# Relicensing Study 3.3.12

# EVALUATE FREQUENCY AND IMPACT OF EMERGENCY WATER CONTROL GATE DISCHARGE EVENTS AND BYPASS FLUME EVENTS ON SHORTNOSE STURGEON SPAWNING AND REARING HABITAT IN THE TAILRACE AND DOWNSTREAM FROM CABOT STATION

## Updated Study Report Summary

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

*Prepared for:*

FirstLight GDF SUEZ

*Prepared by:*

Gomez and Sullivan Engineers

**SEPTEMBER 2015**

## 1.1 Study Summary

The goals of this study are to determine the frequency with which the emergency water control gates are operated, describe the operation of the bypass flume that results in bypass flume spill events, and evaluate the impact of these events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat downstream of Cabot Station. The Federal Energy Regulatory Commission's (FERC) Study Plan Determination Letter (SPDL) dated February 21, 2014 required FirstLight to conduct an analysis of historical emergency water releases for the period 2005 through 2012. FirstLight was then required to consult with stakeholders to determine the need for fieldwork.

The Initial Study Report for this study was filed in September 2014 and included an analysis of gate operations on a 10-minute time step for years 2005-2012 during the shortnose sturgeon spawning period, April through June. The results were presented at the Initial Study Report meeting on September 30, 2014. Additional information related to discussions at the Initial Study Report meeting was filed with the meeting summary on October 15, 2014. Some stakeholders filed comments and posed additional questions on the data analysis and next steps related to evaluating the impact of emergency gate spill events on shortnose sturgeon spawning and rearing habitat downstream of Cabot Station.

On January 22, 2015, FERC issued another SPDL with guidance on how to proceed on this study. FERC recommended that FirstLight complete the historical data analysis and consult with stakeholders by March 31, 2015, so that if fieldwork is necessary, it can be conducted during the 2015 field season.

A meeting was held with interested stakeholders on February 4, 2015 on this and other relicensing studies. As an action item from the meeting, FirstLight agreed to re-analyze operations data on 1-minute time steps during selected periods, to confirm the reasons for use of the Cabot Station emergency spill gates. In addition, FirstLight agreed to investigate and describe, if appropriate, a study approach using the River 2D model to evaluate velocity changes in the study area due to gate releases in lieu of field velocity measurements.

On March 18, 2015, FirstLight provided stakeholders with a memo containing additional analysis related to the study. On March 24, 2015, FirstLight held a meeting to discuss Study 3.3.12 and other relicensing studies. The purpose of the meeting was to review the data presented to date and to discuss the potential options for further analysis, if necessary. The related correspondence is included herein as Appendix A.

## 1.2 Study Progress Summary

Task 1: Analysis of Existing Data

As discussed above, an initial analysis of existing data was filed in the Initial Study Report in September 2014 and the results were presented at the Initial Study Report meeting on September 30, 2014. The Initial Study Report summarized the operation of the emergency spill gates and log sluice/bypass flume from April 1-June 30, 2005 through 2012. The data show that 0.6% of the time, more than two emergency spill gates were open to some degree. With regard to the sluice gate releases, most of the time the gate is open is related to downstream fish passage requirements. Less than 4% of the time, the gate is opened to more than 7 feet for operational reasons (i.e., to pass trashrack debris downstream).

On March 18, 2015, FirstLight provided stakeholders with a memo containing additional analysis related to the study. On March 24, 2015, FirstLight held a meeting to discuss the additional data analysis. Included in the March 18, 2015 memo (included in Appendix A) was additional analysis of analyze operations data on a 1-minute time step during selected periods, and an explanation of the reasons for use of the Cabot emergency spill gates during these events. Also in the memo FirstLight provided a study approach to use

the River 2D model to evaluate velocity changes in the study area due to gate releases in lieu of field velocity measurements.

As presented in the memo, large-magnitude discharges (defined as five or more gates open) were attributed to three main factors:

1. Emergency-triggered events.

2. Trashrack debris management.

3. Log boom debris management or other special maintenance conditions.

All of the occurrences after May 2008 were emergency-triggered events, and no events with five or more gates open occurred in 2011 or 2012.

Task 2: Scenario Development

This task was contingent on whether additional field study is required. At this time, no scenarios for field study have been developed.

Task 3: Field Verification of Conditions (if necessary)

Based on discussions with stakeholders during the March 24, 2015 meeting, it was agreed that field data collection will not be performed for this study. Instead, FirstLight agreed to conduct its River 2D analysis to define the critical flow (resulting in sedimentation/scour or potential adverse impacts to sturgeon spawning) under different water surface elevations.

FirstLight proposes to use the two-dimensional hydraulic model that is being developed as part of Study No. 3.3.1 (Instream Flow Study) for Reach 3 to assess the potential for sediment impacts (scour and deposition) to sturgeon spawning areas in the river reach just downstream of Cabot Station. The 2D model extends from just upstream of the Rawson Island/rock dam area of the Connecticut River to just downstream of the pedestrian bike path bridge near the Deerfield/Connecticut River confluence.

The 2D model is capable of predicting depth-averaged hydraulic parameters (e.g., depth, velocity, shear stress) within the proposed area of interest. As part of Study No. 3.3.1, the model will be calibrated to (and validated with) field-collected water surface elevations and water velocities from multiple flow scenarios. Due to the depth-averaged nature of the model, it is not capable of predicting vertical flow distributions.

The model results are expected to be reasonably accurate throughout the river except in areas very close (150 feet or less) to the toe of the Cabot emergency spillway. This area is primarily boulder and bedrock. FirstLight anticipates using the model's velocity and shear stress output to estimate sediment mobilization potential throughout the sturgeon spawning area. The sediment substrate mapping conducted in the reach (also as part of Study No. 3.3.1) will be used to identify what size substrates may be available to be transported from various portions of the river. The combined sediment mobilization potential and substrate mapping analysis will allow FirstLight to identify whether mobilization will occur, and, if so, what size particles (e.g., silt, sand, gravel) may be transported downstream, potentially affecting sturgeon spawning areas or other areas of concern.

Task 4: Data Analysis and Reporting

FirstLight will conduct the remaining data analysis once the River 2D model is completed for the instream flow study as described in Study No. 3.3.1. A report will be completed in March 2016.

## 1.3 Variances from Study Plan and Schedule

None.

## 1.4 Remaining Activities

Using the River 2D model, FirstLight will simulate various bypass flows and emergency spill conditions under various tailwater elevations to determine critical flows through the emergency spill gates. Once critical flows are identified FirstLight will use the data analyzed under Task 1 of this study to summarize the frequency, duration and causes of these critical flows. FirstLight will document those causes that are related to emergency conditions in its final report.

# Appendix A
# Correspondence Log

**From:** Jason George
**Sent:** Wednesday, March 18, 2015 2:17 PM
**To:** Warner, John; Ken'; 'Karl Meyer'; Melissa'; 'William McDavitt - NOAA Affiliate'; 'Jessica Pruden - NOAA Federal'; Caleb '; 'Brandon.Cherry@FERC.Gov'; 'William.Connelly@FERC.Gov'; 'Stephen Kartalia'; 'Nicholas.Ettema@FERC.gov'; 'kkennedy@tnc.org'; 'Andrea Donlon'; 'Don Pugh'; 'jennifer_griffin@transcanada.com'; Jesse '; Ragonese, John; mkieffer@usgs.gov
**Cc:** 'John Howard'; Tom Sullivan; Stira, Robert; 'Bryan Apell'; Tomicheck, Chris; Wood, Julia; Mark Wamser
**Subject:** RE: FirstLight Relicensing Meeting - Fisheries and Aquatic Studies 3/24/15
**Attachments:** 2015-03-24 Fisheries Meeting Agenda.pdf; 3_3_2_Revised_Study_Plan.pdf; 3_3_6 _Revised_Study_Plan.pdf; Memo to Stakeholders - 3 3 12 SNS additional data.pdf

Good afternoon,

Attached is the agenda for our upcoming meeting on March 24, 2015. The meeting will be held at the Hampton Inn, Greenfield, MA. Also attached are study plan revisions for the adult shad study (Study No. 3.3.2) and the shad spawning study (Study No. 3.3.6) as well as a memo summarizing additional data analysis for the Cabot spill gate study (Study No. 3.3.12). (Appendix to 3.3.12 will be sent separately – too large to email.)

Please contact me if you have any questions. Thanks,

Jason George
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Gomez and Sullivan Engineers, DPC
PO Box 2179
Henniker, NH 03242
Office: (603) 428-4960
Cell: (603) 340-7666
jgeorge@gomezandsullivan.com

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**From:** Jason George
**Sent:** Wednesday, February 18, 2015 5:01 PM
**To:** Mark Wamser; FirstLight Relicensing; Warner, John; 'Ken''; 'Karl Meyer'; 'Melissa''; 'William McDavitt - NOAA Affiliate'; 'Jessica Pruden - NOAA Federal'; 'Caleb ''; 'Brandon.Cherry@FERC.Gov'; 'William.Connelly@FERC.Gov'; 'Stephen Kartalia'; 'Nicholas.Ettema@FERC.gov'; 'kkennedy@tnc.org'; 'Andrea Donlon'; 'Don Pugh'; 'jennifer_griffin@transcanada.com'; 'Jesse ''; Nedeau, Ethan; Ragonese, John
**Cc:** 'John Howard'; Tom Sullivan; Stira, Robert; 'Bryan Apell'; Tomicheck, Chris; Kulik, Brandon; Wood, Julia
**Subject:** RE: FirstLight Relicensing Meeting - Fisheries and Aquatic Studies

Good afternoon,

Attached are the meeting minutes from the February 4, 2015 fisheries group relicensing meeting. Additional information relative the action items will be provided.

Thank you,

Jason

-----Original Appointment-----
**From:** Jason George
**Sent:** Tuesday, February 17, 2015 9:05 AM
**To:** Mark Wamser; FirstLight Relicensing; Warner, John; Ken'; 'Karl Meyer'; Melissa'; 'William McDavitt - NOAA Affiliate'; 'Jessica Pruden - NOAA Federal'; Caleb '; 'Brandon.Cherry@FERC.Gov'; 'William.Connelly@FERC.Gov'; 'Stephen Kartalia'; 'Nicholas.Ettema@FERC.gov'; 'kkennedy@tnc.org'; 'Andrea Donlon'; 'Don Pugh'; 'jennifer_griffin@transcanada.com'; Jesse '; Nedeau, Ethan; Ragonese, John
**Cc:** John Howard; Tom Sullivan; Wood, Julia; Stira, Robert; 'Bryan Apell'; Tomicheck, Chris; Kulik, Brandon
**Subject:** FirstLight Relicensing Meeting - Fisheries and Aquatic Studies
**When:** Tuesday, March 24, 2015 9:00 AM-2:00 PM (UTC-05:00) Eastern Time (US & Canada).
**Where:** TBD

Good morning,

Please reserve Tuesday March 24, 2015 for a potential meeting or conference call as a follow-up to the previous meeting on 2/4/2015. Prior to the meeting, we will be providing stakeholders with updates related to the actions items from the last meeting. Please forward this invite to other stakeholders as you see fit.

Thank you.

Jason George

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From: Mark Wamser
Sent: Wednesday, February 11, 2015 8:20 AM
To: FirstLight Relicensing; Jason George; 'John Warner'; 'Sprankle@gomezandsullivan.com; Ken'; 'Karl Meyer'; 'Grader@gomezandsullivan.com; Melissa'; 'William McDavitt - NOAA Affiliate'; 'Jessica Pruden - NOAA Federal'; Caleb '; 'Brandon.Cherry@FERC.Gov'; 'William.Connelly@FERC.Gov'; 'Stephen Kartalia'; 'Nicholas.Ettema@FERC.gov'; 'kkennedy@tnc.org'; 'Andrea Donlon'; 'Don Pugh'; 'jennifer_griffin@transcanada.com'; 'Theodore Castro-Santos'; 'Gabe Gries'; 'lael.will@state.vt.us'; 'Leddick@gomezandsullivan.com; Jesse '; 'Ethan Nedeau'; John Ragonese (john_ragonese@transcanada.com)
Cc: John Howard; Tom Sullivan; 'Julia Wood'; Robert'; 'Bryan Apell'; 'Chris Tomichek'; 'Brandon Kulik'
Subject: Follow-up from February 4, 2015 Meeting

All-

At the February 4, 2015, the group discussed the potential need for another meeting to resolve some lingering issues on the study plans discussed on Feb 4. We agreed to send out a doodle poll to establish a follow-up meeting date. Please complete the doodle poll link below. Thanks Mark

http://doodle.com/fub77rgk2ktsxemg

-----Original Message-----

From: firstlight@gomezandsullivan.com [mailto:firstlight@gomezandsullivan.com]
Sent: Tuesday, February 03, 2015 1:31 PM
To: Jason George; 'John Warner'; 'Sprankle@gomezandsullivan.com; Ken'; 'Karl Meyer'; 'Grader@gomezandsullivan.com; Melissa'; 'William McDavitt - NOAA Affiliate'; 'Jessica Pruden - NOAA Federal'; 'Slater@gomezandsullivan.com; Caleb '; 'Brandon.Cherry@FERC.Gov'; 'William.Connelly@FERC.Gov'; 'Stephen Kartalia';

'Nicholas.Ettema@FERC.gov'; 'kkennedy@tnc.org'; 'Andrea Donlon'; 'Don Pugh'; 'jennifer_griffin@transcanada.com'; 'Theodore Castro-Santos'; 'Gabe Gries'; 'lael.will@state.vt.us'; 'Leddick@gomezandsullivan.com; Jesse '; 'Ethan Nedeau'
Cc: 'Howard@gomezandsullivan.com; John Howard; Mark Wamser; Tom Sullivan; 'Julia Wood';
'Stira@gomezandsullivan.com; Robert'; 'Bryan Apell'; 'Chris Tomichek'; 'Brandon Kulik'
Subject: RE: Northfield / Turners Falls Fisheries Group Meeting

Hello,

Please find attached the presentation and agenda for the Northfield / Turners Falls Fisheries Group Meeting (2/4/2015)

Thank you.

If you have any questions, comments or request please email to FirstLight@gomezandsullivan.com

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# Memo to FirstLight Relicensing Stakeholders

**Date: March 18, 2015**
**RE: Study No. 3.3.12 - Evaluate Frequency and Impact of Emergency Water Control Gate Discharge Events and Bypass Flume Events on Shortnose Sturgeon Spawning and Rearing Habitat**

This memo is a follow-up to the relicensing meeting with stakeholders on February 4, 2015. As an action item from the meeting, FirstLight agreed to re-analyze operations data on a 1-minute time step during selected periods, to confirm the reasons for use of the Cabot emergency spill gates during these events. Also, FirstLight agreed to investigate and describe, if appropriate, a study approach using the River 2D model to evaluate velocity changes in the study area due to gate releases in lieu of field velocity measurements.

## Background

The goals of this study are to determine the frequency with which the emergency water control gates are operated, describe the operation of the log sluice, and evaluate the impact of these operations on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat downstream of Cabot Station (see Figure 1, from Kieffer and Kynard, 2012). The purpose of this memorandum is to present more detailed data from times when five or more spill gates were open simultaneously.

The Initial Study Report for this study was filed in September 2014 and included an analysis of gate operations on a 10-minute time step for years 2005-2012 during the shortnose sturgeon spawning period, April through June. The results were presented at the Initial Study Report meeting on September 30, 2014. Additional information related to discussions at the Initial Study Report meeting was filed with the meeting summary on October 15, 2014. Some stakeholders filed comments and posed additional questions on the data analysis and next steps related to evaluating the impact of emergency gate spill events on shortnose sturgeon spawning and rearing habitat downstream of Cabot Station.

On January 22, 2015, FERC issued a study plan determination letter with guidance on how to proceed on this study. FERC recommended that FirstLight complete the historical data analysis and consult with stakeholders by March 31, 2015, so that if fieldwork is necessary, it can be conducted during the 2015 field season. As explained above, a meeting was held with interested stakeholders on February 4, 2015; an additional meeting is planned for March 24, 2015 to discuss this memo and other relicensing studies.

## Additional Analysis of Spill Gate Data

### *One-Minute Time Step for Five or More Gate Events*

Data related to gate openings were initially analyzed on a 10-minute step. After further discussions with the FirstLight operators, this time step may not have been adequate to fully characterize emergency related events. Therefore, data on a one-minute time step were obtained and analyzed for the periods consistent with the initial report when five or more gates were open (Table 4-2 from the Initial Study Report).

The figures depicting each event are provided in Appendix A. Data series were obtained from FirstLight for: canal forebay water surface elevation; opening of each of the emergency spill gates; and Cabot Station generation. Forebay elevation and gate openings were used to calculate total discharge through the gates in cubic feet per second (cfs), and Cabot Station generation was converted from megawatt output to total discharge in cfs. Also shown in each figure is river flow; for this parameter, data were

obtained from the USGS Montague gage on a 15-minute time step and prorated to remove the Deerfield River flow. Additional details on these methods are provided in the Initial Study Report and are not repeated here.

