Conceptual Design Report
North and South Easton Pond Dams Resiliency Project

City of Newport
Newport, RI

December 2023

FUSS & O'NEILL

317 Iron Horse Way
Suite 204
Providence, RI 02908

Table of Contents

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City of Newport

1 Project Overview

The City of Newport Department of Utilities (NWD) has retained Fuss & O'Neill, Inc. (F&O) to further evaluate two alternatives to improve the resilience of the North Easton Pond Dam (NEPD) and South Easton Pond Dam (SEPD) against future intense coastal and inland storms in Newport and Middletown, Rhode Island. This design report is a continuation from a previous phase of work summarized in Fuss & O'Neill's Report titled Climate Change Resiliency Assessment - Technical Memorandum North and South Easton Pond Reservoirs, dated April 2019. This current report summarizes the following primary elements:

- Updated topographic survey,
- Refined hydrologic and hydraulic analysis for the dams and their contributing watersheds,
- Conceptual resiliency alternatives including designation of the recommended alternative, and
- Updated opinion of costs and a Benefit Cost Analysis following the FEMA Toolkit for the recommended plan.

The recommended alternative is an amended version of Alternative 4 that was presented from the 2019 Climate Resiliency Memorandum. The recommended alternative includes:

- Raising and armoring the South Easton Pond (SEP) south, east, and a portion of the north embankments to elevation 12.1 feet,
- Rasing and armoring the North Easton Pond (NEP) south and west embankments to elevation 13.4 feet,
- Removing and reconstructing the SEP primary spillway to a width of 120-feet and installing a hydraulic crest gate to operate over a range of elevations, and
- Installing a flap and/or tide gate across the Moat channel near J Paul Braga Jr. Memorial Field.

References to "right" and "left" herein are made from the perspective of a person facing in a downstream direction.

2 Data Collection

As part of the current evaluation program, a topographic survey and site visit were completed. These investigations and evaluations are described in the following sections.

2.1 Topographic Survey

A limited topographic survey was completed by Control Point Associates, of Southborough, MA in June and August 2022. The survey references the North American Vertical Datum of 1988 (NAVD88) datum and NAD State Plan (NAD83) coordinates.

Fuss & O'Neill visited the site on August 3, 2022 to field verify conditions identified in the topographic survey at visible portions of the site above the water surface.

The topographic survey was reviewed to identify new information that was not available at the time that the 2019 Climate Resiliency Memorandum was prepared. The survey included the following:

- Bathymetric survey performed within 50 feet of the upstream and downstream area of the two primary spillways.

- Centerline crest elevations obtained at approximately 50-foot intervals at sections of the NEPD and SEPD embankments that did not have previous topographic survey data available. These segments include:
    - South Dam: East and south embankments.
    - North Dam: Embankment between the North and South Ponds and dike embankment east of the Newport Water Plant at 100 Bliss Mine Road.

The topographic survey provided new information regarding the embankment elevations assumed in the 2019 Climate Resiliency Memorandum. The topographic survey data indicated that the general elevations assumed in past evaluations were higher than the current observed conditions. The assumed elevations and updated elevations that were used in the modeling are summarized in Table 1: Updated Elevations. The difference was noted at both NEPD and SEPD.

Table 1: Updated Elevations

Embankments	Lowest Assumed Embankment Elevations (2019)	Lowest Surveyed Embankment Elevations (June and August 2022)
NEPD	13.38	11.55
SEPD	11.13	9.64

Upon further discussion with the City, the apparent source of the discrepancy in embankment elevations was likely due to embankment erosion, which the City frequently repairs, caused by wind generated pond waves . Some of these repairs have been conducted since the previous topographical survey in 2019. Figures 1 and 2 depict photos provided by the City of the NEP embankments after Hurricane Ida (September 1 to 5, 2021) that shows the severe erosion due to the wind generated wave action. Without further improvements, portions of the dam are expected to continue to experience erosion due to these waves.

Figures 1 and 2: Embankment damage following Hurricane Ida on the NEP embankment (Photo provided by City)

The implications of the irregular crest elevations and lower elevations than previously considered in 2019 are as follows:

- The earthen embankments are susceptible to overtop under more frequent and less severe storm conditions than previously identified. The potential for overtopping is increased for both coastal and inland flood.
- Although the City makes repairs to the embankments, the embankments are still unprotected against overtopping and at risk of eroding.

3 Hydrologic & Hydraulic Analysis

3.1 Summary of 2023 Hydrologic & Hydraulic Analysis

An updated hydrologic & hydraulic analysis of the project area was prepared in order to:

- Provide a refined understanding of the existing infrastructure and its ability to accommodate relevant inland and tidal flooding events,
- Analyze the system's vulnerability to present-day and future flood scenarios (as informed by 2070 climate predictions),

- Evaluate two alternatives for improvement of the dams as identified in the 2019 Climate Resiliency Memorandum,
- Recommend an alternative based on hydrologic and hydraulic analysis and summarize the alternative's ability to manage for present-day and 2070 climate conditions, and
  Select an inflow design flood for the improved dams based on accepted guidance.

3.2 Existing Vulnerabilities

Updated topographic survey and rainfall-runoff calculations applied to a new hydraulic model informed the following conclusions regarding the existing infrastructure in the project area:

- The present-day 50-year inland precipitation event could exceed the capacity of both dams and overtop existing low points in their embankments. Under predicted 2070 climate conditions, the SEPD capacity may be exceeded by the 10-year inland flood, potentially resulting in overtopping and failure for what is a substantially smaller storm frequency. Overtopping and resultant erosion is a common mechanism for dam failure.
- Modeling demonstrated a breach of the NEPD embankment during the present-day 50-year inland precipitation event could result in a "domino" breach scenario in which SEPD subsequently overtops and fails, exacerbating flooding at downstream locations.
- SEPD limits the overall system's resilience to saltwater intrusion. Estimates indicate that saltwater intrusion through the SEPD primary spillway could occur during the present-day 20-year coastal surge event and during the 2070 predicted 1-year coastal surge event (i.e., by 2070, saltwater intrusion through the spillway could occur on an annual basis).
- The SEPD primary spillway requires modification to increase its hydraulic capacity for the inflow design flood (IDF).
- Overtopping of the existing dam embankments due to coastal surge could occur during the present-day 100-year (SEP Dam) and 200-year (NEP Dam) events. Overtopping due to coastal surge is predicted during the 5-year (SEP Dam) and 50-year (NEP Dam) events by 2070.

The above information is summarized in Figure 3, which displays key infrastructure elevations as they relate to inland flood elevations calculated by the Fuss & O'Neill hydraulic model and coastal surge elevations as reported by the US Army Corps of Engineers and adjusted by Woods Hole Group in the 2019 Climate Resiliency Memorandum.

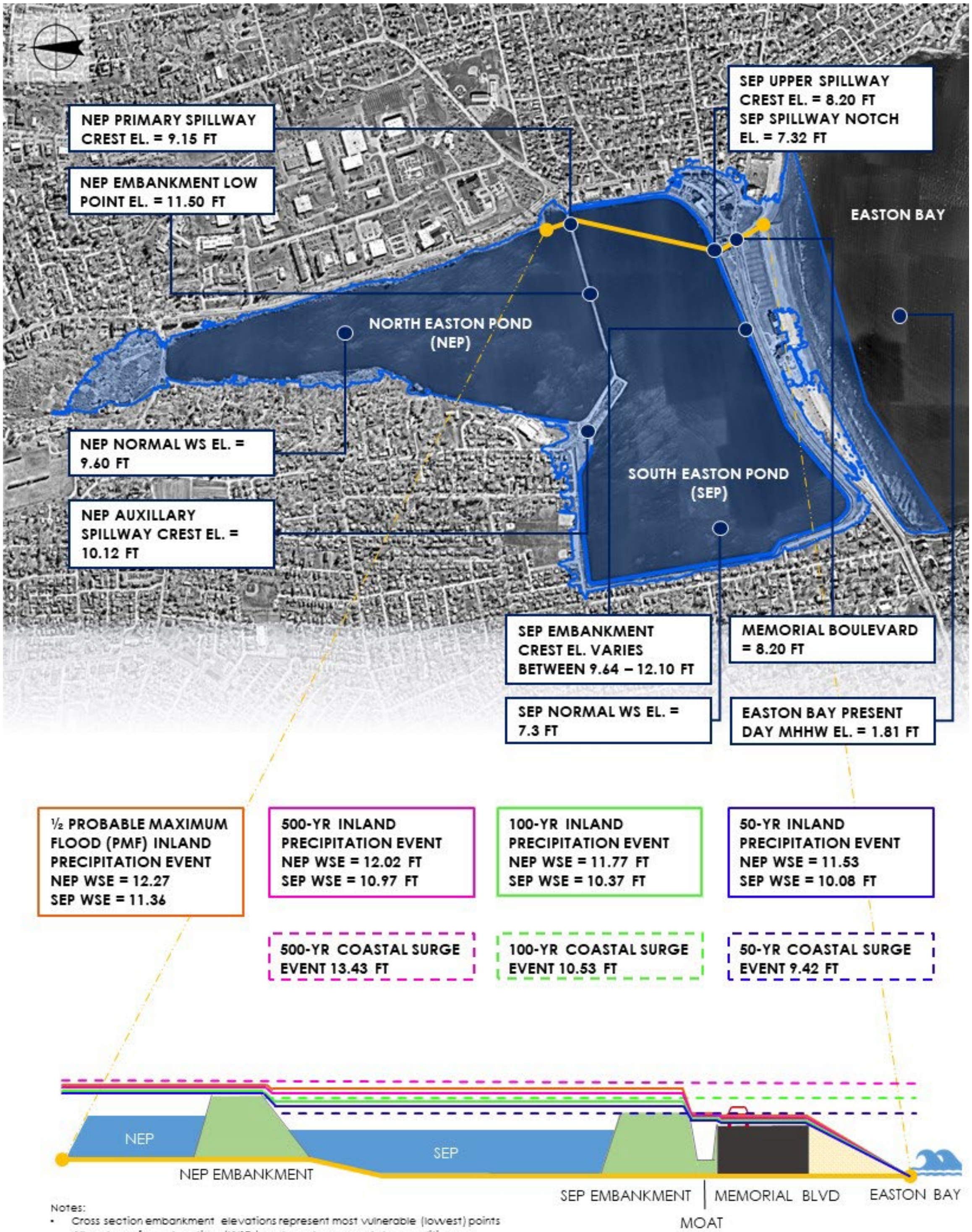


Figure 3: Peak Water Surface Elevation Plan & Profile View for Existing Conditions (Present-Day)

3.3 Proposed Alternatives

Fuss & O'Neill studied two alternatives for potential improvements to the dams. These alternatives, Alternative 2 and Alternative 4, were recommended for further evaluation as part of the 2019 Climate Resiliency Memorandum.

Alternative 2 included:

- Raising the NEP south and west embankments to elevation 13.4 feet to limit overtopping due to inland flooding,
- Raising the SEP south, east, a portion of the north (south of the sediment basin), and a portion of the west (that was not previously raised) embankments to elevation 12.1 feet to limit overtopping due to inland and coastal flooding,
- Reconstructing and armoring dam embankments with articulated concrete block mats to reduce the risk of erosion caused by wave attack, Moat flows, and unlikely overtopping events,
- Retrofitting the NEP auxiliary spillway with a gate structure to provide full closure to elevation 13.4 feet to prevent saltwater intrusion backflowing up the Moat channel,
- Removing and reconstructing the SEP primary spillway with a hydraulic barrier to provide closure to elevation 12.1 feet to prevent saltwater intrusion.

Alternative 4 included:

- Raising the NEP south and west embankments to elevation 13.4 feet to limit overtopping due to inland flooding,
- Raising the SEP south, east, a portion of the north (south of the sediment basin), and a portion of the west (that was not previously raised) embankments to elevation 12.1 feet to limit overtopping due to inland and coastal flooding,
- Reconstructing and armoring dam embankments with articulated concrete block mats to reduce the risk of erosion caused by wave attack, Moat flows, and unlikely overtopping events,
- Retrofitting the NEP auxiliary spillway with a gate structure to provide full closure to elevation 13.4 feet to prevent saltwater intrusion backflowing up the Moat channel,
- Removing the SEP primary spillway, constructing a spillway with a higher hydraulic capacity and installing a gate structure to provide closure to elevation 12.1 feet to prevent saltwater intrusion.

To account for vulnerabilities at the existing dams and to provide resilience for 2070 predicted climate conditions, Fuss & O'Neill recommends proceeding with Alternative 4 which includes several modifications that are recommended as amended by this study. A conceptual drawing of the recommended alternative can be seen in Figure 4. The recommended alternative proposes:

- Raising the NEP south and west embankments to elevation 13.4 feet to limit overtopping due to inland flooding,
- Raising the SEP south, east, a portion of the north (south of the sediment basin), and a portion of the west (that was not previously raised) embankments to elevation 12.1 feet to limit overtopping due to inland and coastal flooding,
- Reconstructing and armoring dam embankments with articulated concrete block mats to reduce the risk of erosion caused by wave attack, Moat flows, and overtopping events,
- Reconstructing the SEP spillway to a width of 120 feet and installing a hydraulic crest gate to range from elevations 5.1 to 12.1, allowing for varied pool elevations and preventing saltwater intrusion through the SEP spillway,

- Constructing a tidal/flap gate in the Moat near J Paul Braga Jr Memorial Field to prevent saltwater intrusion through the NEP auxiliary spillway. The SEP embankment east of the gate will remain at existing conditions to allow stormwater from surrounding neighborhoods into SEP and prevent increased water surface elevations in the moat and surrounding area.

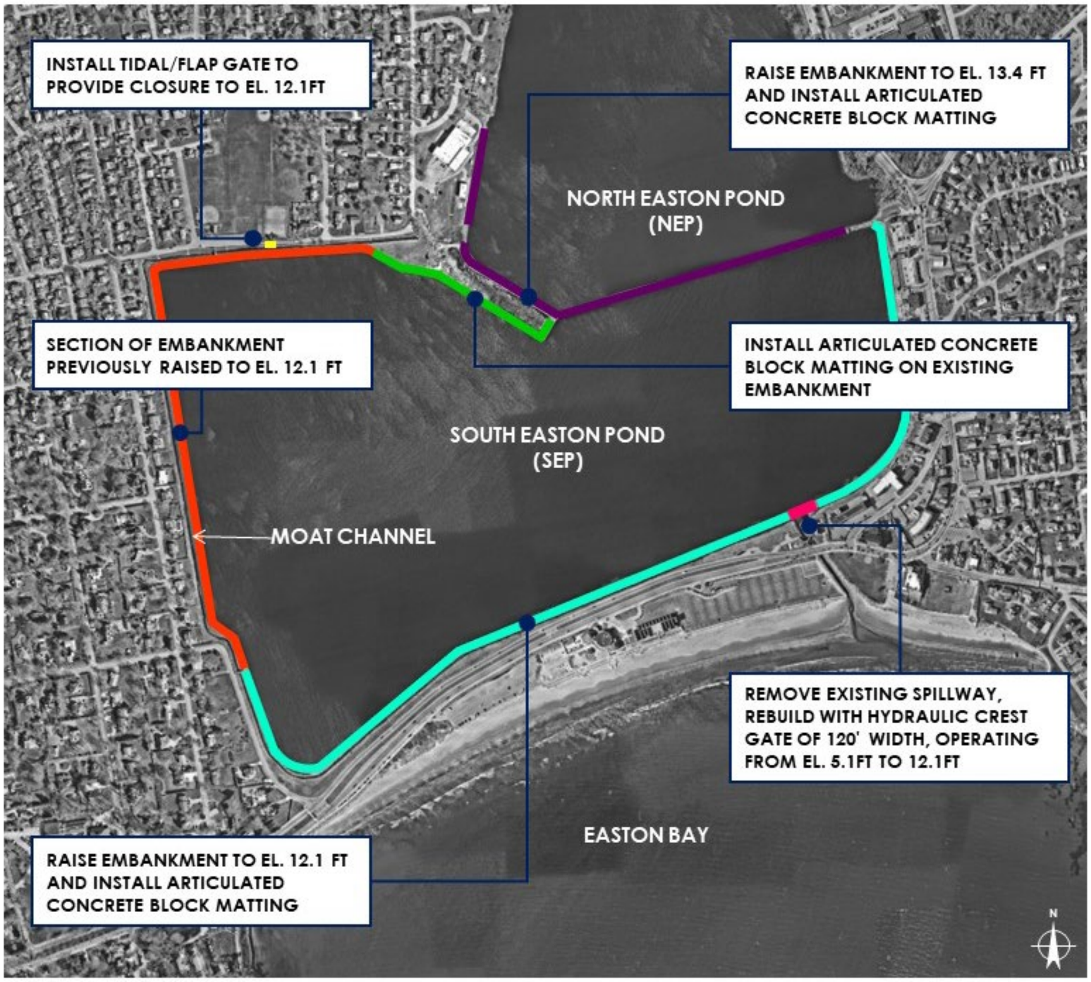


Figure 4: Recommended improvements to NEPD and SEPD.

Table 2 summarizes present-day and 2070 flood protection levels under existing conditions and under the recommended alternative. Figure 5 displays these results at the project site.

Table 2: Comparison of Flood Protection for Existing Conditions and Recommended Alternative

Climate Conditions	Scenario	Overtopping via Inland Flooding	Saltwater Intrusion
Present Day	Existing Conditions	10-year storm	10-year coastal surge
	Recommended Alternative	500-year storm	200-year coastal surge
2070	Existing Conditions	Lower than 10-year [1]	MHHW, no surge [2]
	Recommended Alternative	500-year storm	20-year coastal surge

[1] The smallest inland flood modeled was that of the 10-year precipitation. Modeling predicted this storm would overtop the existing SEP Dam embankments under predicted 2070 climate conditions.

[2] Modeling suggests the 2070 1-year coastal surge would overtop the SEP Dam primary spillway under existing conditions. Therefore, existing conditions protect only through mean higher high water (high tide) for predicted 2070 climate conditions.

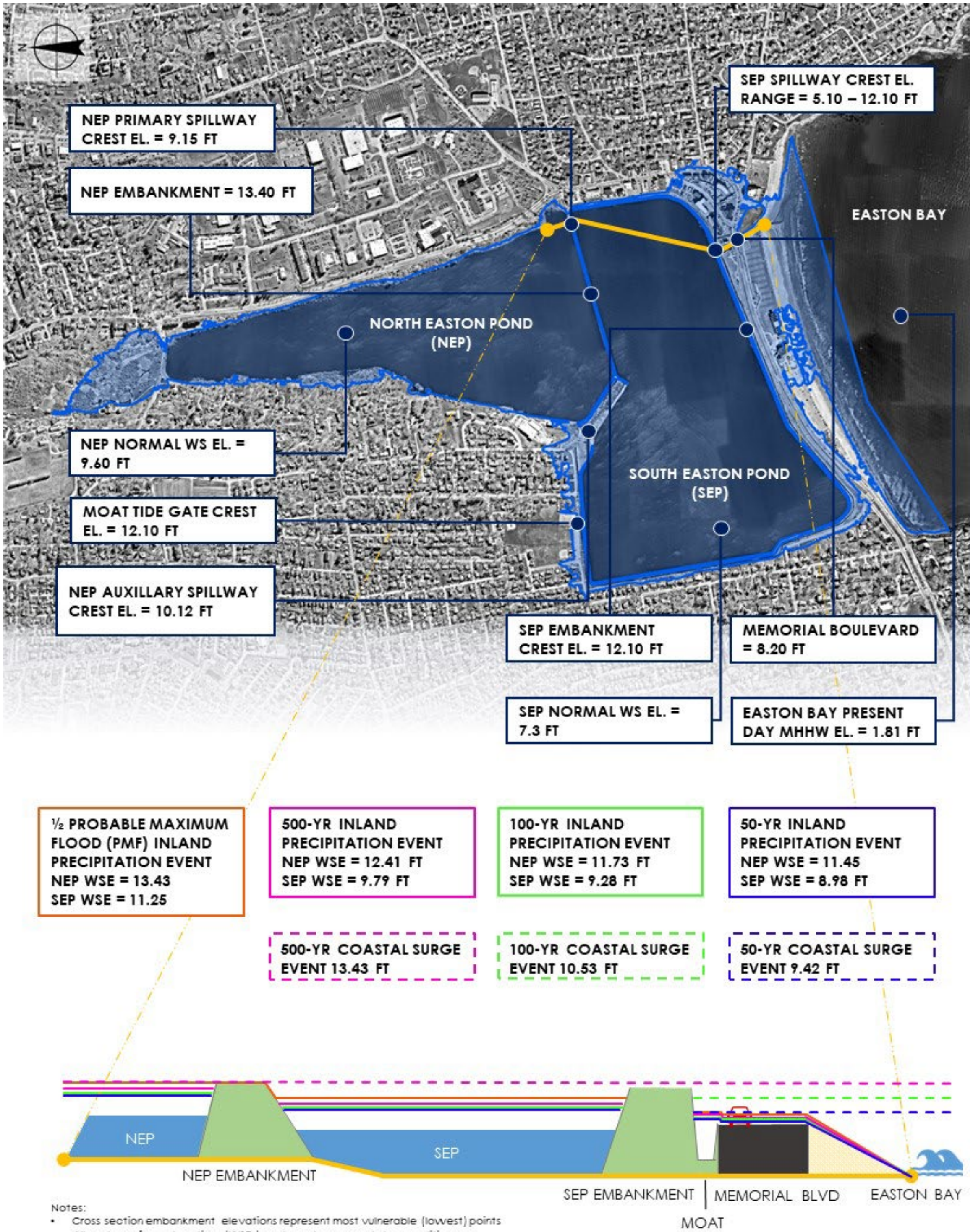


Figure 5: Peak Water Surface Elevation Plan & Profile View for Recommended Alternative (Present-Day)

3.4 Inflow Design Flood

The inflow design flood (IDF) is the storm event for which the dam spillways, embankments, and other components are designed. Fuss & O'Neill determine the IDF at both dams to be the present-day ½ Probable Maximum Flood (PMF) magnitude based on an incremental consequence analysis of dam breach scenarios and their resultant effect on downstream hazard. The PMF is defined as the most severe precipitation and resultant flows that could be expected to occur in a given location. The incremental consequence analysis employed multiple hazard criteria that were measured and compared at a range of locations downstream of the dams. A 120-foot wide spillway and crest gate appear to provide the hydraulic capacity necessary to prepare for (by lowering pre-storm storage in SEP Dam) and accommodate the ½ PMF as the IDF.

4 Recommended Plan

The recommended plan is Alternative 4 with some modifications from the 2019 Climate Resiliency Memorandum. These design changes were initiated after reviewing the updated topographic survey and H&H modeling.

4.1 Embankments

In this updated alternative a total of 7,900 feet of embankments surrounding the NEP and SEP would be raised and armored, and 1,150 feet would just be armored.

The embankments would be:

- Raised to elevation 13.4 feet for the NEP embankments and elevation 12.1 feet for the SEP embankments,
- Armored with Articulated Concrete Block (ACB) matting, similar to the repairs done on the SEP western embankment, to protect against wave action and overtopping, and
- Able to be modified to provide a stable walking path.

4.2 Spillways

The North Pond auxiliary spillway has recently been removed and replaced in kind in the Summer of 2023. No hydraulic gate is proposed for this spillway, however, the spillway replacement design included a wider weir wall footing and therefore the ability to retrofit a gate in the future.

Included in this recommended plan is:

- The removal and reconstruction of the SEP primary spillway and the installation of a hydraulically powered crest gate. The SEP primary spillway would be widened from its current hydraulic width of 100 feet and height of 4.5 feet to have a hydraulic width of 120 feet and height of 7 feet. The gate would connect to constructed concrete piers on either side of the gate.
- An example of crest gates can be seen in Figure 6.

Figure 6: Crest Gate Examples (top http://steelfabinc.com/product/crest-gates/) (bottom: https://www.designboom.com/architecture/mose-flood-barrier-venice-storm-alex-10-05-2020/)

- A prefabricated building with a power connection would be constructed near the gate and would house the controls for the gate. The crest gate could be deployed manually from this building.
- This gate could also be deployed automatically with sensors both in SEP and in the Moat. When the water levels in the pond reach a predesignated (by the NWD) elevation, the gate could lower automatically to allow water to drain from the pond. When the water levels in the Moat increase due to coastal flooding, the gate could be programmed to close to prevent saltwater intrusion from coastal waters flowing into the pond through the spillway.
- This gate would stay in a "partially open" position during daily, non-event days and allow water to flow over it and act in a similar fashion to the existing spillway. During a storm, the gate could be closed to the elevation of the surrounding embankments to give the reservoir a higher capacity as well as prevent saltwater instruction until the water reaches the elevation of the embankments.
- A generator with a gas hook-up would be required to supply power and piers on either side of the gate would be constructed to house the hydraulic components of the gate.

4.3 Tidal/Flap Gate

The gates at J Paul Braga Jr. Memorial Field would span across the Moat and perpendicular to the SEP north embankment.

- This gate would be a tidal gate, a flap gate, or a combination of both.
- The top of the gate would be at elevation 12.1 feet and would tie into the Field and the SEP north embankment.
- This gate would allow one-way flow to allow water to flow from the NEP auxiliary spillway through the Moat and discharge to Easton's Bay, however, during storm surge conditions the gate in conjunction with the SEP embankment would prevent saltwater intrusion into SEP.
- This gate is automatic, they do not require human intervention outside of maintenance.

Whether the gate is a tidal or flap gate depends on how high the flows in the diversion channel are during normal day conditions. A combination of these gates could be constructed and would operate in the sense that the flap gate would be built into the tidal gate. How easily the flap gate opens to allow for flow through it can be adjusted. Figure 7 shows an example of a tidal gate.

Figure 7: Tidal gate example (https://watermanusa.com/products/large-custom-gates/self-regulating-tide-gates/)

5 Opinion of Costs

The budgetary opinion of construction cost associated with embankment raising and armoring alternatives and hydraulic barriers are summarized in Table 3. These costs include a 25 percent contingency and are typically expected to be accurate within -15% to +30% (depending on market conditions and other factors at the time of construction), resulting in a stated construction cost range.

It should also be noted that the costs only include construction costs and do not include long-term operation and maintenance costs. Detailed opinions of cost are provided in Attachment D, based on assessments of material quantities corresponding to conceptual plan.

Table 3: Order-of-Magnitude Opinions of Probable Construction Costs for Conceptual Alternatives

Budgetary Opinion of Cost	-15%	+30%
$43.1M	$37.9M	$53.4

6 Benefit Cost Analysis

Fuss & O'Neill prepared a Benefit-Cost Analysis (BCA) to evaluate the cost effectiveness of the recommended alternative based on the FEMA methodology that will be the basis of any future FEMA funding. The BCA Memorandum is included in Attachment E and includes a summary of the BCA, supporting references, and the preliminary output from the BCA Toolkit Version 6.0 Software. The FEMA BCA is a method that determines the future risk reduction benefits of a hazard mitigation project and compares those benefits to its costs. The result is a Benefit-Cost Ratio (BCR). A project is considered cost-effective when the BCR is 1.0 or greater.

The BCR is calculated by comparing the budgetary opinion of cost with the economic benefit associated with mitigating damages from the relevant hazard events. The hazard events evaluated as part of the BCA include inland flooding, coastal storm surge, and wind attack. Benefits are calculating using a combination of data from the H&H analyses, historical damaged experienced by the City of Newport at the dams, as well as coastal storm surge data from previous technical reports to professionally estimate damages per the FEMA BCA guidelines. Benefit items include but are not limited to the dam itself, utilities, structures, as well as the safety of the general public in the downstream area.

Based on the assumptions and methodology outlined in the BCA Analysis Memorandum, the BCR provided for the North Easton Dam project is 1.20, which indicates that the project is cost effective in accordance with FEMA BCA guidance. Detailed output from the FEMA Toolkit is included within the BCA Analysis Memorandum.

7 Next Steps

The following major steps are recommended to implement this project. This list is not intended to be all inclusive but to summarize the major next steps.

- Apply for FEMA's Building Resilient Infrastructure and Communities (BRIC) grant. The program would fund 75% of the final design and construction costs. A 25% match would need to be provided by the applicant which would be about $10.8 million for the recommended alternative.
- Meet with Rhode Island Emergency Management Agency (RIEMA) staff to review the hydraulic modeling and confirm the design criteria and recommendations. The hydraulic model developed for this project is complicated and unusual and buy-in from RIEMA is recommended.
- Meet with Rhode Island Coastal Resources Management Council (CRMC) to review the project and confirm permitting pathways for the improvements.
- Once funding is secured, final engineering design and permitting of the recommended alternative should be completed. As part of this process, the construction o[inions of cost should be updated and refined. This task should also define operation, maintenance and training requirements for this project.
- Right-of-way access to the allow construction of the proposed tidal/flap gate at J Paul Braga Jr. Memorial Field should be investigated. It is understood that this Field is currently City owned property.

Attachment A

Previous Reports and References

The following report was referenced during the completion of this report:

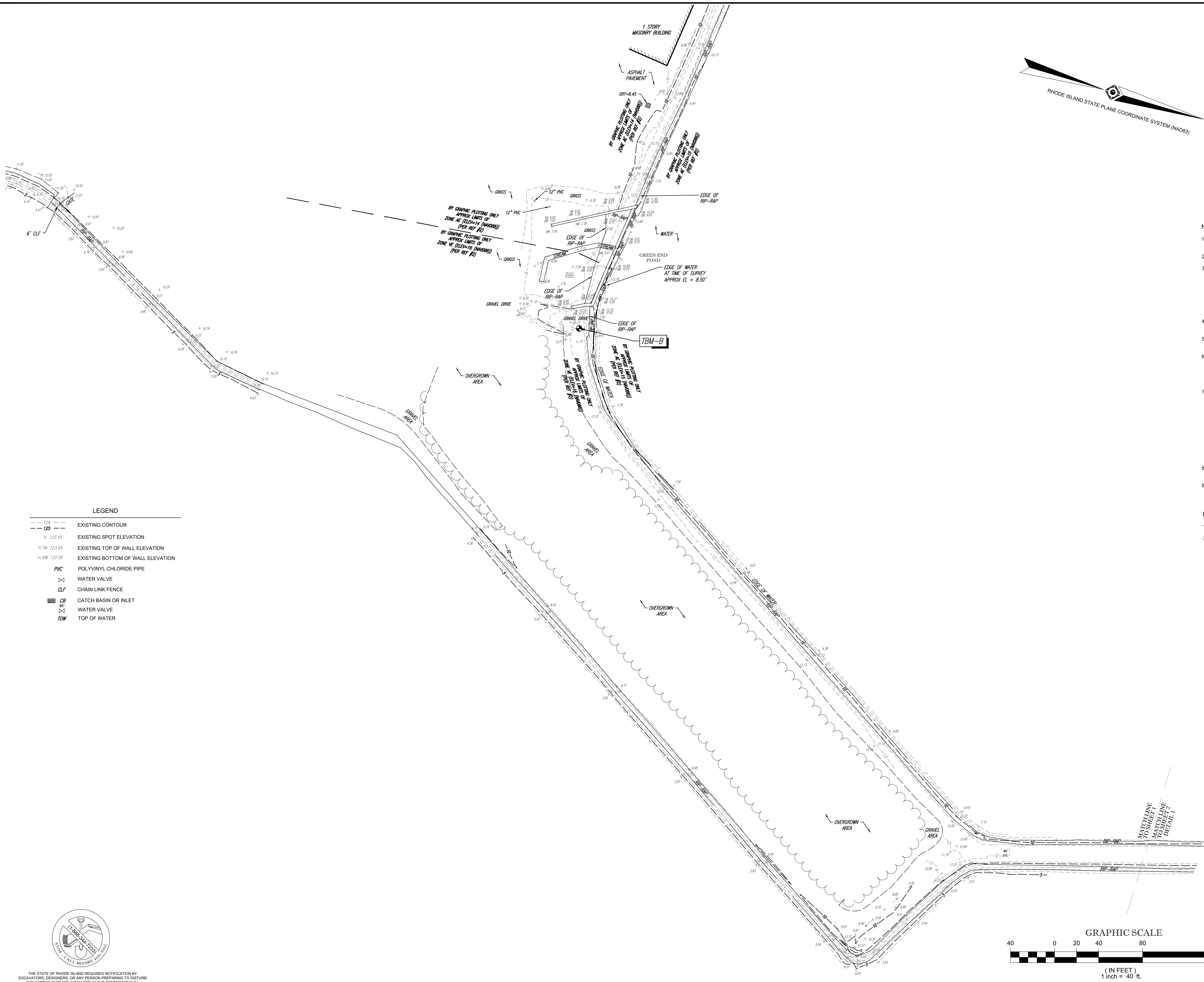
1. "Climate Resiliency Assessment Technical Memorandum North and South Easton Pond Reservoirs", Fuss & O'Neill and Woods Hole Group, April 2019.
2. Easton Pond North Dam Visual Inspection/Evaluation Report, Pare Corporations, August 22, 2013.
3. "Easton Pond North Dam Inspection Report Checklist", McMahon Associates, May 23, 2011.
4. "Final Report Easton Pond Dam and Moat Study", Fuss & O'Neill, September 2007.
5. "Plan of Waste-Way in North dam at Easton Pond", Newport, January 1898.
6. "Dam Inspection Report", Department of Environmental Management, October 18, 1985.
7. Site Photographs, 1980.
8. Site Photographs, October 1980, May 1978.

The following were referenced during the completion of the visual inspection and preparation of this report and the development of the recommendation presented herein:

1. "Guidelines for Reporting the Performance of Dams" National Performance of Dams Program, August 1994.
2. "ER 110-2-106-Recommended Guidelines for Safety Inspection of Dams", Department of the Army, September 26, 1979.
3. "Design of Small Dams", US Department of the Interior Bureau of Reclamation, 1987.

Attachment B

Topographic Survey



LEGEND

— — 124 — — / — — 125 — —	EXISTING CONTOUR
× 123.45	EXISTING SPOT ELEVATION
× TW 123.45	EXISTING TOP OF WALL ELEVATION
× BW 122.95	EXISTING BOTTOM OF WALL ELEVATION
PVC	POLYVINYL CHLORIDE PIPE
⋈	WATER VALVE
CLF	CHAIN LINK FENCE
CB	CATCH BASIN OR INLET
WV ⋈	WATER VALVE
TOW	TOP OF WATER

LOCUS MAP
© 2013 ESRI WORLD STREET MAPS
NOT TO SCALE

NOTES:

1. PROPERTY KNOWN AS LOT 731 AS SHOWN ON THE CITY OF NEWPORT, NEWPORT COUNTY, STATE OF RHODE ISLAND; ASSESSOR'S MAP NO. 11.
2. AREA = NOT CALCULATED.
3. LOCATION OF UNDERGROUND UTILITIES ARE APPROXIMATE. LOCATIONS AND SIZES ARE BASED ON UTILITY MARK-OUTS, ABOVE GROUND STRUCTURES THAT WERE VISIBLE & ACCESSIBLE IN THE FIELD, AND THE MAPS AS LISTED IN THE REFERENCES AVAILABLE AT THE TIME OF THE SURVEY. AVAILABLE AS-BUILT PLANS AND UTILITY MARKOUT DOES NOT ENSURE MAPPING OF ALL UNDERGROUND UTILITIES AND STRUCTURES. BEFORE ANY EXCAVATION IS TO BEGIN, ALL UNDERGROUND UTILITIES SHOULD BE VERIFIED AS TO THEIR LOCATION, SIZE AND TYPE BY THE PROPER UTILITY COMPANIES. CONTROL POINT ASSOCIATES, INC. DOES NOT GUARANTEE THE UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA EITHER IN SERVICE OR ABANDONED.
4. THIS PLAN IS BASED ON INFORMATION PROVIDED BY A SURVEY PREPARED IN THE FIELD BY CONTROL POINT ASSOCIATES, INC. AND OTHER REFERENCE MATERIAL AS LISTED HEREON.
5. THIS SURVEY WAS PREPARED WITHOUT THE BENEFIT OF A TITLE COMMITMENT AND IS SUBJECT TO THE RESTRICTIONS, COVENANTS AND/OR EASEMENTS THAT MAY BE CONTAINED THEREIN.
6. BY GRAPHIC PLOTTING ONLY PROPERTY IS LOCATED IN FLOOD HAZARD ZONE AE (AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD; BASE FLOOD ELEVATIONS DETERMINED; ELEVATION VARIES) AND FLOOD HAZARD ZONE VE (SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD; COASTAL FLOOD ZONE WITH VELOCITY HAZARD (WAVE ACTION); BASE FLOOD ELEVATIONS DETERMINED; ELEV=16 (NAVD88)) PER REF. #2
7. ELEVATIONS REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), BASED ON GPS OBSERVATIONS UTILIZING THE KEYSTONE VRS NETWORK (KEYNETGPS).

   TEMPORARY BENCH MARKS SET:

   TBM-A: BOX CUT INTO CONCRETE HEADWALL AT ELEVATION = 13.30'

   TBM-B: NAIL SET AT ELEVATION= 13.51'

   PRIOR TO CONSTRUCTION IT IS THE CONTRACTOR'S RESPONSIBILITY TO VERIFY THAT THE BENCHMARKS ILLUSTRATED ON THIS SKETCH HAVE NOT BEEN DISTURBED AND THEIR ELEVATIONS HAVE BEEN CONFIRMED. ANY CONFLICTS MUST BE REPORTED PRIOR TO CONSTRUCTION.
8. THE OFFSETS SHOWN ARE NOT TO BE USED FOR THE CONSTRUCTION OF ANY STRUCTURE, FENCE, PERMANENT ADDITION, ETC.
9. PER CONTRACTUAL AGREEMENT WITH CLIENT, CONTROL POINT ASSOCIATES, INC. HAS NOT PERFORMED A BOUNDARY SURVEY OF THE SUBJECT PROPERTY.

REFERENCES:

1. THE TAX ASSESSOR'S MAP OF NEWPORT, NEWPORT COUNTY, MAP #11.
2. MAP ENTITLED "NATIONAL FLOOD INSURANCE PROGRAM, FIRM, FLOOD INSURANCE RATE MAP, NEWPORT COUNTY, RHODE ISLAND (ALL JURISDICTIONS) PANEL 181 OF 226," MAP NUMBER 44005C0181J, MAP REVISED: SEPTEMBER 4, 2013.

No.	DESCRIPTION OF REVISION	FIELD CREW	DRAWN:	APPROVED:	DATE
3	ADDITIONAL TOPOGRAPHIC DETAIL ADDED	C.W.	D.R.L.	C.E.L.	8-05-2022
2	WALL BREAKLINES ADDED	-	R.J.K.	C.E.L.	8-30-2021
1	REVISED PER CLIENT COMMENTS	-	R.J.K.	C.E.L.	8-16-2021

THIS SURVEY HAS BEEN CONDUCTED AND THE PLAN HAS BEEN PREPARED PURSUANT TO 435-RICR-00-00-1.9 OF THE RULES AND REGULATIONS ADOPTED BY THE RHODE ISLAND STATE BOARD OF REGISTRATION FOR PROFESSIONAL LAND SURVEYORS ON APRIL 28, 2018 AS FOLLOWS:

1. TYPE OF BOUNDARY SURVEY: MEASUREMENT SPECIFICATION
   COMPREHENSIVE BOUNDARY SURVEY I
2. OTHER TYPE OF SURVEY: MEASUREMENT SPECIFICATION:
   DATA ACCUMULATION SURVEY III
   (PLANIMETRIC SURVEY, TOPOGRAPHIC SURVEY)
   VERTICAL CONTROL STANDARD V-3
   TOPOGRAPHIC SURVEY ACCURACY T-1
3. THE PURPOSE FOR THE CONDUCT OF THE SURVEY AND FOR THE PREPARATION OF THIS PLAN IS AS FOLLOWS:
   OBTAIN TOPOGRAPHIC AND PLANIMETRIC INFORMATION FOR USE AS A BACKGROUND DOCUMENT FOR SITE PLAN PREPARATION.

NOT A VALID ORIGINAL DOCUMENT UNLESS EMBOSSED
WITH RAISED IMPRESSION OR STAMPED WITH A BLUE INK SEAL.

GRAPHIC SCALE
40 0 20 40 80 160
(IN FEET)
1 inch = 40 ft.

CHARLES E. LENT
RHODE ISLAND PROFESSIONAL LAND SURVEYOR #1925
CERTIFICATE OF AUTHORIZATION #A350

8-05-2022
DATE

FIELD DATE: 6-22-2021
FIELD BOOK NO.: 21-04 MA
FIELD BOOK PG.: 57

TOPOGRAPHIC SURVEY
FUSS & O'NEILL, INC.

