

Relicensing Study 3.5.1

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES

ADDENDUM 3- TIGER BEETLES

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

Prepared for:



Prepared by:

Kleinschmidt



GOMEZ AND SULLIVAN
ENGINEERS

Chris Davis

MARCH 2019

TABLE OF CONTENTS

1	INTRODUCTION	1-1
2	STAKEHOLDER COMMENTS	2-1
3	ANALYSIS.....	3-1
3.1	Study Reach	3-1
3.1.1	Montague Cobblestone Tiger Beetle Habitat.....	3-1
3.1.2	Rainbow Beach Puritan Tiger Beetle Habitat	3-2
3.1.3	Tiger Beetle Biology.....	3-2
3.1.4	Time of Year and Day for Habitat Use	3-3
3.2	Factors Impacting Montague and Rainbow Beach Water Levels	3-7
3.2.1	Cobblestone Tiger Beetle- Montague Hydraulics.....	3-7
3.2.2	Puritan Tiger Beetle- Rainbow Beach Hydraulics	3-7
3.3	Connecticut River Hydrology below Cabot Station.....	3-8
3.4	Synthetic Hydrographs.....	3-11
3.5	Period of Record Assessment	3-15
3.5.1	Observed Rainbow Beach Water Elevation Hydrographs	3-16
4	SUMMARY.....	4-1
4.1	Cobblestone Tiger Beetles	4-1
4.2	Puritan Tiger Beetles.....	4-1
5	REFERENCES CITED	5-1
6	APPENDIX A- OTHER SYNTHETIC HYDROGRAPHS SIMULATED.....	6-1

LIST OF TABLES

Table 3.3-1: Montague USGS Gage Exceedance Flows (Period of Record 1940-2017) 3-8

LIST OF FIGURES

Figure 3.1.2-1: Rainbow Beach from a Drone (Source: YouTube) 3-6
Figure 3.1.2-2: Rainbow Beach from a Drone (Source: YouTube) 3-6
Figure 3.2.1-1: Montague Rating Curve 3-9
Figure 3.2.2-1: Rainbow Beach Rating Curve 3-10
Figure 3.4-1 Rainbow Beach Water Elevations- Scenario 1 (Cabot Peak One Unit= 2,288 cfs and base flow of 2,000 cfs vs Equivalent Stable Flow of 2,381 cfs) under High and Low Holyoke Dam water elevations 3-13
Figure 3.4-2 Rainbow Beach Water Elevations- Scenario 6 (Cabot Peak Six Units= 13,728 cfs and base flow of 2,000 cfs vs Equivalent Stable Flow of 4,288 cfs) under High and Low Holyoke Dam water elevations 3-14
Figure 3.5-1: Montague Elevation Duration Curves, Based: a) baseline and run-of-river operations, b) 42-year period of record, c) July 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum CTB adult and larval habitat elevations. 3-17
Figure 3.5-2: Montague Elevation Duration Curves, Based: a) baseline and run-of-river operations, b) 42-year period of record, c) July 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum CTB adult and larval habitat elevations. 3-18
Figure 3.5-3: Rainbow Beach Elevation Duration Curves, Based: a) baseline and run of river operations, b) 42-year period of record, c) July 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum PTB adult and larval habitat elevations 3-19
Figure 3.5-4: Rainbow Beach Elevation Duration Curves, Based: a) baseline and run of river operations, b) 42-year period of record, c) August 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum PTB adult and larval habitat elevations 3-20
Figure 3.5.1-1: 15-Minute Hydrograph of Montague Gage Flows and Rainbow Beach water elevations from July 2-9, 2012 3-21
Figure 3.5.1-2: 15-Minute Hydrograph of Montague Gage Flows and Rainbow Beach water elevations from September 3-10, 2012 3-22

LIST OF ABBREVIATIONS

cfs	cubic feet per second
CTB	Cobblestone tiger beetle
FERC	Federal Energy Regulatory Commission
FirstLight or FL	FirstLight Hydro Generating Company
ft	feet
hrs	hours
NGVD29	National Geodetic Vertical Datum of 1929
NHESP	Natural Heritage and Endangered Species Program
MADFW	Massachusetts Division of Fisheries & Wildlife
PTB	Puritan tiger beetle
USGS	United States Geological Survey
WSEL	water surface elevation

1 INTRODUCTION

On March 1, 2016, FirstLight Hydro Generating Company (FirstLight) filed with the Federal Energy Regulatory Commission (FERC) Study Report No. 3.5.1 *Baseline Inventory of Wetland, Riparian and Littoral Habitat in the Turners Falls Impoundment and Assessment of Operational Impacts on Special-Status Species*.

On October 14, 2016, FirstLight filed Addendum 1 to Study No. 3.5.1. On April 3, 2017, FirstLight filed Addendum 2 to Study No. 3.5.1.

On October 9, 2018, FirstLight held its Study Report Meeting in which Addendum 2 was discussed and filed its meeting summary on October 24, 2018 per FERC regulations. Stakeholder comments on the meeting summary and addendum were due by November 23, 2018. Comments on Study No. 3.5.1 were filed by the Massachusetts Division of Fisheries & Wildlife (MADFW). Some of the comments filed on Study No. 3.5.1 requested additional information, and some of the comments questioned FirstLight's analysis and conclusions. On December 21, 2018, FirstLight filed its response to comments with FERC. In its responsiveness summary, FirstLight stated it would provide a supplemental analysis on Cobblestone and Puritan Tiger Beetles by March 1, 2019.

2 STAKEHOLDER COMMENTS

As noted above, comments on Study No 3.5.1 Addendum 2 were received from the MADFW. In its response to comments, FirstLight cataloged the comments received such as MADFW-1 (refers to the first MADFW comment on Study No. 3.5.1), MADFW-2, etc. In its response to comments, FirstLight indicated which comments (MADFW-1, etc.) it would address in an addendum to Study No. 3.5.1. Some comments were addressed in FirstLight's Response to Comments, which were filed with FERC on December 21, 2018. Comments FirstLight indicated it would address in an addendum included MADFW-4, MADFW-6, MADFW-7 and MADFW-8. Each of the four comments are repeated below. FirstLight is providing a single response to all four comments in Section 3.0 of this document.

MADFW-4 Cobblestone and Puritan Tiger Beetle

Comment: Addendum 2 (filed April 3, 2017)

Based on updated figures and the raw data provided in Addendum 2, the Division revised and updated FL's Tables 2.2-1 and 2.2-2 (CTB) and Tables 2.3-1 and 2.3-2 (PTB) to illustrate the mean number of hours that each elevation is inundated during July and August (see Tables A and B, below). We selected the primary adult active season (July 1 through August 31) for illustrative purposes, although adults have been documented to emerge as early as June 21 and remain active as late as September 7.

The FL Tables 2.2-1 and 2.2-2 (CTB) and Tables 2.3-1 and 2.3-2 (PTB) assume a greater extent of habitat than is practically available to either species. For example, data indicate that mean flows seldom decrease below 2,500 cfs, so any potentially suitable habitats for CTB in Montague below 106 ft are almost always inundated and therefore not typically available; therefore, it should be excluded as suitable habitat. For PTB, suitable habitat generally ends at an upper elevation of approximately 104 ft; elevations above this are thickly vegetated and therefore generally unsuitable for the species. Therefore, the updated tables below (Tables A and B) have been revised to more accurately cover the range of suitable habitats that are actually available to the species at both sites.

We also designated elevational ranges of suitable habitat according to their potential usage by adult and larval lifestages. For example, as larval burrows tend to be concentrated in the upper 25% (vertical range) of suitable habitat with little to no vegetation, for CTB we assume that larval habitats occur above an elevation of approximately 110 ft. For PTB, we assume that larval habitats occur above approximately 102.75 ft (and below 104 ft, where habitats become thickly vegetated). Adults use all suitable habitats for the range of different but necessary life functions (e.g., foraging, sheltering, mating, egg-laying, etc.); the loss of access to portions of the elevational range constitutes an important loss of habitat.

Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)
 BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS
 FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS
 SPECIES- ADDENDUM 3 TIGER BEETLES

Table A: Cobblestone Tiger Beetle
 (MADFW updates to FL Table 2.2-1 and 2.2-2 in Addendum 2)

					Hours Inundated / Day				
		WSEL (ft)	Flow (cfs)	% Habitat Available	July Mean	July S.D.	August Mean	August S.D.	
Adult Habitat	Larval Habitat (approx.)	112	16200	2.90%	10.4	0.3	7.6	0.6	
		111	13300	12.10%	12.8	0.4	9.6	0.5	
		110	10500	26.70%	14.7	0.6	11.7	0.4	
			109	8200	45.20%	16.6	0.7	14	0.4
			108	6000	64.40%	19.1	0.9	16.5	0.4
			107	4200	84.20%	22.3	1	20.9	0.6
			106	2500	100.00%	23.4	0.8	23	0.9

Table B: Puritan Tiger Beetle
 (MADFW updates to FL Table 2.3-1 and 2.3-2 in Addendum 2)

					Hours Inundated / Day				
		WSEL (ft)	Flow (cfs)	% Habitat Available	July Mean	July S.D.	August Mean	August S.D.	
Adult Habitat	Larval Habitat (approx.)	103.75	18500	4.30%	5.2	3	2.7	2.2	
		103.25	16500	12.60%	6.3	3.3	3.6	2.6	
		102.75	14500	26.30%	7.4	3.7	4.6	3	
			102	12000	56.30%	9	3.9	6	3.3
			101.5	9500	78.00%	10.7	4	7.4	3.6
			100.75	7000	100.00%	13.3	3.8	10.1	3.8
			100	4000	100.00%	15.9	3.5	12.8	3.9

Table A and B included in MADFW's November 13, 2018 comment letter

MADFW-6 Puritan Tiger Beetle

Comment: Puritan Tiger Beetles FL results and Table B (below) indicate that, at maximum generation from Station 1 and Cabot Station (15,938 cfs plus Deerfield flows), nearly 90% of available adult habitat and >30% of available larval habitat for PTB at Rainbow Beach is inundated on a daily (or near daily) basis during the adult lifestage. For example, at maximum generation, approximately 90% of available adult habitat (elevation 100-103.25 ft) and >30% of available larval habitats (elevation 102.75-103.75 ft) are inundated an average of 6.3 hours per day in July and 4.6 hours per day in August. At more modest Project flows of 12,000 cfs (approximately equal to flows from Station 1, four (4) Cabot Units, and the Deerfield River), 64% of available adult habitat is inundated an average of 9.0 hours per day in July and 6.0 hours per day in August.

Comparing Tables A and B, it is apparent that inundation of PTB habitats at Rainbow Beach exhibits considerably more variation around the mean than are observed in Montague. The variation around the mean indicates that hydraulics at Rainbow Beach are more complicated than the simple flow vs. WSEL relationship presented in the Addendum. This likely reflects both distance from Cabot Station and, in particular, the effects of Holyoke Impoundment levels on the flow vs. WSEL relationship at Rainbow Beach. HG&E reduces Holyoke Impoundment elevations (Holyoke Project FERC No. 2004) in response to upstream Cabot peaking operations in order to moderate the magnitude of WSEL changes at Rainbow Beach and reduce impacts to PTB habitats. By drawing down the Holyoke Impoundment in advance of the arrival of peaked flows released from Cabot Station, current Holyoke operations aim to reduce the magnitude of habitat inundation at Rainbow Beach caused by Cabot Station. Therefore, in order for operations of FL to be fully represented, **the Division recommends that FL conduct a more thorough hydraulic analysis for Rainbow Beach to account for how Project operations interact with the range of Holyoke Impoundment levels. This will allow FL to better assess the magnitude, duration and frequency of habitat inundation for PTB. In addition, we recommend that the analysis include a range of modeling runs in which Cabot peaking occurs on top of varying baseline river flows (e.g., 2,000 cfs, 4,000 cfs, 6,000 cfs, 8,000 cfs, and 10,000 cfs).**

MADFW-7 Adult Puritan and Cobblestone Tiger Beetles

Comment: *FL results clearly show that both species are experiencing regular and substantial inundation of adult habitats on a daily or near daily basis during July and August. To better elucidate Project effects on key adult behaviors, we recommend that FL limit its assessment of the extent, duration and frequency of inundation to the typical daily adult active period (9:00AM – 8:30PM), excluding the hours outside this period.*

MADFW-8 Larval Puritan and Cobblestone Tiger Beetles

Comment: *FL results clearly show that both species are experiencing regular and substantial inundation of larval habitats on a daily or near daily basis during July and August; however, the analysis does not sufficiently cover the full period of larval activity. FL should provide updated tables, modeled after the Table A and B, showing the mean number of hours per day (including one standard deviation) larval habitats are inundated between May 15 and October 15 (with each month assessed separately). This should provide a better understanding of how larvae are affected by Project operations. Because larvae are active during both day and night, and given the more complex hydraulics effecting PTB at Rainbow Beach, the updated should be used to assess the extent, duration and frequency of larval habitat inundation for all hours (day and night).*

3 ANALYSIS

3.1 Study Reach

The Turners Falls Project generation facilities are comprised of Cabot Station and Station No. 1. FirstLight operates Cabot Station as a peaking facility when inflow to the Project is less than its hydraulic capacity of 13,728 cfs. Cabot has 6-equally sized units each with a hydraulic capacity of 2,288 cfs. FirstLight's Station No. 1 has a hydraulic capacity of 2,210 cfs, but is not operated as a peaking facility. Station No. 1 typically operates when a) flows are too low to operate a single Cabot unit or b) when the hydraulic capacity of Cabot is exceeded.

The Deerfield River flows into the Connecticut River approximately a half mile downstream of Cabot Station. The Connecticut River confluence with the Deerfield is just upstream of the Montague United States Geological Survey (USGS) Gage. As discussed in Study 3.3.1 *Instream Flow Study*, Reach 4 extends from the Montague USGS Gage to Sunderland Bridge (Route 116) and Reach 5 extends from Sunderland Bridge to a natural hydraulic control (called "The Narrows") located near the Dinosaur Footprints Reservation.

The Holyoke Hydroelectric Project (FERC No. 2004) (Holyoke Project) is located approximately four miles downstream of the Dinosaur Footprints Reservation. The current FERC license for the Holyoke Project permits the water surface elevation at the Holyoke Dam to vary between 99.47 and 100.67 feet (ft.) (National Geodetic Vertical Datum of 1929 (NGVD29)) or a fluctuation of 1.2 ft. Based on Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment and below Cabot Station*, the Holyoke Dam backwater is prominent in the lower portion of Reach 5, however, the backwater effect dampens in the lower part of Reach 4.

3.1.1 Montague Cobblestone Tiger Beetle Habitat

Cobblestone Tiger Beetle (CTB) habitat is located on the east bank of the Connecticut River opposite the mouth of the Deerfield River ([Figure 3.1.1-1](#)). A population of CTB's were discovered in 2000 at the "Montague" location. Per Chris Davis (personal communication, 2019), a recognized tiger beetle expert, he surveyed the Montague site in 2000 and had a peak daily count of 72 adults. From mark/recapture of Puritan Tiger Beetles (PTB) at Rainbow Beach conducted by Mr. Davis over many years, the peak count represents 38% of the total adult count for a given year (personal communication, 2019). Based on this, the estimated total population of CTBs in 2000 was approximately +/-190 adults (72/0.38). The number observed at this location in 2000 is considerably higher than the numbers observed at other locations on the Connecticut River; for example, at locations surveyed in New Hampshire in 2014, CTB were observed at seven out of 13 sites, but the highest count at a site was 12 individuals, some of which could have been the same individual counted multiple times ([TransCanada 2016](#)). In the past, counts at these sites have ranged from seven to 58 individuals ([NHFG 2015](#)). As such, the CTB count in 2000 could have represented a larger population than typically exists along the river. The last credible sighting of an adult at the Montague location occurred in 2008. FirstLight contracted with Mr. Davis who searched the Montague site for CTB's during the summers of 2014, 2017 and 2018; none were found. In addition to these three surveys, Mr. Davis indicated that an additional 1-2 single day visits were conducted between 2008 and 2018 and no larval or adult CTBs were found. For the latest 2018 study, adult surveys were conducted 10 times between July 10 and August 30, 2018 and larval surveys were conducted five times between September 6 and October 10, 2018.