The figures in Appendix A and the associated data were discussed with the FirstLight Operations Manager to understand the conditions surrounding these events and to determine which were related to emergency triggers. Based on discussions with the FirstLight Operations Manager, the events were attributed to three main factors, described below. Table 1 summarizes these events.

1. Emergency-triggered events. These are triggered when the canal forebay water surface elevation is at or above 174.3 feet. If this level is reached, the emergency gates open automatically to varying degrees, based on the specific condition. The spill gates will also open automatically if a full station trip occurs at Cabot Station. Gates are closed manually once the operator assesses the situation.
2. Trashrack debris management. These procedures were occasionally used by an operator during periods when river flows were high (>35,000 cfs) or above the canal capacity (>18,000 cfs) for the period 2005-2008. During this procedure, the emergency spill gates were opened during the trashrack raking period to manage excess water in the canal. Cabot units were usually backed-off so trash could be cleaned off the racks and moved downstream through the log sluice. The spill gates were used on occasion to manage excess water. These practices are no longer in place (hence the term "Antiquated Operations" in Table 1). From 2008 to the present, the normal practice is if Cabot Station generation is reduced for trashrack cleaning , canal elevations are managed by controlling inflow at the canal gatehouse.
3. Log boom debris management or other special maintenance conditions (e.g., on 4/1/2006, an operator needed to move debris off the log boom during a headgate closure).

Within the period of interest, there were a total of 26 occurrences when at least five gates were open to some degree; of these 26 events, 9 were emergency-related (see Table 1 and Figures in Appendix A). All of the other events (except one on 4/1/2006) were related to the practices sometimes used in the past during trashrack cleaning, described above. All of the occurrences after 5/7/2008 were emergency-triggered events, and no events with five or more gates open occurred in 2011 or 2012.

*Summary of Frequency and Magnitude of Spill Gate Usage (2005-2012)*

In addition to the 1-minute time step data analysis presented above, the 10-minute time step data from 2005-2012 (April – June) are summarized further, building off previous analyses. For each year, the number of gates that were open per time interval were counted (these data were previously presented in the Initial Study Report, Table 4-1). Using this dataset, the range of discharges (average, minimum and maximum) were presented for each gate opening (Table 2). Concurrent river flow is also presented. This shows how much water is being discharged based on the number of gates used, in relation to river flow. For example, in 2012, four spill gates were open for 15 10-minute intervals; the average discharge through these four gates was 3,264 cfs, (range: 2,594- 3,528 cfs) while average river discharge was 28,007 cfs (range: 18,800 - 34,100cfs).

Velocity and Sediment Proposed Analysis

This section describes a study approach using the River 2D model to evaluate velocity changes in the study area due to emergency spill gate releases in lieu of field velocity measurements. The study plan objective is to evaluate the impact of spill events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat below Cabot Station.

Based on feedback at the last stakeholder meeting, it was determined that the field work could not be performed during the sturgeon spawning season because formal Endangered Species Act consultation had not been initiated. This alternative method has benefits because various river flow and spill gate/Cabot discharge scenarios can be modeled regardless of season.

If mutually agreeable by fisheries agency stakeholders, FirstLight proposes to use the two-dimensional (2D) hydraulic model that is being developed as part of Study No. 3.3.1 (Instream Flow Study) for Reach 3 to assess the potential for sediment impacts (scour and deposition) to sturgeon spawning areas in the river reach just downstream of Cabot Station. The 2D model extends from just upstream of the Rawson Island/rock dam area of the Connecticut River to just downstream of the railroad crossing near the Deerfield/Connecticut River confluence, covering the area of interest.

The 2D model is capable of predicting depth-averaged hydraulic parameters (e.g., depth, velocity, shear stress) within the proposed area of interest. As part of Study No. 3.3.1, the model will be calibrated to (and validated with) field-collected water surface elevations and water velocities from multiple flow scenarios. Due to the depth-averaged nature of the model, it is not capable of predicting vertical flow distributions.

The model results are expected to be acceptable throughout the river except in areas very close (150 feet or less) to the toe of the Cabot emergency spillway. This area is primarily boulder and bedrock (see attached Figure 2). We anticipate using the model's velocity and shear stress output to estimate sediment mobilization potential throughout the area of interest. The sediment substrate mapping conducted in the reach (also as part of Study No. 3.3.1) will be used to identify what size substrates may be available to be transported from various portions of the river. The combined sediment mobilization potential and substrate mapping analysis will allow FirstLight to identify what size particles (e.g., silt, sand, gravel) may be transported downstream, potentially affecting sturgeon spawning areas or other areas of concern. Additionally, the analysis will reveal whether the spawning/rearing areas may be susceptible to active sediment transport (bed scour).

FirstLight proposes to conduct this portion of the analysis in 2015, once the model is completed for the instream flow study as described in Study No. 3.3.1.

**Table 1: Reasons for Use of Five or More Spill Gates (April 1-June 30, 2005-2012)**

| Date | Number of gates open | Reason | Emergency Triggered |
|---|---|---|---|
| 4/2/2005 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 4/3/2005 | 6 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 4/5/2005 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 4/7/2005 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 4/8/2005 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 4/17/2005 | 6 | Trashrack Cleaning, Antiquated Operations | No |
| 4/26/2005 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 5/6/2005 | 5 | Trashrack Cleaning, Antiquated Operations | No |
| 6/2/2005 | 5 | Trashrack Cleaning, Antiquated Operations | No |
| 4/1/2006 | 5 | (Low Magnitude Spill Event) Headgate Maintenance | No |
| 4/26/2006 | 5-6 | Trashrack Cleaning, Antiquated Operations | No |
| 5/5/2006 | 5 | Large log on trashracks, Antiquated Operations | No |
| 5/14/2006 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 6/11/2006 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 6/12/2006 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 6/29/2006 | 5 | High Flow, Trashrack Cleaning, Antiquated Operations | No |
| 6/4/2007 | 6-8 | Unit Trip | Yes |
| 6/27/2007 | 6-8 | Station Trip, Lightning Storm | Yes |
| 5/7/2008 | 5 | Trashrack Cleaning, Antiquated Operations | No |
| 6/8/2008 | 5 | High Canal Level | Yes |
| 6/2/2009 | 7 | High Canal Level | Yes |
| 6/15/2009 | 7 | High Canal Level | Yes |
| 5/4/2010 2:40 | 8 | High Canal Level | Yes |
| 5/4/2010 4:00 | 8 | High Canal Level | Yes |
| 5/26/2010 | 6 | Station Trip, Wind Storm | Yes |
| 6/14/2010 | 8 | High Canal Level | Yes |

*Summary:* *Total Events = 26*

*Emergency triggered = 9*

*Antiquated Operation = 16*

*Other = 1*

*Notes: There were no occurrences when >4 spill gates were open during the period April 1-June 30, in 2011 or 2012 based on the 10-minute time step analyzed.*

**Table 2: Frequency and Discharge Magnitude of Emergency Spill Gate Openings and River Discharge from April 1-June 30, 2005-2012 (10-minute time step)**

*Original Table from Initial Study Plan:*

**Table 4-1: Frequency of Emergency Spill Gate Openings from April 1-June 30, 2005-2012.**

| Number of gates open | Occurrences per year (10-minute intervals) | | | | | | | | | Frequency |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total | |
| 0 (no gates open) | 4,742 | 4,121 | 5,437 | 6,057 | 2,320 | 6,145 | 4,001 | 9,589 | 42,412 | 40.5% |
| 1 | 7,915 | 8,749 | 7,278 | 6,981 | 9,821 | 6,930 | 9,032 | 3,455 | 60,161 | 57.4% |
| 2 | 190 | 80 | 302 | 31 | 951 | 16 | 41 | 13 | 1,624 | 1.5% |
| 3 | 156 | 42 | 53 | 11 | 3 | 4 | 29 | 32 | 330 | 0.3% |
| 4 | 55 | 80 | 30 | 16 | 7 | 0 | 1 | 15 | 204 | 0.2% |
| 5 | 42 | 28 | 0 | 8 | 0 | 1 | 0 | 0 | 79 | 0.1% |
| 6 | 4 | 4 | 2 | 0 | 0 | 4 | 0 | 0 | 14 | 0.0% |
| 7 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0.0% |
| 8 | 0 | 0 | 2 | 0 | 0 | 4 | 0 | 0 | 6 | 0.0% |
| Total Readings | 13,104 | 13,104 | 13,104 | 13,104 | 13,104 | 13,104 | 13,104 | 13,104 | 104,832 | |

*Note: As an example of how to read the table, the value of 4,742 means that from April 1 to June 30, 2005, there were 4,742 readings (based on a 10-minute interval) out of 13,104 when no spill gates were open.*

*Spill Gate and River Discharge Added:*

| Number of gates open | 2005 | | | | | | | 2006 | | | | | | | 2007 | | | | | | | 2008 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | | 2006 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | | 2007 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | | 2008 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | |
| | | Mean | Min | Max | Mean | Min | Max | | Mean | Min | Max | Mean | Min | Max | | Mean | Min | Max | Mean | Min | Max | | Mean | Min | Max | Mean | Min | Max |
| 0 | 4742 | 0 | 0 | 0 | 15,043 | 2,850 | 82,000 | 4121 | 0 | 0 | 0 | 15,458 | 5,470 | 69,400 | 5437 | 0 | 0 | 0 | 11,773 | 2,280 | 88,500 | 6057 | 0 | 0 | 0 | 12,387 | 2,660 | 79,500 |
| 1 | 7915 | 259 | 2 | 1,135 | 35,802 | 6,690 | 92,300 | 8749 | 448 | 0 | 1,128 | 31,151 | 5,840 | 74,600 | 7278 | 331 | 1 | 1,130 | 35,534 | 2,610 | 91,100 | 6981 | 162 | 0 | 1,163 | 41,359 | 3,500 | 82,200 |
| 2 | 190 | 1,286 | 92 | 2,233 | 46,184 | 10,800 | 92,000 | 80 | 1,388 | 146 | 2,259 | 37,503 | 11,600 | 72,600 | 302 | 571 | 113 | 2,315 | 40,751 | 8,150 | 72,800 | 31 | 1,286 | 282 | 2,457 | 29,618 | 2,910 | 60,300 |
| 3 | 156 | 2,631 | 1,532 | 3,441 | 63,108 | 15,300 | 92,600 | 42 | 2,288 | 878 | 3,347 | 38,852 | 15,900 | 69,100 | 53 | 2,787 | 762 | 3,334 | 53,921 | 15,900 | 79,400 | 11 | 1,761 | 190 | 3,340 | 30,052 | 3,900 | 72,700 |
| 4 | 55 | 3,335 | 2,340 | 4,401 | 62,647 | 18,100 | 92,300 | 80 | 3,133 | 128 | 4,151 | 39,918 | 14,400 | 69,100 | 30 | 4,000 | 3,362 | 4,463 | 28,397 | 16,500 | 42,000 | 16 | 3,324 | 337 | 4,209 | 48,303 | 7,140 | 63,400 |
| 5 | 42 | 4,582 | 3,705 | 5,399 | 49,298 | 21,800 | 79,800 | 28 | 4,220 | 556 | 5,196 | 36,700 | 14,400 | 52,900 | - | - | - | - | - | - | - | 8 | 3,912 | 1,114 | 4,400 | 22,125 | 7,500 | 24,500 |
| 6 | 4 | 4,747 | 4,155 | 5,164 | 55,700 | 20,700 | 90,700 | 4 | 5,160 | 5,086 | 5,252 | 21,625 | 21,600 | 21,700 | 2 | 4,142 | 2,358 | 5,927 | 12,800 | 12,200 | 13,400 | - | - | - | - | - | - | - |
| 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 7,541 | 7,429 | 7,653 | 13,200 | 12,200 | 14,200 | - | - | - | - | - | - | - |

| Number of gates open | 2009 | | | | | | | 2010 | | | | | | | 2011 | | | | | | | 2012 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | | 2010 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | | 2011 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | | 2012 Count | Spill Gate Discharge (cfs) | | | River Discharge (cfs) | | |
| | | Mean | Min | Max | Mean | Min | Max | | Mean | Min | Max | Mean | Min | Max | | Mean | Min | Max | Mean | Min | Max | | Mean | Min | Max | Mean | Min | Max |
| 0 | 2320 | 0 | 0 | 0 | 12,528 | 3,950 | 56,900 | 6145 | 0 | 0 | 0 | 10,144 | 3,390 | 63,200 | 4001 | 0 | 0 | 0 | 16,143 | 2,280 | 73,300 | 9589 | 0 | 0 | 0 | 13,614 | 2,700 | 42,700 |
| 1 | 9821 | 269 | 3 | 1,235 | 24,557 | 4,250 | 67,900 | 6930 | 231 | 0 | 1,246 | 25,314 | 3,410 | 74,400 | 9032 | 303 | 0 | 1,194 | 39,032 | 3,650 | 86,600 | 3455 | 215 | 0 | 1,132 | 23,095 | 2,730 | 44,700 |
| 2 | 951 | 1,214 | 87 | 2,120 | 19,656 | 5,090 | 49,500 | 16 | 1,474 | 189 | 2,309 | 14,459 | 5,780 | 51,800 | 41 | 1,489 | 495 | 2,253 | 49,682 | 6,200 | 84,000 | 13 | 1,379 | 674 | 2,115 | 20,345 | 5,450 | 34,400 |
| 3 | 3 | 1,843 | 713 | 3,180 | 14,100 | 9,800 | 16,500 | 4 | 2,329 | 1,262 | 3,422 | 18,623 | 6,160 | 52,300 | 29 | 2,379 | 352 | 3,492 | 59,534 | 7,400 | 78,700 | 32 | 2,702 | 1,201 | 3,461 | 32,037 | 5,800 | 44,100 |
| 4 | 7 | 3,063 | 2,578 | 3,423 | 24,457 | 24,300 | 24,800 | - | - | - | - | - | - | - | 1 | 476 | 476 | 476 | 6,460 | 6,460 | 6,460 | 15 | 3,264 | 2,594 | 3,528 | 28,007 | 18,800 | 34,100 |
| 5 | - | - | - | - | - | - | - | 1 | 3,367 | 3,367 | 3,367 | 7,350 | 7,350 | 7,350 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | - | - | - | - | - | - | - | 4 | 4,069 | 2,416 | 5,745 | 9,838 | 7,170 | 17,800 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 7 | 2 | 3,068 | 2,750 | 3,385 | 14,850 | 13,700 | 16,000 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 | - | - | - | - | - | - | - | 4 | 4,612 | 2,187 | 8,223 | 15,350 | 11,400 | 17,800 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

*River Discharge = Data obtained from USGS Gage: Connecticut River at Montague City, MA (USGS 01170500).*