100 BLISS MINE ROAD
MAP 11, LOT 731
CITY OF NEWPORT, NEWPORT COUNTY
STATE OF RHODE ISLAND

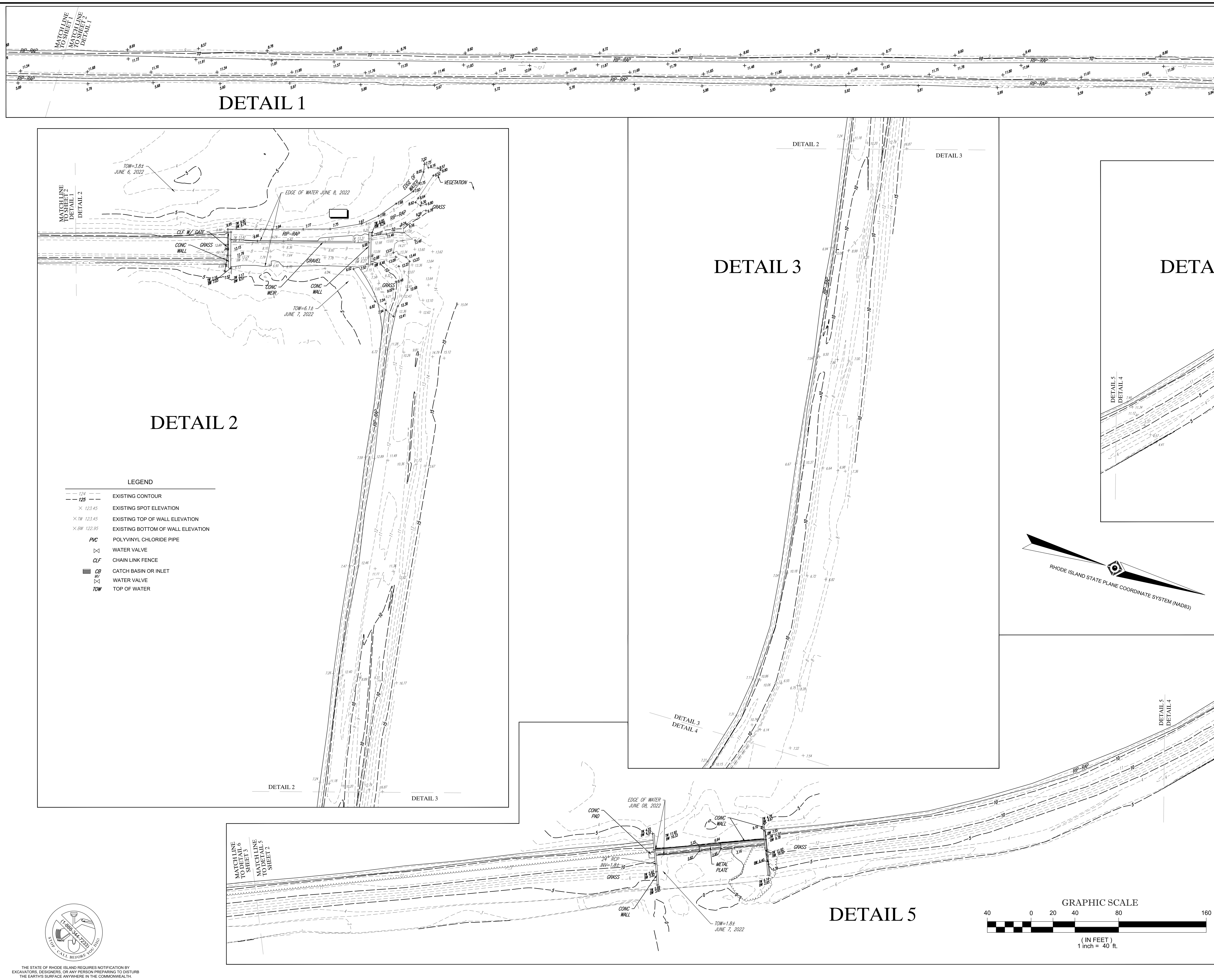
FIELD CREW: J.S.A.
DRAWN: R.J.K.

CONTROL POINT ASSOCIATES, INC.
352 TURNPIKE ROAD
SOUTHBOROUGH, MA 01772
508.948.3000 - 508.948.3003 FAX
WWW.CPASURVEY.COM
ALBANY, NY 518-217-5010
CHALFONT, PA 215-712-9800
HAUPPAUGE, NY 631-580-2645
MANHATTAN, NY 646-780-0411
MT LAUREL, NJ 609-857-2099
WARREN, NJ 908-668-0099

REVIEWED:	APPROVED:	DATE	SCALE	FILE NO.	DWG. NO.
C.E.L.	C.E.L.	7-15-2021	1"=40'	03-210154-00	1 OF 3

1-888-344-7233
STOP - CALL BEFORE YOU DIG!

THE STATE OF RHODE ISLAND REQUIRES NOTIFICATION BY EXCAVATORS, DESIGNERS, OR ANY PERSON PREPARING TO DISTURB THE EARTH'S SURFACE ANYWHERE IN THE COMMONWEALTH.



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3. THE PURPOSE FOR THE CONDUCT OF THE SURVEY AND FOR THE PREPARATION OF THIS PLAN IS AS FOLLOWS:
   OBTAIN TOPOGRAPHIC AND PLANIMETRIC INFORMATION FOR USE AS A BACKGROUND DOCUMENT FOR SITE PLAN PREPARATION.

NOT A VALID ORIGINAL DOCUMENT UNLESS EMBOSSED WITH RAISED IMPRESSION OR STAMPED WITH A BLUE INK SEAL.

8-05-2022
DATE

CHARLES E. LENT
RHODE ISLAND PROFESSIONAL LAND SURVEYOR #1925
CERTIFICATE OF AUTHORIZATION #A350

FIELD DATE: 6-22-2021
FIELD BOOK NO.: 21-04 MA
FIELD BOOK PG.: 57
FIELD CREW: J.S.A.
DRAWN: R.J.K.

TOPOGRAPHIC SURVEY
FUSS & O'NEILL, INC.

100 BLISS MINE ROAD
MAP 11, LOT 731
CITY OF NEWPORT, NEWPORT COUNTY
STATE OF RHODE ISLAND

CONTROL POINT ASSOCIATES, INC.
352 TURNPIKE ROAD
SOUTHBOROUGH, MA 01772
508.948.3000 - 508.948.3003 FAX
WWW.CPASURVEY.COM
ALBANY, NY 518-217-5010
CHALFONT, PA 215-712-9800
HAUPPAUGE, NY 631-580-2645
MANHATTAN, NY 646-780-0411
MT LAUREL, NJ 609-857-2099
WARREN, NJ 908-668-0099

REVIEWED:	APPROVED:	DATE	SCALE	FILE NO.	DWG. NO.
C.E.L.	C.E.L.	7-15-2021	1"=40'	03-210154-00	2 OF 3

THE STATE OF RHODE ISLAND REQUIRES NOTIFICATION BY EXCAVATORS, DESIGNERS, OR ANY PERSON PREPARING TO DISTURB THE EARTH'S SURFACE ANYWHERE IN THE COMMONWEALTH.

DETAIL 6

LEGEND

124 / 125	EXISTING CONTOUR
× 123.45	EXISTING SPOT ELEVATION
× TW 123.45	EXISTING TOP OF WALL ELEVATION
× BW 122.95	EXISTING BOTTOM OF WALL ELEVATION
PVC	POLYVINYL CHLORIDE PIPE
	WATER VALVE
CLF	CHAIN LINK FENCE
CB	CATCH BASIN OR INLET
WV	WATER VALVE
TOW	TOP OF WATER

DETAIL 7

THE STATE OF RHODE ISLAND REQUIRES NOTIFICATION BY EXCAVATORS, DESIGNERS, OR ANY PERSON PREPARING TO DISTURB THE EARTH'S SURFACE ANYWHERE IN THE COMMONWEALTH.

GRAPHIC SCALE

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

No.	DESCRIPTION OF REVISION	FIELD CREW	DRAWN:	APPROVED:	DATE
3	ADDITIONAL TOPOGRAPHIC DETAIL ADDED	C.W.	D.R.L.	C.E.L.	8-05-2022
2	WALL BREAKLINES ADDED	-	R.J.K.	C.E.L.	8-30-2021
1	REVISED PER CLIENT COMMENTS	-	R.J.K.	C.E.L.	8-16-2021

THIS SURVEY HAS BEEN CONDUCTED AND THE PLAN HAS BEEN PREPARED PURSUANT TO 435-RICR-00-00-1.9 OF THE RULES AND REGULATIONS ADOPTED BY THE RHODE ISLAND STATE BOARD OF REGISTRATION FOR PROFESSIONAL LAND SURVEYORS ON APRIL 28, 2018 AS FOLLOWS:

1. TYPE OF BOUNDARY SURVEY: MEASUREMENT SPECIFICATION
   COMPREHENSIVE BOUNDARY SURVEY — I
2. OTHER TYPE OF SURVEY: MEASUREMENT SPECIFICATION:
   DATA ACCUMULATION SURVEY — III
   (PLANIMETRIC SURVEY, TOPOGRAPHIC SURVEY)
   VERTICAL CONTROL STANDARD — V-3
   TOPOGRAPHIC SURVEY ACCURACY — T-1
3. THE PURPOSE FOR THE CONDUCT OF THE SURVEY AND FOR THE PREPARATION OF THIS PLAN IS AS FOLLOWS:
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CHARLES E. LENT — 8-05-2022 DATE
RHODE ISLAND PROFESSIONAL LAND SURVEYOR #1925
CERTIFICATE OF AUTHORIZATION #A350

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C.E.L.	C.E.L.	7-15-2021	1"=40'	03-210154-00	3 OF 3

Attachment C

Hydraulic and Hydrologic Technical Memorandum

North and South Easton Pond Dams
2023 Hydrologic & Hydraulic Analysis

City of Newport
Newport, Rhode Island

December 2023

FUSS & O'NEILL

317 Iron Horse Way
Suite 204
Providence, RI 02908

Table of Contents

North and South Easton Ponds 2023 Hydrologic and Hydraulic Analysis

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Appendices — End of Report

1 Executive Summary

North Easton Pond Dam (NEP Dam) and South Easton Pond Dam (SEP Dam) are critical drinking water infrastructure for the City of Newport, Rhode Island and surrounding communities. The dams have been subject to inland and tidal flood events and associated damages. This technical memorandum summarizes a hydrologic and hydraulic analysis performed by Fuss & O'Neill to evaluate alternatives for improving the climate resilience of the dams and their appurtenances. The analyses presented in this memorandum builds upon and updates previous analyses carried out by Fuss & O'Neill.

The main goals of this 2023 Hydrologic and Hydraulic Analysis are as follows:

- Provide a refined understanding of the existing infrastructure and its ability to accommodate relevant inland and tidal flooding events
- Analyze the system's vulnerability to present-day and future flood scenarios (as informed by 2070 climate projections)
- Evaluate two alternatives for improvement of the dams as identified in a previous report prepared by Fuss & O'Neill
- Recommend an alternative based on hydrologic and hydraulic analyses and summarize the alternative's ability to accommodate present-day and 2070 climate conditions
- Select an inflow design flood for the dams based on accepted design standards and guidance

Methodology, model inputs, assumptions, and results are described in the following pages. The conclusions most relevant to the goals of the analysis can be summarized as follows:

1. **<u>Existing Vulnerabilities</u>**

- Modeling indicated the present-day 50-year inland precipitation event could exceed the capacity of both dams by overtopping existing low points in their embankments, and cause subsequent dam failures. Modeling indicated the predicted 2070 10-year inland precipitation event could exceed the SEP Dam capacity, potentially resulting in overtopping and failure.
- Modeling demonstrated a breach of the NEP Dam embankment during the present-day 50-year inland precipitation event could result in a "domino" breach scenario in which the SEP Dam subsequently overtops and fails, exacerbating flooding at downstream locations.
- SEP Dam limits the overall system's resilience to saltwater intrusion. Estimates indicate that saltwater intrusion through the SEP Dam primary spillway could occur during the present-day 20-year coastal surge event and during the 2070 predicted 1-year coastal surge event (i.e., by 2070, saltwater intrusion through the spillway could occur on an annual basis).
- Overtopping of the existing dam embankments due to coastal surge could occur during the present-day 100-year (SEP Dam) and 200-year (NEP Dam) events. Overtopping due to coastal surge is predicted during the 5-year (SEP Dam) and 50-year (NEP Dam) events by 2070.

2. **<u>Recommended Alternative (Alternative 4)</u>**

Fuss & O'Neill studied two alternatives for potential improvements to the dams. These alternatives, Alternative 2 and Alternative 4, were recommended for further evaluation as part of a previous assessment of the dams' resilience to the effects of climate change. To account for vulnerabilities at the existing dams and to provide resilience for 2070 predicted climate conditions, Fuss & O'Neill recommends proceeding with Alternative 4 (as amended by this study). The recommended alternative proposes:

- Raising NEP Dam embankment crest to elevation 13.4 to limit overtopping due to inland flooding
- Raising the SEP Dam embankment crest to elevation 12.1 to limit overtopping due to inland and coastal flooding
- Reconstructing the SEP Dam spillway to a width of 120 feet and installing a hydraulic crest gate to range from elevations 5.1 to 12.1, allowing for varied pool elevations and preventing saltwater intrusion through the SEP Dam spillway
- Constructing a tidal/flap gate in the moat near J Paul Braga Jr Memorial Field to prevent saltwater intrusion through the NEP Dam auxiliary spillway. The SEP Dam embankment east of the gate will remain at existing elevations to allow stormwater from surrounding neighborhoods into SEP and prevent increased water surface elevations in the moat and surrounding area
- Reconstructing and armoring dam embankments with articulated concrete block mats to reduce the risk of erosion caused by wave attack, moat flows, and unlikely overtopping events

Table 1 summarizes present-day and 2070 flood protection levels under existing conditions and under the recommended alternative. Figure 1 and Figure 2 display selected results at the project site.

Table 1: Comparison of Flood Protection for Existing Conditions and Recommended Alternative

Climate Conditions	Scenario	Overtopping via Inland Flooding	Saltwater Intrusion
Present-Day	Existing Conditions	10-year storm	10-year coastal surge
	Recommended Alternative	500-year storm	200-year coastal surge
2070	Existing Conditions	Lower than 10-year [1]	MHHW, no surge [2]
	Recommended Alternative	500-year storm	20-year coastal surge

[1] The smallest inland flood modeled was that of the 10-year precipitation. Modeling predicted this storm would overtop the existing SEP Dam embankments under predicted 2070 climate conditions.
[2] Modeling suggests the 2070 1-year coastal surge would overtop the SEP Dam primary spillway under existing conditions. Therefore, existing conditions protect only through mean higher high water (high tide) for predicted 2070 climate conditions.

3. Inflow Design Flood

The inflow design flood (IDF) is the storm event for which the dam spillways, embankments, and other components are designed. Fuss & O'Neill determined the IDF at both dams to be the present-day ½ probable maximum flood (PMF) magnitude based on an incremental consequence analysis of dam breach scenarios and their resultant effect on downstream hazard. The PMF is defined as the most severe precipitation and resultant flows that could be expected to occur in a given location. The incremental consequence analysis employed multiple hazard criteria that were measured and compared at a range of locations downstream of the dams. A 120-foot wide spillway and crest gate appear to provide the hydraulic capacity necessary to prepare for (by lowering pre-storm storage in SEP Dam) and accommodate the ½ PMF as the IDF.

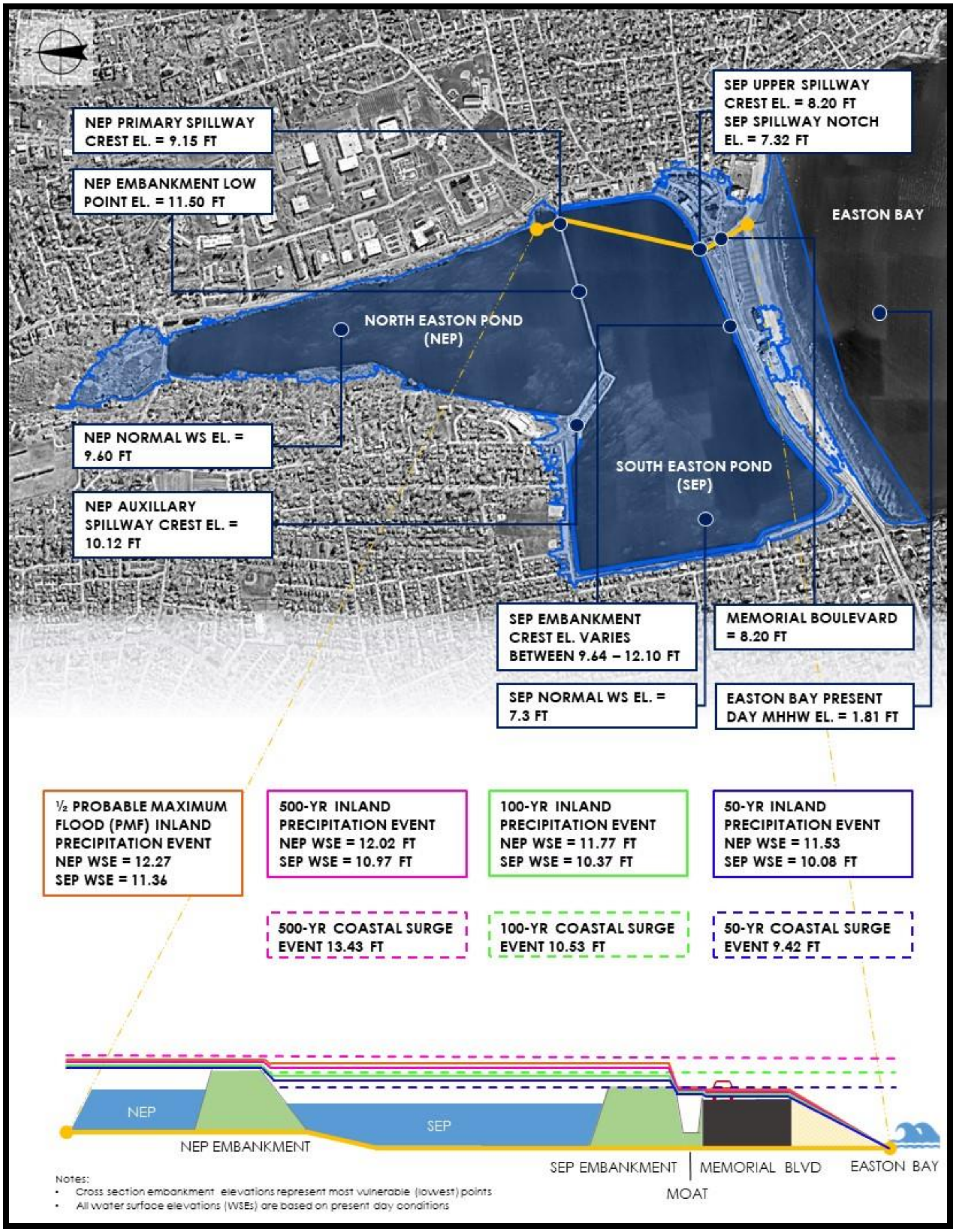


Figure 1: Peak Water Surface Elevations Plan & Profile View for Existing Conditions (Present-Day)

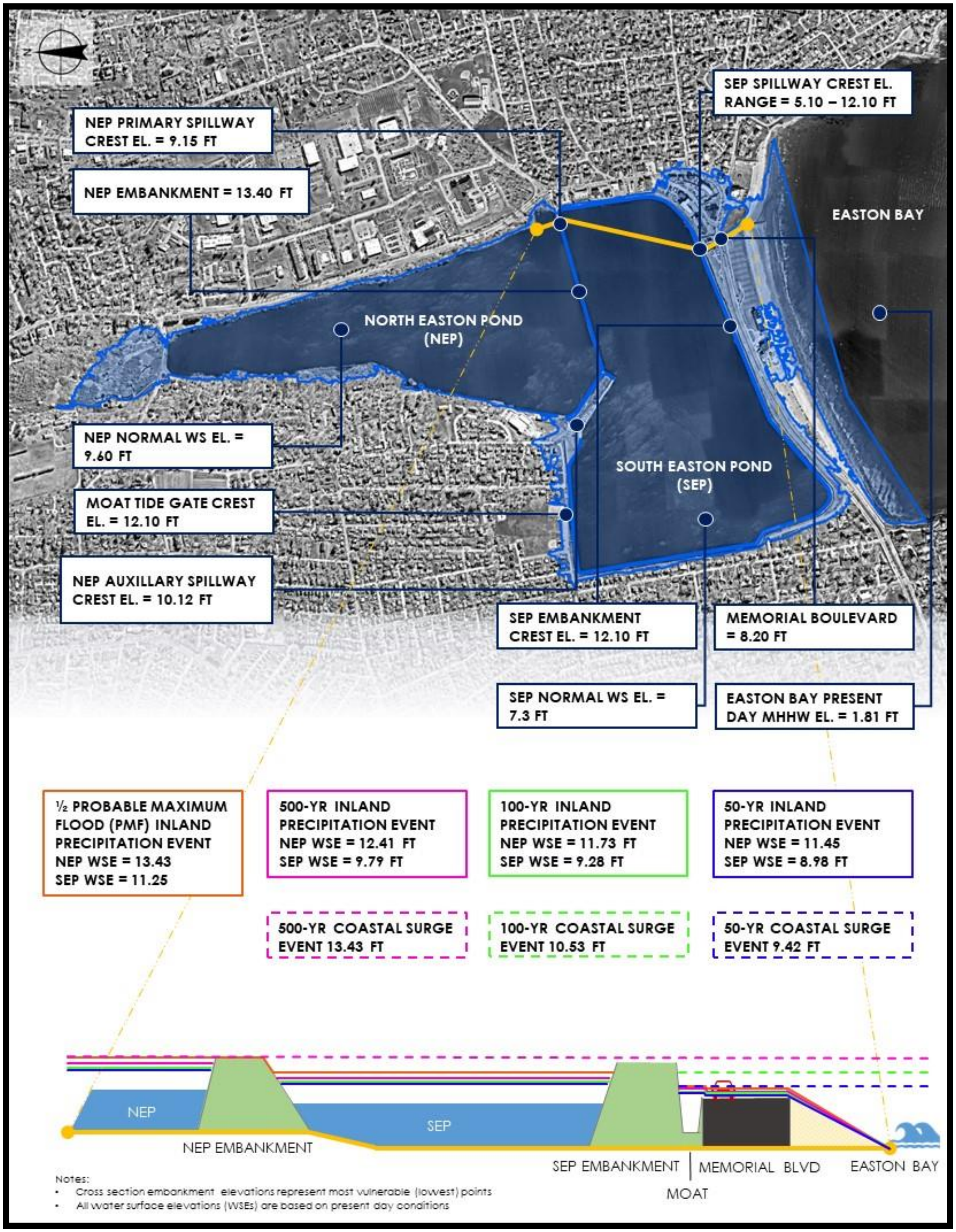


Figure 2: Peak Water Surface Elevations Plan & Profile View for Recommended Alternative (Present-Day)

2 Introduction

The hydrologic and hydraulic analyses discussed in this report evaluated vulnerabilities and studied proposed improvements at North Easton Pond Dam (NEP Dam) and South Easton Pond Dam (SEP Dam). Together, the dams, their appurtenances, and their reservoirs represent critical drinking water infrastructure for the City of Newport, Rhode Island, and neighboring communities. The City of Newport engaged Fuss & O'Neill to analyze and provide recommendations to mitigate present-day and future flood hazard vulnerabilities in the project area. Ultimately, the data presented in this report will inform future design in addition to benefit-cost analysis calculations in support of funding applications.

2.1 Existing Conditions

The City of Newport Department of Utilities Water Division (NWD) operates and maintains the raw water supply reservoirs, embankments, withdrawal/pumping systems, and treatment/distribution systems for residents and businesses in the City of Newport, the Town of Middletown, and the Town of Portsmouth. NEP Dam and SEP Dam are major components of this system. Their reservoirs contain a substantial portion of the NWD's drinking water supply: NEP Dam (Rhode Island State ID 584) and SEP Dam (Rhode Island State ID 585) each impound approximately 1,000 acre-feet of water at their respective normal pool elevations. Figure 3 displays the dams and the surrounding project area.

2.1.1 North Easton Pond Dam

NEP Dam is located immediately upstream of SEP Dam. Its embankment is approximately 2,800 feet long, including a portion running west to east that divides the two ponds. This portion could be considered an embankment of either dam but is viewed as the embankment for the NEP Dam under this analysis. A system of water mains and intake pipes reportedly runs below the NEP Dam embankment to the NWD Station 1 treatment facility. NEP Dam's primary spillway, a 130-foot-long concrete weir lined with riprap, is located at the southeastern corner of the reservoir. A 100-foot-wide auxiliary spillway and its discharge channel are situated at the southwestern corner of the reservoir, directly to the south of the NWD treatment plant. A vegetated sediment basin lies to the south of the NEP Dam auxiliary spillway between the two impoundments.

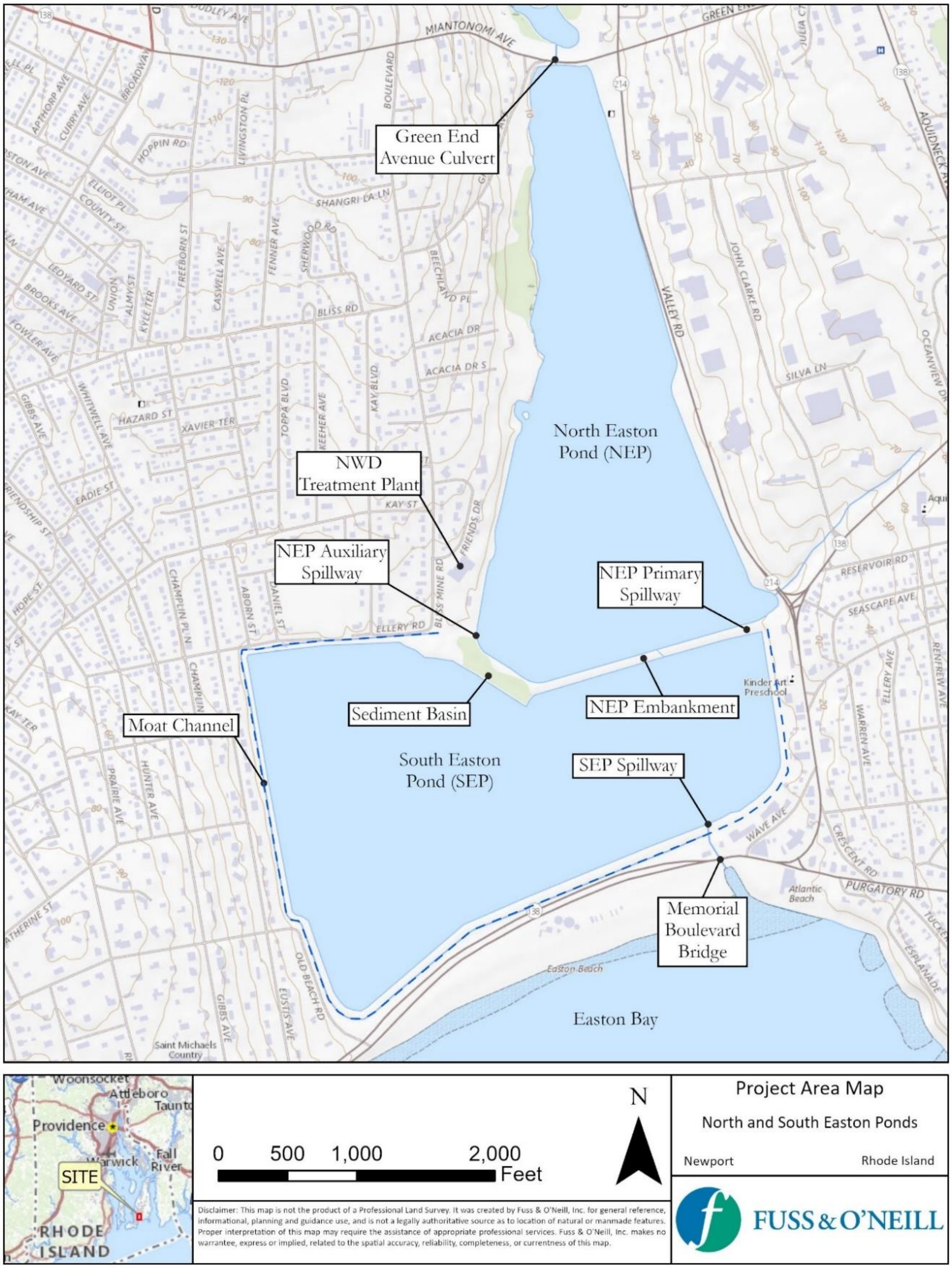


Figure 3: Overall Project Area Map for North and South Easton Ponds

2.1.2 South Easton Pond Dam

SEP Dam is directly downstream and south of NEP Dam. SEP Dam is surrounded by critical infrastructure including a state highway (Memorial Boulevard, Route 138A), an ultraviolet stormwater disinfection system, a sewage pumping station, and a public beach (Easton Beach). There are numerous residential and commercial properties in the direct vicinity of the dam, in addition to the roads and utilities that connect them. South Easton Pond was constructed in portions of what was previously a low-lying marsh area, necessitating a ringed embankment and moat around the impoundment.

The crest of the earthen embankment is generally narrow with steep side slopes. Recent reconstruction widened and armored the embankment with articulated concrete block (ACB) mats to mitigate erosion damage from frequent reservoir wave attack and flood flows in the moat channel.

The moat conveys discharge from the NEP Dam auxiliary spillway, as well as several stormwater outfalls from adjacent neighborhoods. These flows ultimately merge with discharge from the SEP Dam primary spillway, travel under the Memorial Boulevard Bridge, and outlet to Easton Bay. The moat channel has limited hydraulic capacity resulting in flow velocities that can damage SEP Dam's earthen embankments. These velocities are particularly concerning at the southwestern corner of SEP Dam, adjacent to Old Beach Road, and along the SEP Dam's southern embankment.

2.2 Previous Hydrologic and Hydraulic Analyses

Where appropriate, the current analyses made use of data from previous hydrologic and hydraulic reports produced by the City of Newport and Fuss & O'Neill. In some cases, previous reporting and data were updated or modified to reflect current conditions at the site and/or to incorporate new methodology and modeling techniques.

2.2.1 Easton Pond Dam and Moat Study, September 2007

This report was completed by Fuss & O'Neill to develop a flood hazard mitigation strategy at the dams and their associated moat system. A hydraulic model of the moat was created using the Hydraulic Engineering Center's River Analysis System (HEC-RAS). The model incorporated surveyed cross-section geometry and visual field assessments of Manning's roughness coefficient. Flood hydrographs from a TR-20 hydrologic model informed steady-state flow rates. This model and the associated reporting served as the basis for further analysis conducted in 2019.

2.2.2 Climate Resiliency Assessment Technical Memorandum North and South Easton Pond Reservoirs, April 2019

This technical memorandum, referred to as the "2019 Climate Resiliency Memorandum" throughout the following pages, was produced by Fuss and O'Neill and Woods Hole Group to summarize threats posed by climate change and to identify means of promoting climate resiliency at the dams. Fuss & O'Neill updated the 2007 Easton Pond Dam and Moat Study as a part of the 2019 Climate Resiliency

Memorandum. Rainfall depths used for hydrologic modeling were updated to incorporate precipitation values from the Rhode Island Department of Environmental Management (RIDEM) Stormwater Design and Installation Standards Manual. The project included modeling of the ½ probable maximum flood (½ PMF) as the presumed inflow design flood (IDF) for the dams. Ultimately, this report provided a high-level review of flood- and climate-related hazards at the dams and suggested further study of two alternatives for improvements, referred to as Alternative 2 and Alternative 4. Both alternatives included raising the dam embankments, stabilizing currently unarmored embankments with ACB matting, and installation of crest gates at the dam spillways to reduce the risk of saltwater intrusion from coastal flooding. Alternative 4 differed from Alternative 2 in that it included a modified primary spillway at SEP Dam to provide additional hydraulic capacity and flexibility in reservoir water levels.

3 2023 Hydrologic Analysis

Hydrologic modeling for the current analysis built upon that completed for the 2019 Climate Resiliency Memorandum. Previous data were updated and incorporated within the Hydraulic Engineering Center's Hydrologic Modeling System (HEC-HMS). The HEC-HMS model employed Soil Conservation Service (SCS) Curve Number and TR-55 Time of Concentration methodologies to develop rainfall-runoff estimates for individual subbasins under a range of storm events.

The delineated watershed contributing to the project area was adapted from the 2019 Climate Resiliency Memorandum after a review of the Newport stormwater system and the incorporation of updated LiDAR topography. The total watershed area contributing to North and South Easton ponds was determined to be approximately 4.37 square miles. The total watershed area contributing to the moat and its eventual discharge to Easton Bay is approximately 5.31 square miles. Figure 4 displays the watershed and subbasins developed for the current analysis. Characteristics of the delineated watershed and individual subbasins are included in Appendix A.

3.1 Curve Number and Time of Concentration

Subbasin curve numbers developed for the 2019 Climate Resiliency Memorandum were reviewed and compared against current land use data (USGS, 2018), aerial imagery, and NRCS soil types (NRCS, 2019). This analysis indicated curve numbers from the 2019 Climate Resiliency Memorandum remain accurate for use in the current model.

Time of concentration values for modeled subbasins were adjusted from the 2019 analysis using updated survey and LiDAR data.

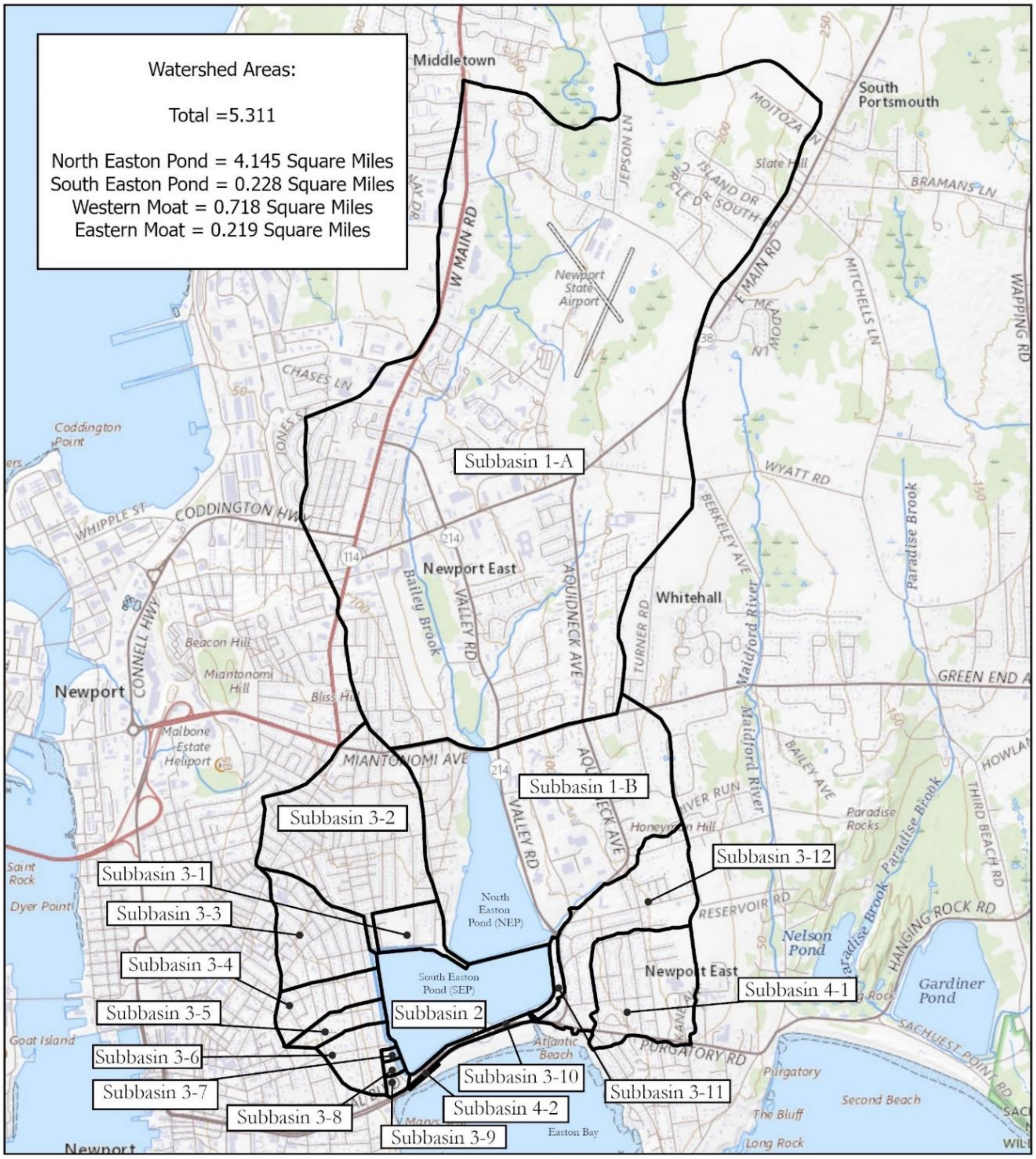


Figure 4: Watershed and Subbasin Delineation Map for North and South Easton Ponds

3.2 Storm Events

A range of precipitation events were simulated in the HEC-HMS model to produce corresponding flood hydrographs for each subbasin. These included:

- Present-day rainfall values for the 10-year, 50-year, 100-year, and 500-year storm events as reported by RIDEM and the Northeast Regional Climate Center (NRCC, 2022)
- Predicted rainfall values for the same events under 2070 climate conditions based on Resilient Massachusetts Action Team (RMAT) data
- Precipitation values for the probable maximum flood (PMF) as calculated via HMR-52 (see Section 3.2.2) within HEC-HMS
- Precipitation values for the 2070 PMF as predicted by applying a 7% increase recommended by the State of Colorado (Colorado, 2020)

3.2.1 Present-Day and 2070 Storm Events

Rainfall depths for present-day storm events are reported within the RIDEM Rhode Island Stormwater Design and Installation Standards Manual for Newport County. For the same storm events under 2070 climate conditions, rainfall depths were generated using the RMAT Climate Change Projections Dashboard at Site 7823, Fall River, Massachusetts. This location was chosen based on its proximity to the project site and the lack of comparable precipitation projections for the state of Rhode Island. Table 2 summarizes rainfall depths for storm events analyzed in the HEC-HMS model.

Table 2: Present-Day and Predicted 2070 Rainfall Depths for Analyzed Storm Events

Storm Event	Present-Day Rainfall Depth (in) [1]	Predicted 2070 Rainfall Depth (in) [2]
10-Year, 24-Hour	4.90	6.80
50-Year, 24-Hour	7.30	9.30
100-Year, 24-Hour	8.60	10.40
500-Year, 24-Hour	12.17	13.30

[1] RIDEM/NRCC, [2] RMAT

Within the HEC-HMS model, these rainfall depths were distributed across the subbasins to generate peak flows at subbasin discharge locations for each storm event. Results are summarized in Appendix A.

3.2.2 Probable Maximum Flood

The probable maximum flood (PMF) is commonly used in dam and spillway design. The flood hydrograph produced by the probable maximum precipitation (PMP) informs adequacy assessments of dam embankments and spillway hydraulic capacity. Due to their impoundment of community drinking water and their proximity to inhabited areas, NEP Dam and SEP Dam are classified as high-hazard dams. Under the Federal Emergency Management Agency's (FEMA) "prescriptive" design approach, the typical inflow design flood (IDF) for a high-hazard dam is the PMF (Federal Emergency Management Agency, 2013). Variance from the prescriptive approach is acceptable as outlined in Section

4. However, calculation of the PMF and relevant fractions of the PMF are still necessary for evaluation and design.

The PMP was determined in adherence with Hydrometeorological Report No. 51 (HMR-51) and Hydrometeorological Report No. 52 (HMR-52) prepared by the National Weather Service. The HMR-52 Probable Maximum Precipitation routine in HEC-HMS defined the distribution and depth of rainfall across the subbasins. The PMP was calculated at 38.5 inches over a period of 72 hours. The temporal distribution of rainfall for the PMF is included in Appendix A. The PMF flood hydrograph was produced by applying this rainfall event to the watershed. To generate fractions of the PMF, as necessary under incremental consequence analysis (see Section 4), reduction factors were applied to the PMF hydrograph. For example, a factor of 0.5 was applied to the PMF hydrograph to produce the ½ PMF hydrograph.

The 2070 PMF was simulated by applying a 7% precipitation increase as recommended by the State of Colorado (Colorado, 2020). While FEMA acknowledges there is not yet a standard approach for predicting future PMF magnitudes, the State of Colorado is one of a handful of states that has established such a magnification factor.

4 2023 Hydraulic Analyses

Fuss & O'Neill developed a 2-dimensional hydraulic model for the project area using HEC-RAS. Within the hydraulic model, flood hydrographs from the HEC-HMS model were routed through the NEP Dam, SEP Dam, and the moat channel for a variety of hypothetical storms and scenarios. Most relevant for the current project were the determination of the appropriate Inflow Design Flood (IDF) and the assessment of proposed improvements to the dams under a range of storm events, both for present-day and future precipitation and sea level rise conditions.

4.1 Hydraulic Model Development

A terrain raster (Figure 5) was developed for the project area to serve as the base for the larger hydraulic model. The terrain combines LiDAR topography publicly available through the National Oceanic and Atmospheric Administration (NOAA, 2016) with site-specific topographic survey data provided by Control Point Associates, Inc. (June 2021), R.P. Iannuccillo and Sons (July 2012), Waterman Engineering Co. (March 2008), and Apex Environmental, Inc. (October 2004). A table summarizing topographic data used to develop the terrain is included in Appendix B. The terrain was also modified to properly represent existing and proposed spillways in addition to potential dam breach locations.

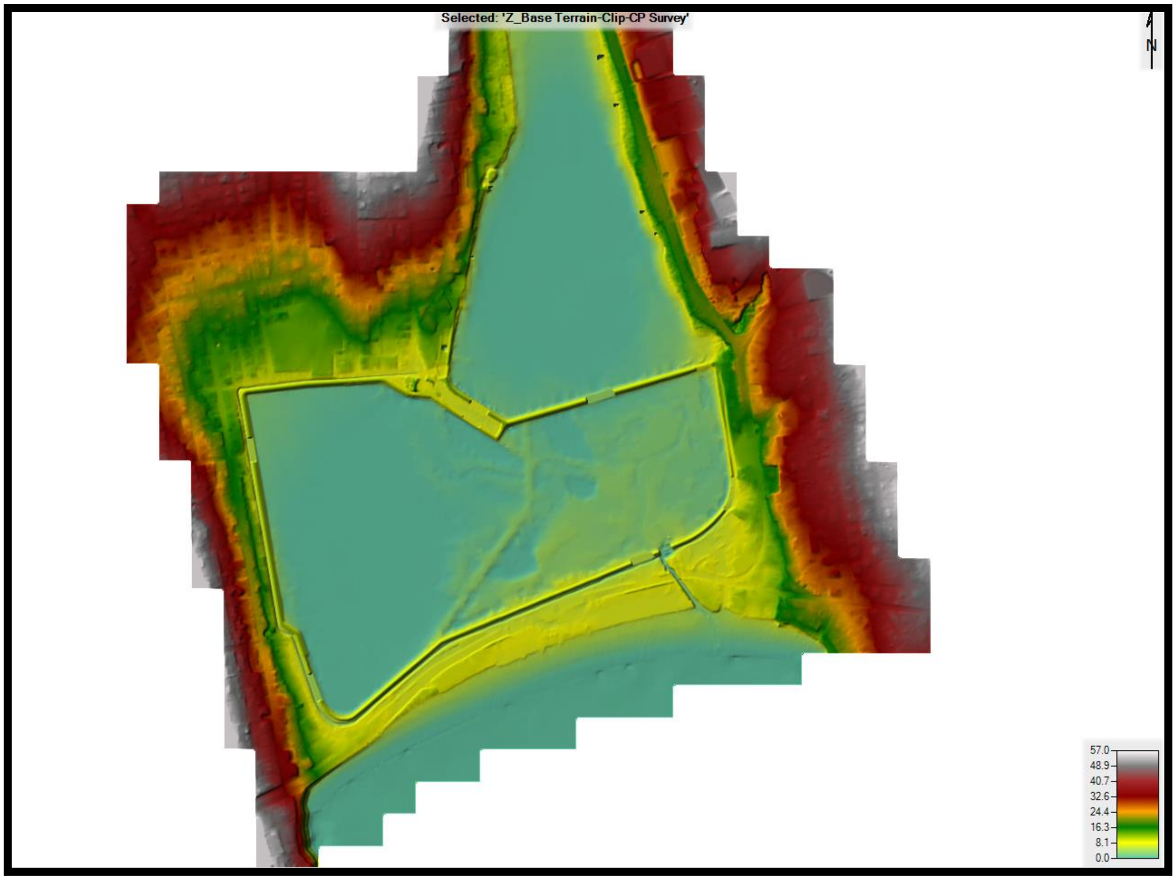


Figure 5: Terrain raster developed for the hydraulic model

A 2-dimensional mesh (Figure 6) was created for the project area to calculate precise topographic characteristics and hydraulic properties for individual cell areas across the relevant terrain and infrastructure. The cell mesh covers both dams, their embankments, the moat, and the surrounding neighborhoods. The mesh extends to the north and terminates shortly upstream of the Green End Avenue culvert. Cell orientations were modified such that faces aligned with pond embankments, spillways, and other terrain features.

