SAN FRANCISCO WATERFRONT COASTAL FLOOD STUDY, CALIFORNIA

APPENDIX G
MONITORING AND ADAPTATION PLAN

JULY 2026

USACE TULSA DISTRICT | THE PORT OF SAN FRANCISCO

US Army Corps of Engineers

PORT OF SAN FRANCISCO

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

Acronym	Definition
ACT	Adaptation Confirmation Threshold
AMT	Adaptation Management Team
ERA	Early Resilience Action
ERDC	Engineer Research and Development Center
HTRW	Hazardous, Toxic, and Radioactive Waste
IFR/EIS	Integrated Feasibility Report and Environmental Impact Statement
MAP	Monitoring and Adaptation Plan
NASA	National Aeronautics and Space Agency
NOAA	National Oceanic and Atmospheric Agency
PAR	Project Adaptation Report
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
POSF	Port of San Francisco
RSLC	Relative Sea Level Change
SFWCFS	San Francisco Waterfront Coastal Flood Study
USACE	U.S. Army Corps of Engineers

1.0 Introduction

This appendix provides a feasibility-level Monitoring and Adaptation Plan (MAP) for the San Francisco Waterfront Coastal Flood Study (SFWCFS) Final Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS), which proposes coastal and combined flood risk management opportunities for the San Francisco waterfront. This appendix also presents the initial development of strategies and processes for implementation of the Recommended Plan. These strategies and processes will be more fully developed and coordinated during the design phase of the project.

This MAP describes the goals, governance, and process for successful phasing, monitoring, and adaptation of the Recommended Plan. Additionally, the MAP is structured to be a living document and is expected to be updated throughout the project life (100 years), by the U.S. Army Corps of Engineers (USACE) and the Port of San Francisco (POSF), in coordination with other collaborating agencies.

Relative sea level change (RSLC) is the main driver of coastal flood risk in the study area. There is considerable uncertainty about the rate of RSLC. Different rates of RSLC will necessitate implementing coastal and combined flood risk management actions at different times. The MAP provides a basis for determining the scale and timing of adaptation actions to mitigate coastal flooding risks.

1.1 Purpose of the MAP

The purpose of this MAP is to provide a framework that will ensure long-term project success. Project success is determined by monitoring metrics that are tied to project objectives, targets, and thresholds. The goals, activities, and procedures outlined in this MAP will be fully defined by the Adaptation Management Team (AMT) (Section 5) during the design phase, prior to project construction.

As a living document, this MAP will be updated, added to, and refined as the project progresses over time. It is expected that adjustments to project design, implementation, monitoring, evaluations, and adaptive actions will occur as the AMT learns from the implementation of the project as sea level changes. This version of the MAP includes a general process for phasing, monitoring, and adaptation that is expected to be refined by the AMT over time.

1.2 Adaptation Strategy

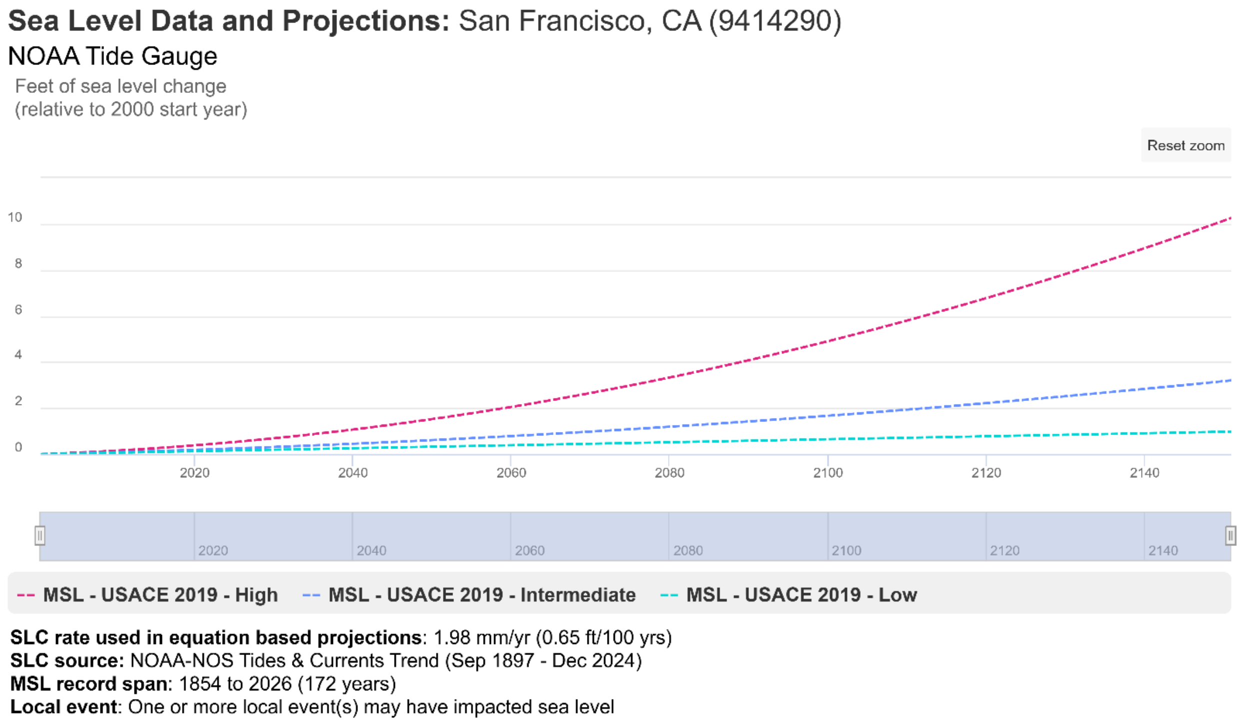
There are many uncertainties that need to be considered if the final Recommended Plan is to be an economically efficient, risk-informed plan that addresses multiple hazards. These uncertainties include but are not limited to a high level of uncertainty in the rates of RSLC along the San Francisco shoreline and resulting coastal flood damages; the high risk of life loss and injury in the event of an earthquake; the residual life of historic assets along the waterfront that are implicated by the plan that will require replacement in the next 40 years; and affordability of the plan, now and in the future.

The Project Delivery Team (PDT) will consider these uncertainties, conduct further Regret and Adaptation Analysis, and review public comment on the draft report to make changes to the Recommended Plan and to develop a more refined Phasing Plan and revisions to the MAP during the design phase.

In developing the Recommended Plan, the PDT used 2040 and 2090 as planning-level proxies for First and Subsequent Actions. Using the Future Without Project and Future With Project conditions risk and comprehensive benefits analyses, the PDT arrived at the Recommended Plan with a series of First Actions to address 1.5 feet of RSLC, with a range of potential Subsequent Actions to address higher rates of RSLC through the end of the Period of Analysis. Both the First and Subsequent Actions were drawn from the existing alternatives.

To address the uncertainties detailed above within the Recommended Plan, the PDT proposes to continue applying a Regrets and Adaptation Analysis. An initial regrets analysis was undertaken in developing the Recommended Plan and will be refined as the project advances to support decision-making about the cost and scale of First and Subsequent Actions.