**Figure 1: Shortnose sturgeon spawning area in relation to Cabot Spill Gates.**

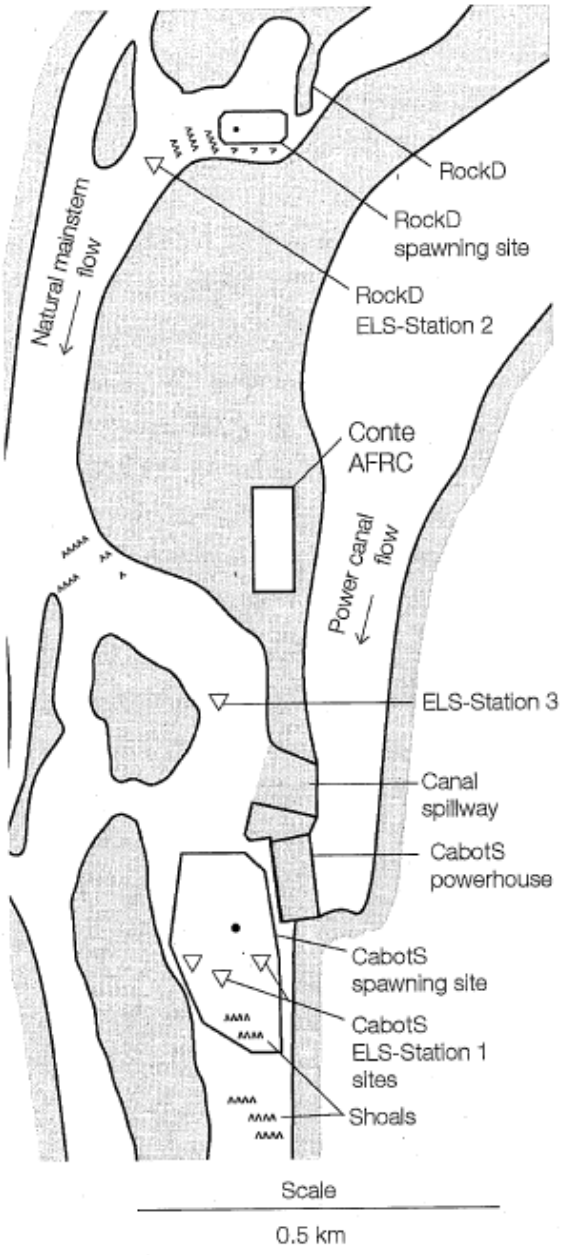
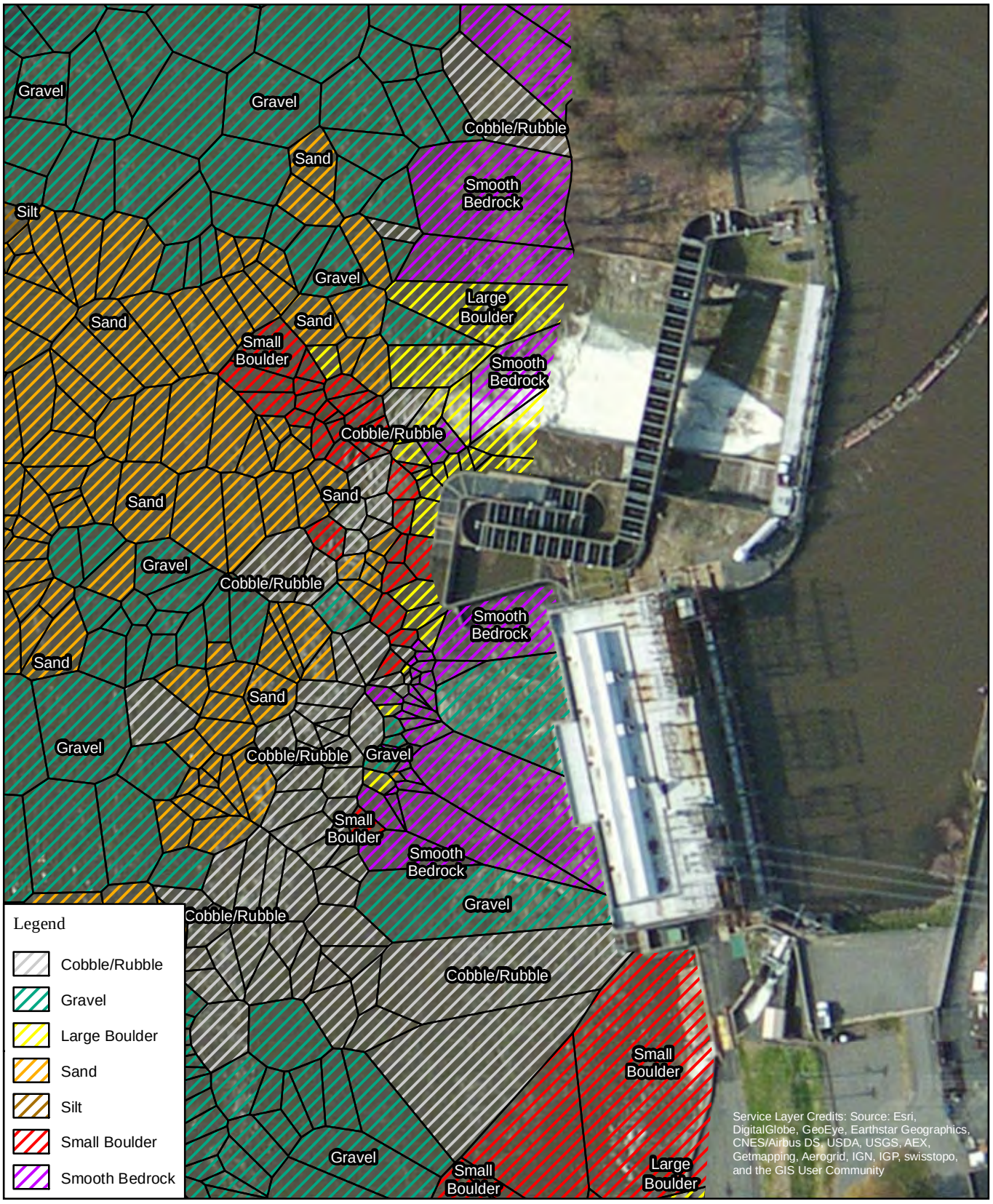



*Fig. 2. Map of the MontSR showing the two spawning sites (RockD and CabotS) and features of the CabotS hydropower facility; black circles = permanent bottom velocity sampling stations; triangles = ELS drift net sampling stations; and Shoals = areas exposed during low discharge.*

