TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 26
Cobblestone and Puritan Tiger Beetle Survey

Study Report

CLASSIFICATION - PUBLIC

In support of Federal Energy Regulatory Commission Relicensing of:

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

Prepared for

TransCanada Hydro Northeast Inc.
4 Park Street, Suite 402
Concord, NH 03301

Prepared by

Normandeau Associates, Inc.
25 Nashua Road
Bedford, NH 03110

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EXECUTIVE SUMMARY

Puritan and cobblestone tiger beetles have historically sustained populations on the Connecticut River in New Hampshire and Vermont. Both species have extremely restricted habitat. The Puritan tiger beetle prefers patches of fine sand and historically sustained one population in Claremont, NH and one in Charlestown, NH (Hill and Knisley, 1993) within the Bellows Falls project-affected area, according to TransCanada's project boundary maps. One additional population was historically found on the Connecticut River in Hartland, VT, but according to TransCanada's project boundary maps, it was outside of the project-affected area (Hill and Knisley, 1993).

The cobblestone tiger beetle is found on cobble and gravel beaches where vegetation is present but sparse. Prior to this study, six sites known to support this species had been documented within the project-affected area between Johnston Island in the riverine section below Wilder Dam, and Walpole Island within the riverine section downstream of Bellows Falls dam. The goal of this study was to conduct a field survey to detect and gather information on known and new Puritan and cobblestone tiger beetle populations along the Connecticut River throughout the project-affected area and to determine the potential effects of project operations (including recreational activities) on these species.

Due to the lack of any recent Puritan tiger beetle observations in the study area and the scarcity of appropriate habitat, site selection focused on cobblestone tiger beetle habitat. Thirteen sites within the project-affected area were selected for survey based on habitat characteristics. Three separate searches were conducted during the adult flight period in early July, late July, and mid-August, 2014. Two biologists equipped with close-focus binoculars and aerial nets searched each survey location for one person-hour under sunny, humid conditions when adult tiger beetles were likely to be most active. When target species were observed, scientists noted habitat type, observed behavior, and photographed the individual when possible. Scientists also searched for arthropod burrows in the survey area and collected detailed information about available habitat at each site.

Adult cobblestone tiger beetles were positively identified with high certainty at seven of the 13 survey sites. No cobblestone tiger beetles were observed during surveys with starting temperatures less than 23°C, but neither wind speed, cloud cover, nor time of day appeared to affect their presence/absence. Average cobble size ranged from 5-8 cm at all sites with multiple cobblestone tiger beetle observations, and the species was absent at most sites with cobble size averaging either smaller or larger than this range. Finally, analysis of hydraulic and operations modeling outputs (from Studies 4 and 5) suggest that some sites with cobblestone tiger beetle observations experienced occasional but infrequent complete habitat inundation and most sites experienced frequent partial habitat inundation. Based on this analysis it can be concluded that normal project operations are likely have little effect on the fitness of current cobblestone tiger beetle populations.

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LIST OF ABBREVIATIONS

FWS	U.S. Department of the Interior-Fish and Wildlife Service
LHER	Larval habitat elevation range
NHFGD	New Hampshire Fish and Game Department
RTK	Real Time Kinematic
RSP	Revised Study Plan
SGCN	Species of Greatest Conservation Need
TransCanada	TransCanada Hydro Northeast Inc.
VANR	Vermont Agency of Natural Resources
VDFW	Vermont Department of Fish and Wildlife
WSE	Water surface elevation

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1.0 INTRODUCTION

In its study request, Vermont Agency of Natural Resources (VANR) identified potential issues associated with Wilder, Bellows Falls, and Vernon project operations on two species of tiger beetle. One of these species, the Puritan tiger beetle (*Cicindela puritana*), is listed as threatened federally and in the State of Vermont. It is listed as endangered in the State of New Hampshire. The cobblestone tiger beetle (*Cicindela marginipennis*) is listed as threatened in both New Hampshire and Vermont.

Specifically, potential habitat disturbance, alteration, and loss, as well as sedimentation due to flooding or inundation could negatively affect these species. TransCanada conducted this Cobblestone and Puritan Tiger Beetle Survey to detect and gather information on known and new cobblestone tiger beetle and Puritan tiger beetle populations along the Connecticut River throughout the Wilder, Bellows Falls, and Vernon project-affected areas.

The cobblestone tiger beetle has been found in the vicinity of the projects on the Connecticut River with existing records spanning from Walpole Island to Johnston Island (see Table 3.1). A previous record also exists as far south as the West River, but that record is just outside the defined influence of project operations on the Connecticut River. A new West River site, approximately 0.5 mile downstream of the existing record was also surveyed during this study.

The cobblestone tiger beetle has an extremely restricted habitat and is found on cobble and gravel beaches on medium and large rivers (Leonard and Bell, 1998). Adults inhabit areas of cobble, gravel, and sand where vegetation is sparse. Often, this habitat is found on river edges and the upstream side of riverine islands where the river deposits small to medium-sized cobble in times of high flow. The larvae may dig burrows in wet sand found interspersed among cobblestones (Pearson et al., 2006), but little data are available to confirm cobblestone tiger beetle burrowing habitat preferences since the burrows are difficult to find and larvae have not been taxonomically described (Leonard and Bell, 1998).

The Puritan tiger beetle has been historically documented in the vicinity of the study area. The distribution of Puritan tiger beetle, both historical and current, is restricted to two disjunct regions, the Chesapeake Bay in Maryland and the Connecticut River in New England. The historical distribution in New England included locations on the Connecticut River that extended from Claremont, NH, to Cromwell, CT. Puritan tiger beetle was considered extirpated from nine of these sites in 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-affected area from one site in Claremont, NH and one site in Charlestown, NH (Hill and Knisley, 1993). A single Vermont siting was historically documented along the Connecticut River in the Town of Hartland, despite intense searching by tiger beetle experts, no occurrences have been found upstream of Hadley, MA in the past 25 years (Hill and Knisley, 1993).

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 mm [Omland, 2002]). In some instances, suitable habitat may be embedded in wide beaches (e.g., Northampton, MA) but in other instances, the beach may be quite narrow (e.g., 4 to 6 meters in Cromwell, CT). 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) performed a genetic analysis of individuals from the two regions and concluded that the occurrences on the Connecticut River "have to be considered as independent units."

Project operations and land uses have the potential to cause direct adverse effects on tiger beetle populations through effects on the buried egg and pupal stages and on the fossorial larval stage. Direct effects on adult beetles are unlikely due to their vagility. Threats to larval habitat are primarily due to vegetative succession mediated by diminished erosion and deposition dynamics. Inundation may not affect buried life stages because tiger beetles have adapted to tolerate some submersion, but the extent of this tolerance is species-dependent (Brust and Hoback, 2005). It is also likely that larvae dwell at higher elevations than the daily inundation zone on riverbanks (Omland, 2002). However, if regular inundation exceeding the tolerance limits of the target species occurs, it could have adverse effects on populations.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study was to conduct a survey to detect and gather information on known and new cobblestone tiger beetle and Puritan tiger beetle populations along the Connecticut River throughout the project-affected areas, from the upper extent of the Wilder impoundment to approximately 1.5 miles downstream of Vernon dam; and to determine the potential effects of project operations on these two species of tiger beetles.

The objectives of this study were to:

- Obtain baseline distributional and abundance data and map occurrences of cobblestone and Puritan tiger beetle populations along the Connecticut River throughout the project-affected areas;
- Define the particular habitat requirements of each species;
- Assess the vulnerability of each species to disturbances such as siltation, flow fluctuations, and changes in shoreline composition and vegetation;
- Identify areas where suitable habitat may exist for these tiger beetle species and the portions of those habitats affected by project operations; and
- Assess whether project operations are adversely affecting the survival success of adult and larval cobblestone and Puritan tiger beetles.

The Revised Study Plan (RSP) for this study as supported by stakeholders in 2013, was approved without modification in FERC's September 13, 2013 Study Plan Determination.

3.0 STUDY AREA

The study area encompassed the Wilder, Bellows Falls, and Vernon impoundments and riverine reaches below each dam. Thirteen sites were selected based on the existence of previous or historic cobblestone tiger beetle records, selection of potential habitat using aerial photos, and confirmation of suitable habitat during field reconnaissance: Mascoma River, Johnston Island, Burnaps Island, Hart Island, Sumner Falls, Chase Island, Claremont Island, Ascutney Riverbank, Sugar River (habitat patches on both sides of Connecticut River), Jarvis Island, Saxtons River, Walpole Island, and West River (Table 3.1; Figure 3.1). Privileged locational information is included in Appendix C of the Privileged version of this report.

Table 3.1. Sites surveyed for cobblestone tiger beetles.

Site ID#	Site Name	Site Location	Area (acres)	Last Observation
26-01	Mascoma River	Wilder Riverine	0.48	n/a
26-02	Johnston Island	Wilder Riverine	0.44	2007
26-03	Burnaps Island	Wilder Riverine	1.19	1993
26-04	Sumner Falls	Wilder Riverine	0.45	1996
26-05	Hart Island	Wilder Riverine	1.75	2007
26-06	Chase Island	Bellows Falls Impoundment	1.68	2006
26-07	Claremont Island	Bellows Falls Impoundment	0.04	n/a
26-08	Ascutney Riverbank	Bellows Falls Impoundment	0.15	n/a
26-09a	Sugar River-VT	Bellows Falls Impoundment	0.18	n/a
26-09b	Sugar River-NH	Bellows Falls Impoundment	0.14	n/a
26-10	Jarvis Island	Bellows Falls Impoundment	0.40	n/a
26-11	Saxtons River	Bellows Falls Riverine	0.50	n/a
26-12	Walpole Island	Bellows Falls Riverine	0.61	2003
26-13	West River	Vernon Impoundment	0.58	2013[1]

[1] Original site is still present but 600 meters upstream of Study 26 survey site.

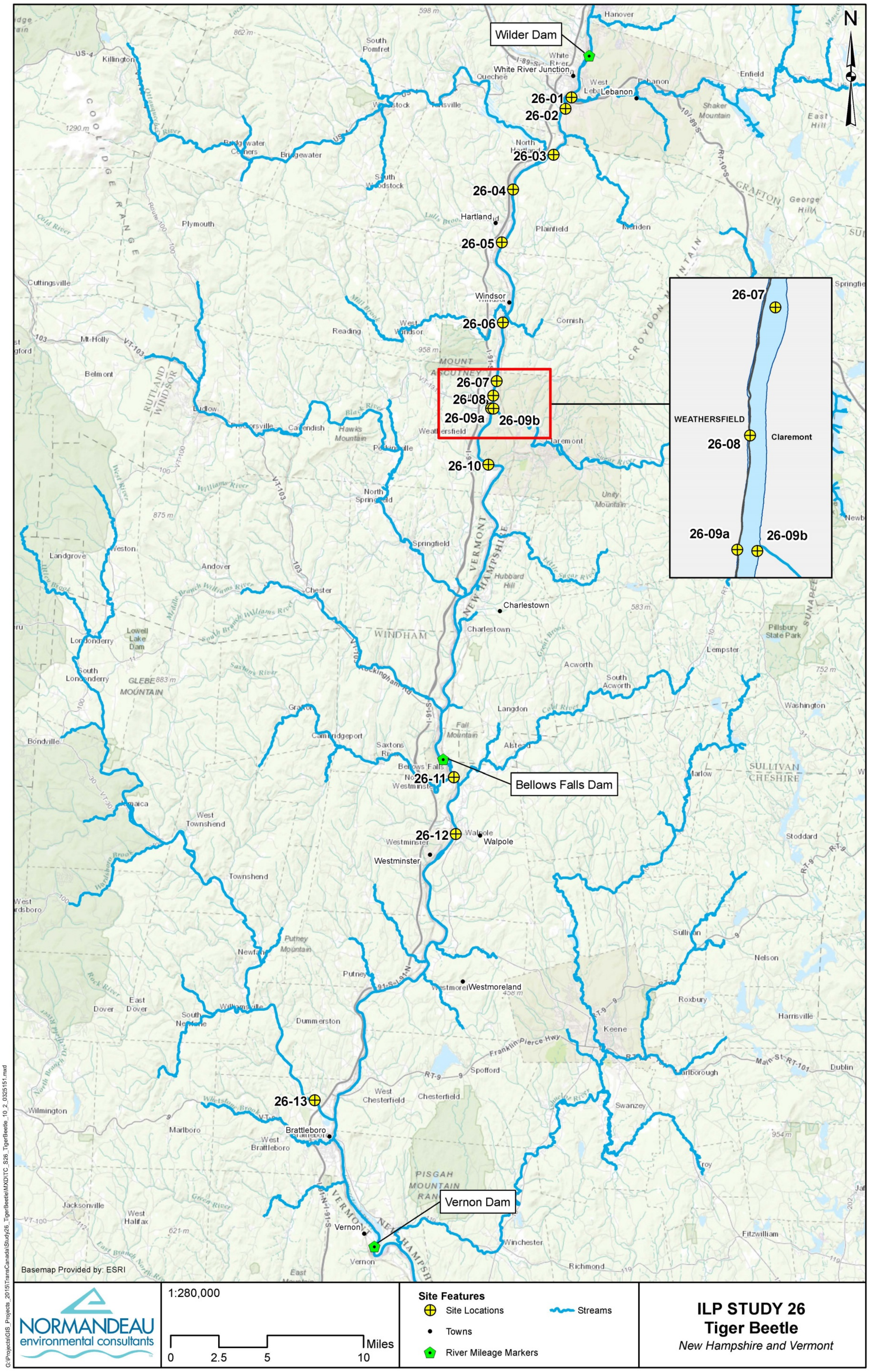

Figure 3.1. Cobblestone tiger beetle study sites.

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4.0 METHODS

4.1 Refinement of Study Plan

The RSP for Study 26 specified surveys for both cobblestone tiger beetle and Puritan tiger beetle and intense search efforts for larval use of survey sites including excavation of burrows and laboratory identification of larval specimen. During the site selection and permit acquisition process in the spring of 2014, the study plan underwent several necessary revisions. On June 30, 2014, the U.S. Fish and Wildlife Service (FWS), New Hampshire Fish and Game Department (NHFGD), and Vermont Department of Fish and Wildlife (VDFW) were notified by email of needed adjustments to the study field schedule and scope, as described below.