A topographic survey of the Montague site was conducted as part of Study No. 3.5.1. Based on consultation with the Massachusetts Natural Heritage and Endangered Species Program (NHESP), available habitat at the Montague location for CTB adults and larvae is as follows:

Adults: Available habitat is between elevations 106.0 to 112.0 ft NGVD29

Larvae: Available habitat is between elevations 110.0 to 112.0 ft NGVD29

3.1.2 *Rainbow Beach Puritan Tiger Beetle Habitat*

PTB habitat is available at Rainbow Beach and to a lesser extent at the North Bank, both located about 25 miles downstream of Cabot Station and about 9.4 miles upstream of Holyoke Dam ([Figure 3.1.1-1](#)).

A topographic survey of the Rainbow Beach and North Bank sites was conducted as part of Study No. 3.5.1. Based on consultation with the NHESP, available habitat for PTB adults and larvae is as follows:

Adults: Available habitat is between elevations 101.0 to 104.0 ft NGVD29

Larvae: Available habitat is between elevations 102.75 to 104.0 ft NGVD29

Above elevation 104.0 ft there is vegetation.

Rainbow Beach is jointly owned by the Massachusetts Department of Fish and Game, Massachusetts Division of Fisheries and Wildlife (MADFW) and the City of Northampton, MA. Rainbow Beach is also considered a Natural Heritage Area by the MADFW. The beach receives heavy recreation use during the summer, and during daylight hours, when PTB activity is the greatest. Boaters commonly anchor near the shoreline or “beach” their boats on the Rainbow Beach shoreline. In addition, there is heavy foot traffic on the beach. The two YouTube video links below provide a sense of the level of boat and foot traffic on the beach. [Figure 3.1.2-1](#) and [3.1.2-2](#) are pictures of Rainbow Beach (which are screen shots of the YouTube videos).

<https://www.youtube.com/watch?v=2v2bSRT2H4k&t=50s>

<https://www.youtube.com/watch?v=LhG-hUu9Z4>

3.1.3 *Tiger Beetle Biology*

Tiger beetles are often the top invertebrate predator in the areas they inhabit. The Tiger Beetle family is highly diverse, with nearly 100 species and over 100 subspecies and color forms that exist in the United States, which inhabit a variety of habitats such as open sand flats, dunes, water edges, beaches, woodland paths, and sparse grassy areas (USFWS 1993). The various types of Tiger Beetle often have specific habitat requirements that allow them to persist. Adult Tiger Beetles are swift runners, with maximum speeds of studied species ranging from 3.34 to 8.17 ft/s ([Kamoun and Hogenhout 1996](#)).

3.1.3.1 Puritan Tiger Beetle

PTB's undergo a 2-year life cycle, most of which consists of a larval period. Larvae hatch in late July or August as first instars approximately 6mm long, remaining in this stage for 1-2 weeks, before molting and becoming second instars, with burrows up to 50 cm deep ([Hill and Knisley 1993](#); [USFWS 2000](#)). They over-winter and become active again the following spring, when they molt and enter the third instar stage, containing burrows up to 100 cm deep ([Hill and Knisley 1993](#); [USFWS 2000](#)); they then pupate into adults in late spring.

Larval PTB's are relatively immobile and reside in burrows. To feed, they capture prey organisms that pass near their burrow mouth ([Knisley and Fenster 2009](#)). They have been documented using relatively bare, erodible bluff faces with sandy soil along Chesapeake Bay coastal areas ([Hill and Knisley 1993](#)). In contrast, they have been documented using the upper portions of sandy beaches, and occasionally near the water's edge, on the Connecticut River. The larvae are most active in the spring and fall, and may have a period of summer dormancy ([USFWS 2000](#)).

Adult PTB's are a medium-sized terrestrial beetle at 11.5-12.4 mm long ([USFWS 2000](#)). They are visual hunters that prey on other insects, and occasionally scavenge on dead fish and crabs along shorelines ([Knisley and Fenster 2009](#)). Their preferred foraging habitats are sandy beach areas with little to no vegetation along rivers and coastal areas; these locations are often near upper beach areas and/or bluffs where they deposit their eggs ([Hill and Knisley 1993](#); [USFWS 2000](#)). They emerge from mid-June to August, with their numbers peaking in early-to-mid July, after which the population size rapidly declines with very few adults remaining by mid-August ([Hill and Knisley 1993](#); [USFWS 2000](#)). They have a relatively short life-span, ranging from several days to weeks, averaging approximately one week. In New England, adults require sandy beaches for mating and foraging; they mate primarily in mid-to-late July, after which females lay eggs in the sand that will take approximately one week to hatch ([USFWS 2000](#)).

3.1.3.2 Cobblestone Tiger Beetle

The information on the life history and locations of CTB is lacking, though they are known to inhabit areas of islands and river shoreline with cobble, sand, and sparse vegetation ([NHFG 2005](#)). Typically, this would occur on riverbends and the upper ends of islands where substrate is relatively coarse. The CTB would typically concentrate in the middle of cobbled shoreline areas, approximately 6-15 feet from the water's edge ([NHFG 2005](#)). Their minimum required habitat size is approximately 0.2 acres with a sand and vegetation cover of 20-50% and 1-3 inch cobble ([NHFG 2005](#)). Juveniles make burrows in sand beneath, between, and around cobbles. Similar to PTB, they have a 2-year life-history and for this study, it is assumed that they follow a similar life-history pattern as PTB, though they prefer different habitat (i.e. areas with coarser substrate) than PTB.

3.1.3.3 Tiger Beetle Inundation

Though inundation studies on PTBs and CTBs have not been performed, studies have been performed on inundation and survival for some river shoreline-dwelling species of Tiger Beetles. Survival of third instar *Cicindela hirticollis* was high for long periods submerged in aerated water, with all larvae surviving for four consecutive days of continuous submersion, declining to approximately 40% by eight consecutive days of continuous submersion ([Brust et al. 2005](#)). This was considerably higher than survival observed when inundated by hypoxic water ([Brust et al. 2005](#)). Flowing water in the Connecticut River would be more similar to aerated conditions rather than hypoxic conditions. Riverine populations of larvae that become submerged could remain in their burrows and extract dissolved oxygen from the flowing river waters ([Brust et al. 2005](#)), and would not be subjected to being incapacitated by hypoxia. Recovery¹ times for larvae exposed to hypoxic water increased linearly with increasing immersion time; the ratio of recovery time to immersion time was between 0.068 and 0.081 times the minutes immersed ([Brust et al. 2005](#)).² Recovered larvae, having been removed from their burrows for the survival trials, typically began burrowing in the sand within 10 minutes after recovery ([Brust et al. 2005](#)). Though no studies have been performed on the effects of repeated inundation (i.e. on a daily basis), at one Connecticut River location, PTB larvae are subjected to tidal flooding twice daily ([Hill and Knisley 1993](#)).

3.1.4 Time of Year and Day for Habitat Use

Based on consultation with NHESP, use of the Montague and Rainbow Beach habitat is dependent on time of year and time of day. The following periods define the active periods for the CTB and PTB. Note that

¹ Recovered larvae were considered those that could right themselves immediately after being flipped over onto their backs on wet sand.

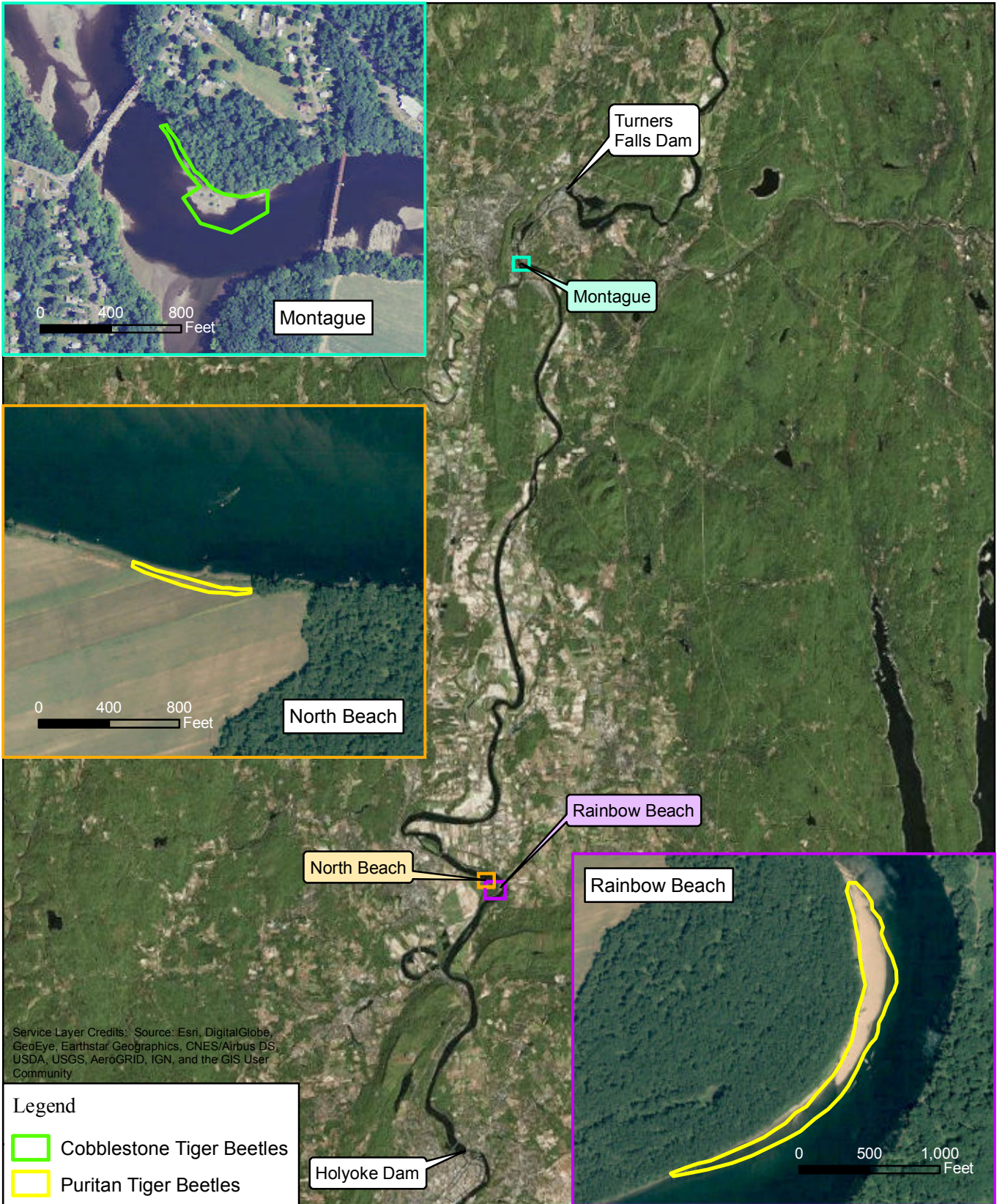
² For example, if immersion lasted for six hours (360 minutes), then 0.068 to 0.081 times the minutes immersed is equal to 24.48 to 29.16 minutes.

Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS
FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS
SPECIES- ADDENDUM 3 TIGER BEETLES

the NHESP indicated the time of day for adults is from 9AM to 8:30PM; however, the operations model, described later, is on an hourly time step, thus we rounded to 8PM.

Larval (24 hours/day):
May 15-May 31
Jun 1-30
Jul 1-31
Aug 1-31
Sep 1-30
Oct 1-15

Adult (9AM to 8PM):
Jun 21-30
Jul 1-31
Aug 1-31
Sep 1-7



FIRSTLIGHT HYDRO GENERATING COMPANY
 Northfield Mountain Pumped Storage Project No. 2485
 Turners Falls Hydroelectric Project No. 1889

STUDY 3.5.1

Figure 3.1.1-1
 Tiger Beetle Habitat Locations
 Downstream of Cabot Station



Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS
FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS
SPECIES- ADDENDUM 3 TIGER BEETLES



Figure 3.1.2-1: Rainbow Beach from a Drone (Source: YouTube)



Figure 3.1.2-2: Rainbow Beach from a Drone (Source: YouTube)

3.2 Factors Impacting Montague and Rainbow Beach Water Levels

3.2.1 Cobblestone Tiger Beetle- Montague Hydraulics

The Montague habitat is located approximately a half-mile below Cabot Station. Because of its close proximity there is very limited travel time and attenuation of flows from Cabot Station. Water elevations at the Montague site are a function of:

- Flows (magnitude, timing and duration) of Turners Falls Dam spill, Turners Falls bypass flow (base flow), Station No. 1 and Cabot discharges.
- Flows (magnitude, timing and duration) from the Deerfield River. The lowermost hydroelectric station on the Deerfield River is Station No. 2, which is operated as a peaking facility. It has a minimum flow requirement of 200 cfs and the maximum hydraulic capacity of the facility is approximately 1,445 cfs. Based on past hydraulic modeling associated with the Reach 3 instream flows study, flows from the Deerfield River typically have little influence on Montague water levels.

Also, based on the hydraulic modeling, the Holyoke Impoundment elevation does not impact water elevations, and therefore CTB habitat, at Montague. Shown in [Figure 3.2.1-1](#) is the rating curve at the Montague site (the rating curve is based on the USGS rating curve for the Montague USGS gage).

[Figure 3.2.1-1](#) depicts the minimum and maximum elevations of adult and larval CTB habitats. Note that even under median monthly flows (non-peaking conditions) the adult CTB habitat is inundated.

FirstLight and predecessor owners have operated Cabot as a peaking facility for over a century, yet CTB were historically found at Montague site even under peaking operations. Peaking conditions have not materially changed in decades. Because CTBs were present at the Montague location during the current peaking regime, there is no information to suggest that peaking at Cabot Station, which has not changed in over a century, is related to the absence of this species from the area at the present time

3.2.2 Puritan Tiger Beetle- Rainbow Beach Hydraulics

Water elevations at the Rainbow Beach site are complex due to a range of conditions. Water elevations are function of:

- Flows (magnitude, timing and duration) of Turners Falls Dam spill, Turners Falls bypass flow (base flow), Station No. 1 and Cabot discharges. In addition to the magnitude, timing and duration, because Rainbow Beach is located further downstream of Cabot, there is an attenuation and lag of flows. The attenuation and lag is a function of the magnitude, duration and timing of flows at the Turners Falls Project.
- The Connecticut River hydraulics between Cabot and Rainbow Beach. Vertical (increases or decreases in the channel bed elevation) and horizontal (constriction or expansion of the channel width) can impact the attenuation and lag of flow. One area that impacts Rainbow Beach water elevations is the “Narrows”, a hydraulic control located above Holyoke Dam, but below Rainbow Beach.
- Water level management at Holyoke Dam. As noted earlier, water elevations at Holyoke Dam can range between 99.47 and 100.67 ft.