The analysis completed to date considered the regret of over- or underinvestment in response to increasing risks based on the USACE Low, Intermediate, and High RSLC scenarios (**Figure G-1)**, and the high current seismic risk.



Source: Sea Level Analysis Tool (USACE 2026)

All projections are baselined to the year 2000 for the purposes of illustration. Inputs for analysis were developed in accordance with USACE requirements, detailed in Annex B.1.1 Coastal Extreme Water Levels and High Tide Flooding .

Figure G-1: USACE RSLC Scenarios

Examples of regret of overinvestment that were considered include:

- Negative net benefits associated with construction of plan features too far in advance of RSLC increasing floods to the design water level
- Introducing future coastal life safety risk by raising the existing shoreline where retreat from the future floodplain is a viable option
- Inability for the current generation to pay (e.g., insufficient funding in the USACE annual budget or insufficient local capital funding for the coastal and combined flood risk management project local match and/or required Hazardous, Toxic, and Radioactive Waste (HTRW) cleanup activities)

Examples of underinvestment that were considered include:

- Substantial monetary and non-monetary damages due to coastal flooding overtopping the shoreline (high residual risk)
- Failure to address seismic life safety risk in vulnerable structures along the shoreline

- Loss of historic resources before planned wharf replacements
- Non-adaptive initial investment
- Inability for a future generation to pay

In the plan refinement phase of the study, the PDT will further develop the regrets analysis and undertake an adaptation analysis. The PDT intends to use this Regrets and Adaptation Analysis to shape a final recommendation regarding Federal and local investment in a coastal and combined flood risk management system by:

- Examining first and possible subsequent adaptation actions and the scaling (sizing) of these actions
- Considering both phasing and anticipatory (precautionary) actions given the uncertainties
- Developing defined triggers to begin design or construction of subsequent adaptation actions

This additional analysis will allow the PDT to develop a Phasing Plan with adaptation pathways and defined triggers for subsequent action that can be considered as part of the Recommended Plan.

The adaptation analysis will include an examination of the timing of subsequent adaptation actions, the lead time to design and construct those actions, and when design or construction work needs to start given the projected performance of adaptation actions under the USACE Low, Intermediate, and High RSLC scenarios.

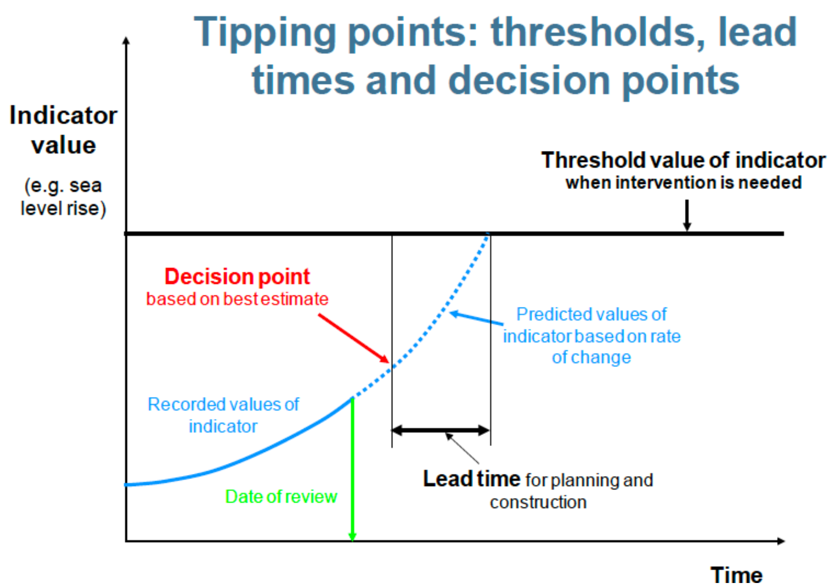
The current state of RSLC science has a level of uncertainty that does not allow the PDT to recommend one RSLC scenario to inform scaling of actions and phasing, which is consistent with study guidance. Certainty on the rates of RSLC will improve over time and the PDT expects the Federal government and the State of California to continue to publish new guidance related to RSLC projections with increasing levels of confidence to support decision-making, reinforcing the need for a flexible decision-making framework.

Based on current science, the Low, Intermediate, and High RSLC scenarios do not produce significant differences until between 2040 and 2050 (**Figure G-1**). With improving science and understanding of emissions in the coming decades, it is reasonable to assume that between 2040 and 2050, USACE and POSF will have greater certainty about the actual RSLC trajectory.

When assessing the trigger points to plan for the Subsequent Actions, it is important to understand and consider the timescales for planning, design, construction, and acquisition of funding to estimate a “lead time.” **Figure G-2** depicts how to consider lead time in an adaptation framework.

The PDT estimated an initial lead time that suggested if the RSLC tracks the projected High USACE rate of rise, USACE would need to request, and Congress would need to authorize and appropriate funding, for the design of the Subsequent Action(s) before the construction of the First Actions are completed. Furthermore, the recommendation would need to be authorized, and funding appropriated before any RSLC monitoring program may signal that the rate of rise is tracking on the High USACE RSLC curve.

This finding suggests considering a range of precautionary (anticipatory) actions in the Recommended Plan. This finding also suggests phasing and scaling of adaptation actions in a manner that allows both the Federal and non-Federal Sponsor sufficient time to program the financial resources needed to execute subsequent adaptation action(s).



Source: (USACE 2019a)

Figure G-2: Impacts of Thresholds and Tipping Points on Future Decisions

The regrets analysis will continue to examine the regret of overinvestment and underinvestment, with a primary focus on First Actions and Subsequent Actions in the Recommended Plan, to shape a final recommendation for consideration by decision-makers.

As the PDT continues to work on the regret analysis, the intent is to assess the following uncertainties and external factors that may influence an economically efficient adaptation pathway:

- The effect of different RSLC scenarios and the potential for over- or underinvestment
- The spreading of investment over time to make it affordable to this and future generations
- An early action that precludes a preferable future action (such as raising the shoreline now and preventing a future retreat scenario)

- Coastal life safety risk if new Coastal Storm Flood Management adaptations are holding back the tide on a regular basis, where breach due to earthquake or overtopping might lead to risk to life, and options exist for reducing this risk through targeted retreat actions
- The opportunity to combine flood and seismic risk management that would lead to improved life safety and reduced earthquake damages
- The residual life of the assets along the shoreline and the potential loss of historic resources due to asset deterioration prior to a robust shoreline intervention
- Inability to adapt the First Actions to accommodate the actual rate of RSLC

2.0 Implementation Strategy

As a multi-billion-dollar project, significant Federal and local resources will be allocated to implement the Recommended Plan components and adaptations that address risk ahead of its arrival. The implementation strategy is flexible but structured to support responsive action under changing conditions. It allows for adjusting implementation based on available funding while addressing areas with highest impact first. The implementation strategy is informed by four components (**Table G-1**): Phasing Approach, Early Resilience Actions (ERAs), the MAP, and the Authorization Recommendations.

