Relicensing Study 3.1.2

Northfield Mountain / Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability

Evaluating the Impact of Increasing the Useable Storage Volume of the Upper Reservoir on Streambank Erosion in the Turners Falls Impoundment

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

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LIST OF ABBREVIATIONS

BL	Baseline Condition
BSTEM	Bank Stability and Toe Erosion Model
DLA	Draft License Application
EGL	Energy Grade Line
El.	Elevation
EUS	Expanded Use Scenario
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
FLA	Final License Application
Gomez and Sullivan	Gomez and Sullivan Engineer, DPC
HEC-RAS	Hydraulic Engineering Center – River Analysis System
HEC-ResSim	Hydraulic Engineering Center – Reservoir System Simulation
ILP	Integrated Licensing Process
NGVD29	National Geodetic Vertical Datum of 1929 (US Feet)
NMFS	National Marine Fisheries Service
Pump/Gen	Northfield Mountain pump and generation schedule
RSP	Revised Study Plan
S&A	Simons & Associates
SPDL	Study Plan Determination Letter
Study No. 3.1.2	Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impacts on Existing Erosion and Bank Instability*
Study No. 3.2.2	Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot Station*
Study No. 3.8.1	Study No. 3.8.1 *Evaluate the Impact of Current and Potential Future Models of Operations on Flow, Water Elevation and Hydropower Generation*
TFI	Turners Falls Impoundment
the Operations Model Study	Study No. 3.8.1 *Evaluate the Impact of Current and Potential Future Models of Operations on Flow, Water Elevation and Hydropower Generation*
the Causation Study	Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impacts on Existing Erosion and Bank Instability*
the Commission	Federal Energy Regulatory Commission
the Hydraulic Model Study	Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot Station*
USGS	Unites States Geological Survey
WSEL	Water Surface Elevation

1 INTRODUCTION

FirstLight Hydro Generating Company (FirstLight) is the current licensee of the Northfield Mountain Pumped Storage Project (FERC No. 2485) and the Turners Falls Hydroelectric Project (FERC No. 1889). FirstLight has initiated the process of relicensing the two Projects with the Federal Energy Regulatory Commission (FERC, the Commission) using FERC's Integrated Licensing Process (ILP). The current licenses for the Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both set to expire on April 30, 2018.

As part of the ILP, FirstLight has conducted a wide variety of studies to examine the impacts, if any, that Project operations may have on various environmental resources, including streambank erosion in the Turners Falls Impoundment (TFI). On August 14, 2013, FirstLight filed the Revised Study Plan (RSP) with the Commission detailing the methodology for the relicensing studies. Included in the RSP was Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impacts on Existing Erosion and Bank Instability* (Study No. 3.1.2 or the Causation Study). The goals of Study No. 3.1.2 were to evaluate and identify the causes of erosion in the TFI and to determine to what extent they are related to Project operations. The methodology and scope for Study No. 3.1.2 were approved with modifications by the Commission in its September 13, 2013 Study Plan Determination Letter (SPDL). FirstLight filed the final report (Volumes I-III) for Study No. 3.1.2 with the Commission on April 3, 2017 (FirstLight, 2017b)[1].

By letter dated November 12, 2015, the National Marine Fisheries Service (NMFS) requested the Commission modify Study Nos. 3.1.2 and 3.8.1 *Evaluate the Impact of Current and Potential Future Models of Operations on Flow, Water Elevation and Hydropower Generation* (Study No. 3.8.1 or the Operations Model Study) if FirstLight proposed a change in Project operation in the Draft or Final License Application (DLA, FLA). In its DLA, filed with the Commission on December 2, 2015, FirstLight proposed to increase the useable storage volume in the Upper Reservoir. FirstLight acknowledged in its DLA filing that it would conduct additional analysis on the associated effects, if any, of this proposed change. By letter dated March 1, 2016, FirstLight filed its proposed methodology for this additional analysis with the Commission.

The additional analysis used to evaluate the impact of increasing the useable storage volume of the Upper Reservoir on streambank erosion in the TFI was conducted by the primary authors of Study No. 3.1.2, including: Simons & Associates (S&A), Cardno, and Gomez and Sullivan Engineers, DPC (Gomez and Sullivan). The evaluation focused on the use of three primary models: HEC-ResSim (operations model), HEC-RAS (one-dimensional hydraulic model), and the Bank Stability and Toe Erosion Model (BSTEM). Detailed information pertaining to the technical background of the models, as well as how the models were used throughout the TFI, can be found in the final reports for Study No. 3.1.2 (FirstLight, 2017b), Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot Station* (Study No. 3.2.2 or Hydraulic Model Study) (FirstLight, 2015), and Study No. 3.8.1 (FirstLight, 2017a).

The ensuing sections provide additional information pertaining to the methodology used for this analysis (Section 2), modeling results (Section 3), and conclusions (Section 4).

[1] It should be noted that the final report (Vol. I-III) for Study No. 3.1.2 was originally filed with FERC on October 14, 2016; however, FirstLight re-issued the final report on April 3, 2017 to address stakeholder comments.

2 METHODOLOGY

FirstLight relied on a combination of modeling platforms to evaluate the impact of increasing the useable storage volume of the Upper Reservoir on streambank erosion in the TFI. The models used for this evaluation included: HEC-ResSim (operations model), HEC-RAS (one-dimensional hydraulic model), and BSTEM. As mentioned in the previous section, detailed information pertaining to each model can be found in the final reports for Study No. 3.1.2 (BSTEM and HEC-RAS) (FirstLight, 2017b); Study No. 3.2.2 (HEC-RAS) (FirstLight, 2015); and Study No. 3.8.1 (FirstLight, 2017a).

The first step in this evaluation was to identify a representative year, or years, to analyze. For the purpose of this report, the 2002 hydrology and the 2009 pump and generation (pump/gen) schedule for Northfield Mountain were selected.[2] The 2002 hydrology was selected as flows at the United States Geological Survey (USGS) gage on the Connecticut River at Montague, MA for this year are generally lower than average as compared to the recent period of record (i.e. between 1975 and 2015)[3], as shown in Figure 2-1. However, 2002 included a period with peak flows from Vernon in excess of 60,000 cfs unlike the more recent years of 2012 and 2013 which did not include any hour with peak flows in excess of 60,000 cfs. Figure 2-2 provides the monthly flow duration curves for July, August, and September 2002 as compared to the same months for the 1975 to 2015 period. During these three months, flows in the Connecticut River are generally at their lowest and Northfield Mountain operations are generally higher than the other months. The combination of low river flow and high Northfield Mountain use tends to increase the effects on water levels and velocities in the TFI caused by Northfield Mountain pumping and generation. During higher river flow conditions, the effects of variations in Northfield Mountain operations would be at least partially masked by the natural higher river flows and velocities.

By selecting a lower flow period, as opposed to a high flow period, FirstLight simulated a period when the potential for Project operations to cause erosion would be the greatest. As discussed in FirstLight, 2017b, water level fluctuations due to hydropower operations are greatest during low flow periods when the Project operates more frequently. Based on the results of the analysis conducted in the initial report (FirstLight, 2017b), the Project does not operate as much during high flow periods and the French King Gorge becomes the hydraulic control for the middle and upper portions of the TFI. Although the vast majority of erosion occurs during high flow periods, it is caused by natural high flows and not Project operations. Given this, if Project operations were to have an impact on erosion it would more likely be during a low flow period as opposed to a high flow period. Nevertheless, given that the 2002 hydrology also included high flow periods, the impact of expanded use of the Upper Reservoir on TFI erosion during high flow periods was accounted for.