FirstLight developed a rating curve for Rainbow Beach, but it required running two models- the operations model and the hydraulic model. As discussed in Study No. 3.8.1 *Operations Model*, FirstLight developed an operations model of Connecticut River on an hourly time step for the period January 1, 1962 and December 31, 2003. The model simulated baseline (existing) conditions. As discussed in Study No. 3.2.2

Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot, FirstLight developed a calibrated hydraulic model of the reach from Montague downstream to Holyoke Dam. To develop the Rainbow Beach rating curve, the operations model was run on an hourly time step for the 42 years of record. Output from the model—specifically flows at Montague- were then entered as inflow hydrograph in the hydraulic model. Because the Rainbow Beach water elevations are also influenced by the Holyoke Dam water surface elevation, the hydraulic model was run twice. One run assumed the Holyoke Dam water surface elevation was fixed at elevation 99.47 feet and the other assumed the Holyoke Dam water surface elevation was fixed at elevation 100.67 feet, thus covering the range of operation. Shown in [Figure 3.2.2-1](#) are the rating curves as well as three horizontal lines representing minimum and maximum elevations of where adult and larval PTB habitats are located.

Rather than simulating a high and low Holyoke Dam water elevation, FirstLight would have preferred to have used hourly observed Holyoke Dam water elevations for the 42-year period of record. FirstLight contacted the Holyoke Licensee several times to request the Holyoke Dam hourly water elevations, but were denied. Given the lack of hourly Holyoke Dam water elevations, FirstLight chose to model the high and low end of the range of Holyoke Dam water elevations.

3.3 Connecticut River Hydrology below Cabot Station

A flow duration analysis was conducted of the mean daily flows recorded at the Montague USGS Gage. Shown in [Table 3.3-1](#) are the 25%, 50% and 75% exceedance flows at the Montague USGS Gage for the months of May, Jun, Jul, Aug, Sep and Oct (the larval and adult tiger beetle periods) based on the period 1940-2017.

Table 3.3-1: Montague USGS Gage Exceedance Flows (Period of Record 1940-2017)

Exceedance Flow	May	Jun	Jul	Aug	Sep	Oct
25%	28,675 cfs	15,400 cfs	8,795 cfs	7,327 cfs	6,950 cfs	11,100 cfs
50%	18,900 cfs	10,000 cfs	5,710 cfs	4,695 cfs	4,630 cfs	6,760 cfs
75%	12,700 cfs	6,537 cfs	3,740 cfs	3,030 cfs	2,977 cfs	4,082 cfs

Regarding CTB, [Figure 3.2.1-1](#) shows the median (50%) monthly flows relative to where the CTB habitats are located. Similarly, regarding PTB, [Figure 3.2.2-1](#) shows the median monthly flows (based on the Montague USGS gage) relative to where PTB habitats are located. The median monthly flows dampen the effect of Cabot peaking on Rainbow Beach water elevations.

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

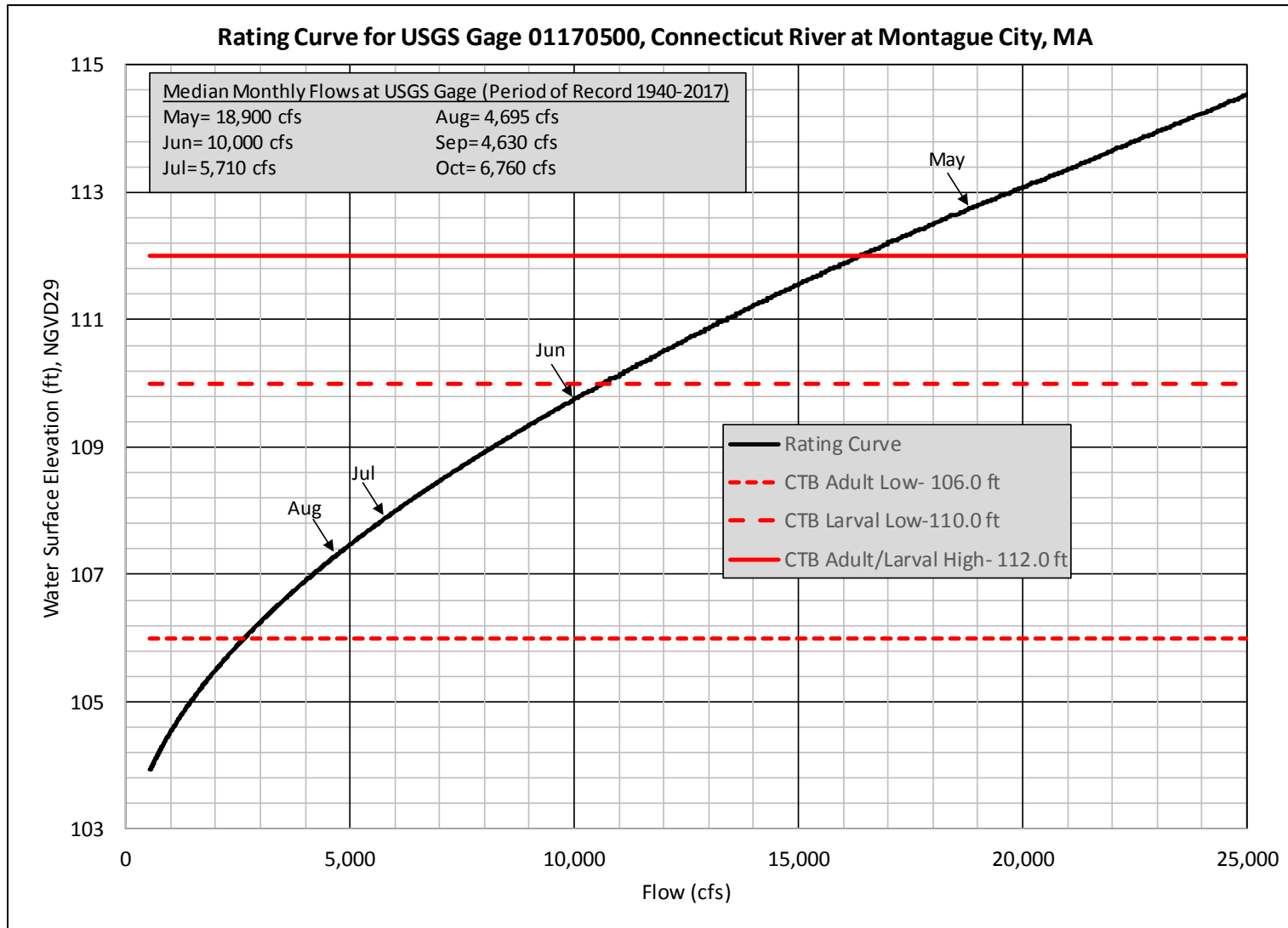


Figure 3.2.1-1: Montague Rating Curve

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

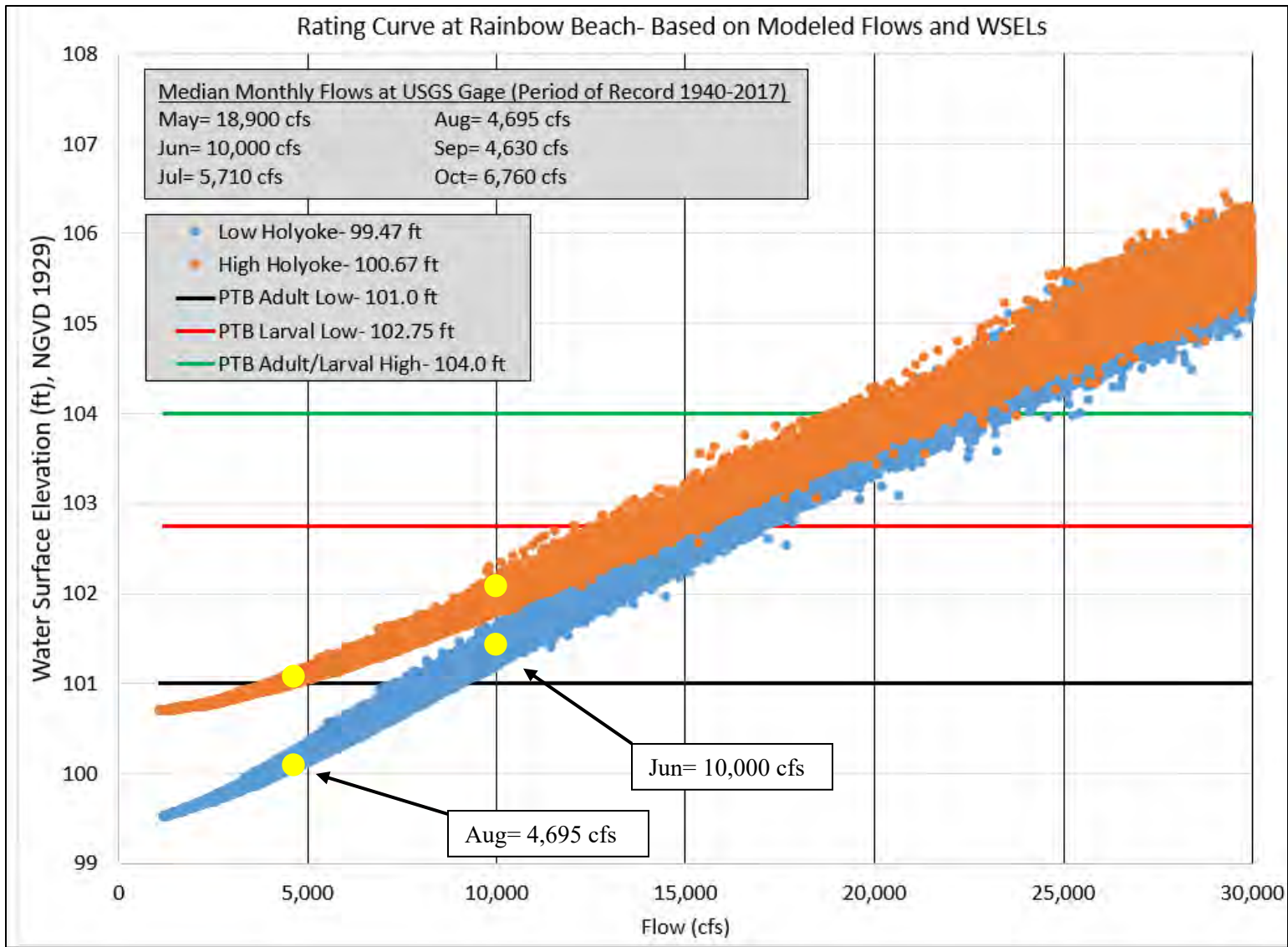


Figure 3.2.2-1: Rainbow Beach Rating Curve

3.4 Synthetic Hydrographs

FirstLight developed a series of “synthetic” time varying hydrographs to evaluate the impact of flows on water elevations at Montague and Rainbow Beach. The flow variables that can influence water elevations at Montague and Rainbow Beach include:

- Base flow- how much water is in the river, prior to bringing a Cabot unit(s) on line. As noted earlier, Station No. 1 is not operated as a peaking facility, thus this assessment focused on Cabot operations.
- How many Cabot units are brought on-line above the base flow- can range between 1 (2,288 cfs) and 6 (13,728 cfs) units.
- How many hours do the Cabot units operate, before shutting the units down and going back to a base flow.
- In addition to the three flow-related bullets above, the Holyoke Dam water elevation can influence habitat at Rainbow Beach (not the case at Montague).

For the synthetic hydrograph modeling, it was assumed there was no tributary inflow between Montague and Holyoke Dam. In reality tributary inflow, while generally very low especially during the summer, would tend to partially mask the changes in the flows between Montague and Holyoke Dam.

In MDFW-6, NHESP requested FirstLight to conduct an analysis of how Holyoke Dam water elevation management influence PTB habitat at Rainbow Beach. NHESP also recommended that the analysis include a range of modeling runs in which Cabot peaking occurs on top of varying base flows of 2,000, 4,000, 6,000, 8,000 and 10,000 cfs.

As the four bullets above describe, there are numerous combinations of flow and Holyoke Dam water elevation management that can influence Rainbow Beach water elevations. FirstLight simulated several scenarios including the ones requested by NHESP and has included the findings in [Appendix A](#). For explanatory purposes, FirstLight selected two scenarios as described below.

Scenario 1

- Base flow at Montague of 2,000 cfs for 3 consecutive hours from noon to 3 pm (3 hrs).
- Peak one Cabot unit (2,288 cfs) for 4 consecutive hours from 3 pm to 7 pm for a total Montague flow of 4,288 cfs.
- Revert back to a base flow at Montague of 2,000 cfs for 17 consecutive hours from 7 pm to noon (17 hrs).
- The total volumetric flow would be $(3 \text{ hrs} \times 2,000 \text{ cfs}) + (4 \text{ hrs} \times 4,288 \text{ cfs}) + (17 \text{ hrs} \times 2,000 \text{ cfs}) = 49,152 \text{ cfs-hrs}$ over a 24-hour period.
- Scenario 1 was run with a) a constant Holyoke Dam water elevation of 99.47 ft and b) a constant Holyoke Dam water elevation of 100.67 ft.
- Scenario 1 was also run assuming a stable flow over the 24 hours. In this case the stable flow would be equivalent to the volume of water used in the peaking scenario or $49,152 \text{ cfs-hrs} / 24 \text{ hrs} = 2,381 \text{ cfs}$. The stable flow was also run with two constant Holyoke Dam water elevations of 99.47 ft and 100.67 ft.

[Figure 3.4-1](#) shows the results for Scenario 1. Shown on the figure are the following:

Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS
FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS
SPECIES- ADDENDUM 3 TIGER BEETLES

- Minimum and maximum habitat elevations for PTB larval and adult.
- Rainbow Beach water elevations under constant Holyoke Dam water elevations of 99.47 and 100.67 ft.
- Rainbow Beach water elevations under one Cabot unit peaking versus a stable flow.
- As [Figure 3.4-1](#) shows peaking one Cabot unit results in an attenuation and lag of when the peak flow arrives at Rainbow Beach.

Scenario 6 (note that Scenarios 2-5 and Scenarios 7-10 are included in Appendix A)

- Base flow at Montague of 2,000 cfs for 3 consecutive hours from noon to 4 pm (3 hrs).
- Peak all six Cabot units (13,728 cfs) for 4 consecutive hours total Montague flow of 15,728 cfs
- Revert back to a base flow at Montague of 2,000 cfs for 17 consecutive hours from 7 pm to noon (17 hrs).
- The total volumetric flow would be 3 hrs x 2,000 cfs + 4 hrs x 15,728 cfs + 17 hrs x 2,000 cfs = 102,912 cfs-hrs over a 24-hour period.
- Scenario 6 would be run with a) a constant Holyoke Dam water elevation of 99.47 ft and b) a constant Holyoke Dam water elevation of 100.67 ft.
- Scenario 6 was also run assuming a stable flow over the 24 hours. In this case the stable flow would be equivalent to the volume of water used in the peaking scenario or $102,912 \text{ cfs-hrs} / 24 \text{ hrs} = 4,288 \text{ cfs}$. The stable flow was also run with two constant Holyoke Dam water elevations of 99.47 ft and 100.67 ft.

[Figure 3.4-2](#) shows the results for Scenario 6. Shown on the figure are the following:

- Minimum and maximum habitat elevations for PTB larval and adult.
- Rainbow Beach water elevations under constant Holyoke Dam water elevations of 99.47 and 100.67 ft.
- Rainbow Beach water elevations under six Cabot unit peaking versus a stable flow.
- As [Figure 3.4-2](#) shows peaking all six Cabot units' results in an attenuation and lag of when the peak flows arrives at Rainbow Beach. In this case, an afternoon Cabot peak starts to have increases in the Rainbow Beach water elevations not until the evening/night hours.