Figure 6: A 2-dimensional cell mesh developed for hydraulic modeling

Internal 2-dimensional mesh connections were added to the model geometry to represent hydraulic structures including dam spillways, culverts, bridges, and potential dam breach locations. Surveyed elevations of each spillway were incorporated to ensure an accurate accounting of flow through and over the structures. Land cover data, survey data, aerial imagery, and knowledge of the site informed Manning's roughness coefficient (Manning's n) selections for the model area. The National Land Cover Dataset (NLCD) provided a valuable starting point for estimating Manning's n, but site-specific refinement was necessary. A map of Manning's n values applied to the project is included in Appendix B. Inflow boundary condition lines were established for each subbasin modeled in HEC-HMS. Boundary condition lines referenced the respective subbasin's flow hydrograph produced by the hydrologic model (see Appendix B).

4.2 Existing Vulnerabilities and Climate Resilience Alternatives

The hydraulic model assessed existing conditions and improvement alternatives at NEP and SEP dams to understand current vulnerabilities and demonstrate proposed resilience to impacts from flooding. The model incorporated resultant inflows from a range of present-day and predicted 2070 inland precipitation events. It also considered how rising sea levels and corresponding changes to tidal activity might affect existing infrastructure and proposed improvements. Two alternatives for modification of the dams were identified in the 2019 Climate Resiliency Memorandum: Alternative 2 and Alternative 4, as described in Section 4.2.2 and Section 4.2.3.

4.2.1 Existing Conditions

To fully understand improvements provided by the two proposed alternatives, Fuss & O'Neill completed an updated assessment of existing conditions for the NEP Dam and SEP Dam under a range of storm scenarios. Both present-day and predicted 2070 climate conditions were considered. Flood hydrographs for various inland flood events were produced through Fuss & O'Neill's hydrologic modeling, while sea level and coastal surge data were provided by the US Army Corps of Engineers (USACE) North Atlantic Coast Comprehensive Study (NACCS) as adjusted by Woods Hole Group (Table 3). Present-day and predicted 2070 storm events were modeled with corresponding mean higher high water (MHHW) values as the tailwater elevation in Easton Bay.

Table 3: Present Day and Adjusted (Future) NACCS Joint Probability Inundation Profiles

Return Period	Probability	Water Surface Elevation (ft.)			
		Present	2030	2050	2070
MHHW	Tides (no surge)	1.81	2.37	3.53	5.09
1	100.0%	4.55	5.11	6.27	7.83
2	50.0%	5.31	5.87	7.03	8.59
5	20.0%	6.37	6.93	8.09	9.65
10	10.0%	7.22	7.78	8.94	10.50
20	5.0%	8.13	8.69	9.85	11.41
50	2.0%	9.42	9.98	11.14	12.70
100	1.0%	10.53	11.09	12.25	13.81
200	0.5%	11.77	12.33	13.49	15.05
500	0.2%	13.43	13.99	15.15	16.71
1000	0.1%	14.62	15.18	16.34	17.90

(USACE, August 2015)

Overtopping of earthen embankments is a primary mechanism for dam failure. Overtopping could occur when inflow from inland precipitation events exceeds the storage capacity of either dam and resultant water surface elevations force flow over the embankment crest at one or more locations. Overtopping could also occur due to coastal surge events that raise sea level elevations over the crest of the SEP Dam and/or NEP Dam.

Saltwater intrusion at SEP Dam and/or NEP Dam could result in contamination of drinking water for the City of Newport and other dependent communities. Saltwater intrusion could occur due to sea levels rising and backwatering the dam spillway(s) or through overtopping of dam embankments during larger coastal surge events.

Elevations at several locations along dam embankments and spillways were used as benchmarks for determining the protection each dam provides against embankment overtopping and saltwater intrusion. The topographic survey completed for the current analysis documented embankment low points as summarized in Figure 13. Survey of the existing embankment separating the NEP Dam and SEP Dam reported elevations as low as 11.5 feet. The surveyed low point in the NEP Dam primary spillway is 9.15, while the surveyed low point in the NEP Dam auxiliary spillway is 10.12 feet. A large portion of the SEP Dam embankment was previously reconstructed to an elevation of approximately 12.1 feet following storm erosion and wave attacks. Still, topographic survey for the current analysis reported low points along the northern, eastern, southern, and western embankments of SEP Dam at approximately 9.15, 9.80 feet, 11.18 feet, and 10.57 feet, respectively. The surveyed low point in the SEP Dam primary spillway is 7.32 feet.

Existing conditions modeling results summarized in Table 4 indicate both NEP Dam and SEP Dam could overtop as a result of the present-day 50-year inland precipitation event. This recurrence interval is lowered to the 10-year inland event for SEP Dam under predicted 2070 climate conditions, indicating more frequent overtopping of the dam embankment in the future.

The limiting factor for resilience to tidal actions and/or coastal surge appears to be the potential for saltwater intrusion through the SEP Dam spillway. Saltwater intrusion through the SEP Dam spillway could occur during the present-day 20-year coastal surge event. Predicted 2070 conditions could result in saltwater intrusion through the SEP Dam spillway on an annual basis.

Overtopping of SEP Dam embankments due to coastal surge could occur during the present-day 100-year event. NEP Dam appears to be threatened by overtopping due to coastal surge during the present-day 200-year event. Under predicted 2070 conditions, the SEP Dam could be overtopped by the 5-year coastal surge event and the NEP Dam embankment could be overtopped by the 50-year coastal surge event. A complete table of results for all modeled scenarios is included in Appendix B.

Table 4: Present-Day and 2070 Inland Flooding Results for Existing Conditions [1]

Dam	Low Point in Primary Spillway	Low Point in Aux. Spillway	Low Point on Embankment	Recurrence Interval for Overtopping Due to Inland Flooding	Recurrence Interval for Saltwater Intrusion via Spillway	Recurrence Interval for Overtopping Due to Coastal Surge
NEP Dam	9.15	10.12	11.50	2023: 50-year (11.53) 2070: 50-year (11.85)	2023: 50-year (9.42) 2070: 5-year (9.65)	2023: 200-year (11.77) 2070: 50-year (12.70)
SEP Dam	7.32	N/A	9.64	2023: 50-year (10.08) 2070: 10-year (9.94)	2023: 20-year (8.13) 2070: 1-year (7.83)	2023: 100-year (10.53) 2070: 5-year (9.65)

[1] All elevations in feet (NAVD88)

Based on these results, the dams should be improved to protect against overtopping due to inland floods and coastal surge events, as well as to prevent saltwater intrusion through the dam spillways. Such modifications are necessary to account for vulnerabilities demonstrated under present-day climate conditions and to prepare for predicted increases in precipitation and exacerbated coastal surge in 2070.

4.2.2 Proposed Alternative 2

Alternative 2, as described in the 2019 Climate Resiliency Memorandum, proposed raising the embankments of NEP Dam and SEP Dam to uniform elevations of 13.4 and 12.1 feet, respectively. The proposed NEP Dam embankment elevation was chosen to restore what appears to be the original elevation of the embankment prior to settling and erosion. The proposed SEP Dam embankment elevation was selected to match previous improvements to a portion of the dam's western embankment in response to wave attack and erosion.

In addition to embankment raising, Alternative 2 proposed the installation of a crest gate at the SEP Dam primary spillway. Since the path for saltwater intrusion through the NEP Dam primary spillway is first through the SEP Dam spillway and reservoir, a crest gate at the SEP Dam spillway would provide protection from saltwater intrusion for both the SEP Dam spillway and NEP Dam primary spillway. As such the 2019 Climate Resiliency Memorandum proposed a crest gate at the NEP Dam auxiliary spillway to prevent saltwater intrusion via the moat. However, initial modeling of Alternative 2 revealed that raising the entirety of the SEP dam embankment to an elevation of 12.1 feet would restrict an existing transfer of flow from the moat and sediment basin near the NEP Dam auxiliary spillway into the SEP Dam (Figure 7). Restricting this flow by raising the SEP Dam embankment near the sediment basin appeared to increase water surface elevations in the moat and surrounding areas for the 50-year and 100-year storms.

As such, the current analysis evaluated the installation of a tidal/flap gate in the moat approximately 1000 feet downstream of the NEP Dam auxiliary spillway, near J Paul Braga Jr Memorial Field. This gate would allow the preservation of existing embankment elevations of the SEP Dam near the sediment basin while mitigating saltwater intrusion. Inland flows from the surrounding neighborhood and NEP Dam auxiliary spillway will enter SEP similar to existing conditions without increasing water surface elevations As amended, Alternative 2 would necessitate designing and constructing the SEP Dam embankment near the sediment basin to allow overtopping without a breach. While embankment armoring in the form of articulated concrete blocks (ACBs) is proposed for the entirety of both NEP and SEP dam embankments, design requirements to allow for overtopping go beyond ACB armoring to include embankment slope and flow velocity considerations.

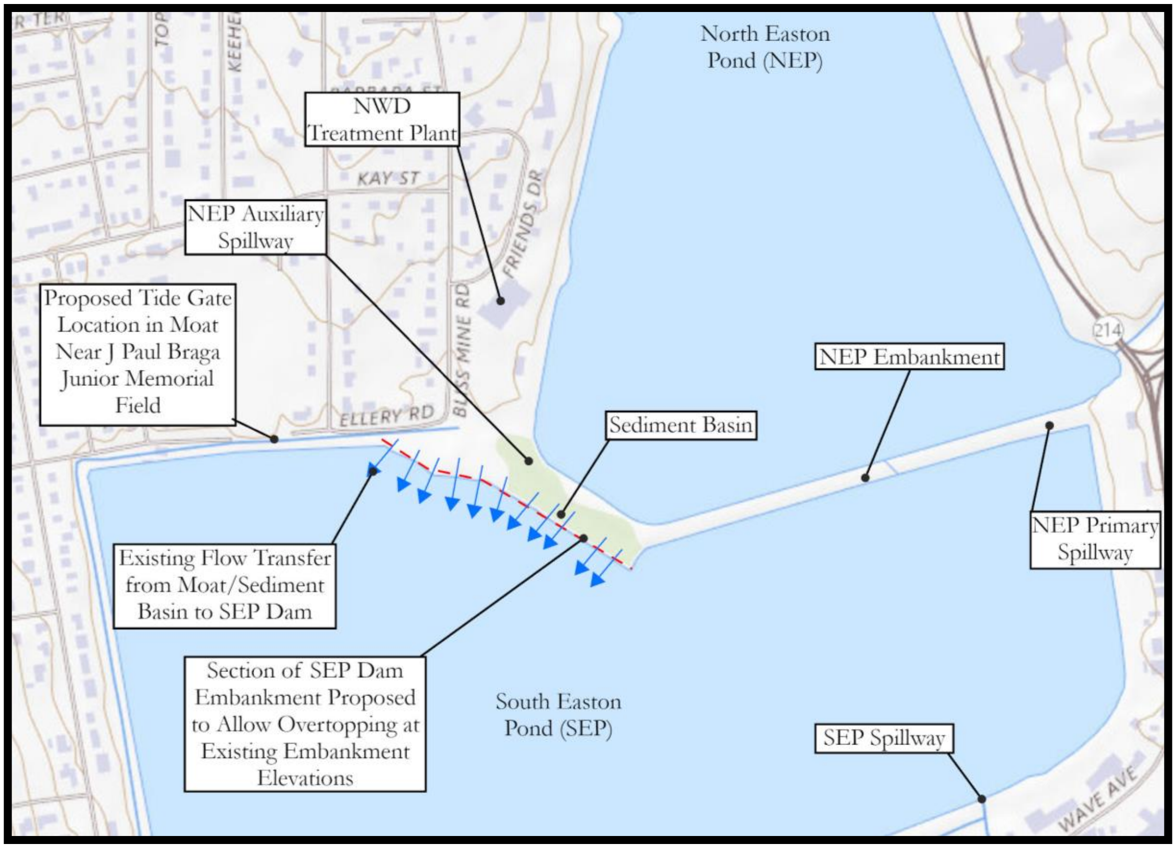


Figure 7: Existing flow transfer near sediment basin and proposed tidal/flap gate near J Paul Braga Memorial Field

To assess Alternative 2, a new terrain was developed within HEC-RAS that included the raised dam embankments. Modeled spillway elevations and dimensions matched those of existing conditions. Model results for Alternative 2 are summarized in Table 5.

Table 5: Present-Day and 2070 Inland Flooding Results for Alternative 2 [1]

Dam	Low Point in Primary Spillway	Low Point in Aux. Spillway	Proposed Low Point on Embankment	Recurrence Interval for Overtopping Due to Inland Flooding	Recurrence Interval for Saltwater Intrusion/Coastal Overtopping [2]
NEP Dam	9.15	10.12	13.4	2023: ½ PMF (13.46) 2070: ½ PMF (13.49)	2023: 500-year (13.43) 2070: 100-year (13.81)
SEP Dam	7.32	N/A	12.1	2023: ½ PMF (12.17) 2070: ½ PMF (12.18)	2023: 500-year (13.46) 2070: 50-year (12.70)

[1] All elevations in feet (NAVD88)
[2] Crest gate at SEP Dam spillway and tidal/flap gate in moat prevent saltwater intrusion up to 12.1 feet. As such, saltwater intrusion is expected to occur only during coastal surge events that overtop the dam embankments.

Table 6 compares protections provided by Alternative 2 with protections provided by existing conditions. Alternative 2 appears to increase protection against embankment overtopping during inland flood events and saltwater intrusion or embankment overtopping due to tidal activity and coastal surge events.

Table 6: Comparison of Protection Levels for Existing Conditions and Alternative 2

Climate Conditions	Scenario	Protects Against Overtopping via Inland Flooding Through Recurrence Interval:	Protects Saltwater Intrusion/Coastal Overtopping Through Recurrence Interval:
Present-Day	Existing Conditions	10-year storm	10-year coastal surge
	Alternative 2	500-year storm	200-year coastal surge
2070	Existing Conditions	Lower than 10-year [1]	MHHW, no surge [2]
	Alternative 2	500-year storm	20-year coastal surge

[1] The smallest inland flood modeled was that of the 10-year event, which was found to overtop the SEP Dam embankments in 2070 for the existing infrastructure.

[2] Modeling suggests the 2070 1-year coastal surge would overtop the SEP Dam spillway for existing conditions. Therefore, existing conditions protect only through normal high tides for 2070 climate conditions.

Despite the potential increase in protection provided by Alternative 2, the protection results largely from the impoundment of additional flow volume during extreme storm events. Because the embankments are raised and overtopping is prevented or reduced for relevant storms without a proportional increase in spillway flow capacity, peak water surface elevations for extreme storm events are higher under Alternative 2 than under existing conditions (Table 7). Further, modeling suggested both NEP Dam and SEP Dam would still overtop during the ½ PMF event. It is likely that the NEP Dam could be reconstructed to allow for overtopping without a breach. However, considering physical constraints and potential permitting implications, reconstructing the entirety of the SEP Dam embankment to allow for overtopping may be an impracticable solution.

Table 7: Peak Water Surface Elevations in NEP and SEP Dams Under Existing Conditions and Alternative 2

Dam	Scenario	100-Year Storm Peak WSE (ft)	500-Year Storm Peak WSE (ft)	½ Probable Maximum Flood Peak WSE (ft)
NEP	Existing Conditions	11.77	12.02	12.27
	Alternative 2	11.81	**12.50**	**13.46**
SEP	Existing Conditions	10.37	10.97	11.36
	Alternative 2	10.39	**11.33**	**12.17**

As discussed in Section 4.3, an increase in stored volume during extreme storm events could be expected to exacerbate hazards associated with a dam breach. Accordingly, Alternative 4 was modeled to determine if increased hydraulic capacity at the SEP Dam primary spillway could provide the same improvements as Alternative 2 while reducing peak water surface elevations and associated dam breach hazards.

4.2.3 Proposed Alternative 4

Alternative 4 proposed the same modifications as Alternative 2: raising the embankments to elevations 13.4 and 12.1 respectively for NEP and SEP dams, installing gates to protect the reservoirs from saltwater intrusion due to tidal activity and/or coastal surge, and armoring the pond embankments with ACB to mitigate erosion. The primary difference under Alternative 4 is the modification of the SEP spillway to provide additional hydraulic capacity. In the 2019 Climate Resiliency Memorandum, it was suggested that operable "crest gates at the SEP [Dam] …spillway [could] provide adaptive hydraulic capacity" to maintain freeboard between peak water surface elevations and embankment crests during relevant storm events. Further, a crest gate that operates over a range of elevations would allow for preemptive draining and additional storage capacity in SEP Dam leading up to and during extreme storm events.

Modeling for Alternative 4 followed an iterative approach in which the SEP Dam primary spillway crest elevation was lowered (thereby lowering the SEP Dam pool elevation) and widened as necessary to reduce peak water surface elevations during extreme storm events. Ultimately, a 120-foot-wide spillway lowered to an elevation of 5.1 feet was found to lower peak water surface elevations in SEP Dam below those reported for existing conditions during extreme storms (500-year and above) as summarized in Table 8. As such, Alternative 4 is expected to provide the same level of protection for inland storms, tidal activity, and coastal surge events as Alternative 2 while decreasing potential hazards associated with a dam breach. Elevation 5.1 was chosen as the minimum crest gate elevation in alignment with the predicted 2070 MHHW level (5.09 feet).

Table 8: Peak Water Surface Elevations in NEP and SEP Dam Under Existing Conditions and Alternatives

Dam	Scenario	100-Year Storm Peak WSE (ft)	500-Year Storm Peak WSE (ft)	½ Probable Maximum Flood Peak WSE (ft)
NEP	Existing Conditions	11.77	12.02	12.27
	Alternative 2	11.81	**12.50**	**13.46**
	Alternative 4	11.73	12.41	13.43
SEP	Existing Conditions	10.37	10.97	11.36
	Alternative 2	10.39	**11.33**	**12.17**
	Alternative 4	9.28	9.79	10.59

Because peak water surface elevations in NEP Dam still exceed that dam's proposed embankment elevations during the ½ PMF event, the embankment separating NEP and SEP Dam should be designed and constructed to overtop without forming a breach. Further, it was necessary to model Alternative 4 to determine the inflow design flood by evaluating dam breach hazards under proposed conditions. That process, in combination with modeling of more frequent large storm events without a breach to ensure downstream elevations are not increased, assisted in confirming Alternative 4 as the recommended alternative. Improvements Proposed under Alternative 4 are summarized in Figure 8.

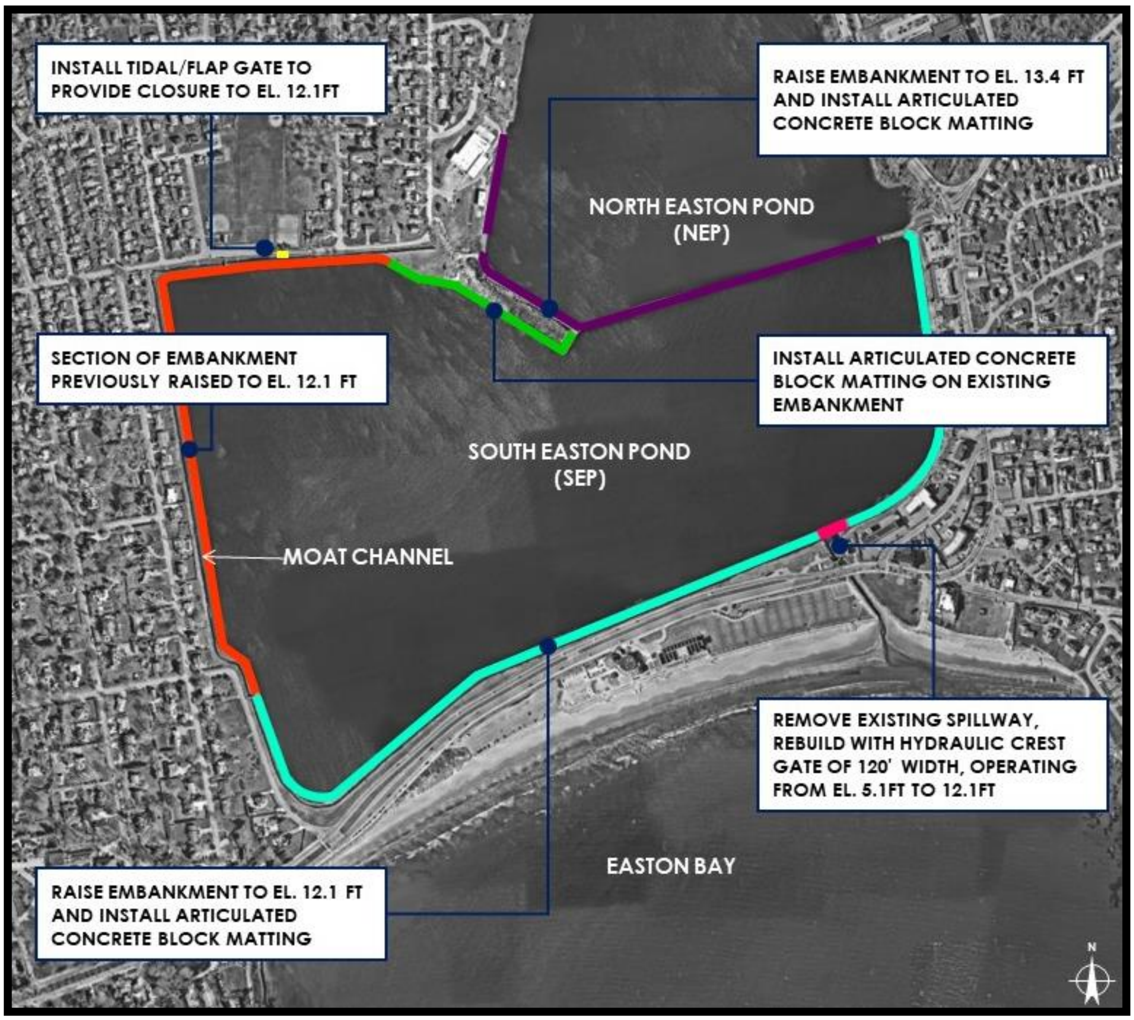


Figure 8: Summary of Improvements Proposed Under Amended Alternative 4

4.3 Inflow Design Flood Determination

The Inflow Design Flood (IDF) is critical in determining a dam's suitability under existing conditions and an important factor in the design of potential modifications. The IDF resulting from the corresponding inland precipitation event informs the design of spillways, embankment elevations, and other dam components. FEMA states "If significant modifications are…required to the dam and appurtenant structures, the IDF should be updated to reflect the new guidelines and/or hydrologic data." and that "modifications, like raising the dam…can increase the downstream consequences should the dam fail during an extreme flood event…" (Federal Emergency Management Agency, 2013) As such, and because modifications were deemed necessary based on vulnerabilities under existing conditions, Alternative 4 was modeled to determine the applicable IDF at the NEP Dam and SEP Dam.

Under a "prescriptive" approach, the IDF is based solely on the dam's "hazard potential classification" as defined by FEMA (Table 9). Both the NEP Dam and SEP Dam meet FEMA criteria for a high-hazard dam. Accordingly, the IDF for each pond under a prescriptive approach would be the probable maximum flood (PMF). However, FEMA (Federal Emergency Management Agency, 2013) outlines a process for an incremental consequence analysis to provide for a more refined and site-specific IDF selection. An incremental consequence analysis compares flood hazards during scenarios in which a dam does not fail (pre-breach) and scenarios in which the dam fails (post-breach) during the same storm event. Under this analysis, a storm of smaller magnitude than that dictated by a prescriptive approach may be selected as the IDF if the modeling of that storm demonstrates an insignificant increase in hazard from pre-breach to post-breach conditions. Site-specific IDF selection may result in cost-savings associated with design and construction while adhering to FEMA, Federal Energy Regulatory Commission (FERC), and state agency best practices and requirements.

Table 9: FEMA IDF Requirements for Dams Using a Prescriptive Approach

Hazard Potential Classification	Definition of Hazard Potential Classification	Inflow Design Flood
High	Probable loss of life due to dam failure or misoperation (economic loss, environmental damage, or disruption of lifeline facilities may also be probable, but are not necessary for this classification)	PMF[1]
Significant	No probable loss of human life but can cause economic loss, environmental damage, or disruption of lifeline facilities due to dam failure or misoperation	0.1% Annual Chance Exceedance Flood (1,000-year Flood)[2]
Low	No probable loss of human life and low economic and/or environmental losses due to dam failure or misoperation	1% Annual Chance Exceedance Flood (100-year Flood) or a smaller flood justified by rationale

(1) Incremental consequence analysis or risk-informed decision making may be used to evaluate the potential for selecting an IDF lower than the prescribed standard. An IDF less than the 0.2% annual chance exceedance flood (500-year flood) is not recommended.

(2) Incremental consequence analysis or risk-informed decision making studies may be used to evaluate the potential for selecting an IDF lower than the prescribed standard. An IDF less than the 1% annual chance exceedance flood (100-year flood) is not recommended.

(Federal Emergency Management Agency, 2013)

FEMA and FERC both outline a process for incremental consequence analysis under which increases in flood hazards due to a dam breach are evaluated for varying storm magnitudes. The process begins with modeling the recommended low-end IDF storm. Progressively larger storm events, such as fractions of the PMF through the full PMF are then applied to the model until it can be demonstrated that the dam's failure does not significantly increase flood hazards in the surrounding area (Figure 9). Note 1 under Table 9, dictates the minimum potential IDF for evaluation at a high-hazard dam is the 500-year storm.

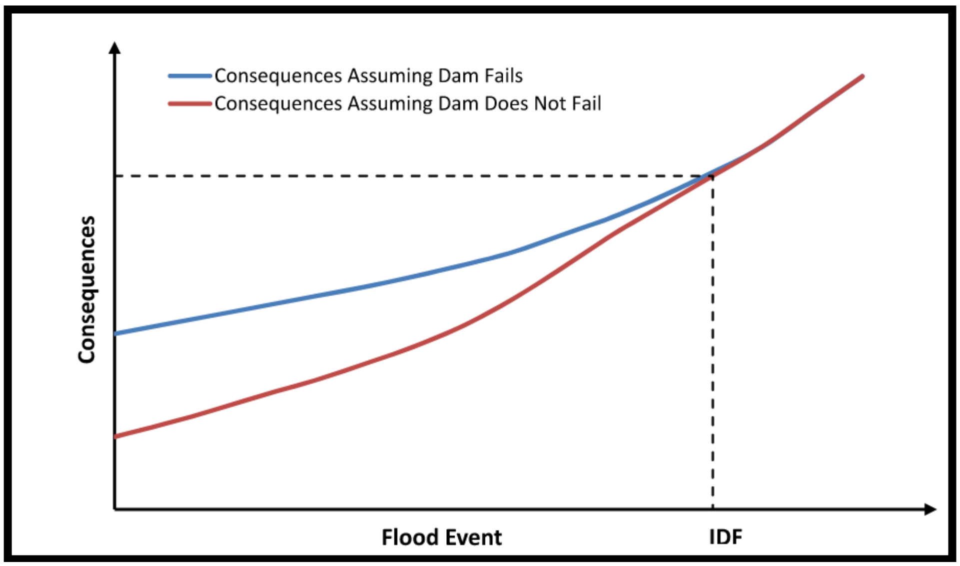


Figure 9: Conceptual Comparison of Incremental Consequence (Federal Emergency Management Agency, 2013)

As stated by FEMA, "There is much debate regarding what qualifies as a 'significant incremental consequence.' Methods of assessing the incremental increase in consequences vary from examining individual structures in the inundation zone to applying general criteria along the entire downstream inundation reach…Such criteria should not be viewed as absolute decision-making thresholds. Rather sensitivity analyses and engineering judgement must be applied. Since dam failure analyses and flood routing studies do not provide certain results, evaluation of the consequences of failure should be reasonably conservative. The application of more detailed methods such as two-dimensional flow modeling may justify a less conservative conclusion." (Federal Emergency Management Agency, 2013)

To provide metrics for an incremental consequence analysis, Fuss & O'Neill assessed pre- and post-breach flood depth and velocity results under multiple hazard criteria at numerous locations in the vicinity of NEP Dam and SEP Dam. Point locations, as shown in Figure 10, were established at houses and otherwise inhabited structures (e.g. hotels), along potential access and egress routes, and at other key infrastructure near the dams.

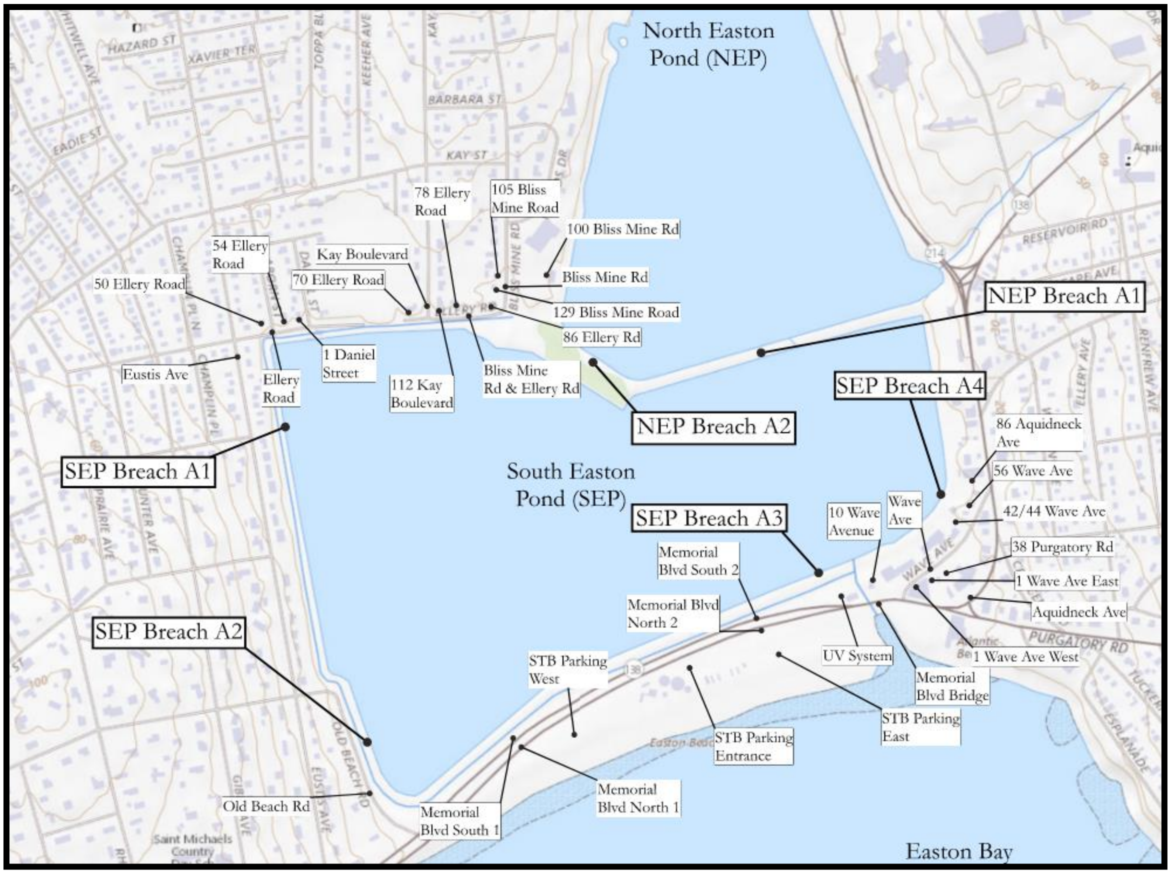


Figure 10: Point locations used for incremental consequence analysis near NEP and SEP dams

4.3.1 Flood Hazard Increase Criteria

Fuss & O'Neill utilized multiple criteria to determine the significance of increases in flood hazard for pre- and post-breach scenarios at the established point locations. It is important to note that some level of increase is generally to be expected under dam breach conditions. However, during extreme storm events, flood hazards typically exist downstream of the dam separate from a potential failure. For that reason, the goal of an incremental consequence analysis is to determine the storm magnitude under which increases in hazard due to a dam breach can be considered insignificant and acceptable (i.e. they do not increase pre-breach flood hazards beyond an established threshold and/or as informed by engineering judgement).

FERC 2-Foot Difference

The first and simplest criterion for evaluating increases in hazard was drawn from *Engineering Guidelines for the Evaluation of Hydropower Projects: Chapter 2- Selecting and Accommodating Inflow Design Floods for Dams* (Federal Energy Regulatory Commission, 2015). This guidance states "When a dam break analysis shows downstream incremental effects of approximately two feet or more in an inhabited area, engineering judgment and further analysis may be necessary to evaluate the need for modification to the dam." Therefore, Fuss & O'Neill considered any increase in flood depth of 2 feet or more between pre-breach and post-breach scenarios unacceptable.

USBR Flood Danger Charts

Criteria established by the United States Bureau of Reclamation (USBR) within *Downstream Hazard Classification Guidelines* (Bureau of Reclamation, 1988) were applied to the chosen point locations. USBR charts display depth-velocity thresholds for low danger, a mid-range zone in which engineering judgement is necessary to determine danger, and high danger. Separate charts and corresponding depth-velocity dangers are available based on the specific at-risk infrastructure or hazard type being evaluated.

Both with and without a breach, flooding near NEP Dam and SEP Dam has the potential to impact houses, roads, and areas that are generally inhabited by people of all ages. As such, relevant pre- and post-breach results were plotted on applicable USBR charts. An example chart, as adapted and published by the State of Maryland (State of Maryland, May 2018) is shown in Figure 11. A slight increase in pre- to post-breach depth and/or velocity alone was not automatically considered significant. If flood dangers for pre-breach and post-breach scenarios both fell within either the low danger zone or the high danger zone for a given location, increases were considered insignificant. For example, if the depth-velocity danger was classified as high prior to the dam breach, significant hazard exists whether the dam fails or not. Therefore, a slight increase in depth or velocity due to a dam breach would not significantly change the hazard. However, if pre-breach depth-velocity danger fell within the low danger zone and post-breach depth-velocity danger plotted above the high danger threshold, the increase could be considered significant. The process became more complicated when pre-breach danger fell within the low danger zone and was increased to the judgement zone under post-breach conditions, or pre-breach danger fell within the judgement zone and was increased above the high danger threshold under post-breach conditions. Fuss & O'Neill applied additional criteria to determine whether hazard increases were acceptable when they required engineering judgement.

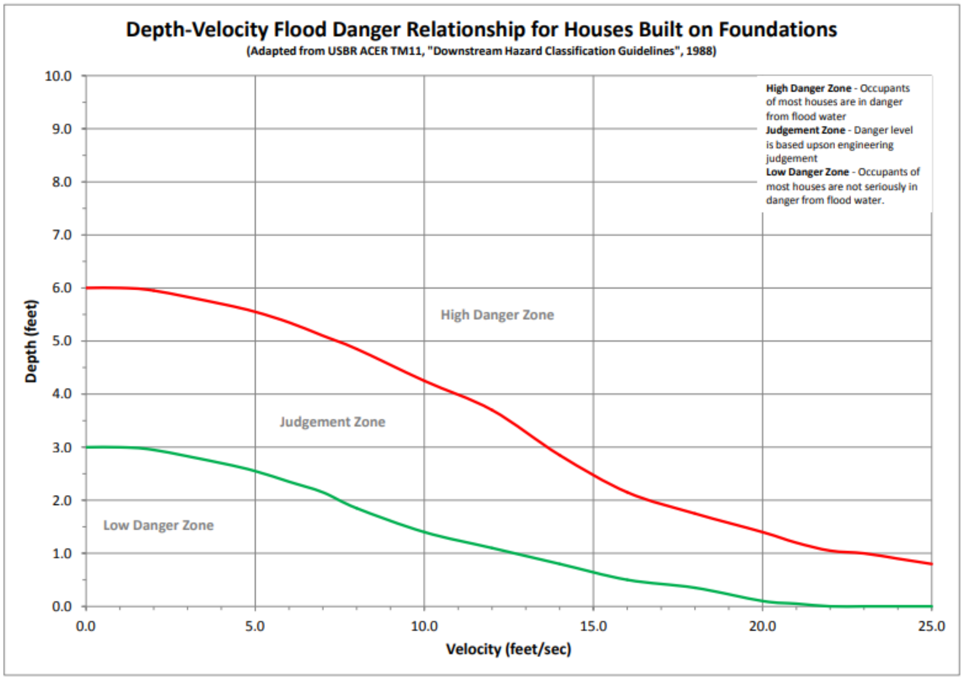


Figure 11: Depth-Velocity Flood Danger Relationship for Houses Built on Foundations (State of Maryland, 2018)

Engineering Judgement Criteria

As indicated by FEMA and the USBR flood danger charts, engineering judgement is necessary not only to establish an incremental consequence analysis at each unique site but also to determine what constitutes a "significant" increase in flood hazard from pre-breach to post-breach scenarios. The FERC and USBR criteria provide a basic framework for determining flood hazard increases. Fuss & O'Neill employed the following additional criteria summarized by FEMA (Federal Emergency Management Agency, n.d.) to evaluate hazards within the USBR judgement zone. Results for flood danger as it relates to houses generally fell at or below the low danger threshold on the relevant USBR chart. Therefore, no judgement zone criteria were applied to this hazard type.

- **Judgement Zone Criteria for Vehicles:** The National Weather Service indicates 2-feet of water could be sufficient to float a vehicle (National Weather Service, 1999). In addition, a depth of 1.5 feet flowing at a velocity of 6 feet per second "is sufficient to move a vehicle downstream." (Federal Emergency Management Agency, n.d.)
- **Judgement Zone Criteria for Adults:** FEMA summarizes various flood depth-velocity considerations for adults and children (Federal Emergency Management Agency, n.d.) as follows:
    - "An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second."

- Jonkman and Penning-Roswell indicate human instability in flood waters can occur at any velocity greater than 5.5 feet per second (Jonkman, S. and Penning-Roswell, E., 2008)

- **Judgement Zone Criteria for Children:** While there do not appear to be sufficient data for how flood depth and velocity relate to a child's instability while wading, the CDC reports the minimum average height of a 5-year-old child in the United States to be 3.33 feet (40 inches, CDC 2000). Fuss & O'Neill applied a ratio of 3.33/5 to the criteria summarized by FEMA (for a 5-foot-tall adult) to establish a depth of 2 feet as a judgement zone criterion for children.

Judgement zone criteria were applied as additional layers on the USBR charts. If pre-beach danger fell within the low danger zone and was increased to the judgement zone under post-breach conditions, the increase would be considered significant if the post-breach danger clearly exceeded the judgement zone criteria. Similarly, if pre-breach conditions fell below the USBR high danger threshold, but above the judgement zone criteria threshold, the pre-breach danger was classified as high, and an increase was not considered significant unless it exceeded the FERC 2-foot difference criteria. Examples are shown in Figure 12, where lower values on each graphed line represent pre-breach depth-velocity values, and larger values represent post-breach depth-velocity values. In this example, green lines represent increases that could be considered acceptable, while dark red lines represent potentially unacceptable hazard increases.