The 2009 pump/gen schedule was chosen as it represented a typical year of current operations. Figure 2-3 provides duration curves for the daily water volume (acre-feet) for generation at Northfield Mountain in 2009, as compared to 2000-2007, 2008, 2011, 2012, 2013, and 2014. This figure indicates that the daily volume of water used for generation in 2009 was about average for the 2000-2014 period and higher than the recent years of current Northfield Mountain operations. Data from 2010 were not included in this figure due to the extended outage at Northfield Mountain during that year.

The HEC-ResSim model was then run using the input parameters from 2002 (hydrology) and 2009 (pump/gen) and the operating equipment that is currently in-place. The results of this run represented the **Baseline Condition (BL)**. FirstLight operations personnel then modified the 2009 pump/gen schedule

[2] In addition to the reasons listed above, the 2002 hydrology and 2009 pump/gen schedule were also selected to ensure consistency with past analyses which have been conducted (i.e., winter 2014/2015 temporary amendment).
[3] While the USGS Gage at Montague provides daily flows starting in 1903, the period of record used for this analysis begins in 1975 due changes in the regulation of the Connecticut River Basin (e.g. construction of flood storage facilities, implementation of minimum flow requirements).

(with the benefit of hindsight) to determine how the Project would have operated in this time period if the additional Upper Reservoir storage capacity had been available. The modified 2009 schedule, combined with the actual 2002 hydrology, was then run through HEC-ResSim; the results of this run represented the **Expanded Use Scenario (EUS)**. Table 2-1 provides a summary of the modeling scenarios.

The HEC-ResSim outputs (Vernon discharge, Northfield Mountain pump/gen flows, Ashuelot and Millers River flows, and TFI elevation at the Turners Falls (TF) Dam) from both scenarios were then run through HEC-RAS to determine the flow, water surface elevation (WSEL), and Energy Grade Line (EGL) slope at each TFI detailed study site for each scenario.[4] HEC-RAS outputs were then used as input parameters for BSTEM. BSTEM runs were executed for both scenarios at all 25 TFI detailed study sites. For both the BL and EUS, BSTEM runs were executed with boat waves on and off. Aside from the HEC-RAS outputs, all other BSTEM parameters were the same as those used for Study No. 3.1.2 (e.g., cross-section geometry, geotechnical properties, boat waves, etc.). The difference in the amount of erosion from the BSTEM results for the BL and EUS, if any, were attributed to the increased use of the Upper Reservoir storage.

Figure 2-4 provides a graphic depiction of the various models, input and output parameters used for this evaluation.

Table 2-1: Summary of Modeling Scenarios

Modeling Scenario	Input Hydrology	Input Pump/Gen
Baseline Condition	2002	2009
Expanded Use Scenario	2002	Modified 2009

[4] The detailed study sites which were examined as part of this evaluation are the same sites used in the final report for Study No. 3.1.2 (FirstLight, 2017b).