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

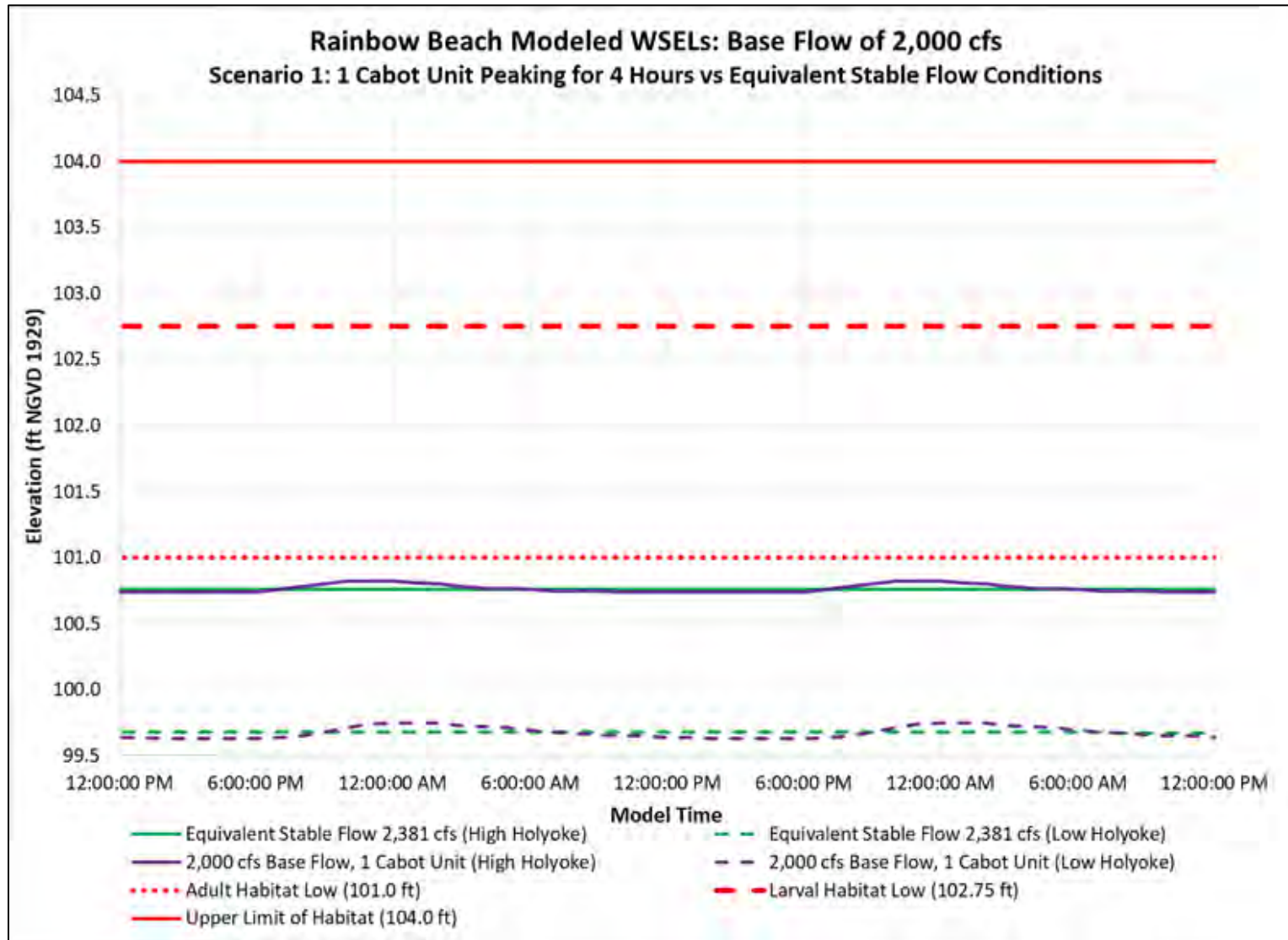


Figure 3.4-1 Rainbow Beach Water Elevations- Scenario 1 (Cabot Peak One Unit= 2,288 cfs and base flow of 2,000 cfs vs Equivalent Stable Flow of 2,381 cfs) under High and Low Holyoke Dam water elevations

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

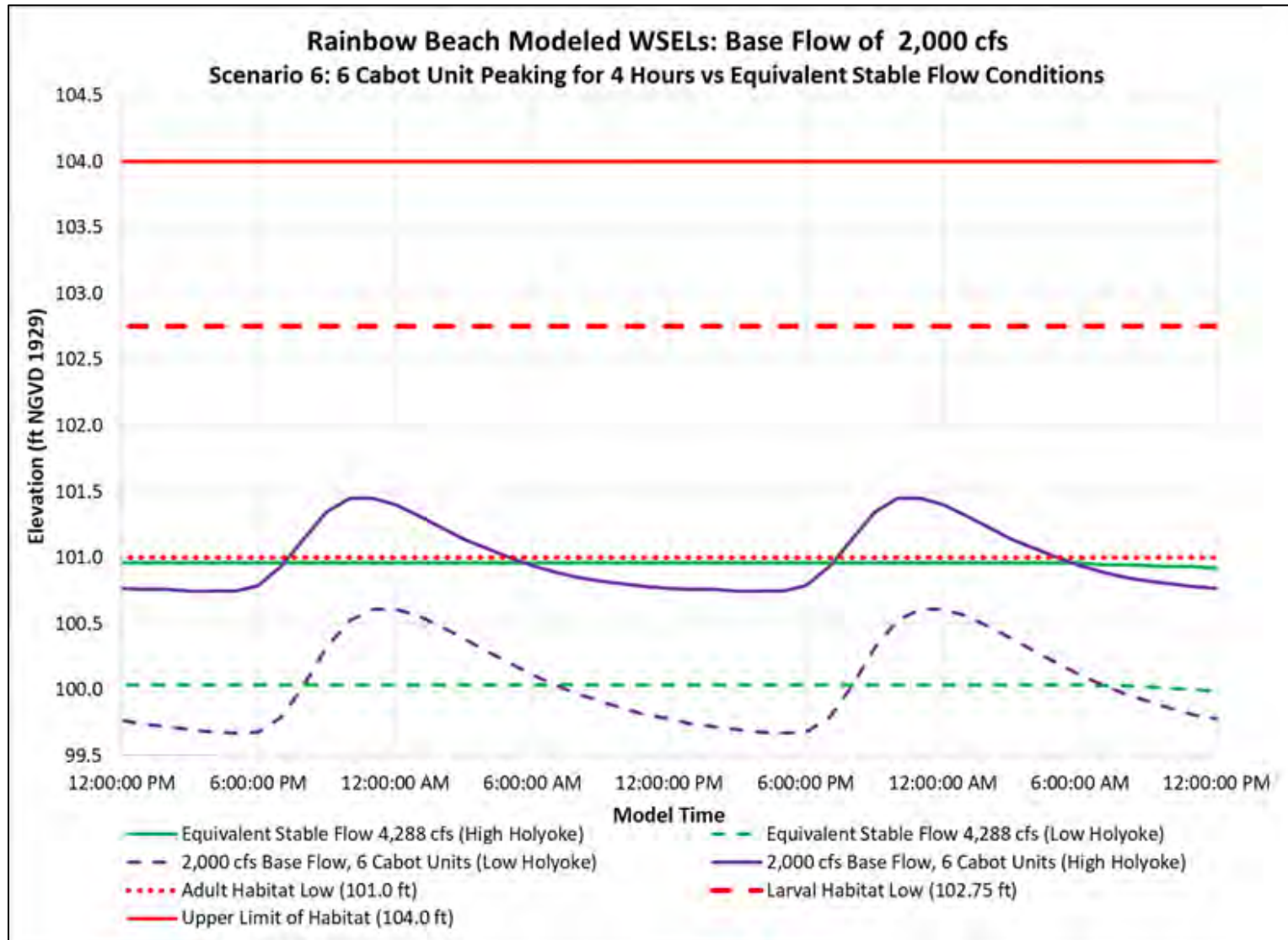


Figure 3.4-2 Rainbow Beach Water Elevations- Scenario 6 (Cabot Peak Six Units= 13,728 cfs and base flow of 2,000 cfs vs Equivalent Stable Flow of 4,288 cfs) under High and Low Holyoke Dam water elevations

3.5 Period of Record Assessment

In addition to the synthetic hydrographs, FirstLight conducted a period of record analysis from January 1, 1962 to December 31, 2003. Specifically, FirstLight used the operations model to simulate two scenarios-baseline (existing) conditions and run-of-river operations. Under the run-of-river operation, the Wilder, Bellows Falls, Vernon and Turners Falls Projects were operated as run-of-river, while Northfield Mountain operated as it currently does. Although the run-of-river scenario simulated Northfield Mountain under its current operation, the flow regime below Cabot was maintained smooth as the Turners Falls Impoundment was used to buffer times of pumping and generating.

Using the Montague flows from the operations model, the HEC-RAS hydraulic model (from Montague to Holyoke Dam) was then run on an hourly time step. Note that the hydraulic model did account for the intervening inflow between Montague and the Holyoke Dam. Ideally, FirstLight would have preferred to run this period of record with the observed Holyoke Dam hourly water elevations from 1962 to 2003. However, as noted earlier, FirstLight requested the Holyoke Licensee to provide hourly water elevations at Holyoke Dam, but were denied. Given the lack of an hourly Holyoke Dam water elevation, four scenarios were simulated in the hydraulic model as follows:

- Baseline conditions and a fixed high Holyoke Dam water elevation of 100.67 ft.
- Baseline conditions and a fixed low Holyoke Dam water elevation of 99.47 ft.
- Run of River conditions and a fixed high Holyoke Dam water elevation of 100.67 ft.
- Run of River conditions and a fixed low Holyoke Dam water elevation of 99.47 ft.

As noted earlier, CTB and PTB larval are active 24 hrs/day from mid-May to mid-Oct, while adults are active from approximately 9 am to 8 pm from mid-Jun to early Sep. The heart of the active period is July and August when daylight hours are longest and air temperatures are warm. Also, as noted earlier, the long-term median July and August flows at the Montague USGS gage are 5,710 and 4,695 cfs, respectively; these are the low flow periods of the year.

For purposes of the four hydraulic modeling scenarios described above, Montague (CTB) and Rainbow Beach (PTB) elevation duration curves were developed based on the following criteria:

- Only the months of July and August (a separate plot for each month)
- Only the hours of 9 am to 8 pm.
- The duration assessment was parsed to include only flows at Montague that were less than 18,000 cfs. A flow of 18,000 cfs was determined as a reasonable boundary for flow at the Montague gage under peak generation at Cabot Station, flows from the Deerfield River, and flows from tributaries between the Montague Gage and Holyoke Dam. There are other times in July and August where flows exceed 18,000 cfs, which exceed the hydraulic capacity of the Turners Falls Hydroelectric Project.

Shown in [Figure 3.5-1](#) is the following:

- Minimum and maximum larval and adult CTB habitat elevations.
- Elevation duration curves at Montague under run-of-river and baseline conditions for the month of July.

[Figure 3.5-2](#) is the same as [Figure 3.5-1](#), but for the month of August.

Shown in [Figure 3.5-3](#) is the following:

- Minimum and maximum larval and adult PTB habitat elevations.
- Elevation duration curves at Rainbow Beach under run-of-river and baseline conditions under a high Holyoke elevation (the dashed lines are High Holyoke) for the month of July.
- Elevation duration curves at Rainbow Beach under run-of-river and baseline conditions under a low Holyoke elevation (the solid lines are low Holyoke for the month of July).

Based on [Figure 3.5-3](#), there is little difference in Rainbow Beach water elevations between run-of-river and baseline conditions for the month of July. [Figure 3.5-4](#) is the same as [Figure 3.5-3](#), but for the month of August. Again, there is little difference in Rainbow Beach water elevations between run-of-river and baseline conditions.

3.5.1 Observed Rainbow Beach Water Elevation Hydrographs

In 2012, FirstLight installed a water level logger at Mitch's Marina³ near Rainbow Beach to understand water levels. The water level logger recorded the water depth (subsequently converted to a water surface elevation) every 15 minutes from April 30 to October 24, 2012. Weekly hydrographs were developed and were included in Appendix C of FirstLight's Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment and below Cabot Station* filed with FERC on March 31, 2015. As noted earlier in this document, FirstLight was unable to obtain from the Holyoke Licensee the Holyoke Dam water elevations during this period.

Shown in [Figure 3.5.1-1](#) and [Figure 3.5.1-2](#) are 15-minute hydrographs of Montague USGS Gage flows and Rainbow Beach water elevations from July 2-9, 2012 and September 3-10, 2012, respectively. Also, shown on the plots are the maximum and minimum elevations between which adult and larval PTB habitat is located. As the figures show, the blue lines represent the Montague USGS Gage flows and reflect Cabot peaking operations. Again, the maximum capacity of Cabot Station is 13,728 cfs and during some of the periods shown on the figures, all of the Cabot units were operating. As noted earlier and supported by these observed water elevations, there is a lag and attenuation of flows by the time it reaches Rainbow Beach. For both hydrographs, only the lower portion of Rainbow Beach is inundated for a few hours in the night, but most of the adult PTB habitat remains available up to elevation 104 ft. Relative to larval PTBs, even under full Cabot peaking operations none of the larval PTB habitat is inundated.

³ Mitch's Marina is located approximately 1.1 miles downstream of Rainbow Beach.

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

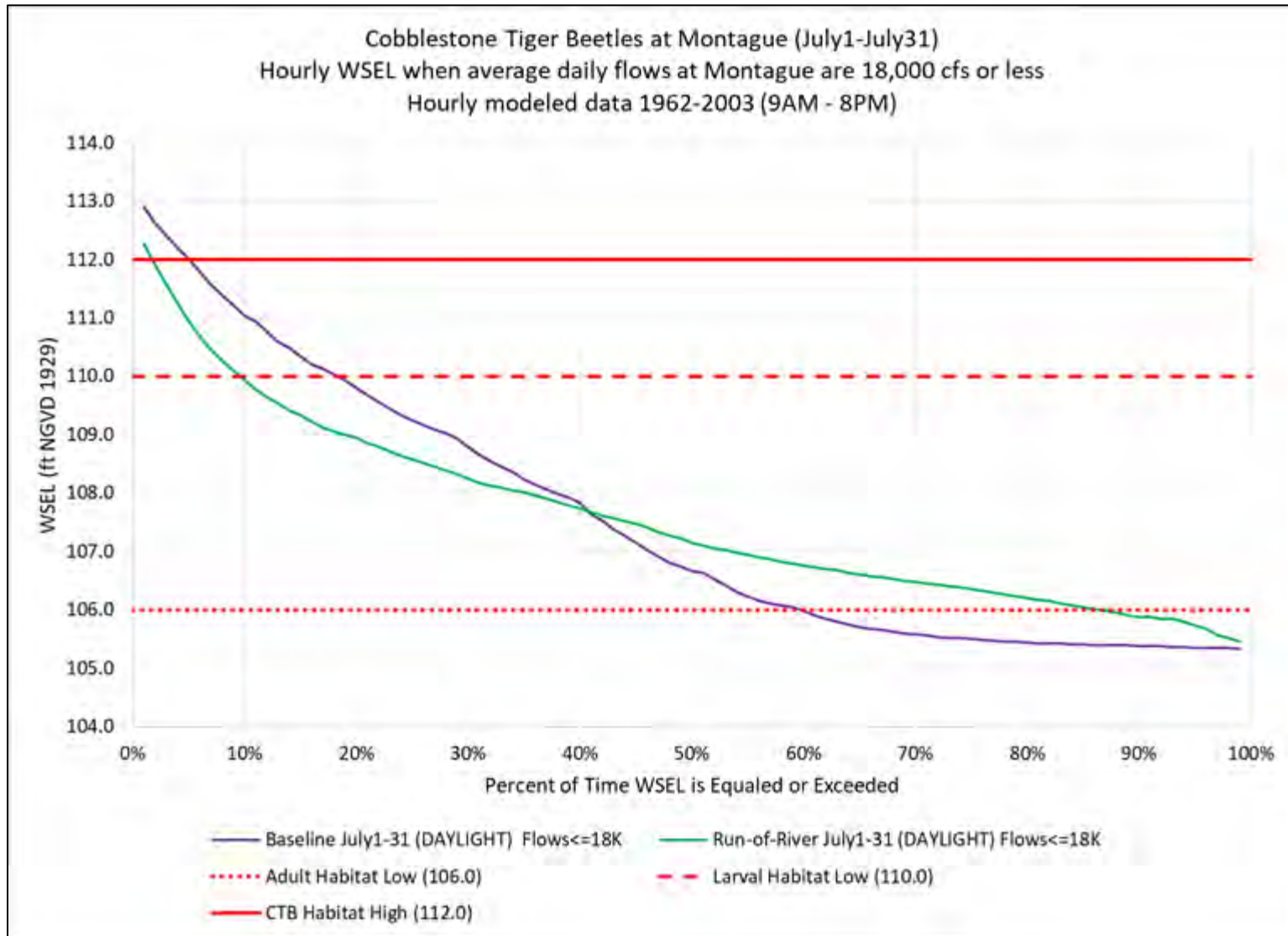


Figure 3.5-1: Montague Elevation Duration Curves, Based: a) baseline and run-of-river operations, b) 42-year period of record, c) July 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum CTB adult and larval habitat elevations.