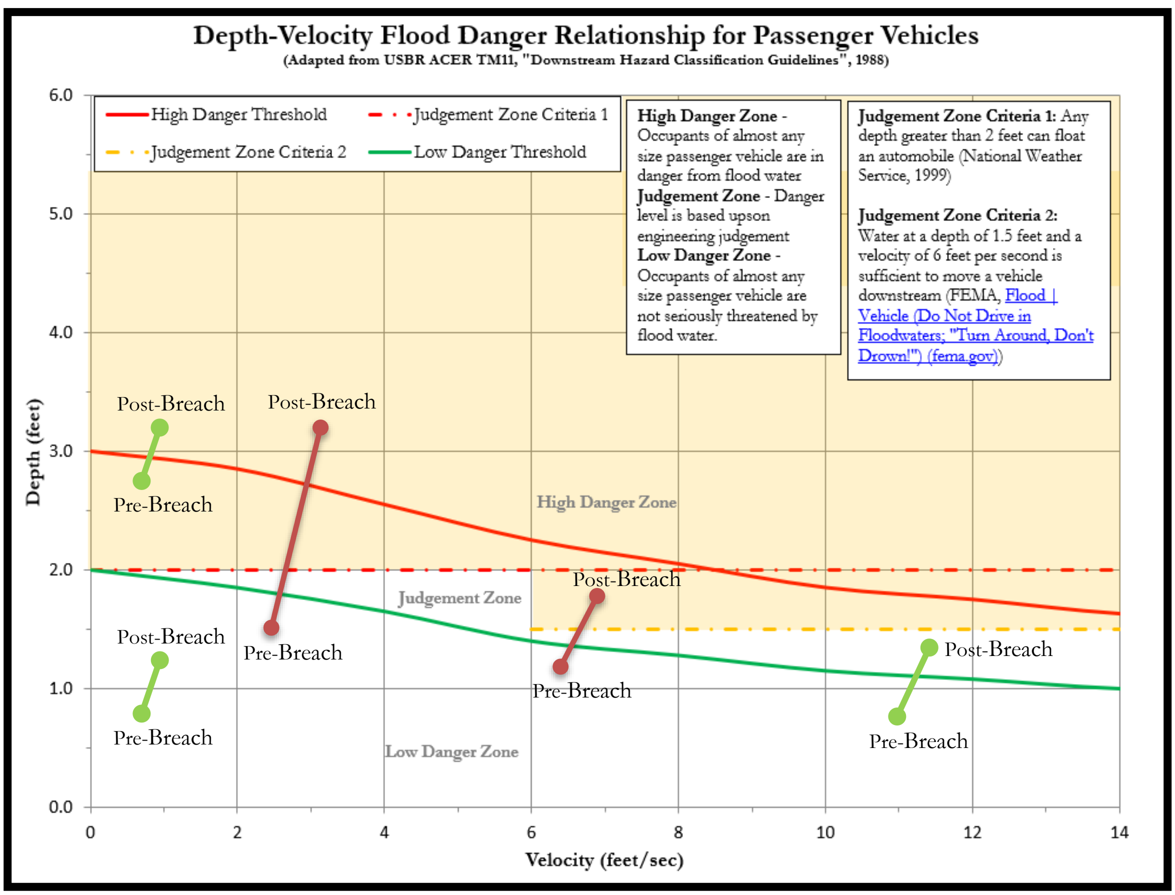
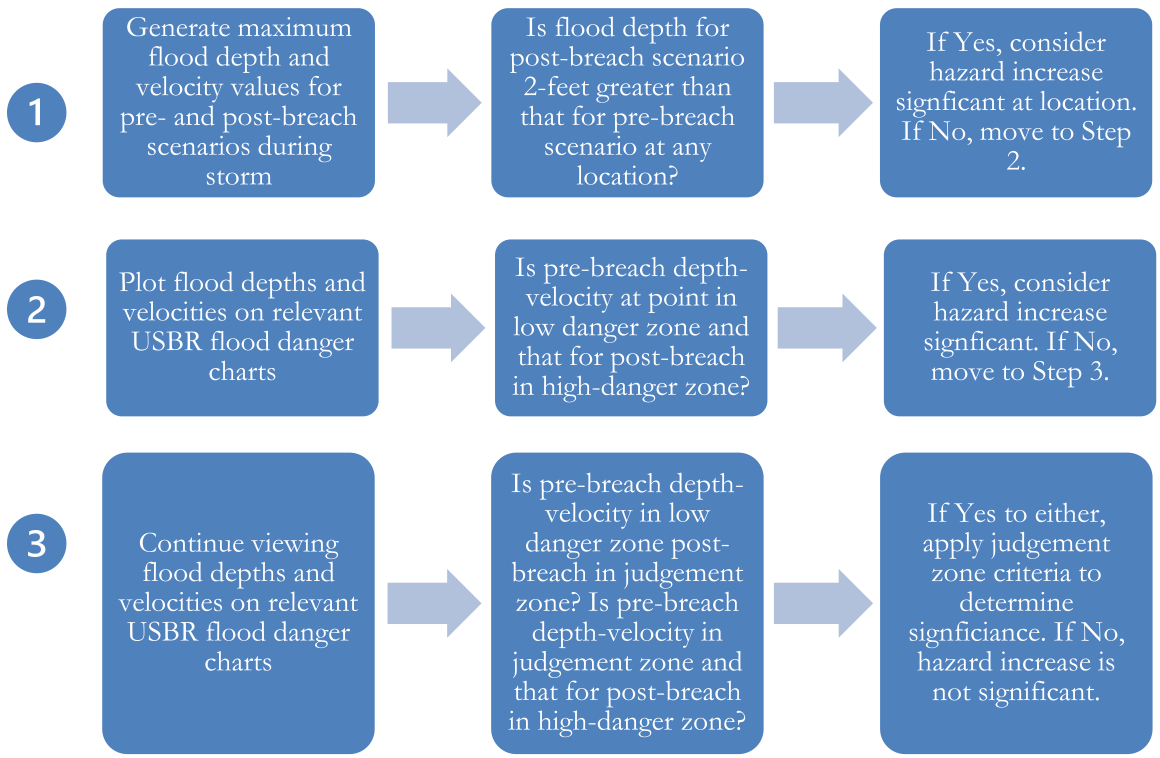


Figure 12: USBR Flood Danger Chart for Vehicles with Judgement Zone Criteria Applied

In summary, Fuss & O'Neill developed the following process for determining the significance of flood hazard increases at each location and applying engineering judgement as necessary.



4.3.2 Breach Model Inputs

Modeling of flood hazards posed by dam breach scenarios required a range of initial conditions data and input parameters as described, in part, below.

- **Initial Conditions:**
  - Initial water surface elevations in the reservoirs were set to the surveyed normal pool elevations for NEP and SEP dams within models for existing conditions and Alternative 2. Alternative 4 was modeled assuming the pool elevation for SEP Dam is lowered to elevation 5.1 prior to extreme storm events (500-year and above) as discussed in Section 4.2.3. This elevation could be refined to determine the ideal configuration for specific extreme storm events through additional modeling.
  - Normal flows were established as initial conditions prior to routing the potential IDF storm through the system
  - The downstream boundary condition for the model was set to approximate mean higher high water for the present-day climate conditions. This boundary condition was used to isolate and evaluate the potential hazard increase resulting

from a dam failure alone, which may have otherwise been dampened or obscured by the incorporation of coastal surge events during the IDF analysis. This assumption provides more conservative hazard increase results, as probabilistic modeling demonstrates inland precipitation events are often coupled with coastal surge.

- **Dam Breach Locations and Parameters**
  - Theoretical dam breach locations were chosen to assess the localized effects of dam failure at multiple points in the NEP and SEP dam embankments. Dam breach locations and the corresponding present-day storm during which the localized existing crest elevation would be exceeded are displayed in Figure 13. These locations correspond with surveyed low points in the existing dam embankments that may be prone to overtopping and subsequent failure, and/or were chosen based on their proximity to downstream development and infrastructure.
  - Dam breach scenarios were modeled for sensitivity under breach geometry and timing parameters from two commonly accepted breach parameter estimation methods: Froehlich 2008 (Froehlich, 2008) and Von Thun & Gillette (Von Thun & Gillette, 1990) This sensitivity analysis demonstrated that the Von Thun & Gillette methodology produced more conservative results. For this reason, results from dam breach scenarios using Von Thun & Gillette methodology were compared with pre-breach conditions.
  - Dam breaches were set to occur at the respective peak water surface elevation within each pond during the modeled storm event as dictated by FERC (Federal Energy Regulatory Commission, 2015).
  - For storm events that did not overtop the dam embankments, dam breaches were modeled as a piping failure in the same location.

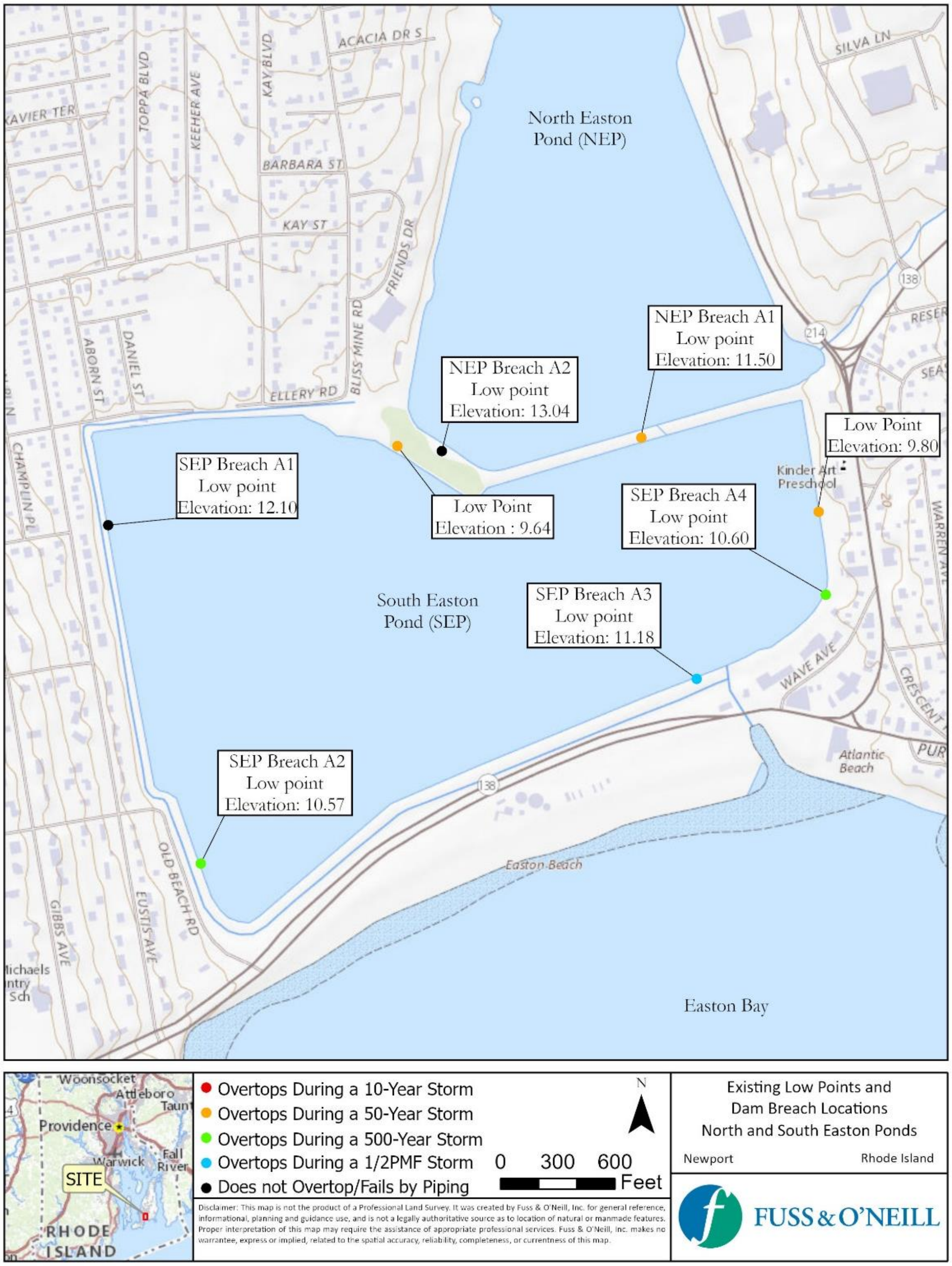


Figure 13: Modeled dam breach locations and existing embankment low points at NEP Dam and SEP Dam

4.3.3 Incremental Consequence Analysis Results

While preliminary incremental consequence analysis was performed for existing conditions and Alternative 2, results for those scenarios were ultimately relevant only for comparison with results of Alternative 4. The incremental consequence analysis results for existing conditions and Alternative 2 demonstrated significant increases in hazards associated with dam breaches during the 500-year storm and ½ PMF events (see Appendix B). In addition, vulnerabilities of the existing dam infrastructure to present-day and future inland and coastal flooding, as discussed in Section 4.2.1, demonstrated the need for modifications at the NEP Dam and SEP Dam. Initial modeling of Alternative 2 indicated peak water surface elevations in both ponds would be substantially higher during extreme storm events (those that are often selected as the IDF) due to raised embankments lacking a proportional increase in spillway discharge capacity. Alternative 4 included a modified SEP Dam primary spillway to address this rise in peak water surface elevations and reduce potential hazards associated with a dam breach. Accordingly, results presented in this report focus primarily on conditions associated with Alternative 4 and the ½ PMF to ensure the proposed modifications can accommodate that event without significantly increasing hazards during a breach.

The controlling results among data from all breach locations (i.e. those resulting in the largest increase in flood depths) were plotted on the USBR Charts. In viewing the results, it is important to recall that the goal of an incremental consequence analysis is not to determine the storm for which there is no increase in depth or velocity due to a dam breach. Instead, an incremental consequence analysis acknowledges some level of hazard exists downstream of the dam prior to a breach and seeks to determine the storm during which a dam breach does not significantly increase that existing hazard.

<u>Alternative 4: 500-Year Storm</u>

It is possible that future modeling could determine a configuration of the SEP Dam spillway under which the 500-year storm could be considered the IDF. However, as discussed above, the preliminary incremental consequence analysis for existing conditions and Alternative 2 demonstrated significant increases in hazards during the 500-year storm and ½ PMF events. Based on these results and as a conservative measure, the incremental consequence analysis for Alternative 4 focused on the ½ PMF as the low-end IDF.

<u>Alternative 4: ½ PMF</u>

Following the determination that the 500-year storm was not suitable for selection as the IDF, breach scenarios were modeled for the ½ PMF event. Incremental consequence analysis for Alternative 4 under the ½ PMF demonstrated largely insignificant increases in hazard from pre-breach to post-breach conditions. Results for each hazard type are discussed under the respective USBR charts on the following pages. Ultimately, the increases in hazard shown for the ½ PMF were determined to be acceptable. As such, the ½ PMF was selected as the IDF for both NEP Dam and SEP Dam.

<u>Alternative 4: ½ PMF Domino</u>

FEMA recommends that "the flood wave that…from failure of [a] dam should be routed to evaluate if any…downstream dams would potentially breach in domino-like action." (Federal Emergency Management Agency, 2013). As such, a breach at NEP Dam was evaluated to determine if it would result in overtopping of the SEP Dam embankments during the ½ PMF event. Results indicated that the peak water surface elevation in SEP Dam after a breach of NEP Dam would rise to 11.24, lower than the proposed SEP embankment elevation (12.1) and, therefore, not expected to result in a breach.

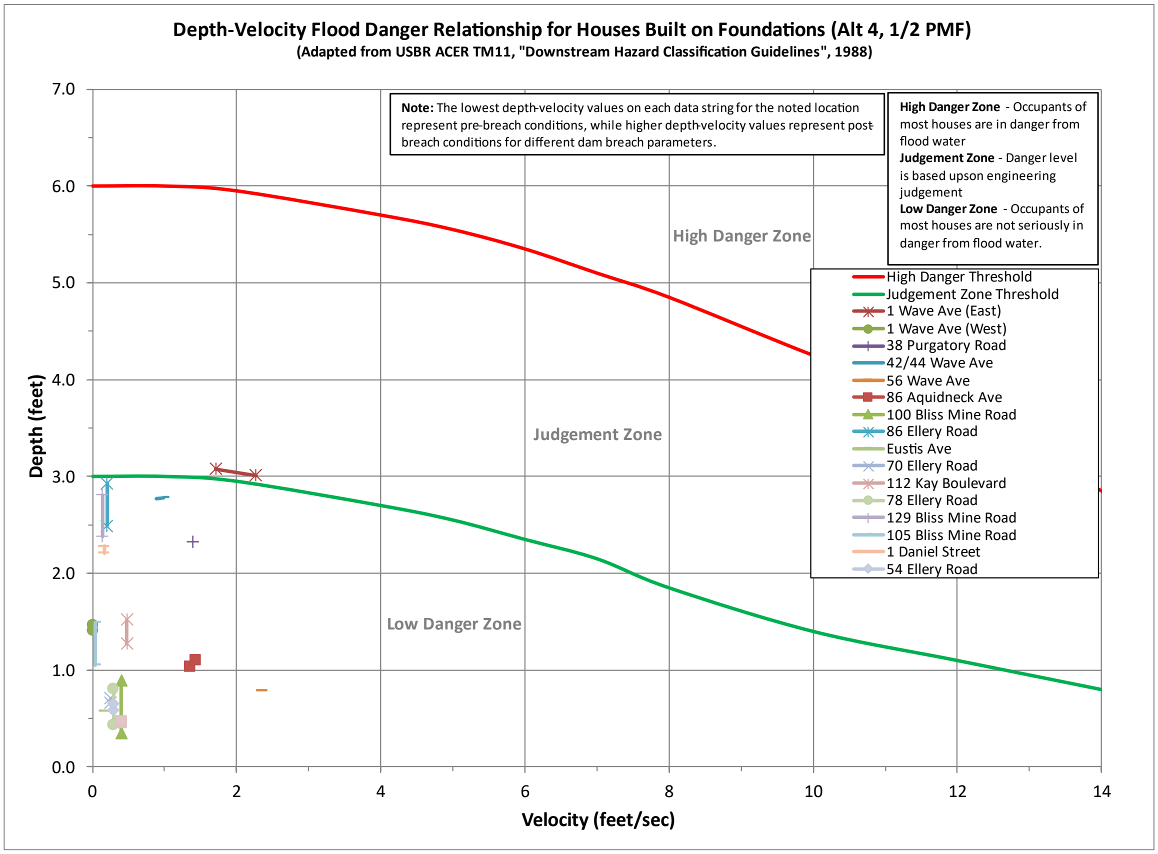


Figure 14: Depth-Velocity Flood Danger Relationship for Houses Built on Foundations Under Alternative 4 During ½ PMF

½ PMF Depth-velocity flood dangers for houses built on foundations during pre- and post-breach scenarios for Alternative 4 are shown in Figure 14. Only those locations that correspond with houses, or other structures assumed to be inhabited (e.g. hotels), are displayed. As shown, post-breach conditions result in some increase in depth and/or velocity for most locations. However, all results are within the low danger zone or the minimum range of the judgement zone. Accordingly, the increases for this hazard type were deemed acceptable.

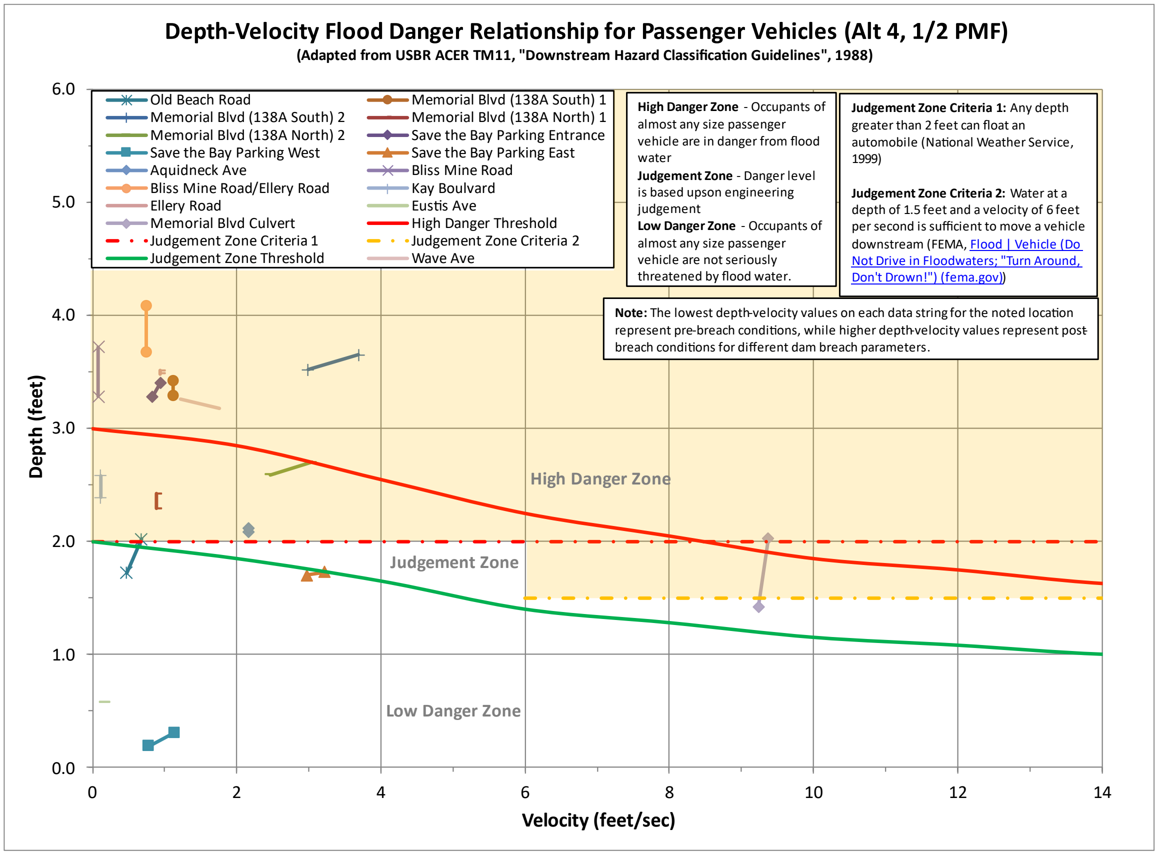


Figure 15: Depth-Velocity Flood Danger Relationship for Passenger Vehicles Under Alternative 4 During ½ PMF

½ PMF depth-velocity flood dangers as they relate to passenger vehicles during pre- and post-breach scenarios for Alternative 4 are shown in Figure 15. Only locations that correspond with a potential access/egress route are displayed. Post-breach conditions result in a slight increase in depth and/or velocity for most locations. However, many locations report depth-velocity values within the high danger zone (as defined either by USBR or judgement zone criteria) prior to a breach. At Old Beach Road and Memorial Boulevard Culvert, the increase in danger ratings shown are partially due to a reduction in pre-breach depth and velocity at these locations from existing conditions to Alternative 4. Without these reductions, the pre-breach danger would already be high. It is worth considering that Alternative 4 would both reduce pre-breach danger at these locations during extreme storms and would reduce the risk of a dam breach caused by overtopping or erosion. These potential failure mechanisms would be mitigated by embankment raising and armoring. While Old Beach Road may not be a viable access/egress route during a breach scenario under Alternative 4, it appears the three homes that would utilize Old Beach Road have viable and direct emergency egress routes by foot to the west. The possibility of closing Memorial Boulevard will be assessed during development of operations and maintenance plans for SEP Dam. Considering these additional points of context, the increases at these locations were deemed acceptable.

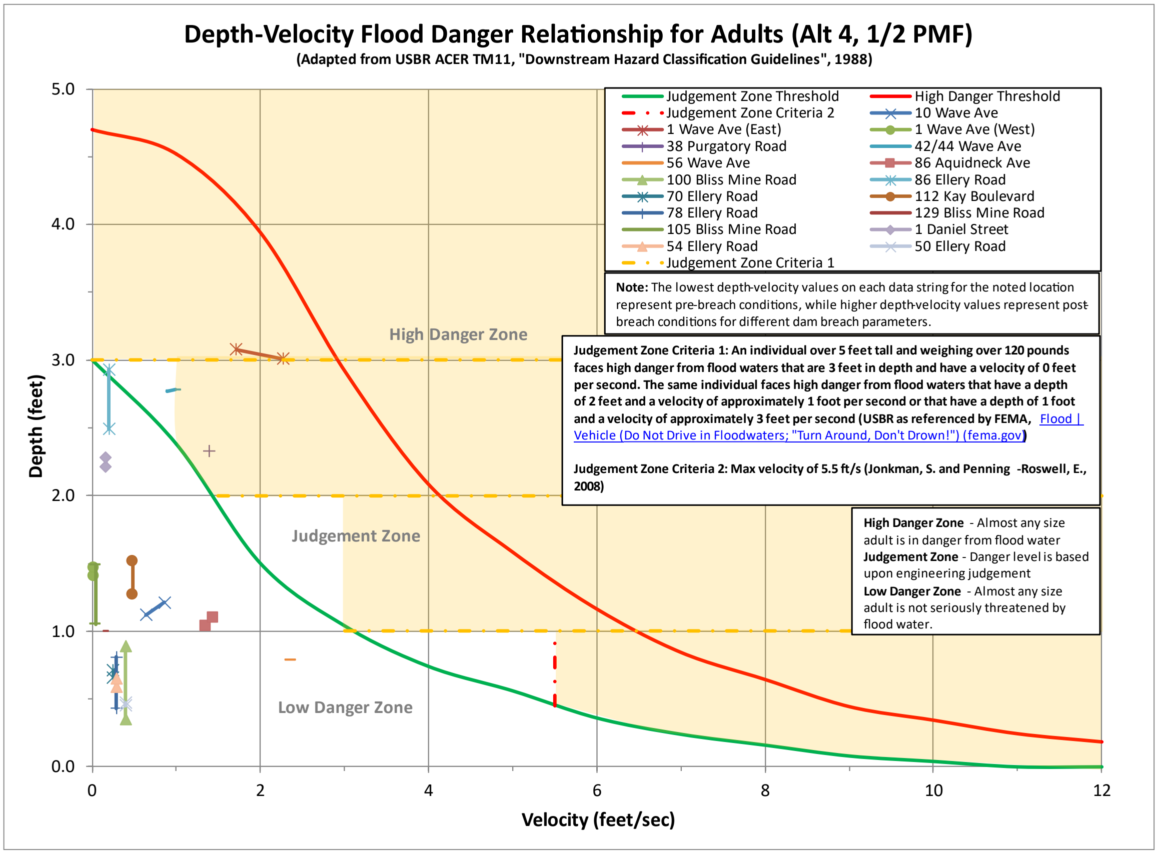


Figure 16: Depth-Velocity Flood Danger Relationship for Adults Under Alternative 4 During 1/2 PMF

Depth-velocity flood dangers as they relate to wading adults during pre- and post-breach scenarios for Alternative 4 are shown in Figure 16. Only locations that are likely to be inhabited are displayed. Post-breach conditions result in a slight increase in depth and/or velocity for most locations. However, all increases for post-breach conditions appear to fall within the same danger zone (as defined either by USBR or judgement zone criteria) as for pre-breach conditions at the same location. As such, increases shown for this flood hazard type were considered acceptable.

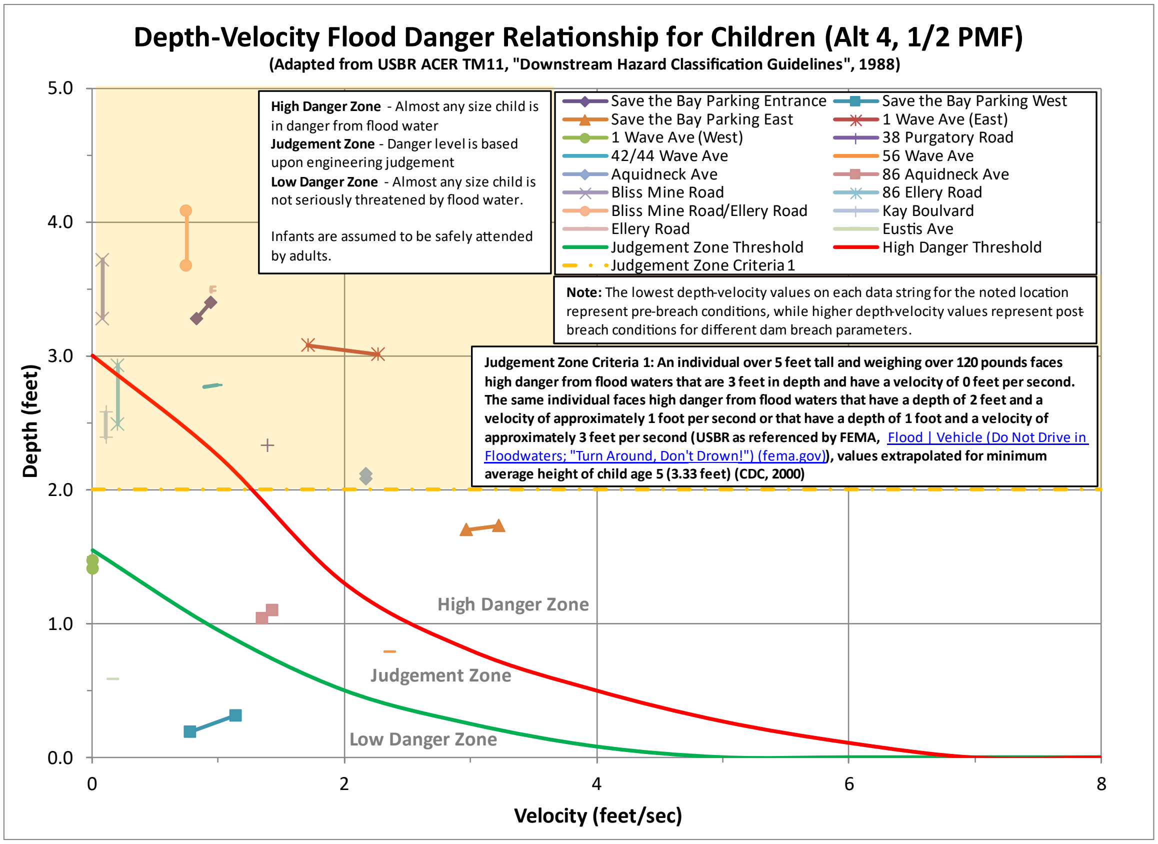


Figure 17: Depth-Velocity Flood Danger Relationship for Children Under Alternative 4 During 1/2 PMF

Depth-velocity flood dangers as they relate to wading children during pre- and post-breach scenarios for Alternative 4 are shown in Figure 17. Only locations that are likely to be inhabited are displayed. Post-breach conditions result in a slight increase in depth and/or velocity for most locations. However, all increases for post-breach conditions appear to fall within the same danger zone (as defined either by USBR or judgement zone criteria) as those for pre-breach conditions at the same location. As such, increases shown for this flood hazard type were considered acceptable.

5 Discussion and Conclusion

Hydrologic and hydraulic analyses summarized in this report sought to provide recommendations for mitigation of flood vulnerabilities at the NEP Dam and SEP Dam under both present-day and future climate conditions. Evidenced by historical flooding and damage, in addition to modeling performed as part of the current analysis, both dams are at risk of damage or failure resulting from inland flooding and tidal/coastal surge activity. Inland flood model results and sea level rise projections were analyzed to identify the following vulnerabilities for the existing dams:

- Modeling indicated the present-day 50-year inland precipitation event could exceed the capacity of both dams, overtop existing low points in their embankments, and cause subsequent dam failures. Under predicted 2070 climate conditions, the SEP Dam capacity may be exceeded by the 10-year inland flood.
- Modeling demonstrated a breach of the NEP Dam embankment during the present-day 50-year inland precipitation event could result in a "domino" breach scenario in which the SEP Dam subsequently overtops and fails, exacerbating flooding at downstream locations.
- SEP Dam limits the overall system's resilience to saltwater intrusion. Estimates indicate that saltwater intrusion through the SEP Dam primary spillway could occur during the present-day 20-year coastal surge event and during the 2070 predicted 1-year coastal surge event (i.e., by 2070, saltwater intrusion through the spillway could occur on an annual basis).
- Overtopping of the existing dam embankments due to coastal surge could occur during the present-day 100-year (SEP Dam) and 200-year (NEP Dam) events. Overtopping due to coastal surge is predicted during the 5-year (SEP Dam) and 50-year (NEP Dam) events by 2070.

The above vulnerabilities were determined primarily by isolating inland flooding and coastal surge events to evaluate the separate effects of each. 2070 inland flood scenarios were modeled with expected increases in mean higher high water – a readily available approximation of future tide conditions -- as the downstream boundary condition.

<u>Alternative 2</u>

Fuss & O'Neill evaluated two potential alternatives for modification of the dams to mitigate overtopping and erosion and to provide climate resilience. Modeling demonstrated that Alternative 2 would increase storage capacity, prevent saltwater intrusion through the spillways, and reduce the frequency of overtopping due to inland and/or coastal flooding. However, peak water surface elevations during extreme storms within NEP Dam and SEP Dam were reported as substantially higher than those for existing conditions. Higher peak water surface elevations during these storms would result in an increase in downstream flood hazards associated with a potential dam breach. For this reason, Alternative 2 was not selected as the recommended alternative.

Alternative 4 (Recommended Alternative)

Based on modeling, Alternative 4 would provide the same improvements as Alternative 2: enacting significant protections against inland and coastal flooding for present-day and predicted 2070 climate conditions. In addition, Alternative 4 appears to reduce peak water surface elevations in the SEP Dam by providing a crest gate that can operate over a range of elevations from 5.1 feet to 12.1 feet for an enlarged 120-foot-wide spillway.

As part of final design of the recommended alternative, additional hydraulic modeling should be carried out to develop an operations plan for the proposed gated SEP spillway. The proposed crest gate would likely require multiple sections and could necessitate varied elevations or timing considerations for different storm and tide combinations. This configuration will also be informed by gate manufacturer specifications.

Under normal conditions, the crest gate should be designed to retain a normal pool elevation of 7.3, similar to existing conditions. The gate configuration will also maintain discharge rates at the SEP Spillway that prevent increases in water surface elevations downstream of the dam.

Ahead of storms projected to be equal to or larger than the 500-year inland event, the gate would be dropped to a low elevation of 5.1 to provide additional storage capacity in SEP Dam. The current analysis determined that lowering the SEP spillway crest, thereby providing additional storage and flow capacity, would accommodate the IDF (1/2 PMF). The gate can also be raised up to elevation 12.1 (matching proposed embankment elevations) to prevent saltwater intrusion through the spillway.

A key component of Alternative 4 is the stabilization and armoring of dam embankments and, in specific areas, reconstructing and armoring dam embankments to allow for overtopping without a breach. Modeling and design may be necessary to understand and meet design criteria for periodic overtopping.

In conclusion, to account for vulnerabilities at the existing dams and to provide resilience for future climate conditions, Fuss & O'Neill recommend proceeding with proposed Alternative 4, which includes:

- Raising NEP Dam embankment crest to elevation 13.4 to limit overtopping due to inland flooding
- Raising the SEP Dam embankment crest to elevation 12.1 to limit overtopping due to inland and coastal flooding
- Reconstructing the SEP Dam spillway to a width of 120 feet and installing a hydraulic crest gate to range from elevations 5.1 to 12.1, allowing for varied pool elevations and preventing saltwater intrusion through the SEP Dam spillway
- Constructing a tidal/flap gate in the moat near J Paul Braga Jr Memorial Field to prevent saltwater intrusion through the NEP Dam auxiliary spillway. The SEP Dam embankment east of the gate will remain at existing elevations to allow stormwater from surrounding neighborhoods into SEP and prevent increased water surface elevations in the moat and surrounding area

- Reconstructing and armoring dam embankments with articulated concrete block mats to reduce the risk of erosion caused by wave attacks, moat flows, and unlikely overtopping events

Table 10 summarizes present-day and 2070 flood protection levels offered under existing conditions and under proposed Alternative 4. Figure 1 and Figure 2 display selected results at the project site.

Table 10: Comparison of Flood Protection Levels for Existing Conditions and Proposed Alternative 4

Climate Conditions	Scenario	Overtopping via Inland Flooding	Saltwater Intrusion
Present-Day	**Existing Conditions**	10-year storm	10-year coastal surge
	Recommended Alternative	500-year storm	200-year coastal surge
2070	**Existing Conditions**	Lower than 10-year [1]	MHHW, no surge [2]
	Recommended Alternative	500-year storm	20-year coastal surge

[1] The smallest inland flood modeled was that of the 10-year precipitation. Modeling predicted this storm would overtop the existing SEP Dam embankments under predicted 2070 climate conditions.
[2] Modeling suggests the 2070 1-year coastal surge would overtop the SEP Dam spillway under existing conditions. Therefore, existing conditions protect only through mean higher high water (high tide) for predicted 2070 climate conditions.

6 References

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Appendix A

Supporting Hydrologic Information

Subbasin Characteristics

Subbasin Name	Discharge Location	Area (Acres)	Composite Curve Number	Time of Concentration (Minutes)
Subbasin 1-A	North Easton Pond	2167.429	83.6	277.1
Subbasin 1-B	North Easton Pond	485.571	87.5	61.45
Subbasin 2	South Easton Pond	146.17	97	7.04
Subbasin 3-1	West Moat	32.937	82.4	24.64
Subbasin 3-2	West Moat	232.097	88	51.77
Subbasin 3-3	West Moat	84.639	90.2	32.93
Subbasin 3-4	West Moat	42.182	87.3	20.72
Subbasin 3-5	West Moat	21.241	81.6	24.92
Subbasin 3-6	West Moat	36.617	81.6	15.96
Subbasin 3-7	West Moat	2.16	79.6	6.11
Subbasin 3-8	West Moat	3.162	79.8	6
Subbasin 3-9	West Moat	4.7	80.6	6.7
Subbasin 3-10	East Moat	8.622	91	6
Subbasin 3-11	East Moat	8.193	94	6
Subbasin 3-12	East Moat	123.641	86.1	46.48
Subbasin 4-1	Away from Project	116.94	85.9	23.4
Subbasin 4-2	Away from Project	1.178	91	6

Present-Day Subbasin Peak Flow Summary

Subbasin Name	2-Year (cfs)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)	1/2 PMF (cfs)
Subbasin 1-A	447.6	817.4	1399.2	1718.9	2600	4313.1
Subbasin 1-B	349	596.6	970.5	1172	1720.9	2650.7
Subbasin 2	377.6	568.7	853.4	1007.1	1428.6	1407.5
Subbasin 3-1	32.3	59.5	101.8	124.8	187.6	268.1
Subbasin 3-2	190.3	322.5	521.5	628.6	920.1	1281.9
Subbasin 3-3	99.9	163.7	258.6	309.6	448.3	403.7
Subbasin 3-4	55.3	94.4	153.2	184.8	270.8	220.7
Subbasin 3-5	20	37.2	64.3	79	119.4	106.1
Subbasin 3-6	42	78.5	135.3	166.3	251	178.9
Subbasin 3-7	3.1	6	10.5	12.9	19.7	14.6
Subbasin 3-8	4.5	8.7	15.2	18.8	28.6	21.2
Subbasin 3-9	6.9	12.9	22.5	27.7	42	27.2
Subbasin 3-10	19.7	31.9	49.8	59.4	85.6	83.2
Subbasin 3-11	20.5	31.8	48.5	57.6	82.1	79.1
Subbasin 3-12	100.4	174.9	288.2	349.4	516.1	785.2
Subbasin 4-1	137	238.7	393	476.1	702.7	967.7
Subbasin 4-2	2.6	4.2	6.6	7.9	11.4	11.1

Predicted 2070 Subbasin Peak Flow Summary

Subbasin Name	2-Year (cfs)	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)	1/2 PMF (cfs)
Subbasin 1-A	746.3	1276.7	1891.5	2163	2878.8	4615
Subbasin 1-B	549.9	892.8	1280.1	1449.4	1893.5	2836.2
Subbasin 2	533	794.2	1089.8	1219.7	1561.8	1506
Subbasin 3-1	54.3	92.9	137.1	156.5	207.4	286.9
Subbasin 3-2	297.6	480.2	686	776	1011.8	1371.6
Subbasin 3-3	151.8	238.9	336.9	379.7	492	431.9
Subbasin 3-4	87.1	141	201.7	228.2	297.8	236.2
Subbasin 3-5	33.9	58.6	86.9	99.4	132.1	113.6
Subbasin 3-6	71.5	123.4	183	209.1	277.7	191.4
Subbasin 3-7	5.4	9.5	14.3	16.4	21.8	15.6
Subbasin 3-8	7.9	13.8	20.7	23.7	31.7	22.7
Subbasin 3-9	11.8	20.5	30.5	34.9	46.5	29.1
Subbasin 3-10	29.6	46.1	64.6	72.7	93.9	89
Subbasin 3-11	29.7	45.1	62.4	70	89.9	84.6
Subbasin 3-12	160.8	264.6	382.2	433.7	568.5	840.2
Subbasin 4-1	219.5	360.9	520.7	590.6	773.9	1035.4
Subbasin 4-2	3.9	6.1	8.6	9.7	12.5	11.9

PMF Temporal Rainfall Distribution

The total precipitation depth was temporally distributed by dividing the rainfall into 6-hour increments, with the most intense 6-hour period of the storm further divided into 1-hour increments. The 72-hour rainfall distribution applied to the IDF analysis described in Section 4 is summarized below.

