CLE Engineering, Inc.

Photo taken from Buzzards Bay Project National Estuary Program website

STUDY ON EEL POND IMPROVEMENTS

June 2005

Revised January 2006

Prepared for:
Town of Mattapoisett
Board of Selectmen

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TABLE OF CONTENTS:

LIST OF FIGURES & TABLES

LIST OF EXHIBITS:

LIST OF EXHIBITS (continued):

LIST OF EXHIBITS (continued):

LIST OF EXHIBITS (continued):

LIST OF APPENDICES

- Letter dated June 16, 2005 from Russ Kempton, New England Geophysical to Mr. Nicholson, Town of Mattapoisett, RE: GPR Location Survey of Forced Main from STA 17+90 to STA 24+00

- GeoTechnical Test Report for Eel Pond Project East Channel, by GeoTesting Express, dated June 10, 2005 & September 27, 2005

- Plans Titled: "Eel Pond, Mattapoisett Harbor" by CLE Engineering, Inc., dated: 06-07-05, Revised 12-07-05, 5-sheets

EXECUTIVE SUMMARY:

Following several studies from 1992 to 2001, there has been increasing concern over the condition of Eel Pond, which at least one report concluded was among the most eutrophic embayments within the Buzzards Bay Monitoring Program. As a follow on to these studies, CLE was provided a contract for engineering services by The Town of Mattapoisett to perform a study that was intended to find ways to increase salt-water flow and improve the water quality within Eel Pond. Most of the prior reports cited the general lack of sufficient exchange with the adjacent tidal waters of Mattapoisett Harbor, which became one of the focuses of this study. In addition, tasks were included to provide detailed topographic mapping of the pond and adjacent areas, and investigation of the existing 12" sewage force main that crosses both the railroad embankment and the Western channel. These studies have been completed by CLE and are presented in this report and summarized in the following paragraphs.

Mapping and Sewer Line: Topographic mapping of Eel Pond and its adjacent environment, including resource areas, shellfish, water bodies, beaches, entrance channels and the existing sewer line route has been completed and is attached to this report. The Town of Mattapoisett located the sewer pipeline using Ground Penetrating Radar (see attached report). The identified sewer line locations were then surveyed by CLE and included in the attached map. In general, the sewer line was buried approximately five feet below existing grade; however, the portion of the pipe that crosses the West channel was found to have only 18" of cover at the deepest point of the channel. This is a matter of serious concern, as a major storm event (such as a hurricane) could uncover and possibly rupture the pipe. Such an event would be catastrophic in that it would cause several million gallons of raw sewage to be discharged into the Harbor before it could be repaired. CLE has recommended that plans be made to close the West Channel by filling and restoring the original beach grades to an elevation of +6.5 MLW (+5.5 NGVD). However, in order to perform this closure, plans must be made to enlarge the East Channel and increase the size of the railroad culvert.

Improving the Flushing of Eel Pond: CLE created a computer model of the Eel Pond watershed and connecting channels. A number of programs were then run simulating the existing conditions as well as various potential improvements, along with the tidal effects and rainstorms ranging from minor to extremely severe. The average daily exchange within Eel Pond (without rainfall) is presently 65%. If the East Channel is dredged as outlined herein, the exchange will improve to 84%, which is an increase of 30%. If the East channel is dredged, and the West channel closed, the exchange drops to 40%, or a reduction of 39%, thus CLE cannot recommend closing the West channel until railroad culvert improvements are completed. However, if the East Channel is dredged, the West channel closed and it is combined with enlarging the railroad culvert, the flows improve to 120% of the original volume, or an improvement of 86%.

Enlarging the Railroad Culvert: CLE investigated several methodologies, and performed a number of calculations with respect to the optimal method and size of a new culvert

under the railroad embankment. It was determined that a 24' x 8' culvert would provide the most optimal flow, while providing adequate scour protection during most storm conditions. In addition, when considering a hurricane storm surge event, the 24' culvert was also found to be the minimum advisable culvert that would provide adequate storm surge flowage. The size of the culvert was found to be critical toward reducing the damage to the barrier beach from storm surge overtopping.

<u>Phased Approach & Conclusions:</u> Based on the results of this study, it is reasonable to conclude that the water quality of Eel Pond can be improved, and the existing sewer line protected by taking a phased approach.

- CLE recommends a Phase 1 program that would require dredging the Eastern channel to Eel Pond. This would involve dredging approximately 6,100 cubic yards from the channel and removing the restriction at its mouth. Dredging would improve the flushing and water quality by increasing the tidal flows to Eel Pond by 30%. In addition, the flowage through the West Channel would be reduced by approximately 40%, thereby reducing the short term erosion risks to the sewer pipeline.
- CLE recommends a Phase 2 program that would involve installing a new 24' x 8' culvert adjacent to the existing culvert, using the open-cut method and temporarily bypassing the existing utilities. Opening of the new culvert could be followed by a closure of the Western Channel, and filling in the contours of the adjacent barrier beach with approximately 7,000 cubic yards of material. This would improve the tidal exchange in Eel Pond by almost double the present rate, and provide far better protection for the existing sewer force pipeline.
- At some point in the above process, CLE recommends replacing the portions of the asbestos cement pipeline in the railroad embankment and barrier beach with a more durable material such as HDPE.

When completed, this program would greatly improve the tidal exchange of Eel Pond, as well as better protect the harbor from an unfortunate environmental accident by way of an untimely sewer pipeline break.

INTRODUCTION

Engineer/Firm Assigned

Pursuant to a proposal dated April 15, 2005, the Town of Mattapoisett contracted CLE Engineering, Inc. (CLE) to perform surveying and engineering services. The scope of services included developing existing conditions site plans, engineering design and evaluations, hydrographical modeling, construction cost estimates, analysis of impacts from proposed activities and the preparation of permit applications and supporting documents for the improvements to the Eel Pond drainage system. CLE performed the services referenced in this report. Questions regarding this report, its scope and/or content should be addressed to John DeRugeris, P.E. or Susan Nilson, P.E. at (508) 748-0937.

This report has been prepared for the Town of Mattapoisett with the intent that it will be utilized for assessing the existing conditions of Eel Pond and proposed improvements. Any other use, publication or the like of any data contained herein, by other parties without express consent of CLE Engineering is prohibited.

Reference Documents

The following is a list of the references that were used for this project.

- Baywatchers II, :Nutrient Related Water Quality of Buzzards Bay Embayments: A Synthesis of Baywatchers Monitoring 1992-1998" Produced by the Coalition for Buzzards Bay
- "Eel Pond Water Quality Analysis and Nitrogen Loading Evaluation", by Horsley & Witten, Inc. dated April 1998
- "Nitrogen Management Options for Eel Pond, Mattapoisett" by Nick Nicholson, Mattapoisett Water Department, January 30, 1999
- Letter dated September 18, 2001 from Applied Coastal Research and Engineering, Inc. to Rebecca Haney, CZM Coastal Geologist, RE: Eel Pond, Mattapoisett
- "Atlas of Tidally Restricted Salt Marshes in Buzzards Bay Watershed", Buzzards Bay Project National Estuary Program, MA CZM, June 2002
- Letter dated May 23, 1005 from Gregory Sawyer, Marine Biologist, Division of Marine Fisheries to Michael Botelho, Town Administrator, Town of Mattapoisett, RE: May 10, 2005 Shellfish Survey of Eel Pond

SITE DESCRIPTION

Eel Pond is a small coastal salt pond containing approximately 30 acres, and is located within the Northwest shoreline of Mattapoisett Harbor. It is directly west of Mattapoisett Village, and is surrounded by developed land on the East, salt marsh on the North and West, a Golf Course on the Northwest and a coastal barrier beach on the South. The main source of fresh water (other than run-off from adjacent land) is Tub Mill Brook, which enters from the North. The main connection to salt water (Mattapoisett Harbor) is through two channels, one located at the extreme East end, and one located at the extreme West end of the pond (Figure 1). The East channel is believed to be the original connection, and it includes two smaller salt ponds along its route that are approximately two acres each. The East Channel has two restrictions, one being a box culvert, which is situated within a former railroad embankment. The embankment forms somewhat of a barrier separating Eel Pond from the Harbor over approximately one third of its length. The remaining two-thirds of the former railroad alignment was destroyed by hurricanes and, with little exception is no longer evident. The second obstruction in the East Channel is two-fold, consisting of the shallow braided connecting channel and a rocky shoal at its entrance. The high point of the channel, at the shoal is presently +2.5 feet above mean low water (MLW), (or +1.2 NVGD). The West Channel cuts through a salt marsh, then the barrier beach, and with the exception of a shoal at its entrance, it is relatively unimpeded; as such it presently carries most of the salt-water ebb and flow of the tides.

Eel Pond has filled in with upland sediment over the years and its bottom elevation is now approximately +1.3 to +2.3 MLW, (or 0.0 to +1.0 NGVD as shown on the attachments). High water stages (exclusive of storm water effects) lag behind the Harbor by an hour or more, and reach +3.8 to +4.8 (MLW) depending on the Harbor's tidal range for the particular day. Low water ranges from +2.2 to +2.4 (MLW), again depending on the tidal range of the Harbor. This puts net water depths in the pond from 0.0 to 2.4 feet, with the higher tidal elevations generally lagging the Harbor high tides by one to two hours. Because of its low rate of tidal exchange, and the inflow of upland fresh water, Eel Pond has been rated among the most eutrophic embayments within the Baywatchers Monitoring Program (1992-1998) performed by the Coalition for Buzzards Bay.

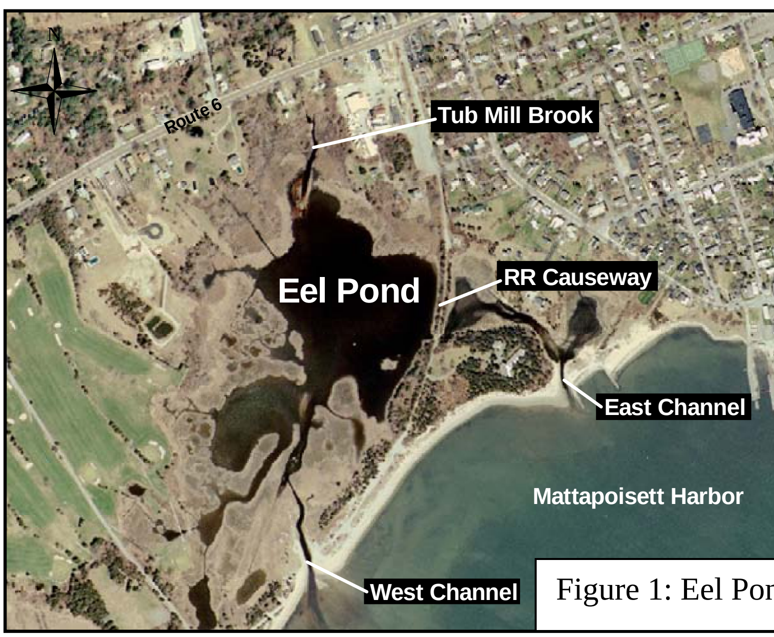


Figure 1: Eel Pond

A twelve inch (12") diameter sewage force (pressure) main traverses the barrier beach from the railroad embankment to where it crosses the West Channel, then is routed toward Fairhaven via an upland service road. The pipe material is asbestos cement, and it is generally unprotected except by earth cover; however, the portion of the pipe that crosses the West Channel is said to be encased in approximately six inches of concrete. Based on the Ground Penetrating Radar survey conducted by The Town of Mattapoisett, the cover over the pipe is approximately five to six feet over most of its alignment; however, at the point where it crosses the West Channel its soil cover is quite thin (approximately 18" of cover at the deepest point of the channel). The alignment of the West Channel has migrated further to the west since the pipe was first installed, and presently the center of the channel is believed to have migrated to the extreme west end of the concrete encasement. The age of the pipe, the lack of cover and migration of the West Channel all represent serious concerns with respect to the environmental safety of Mattapoisett Harbor and Buzzards Bay.

DESCRIPTION OF FIELD WORK

As part of its task order for the subject project, CLE performed detailed topographic and hydrographic surveys of Eel Pond and the surrounding areas including portions of the barrier beach, the East and West channels, and the nearby wetlands. Water depths were also obtained for the East and West channels as well as their connections to Mattapoisett Harbor. The Horizontal Datum used was NAD 83, and Vertical Datum utilized was NGVD, which is approximately 1.3 feet above local mean low water (MLW). Land portions of the surveys were performed using Real Time Kinematic (RTK) GPS survey systems, using a survey grid appropriate to the topography. RTK GPS has a moving or "On the Fly" (OTF) accuracy of one to two centimeters, and the system stores the survey points in a data collector.

In Eel Pond and the channels, where water depths were 12" or greater hydrographic surveys were performed using automated GPS/ electronic sounder survey systems. Water elevation levels were logged during the surveys from tide staffs, and the final hydrographic data was converted to project datum. Where water depths were too shallow for operation of the survey boat, additional RTK-GPS shots were taken to fill in the transitional zones. All of the above survey data was reduced and converted to a topographic map of the study area using AutoCAD Version 2000, computer aided drafting software. The maps were then used to prepare the hydrological studies that are also part of this report.

In addition to topographic surveys, CLE worked with the Town of Mattapoisett Water and Sewer Department to locate the existing Asbestos Cement Force Main that connects the sewer system of the Town of Mattapoisett to the Fairhaven Treatment Plant. This is a 12" pressure pipe that was installed in the late 1970s across the railroad embankment, then the barrier beach that fronts Eel Pond. Figure 2 below shows the approximate area of the pipe alignment that was surveyed using Ground Penetrating Radar (GPR).

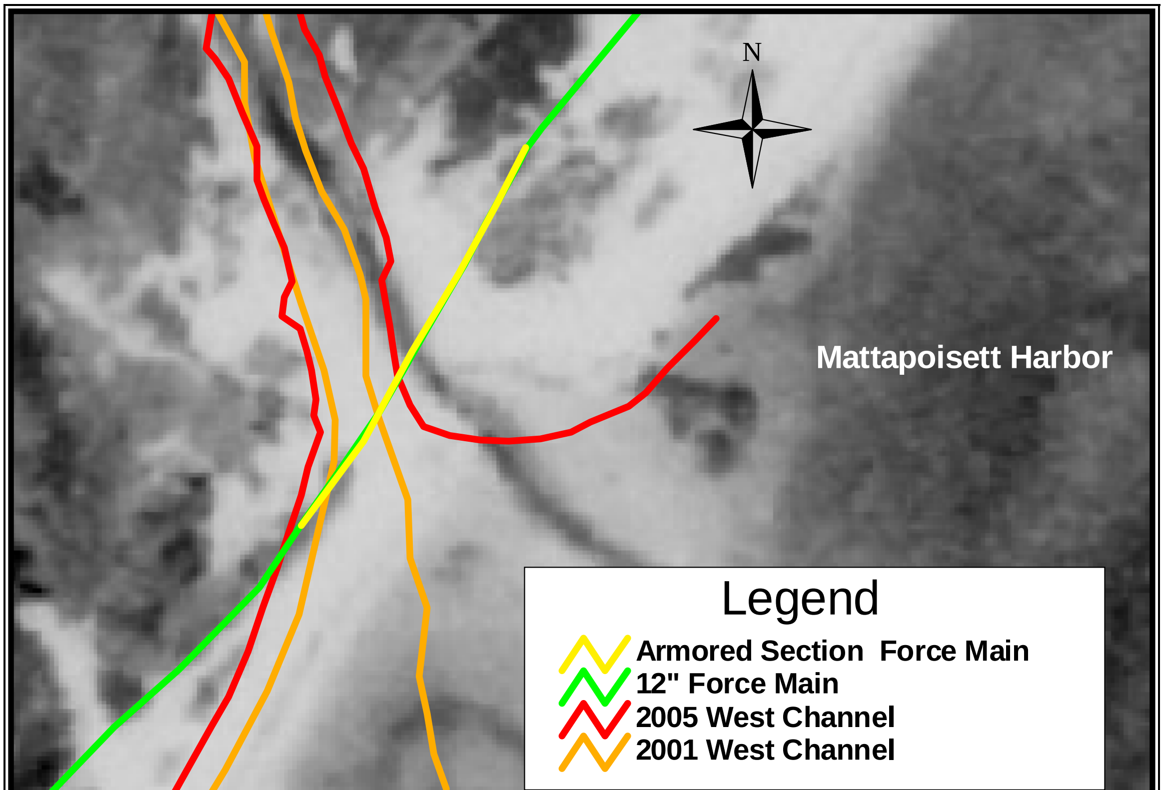


Figure 2: Pipe Alignment & West Channel

During the month of June 2005, the Town of Mattapoisett and New England Geophysical performed Ground Penetrating Radar (GPR) investigations of the pipe alignment shown in Figure 2. In conjunction with that investigation CLE provided survey services to locate the GPR soundings using RTK GPS, and referencing the location and elevation to NAD 83 and NGVD vertical datum. Using the information provided by New England Geophysical a plan and profile of the pipeline was mapped and added to the topographic plan prepared by CLE. In addition a profile of the pipeline was prepared and is included in Figure 3.

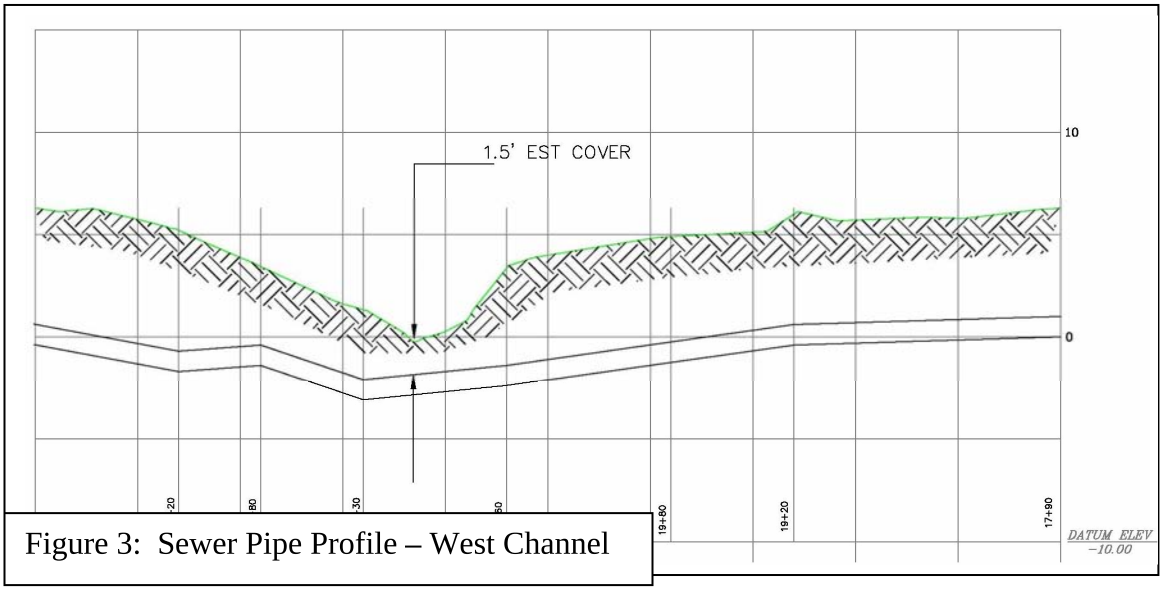


Figure 3: Sewer Pipe Profile – West Channel

The surveyed profile of the pipeline was overlaid on the topographic data obtained by CLE, as it is shown above. It clearly shows that at the point where the pipe crosses the channel, the deepest part of the West Channel is only 1.5 feet above the top of the pipe barrel, and therefore only 12 inches away from the top of the concrete encasement. This is a source of significant concern over two issues:

(1) The West Channel is known to be migrating to the West. If the channel continues its present migration where the pipe burial is much shallower, it may begin to expose the pipe. Further, while the exact location of the concrete encasement is not known, it is estimated that the present location of the West Channel is very near to the end of that encasement. Thus any further migration to the West could potentially expose bare unprotected pipe.

(2) It is known that the flows out the Western Channel have increased as the Eastern Channel literally continues to choke itself off due to the structural restrictions. This means that the Eastern channel will be come less viable with respect to its ability to carry storm flows, such as the hurricane overtopping. This would, in-turn route more water toward the Western Channel, and in the event of a severe storm surge, overtopping flows could gouge the existing Western Channel even wider and deeper. Exposure of the pipe under such severe flows could cause it to rupture and begin spilling most of the untreated sewage into the Harbor.

The Mattapoisett lift station cycles approximately every 20 minutes (thus there is little reserve storage), and a total of approximately 210,000 gallons of raw sewage is pumped through this pipeline every day to the Fairhaven treatment plant. <u>Any failure of this sewer line would be catastrophic, as it would cause 210,000 gallons of raw sewage to be discharged into Mattapoisett Harbor and Buzzards Bay every day until the line could be repaired. During the aftermath of a severe hurricane, this could amount to several days.</u>

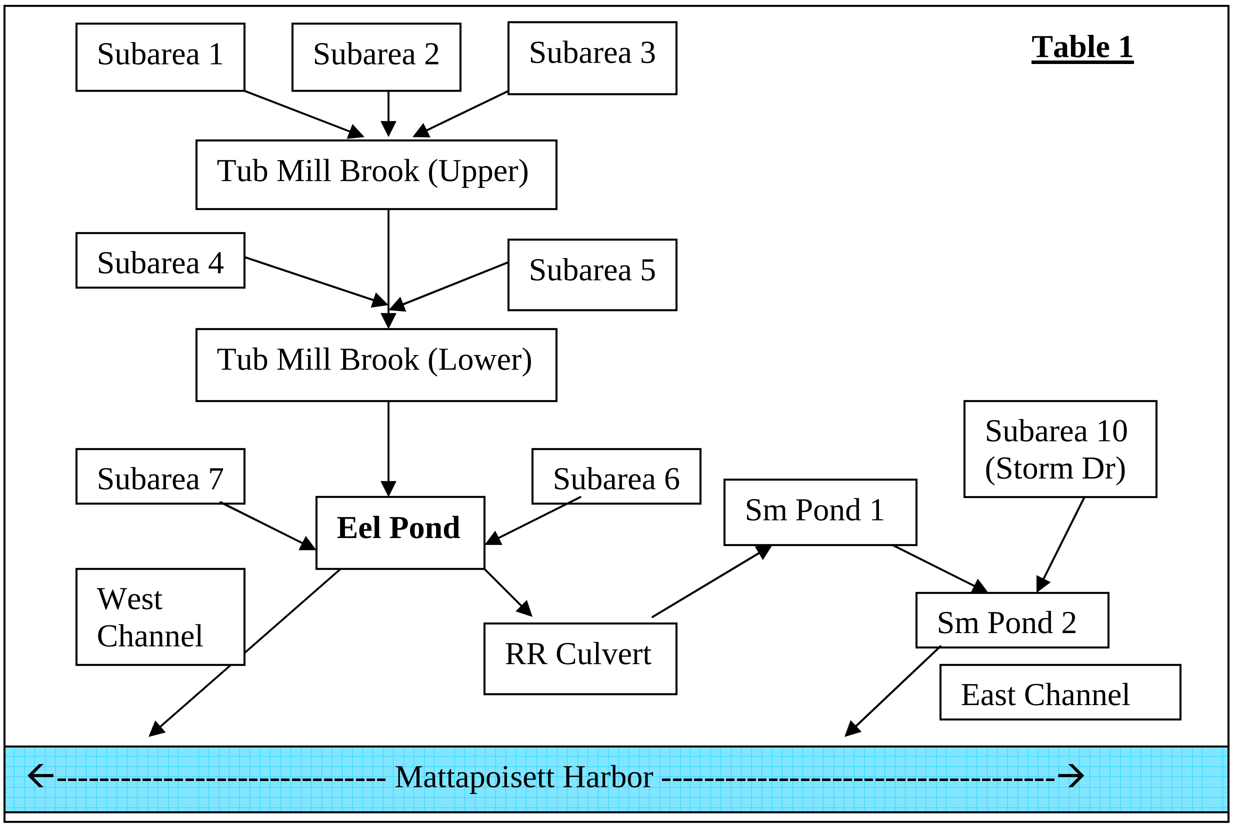
One of the present contingency plans to avert this catastrophe would be to truck the sewage to Fairhaven using tankers, this would require at least 4 to 6 five thousand (5,000) gallon tank trucks running around the clock, and even at this rate trucking (considering potential hurricane related road closures and power failures) may not be able to keep up with peak flows. CLE therefore recommends that serious consideration be given to improving the East Channel to a condition where it can contain known storm flows, and closing the West Channel. Further, CLE recommends the portion of the sewer line that lies within the potential "wash-out" zone of the West Channel, be replaced with more suitable material for submarine crossings.

HYDROLOGIC STUDIES

As part of its task order to study the flow issues of both tidal exchange (flushing), and storm water flows, CLE preformed a watershed flow analysis of Eel Pond and its surroundings. This included preparing a computer model of the Eel Pond watershed and its connections to Mattapoisett Harbor.

Model Configuration:
To fulfill the modeling task of this study, CLE utilized the Haestad Methods "Pond Pack" software, which utilizes baseline programs such as TR-20 and TR-55 to model flows of watersheds. The Model area was mapped from USGS charts and aerial photographs, followed up by field investigations of critical drainage culverts and junctions. The details of the various water sheds, catchments and routes are available upon request (Hydrologic printout) for the various conditions, however a generalized map is included in Table 1 below:

Table 1



Input to models included "No Rain", 2 year (3" rainfall), 10 year (4.5" rainfall) and 100 year (7.1" rainfall) storms. In addition smaller, more common storms, such as 1 and 2 inch rainfalls were checked to assess their relevant significance. Tidal conditions from Mattapoisett Harbor were added to the outfalls of the two channels, which included a typical mean tide of a 3.9 foot range, as well as a typical spring tide of 5.74 foot range. Also as a verification of adequacy of the railroad culvert, one storm surge tide that approximated a +11.0 NGVD surge was run with the 100 year storm condition to check flow velocity and scouring potential.

Model Results:
Eel Pond Flushing:

Several model conditions were run to compute the various conditions that Eel Pond is subjected to during mean and spring tides, as well as various rain events. As part of the study the following Mean Tidal Range hydrographs were run as shown in Table 2[1]:

	Harbor Max Tide El. NGVD	Eel Pond Max Tide El. NGVD	Eel Pond Max Flow (Peak cfs)	RR Culv Max Flow (Peak cfs)	RR Culv Flow Area (s. ft.)	RR Culv Flow Vel (fps)
Mean Tide						
Existing						
No Rain	2.85	2.47	171.00	36.00	12.35	2.91
Mean Tide						
Dredge Only (West Channel Open)						
No Rain	2.85	2.52	191.00	54.00	12.60	4.29
2 yr Storm	2.85	2.65	150.00	51.00	13.25	3.85
Mean Tide						
Dredge Only, Close West Channel						
No Rain	2.85	1.75	57.00	57.00	8.75	6.51
2 yr Storm	2.85	2.20	55.00	55.00	11.00	5.00
Mean Tide						
Dredge, Add 24' Culvert Close West Channel						
No Rain	2.85	2.71	247.00	247.00	59.62	4.14
2 yr Storm	2.85	2.75	220.00	220.00	60.50	3.64

Table 2: Mean Tide Range Analysis

The individual elevation curves for the mean tidal range and hydrographs are included as Exhibits 1 through 57. A summary of those models is presented below in Table 3.

Condition	**Tide Range** (ft. NGVD)	**Rainfall** (Storm)	**Eel Pond Flush** (% of Orig Volume)	**East Channel** (% of Total)	**West Channel** (% of Total)
Existing	Mean	Dry	64.84%	14.69%	85.31%
Dredge Only	Mean	Dry	83.94%	40.69%	59.31%
Dredge Only Close West Chan	Mean	Dry	39.79%	39.79%	0.00%
Dredge & 24' Culv- Close West Chan	Mean	Dry	120.51%	120.51%	0.00%
Condition	**Tide Range** (ft. NGVD)	**Rainfall** (Storm)	**Eel Pond Flush** (% Increase)	**East Channel** (% Increase)	**West Channel** (% Decrease)
Existing	Mean	Dry	0.00%	100.00%	0.00%
Dredge Only	Mean	Dry	29.46%	277.06%	30.48%
Dredge Only Close West Chan	Mean	Dry	-38.64%	270.90%	100.00%
Dredge & 24' Culv- Close West Chan	Mean	Dry	85.86%	820.54%	100.00%

Table 3: Summary of Eel Pond Mean Tide Hydrologic Conditions

[1] The model used a 26-foot size culvert to account for the proposed 24-foot culvert in addition to the cross-sectional area of the existing area.

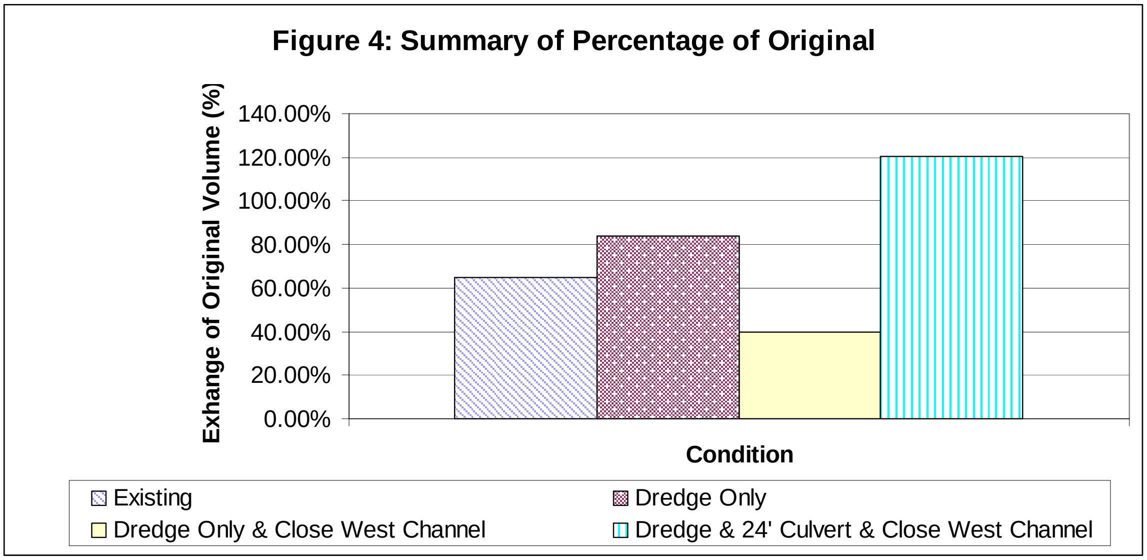


Figure 4: Summary of Percentage of Original
Exhange of Original Volume (%)
140.00%
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Condition
Existing
Dredge Only
Dredge Only & Close West Channel
Dredge & 24' Culvert & Close West Channel

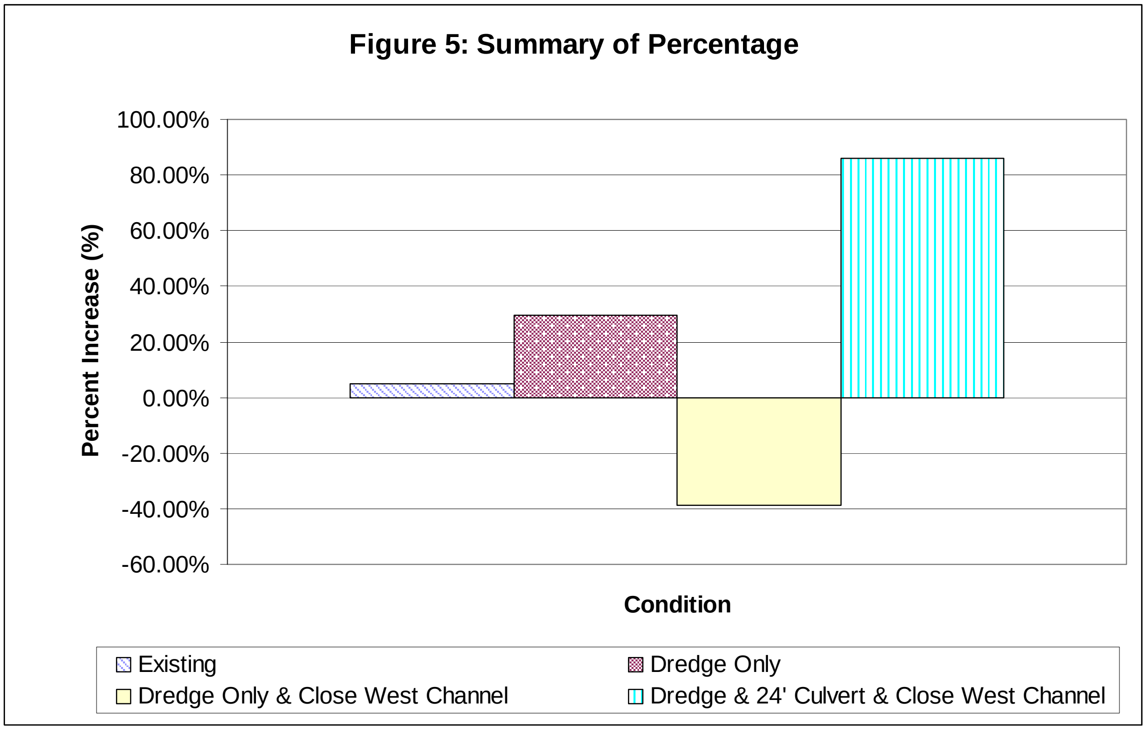


Figure 5: Summary of Percentage
Percent Increase (%)
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
-20.00%
-40.00%
-60.00%
Condition
Existing
Dredge Only
Dredge Only & Close West Channel
Dredge & 24' Culvert & Close West Channel

There are a number of important analyses that can be drawn from this summary chart; they are as follows:

1. With each daily tide there is a minor tide then a major tide. The minor tide is usually approximately 75% of the height of the major tide (see typical tidal curves used in this study – Exhibits 1 & 12 (Mean & Spring Dry Existing). All tides run in cycles, with each cycle having a maximum (spring) and minimum (neap) elevation difference between high and low; the "Mean Tide" represents a mathematical average of the high and low cycles over a given period or "epoch". Because the "Mean Tide" is the functional average condition, this will be the focus of the tidal flushing analysis, since it is known that while there will be higher and lower cycles, they should mathematically all average out to the mean condition. The high tidal volume of Eel Pond is approximately 820,000 cubic feet on the lower of the two daily tides, and approximately 1,600,000 cubic feet at the higher of the mean cycle. The daily total is approximately 2,420,000 cubic feet. In its present condition during a mean tide Eel Pond exchanges about 65% of its volume twice a day, leaving approximately 35% of the original volume. Between each tide the residual water mixes with the new incoming water for a period of tide. Typically, the water in the region most distant from the salt-water outlets mixes less than the region closer to the outlet(s). This leaves a condition of variable salinity from one part of the pond to the other that has shown itself in the variety of wetland grasses that are found around the perimeter.

2. It can also be noted that at the present time approximately 85% of the present tidal flow occurs through the West Channel, with the remainder of 15% flowing through the East Channel. This imbalance occurs for a number of reasons; however, two conditions are the primary cause: one is a restriction caused by the Rail Road Culvert, which measures only 5.0 feet wide by 5.5 high, with an invert elevation of +1.3 MLW (0.0 NGVD) (See Figure 6). The second restriction occurs all along the East Channel before it empties into Mattapoisett Harbor. The restriction is caused by the shallow, almost braided condition of the east channel (in general), which culminates near the harbor jetties where an area of large gravel that runs the width of the channel that is at approximately elevation +2.5 MLW (+1.2 NGVD), (See Figure 7).

Figure 6: Railroad culvert, East Channel

Figure 7: East Channel Entrance, 2.5’ above mean low water – restricting half of tide cycle

3. An example of the typical tidal restriction is shown in Exhibit 1, which represents the comparison of a Mean tidal curve for Mattapoisett Harbor versus that of the same tidal cycle in Eel Pond. Note that because the high tide in Eel Pond lags the harbor by over an hour, the high tide in Eel Pond is approximately 0.4 feet lower, because the flow restrictions do not allow the volume of water needed to fill Eel Pond to pass through the channels. Additionally note that the low tide in Eel Pond is about +2.3 MLW (+1.0 NGVD). This is because the restrictions at the entrance to the harbor act as a dam, and will not let all of the water out. As a result of this long-term restriction, Eel Pond has acted as a detention pond, and essentially trapped much of any silt-laden run-off from upland sources. Eventually the pond filled with mud to the approximate level of the tidal restrictions. Figure 9, shows the present profile of Eel Pond, and the East and West channels, Figure 8 shows the route used to take the profiles.

Figure 8: Approximate route of profiles

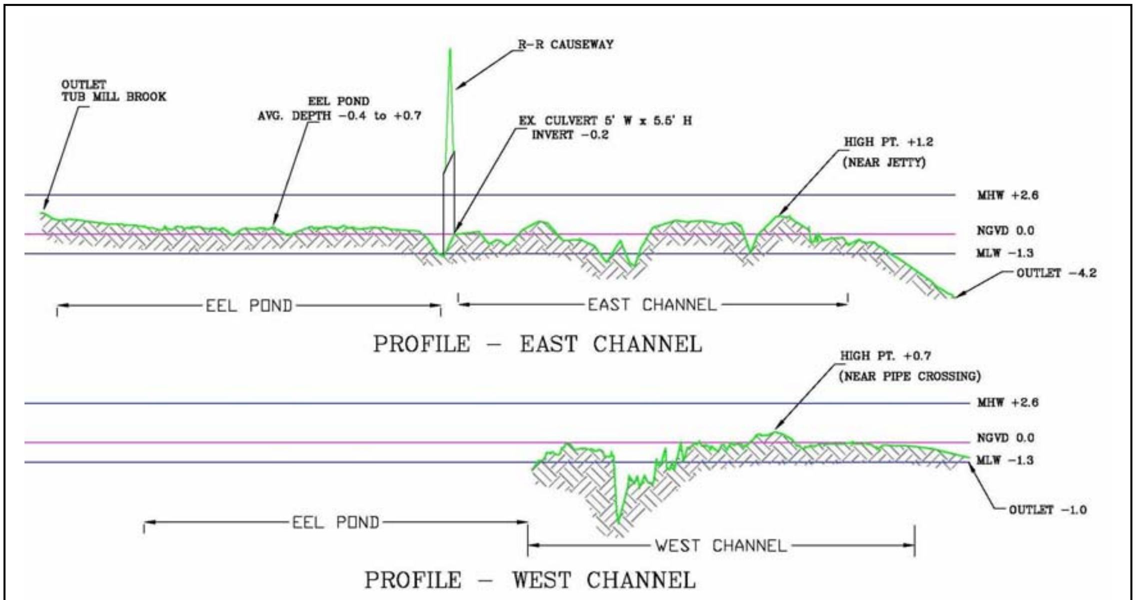


Figure 9: Profiles of Eel Pond, and East & West Channels

4. Another part of the study tasked to CLE was to determine what could be done to improve the water flow in and out of Eel Pond (flushing). Three methods of improving flow to and from Eel Pond were investigated; the first was to improve the East Channel by dredging. A number of channel sizes and widths were analyzed, the most effective channel was determined to be one approximately 30 feet wide at the base, with a depth of –2.7 MLW (-4.0 NGVD), the channel would have 3:1 sideslopes to meet the existing grade lines. Cross sections of the proposed channel are included in the Appendix section. Generally speaking the proposed channel fits within the “top of bank” lines that bound the existing channel; however, there are two places where the channel is narrow, and it is bounded by salt marsh on one or both sides. These locations occur adjacent to the existing jetty (See Figure 7) and between the small ponds designated as 1 & 2 in this report (See Figure 10).

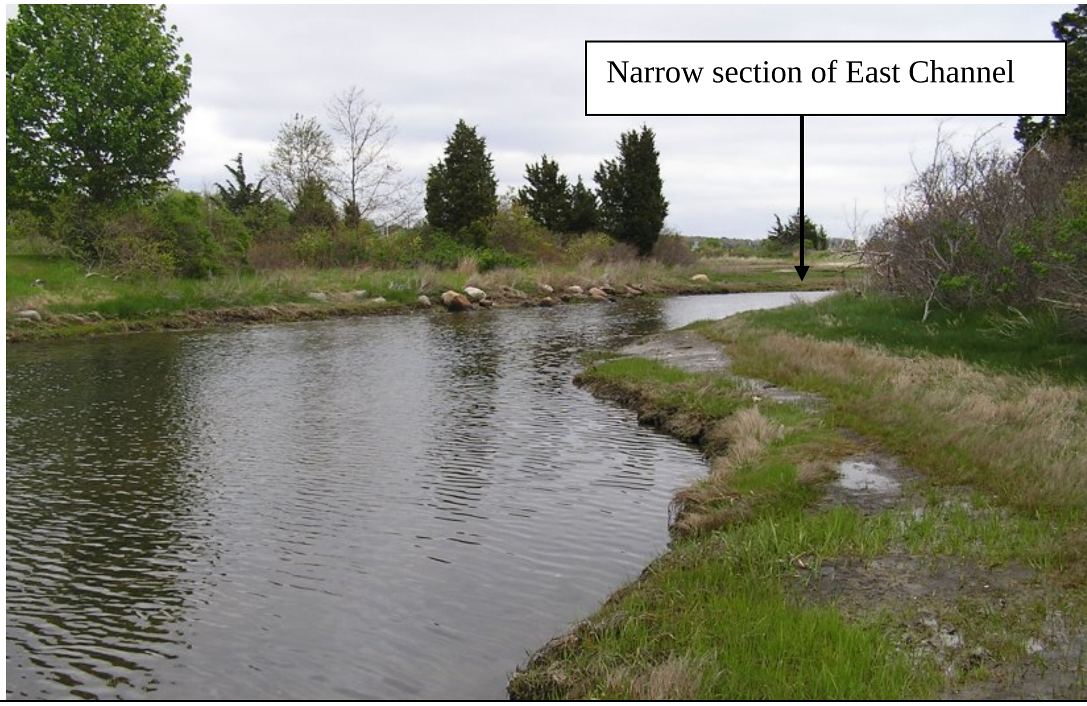


Figure 10: East Channel

5. In addition to dredging, CLE investigated increasing the size of the culvert under the railroad embankment. It is envisioned that the most viable way to increase the size of the culvert would be to select a location approximately 50 feet Northeast of the existing culvert and construct an open cut, sheeted excavation large enough to allow "open cut" installation of precast culverts. This would also require the temporary bypassing of existing utilities, the most difficult of which would be the bypassing of the existing asbestos cement sewage force main. The temporary sewer bypass could be accomplished by installing a HDPE bypass pipe around the excavation while the construction is taking place. Typically such tie-ins require two to three hours, and are performed late at night when sewer flows are low. In addition, the temporary access would need to be provided for the one homeowner that resides on Goodspeed Island. It is expected that the entire road closure would last about two weeks. A typical precast culvert (manufactured in Rehoboth, MA) is shown in Figure 11, spans of up to 30 feet are available.

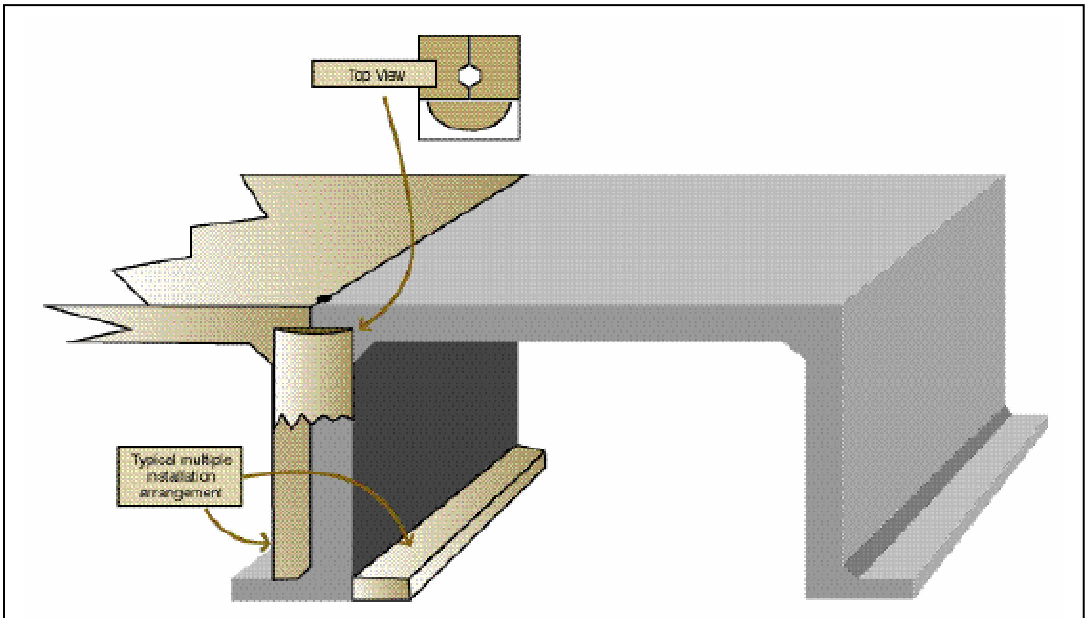


Figure 11: Typical precast culvert section ® Oldcastle Precast

6. Based on the preliminary dredging and culvert designs discussed above CLE did an analysis using on the following scenarios:
    a. Dredging only to a depth of –2.7 MLW by a 30 foot base width, and no change to the West Channel or Railroad culvert.
    b. Dredging only to a depth of –2.7 MLW by a 30 foot base width, closing the West Channel and no change to the Railroad culvert.
    c. Dredging only to a depth of –2.7 MLW by a 30 foot base width, closing the West Channel, and enlarging the railroad culvert to 20'.

    Based on a no-rainfall condition (matching the baseline condition of mean tide range, no rain & existing conditions), the following comparison can be drawn from Tables 2 & 3.
    a. If dredging only is performed, and the West channel is left open, the flows in Eel Pond increase from 65% to 84%, or an increase in flow volume of about 30%.
    b. If dredging only is performed, and the West channel is closed the flows in Eel Pond are reduced to 40%, or a reduction by about 60%.
    c. If dredging is performed, and a 24' culvert is installed, and the West channel is closed the flows in Eel Pond increase from 64% to 120%, or an increase of 186%.

    In addition to the above, an analysis was performed of the flow velocities that would occur in the new channel under both mean and spring tidal conditions, and how flow velocity would be affected by the closure of the west channel.

Hydrographs show that under a "dredging only" condition, that is dredging, without enlarging the culvert or closing the West Channel, the flow velocities under most conditions are quite low (well under 1.0 foot per second). This condition will make the channel prone to shoaling from fine-grained materials (silt). However, when the Culvert is enlarged, and the West channel is closed the new flow velocities range from 1.1 to 2.0 feet per second. This is enough velocity to keep the channel somewhat free of silt, however will allow the deposition of sand and gravel. As such the new channel area has a potential to become viable shellfish habitat.

This means that a phased program could be employed to accomplish long and short-term needs of Eel Pond as well as the sewer issue. If a Phase 1 program were put in place to dredge the East Channel, the flows in Eel Pond would be increased by 30%, and the flows in the West channel would be reduced by about 30%. However, Dredging only would not allow the West Channel to be closed, as this would reduce the Eel Pond flows to about 60% of the present levels, as well as present a serious storm surge issue.

A Phase 2 program could also be instituted when funding becomes available to install a new culvert under the railroad embankment. The flow calculations that were used to size the culvert indicate that the culvert should be about 24 feet wide by 8 feet high, with an invert depth of –1.7 feet MLW (-3.0 NGVD). It should be noted that while smaller culverts would function well in most rainfall storm events, a 24 foot culvert would allow for a reasonably secure closure of the West channel, and would give reasonable assurance that erosion would be contained and the West channel would remain closed in the event of a barrier beach overtopping by storm surge.

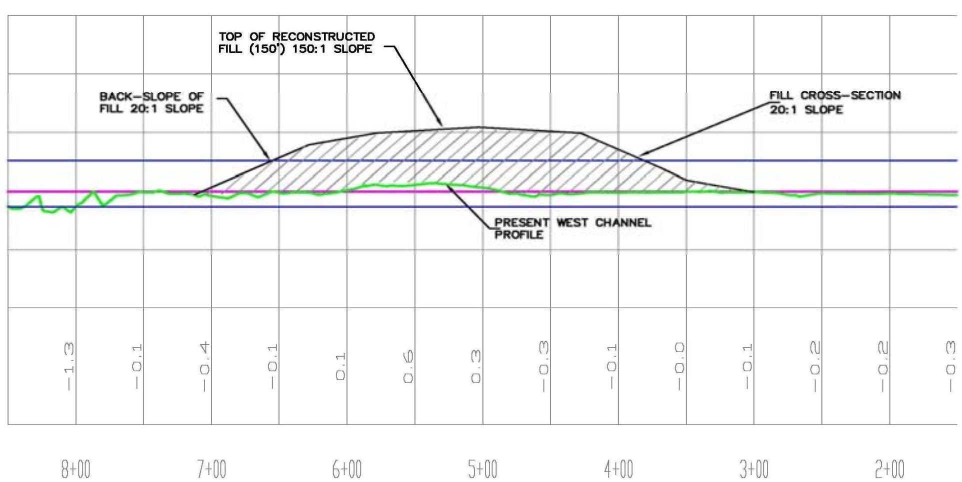


Figure 12: Profile of closing the West Channel

7. It should be noted that most of the discussion above is based on tidal fluctuations only; none of the data thus far has included the effects of rain. CLE also performed calculations for various storm events ranging from 1" to 7.1" (100 year). The purpose of the rainfall analysis was two-fold, (1) to calculate the estimated volume of rainfall (fresh water) that enters Eel Pond during a classic storm event. In addition, while some of the larger storm events are by definition, rare, they are useful in determining cumulative rainfall from numerous, shorter duration storms that are far more common in New England. Table 4 shows the volumes of fresh water generated by the various classic storm events:

TABLE 4: Rainfall runoff into Eel Pond

Condition	**Tide Range** (ft. NGVD)	**Rainfall** (Storm)	**Eel Pond Fresh W** (cf)	**Eel Pond Vol** % Fresh
Existing	N/A	Dry	0	0.00%
Existing	N/A	1"	7,200	0.44%
Existing	N/A	2"	281,000	17.35%
Existing	N/A	3"	832,380	49.46%
Existing	N/A	4.5"	2,477,177	147.20%

Rainfall events shown in this report are as follows: 1 & 2 inch are 1 year or more frequent storms, 3" is a 2 year storm (typically used for storm drain design), and 4.5" is a 10 year storm event, which could also emulate the effects of a series of smaller storms spaced over several days. It can be seen from the table above, that a 1 inch storm by itself does not represent a significant issue, as most of the rainfall is absorbed by the environment before it reaches Eel Pond. However, larger storms, (which could also be 1" storms) could produce more significant flows if the ground is already saturated from prior storms. The baseline condition of Tub Mill Brook was also measured during a relatively dry period and was found to be 2.5 cfs, which while small, was factored into the freshwater intrusion volumes. It can be ascertained from these analyses that prolonged periods of sustained rainfall will produce significant volumes of fresh water intrusion into Eel Pond, which in turn dilutes the salinity of the pond, and takes a considerable time to flush out under the present conditions.

CALCULATIONS FOR SIZING RAILROAD CULVERT:

After much study of the existing culvert, the historic nature of the stone bridge and the surroundings, it was determined that the most cost effective methodology for increasing the size of the existing railroad culvert was to build an additional culvert elsewhere in the present embankment. Because any culvert is subjected to both normal and extreme conditions, its design must be planned around both; as such CLE performed a number of hydrograph studies for various sized culverts that took into account both routine and extreme events. Consideration was given to several rainfall storm events, and applied to culvert sizes ranging from 10' wide x 8' high to 24' wide x 8' high. Culvert widths were calculated in 4 to 6-foot size increments. Storm events considered were 4.5" (10 year), 7.1" (100 year), and 100-year rainfall combined with storm surge over topping.

<u>Simulated Storm Surge Model Methodology:</u>
Unfortunately, storm surge overtopping is almost impossible to model with present day commercially available software. As such, calculations for such a condition were based on an approximation of the conditions that occurred during Hurricane Bob, wherein the storm surge reached an approximate elevation of +12.3 MLW (+11.0 NGVD). Typical storm surges in Buzzards Bay, while severe – last only a short time, normally an hour or less (see Figure 13 below). However, for purposes of modeling, once tidal inundation were to exceed the height of the barrier beach, the model's routing conditions would change dramatically, and that flow would occur freely in and out of Eel Pond over the beach crest. To simulate the beach overtopping the West Channel "dam" was widened and held at elevation 5.5 so that an approximation of the time and flow velocity could be attained. Compensation also needed to be given for the condition of a +12.3 MLW surge and the consequential inundation of a considerable amount of land. This is because once the surge begins to recede; it would take additional time for the inundation to flow back to the bay. To allow for this factor, the model's period of inundation was extended by one hour. Once the surge again fell to an elevation below the beach crest (assuming erosion has not been too severe) routing would return to the original modeled condition, and the program would then resume giving viable results.