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

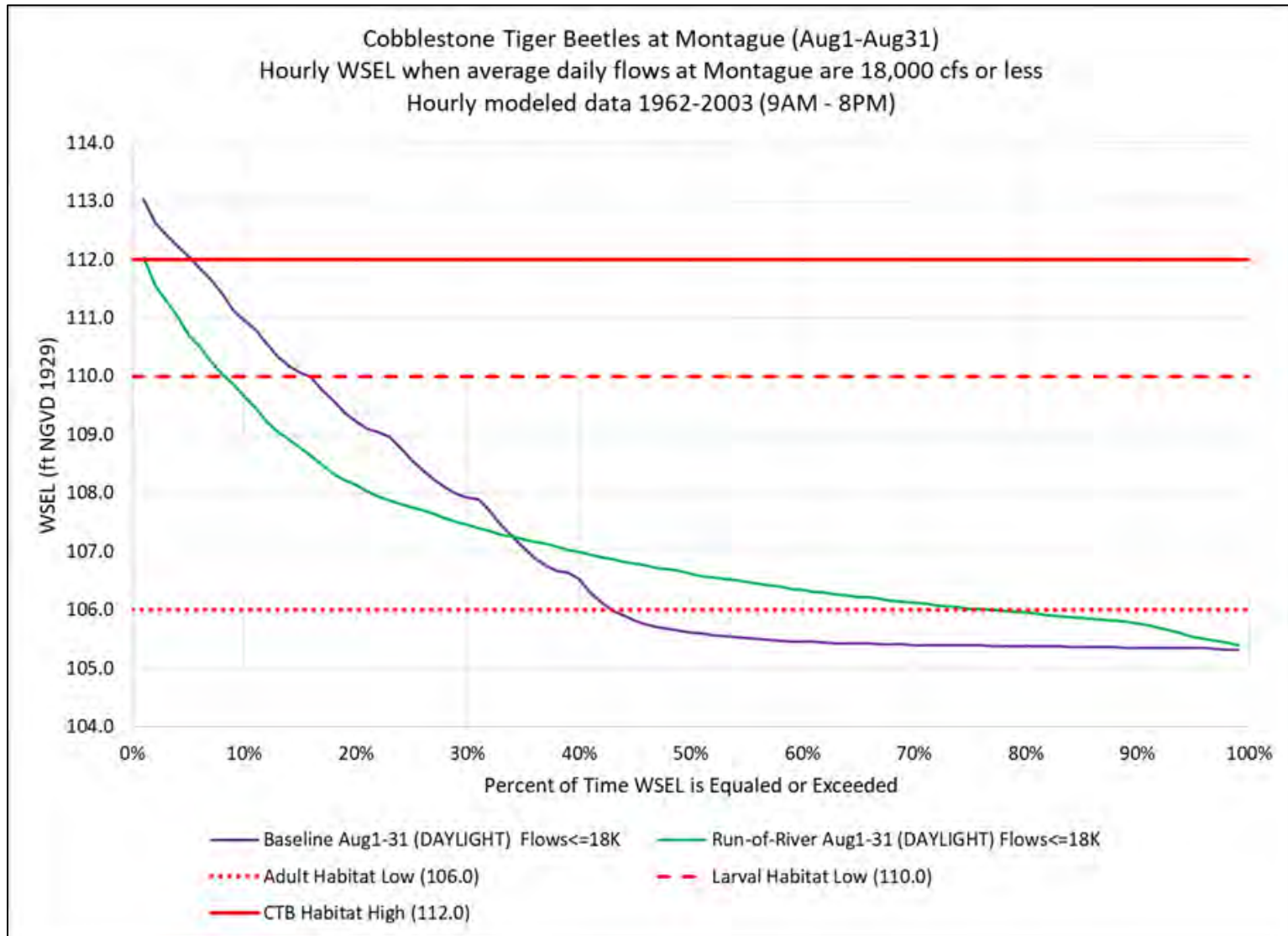


Figure 3.5-2: Montague Elevation Duration Curves, Based: a) baseline and run-of-river operations, b) 42-year period of record, c) July 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum CTB adult and larval habitat elevations.

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

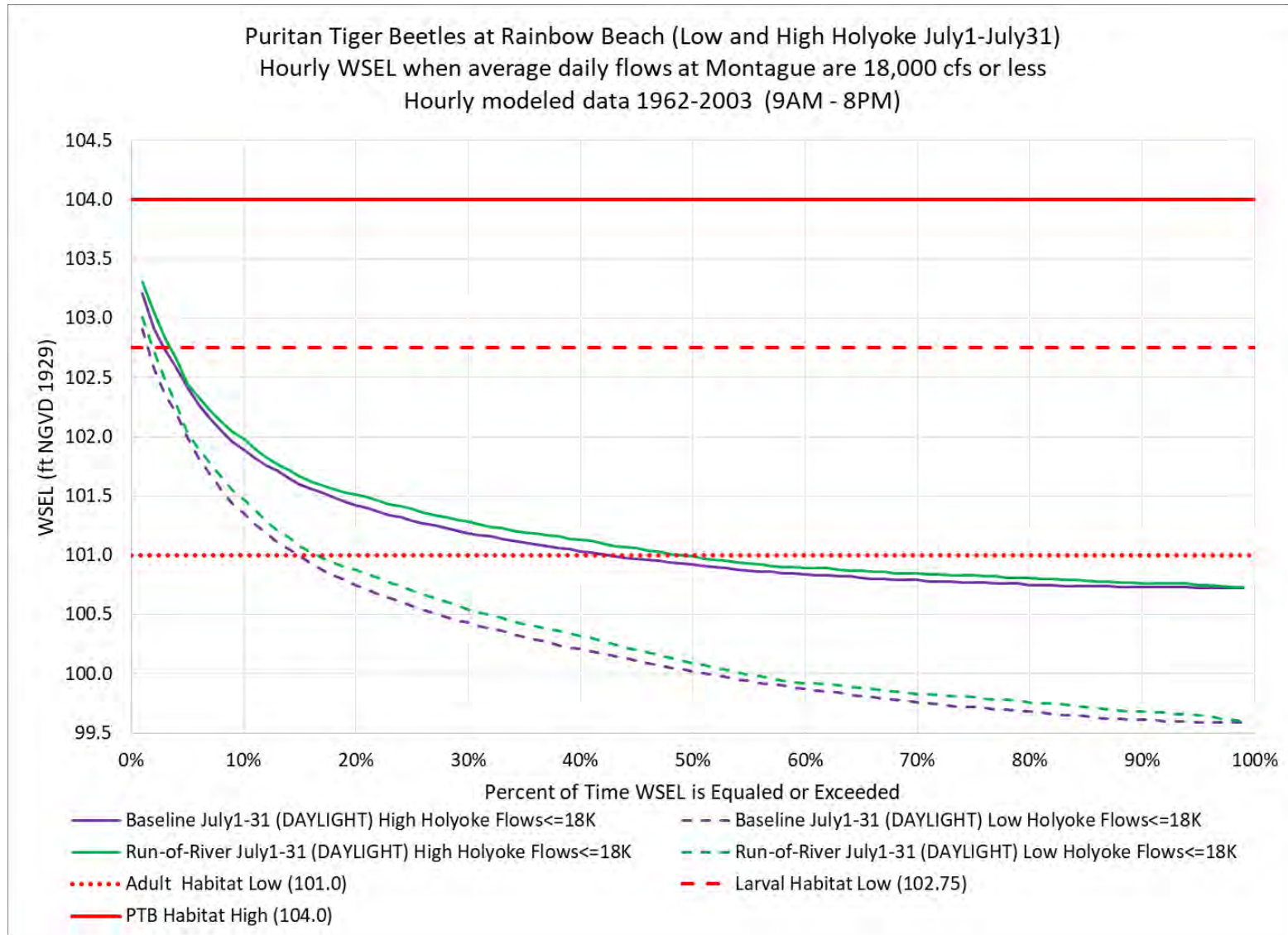


Figure 3.5-3: Rainbow Beach Elevation Duration Curves, Based: a) baseline and run of river operations, b) 42-year period of record, c) July 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum PTB adult and larval habitat elevations.

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

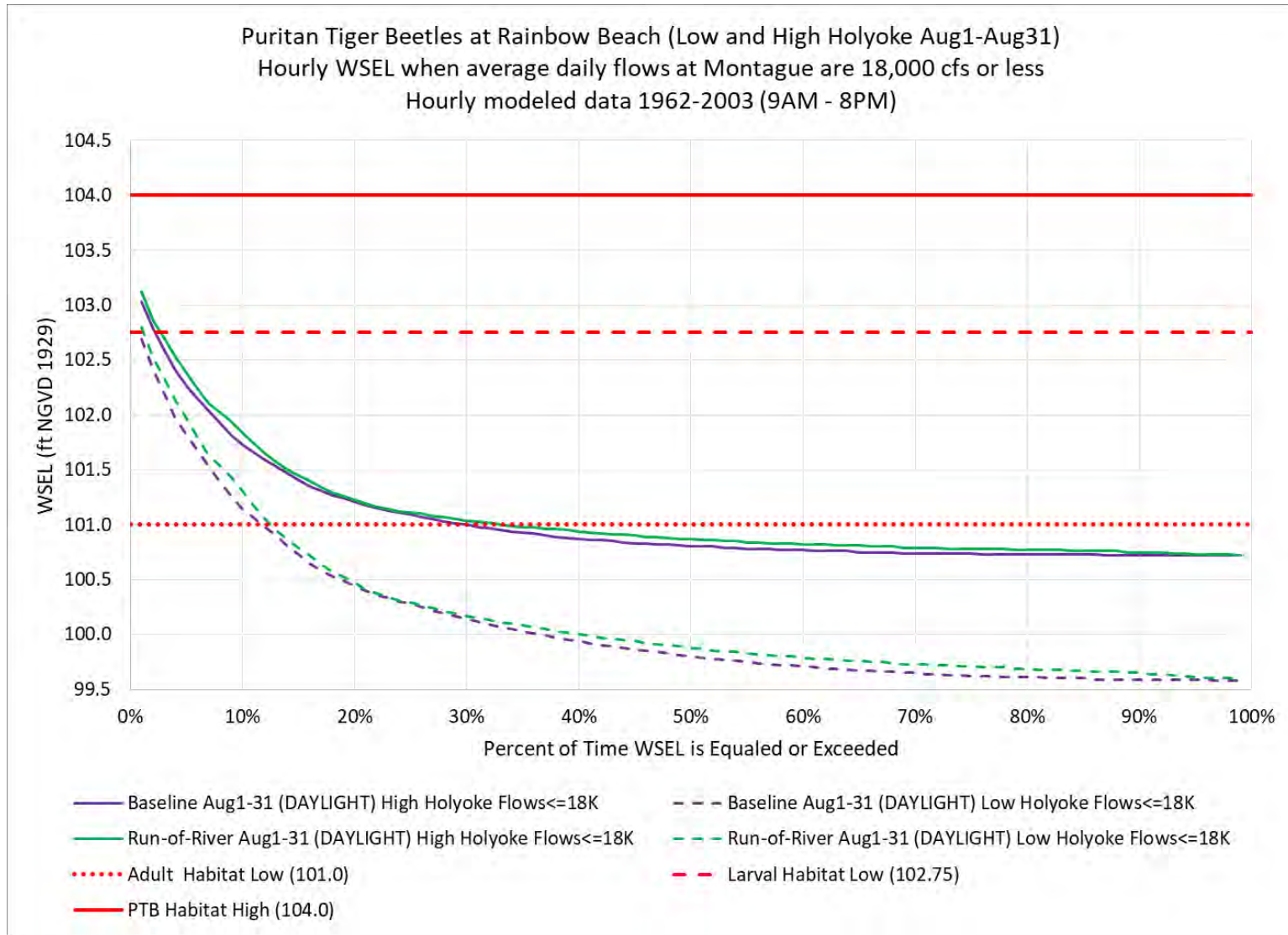


Figure 3.5-4: Rainbow Beach Elevation Duration Curves, Based: a) baseline and run of river operations, b) 42-year period of record, c) August 1-31, d) Daylight Hours of 9 AM to 8 PM, e) flows less than 18,000 cfs at Montague along with minimum and maximum PTB adult and larval habitat elevations.

