APPENDIX

CONSTRUCTION SCHEDULE

CONSTRUCTION SCHEDULE

TASK	TIMELINE
DESIGN AND COORDINATION	
100% DESIGN DEVELOPMENT	4 MONTHS
PERMITTING PROCESS	
SURVEY AND GEOTECHNICAL INVESTIGATION	1 MONTH
PERMITTING DRAWINGS (50% CD-LEVEL)	2 MONTHS
PERMITTING DRAWINGS (75% CD-LEVEL)	1 MONTH
MEPA ENF - APPLICATION PREPARATION TO APPROVAL	5 MONTHS
MEPA SINGLE ENVIRONMENTAL IMPACT REPORT - PREPARATION TO APPROVAL	6 MONTHS
BOSTON CONSERVATION COMMISSION - NOI	3 MONTHS
BWSC SITE PLAN REVIEW	12 MONTHS
MASSDEP CH 91 - APPLICATION PREPARATION TO APPROVAL	7 MONTHS
ACOE - PRECONSTRUCTION NOTIFICATION	7 MONTHS
CONSTRUCTION DRAWINGS	
100% CONSTRUCTION DOCUMENTS REVIEW	1 MONTH
BID PROCESS	
BID DOCUMENTS REVIEW	3 WEEKS
BIDDING PERIOD	2 MONTHS
CONSTRUCTION PROCESS	
CONSTRUCTION SCHEDULE	18 MONTHS

BENEFIT COST ANALYSIS

TETRA TECH

Memo

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Date:	6/29/2023
Subject:	Tenean Beach Preliminary BCA Results

1.0 INTRODUCTION

This memorandum (memo) has been developed to calculate a benefit-cost ratio for the Dorchester Waterfront project located at Tenean Beach. This current analysis builds upon the previous benefit-cost analysis work that was completed for a wider array of projects as documented in the *Climate Ready Dorchester Preliminary BCA Memo*, dated 4 April 2020.

2.0 METHODOLOGY

This benefit-cost analysis uses previous data and information compiled for the *Climate Ready Dorchester Preliminary BCA Memo* and updates key data inputs to develop a benefit-cost ratio consistent with current data and reports for the Tenean Beach improvements. This benefit-cost analysis is also consistent with the general procedures described in the *Climate Ready Boston – Approach and Methodology for Asset Data Collection and Exposure Analysis and Consequence Analysis, Version 1.0*, dated 17 October 2016.

The primary steps in this analysis include:

1. Updating of previously developed structure inventory database to
   a. extract only structures impacted/protected by the proposed Tenean Beach improvements and
   b. update structure and content values for the selected structures to 2023 price levels.
2. Incorporate current hydraulic modeling results for the without- (existing) and with-project (proposed) conditions.
3. Model economic damages for the with- and without-project conditions, which includes estimating damages for the following categories:
   a. Direct physical damages to buildings and their contents
   b. Displacement costs
   c. Mental stress and anxiety costs
   d. Lost productivity costs
   e. Roadway transportation detour costs
4. Calculate annualized benefits and costs for generating a resulting benefit-cost ratio.

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3.0 BENEFIT-COST ANALYSIS

3.1 PROJECT BENEFITS

Project benefits are estimated as expected annual damages (EAD), which is the annualized difference in damages between the without- and with-project conditions. A summary of the assumptions for each damage category included in this analysis is provided below, including a summary of the final project benefits.

3.1.1 Structures and Contents

Structure and content damages covers the building-related losses associated with direct contact with flood waters. Structure damage relates to the structural components of building such as foundations, walls, and utilities. The content damages reflect damage to the non-structural components of building such as furniture, fixtures, cabinetry and other personal property and equipment.

For this analysis, a detailed structure inventory was already prepared and used in the 2020 BCA analysis referenced previously. This inventory covered a much larger area beyond the Tenean Beach project location. Therefore, the previous structure inventory was compared with the latest hydraulic modeling[1] for the Tenean Beach project area, and the specific structures impacted by this proposed project were extracted. Then these remaining 151 structures in the inventory were updated with current structure and content values using an average escalation factor from several sources including the US Army Corps of Engineers and US Census Bureau data[2].

Damages for each building were then calculated based on depths at each structure point after accounting for changes in ground elevation and estimated first floor elevations. Depth-to-damage functions were taken from several sources[3] to ensure each structure occupancy type was accounted for. The total damages for the with- and without-project conditions are provided below.

