded movements and net passage by operating period, 2015.

Species/ Genera	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed[a]
	First Date	Last Date	Obser-vations	Net No. Passed[a]	First Date	Last Date	Obser-vations	Net No. Passed[a]		
Bass	May 12	July 15	787	-47	July 16	Nov 3	474	0	May 25	-47
White Sucker	May 3	May 26	91	7	NA	NA	0	0	May 5	7
Walleye	May 10	June 22	36	2	July 21	Oct 15	22	0	May 14	2
Trout	May 20	July 15	87	15	July 16	Sep 21	193	-7	July 8	8
Sunfish	May 29	July 15	15	1	Aug 7	Sep 18	38	6	Sep 3	7
Bullhead	No observations									
Crappie	No observations									
Pike/Pickerel	No observations									
Yellow Perch	No observations									
Carp	No observations									
Other	No observations									

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative net passage value indicates overall net downstream movement.

Vernon Project

The fish ladder operated from May 5, 2015, to January 6, 2016. Opening was delayed in the spring from the planned mid-April date due to high water and late snow melt delaying internal and external (FWS) pre-season inspections and subsequent maintenance. Overall, 10 of the 11 target resident species/genera were recorded. Of the target species/genera, only Yellow Perch was not recorded; the category of "other" included primarily Channel Catfish (Table 3.5-7). Note that long-standing operating procedures dictate that attraction flow (i.e., the volume supplied via the attraction water pumps of 200 cfs) is shut down overnight and operates generally from 7:00 a.m. to 7:00 p.m. during the normal passage season, although other supplemental flows (flow in the fish ladder itself, downstream fishway flows) operate at night.

The majority of net passage for all species but sunfish, and for all species combined, occurred during the fish ladder's normal operating season (from opening in spring through July 15). Cumulative net passage of 80 percent was reached for White Sucker on May 7, for Walleye on June 10, for trout on July 12, for bullhead on June 21, for crappie on May 30, and for pike and pickerel on July 11. Common Carp and "other" species both reached 80 percent cumulative net passage on July 20.

Bass were the most common species recorded in the ladder followed by sunfish. All species, except Common Carp, were recorded during the extended season after July 15, but only in very small numbers with the exception of sunfish and bass, which were recorded more frequently during that period. For bass, cumulative net passage reached 69 percent of net passage by July 15 and 80 percent by August 20. For sunfish, cumulative net passage reached only 17 percent by July 15, 50 percent by August 26, and 80 percent by September 6 (Study 17).

Table 3.5-7. Vernon fish ladder total recorded movements and net passage by operating period, 2015.

Species/ Genera	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed[a]
	First Date	Last Date	Obser-vations	Net No. Passed[a]	First Date	Last Date	Obser-vations	Net No. Passed[a]		
Bass	May 5	July 15	8,954	522	July 16	Nov 6	925	239	Aug 20	761
White Sucker	May 5	June 27	4,381	325	July 23	Oct 31	5	-3	May 7	322
Walleye	May 5	July 1	187	49	July 22	Nov 6	17	9	June 10	58
Trout	May 12	July 12	138	24	July 31	Dec 22	12	6	July 12	30
Sunfish	May 7	July 15	2,244	204	July 16	Oct 22	5,794	984	Sep 6	1188
Bullhead	May 10	July 15	11	3	July 20	Aug 13	3	-1	June 21	2
Crappie	May 16	June 11	14	14	NA	NA	0	0	May 30	14
Pike/Pickerel	May 6	July 11	3	-1	NA	NA	0	0	July 11	-1
Yellow Perch	No observations									
Common Carp	May 25	July 15	160	6	July 20	July 23	8	2	July 20	8
Other	May 10	July 13	233	9	July 20	Dec 10	27	3	July 20	12

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative net passage value indicates overall net downstream movement.

3.5.1.4 Migratory Species

The Connecticut River in the vicinity of the Vernon, Bellows Falls, and Wilder Projects supports a variety of migratory species. They include the catadromous American Eel and anadromous species including Atlantic Salmon, American Shad, and Sea Lamprey. Before reaching Vernon and the upstream Projects, migratory fish must first successfully pass the hydroelectric facilities at Holyoke (RM 87) and then move upstream via the various routes at Turners Falls (RM 122).

While Atlantic Salmon have occurred historically in the Project areas, current management and stocking efforts have been curtailed because of poor returns. Similarly, Blueback Herring made limited historical use of the Project areas based on reported collections or observations in recent decades, but none have been observed since 2000. The historical upstream extent of the range of both Blueback Herring and American Shad in the Connecticut River is understood to be Bellows Falls due to the natural gradient of the river (VT WAP Team, 2015).

Table 3.5-8 provides historical upstream passage counts for migratory species at the three Projects, excluding American Eel. Historically, American Eel passage through the fish ladders was not tabulated. While eel passage counts provide an index of eel migratory activity, video recording of eel passage is considered to be inaccurate because the fishway structures that guide fish to counting windows are not necessarily effective for guiding eels past the window and bottom-oriented eels moving at night may not trigger the video recording motion sensing component.

Upstream fish passage facilities are operated in spring and fall based on an annual schedule provided by CRASC and depend on passage counts at downstream hydroelectric projects (see Section 2.1, *No-action Alternative*). As of 2016, fish ladders are operated from May 15 through July 15 at Wilder for Atlantic Salmon if Atlantic Salmon pass Bellows Falls, at Bellows Falls for Atlantic Salmon if Atlantic Salmon pass Vernon, and for Sea Lamprey if 100 individuals are counted passing Vernon and from April 15 through July 15 at Vernon for Atlantic Salmon and American Shad (and for Blueback Herring, but none have passed Vernon since 2000). In fall, if required, and for Atlantic Salmon only, fish ladders would operate from September 15 to November 15.

Table 3.5-8. Annual upstream passage counts for the Vernon, Bellows Falls, and Wilder fish ladders.

Year	Vernon			Bellows Falls			Wilder		
	American Shad	Atlantic Salmon	Sea Lamprey	American Shad	Atlantic Salmon	Sea Lamprey	American Shad	Atlantic Salmon	Sea Lamprey
1981	97	8	306						
1982	9	0	5						
1983	2,597	0	379						
1984	335	0	195	1	0	0			
1985	833	4	1,257	0	2	10			
1986	982	4	573	0	2	11			
1987	3,459	10	667	39	8	35	0	3	0
1988	1,370	5	281	24	3	0	0	2	0
1989	2,953	0	205	c	c	c	c	c	c
1990	10,894	9	387	0	5	47	0	1	0
1991	37,197	6	750	65	3	34	0	1	0
1992	31,155	13	749	103	4	89	0	0	0
1993	3,652	7	627	2	0	17	c	c	c
1994	2,681	8	767	3	3	34	0	1	0
1995	15,771	5	509	147	1	44	c	c	c
1996	18,844	9	853	1	3	180	0	0	0
1997	7,384	4	1,506	46	0	40	c	c	c
1998	7,289	12	16,438	55	3	198	d	d	d
1999	5,097	8	836	110	2	195	d	1	d
2000	1,548	5	855	9	2	102	d	2	d
2001	1,744	1	3,212	d	1	d	d	d	d
2002	356	3	2,210	d	d	d	d	d	d
2003	268	0	8,119	c	c	c	c	c	c
2004	653	1	3,668	d	1	d	d	1	d

Year	Vernon			Bellows Falls			Wilder		
	American Shad	Atlantic Salmon	Sea Lamprey	American Shad	Atlantic Salmon	Sea Lamprey	American Shad	Atlantic Salmon	Sea Lamprey
2005	167	4	3,669	3	3	229	[d]	2	[d]
2006	133	4	2,895	0	0	261	[c]	[c]	[c]
2007	65	5	17,049	0	3	709	0	0	0
2008	271	8	22,434	0	8	2233	0	4	2
2009	16	7	1,532	0	4	100	0	1	0
2010	290	8	3,179	0	4	392	0	2	0
2011	46	9	329	1	6	74	0	3	0
2012	10,715	4	696	0	2	99	0	2	0
2013	18,220	e	1,008	0	e	213	0	e	0
2014	27,706	11	399	0	2	212	0	0	0
2015[a]	39,196	6	2,440	44	1[b]	970	0	1	2
2016	35,732	0	5,539	1,973	0	1,619	c	c	c

Sources: CRASC (2016); FWS (2015, 2014a, 2013a); Normandeau (2011); Vermont Fish & Wildlife (2010); ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Net upstream passage counts from ILP Study 17.

b. One salmon assumed to pass Bellows Falls since one was recorded at Wilder.

c. Fish ladder was not operated.

d. Fish ladder was operated but not monitored; Atlantic Salmon counts from radio telemetry.

e. No salmon were released above Holyoke.

American Eel

The American eel is a catadromous fish species, typically spending the majority of its life cycle in freshwater and returning to the sea to spawn. Various developmental stages of the species occur in freshwater, coastal waters and the open ocean as far north as Labrador and Greenland along the North American east coast to as far south as the Gulf of Mexico and northern South America (Facey and Van Den Avyle, 1987). Following spawning in the Sargasso Sea (south of Bermuda, east of the Bahamas), larvae, called leptocephali, are transported from spawning areas to the eastern seaboard by ocean currents (Facey and Van Den Avyle, 1987). While drifting, leptocephali metamorphose, becoming a transparent but miniature post-larval version of an eel called a glass eel. American Eels migrate toward freshwater from the ocean in the form of glass eels. As they enter coastal areas, the body begins to pigment and the eels are then known as elvers (Facey and Van Den Avyle, 1987). The majority of glass eels and elvers reach the coastal rivers of New England during the spring (March–June). As elvers enter the juvenile growth phase, they become known as yellow eels and remain in that phase until they begin to metamorphose into the sexually mature silver-phase and prepare to emigrate to the ocean for spawning. When in freshwater, American Eels tend to be bottom dwellers, increasing their activity levels at night (Scott and Crossman, 1973). They prefer to hide in burrows, plant masses, or other natural substrate shelters (Facey and Van Den Avyle, 1987).

Sexual differentiation does not occur until eels are about 8 to 10 inches (20 to 25 centimeters [cm]) long. American Eels may spend between 5 and 24 years in freshwater and sexual maturing takes place in the later summer or fall (ASMFC, 2014; Smith and Tighe, 2002). Upon initiation of maturity, eels stop feeding, develop a sharply bicolored body pattern (gray to black dorsal side and white ventral side, known as silver eels), eyes and pectoral fins enlarge, and the individual begins to move downstream. Emigrating silver eels primarily move at night and are also stimulated by pulses in flow associated with rain events. The minimum size of silver eels is approximately 11.5 inches (29 cm) for males and 18 inches (45 cm) for females. Female American Eels grow much larger than males and average 24 to 39 inches (60 to 100 cm). American Eels are among the most highly fecund fish species with egg production estimates reported to reach up to 10 million eggs.

During Study 10, only three eels were collected despite the extended sampling effort (spring, summer, and fall). All three were collected during the fall (September and October) sampling. Two of the three eels were identified as silver eels based on morphometric parameters. One was collected in the Wilder impoundment and 1 in the Vernon riverine reach. The third eel was also collected in the Vernon riverine reach and identified as a juvenile (yellow eel).

Study 11 was conducted in 2015 to evaluate the presence of eels throughout the approximate 122-mile extent of the Project areas. A total of 102 mainstem and 24 tributary locations was sampled by electrofishing and a 24-hour, baited eel trap set was conducted at each of the 126 sites selected. Three types of bait were tried during sets but no eels were collected in the traps. Three eels (>18 inches) were collected at two sampling locations in the Bellows Falls impoundment. One eel was determined to be a silver eel based on morphometric parameters, and the other two were determined to be immature yellow eels. The dominant substrate where eels were captured was sand, silt, clay and this was also the dominant substrate throughout most of the study area. No characteristics of those two sites differentiated them from other stations sampled.

The low catches of eels recorded in Study 11 have been similarly observed in other Connecticut River studies. Yoder et al. (2009) conducted a fish assemblage and habitat assessment of the Upper Connecticut River from Lake Francis (RM 325.6) to Turners Falls (RM 122). Electrofish sampling over the 203.6 miles covered by Yoder et al. (2009) collected only two American Eels—one was captured in the Vernon impoundment below VY and the other was captured upstream of Turners Falls, outside the Study 11 study area. Similarly, annual electrofishing at VY within the lower Vernon impoundment recorded 27 American Eels in 25 years of sampling (1991–2014; Normandeau, 2015b).

Greater numbers of eels were identified in Study 17 and in Study 18 although the focus of these studies was specific to identifying areas where eels might congregate at the dams in an attempt to migrate upstream. Net upstream passage of American Eels recorded at the fish ladders in 2015 for Study 17 indicated the fewest numbers migrating upstream at Wilder (52), slightly greater numbers at Bellows Falls (60), and substantially higher passage at Vernon (1,545). In 2016, CRASC reported only a net downstream passage of 920 American Eels detected in the Vernon ladder (CRASC, 2016).

In 2015, Study 18 identified no American Eels below Wilder dam, 3 eels below Bellows Falls dam, and 80 eels below Vernon dam during a period of approximately 5 months of weekly nighttime observations and eel pot sampling. Eel use of the Vernon fish ladder outweighed collections elsewhere at the dam and indicate it as the preferred route for upstream passage (see Section 3.5.2.2, *Effects on Resident Fish Passage*, for further discussion). In 2016, Study 18 was conducted again at Vernon, and included weekly nighttime observations from late July through mid-October, and fabrication and operation of an eel ramp trap near the fish ladder entrance for upstream migrating eels beginning in early September. Seventy eels were identified in nighttime observations and only 1eel was collected from the ramp trap (Study 18, 2016 report supplement); however, the survey began relatively late in the season. Though no aggregations of upstream migrating eels were identified, sites where most eels were observed included the fish ladder entrance area and approach (n = 11), stanchion bay leakage and the associated bedrock outcrop (n = 25), and the tainter gate areas (primarily deep gates set below the tainter gates, n = 34) (see Section 3.5.2.3, *Effects on Upstream Passage of Migratory Fish*).

As part of its relicensing studies, FirstLight implemented a study of upstream passage of American Eels at the Turners Falls Project in 2014 (FirstLight, 2016b).

As a result, FirstLight collected and subsequently released nearly 6,000 juvenile eels upstream of Turners Falls dam that year. Although it is unknown how many eels pass the Turners Falls Project undetected, the low abundance observed at Vernon suggests that incidental passage is not substantial. Therefore, the influence that the experimental passage of eels in 2014 (without experimental passage in 2015 and 2016) may have had on observations of eels at Vernon in 2015 and 2016 is also unknown.

Study 20 reviewed the scientific literature on environmental cues associated with downstream migration of silver American Eel in the Connecticut River basin and the Northeast. The cues that trigger adult eel migration are generally, though not necessarily specifically, understood. Primary cues include water temperature and increased river flow. Other factors that have been hypothesized to act as cues, either singly or in combination include precipitation, changes in atmospheric pressure (associated with precipitation), and increased turbidity or other chemical factors (associated with precipitation and increased flow).

In New England and mid-Atlantic rivers, spawning emigrations begin in the late summer and seem to be concentrated in the fall, specifically in October (Haro, 2003; Winn et al., 1975), although winter emigrations have been noted (Euston et al., 1997; Facey and Helfman, 1985). The timing of maturation and subsequent emigration is associated with water temperature, which establishes bounds of the emigration period as well as potentially triggering movements. In the Connecticut River, downstream passage has been documented as occurring when water temperature is from 45.5 to 68.0°F (7.5 to 20°C). It has been hypothesized that a migratory response to a drop in water temperature synchronizes emigrating silver eels, increasing their chances of reaching the Sargasso Sea simultaneously (CESAR, 2010; FWS, 2007a).

Silver eel migration in the Connecticut River appears to occur primarily at night with peak activity within several hours after sunset. Lunar illumination may influence migration with intervals of low light proximal to the new moon promoting migratory behavior. However, any effect of lunar illumination has been found to be less important than environmental cues, such as water temperature and flow.

American Shad

American Shad are an anadromous, highly migratory, coastal pelagic, schooling species that spend the majority of their life at sea (Munroe, 2002; Stier and Crance, 1985). American Shad are found along the Atlantic coast from northern Labrador down to the St. John's River, Florida. They are the largest member of the herring family (Clupeidae) and females are larger than males at all ages. Mature male shad range from 12.0 to 17.5 inches (30.5 to 44.7 cm) and mature females range from 15 to 19 inches (38.3 to 48.5 cm) (Stier and Crance, 1985). The historical upstream extent of the range of American Shad in the Connecticut River is understood to be Bellows Falls because of the natural steep falls at this location (VT WAP Team, 2015). In some years, small numbers of American shad have passed upstream of Bellows Falls dam (Table 3.5-8). However, access to habitat upstream of the dam may be artificial due to the provision of fish passage upstream of the natural migration limit.

Shad form large schools during their time at sea, ranging vertically from surface waters to a depth of 772 ft (220 meters, Munroe, 2002). Adult shad return to coastal rivers to spawn during the spring when water temperatures are 61.7 to 66.2°F (16.5 to 19.0°C). In New England waters, males typically reach sexual maturity between ages 3 and 5 and females between ages 4 and 6. American Shad are prolific spawners, and large females can produce up to 600,000 eggs. Reproductive rates are highest in the southern portion of the species range and in older and larger females. Male shad arrive at spawning areas ahead of females. Although shad spawn only in freshwater, there does not appear to be any required distance upstream of brackish water (Stier and Crance, 1985). Shad runs typically reach far upriver and often to the headwaters. Spawning occurs in river areas characterized by broad flats with relatively shallow water (3.3 to 19.7 ft, 1 to 6 meters) and moderate current (0.98 to 3.3 ft/s [0.3 to 1.0 meter/s]). Viable eggs have been recorded over bottom types ranging from fine sand to coarse rock and ledge but never over silt or mud bottom (Munroe, 2002). Northern populations of American Shad exhibit high post-spawning survival and are considered iteroparous (repeat spawners). Fertilized eggs slowly sink to the bottom where they water-harden. Hatching takes place during a 6- to 15-day period (depending on water temperature), and the majority of larvae emerge during June. Larvae may remain in fresh water or drift into brackish water and grow rapidly, transforming into juveniles approximately 4 to 5 weeks after hatching (Stier and Crance, 1985). Juvenile shad form schools and gradually move downriver prior to departing for the ocean during late fall of the same year that they were hatched.

In Study 10, 79 American Shad were captured across all sampling locations, seasons and gear types (Figure 3.5-5 and Table 3.5-3), totaling 0.7 percent of the catch for this study. During spring sampling, 3 adult shad were captured in the Vernon riverine reach below Vernon dam. These fish amounted to 2.8 percent of the fish captured during spring sampling in the Vernon riverine reach and 0.1 percent of the total spring catch when considering all gear types and sampling locations. Summer sampling captured a total of 33 young-of-year American Shad. The majority of shad captured in the summer were from the Bellows Falls riverine reach (n = 31) with an additional 2 captured in the Vernon riverine reach. Shad contributed a small percentage to the overall species composition in the summer when considering all gear types and sampling locations (0.9 percent) and had a slightly greater contribution when considering only the reach where they were captured (Bellows Falls riverine = 6.3 percent, Vernon riverine = 1.9 percent). Forty-three young-of-year shad were captured during fall sampling—10 from the Bellows Falls riverine reach, 16 from the Vernon impoundment, and 17 from the Vernon riverine reach. These fish accounted for 1.1 percent of the total catch across all gears and location during fall sampling and ranged from 1.3 percent of the fish captured in the Bellows Falls riverine reach to 12.1 percent of the fish from the Vernon riverine reach.

In Study 17, net upstream passage of adult American Shad was assessed at the Vernon and Bellows Falls fish ladders. No passage occurred or was expected at Wilder. At Vernon, adult shad were recorded in the fish ladder from May 10, 2015, through August 22, 2015, during which a total net upstream passage of 39,196 individuals was recorded, and at Bellows Falls, 44 shad were counted between May 26, 2015, and June 20, 2015 (Table 3.5-3).

In 2016, CRASC reported net upstream passage of shad at Vernon of 35,732 and 1,973 at Bellows Falls (Table 3.5-8) during the regular springtime fish ladder operational season. The proportional net passage of American Shad at Vernon relative to FirstLight's Turners Falls Gatehouse fish ladder was 67 percent in 2015, and 66 percent in 2016 (CRASC, 2016), exceeding the CRASC management goal of 40 to 60 percent.

Study 21 included an assessment of 65 radio-tagged adult shad and their migratory movements in the river from the Vernon riverine reach upstream to Bellows Falls dam. Fifty-four shad were tagged and released into the Vernon impoundment and 11 had been released downstream of Vernon and successfully passed upstream through the fish ladder (another shad had passed the fish ladder as detected by its passive integrated transponder (PIT) tag but had lost its radio tag and was unavailable for tracking upstream of the fish ladder). Approximately 28 percent of those shad continued upstream and were detected in the Bellows Falls tailrace. No tracking was conducted upstream of Bellows Falls dam, so it is not known if any of these shad were included in the 44 counted passing Bellows Falls in Study 17. It is likely that the remaining 72 percent not tracked to Bellows Falls found suitable spawning habitat in the approximate 31-mile reach between Vernon dam and Bellows Falls since radio-tagged fish were tracked and eggs and/or larvae were collected throughout this reach.

Results of Study 21 related to upstream passage, downstream passage route selection, and turbine survival at Vernon are discussed in Section 3.5.2.2*, Effects on Resident Fish Passage*, and Section 3.5.2.6, *Effects on Turbine Survival*. Study 22 included an assessment of the timing of the shad outmigration at Vernon, downstream passage route selection, and turbine survival and is also discussed in Section 3.5.2.2*, Effects on Resident Fish Passage*, and Section 3.5.2.6*, Effects on Turbine Survival*.

Sea Lamprey

The Sea Lamprey is an elongate, eel-like anadromous species found along the Atlantic coast from Labrador to Florida (Flescher and Martini, 2002; Smith, 1985). Adult Sea Lamprey reach an average length of 28 inches (72 cm) at the start of spawning with a maximum recorded length of 35 inches (90 cm; Flescher and Martini, 2002). Sexually mature adults are characterized by strong sexual dimorphism with male lamprey developing a pronounced dorsal ridge and female lamprey developing a prominent ventral fold.

While at sea, adult lamprey parasitize a range of fish species by attaching to them, using 11 to 12 rows of horny, hooked teeth located in an oral hood. Sea lamprey typically attach to the side of their prey and rasp at the flesh until they can feed on blood. Adult lamprey return to coastal streams during the spring, peaking during May and June in Gulf of Maine rivers. Sea Lamprey seek out river or stream reaches that contain suitable habitat in terms of substrate and current, typically using gravel substrate and swift current velocities. Eggs are deposited in a shallow nest depression constructed on the bottom. The majority of spawning adults are 8 years of age (Beamish and Medland, 1988), and an average female contains 200,000 eggs. Deposited eggs develop during a 10- to 13-day period after which the larvae (called ammocoetes) develop gill clefts, an oral hood and body pigmentation (Flescher and Martini, 2002). Ammocoetes travel downstream to low velocity areas with muddy or sand bottom where they construct a shallow burrow. Ammocoetes are filter feeders and diatoms make up the majority of their diet. The larval period generally lasts for 5 years (Beamish and Medland, 1988) after which ammocoetes transform into juveniles during a 4- to 6-month period. During the transformation, eyes and related musculature, teeth, a new oral hood, salivary glands, new kidneys and pigmentation develop (Flescher and Martini, 2002). Juvenile lamprey move away from the river bottom and downstream where they are capable of entering seawater and adopting a parasitic life style.

FWS lists the current upstream extent of Sea Lamprey range as Bellows Falls dam, noting; however, reproduction has been documented as far north as the White River, Vermont (FWS, 1999). Others have documented Sea Lamprey upstream and downstream of Bellows Falls dam including Yoder et al. (2009). In certain years, hundreds to more than 2,000 lamprey have been recorded passing the Bellow Falls fish ladder, although numbers are typically low and inconsistent from year to year (Table 3.5-8). Thirty-three individuals were collected during the 2008 electrofishing survey (Yoder et al., 2009), which sampled approximately 4.3 river miles of habitat in the Bellows Falls impoundment and 0.6 river mile downstream of the Bellows Falls dam. Abundance relative to total catch at the 4 sites where lamprey were present in the impoundment ranged from 0.59 to 1.49 percent. At the single station sampled below the dam, 5 individuals were collected representing 2.28 percent of the total catch (Yoder et al., 2009). In the 2008 surveys, Yoder et al. (2009) also documented Sea Lamprey just downstream of Wilder dam and the confluence of the White River with the Connecticut River where a total of 9 individuals was collected in approximately 3.1 river miles of habitat. In Study 10, Sea Lamprey were collected in all river reaches downstream of Bellows Falls and represented 0.5 percent (n = 62) of the total species composition. Sea Lamprey ammocoetes were identified in samples throughout the Project areas below Wilder dam but were absent from the Bellows Falls bypassed reach. During spring sampling a total of 38 ammocoetes (contributing 1.0 percent of the total spring species percent composition) was captured. Similarly, 15 ammocoetes were collected in summer sampling and contributed 0.4 percent of the total species percent composition for that season. During fall, 9 ammocoetes were captured contributing 0.2 of the total species percent composition for that sampling season with the upper most capture location in the Bellows Falls impoundment and the most downstream occurrence in the Vernon riverine reach.

In Study 17, net upstream passage of Sea Lamprey at the Vernon fish ladder was 2,440, or 29 percent of Turners Falls passage (CRASC, 2016). Net upstream passage at Bellows Falls was 971 individuals, or 40 percent of that recorded at Vernon. Two Sea Lamprey were also recorded passing Wilder dam.

In Study 16, 23 study sites were distributed among 5 reaches from the Wilder riverine reach down to the Vernon riverine reach and were pre-selected based on habitat suitability criteria. In the Bellows Falls and Vernon impoundments, site selection focused on the mouths of large- and medium-sized tributaries (second to sixth order streams) and island bars. Radio telemetry tracking of tagged adult Sea Lamprey was used to further inform and adjust the selection of sites. Telemetry relocations in areas of suitable habitat were considered to be verification of pre-selected sites for spawning habitat assessment, and in a few cases, was the rationale for adjusting site selection. Many telemetry locations occurred in water that was too deep and/or turbid to visually verify spawning behavior, conditions likely exacerbated by generally high flows during the spawning season. As a result, sites that could not be adequately surveyed for evidence of spawning, and that had not been characterized as having insufficient suitable habitat, were revisited in August or September 2015 during low-flow conditions when the maximum amount of habitat was exposed or accessible to survey. That supplementary habitat assessment included the recording of nest elevations for use in analyses of potential Project effects. Of the 23 sites surveyed, 4 were determined to have unsuitable habitat (e.g., fine substrate dominance, excessive embeddedness of coarse substrates, and lack of swift flows; or insufficient habitat [e.g., some characteristics of suitable habitat were observed, but others were lacking, within the Project-influenced area of the study site]). Of the remaining 19 sites, 16 (84 percent) were classified as active spawning areas and 3 (16 percent) were classified as having suitable habitat, but with no evidence of spawning (see Section 3.5.2.1, *Effects of Normal Project Flow and Impoundment Operations*).

Atlantic Salmon

Atlantic Salmon is a highly migratory, anadromous fish species that was indigenous to suitable riverine habitat from northeastern Labrador south to the Housatonic River which flows into Long Island Sound (Kocik and Friedland, 2002). Numerous reviews detailing the life history of Atlantic Salmon exist (NMFS, 2009; Fay et al., 2006; Kocik and Friedland, 2002). Adult Atlantic Salmon begin to return to natal freshwater rivers during the spring and continue into October, often producing a spring and a fall run. The majority of fish returning to rivers in New England have been at sea for 2 years. A lesser component of the run consists of 1or 3 sea-winter fish and repeat spawners. Nests, or redds, are constructed by female salmon and eggs are deposited and immediately fertilized by male salmon during the late fall, generally in riffle habitat with coarse gravel substrate. Following the fall spawn, approximately 20 percent of spent adult salmon (called kelts) move downstream to the ocean but the majority return to the ocean the following spring (Baum, 1997).

Eggs remain in the gravel until hatching during the early spring. Following a 3 to 6-week period, the young salmon emerge as fry and begin to actively seek food. As fry begin to feed, they develop cryptic vertical stripes and are then known as parr. Atlantic Salmon in the Gulf of Maine typically remain in the parr stage for 1 to 3 years and remain resident to the freshwater river. Following that period, parr undergo a series of physiological and morphological changes known as smoltification during which they lose their parr markings and develop a streamlined, silvery body and a pronounced forked tail. In this smolt stage salmon migrate downstream to the ocean. This downstream migration takes place during spring (April to June). Outmigrating smolts must adapt to changes in water temperature, pH, DO, salinity, pollution levels, predation, and other factors as they move downstream.

Atlantic Salmon fry and smolts were stocked in tributaries throughout the Connecticut River Basin from 1968 to 2013, with an annual stocking goal of 10 million fry per year. Atlantic Salmon smolts migrating downstream from tributaries upstream of the Project areas must pass downstream through the Projects. During July 2012, FWS announced that it would no longer produce hatchery-reared stock for the effort to restore Atlantic Salmon to the Connecticut River basin due to the continued costs for low numbers of returns. New Hampshire, Vermont, and Massachusetts followed suit and discontinued their stocking programs after 2013 when approximately 580,700 fry were stocked in the watershed upstream of the Projects (FWS, 2013a). The State of Connecticut subsequently developed and operates the "Salmon Legacy Program" at a much reduced scale (FWS, 2014a).

No Atlantic Salmon were collected in Study 10, and very few Atlantic Salmon were counted passing upstream at the three Projects during Study 17 in 2015. One was counted at Wilder, one at Bellows Falls, and six at Vernon. No salmon were counted in 2016 upstream of Holyoke where only three were counted (CRASC, 2016). Access to habitat is provided at all mainstem dams, so any future Atlantic Salmon population increases would presumably result in the reintroduction of the species to the Project areas.

3.5.1.5 Freshwater Mussels

Freshwater Mussels

TransCanada conducted various surveys of freshwater mussels in support of Project relicensing that are detailed in the following study reports:

- ILP Study 24, Dwarf Wedgemussel and Co-Occurring Mussel Survey – Phase 1 Report;
- ILP Study 24, Dwarf Wedgemussel and Co-Occurring Mussel Survey – Phase 2 Report; and
- ILP Study 24, Dwarf Wedgemussel and Co-Occurring Mussel Survey – Development of Delphi Habitat Suitability Criteria Report.

The Connecticut River watershed in New Hampshire and Vermont supports 9 species of freshwater mussels, 7 of which are found within the mainstem of the Connecticut River and near the mouth of mainstem tributaries, including the federally endangered dwarf wedgemussel (discussed in detail in Section 3.7, *Threatened and Endangered Species*), which is also listed as endangered in New Hampshire and Vermont.

Species Descriptions[32]

Eastern elliptio is the most common freshwater mussel species in New Hampshire. It is a medium-sized mussel up to 5 inches in length, and can be highly variable in coloration, size, and shape. The species is found in all major watersheds in lakes, ponds, streams, and rivers in all substrate types. It is not likely to occur in high gradient streams where no other mussels occur. It uses a large number of host fish including perch, bass, sunfish, and pickerel.

Eastern lampmussel is a common medium sized to large mussel reaching 5 inches in length. The thick shell varies in coloration from yellowish-green to brownish-black often with numerous green rays on shell. The inner shell is white or bluish-white. The species is found in coastal watersheds, as well as the Connecticut and Merrimack River watersheds in sandy and gravely substrates of rivers, streams, lakes, and ponds, mainly in coolwater or warmwater habitats. It uses a variety of host fish including bass, perch, sunfish, and crappie.

Eastern floater is a common medium sized to large, elongate mussel up to 7 inches in length. The shell is very thin and colored greenish-yellow or brownish. The inner shell is silvery-white or metallic-bluish. The species is found in the coastal, Connecticut, Merrimack, and Androscoggin River watersheds in small rivers and streams as well as ponds and lakes, and some wetlands, not usually in fast moving currents. It prefers sandy, muddy, or silt substrates. It uses a wide variety of fish species as host fish such as Yellow Perch, Bluegill, and White Sucker.

Triangle floater is a common, medium sized mussel up to 3 inches in length. Shell color is generally a mix of greenish-brown or yellow. The inner shell is pinkish or bluish-white. The species is found in all major watersheds in New Hampshire most commonly in rivers and streams with sand or gravel substrates. It can tolerate a range of flows and substrates and seems to prefer low-gradient rivers with low to moderate velocities. It uses a variety of host fish including the Common Shiner, White Sucker, and Largemouth Bass (NHFGD, 2015).

Alewife floater is identified as a SGCN in both New Hampshire and Vermont. It is a large, elongate and thin mussel reaching 6-7 inches in length. Shells are usually yellowish-brown or blackish and have prominent growth lines. The inside shell is usually a white or pinkish color. The species is found in parts of the Connecticut River downstream of Bellows Falls including in most major tributaries, and in the

32 If not otherwise cited, species descriptions are from NHFGD (undated).

Merrimack River, and coastal watersheds of New Hampshire in rivers, streams, ponds, and lakes. It seems to tolerate a range of flows and substrate types, including sand, sand and gravel, and silt. Host fish include the anadromous Alewife, Blueback Herring, and American Shad (NHFGD, 2015; VT WAP Team, 2015).

Creeper is identified as a SGCN in New Hampshire. It is medium sized, growing up to 3 inches. The shell is greenish-brown or yellowish-brown with a rough appearance from prominent growth lines. It is uncommonly found in most major watersheds in New Hampshire, including the lower Connecticut River, generally in small streams and rivers with sand, cobble, or gravel substrates. It seems to prefer low to moderate flow velocities. Host fish include Largemouth Bass, Yellow Perch, Fathead Minnow, Fallfish, Golden Shiner, and Bluegill. Creepers may also use amphibians as hosts, such as the Northern two-lined salamander (NHFGD, 2015).

The dwarf wedgemussel is a small wedge-shaped mussel measuring 1-1.5 inches. Shell color varies from yellowish-brown to blackish-brown and the inner shell is bluish-white. It is found in the Connecticut River mainstem and some tributaries (NHFGD, 2015; VT WAP Team, 2015). It is a generalist in terms of preference for stream size, substrate, and flow conditions (Nedeau, 2008; Nedeau, 2006; McLain and Ross, 2005; Michaelson and Neves, 1995; Strayer and Ralley, 1993). It inhabits small streams less than 5 meters wide to large rivers more than 100 meters wide and is found in a variety of substrate types including clay, sand, gravel, and pebble, and often in areas of rivers with large amounts of silt (e.g., depositional areas and near banks). The dwarf wedgemussel inhabits very shallow water along streambanks and can move laterally or horizontally in the substrate as water levels fluctuate (Nedeau, 2006), but they have also been found at depths of 25 ft in the Connecticut River (Nedeau, 2006). Fish hosts include the Tessellated Darter, Slimy Sculpin, Banded Killifish, and Atlantic Salmon, as well as Mottled Sculpin and Striped Bass (Nedeau, 2008) (see Section 3.7, *Threatened and Endangered Species*, for detailed discussion of this species).

Survey Results

Mussel surveys were conducted in 2011 and 2013 at 210 sites. A total of 147 sites was in impoundments and 24 sites were located immediately downstream from dams (8 sites below each dam). Surveys were carried out between May and October in both years, and included semi-quantitative mussel sampling (i.e., timed searches) and documentation of habitat conditions. Surveys were typically conducted by SCUBA diving in deep (>5 ft) water and snorkeling in shallow areas. Table 3.5-9 summarizes mussel species found within the Project areas during field surveys conducted in 2011 and 2013.

Table 3.5-9. Freshwater mussel species found in the Wilder, Bellows Falls, and Vernon Project areas, 2011 and 2013.

Species (status)	Wilder Imp.	Wilder Riverine	Bellows Falls Imp.	Bellows Falls Riverine	Vernon Imp.	Vernon Riverine
Eastern Elliptio	X	X	X	X	X	X
Eastern Lampmussel	X	X	X	X	X	X
Eastern Floater			X	X	X	X
Alewife Floater (NH SGCN, VT SGCN)			X	X	X	X
Triangle Floater (NH SGCN)	X	X	X	X	X	
Creeper (NH SGCN)	X		X		X	
Dwarf Wedgemussel (endangered, federally and in NH and VT)	X		X			

Source: ILP Study 24, *Dwarf Wedgemussel and Co-Occurring Mussel Survey – Phase 1 Report*

Sixty-nine dwarf wedgemussels were counted in the Wilder and Bellows Falls impoundments; none were found in the Vernon impoundment or in the downstream riverine reaches (see Section 3.7, *Threatened and Endangered Species*). Six other species of freshwater mussels were found during the surveys: eastern elliptio, eastern lampmussel, Alewife floater, triangle floater, creeper, and eastern floater. The mussel communities were dominated by eastern elliptio and eastern lampmussel, which were found at 95.2 and 87.6 percent of survey sites, respectively. Together, these 2 species comprised more than 99 percent of the mussels observed at most survey sites. Alewife floaters were the third most common species overall, occurring at 12.6 percent of all survey sites, and at 66.7 percent of all survey sites located downstream from the Bellows Falls dam. A total of 460 Alewife floaters was counted, including 2 upstream from the Bellows Falls dam, 217 below the Bellows Falls dam, 166 in the Vernon impoundment, and 75 below the Vernon dam.

The other 3 species were far less common. Creepers were found at 22 survey sites (10.5 percent) and usually only present at very low numbers. It was found at 2 sites (2 animals) in the Wilder impoundment, 2 sites (2 animals) in the Wilder riverine reach, 14 sites (44 animals) in the Bellows Falls impoundment (mostly in the lower Black River), and 4 sites (6 animals) in the Vernon impoundment. None were found immediately downstream from any of the dams. Triangle floaters were found at 31 survey sites (14.8 percent) and usually at very low numbers, including at 10 sites (19 animals) in the Wilder impoundment, and 4 sites (6 animals) in the riverine reach, 9 sites (18 animals) in the Bellows Falls impoundment, and 2 sites (2 animals) in the Vernon impoundment. Triangle floaters were also found downstream from the Wilder dam (3 live animals) and Bellows Falls dam (5 live animals). Eastern floaters occurred primarily in two locations: in the lower Black River in the Bellows Falls impoundment and within the downstream half of the Vernon impoundment.

The three fluvial (i.e., not found in lake environments) mussel species—dwarf wedgemussel, triangle floater, and creeper—were rare and patchily distributed. Dwarf wedgemussels were not found in the Wilder riverine reach where the species was historically known to occur (e.g., Sumner Falls or Cornish Covered Bridge), and densities of other fluvial species (triangle floater and creeper) were also very low in the Wilder riverine reach which contained the lowest species richness and mussel density (all species) among the areas surveyed, and had the poorest quality mussel habitat. Important areas for the rare fluvial species in the Wilder impoundment were primarily confined to a 14-mile reach in the upper third of the impoundment. Important areas for the three fluvial species in the Bellows Falls impoundment appeared to include Wethersfield Bow, the Connecticut River near the Black River confluence, and the lower Black River. Eastern elliptio and eastern lampmussel are the only two species with robust populations throughout all study areas, although alewife floater populations may also be stable in areas of the Connecticut River downstream from the Bellows Falls dam.

3.5.2 Environmental Effects

Continued operations of the Wilder, Bellows Falls, and Vernon Projects will maintain the current modest daily and sub-daily fluctuations in impoundment water levels, variations in discharge flows, and instream flow alterations in the downstream riverine reaches that can affect aquatic habitat, spawning and reproduction, and migration. The presence and operations of turbines can affect rates of impingement, entrainment, survival and/or migration timing. Since TransCanada does not propose to change Project operations, the environmental effects identified in this section are expected to remain the same under new licenses.

3.5.2.1 Effects of Normal Project Flow and Impoundment Operations

Effects on Aquatic Habitat

Current Project operations include variable discharges ranging from minimum flows to full generating capacity during normal (non-spill) Project operations and during high flow and spill conditions which increase discharges above Project generating capacities. Operations have the effect of changing WSEs and associated water depths, wetted area, and availability of riparian cover in both the impoundment reaches upstream of each dam and in the downstream riverine reaches. Although changes in impoundment WSEs generally exert little to no influence on mainstem wetted areas and water velocities in the uppermost reaches of the impoundments, peaking operations in downstream riverine reaches can have effects that increase water velocities and affect wetted area in the shallow, low-sloped habitat types. For example, high flow levels can alter the character of riverine reach mesohabitat units, especially riffles which tend to "flood-out" and appear more like run habitats. Glide habitats can also take on a more run-like appearance at higher flows, and runs tend to get deeper and faster but still retain the characteristics of a run habitat. In contrast to riffle habitats, pool habitats change the least in response to flow changes.

The magnitude and rate of change in WSEs varies spatially within and between impoundments and downstream reaches, as well as temporally according to inflows, and changes in Project outflows. Typically, impoundment WSEs during periods of normal Project operations fluctuate approximately 2.5 ft at Wilder dam, 1.8 ft at Bellows Falls dam, and 1.8 ft at Vernon dam on a daily or sub-daily basis (see Section 2.1.1.4, *Existing Project Facilities*). Fluctuations in water levels can alternately expose and inundate shallow margin habitats. Project-related water level fluctuations can potentially affect resources dependent upon these habitats such as fish eggs or nests; small, newly emerged fish fry; and water-dependent lifestages of terrestrial species (see Section 3.6, *Terrestrial Resources*).

Dwarf wedgemussels and co-occurring mussel species are relatively sedentary, year-round residents of the Connecticut River and require instream habitat and host fish for all aspects of their life cycle. Project effects specific to mussels and in particular, to the federally endangered dwarf wedgemussel (see Section 3.7.2.5), have yet to be fully evaluated.

As noted in Studies 14-15, effects on spawning by some species can occur even when nests are not completely dewatered, as adult members of the Centrarchid family (e.g., bass and sunfish) will guard the nest from potential predation until eggs have hatched and fry dispersed, and thus require minimum depths to remain at the nest until their guardian role is fulfilled. Environmental effects on fish spawning and rearing are addressed in more detail in the following sections.

The greater magnitude of fluctuation in WSEs in the riverine reaches downstream of each Project combined with the typically shallower nature of riverine habitats results in greater potential for WSE-related effects on aquatic resources in the flowing reaches. In general, daily fluctuations in WSE in the 3 riverine reaches can be up to 5 to 6 ft in the vicinity of the Project dams during normal operations, though fluctuations are typically attenuated to 3 to 4 ft in the lower portions of riverine reaches (Study 5). Pool habitats, which represent 40 to 60 percent (by length) of aquatic habitat in the 3 riverine reaches (Figure 3.5-1), are less subject to streambed exposure during periods of minimum flow releases, due to their steeper streambanks and deeper habitat, than are shallower mesohabitat types such as glides and riffles. Riverine areas with expansive bar or shoal habitats, such as the vicinity of Chase Island in the Wilder riverine reach or Stebbins Island in the Vernon riverine reach are subject to wide variations in wetted habitat area during normal Project operations. These areas are also heavily used for spawning by several species of fish (as reported in Studies 14-15, Study 16, and Study 21, and discussed in the species-specific sections below).

In the Project impoundments, the majority of margin habitat along the mainstem channels are steeply sloped and mid-channel habitats are far deeper than the fluctuations in WSEs; consequently relatively little change in wetted width occurs during normal Project operations. Exceptions may occur in shallow, low-slope habitats such as those in the margins of backwaters, mid-channel island complexes, and at deltas formed at the mouths of tributaries.

The change in acreage of wetted habitat from normal high elevation to normal low elevation was estimated for the 12 of 41 backwaters in the Project areas that were assessed for spawning in Studies 14-15. Percent reductions in habitat area ranged from a low of 4 percent in Vernon backwater 14-VB-045 to almost 90 percent in Wilder backwater 14-WB-016 (Table 3.5-10), with a mean change of 36 percent among the 12 backwaters. The larger magnitude of WSE fluctuations in the Wilder impoundment (assessed with a 3-foot change, rounded up from the normal 2.5-foot range) is largely responsible for the high estimates of dewatered backwater habitat in that reach (averaging 55 percent), in comparison to the approximate 2-foot fluctuations in the Bellows Falls backwaters and the approximate 1-foot changes in the Vernon backwaters, which produced estimated acreage reductions of 20 percent and 14 percent, respectively. Another factor is the relative location of backwater habitats in each impoundment. Four of the 6 sampled backwaters in the Wilder impoundment were located in the upper, shallower half of the impoundment. In contrast, all 13 available (and all 6 sampled) backwaters in both the Bellows Falls and the Vernon impoundments are located in the lower halves of each impoundment, and consequently have higher proportions of deeper water which is less subject to dewatering.

Table 3.5-10. Change in backwater acreage under normal Project operations.

Impoundment (WSE in NAVD88)	Studies 14-15 Backwater Site ID	Acres @ High WSE	Acres @ Low WSE	% Reduction in Acres
Wilder High WSE: 384.0 ft Low WSE: 381.0 ft Diff: 3 ft	14-WB-012	34.25	25.26	26
	14-WB-016	6.33	0.67	89
	14-WB-028	33.25	13.27	60
	14-WB-032	34.06	20.29	40
	14-WB-051	5.08	1.06	79
	14-WB-060	22.38	14.03	37
			Average:	**55**
Bellows Falls High WSE: 291.0 ft Low WSE: 289.0 ft Diff: 2 ft	14-BB-019	29.58	25.69	13
	14-BB-030	170.7	121.19	29
	14-BB-033	76.44	62.03	19
			Average:	**20**
Vernon High WSE: 219.0 ft Low WSE: 218.0 ft Diff: 1 ft	14-BB-039	133.66	107.37	20
	14-VB-045	75.33	72.22	4
	14-VB-050	256.68	211.45	18
			Average:	**14**

Source: ILP Study 14-15, *Resident Fish Spawning in Impoundments and Riverine Sections Studies*

Because of the shallower nature and greater magnitude of WSE fluctuations in riverine reaches than in impoundment reaches, the associated changes in wetted area are also greater. The percent change in wetted widths in each of the 3 riverine reaches during normal Project operations was estimated as part of the 1D instream flow study conducted in ILP Study 9, *Instream Flow Study*. Mean percent change in wetted widths varied by mesohabitat type, with the least change for riffles in the Bellows Falls riverine reach, and the largest changes for runs in the Bellows Falls and Wilder, and riffles in the Wilder reach, respectively (Table 3.5-11). Margin or shoal habitats that are regularly dewatered are not likely to support aquatic resources, except for transitory rearing by mobile species (e.g., fish). Rearing or spawning by species such as mussels or nest-guarding fish are not likely to inhabit such areas due to the regularity of dewatering, although extended periods of high flows outside Project control as a result of spring runoff or storm events can lead to egg deposition or nest building in areas that may be dewatered later when Project operations return to normal.

Table 3.5-11. Percentage change in riverine wetted width under normal Project operations.

Reach	Habitat Type	No. of Habitats	% Change in Wetted Width Under Normal Project Operations		
			Min.	Max.	Mean
Wilder riverine	Pool	13	5	38	16
	Glide	9	4	24	14
	Run	11	12	72	41
	Riffle	4	6	53	30
Bellows Falls riverine	Pool	6	5	21	11
	Glide	7	5	49	23
	Run	4	27	72	47
	Riffle	2	4	9	7
Vernon riverine	Pool	4	2	18	12
	Glide	3	3	37	15
	Run	6	9	61	27
	Riffle	0	-	-	-

Source: ILP Study 9, *Instream Flow Study*

Study 8 was conducted in 2014 to assess the movement of coarse sediment (gravel and cobble) in the downstream riverine reaches and tributary mouths in the three Project areas as it relates to the availability and stability of coarse-grained benthic habitats. The study evaluated 18 representative sites, and coarse-grained substrates were quantified using pebble counts at each site over 2 sampling rounds. Availability of habitat for coarse-grain-substrate dependent biota was also evaluated based on embeddedness condition using established methods (Barbour et al., 1999). Study 8 identified embeddedness conditions that indicate habitat for coarse-grain-substrate dependent biota is available along the Connecticut River in the Project areas. Additional analysis using modeled data from Study 4 included development of (1) peak-flow statistics, and (2) critical shear stress criteria for coarse-grained substrate.

Study results indicate that most of the evaluated coarse-grained substrates are stable at flows less than the applicable Project's maximum station discharge, and that flows greater than that are the dominant factors that contribute to the availability and stability of coarse-grained benthic habitat. Based on the presence and stability of coarse-grained substrates, habitat is persistent for coarse-grain-substrate dependent fauna, including different life-history stages of anadromous and riverine fish, and aquatic invertebrates. Studies 2-3 evaluated sediment removal and transport of fine-grained materials (as part of supplemental analysis to be included in the final study report, still in progress). Measured flow velocities at a subset of Studies 2-3 study sites were compared to published guidelines on threshold flow velocities needed to entrain fine sediments and remove them from the river banks. Results of that analysis indicate that under normal Project operations, flow velocities in the impoundments are much lower than threshold velocities. In the riverine reaches threshold velocities can occur at flows from approximately half of full generation flows at Vernon, to near maximum generation flows at Wilder and Bellows Falls (see Section 3.3, *Geologic and Soil Resources)*. Therefore, TransCanada concludes that normal Project operations do not significantly affect aquatic habitats due to sediment transport.

Effects on Riverine Flow—Habitat Relationships

Study 9 was conducted to evaluate the relationships between aquatic habitats and river flows in the reaches downstream of each Project dam. The study was based primarily on Physical Habitat Simulation (PHABSIM) as one aspect of the Instream Flow Incremental Methodology process for the evaluation of instream flow needs for aquatic habitats. PHABSIM uses depth, velocity and substrate as primary measures of aquatic habitat.

Eighty-five 1D transects, inclusive of split and side channels, were established: 43 in the Wilder riverine reach, 19 in the Bellows Falls riverine reach, 7 in the Bellows Falls bypassed reach, and 16 in the Vernon riverine reach. Two 2D sites were chosen to represent island complexes in the Wilder riverine reach, 1 site specifically selected for modeling dwarf wedgemussel habitat. Sumner Falls, a unique bedrock feature downstream of Wilder dam, was evaluated using a combination of a qualitative demonstration flow assessment and quantitative depth and wetted width measurements. The field portion of the study involved detailed measurements of water depths and velocities over a range of Project-controlled flows. These data along with Study 7 habitat mapping and literature-based habitat preferences for macroinvertebrates and 9 target fish species and lifestages, were used to develop habitat suitability curves and habitat index values that were calculated for all 9 species/lifestages found within each reach.

The habitat index versus flow relationships were then used to develop a habitat duration time series to represent the magnitude and duration of available habitat seasonally, over critical periods, and/or in critical locations or habitat types under different operational regimes and inflow hydrologies (study results of this analysis have been recently completed but not yet filed). These analyses used hydrology based on Project operations and inflow developed from Study 5 to evaluate the effects of current Project operations on an annual and seasonal basis for the target species and lifestages. In general, habitat suitability for fish species and their lifestages was highest for flows nearer current minimums and lowest for flows exceeding current Project peaking capacity for all reaches. Habitat duration results demonstrate that during summer (July to September) the highest habitat suitability is maintained for a longer period versus other seasons, a function of water availability which limits project peaking operations. In contrast, in the spring (April to June) lower seasonal habitat suitability occurs for longer periods due to flows often exceeding Project capacity.

Pending additional stakeholder consultation, alternative operational regimes may be analyzed, and dual-flow analyses will be conducted. Dual-flow analyses provide information on potential Project effects due to daily flow fluctuations between base or minimum flow and peaking flows and involves comparing habitat at a range of flows with habitat at a base or given flow. At each simulated flow, the amount of usable habitat is the amount of habitat that overlaps in space of suitable locations that were available at the base flow. This is most often identified as persistent habitat, and the analysis assumes that the target lifestage is generally immobile as flows change (e.g., fish eggs, mussels, and some fry lifestages).

Effects on Tributary and Backwater Access

The buildup or shifting of coarse sediments at the mouths of many small to medium tributaries can also lead to shallow, high gradient confluences during periods of low water levels, and can potentially influence the ability of fish to access those tributaries for spawning or rearing. Observations during Study 8 site visits indicated that tributaries are a primary source of coarse-grained substrates to the Connecticut River where large accumulations of coarse-grained substrate were observed adjacent to the confluences of tributaries such as the Saxtons and Cold rivers located downstream of Bellows Falls. Similar observations were made during Study 13, which was conducted to assess whether water level fluctuations from Project operations impede fish movement into and out of tributaries and backwater areas within the Project areas and whether normal Project operations affect available fish habitat and water quality in those tributaries and backwater areas. Thirty-six study sites were randomly selected from the set of all smaller tributaries (first through third order streams) that enter the Project areas, and the Cold River (fifth order stream) was included at the request of New Hampshire Fish and Game Department (NHFGD). Field work 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 extent of the Project-affected reach was estimated for each study site. Water quality data were collected and photographs were taken during each site visit.

Analysis of Project effects was based on summer/fall 2014 field observations and water level logger data as well as on hydraulic and operations model data (Studies 4 and 5) for the springtime spawning period (April 1 to June 30). Analysis included only effects from water depths at the confluence with the mainstem. Neither the springtime analysis nor the 2014 field-based analysis considered effects associated with low tributary inflows or tributary flow-related water depths. The majority of study sites (27 or 73 percent) had summer/fall 2014 water depths of 0.5 ft or greater (the study criterion for minimum accessible water depth) at the confluence cross section at least 75 percent of the time based on each site's water level logger data period of record. Twenty-one sites (57 percent) had depths greater than 0.5 ft for greater than 97 percent of the time, including all backwater sites.

Analysis of springtime access restrictions focused on the range of WSEs during normal Project operations only and used very conservative criteria to categorize predicted access restrictions. Access restrictions were defined as "negligible" if they occurred on fewer than 10 percent of springtime days in up to 3 modeled inflow hydrologies and "infrequent" in 4 or all 5 modeled inflow hydrologies. "Occasional" access restrictions were defined as occurring for 10 percent or more of springtime days in up to 3 modeled inflow hydrologies, and "frequent" access restrictions were those that occurred in 4 or all 5 modeled inflow hydrologies. Table 3.5-12 summarizes the number of study sites affected based on these criteria for 2 broader categories of restriction of a "50 percent criterion" where at least 50 percent of all hours under normal Project operations in each day provided 0.5 ft or more of water depth at the confluence, and a "100 percent criterion" where all hours under normal Project operations in each day had to provide 0.5 ft or more of water depth at the confluence. The 100 percent-of-day criterion is considered too conservative to base analysis of Project effects on since it is reasonable to assume that access for up to half of each day is sufficient for fish desiring to enter a tributary or backwater on that day.

Table 3.5-12. Summary of modeled spring access restrictions to study sites under normal (non-spill) Project operations for 50% and 100%-of-day criteria.

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

Source: ILP Study13, *Tributary and Backwater Fish Access and Habitats Study*

Four sites (10.8 percent) were predicted to have “frequent” access restrictions under the 50 percent-of-day criterion on 10 percent or more of springtime days under normal Project operations. These sites (all first or second order streams) were also restricted from 24 percent to 100 percent of occurrences in 2014. Three of these sites are in the Wilder riverine section and 1 is located in the Vernon impoundment. Based on field observations, access at these sites is largely affected and determined by the amount of flow in the tributaries themselves rather than mainstem WSEs. These 4 sites also have limited Project-influenced reaches (less than 100 ft), culverts, and/or natural or human-made blockages that restrict access.

Another 9 sites (24 percent) were predicted to have “occasional” access restrictions and of those, 4 were below the 25 percent of occurrence threshold in summer/fall 2014; 3 had 2014 access restrictions between 40.5 and 58.6 percent of occurrences. The remaining 2 were undetermined in 2014 due to a lack of mainstem water level logger data, and 1 of these (the Cold River, a fifth order stream tributary) generally has sufficient inflow and depth even in the summer/fall to maintain access. Access at these sites is also affected and determined by the amount of flow in the tributaries themselves rather than mainstem WSEs. Five of the “occasionally” restricted sites also have non-Project-related limitations including short Project-influenced reaches (less than 300 ft), culverts, variable thalweg profiles, and/or natural blockages that restrict access. Furthermore, these sites constitute a small fraction of all available fish habitat in tributaries and backwaters within the Project areas, and Study 13 focused on the smallest tributaries (first, second, and third order streams), which would be most likely to have limited stream flow on their own. It is very likely that adequate access exists at the many other larger tributaries (fourth order stream or higher) and in backwaters throughout the Project areas.

Project operations do not appear to alter water quality in tributaries and backwaters based on water quality data collected in 2014, which generally met state water quality standards. Results of the 2012 and 2015 water quality studies (Normandeau, 2013a; Study 6) also indicate that water quality in the mainstem is supportive of fish productivity. Therefore, normal Project operations under new licenses will have little effect on the ability of fish to access small tributaries on most days and will continue to provide access to backwaters and larger tributaries throughout the Project areas. Factors other than normal Project operations may continue to limit access into small tributaries.

Effects on Resident Fish Spawning and Reproduction

As indicated in the discussion of Study 10 in Section 3.5.1.3, *Resident Fish Populations*, 40 species of resident fish rear and spawn within the Project areas and are thus subject to potential effects from Project operations. The spawning lifestages of species that build nests are particularly susceptible because, unlike the rearing lifestage, nests are immobile and cannot move in response to changes in flow and associated WSEs. The effects of Project operations on spawning by resident fish species in impoundments and riverine reaches were assessed by

Studies 14-15. The number of spawning observations made for each of these species during the 2015 field season is listed in Table 3.5-13.

Overall, 1,057 observations were made at individual egg masses or nests of resident species (Table 3.5-13), including abundant observations for Yellow Perch egg masses, sunfish (Bluegill and Pumpkinseed) nests, Smallmouth Bass nests, and Fallfish nests. In contrast, few spawning observations were made for many species known to be relatively abundant in the Project areas, likely due to restricted spawning locations not encompassed by the randomized sampling design (Northern Pike, Chain Pickerel, Black Crappie), difficulty in detecting actual spawning locations for small species (Golden and Spottail Shiner), or spawning outside Project-affected areas, such as in tributaries upstream of Project influence (White Sucker, Walleye), or deeper water habitats not affected by normal Project operations (Walleye, other species). The potential effects of normal Project operations on resident fish spawning are summarized in Table 3.5-14 and for each species below. Details on sampling designs, field protocols, and site-specific spawning results are included in the revised final study report for Studies 14–15.

Yellow Perch

Yellow Perch is a common species distributed throughout the Project areas. Newly laid egg masses were observed in backwater habitats over a 6- to 14-day period following initiation of backwater surveys. Elevation measurements representing more than 800 egg masses were collected in April and May 2015 (Table 3.5-13). Yellow Perch deposited egg masses on the bare substrate and draped over aquatic vegetation, woody debris, and inundated riparian vegetation. Many egg masses deposited on the latter feature were subsequently dewatered when backwater water levels decreased as a result of decreasing inflows after high flows and impoundment WSEs returned to normal Project fluctuations. Although limited springtime water visibilities prevented assessment of spawning activities in deeper, protected waters, overall up to 71 percent of Yellow Perch eggs deposited in shallow backwater habitats were exposed to air during periods of minimum WSEs in 2015.

Comparison of median egg mass elevations collected in 2015 with the periodicity of backwater elevations from 5 modeled inflow hydrologies (Study 5) suggested that WSEs typically do not drop below the 2015 median egg mass elevations in the Bellows Falls and Vernon impoundments (0 to 5 percent of days in the Yellow Perch spawning period) but may drop below the median elevation in Wilder backwaters on 33 to 62 percent of days (Table 3.5-14). That analysis compared elevations of egg masses collected in 2015 with WSEs under a suite of different modeled inflow hydrologies and does not account for the fishes' ability to choose different spawning elevations under different flow conditions. Despite this relatively high level of potential effect, Yellow Perch remained the first or second most abundant fish species captured in all three Project impoundments (Study 10).

Sunfish (Bluegill and Pumpkinseed)

The two targeted sunfish species were regularly observed in most backwater habitats in the spring and summer of 2015. Survey measurements were taken on

120 sunfish nests, which were similarly distributed between the Bellows Falls and Vernon impoundments (Table 3.5-13). Although sunfish and older silted nests were regularly observed in the Wilder impoundment, few active nests were found prior to cessation of sampling in early July. Also, very few active sunfish nests containing eggs or fry were observed, likely because of the very short duration of egg incubation and fry dispersion (less than 1 week). Despite these limitations, data collected on the active nests indicated that some percentage of sunfish nests was either dewatered or, more likely, abandoned because of insufficient depths. Male adult sunfish will remain and guard the developing eggs from predation until hatching; consequently, this analysis assumed that a minimum depth of 0.5 ft was necessary to ensure nest success.

Overall, an average of 23 percent of sunfish nests monitored in 2015 were either dewatered or maintained depths less than 0.5 ft in Project impoundments. Comparing median nest elevations (with the added 0.5-ft buffer) observed in 2015 with projected WSEs during 5 modeled inflow hydrologies (Study 5) suggested that WSEs drop below this criteria for an average of 33 to 64 percent of days in the Wilder impoundment, 2 to 23 percent of days in the Bellows Falls impoundment, and 1 to 5 percent of days during the sunfish spawning period in the Vernon impoundment (Table 3.5-14). These percentages represent conservative estimates because, as noted above, the entire duration of sunfish egg deposition, hatching, and fry dispersion is expected to be completed in 3 to 5 days, whereas the analysis above is based on the full 40-day duration of the spawning season. In other words, many nests could progress successfully in-between individual dewatering events. Also, like all species, it is likely that sunfish would spawn at different elevations in years with different WSE characteristics (Studies 14–15).

Fallfish

Twenty-six new Fallfish nests were assessed in all 3 riverine reaches and in tributaries to the Bellows Falls impoundment in 2015 (Table 3.5-13). Although Fallfish adults do not guard their nests after egg deposition, this analysis assumed that a minimum depth of 0.5 ft was necessary to ensure successful egg incubation and fry dispersion. None of the Fallfish nests observed in the impoundment-influenced reaches of Bellows Falls tributaries were susceptible to dewatering in 2015; however, 5 of the 14 nests observed in Wilder and Vernon riverine reaches were either dewatered or else subject to depths <0.5 ft during the assumed 15-day incubation period.

Comparison of the 2015 median nest elevations (plus 0.5 ft) against predicted WSEs during 5 modeled inflow hydrologies (Study 5) suggested that, like for the species described above, potential dewatering of median nest elevations was more likely in the Wilder reach (average of 32 to 61 percent in riverine habitats) than in the Bellows Falls (0 percent of days) or the Vernon (0 to 14 percent of days) riverine reaches (Table 3.5-14).

Table 3.5-13. Resident species spawning observations in 2015 according to habitat type, reach, and species.[a]

Habitat Type	Impoundment Backwaters			Impoundment Tributaries			Riverine Riffles			Riverine Islands			All Reaches
Reach	Wilder	Bellows Falls	Vernon	Wilder	Bellows Falls	Vernon	Wilder	Bellows Falls	Vernon	Wilder	Bellows Falls	Vernon	
Yellow Perch	216	561	42	NA	NA	NA	NA	NA	NA	NA	NA	NA	**819**
Bluegill and Pumpkinseed	2	53	65	NA	NA	NA	NA	NA	NA	NA	NA	NA	**120**
Fallfish	NA	NA	NA	0	12	0	NA	NA	NA	5	7	2	**26**
Smallmouth Bass	NA	NA	NA	14	13	4	NA	NA	NA	21	15	8	**75**
Largemouth Bass	3	2	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	**5**
White Sucker	NA	NA	NA	11	0	0	0	0	0	NA	NA	NA	**11**
Walleye	NA	NA	NA	0	0	0	0	1	0	NA	NA	NA	**1**
Northern Pike	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
Chain Pickerel	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
Black Crappie	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
Golden Shiner	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0**
Spottail Shiner	0	0	0	0	0	0	NA	NA	NA	0	0	0	**0**

Source: ILP Studies 14-15, *Resident Fish Spawning in Impoundments and Riverine Sections Studies*

a. NA indicates species was not a target in that habitat type.

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Table 3.5-14. Average proportion of days WSEs drop below specified spawning elevation criteria according to species spawning periodicity, reach/habitat type, and modeled inflow hydrologies.

Species	Reach/Habitat Type	DRIER <						OPERATIONS UNDER NORMAL CONDITIONS (from ILP Study 5, *Operations Modeling Study*)						> WETTER		
		1992			1989			1994			2007			1990		
		% Days Below Min.	% Days Below Median	% Days Below Max.	% Days Below Min.	% Days Below Median	% Days Below Max.	% Days Below Min.	% Days Below Median	% Days Below Max.	% Days Below Min.	% Days Below Median	% Days Below Max.	% Days Below Min.	% Days Below Median	% Days Below Max.
Yellow Perch	Wilder BWs	10	45	77	8	33	69	21	53	83	21	42	65	27	62	90
	Bellows BWs	0	0	4	0	4	13	0	5	15	0	3	8	0	0	0
	Vernon BWs	0	0	3	0	0	0	0	5	10	0	0	8	0	1	21
Sunfish	Wilder BWs	62	64	70	42	50	61	26	33	45	26	43	49	32	37	42
	Bellows BWs	10	22	47	8	17	35	0	2	12	0	23	42	6	14	31
	Vernon BWs	0	1	25	0	5	27	0	1	14	0	4	19	0	5	23
Fallfish	Wilder islands	61	61	61	33	34	34	40	40	42	35	35	36	31	32	32
	Bellows tribs.	0	0	5	0	0	0	0	0	2	0	0	3	0	0	0
	Bellows islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vernon islands	10	14	38	0	0	0	0	5	10	0	5	5	0	0	5
Smallmouth Bass	Wilder tribs.	6	41	46	0	22	35	2	11	31	2	20	31	0	19	31
	Bellows tribs.	4	7	36	3	6	25	0	0	11	0	6	29	2	5	20
	Vernon tribs.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wilder islands	48	54	79	44	50	74	38	39	64	38	48	70	40	45	69
	Bellows islands	5	34	46	4	22	29	0	1	6	0	29	34	4	15	25
	Vernon islands	6	34	78	0	16	47	0	9	28	0	22	59	6	13	47

Source: ILP Studies 14–15, *Resident Fish Spawning in Impoundments and Riverine Sections Studies*

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Smallmouth Bass

Smallmouth Bass, a significant component of the fisheries community in the Project impoundments, were the first or second most frequently captured species in each of the 3 riverine reaches (Study 10). Spawning surveys located and assessed 75 active Smallmouth Bass nests, 31 nests in the 3 impoundments (in lower tributaries or associated deltas), and 44 nests at island habitats in the 3 riverine reaches (Table 3.5-13). Of the Smallmouth Bass nests located in the impoundments, 1 was dewatered and 4 nests were subject to depths less than 1 foot, the assumed minimum depth criteria for continued residence of male adult Smallmouth Bass. Smallmouth Bass nests were more vulnerable to dewatering or insufficient depths in the riverine reaches, where 15 of the 44 riverine nests (34 percent) were either dewatered (4 nests) or subject to depths <1.0 ft (11 nests).

The predicted WSEs over 5 modeled inflow hydrologies (Study 5) suggests that 50 percent of Smallmouth Bass nests (using the median nest elevations) measured in 2015 could be dewatered in 39 to 54 percent of days over the Smallmouth Bass spawning period in the Wilder riverine reaches. As seen for the species listed above, the percentage of potential dewatering events is lower in the downstream riverine reaches, at 1 to 34 percent of days in the Bellows Falls riverine reach and 9 to 34 percent of days in the Vernon riverine reach (Table 3.5-14). Although the duration of a Smallmouth Bass spawning event (from egg deposition to fry dispersion) is relatively long (up to 30 days or more), this species appears somewhat more adaptable in spawning than sunfish or Fallfish, which appeared to construct nests in 2015 in proximity to older nests from prior years. In some locations new, cleaned Smallmouth Bass nests were observed in shallow water but neither adults, eggs, nor fry were observed on them, which suggests that these nests were abandoned prior to egg deposition. The relatively high abundance of Smallmouth Bass in the riverine reaches suggests this species is somewhat immune to the observed effects on spawning by Project operations, particularly in the more dynamic riverine reaches.

Largemouth Bass

Largemouth Bass were regularly observed roaming along margin habitats during spring backwater surveys, but as spawning progressed only 5 confirmed Largemouth Bass nests were located (Table 3.5-13), an insufficient number with which to assess Project effects. The relative lack of nest observations for this species may be due to the depth of spawning and the frequency of rain events and turbid conditions that occurred during June 2015 and due to the more indistinct nature of Largemouth Bass nests in comparison to the distinctively cleaned appearance of Smallmouth Bass and sunfish nests that were regularly observed.

White Sucker

Spawning by White Suckers was assessed by deploying 242 egg blocks at 16 impoundment tributaries and 12 riverine riffle habitats for a total sampling time of 4,168 block/days. Despite this level of effort, only 62 confirmed White Sucker eggs were collected on 11 blocks deployed in 2 tributaries to the Wilder impoundment (Table 3.5-13). All blocks containing eggs were subsequently found to be located upstream of the Projects full-pool elevation. Based on these data and the observation of staging schools of suckers at other sampling locations, TransCanada concluded that most spawning by suckers in tributaries occurs upstream of Project influence. Furthermore, the lack of collected eggs on blocks deployed in shallow mainstem riffles of riverine reaches also suggests that mainstem spawning likely occurs in deeper habitats not subject to dewatering at low flows (Study 14-15).

Walleye

Sampling effort for Walleye spawning was conducted using the same egg blocks deployed for White Suckers, yet only a single Walleye egg was collected on a block deployed in the lower reaches of the Cold River in the Bellows Falls riverine reach (Table 3.5-13). Fish passage data from Study 17 showed that egg blocks were deployed during the period of upstream migration by both White Suckers and Walleyes, and frequent observations of fishermen targeting Walleyes in the immediate vicinity of egg block locations also indicated that blocks were deployed near fish aggregations during the period of spawning migration. The lack of Walleye egg collections suggests that spawning either occurred in tributaries upstream of Project influence or in mainstem riffles deeper than the deployed egg blocks, and were thus not subject to dewatering (Studies 14–15).

Northern Pike and Chain Pickerel

Spawning surveys targeting shallow water spawning by Northern Pike and Chain Pickerel were conducted in 12 backwater habitats in the three Project impoundments. More than 180 surveys, most of which extended over 1 mile in length, failed to locate active spawning by either species (Table 3.5-13), although adult fish were observed in shallow, vegetated habitats in most backwaters. Backwater surveys were initiated several weeks following ice-out and water temperatures during surveys were well within the published range of temperatures known to illicit spawning activities by both species. Any spawning that may have occurred prior to initiation of backwater surveys would have occurred during a period of high, uncontrolled flow that likely resulted in WSEs well above levels manageable by the Project facilities. The lack of spawning observations may thus be associated with a highly restricted distribution of selected spawning locations; spawning occurring in deeper water limiting detection of spawning activities and thus not subject to dewatering; or other unknown factors (Studies 14–15).

Black Crappie

Black Crappie are reportedly a common fish species in angler catches in some backwater habitats; however, they were a relatively uncommon component of the fish assemblage catches (Study 10) and no Black Crappie nests were detected in Studies 14–15 in 2015 (Table 3.5-13).

Golden and Spottail Shiners

Gravid individuals of both shiner species were captured in June 2015; however, actual spawning behavior or specific egg deposition locations were not found (Table 3.5-13), although a field crew did observe and photograph a spawning aggregation of Rosyface Shiners (not a target species in Studies 14–15) spawning over an active Fallfish nest (Figure 3.5-6).

Source: ILP Study 14-15, *Resident Fish Spawning in Impoundments and Riverine Sections Studies*

Figure 3.5-6. Photo of Rosyface shiner spawning aggregation with captured male shiner (inset).

Effects on Migratory Fish Spawning and Reproduction

Sea Lamprey

Project effects analyses on spawning Sea Lamprey included calculations of the incidence of nest exposure using water level logger data and Operations Model (Study 5) output. Water level logger data were specific to 2015 field conditions, whereas modeling was done for 5 modeled inflow hydrologies, representing a range of river flow conditions and simulated Project operations in terms of flows, impoundment elevations, and energy production. For the analyses, the Sea Lamprey spawning season was conservatively defined as May 15 to July 15, 2015, based on upstream passage records at Vernon dam, water temperature, and the general gestation period for lamprey eggs.

Water level loggers were deployed in 2015 for Studies 14–15, and/or Study 16. For each study site, except those characterized with insufficient spawning habitat, water level logger data were used to calculate the observed range and mean WSE, and rate of change in WSE. For each identified nest with a recorded elevation, the range and mean occurrence and range and mean duration of exposures were also calculated. Then, the same calculations were made using WSE output from the operations model.

Of the 16 active spawning sites, 3 (19 percent) had “no Project effects,” meaning that no nest elevations were exposed in any portion of the 2-month modeling analysis. One site was in riverine habitat, and 2 were in impoundment habitats, though those were both in tributaries rather than the mainstem. Nine sites (56 percent) were found to have “moderate Project effects,” meaning that some nests were exposed (at any point in the analysis), but at least 1 nest elevation was continuously inundated in all modeled inflow hydrologies. Two sites with “‘moderate Project effects” were located downstream of Vernon dam in the reach affected by Turners Falls Project operations. The remaining 4 sites (25 percent) experienced “Project effects,” meaning all nests were exposed at some point during the 2-month modeling analysis, regardless of frequency or duration.

In 2015, the frequency and duration of nest exposure were greatest at Wilder riverine reach sites, particularly those closest to the dam where WSE fluctuations were the greatest. However, for nests that experienced exposure, the average period of exposure at each site was no more than 11 hours based on 2015 level logger data and, except for 1 specific nest elevation at 1 site, less than 24 hours for all model years (detailed data on nest exposure are presented in Excel format for 2015 and for modeled inflow hydrologies, in Appendices E and F, respectively, of the final Study 16 report). It is probable that the selection of a nest location by Sea Lamprey, is somewhat dependent on the particular water year as lamprey will build nests at locations where water levels are suitable at that time.

Nest structure condition was evaluated by comparing nest characterization criteria for those nests that had repeated visits. Limited data were available because many specific sites could not be located during high flow (including high operational discharge into riverine reaches), were located only once, or were not located until after the spawning season. The most frequently revisited nests were those that were capped; however, it was determined that the nest caps protected nest structures from the forces of water velocity, and altered deposition of fine substrates in the nest, so those sites were disregarded in this evaluation. Nest condition was classified in terms of overall structure and an increased condition classification value was interpreted as nest structure degradation. Substrate embeddedness inside the nest and the amount that coarse substrates (gravel–

boulder) were embedded in fine substrates (mud–sand) was classified, and a decreased embeddedness classification value was interpreted as scour, while an increased value was interpreted as deposition. Of 13 nests evaluated, structure degradation was noted for 8 (62 percent), and 5 of those were attributed to tributary effects[33]; nest scour was noted for 5 of 13 nests (38 percent), and 4 of those were attributed to tributary effects; and sediment deposition was noted in 7 of 13 nests (54 percent), and 4 of those were attributed to tributary effects.

American Shad

American Shad spawn in river reaches dominated by broad flats with relatively shallow water (3 to 19 ft) and moderate currents (1.0 to 3.2 ft/s) (Munroe, 2002). Fertilized eggs are semi-buoyant and non-adhesive. Following fertilization, American Shad eggs sink toward the bottom where they increase in diameter due to water-hardening, which may cause them to lodge into the bottom substrate. Most shad eggs travel between 1 and 4 miles (1.6 and 6.4 km) downstream of their spawning location prior to hatch (Marcy, 1976).

Study 21 included an assessment of American Shad spawning in the Project areas from Bellows Falls dam downstream to the Vernon riverine reach. Spawning surveys were conducted on 30 nights between May 26 and July 2, 2015. Sampling locations were selected based on the presence of radio-tagged shad that had been released into the Vernon impoundment or had been released downstream of Vernon and successfully passed upstream through the Project. Tagged shad were tracked throughout the Vernon impoundment and up to Bellows Falls dam to potential spawning locations. A total of 120 ichthyoplankton net samples at 60 trawling locations was collected. Approximately 38 percent (46 of the 120) of the ichthyoplankton net samples contained American Shad eggs or larvae. Overall, 794 eggs and larvae were collected at just over half (31 of 60) of the sampling locations. The majority of eggs and larvae were contained in samples collected in the Vernon riverine reach (46.3 percent of total) and the Bellows Falls riverine reach (48.6 percent of total).

Collected eggs were examined and a developmental stage was assigned. The majority of eggs collected (78 percent) were determined to be stage 1 (blastodisk stage, occurs within 0.5 hour of spawn). Eggs classified as older (stages 2 through 9) were also collected but in lower abundance. American Shad yolk-sac and post yolk-sac larvae were also observed in low numbers with each lifestage representing 1 percent of the total catch. For all stage 1 eggs, a back-calculated spawn location was determined using the estimated time between spawn and egg collection along with water velocity at the point of collection to determine the approximate distance upstream of the collection point where the egg was likely spawned. Back-calculated

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[33] Tributary effects include tributary inflows that increased WSE, velocity, and/or suspended sediments. Spawning habitat in those sites tended to occur toward the upper extent of the Project-influenced reaches where stream gradients began to increase and Project impoundment effects were negligible.

spawning locations were not calculated for eggs older than stage 1 because the water velocity information collected at the time of measurement was less likely to be representative over longer periods and potentially consisted of varied river flows. Based on back calculations, 6 general spawning areas were identified: Bellows Falls tailrace and immediate downstream reach; Vernon tailrace and Stebbins Island reach; in the vicinity of the confluences of the Cold River, Mad Brook, and Mill Brook in the Bellows Falls riverine reach; and upstream of the Route 119 Bridge in the lower Vernon impoundment (with less evidence and based on a single stage 1 egg collected downstream). Additional analysis of spawning is not complete at this time and results will be included in the FLAs. FirstLight also conducted a study that evaluated American Shad spawning in which spawning activity was observed and eggs collected in the Vernon riverine reach (FirstLight, 2016c).

3.5.2.2 Effects on Resident Fish Passage

Project effects related to resident fish passage concern the types and numbers of resident species that might use the fish ladders during the normal operating season for migratory species (see Sections 2.1.1.5, 2.1.2.5, and 2.1.3.5, *Existing Environmental Measures*, for each Project) and those resident species that might use the fish ladders beyond the current operating season.

It is important to note that the number of "observations" in the tables below does not indicate the total number of individuals observed since milling was commonly observed (i.e., the back and forth transit movement of the same fish past the counting window.)

Wilder Project

The majority of net passage for all resident species, except trout, and for all resident species combined occurred during the fish ladder's normal operating season (from opening in spring through July 15). While most species exhibited passage during the spring over a range of river flow conditions, a concentrated period of passage of bass and Walleye occurred in the fall and appeared to be associated with a brief spike in total river discharge that resulted in spilling conditions. During much of the 2015 extended operating season, and particularly in the winter, relatively few counts were made of trout that may have spent extended periods in the ladder (see Study 17).

Table 3.5-15 summarizes total recorded movements and percent of net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. For the 4 resident species with net upstream passage, the percentage of net passage to total movements ranged from 5.1 to 13.9 percent during the normal operating season. For the 3 species with net upstream passage after July 15, net passage ranged from 2.0 to 3.8 percent of total movements. For the entire 2015 study season, net upstream passage ranged from 3.4 to 6.5 percent of total movements. For all resident species combined, the total net passage was 8.2 percent through July 15, 2.1 percent after that date, and 3.8 percent overall. While more total movements were recorded after July 15, the total net upstream passage (n = 52) was low during that period and low overall (n = 130). Therefore, TransCanada concludes that there are no effects to, as most, negligible effects on resident species, regardless of fish ladder operating season.

Table 3.5-15. Wilder fish ladder resident net passage by operating period, 2015.

Species/ Genera	Ladder Opening–July 15			July 16–Ladder Closing			Total 2015 Study Period		
	Observations	Net No. Passed[a]	% Net No. Passed	Observations	Net No. Passed[a]	% Net No. Passed	Observations	Net No. Passed[a]	% Net No. Passed
Bass	548	28	5.1	321	11	3.4	869	39	4.5
White Sucker	19	1	5.3	0	0	NA	19	1	5.3
Walleye	111	13	11.7	210	8	3.8	321	21	6.5
Trout	267	37	13.9	1,887	37	2.0	2,154	74	3.4
Sunfish	3	-1	-33.3	48	-4	-8.3	51	-5	-9.8
Bullhead	No observations								
Crappie	No observations								
Pike/Pickerel	No observations								
Yellow Perch	No observations								
Carp	No observations								
Other	No observations								
Total	948	78	8.2	2,466	52	2.1	3,414	130	3.8

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative values indicate net downstream passage.

Bellows Falls Project

There was very low fish ladder usage overall. The majority of net passage for all resident species, except sunfish, and for all resident species combined occurred during the fish ladder's normal operating season (from opening in spring through July 15). Bass passage was distributed over a range of flows including spill during spring and summer. White Sucker passage occurred only during the period in spring when freshet flows were receding. Walleye, trout, and sunfish passage was sporadic and distributed over a variety of flow scenarios from spring until early fall (see Study 17).

Table 3.5-16 summarizes total recorded movements and percent of net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. For the 4 resident species with net upstream passage, the percentage of net passage to total movements ranged from 5.6 to 17.2 percent during the normal operating season. For sunfish, which was the only species with net upstream passage after July 15, net passage was 15.8 percent of total movements. For the entire 2015 study season, net upstream passage ranged from 2.9 to 13.2 percent. For all resident species combined, total net passage was -2.2 percent through July 15, -0.1 percent after that date, and -1.38 percent overall (i.e., net overall downstream movement, influenced primarily by the greater proportion of bass movements). Given the very low fish ladder usage and net downstream passage, TransCanada concludes that there are no effects on resident species, regardless of fish ladder operating season.

Table 3.5-16. Bellows Falls fish ladder resident net passage by operating period, 2015.

Species/ Genera	Ladder Opening–July 15			July 16–Ladder Closing			Total 2015 Study Period		
	Observations	Net No. Passed[a]	% Net No. Passed	Observations	Net No. Passed[a]	% Net No. Passed	Observations	Net No. Passed[a]	% Net No. Passed
Bass	787	-47	-6.0	474	0	0.0	1,261	-47	-3.7
White Sucker	91	7	7.7	0	0	NA	91	7	7.7
Walleye	36	2	5.6	22	0	0.0	58	2	3.4
Trout	87	15	17.2	193	-7	-3.6	280	8	2.9
Sunfish	15	1	6.7	38	6	15.8	53	7	13.2%
Bullhead	No observations								
Crappie	No observations								
Pike/Pickerel	No observations								
Yellow Perch	No observations								
Carp	No observations								
Other	No observations								
Total	1,016	-22	-2.2	727	-1	-0.1	1,743	-23	-1.3

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative values indicate net downstream passage.

Vernon Project

The majority of net passage for all resident species, except sunfish, and for all resident species combined occurred during the fish ladder's normal operating season (from opening in spring through July 15). Bass passage was distributed over a range of flows including spill during spring and summer. White Sucker passage occurred only during the period in spring when freshet flows were receding. Walleye, trout, and sunfish passage was sporadic and distributed over a variety of flow scenarios from spring until early fall (Study 17). Because of the long-standing operating procedure of shutting off of attraction flow pump discharge overnight (see Section 3.5.1.3, *Resident Fish Populations*), diel periodicity of fish activity is likely affected both by species behavior and by fish ladder operations.

Table 3.5-17 summarizes total recorded movements and percent of net passage during the normal fish ladder operating season, the 2015 extended season from July 16 on, and over the entire 2015 study season. For the 9 resident species with net upstream passage, the percentage of net passage to total movements ranged from 3.86 to 27.3 percent (and 100 percent for crappie) during the normal operating season. For the 6 resident species with net upstream passage after July 15, the percentage of net passage to total movements ranged from 11.1 to 52.9 percent.

For the entire 2015 study season and the 9 species with net upstream passage, the percent of net passage ranged from 4.69 to 28.4 percent (100 percent for crappie) of total movements. For all resident species combined, total net passage was 7.1 percent through July 15, 18.2 percent after that date, and 10.4 percent overall. The Vernon fish ladder usage had more resident species and substantially more total movements and net upstream passage than did the Wilder and Bellows Falls fish ladders. However, net upstream passage for resident species was negative, zero, or less than 10 individuals after July 15 for all species, except bass and sunfish. Sunfish had higher net passage after July 15 (n = 984) than earlier in the season (n = 204). Cumulative net passage for sunfish reached only 17 percent by July 15, but had reached 50 percent by August 26, and 80 percent by September 6. Approximately 31 percent of all bass recorded in 2015 (239 of 761) had net passage after July 15, but cumulative passage on that date was 69 percent, and had reached 80 percent by August 20 (Study 17).

White Sucker and Walleye were present upon opening of the Vernon fish ladder on May 5, 2015 and according to FWS in its study comments, White Sucker and Walleye runs may have been missed due to the late opening. TransCanada reviewed 2016 Salmonsoft recordings made by VANR from April 15 through May 31 to determine the level of ladder usage by these species. Note that conditions (e.g., flows, temperature) and the number of fish observed in fish ladders will vary from year to year, making comparisons between the numbers of fish observed during specific time frames in different years problematic.

However, results of the 2016 evaluation show net upstream passage through May 31 of 7 Walleye and 148 White Sucker, compared to 2015 results through May 31 of 46 Walleye and 326 White Sucker with the later fish ladder opening that year. The first net passage in 2016 occurred on April 17 for Walleye and on April 16 for White Sucker and 100 percent net passage occurred on May 17 and May 23, respectively. In 2015, both species were recorded with net upstream passage upon fish ladder opening on May 5, 2015. By May 31, 2015, cumulative net passage was 79 percent for Walleye and 100 percent for White Sucker (100 percent cumulative passage had occurred on May 14). Overall, more net passage was recorded for both species during the shorter 2015 period from May 5 through May 31 than during the longer period from April 15 through May 31, 2016.

Overall, the seasonality of passage for most resident species at Vernon suggests that effects on these species are minimal and extension of the passage season beyond the existing migratory species passage season is not warranted.

Table 3.5-17. Vernon fish ladder resident net passage by operating period, 2015.

Species/ Genera	Ladder Opening - July 15			July 16 - Ladder Closing			Total 2015 Study Period		
	Observations	Net No. Passed[a]	% Net No. Passed	Observations	Net No. Passed[a]	% Net No. Passed	Observations	Net No. Passed[a]	% Net No. Passed
Bass	8,954	522	5.8	925	239	25.8	9,879	761	7.7
White Sucker	4,381	325	7.4	5	-3	-60.0	4,386	322	7.3
Walleye	187	49	26.2	17	9	52.9	204	58	28.4
Trout	138	24	17.4	12	6	50.0	150	30	20.0
Sunfish	2,244	204	9.1	5,794	984	17.0	8,038	1,188	14.8
Bullhead	11	3	27.3	3	-1	-33.3	14	2	14.3
Crappie	14	14	100.0	0	0	NA	14	14	100.0
Pike/Pickerel	3	-1	-33.3	0	0	NA	3	-1	-33.3
Yellow Perch	No observations								
Carp	160	6	3.8	8	2	25.0	168	8	4.8
Other	233	9	3.9	27	3	11.1	260	12	4.6
Total	16,325	1,155	7.1	6,791	1,239	18.2	23,116	2,394	10.4

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative values indicate net downstream passage.