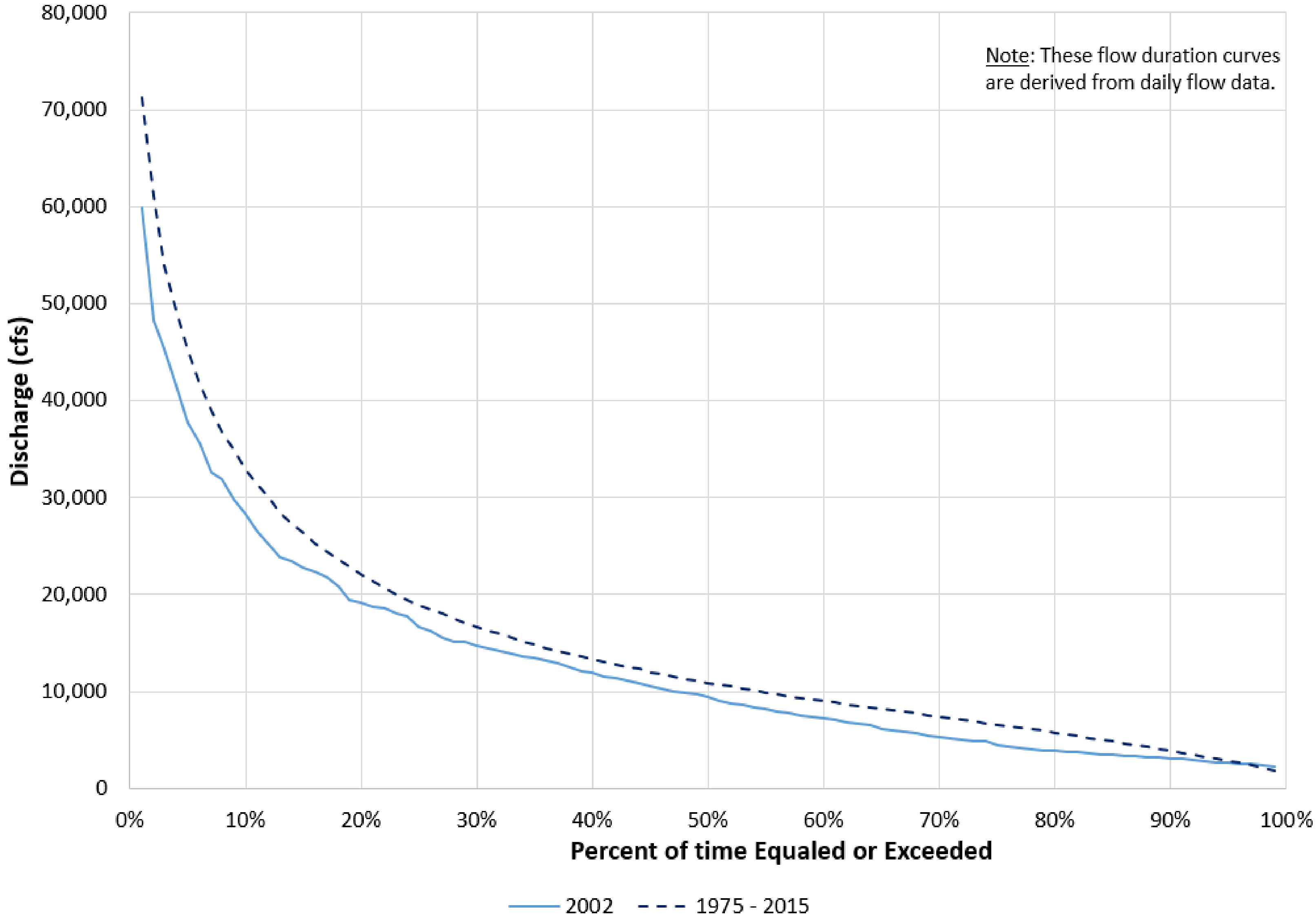

Figure 2-1: Montague USGS Gage – Comparison of Annual Flow Duration Curve

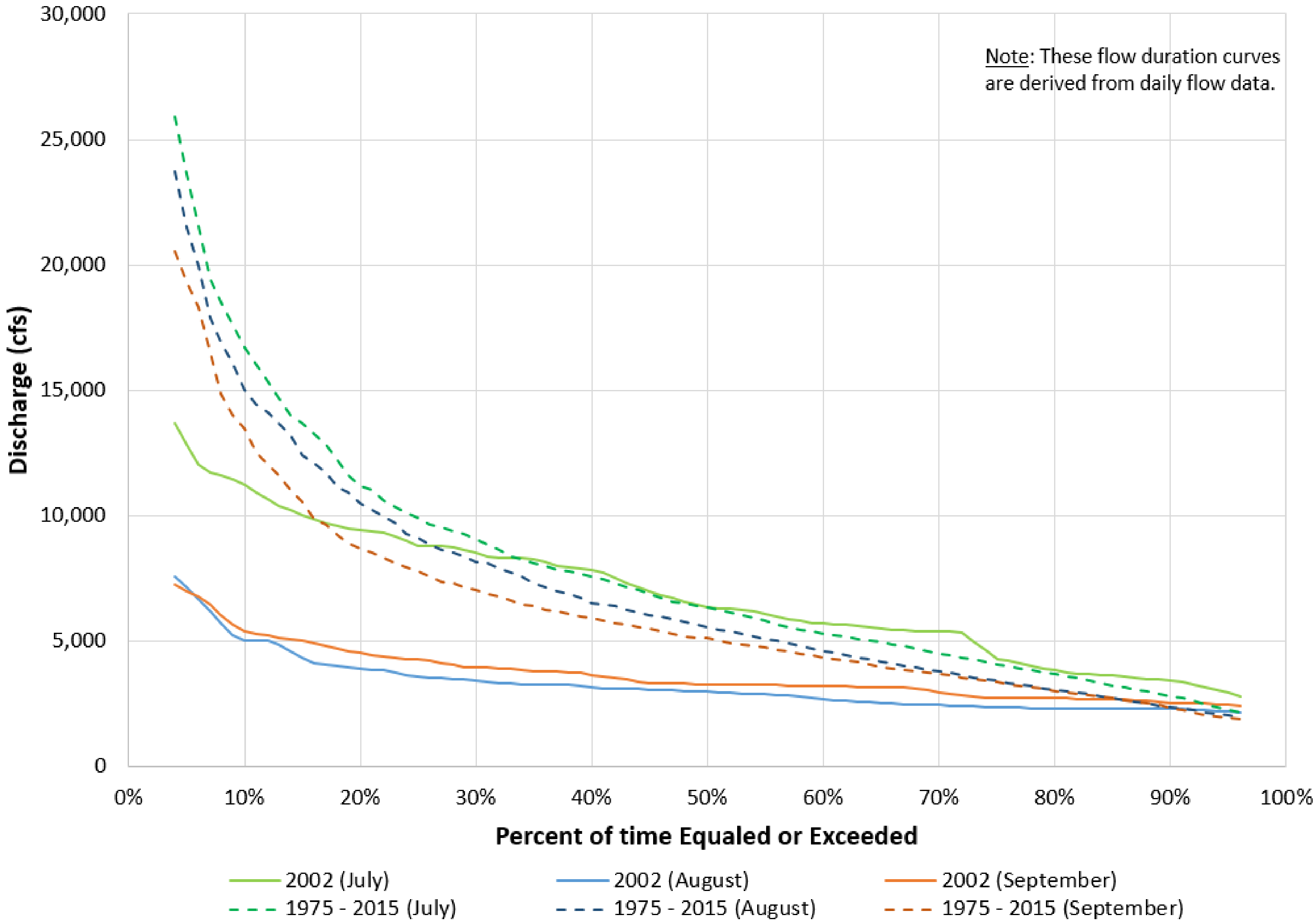

Figure 2-2: Montague USGS Gage – Comparison of Monthly Flow Duration Curves for July, August, and September

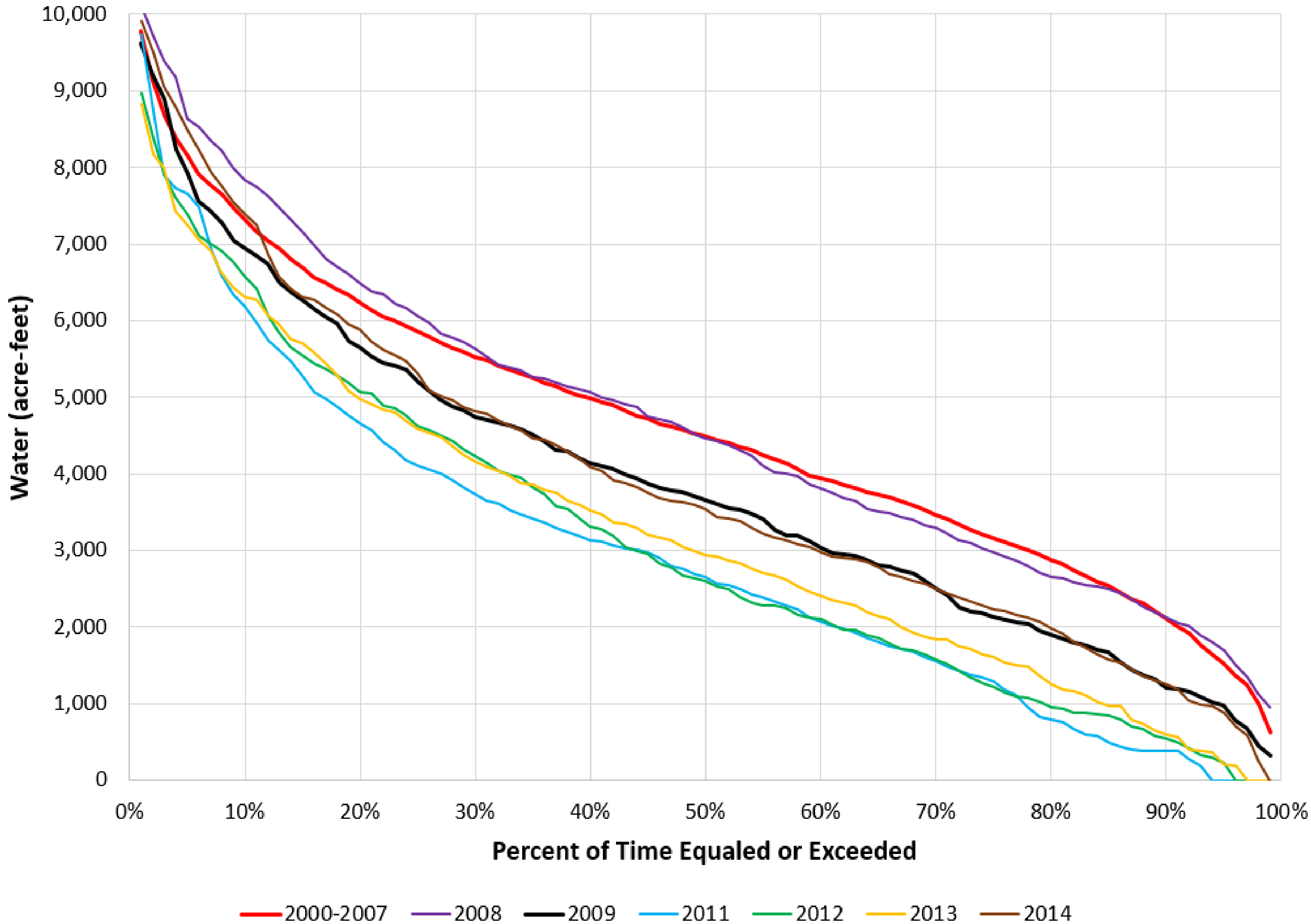

Figure 2-3: Daily Volume (acre-feet) of Water Use at Northfield Mountain for Generation