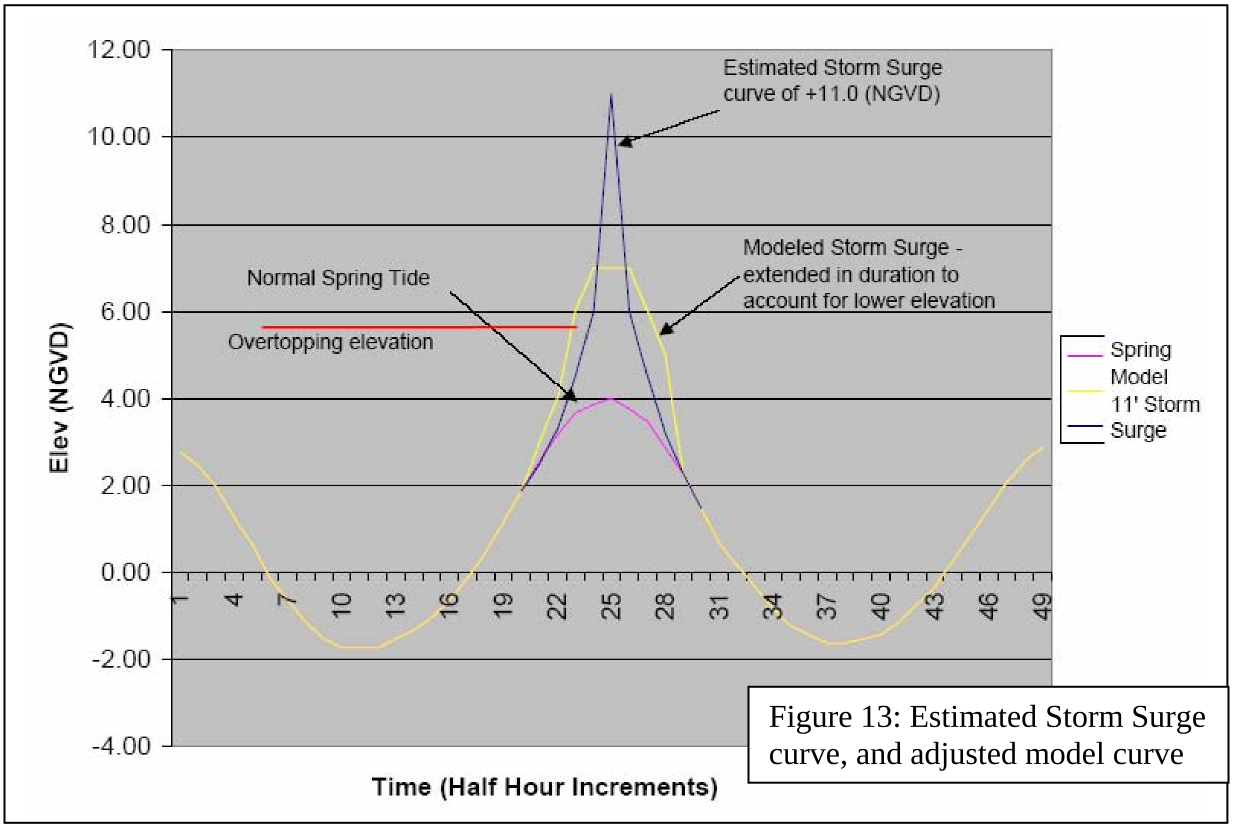


Figure 13: Estimated Storm Surge curve, and adjusted model curve

Table 5, below shows the storm conditions considered in the culvert design, and the flow conditions that occur under each condition. The factor considered most important was the flow velocity through the culvert, as excessive velocity would cause scouring of the headwalls, leading to possible breach of the railroad embankment. Failure of the railroad embankment could in turn rupture the embedded sewer line, and could again create a condition not unlike a break of the sewer line at the Western Channel. The design criteria for the culvert was based on maintaining the present day flow velocities for all rainfall events, and containing the extreme condition of a storm surge overtopping to a culvert velocity of between 5 and 7.5 feet per second for the shortest a time as possible.[2]

Size New Culvert for Closing West Channel

	Harbor Max Tide El. NGVD	Eel Pond Max Tide El. NGVD	Eel Pond Max Flow (Peak cfs)	RR Culv Max Flow (Peak cfs)	RR Culv Flow Area (s. ft.)	RR Culv Flow Vel (fps)
Spring Tide						
Existing						
No Rain	4.00	3.51	220.00	50.00	17.55	2.85
2 yr Storm	4.00	3.61	244.00	57.00	18.05	3.16
10 yr Storm	4.00	3.91	306.00	61.00	19.55	3.12
100 yr Storm	4.00	4.40	420.00	90.00	22.00	4.09
Spring Tide						
Dredge - Add 10' x 8' Culvert (inv. -3.0 NGVD)						
No Rain	4.00	3.53	300.00	300.00	65.30	4.59
10 yr Storm	4.00	3.94	354.00	354.00	69.40	5.10
100 yr Storm	4.00	4.43	428.00	428.00	74.30	5.76
Spring Tide						
Dredge - Add 16' x 8' Culvert (inv. -3.0 NGVD)						
No Rain	4.00	3.67	364.00	364.00	106.72	3.41
10 yr Storm	4.00	4.01	461.00	461.00	112.16	4.11
100 yr Storm	4.00	4.43	560.00	560.00	118.88	4.71
Spring Tide						
Dredge - Add 22' x 8' Culvert (inv. -3.0 NGVD)						
No Rain	4.00	3.72	453.00	453.00	147.84	3.06
10 yr Storm	4.00	4.03	561.00	561.00	154.66	3.63
100 yr Storm	4.00	4.42	630.00	630.00	163.24	3.86
Storm Surge In	7.00	5.00	1460.00	1460.00	176.00	8.30
Storm Surge Out	7.00	5.00	1300.00	1300.00	176.00	7.39
Spring Tide						
Dredge - Add 26' x 8' Culvert (inv. -3.0 NGVD)						
No Rain	4.00	3.75	427.00	427.00	175.50	2.43
10 yr Storm	4.00	4.03	531.00	531.00	182.78	2.91
100 yr Storm	4.00	4.41	688.00	688.00	192.66	3.57
Storm Surge In	7.00	5.00	1568.00	1568.00	208.00	7.54
Storm Surge Out	7.00	5.00	1450.00	1450.00	208.00	6.97

Table 5: New Culvert flow calculation summary

[2] The model used a 26-foot size culvert to account for the proposed 24-foot culvert in addition to the cross-sectional area of the existing culvert.

Table 5 is summarized in Figure 14, which provides an overview of the flow velocity conditions that would occur through a new culvert for a number of storm events with the West Channel blocked. The existing conditions are also provided for comparison.

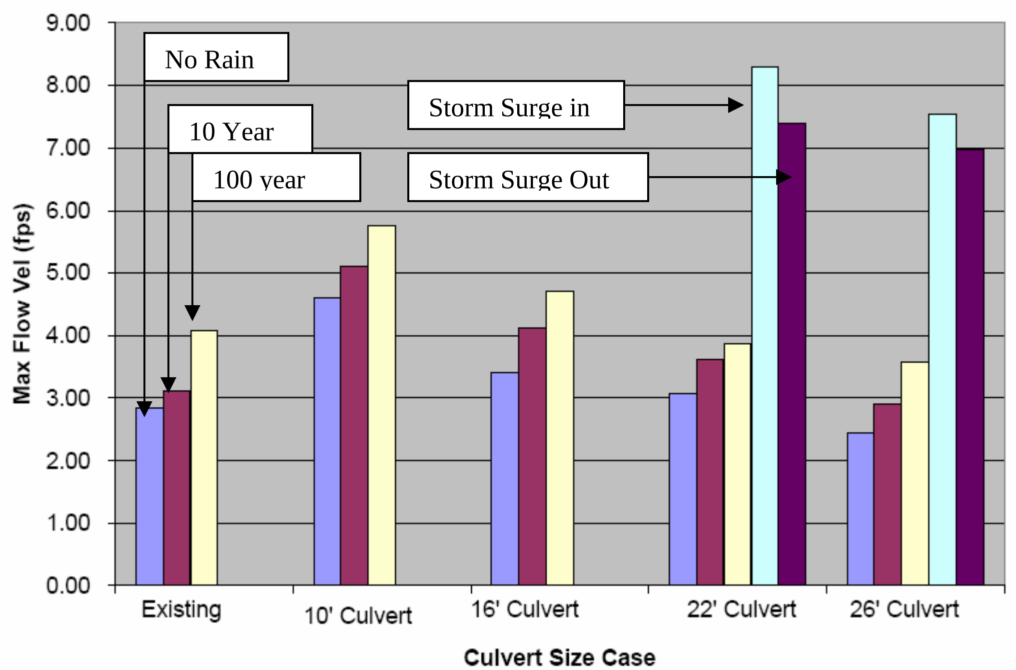


Figure 14: Summary of flow velocity conditions for several culvert sizes

Normal peak flow velocities through the existing railroad culvert with the West Channel open, range from between 2.8 and 3.2 feet per second, occasionally the flow could exceed 4.0 feet per second. This seems to have been a stable condition at the existing culvert for many years. Even so there is still evidence of scour at the openings, which leads one to the opinion that it is not prudent to change the culvert condition to exceed these flow values. It can be noted from the chart and the preceding analysis that dredging and closing the West Channel would require the enlargement of the existing railroad culvert. A number of hydrographs were computed using culverts that ranged in size from 10'(W) by 8' (H), to 26' (W) by 8' (H); each culvert was also checked for performance during a classic 10 and 100-year storm rainfall event. The tidal elevation and hydrograph charts are included as Exhibits 30 to 57. It can be ascertained by viewing these charts that a 10' x 8' culvert is too small for most rainfall storm events, as flow velocities and durations would increase considerably, also a 16' x 8' culvert shows only a slight increase. Under all rainfall "only" conditions the 20' x 8' and the 24' x 8' culverts showed reduced flow velocities, and considerably improved flushing of Eel Pond.

The deciding and most unpredictable condition of storm surge however rules out the 20' x 8' culvert, as flow velocities during a storm surge event could exceed 8 feet per second. To further demonstrate the severity of high flow velocities Figure 15 shows the water elevation difference from one side of a 26 foot culvert to the other, as well as the water level difference from the first small pond to the second. (The model used a 26-foot size culvert to account for the proposed 24-foot culvert in addition to the cross-sectional area of the existing culvert).

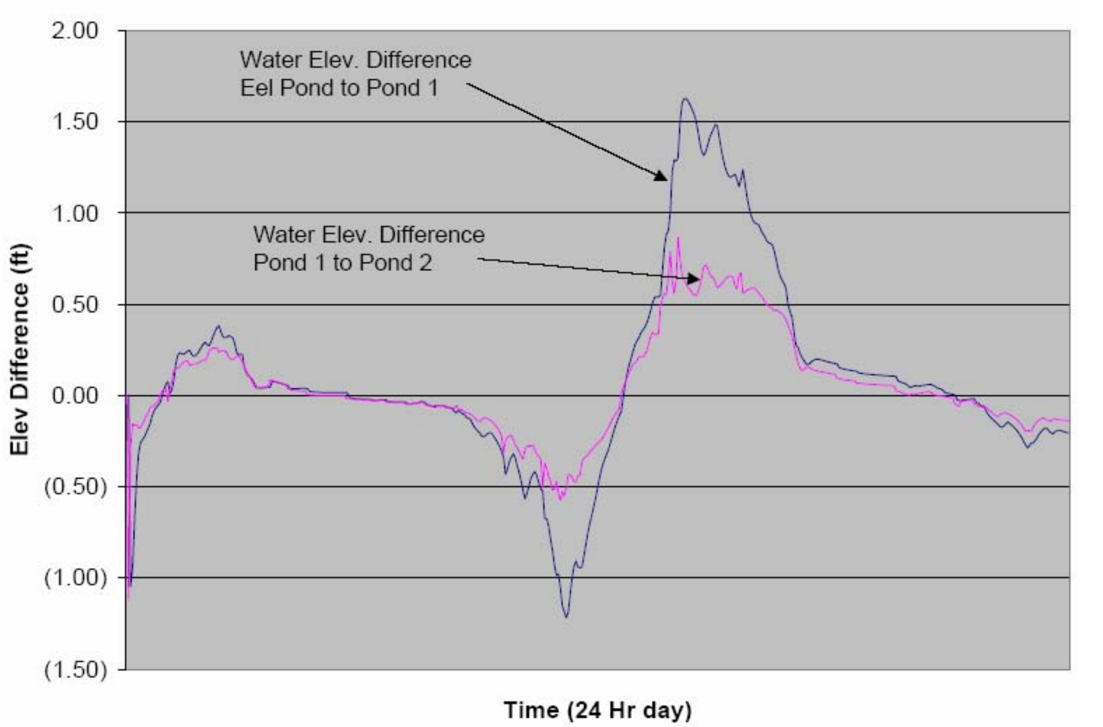


Figure 15: Water elevation difference Eel Pond to Pond 1 & Pond 1 to Pond 2, based on 26' culvert, 100 year rain event and storm surge

During the peak incoming surge the water elevation from one side of the culvert to the other will exceed one foot for a short time (this is not considered serious), however during the outflow of the storm surge the flows would reach such velocity that the water elevation from one side of the culvert to the other would exceed one foot for over 2 hours, and would exceed 18" for about 30 minutes. This is sufficient time for serious erosion to occur, thus it clearly indicates that the wing walls and invert of the culvert would need to be heavily armored. The lower line on the chart also shows considerable elevation difference between Pond 1 and Pond 2, indicating considerable flow velocities occurring in the channel between the two water bodies. This clearly indicates that the size of the planned dredged channel of 30' base width and –2.7 MLW (-4.0 NGVD), is also a minimal channel design, since a smaller channel would only cause more flow restriction during a storm surge event, and thus more potential for erosion damage.

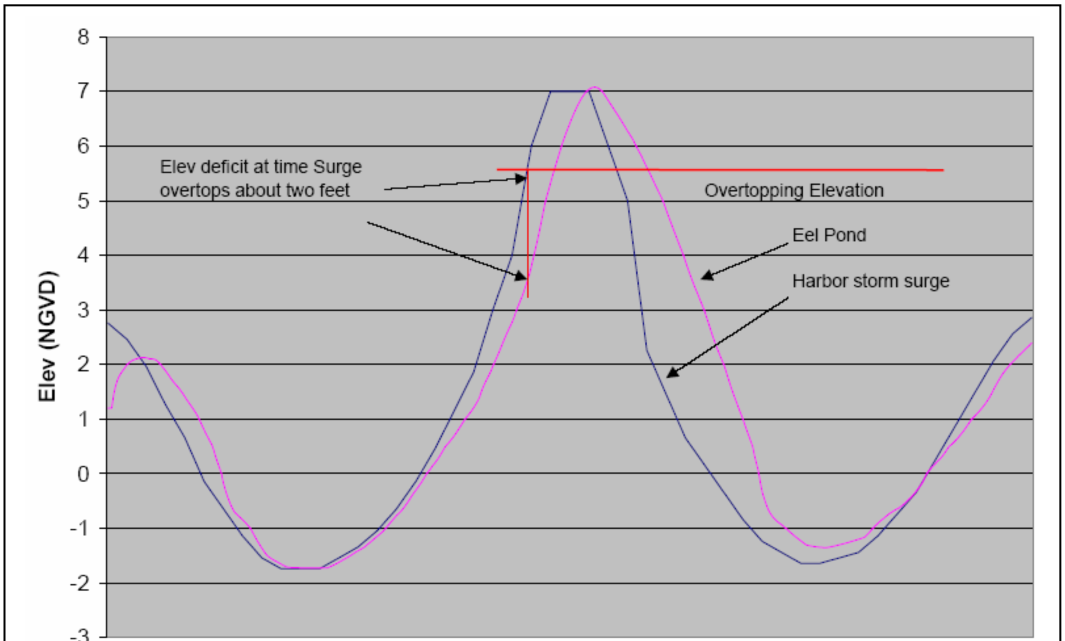


Figure 16: Model simulated storm surge condition

Also of concern is the erosion that would take place at the barrier beach and blocked West Channel as the overtopping occurred. Figure 16, which shows the water elevations in Eel Pond versus the Harbor elevations as the storm surge approaches. Note that at the point of overtopping, the water level in Eel Pond is about 2.5 feet lower than the Harbor. This condition while it will start as a trickle, will quickly increase in size, volume and velocity until the water level in Eel Pond matches that of the storm surge elevation. This will cause a condition that will quickly cause erosion to the West Channel plug and the beach crest, how much erosion takes place will depend on the amount of time that the water levels remain different between Eel Pond and the surge elevation. Historically, however the more severe erosion takes place as the surge recedes, as the erosion from the incoming surge usually creates gullies that become focus point of residual outflows. Again, the severity of erosion is proportional to the time that the water elevations remain different. A larger railroad culvert will reduce the time required for both transitions to take place, and thus will reduce the severity of the erosion.

The conclusion of the culvert design study is that the minimum culvert size to be considered would be a 24’ x 8’ culvert, and that the culvert wings and inverts should be protected from scour. The rational for a conservative design is substantiated by the need to protect the sewer main that is buried within the embankment during a storm surge event.

COST ESTIMATES

CLE prepared the following preliminary cost estimate for the culvert replacement, dredging of the East Channel and closure of the West Channel. This estimate is preliminary and subject to change as the final design is completed. No allowances have been made for alternate disposal sites for the dredge material as it is assumed that it will be used in the closure of the West Channel.

Town of Mattapoisett
Eel Pond – Improvements Preliminary Cost Estimate

Culvert Work		
Mobilization/Demobilization	$	15,000
Temporary shoring	$	40,000
Excavation	$	25,000
Fill	$	25,000
Utility supports	$	50,000
Precast Structure	$	50,000
Placement	$	30,000
Subtotal:	*$*	*235,000*
OH/profit	$	47,000
Subtotal:	*$*	*282,000*
Dredging of East Channel		
Mobilization/Demobilization	$	75,000
Dredging (9,700 cy @ $12/cy)	$	116,400
Beach nourishment/grading	$	50,000
Backhoe work	$	15,000
Subtotal:	*$*	*256,400*
Closure of West Channel		
Placement and grading:	$	10,000
Subtotal:	*$*	*10,000*
Estimated Total Project Cost:	***$***	***548,400***

IDENTIFICATION OF PERMITS REQUIRED

CLE has identified the following required permit applications for the proposed project based on the following project components:

- East Channel Dredging = approximately 9,700 cy
- Beach Nourishment = 132,025 sf
- Fill in West Channel & Beach Nourishment = approximately 9,700 cy
- New Culvert

Due to the uniqueness of this site and restoration benefits of the proposed project, the application and supporting documentation would describe the project as a proactive restoration project. The permits identified below are based on the agencies' review of the project as such a project.

Local:

- Notice of Intent filing to the Mattapoisett Conservation Commission and Department of Environmental Protection Southeast Regional Office

State:

- Environmental Notification Form to the Massachusetts Executive Office of Environmental Affairs
- Water Quality Certificate Application for Major Project Certification BRP WW 08 based on a dredge volume greater than 5,000 cy
- Division of Waterways Chapter 91 Permit BRP WW 01 application
- Division of Waterways Chapter 91 License BRP WW 01 application for licensing any proposed new structures located below mean high water (new culvert).
- Consistency Statement submitted to the Massachusetts Office of Coastal Zone Management

Federal:

- U.S. Army Corps of Engineers Programmatic General Permit Category II. Application includes submittal to the Massachusetts Historical Commission, the Narragansett Tribal Historic Preservation Officer and the Wampanoag Tribal Historic Preservation Officer

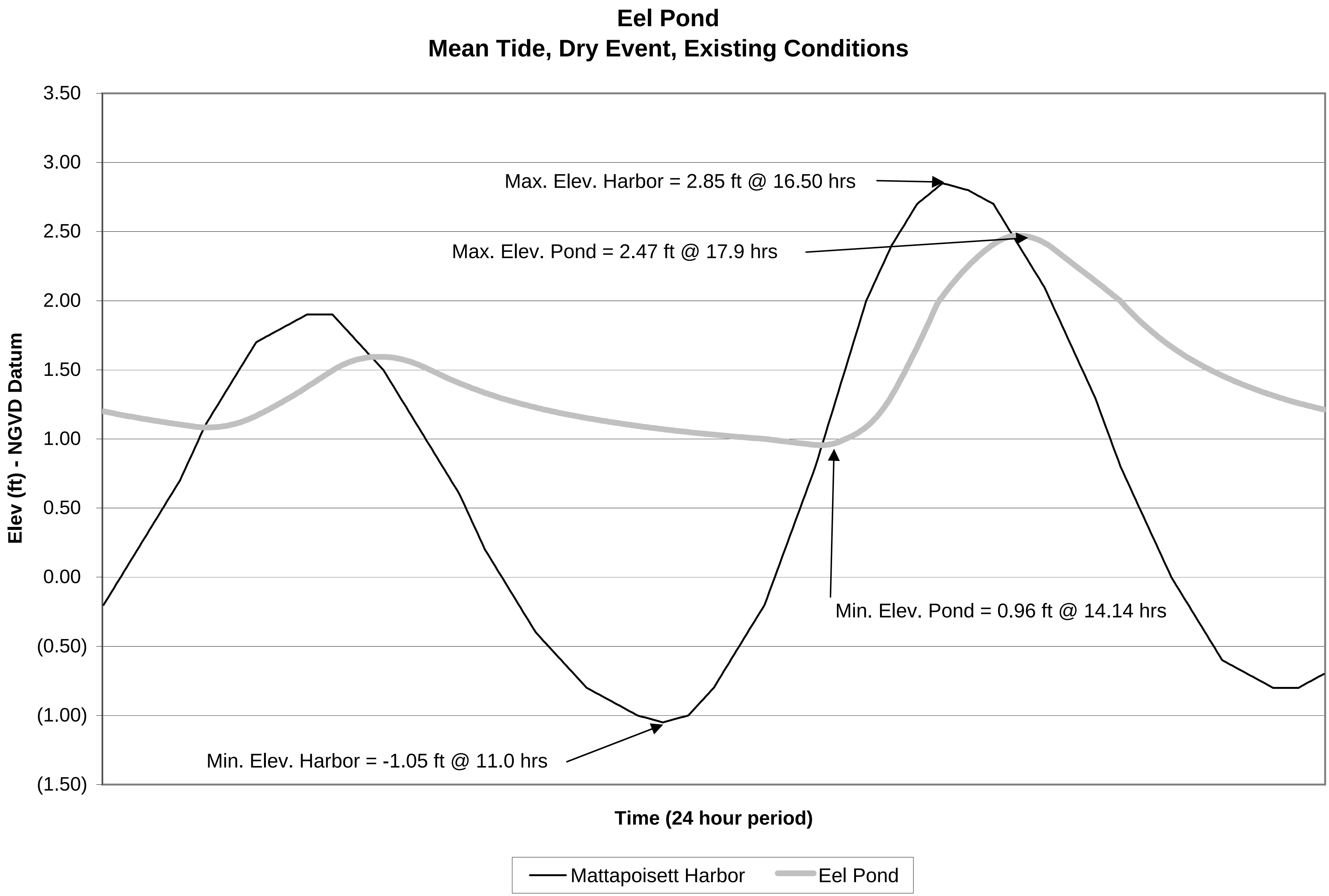

Eel Pond
Mean Tide, Dry Event, Existing Conditions
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
(0.50)
(1.00)
(1.50)
Elev (ft) - NGVD Datum
Max. Elev. Harbor = 2.85 ft @ 16.50 hrs
Max. Elev. Pond = 2.47 ft @ 17.9 hrs
Min. Elev. Pond = 0.96 ft @ 14.14 hrs
Min. Elev. Harbor = -1.05 ft @ 11.0 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 1

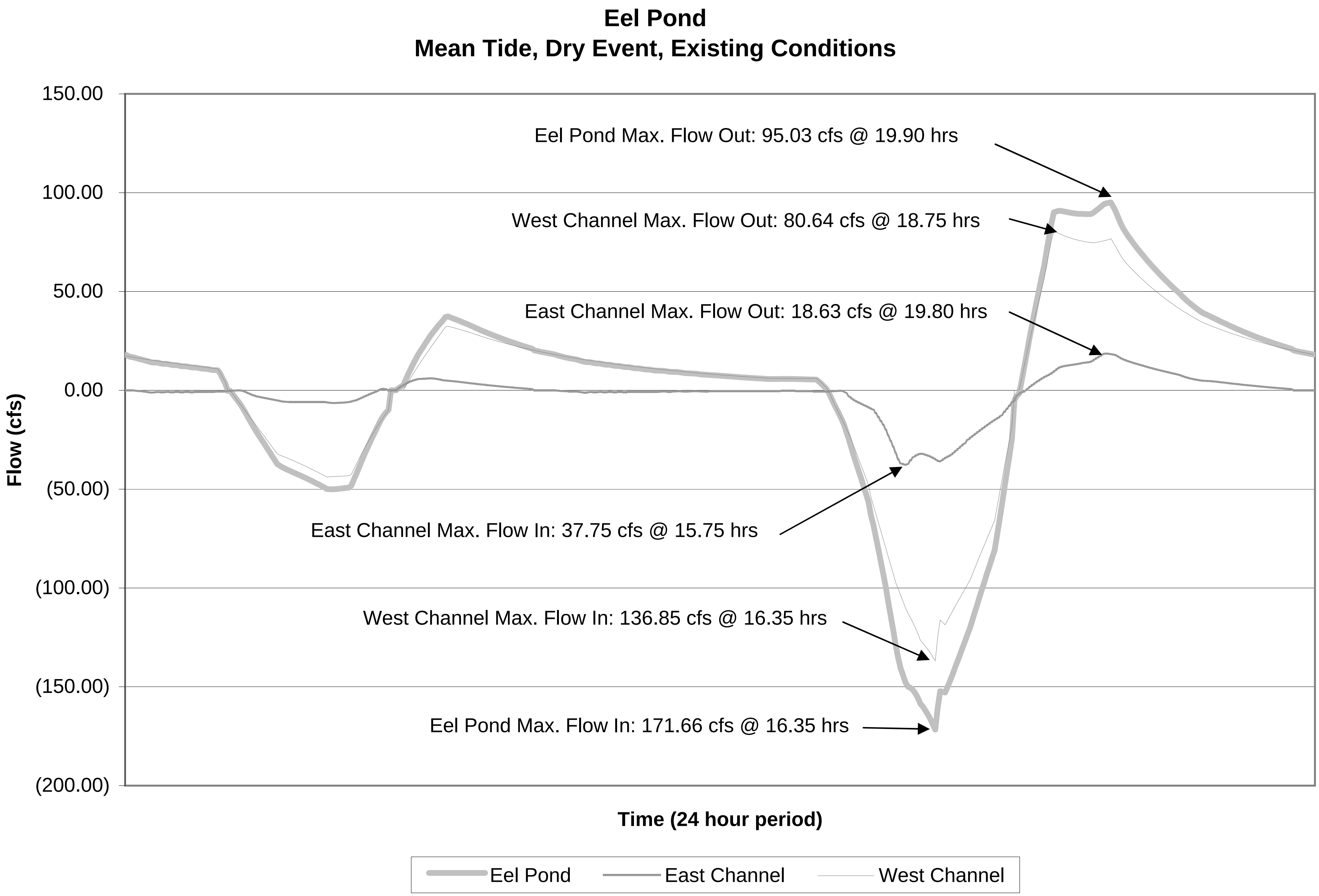

Eel Pond
Mean Tide, Dry Event, Existing Conditions
150.00
100.00
50.00
0.00
(50.00)
(100.00)
(150.00)
(200.00)
Flow (cfs)
Time (24 hour period)
Eel Pond Max. Flow Out: 95.03 cfs @ 19.90 hrs
West Channel Max. Flow Out: 80.64 cfs @ 18.75 hrs
East Channel Max. Flow Out: 18.63 cfs @ 19.80 hrs
East Channel Max. Flow In: 37.75 cfs @ 15.75 hrs
West Channel Max. Flow In: 136.85 cfs @ 16.35 hrs
Eel Pond Max. Flow In: 171.66 cfs @ 16.35 hrs
Eel Pond
East Channel
West Channel

Exhibit 2

Eel Pond
Mean Tide, 2-Year Storm Event, Existing Conditions

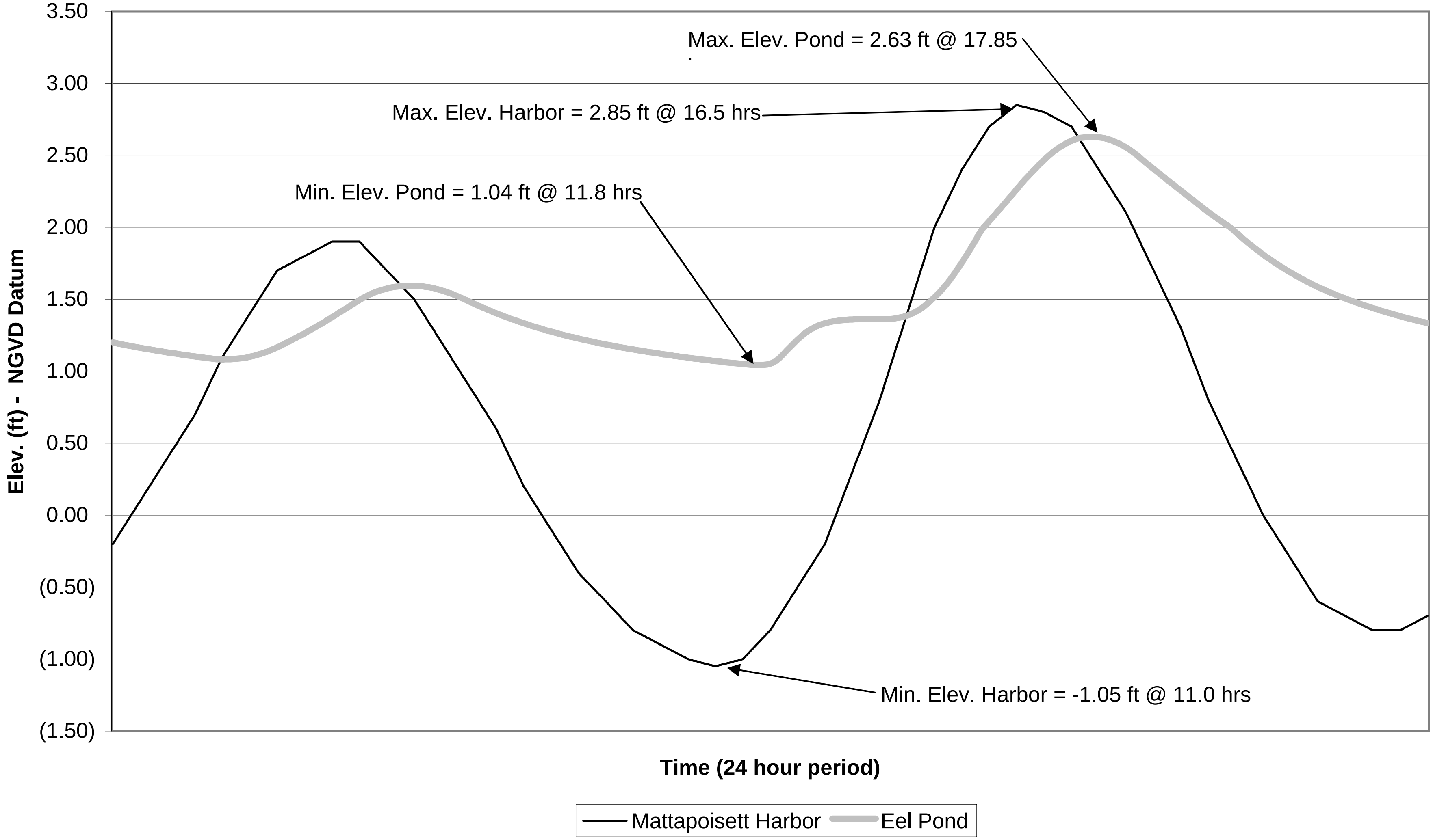


Exhibit 3

Eel Pond
Mean Tide, 2-Year Storm Event, Existing Conditions

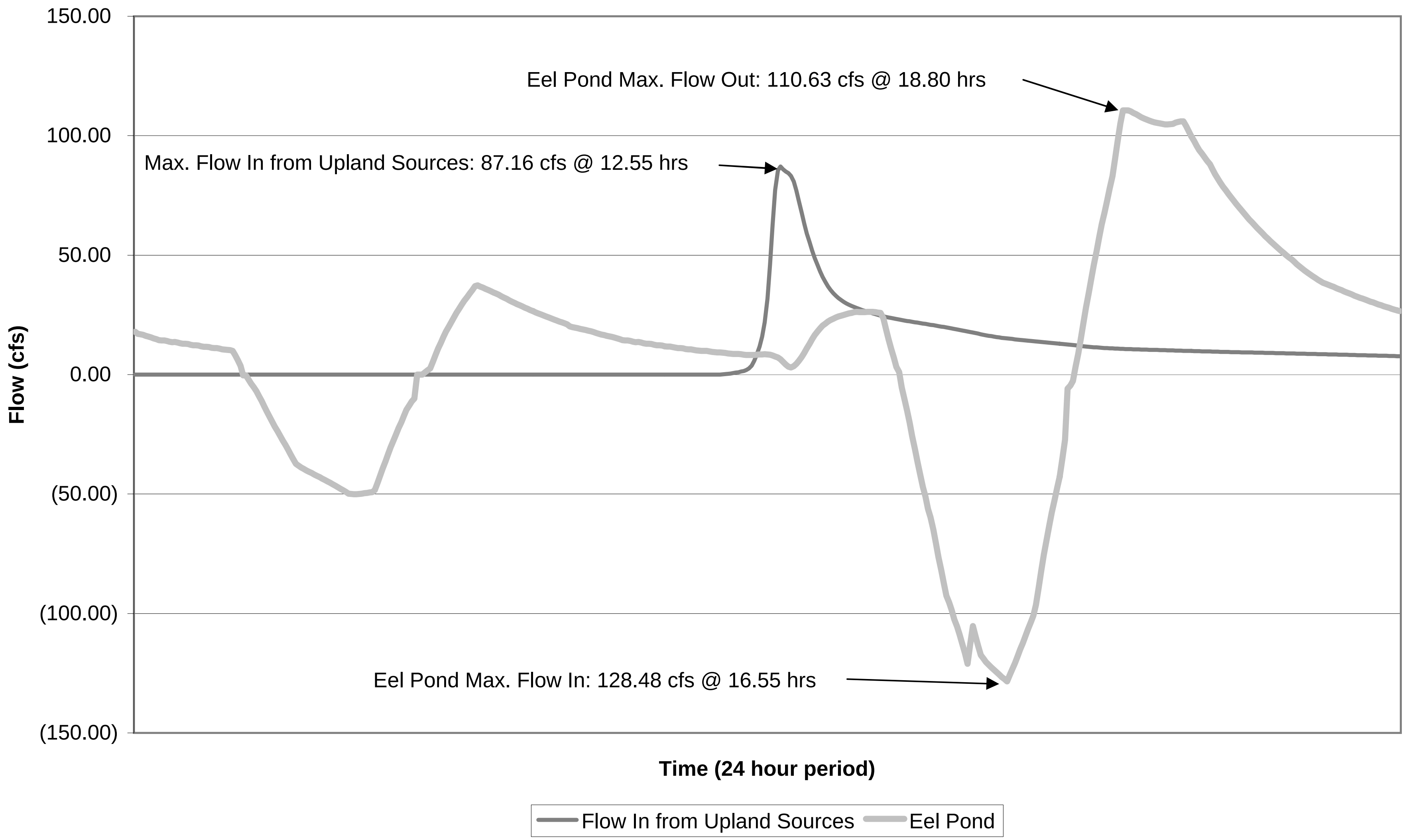


Exhibit 4

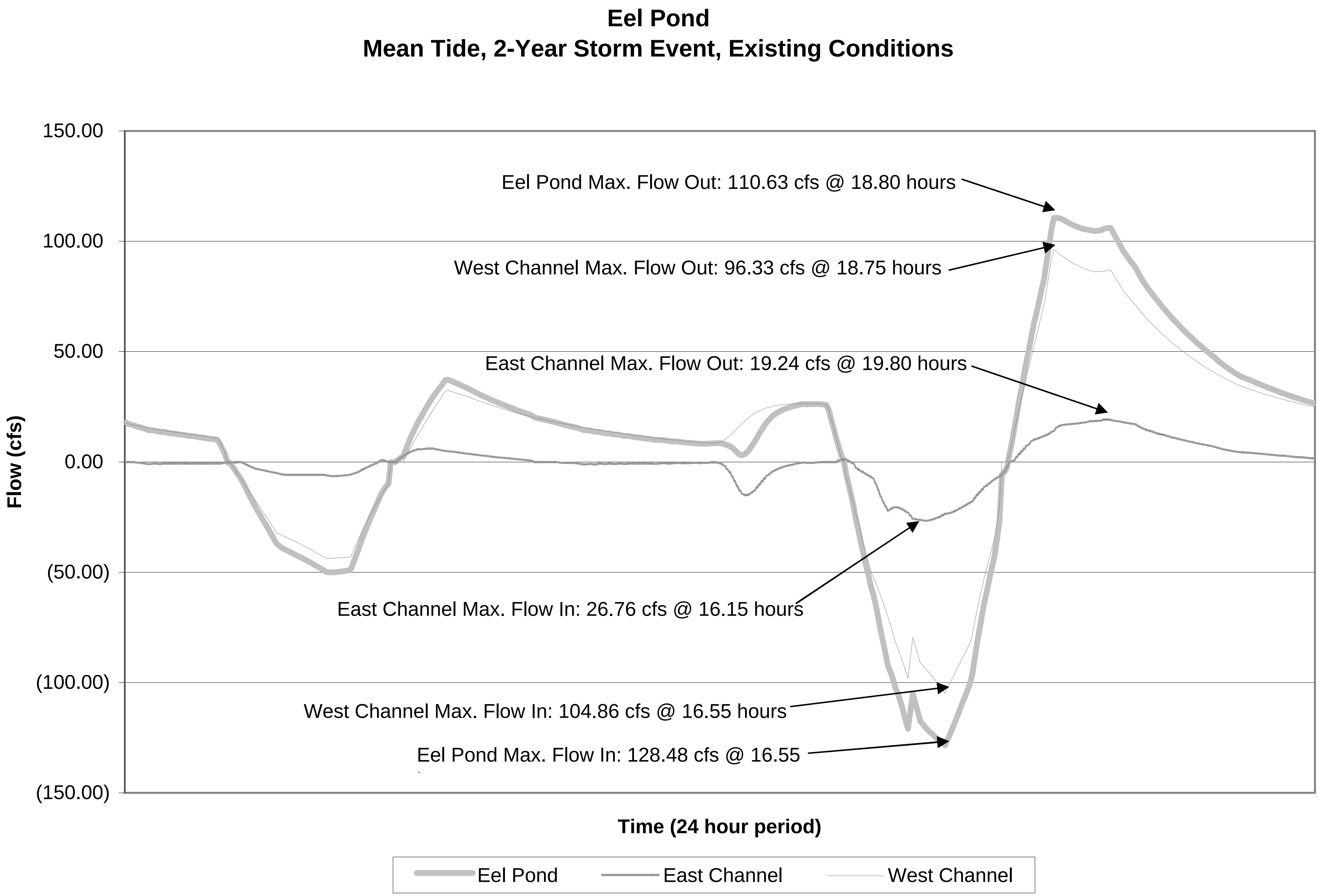

Eel Pond
Mean Tide, 2-Year Storm Event, Existing Conditions
150.00
100.00
50.00
0.00
(50.00)
(100.00)
(150.00)
Flow (cfs)
Eel Pond Max. Flow Out: 110.63 cfs @ 18.80 hours
West Channel Max. Flow Out: 96.33 cfs @ 18.75 hours
East Channel Max. Flow Out: 19.24 cfs @ 19.80 hours
East Channel Max. Flow In: 26.76 cfs @ 16.15 hours
West Channel Max. Flow In: 104.86 cfs @ 16.55 hours
Eel Pond Max. Flow In: 128.48 cfs @ 16.55
Time (24 hour period)
Eel Pond
East Channel
West Channel