3.5.2.3 Effects of Upstream Passage on Migratory Fish

The Wilder, Bellows Falls, and Vernon Projects have successfully passed migratory fish upstream (Table 3.5-8) since construction of passage facilities in the early 1980s. Wilder and Bellows Falls upstream fish ladders were designed to pass Atlantic Salmon, and the Vernon fish ladder was designed to pass both Atlantic Salmon and American Shad. Based on species' migratory ranges and current status, upstream passage is relevant at all three Projects for juvenile American Eel, and for adult Sea Lamprey and adult American Shad at Bellows Falls and Vernon.

Atlantic Salmon restoration efforts have been suspended by federal and state resource agencies due to poor returns and, therefore, this species was not included in this environmental analysis although recorded values are included the tables below for completeness. See also Table 3.5-8 in Section 3.5.1.4, *Migratory Species,* for historical upstream passage counts through 2016. The future well-being of salmon during passage, should populations rebound, would result from the continued operation of fish passage facilities and the close interaction of TransCanada with resource agencies. Since Blueback Herring are not present in the Project areas, that species is also excluded from further discussion.

Tables 3.5-18, 3.5-19, and 3.5-20 summarize fish ladder use by migratory species as recorded in 2015 for Study 17, as discussed for each Project below. Results are delineated between the normal fish ladder operating season and the extended 2015 operating season.

Table 3.5-18. Wilder fish ladder percent of migratory net passage by operating period, 2015.

Species	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed
	First	Last	Obser-vations	Net No. Passed	First	Last	Obser-vations	Net No. Passed		
American Eel	June 2	July 13	66	28	July 20	Nov 9	288	24	Sep 30	52
Sea Lamprey	May 30	June 2	6	2	NA	NA	0	0	June 2	2
Atlantic Salmon	NA	NA	0	0	Oct 5	Oct 5	1	1	NA	1
American Shad	No observations									
Total			72	30			289	25		55

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

Table 3.5-19. Bellows Falls fish ladder percent of migratory net passage by operating period, 2015.

Species	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed
	First	Last	Obser-vations	Net No. Passed	First	Last	Obser-vations	Net No. Passed		
American Eel	June 21	July 15	91	-17	July 16	Nov 1	339	77	Sep 13	60
Sea Lamprey	May 19	July 7	3,712	970	NA	NA	0	0	June 1	970
American Shad	May 26	June 20	130	44	NA	NA	0	0	May 30	44
Atlantic Salmon	June 8	June 8	2	1[b]	NA	NA	0	0	NA	1[b]
Total			3,935	998			339	77		1,075

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative values indicate net downstream passage.

b. One salmon was assumed to have passed since one salmon was observed at Wilder.

Table 3.5-20. Vernon fish ladder percent of migratory net passage by operating period, 2015.

Species	Ladder Opening–July 15				July 16–Ladder Closing				80% Net Passage Date	Total Net No. Passed
	First	Last	Obser-vations	Net No. Passed	First	Last	Obser-vations	Net No. Passed		
American Eel	May 21	July 15	4,180	1,088	July 16	Dec 16	4,109	457	July 21	1,545
Sea Lamprey	May 13	July 14	12,959	2,439	July 18	July 18	1	1	May 31	2,440
American Shad	May 10	July15	71,541	39,203	July 17	Nov 9	37	-7	May 30	39,196
Atlantic Salmon	May 20	July 12	6	6	NA	NA	0	0	June 17	6
Total			88,686	42,736			4,147	451		43,184

Source: ILP Study 17, *Upstream Passage of Riverine Fish Species Assessment*

a. Negative values indicate net downstream passage

Wilder Project

American Eel

In Study 17, American Eels were recorded from June 2 through November 9 with a total net passage of 52. The most concentrated activity (53.8 percent of total net passage) occurred from early June through July 15 (Table 3.5-18), the end of the normal fish ladder operating season. Peak net passage occurred on June 27 and July 9 with net passage of 4 eels on each occasion. Activity was distributed around-the-clock, likely owing to milling (i.e., the back and forth transit movement of the same eel past the counting window) but with a strong preponderance toward nighttime hours. A second period of concentrated activity occurred from late September through mid-October that resulted in 23 percent of the total net passage for the year. A 1-day peak occurred on October 17 with net passage of 4 eels. More total movements were recorded after July 15 than before that date, but net passage during this period was 46 percent of total net passage for the year. Therefore, even though the Wilder fish ladder was not designed for American Eel, the low but overall net upstream passage value from Study 17 suggests that eels can successfully navigate the fish ladder. TransCanada concludes that Project effects related to upstream passage for this species are virtually none because of the lack of eels observed during Study 18 where upstream migrating eels were observed in 24 weekly nighttime surveys conducted from May 6 to October 12, 2015.

Sea Lamprey

Study 17 recorded only 2 Sea Lamprey passing upstream of the Wilder Project. Passage occurred on May 30 and June 2 during the normal fish ladder operating season (Table 3.5-18). Because of this low number and rare historical occurrences (2 individuals in a single year prior to 2015, see Table 3.5-8 in Section 3.5.1.4, *Migratory Species*), TransCanada concludes that there are no Project effects related to upstream passage for this species.

Bellows Falls Project

American Eel

American Eels were recorded in the Bellows Falls fish ladder from June 21 through November 1, with a total net passage of 60 (Table 3.5-19). The most concentrated activity occurred from early July through mid-September. All passage was net downstream from the opening of the fish ladder through July 15 (n = -17). Peak upstream passage occurred on 12 days later during the summer, and cumulatively, 80 percent of total net passage occurred by September 13. American Eel activity was recorded around-the-clock, but with a strong preponderance toward the nighttime. More total movements were recorded after July 15 than before that date and all net upstream passage occurred during this period.

During Study 18, only 3 eels were observed migrating upstream at Bellows Falls, so no migratory aggregations were identified. All 3 observations were during the summer, on July 8, July 21, and August 25. Two observations were made in the tailrace near the fish ladder entrance and 1 was made in the upper portion of the bypassed reach. Even though the Bellows Falls fish ladder was not designed for American Eel, TransCanada concludes that Project effects related to upstream passage for this species are negligible to minimal because of the small number of eels that would be available to pass upstream, as observed during Study 18. The low but overall net upstream passage value from Study 17 suggests that eels can successfully navigate the fish ladder, although some portion may not have access outside the current operating season.

Sea Lamprey

For Study 17, Sea Lamprey were recorded in the Bellows Falls fish ladder from May 19 through July 7 with a total net passage of 970, all during the normal fish ladder operating season (Table 3.5-19). Peak upstream passage occurred from May 29 through June 1, and cumulatively, 80 percent of net passage occurred by June 1. Sea Lamprey were recorded around-the-clock with a preponderance toward daytime. Net passage at Bellows Falls was 40 percent of net passage at Vernon. Wide fluctuations in historical passage have occurred at both Vernon and Bellows Falls (see Table 3.5-8 in Section 3.5.1.4, *Migratory Species*), and the proportion of lamprey passing Vernon that also pass Bellows Falls has also varied widely. Passage at Bellows Falls in 2015 and 2016 was higher than in most previous years, except 2008, which had the peak recorded passage at Bellows Falls of 2,233 since records began in 1984 (Table 3.5-8). It is unknown at this time if recent increases in passage are anomalous or suggest an overall increasing trend. Despite the fact that the Bellows Falls fish ladder was not designed specifically to pass Sea Lamprey, it is apparent that this species is able to access and use the ladder. Therefore, TransCanada concludes that there are unlikely to be Project effects related to upstream passage for this species.

American Shad

American Shad use the Bellows Falls fish ladder even though Bellows Falls is considered the historical upstream migratory extent of the species. Study 17 recorded a net passage of 44 in 2015 (Table 3.5-19). Shad were recorded from May 26 through June 20; peak passage occurred from May 28 through May 30, and 80 percent cumulative passage occurred on May 30. Shad were recorded during both day and night, but with a strong preponderance toward daytime (between 8:00 a.m. to 7:00 p.m.). Passage activity was most concentrated during a period of relatively low total river discharge following the spring freshet. Net passage of American Shad at Bellows Falls in 2015 was 0.1 percent of passage at Vernon. In 2016, passage at Bellows Falls was 1,973 (a historical record) and 5.5 percent of Vernon passage, yet Vernon passage in 2016 was only 91 percent of 2015 passage. Between 2005 and 2014, the only shad recorded passing Bellows Falls were in 2005 (n = 3) and 2011 (n = 1), although prior records from 1984 to 2000 show low levels of passage in most years (maximum = 147, mean = 38) (Table 3.5-8). The Bellows Falls fish ladder was not designed specifically to pass American Shad, but it is apparent that shad are able to access and use the ladder. Therefore, TransCanada concludes that there are unlikely to be Project effects related to upstream passage for this species.

Vernon Project

As noted above, the long-standing operating procedure of shutting down the attraction flow pump discharge at night may affect diel periodicity of fish activity based on both species behavior and fish ladder operations.

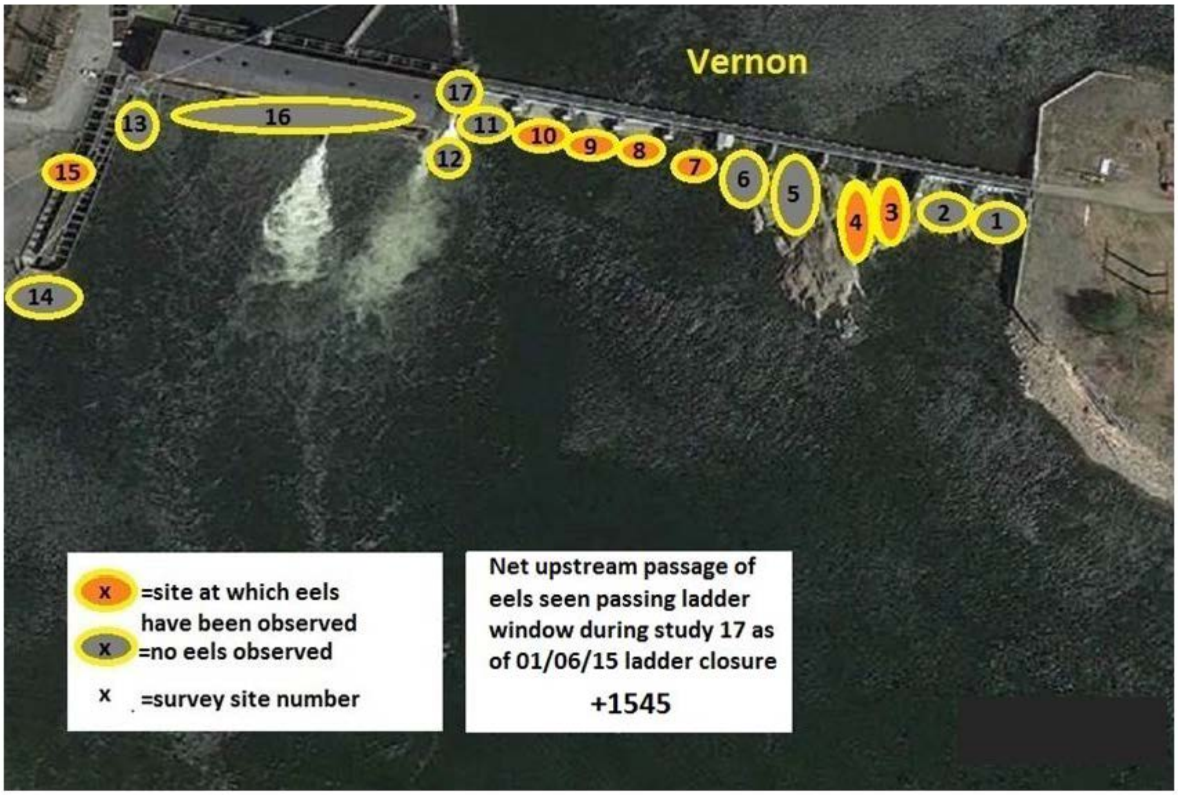
American Eel

American Eels were recorded from May 21 through December 16, 2015 in Study 17 (see Table 3.5-20 above). Net passage was 1,545 with about 70 percent of cumulative net passage occurring during the normal fish ladder operating season (through July 15), and 80 percent cumulative net passage by July 21. The most concentrated activity occurred from late May through July. Peak upstream passage occurred on 3 days in spring and 1 day in summer. CRASC (2016) reported only net downstream passage of 920 eels in 2016.

A total of 80 eels was recorded in Study 18 in 2015 over 24 weeks of surveys conducted from May 7 to October 13. All observations occurred between June 17 and September 28. Most were observed in summer with 41.3 percent of the total observed during the normal fish ladder operating season. Eels were observed at 4 discernible site types: the fish ladder window and surrounding area viewed from the catwalk surrounding the ladder (site no. 15), an area in the vicinity of the submerged flood gates below 4 tainter gates (site no. 10) just east of the powerhouse, a submerged flood gate below 1 of the hydraulic panels (site no. 7), and an area of emergent rocks below stanchion bays (site nos. 3 and 4) (Figure 3.5-7).

While no large aggregations of eels were observed at any surveyed location, the fish ladder was the site where eels were most frequently observed with 39 individuals (49 percent of the total), likely as a result of extended fish ladder operations conducted for Study 17. The submerged flood gate sites collectively yielded 36 eel observations (45 percent of the total) (Table 3.5-21).

All of the eels observed at the fish ladder in 2015 were seen swimming by the window and thus using the fish ladder to move upstream. Behavioral notes of the eels observed at the Vernon flood gate sites indicated that many individuals did not seem to be attempting to migrate upstream at the time of observation and appeared to be taking cover under the overhead lip of these submerged structures. Most eels (66 percent) were in the 12 to 18-inch (30-45 cm) size class and another 30 percent were in the 6 to 12-inch (15-30 cm) size class. Very few eels were in the 18-inch (> 45 cm) or larger size class (Table 3.5-21).



Source: ILP Study 18, *American Eel Upstream Passage Assessment*

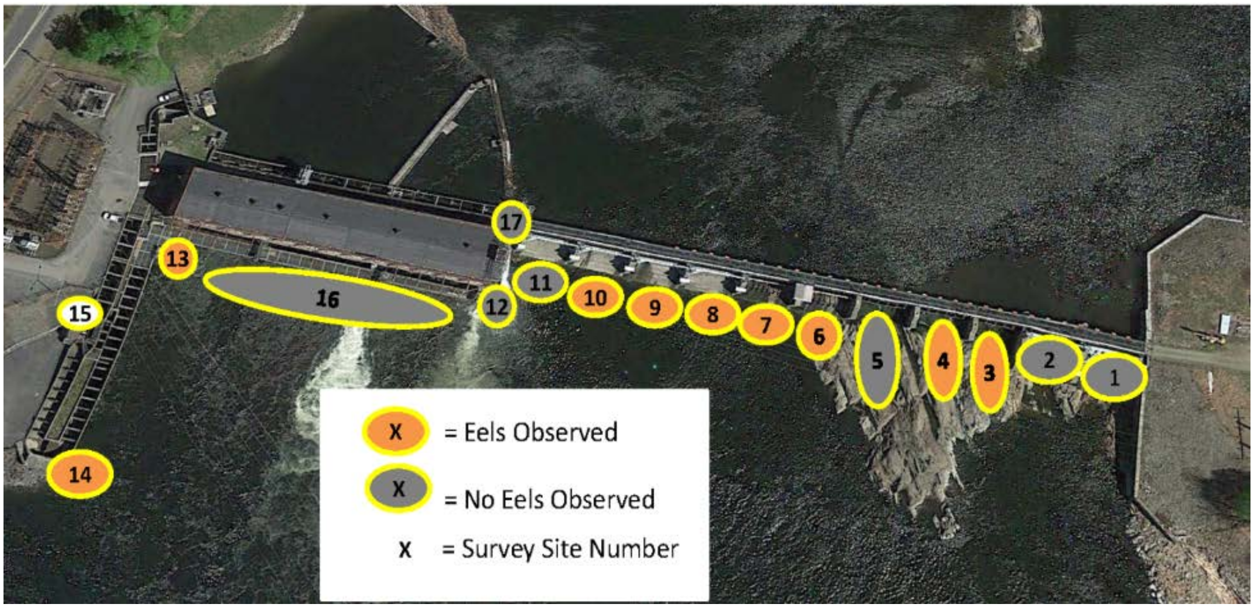
Figure 3.5-7. American Eel systematic survey locations at Vernon, 2015.

Table 3.5-21. Distribution of eel size classes observed by site and major location type at Vernon, 2015.

		Site Type							**Total**
		Fish Ladder	**Flood Gates below Tainter Gates**			**Flood Gate below Hydraulic Panel**	**Rocks below Stanchion Bays**		
Site Number:		**15**	**10**	**9**	**8**	**7**	**4**	**3**	
Size class	6-12 in.	12	2	2	4	1	3	0	24
	12-18 in.	24	3	3	17	4	1	1	53
	>18 in.	3	0	0	0	0	0	0	3
Total		39	5	5	21	5	4	1	80

Source: ILP Study 18, *American Eel Upstream Passage Assessment*

TransCanada conducted additional surveys at Vernon in 2016 to evaluate eel presence below the dam in the absence of normal fish ladder operations. Surveys were conducted from July 28 to October 20 using the same general methodology as was used in 2015. During weekly visits over 13 weeks, 70 eels were observed (Figure 3.5-8 and Table 3.5-22).



Source: ILP Study 18, *American Eel Upstream Passage Assessment*

Figure 3.5-8. American Eel systematic survey locations at Vernon, 2016.

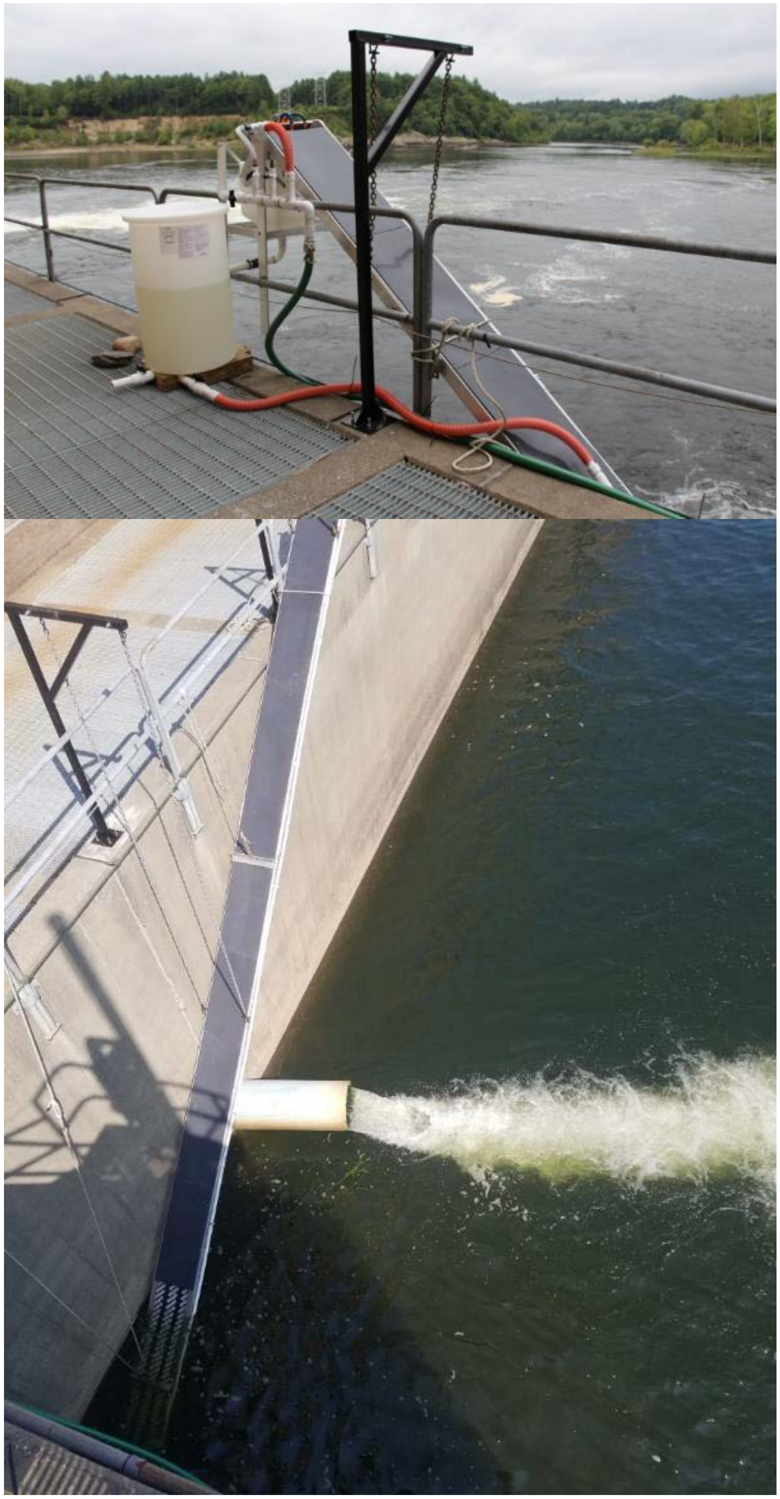
These results may be conservative because eels were not marked (as they were in 2015 for studies at all three Projects to determine whether eels observed at one Project migrated upstream to the next Project), thus some eels could have been counted more than once in 2016. Most eels (66 percent) were more than 8 inches (20 cm) in length and another 33 percent were in the 4 to 8-inch (10–20 cm) size class (Table 3.5-22). A majority of all eel observations occurred in 2 weekly surveys on August 18 and August 25 (51.4 percent of the total) and cumulative observations reached 90 percent by September 9. Overall, Site Nos. 3 and 10 had the most frequent observations, 27 percent and 24 percent, respectively, and had more observations than the area near the fish ladder entrance (15.7 percent) (Figure 3.5-8 and Table 3.5-22).

Table 3.5-22. Distribution of eel size classes observed by site and major location type at Vernon, 2016.

		Site Type								Total
		Fish Ladder	Flood Gates below Tainter Gates					Rocks Below Stanchion Bays		
Site number:		**17**	**12**	**11**	**10**	**9**	**8**	**5**	**3**	
Size class	<10 cm (<4 in.)	0	0	0	0	0	0	0	1	1[a]
	10–20 cm (4–8 in.)	1	1	0	7	1	1	2	10	23
	>20 cm (8 in.)	10	3	8	10	4	1	2	8	46
Total		11	4	8	17	5	2	4	19	70

Source: ILP Study 18, *American Eel Upstream Passage Assessment, Study Supplement*

a. Due to flowing water and water depth, eel size may have been misjudged and is possible eel belongs in 10–20 cm size class.



Source: ILP Study 18, *American Eel Upstream Passage Assessment, Study Supplement*

Figure 3.5-9. Temporary eel trap and ramp, Vernon, 2016.

The 2016 study also included fabrication and installation of a temporary eel ramp and trap near the fish ladder entrance. The system was designed in consultation with the aquatics working group, which visited the site to determine ramp location, angle of incline, and needed water flows. The ramp and collection tank are shown in Figure 3.5-9. The ramp began operation on September 6 and a single eel, which was 10.9 inches (27.6 cm) in length, was collected on September 23.

The results of Study 18 in both years indicate that a small number of eels may attempt to migrate upstream past Vernon, and in the absence of the release in 2014 of nearly 6,000 eels upstream of Turners Falls dam (see Section 3.5.1.4, *Migratory Species*), substantial numbers of eels do not appear to use the Vernon fish ladder either. Therefore, TransCanada concludes that the Vernon Project has, at most, negligible effects on upstream migrating eels.

Sea Lamprey

In Study 17, Sea Lamprey were recorded from May 13 through July 18, 2015 (see Table 3.5-20 above) with a total net passage of 2,440, which peaked on May 28 and June 1. Cumulatively, 80 percent of the total net passage count was recorded on May 31. Sea Lamprey passage was most concentrated during a period of relatively low total river discharge following the spring freshet. However, a reduced rate of passage also occurred during a variety of subsequent discharge scenarios including spill.

In 2016 and similar to passage results at Bellows Falls, Sea Lamprey passage at Vernon was higher than in 2015 (5,539, see Table 3.5-8 above). It is unknown at this time if recent increases in passage are anomalous or suggest an overall increasing trend. Despite the fact that the Vernon fish ladder was not designed specifically to pass Sea Lamprey, it is apparent that this species is able to access and use the ladder. Therefore, TransCanada concludes that there are unlikely to be Project effects related to upstream passage for this species.

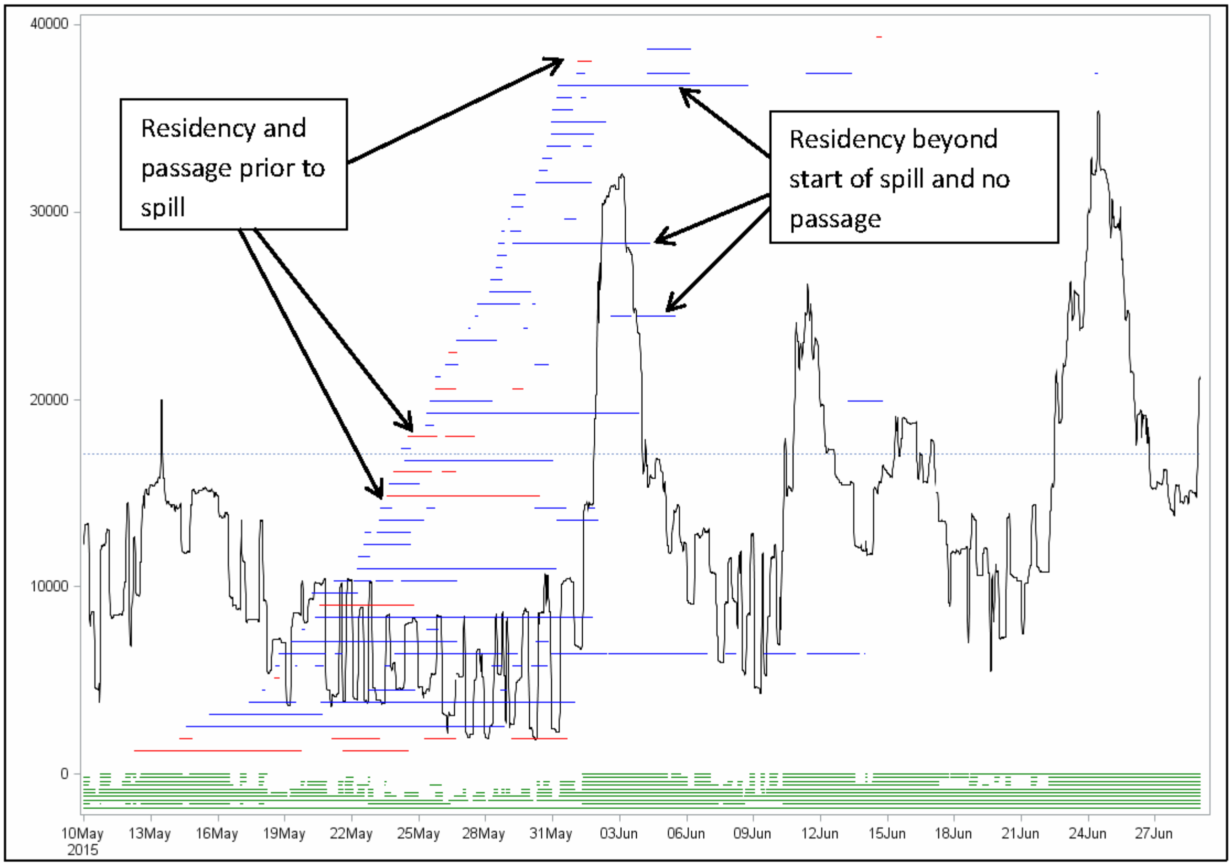
American Shad

American Shad were the dominant migratory species counted for Study 17 in the Vernon fish ladder (see Table 3.5-20 above) with an historical record of net passage (n = 39,196) from May 10 through August 22, 2015 (see Table 3.5-20 above). After June 20, net passage counts indicated mostly downstream movements and after July 15, all net passage was downstream. Peak upstream passage occurred on May 18 when 10 percent of the total net passage occurred. The 80 percent cumulative passage occurred on May 30. Net passage was 67 percent, proportional to FirstLight's Turners Falls Gatehouse fish ladder passage (FWS, 2015), which exceeds the CRASC management goal of 40 to 60 percent (see Section 3.5.1.1, *Fisheries Overview*). Activity was most concentrated during a period of relatively low total river discharge following the spring freshet, and while activity within the ladder was recorded during day and night hours (indicating that lack of attraction pump flow does not completely disallow passage), the preponderance of fish movement occurred during the daytime hours (between 8:00 a.m. and 7:00 p.m.).

Study 21 (report in revision at this time) included evaluation of upstream passage of adult American Shad at Vernon. The study included assessment of approach, tailrace residency, attraction to the fish ladder, movement within the fish ladder, and subsequent passage upstream for shad tagged with both radio and PIT tags (dual-tagged) and for PIT-tagged shad (to evaluate movement within the fish ladder). Tagged shad were released into the Turners Falls impoundment on 3 dates in May 2015. Because FirstLight was conducting a similar passage study (FirstLight, 2016c), some shad released for that study arrived at and were monitored within the Vernon Project area for Study 21. Dual-tagged shad from both TransCanada and FirstLight studies were detected downstream of Vernon (n = 184) including those released into the Turners Falls impoundment and 6 that had migrated into the impoundment after successfully passing Turners Falls dam. Of these, 64 were detected in the Vernon Project area. An additional 71 PIT-tagged shad were detected at PIT-monitoring stations at the entrance or within the fish ladder, thus 135 individuals were determined to have entered the Vernon study area and were considered “available” for the calculation of upstream fish ladder performance metrics.

Residence Time—Residency was calculated for dual-tagged shad only (since PIT-tagged shad were only monitored within the fish ladder) with valid detections to calculate residency (60 of 64).[34] The median downstream residence time was just less than 2 days and ranged from 4.5 hours to 18.8 days. There was no statistically significant difference between the mean residence time recorded for dual-tagged shad that successfully passed upstream versus those that eventually fell back downstream and did not pass. Dual-tagged shad had the highest presence during the second half of May and the number dropped steeply during the first few days of June, coinciding with an increase in total river flow and periods of spill. Periods of spill encompassing less than 25 percent of total residence time for any individual resulted in passage for 1 of 10 shad (10 percent), and periods of spill from 25 to 100 percent of residency for any individual resulted in passage for 2 of 10 shad (20 percent), 1 of which passed after spending its entire but short residency of 5.1 hours under spill conditions. Figure 3.5-10 overlays tailrace residence periods for upstream migrating adult shad with total river flow conditions, presence of spill (i.e., flow conditions exceeding station capacity of 17,100 cfs), and operational conditions of turbine Unit Nos. 1–10.

[34] Although a total of 64 dual-tagged shad was determined to have entered the study area, due to missing detection information at one or more monitoring stations, a downstream residency time could not be calculated for 4 of those individuals. Presence of these individuals in the study area was based on detections within the fish ladder.



Source: ILP Study 21, *American Shad Telemetry Study – Vernon* (revision in progress)
Notes: Solid black line – 2015 total river flow (cfs)
Dashed blue line – Project generating capacity
Red lines – downstream residence events resulting in successful passage
Blue lines – downstream residence events resulting in unsuccessful passage
Green lines – operational status of Unit No. 1 (upper) through Unit No. 10 (lower) where green = unit on and blank spaces = unit off

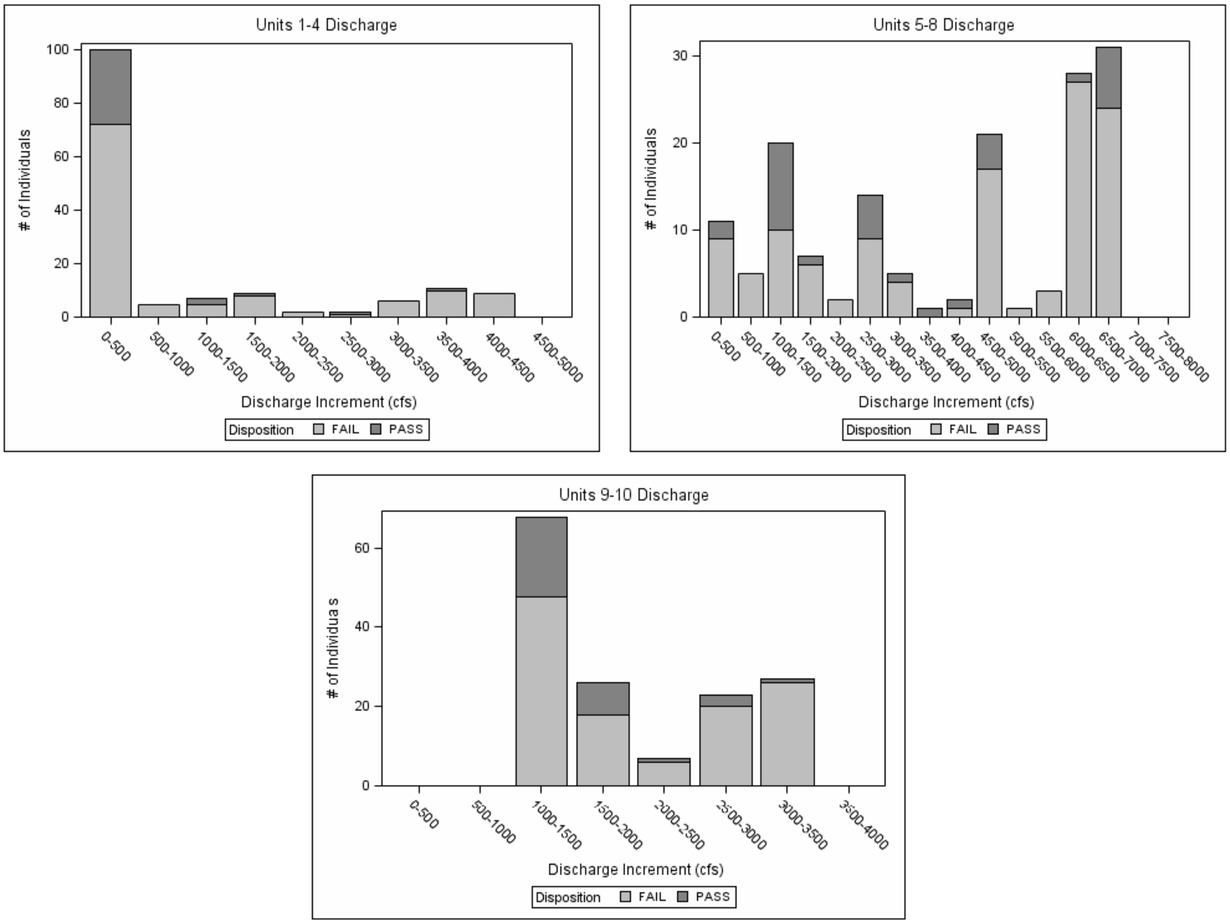
Figure 3.5-10. Temporal distribution of downstream residence times for radio-tagged adult American Shad below Vernon dam.

Nearfield Attraction and Forays—Nearfield attraction to the fish ladder was defined as the proportion of dual-tagged fish that entered the fish ladder in relationship to the total number of dual-tagged fish available (e.g., the number of dual-tagged shad determined to have moved into the detection range of monitoring stations located in the tailrace, spillway, and turbine discharge areas). Overall, nearfield attraction was 56.3 percent (36 of 64). This rate falls within the range of attraction effectiveness values (11 percent to 73 percent) observed at other facilities where similar studies were conducted with adult shad, although the size and configuration of other projects varied (e.g., Normandeau and Gomez and Sullivan, 2012; Normandeau, 2008). Once shad entered into the tailrace area, the median duration prior to arrival at the fish ladder entrance was just over 20 hours.

Thirty-six dual-tagged shad (as recorded at the fish ladder entrance) and 71 PIT-tagged shad were detected at the fish ladder entrance (or at the first bend within the fish ladder). For these 107 individuals, each upstream passage attempt, or "foray," was defined by an initial detection at the fish ladder entrance. Following that initial detection, tagged shad may have departed the fish ladder entrance back into the tailrace or been recorded at upstream points within the fish ladder prior to (1) successful passage or (2) termination of the entry attempt and movement back downstream and away from the fish ladder entrance. The number of forays for an individual tagged shad ranged from a high of 33 to a low of 1 (mean = 1.8; median = 1). The majority (78 percent) of forays were initiated when attraction flows from the attraction flow pumps were greater than 150 cfs and forays that resulted in eventual passage success were generally initiated at a high attraction flow (97 percent of successful passage events).

During normal seasonal upstream passage fish ladder operations from April 15 through July 15, operating preference is generally given first to Unit No. 10, followed by Unit Nos. 8 or 7, then Unit No. 9, Unit Nos. 5 or 6, and lastly, Unit Nos. 1–4. Operations during 2015 followed these guidelines, and discharge for Unit Nos. 1–4 (farthest away from the fish ladder entrance) was lowest during May, coinciding with the lower flow portion of the 2015 study period as well as the majority of foray events. Successful and unsuccessful foray events occurred over a range of discharge values for Unit Nos. 5–8. The majority of successful forays occurred when Unit Nos. 1–4 were offline, and either Unit No. 9 or No. 10 (closest to the fish ladder entrance and first on/last off unit during fish ladder operations) was operating. The majority of successful foray events took place under periods when Unit No. 10 was in operation and Unit No. 9 was offline. Figure 3.5-11 provides the distribution of initiation times for successful and unsuccessful upstream fishway foray events for 500 cfs increments of Units 1-4, 5-8, and 9-10 discharge.

When all 10 units were in operation, the percentage of foray events ending in successful passage was low (2 of 28). When unit operations for the full duration of the study period were considered, all 10 units were in operation nearly 50 percent of the period. The total flow at the time of initiation of foray events ranged between 1,958 and 15,031 cfs (mean = 6,019 cfs) for successful upstream forays and between 1,856 and 27,054 cfs (mean = 8,893 cfs) for unsuccessful upstream forays. Differences in average total discharge at the time of foray initiation were statistically significant for successful and unsuccessful upstream fish ladder forays ($t = 3.88$; $p = 0.0002$). When the presence of spill conditions was considered, spill discharge at the time of initiation of foray events ranged between 0 and 1,199 cfs for successful upstream forays and between 0 and 15,186 cfs for unsuccessful upstream forays. Only a single successful upstream foray was initiated during a period of spill.



Source: ILP Study 21, *American Shad Telemetry Study - Vernon*

Figure 3.5-11. Frequency distribution of unit discharge (cfs) coinciding with the initiation of successful and unsuccessful upstream fish ladder forays at Vernon, 2015.

Fish Ladder Entrance Efficiency—Entrance efficiency was defined as the proportion of all PIT- and dual-tagged fish that entered the fish ladder and were subsequently detected in the vicinity of the counting house window. When all tagged shad entering the fish ladder were considered (107 total individuals; 71 PIT-tagged and 36 dual-tagged), entrance efficiency was estimated at 67.2 percent. Once within the fish ladder entrance, the median duration prior to arrival at the counting house window was approximately 2 hours, although times ranged from 15 minutes to slightly more than 2 days.

The counting house consists of a regulating pool provided with a constant water flow at a constant surface elevation. Fish are guided by flow and crowder screens through a narrow opening and past the counting window. The counting house forms the transition between the lower and longer Ice Harbor section of 26 overflow weir pools, each 12 inches higher than the last, and the upper and shorter vertical slot section consisting of 25 pools, each 6 inches higher than the last. The majority of unsuccessful forays terminated at points either (1) between the fish ladder entrance and the first bend or (2) where the fish ladder transitions to a vertical slot upstream of the counting window to the exit.

Internal Fish Ladder Efficiency—Internal efficiency was defined as the proportion of all PIT- and dual-tagged fish that entered the fish ladder and were subsequently determined to have exited the upstream end and remained upstream of Vernon dam for greater than 48 hours. When all tagged shad entering the fish ladder are considered (107 total individuals; 71 PIT-tagged and 36 dual-tagged), internal efficiency was estimated at 49.5 percent (95 percent confidence interval = 40.2 to 58.9 percent). Once within the fish ladder, the median time to pass through the entire structure was 3.5 to 4 hours, although times ranged from 1 hour to 4.2 days.

The median time of passage for an adult shad moving upstream from the entrance to the counting window was approximately 2.5 hours and from the counting window upstream to the exit was approximately 1.5 hours. Final passage times were identified for 53 individuals as they exited the upstream end of the fish ladder. All shad exiting the upstream fish ladder into the Vernon impoundment did so when river flows were below maximum station generating capacity. Although river flows were below capacity, a limited amount of spill (approximately 1,000 cfs) was present at the time of fish ladder exit for 5 shad that passed during early June.

Based on the upstream passage results of Studies 17 and 21 (recognizing that tagged fish are subject to tagging and handling effects, which reduce observed passage in Study 21), it is apparent that adult American Shad are able to successfully locate and navigate through the Vernon fish ladder in large numbers and at rates that exceed the CRASC management plan. Therefore, it is unlikely that there are effects from Project operations on this species.

3.5.2.4 Effects on Downstream Passage of Migratory Fish

The Wilder, Bellows Falls, and Vernon Projects have successfully passed migratory fish downstream since construction of passage facilities in the early 1990s (see Sections 2.1.1.5, 2.1.2.5, and 2.1.3.5, *Existing Environmental Measures*, for each Project). Safe and timely downstream passage through 1 or more of the Projects is important for adult American Eel and for juvenile and adult American Shad. Three relicensing studies evaluated downstream passage at the Wilder, Bellows Falls, and Vernon Projects for migratory fish species as described below.

All Projects—American Eel

Study 19 was conducted to evaluate movement rates, timing, and proportions of silver American Eels passing via various routes at each of the three Projects, including through turbines, downstream passage facilities, spillways, and the Bellows Falls bypassed reach. Eels for the study were imported from Newfoundland, Canada, due to the large number of eels needed to conduct the simultaneous TransCanada and FirstLight American Eel downstream passage studies and the inadequate number of eels available within the Connecticut River

Basin. Imported eels were subjected to pathological testing and quarantine, and all required permits were secured, prior to importation and release into the Project areas.

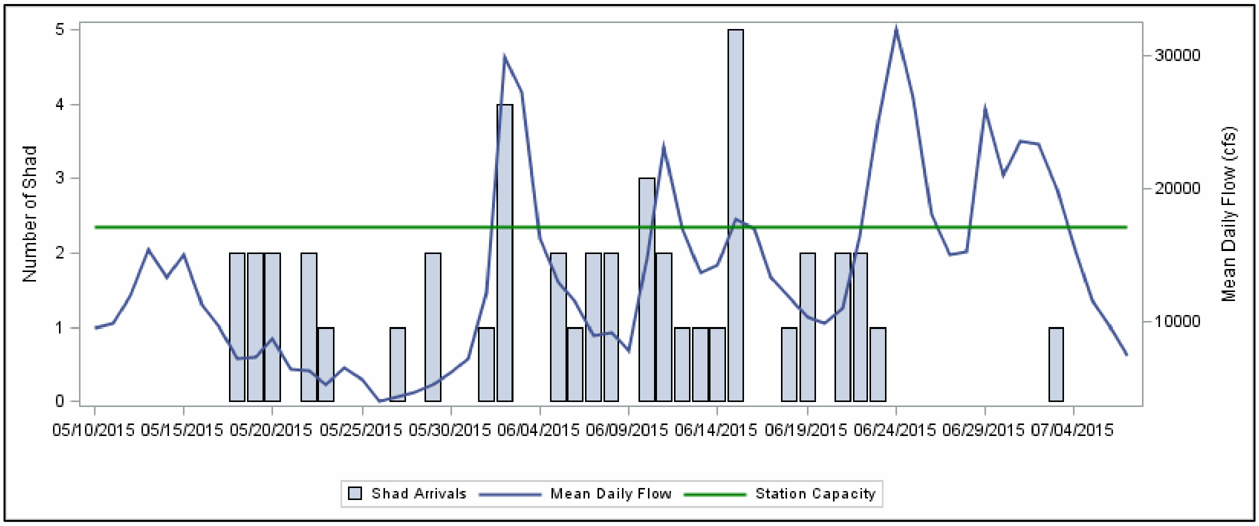
In 2015, 50 eels were radio-tagged and released upstream of each Project in separate groups of 10. An additional 20 eels were released in 2 groups of 10 eels into the Bellows Falls power canal to avoid unintentional passage over the dam during periods of spill. Radio receivers were located to detect eels in each Project forebay and at all available downstream passage routes at each Project, including at the Bellows Falls power canal entrance and at the dam. Because of a data processing error discovered after the Study 19 report was filed, some downstream passage telemetry data may have been inaccurately reported. Those data are currently being reanalyzed and will be reported in a revised study report. Therefore, results related to downstream route selection and residency of radio-tagged eels are not available at this time and Project effects, if any, will be reported in the FLAs.

Vernon Project—Adult American Shad

Study 21 (report revision in progress) included evaluation of downstream passage of tagged adult American Shad through the Vernon Project. Sixty-five individuals were potentially available for monitoring from 54 that were collected at the Vernon fish ladder trapping facility, radio-tagged, and purposely released upstream of Vernon dam and 11 that had volitionally passed upstream through the fish ladder and had retained their radio tags to allow them to be tracked above Vernon prior to later detection during downstream migration at Vernon.

Travel and Residence Time

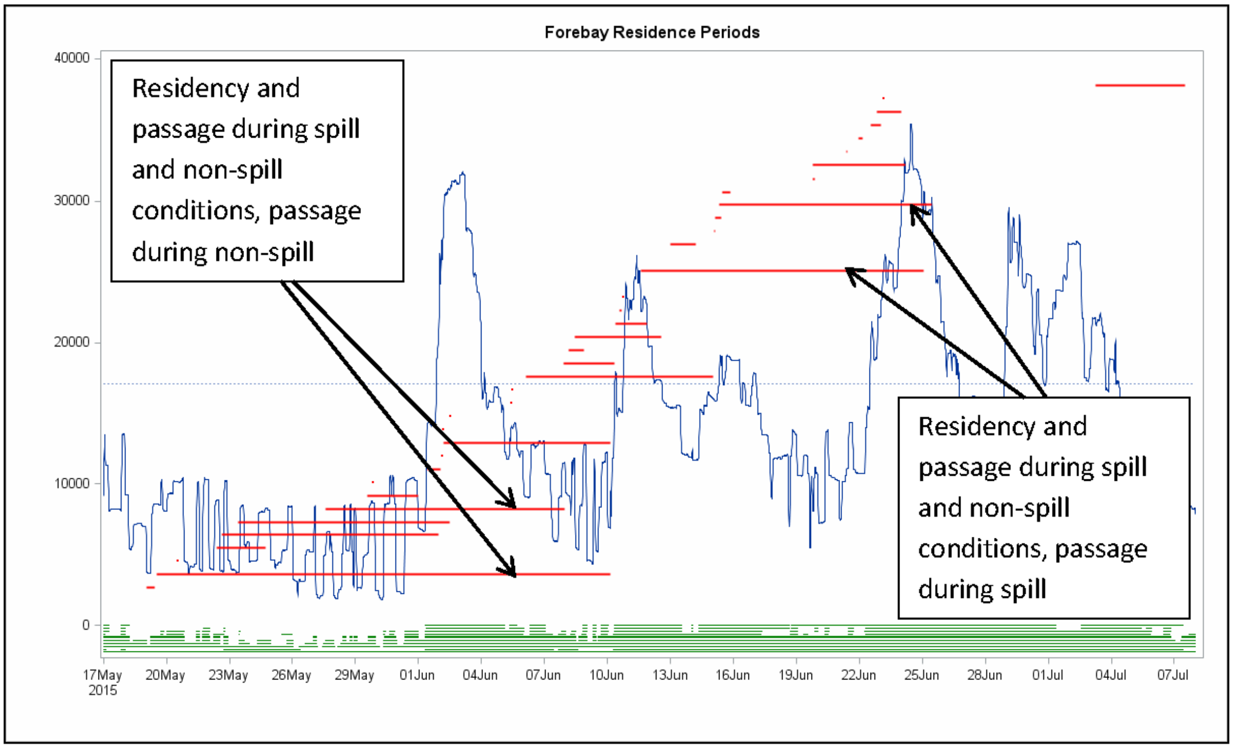
The time from release upstream of Vernon or from volitional upstream passage through the Vernon fishway to the subsequent return detection in the forebay ranged from approximately 21 hours to 39.5 days with a median time of 12.3 days. Fifty-nine shad (91 percent) were subsequently detected in the forebay, and of those, 9 individuals (15 percent) were determined to be mortalities following removal from the trashracks. It could not be determined whether those individuals died following return to Vernon or whether they had drifted downstream following mortality upstream, so they were excluded from further analysis. Conflicting detections for 1 additional shad between the TransCanada and FirstLight detections required removing that individual from further analysis. For the remaining 49 individuals, a forebay residence time could be determined for 39 of them (3 were not detected in the forebay but were detected downstream after passage, and 7 were detected in the forebay but not at any downstream monitoring station or through manual monitoring downstream). Shad returned to the forebay area from May 18 to July 3. The majority of returns occurred during June with minor peaks in the daily number of downstream migrants coinciding with peaks in the mean daily river flow (Figure 3.5-12). Forebay residence time ranged from several minutes to greater than 21 days (median just under 12 hours) and was shortest for fish that passed via the fish pipe (median = 36 minutes) and higher for those passing via Unit Nos. 5–8 (median = 17.8 hours) and Unit Nos. 9–10 (median = 1.2 days).



Source: ILP Study 21, *American Shad Telemetry Study* (report revision in progress)

Figure 3.5-12. Distribution of forebay entry dates for radio-tagged shad approaching Vernon dam during downstream migration relative to mean daily flow (cfs), 2015.

River and operational conditions varied over the full duration of forebay residence time for individual shad. Figure 3.5-13 overlays forebay residence times with the total river flow conditions, presence of spill (i.e., flow conditions exceeding Project generating capacity of 17,100 cfs) and operational condition of Unit Nos. 1–10. Individuals with relatively short forebay residence times (less than or equal to 12 hours) were generally associated with periods when river flows exceeded Project capacity (i.e., spill).



Source: ILP Study 21, *American Shad Telemetry Study* (report revision in progress)
Notes: Solid blue line – 2015 total river flow (cfs)
Dashed blue line - Project generating capacity
Red lines - forebay residence times for radio-tagged shad
Green lines - operational status of Unit Nos. 1 (upper) through 10 (lower) where green = unit on and blank spaces = unit off

Figure 3.5-13. Temporal distribution of forebay residence times for radio-tagged adult shad emigrating past Vernon dam, 2015.

Route Selection

A definitive passage route could not be determined for approximately one-third of the radio-tagged shad passing downstream of Vernon. For those with known routes, the majority were determined to have passed via spill (36 percent) and through the fish pipe (19 percent) with the remainder using the turbine units. None passed via Unit Nos. 1–4 or via the smaller fish tube located along the western shoreline, adjacent to Unit No. 10 (Table 3.5-23).

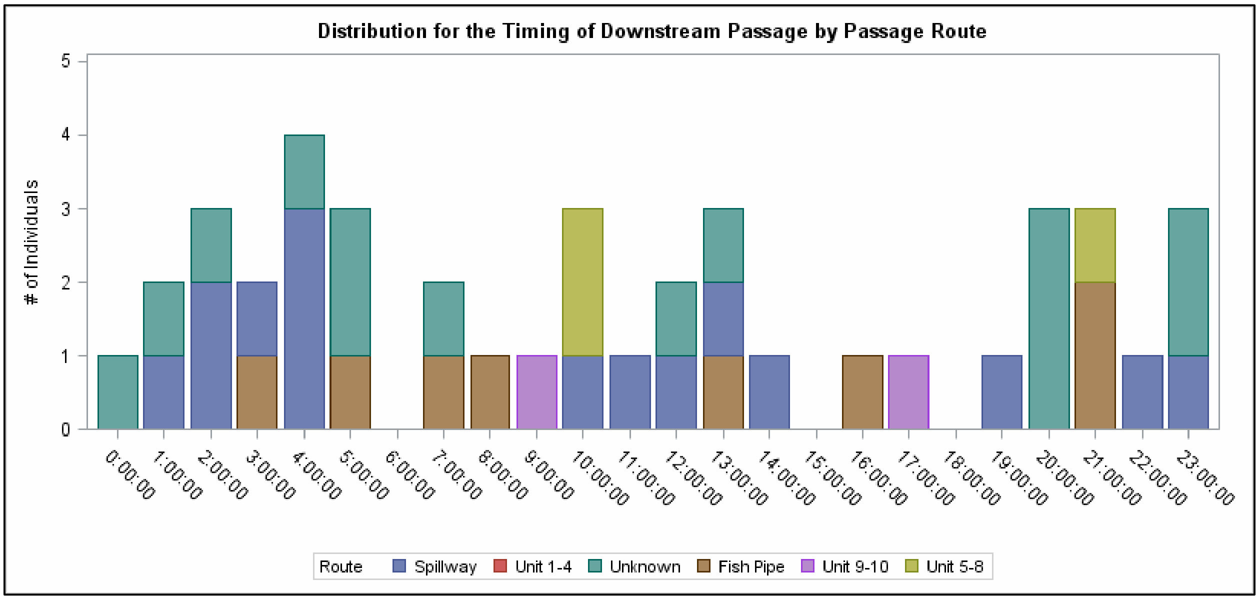
Table 3.5-23. Final disposition and downstream passage routes of radio-tagged adult American Shad at Vernon, 2015.

Final Disposition	Downstream Passage Route	Number	% of Total Passed
Total Available		**65**	
No return from upstream	-	6	
Approached but did not pass	-	7	
Mortality on trashracks	-	9	
Excluded due to data conflicts	-	1	
Subtotal (did not pass)		**17**	
Passed downstream of Vernon	Turbine Units 1–4	0	0.0
	Turbine Units 5–8	3	7.1
	Turbine Units 9–10	2	4.8
	Fish tube	0	0.0
	Fish pipe	8	19.0
	Spillway	15	35.7
	Unknown	14	33.3
Total passing Vernon		**42**	**-**

Source: ILP Study 21, *American Shad Telemetry Study – Vernon* (report revision in progress)

The majority of downstream passage events occurred when all 10 units were in operation, nearly 50 percent of the time during the study period. The temporal pattern of downstream passage events relative to total station discharge and spill discharge at Vernon is presented in Figure 3.5-14. Peaks in downstream passage events generally coincided with peaks in both total flow and project spill. The timing of downstream passage events appeared to be fairly uniform in distribution with no strong pattern in the diel timing of downstream passage when examined by route selection (Figure 3.5-14). This is likely a function of a relatively small sample size.

Five individuals carrying only PIT-tags (of 41 that detected passing upstream through the fish ladder, see Section 3.5.2.3, *Effects of Upstream Passage on Migratory Fish*) were later detected passing downstream via the fish pipe. They passed during the same period as observed for radio-tagged shad. The period of travel and residence in the Connecticut River upstream of Vernon until downstream passage at Vernon potentially included time spent in the forebay, impoundment, and Bellows Falls riverine reach and ranged from 9 to 34 days for these 5 individuals. PIT-tagged shad were not included in the evaluation of downstream route selection. Due to the inability to detect PIT-tagged shad as they returned to the forebay, it was not possible to calculate an accurate upstream residence time for those individuals. With regard to route selection, only the fish pipe had PIT-tag coverage. As a result, inclusion of PIT-tagged individuals in the assessment of route selection along with the radio-tagged individuals would bias the overall route distribution results because detection efficiency for PIT-tagged fish at all routes other than the fish pipe was equal to zero (due to lack of coverage). As a result, any PIT-tagged individuals passing via spill, the fish tube, or Unit Nos. 1-10 would not be represented.



Source: ILP Study 21, *American Shad Telemetry Study* (report revision in progress)

Figure 3.5-14. Distribution of the observed downstream passage times for radio-tagged adult American shad at Vernon.

Downstream Passage Survival

The downstream progress of the 42 radio-tagged shad known to have passed Vernon was evaluated by reviewing the existing telemetry data collected as part of Study 21 and for the FirstLight monitoring associated with their concurrent adult shad study at Northfield Mountain and Turners Falls (FirstLight, 2016d). For each individual passing Vernon, the time series of stationary telemetry data was reviewed, and detections were noted at the upstream end of Stebbins Island at Northfield Mountain and at Turners Falls.

The degree of downstream progress following passage at Vernon is potentially influenced by a number of factors, including injury and mortality associated with dam passage, natural mortality (i.e., predation, post-spawn effects, and body condition), and incidental tag loss. Considering all of those factors, the downstream progress for radio-tagged adult shad following passage at Vernon is shown by passage route in Table 3.5-24. Of the 42 individuals known to have passed Vernon, 79 percent were detected at monitoring station 1, 60 percent were detected at Northfield Mountain, and 55 percent were detected at Turners Falls.

Although comparisons among known passage routes are limited by sample size, individuals passing Vernon via Unit Nos. 9–10 and via the fish pipe showed a higher degree of downstream progress as indicated by detection at Turners Falls, (100 percent, and 75 percent, respectively) than individuals passing via spill (60 percent), or Unit Nos. 5–8 (33 percent).

Table 3.5-24. The number of individuals detected by telemetry monitoring following downstream passage at Vernon by passage route, 2015.

Passage Route	Number of Individuals Detected				% Reaching Turners Falls
	Passing Vernon	Upstream of Stebbins Island	Northfield Mountain	Turners Falls	
Fish pipe	8	7	6	6	75.0
Spill	15	14	10	9	60.0
Unit Nos. 5–8	3	1	1	1	33.3
Unit Nos. 9–10	2	2	2	2	100.0
Unknown	14	9	6	5	35.7
Total	42	33	25	23	54.8

Source: ILP Study 21, *American Shad Telemetry Study* (report revision in progress)

Based on the results of Study 21, TransCanada concludes that the Vernon Project does not appear to hinder the ability of adult shad to locate downstream passage routes or delay the timing of emigration. Recognizing that there are non-Project related reasons that adult shad may incur post-spawn mortality, TransCanada also concludes that the Vernon Project does not appear to significantly affect adult American Shad to safely pass the Project (78.6 percent were detected at Stebbins Island, and nearly 55 percent at Turners Falls).

Vernon Project—Juvenile American Shad

Study 22 evaluated proportional route selection and forebay residency time for juvenile shad by radio-tagging and systematically monitoring movement and passage tagged shad through the Vernon Project. A total of 310 juvenile shad was tagged and released upstream of Vernon dam on 15 occasions during a 6-week period between September 25 and October 30, 2015. Fish were tagged and released in groups of 13–20 and released in 3 general areas (east, west and mid-river) along a perpendicular transect across the river, which originated near the VY cooling water intake located approximately 0.75 mile upstream of Vernon dam. Remote telemetry monitoring occurred at the Vernon forebay, log boom and diversion boom, fish pipe, fish tube, turbines, tailrace, and spillway.

Because of a data processing error discovered after the Study 22 report was filed, some downstream passage telemetry data may have been inaccurately reported. Those data are currently being reanalyzed and will be reported in a revised study report. Therefore, results related to downstream route selection and residency of radio-tagged juvenile shad are not available at this time and an assessment of Project effects will be provided in the FLAs.

Study 22 also included evaluation of the timing of the 2015 emigration run in the vicinity of the entrance to the downstream fish pipe (the primary existing downstream passage route) in the forebay near the powerhouse by continuous hydroacoustic sampling (i.e., sonar). The time series of the acoustic index of abundance was used to determine the onset, departure, timing and duration of peak abundance, diel periodicity, and depth distribution of juvenile shad. Temporal trends were verified by 3 independent complementary sampling methods: (1) discrete cast net samples in the forebay, (2) visual observations of fish near the surface in the forebay, and (3) electrofishing samples immediately upstream of the forebay.

Results of the hydroacoustic evaluation showed that schooling fish first appeared in the Vernon forebay on August 17 and last appeared on October 30 (74 days); however, they were not consistently present until the beginning of September. Fish density increased through September to the highest density on October 3, decreased on subsequent days, and then peaked moderately on 2 isolated late occasions (October 23 to 24 and 30) before declining to zero by November. The major peak started with a steady increase in fish density from September 25 to the highest peak on October 3 and then steadily declined to October 8 (a duration of 13 days) before density increased again over several days of fluctuation. The second highest daily mean fish density occurred on October 24 during a 2-day peak on October 23 and 24. A single-day peak having the fifth highest daily mean fish density occurred on October 30. These temporal trends are consistent with a single major outmigration run followed by two pulses of late migrants. Timing of the emigration observed in this study was in reasonable agreement with observations made by others in other locations in the Connecticut River in the past (e.g., Normandeau, 2015b; O’Leary and Kynard, 1986). As observed in other studies (O’Donnell and Letcher, 2008; O’Leary and Kynard, 1986; Leggett and Whitney, 1972), fish school echoes were most abundant following a sharp decrease in water temperature and were absent once water temperatures remained below 50°F (10°C). Results of this study indicate some correlation between density in the forebay and river flow, in addition to peak densities triggered by decreasing water temperature.

Fish density was highest during the afternoon and dusk, periods when juvenile shad are known to move at other locations in the Connecticut River (O’Leary and Kynard, 1986). Schools concentrated in the mid-water column generally in an approximate 20- to 33-foot (6- to 10-meter) range during the day and then migrated up toward the surface before and during dusk. There was a central tendency of school echoes found closer to the surface and within the depth layer of the fish pipe opening later in the season during October.

Based on hydroacoustic evaluation and the complementary sampling, juvenile shad were determined to have successfully passed Vernon since fish density representative of juvenile shad within the forebay quickly decreased from observed peak densities with some peak densities lasting only 1 or 2 days and tracked echoes of juvenile-shad-sized fish primarily moved through the beam in the west-southwesterly direction toward the fish diversion boom and the powerhouse. There was no evidence that juvenile shad accumulated in the forebay over the emigration season, which would have been indicative of a migratory barrier or migratory delay. Therefore, it is unlikely that Project operations impede timely movement of juvenile American Shad through the Vernon Project.

3.5.2.5 Effects on Impingement and Entrainment

Study 23 was a literature-based evaluation of impingement and entrainment susceptibility and effects of a representative group of fish species based on the overall fish assemblage for each Project. These target species were primarily identified based on a combination of life history strategies, their relative abundance in the impoundment community, and their trophic guild. Additional species were added when a major family or trophic guild was not included based on those criteria.

For individuals susceptible to entrainment and impingement, avoidance of the intakes is related to fish size and swimming performance (Castro-Santos and Haro, 2005). A literature review of swim speed information was conducted for the 15 target fish species that inhabit the Wilder, Bellows Falls, or Vernon impoundments to compare available swim performance data for these species to measured water velocity proximal to the Project intakes. Intake or approach velocities were calculated for the various turbine unit types at the Projects (Table 3.5-25).

Table 3.5-25. Calculated intake velocities at Wilder, Bellows Falls, and Vernon.

Project and Unit	Maximum Potential Turbine Discharge (cfs)	Calculated Intake Velocity (ft/s)
Wilder Units 1–2	5650	2.2
Wilder Unit 3	825	1.4
Bellows Falls Units 1–3	3850	2.2
Vernon Units 1–4	1100	1.4
Vernon Units 5–8	1860	2.5
Vernon Units 9-10	2060	2.1

Source: ILP Study 23, *Fish Impingement, Entrainment, and Survival Study*

Impingement

Fish impingement is a function of trashrack spacing. Fish body widths for representative species and lengths were taken from the scientific literature or derived via calculation from body width proportions (Smith, 1985) to determine the tendency of fish to be impinged at Project trashracks (Table 3.5-26). The rate of impingement for species/body lengths is also a function of their ability to escape the flow field associated with the intake structures.

Table 3.5-26. Fish body widths for representative lengths of target fish at the Wilder, Bellows Falls, and Vernon Projects.

Target Species	Max. Adult Length[a]	Body Width (BW) for Given Total Length (TL) (in.)						BW as % of TL
		TL=5	TL=10	TL=15	TL=20	TL=30	TL=40	
American Eel	45	0.2	0.4	0.6	0.8	1.1	1.5	3.8
White Sucker	25	0.9	1.8	2.7	3.6			17.8
Bluegill	10	0.8	1.7					16.8
Largemouth Bass	20+	0.8	1.7	2.5	3.3			16.5
Smallmouth Bass	20	0.8	1.6	2.4	3.2			15.8
American Shad[b]	18	0.8	1.6	2.5	3.3			16.4
Fallfish	20	0.8	1.6	2.4	3.2			16.1
Golden Shiner	12	0.7	1.3	2				13
Spottail Shiner	6	0.9						18
Northern Pike	40+	0.8	1.6	2.4	3.2	4.8	6.4	16
Brown Bullhead	12	1	2.1	3.1				20.6
Yellow Perch	15	0.7	1.4	2.1				14.1
Walleye	34	0.8	1.5	2.3	3	4.5		15
Tessellated Darter	4.5	0.8						16.9
Sea Lamprey	36	0.4	0.8	1.2	1.6	2.3		7.8[c]

Source: ILP Study 23, *Fish Impingement, Entrainment, and Survival Study*

a. As indicated in Langdon et al. (2006).

b. American Shad included as a target species at Vernon only.

c. Body depth was used instead of body width since body width information was not available and Lamprey are more or less cylindrical in cross section.

Wilder Project

For the 14 target species at Wilder and their representative lengths, no calculated body widths were wider than the trashrack clear spacing on Unit Nos. 1 and 2 (5.0 inches); therefore, impingement is unlikely. Unit No. 3 has a narrower clear spacing (1.625 inches). As a result, most of the target species that can reach 15 inches or more in total length (Table 3.5-26) have a calculated body width that may leave them vulnerable to impingement on the Unit No. 3 trashracks.

Bellows Falls Project

Bellows Falls Unit Nos. 1–3 are all shielded by trashracks with 4.0-inch clear spacing. Of the 14 target species, only Northern Pike and Walleye with a body length greater than 30 inches (Table 3.5-26) reached calculated body widths wider than the trashrack clear spacing that could make them vulnerable to impingement.

Vernon Project

Vernon Unit Nos. 1–8 have clear spacing of 1.75 inches, and as a result, most of the target species that can reach 15 inches or more in total length (Table 3.5-26) have a calculated body width that may leave them vulnerable to impingement. Unit Nos. 9 and 10 have a 3.625-inch clear spacing, and similar to Bellows Falls, only Northern Pike and Walleye with a body length greater than 30 inches reached calculated body widths wider than the Unit Nos. 9 and 10 trashrack clear spacing that could make them vulnerable to impingement.

Entrainment

Assessing entrainment potential included an examination of the characteristics of each Project relative to life history and behavioral traits of the target species, including swim speed. Juvenile individuals of littoral fish species (i.e., Bluegill, Largemouth Bass, and Smallmouth Bass) are likely more susceptible to entrainment than adults of those species due to their lesser swimming abilities. However, these species are more prevalent in shallower, shoreline habitat and would likely have a lower entrainment potential at units positioned near the center of the channel. Likewise, the preference for more nearshore habitat of forage species such as Golden and Spottail Shiner may help to offset their relatively weak swimming ability and lower their entrainment potential. Entrainment potential for pelagic, predatory species such as Walleye and Yellow Perch may be increased while following prey species into the intake areas (i.e., during the fall out migration of juvenile American Shad at Vernon). Adults of those species are strong swimmers and should be capable of avoiding intake velocities at all three Projects. However, the ability to react to intake velocities may be reduced for injured fish or those that become lethargic due to loss or reduction of swimming ability, which can occur in coldwater conditions. Members of the target fish community most susceptible to entrainment are those whose life history strategies include downriver movement, and small bodied (i.e., juvenile) fish. As reported in Winchell et al. (2000), there is little difference in fish size distributions for the wide range of bar rack clear spacing represented in the reviewed studies. Across all rack spacings, 94 percent of entrained fish were less than 8 inches long.

Comprehensive reviews of entrainment data (EPRI, 1997; FERC, 1995) suggest that several factors can influence the potential of entrainment at any given hydroelectric project as summarized in Table 3.5-27 and described for each Project below.

Table 3.5-27. Comparison of factors that may influence entrainment of target fish species at the Wilder, Bellows Falls, and Vernon Projects.

Influencing Factors	Wilder	Bellows Falls	Vernon
Intake adjacent to shoreline	Yes	No	Yes
Intake location in littoral zone	No	No	Yes
Abundant littoral zone species	Yes	Yes	Yes
Abundant clupeids	No	No	Yes
Obligatory migrants	Few	Some	Yes
Intake depth (ft) at max./min. impoundment elevation	~30	surface	~5
Approach velocity (ft/s)	1.4–2.2	2.2	1.4–2.5
Maximum station capacity (cfs)	10,700	11,400	17,100
Seasonal impoundment drawdown	No	No	No
Water quality	No	No	No

Source: ILP Study 23, *Fish Impingement, Entrainment, and Survival Study*

Wilder Project

Factors reducing entrainment potential at Wilder are the lack of clupeids, low numbers of obligatory migrants, relatively deep intakes (upper intake elevations are approximately 30 ft below the maximum operating impoundment level), and the lack of a seasonal impoundment drawdown. Approach velocities at the trashracks were estimated to be relatively low (1.4 to 2.2 ft/s), which also helps reduce the likelihood of entrainment. Primary factors increasing entrainment potential may include the location of the intakes relative to the shoreline (within approximately 200 ft).

Bellows Falls Project

Primary factors reducing entrainment potential at Bellows Falls may include the lack of clupeids, low numbers of obligatory migrants, lack of a seasonal impoundment drawdown, and the absence of a natural shoreline (i.e., suitable littoral habitat) adjacent to the intake structure due to the presence of the elongated power canal. Approach velocities at the trashracks were estimated to be relatively low (2.2 ft/s), which will also help reduce the likelihood of entrainment because many fish can swim faster than this. Primary factors increasing entrainment potential include the shallow depth of the upper intake elevations (surface level) in relation to the maximum operating impoundment level.

Vernon Project

The primary factors reducing entrainment potential are slightly reduced intake depths (upper intake elevations are approximately 5 ft below the maximum operating impoundment level) and the lack of a seasonal impoundment drawdown. Approach velocities at the trashracks were estimated to be relatively low (1.4 to 2.5 ft/s), which will also help reduce the likelihood of entrainment. Primary factors increasing entrainment potential at Vernon may include the location of the intakes relative to the shoreline (within approximately 300 ft) as well as the large number of obligatory migrants (juvenile American Shad) upstream of the Project.

Overall Entrainment Potential

The resulting qualitative assessment of entrainment potential used Project-specific factors along with data previously described from the literature (i.e., habitat and life history, swim speeds, and comparable hydroelectric locations as summarized in EPRI, 1997) to evaluate the potential entrainment of target fishes at each of the Projects. The qualitative assessment used a multi-step rank from high (H) to medium (M) to low (L). An overall entrainment potential was assigned to each target species and lifestage at each Project (Table 3.5-28), which indicates the potential for adverse Project effects on some species and lifestages. Note that the likelihood of entrainment for a particular species or lifestage in the vicinity of the intakes may be low due to low abundance in the impoundment (see Section 3.5.1.3, *Resident Fish Populations*, and Section 3.5.1.4, *Migratory Species*), but if present in the Project forebays, these species and lifestages would be expected to have the same overall potential for entrainment as estimated in Table 3.5-28.

Table 3.5-28. Overall qualitative assessment of the entrainment potential of target fish species for the Wilder, Bellows Falls, and Vernon Projects.

Species and Lifestage	Wilder	Bellows Falls	Vernon
American Shad			
Juvenile	NA[a]	NA[a]	H
Adult	NA[a]	NA[a]	H-M
American Eel			
Juvenile	M-L	M-L	L
Adult	H-M	H-M	H-M
Bluegill			
Juvenile	H-M	H-M	H-M
Adult	M-L	M-L	M-L
Brown Bullhead			
Juvenile	M-L	M-L	M-L
Adult	L	L	L
Fallfish			
Juvenile	L	L	L

Species and Lifestage	Wilder	Bellows Falls	Vernon
Adult	L	L	L
Golden Shiner			
Juvenile	H-M	H-M	H-M
Adult	M-L	M-L	M-L
Largemouth Bass			
Juvenile	M	M	H-M
Adult	M-L	M-L	M
Northern Pike			
Juvenile	L	L	M-L
Adult	L	L	L
Sea Lamprey			
Juvenile	M-L	M-L	M
Adult	L	L	L
Smallmouth Bass			
Juvenile	M	M	H-M
Adult	M-L	M-L	M-L
Spottail Shiner			
Juvenile	H-M	H-M	H-M
Adult	H-M	H-M	H-M
Tessellated Darter			
Juvenile	M-L	M-L	L
Adult	M-L	M-L	L
Walleye			
Juvenile	M	M	H-M
Adult	M-L	M-L	M-L
White Sucker			
Juvenile	M	M	M
Adult	M-L	M-L	M-L
Yellow Perch			
Juvenile	H-M	H-M	H-M
Adult	M-L	M-L	M-L

Source: ILP Study 23, *Fish Impingement, Entrainment, and Survival Study*

3.5.2.6 Effects on Turbine Survival

Study 19 included direct turbine survival studies of tagged silver-phase American Eels emigrating through the Wilder, Bellows Falls, and Vernon Projects during typical operating conditions. Study 22 included turbine survival studies of tagged juvenile American Shad emigrating through Vernon during typical operating conditions. Study 23 used a desktop approach to estimate turbine survival rates for target species of both resident and migratory fish at the Projects. The report in in revision at this time but available information is included herein.

Desktop Analysis of Turbine Survival

Franke et al. (1997) defines the 3 primary risks to emigrating fish passing through the turbine environment as: (1) mechanical mechanisms; (2) fluid mechanisms; and (3) pressure mechanisms. Mechanical mechanisms are primarily defined as forces on a fish's body resulting from direct contact with turbine structural components (e.g., rotating runner blades, wicket gates, stay vanes, discharge ring, draft tube, passage through gaps between the blades and hub, or at the distal end of blades or other structures placed into the water passageway). The probability of that contact depends on the distance between blades, number of blades, and fish body length. Additional sources of mechanical injury may include gap grinding, abrasion, wall strike, and mechanical chop. Fluid mechanisms are defined as shear-turbulence (the effect on fish of encountering hydraulic forces due to rapidly changing water velocities) and cavitation (injury resulting from forces on fish body due to vapor pockets imploding near fish tissue). Impacts from pressure result from fish inability to adjust from regions of high pressure immediately upstream of turbines to regions of low pressure immediately downstream of turbines. Results from most studies indicate that mechanical related injuries are the dominant source of mortality for fish in the turbine environment at low head (less than 100 ft) projects (Franke et al., 1997). Blade strike is considered the primary mechanism of mortality when fish pass through turbines (Cada, 2001; Eicher Associates Inc., 1987) and pressure related injuries appear to be of minor secondary importance when working at low head hydroelectric projects.

Study 23 included calculation of blade strike potential and estimated survival at applicable turbine settings for each of the turbine types at each Project (e.g., at maximum unit discharge, peak unit efficiency, and minimum flow) as discussed below.

Wilder Project

Blade strike potential and estimated survival rates were calculated for the 2 adjustable-blade Kaplan turbines (Unit Nos. 1 and 2) and the vertical Francis turbine (Unit No. 3). Under typical full load (higher than the discharge at peak unit efficiency) for Unit Nos. 1 and 2, survival estimates ranged from 95 to 99 percent for small (4- to 8-inch) fish, from 86 to 95 percent for 15-inch fish, and from 45 to 91 percent for 30-inch fish. At Unit No. 3 under minimum flow only (because that is typical operation for the unit), survival estimates ranged from 72 to 93 percent for small (4- to 8-inch) fish, from 47 to 73 percent for 15-inch fish, and from 0 to 47 percent for 30-inch fish.

Bellows Falls Project

Blade strike potential and estimated survival rates were calculated for the 3 vertical Francis units at maximum unit discharge, at peak unit efficiency, and at minimum flow. Under all scenarios, survival estimates ranged from 87 to 97 percent for small (4- to 8-inch) fish and from 52 to 88 percent for larger (15- and 30-inch) fish.

Vernon Project

Blade strike potential and estimated survival rates were calculated for the 4 vertical Kaplan units (Nos. 5–8) and the 6 vertical Francis units (Nos. 1–4 and Nos. 9 and 10) at maximum unit discharge, at peak unit efficiency, and at minimum flow (Unit Nos. 5–8 and No. 10 only, since those are the units used for minimum flow). Under all scenarios for the Kaplan turbines, survival estimates ranged from 78 to 98 percent for small (4- to 8-inch) fish, from 59 to 83 percent for 15-inch fish, and from 18 to 86 percent for 30-inch fish. Survival estimates for the Francis units ranged from 80 to 96 percent for small (4- to 8-inch) fish under all scenarios, and for larger fish, survival estimates ranged from 62 to 85 percent for 15-inch fish and from 24 to 71 percent for 30-inch fish.

American Eel

The turbine survival portion of Study 19 was conducted in late October and early November 2015 at the Wilder, Bellows Falls, and Vernon Projects. Adult American Eels (imported, see Section 3.5.2.4*, Effects on Downstream Passage of Migratory Fish*) were tagged using the HI-Z Turb'N (HI-Z) tag (Heisey et al., 1992) recapture technique and associated statistical methods to estimate immediate (1-hour) and delayed (48-hour) survival. For comparison purposes, control eels were tagged and released at each Project but were not subjected to passage through turbines. Tagged "treatment" eels were released into the intakes of designated turbine units at each Project. After passage, live and dead eels were captured and the condition of each was examined. At the end of the 48-hour holding period, tags were removed and all alive and uninjured eels were released to the river. Survival and malady-free rates were estimated for each passage location with the exception of Wilder Unit No. 3 where the study was suspended because of low recapture rates (see below). Descriptions of the observed injuries were recorded to help assess the probable causal mechanisms for injury/mortality. Fish free of visible injuries, having less than 20 percent scale loss per side and free of loss of equilibrium were designated with a malady-free status. Study results are discussed below for each Project and summarized in Table 3.5-29.

Wilder Project

For Study 19, 10 eels were released through Francis Unit No. 3 (the minimum flow unit); however, testing at that unit was curtailed after the release when it was determined that most of the discharge from this unit was directed to the upstream fish ladder for attraction flow required for the simultaneous and extended-season upstream passage operations required for Study 17, and the features within the fish ladder prevented the recapture of 7 of those 10 eels. Fifty eels were released through Kaplan Unit No. 2, and 40 eels (80 percent) were recaptured alive, while 7 (14 percent) were retrieved dead. Only dislodged inflated HI-Z tags were retrieved on 3 (6 percent) treatment eels. The eels with only the HI-Z tags recaptured were assigned a dead status. Ten control eels were also released.

The direct survival estimate of 62.2 percent for eels passing through Kaplan Unit No. 2 was lower at this unit than any of the other units tested at Bellows Falls and Vernon. The injury rate (42.6 percent) for the recaptured eels was also the highest observed, and 36.2 percent of the injuries were classified as major. These injuries were primarily bruised or severed bodies. Similar survival and injury results would be expected for the untested, but similar, Kaplan Unit No. 1. This direct survival estimate falls in the middle of the range of predicted survival estimated in Study 23 (in revision) of 45 to 91 percent at discharge flows similar to flows during testing (Table 3.5-29).

Although the Francis Unit No. 3 was not able to be tested because of the configuration of the discharge, its characteristics are similar to the Francis turbine tested at Vernon Unit No. 4 (see below). The small Francis turbine at Wilder has 14 buckets, a runner speed of 212 revolutions per minute (rpm), and a runner diameter of 72 inches. The turbine at Vernon Unit No. 4 has 13 buckets, a runner speed of 133.3 rpm, and a runner diameter of 62.5 inches. The 48-hour survival of eels passed through this turbine was 93.5 percent. Based on these results, adult eels passing through Wilder Unit No. 3 could have a similar survival rate; however, Study 23 results (in revision) predict much lower survival values for Unit No. 3 (0 to 50 percent), depending on the Franke et al. (1997) correlation factors and fish entry point in the turbine (e.g., blade tip, mid-blade, and near hub).

Bellows Falls Project

Fifty eels were released in Study 19 through the Francis Unit No. 2 along with 10 control eels. Both treatment and control eels had a recapture rate of 100 percent, but the recapture rate of 97.4 percent for the combined controls from all of the Projects was used in the analysis. The estimated immediate (1-hour) survival was 100 percent. The 48-hour direct survival rate of 98 percent for eels passing Unit No. 2 was the highest obtained at any of the turbines tested at the Projects. The injury rate of 14 percent was the second lowest observed, and only 6 percent of the examined eels had injuries considered major. Injuries were primarily bruises to the body. Because all of the Bellows Falls units are similar, eels should incur little mortality and injury passing the Bellows Falls turbines. This direct survival estimate is higher than the range of predicted survival estimated in Study 23 (54 to 77 percent) at discharge flows similar to flows during testing (Table 3.5-29).

Vernon Project

For Study 19, eels were released on 4 days at Vernon—48 eels through the Francis Unit No. 4; 48 eels through the Kaplan Unit No. 8 discharging 1,000 cfs; 50 eels through Unit No. 8 discharging 1,700 cfs; and 48 eels through the Francis Unit No. 9. Control eels were released on 2 dates during the study (10 eels and 9 eels). Recapture rates were high at 93.8 percent at Unit No. 4; 95.8 percent at Unit No. 8

at 1,000 cfs; 88.0 percent at Unit No. 8 at 1,700 cfs; and 95.8 percent at Unit No. 9. The recapture rate of 97.4 percent for the combined controls from all of the Projects was used in the subsequent analysis. Inflated, dislodged HI-Z tags were retrieved on 1 at Unit No. 4; 2 at Unit No. 8 at 1,000 cfs; and 4 at Unit No. 8 at 1,700 cfs. The eels with only the HI-Z tags recaptured were assigned a dead status.

The 48-hour direct survival was highest (97.9 percent) for eels passed through the larger Francis turbine Unit No. 9 at Vernon. This unit also had the lowest injury rate (8.7 percent) of any of the turbines tested. Additionally, none of the injuries (bruises on head and body and fin damage) were classified as major. This survival estimate is higher than the range of predicted survival estimated in Study 23 (57 to 79 percent) at discharge flows similar to flows during testing (Table 3.5-29).

The smaller Francis Unit No. 4 also had a relatively high, 48-hour survival of 93.5 percent; however, 36.5 percent were injured, primarily bruises to head and body, and 20 percent of the eels had major injuries. This survival estimate is much higher than the range of predicted survival estimated in Study 23 (24 to 62 percent) at discharge flows similar to flows during testing (Table 3.5-29).

The Kaplan Unit No. 8 had a higher 48-hour survival (87.5 percent) at the lower discharge tested (1,000 cfs) than at the higher discharge (1,700 cfs) for which the survival was 74 percent. Injury rates were similar, 28.3 and 27.3 percent, respectively, for the 2 discharge rates. Although injury rates were similar, the lower discharge inflicted fewer major injuries (8.7 percent) than the higher discharge (22.7 percent). Additionally, more fish were severed at the higher discharge. This survival estimate is slightly higher than the range of predicted survival estimated in Study 23 (17 to 82 percent) at discharge flows similar to flows during testing (Table 3.5-29).

Table 3.5-29. Comparison of direct survival and injury, and predicted survival of adult eels passed through Wilder, Bellows Falls, and Vernon turbines, 2015.

Project	**Wilder**	**Bellows Falls**	**Vernon**			
Turbine Type	**Kaplan**	**Francis**	**Francis**	**Kaplan**	**Kaplan**	**Francis**
Unit Tested	**No. 2**	**No. 2**	**No. 4**	**No. 8**	**No. 8**	**No. 9**
Average Unit Discharge During Testing	4,748	3,229	992	1,236	1,681	1,308
Runner Speed (rpm)	112.5	85.7	133.3	144	144	75
Runner Diameter (inches)	180	174	62.5	122	122	110
48-hour Survival (%)	62.0	98.0	93.5	87.5	74.0	97.9
Visibly Injured (%)	42.6	14.0	35.6	28.3	27.3	8.7
Major Injuries (%)	36.2	6.0	20.0	8.7	22.7	0.0
Dominant Injury	Severed or bruised body	Bruises on body/head	Bruises on body/head	Bruises on body/head	Severed body	Bruises on body/head
Predicted Survival at Approximate Tested Discharge (%)[a]	45–91	54–77	24–62	17–82	18–85	57–79

Source: ILP Study 19, *American Eel Downstream Passage Assessment*; ILP Study 23, *Fish Impingement, Entrainment, and Survival Study*

a. Data are from Study 23. Predicted survival ranges are based on Franke et al. (1997) correlation factors and different fish entry points (e.g., blade tip, mid-blade, and near hub).

Juvenile American Shad

Vernon Project

Direct turbine survival studies for juvenile American Shad were conducted at Vernon as part of Study 22 during the fall of 2015. Approximately 500 juvenile shad for this study were transported from the North Attleboro National Fish Hatchery in Massachusetts to Vernon. Because of high mortality rates within a day or 2 after being placed in the holding tank, a decision was made to use wild in-river fish even though they were much smaller. High mortality of hatchery fish was also observed in the 2014 tagging experiments conducted on wild and hatchery juvenile shad (Normandeau, 2014). As a result, 600 wild fish were collected upstream of Vernon dam. Each fish of sufficient size for tagging was fitted with a miniature radio transmitter and a HI-Z tag using standard procedures (Heisey et al., 1992) and associated statistical methods to estimate immediate (1-hour) and delayed (48-hour) survival. For comparison purposes, control shad were tagged and released but were not subjected to passage through turbines. Tagged fish were introduced individually into the penstocks of Unit Nos. 4 and 8 (151 and 150, respectively) by an induction apparatus, and 150 control fish were released directly into the tailrace. While Unit Nos. 9 and 10 were not evaluated in the relicensing study, Unit No. 10 had been tested previously (Normandeau, 1995) and results of that study are included here for completeness. Testing occurred at Unit No. 8 on October 7, 8, and 10 and at Unit No. 4 on October 10 and 11, 2015.

Fish showing erratic behavior or external injuries and/or fungal infections were rejected and not used in the analysis. After release of both treatment and control fish, the fish were tracked downstream of the powerhouse and retrieved once they were buoyed to the surface by the inflated HI-Z tag. Because of the high mortality of control fish (30.3 percent) at 48 hours, only the 1-hour direct survival estimates could be made reliably. Estimated survival was 91.7 percent for Francis Unit No. 4 and 95.2 percent for Kaplan Unit No. 8, these survival rates are near the median and mean direct survival estimates attained at numerous similar direct survival studies conducted on juvenile clupeids at other projects (referenced in Study 22) and at Vernon's Francis Unit No. 10 in 1995 (Normandeau, 1995).