*From Kieffer and Kynard, 2012.*




FirstLight
GDF SUEZ

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

N

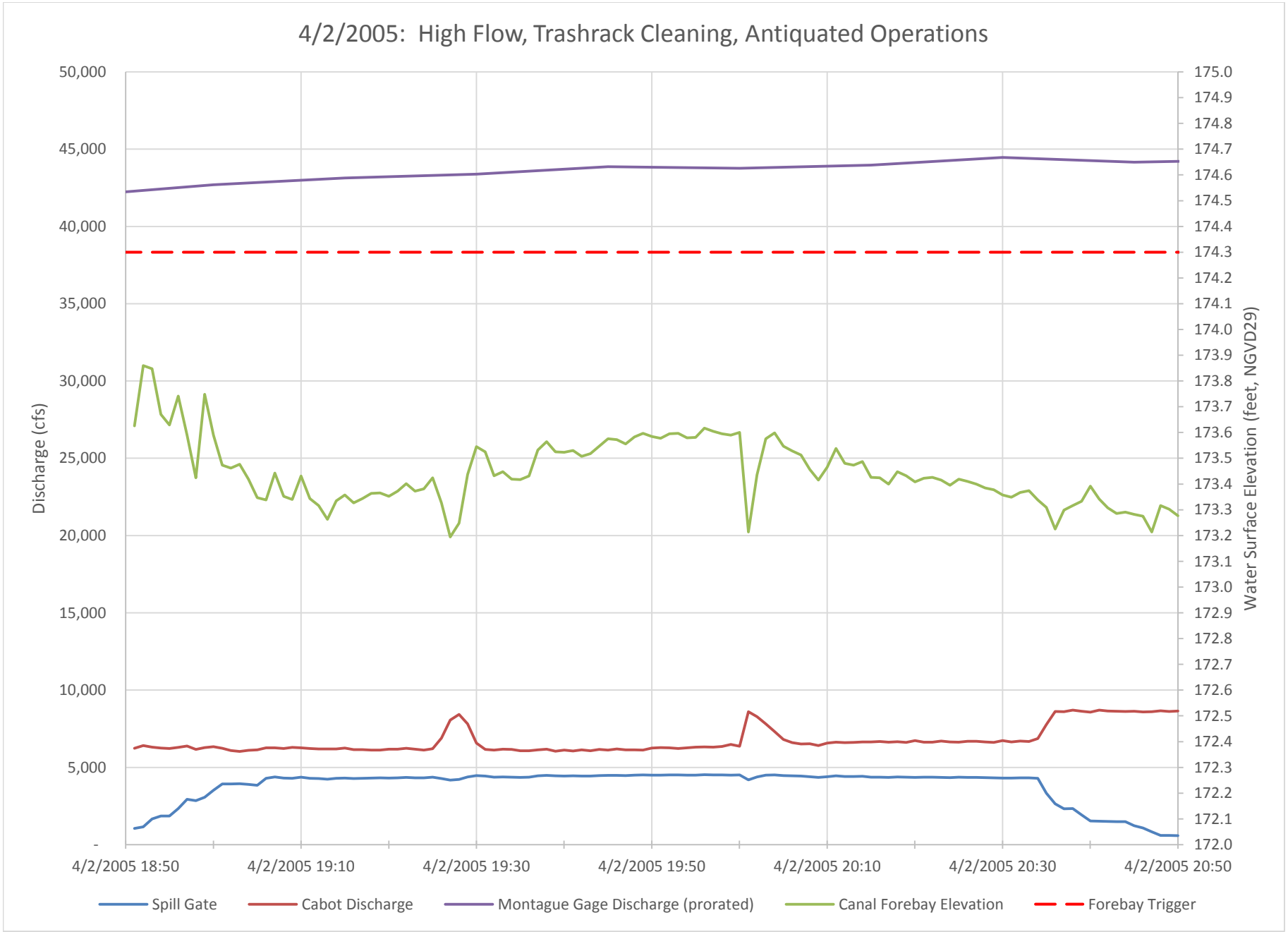
0 50 100 200
Feet

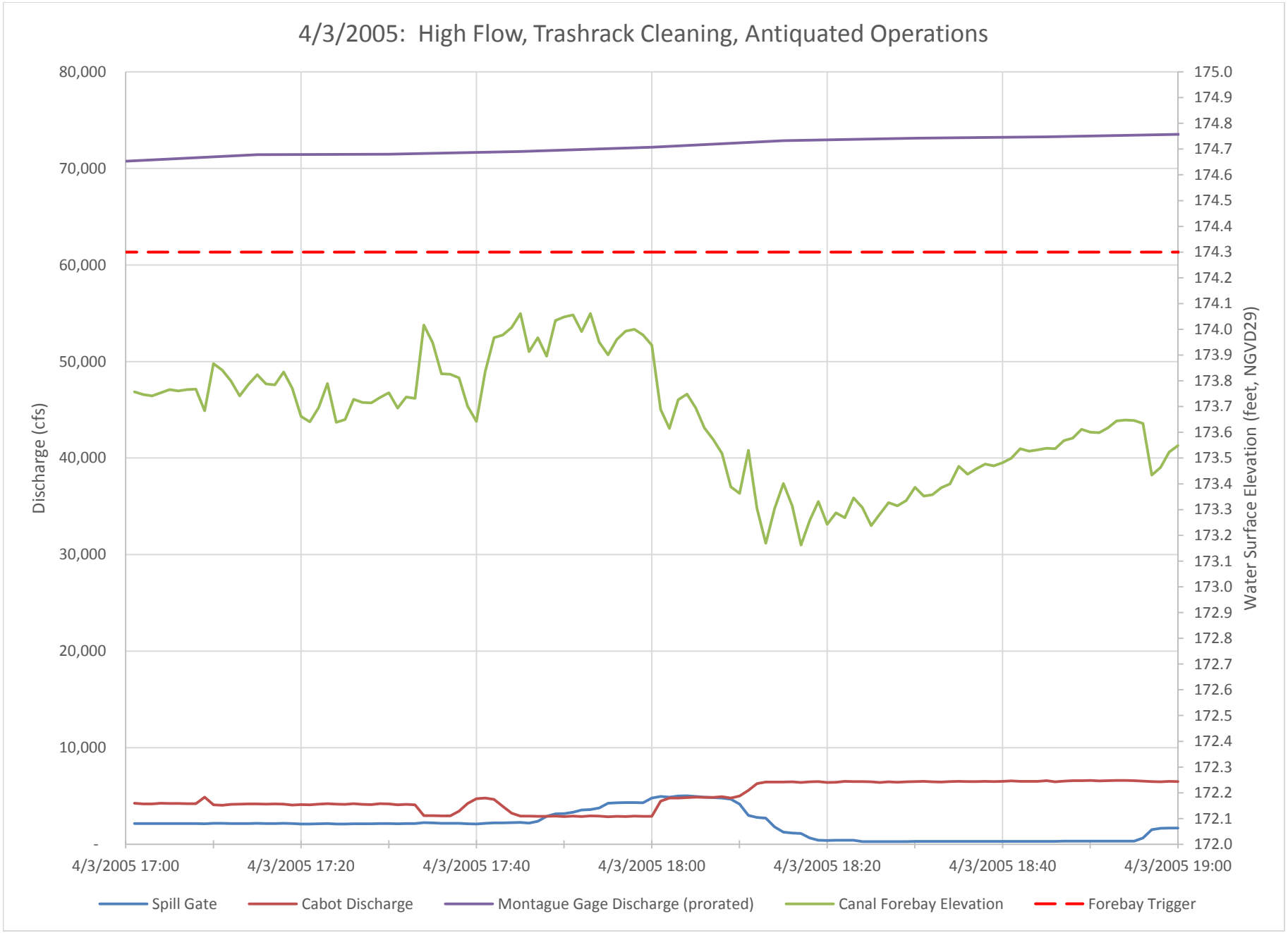
Substrate near Cabot Station

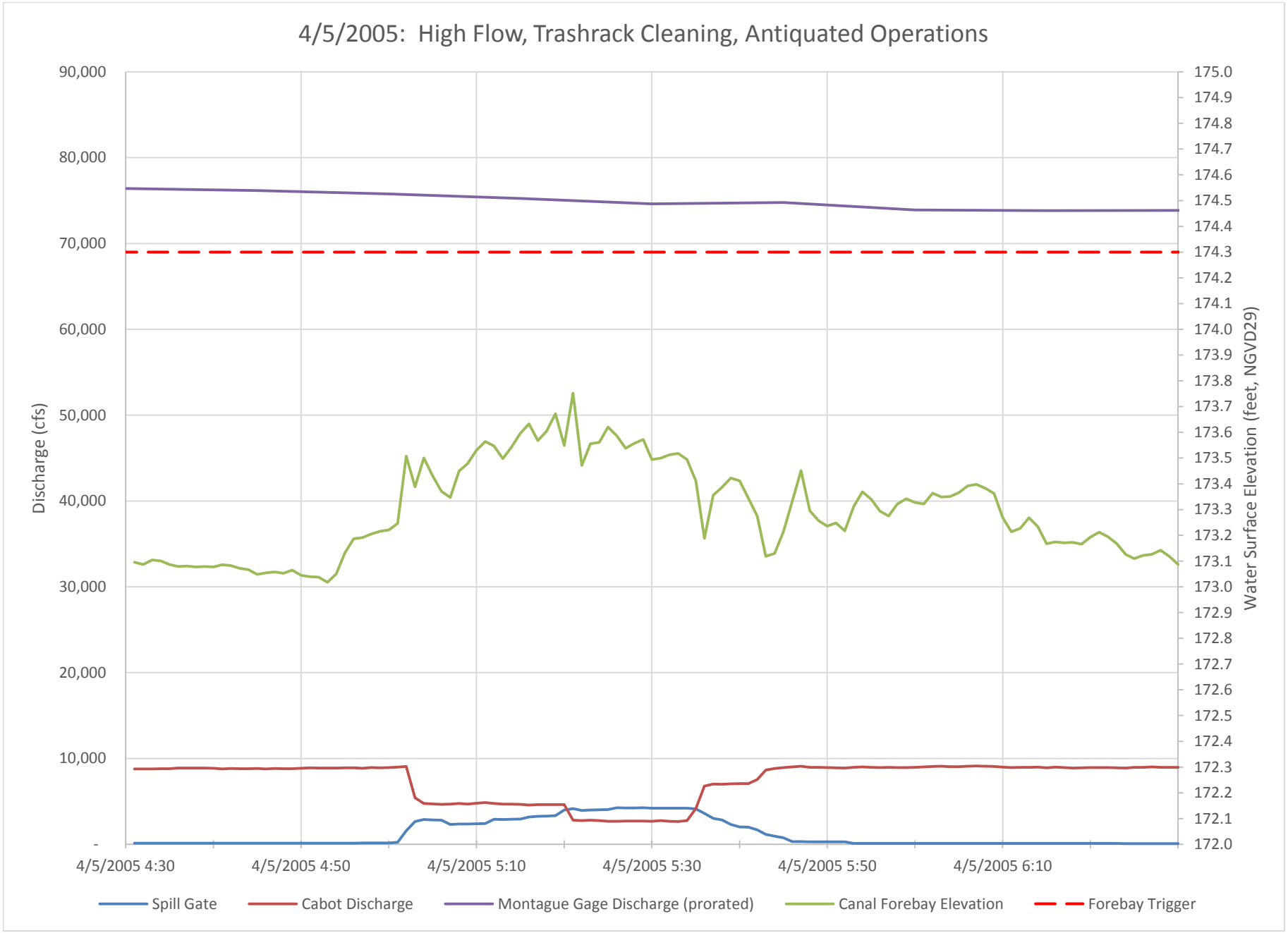


Path: W:\gis\maps\substrate_near_cabot.mxd

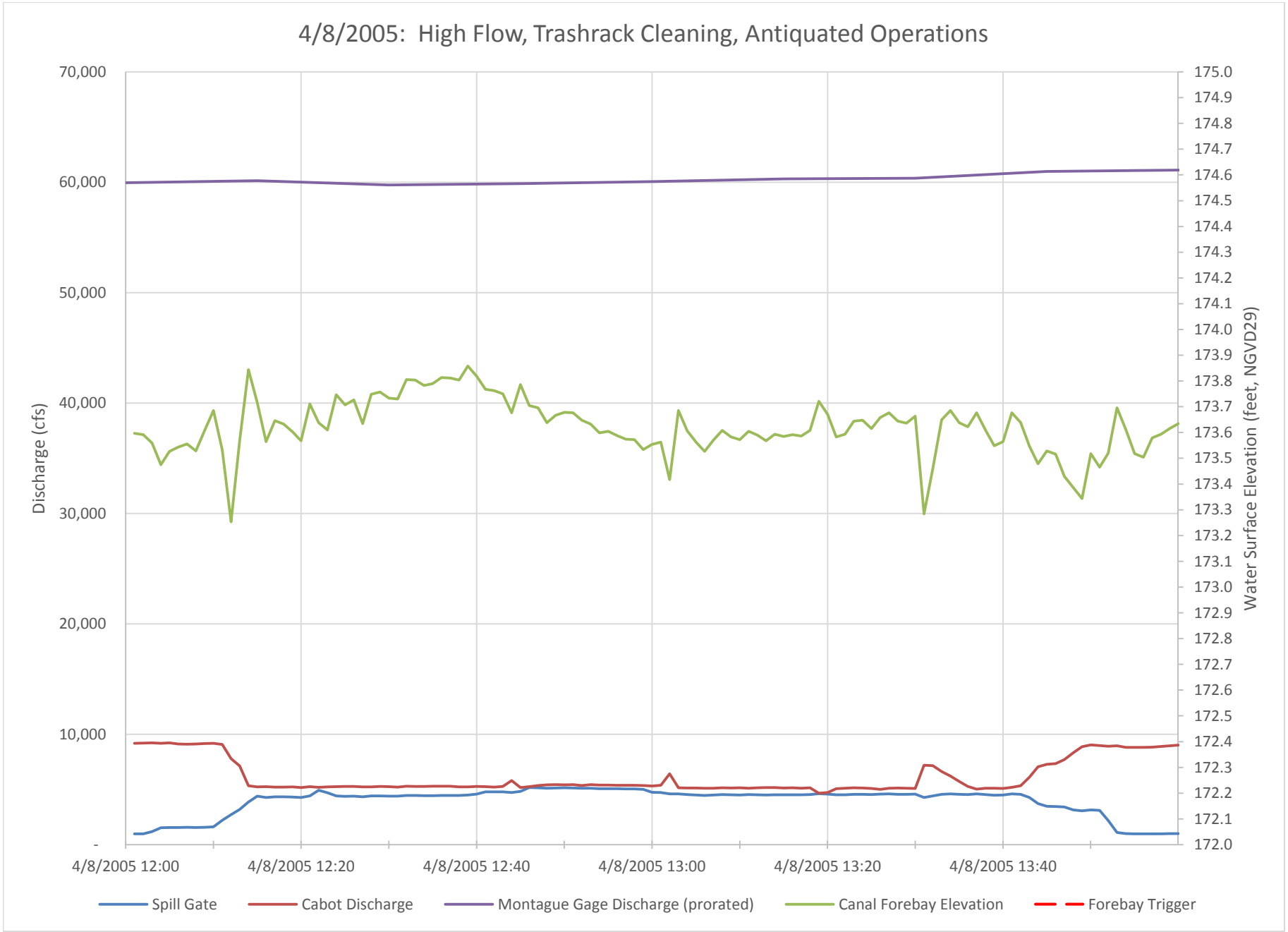
**Appendix A: Figures Showing Spill Gate, Cabot Station, and Connecticut River Discharge and Canal Forebay Elevation for periods when five or more spill gates were open, April – June, 2005-2012.**

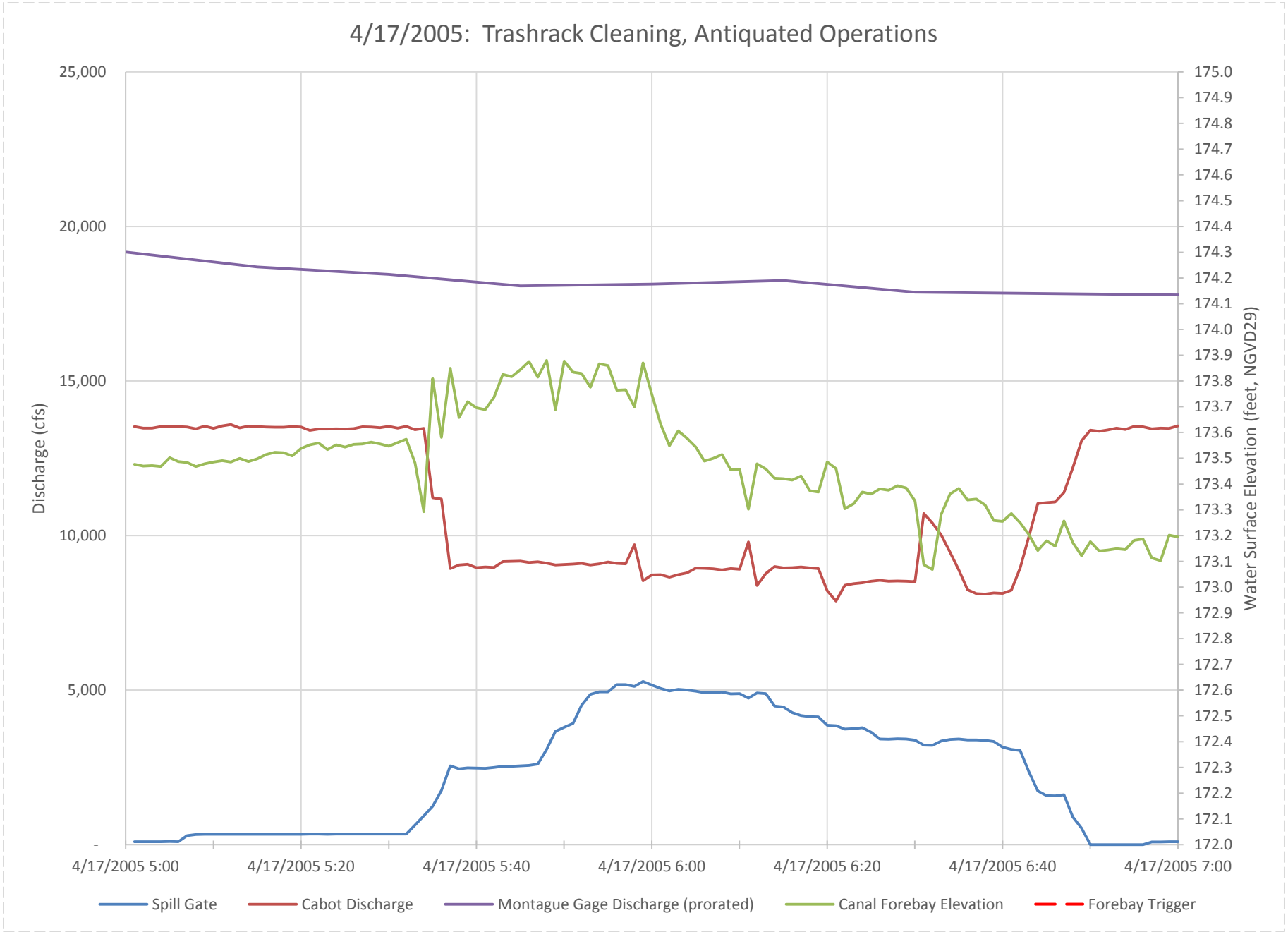

4/2/2005: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/2/2005 18:50
4/2/2005 19:10
4/2/2005 19:30
4/2/2005 19:50
4/2/2005 20:10
4/2/2005 20:30
4/2/2005 20:50
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

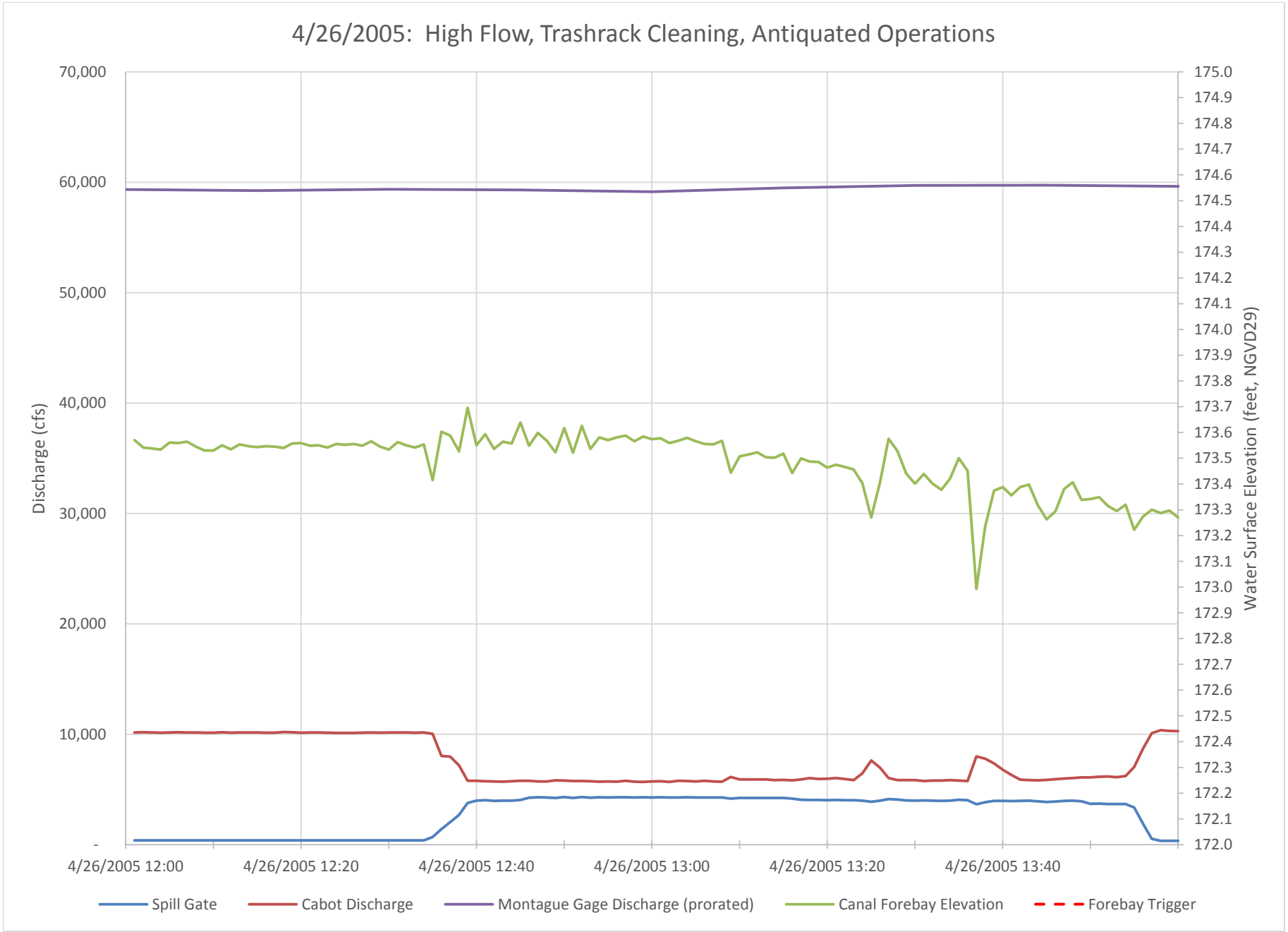

4/3/2005: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/3/2005 17:00
4/3/2005 17:20
4/3/2005 17:40
4/3/2005 18:00
4/3/2005 18:20
4/3/2005 18:40
4/3/2005 19:00
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

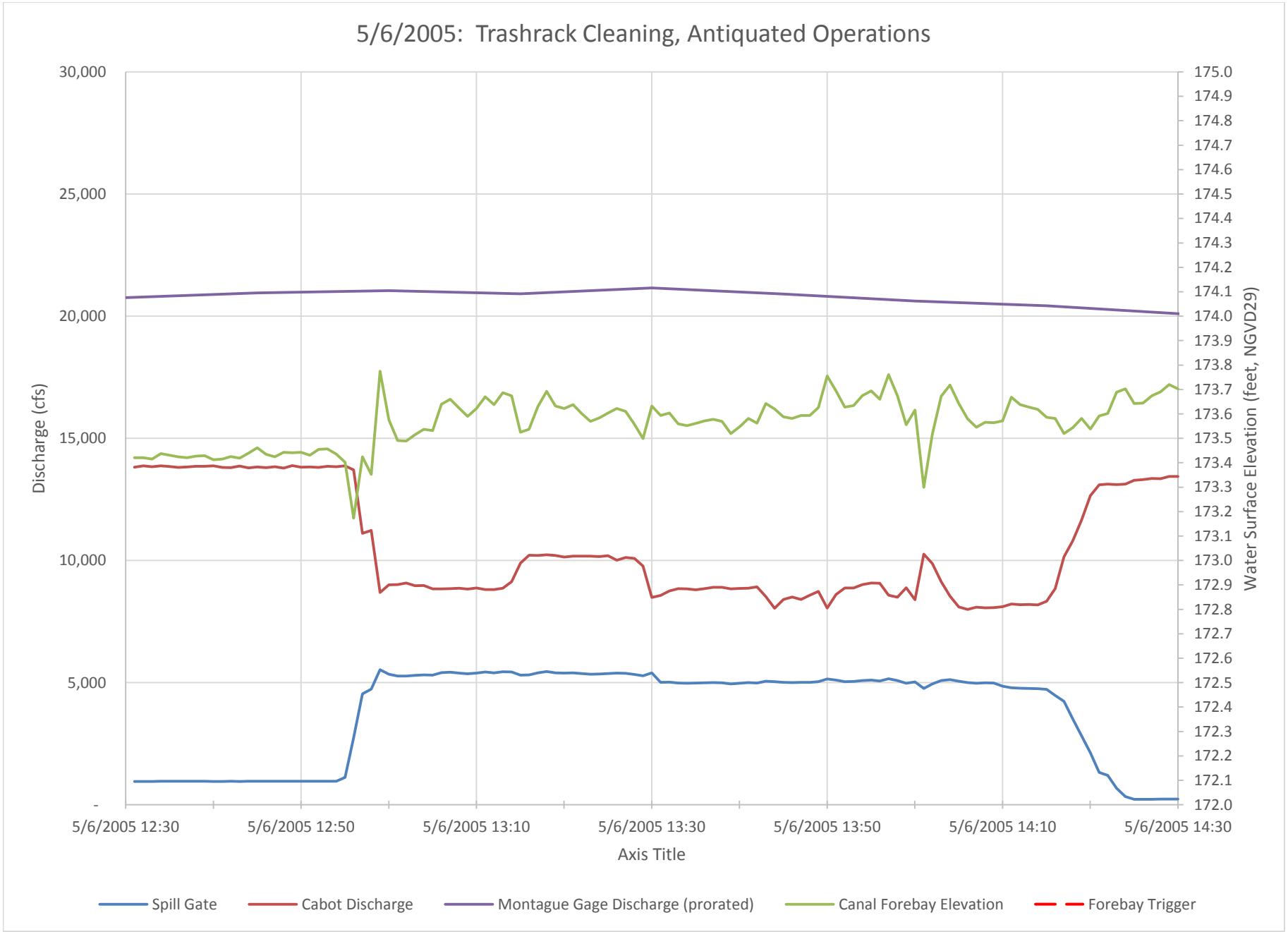

4/5/2005: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/5/2005 4:30
4/5/2005 4:50
4/5/2005 5:10
4/5/2005 5:30
4/5/2005 5:50
4/5/2005 6:10
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

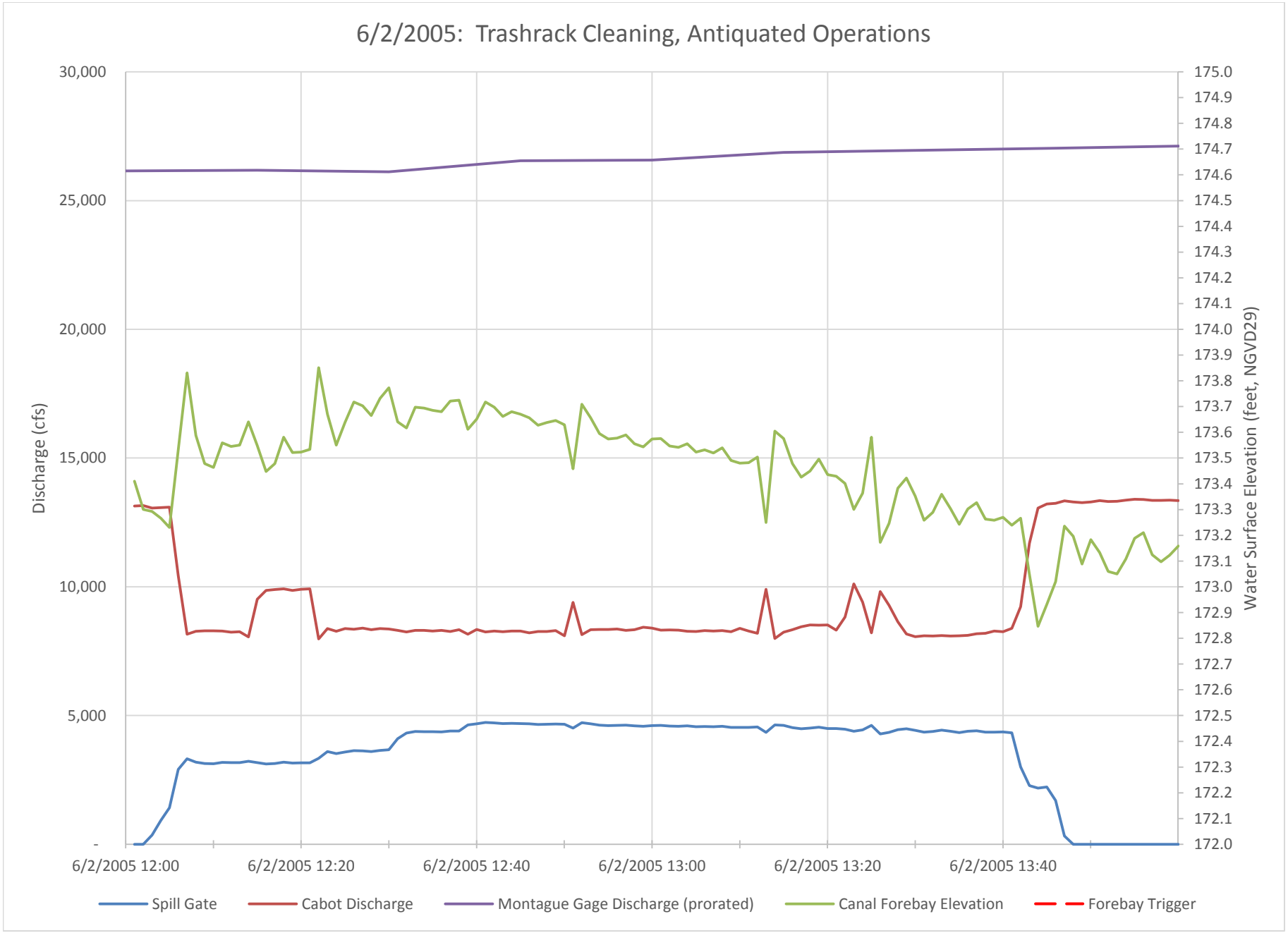

4/7/2005: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
60,000
50,000
40,000
30,000
20,000
10,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/7/2005 13:00
4/7/2005 13:20
4/7/2005 13:40
4/7/2005 14:00
4/7/2005 14:20
4/7/2005 14:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