- The RSP described sampling one time per month in mid-June, mid-July and early August. The study plan adjustment retained three sampling events but condensed them into the period from early July into mid-August. The state records for cobblestone tiger beetle all indicated observations between July 7 and August 28. Dr. Kristian Omland, a recognized expert in cobblestone tiger beetles who contributed to the development of the study plan and field work, concurred with delaying the start of the survey period until the second week in July. Dr. Omland has no record of cobblestone tiger beetle in Vermont prior to July 8. The study adjustment proposed beginning the field surveys after that date and subsequently sampling every two weeks until mid-August.
- The RSP described sampling 30 minutes for adults and 30 minutes for larval burrows. The sample approach adjustment focused on adults because the cobblestone tiger beetle larvae and their burrows have not been scientifically described. Field biologists were unable to distinguish burrows or larvae from other tiger beetles, including the common shore tiger beetle, which appears to be ubiquitous on the Connecticut River. The adjusted study plan increased the survey time for adults to a 60 person-minute survey at each site and provided for a qualitative estimate of the number of tiger beetle burrows.
- The RSP described collecting cobblestone tiger beetle larvae if more than 10 burrows were identified. Per requests from VDFW and NHFGD, the study was adjusted to exclude collection of larvae. Because they have not been scientifically described, larval collection would not aid positive identification of cobblestone tiger beetle and would unnecessarily diminish the population.
- The RSP described sampling for the federally-threatened Puritan tiger beetle. No Puritan tiger beetles have been observed since 1932 within the study area, despite multiple surveys since that date (Hill and Knisley, 1993). The FWS did not issue a collection permit for Puritan tiger beetles for this study because of the low likelihood of our finding this species (S. von Oettingen, FWS, email dated April 15, 2014). The study adjustment concentrated the site selection on cobblestone tiger beetle because of the higher probability of

locating this species, but scientists still thoroughly searched any appropriate Puritan tiger beetle habitat within the chosen survey sites.

4.2 Site Selection

Thirteen sites were selected for the study. Six of these sites were locations with previous state records (Table 3.1 above), and survey site 26-01 (Mascoma River) was specifically requested by VANR. In order to select the remaining six survey locations, scientists remotely identified areas of interest focusing on mainstem islands, cobble collected at the mouths of tributaries, and cobble collected on riverbanks. They performed site visits to assess habitat suitability in the field and used this data to finalize survey site selection.

In order 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 cobblestone tiger beetle habitat. Areas of interest contained appropriate cobble substrate and sparse vegetation. Particular attention was paid to upstream-facing sections of islands, river edges lacking steep slopes, and tributaries with appropriate habitat and/or previous cobblestone tiger beetle records beyond the study area.

Field reconnaissance occurred from June 23 - July 1, 2014. Potentially suitable areas were visited by boat or on foot to examine habitat features and access logistics. In addition, previous record locations were examined for larval burrows and adult specimens. During reconnaissance, no cobblestone tiger beetles were observed, but it was early in the summer and heat/humidity had not yet reached ideal conditions (Dr. Kristian Omland, personal communication). Site selection was finalized in early July, 2014. Prior to conducting the field surveys, endangered species collection permits were obtained from VDFW and NHFGD for the cobblestone tiger beetle.

4.3 Field Surveys

Three separate searches (as recommended by Hudgins, 2012) were conducted during the adult flight period in early July, late July, and mid-August. Due to inconsistent weather conditions and access complications (e.g., low flows, rough waters, poor survey conditions) Burnaps Island and Chase Island were each surveyed once in early September. One marginal site (Saxtons River, Site 26-12) was visited only twice. For each search, two or three biologists equipped with close-focus binoculars and aerial nets searched each survey location for one person-hour. Searches were conducted by walking along each beach or cobble bar in a serpentine pattern until the area was completely searched (Hudgins et al., 2011). Once the entire habitat area had been walked, scientists focused efforts on searching ideal micro-habitats specific to each study site and locations where the target species had previously been observed.

Searches were conducted under sunny, humid conditions generally from 10:00-16:00 when adult tiger beetles are most active. Searchers noted the presence of adult cobblestone tiger beetles and other tiger beetles, predominantly the Common Shore Tiger Beetle (*Cicindela repanda*), but also occasionally the Six-Spotted Tiger Beetle and the Punctured Tiger Beetle (*C. sexguttata* and *C. punctulata,* respectively). Abundance was recorded as the number of observations per person-hour but since the survey sites had very different areas the percentage of individuals present that were counted likely varied widely between sites and since beetles take flight, double-counting may have occurred. When a cobblestone tiger beetle was observed, scientists noted habitat type, observed behavior, and photographed the individual when possible (see examples in Appendix A). Occasional individuals of the target species were netted to confirm and document identification. Individuals of the target species observed after the allotted survey time were noted separately.

Searchers also noted any active or inactive arthropod burrows observed at the site. Grass stems were occasionally used to probe active tiger beetle burrows, measure burrow depth, and estimate angle relative to vertical.

4.4 Habitat Assessment

Field staff conducted one detailed habitat assessment at each survey site. Substrate, vegetative cover, land use, and other pertinent habitat information was recorded on field data sheets (Appendix B). To characterize and quantify cobble size, field staff selected five representative one-square-meter quadrats. In each quadrat, 10 random pieces of gravel or cobble were selected and the longest axis of each piece was measured and recorded. The surveyor then noted percent cover of woody, herbaceous, and invasive vegetative cover in each quadrat. Apparent suitable habitat at each survey site was delimited using a GPS unit capable of sub-meter accuracy. The elevation range was delineated using a Real Time Kinematic (RTK)-GPS in 2015 during the course of other field studies.

5.0 RESULTS AND DISCUSSION

During surveys conducted between July and September 2014, the cobblestone tiger beetle was found to be widely distributed throughout the study area. Appropriate habitat and survey observations of cobblestone tiger beetle were most common between Hartland and Westminster, Vermont.

Adult cobblestone tiger beetles were positively identified with high certainty at seven of the 13 survey sites (Table 5.1). Searchers found them at least once at each of the five previously recorded sites, once at the West River tributary (Site 26-13) downstream from a previous record, and at one new location along the Ascutney riverbank (Site 26-08). At two survey sites, Hart Island (Site 26-05) and Walpole Island (Site 26-12), cobblestone tiger beetles were observed during all three survey visits between July and August. Scientists found the target species during two surveys at Johnston Island (Site 26-02), Burnaps Island (Site 26-03) and Ascutney riverbank (Site 26-08) and during one survey at Chase Island (Site 26-10) and the West River (Site 26-13). The target species was not observed during the two surveys performed on September 4, 2014 (See Section 4.3), which was potentially just outside the optimal adult flight period.

Scientists observed reproductive behavior (adults clasping) at four survey sites (Table 5.1). However, presence of cobblestone tiger beetle burrows could not be confirmed within the scope of this study. Neither the burrows nor the larval stage of this species are described in current scientific literature. All tiger beetle burrows observed during this study fit the description of common shore tiger beetle burrows (see Appendix A) which were observed at the NH Sugar River site (Site 26-09b), West River (Site 26-13), Johnston Island (Site 26-02) and Burnaps Island (Site 26-03) locations, but collecting detailed data about their abundance and elevation was beyond the scope of this study. The number of cobblestone tiger beetle sightings at each site for each survey period is also shown in Table 5.1. These data do not represent the number of animals at each site, because a single animal may have been observed multiple times. However, these data do imply that some survey sites including Johnston Island (Site 26-02), Burnaps Island (Site 26-03), Ascutney riverbank (Site 26-08), and Walpole Island (Site 26-12) may support higher numbers of this species than other survey sites.

Table 5.1. Cobblestone tiger beetle summary of survey effort and observation results.

Survey Date	26-01 Mascoma River	26-02 Johnston Island	26-03 Burnaps Island	26-04 Sumner Falls	26-05 Hart Island	26-06 Chase Island	26-07 Claremont Island	26-08 Ascutney Riverbank	26-09 Sugar River (VT)	26-09b Sugar River (NH)	26-10 Jarvis Island	26-11 Saxtons River	26-12 Walpole Island	26-13 West River
7/8/2014						Present (4)	Absent	Absent	Absent	Absent	Absent			
7/9/2014				Absent								Absent	Present (5)	Present (2)
7/10/2014	Absent	Present (7)			Present (4)									
7/22/2014						Absent	Absent	Present (8)	Absent	Absent[1]	Absent[1]			
7/23/2014	Absent	Present (3)		Absent	Present (4)									
7/24/2014			Present (12)										Present (1)	Absent
8/12/2014	Absent	Absent		Absent	Present (1)									
8/18/2014			Present (1)										Present (7)	Absent
8/19/2014							Absent	Present (12)	Absent	Absent	Absent			
8/21/2014												Absent		
9/3/2014			Absent			Absent								

Note: Blue border represents surveys where mating behavior was noted. Numbers in ( ) represent the number of individuals observed during each site visit.
[1] One cobblestone tiger beetle observed with low certainty during the survey period.

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During the tiger beetle surveys, searchers made a number of incidental observations outside of official survey times. Table 5.2 shows the dates/locations of these observations.

Table 5.2. Incidental observations of cobblestone tiger beetle adults.

Site ID#	Site Name	7/9/2014	7/23/2014	7/24/2014
26-02	Johnston Island		1	
26-03	Burnaps Island			6
26-04	Sumner Falls		1	
26-12	Walpole Island	2		

5.1 Survey Conditions

During each survey period, scientists noted the time of day, cloud cover, air temperature, and wind speed. Previous field observations and the current understanding of tiger beetle biology suggest that cobblestone tiger beetle activity peaks during periods of high temperature and humidity with low winds (Dr. Kristian Omland, personal communication), and survey days were selected for these conditions. Start-of-survey temperatures ranged from 19°C - 31°C, and wind speeds ranged from 0 - 4 on the Beaufort Scale, an empirical measure that relates wind speed to observed conditions at sea or on land (NWS, no date). Survey cloud cover varied from 2% - 100%.

Surveys were conducted during optimal conditions, and within this range of survey conditions, air temperature, wind speed, and cloud cover appeared to have little or no impact on the presence/absence of the target species. No cobblestone tiger beetles were observed during surveys with starting temperatures less than 23°C (Figure 5.1), but the five surveys conducted at those temperatures were at sites where no target species were observed even during warmer conditions. Cobblestone tiger beetle presence/absence did not appear to be affected by wind speed, cloud cover, or time of day within the windows described within the survey methods. However, this study was not designed to identify the critical activity periods or characteristics of cobblestone tiger beetle behavior.

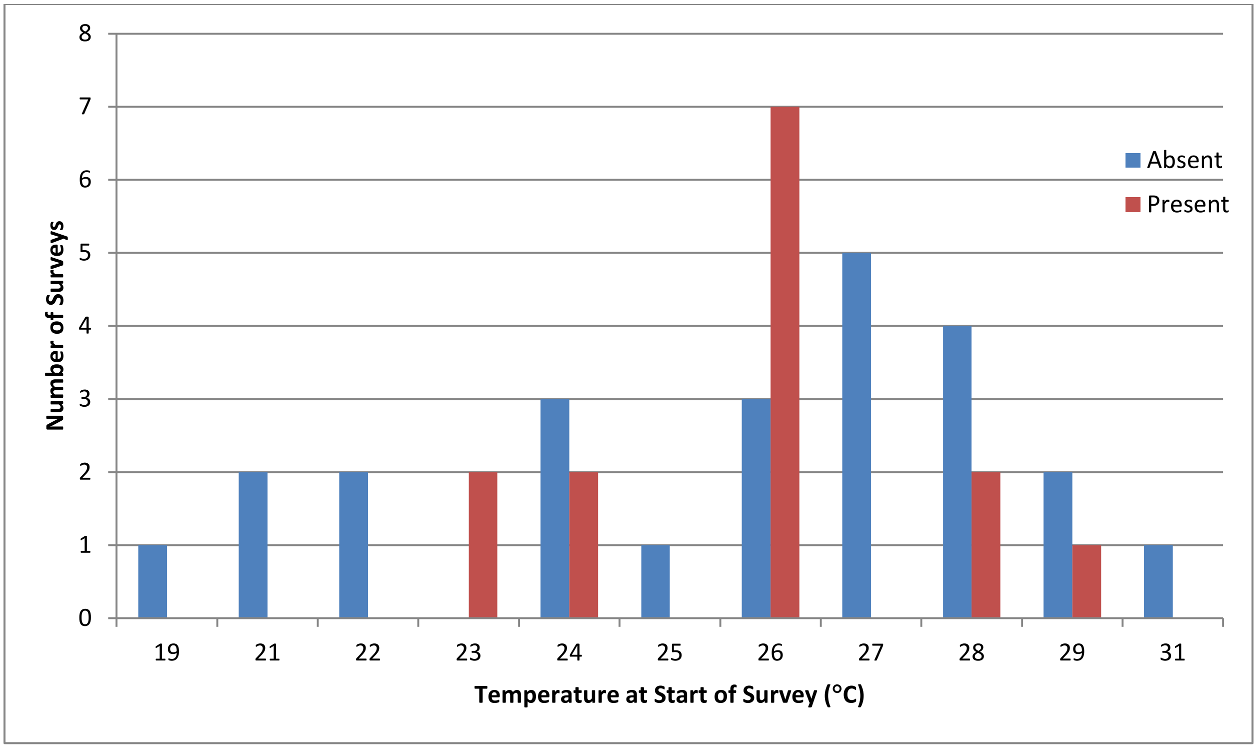

Figure 5.1. Relationship between air temperature and presence/absence of cobblestone tiger beetle.

5.2 Habitat Features

During a detailed habitat assessment at each survey site, scientists measured average a-axis (longest axis) of cobble and percent cover of woody, herbaceous, and invasive species. In addition, scientists ranked categorically the three most abundant substrate types (boulder, cobble/gravel, and sand). After the habitat perimeter was delineated, approximate habitat area was also calculated. Average cobble size ranged from 2.1 - 11.8 cm with standard deviations between 1.0 - 6.7 cm, and average vegetated cover was between 1% and 51%. Small and medium cobble were the most abundant substrate types and site area ranged from 1,750 - 76,100 square feet with a mean area of 26,700 square feet.

Adult cobblestone tiger beetles appeared to have specific habitat preferences related to the size and variability of cobble substrate, but not to other site characteristics such as vegetative cover or habitat area. Although no specific conclusions can be drawn about this relationship without a larger scale study, this study showed some observable trends. For purposes of analysis, survey locations where cobblestone tiger beetles were present during at least two of the three surveys were considered high-quality habitat. The mean cobble size ranged from 5 to 8 cm in all high-quality habitats, and the target species was absent at most sites with cobble averaging either smaller or larger than this range (Figure 5.2). The degree of uniformity of cobble sizes also appeared important. Figure 5.3 shows that the cobble diameter variability (measured as standard deviation of the a-axis) of high-quality survey sites also fell within a specific range (2 cm – 4 cm).