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

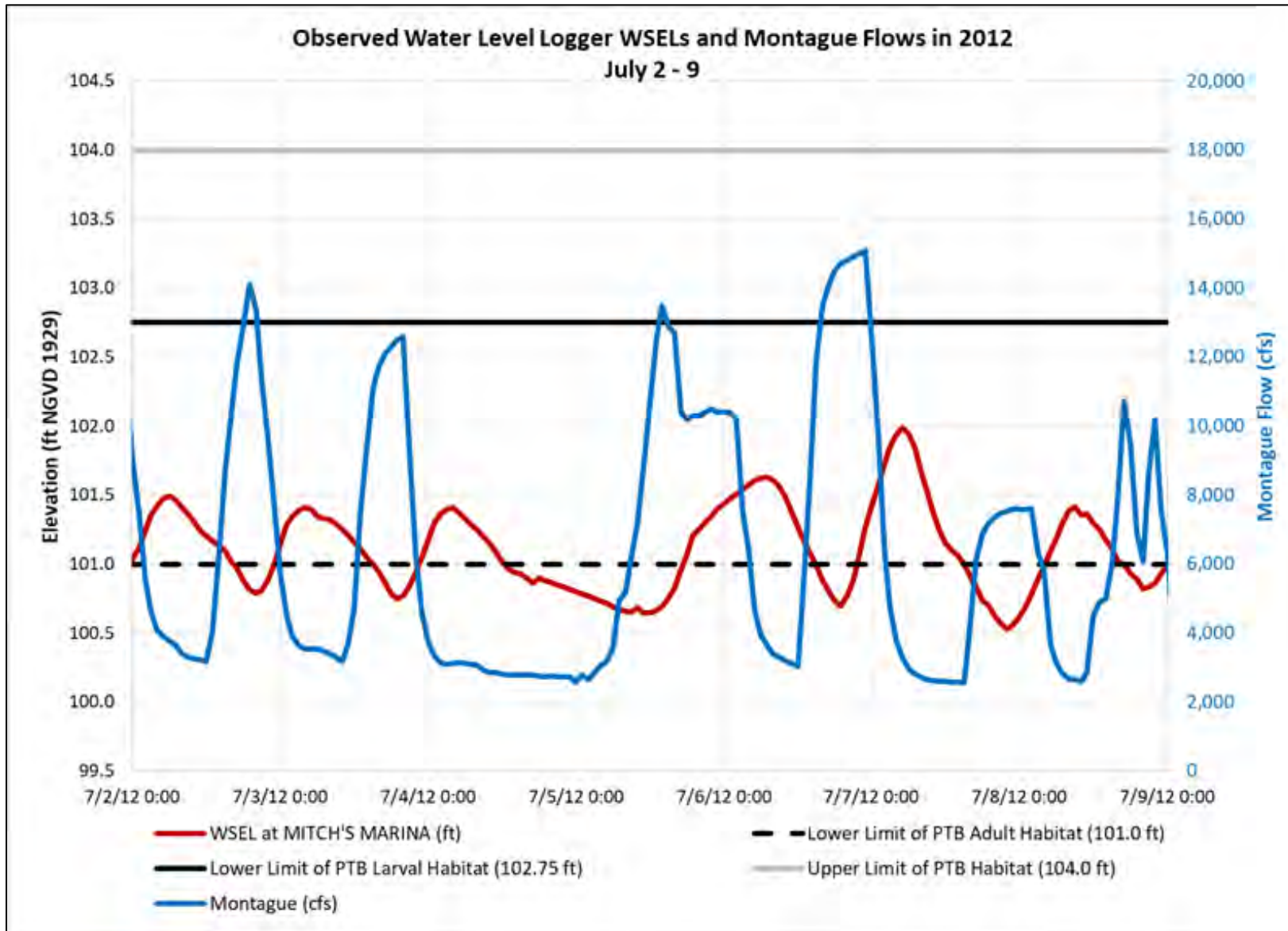


Figure 3.5.1-1: 15-Minute Hydrograph of Montague Gage Flows and Rainbow Beach water elevations from July 2-9, 2012

BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

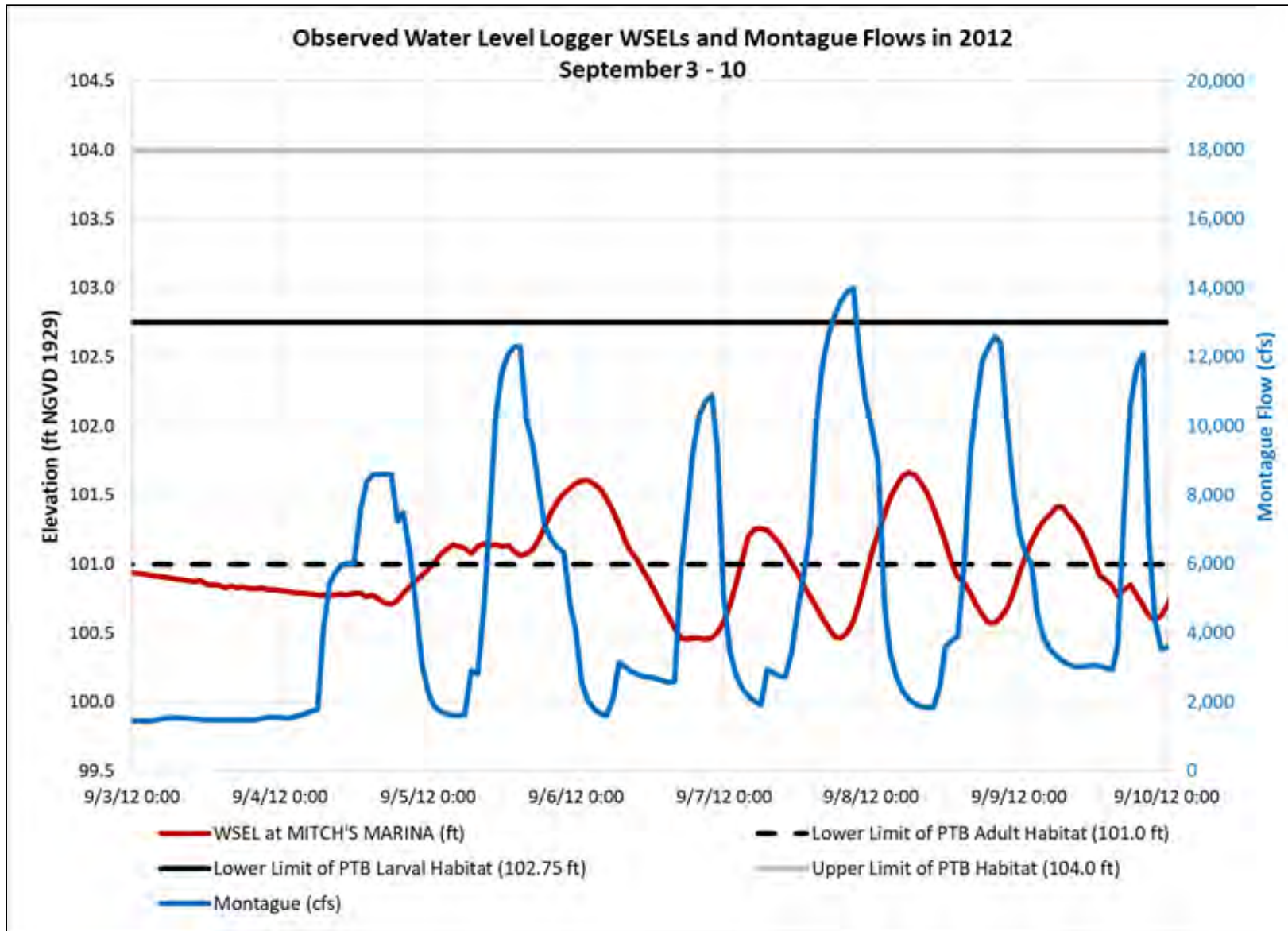


Figure 3.5.1-2: 15-Minute Hydrograph of Montague Gage Flows and Rainbow Beach water elevations from September 3-10, 2012

4 SUMMARY

4.1 Cobblestone Tiger Beetles

The period of record analysis showed that under baseline conditions, the duration of time the minimum adult CTB habitat elevation of 106.0 feet is exceeded occurs less frequently than under run-of-river operations. Due to the location of the CTB habitat near Cabot Station, baseline operations inundates the upper elevations of CTB larval and adult habitat more frequently than run-of-river operations. The percent of time CTB larval and adult habitat starts to become inundated under baseline and run-of-river conditions (when the daily average flow at Montague were 18,000 cfs or less) was as follows:

- CTB larval- July- 16% and 10% of the time under baseline and run-of-river conditions, respectively.
- CTB larval- August- 14% and 9% of the time under baseline and run-of-river conditions, respectively.
- CTB adult- July- 60% and 87% of the time under baseline and run-of-river conditions, respectively.
- CTB adult- August- 43% and 77% of the time under baseline and run-of-river conditions, respectively.

Based on the Montague USGS Gage rating curve, flows exceeding 17,000 cfs result in water elevations above the upper elevation of the CTB larval and adult habitat. These high flows occur frequently, especially in May and June and are outside of FirstLight's control.

Cabot Station has operated as a peaking facility for over a century, yet prior to 2008 CTB were documented at Montague. Over five CTB surveys of the Montague site have been conducted since 2008 and no adult or larval CTB's have been located. Because CTBs were present at the Montague location during the current peaking regime, there is no information to suggest that peaking at Cabot Station, which has not changed in over a century, is related to the absence of this species from the area at the present time.

4.2 Puritan Tiger Beetles

The synthetic hydrographs (see Appendix A) showed:

- When Cabot peaks in the afternoon, the discharges are attenuated and lagged by the time the Cabot "discharges" get to Rainbow Beach. The Cabot discharges generally reach Rainbow Beach during the night when there is no adult PTB activity.
- Maintaining a lower Holyoke Dam water elevation does far more benefit to adult PTB habitat than restricting Cabot peaking operations.
- At higher base flows, even run-of-river operations impact adult PTB habitat.

The period of record analysis showed that under baseline conditions, adult PTB habitat is affected a lower percentage of the time than run-of-river operations.

The observed hydrographs further confirmed that Cabot peaking flows arrive at Rainbow Beach at night, outside the active period of adult PTBs.

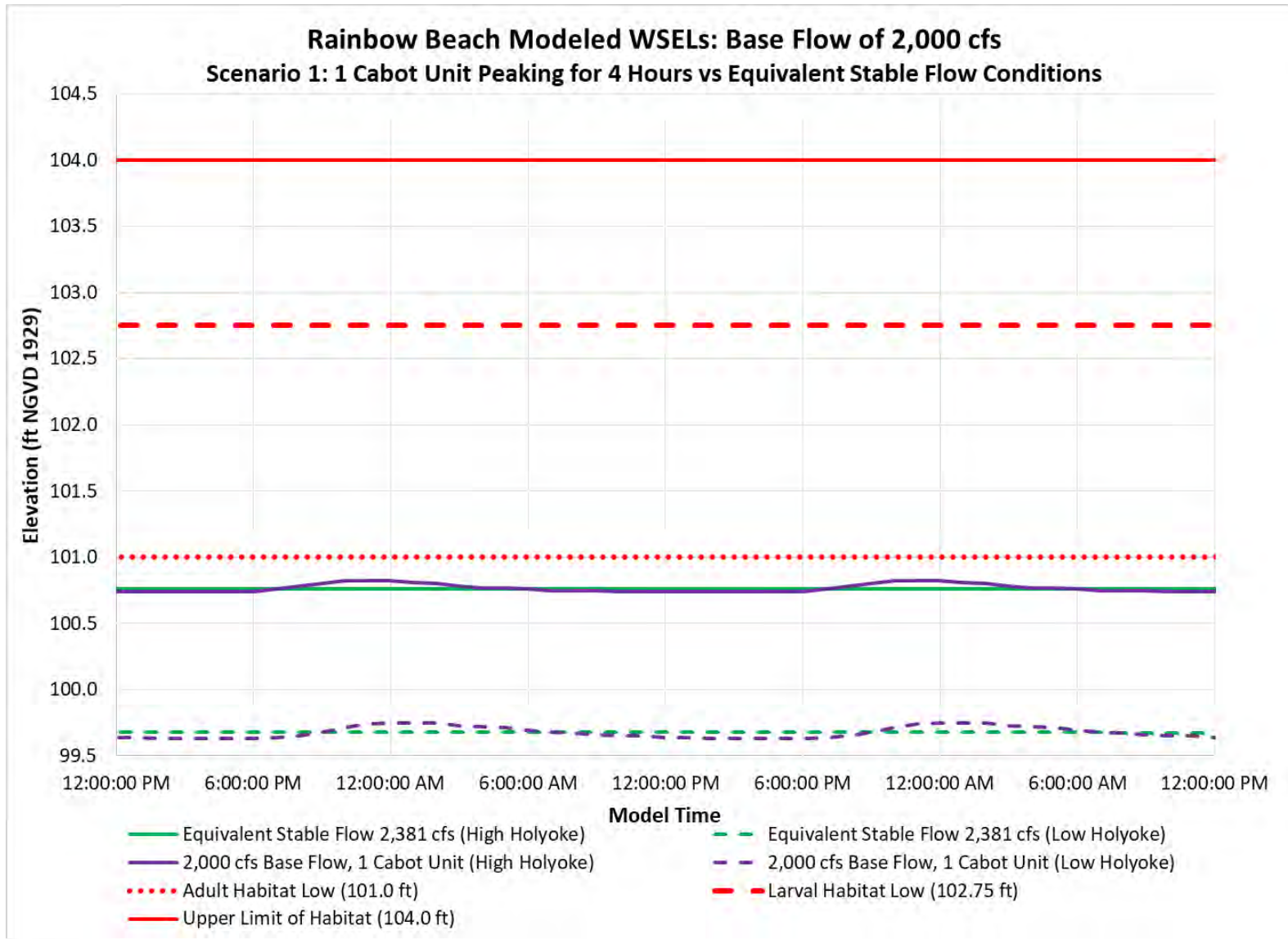
5 REFERENCES CITED

- Brust, M.L, Hoback, W.W., Skinner, K.F., and C.B. Kinsley. 2005. Differential immersion survival by populations of *Cicindela hirticollis*. *Annals of the Entomological Society of America* 98: 973-979.
- Hill, J.M. and C.B. Knisley. 1993. Puritan Tiger Beetle Recovery Plan. Prepared for the U.S. Fish and Wildlife Service, September 1993.
- Kamoun, S., and S.A. Hogenhout. 1996. Flightlessness and rapid terrestrial locomotion in Tiger Beetles of the *Cicindela L.* subgenus *Rivacindela van Nidek* from saline habitats of Australia. *The Coleopterists Bulletin* 50(3): 221-230.
- Knisley, C.B. and M.S. Fenster. 2009. Studies of the Puritan Tiger Beetle (*Cicindela puritana*) and its habitat: Implications for Management. Final Report to the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office.
- New Hampshire Fish and Game Department (NHFG). 2005. New Hampshire Wildlife Action Plan – Appendix A: Species Profiles.
- New Hampshire Fish and Game Department (NHFG). 2015. New Hampshire Wildlife Action Plan – Appendix A: Species Profiles.
- TransCanada Hydro Northeast, Inc. (TransCanada). 2016. ILP Study 26: Cobblestone and Puritan Tiger Beetle Survey. Prepared by Normandeau Associates, Inc. June, 2016.
- U.S. Fish and Wildlife Service (USFWS). 2000. Biological Opinion on the Proposed Population Augmentation of the Federally-Threatened Puritan Tiger Beetle (*Cicindela puritana*) to Rainbow Beach, Massachusetts.