Annual Exceed. Probability (AEP)	Without-Project Damages		With-Project Damages		Structure and Content Benefits
	Structures	Contents	Structures	Contents	
5%	$1,252,412	$5,760,450	$0	$0	$7,012,862
2%	$2,426,191	$10,266,436	$44,727	$39,411	$12,608,490
1%	$5,299,015	$30,975,446	$45,751	$42,278	$36,186,431
0.5%	$9,087,832	$43,456,805	$47,117	$46,101	$52,451,418
0.2%	$12,174,795	$53,364,095	$58,758	$63,306	$65,416,825

3.1.2 Disruption Costs

Displacement costs to building owners is generally calculated as a one-time disruption cost, along with a recurring monthly rental cost. For this analysis, only the disruption portion of overall displacement costs has been estimated. This is because the monthly rental cost is significantly driven by the assumptions used to estimate overall duration until

[1] Hydraulic modeling completed by Woods Hole Group, which provided water surface elevations for (a) existing and proposed conditions, (b) the 20-, 50-, 100-, 200- and 500-yr flood events, and (c) the 2030 time horizon hydraulic conditions.
[2] https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll9/id/2596 and https://www.census.gov/construction/cpi/current.html
[3] Depth damage functions taken primarily from *North Atlantic Coast Comprehensive Study* (January 2015) and others taken from USACE's HEC-LifeSim model.

structure owners can reoccupy. These reoccupation durations are often arbitrary and difficult to reasonably estimate, and as such have not been estimated at this time. However, the disruption costs are a one-time cost applied to inundated structures with a well-documented cost per square foot already developed by FEMA[4]. The following table provides a summary of the without- and with-project disruption costs.

AEP	Disruption Costs (without-project)	Disruption Costs (with-project)	Disruption Benefits
5%	$164,211	$0	$164,211
2%	$233,552	$1,301	$232,251
1%	$242,111	$1,301	$240,810
0.5%	$397,110	$1,301	$395,809
0.2%	$583,730	$1,535	$582,195

3.1.3 Stress and Anxiety

This damage category is intended to characterize human health impacts following a flood that may result in decreased quality of life through adverse mental health. Based on FEMA's BCA Toolkit[5] the current value per inundated resident is $2,443. This value was applied to all inundated residential structures, with adjustments for multi-unit residential structures, as well as assumed number of persons per unit taken from US Census data[6]. The following table provides a summary of the without- and with-project mental stress and anxiety costs.

AEP	Stress Costs (without-project)	Stress Costs (with-project)	Stress Benefits
5%	$0	$0	$0
2%	$89,902	$0	$89,902
1%	$123,616	$0	$123,616
0.5%	$219,137	$0	$219,137
0.2%	$309,040	$0	$309,040

3.1.4 Lost Productivity

Lost productivity is intended to estimate worker productivity impacts that arise due to adverse human health impacts following a flood event. Based on FEMA's BCA Toolkit methodology, a value of $8,736 was used for each worker whose residence is inundated. The assumed number of workers per residential unit was calculated from US Census data for the city of Boston[7]. The following table provides a summary of the without- and with-project lost productivity costs.

AEP	Lost Productivity (without-project)	Lost Productivity (with-project)	Lost Productivity Benefits
5%	$0	$0	$0
2%	$223,642	$0	$223,642
1%	$307,507	$0	$307,507
0.5%	$545,126	$0	$545,126

[4] See *Benefit-Cost Analysis Sustainment and Enhancements, Standard Economic Value Methodology Report, Version 9.0*, dated 30 June 2020.
[5] https://www.fema.gov/grants/tools/benefit-cost-analysis
[6] https://www.census.gov/quickfacts/fact/table/bostoncitymassachusetts/PST120222
[7] https://www.census.gov/quickfacts/fact/table/bostoncitymassachusetts/PST120222

0.2%	$768,768	$0	$768,768

3.1.5 Transportation Detours

This damage category addresses impacts to roadway traffic that would incur detours, and thus added travel times, during a flood event. A review of local traffic count data from MassDOT was completed to determine estimates of daily vehicle traffic, and the nearest surface road with traffic counts is on Morrisey Boulevard[8]. MassDOT estimates that 35,875 vehicles travel along Morrisey Blvd just north of Conley Street. Using this daily traffic value with assumed closure durations for each flood magnitude, an estimated added detour time (currently 5-minutes), and an estimated employee compensation rate of $48.23 per hour for the City of Boston[9], total detour costs were estimated.