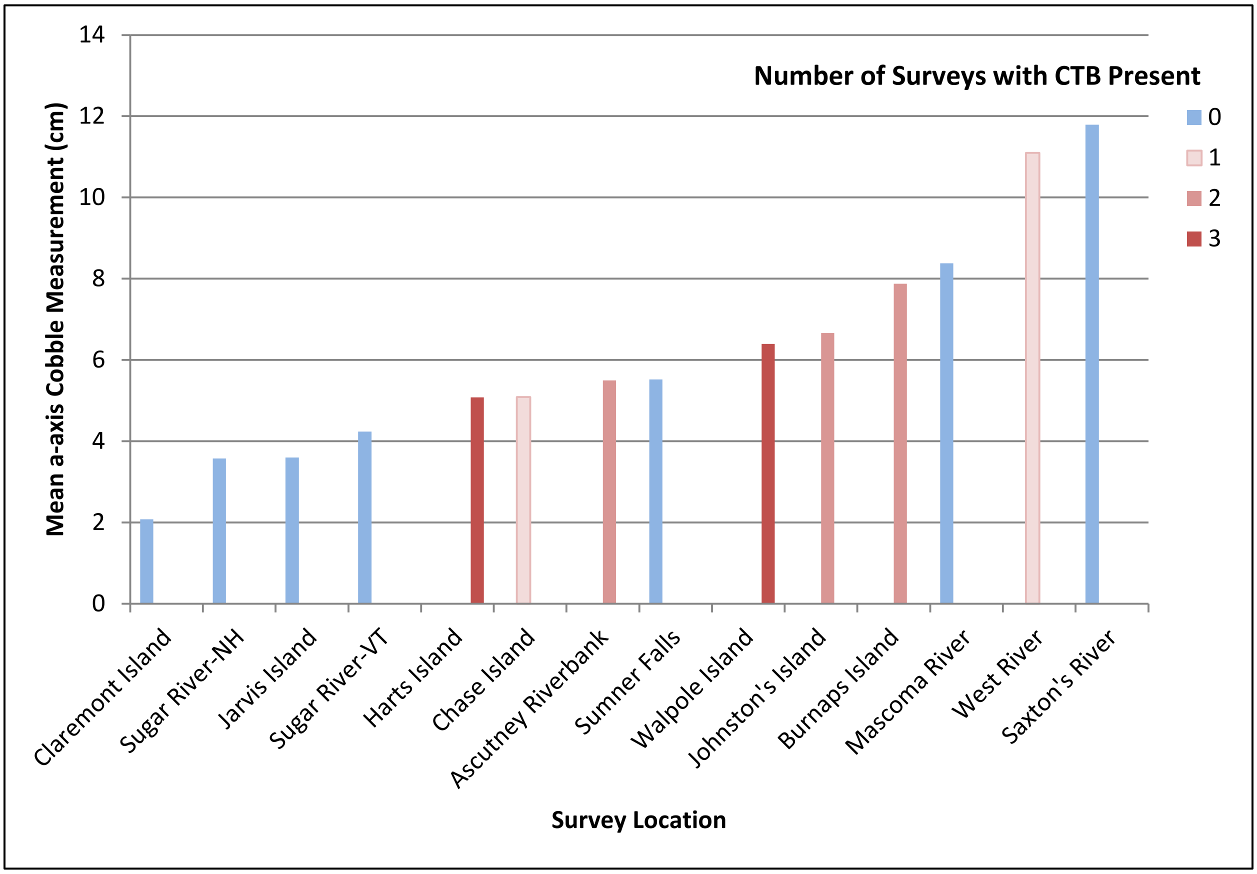

Figure 5.2. Relationship between mean cobble size and presence of cobblestone tiger beetle (CTB) adults.

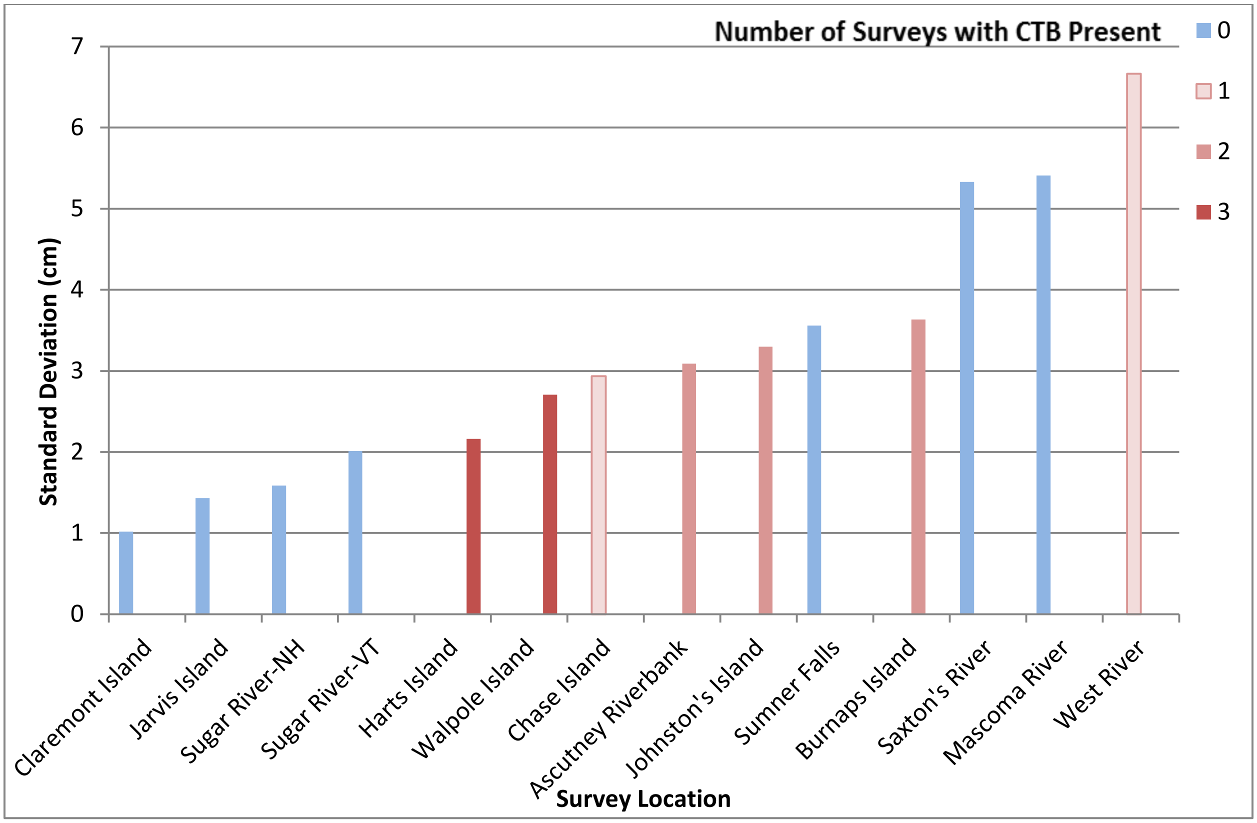

Figure 5.3. Relationship between cobble size standard deviation and presence of cobblestone tiger beetle (CTB) adults.

Overall vegetative cover at survey sites ranged from 1% - 51% with a mean percent cover of 26%. Vegetation observed at the high quality survey sites fit a certain profile: sparse, low vegetation dominated by hemp dogbane (*Apocynum cannabinum)* with generally low species richness. Low willows (including sand bar willow [*Salix exigua ssp interior;* listed as Endangered in New Hampshire]), obedient plant (*Physostegia virginiana;* listed as Threatened in Vermont), goldenrods (*Solidago spp.)* and a variety of other herbaceous species were often present but were more dominant in the extreme high elevation habitat sections where fewer cobblestone tiger beetles were observed. Although the invasive purple loosestrife (*Lythrum salicaria*) was commonly observed at survey sites, its mean percent cover never exceeded 5%.

5.3 Land Use

Land use varies widely among survey sites based on suitability for recreational use as well as existing human infrastructure (Table 5.3). The northern-most sites - Mascoma River (Site 26-01), Johnston Island (Site 26-02), and Burnaps Island (Site 26-03) - have some limited recreational use, mostly fishing near the mouth of the Mascoma River and the occasional canoe or kayak. However, the river is choppy in places between Johnston Island and Sumner Falls (Site 26-04), and there are few easily accessible public boat launches in the area. As a result, the private canoe rental companies do not frequently drop off boaters in this area. However, the center of Burnaps Island contains a Connecticut River Paddlers' Trail camping area with posted signs. Additional relevant land uses include a sewage treatment plant just north of the Mascoma River in Lebanon, NH and dense commercial development on both sides of the Connecticut River between the Mascoma River and Johnston Island (West Lebanon, NH; White River Junction, VT).

In the portion of the Wilder riverine reach between Sumner Falls and Jarvis Island (Site 26-10), there is extensive recreational use on the river. Private canoe rental and boating expedition companies drop off customers in canoes/kayaks/rafts at a number of public boat launches. As a result, the survey sites in this area are used frequently as break points, picnic areas, swimming areas, and likely campsites. The impounded river is wide and deep in the vicinity of Jarvis Island, and a public boat launch (Ashley Ferry Boat Landing) allows access to motorized boats for fishing and recreational water activities.

The Saxtons River survey site (Site 26-11) does not appear to be frequently visited for recreational activities. It is situated just below the Bellows Falls tailrace and can only be easily accessed by wading down the Saxtons River when flows are very low. Although some human litter was seen at the site, no people were observed during surveys. Approximately 1,000 feet upstream on the Saxtons River is a public swimming area in frequent use during the summer months. The surrounding land use is largely residential.

Walpole Island (Site 26-12) lies just below the Route 123 Bridge in Walpole, NH. Although there is a public canoe launch approximately ½ mile upstream, no recreational boaters were observed during surveys. However, canoers and kayakers likely use the island occasionally as a break point or picnic area. The island sits near the NH side of the river, where the adjacent land use is agricultural.

The West River (Site 26-13), the southern-most survey site in this study, is an area of cobble on the bank of the West River that is frequented by swimmers, sunbathers, and boaters. The adjacent land contains several public playing fields and a gravel parking lot. Several foot paths to the edge of the river make launching a canoe or kayak possible, but there is no official boat launch.

Table 5.3. Primary land uses at study sites.

Site ID#	Site Name	# of Surveys with CTB Present	Land Use
26-01	Mascoma River	0	Fishing, recreation occurs near Lebanon public boat launch at Two Rivers Park. Large area of informal and dispersed uses along the Mascoma river near this area. Off-road vehicle access only to mouth of the Mascoma and CT Rivers.
26-02	Johnston Island	2	Fishing, infrequent canoe/kayak/raft break point. No camping.
26-03	Burnaps Island	2	Canoe/kayak/raft break point. Part of the Connecticut River Paddlers Trail. People camp along a sandy beach on the island as well as the identified campsite area in the woods on the island.
26-04	Sumner Falls	0	Large recreation area. Launching point for canoes/kayaks/rafts; sandy beach; picnic area.
26-05	Hart Island	3	Canoe/kayak/raft break point. Not a campsite area but people canoe/kayaking from Sumner Falls will stop on Hart Island for a picnic and exploration. Also used during busy weekends for camping along the Connecticut River when Burnaps Island is already full with campers.
26-06	Chase Island	1	Occasional canoe/kayak/raft break point. Wildlife management area.
26-07	Claremont Island	0	Occasional canoe/kayak/raft break point
26-08	Ascutney Riverbank	2	Occasional canoe/kayak/raft break point
26-09a	Sugar River-VT	0	Occasional canoe/kayak/raft break point
26-09b	Sugar River-NH	0	Occasional canoe/kayak/raft break point
26-10	Jarvis Island	0	Frequent canoe/kayak/raft break point; motorized boating; fishing.
26-11	Saxtons River	0	None directly observed. Where Saxtons River meets the Connecticut River there is access for fishing and swimming and a possible informal hand-launch. This is not an identified recreation site but is accessible and used by people. No camping.
26-12	Walpole Island	3	Occasional canoe/kayak/raft break point
26-13	West River	1	Swimming; canoe/kayak/raft unofficial launch but busy in the summer months.

6.0 ASSESSMENT OF PROJECT EFFECTS

Project operations have the potential to cause direct adverse effects on cobblestone tiger beetle populations. Adult individuals are winged and therefore generally able to avoid direct mortality from project-related water level fluctuations, but they may suffer energetic costs from temporary loss of foraging habitat during multi-day periods of habitat inundation. Similarly, if daily water level fluctuations or recreational activity (albeit not a direct project effect) cause larval burrows to collapse frequently, there may be an energetic cost of re-excavating burrows, which would divert resources from larval growth and maturation.

Cobblestone tiger beetle burrowing behavior, burrowing habitat and larval morphology are currently undescribed. As a result, this study can only hypothesize about potential project effects based on water level fluctuations at survey sites, larval characteristics typical among common tiger beetle species, and the presence/absence of adult cobblestone tiger beetles at study sites.

Recreation is mentioned as a potential threat to tiger beetle populations in both the FWS Puritan Tiger Beetle Recovery Plan (Hill and Knisley, 1993) and the Cobblestone Tiger Beetle profile in the NH Wildlife Action Plan (Pyzikiewicz, 2005, and 2015 revision). However, the recreational use of this study's survey sites is relatively infrequent and not project related. In contrast, the Massachusetts population of Puritan tiger beetles occurs on a beach "regularly crowded with sunbathers" (Babione, 2003). No information is currently available to assess the impacts canoe stopovers and camping have on established tiger beetle populations in the shorelines adjacent to the Project-affected areas.

6.1 Hydraulic and Operations Modeling

In July 2015, scientists revisited the study sites and collected habitat range elevation data using a Real Time Kinematic (RTK)-GPS. At each site, scientists measured the elevation range between the estimated lowest and highest elevation of suitable habitat at the site. The low habitat elevation was measured based on vegetation whether or not it was submerged at that time. The high habitat elevation was measured at the approximate location where sand replaced cobble substrate or vegetation became thick and changed character. Project-related water level fluctuations were analyzed using the RTK data and Hydraulic and Operations Model (Studies 4 and 5) outputs (Table 6.1).

First, Hydraulic Model (Study 4) cross sections were identified at, or nearest to, the study sites. Rating curves at those locations were analyzed to determine if the range of measured habitat elevations fell within the modeled range of water surface elevations (WSEs) at each study site. Based on this information, it was determined that some portion of the cobblestone tiger beetle habitat at twelve of the study sites potentially lies within the range of normal project operations for the applicable project. The thirteenth site, Site 26-13 (West River), was located upstream in the tributary beyond the extent of modeled cross sections and was therefore not included in model data analysis. Based on review of topographic maps and field observations conducted for other studies, this site appears to be outside of the project-affected area which may extend up the West River approximately to the I-91 Bridge.

WSEs at study sites 26-01 through 26-12 were examined using output from the Operations Model (Study 5), which calculated the approximate WSEs at study sites during five operational years. Output from the Operations Model was used to further analyze the timing, frequency, and duration of water level fluctuations during the study's time periods of interest. For this study, the model output included hourly water surface elevations from each site (excluding Site 26-13) in the months of June, July, and August in order to examine the effects of project-related water fluctuations on habitat availability during cobblestone tiger beetle adults' active foraging and breeding times. Year-round seasonal average water surface elevations were used to estimate possible project effects on overwintering burrowed larvae.

Table 6.1. Hydraulic model screening of project effects on habitat elevation[1] ranges.