Exhibit 5

Eel Pond
Mean Tide, 10-Year Storm Event, Existing Conditions

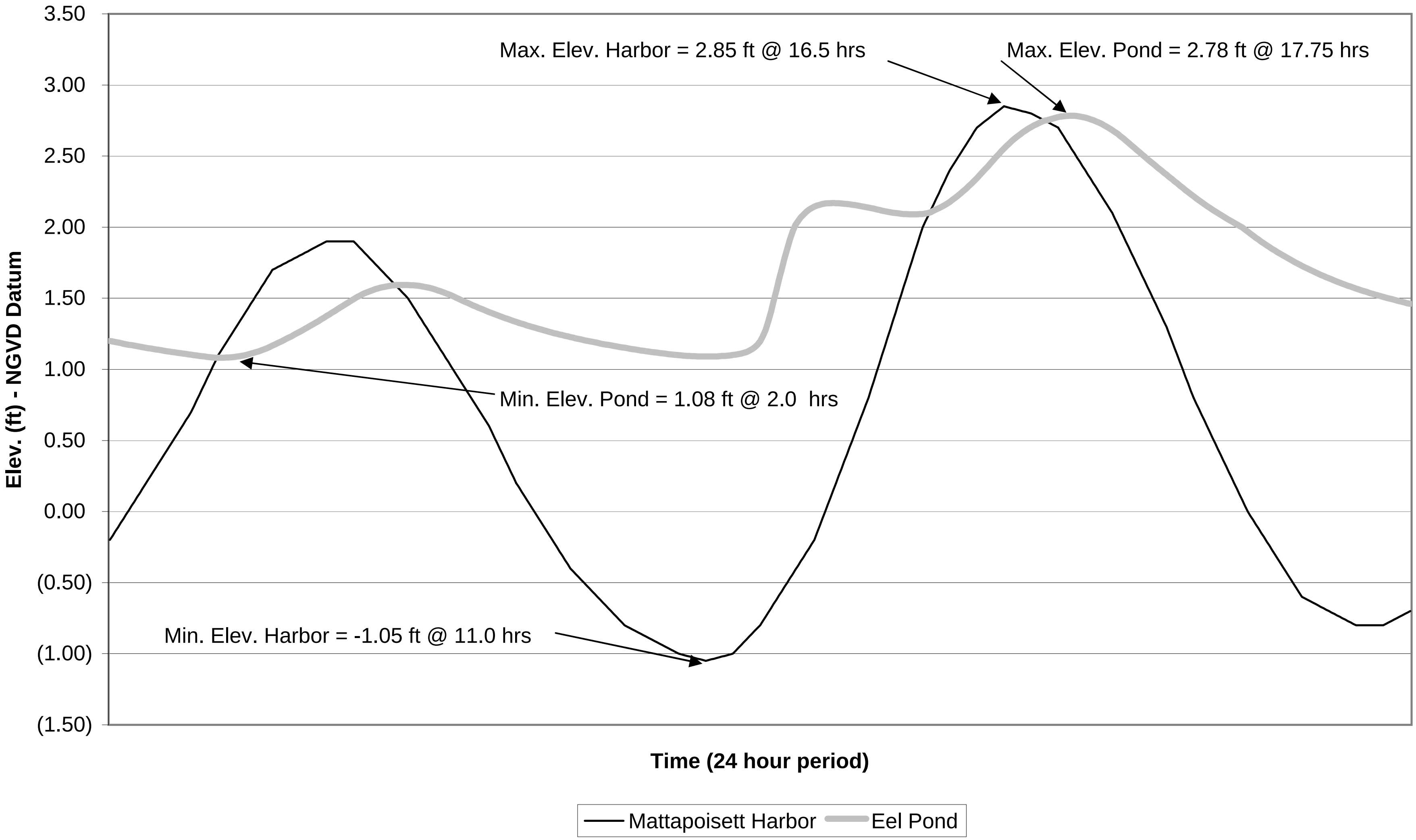


Exhibit 6

Eel Pond
Mean Tide, 10-Year Storm Event, Existing Conditions

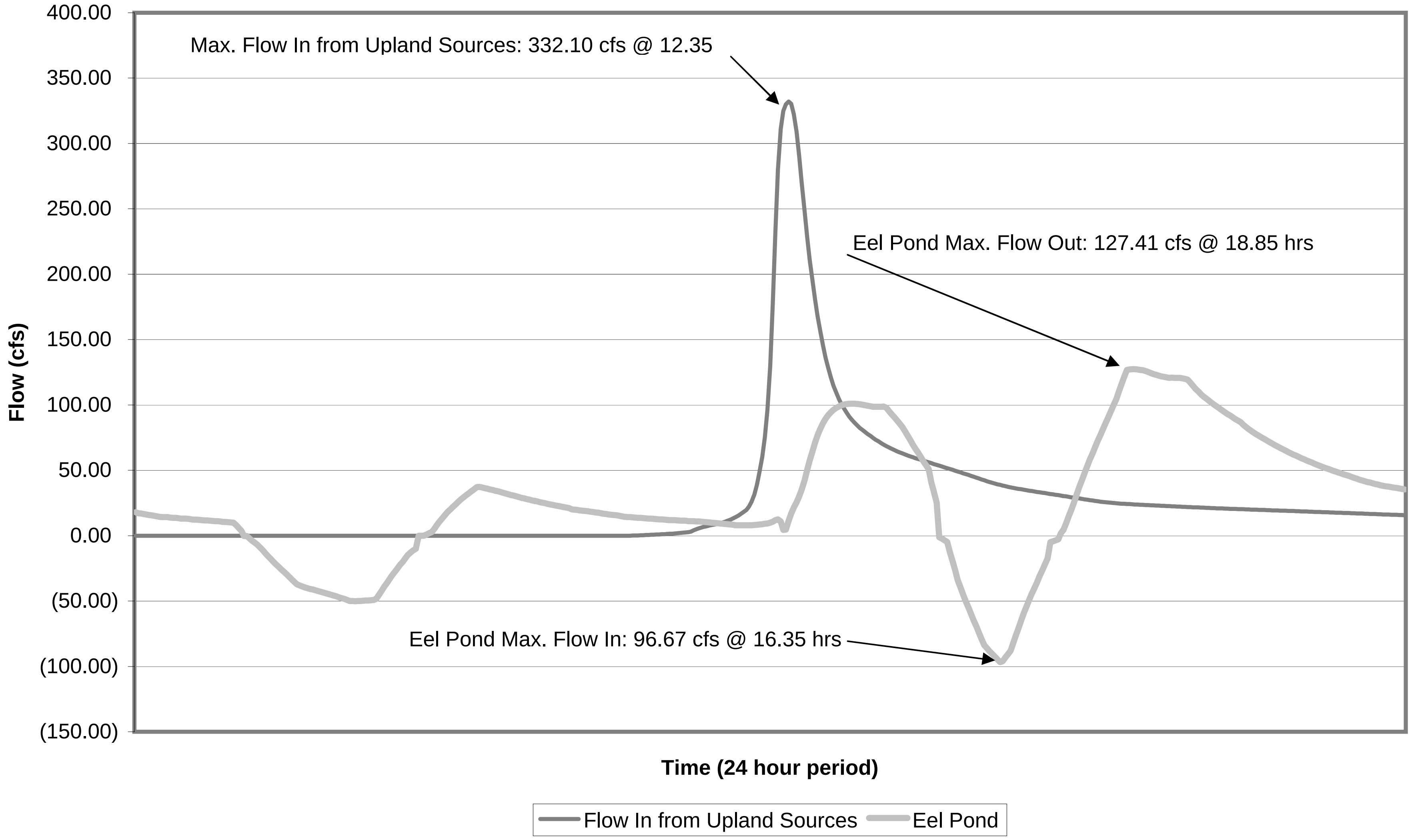


Exhibit 7

Eel Pond
Mean Tide, 10-Year Storm Event, Existing Conditions

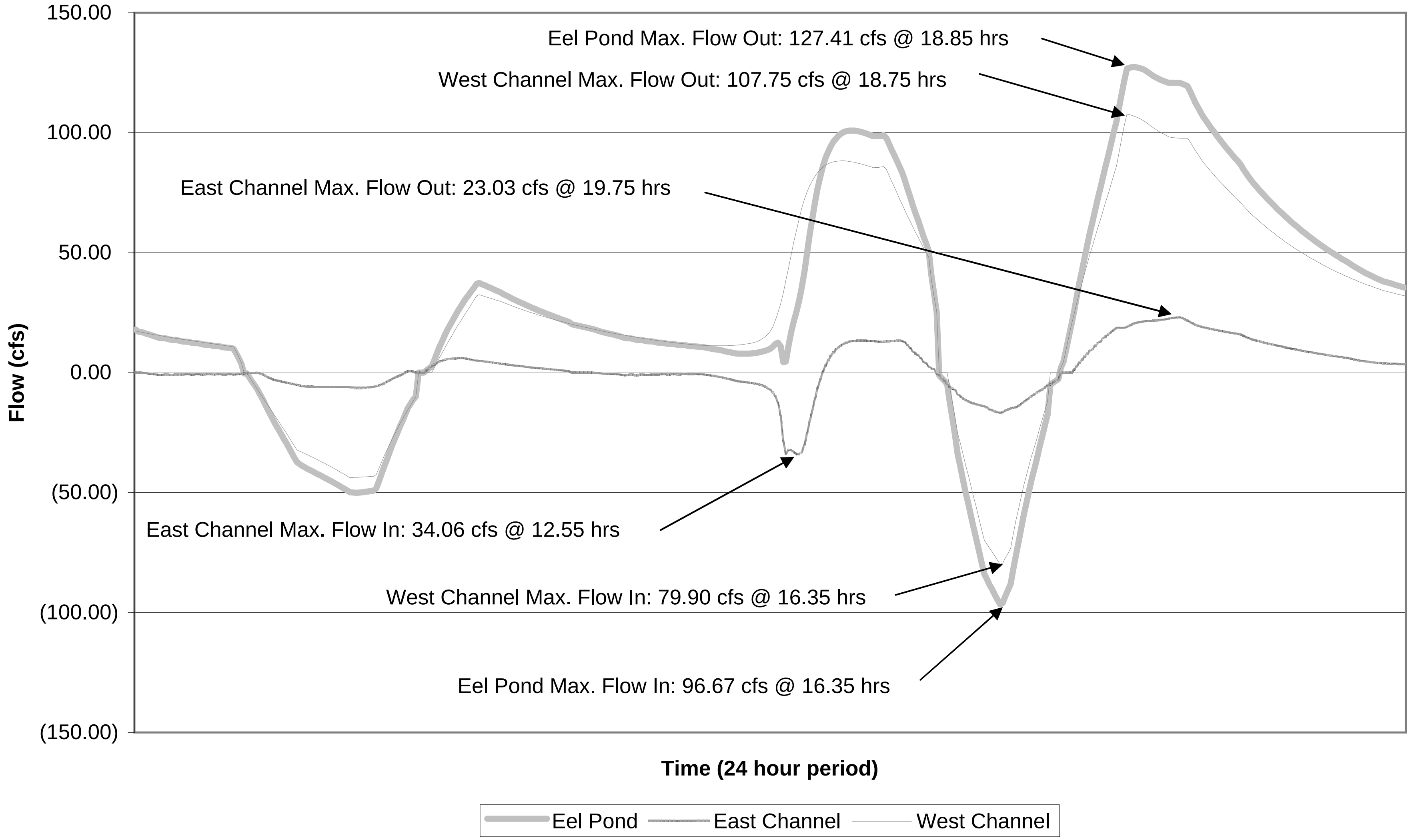


Exhibit 8

Eel Pond
Mean Tide, 100-Year Storm Event, Existing Conditions

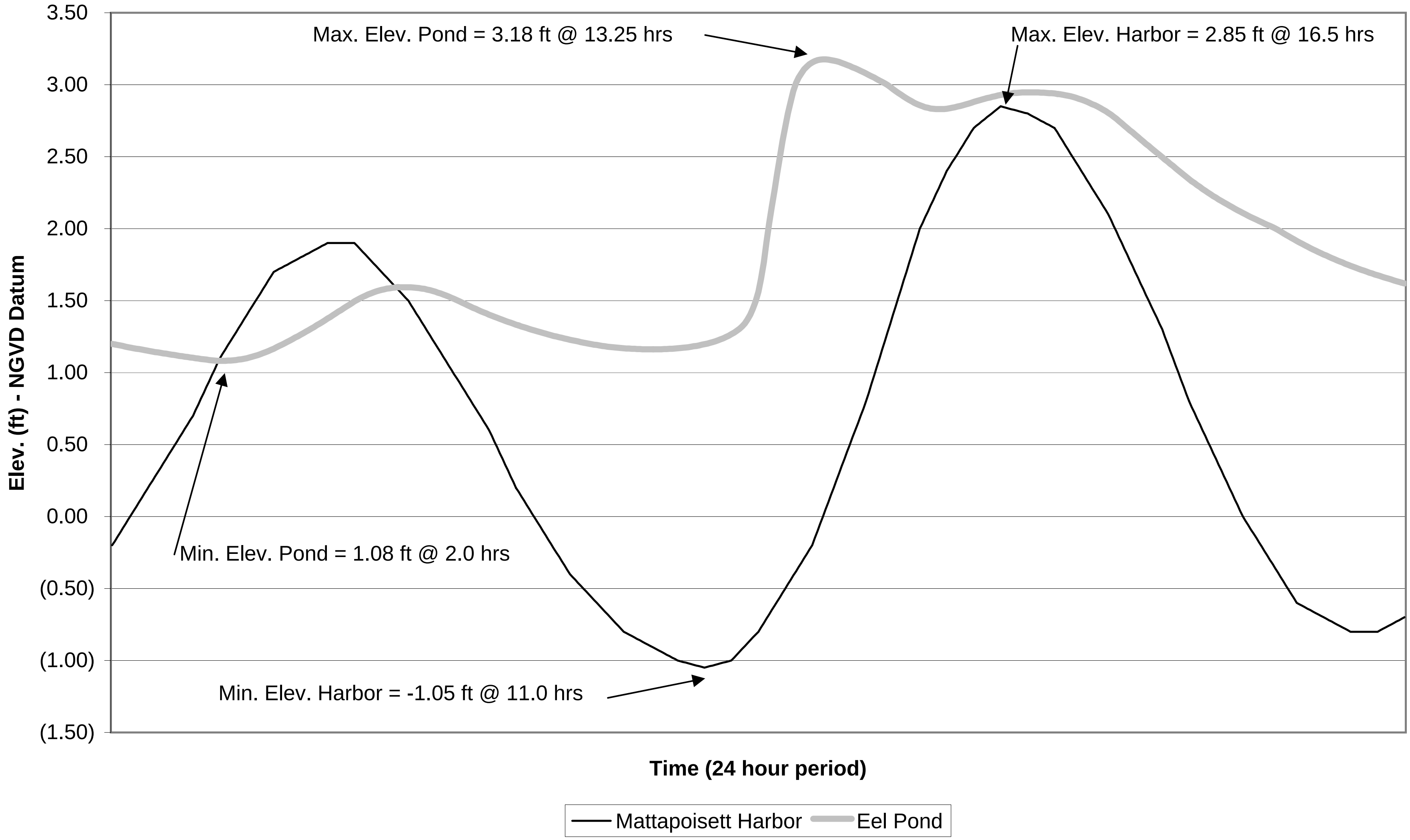


Exhibit 9

Eel Pond
Mean Tide, 100-Year Storm Event, Exisiting Conditions

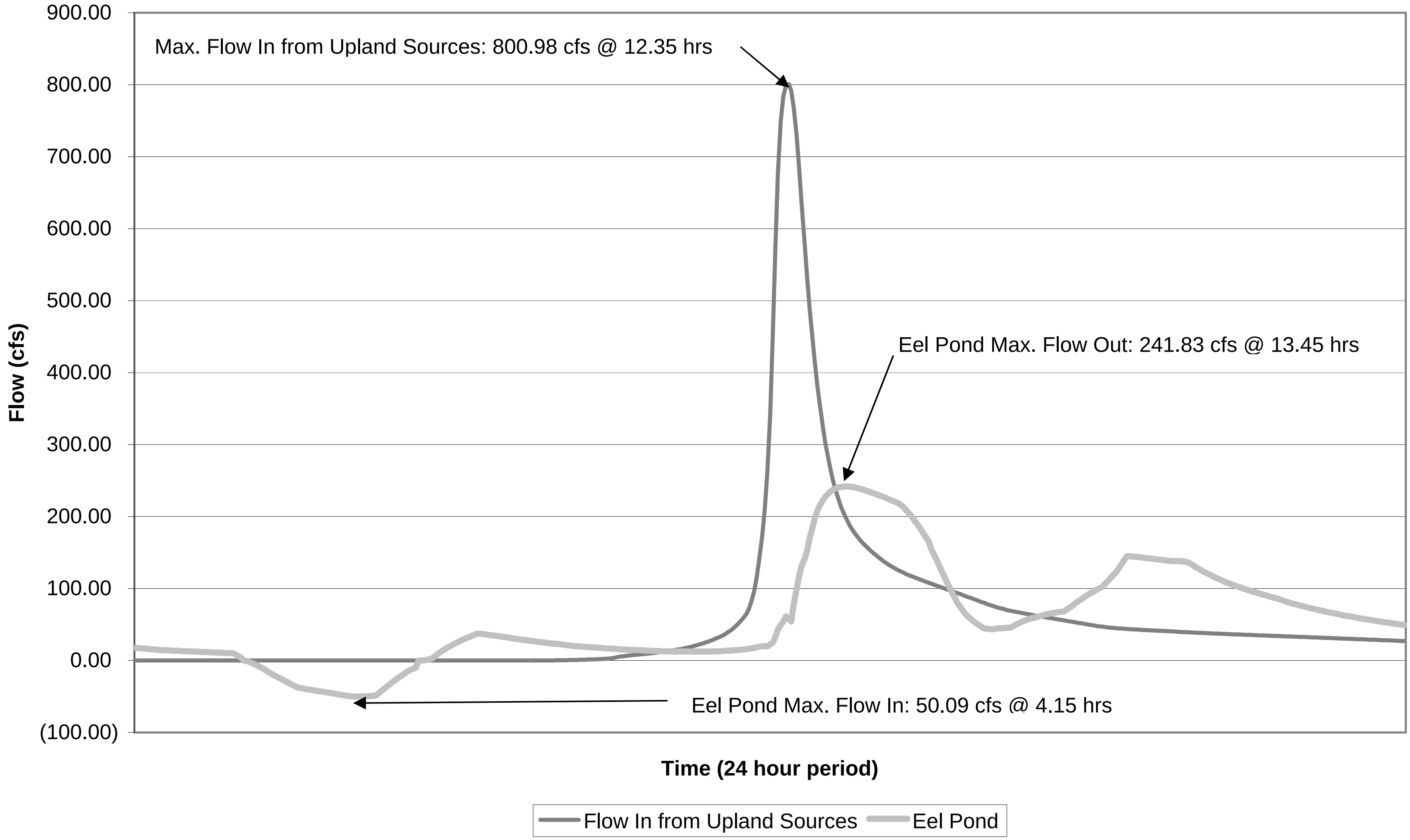


Exhibit 10

Eel Pond
Mean Tide, 100-Year Storm Event, Existing Conditions

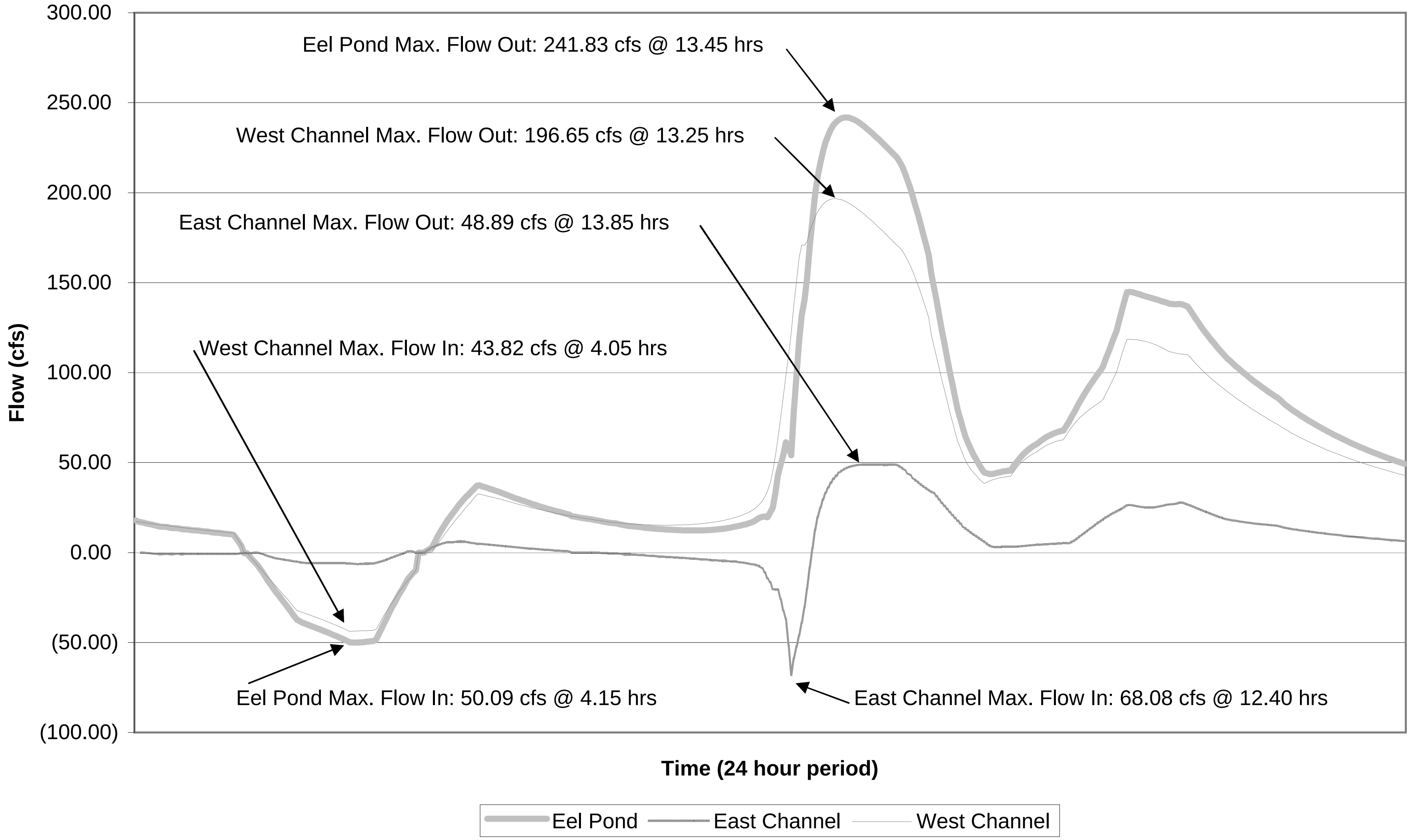


Exhibit 11

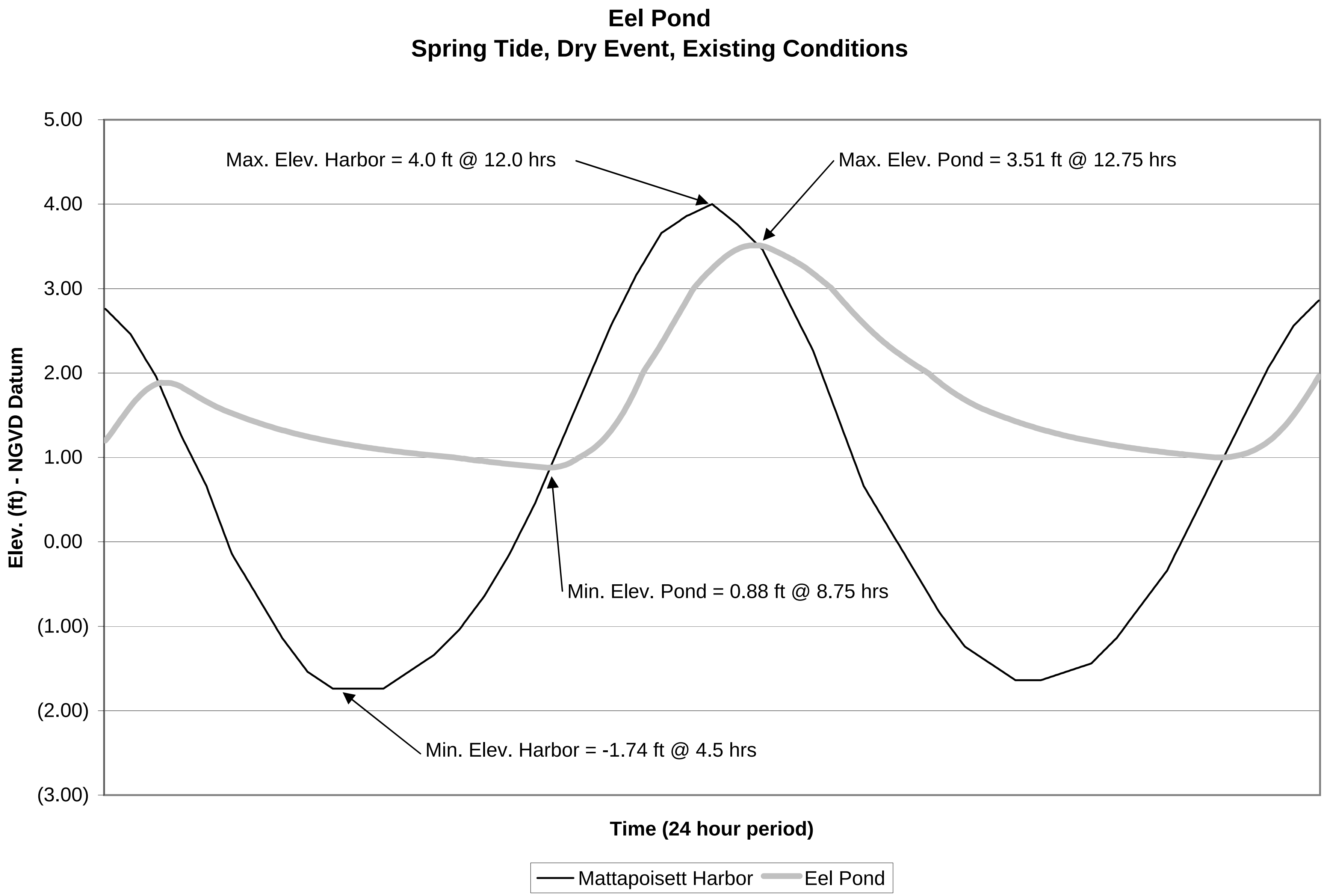

Eel Pond
Spring Tide, Dry Event, Existing Conditions
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Max. Elev. Harbor = 4.0 ft @ 12.0 hrs
Max. Elev. Pond = 3.51 ft @ 12.75 hrs
Min. Elev. Pond = 0.88 ft @ 8.75 hrs
Min. Elev. Harbor = -1.74 ft @ 4.5 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 12

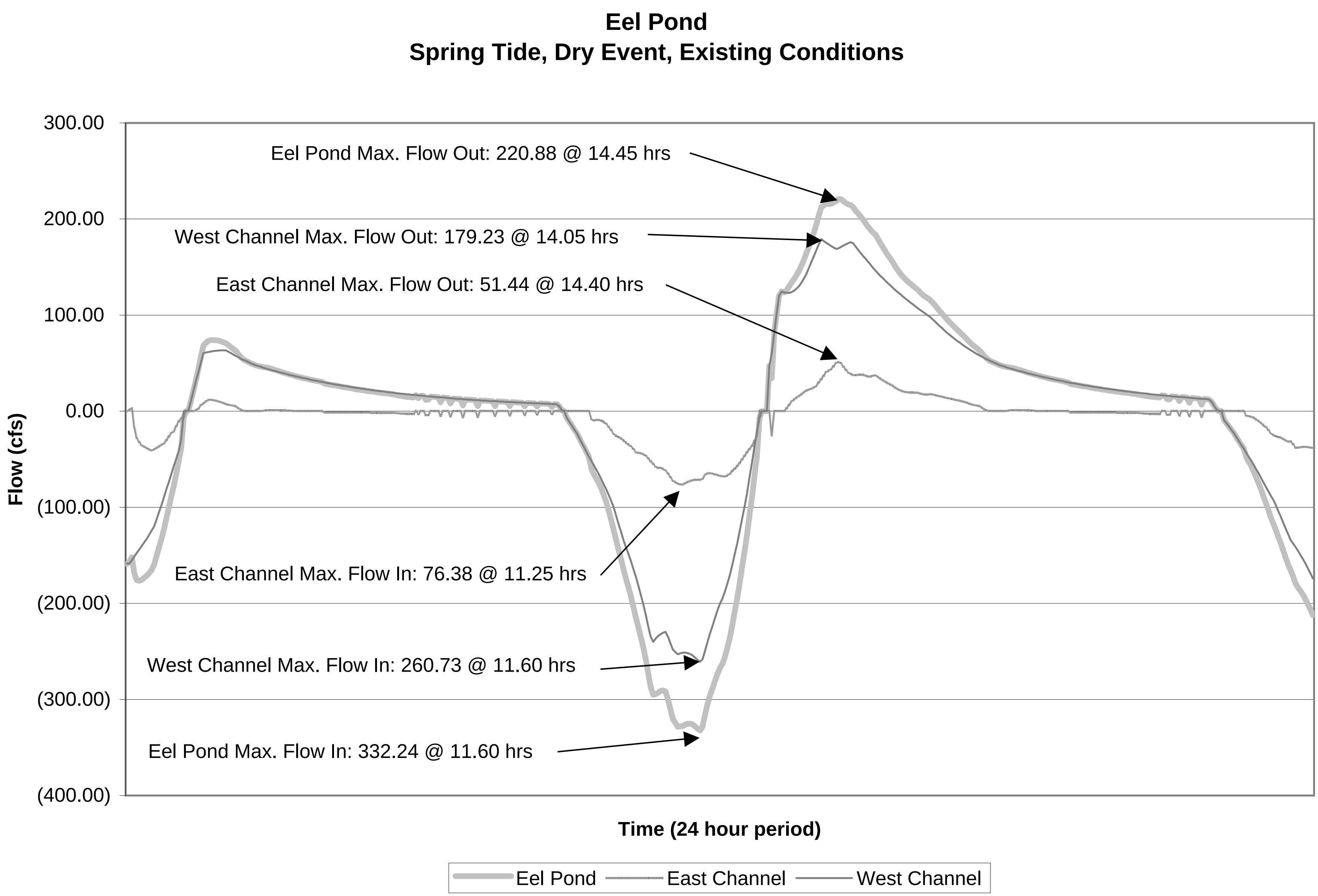

Eel Pond
Spring Tide, Dry Event, Existing Conditions
300.00
200.00
100.00
0.00
(100.00)
(200.00)
(300.00)
(400.00)
Flow (cfs)
Time (24 hour period)
Eel Pond Max. Flow Out: 220.88 @ 14.45 hrs
West Channel Max. Flow Out: 179.23 @ 14.05 hrs
East Channel Max. Flow Out: 51.44 @ 14.40 hrs
East Channel Max. Flow In: 76.38 @ 11.25 hrs
West Channel Max. Flow In: 260.73 @ 11.60 hrs
Eel Pond Max. Flow In: 332.24 @ 11.60 hrs
Eel Pond
East Channel
West Channel

Exhibit 13

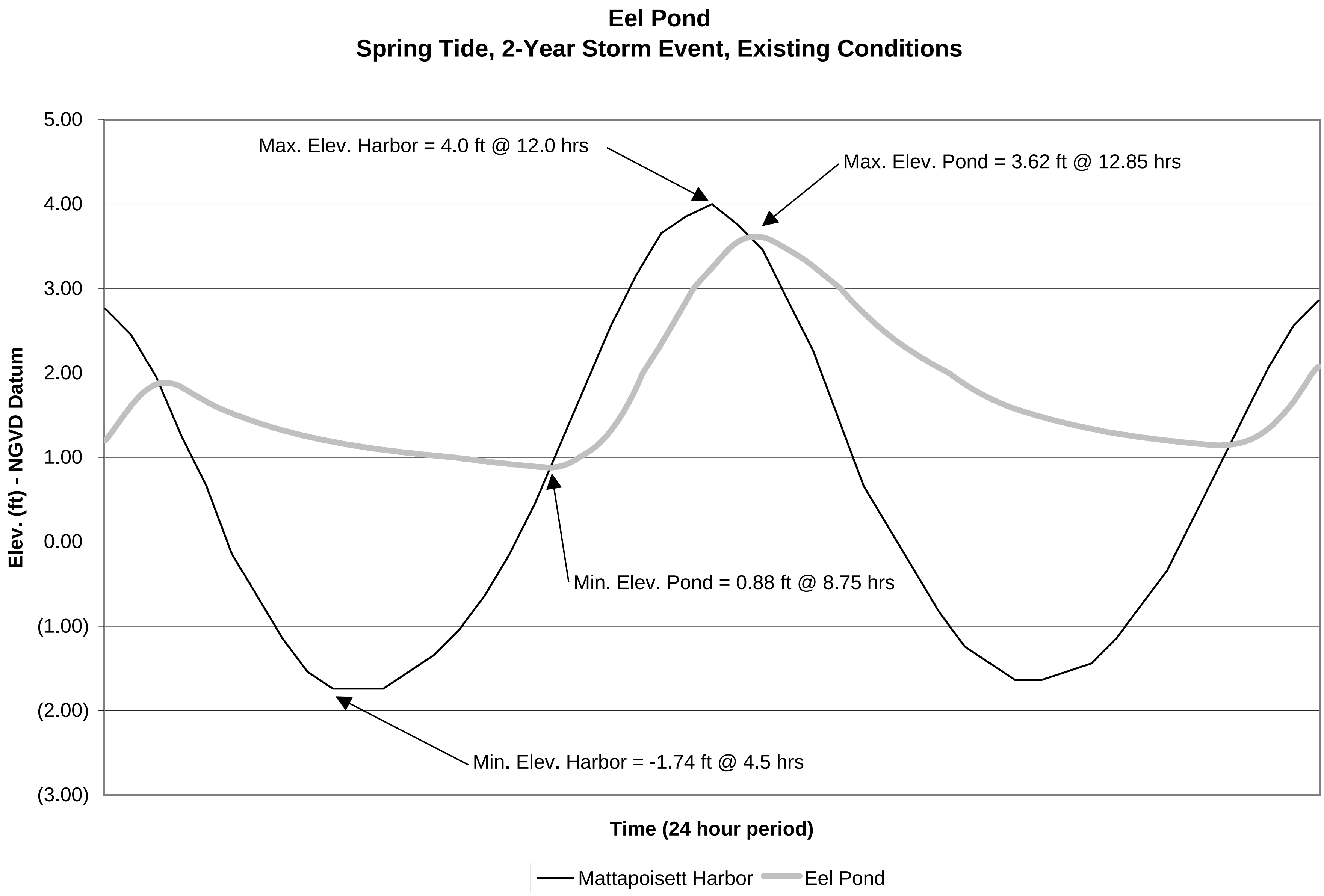

Eel Pond
Spring Tide, 2-Year Storm Event, Existing Conditions
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Max. Elev. Harbor = 4.0 ft @ 12.0 hrs
Max. Elev. Pond = 3.62 ft @ 12.85 hrs
Min. Elev. Pond = 0.88 ft @ 8.75 hrs
Min. Elev. Harbor = -1.74 ft @ 4.5 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 14

Eel Pond
Spring Tide, 2-Year Storm Event, Existing Conditions

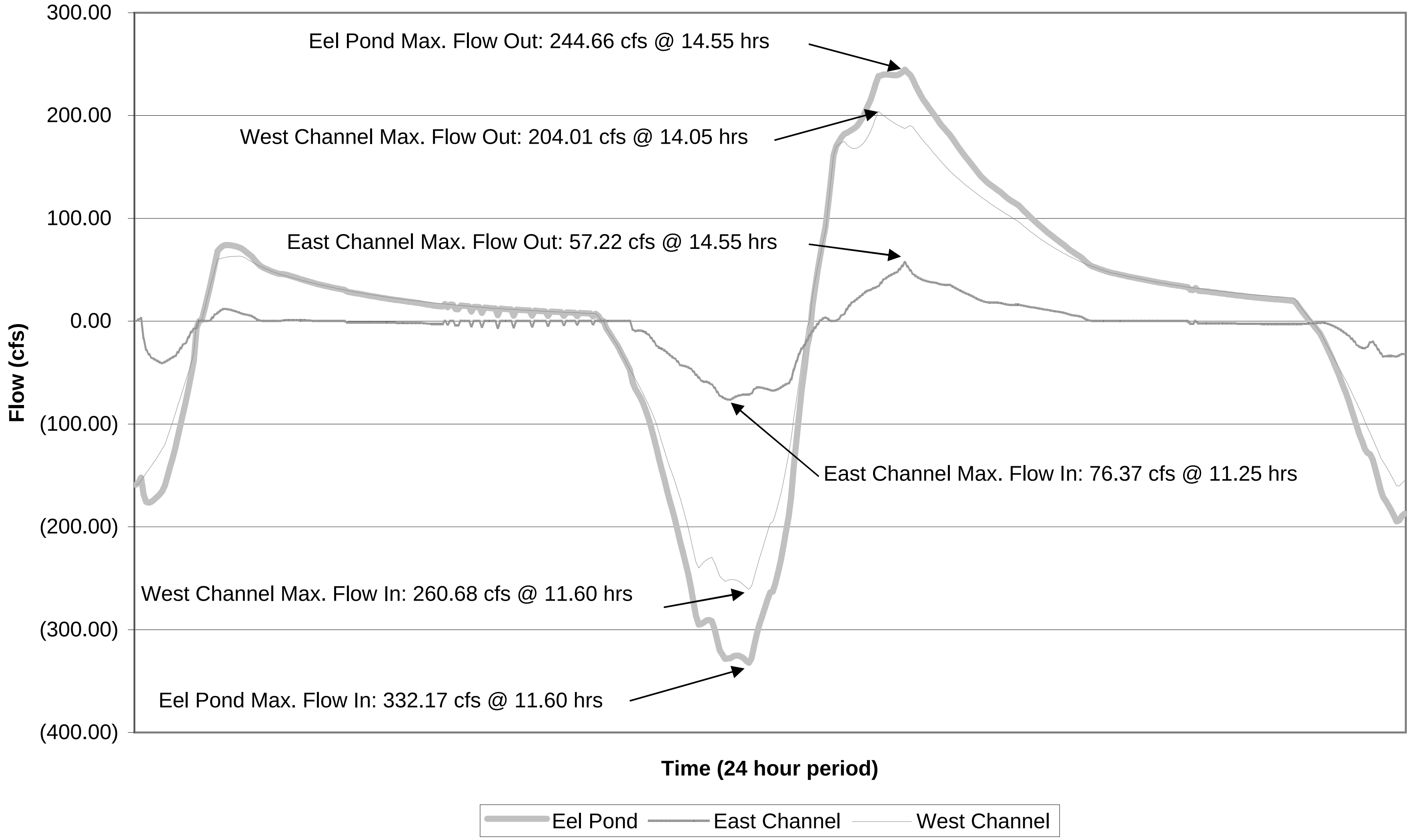


Exhibit 15

Eel Pond
Spring Tide, 10-Year Storm Event, Existing Conditions

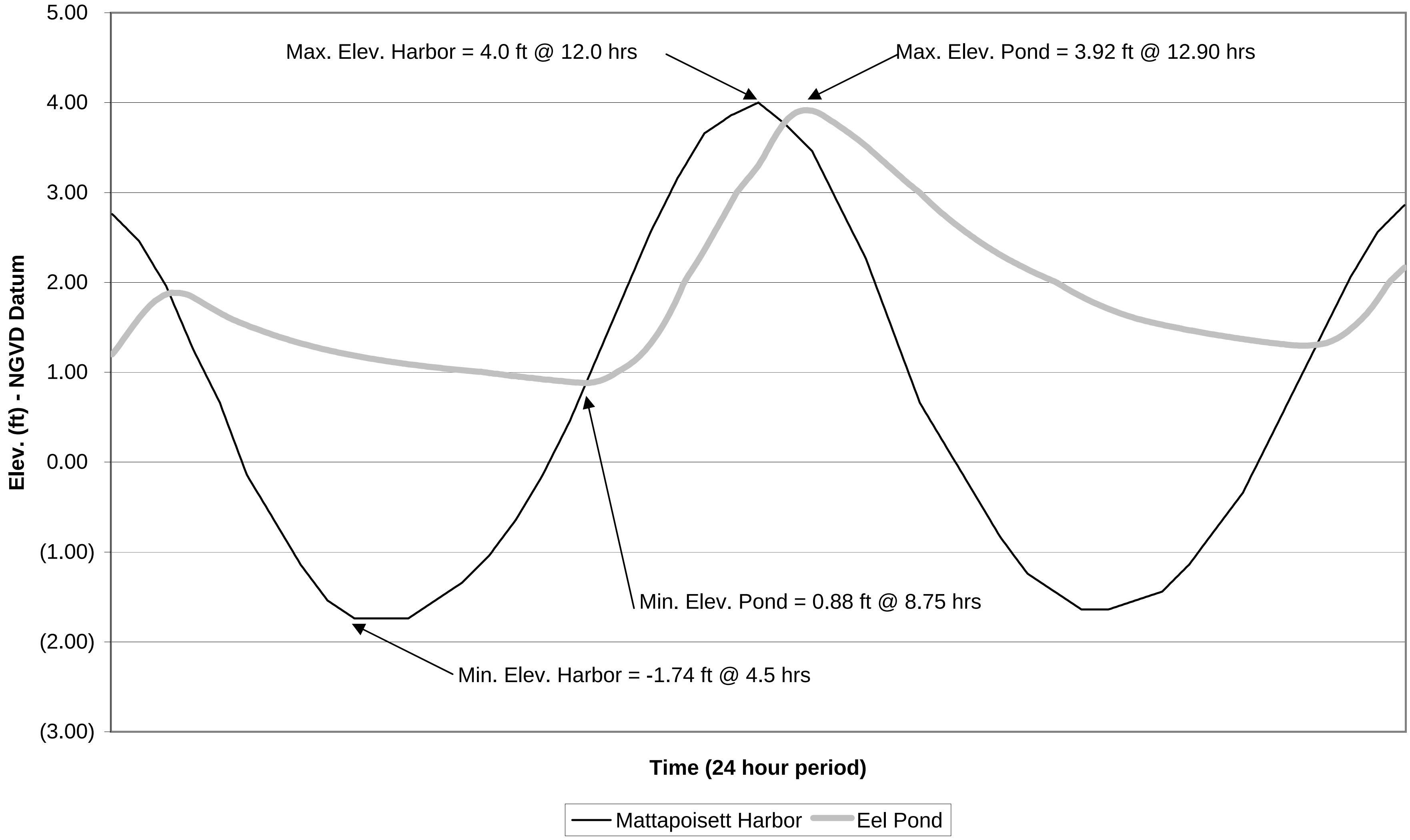


Exhibit 16

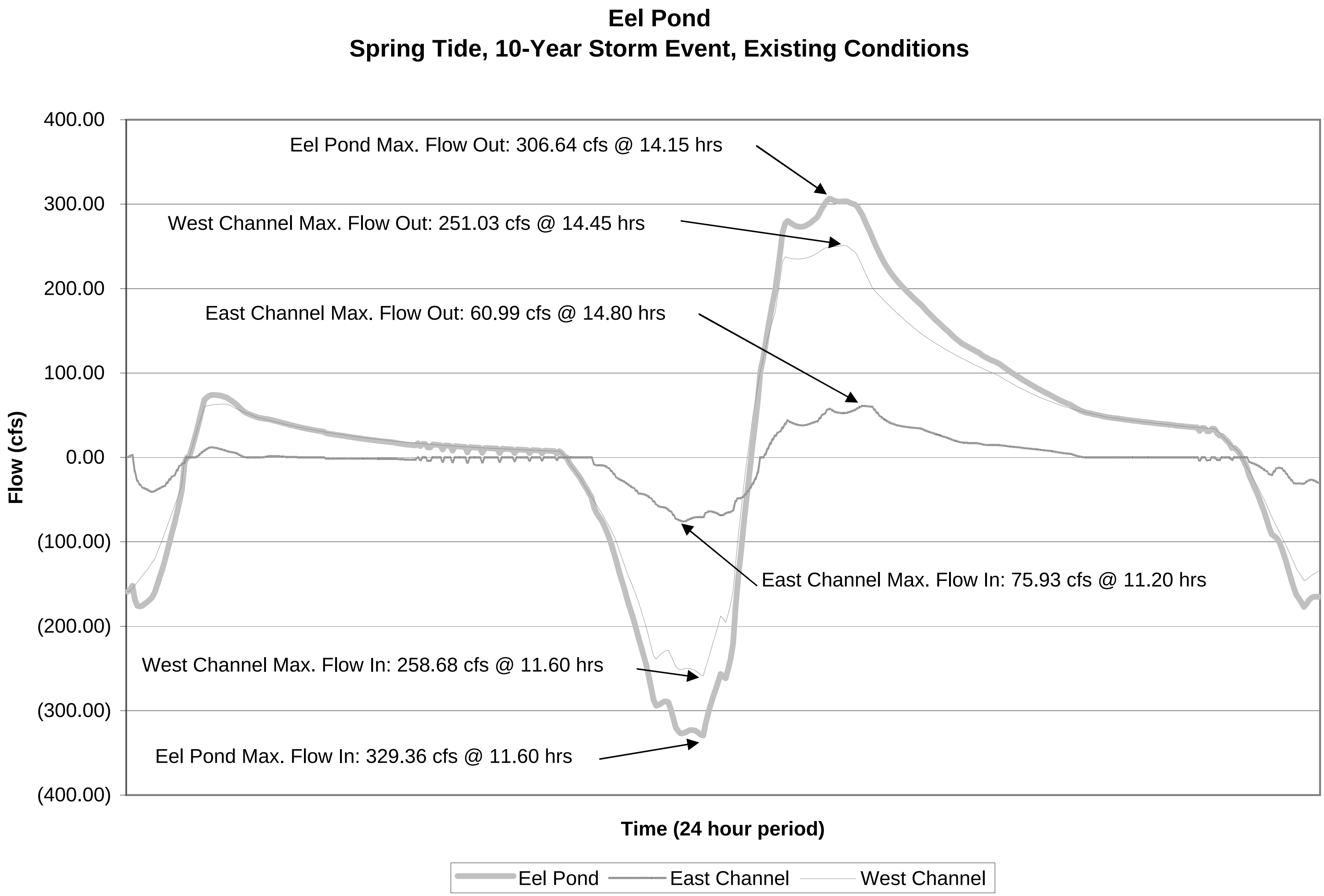

Eel Pond
Spring Tide, 10-Year Storm Event, Existing Conditions
400.00
300.00
200.00
100.00
0.00
(100.00)
(200.00)
(300.00)
(400.00)
Flow (cfs)
Time (24 hour period)
Eel Pond Max. Flow Out: 306.64 cfs @ 14.15 hrs
West Channel Max. Flow Out: 251.03 cfs @ 14.45 hrs
East Channel Max. Flow Out: 60.99 cfs @ 14.80 hrs
East Channel Max. Flow In: 75.93 cfs @ 11.20 hrs
West Channel Max. Flow In: 258.68 cfs @ 11.60 hrs
Eel Pond Max. Flow In: 329.36 cfs @ 11.60 hrs
Eel Pond
East Channel
West Channel

Exhibit 17

Eel Pond
Mean Tide, Dry Event, Dredging Only with West Channel Open

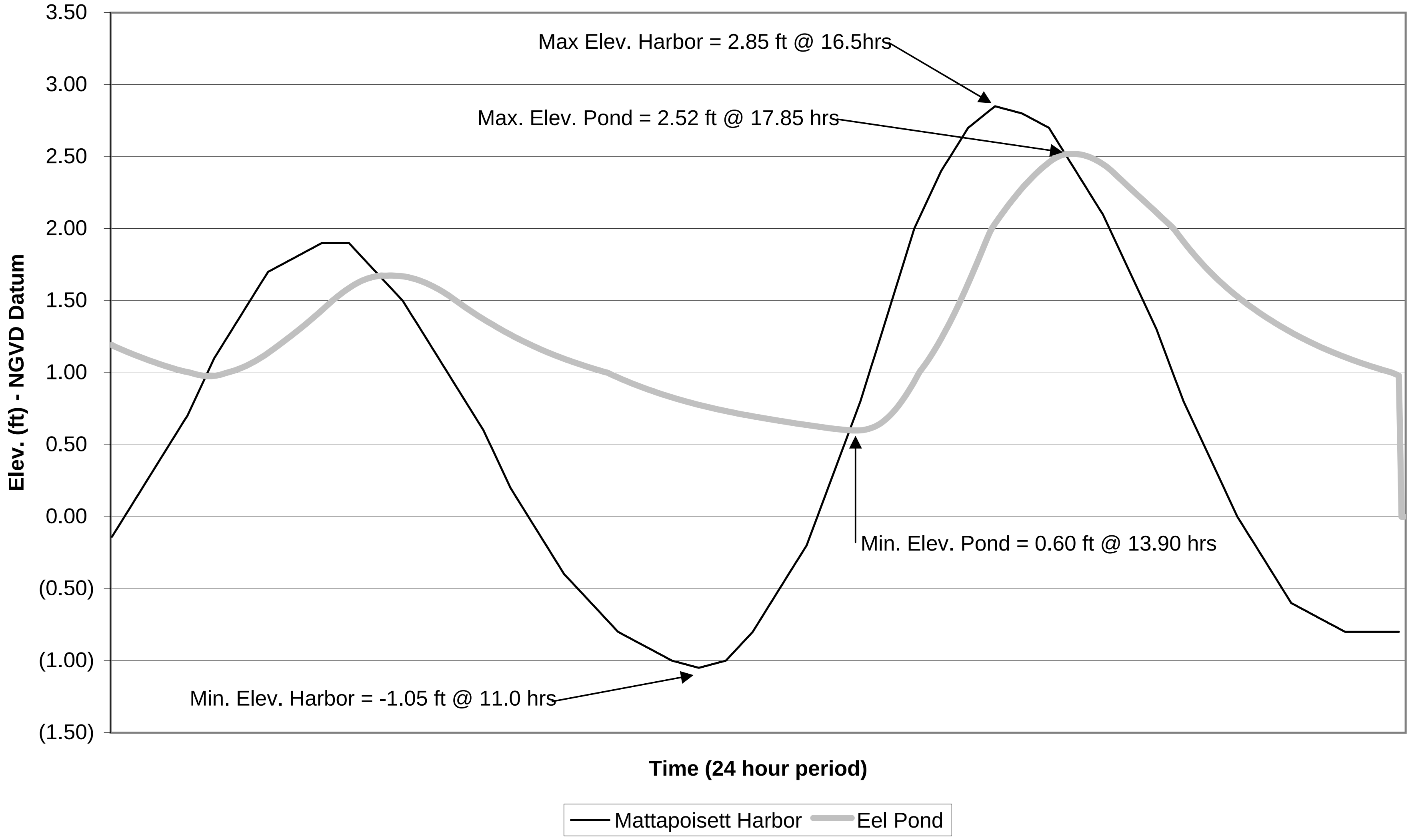


Exhibit 18

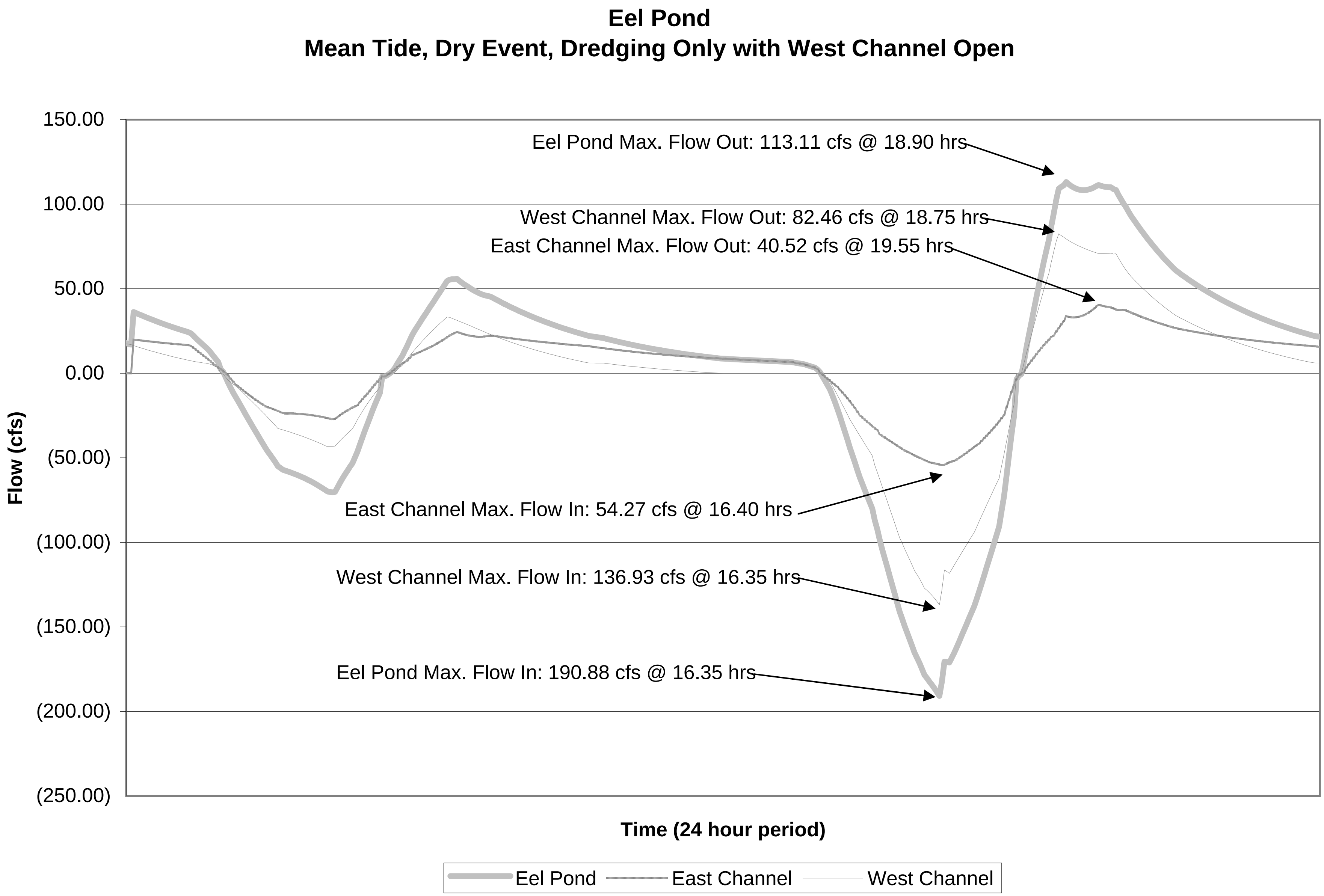

Eel Pond
Mean Tide, Dry Event, Dredging Only with West Channel Open
150.00
100.00
50.00
0.00
(50.00)
(100.00)
(150.00)
(200.00)
(250.00)
Flow (cfs)
Time (24 hour period)
Eel Pond Max. Flow Out: 113.11 cfs @ 18.90 hrs
West Channel Max. Flow Out: 82.46 cfs @ 18.75 hrs
East Channel Max. Flow Out: 40.52 cfs @ 19.55 hrs
East Channel Max. Flow In: 54.27 cfs @ 16.40 hrs
West Channel Max. Flow In: 136.93 cfs @ 16.35 hrs
Eel Pond Max. Flow In: 190.88 cfs @ 16.35 hrs
Eel Pond
East Channel
West Channel