Table G-1: Implementation Strategy Overview

Implementation Strategy Component	Role in Implementation Strategy
Phasing Approach	The Phasing Approach is a decision framework to enable prioritized, incremental construction of First Actions for cost-effective risk reduction when construction of the entire array of First Actions at once (consistent with the engineering recommendation) is not possible due to limitations such as funding or access. It establishes a process for developing a hierarchy of construction, based on coastal flood risk, fair treatment of all communities, and additional phasing criteria. It provides an approach to support construction decision-making in the design phase, while remaining flexible to respond to uncertainty in funding streams and other changing conditions. The PDT designed the Phasing Approach to achieve cost-effective risk reduction for First Actions.
ERAs	The candidate ERAs propose predefined increments of the Recommended Plan that meet the guiding principles and will facilitate its construction under constrained implementation conditions. ERA identification was informed by the Phasing Approach (above), with an emphasis on the areas with highest risk and consideration of implementation complexity (e.g. where projects could be delivered relatively quickly, or where projects could become critical path).
MAP	The MAP is a defined process to monitor risk and support decision-making for successful implementation of Subsequent Actions, thereby delivering the benefits of the Recommended Plan through input from a technical team. It includes the creation of an AMT, a monitoring program, and a reporting and decision-making process. The PDT designed the MAP to achieve cost-effective risk reduction for Subsequent Actions, which may prove to be a crucial component of providing equitable protection throughout the study area. Depending on the rate of RSLC, components of the monitoring program could influence the timing or design of First Actions.

The principles guiding the implementation strategy support the planning goals identified during for this study. The implementation strategy guiding principles are to:

- Address risk at the right time and prioritize immediate flood vulnerability
- Achieve cost-effective risk reduction measures
- Apply innovative approaches to address complex challenges
- incorporate fair treatment of communities in decision-making
- Leverage interagency participation and cost sharing in proactive resiliency investments
- Use a systems approach to flood risk

The implementation strategy establishes adaptive action processes and decision points to facilitate continued refinement of Recommended Plan features and construction timing, consistent with the formulation process documented in this MAP. It also establishes a monitoring program to track and assess risk conditions, with the potential to facilitate cross-agency participation in resilience planning. It is impractical to prescribe specific conditions or agency priorities for project implementation 30 to 40 years into the future. Consequently, the implementation strategy defines the overarching strategies, priorities, and processes to make and defend future adaptation decisions and refinements that ensure that Subsequent Actions achieve the risk reduction function and comprehensive benefit performance anticipated in the Recommended Plan.

3.0 Phasing Approach

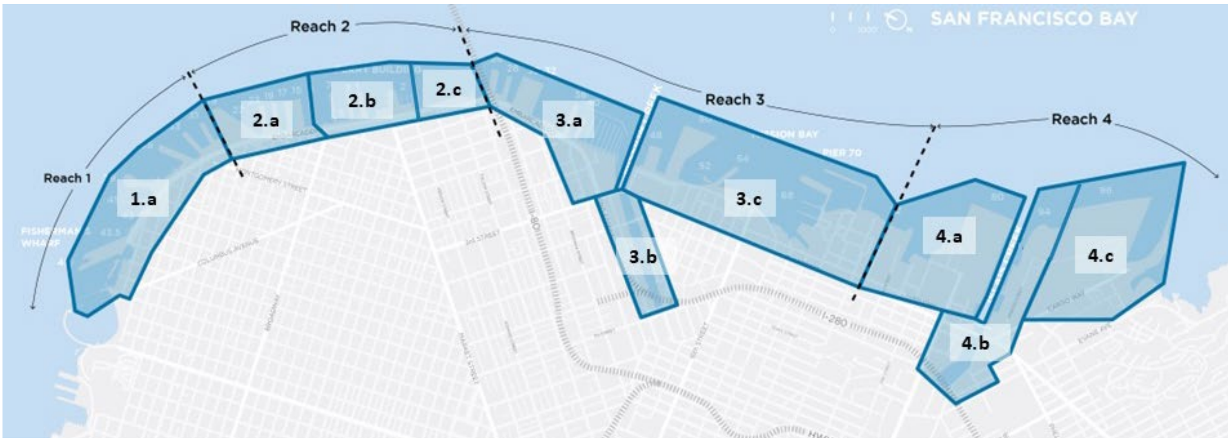
The Phasing Approach creates a decision framework to enable prioritized, incremental construction of the First Actions of the Recommended Plan. It supports decision-making under scenarios where local or Federal funding for design and construction is received in increments rather than a funding stream to construct all First Actions at once. The Phasing Approach also affords flexibility under circumstances that may support phased construction to increase cost effectiveness or reduce disruption by aligning construction with other investments in the project area. This section will describe the approach for phasing construction of the First Actions. However, the ultimate order of phases and sequencing of specific actions will be developed in the design phase. The Phasing Approach includes four steps to be completed during the design phase:

- Step 1) **define geographic subunits** to be phased over time
- Step 2) **establish criteria and ratings** for each subunit for each criterion
- Step 3) **prioritize geographies** using the completed phasing criteria to identify the preferred order of subunits for construction
- Step 4) facilitate a **decision-making** process to confirm the Phasing Plan and advance into detailed construction sequencing.

The approach is intended to be iterative (e.g., the order and boundaries of subunits can be adjusted as conditions change).

3.1 Step 1: Geographic Subunits

There are an infinite number of ways to subdivide the waterfront for phasing. With every approach, there will be critical infrastructure that crosses boundaries and will require careful consideration. The PDT developed draft geographic subunits to support phasing (**Figure G-3**). The PDT developed draft subunits primarily based on shoreline elevation and considerations related to hydrologic connectivity, while recognizing the subunits are not entirely hydrologically separable from one another. Where appropriate, the PDT adjusted draft subunit boundaries to align with the interface between measures to support efficient construction (rather than ending a subunit just a short stretch before the end of a given seawall or levee, for example). The reference number of the subunit does not correspond to priority or construction sequence; it is for identifying a discrete subunit. In the design phase, the Design PDT will confirm or refine the geographic subunits. The Design PDT will also consider the implementation timing of relevant interior drainage and other utility components of the Recommended Plan.



Subunit reference numbers (e.g., 1.a, 4.c) do not indicate order or priority. Subunit boundaries can be updated iteratively. Draft subunit boundaries are defined by reach boundaries, coastal flood risk, and measure type in the Recommended Plan.

Figure G-3: Draft Geographic Phasing Subunits

3.2 Step 2: Criteria and Rating

The PDT developed draft prioritization criteria and two draft datasets to support rating of each subunit. The criteria reflect the implementation strategy guiding principles. In the design phase, the Design PDT will confirm or refine the full list of criteria to prioritize implementation of each geographic subunit. During the design phase, each criterion will be examined in isolation and then compared with other criteria.