Site ID#	Location	Project Area	River Position	Species Observed?	Model Node #	Model Max. WSE (ft)[a] NAVD88	Min Habitat Elev (ft) NAVD88	Max Habitat Elev (ft) NAVD88	Habitat Inundation Under Normal Project Operations Based on Hydraulic Model Output
26-01	Mascoma River	Wilder Riverine	Tributary Rivers Edge	N	844	327.9	326.7	327.2	Min Habitat Elev inundated at project-controlled flows ~7,500 cfs or higher. Max Habitat Elev inundated at project-controlled flows 9,000 cfs or higher.
26-02	Johnston Island	Wilder Riverine	Mainstem Island	Y	839 - 838	326.1	325.8	327.8	Max Habitat Elev never inundated at upstream or downstream ends of site under normal project operations. At upstream end of site, Min Habitat Elev inundated at project-controlled flows ~9,700 cfs or higher. At downstream end of site, Min Habitat Elev never inundated under normal project operations.
26-03	Burnaps Island	Wilder Riverine	Mainstem Island	Y	807 - 806	320.7 upstream 320.2 downstream	319.1	321.9	Max Habitat Elev never inundated at upstream or downstream ends of site. At upstream end of site, Min Habitat Elev inundated at project-controlled flows ~7,500 cfs or higher. At downstream end of site, Min Habitat Elev inundated at project-controlled flows ~8,500 cfs or higher.
26-04	Sumner Falls	Wilder Riverine	Mainstem Rivers Edge	Y	779 - 778	310.8 upstream 310.4 downstream	307.7	315.5	Max Habitat Elev never inundated at upstream or downstream ends of site. At upstream end of site, Min Habitat Elev inundated at project-controlled flows ~1,500 cfs or higher. At downstream end of site, Min Habitat Elev inundated at project-controlled flows 4,000 cfs or higher.
26-05	Hart Island	Wilder Riverine	Mainstem Island	Y	752	304.9	302.3	305.5	Max Habitat Elev never inundated under normal project operations. Min Habitat Elev inundated at project-controlled flows >~5,700 cfs.
26-06	Chase Island	Wilder Riverine, Bellows Falls Impoundment	Mainstem Island	Y	709 - 708	297.4 upstream 297.1 downstream	294.8	296.5	At upstream end of site, Min Habitat Elev inundated at project-controlled flows ~5,500 cfs or higher and Max Habitat Elev inundated at project-controlled flows 9,000 cfs or higher. At downstream end of site, Min Habitat Elev inundated at project-controlled flows 6,000 cfs or higher and Max Habitat Elev inundated at project-controlled flows ~9,500 cfs or higher
26-07	Claremont Island	Bellows Falls Impoundment	Mainstem Island	N	677	294.5	291.5	294.6	Max Habitat Elev never inundated under normal project operations. Min Habitat Elev inundated at project-controlled flows ~3,200 cfs or higher.
26-08	Ascutney Riverbank	Bellows Falls Impoundment	Mainstem Rivers Edge	Y	671	294.0	291.6	297.2	Max Habitat Elev never inundated under normal project operations. Min Habitat Elev inundated at project-controlled flows ~4,300 cfs or higher.
26-09a	Sugar River-VT	Bellows Falls Impoundment	Tributary Mouth	Y?	666	293.7	291.6	291.9	Min Habitat Elev inundated at project-controlled flows ~4,700 cfs or higher. Max Habitat Elev inundated at project-controlled flows ~ 5,700 cfs or higher.
26-09b	Sugar River-NH	Bellows Falls Impoundment	Tributary Mouth	Y?	666	293.7	291.1	292.2	Min Habitat Elev inundated at project-controlled flows 2,000 cfs or higher. Max Habitat Elev inundated at project-controlled flows 7,000 cfs or higher.
26-10	Jarvis Island	Bellows Falls Impoundment	Mainstem Island	Y?	634	292.6	291.3	292.9	Max Habitat Elev never inundated under normal project operations. Min Habitat Elev inundated at project-controlled flows 5,000 cfs or higher.
26-11	Saxtons River	Bellows Falls Riverine	Confluence	N	489 - 488	229.2 upstream 229.0 downstream	226.7	229.3	Max Habitat Elev never inundated under normal project operations. Min Habitat Elev inundated at project-controlled flows ~6,400 cfs or higher.
26-12	Walpole Island	Bellows Falls Riverine	Mainstem Island	Y	448	223.8	221.3	223.5	Min Habitat Elev inundated at project-controlled flows ~5,500 cfs or higher. Max Habitat Elev at project-controlled flows ~11,000 cfs or higher (nominal project generating capacity = 11,700 cfs).

a. Approximate hydraulic model maximum WSE elevation at the site under normal project operations.

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

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6.2 Assessment of Project Effects on Adults

At each of the study sites 26-01 through 26-12, Operations Model output provided hourly WSEs during the summer months for five modeled hydrologies. Daily curves using these outputs indicate to what extent project-related water fluctuations affect habitat inundation at each site. Project operations affect each site differently, and the following assessment of project effects on cobblestone tiger beetle adults takes into account the following factors: impoundment vs. riverine sites and elevation of habitat.

Study sites in riverine sections of the river (Table 6.1) experience notably larger daily water level fluctuations than sites in impoundment sections. Figures 6.2-1 and 6.2-2 show a comparison of WSE curves for two typical summer days at a riverine site (Johnston Island Site 26-02) and an impoundment site (Jarvis Island Site 26-10). Riverine site WSEs also show a discernible daily pattern corresponding with higher flows during the most active periods of summer power generation from the late morning to late afternoon.

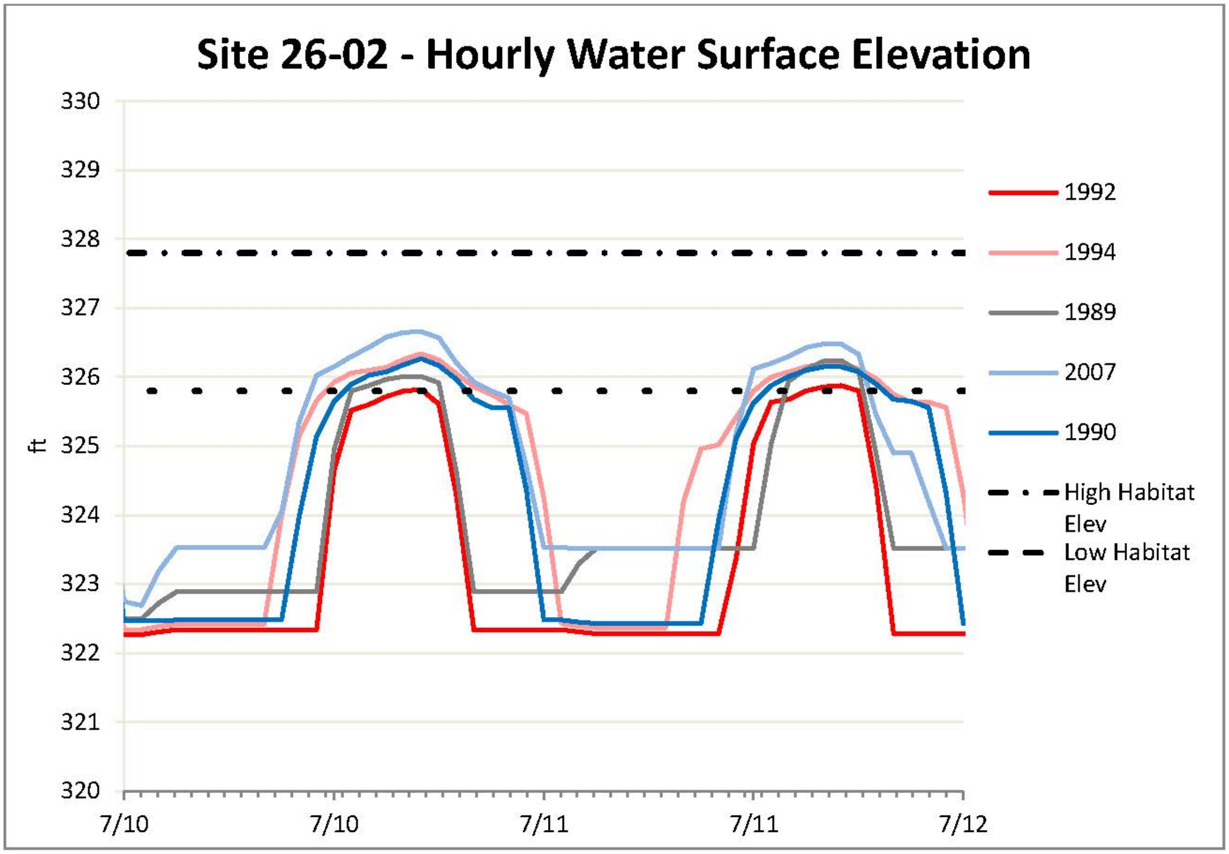

Figure 6.1-1. Hourly water surface elevation for Site 26-02 Johnston Island, a riverine site, during two typical summer days.

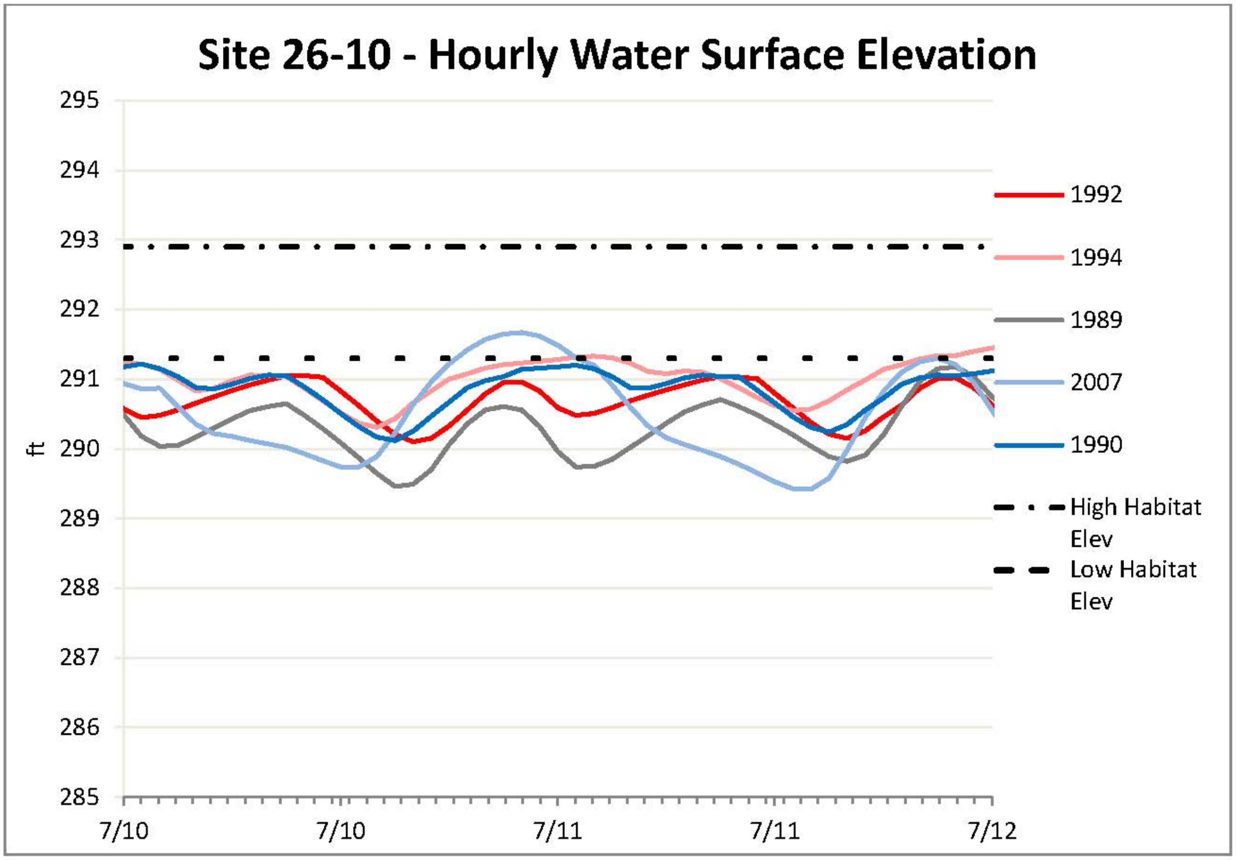

Figure 6.2-2. Hourly water surface elevation for Site 26-10 Jarvis Island, an impoundment site, during two typical summer days.

Habitat elevation at each site determines the extent to which WSE changes can impact cobblestone tiger beetles. Table 6.1 shows the lowest and highest measured habitat elevation for each study site. Sites with either a wide range of habitat elevation or habitat located at a high elevation relative to typical WSEs are insulated from frequent complete inundation. Figures 6.2-3 to 6.2-15 show each study site's daily WSE curves between June and August and the relationship between each site's WSEs and the site's high and low habitat elevations. The figures include periods of non-project related high flows and WSEs, as indicated in the infrequent, non-typical large spikes in WSE in the graphs.

Site 26-01: Mascoma River

Figure 6.2-3 shows hourly WSE for Site 26-01, a sand and cobble bar located approximately 1,000 feet upstream in the Mascoma River. The average cobble a-axis (8.4 cm) and standard deviation (5.4 cm) both exceed the ideal ranges for these parameters (see Section 5.2) indicating potentially unideal habitat. No cobblestone tiger beetles were observed here in this study (Table 5.1), and no prior records, either before or after the Wilder Project began operation, existed for this location. Site 26-01 has a narrow habitat elevation range for cobblestone tiger beetles (0.5 feet), making it highly susceptible to inundation due to changes in WSE.

The effects of project operations on Site 26-01's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-3). It is important to note that modeling data was only available at the confluence with the Connecticut River mainstem, and the study site is located approximately 1,000 feet upstream in the tributary. Therefore, modeled WSEs are not fully representative of WSE conditions at the study site. In addition, discharges from the Mascoma dam likely influence WSEs at this site. The percentage of days during which the modeled WSE exceeded maximum habitat elevation (completely inundated the habitat range) for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00; Dr. Kristian Omland, personal communication), this occurred between 62% and 94% of days.

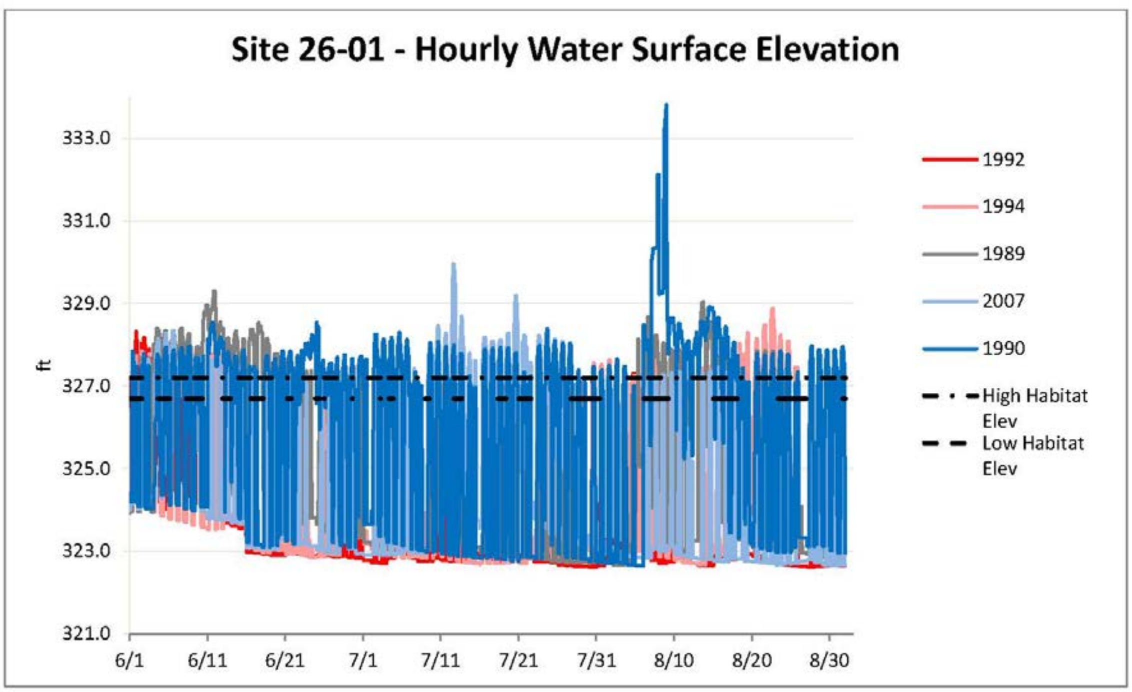

Figure 6.2-3. Modeled daily WSE, June through August at Mascoma River site for the five representative years.