Exhibit 19

Eel Pond Mean Tide, Dry Event, Dredging Only with West Channel Closed

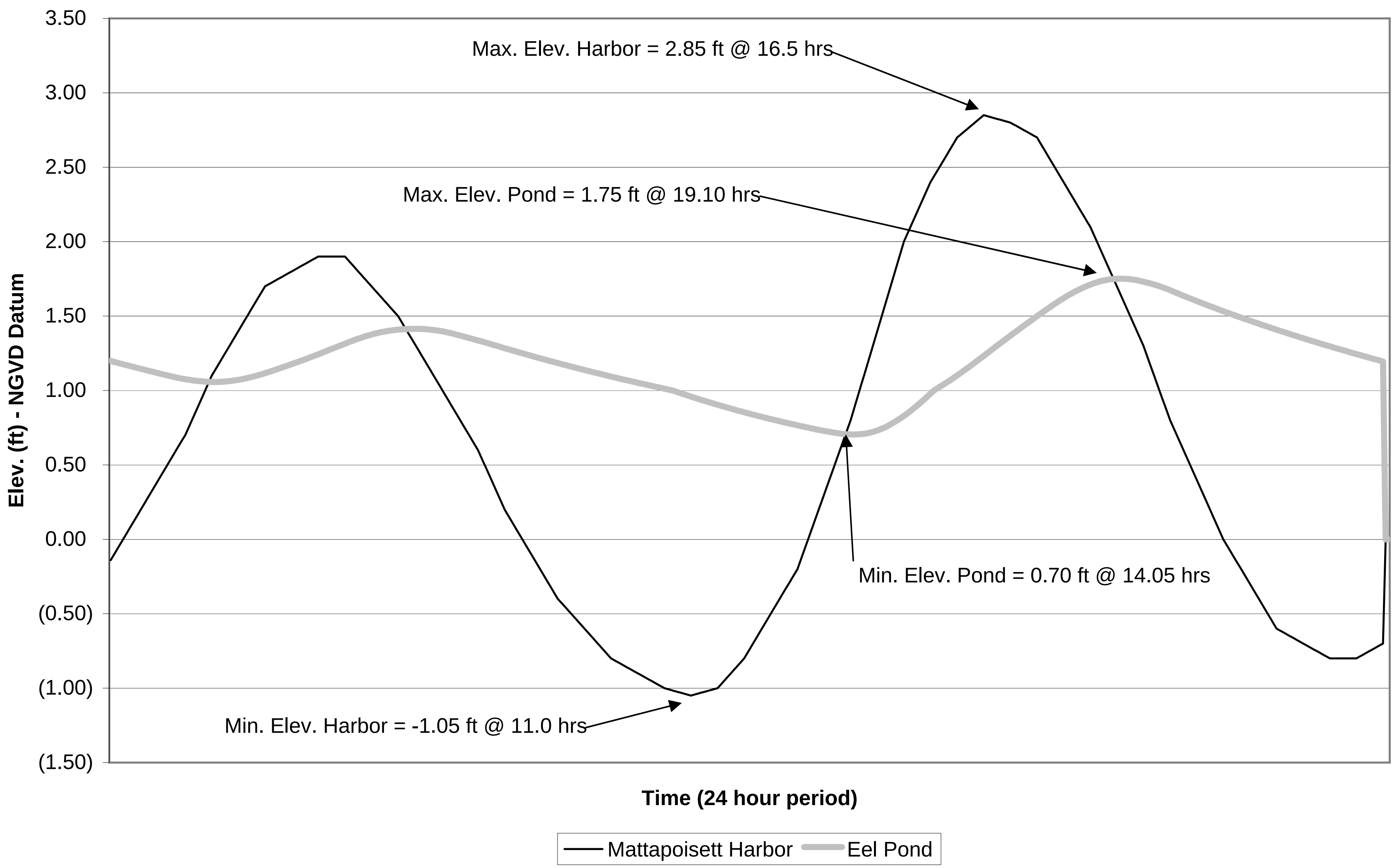


Exhibit 20

Eel Pond
Mean Tide, Dry Event, Dredging Only with West Channel Closed

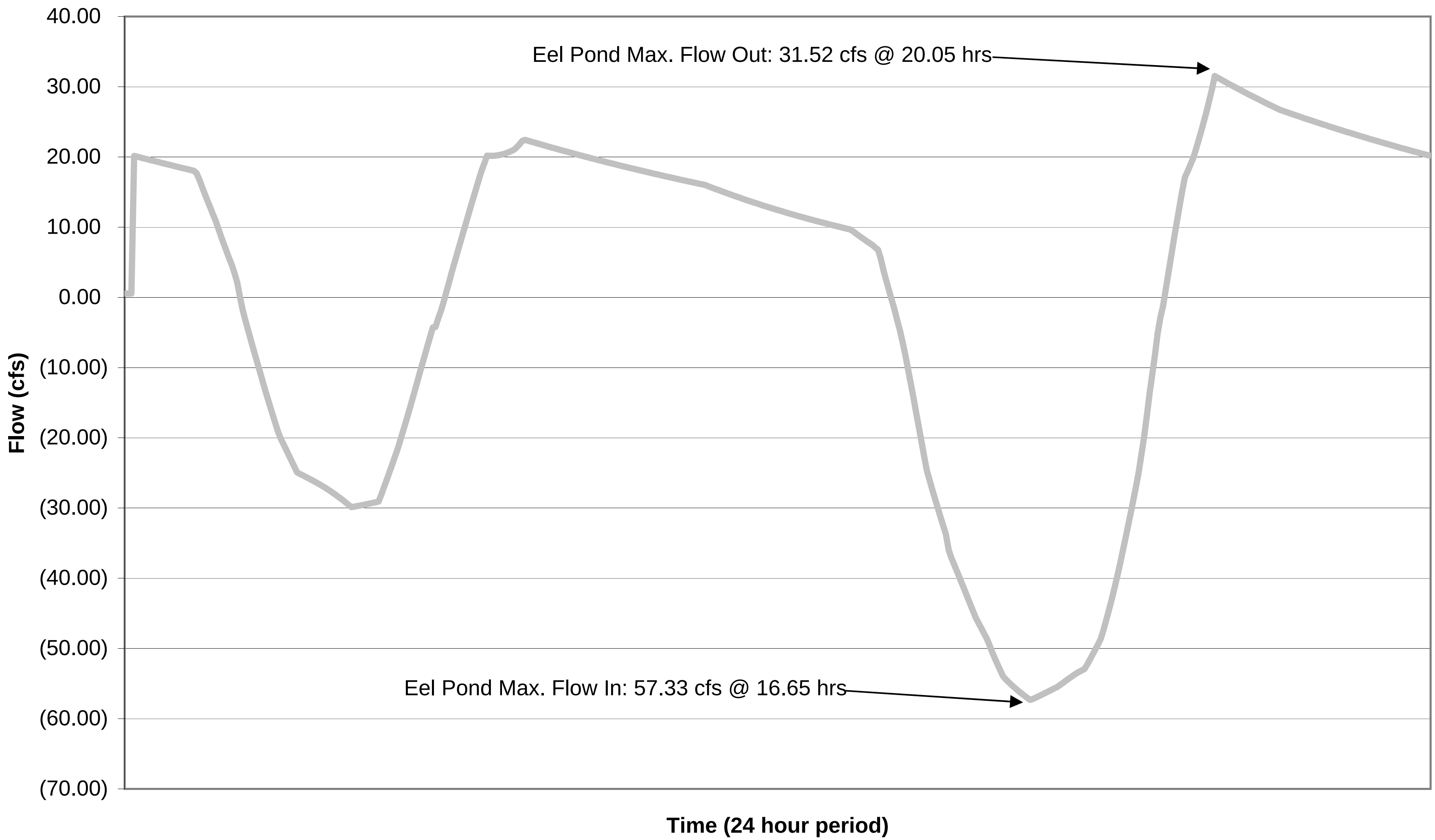


Exhibit 21

Eel Pond
Mean Tide, 2-Year Storm Event, Dredging Only with West Channel Open

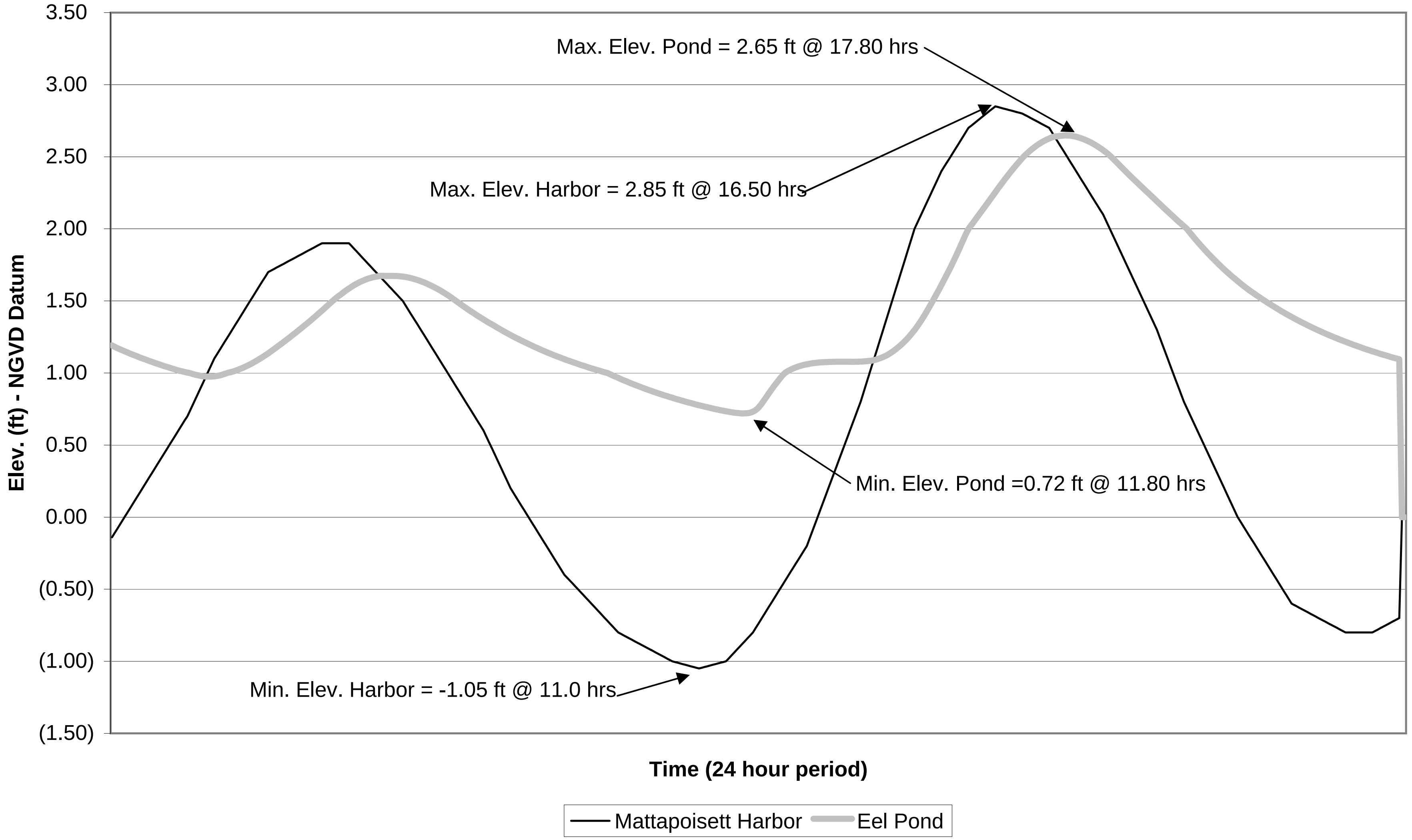


Exhibit 22

Eel Pond
Mean Tide, 2-Year Storm Event, Dredging Only with West Channel Open

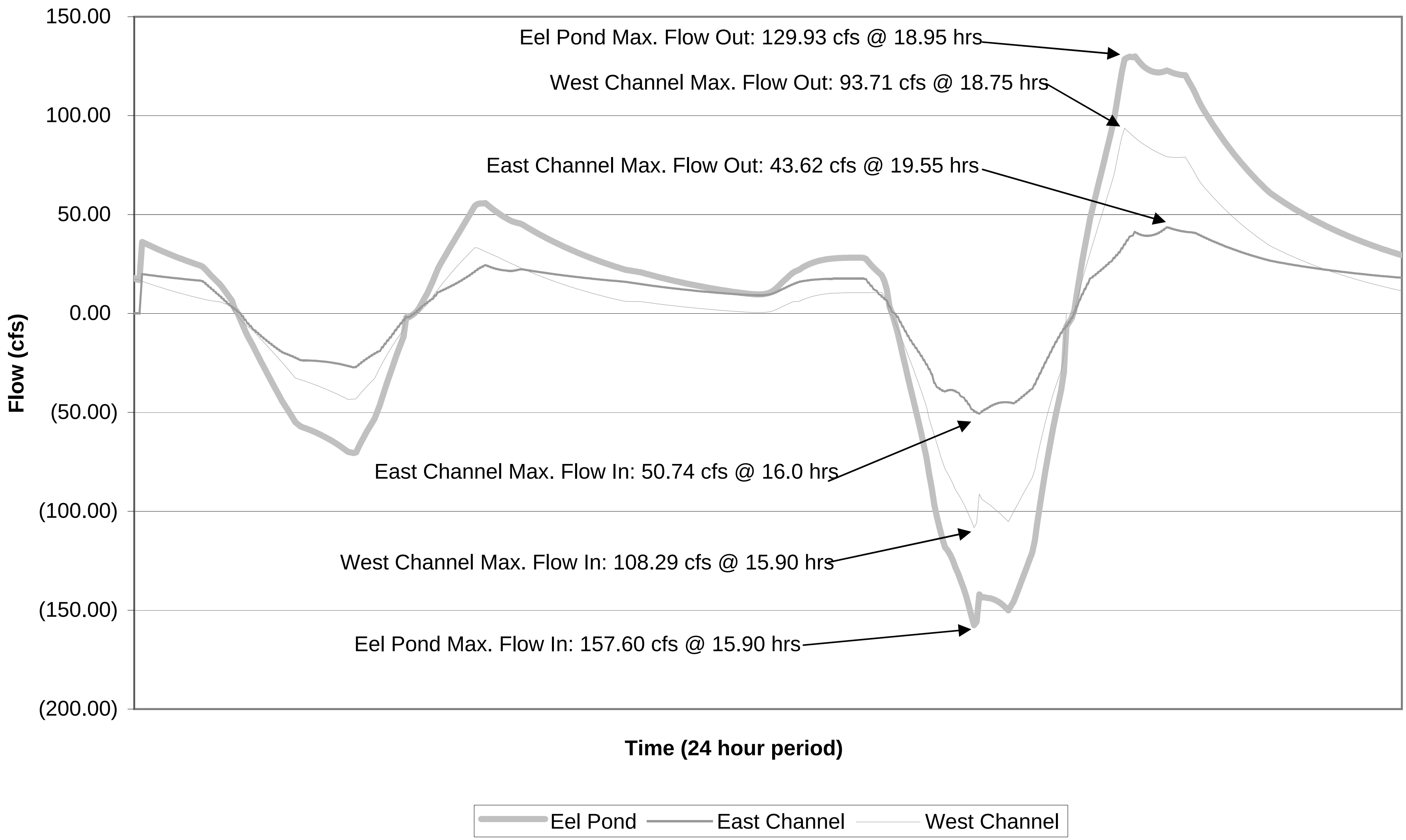


Exhibit 23

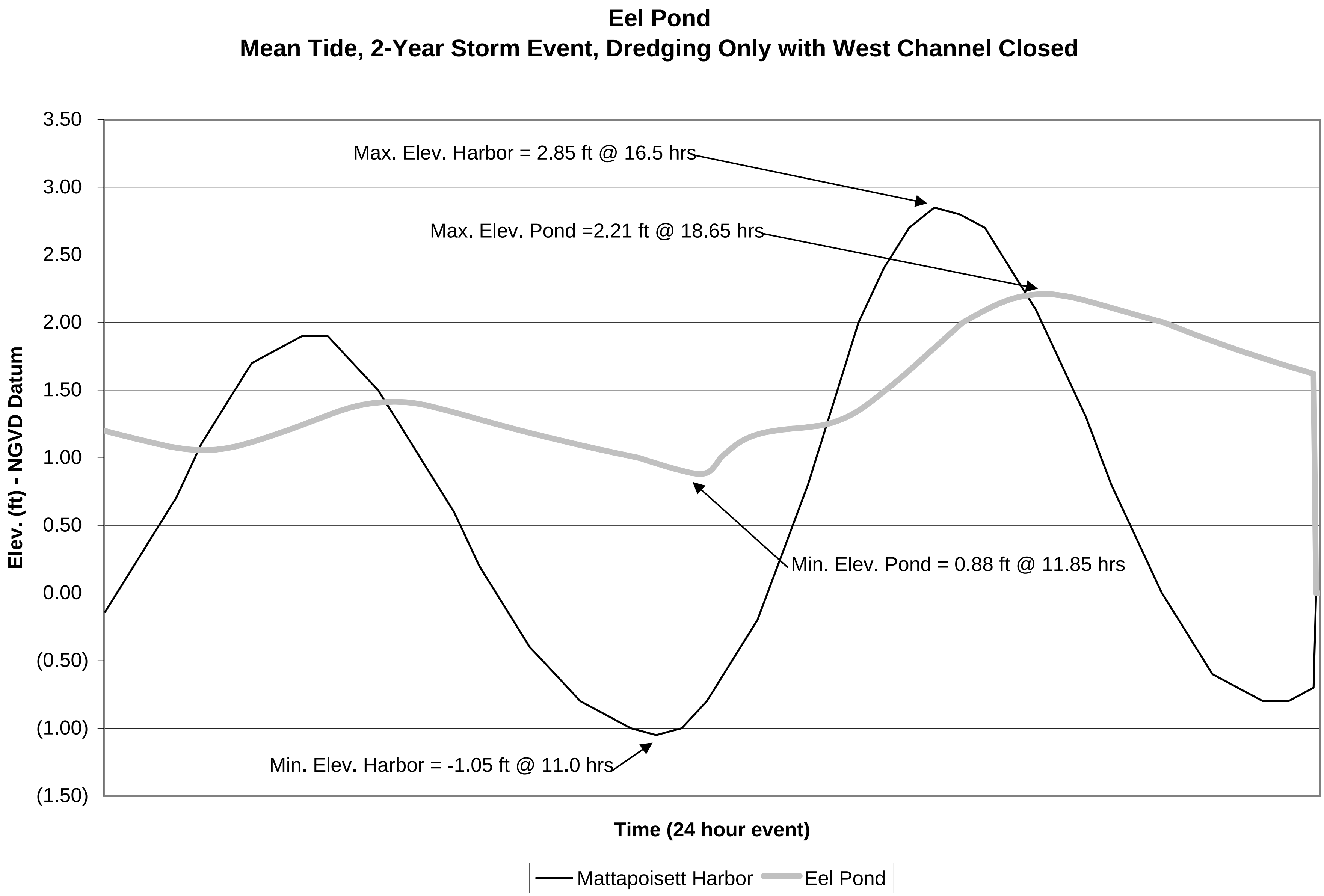

Eel Pond
Mean Tide, 2-Year Storm Event, Dredging Only with West Channel Closed
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
(0.50)
(1.00)
(1.50)
Elev. (ft) - NGVD Datum
Max. Elev. Harbor = 2.85 ft @ 16.5 hrs
Max. Elev. Pond =2.21 ft @ 18.65 hrs
Min. Elev. Pond = 0.88 ft @ 11.85 hrs
Min. Elev. Harbor = -1.05 ft @ 11.0 hrs
Time (24 hour event)
Mattapoisett Harbor
Eel Pond

Exhibit 24

Eel Pond
Mean Tide, 2-Year Storm Event, Dredging Only with West Channel Closed

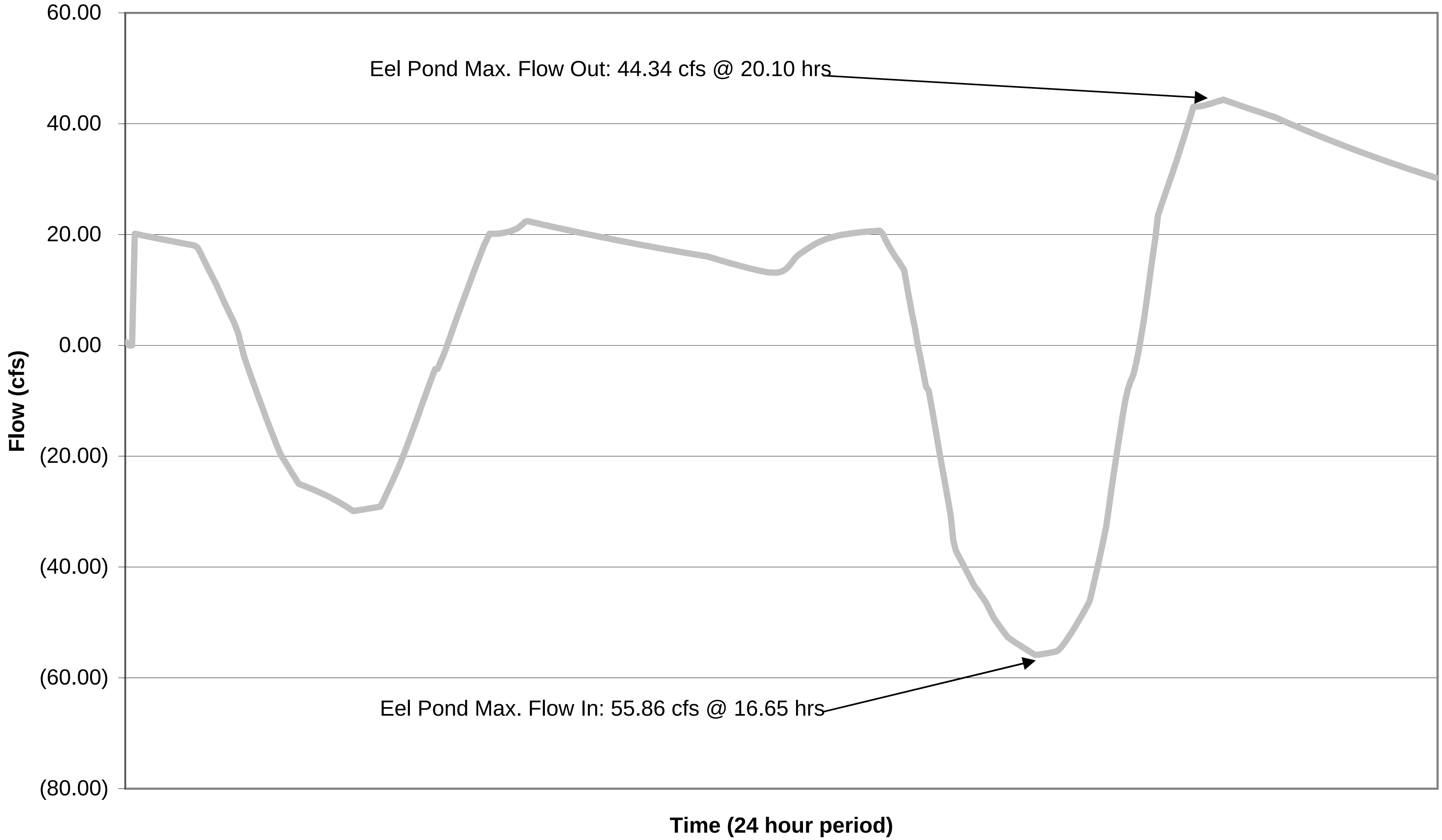


Exhibit 25

Eel Pond
MeanTide, 10-Year Storm Event, Dredging Only with West Channel Open

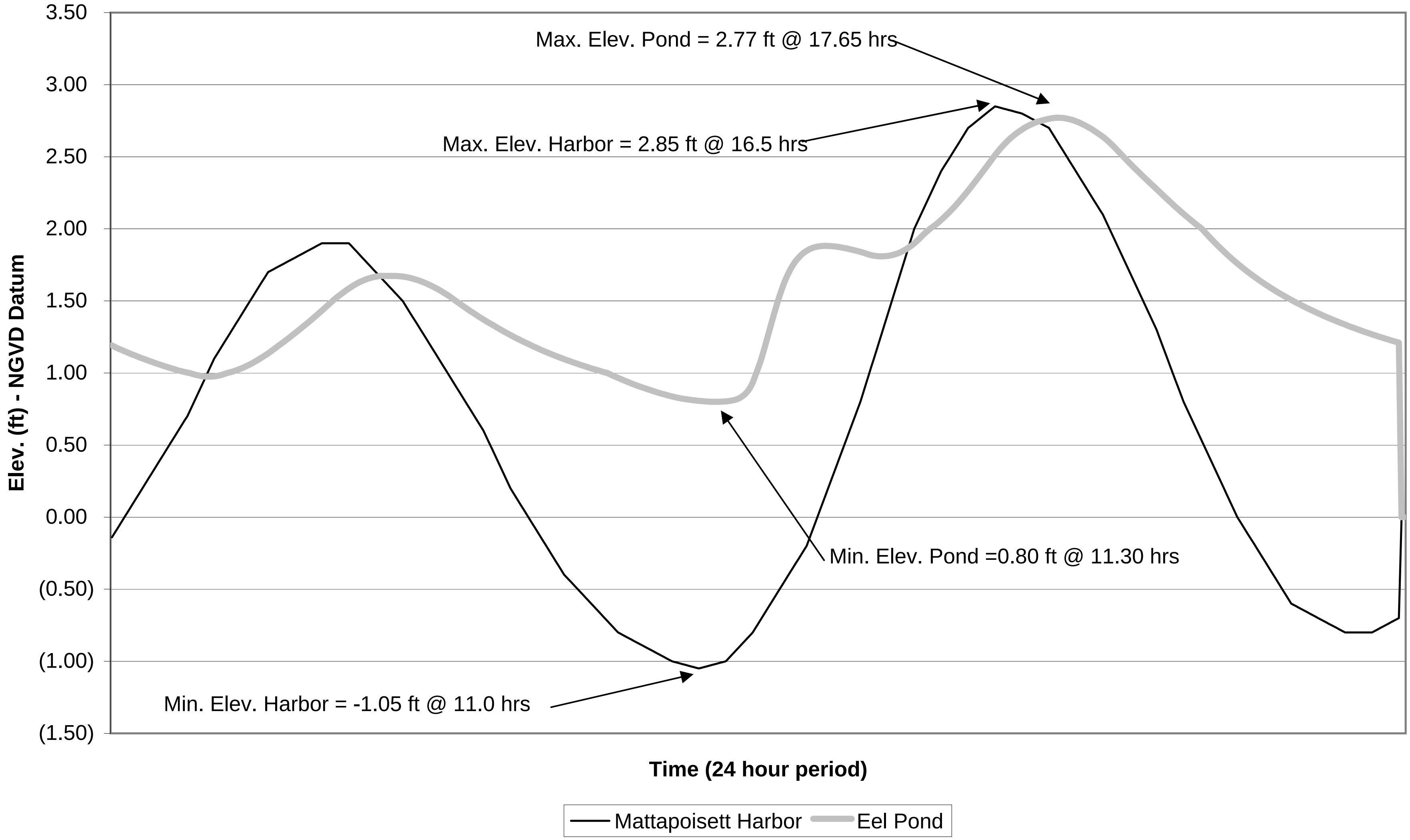


Exhibit 26

CLE Engineering, Inc.
(508) 748-0937

Town of Mattapoisett
CLE #04054.100

Eel Pond
Mean Tide, 10-Year Storm Event, Dredging Only with West Channel Open

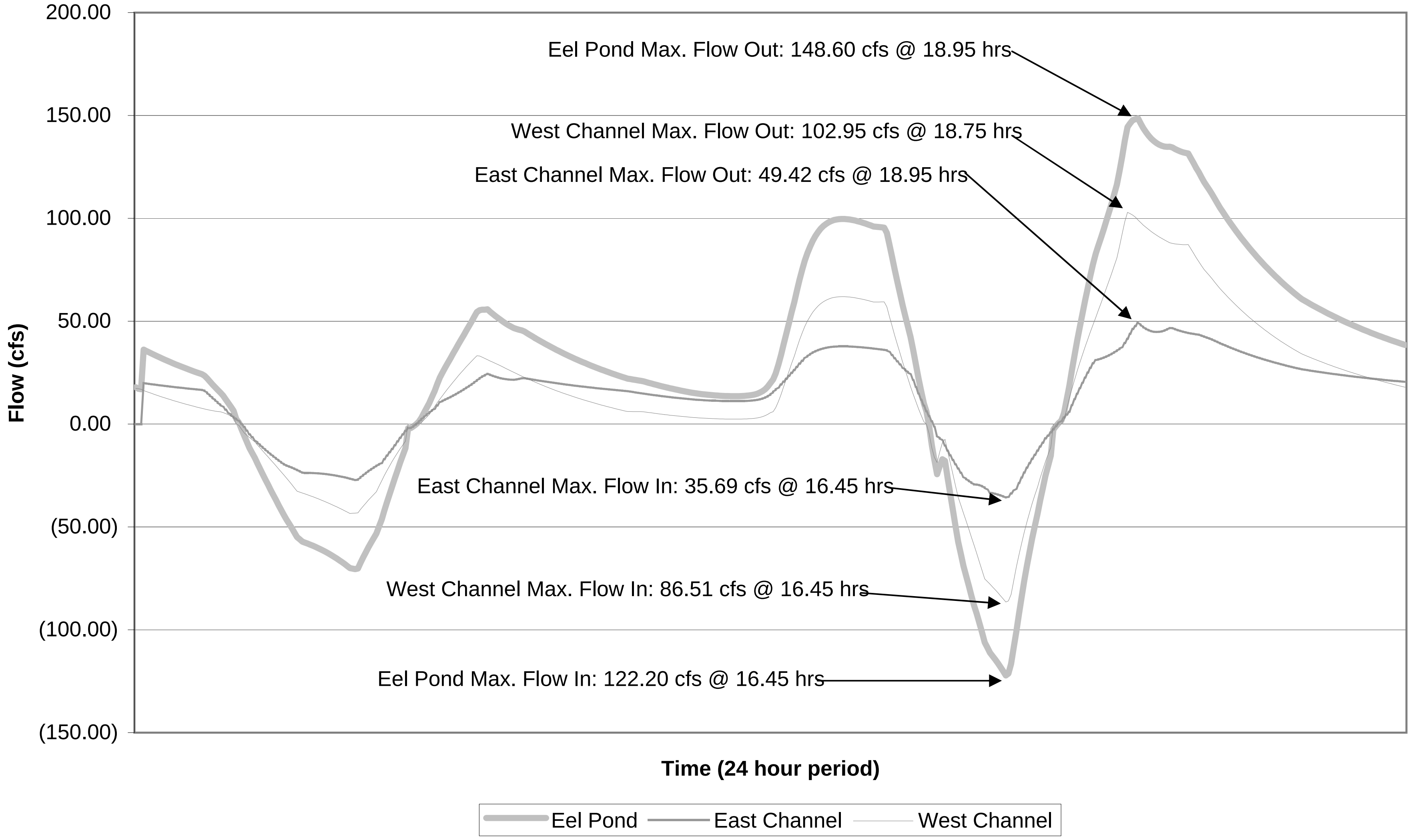


Exhibit 27

Eel Pond
Mean Tide, 100-Year Storm Event, Dredging Only with West Channel Open

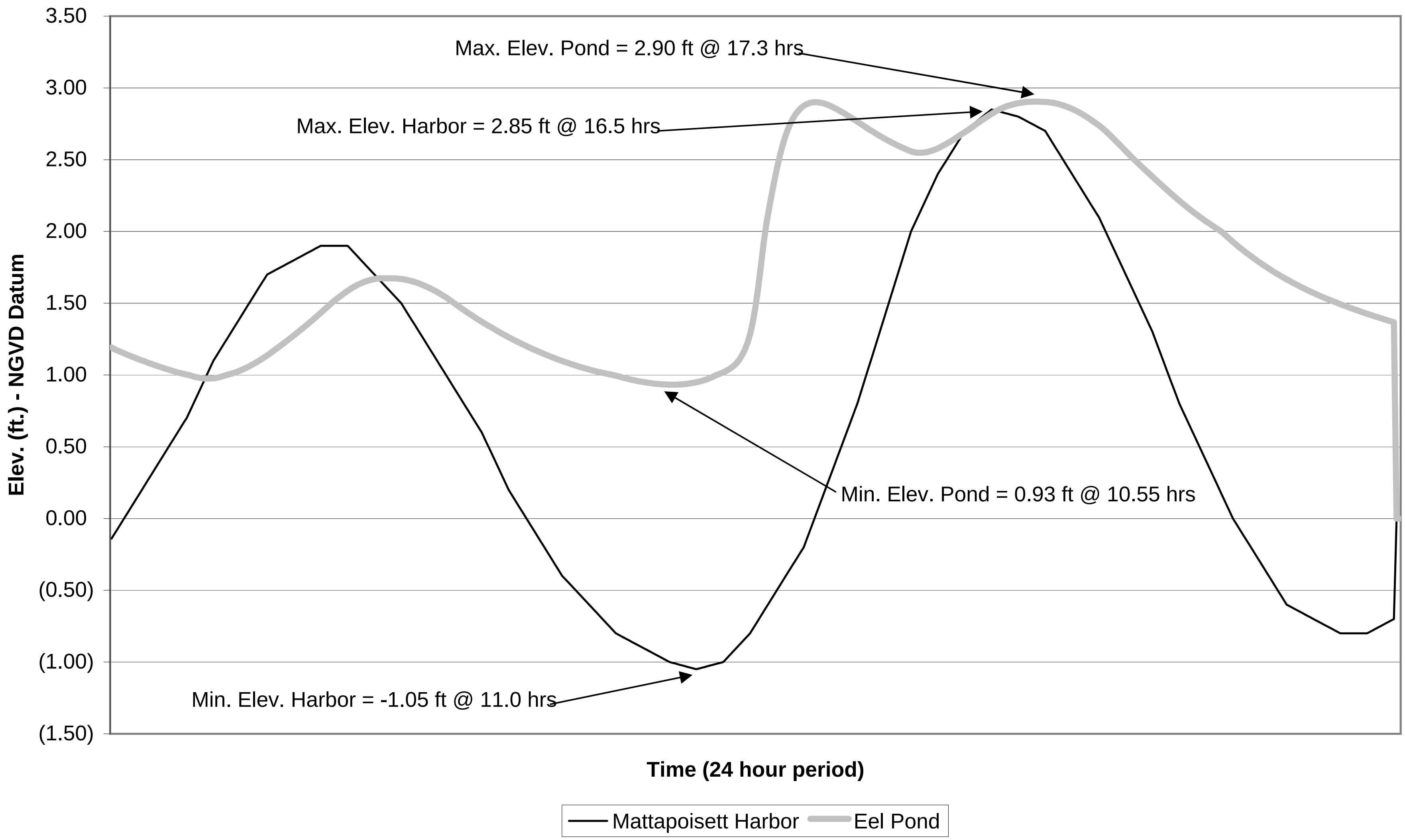


Exhibit 28

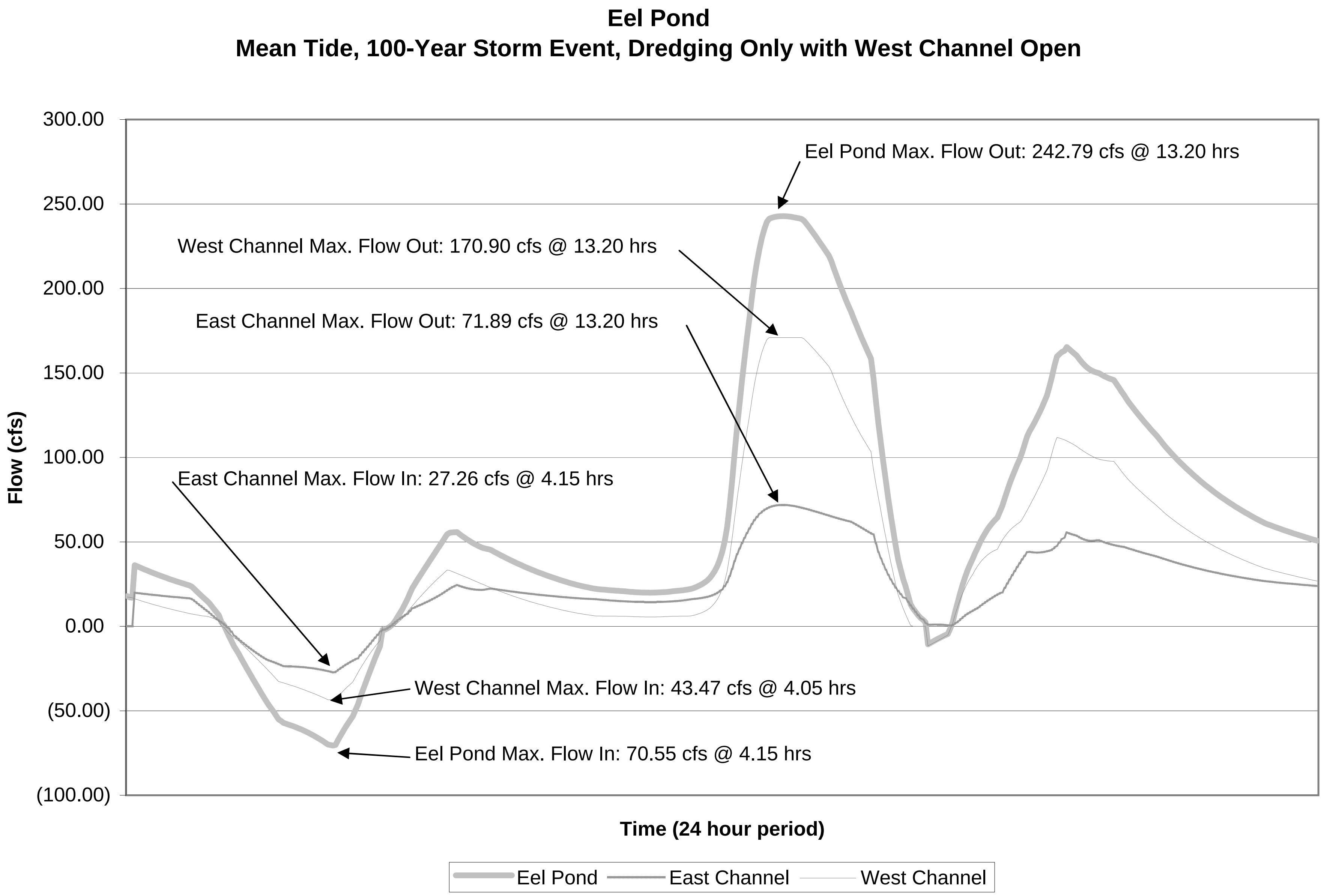

Eel Pond
Mean Tide, 100-Year Storm Event, Dredging Only with West Channel Open
300.00
250.00
200.00
150.00
100.00
50.00
0.00
(50.00)
(100.00)
Flow (cfs)
Time (24 hour period)
Eel Pond Max. Flow Out: 242.79 cfs @ 13.20 hrs
West Channel Max. Flow Out: 170.90 cfs @ 13.20 hrs
East Channel Max. Flow Out: 71.89 cfs @ 13.20 hrs
East Channel Max. Flow In: 27.26 cfs @ 4.15 hrs
West Channel Max. Flow In: 43.47 cfs @ 4.05 hrs
Eel Pond Max. Flow In: 70.55 cfs @ 4.15 hrs
Eel Pond
East Channel
West Channel

Exhibit 29

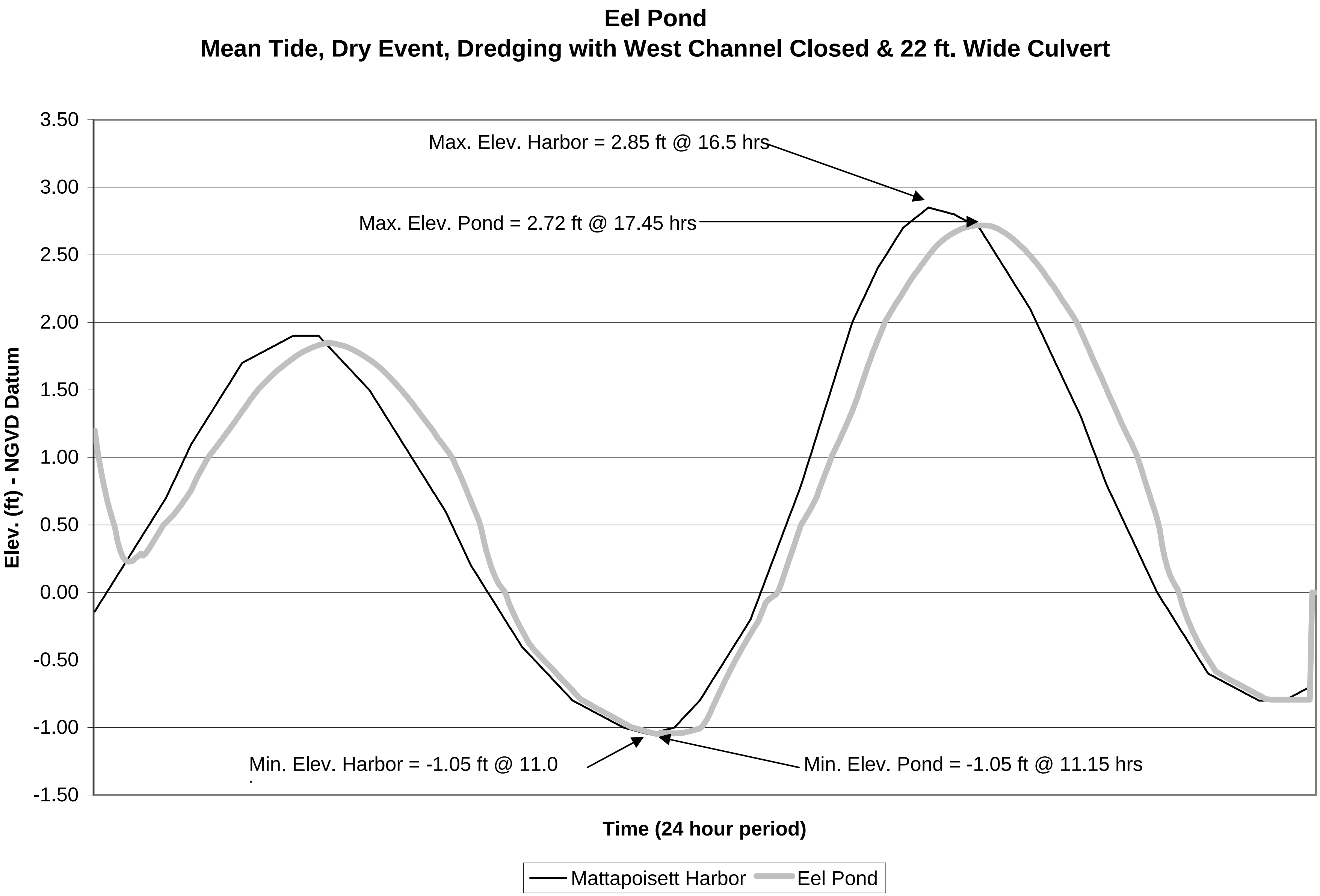

Eel Pond
Mean Tide, Dry Event, Dredging with West Channel Closed & 22 ft. Wide Culvert
Max. Elev. Harbor = 2.85 ft @ 16.5 hrs
Max. Elev. Pond = 2.72 ft @ 17.45 hrs
Min. Elev. Harbor = -1.05 ft @ 11.0
Min. Elev. Pond = -1.05 ft @ 11.15 hrs
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
Elev. (ft) - NGVD Datum
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 30

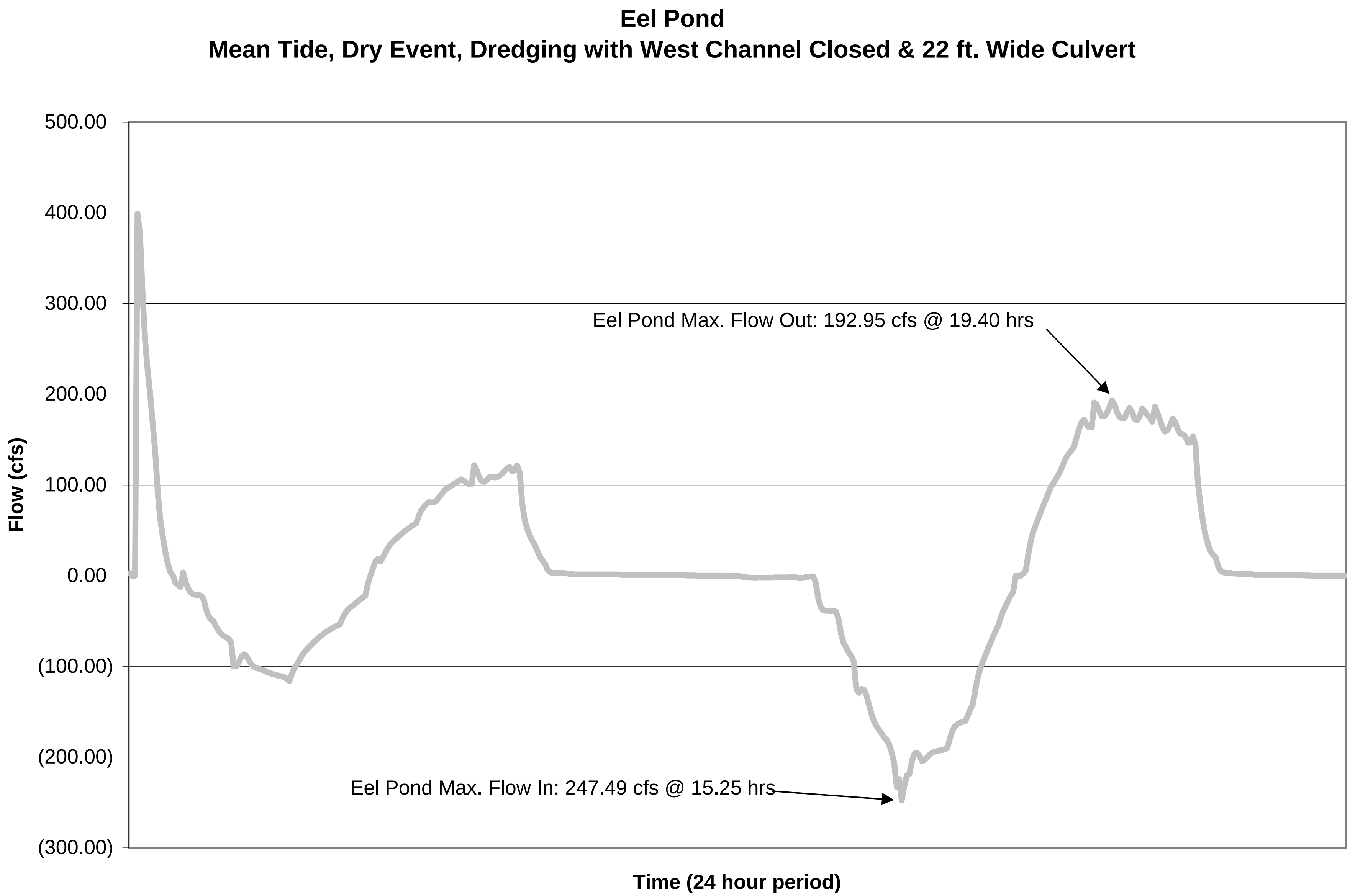

Eel Pond
Mean Tide, Dry Event, Dredging with West Channel Closed & 22 ft. Wide Culvert
500.00
400.00
300.00
200.00
100.00
0.00
(100.00)
(200.00)
(300.00)
Flow (cfs)
Eel Pond Max. Flow Out: 192.95 cfs @ 19.40 hrs
Eel Pond Max. Flow In: 247.49 cfs @ 15.25 hrs
Time (24 hour period)

Exhibit 31

Eel Pond
Mean Tide, 2-Year Storm Event, Dredging with West Channel Closed & 22 ft. Wide Culvert

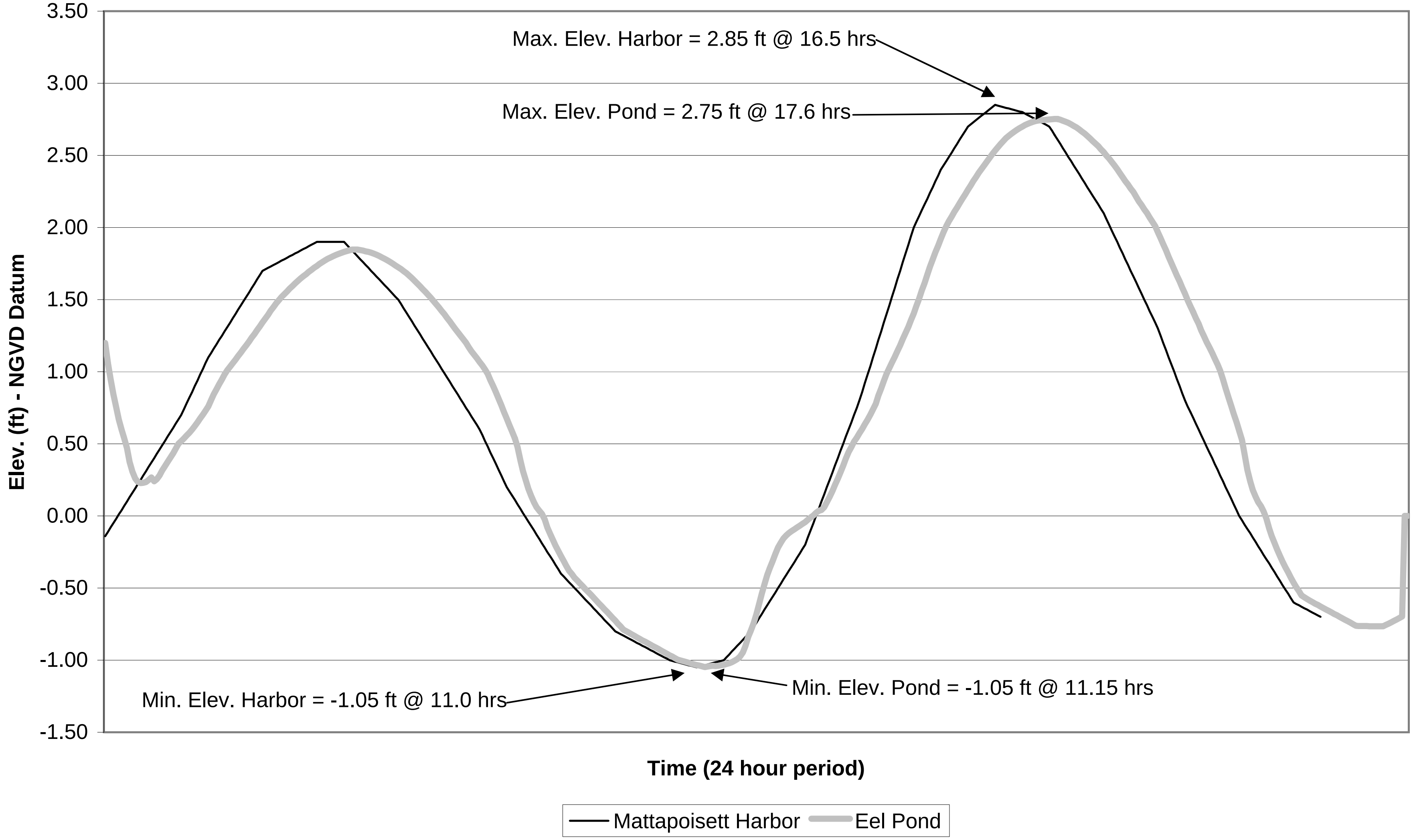


Exhibit 32

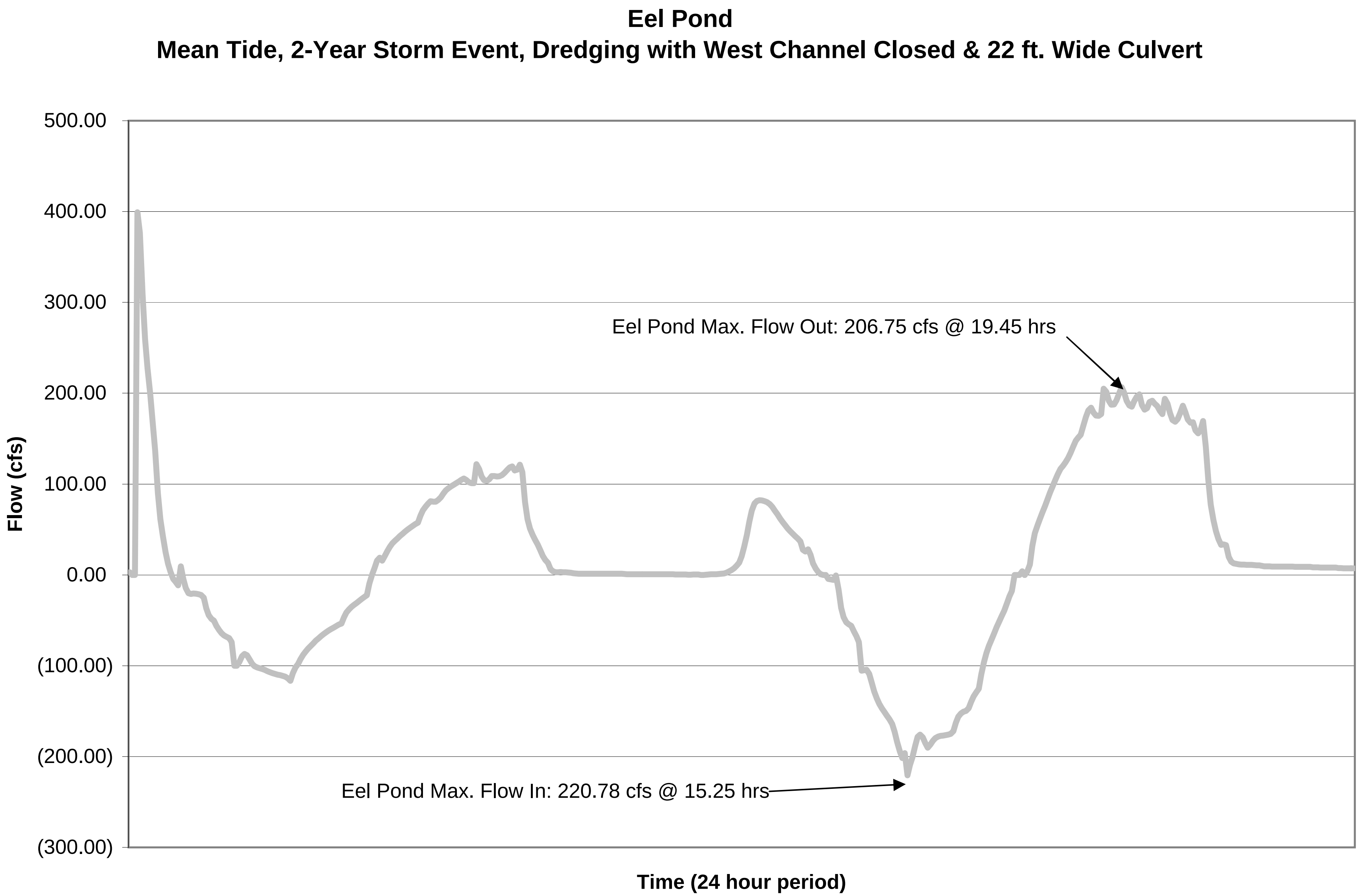

Eel Pond
Mean Tide, 2-Year Storm Event, Dredging with West Channel Closed & 22 ft. Wide Culvert
500.00
400.00
300.00
200.00
100.00
0.00
(100.00)
(200.00)
(300.00)
Flow (cfs)
Eel Pond Max. Flow Out: 206.75 cfs @ 19.45 hrs
Eel Pond Max. Flow In: 220.78 cfs @ 15.25 hrs
Time (24 hour period)

Exhibit 33

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 10 ft. Wide Culvert

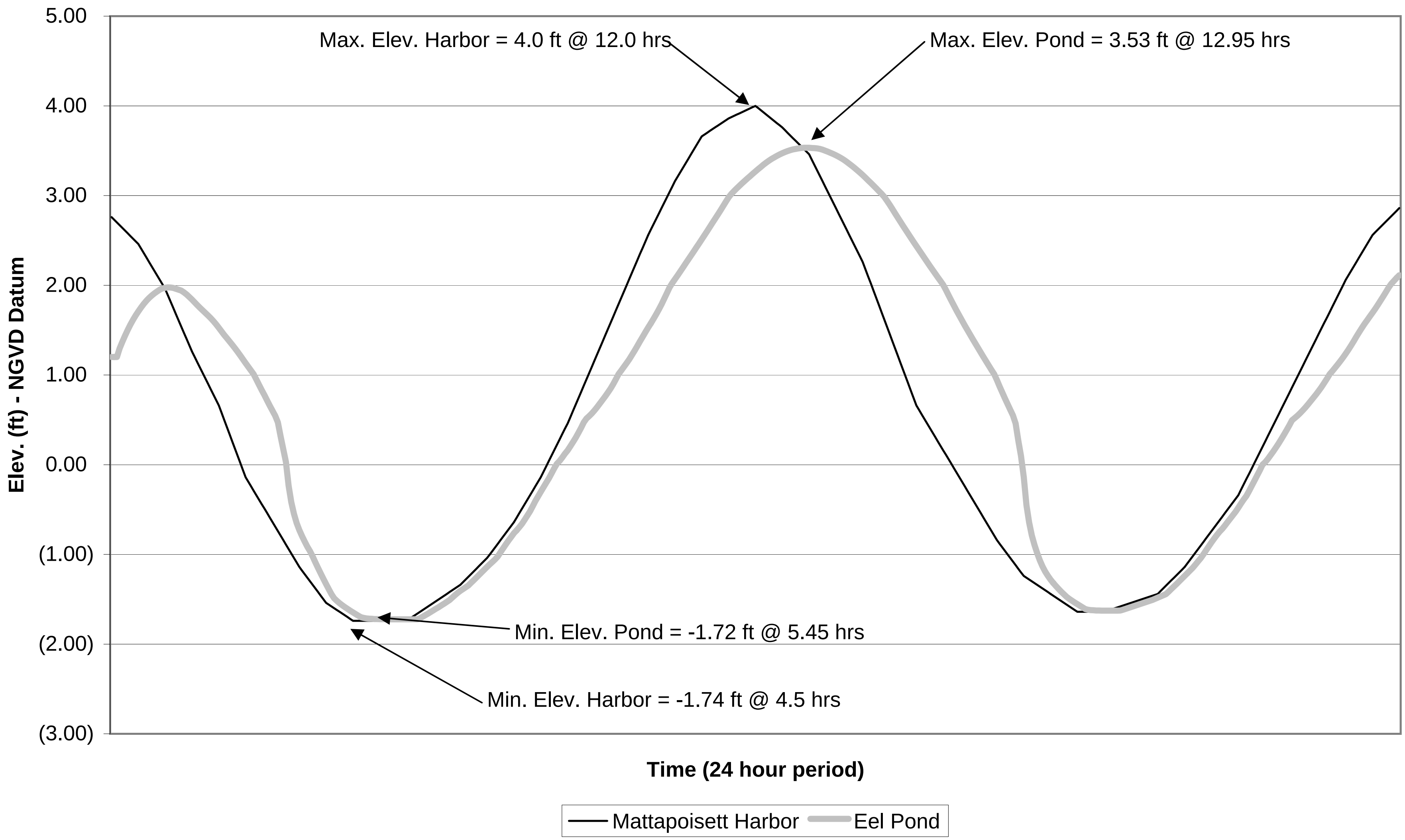


Exhibit 34

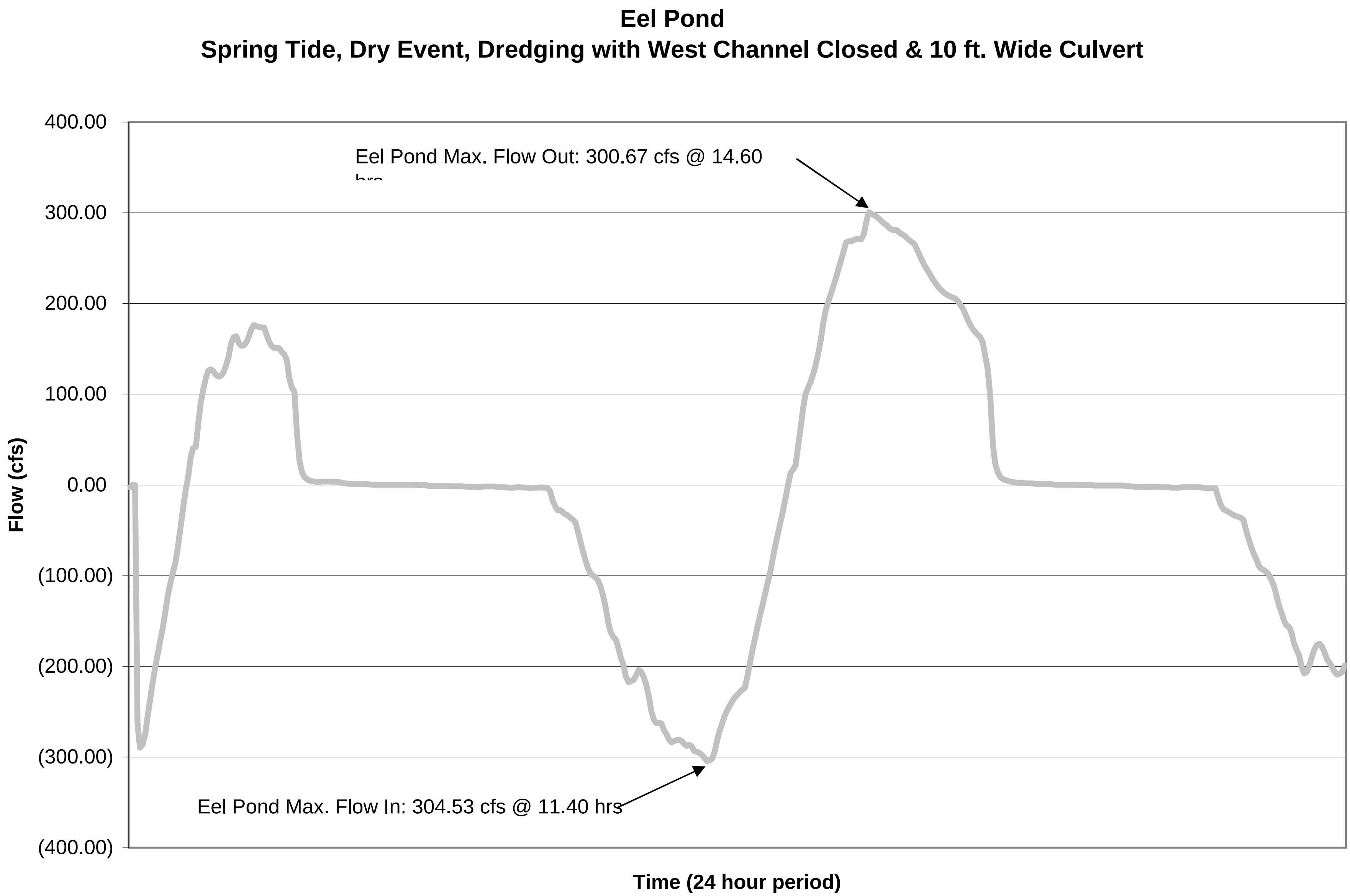

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 10 ft. Wide Culvert
400.00
300.00
200.00
100.00
0.00
(100.00)
(200.00)
(300.00)
(400.00)
Flow (cfs)
Eel Pond Max. Flow Out: 300.67 cfs @ 14.60 hrs
Eel Pond Max. Flow In: 304.53 cfs @ 11.40 hrs
Time (24 hour period)