AEP	Traffic Detour Costs (without-project)	Traffic Detour Costs (with-project)	Traffic Detour Benefits
5%	$24,036	$0	$24,036
2%	$36,054	$0	$36,054
1%	$72,109	$0	$72,109
0.5%	$144,218	$0	$144,218
0.2%	$288,435	$0	$288,435

3.1.6 Expected Annual Damages

Expected annual damages (EAD) are estimated in the following table.

AEP	Total Damages (without-project)	Total Damages (with-project)	Total Benefits	Contribution to EAD
5%	$7,201,109	$0	$7,201,109	$292,381
2%	$13,275,779	$85,439	$13,190,339	$220,709
1%	$37,019,803	$89,331	$36,930,472	$222,779
0.5%	$53,850,228	$94,520	$53,755,708	$180,531
0.2%	$67,488,863	$123,600	$67,365,263	$134,057
			Expected Annual Damages	**$1,050,457**

3.2 PROJECT COSTS

A detailed line-item construction cost estimate has been developed for this project. The total cost includes all proposed elements of the project and is summarized in the table below.

Summary Category	Construction Cost
Stabilization and Demolition	$523,220
Public Utilities	$1,897,289
Site Utilities	$500,000
Earthwork	$2,665,523
Roadway Building	$976,919

[8] https://mhd.public.ms2soft.com/tcds/tsearch.asp?loc=Mhd&mod=
[9] https://www.bls.gov/news.release/pdf/ecec.pdf

Site Surfacing	$2,155,183
Landscaping and Plantings	$1,751,136
Sub-Total	$10,460,271
Contingency (15%)	$1,569,041
Total Cost	**$12,029,312**

In addition to construction, an annual operations and maintenance (O&M) cost has been estimated as 1% of the total construction cost above. This annual O&M is assumed to be incurred every year after construction and for the length of the project life.

4.0 RESULTS

4.1 BENEFIT-COST RATIO

The benefits (EAD) and costs for this project have been annualized based on two different discount rates (3% and 7%) and assumes a 50-year project life. The subsequent table provides the annualized benefits, annualized costs, benefit-cost ratio, and total net benefits for the Tenean Beach project.

Item	Benefit-Cost Ratio (3% Disc. Rate)	Benefit-Cost Ratio (7% Disc. Rate)
Annualized Benefits	$879,741	$699,964
Annualized Costs	$498,162	$681,297
Benefit-Cost Ratio	**1.77**	**1.03**
Net Annualized Benefits	$381,580	$18,667

4.2 LOWER BOUND ANALYSIS

The analysis presented above likely reflects a lower bound analysis. Many of the assumptions used were conservative in their impact, and other benefit categories have been omitted due to limited information available at this time. The following is a list of potential benefit assumptions that could lead to higher benefits with further analysis.

- Many other potential damage categories were not modeled for the benefits estimation. These other damage categories include but are not limited to:
  - Transportation losses for subway/rail lines – The Red Line subway runs directly through the study area, and there is potential that the tracks are inundated or jeopardized during large magnitude flood events.
  - Utility loss of service impacts (electrical, potable water, wastewater) – There are metrics available to estimate these losses over assumed outage duration periods. Due to limited information currently on flood durations, and potential outage periods, these were not estimated.
  - Environmental or ecosystem services benefits – There is insufficient information at this time to make a determination on potential environmental or ecosystem services benefits.
  - Recreation benefits – Flood events often inundate, and thus limit, recreational use areas and opportunities. Recreational facilities in the area have not been analyzed at this time.
  - Emergency response costs – Flooding often causes increased emergency response costs for fire and police departments, and it is likely that some additional emergency services would be expected for flooding in this area.
- The provided hydraulic models used in this analysis account for the existing and proposed hydraulic conditions that are expected in the year 2030. It should be noted that no additional time horizons were used in this benefit-cost analysis. But previous analysis[10] used additional time horizon hydraulic information to estimate EAD in the years 2050 and 2070 and incorporated those time horizons into the previous benefit-cost analysis efforts. Results from the inclusion of 2050 and 2070 hydraulics led to significant increases in EAD as time progresses and climate change impacts are incurred to this study area. Thus, a higher benefit-cost ratio could be expected if further climate change impacts are included in this analysis. Using the current benefit-cost analysis presented above and adjusting EAD at a similar rate as the previous reporting, benefit-cost ratios could more than double if accounting for future hydraulic changes.

[10] *Climate Ready Dorchester Preliminary BCA Memo*, dated 4 April 2020, prepared by Tetra Tech.