Site 26-02: Johnston Island

Figure 6.2-4 shows hourly WSE for Site 26-02, the upstream side of a mainstem island. The average cobble a-axis (6.7 cm) and standard deviation (3.3 cm) both fall within the ideal ranges for these parameters (see Section 5.2) indicating potentially high-quality habitat. Cobblestone tiger beetles were observed here during this study (Table 5.1). Site 26-02 has a moderately large habitat elevation range for cobblestone tiger beetles (2 feet), providing some protection from complete inundation.

The effects of project operations on Site 26-02's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-4). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 0% and 2% of days. Partial habitat inundation occurred between 25% and 75% of days.

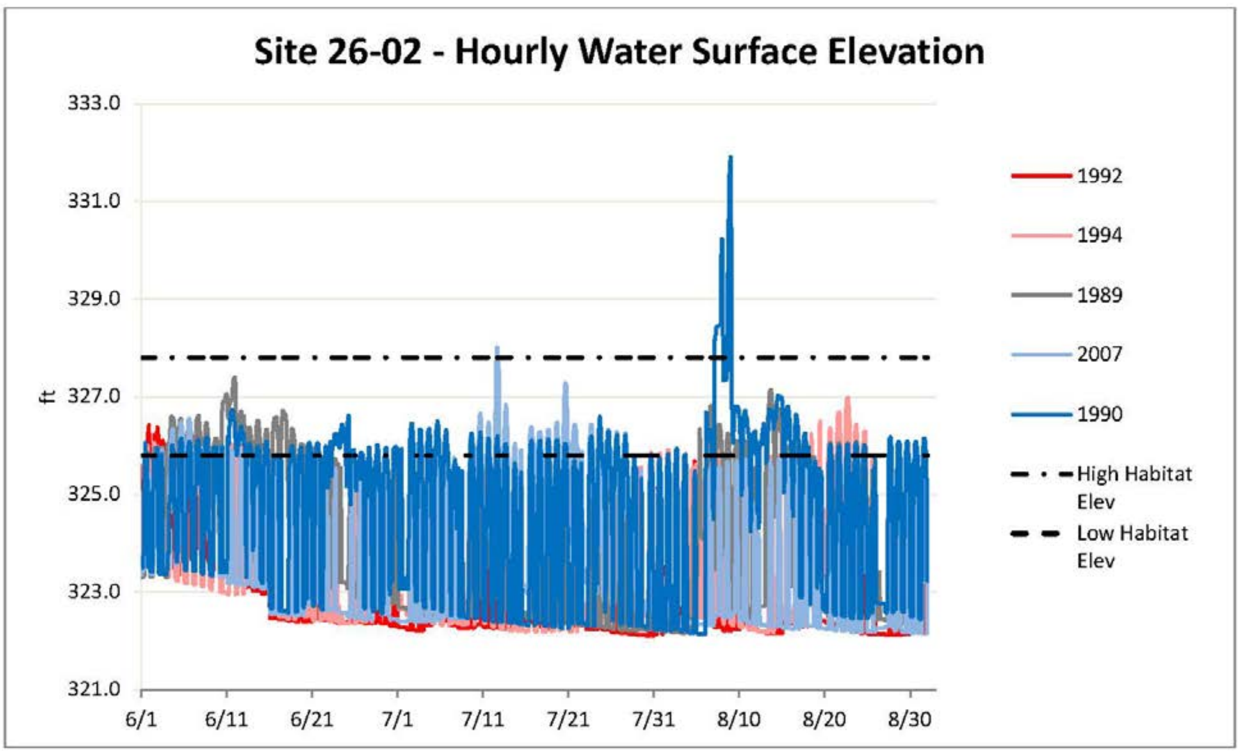

Figure 6.2-4. Modeled daily WSE, June through August at Johnston Island site for the five representative years.

Site 26-03: Burnaps Island

Figure 6.2-5 shows hourly WSE for Site 26-03, the upstream side of a mainstem island. The average cobble a-axis (7.9 cm) and standard deviation (3.6 cm) both fall within the ideal ranges for these parameters (see Section 5.2) indicating potentially high-quality habitat. Cobblestone tiger beetles were observed here during this study (Table 5.1). Site 26-03 has a moderately large habitat elevation range for cobblestone tiger beetles (2.8 feet), providing some protection from complete inundation.

The effects of project operations on Site 26-03's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-5). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 0% and 4% of days. Partial habitat inundation occurred between 84% and 97% of days.

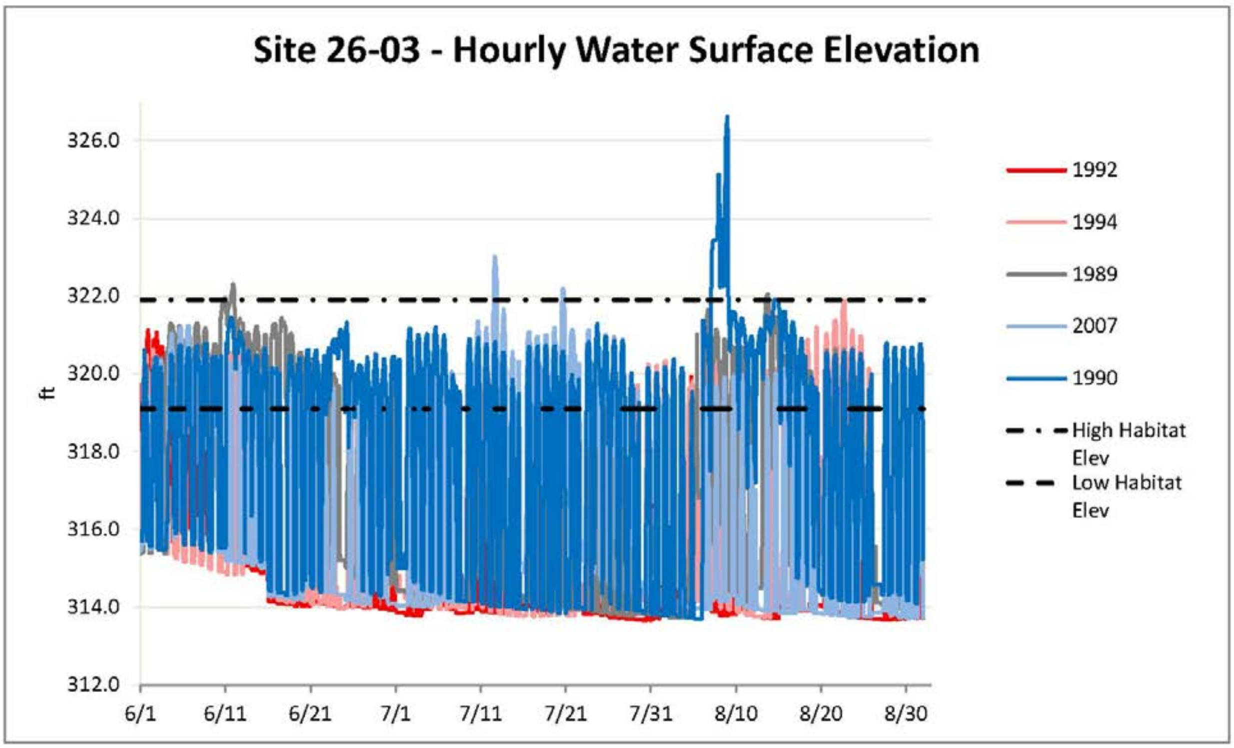

Figure 6.2-5. Modeled daily WSE, June through August at Burnaps Island site for the five representative years.

Site 26-04: Sumner Falls

Figure 6.2-6 shows hourly WSE for Site 26-04, a sand and cobble bar located on the edge of the mainstem. The average cobble a-axis (5.5 cm) and standard deviation (3.5 cm) both fall within the ideal ranges for these parameters (see Section 5.2) indicating potentially high-quality habitat. No cobblestone tiger beetles were observed here in this study (Table 5.1), though prior records exist for this location. Site 26-04 has a very large habitat elevation range for cobblestone tiger beetles (7.8 feet), providing almost complete protection from total inundation.

The effects of project operations on Site 26-04's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-6). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this never occurred. Partial habitat inundation occurred between 96% and 100% of days

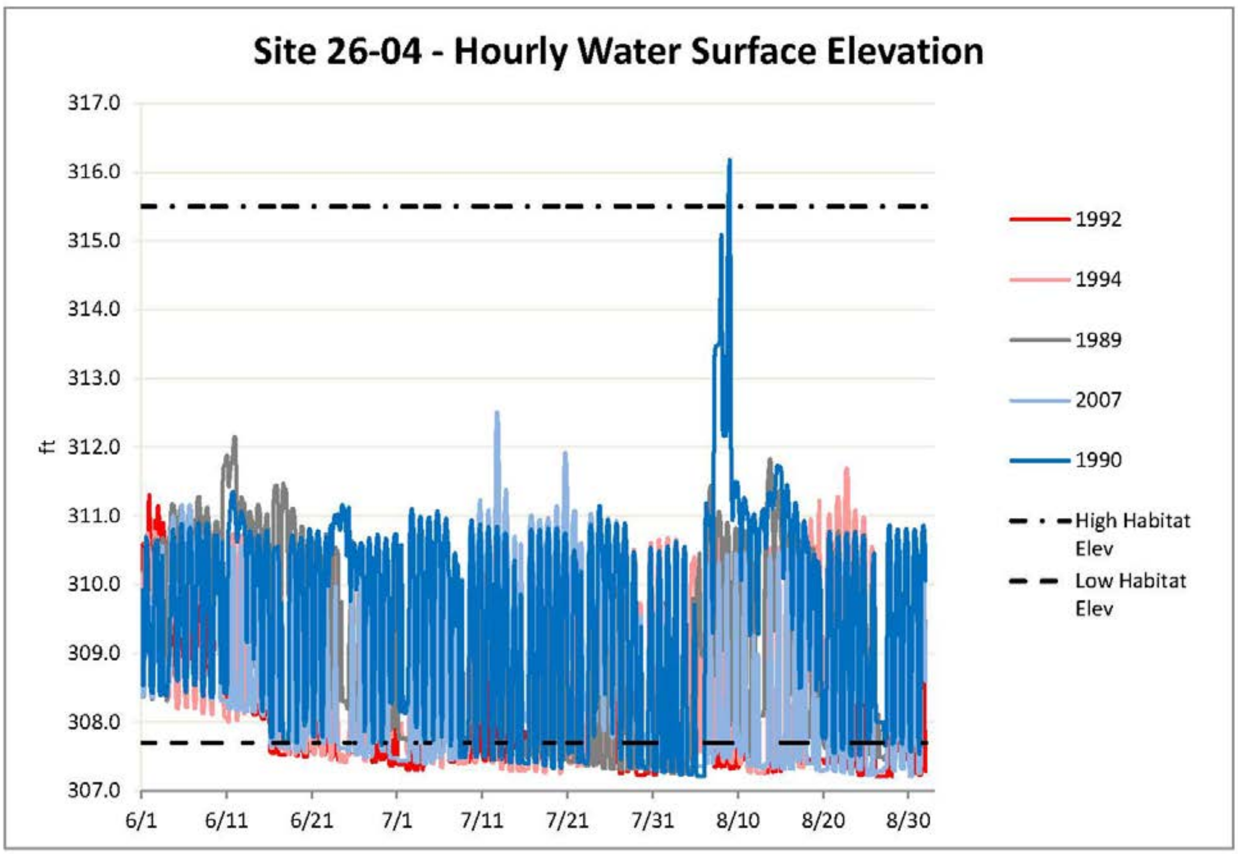

Figure 6.2-6. Modeled daily WSE, June through August at Sumner Falls site for the five representative years.

Site 26-05: Hart Island

Figure 6.2-7 shows hourly WSE for Site 26-05, the upstream side of a mainstem island. The average cobble a-axis (5.1 cm) and standard deviation (2.2 cm) both fall within the ideal ranges for these parameters (see Section 5.2) indicating potentially high-quality habitat. Cobblestone tiger beetles were observed here during this study (Table 5.1). Site 26-05 has a moderately large habitat elevation range for cobblestone tiger beetles (3.2 feet), providing some protection from complete inundation.

The effects of project operations on Site 26-05's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-7). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 1% and 20% of days. Partial habitat inundation occurred between 64% and 91% of days.

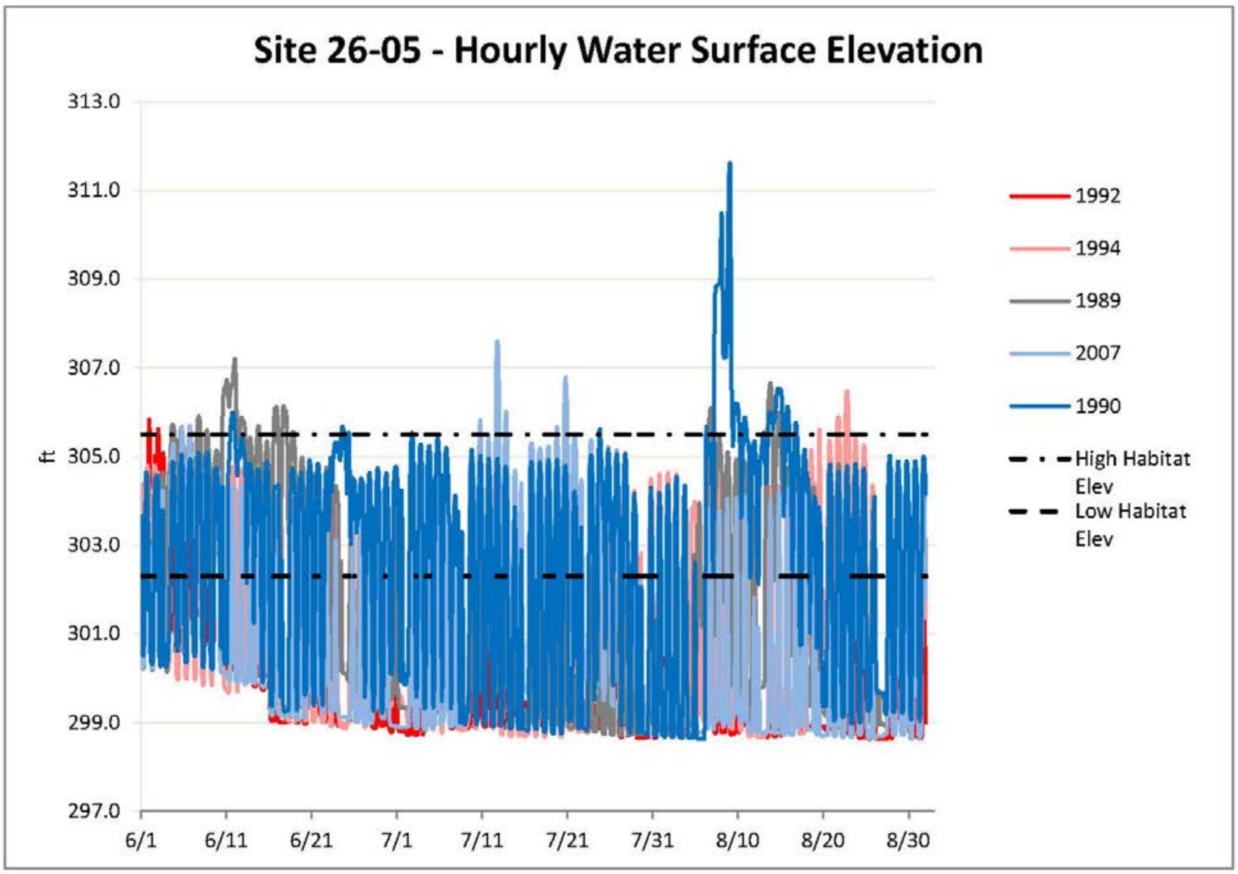

Figure 6.2-7. Modeled daily WSE, June through August at Hart Island site for the five representative years.