Exhibit 35

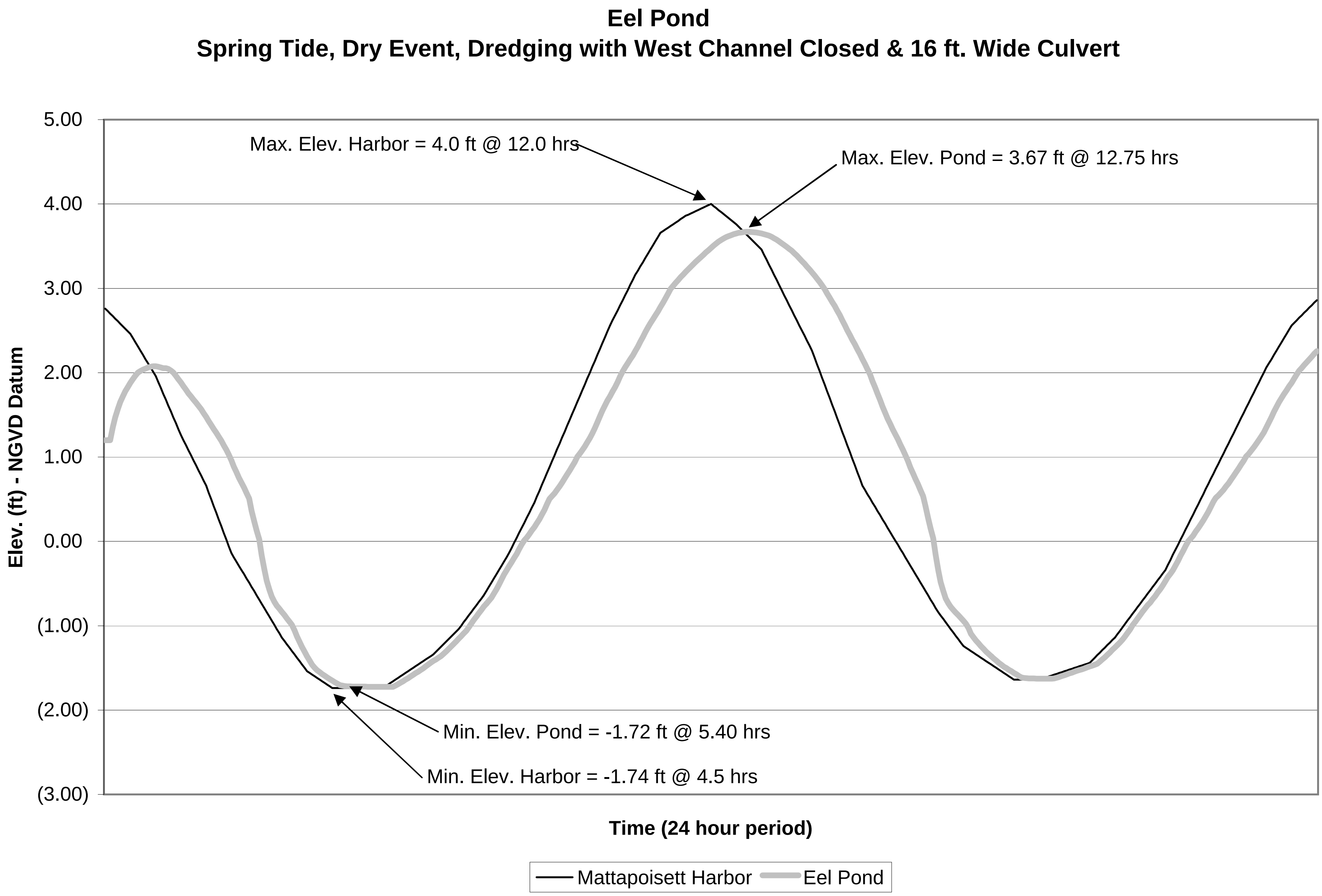
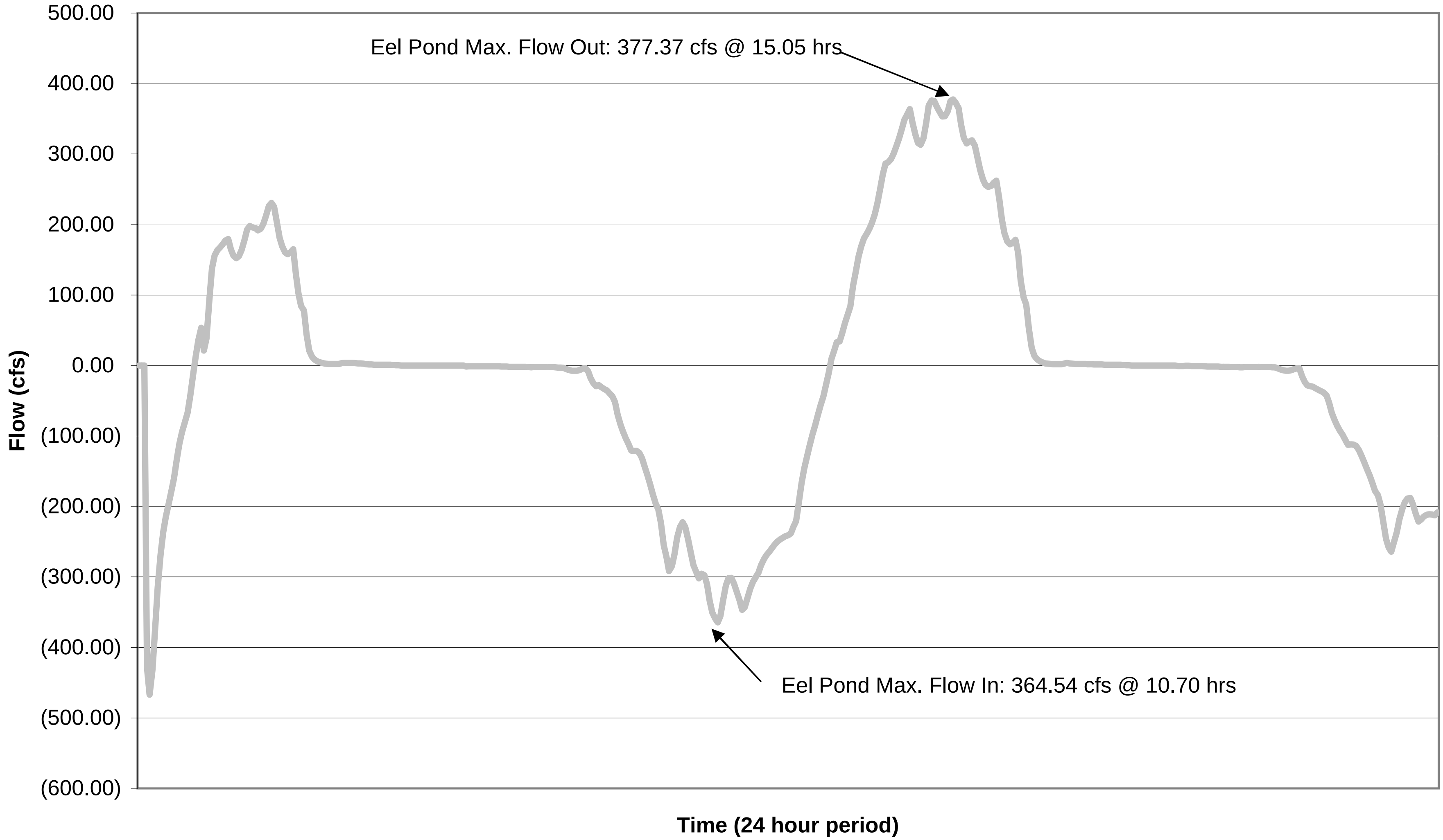

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 16 ft. Wide Culvert
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Max. Elev. Harbor = 4.0 ft @ 12.0 hrs
Max. Elev. Pond = 3.67 ft @ 12.75 hrs
Min. Elev. Pond = -1.72 ft @ 5.40 hrs
Min. Elev. Harbor = -1.74 ft @ 4.5 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 36

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 16 ft. Wide Culvert



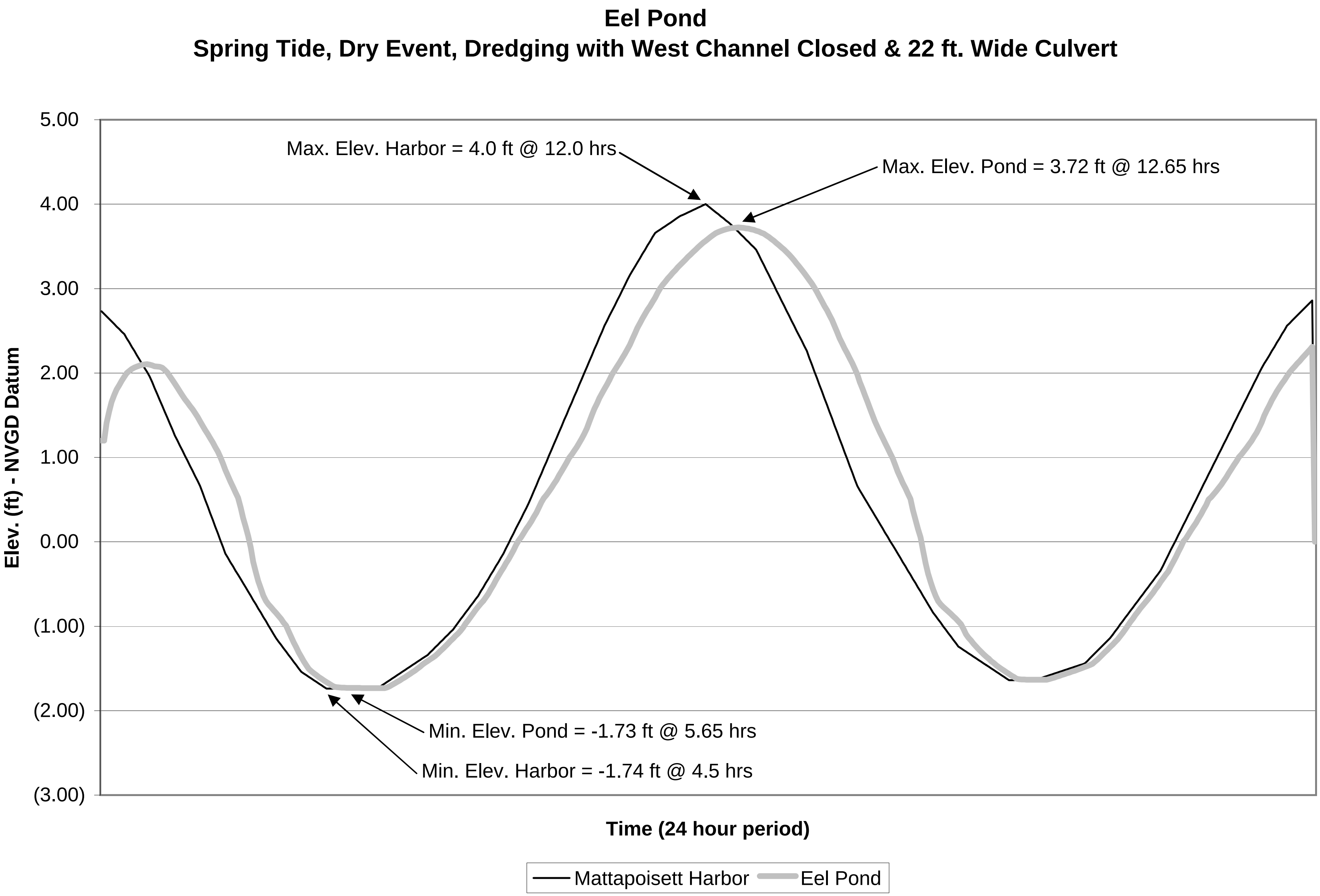

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 22 ft. Wide Culvert
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NVGD Datum
Max. Elev. Harbor = 4.0 ft @ 12.0 hrs
Max. Elev. Pond = 3.72 ft @ 12.65 hrs
Min. Elev. Pond = -1.73 ft @ 5.65 hrs
Min. Elev. Harbor = -1.74 ft @ 4.5 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 38

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 22 ft. Wide Culvert

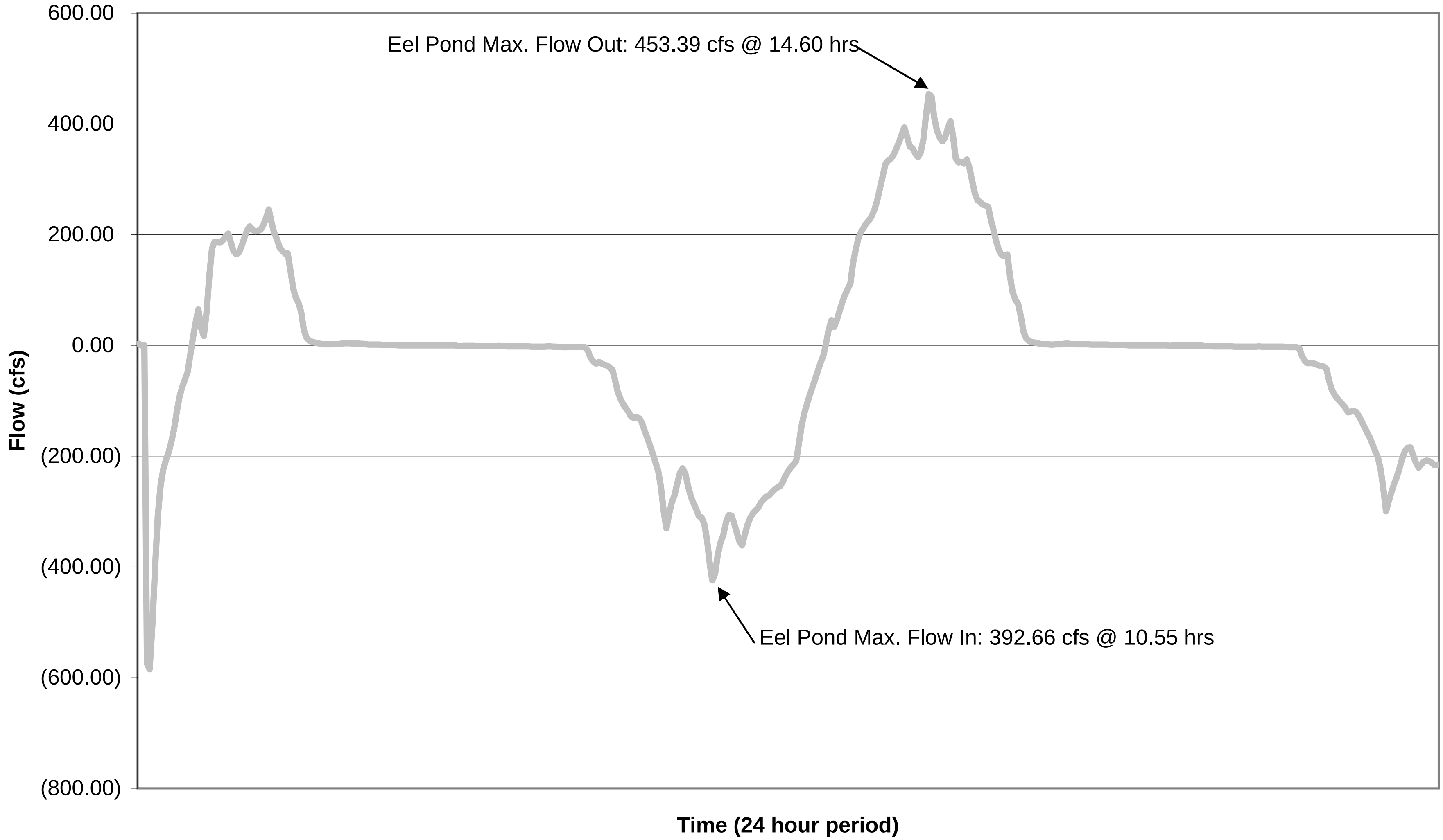


Exhibit 39

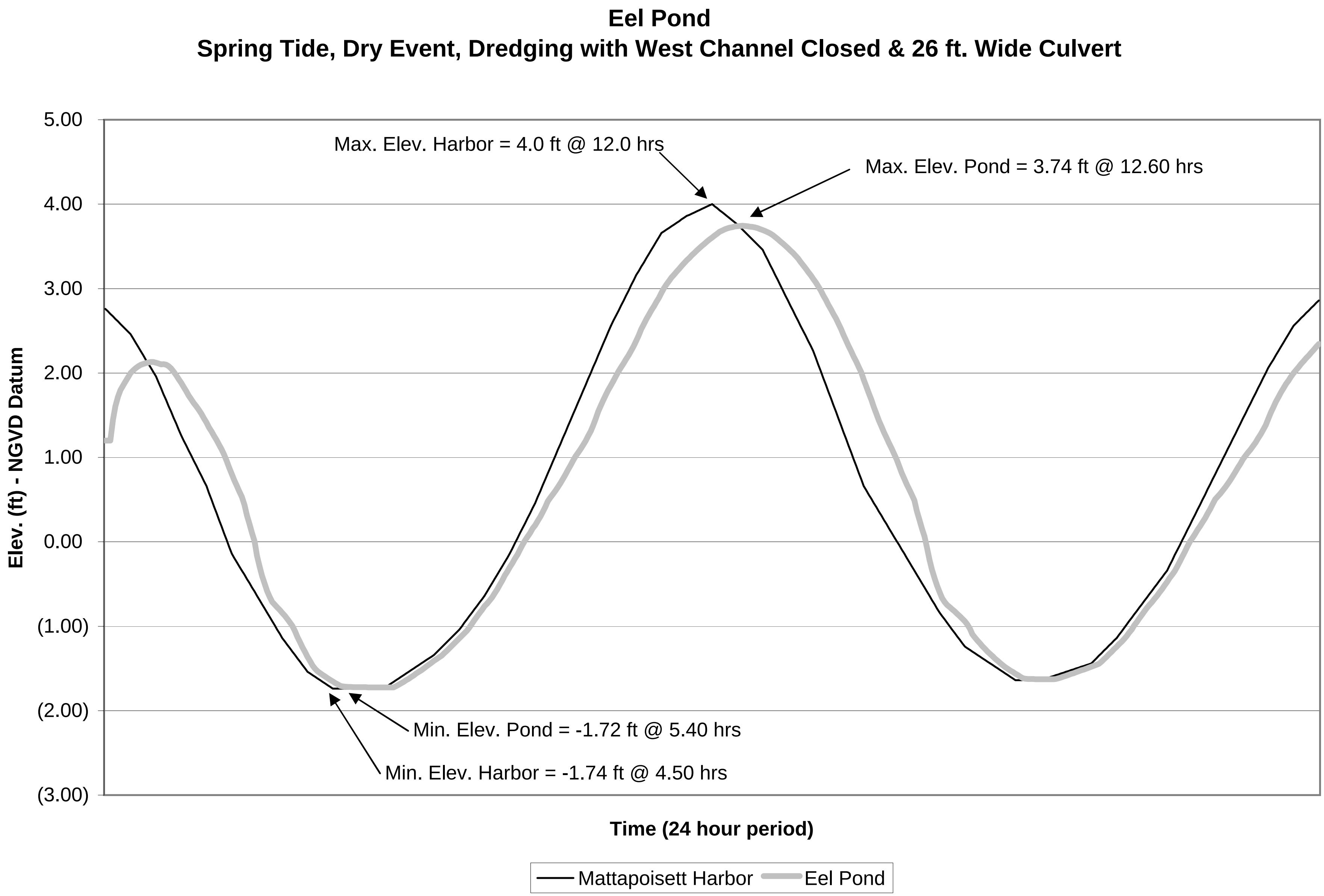

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 26 ft. Wide Culvert
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Max. Elev. Harbor = 4.0 ft @ 12.0 hrs
Max. Elev. Pond = 3.74 ft @ 12.60 hrs
Min. Elev. Pond = -1.72 ft @ 5.40 hrs
Min. Elev. Harbor = -1.74 ft @ 4.50 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 40

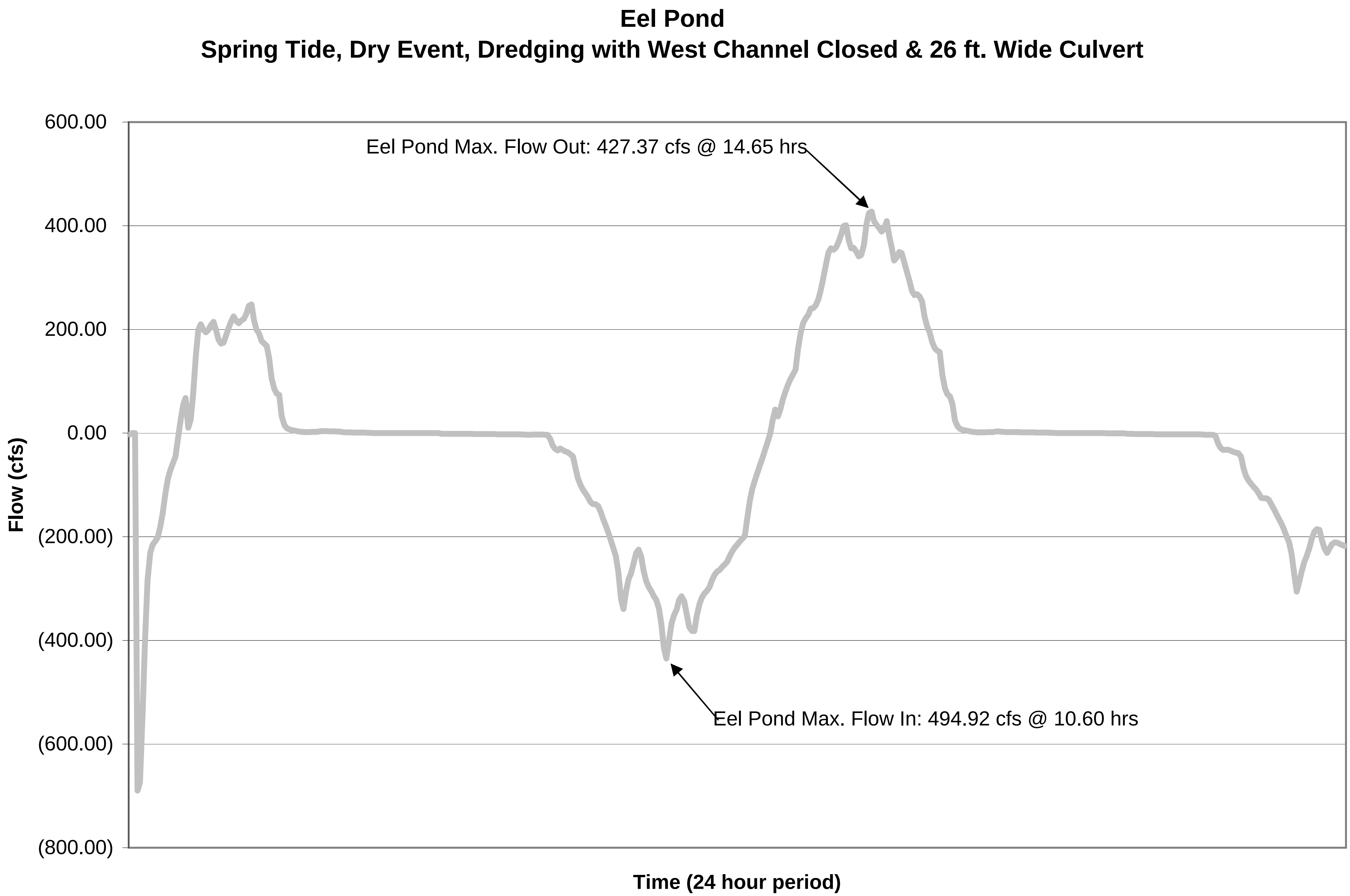

Eel Pond
Spring Tide, Dry Event, Dredging with West Channel Closed & 26 ft. Wide Culvert
600.00
400.00
200.00
0.00
(200.00)
(400.00)
(600.00)
(800.00)
Flow (cfs)
Eel Pond Max. Flow Out: 427.37 cfs @ 14.65 hrs
Eel Pond Max. Flow In: 494.92 cfs @ 10.60 hrs
Time (24 hour period)

Exhibit 41

Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 10 ft. Wide Culvert

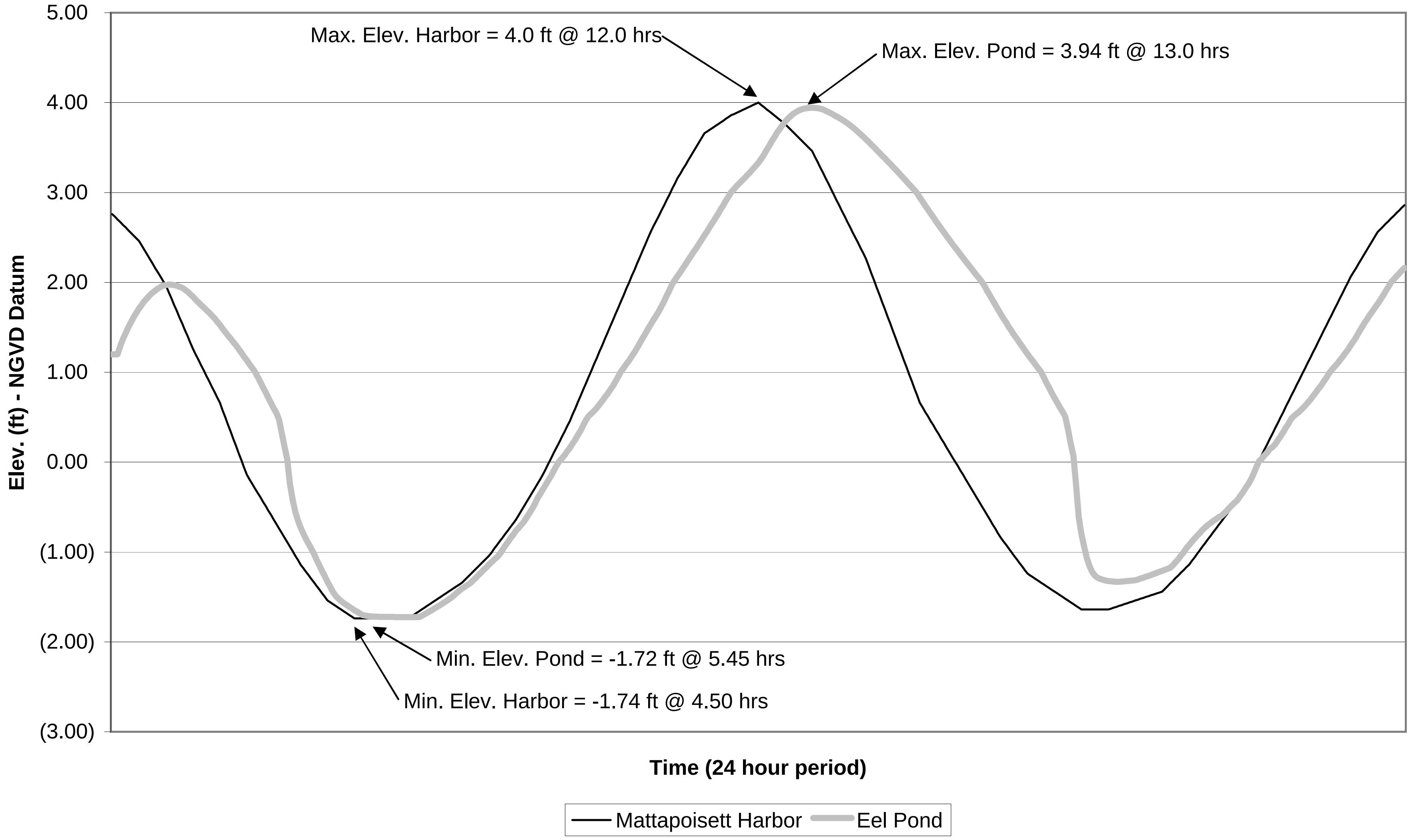
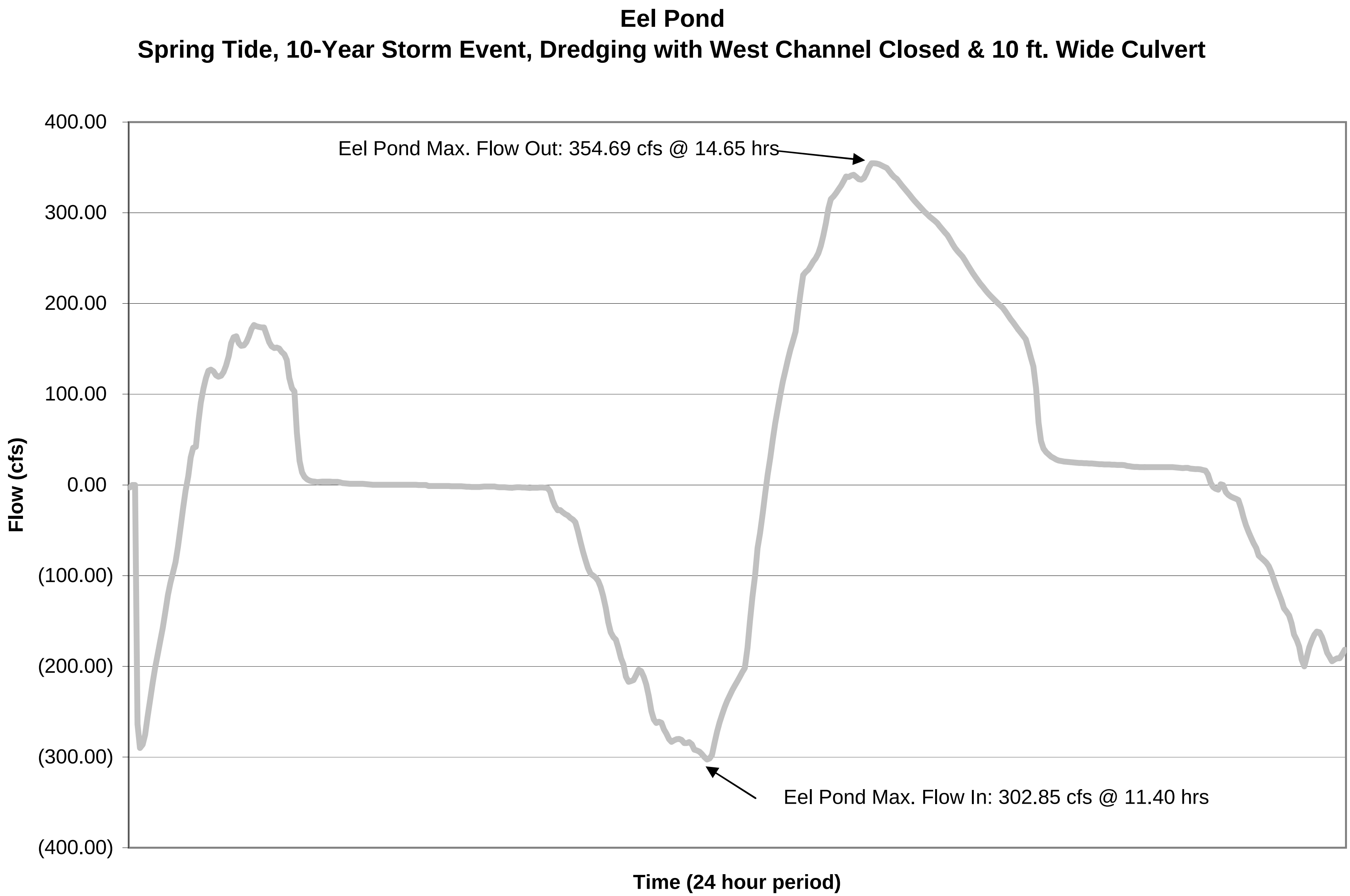


Exhibit 42


Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 10 ft. Wide Culvert
Eel Pond Max. Flow Out: 354.69 cfs @ 14.65 hrs
Eel Pond Max. Flow In: 302.85 cfs @ 11.40 hrs
400.00
300.00
200.00
100.00
0.00
(100.00)
(200.00)
(300.00)
(400.00)
Flow (cfs)
Time (24 hour period)

Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 16 ft. Wide Culvert

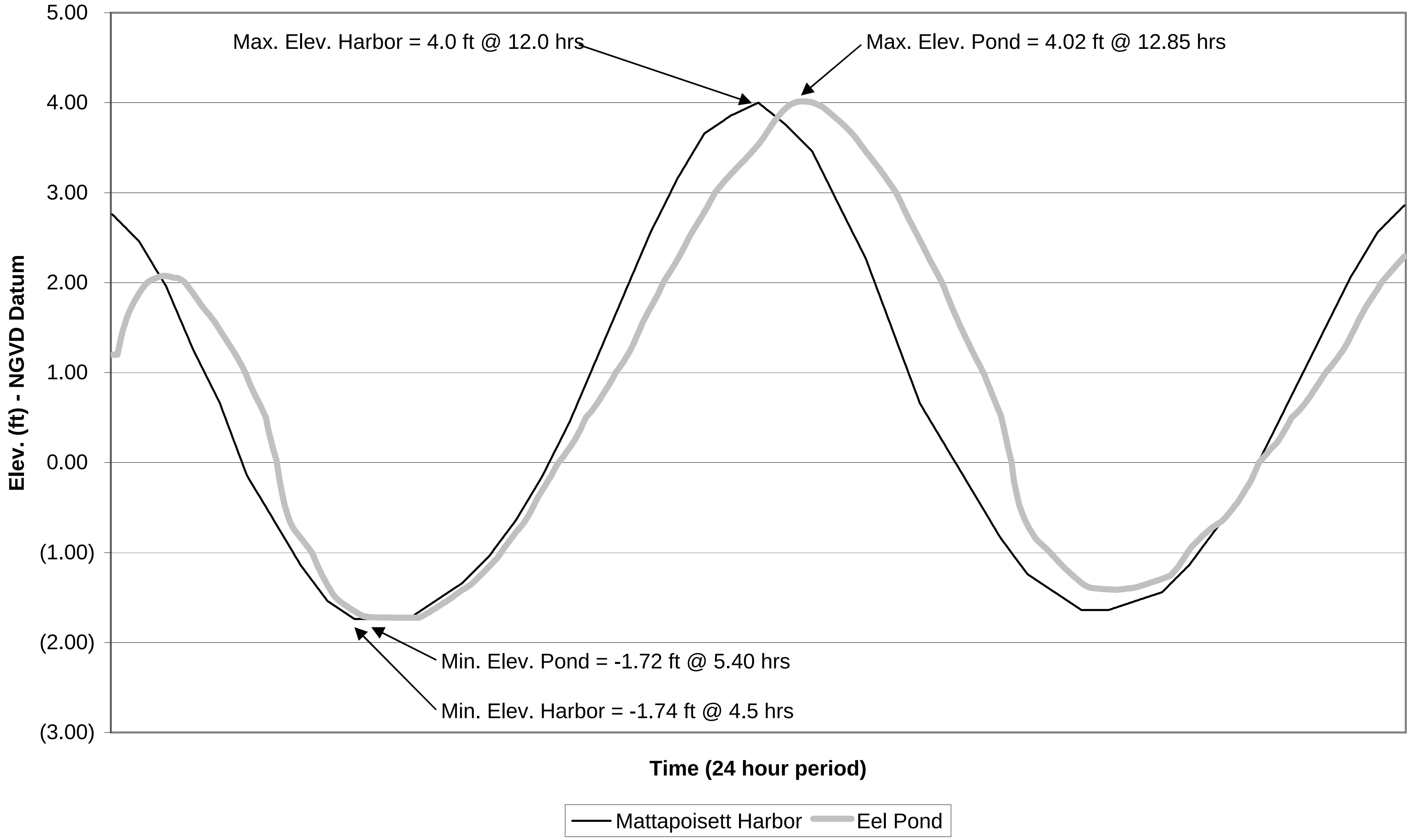


Exhibit 44

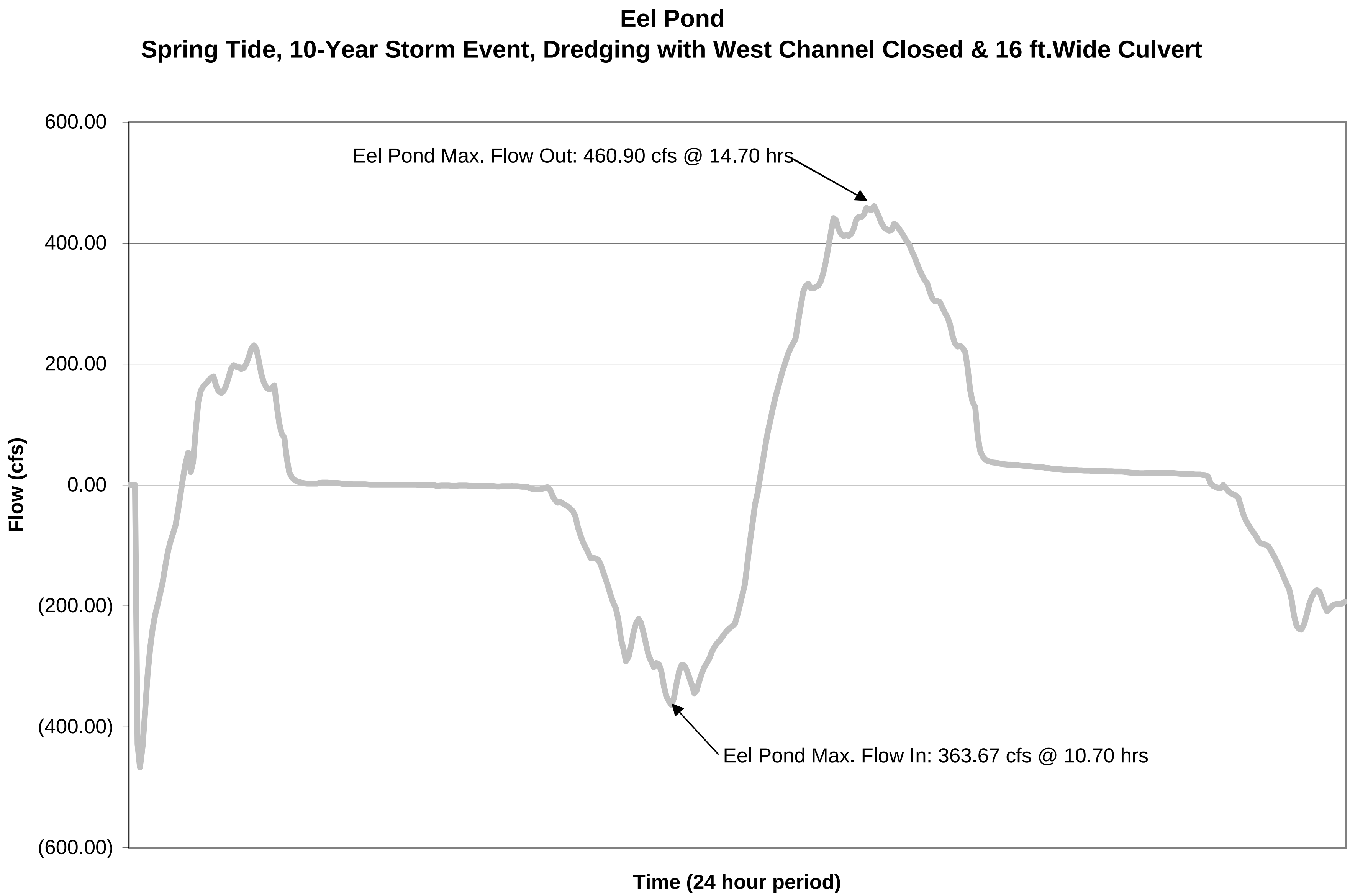

Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 16 ft.Wide Culvert
600.00
400.00
200.00
0.00
(200.00)
(400.00)
(600.00)
Flow (cfs)
Eel Pond Max. Flow Out: 460.90 cfs @ 14.70 hrs
Eel Pond Max. Flow In: 363.67 cfs @ 10.70 hrs
Time (24 hour period)

Exhibit 45

Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 22 ft. Wide Culvert

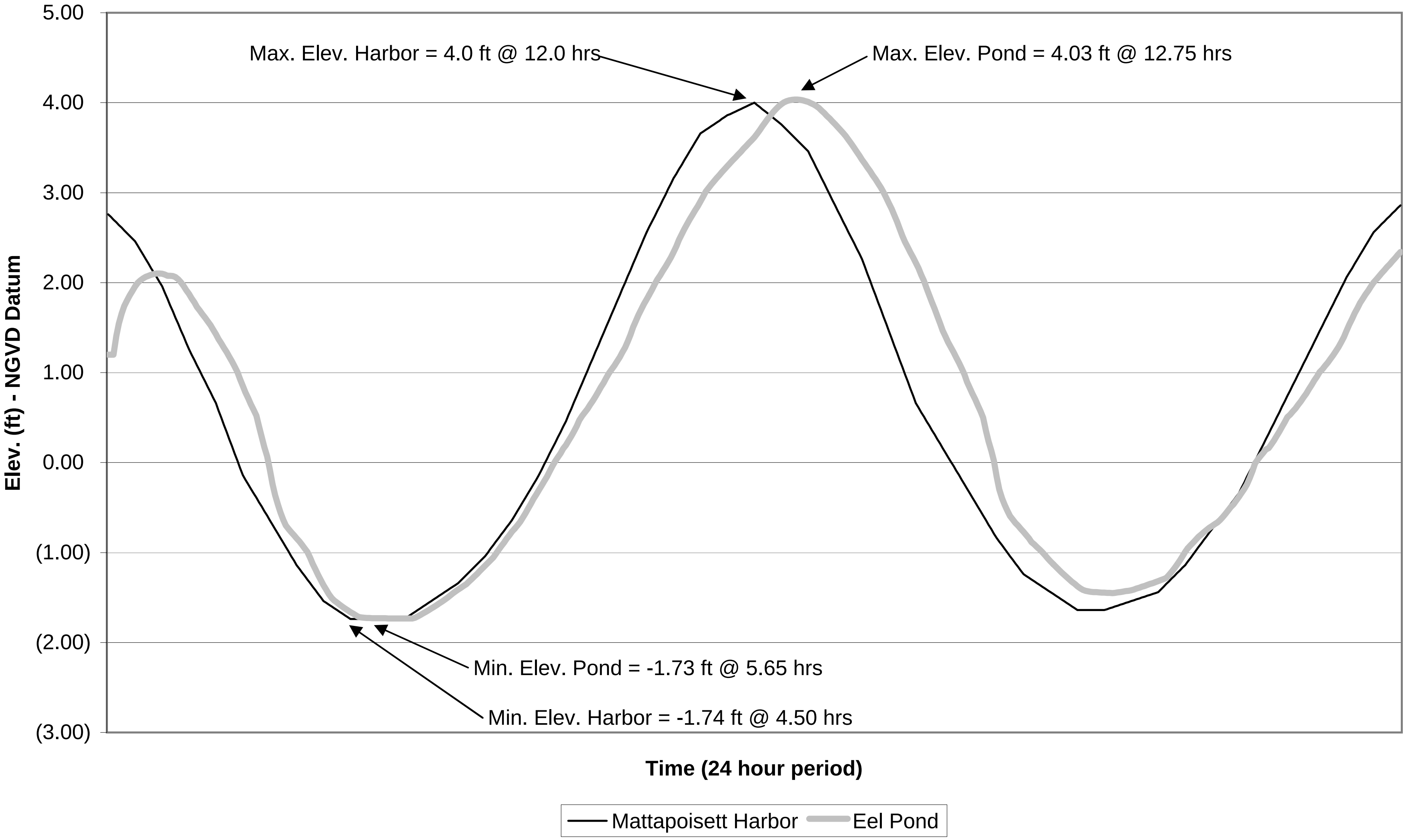


Exhibit 46

Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 22 ft. Wide Culvert

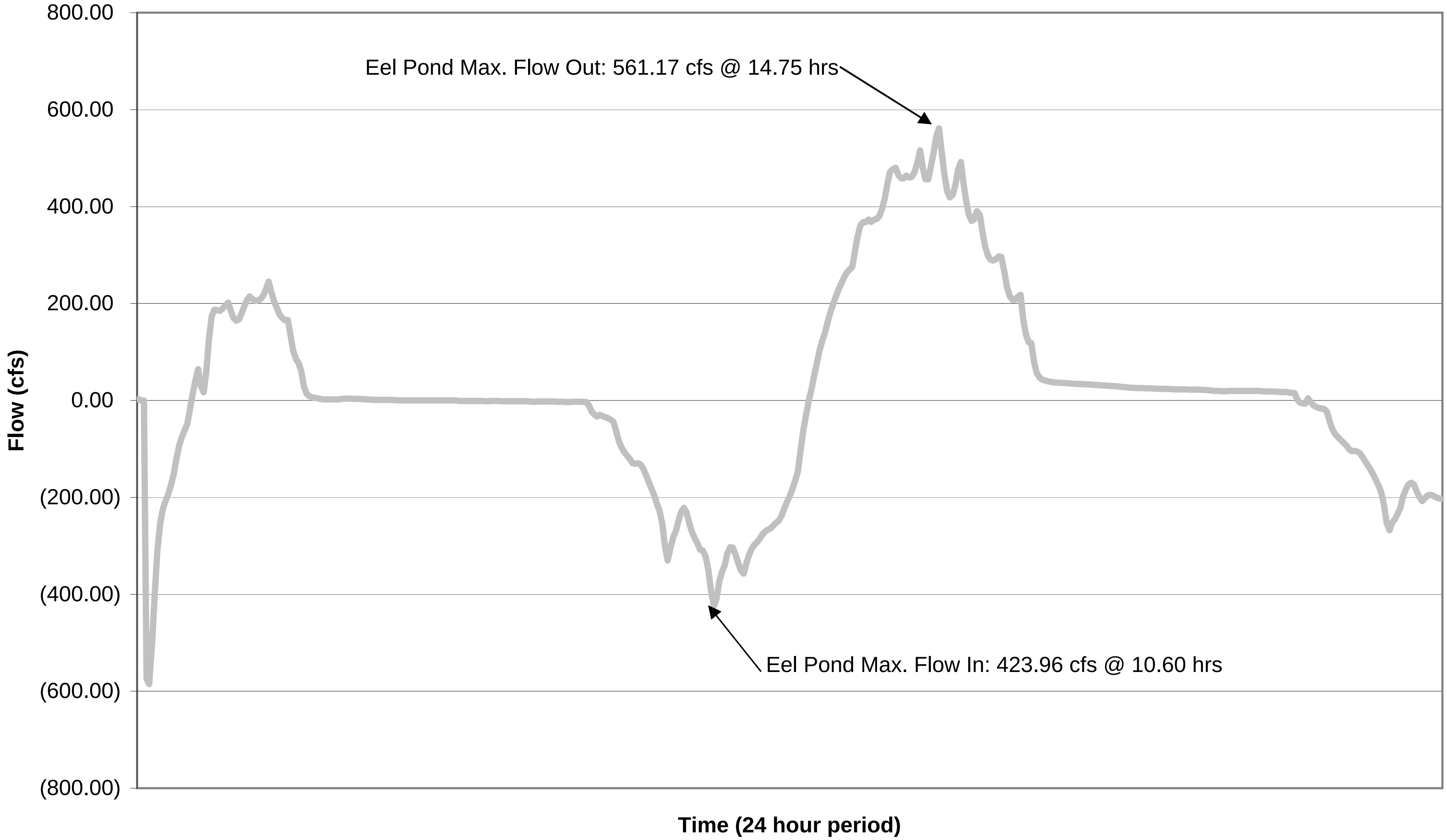


Exhibit 47

Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 26 ft. Wide Culvert

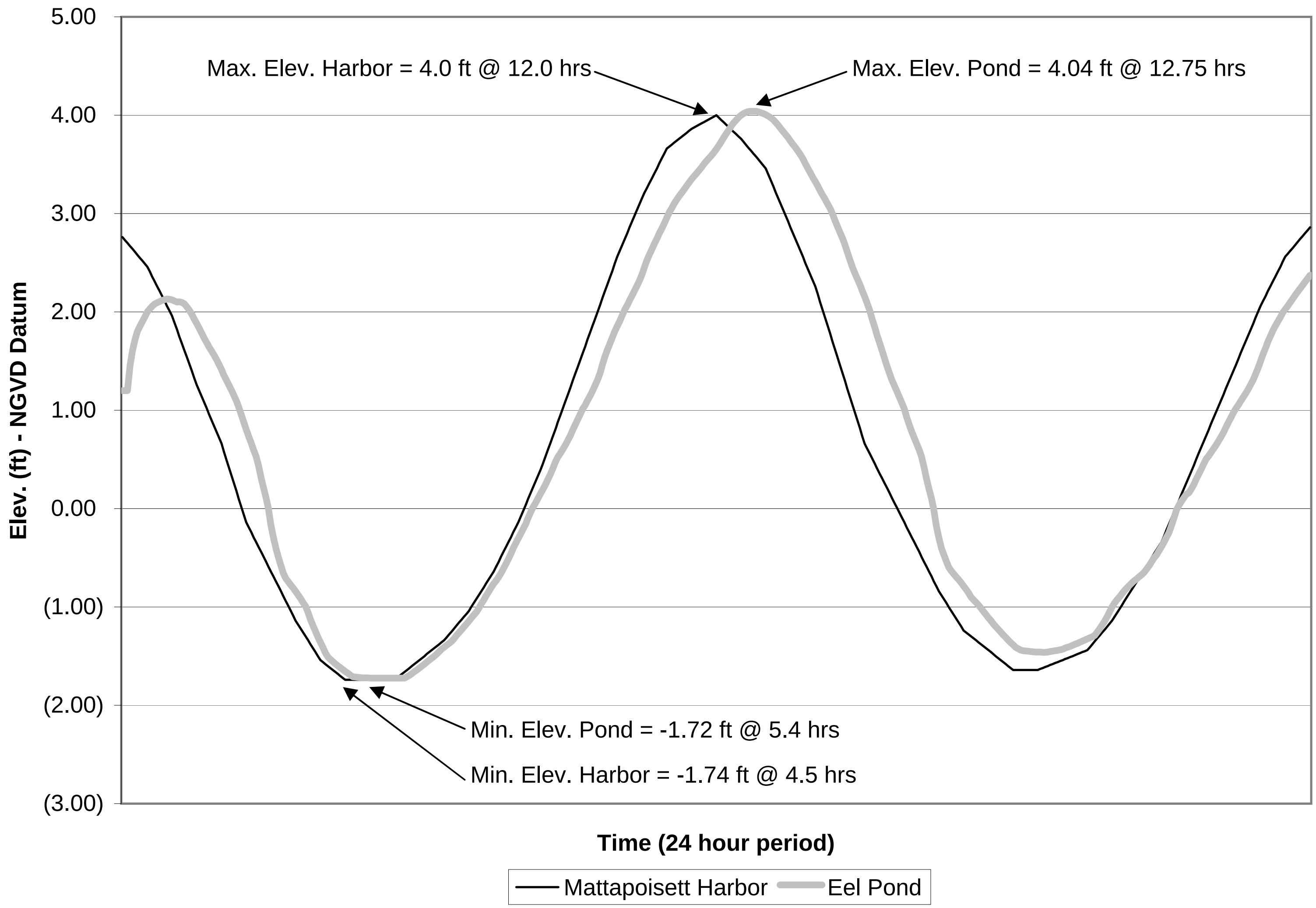


Exhibit 48

Eel Pond
Spring Tide, 10-Year Storm Event, Dredging with West Channel Closed & 26 ft. Wide Culvert