The estimated survival rates for the Francis turbines (Unit Nos. 4 and 10) and the Kaplan turbine (Unit No. 8) tested at Vernon followed the trends observed for the relationship between survival and runner diameter and number of blades. Unit No. 4 has the smallest diameter (62.5 inches) and the lowest survival (91.7 percent) while survival rates were higher (94.7 percent) for the larger Francis Unit No. 10 (156 inches), and 95.2 percent for the Kaplan Unit No. 8 (122 inches). The effect of the number of blades on survival was most evident when comparing the results for the 5-bladed Unit No. 8 to those for the 13-bladed Unit No. 4. The relative high survival (94.7 percent) for the 15-bladed Unit No. 10 was primarily due to its larger diameter and slower runner speed (74 rpm). Unit No. 4 runner speed is 133 rpm, nearly twice that of Unit 10. Operational head was not a factor because all 3 Vernon units have a similar operating head.

In Study 23, the ranges of estimated survival rates for 4-inch fish at each unit type and at flows similar to those tested in Study 22 encompass the direct survival results and thus results from both studies are in agreement. Study 23 results indicate survival of 90 to 95 percent at Unit Nos. 1–4, 89 to 98 percent at Unit Nos. 5–8, and 93 to 97 percent at Unit Nos. 9 and 10 (Table 3.5-30).

Table 3.5-30. Comparison of direct and estimated survival rates for juvenile American Shad at Vernon.

Unit No.	Test Date	Flow (cfs)	Study 22	Study 23	
			1-Hour Survival (%)	Flow Type	Calculated Survival (%)
4	Oct 10	1,298	91.7	Peak efficiency / maximum discharge	90–95
4	Oct 11	1,370	91.7	Peak efficiency / maximum discharge	90–95
8	Oct 7	1,234	95.2	Peak efficiency	89–98
8	Oct 8	1,233	95.2	Peak efficiency	89–98
8	Oct 10	1,157	95.2	Peak efficiency	89–98
10	NA	NA	94.7	All flows	93–97

Source: ILP Study 22, *Downstream Migration of Juvenile American Shad – Vernon*; ILP Study 23, *Fish Impingement, Entrainment, and Survival Study*

Based on turbine characteristics, estimated direct juvenile American Shad survival for the 3 turbine types tested, and a previous direct survival study on juvenile Atlantic Salmon at Vernon (Normandeau, 1996), juvenile shad should fare best passing through Kaplan Unit Nos. 5–8, followed by Francis Unit Nos. 9 and 10. The smaller Francis Unit Nos. 1–4 would likely be least fish friendly.

3.5.3 Cumulative Effects

3.5.3.1 Migratory Fish Passage

Because hydroelectric dams influence both upstream and downstream fish migration within river systems, FERC (in SD2) identified the geographical extent of potential cumulative effects on anadromous, catadromous, and diadromous fish species to include the Connecticut River from Long Island Sound upstream to each species' historical habitat range.

Upstream Passage

Before reaching the Vernon dam fish ladder, the most downstream of the 3 TransCanada Projects, migratory fish that return to the Connecticut River from marine environments must first successfully pass upstream through the hydroelectric facilities at Holyoke (RM 87) and then move upstream via the various routes at Turners Falls (RM 122). The number of diadromous fish passing upstream of FirstLight's Turners Falls Gatehouse fish ladder and the ratio of those passing Vernon in 2015 (FWS, 2015; Study 17) were as follows: Atlantic Salmon, 200 percent (3 Atlantic Salmon were reported as released at Turners Falls Gatehouse, but 6 were reported passing Vernon); American Shad, 68 percent; and Sea Lamprey, 29 percent. No cumulative effects within the TransCanada Projects have been identified or evaluated, and as noted in Section 3.5.2.3, *Effects on Upstream Passage of Migratory Fish*, the TransCanada Project fish ladders do not appear to pose barriers to upstream passage for these species within their natural ranges.

Downstream Passage

Cumulative effects may accrue for American Eels, some of which must pass 1 or more TransCanada Projects during emigration. As noted in Section 3.5.2.4, *Effects on Downstream Passage of Migratory Fish*, data from Study 19 are currently being reanalyzed and will be reported in a revised study report, as well as related results in a revised Study 23 report. Therefore, results related to downstream route selection and residency of eels are not available at this time, a discussion of cumulative effects will be provided in the FLAs.

3.5.3.2 Resident Fish, Mussels, Sediment Movement

In SD2, FERC identified the geographical extent of cumulative effects on resident fish species, freshwater mussels, and sediment movement to include the upper extent of the Wilder impoundment downstream to the Route 116 Bridge in Sunderland,[35] Massachusetts. FERC chose this geographic area because "the operation of the 5 Projects (TransCanada and FirstLight Projects) could be a contributing factor to sediment movement within the river and cumulative effects on resident fisheries and freshwater mussel habitat in this area."

Based on the results of Studies 2–3 (see Section 3.3, *Geologic and Soil Resources*) and Study 6 (see Section 3.4.2.2, *Environmental Effects, Water Quality*), negligible effects will occur from TransCanada's normal Project operations on sediment movement or on levels of turbidity that might indicate sediment movement large enough to affect fish and aquatic species or their habitats downstream. Therefore, no cumulative effects on resident fish and mussels due to sediment movement from the TransCanada Projects are likely and were not evaluated.

[35] From FERC SD2: The Route 116 Bridge is located at the approximate upstream extent of the Holyoke Project (FERC No. 2004) impoundment.

3.5.4 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures related to fish and aquatic resources. However, TransCanada will continue to implement the following environmental measures that support protection of fish and aquatic resources in new licenses:

- Operate upstream and downstream passage facilities seasonally for migratory species in consultation with CRASC. Based on the results of Study 17, extending the upstream fish passage season at the Projects for resident species is not warranted.
- Continue to normally operate the projects in a manner similar to historic operation, characterized by a limited range of WSE fluctuation (within the overall range of impoundment range) and drawdown rates (normally 0.1 to 0.2 ft per hour and no more than 0.3 ft per hour).
- Provide minimum flows in accordance with the current licenses and continue to provide the typically higher minimum flows from generation.

3.5.5 Unavoidable Adverse Effects

As discussed above, some minor, adverse effects from normal Project operations will continue to occur under new licenses, including dewatering of some fish eggs or nests during the spawning season for some resident species and for migratory species, such as the Sea Lamprey. The level of adverse effects varies depending on the water year as suggested by Study 5 modeling output, but overall these effects are small for most fish species. Some injury or mortality to downstream migrating American Eels and American Shad will continue to occur through impingement, entrainment, or turbine mortality, although these effects are generally small.

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3.6 Terrestrial Resources

3.6.1 Affected Environment

The Connecticut River corridor within the Wilder, Bellows Falls, and Vernon Projects provides terrestrial habitat for a variety of terrestrial species. The "terrestrial study area" is defined as lands with flowage easements retained by TransCanada, lands owned in fee by TransCanada, the Project-affected riverine reaches downstream of each dam, plus a 200-foot buffer (Figure 3.6-1). The terrestrial study area extends from the upper extent of the Wilder impoundment to about 1.5 miles below Vernon dam and encompasses approximately 9,200 acres.

As part of the relicensing process, TransCanada conducted several studies to gather information necessary to understand the potential effects of the Wilder, Bellows Falls, and Vernon Projects and associated WSE fluctuations on terrestrial resources. These studies included:

- Jesup's Milk Vetch Hydrologic Study (Normandeau, 2013b);
- Rare, Threatened, and Endangered Plant and Exemplary Natural Community Assessment (Normandeau, 2013c);
- ILP Study 25, Dragonfly and Damselfly Inventory and Assessment;
- ILP Study 26, Cobblestone and Puritan Tiger Beetle Survey;
- ILP Study 27, Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats;
- ILP Study 28, Fowler's Toad Survey; and
- ILP Study 29, Northeastern Bulrush Survey.

3.6.1.1 Botanical Resources

The terrestrial study area supports a variety of vegetative cover types and a diversity of land uses. To quantify and properly describe the available habitat within the terrestrial study area, land use and vegetative cover types were mapped as part of Study 27. Vegetation cover type boundaries were digitized from aerial photos using stereo imaging software. Because aquatic vegetation was not visible at the time of the imagery flight, aquatic beds were mapped from true-color orthophotographs (U.S. Department of Agriculture, 2009) and refined during field work. During photointerpretation, other resources were referenced for supporting information, including hydric soil maps, National Wetlands Inventory (NWI) maps, hydrology maps, topographic maps, and additional publicly available aerial photographs, as needed, to confirm features.

Upland vegetation cover is predominantly forest (64 percent of the upland cover) followed by agricultural land (29 percent of the upland cover) (Table 3.6-1). Agricultural use, primarily cropland and pasture/hayfield, is the predominant cover type over much of the more level terrain adjacent to the river, especially along the

Wilder impoundment. Wetlands are widely distributed across the terrestrial study area with the majority consisting of aquatic vegetation (43 percent of the wetland cover), emergent (25 percent of the wetland cover), deciduous forested (22 percent of the wetland cover), and scrub-shrub (10 percent of the wetland cover) cover types.

Upland Forest

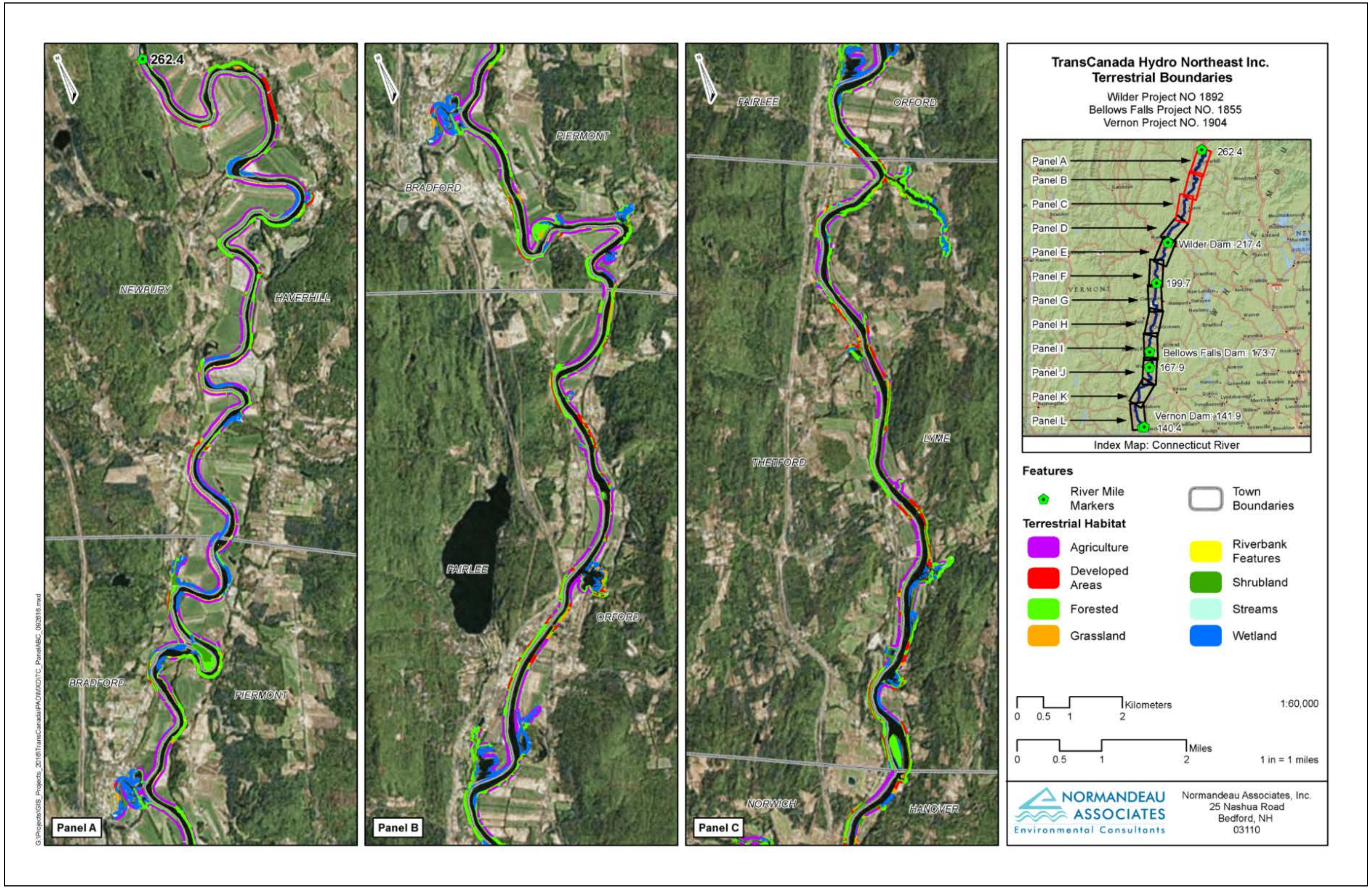
Upland and Riparian Hardwood

The upland hardwood canopy component includes a relatively homogenous group of trees dominated by sugar maple, northern red oak, American beech, and basswood. Shrubs are generally sparse with the exception of the invasive species glossy buckthorn and bush honeysuckle at a few sites. However, the herbaceous component of the forests is diverse and includes wild-lily-of–the-valley, wild sarsaparilla, white wood aster, rough horsetail, hog peanut, and a variety of fern species.

Riparian hardwood forest differs from upland hardwood forest primarily with respect to plant species and the potential for flooding. Typical dominant canopy species for this cover type include silver maple, eastern cottonwood, slippery elm, green ash, and boxelder. Bush honeysuckle and glossy buckthorn are common in the understory, and cinnamon fern, Japanese knotweed, ostrich fern, and rough horsetail are abundant in the herbaceous layer. These forests are likely to flood on a seasonal or annual basis. As evidence of the river's influence on these communities, fine litter is replaced by alluvial sediment deposits in areas subject to periodic flooding. Coarse litter is abundant in the form of trees, limbs, and other debris washed in during high water events.

The results of Study 27 indicate that the majority of the upland hardwood forests in the terrestrial study area are at a mid-successional stage. They are dominated by trees at an intermediate age and height but include a few large trees and a limited shrub and sapling layer. The canopy reaches heights of 60 to 90 feet, and canopy closures range from 60 to 90 percent. Most of the upland hardwood forest is relatively high in elevation and shows little evidence of flood scour or deposition.

Upland hardwood forest is the predominant cover type in the terrestrial study area covering 24 percent of the entire terrestrial study area, and it is most abundant within the Vernon impoundment (812 acres, 33 percent of the combined Vernon impoundment and short riverine reach; see Table 3.6-1).



Source: ILP Study 27, *Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study*

Figure 3.6-1. Terrestrial study area.

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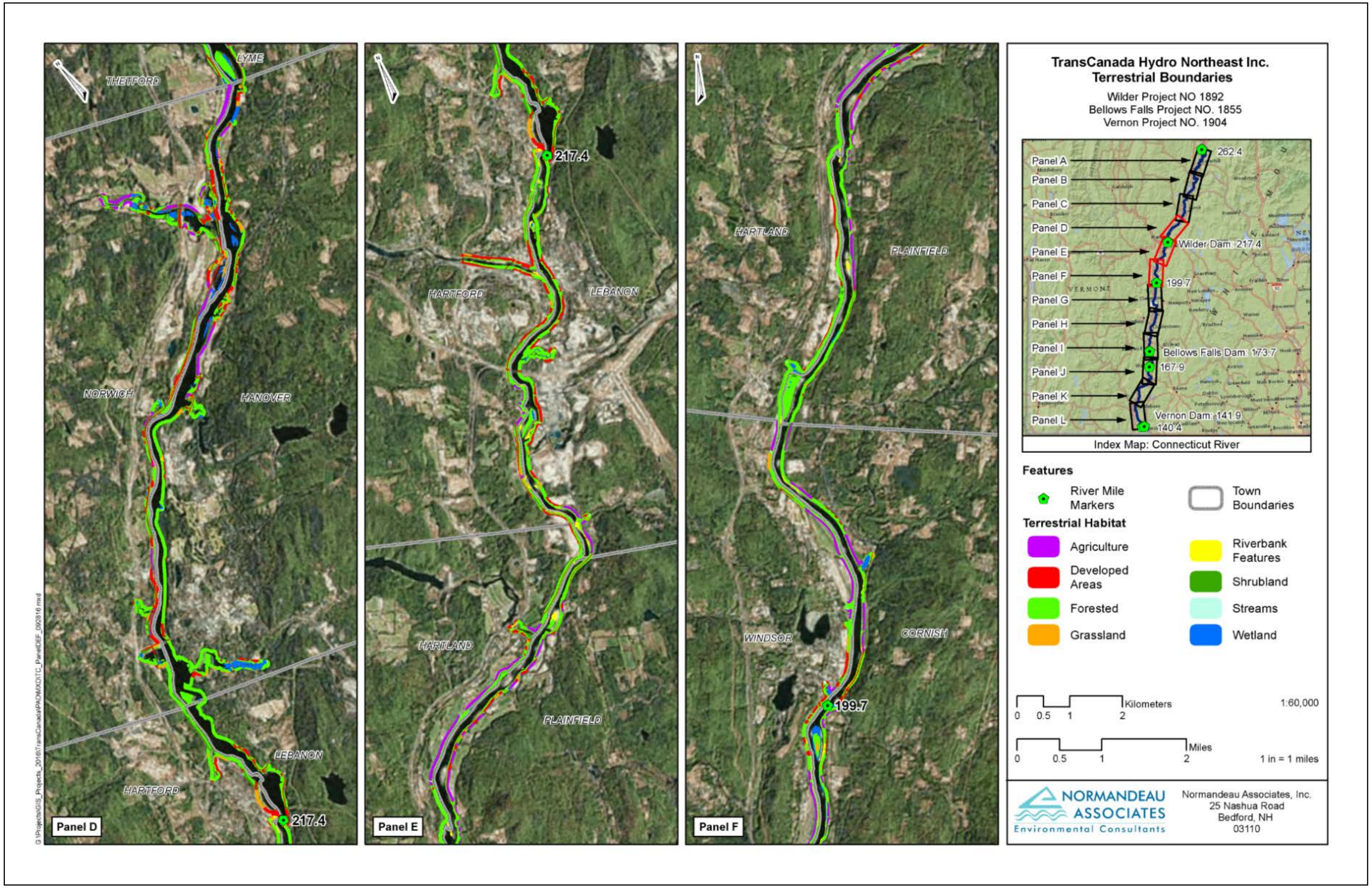

Source: ILP Study 27, *Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study*

Figure 3.6-1. Terrestrial study area (continued).

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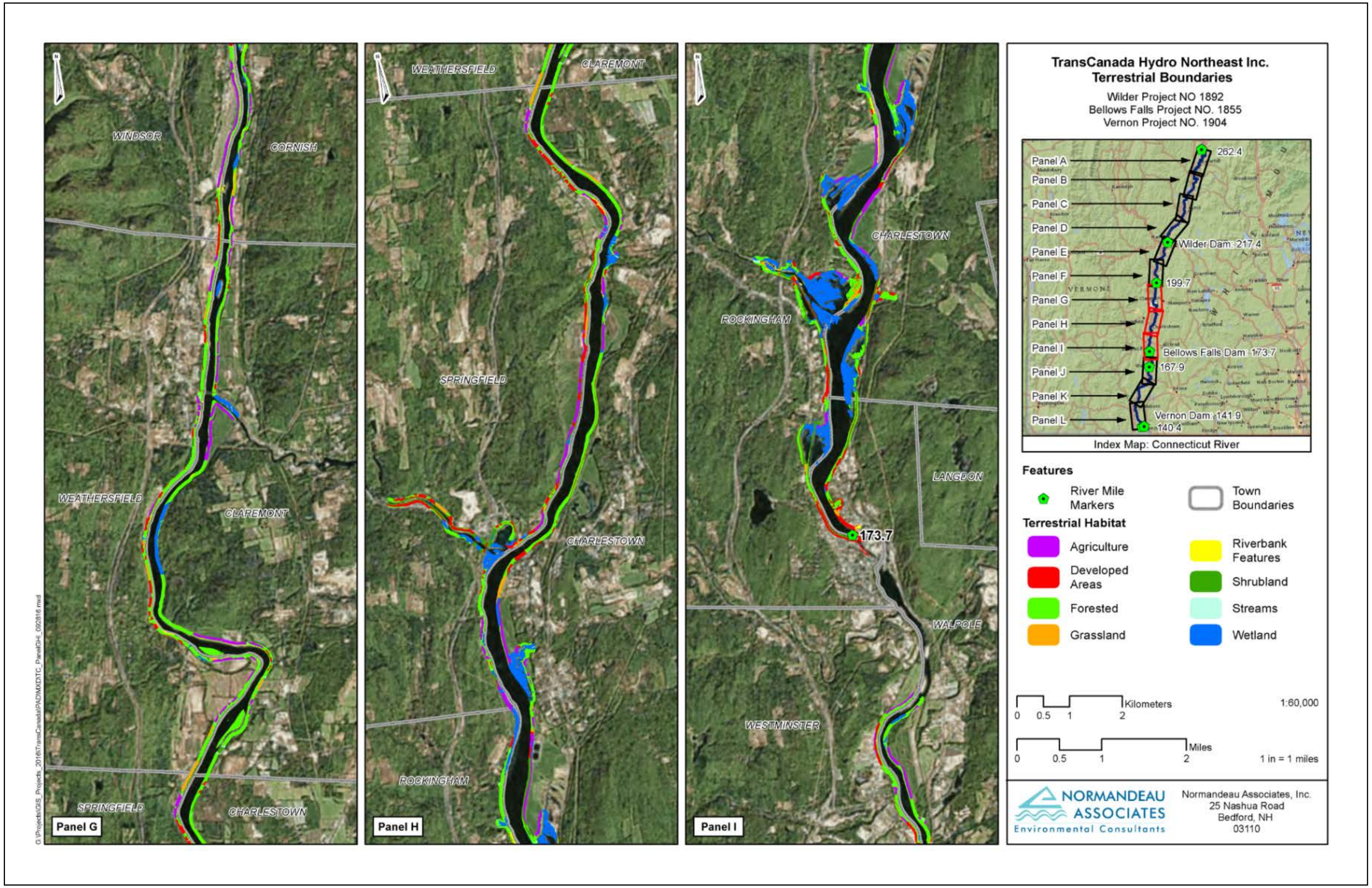

Source: ILP Study 27, *Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study*

Figure 3.6-1. Terrestrial study area (continued).

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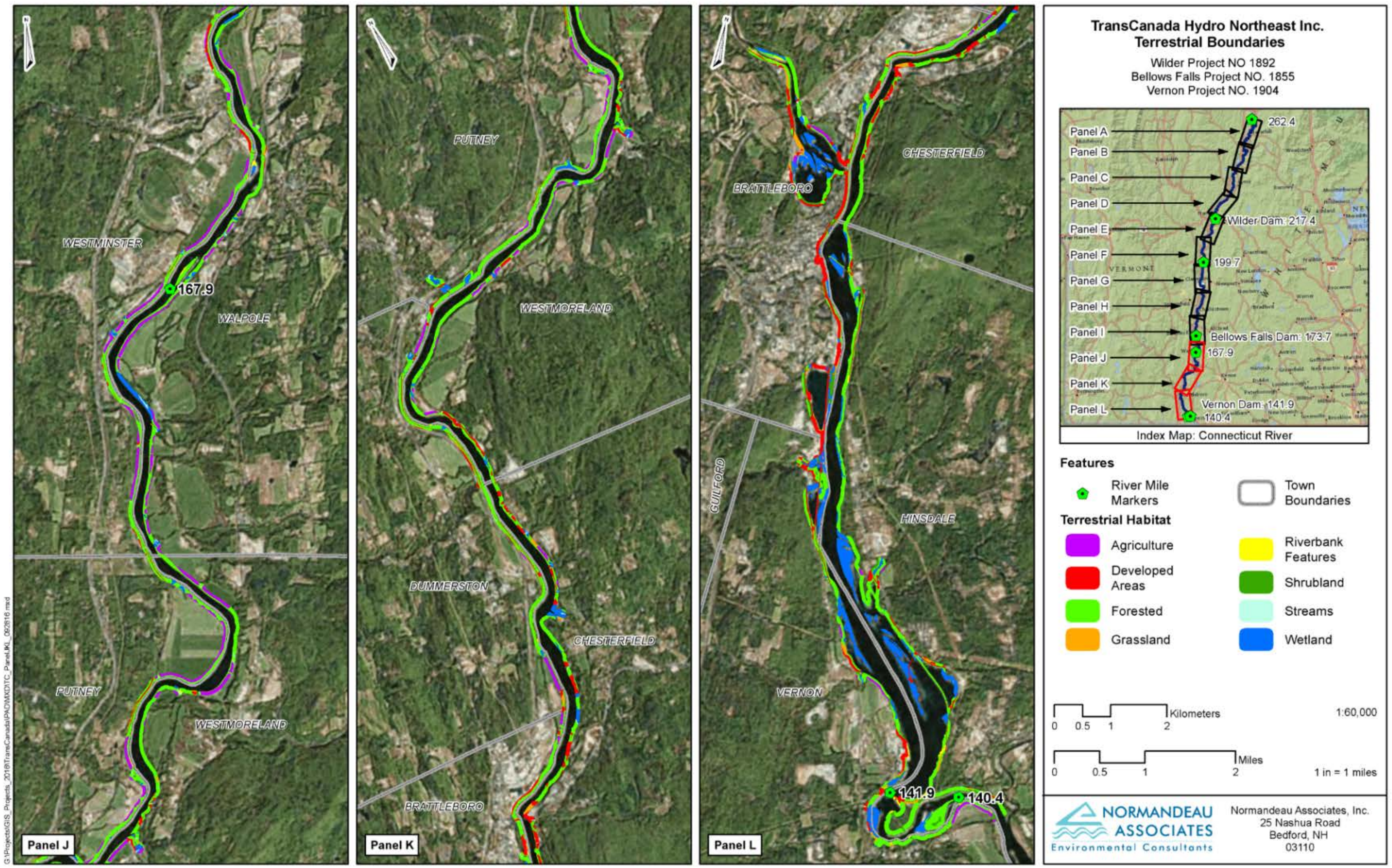

Source: ILP Study 27, *Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study*

Figure 3.6-1. Terrestrial study area (continued).

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Table 3.6-1. Acreages of cover types within the 200-foot terrestrial study area.

Cover Code	Cover type	Wilder	Wilder Riverine	Bellows Falls	Bellows Falls Riverine	Vernon[a]	Total Acres	% of Terrestrial Study Area
Upland								
H	Hardwood	486.3	379.2	469.8	59.1	812.1	2206.4	24.1
H/S	Hardwood/softwood	364.3	134.9	193.9	5.7	235.3	934.2	10.2
S	Softwood	328.2	61.7	69.1	1.2	48.1	508.2	5.6
SHR	Shrub	126.6	12.2	84.3	6.6	40.9	270.6	3.0
H/SHR	Hardwood/shrub	3.1	5.2	0.4	0.6	6.1	15.3	0.2
SHR/G	Shrub/grassland	0	0	0	0	0	0	0.0
OLD FIELD	Old field	21.2	3.5	15.3	0	2.9	42.9	0.5
GRASS	Maintained grassland	62.0	19.9	43.5	1.2	34.2	160.8	1.8
CROP	Crop	597.3	146.2	188.9	17.6	215.9	1166.0	12.7
PASTURE	Pasture/hayfield	307.8	15.3	74.6		53.4	451.2	4.9
	Total	**2296.8**	**778.1**	**1139.8**	**92.0**	**1448.9**	**5755.6**	**62.9**
Wetland								
PFO1	Deciduous forested	141.3	7.7	142.2		124.1	415.3	4.5
PFO4	Coniferous forested	0.7	0	0	0	0	0.7	< 0.1
PFO1/4	Mixed forested	5.3	0	0.4	0	3.6	9.3	0.1
PFO1/PSS	Deciduous forested/shrub	1.7	0	26.8	0	7.6	36.0	0. 4
PFO1/PEM	Deciduous forested/ emergent	0	0	1.0	0	0.7	1.7	< 0.1
PSS	Scrub-shrub	48.3	1.8	35.3	0	33.9	119.3	1.3
PSS/PEM	Scrub-shrub/emergent	25.6	0.6	16.1	0	7.9	50.3	0. 6
PEM	Emergent	133.1	4.7	241.0	0	108.2	486.9	5.3
PEM5	Phragmites	7.3	0	4.7	0	22.8	34.8	0.4
PERENN	Perennial stream	7.1	1.9	4.6	0.7	10.9	25.2	0.3
INTERMIT	Intermittent stream	1.2	0.4	1.9	0	2.1	5.6	0.1
PUB	Pond	11.6	0	3.7	0	7.1	22.4	0.3
PVP	Possible vernal pool	0.5	0.3	1.3	0	1.5	3.6	< 0.1

Cover Code	Cover type	Wilder	Wilder Riverine	Bellows Falls	Bellows Falls Riverine	Vernon[a]	Total Acres	% of Terrestrial Study Area
PAB/RAB	Submerged aquatic vegetation	318.0	0	258.3	0	326.9	903.2	9.9
	Total	**701.7**	**17.4**	**737.3**	**0.7**	**657.3**	**2114.3**	**23.1**
Developed								
Comm	Commercial	47.5	47.4	31.3	24.1	73.4	223.7	2.4
Res	Residential	135.5	36.6	108.9	1.0	81.7	363.6	4.0
Sub	Suburban	0	0	9.3	0	19.2	28.5	0.3
Mineral/dams	Dams	1.4	25.8	3.4	0	2.1	32.8	0.36
Infra	Infrastructure	154.6	70.9	89.6	17.0	129.1	461.3	5.04
	Total	**339.0**	**180.7**	**242.5**	**42.1**	**305.5**	**1109.9**	**12.1**
Riverine Features								
Ledge	Bedrock ledge	0.2	4.1	0.5	20.1	2.1	26.9	0.29
Rocky	Rocks and boulders	0.4	3.1	0.2	0	1.9	5.6	0.06
Gravel	Gravel	0.3	19.0	1.9	6.8	3.5	31.6	0.34
Sand-mud	Sand-mud	0.9	27.3	2.7	0	10.3	41.1	0.45
Riverbank	Riverbank	9.2	4.5	18.9	0	5.7	38.3	0.42
Eroding bank	Eroding bank	20.9	0	7.2	0	1.4	29.5	0.32
Riprap	Riprap	0.3	0.2	0	0	0.3	0.9	0.01
	Total	**32.2**	**58.2**	**31.4**	**26.9**	**25.2**	**173.9**	**1.9**
	Grand Total	3369.4	1034.5	2150.9	161.8	2437.0	9153.6	**100.0**
	% of Total	36.8%	11.3%	23.5%	1.8%	26.6%	100.0%	

Source: ILP Study 27, *Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study*

a. Includes Vernon impoundment and 1.5 miles below Vernon dam.

b. Wetland acreage totals are corrected from the study report (report supplement filed November 30, 2016).

Mixed Hardwood/Softwood Forest

The upland mixed forest canopy includes both hardwood and softwood components. White pine and eastern hemlock make up the softwood component of the canopy, and the hardwoods are predominantly northern red oak and sugar maple. The understory is generally lacking in shrubs with the exception of glossy buckthorn and witch hazel, and the herbaceous layer is diverse but sometimes sparse or patchy. Frequently occurring herbaceous species include poison ivy and a variety of fern species.

Results of Study 27 indicate that most of the mixed forests are at a mid-successional stage. They are dominated by trees at an intermediate age and height but include a few large trees and a limited shrub and sapling layer. Canopy species reach heights of 80 to 100 feet, and canopy closures range from 60 to 90 percent. Fine litter includes up to several inches of leaves, and coarse litter ranges from a few to many deadfalls and downed limbs. Nearly all of this cover type is located on higher elevation terraces and slopes with little evidence of flood scour or deposition.

Upland mixed forest is common throughout the area covering 10 percent of the terrestrial study area. However, it is most abundant in the reach encompassing the Wilder impoundment and the free flowing section of the river downstream of Wilder (see Table 3.6-1).

Softwood Forest

Softwood forest is dominated by eastern hemlock and white pine, but often includes a variety of common hardwood species, such as northern red oak, red maple, and sugar maple. Because of the dense canopy cover, the understory and herbaceous layers remain very sparse. In the terrestrial study area, most softwood forests are at a medium successional stage with most trees at an intermediate age and height, a few large trees, and a limited shrub and sapling layer. Canopy species reach heights of 60 to 100 feet, and canopy closures are 80 percent or higher. Fine litter is composed of several inches of leaves, and coarse litter ranges from a few to many deadfalls and downed limbs.

The results of Study 27 indicate that most softwood forests in the area occur on steep slopes and terraces with little evidence of flood scour or deposition. Softwood forest is very abundant along the periphery of the Wilder impoundment (328 acres, 10 percent of that area; see Table 3.6-1). The largest expanse of this cover type is along the eastern side of the impoundment between the dam and Hanover, New Hampshire (see Figure 3.6-1).

Grassland and Agricultural Lands

Agricultural uses, which are primarily cropland and pasture/hayfield, are the predominant cover type over the level terrain adjacent to the river, especially along the Wilder impoundment. When combined, the cover types pasture/hayfield, crop, maintained grassland, and old field make up 20 percent (1,821 acres) of the upland cover in the terrestrial study area (see Table 3.6-1).

Wetlands

Palustrine wetlands include all non-tidal freshwater wetlands dominated by trees, shrubs, persistent emergent vegetation, emergent mosses, or lichens (Cowardin et al., 1979). They offer a variety of habitat types for wildlife from vegetated beaver ponds to open marshes to vernal pools. Wetland habitats cover 1,211 acres or 23 percent of the terrestrial study area (see Table 3.6-1). Palustrine cover types occurring in these areas are divided into four basic sub-categories: aquatic vegetation, emergent wetland, scrub-shrub wetland, and forested wetland.

Aquatic Vegetation

The aquatic vegetation cover type is the most abundant wetland cover type, covering 903 acres (see Table 3.6-1). Aquatic beds are typically composed of floating and submerged aquatic vegetation and grow abundantly in shallow water zones in the lower ends of all three impoundments, as well as in the mouths of the larger tributaries. Aquatic bed vegetation also occurs in the upper reaches of the impoundments in small patches and narrow discontinuous bands in shallow water along the edges of the river, many of which were too small to map. Most species are found in all three impoundments, and many of the same species predominate in the three impoundments including white water lily, Eurasian water-milfoil, water celery, waterweed, and water stargrass.

Aquatic vegetation is typically found in silty-sandy substrates, and vegetative cover varies from dense floating and mid-column cover with 100 percent canopy closure to relatively sparse cover with little or no floating-leaved canopy. Species composition varies between areas and is influenced by factors such as water depth and water current. For example, during Study 27, white water lily was usually found in more protected areas with slower currents and shallow depths, whereas water celery grew abundantly in areas with faster currents and to observed water depths of up to 8 feet.

Emergent Wetlands

Emergent wetlands are characterized by the presence of herbaceous hydrophytes for most of the growing season. These wetlands are often referred to as marshes, meadows, or fens. In the terrestrial study area, the largest emergent wetland stands are vegetated by dense stands of broad-leaved cattail and softstem bulrush. Other dominant emergent species include rice cutgrass, woolgrass, American bur-reed, water-horsetail, narrow-leaf cattail, pickerel weed, duck potato, and numerous sedges. Invasive non-native wetland species, such as reed canary grass, purple loosestrife, and Phragmites, are also abundant (see Section 3.6.1.2, *Invasive Plant Species*).

Emergent wetlands in the area are typically located within 1 foot of estimated high water levels and are typically saturated or subject to frequent flooding. Water stains on the stems indicate that these marshes are periodically inundated from 6 to 18 inches. Emergent marshes are the most abundant wetland cover type in the terrestrial study area (PEM and PEM5 coverages combined make up 43 percent of the combined Projects' wetland habitat; see Table 3.6-1). They are located in coves, protected shorelines, old river channels, and deltas at the mouths of tributaries. Emergent wetlands in the Wilder impoundment are located primarily in the upstream reach from the vicinity of Fairlee, Vermont, to Bradford, Vermont (see Figure 3.6-1). At Bellows Falls, which accounts for nearly 50 percent of the terrestrial study area total for this cover type (see Table 3.6-1), large expanses of emergent wetlands are present in the lower third of the impoundment (see Figure 3.6-1). In the Vernon impoundment, emergent wetlands are found primarily in the broad delta at the mouth of the West River and downstream of Brattleboro (see Figure 3.6-1).

Scrub-Shrub Wetlands

Scrub-shrub wetlands are dominated by woody vegetation less than 20 feet tall. In the terrestrial study area, the scrub-shrub cover is dominated by the invasive non-native glossy buckthorn. However, speckled alder, black willow, and silky dogwood are also common. Canopy height ranges from 6 to 20 feet, and canopy cover ranges widely from 20 to 100 percent. The overall herbaceous component is relatively diverse and consists of species such as wrinkled goldenrod, jewelweed, false nettle, cleavers, common horsetail, meadow horsetail, climbing nightshade, giant goldenrod, sensitive fern, and ostrich fern. Structural diversity and patchiness are low in areas of dense shrub cover but moderate to high in the vegetative communities with more open cover enabling robust herbaceous growth.

Scrub-shrub wetlands in the terrestrial study area are frequently located slightly higher in elevation than emergent marshes, but they still experience frequent inundation as exhibited by multiple debris lines and water stains on lower trunks and leaves. In larger coves, the scrub-shrub cover type often forms a band between emergent marshes and the upland or forested wetland.

Scrub-shrub wetlands make up 14 percent of wetland habitat in the terrestrial study area (170 acres; combined PSS and PSS/PEM cover types in Table 3.6-1). The distribution of scrub-shrub wetlands is similar across all three impoundments and occurs in backwaters, along shorelines, on islands and peninsulas, and in the lower reaches of tributaries. Scrub-shrub wetlands are found throughout the Wilder impoundment but primarily in the lower half of the Bellows Falls and Vernon impoundments (see Figure 3.6-1).

Forested Wetlands

Forested wetlands are dominated by deciduous woody vegetation greater than 20 feet tall throughout the terrestrial study area. Eastern cottonwood, silver maple, boxelder, green ash, and slippery elm are prominent in the overstory and understory. Ostrich fern, sensitive fern, jewelweed, rough horsetail, and Canada nettle are abundant in the herbaceous layer. In addition, non-native invasive plants such as glossy buckthorn, stilt grass, and Japanese knotweed were noted at some locations during terrestrial habitat mapping and field work for Study 27.

Deciduous forested wetlands in the terrestrial study area are at an early to mid-successional stage. Canopy species reach heights of 60 to 80 feet, and canopy closure ranges widely from 30 to 80 percent. Structural diversity is generally moderate, patchiness is low, and fine litter consists of leaves and herbaceous plant debris. Coarse litter is common and includes deadfalls and downed limbs as well as woody debris and herbaceous material deposited as debris. Although some deciduous forested wetlands appear to experience periodic inundation, many are located at high elevations and flood less frequently.

Deciduous forested wetlands are the second-most abundant wetland cover type in the terrestrial study area (415.3 acres, 4.54 percent of combined areas; see Table 3.6-1). These wetlands are evenly distributed across the three impoundments and are generally found in medium to large tracts in backwaters, along point bars, and in the lower reaches of tributaries. Deciduous forested wetlands are found in the upper reaches of the Wilder impoundment, largely in the lower part of the Bellows Falls impoundment, and throughout the Vernon impoundment (see Figure 3.6-1).

3.6.1.2 Invasive Plant Species

Invasive plant species are very prevalent throughout the Connecticut River Valley, as indicated by the Invasive Species Atlas (IPANE, 2016), and have been observed in abundance along the banks and in most vegetation communities within the terrestrial study area. Twenty-seven plant species designated as invasive, non-native species and one additional plant considered potentially invasive were documented in the terrestrial study area during Study 27 habitat mapping and during the 2012 rare species and exemplary community survey (Normandeau, 2013c). More than 163 acres of discrete stands of invasive plants were mapped as part of Study 27. The majority of species occur along more than one impoundment (Table 3.6-2).

Japanese knotweed is the most widespread invasive species. Dense stands were mapped along the shoreline and on islands and in a variety of habitats, and 79 acres were verified in the field in the terrestrial study area. It is common along the edges of agricultural fields bordering the river, on riverbanks, and disturbed slopes. It also occurs as discrete smaller patches within larger, typically forested plant communities.

Table 3.6-2. Invasive plant species observed in the terrestrial study area.

Common Name	Location	Growth Form	Special Status NH / VT [b,c,d]
Climbing nightshade *Solanum dulcamara*	Vernon, Wilder	Herb	
Black locust *Robinia pseudoacacia*	Vernon	Tree	Restricted
Brittle naiad *Najas minor*	Bellows, Wilder	Submerged Aquatic	None / Class B
Bush honeysuckles *Lonicera sp.*	All impoundments	Shrub	Prohibited / Class B
Canada bluegrass[a] *Poa compressa*	Entire study area	Forb	
Coltsfoot *Tussilago farfara*	Bellows	Herb	
Common buckthorn *Rhamnus cathartica*	Vernon, Wilder	Tree	Prohibited / Class B
Phragmites *Phragmites australis*	All impoundments	Forb	None / Class B
Crown-vetch[a] *Securigera varia*	Wilder	Herb	Restricted
Dame's rocket *Hesperis matronalis*	Wilder riverine	Herb	Prohibited
Eurasian water-milfoil *Myriophyllum spicatum*	All impoundments	Submerged Aquatic	Class B
Forget-me-not *Myosotis sp.*	All impoundments	Herb	
Garden loosestrife[a] *Lysimachia vulgaris*	Entire study area	Herb	
Glossy buckthorn *Rhamnus frangula (Frangula alnus)*	All impoundments	Shrub	Prohibited / Class B
Japanese barberry *Berberis thunbergii*	All impoundments	Shrub	Prohibited / Class B
Japanese knotweed *Polygonum cuspidatum (Fallopia japonica)*	All impoundments	Herb	Prohibited / Class B
Japanese stilt grass *Microstegium vimineum*	Wilder riverine	Forb	Prohibited

Common Name	Location	Growth Form	Special Status NH / VT [b,c,d]
Mile-a-minute vine *Polygonum perfoliatum*	All impoundments	Vine	Prohibited
Moneywort *Lysimachia nummularia*	Vernon, Bellows	Herb	Restricted
Multiflora rose *Rosa multiflora*	All impoundments	Shrub	Prohibited
Oriental bittersweet *Celastrus orbiculatus*	All impoundments	Vine	Prohibited / Class B
Purple loosestrife *Lythrum salicaria*	All impoundments	Herb	None / Class B
Reed canary grass *Phalaris arundinacea*	All impoundments	Forb	Restricted
Russian olive *Elaeagnus angustifolia*	Wilder	Shrub	Restricted
Spotted knapweed *Centaurea biebersteinii*	Vernon	Herb	Prohibited
Swallow-wort[a] *Cynanchum sp.*	Entire study area	Vine	Prohibited / Class A (pale); Class B (black)
Winged euonymus (Burning bush) *Euonymus alatus*	Vernon	Shrub	Prohibited / Class B
Yellow flag iris *Iris pseudacorus*	All impoundments	Herb	Prohibited / Class B

Source: IPANE (2016), ILP Study 27, *Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats*

a. Observed in the study area during the 2012 rare, threatened, and endangered plant and exemplary natural community field surveys (Normandeau, 2013c).
b. New Hampshire Department of Agriculture "Watch List" (NHDA, 2015).
c. New Hampshire Department of Agriculture List of Prohibited Species (NHDA, 2012).
d. Vermont Agency of Agriculture, Food & Markets (VAAFM, 2012).

Approximately 35 acres of Phragmites-dominated scrub-shrub and emergent wetland cover were mapped in the terrestrial study area. This species forms clonal stands in herbaceous wetlands, frequently forming dense monocultures to the exclusion of native species. These larger stands are most prevalent in the extensive emergent wetlands found in the lower reaches of the Vernon impoundment. Approximately two-thirds of the Phragmites found in the terrestrial study area occur at Vernon (22.8 acres) with lesser amounts and smaller stands in the Wilder (7.3 acres) and Bellows Falls (4.7 acres) portions of the terrestrial study area. Smaller stands are common in the middle reaches of Bellows Falls and Vernon impoundments. This species is relatively uncommon on riverine reaches.

3.6.1.3 Wildlife Resources

During the relicensing studies listed in the beginning of this section, a total of 87 species of wildlife was recorded as incidental observations in Study 27 and occasionally during species-specific surveys in other terrestrial studies. Table 3.6-3 provides a complete list of wildlife species observed; **bolded** species in the table are typically associated with wetlands or open waters in the Northeast.

Table 3.6-3. Wildlife species observed during ILP studies, 2012–2015.

Common Name	Scientific Name
Amphibians/Reptiles	
American bullfrog	***Lithobates catesbeianus***
American toad	***Anaxyrus americanus***
Common snapping turtle	***Chelydra serpentina***
Fowler's toad	***Bufo fowleri***
Gray tree frog	***Hyla versicolor***
Green frog	***Lithobates clamitans melanota***
Spring peeper	***Pseudacris crucifer***
Wood frog	***Lithobates sylvaticus***
Mammals	
American beaver	***Castor canadensis***
Eastern gray squirrel	*Scirius carolinensis*
Mink	***Mustela vison***
Muskrat	***Ondatra zibethicus***
Opossum	*Didelphis virginiana*
Red fox	*Vulpes*
Red squirrel	*Sciurus vulgaris*
White-tailed deer	*Odocoileus virginianus*
Birds	
American crow	*Corvus brachyrhynchos*
American goldfinch	*Spinus tristis*
American kestrel	*Falco sparvarious*

Common Name	**Scientific Name**
American redstart	*Setophaga ruticilla*
American robin	*Turdus migratorius*
American woodcock	*Scolopax minor*
Bald eagle	***Haliaeetus leucocephalus***
Bank swallow	***Riparia***
Barn swallow	*Hirundo rustica*
Belted kingfisher	***Megaceryle alcyon***
Black-and-white warbler	*Mniotilta varia*
Blackburnian warbler	*Setophaga fusca*
Black-capped chickadee	*Poecile atricapillus*
Black-throated blue warbler	*Setophaga caerulescens*
Black-throated green warbler	*Setophaga virens*
Blue jay	*Cyanocitta cristata*
Blue-headed vireo	*Vireo solitarius*
Bobolink	*Dolichonyx oryzivorus*
Broad-winged hawk	*Buteo platypterus*
Brown creeper	*Certhia americana*
Brown-headed cowbird	*Molothrus ater*
Canada goose	***Branta canadensis***
Cedar waxwing	*Bombycilla cedrorum*
Chestnut-sided warbler	*Setophaga pensylvanica*
Common merganser	***Mergus merganser***
Common nighthawk	***Chordeiles minor***
Common raven	*Corvus corax*
Common yellowthroat	*Geothlypis trichas*
Double-crested cormorant	***Phalacrocorax auritus***
Downy woodpecker	*Picoides pubescens*
Eastern kingbird	*Tyrannus*
Eastern phoebe	*Sayornis phoebe*
Eastern wood-pewee	*Contopus virens*
European starling	*Sturnus vulgaris*
Fish crow	*Corvus ossifragus*

Common Name	Scientific Name
Gray catbird	*Dumetella carolinensis*
Great blue heron	***Ardea herodias***
Great crested flycatcher	*Myiarchus crinitus*
Great egret	***Ardea alba***
Green heron	***Butorides virescens***
Hairy woodpecker	*Picoides villosus*
Hermit thrush	*Catharus guttatus*
House wren	*Troglodytes aedon*
Killdeer	*Charadrius vociferus*
Mallard	***Anas platyrhynchos***
Mourning dove	*Zenaida macroura*
Northern cardinal	*Cardinalis*
Northern flicker	*Colaptes auratus*
Northern waterthrush	*Parkesia noveboracensis*
Osprey	***Pandion haliaetus***
Ovenbird	*Seiurus aurocapilla*
Peregrine falcon	*Falco peregrinus*
Pileated woodpecker	*Dryocopus pileatus*
Red-bellied woodpecker	*Melanerpes carolinus*
Red-eyed vireo	*Vireo olivaceus*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	***Agelaius phoeniceus***
Rock dove	*Columba livia*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Rough-legged hawk	*Buteo lagopus*
Ruby-throated hummingbird	*Archilochus colubris*
Scarlet tanager	*Piranga olivacea*
Song sparrow	*Melospiza melodia*
Spotted sandpiper	***Actitis macularius***
Tree swallow	*Tachycineta bicolor*
Turkey vulture	*Cathartes aura*
Veery	*Catharus fuscescens*

Common Name	Scientific Name
Wild turkey	*Meleagris gallopavo*
Winter wren	*Troglodytes hiemalis*
Wood duck	***Aix sponsa***
Wood thrush	*Hylocichla mustelina*
Yellow-bellied flycatcher	*Empidonax flaviventris*

Sources: ILP Study 25, *Dragonfly and Damselfly Inventory and Assessment*; ILP Study 26, *Cobblestone and Puritan Tiger Beetle Survey*; ILP Study 27, *Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study*; and ILP Study 28, *Fowler's Toad Survey*

Reptiles and Amphibians

American toads, spring peepers, green frogs, and bullfrogs were observed or heard in most of the quieter waters with emergent wetlands and aquatic beds. These regular incidental observations were made during field work for ILP Studies 25, 26, and 27. In addition, the field work for Study 28 included both standard call surveys and acoustic monitoring targeting Fowler's toad (state-listed in New Hampshire and Vermont; see Section 3.6.1.4), and survey scientists recorded all observations of other amphibian species.

One Fowler's toad was detected using acoustic monitoring during Study 28, but none were detected during the standard call surveys. Other amphibians were heard calling at all survey locations from the riverine reach downstream of Wilder dam in Lebanon, New Hampshire, to Stebbins Island downstream of Vernon dam. All other amphibian species potentially present in the survey area based on their known distribution, and that are expected to call during the month of June, were detected (e.g., American toad, spring peeper, green frog, bull frog, and gray treefrog). American toad was the species most commonly heard, both in terms of number of times detected and geographic distribution throughout the Study 28 study area.

Insects

Large, riverine systems such as the Connecticut River provide habitat for scores of insects that rely on aquatic habitat. Unique terrestrial habitats for insects within the terrestrial study area include riparian forest; riparian agriculture/grassland; and riverine edge features including banks, riprap, cliffs, and rocky shore. In addition, riverine islands and tributary confluences often create bars of sand, cobble, and gravel where insects are found.

Because hundreds of insect species spend their larval stage in rivers and emerge as adults, the shoreline interface between these aquatic and terrestrial environments is extremely important. For example, dragonfly and damselfly nymphs crawl from the river and emerge as adults on the banks of the river. Study 25 included a baseline inventory of dragonflies and damselflies (odonates) emerging along the shoreline throughout the terrestrial study area, during which 19 species of dragonfly and damselfly were identified. The three sites with the fewest odonate observations were in the riverine reaches. The two sites in the Wilder riverine reach had the fewest observations, with each site recording nine individual odonates of 5 species each, on study transects. The site in the Bellows Falls riverine reach had 30 odonate observations of 7 species. The site in the Vernon riverine reach had 159 odonate observations of 9 species, more than any other site.

The most frequently observed odonate species, which were recorded at least once at each Study 25 survey site, were zebra clubtail, riverine clubtail, rusty snaketail, cobra clubtail, rapids clubtail, and spinecrowned clubtail. In addition, prince baskettail and black-shouldered spinyleg were each observed more than 50 times during the study. Many state-listed species were observed during this study and are discussed further in Section 3.6.1.4, *Sensitive Terrestrial Species*.

Tiger beetles are among the many insect species using the cobble and sand habitat found on riverine island edges and at tributary confluences. In Study 26, the common shore tiger beetle was observed most frequently throughout the terrestrial study area, using sun-exposed cobble, gravel, and sand for foraging and mating. Adjacent sandy and loose substrates support burrows where larval stages develop for one to two summers before emerging as mating adults (Leonard and Bell, 1999). Study 26 obtained baseline distributional and abundance data for cobblestone tiger beetle (state-listed in both New Hampshire and Vermont, see Section 3.6.1.4) and Puritan tiger beetle, although that species was not observed (federally listed as threatened; see Section 3.7, *Threatened and Endangered Species*). However, common shore tiger beetles were observed at least once at each of the 14 study sites, and scientists discovered active common shore tiger beetle burrows directly adjacent to two study sites. Although study sites were selected from a variety of locations throughout the terrestrial study area (except the Wilder impoundment, where no suitable habitat could be identified), appropriate habitat was most common in the Wilder riverine reach and the Bellows Falls impoundment.

Mammals

Although a variety of mammalian species use the terrestrial study area habitat, no targeted relicensing studies focused on mammal inventory or habitat assessment. However, many incidental observations were recorded during Studies 25, 26, 27 and 28. Study scientists observed beaver lodges and dams in backwaters and evidence of bank dens on the mainstem, mostly in the three impoundments. Muskrat were observed in the larger emergent marshes, primarily in the lower Vernon impoundment. A white-tailed deer fawn observed on Chase Island indicates the value of such locations for nursery habitat. Finally, tracks of raccoon, deer, mink, opossum, and mice were frequently observed along the river shorelines.

Birds

Although various bird species use the terrestrial study area habitat, no targeted relicensing studies focused on avian inventory, and habitat assessment was limited to bald eagle nesting and roosting habitat. Bird activity was incidentally observed throughout the field surveys conducted for Studies 25, 26, 27, 28, and 29 in 2014 and 2015. Twelve species of wading birds and waterfowl were observed, including common mergansers observed throughout the terrestrial study area and a brood of six young that were observed in the Vernon impoundment. Wood ducks were observed in multiple backwater and floodplain areas throughout the Bellows Falls impoundment, and mallards were noted in both Wilder and Vernon impoundments. Other waterfowl species including Canada geese and double-crested cormorants were also abundant. Shoreline-dependent species were noted throughout the terrestrial study area. Spotted sandpipers were frequently seen along the water's edge on both protected and exposed shoreline and gravel bars throughout the river. Bank swallow colonies were relatively common throughout the Wilder and Vernon impoundments on bare banks. Belted kingfisher, great blue heron, and green heron were common throughout the terrestrial study area. These species were usually noted perching on trees and, when disturbed, would leave the roost tree and fly up or downstream from the observer's location. Great egrets were observed only once in the lower reaches of the Vernon impoundment near Vernon dam.

Juvenile and adult bald eagles were observed at multiple locations throughout the terrestrial study area, as were numerous other species of raptors including turkey vulture, osprey, red-tailed hawk, broad-winged hawk, American kestrel, and a peregrine falcon (at the Vernon impoundment). The importance of the Connecticut River corridor for bird migration (see discussion below at *Significant Wildlife Habitats*) was evident when flocks and individual passerines were observed, including mixed warbler flocks in May and June and common nighthawk in August.

Significant Wildlife Habitats

Riparian Zone

The term "riparian" refers to anything connected or immediately adjacent to the shoreline or bank of a river. The riparian zone can include floodplain, wetland (forested, scrub-shrub, or emergent), upland forest, or grassland. The riparian zone serves as the primary interface between riverine and upland habitats, influencing both the primary productivity and food resources within the river. Primary wildlife resources associated with riparian habitats include early spring plant growth in lowland riparian habitats, which provide food sources for migrating birds, black bear, white-tailed deer, and otter. In addition, bank swallows and belted kingfishers dig nesting sites in sandy riparian areas adjacent to rivers (Sperduto and Kimball, 2011), and aquatic, larval dragonflies use undercut riverbanks to leave their larval exuviae behind and emerge as flying adults (see Section 3.6.1.4).

Amphibian Breeding

River backwaters and associated riparian flowage can create vernal pools or temporary spring-filling basins. When vernal pools become inundated with water in the spring, certain amphibians lay eggs in the pools (e.g., spotted salamander, wood frog, blue-spotted salamander, Jefferson salamander, and Fowler's toad; Coburn, 2004). A complex and unique cycle of predation and reproduction occurs each year among larval amphibians, breeding invertebrates, and external predators, driven by the length of time that passes before the pool dries up in the summer.

River channels also frequently spread into vast, emergent wetland features such as Upper Meadows in Rockingham, Vermont, and Lower Meadows in Charlestown, New Hampshire. These permanent waterbodies offer habitat for green frog, bullfrog, and red-spotted newt breeding. American toads can also breed in emergent wetlands, as well as river shallows, vernal pools, or even water-filled ditches found in the terrestrial study area (Kenney and Burne, 2000).

Bald Eagle Breeding/Wintering

Bald eagles breed and overwinter in the vicinity of the Connecticut River in the terrestrial study area. Eagles generally nest in mature softwoods with easy access to fishing and limited disturbance. They establish winter roosts in mature pine stands close to features that maintain open water during sub-freezing winter temperatures (e.g., dams, fast-flowing stretches, outfalls). Ideal winter roosts also face southeast to catch early morning sun. Bald eagles are federally protected under the Bald and Golden Eagle Protection Act (16 U.S.C. § 668–668c) and are state-listed as threatened in New Hampshire and endangered in Vermont. For a full species account, see Section 3.6.1.4.

Migratory Songbird Stopovers

The Connecticut River serves as a migratory pathway for birds. Habitat between Charlestown, New Hampshire, and the Massachusetts border, which includes the Bellows Falls impoundment, Bellows Falls riverine reach, and the Vernon impoundment, has been designated as an Important Bird Area, a program implemented by the National Audubon Society, the U.S. partner for Birdlife International (National Audubon Society, 2016). The program is an effort to identify and conserve areas that are vital to birds and other biodiversity. Important Bird Areas must meet at least one of the following four criteria:

- Species of conservation concern;
- Species that are vulnerable because their populations are concentrated in one general habitat or biome type, also termed "responsibility species";
- An outstanding example of a representative or rare habitat type; or
- Species, or groups of similar species, that are vulnerable because they occur at high densities due to their congregatory behavior.

As a north-south running feature, the Connecticut River provides an important orientation tool for bird species during their migration. Between 1996 and 1998, during 6 days of surveys, an average of 3,782 migratory birds was observed annually near the White River confluence with the Connecticut River just below Wilder dam (Litwin et al., 2006). The number of birds observed per survey correlated strongly with proximity to the river and even more strongly at lower Connecticut River survey sites in Massachusetts (Litwin et al., 2006).

Locations within and adjacent to the Project areas providing stopover habitat include the Wantastiquet Mountain Natural Area adjacent to the Vernon impoundment in Chesterfield, New Hampshire, which has diverse acidic talus/rocky summit forests and provides stopover habitat for warblers during spring migration (Visit New Hampshire, 2012).

3.6.1.4 Sensitive Terrestrial Species

Sensitive terrestrial species include state-listed species or species considered imperiled. Large numbers of rare plant species are concentrated along the Connecticut River's banks and floodplains. These riverine and riparian habitats also support state listed wildlife species. During the 2012 and 2014 field seasons, TransCanada worked with the New Hampshire Natural Heritage Bureau (NHNHB) and Vermont Natural Heritage Inventory (VTNHI) to develop a database of known records of state-listed species. This consultation resulted in the identification of 79 listed species that occur within 1,000 feet of the river's edge from the upstream extent of the Wilder impoundment to 1.5 miles downstream of Vernon dam (i.e., including those records outside the 200-foot terrestrial study area) (Table3.6-4). All federally listed terrestrial and aquatic wildlife and botanical species that are known to occur or that may occur within the Project areas are discussed in Section 3.7, *Threatened and Endangered Species*.

Invertebrates

Cobblestone Tiger Beetle

The cobblestone tiger beetle is listed as threatened in both New Hampshire and Vermont. It has an extremely restricted habitat and is found on cobble and gravel beaches on river edges and the upstream side of riverine islands where the river deposits small- to medium-sized cobble in times of high flow (Leonard and Bell, 1999). Before Study 26, individuals of this species were found in the vicinity of the Wilder, Bellows Falls, and Vernon Project areas with existing records spanning from Johnston Island (Lebanon, New Hampshire, in the Wilder riverine reach) to Walpole Island (Walpole, New Hampshire, in the Bellows Falls riverine reach). A previous record also existed as far south as the West River (Brattleboro, Vermont, in the Vernon impoundment), but that record was just outside the defined influence of Vernon Project operations.

Table 3.6-4. State-listed terrestrial species that occur or may occur within 1,000 feet of the Connecticut River within the Project areas.

Scientific Name	Common Name	VT Status[a]	NH Status[a]	Federal Status[a]	Habitat
Invertebrate Animals (excluding freshwater mussels, see Section 3.5, *Fish and Aquatic Resources*)					
Cicindela marginipennis	Cobblestone tiger beetle	T	E	---	Sandy beaches on river's edge (Leonard and Bell, 1998)
Cicindela puritana	Puritan tiger beetle	T	T	T	Sandy beaches on river's edge (Leonard and Bell, 1998)
Gomphus ventricosus	Skillet clubtail	---	SC	---	Medium to large rivers with mud bottom (Nikula et al., 2003)
Stylurus amnicola	Riverine clubtail	---	SC	---	Medium to large rivers with sand, gravel, or mud bottom (Nikula et al., 2003)
Vertebrate Animals[b]					
Rana pipiens	Northern leopard frog	---	SC	---	Wet open meadows, wet fields, river floodplains
Glyptemys insculpta	Wood turtle	---	SC	---	Meandering streams with sandy bottoms
Myotis septentrionalis	Northern long-eared bat	E	T	T	Upland forests, caves (Lacki et al., 2009; Sasse and Perkins, 1996)
Dendroica cerulea	Cerulean warbler	---	SC	---	Mature, deciduous, floodplain forests
Haliaeetus leucocephalus[c]	Bald eagle[c]	E	T	P[c]	Large lakes and rivers; large, riparian trees for nesting, roosting
Podilymbus podiceps	Pied-billed grebe	---	T	---	Freshwater ponds with large areas of emergent vegetation, marshy edges of rivers/lakes

Scientific Name	Common Name	VT Status[a]	NH Status[a]	Federal Status[a]	Habitat
Plants[d]					
Acer nigrum	Black maple	---	T	---	Rich, mesic forests, riparian forests
Adlumia fungosa	Allegheny-vine	---	E	---	Rocky forests, cliff bases, gardens
Allium schoenoprasum	Wild chives	---	E	---	Riverbanks, shoreline outrcrops, meadows, fields, roadside, and vacant lots
Arabis pycnocarpa	Hairy eared-rockcress	---	E	---	Ledges, rock outcrops, rocky woodands
Arisaema dracontium	Green dragon	T	E	---	Floodplain forest (NHNHB; VTNHI); rich mesic forests, riparian forests
Asclepias quadrifolia	Four-leaved milkweed	---	E	---	Forests and woodlands, associated with rich soils and/or circumneutral bedrock
Asclepias tuberosa	Butterfly milkweed	T	E	---	Dry fields, sand plains, roadsides, disturbed areas
Astragalus robbinsii var. jesupii	Jesup's milk vetch	E	E	E	River shore beaches and ledges, cliffs, and talus
Bromus kalmii	Kalm's brome	---	E	---	Dry, mesic soils of outcrops, open forests and woodlands, less frequently in wet mesic meadows and riparian forests
Calystegia spithamaea	Upright false bindweed	T	E	---	Sandy fields, roadsides, clearings, railroads, woodlands, and sad plain grasslands
Cardamine concatenata	Cut-leaved toothwort	---	E	---	Rich, moist woods and talus (NHNHB; VTNHI)
Cardamine maxima	Large toothwort	---	T	---	Rich, mesic, upland and riparian forests
Carex aurea	Golden-fruited sedge	---	T	---	Rich fens and seeps; rich wet meadows; calcareous riverside seeps (NHNHB; VTNHI); Cobble pavement and seepy outcrop river shorelines, wet ledges, and borrow pits

Scientific Name	Common Name	VT Status[a]	NH Status[a]	Federal Status[a]	Habitat
Carex baileyi	Bailey's sedge	---	T	---	Rich fens and seeps; rich swamps; rich wet meadows (NHNHB; VTNHI); lake shores, stream edges, ditches, meadows, and other low wet ground
Carex foenea	Bronze sedge	E	---	---	Woodlands, cliffs, sandy fields, and open, disturbed soil
Carex garberi	Elk sedge	T	T	---	Calcareous riverside seeps (NHNHB; VTNHI); river shores in high pH bedrock, usually seepy outcrops or cobble pavement
Carex granularis	Limestone-meadow sedge	---	E	---	Rich fens and seeps; rich wet meadows (NHNHB; VTNHI) shorelines, disturbed soils, meadows, high pH bedrock
Carex retroflexa	Reflexed sedge	--	E	---	Mesic to dry-mesic, deciduous forests, woodlands, clearings and open areas
Carex trichocarpa	Hairy-fruited sedge	---	E	---	Rich swamps (NHNHB; VTNHI) wet meadows, ditches, lake shores, riverside margins
Crassula aquatica	Pygmy-weed	---	E	---	Aquatic bed; brackish marshes, mudflats, and margins of freshwater pools and rivers (NHNHB; VTNHI); open, often muddy shorelines, brackish tidal rivers and non-tidal rivers
Crocanthemum bicknellii	Plains frostweed	T	---	---	Open, sandy soils of woodlands, roadsides, clearings, dry fields, and sandplains
Crotalaria sagittalis	Rattlebox	T	E	---	Sandy soil of fields, roadsides, borrow pits, and pond shores
Cynoglossum virginianum ssp. boreale	Wild hound's-tongue	T	E	---	Deciduous and mixed evergreen-deciduous forests, trails, old logging roads
Cyperus diandrus	Low cyperus	E	---	---	Moist to wet, usually sandy or peaty, shorelines

Scientific Name	Common Name	VT Status[a]	NH Status[a]	Federal Status[a]	Habitat
Cyperus houghtonii	Houghton's umbrella sedge	T	E	---	Dry, sandplain openings (NHNHB; VTNHI); Dry mesic to xeric \sands and edges, roadsides, lake shores, sandplains, and woodlands
Cyperus squarrosus	Incurved umbrella sedge	---	E	---	River and lake shores, usually in sand
Cypripedium arietinum	Ram's-head lady's-slipper	T	E	---	Deciduous and mixed evergreen-deciduous forests, often on enriched soils due to bedrock influence or colluvial deposits, swamps
Diplazium pycnocarpon	Narrow-leaved glade fern	---	E	---	Rich, mesic woods
Equisetum palustre	Marsh horsetail	T	E	---	Lake and stream shores, marshes, river shore seeps, and pools
Eupatorium sessilifolium	Upland thoroughwort	E	E	---	Rocky forests and woodlands, edges of rock balds
Galearis spectabilis	Showy orchid	---	T	---	Rich, usually deciduous forests, areas influenced by high pH bedrock or colluvial deposits
Gentianella quinquefolia	Stiff dwarf-gentian	---	E	---	Fields, pastures, roadsides, banks, pond shores, commonly in regions of high-pH bedrock
Geum fragarioides	Appalachian barren-strawberry	---	T	---	Forests, woodlands, riparian terraces, river banks, fields, clearing, logging roads
Glyceria acutiflora	Sharp manna-grass	E	E	---	Shallow water of pools, lakes, and streams
Hackelia virginiana	Virginia stickseed	---	E	---	Mesic, deciduous forests, talus, cliff bases, high pH bedrock
Helianthus strumosus	Harsh sunflower	T	---	---	Deciduous forest, riverbanks, fields, roadsides, open rights-of-way
Heteranthera dubia	Grass-leaved mud-plantain	---	T	---	Aquatic beds, southern riverbanks (NHNHB; VTNHI); shallow, still or slow-moving, circumneutral to basic water of lakes and rivers
Hydrophyllum virginianum	Eastern waterleaf	---	T	---	Mesic, often rich, deciduous forests, riparian forests

Scientific Name	Common Name	VT Status[a]	NH Status[a]	Federal Status[a]	Habitat
Hypericum ascyron	Great St. John's-wort	T	E	---	Calcareous riverside seeps (NHNHB; VTNHI); riparian forests, river banks, low fields
Isoetes engelmannii	Engelmann's quillwort	T	E	---	Shallow waters of lakes and rivers, sometimes emergent
Isoetes riparia var. canadensis	Canada shore quillwort	---	E	---	Sandy and muddy margins of streams and lakes, including tidal shorelines
Lechea mucronata	Hairy pinweed	E	---	---	Fields, roadsides, waste areas, woodlands, clearings
Lespedeza hirta	Hairy bush-clover	T	---	---	Woodlands, forest clearings, dry openings
Liparis loeselii	Loesel's wide-lipped orchid	---	T	---	Rich fens and seeps; northern rich swamps; rich wet meadows; calcareous riverside seeps (NHNHB; VTNHI); Mesic to hydric, open soils of meadows, fens, shorelines, and, disturbed places such as abandoned borrow pits and cleared rights-of-way
Lobelia kalmii	Brook lobelia	---	T	---	Calcareous riverside seeps; rich, wet meadows (NHNHB; VTNHI); Fens, stream shores, seepy river shore outcrops, and disturbed soil in regions with high pH-bedrock
Mimulus moschatus	Musky monkey-flower	---	E	---	River and stream shores, seeps, stream-side meadows, low roadsides, ditches
Nabalus serpentarius	Lion's-foot rattlesnake-root	---	E	---	Woodlands, rocky slopes, cliffs roadsides, powerline rights-of-way, sandplains, clearings
Nuphar microphylla	Small-leaved pond-lily	---	E	---	Ponds
Packera paupercula	Balsam groundsel	---	T	---	Rich fens and seeps; calcareous riverside seeps (NHNHB; VTNHI); rivershore outcrops and gravels, woodlands, ridges
Panax quinquefolius	American ginseng	---	T	---	Rich, mesic forests, often on rocky slopes near cliff bases, rarely in wet-mesic forests that are influenced by high-pH bedrock

Scientific Name	Common Name	VT Status[a]	NH Status[a]	Federal Status[a]	Habitat
Parnassia glauca	Fen grass-of-parnassus	---	T	---	Fends, river-shore seeps, wet meadows, rarely also found in wet lawns and in ditches, usually in high-pH bedrock regions
Physostegia virginiana	Obedient plant	T	---	---	Fields, roadsides, gardens, river shores, lake shores
Potamogeton alpinus	Reddish pondweed	---	E	---	Shallow, still or slow moving, circumneutral to basic lakes and rivers
Potamogeton nodosus	Long-leaved pondweed	---	T	---	Aquatic beds (NHNHB; VTNHI); Shallow, still or slow moving, circumneutral to basic lakes and rivers
Potamogeton vaseyi	Vasey's pondweed	---	E	---	Aquatic beds (NHNHB; VTNHI); Shallow, still or slow moving, slightly acidic to basic water of lakes and rivers
Potamogeton zosteriformis	Flat-stem pondweed	---	E	---	Aquatic beds (NHNHB; VTNHI); Shallow, still or slow moving, circumneutral to basic lakes and rivers
Pterospora andromedea	Pine-drops	E	E	---	Deciduous to mixed evergreen-deciduous forests
Pycnanthemum virginianum	Virginia mountain-mint	---	E	---	Fields, banks, roadsides, clearings
Quercus macrocarpa	Mossy-cup oak	---	E	---	Swamps, riparian and lacustrine forests, dry mesic to mesic soil of forests in regions of high pH bedrock
Sagittaria cuneata	Northern arrowhead	---	E	---	Circumneutral to slightly basic waters of lakes, slow-moving streams, and pools
Sagittaria rigida	Sessile-fruited arrowhead	---	E	---	Aquatic beds; sandy pond shores /sand plain basin marshes (NHNHB; VTNHI);lakes, river shores, backwaters, pools including fresh to brackish tidal rivers

Scientific Name	Common Name	VT Status[a]	NH Status[a]	Federal Status[a]	Habitat
Salix exigua ssp. interior	Sandbar Willow	---	E	---	Sand, gravel, and cobble shorelines of major rivers, less frequently lake shores, rarely in borrow pits
Sanicula odorata	Clustered sanicle	---	E	---	Rich mesic forests, including uplands and riparian types
Sanicula trifoliata	Large-fruited sanicle	---	T	---	including uplands and riparian types
Scirpus ancistrochaetus	Northeastern bulrush	E	E	E	Wet fields, lake borders, graminoid marshes, temporary pools
Senna hebecarpa	Northern wild senna	T	E	---	Fields, roadsides, forest borders, riparian corridors
Solidago speciosa	Showy goldenrod	---	E	---	Fields, roadsides, clearings
Spiranthes lucida	Shining ladies'-tresses	---	E	---	River and lake shores, most prevalent in areas influenced by high-pH bedrock, also in seeps and meadows
Staphylea trifolia	American bladdernut	---	T	---	Forest borders and fragments, woodlands, rocky, slopes, roadsides
Stuckenia pectinata	Sago false pondweed	---	E	---	Aquatic beds, salt marshes, mudflats, and borders (NHNHB; VTNHI); shallow, still, or slow moving, neutral to basic waters of lakes and rivers
Triantha glutinosa	Sticky false asphodel	T	E	---	Rich fens and seeps, calcareous riverside seeps (NHNHB; VTNHI);Fens, meadows, Rivershore seeps in regions of high-pH bedrock or till

Source: 2014 and 2013 data-sharing agreements with NHNHB and VTNHI, and sources as listed in the table and notes b and d.

a. SC – Special Concern; T – Threatened; E – Endangered; “---“ – not listed.

b. Vertebrate habitat associations are from DeGraaf and Yamasaki (2001) unless otherwise noted.

c. The bald eagle is federally protected under the Bald and Golden Eagle Protection Act (16 U.S.C. § 668-668c).

d. Plant habitat associations are from Haines (2011) or McGee and Ahles (1999) unless otherwise noted.

Study 26 commenced with a desktop analysis to review sites of previous records and identify potentially suitable new habitat available to cobblestone tiger beetles in the study area. Sources of data included maps of cobblestone tiger beetle observations and existing aerial photographs. Survey sites were subsequently chosen from these habitat areas based on accessibility and field checks to verify the habitat suitability. The 13 selected sites were each visited 3 times during the summer of 2014 in warm, humid conditions (ideal foraging/breeding conditions for adults).

During Study 26, the cobblestone tiger beetle was found to be widely distributed throughout the study area. Adult cobblestone tiger beetles were positively identified at 7 of the 13 survey sites. Survey scientists found them at least once at each of the 5 previously recorded sites, and at 2 survey sites, Hart Island (Wilder riverine reach) and Walpole Island (Bellows Falls riverine reach); cobblestone tiger beetles were observed during all 3 survey visits between July and August 2014. One new site, a mainstem riverbank cobble bed in Ascutney, Vermont, was identified for the species.

In an assessment of habitat features of occupied sites, Study 26 results indicate that adult cobblestone tiger beetles have specific habitat preferences related to the size and variability of cobble substrate. The mean cobble size ranged from about 2 to 3 inches in all high-quality habitats, and the target species was absent at most sites with cobble averaging either smaller or larger than this range. In addition, the cobble diameter variability (measured as standard deviation of the a-axis) of high-quality survey sites fell within an approximate range of 0.75 to 1.5 inches. Among the study sites, the majority of appropriate habitat was available in the Wilder riverine reach with one high-quality site in the Bellows Falls riverine reach.

Dragonflies and Damselflies (Odonates)

Seven of Vermont's dragonflies and damselflies that occur in the terrestrial study area have been designated as a SGCN—spine-crowned clubtail, rapids clubtail, skillet clubtail, cobra clubtail, rusty snaketail, riverine clubtail, and zebra clubtail. An eighth species, common sanddragon, which had not been recorded in Vermont prior to the commencement of Study 25, may be rare. Two of the species listed above—rapids clubtail and skillet clubtail—are also state-listed as special concern in New Hampshire, but none of these species have federal conservation status.

Although dragonflies are most frequently observed as adults, they spend most of their life cycle as aquatic larvae. After growing for a year or more, larvae crawl from the water and metamorphose to adults. Eclosure occurs when the adult form exits the larval exoskeleton. After eclosure, the individual dries and hardens before taking flight. During eclosion, odonates are unable to move until the process is complete, making it a particularly vulnerable part of their life cycle (Paulson, 2011; Silsby, 2001).

Because the distribution of habitat of the above-listed focal species has not been well understood, Study 25 was designed to inventory the large river-dependent odonate assemblages in the terrestrial study area, including life history, ecology, and behavior information for each species. Six surveys were conducted between June 1 and July 30, 2015, where survey scientists systematically searched 11 survey sites for eclosing odonates and collected data about available riverbank habitat. The following information was collected for each of the six focal species found during Study 25:

- Spine-crowned clubtail was found at three sites in the Vernon study area and at a single site in the Bellows Falls impoundment. This species was previously only known to occur in the Vernon study area, so this represents an extension of the species' known range. Although it was found at four different sites, spine-crowned clubtail was only observed 10 times. Nine of the 10 observations came from sites in impoundments, and 7 of those were in sites immediately upstream of the dams, suggesting that the species may be more likely to occur in impounded areas of the river.

- Rapids clubtail was only located at a single site in the Wilder impoundment, where a single exuvia was found during transect surveys. This represents a range extension over previous surveys, in which this species had been recorded only in the Vernon study area and in extremely low densities (Hunt, 2012; Hunt et al., 2010). Failure to detect the species in the Vernon, and possibly Bellows Falls, study sites is likely a result of low densities, rather than extirpation.

- Cobra clubtail was detected at nine study sites and was the most frequently found species during transect surveys. However, it was not found at study sites immediately upstream or downstream of Wilder dam. This species was also not found in the vicinity of these sites during 2005–2006 field work (Hunt et al., 2010).

- Rusty snaketail was only recorded in riverine reaches. No site had high numbers of this species, although 7 of the 10 exuvia were collected from the same site near Stebbins Island. This species has been previously found in the Bellows Falls and Vernon impoundments as well as the Bellows Falls riverine reach; it likely still occurs in these areas but at low densities. Notably, this species was found at both study sites in the Wilder riverine reach, despite those sites having the lowest odonate abundances.

- Riverine clubtail was recorded at eight sites. It was absent from the Wilder riverine reach but was found in the remaining impoundments and riverine reaches, although it was also not found at the site just above Wilder dam in the Wilder impoundment. This finding is consistent with previous surveys (Hunt, 2012; Hunt et al., 2010) in which the species was not found in this stretch of river. Of special note was a teneral (adult odonate not yet capable of sustained flight) observed on July 29, 2015, in Lyme, New Hampshire. This species had not previously been recorded as an adult after July 1 in New Hampshire and is only previously known in Vermont from exuviae. This observation contributes to an understanding of the flight season of this rarely observed species.

- Zebra clubtail was observed in the Bellows Falls and Wilder study areas and was widespread within them. This species was not observed at the sites immediately above either dam.

Vertebrates

Bald Eagle

Several sections of the terrestrial study area provide both breeding and winter roosting habitat for bald eagles. The bald eagle is federally protected under the Bald and Golden Eagle Protection Act (16 U.S.C. § 668–668c) and the Migratory Bird Treaty Act, and it is currently state-listed as threatened in New Hampshire and endangered in Vermont, although New Hampshire is currently considering de-listing the species.[36] Because bald eagles are not federally listed as threatened or endangered, information about their use of the lands within the Wilder, Bellows Falls and Vernon Project areas was not available from FWS. However, because the bald eagle is federally protected under the Bald and Golden Eagle Protection Act, it is covered in this section as a federally protected species. The species is also protected as part of the Migratory Bird Treaty Act (listed in 50 C.F.R. § 10.13).

TransCanada obtained information about bald eagle nesting and wintering from NHNHB, VNHI, and New Hampshire Audubon (NHA). During the 2016 mid-winter eagle survey on January 9, 2016, a volunteer survey effort coordinated by NHA, 21 bald eagles were observed along the Connecticut River, including 14 adults and 7 immatures. According to VNHI and NHNHB, bald eagles roost in two locations in the Project areas during the winter: near Vernon dam in Vernon, Vermont, and in the north end of Westmoreland, New Hampshire. As part of Study 27, aerial photo interpretation followed by field verification identified 12 additional softwood stands that appear to offer suitable winter roosting conditions: six in Vermont and six in New Hampshire. They are all located essentially on the Connecticut River bank, with two located on tributary inlets (Mink Brook and Clay Brook) and two located on islands (Gilman Island and an unnamed island in Lyme, New Hampshire). These potentially suitable winter roosting sites are relatively evenly distributed throughout the terrestrial study area, and although the distribution is not extensive in comparison to the entire size of the terrestrial study area, winter roosting habitat is unlikely to be a limiting resource. Bald eagles are highly mobile using multiple roosts in the course of a winter, and communal roosting behavior is common (Buehler, 2000).

The locations and conditions of existing bald eagle nests in the terrestrial study area were summarized from data provided by NHA's ongoing Connecticut River Bald Eagle Restoration and Habitat Protection Project, which TransCanada supported

[36] http://www.wildlife.state.nh.us/legislative/documents/fis-1000-species-ip.pdf.

with a multi-year grant of nearly a quarter of a million dollars (NHA 2014, 2013, 2012). In the 2014 breeding season, NHA documented nine nests within the study area, eight of which were active (NHA, 2014). This was an increase from six nests (five active) in 2012, when NHA began tracking nests along the Connecticut River, and seven nests (six active) were observed in 2013. Productivity of the nests was 0.8, 0.7, and 0.6 fledged young per nest in 2012, 2013, and 2014, respectively. While the overall productivity of these nests is lower than for nests throughout the entire watershed (NHA, 2014, 2013, 2012), low nest success in 2014 was also observed across the watershed. Cold weather and heavy snow in March likely depressed hatching rates throughout Vermont and New Hampshire in 2014. The current active nests are located in Piermont, Plainfield, and Hinsdale (two nests), New Hampshire; and in Newbury, Hartford, Rockingham, and Dummerston, Vermont (Table 3.6-5). All known locations of nests are within approximately 125 feet of the Connecticut River shoreline.

Table 3.6-5. Bald eagle nest tree locations and conditions within the terrestrial study area.

Town	Distance to River	Setting	Tree Type	Tree Condition	Diameter at Breast Height	Predator Guard?	Years Active
Newbury, VT	~ 200 ft	Bank tributary	White Pine	Live	Unknown	No	2012, 2013, 2014
Piermont, NH	Unknown	Unknown	Unknown	Unknown	Unknown	No	2014
Hartford, VT	>25 ft	River bank	White Pine	Live	Unknown	No	2012, 2013, 2014
Plainfield, NH	~ 25 ft	River bank	White Pine	Live	Unknown	No	2012, 2013, 2014
Claremont, NH	>25 ft	River bank	White Pine	Live	Unknown	No	none
Rockingham, VT	>125 ft	Upland	Cottonwood	Live	Unknown	Yes	2012, 2013, 2014
Dummerston, VT	>25 ft	River bank	White Pine	Dead	Unknown	No	2014
Hinsdale, NH	>100 ft	Small island	White Pine	Live	Unknown	No	2014
Hinsdale, NH	~125 ft	Upland	White Pine	Live	25 inches	Yes	2012, 2013, 2014

Source: NHA (2014, 2013, 2012)

Cerulean Warbler

The cerulean warbler is a species of special concern in New Hampshire; three small populations are known to exist in the state. The species has not been observed at its most reliable breeding site in the state, Pawtuckaway State Park, since 2012 (NHFGD, 2015). The cerulean warbler is known to occupy mature floodplain forest (NHFGD, 2015; DeGraaf and Yamasaki, 2001), but in New Hampshire has been recorded mostly in upland hardwood forests (NHFGD, 2015). The only location with multiple records in the vicinity of the combined Wilder, Bellows Falls, and Vernon Projects is Mount Wantastiquet in Hinsdale, New Hampshire. Because of the significant elevation difference between the Vernon Project area and the known element occurrences (EOs; i.e., plants and exemplary natural communities) on Mount Wantastiquet, it is unlikely that Project operations have any effect on the cerulean warbler. No targeted relicensing studies were requested or performed for this species, and the species was not incidentally observed during any field studies.

Fowler's Toad

Fowler's toad is considered a high priority SGCN in Vermont and is listed as an S1 "Very Rare" species in Vermont's wildlife action plan (VT WAP Team, 2015). This species was listed as endangered by Vermont in 2015 and is considered a Species of Special Concern in New Hampshire. It has no federal status. Verified reports of the Fowler's toad span from White River Junction, Vermont, where it was first reported and photographed in 1983, to Vernon, Vermont, where a population was well documented from 1994 through 2007. Although the Vernon record is the sole record from the Connecticut River itself, the other records are primarily from towns adjacent to the river and therefore define the possible range of Fowler's toad in the vicinity of the Connecticut River.

Study 28, was conducted in the summer of 2014 and commenced with a desktop analysis to identify potentially suitable habitat available to Fowler's toads in the terrestrial study area within the geographic range of previous observations. Sources of data included relevant reports and maps created from concurrent studies as well as existing maps and aerial photos. Survey sites were subsequently chosen from these habitat areas based on accessibility at night, private landowner permission, and field checks to verify the habitat suitability. Both standard nocturnal call surveys and acoustic surveys were performed, and one population of Fowler's toad was confirmed in a breeding pool on Stebbins Island, just below Vernon dam.

Suitable habitat for Fowler's toad requires pools with reasonably stable hydrology for breeding, and bare, sandy soils suitable for estivation and hibernation in proximity. This combination of conditions in proximity to each other appears to be inherently rare on the Connecticut River. In general, persistent, shallow pools tend to be concentrated in and around large wetland features associated with bays and old oxbows (e.g., Herricks Cove in Rockingham, Vermont). However, the most extensive areas of bare, sandy soils in the study area are associated directly with the banks of the river and some of the islands. Locations with both potential breeding pools and bare soils appear to be most abundant in the Wilder riverine reach and the Bellows Falls impoundment where potential breeding pools form on sand bars and behind scour deposits and where sandy soils area also available. However, Fowler's toad was absent from these sites during Study 28.

Plants

In the 2012 growing season, TransCanada conducted a field survey for state-listed rare, threatened, or endangered (RTE) plants and communities within the immediate environs of the Connecticut River. The survey area extended from the upper end of the Wilder impoundment to Vernon dam (Normandeau, 2013c). The survey assessed the current status of individual populations of all plant species listed by New Hampshire and Vermont that are potentially influenced by Project operations. A total of 185 EOs was identified for potential survey in the study, 66 in Vermont and 119 in New Hampshire. Of these, surveys were performed for 175 EOs (95 percent), and surveys were not attempted for the remaining 10 EOs (5 percent) due to access or logistical difficulties. Ninety-two EOs were located in 2012 (53 percent) and 43 new EOs were documented, bringing the total number of documented extant EOs in the terrestrial study area to 135 in the 2012 survey.