The draft prioritization criteria include:

- **Near-Term Coastal Flood Risk** (priority for earlier construction in areas that will reduce risk to people, economy, and environment)
- **At-Risk Critical Infrastructure and Other Risk Factors** (priority for earlier construction in areas that will reduce risk to at-risk critical infrastructure and minimize related economic, environmental, and social impacts; may also prioritize areas where shoreline infrastructure is older or in poorer condition)
- **Socioeconomic Benefits** (priority for earlier construction in areas where the First Actions will provide socioeconomic benefits)
- **Coordination with Development and Infrastructure** (advancing or delaying construction to align with that of adjacent development or infrastructure projects to minimize disruption or maximize efficiency)
- **Complexity** related to:

  - **Environmental Compliance, HTRW, Engineering, and Real Estate** (advancing or delaying construction based on expected length of environmental regulation and permitting processes, HTRW cleanup, technical engineering, and real estate acquisition)
  - **Systems and Separability** (advancing or delaying construction based on the interrelationships between the zones, such as utility and transportation infrastructure that crosses subunit boundaries, dependences between and within the subunits, and challenges at the transition at the interface between two subunits where one is constructed before the other)
- **Governance and Funding** (advancing or delaying construction based on anticipated funding availability and timing, including assumptions or agreements about which agencies are funding which elements of the work in a subunit)
- **Avoided Disruption** (advancing or delaying construction to reduce construction disruption to residents, tenants, businesses, commuters, and the public)
- **Public Input on Phasing and Construction** (considering public feedback from POSF and City engagements in determining phasing of the geographies) Public input may reveal impacts or values that are unknown to the Design PDT; dialogue will happen during the design phase

3.3 Step 3: Subunit Prioritization

The PDT did not define a prioritized order of the subunits for all First Actions (i.e., a draft Phasing Plan) to avoid setting phasing expectations in advance of a public engagement process on phasing and construction. In addition, while substantial data is available at the time of the study, some criteria (such as those related to local and Federal funding and coordination with adjacent projects) are timely in nature, thus it may be premature to establish a meaningful Phasing Plan prior to the design phase.

The Design PDT will review the completed criteria ratings and use cross-disciplinary discourse and public input to determine the recommended phasing (order of construction) of the subunits. The Design PDT will conduct a preliminary draft phasing order based on the coastal flood hazard criterion, and then adjust this initial order based on the remaining criteria. This prioritization process will be iterative, and POSF and City envision soliciting public input throughout the process.

Step 3 applies a similar approach to project phasing as was used for identifying the Recommended Plan. Experts across multiple disciplines will review the criteria ratings and identify the most reasonable order of the subunits.

3.4 Step 4: Decision-Making on Phasing Plan

Once the recommended phasing of subunits has been proposed by the Design PDT and informed by a public process, USACE and POSF leadership will review and confirm the prioritized order of subunits (Phasing Plan) and the Design PDT will advance into more detailed construction sequencing and analysis to support further design, permitting, environmental review, and construction.[1] For the Non-Federal Sponsor, POSF and City leadership should discuss and agree on the Phasing Plan with consideration of how it impacts major infrastructure systems and communities. The Phasing Plan will be iterative and may be revisited as conditions change over time. The PDT also identified ERAs (Section 4.0) to advance incremental projects before a Phasing Plan for all First Actions is complete. USACE and POSF leadership will validate and approve the Phasing Plan, consistent with USACE and POSF priorities.

4.0 Early Resilience Actions

The ERAs, or early actionable elements, are segments of the Recommended Plan that meet the guiding principles and will facilitate its construction under constrained implementation conditions. These segments may be initiated first, reducing near-term risk and delivering other early benefits. While the Phasing Approach establishes criteria to successfully carry out the project through design and construction, ERAs support expedited risk reduction when implementation is constrained in any way (e.g., funding and acquisitions). One or more ERAs may be comparable to the first few actionable elements of the Phasing Approach. ERAs also reflect the PDT's recognition of the need to identify areas that can move quickly to design and construction to address near-term flood risk to critical infrastructure and facilities and provide early opportunities to pilot innovative approaches to address complex challenges.

The PDT considered areas with higher near-term flood hazards (**Figure G-4**) alongside the other phasing criteria (Section 3.2), and the implementation strategy guiding principles. The team also considered three potential programmatic motivations to advance a portion of the Recommended Plan as an ERA: (1) the candidate ERA presents an opportunity to reduce risk quickly (e.g., high-risk area, short lead time, less disruptive, less complex); (2) the candidate ERA may become critical path to deliver the First Actions of the Recommended Plan; and (3) the candidate ERA presents an opportunity to strategically leverage other public and private resources (thus greater efficiency) through coordination with capital or development projects. The PDT identified three candidate ERAs to be further refined and confirmed during Preconstruction Engineering and Design (PED) (**Figure G-5**).

[1] Each subunit may constitute multiple construction projects.