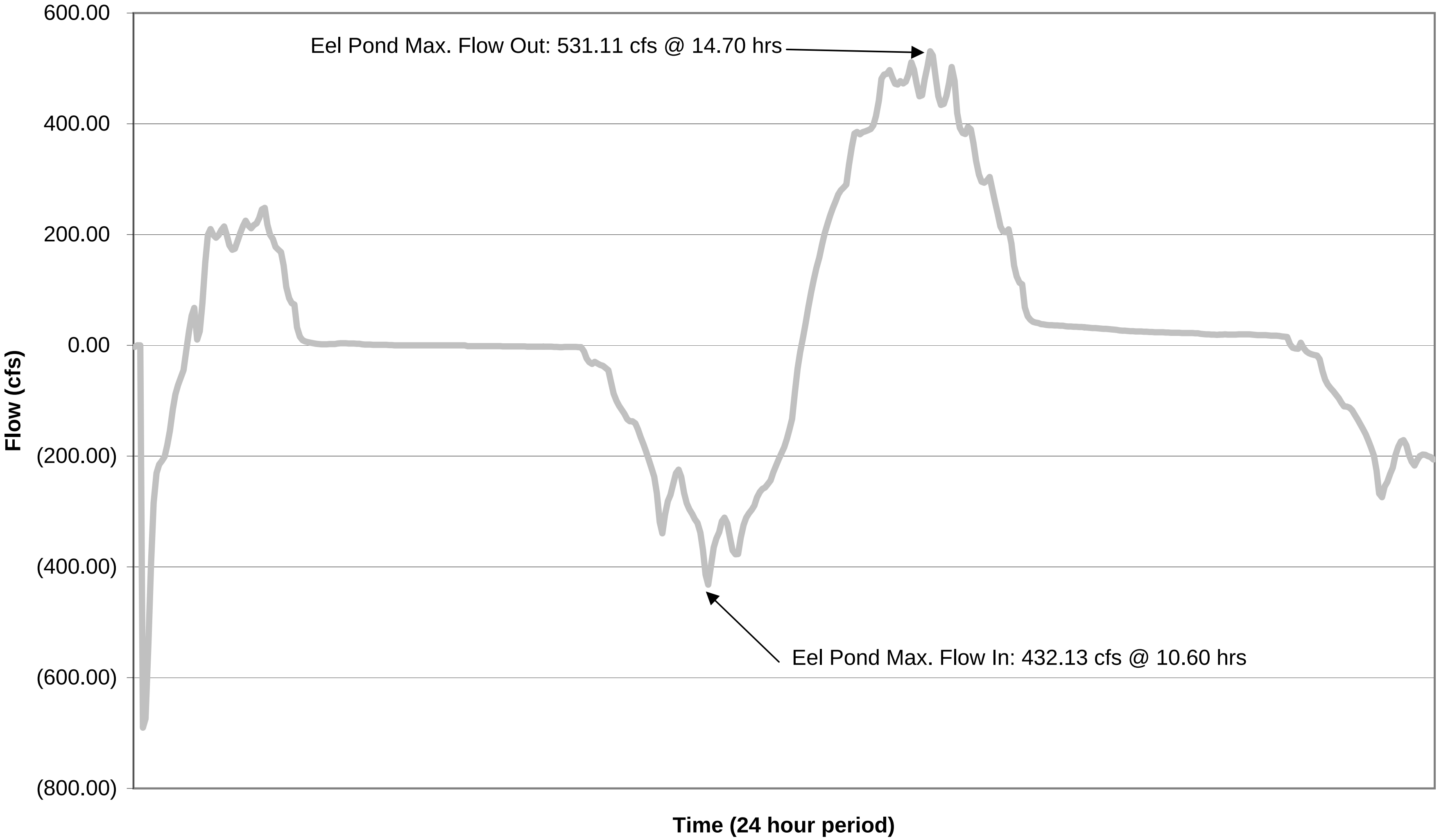


Exhibit 49

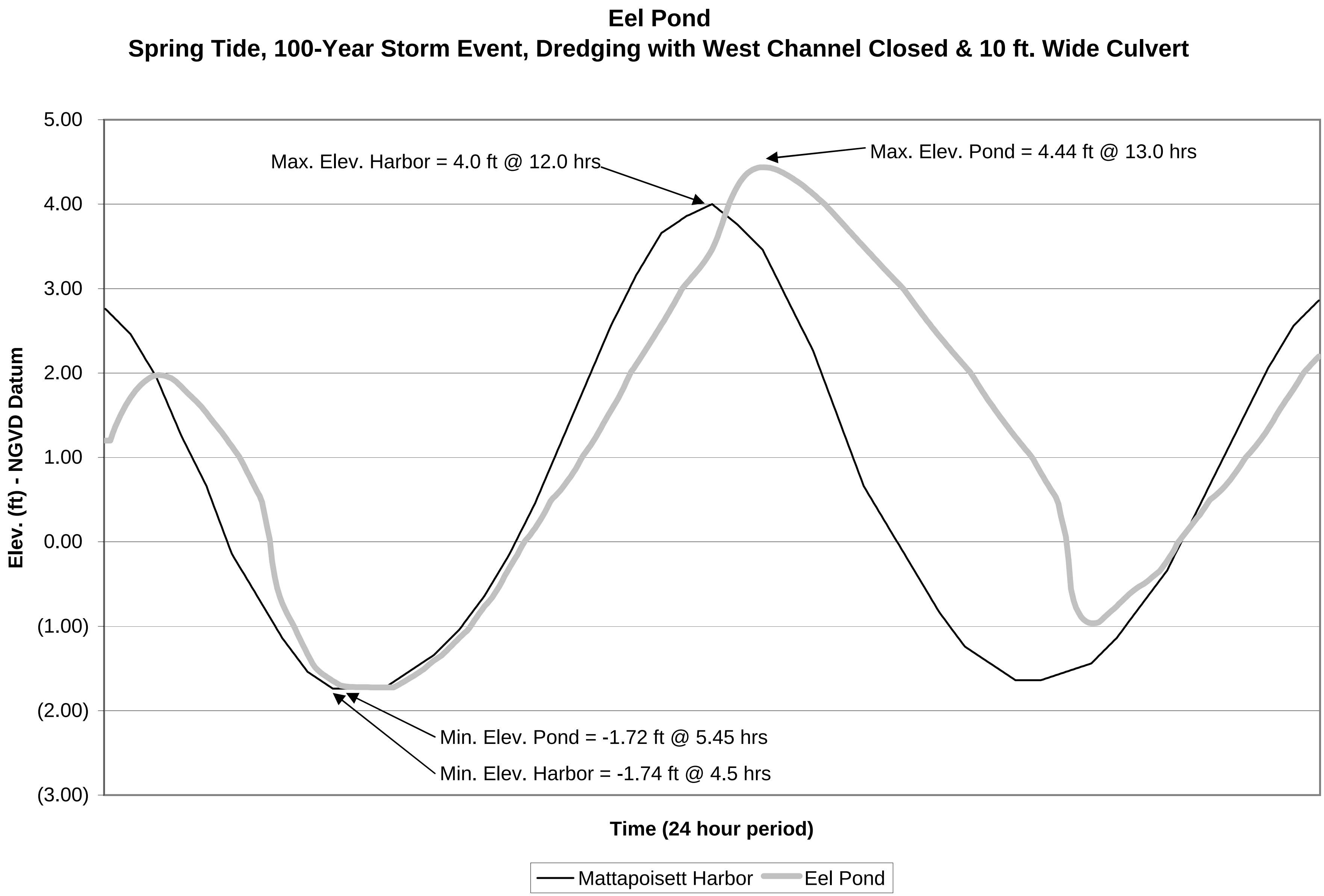

Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 10 ft. Wide Culvert
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Max. Elev. Harbor = 4.0 ft @ 12.0 hrs
Max. Elev. Pond = 4.44 ft @ 13.0 hrs
Min. Elev. Pond = -1.72 ft @ 5.45 hrs
Min. Elev. Harbor = -1.74 ft @ 4.5 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 50

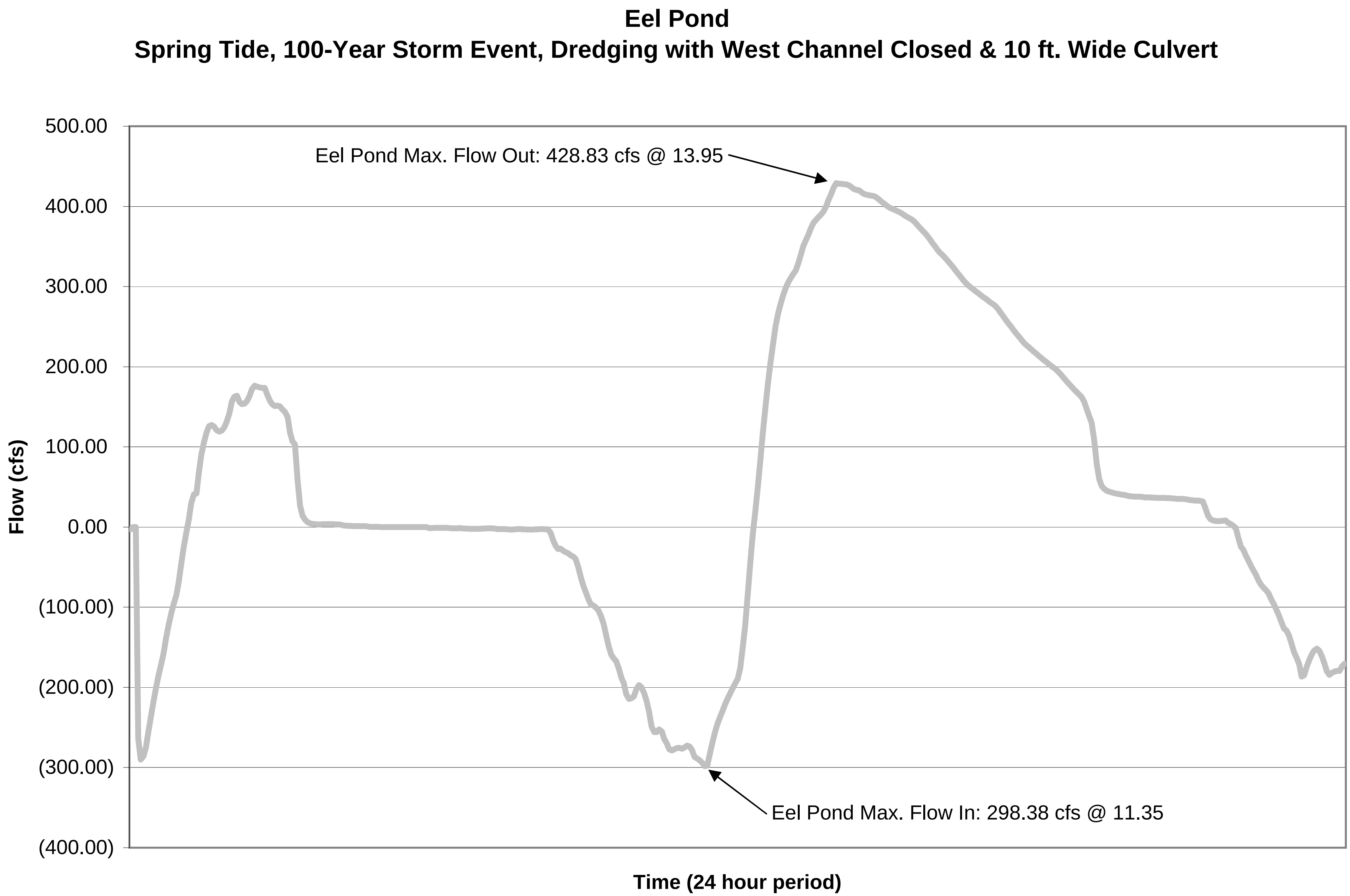

Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 10 ft. Wide Culvert
500.00
400.00
300.00
200.00
100.00
0.00
(100.00)
(200.00)
(300.00)
(400.00)
Flow (cfs)
Eel Pond Max. Flow Out: 428.83 cfs @ 13.95
Eel Pond Max. Flow In: 298.38 cfs @ 11.35
Time (24 hour period)

Exhibit 51

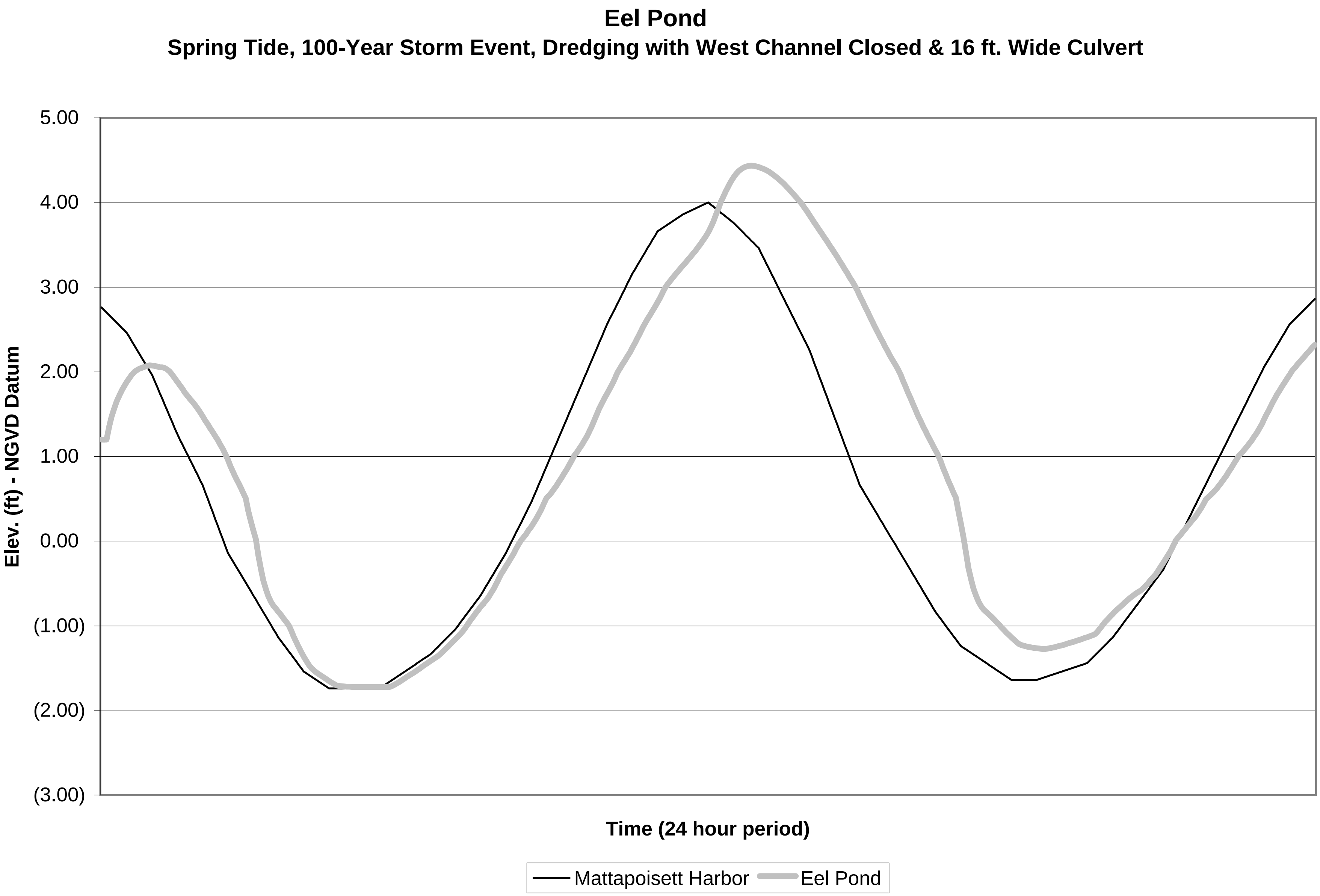

Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 16 ft. Wide Culvert
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 52

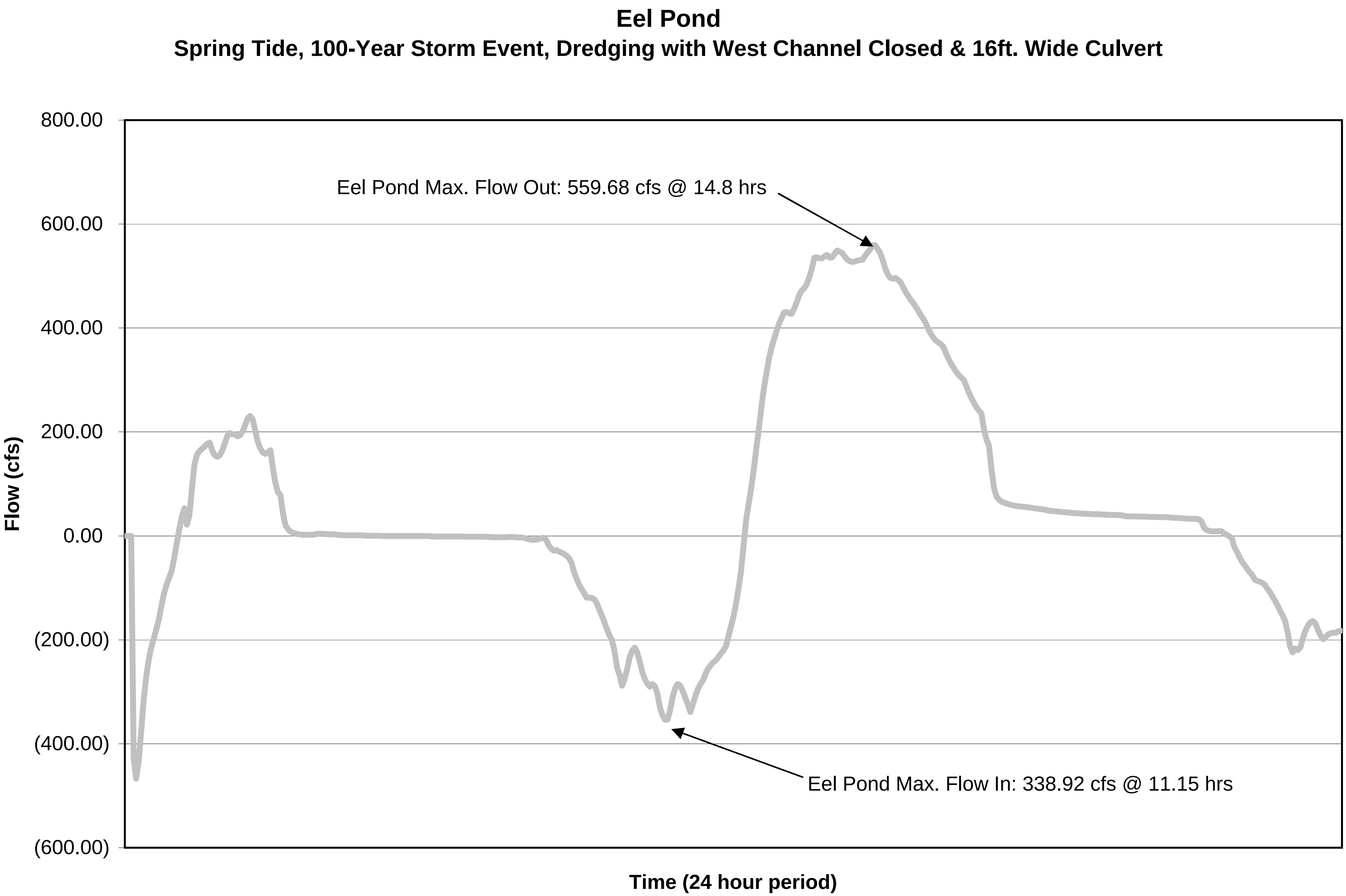

Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 16ft. Wide Culvert
800.00
600.00
400.00
200.00
0.00
(200.00)
(400.00)
(600.00)
Flow (cfs)
Eel Pond Max. Flow Out: 559.68 cfs @ 14.8 hrs
Eel Pond Max. Flow In: 338.92 cfs @ 11.15 hrs
Time (24 hour period)

Exhibit 53

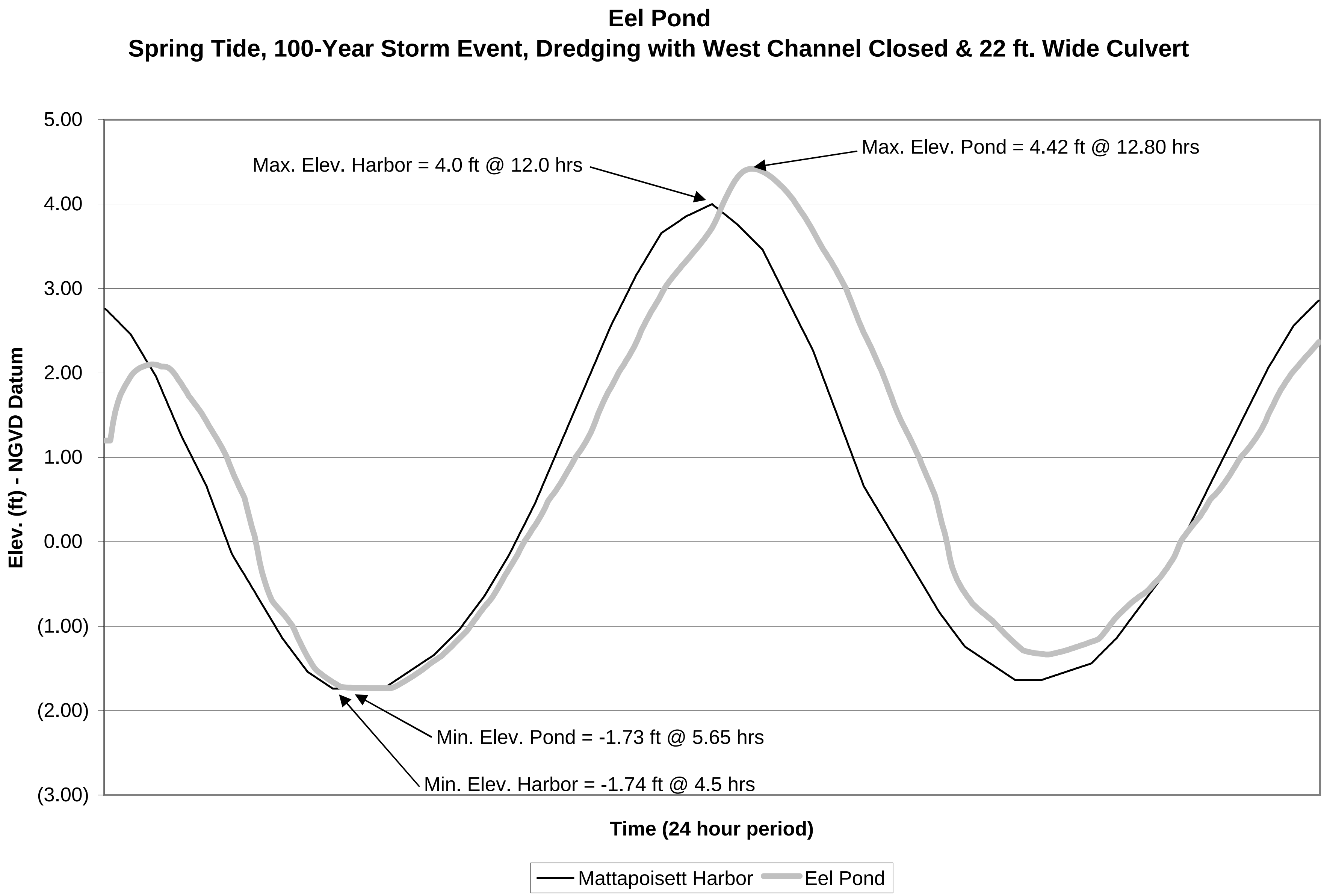
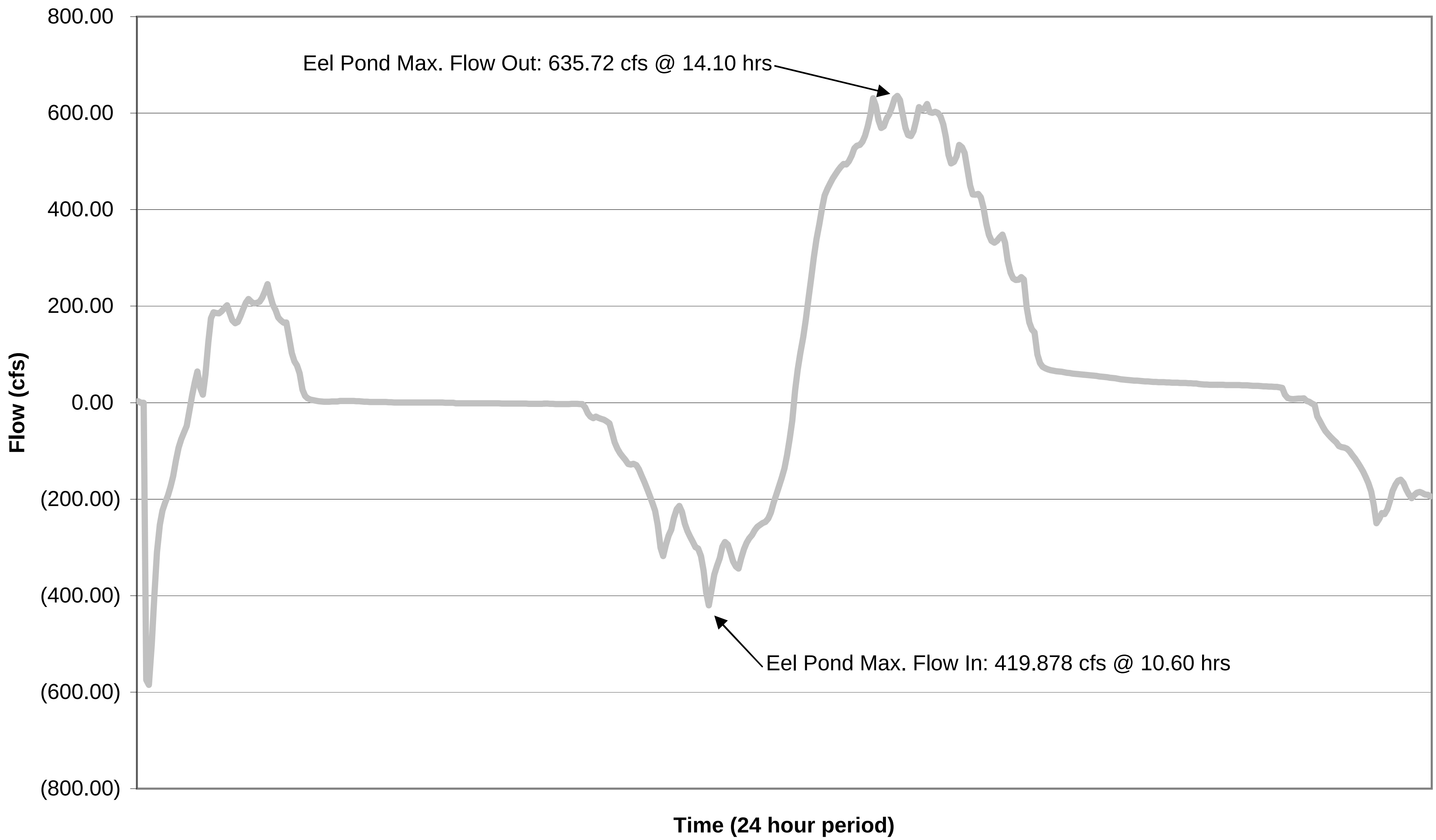

Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 22 ft. Wide Culvert
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Max. Elev. Harbor = 4.0 ft @ 12.0 hrs
Max. Elev. Pond = 4.42 ft @ 12.80 hrs
Min. Elev. Pond = -1.73 ft @ 5.65 hrs
Min. Elev. Harbor = -1.74 ft @ 4.5 hrs
Time (24 hour period)
Mattapoisett Harbor
Eel Pond

Exhibit 54

Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 22 ft. Wide Culvert



Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 26 ft. Wide Culvert

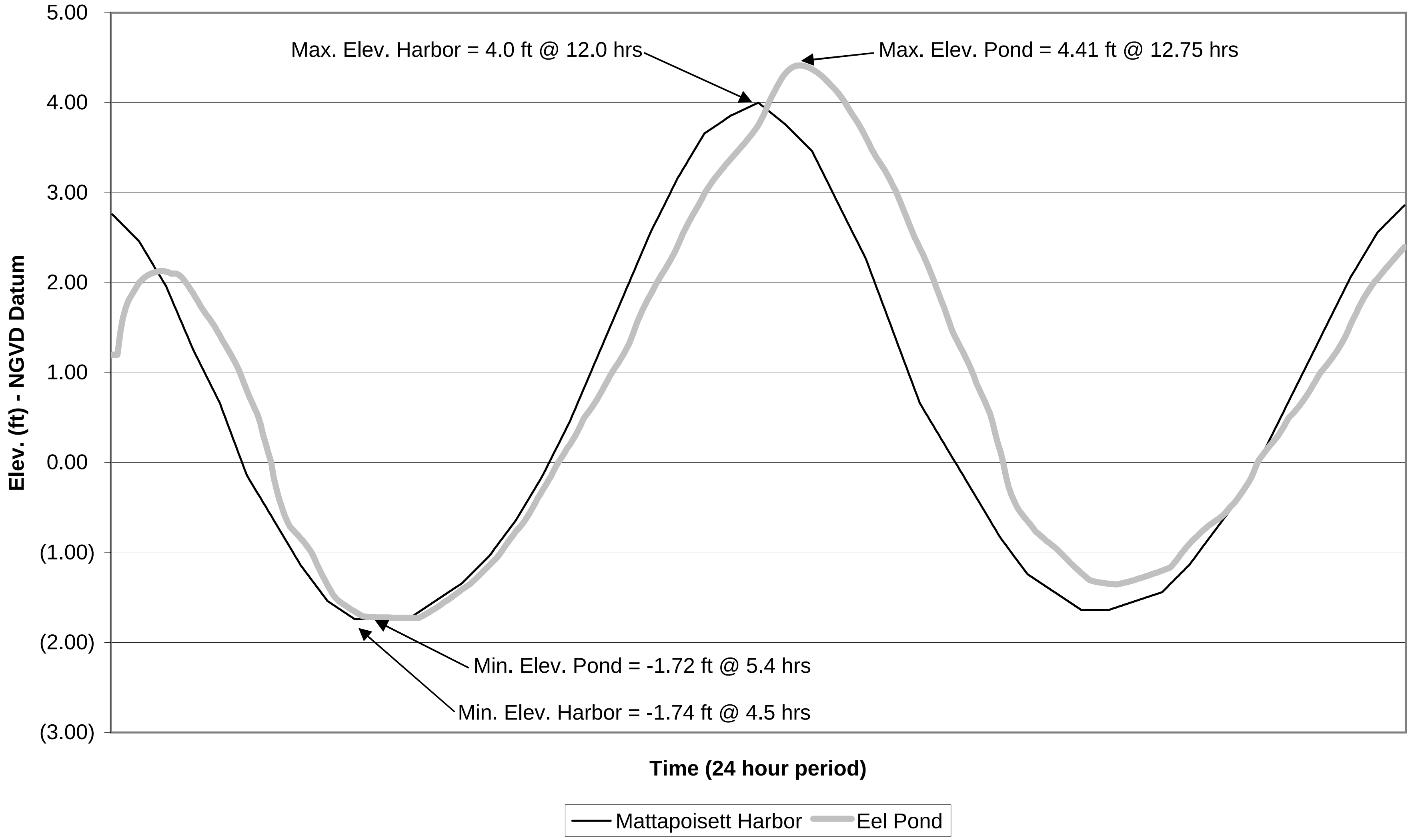


Exhibit 56

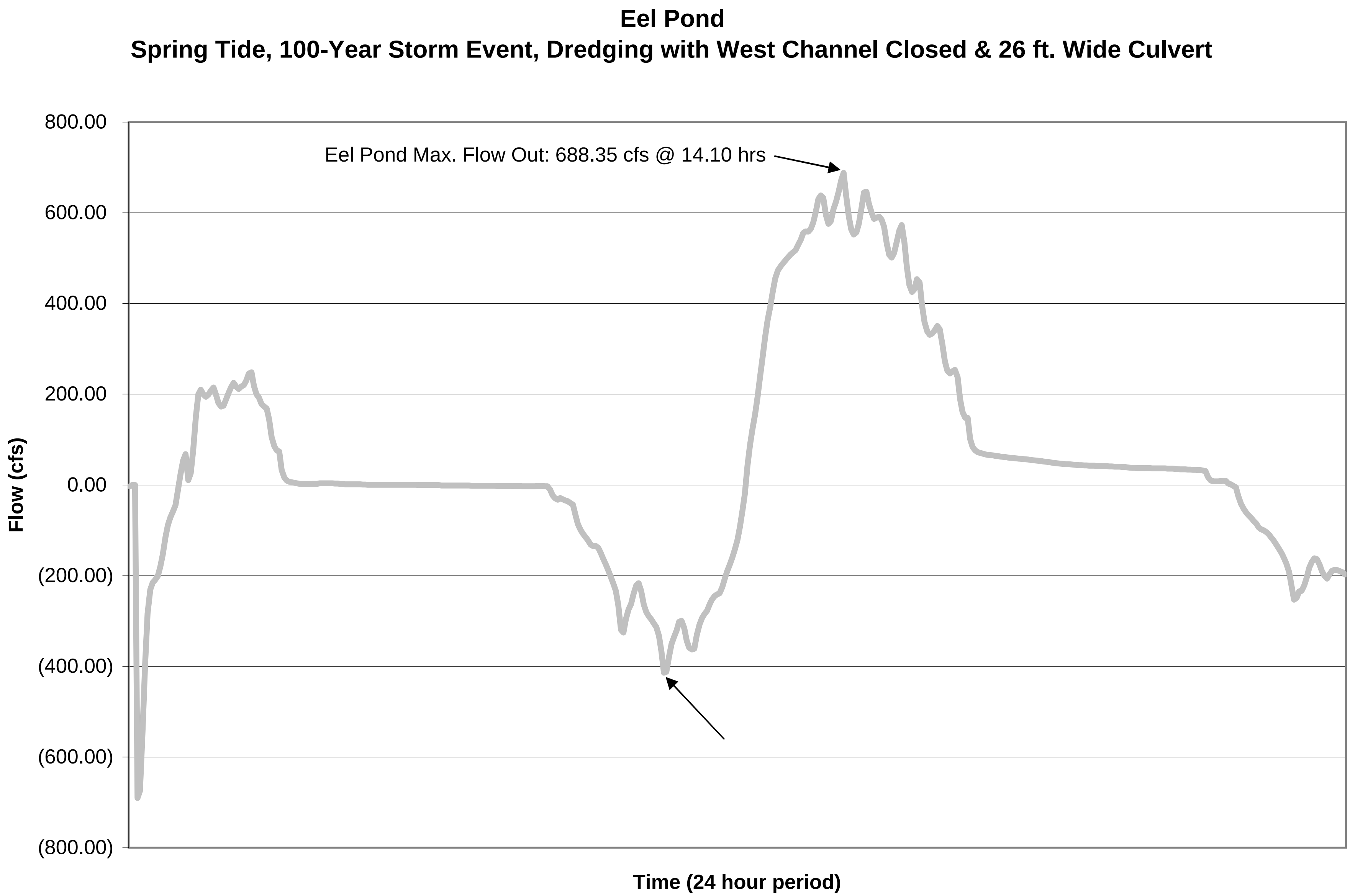

Eel Pond
Spring Tide, 100-Year Storm Event, Dredging with West Channel Closed & 26 ft. Wide Culvert
Eel Pond Max. Flow Out: 688.35 cfs @ 14.10 hrs
800.00
600.00
400.00
200.00
0.00
(200.00)
(400.00)
(600.00)
(800.00)
Flow (cfs)
Time (24 hour period)

Exhibit 57

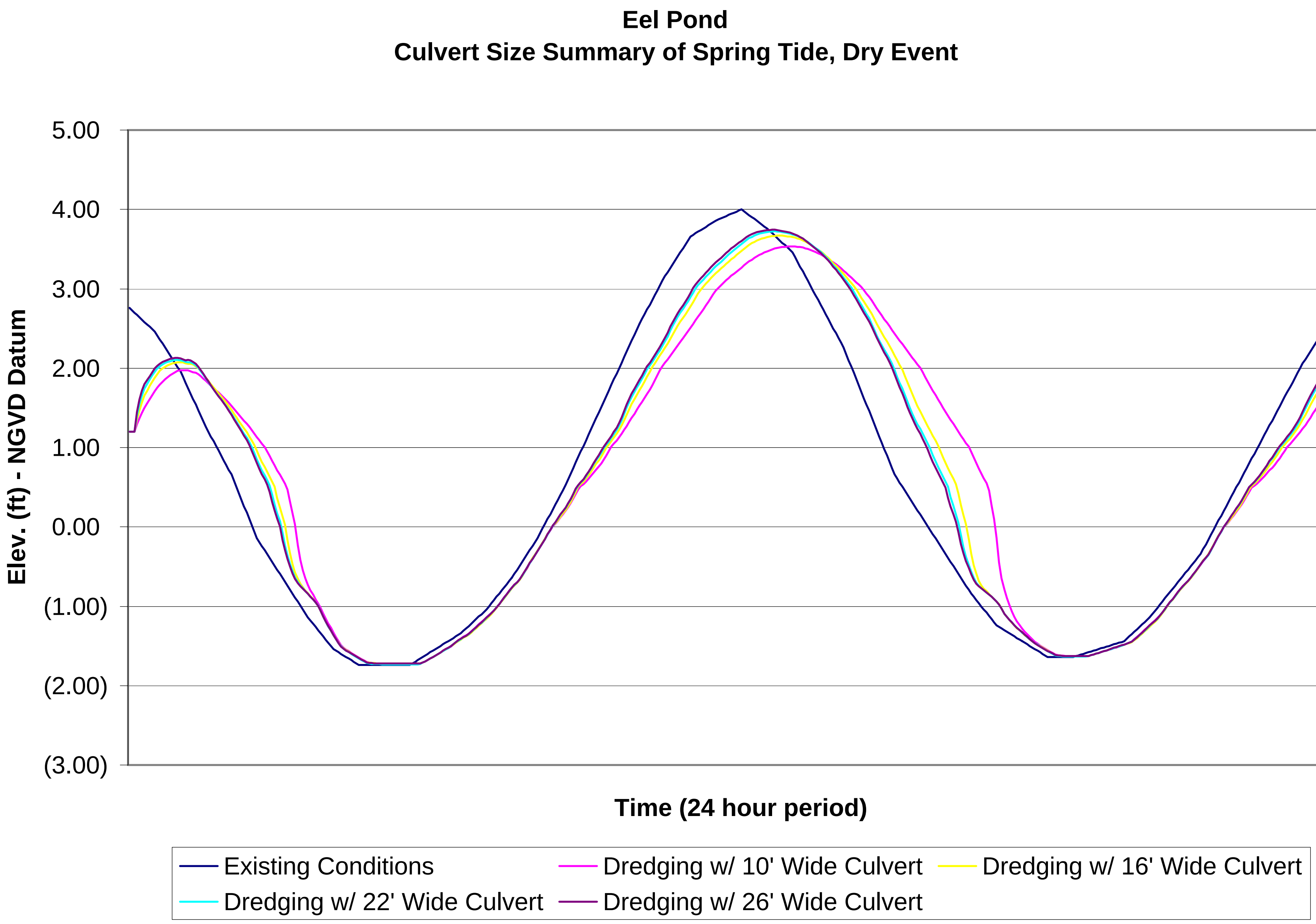

Eel Pond
Culvert Size Summary of Spring Tide, Dry Event
5.00
4.00
3.00
2.00
1.00
0.00
(1.00)
(2.00)
(3.00)
Elev. (ft) - NGVD Datum
Time (24 hour period)
Existing Conditions
Dredging w/ 10' Wide Culvert
Dredging w/ 16' Wide Culvert
Dredging w/ 22' Wide Culvert
Dredging w/ 26' Wide Culvert

Exhibit 58

Eel Pond
Culvert Size Summary of Spring Tide, 10-Year Storm Event

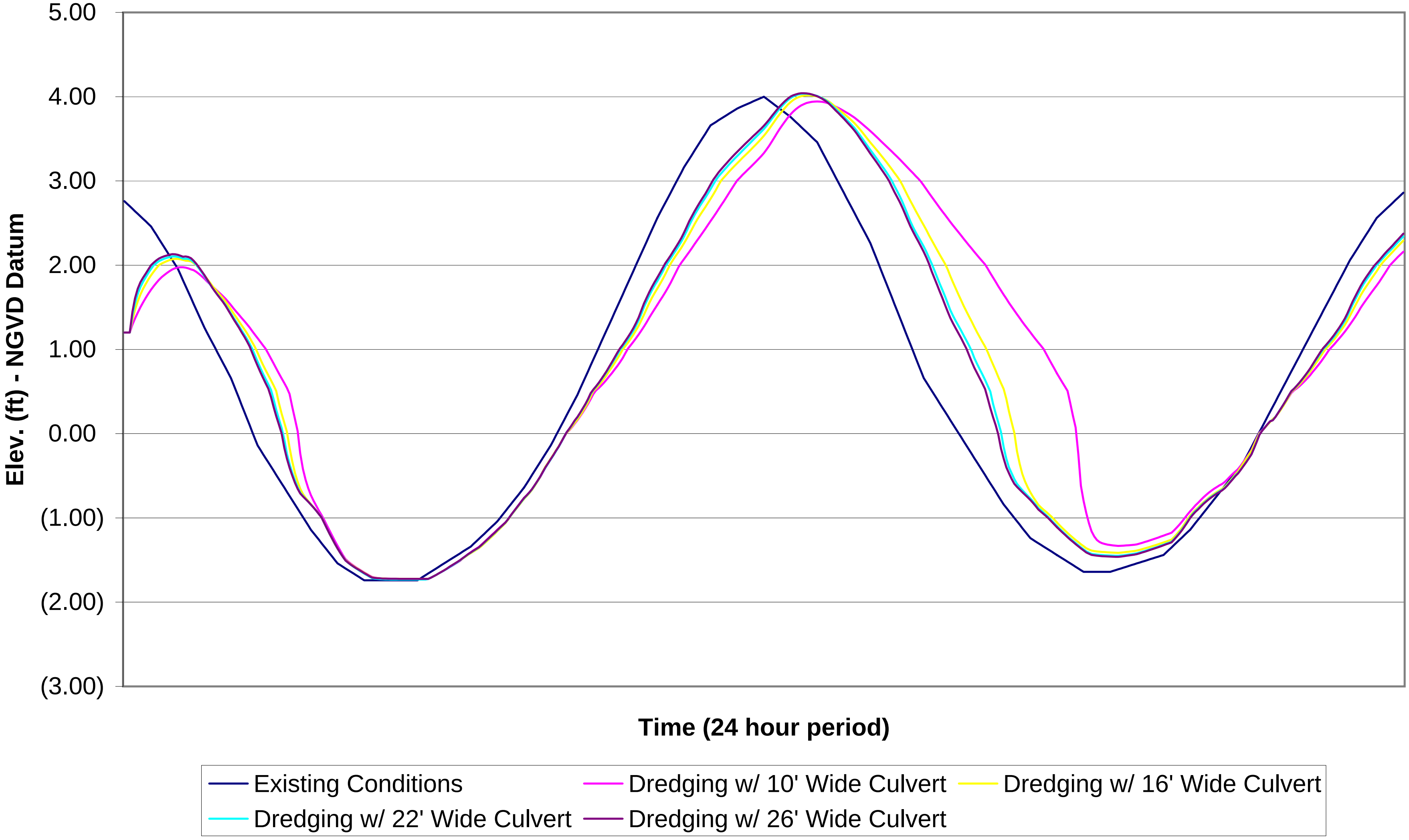


Exhibit 59

Eel Pond
Culvert Size Summary of Spring Tide, 100-Year Storm Event

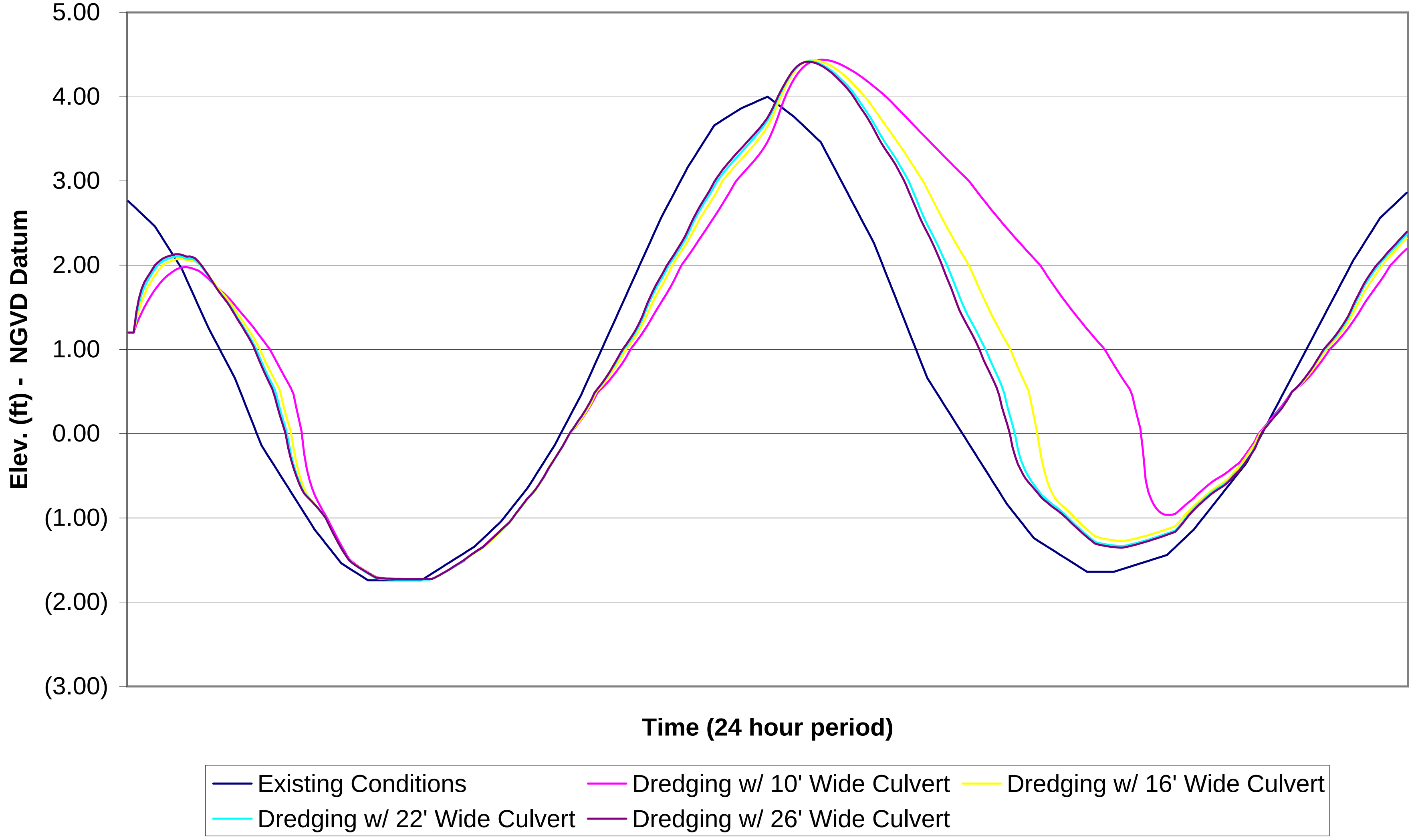


Exhibit 60

Eel Pond
Culvert Size Summary of Spring Tide, Dry Event

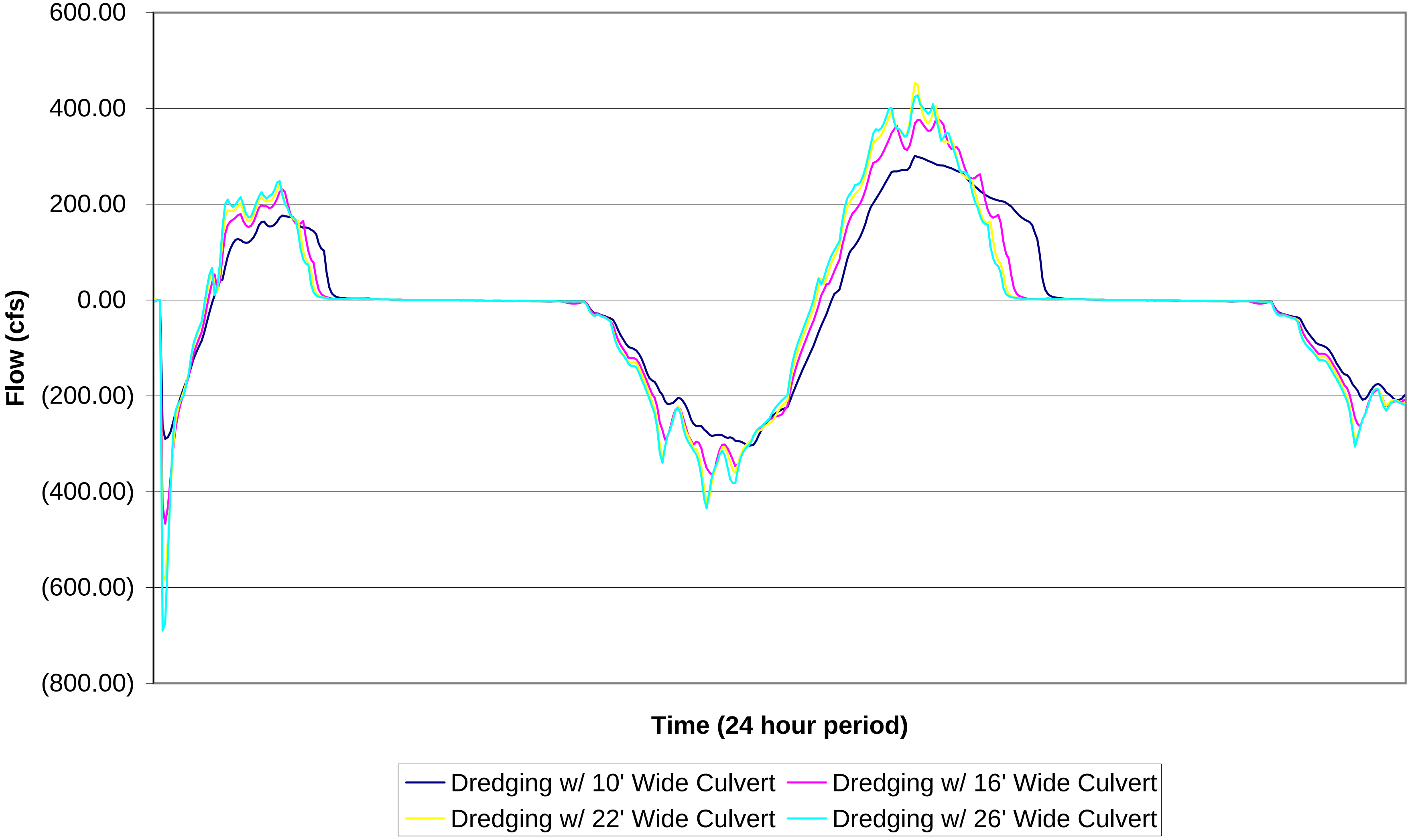
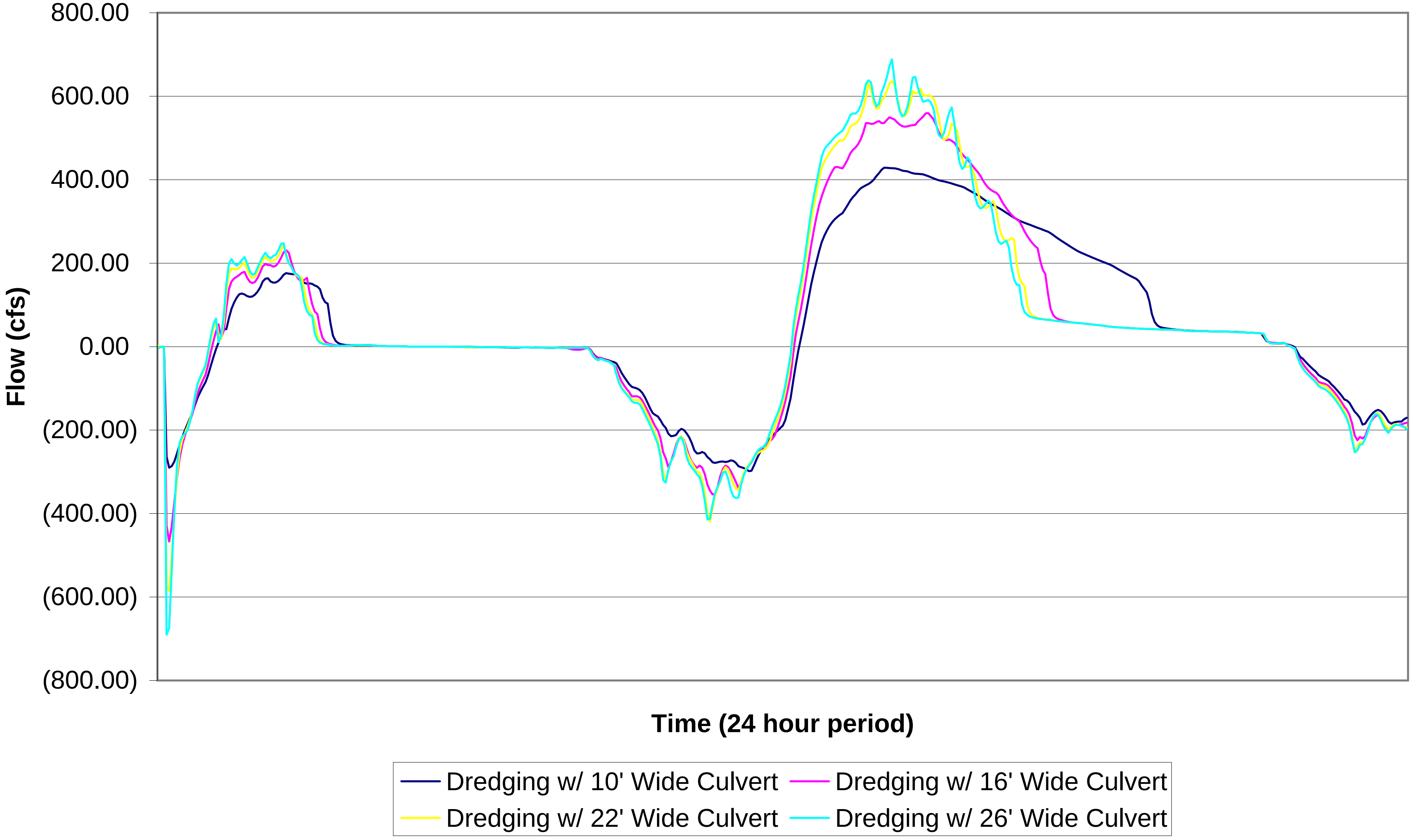


Exhibit 61

Eel Pond
Culvert Size Summary of Spring Tide, 10-Year Storm Event

Exhibit 62

Eel Pond
Culvert Size Summary of Spring Tide, 100-Year Storm Event



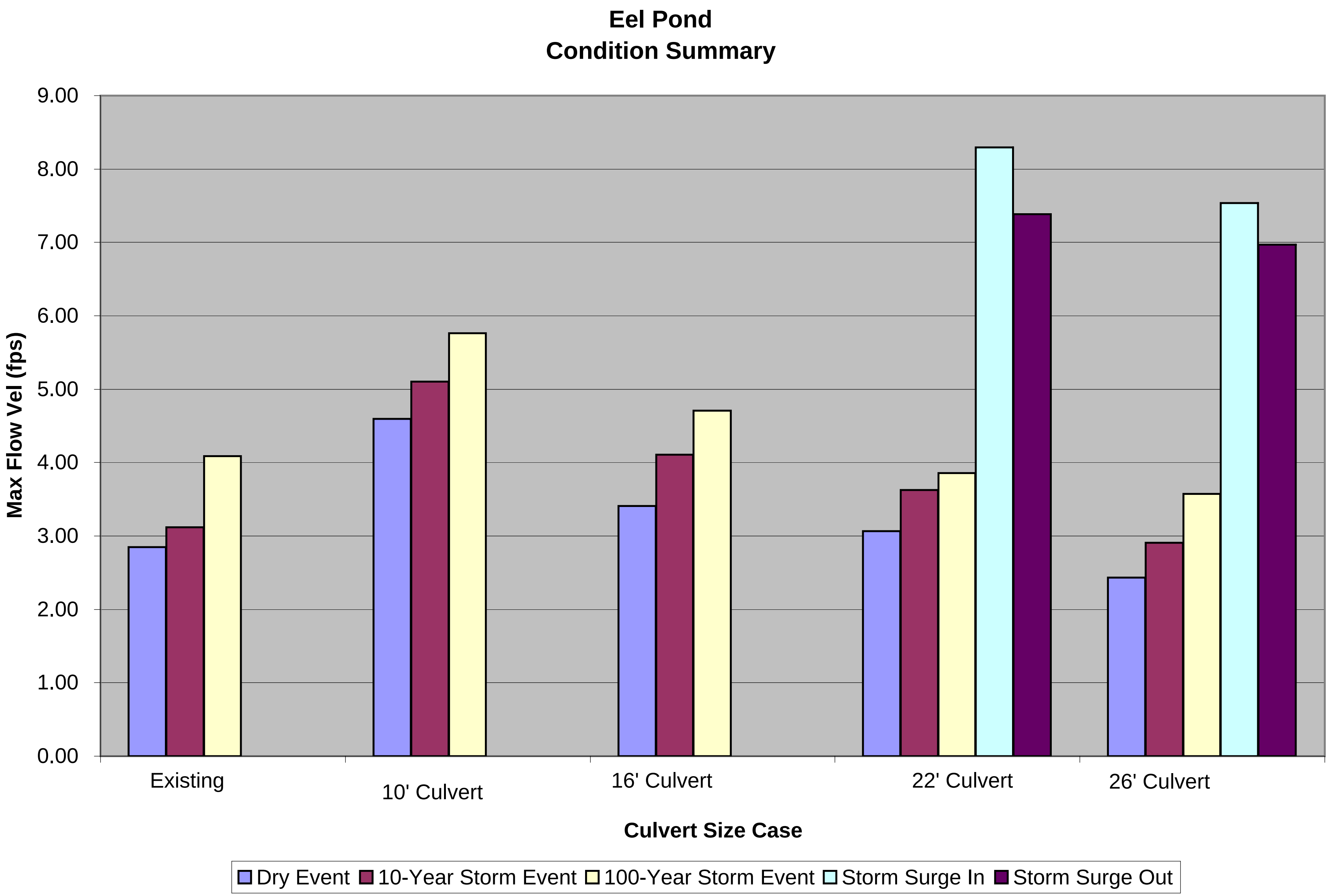

Eel Pond
Condition Summary
Max Flow Vel (fps)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Existing
10' Culvert
16' Culvert
22' Culvert
26' Culvert
Culvert Size Case
Dry Event
10-Year Storm Event
100-Year Storm Event
Storm Surge In
Storm Surge Out

Exhibit 64

New England Geophysical

WWW.NEWENGLANDGEOPHYSICAL.COM

Ground Penetrating
Radar Studies

Radiological Surveys

June 16, 2005

Mr. Bill Nicholson
Water Department
Town of Mattapoisett
Mattapoisett, MA 02739

Re: GPR Location Survey of Forced Main from STA 17+90 to STA 24+00

Mr. Nicholson:

On May 23, 2005 we began a ground penetrating radar study of the immediate area on both sides of the Eel Pond channel. The purpose of this study was to determine the channel crossing location and depth of an existing 12" AC forced sewer main.