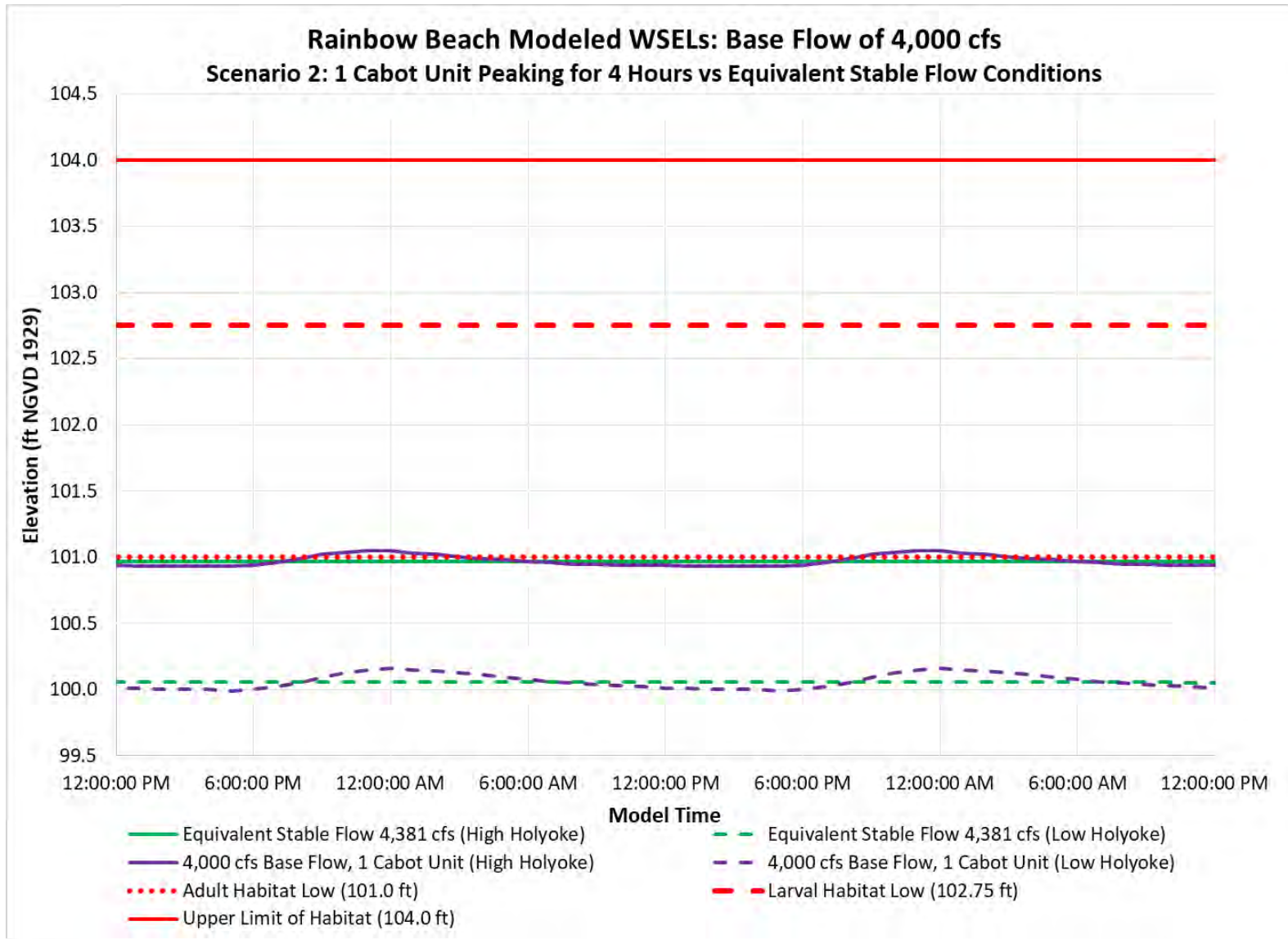
6 APPENDIX A- OTHER SYNTHETIC HYDROGRAPHS SIMULATED

Scenario	Peaking Operations				Stable Flow
	Base Flow (cfs)	Number of Cabot Units and Flow (cfs)	Number of Hours Cabot Units are on-line (hrs)	Downstream Holyoke Boundary Conditions (ft)	Equivalent Stable Flow (cfs)
1	2,000	1 (2,288)	4	99.47	2,381
				100.67	
	2,000	1 (2,288)	4	99.47	2,381
				100.67	
2	4,000	1 (2,288)	4	99.47	4,381
				100.67	
	4,000	1 (2,288)	4	99.47	4,381
				100.67	
3	6,000	1 (2,288)	4	99.47	6,381
				100.67	
	6,000	1 (2,288)	4	99.47	6,381
				100.67	
4	8,000	1 (2,288)	4	99.47	8,381
				100.67	
	8,000	1 (2,288)	4	99.47	8,381
				100.67	
5	10,000	1 (2,288)	4	99.47	10,381
				100.67	
	10,000	1 (2,288)	4	99.47	10,381
				100.67	
6	2,000	6 (13,728)	4	99.47	4,288
				100.67	
	2,000	6 (13,728)	4	99.47	4,288
				100.67	
7	4,000	5 (11,440)	4	99.47	5,907
				100.67	
	4,000	5 (11,440)	4	99.47	5,907
				100.67	
8	6,000	4 (9,152)	4	99.47	7,525
				100.67	
	6,000	4 (9,152)	4	99.47	7,525
				100.67	
9	8,000	3 (6,864)	4	99.47	9,144
				100.67	
	8,000	3 (6,864)	4	99.47	9,144
				100.67	
10	10,000	2 (2,288)	4	99.47	10,763
				100.67	
	10,000	2 (2,288)	4	99.47	10,763
				100.67	

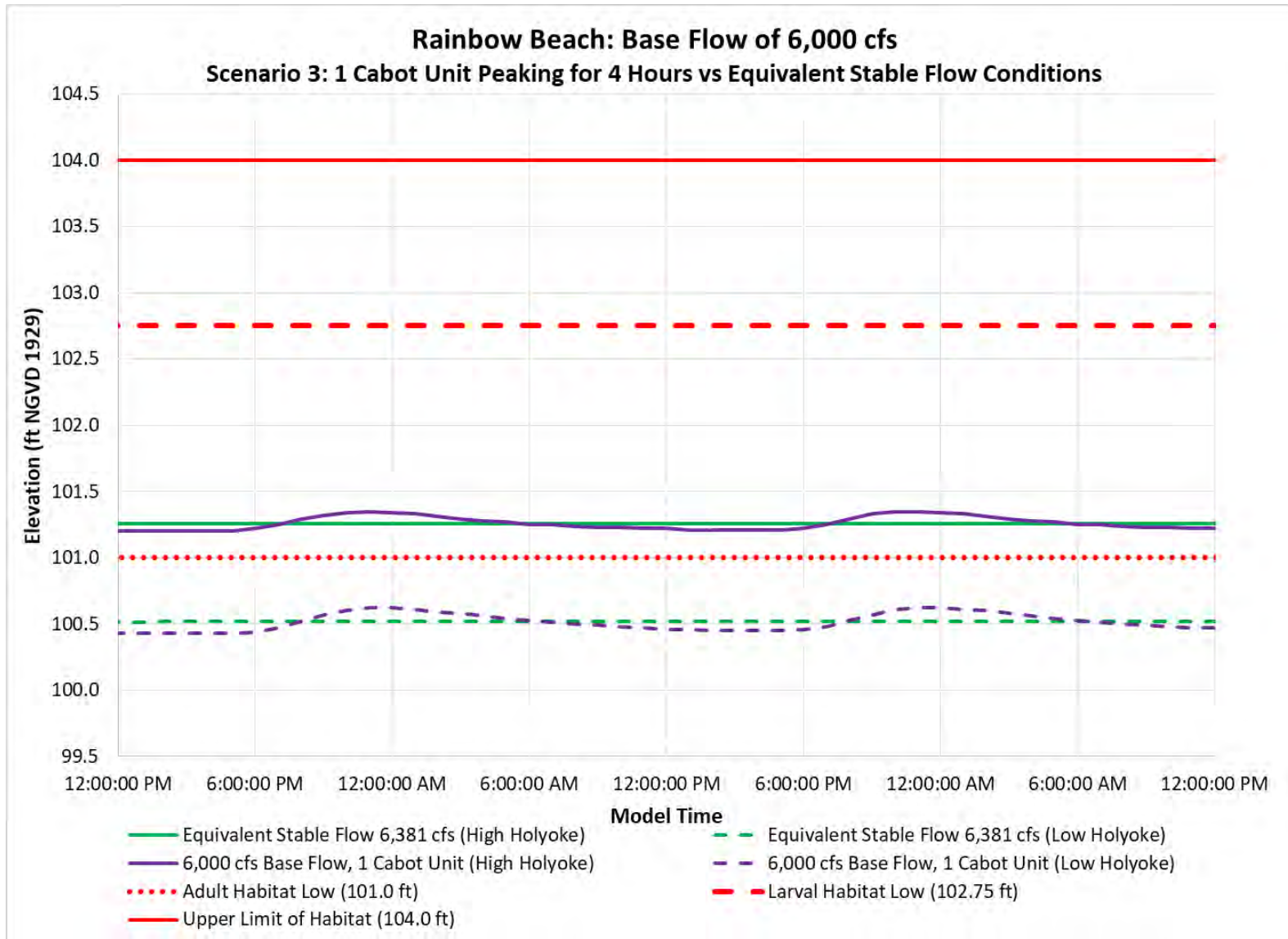
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



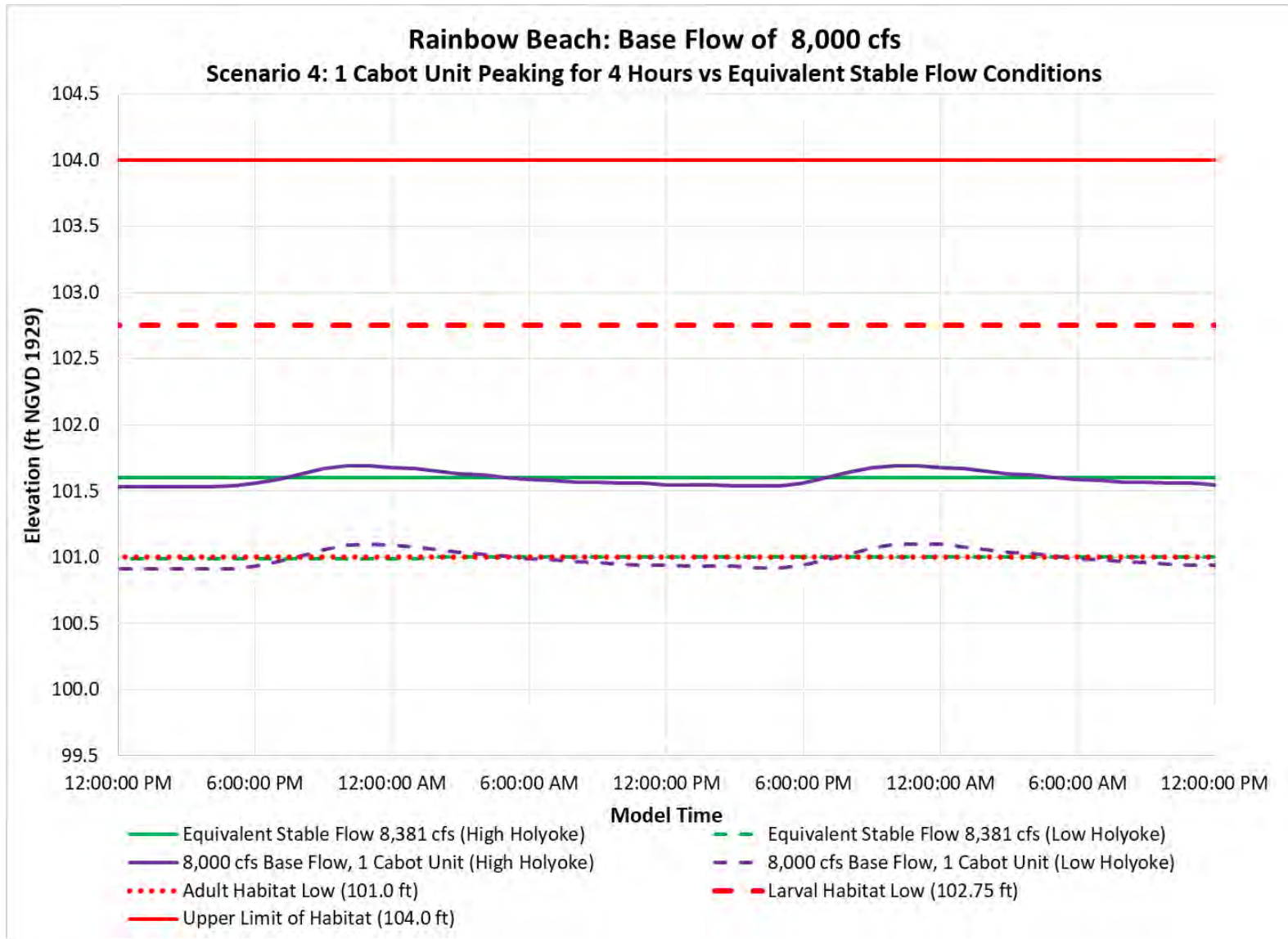
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



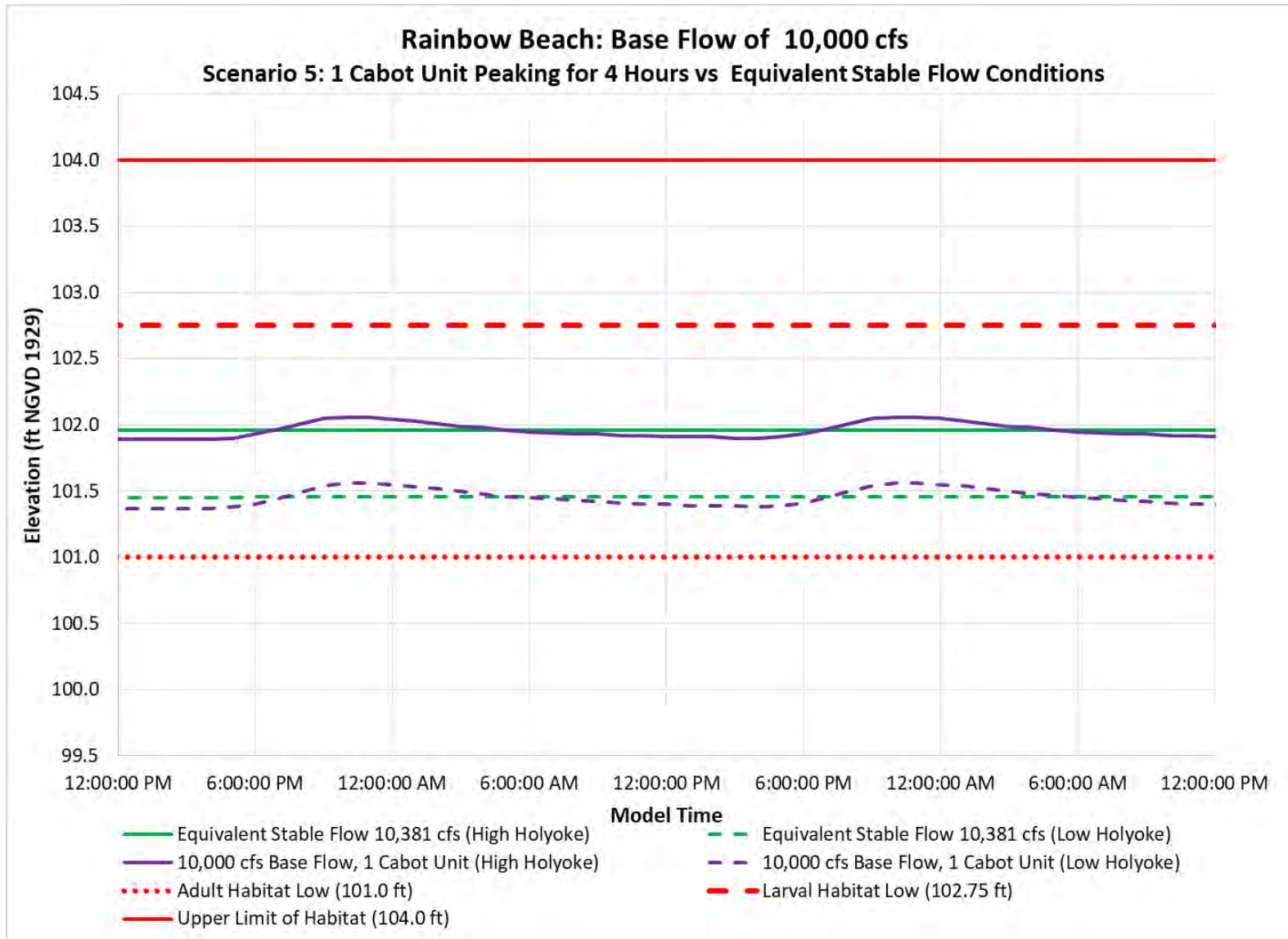
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