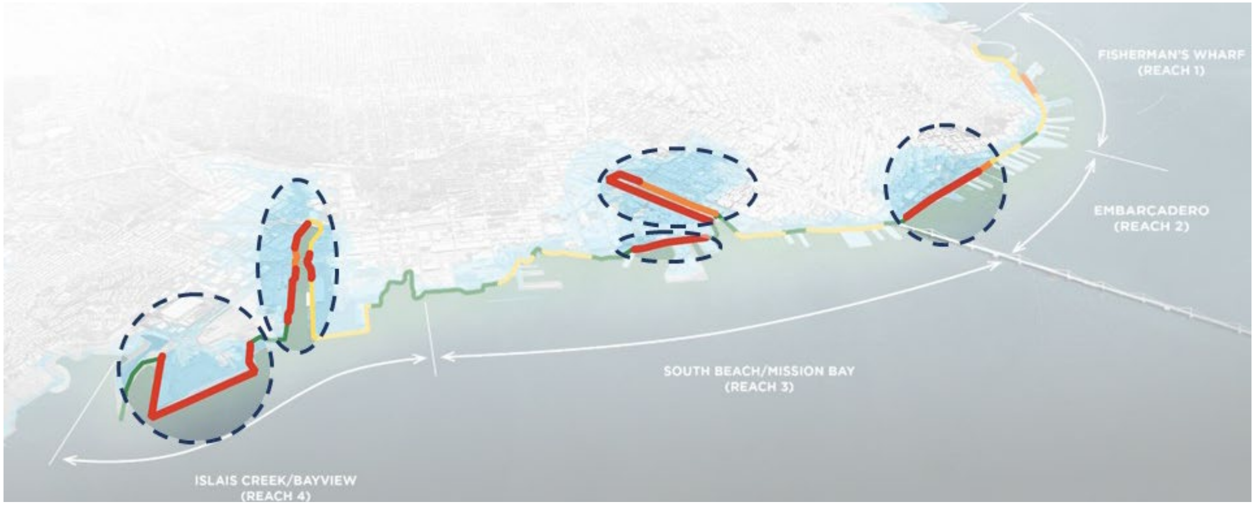


Figure G-4: Areas with Higher Near-Term Flood Hazard

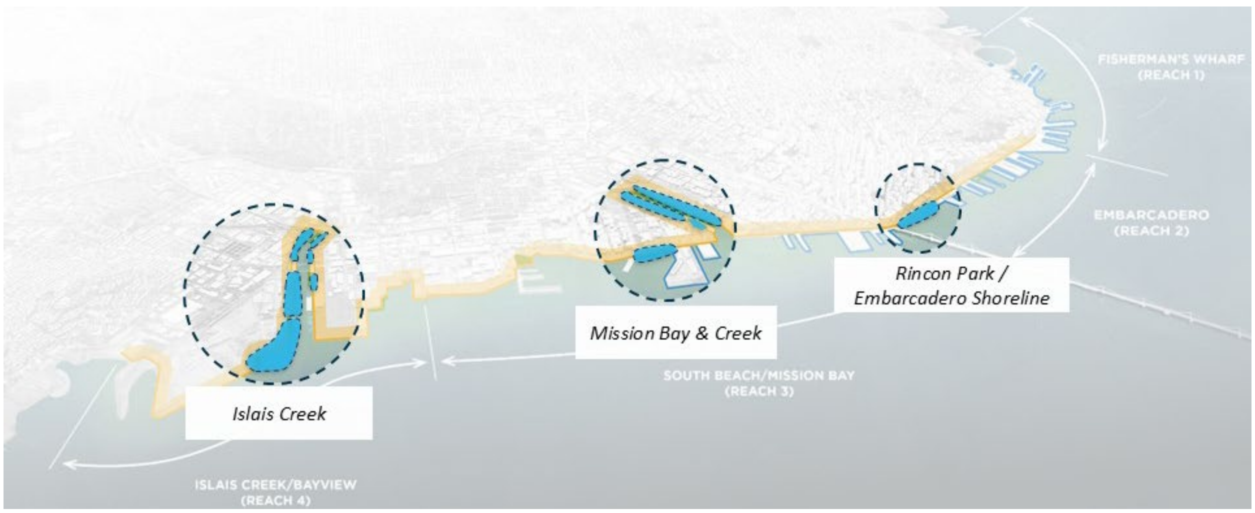


Figure G-5: Candidate ERAs

From north to south, these include:

- **Rincon Park / Embarcadero Shoreline (approximately Pier 14 to Pier 22.5)**: ERA may include a raised and rebuilt bulkhead seawall, ground improvement, natural and nature-based features, elevating buildings, interior drainage infrastructure, and concrete curbs around pier perimeters. The PDT prioritized this area as a candidate ERA primarily because of the following characteristics:
  - Low-lying area with near-term coastal flood risk
  - Critical local and regional assets at risk (e.g., BART and Muni tunnels)
  - Lower construction disruption (minimal impacts to roadway)

    - Opportunity to pilot engineering and construction approaches in an area with complex subsurface conditions

- **Portion(s) of Mission Bay and Creek**: ERA may include levees, floodwalls, ground improvement, closure structures, natural and nature-based features, floodproofing buildings, and interior drainage infrastructure. The PDT prioritized this area as a candidate ERA primarily due to the following characteristics:
    - Low-lying areas with near-term coastal flood risk
    - Critical assets at risk (e.g., wastewater infrastructure and transportation facilities)
    - Construction in the portion of Mission Bay just south of Pier 50 is separable from other First Actions and has relatively low systems complexity
    - Construction in some areas along the creek may be associated with long lead time (e.g., due to HTRW or real estate considerations), pending further investigation in PED or beyond; potential for this area to become critical path for completing construction of entire First Actions
- **Portion(s) of Islais Creek**: ERA may include levees, floodwalls, raised and reconstructed portion of wharves; ground improvement; closure structures; natural and nature-based features; removal of select buildings that straddle the coastal defenses; interior drainage infrastructure. The PDT prioritized this area as a candidate ERA primarily because of the following characteristics:
    - Low-lying areas with near-term coastal flood risk
    - Critical assets at risk (e.g., wastewater infrastructure and transportation facilities)
    - Construction in some areas along the creek may be associated with long lead time (e.g., due to HTRW or real estate considerations), pending further investigation in PED or beyond; the potential for this area to become the critical path for completing construction of the entire First Actions

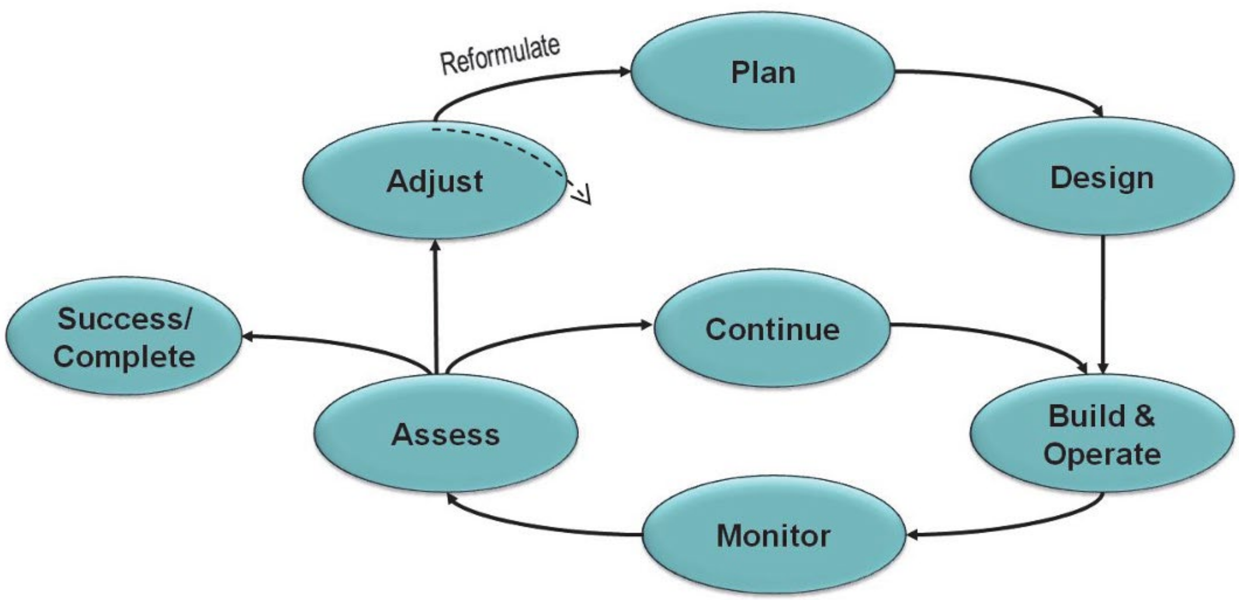
These potential ERAs are subject to change through ongoing discussion and potentially public input. Any ERAs selected in PED remain subject to all requirements related to environmental compliance and permitting processes as well as any necessary agreements between USACE and POSF.

5.0 Monitoring and Adaptation Plan

The MAP establishes a process to monitor risk and support decision-making for successful implementation of Subsequent Actions, delivering the benefits of the Recommended Plan over time. It includes the creation of an AMT, a monitoring program with associated metrics and decision thresholds, assessment and reporting guidance, and a decision-making framework. The MAP is primarily designed to support decision-making for Subsequent Actions. However, the monitoring program may inform implementation of First Actions, especially if RSLC is trending high (Section 5.4).