The GPR data was collected using a 400Mhz antenna that seemed to offer the best resolution for sand-based soils. Upon review of the data it was determined that the pipe location could be imaged along the abandoned railroad bed (West side of channel) but a lower frequency antenna would be needed to penetrate the salinity of the sand and sediment based soils in the immediate area of the channel..

A second attempt to locate the line was conducted on Tuesday, May 31, 2005 using a 200Mhz GPR system. The pipe and subsurface trench was located and staked.

Pipe station location and the measured depth:

STA 17+90	5' 4"	STA 21+30	3" 10"
STA 19+20	5' 6"	STA 21+80	4' 8"
STA 19+80	5' 1"	STA 22+20	4' 9"
STA 20+60	4' 11"	STA 22+80	5' 1"

The measured pipe depth from STA 22+80 to the shutoff valve located in the (YMCA) road was consistent at 5' 1" to 5' 2".

Attached are several GPR and site images for your files.

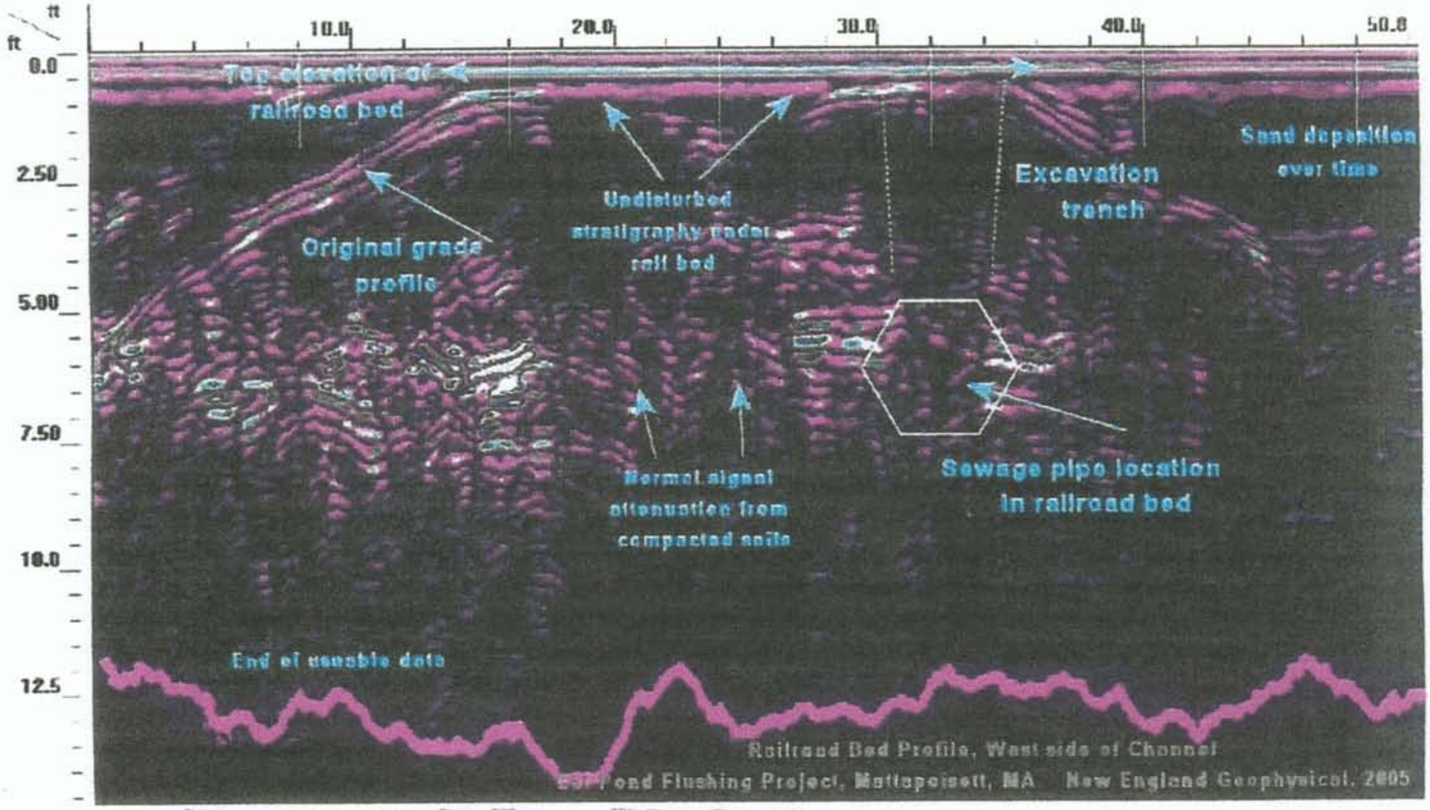
Please contact me if you have any question on this information.

Thank you.

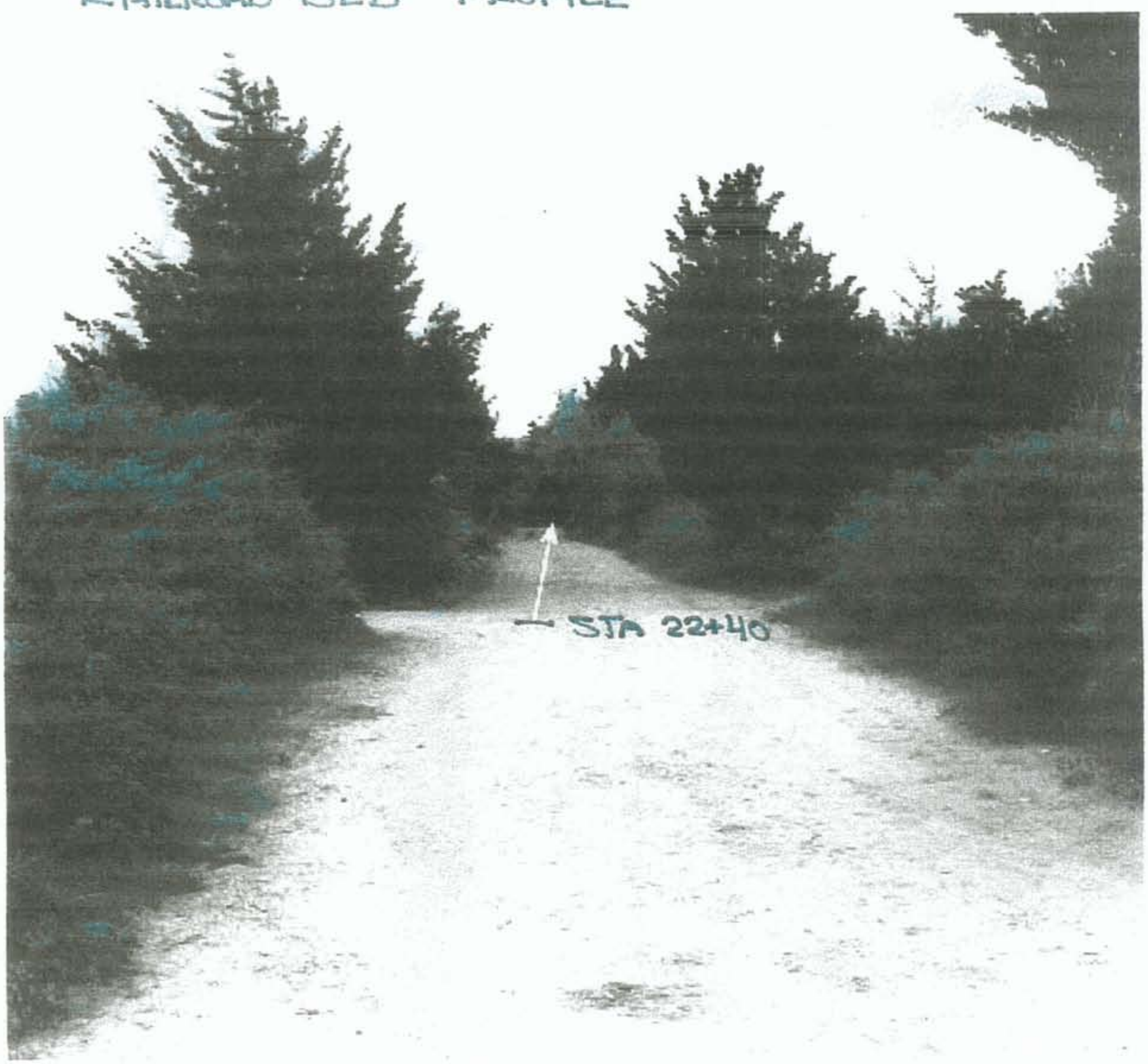
Russ Kempton
New England Geophysical

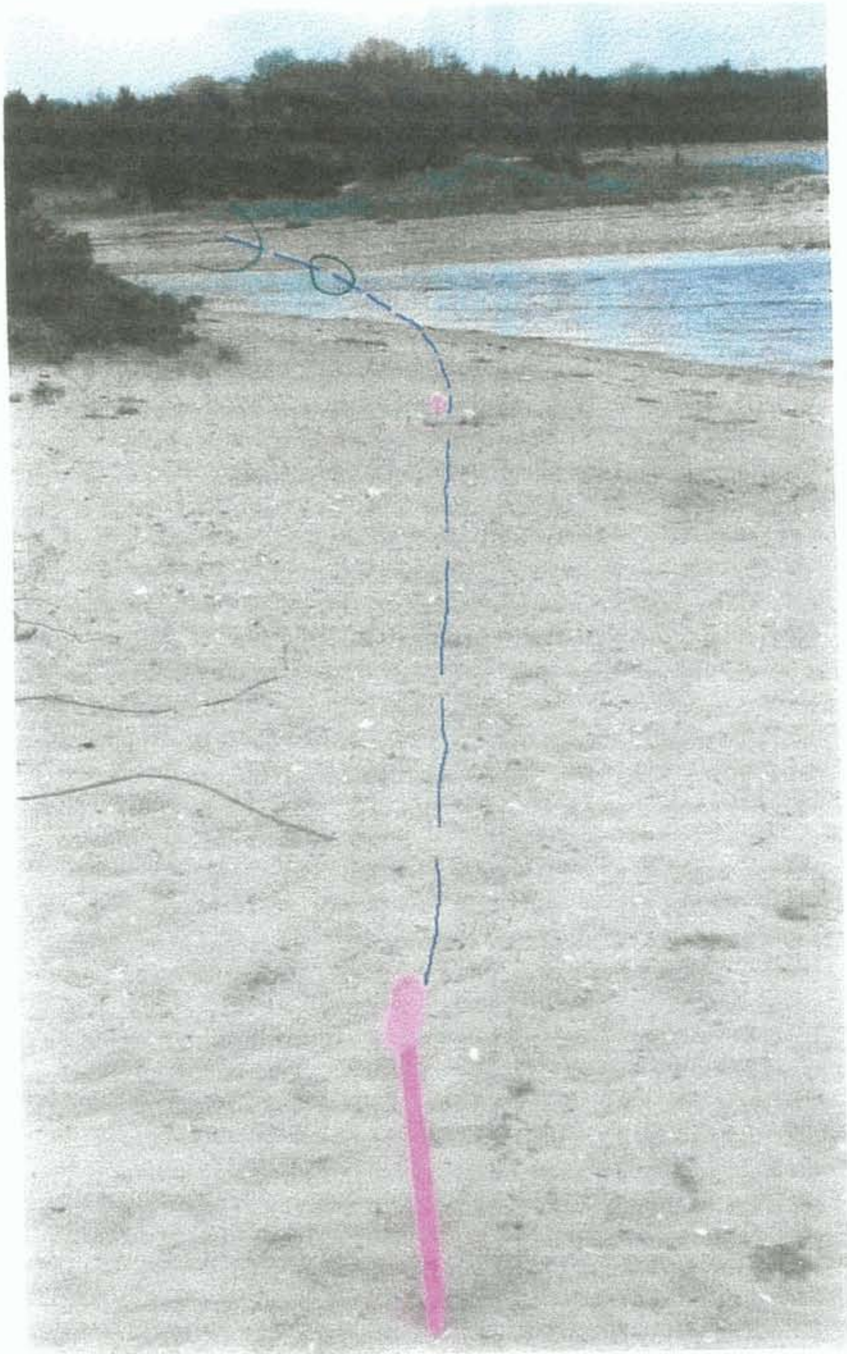
P.O. Box 440
Mendon, MA 01756

CHANNEL AT LOW TIDE
MAY 31, 2005

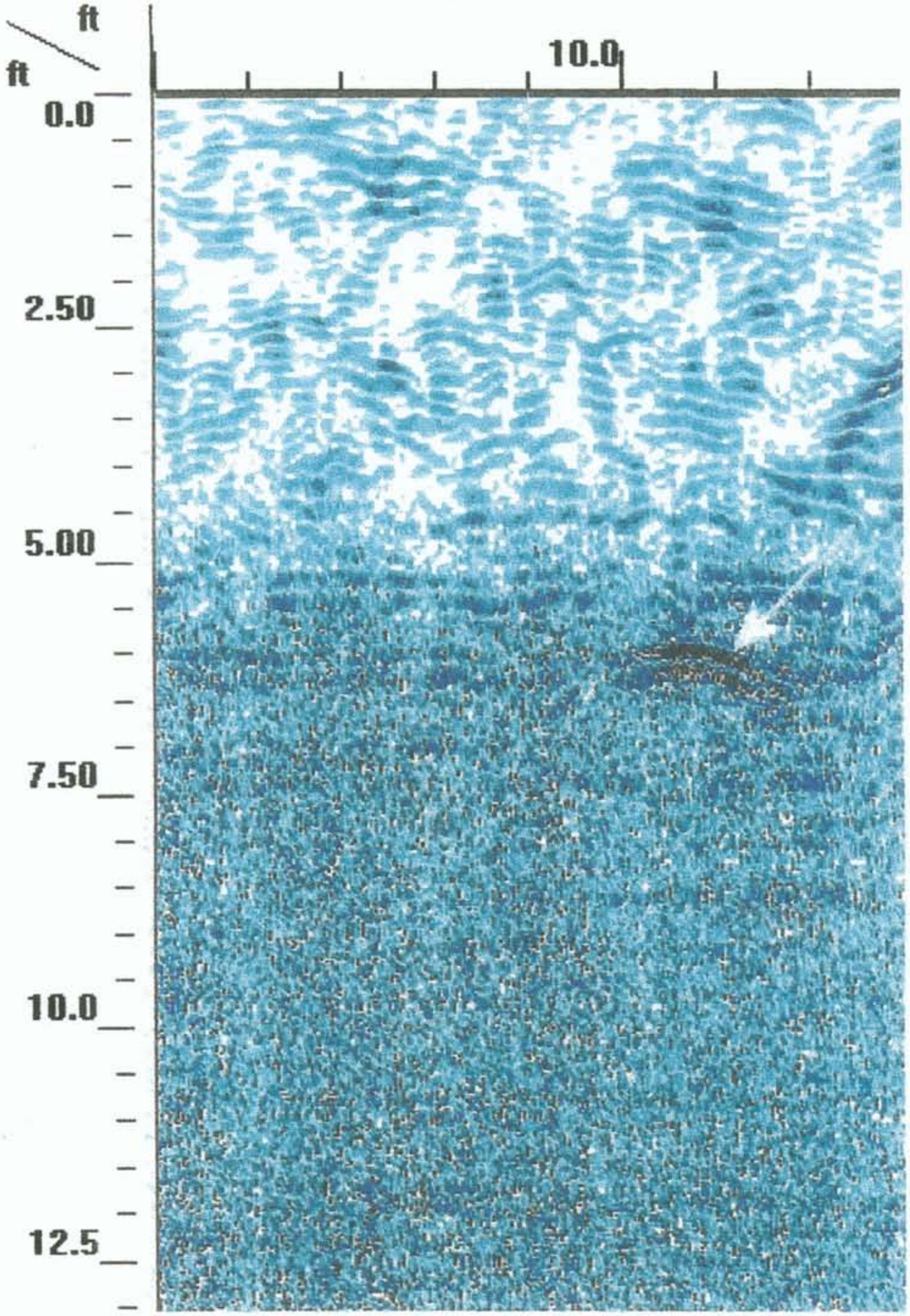


RAILROAD BED PROFILE

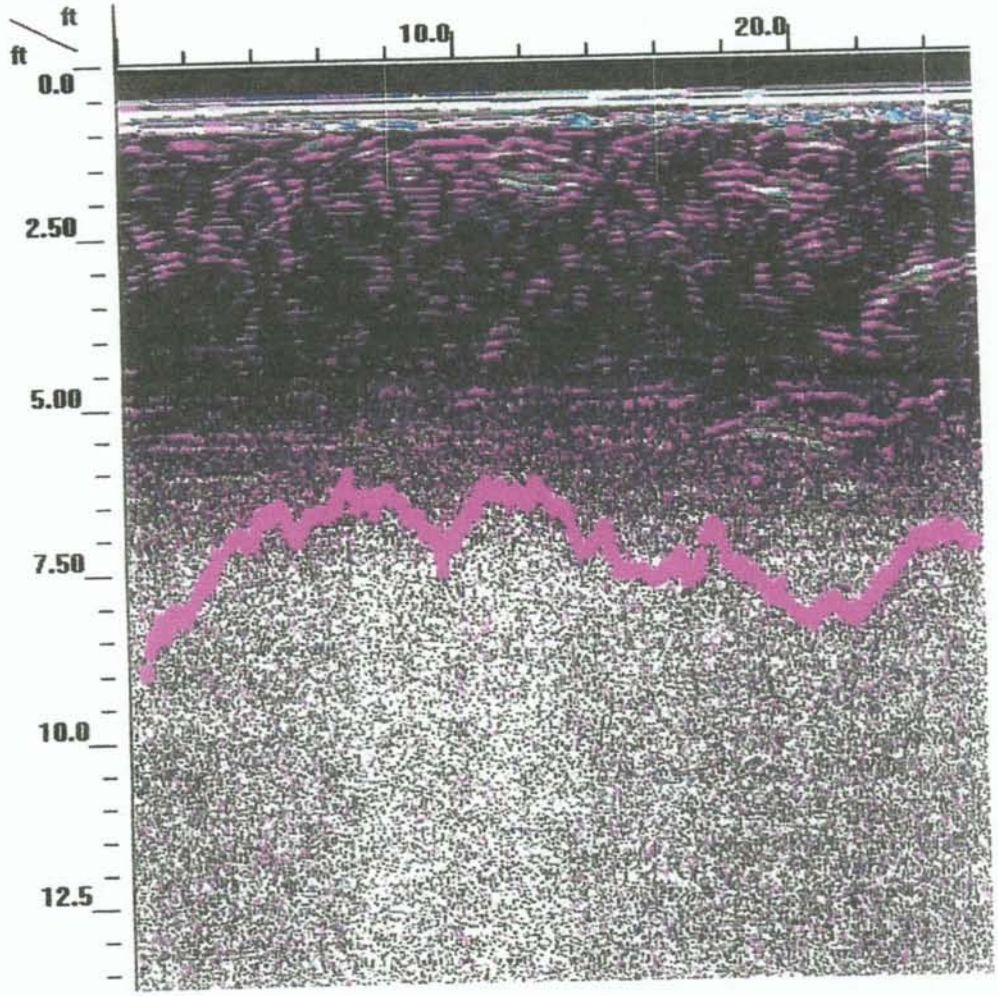




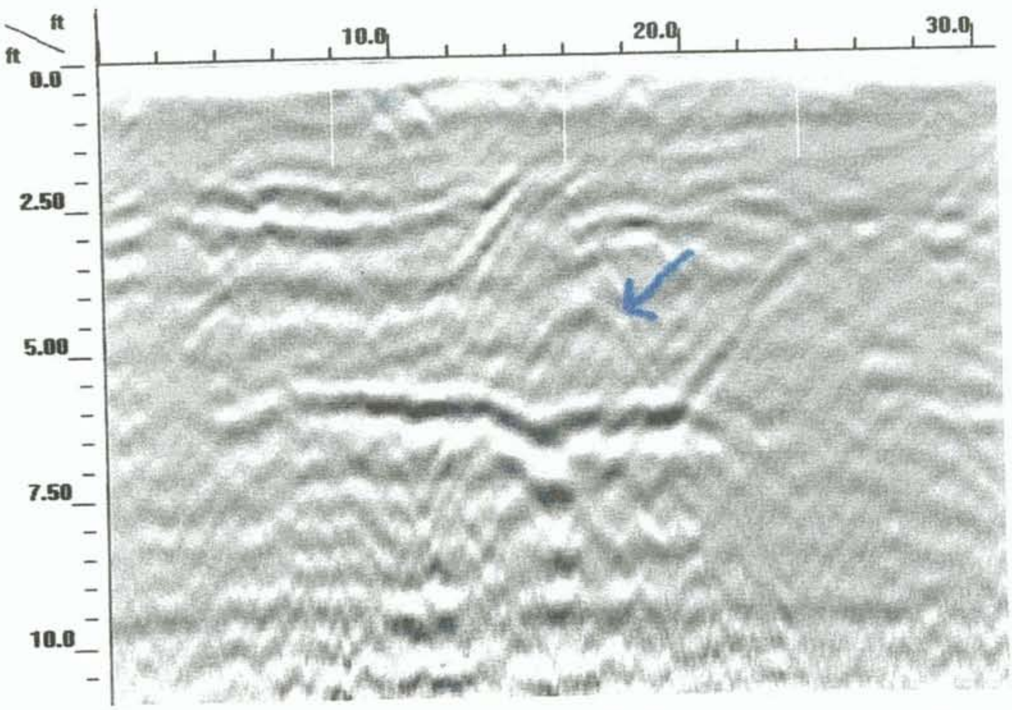
PIPE LOCATION



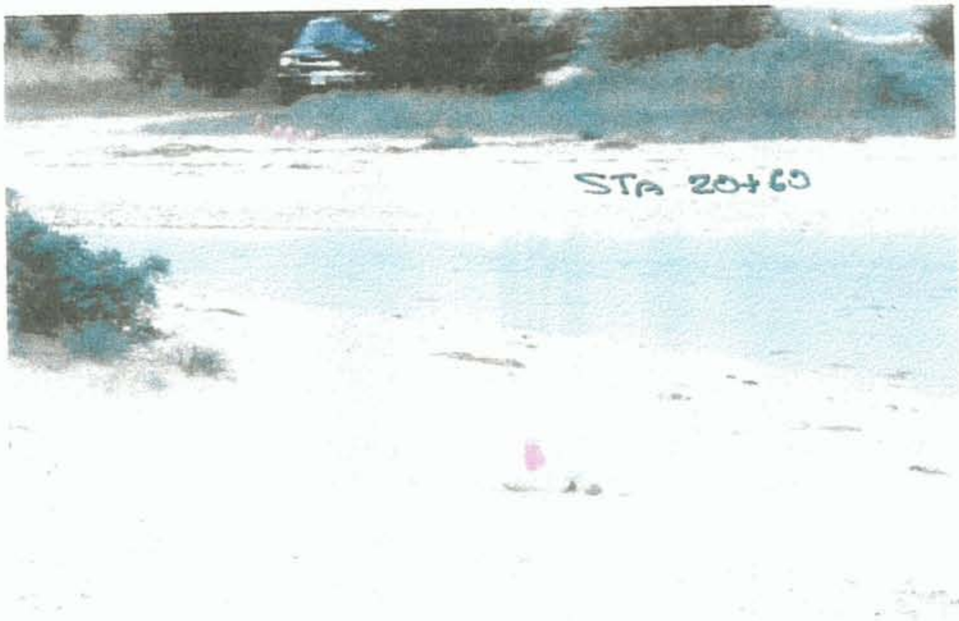
STA 20+60



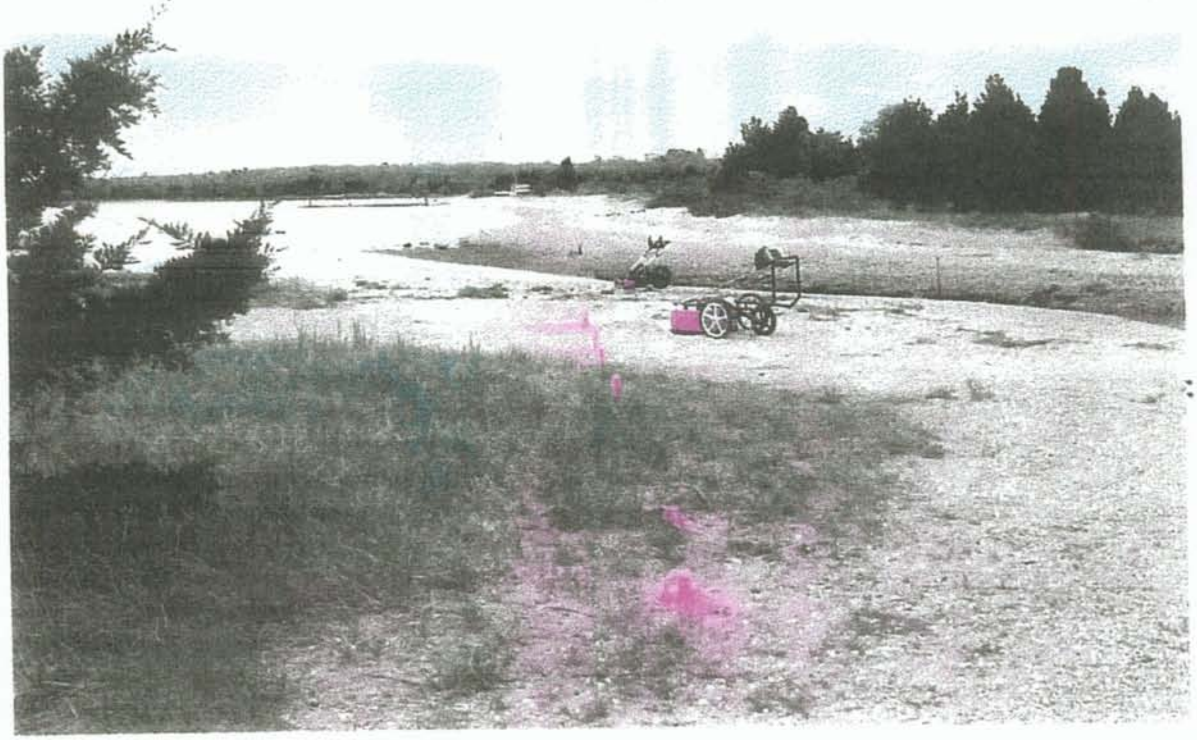
STA 19+80

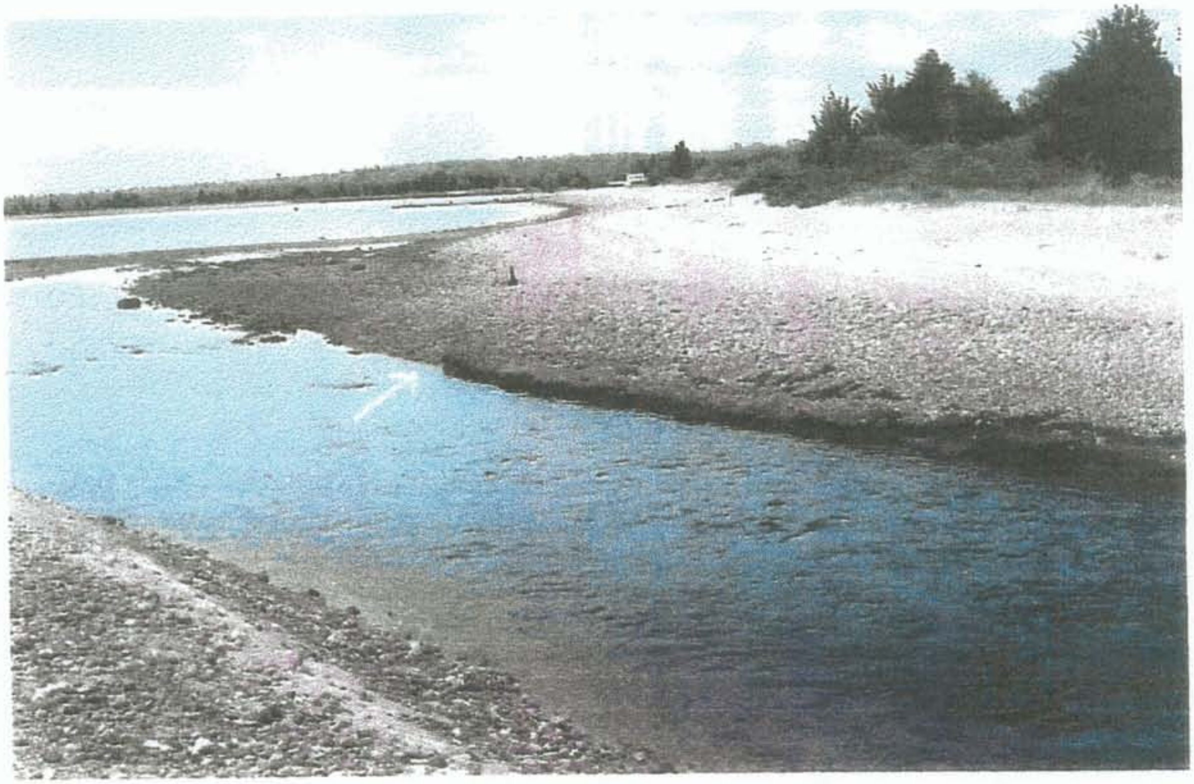


PIPE ADJACENT TO PEAT DEPOSIT
WESTERLY SIDE OF CHANNEL

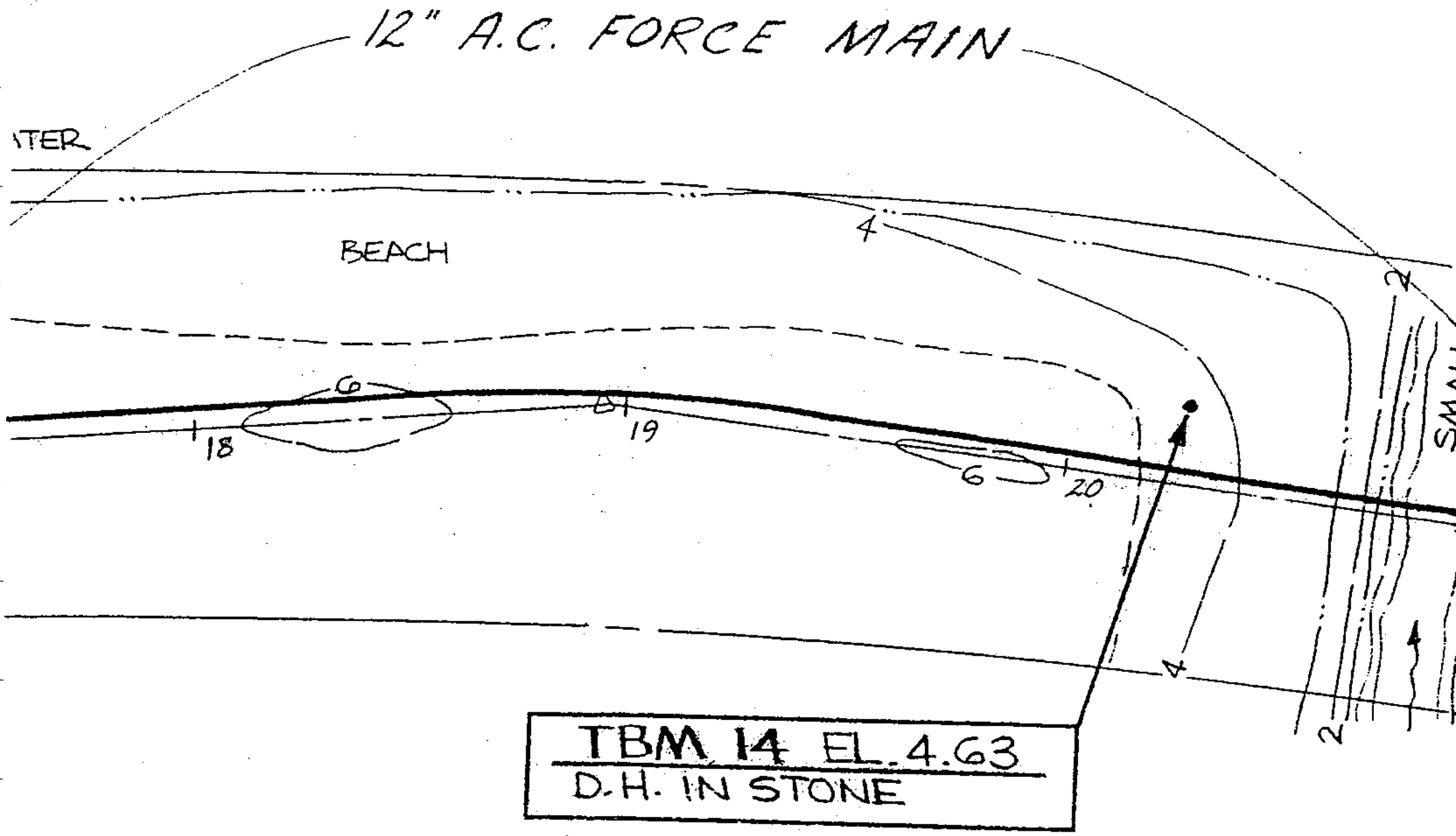


6-16-05





PIPE LOCATION AT ARROW



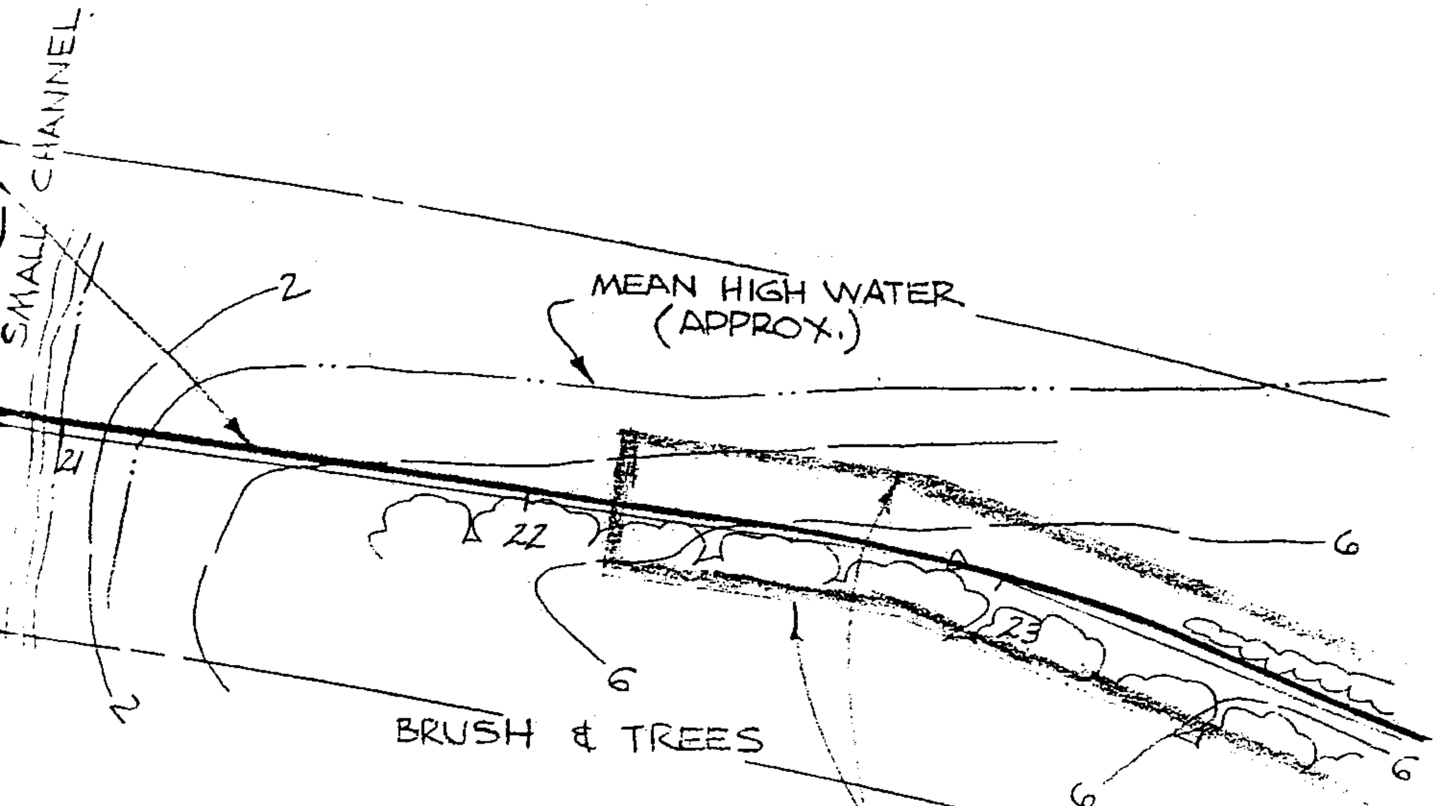
-AN

Dennis H. Bianchi

'E NO LESS

REFERENCE: MATT. T.& B. BK. 2

DRAWN BY LJP		CHECKED BY
TRACED BY RWK		APPROVED BY
NO.	DATE	REVISIONS



NOTE:
A TEMPORARY CONSTRUCTION EASEMENT EXTENDS 13 FEET ON EACH SIDE OF THE PERMANENT EASEMENT SHOWN.

. PG. 248

	BY

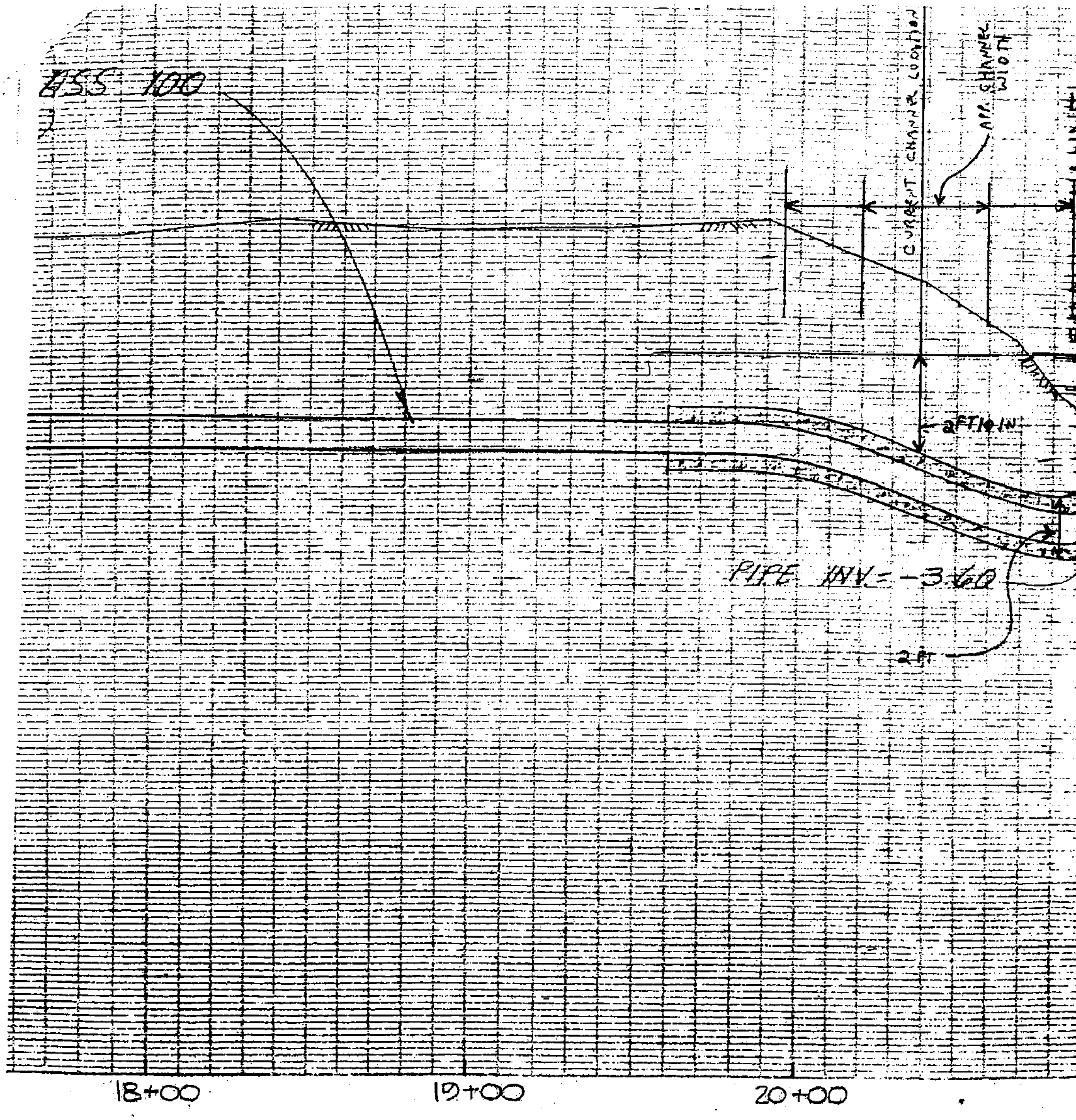
FORCE MAIN
STA. 12+00 TO STA. 24+00

WATER POLLUTION CONTROL PROGRAM
BOARD OF SELECTMEN
TOWN OF MATTAPOISETT, MASS.

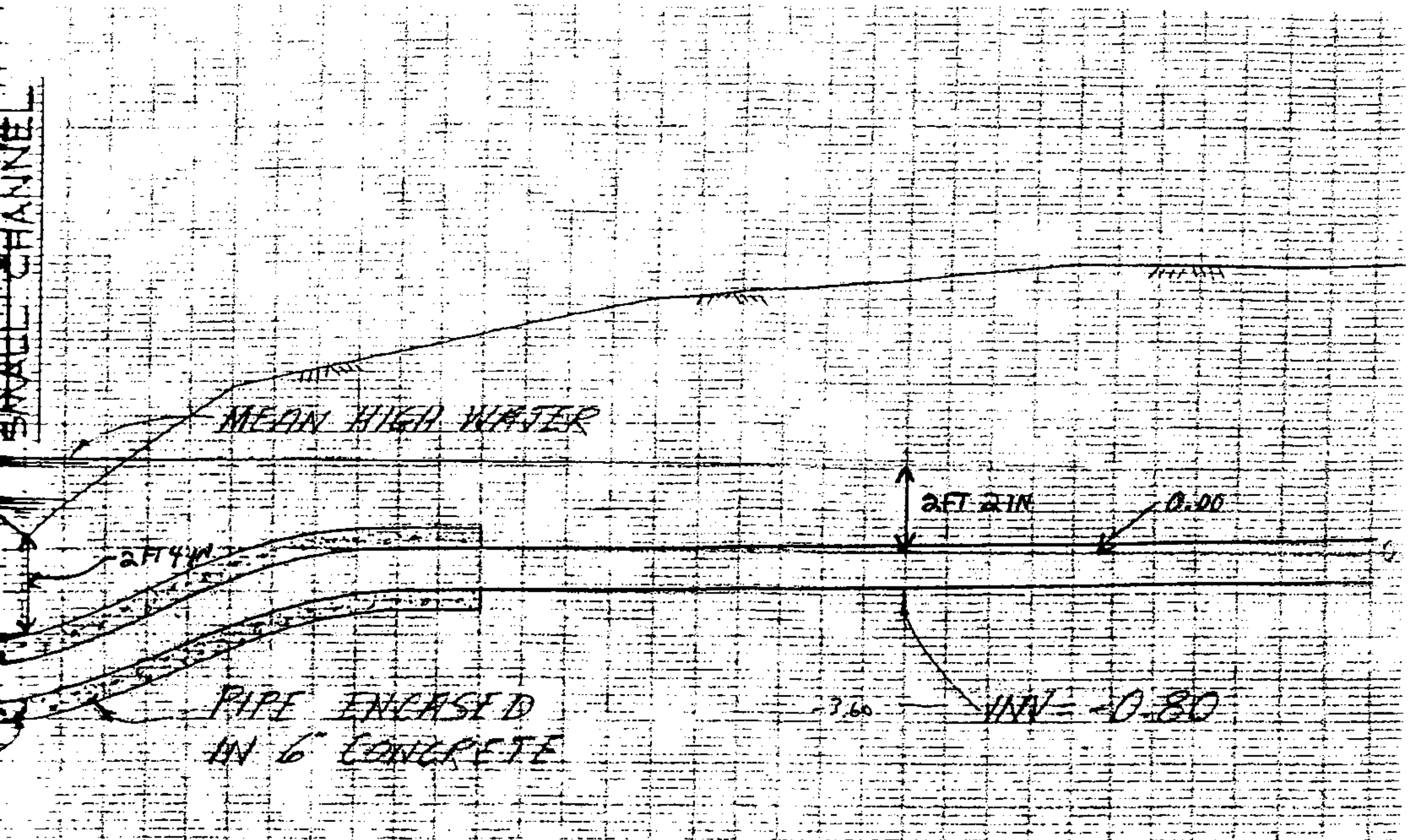
TIGHE & BOND, CONSULTING ENGINEERS
HOLYOKE, MASS.