Individual occurrences of rare species and exemplary natural communities proximal to normal Project operational flows correspond to one of three broad groups: (1) aquatic floating leaved and submerged species that remain inundated during daily operational flows; (2) aquatic to emergent species that are partially or entirely within the range of normal daily operational flows; and (3) species that are restricted entirely or in large part to areas on the riverbank above normal daily operational flows (inundated by flows exceeding maximum station discharge). No RTE species occur both above and below the normal operational range of flows or impoundment water levels, and no species were confined entirely to the operational flows or impoundment water level ranges. Populations of species that occurred partially within the normal operational range were usually centered or concentrated either above or below operational flows; however, some individual patches or subpopulations occurred entirely within the normal operational range (e.g., pygmy-weed, obedient plant, and common silverweed). Additional examples of each species groups were documented during the 2012 study.

One-hundred-sixty-three state-listed plant species and exemplary communities were to be incidentally investigated in 2014 during Study 27, if the EOs were located on public or TransCanada-owned or leased land. Of those 163 EOs, 88 had been located since 1990 and 75 had not been observed since that date, and the 2014 survey focused on the 88 more recent observations. Seven EOs were confirmed during the 2014 field verification, including five silver maple-wood nettle-ostrich fern floodplain communities, and two rare species, black maple and obedient plant.

3.6.2 Environmental Effects

3.6.2.1 Botanical Resources

Vegetation communities, particularly along large river systems, are hydrologically and physically influenced by the river in several ways:

- Flooding by periodic high waters resulting from snowmelt and precipitation;
- Scour by ice, water, and debris;

- Short-term, water level fluctuations; and
- Low flow conditions.

On a regulated system such as the Connecticut River, large water inputs exceeding the generating capacity of the Wilder, Bellows Falls, and Vernon Projects during snowmelt and large precipitation events determine flood levels and scour events, while impoundment WSE changes and discharge from normal Project operations affect day-to-day water level fluctuations. Vegetation communities respond to high water events and normal Project operations in different ways. Lower elevation communities (marshes and scrub-shrub wetlands) are largely controlled by normal Project operations, and the higher elevation communities (forested wetlands) are controlled by high water events resulting in flooding and scour. This analysis focuses primarily on water levels that coincide with normal Project operations (excluding periods of high water and spill).

The vascular vegetation communities bordering the river in the terrestrial study area can be described according to their positions relative to water level fluctuation zones. The wide diversity of vegetative communities along the Connecticut River reflects varying hydrologic conditions throughout the terrestrial study area and adjacent aquatic areas. Submerged aquatic vegetation occurs almost exclusively below the lower limit of daily and sub-daily water level fluctuations associated with normal Project operations. Emergent and scrub-shrub wetlands are also most commonly found within the zone influenced by normal Project operations. Wetlands higher in the hydrologic gradient, primarily forested wetlands, are typically located above normal Project operational WSEs, as are other riparian vegetation communities bordering the river. By virtue of location, the vegetation in the riparian zone must be able to tolerate occasional flooding, and in the case of floodplains, this vegetation is specifically adapted to periodic flood events and other high flows beyond the range of normal Project operations.

The various vegetation communities and their positions relative to current WSEs under normal Project operations, and thus the potential for Project-related effects, are described in more detail in the following sections. However, because the existing vegetation communities have developed under, and are adapted to, the current normal Project operations, and TransCanada is not proposing to alter normal Project operations, no new effects on vegetation communities are anticipated.

Project maintenance activities, including recreation area maintenance, occur from time to time along the river banks. These activities are generally localized and minor in nature. Such activities are conducted in accordance with state and federal wetlands regulations and related stormwater pollution prevention measures and best management practices to avoid compromising riverbank integrity or creating shoreline erosion that might otherwise lead to localized sediment transport or adverse effects on riparian and wetland vegetation. Because no new activities are proposed, no new effects on riparian and wetland vegetation are anticipated.

Aquatic Vegetation

Because aquatic vegetation is susceptible to desiccation and scour, it proliferates in areas that are protected from strong currents and are not exposed at low flow water levels. The most well-developed aquatic communities occur in backwaters and the mouths of large tributaries to the Connecticut River, where they are both protected from scour and high currents but are situated in sufficient water depth to remain covered at low water levels. Riverine aquatic beds are also prevalent in the upper reaches of the three impoundments. Submerged aquatic vegetation is much less common, and no beds were large enough to map on the truly riverine sections below the dams, where scour and current are too strong for most aquatic species to persist.

Emergent and Scrub-shrub Wetlands

Emergent and scrub-shrub wetlands tend to be tolerant of short- and long-term inundation, but are vulnerable to scour by currents and ice, as reflected by their prevalence in protected locations. Deep-marsh emergent vegetation such as pickerel weed, cattail, and soft-stem bulrush dominate in the lower elevations of the emergent marsh zones, anecdotally appearing to seldom be exposed at low water levels. Low scrub-shrub vegetation was often observed at slightly higher elevations and was observed to experience frequent inundation and water level fluctuation. Tall scrub-shrub wetlands are higher in elevation and were observed to be only periodically inundated or saturated.

Emergent and scrub-shrub wetlands are generally absent from terrestrial study area sections that experience strong river currents. This is evident along sections of the mainstem riverbanks and on the leading tips of islands where vegetation was generally sparse or absent. Some species such as sand willows, dogbane, obedient plant, and cardinal flower were found with low sparse cover across areas observed to experience frequent inundation and scour. These species have adapted to tolerate active flow conditions to some extent, although they can be periodically destroyed during flood events (e.g., above normal Project operational flows). Such early successional communities are less able to compete in more heavily vegetated areas.

Forested Wetlands

Forested wetlands in the Northeast are not adapted to tolerate prolonged or frequent inundation. This was observed in the terrestrial study area where forested wetlands occur either on terraces or tributary mouths above the zone of normal Project operational WSEs. These forested wetlands are typically small in size and seldom occur along the riverbank. They are more frequently found adjacent to beaver impoundments or backwaters at elevations that are several feet higher than the emergent marsh and presumably inundated only during high water events. They also are found at tributary mouths where signs of flooding were limited to larger debris and sediment deposits typically associated with high water events.

Floodplain Forests

Most floodplain forests occur on terraces that are higher in elevation than the zone of normal Project operations and therefore above the influence of Project-related water level fluctuations. An exception is silver maple floodplain forest, some of which occur on several islands and low terraces adjacent to the Connecticut River. Several low-lying forested floodplains, such as Ash Swamp Brook (in the lower Vernon impoundment just upstream of the dam), showed evidence of periodic inundation or saturation near the zone of normal Project operations. Most other silver maple floodplain forests appear to be well above the zone of normal Project operations and demonstrate classic annual or seasonal flood evidence based on scour marks, sediment deposition in the soils, and large flood debris trapped in trees or bushes.

Upland and Riparian Habitats

The upland and riparian habitats bordering the Connecticut River are above elevations affected by normal Project operations. These include upland riverbanks, riparian habitats, and agricultural fields. Although the vegetation in these habitats is not adapted to frequent inundation or scour, it can generally tolerate periodic flooding and infrequent scour. These communities provide important substrate stabilization when such events occur.

3.6.2.2 Wildlife Resources

In the terrestrial study area, low elevation vegetative communities (marshes and scrub-shrub wetlands) are largely controlled by normal Project operations and can be affected by daily water level fluctuations. These communities have established themselves to adapt to the daily hydrology of the river, and the wetland-dependent wildlife species have followed. Amphibians such as American toads, spring peepers, green frogs, and bullfrogs breed in Project-affected emergent and scrub-shrub wetlands.

Notches and overhangs in banks may occur as a result of daily water level fluctuations (see Section 3.3, *Geologic and Soils Resources*). Certain wildlife species that rely on shallow, benthic infauna (e.g., migratory shorebirds) use these areas. Spotted sandpiper were frequently seen along the water's edge on both protected and exposed shoreline and gravel bars throughout the river, but no targeted study was requested or performed to assess shorebird habitat use or availability. More significant bank erosion caused by larger precipitation events benefits some wildlife species, including bank-nesting species (belted kingfisher and bank swallows) as well as mink and otter that use undercut riverbanks for travel and cover. Also, dragonfly and damselfly larvae emerge from the water and use undercut and eroded banks for eclosure (see Section 3.6.2.4, *Sensitive Species*). Because no changes in Project operations are proposed, no new effects on wildlife resources are anticipated.

Project maintenance activities, including road and facility maintenance, and recreation activities occur at the Projects. Maintenance activities are generally localized and minor in nature and recreation occurs at already developed recreational facilities. Because no changes in such activities are proposed, no new effects on wildlife resources are anticipated.

3.6.2.3 Invasive Species

Invasive species, which are prevalent throughout the Connecticut River Valley, as indicated by the Invasive Species Atlas (IPANE, 2016), were observed in abundance along the banks and in most vegetation communities along the study corridor. Alterations in daily water level fluctuations resulting from normal Project operations may maintain openings in native vegetative communities as they adapt to changes in the hydrologic regime, but no changes are proposed to the current Project operations at this time, so additional Project-related vegetation disturbance is unlikely. However, non-native invasive plant species likely will continue to thrive in the terrestrial study area as a result of their ability to aggressively colonize new habitats. While active disturbance is known to create opportunities for colonization by invasive plants, it is unlikely that any of these factors are directly caused or aggravated by daily water fluctuations from normal Project operations.

3.6.2.4 Sensitive Species

Fowler’s Toad

The effect of changes in WSE at any potential Fowler’s toad breeding site is mediated by the relative arrangement of potential breeding habitat (pools), its connection to the river (direct, indirect, upstream, downstream), and any features (banks, sandbars, wetlands, human-made structures) that could slow water fluctuations and buffer their magnitude. Periodic (every 5 to 15 years) high-energy, high-water events are needed to maintain suitable estivation and hibernation habitat for Fowler’s toads along the Connecticut River. In the absence of major flood events, smaller daily WSE fluctuations can also create conditions that scour away litter and/or discourage vegetation from growing. However, these daily WSE fluctuations can also make otherwise physically suitable breeding pools unsuitable because toad eggs and tadpoles can be easily washed into the river by WSE fluctuations, where they will not survive. Study 28 examined the magnitude and frequency of water level fluctuations under normal Project operations and their potential effects on Fowler’s toad breeding habitat.

Four study sites with suitable habitat in the Wilder riverine reach are estimated to have Project effects (as defined in Study 28 where modeled WSEs are predicted to be greater than 3 feet more than 90 percent of the time during the breeding season), which is not surprising given that water level fluctuations are typically higher in the riverine reaches than in the impoundments. At the Stebbins Island site in the Vernon riverine reach, the only site where Fowler’s toad are known to occur, the modeled WSEs indicated moderate Project effects. While water level fluctuations of more than 3 feet occurred more than 90 percent of days during the breeding season, the site's topography and orientation tends to protect it from scour during non-flooding conditions, and it does not appear to entirely dewater except at low water levels and low flows.

The best Fowler's toad habitat along the Connecticut River is created in locations that are affected by large water fluctuations and high velocities from flood flows, but where, during the breeding season, the adverse effects of scour and dewatering are buffered by the topography of the site. This type of WSE fluctuation regime is uncommon along the Connecticut River as a whole, but occurs at Stebbins Island, where Fowler's toad was confirmed present and, based on historical records, where the population has persisted. Because TransCanada does not propose to change normal Project operations, new effects of the Vernon Project on Fowler's toad are not anticipated. Boat-accessed camping occurs at the Stebbins Island canoe rest area as part of the Connecticut River Paddlers' Trail, which is owned and managed by TransCanada as a non-Project primitive campsite (see Section 3.8.1.1, *Recreation Resources*). The camping area is typically accessed in the vicinity of Fowler's toad habitat but the campsite itself is located in the middle of the island amidst understory vegetation (Study 30, *Recreation Facility Inventory and Use & Needs Assessment*). Therefore, it is unlikely that recreational activities at the site will adversely affect the species or its habitat.

Cobblestone Tiger Beetle

Adults

Adult tiger beetles are winged and can avoid most direct mortality from habitat inundation. However, indirect energetic costs from daily water fluctuations are possible. Adult cobblestone tiger beetles are most active on the sides and upstream ends of riverine islands during the hottest part of humid summer days (Leonard and Bell, 1999; Study 26), corresponding with times of peak hydroelectric power generation. If Project-related water fluctuations cause WSEs to frequently exceed this species' highest habitat elevations, cobblestone tiger beetle populations could be adversely affected.

In Study 26, operations modeling data (from Study 5) were used to determine the frequency with which the cobblestone tiger beetle habitat at each study site became completely inundated as a result of normal Project operations. The study sites currently occupied by adults become fully inundated during the adult daily active period no more than 20 percent of the days during the summer, based on modeled data. Therefore, while normal Project operations may have some effect, overall these operations are unlikely to negatively affect the fitness of current cobblestone tiger beetle populations. Recreational use occurs in the vicinity of several Study 26 sites but is generally limited and not at TransCanada formal recreation areas and therefore not affected by the Projects.

Larvae

Cobblestone tiger beetle larvae are currently undescribed, but if other sympatric tiger beetle species are a valid indicator, cobblestone tiger beetle larvae are adapted to tolerate some inundation while within burrows (Brust et al., 2005). Seasonal averages based on Study 5 data show that, during most of the year, typical Project operations do not create constant inundation in presumed burrow locations at the sites known to support adult cobblestone tiger beetles. During the spring freshet, when 8 of the 12 study sites have modeled mean WSEs above presumed burrowing elevations, cobblestone tiger beetles likely occur exclusively in their flood-tolerant burrows. Although larval habitat and behavior have yet to be described, the presence of adults at 7 of the 13 study sites indicates at least moderate larval success; therefore, continued Project operations are not likely to affect this species in the larval stage.

Dragonflies and Damselflies

Normal Project operations may cause direct, adverse effects on odonate populations. There are two potential types of adverse effects: (1) loss of habitat when the entire bank height becomes inundated and (2) direct mortality from rising water levels at the time of eclosion if the water rises enough to submerge the individual.

Appropriate habitat for odonates consists of fine aquatic substrates (sand and silt) for larvae with nearby steep, sparsely vegetated banks for eclosion. Habitat needed during the critical emergence period may be unavailable when the entire bank height becomes inundated. To assess Project effects on habitat, during Study 25, TransCanada analyzed hourly WSE data from the hydraulic and operations models (Studies 4 and 5) durig the critical period for emergence from May 15 to August 31, between 04:00 and 21:00 (Hunt, 2012; Paulson, 2011). Hydraulic rating curves near each study site were analyzed to determine whether the range of measured habitat elevations fell within the modeled range of normal Project operational WSEs. At all study sites, the maximum habitat elevation was never inundated under normal Project operations leaving at least some portion of the suitable habitat range available for larvae to emerge and initiate eclosion.

The most sensitive stage for odonate emergence is the eclosion period, when odonates have started to shed their exoskeleton but are not yet capable of climbing or flight. Although the vertical distance a dragonfly climbs before eclosure varies by species, based on the observations detailed in Study 25, the conservative benchmark of 8 inches from the water surface was selected for assessing direct mortality risk. The entire eclosion process takes about 20 to 45 minutes depending on species (average about 30 minutes). Water level logger data, recorded every 15 minutes at each study site, were used to evaluate rates of water level change. During normal Project operations, the rate of water level rise typically was considerably less than 8 inches in 30 minutes. However, 8-inch rises in water elevation per half-hour were recorded with a less than 2 percent frequency at 5 of the 11 study sites, including at all four sites in the riverine reaches below Wilder, Bellows Falls, and Vernon dams. There was no statistically significant difference in in 8-inch water level increases that occurred during periods of normal Project operations or periods of storm events. Therefore, normal Project operations are unlikely to cause substantial mortality of sensitive dragonfly species in the Project areas. Effects of Project maintenance, agricultural leases, or recreation activities were not evaluated in Study 25, but it is unlikely that these activities adversely affect the species or its habitat.

Bald Eagles

For nesting, bald eagles require mature softwood stands with easy access to riverine food resources. Once a territory is established and a suitable nesting tree is identified, eagle pairs return to established nests each year. Both floodplain forests and terrestrial forests within the terrestrial study area are generally higher in elevation than the zone of normal Project operations and, therefore, above the influence of normal Project-related water level fluctuations. However, nesting trees immediately adjacent to the river are more susceptible to downing during high flow events that scour or undercut banks.

For roosting habitat, bald eagles also prefer mature softwoods with an emphasis on softwood stands rather than individual trees. Availability of food resources during winter is also a critical component of roosting habitat, and open, unfrozen water provides eagles with the ability to fish and hunt waterfowl. Normal Project operations are unlikely to affect conifer stands, which are generally above the influence of daily water fluctuations. In addition, when a suitable conifer stand is available, dam operations can improve or create roosting habitat. The known winter roosting area mapped by NHNHB is located directly below Vernon dam, where dam operations maintain open water across a range of winter temperature and weather conditions.

Project maintenance activities, including road and facility maintenance, and recreation activities occur at the Projects. Maintenance activities are generally localized and minor in nature, and recreation occurs at already developed recreational facilities. Because TransCanada does not propose to change these activities, no new effects on bald eagles and their habitat are anticipated, other than the occasional need to remove hazard trees that might provide nesting or roosting habitat.

Plants

Many rare plant species populations have adapted to, tolerate, or rely on the existing flow regime associated with the particular zone in which they occur. Because normal Project operational flows have been in place nearly 40 years under the existing licenses, rare species intolerant of daily inundation probably did not occur in lower riverbank zones historically (i.e., prior to dam construction) or have since been relegated to areas either above or below the normal Project operational range, where habitat conditions remain suitable for the particular individual species.

Some species (or individual populations) apparently tolerate or benefit from the daily inundation associated with normal operational flows. Two newly discovered populations of the New Hampshire-listed as endangered pygmy-weed (Normandeau, 2013c) occurred entirely within normal operational ranges: one along the Vernon impoundment and one in the tailrace vicinity of Bellows Falls. The only other New Hampshire pygmy-weed population found in the terrestrial study area was a previously documented population occurring below the normal operational range in shallow water of a stream inlet of the Bellows Falls impoundment. The locations of the newly discovered populations are consistent with the ecology of this primarily fresh-tidal species and may indicate a positive response to the daily fluctuations of normal Project operations.

Obvious active or imminent erosion threatening individual sensitive species populations was infrequent according to the 2012 RTE survey (Normandeau, 2013c). Only a few populations were on riverbanks with obviously unstable, unconsolidated sediments or deeply undercut banks. Two examples are hairy-eared rockcress and fescue sedge, both of which are also documented from eroding, sandy banks above operational ranges (one location each). Because there are no proposed changes to existing operations, effects of the Projects on sensitive plants will be minimal. In cases where maintenance activities could adversely affect sensitive species or their habitats, TransCanada works in consultation with the NHNHB and VTNHI to prevent or mitigate those effects. For example, routine dredging of the Pine Street boat launch in the Bellows Falls impoundment was conducted in 2015 under state and federal wetlands permits. Because sensitive submerged aquatic plants had been recorded at that site, TransCanada mapped and relocated sensitive species pursuant to a plan approved by NHNHB. In 2016 transplants were monitored and a report submitted to NHNHB. Monitoring will continue in 2017.

3.6.3 Cumulative Effects

As described in Section 3.2.2.4, FERC identified the geographic scope of cumulative effects on terrestrial and floodplain communities to include the 100-year floodplain (as defined by the Federal Emergency Management Agency) adjacent to the Project-affected areas from the upstream extent of the Wilder impoundment downstream beyond the Vernon Project to the Route 116 Bridge in Sunderland, Massachusetts. FERC chose this geographic area because the operations of the TransCanada and downstream FirstLight Projects, “in combination with other land uses in the Connecticut River Basin, may cumulatively affect floodplain communities adjacent to Project reservoirs and downstream riverine reaches in this area.”

Since the commencement of water regulation on the Connecticut River, cumulative changes have likely occurred within the riparian and terrestrial habitats within the 100-year floodplain of the river. Vegetative communities, including populations of sensitive plant species and non-native invasive species, have adjusted their extent and elevation according to their individual inundation tolerances and soil requirements, and wildlife have, in turn, adjusted their habitat use.

Future cumulative changes in the 100-year floodplain from the normal operations of the Wilder, Bellows Falls, and Vernon Projects are not expected because TransCanada is not proposing changes in Project operations. The most likely sources of cumulative impacts predicted for the 100-year floodplain will result from indirect impacts from continuing residential and commercial development and expansion of human infrastructure.

3.6.4 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures related to terrestrial resources. In cases where maintenance activities could adversely affect terrestrial species or their habitats, TransCanada works in consultation with the NHNHB and VTNHI to prevent or mitigate those effects (see, for example, discussion of sensitive plants in Section 3.6.2.4, *Sensitive Species*). For example, routine dredging of the Pine Street boat launch in the Bellows Falls impoundment was conducted in 2015 under state and federal wetlands permits. Since sensitive submerged aquatic plants had been recorded at that site, TransCanada mapped and relocated sensitive species pursuant to a plan approved by NHNHB. In 2016 transplants were monitored and a report submitted to NHNHB. Monitoring will continue in 2017.

3.6.5 Unavoidable Adverse Effects

Normal Project operations have few adverse effects on current terrestrial wildlife and botanical resources in the Wilder, Bellows Falls, and Vernon Project areas. However, Studies 25, 26, 27, 28, and 29 have identified some minor effects and/or inconclusive results (Section 3.6.2, *Environmental Effects, Terrestrial Resources*). Normal recreation area maintenance or construction maintenance activities could potentially affect some terrestrial species or their habitats on a limited and/or localized basis.

3.7 Threatened and Endangered Species

3.7.1 Affected Environment

Listings of all federally threatened and endangered species were obtained from map and database information provided by FWS. Within the Wilder, Bellows Falls, and Vernon Project areas, five federally protected species either occur or have historically occurred (Table 3.7-1). These species, their habitat requirements, and their current status in the Project areas are detailed in the following sections. Targeted relicensing studies were conducted to search the Project areas for the federally endangered Jesup's milk vetch in 2012 (Normandeau, 2013b) and northeastern bulrush in 2014 (Study 29). In 2014, TransCanada also searched the Project areas for suitable Puritan tiger beetle habitat as part of Study 26, and in 2011, 2013, and 2014, surveys were conducted to search for the dwarf wedgemussel (Study 24).

Table 3.7-1. Federally listed species within the Project areas.

Scientific Name	**Common Name**	**VT Status[a]**	**NH Status[a]**	**Federal Status[a]**	**Habitat**
Invertebrate Animals					
Cicindela puritana	Puritan tiger beetle[b]	T	T	T	Sandy beaches on river's edge
Alasmidonta heterodon	Dwarf wedgemussel	E	E	E	Variable-sized rivers with stable flow and substrate
Vertebrate Animals					
Myotis septentrionalis	Northern long-eared bat	E	T	T	Upland forests, caves
Plants					
Astragalus robbinsii var. jesupii	Jesup's milk vetch	E	E	E	River banks
Scirpus ancistrochaetus	Northeastern bulrush	E	E	E	Emergent wetland with intermittently exposed substrate

Source: FWS (2016b)

a. T – Threatened, E – Endangered

b. Species likely extirpated. The last individual was observed the Bellows Falls Project area in 1932. The nearest known extant population is located at Rainbow Beach in Northampton, Massachusetts, downstream of the Projects and in the Holyoke impoundment.

3.7.1.1 Puritan Tiger Beetle

FWS lists the Puritan tiger beetle as threatened (55 FR 32088–32094). FWS has not designated critical habitat for this species. It has greenish-bronze outer wing plates with extensive white patterning and a distinct angle on each side as the plate approaches the ventral apex. Larval density of Puritan tiger beetle is highest along big rivers in sparsely vegetated patches of fine to medium sand (particles predominantly 0.125 to 0.5 millimeters [Omland, 2002]). In some instances, suitable habitat may be embedded in wide beaches (e.g., at Northampton, Massachusetts), but in other instances, the beach may be quite narrow (e.g., 13 to 20 feet wide in Cromwell, Connecticut). Although the Puritan tiger beetle is associated with clay banks in Maryland, this may not be relevant to habitat preferences in New England (Vogler et al., 1993).

According to the Recovery Plan for the Puritan tiger beetle (FWS, 1993a), the species has been historically documented in the vicinity of the Project areas. The historical distribution in New England included locations on the Connecticut River that extended from Claremont, New Hampshire, to Cromwell, Connecticut. Puritan tiger beetle was considered extirpated from nine of these sites by the early 1900s, with the latest collection records in the 1930s (Knisley, 1987, cited in Hill and Knisley, 1993). In New Hampshire, the Puritan tiger beetle is only known historically in the Bellows Falls Project area from one site in Claremont, New Hampshire, and one site in Charlestown, New Hampshire (Hill and Knisley, 1993). An additional single Vermont siting was historically documented along the Connecticut River in the town of Hartland, Vermont. However, despite intense searching by tiger beetle experts, no occurrences have been found upstream of Hadley, Massachusetts, in the past 25 years (Hill and Knisley, 1993).

As part of Study 26, the Wilder, Bellows Falls and Vernon Project areas were researched for potential Puritan tiger beetle habitat. To select areas of interest, aerial photography and data from preliminary aquatic and terrestrial habitat mapping (from Studies 7 and 27) were examined for patches of potentially suitable habitat. Areas of interest contained fine to medium sand and sparse vegetation, but no new suitable habitat was found in the Project areas. As a result, Study 26 site selection focused on cobblestone tiger beetle habitat because of the higher probability of locating this species, but scientists still thoroughly searched for Puritan tiger beetles within the chosen survey sites. The species was not observed during Study 26, so all Puritan tiger beetle records in the Project area remain historical.

3.7.1.2 Northern Long-eared Bat

FWS listed northern long-eared bat as threatened in 2015 (81 FR 1900–1922) based on severe population declines due to the fungal disease called white-nose syndrome. Until the onset of this disease, the non-migratory northern long-eared bat was widespread throughout the Northeast. In summer, this species uses a wide variety of upland forest types. FWS has not designated critical habitat for this species, but issued regulations in 2016 under Section 4(d) of the ESA (50 C.F.R.

§ 17.40(o)). Those regulations prohibit incidental take of the species within the zone where white-nose syndrome occurs and related actions that could result in incidental take, such as tree removal (except for removal of hazard trees) within 0.25 mile of a known hibernaculum, or that cuts or destroys known occupied maternity roost trees, or any other trees within a 150-foot radius from the maternity roost tree, during the pup season (June 1 through July 31). Purposeful removal from human structures is also not prohibited.

Unlike most other species of bat in the Northeast that prefer to forage along forest edges and watercourses, northern long-eared bats forage primarily under the canopy using a combination of hawking and gleaning (e.g., catching flying insects in the air, or plucking them from surfaces) behaviors to capture prey (Brack and Whitaker, 2001). In summer, this species typically roosts under the exfoliating bark or in cracks and crevices of trees greater than 3 inches in diameter at breast height (Lacki et al., 2009; Sasse and Perkins, 1996). It overwinters in hibernacula (typically caves) that offer steady temperatures just above freezing and adequate humidity (Van Zyll de Jong, 1985). Northern long-eared bat was state and federally listed after the development and implementation of the Project study plans, and there were no requests from stakeholders to evaluate this species; therefore, the species was not evaluated within the Project areas.

3.7.1.3 Northeastern Bulrush

Northeastern bulrush is a federally listed endangered perennial species in the sedge family. This species looks similar to several common species, but the most reliable diagnostic feature is the presence and length of bristles with recurved barbs on the fruit. Habitat requirements for northeastern bulrush are variable and can range from inundated pond margins to emergent wetlands with a subsurface water table. The common characteristics of northeastern bulrush habitat in the northern part of its range are an open canopy and an intermittently variable water table. It is hypothesized that receding water caused by seasonal variation or the removal of an impoundment (beaver dam or structure) exposes bare substrate that the northeastern bulrush requires for flowering and germination. Without intermittently exposed substrate, the bulrush appears to be outcompeted by other species adapted to more consistent water levels. Drastic changes in hydrology, such as prolonged inundation or drought, have also been shown to adversely affect the species (FWS, 2008, 1993c; Royte and Lortie, 2000).

The northeastern bulrush was classified as federally endangered in 1991 (56 FR 21091–21096) with 9 known occurrences in New Hampshire and 22 in Vermont, one of which is on the Connecticut River in the Bellows Falls Project area. FWS has not designated critical habitat for this species. FWS issued a Recovery Plan for the northeastern bulrush in 1993 (FWS, 1993c).

As part of Study 29, scientists searched for the known population of northeastern bulrush and attempted to locate undocumented populations within the Wilder, Bellows Falls, and Vernon Project areas. Four sites contained high potential northeastern bulrush habitat in at least portions of the site, but no individuals of the species were observed. This includes negative findings from the previously documented Bellows Falls site, at which northeastern bulrush had been last observed in 1999.

3.7.1.4 Jesup's Milk Vetch

FWS listed the Jesup's milk vetch is as endangered in 1987 (52 FR 21481–21484). FWS has not designated critical habitat for this species. Jesup's milk vetch grows in rock crevices within calcareous ledge along the upper reaches of the scour zone of the river (FWS, 2010). This perennial plant uses a taproot for stability and to hold nutrients. It is flood-tolerant, which allows it to outcompete many other species, but non-native species such as black swallowwort and Morrow's honeysuckle (*Lonicera morrowii*) are becoming a threat as they encroach on the rocky shoreline habitat on the Connecticut River (FWS, 2010).

Jesup's milk vetch occurs naturally at only three known sites in the world, all along the Connecticut River downstream of Wilder dam: Sumner Falls (Plainfield, New Hampshire); Jarvis Hill (Claremont, New Hampshire); and Hartland Ledges (Hartland, Vermont). The Jarvis Hill site lies within the Wilder riverine reach and at the most upstream extent of the Bellows Falls impoundment. Another site that lies above the RTE project area, Cornish Ledges in Cornish, New Hampshire, is an introduction site where Jesup's milk vetch establishment is being attempted.

FWS prepared a Recovery Plan for the species in 1989 (FWS, 1989) and included actions to:

- Protect known populations;
- Seek protection of essential habitats; and
- Ensure continuation of pre-1989 dynamics of the portion of the Connecticut River ecosystem directly affecting known populations.

The three natural Jesup's milk vetch populations and the introduction site have been the subject of long-term monitoring by NHNHB and VTNHI based on the requirements of the initial Recovery Plan (FWS, 1989). In 2012, TransCanada conducted a hydrologic study to facilitate the states' long-term monitoring of the species (Normandeau, 2013b). The study developed stage-discharge rating curves for the four sites relative to flows at the USGS West Lebanon gage with the goal of determining at what flows certain features may become inundated, such as at established reference bolts and plant locations. The results of this study are discussed in Section 3.7.3.

3.7.1.5 Dwarf Wedgemussel

FWS listed the dwarf wedgemussel as endangered (55 FR 9447–9451) in 1990 (for a review of its listing history, see FWS, 2013b, 2007b, 1993b). It is the only federally listed endangered mussel in New England, and it is listed as endangered by every northeastern state where it occurs (Connecticut, Massachusetts, Vermont, New Hampshire, New York, New Jersey, Pennsylvania, and Maryland), as well as states in the southern end of its range. It is considered to be extirpated in Canada (Committee on the Status of Endangered Wildlife in Canada, 2009). FWS has not established critical habitat for the dwarf wedgemusssel, and no habitat conservation plans have been published for the species. FWS issued a Recovery Plan for this species with the main goals of protecting and enhancing habitat of current dwarf wedgemussel populations and establishing or expanding populations within rivers or river corridors historically supporting the species (FWS, 1993b). The latest 5-year review (FWS, 2013b) concluded that dwarf wedgemussel should continue to remain listed as endangered because criteria specified in the Recovery Plan to delist the species or down-list it to threatened have not been (and may never be) met.

Dwarf wedgemussels have a lower fecundity than most other mussel species (McLain and Ross, 2005; Michaelson and Neves, 1995). Larvae, called glochidia, are released between March and May following spawning the prior summer and becoming gravid the prior fall (Michaelson and Neves, 1995). To complete larval development and metamorphose into juveniles, glochidia typically attach to the fins or gills of a fish for several weeks. Mussels have species-specific preferences for host fish. The Tessellated Darter is considered the primary host for dwarf wedgemussels in the Connecticut River watershed, and its range is most congruent with that of the dwarf wedgemussel (Nedeau, 2008). Several other fish have been identified as potential hosts, including Slimy Sculpin, Mottled Sculpin, Atlantic Salmon, Striped Bass, and Banded Killifish (Nedeau, 2008). In Study 12, Tessellated Darter were found nearby or in the general vicinity (within 1 to 2 miles up or downstream) of most locations were dwarf wedgemussels were found. Darters were also present near some mussel survey sites where no dwarf wedgemussels were found (e.g., near Sumner Falls). In Study 10, Tessellated Darter, Slimy Sculpin, and Banded Killifish were collected in all river reaches and accounted for 9.4 percent, 1 percent, and 0.2 percent, respectively, of the total catch of all collected species.

The parasitic phase of a mussel's life cycle is one of the few opportunities for long-distance dispersal. Tessellated Darters have limited mobility—they may move less than 100 meters during their short lives—thus the dispersal ability of dwarf wedgemussels is low and the rate at which they might recolonize former habitat is slow (McLain and Ross, 2005). The life span of a dwarf wedgemussel is considered less than 12 years (Michaelson and Neves, 1995), which is short compared with many other freshwater mussel species in the Northeast. Short life spans, low fecundity, high degree of host specificity, limited dispersal ability of its host species (except for the Atlantic salmon and striped bass), and low population densities likely all contribute to the endangered status of the dwarf wedgemussel.

The historical range of the dwarf wedgemussel included 70 locations in 15 major Atlantic coastal watersheds from North Carolina to eastern New Brunswick. By the early 1990s, its range was thought to have shrunk to about 20 locations in 8 watersheds (FWS, 1993b). In the last 25 years, biologists rediscovered populations that were considered extirpated and discovered entirely new populations (FWS, 2013b; Nedeau, 2008; Strayer et al., 1996). It is currently known from at least 70 locations in 15 major watersheds, with the largest populations in the Connecticut River watershed and in the Neversink River in New York. It currently occurs in 14 rivers in the Connecticut River watershed, including 4 in Connecticut, 4 in Massachusetts, 3 in Vermont (Black River, Ottauquechee River, and Connecticut River), and 4 in New Hampshire (Ashuelot River, South Branch Ashuelot River, Johns River, and Connecticut River). The upper Connecticut River mainstem is thought to support the largest populations remaining in the world (Nedeau, 2008), although field data collected from 2011 to 2014 in parts of the Middle and Southern Macrosites of the Connecticut River suggest potential declines and highlighted uncertainty about population size (Study 24; see also Section 3.5.1.4).

In Study 24, dwarf wedgemussel were found consistently along a 14-mile reach of the Wilder impoundment, from 27 to 41 miles upstream from the dam. This range generally corresponds to the 16-mile range documented in 2006 (Nedeau, 2006), the main difference being that animals were found slightly farther downstream in 2006 than in 2011 or 2013. Dwarf wedgemussel were not found immediately downstream from Wilder dam. The mussel community in the riverine reach farther downstream of Wilder dam exhibited low species richness and low abundance compared to the other survey areas. Dwarf wedgemussel were only found near Chase Island and were not found at two of the historical monitoring sites near Cornish Covered Bridge or Sumner Falls, or at other sites between Wilder dam and Cornish Covered Bridge.

Dwarf wedgemussel were found over a 17-mile distance in the Bellows Falls impoundment, but always at low densities. The same was generally true for the co-occurring triangle floater and creeper, two species that have similar habitat preferences and usually co-occur with dwarf wedgemussel (see Section 3.5.1.4). The Bellows Falls impoundment contains a tributary population of dwarf wedgemussel, in the lower Black River. Dwarf wedgemussel were not found immediately downstream from Bellows Falls dam.

Dwarf wedgemussel were not found in the Vernon impoundment or below Vernon dam; this finding corroborates results of the few recent surveys conducted in the impoundment (Nedeau, 2005). However, dwarf wedgemussel were found in the impoundment near Brattleboro, Vermont, 30 years ago (VT WAP Team, 2015).

3.7.2 Environmental Effects

3.7.2.1 Puritan Tiger Beetle

The Puritan tiger beetle is presumed extirpated from the Wilder, Bellows Falls, and Vernon Project areas. The desktop analysis and field verification conducted for Study 26 confirmed that no suitable habitat is currently available in the Project areas. Therefore, TransCanada concludes that continuing Project operations will not affect this species.

3.7.2.2 Northern Long-Eared Bat

Although no study for northern long-eared bat was conducted in the Project areas, their preference for foraging and roosting under the forest canopy suggests that continuing Project operations and maintenance are not likely to adversely affect this species because the existing forest canopy is not likely to be disturbed other than for hazard tree removal or for other incidental tree removal conducted for purposes of routine facility maintenance. Such activities will be conducted in accordance with 50 C.F.R. § 17.40(o) (see Section 3.7.1.2).

3.7.2.3 Northeastern Bulrush

Northeastern bulrush does not normally occur in large riverine habitats. All four sites within the Project areas with suitable habitat for northeastern bulrush are occupied by beavers and their dams that control water levels in the wetlands behind those dams. Beavers are extremely unlikely to build dams in locations or at heights that are inundated on a continual or frequent (e.g., daily/weekly) basis as a result of normal Project operations, particularly during the growing season. In addition, the water level behind the beaver dams at all four sites may produce prolonged high water levels within the sites, resulting in temporary or permanent suppression, reduction, or elimination of the species from the sites that is unrelated to Project operations.

Non-flow-related Project effects, such as from recreation areas or leasing of fee-owned Project land for agricultural activity, could also affect populations if located in proximity to those activities. Two of the four sites with suitable habitat identified in Study 29 are located adjacent to agricultural operations in the applicable Project's boundary. Direct agricultural impacts (e.g., runoff) may occur but are unrelated to Project operations. One site with suitable habitat is located within the applicable Project's boundary near a road and non-TransCanada owned car top boat launch. Road runoff could have an adverse effect on habitat, but it is unlikely that boating or the occasional camping that may occur there (Study 30) would cause adverse effects on northeastern bulrush habitat. The fourth site, while within the applicable Project's boundary, did not appear to have such associated activities. Therefore, TransCanada concludes that continuing Project operations will not adversely affect northeastern bulrush.

3.7.2.4 Jesup's Milk Vetch

The 2012 Jesup's milk vetch study (Normandeau, 2013b) found no evidence to suggest that normal Project operational flow ranges affect Jesup's milk vetch individuals or populations. The lowest elevations at which Jesup's milk vetch plants grew were equated to discharges of 29,000 cfs at the Jarvis Hill site and 38,000 cfs at the Sumner Falls site, which is much greater than the normal operational flows from Wilder (700 to 10,500 cfs). It is likely that scour from high flows (well above normal Project operations) may be an important influence in the establishment or maintenance of Jesup's milk vetch plants. No routine maintenance or recreation activities occur at Jesup's milk vetch sites. Although whitewater boating at Sumner

Falls occurs in the general vicinity of the Jesup's milk vetch site (see Section 3.8.1.1), TransCanada has no formal recreational area, and access to the falls for boating is owned and management by the town of Hartland, Vermont. Therefore, continued Project operations will not adversely affect Jesup's milk vetch.

Another factor influencing Jesup's milk vetch growth is the presence of invasive species, such as black swallowwort which thrives in conditions similar to those preferred by Jesup's milk vetch. NHNHB and VTNHI are employing active vegetation management techniques including the use of approved herbicides and removal of black swallowwort during the growing season on a periodic basis.

3.7.2.5 Dwarf Wedgemussel

FWS issued the Recovery Plan for the dwarf wedgemussel in 1993 (Moser, 1993); in the 24 years since it was published, there have been two 5-year reviews (2007 and 2013) but no updates to the recovery actions identified in the original document. The recovery actions described in the Recovery Plan (see Table 4 of that document for a stepdown recovery outline) fall under seven broad categories:

1. Collect basic data needed for protection of dwarf wedgemussel populations (conduct population and habitat surveys, identify essential habitat and key areas in need of protection, identify and determine significance of specific threats);

2. Preserve dwarf wedgemussel populations and occupied habitats (use existing legislation and regulations, and determine and implement protection strategies);

3. Encourage protection of the species through development of an educational awareness program;

4. Conduct life history studies and identify ecological requirements of the species;

5. Determine the feasibility of re-establishing populations within the species' historical range and, if feasible, introduce the species into such areas;

6. Develop and implement a program to monitor population levels and habitat conditions of presently established and introduced populations; and

7. Periodically assess overall success of the recovery program and recommend appropriate actions (changes in recovery objectives, downlisting, implementing new measures, and other studies).

Continued operation of TransCanada's Wilder, Bellows Falls, and Vernon Projects relates broadly and indirectly to some of these seven recovery actions. The Project areas include nearly all Southern and Middle Macrosites for dwarf wedgemussels, which are regarded as two of the largest populations remaining in the species' range. The presence and operations of the Projects have helped to shape dwarf wedgemussel population distribution, size, and habitat in these areas, although the direction and magnitude of such effects remains unknown. The dwarf wedgemussel studies conducted in the Project areas from 2011 to 2014 as part of Study 24, as well as other modeling and fish and aquatics studies, such as Studies 4, 5, 9, 10, and 12, provide comprehensive information on dwarf wedgemussel populations, co-occurring species, presence of potential host fish species, and habitat in the Project areas, as well as potential effects of Project operations (e.g., water level fluctuations) on the species.

Dwarf wedgemussels and co-occurring mussel species are relatively sedentary, year-round residents of the Connecticut River and require instream habitat and host fish for all aspects of their life cycle. At this time, assessment of the effects of Project operations on dwarf wedgemussel remains in progress and will be reported in the FLAs.

3.7.3 Cumulative Effects

No cumulative effects related to federally listed threatened or endangered species have been identified, so no cumulative effects on these species are evaluated as part of this environmental analysis.

3.7.4 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures related to federally listed threatened or endangered species.

3.7.5 Unavoidable Adverse Effects

Normal Project operations have no identified adverse effects on current federally threatened or endangered terrestrial species that are located in the Wilder, Bellows Falls, and Vernon Project areas and were evaluated in this environmental analysis.

Dwarf wedgemussel is the only federally listed aquatic species known to be present within the Project areas. Once assessment of the effects of Project operations is completed, unavoidable adverse effects, if any, will be identified in the FLAs.

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3.8 Recreation Resources and Land Use

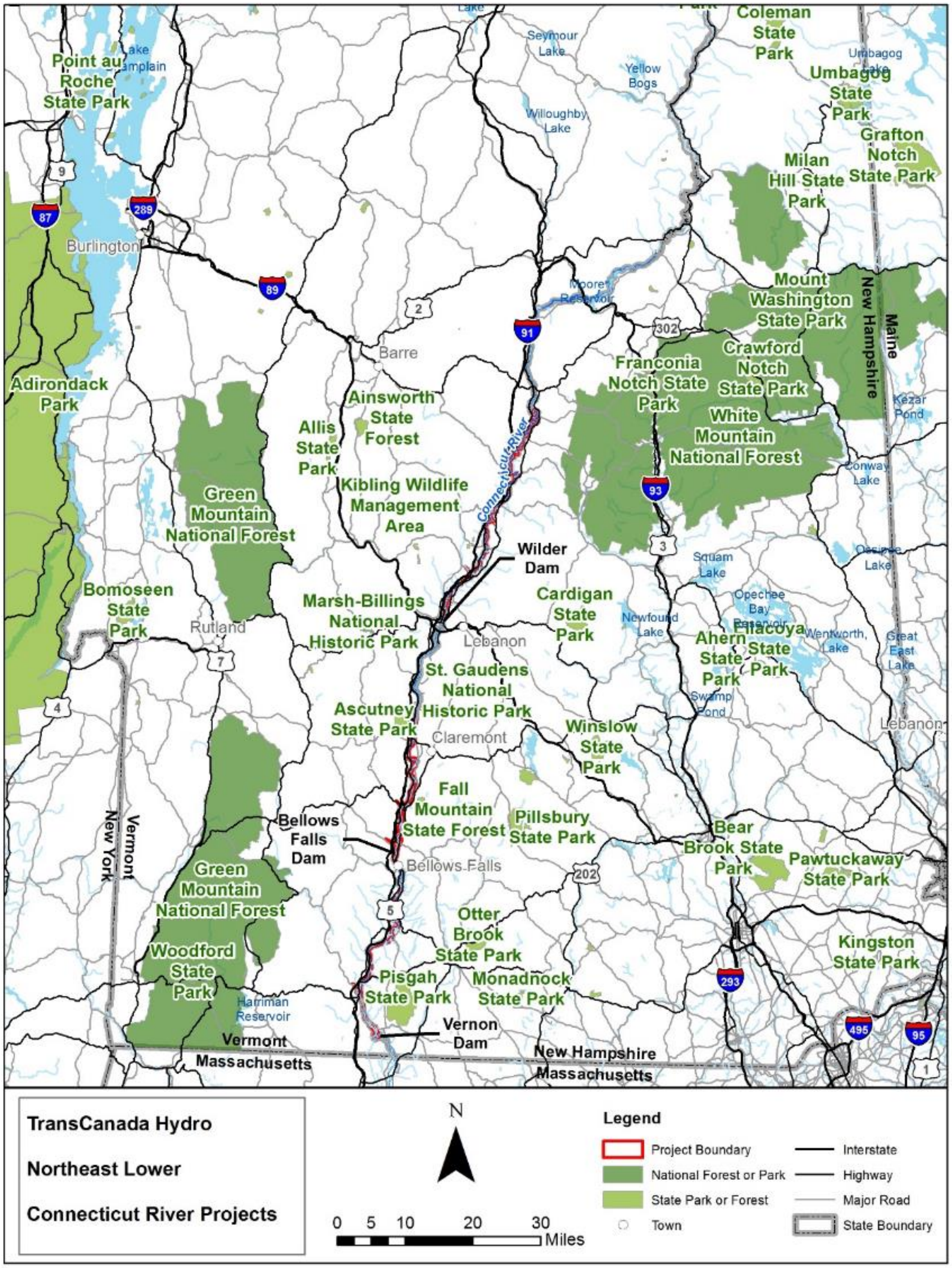
TransCanada developed and conducted ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*, to assess existing recreational facilities and uses at the Projects and ILP Study 31, *Whitewater Boating Study*, to assess whitewater resources potentially affected by the Wilder and Bellows Falls Project operations. The methodologies for the Study 30 included facility inventories and condition assessments, spot counts, trail and traffic counters, aerial photography review, visitor surveys and interviews (i.e., exit interviews and mail surveys), and recreation site use records. Methodologies for Study 31 included multiple flow assessments with various skilled paddlers in different types of crafts. Unless otherwise stated, all of the following information has been sourced from Study 30, Study 31, and Project PADs (TransCanada, 2012a, 2012b, 2012c).

3.8.1 Affected Environment

3.8.1.1 Recreation Resources

Regional Recreation Resources

Numerous regional public recreation resources surround the three Project impoundments including access for boating (flatwater and whitewater), fishing, hiking, camping, picnicking, swimming, wildlife viewing, and educational programming, as shown in Figure 3.8-1. Recreation sites in proximity to the Projects provide river boating access, hiking and nature observation opportunities, while numerous state lands provide opportunities for hiking, hunting, and enjoyment of the outdoors. Some of the nearby regional recreation resources on federal lands include White Mountain National Forest (approximately 30 miles northeast of Wilder dam), Marsh-Billings National Historic Park (approximately 12 miles southwest of Wilder dam), and Green Mountain National Forest (approximately 35 miles northwest of Wilder dam and 30 miles west of Bellows Falls and Vernon dams). Numerous state, county, and local governments also provide recreational opportunities and facilities in the region and along the Connecticut River. State Parks, listed from north to south, include: Cardigan State Park (approximately 18 miles east of Wilder dam), Ascutney State Park (approximately 17 miles south of Wilder dam), Winslow State Park (approximately 34 miles northeast of Bellows Falls dam), Pillsbury State Park (approximately 18 miles northeast of Bellows Falls dam), Otter Brook State Park (approximately 19 miles northeast of Vernon dam), and Pisgah State Park (approximately 6 miles northeast of Vernon dam). Fall Mountain State Forest is located in Charlestown and Langdon, New Hampshire, adjacent to the Bellows Falls impoundment.



Source: TransCanada (2012a, 2012b, and 2012c)

Figure 3.8-1. Regional recreation resources in proximity to the Projects.

The Connecticut River Paddlers' Trail is a regional resource for multi-day canoe/kayak trips along the Connecticut River. It extends along the length of the Connecticut River in Vermont and New Hampshire and offers visitors a series of access points and primitive campsites. The trail is managed by a group of partner organizations who collaborate on trail development and stewardship (Connecticut River Paddlers' Trail, 2016).

Numerous other FERC licensed hydropower projects along the Connecticut River also provide recreation opportunities in the region, including the Fifteen Mile Falls Project (comprising the Moore, Comerford, and McIndoes developments); and a portage trail and primitive campsite at the Dodge Falls Project, located upstream of the Wilder Project; and the Northfield Mountain and Turners Falls Projects located downstream of Vernon Project. The Deerfield River, which flows into the Connecticut River at Greenfield, Massachusetts, has 9 dams that also provide recreational opportunities including whitewater boating, within approximately 20 miles of Vernon. In addition, USACE operates several flood control projects in the region that provide water and land based recreation opportunities.

Project-related Recreation Resources

People from the towns and communities throughout the Connecticut River Valley, including Vermont, New Hampshire, and Massachusetts, enjoy visiting recreation facilities and engaging in recreation opportunities in the Project areas. Interstate Route 91 and U.S. Route 5 run along the Vermont side of the valley, while New Hampshire Route 10 and Route 12 run along the New Hampshire side, providing highway access throughout the Connecticut River Valley. The Boston and Maine Railroads run along the Vermont side nearly paralleling U.S. Route 5. These railroad tracks make recreation access difficult to many areas along the three Project impoundments. Various managing entities including state, municipal, non-governmental organizations, private landowners, and TransCanada provide access to Project lands and waters for the various recreation facilities. The existing recreation setting is discussed by Project and river reach from upstream to downstream, followed by a description of the amount of recreation use at Project-related sites.

Wilder Project Recreation Resources

The Wilder Project is located between Hartford, Vermont, and Lebanon, New Hampshire, at RM 217.4 on the Connecticut River. The Project impoundment extends upstream about 45 miles to a point several miles downstream of both the Wells River and Ammonoousuc River confluences, located in the villages of Wells River, Vermont, and Woodsville, New Hampshire. The Wilder impoundment has a maximum WSE of 385 ft, resulting in about 105 miles of shoreline at full pond, which is predominantly surrounded by railroad corridors, low-lying wetlands, and agricultural fields. Private landowners or local municipalities own the majority of land surrounding the impoundment (Table 3.8-1). Table 3.8-2 summarizes TransCanada's Wilder Project recreation facilities.

Developed recreation sites near to the Wilder Project provide opportunities for camping, fishing, hiking, boating (motorized and canoe/kayaking), swimming, hunting, and winter sports such as ice fishing, snowmobiling, cross-country skiing, and ice skating. TransCanada holds fee ownership of 123 acres of land in the Wilder Project boundary, 59 acres of which is set aside for public outdoor recreation use. Developed recreation facilities adjacent to the Project include boat ramps and boat launches, canoe launches, campsites, picnic areas, day use areas, athletic fields, shoreline docks, and a portage trail.

The most popular recreation activities at the Wilder impoundment are canoeing/kayaking, boating and boat-based fishing; however, waterfowl hunting and hiking are also prevalent near the Project. New Hampshire and Vermont residents can obtain a permit for hunting along the Connecticut River Birding Trail.[37] Bird hunting season in New Hampshire is open in August and March, depending on the species type (NHFGD, 2016c). In Vermont, bird hunting permits are issued for the calendar year, but, the waterfowl season generally occurs between September and December (VFWD, 2015). Hiking opportunities in proximity to the Project are available on the Appalachian Trail, Montshire Science Museum Riverwalk Trail, Bald Mountain Trail, and Kilowatt Park North and South Trails. Public recreation facilities and opportunities adjacent to and crossing the Wilder Project boundary are shown on Figure 3.8-2.

Table 3.8-1. Public recreation areas at the Wilder Project.

Site Name	River Mile	Town	Manager
Connecticut River Paddlers' Trail campsite: Harkdale Farm	259.5	Newbury, VT	Upper Valley Land Trust
Newbury-Haverhill Bridge access	257.5	Haverhill, VT	VDFG
Bedell Bridge State Park	255	Haverhill, NH	NH Parks and Recreation
Connecticut River Paddlers' Trail campsite: Vaughn Meadows	254	South Newbury, VT	Upper Valley Land Trust
Bugbee Landing access point	248	Bradford, VT	VDFG
Connecticut River Paddlers' Trail campsite: Bugbee Landing	248	Bradford, VT	Bradford Elementary School
Connecticut River Paddlers' Trail campsite: Underhill Camp	245	Piermont, NH	Piermont, NH, Conservation Commission
Orford boat landing	239	Orford, NH	Town of Orford, NH

[37] The Connecticut River Birding Trail is not a linked *trail* with connecting paths but a joint conservation, education and tourism venture that identifies 128 prime places for birding in the Connecticut River watershed.

Site Name	River Mile	Town	Manager
Connecticut River Paddlers' Trail campsite: Pastures Campground	239	Orford, NH	Private Landowner
Connecticut River Paddlers' Trail campsite: Birch Meadow	236.5	Fairlee, VT	Hulbert Outdoor Center; Upper Valley land Trust
Connecticut River Paddlers' Trail campsite: Roaring Brook	234	Thetford, VT	Upper Valley Land Trust
North Thetford Landing	232.5	Thetford, VT	State of VT
Hewes Brook boat launch	228	Lyme, NH	Lyme, NH, Conservation Commission
Ompompanoosuc launch	225	Pompanoosuc, VT	State of VT
Connecticut River Paddlers' Trail campsite: Patchen's Point	224	Norwich, VT	Friends of Patchen Miller
Norwich Landing	216	Norwich, VT	Town of Norwich, VT
Wilson's (Fullington) Landing	221	Hanover, NH	Town of Hanover, NH
Ledyard Canoe Club	218.5	Hanover, NH	Dartmouth College
East Wilder boat launch	216	West Lebanon, NH	City of Lebanon, NH
Hartford (Wilder) picnic area at Kilowatt Park (North)	219.3	Hartford, VT	TransCanada, leased to Town of Hartford, VT
Gilman Island Titcomb Cabin managed through Dartmouth Outing Club **Connecticut River Paddlers' Trail campsite**	217.5	Hanover, NH	Island leased to Dartmouth College (the Outing Club manages Titcomb Cabin) Primitive campsite maintained by TransCanada
Wilder dam (Olcott Falls) boat launch at Kilowatt Park (South)	216	Hartford, VT	TransCanada, leased to Town of Hartford, VT
Wilder dam fish ladder and angler parking	215	Hartford, VT	TransCanada
Lebanon (Wilder dam) picnic area, vista, and hiking trails	215	West Lebanon, NH	TransCanada

Site Name	River Mile	Town	Manager
Wilder dam portage and downstream natural areas	215.5	West Lebanon, NH	TransCanada
Downstream of Wilder Project Boundary			
Lyman Point Park launch	217	Hartford Township, VT	Hartford, VT, Township
Two Rivers Park and Lebanon public boat launch	215	Lebanon, NH	City of Lebanon, NH
Blood's Brook launch (True's Brook Landing)	213	Lebanon, NH	NHFGD
Ottaquechee boat launch	212	North Hartland, VT	Town of Hartland, VT
Connecticut River Paddlers' Trail campsite: Burnaps Island Campsite	212	Plainfield, NH	Upper Valley Land Trust
Sumner Falls (Hartland Rapid)	209	Hartland, VT	Town of Hartland, VT
Connecticut River Paddlers' Trail Campsite: Burnham Meadow Campsite	205	Windsor, VT	Upper Valley Land Trust
Cornish boat landing	202	Cornish, VT	NHFGD

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned Project recreation site

Table 3.8-2. Wilder Project recreation sites and facilities.

Recreation Site Name	Recreation Facilities
Hartford (Wilder) picnic area at Kilowatt Park (North)	Kilowatt Park North River Trail to Kilowatt Park (South) (wildlife viewing area; courtesy dock/hand-launch area; picnic area with 7 tables, 3 grills, 3 benches; paved parking with capacity for approximately 10 vehicles; 2 grass parking areas; dog waste disposal station; port-a-potty
Gilman Island and Titcomb Cabin	Primitive campsite and rental cabin. Gilman Island provides campers with a primitive campsite for 15 to 30 tents, a picnic table, a fire pit with grilling grate, various hiking trails, and a privy. Titcomb Cabin provides lodging for 10 people.
Wilder dam (Olcott Falls) boat launch at Kilowatt Park (South)	Single-lane, concrete boat ramp; dock; Kilowatt Park South River Trail to Kilowatt Park (North) 3 picnic tables; 2 benches; 2 athletic fields; dog waste disposal station; 3 gravel parking areas with capacity for a total of 30 vehicles; port-a-potty

Recreation Site Name	Recreation Facilities
Wilder dam portage and picnic area	Portage trail; put-in downstream of Wilder dam; take-out; parking area
Lebanon (Wilder dam) picnic area vista and hiking trails	3 picnic tables; walking trails 2 gravel parking lots
Wilder dam fish ladder and angler parking	1 picnic table; gazebo; fish ladder viewing window; gravel parking area

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Wilder Project Recreation Sites

TransCanada owns and manages six formal Project recreation sites at the Wilder Project, Kilowatt Park (North and South) operated and maintained by Town of Hartford (agreement), Wilder dam portage and picnic area, Lebanon (Wilder dam) picnic area vista and hiking trails, Wilder dam fish ladder and angler parking, and Gilman Island, operated and maintained by Dartmouth College (lease) and TransCanada. Table 3.8-2 summarizes Wilder Project recreation facilities as described below.

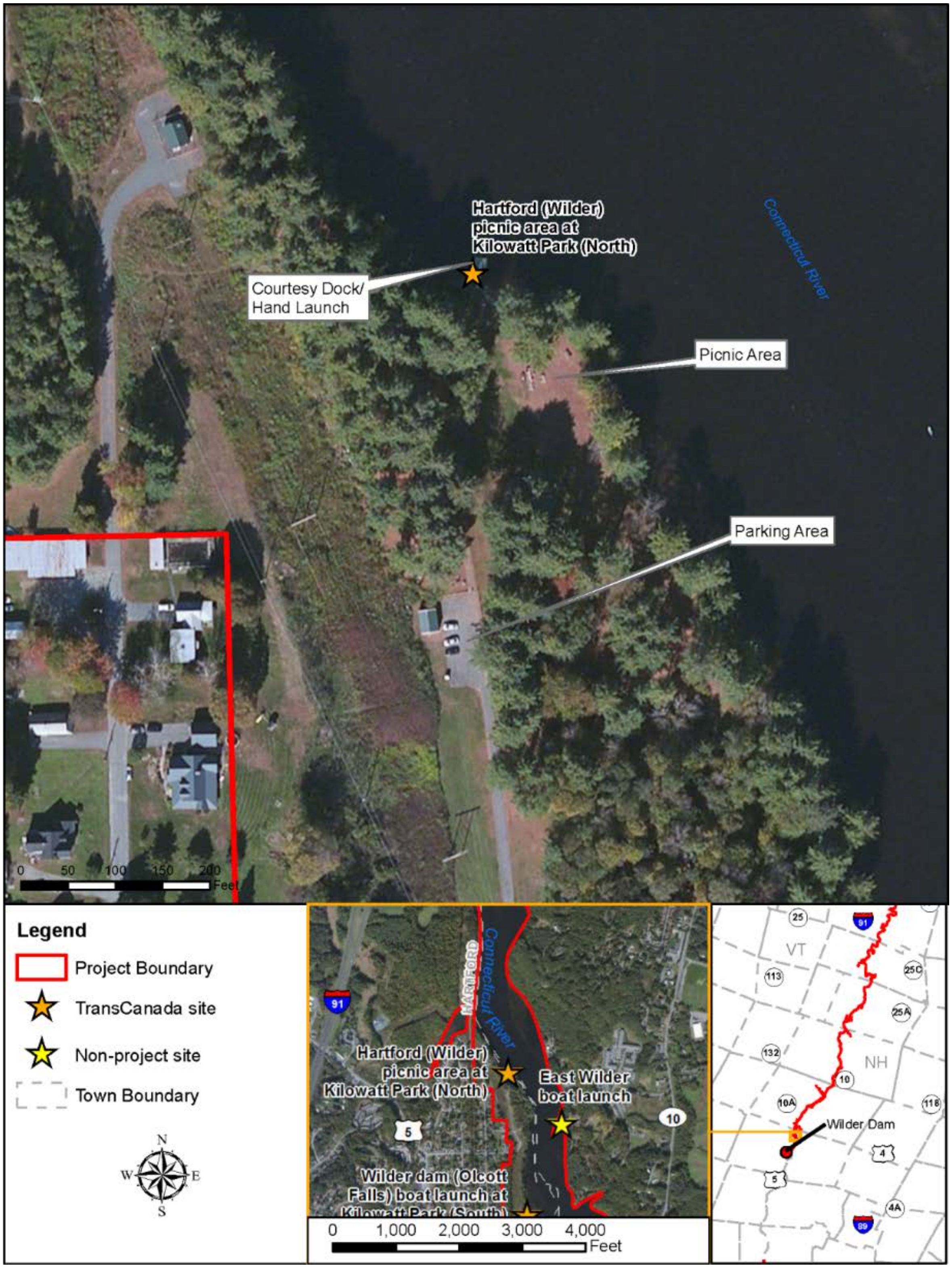
TransCanada owns and manages the Hartford (Wilder) picnic area at Kilowatt Park (North) through a cooperative use agreement with the Town of Hartford, Vermont. The site is located on Gillette Street on the west side of the river in Hartford (see Figure 3.8-2). Facilities include a picnic area with seven picnic tables, three grills, and three benches; an open area for viewing wildlife; a hand-launch area for car-top boat launching with a dock; and walking trails of varying lengths that connect to Kilowatt Park (South). The park also provides paved parking for about 10 vehicles with grass overflow parking and port-a-potty. Because dog walking is popular at this site, TransCanada provides a dog waste disposal station. The facility inventory condition assessment reported the site condition and visible condition scores for this site as *excellent*.

TransCanada also owns and manages the Wilder dam (Olcott Falls) boat launch at Kilowatt Park (South) through a cooperative use agreement with the Town of Hartford. The site lies directly above Wilder dam on Wilder Dam Road on the west side of the river in Hartford, Vermont (Figure 3.8-3). Project recreation facilities include a single-lane, concrete boat ramp with an L-shaped dock, a picnic area with three picnic tables and two benches, two athletic fields with bleachers, and walking trails of varying lengths that connect to Kilowatt Park (North). Other amenities include three gravel parking areas with capacity for 30 vehicles, port-a-potties, and dog waste disposal stations. Popular activities include walking/hiking, boat launching, and using the athletic field. The facility inventory condition assessment reported site condition and visible condition scores for this site as *excellent*.

The Wilder dam portage and picnic area provides portage around the east side of Wilder dam on the New Hampshire side of the river (Figure 3.8-4). The take-out is located just downstream from the overhead transmission lines at the upstream boat barrier about 1,000 feet upstream of the dam and includes stairs leading up the riverbank. The portage trail follows a grassy path that runs along the bank, parallel to Highway 10, and then crosses a parking area and follows a gravel road to a gravel foot path with granite stairs to a sand/gravel beach. The trail's total length is about 0.2 mile with an elevation gain of 33 feet and an elevation loss of 90 feet. The average uphill slope is 4.7 percent, and the average downhill slope is −8.2 percent. The parking area between the dam and New Hampshire Route 10 can accommodate about five vehicles. This site is mostly used by shoreline fishermen and car-top access boaters. The facility inventory condition assessment reported a site condition score of *good* and a visible condition score for this site as *excellent.*

Lebanon (Wilder dam) picnic area vista and hiking trails are directly adjacent to Wilder dam on the east side of the river in West Lebanon, New Hampshire, and the Wilder dam fish ladder and angler parking is directly adjacent to and downstream of Wilder dam on the west side of the river in Hartford, Vermont (Figure 3.8-5). The picnic area vista and hiking trails overlook the dam and impoundment, and the site serves as a trailhead to hiking opportunities to Boston Lot Lake. Project recreation facilities at the fish ladder include a picnic area with one table and a gazebo and a fish ladder viewing window, located at the east end of the powerhouse and accessed using a gated stairway. The site is open seasonally and is popular in the spring with anglers fishing the tailrace. The facility inventory condition assessment reported site and visible condition scores here as *excellent*.

TransCanada owns and manages Gilman Island through a lease with Dartmouth College. The Dartmouth College Outing Club maintains and operates Titcomb Cabin for overnight accommodations and functions. Also located on the island is a primitive canoe campsite maintained by TransCanada in cooperation with the Connecticut River Paddlers' Trail. The island is boat-in only and available to the public as part of the Connecticut River Paddlers' Trail (Figure 3.8-6). Gilman Island provides campers with a primitive campsite for 15 to 30 tents, a picnic table, a fire pit with grilling grate, various hiking trails, and a privy. Titcomb Cabin provides lodging for 10 people. The cabin is available for rent between May 1 and November 30. The facility inventory condition assessment reported the site condition and visible condition scores for this site as *excellent*.

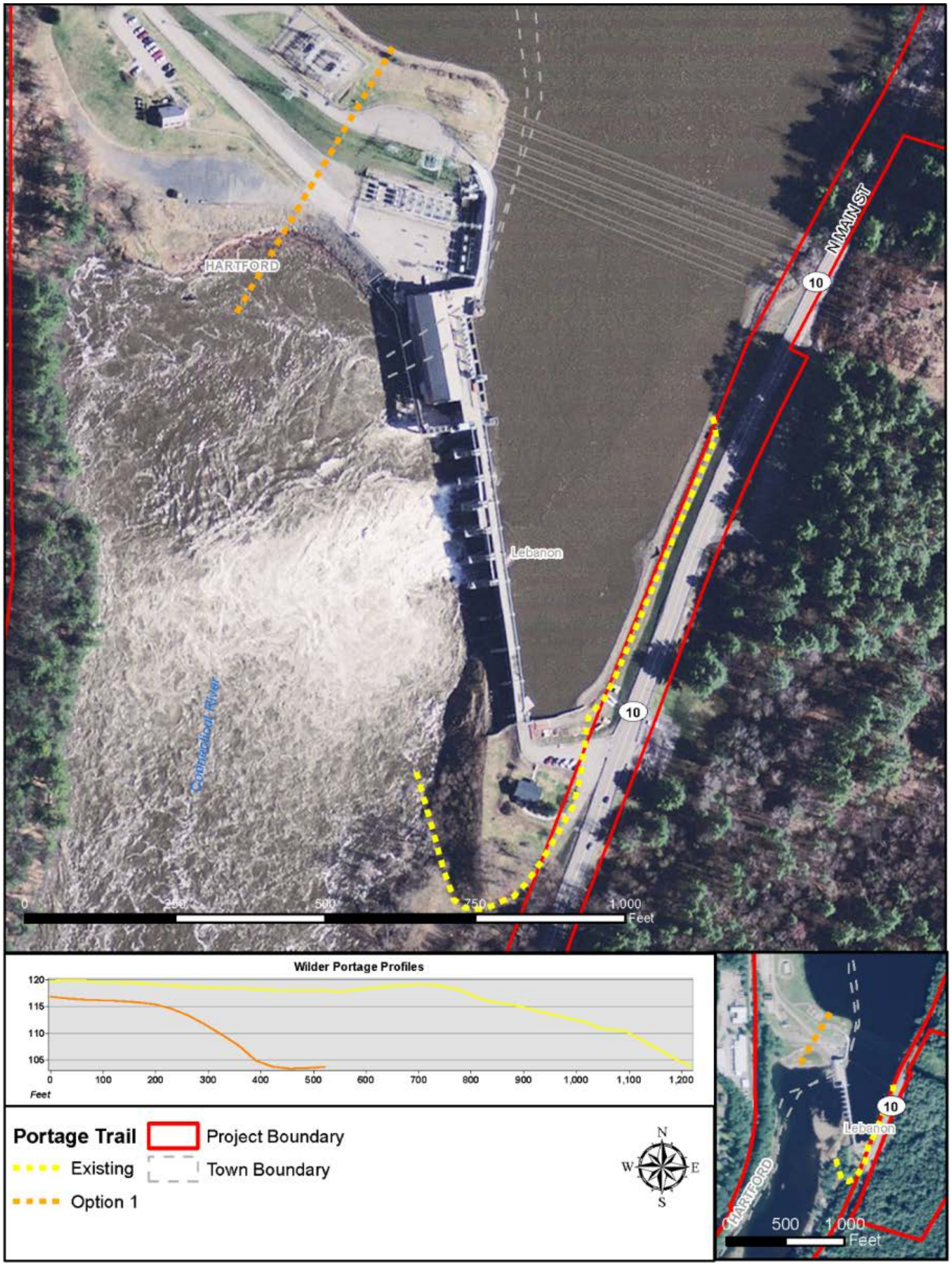


Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-2. Hartford (Wilder) picnic area at Kilowatt Park (North).

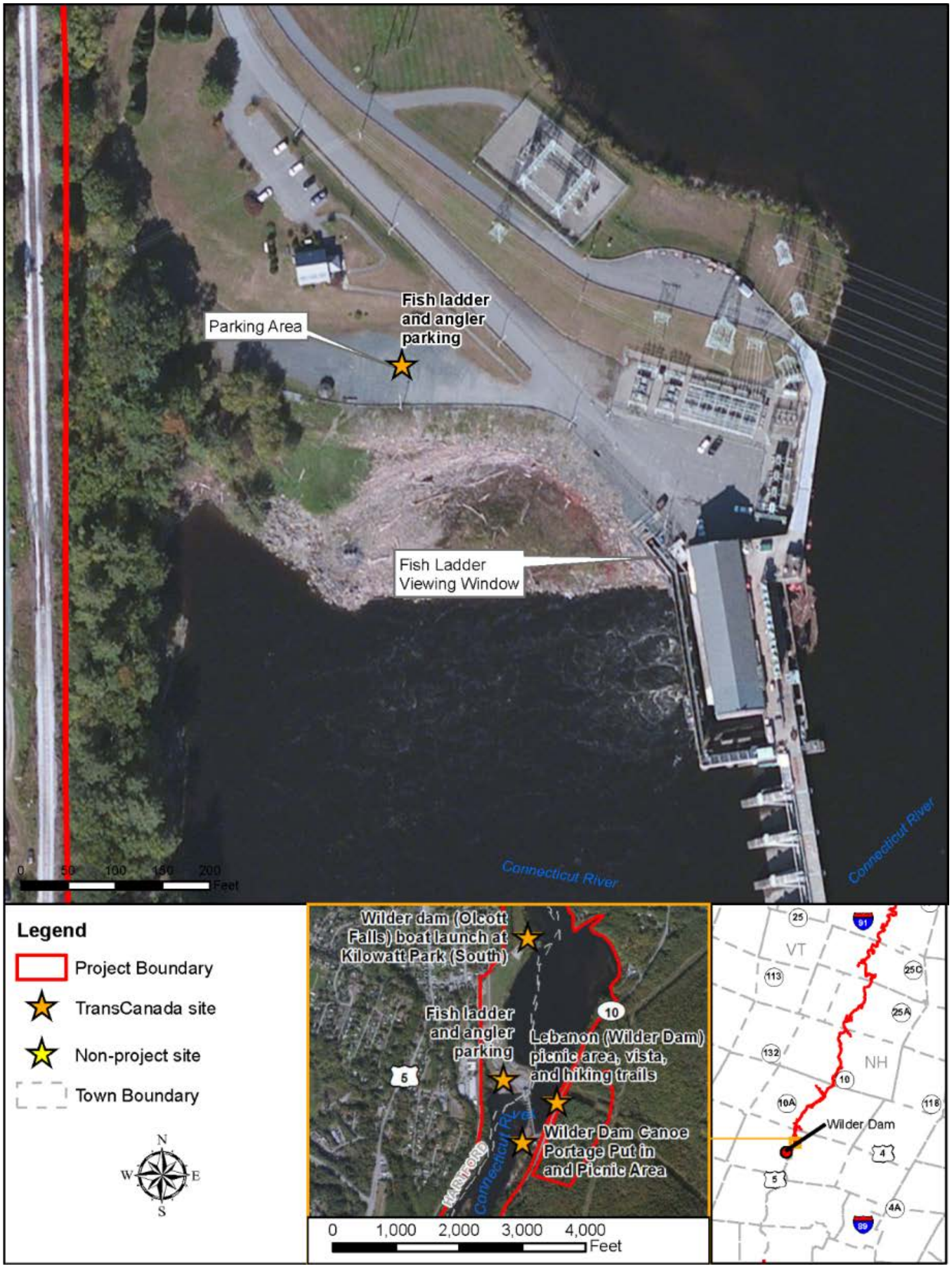
Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-3. Wilder dam (Olcott Falls) boat launch at Kilowatt Park (South).



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-4. Wilder dam portage and picnic area.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-5. Wilder dam fish ladder and angler parking.

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-6. Gilman Island, including Titcomb Cabin and primitive campsites.

Wilder Project Recreation Use

TransCanada conducted an in-depth study from March 2014 through February 2015 to assess the type and level of recreation use at formal recreation sites providing access and opportunities adjacent to and into the Wilder Project boundary. Data collection objectives included determination of the amount of recreation use at both Project and non-Project recreation sites, user opinions about existing recreation sites, and user perceptions related to their use of the sites. Recreation use estimates were based on traffic counts, spot counts, interview data, and facility operator estimates where possible. Study staff deployed traffic counters at 10 access sites. Use is reported as *recreation days,* which FERC defines as each visit by a person to a development for recreational purposes during any portion of a 24-hour period. Data regarding user opinions were obtained through the recreation use survey and a regional mail survey.[38]

The total annual recreation use of all surveyed recreation sites at the Wilder Project was estimated to be 234,403 recreation days. Table 3.8-3 provides a breakdown of estimated use by season.

Table 3.8-3. Estimated use (in recreation days) at Wilder study area recreation sites from March 2014 through February 2015.

Site Name	Peak Season Use[a]	Off Season Use	Use from March 1, 2014 to February 28, 2015
Newbury-Haverhill Bridge	1,958	1,257	3,216
Bedell Bridge State Park	15,194	1,575	16,769
Bugbee Landing access point	1,478	1,117	2,596
Orford boat landing	12,381	1,685	14,066
North Thetford Landing	2,592	1,746	4,338
Hewes Brook car-top boat launch	250	210	459
Ompompanoosuc launch	1,459	140	1,599
Wilson's (Fullington) Landing	25,706	3,247	28,953
Ledyard Canoe Club	749	Closed	749
Norwich Landing	768	Closed	768
Wilder picnic area (Kilowatt Park North)	32,202	7,258	39,459
Hartford Park at (Kilowatt Park South)	56,624	2,173	58,797

[38] In support of Study 30, a mail-back survey was sent to randomly selected residents within the counties surrounding the Projects.

Site Name	Peak Season Use[a]	Off Season Use	Use from March 1, 2014 to February 28, 2015
East Wilder boat launch	1,517	Closed	1,517
Wilder dam fish ladder/fishing access	806	Closed	806
Wilder portage put-in	326	1,397	1,723
Lebanon (Wilder dam) picnic area vista and hiking trails	10,262	6,529	16,791
Lyman Point Park launch	1,498	Closed	1,498
Two Rivers Park and Lebanon public boat launch	5,910	1,024	6,935
Blood's Brook launch (a.k.a. True's Landing) (Lebanon launch)	4,688	499	5,187
Ottaquechee boat launch	3,728	160	3,888
Sumner Falls (Hartland Rapids)	20,090	167	20,257
Cornish boat landing	4,032	Closed	4,032
		Total	**234,403**

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned and operated Project recreation site

a. Peak season defined as May 1 to October 15

In addition to determining the type and amount of use at each of the surveyed sites, the degree to which each recreation site had the capacity to sustain the recreation activity occurring there was estimated. Table 3.8-4 summarizes the amount of formal and estimated informal parking spaces at each of the sites and the average and maximum number of vehicles observed during weekend spot counts between May 1 and October 15, 2014, the peak recreational season. Formal parking is defined as a hardened surface (either asphalt or concrete) with designated parking spaces (striping and/or concrete parking blocks). Table 3.8-4 shows which sites could be at or near capacity; however, because some sites provide supplemental informal parking such as or grassy areas that can accommodate vehicles, and space along the shoulders of local roads, on beaches, or in the woods, it is not always clear exactly when a site reaches, or exceeds its functional capacity. Parking at TransCanada-owned sites is described below.

Table 3.8-4. Wilder Project recreation site parking lot use.

Site Name	No. of Parking Areas	Has Formal Parking Spaces	No. of Designated Parking Spaces	Estimated No. of Informal Parking Spaces[a]	Average No. of Peak Season Weekend Vehicles	Max. Peak Season Vehicles	Date(s) of Maximum (2014)	Notes
Newbury-Haverhill Bridge	1	No		10	1.8	13	9/7	Additional parking available on mowed grass; capacity for 13 vehicles is likely
Bedell Bridge State Park	2	Yes	16	>80	4.2	25	5/18	Lots of additional parking available onsite; capacity for 80 to 100 vehicles
Bugbee landing access point	1	No		>100	1.6	12	7/12	Site has no designated spaces
Orford boat landing	2	Yes	24	Not applicable	4.7	20	6/21	Well-designed site completed in 2012–2013
North Thetford Landing	1	No		15+	2.5	9	6/28	Large, gravel parking area
Hewes Brook car-top boat launch	1	No		5	0.3	2	5/11, 9/24	Lightly used site
Ompompanoosuc Launch	1	No		9	1.5	9	9/21	Parking can be limited by parking in turnaround and by any vehicles with trailers
Wilson's (Fullington) Landing	1	No		15-20	5.2	18	7/20	Square, large gravel lot without designated spots
Ledyard Canoe Club	1	Yes	25+		0.9	6	5/17, 6/15, 6/21	Multi-use lot for Dartmouth College
Norwich Landing	1	No		5	1.1	7	6/7	Not designed for trailers

Site Name	No. of Parking Areas	Has Formal Parking Spaces	No. of Designated Parking Spaces	Estimated No. of Informal Parking Spaces[a]	Average No. of Peak Season Weekend Vehicles	Max. Peak Season Vehicles	Date(s) of Maximum (2014)	Notes
Wilder picnic area (Kilowatt Park North)	3	No		10+	3.1	13	9/21	Multi-use
Hartford Park (Kilowatt Park South)	3	No		100+	6.2	104	5/14	Multi-use
East Wilder boat launch	1	No		5+	1.7	9	6/22	Parking occurs along East Wilder Road shoulder on busiest days
Wilder dam fish ladder/fishing access	1	No		20+	0.8	4	6/8	Large area for a lightly used site
Wilder dam canoe portage put-in	1	No		5+	0.5	8	9/7	Parking area compromised by debris pile storage
Lebanon picnic area vista and hiking trail	1	No		20+	10.1	25	6/22	Gravel parking areas
Lyman Point Park launch	2	Yes	25		1.8	51	8/9	Parking shared with local office buildings on east and west side of railroad tracks; maximum number of vehicles recorded during Native American festival, not related to river access
Two Rivers Park and Lebanon public boat launch	2	No		20+	0.9	4	7/3, 7/12, 8/10	Large informal site with multiple parking areas

Site Name	No. of Parking Areas	Has Formal Parking Spaces	No. of Designated Parking Spaces	Estimated No. of Informal Parking Spaces[a]	Average No. of Peak Season Weekend Vehicles	Max. Peak Season Vehicles	Date(s) of Maximum (2014)	Notes
Blood's Brook Launch (a.k.a. True's Landing) (Lebanon Launch)	1	No		5	0.6	4	7/19	Dirt road with small openings alongside for parking
Ottaquechee boat launch	1	No		5	0.9	5	6/21, 6/22, 7/26	Dirt road with small opening for two to three vehicles; some users park along riverbank/woods during low flow periods
Sumner Falls (Hartland Rapids)	3	No		20	6.2	23	7/26	Various informal, multiple parking areas of different sizes; main parking area could accommodate 10 vehicles
Cornish Boat Landing	1	No		15+	4.4	35	7/19	Site hosts canoe events with overflow parking along New Hampshire Route 12

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned and operated Project recreation site

a. Estimated numbers of informal parking spaces are based on gravel parking area; typically, these areas are surrounded by lawn by design, providing additional parking and much higher capacity while balancing maintenance costs.

Wilder picnic area at Kilowatt Park (North)—This site offers limited designated parking spaces; however, it also provides a large amount of maintained grassy area for additional parking, which at times receives use as noted in Table 3.8-4. The site receives regular use during peak season weekends, and the mowed grassy areas adjacent to the gravel parking lot provide more than sufficient space to accommodate visitor parking during peak demand periods.

Wilder dam (Olcott Falls) boat launch at Kilowatt Park (South)—This site provides multi-sport ball fields that receive extensive use during the spring and fall soccer and lacrosse seasons. Traffic counts captured the high concentrations of activity related to the sport practices and game use at this site. Spot counts confirmed that parking is adequate but could be limiting to trailer parking at the boat ramp during these times.

Wilder dam fish ladder—The fish ladder and angler parking area appears to be more than sufficient to accommodate the low amount of use occurring on the Vermont side downstream of the dam. However, the fish ladder was not operating during site visits and the gate to the viewing window was closed thus restricting public access.

Lebanon picnic area vista and hiking trail—This parking lot and picnic area is popular with hikers visiting the non-Project Boston Lot Lake (part of the Connecticut River Birding Trail) and day-users having lunch (often in their vehicles) while viewing the dam and impoundment. TransCanada staff use the adjacent parking lot for parking and storage of large equipment, which informally discourages public use.

Wilder dam canoe portage put-in—This site provides anglers use of the gravel access road and parking area just downstream of the dam and is most popular in the spring. The parking area is also used as a temporary staging area for river debris from the dam, which reduces the overall amount of parking available. The size of the debris pile varies throughout the year because TransCanada regularly removes debris from the powerhouse intakes and stores it at this location prior to final treatment and removal.

Gilman Island including Titcomb Cabin—Gilman Island is part of the Connecticut River Paddlers' Trail. Primitive camping is first come, first served and is used extensively by paddling groups. Titcomb Cabin rentals are administered by Dartmouth College. In 2014, the cabin was booked 116 nights during the open season (May 1–November 30).

Wilder Visitors' Opinions and Perceptions

In general, interview respondents expressed satisfaction with the condition of both TransCanada Project recreation facilities and existing public facilities associated with the Wilder Project. Eighty-four percent of visitors interviewed rated their satisfaction with the condition of TransCanada Project recreation sites as either *moderately satisfied* or *extremely satisfied* (scores of 7, 8 or 9) (Table 3.8-5). Of the visitors who reported dissatisfaction with the condition of the existing Project and non-Project facilities, their primary reasons were the presence of trash, lack of toilets, and poor road/ramp surface conditions. Visitors interviewed reported dissatisfaction (scores of 1, 2, or 3) or *slightly satisfied* to *not at all satisfied*) with the condition of the following TransCanada Project recreation sites: Wilder dam picnic area (Kilowatt Park North and South [2 respondents]).

Table 3.8-5. Satisfaction with the condition of Wilder Project sites.

Location	Extremely Satisfied		Moderately Satisfied		Neutral (percent)		Slightly Satisfied	Not at All Satisfied	
	9	8	7	6	5	4	3	2	1
Non-Project recreation sites	49.5	15.0	21.4	2.9	6.3	1.5	1.9	1.5	0.0
Wilder Project recreation sites	53.1	10.2	22.4	2.0	8.2	0.0	4.1	0.0	0.0

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Approximately 81.0 percent of visitors reported being *extremely satisfied* or *satisfied* (scores of 7, 8, or 9) with the amount of recreation access provided to the Wilder Project. Table 3.8-6 presents visitor satisfaction with the number and type of recreation opportunities that provide access to the Wilder Project. Wilder Project area recreation sites were also rated as *extremely safe* by 79 percent of respondents. Safety concerns stemmed from broken glass at multiple sites, the condition of boat launches and the retaining wall at Hartford Park (Kilowatt Park South), and the presence of drug paraphernalia in the Wilder picnic area (Kilowatt Park North).

Table 3.8-6. Satisfaction with the number and type of recreational opportunities at Wilder Project.

Study Area	Extremely Satisfied		Moderately Satisfied		Neutral (percent)		Slightly Satisfied	Not at All Satisfied	
	9	8	7	6	5	4	3	2	1
All Wilder recreation sites	32.0	13.8	35.2	5.1	10.7	0.4	1.6	0.8	0.4

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Bellows Falls Project Recreation Resources

The Bellows Falls Project dam is located between Rockingham, Vermont, and Walpole, New Hampshire, at RM 173.7 on the Connecticut River and the powerhouse is located about 1,700 feet downstream of the dam (see Figure 1-1). The Project impoundment extends upstream about 26 miles to Chase Island at Windsor, Vermont, about 1 mile below the Windsor Bridge. Bellows Falls impoundment has a maximum WSE of 291.6 ft, resulting in about 74 miles of shoreline at full pond, which is predominantly surrounded by flat lands and agricultural fields. The lands immediately adjacent to the dam consist primarily of residential and industrial developments. Private landowners own most of the lands surrounding the impoundment; however, state, municipal, private entities, and TransCanada provide recreation access to Project lands and waters.

Developed recreation sites near the Project provide opportunities for camping, fishing, hiking, boating access (motorized and canoe/kayaking), swimming, hunting, and winter sports such as ice fishing, snowmobiling, cross-country skiing, and ice skating. TransCanada owns 835 acres of land within the Bellows Falls Project boundary, 86 acres of which are set aside for public outdoor recreational use. Developed recreation facilities at the Project include boat ramps, fishing platforms, picnic areas, marinas, visitor's center, and portage trails (Table 3.8-7).

Numerous hiking trails are located in the surrounding areas. Although the Connecticut River is a migratory flyway, Herrick's Cove in Rockingham, Vermont, is the only specified Connecticut River Birding Trail stop within the Project. The most popular recreation activities at the Bellows Falls impoundment are fishing from shore and by boat, picnicking/family gathering, canoeing/kayaking, and ice fishing.

Table 3.8-7. Public recreation areas at the Bellows Falls Project.