Cumulative Storm Time (hours)	Cumulative Rainfall Depth (in)	Cumulative Storm Time (hours)	Cumulative Rainfall Depth (in)
6	0.4	**42**	4.3
12	0.9	**48**	5.4
18	1.4	**54**	6.9
24	2.0	**60**	10.8
30	2.6	**66**	36.4
36	3.4	**72**	38.5

HEC-HMS Model Reports

Project: 20060901.d64.2023
Simulation Run: 10-Year
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:47

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
SubWatershed 1 - A	3.39
SubWatershed 1 - B	0.76
SubWatershed 2	0.23
SubWatershed 3 - 3	0.13
SubWatershed 3 - 4	0.07
SubWatershed 3 - 6	0.06
SubWatershed 3 - 1	0.05
SubWatershed 3 - 2	0.36
SubWatershed 3 - 12	0.19
SubWatershed 4 - 1	0.18
SubWatershed 3 - 5	0.03
SubWatershed 3 - 8	0
SubWatershed 3 - 7	0
SubWatershed 3 - 9	0.01
SubWatershed 3 - 10	0.01
SubWatershed 3 - 11	0.01
SubWatershed 4 - 2	0

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
SubWatershed 1 - A	0	83.6
SubWatershed 1 - B	0	87.5
SubWatershed 2	0	97
SubWatershed 3 - 3	0	90.2
SubWatershed 3 - 4	0	87.3
SubWatershed 3 - 6	0	81.6
SubWatershed 3 - 1	0	82.4
SubWatershed 3 - 2	0	88
SubWatershed 3 - 12	0	86.1
SubWatershed 4 - 1	0	85.9
SubWatershed 3 - 5	0	81.6
SubWatershed 3 - 8	0	79.8
SubWatershed 3 - 7	0	79.6
SubWatershed 3 - 9	0	80.6
SubWatershed 3 - 10	0	91
SubWatershed 3 - 11	0	94
SubWatershed 4 - 2	0	91

Transform: Scs

Element Name	Lag	Unitgraph Type
SubWatershed 1 - A	277.1	Standard
SubWatershed 1 - B	61.45	Standard
SubWatershed 2	7.04	Standard
SubWatershed 3 - 3	32.93	Standard
SubWatershed 3 - 4	20.72	Standard
SubWatershed 3 - 6	15.96	Standard
SubWatershed 3 - 1	24.64	Standard
SubWatershed 3 - 2	51.77	Standard
SubWatershed 3 - 12	46.48	Standard
SubWatershed 4 - 1	23.4	Standard
SubWatershed 3 - 5	24.92	Standard
SubWatershed 3 - 8	6	Standard
SubWatershed 3 - 7	6.11	Standard
SubWatershed 3 - 9	6.7	Standard
SubWatershed 3 - 10	6	Standard
SubWatershed 3 - 11	6	Standard
SubWatershed 4 - 2	6	Standard

Project: 20060901.d64.2023
Simulation Run: 10-Year
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:47

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	817.37	01Jan2022, 17:06	2.68
Sink - 1	3.39	817.37	01Jan2022, 17:06	2.68
SubWatershed 1 - B	0.76	596.61	01Jan2022, 13:06	3.47
SubWatershed 2	0.23	568.69	01Jan2022, 12:08	4.54
SubWatershed 3 - 3	0.13	163.71	01Jan2022, 12:36	3.77
SubWatershed 3 - 4	0.07	94.43	01Jan2022, 12:23	3.49
SubWatershed 3 - 6	0.06	78.46	01Jan2022, 12:18	2.94
SubWatershed 3 - 1	0.05	59.51	01Jan2022, 12:28	3.01
SubWatershed 3 - 2	0.36	322.51	01Jan2022, 12:56	3.53
SubWatershed 3 - 12	0.19	174.92	01Jan2022, 12:50	3.34
SubWatershed 4 - 1	0.18	238.73	01Jan2022, 12:26	3.34
SubWatershed 3 - 5	0.03	37.23	01Jan2022, 12:28	2.93
SubWatershed 3 - 8	0	8.68	01Jan2022, 12:08	2.78
SubWatershed 3 - 7	0	5.96	01Jan2022, 12:08	2.76
SubWatershed 3 - 9	0.01	12.93	01Jan2022, 12:08	2.85
SubWatershed 3 - 10	0.01	31.86	01Jan2022, 12:07	3.88
SubWatershed 3 - 11	0.01	31.8	01Jan2022, 12:07	4.2
SubWatershed 4 - 2	0	4.25	01Jan2022, 12:07	3.88

Project: 20060901.d64.2023
Simulation Run: 50-Year
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:44

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	1399.17	01Jan2022, 17:01	4.64
Sink - 1	3.39	1399.17	01Jan2022, 17:01	4.64
SubWatershed 1 - B	0.76	970.53	01Jan2022, 13:05	5.74
SubWatershed 2	0.23	853.38	01Jan2022, 12:08	6.93
SubWatershed 3 - 3	0.13	258.61	01Jan2022, 12:35	6.09
SubWatershed 3 - 4	0.07	153.18	01Jan2022, 12:23	5.78
SubWatershed 3 - 6	0.06	135.33	01Jan2022, 12:18	5.13
SubWatershed 3 - 1	0.05	101.75	01Jan2022, 12:27	5.21
SubWatershed 3 - 2	0.36	521.51	01Jan2022, 12:55	5.81
SubWatershed 3 - 12	0.19	288.23	01Jan2022, 12:50	5.6
SubWatershed 4 - 1	0.18	392.97	01Jan2022, 12:26	5.61
SubWatershed 3 - 5	0.03	64.26	01Jan2022, 12:28	5.12
SubWatershed 3 - 8	0	15.2	01Jan2022, 12:08	4.94
SubWatershed 3 - 7	0	10.48	01Jan2022, 12:08	4.92
SubWatershed 3 - 9	0.01	22.5	01Jan2022, 12:08	5.03
SubWatershed 3 - 10	0.01	49.8	01Jan2022, 12:07	6.23
SubWatershed 3 - 11	0.01	48.55	01Jan2022, 12:07	6.58
SubWatershed 4 - 2	0	6.64	01Jan2022, 12:07	6.23

Project: 20060901.d64.2023
Simulation Run: 100-Year
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:47

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
SubWatershed 1 - A	3.39
SubWatershed 1 - B	0.76
SubWatershed 2	0.23
SubWatershed 3 - 3	0.13
SubWatershed 3 - 4	0.07
SubWatershed 3 - 6	0.06
SubWatershed 3 - 1	0.05
SubWatershed 3 - 2	0.36
SubWatershed 3 - 12	0.19
SubWatershed 4 - 1	0.18
SubWatershed 3 - 5	0.03
SubWatershed 3 - 8	0
SubWatershed 3 - 7	0
SubWatershed 3 - 9	0.01
SubWatershed 3 - 10	0.01
SubWatershed 3 - 11	0.01
SubWatershed 4 - 2	0

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
SubWatershed 1 - A	0	83.6
SubWatershed 1 - B	0	87.5
SubWatershed 2	0	97
SubWatershed 3 - 3	0	90.2
SubWatershed 3 - 4	0	87.3
SubWatershed 3 - 6	0	81.6
SubWatershed 3 - 1	0	82.4
SubWatershed 3 - 2	0	88
SubWatershed 3 - 12	0	86.1
SubWatershed 4 - 1	0	85.9
SubWatershed 3 - 5	0	81.6
SubWatershed 3 - 8	0	79.8
SubWatershed 3 - 7	0	79.6
SubWatershed 3 - 9	0	80.6
SubWatershed 3 - 10	0	91
SubWatershed 3 - 11	0	94
SubWatershed 4 - 2	0	91

Transform: Scs

Element Name	Lag	Unitgraph Type
SubWatershed 1 - A	277.1	Standard
SubWatershed 1 - B	61.45	Standard
SubWatershed 2	7.04	Standard
SubWatershed 3 - 3	32.93	Standard
SubWatershed 3 - 4	20.72	Standard
SubWatershed 3 - 6	15.96	Standard
SubWatershed 3 - 1	24.64	Standard
SubWatershed 3 - 2	51.77	Standard
SubWatershed 3 - 12	46.48	Standard
SubWatershed 4 - 1	23.4	Standard
SubWatershed 3 - 5	24.92	Standard
SubWatershed 3 - 8	6	Standard
SubWatershed 3 - 7	6.11	Standard
SubWatershed 3 - 9	6.7	Standard
SubWatershed 3 - 10	6	Standard
SubWatershed 3 - 11	6	Standard
SubWatershed 4 - 2	6	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	1718.88	01Jan2022, 16:59	5.74
Sink - 1	3.39	1718.88	01Jan2022, 16:59	5.74
SubWatershed 1 - B	0.76	1172.01	01Jan2022, 13:05	6.99
SubWatershed 2	0.23	1007.12	01Jan2022, 12:08	8.23
SubWatershed 3 - 3	0.13	309.57	01Jan2022, 12:35	7.37
SubWatershed 3 - 4	0.07	184.77	01Jan2022, 12:23	7.04
SubWatershed 3 - 6	0.06	166.3	01Jan2022, 12:18	6.36
SubWatershed 3 - 1	0.05	124.77	01Jan2022, 12:27	6.44
SubWatershed 3 - 2	0.36	628.59	01Jan2022, 12:55	7.07
SubWatershed 3 - 12	0.19	349.38	01Jan2022, 12:49	6.85
SubWatershed 4 - 1	0.18	476.1	01Jan2022, 12:26	6.86
SubWatershed 3 - 5	0.03	79	01Jan2022, 12:28	6.34
SubWatershed 3 - 8	0	18.77	01Jan2022, 12:07	6.16
SubWatershed 3 - 7	0	12.94	01Jan2022, 12:08	6.13
SubWatershed 3 - 9	0.01	27.73	01Jan2022, 12:08	6.25
SubWatershed 3 - 10	0.01	59.42	01Jan2022, 12:07	7.51
SubWatershed 3 - 11	0.01	57.55	01Jan2022, 12:07	7.87
SubWatershed 4 - 2	0	7.92	01Jan2022, 12:07	7.51

Project: 20060901.d64.2023
Simulation Run: 500-Year
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:44

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	2600.04	01Jan2022, 16:56	8.81
Sink - 1	3.39	2600.04	01Jan2022, 16:56	8.81
SubWatershed 1 - B	0.76	1720.86	01Jan2022, 13:04	10.46
SubWatershed 2	0.23	1428.56	01Jan2022, 12:08	11.79
SubWatershed 3 - 3	0.13	448.31	01Jan2022, 12:35	10.88
SubWatershed 3 - 4	0.07	270.78	01Jan2022, 12:22	10.54
SubWatershed 3 - 6	0.06	250.99	01Jan2022, 12:17	9.79
SubWatershed 3 - 1	0.05	187.61	01Jan2022, 12:27	9.88
SubWatershed 3 - 2	0.36	920.14	01Jan2022, 12:54	10.55
SubWatershed 3 - 12	0.19	516.11	01Jan2022, 12:49	10.32
SubWatershed 4 - 1	0.18	702.66	01Jan2022, 12:25	10.35
SubWatershed 3 - 5	0.03	119.37	01Jan2022, 12:27	9.77
SubWatershed 3 - 8	0	28.58	01Jan2022, 12:07	9.57
SubWatershed 3 - 7	0	19.71	01Jan2022, 12:07	9.54
SubWatershed 3 - 9	0.01	42.01	01Jan2022, 12:08	9.68
SubWatershed 3 - 10	0.01	85.62	01Jan2022, 12:07	11.04
SubWatershed 3 - 11	0.01	82.15	01Jan2022, 12:07	11.42
SubWatershed 4 - 2	0	11.42	01Jan2022, 12:07	11.04

Project: 20060901.d64.2023
Simulation Run: 1/2 PMF
Simulation Start: 31 December 2021, 24:00
Simulation End: 3 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:44

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	4313.12	03Jan2022, 19:45	15.53
Sink - 1	3.39	4313.12	03Jan2022, 19:45	15.53
SubWatershed 1 - B	0.76	2650.7	03Jan2022, 16:06	18.49
SubWatershed 2	0.23	1407.48	03Jan2022, 15:12	19.32
SubWatershed 3 - 3	0.13	403.68	03Jan2022, 15:38	15.41
SubWatershed 3 - 4	0.07	220.7	03Jan2022, 15:26	15.2
SubWatershed 3 - 6	0.06	178.92	03Jan2022, 15:21	14.25
SubWatershed 3 - 1	0.05	268.13	03Jan2022, 15:30	18.22
SubWatershed 3 - 2	0.36	1281.87	03Jan2022, 15:56	17.76
SubWatershed 3 - 12	0.19	785.22	03Jan2022, 15:51	18.44
SubWatershed 4 - 1	0.18	967.7	03Jan2022, 15:29	18.5
SubWatershed 3 - 5	0.03	106.15	03Jan2022, 15:30	14.75
SubWatershed 3 - 8	0	21.22	03Jan2022, 15:11	15.57
SubWatershed 3 - 7	0	14.57	03Jan2022, 15:11	15.5
SubWatershed 3 - 9	0.01	27.2	03Jan2022, 15:12	14.8
SubWatershed 3 - 10	0.01	83.17	03Jan2022, 15:11	18.91
SubWatershed 3 - 11	0.01	79.08	03Jan2022, 15:11	19.13
SubWatershed 4 - 2	0	11.11	03Jan2022, 15:11	18.92

Project: 20060901.d64.2023
Simulation Run: 10-Year 2070
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:47

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	1276.74	01Jan2022, 17:02	4.23
Sink - 1	3.39	1276.74	01Jan2022, 17:02	4.23
SubWatershed 1 - B	0.76	892.78	01Jan2022, 13:05	5.26
SubWatershed 2	0.23	794.18	01Jan2022, 12:08	6.43
SubWatershed 3 - 3	0.13	238.93	01Jan2022, 12:35	5.61
SubWatershed 3 - 4	0.07	140.98	01Jan2022, 12:23	5.29
SubWatershed 3 - 6	0.06	123.42	01Jan2022, 12:18	4.67
SubWatershed 3 - 1	0.05	92.9	01Jan2022, 12:27	4.74
SubWatershed 3 - 2	0.36	480.18	01Jan2022, 12:55	5.33
SubWatershed 3 - 12	0.19	264.65	01Jan2022, 12:50	5.12
SubWatershed 4 - 1	0.18	360.89	01Jan2022, 12:26	5.13
SubWatershed 3 - 5	0.03	58.6	01Jan2022, 12:28	4.65
SubWatershed 3 - 8	0	13.83	01Jan2022, 12:08	4.48
SubWatershed 3 - 7	0	9.53	01Jan2022, 12:08	4.46
SubWatershed 3 - 9	0.01	20.5	01Jan2022, 12:08	4.57
SubWatershed 3 - 10	0.01	46.09	01Jan2022, 12:07	5.73
SubWatershed 3 - 11	0.01	45.08	01Jan2022, 12:07	6.08
SubWatershed 4 - 2	0	6.14	01Jan2022, 12:07	5.73

Project: 20060901.d64.2023
Simulation Run: 50-Year 2070
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:44

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	1891.49	01Jan2022, 16:58	6.34
Sink - 1	3.39	1891.49	01Jan2022, 16:58	6.34
SubWatershed 1 - B	0.76	1280.11	01Jan2022, 13:05	7.67
SubWatershed 2	0.23	1089.83	01Jan2022, 12:08	8.93
SubWatershed 3 - 3	0.13	336.9	01Jan2022, 12:35	8.05
SubWatershed 3 - 4	0.07	201.71	01Jan2022, 12:23	7.72
SubWatershed 3 - 6	0.06	182.96	01Jan2022, 12:18	7.03
SubWatershed 3 - 1	0.05	137.14	01Jan2022, 12:27	7.11
SubWatershed 3 - 2	0.36	686.02	01Jan2022, 12:55	7.75
SubWatershed 3 - 12	0.19	382.23	01Jan2022, 12:49	7.52
SubWatershed 4 - 1	0.18	520.7	01Jan2022, 12:26	7.54
SubWatershed 3 - 5	0.03	86.94	01Jan2022, 12:27	7.01
SubWatershed 3 - 8	0	20.7	01Jan2022, 12:07	6.82
SubWatershed 3 - 7	0	14.27	01Jan2022, 12:08	6.79
SubWatershed 3 - 9	0.01	30.54	01Jan2022, 12:08	6.92
SubWatershed 3 - 10	0.01	64.58	01Jan2022, 12:07	8.2
SubWatershed 3 - 11	0.01	62.39	01Jan2022, 12:07	8.56
SubWatershed 4 - 2	0	8.61	01Jan2022, 12:07	8.2

Project: 20060901.d64.2023
Simulation Run: 100-Year 2070
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:44

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	2163.03	01Jan2022, 16:57	7.28
Sink - 1	3.39	2163.03	01Jan2022, 16:57	7.28
SubWatershed 1 - B	0.76	1449.44	01Jan2022, 13:04	8.73
SubWatershed 2	0.23	1219.71	01Jan2022, 12:08	10.02
SubWatershed 3 - 3	0.13	379.71	01Jan2022, 12:35	9.13
SubWatershed 3 - 4	0.07	228.24	01Jan2022, 12:22	8.8
SubWatershed 3 - 6	0.06	209.07	01Jan2022, 12:18	8.08
SubWatershed 3 - 1	0.05	156.53	01Jan2022, 12:27	8.17
SubWatershed 3 - 2	0.36	775.98	01Jan2022, 12:55	8.82
SubWatershed 3 - 12	0.19	433.69	01Jan2022, 12:49	8.59
SubWatershed 4 - 1	0.18	590.63	01Jan2022, 12:25	8.61
SubWatershed 3 - 5	0.03	99.4	01Jan2022, 12:27	8.06
SubWatershed 3 - 8	0	23.73	01Jan2022, 12:07	7.87
SubWatershed 3 - 7	0	16.36	01Jan2022, 12:08	7.84
SubWatershed 3 - 9	0.01	34.94	01Jan2022, 12:08	7.97
SubWatershed 3 - 10	0.01	72.66	01Jan2022, 12:07	9.29
SubWatershed 3 - 11	0.01	69.97	01Jan2022, 12:07	9.66
SubWatershed 4 - 2	0	9.69	01Jan2022, 12:07	9.29

Project: 20060901.d64.2023
Simulation Run: 500-Year 2070
Simulation Start: 31 December 2021, 24:00
Simulation End: 1 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:44

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	2878.83	01Jan2022, 16:55	9.79
Sink - 1	3.39	2878.83	01Jan2022, 16:55	9.79
SubWatershed 1 - B	0.76	1893.45	01Jan2022, 13:04	11.56
SubWatershed 2	0.23	1561.81	01Jan2022, 12:08	12.92
SubWatershed 3 - 3	0.13	491.95	01Jan2022, 12:35	11.99
SubWatershed 3 - 4	0.07	297.82	01Jan2022, 12:22	11.65
SubWatershed 3 - 6	0.06	277.67	01Jan2022, 12:17	10.89
SubWatershed 3 - 1	0.05	207.38	01Jan2022, 12:27	10.98
SubWatershed 3 - 2	0.36	1011.84	01Jan2022, 12:54	11.66
SubWatershed 3 - 12	0.19	568.51	01Jan2022, 12:49	11.42
SubWatershed 4 - 1	0.18	773.87	01Jan2022, 12:25	11.46
SubWatershed 3 - 5	0.03	132.07	01Jan2022, 12:27	10.87
SubWatershed 3 - 8	0	31.67	01Jan2022, 12:07	10.67
SubWatershed 3 - 7	0	21.84	01Jan2022, 12:07	10.64
SubWatershed 3 - 9	0.01	46.5	01Jan2022, 12:08	10.78
SubWatershed 3 - 10	0.01	93.87	01Jan2022, 12:07	12.17
SubWatershed 3 - 11	0.01	89.91	01Jan2022, 12:07	12.55
SubWatershed 4 - 2	0	12.52	01Jan2022, 12:07	12.17

Project: 20060901.d64.2023
Simulation Run: Projected 0.5 PMF
Simulation Start: 31 December 2021, 24:00
Simulation End: 3 January 2022, 24:00

HMS Version: 4.10
Executed: 05 December 2023, 18:47

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
SubWatershed 1 - A	3.39	4615.04	03Jan2022, 19:45	16.62
Sink - 1	3.39	4615.04	03Jan2022, 19:45	16.62
SubWatershed 1 - B	0.76	2836.25	03Jan2022, 16:06	19.79
SubWatershed 2	0.23	1506.01	03Jan2022, 15:12	20.67
SubWatershed 3 - 3	0.13	431.94	03Jan2022, 15:38	16.49
SubWatershed 3 - 4	0.07	236.15	03Jan2022, 15:26	16.27
SubWatershed 3 - 6	0.06	191.44	03Jan2022, 15:21	15.25
SubWatershed 3 - 1	0.05	286.9	03Jan2022, 15:30	19.5
SubWatershed 3 - 2	0.36	1371.6	03Jan2022, 15:56	19
SubWatershed 3 - 12	0.19	840.18	03Jan2022, 15:51	19.73
SubWatershed 4 - 1	0.18	1035.44	03Jan2022, 15:29	19.79
SubWatershed 3 - 5	0.03	113.58	03Jan2022, 15:30	15.79
SubWatershed 3 - 8	0	22.71	03Jan2022, 15:11	16.66
SubWatershed 3 - 7	0	15.59	03Jan2022, 15:11	16.58
SubWatershed 3 - 9	0.01	29.1	03Jan2022, 15:12	15.84
SubWatershed 3 - 10	0.01	88.99	03Jan2022, 15:11	20.23
SubWatershed 3 - 11	0.01	84.62	03Jan2022, 15:11	20.47
SubWatershed 4 - 2	0	11.89	03Jan2022, 15:11	20.25

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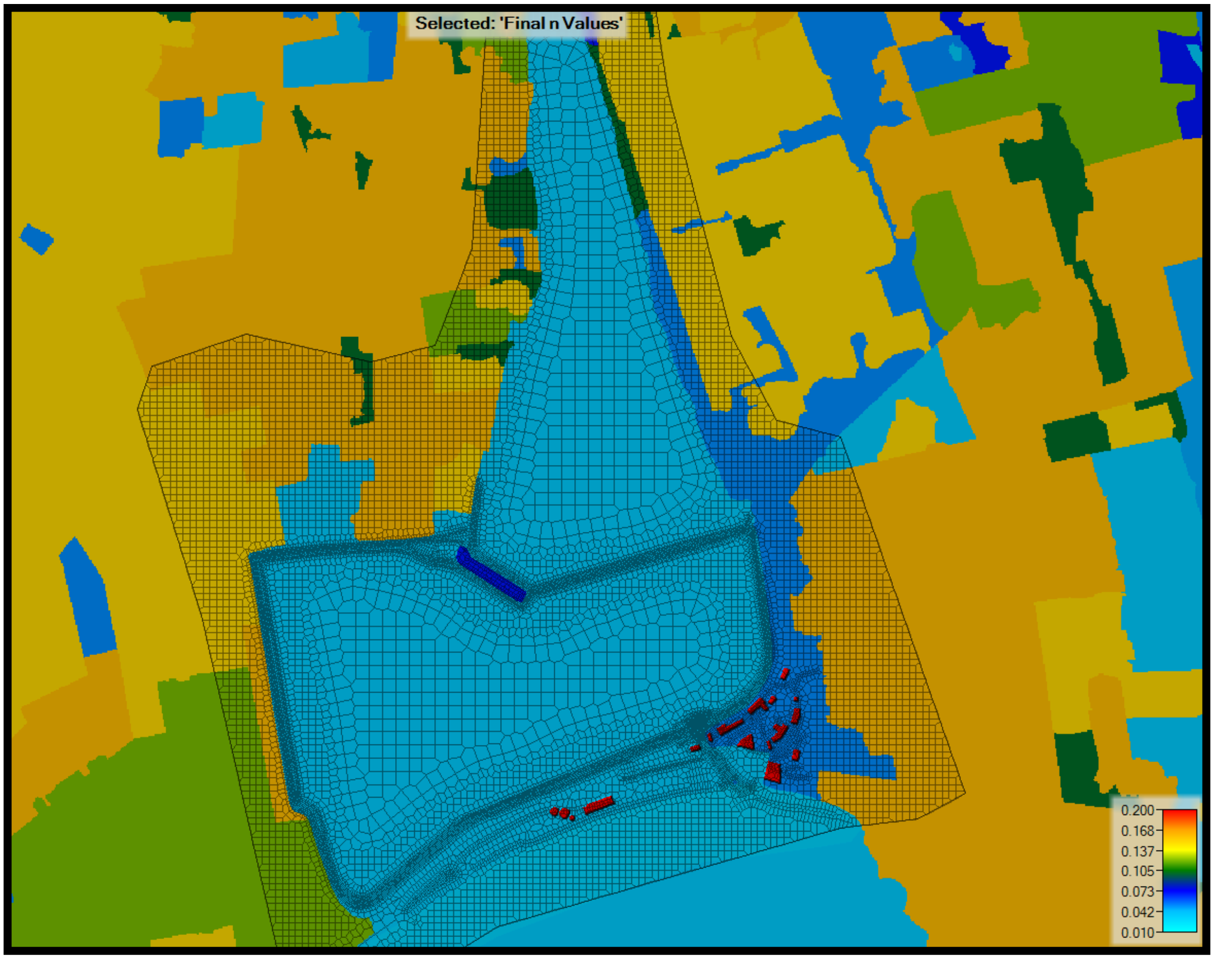
Appendix B

Supporting Hydraulic Information

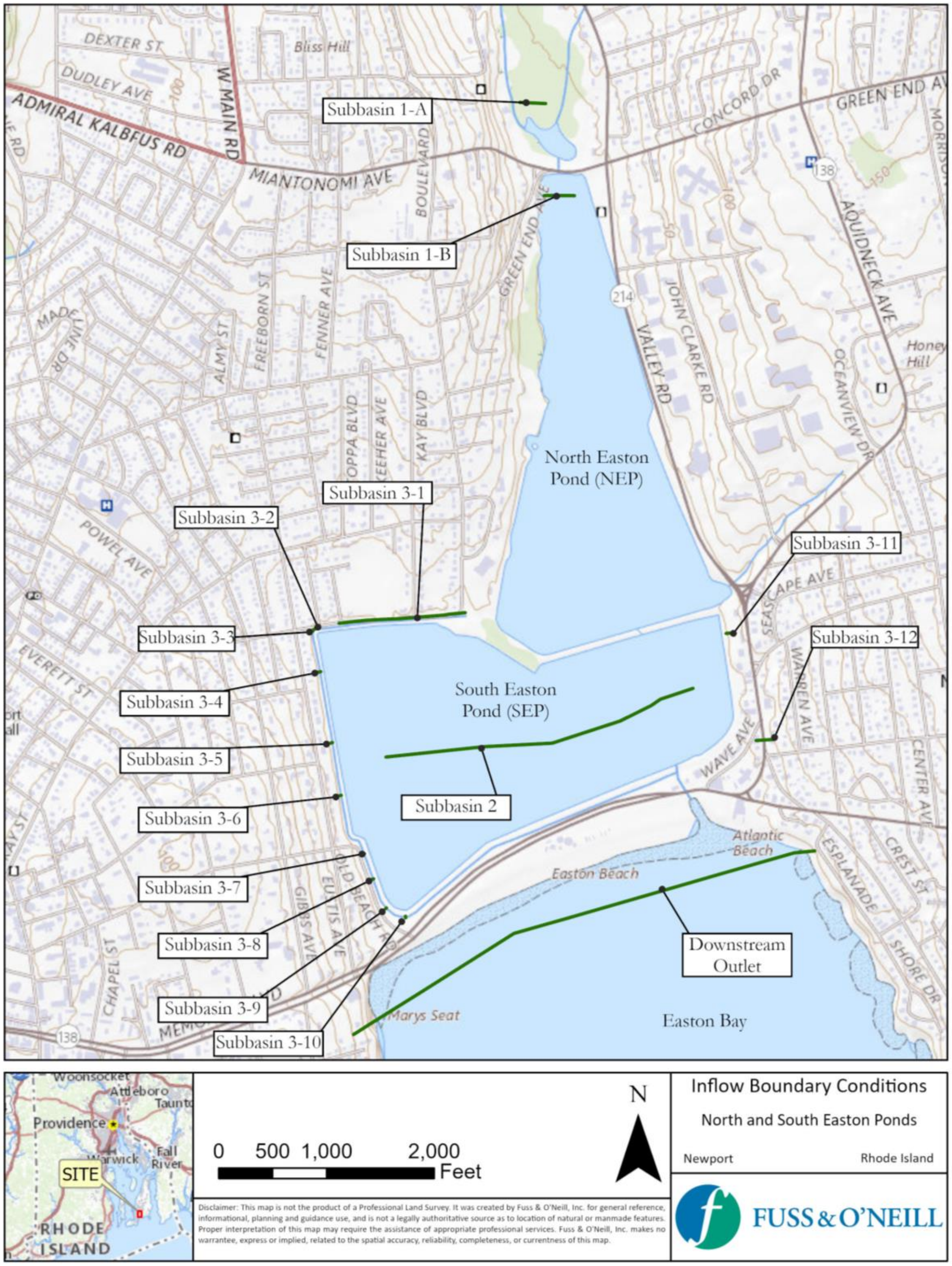
Topographic Data Summary Table

Plan Title	Source/Surveyor	Date Produced	Description
Lidar Topography	National Oceanic and Atmospheric Administration	2016	Lidar topography obtained through the NOAA Data Access Viewer used in any remaining project areas not covered by survey
Topographic Survey	Control Point Associates, Inc.	June 2021	Survey of the Eastern and Southern embankments of South Easton Pond and the embankment between North and South Easton Pond
As-Built Survey	R.P. Iannuccillo and Sons	July 2012	As-built survey used for the Western and Northern embankments of South Easton Pond
Topographic Survey Plan, Easton's Pond, Newport, Rhode Island	Waterman Engineering Co.	March 2008	Topographic survey used for the Western and Northern embankments of South Easton Pond
Bathymetric Survey Plan, South Easton Pond, Bottom Elevations	Apex Environmental, Inc.	October 2004	Bathymetric survey used for the bottom of South Easton Pond
Bathymetric Survey Plan, North Easton Pond, Bottom Elevations	Apex Environmental, Inc.	October 2005	Bathymetric survey used for the bottom of North Easton Pond

Manning's N Values Map



Inflow Boundary Conditions Map



Disclaimer: This map is not the product of a Professional Land Survey. It was created by Fuss & O'Neill, Inc. for general reference, informational, planning and guidance use, and is not a legally authoritative source as to location of natural or manmade features. Proper interpretation of this map may require the assistance of appropriate professional services. Fuss & O'Neill, Inc. makes no warrantee, express or implied, related to the spatial accuracy, reliability, completeness, or currentness of this map.

Peak Water Surface Elevations Summary

NEP Dam Present-Day Inland Flood Elevations Summary [1]

Alternative	Embankment Low Point Elevation	Spillway Elevation	10-Yr WSE	50-Yr WSE	50-Yr North Breach WSE [2]	100-Yr WSE	500-Yr WSE	500-Yr North Breach WSE [2]	½ PMF WSE	½ PMF North Breach WSE [2]
Existing Conditions	11.5	9.15	10.96	11.53	11.53	11.77	12.02	12.02	12.27	12.27
Alternative 2	13.4	9.15	10.97	11.54		11.81	12.50		13.46	13.46
Alternative 4	13.4	9.15	10.06	11.45		11.73	12.41		13.43	13.43

SEP Dam Present-Day Inland Flood Elevations Summary [1]

Alternative	Embankment Low Point Elevation	Spillway Elevation	10-Yr WSE	50-Yr WSE	50-Yr North Breach WSE [2]	100-Yr WSE	500-Yr WSE	500-Yr North Breach WSE [2]	½ PMF WSE	½ PMF North Breach WSE [2]
Existing Conditions	9.64	7.32	9.34	10.08	10.46	10.37	10.97	11.17	11.36	11.43
Alternative 2	12.1	7.32	9.27	10.02		10.39	11.33		12.17	12.26
Alternative 4	12.1	VARIES	8.09	8.98		9.28	9.79		10.59	11.25

NEP Dam 2070 Inland Flood Elevations Summary [1]

Alternative	Embankment Low Point Elevation	Spillway Elevation	10-Yr WSE	50-Yr WSE	100-Yr WSE	500-Yr WSE	½ PMF WSE
Existing Conditions	11.5	9.15	11.42	11.85	11.92	12.07	12.31
Alternative 2	13.4	9.15	11.43	11.95	12.16	12.68	13.49
Alternative 4	13.4	9.15	11.33	11.87	12.09	12.61	13.47

SEP Dam 2070 Inland Flood Elevations Summary [1]

Alternative	Embankment Low Point Elevation	Spillway Elevation	10-Yr WSE	50-Yr WSE	100-Yr WSE	500-Yr WSE	½ PMF WSE
Existing Conditions	9.64	7.32	9.94	10.51	10.72	11.08	11.42
Alternative 2	12.1	7.32	9.88	10.58	10.86	11.56	12.18
Alternative 4	12.1	VARIES	8.85	9.42	9.60	9.96	10.74

[1]Cells highlighted in red indicate embankments for that alternative will be overtopped by noted elevation.

[2]Breach scenarios for NEP Dam are reported in this table only in cases where NEP Dam is overtopped by the relevant storm event. Further, these scenarios were only necessary for present day climate conditions to inform inflow design flood.

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Incremental Consequence Analysis Results

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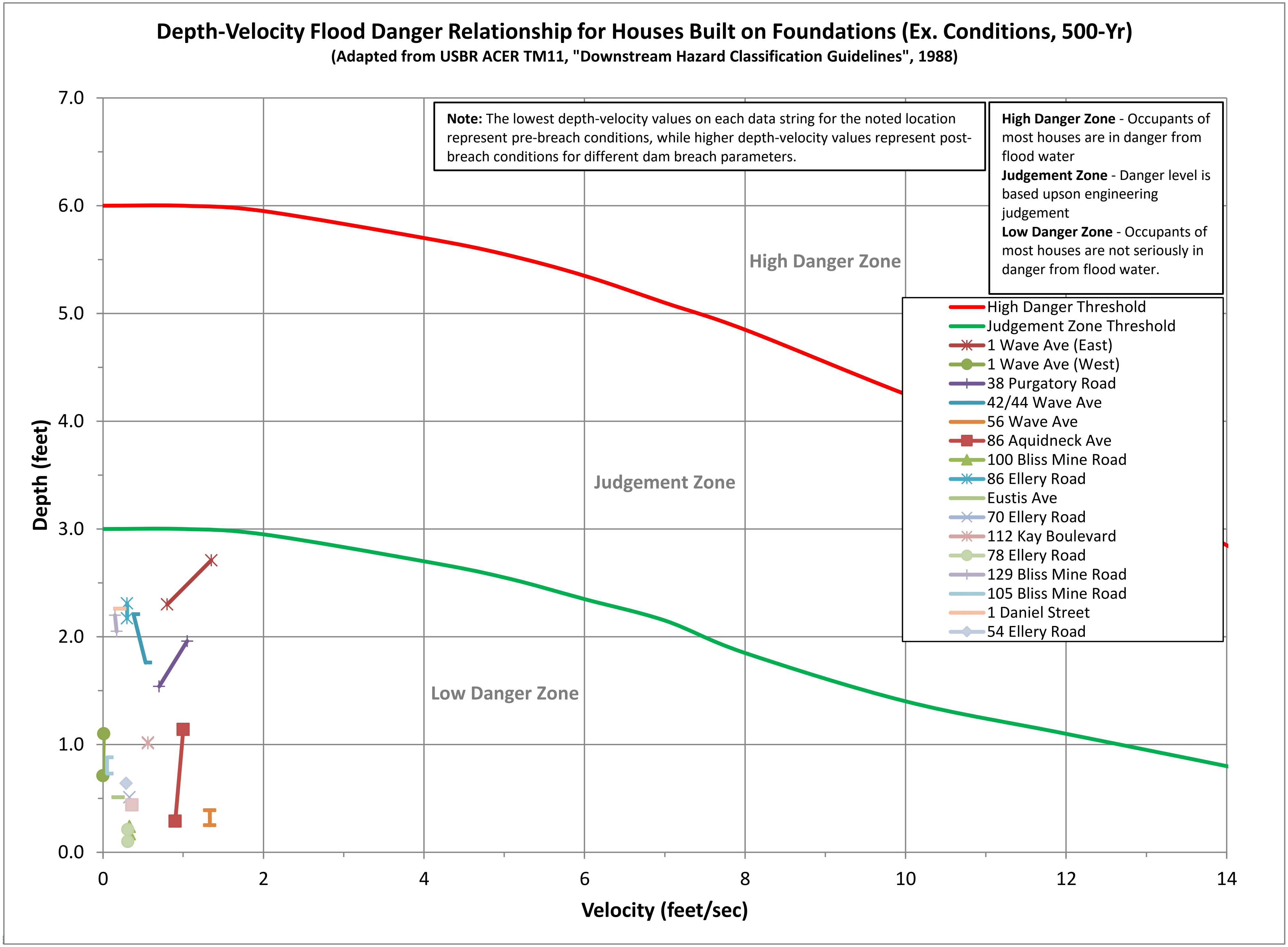
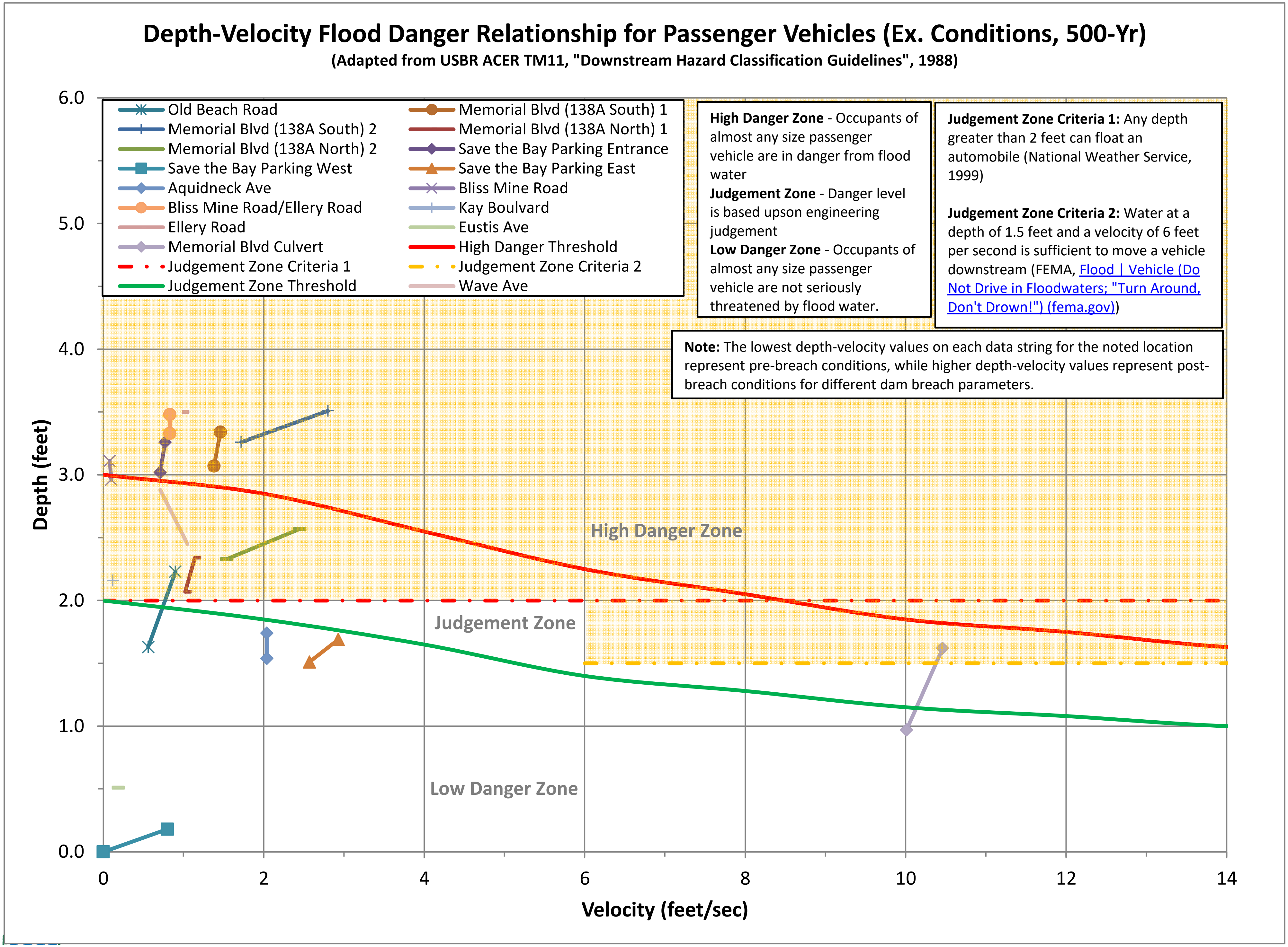
INFLOW DESIGN FLOOD INVESTIGATION

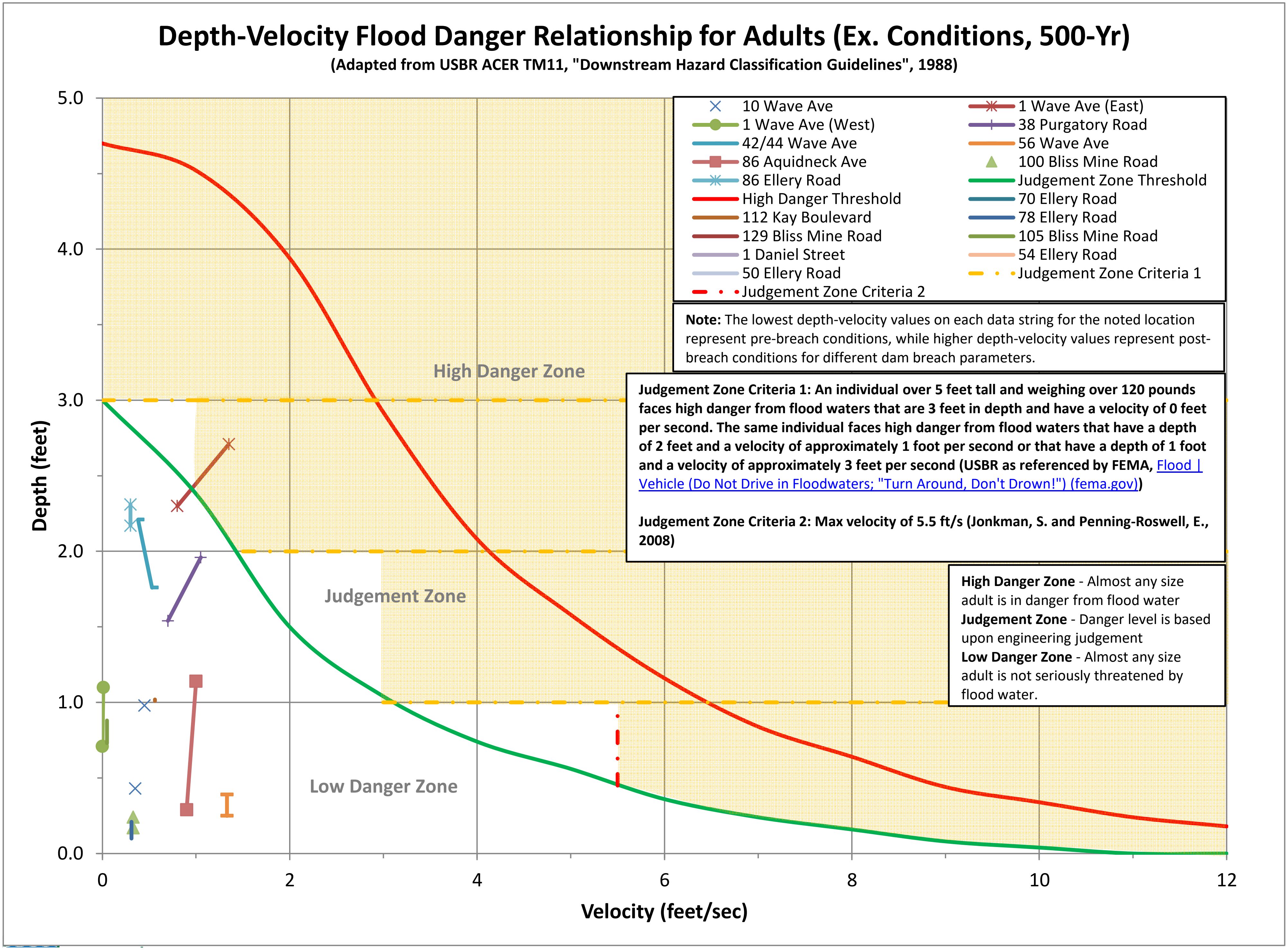
SUMMARY OF INCREMENTAL CONSEQUENCE ANALYSIS RESULTS FOR EXISTING CONDITIONS 500-YEAR STORM