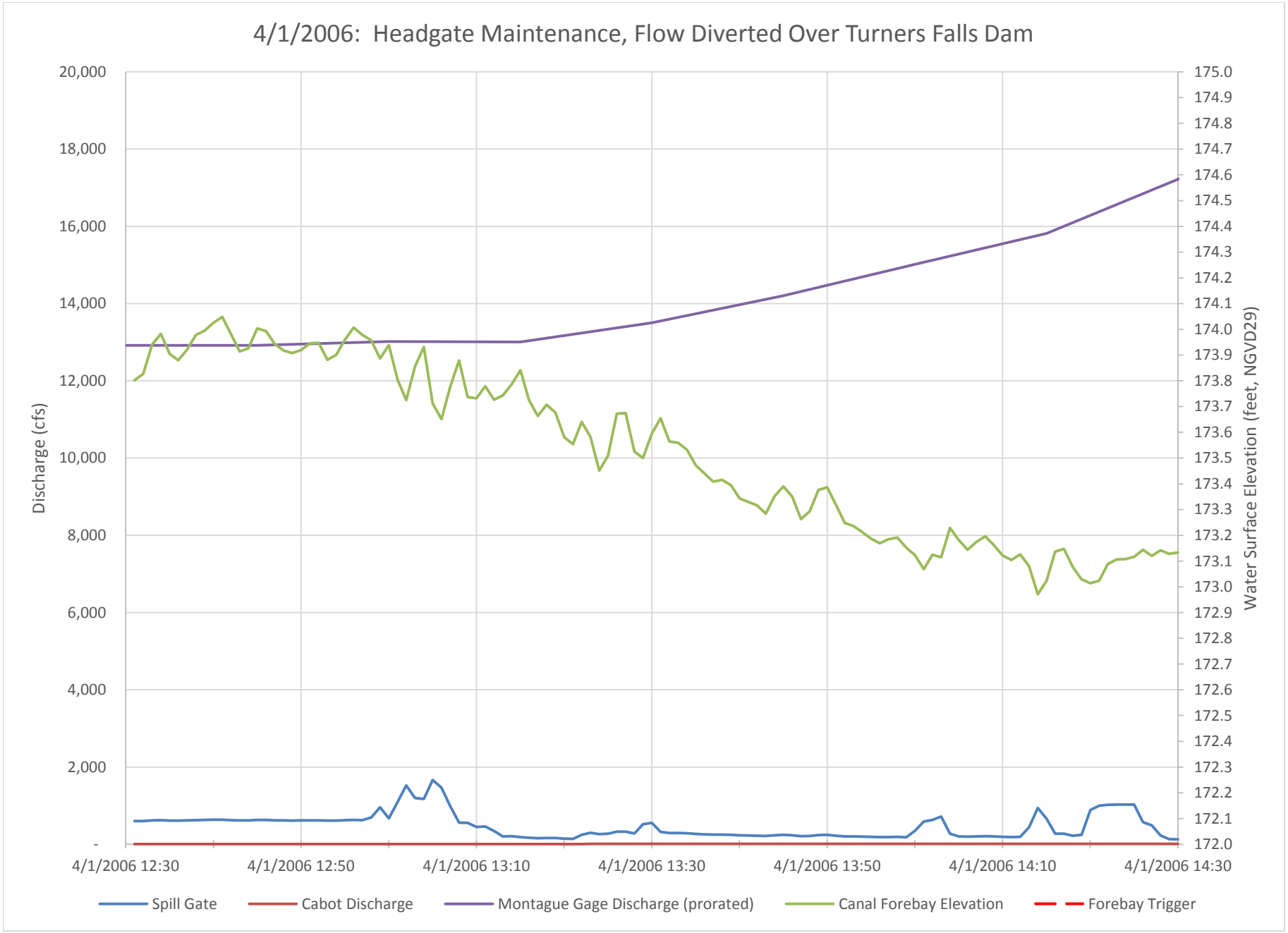

4/8/2005: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/8/2005 12:00
4/8/2005 12:20
4/8/2005 12:40
4/8/2005 13:00
4/8/2005 13:20
4/8/2005 13:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

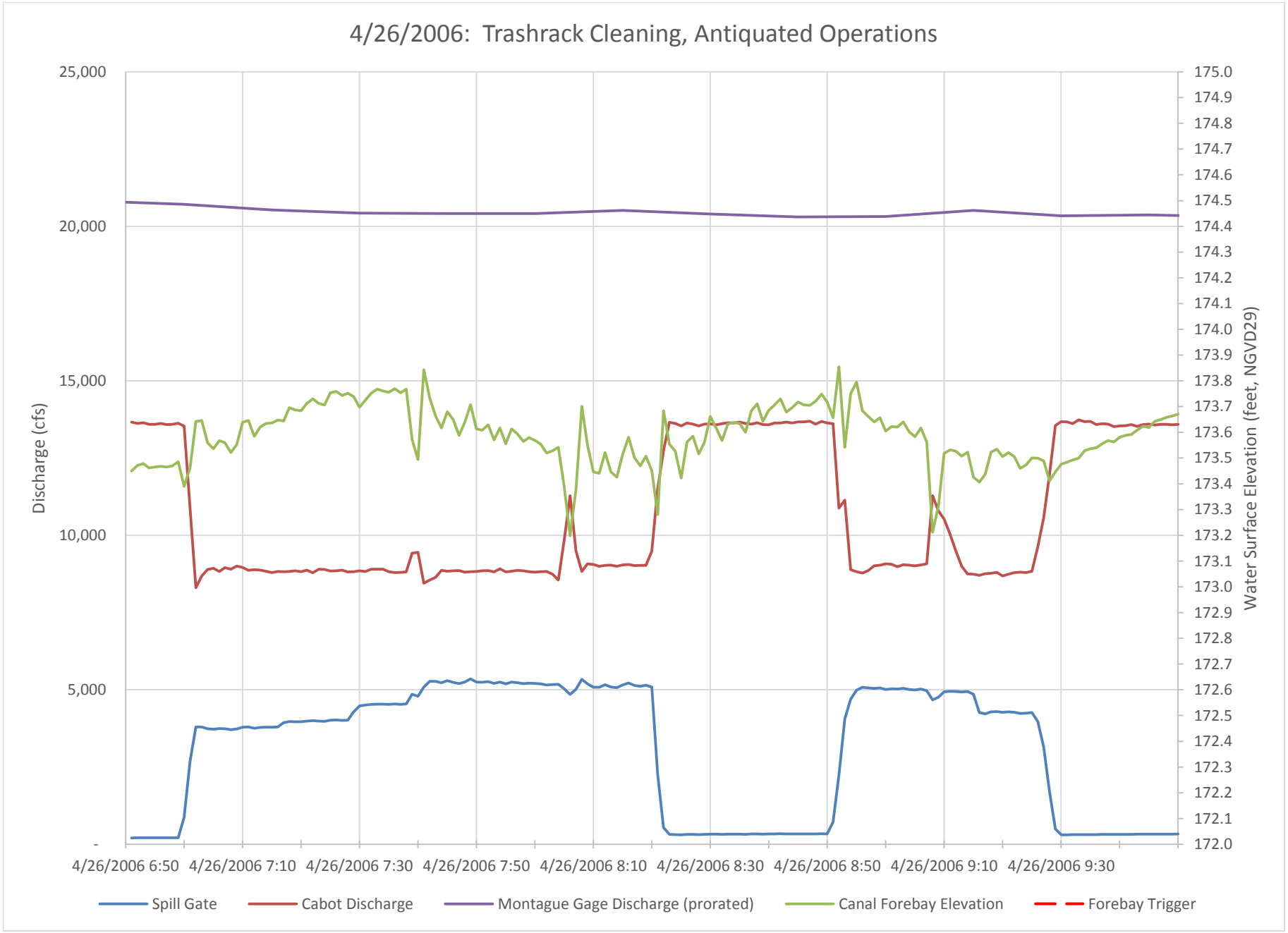

4/17/2005: Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/17/2005 5:00
4/17/2005 5:20
4/17/2005 5:40
4/17/2005 6:00
4/17/2005 6:20
4/17/2005 6:40
4/17/2005 7:00
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger


4/26/2005: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
Water Surface Elevation (feet, NGVD29)
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/26/2005 12:00
4/26/2005 12:20
4/26/2005 12:40
4/26/2005 13:00
4/26/2005 13:20
4/26/2005 13:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

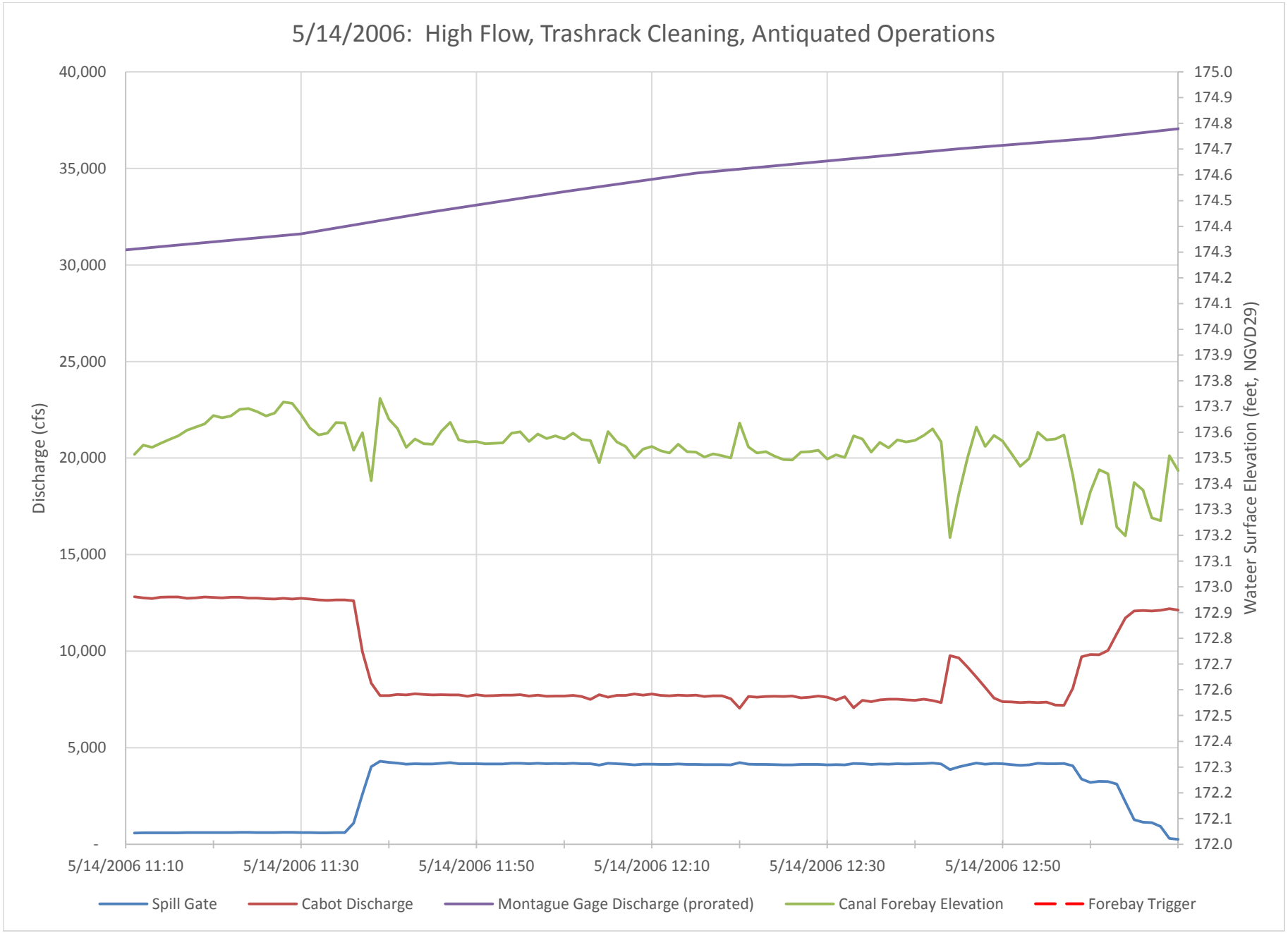

5/6/2005: Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
30,000
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
5/6/2005 12:30
5/6/2005 12:50
5/6/2005 13:10
5/6/2005 13:30
5/6/2005 13:50
5/6/2005 14:10
5/6/2005 14:30
Axis Title
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

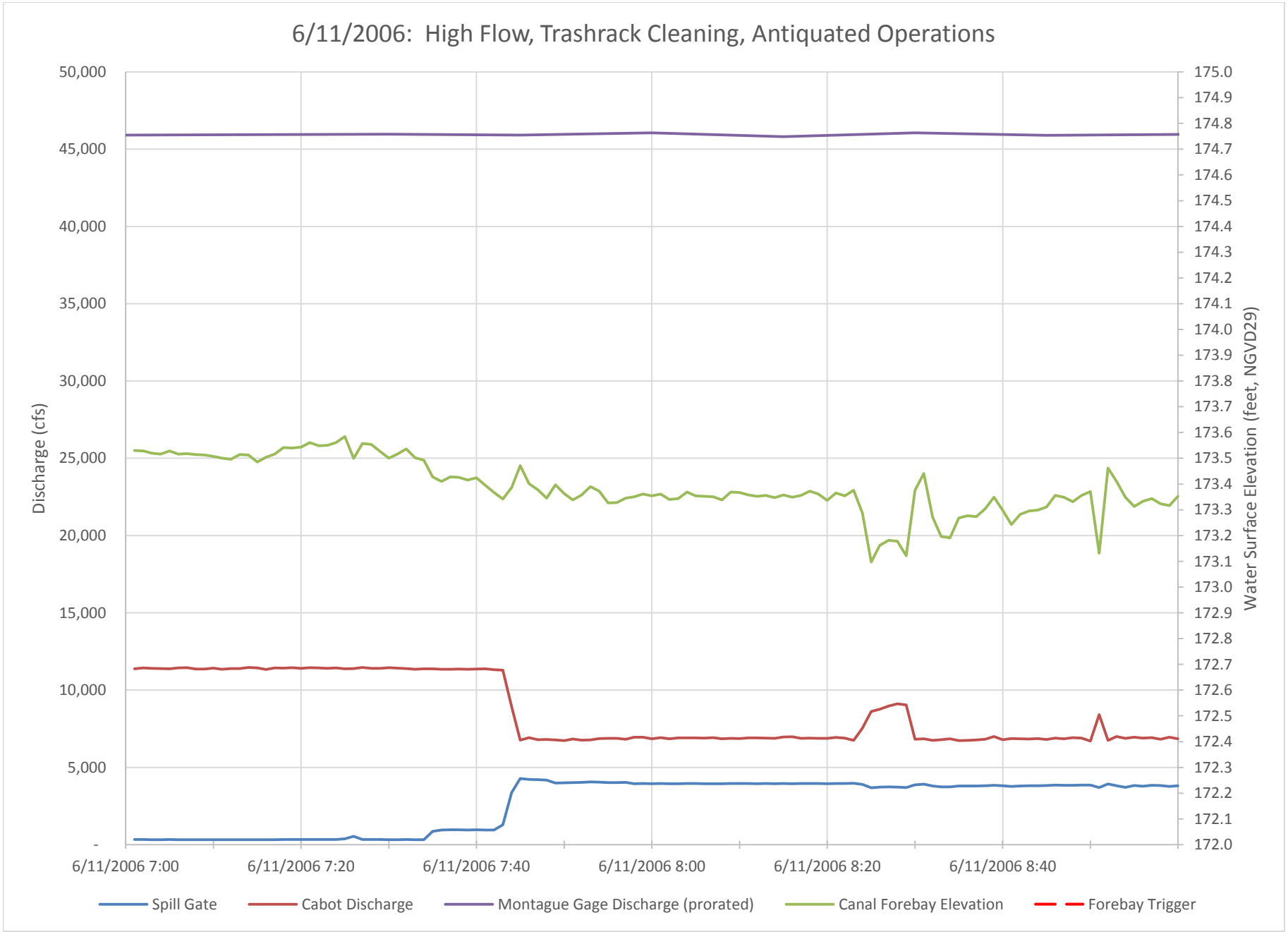

6/2/2005: Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
30,000
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/2/2005 12:00
6/2/2005 12:20
6/2/2005 12:40
6/2/2005 13:00
6/2/2005 13:20
6/2/2005 13:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