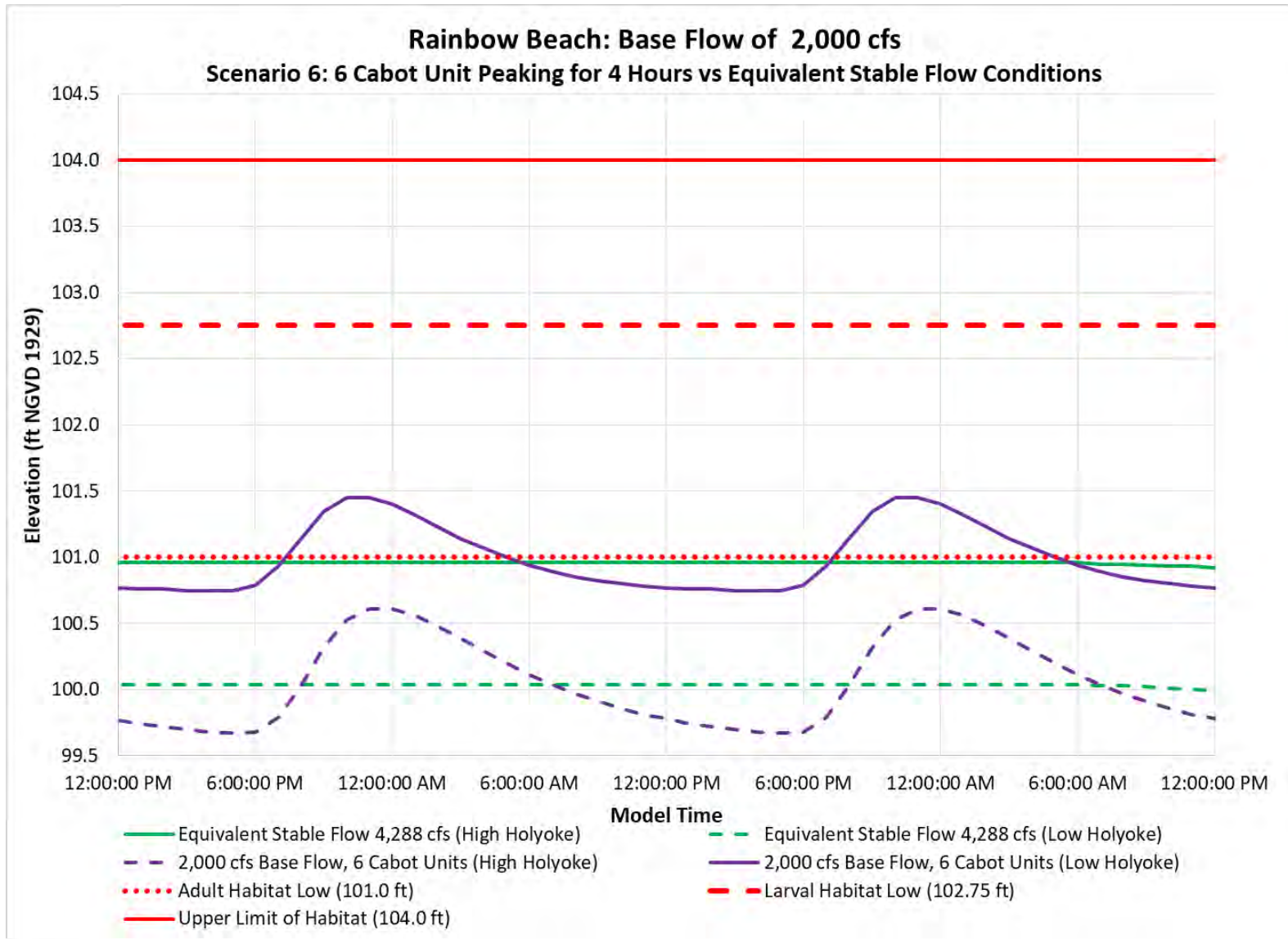
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



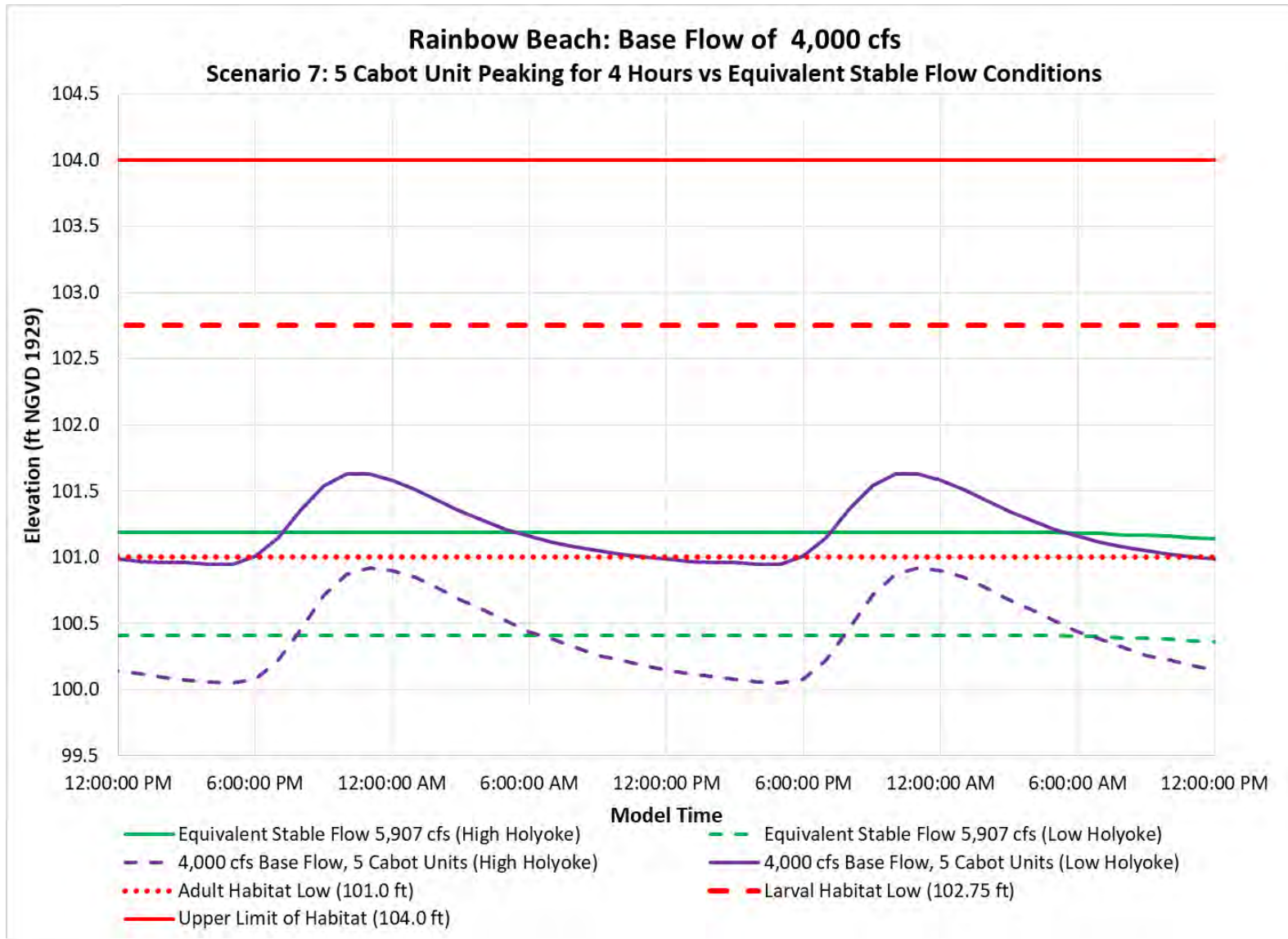
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



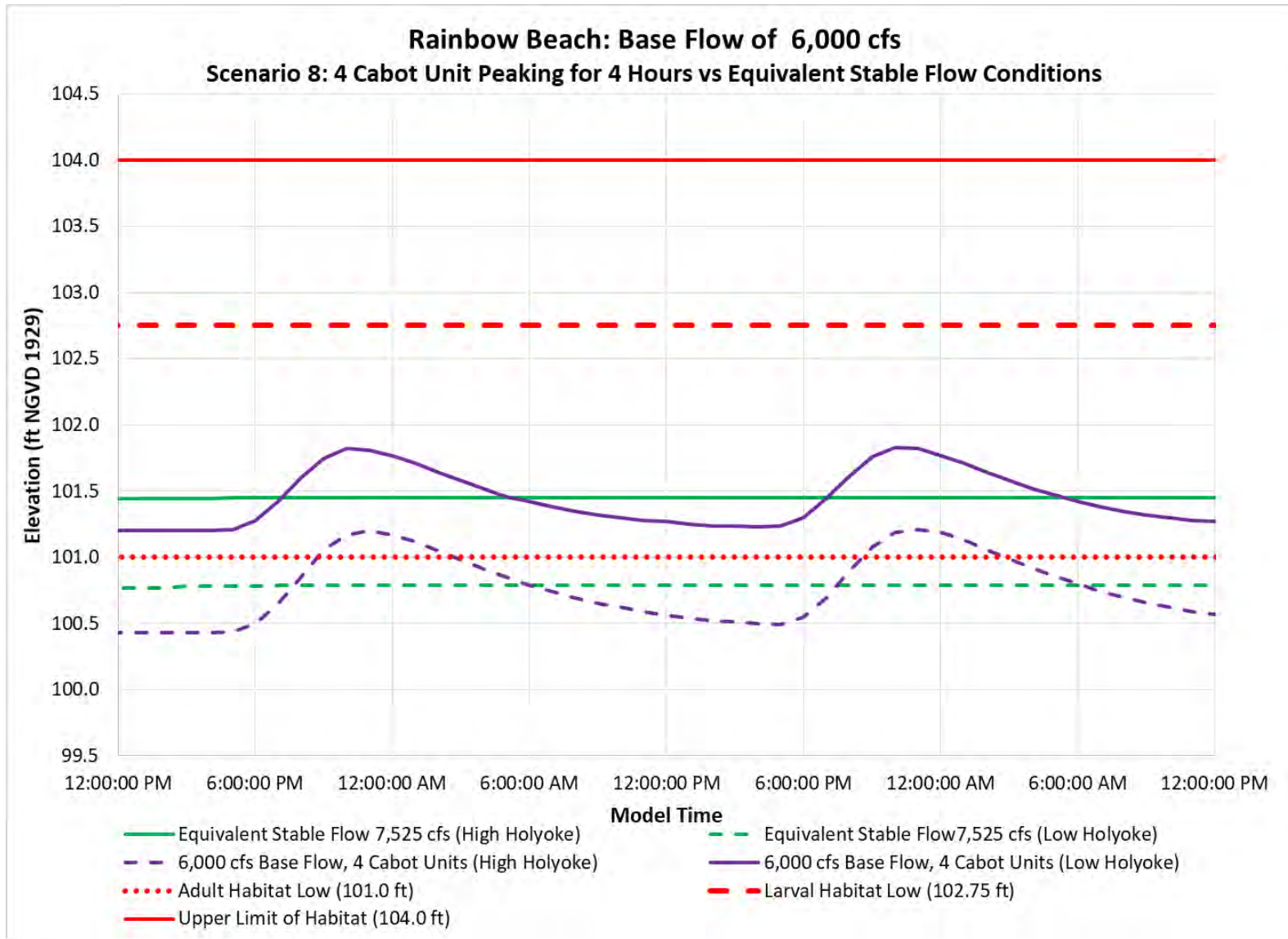
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



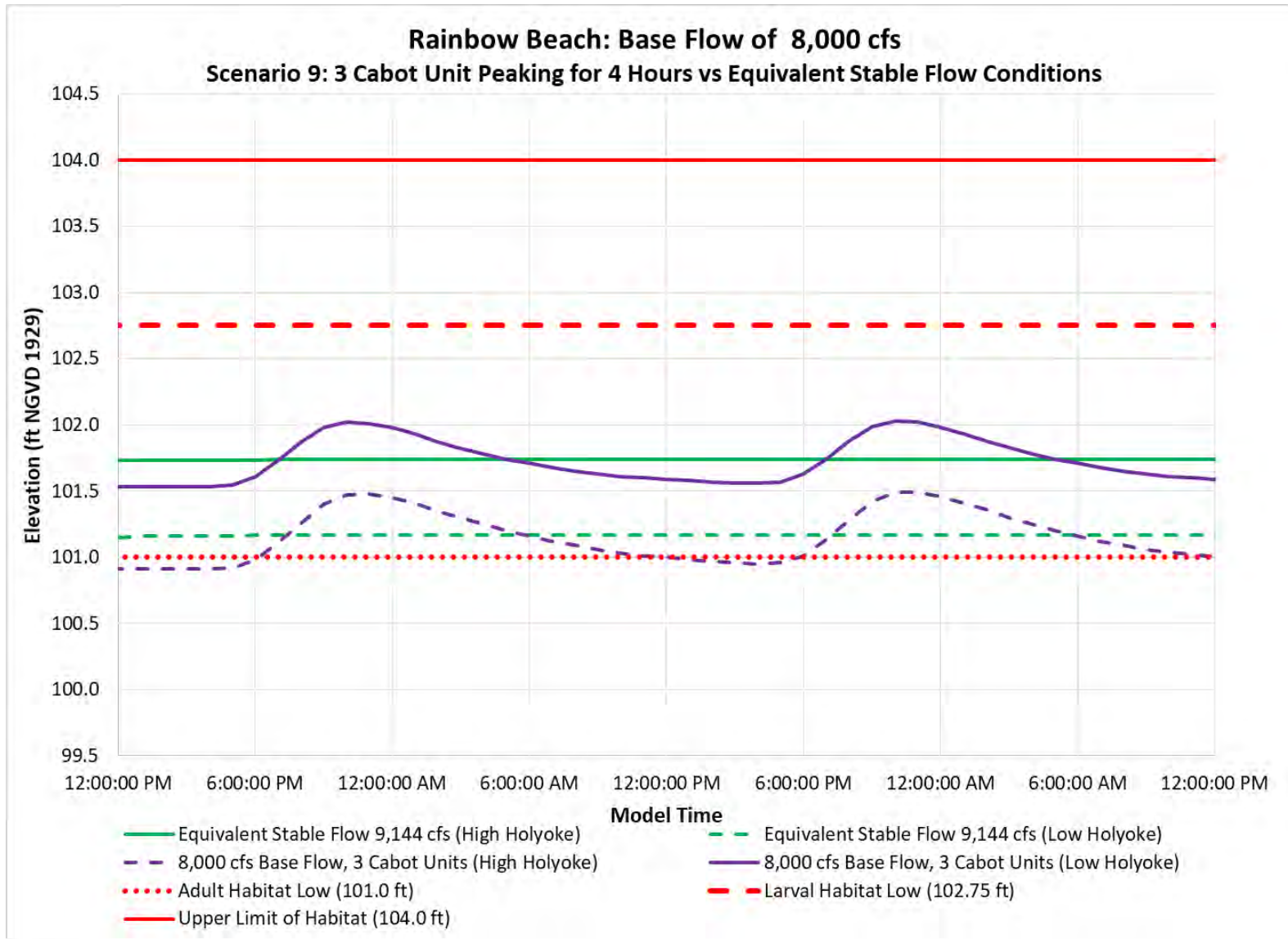
BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES



BASELINE INVENTORY OF WETLAND, RIPARIAN, AND LITTORAL HABITAT IN THE TURNERS FALLS IMPOUNDMENT, AND ASSESSMENT OF OPERATIONAL IMPACTS ON SPECIAL STATUS SPECIES- ADDENDUM 3 TIGER BEETLES