5.1 Adaptive Management and Adaptive Risk Reduction

The PDT developed the MAP based on the principles of adaptive management used for ecosystem restoration projects. Adaptive Management, as defined by the USACE Engineer Research and Development Center (ERDC) TN-EMRRP-EBA-10, "is a process wherein management actions can be changed in response to monitored system response, so as to maximize efficacy or achieve a desired ecological state" (USACE 2012). The basic steps and how they are interconnected within an adaptive management plan are outlined on **Figure G-6**. Combining the adaptive management approach with the concept of adaptive risk reduction as described in EP 1100-2-1 (USACE 2019a), this study takes a similar approach to maintain performance of the system and keep risk below a defined risk threshold.[2]



Source: (USACE 2012)

Figure G-6: Steps in Adaptive Management

[2] This combined approach seeks to maintain performance of the system and keep risk below a defined risk threshold, whereas the traditional adaptive management approach seeks to achieve a desired ecological state.

5.2 MAP Process Overview

The MAP process begins in the design phase and culminates with construction of Subsequent Actions. In line with the adaptive risk reduction approach described in EP 1100-2-1 (USACE 2019a), the process is designed to complete construction of Subsequent Actions before the arrival of the risk threshold defined by performance criteria described in Section 5.4.

The process begins with the AMT monitoring the study area to determine when the combination of physical and social conditions warrant action, acting like a trigger point in the overall process. Given the complexity of the study area and the broad suite of metrics informing this trigger point, the PDT referred to this moment as the Adaptation Confirmation Threshold (ACT): the instance in which the AMT confirms that multi-metric conditions indicate the need to initiate design for adaptations to maintain the desired level of performance of the Recommended Plan (Section 5.4). The AMT presents the justification for the ACT in a report to USACE and POSF leadership, and leadership decides whether they agree that it is time to act or hold for additional information or changing conditions (**Figure G-7**).

Once USACE and POSF leadership agree that combined conditions reach the ACT, leadership directs a multidisciplinary PDT to develop a Project Adaptation Report (PAR). The PAR is a new reporting vehicle designed to document updates to the Subsequent Actions based on changed conditions and to validate how the refined Subsequent Actions deliver the desired performance of the Recommended Plan (Section 5.5). Once the PAR is complete and approved, it will be sent to the U.S. Congress for authorization. The project can then advance to design and construction (**Figure G-8**). Supplemental NEPA and environmental compliance consultations would be completed for the Subsequent Action measures prior to construction.

Figure G-7: MAP Process (1 of 2): Monitoring and the ACT

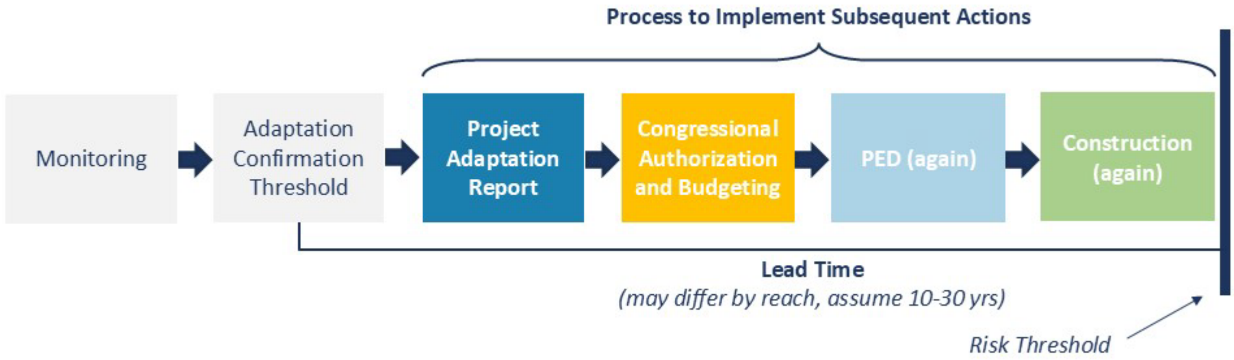


Figure G-8: MAP Process (2 of 2): Process to Implement Subsequent Actions

5.3 Adaptation Management Team

The AMT will be a multidisciplinary, technical body responsible for monitoring, synthesizing results, and reporting to USACE and POSF leadership. The AMT will be chartered at the start of the design phase and led by USACE and POSF. USACE and POSF may invite other agencies to serve on the AMT.

The AMT will coordinate monitoring, assist in the evaluation of monitoring data and adaptation planning, and provide technical expertise and recommendations to USACE and POSF. USACE and POSF leadership have final determination on all actions and adaptations recommended by the AMT. USACE and POSF staff are responsible for ensuring that monitoring data and assessments are properly used in the decision-making process. They are also responsible for project documentation, reporting, and external communication.

The AMT communication structure will be included in the AMT charter that will be developed. It is envisioned that the AMT would meet at least once per year to coordinate monitoring, assess interim results, and discuss potential adjustments to the MAP. The AMT will produce a Synthesis Report no less than every 5 years for USACE and POSF leadership review.

5.4 Monitoring Program

The monitoring program includes monitoring objectives, a monitoring period, a suite of monitoring metrics and associated risk equation to determine when to act, and reporting requirements.

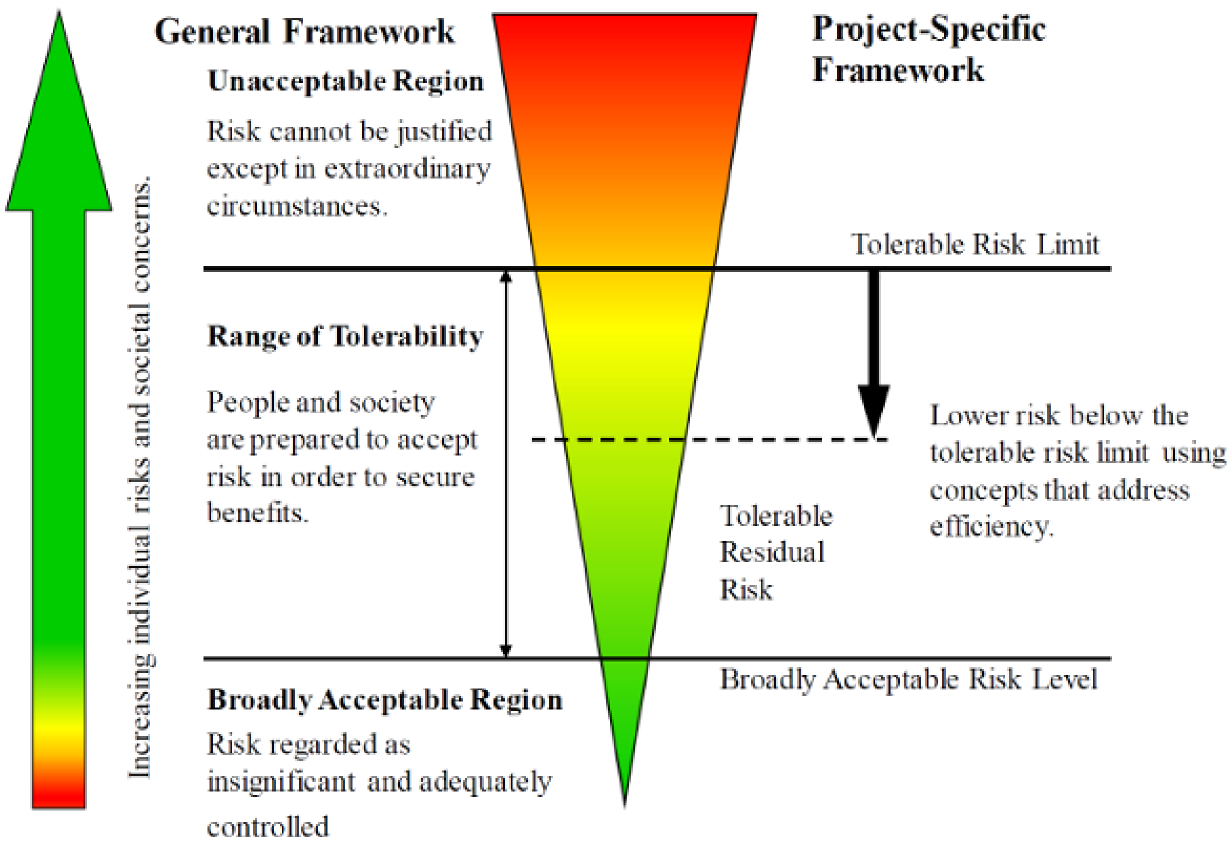
The PDT structured the monitoring program similar to that of a monitoring and adaptive management plan for ecosystem restoration. However, there are differences due to the project mission/authority and the complexity of changing risks and conditions in the study area. Key differences include:

- <u>Risk Equation to Determine Action</u>: An adaptive management plan for ecosystem restoration includes performance measures (desired effects) and risk endpoints (undesired effects), each with an associated metric, and action criteria (or triggers) for each metric. This project requires a *risk equation* to determine when the combined measurable conditions have reached the ACT (i.e., the moment at which leadership must make a decision to have enough time to implement Subsequent Actions before the risk threshold is exceeded). The ACT is like a multi-metric trigger.

- <u>Emphasis on Data Synthesis</u>: Physical monitoring for all metrics is already underway through cross-agency Federal efforts, State programs, and local research. This project requires gathering and synthesizing the latest results, rather than conducting new physical monitoring, in most cases.
- <u>Monitoring Program Development and Implementation:</u> As described in ERDC TN-EMRRP-EBA-10, a "key to developing the monitoring plan is to match the level of the monitoring effort to the needs of management for decision-making" (USACE 2012). An adaptive management plan for ecosystem restoration requires a detailed monitoring plan and data management plan at the feasibility stage. This project requires less detail at the feasibility stage, primarily focused on the process, decision-making framework, the suite of metrics, and the risk equation to determine when conditions have reached the ACT. The AMT will be chartered early in the design phase, and the AMT will elaborate on the detail required for the monitoring plan and for data management. Like adaptive management for ecosystem restoration, details of the monitoring program can be iteratively updated over time.

5.4.1 Monitoring Program Objectives: Risk Threshold and the Performance of the Recommended Plan

As described in RMC-TR-2021-05, the concept of tolerable risk (**Figure G-9**) is integral to the concept of risk-informed decision-making. "USACE has elected to require that decision-makers consider information – often subjectively – that cannot easily be included in calculations within the decision regarding tolerability" (USACE 2021). The tolerable risk threshold (tolerable risk "limit" on **Figure G-9**) is a conceptual threshold that may vary from person to person, and it is up to decision-makers to determine how to define and manage to it based on context-specific conditions.



Source: RMC-TR-2021-05 (USACE 2021). It was adapted and modified from a figure in ER 1110-2-1156 (USACE 2014), which was derived from the Health and Safety Executive framework for the tolerability of risk (HSE 2001).

Figure G-9: Tolerability Framework

For the purposes of this monitoring program, the PDT defined the tolerable risk threshold for the entire study area as low consequences for people, economy, and ecology in the event of a 1% annual exceedance probability (100-year) coastal flood event. Residual risk – due to less frequent, higher magnitude coastal flood events – was considered tolerable.

Therefore, the **primary objective** of this monitoring program is to identify when leadership must make decisions to have sufficient lead time to implement Subsequent Actions *before* the study area reaches the tolerable risk threshold.

The **secondary objective** of this monitoring program is to identify when leadership must make decisions to implement Subsequent Actions in time in the name of efficiency (efficient use of public resources and reduced construction disruption).

The PDT structured this monitoring program to match the level of effort to the needs of management for decision-making. For example, the AMT is not expected to conduct a detailed risk analysis comparable to the evaluation performed for comprehensive benefits every 5 years. Rather, the risk conditions will be approximated based on the best-available understanding of changes to the hazards, the built environment, and social and environmental conditions.

5.4.2 Monitoring Period: Maintaining Performance throughout the Period of Analysis

The monitoring period begins early in the design phase once the AMT is chartered. It extends until the AMT and USACE and POSF leadership agree that the performance of the Recommended Plan has been sufficiently addressed for the Period of Analysis (2040-2140).

5.4.3 Suite of Monitoring Metrics, Risk Equation, and Database Management

Monitoring Metrics: The AMT will monitor the following metrics to determine when the ACT has been reached. **Table G-2** indicates whether AMT monitors the metric via desktop review of forthcoming reports (desktop) or via consultation with Federal, State, and local experts (consultation). Some metrics may be listed for consultation that are eventually incorporated into standard reporting processes and would convert to desktop review in the future.

Metrics with an asterisk (*) are part of the conceptual risk equation used to support the AMT's determination of the ACT.

Table G-2: Monitoring Metrics and Data

Metric	Data and Description
Relative Sea Level Change* (desktop)	Desktop review of Sea Level Rise Interagency Task Force Reports, Data, and Interactive Tools. Observation-based extrapolations for both the Presidio gauge and for the Southwest Region (i.e., California Coast), 20-30 years into the future, based on tide gauge data and altimetry. Both are available directly through the Sea Level Rise Interagency Task Force data tool. This dataset reflects the effects of vertical land movement (not neighborhood scale).
Neighborhood-Scale Subsidence* (consultation)	Regional subsidence estimates incorporated in RSLC trajectory will not capture neighborhood-scale subsidence. Recommend consulting with local and regional experts for the latest neighborhood scale subsidence conditions, trends, and extrapolations.
1% Extreme Tide Magnitude* (desktop)	Desktop review of National Oceanic and Atmospheric Agency / National Aeronautics and Space Agency (NOAA / NASA) published estimates for the Presidio tide gauge. Federal agencies have approved these estimates and will update them using approved methodology. NOAA / NASA updates consider non-stationarity.
Pacific Coast Wave Dynamics* (consultation)	Emerging science from Federal agencies (may be included in next Task Force update). There is growing evidence that Pacific Coast waves are growing larger, and this will impact the long-period swell waves propagating through the Golden Gate.