Site Name	River Mile	Town	Manager
Connecticut River Paddlers' Trail campsite: Wilgus State Park	191	Weathersfield, VT	State of VT
Ashley Ferry boat landing	187	Claremont, NH	State of NH
Connecticut River Paddlers' Trail campsite: Student Conservation Association	184	Charlestown, NH	Student Conservation Association
Hoyts Landing	179	Springfield, VT	State of VT
Patch Park	178	Charlestown, NH	Town of Charlestown, NH
Charlestown boat launch and picnic area	177	Charlestown, NH	TransCanada
Connecticut River Paddlers' Trail campsite: Lower Meadow	174	Charlestown, NH	TransCanada (non-Project)
Green Mountain Marina	173	Rockingham, VT	Private

Site Name	River Mile	Town	Manager
Herrick's Cove boat launch and picnic area	173	Rockingham, VT	TransCanada
Pine Street boat launch and portage trail take-out	170	North Walpole, NH	TransCanada
Bellows Falls fish ladder visitor center	169	Rockingham, VT	TransCanada
Bellows Falls dam portage put-in	168	Walpole, NH	Town of Walpole, NH
Cold River hand-launch	168	North Walpole, NH	NHDOT
Connecticut River Paddlers' Trail campsite: Westminster Campsite	167	Westminster Station, VT	Vermont River Conservancy
NHDFG car-top access	166	Walpole, NH	NHDFG

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned and operated Project recreation site

Bellows Falls Project Recreation Sites

TransCanada owns and operates four formal Project recreation sites at the Bellows Falls Project, including the Charlestown boat launch and picnic area, Herrick's Cove boat launch and picnic area, Pine Street boat launch and portage trail take-out, and the Bellows Falls fish ladder and visitor center (see Table 3.8-7). Table 3.8-8 shows Bellows Falls Project recreation sites and facilities, as described below.

Table 3.8-8. Bellows Falls Project recreation sites and facilities.

Recreation Site Name	Recreation Facilities
Charlestown boat launch and picnic area	Hand-carry boat launch; dock; 6 picnic tables; 6 grills; grass walking trail gravel/grass parking areas with capacity for 15 vehicles with trailers; 3 port-a-potties
Herrick's Cove boat launch and picnic area	Double-lane, concrete boat launch; 2 docks; 3 picnic areas with 26 picnic tables and 24 grills; shoreline walking trail); parking area with capacity for 20 vehicles; 5 port-a-potties
Pine Street boat launch and portage trail take-out	Single-lane, gravel boat launch; dock; picnic area with 1 picnic table and 2 benches; portage take-out[a]; grass parking area with capacity for 30 vehicles with trailers
Bellows Falls fish ladder and visitors center[b]	Visitor center with interpretive displays (historic and ecological); fish ladder viewing window

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

a. The portage take-out at Pine Street is within the Project boundary but the portage put-in is located below Bellows Falls dam on land owned by the Town of Walpole, NH, outside the Project boundary.

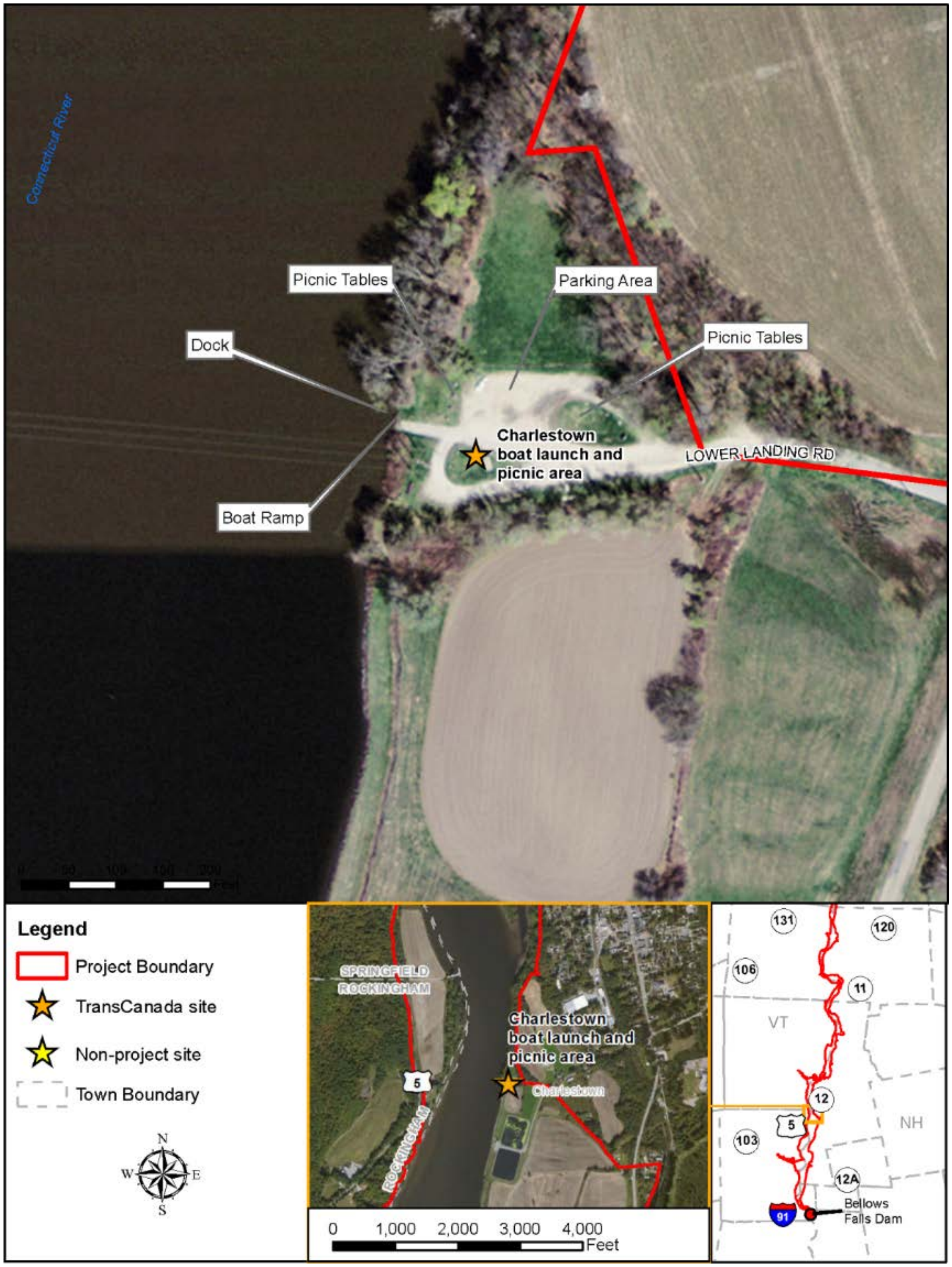
b. Operated by the Nature Museum at Grafton through an agreement with TransCanada.

The Charlestown boat launch and picnic area are located upstream of Bellows Falls dam on the east side of the river in Charlestown, New Hampshire (Figure 3.8-7). Project recreation facilities include a boat launch; a picnic area with six tables and grills; and grass walking trails. Other amenities include gravel and grass parking areas with capacity for 15 vehicles, and port-a-potties. The most popular recreation activities at this site are picnicking, grilling, and boating (motorized and non-motorized). The facility inventory condition assessment reported the site condition and visible condition scores for this site as *good*. Since the final Study 30 report was prepared and submitted to FERC, TransCanada replaced a grill, replaced the wood parking ties with boulders, re-graded the parking area, and temporarily converted the trailered boat launch to a hand-carry boat launch due to safety concerns. A new launch for trailered boats is being designed and construction is anticipated once design and permits are complete.

Herrick's Cove boat launch and picnic area is located upstream of Bellows Falls dam in Bellows Falls, Vermont, on the west side of the river (Figure 3.8-8). Project recreation facilities include a double-lane, concrete boat ramp with 2 docks; 3 picnic areas with 26 tables and 24 grills; and shoreline walking trails. Other amenities include a parking area with capacity for 20 vehicles and port-a-potties. Popular recreation activities at this site include birding, picnicking, walking/hiking, boating, and fishing. TransCanada sponsors the annual Wildlife Festival at Herricks Cove, an event that brings in hundreds of visitors to the park to learn about regional wildlife and their habitats. The facility inventory condition assessment reported the site condition and visible condition scores for this site as *excellent*. Since the final Study30 report was prepared and submitted to FERC, TransCanada completed maintenance dredging of the launch area.

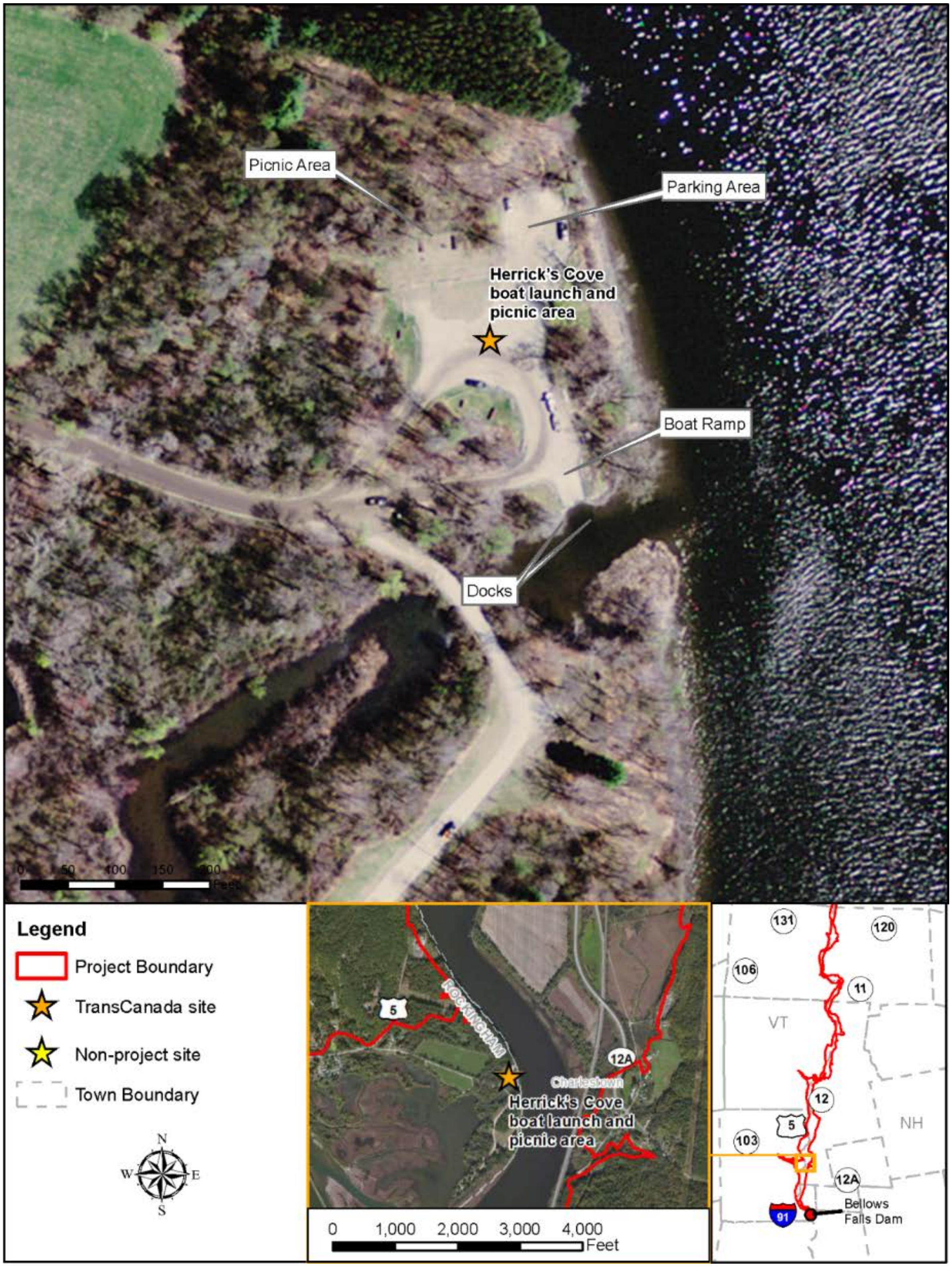
The Pine Street boat launch and portage trail take-out is located just upstream of the Bellows Falls dam in North Walpole, New Hampshire, on the east side of the river (Figure 3.8-9). This site is used primarily as the portage take-out for downriver canoe trips and for boat launching. Project recreation facilities include a single-lane, gravel boat launch; a dock; a picnic area with one table and two benches; and a portage take-out. Other amenities include a parking area with capacity for 30 vehicles with trailers. The facility inventory condition assessment reported the site condition and visible condition scores for this site as *good*. Since the final study report was prepared and submitted to FERC (Study 30), TransCanada dredged the boat ramp to improve the boat launch conditions.

The canoe portage around Bellows Falls dam is located on the New Hampshire side of the river. The portage take-out is at the Pine Street boat launch. The trail follows Pine Street, Spruce Street, and Church Street for about 0.4 mile to the Arch Bridge. The trail continues along Killeen Street and along the shoulder of Main Street (New Hampshire Route 12) for 1.1 mile, then turns down a paved access road to the river and the put-in location that is outside the Project boundary and located on land owned by the Town of Walpole, New Hampshire. The total length of the trail is about 1.5 miles with an elevation gain of 138 feet and an elevation loss of 189 feet. The average uphill slope is 3.6 percent and the average downhill slope is -4.2 percent.



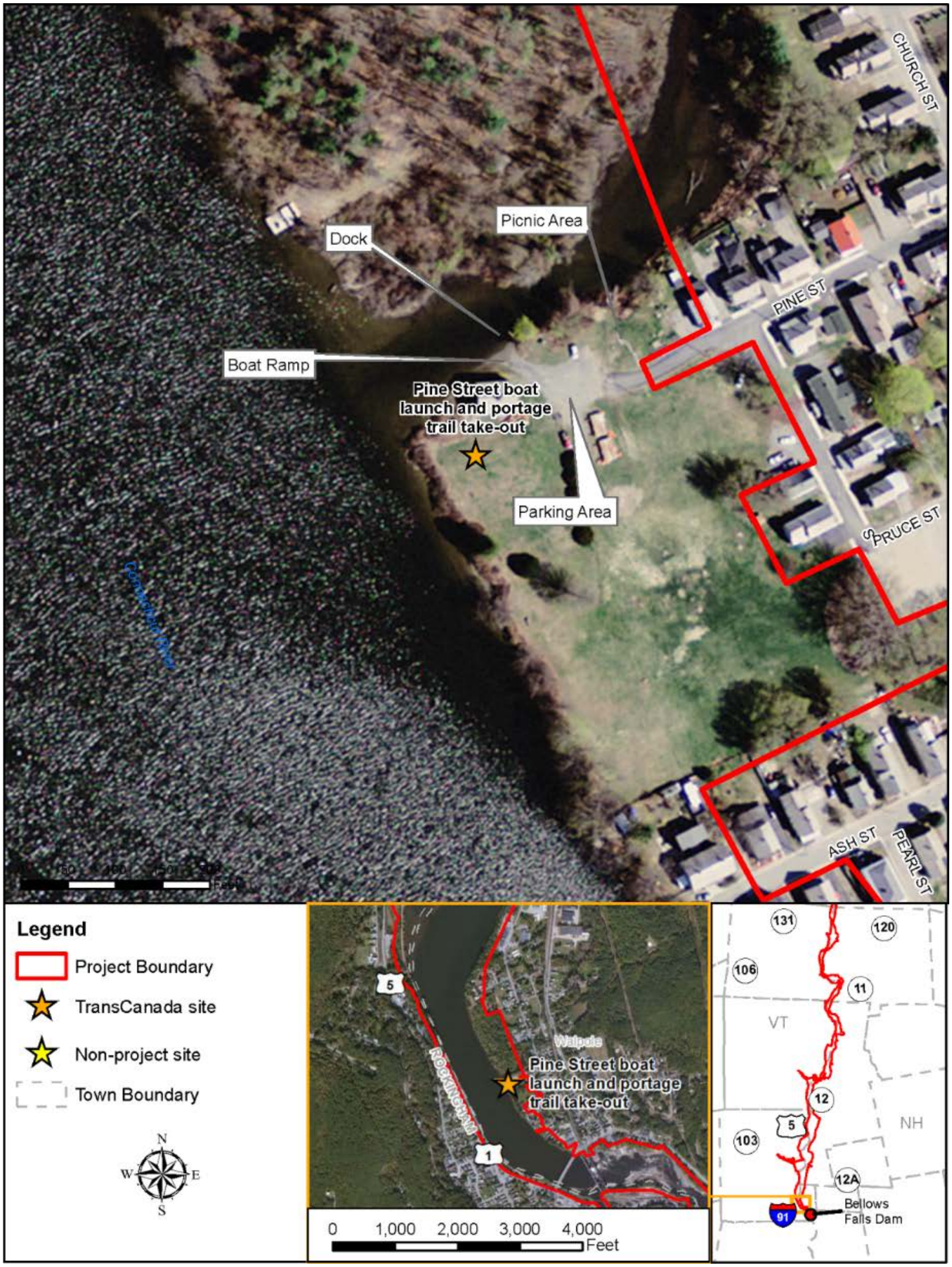
Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-7. Charlestown hand-carry boat launch and picnic area.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-8. Herrick's Cove boat launch and picnic area.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

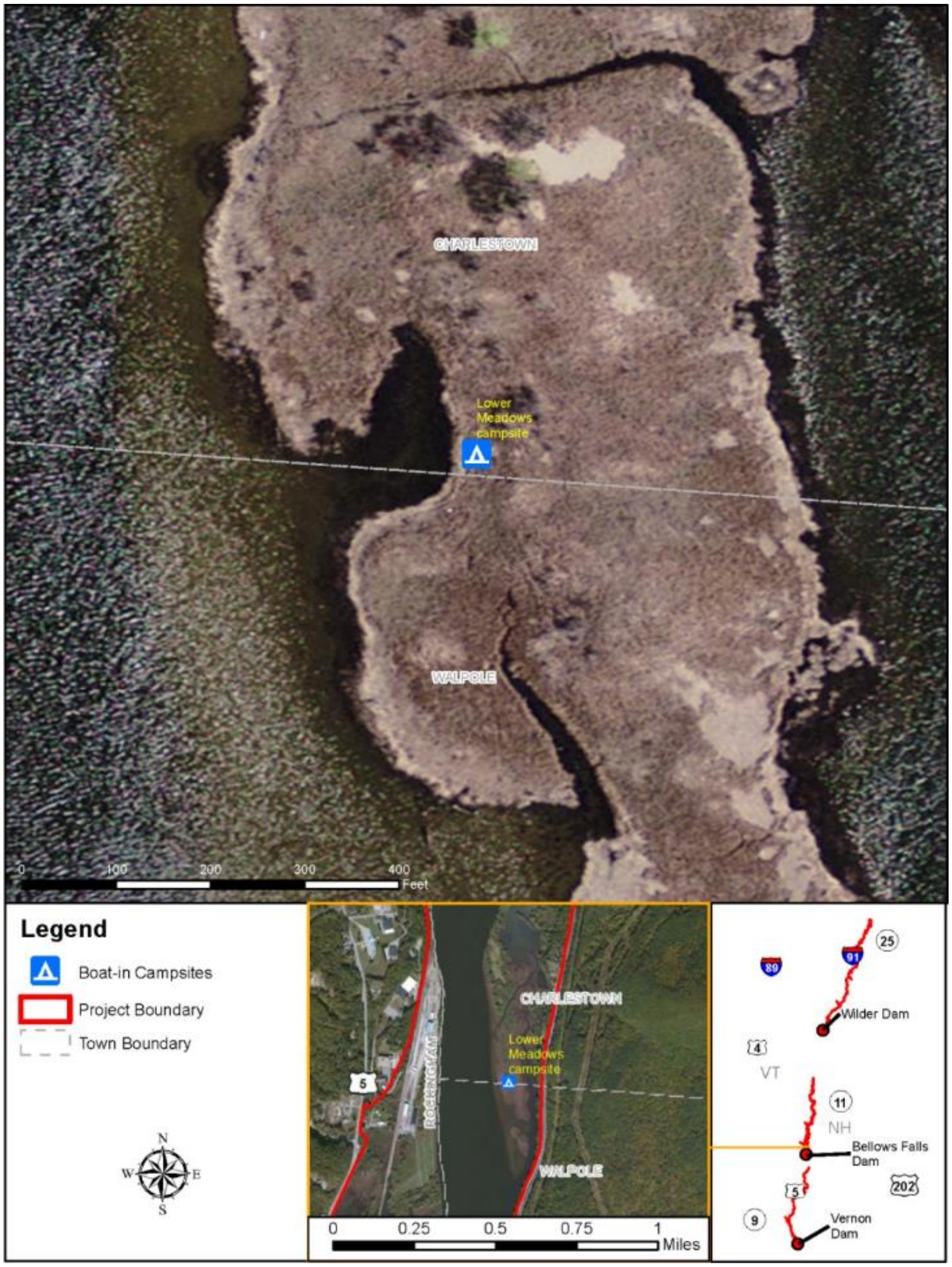
Figure 3.8-9. Pine Street boat launch and portage trail take-out.

The Bellows Falls fish ladder and visitor center are located in Bellows Falls, Vermont, on the west side of the river (Figure 3.8-10). This site is primarily an educational center and nature museum run by the Nature Museum of Grafton, Vermont, under an agreement with TransCanada. Project facilities include a fish ladder viewing window and a visitor center with historic and ecological interpretive displays. The facility inventory condition assessment reported the site condition and visible condition scores for this site as *excellent*.

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-10. Bellows Falls fish ladder and visitor center.

Lower Meadow Campsite is one of the non-Project TransCanada-owned primitive campsites along the Connecticut River Paddlers' Trail. Lower Meadow is located in South Charlestown, New Hampshire on the east side of the river and is boat accessible only (see Figure 3.8-11). The campsite can accommodate four tents on two wooden platforms, and includes a fire pit with grilling grate, a river trail, and a privy.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-11. Lower Meadow campsite.

Bellows Falls Project Recreation Use

From March 2014 through February 2015, TransCanada conducted an in-depth study of the type and level of recreation use at formal recreation sites providing access and opportunities adjacent to and in the Bellows Falls Project boundary. Data collection objectives included determining the amount of recreation use at Project and non-Project recreation sites and user opinions with regard to existing recreation sites and user perceptions related to their use of the sites. Recreation use estimates for public recreation sites were based on traffic counts, spot counts, interview data, and facility operator estimates where possible. Study staff deployed traffic counters at six access sites. Data regarding user opinions were obtained through the recreation use survey and the regional mail survey.

The total annual recreation use of all surveyed recreation sites at the Bellows Falls Project was estimated to be 312,126 recreation days. Table 3.8-9 provides a breakdown of estimated use by season.

Table 3.8-9. Estimated use (in recreation days) at Bellows Falls recreation sites from March 2014 through February 2015.

Site Name	Peak Season Use[a]	Off Season Use	Use from March 1, 2014 to February 28, 2015
Wilgus State Park	8,800	Closed	8,800
Ashley Ferry boat landing	37,299	17,040	54,339
Hoyts Landing	87,178	11,581	98,759
Patch Park	1,982	931	2,914
Charlestown boat launch and picnic area	**31,604**	**3,648**	**35,252**
Herrick's Cove boat launch and picnic area	**42,969**	**16,812**	**59,781**
Pine Street boat launch and portage take-out	**1,042**	**279**	**1,321**
Bellows Falls fish ladder and visitors center	**1,196**	**0**	**1,196**
Bellows Falls portage put-in	22,341	7,229	29,570
Connecticut River car-top access (NHFGD)	18,032	1,565	19,597
Cold River hand-launch site	504	93	597
		Total	**312,126**

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned and operated Project recreation site

a. Peak season defined as May 1 to October 15.

In addition to determining the type and amount of use at each of the surveyed sites, the degree to which each site had the capacity to sustain the recreation activity occurring there was estimated. Table 3.8-10 summarizes the amount of formal and estimated informal parking spaces at each of the sites and the average and maximum number of vehicles observed during weekend spot counts between May 1 and October 15, 2014. Formal parking is defined as a hardened surface (either asphalt or concrete) with designated parking spaces (striping and/or concrete parking blocks). Table 3.8-10 shows which sites could be at or near capacity; however, because some sites provide supplemental informal parking such as or grassy areas that can accommodate vehicles, and space along the shoulders of local roads, on beaches, or in the woods, it is not always clear exactly when a site reaches, or exceeds its functional capacity. Parking at TransCanada-owned sites is described below.

Charlestown boat launch and picnic area—This site was well below capacity throughout the study period. Staff observed potential launch users arrive and assess the condition of the boat ramp and then leave without launching their boats. During the field study, the concrete blocks that form the boat ramp were broken and exhibited large potholes. This condition likely led to underuse throughout the study period. TransCanada has since removed the concrete blocks, modified the boat launch to hand-carry only, and renovated the parking and picnic areas.

Herrick's Cove boat launch and picnic area—Herrick's Cove is a popular recreation destination, in part, because of its location at the confluence of the Williams River with the Connecticut River and the site amenities which include the launch ramp, picnic areas, and ample space for relaxing along the river for birding and walking. This large site is popular throughout the year and is host to a number of events, the largest of which is the TransCanada-sponsored Wildlife Festival. Interview respondents indicated that more public safety patrols are needed at this site. Parking capacity is not an issue because the large expanses of grass adjacent to the gravel parking areas can accommodate additional parking. The boat launch was dredged in November 2016 after the field study concluded, in advance of the 2017 boating season.

Pine Street boat launch—This site is popular for launching boats into the Bellows Falls impoundment. Informal parking is provided on the grass of the multi-use field overlooking the Connecticut River, no formal parking exists. The boat ramp provides access to a small cove about 100 feet from the main channel of the Connecticut River. The boat launch area was dredged in December 2015 after the field study concluded, in advance of the 2016 boating season.

Table 3.8-10. Bellows Falls Project recreation site parking lot use.

Facility	No. of Parking Areas	Has Formal Parking Spaces	No. of Designated Parking Spaces	Estimated No. of Informal Parking Spaces[a]	Average No. of Peak Season Weekend Vehicles	Max. Peak Season Vehicles	Date(s) of Maximum (2014)	Notes
Ashley Ferry boat landing	1	No		20-30	4.9	25	7/19	Popular for lunch crowd and drive in/outs
Hoyts Landing	3	Yes	28	20+	21.0	51	8/24	Popular for fishing tournaments, ice access
Patch Park	3	No		50+	2.6	32	5/17	Multi-use park; lower parking area on large lawn
Charlestown boat launch and picnic area	1	No		15+	2.5	4	7/12	Poorly designed for parking with trailers, poor ramp conditions deterred boat launching
Herrick's Cove boat launch and picnic area	2	No		200+	7.3 boat launch 7.6 picnic area	41	6/21	Hosts festivals with overflow parking on grass fields
Pine Street boat launch and portage take-out	1	No		30+	1.5	9	6/22	Host fishing tournaments with overflow parking on grass field
Bellows Falls visitor center	1	Yes	6		1.9	6	7/13	Parking is also available on the street and in front of the post office
Bellows Falls Historic Park and trail system	1	Yes	15		0.6	3	5/4, 8/17, 9/28	Grass parking areas
Bellows Falls dam portage put-in	2	No		20+	1.9	6	6/21, 7/31	Various sized multiple parking areas along river

Facility	No. of Parking Areas	Has Formal Parking Spaces	No. of Designated Parking Spaces	Estimated No. of Informal Parking Spaces[a]	Average No. of Peak Season Weekend Vehicles	Max. Peak Season Vehicles	Date(s) of Maximum (2014)	Notes
Cold River hand-launch site	1	No		5+	2.0	3	8/6	Poor road condition, highway pull-off area used more frequently and has larger capacity
Connecticut River car-top access (NHFGD)	1	No		10	0.4	6	5/23, 6/22, 7/13, 9/10	Where people park depends on road condition; when road is in poor condition, people park along roadway entrance pull-offs

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned and operated Project recreation site

a. Estimated numbers of informal parking spaces are based on gravel parking area; typically, these areas are surrounded by lawn by design, providing additional parking and much higher capacity while balancing maintenance costs.

Bellows Falls Visitors' Opinions and Perceptions

In general, interview respondents expressed satisfaction with the condition of existing facilities. Eighty percent of visitors interviewed rated their satisfaction with the condition of both TransCanada Project recreation facilities and existing public facilities associated with the Bellows Falls Project. Results indicated that just over 88 percent of visitors interviewed rated their satisfaction with the condition of the TransCanada Project recreation sites as either *moderately satisfied* or *extremely satisfied* (scores of 7, 8, or 9) (Table 3.8-11). Of the visitors who reported dissatisfaction with the condition of the existing Project and non-Project facilities, the primary reasons cited included trash, lack of toilets, poor road/ramp surface conditions. Dissatisfaction with the condition of TransCanada Project recreation sites (scores of 1, 2, or 3, or *not at all satisfied* to *slightly satisfied*) were recorded at Charlestown boat launch and picnic area (2 respondents) and Pine Street boat launch and portage trail take-out (1 respondent).

Table 3.8-11. Satisfaction with the condition of Bellows Falls Project recreation sites.

Location	Extremely Satisfied		Moderately Satisfied		Neutral (percent)		Slightly Satisfied		Not at All Satisfied
	9	8	7	6	5	4	3	2	1
Non-Project recreation sites	31.5	19.1	22.5	1.1	11.2	2.2	5.6	1.1	5.6
Bellows Falls Project recreation sites	58.8	17.6	11.8	3.9	2.0	0.0	0.0	0.0	5.9

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Approximately 71.4 percent of visitors reported being either *moderately satisfied* or *extremely satisfied* (scores of 7, 8, or 9) with the amount of recreation access provided to the Bellows Falls Project. Table 3.8-12 presents visitor satisfaction with the number and type of recreation opportunities that provide access to the Bellows Falls Project. The Bellows Falls Project area was also rated as extremely safe by 75 percent of respondents. Safety concerns related to suspicious individuals who were loitering at Herrick's Cove boat launch and picnic area and the lack of police presence at the site.

Table 3.8-12. Satisfaction with the number and type of recreational opportunities at Bellows Falls Project.

Study Area	Extremely Satisfied		Moderately Satisfied		Neutral (percent)		Slightly Satisfied	Not at All Satisfied	
	9	8	7	6	5	4	3	2	1
All Bellows Falls recreation sites	32.1	14.3	25.0	2.9	17.1	0.7	2.9	2.1	2.9

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Vernon Project Recreation Resources

The Vernon Project is located between Vernon, Vermont, and Hinsdale, New Hampshire, at RM 141.9 on the Connecticut River (see Figure 3.8-1). The Project impoundment extends approximately 26 miles upstream from the dam, terminating in the vicinity of the Walpole Bridge (Route 123) at Westminster Station, Vermont. Vernon impoundment has a maximum water surface elevation of 220 ft, resulting in about 69 miles of shoreline at full pond. Developed recreation facilities at the Project include boat ramps, car-top boat launches, marinas, picnic areas, campsites, and a portage take-out (Table 3.8-13). Developed recreation sites provide opportunities for camping, fishing, hiking, boating (motorized and canoe/kayaking), swimming, hunting, and winter sports such as ice fishing, snowmobiling, cross-country skiing, and ice skating. TransCanada owns 287 acres of land in the Vernon Project area, 34 acres of which are set aside for public outdoor recreational use.

Many towns adjacent to the Project boundary make avaiable hiking trails to the public. These trails include the Wantastiquet-Monadnock Greenway Trail in Chesterfield and Hinsdale, New Hampshire, and the Windmill Hill and Pinnacle Ridge connector trail from Rockingham, Vermont, to the Putney-Dummerston line in Vermont. The Connecticut River serves as a migratory flyway, though there are few bird hunting grounds surrounding the Vernon Project area. The most popular recreation activities at the Vernon impoundment are fishing from shore and by boat, ice fishing, and canoeing/kayaking.

Table 3.8-13. Public recreation areas at the Vernon Project.

Site Name	River Mile	Town	Manager
Putney boat landing	157	Putney, VT	State of VT
Dummerston Landing	152	Dummerston, VT	State of VT
River Road access	149	Chesterfield, NH	Town of Chesterfield, NH
Old Ferry Road access	147	Brattleboro, VT	State of VT
Retreat Meadows boat launch	145	Brattleboro, VT	Brattleboro
West River Marina	145	Brattleboro, VT	Private (open to public)
Norm's Marina	144	Hinsdale, NH	Private (open to public)
Hinsdale Island	144	Hinsdale, NH	State of NH
Fisherman access area	142	Vernon, VT	Private (open to the public, owned by Cersosimo Lumber Co.)
Prospect Street Launch	139	Hinsdale, NH	Town of Hinsdale, NH
Vernon canoe portage	138	Vernon, VT	TransCanada
Vernon Glen	138	Vernon, VT	TransCanada
Governor Hunt recreation area and boat launch	137	Vernon, VT	TransCanada
Vernon Neck open space	136	Hinsdale, NH	TransCanada
Windyhurst	159	Westmoreland, NH	Private landowner
Wantastiquet-Hinsdale Canoe rest area	142	Hinsdale, NH	TransCanada (non-Project)
Stebbins Island canoe rest area	137	Hinsdale, NH	TransCanada (non-Project)

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*
Note: **Bold type face** – TransCanada-owned and operated Project recreation site

Vernon Project Recreation Sites

TransCanada owns and operates four formal Project recreation sites at the Vernon Project, including the Vernon canoe portage, Vernon Glen picnic area, Governor Hunt Recreation Area and boat launch, and Vernon Neck open space (Figure 3.8-12). Table 3.8-14 provides a summary of TransCanada-owned Project recreation sites and facilities which are described below.

Table 3.8-14. Vernon Project recreation sites and facilities.

Recreation Site Name	Recreation Facilities
Vernon canoe portage	Portage take-out area, parking along main road
Vernon Glen	Picnic area with 5 tables and 4 grills, parking area with capacity for 4 vehicles, and a port-a-potty
Governor Hunt Recreation Area and boat launch	Fish ladder viewing window (separate entrance), picnic area with 5 tables and 5 grills, beach, 3 port-a-potties, asphalt parking near fish ladder, and parking area near picnic and beach area
Vernon Neck open space	Undeveloped open space

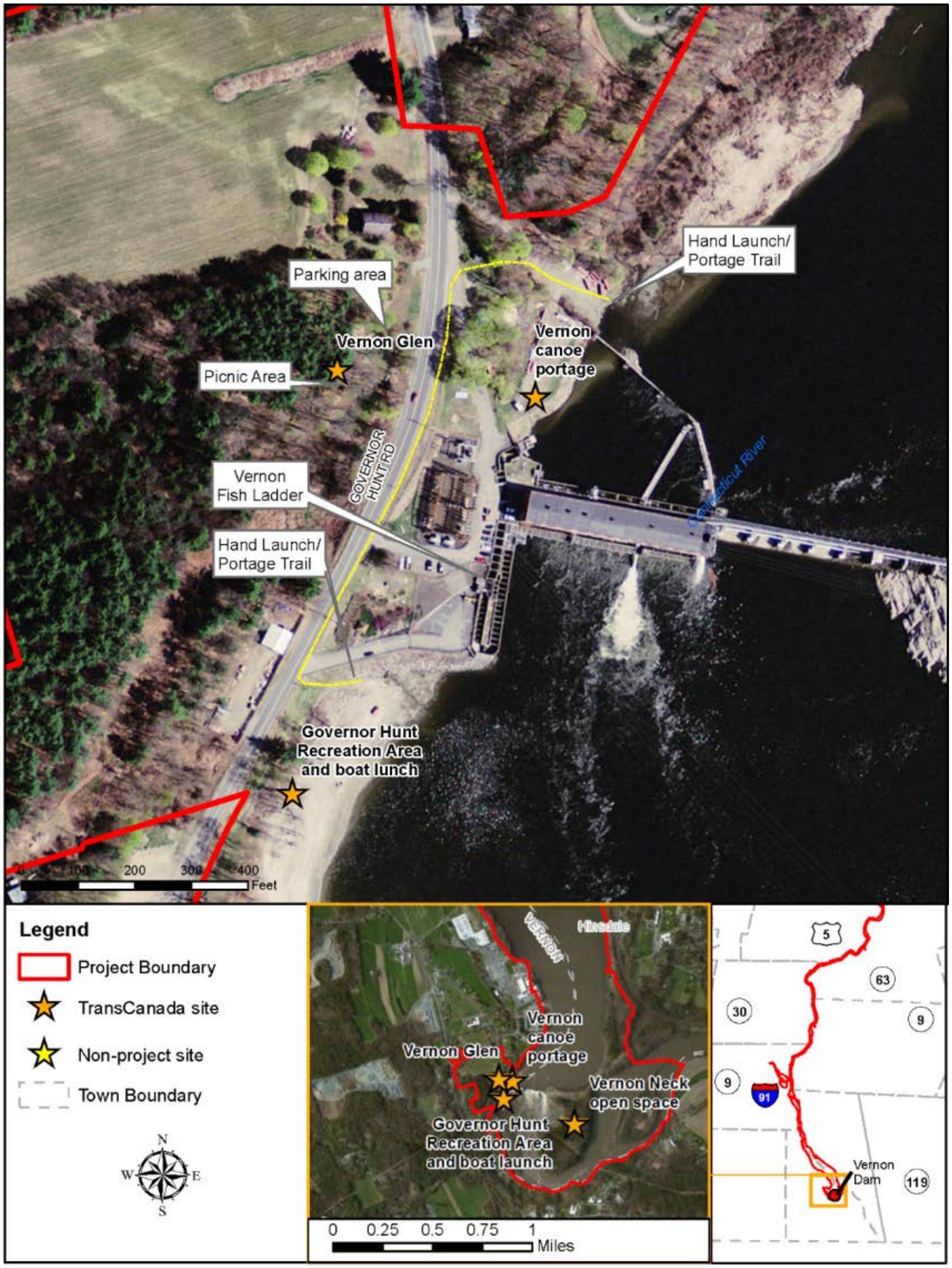
Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

The Vernon canoe portage is located directly upstream of the Vernon powerhouse on the west side of the river in Vernon, Vermont. The portage take-out is just upstream up the log boom (debris barrier) located in the powerhouse forebay. The portage trail follows Governor Hunt Road, passes the Vernon Glen picnic area, and extends about 0.2 mile to the put-in on a sandy beach downstream of Vernon dam at the Governor Hunt Recreation Area. The existing trail has an elevation gain of 32 feet and an elevation loss of 47 feet. The average uphill slope is 9.8 percent and the average downhill slope is -5.5 percent. Recreation monitoring consisting of 54 spot counts did not observe any users at the take-out location.

Vernon Glen is located east of the canoe portage take-out site in Vernon, Vermont. This site has no access to the Connecticut River and is solely a picnic area consisting of five picnic tables and four grills. Informal parking, which can accommodate four vehicles, and a port-a-potty are also provided at the site. No users were observed during recreation monitoring at Vernon Glen.

Governor Hunt Recreation Area and boat launch are located directly downstream of Vernon dam on the west side of the river in Vernon, Vermont. This site also includes the Vernon fish ladder public viewing area, which is accessed from a separate vehicle entrance. Other Project recreation amenities include a picnic area with five tables and grills, a boat launch area that serves as a launch for trailered boats, a put-in for the canoe portage route, and a beach. TransCanada also provides a parking area near the picnic area and beach. The most common recreation activities at this site are swimming from shore, sunbathing along the sandy beach, fishing from shore, picnicking, car-top boat launching, motorboat launching, and visiting the fish viewing window when the fish ladder is operating. A concrete-tie boat ramp is located at the site, and is in need of repair and upgrades; but the site lends itself to launching despite this condition. The Vernon fish ladder is open mid-May through late June during the spring migration during which hours of operation may vary.

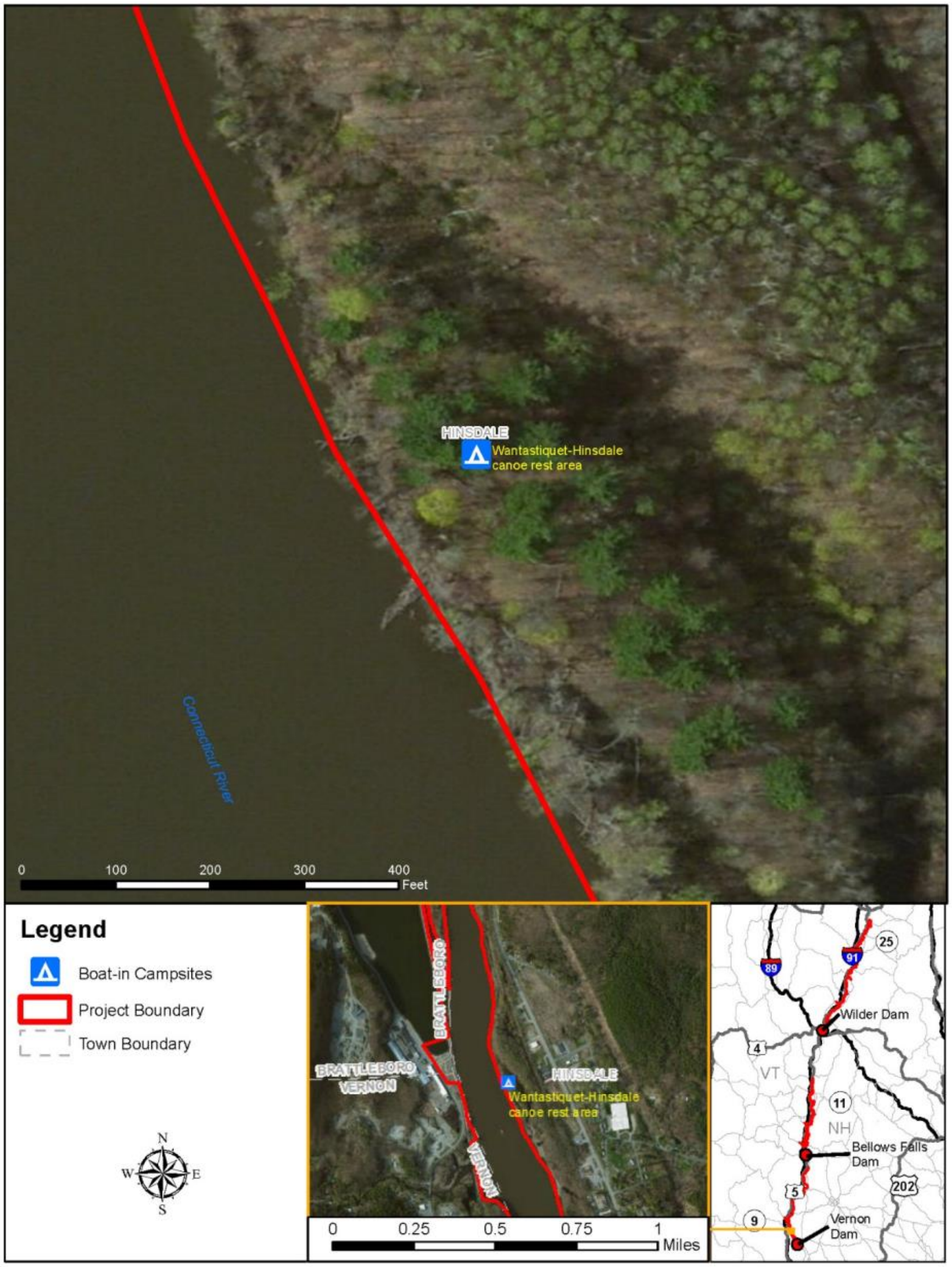
The Vernon Neck open space is located directly adjacent to the dam on the east side of the river in Hinsdale, New Hampshire. This site is undeveloped and only accessible by foot, although the site exhibits use from illegal all-terrain vehicle trail users. An informal primitive campsite on a bench overlooks the river but there are no Project facilities located at this site.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-12. Vernon Project recreation sites.

TransCanada also provides two non-Project primitive boat-in camping areas that are part of the Connecticut River Paddlers' Trail Campsites. The Wantastiquet-Hinsdale canoe rest area in North Hinsdale, New Hampshire, on the east side of the Connecticut River. It has capacity for five tents, along with a picnic table, fire pit, and privy house (Figure 3.8-13).



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-13. Map of Wantastiquet canoe rest area (campsite).

Stebbins Island is another non-Project, primitive boat-in campsite located about a mile downstream of Vernon dam. It provides four to five primitive campsites as part of the Connecticut River Paddlers' Trail (Figure 3.8-14). Amenities at this site include one picnic table, a self-made fire pit (surrounding stones), and a privy.

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-14. Stebbins Island canoe rest area.

Vernon Project Recreation Use

From March 2014 through February 2015, TransCanada conducted an in-depth study to assess the type and level of recreation use at formal recreation sites providing access and opportunities adjacent to and within the Vernon Project boundary. Data collection objectives included the determination of the amount of recreation use at Project and non-Project recreation sites and user opinions on existing recreation sites and user perceptions related to their use of the sites. Recreation use estimates for study area public recreation sites were based on traffic counts, spot counts, interview data, and facility operator estimates where possible. Study staff deployed traffic counters at two access sites. Data on user opinions were obtained through the recreation use survey and the regional mail survey.

The total annual recreation use of all surveyed recreation sites at the Vernon Project was estimated to be 72,388 recreation days. Table 3.8-15 provides a breakdown of estimated use by season.

Table 3.8-15. Estimated use (in recreation days) at Vernon Project recreation sites from March 2014 through February 2015.

Site Name	Peak Season Use[a]	Off Season Use	Use from March 1, 2014, to February 28, 2015
Putney Boat Landing	2,035	1,474	3,510
Dummerston Landing	6,960	1,824	8,784
(Chesterfield) River Road access	1,555	Closed	1,555
Old Ferry Road access	3,629	Closed	3,629
Retreat Meadows boat launch	2,438	2,212	4,650
West River Marina	2,035	Closed	2,035
Norm's Marina	4,320	Closed	4,320
Fort Hill Rail Trail	2,803	2,212	5,015
Hinsdale access	518	Closed	518
Fisherman Access area	922	1,327	2,249
Broad Brook access	211	Closed	211
Prospect Street Launch	4,762	590	5,351
Vernon canoe portage	0[b]	0[b]	0[b]
Vernon Glen	0[b]	0[b]	0[b]
Governor Hunt Recreation Area and boat launch	27,274	3,287	30,561
		Total	**72,388**

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned and operated Project recreation site

a. Peak season defined as May 1 to October 15

b. Spot counts were made but staff did not see anyone at the site during the visits that were made during the study period.

In addition to determining the type and amount of use at each of the surveyed study sites, the degree to which each recreation site had the capacity to sustain the recreation activity occurring there was estimated. Table 3.8-16 summarizes the amount of formal and estimated informal parking spaces at each of the Vernon Project sites and the average and maximum number of vehicles observed during weekend spot counts between May 1 and October 15, 2014. The table shows which sites could be at or near capacity; however, because some sites provide supplemental informal parking such as grassy areas that can accommodate vehicles, and space along the shoulders of local roads, on beaches, or in the woods, it is not always clear exactly when a site reaches, or exceeds its functional capacity. Parking at TransCanada-owned sites is described below.

Vernon canoe portage and Vernon Glen—These sites were part of the regular spot count and interview efforts and were sampled on 54 dates. No users were ever observed; the reason may be because of the popularity of the upstream Prospect Street launch, located about 1.2 RM upstream from Vernon dam in Hinsdale, New Hampshire, as the primary take-out by large groups that organize downriver trips (e.g., summer camps). The proximity of Vernon Glen to the Governor Hunt Recreation Area and boat launch also likely explains the lack of use observed at the Glen during the study.

Governor Hunt Recreation Area and boat launch—This site includes one of the largest beaches along the Connecticut River within the three Project areas and is a popular destination for families who wish to swim. During the study, TransCanada completed a number of improvements, including cutting down several dead trees, using the trunks to designate the limits of the parking area, and re-grading the parking area. Parking along the beach was popular before TransCanada made these improvements, and it continues to be popular with visitors who are picnicking near their vehicles on the beach. Because of the designated parking and the traditional practice of parking on the beach, crowding to the point of reaching capacity was not observed. Use of the fish ladder parking area was well below capacity, and parked vehicles were rarely observed in the lot. One instance was associated with an angler fishing from the shore in the tailrace.

Vernon Neck—The Vernon Neck Open Space and Demonstration Forest Area is designated as a natural area with only limited public use under Article 33 of the Project license. It is partially accessible by vehicle and by a rail trail.

Table 3.8-16. Vernon Project recreation site parking lot use.

Site Name	No. of Parking Areas	Has Formal Parking Spaces	No. of Designated Parking Spaces	Estimated No. of Informal Parking Spaces[a]	Average No. of Peak Season Weekend Vehicles	Max. Peak Season Vehicles	Date(s) of Maximum (2014)	Notes
Putney boat landing	1	No		5	2.0	9	7/5	Small parking area, limited to two trailers at time
Dummerston Landing	1	No		10	0.8	4	5/10	During low flows unable to launch; when Putney boat landing is full, serves as overflow parking area
(Chesterfield) River Road access	1	No		10	2.1	12	8/10	Rarely used site; informal gravel lot with shoulder parking on River Road
Old Ferry Road access	2	No		35	3.3	21	6/28	Two large informal parking areas
Retreat Meadows boat launch	1	No		5	2.8	11	6/8	Parking predominantly on shoulder of Route 30; ice access
West River Marina	2	Yes	25		2.3	8	8/24	Mixed parking with restaurant and businesses; two informal spaces by hand-launch area
Hinsdale access	2	No		15	0.5	20	6/7	Island with rarely used two parking areas; however, 20 vehicles onsite the day of the Brattleboro Parade (all parade attendees, not visitors to recreation site)

Site Name	No. of Parking Areas	Has Formal Parking Spaces	No. of Designated Parking Spaces	Estimated No. of Informal Parking Spaces[a]	Average No. of Peak Season Weekend Vehicles	Max. Peak Season Vehicles	Date(s) of Maximum (2014)	Notes
Norm's Marina	1	No		100	5.1	33	8/23	Large parking area and grass overflow areas
Fisherman access area	1	No		25+	0.8	10	5/10	Large parking area and grass overflow areas; popular because of fishing, ice access
Broad Brook access	1	No		3	0.2	2	7/12, 7/13	Concrete blocks restrict access and limit parking to three vehicles
Fort Hill Rail Trail	1	No		10	2.8	9	7/26	Gravel parking area popular with trail users and hand-launch area
Prospect Street launch	2	No		15+	4.6	15	9/7	Popular site with good parking and used by downriver canoe groups as main take-out
Vernon canoe portage	1	No		4+	0	0		Shoulder parking along access road
Vernon Glen	1	No		4+	0	0		Additional parking on grass field; did not spot any users during study
Governor Hunt Recreation Area and boat launch	3	No		30+	4.7	24	6/7	New formal parking area and consistent, historical practice of parking on beach

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Note: **Bold type face** – TransCanada-owned and operated Project recreation site

a. Estimated numbers of informal parking spaces are based on gravel parking area; typically, these areas are surrounded by lawn by design, providing additional parking and much higher capacity while balancing maintenance costs

Vernon Visitors' Opinions and Perceptions

In general, interview respondents expressed satisfaction with the condition of existing facilities. Seventy-five percent of visitors interviewed rated their satisfaction with the condition of TransCanada Project recreation sites as either *moderately satisfied* or *extremely satisfied* (scores of 7, 8, or 9) (Table 3.8-17). Of those who reported dissatisfaction with the condition of the existing Project and non-Project facilities, the primary reasons were the presence of trash, lack of toilets, and poor road/ramp surface conditions. Dissatisfaction with the condition of TransCanada Project recreation sites, (scores of 1, 2, 3, or 4, or *slightly satisfied* to *not at all satisfied*) were recorded at Governor Hunt Recreation Area (including the fish ladder) and boat launch (6 respondents).

Table 3.8-17. Satisfaction with condition of Vernon Project recreation sites.

Location	Extremely Satisfied (percent)		Moderately Satisfied	Neutral			Slightly Satisfied	Not at All Satisfied	
	9	8	7	6	5	4	3	2	1
Non-Project recreation sites	33.1	14.4	24.5	9.4	6.5	2.2	5.8	3.6	0.7
Vernon Project recreation sites	14.3	21.4	38.1	4.8	7.1	4.8	4.8	0.0	4.8

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Approximately 71.1 percent of visitors reported being either *moderately satisfied* or *extremely satisfied (*scores of 7, 8, or 9*)* with the amount of recreation access provided to the Vernon Project. Table 3.8-18 presents visitor satisfaction with the number and type of recreation opportunities that provide access to the Vernon Project. The Vernon Project area was also rated as *extremely safe* by 73 percent of respondents. Safety concerns were limited to water safety (e.g., no lifeguards at Governor Hunt Recreation Area) and broken glass at multiple sites.

Table 3.8-18. Satisfaction with the number and type of recreational opportunities at Vernon Project.

Study Area	Extremely Satisfied (percent)		Moderately Satisfied	Neutral			Slightly Satisfied	Not at All Satisfied	
	9	8	7	6	5	4	3	2	1
All Vernon recreation sites	23.3	22.8	25.0	6.1	10.0	5.6	2.8	3.3	1.1

Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Whitewater Boating

Sumner Falls

Sumner Falls is a section of the Connecticut River about 9 miles downstream of Wilder dam outside the Project boundary, that presents a series of ledges that span the width of the river. The exposed bedrock in the area creates a 0.25-mile stretch of rapids used by whitewater boaters because the river drops 7 vertical feet in this short distance (Figure 3.8-15). According to Lessels (1998), Sumner Falls is runnable at almost any water level, and whitewater boaters find it interesting enough at most flows to spend the better part of a day in this location. Sumner Falls is not a classic river run where boaters put-in and take-out at a downstream location as many boaters tend to put in and take out at Sumner Falls repeatedly for play boating. It is reliable (often daily) and a popular summer play spot (Lessels, 1998). Open-faced boats and canoes typically portage around the ledges. Outfitters and kayak clubs (The Great River Outfitters, North Star Canoe rental, and Dartmouth Outing Club) commonly use this site, and during peak seasons, visit this site multiple times a day to drop off kayaks, canoes, tubes, and rafts.

Under the current FERC license, TransCanada generates a continuous minimum flow of 700 cfs (FERC requires 675 cfs or inflow) from Wilder dam. Discharges from Wilder dam are made in response to inflow, regional electric demand, and associated energy prices. During periods when average daily flows are less than maximum station flow capacity, the Project uses the limited daily storage in the impoundment to absorb upstream inflows 45 miles upstream of the dam as well as intermediate drainage, while generating at the dam. Generation schedules are established to meet the generation requirements by NE-ISO. During the course of any day, generation can vary between the required minimum flow and full capacity if high inflows flows are present. During periods of sustained high inflows that exceed station capacity, Project generation is dispatched in a must-run status to use available water for generation and flood control via spill. In all cases, the Project operates within the normal range of impoundment elevation or high water operating procedures.

Local boaters frequently time their trips to Sumner Falls based on information from USGS gage no. 01144500, Connecticut River at West Lebanon, New Hampshire, which measures flow from Wilder dam and the White River just downstream of the dam. Unless other tributaries downstream of this gage contribute sufficient flows, Sumner Falls receives essentially the same flow as the Connecticut River at West Lebanon during the summer (as recorded by USGS gage no. 01144500). Travel time for releases from Wilder dam to Sumner Falls is about 2 hours. In addition, generation schedules as well as real-time flow information is available through phone (for boating 1-800-452-1737) or the “WaterLine” website (www.h2oline.com) providing opportunity flow information for boaters and public safety flow information for anglers that also use the Sumner Falls site for wading and fly fishing.

Source: ILP Study 31, *Whitewater Boating Flow Assessment*

Figure 3.8-15. Sumner Falls rapids and features.

To evaluate the whitewater boating resources at Sumner Falls, TransCanada conducted a controlled study of whitewater flow releases (Study 31). The study was designed to provide information about the boating conditions at various flows at Sumner Falls. Five flows—3,750; 4,700; 6,700; 7,800; and 13,000 cfs—were evaluated during a weekend in summer 2014. Participants paddled a variety of watercraft including kayaks, closed canoes, a squirt boat, a cataraft, and a stand-up paddle board. During the study, boaters used the International Scale of River Difficulty to rate whitewater in the bypassed reach under each of the flows.[39] Responses ranged from Class II at 3,700 cfs to Class IV- at 13,000 cfs (see Table 3.8-19). Most participants also suggested that at flows between 7,800 and 13,000 cfs, users should have at least an intermediate level whitewater boating skill set. At lower flows, between 3,750 and 6,700 cfs, novice and beginners could enjoy the whitewater opportunities throughout the area. However, based on the ratings, and observations of use at the site, a wide range of opportunities exist and a wide range of boaters use generation flows above minimum flow (from Wilder dam) at Sumner Falls.

Table 3.8-19. Participant whitewater class difficulty ratings for Sumner Falls.

Watercraft	Flow				
	3,750 cfs	4,700 cfs	6,700 cfs	7,800 cfs	13,000 cfs
Canoe	Not evaluated	II+	III	III	III
Cataraft	II	II+	II+	III	III+
Kayak - creek boat	II to III	II to III+	II to III	II to III+	III to IV-
Kayak - hybrid	Not evaluated				
Kayak - play boat	II	II to III	II to III	II to III	II to III
Kayak - river boat	II	II+ to III-	II+ to III-	III-	III-
Squirt boat	II+ to III-	II+ to III-	II+ to III-	II to III	III
Stand up paddleboard	II	II to III	II to III	III	II to III

Source: ILP Study 31, *Whitewater Boating Flow Assessment*

Acceptable flow ranges for various whitewater experiences were developed using responses from study participants to a flow-acceptability survey. Study participants rated nine characteristics of boating for each flow, including boatability, difficult rapids, large hydraulics, availability of playboating, potential instream hazards, and

[39] Class I – easy, Class II – novice, Class III – intermediate, Class IV – advanced, and Class V – expert rapids as rated by American Whitewater using the International Scale of River Difficulty (American Whitewater, 2016).

overall whitewater challenge. All boaters rated the Sumner Falls site and each flow as higher than acceptable across the entire range of flows.

Boatability by kayak, canoe, cataraft, stand-up paddle board, and squirt boat was evaluated during the study period. Kayak users had varying flow preferences between 3,700 and 13,000 cfs; canoe users generally preferred flows between 7,800 and 13,000 cfs; cataraft users preferred flows at both 6,700 and 13,000 cfs; stand-up paddle boarder preferred flows at 6,700 and 7,800 cfs; and the single squirt boater did not note a particular preference. The varying preferences highlight the wide boating interests and varying skill levels of whitewater recreationists in this area.

The Sumner Falls rapid complex has two well-known wave features—Main Wave and Sign Wave. During the field study, Main Wave was very popular at all flows below 13,000 cfs and very user-friendly because it provides routes through the ledge complex for those not interested in play-boating and opportunities for a wide range of boater skills and interests (Figure 3.8-15). Sign Wave, which develops at the head of the rapid complex on the New Hampshire side of the river, typically does not take shape until at least 11,500 cfs and becomes surfable at around 13,000 cfs. Flow in this range requires all Wilder units to be generating with additional flows either from spill or from contributing tributaries downstream of Wilder dam. During the whitewater boating study, participants also explored other areas throughout the Sumner Falls complex and generated names to describe these places during the survey portions of the study. Boaters of all types and abilities made runs through or attempted to surf in various waves and features throughout the area.

The Sumner Falls complex offers several opportunities as a park-and-play whitewater resource in a range of flows with some features coming into optimal conditions at certain levels and not at others. Generally, at flows between 3,800 to 5,000 cfs, Main Wave (or Summer Wave as it is known locally) is the preferred feature because of its shape and consistency, and its good eddy service (a hydraulic feature boaters can use to easily paddle upstream close to the rapid). Main Wave is so-named because this is the primary feature when river flow is approximately 3,800 cfs to 5,000 cfs. This flow is within the range of operations of one of Wilder's two larger generating units. The name also refers to its consistency and the fact that other local rivers or streams in relative proximity to the Connecticut River often do not have enough water for boaters to play during summer in the absence of substantial precipitation, although through boating is still available.

Under typical project operations, boaters have about a half hour every day to boat the rising limb of the hydrograph in the 4,000- to 6,000-cfs range to surf the Main Wave, which typically is between 3:30 p.m. and 4:00 p.m. (adjusted for the 2-hour time lag) (Study 31). The same flow range also occurs during the falling limb of the hydrograph, after dark (between 10:00 p.m. to 10:30 p.m.). TransCanada (Study 31) estimates flows for Main Wave (assumed broadly to be between 4,000 and 6,000 cfs) will occur between roughly 30 to 40 percent of daylight hours between June 1 and October 31, and flows between 11,000 and 13,500 cfs (the preferred range for Sign Wave) will occur between about approximately 1 and 7 percent of the same period. As described above, these preferred flow ranges typically occur during the afternoon and evening hours. Primary factors that could result in deviations from these generalized trends during the warmer months addressed here include large precipitation events, changes in economic drivers from NE-ISO because of regional electric supply or demand, or outages at Wilder (e.g., rewinding a turbine, replacing runners). However, the data suggest that boating opportunities at the preferred levels for the two primary play spots at Sumner Falls occur regularly under current Project operations during the summer-fall daylight hours.

Bellows Falls Bypassed Reach

The Bellows Falls bypassed reach of the Connecticut River begins at Bellows Falls dam and extends downstream about 0.64 mile (3,500 ft) to the tailrace of the Bellows Falls powerhouse between the Village of Bellows Falls, Vermont, and North Walpole, New Hampshire. The bypassed reach is created by the diversion of river flow through the Bellows Falls powerhouse, leaving the natural river channel with diminished flow. Flows in the bypassed reach vary depending on the time of the year, operational needs and constraints, and weather events. FERC does not have a current license requirement to provide flow into the bypassed reach. TransCanada estimates that leakage through the spillway is from about 125 to 300 cfs of flow into the bypassed reach. Although TransCanada owns a portion of the New Hampshire shoreline and holds the flowage rights on the remainder, it does not own the land necessary for adequate public access or safety to the bypassed reach. Boating has never been sanctioned or encouraged in the bypassed reach because of high flow danger concerns and lack of suitable ingress and egress. The reach receives substantial flows only during the spring freshet, large precipitation events, and outages at the powerhouse requiring water to be spilled at the dam. The fish barrier dam, located about 0.4 mile downstream of Bellows Falls dam, presents a serious and potentially fatal drowning hazard from the turbulence that boaters will encounter if they were to pass over the dam. Thus, the potential boatable section of the bypassed reach is the short section between the main dam and the fish barrier dam.

Public access to the bypassed reach is severely limited. The portage trail skirts the entire bypassed reach with the put-in location for downriver, multi-day canoe trips downstream of the confluence of the bypassed reach with the main channel downstream of the tailrace. There is no portage trail around the fish barrier dam that enables downstream navigation within the bypassed reach.

To evaluate the potential of the bypassed reach to support whitewater boating, TransCanada conducted a controlled release whitewater boating study (Study 31). The study was designed to provide information about potential boating conditions at various flows in the bypassed reach. Nine flows—1,580, 2,020, 2,370, 2,900, 3,300, 4,370, 5,560, 7,400, and 9,660 cfs—were evaluated over a weekend in the late spring 2015. Participants selected for the study had, at a minimum, selfidentified *advance* to *expert* whitewater boating experience. Participants paddled a variety of kayaks and closed canoes. During the study, boaters used the International Scale of River Difficulty to rate whitewater in the bypassed reach under each of the flows. Boaters rated the bypassed reach Class II to Class IV, depending on the type of boat, the level of flow, and the features of the bypassed reach.

Boater access to the reach for the whitewater boating study required descending a steep embankment from TransCanada's property on New Hampshire Route 12 in North Walpole and ascending via the east side of the riverbank up a similarly steep embankment across private property to the road shoulder about 0.5 mile from TransCanada's property on New Hampshire Route 12.

Although boating has not been allowed in this location, study participants reported that the reach was boatable at more than one flow demonstrated in Study 31. The Bellows Falls bypassed reach has three features of interest to boaters within the study reach—a large dome rock near the top of the run and two wave trains. For each flow studied, participants were asked to rate the difficulty and challenge of navigating whitewater in this reach (see Table 3.8-20). Responses ranged from a Class II rating at flows of 1,580 cfs to a Class IV rating at flows of 9,660 cfs, while the majority of boaters reported the difficulty as Class III. Based on average scores, the preferred flow level best suited for boating instruction was 2,020 cfs. At this flow, novices and beginners could boat in the bypassed reach, but at flows above 2,370 cfs, more advanced skills are required.

Table 3.8-20. Participant whitewater class difficulty ratings for Bellows Falls bypassed reach.

Flows	Participant Whitewater Class Ratings for Bellows Falls Bypassed Reach									
	II	II+	II to III	III-	III	III+	III to IV	III+ to IV-	IV-	IV
1,580	3	1	1	--	3	--	--	--	--	-
2,020	1	1	--	--	2	--	--	--	--	--
2,370	--	1	3	--	7	--	--	--	--	--
2,900	--	1	1	--	2	--	--	--	--	--
3,300	--	--	2	--	6	1	--	--	--	--
4,370	1	--	--	1	3	4	--	1	--	--
5,560	--	--	--	1	2	3	1	--	--	1
7,400	--	--	--	1	1	1	--	--	--	3
9,660	--	--	--	1	--	--	--	--	1	4

Source: ILP Study 31, *Whitewater Boating Flow Assessment*

While all flows were considered boatable by the participants, participants had different opinions regarding which flows were optimal, depending on skill level and craft. Survey respondents stated that the two optimal flows for playboating were between 2,020 to 2,900 cfs and between 4,370 to 5,560 cfs. The weighted average for highest quality flow was 3,880 cfs. Most participants agreed that the boating public would boat the Bellows Falls bypassed reach if sufficient flows and adequate access were available and the fish barrier dam was removed.

Boaters were asked to indicate what they consider the minimum acceptable flow (i.e., enough flow for an enjoyable recreation experience) and optimal flow relative to those they had just experienced. Both minimum and optimal flow ranges were different between canoe and kayak user groups. Canoe user scores for the minimum flow showed a convergence in scores at 2,370 cfs and below. For kayakers, scores for the minimum acceptable flow converged in two areas—the first between 2,020 and 3,300 cfs and a second, weaker overall response when the minimum acceptable flow was 4,370 cfs. These responses stemmed from the diversity in the boater interests—some were seeking more challenge while others were looking for play spots with easy eddy service into standing waves for surfing.

Boater responses to the optimal flow relative to the flow they just boated were similarly diverse; both canoer and kayaker results showed a spread in flows with a double convergence among the kayakers similar to the minimum flow responses. The greatest number of kayakers indicated that the flow that came closest to their preferred flow was somewhere between 2,370 cfs or slightly higher and 3,300 cfs and slightly lower. Interestingly, only four kayakers boated the 2,900 cfs flow, and only one of the four reported this as the preferred flow. The flow level just above this level, 3,300 cfs, was boated by eight kayakers and six of them indicated the optimal flow as slightly lower, suggesting the 2,900 cfs level is relatively close to one of the optimal flows. Kayak participant scores also converged between 4,370 cfs and 5,560 cfs with a majority indicating slightly higher flow than 4,370 cfs, and a majority wanted slightly lower than 5,560 cfs suggesting an optimal flow around 5,000 cfs.

Kayakers found the length of the run to be too short but highly navigable. Many of the kayakers were highly skilled and preferred higher flows of 4,370 cfs. Canoeists also found the length of the run to be too short, and the majority preferred lower flows of 2,020 cfs. The length of the run, however, cannot be extended because of the fish barrier dam located just below the second wave train.

Although the boaters who participated in the study found the bypassed reach to provide an acceptable boating experience, in comparison with other opportunities within 2 hours and throughout New England as a whole, the reach was rated as average and below average for canoes. Furthermore, some key factors limit the potential of the reach as being a significant boating opportunity—shortness of length and dynamic play spots, public access, and safety concerns, which include not only the fish barrier dam at the downstream end of the reach but whether or not boaters at a novice or intermediate level could find themselves over their ability in many of the flows that were evaluated.

3.8.1.2 Land Use

Land Uses in the Vicinity of the Projects

Land use in the Connecticut River Valley is predominantly rural and agricultural, and a considerable portion of the land is undeveloped and forested. Much of the land in the valley has been preserved by property owners using various conservation easements for agriculture, open space, and habitat protection. Bottomland agriculture in the area is used for dairy, vegetable, and hay farming. Along the New Hampshire and Vermont sides of the Connecticut River, a majority of the land is zoned for limited residential use with infrequent commercial and industrial sites (NHDES, 1991). This development pattern was established in early settlement days and continues today, consisting of mosaic villages and small cities surrounded by rural areas. The juxtaposition of dense villages with working forestlands and agricultural fields defines the character of the Connecticut River Valley. While industrial land use is rare near the river, railroad tracks are commonly found along the banks of both sides of the river and in proximity to the Projects. The primary land uses adjacent to the Project boundaries are recreation, agriculture, and wildlife habitat.

TransCanada holds fee ownership of 123 acres of land for the Wilder Project. Of this acreage, 43 acres are used for the powerhouse area (including about 15 acres extending 0.5 mile below Wilder dam along both sides of the river for angler access and public day use), 59 acres are for public outdoor recreation use, 10 acres have been licensed to Dartmouth College for recreation use, and 11 acres are retained in a natural state.

TransCanada holds fee ownership of 835 acres for the Bellows Falls Project. Of this acreage, 62 acres are used for the powerhouse, dam, and related facilities; 86 acres are for public outdoor recreational use; 60 acres have been set aside as natural lands; and the remaining 627 acres support local agriculture and wildlife and wetland values. These holdings, dispersed along the impoundment, include river setbacks, flood plains, marsh areas, large open pasture lands, abandoned and active (leased) farm lands, and moderately forested undeveloped lands.

TransCanada holds fee-ownership of 287 acres for the Vernon Project. Of this, 16 acres are used for the powerhouse, dam, and related facilities; 34 acres are for public outdoor recreational use; 14 acres have been leased for agricultural and other uses; and 223 acres have been set aside as natural land.

The Connecticut River is a very important aquatic resource in the region, and several agencies have recognized it for its scenic qualities, fisheries, and navigability. The Connecticut River is a designated river under the New Hampshire Rivers Management and Protection Program and was designated a National Blueway by the U.S. Department of the Interior (DOI) in May 2012. It was nominated and designated an American Heritage River in 1997 under Presidential Executive Order 13601, and, in 2005, the Connecticut River was designated a National Scenic Byway.

No segments of the Connecticut River have been designated for inclusion in the Wild and Scenic River System. However, two segments are listed in the Nationwide Rivers Inventory, which identifies potential candidates for inclusion in the Wild and Scenic River System. The first segment is a 24-mile reach downstream of the Wilder Project from Windsor, Vermont, to the confluence of the Williams River in Rockingham, Vermont. *Hydrology* is the outstandingly remarkable value supporting this listing. The second segment is an 18-mile reach downstream of the Bellows Falls Project from the Route 23 Bridge in Walpole, New Hampshire, to the Route 9 Bridge in Brattleboro, Vermont. *Hydrology*, *botanical*, and *historical* are the outstandingly remarkable values supporting this listing. Both segments were listed in 1982. Federal agencies are required to assess whether a federal action could diminish the outstandingly remarkable values for which a segment is listed in the Nationwide Rivers Inventory. Dams at the Bellows Falls and Wilder and Projects were originally constructed in the early and late 1800s, respectively, well before the listing of these two segments, and TransCanada proposes no change in the facilities and operation of either Project. Consequently, relicensing of the Projects will not diminish the outstandingly remarkable values for which these segments of the Connecticut River were listed.

Project Lands under Study for Inclusion in National Trails System or Wilderness Area

The Appalachian Trail crosses the Wilder Project using the Ledyard Bridge (New Hampshire Route 10A and Vermont Route 10A) between Norwich, Vermont, and Hanover, New Hampshire. This 2,174-mile-long National Scenic Trail is a continuous marked footpath from Springer Mountain in Georgia to the summit of Katahdin in Maine's Baxter State Park. The Appalachian Trail is a component of both the National Trails System and a unit of the National Park System. The trail enters the Wilder Project area in Hartford and Norwich, Vermont; passes through downtown Hanover, New Hampshire; and continues north through Lyme, Orford, and Piermont, New Hampshire. No National Trails System segments are located in proximity to the Bellows Falls or Vernon Projects.

No areas at or in the vicinity of the three Projects are included in or have been designated as wilderness areas, recommended for such designation, or designated as a wilderness study area under the Wilderness Act.

National Wild and Scenic River System Designation

Under the National Wild and Scenic Rivers System, in January 1980, the Connecticut River from Newbury, Vermont, to Vernon, Vermont, was identified in the recreation rivers study under a preliminary list of rivers under evaluation for this designation. However, this reach of the Connecticut River is not free-flowing because of the three hydroelectric projects in this region (Wilder, Bellows Falls, and

Vernon) and, to date, no segments of the river within the Project area have been designated under this program.

Silvio O. Conte National Fish and Wildlife Refuge

The Silvio O. Conte National Fish and Wildlife Refuge was established in 1997 to conserve, protect, and enhance the abundance and diversity of native plant, fish, and wildlife species and the ecosystems on which they depend throughout the entire 7.2-million-acre Connecticut River Watershed. The refuge was designed to include the entire Connecticut River Watershed because legislators realized that the whole river system and its watershed required protection to protect migratory fish and other aquatic species and that the health of any aquatic ecosystem is linked to the health of the whole watershed upstream. It is one of only three refuges in the National Wildlife Refuge System that has “Fish” in its title (FWS, 2014b).

To accomplish the purposes of the Conte Act,[40] areas that contribute substantially or in unique ways to protecting the fish, birds, federally listed species, wetlands, and overall biodiversity within the watershed were identified. Land acquisition, a traditional conservation tool, is limited to a few high priority sites or Special Focus Areas. As of August 2014, the refuge comprises more than 36,000 acres extending from northern Vermont and New Hampshire to southern Connecticut (FWS, 2014b). The Nulhegan Basin Division in Vermont's Northeast Kingdom is the largest and accounts for more than 26,000 acres. One additional division is located in Vermont, 2 divisions are located in northern New Hampshire, 10 are located in Massachusetts, and 3 are located in Connecticut. All of these areas are outside of and a considerable distance from the three Projects.

Other Designations

In May 2012, DOI designated the Connecticut River as America’s first National Blueway (a water trail). DOI will give the Connecticut River (and other to-be designated rivers) priority for the conservation and restoration programs that it administers, such as water conservation or recreation. The Connecticut River is also designated as an American Heritage River, which recognizes its historic and scenic value. The project is intended to highlight the way that rivers unite the regions through which they flow. The designation is an effort to give federal recognition and support to local conservation measures.

[40] Public Law 102-226 (105 Stat. 1655), approved December 11, 1991.

3.8.2 Environmental Effects

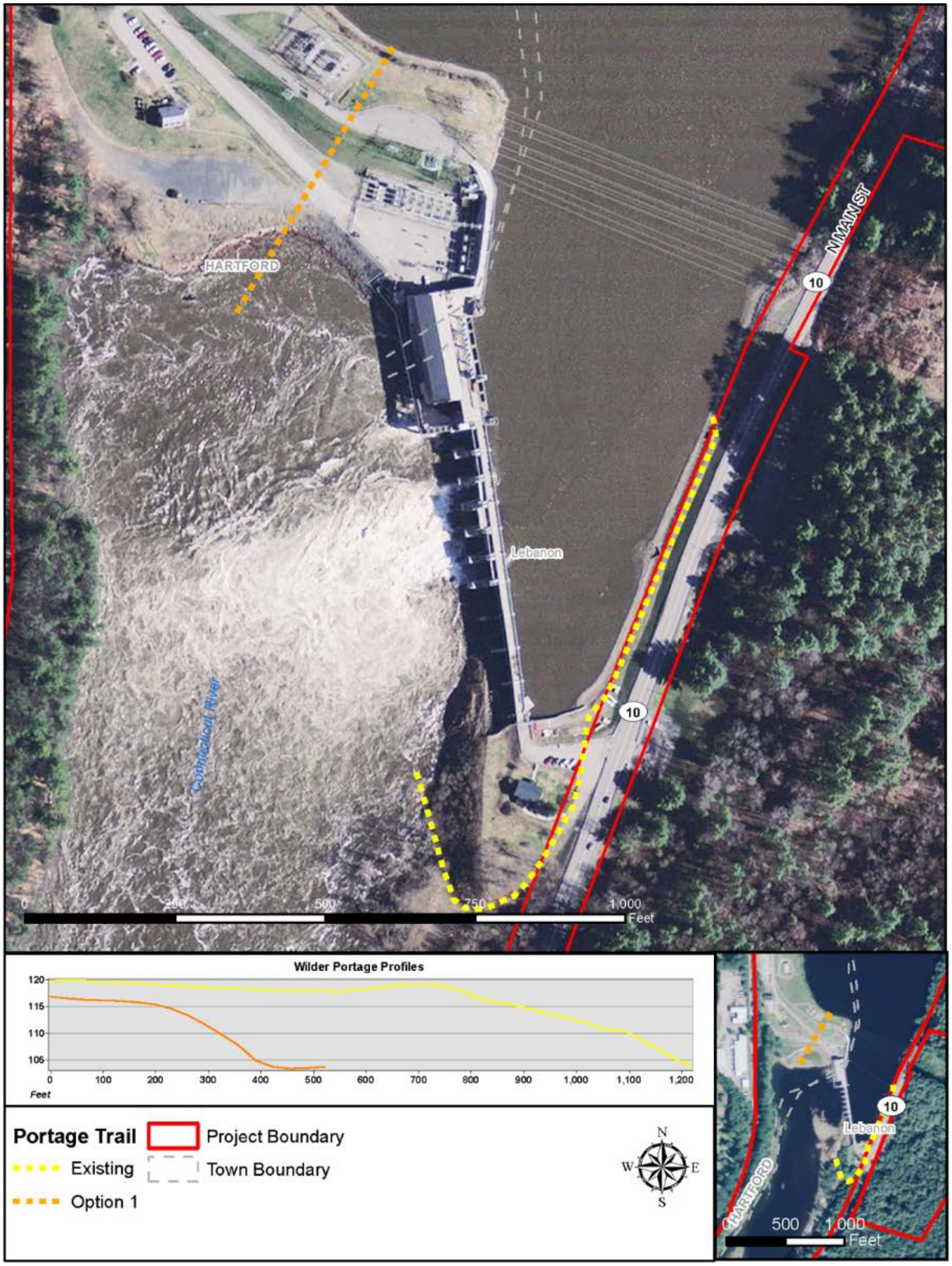
3.8.2.1 Recreation Resources

TransCanada does not propose any new measures for recreation or land use at the Wilder, Bellows Falls, and Vernon Projects. TransCanada will continue to operate and maintain the existing Project recreation facilities throughout the term of any new licenses and will continue to permit state and local entities to operate recreational facilities that provide access to Project lands and waters for recreational boating, fishing, picnicking, and environmental education. Stakeholder comments during study plan development stages of the relicensing process requested TransCanada document the existing canoe portage trails around each of the three Projects. In addition, stakeholders also suggested TransCanada evaluate the whitewater boating potential within the Bellows Falls bypassed reach. TransCanada is not proposing any changes to the portages or making changes to its policies that will allow boating within the bypassed reach.

Wilder Portage

Potential alternative portage trail routes were evaluated in Study 30 using aerial imagery, publically available elevation data, and photographs taken to document potential locations. The evaluations took a planning level look at the existing portage trail. The values for elevation gain and loss, as well as percent slope estimates were not field verified as part of this effort.

An evaluation of the potential for a portage trail option on the Vermont side of the river identified a shorter portage route (0.1 mile) around Wilder. Due to safety and security concerns associated with critical energy infrastructure and operation facilities located on the Vermont side of the dam, TransCanada does not propose changing the location of the Wilder portage trail. Figure 3.8-16 shows the existing portage trail and the alternative route evaluated.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-16. Wilder dam portage trail.

Wilder Project/Sumner Falls Whitewater

Continued operation of the Wilder Project will continue to support existing recreational use of Sumner Falls downstream of the Project. Sumner Falls will continue to experience a variety of flow levels throughout the year, particularly throughout the summer and fall seasons with flows predominantly originating from Wilder powerhouse. TransCanada demonstrated that Sumner Falls is boatable at a wide range of flow conditions and provides something for everyone at almost all times (Study 31). Boating literature indicates Sumner Falls is boatable even at flows lower than those studied. Preferred flow ranges are provided almost daily during the summer in response to regional power demand and Project generation. Consequently, numerous boating opportunities will continue to be available at the Sumner Falls complex for the duration of a future license. Additional whitewater boating opportunities exist throughout the region, including several reaches of the Deerfield River, the Ashuelot River, the West River, Millers River, and farther away on the Kennebeck River in Maine. Some of these boating opportunities depend on natural flows, but several are available through the recreation season because of scheduled flow releases, including reaches on the Deerfield River, the West River, and the Millers River. TransCanada's proposal to continue to operate Wilder dam based upon schedules and requests from NE-ISO will continue to provide whitewater boating opportunities at Sumner Falls throughout the summer when other boating opportunities are unavailable because of the lack of natural flow.

Bellows Falls Portage

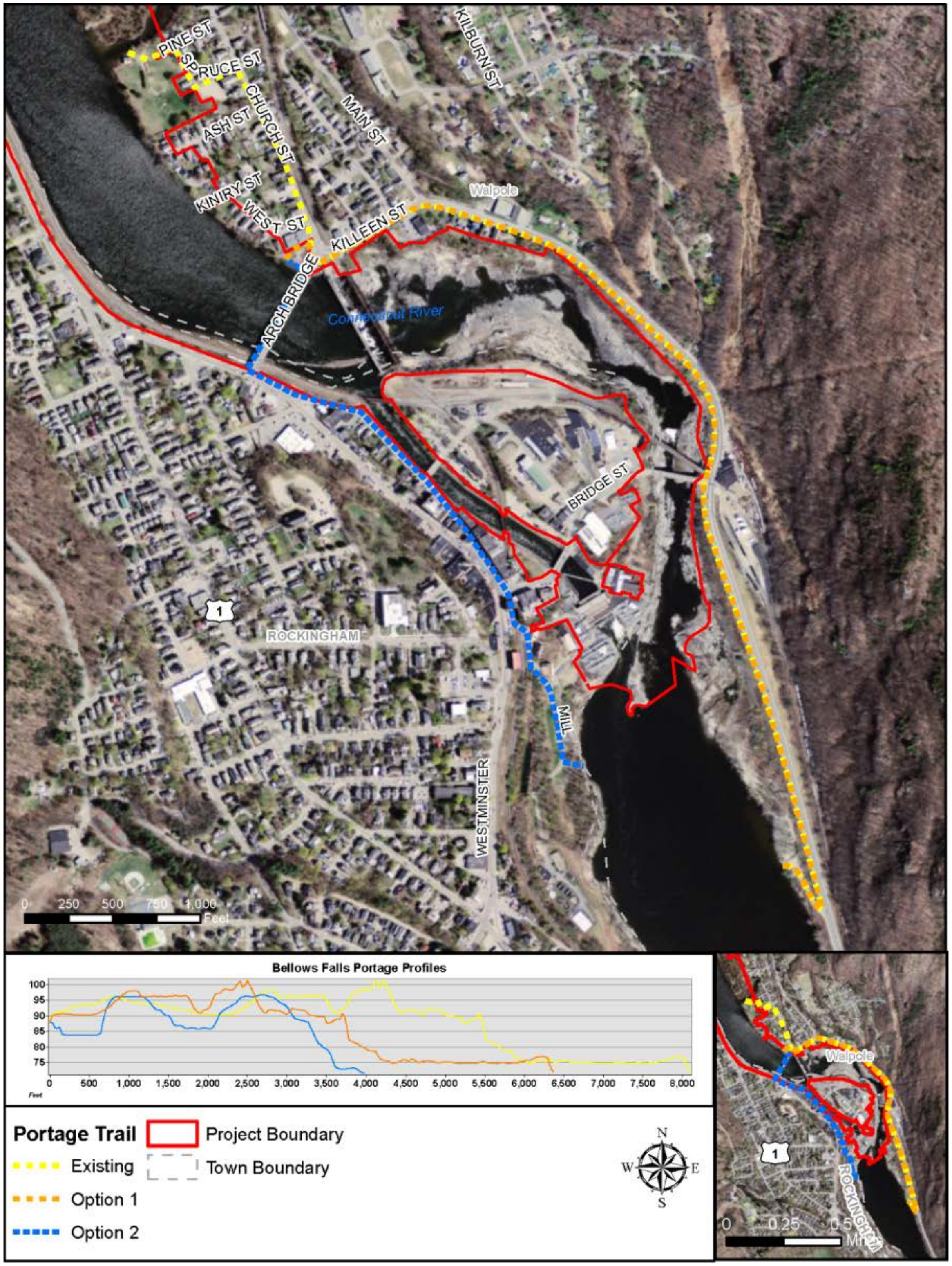
Potential alternative portage trail routes were evaluated in Study 30 using aerial imagery, publically available elevation data, and photography taken to document potential locations. The evaluations took a planning level look at the existing portage trail. The values for elevation gain and loss, as well as percent slope estimates were not field verified as part of this effort. Figure 3.8-17 shows the portage trail and option routes evaluated.

Two potential alternatives for shortening the portage trail were investigated. Both options include moving the take-out location from Pine Street to just upstream of the Arch Bridge; however, this potential take-out location is not ideal because of its proximity to the dam spill gates and boat barrier and potential strong currents during spilling at the dam. TransCanada typically installs the boat barrier upstream of the dam and canal entrance across the river essentially under the Arch Bridge after the spring freshet. Boaters who are engaging in early downriver canoe trips and are looking to portage from the Arch Bridge before the boat barrier is in place run the risk of missing this take-out, which could be fatal if the dam were spilling. If the boat barrier were in place, and conditions lent themselves to using a theoretical take-out at the shoreline just upstream from the New Hampshire abutment of the Arch Bridge, boaters would be about 0.3 mile closer to the existing put-in if they followed the existing trail. This option would remove about 40 feet of elevation gain and loss.

Another alternative would involve a take-out on the New Hampshire shore as stated above, but visitors would be required to cross the river via the Arch Bridge to Vermont and proceed through downtown Bellows Falls to Mill Street, across active railroad tracks, to the relatively new Heritage Trail located between the Bellows Falls switchyard and the wastewater treatment plant. This option would consist of a 0.8-mile hike with a total elevation gain of 115 feet and a total elevation loss of 156 feet. The average uphill slope is 6.0 percent, and the average downhill slope is −5.7 percent.

Moving the put-in location to the upper end of the Bellows Falls bypassed reach was dismissed as a viable option because of safety concerns. The only water intentionally released into the bypassed reach is spillage (i.e., spring freshet, heavy precipitation events, or during plant outages) when flows are too high for downriver canoes to navigate the bypassed reach. Furthermore, the fish barrier dam presents a substantial obstacle with limited portage options. This feature is extremely dangerous and was excluded from the whitewater boating study (Study 31), which included expert boaters who were assessing the feasibility of boating in the bypassed reach. Currently, the seals on the dam gates leak about 125 cfs and can give the impression of boatable water in the bypassed reach, shortening the portage trail; however, at this low volume of water, it is unlikely the trip would be enjoyable or even possible without numerous hits, stops, and drags along the bottom. Carrying a canoe and gear over the rocky shoreline of the bypassed reach for any distance would be challenging and pose risk of injury. For reference, the lowest flow studied under the whitewater boating study was 1,580 cfs, and at all whitewater evaluation flows, boater safety relative to the fish barrier dam was paramount to other concerns associated with the potential for boating in the reach. TransCanada does not own any property along the route except at its office facility on New Hampshire Route 12, which as reported in Study 32 was used to access the bypassed reach through a temporary cut in the chain link fence and was characterized by study participants as very steep. For these reasons, putting in on the downstream side of the dam (in the bypassed reach) is not a viable portage trail option.