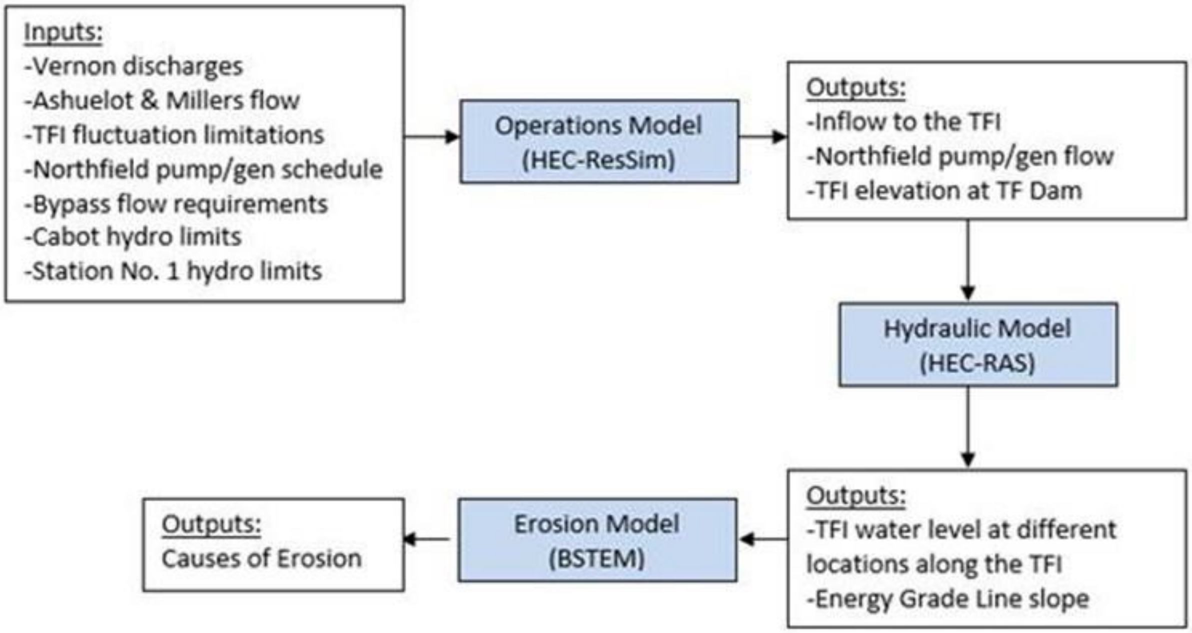

Figure 2-4: Models, Input and Output Parameters used to evaluate the Impact of Increasing the Useable Storage Volume of the Upper Reservoir on Streambank Erosion in the TFI

3 RESULTS

3.1 HEC-ResSim

As depicted in Figure 2-1, the operations model outputs pertinent to evaluating the expanded use of the Upper Reservoir on TFI erosion are inflow to the TFI, Northfield Pump/Gen flow, and TFI elevation at TF Dam. Inflow to the TFI (i.e., Vernon discharges and Ashuelot and Millers River flows) does not vary between the BL and EUS, because the same hydrology (i.e., 2002) was used for each scenario. As expected, the EUS results in more pumping and generation; however, the increase is rather minor as depicted by the flow duration curves provided in Figure 3.1-1 and Figure 3.1-2. The resulting impact to the TFI WSEL is likewise minimal, as depicted by the WSEL duration curves provided in Figure 3.1-3. As observed in the figures, the difference in the BL and EUS WSEL's for any given percentile ranges from -0.27 feet to 0.12 feet, with an average difference of -0.01 feet. The results of this analysis demonstrate the minimal impact expanded use of the Upper Reservoir has on TFI WSELs' over the course of the year (i.e. -0.01 feet on average).

Full details of the HEC-ResSim model, including model setup, calibration, and analyses were provided in the study report for Study No. 3.8.1 *Evaluate the Impact of Current and Potential Future Models of Operations on Flow, Water Elevation and Hydropower Generation* (FirstLight, 2017a).