Site 26-06: Chase Island

Figure 6.2-8 shows hourly WSE for Site 26-06, the upstream side of a mainstem island. The average cobble a-axis (5.1 cm) and standard deviation (2.9 cm) both fall within the ideal ranges for these parameters (see Section 5.2) indicating potentially high-quality habitat. Cobblestone tiger beetles were observed here during this study (Table 5.1). Site 26-06 has a somewhat narrow habitat elevation range for cobblestone tiger beetles (1.7 feet), providing some protection from complete inundation.

The effects of project operations on Site 26-06's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-8). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 14% and 63% of days. Partial habitat inundation occurred between 29% and 55% of days.

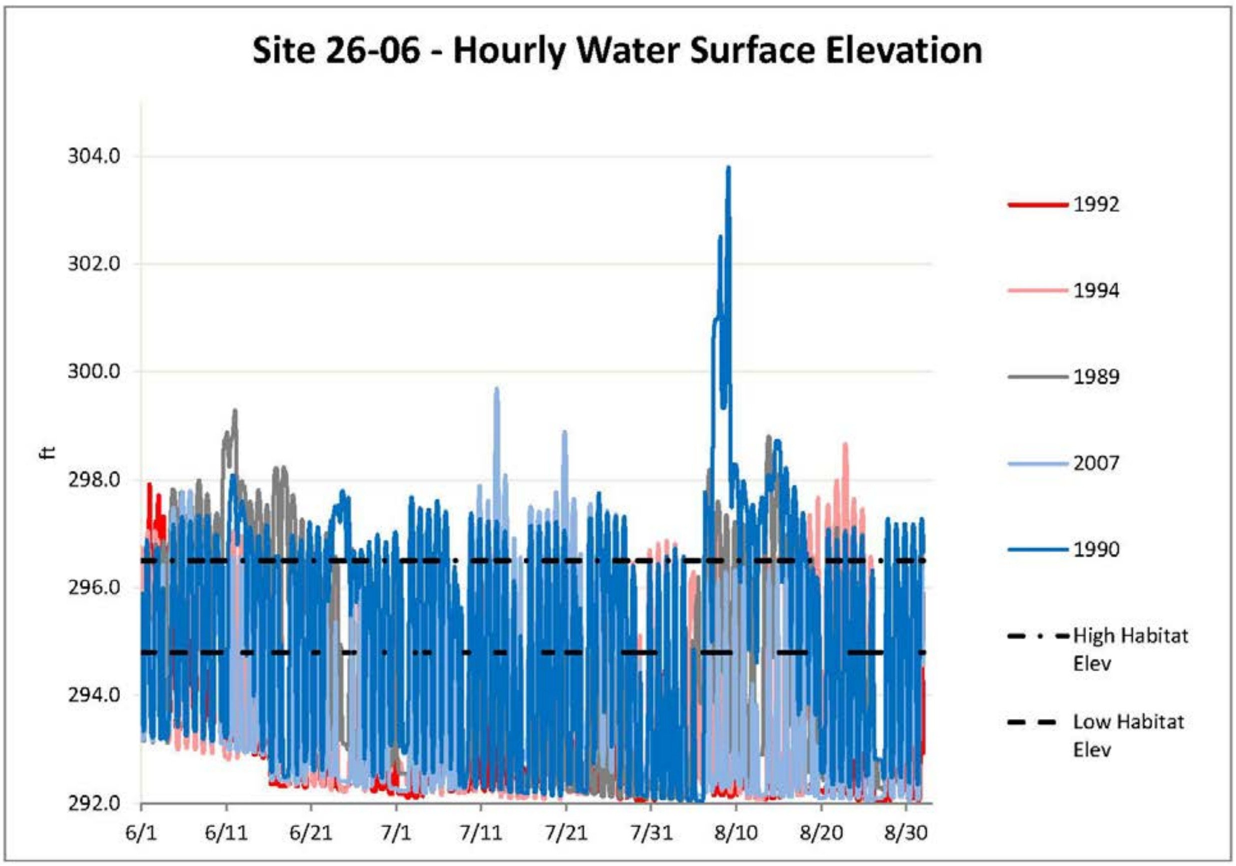

Figure 6.2-8. Modeled daily WSE, June through August at Chase Island site for the five representative years.

Site 26-07: Claremont Island

Figure 6.2-9 shows hourly WSE for Site 26-07, the upstream side of a mainstem island. The average cobble a-axis (2.1 cm) and standard deviation (1.0 cm) both fall below the ideal ranges for these parameters (see Section 5.2) indicating potentially low-quality habitat. No cobblestone tiger beetles were observed here in this study (Table 5.1), and no prior records, either before or after the Wilder Project began operation, existed for this location. Site 26-07 has a moderately large habitat elevation range for cobblestone tiger beetles (3.1 feet), providing some protection from complete inundation.

The effects of project operations on Site 26-07's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-9). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 0% and 8% of days. Partial habitat inundation occurred between 47% and 82% of days.

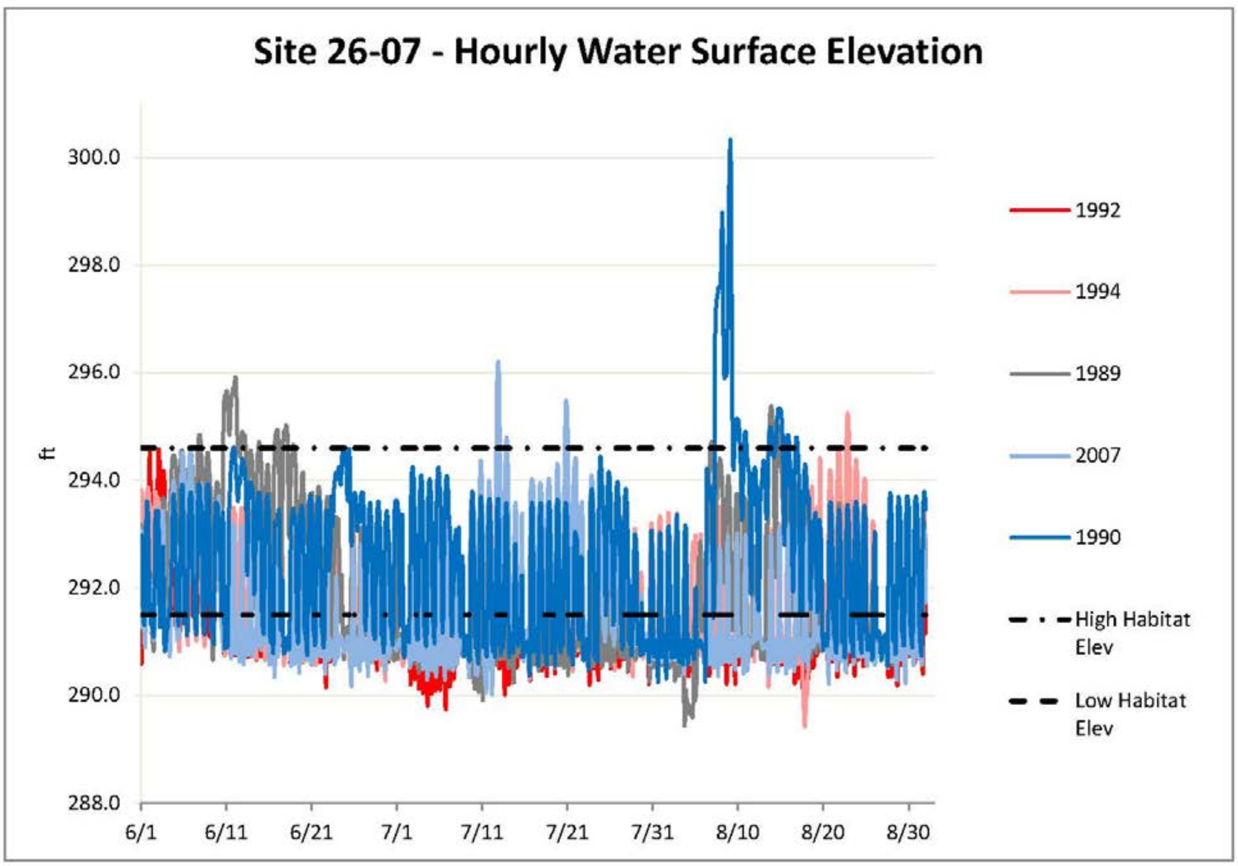

Figure 6.2-9. Modeled daily WSE, June through August at Claremont Island site for the five representative years.

Site 26-08: Ascutney Riverbank

Figure 6.2-10 shows hourly WSE for Site 26-08, a sand and cobble bar located on the edge of the mainstem. The average cobble a-axis (5.5 cm) and standard deviation (3.1 cm) both fall within the ideal ranges for these parameters (see Section 5.2) indicating potentially high-quality habitat. Cobblestone tiger beetles were observed here during this study (Table 5.1). Site 26-08 has a large habitat elevation range for cobblestone tiger beetles (5.6 feet), providing protection from complete inundation.

The effects of project operations on Site 26-08's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-10). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this never occurred. Partial habitat inundation occurred between 38% and 84% of days.

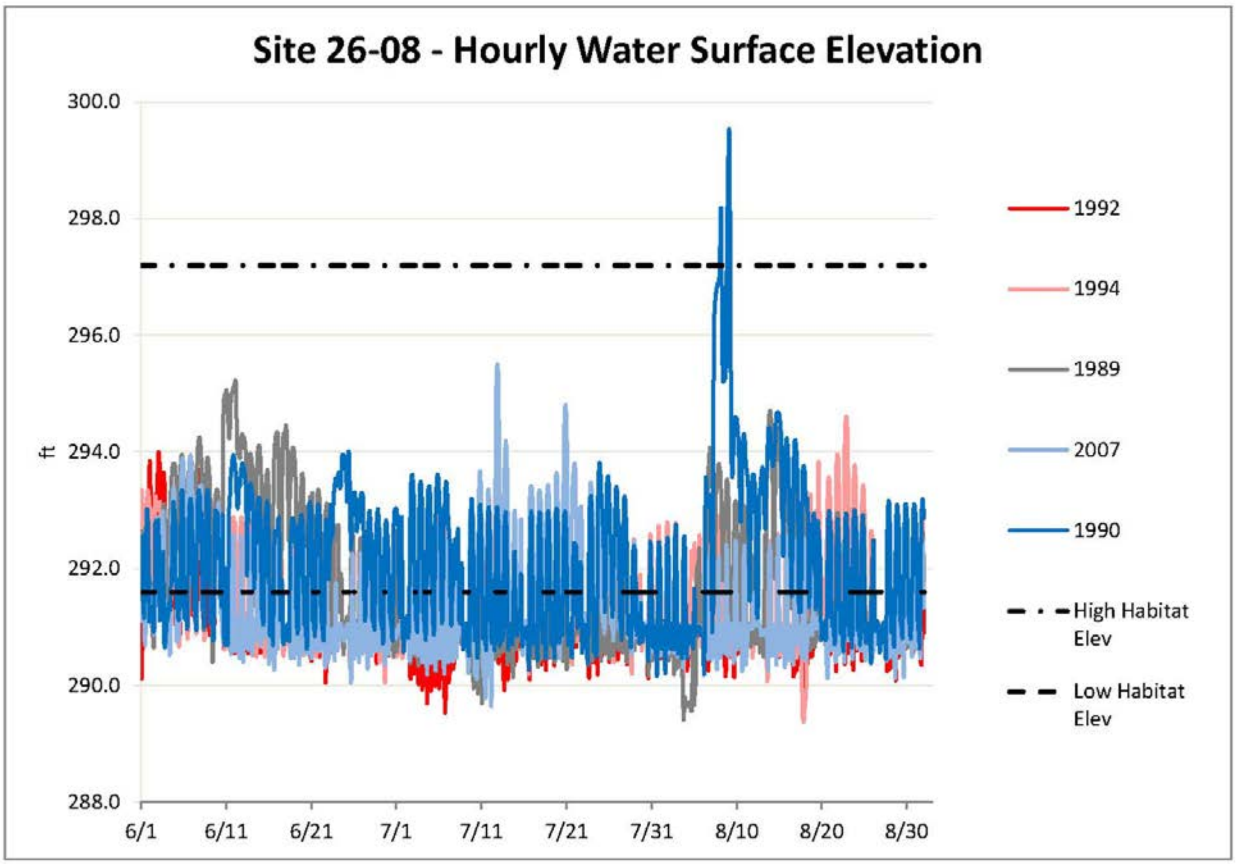

Figure 6.2-10. Modeled daily WSE, June through August at Ascutney Riverbank site for the five representative years.

Site 26-09a/b: Sugar River

Figures 6.2-11 and 6.2-12 show hourly WSE for Sites 26-09a/b, two gravel/cobble bars at the mouths of a tributary on opposite sides of the mainstem. The average cobble a-axis for the east and west sites (3.6cm and 4.2cm, respectively) and standard deviation (1.6cm and 2.0cm) both fall below the ideal ranges for these parameters (see Section 5.2) indicating potentially low-quality habitat. No cobblestone tiger beetles were observed here in this study (Table 5.1), and no prior records, either before or after the Wilder Project began operation, existed for this location. Sites 26-09a and 26-09b have narrow or somewhat narrow habitat elevation ranges for cobblestone tiger beetles (East Side=0.3 feet; West Side=1.1 feet), making the sites vulnerable to complete inundation.

The effects of project operations on Site 26-09a and 26-09b's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figures 6.2-11, 6.2-12). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 9% and 34% of days on the east side and between 13% and 45% of days on the west side. Partial habitat inundation occurred between 20% and 46% of days on the east side (Site 26-09a), and between 2% and 15% of days on the west side (Site 26-09b).