SCALE: HORIZ. 1" = 40'
VERT. 1" = 4'

DATE: APRIL 1977



ØSS 100
CURRENT CHANNEL LOCATION
APP. CHANNEL WIDTH
2FT10IN
PIPE INV = -3.60
2FT
18+00
19+00
20+00


SMALL CHANNEL
MEAN HIGH WATER
2FT 4IN
2FT 2IN
0.00
PIPE ENCASED
IN 6" CONCRETE
-3.60
INV= -0.80
21+00
22+00
23+00
24+00

GeoTesting
express

1145 Massachusetts Avenue
Boxborough, MA 01719
978 635 0424 Tel
978 635 0266 Fax

Geotechnical Test Report

June 10, 2005

Eel Pond Project

East Channel

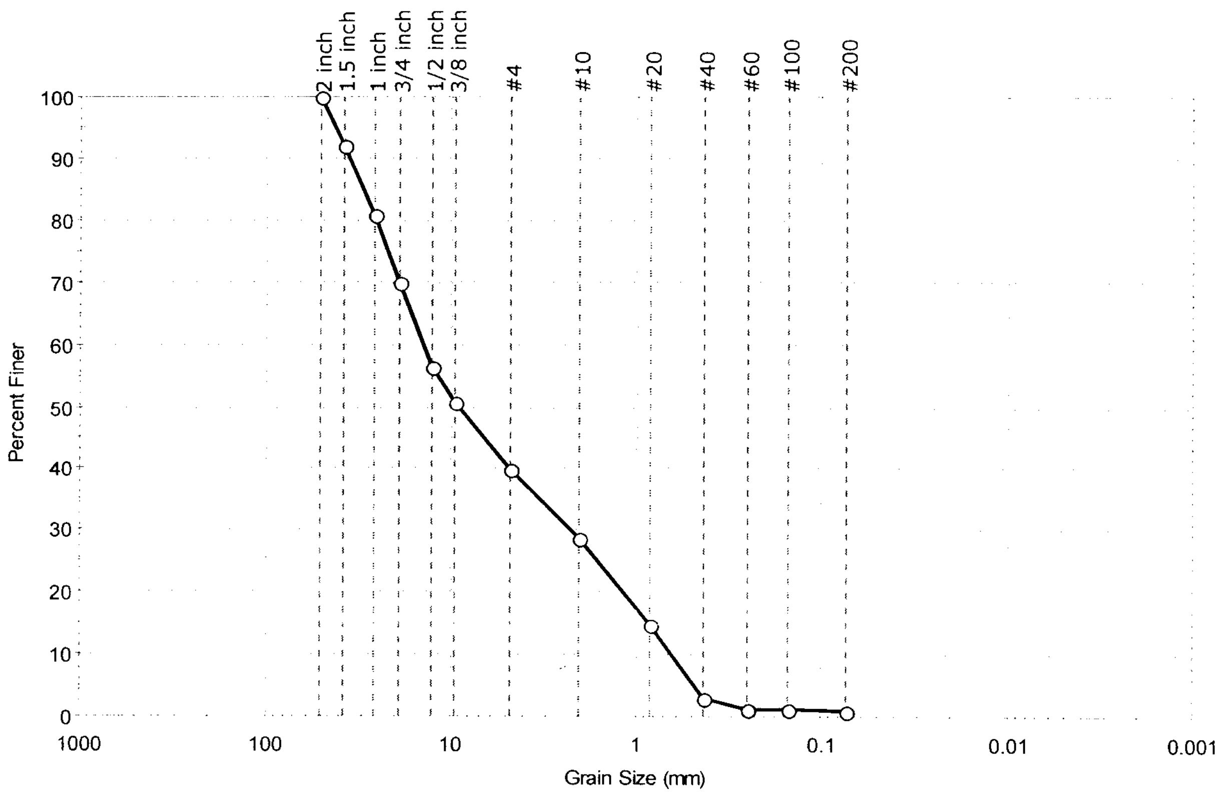
Prepared for:

cle CLE Engineering, Inc.

GeoTesting express

Client:	CLE Engineering				
Project:	Eel Pond				
Location:	East Channel			Project No:	GTX-5949
Boring ID: ---		Sample Type:	bag	Tested By:	pcs
Sample ID:S1		Test Date:	06/06/05	Checked By:	jdt
Depth : ---		Test Id:	70393		
Test Comment:	---				
Sample Description:	Moist, black gravel with sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	60.3	38.8	0.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 inch	50.80	100		
1.5 inch	38.10	92		
1 inch	25.70	81		
3/4 inch	19.00	70		
1/2 inch	12.70	56		
3/8 inch	9.51	51		
#4	4.75	40		
#10	2.00	29		
#20	0.84	15		
#40	0.42	3		
#60	0.25	1		
#100	0.15	1		
#200	0.074	1		

Coefficients

D_{85} =29.7132 mm D_{30} =2.2155 mm

D_{60} =14.1587 mm D_{15} =0.8515 mm

D_{50} =9.0765 mm D_{10} =0.6383 mm

C_u =22.182 C_c =0.543

Classification

ASTM Poorly graded gravel with sand (GP)

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

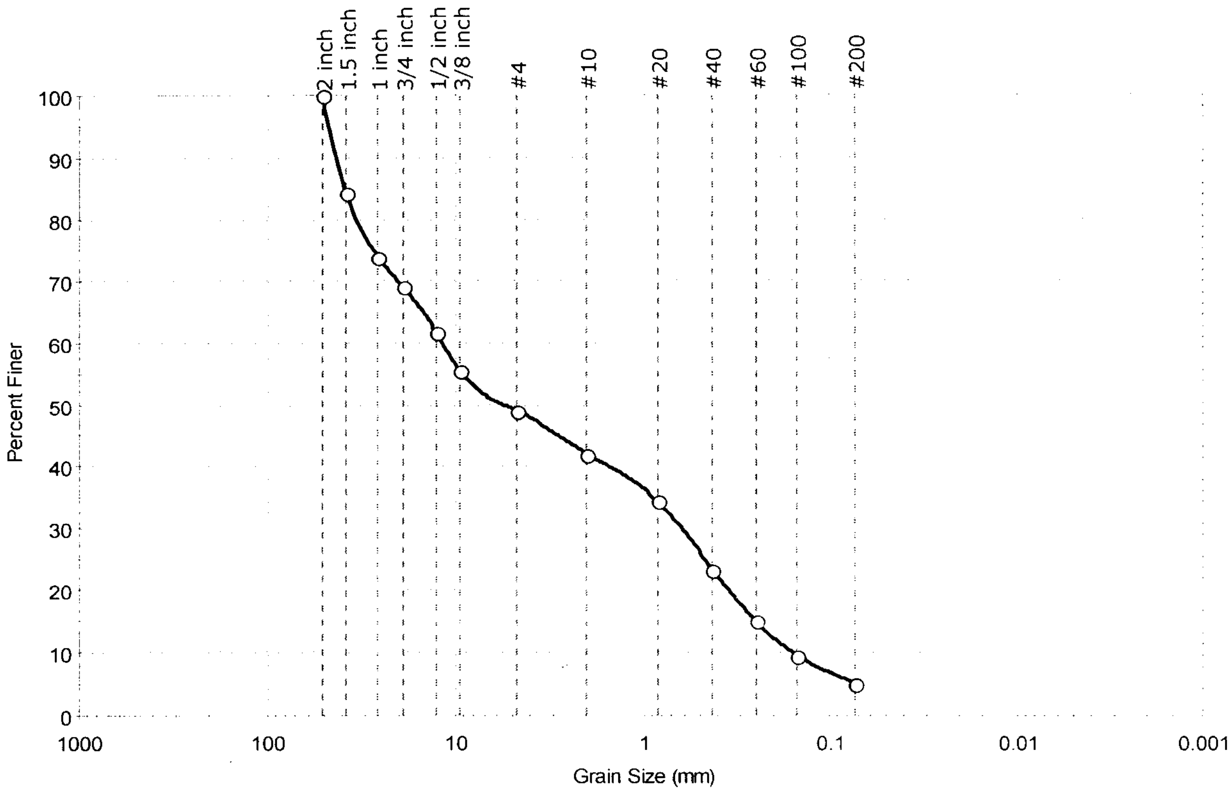
Sand/Gravel Hardness : HARD

GeoTesting express

Client: CLE Engineering			
Project: Eel Pond			
Location: East Channel		Project No:	GTX-5949
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:S2	Test Date: 06/03/05	Checked By:	jdt
Depth : ---	Test Id: 70394		

Test Comment: ---
Sample Description: Moist, black gravel with sand and silt
Sample Comment: ---

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	51.0	43.9	5.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 inch	50.80	100		
1.5 inch	38.10	85		
1 inch	25.70	74		
3/4 inch	19.00	69		
1/2 inch	12.70	62		
3/8 inch	9.51	55		
#4	4.75	49		
#10	2.00	42		
#20	0.84	35		
#40	0.42	23		
#60	0.25	15		
#100	0.15	10		
#200	0.074	5		

Coefficients

D_{85} =38.4535 mm D_{30} =0.6373 mm
D_{60} =11.7857 mm D_{15} =0.2505 mm
D_{50} =5.2517 mm D_{10} =0.1554 mm
C_u =75.841 C_c =0.222

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

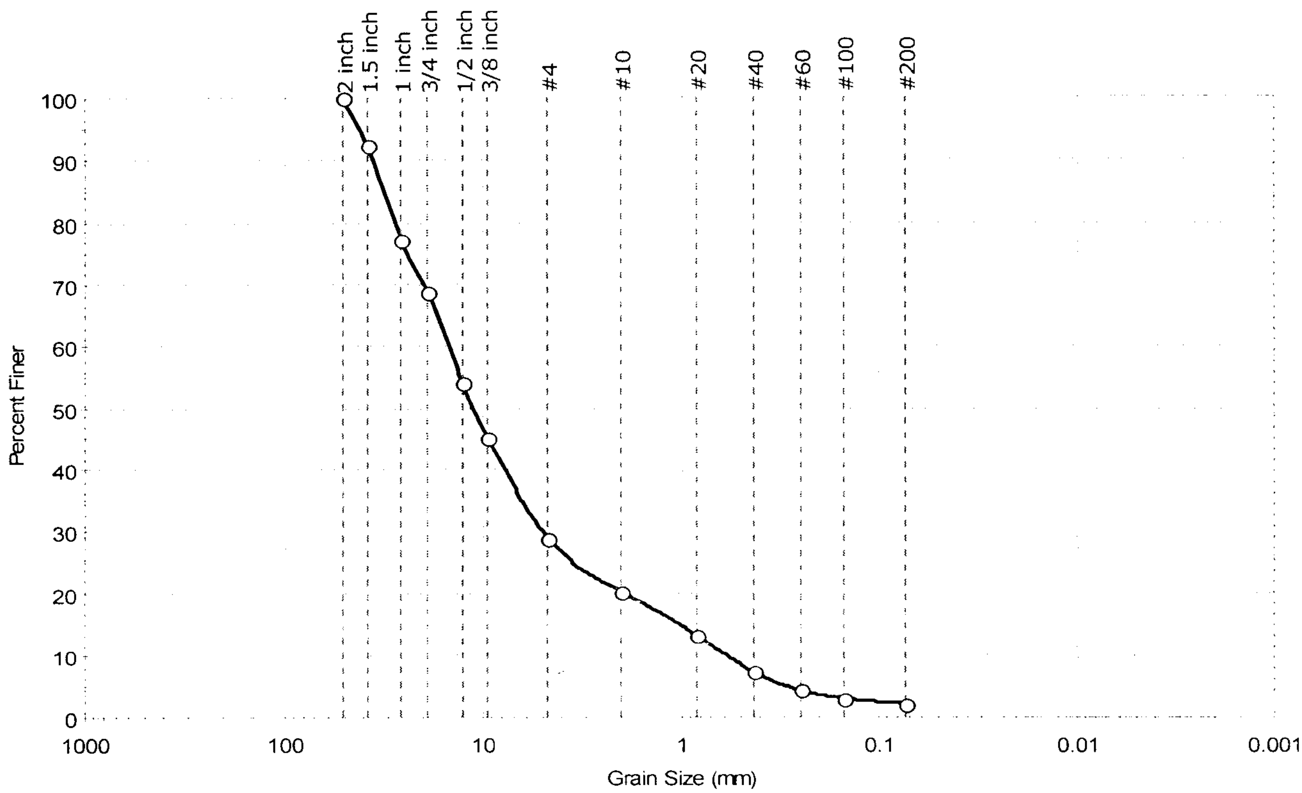
Sand/Gravel Hardness : HARD

printed 6/10/2005 9:15:37 AM

GeoTesting express

Client: CLE Engineering			
Project: Eel Pond			
Location: East Channel		Project No:	GTX-5949
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:S3	Test Date: 06/06/05	Checked By:	jdt
Depth : ---	Test Id: 70395		
Test Comment: ---			
Sample Description: Moist, black gravel with sand			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	71.0	26.9	2.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 inch	50.80	100		
1.5 inch	38.10	92		
1 inch	25.70	77		
3/4 inch	19.00	69		
1/2 inch	12.70	54		
3/8 inch	9.51	45		
#4	4.75	29		
#10	2.00	20		
#20	0.84	13		
#40	0.42	7		
#60	0.25	4		
#100	0.15	3		
#200	0.074	2		

Coefficients

D_{85} =31.5349 mm	D_{30} =4.9465 mm
D_{60} =14.9312 mm	D_{15} =1.0351 mm
D_{50} =11.1114 mm	D_{10} =0.5794 mm
C_u =25.770	C_c =2.828

Classification

ASTM Well-graded gravel with sand (GW)

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

printed 6/10/2005 9:16:08 AM

GeoTesting
express

1145 Massachusetts Avenue
Boxborough, MA 01719
978 635 0424 Tel
978 635 0266 Fax

Transmittal

TO:

Ms. Susan Nilson
CLE Engineering
15 Creek Road
Marion, MA 02738

DATE: 9/27/2005	GTX NO: 5949
RE: Eel Pond Project	

COPIES	DATE	DESCRIPTION
1	9/27/2005	**June 2005 Laboratory Test Reports**
		3 Grain Size Analyses (ASTM D 422) – sieve portion only

REMARKS:

CC:

SIGNED: ______________________
Joe Tomei – Laboratory Manager

APPROVED BY: ______________________
Gary Torosian – Director of Testing Services

GeoTesting
express

1145 Massachusetts Avenue

Boxborough, MA 01719

978 635 0424 Tel

978 635 0266 Fax

Geotechnical Test Report

September 27, 2005

Eel Pond Project

East Channel

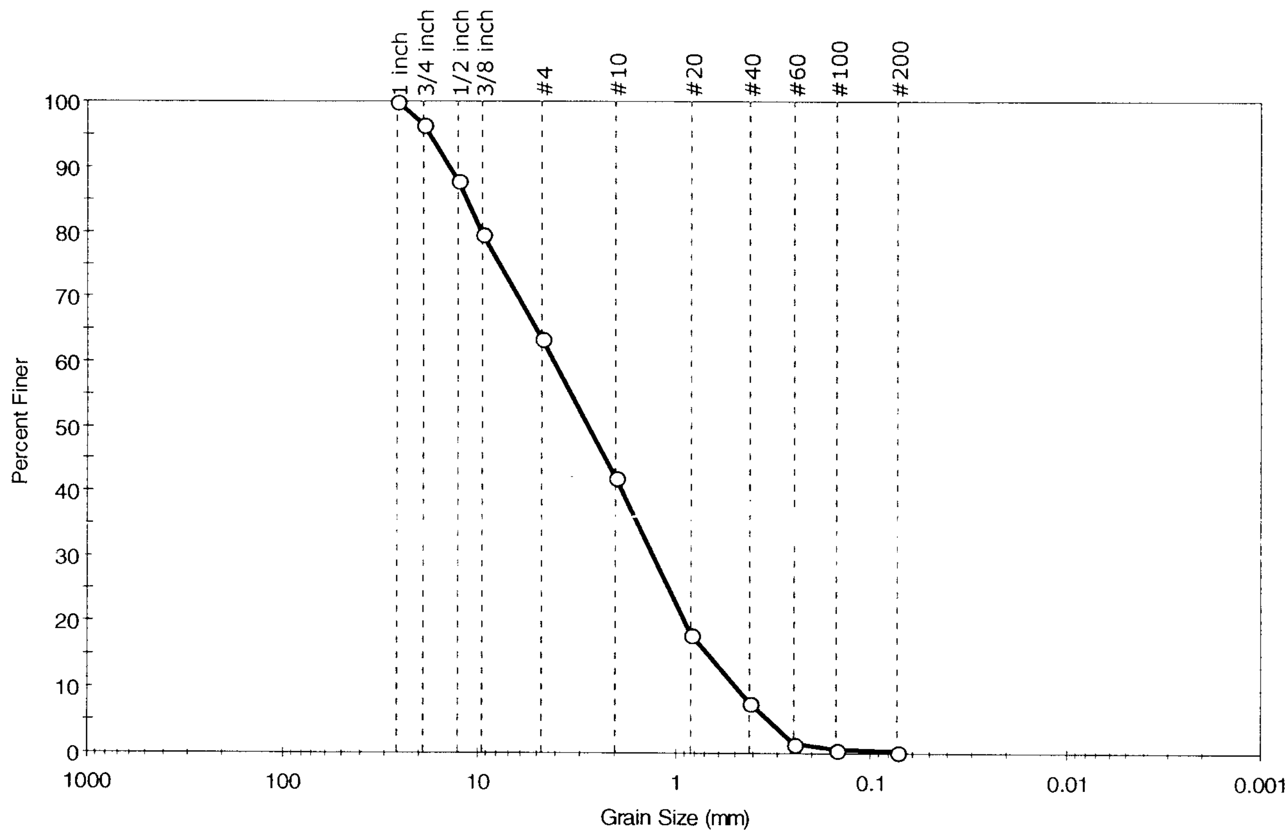
Prepared for:

cle CLE Engineering, Inc.

GeoTesting express

Client:	CLE Engineering		
Project:	Eel Pond		
Location:	East Channel	Project No:	GTX-5949
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:S4B	Test Date: 09/20/05	Checked By:	jdt
Depth : ---	Test Id: 77795		
Test Comment:	---		
Sample Description:	Moist, dark yellowish brown sand with gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	36.5	63.2	0.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 inch	25.70	100		
3/4 inch	19.00	96		
1/2 inch	12.70	88		
3/8 inch	9.51	80		
#4	4.75	63		
#10	2.00	42		
#20	0.84	18		
#40	0.42	8		
#60	0.25	1		
#100	0.15	0		
#200	0.074	0		

Coefficients

D_{85} = 11.4614 mm D_{30} = 1.2884 mm

D_{60} = 4.1278 mm D_{15} = 0.6837 mm

D_{50} = 2.7406 mm D_{10} = 0.4874 mm

C_u = 8.469 C_c = 0.825

Classification

ASTM: Poorly graded sand with gravel (SP)

AASHTO: Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

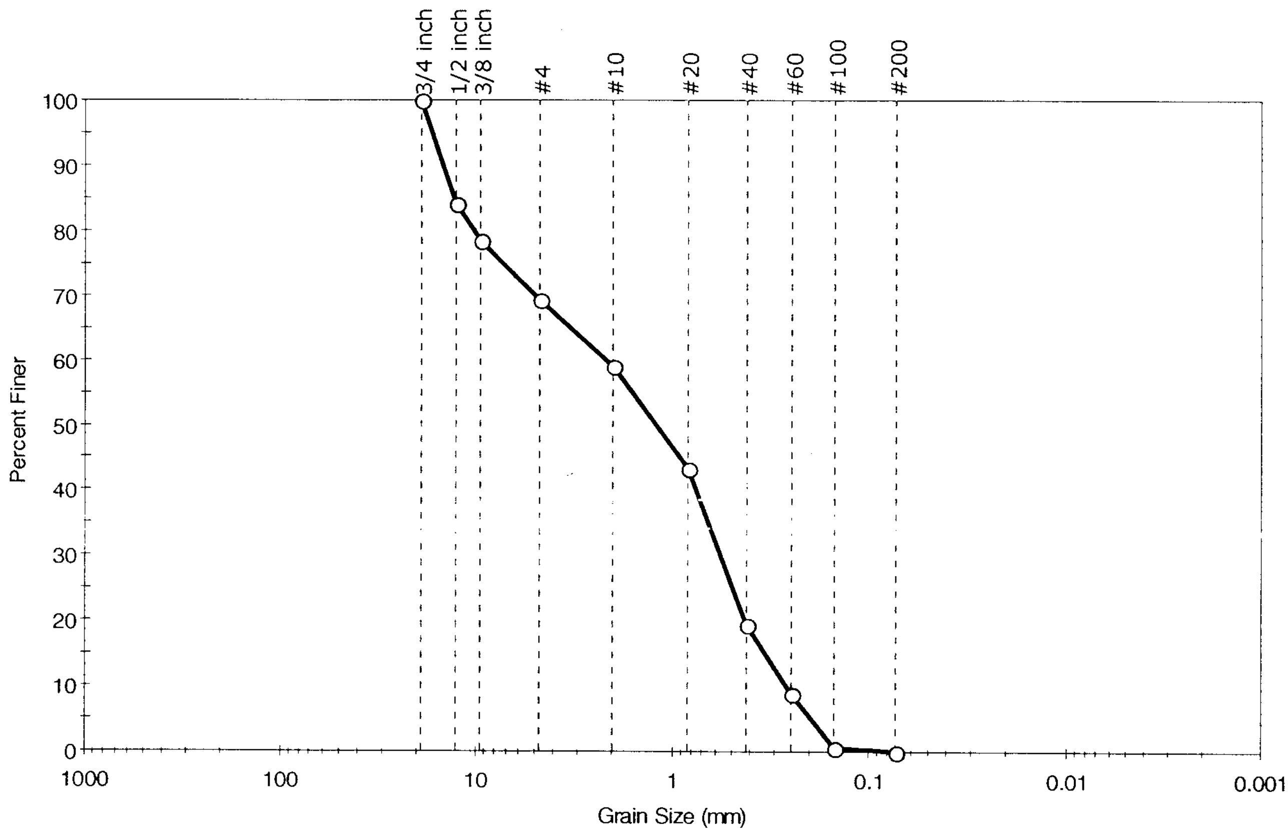
Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

GeoTesting express

Client: CLE Engineering			
Project: Eel Pond			
Location: East Channel		Project No:	GTX-5949
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:S5	Test Date: 09/27/05	Checked By:	jdt
Depth : ---	Test Id: 77796		
Test Comment: ---			
Sample Description: Dry, very pale brown sand with gravel			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	30.5	69.4	0.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/4 inch	19.00	100		
1/2 inch	12.70	84		
3/8 inch	9.51	79		
#4	4.75	69		
#10	2.00	59		
#20	0.84	43		
#40	0.42	19		
#60	0.25	9		
#100	0.15	0		
#200	0.074	0		

Coefficients

D_{85} =12.9878 mm	D_{30} =0.5710 mm
D_{60} =2.1523 mm	D_{15} =0.3385 mm
D_{50} =1.2075 mm	D_{10} =0.2637 mm
C_u =8.162	C_c =0.574

Classification

ASTM Poorly graded sand with gravel (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

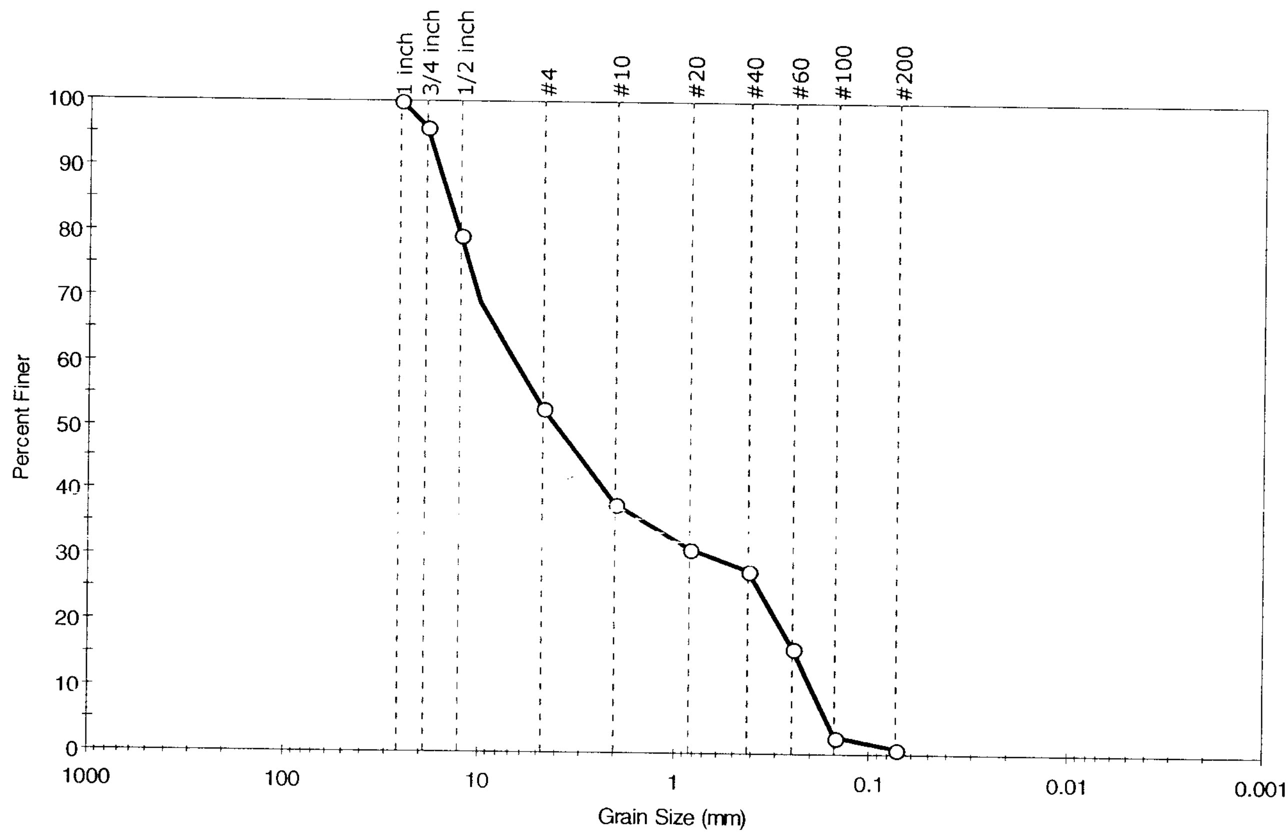
Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

GeoTesting express

Client: CLE Engineering			
Project: Eel Pond			
Location: East Channel		Project No:	GTX-5949
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:S6	Test Date: 09/27/05	Checked By:	jdt
Depth : ---	Test Id: 77797		
Test Comment: ---			
Sample Description: Moist, dark yellowish brown sand with gravel			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	47.1	52.0	0.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 inch	25.70	100		
3/4 inch	19.00	96		
1/2 inch	12.70	79		
	0.000	69		
#4	4.75	53		
#10	2.00	38		
#20	0.84	31		
#40	0.42	28		
#60	0.25	16		
#100	0.15	3		
#200	0.074	1		

Coefficients

D_{85} = 14.5844 mm D_{30} = 0.6424 mm

D_{60} = 6.6010 mm D_{15} = 0.2385 mm

D_{50} = 4.0162 mm D_{10} = 0.1970 mm

C_u = 33.508 C_c = 0.317

Classification

ASTM Poorly graded sand with gravel (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

GeoTesting
express

WARRANTY and LIABILITY

GeoTesting Express (GTX) warrants that all tests it performs are run in general accordance with the specified test procedures and accepted industry practice. GTX will correct or repeat any test that does not comply with this warranty. GTX has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

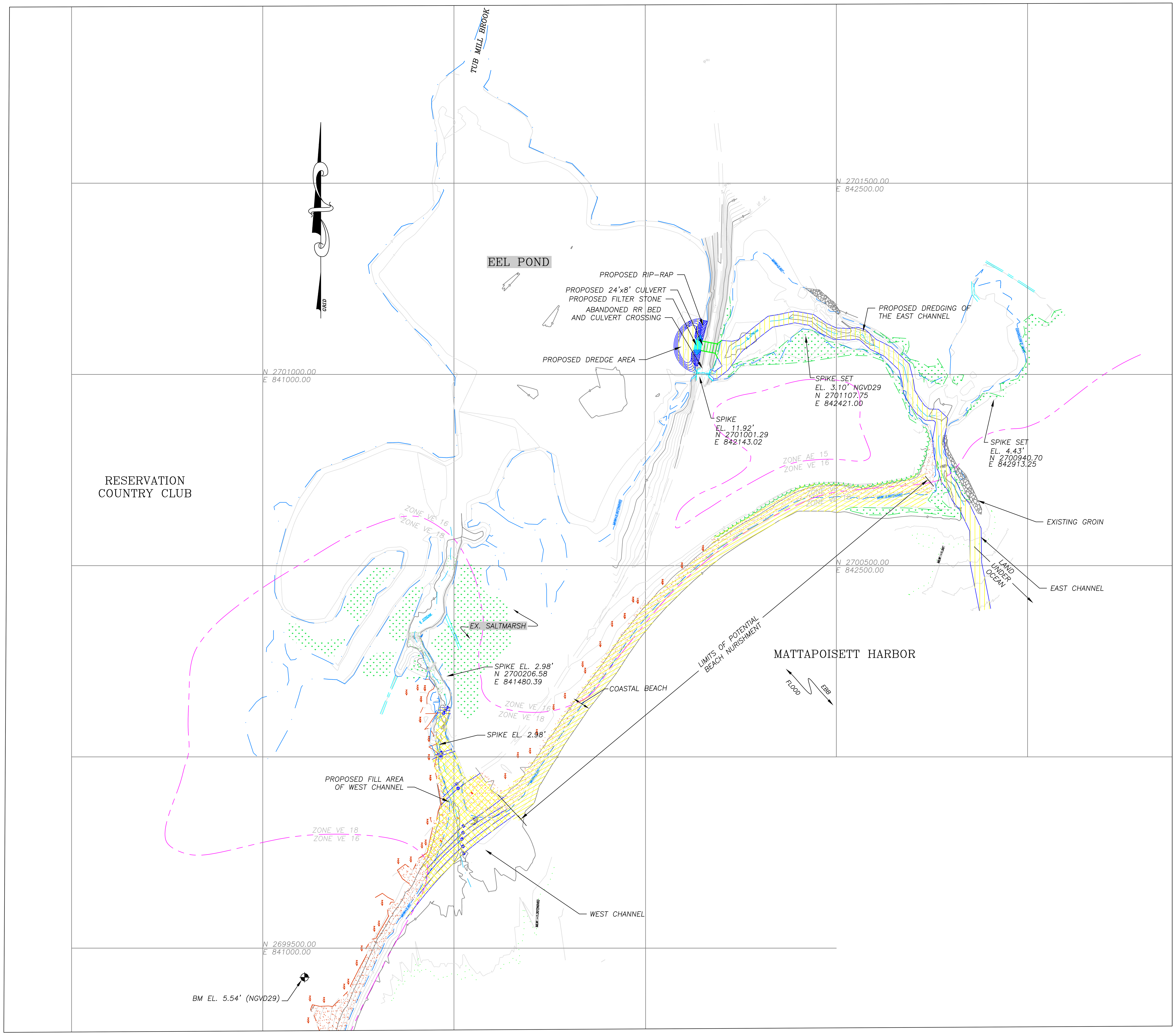
GTX may report engineering parameters that require us to interpret the test data. Such parameters are determined using accepted engineering procedures. However, GTX does not warrant that these parameters accurately reflect the true engineering properties of the *in situ* material. Responsibility for interpretation and use of the test data and these parameters for engineering and/or construction purposes rests solely with the user and not with GTX or any of its employees.

GTX's liability will be limited to correcting or repeating a test which fails our warranty. GTX's liability for damages to the Purchaser of testing services for any cause whatsoever shall be limited to the amount GTX received for the testing services. GTX will not be liable for any damages, or for any lost benefits or other consequential damages resulting from the use of these test results, even if GTX has been advised of the possibility of such damages. GTX will not be responsible for any liability of the Purchaser to any third party.

Commonly Used Symbols

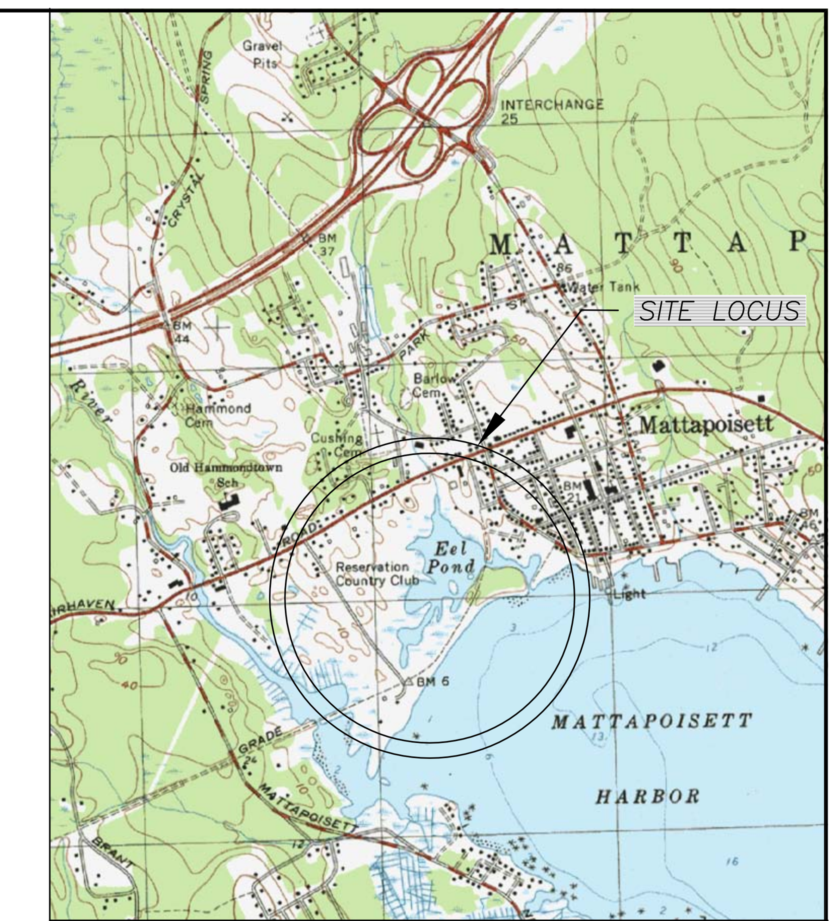
A	pore pressure parameter for $\Delta\sigma_1 - \Delta\sigma_3$
B	pore pressure parameter for $\Delta\sigma_3$
CIU	isotropically consolidated undrained triaxial shear test
CR	compression ratio for one dimensional consolidation
C_c	coefficient of curvature, $(D_{30})^2 / (D_{10} \times D_{60})$
C_u	coefficient of uniformity, D_{60}/D_{10}
C_c	compression index for one dimensional consolidation
C_α	coefficient of secondary compression
c_v	coefficient of consolidation
c	cohesion intercept for total stresses
c'	cohesion intercept for effective stresses
D	diameter of specimen
D_{10}	diameter at which 10% of soil is finer
D_{15}	diameter at which 15% of soil is finer
D_{30}	diameter at which 30% of soil is finer
D_{50}	diameter at which 50% of soil is finer
D_{60}	diameter at which 60% of soil is finer
D_{85}	diameter at which 85% of soil is finer
d_{50}	displacement for 50% consolidation
d_{90}	displacement for 90% consolidation
d_{100}	displacement for 100% consolidation
E	Young's modulus
e	void ratio
e_c	void ratio after consolidation
e_o	initial void ratio
G	shear modulus
G_s	specific gravity of soil particles
H	height of specimen
PI	plasticity index
i	gradient
K_o	lateral stress ratio for one dimensional strain
k	permeability
LI	Liquidity Index
m_v	coefficient of volume change
n	porosity
PI	plasticity index
P_c	preconsolidation pressure
p	$(\sigma_1 + \sigma_3) / 2$, $(\sigma_v + \sigma_h) / 2$
p'	$(\sigma'_1 + \sigma'_3) / 2$, $(\sigma'_v + \sigma'_h) / 2$
p'_c	p' at consolidation
Q	quantity of flow
q	$(\sigma_1 - \sigma_3) / 2$
q_f	q at failure
q_o, q_i	initial q
q_c	q at consolidation
S	degree of saturation
SL	shrinkage limit
s_u	undrained shear strength
T	time factor for consolidation

T	temperature
t	time
U, UC	unconfined compression test
UU, Q	unconsolidated undrained triaxial test
u_a	pore gas pressure
u_e	excess pore water pressure
u, u_w	pore water pressure
V	total volume
V_g	volume of gas
V_s	volume of solids
V_v	volume of voids
V_w	volume of water
V_o	initial volume
v	velocity
W	total weight
W_s	weight of solids
W_w	weight of water
w	water content
w_c	water content at consolidation
w_f	final water content
w_l	liquid limit
w_n	natural water content
w_p	plastic limit
w_s	shrinkage limit
w_o, w_i	initial water content
α	slope of q_f versus p_f
α'	slope of q_f versus p_f'
γ_t	total unit weight
γ_d	dry unit weight
γ_s	unit weight of solids
γ_w	unit weight of water
ε	strain
ε_{vol}	volume strain
ε_h, ε_v	horizontal strain, vertical strain
μ	Poisson's ratio, also viscosity
σ	normal stress
σ'	effective normal stress
σ_c, σ'_c	consolidation stress in isotropic stress system
σ_h, σ'_h	horizontal normal stress
σ_v, σ'_v	vertical normal stress
σ_1	major principal stress
σ_2	intermediate principal stress
σ_3	minor principal stress
τ	shear stress
φ	friction angle based on total stresses
φ'	friction angle based on effective stresses
φ'_r	residual friction angle
φ_{ult}	φ for ultimate strength



AHTL	3.96'
MHHW	2.83'
MHW	2.60'
NGVD1929	0.00
MLW	-1.30'
MLLW	-1.44'

NGVD29 DATUM SHIFT CHART



LOCUS MAP
MARION QUADRANGLE
SCALE: 1" = 2,083'

NOTES:

1. RESULTS OF TOPOGRAPHY FROM SURVEYS DATED 05/23/05, 05/31/05, 06/02/05, AND 06/07/05. RESULTS OF HYDROGRAPHY FROM SURVEY DATED 05/31/05.
2. SOUNDINGS ARE IN FEET AND TENTHS, AND REFER TO NGVD 1929 DATUM. CONTOURS ARE IN FEET AND REFER TO NGVD29.
3. BENCHMARK IS BM SPIKE NEAR WEST CHANNEL, EL. 2.98' (NGVD 29) N2700206.58, E841480.39, AND RR SPIKE AT RR CULVERT CROSSING EL. 11.92' N2701001.29, E842143.02.
4. COORDINATES ARE BASED ON THE MASS. STATE PLANE NAD83.
5. PROJECT SITE IS LOCATED IN FLOOD ZONE VE ELEV 16' & 18' NGVD ACCORDING TO FEMA FIRM MAP 255214 0010G, REVISED SEPTEMBER 30, 1995.
6. THE PROCESS OF LOCATING THE EXISTING SEWER FORCEMAIN WAS CONDUCTED BY OTHERS AND CLE CANNOT GUARANTEE THE ACCURACY NOR DOES CLE WARRANT THE LOCATION OF SAID FORCEMAIN. CLE LOCATED SURVEY MARKERS OF SEWER FORCEMAIN ONLY.
7. THE INFORMATION DEPICTED ON THIS PLAN REPRESENTS THE RESULTS OF SURVEYS PERFORMED ON THE DATES SHOWN, AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS AT THAT TIME. INTERPOLATED INFORMATION FROM BETWEEN SOUNDING RUNS IS NOT GUARANTEED. SHOALS, OBSTRUCTIONS OR OTHER DIFFERING CONDITIONS MAY EXIST BETWEEN THESE RUNS. NO SURVEYS WERE CONDUCTED TO LOCATE PROPERTY LINES, CHANNEL LIMITS, EASEMENTS, UTILITIES, GEOTECHNICAL FEATURES, STRUCTURES, HABITATS OR ANY OTHER PHYSICAL FEATURES RELATING TO THE PROJECT SITE, NOR DOES CLE WARRANT THE EXISTENCE OR LOCATION OF SAID PHYSICAL FEATURES.
8. POSSESSION AND USE OF THE MATERIAL CONTAINED ON THESE DRAWINGS IS GRANTED ONLY IN CONNECTION WITH ITS USE AS IT RELATES TO THE TITLED PROJECT, ANY OTHER USE, REPRODUCTION OR DISCLOSURE OF THE INFORMATION CONTAINED HEREON IS EXPRESSLY PROHIBITED WITHOUT THE WRITTEN CONSENT OF CLE ENGINEERING INC.

GRAPHIC SCALE

125 0 62.50 125 250 500

(IN FEET)
1 inch = 125 ft.

PROJECT:

EEL POND
MATTAPOISETT HARBOR, MA

CLIENT:

TOWN OF MATTAPOISETT
P.O. BOX 435
MATTAPOISETT, MA 02739

CLE ENGINEERING, INC.
15 Creek Road, Marion, MA 02738 (508) 748-0937

SHEET 1 OF 5

PROJECT SITE PLAN

SCALE: 1" = 125'	CHECKED	DATE 06-07-05	DRAWING No. ExistCond_053105_Permit_R1
DRAWN BY: PNJ/WP	BY: SEN	REV. 12-07-05	COMP.CODE 04054.100

REVISION No.	DATE	COMMENT

N/F MAHONEY & SONS, INC.
M10-L27
EX. SALTMARSH
EX. DITCH (TYP.)
EX. DILAPIDATED FOOTBRIDGE (TIMBER)
SPIKE EL. 2.98' (NGVD)
N 2700206.58
E 841480.39
ZONE VE 16
ZONE VE 18
M10-L144
M10-L145
LIMITS OF POTENTIAL BEACH NURISHMENT
LIMIT OF EXIST. BEACHGRASS
EX. BEACH GRASS
WEST CHANNEL
EX. 12"Ø SEWER FORCE MAIN
N 2700000.00
E 841000.00
N 2700000.00
E 842000.90
PROPOSED FILL AREA OF WEST CHANNEL
APPROX. PROP. LINE
N/F RESERVATION GOLF CLUB, INC.
M10-L175
MHW=2.60'
MLW -1.30'(NGVD)
WEST BASELINE
N/F TOWN OF MATTAPOISETT
M10-L143
N 2699500.00
E 841500.00
BM EL. 5.54' (NGVD)
MATTAPOISETT HARBOR
FLOOD
EBB
LEGEND
EXISTING GROUND CONTOUR
PROPOSED GROUND CONTOUR
EXISTING SOUNDING
EXISTING SALTMARSH
EXIST. BEACH GRASS
EDGE OF DIRT ROAD
SAMPLE LOCATION
MLW -1.30' (NGVD)
MHW 2.60' (NGVD)
EX. MANHOLE
FEMA FLOOD ZONE
NOTES:
SEE NOTES ON SHEET 1.
GRAPHIC SCALE
(IN FEET)
1 inch = 50 ft.
PROJECT:
EEL POND
MATTAPOISETT HARBOR, MA
CLIENT:
TOWN OF MATTAPOISETT
P.O. BOX 435
MATTAPOISETT, MA 02739
cle
CLE ENGINEERING, INC.
15 Creek Road, Marion, MA 02738 (508) 748-0937
SHEET 2 OF 5
WEST CHANNEL
SCALE: 1" = 50'
CHECKED BY: SEN
DATE 06-07-05
REV. 12-07-05
DRAWING No. ExistCond_053105_Permit_R1
COMP.CODE 04054.100
DRAWN BY: PNJ/WP
REVISION No.
DATE
COMMENT

EEL POND
MATTAPOISETT HARBOR
PROPOSED RIP-RAP
PROPOSED 24'x8' CULVERT
PROPOSED FILTER STONE
PROPOSED DREDGE AREA
PAINT ON HEADWALL EL. 11.64'
ABANDONED RR BED AND CULVERT CROSSING
TOE OF SLOPE
PROPOSED DREDGING OF THE EAST CHANNEL
N/F DENNIS MAHONEY & SONS, INC. M10-L54
N/F HURLEY M10-L58
RR SPIKE SET EL. 3.10' NGVD29 N 2701107.75 E 842421.00
RR SPIKE EL. 11.92' N 2701001.29 E 842143.02
RR SPIKE EL. 11.46'
N 2701000.00 E 842000.54
N 2701000.00 843000.00
EAST CHANNEL
CLE TIDE POST SET (TYP.)
N/F MAHONEY FAMILY REALTY TRUST M10-L29
N/F MAHONEY FAMILY REALTY TRUST M10-L29A
N/F MAHONEY FAMILY REALTY TRUST M10-L28A
N/F ABEEL NEILSON TR M10-L28
N/F TOWN OF MATTAPOISETT M10-L30
N/F TOWN OF MATTAPOISETT M10-L29B
N/F MAHONEY & SONS, INC. M10-L27
N/F J. GIBBONS ASS M10-L61
N/F OLIVER M10-L60
N/F HURLEY M10-L59
SPIKE SET EL. 4.43'(NGVD) N 2700940.70 E 842913.25
APPROX. PROP. LINE
APPROX. PL
ZONE AE 15
ZONE VE 16
COASTAL BEACH
MHW 2.60'(NGVD)
MLW -1.30'
EX. STONE JETTY
EX. TREELINE
EX. ROCKS (FLOW RESTRICTION)
EX. SALT MARSH
EAST BASELINE
LAND UNDER OCEAN
FLOOD
EBB
N 2700500.00 E 842500.00
STONE BOUND EL. 3.90'
M10-L145
LIMITS OF POTENTIAL BEACH NOURISHMENT
SPIKE EL. 2.98' (NGVD) N 2700206.58 E 841480.39
EX. DILAPIDATED FOOTBRIDGE (TIMBER)
LEGEND
EXISTING GROUND CONTOUR
PROPOSED GROUND CONTOUR
EXISTING SOUNDING
EXISTING SALTMARSH
EXIST. BEACH GRASS
EDGE OF DIRT ROAD
SAMPLE LOCATION
MLW -1.30' (NGVD)
MHW 2.60' (NGVD)
EX. MANHOLE
FEMA FLOOD ZONE
NOTES:
SEE NOTES ON SHEET 1.
GRAPHIC SCALE
(IN FEET)
1 inch = 50 ft.
PROJECT:
EEL POND
MATTAPOISETT HARBOR, MA
CLIENT:
TOWN OF MATTAPOISETT
P.O. BOX 435
MATTAPOISETT, MA 02739
cle
CLE ENGINEERING, INC.
15 Creek Road, Marion, MA 02738 (508) 748-0937
SHEET 3 OF 5
EAST CHANNEL
SCALE: 1" = 50'
CHECKED BY: SEN
DATE 06-07-05
REV. 12-07-05
DRAWN BY: PNJ/WP
DRAWING No. ExistCond_053105_Permit_R1
COMP.CODE 04054.100
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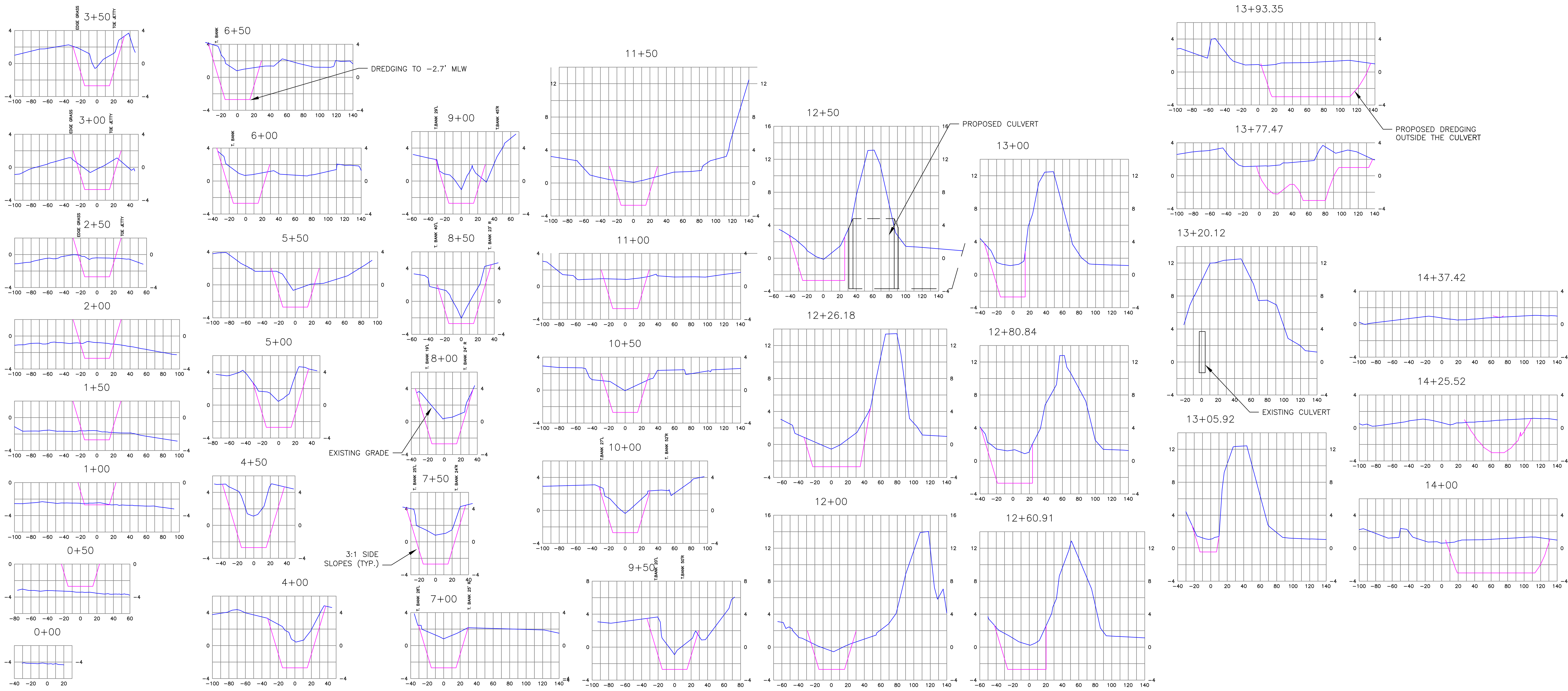
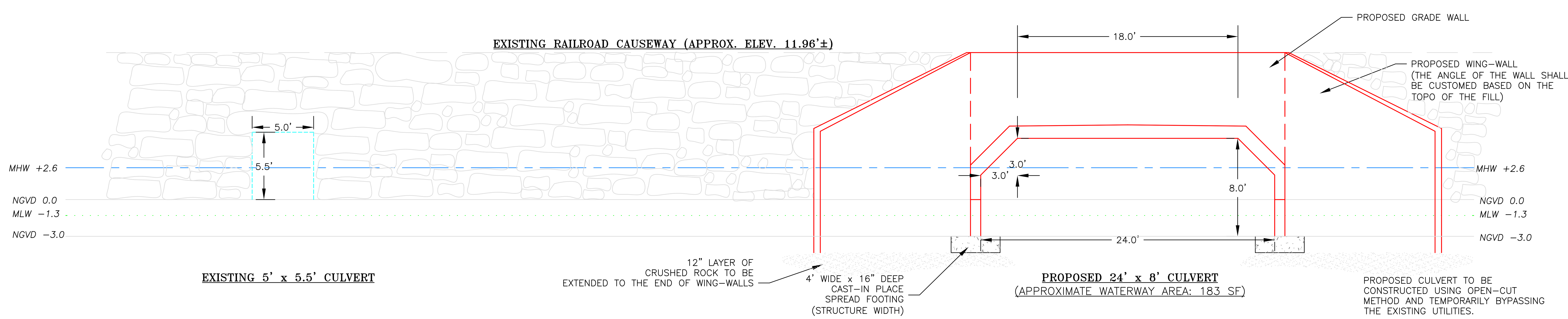
DATE
COMMENT



EAST CHANNEL SECTIONS

SCALE: 1"=60'H, 1"=6'V

NOTES:
SEE NOTES SHEET 1.



SCALE: 1"=5'

PROJECT:
EEL POND
MATTAPOISETT HARBOR, MA

CLIENT:
TOWN OF MATTAPOISETT
P.O. BOX 435
MATTAPOISETT, MA 02739

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SHEET 4 OF 5

EAST CHANNEL SECTION

SCALE: AS STATED	CHECKED	DATE 06-07-05	DRAWING No. ExistCond_053105_Permit_R1
DRAWN BY: PNJ/WP	BY: SEN	REV. 11-10-05	COMP.CODE 04054.100
REVISION No.	DATE	COMMENT	

WEST CHANNEL PROFILE

NOTES:
SEE NOTES SHEET 1.

WEST CHANNEL SECTIONS

SCALE: 1"=60'H, 1"=6'V

PROJECT:

EEL POND
MATTAPOISETT HARBOR, MA

CLIENT:

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WEST CHANNEL PROFILE
WEST CHANNEL SECTION

SHEET 5 OF 5

SCALE: AS STATED	CHECKED	DATE 06-07-05	DRAWING No. ExistCond_053105_Permit_R1
DRAWN BY: PNJ/WP	BY: SEN	REV. 11-10-05	COMP.CODE 04054.100
REVISION No.	DATE	COMMENT	