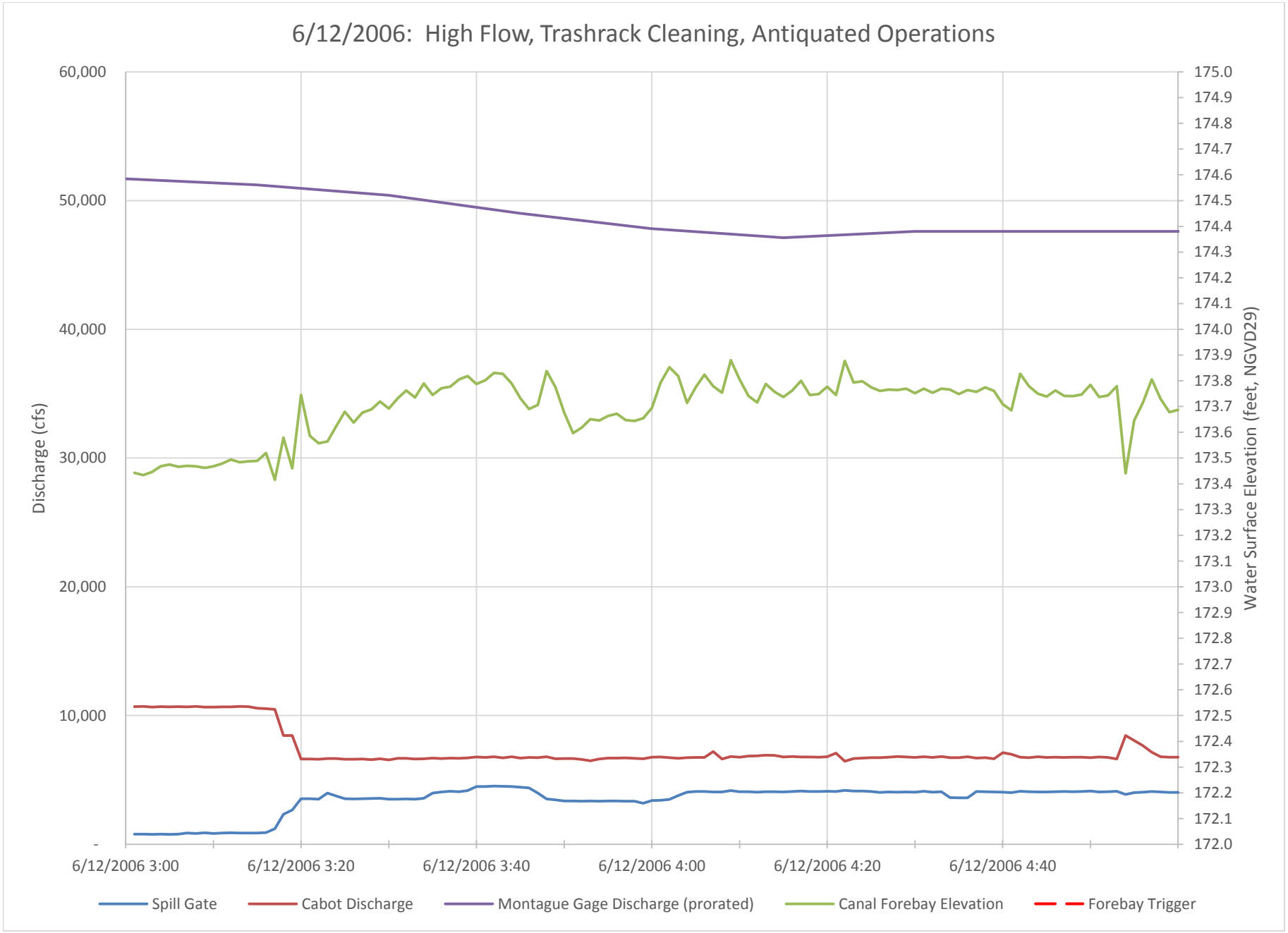

4/1/2006: Headgate Maintenance, Flow Diverted Over Turners Falls Dam
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/1/2006 12:30
4/1/2006 12:50
4/1/2006 13:10
4/1/2006 13:30
4/1/2006 13:50
4/1/2006 14:10
4/1/2006 14:30
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

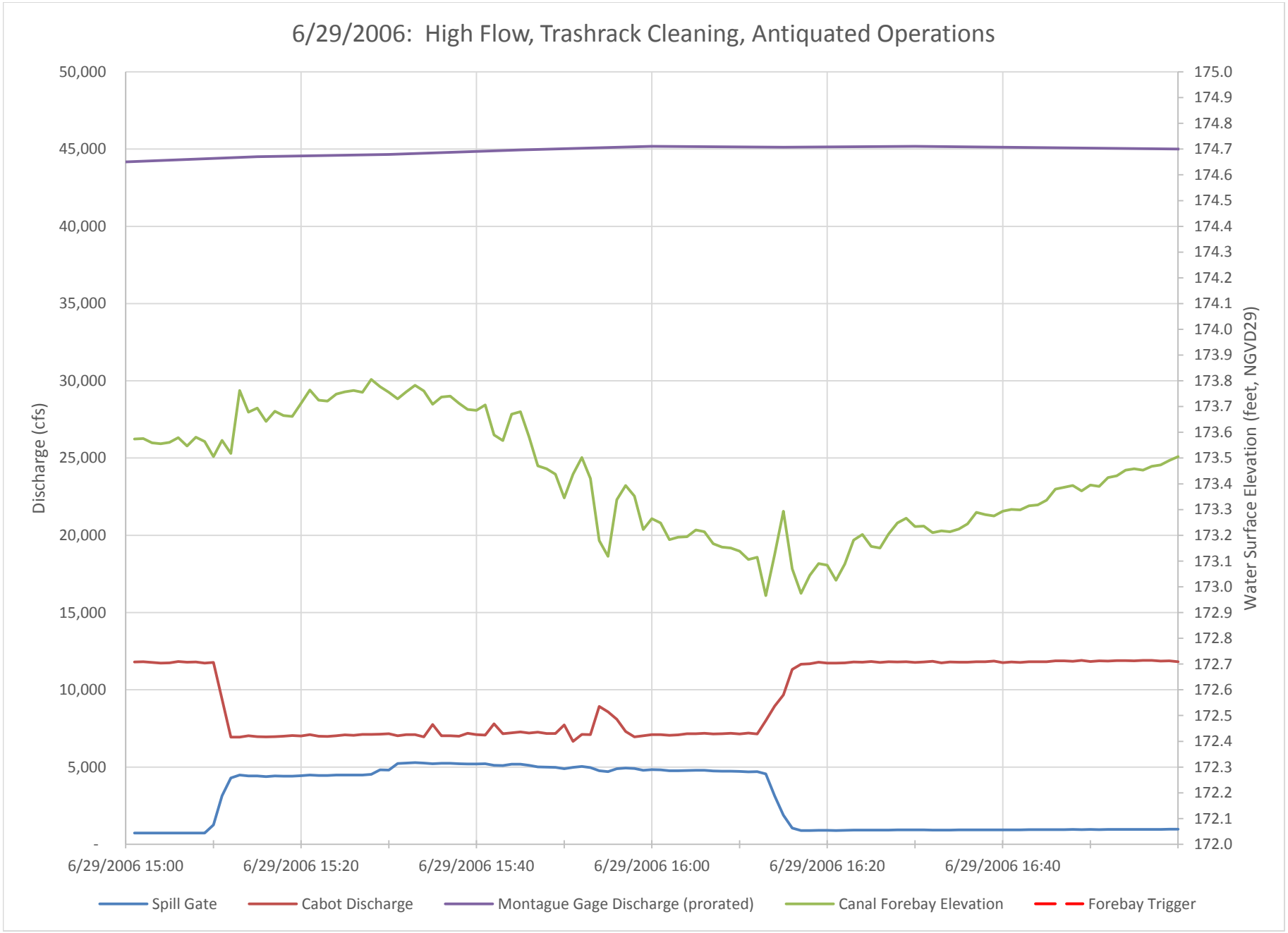

4/26/2006: Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
4/26/2006 6:50
4/26/2006 7:10
4/26/2006 7:30
4/26/2006 7:50
4/26/2006 8:10
4/26/2006 8:30
4/26/2006 8:50
4/26/2006 9:10
4/26/2006 9:30
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

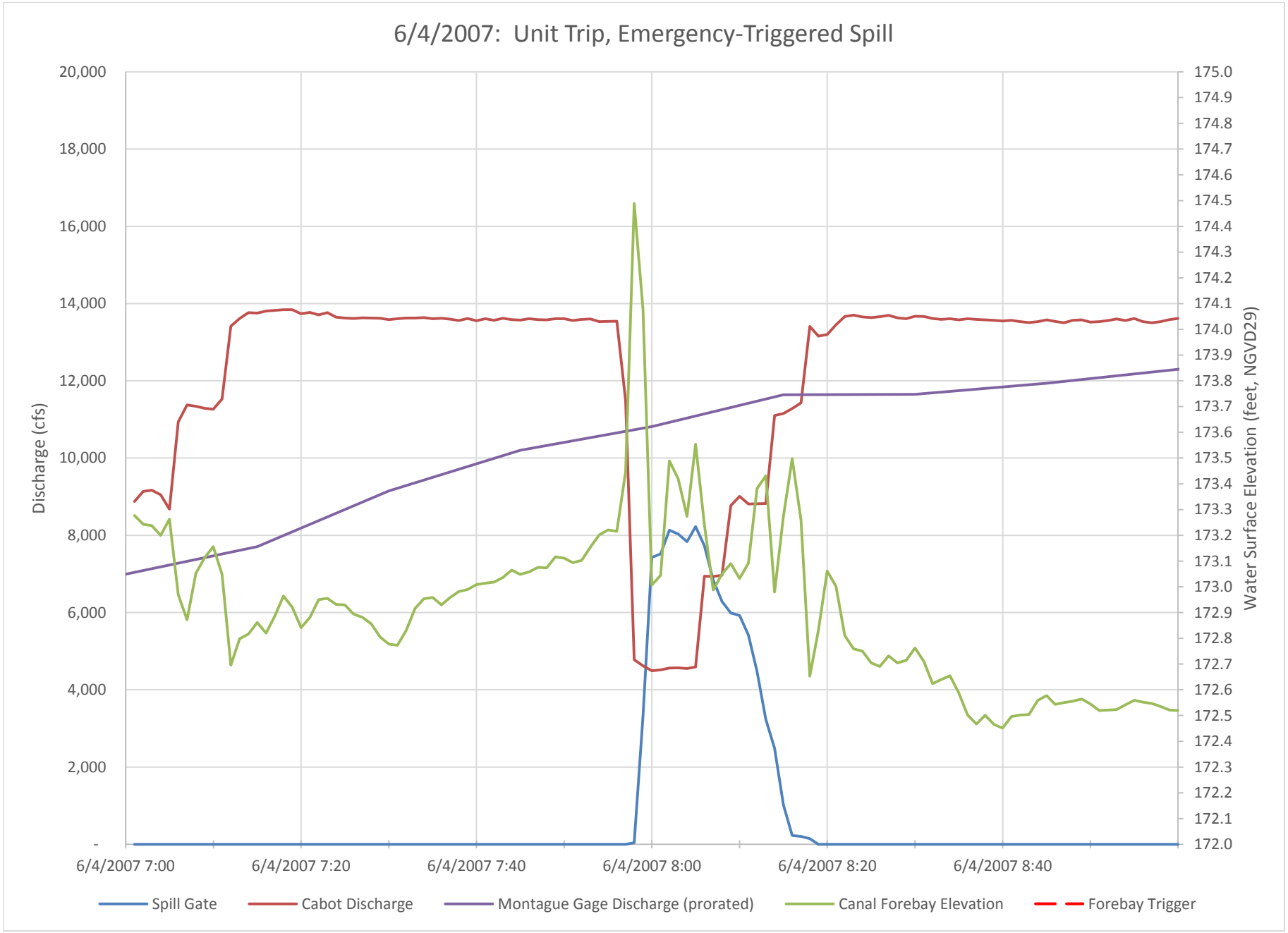

5/5/2006: Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
5/5/2006 12:00
5/5/2006 12:20
5/5/2006 12:40
5/5/2006 13:00
5/5/2006 13:20
5/5/2006 13:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

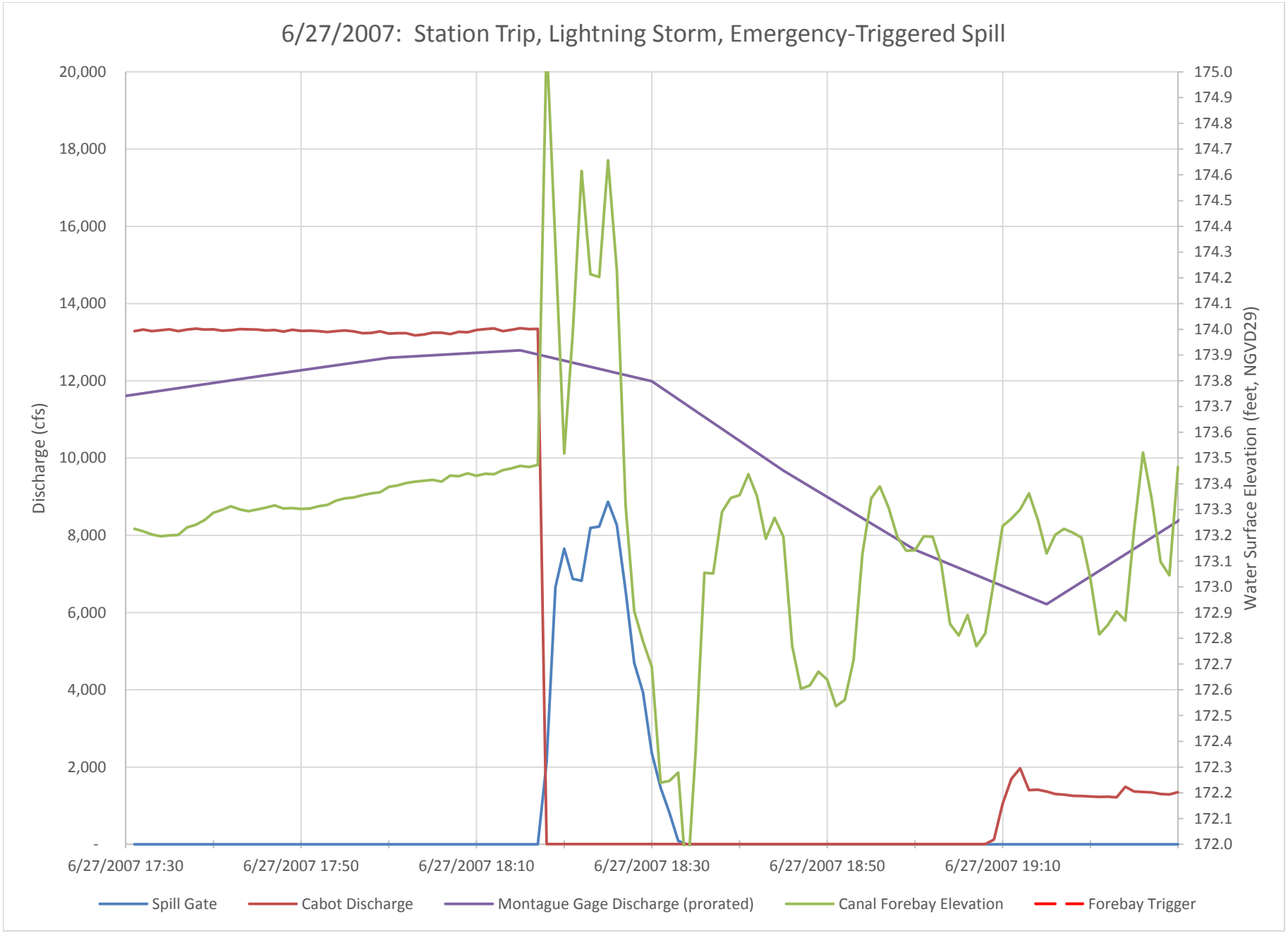

5/14/2006: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Wateer Surface Elevation (feet, NGVD29)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
5/14/2006 11:10
5/14/2006 11:30
5/14/2006 11:50
5/14/2006 12:10
5/14/2006 12:30
5/14/2006 12:50
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