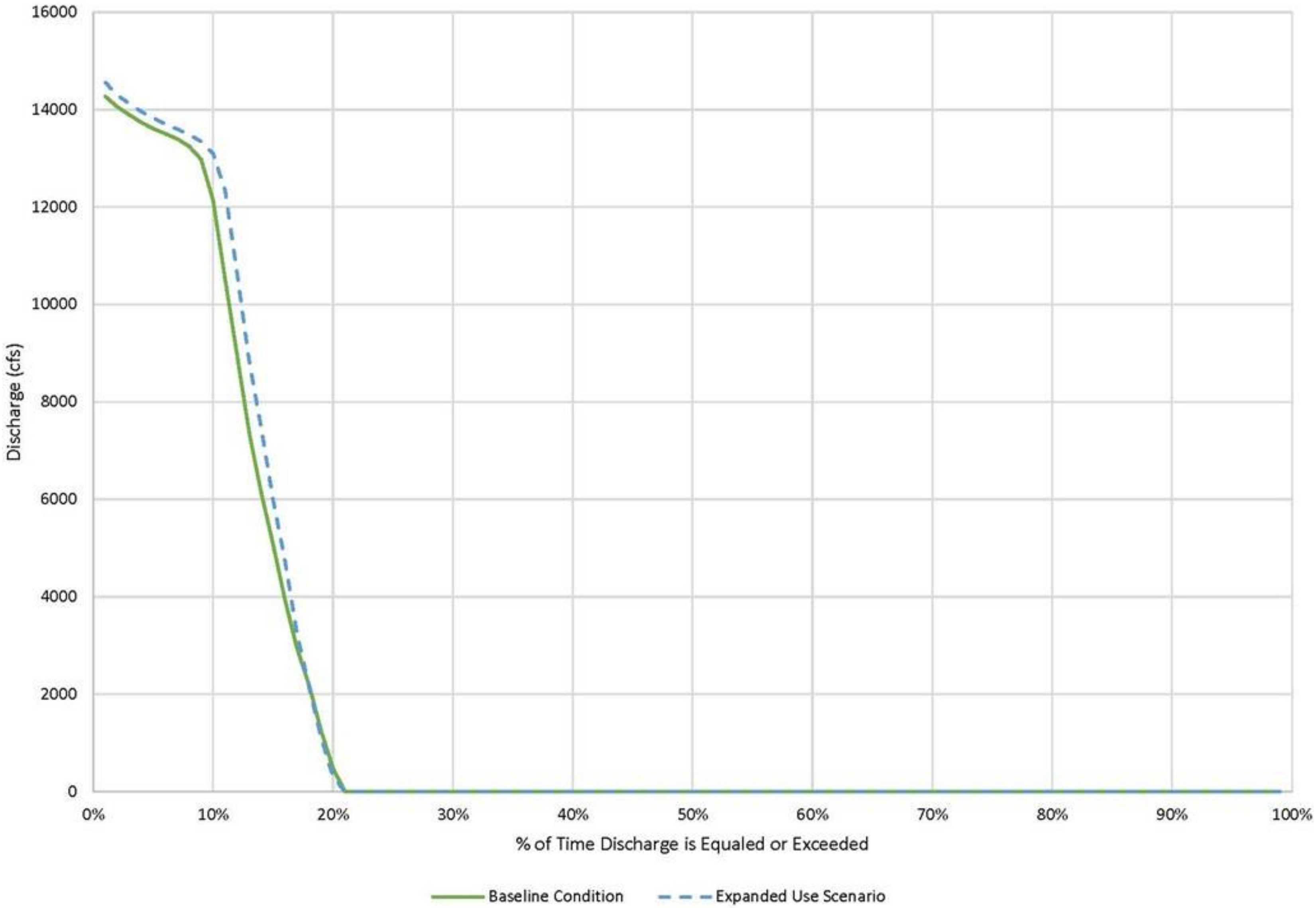

Figure 3.1-1: Comparison of Operations Model Results – Northfield Pumping

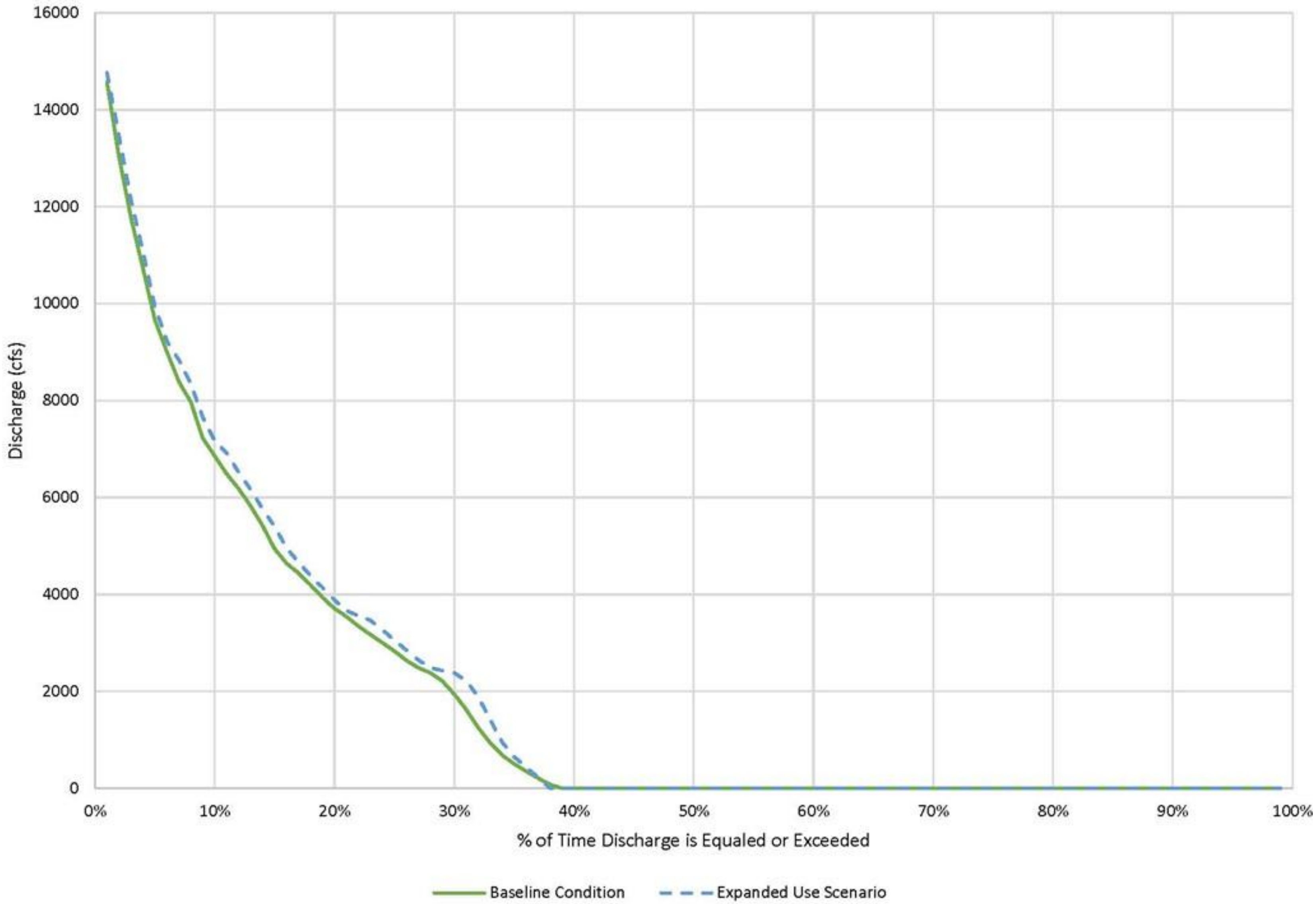

Figure 3.1-2: Comparison of Operations Model Results – Northfield Generation

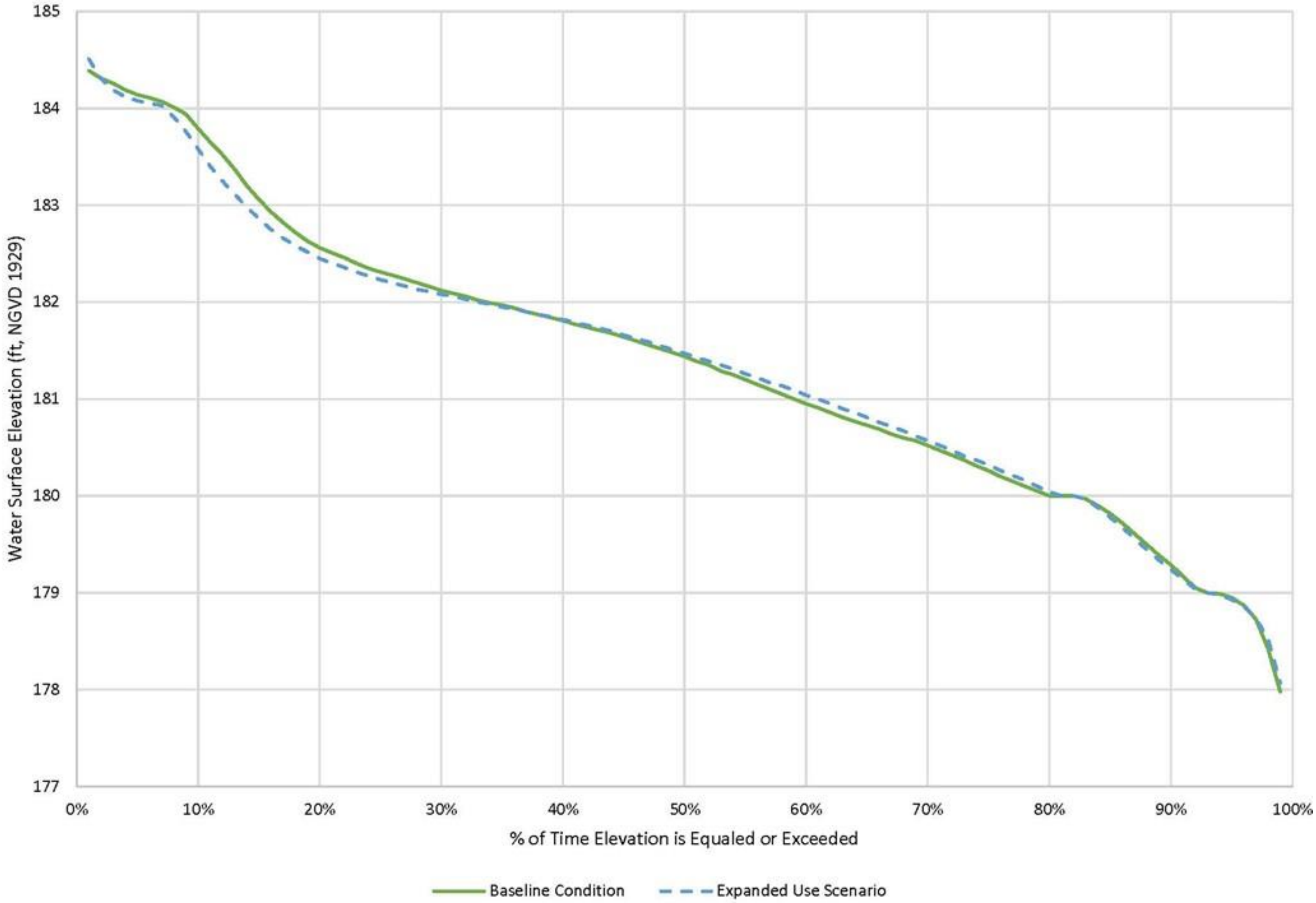

Figure 3.1-3: Comparison of Operations Model Results – TFI Level at TF Dam

3.2 HEC-RAS

Hydraulic modeling using an unsteady one-dimensional HEC-RAS model was conducted for both the BL and EUS to generate hourly WSEL's and EGL slopes at the 25 detailed study sites located throughout the TFI. To ensure the BL and EUS were directly comparable, the HEC-RAS input parameters used for this evaluation were based on the outputs from the HEC-ResSim model as opposed to empirical data; however, the HEC-RAS model was previously calibrated using empirical data (FirstLight, 2015) and is the same model which was used for the initial study (FirstLight, 2017b). Full details of the HEC-RAS model, including the collection of the field data, model setup, calibration, and analyses were provided in the study report for Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and Below Cabot* dated March 2015 (FirstLight, 2015). Output parameters from the HEC-RAS model were then used as input parameters for BSTEM.

As discussed in the Study No. 3.1.2 final report (FirstLight, 2017b), TFI riverbanks are typically characterized by a lower and upper riverbank. The lower bank is typically a flat, beach-like feature that is submerged or experiences daily water level fluctuations during low to moderate flows as a result of hydropower peaking operations. As one moves away from the normal edge-of-water, the lower bank transitions to an upper bank; the toe of which is clearly identifiable on most cross-section survey plots. The upper bank is typically steep, has some degree of vegetation, and is usually above the water surface except during high flows. The distinction between the lower and upper bank is an important one given that BSTEM modeling conducted for the initial study found that when the water surface rests on the lower bank (i.e., below the toe of the upper bank) the forces acting at the water surface and along the submerged banks typically do not cause erosion at lower flows and minimal erosion at moderate flows. It is not until the water surface rises and rests on the upper bank during high flow events that riverbank erosion potentially commences.

To analyze the location and duration of the water surface observed during the BL and EUS a water level duration analysis was conducted using the results of the HEC-RAS modeling. The results of this analysis determined the percent of time the water surface rested at a given elevation in relation to the toe of the upper bank at four detailed study sites. A similar analysis was conducted for the initial study using the hydrology from the period 2000-2014 (FirstLight, 2017b, Section 5.1.3). For consistency, a subset of the same detailed study sites were used for this analysis as were used for the final study report. In addition to being consistent with the sites chosen for the initial study, the selected sites spanned the geographic extent of the TFI, were located in areas with varying hydraulic characteristics, and were found to be representative of the other sites in proximity to them. The results of the analysis (summarized in Table 3.2-1) found the following:

- At **Site BC-1R** (HEC-RAS transect 3518, in Barton Cove), the water surface rests on the lower bank (defined as that portion of the bank below El. 184.0) 92% of the time for the BL and 93% of the time for the EUS;

- At **Site 75BL** (HEC-RAS transect 25845, just downstream of the Northfield Mountain tailrace), the water surface rests on the lower bank (defined as that portion of the bank below El. 184.0) 85% of the time for the BL and 86% of the time for the EUS;

- At **Site 5CR** (HEC-RAS transect 56235, just downstream of the Rt. 10 Bridge), the water surface rests on the lower bank (defined as that portion of the bank below El. 184.0) 79% of the time for the BL and 80% of the time for the EUS; and

- At **Site 4L** (HEC-RAS transect 72416, just downstream of the NH-MA Stateline), the water surface rests on the lower bank (defined as that portion of the bank below El. 184.0) 77% of the time for the BL and 78% of the time for the EUS.

As demonstrated above, and in Table 3.2-1, the water surface rests on the lower bank (i.e., below the toe of the upper bank) for the vast majority of the time for both the BL and EUS. This is consistent with the results of the analysis conducted for the initial study which used the period 2000 to 2014. The results of this analysis provides important context when reviewing the results of the BSTEM modeling discussed in the next section.

Table 3.2-1 Elevation Duration Analysis Results

Detailed Study Site	Toe of Upper Bank – El.*	Water Level Duration – BL		Water Level Duration - EUS	
		% Time on Lower Bank	% Time on Upper Bank	% Time on Lower Bank	% Time on Upper Bank
BC-1R	184	92	8	93	7
75BL	184	85	15	86	14
5CR	184	79	21	80	20
4L	184	77	23	78	22

** NGVD29, Feet*

3.3 BSTEM

The purpose of the BSTEM analysis conducted for this evaluation was to quantify the change in bank-erosion rates under the EUS when compared to BL. The difference in bank-erosion rates between the two scenarios would indicate what impact, if any, increasing the useable storage volume of the Upper Reservoir would have on streambank erosion in the TFI.

For this analysis, the same version of BSTEM used in the initial study was again used; modeling was conducted using a one-hour time step. The same initial bank geometry and bank-material properties were also used as those used for the initial calibration runs, thereby providing for an internally consistent analysis. Bank-erosion rates at all 25 detailed study sites were simulated for the hydraulic conditions previously discussed. HEC-RAS outputs, including hourly WSEL and EGL slope, were used as BSTEM input parameters for both scenarios. All simulations were initially conducted with the boat-wave sub-model engaged. Another set of simulations were then conducted with the sub-model turned off to determine the role of boat waves on bank erosion. In total for this analysis, four sets of BSTEM simulations were conducted:

- Baseline, Waves On
- Baseline, Waves Off
- Expanded Use, Waves On
- Expanded Use, Waves Off

The results of the BSTEM simulations are shown in Table 3.3-1 and Figure 3.3-1, which depict the average annual bank erosion rates simulated at each location expressed in $ft^3/ft/yr$ for both the BL and EUS.