Portage options along the Vermont side of the river are similarly restricted. The railroad operates along the entire Vermont shoreline from the rail station in Bellows Falls north to the Williams River. Access across railroad property is prohibited. Similarly, boating past the TransCanada boat barrier and the log boom that protects the entrance to the power canal is extremely dangerous because no viable exit points are available along the canal.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

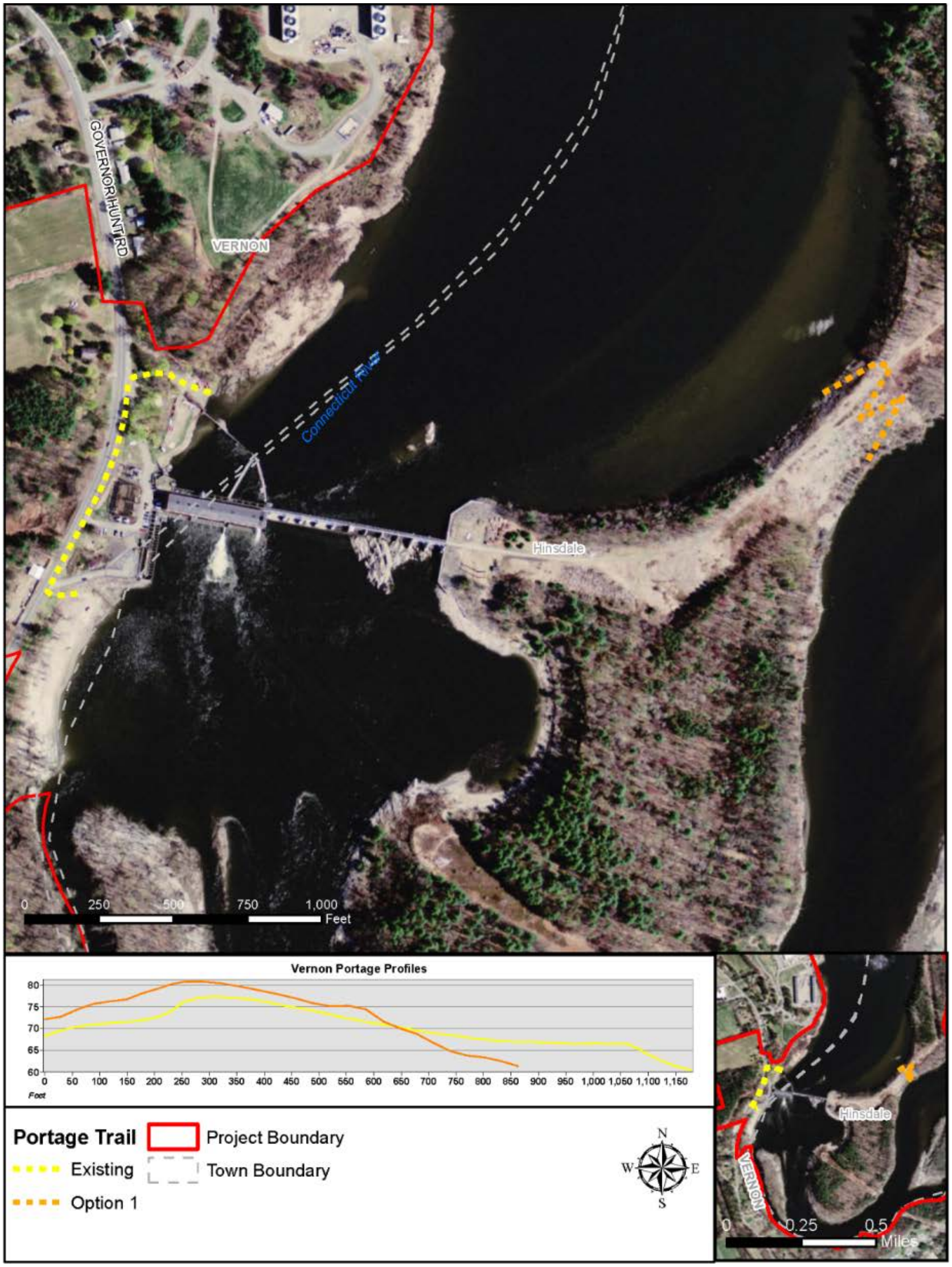
Figure 3.8-17. Bellows Falls dam portage trail.

Bellows Falls Bypassed Reach Whitewater

TransCanada proposes to continue to operate the Project as it does currently. Consequently, boating will continue to be discouraged in the Bellows Falls bypassed reach because the area only receives flows during the spring freshet, during large precipitation events, and during outages at the powerhouse requiring water to be spilled. Typically, flows are unstable (rising) and peak at higher than the 5,000 cfs flow identified as optimal. Safe boater access and egress to the bypassed reach will be difficult to develop, and this, coupled with hazardous conditions created by the existing fish barrier dam, will create an unacceptable risk to the public. Because no public access into the bypassed reach currently exists, whitewater boating opportunities will not change at the Project.

Vernon Portage

An alternative portage route was evaluated in Study 30 using aerial imagery, publically available elevation data, and photography taken to document potential locations. The evaluation took a planning level look at the existing portage trail. The values for elevation gain and loss, as well as percent slope estimates were not field verified as part of this effort. Figure 3.8-18 shows the portage trail and option routes evaluated. The optional route would require a set of switchbacks up and over the Vernon Neck peninsula on the New Hampshire side of the dam. A path in this location would reduce the overall portage distance by about 300 feet; however, the banks on the New Hampshire side are very steep and would require switchback trail construction. Construction on this steep but narrow portion of the Vernon Neck could raise structural concerns since although natural, the neck represents an embankment; one that is inspected and maintained as an element in TransCanada's dam safety program. Negotiating switchbacks with canoes and gear on the steep slopes for such a modest reduction in overall portage trail length would provide little improvement over the existing portage trail, which provides gentle, flat access and a park with picnic tables, a situation that would be hard to replicate on the opposite side of the river without significant capital expenditure, making pursuit of such an alternative impractical.



Source: ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*

Figure 3.8-18. Vernon dam portage trail.

3.8.2.2 Land Use

TransCanada owns very little land around the impoundments beyond the property required to operate the dam, powerhouse, and accompanying transmission facilities and small parcels in the flood plain that are leased to area farmers. TransCanada does not propose any measures that will expand the footprints of, or alter the primary uses of the Project facilities at the Wilder, Bellows Falls, and Vernon Projects. Therefore, TransCanada does not propose changes in Project land use within the Project boundaries.

3.8.3 Cumulative Effects

FERC SD2 identified the potential for multi-day canoeing opportunities, traveling the approximate 287-river mile stretch of the Connecticut River from downstream of Murphy dam to Holyoke dam, to be cumulatively affected by the three TransCanada Projects and the two downstream FirstLight Projects. The riverine reaches of the Connecticut River become navigable downstream of Murphy dam in Pittsburg, New Hampshire, and multi-day canoe trips are marketed to summer camps, non-profit organizations, commercial canoe liveries, and academic programs along the Connecticut River Paddlers' Trail to the mouth at Long Island Sound. Primitive campsites are provided along most of the river for non-motorized boats via the Connecticut River Paddlers' Trail. The Paddlers' Trail currently has campsites on more than 300 miles of the river. Between Murphy dam and the most downstream dam in Holyoke, Massachusetts, paddlers must navigate around 10 dams, including the three Project dams that are located centrally within this reach. The presence of portage trails, take-outs, and put-ins around dams are essential elements to downstream paddler trips. TransCanada provides portage trails around each of its three dams within this stretch of river.

3.8.4 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures related to recreation or land use resources. However, TransCanada will continue to maintain the FERC approved public recreation sites for the duration of a future license.

3.8.5 Unavoidable Adverse Effects

No unavoidable adverse effects on recreation resources or land use were identified in the environmental analysis. As discussed in Section 3.8.2, *Environmental Effects, Recreation and Land Use*, TransCanada evaluated alternatives for canoe portages at each Project and evaluated the potential for whitewater boating in the Bellows Falls bypassed reach. In all cases, alternatives were determined to be impractical, unsafe, or not feasible. TransCanada owns very little land around the impoundments beyond the property required to operate the dams, powerhouses, and accompanying transmission facilities, and various parcels adjacent to those facilities that include backwatered wetlands and floodplain terraces that are kept as natural areas or to support agriculture.

3.9 Aesthetic Resources

3.9.1 Affected Environment

3.9.1.1 General Description

The Projects are located along the border between Vermont and New Hampshire, spanning approximately 122 river miles from north to south. This area is known as the Connecticut River Valley and is acknowledged for its scenic views of mountains, historic villages, and open farmland. The Connecticut River Valley is surrounded by the Green Mountains to the west in Vermont and the White Mountains to the east in New Hampshire. The U.S. Department of Transportation's Federal Highway Administration recognizes the valley for its scenery and has designated various road segments along the river—most notably Vermont Route 5 and New Hampshire Routes 10, 11, and 12A and all Connecticut River bridge crossings—as part of the Connecticut River National Scenic Byway. Land use along the corridor of the Connecticut River is primarily rural and agricultural with considerable land forested and undeveloped. The river itself is an important landmark and destination, integral to the history of small towns and cities that lie along its shores and central to stimulating tourism throughout the valley. The mix of open space, villages, farms, country roads, mountainous terrain, historic architecture, and surface waters in the area provides for scenic vistas and a serene landscape.

The settlement patterns of Europeans in the Connecticut River Valley developed into a mosaic of villages and small cities surrounded by rural areas. This pattern of development persists in many areas in the Connecticut River Valley today, and it appeals to both visitors and residents (NHDES, 1997b). Town squares with white houses and churches, stately brick homes, and rows of brick mill buildings provide a historic architectural heritage of outstanding quality (NHDES, 1997b). The river provides views of long stretches of water, surrounding wetlands full of wildlife, views from the river of distant peaks, church steeples, vast agricultural fields and farmlands, and traditional New England homes such as those in Orford, North Walpole, the village of Bellows Falls, and Brattleboro.

The three Projects are located in the fertile soils of the Connecticut River Valley, so much of the surrounding land use types are agricultural and forested areas. Other land use types include rural residential areas; commercial, industrial, and transportation developments, and wetlands. Railroad tracks are commonly found along the banks and in proximity to the Projects along the New Hampshire and Vermont shorelines.

Overall, the three Project impoundments are aesthetically pleasing to view. Changes in scenic conditions associated with operations are limited to a narrow band of exposed bank associated with impoundment drawdown within the normal Project operating ranges (see Section 3.4, *Water Resources*). Exposed mudflats and shoal areas surrounding tributaries in the more downstream portions of the impoundments are the result of river profile operations implemented when inflows are anticipated to exceed Project generating capacity and necessary to contain high flows within the banks of the Connecticut River upstream. Temporal and seasonal changes in the amount of exposed shoreline are most noticeable where the river bank slopes are gentle. This type of shoreline highlights the visual contrasts of changing impoundment elevations compared to steep or armored shorelines because the changes expose the native soils below the vegetation at the high water mark. Because of the size of the Connecticut River and its prominence within the greater landscape setting, a temporal change in impoundment elevation related to normal Project operations is likely barely perceptible to most observers in the vicinity of the Projects.

3.9.1.2 Wilder Project

The Wilder impoundment stretches about 45 miles between the towns of White River Junction, Vermont, and West Lebanon, New Hampshire, north to the villages of Newbury, Vermont, and Haverhill, New Hampshire. The River Road in New Hampshire, north of the East Thetford Bridge to the Orford town line, has been designated a town scenic road.

The mix of open space, villages, farms, country roads, mountainous terrain, historic architecture, and surface waters in the area provide for scenic vistas and an attractive landscape. Aquatic vegetation can be found in coves and shoal areas along the Wilder impoundment.

Wilder dam and powerhouse, which are adjacent to New Hampshire Route 10, are clearly visible to motorists from this road and to visitors at the scenic picnic overlook across from the dam on the same road. The brick construction of the powerhouse, although newer, is consistent with that of more historic buildings throughout the Connecticut River Valley because brick was a common building material during the era of construction for the area. The duration of the view to motorists on New Hampshire Route 10 is short because only about 0.25 mile of the road parallels the dam and impoundment before turning away from the river at the dam. The fish ladder provides a viewing area to people visiting the dam. Views of the Wilder Project are provided at public access points up and down the river and from the Haverhill-Newbury, Piermont-Bradford, Orford, Lyme-Thetford, and Ledyard (Hanover-Norwich) bridges and select sections of U.S. Interstate 91, U.S. Route 5, and local roads paralleling the river.

Operation of the Wilder Project is visible from numerous points around the Project. The normal operating range of the Wilder Project is 2.5 feet or less (between El. 382.0 and 384.5 ft, NGVD29), depending on inflow, as described in Section 2.1.3.4, *Existing Project Operations.* The primary effect on aesthetic resources is the amount of shoreline that is visible as the Project stores and releases water for generation needs. TransCanada mitigates these effects by voluntarily holding the impoundment level at a minimum elevation of 382.5 feet at the dam from Friday at

4:00 p.m. through Sunday at midnight during the summer recreation season (May 21–September 16).

Information about visitor needs related to the aesthetic resources of the Wilder Project was collected from surveys conducted in support of Study 30, *Recreation Facility Inventory and Use & Needs Assessment*. Of the 252 people who were surveyed at Wilder Project public recreation study sites as part of the recreation study, 87 percent reported the aesthetic quality of the Wilder Project as *extremely appealing* or *appealing* (scores of 7, 8, or 9 on the 9-point Likert (rating) scale), while 12 percent (scores of 4, 5 or 6 on the rating scale) rated the aesthetic resources as *average*.

According to individuals surveyed at public recreation areas in the Wilder Project area, aesthetic attributes include being well maintained, private, clean, and quiet; having sufficient vegetation and foliage; having a view of the dam, river, and mountains, being near agricultural fields and farmhouses, and being able to see wildlife. Of the 252 respondents surveyed, only 1 listed the scenic quality of the Project as *unappealing*. Aesthetic detractors identified by visitors included insufficient seclusion, muddy riverbanks and dirty water, traffic noise, bank erosion, and vandalism.

3.9.1.3 Bellows Falls Project

Bellows Falls dam and powerhouse are located among the exposed rocky gorge and in the villages of Bellows Falls, Vermont, and North Walpole, New Hampshire. The Project was developed to capitalize on the notable drop in this section of the river, after which the village of Bellows Falls is named. The historic mill used the drop in the river for water power to run the mill. The commercial district developed around the mill and along Canal Street, which parallels the power canal that provides the water to the Bellows Falls powerhouse, all of which are part of the Bellows Falls Downtown Historic District. Because of the Project's location and age, it is a prominent feature in the village with historic mill buildings adjacent to the canal and the Project works. The Bellows Falls visitor/environmental education center invites the public to the facility, enhancing education opportunities of the hydropower project within the Bellows Falls Downtown Historic District. The steep rocky hillsides surrounding the Project are heavily wooded with mixed hardwood interspersed with conifers.

Operation of the Project is visible from only a limited number of viewpoints because much of the land surrounding the Project is privately owned. The normal impoundment operating range is 1.8 feet between 289.6 to 291.4 feet (NGVD29). On weekends and holidays during the summer recreation season, TransCanada voluntarily maintains a minimum impoundment level of 289.6 feet at the dam to mitigate adverse aesthetic effects during the primary recreation season. During high flow periods, TransCanada uses what flow it can for power generation and releases the remaining water to the bypassed reach, creating turbulent whitewater that falls through the rocky gorge at the Project, as discussed in the Bellows Falls Bypassed Reach section, below.

Sources of information about visitor needs related to the aesthetic resources of the Bellows Falls Project are provided in ILP Study 30, *Recreation Facility Inventory and Use & Needs Assessment*, and ILP Study 32, *Bellows Falls Aesthetic Flow Study*. Respondents to the surveys in support of Study 30 gave Bellows Falls recreation sites and views of the Bellows Falls Project area good scores for visual aesthetics; 82 percent of respondents rated the scenic quality as *appealing* or higher. Respondents recommended (1) considering the scenic value of undeveloped lands for future development of any shoreline properties and (2) incorporating measures to protect areas of significant scenic value. U.S. Route 5 from Brattleboro to Bellows Falls parallels the river and is part of the Connecticut River National Scenic Byway. Of the 140 people surveyed at Bellows Falls public recreation study sites, 82 percent of the respondents rated the scenic quality as *appealing* or *extremely appealing*, (scores of 7, 8 or 9 on the 9-point Likert (rating) scale), while 17 percent (scores of 4, 5 or 6 on the rating scale) of the respondents rated the scenery as *average*.

Aesthetic attributes from individuals surveyed included scenic views of mountains and the river, ability to see wildlife such as bald eagles, sandy beaches, sufficient trees and vegetation, quietness, lack of development, open space, and privacy. Aesthetic detractors included trash at the site of the interview and in the river and insufficient maintenance of trees and brush.

Bellows Falls Bypassed Reach

The Bellows Falls bypassed reach extends about 0.64 mile from the dam to the confluence with the tailrace of Bellows Falls powerhouse. Flows in the bypassed reach correspond with the spring freshet and large precipitation events when river flows exceed Project generating capacity, and during outages at the powerhouse that require water to be diverted to the dam and spilled into the bypassed reach. During the majority of the year, the only flows in the bypassed reach are the result of leakage through spillway gate seals and stanchion boards, which vary from year to year.

TransCanada conducted Study 32 to characterize aesthetic conditions in the Bellows Falls bypassed reach at various flows. The study included recording video footage and taking photographs from three key observation points (KOPs) at eight different flow levels. A focus group evaluated six flows, and four of the lowest flows were qualitatively analyzed subsequent to the focus group. Demonstration flows included 125 cfs (leakage); 500 cfs; 1,000 cfs, 1,580 cfs; 2,370 cfs; 3,300 cfs; 4,370 cfs; and 5,560 cfs. At flows less than 1,580 cfs, the scenic quality of flows in the bypassed reach was not noticeably different. The station maximum hydraulic capacity (flows controllable by power generation) is about 11,400 cfs.

The three KOPs (Figures 3.9-1, 3.9-2, and 3.9-3) provide the primary opportunities for the public to view the bypassed reach. KOP 1 is located on Arch Bridge looking over the dam, through the train trestle, downstream into the reach. Pedestrian access is not limited at this KOP. Overall, views from this KOP are severely obstructed by the train trestle and it is almost impossible to view details of flow in the riverbed of the bypassed reach from this location.

KOP 2 is located along New Hampshire Route 12 looking upstream; no pedestrian access to the river side of the road is available at this location (the sidewalk is on the opposite side of the road from the bypassed reach); vehicles have an unobstructed viewing window of approximately 150 feet, which at common travel speeds between 30 to 50 mph along this route result in very short duration views into the bypassed reach. Drivers travelling north on New Hampshire Route 12 are provided the best views as they approach the viewing window—the gap in vegetation that provides clear views—to the bypassed reach. Drivers traveling south on the same road have to turn their heads and look over their shoulders as they pass the viewing window to see the bypassed reach. Focus group participants rated views from KOP 2 as much higher than KOP 1 because the view of the bypassed reach is improved compared to KOP 1; however, the focus group setting looked at photographs and video footage which do not represent the timing of the views from moving vehicles on New Hampshire Route 12.

KOP 3 is located on Vilas Bridge with views upstream over the top of the train trestle and downstream into the lower segment of the bypassed reach. This bridge is closed and concrete jersey barriers prohibit public use, although locals occasionally use it. The total number of pedestrian users crossing Vilas Bridge is likely low because few residents along New Hampshire Route 12 potentially use it as a way into the village of Bellows Falls, but because these potential viewers are walking, their viewing times are likely longer than from the other KOPs. The train trestle obscures a portion of views upstream from this location, and foreground views immediately below the train trestle center on the fish barrier dam. Focus group participants indicated that differences between flows were most visible from KOP 3. All focus group participants, except one, liked the view of the leakage (125 cfs) flow (typical existing conditions for much of the year) at this KOP.

Source: ILP Study 32, *Bellows Falls Aesthetic Flow Study*

Figure 3.9-1. View from KOP 1, Arch Bridge over the dam into the Bellows Falls bypassed reach at 125 cfs (typical existing conditions when not spilling).

Source: ILP Study 32, *Bellows Falls Aesthetic Flow Study*

Figure 3.9-2. View from KOP 2, New Hampshire Route 12 looking over the guard rail into the Bellows Falls bypassed reach at 125 cfs (typical existing conditions when not spilling).

Source: ILP Study 32, *Bellows Falls Aesthetic Flow Study*

Figure 3.9-3. View from KOP 3, Vilas Bridge looking upstream into the Bellows Falls bypassed reach at 125 cfs (typical existing conditions when not spilling).

Overall, focus group participants acknowledged that seasonal variation in flows are important. They noted that spring flows in the bypassed reach are appreciated because they reflect the seasonal nature of snow melt and runoff, while lower flows reflect the nature of summer conditions throughout the watershed. Most focus group participants reported enjoying the experience of viewing very high flows associated with spring runoff and flood conditions. The speed, sound, and power of water in the bypassed reach elicit a sense of awe of the natural forces of the water during the spring runoff. Focus group participants also believe that some flows, even leakage flows, are important to the aesthetics of the bypassed reach because flow brings the river to life. In all cases, flows were free of visible debris, foam, trash, and other constituents that could negatively affect overall aesthetics in the bypassed reach.

As noted in Study 32 focus group participants gave higher aesthetic value scores to flows in the bypassed reach than to leakage flow. Higher flows make the reach look more like an unregulated river, making the reach look more *alive*. Focus group participants also considered that aesthetic flows in the bypassed reach will be of low importance to the public under today's conditions because access to viewing areas where the public could experience aesthetic flows is limited. Most of the land on the west side of the reach is privately owned and has heavy industrial use. The land on the east side of the reach largely comprises residential properties, and the Vilas Bridge across the bypassed reach between New Hampshire and Vermont is technically not open for public access. Consequently, access to viewing the bypassed reach requires visitors to trespass, limiting the ability of the public to view aesthetic flows. Even though public viewpoints are generally limited, the majority of the participants agreed that some flow, even low leakage flow, is important to the aesthetic value of the bypassed reach.

3.9.1.4 Vernon Project

Views of the Connecticut River at the Vernon Project area are provided at public access points up and down the river; from the Walpole-Westminster Bridge, Route 9 Bridge in Brattleboro, and Route 119 Bridge in Brattleboro, along some sections of Interstate 91, U.S. Route 5, Vermont Route 142, New Hampshire Route 119, and local roads; and along the rail trail paralleling the river in New Hampshire. Railroad tracks along the shoreline limit access to the river and corresponding views in the nearby Town of Brattleboro, which contains the largest concentration of population along this stretch of the river.

Vernon dam is located adjacent to Vermont Route 142. Motorists have an unobstructed view of the dam and Project facilities on this road. The fish ladder viewing area and Governor Hunt Recreation Area also provide direct views of the dam and tailrace areas. The powerhouse is composed of brick, a common building material used at the time of construction in 1909.

Operation of the Project is visible from several viewpoints near the Project and along many local scenic roads and highways. The normal operating range of the impoundment is 1.8 feet (between El. 218.3 and 220.1 ft, NGVD29). The primary effect of operations is the amount of shoreline that is visible as the Project stores and releases water for generation needs. TransCanada mitigates these effects by voluntarily maintaining a minimum impoundment level 218.6 ft from Friday at 4:00 p.m. through Sunday at midnight during the summer recreation season.

Of the 179 people who were surveyed at Vernon Project public recreation sites as part of Study 30, 84 percent of respondents rated the scenic quality as *appealing* or *extremely appealing* (scores of 7, 8 or 9 on the 9-point Likert (rating) scale), while 15 percent (scores of 4, 5 or 6 on the rating scale) of the respondents rated the scenery as *average*. Aesthetic attributes at the Vernon Project area deemed by survey respondents to be important included scenic views of mountains and the river, ability to see wildlife such as bald eagles, sandy beaches, sufficient trees and vegetation, quietness, lack of development, open space, and privacy. Aesthetic detractors included trash at the site and in the river and insufficient maintenance of trees and brush.

3.9.2 Environmental Effects

The Connecticut River Valley is a significant landform and integral part of the towns along the river. Agricultural use of lands along the river as well as historic towns and associated industry and cultural uses maintain the historical mixed character of the valley. These types of uses and the resulting visual character are marketed by New Hampshire and Vermont tourism bureaus, towns, and businesses throughout the region and serve to stimulate tourism within the valley.

Because the facilities associated with the three Projects have already been constructed and no new facilities or changes in operations are proposed, no new effects on aesthetic resources will occur; therefore, there will be no incremental effects on aesthetic resources associated with the Projects as proposed.

3.9.3 Cumulative Effects

No cumulative effects related to aesthetic resources have been identified, so no cumulative effects on these species are evaluated as part of this environmental analysis.

3.9.4 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures related to aesthetic resources. The overall aesthetic value of flow in the Bellows Falls bypassed reach depends on whether or not people can see it. Focus group participants noted that no reasonable public access to the bypassed reach is available, and the viewpoints from a car are fleeting. On foot, the viewpoints are hard to get to, often requiring trespassing on private land or the train tracks. As a result of difficult access, focus group participants reported that designed aesthetic flows (flows more than leakage) in the bypassed reach will not be readily viewable and therefore will be underappreciated. Extrapolating from the focus group discussion points that indicated any flow in the bypassed reach is better than no flow, continuing the current leakage in the channel will maintain the aesthetic value in the bypassed reach. Characterizing which features are visible and which are submerged and no longer visible as the water rises, and their relative aesthetic value, does not suggest that any specific flow is more aesthetically pleasing than another.

3.9.5 Unavoidable Adverse Effects

No unavoidable adverse effects on aesthetics were identified in the environmental analysis.

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3.10 Cultural and Historic Resources

The issuance of new licenses by FERC for the continued operation of the Wilder, Bellows Falls, and Vernon Projects constitute undertakings that are subject to review under Section 106 of the NHPA of 1966, as amended, and its implementing regulations 36 C.F.R. § 800. Section 106 requires federal agencies to take into account the effects of their actions on historic properties and afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on such undertakings. In consultation with the SHPOs in Vermont and New Hampshire (Vermont State Historic Preservation Officer [VTSHPO] and New Hampshire State Historic Preservation Officer [NHSHPO]), FERC is responsible for determining the Projects' Area(s) of Potential Effects (APEs), ensuring the identification of historic properties within the APEs, determining whether the relicensing of the Projects will impact any historic properties, and resolving any potential adverse effects by seeking ways to avoid, minimize, or mitigate the effects. The term "historic property" means any building, site, structure, object, or district that is listed or eligible for listing in the National Register. TCPs are a type of historic property eligible for the National Register because of their association with cultural practices or beliefs of a living community that: (1) are rooted in that community's history; or (2) are important in maintaining the continuing cultural identity of the community (Parker and King, 1998).

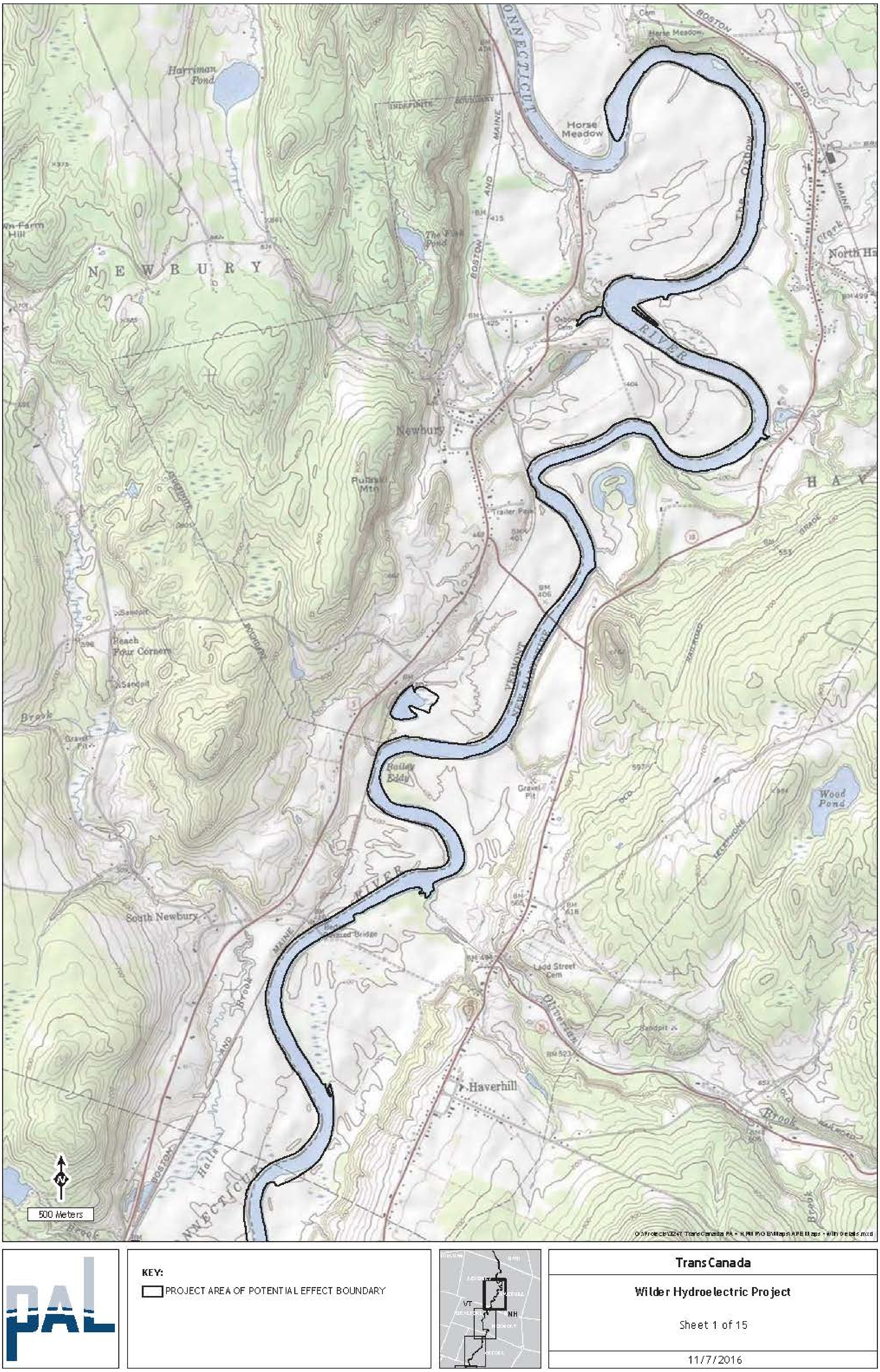
In its December 21, 2012, NOI to file a license application, FERC designated TransCanada as its non-federal representative for carrying out informal consultation, pursuant to Section 106 of the NHPA. TransCanada has conducted a number of studies to identify National Register-listed and National Register-eligible archaeological sites, historic architectural resources, and TCPs within the APEs. The following information summarizes the results of those investigations and the status of consultation regarding the effects of the relicensing of the Projects on historic properties.

3.10.1 Affected Environment

3.10.1.1 Area of Potential Effects

The affected environment for historic and cultural resources conforms to the APE determined by FERC, in consultation with the VTSHPO, NHSHPO, Narragansett Indian Tribal Preservation Officer (NITHPO), and the Nolumbeka Project. An APE is "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist" (36 C.F.R. § 800.16(d)). By letter dated November 27, 2013, FERC determined that the APEs for the Projects consist of all lands within the Project boundaries owned in fee simple by TransCanada and 33 ft (10 meters) of land inland from the top of bank in areas along the Connecticut River and affected portions of tributaries where TransCanada holds flowage rights (Figures 3.10-1 through 3.10-3). In its letter, FERC requested concurrence on this determination from the VTSHPO and NHSHPO. On January 9, 2014, the VTSHPO filed its concurrence with the APE for lands located in Vermont (see Table 3.10-1 below). The NHSHPO did not respond with formal concurrence on the APE determination for lands located in New Hampshire but has indicated its agreement through the acceptance of the Phase IA and Phase IB cultural resources reports.

The Project APEs are further described by the cultural context in which the area developed. The cultural context is divided into three major temporal periods: Pre-Contact, Contact, and Post-Contact. The descriptions of the periods below were derived from cultural resource management reports that provide the findings of archaeological and historic architectural investigations that were conducted to identify historic properties within the Project APEs.



Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-1. Wilder Project Area of Potential Effects.

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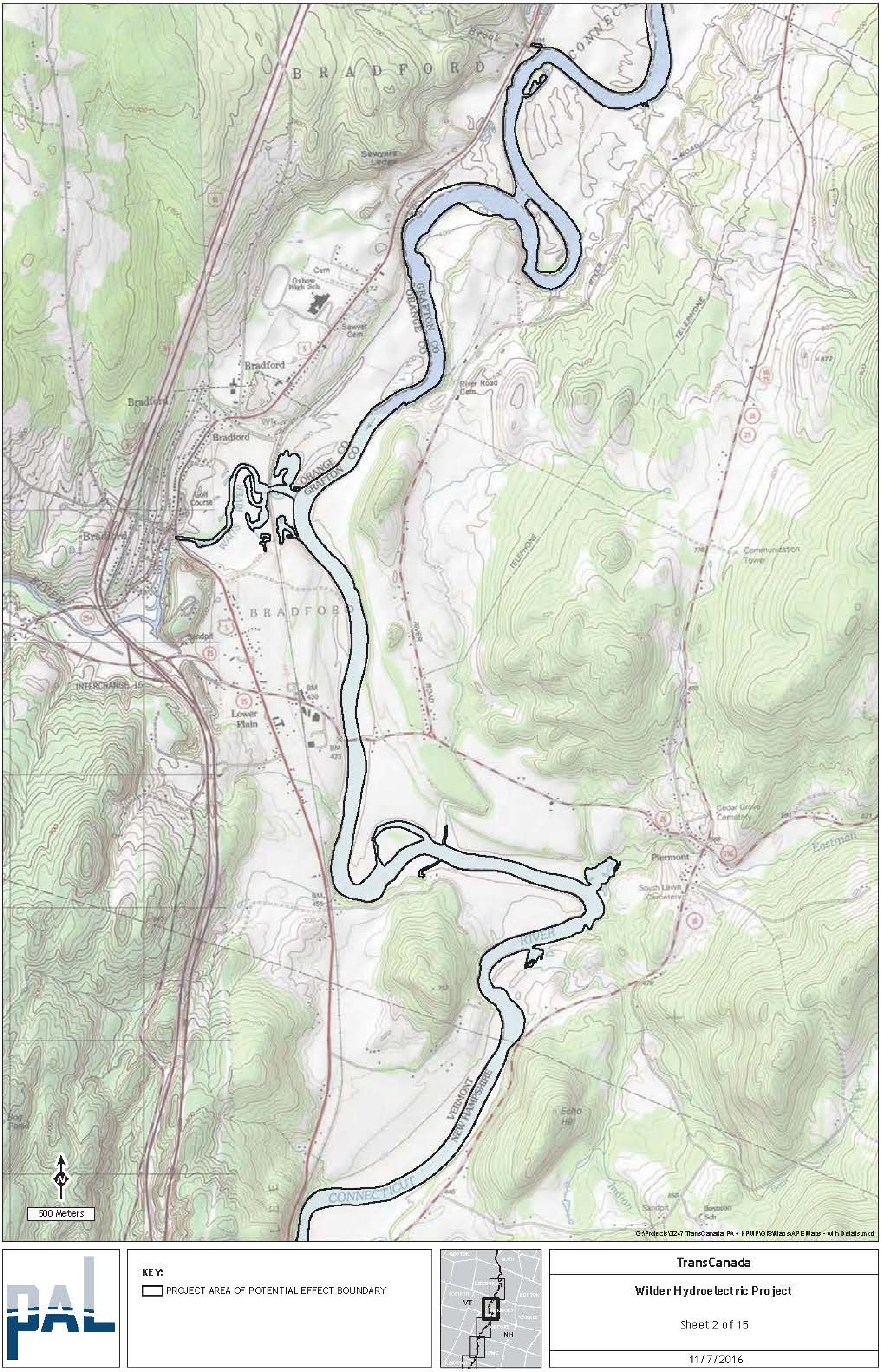

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-1. Wilder Project Area of Potential Effects (continued).

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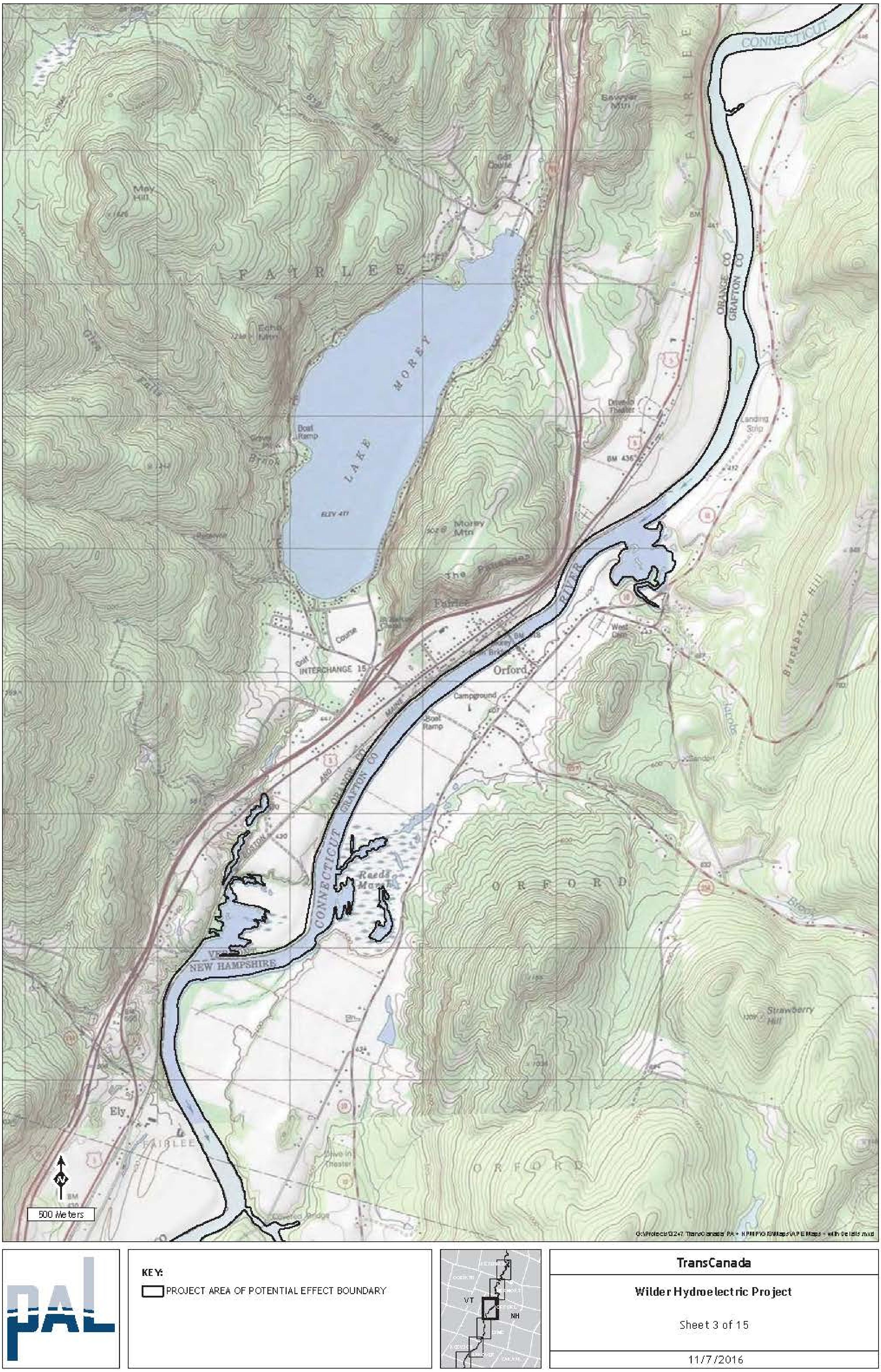

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-1. Wilder Project Area of Potential Effects (continued).

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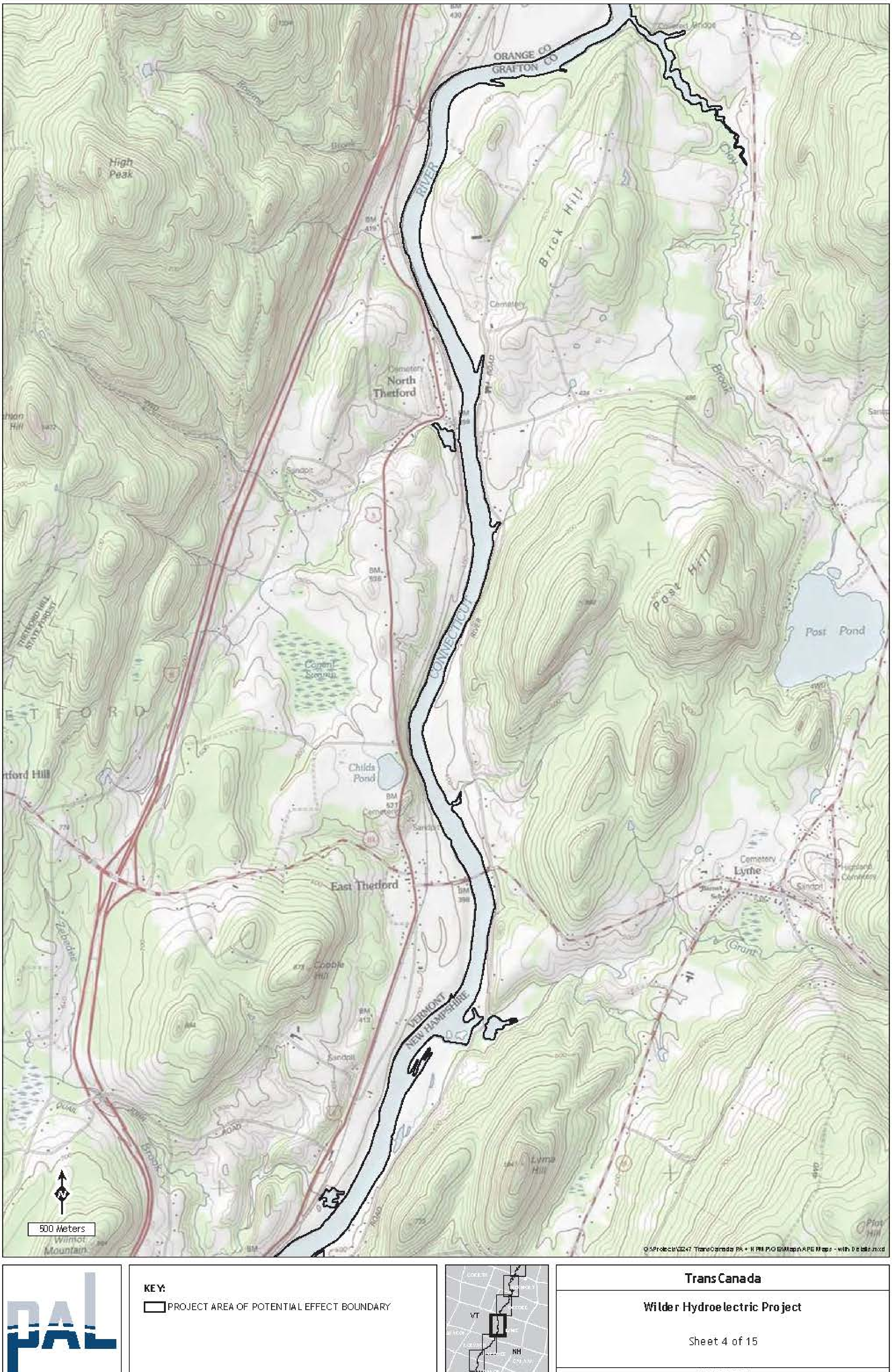

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-1. Wilder Project Area of Potential Effects (continued).

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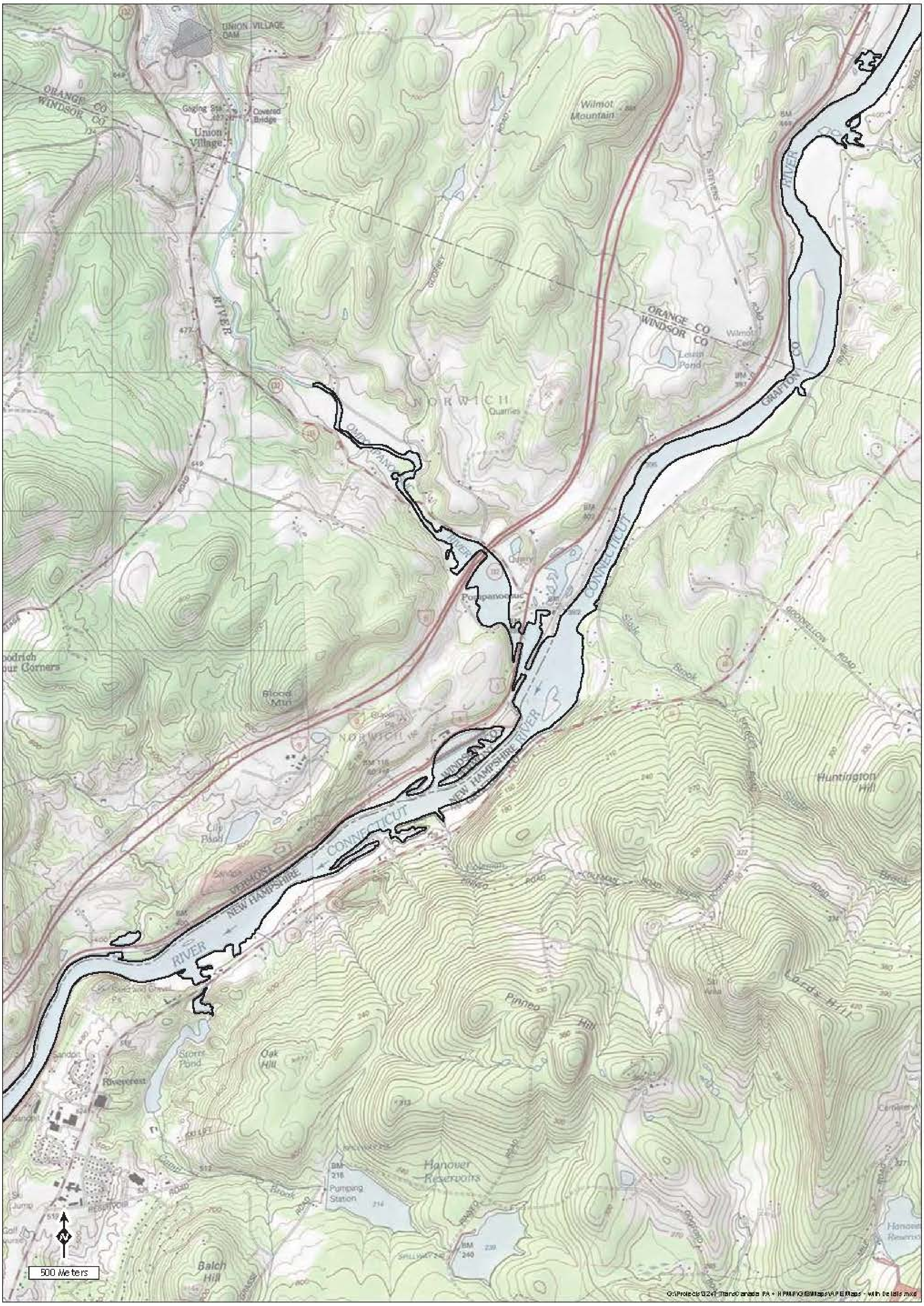
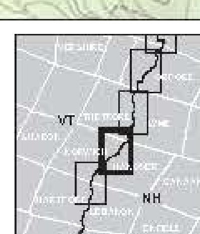


KEY:
PROJECT AREA OF POTENTIAL EFFECT BOUNDARY



TransCanada
Wilder Hydroelectric Project
Sheet 5 of 15
11/7/2016

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-1. Wilder Project Area of Potential Effects (continued).

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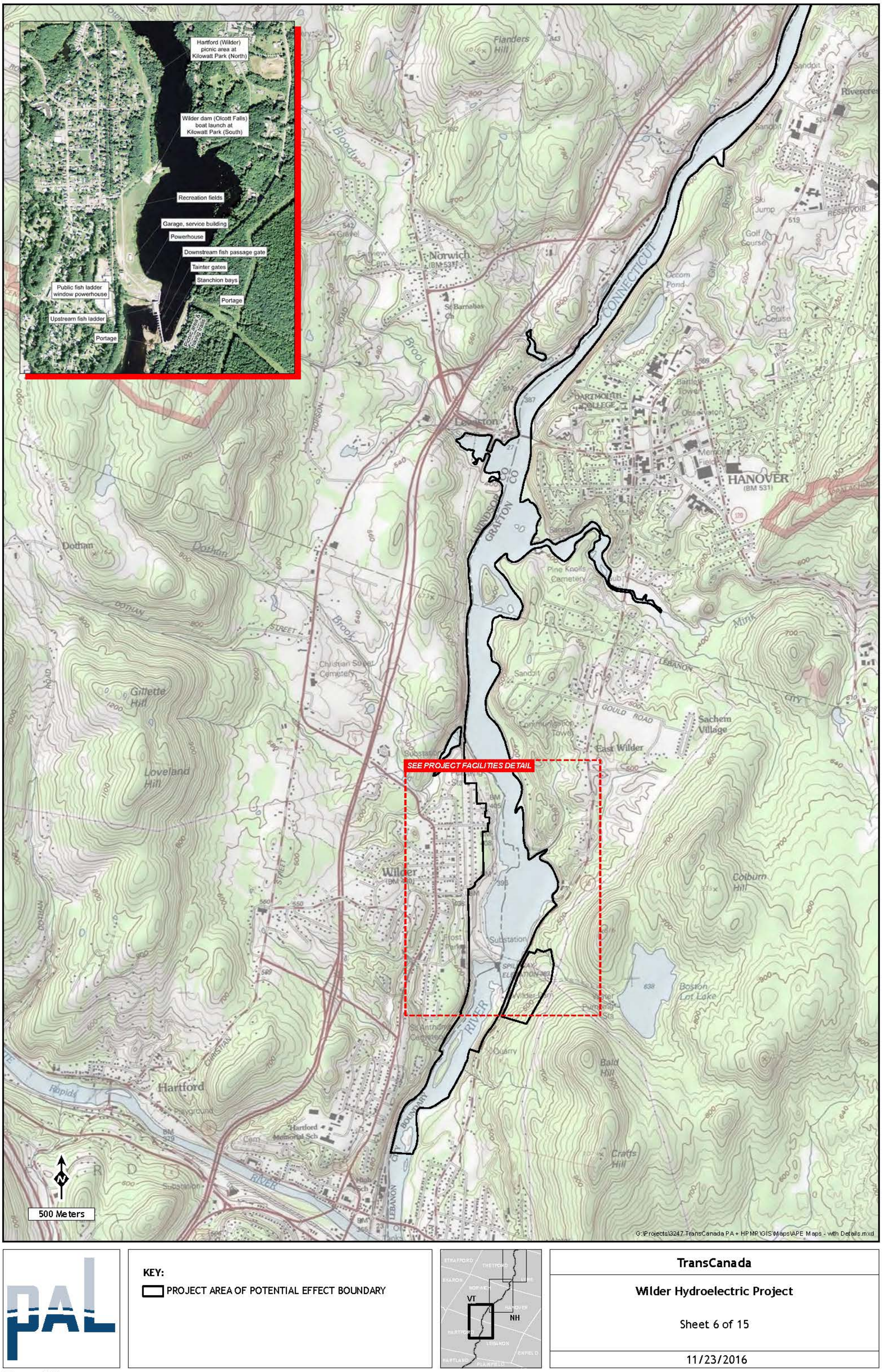

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-1. Wilder Project Area of Potential Effects (continued).

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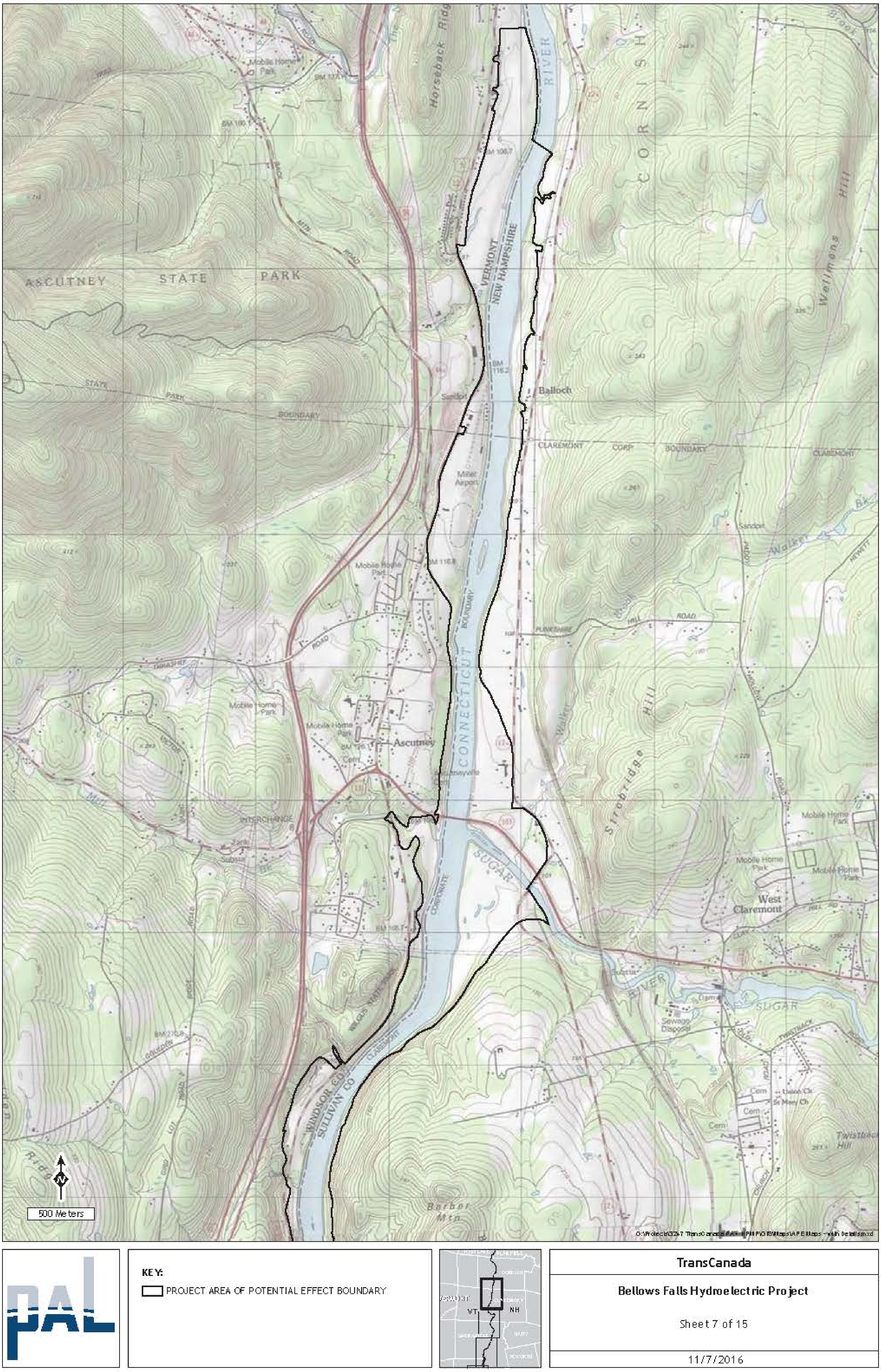

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-2. Bellows Falls Project Area of Potential Effects.

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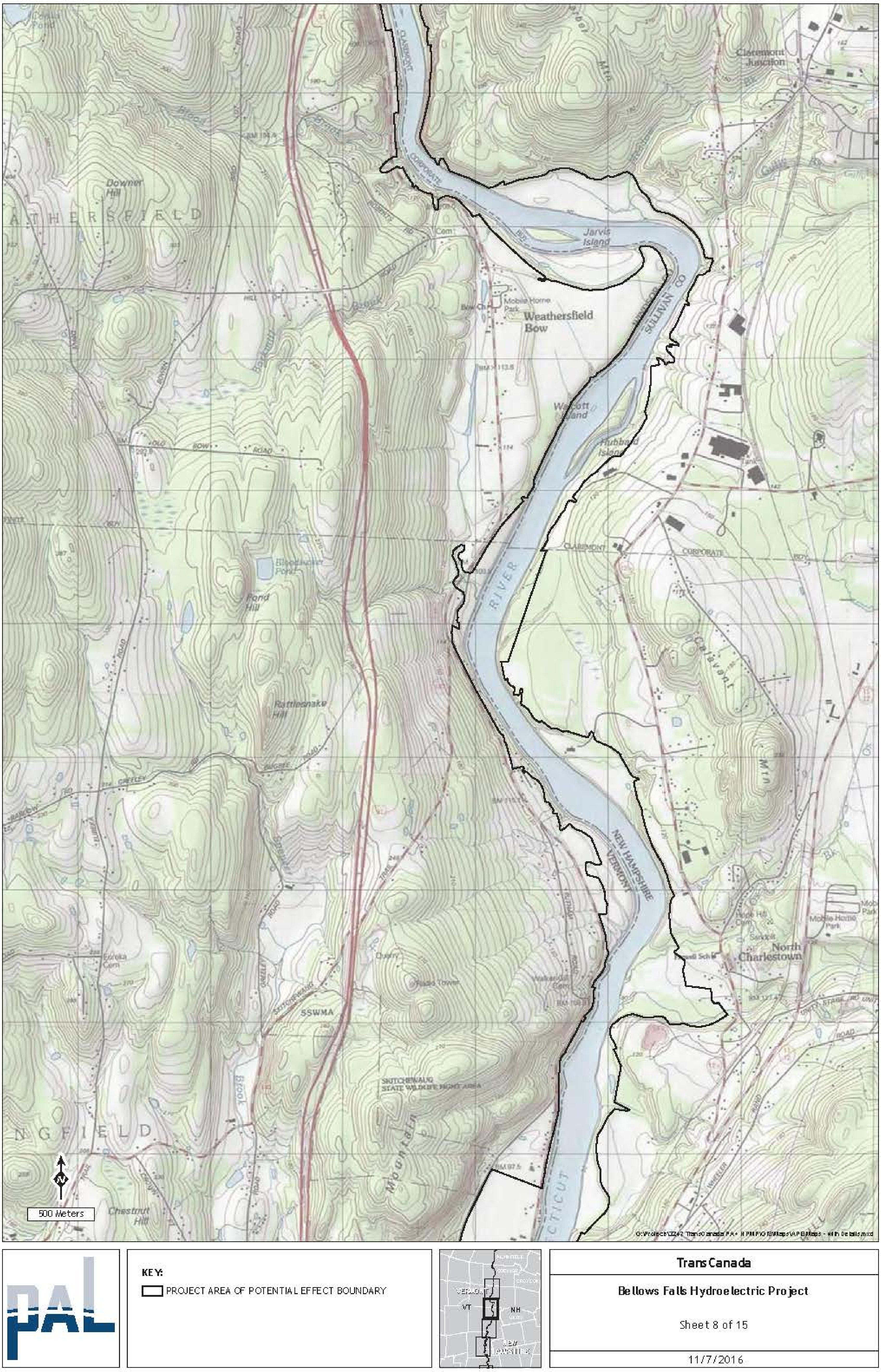

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-2. Bellows Falls Project Area of Potential Effects (continued).

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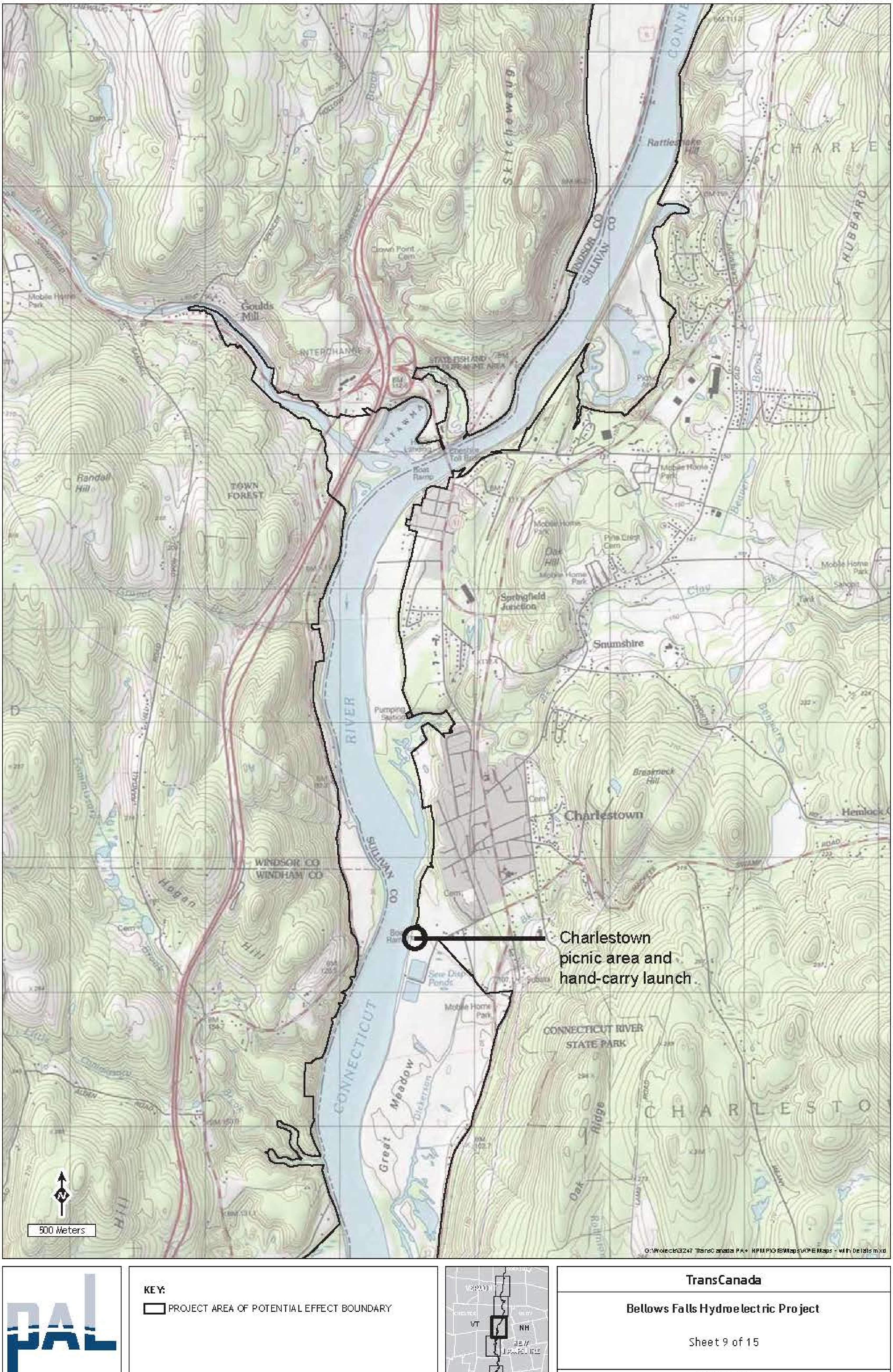

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-2. Bellows Falls Project Area of Potential Effects (continued).

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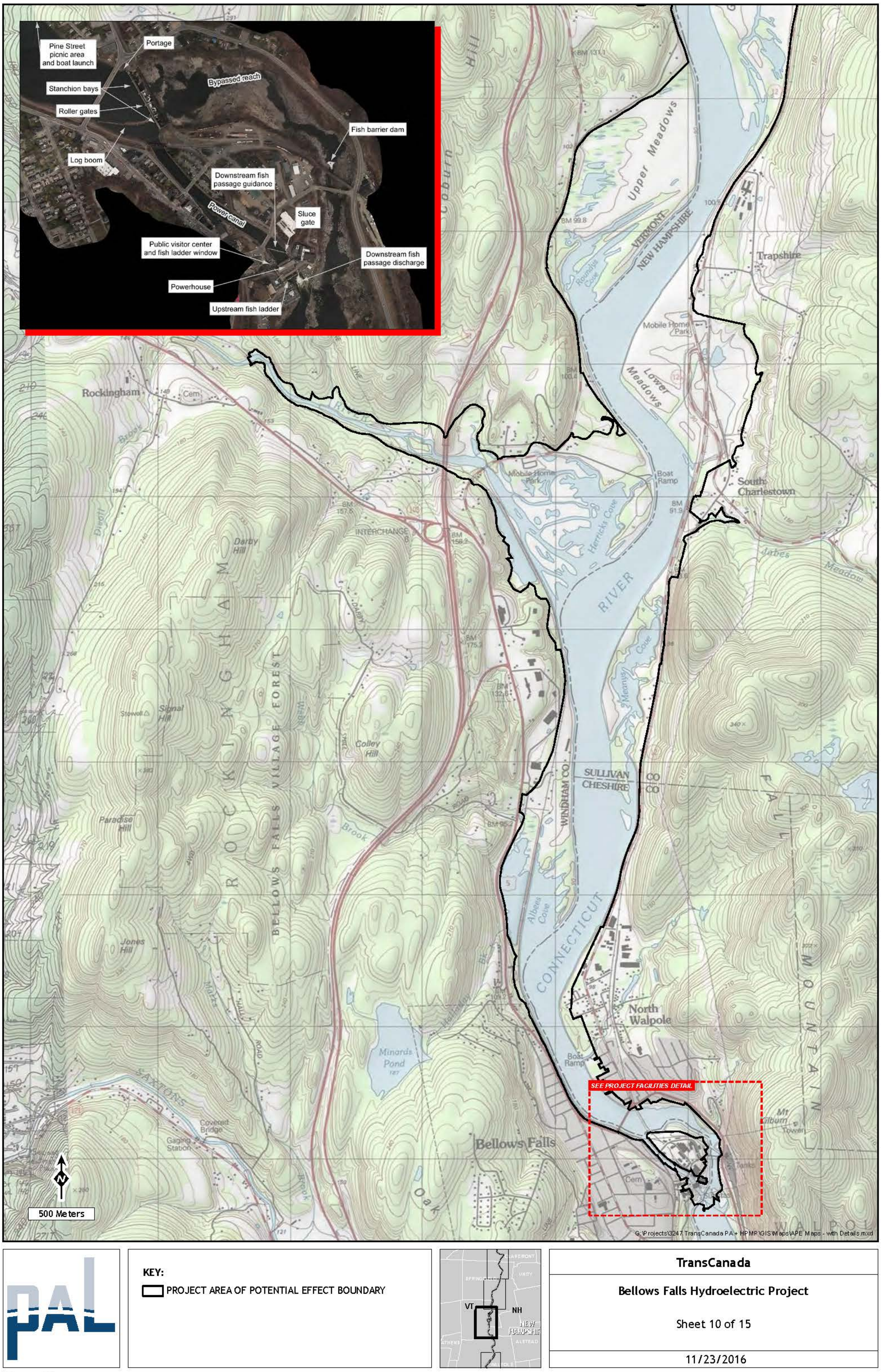

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-2. Bellows Falls Project Area of Potential Effects (continued).

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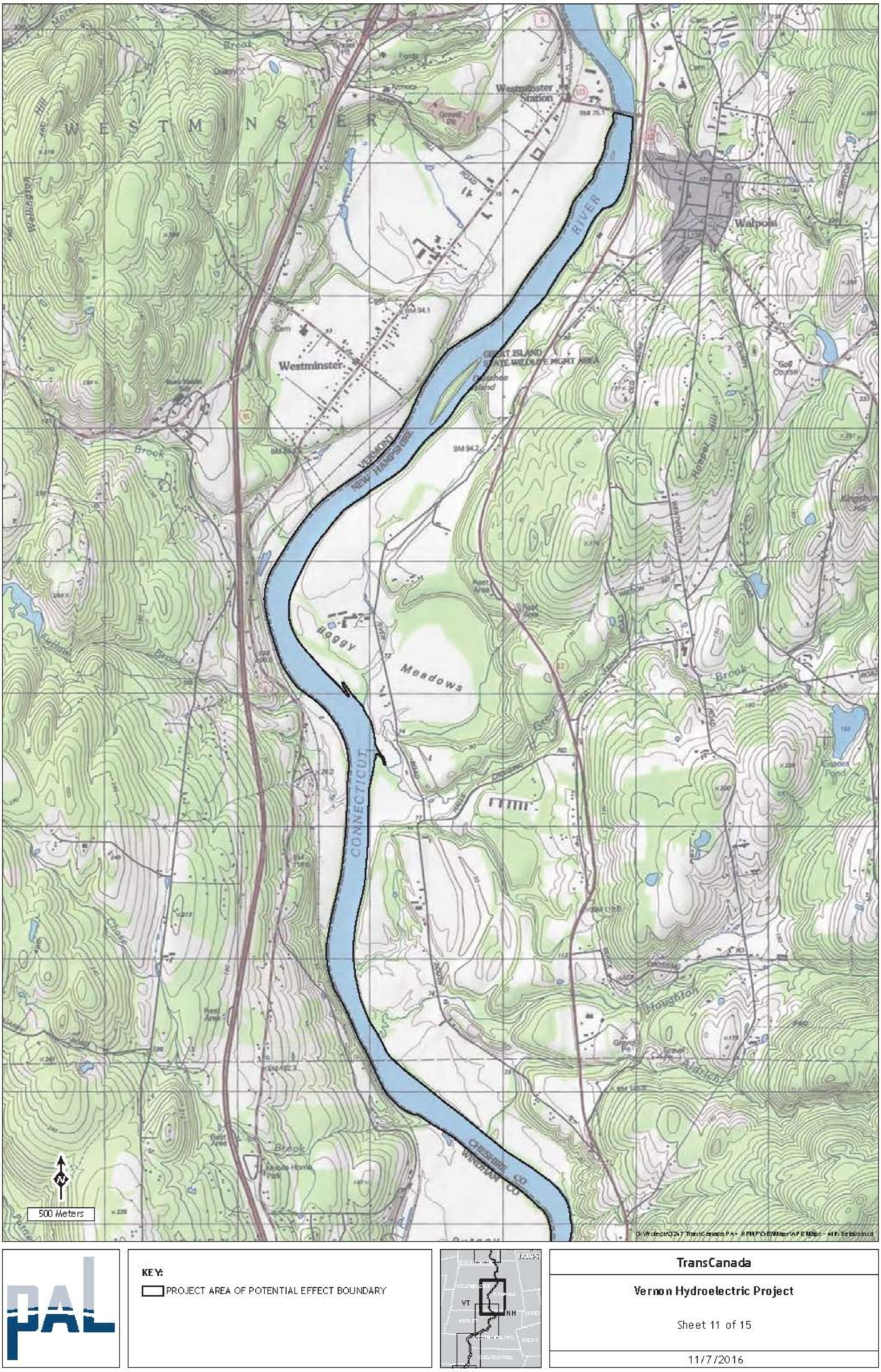

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-3. Vernon Project Area of Potential Effects.

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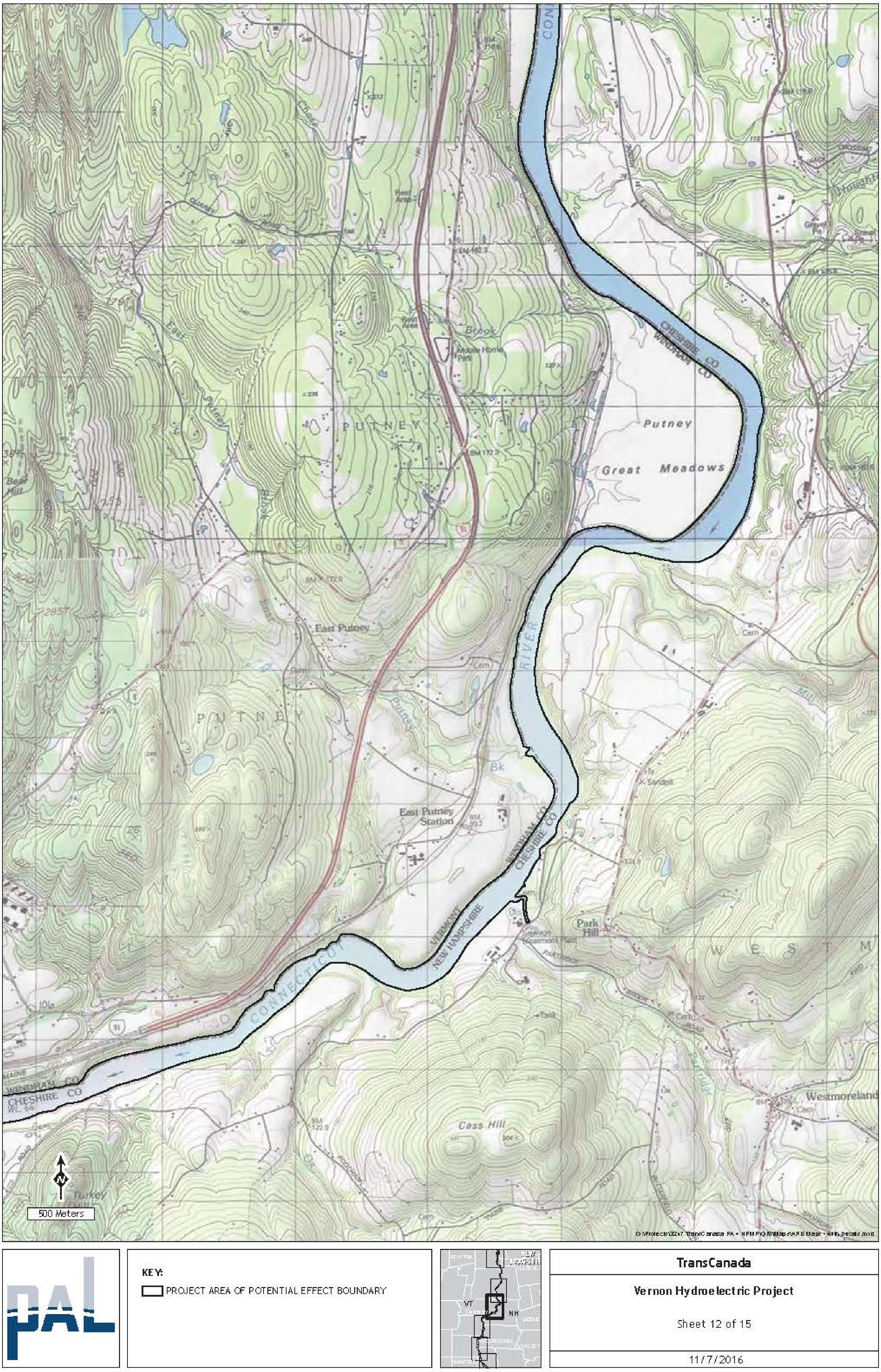

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-3. Vernon Project Area of Potential Effects (continued).

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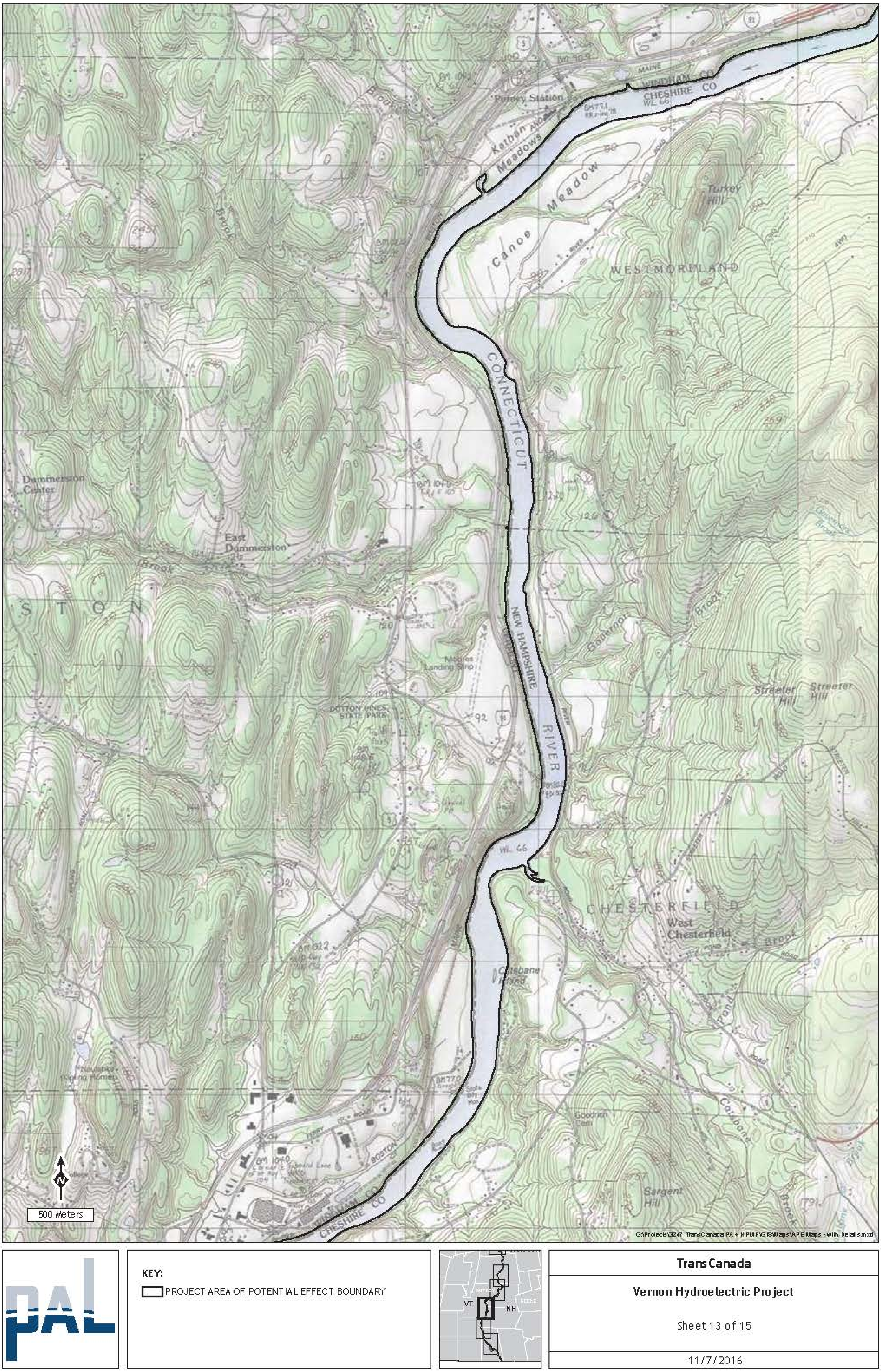

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-3. Vernon Project Area of Potential Effects (continued).

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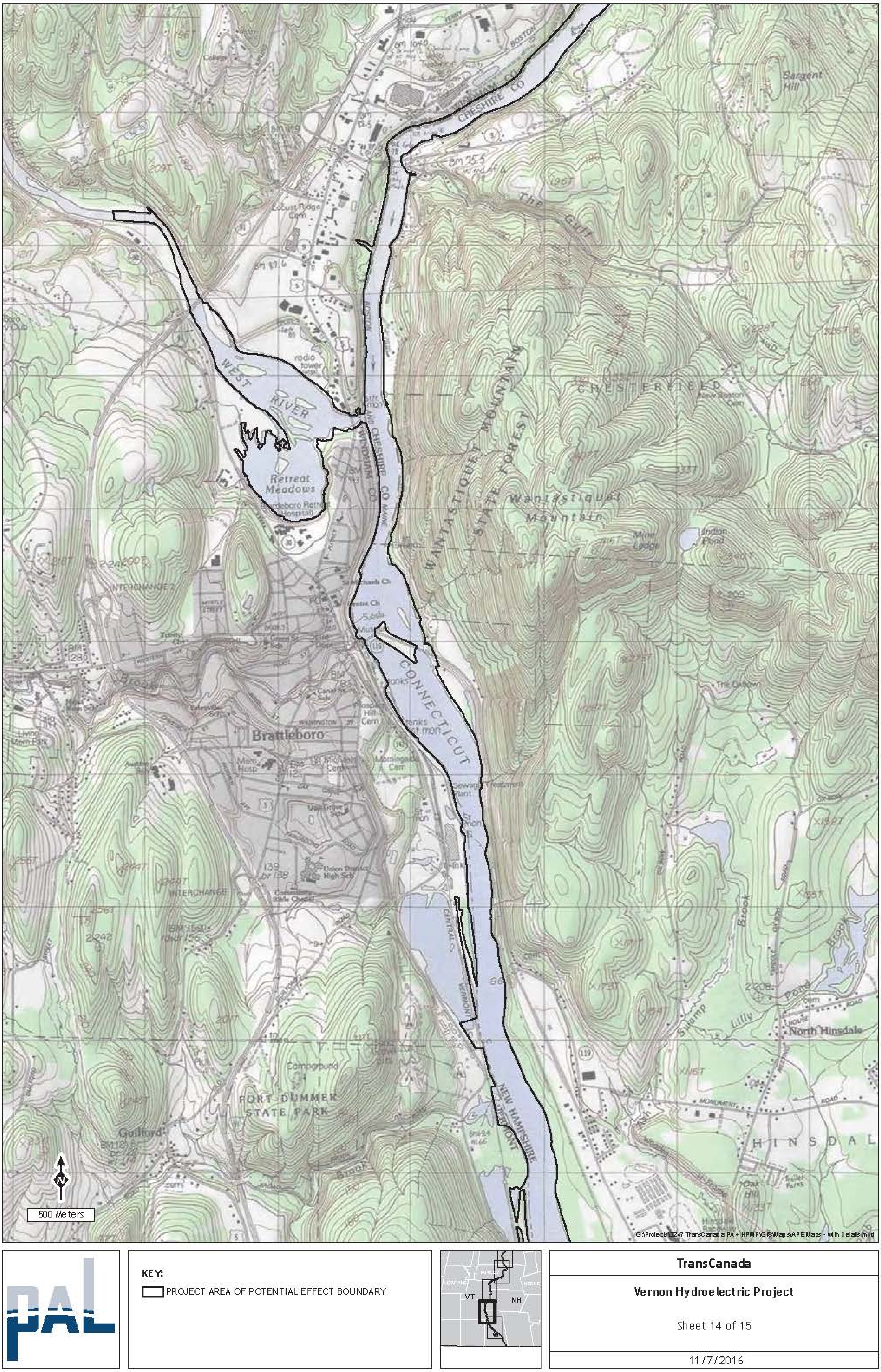

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-3. Vernon Project Area of Potential Effects (continued).

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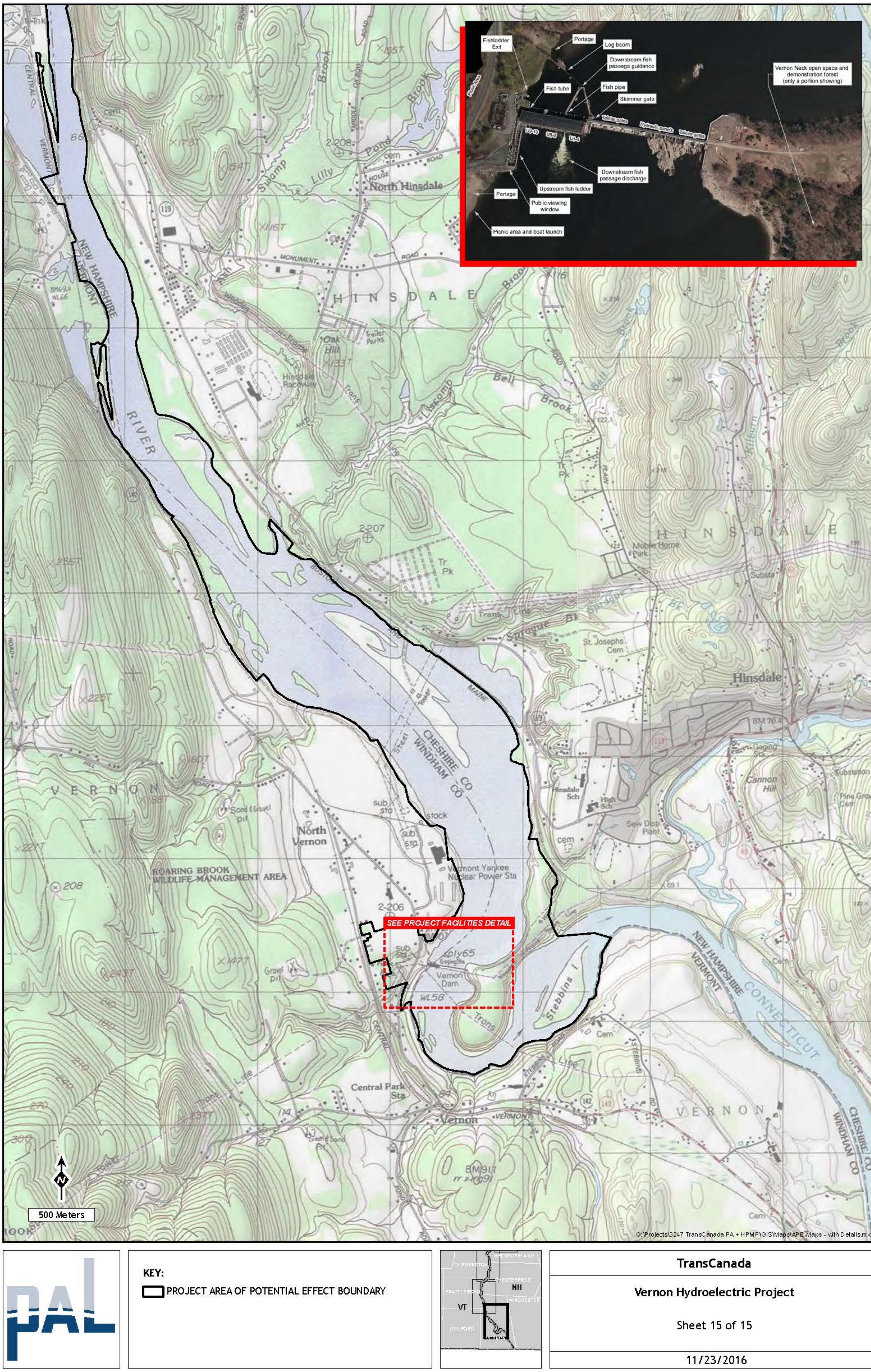

Source: ILP Study 33, *Cultural and Historic Resources Study*

Figure 3.10-3. Vernon Project Area of Potential Effects (continued).