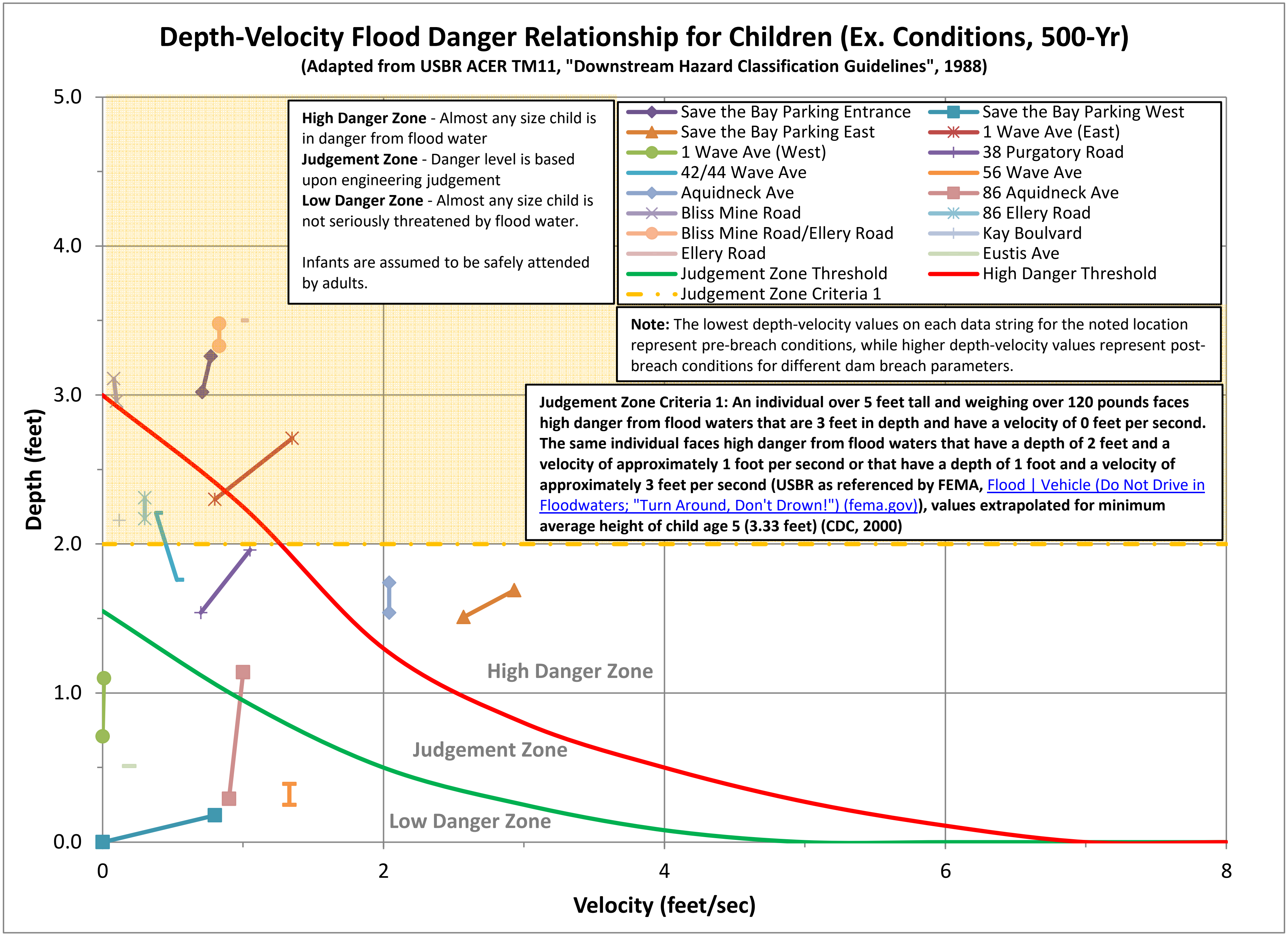
Existing Conditions				
Location	No Breach Depth	No Breach Velocity	Breach Parameter Estimation Methodology	
			Von Thun & Gillette (VTG)	VTG Velocity
Old Beach Road	1.63	0.56	2.23	0.90
Memorial Blvd (138A South) 1	3.07	1.38	3.34	1.46
Memorial Blvd (138A South) 2	3.26	1.72	3.51	2.80
Memorial Blvd (138A North) 1	2.07	1.02	2.34	1.14
Memorial Blvd (138A North) 2	2.33	1.54	2.57	2.45
Save the Bay Parking Entrance	3.02	0.71	3.26	0.77
Save the Bay Parking West	0.00	0.00	0.18	0.80
Save the Bay Parking East	1.51	2.57	1.69	2.93
10 Wave Ave	0.43	0.35	0.98	0.45
1 Wave Ave (East)	2.30	0.80	2.71	1.35
1 Wave Ave (West)	0.71	0.00	1.10	0.01
38 Purgatory Road	1.54	0.70	1.96	1.05
42/44 Wave Ave	1.76	0.53	2.21	0.38
56 Wave Ave	0.25	1.33	0.39	1.33
Aquidneck Ave	1.54	2.04	1.74	2.04
86 Aquidneck Ave	0.29	0.90	1.14	1.00
100 Bliss Mine Road	0.17	0.33	0.24	0.33
Bliss Mine Road	2.96	0.10	3.11	0.08
86 Ellery Road	2.17	0.30	2.31	0.30
Bliss Mine Road/Ellery Road	3.33	0.83	3.48	0.83
Kay Boulvard	2.16	0.12	2.16	0.12
Ellery Road	3.50	0.99	3.50	0.99
Eustis Ave	0.51	0.19	0.51	0.19
Memorial Blvd Culvert	0.97	10.01	1.62	10.46
UV System	2.14	2.49	2.89	3.17
70 Ellery Road	0.51	0.33	0.51	0.33
112 Kay Boulevard	1.01	0.56	1.02	0.56
78 Ellery Road	0.10	0.31	0.21	0.31
129 Bliss Mine Road	2.05	0.17	2.20	0.15
105 Bliss Mine Road	0.73	0.05	0.88	0.05
1 Daniel Street	2.26	0.21	2.26	0.21
54 Ellery Road	0.64	0.29	0.64	0.29
50 Ellery Road	0.44	0.36	0.44	0.36
Wave Ave	2.45	1.05	2.88	0.71
South Easton Pond Dam				


Depth-Velocity Flood Danger Relationship for Houses Built on Foundations (Ex. Conditions, 500-Yr)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone - Occupants of most houses are in danger from flood water
Judgement Zone - Danger level is based upson engineering judgement
Low Danger Zone - Occupants of most houses are not seriously in danger from flood water.
High Danger Zone
Judgement Zone
Low Danger Zone
High Danger Threshold
Judgement Zone Threshold
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Eustis Ave
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
Depth (feet)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
Velocity (feet/sec)



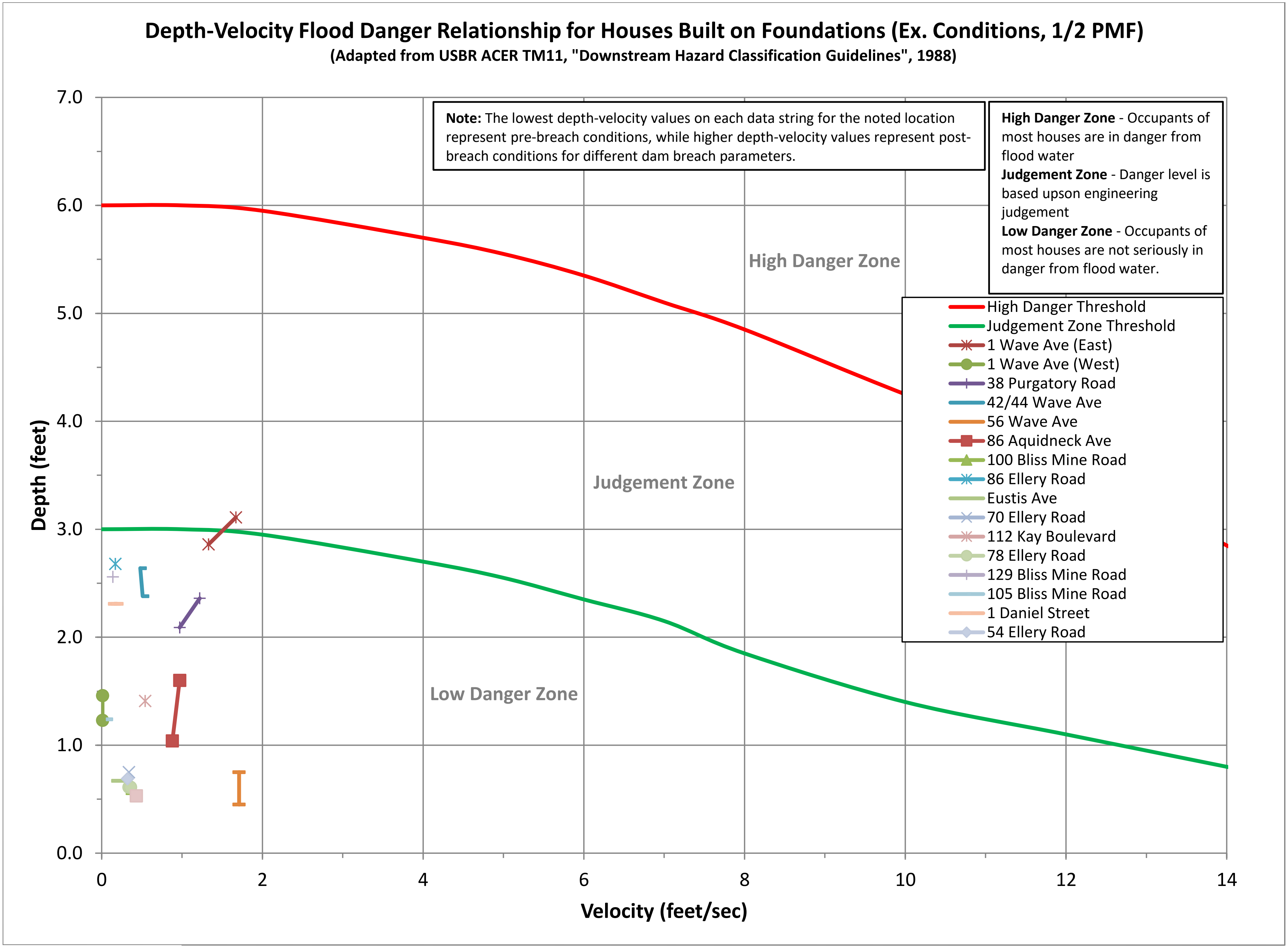
Depth-Velocity Flood Danger Relationship for Passenger Vehicles (Ex. Conditions, 500-Yr)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Old Beach Road
Memorial Blvd (138A South) 2
Memorial Blvd (138A North) 2
Save the Bay Parking West
Aquidneck Ave
Bliss Mine Road/Ellery Road
Ellery Road
Memorial Blvd Culvert
Judgement Zone Criteria 1
Judgement Zone Threshold
Memorial Blvd (138A South) 1
Memorial Blvd (138A North) 1
Save the Bay Parking Entrance
Save the Bay Parking East
Bliss Mine Road
Kay Boulvard
Eustis Ave
High Danger Threshold
Judgement Zone Criteria 2
Wave Ave
High Danger Zone - Occupants of almost any size passenger vehicle are in danger from flood water
Judgement Zone - Danger level is based upson engineering judgement
Low Danger Zone - Occupants of almost any size passenger vehicle are not seriously threatened by flood water.
Judgement Zone Criteria 1: Any depth greater than 2 feet can float an automobile (National Weather Service, 1999)
Judgement Zone Criteria 2: Water at a depth of 1.5 feet and a velocity of 6 feet per second is sufficient to move a vehicle downstream (FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
Velocity (feet/sec)

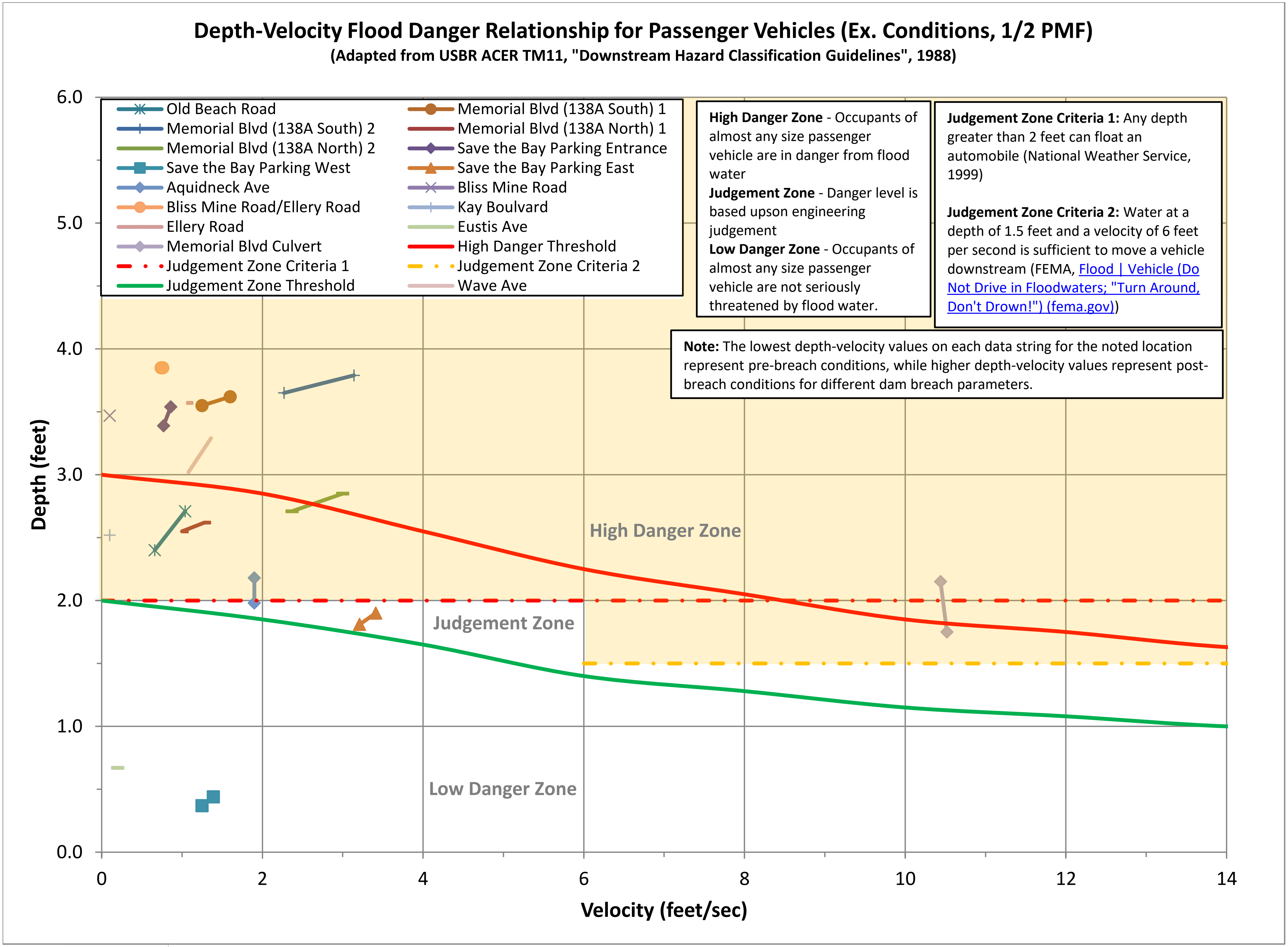

Depth-Velocity Flood Danger Relationship for Adults (Ex. Conditions, 500-Yr)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Depth (feet)
Velocity (feet/sec)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
10 Wave Ave
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Judgement Zone Threshold
High Danger Threshold
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
50 Ellery Road
Judgement Zone Criteria 1
Judgement Zone Criteria 2
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Judgement Zone Criteria 2: Max velocity of 5.5 ft/s (Jonkman, S. and Penning-Roswell, E., 2008)
Judgement Zone
High Danger Zone - Almost any size adult is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size adult is not seriously threatened by flood water.
Low Danger Zone


Depth-Velocity Flood Danger Relationship for Children (Ex. Conditions, 500-Yr)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
High Danger Zone - Almost any size child is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size child is not seriously threatened by flood water.
Infants are assumed to be safely attended by adults.
Save the Bay Parking Entrance
Save the Bay Parking West
Save the Bay Parking East
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
Aquidneck Ave
86 Aquidneck Ave
Bliss Mine Road
86 Ellery Road
Bliss Mine Road/Ellery Road
Kay Boulvard
Ellery Road
Eustis Ave
Judgement Zone Threshold
High Danger Threshold
Judgement Zone Criteria 1
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov)), values extrapolated for minimum average height of child age 5 (3.33 feet) (CDC, 2000)
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
Velocity (feet/sec)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8

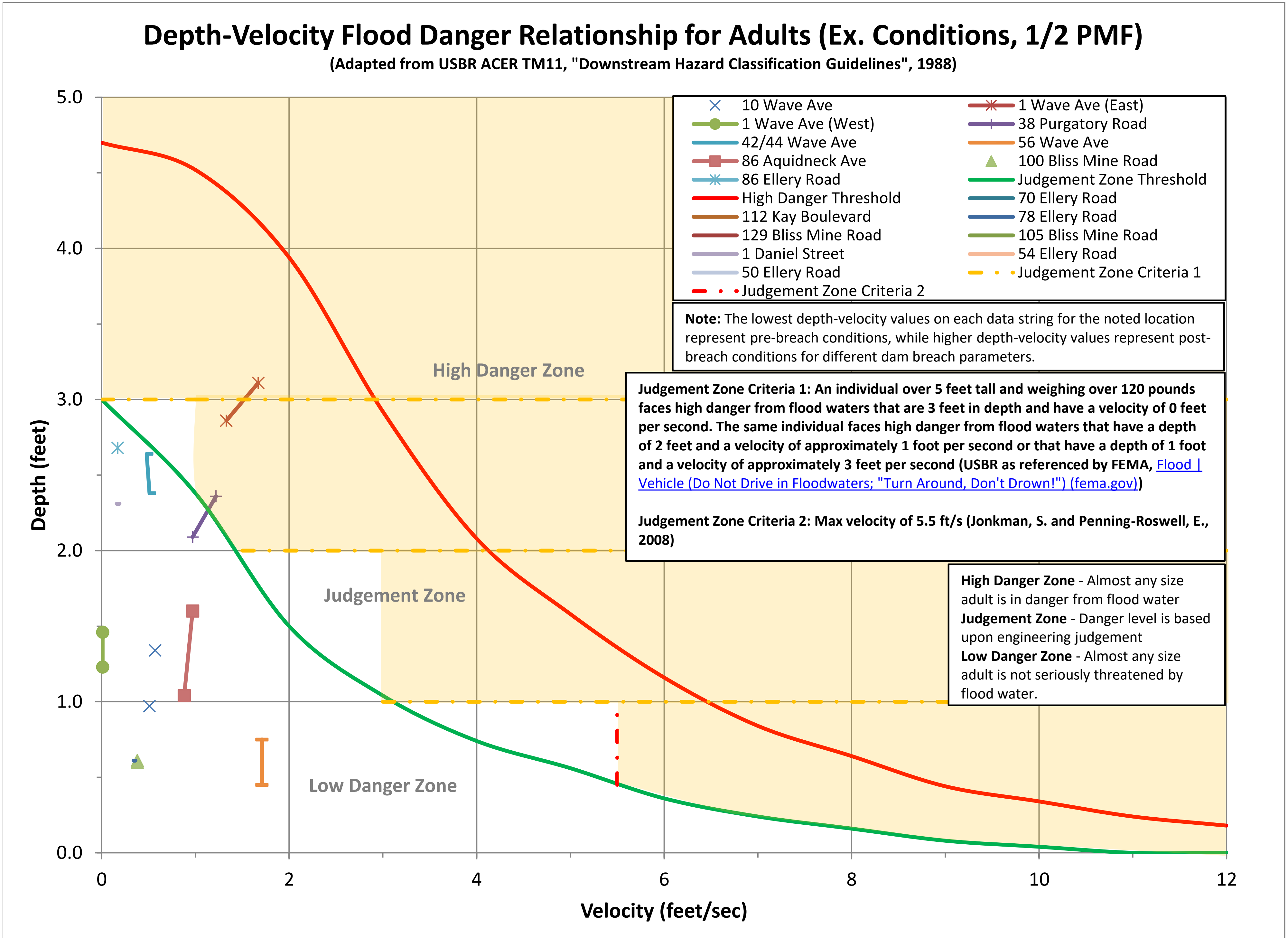
FUSS & O'NEILL

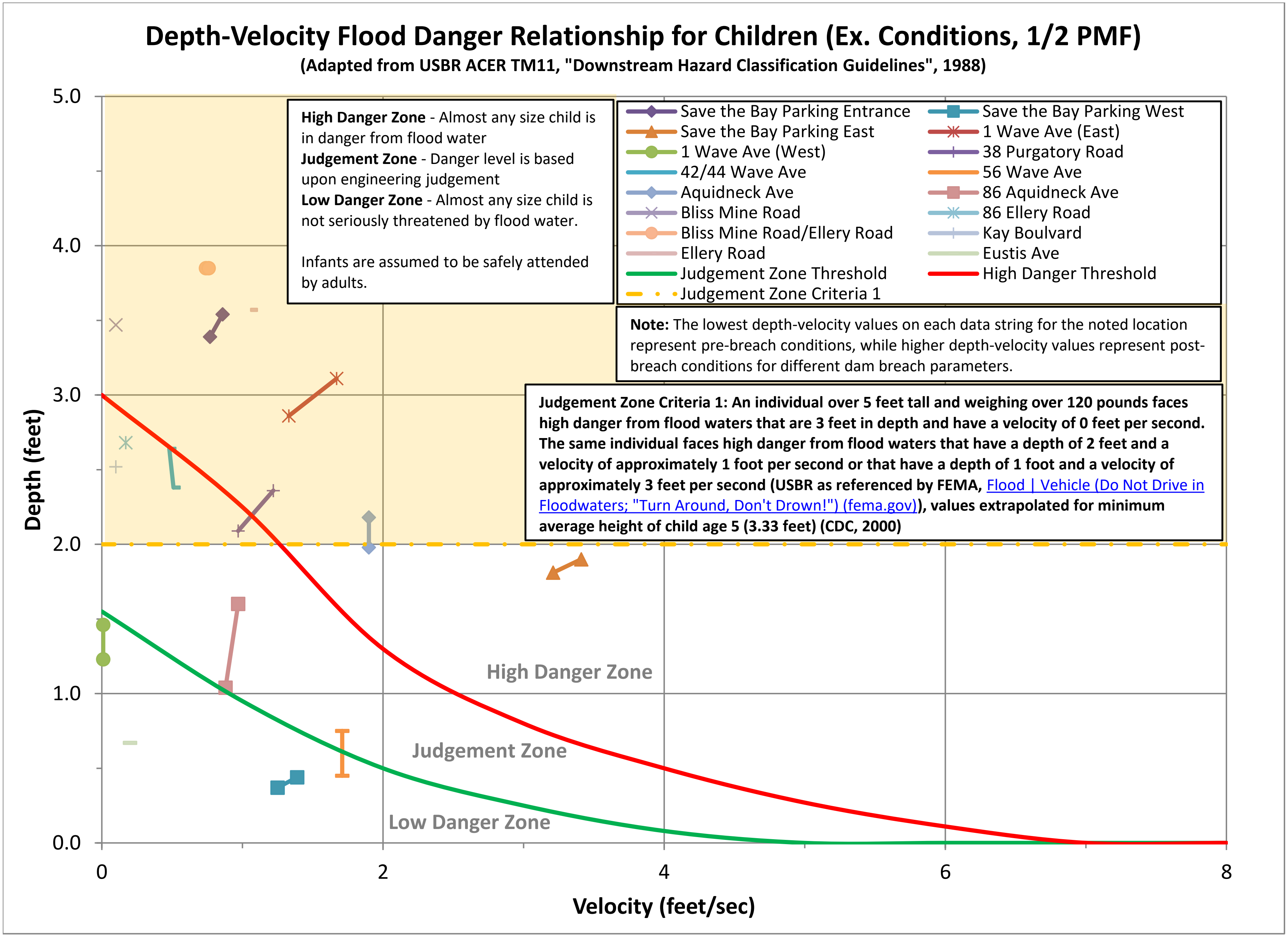
INFLOW DESIGN FLOOD INVESTIGATION				
SUMMARY OF INCREMENTAL CONSEQUENCE ANALYSIS RESULTS FOR EXISTING CONDITIONS 1/2 PMF EVENT				
Existing Conditions				
Location	No Breach Depth	No Breach Velocity	Breach Parameter Estimation Methodology	
			Von Thun & Gillette (VTG)	VTG Velocity
Old Beach Road	2.40	0.66	2.71	1.04
Memorial Blvd (138A South) 1	3.55	1.25	3.62	1.60
Memorial Blvd (138A South) 2	3.65	2.27	3.79	3.14
Memorial Blvd (138A North) 1	2.55	1.00	2.62	1.28
Memorial Blvd (138A North) 2	2.71	2.37	2.85	3.00
Save the Bay Parking Entrance	3.39	0.77	3.54	0.86
Save the Bay Parking West	0.37	1.25	0.44	1.39
Save the Bay Parking East	1.81	3.21	1.90	3.41
10 Wave Ave	0.97	0.51	1.34	0.57
1 Wave Ave (East)	2.86	1.33	3.11	1.67
1 Wave Ave (West)	1.23	0.01	1.46	0.01
38 Purgatory Road	2.09	0.97	2.36	1.22
42/44 Wave Ave	2.38	0.51	2.64	0.48
56 Wave Ave	0.45	1.71	0.75	1.71
Aquidneck Ave	1.98	1.90	2.18	1.90
86 Aquidneck Ave	1.04	0.88	1.60	0.97
100 Bliss Mine Road	0.61	0.38	0.60	0.38
Bliss Mine Road	3.47	0.10	3.47	0.10
86 Ellery Road	2.68	0.17	2.68	0.17
Bliss Mine Road/Ellery Road	3.85	0.74	3.85	0.76
Kay Boulvard	2.52	0.10	2.52	0.10
Ellery Road	3.57	1.06	3.57	1.06
Eustis Ave	0.67	0.20	0.67	0.20
Memorial Blvd Culvert	1.75	10.52	2.15	10.44
UV System	2.69	2.91	3.24	3.79
70 Ellery Road	0.75	0.34	0.75	0.34
112 Kay Boulevard	1.41	0.54	1.41	0.54
78 Ellery Road	0.61	0.34	0.61	0.36
129 Bliss Mine Road	2.56	0.14	2.56	0.14
105 Bliss Mine Road	1.24	0.06	1.24	0.06
1 Daniel Street	2.31	0.16	2.31	0.19
54 Ellery Road	0.69	0.32	0.69	0.32
50 Ellery Road	0.53	0.43	0.53	0.43
Wave Ave	3.02	1.08	3.29	1.36
South Easton Pond Dam [3]				


Depth-Velocity Flood Danger Relationship for Houses Built on Foundations (Ex. Conditions, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone - Occupants of most houses are in danger from flood water
Judgement Zone - Danger level is based upson engineering judgement
Low Danger Zone - Occupants of most houses are not seriously in danger from flood water.
High Danger Zone
Judgement Zone
Low Danger Zone
High Danger Threshold
Judgement Zone Threshold
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Eustis Ave
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
Depth (feet)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
Velocity (feet/sec)



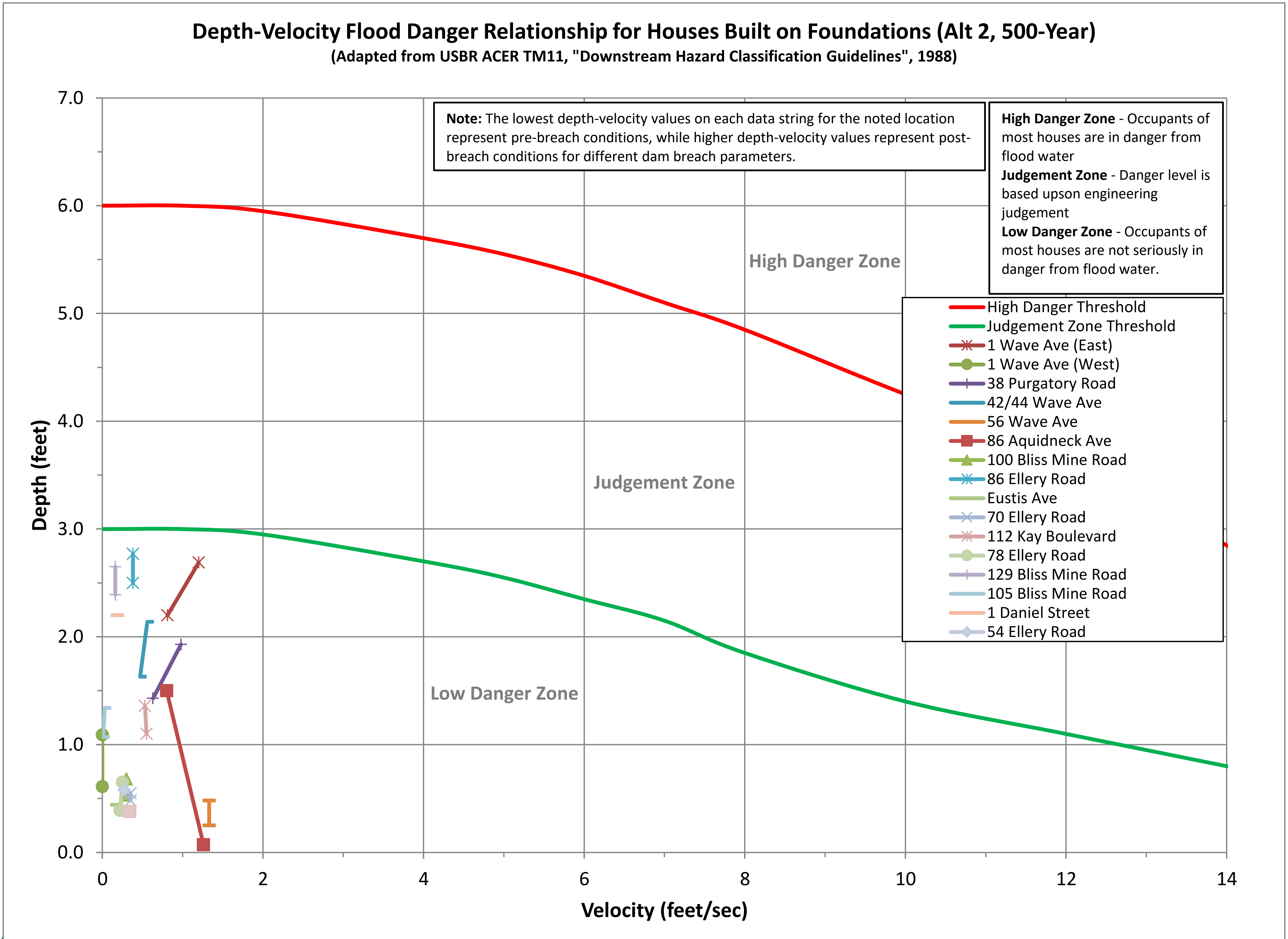
Depth-Velocity Flood Danger Relationship for Passenger Vehicles (Ex. Conditions, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Old Beach Road
Memorial Blvd (138A South) 1
Memorial Blvd (138A South) 2
Memorial Blvd (138A North) 1
Memorial Blvd (138A North) 2
Save the Bay Parking Entrance
Save the Bay Parking West
Save the Bay Parking East
Aquidneck Ave
Bliss Mine Road
Bliss Mine Road/Ellery Road
Kay Boulvard
Ellery Road
Eustis Ave
Memorial Blvd Culvert
High Danger Threshold
Judgement Zone Criteria 1
Judgement Zone Criteria 2
Judgement Zone Threshold
Wave Ave
High Danger Zone - Occupants of almost any size passenger vehicle are in danger from flood water
Judgement Zone - Danger level is based upson engineering judgement
Low Danger Zone - Occupants of almost any size passenger vehicle are not seriously threatened by flood water.
Judgement Zone Criteria 1: Any depth greater than 2 feet can float an automobile (National Weather Service, 1999)
Judgement Zone Criteria 2: Water at a depth of 1.5 feet and a velocity of 6 feet per second is sufficient to move a vehicle downstream (FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
Velocity (feet/sec)

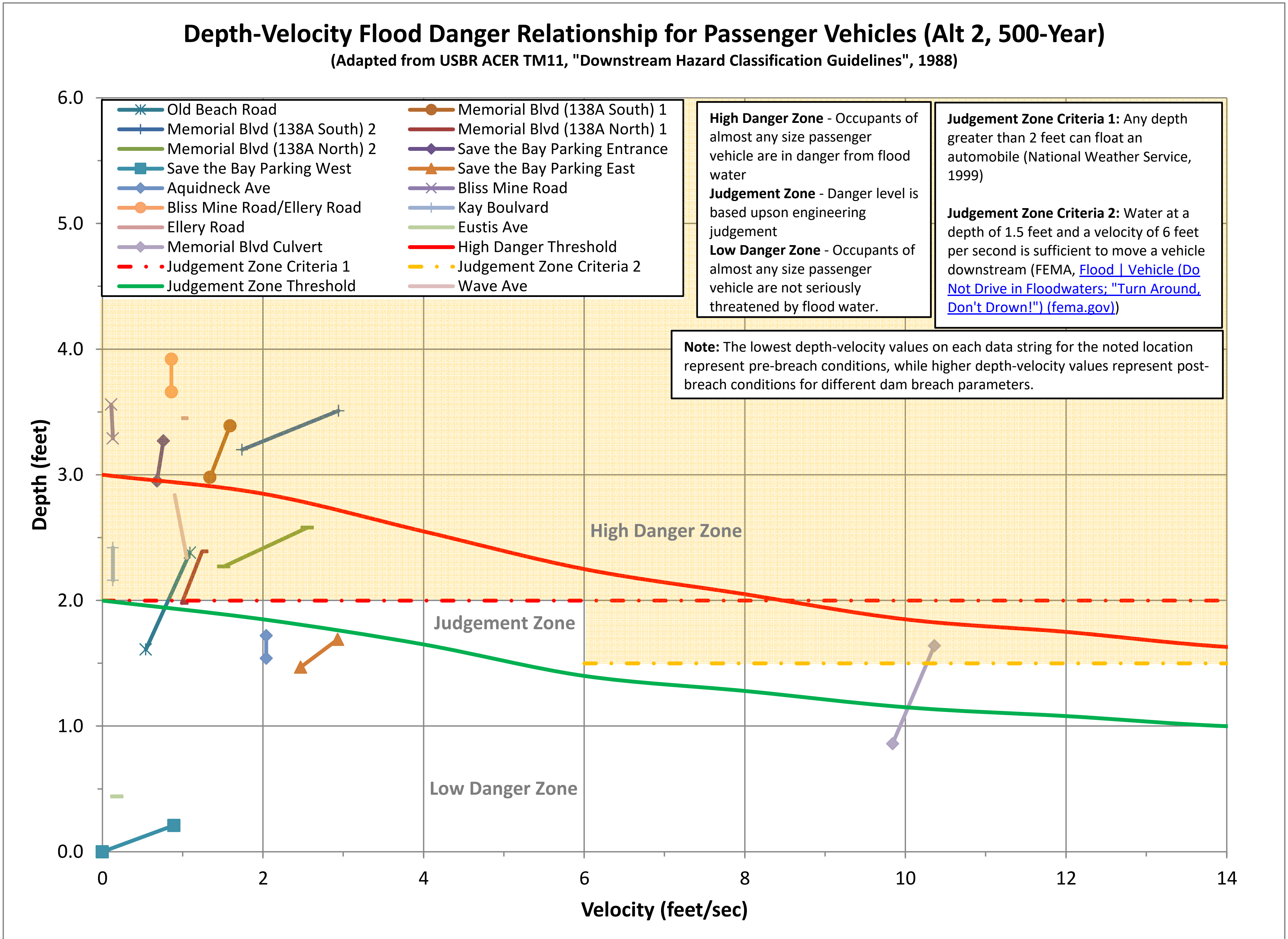

Depth-Velocity Flood Danger Relationship for Adults (Ex. Conditions, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Depth (feet)
Velocity (feet/sec)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
10 Wave Ave
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Judgement Zone Threshold
High Danger Threshold
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
50 Ellery Road
Judgement Zone Criteria 1
Judgement Zone Criteria 2
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Judgement Zone Criteria 2: Max velocity of 5.5 ft/s (Jonkman, S. and Penning-Roswell, E., 2008)
Judgement Zone
High Danger Zone - Almost any size adult is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size adult is not seriously threatened by flood water.
Low Danger Zone


Depth-Velocity Flood Danger Relationship for Children (Ex. Conditions, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
High Danger Zone - Almost any size child is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size child is not seriously threatened by flood water.
Infants are assumed to be safely attended by adults.
Save the Bay Parking Entrance
Save the Bay Parking West
Save the Bay Parking East
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
Aquidneck Ave
86 Aquidneck Ave
Bliss Mine Road
86 Ellery Road
Bliss Mine Road/Ellery Road
Kay Boulvard
Ellery Road
Eustis Ave
Judgement Zone Threshold
High Danger Threshold
Judgement Zone Criteria 1
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov)), values extrapolated for minimum average height of child age 5 (3.33 feet) (CDC, 2000)
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
Velocity (feet/sec)