Although informative, to determine the impact of expanded use of the Upper Reservoir on TFI erosion, emphasis should not be placed on the absolute values of the unit-erosion rates, but instead on the difference in erosion rates between the BL and EUS (Table 3.3-2). As shown in Table 3.3-2, the EUS had no measurable impact on bank-erosion rates. When including the effect of boat waves, more than 75% of the sites showed no increase in unit-erosion rates due to the EUS, while 90% showed less than a 0.011 $ft^3/ft/yr$ increase. The maximum increase was limited to 0.032 $ft^3/ft/yr$ at Site 75BL in the vicinity of Northfield Mountain. All values shown in Table 3.3-2 are well within the accuracy of the underlying data and/or the sensitivity of the model and yield immeasurable differences in unit-erosion rates. In other words, increasing the useable storage volume of the Upper Reservoir resulted in no impact on streambank erosion in the TFI when comparing the EUS to BL conditions. This is further illustrated by looking at the difference in the height of the “bars” in Figure 3.3-1. The complete distribution of changes in unit bank-erosion rates due to the EUS is shown in Figure 3.3-2.

Table 3.3-1: Results of BSTEM simulations showing average, annual bank-erosion rates expressed per unit length of channel (one foot) under Baseline (BL) conditions and for the Expanded Use Scenario (EUS).

Site	BL	BL Waves Off	EUS	EUS Waves Off
	$ft^3/ft/y$			
11L	0.031	0.031	0.028	0.028
2L – Pre	1.06	1.06	1.05	1.05
2L -Post	0.058	0.050	0.058	0.050
303BL	0.097	0.097	0.093	0.093
18L	0.248	0.237	0.248	0.237
18L	0.248	0.237	0.248	0.237
3L	1.07	1.07	1.066	1.062
3R-Post	0.103	0.100	0.102	0.098
21R	0.819	0.747	0.822	0.747
4L	0.000	0.000	0.000	0.000
29R[5]	25.1	25.0	25.1	25.0
10L	0.022	0.000	0.022	0.000
10R-Post	0.000	0.000	0.000	0.000
6AL-Pre	0.054	0.032	0.054	0.032
6AL-Post	0.000	0.000	0.000	0.000
6AR-Post	0.022	0.000	0.022	0.000
119BL	2.00	1.93	2.00	1.94
7L	0.506	0.484	0.517	0.484
7R	0.161	0.140	0.161	0.151
8BL	0.000	0.000	0.000	0.000
8BR-Pre	0.140	0.129	0.140	0.129
8BR-Post	0.000	0.000	0.000	0.000
87BL	0.710	0.614	0.721	0.614
75BL	0.753	0.603	0.786	0.635
9R-Pre	1.44	0.000	1.44	0.000
9R-Post	0.065	0.000	0.065	0.000
12BL	1.84	0.140	1.85	0.183
BC-1R	0.194	0.000	0.194	0.000

[5] Site 29R – regardless of the flow series the failure occurs on the first time step.

Table 3.3-2: Differences in unit bank-erosion rates as a result of Expanded Use of the Upper Reservoir

Transects	EUS-BL
	$ft^3/ft/y$
11L	-0.003
2L-Pre	-0.001
2L-Post	0.000
303BL	-0.004
18L	0.000
3L	-0.007
3R-Pre	-0.013
3R-Post	-0.001
21R	0.004
4L	0.000
29R	-0.005
5CR	-0.011
26R	0.011
10L	0.000
10R-Post	0.000
6AL-Pre	0.000
6AL-Post	0.000
6AR-Post	0.000
119BL	0.000
7L	0.011
7R	0.000
8BL	0.000
8BR-Pre	0.000
8BR-Post	0.00
87BL	0.011
75BL	0.032
9R-Pre	0.000
9R-Post	0.000
12BL	0.011
BC-1R	0.000

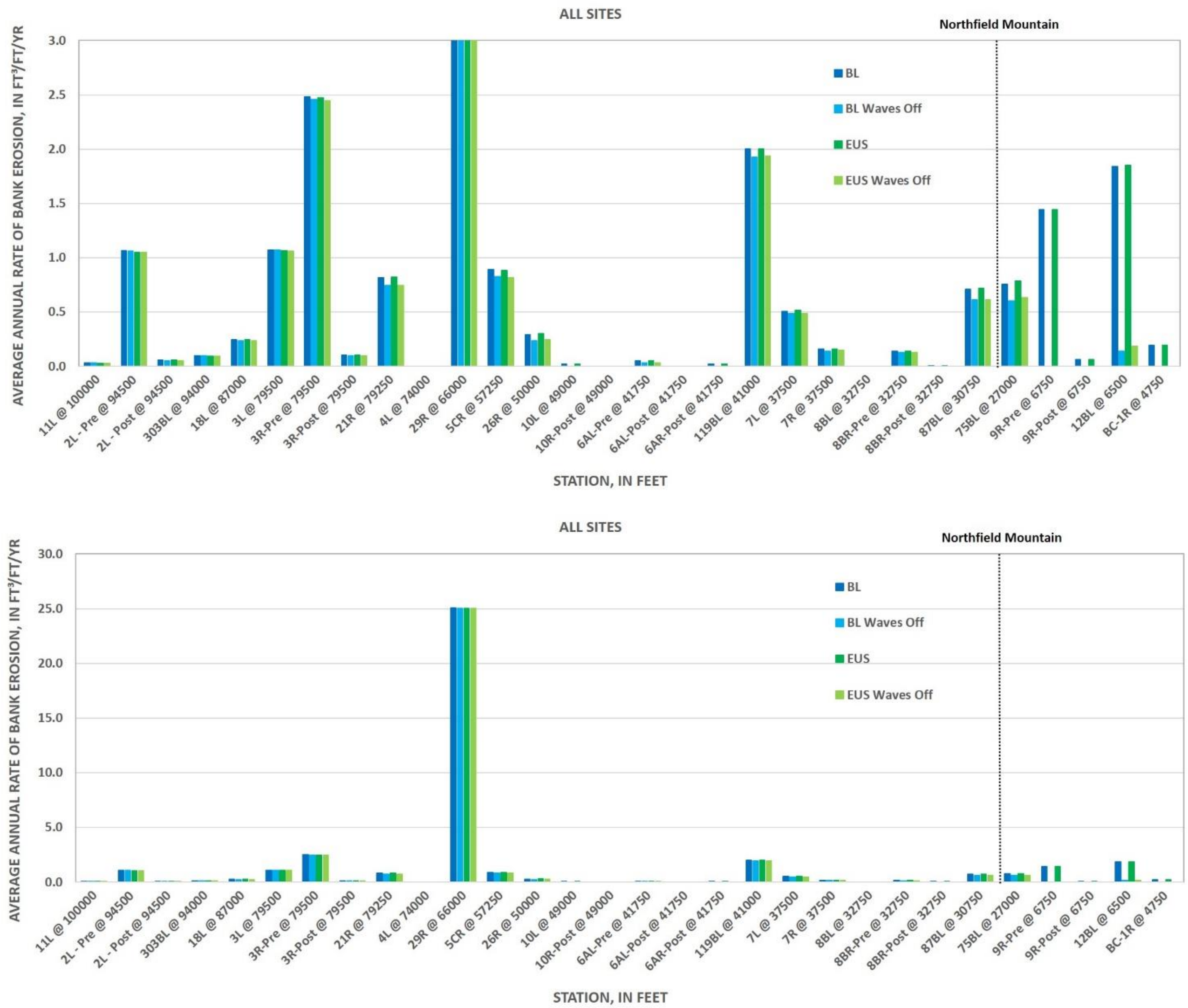

Figure 3.3-1: Average, annual bank-erosion rates per unit length (one ft) of channel under Baseline conditions and the Expanded Use Scenario.
Top plot has a reduced y-axis scale to show detail. The effect of expanded operations is the difference between the height of the bars

