



MEMORANDUM

September 18, 2020

TO: MEMBERS, PORT COMMISSION
Hon. Kimberly Brandon, President
Hon. Willie Adams, Vice President
Hon. Gail Gilman
Hon. Doreen Woo Ho

FROM: Elaine Forbes
Executive Director 

SUBJECT: Informational presentation regarding the Embarcadero Seawall Multi-Hazard Risk Assessment, public engagement, and seismic and flood measures for the Embarcadero Seawall

DIRECTOR'S RECOMMENDATION: Information Only – No Action Required

EXECUTIVE SUMMARY

This report provides key findings from the Embarcadero Seawall Multi-Hazard Risk Assessment (MHRA), a summary of feedback from the Waterfront Resilience Program (Program) public outreach and an overview of seismic and flood mitigation measures currently under development to provide the tools necessary to identify the Proposition A Embarcadero Seawall Earthquake Safety Bond (Proposition A) projects by January 2021. The report ends with a set of next steps for the Program.

The publication of the MHRA is a key Program milestone, and represents the completion of two years of critical investigation work to collect and analyze the data necessary for development of Proposition A projects and for future projects in Phase 2 of the Embarcadero Seawall Program.

The purpose of the report is to provide the Port Commission with an overview of the major findings of the MHRA and update on progress to seismic and flood interventions the Waterfront Resilience Program team is developing to make the waterfront safer and more resilient to earthquake and flood hazards and damages described in the MHRA. Over this Fall, the Program team will develop a range of alternatives to reduce seismic and flood risk. Staff will share these alternatives with the Port Commission and the public for review and comment prior to making Proposition A project recommendations to the Port Commission, targeted for January

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2021. Staff will seek Port Commission endorsement of Proposition A project recommendations by the end of March 2021, enabling the Program team to advance to preliminary design and environmental review.

The MHRA provides a foundation for Embarcadero Seawall Program development. The MHRA includes new modeling of physical earthquake and coastal flood damages, recovery times, and economic loss predictions – all at four earthquake levels and water levels assuming a variety of sea level rise scenarios. This will allow staff to quantify the fiscal benefits of investment.

The Port developed a number of important tools (sitewide subsurface soil mapping, earthquake ground shaking hazard models, advanced engineering models of the Seawall, Hazus earthquake model of Port buildings and marine structures on the Embarcadero) to carry out the MHRA that are currently being used in the design of seismic and flood risk reduction measures and alternatives.

With the completion of the MHRA, the Port is taking action and moving quickly to share results and potential strategies (called “measures”) for responding to these risks and identify Proposition A projects.

Program Staff are targeting the end of January 2021 to make recommendations to the Port Commission for Proposition A projects and will seek direction from the Commission by the end of March 2021. As further described in this report, project selection for Proposition A funding includes the following components:

- Data, tools and findings from the MHRA;
- Development of seismic measures;
- Development of flood measures; and
- An alternatives development process that combines seismic and flood measures and other considerations (historic, public realm, Bay ecology, capital needs) into a range of alternatives for the entire Embarcadero Seawall area, so decision-makers and the public can see (and agree) that the final recommended projects for Proposition A funding represent an efficient use of bond funding.
- Concurrent with planning for Proposition A projects in the Embarcadero Seawall area, the Port is developing flood risk mitigation alternatives with the U.S. Army Corps of Engineers (USACE) for the entire Southern Waterfront from Mission Creek to Heron’s Head Park.

The MHRA and other work underway in the Program to develop Proposition A bond projects is consistent with the vision set forth in the Seawall Earthquake Safety General Obligation Bond Report for Proposition A (Bond Report)¹, including the following goals from that report:

- *“Act quickly to improve disaster preparedness*
- *Reduce earthquake damage and disruption*
- *Improve flood resilience*
- *Enhance the City and the bay*
- *Preserve historic resources*

¹ A copy of the Bond Report can be found at:
<https://onesanfrancisco.org/sites/default/files/2019-05/Agenda%20Item%205%20-%20Seawall%20Bond%20Report.pdf>

- *Engage the community*²

Since the Bond Report was published, the Port formed the Waterfront Resilience Program (WRP), extending the reach of the Port's resilience efforts Portwide. Proposition A bond funding is focused on the northern waterfront, but the Program team is developing a revised set of Principles for the whole waterfront. A key addition – validated through public outreach – is a focus on equity in all elements of the Program. Staff will present revised goals to the Port Commission for review and engagement this Fall.

This report provides an opportunity for the Port Commission to ask questions and provide policy guidance and direction to Program staff to ensure that the Program is aligned with the Port Commission's vision.

WATERFRONT RESILIENCE PROGRAM OVERVIEW

The Port established the Port's Waterfront Resilience Program (WRP) to ensure that the entire 7½ mile waterfront, and its important regional and citywide assets, are resilient in the face of hazards such as earthquakes, flooding, and sea level rise due to climate change.