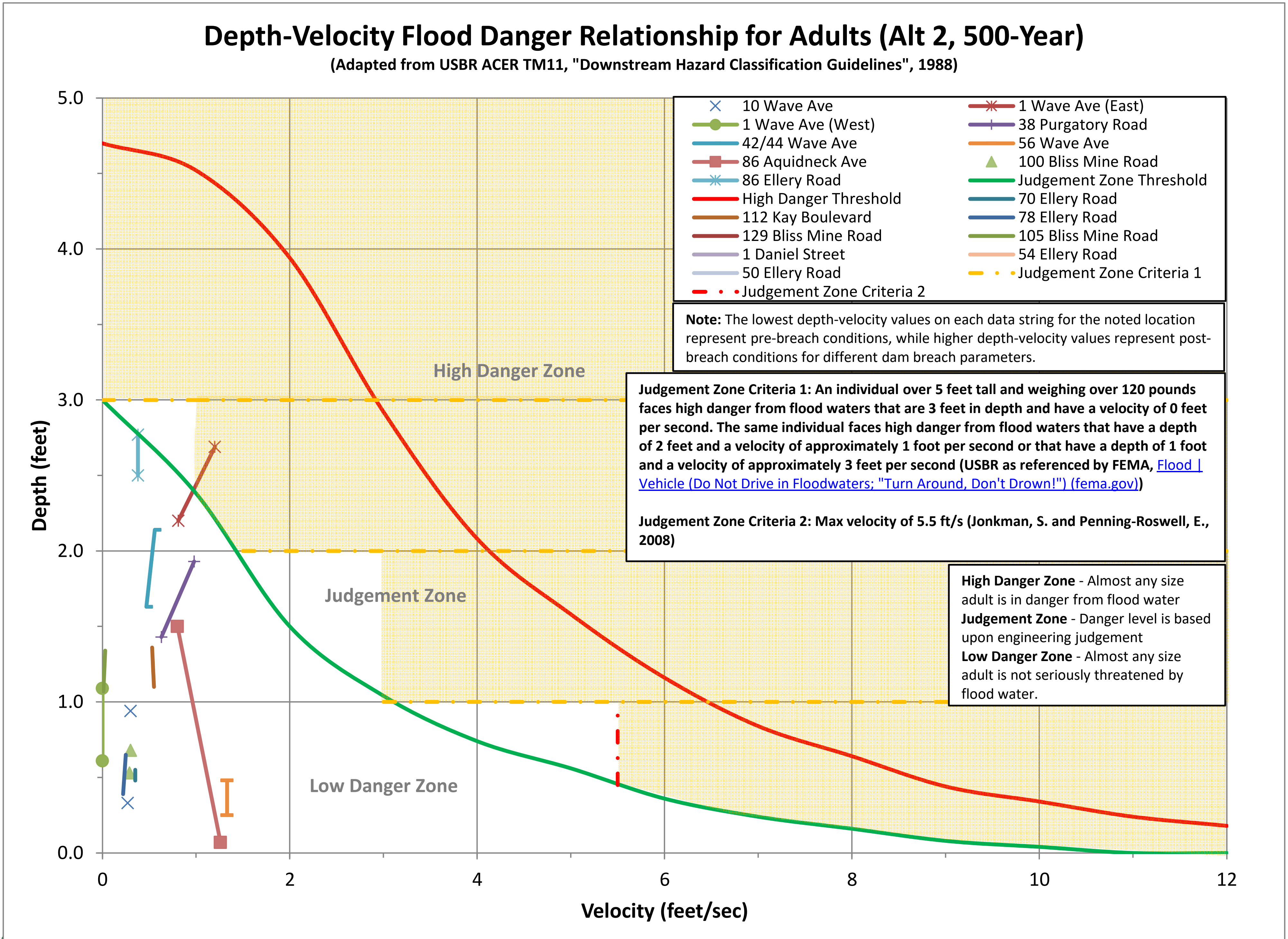
FUSS & O'NEILL

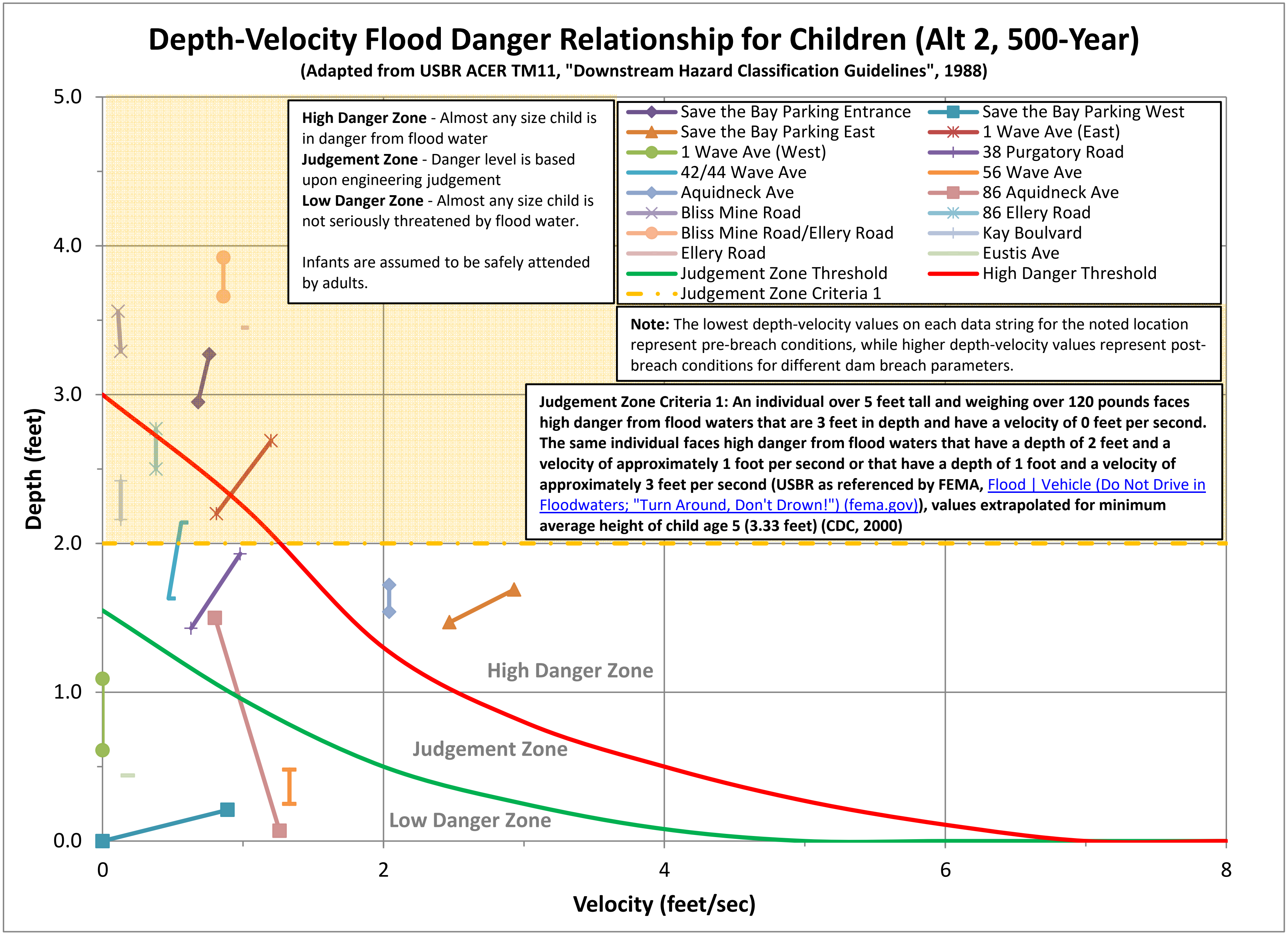
INFLOW DESIGN FLOOD INVESTIGATION SUMMARY OF INCREMENTAL CONSEQUENCE ANALYSIS RESULTS FOR ALTERNATIVE 2 500-YEAR STORM				
Alternative 2				
Location	No Breach Depth	No Breach Velocity	Breach Parameter Estimation Methodology	
			Von Thun & Gillette (VTG)	VTG Velocity
Old Beach Road	1.61	0.54	2.38	1.09
Memorial Blvd (138A South) 1	2.98	1.34	3.39	1.59
Memorial Blvd (138A South) 2	3.20	1.74	3.51	2.94
Memorial Blvd (138A North) 1	1.98	0.99	2.39	1.24
Memorial Blvd (138A North) 2	2.27	1.51	2.58	2.55
Save the Bay Parking Entrance	2.95	0.68	3.27	0.76
Save the Bay Parking West	0.00	0.00	0.21	0.89
Save the Bay Parking East	1.47	2.47	1.69	2.93
10 Wave Ave	0.33	0.27	0.94	0.30
1 Wave Ave (East)	2.20	0.81	2.69	1.20
1 Wave Ave (West)	0.61	0.00	1.09	0.00
38 Purgatory Road	1.43	0.63	1.93	0.98
42/44 Wave Ave	1.63	0.47	2.14	0.56
56 Wave Ave	0.25	1.33	0.48	1.33
Aquidneck Ave	1.54	2.04	1.72	2.04
86 Aquidneck Ave	0.07	1.26	1.50	0.80
100 Bliss Mine Road	0.53	0.29	0.68	0.30
Bliss Mine Road	3.29	0.13	3.56	0.11
86 Ellery Road	2.50	0.38	2.77	0.38
Bliss Mine Road/Ellery Road	3.66	0.86	3.92	0.86
Kay Boulvard	2.16	0.13	2.42	0.13
Ellery Road	3.45	0.99	3.45	0.99
Eustis Ave	0.44	0.18	0.44	0.18
Memorial Blvd Culvert	0.86	9.84	1.64	10.36
UV System	2.08	2.57	2.97	3.28
70 Ellery Road	0.48	0.35	0.55	0.35
112 Kay Boulevard	1.10	0.55	1.36	0.53
78 Ellery Road	0.39	0.22	0.65	0.25
129 Bliss Mine Road	2.39	0.16	2.65	0.16
105 Bliss Mine Road	1.07	0.01	1.34	0.03
1 Daniel Street	2.20	0.19	2.20	0.19
54 Ellery Road	0.58	0.27	0.58	0.27
50 Ellery Road	0.38	0.34	0.38	0.34
Wave Ave	2.34	1.05	2.84	0.90
South Easton Pond Dam [3]				


Depth-Velocity Flood Danger Relationship for Houses Built on Foundations (Alt 2, 500-Year)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone - Occupants of most houses are in danger from flood water
Judgement Zone - Danger level is based upson engineering judgement
Low Danger Zone - Occupants of most houses are not seriously in danger from flood water.
High Danger Zone
Judgement Zone
Low Danger Zone
High Danger Threshold
Judgement Zone Threshold
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Eustis Ave
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
Depth (feet)
Velocity (feet/sec)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14



Depth-Velocity Flood Danger Relationship for Passenger Vehicles (Alt 2, 500-Year)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Old Beach Road
Memorial Blvd (138A South) 2
Memorial Blvd (138A North) 2
Save the Bay Parking West
Aquidneck Ave
Bliss Mine Road/Ellery Road
Ellery Road
Memorial Blvd Culvert
Judgement Zone Criteria 1
Judgement Zone Threshold
Memorial Blvd (138A South) 1
Memorial Blvd (138A North) 1
Save the Bay Parking Entrance
Save the Bay Parking East
Bliss Mine Road
Kay Boulvard
Eustis Ave
High Danger Threshold
Judgement Zone Criteria 2
Wave Ave
High Danger Zone - Occupants of almost any size passenger vehicle are in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Occupants of almost any size passenger vehicle are not seriously threatened by flood water.
Judgement Zone Criteria 1: Any depth greater than 2 feet can float an automobile (National Weather Service, 1999)
Judgement Zone Criteria 2: Water at a depth of 1.5 feet and a velocity of 6 feet per second is sufficient to move a vehicle downstream (FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
Velocity (feet/sec)


Depth-Velocity Flood Danger Relationship for Adults (Alt 2, 500-Year)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
10 Wave Ave
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Judgement Zone Threshold
High Danger Threshold
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
50 Ellery Road
Judgement Zone Criteria 1
Judgement Zone Criteria 2
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Judgement Zone Criteria 2: Max velocity of 5.5 ft/s (Jonkman, S. and Penning-Roswell, E., 2008)
High Danger Zone - Almost any size adult is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size adult is not seriously threatened by flood water.
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
Velocity (feet/sec)



Maryland Department of the Environment

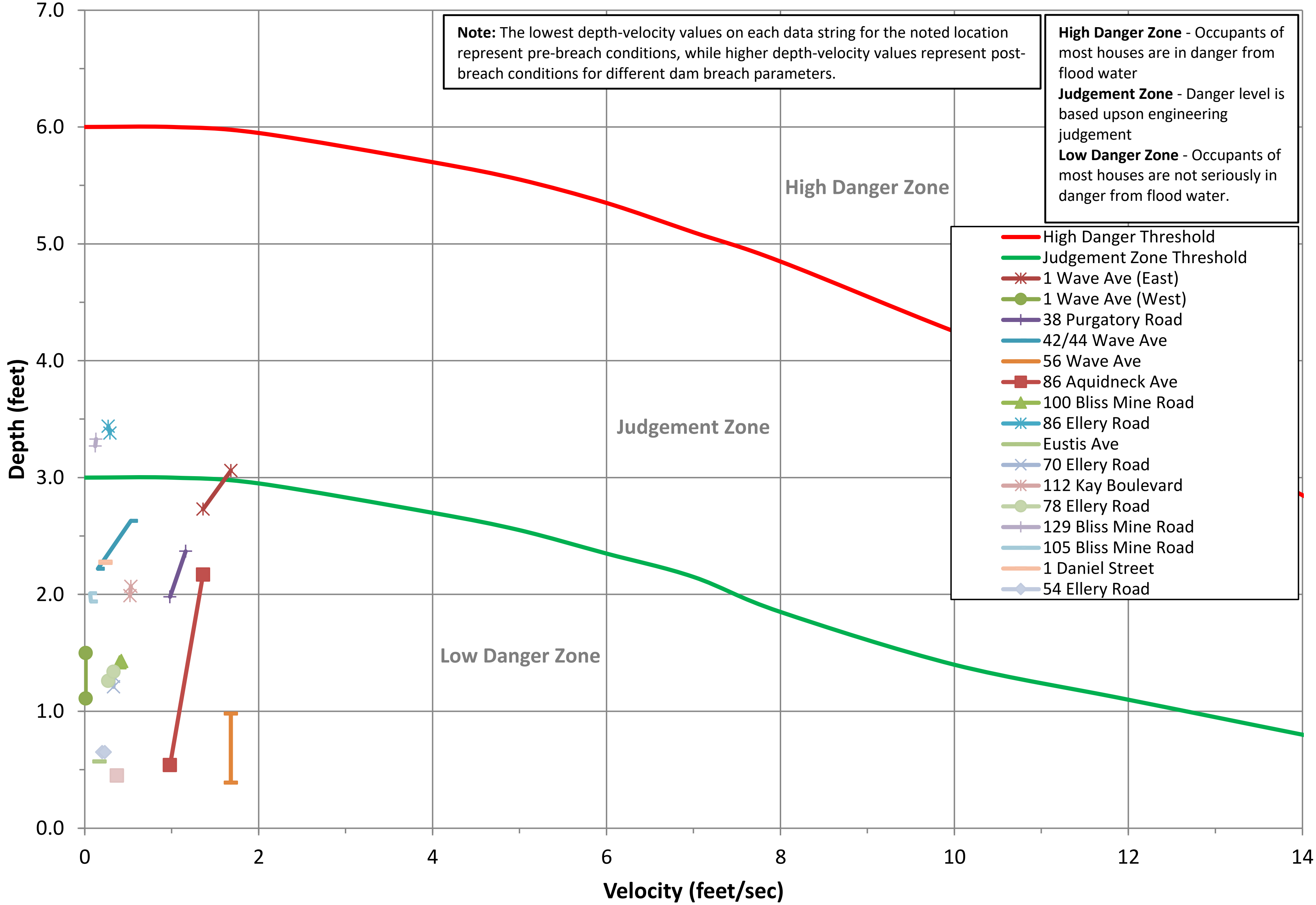
April 2018

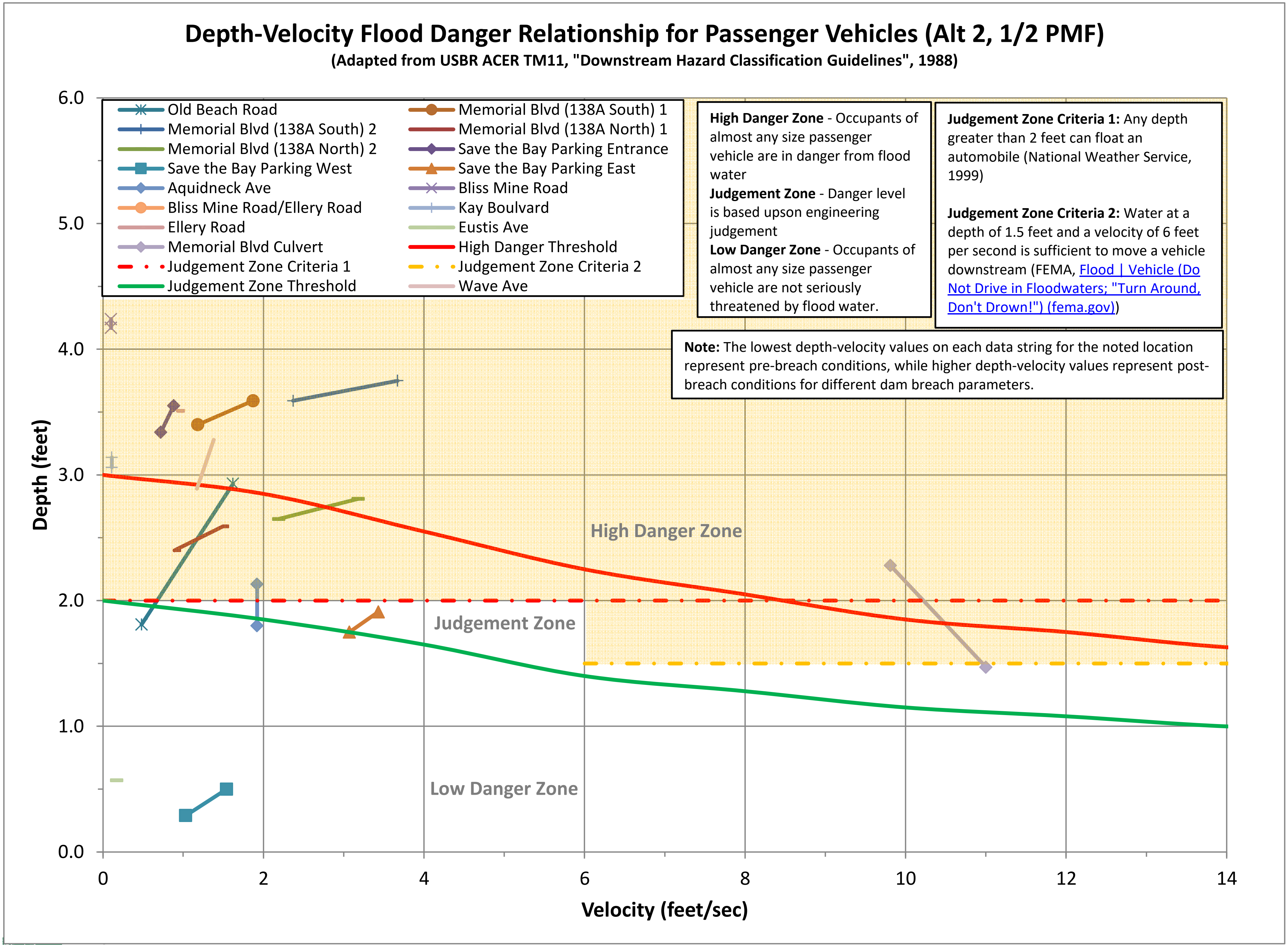
INFLOW DESIGN FLOOD INVESTIGATION
SUMMARY OF INCREMENTAL CONSEQUENCE ANALYSIS RESULTS FOR ALTERNATIVE 1/2 PMF EVENT

Alternative 2				
Location	No Breach Depth	No Breach Velocity	Breach Parameter Estimation Methodology	
			Von Thun & Gillette (VTG)	VTG Velocity
Old Beach Road	1.81	0.48	2.93	1.62
Memorial Blvd (138A South) 1	3.40	1.18	3.59	1.87
Memorial Blvd (138A South) 2	3.59	2.37	3.75	3.67
Memorial Blvd (138A North) 1	2.40	0.89	2.59	1.49
Memorial Blvd (138A North) 2	2.65	2.19	2.81	3.18
Save the Bay Parking Entrance	3.34	0.72	3.55	0.88
Save the Bay Parking West	0.29	1.03	0.50	1.54
Save the Bay Parking East	1.75	3.07	1.91	3.43
10 Wave Ave	0.88	0.45	1.50	0.41
1 Wave Ave (East)	2.73	1.36	3.06	1.68
1 Wave Ave (West)	1.11	0.01	1.50	0.01
38 Purgatory Road	1.98	0.98	2.37	1.16
42/44 Wave Ave	2.22	0.15	2.63	0.53
56 Wave Ave	0.39	1.68	0.98	1.68
Aquidneck Ave	1.80	1.92	2.13	1.92
86 Aquidneck Ave	0.54	0.98	2.17	1.36
100 Bliss Mine Road	1.42	0.40	1.43	0.42
Bliss Mine Road	4.17	0.10	4.24	0.10
86 Ellery Road	3.38	0.29	3.44	0.27
Bliss Mine Road/Ellery Road	4.53	0.76	4.60	0.78
Kay Boulvard	3.06	0.11	3.14	0.11
Ellery Road	3.51	0.94	3.51	0.93
Eustis Ave	0.57	0.17	0.57	0.17
Memorial Blvd Culvert	1.47	11.00	2.28	9.81
UV System	2.57	3.58	3.51	4.36
70 Ellery Road	1.21	0.33	1.30	0.33
112 Kay Boulevard	1.99	0.52	2.07	0.53
78 Ellery Road	1.26	0.27	1.34	0.33
129 Bliss Mine Road	3.27	0.12	3.33	0.13
105 Bliss Mine Road	1.94	0.07	2.01	0.06
1 Daniel Street	2.27	0.24	2.28	0.24
54 Ellery Road	0.65	0.20	0.65	0.23
50 Ellery Road	0.45	0.37	0.45	0.37
Wave Ave	2.89	1.17	3.28	1.38
South Easton Pond Dam [3]				

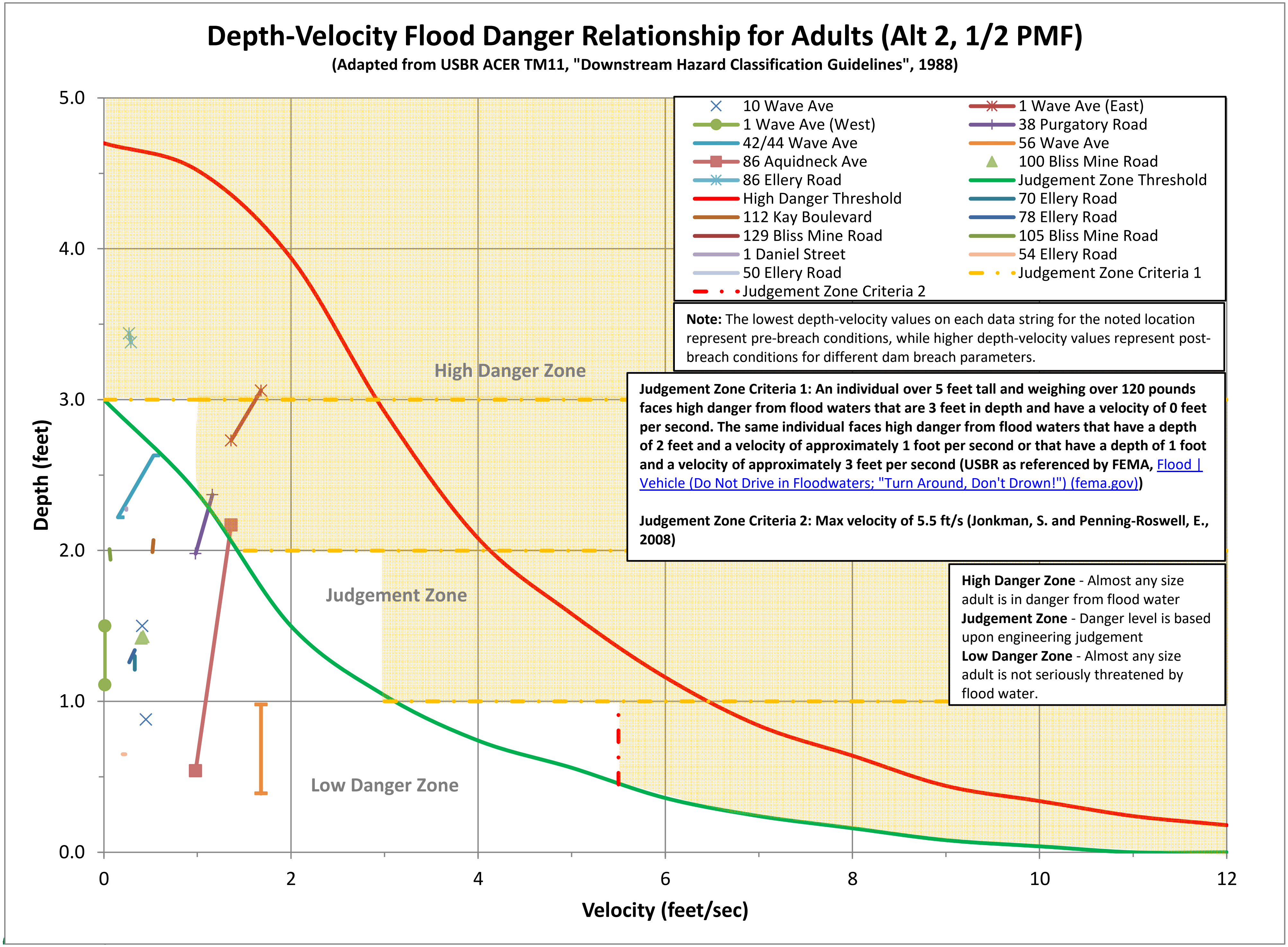
Depth-Velocity Flood Danger Relationship for Houses Built on Foundations (Alt 2, 1/2 PMF)

(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)

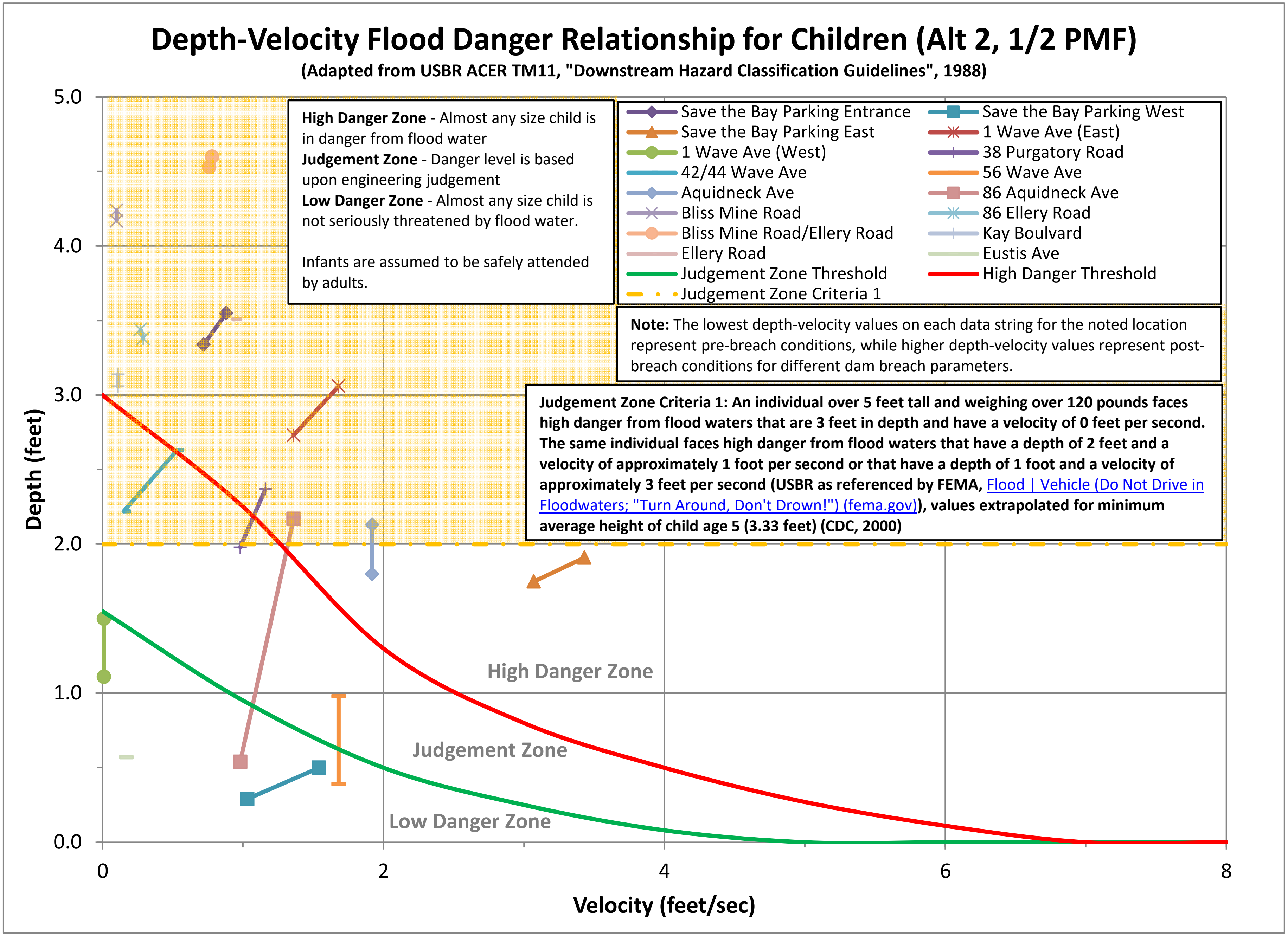




Depth-Velocity Flood Danger Relationship for Passenger Vehicles (Alt 2, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Old Beach Road
Memorial Blvd (138A South) 2
Memorial Blvd (138A North) 2
Save the Bay Parking West
Aquidneck Ave
Bliss Mine Road/Ellery Road
Ellery Road
Memorial Blvd Culvert
Judgement Zone Criteria 1
Judgement Zone Threshold
Memorial Blvd (138A South) 1
Memorial Blvd (138A North) 1
Save the Bay Parking Entrance
Save the Bay Parking East
Bliss Mine Road
Kay Boulvard
Eustis Ave
High Danger Threshold
Judgement Zone Criteria 2
Wave Ave
High Danger Zone - Occupants of almost any size passenger vehicle are in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Occupants of almost any size passenger vehicle are not seriously threatened by flood water.
Judgement Zone Criteria 1: Any depth greater than 2 feet can float an automobile (National Weather Service, 1999)
Judgement Zone Criteria 2: Water at a depth of 1.5 feet and a velocity of 6 feet per second is sufficient to move a vehicle downstream (FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
Velocity (feet/sec)

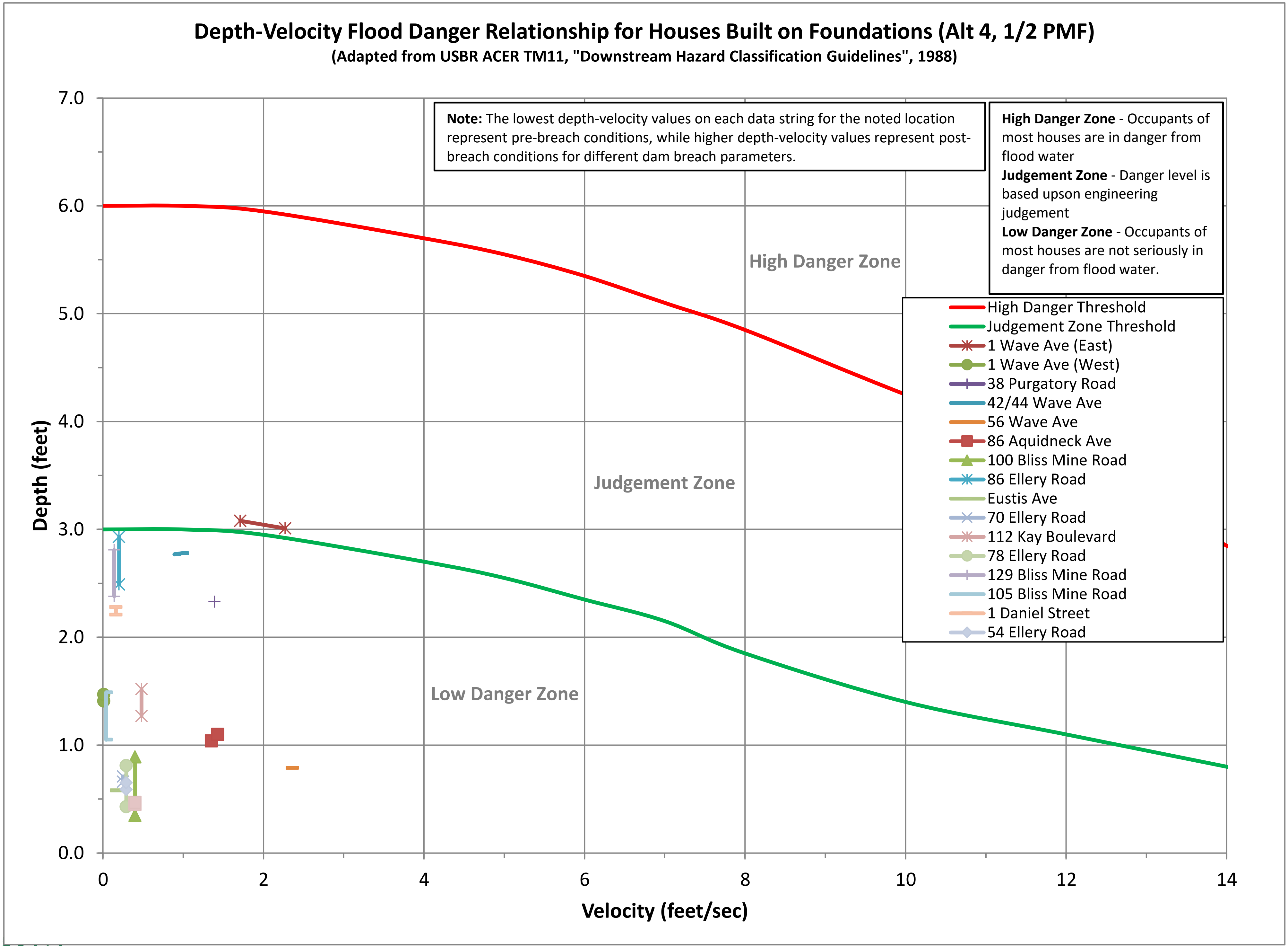


Depth-Velocity Flood Danger Relationship for Adults (Alt 2, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
5.0
4.0
3.0
2.0
1.0
0.0
Depth (feet)
0
2
4
6
8
10
12
Velocity (feet/sec)
10 Wave Ave
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Judgement Zone Threshold
High Danger Threshold
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
50 Ellery Road
Judgement Zone Criteria 1
Judgement Zone Criteria 2
High Danger Zone
Judgement Zone
Low Danger Zone
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Judgement Zone Criteria 2: Max velocity of 5.5 ft/s (Jonkman, S. and Penning-Roswell, E., 2008)
High Danger Zone - Almost any size adult is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size adult is not seriously threatened by flood water.

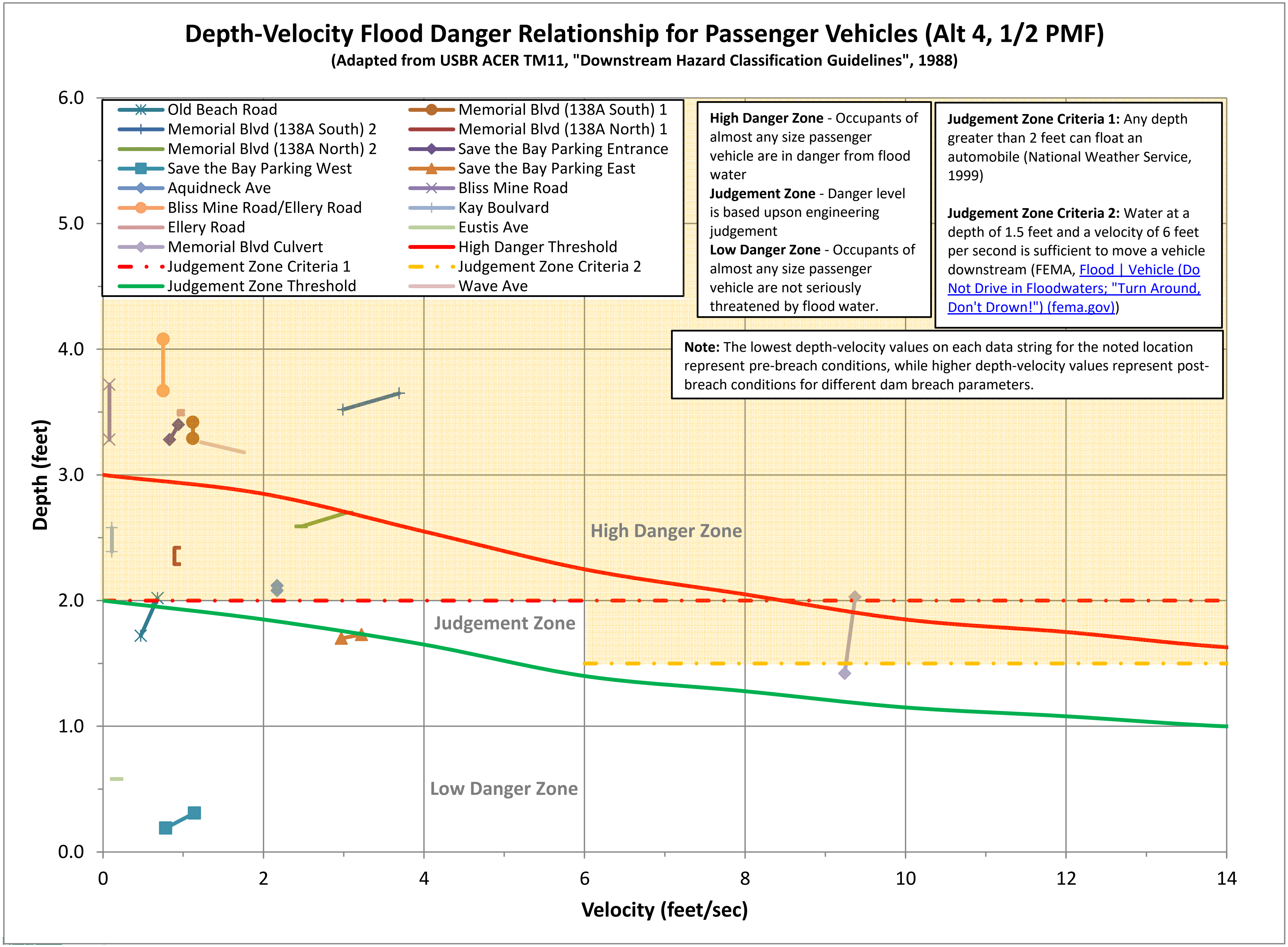


Depth-Velocity Flood Danger Relationship for Children (Alt 2, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
High Danger Zone - Almost any size child is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size child is not seriously threatened by flood water.
Infants are assumed to be safely attended by adults.
Save the Bay Parking Entrance
Save the Bay Parking West
Save the Bay Parking East
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
Aquidneck Ave
86 Aquidneck Ave
Bliss Mine Road
86 Ellery Road
Bliss Mine Road/Ellery Road
Kay Boulvard
Ellery Road
Eustis Ave
Judgement Zone Threshold
High Danger Threshold
Judgement Zone Criteria 1
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov)), values extrapolated for minimum average height of child age 5 (3.33 feet) (CDC, 2000)
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
Velocity (feet/sec)

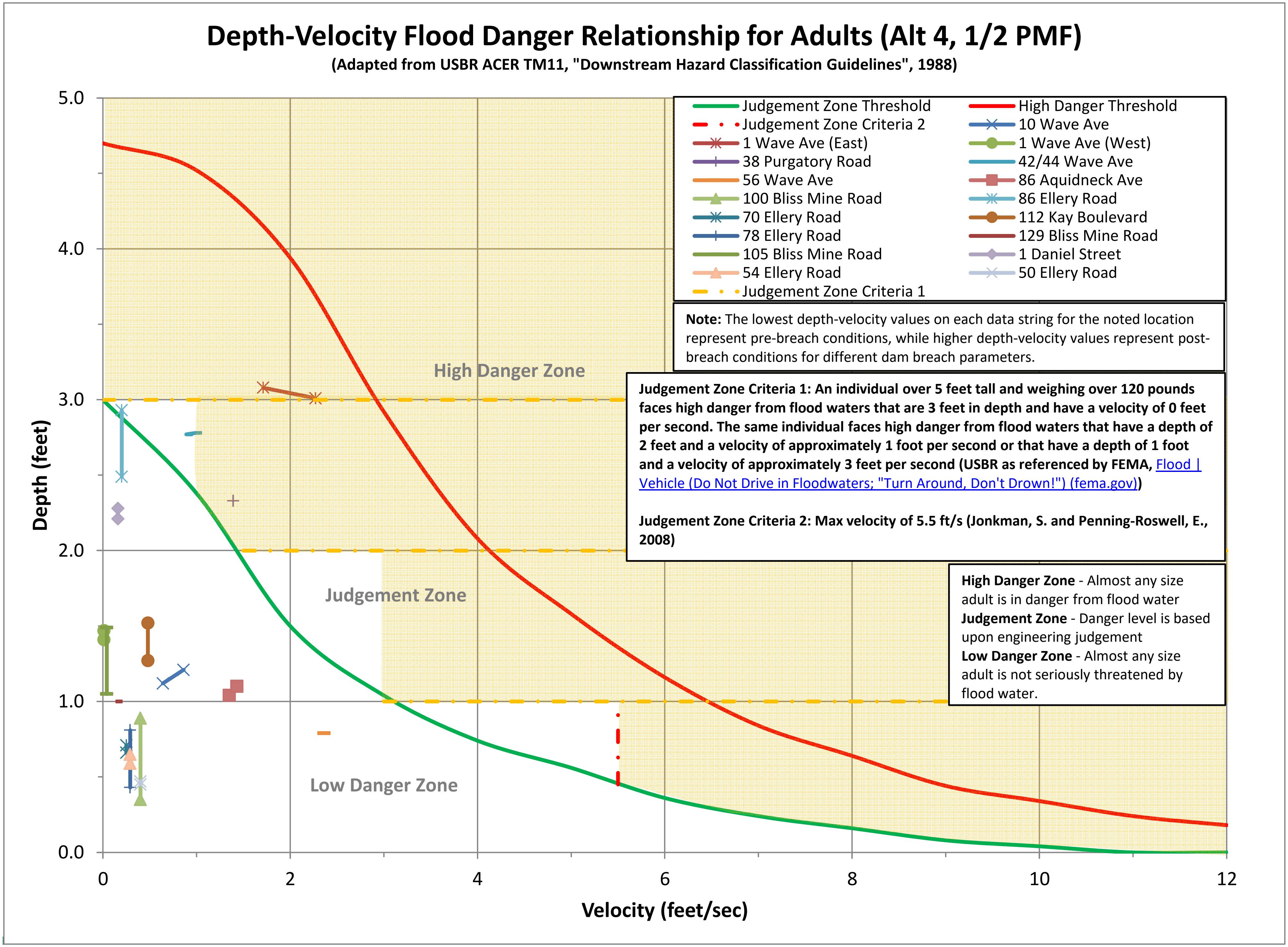
INFLOW DESIGN FLOOD INVESTIGATION SUMMARY OF INCREMENTAL CONSEQUENCE ANALYSIS RESULTS FOR ALTERNATIVE 4 1/2 PMF EVENT				
Alternative 4				
Location	No Breach Depth (Alternative 4)	No Breach Velocity (Alternative 4)	Breach Parameter Estimation Methodology	
			Von Thun & Gillette (VTG)	VTG Velocity
Old Beach Road	1.72	0.47	2.02	0.68
Memorial Blvd (138A South) 1	3.29	1.12	3.42	1.12
Memorial Blvd (138A South) 2	3.52	2.99	3.65	3.69
Memorial Blvd (138A North) 1	2.29	0.89	2.42	0.89
Memorial Blvd (138A North) 2	2.59	2.47	2.70	3.04
Save the Bay Parking Entrance	3.28	0.83	3.40	0.94
Save the Bay Parking West	0.19	0.78	0.31	1.14
Save the Bay Parking East	1.70	2.97	1.73	3.22
10 Wave Ave	1.12	0.64	1.21	0.86
1 Wave Ave (East)	3.08	1.71	3.01	2.27
1 Wave Ave (West)	1.41	0.01	1.47	0.01
38 Purgatory Road	2.33	1.39	2.33	1.39
42/44 Wave Ave	2.77	0.89	2.78	0.99
56 Wave Ave	0.79	2.36	0.79	2.36
Aquidneck Ave	2.08	2.17	2.12	2.17
86 Aquidneck Ave	1.04	1.35	1.10	1.43
100 Bliss Mine Road	0.35	0.40	0.89	0.40
Bliss Mine Road	3.28	0.08	3.72	0.08
86 Ellery Road	2.49	0.20	2.93	0.20
Bliss Mine Road/Ellery Road	3.67	0.75	4.08	0.75
Kay Boulvard	2.39	0.11	2.58	0.11
Ellery Road	3.48	0.94	3.51	0.94
Eustis Ave	0.58	0.17	0.58	0.17
Memorial Blvd Culvert	1.42	9.24	2.03	9.37
UV System	2.60	3.09	2.94	3.74
70 Ellery Road	0.66	0.25	0.71	0.25
112 Kay Boulevard	1.27	0.48	1.52	0.48
78 Ellery Road	0.43	0.29	0.81	0.29
129 Bliss Mine Road	2.38	0.14	2.81	0.14
105 Bliss Mine Road	1.05	0.04	1.49	0.04
1 Daniel Street	2.21	0.16	2.28	0.16
54 Ellery Road	0.59	0.29	0.65	0.29
50 Ellery Road	0.45	0.40	0.47	0.40
Wave Ave	3.26	1.22	3.18	1.76
South Easton Pond Dam [3]				