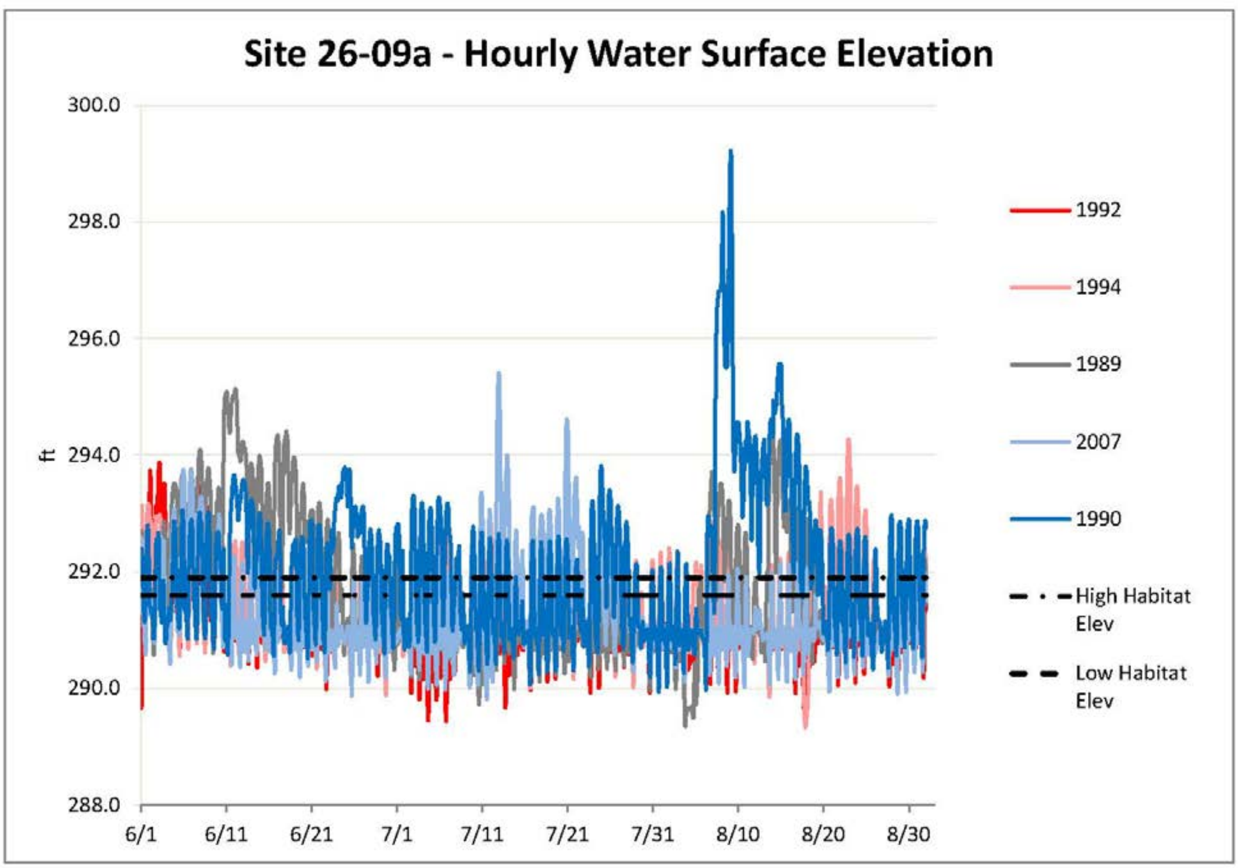

Figure 6.2-11. Modeled daily WSE, June through August at Sugar River West site for the five representative sites.

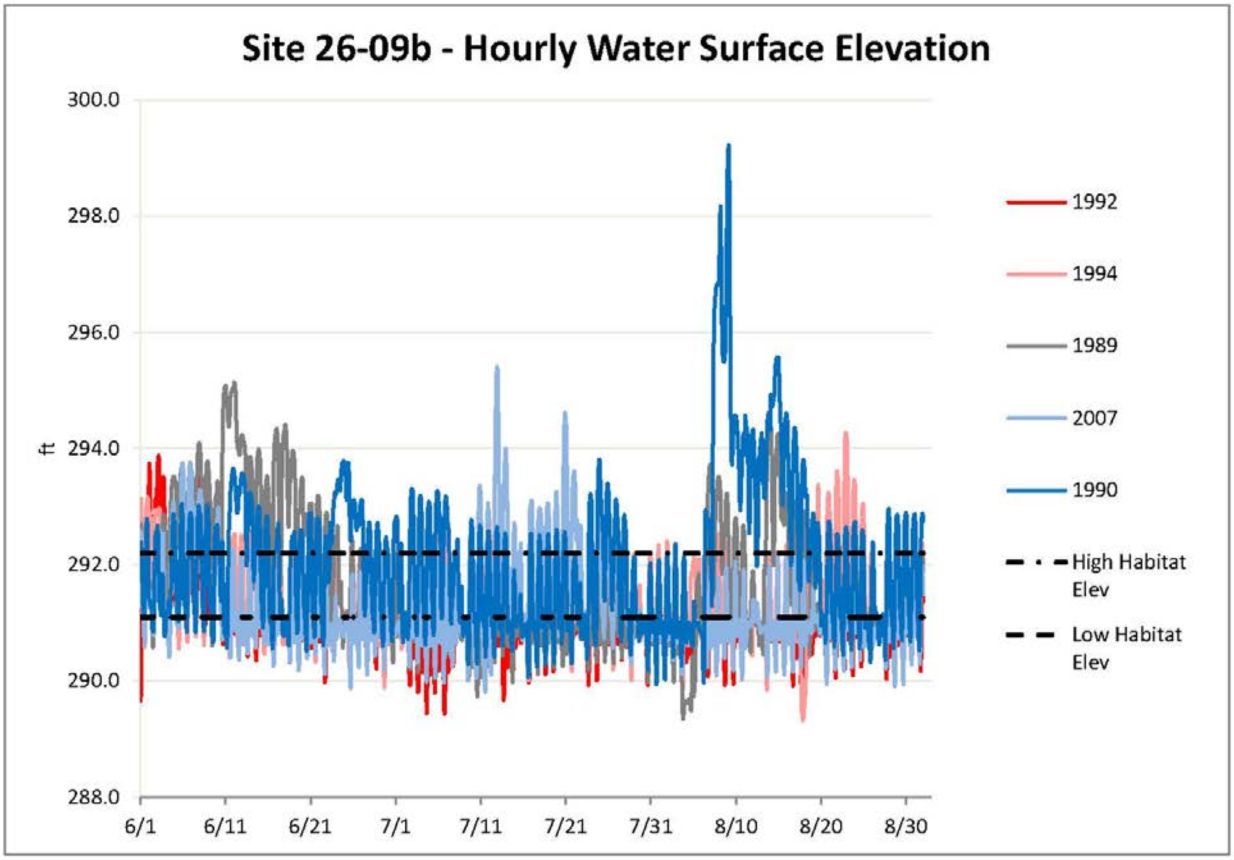

Figure 6.2-12. Modeled daily WSE, June through August at Sugar River East site for the five representative years.

Site 26-10: Jarvis Island

Figure 6.2-13 shows hourly WSE for Site 26-10, the upstream side of a mainstem island. The average cobble a-axis (3.6 cm) and standard deviation (1.4 cm) both fall below the ideal ranges for these parameters (see Section 5.2) indicating potentially low-quality habitat. No cobblestone tiger beetles were observed here in this study (Table 5.1), and no prior records, either before or after the Wilder Project began operation, existed for this location. Site 26-10 has a somewhat narrow habitat elevation range for cobblestone tiger beetles (1.6 feet), making it potentially vulnerable to complete inundation.

The effects of project operations on Site 26-10's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-13). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 0% and 4% of days. Partial habitat inundation occurred between 7% and 25% of days.

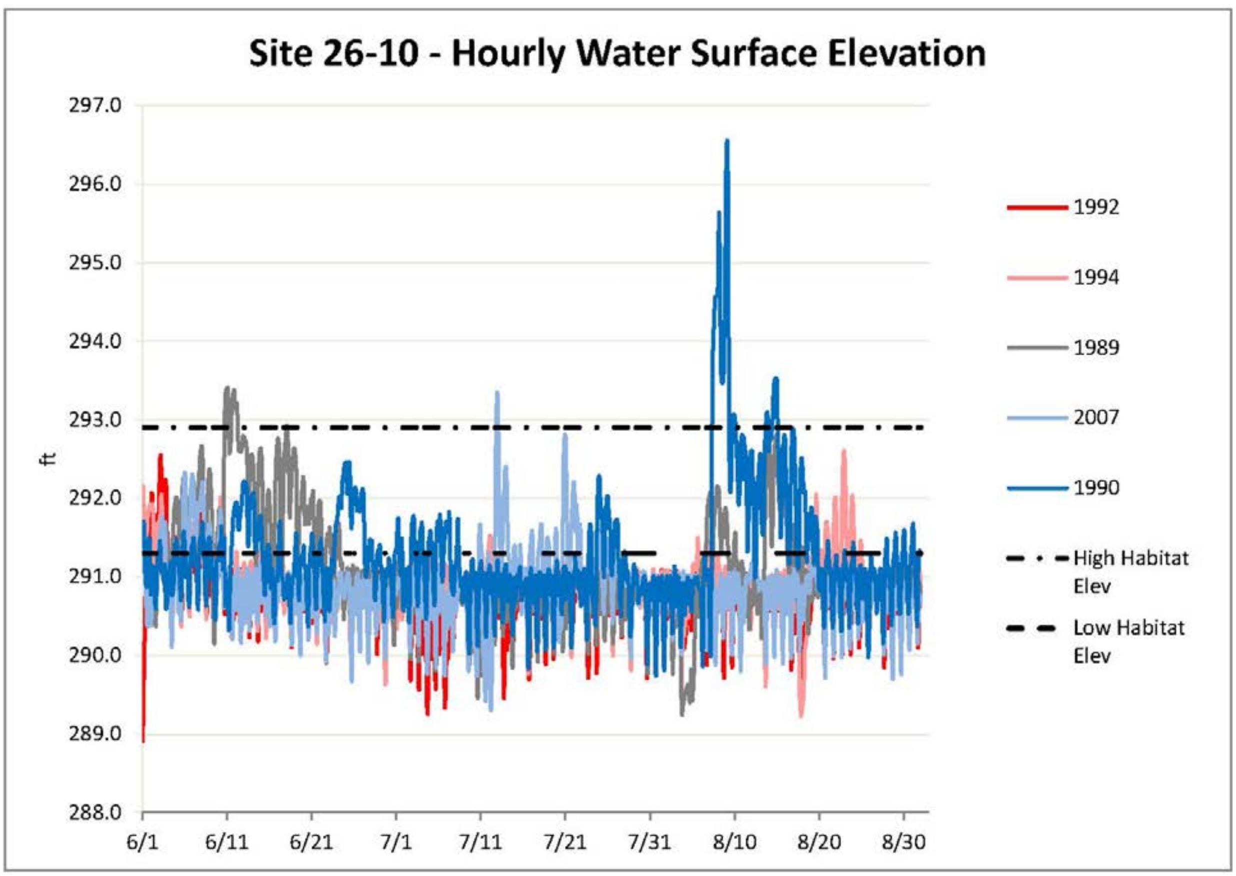

Figure 6.2-13. Modeled daily WSE, June through August at Jarvis Island site for the five representative years.

Site 26-11: Saxtons River

Figure 6.2-14 shows hourly WSE for Site 26-11, a sand and cobble bar located at the mouth of the Saxtons River. The average cobble a-axis (11.8 cm) and standard deviation (5.3 cm) both exceed the ideal ranges for these parameters (see Section 5.2) indicating potentially low-quality habitat. No cobblestone tiger beetles were observed here in this study (Table 5.1), and no prior records, either before or after the Bellows Falls Project began operation, existed for this location. Site 26-11 has a moderately large habitat elevation range for cobblestone tiger beetles (2.6 feet), providing some protection from complete inundation.

The effects of project operations on Site 26-11's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-14). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 0% and 15% of days. Partial habitat inundation occurred between 82% and 97% of days.

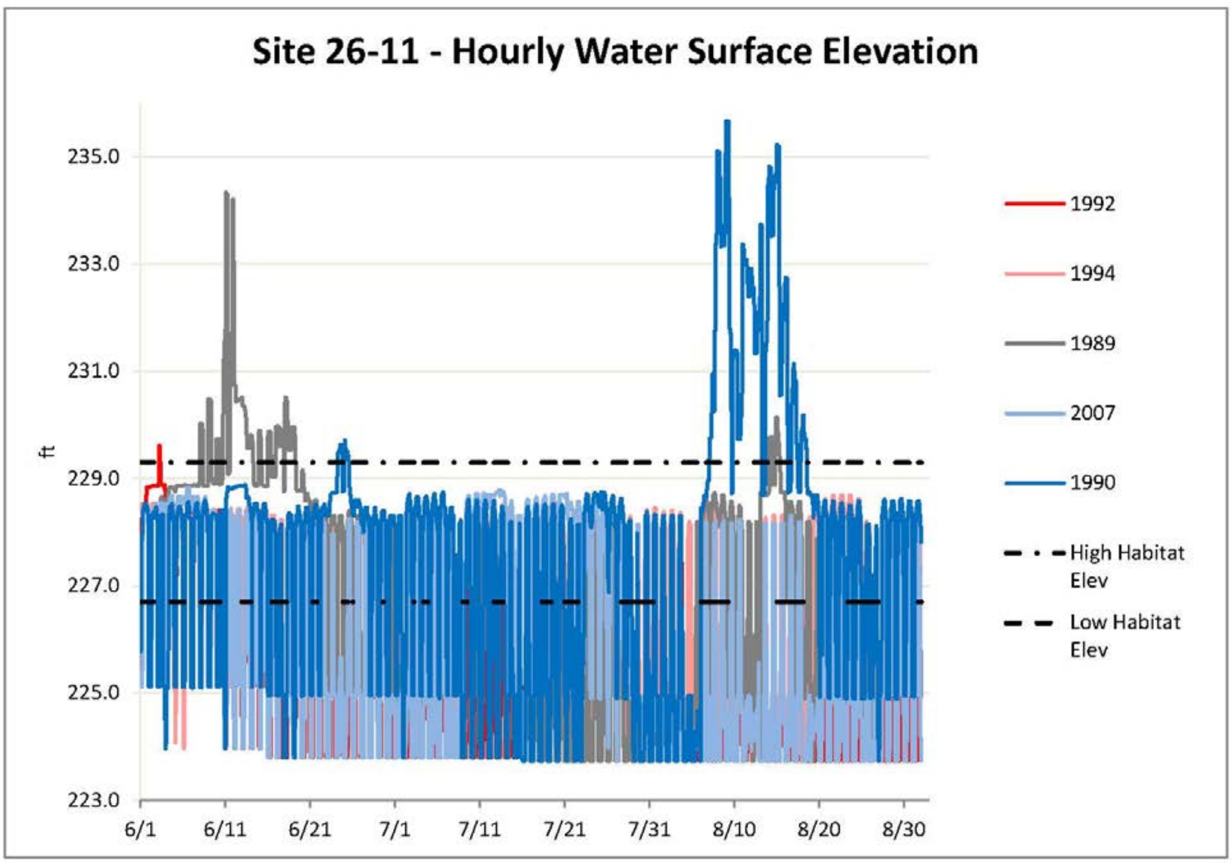

Figure 6.2-14. Modeled daily WSE, June through August at Saxtons River site for the five representative years.