The WRP includes several initiatives to increase the resilience of the waterfront; all include robust community engagement consistent with Port Commission policies and Port practice. The WRP includes the following initiatives, which are also represented in Figure 1:

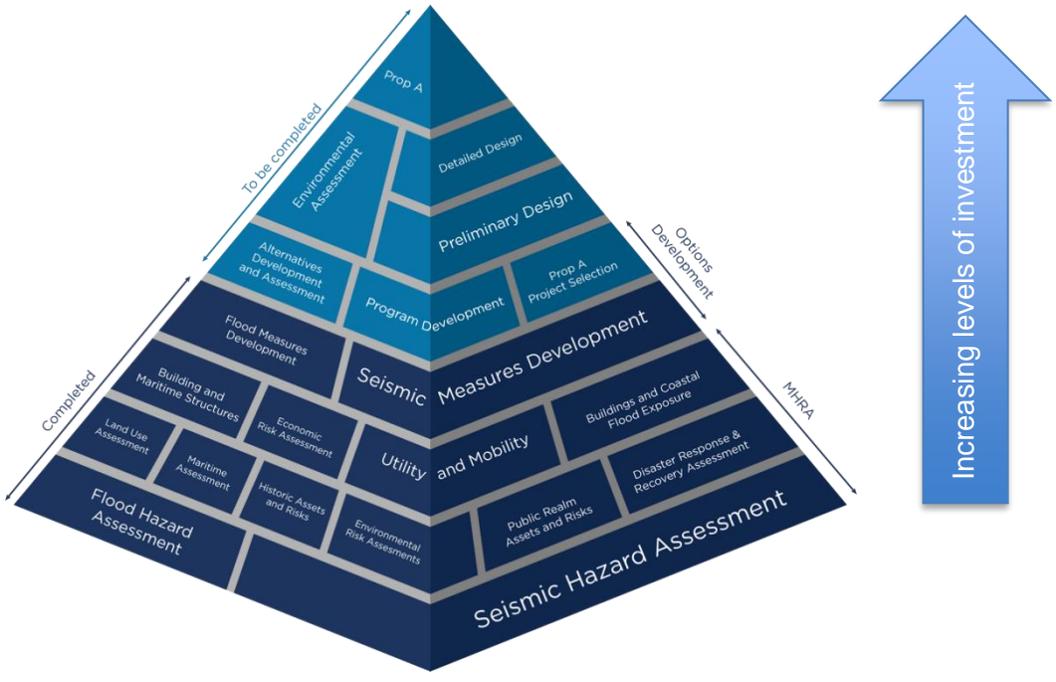
- **Embarcadero Seawall:** A City sponsored effort, that the Port is entrusted to implement, to reduce seismic and flood risk along the waterfront from Fisherman's Wharf to Mission Creek. In November 2018, voters of the City and County of San Francisco voted overwhelmingly to support Proposition A, the San Francisco bond initiative to provide \$425 million to upgrade and repair a portion of the 100 year-old Embarcadero Seawall. The overall repair is estimated to cost up to \$5 billion; this figure will be revised this Fall when the Program team produces cost estimates. Program staff will use the MHRA results and public feedback to develop a range of potential seismic and flood risk reduction project alternatives this Fall. Staff will present Proposition A project recommendations with the target of January 2021 and seek Port Commission endorsement of Proposition A projects by the end of March 2021.
- **USACE / Port of San Francisco Waterfront Flood Resiliency Study:** USACE awarded the Port of San Francisco a "New Start" in 2018 which authorized a General Investigation of flood risk along the San Francisco Bay waterfront. As a result, the U.S. Army Corps of Engineers (USACE) is studying flood risk along San Francisco's bayside shoreline, from Aquatic Park to Heron's Head Park in partnership with the Port. The approximately five-year USACE Flood Resilience Study will identify vulnerabilities and recommend strategies to reduce current and future flood risks for consideration for federal investment and implementation.
- In addition to these efforts, Program staff is supporting other areas of work to improve resilience along the 7 ½ mile waterfront:
 - Floodproofing the piers assesses the options available to adapt the piers to be resilient to elevated sea levels.
 - The Southern Waterfront Seismic Vulnerability Study – similar to the 2016 Seawall Earthquake Vulnerability Assessment – will use existing geotechnical

² Proposition A Seawall Earthquake Safety General Obligation Bond Report, 2018, Page 19.

information in the Port's Southern Waterfront to assess earthquake risk to Port facilities in the area.

- The Islais Creek Adaptation Study, a joint effort by the Port, the San Francisco Municipal Transportation Agency and City Planning, is examining sea level rise and flood risk in the Islais Creek/Bayview neighborhood, with a focus on transportation assets.
- The Program also represents the Port with participation in citywide and regional adaptation and resilience efforts led by others.

Figure 1: Waterfront Resilience Program Development



The WRP plays a supporting role for other vital Port initiatives that advance resilience, including the Waterfront Plan Update and the Historic Piers Rehabilitation Program.