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Pre-Contact Period Land Use and Settlement Patterns

PaleoIndian Period (9500–7000 Before Christ [B.C.])

The PaleoIndian Period in northern New England began about 9500 B.C. following the retreat north of the Wisconsin glaciation. It is hypothesized that PaleoIndian populations were highly mobile on the landscape and had an adaptive technology geared toward the intensive exploitation of a limited number of game species. This locational mobility would have increased the probability of resource encounters. Evidence to support this theory is derived from a scattered number of PaleoIndian sites, most of which reflect short-duration, ephemeral campsites. In the vicinity of the Wilder, Bellows Falls, and Vernon Projects, known sites containing evidence for PaleoIndian occupations are rare. These sites are typically recognized by the presence of fluted projectile points, exotic lithic materials, or assemblages including gravers, scrapers, and channel flakes. Northern New England PaleoIndian sites tend to be situated on sandy, well-drained landforms in broad Pleistocene valleys. Because of the continued incision of rivers and diminishing water levels, PaleoIndian sites can be somewhat remote from current waterways. These sites can also be deeply buried as a result of continued aeolian action in the sandy valleys.

Although no PaleoIndian sites have been discovered in the immediate vicinity of the Project APEs, several nearby finds document occupation of the region during the latter part of the period. One southern Vermont site yielded a Clovis-like fluted projectile point, and a site in the Missisquoi River valley in northern Vermont contained a varied artifact assemblage including diagnostic Plano fluted points, knives, scrapers, gravers, hammer and anvil stones, and chipping debris.

The Archaic Period (7000–800 B.C.) in northern New England spans roughly 6,000 years and is marked by a gradual settling of the region by an influx of Native American groups. Archaeological evidence suggests that settlement and subsistence patterns during this period were somewhat dynamic and shifting and likely represent a response to the dynamic and shifting climatic conditions in the wake of the final retreat of the Laurentide ice sheet. The Early Archaic Period (7000–5500 B.C.) coincides with a substantial temperature increase referred to as the Hypsithermal period (6000–1500 B.C.). During this time, average temperatures were higher than they are now and plant and animal communities reacted accordingly. Dry, warm summers and dry, cold winters encouraged the spread of pine-dominated forests but also precipitated the decline of the megafauna populations on which earlier human communities had depended. In their place, smaller prey, such as deer and bear, emerged, as well as a broader range of riverine, estuarine, and plant life that could not survive under the previously frigid conditions.

A small number of Early Archaic sites have been recorded in Vermont and New Hampshire. The John's Bridge Site (VT-FR-69) on the Missisquoi River dates to about 5900 B.C. The site contained five deep pits; a large assemblage of chert, quartzite, and quartz chipping debris; and a collection of tools, including Swanton

Corner-Notched projectile points, skinning knives, perforators, scrapers, and abrading stones. In New Hampshire, recent studies indicate that the course of major waterways throughout the state changed dramatically from 10,000 to 7000 Before Present (B.P.) and did not stabilize into their current channels until ca. 7000 B.P. The sediment erosion and accumulation resulting from these hydraulic dynamics likely destroyed and/or deeply buried many cultural deposits, resulting in low archaeological visibility for sites dating to the Early Archaic Period. The identification of deeply buried Early Archaic sites on floodplains, including the Merrimack River and Lamprey River, provide evidence of this phenomenon.

The Middle Archaic Period (5500–4000 B.C.) corresponds with a shift from the dry conditions of the preceding period to a climate characterized by significant increases in precipitation, perhaps as much as 25–30 percent higher than current levels. Increased rainfall and snowmelt caused extensive flooding along major river systems, as observed through rapid sedimentation sequences and channel migration along portions of the Missisquoi River floodplain. Vegetation patterns also shifted in response to the increased rainfall as the pine-dominated landscape gave way to a deciduous forest of oak, beech, sugar maple, elm, ash, and beech, with smaller numbers of hemlock and white pine. With the emergence of this “mast” forest, deer populations expanded and likely became a major subsistence focus. Bear, wolf, otter, and wild turkey also emerged in greater numbers, while comparatively smaller populations of moose, elk, and caribou persisted in spruce-fir northern hardwood forests.

The Middle Archaic Period is defined by three stemmed projectile points that have their origin along the Atlantic coastal plain: Neville, Neville Variant, and Stark. The Neville type was identified at a site in Manchester, New Hampshire, that contained a substantial collection of these points, some with slightly bifurcate bases hinting at their Early Archaic lineage. Neville, Neville Variant, and Stark points are often found in association with steep-bitted scrapers, flake knives, perforators, adzes, axes, and choppers. In New Hampshire, there appears to have been an increasing reliance on the use of volcanic material in the production of tools quarried from such sources as Ossipee Mountain and the Boston Basin, although quartz remained the raw material of choice. Heavy woodworking tools also were common and suggest the manufacture of dugout canoes during this period, perhaps in response to the increased river travel concomitant with increased precipitation.

To date, only six Middle Archaic sites have been identified in Vermont on the basis of Stark or Neville points. These sites were identified along the shores of Lakes Bomoseen and Champlain near the outlet of Shelburne Pond. This limited database suggests that Middle Archaic sites were oriented toward ponds, lakes, and rivers with an attendant emphasis on seasonal rounds. Base camps and residential camps are provisionally hypothesized, although physical evidence of houses or shelters has yet to be identified in the Northeast and none have been identified within the Project APEs.

In New Hampshire, Middle Archaic components have been identified along large rivers and their tributaries, on secondary perennial streams, and on high terraces away from major rivers. The Robert Thorndike collection from Windham contained at least one Neville point as did the Harlan Marshall Collection from the shores of Lake Massabesic and along Cohas Brook. Archaeologically recorded Middle Archaic sites in New Hampshire include the Dickey Plains Site II in Manchester and NH 31-20-5 in Belmont. The Paul H. Holmes Site (NH46-10) is a small Middle to Terminal Archaic Period campsite in Plaistow, New Hampshire.

Environmental conditions during the Late Archaic Period (4000–900 B.C.) were marked by a climatic shift to drier and slightly warmer conditions with a significant decrease in precipitation. River and lake flooding became an uncommon event, as reflected in the lack of substantial alluvial deposits along the Missisquoi River and a dramatic drop in the Shelburne Pond water table. During this period, oak, pine, and beech reached their full extent, while hemlock became much scarcer in response to the increasing dryness. Wetlands also became more abundant along river margins. Animal communities remained essentially the same as the preceding period, but deer likely became even more plentiful with the full maturation of the mast forest. Wetland/estuarine resources became an even greater subsistence resource.

Perhaps in response to an increasingly resource-rich natural environment, Late Archaic populations underwent a substantial growth spurt relative to previous periods. This growth spurt, in turn, spurred an elaboration of settlement and subsistence models and a diversification in lithic technology unprecedented in the Pre-Contact Period record. As a means to better categorize and interpret the many local expressions of Late Archaic culture, the period has been divided into three traditions: the Laurentian, the Narrow Point, and the Susquehanna.

Several examples of Late Archaic Period sites within the Bellows Falls Hydroelectric Project area appear within Springfield, Vermont, clustered about Skitchewaug Mountain on the adjacent floodplain terrace. Site VT-WN-453, located on the north end of the terrace, produced two or three possible living surfaces and two projectile points. Site VT-WN-454, also located on the north end of the terrace, produced projectile points, chipping debris, hammerstones, and pottery dating to the Late/Terminal Archaic Periods.

The Hunter Archaeological Site at the confluence of the Connecticut and Sugar rivers in Claremont, New Hampshire, contains a Late Archaic component along with Middle and Late Woodland components within its seven identified occupational levels. The site was undisturbed and well-stratified and produced over 150 hearths, a human burial, pottery, and numerous lithic artifacts.

Woodland Period (900 B.C.–Anno Domini [A.D.] 1600)

The Woodland Period in New England is marked, in the earliest phases, by a remarkable degree of continuity with the previous Archaic Period traditions. By the end of the Woodland Period, a series of dramatic developments, including the development of horticulture and the earliest contacts with European populations, changed Native American culture in profound ways.

Climatic conditions during the Early Woodland Period (900–100 B.C.) remained essentially the same as those that marked the Late Archaic Period after 1000 B.C. Cooler, wetter conditions encouraged the decline of nut-bearing vegetation in favor of hemlock, pine, and birch and imposed limits on the biotic carrying capacity of the region relative to earlier periods. Human populations in Vermont responded to this change by continuing a broad-based hunting and gathering strategy, but one more explicitly oriented toward rivers, lakes, and ponds with limited seasonal use of upland settings. In short, general cultural settlement and subsistence patterns did not change dramatically from the Late Archaic to the Early Woodland. Group sizes are assumed to have been relatively small, perhaps 30–50 people, that in some cases splintered into even smaller residential camps of 5–15 individuals.

Diagnostic cultural material for the Early Woodland Period includes stemmed and side-notched Adena and Meadowood projectile points. Both point types are relatively rare and tend to occur in small numbers within Early Woodland assemblages. Lagoon points are also diagnostic of the period but are far more common in southern New England. Early Woodland lithic assemblages comprise a high percentage of “exotic” lithic materials, including Munsungen cherts from northern Maine and Onondaga cherts from New York State, and speak to an expansion and elaboration of long-distance trade networks. Low-fired Vinette I pottery, which seems to make its first appearance during the Late/Transitional Archaic periods, also becomes much more visible in the archaeological record of that time. Ceramic sherds recovered from the Eddy Site at Amoskeag Falls and the Beaver Meadow Brook at Sewall’s Falls in Concord represent some of the earliest pottery in New Hampshire and appear to straddle the Late Archaic and Early Woodland periods. Artifacts and radiocarbon dates derived from the Stewartstown-Canaan Bridge Site (VT-ES-2) in Canaan, Vermont, represent a living site occupied during the Early and Middle Woodland periods. Pottery and lithic materials were recovered from the site, and the lithics were manufactured from cherts and rhyolites.

The occurrence of Early Woodland occupations is poorly represented in the archaeological record. Some have suggested that this low density of sites throughout New England indicates a population decline associated with any number of causal factors, including unfavorable environmental conditions and possible epidemic diseases. This assertion may be more a function of a lack of recognition of Early Woodland components from a cultural material perspective than of a real decline in numbers.

Beginning about 150 B.C., the climate appears to have stabilized, as the previously damp and cold environment gave way to generally drier and warmer conditions marking the beginning of the Middle Woodland Period (100 B.C.–A.D. 1050). If the number of identified sites is any guide, it appears that population densities increased during this period as well but were aggregated almost exclusively in the

Champlain and Connecticut River valleys. This population expansion may have overtaxed the subsistence resources of the changing environment and led to a more diffuse hunting and gathering strategy that saw a return to a more intensive exploitation of the uplands.

Pottery also took on an increasingly diverse stylistic profile, including grit-tempered coil-built vessels with a stamped, incised, and dentate decoration of varying quality. The elaboration of pottery design may be related to the population expansion hypothesized for the period, when diverse groups may have felt a cultural imperative to distinguish themselves through decorative motifs.

The Middle Woodland Period in Vermont has been fairly well documented by several excavations in the Champlain Lowland. Perhaps for this reason, the period has taken on a degree of interpretive complexity that has resulted in the creation of four phases: the Winooski (100 B.C.–A.D. 300), Fox Creek (A.D. 300–500), Intervale (A.D. 500–800), and Colchester (A.D. 800–1050). Like the phases defined for the Late Archaic Period, these phases tend to overlap, if not coincide, and reflect regional variation on a basic adaptive suite. The Winooski Site, on the east bank of the Winooski River close to Lake Champlain, is the best known and most studied Middle Woodland Period site in western Vermont.

Technologically, Jack’s Reef Corner-Notched projectile points function as the most diagnostic artifact for this period, although Levanna and Jack’s Reef Pentagonal points are also common. Raw material types derive from both local and non-local sources. Pottery also became increasingly stylistically diverse and included grit-tempered, coil-built vessels with stamped, incised, dentate decoration of varying quality.

The Late Woodland Period (A.D. 1050–1600) represents a period of continuity and innovation, in which lithic technologies, an interpretive mainstay in archaeology, underwent very little change, while at the same time the development of horticulture dramatically altered the social and cultural landscape for Native American communities. During this period, archaeological and ethnohistorical writings begin to make reference to distinct Native American communities such as the Iroquois and the Abenaki. This distinction is not arbitrary but appears to indicate increasing levels of self-identification among these populations as reflected in distinctive ceramic styles and restricted trade networks relative to earlier periods.

The adoption of horticulture is undoubtedly the most significant cultural adaptation during the Late Woodland Period and had serious, identifiable repercussions for nearly every other aspect of Native American life. Settlement patterns became markedly more sedentary from A.D. 1100 to 1450 and residential groups became larger. Villages comprising small hamlets adjacent to cultivated fields began to emerge and appear to have been occupied during the growing season.

Large habitation sites concentrated along major river valley corridors appeared—a phenomenon that likely reflects the increased desirability of floodplain environments for horticultural purposes. The multicomponent Skitchewaug Site

(VT-WN-41) in Springfield, Vermont, along the western bank of the Connecticut River, is one such site. It has yielded some of the most detailed and informative data, including carbonized maize, beans, and kernels dating as early as 1100, and the deeply buried remains of two semi-subterranean pit structures. These 4- to 6-meter wide oval structures are visible as a series of superimposed living surfaces separated by what are likely sterile flood deposits. Similar structures have been identified upriver in Windsor and Fairlee, Vermont. The Donohue Site (VT-CH-94) on the Winooski Intervale in Burlington contained the remains of a residential hamlet similar to that unearthed at Skitchewaug, although with less clear-cut evidence of habitation structures.

Despite the evidence for large habitation sites, small residential camps are the most common site type identified for the Late Woodland Period in Vermont. These small camps appear in every type of environmental niche and, while often containing restricted artifact assemblages, likely represent a broad range of functions. Small upland camps containing Levanna points have been interpreted as family hunting camps occupied for several months during the fall and winter to capitalize on hunting and trapping opportunities. Sites of this nature have been identified around Shelburne Pond and Sunderland Brook on the northwestern side of Vermont, along the Hoosic River floodplain in Pownal, along the Wallomsac River and Jewett Brook in the extreme southwestern corner of Vermont, and in upland locations along the West River in Jamaica (Salmon Hole Site) in the south-central portion of Vermont. All were dated by the presence of Levanna projectile points and are assumed to date to relatively early in the Late Woodland Period.

Contact, Exploration, and Conflict, and the Early Settlement Period (circa 1600–1730)

The Western Abenaki, concentrated in the Connecticut River Valley, was the dominant native group in Vermont and western New Hampshire at the time of European contact. Valuable allies to the French in the struggle against the English for dominion in northern New England, the Abenaki waged pitched battles against the Mohawk for control of the lucrative fur trade up and down the Connecticut and St. Lawrence rivers. The lines drawn between these two Native groups reflected not merely the priority of newly introduced economic interests, but also the priority of cultural survival in ancient societies decimated by disease and warfare.

As a result of their inland location and because of the long shadow cast by their Iroquoian neighbors to the west, little is known about the Abenaki during the Contact Period. It is assumed that settlement and subsistence patterns practiced during the Late Woodland Period were carried through but that subsequent disease and warfare reduced Abenaki numbers and likely precipitated a shift in survival strategies. One of the major documented shifts in settlement practices during the seventeenth century was the establishment of French Jesuit missions along the Connecticut River to the east and near Lake Champlain and along the St. Lawrence and Hudson rivers to the west. The establishment of these “permanent” Catholic settlements did not preclude the continuance of seasonal rounds among the Native groups that populated them, nor did they guarantee Catholic conversion. They did, however, provide shelter from hostile European and Native groups, food and farming opportunities, and a central meeting place for Abenaki families displaced by war and disease.

Native Americans had long come to the "Great Falls" of present-day Bellows Falls on both sides of the Connecticut River to hunt and fish. Although not assigned a temporal or cultural affiliation, the Bellows Falls Petroglyph Site (VT-WD-8) on the west bank of the Connecticut River at the base of the Great Falls is similar to other petroglyphs that have been dated to the Woodland and Contact periods (Lenik, 2002; Mulholland et al., 1988). Two sets of petroglyphs (rock carvings) are located 35 and 55 feet south of the Vilas Bridge that crosses from Bellows Falls, Vermont, to Walpole, New Hampshire. The petroglyphs are carved into massive granite outcroppings. The petroglyphs depict life-size, oval or round, anthropomorphic "heads" with "eyes" and "mouths" and a number of them have "horn" or pronged projections. These projections are believed to represent superior power or attributes (i.e., shaman spirits). Any habitation or resource procurement site(s) associated with the petroglyphs would have been located on higher river banks and not in the down cut of the river bed itself.

As the location of migrating salmon, the falls also marked the highest point of the river that migrating shad could swim, and they could be hunted in great numbers in the pools at the base of the falls. Though no permanent Native American settlement is known to have existed at Great Meadows or Westmoreland, it is known to have been a favorite campground for Natives traveling through the area and had some importance as a known site for pow-wows centered on a large rounded glacial erratic on the bank of the Ox Brook near where it flows into the Connecticut.

The only recorded Native American activity in the vicinity of Chesterfield, New Hampshire, is believed to have been centered on the Wantastiquet or West River Mountain. The summit affords an excellent view of the far bank, as well as the river itself, both north and south. During the successive frontier wars, Native Americans used the hill as a lookout from which they could see all river traffic, as well as keep an eye on the garrison in Fort Dummer on the western shore of the river. As a result of this activity, the summit of the mountain is referred to as "Indian's Great Chair." The rugged terrain of Chesterfield, and the fact that it was blocked from easy river access by the West River Mountain, meant that it was seldom used by the Native Americans as anything other than hunting grounds containing occasional small seasonal camps. Most known Native American activity was confined to the Connecticut River and its shores, including Catsbane Island, a point often used when Native Americans sought to ford the wide river.

Coopers Point in what is now Hinsdale, New Hampshire, had been the main home to the Squakheags for its strategic importance and because the bend in the river around it was known as an excellent fishing location ("squakheag" is thought to mean the spearing place, a reference to fishing for salmon). The Squakheags built an earthen fortification on the bluff to defend against attacking Mohawk war parties. Unfortunately, the fort proved worthless and the Squakheags suffered badly at the hands of the Mohawk. Consequently, by 1687, the Squakheags were obliged to migrate north into Canada to escape the Mohawk and signed their land over to the English settlers in Northfield, Massachusetts.

One of the most significant areas of Contact Period Native American activity in this section of the Connecticut River Valley (and possibly all of New Hampshire) is at the location of Fort Hill in Hinsdale and the surrounding countryside on both sides of the river. This fortified village of about 500 residents was built in the fall of 1663, attacked by a large Iroquois war party in December, and abandoned during the early months of 1664. It has been archaeologically sampled and a large inventory of artifacts was recovered, along with food remains from 97 features (mostly hearths and storage pits). The land base around the Squakheag village was largely intact, because the nearest colonial town was more than 40 miles away and English encroachment had not occurred at that time.

The area of "Great Meadows" in Vermont along the Connecticut River, later settled by the English as Putney, was well known to Native American populations for its good, alluvial clays, which fostered the growth of large stands of pine and butternut trees. Evidence of Contact Period Native American occupation in this region is scant, though it is known that there were seasonal encampments on the New Hampshire side of the river at Westmoreland. The area is thought to have belonged to the territory of the Squakheag, who may have used it as seasonal hunting grounds. Canoe Brook, a small rapid stream that flows down from the hills into the Connecticut River, is so called because a carved-out Native canoe was recovered from it, indicating the stream's use as part of a Native waterway transportation network.

The area that now encompasses Brattleboro, Vermont, contains evidence of Native American occupation in the form of engraved rocks bearing petroglyphs found in the vicinity of the West River where it joins with the Connecticut. It is believed that "the Cove" was a favorite hunting ground for Native Americans and probably the site of seasonal hunting camps. In 1850, a farmer plowing his fields uncovered a Native American burial that contained several artifacts, including a pipe, lithic points, and a pestle.

The Vernon, Vermont, vicinity near a significant bend in the Connecticut River, was the site of several substantial Native American settlements in the years before the arrival of Europeans. All of these sites are reported to contain Late Woodland/ Contact Period and early Post-Contact Period components.

Today, tribal groups that have identified themselves as having traditional cultural connections to the Connecticut River Valley in New Hampshire and Vermont consist of the federally recognized Narragansett Indian Tribe, based in southern Rhode Island, and the Vermont state-recognized Abenaki Nation, including the Elnu Abenaki Tribe, the Nulhegan Abenaki Tribe, the Koasek Traditional Band of the Koas Abenaki Nation, and the Abenaki Nation at Missisquoi. There are no New

Hampshire recognized Indian Tribes; however, there are New Hampshire-based Tribal interests in the Project areas, including the Abenaki Nation of New Hampshire.

Post-Contact Period Land Use and Settlement Patterns (A.D. 1730–Present)

Until 1738, New Hampshire was part of the Massachusetts Bay Colony. European settlement north along the Connecticut River was sparse, and the area along the Connecticut River to Canada, east to the Merrimack River settlements and west to the Hudson River in New York, was a vast stretch of unbroken wilderness. By action of the General Court of Massachusetts in January 1735, surveyors were sent to establish townships from the Merrimack west to the Great Falls (now Walpole, New Hampshire) of the Connecticut and south to earlier grants. These fortified townships were intended to provide tiers of defense along the Connecticut River to protect the Bay Colony's western territory. Each of the towns was laid out to be 6 miles square from "Great Falls" on the east side of the river to Arlington (now Winchester, New Hampshire) and not to extend more than 6 miles from the river. The four original fortified townships on the east side of the river were established as No. 1 Chesterfield, No. 2 Westmoreland, No. 3 Walpole, and No. 4 Charlestown. Fortified towns were also authorized on the west side of the river in what became Vermont: No. 1 Westminster, No. 2 Putney, No. 3 Dummerston, and No. 4 Brattleboro.

Vermont received its first European settlement in the 1740s when New Hampshire Governor Benning Wentworth began issuing grants (later referred to as the New Hampshire Grants) to spur development west of the Connecticut River. Vermont's first town, Bennington, was chartered by Wentworth in 1749. The colony of New York also claimed Vermont and issued some grants for the same lands, sparking ownership disputes. The settlers of Vermont ultimately decided to make a break from both New York and New Hampshire by forming their own government. On July 8, 1777, a group of delegates met in Windsor and ratified Vermont's own version of the Declaration of Independence. At that time, the state was divided into two counties: Bennington to the west and Cumberland to the east. The next several decades saw the two parent counties split and re-amalgamate into a mosaic of smaller counties. In 1781, Cumberland County was subdivided to create the smaller counties of Windham, Windsor, and Orange. Chittenden County was incorporated in 1787. Vermont was admitted into the Union as the fourteenth state in March 1791.

With the exception of the fortified townships, most of the other towns and cities through which the Project APEs extend were established in the 1760s through the granting of land to groups of settlers who came from other colonies in search of fertile agricultural lands along the Connecticut River. These towns include Hartford and Norwich, Vermont, and Lyme, New Hampshire, which were all chartered in 1761 through grants from the New Hampshire colonial government. As their names reflect, the petitioners who received the grants were groups from Connecticut. Throughout the Colonial Period (1675–1775) and into the early nineteenth century, the settlements were relatively small and town populations seldom exceeded more than a few hundred persons. The settlements generally grew up along the Connecticut River and its tributaries, where the most productive farmland was to be found. Most were self-sufficient and had their own gristmills and sawmills to process grains and lumber for local consumption. The founding of Dartmouth College in Hanover, New Hampshire, in 1771 by Reverend Eleazar Wheelock was a major event the region's history and had a major impact on the settlement and development of Hanover and surrounding towns.

The pace of settlement quickened during the first half of the nineteenth century, when agricultural production was at its height and a diverse range of industrial operations was established throughout the Connecticut River Valley. The main agricultural products were grain crops and cattle. The raising of Merino sheep for wool became a significant industry when high tariffs were placed on British imports and became especially important in towns such as Fairlee and Weathersfield, Vermont, where poor soils could not support high-yield plant crops.

The progression of industrial operations at the numerous mill privileges along the Connecticut River and its tributaries began with tanneries, gristmills, and sawmills that were put in place to process local agricultural and lumber products. During the early nineteenth century, textile spinning and carding operations began to appear. By the mid-nineteenth century, industrial production in the region was characterized by a profusion of specialized factories that often utilized previously developed mill privileges. The vast lumber reserves of the Connecticut River Valley contributed to the establishment of numerous wood processing industries. Paper production became important after the region's first paper mill was established in the village of Bellows Falls in Rockingham, Vermont. Other towns that developed significant paper industries in the nineteenth century were Newbury, Thetford, Hartford, Putney and Brattleboro, Vermont, and Haverhill and Hinsdale, New Hampshire. Furniture was another prominent wood-product industry, especially in Newbury and Windsor, Vermont, and Lebanon, New Hampshire. Other major industries in the valley included metal-working and textiles.

The establishment of rail service to the Connecticut River Valley in New Hampshire and Vermont during the late 1840s spurred new settlement and development in the area's industrial and agricultural sectors. The Cheshire Railroad, which connected the area to the port of Boston via the Fitchburg Railroad, was completed through Westmoreland and Walpole, New Hampshire by 1847. White River Junction became the area's most important transportation crossroads when five different railroads (the Vermont Central Railway and Connecticut River Railroad in 1847, the Connecticut and Passumpsic Rivers Railroad in 1848, the Northern New Hampshire Railroad in 1849, and the Woodstock Railroad in 1863) were laid through the village. The arrival of the railroads contributed to making tourism an important industry in many Connecticut River communities. Later in the century, sculptor Augustus Saint-Gauden and 100 artists, sculptors, writers, designers, and politicians turned Cornish, New Hampshire, into one of the nation's most famous art colonies.

The populations of most area towns increased substantially from 1830 to 1870 as newcomers came to farm or take jobs in the new factories in the valley. Immigrants from Europe and Canada made up a large percentage of the new population. During the last quarter of the nineteenth century, however, most of the towns in the region suffered drastic population declines as residents moved west in search of better agricultural lands or to find work in urban industrial centers. That trend was not reversed until the second half of the twentieth century when the area attracted new commercial and residential development. The construction of interstate Highways 89 and 91 were major contributors to that reversal. Nearly all the communities have increased their population because of new commercial or industrial developments or as residential bedroom communities to the larger urban centers such as Hanover and Lebanon, New Hampshire, and Springfield, Vermont, and construction sparked new development.

3.10.1.2 Pre-Contact and Post-Contact Archaeological Properties

TransCanada has completed a number of archaeological surveys for the Wilder, Bellows Falls, and Vernon Projects as part of the current relicensing effort. These surveys consist of Phase IA archaeological reconnaissance to identify known archaeological sites and additional areas of archaeological sensitivity where documented and previously unrecorded sites are likely to exist; Phase IB archaeological identification to locate and identify known and undocumented archaeological resources in archaeologically sensitive areas where active erosion is occurring; and Phase II site evaluations to determine the National Register eligibility of identified archaeological sites in active erosion areas. The archaeological investigations were not designed to ascertain the causation, extent, or mechanics of the observed erosion at the Wilder, Bellows Falls, and Vernon Projects (see Section 3.3, *Geologic and Soil Resources*, for details about erosion within the Project areas).

The results of the archaeological investigations are presented in the following technical reports that comprise the bulk of ILP Study 33, *Cultural and Historic Resources Study*:

- Phase IA Archaeological Reconnaissance Survey, Vernon Hydroelectric Project (FERC No. 1904), Windham County, Vermont and Cheshire County, New Hampshire (Cherau and O'Donnchadha, 2008);
- Phase IA Archaeological Reconnaissance Survey, Wilder Hydroelectric Project, Windsor and Orange Counties, Vermont, and Grafton County, New Hampshire (Hubbard et al., 2013a);
- Phase IA Archaeological Reconnaissance Survey, Bellows Falls Hydroelectric Project, Windham and Windsor Counties, Vermont, and Cheshire and Sullivan Counties, New Hampshire (Hubbard et al., 2013b);
- Phase IA Archaeological Reconnaissance Survey Update, Vernon Hydroelectric Project, Windham County, Vermont, and Cheshire County, New Hampshire (Cherau and Duffin, 2014);

- Phase IB Archaeological Identification Survey, Wilder Hydroelectric Project), Bellows Falls Hydroelectric Project, and Vernon Hydroelectric Project, New Hampshire (Elquist and Cherau, 2015);
- Phase IB Archaeological Identification Survey, Wilder Hydroelectric Project, Bellows Falls Hydroelectric Project, and Vernon Hydroelectric Project, Vermont (Elquist and Cherau, 2016a);
- Archaeological Phase II Determination of Eligibility, Lampshire Meadow Site (27-GR-232), Wilder Hydroelectric Project, Lyme, Grafton County, New Hampshire (Elquist and Cherau, 2016b); and
- Phase II Archaeological Site Evaluations, Wilder Hydroelectric Project and Vernon Hydroelectric Project, Orange and Windham Counties, Vermont (Elquist and Cherau, 2016c).

The archaeological report submittal dates and agency responses received to date are presented in Table 3.10-1. The Phase IA surveys consisted of archival research, pedestrian surveys (where access was permitted) and boatover visual inspections to identify recorded archaeological sites and sensitivity for undocumented sites along the impoundment shorelines upstream and downstream of the Project dams. As part of the relicensing process, and as specified in Study Plan 33, FERC, TransCanada, and the SHPOs agreed that Phase IB identification surveys would only be conducted in archaeologically sensitive areas where active erosion is occurring. Phase IB surveys were limited to the identified active erosion areas on fee-owned and flowage land and no other Project-related impacts were identified in these areas. On the Vermont side of the Connecticut River, active erosion was identified in 34 archaeologically sensitive areas (18 at the Wilder Project, 10 at the Bellows Falls Project, and six at the Vernon Project). The Phase IA survey identified 18 recorded sites (8 at the Wilder Project, 9 at the Bellows Falls Project, and 1 at the Vernon Project) in archaeologically sensitive active erosion areas on the Vermont side of the river. On the New Hampshire side of the Connecticut River, active erosion was identified in 33 archaeologically sensitive areas (17 at the Wilder Project, 11 at the Bellows Falls Project, and 5 at the Vernon Project). The Phase I survey identified 15 recorded sites (7 at the Wilder Project, 7 at the Bellows Falls Project, and 1 at the Vernon Project) in archaeologically sensitive active erosion areas on the New Hampshire side of the river.

Table 3.10-1. Cultural Resources report submittals and agency responses, Wilder, Bellows Falls, and Vernon Projects.

Report	Submittal Date	Recipient(s)	Reviewer Response
Phase IA Reconnaissance Survey for Vernon Project, NH and VT	April 10, 2008	NHSHPO, VTSHPO	NHSHPO concurrence, letter dated May 22, 2008. No VTSHPO response.
	June 19, 2013	NITHPO	No comment.
	July 1, 2013	FERC	No comment.
Phase IA Reconnaissance Survey for Wilder and Bellows Falls Projects, NH and VT	May 29, 2013	NHSHPO, VTSHPO, NITHPO	NHSHPO concurrence on Phase IA survey results and request for phased archaeological surveys in erosion areas, letter dated June 25, 2013. VTSHPO concurrence on Phase IA survey results and APE determination and request for Phase IB and Phase II surveys in erosion areas, letter dated July 15, 2013.
	July 1, 2013	FERC	No comment.
Phase IA Reconnaissance Survey Update, Vernon Project, NH and VT	December 23, 2014	FERC, NHSHPO, VTSHPO, NITHPO, and The Nolumbeka Project	NHSHPO concurrence on Phase IA survey update results, email dated February 26, 2015. No FERC, VTSHPO, NITHPO, or The Nolumbeka Project response.
Phase IB Archaeological Identification Survey, Wilder, Bellows Falls, and Vernon Projects, NH, portions	October 29, 2015	NHSHPO	NHSHPO concurrence on Phase IB survey results and proposal for Phase II site determination of eligibility, letter dated December 16, 2015.
	March 23, 2016	FERC, NITHPO, and The Nolumbeka Project	No response.

Report	Submittal Date	Recipient(s)	Reviewer Response
Phase IB Archaeological Identification Survey, Wilder, Bellows Falls, and Vernon Projects, VT, portions	March 14, 2016	VTSHPO	VTSHPO approval of Phase II evaluations of the recommended potentially eligible pre-contact sites, with the caveat that the "concurrence does not represent concurrence by the VTSHPO that this level of Phase II effort constitutes the full scope of Phase II study necessary within the three Projects subject to re-licensing at this time. We fully expect that a much broader Phase II effort will be required to satisfy the Section 106 requirements for these projects," email dated April 20, 2016.
	March 23, 2016	FERC, NITHPO, and The Nolumbeka Project	No response.
Archaeological Phase II Determination of Eligibility, Lampshire Meadow Site (27-GR-232), Wilder Project, NH	August 3, 2016	FERC, NHSHPO, NITHPO, and The Nolumbeka Project	NHSHPO concurrence on Phase II National Register eligibility recommendations and development of protective measures and establishment of a site monitoring program, letter dated August 18, 2016.
Phase II Archaeological Site Evaluations, Wilder and Vernon Projects, VT	pending		

Report	Submittal Date	Recipient(s)	Reviewer Response
Historic Architectural Resources Survey: Wilder Hydroelectric Project, Hartford, Vermont, and Lebanon, New Hampshire; Vernon Hydroelectric Project, Vernon, Vermont, and Hinsdale, New Hampshire; Bellows Falls Hydroelectric Project, Bellows Falls, Rockingham, Vermont, and Walpole, NH	May 28, 2015	FERC, NHSHPO, and VTSHPO	NHSHPO requested that the information be broken out into its Project Area Form format, letter dated June 29, 2015. VTSHPO did not comment.
New Hampshire Division of Historical Resources Project Area Forms for the Wilder Hydroelectric Project, Bellows Falls Hydroelectric Project, and Vernon Hydroelectric Project	June 30, 2015	NHSHPO	NHSHPO concurred that the Wilder dam is eligible for the National Register and recommended that the relicensing of the Projects will have no adverse effect on historic architectural properties, letter dated August 27, 2015.

Phase IB surveys consisted of hand excavations in the form of 1.6-x-1.6-ft (50-x-50-cm) test pits to locate and identify belowground pre- and post-contact cultural deposits. The Phase IB surveys were conducted for the archaeologically sensitive active erosion areas in all three Projects on fee-owned lands and in private flowage lands where landowner permissions were obtained by TransCanada. Phase II investigations were subsequently conducted in active erosion areas in the Wilder and Vernon Projects where the Phase IB surveys identified and recommended previously recorded and newly identified pre-contact archaeological sites as being potentially eligible for listing in the National Register. The Phase II investigations consisted of hand excavations in the form of additional test pits and larger test units measuring 3.3-x-3.3 ft (1-x-1 meter) to investigate the age, size, integrity, and internal composition and complexity of the archaeological deposits. Radiocarbon dating of wood charcoal and seed remains recovered in cultural feature contexts (i.e., fire pits, hearths, and storage pits) was completed as part of the Phase II investigations to assist in dating the site occupations.

The findings of the Phase IA, Phase IB, and Phase II archaeological investigations are summarized below.

Wilder Project

Archival research undertaken for the 2013 Phase IA survey of the Wilder Project documented 56 locations within or immediately adjacent to the Project APE that could contain post-contact archaeological sites (27 in Vermont and 29 in New Hampshire; Tables 3.10-2 and 3.10-3). Of these 56 locations, 5 were verified in the field during the Phase IA survey and assigned state inventory archaeological site numbers. As a result of the Phase IA field survey and research, 48 archaeological sites were identified, including the 5 field-verified sites: 31 sites in Vermont (28 on flowage lands including river shoreline and 3 on fee-owned lands); and 17 sites in New Hamphire (16 on flowage lands and 1 on fee-owned lands) (Table 3.10-4). Prior to the Phase IA survey, 2 of the sites had been determined potentially eligible for listing in the National Register (VT-OR-34 and VT-OR-35) and 1 had been determined ineligible for the National Register. The National Register eligibility of the other 45 identified sites within the Wilder Project APE had not been determined at the time of the Phase IA survey. The Phase IA survey also identified approximately 86 miles of the Wilder Project shoreline (on both sides of the river) as archaeologically sensitive, including the locations of recorded and documented sites, of which approximately 7 miles (35 areas) were identified as being in active erosion areas.

Table 3.10-2. Documented post-contact archaeological resources within or directly adjacent to the Wilder Project APE identified on historic maps (Vermont).

Project ID Number	Description	Identification on Historic Maps					Notes
		Doolittle (1796)	Beers (1869; 1877)	USGS (1931)	USGS (1933)	Other USGS	
NE-1	Toll house		(1877) appears as *Toll Ho.*			(1935a, 1941)	Identified as standing architecture
BR-1	Dwelling or mill?		(1877) may appear as *mill*			(1935a, 1941)	
BR-2	Dwelling		(1877) appears as *E. Smalley*		(1933)		
FA-1	Ferry launch	X	(1877)				
TH-1	Ferry launch	X	(1877)				
TH-2	Bridge		(1877)	Appears in use	Appears in use		Located (VT-OR-100)
TH-3	Ferry launch	X	(1877)				
TH-4	Ferry launch	X	(1877)				
TH-5	Toll house		(1877) appears as *Toll H.*				
TH-6	Dwelling		(1877) appears as *C.D. Dimick*				
TH-7	Bridge		(1877) roads end at bank indicating possible bridge location				

Project ID Number	Description	Identification on Historic Maps					Notes
		Doolittle (1796)	Beers (1869; 1877)	USGS (1931)	USGS (1933)	Other USGS	
NO-1	Ferry launch	X	(1869)				
NO-2	Ferry launch	X	(1969)			(1906, 1908)	
NO-3	Dwelling		(1969) appears as *D. Huckett*			(1906, 1908)	
NO-4	Ferry launch	X	(1869)			(1906, 1908)	
NO-5	Bridge	X	(1869)			(1906, 1908)	
NO-6	Bridge		(1869) appears in use			(1906, 1908) appears in use	Located (VT-WN-477)
NO-7	Saw mill		(1869) appears as *S. Mill*			(1906, 1908)	Located (VT-WN-478)
NO-8	Dwelling		(1869) appears as *M. Bartlett*			(1906, 1908)	
NO-9	Grist mill		(1869) appears *S G. Mill*			(1906, 1908)	
NO-10	Native American burial ground		(1869)				Goddard and Partridge (1905); J. Moody (pers. comm.)
NO-11	Dwelling		(1869)			(1906, 1908)	First settlement (1765); based on historical marker

Project ID Number	Description	Identification on Historic Maps					Notes
		Doolittle (1796)	Beers (1869; 1877)	USGS (1931)	USGS (1933)	Other USGS	
NO-12	Bridge		(1869) appears with road			(1906, 1908) replaced with steel truss bridge	
NO-13	Ferry launch		(1869)				Goddard and Partridge (1905)
HA-1	Saw mill		(1869)			(1906, 1908)	Whitelaw (1769) appears as Phelps Saw Mill Adjacent to fee-owned lands in TransCanada recreation area; site submerged or destroyed based on 2013 Phase IA survey
HA-2	Bridge		(1869)			(1906, 1908)	Adjacent to fee-owned lands in TransCanada recreation area; no identified bridge remains or abutments during 2013 Phase IA survey
HA-3	Paper mill		(1869) appears *French as Chandler Paper Mill*			(1906, 1908)	Located (VT-WN-480); fee-owned lands in TransCanada recreation area

Table 3.10-3. Documented post-contact archaeological resources within or directly adjacent to the Wilder Project APE identified on historic maps (New Hampshire).

Project ID Number	Description	Identification on Historic Maps						Notes
		Walling (1860)	USGS (1931)	USGS (1933)	Other USGS	Hurd (1892)	Holland (1784)	
HA-1	Dwelling				(1935a, 1941, 1984)			
HA-2	Dwelling				(1935a, 1941)			Cellar hole identified outside project area
HA-3	Toll house	Appears as *Toll House*			(1935a, 1941)	Appears as *Toll House*		Identified as standing architecture
OR-1	Dwelling	Appears as *First Settlement*						
OR-2	Native American burial ground	Appears as *Indian Burial Ground*						Possibly identified (27-GR-234)
LY-1	Bridge	Appears in use as *Lime Bridge*	Appears in use	Appears in use		Appears in use as *Lime*		Located (27-GR-230)
LY-2	Toll house	Appears as *Toll House*						
LY-3	Dwellings (3)	One appears as *J. Butler,* other two unnamed						

Project ID Number	Description	Identification on Historic Maps						Notes
		Walling (1860)	USGS (1931)	USGS (1933)	Other USGS	Hurd (1892)	Holland (1784)	
LY-4	Toll house and ferry launch	Appears as *Toll House*	Appears (toll house only)	Appears (toll house only)		Appears as *Toll House*		Beers (1877) appears as Toll Ho.; ferry in Doolittle (1796)
LY-5	Dwelling		X	X				
LY-6	Bridge	X				Appears as *Thetford Bridge*		Beers (1877)
LY-7	Ferry launch							Doolittle (1796)
LY-8	Ferry launch							Doolittle (1796)
HN-1	Dwelling	Appears as *Dr. Smalley*						
HN-2	Dwelling	Appears as *I. & H.B. Lord*						
HN-3	Dwelling	Appears as *J. Hemenway*			(USGS 1906, 1908)			
HN-4	Dwelling	Appears as *E.S. Coswell*			(USGS 1906, 1908)			
HN-5	Bridge				(USGS 1906, 1908)			Doolittle (1796)

Project ID Number	Description	Identification on Historic Maps						Notes
		Walling (1860)	USGS (1931)	USGS (1933)	Other USGS	Hurd (1892)	Holland (1784)	
HN-6	Ferry launch				(USGS 1906, 1908)			Doolittle (1796)
HN-7	Ferry launch				(USGS 1906, 1908)			Doolittle (1796)
HN-8	Ferry launch				(USGS 1906, 1908)			Doolittle (1796)
HN-9	Ferry launch				(USGS 1906, 1908)			Doolittle (1796)

Project ID Number	Description	Identification on Historic Maps						Notes
		Walling (1860)	USGS (1931)	USGS (1933)	Other USGS	Hurd (1892)	Holland (1784)	
HN-10	Dwelling				(USGS 1981, 1989, 2001)			Fee-owned lands leased to Dartmouth Outing Club (Dartmouth College) Original one room "Titcomb Cabin" built in 1952 by Dartmouth Outing Club; destroyed by fire in 2009; rebuilt by Dartmouth College students and dedicated in 2012; no visible remains of 1952 cabin identified during 2013 Phase IA survey
LE-1	Bridge	X			(USGS 1906, 1908)			
LE-2	Mills (2)	Appears as *White River Falls Carp Mills*			(USGS 1906, 1908)			
LE-3	Saw mill	Appears as *saw mill*			(USGS 1906, 1908)			

Project ID Number	Description	Identification on Historic Maps						Notes
		Walling (1860)	USGS (1931)	USGS (1933)	Other USGS	Hurd (1892)	Holland (1784)	
LE-4	Dwellings (7)				(USGS 1906, 1908)			
LE-5	Mill				(USGS 1906, 1908)	Appears as *Olcott Falls Pulp Co.*		
LE-6	Canal				(USGS 1906, 1908)			Near city of Lebanon boat launch; post-2013 Phase IA survey discovery of possible wood lock remains on NH shoreline in normally inundated area

Phase IB surveys for the Wilder Project APE were conducted in 6 of the 17 archaeologically sensitive active erosion areas on the New Hampshire side of the Connecticut River, and in 8 of the 18 archaeologically sensitive active erosion areas on the Vermont side of the river, totaling approximately 2 miles. Phase IB investigations of the remaining 21 sensitive erosion areas at the Wilder Project were not conducted because property owners either did not respond to inquiries or denied access for study purposes, leaving approximately 5 miles of unsurveyed sensitive shoreline in active erosion areas and another approximately 79 miles of unsurveyed archaeologically sensitive shoreline areas in the overall Wilder Project.

On the New Hampshire side of the river, the 17 archaeologically sensitive erosion areas targeted for Phase IB surveys in the Wilder Project APE contain 7 sites (27-GR-112, 27 GR-208, 27-GR-224, 27-GR-228, 27-GR-229, 27-GR-232, and 27-GR-234) identified during the Phase IA surveys. Landowner permission to conduct Phase IB surveys was granted on private lands that contain two of the recorded pre-contact sites (27-GR-228 and 27-GR-232). The Clay Bank Site (27-GR-228) in Piermont was first recorded during the Phase IA survey as a possible pre-contact camp site based on the presence of fire-reddened soils eroding out of the riverbank. The Phase IB investigations determined that the fire-reddened soils were the result of natural processes and the Clay Bank Site does not contain potentially significant cultural deposits and was not recommended for listing in the National Register. The pre-contact Lampshire Meadow Site (27-GR-232) in Lyme was also first recorded during the Phase IA survey on the basis of lithic cultural materials eroding out of the riverbank. The Phase IB testing recovered lithic debitage (byproducts of chipped stone tool making) and chipped stone tools, and the site was recommended potentially eligible for listing in the National Register. Phase II site evaluation was recommended to determine National Register eligibility. The Phase IB surveys also identified one new site designated Parcel 208/390 Site (27-GR-268) in Piermont, which yielded pre-contact lithic materials in a redeposited alluvium subsurface context in the Project APE. The lithic deposits in the tested area were not recommended as being National Register eligible, but the potential exists for more intact pre-contact deposits to be present north and outside the active erosion area in the Project APE. On December 16, 2015, the NHSHPO concurred with the findings and recommendations of the Phase IB survey in the New Hampshire portion of the Wilder Project APE (see Table 3.10-1).

The Phase II site evaluation of the Lampshire Meadow Site (27-GR-232) in Lyme, New Hampshire, yielded additional cultural materials (lithic debitage and chipped stone tools) and features from four distinct activity loci, one of which (Locus 1) produced an early Middle Archaic Period radiocarbon date. The Locus 1 cultural deposits were determined to possess good physical integrity and high research potential, and were recommended significant and eligible for listing in the National Register. The other three activity Loci (2, 3, and 4) were not recommended as being eligible for listing in the National Register. On August 18, 2016, the NHSHPO concurred with the National Register-eligibility recommendation for the pre-contact Lampshire Meadow Site (27-GR-232) (see Table 3.10-1).

On the Vermont side of the river, the 18 archaeologically sensitive erosion areas targeted for Phase IB surveys in the Wilder Project APE contain 8 sites (VT-OR-21, VT-OR-34, VT-OR-35, VT-OR-62, VT-OR-72, VT-OR-97, VT-OR-101, and VT-WN-479) identified during the Phase IA surveys. Landowner permission to conduct Phase IB surveys was granted on private lands that contain four of the recorded pre- and post-contact sites (VT-OR-34, VT-OR-35, VT-OR-62, and VT-OR-72). The pre-contact Farrell Site (VT-OR-34) in Fairlee yielded evidence of multiple living features including possible house floors and storage pits, aboriginal pottery, lithic debitage, and chipped stone tools, indicating the presence of a potentially significant and National Register-eligible Woodland Period habitation site.

Phase II site evaluation was recommended to determine National Register eligibility. The pre-contact Kenneth Carson Site (VT-OR-35) in Bradford did not yield any significant cultural deposits in the Project APE and was recommended as not eligible for listing in the National Register. The pre-contact Site VT-OR-62 in Bradford yielded lithic debitage and a cooking pit feature of unknown temporal affiliation, and was recommended potentially eligible for listing in the National Register. Phase II site evaluation was recommended to determine National Register eligibility. The post-contact D. Ross Residence (VT-OR-72) in Fairlee was determined to have poor physical integrity and was not recommended eligible for listing in the National Register. The Phase IB surveys identified three new sites: VT-OR-108, VT-OR-109, and VT-OR-110. The pre-contact Lower Plain Site (VT-OR-108) in Bradford yielded aboriginal pottery sherds, lithic debitage, calcined animal bone, and chipped stone tools, indicating the presence of a potentially National Register-eligible Woodland Period camp site. Phase II site evaluation was recommended to determine National Register eligibility. The pre-contact Parcel 454/390 Site (VT-OR-109) in Bradford did not yield any significant cultural deposits in the Project APE and was recommended as not eligible for listing in the National Register. The pre-contact Roaring Brook Site (VT-OR-110) in Thetford yielded lithic debitage, indicating the presence of a short-term hunting camp of unknown temporal affiliation, and was recommended as potentially eligible for listing in the National Register. Phase II site evaluation was recommended to determine National Register eligibility.

The VTSHPO did not provide formal concurrence on the National Register-eligibility recommendations for the sites investigated during the Phase IB surveys. However, on April 20, 2016, the VTSHPO concurred with the recommended Phase II evaluations and approved the proposed Phase II evaluation methodology at the four pre-contact sites recommended as potentially National Register eligible in active erosion areas in Bradford, Fairlee, and Thetford, Vermont (VT-OR-34, VT-OR-62, VT-OR-108, and VT-OR-110). The Phase II site evaluations resulted in the recovery of additional cultural materials (lithic debitage, diagnostic chipped stone tools, organics, and aboriginal pottery) and radiocarbon-dated features that indicate occupations in the Late Archaic through Late Woodland Periods. The Phase II evaluations have resulted in the recommendation that all four of these Vermont pre-contact sites in the Wilder Project APE are eligible for listing in the National Register since they possess good physical integrity and have the potential to address research questions related to Late Archaic and Woodland Period settlement and subsistence patterns in the Connecticut River Valley. When the Phase II evaluation report has been finalized, it will be submitted to the VTSHPO for review and concurrence.

Table 3.10-4 presents the current status of recorded archaeological sites in the Wilder Project APE, including 4 newly recorded pre-contact sites (3 in Vermont and 1 in New Hampshire). Of the 52 identified archaeological sites, 1 site has been determined as being eligible for listing in the National Register, 4 sites are recommended as eligible for listing in the National Register, and 5 sites are determined or recommended to be ineligible. The National Register eligibility of the other 42 recorded sites remains undetermined because these sites are not located in active erosion areas, are not threatened by current Project operations, or are in areas that were not accessible for further study (i.e., no landowner access granted).

Table 3.10-4. Recorded pre-contact and post-contact archaeological sites within or directly adjacent to the Wilder Project APE.

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-GR-112/ Ingalls	Haverhill, NH	P	Recorded in 1994 as multiple stratified components; burnt maize, beans, and a large important ceramic assemblage*	Pre-contact (Late Woodland)	Flowage (in active erosion area; no landowner access for Phase IB survey	Undetermined
27-GR-141/ unnamed	Haverhill, NH	P	Recorded in 1951 as a mortar and 80-pound pestle*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
27-GR-143/ unnamed	Haverhill, NH	P	Recorded in 1978 as human skeletal remains*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
27-GR-144/ Bedell Bridge State Park	Haverhill, NH	PH	*Pre-contact:* Recorded in 1977 and 1993 as quartz and quartzite chipping debris, soapstone fragments, an adze, and pottery sherds * *Post-contact:* Recorded in 1977 and 1993 as historic bridge abutment and central pier. Documentary evidence of a French Fort at location*	Pre-contact (unknown); EuroAmerican (bridge ca. 1805–1979; fort ca 1704–1761)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-GR-151/ unnamed	Lyme, NH	P	Recorded in 1951 as a campsite, no other information available*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
27-GR-178/ unnamed	Hanover, NH	P	Recorded in 1951 as pottery sherds and a probable Levanna projectile point*	Pre-contact (Middle-Late Woodland)	Flowage (no active erosion; no Project threats)	Undetermined
27-GR-202/ Orford Toll House	Orford, NH	H	Recorded in 2000 as nails, glass, brick, animal bones, ceramics, buttons, pipe stems and bowls, coal and coal slag*	EuroAmerican (mid-nineteenth to early twentieth century)	Flowage (no active erosion; no Project threats)	Undetermined
27-GR-208/ Robie Farm	Piermont, NH	P	Recorded in 1996 as two probable hearth features containing fire-cracked rock and rhyolite shatter*	Pre-contact (unknown)	Flowage (in active erosion area; no landowner access for Phase IB survey)	Undetermined
27-GR-224/Fenn	Haverhill, NH	P	Recorded in 2008 as three Levanna projectile points and quartz biface fragment*	Pre-contact (Middle-Late Woodland)	Flowage (in active erosion area; no landowner access for Phase IB survey)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-GR-228/Clay Bank	Piermont, NH	H	Recorded in 2013, TransCanada Phase IA survey: Lenticular feature with fire-reddened soils and charcoal; re-interpreted in 2015 TransCanada Phase IB survey as post-contact and/or natural soil anomalies+	Post-contact (or natural)	Flowage (in active erosion area)	Ineligible; Phase IB (NHSHPO concurrence December 16, 2015)
27-GR-229/ Cotton Stone Meadow	Orford, NH	P	Recorded in 2013, TransCanada Phase IA survey: Two parallel burn layers separated by alluvium with reddish soils, charcoal, and calcined bone. Five pieces of hornfels chipping debris	Native American (unknown)	Flowage (in active erosion area; no landowner access for Phase IB survey)	Undetermined
27-GR-230/ North Thetford Bridge	Lyme, NH	H	Recorded in 2013, TransCanada Phase IA survey: Both abutments and central pier still standing; abutment on Vermont side is concrete, while other two elements are mortared stone	EuroAmerican originally built in 1896; closed to traffic in the 1950s; span collapsed in 1972–1973	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-GR-231/ Post Hill Riverside Dump	Lyme, NH	H	Recorded in 2013, TransCanada Phase IA survey: Historic trash dump with automobile parts, enamelware, cans, and scrap metal	EuroAmerican (mid-twentieth century)	Flowage (no active erosion; no Project threats)	Undetermined
27-GR-232/ Lampshire Meadow	Lyme, NH	P	Recorded in 2013, TransCanada Phase IA, 2015 Phase IB, and 2016 Phase II: Four activity areas or loci; Locus 1 is high density concentration of lithic debitage, chipped stone tools, and fire pit feature with wood charcoal radiocarbon-dated to Middle Archaic Period+	Pre-contact (Middle Archaic)	Flowage (in active erosion area)	Eligible Phase II (Locus 1 only—NHSHPO concurrence August 18, 2016)

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-GR-233/ Gilman Island Dump	Hanover, NH	H	Recorded in 2013, TransCanada Phase IA survey: Bottles, ceramics, machine-wrought square nails, cans	EuroAmerican (early to mid-twentieth century)	Fee-owned (Parcel #16) (outside and not affected by the primitive camp site and "Titcomb Cabin" on land leased to the Dartmouth Outing Club [Dartmouth College]; no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined
27-GR-234/ Red Cliff	Orford, NH	P	Recorded in 2013, TransCanada Phase IA survey: A 15–20 cm deep feature containing orange soils underlain by thin black layer; no artifacts; not unequivocally cultural, but historic maps call the area the "Indian Burial Ground" (Walling, 1860)	Native American (unknown)	Flowage (in active erosion area; no landowner access for Phase IB survey)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-GR-235/ Olcott Falls East	Lebanon, NH	H	Recorded in 2013, TransCanada Phase IA survey: Multiple structures, including a grist and saw mill, canal, paper mill and associated structures, several dams, and a bridge	EuroAmerican (early late eighteenth to mid-twentieth century)	Flowage (no active erosion; no Project threats)	Undetermined
27-GR-268/ Parcel 208/390 (new)	Piermont, NH	P	Recorded in 2015, TransCanada Phase IB survey: Lithic debitage recovered in redeposited alluvial soils+	Pre-contact (unknown)	Flowage (in active erosion area)	Undetermined Phase IB (ineligible in tested erosion area only—NHSHPO concurrence December 16, 2015)
VT-OR-15/ unnamed	Bradford, VT	P	Recorded in 1981 as surface-collected lithic tools including points, drills, a scraper, and a hoe*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-18/ Carson Farm	Newbury, VT	P	Recorded in 1985 as pottery sherds, lithics, charred nuts, and charcoal*	Pre-contact (Early Woodland)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-OR-19/ Harriman Brook	Newbury, VT	P	Recorded in 1989 as nine hearth features, large assemblage of lithics (including tools and points), pottery, fire cracked rock, and organics*	Pre-contact (Middle-Late Woodland)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-21/ Lord Farm	Bradford, VT	P	Recorded in 1989 as one chert flake, one rhyolite flake*	Pre-contact (unknown)	Flowage (in active erosion area; no landowner access for Phase IB survey)	Undetermined
VT-OR-22/ Carson Farm 2	Newbury, VT	PH	*Prehistoric:* Recorded in 1989 as one quartzite flake* *Historic:* Recorded in 1989 as unspecified historic artifacts*	Pre-contact (unknown) EuroAmerican (ca 1609-1790)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-34/Farrell	Fairlee, VT	P	First recorded in 1992; TransCanada 2015 Phase IB and 2016 Phase II: Lithic debitage, aboriginal pottery, chipped stone tools, calcined animal and bird bone; charred tobacco seeds, large refuse pit feature with Late Woodland radiocarbon date+	Pre-contact (Late Woodland)	Flowage (in active erosion area)	Recommended eligible Phase II (pending VTSHPO concurrence)

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-OR-35/ Carson	Bradford, VT	H	Recorded in 2003 as 37 organic features of possible pre-contact origin*; in 2015, TransCanada Phase IB survey: Organic stains were reinterpreted as post-contact plow zone scars+	Post-contact (plow zone)	Flowage (in active erosion area)	Ineligible Phase IB (VTSHPO informal concurrence April 20, 2016)
VT-OR-36/ unnamed	Newbury, VT	H	Unspecified* (no VTSHPO form on file)	EuroAmerican (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-38/ Fairlee Pond Grist Mill	Fairlee, VT	H	Recorded in 1993 as a grist mill with intact walls but no roof*	EuroAmerican (ca 1760-1790)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-41/ Palmer	Thetford, VT	P	Recorded in 1991 as numerous and diverse lithic assemblage	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/Cultural Affiliation	Location Relative to the Project/Effects	National Register Eligibility
VT-OR-45/ Bradford-Piermont Toll House	Bradford, VT	PH	*Prehistoric:* Recorded in 1994 as three rhyolite flakes, one fragment of fire cracked rock, and a culturally undetermined human burial nearby* *Historic:* Recorded in 1994 as a large assemblage of brick, metal, glass, ceramic, bone, etc.*	Pre-contact (unknown); EuroAmerican (ca 1826–1930s)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-62/ unnamed	Bradford, VT	P	First recorded in 1999; TransCanada 2015 Phase IB and 2016 Phase II: Lithic debitage, chipped stone tools, fish bone, calcined bone; four features including cooking pits and a fire pit, radiocarbon dates from Late Archaic, Middle and Late Woodland periods+	Pre-contact (Late and Terminal Archaic; Middle and Late Woodland)	Flowage (active erosion area)	Recommended eligible Phase II (pending VTSHPO concurrence)
VT-OR-63/ unnamed	Bradford, VT	H	Recorded in 1999 as granite blocks, brick, and ceramic sherds; possible subsurface evidence of a foundation*	EuroAmerican (unknown)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-OR-67/ Davenport	Fairlee, VT	P	Recorded in 2001 as one chert flake and possible fire cracked rock*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Ineligible (2001 VTSHPO determination for bridge rehabilitation project)
VT-OR-72/ D. Ross Residence	Fairlee, VT	H	First recorded in 2000; TransCanada 2015 Phase IB as cellar hole with few disarticulated foundation fieldstones; mid-late nineteenth century domestic and structural debris+	EuroAmerican (ca. late nineteenth century)	Flowage (in active erosion area)	Ineligible Phase IB (VTSHPO informal concurrence April 20, 2016)
VT-OR-95/Bedell Covered Bridge	Newbury, VT	H	Recorded in 2013, TransCanada Phase IA survey: Both abutments and center pier (still standing); the abutment on the Vermont bank consists of dry-laid stone with wooden and cement elements	EuroAmerican (first of five bridges at location was built in 1806; most recent bridge 1866-1979)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-OR-96/ Double Draw Dump	Bradford, VT	H	Recorded in 2013, TransCanada Phase IA survey: Automobile parts, appliances, bottles and cans, scrap metal, farm equipment, an unidentified belt-drive assembly which may be related to a nearby historic mill	EuroAmerican (early to mid-twentieth century)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-97/ Palisades	Fairlee, VT	P	Recorded in 2013, TransCanada Phase IA survey: Living surface feature with fire cracked rock, a rhyolite biface, and a cow molar found in the slump	Pre-contact (unknown)	Flowage (in active erosion area; no landowner access for Phase IB survey)	Undetermined
VT-OR-98/ Fairlee Dump	Fairlee, VT	H	Recorded in 2013, TransCanada Phase IA survey: Cans and bottles, enamel cookware, ceramics, etc.	EuroAmerican (mid-twentieth century)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-99/ Roaring Brook Dump	Thetford, VT	H	Recorded in 2013, TransCanada Phase IA survey: Cans and bottles, stoneware jugs, automobile parts, scrap metal, etc.	EuroAmerican (early to mid-twentieth century)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-OR-100/ North Thetford Bridge	Thetford, VT	H	Recorded in 2013, TransCanada Phase IA survey: Bridge features; both abutments and the center pier still standing; both elements in NH are mortared stone, and the VT abutment is made of concrete	EuroAmerican (Built in 1896; closed to traffic in the 1950s; destroyed in 1972–1973)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-101/East Thetford River Dump	Thetford, VT	H	Recorded in 2013, TransCanada Phase IA survey: Early machine-made bottles, flat iron trivet, bronze/copper kerosene lamp, ceramics	EuroAmerican (early twentieth century)	Flowage (in active erosion area; no landowner access for Phase IB survey)	Undetermined
VT-OR-102/Pavillion Road Dump	Thetford, VT	H	Recorded in 2013, TransCanada Phase IA survey: Automobiles, tires, appliances	EuroAmerican (mid-twentieth century)	Flowage (no active erosion; no Project threats)	Undetermined
VT-OR-108/ Lower Plain (new)	Bradford, VT	P	Recorded in TransCanada 2015 Phase IB and 2016 Phase II: Lithic debitage, chipped stone tools, and aboriginal pottery+	Pre-contact (Middle to Late Woodland)	Flowage (in active erosion area)	Recommended eligible Phase II (pending VTSHPO concurrence)

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-OR-109/ Parcel 454/390 (new)	Bradford, VT	P	Recorded in 2015 TransCanada Phase IB: Single lithic debitage in alluvial soils+	Pre-contact (unknown)	Flowage (in active erosion area)	Ineligible Phase IB (VTSHPO informal concurrence April 20, 2016)
VT-OR-110/ Roaring Brook (new)	Thetford, VT	P	Recorded in TransCanada 2015 Phase IB and 2016 Phase II: Lithic debitage, aboriginal pottery, and chipped stone tools+	Pre-contact (Woodland)	Flowage (in active erosion area)	Recommended eligible Phase II (pending VTSHPO concurrence)
VT-WN-237/ Gleason	Norwich, VT	H	Recorded in 1995 as the buried remains of two or more structures related to a previous building on this spot*	EuroAmerican (late nineteenth century)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-477/ Lower Ompompanoosuc Bridge	Norwich, VT	H	Recorded in 2013, TransCanada Phase IA survey: Bridge abutments; both abutments extant; dry-laid stone with cement elements	EuroAmerican (first of several bridges at location built in either 1771 or 1787; latest bridge from 1866–1954)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-WN-478/ Patterson Chair Factory	Norwich, VT	H	Recorded in 2013, TransCanada Phase IA survey: Dry-laid foundation wall and associated wooden shed (left bank) and corresponding L-shaped cement wall projecting into river (right bank)	EuroAmerican (early to mid-nineteenth century)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-479/ Wilder Falls	Hartford, VT	P	Recorded in 2013, TransCanada Phase IA survey: Hearth feature, chipping debris (rhyolite, hornfels, chert), one hornfels biface, and calcined bone	Native American (unknown)	Fee-owned/ flowage (in active erosion area, boat access not possible, safe access only by land through adjacent private properties—not granted for Phase IB survey	Undetermined
VT-WN-480/ Olcott Falls Industrial Complex	Hartford, VT	H	Recorded in 2013, TransCanada Phase IA survey: Multiple structures including a paper mill and associated structures, several dams and dam improvements, and a bridge	EuroAmerican (late eighteenth century to mid-twentieth century)	Fee-owned/flowage (in TransCanada recreation area-no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined

State Site Number/Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-WN-481/ Kilowatt Park	Hartford, VT	H	Recorded in 2013, TransCanada Phase IA survey: Bottle glass, ceramics, and metal fragments	EuroAmerican (early to mid-nineteenth century)	Fee-owned/ flowage (in TransCanada recreation area- no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined
F.S. 3 (OR)/ "Indian Mounds"	Bradford, VT	P	Recorded in 1976 as "some" projectile points located in "Indian mounds" *	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
F.S. 21 (WN)/ unnamed	Norwich, VT	U	Recorded in 1991 as low density deposit of lithic debitage *	Unknown	Flowage (no active erosion; no Project threats)	Undetermined

a. P – strictly pre-contact, PH – multi-component site with pre-contact and post-contact components, H – strictly post-contact.

b. * – No exposed cultural materials identified during Phase IA reconnaissance survey (Hubbard et al., 2013a).

\+ – Cultural deposits identified during Phase IB identification surveys (Elquist and Cherau, 2016a, 2015) and Phase II site evaluations (Elquist and Cherau, 2016b, 2016c).

Bellows Falls Project

Archival research undertaken for the 2013 Phase IA survey of the Bellows Falls Project documented 26 locations within or immediately adjacent to the Project APE that could contain post-contact archaeological sites (12 in Vermont and 14 in New Hampshire; Tables 3.10-5 and 3.10-6). Of these 26 locations, 6 were verified in the field during the Phase IA survey and assigned state inventory archaeological site numbers. As a result of the Phase IA field survey and research, 43 archaeological sites were identified, including the 6 field-verified sites: 26 sites in Vermont (16 on private flowage lands, 8 on fee-owned lands and adjacent private flowage, and 2 on fee-owned lands); and 17 sites in New Hampshire (6 on private flowage lands, 5 on fee-owned and adjacent private flowage, and 6 on fee-owned lands) (Table 3.10-7). Prior to the Phase IA survey, 3 of the sites had been listed in the National Register, 3 had been determined eligible for listing in the National Register, and 1 site had been determined ineligible for the National Register. The National Register eligibility of the other 36 identified sites in the Bellows Falls Project had not been determined at the time of the Phase IA survey. The Phase IA survey also identified approximately 59 miles of the Bellows Falls Project shoreline (on both sides of the river) as archaeologically sensitive, including the locations of recorded and documented sites, of which approximately 5 miles (21 areas) were identified as being in active erosion areas.

Table 3.10-5. Documented post-contact archaeological resources within or directly adjacent to the Bellows Falls Project APE identified on historic maps (Vermont).

Project ID Number	Description	Identification on Historic Maps					Notes
		Walling (1860)	Beers (1869)	USGS (1929)	USGS (1930)	USGS (1957a,b)	
RO-1	Dwelling		Appears as *D.K. Barry*		X		Fee-owned, above shoreline; no archaeological evidence of site identified during 2013 Phase IA survey; no Project impacts or threats noted
RO-2	Dwelling		Appears as *G.C. Bidwell*				Fee-owned, above shoreline; no archaeological evidence of site identified during 2013 Phase IA survey; no Project impacts or threats noted
RO-3	Cabins (13)				(8 cabins)	(10 cabins)	Fee-owned, above shoreline; no archaeological evidence of site identified during 2013 Phase IA survey; no Project impacts or threats noted
SP-1	Schoolhouse			Appears as *River School*			
SP-2	Dwelling		Appears as *D.A. Gill*	X		X	

Project ID Number	Description	Identification on Historic Maps					Notes
		Walling (1860)	Beers (1869)	USGS (1929)	USGS (1930)	USGS (1957a,b)	
SP-3	Wentworth Ferry and Crown Point Road	X	Road only				
SP-4	Bridge abutments	X	X	X			Phase IA Survey identified as Site VT-WN-476
SP-5	Schoolhouse		Appears as *School No, 19*				
WE-1	Dwelling (Probably destroyed by new Ascutney Bridge)		Appears as *H.H. Graves*	X		X	Probably destroyed by new Ascutney Bridge
WE-2	Ferry launch and ferry house	X	Ferry only appears as *Ashley's Ferry*	X			
WE-3	Tuttle Cemetery (In use between 1772-1882)					X	In use 1772-1882; visible gravestones
WE-4	Bridge abutments	Appears as *Claremont Bridge*	X	X		X	

Table 3.10-6. Documented post-contact archaeological resources within or directly adjacent to the Bellows Falls Project APE identified on historic maps (New Hampshire).

ID Number	Description	Identification on Historic Maps						Notes
		Holland (1784)	Walling (1860)	Hurd (1892)	USGS (1929)	USGS (1930)	USGS (1957a,b)	
CH-1	Dwelling			X	X		X	Phase IA survey identified as possible Site 27-SU-34
CH-2	Dwelling				X		X	Phase IA survey identified as likely Site 27-SU-4
CH-3	Dwelling						X	Phase IA survey identified as likely Site 27-SU-4
CH-4	Dwelling					X	X	
CH-5	Dwelling					X		Phase IA survey identified as Site 27-SU-46
CH-6	Possible trout pond			X				Phase IA survey identified as Site 27-SU-49
CH-7	Ferry launch		Appears as *Ferry*					
CL-1	Dwelling			Appears as *C.V. Paddock II*				

ID Number	Description	Identification on Historic Maps						Notes
		Holland (1784)	**Walling (1860)**	**Hurd (1892)**	**USGS (1929)**	**USGS (1930)**	**USGS (1957a,b)**	
CL-2	Bridge abutment		X	X	X		X	
CL-3	Toll house		Appears as *Toll House*	Appears as *Toll House*	X			
CL-4	Dwelling	X						
CL-5	Ferry launch (Appears as *Ashley's Ferry* on Carrigain 1816 map)		Appears as *Ashley's Ferry*		Appears as *Ashley's Ferry*			Carrigain (1816) map appears as Ashley's Ferry
CL-6	Dwelling		Appears as *I. Hubbard Esq.*	Appears as *L.H. Long*				
WA-1	Rail spur					X	X	Phase IA survey identified as Site 27-CH-169

Phase IB surveys for the Bellows Falls Project APE were conducted in 10 of the 11 archaeologically sensitive active erosion areas on the New Hampshire side of the Connecticut River and 4 of the 10 archaeologically sensitive active erosion areas on the Vermont side of the river, totaling approximately 4 miles. Phase IB investigations of the remaining 7 sensitive erosion areas at the Bellows Falls Project were not conducted because property owners either did not respond to inquiries or denied access for study purposes, leaving approximately 1 mile of unsurveyed sensitive shoreline in active erosion areas and another 54 miles of unsurveyed archaeologically sensitive shoreline areas in the overall Bellow Falls Project.

On the New Hampshire side of the river, the 11 archaeologically sensitive erosion areas targeted for Phase IB surveys in the Bellows Falls Project APE contain seven sites (27-SU-7, 27-SU-43, 27-SU-44, 27-SU-45, 27-SU-47, 27-SU-48, and 27-CH-170). Landowner permission to conduct Phase IB surveys was granted on private lands that contain all seven of the recorded pre- and post-contact period sites. The Phase IB survey at the pre-contact Red Flake Site (27-SU-7) in Charlestown did not yield any pre-contact cultural deposits, and it was considered possible that the portion of the riverbank previously identified as containing cultural deposits has been lost through erosion and/or that the site area was actually located farther to the north and outside the active erosion area. The National Register eligibility of this site, therefore, remains undetermined. The cluster of three recorded pre-contact sites in the Great Meadows section of Charlestown (27-SU-43, 27-SU-44, and 27-SU-45) identified during the Phase IA survey on the basis of burn layers or hearth-like features was re-examined during the Phase IB investigations and determined to be natural and/or post-contact in origin, and not eligible for the National Register. The Phase IB survey at the pre-contact Lower Meadows Site (21-SU-47) in Charlestown did not recover any pre-contact cultural deposits in intact soils, and the site was not recommended as National Register eligible. The Phase IB survey at the pre-contact Meaney's Cove II Site (21-SU-48) in Charlestown did not yield any pre-contact cultural, but localized flooding at the time of the Phase IB fieldwork prevented full access to the erosion area. The potential remains for pre-contact cultural deposits in the untested portion of the erosion area and the site's National Register eligibility remains undetermined. The one post-contact site, the Marshall Street Trash Dump (21-CH-170) in Walpole, was investigated during the Phase IB survey and determined to contain nineteenth-century domestic materials redeposited in a twentieth-century dumping area and is not eligible for the National Register. The Phase IB surveys also identified two new sites: the pre-contact Parcel B.F. 265 Site (27-SU-53) in Claremont, which yielded one piece of lithic debitage in redeposited alluvium; and the pre-contact Lower Meadows II Site (21-SU-54) in Charlestown, which yielded low densities of nondiagnostic lithic chipping debris in redeposited alluvium. Neither site was recommended significant or eligible for listing in the National Register. On December 16, 2015, the NHSHPO concurred with the findings and recommendations of the Phase IB survey in the New Hampshire portion of the Bellows Falls Project APE. No Phase II site evaluations have been conducted.

On the Vermont side of the river, the 10 archaeologically sensitive erosion areas targeted for Phase IB survey in the Bellows Falls Project APE contain nine sites (VT-WN-46, VT-WN-61, VT-WN-102, VT-WN-186, VT-WN-192, VT-WN-453, VT-WN-473, VT-WN-474, and VT-WD-291) identified during the Phase IA surveys. Landowner permission to conduct Phase IB surveys was granted on private lands that contained five of the recorded pre-contact sites (VT-WN-46, VT-WN-102, VT-WN-192, VT-WN-453, and VT-WD-291). Three of these sites (VT-WN-102, VT-WN-192, and VT-WN-453) overlap Erosion Area 5 in Springfield and are downslope from three other recorded pre-contact sites (VT-WN-45, VT-WN-55, and VT-WN-454) located on an adjacent upper terrace. The lithic debitage recovered along the riverbank during the Phase IB survey appears to be redeposited from the adjacent upper terraces and recorded sites outside the Project APE. The lower terrace containing the three Project sites (VT-WN-102, VT-WN-192, and VT-WN453) also has the potential to contain deeply buried cultural deposits below roadfill and alluvial strata so their National Register eligibility remains undetermined. The Phase IB survey tested the southern portion of the Cheshire Bridge Site (VT-WN-46) in Springfield, but no cultural materials were found. The site's National Register eligibility remains undetermined, however, because of the possible presence of intact cultural deposits in the untested areas to the north of the tested portion of Erosion Area 6 in the Project APE. The Phase IB survey of the Upper Meadows Site (VT-WD-291) in Rockingham did not yield any cultural deposits in the upper alluvial strata. The potential for deeply buried pre-contact cultural deposits in this area (Erosion Area 9) exists, and the site's National Register eligibility remains undetermined. The VTSHPO has not yet formally commented on the findings and recommendations of the Phase IB survey in the Bellows Falls Project APE where no potentially significant archaeological sites were identified. No Phase II site evaluations are recommended.

Table 3.10-7 presents the current status of recorded archaeological sites in the Bellows Falls Project APE, including two newly recorded pre-contact sites in New Hampshire. Of the 45 identified archaeological sites, 3 are listed in the National Register, 3 are eligible for listing, and 8 are ineligible. The National Register eligibility of the other 31 identified sites remains undetermined because these sites are not located in active erosion areas, are not threatened by current Project operations, or are in areas that were not accessible for further study (i.e., no landowner access granted).

Table 3.10-7. Recorded pre-contact and post-contact archaeological sites within or directly adjacent to the Bellows Falls Project APE.

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-CH-169/ North Walpole Rail Spur and Yard	Walpole, NH	H	Recorded in 2013, TransCanada Phase IA Survey: Evidence of old rail beds, concrete foundations, and stored railroad equipment (e.g., ties, track)	Euro-American (nineteenth/ twentieth century)	Fee-owned (partially in TransCanada recreation area; no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined
27-CH-170/ Marshall Street Trash Dump	Walpole, NH	H	Recorded in 2013, TransCanada Phase IA Survey: Historic trash dump with glass, ceramics, and an abundance of coal ash; 2015 Phase IB survey identified nineteenth-century domestic debris intermixed+	Euro-American (early to mid-twentieth Century	Flowage (in active erosion areas)	Ineligible Phase IB (NHSHPO concurrence December 16, 2015)
27-SU-4/ unnamed	Charlestown, NH	PH	Recorded in 1959 as two culturally unaffiliated human burials, stone drill, scraper, and projectile point. Also two historic cellar holes.*	Pre-contact (unknown); Euro-American	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-SU-5/ Hunter	Claremont, NH	P	Recorded in 1952 as stratified site with seven identified occupation levels, 150+ hearths, one human burial, numerous lithic artifacts and pottery.*	Pre-contact (Late Archaic, Middle and Late Woodland)	Flowage (no active erosion; no Project threats)	Listed (June 7, 1976)
27-SU-7/ Red Flake	Charlestown, NH	P	Recorded in 1989 as four hearths, a possible living surface (65m long), fire-cracked rock, pottery, calcined bone, chipping debris*; 2015 TransCanada Phase IB testing recovered no new cultural materials+	Pre-contact (Middle Woodland)	Flowage (partly in active erosion area)	Undetermined
27-SU-12/ Highter Farm	Charlestown, NH	P	Recorded in 1952 as six pieces of chipping debris*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
27-SU-16/ unnamed	Claremont, NH	P	Recorded in 1958 as low density of quartz chipping debris on the surface*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
27-SU-34/ Lovers Lane I	Charlestown, NH	H	Recorded in 2003 as a square earthen structure or possible military gun emplacement	Euro-American (possibly eighteenth century)	Fee-owned (no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-SU-35/ Lovers Lane II	Charleston, NH	H	Recorded in 2003 as a square earthen "foundation"	Euro-American (unknown)	Fee-owned (no active erosion or other Project impacts, potential threat from unauthorized pedestrian use noted during the 2013 Phase IA survey)	Undetermined
27-SU-41/ Meany's Cove	Charlestown, NH	P	Recorded in 2010 as quartz chipping debris and cores, a chert flake, hammerstone, projectile point, calcined bone, fire-altered rock, possible hearth feature*	Pre-contact (unknown)	Fee-owned (no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Eligible (NHSHPO concurrence date unknown)
27-SU-43/ Great Meadows I	Charlestown, NH	H	Recorded in 2013, TransCanada Phase IA survey: Hearth feature with reddened soils and abundant charcoal; reinterpreted in 2015 TransCanada Phase IB as post-contact and/or natural in origin+	Post-contact (or natural)	Fee-owned/flowage (in active erosion area)	Ineligible Phase IB (NHSHPO concurrence December 16, 2015)

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-SU-44/ Great Meadows II	Charlestown, NH	H	Recorded in 2013, TransCanada Phase IA survey: Burn layer with one piece of fire-cracked rock ; re-interpreted in 2015 TransCanada Phase IB as post-contact and/or natural in origin+	Post-contact (or natural)	Fee-owned/flowage (in active erosion area)	Ineligible Phase IB (NHSHPO concurrence December 16, 2015)
27-SU-45/ Great Meadows III	Charlestown, NH	H	Recorded in 2013, TransCanada Phase IA survey: Burn layer with 57 fragments of fire-cracked rock ; reinterpreted in 2015 TransCanada Phase IB as post-contact and/or natural in origin+	Post-contact (or natural)	Fee-owned/flowage (in active erosion area)	Ineligible Phase IB (NHSHPO concurrence December 16, 2015)
27-SU-46/ Great Meadow Farmhouse Foundation	Charlestown, NH	H	Recorded in 2013, TransCanada Phase IA survey: Dry-laid farmhouse foundation and associated farm equipment	Euro-American (late nineteenth to early twentieth century)	Fee-owned (no active erosion; no Project threats)	Undetermined
27-SU-47/ Lower Meadows	Charlestown, NH	P	Recorded in 2013, TransCanada Phase IA survey: One lithic debitage recovered in eroded soils; 2015 TransCanada Phase IB no additional cultural materials+	Pre-contact (unknown)	Fee-owned/flowage (in active erosion area)	Ineligible Phase IB (NHSHPO concurrence December 16, 2015)

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-SU-48/ Meany's Cove II	Charlestown, NH	P	Recorded in 2013, TransCanada Phase IA survey: Three burn features with reddened soils, charcoal, and an unmodified shistose manuport; 2015 TransCanada Phase IB no new cultural deposits+	Pre-contact (unknown)	Fee-owned/flowage (in active erosion area)	Undetermined Phase IB (ineligible in tested erosion area only—NHSHPO concurrence December 16, 2015)
27-SU-49/ Meany's Cove Historic	Charlestown, NH	H	Recorded in 2013, TransCanada Phase IA survey: Well-constructed, dry-laid stone wall, apparently structural, and an oversized groundwater well. Function unknown, but interpreted as a possible trout farm	Euro-American (mid/late nineteenth century)	Fee-owned (no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined
27-SU-53/ Parcel B.F. 265 (new)	Claremont, NH	P	Recorded in 2015, TransCanada Phase IB: 1 lithic debitage in redeposited alluvial soils+	Pre-contact (unknown)	Flowage (in active erosion area)	Ineligible Phase IB (NHSHPO concurrence December 16, 2015)

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
27-SU-54/ Lower Meadows II (new)	Charleston, NH	P	Recorded in 2015, TransCanada Phase IB: 2 lithic debitage in plowed soils over alluvium+	Pre-contact (unknown)	Flowage (in active erosion area)	Ineligible Phase IB (NHSHPO concurrence December 16, 2015)
VT-WD-8/ Bellows Falls Petroglyphs	Rockingham, VT	P	Recorded in 1977 as numerous aboriginal face petroglyphs arranged into two clusters	Pre-contact (unknown)	Fee-owned (no active erosion or other Project impacts, but past natural and human alterations noted during the 2013 Phase IA survey)	Listed (National Register nomination March 30, 1981; contributing element of the Bellows Falls Island Multiple Resource Area (Mulholland et al., 1988)
VT-WD-23/ Conn. River Flowback (Pinello's Site #16)	Rockingham, VT	P	Recorded in 1977 as a groundstone celt*	Pre-contact (Woodland)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WD-76/ John Robertson and Son Paper Co.	Springfield, VT	H	Recorded in 1988 as exterior brick wall and large outflow pipe associated with documented pulp mill (circa 1895/1891)	Euro-American (late nineteenth century)	Fee-owned (no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined (located within the Bellows Falls Island Multiple Resource Area Mulholland et al., 1988)

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-WD-291/ Upper Meadows	Rockingham, VT	P	Recorded in 2013, TransCanada Phase IA survey: Three fragments of fire-cracked rock; 2015 TransCanada Phase IB survey did not identify any cultural deposits at top of embankment+	Pre-contact (unknown)	Fee-owned/flowage (in active erosion area)	Undetermined Phase IB (potential for deeply buried cultural deposits, informal VTSHPO concurrence April 20, 2016)
VT-WN-38/ Caches Blades	Springfield, VT	P	Recorded in 1977 as fourteen large cache blades, one human burial, chipping debris, groundstone adze and pestle-shaped object, pottery, scraper, and point fragments*	Pre-contact (Middle Woodland)	Fee-owned/flowage (no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined
VT-WN-39/ Wilgus Park (Pinello's Site #5)	Weathersfield, VT	P	Recorded in 1978 as two "fish spears" and numerous other artifacts*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-41/ Skitchewaug	Springfield, VT	P	Recorded in 1978 (with multiple updates through 1998) as a stratified village site, many features (living surfaces, hearths, storage pits), two human burials, early evidence of agriculture, many artifacts*	Pre-contact (Late Archaic to Woodland)	Fee-owned/flowage (no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Listed in State Register and determined National Register eligible (December 18, 1987)

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-WN-45/ Locus 16-1	Springfield, VT	P	Recorded in 1977 and 1983 as three hearths, projectile points, bifaces, grinding stone, scraper, chipping debris (2000+), pottery*	Pre-contact (Late Archaic to Woodland)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-46/ Cheshire Bridge	Springfield, VT	P	Recorded in 1978 as one to two hearth features, fire-cracked rock, pottery, chipping debris, projectile points, "pitted stones"*; 2015 TransCanada Phase IB survey did not identify any cultural deposits at top of embankment in erosion area+	Pre-contact (Middle to Late Woodland)	Fee-owned/flowage (in active erosion area)	Undetermined Phase IB survey (ineligible in tested erosion area only, informal VTSHPO concurrence April 20, 2016)
VT-WN-47/ unnamed	Springfield, VT	P	Recorded in 1978 as unidentified Native American artifacts found based on informant interview*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-49/ Pinello's Site #14	Springfield, VT	P	Recorded in 1978 as three alleged human burials and 30 stone artifacts*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-WN-61/ Hoyt's Landing	Springfield, VT	P	Recorded in 1986 as two hearths, chipping debris, fire-cracked rock, potter, calcined bone, charred nutshells*	Pre-contact (Woodland)	Flowage (no active erosion; no Project threats)	Eligible (November 24, 1990)
VT-WN-102/ Blais 16-NV1 and 16-NV2	Springfield, VT	P	Recorded in 1983 as five hearths, fire-cracked rock, potter, chipping debris, burnt butternut shells, calcined bone*	Pre-contact (unknown)	Fee-owned/flowage (partially in active erosion area)	Undetermined Phase IB (potential for deeply buried cultural deposits, informal VTSHPO concurrence April 20, 2016)
VT-WN-103/ Blais 16-NV3	Springfield, VT	P	Recorded in 1983 as three hearths, fire-cracked rock, pottery, calcined bone, chipping debris, shell*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-186/ Oak Knoll Farm	Windsor, VT	P	Recorded in 1992 as multiple features (living surfaces/ hearths, chipping debris, fire-cracked rock, calcined bone, shell, burnt maize, one human burial (relocated)	Pre-contact (Woodland)	Flowage (no active erosion; no Project threats)	Eligible (June 4, 1997)

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-WN-187/ Colonel Barrett's	Springfield, VT	PH	*Pre-contact*: Recorded in 1993 as one projectile point, pestle, anvil stones, chipping debris, pottery.* *Historic*: Recorded in 1993 as nails, ceramics, and glass, possibly associated with the eighteenth century blockhouse nearby*	Pre-contact (Middle Woodland); Euro-American (early eighteenth century)	Fee-owned/flowage (no active erosion or other Project impacts or threats noted during the 2013 Phase IA survey)	Undetermined
VT-WN-192/ Blais	Springfield, VT	P	Recorded in 1998 as hearths*	Pre-contact (unknown)	Fee-owned/flowage (partially in active erosion area)	Undetermined Phase IB (potential for deeply buried cultural deposits, informal VTSHPO concurrence April 20, 2016)
VT-WN-260/ Reddick	Windsor, VT	P	Recorded in 1998 as three pieces of quartz chipping debris*	Pre-contact (unknown)	Flowage (no active erosion/no Project threats)	Undetermined
VT-WN-450/ unnamed	Springfield, VT	P	Recorded in 2003 as two hearths*	Pre-contact (unknown)	Flowage (no active erosion/no Project threats)	Undetermined

State Site Number/ Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project/ Effects	National Register Eligibility
VT-WN-453/ unnamed	Springfield, VT	P	Recorded in 2008 as two to three possible living surfaces, two projectile points*	Pre-contact (Late Archaic)	Fee-owned/flowage (partially in active erosion area)	Undetermined Phase IB (potential for deeply buried cultural deposits, informal VTSHPO concurrence April 20, 2016)
VT-WN-454/ unnamed	Springfield, VT	P	Recorded in 2008 as projectile points, chipping debris, hammerstones, pottery, mostly surface collected*	Pre-contact (Late/Terminal Archaic)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-464/ River Fog	Weathersfield, VT	P	Recorded in 2010 as chipping debris, possibly in a secondary context*	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Ineligible (June 28, 2011)
VT-WN-473/ Oak Knoll Farm II	Windsor, VT	P	Recorded in 2013, TransCanada Phase IA survey: Three pieces of quartz chipping debris	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number / Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal / Cultural Affiliation	Location Relative to the Project / Effects	National Register Eligibility
VT-WN-474/ Jarvis	Weathersfield, VT	P	Recorded in 2013, TransCanada Phase IA survey: Five-meter-long, black soil stain with a localized fire-reddened patch; probably hearth and/or living surface	Pre-Contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-475/ Skitchewaug River Road	Springfield, VT	P	Recorded in 2013, TransCanada Phase IA survey: Low density of quartz and quartzite chipping debris originally identified by TransCanada in 1997	Pre-contact (unknown)	Flowage (no active erosion; no Project threats)	Undetermined
VT-WN-476/ Lower Black River Bridge	Springfield, VT	H	Recorded in 2013, TransCanada Phase IA survey: A pair of old bridge abutments	Euro-American (1860-1929; may be earlier, but no later than 1959	Flowage (no active erosion; no Project threats)	Undetermined

a. P – Strictly pre-contact, PH – Multi-component site with pre-contact and post-contact components, H – strictly post-contact.

b. * – No exposed cultural materials identified during Phase IA reconnaissance survey (Hubbard et al., 2013b).
 ⁺ – Cultural deposits identified during Phase IB identification surveys (Elquist and Cherau, 2016a, 2015).