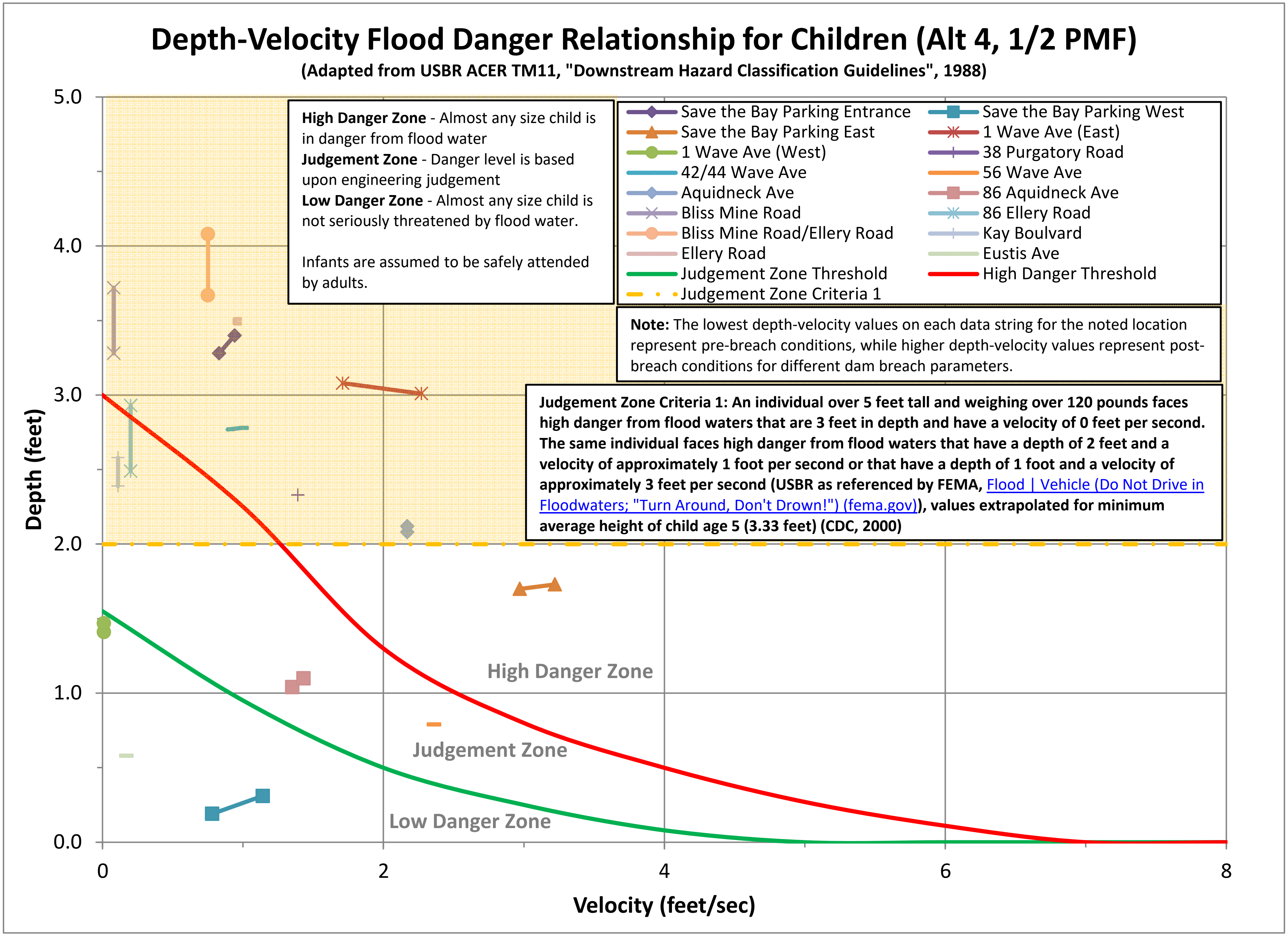


Depth-Velocity Flood Danger Relationship for Houses Built on Foundations (Alt 4, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone - Occupants of most houses are in danger from flood water
Judgement Zone - Danger level is based upson engineering judgement
Low Danger Zone - Occupants of most houses are not seriously in danger from flood water.
High Danger Zone
Judgement Zone
Low Danger Zone
High Danger Threshold
Judgement Zone Threshold
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
Eustis Ave
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
Depth (feet)
Velocity (feet/sec)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
0
2
4
6
8
10
12
14



Depth-Velocity Flood Danger Relationship for Passenger Vehicles (Alt 4, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Old Beach Road
Memorial Blvd (138A South) 2
Memorial Blvd (138A North) 2
Save the Bay Parking West
Aquidneck Ave
Bliss Mine Road/Ellery Road
Ellery Road
Memorial Blvd Culvert
Judgement Zone Criteria 1
Judgement Zone Threshold
Memorial Blvd (138A South) 1
Memorial Blvd (138A North) 1
Save the Bay Parking Entrance
Save the Bay Parking East
Bliss Mine Road
Kay Boulvard
Eustis Ave
High Danger Threshold
Judgement Zone Criteria 2
Wave Ave
High Danger Zone - Occupants of almost any size passenger vehicle are in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Occupants of almost any size passenger vehicle are not seriously threatened by flood water.
Judgement Zone Criteria 1: Any depth greater than 2 feet can float an automobile (National Weather Service, 1999)
Judgement Zone Criteria 2: Water at a depth of 1.5 feet and a velocity of 6 feet per second is sufficient to move a vehicle downstream (FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
14
Velocity (feet/sec)


Depth-Velocity Flood Danger Relationship for Adults (Alt 4, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
Judgement Zone Threshold
High Danger Threshold
Judgement Zone Criteria 2
10 Wave Ave
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
86 Aquidneck Ave
100 Bliss Mine Road
86 Ellery Road
70 Ellery Road
112 Kay Boulevard
78 Ellery Road
129 Bliss Mine Road
105 Bliss Mine Road
1 Daniel Street
54 Ellery Road
50 Ellery Road
Judgement Zone Criteria 1
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov))
Judgement Zone Criteria 2: Max velocity of 5.5 ft/s (Jonkman, S. and Penning-Roswell, E., 2008)
High Danger Zone - Almost any size adult is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size adult is not seriously threatened by flood water.
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
10
12
Velocity (feet/sec)


Depth-Velocity Flood Danger Relationship for Children (Alt 4, 1/2 PMF)
(Adapted from USBR ACER TM11, "Downstream Hazard Classification Guidelines", 1988)
High Danger Zone - Almost any size child is in danger from flood water
Judgement Zone - Danger level is based upon engineering judgement
Low Danger Zone - Almost any size child is not seriously threatened by flood water.
Infants are assumed to be safely attended by adults.
Save the Bay Parking Entrance
Save the Bay Parking West
Save the Bay Parking East
1 Wave Ave (East)
1 Wave Ave (West)
38 Purgatory Road
42/44 Wave Ave
56 Wave Ave
Aquidneck Ave
86 Aquidneck Ave
Bliss Mine Road
86 Ellery Road
Bliss Mine Road/Ellery Road
Kay Boulvard
Ellery Road
Eustis Ave
Judgement Zone Threshold
High Danger Threshold
Judgement Zone Criteria 1
Note: The lowest depth-velocity values on each data string for the noted location represent pre-breach conditions, while higher depth-velocity values represent post-breach conditions for different dam breach parameters.
Judgement Zone Criteria 1: An individual over 5 feet tall and weighing over 120 pounds faces high danger from flood waters that are 3 feet in depth and have a velocity of 0 feet per second. The same individual faces high danger from flood waters that have a depth of 2 feet and a velocity of approximately 1 foot per second or that have a depth of 1 foot and a velocity of approximately 3 feet per second (USBR as referenced by FEMA, Flood | Vehicle (Do Not Drive in Floodwaters; "Turn Around, Don't Drown!") (fema.gov)), values extrapolated for minimum average height of child age 5 (3.33 feet) (CDC, 2000)
High Danger Zone
Judgement Zone
Low Danger Zone
Depth (feet)
5.0
4.0
3.0
2.0
1.0
0.0
0
2
4
6
8
Velocity (feet/sec)

Attachment D

Opinion of Cost

FUSS & O'NEILL, INC.

317 Iron Horse Way, Suite 204
Providence, RI 02908

OPINION OF COST - Budgetary		DATE PREPARED : 10/3/2022	SHEET 1 OF 1
PROJECT :	North and South Easton Pond Embankment Resiliency Project	BASIS :	RS Cost Means
LOCATION :	Newport, RI		2021-2022 RIDOT and MassDOT WAUP
DESCRIPTION:	Gate installation and embankment raising north and south embankments		Previous Experience
DRAWING NO. :	20060901.D64 - South Easton Pond Dam Repairs and Improvements	ESTIMATOR : RKM	CHECKED BY : CLB

Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Cost are made on the basis of Fuss & O'Neill's experience and qualifications and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM DESCRIPTION	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
North Pond Embankment					
1	**EROSION AND SEDIMENT CONTROLS**				
	Turbidity Curtain	LF	7,846	$50	$392,300
	Straw Wattles	LF	7,846	$10	$78,500
	Construction Entrance (crushed stone)	CY	30	$90	$2,700
	Construction Entrance (geotextile)	SY	30	$10	$300
	EROSION AND SEDIMENT CONTROLS SUBTOTAL				**$473,800**
2	**SITE ACCESS**				
	Construction Access Over Moat Channel - temporary bridge	LS	1	$150,000	$150,000
	SITE ACCESS SUBTOTAL				**$150,000**
3	**EMBANKMENT REPAIRS**				
	Remove Vegetation/Grubbing	SY	22,500	$15	$337,500
	Earth Excavation	CY	9,754	$50	$487,700
	Fine Grading	SY	11,576	$10	$115,800
	Embankment Soil Excavation and Replacement	CY	21,775	$45	$979,900
	Articulating Concrete Slope Protection	SF	324,000	$30	$9,720,000
	Geotextile Fabric	SY	41,580	$10	$415,800
	Geogrid Reinforcement	SY	19,800	$15	$297,000
	Compacted Washed Gravel	CY	30,382	$40	$1,215,300
	6" R-1 Riprap	CY	3,000	$90	$270,000
	R-7 Riprap Buttress	CY	1,500	$150	$225,000
	Riprap Relocation	CY	750	$86	$64,500
	EMBANKMENT REPAIRS SUBTOTAL				**$14,128,500**
4	**SOUTH POND SPILLWAY REPLACEMENT**				
	Removal of Existing Spillway	CY	370	$1,800	$666,700
	Removal of Existing Wingwalls	CY	15	$1,800	$27,000
	Over Excavation (earth)	CY	112	$50	$5,600
	Mud Mat	CY	37	$1,500	$55,600
	Spillway Base Reconstruction (Cast-in-Place Concrete)	CY	370	$2,500	$925,900
	SPILLWAY REPLACEMENT SUBTOTAL				**$1,680,800**
5	**SITE IMRPOVEMENTS AND RESTORATION**				
	4" Loam	SY	16,000	$6	$96,000
	Erosion Control Seed Mix	SY	16,000	$3	$48,000
	SITE IMRPOVEMENTS AND RESTORATION SUBTOTAL				**$144,000**
6	**GATE INSTALLATION**				
	Piers for gate support (reinforced concrete)	CY	450	$2,500	$1,125,000
	Gate Tie In	CY	2	$2,500	$5,000
	Crane and crew 40 ton (3 or 4 days)	Day	4	$2,151	$8,600
	Hauling to site	DAY	2	$1,200	$2,400
	Automatic Generator (gas) (10' away own cabinet, run natural gas to it)	EACH	1	$150,000	$150,000
	Housing (10x10x8) Pre-Fabricated Building	EACH	1	$80,000	$80,000
	Housing (10x10x8) Pre-Fabricated Building Installation	EACH	1	$35,000	$35,000
	Gas Hookup	LS	1	$40,000	$40,000
	Controls/ Communication Installed	LS	1	$75,000	$75,000
	Reservoir/Gate Controls Package (ie. tide gauges)	LS	1	$250,000	$250,000
	Power service	LS	1	$3,750	$3,750

	Gate Structure	LS	1	$3,350,000	$3,350,000
	Tidal/Flap Gate (APPROX. includes earthwork)	LS	1	$500,000	$500,000
	GATE INSTALLATION SUBTOTAL				**$5,624,750**
	EMBANKMENT SUBTOTAL				**$22,201,850**
	GENERAL				
	Mobilization & Demobilization	LS	1	10%	$2,220,200
	Construction Survey Layout and As-Built Mapping	LS	1	$20,000	$20,000
	Field and Laboratory Testing	LS	1	$50,000	$50,000
	Insurance and Bonds	LS	1	5%	$1,110,100
	Control of Water	LS	1	20%	$4,440,400
	Engineering	LS	1	20%	$4,440,400
	GENERALSUBTOTAL				**$12,281,100**
	OVERALL SUBTOTAL				**$34,482,950**
	CONTINGENCY (25%)				$8,620,800
	OVERALL TOTAL INCLUDING CONTINGENCY				**$43,104,000**
	SUBTOTAL -15% TO +30% (ROUNDED TO NEAREST $1,000)	**$37,932,000**		**TO**	**$53,449,000**

Notes:

Attachment E

Benefit Cost Analysis Report

FUSS & O'NEILL

MEMORANDUM

TO: Rob Schultz, Director of Utilities, City of Newport

FROM: Ken Berchielli, MS, EIT; Dean Audet, PE

DATE: December 8, 2023

RE: North and South Easton Pond Dams Resilience Project
BCA Analysis Memorandum

Fuss & O'Neill, Inc. (F&O) has completed a Benefit-Cost Analysis (BCA) as part of the North and South Easton Pond Dams Resilience Project. This memorandum provides a summary of the BCA along with supporting references to be used for inclusion with a future FEMA BRIC application to the US Federal Emergency Management Agency (FEMA) to secure funding for future phases of the project.

FEMA BCA Requirements

The FEMA BCA is a method that determines the future risk reduction benefits of a hazard mitigation project and compares those benefits to its costs. The result is a Benefit-Cost Ratio (BCR). A project is considered cost-effective when the BCR is 1.0 or greater. The FEMA BCA Toolkit Version 6.0 was used to complete the analysis. There are two categories for alternative cost effectiveness methodology to modify the threshold for mitigation projects that are considered cost effective under limited conditions. The categories include a 3% discount rate and 7% discount rate that weigh the total benefits to an adjusted net present value. Pursuant to the FY23 BRIC Notice of Funding Opportunities Overview, FEMA has established a set discount rate of 3% to be used in a BCA for hazard mitigation projects for the FY 2023 BRIC cycle. In previous grant application windows, FEMA has released a memorandum to the applicants summarizing the requirements for alternative cost-effectiveness methodology. It is assumed that the 3% discount rate is satisfactory due to the statement in the Notice of Funding Opportunities Overview, however Fuss & O'Neill will coordinate with FEMA staff to confirm if a formal letter will be released to confirm the appropriate discount rate. For the purpose of this memorandum, the 3% discount rate was used for all benefits.

Methodology

The North and South Easton Pond Dam Resilience Project involves evaluating alternatives to enhance the resilience of North and South Dams against coastal and inland storm events in Newport and Middletown, Rhode Island. The earthen embankments are susceptible to overtopping under more frequent and less severe storm conditions for both inland flooding and coastal flooding. In addition, the primary spillway of the South Easton Pond Dam is susceptible to saltwater intrusion from coastal flooding.

The recommended alternative includes select segments of the north pond and south pond embankments to protect against overtopping. The North Pond's southern and western embankments will be elevated to a constant crest elevation of 13.4 feet. The South Pond southern and eastern embankments to EL. 12.1 feet. Crest elevations are in reference to the NAVD88 datum. The embankment slopes will be armored and designed to be overtopped by fortifying the ground surface with articulated concrete block matting. In addition, the primary spillway of the south dam will be removed and replaced with provisions for a hydraulic crest gate. Additional detail regarding the design criteria of the recommended alternative is provided in the Conceptual Design Report developed by Fuss &O'Neill.

Elevating the embankment provides additional freeboard against inland flooding and coastal storm surge. Stone armor and articulating concrete block matting will provide enhanced protection against overtopping from wave action and wind attack. The combination of the mitigation items will make the dam resilient to inland flooding and dry weather wind events up to the 500-year recurrence interval. For coastal storm surges, the hydraulic crest gate will make the dam resilient up to the 200-year storm surge. The mitigation actions will work to protect utilities, structures, and the public from the effects of a dam failure.

The hazard events considered for the BCA include inland flooding and subsequent dam breaches, wind damage, and coastal flooding. The cost-benefit ratio was calculated by comparing the budgetary opinion of cost developed by Fuss & O'Neill with the economic benefits associated with mitigating the impacts of the hazard events. These benefits were determined using the FEMA BCA Calculator. Structures, utilities, as well as other ancillary benefit items were evaluated under the hazard conditions listed above. These line items (referred to as 'benefit items' herein) are tabulated in Attachment B of this Memorandum.

To evaluate inland flooding, HEC-RAS modeling was completed by Fuss & O'Neill to determine the increase in water surface elevations in both impoundments due to inland storm events. Once the recurrence interval was determined at which either dam could overtop, dam breach analyses were completed at various low points along both the North and South Dam Embankments. Tailwater depths in the moat channel around the south dam were compared directly with flood depths from breach inundation mapping to determine subsequent damages to structures, utilities, or personnel in the downstream area. Detailed H&H modeling results are included Conceptual Design Report.

Wind attack benefits were determined by evaluating historical damage from wind events experienced in the City of Newport at the North and South dams, specifically Hurricane Ida. Sustained wind speeds from the historical events were evaluated and assigned recurrence intervals, to determine a conservative recurrence interval where the dams would likely breach due to wave action from wind attack. This assumption is outlined in detail below.

Storm surge benefits were determined using the Climate Resilience Assessment Technical Memorandum for North and South Easton Pond Reservoir (prepared by Fuss & O'Neill, May 2019). The present-day 20-year storm surge elevations are above the crest elevation of the primary spillway, thus introducing saltwater intrusion into the south reservoir.

Assumptions used in BCA

- Overtopping as a result of inland storm events will cause dam failure (breach in embankment).
- Wind-related failures due to wave action against the embankment slopes are assumed to occur at the 50-year sustained wind speed provided in the 2009 Design Criteria Memorandum for South Easton Pond Dam (produced by F&O). This is based on historical damage experienced by the City of Newport at the North and South Easton Pond Dams.
- Sustained Wind speeds for historically expected damage events were obtained from the National Climatic Data Center (NCDC).
- The number of customers served for utility benefit items was provided by the City of Newport Water Department.
- Damages associated with potable water are included for each hazard mode. A breach in the embankment would require a boil water advisory for customers for a minimum of three days based on discussions with the City of Newport.
- Traffic counts were obtained from the RIGIS Environmental Data Center.

Summary of BCA Inputs

- Property Structure – Varies based on the type of structure. Structures selected as "other" include damages to the dam embankment or additional costs associated with items that are not available in the BCA standard structures (i.e. emergency response, loss of life, etc.).
- Hazard Type –Dam/Levee Break.
- Damage Frequency Relationship – Professional expected damages or historical expected damages.
- Mitigation Action Type – "Other" was selected due to the limited options available in the FEMA BCA Toolkit under the Dam/Levee Break Module.
- Project Useful Life – Assumed to be 50 years.
- Initial Project Costs – Order of magnitude cost estimates were completed by F&O as part of the overall project. The initial project costs are equal to $43,104,000.
- Annual Maintenance – Assumed to be $10,000.
- Professional/Historical Expected Damages Before Mitigation – Damages were estimated by reviewing water surface elevations and velocities due to a dam failure based on inland hydrologic and hydraulic modeling. Damages are limited to the dam itself and the downstream area (Memorial Boulevard). Methods to estimate costs vary based on the property structure type. Recurrence intervals were determined based on the hazard type.
- Professional/Historical Expected Damages After Mitigation – The proposed project is designed to protect the dam against a 500-year hazard event for inland flooding and wind attack, as well as a 200-year hazard event for storm surges.

Results

Based on the assumptions and methodology outlined in this memorandum, the BCR provided for the North Easton Dam project is 1.20 at the 3% indicating that the project is cost effective. Detailed output from the FEMA Toolkit is included in Attachment D.

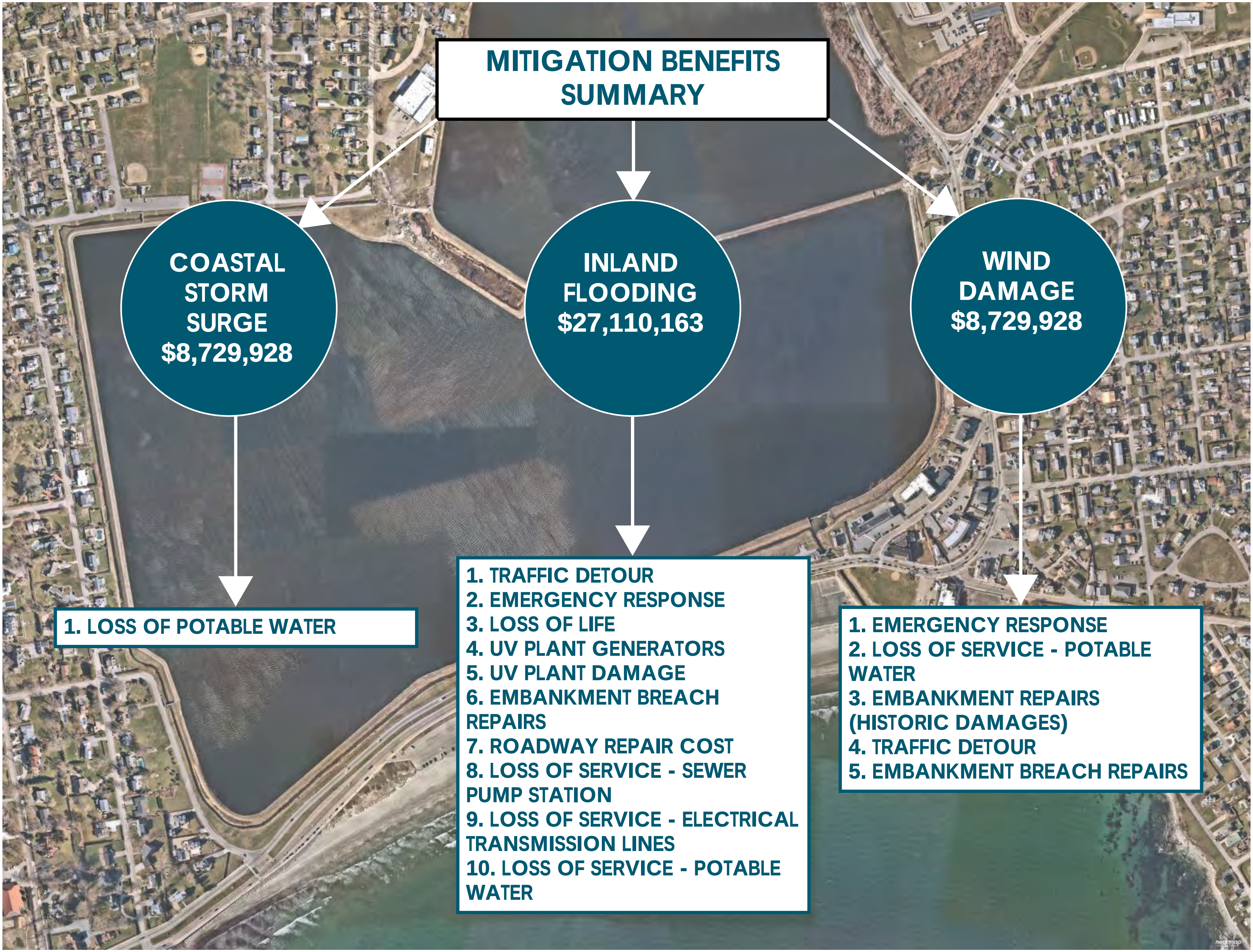
Attachments

A. Mitigation Benefits Summary
B. BCA Data Tabulation
C. References
D. FEMA BCA Toolkit Output

/sms

Appendix A

Mitigation Benefits Summary


MITIGATION BENEFITS SUMMARY
COASTAL STORM SURGE $8,729,928
INLAND FLOODING $27,110,163
WIND DAMAGE $8,729,928
1. LOSS OF POTABLE WATER
1. TRAFFIC DETOUR
2. EMERGENCY RESPONSE
3. LOSS OF LIFE
4. UV PLANT GENERATORS
5. UV PLANT DAMAGE
6. EMBANKMENT BREACH REPAIRS
7. ROADWAY REPAIR COST
8. LOSS OF SERVICE - SEWER PUMP STATION
9. LOSS OF SERVICE - ELECTRICAL TRANSMISSION LINES
10. LOSS OF SERVICE - POTABLE WATER
1. EMERGENCY RESPONSE
2. LOSS OF SERVICE - POTABLE WATER
3. EMBANKMENT REPAIRS (HISTORIC DAMAGES)
4. TRAFFIC DETOUR
5. EMBANKMENT BREACH REPAIRS

Appendix B

BCA Data Tabulation

FUSS & O'NEILL

EASTON POND NORTH DAM AND SOUTH DAM COASTAL RESILIENCE PROJECT BCA DATA TABULATION [1] NEWPORT, RI (UPDATED NOVEMBER 2023)								
FAILURE EVENT	MAP MARKER	BENEFIT ITEM	DAMAGE TYPE	LOCATION	DAMAGES BEFORE MITIGATION [2]	DAMAGE RECURRENCE INTERVAL	BENEFITS [3]	SUPPLEMENTAL INFORMATION [4]
INLAND FLOODING	1	Memorial Boulevard (RI-138A) Detour	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$8,069,610	50	$3,737,325	Damages before mitigation are based off detour timing and the shutdown time for Memorial Boulevard (RI 138-A).
	2	Emergency response	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$960,000	50	$444,610	Damages before mitigation are based available emergency response rates within the State of Rhode Island and estimating by F&O.
	3	Loss of Life	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$11,400,000	50	$5,279,747	Damages before mitigation are based on calculations completed by F&O using multiple dam safety manuals related to dam breach analysis.
	4	Pad mounted transformers for UV disinfectant structure	Professional Expected Damages	200 Memorial Blvd, Newport RI	$600,000	50	$277,881	Damages before mitigation are based on the updated 2023 HH Analysis and adjusted costs based off bid prices for the generators.
	5	UV Structure	Professional Expected Damages	200 Memorial Blvd, Newport RI	$3,000,000	50	$1,389,407	Damages before mitigation are based on the updated 2023 HH Analysis and adjusted costs based off bid prices for the UV Structure.
	6	Breached Embankment Repair Cost	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$3,000,000	50	$1,389,407	Estimated by F&O
	7	Roadway Repair Cost	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$700,000	50	$324,195	Estimated by F&O
	8	Loss of sewer pump station	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$8,095,800	50	$3,749,444	Utilizes FEMA standard values, Census data provided by The City of Newport Water Department; and a 10 day shutdown duration
	9	Loss of electrical transmission line	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$10,149,000	50	$4,103,151	Utilizes FEMA standard values, Census data provided by The City of Newport Water Department; and a 3 day shutdown duration
	10	Loss of potable water	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$13,851,198	50	$6,414,996	Utilizes FEMA standard values, Census data provided by The City of Newport Water Department; and a 3 day shutdown duration
WIND DAMAGE	11	Emergency response (sunny day breach occurs)	Professional expected damages - increased recurrence interval based off Hurricane Ida and increased to a 50-	Memorial Boulevard (RI 138-A)	$960,000	50	$444,610	Damages before mitigation are based available emergency response rates within the State of Rhode Island and estimating by F&O.
	12	Loss of potable water (sunny day breach occurs)	Professional expected damages - increased recurrence interval based off Hurricane Ida	Memorial Boulevard (RI 138-A)	$13,851,198	50	$6,414,996	Census data provided by The City of Newport Water Department; Assume 3 day shutdown
	13	Repair Embankment (sunny day breach occurs)	Professional expected damages - increased recurrence interval based off Hurricane Ida	Memorial Boulevard (RI 138-A)	$3,000,000	50	$1,518,056	Utilizes FEMA standard values, Census data provided by The City of Newport Water Department; and a 3 day shutdown duration
	14	Memorial Boulevard (RI-138A) Detour (sunny day breach occurs)	Professional expected damages - increased recurrence interval based off Hurricane Ida	Memorial Boulevard (RI 138-A)	$260,310	50	$254,493	Assume 2 day shutdown to repair damaged sections of the roadway
	15	Repair Embankment from wave action erosion	Historical Expected Damages (Hurricane Ida)	Memorial Boulevard (RI 138-A)	$100,000	25	$97,773	Historical damage costs provided by the City of Newport Water Department
COASTAL STORM SURGE	16	Loss of potable water (saltwater intrusion)	Professional Expected Damages	Memorial Boulevard (RI 138-A)	$13,851,198	20	$16,037,465	Census data provided by The City of Newport Water Department; Assume 3 day shutdown

1. This tables summarizes the results of the BCA and serves as a 'key' for mitigation items included in the BCA.
2. Total damages generally consist of professionally or historically estimated damages completed by F&O. Professionally estimated damages include FEMA standard values where applicable. Total damages include The total damages associated with the hazard, not including inflation.
3. The summation of the calculated annualized damages of all direct damage categories (building, contents, displacement, ecosystem services, and volunteer costs) and converted to net present value using the 3% discount rate.
4. This column is intended to provide basic background information on the benefit item and does not include all references or assumptions associated with each specific benefit item.

Appendix C

References

PREVIOUS REPORTS AND REFERENCES

The following is a list of reports that were utilized during the development of the benefit-cost analysis.

1. "Final BCA Reference Guide", Prepared by the Federal Emergency Management Agency, dated June 2009.
2. "Evaluating Scour at Bridges – Fifth Edition", Prepared by U.S. Department of Transportation Federal Highway Administration, Publication No. FHWA-HIF-12-003, April 2012.
3. "Final Sustainability Benefits Methodology Report", Prepared by the Federal Emergency Management Agency, dated August 23, 2012.
4. "A procedure for Estimating Loss of Life Caused by Dam Failure", Prepared by U.S. Department of the Interior, Dam Safety Office (DSO), September 1999.
5. "Guidance for Completing a Dam Breach Analysis for Small Ponds and Dams in Maryland", Prepared by Maryland Department of the Environment, May 2018.
6. "Introduction to FEMA's Benefit-Cost Analysis (BCA) Module", Prepared by the Federal Emergency Management Agency, dated June 2009.
7. "Spillway Design Flood Investigation North and South Easton Pond Dams", Prepared by Fuss & O'Neill, Inc., dated October 2022.
8. "Climate Resiliency Assessment Technical Memorandum North and south Easton Pond Reservoirs", Prepared by Fuss & O'Neill, Inc., dated May 2019.
9. "Design Criteria Memorandum South Easton Pond Dam Repairs and Improvements", Prepared by Fuss & O'Neill, Inc., dated April 2009.
10. "Emergency Action Plan Easton Pond Dam", Prepared by Fuss & O'Neill, Inc., dated October December 2007.
11. "National Hurricane Center Tropical Cyclone Report – Hurricane Ida, Prepared by John L. Beven II and Robbie Berg", National Hurricane Center, April 4, 2022.
12. "Economic Impact of Tourism in Newport, 2018", Prepared by Tourism Economics, dated August 2019.

Appendix D

FEMA BCA Toolkit Output

FEMA

Benefit-Cost Calculator

V.6.0 (Build 20231108.2102 | Release Notes)

Benefit-Cost Analysis

Project Name: North and South Easton Pond Dam Resiliency Alternatives

				Using 7% Discount Rate			Using 3% Discount Rate (For BRIC and FMA only)		
Map Marker ▲	Mitigation Title	Property Type	Hazard	Benefits (B)	Costs (C)	BCR (B/C)	Benefits (B)	Costs (C)	BCR (B/C)
1	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 2,004,600	$ 43,242,007	0.05	$ 3,737,325	$ 43,361,298	0.09

				Using 7% Discount Rate			Using 3% Discount Rate (For BRIC and FMA only)		
Map Marker ▲	Mitigation Title	Property Type	Hazard	Benefits (B)	Costs (C)	BCR (B/C)	Benefits (B)	Costs (C)	BCR (B/C)
2	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 238,477	$ 0	0.00	$ 444,610	$ 0	0.00
3	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 2,831,913	$ 0	0.00	$ 5,279,747	$ 0	0.00
4	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 149,048	$ 0	0.00	$ 277,881	$ 0	0.00
5	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 745,240	$ 0	0.00	$ 1,389,407	$ 0	0.00
6	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 745,240	$ 0	0.00	$ 1,389,407	$ 0	0.00
7	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 173,889	$ 0	0.00	$ 324,195	$ 0	0.00
8	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 2,011,100	$ 0	0.00	$ 3,749,444	$ 0	0.00
9	Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 2,200,819	$ 0	0.00	$ 4,103,151	$ 0	0.00
10	Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 3,440,830	$ 0	0.00	$ 6,414,996	$ 0	0.00
11	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 238,477	$ 0	0.00	$ 444,610	$ 0	0.00
12	Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 3,440,830	$ 0	0.00	$ 6,414,996	$ 0	0.00
13	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 814,244	$ 0	0.00	$ 1,518,056	$ 0	0.00

				Using 7% Discount Rate			Using 3% Discount Rate (For BRIC and FMA only)		
Map Marker ▲	Mitigation Title	Property Type	Hazard	Benefits (B)	Costs (C)	BCR (B/C)	Benefits (B)	Costs (C)	BCR (B/C)
14	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 136,503	$ 0	0.00	$ 254,493	$ 0	0.00
15	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Dam/Levee Break	$ 52,443	$ 0	0.00	$ 97,773	$ 0	0.00
16	Other @ Memorial Blvd, Newport, Rhode Island, 02840		DFA - Coastal V Flood	$ 8,602,060	$ 0	0.00	$ 16,037,465	$ 0	0.00
TOTAL (SELECTED)				**$ 27,825,713**	**$ 43,242,007**	**0.64**	**$ 51,877,556**	**$ 43,361,298**	**1.20**
TOTAL				**$ 27,825,713**	**$ 43,242,007**	**0.64**	**$ 51,877,556**	**$ 43,361,298**	**1.20**

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Roads & Bridges
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$43,104,000
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$10,000

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2022
Year Property was Built:	1900
Analysis Duration:	123 Use Default:Yes

Roads and Bridges Properties

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Estimated Number of One-Way Traffic Detour Trips per Day:	18,000
Additional Time per One-Way Detour Trip (minutes):	20
Number of Additional Miles:	3
Federal Rate ($):	0.655 Use Default:Yes
Economic Loss Per Day of Loss of Function ($):	260,310

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	ROADS AND BRIDGES	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	31	0	0	0	0	0	8,069,610

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	8,069,610	161,391
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	8,069,610	161,391

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	ROADS AND BRIDGES	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	31	0	0	0	0	0	8,069,610

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	8,069,610	16,138
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	8,069,610	16,138

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$2,004,600
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$2,004,600
Total Mitigation Project Cost:	$43,242,007
Benefit Cost Ratio - Standard:	0.05
Benefit Cost Ratio - Standard + Social:	0.05

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2022
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	960,000	0	0	0	0	0	960,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	960,000	19,200
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	960,000	19,200

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	960,000	0	0	0	0	0	960,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	960,000	1,920
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	960,000	1,920

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$238,477
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$238,477
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2022
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	11,400,000	0	0	0	0	0	11,400,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	11,400,000	227,999
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	11,400,000	227,999

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	11,400,000	0	0	0	0	0	11,400,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	11,400,000	22,799
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	11,400,000	22,799

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$2,831,913
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$2,831,913
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2022
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	600,000	0	0	0	0	0	600,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	600,000	12,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	600,000	12,000

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	600,000	0	0	0	0	0	600,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	600,000	1,200
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	600,000	1,200

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$149,048
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$149,048
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2022
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	3,000,000	0	0	0	0	0	3,000,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	3,000,000	60,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	3,000,000	60,000

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	3,000,000	0	0	0	0	0	3,000,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	3,000,000	6,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	3,000,000	6,000

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$745,240
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$745,240
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2022
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	3,000,000	0	0	0	0	0	3,000,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	3,000,000	60,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	3,000,000	60,000

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	3,000,000	0	0	0	0	0	3,000,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	3,000,000	6,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	3,000,000	6,000

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$745,240
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$745,240
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2022
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	700,000	0	0	0	0	0	700,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	700,000	14,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	700,000	14,000

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	700,000	0	0	0	0	0	700,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	700,000	1,400
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	700,000	1,400

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$173,889
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$173,889
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48534396242718, -71.29740137850912
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Utilities
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1950
Analysis Duration:	74 Use Default:Yes

Utilities Properties

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Type of Service:	Wastewater
Number of Customers Served:	11,130
Value of Unit of Service ($/person/day):	$66 Use Default:Yes
Total Value of Service Per Day ($/day):	$734,580

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	WASTEWATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	10	750,000	0	0	0	0	8,095,800

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	8,095,800	161,915
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	8,095,800	161,915

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	WASTEWATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	10	750,000	0	0	0	0	8,095,800

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	8,095,800	16,191
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	8,095,800	16,191

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$2,011,100
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$2,011,100
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.495714016023896, -71.29334103841956
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Utilities
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1950
Analysis Duration:	74 Use Default:Yes

Utilities Properties

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Type of Service:	Electrical
Number of Customers Served:	11,130
Value of Unit of Service ($/person/day):	$199 Use Default:Yes
Total Value of Service Per Day ($/day):	$2,214,870

Professional Expected Damages Before Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

	ELECTRICAL	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	4	0	0	0	0	0	8,859,480

Annualized Damages Before Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	8,859,480	177,189
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	8,859,480	177,189

Professional Expected Damages After Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

	ELECTRICAL	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	4	0	0	0	0	0	8,859,480

Annualized Damages After Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	8,859,480	17,718
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	8,859,480	17,718

Benefits-Costs Summary

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$2,200,819
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$2,200,819
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.495714016023896, -71.29334103841956
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Utilities
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1930
Analysis Duration:	94 Use Default:Yes

Utilities Properties

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Type of Service:	Potable Water
Number of Customers Served:	33,457
Value of Unit of Service ($/person/day):	$138 Use Default:Yes
Total Value of Service Per Day ($/day):	$4,617,066

Professional Expected Damages Before Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	3	0	0	0	0	0	13,851,198

Annualized Damages Before Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	13,851,198	277,023
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	13,851,198	277,023

Professional Expected Damages After Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	3	0	0	0	0	0	13,851,198

Annualized Damages After Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	13,851,198	27,701
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	13,851,198	27,701

Benefits-Costs Summary

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$3,440,830
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$3,440,830
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1950
Analysis Duration:	74 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	960,000	0	0	0	0	0	960,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	960,000	19,200
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	960,000	19,200

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	960,000	0	0	0	0	0	960,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	960,000	1,920
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	960,000	1,920

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$238,477
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$238,477
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.495714016023896, -71.29334103841956
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Utilities
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Utilities Properties

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Type of Service:	Potable Water
Number of Customers Served:	33,457
Value of Unit of Service ($/person/day):	$138 Use Default:Yes
Total Value of Service Per Day ($/day):	$4,617,066

Professional Expected Damages Before Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	3	0	0	0	0	0	13,851,198

Annualized Damages Before Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	13,851,198	277,023
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	13,851,198	277,023

Professional Expected Damages After Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	3	0	0	0	0	0	13,851,198

Annualized Damages After Mitigation

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	13,851,198	27,701
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	13,851,198	27,701

Benefits-Costs Summary

Other @ 100 Bliss Mine Rd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$3,440,830
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$3,440,830
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1930
Analysis Duration:	94 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	3,000,000	0	0	0	0	0	3,000,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	3,000,000	60,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	3,000,000	60,000

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	500,000	0	0	0	0	0	500,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	500,000	1,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	500,000	1,000

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$814,244
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$814,244
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Roads & Bridges
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1950
Analysis Duration:	74 Use Default:Yes

Roads and Bridges Properties

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Estimated Number of One-Way Traffic Detour Trips per Day:	18,000
Additional Time per One-Way Detour Trip (minutes):	20
Number of Additional Miles:	3
Federal Rate ($):	0.655 Use Default:Yes
Economic Loss Per Day of Loss of Function ($):	260,310

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	ROADS AND BRIDGES	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
50	2	0	0	0	0	0	520,620

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
50	520,620	10,412
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	520,620	10,412

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	ROADS AND BRIDGES	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	1	0	0	0	0	0	260,310

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	260,310	521
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	260,310	521

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$136,503
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$136,503
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Dam/Levee Break
Mitigation Action Type:	Other
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1890
Analysis Duration:	134 Use Default:Yes

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
25	100,000	0	0	0	0	0	100,000

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
25	100,000	4,000
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	100,000	4,000

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
500	100,000	0	0	0	0	0	100,000

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
500	100,000	200
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	100,000	200

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$52,443
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$52,443
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0

Property Configuration

Property Title:	Other @ Memorial Blvd, Newport, Rhode Island, 02840
Property Location:	02840, Newport, Rhode Island
Property Coordinates:	41.48362500662152, -71.30830499870157
Hazard Type:	Coastal V Flood
Mitigation Action Type:	Other
Property Type:	Utilities
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Project Useful Life (years):	50
Project Cost:	$0
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Year of Analysis was Conducted:	2023
Year Property was Built:	1890
Analysis Duration:	134 Use Default:Yes

Utilities Properties

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Type of Service:	Potable Water
Number of Customers Served:	33,457
Value of Unit of Service ($/person/day):	$138 Use Default:Yes
Total Value of Service Per Day ($/day):	$4,617,066

Professional Expected Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
20	3	0	0	0	0	0	13,851,198

Annualized Damages Before Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
20	13,851,198	692,559
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	13,851,198	692,559

Professional Expected Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
200	3	0	0	0	0	0	13,851,198

Annualized Damages After Mitigation

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
200	13,851,198	69,255
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	13,851,198	69,255

Standard Benefits - Ecosystem Services

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Project Area (acres):	0
Percentage of Urban Green Open Space:	0.00%
Percentage of Rural Green Open Space:	0.00%
Percentage of Riparian:	0.00%
Percentage of Coastal Wetlands:	0.00%
Percentage of Inland Wetlands:	0.00%
Percentage of Forests:	0.00%
Percentage of Coral Reefs:	0.00%
Percentage of Shellfish Reefs:	0.00%
Percentage of Beaches and Dunes:	0.00%
Expected Annual Ecosystem Services Benefits:	$0

Benefits-Costs Summary

Other @ Memorial Blvd, Newport, Rhode Island, 02840

Total Standard Mitigation Benefits:	$8,602,060
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$8,602,060
Total Mitigation Project Cost:	$0
Benefit Cost Ratio - Standard:	0
Benefit Cost Ratio - Standard + Social:	0