Site 26-12: Walpole Island

Figure 6.2-15 shows hourly WSE for Site 26-12, the upstream side of a mainstem island. The average cobble a-axis (6.4 cm) and standard deviation (2.7 cm) both fall within the ideal ranges for these parameters (see Section 5.2) indicating potentially high-quality habitat. Cobblestone tiger beetles were observed here during this study (Table 5.1). Site 26-12 has a moderately large habitat elevation range for cobblestone tiger beetles (2.2 feet), providing some protection from complete inundation.

The effects of project operations on Site 26-12's habitat elevation range were analyzed from June 1 – August 30 of five model years (Figure 6.2-15). The percentage of days during which the modeled WSE completely inundated the habitat range for at least one hour was calculated for each model year. During the adult cobblestone tiger beetle's daily active period (10:00-16:00), this occurred between 0% and 17% of days. Partial habitat inundation occurred between 74%-96% of days.

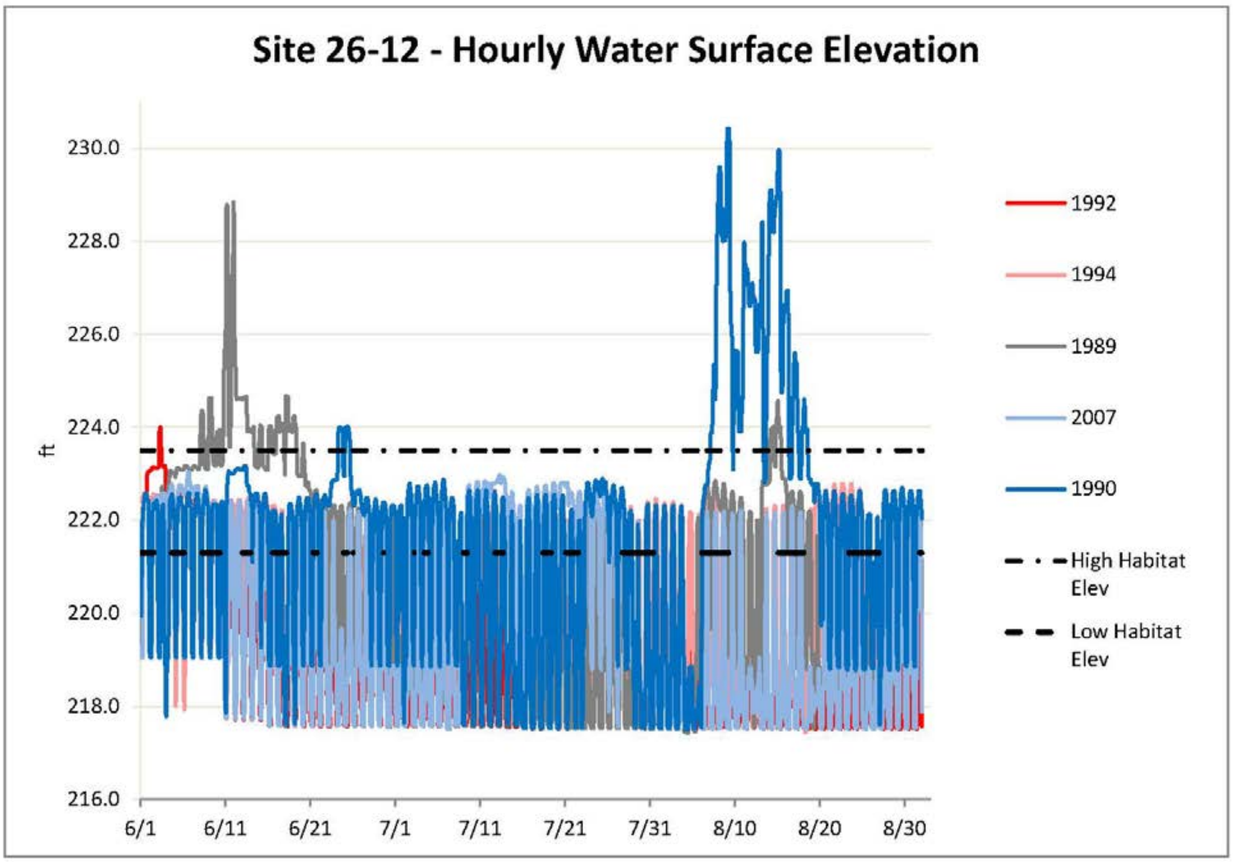

Figure 6.2-15. Modeled daily WSE, June through August at Walpole Island site for the five representative years.

The model output suggests that study sites with occasional but infrequent complete habitat inundation may provide the best habitat for cobblestone tiger beetles. The beetles can tolerate inundation of lower portions of their habitat from normal project operations because the adults are mobile and the larvae are likely to be at the upper elevations that avoid daily inundation (Section 6.3). Periodic inundation can limit vegetative encroachment and control substrate quality, both of which appear to be important for maintenance of suitable habitat. Most sites where cobblestone tiger beetles were observed were completely inundated for at least an hour during the active period (10:00 – 16:00) on fewer than 20% of summer days (Figure 6.2-16) with one exception: Site 26-06 (Chase Island) which was inundated during the adult tiger beetle daily active period from 14% to 63% of summer days, depending on the model year.

Sites where cobblestone tiger beetles were most frequently observed (e.g., Site 26-02 Johnston Island, Sites 26-03 Burnaps Island, 26-05 Hart Island, and 26-12 Walpole Island) were located on the upstream end of riverine islands and consisted of cobble beds with 5-8 cm mean cobble diameter measurements (Figure 5.2). In contrast, impoundment islands (e.g., Site 26-07 Claremont Island and 26-10 Jarvis Island) had lower quality habitat with reduced habitat areas and small cobble size/variability (Figures 5.2, 5.3). Chase Island (Site 26-06) was occupied by cobblestone tiger beetles and had cobble sizes comparable to the other occupied sites. This site is positioned at the upper end of the Bellows Falls impoundment and experiences riverine-like project-related water fluctuations.

6.3 Assessment of Project Effects on Larvae

Cobblestone tiger beetle burrowing behavior/habitat and larval morphology are currently undescribed. As a result, this study can only hypothesize about potential project effects due to project-related water surface elevations at study sites, larval characteristics typical among common tiger beetle species, and the presence/absence of adult cobblestone tiger beetles at study sites.

During this study, scientists observed burrows fitting the description of common shore tiger beetle (5 to 10 cm deep and angled) in sandy or gravelly substrates at three study sites. Although cobblestone tiger beetle adults are reported in cobble habitat (Leonard and Bell, 1998), it is likely that their larval burrows require some sand to reach a sufficient depth (Dr. Kristian Omland, personal communication). Therefore, larval burrows are hypothesized to occur primarily within the highest 25% elevation of the habitat range (henceforth referred to as “larval habitat elevation range” (LHER)). Anecdotally, at the occupied study sites, the LHER occupied the transition between the cobble bed and the sandy substrate found above the observed, estimated high water mark. Within the top 25% of the measured habitat areas, the ratio of interstitial sand to cobble generally increases with elevation.

The life history of the cobblestone tiger beetle is not completely described, but the active breeding period for adults is reported between June and September (Leonard and Bell, 1999). Other tiger beetle species (Common Shore Tiger Beetle, Six-

Spotted Tiger Beetle and the Punctured Tiger Beetle) that occupy some overlapping habitat with the target species have either a one-year or two-year life cycle with egg laying, or oviposition, occurring near the middle of their active period, which varies by species (Leonard and Bell, 1999). Third instar larvae of these similar species overwinter in burrows and either pupate and emerge the following year or overwinter for two years. If cobblestone tiger beetle larvae have a similar life history, oviposition would occur in July/August, pupation would occur in June/July, and larvae would occupy burrows during the fall, winter, and spring.

Flood tolerance is a known trait of cobblestone tiger beetle larvae (Brust et al. 2005), but the length of immersion tolerated varies by species. No literature describes the length of time cobblestone tiger beetle larvae can survive underwater. However, populations of *Cicindela hirticollis* using riverbanks for larval burrowing have survived immersion in the laboratory between 30 hours and 4 days depending on the oxygen levels of the water (Brust et al., 2005). *C. hirticollis* inhabits moist and sandy substrates including riverbanks and possesses a similar life history to the cobblestone tiger beetle. However, *C. hirticollis* does not co-inhabit the study sites discussed in this report.

Seasonal minimum, maximum, and mean hourly WSEs across the five modeled hydrologies were calculated for each study site. Table 6.3-1 presents the modeled seasonal WSE data showing that average WSEs tend to remain below the LHER in all seasons except for spring in both occupied and unoccupied sites. The LHER was inundated during the very highest flows during all seasons, but would generally remain above the water surface in summer, winter and fall, with one exception: Sites 26-09a and 26-09b (Sugar River) whose model outputs show mean WSEs inundating the LHER in all seasons but summer.

Average spring WSEs at all but three sites partially or fully inundated the LHER. Those three sites were all occupied by cobblestone tiger beetle, indicating a possible relationship between spring submergence and target species presence/absence. However, burrowed tiger beetle larvae have generally adapted to tolerate frequent and/or prolonged submersion (Brust and Hoback, 2009), and elevated spring WSEs are most likely a result of high flows due to the spring freshet rather than normal project operations. These very highest flows may also be important contributors to habitat maintenance in the LHER zone by periodically removing encroaching vegetation and maintaining suitable coarse substrates.

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Table 6.3-1. Seasonal maximum, minimum, and mean of modeled daily WSE at all study sites.

Study Site		26-01 Mascoma River	26-02 Johnston Island	26-03 Burnaps Island	26-04 Sumner Falls	26-05 Hart Island	26-06 Chase Island	26-07 Claremont Island	26-08 Ascutney Riverbank	26-09a Sugar River West	26-09b Sugar River East	26-10 Jarvis Island	26-11 Saxtons River	26-12 Walpole Island
LHER High (ft)		327.2	327.8	321.9	315.5	305.5	296.5	294.6	297.2	291.9	292.2	292.9	229.3	223.5
LHER Low (ft)		327.1	327.3	321.2	313.5	304.7	296.1	293.8	295.8	291.8	291.9	292.5	228.7	223.0
Spring														
	Max	339.9	338.2	331.9	322.7	318.2	310.7	307.0	306.1	306.3	306.3	302.8	245.6	239.0
	Mean	328.6	327.0	321.3	311.8	306.0	298.3	295.1	294.6	294.5	294.5	292.9	230.9	225.5
	Min	323.5	323.0	314.8	308.0	299.7	292.8	290.0	289.7	289.7	289.7	288.9	224.0	219.3
Summer														
	Max	333.8	331.9	326.6	316.1	311.6	303.8	300.3	299.5	299.2	299.2	296.5	236.4	231.0
	Mean	324.6	323.7	316.4	308.7	301.1	294.0	291.5	291.2	291.1	291.1	290.6	225.9	220.9
	Min	322.8	322.1	313.6	307.1	298.5	292.0	289.3	289.3	289.3	289.3	289.1	223.7	218.6
Fall														
	Max	341.1	335.5	329.6	319.5	315.1	307.4	303.8	302.9	303.0	303.0	299.8	240.4	235.2
	Mean	325.8	324.6	317.9	309.6	302.6	295.2	292.3	291.9	291.8	291.8	291.0	227.3	222.1
	Min	322.6	322.1	313.6	307.2	298.6	292.0	289.0	288.0	289.0	289.0	288.5	223.7	218.9
Winter														
	Max	338.2	336.5	330.5	320.5	316.0	308.3	304.7	303.8	304.0	304.0	300.7	242.0	236.8
	Mean	325.9	324.8	318.0	309.7	302.7	295.3	292.4	292.0	291.9	291.9	291.1	227.5	222.2
	Min	322.8	322.3	313.9	307.4	298.8	292.2	289.3	289.0	289.0	289.0	288.7	223.7	218.7

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7.0 STUDY CONCLUSIONS

Cobblestone tiger beetle adults were observed at seven of the 13 study sites. Upstream cobble beds on islands located in the riverine sections of the study area appear to provide appropriate habitat for cobblestone tiger beetles where at least a portion of the habitat range is sufficient to avoid inundation from typical daily project operations. Cobble size and variability appear to be effective methods of assessing habitat suitability.

Section 6 discusses the relationship between adult observations, site location in the river, and project-related water fluctuations. 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, 1998; Kristian Omland, personal communication). Typical summer project-related water fluctuations at riverine sites cause WSEs to rise and maintain elevation from late morning to late afternoon during times of greatest power generation. If project-related water fluctuations cause WSEs to exceed the highest habitat elevation at a riverine site, this likely occurs each day during adult cobblestone tiger beetle daily active period.

While adult tiger beetles are winged and can avoid most direct mortality from habitat inundation, there may be associated energetic reproductive costs from loss of habitat during the time when they would eat and breed. The habitats in this study currently occupied by adults become fully inundated during the adult cobblestone tiger beetles' daily active period no more than 20% of the days during the summer based on modeled data. Therefore, while project operations may have some effect, overall operations are unlikely to negatively impact the fitness of current cobblestone tiger beetle populations.

If other tiger beetle species are a valid indicator, cobblestone tiger beetle larvae are adapted to tolerate some inundation while within burrows (Brust and Hoback, 2009). Seasonal averages based on the Operations Model output 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 (Section 6.3). During the spring freshet, when eight of the twelve study sites have modeled mean WSEs above the LHER, cobblestone tiger beetles likely occur exclusively in flood-tolerant burrows. Although larval habitat and behavior have yet to be described, the presence of adults at seven of the thirteen study sites indicates at least moderate larval success.

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APPENDIX A

Survey Photographs

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Cobblestone Tiger Beetle, Ascutney Riverbank - July 22, 2014

Cobblestone Tiger Beetle, Walpole Island – August 18, 2014

Cobblestone Tiger Beetle, Chase Island – July 8, 2014

Cicindela repanda **Larval Burrows , Sugar River – July 8, 2014**

APPENDIX B

Field Data Form

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TransCanada Tiger Beetle Surveys

Crew:___________________________

Location		Date	**Time Start**
Weather:	Cloud cover	Temp	Wind
Relative River Levels		Previous NHB records?	
Adults (ground survey 30 min) (if *C.repanda* present, estimate number**)**			

Number CTB observed Number repanda:	Activity (flight, mating, probing, other)	Habitat

Larval Burrows (ground survey 30 min)				
Number	Active?	Shape (straight, J) Measure 10	Length (cm) Measure 10	Habitat

Habitat (5 m^2 samples in cobblestone habitat)	
Particle size classification (substrate texture for range of typical cobblestone habitat)	
b-axis for gravel and cobble (10 measurements in each sample location)	

Vegetation	Woody (% cover, dom)	Herbaceous (% cover, dom)	Invasives (% cover, dom)
Sample 1 Sample 2 Sample 3 Sample 4 Sample 5			
Relative Elevation (wetted surface vs average high water line)			

Sketch on Back	**Photos** beetles, substrates, habitat	**GPS** habitat boundary if CTB, point if not	**Time end:**

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APPENDIX C

Privileged Locational Information

Not included in public version of this report