Vernon Project

Archival research undertaken for the 2008 Phase IA survey of the Vernon Project documented 26 locations within or immediately adjacent to the Project APE that could contain post-contact archaeological sites (18 in Vermont and eight in New Hampshire; Tables 3.10-8 and 3.10-9). None of these documented site locations were verified in the field during the 2008 Phase IA survey, but 13 previously inventoried archaeological sites were identified within the project boundary: 11 in Vermont on fee-owned and private flowage lands and 2 in New Hampshire on fee-owned and private flowage lands (Table 3.10-10). Prior to the Phase IA survey, 2 sites had been determined eligible for listing in the National Register (1 of which could also be an unlisted National Historic Landmark), and 1 site had been determined potentially eligible for listing in the National Register. The National Register eligibility of the other 10 identified sites in the Vernon Project had not been determined at the time of the Phase IA survey.

The Phase IA survey also identified approximately 43 miles of the Vernon Project shoreline (on both sides of the river) as archaeologically sensitive, including the locations of recorded and documented sites, of which approximately one mile (11 areas) was identified as being in active erosion areas. The 2014 Phase IA survey update for the Vernon Project identified one new pre-contact site in Chesterfield, New Hampshire, based on the presence of two pieces of lithic debitage eroding out of the riverbank on flowage lands. No state inventory number has yet been assigned to this newly identified pre-contact site. The Phase IB survey for the Vernon Project APE was conducted in none of the five archaeologically sensitive active erosion areas on the New Hampshire side of the Connecticut River and three of the six archaeologically sensitive active erosion areas on the Vermont side totaling approximately 0.3 mile. Phase IB investigations of the remaining eight sensitive erosion areas at the Vernon Project were not conducted because property owners either did not respond to inquiries or denied access for study purposes, leaving approximately 0.7 mile of unsurveyed sensitive shoreline in active erosion areas and another 42 miles of unsurveyed archaeologically sensitive shoreline areas in the overall Vernon Project.

On the New Hampshire side of the river, the five archaeologically sensitive erosion areas targeted for Phase IB surveys in the Vernon Project APE do not contain any previously recorded sites. No landowner permission to conduct Phase IB surveys was granted, so no Phase IB surveys have been conducted on the New Hampshire side of the river in Vernon Project APE. On the Vermont side of the river, the six archaeologically sensitive erosion areas targeted for Phase IB surveys in the Vernon Project APE contain one site (VT-FS-6 [WD]) in Putney. Landowner permission to conduct Phase IB surveys was granted on private lands that did not contain any previously recorded sites. The Phase IB surveys identified two new pre-contact sites in Putney. The Putney Brook North Site (VT-WD-354) yielded lithic debitage and ground and chipped stone tools and the Putney Brook South Site (VT-WD-355) yielded lithic debitage. Both sites were considered to represent small resource procurement camps that had the potential to provide information relating to pre-contact riverine adaptations along the Lower Connecticut River Valley in Vermont. They were recommended potentially eligible for listing in the National Register and Phase II site evaluation was recommended.

Table 3.10-8. Documented post-contact archaeological resources within or directly adjacent to the Vernon Project APE identified on historic maps (Vermont).

Project ID Number	Description	Identification on Historic Maps					Notes
		McClellan (1856)	Beers (1869)	USGS (1893)	USGS (1930)	USGS (1957a)	
B-1	Dwelling	Appears as *A. Steward*		X			
B-2	Mill building	Appears as *Hines Newman & Co. machine shop and steam mill*	Appears as *E. Tyler Foundry*				
B-3	Industrial building	Appears, unlabeled	Appears as *Gas Works SMW*				
B-4	Industrial building	Appears, unlabeled	Appears as *Flour & Grain Store House Coal Shed SMW*				
B-5	Industrial building	Appears, unlabeled					
B-6	Industrial building		Appears as *SMW Coal Shed*	X		X	
B-7	Industrial building		Appears as *E. Crosby & Co. Flour Store*				

Project ID Number	Description	Identification on Historic Maps					Notes
		McClellan (1856)	Beers (1869)	USGS (1893)	USGS (1930)	USGS (1957a)	
B-8	Industrial building		Appears as *Flour & Salt Store Frost & Goodhue*				
B-9	Industrial building		Appears, unlabeled				
B-10	Railroad spur		Appears				
B-11	Dwelling (?)	Part of Mrs. S. Brooks Dummer Farm?	Appears, unlabeled	X			Partial fee-owned, near shoreline; no archaeological evidence of site identified during 2008 or 2014 Phase IA surveys; no Project impacts or threats noted during either survey including the 2014 archaeological monitoring program under the existing 2008 Vernon Project HPMP
D-1	Dwelling/ferry landing	Appears as *M. Smith*	Appears				
D-2	Dwelling/ferry landing	Appears as *T. Clark*	Appears as *E. Clark*	X	X	X	
P-1	Dwelling	Appears as *T. White*					

Project ID Number	Description	Identification on Historic Maps					Notes
		McClellan (1856)	Beers (1869)	USGS (1893)	USGS (1930)	USGS (1957a)	
P-2	Ferry landing	No structures	No structures				
P-3	Dwelling, associated with ferry landing?	Appears as *M. Pierce*	Appears as *M. Pierce*				
V-1	Vernon dam worker's camp				X	X	Fee-owned, above shoreline; no archaeological evidence of site identified during 2008 or 2014 Phase IA surveys; no Project impacts or threats noted during either survey including the 2014 archaeological monitoring program under the existing 2008 Vernon Project HPMP
W-1	Bridge abutments						

Table 3.10-9. Documented post-contact archaeological resources within or directly adjacent to the Vernon Project APE identified on historic maps (New Hampshire).

Project ID Number	Description	Identification on Historic Maps						Notes
		Fagan (1858)	Hurd (1892)	USGS (1893/98)	USGS (1935b)	USGS (1954)	USGS (1957a)	
Wa-1	Bridge	Appears	Appears		X	X	X	New bridge built in 1910
We-1	Ferry	Appears as *Britton's Ferry*	Appears	Appears as *Wares Ferry*				
We-2	Ferry	Appears	Appears as *Wares Ferry*	Appears?				
C-1	Ferry	Appears as *Davis Ferry*	Appears as *Gibsons Ferry*	Appears				
C-2	Dwelling	Appears as *R.H. Davis*	Appears as part of ferry	Appears, unlabeled	X	X		
C-3	Ferry	Appears as *Norcross Ferry*	Appears as *Houghton Ferry*	Appears, unlabeled	X	X		
C-4	Eighteenth century log cabin (Moses Smith)							Town histories
H-1	Shattucks Fort (eighteenth century)	Appears as *"site"*						1930 submerged by dam constructed in 1907

The VTSHPO did not provide formal concurrence on the National Register-eligibility recommendations for the Vermont sites identified during the Phase IB surveys. However, on April 20, 2016, the VTSHPO concurred with the recommended Phase II evaluations and approved the proposed Phase II evaluation methodology at the two pre-contact sites recommended as potentially National Register eligible (see Table 3.10-1). The Putney Brook North Site (VT-WD-354) yielded a high density concentration of lithic debitage, designated Locus 1 and less amounts of lithic materials and a shallow pit feature designated Locus 2. The feature produced a radiocarbon date to the Middle Woodland Period and the cultural deposits possess good physical integrity, and the site is recommended as eligible for listing in the National Register. The Putney Brook South Site (VT-WD-355) produced lithic debitage, chipped stone tools including a Late Woodland projectile point, and aboriginal pottery. However, the cultural deposits were recovered in a questionable subsurface context that includes re-deposition from an upper terrace landform. Because of the poor physical integrity of the cultural deposits in the erosion area, and the potential for intact, significant deposits on the upper terrace outside the Project APE, the site's National Register eligibility remains undetermined. The VTSHPO has not yet reviewed the Phase II evaluation results.

Table 3.10-10 presents the current status of recorded archaeological sites at the Vernon Project, including three newly identified pre-contact sites (two in Vermont and one in New Hampshire). Of the 16 identified sites, 3 are eligible for listing in the National Register and 1 is potentially eligible. The National Register eligibility of the other 12 identified sites remains undetermined because these sites are not located in active erosion areas, are not threatened by current Project operations, or are in areas that were not accessible for further study (i.e., no landowner access granted).

Table 3.10-10. Recorded pre-contact and post-contact archaeological sites within or directly adjacent to the Vernon Project APE.

State Site Number /Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal/ Cultural Affiliation	Location Relative to the Project	National Register Eligibility
27-CH-85/ Squakheag Fort/Fort Hill	Hinsdale, NH	P	Features, projectile points, ceramics. glass trade beads, chipping debris (chert, schist)*	Late Woodland/ Contact period village	Fee-owned (included in existing 2008 Vernon Project HPMP-surveillance program in place between TransCanada, NHSHPO and local police; no active erosion or Project impacts or threats noted during the 2008 and 2014 Phase IA surveys including the 2014 archaeological monitoring program)	Eligible; possible National Historic Landmark (not listed)
VT-FS-06 (WD)/ Fort Putney	Putney, VT	H	Recorded location somewhere in Great Meadows-no identified remains*	ca 1755 to ca 1760	Flowage (no active erosion; no Project threats)	Undetermined
VT-FS-15 (WD)/ King Philip's Encampment	Vernon, VT	P	Reported Native American encampment during King Philip's War—no finds, local tradition*	17th Century King Philips War 1675-1676	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number /Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal / Cultural Affiliation	Location Relative to the Project	National Register Eligibility
VT-WD-01/ unnamed	Vernon, VT	P	Recorded in the late 1950s/early 1960 as groundstone pestle, copper beads, poundstone, pottery, burials*	Contact/early historic period?	Fee-owned (exact site location below the dam is unconfirmed) (in TransCanada Vernon Project recreational area; no active erosion or other Project impacts or threats noted during the 2008 and 2014 Phase IA surveys including the 2014 archaeological monitoring program)	Undetermined
VT-WD-03/ "North Bridge" or West River	Brattleboro, VT	P	Recorded in the late 1950s/early 1960s as ground and chipped stone tools, aboriginal pottery*	Early Archaic; Late Archaic (Laurentian); Middle Woodland; Late Woodland	Flowage (no active erosion; no Project threats)	Undetermined
VT-WD-05/ unnamed	Vernon, VT	P	Recorded in the late 1950s/early 1960s as groundstone hammer, pestle, mortar, projectile points*	Unknown	Flowage (no active erosion; no Project threats)	Undetermined
VT-WD-07/ West River Petroglyphs	Brattleboro, VT	P	Recorded in 1968 as the West River petroglyphs	Unknown	Flowage (submerged)	Undetermined

State Site Number /Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal / Cultural Affiliation	Location Relative to the Project	National Register Eligibility
VT-WD-08 (WD)/ unnamed	Vernon, VT	P	Recorded in 1978 as aboriginal pottery, unknown artifacts in Needham Collection*	Unknown	Flowage (no active erosion; no Project threats)	Undetermined
VT-WD-10/ Great Bend Site	Vernon, VT	P	Recorded in 1978 as projectile points, glass trade bead, copper beads, copper "Thunderbird," gorge, gorget, nutting stones, pestle, pottery*	Archaic through Woodland periods; Squakheag Village—contact/early historic period	Flowage (no active erosion/no Project threats)	Eligible (August 2, 1990)
VT-WD-13/ Fort Dummer	Brattleboro, VT	H	Recorded in 1976 as stone foundation remains of fortification and possible nineteenth century building; associated artifact assemblage*	Nineteenth century	Partial Fee-owned and Flowage (submerged in impoundment; no shoreline impacts or Project threats noted during the 2008 and 2014 Phase IA surveys including the 2014 archaeological monitoring program)	Undetermined
VT-WD-18/ unknown	Dummerston, VT	P	No form on file-location only*	No information	Flowage (no active erosion; no Project threats)	Undetermined

State Site Number /Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal / Cultural Affiliation	Location Relative to the Project	National Register Eligibility
VT-WD-34/ unnamed	Brattleboro, VT	P	Recorded in 1984 as two loci: Northern one heavily disturbed, southern one yielded quartz and quartzite flakes, large quartzite scraper and fire-cracked rocks*	Paleoindian and/or Early Archaic Period (?)	Flowage (no active erosion; no Project threats)	Recommended Potentially Eligible
VT-WD-354/ Putney Brook North (new)	Putney, VT	P	Recorded in 2015 and 2016, TransCanada Phase IB and Phase II: lithic debitage, chipped stone tools, cooking pit that produced a Middle Woodland radiocarbon date+	Pre-contact (Middle Woodland)	Flowage (in active erosion area)	Recommended Eligible Phase II (pending VTSHPO concurrence)
VT-WD-355/ Putney Brook South (new)	Putney, VT	P	Recorded in 2015 and 2016, TransCanada Phase IB and Phase II: Lithic debitage, chipped stone tools, and aboriginal pottery+	Pre-contact (Late Woodland)	Flowage (in active erosion area)	Undetermined Phase II (redeposited materials in tested portion) (Pending VTSHPO concurrence)

State Site Number / Name	Project Vicinity	Site Type[a]	Brief Description[b]	Temporal / Cultural Affiliation	Location Relative to the Project	National Register Eligibility
None yet assigned	Hinsdale, NH	P	"Indian encampment"	Suspected part of King Philip's winter encampment 1676-1676	Fee-owned (exact site location is unconfirmed) (in TransCanada Vernon Project designated open space area-only accessible by foot; no active erosion or other Project impacts or threats noted during the 2008 and 2014 Phase IA surveys including the 2014 archaeological monitoring program)	Undetermined
None yet assigned/ Find Spot #1 (new)	Chesterfield, NH	P	2014 TransCanada Phase IA update: 2 lithic debitage+	Pre-contact (unknown)	Flowage (in active erosion area)	Undetermined

a. P – Strictly pre-contact, H – strictly post-contact.

b. * – No exposed cultural materials identified during Phase IA reconnaissance survey (Cherau and O'Donnchadha, 2008).

+ – Cultural deposits identified during the Phase IA update (Cherau and Duffin, 2014), Phase IB identification surveys (Elquist and Cherau, 2016a, 2015), and Phase II site evaluations (Elquist and Cherau, 2016c).

3.10.1.3 Historic Architectural Properties

The Wilder, Bellows Falls, and Vernon Projects have been the subject of a number of studies that have resulted in their identification as historic districts that are eligible for listing in the National Register. Components of the Bellows Falls Project were evaluated for National Register eligibility in 1982, when a portion of the Bellows Falls Canal was listed in the National Register as a contributing resource within the Bellows Falls Downtown Historic District (Henry, 1981). The Bellows Falls Island Multiple Resource Area was subsequently listed in the National Register in 1990 and included a number of historic resources on Bellows Falls Island associated with the industrial development of the area during the nineteenth and early twentieth centuries. The Bellows Falls Hydroelectric Powerhouse was named in the documentation as a contributing resource but was not listed in the National Register because of owner objections (Mulholland et al., 1988). In accordance with the Section 101(a)(6) of the NHPA, the Keeper of the National Register determined the property to be eligible for listing.

In 1992, the Bellows Falls and Vernon Projects were identified as properties eligible for listing in the National Register as historic districts under the Hydroelectric Generating Facilities in Vermont Multiple Property Submission (Bowers, 1992). The Vermont Multiple Property Submission, which was signed by the Keeper of the National Register in 2004, provides the overall context and registration requirements for listing individual hydroelectric power facilities constructed in Vermont between 1882 and 1941. However, documentation to add the Bellows Falls and Vernon Projects to the National Register under the Vermont Multiple Property Submission was never prepared.

The first comprehensive inventory of historic architectural resources within the FERC boundaries of the Wilder, Bellows Falls, and Vernon Projects was compiled in the Deerfield and Connecticut River Hydroelectric Projects System-wide Historical and Photographic Documentation completed in 1999 (Doherty and Kierstead, 1999, hereinafter referred to as the “system-wide documentation”). The purpose of the system-wide documentation was to identify and evaluate historic architectural resources within the FERC boundaries of all the hydroelectric developments that are currently owned by TransCanada on the Deerfield and Connecticut rivers in Massachusetts, New Hampshire, and Vermont. Survey information was used to prepare state-level written and photographic archival documentation as a permanent record of the historic developments and to serve as a baseline for assessing the impacts of subsequent Project-related undertakings. The system-wide documentation included a historic context statement for the development of hydroelectric power facilities on the two rivers and information about all individual aboveground resources within the Project boundaries that contribute to their historical significance. Copies of the documentation for the Connecticut River Projects, including the Wilder, Bellows Falls, and Vernon Projects, were submitted to the VTSHPO and NHSHPO for transmittal to the states’ archives and local archival repositories in the vicinity of the Projects.

In 2006–2008, a TransCanada project to upgrade the generating capacity at the Vernon Project required an amendment to the FERC license. In accordance with Section 106 of the NHPA, FERC and TransCanada consulted with the VTSHPO and NHSHPO and other parties regarding the upgrade's effects on historic properties and determined that the Vernon Project was eligible for listing in the National Register as a historic district. The effects of the proposed 2006–2008 upgrade on the historic powerhouse were resolved through the execution of a Memorandum of Agreement that specified a variety of mitigation activities, including the preparation of an HPMP. Completed and approved in 2008, the HPMP specifies the treatment and management of historic properties within the Vernon Project boundaries (Olausen and Cherau, 2008).

The most recent study was a historic architectural resources survey conducted for the current relicensing effort as part of Study 33. The study report included a summary of past investigations, assessed the current condition of the resources, and evaluated the potential eligibility of the Projects for listing in the National Register as historic districts. The report was submitted to the VTSHPO and NHSHPO for review in May 2015. By a letter dated June 29, 2015, the NHSHPO requested that the information be broken out into its Project Area Form format. A separate form was prepared for each of the three Projects and submitted to the NHSHPO for review on July 30, 2015. By letter dated August 27, 2015, the NHSHPO evaluated the resources of the Wilder Project within New Hampshire as eligible for listing in the National Register. The VTSHPO did not comment on the report. TransCanada, therefore, assumes the VTSHPO's concurrence with the report's conclusions that the resources associated with the development and operation of the Wilder, Bellows Falls, and Vernon Projects are eligible for listing in the National Register as part of a potential historic district at each Project. The findings of the evaluation are summarized below.

Wilder Project

The Wilder Hydroelectric Project Historic District was evaluated eligible for listing in the National Register under Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. Under Criterion A, the district derives its primary significance from its contribution to the broad patterns of economic and social history in New Hampshire and Vermont. The Wilder Project was an important component of the system of six hydroelectric facilities designed to serve the southern New England electrical market that were built by the New England Power Company and related corporations on the Connecticut River in 1909–1957. Vermont hydroelectric stations historically served as the principal source of electricity in the state and thus have contributed to its industrial and economic development. Under Criterion C, the district is significant for its embodiment of mid-twentieth-century hydroelectric project engineering, as evidenced by its massive dam consisting of a 2,200-ft-long, curving, earth-berm section and straight 680-ft-long, concrete spillway; a steel and brick powerhouse; and a vertical-shaft turbine and generator configuration using Kaplan-type, variable-pitch propeller turbines set in specially cast concrete spiral scroll cases and draft tubes. This type of purpose-built, hydroelectric project represented the maturation of large-scale, river-powered, electrical generation facilities and, in its adoption of Kaplan turbines, the Project's continued refinement.

Completed in 1950, the Wilder Project was the second to last in the series of 14 hydroelectric projects constructed along the Connecticut and Deerfield rivers and the fifth of six Connecticut River projects constructed by TransCanada's predecessor companies in 1907–1957. The Wilder Project was designed to supply additional electrical generating capacity to meet peak demands during the post-World War II period when energy consumption spiked upward. The Project was built on the site of an existing hydroelectric plant at Olcott Falls that had been built in 1910 by the International Paper Company. The New England Power Association purchased the property in 1942 and obtained a license to operate the existing hydroelectric facility in 1943. It filed plans with the Federal Power Commission (predecessor of FERC) to build a new 33-MW facility in 1944. The $16-million project faced significant public opposition, however, because of the expansion of the area that would be flooded for the new impoundment. The proposed 2,000-ft-wide dam would raise the water level by 15 ft, extending the existing pond 27 miles upstream near McIndoes Hydroelectric Station. Ultimately, 1,200 acres of land, including 335 acres of farmland, were affected by flooding. In an effort to mitigate damages, the New England Power Association agreed to pay for any submerged land and to move any affected utilities, including railways and roads. Conflicts over estimates of flooding had to be resolved in court, interrupting construction on several occasions, and the Wilder redevelopment was not completed until 1950. Design and construction of the Wilder Project were completed by the New England Power Service Company and the New England Power Construction Company, respectively. Both of those firms were subsidiaries of the New England Power Association.

The completed Wilder Project ranked as the fourth largest hydroelectric development in the New England Power Association system. Technologically, the Wilder Project is typical of mid-twentieth-century hydroelectric generating facilities, which were characterized by a variety of water management techniques and standardized equipment configurations that were interconnected to provide electricity to larger areas. The Wilder powerhouse incorporates the major elements that characterize large-scale hydroelectric generating technology at the time, including multiple, vertical-shaft, variable-pitch, adjustable-blade, Kaplan-type, single-runner, large-diameter, high-horsepower, low-rpm turbines with scroll cases cast into foundations; oil-pressure vertical thrust bearings; improved tailrace draft arrangements; and electromagnetic "cabinet"-type speed governors. Architecturally, the powerhouse demonstrates the continuing evolution of the historicism that typified the design of such facilities since the electrical industry was established. Power companies had favored high-style, dignified designs that could be used to legitimize and dignify their industry by conveying a positive public image. Earlier powerhouses constructed by the New England Power Company and others favored the Renaissance Revival Style, and sometimes Romanesque Revival or Gothic styles. By the mid-twentieth century, however, the Colonial Revival

Style, as evidenced at Wilder, was increasingly favored for public and utility buildings as an expression of American patriotism and ideals.

Original components of the development included the dam, powerhouse, visitors' house, two switchyards, garage, and an oil storage shed. The dam, powerhouse, and switchyards are directly related to electrical generation and distribution, while the garage and oil storage shed are ancillary utilitarian storage structures. The visitors' house is one of two such visitor facilities constructed in the New England Power Association's hydroelectric power system (the other was constructed at the Moore development in the Fifteen Mile Falls Project in 1957) (Table 3.10-11, Figure 3.10-4).

Table 3.10-11. Contributing and non-contributing resources within the Wilder Hydroelectric Project Historic District.

Resource Name	Location	Year Built	National Register Status[a]
Wilder dam	351 Wilder Dam Road, Hartford, VT; Route 10, Lebanon NH	1950	C
Wilder powerhouse	351 Wilder Dam Road, Hartford, VT	1950	C
Visitors' house	Route 10, Lebanon, NH	1950	C
Garage	Wilder Dam Road, Hartford, VT	ca. 1950	C
TransCanada 13.8 kV, 47 kV, and 115 kV switchyard	Wilder Dam Road, Hartford, VT	1950	C
National Grid 115-kV switchyard	Wilder Dam Road, Hartford, VT	1950	C
Fish ladder	351 Wilder Dam Road, Hartford, VT	1988	NC

Source: Daly (2015)

a. C – resource that contributes to the significance of the historic district; NC – non-contributing resource.

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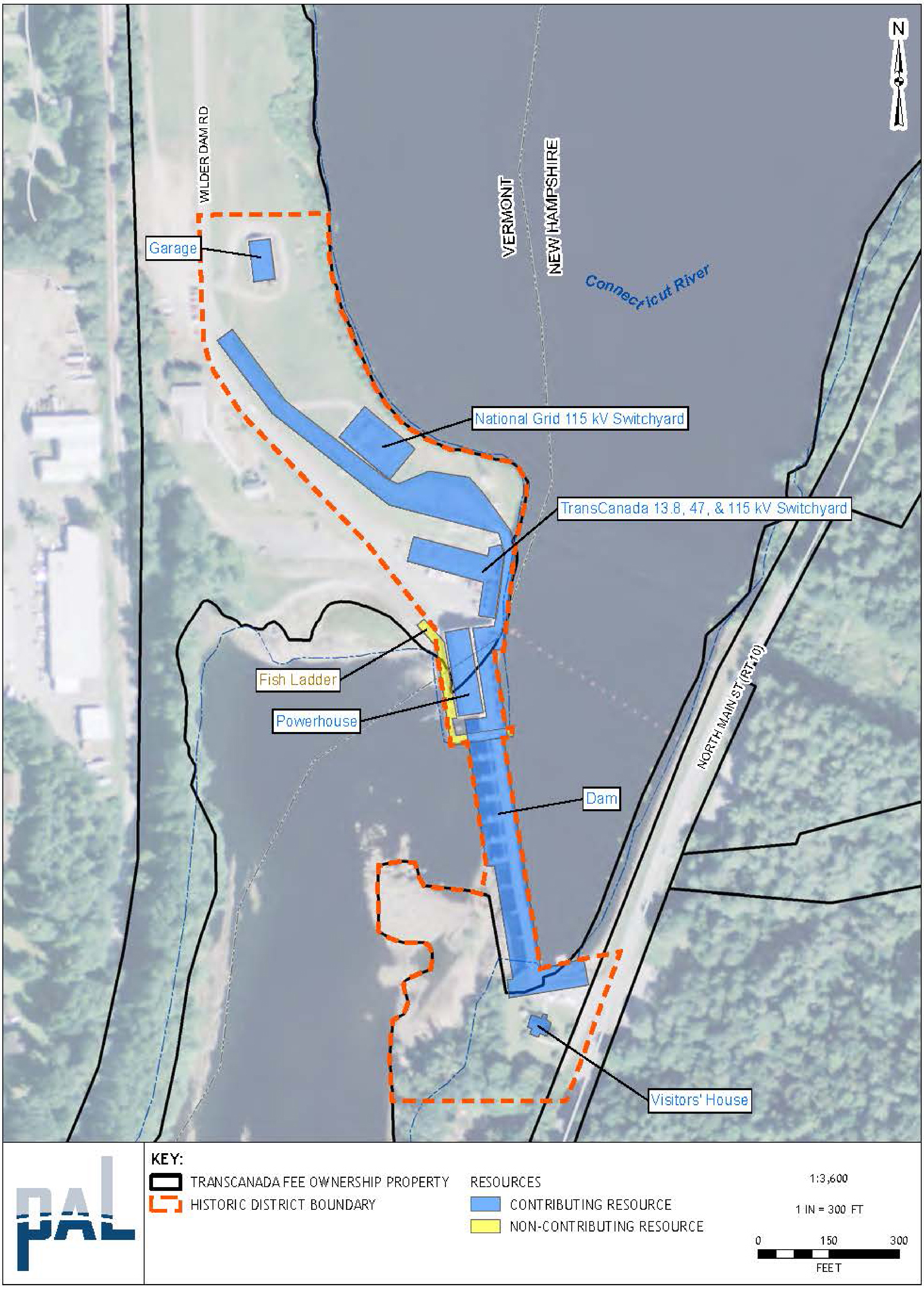

Source: Daly (2015)

Figure 3.10-4. Wilder Hydroelectric Project Historic District.

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Bellows Falls Project

The Bellows Fall Hydroelectric Project Historic District has been determined eligible for listing in the National Register under Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. Under Criterion A, the district possesses significance as an important component of the system of hydroelectric facilities constructed by the New England Power Company and its predecessor corporations on the Connecticut River in 1909–1957. Those hydroelectric stations historically served as the principal source of electricity in the region and thus contributed to its industrial and economic development during the twentieth century. Under Criterion C, the district is significant for its embodiment of early twentieth-century hydroelectric project engineering, specifically as a divided-fall project that incorporated a concrete ogee-profile dam with roller gates, a steel and brick powerhouse, and a vertical-shaft turbine and generator configuration using 1920s Francis-type, single-runner, fixed-blade turbines set in specially cast concrete spiral scroll cases and draft tubes. The development of this type of purpose-built hydroelectric project represented a significant step forward in the evolution of modern, large-scale electrical generation facilities.

The Bellows Falls Project was completed in 1928 on the site of the former Bellows Falls Canal, one of the first transportation canals constructed in the United States. The canal was chartered in 1792 to open the river to navigation around Bellows Falls and was completed in 1802. That same year, Vermont's first paper mill opened on the canal and papermaking soon became Bellows Falls' most important industry. During the ensuing years of the nineteenth century, a dense complex of water-powered mills was constructed along the canal at the south end of Bellows Falls Island and immediately adjacent areas to the west. In 1912, Chace & Harriman purchased the canal company and two small hydroelectric companies and reorganized them into a subsidiary called the Bellows Falls Power Company. In 1918, Chace & Harriman enlarged the canal and erected a new and larger power station with a share of the resultant electricity to be guaranteed to the paper mills.

The paper industry suffered a significant decline in the 1920s. Seeking another form of investment to stay viable, International Paper Company, the area's largest paper manufacturer, merged with Chace & Harriman to become the New England Power Association in 1926. By that time, the construction of the Bellows Falls Project was already underway. During the following 2 years, a dam and gauge house were constructed near the head of the canal and the canal itself was straightened and modified to supply water to a new powerhouse. When the Project was completed in 1928, it had a generating capacity of 40,800 kW, making it one of the region's most important electrical generation facilities.

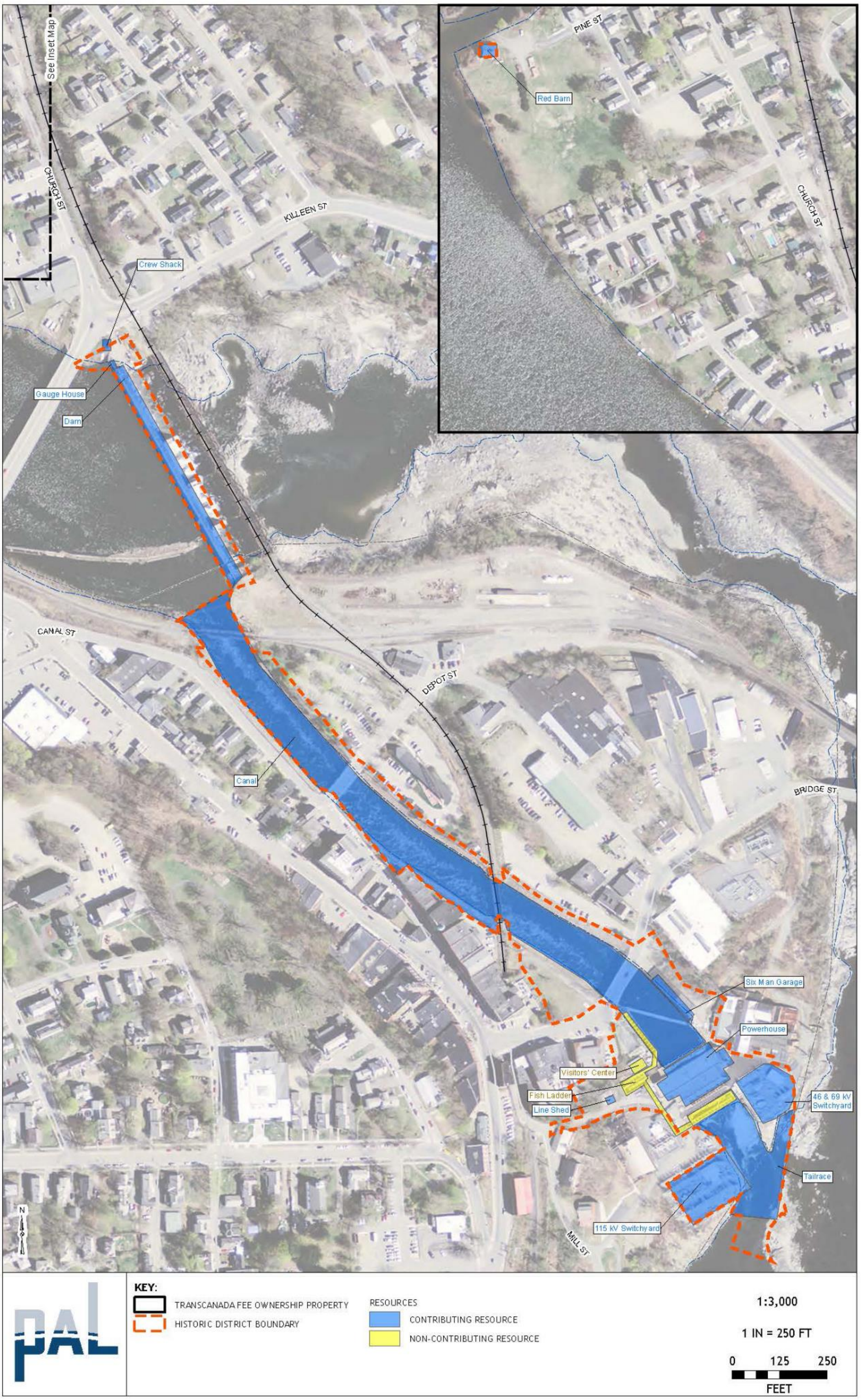
The three primary contributing resources in the Bellows Fall Hydroelectric Development Historic District are the dam, canal, and powerhouse that are associated with the facility's function as a hydroelectric power generating facility. Various ancillary structures also contribute to the significance of the district: the red barn, gauge house, six-man garage, line shed, two switchyards, crew shack, and tailrace. Non-contributing structures consist of the fish ladder and visitors' center, both completed in 1984 (Table 3.10-12, Figure3.10-5).

Table 3.10-12. Contributing and non-contributing resources within the Bellows Falls Hydroelectric Project Historic District.

Resource Name	Location	Year Built	National Register Status[a]
Red barn	Pine Street at CT River, North Walpole, NH	1894–1901	C
Six man garage	Bridge Street, east of Canal, Bellows Falls, Rockingham, VT	1875–1880	C
Gauge house	Intersection of Church and River Sts., North Walpole, NH	ca. 1927	C
Bellows Falls dam	Intersection of Church and River Sts., North Walpole, NH	1927	C
Canal	Canal Street, between Green Mountain RR Bridge and Powerhouse, Bellows Falls, Rockingham, VT	1927	C
Bellows Falls powerhouse	12 Mill Street, Bellows Falls, Rockingham, VT	1928	C
115-kV switchyard	12 Mill Street, Bellows Falls, Rockingham, VT	1928	C
46/69-kV switchyard	12 Mill Street, Bellows Falls, Rockingham, VT	1928	C
Tailrace	CT River, south of Powerhouse, Bellows Falls, Rockingham, VT, and North Walpole, NH	1928	C
Crew shack	Intersection of Church and River Sts., North Walpole, NH	ca. 1930	C
Line shed	Mill Street, Bellows Falls, Rockingham, VT	ca. 1955	C
Visitors' center	17 Bridge Street, Bellows Falls, Rockingham, VT	1984	NC
Fish ladder	17 Bridge Street, Bellows Falls, Rockingham, VT	1984	NC

Source: Daly (2015)

a. C – resource that contributes to the significance of the historic district; NC – non-contributing resource.



Source: Daly (2015)

Figure 3.10-5. Bellows Falls Hydroelectric Historic District.

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Vernon Project

The Vernon Hydroelectric Project Historic District has been determined eligible for listing in the National Register under Criteria A and C at the state level in the areas of Industry, Engineering, and Architecture. Under Criterion A, the district derives its primary significance as the first large-scale hydroelectric development constructed in New England. Developed by Chase & Harriman, which went on to form the largest power generating concern in the region, Vernon dwarfed the output of any hydroelectric plant east of Niagara Falls at the time of its completion in 1909. It was the first hydroelectric plant in the Northeast built to deliver energy via long-distance transmission lines and therefore contributed substantially to the economic development of central Massachusetts and southeastern Vermont. Under Criterion C, the district embodies early twentieth-century hydroelectric engineering concepts through its concentrated-fall type arrangement consisting of an incorporated concrete ogee-profile dam and a connected Renaissance Revival-style steel and brick powerhouse.

The development of this type of purpose-built hydroelectric development represented a significant step in the evolution of modern, large-scale electrical generation facilities. The Vernon Hydroelectric Development Historic District powerhouse and dam also possess significance under Criterion C in the area of Engineering as a work of the significant hydroelectric designer Charles (Chas.) T. Main, Inc.

In the early part of the twentieth century, several bankers and merchants in Brattleboro, Vermont, had obtained New Hampshire and Vermont charters to develop hydroelectric power along the Connecticut River which, with its many waterfalls, had attracted mills since the Colonial Period. In 1907, when the charter holders identified Vernon as a potential site for development, Chace & Harriman took control of the development project, convincing local investors to sign over their charters in exchange for a share of the power. Chace & Harriman's ambitious plan was to build a facility that could send power over high-voltage lines to industries in north-central Massachusetts, a great deal farther than the maximum 35 miles recommended by engineers at the time. Chace & Harriman founded the Connecticut River Power Company and received special permission to enter the Massachusetts market, provided that they establish a Massachusetts-based company as well. Thus they established the Connecticut River Transmission Company of Massachusetts.

Construction began at the Vernon site in 1907, after Chace & Harriman had obtained the land and flowage rights to raise the river 30 ft and flood all or parts of 150 farms. The design of the facility was largely the work of the engineering firm of Charles (Chas.) T. Main, Inc., of Boston. The dam was the first structure of the facility to be completed. Main employed a concrete gravity design that relied on the dam's weight and bedrock foundation to hold back the water behind it. This type of dam was a departure from the rock-filled wooden crib dams that were typical in New England at the time and came into standard use in the region during the first quarter of the twentieth century. When the powerhouse was completed in

1909, its eight generating units produced 20,000 kW, a far greater output than any other hydroelectric station then in operation east of the Niagara Falls Hydroelectric Project. Transformers at Vernon raised the line voltage to 66 kV, enabling it to be transmitted more than 60 miles to Gardner and Fitchburg, Massachusetts, a voltage and distance unprecedented in New England at the time. Capacity was further expanded in 1920 when the powerhouse was extended 112 ft to the west to accommodate two new General Electric 4,200-kW vertical-shaft generators. The most significant hydroelectric components of the Vernon Hydroelectric Project Historic District are the powerhouse and dam. An additional six ancillary structures—the switchyard, crew shack, hoister house, pump house, superintendent's house, and superintendent's garage—are contributing structures. Non-contributing elements consist of the fish ladder constructed in 1981 (Table 3.10-13, Figure 3.10-6).

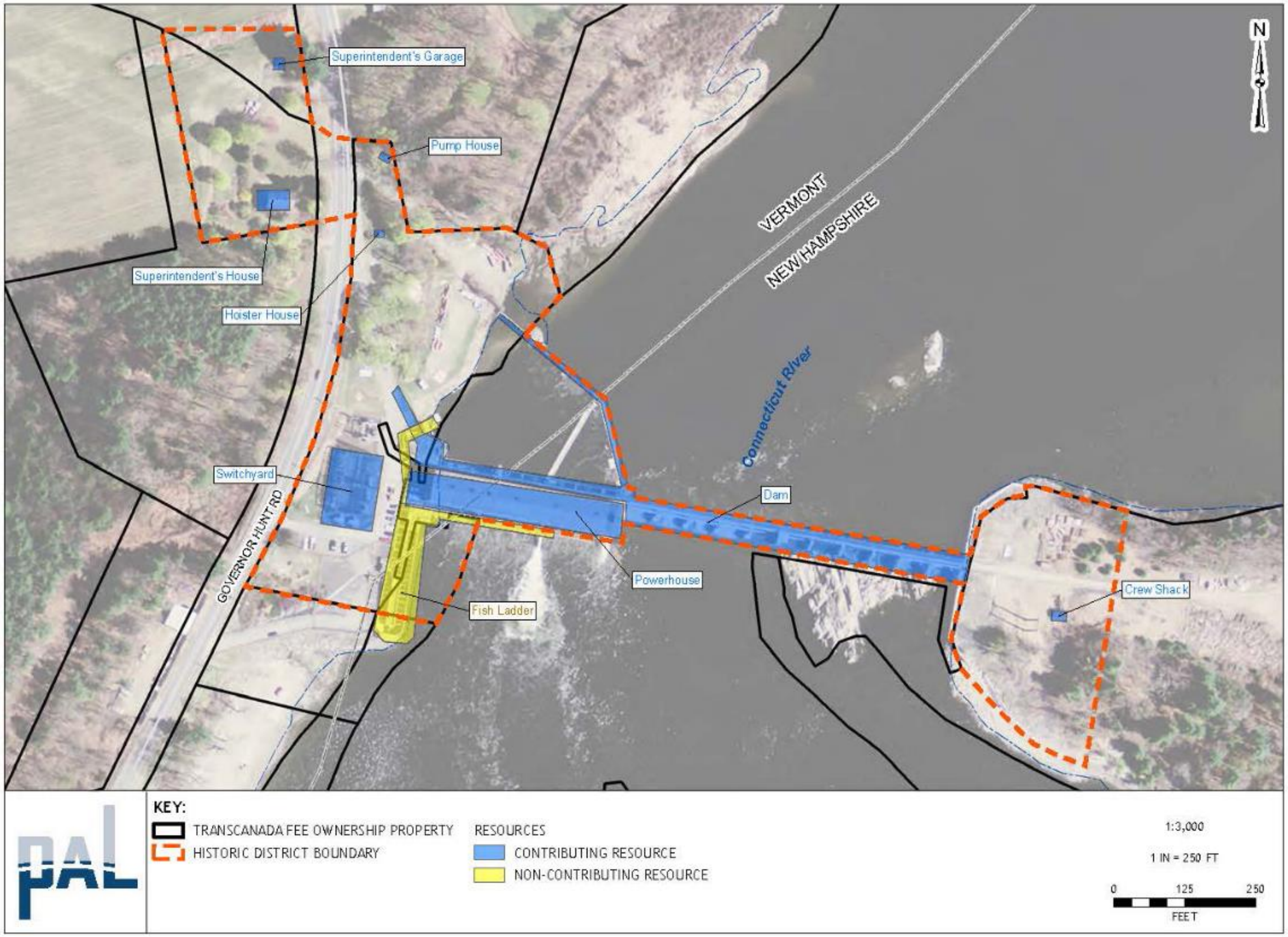
Although the Vernon Project has had substantial modifications of its dam and power generation units, the historic district retains the physical features (as defined in Hydroelectric Generating Facilities in the Vermont Multiple Property Submission) to demonstrate its associations with early twentieth-century hydroelectric power generation and its engineering and architectural significance. The development retains its location and setting on the Connecticut River. The facility's overall design, materials, and workmanship as a concentrated-fall facility with vertical-shaft generation infrastructure within a Renaissance Revival Style powerhouse is preserved, with the spatial and functional relationship among the development's principal components readily discernible. The property expresses its feeling as an early twentieth-century hydroelectric development and its associations with the development of the hydroelectric power generation industry during that era.

Table 3.10-13. Contributing and non-contributing resources within the Vernon Hydroelectric Project Historic District.

Resource Name	Location	Year Built	National Register Status[a]
Superintendent's house	255 Governor Hunt Road, Vernon, VT	1907	C
Superintendent's garage	255 Governor Hunt Road, Vernon, VT	1907	C
Crew shack	East end of Vernon dam, Hinsdale, NH	1909	C
Vernon powerhouse	152 Governor Hunt Road, Vernon, VT	1909, 1920	C
Vernon dam	152 Governor Hunt Road, Vernon, VT	1909	C
Hoister house	Governor Hunt Road, Vernon, VT	1909	C
Pump house	Governor Hunt Road, Vernon, VT	1909	C
Switchyard	152 Governor Hunt Road, Vernon, VT	1909, 1920	C
Fish ladder	152 Governor Hunt Road, Vernon, VT	1981	NC

Source: Daly (2015)

[a] C – Resource that contributes to the significance of the historic district; NC – non-contributing resource.



Source: Daly (2015)

Figure 3.10-6. Vernon Hydroelectric Project Historic District.

3.10.1.4 Traditional Cultural Properties

ILP Study 33, *Cultural and Historic Resources Study* requires TransCanada to conduct a Traditional Cultural Properties (TCP) study for the Wilder, Bellows Falls, and Vernon Projects. The purpose of the study was to review existing literature and provide baseline information that could be used in consultation and coordination with tribes to identify TCPs and Historic Properties of Cultural and Religious Significance to Indian Tribes.

Letters dated October 30, 2012, accompanying the Notices of Intent (NOI) to File Application of New License, including hyperlinks to the Preliminary Application Documents (PADs) for each Project together with a postage-paid return postcard for indicating interest in continued participation in the relicensing process were sent to: Abenaki Nation of Missisquoi; Cowasuck Band of the Pennacook-Abenaki People; Koasek Traditional Abenaki of the KOAS; and the Koasek Traditional Band of the Sovereign Abenaki Nation in an effort to reach out to leaders of Abenaki Tribes or Bands. No return postcards were received.

Solicitation of Interest letters dated November 8, 2012, and November 17, 2012, were sent by FERC to the Mashpee Wampanoag Tribe and Wampanoag Tribe of Gay Head. Follow-up conversations and voice messages were made by FERC staff in December 2012. Neither tribe indicated an interest in the relicensing proceeding. The Narragansett Indian Tribe of Rhode Island expressed an interest in the relicensing proceeding in response to FERC's February 3, 2013, letter of solicitation. Subsequent study requests were filed by the Narragansett Tribe and the Nolembeka Project.

TransCanada's Study Plan for Cultural and Historical Resources (Study 33) was filed on April 15, 2013, but did not include a TCP in its scope. A meeting was held on June 7, 2013 with representatives of the Narragansett Tribe, Nolembeka Project, FERC, and TransCanada to discuss the proposed cultural and historic resources study plan, and yielded clarification and additional information about their study requests. On July 8, 2013, TransCanada filed an updated PSP for Study 33 for additional stakeholder review and comment that included a TCP study. Further clarification was provided through additional meetings and conference calls with FERC, the Narragansett Tribe and the NHSHPO and VTSHPO, and considering comments provided by the VTSHPO and Nolumbeka Project. Following the conclusion of study plan meetings and receipt of comments on its updated PSP, TransCanada filed its RSP on August 14, 2013. FERC approved the RSP for Cultural and Historic Resources without modifications in the SPD letter of September 13, 2013.

By letter dated May 14, 2014, TransCanada reached out to the Narragansett Tribe, introducing the selection of an experienced TCP consultant, requesting an opportunity to meet and discuss tribal participation in the TCP study and planned archaeology studies to be performed in 2014. By email dated July 11, 2014, to the NITHPO and Deputy NITHPO, TransCanada reiterated its interest and invitation to meet and consult on the TCP and archaeology studies. Lastly, by letter dated December 23, 2014, to the Narragansett Tribe providing a copy of the Phase 1A Archaeological Reconnaissance Survey Update for the Vernon Project, TransCanada further inquired about Tribal interest in meeting and participating in the TCP study. TransCanada received no response to any of these requests to meet, consult, or participate in the FERC approved studies.

The TCP study was therefore conducted absent tribal input and largely based on documented information available from a variety of sources and published works. The initial TCP study report was completed and filed May 16, 2016. At the subsequent Study Report meeting held on June 1, 2016, representatives of the Elnu Tribe (Abenaki) and Winter Center for Indigenous Traditions - Abenaki Nation of NH expressed a desire to set up meetings between TransCanada, its TCP consultant, and Abenaki tribal leaders and representatives to further develop and address recommendations on the TCPs listed in the report. Subsequently, consultation meetings were held on October 26 and 27, 2016 with interested tribal representatives to develop a plan for providing comments on the ISR, and to conduct additional literature reviews and interviews in support of study report revisions. That effort remains in progress at this time. Additional study results will be reported in the FLAs if additional information is available by that time.

3.10.2 Environmental Effects

Pursuant to 36 C.F.R. §800.5, following the completion of the historic property identification phase, TransCanada will consult with the VTSHPO and NHSHPO to determine whether the relicensing, operation, and maintenance of the Wilder, Bellows Falls, and Vernon Projects will result in adverse effects to historic properties. The following, therefore, constitutes a preliminary assessment of the potential effects of the relicensing of the Projects.

3.10.2.1 Historic Architectural Properties

TransCanada does not propose to change in Project operations; therefore, it is unlikely that the undertaking will result in adverse effects on historic architectural resources. After its review of information regarding historic architectural resources submitted as part of Study 33, the NHSHPO concurred with that assessment and offered its opinion that the relicensing of the Projects will have no adverse effect on historic architectural resources in New Hampshire. The VTSHPO has not issued an opinion in that regard. During the term of the new licenses, TransCanada may propose improvement or maintenance projects that include alterations to historic buildings or structures. The following is a list of typical types of activities that have the potential to cause effects on historic properties:

- Removal and/or replacement of major mechanical, electrical, and generating equipment that have been in place for more than 50 years and contribute to the understanding of the historical operation of the Projects;

- Alterations to the exterior appearance, including the removal or modification of original architectural details, application of synthetic or other incompatible materials, additions, and permanent partitioning of interiors of historic buildings; and
- New construction that is incompatible with the historic appearance of the Projects.

3.10.2.2 Archaeological Sites

As is the case with historic architectural properties, TransCanada may in the future propose improvement or maintenance projects that could affect archaeological properties during the term of the license. The following is a list of typical types of activities that have the potential to cause effects on archaeological resources:

- Ground disturbing activities (e.g., construction, grading, and tree clearing) in archaeological sites and sensitive areas that are considered to have the potential to impact significant belowground cultural deposits;
- Shoreline modifications resulting from proposed projects that could impact archaeological sites and sensitive areas; and
- Recreational enhancement projects that require construction or provide public access that could result in vandalism of significant archaeological sites or sensitive areas.

Wilder Project

In the Wilder Project APE, nine recorded and documented archaeological sites are located partially or entirely on fee-owned lands, none of which have been determined to be eligible for listing in the National Register (27-GR-233, VT-WN-479, VT-WN-480, VT-WN-481, HA-1, HA-2, HA-3, HN-10, and LE-6) (see Tables 3.10-2 and 3.10-3). These sites have not been identified (or reported) archaeologically and/or their National Register eligibility is currently undetermined. One of the sites (VT-WN-479) in Hartford, Vermont, is in an area of active erosion where Phase IB archaeological survey was proposed; however, the site is only safely accessible by land across private property (because of the steep and unstable river embankment), and no landowner permission was granted for land access. If and when landowner permission is granted to access the site by land, the proposed Phase IB survey will be undertaken. One resource (27-GR-233) is located in the vicinity of a Project camping area, but no effects were identified during the Phase IA reconnaissance survey. Two other resources (VT-WN-480 and VT-WN-481) are located within Project recreation areas. Potential Project-related effects on these two sites as a result of ongoing recreational access and use have not been identified.

No Project impacts or potential threats were identified during the 2013 Phase IA reconnaissance survey of the Wilder Project APE at the other six other sites and sensitive areas on fee-owned lands. These sites along with sensitive areas are recommended for an archaeological monitoring program to be established in the Wilder Project HPMP.

Bellows Falls Project

In the Bellows Falls Project APE, 24 recorded and documented archaeological sites are located partially or entirely on fee-owned lands. Two (VT-WD-8 and VT-WD-41) are listed in the State and/or National Registers and one site (27-SU-41) has been evaluated as being eligible for listing on the National Register (see Tables 3.10-4 and 3.10-5). VT-WD-8 (Bellows Falls Petroglyphs) is not threatened by Project-related impacts, but its location near public areas of the village of Bellows Falls makes it vulnerable to potential vandalism and the site has been altered over time both by human and natural forces. Site VT-WD-41 (Skitchewaug) is listed in the State Register. The Phase IA survey did not identify any Project impacts or threats to this site. Site 27-SU-41 (Meany's Cove) was recorded in 2010 as part of a New Hampshire Department of Transportation project and the Phase IA survey did not identify any Project impacts or threats to the site.

Seventeen other sites (27-CH-169, 27-SU-34, 27-SU-35, 27-SU-46, 27-SU-48, 27-SU-49, VT-WD-76, VT-WD-291, VT-WN-38, VT-WN-46, VT-WN-102, VT-WN-187, VT-WN-192, VT-WN-453, RO-1, RO-2, and RO-3) on fee-owned lands in the Bellows Falls Project APE have either not been identified archaeologically or have not been evaluated for National Register eligibility. No Project impacts or potential threats were identified during the 2013 Phase IA reconnaissance survey of the Bellows Falls Project at any of these sites and sensitive areas, including disturbances from TransCanada-owned recreation areas. These sites along with sensitive areas are recommended for an archaeological monitoring program to be established in the Bellows Falls Project HPMP.

Vernon Project

In the Vernon Project APE, six recorded and documented archaeological sites are located partially or entirely on fee-owned lands. The only one that has been determined eligible for listing in the National Register is Site 27-CH-85 (Squakheag Fort/Fort Hill) located in Hinsdale, New Hampshire (see Tables 3.10-6 and 3.10-7). The site is well known and has previously experienced disturbances by clandestine looting activities. The most recently documented looting dates to the spring/summer of 2008 and involved the laying out of testing grids or units with string and flagging tape and the unauthorized excavation and screening of artifacts. The NHSHPO is aware of these activities and has worked with TransCanada and local police to reduce and eliminate unauthorized site access and excavations. The fee-owned lands in this area are not open to the public for recreational use and the existing maintenance roads follow along 80-year-old overhead electric transmission lines that are gated and locked. No evidence of looting was observed at the site during the 2014 Phase IA reconnaissance survey update and archaeological site monitoring program conducted in accordance with the existing 2008 Vernon Project HPMP. The protection of Site 27-CH-85 is included in the existing 2008 Vernon Project HPMP and will continue to be part of the Vernon Project HPMP update.

The other five archaeological sites on fee-owned lands in the Vernon Project APE (VT-WD-01, VT-WD-13, "Indian Encampment" [no NH site number], B-11, and V-1) have not been identified archaeologically and/or their National Register eligibility is currently undetermined. All five sites along with sensitive areas are included in the 10-year archaeological monitoring program schedule established in the existing Vernon Project HPMP. The most recent monitoring program conducted in 2014 did not identify any project impacts or other potential threats to any of these sites and sensitive areas including disturbances from TransCanada-owned recreation areas (Cherau and Duffin 2014).

3.10.2.3 Traditional Cultural Properties

Potential Project effects on TCPs have not been determined at this time. As described in Section 3.10.1.4, *Traditional Cultural Properties*, effects will be reported in the FLAs to the extent that effects are identified at that time.

3.10.3 Cumulative Effects

No cumulative effects related to cultural and historic resources including TCPs have been identified, so no cumulative effects on those resources are evaluated as part of this environmental analysis.

3.10.4 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures related to cultural and historic resources. The process to establish measures to avoid, minimize, or mitigate effects to historic properties is defined in Section 106 of the NHPA. In accordance with those regulations, TransCanada will consult with the VTSHPO and NHSHPO to determine whether Project-related effects are adverse. In the event that that the relicensing and continued operations and maintenance of the Projects is determined to have an adverse effect on historic properties, TransCanada will consult with the VTSHPO, NHSHPO, FERC, and other consulting parties to seek ways to avoid, minimize, or mitigate the effect through the development of HPMPs for each Project. The HPMPs would be developed in accordance with the joint document prepared by FERC and the ACHP titled: *Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects* (ACHP and FERC, 2002). It is expected that the implementation or development of the HPMPs will be required in accordance with stipulations contained within Programmatic Agreements that FERC will execute with the consulting parties. The HPMPs will define how historic properties within each Project APE will be treated throughout the term of each license. The HPMPs will include but not be limited to the following:

- Identify goals for the long-term monitoring and preservation of historic properties;
- Be integrated with existing management plans and the overall master planning process for the Projects;

- Identify types of maintenance, operation, and new construction activities that have the potential to cause effects on historic properties;
- Establish procedures for consulting with the SHPOs, Indian Tribes, historic preservation experts, and the interested public in the event that a historic property may be affected by Project-related activities;
- Specify measures that would be carried out to resolve adverse effects; and
- Identify the responsible TransCanada officer in charge of executing the HPMP and establishing procedures for training plant operators, maintenance staff, and other employees in its implementation.

3.10.5 Unavoidable Adverse Effects

TransCanada does not propose to change the Projects or the operations or maintenance of the Projects, so unavoidable adverse effects on any known historic property or TCPs are not expected. In the event that a future undertaking is determined to have potential adverse effects on a historic property, the consultation process established in the HPMPs will be followed to resolve those effects. The process to establish measures to avoid, minimize, or mitigate adverse effects to historic properties is defined in Section 106 of the NHPA. In accordance with those regulations, TransCanada will consult with the VTSHPO and NHSHPO to determine whether Project-related effects are adverse. In the event that that the relicensing and continued operations and maintenance of the Projects are determined to have an adverse effect on historic properties, TransCanada will consult with the VTSHPO, NHSHPO, FERC, and other consulting parties such as Tribes to seek ways to avoid, minimize, or mitigate the effects through the development of HPMPs for each Project.

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3.11 Socioeconomics

3.11.1 Affected Environment

Because the affected environment areas for the Wilder, Bellows Falls, and Vernon Projects overlap, the counties within each of the three Project areas are described together to avoid duplication of Project area descriptions. The Wilder Project is located in Orange and Windsor counties, Vermont, and Grafton County, New Hampshire; the Bellows Falls Project is located in Windsor and Windham counties, Vermont, and Sullivan and Cheshire counties, New Hampshire; and the Vernon Project is located in Windham County, Vermont, and Cheshire County, New Hampshire. Collectively, these counties represent the Projects' socioeconomic analysis area.

3.11.1.1 Population and Demographics

Between 2000 and 2010, the total population increased across all counties in the Project areas, except Windsor County. Cheshire, Orange, Windham, and Windsor counties have grown more slowly than their respective states during the last 15 years. Orange County with 42 residents per sq. mi. is the least densely populated county within the Project areas, while Cheshire County with 109 residents per sq. mi. is the most densely populated. All six counties have lower population densities than their respective state's average overall population densities (U.S. Census Bureau, 2010; 2014b). Total county and state populations are shown in Table 3.11-1.

The closest communities to Wilder dam are the cities of Lebanon, New Hampshire, located 3 miles to the east with a population of 13,474 persons, and Hanover, New Hampshire, located 3 miles to the north with a population of 8,411 persons.

Several small communities are located near the Bellows Falls Project. The town of Rockingham, Vermont, has a population of almost 5,200 and includes the village of Bellows Falls. Other larger communities in the area include Springfield, Vermont, 11 miles north of the Bellows Falls dam and Charlestown, New Hampshire, about 7 miles north of the Bellows Falls dam.

The largest city within the portion of the Connecticut River affected by the Vernon Project is Brattleboro, Vermont, located approximately 6 miles to the north of Vernon dam. Brattleboro has a population of approximately 12,000. The city of Keene, New Hampshire, has a population of 23,300 and is located approximately 16 miles east of Vernon dam and 16 miles south of Bellows Falls dam. The communities of Vernon, Vermont, and Hinsdale, New Hampshire, are the closest communities to Vernon dam (U.S. Census Bureau, 2014b).

Table 3.11-1. Population trends in the Project areas, 1990–2014.

State/County	1990	2000	2010	2010–2014 5-Year[a] Average	% Change in Population (2000–2010)	% of State Population (2010–2014 average)	Population per Sq. Mi. (2010)
New Hampshire	**1,109,252**	**1,235,786**	**1,316,470**	**1,321,069**	**7**		**147**
Grafton	74,929	81,743	89,118	89,360	9	7	52
Sullivan	38,590	40,458	43,742	43,291	8	3	81
Cheshire	70,121	73,825	77,117	76,596	4	6	109
Vermont	**562,758**	**608,827**	**625,741**	**626,358**	**3**		**67**
Orange	26,149	28,226	28,936	28,927	3	5	42
Windsor	54,055	57,418	56,670	56,328	-1	9	58
Windham	41,588	44,216	44,513	44,050	1	7	57

Source: U.S. Census Bureau (2010, 2014b)

a. 2010–2014 5-year annual average data were obtained from U.S. Census 5-year American Community Survey statistics. These data, which show the average population over the 5-year period beginning in 2010 and ending in 2014, are more recent that than 2010 decennial census data but are presented as a 5-year average. American Community Survey data should not be directly compared against decennial census data, such as the data presented in columns 1990, 2000, and 2010 because they were collected under a different set of conditions than the decennial census. However, American Community Survey data are more recent and therefore relevant to present here.

3.11.1.2 Total Employment and Labor Force

Median household income is more than $10,000 less in Grafton County, New Hampshire, when compared to New Hampshire's median household income. Sullivan and Cheshire counties' income levels are only slightly higher than Grafton County's. Grafton County has the lowest median household income relative to its respective state's median household income of all the counties in the Project areas. The median household income in Orange and Windsor counties is only slightly lower than the median household income in the state of Vermont, while Windham County's median household income is approximately $4,000 lower than the state median.

The employed labor force in the counties in which the Projects are located was 172,952 on average annually between 2010 and 2014. The employed workforce in the three New Hampshire counties accounts for 15 percent of New Hampshire's workforce, and in the three counties in Vermont accounts for 21 percent of Vermont's employed workforce. Unemployment rates in these counties are approximately equal to or slightly higher than those in their respective states. Overall, the 6 counties in the Project area had an unemployment rate of 6.5 percent on average annually between 2010 and 2014 (U.S. Census Bureau, 2014c). Table 3.11-2 presents a summary of labor force and income figures.

Table 3.11-2. Average county and state labor force and income, 2010–2014.

Location	Civilian Labor Force	Employed	Unemployed	Percent Unemployed	Median Household Income (2010$)
New Hampshire	741,358	693,329	48,029	6	$65,986
Grafton County	47,498	44,957	2,541	5	$55,045
Sullivan County	23,425	21,860	1,565	7	$56,851
Cheshire County	42,854	39,483	3,371	8	$56,139
Vermont	346,979	325,336	21,643	6	$54,447
Orange County	16,274	15,341	933	6	$53,114
Windsor County	30,508	28,745	1,763	6	$53,610
Windham County	24,386	22,566	1,820	7	$50,526

Source: U.S. Census Bureau (2014c)

Of particular note in the Project area is the recent closure of VY near Vernon, Vermont, located in Windham County. In 2013, the plant supported 625 workers. However, power generation operations were suspended indefinitely in 2014, and decommissioning activities commenced in 2015, when the plant's workforce declined to 316 workers (MassLive, 2016). As of May 2016, around 150 workers remain at the plant. According to an economic analysis produced by the University of Massachusetts, the closure of VY "and the loss of its high-pay and benefits to workers will have a significant impact on the largely rural…region." The study found that approximately 1,186 direct, indirect, and induced jobs supported by the plant would be lost in the local region, amounting to more than $105 million in lost labor income (University of Massachusetts, Donahue Institute, 2014).

3.11.1.3 Jobs by Industry

Across all 6 counties, the educational services/healthcare/social assistance market accounted for between 29 and 34 percent of all jobs on average annually between 2010 and 2014. During this same period, Grafton, Sullivan, and Cheshire counties' next largest markets in terms of total jobs were manufacturing (10.2 percent, 19 percent, and 14.7 percent, respectively) and retail trade (11.2 percent, 12.4 percent, and 11.8 percent, respectively). Orange and Windsor counties' next largest market was retail trade (11.9 percent and 10.3 percent, respectively) followed by manufacturing (8.8 percent and 10.0 percent, respectively). Windham County's next largest market was manufacturing (10.0 percent) followed by retail trade (9.5 percent). The arts, entertainment, and recreation, and accommodation and food services market; construction market; and professional, scientific, and management, and administrative and waste management services market also made up sizeable portions of the remaining jobs in the Project areas' counties during this period (U.S. Census Bureau, 2014a). Table 3.11-3 presents jobs by industry.

3.11.2 Environmental Effects

The operation of the Projects has, and will continue to have, a positive effect on local economies in the area. TransCanada employs 28 people at the Wilder Project, including the Connecticut River Office in Lebanon, NH and the Renewable Energy Operations Center in Wilder, Vermont—3 maintenance technicians, 6 specialists, 14 operators, 2 engineers, 2 managers, and 1 administrative staff. TransCanada employs 14 people at the Bellows Falls Project, including the office in North Walpole, New Hampshire—8 maintenance technicians, 3 specialists, 2 managers, and 1 administrative staff. TransCanada employs 7 people at the Vernon Project—5 maintenance technicians, 1 specialist, and 1 manager. It is anticipated that this employment would continue without interruption. TransCanada also has a positive impact on local economies by its outside contracted services that are often locally sourced; by provision of recreational access and resources; and by property tax payments of over $2.37 million to municipalities for the Wilder Project, over $3.9 million for the Bellows Falls Project, and over $2.4 million for the Vernon Project, for a total of over $8.7 million annually.

Table 3.11-3. Jobs by industry, 2010–2014.

Industry	New Hampshire	Grafton, NH	Sullivan, NH	Cheshire, NH	Vermont	Orange, VT	Windsor, VT	Windham, VT
Civilian employed population 16 years and over	693,329	44,957	21,860	39,483	325,336	15,341	28,745	22,566
Agriculture, forestry, fishing and hunting, and mining	0.9%	1.7%	1.5%	1.1%	2.7%	3.1%	2.8%	2.2%
Construction	7.1%	6.9%	7.1%	7.9%	7.4%	9.5%	7.7%	9.1%
Manufacturing	12.7%	10.2%	19.0%	14.7%	10.7%	8.8%	10.0%	10.0%
Wholesale trade	3.0%	1.7%	2.7%	4.9%	2.1%	2.0%	2.3%	3.7%
Retail trade	12.6%	11.2%	12.4%	11.8%	11.6%	11.9%	10.3%	9.5%
Transportation and warehousing, and utilities	3.9%	2.9%	2.9%	4.0%	3.2%	3.6%	3.2%	4.0%
Information	2.1%	1.9%	1.7%	1.6%	1.9%	1.6%	2.0%	2.3%
Finance and insurance, and real estate and rental and leasing	6.4%	3.5%	4.9%	5.3%	4.7%	4.2%	4.4%	4.6%
Professional, scientific, and management, and administrative and waste management services	10.2%	8.6%	6.2%	5.9%	8.6%	7.2%	9.1%	7.5%
Educational services, and health care and social assistance	24.4%	33.6%	28.3%	28.2%	28.4%	30.7%	29.6%	29.5%
Arts, entertainment, and recreation, and accommodation and food services	8.5%	11.1%	6.4%	7.7%	9.2%	6.4%	11.1%	9.9%

Industry	New Hampshire	Grafton, NH	Sullivan, NH	Cheshire, NH	Vermont	Orange, VT	Windsor, VT	Windham, VT
Other services, except public administration	4.3%	3.3%	4.1%	4.2%	4.6%	5.3%	3.5%	4.9%
Public administration	3.9%	3.4%	2.7%	2.8%	4.9%	5.6%	4.0%	2.8%

Source: U.S. Census Bureau (2014a)

Because TransCanada does not propose to construct new facilities, construction effects and economic effects from construction-related spending will not change. Project operations and maintenance will continue as normal because TransCanada does not propose changes to operations. Operation of the three Projects will continue to support current employment associated with the Projects and will continue to support current recreation opportunities encouraging visitation to the Projects and Project areas. Both those employed by TransCanada, contractors used for routine work, and visitors to the Projects will continue to support the local economy as a result of their spending, which will further support additional jobs, income, and sales in the Project areas.

3.11.3 Proposed Protection, Mitigation, and Enhancement Measures

TransCanada is not proposing any new PM&E measures related to socioeconomic resources.

3.11.4 Unavoidable Adverse Effects

No unavoidable adverse effects on socioeconomics were identified in the environmental analysis; however, socioeconomic effects that create an environmental benefit include:

- TransCanada's direct employment and outside contracted services;
- Recreational opportunities;
- Local property tax payments; and
- Provision of dispatchable renewable power, which also supports variable energy resources through reserve capacity (both of which displace fossil-fired generation and reduce power plant emissions), as well as ancillary services from hydropower generation.

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4. DEVELOPMENTAL ANALYSIS

This section analyzes the cost of continued operation and maintenance of the Wilder, Bellows Falls, and Vernon Projects under the no-action and proposed alternatives. Costs are associated only with the operation and maintenance of the hydropower facilities because TransCanada does not propose new protection, mitigation, and enhancement measures beyond those already in place. The costs are presented in 2015 dollars unless otherwise noted.

4.1 Power and Economic Benefits for the Projects

4.1.1 Economic Assumptions

Under its approach to evaluating the economics of hydropower projects as articulated in Mead Corporation, Publishing Paper Division (72 FERC ¶ 61,027, July 13, 1995), FERC employs an analysis that uses current costs to compare the costs of a project and likely alternative power with no consideration for potential future inflation, escalation, or deflation beyond the license issuance date. FERC's economic analysis provides a general estimate of the potential power benefits and costs of a project and reasonable alternatives to project-generated power. The estimate helps to support an informed decision concerning what is the public interest with respect to a proposed license. For the economic analysis of the Wilder, Bellows Falls, and Vernon Projects, financial parameters common to all Projects are shown in Table 4-1.

For the economic analysis of the Wilder, Bellows Falls, and Vernon Projects, financial parameters specific to each Project are shown in Tables 4-2, 4-3, and 4-4, respectively.

Table 4-1. Parameters for economic analysis common to all Projects.

Assumption	Value	
Period of economic analysis (years)	30 year	
Term of financing (years)	20 year	
Cost of capital (long-term interest rate)	8%	
Short-term interest rate (during construction)	5.5%	
Discount rate	8%	
Federal tax rate	35%	
Energy rate ($/MWh) 2015, averaged monthly real-time energy price for Wilder, Bellows Falls, and Vernon	$41.45/MWh	
Capacity rate ($/kW-year) (the 6th Forward Capacity Auction's [FCA #6] [a] rest of pool capacity price for all three Projects)	$41.16/MWh	
Ancillary services value	**Market Values 2015—Wilder**	
	Forward capacity	$1,428,539
	Real-time reserves	$379,359
	VAR support	$32,400
	Market Values 2015—Bellows Falls	
	Forward capacity	$1,684,692
	Real-time reserves	$433,078
	VAR support [b]	$23,748
	Market Values 2015—Vernon	
	Forward capacity	$1,110,637
	Real-time reserves	$298,477
	VAR support [b]	$15,216
	RECs	$1,958,805

a. The FCA #6 capacity rate is the actual (published) 2015 capacity clearing price or rate for the current period.

Table 4-2. Parameters for the economic analysis of the Wilder Project.

Assumption	Value
Project [authorized] capacity (MW)	35.6 MW
10-year (2006–2015) Average annual generation (MWh/year)	166,454 MWh/year
Annual operating and maintenance cost ($/year), 2016	$1,510,000/year
Cost to prepare license application ($)	$3,500,000
Insurance ($/year)	$498,000/year
Local tax rate (based on fiscal year 2015/16)	Wilder Project's effective averaged tax rate is $28.15 per $1,000 on an accumulated assessment of $84,209,900 in 12 towns, resulting in a tax liability of $2,370,233.00
Annual depreciation and amortization expense	$1,430,000
Dependable capacity (kW) ISO-NE average summer-winter capacity supply obligation for the FCA #10 [a]	43,400 kW

a. The FCA #10 is the latest auction for 2019-2020 that TransCanada has participated in, and obligated generation into.

Table 4-3. Parameters for the economic analysis of the Bellows Falls Project.

Assumption	Value
Project [authorized] capacity (MW)	40.8 MW
10-year (2006–2015) Average annual generation (MWh/year)	258,366 MWh/year
Annual operating and maintenance cost ($/year)	$1,761,000/year
Cost to prepare license application ($)	$3,500,000
Insurance ($/year)	$581,000/year
Local tax rate (based on fiscal year 2015/16)	Bellows Falls Project's effective averaged tax rate is $32.13 per $1,000 on an accumulated assessment of $121,847,803 in 10 towns, resulting in a tax liability of $3,915,390.00
Annual depreciation and amortization expense	$1,668,000
Dependable capacity (kW) ISO-NE average summer-winter capacity supply obligation for the FCA #10 [a]	49,000 kW

a. The FCA #10 is the latest auction for 2019-2020 that TransCanada has participated in, and obligated generation into.

Table 4-4. Parameters for the economic analysis of the Vernon Project.

Assumption	Value
Project [authorized] capacity (MW)	32.4 MW
10-year (2006–2015) Average annual generation (MWh/year)	156,578 MWh/year
Annual operating and maintenance cost ($/year)	$1,186,000/year
Cost to prepare license application ($)	$3,500,000
Insurance ($/year)	$392,000/year
Local tax rate (based on fiscal year 2015/16)	Vernon Project's effective averaged tax rate is $22.92 per $1,000 on an accumulated assessment of $106,489,191 in 8 towns, resulting in a tax liability of $2,440,833.00
Annual depreciation and amortization expense	$1,123,000
Dependable capacity (kW) ISO-NE average summer-winter capacity supply obligation for the FCA #10 [a]	32,000 kW

a. The FCA #10 is the latest auction for 2019-2020 that TransCanada has participated in, and obligated generation into.

4.2 Comparison of Alternatives

Tables 4-5, 4-6, and 4-7 compare the power value, annual costs, and net benefits of each project under the no-action alternative, which is the same as TransCanada's Proposed Action.

4.2.1 Wilder Project under the No-action Alternative and TransCanada's Proposed Action

Under the no-action alternative and TransCanada's Proposed Action, the Wilder Project will continue to operate as it currently operates. The Project has an installed capacity of 35.6 MW and generates an average of 166,454 MWh of electricity annually. The average annual cost of alternative power value under the no-action alternative will be $8,739,816.30, or $52.51/MWh. The average annual Project cost will be $3,606,000.00 or $21.66/MWh. Overall, the Project will produce power at a cost that is $5,133,816.30, or $30.84/MWh less than the cost of alternative power.

Table 4-5. Summary of the annual cost of alternative power and annual project costs for the Wilder Project under the No-action Alternative and TransCanada's Proposed Action.

Item	No-action Alternative and TransCanada's Proposed Action
Annual generation (MWh)	166,454 MWh
Annual cost of alternative power	
$/year	$8,739,816.30
$/MWh	$52.51/MWh
Annual project cost	
$/year	$3,606,000.00
$/MWh	$21.66/MWh
Difference between the cost of alternative power and project cost	
$/year	$5,133,816.30
$/MWh	$30.84/MWh

4.2.2 Bellows Falls Project under the No-action Alternative and TransCanada's Proposed Action

Under the no-action alternative and TransCanada's Proposed Action, the Bellows Falls Project will continue to operate as it currently does. The Project has an installed capacity of 40.8 MW and generates an average of 258,366 MWh of electricity annually. The average annual cost of alternative power value under the No-action Alternative will be $12,824,952.00, or $49.64/MWh. The average annual Project cost will be $4,207,000.00, or $16.28/MWh. Overall, the Project will produce power at a cost that is $8,617,952.00, or $33.36/MWh less than the cost of alternative power.

Table 4-6. Summary of the annual cost of alternative power and annual costs for the Bellows Falls Project under the No-action Alternative and TransCanada's Proposed Action.

Item	No-action Alternative and TransCanada's Proposed Action
Annual generation (MWh)	258,366 MWh
Annual cost of alternative power	
$/year	$12,824,952.00
$/MWh	$49.64/MWh
Annual project cost	
$/year	$4,207,000.00
$/MWh	$16.28/MWh
Difference between the cost of alternative power and project cost	
$/year	$8,617,952.00
$/MWh	$33.36/MWh

4.2.3 Vernon Project under the No-action Alternative and TransCanada's Proposed Action

Under the No-action Alternative and TransCanada's Proposed Action, the Vernon Project will continue to operate as it does now. The Project has an installed capacity of 32.4 MW and generates an average of 156,578 MWh of electricity annually. The average annual cost of alternative power value under the No-action Alternative will be $9,873,293.10, or $63.06/MWh. The average annual Project cost will be $2,833,000.00, or $18.09/MWh. Overall, the Project will produce power at a cost that is $7,040,293.10, or $44.96/MWh less than the cost of alternative power.

Table 4-7. Summary of the annual cost of alternative power and annual project costs for the Vernon Project under the No-action Alternative and TransCanada's Proposed Action.

Item	No-action Alternative and TransCanada's Proposed Action
Annual generation (MWh)	156,578 MWh
Annual cost of alternative power	
$/year	$9,873,293.10
$/MWh	$63.06/MWh
Annual project cost	
$/year	$2,833,000.00
$/MWh	$18.09/MWh
Difference between the cost of alternative power and project cost	
$/year	$7,040,293.10
$/MWh	$44.96/MWh

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5. CONCLUSIONS

5.1 Environmental Measures

Section 2.1 provides details on existing environmental measures that TransCanada implements at the Wilder, Bellows Fall, and Vernon Projects. These measures include:

- Minimum flow provisions that are higher than licensed minimum flows;
- Limited impoundment water level fluctuations during normal operations;
- Flooding reduction impoundment operating procedures during natural high flows;
- Impoundment drawdown rate limitations;
- Operation and maintenance of recreational facilities providing river access;
- Flows providing whitewater boating and angling opportunities;
- Undeveloped Project lands open to public providing wildlife and fishery habitat; and
- Upstream and downstream passage facilities.

5.2 Unavoidable Adverse Effects

This section summarizes information presented in the various resource sections of Chapter 3, *Environmental Analysis*. Because TransCanada is not proposing any changes in Project operations, any unavoidable adverse effects would be those identified and related to current Project operations.

5.2.1 Geology and Soils

As discussed in Section 3.3.2, *Environmental Effects, Geologic and Soil Resources*, the normal Project operations that contribute to notching and overhangs that characterize the initial stages in the cycle of erosion are unavoidable, but contribute only a small fraction of the total sediment transported and deposited by the Connecticut River within the impoundments. High natural flows that cannot be controlled or managed by Project operations do affect sedimentation and/or sediment transport in the impoundments and play a much larger role in causing unavoidable adverse effects on other resources such as protected species, aquatic and wetland habitats, or cultural resources discussed in Sections 3.4–3.10. However, as discussed in those sections, the effects caused by Project operational flows and impoundment fluctuations appear to be minimal to none in most cases.

There do not appear to be any adverse effects caused by Vernon Project operations and maintenance on the narrow neck of land known as the Vernon Neck which separates the Vernon impoundment from the tailwater. There is a vegetation management plan in place that limits the growth of potentially dangerous trees and allows regular inspection of this area. No erosion is evident. Surveys have been conducted periodically showing minor changes to the toe of the downstream slope.

5.2.2 Water Resources

Project operations will continue to alter flows in the Connecticut River, resulting in unavoidable adverse effects on some fish and aquatic resources, some terrestrial resources, and potentially cultural and historic resources. Several factors constrain TransCanada's ability to significantly alter flow management over the existing and proposed operational regime, which in turn constrains the ability to alter existing unavoidable effects on other resources. These factors include:

- The amount and timing of water available as a function of upstream inflow and intermediate drainage flow. A portion of this inflow is subject to regulation and can be limited or currently augmented above natural flows during low flow periods, from upstream storage reservoirs.
- Limited generation flow capacity above which spill must occur;
- Safety and flood control operations, which are required during periods of high flows;
- Normal operations, which use only a portion of the overall impoundment storage capacity; and
- Limited impoundment storage, which necessitates spilling rather than storage of available inflows that exceed Project generating capacities.

As discussed in Section 3.4.2.2, E*nvironmental Effects, Water Quality*, the amount of warming (water temperature increases) that will occur as water flows from upstream areas to the Project dams will depend primarily on natural prevailing weather conditions and latitudinal variation. At times, the amount of warming can exceed Vermont's temperature standard (>1°F), especially over the long longitudinal distance from the upstream riverine area to each Project dam and due to larger diurnal temperature changes at upstream riverine reaches. This effect will reflect existing conditions, i.e., short term with limited or negligible impacts.

Stratification of the Project impoundments will occur if weather conditions are conducive, as they were in 2012. Stratification of the Project impoundment can result in depleted DO levels in the hypolimnion, particularly in the forebay, and can fall below state surface water quality standards. Depressed DO levels in the forebays of the Projects will stress aquatic life. However, waters will become oxygenated above state standards as water passes through the Project powerhouses; therefore, the effect of low DO will be confined in the forebay and not affect downstream reaches. Any unavoidable adverse effects related to lower DO in the hypolimnion will be brief, confined to forebay areas, and have limited or negligible impacts.

5.2.3 Fish and Aquatic Resources

As discussed in Section 3.5.2, *Environmental Effects, Fish and Aquatic Resources*, some minor adverse effects from normal Project operations will continue to occur under new licenses, including dewatering of some fish eggs or nests during the spawning season for some resident species and for migratory species such as Sea Lamprey. The level of adverse effects varies depending on the water year as suggested by Study 5 modeling output, but overall these effects are small for most fish species. Some injury or mortality to downstream migrating American Eels and American Shad will continue to occur through impingement, entrainment, or turbine mortality, although these effects are generally small.

5.2.4 Terrestrial Resources

Normal Project operations have few adverse effects on current terrestrial wildlife and botanical resources in the Project areas. However, Studies 25, 26, 27, 28, and 29 identified some minor effects and/or inconclusive results (Section 3.6.2, *Environmental Effects, Terrestrial Resources*). Normal recreation area maintenance or construction maintenance activities could potentially affect some terrestrial species or their habitats on a limited and/or localized basis.

5.2.5 Threatened and Endangered Species

Normal Project operations have no identified adverse effects on current federally threatened or endangered terrestrial species that are located in the Wilder, Bellows Falls, and Vernon Project areas and were evaluated in this environmental analysis. Dwarf wedgemussel is the only federally listed aquatic species known to be present within the Project areas. Once assessment of the effects of Project operations is completed, unavoidable adverse effects, if any, will be identified in the FLAs.

5.2.6 Recreation and Land Use

No unavoidable adverse effects on recreation or land use were identified in the environmental analysis. As discussed in Section 3.8.2, *Environmental Effects, Recreation Resources and Land Use*, TransCanada evaluated alternatives for canoe portages at each Project and evaluated the potential for whitewater boating in the Bellows Falls bypassed reach. In all cases, alternatives were determined to be impractical, unsafe, or not feasible. TransCanada owns very little land around the impoundments beyond the property required to operate the dams, powerhouses, and accompanying transmission facilities, and various parcels adjacent to those facilities that include backwatered wetlands and floodplain terraces that are kept as natural areas or to support agriculture.

5.2.7 Aesthetics

No unavoidable adverse effects on aesthetics were identified in the environmental analysis.

5.2.8 Cultural and Historic Resources

TransCanada does not propose to change the Projects or operations or maintenance of the Projects, so unavoidable adverse effects on any known historic property or TCPs are not expected. If a future undertaking is determined to have potential adverse effects on a historic property, the consultation process established in the HPMPs will be followed to resolve those effects. The process to establish measures to avoid, minimize, or mitigate adverse effects to historic properties is defined in Section 106 of the NHPA. In accordance with those regulations, TransCanada will consult with the VTSHPO and NHSHPO to determine whether Project-related effects are adverse. In the event that that the relicensing and continued operations and maintenance of the Projects is determined to have an adverse effect on historic properties, TransCanada will consult with the VTSHPO, NHSHPO, FERC, and other consulting parties such as Tribes to seek ways to avoid, minimize, or mitigate the effect through the development of HPMPs for each Project.

5.2.9 Socioeconomics

No unavoidable adverse effects on socioeconomics were identified in the environmental analysis; however, socioeconomic effects that create an environmental benefit include:

- TransCanada's direct employment and outside contracted services;
- Recreational opportunities;
- Local property tax payments; and
- Provision of dispatchable renewable power which also supports variable energy resources through reserve capacity (both of which displace fossil-fired generation and reduce power plant emissions), as well as ancillary services from hydropower generation.

5.3 Consistency with Comprehensive Plans

Section 10(a) (2) of the FPA requires TransCanada to review applicable federal and state comprehensive plans, and to consider the extent to which the Projects are consistent with the federal or state plans for improving, developing, or conserving a waterway or waterways affected by the Project. A list of existing FERC-approved State of New Hampshire, State of Vermont, and federal comprehensive plans was provided in FERC's SD2 and updated in October 2016. [41] Of those listed, TransCanada identified and reviewed the following 34 plans that are pertinent to one or more of the Projects. No inconsistencies were found.

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6. CONSULTATION DOCUMENTATION

TransCanada has engaged in consultation with relicensing participants throughout the ILP process to date, from prior to filing of the NOIs and PADs through scoping and study plan development, during study implementation, in study report meetings, and during public comment periods. TransCanada has filed all related licensing materials with FERC. Names and addresses for federal, state, and interstate resource agencies, Indian tribes, and members of the public with which TransCanada has consulted during relicensing up to FLA filing will be included in the FLAs in accordance with 18 C.F.R. §5.18(b)(5)(ii)(G).

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