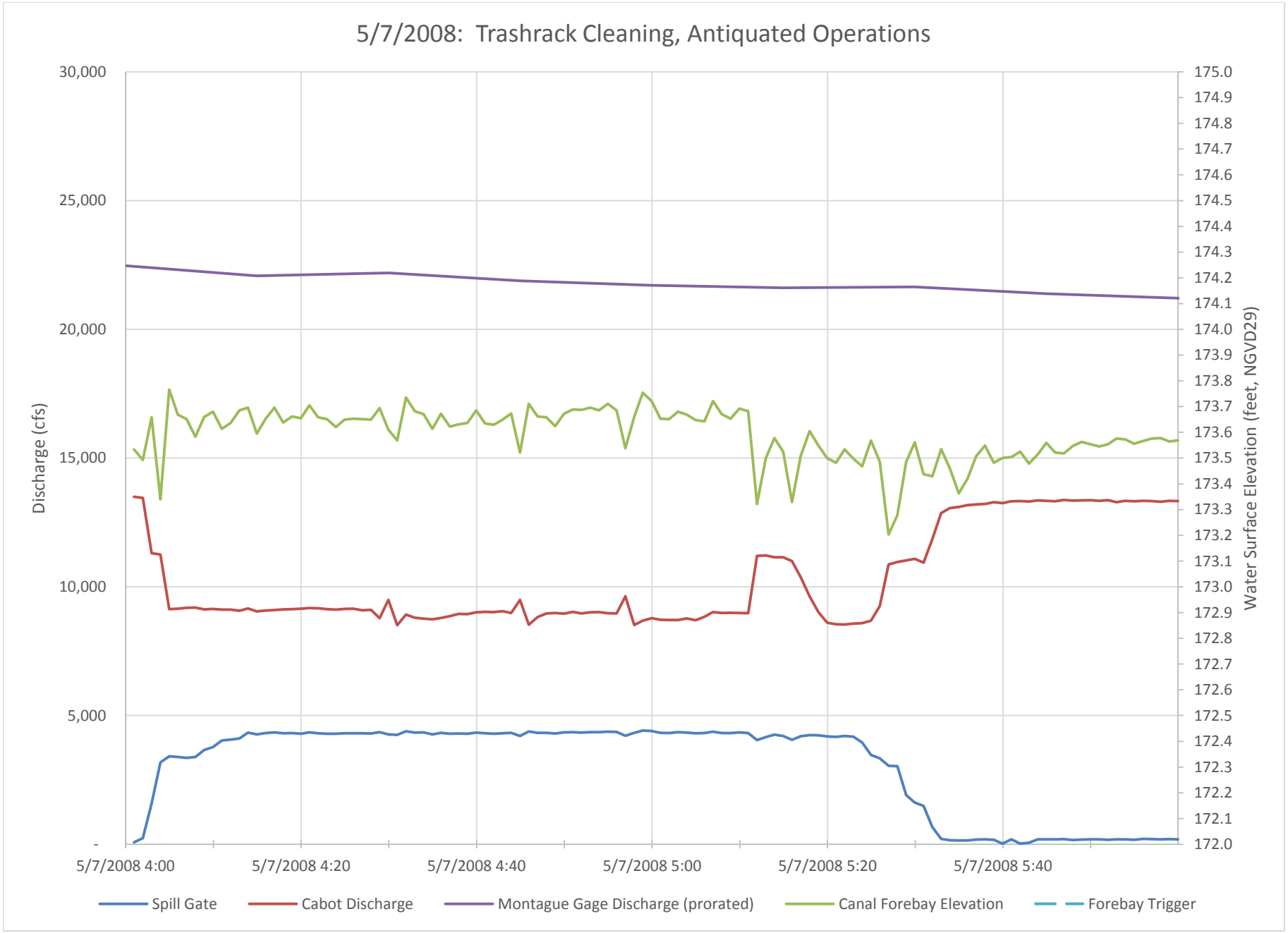

6/11/2006: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/11/2006 7:00
6/11/2006 7:20
6/11/2006 7:40
6/11/2006 8:00
6/11/2006 8:20
6/11/2006 8:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

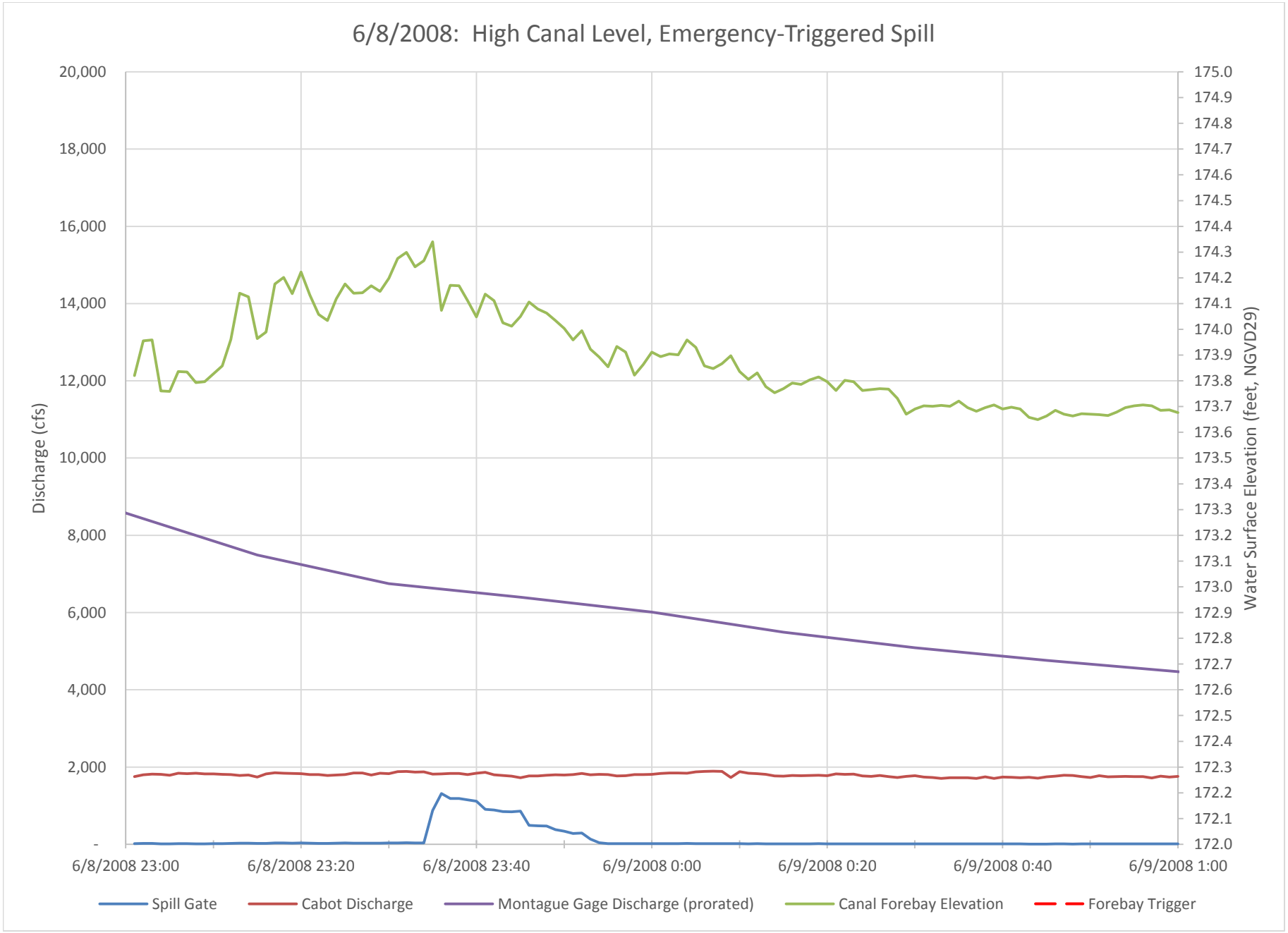

6/12/2006: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
60,000
50,000
40,000
30,000
20,000
10,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/12/2006 3:00
6/12/2006 3:20
6/12/2006 3:40
6/12/2006 4:00
6/12/2006 4:20
6/12/2006 4:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

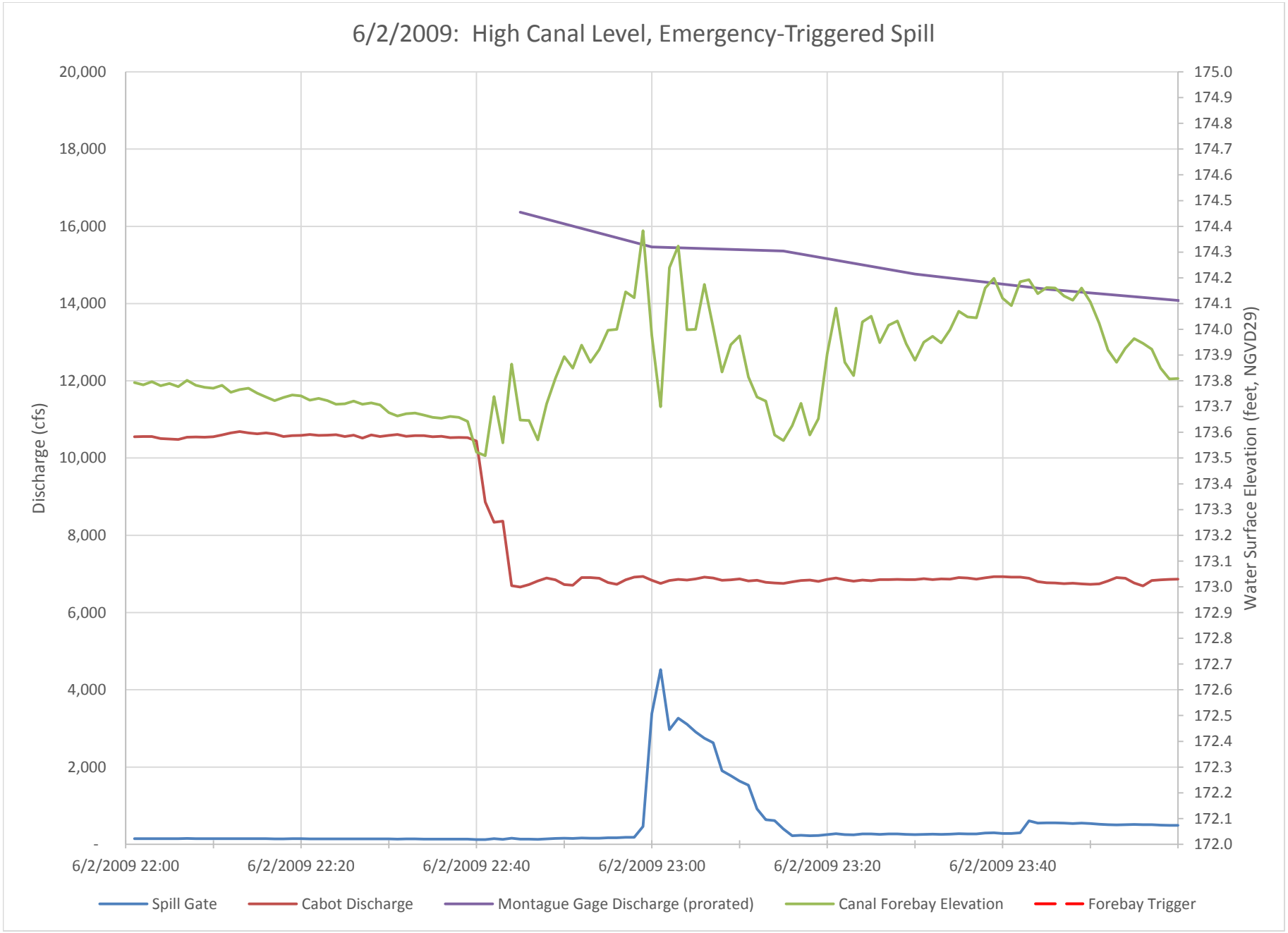

6/29/2006: High Flow, Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/29/2006 15:00
6/29/2006 15:20
6/29/2006 15:40
6/29/2006 16:00
6/29/2006 16:20
6/29/2006 16:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

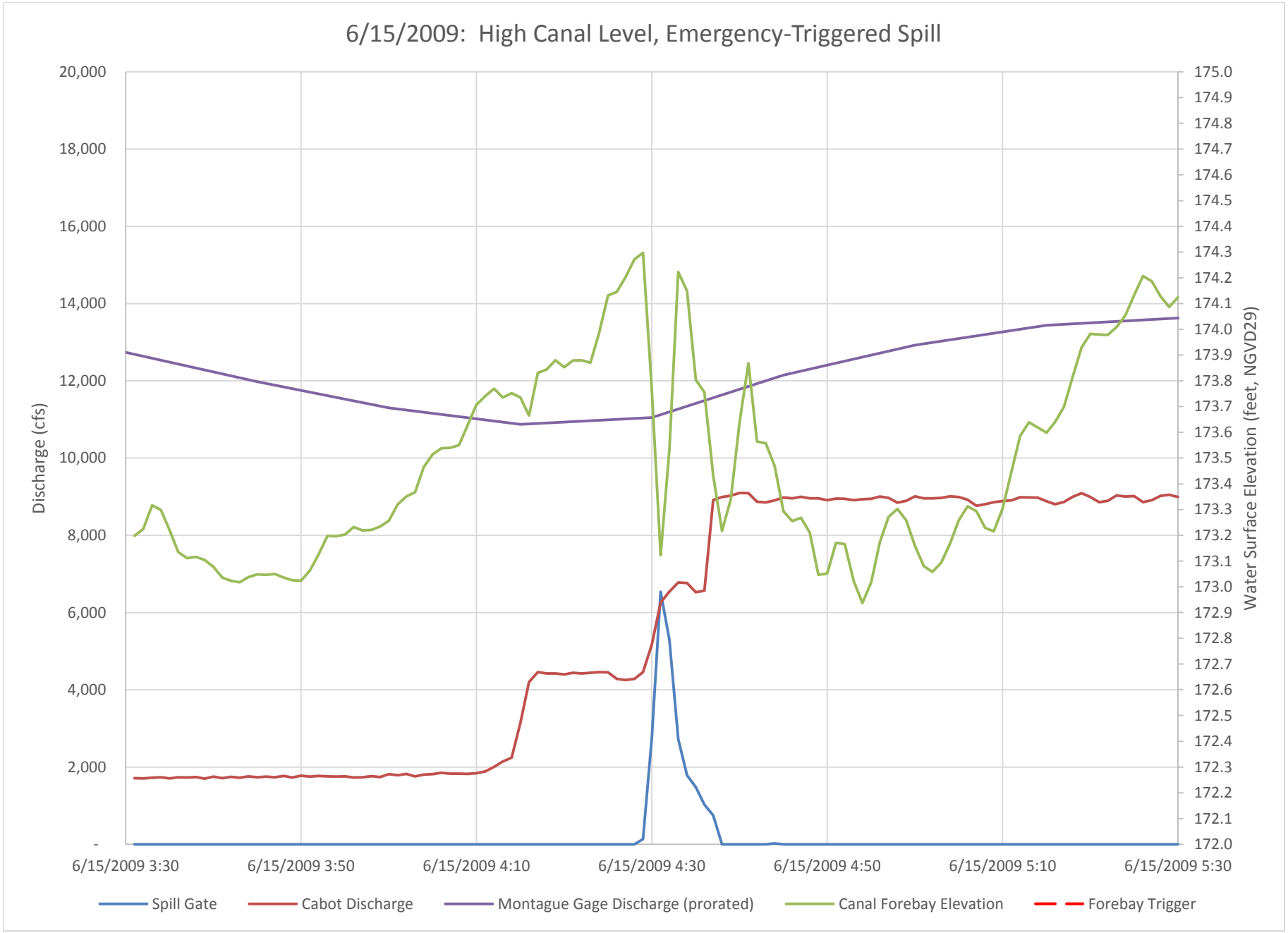

6/4/2007: Unit Trip, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/4/2007 7:00
6/4/2007 7:20
6/4/2007 7:40
6/4/2007 8:00
6/4/2007 8:20
6/4/2007 8:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