All Sites		
Percentile	EUS-BL	EUS-BL Waves Off
	(ft^3/ft/y)	(ft^3/ft/y)
99.99	0.032	0.013
99.9	0.032	0.013
99	0.026	0.012
95	0.011	0.007
90	0.011	0.003
85	0.008	0.002
80	0.001	0.000
75	0.000	0.000
70	0.000	0.000
65	0.000	0.000
60	0.000	0.000
55	0.000	0.000
50	0.000	0.000
45	0.000	0.000
40	0.000	0.000
35	0.000	0.000
30	0.000	0.000
25	-0.001	0.000
20	-0.003	-0.001
15	-0.004	-0.001
10	-0.007	-0.002
5	-0.011	-0.004
1	-0.012	-0.004
0.1	-0.013	-0.004

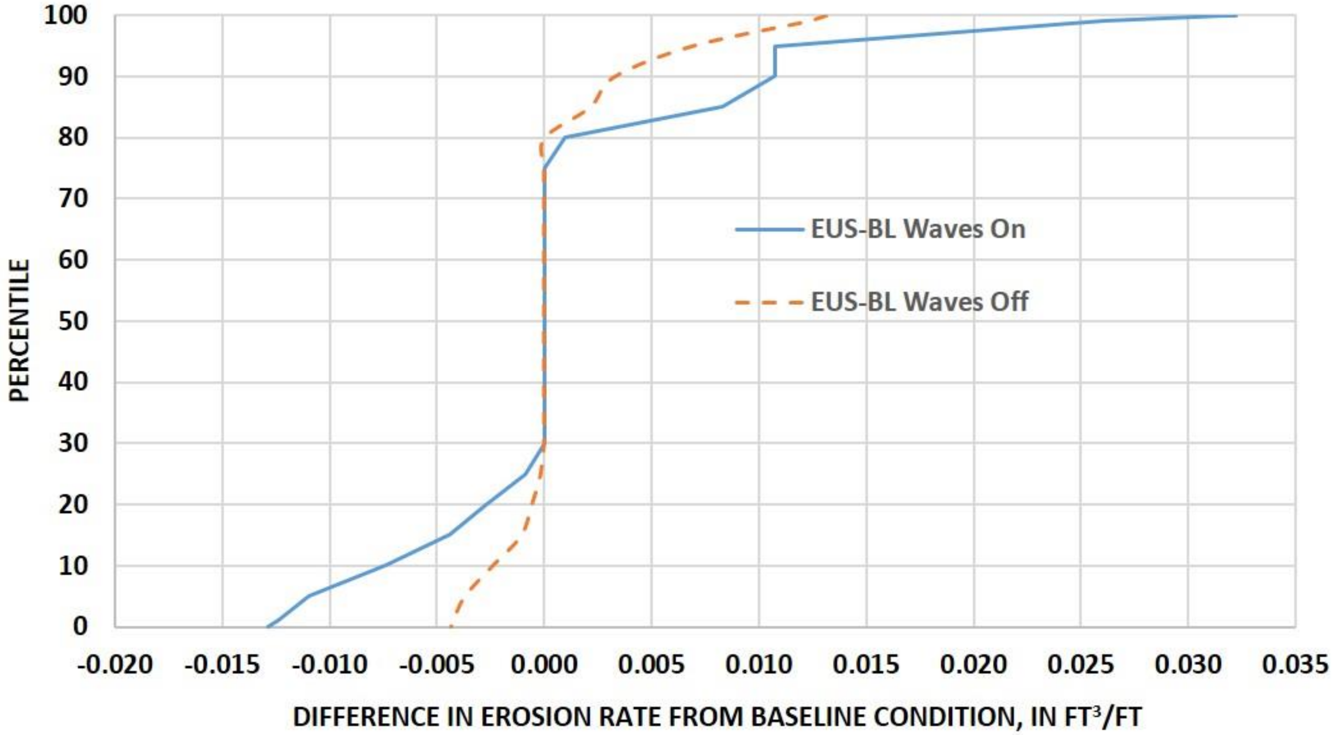

Figure 3.3-2: Distribution of changes in unit bank-erosion rates due to Expanded Use operations along the TFI

4 CONCLUSIONS

The purpose of this evaluation was to quantify the change in bank-erosion rates under the EUS when compared to BL conditions. The difference in bank-erosion rates between the two scenarios (as determined by BSTEM) would indicate what impact, if any, increasing the useable storage volume of the Upper Reservoir would have on streambank erosion in the TFI. In addition to BSTEM, HEC-ResSim and HEC-RAS models were utilized to satisfy the goals of this evaluation.

Outputs from the HEC-ResSim model indicated that although the EUS results in more pumping and generation than the BL condition, the corresponding increase in TFI WSEL is negligible with the difference in WSEL's between the scenarios for any given percentile ranging from -0.27 ft. to 0.12 ft., with an average difference of -0.01 ft. Furthermore, the results of the HEC-RAS water level duration analysis found that the water surface associated with the EUS rests on the lower bank 78-93% of the time. As discussed in FirstLight, 2017b, minimal to no erosion occurs when the water surface rests on the lower bank. It is not until the water surface reaches the upper bank that the vast majority of erosion typically occurs. The results of the analysis conducted for this evaluation are consistent with those discussed in the final study report (FirstLight, 2017b). Additionally, the water level duration analysis also found that there was no discernable difference in the location or duration of the water surface when comparing the BL and EUS.

The results of the BSTEM modeling found that the EUS had no measurable impact on bank-erosion rates when compared to BL conditions. When including the effect of boat waves, more than 75% of the sites showed no increase in unit-erosion rates due to the EUS, while 90% showed less than a 0.011 ft^3/ft/yr increase. The maximum increase was limited to 0.032 ft^3/ft/yr at Site 75BL in the vicinity of Northfield Mountain. The difference between the bank-erosion rates for the BL and EUS at all sites is well within the accuracy of the underlying data and/or the sensitivity of the model and yield immeasurable differences in unit-erosion rates.

The results of the various modeling and analyses conducted for this evaluation found that increasing the useable storage volume of the Upper Reservoir resulted in no impact on streambank erosion in the TFI when comparing the EUS to BL conditions.

5 LITERATURE CITED

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