Metric	Data and Description
Wind-Driven Wave Dynamics* (consultation)	Emerging science from Federal agencies (may be included in next Task Force update). Based on the storms in 2021, 2023, and 2024, there is evidence that windspeeds are increasing with extratropical cyclones and especially cyclone bombs. This would increase wind-driven waves in the Bay.
Climate Science and Projections* (desktop)	Desktop review of National Climate Assessment (U.S. Global Change Research Program). RSLC is influenced by global phenomena, including but not limited to greenhouse gas emissions and ice sheet melting. There is a lag between major shifts in emissions and other drivers compared to when they create a change in relative sea level. Therefore, the monitoring program includes a high-level desktop review of the latest climate science and projections to incorporate consideration of any major findings into decision-making for implementation of Subsequent Actions.
Development and Infrastructure Projects (consultation)	Consultation with City and regional partners on development and infrastructure projects overlapping with or adjacent to the project area.
Changes in Built Environment and Policy* (consultation)	Consultation with City and regional partners on land use changes, zoning changes, and other changes to the build environment that affect risk.
Other Events and Conditions* (consultation)	Consultation with Federal, State, and local partners to consider the implications of events that influence coastal and combined flood risk in the project area, such as a major disaster or damage to the coastal flood defense structure.

Risk Equation: As described in ER 1105-2-101 (USACE 2019b), in the context of coastal flood risk management, flood risk can be conceptualized as a function of the hazard, performance (of a structure such as a levee or seawall), exposure, vulnerability, and consequences. The AMT will use this conceptual risk equation in determining whether the combined conditions have reached the ACT.

Data Management: The AMT will develop a shared space and protocols for data management and data sharing as part of their charter. The nature of the data for this project (all desktop and consultation) warrants a streamlined approach to data management.

5.4.4 Use of Monitoring Results and Analysis: Recognizing the Adaptation Confirmation Threshold

The AMT is responsible for synthesizing monitoring results and determining whether conditions have reached the ACT. Unlike the performance measures within an adaptive management plan for ecosystem restoration, the ACT is determined by the combination of metrics and how they relate to one another. The ACT is also dependent on the anticipated lead time to conduct the process to implement Subsequent Actions.

For the feasibility study, the PDT assumed the lead time for Subsequent Actions may range between 10 and 30 years. The AMT may refine this estimate as conditions change over time, and USACE and POSF leadership will confirm whether the combined conditions reach the ACT.

There are three overarching condition types under which combined conditions could reach the ACT:

- Type 1: Gradually Increasing Risk
    - Example: Risk equation (RSLC extrapolations combined with other physical conditions) suggests conditions will exceed the risk threshold within 30 years.
- Type 2: Opportunity for Efficiency with Gradually Increasing Risk
    - Example: Risk equation (RSLC extrapolations combined with other physical conditions) suggests conditions will exceed the risk threshold within 30 years AND there is a major infrastructure or development project that overlaps the study area planned for construction in 10 years.
- Type 3: Sudden Increase in Risk
    - Example: A barge collision damages a portion of the existing coastal flood defense structure AND risk equation (RSLC extrapolations combined with other physical conditions) suggests conditions will exceed the risk threshold within 30 years.

The AMT can demonstrate in the Synthesis Report what conditions contribute to the ACT, including assumptions regarding lead time for decision-making and the process to implement Subsequent Actions. In addition, early monitoring results may inform the design of First Actions.

5.4.5 Response Options: Subsequent Actions

The range of Subsequent Actions includes proposed actions under a range of RSLC scenarios. Subsequent Actions may include elevating, floodproofing, or retiring buildings and infrastructure; increasing the crest elevation of First Action features; constructing new bulkhead walls and wharves; constructing additional infrastructure to manage interior drainage issues exacerbated by the coastal flood defense; and incorporating natural and nature-based features.

The PDT developed proposed Subsequent Actions to deliver the full benefits of the Recommended Plan during the Period of Analysis. The future project team will update and refine these Subsequent Actions informed by the monitoring and study area conditions at the time.

The AMT must include sufficient lead time to allow for a range of reasonable Subsequent Actions based on current conditions. The AMT is a technical body focused on determining and demonstrating that combined conditions have met the ACT. The AMT is not responsible for proposing specific Subsequent Actions measures as part of their Synthesis Report or validating that proposed Subsequent Actions will achieve the desired performance of the Recommended Plan. This is instead the role of the future project team charged with developing the PAR (Section 5.5).

5.5 AMT Assessment and Reports

The AMT will synthesize monitoring results throughout the monitoring period and produce a Synthesis Report for USACE and POSF at least every 5 years. The AMT will confirm detailed protocols for the Synthesis Report. At a minimum, each report will include an update of the current conditions for every available metric, a summary of changes to level of risk in the project area using the conceptual risk equation and how it relates to the risk threshold, changes to assumptions regarding lead time, and any recommendations for adjustments to the monitoring program.

When the AMT concludes that combined conditions have reached the ACT, the Synthesis Report will also demonstrate and justify how the ACT has been reached, including the physical and social conditions and the assumptions regarding lead time.

5.6 Decision-Making on Subsequent Actions

USACE and POSF leadership are the decision-makers for the recommendation to initiate design and construction of Subsequent Actions of the Recommended Plan. Informed by the AMT Synthesis Reports, USACE and POSF leadership are responsible for confirming that combined conditions have reached the ACT and that it is time to form a multidisciplinary future project team to develop a PAR. The PAR will include:

- Performance Criteria: Clear statement of the performance criteria that Subsequent Actions must meet to deliver the full benefits of the Recommended Plan, as originally defined in the IFR/EIS, and clarifying performance criteria to align with best practice. Performance criteria for Subsequent Actions include minimal risk to the economy, society, and environment under the 1% annual exceedance probability coastal flood event through the end of the Period of Analysis. Any coastal flood defense system created through this project must meet the latest USACE flood and seismic performance criteria. This includes consideration of pedestrian and structural safety overtopping thresholds.
- Summary of Conditions: Summary of updates to study area conditions.
- Refined Actions: Description of refined Subsequent Actions and updated cost estimates.
- Validation: Documentation of how the Subsequent Actions will achieve the performance criteria and deliver full benefits of the Recommended Plan.
- Implementation Plan: Documentation of specific sequencing of the features proposed for implementation in response to risk conditions. The plan will include engineering considerations of the dependencies and efficient order for construction. It will incorporate any study area constraints or opportunities such as access, conflicts, and disruption avoidance.

5.7 MAP Costs

The project first cost includes the costs of the Monitoring and Adaptation Plan at a total cost of $75,746,000. This estimated cost to implement the MAP is referred to as "Adaptive Management & Monitoring" in *Attachment C-1: Recommended Plan First Actions*. It was estimated as 0.7% of the construction first cost and included in the Planning, Engineering and Design Account. This estimate is sufficient to fund participation on the AMT, development of PARs, monitoring, development of synthesis reports, and monitoring of natural and nature-based features.

6.0 References

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