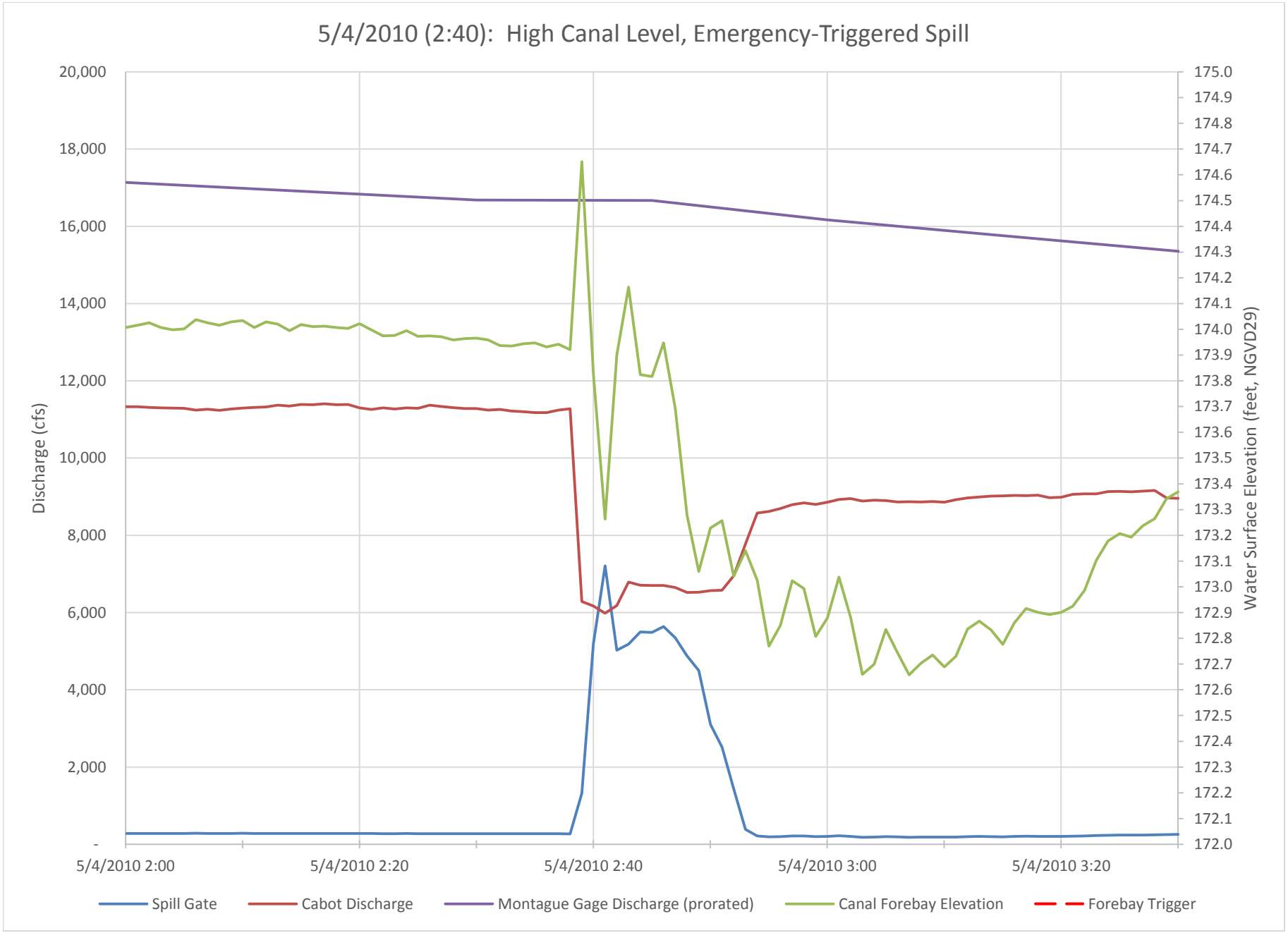

6/27/2007: Station Trip, Lightning Storm, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/27/2007 17:30
6/27/2007 17:50
6/27/2007 18:10
6/27/2007 18:30
6/27/2007 18:50
6/27/2007 19:10
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

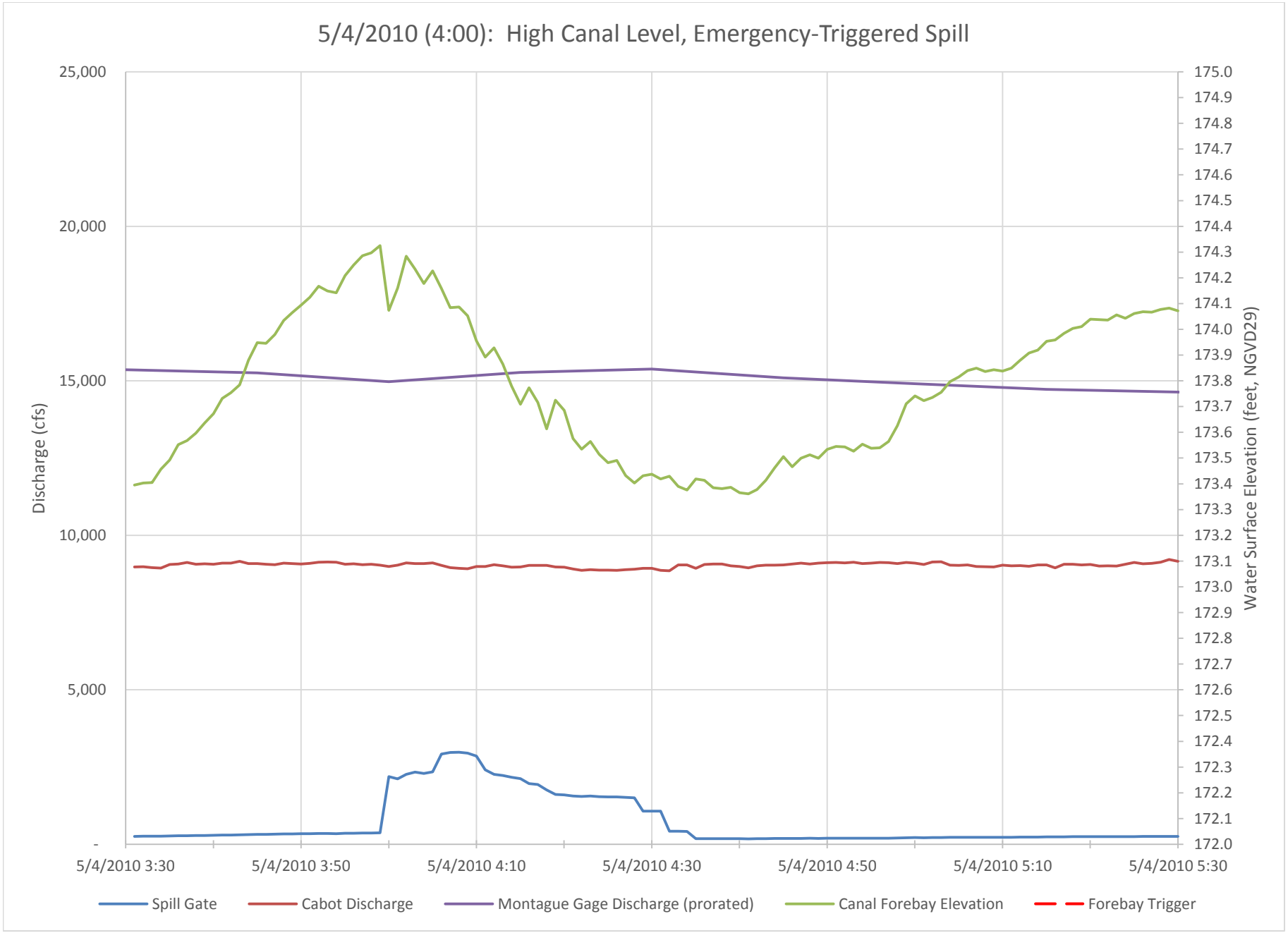

5/7/2008: Trashrack Cleaning, Antiquated Operations
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
30,000
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
5/7/2008 4:00
5/7/2008 4:20
5/7/2008 4:40
5/7/2008 5:00
5/7/2008 5:20
5/7/2008 5:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

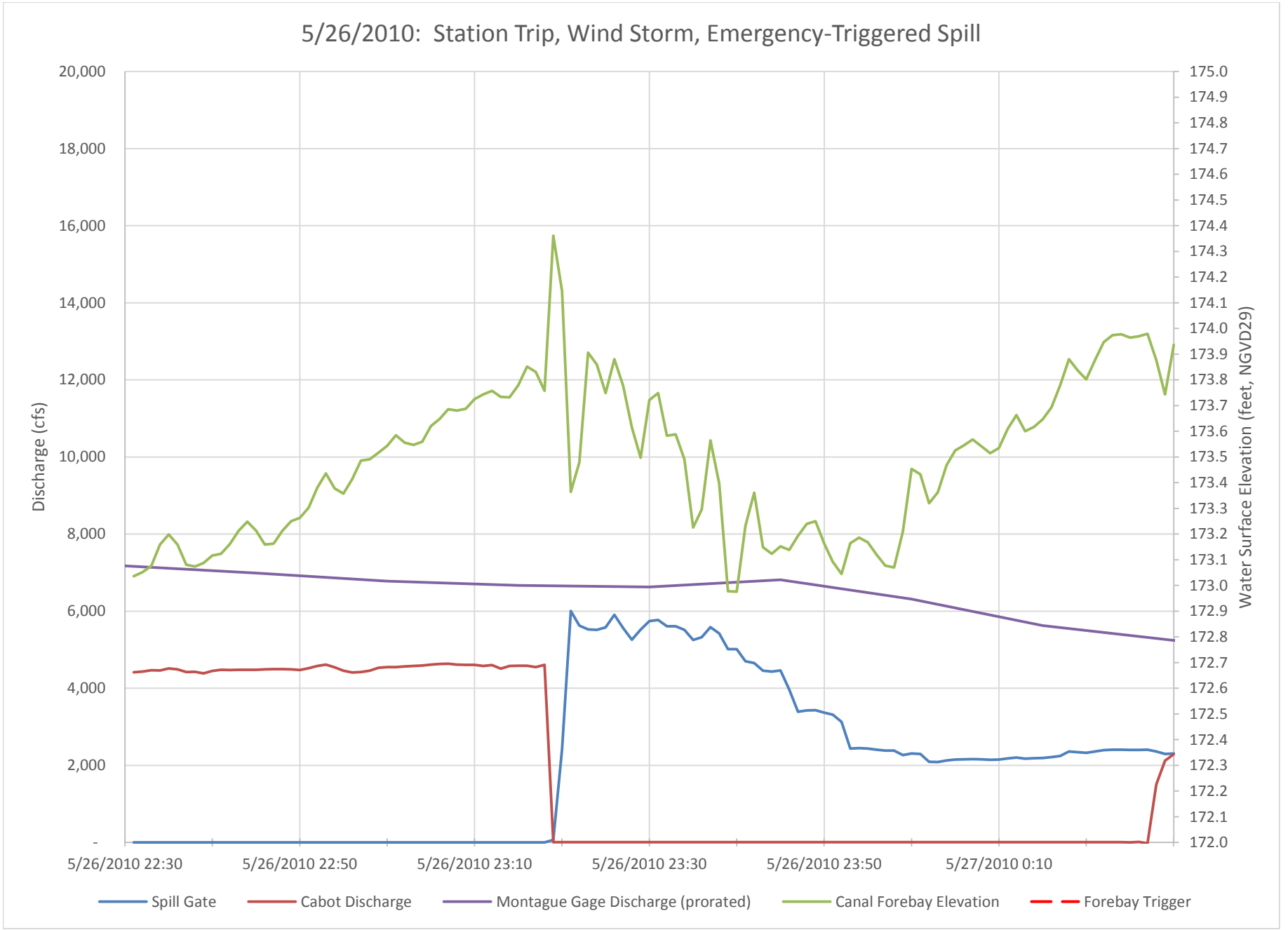

6/8/2008: High Canal Level, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/8/2008 23:00
6/8/2008 23:20
6/8/2008 23:40
6/9/2008 0:00
6/9/2008 0:20
6/9/2008 0:40
6/9/2008 1:00
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger

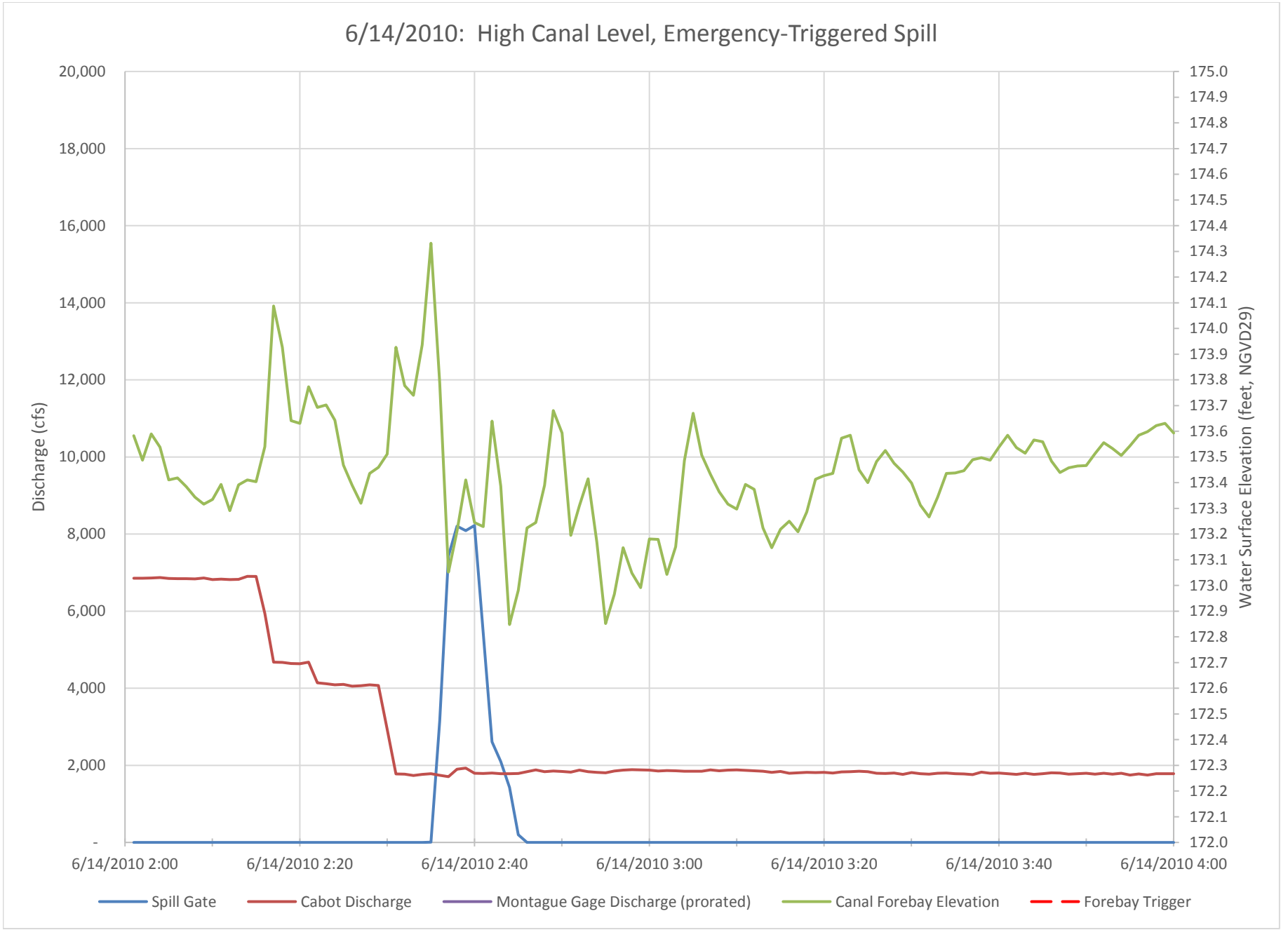

6/2/2009: High Canal Level, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/2/2009 22:00
6/2/2009 22:20
6/2/2009 22:40
6/2/2009 23:00
6/2/2009 23:20
6/2/2009 23:40
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger


6/15/2009: High Canal Level, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/15/2009 3:30
6/15/2009 3:50
6/15/2009 4:10
6/15/2009 4:30
6/15/2009 4:50
6/15/2009 5:10
6/15/2009 5:30
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger


5/4/2010 (2:40): High Canal Level, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
5/4/2010 2:00
5/4/2010 2:20
5/4/2010 2:40
5/4/2010 3:00
5/4/2010 3:20
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger


5/4/2010 (4:00): High Canal Level, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
25,000
20,000
15,000
10,000
5,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
5/4/2010 3:30
5/4/2010 3:50
5/4/2010 4:10
5/4/2010 4:30
5/4/2010 4:50
5/4/2010 5:10
5/4/2010 5:30
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger


5/26/2010: Station Trip, Wind Storm, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
5/26/2010 22:30
5/26/2010 22:50
5/26/2010 23:10
5/26/2010 23:30
5/26/2010 23:50
5/27/2010 0:10
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger


6/14/2010: High Canal Level, Emergency-Triggered Spill
Discharge (cfs)
Water Surface Elevation (feet, NGVD29)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
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173.5
173.4
173.3
173.2
173.1
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
6/14/2010 2:00
6/14/2010 2:20
6/14/2010 2:40
6/14/2010 3:00
6/14/2010 3:20
6/14/2010 3:40
6/14/2010 4:00
Spill Gate
Cabot Discharge
Montague Gage Discharge (prorated)
Canal Forebay Elevation
Forebay Trigger