EMBARCADERO SEAWALL MULTI-HAZARD RISK ASSESSMENT

The MHRA report, attached as Exhibit A, presents a summary of the earthquake and coastal flood risk assessment of the Port of San Francisco's (Port's) northern waterfront, a dense and historic Bayfront stretching 3.5 miles from Hyde Street Pier to the 3rd Street Bridge on Mission Creek and home to the Embarcadero Seawall. As shown by Figure 1, the MHRA provides the required foundation to develop a prioritised program of risk reduction measures for the Embarcadero Seawall area including selection and design of the first projects funded through the voter-approved Proposition A.

To better understand the current and future risks and inform investments to reduce those risks, the Port undertook a robust assessment of two hazards – seismic and flood. The MHRA investigates a range of both earthquake and flood hazard scenarios and evaluates how those scenarios might cause damage and disrupt critical city systems, including transportation and utility infrastructure, buildings, and marine structures along the waterfront and how damage and

disruption might affect the lives of the people who live, work, and recreate along the waterfront and shoreline.

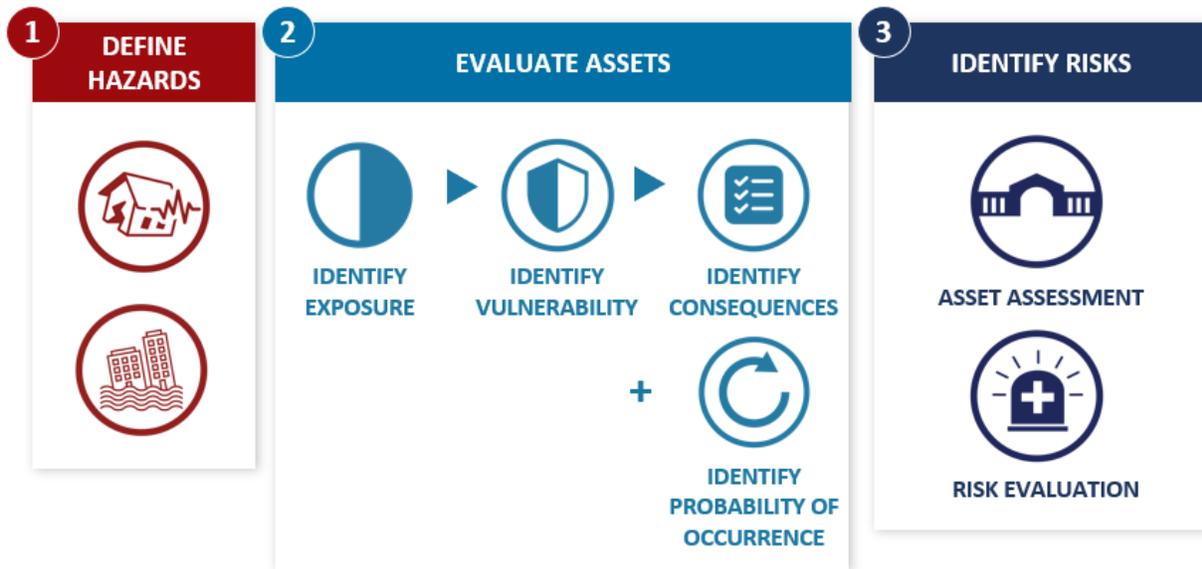
Additionally, the MHRA evaluates the consequences and risks to the waterfront's critical functions, including maritime activities, historic resources, public realm, jobs and small businesses, disaster response, and environmental resources. The detailed MHRA analysis and findings are documented in multiple individual reports.

The key building blocks for the MHRA are defined as follows:

- **Define Hazards**: Natural hazards such as earthquakes and flooding are events with the potential to impact society. The Waterfront Resilience Program focuses on the two hazards with the highest consequences for the San Francisco waterfront and shoreline: earthquakes and flooding. Seismic hazards include effects such as ground shaking and permanent ground displacement resulting from either liquefaction or lateral spreading. Coastal flood hazards captured in this assessment are associated with inundation due to waves, storm surge, atmospheric effects (for example, El Niño), extreme storms, and sea-level rise.
- **Identify Exposure of Assets and Functions**: Exposure refers to the people, buildings, infrastructure systems, and other resources (assets) within the Embarcadero Seawall Program area that may intersect with the defined hazards.
- **Characterize Vulnerability**: Vulnerability refers to the extent to which people, buildings, infrastructure assets, or systems are susceptible to harm from the intensity of a hazard.
- **Identify Consequences**: Consequence is the intersection of hazard, exposure, and vulnerability in which the impacts to people, buildings, infrastructure, systems, services, and functions are characterized, either quantitatively (damage, business losses) or qualitatively (impact to waterfront functions).
- **Identify Risk**: Risk is the combination of consequences and their likelihood of occurrence. Risk is commonly the metric that provokes action based upon a community or organization's tolerance for potential damage and disruption.

Figure 2 below depicts the risk assessment process that the Resilience team used to develop the MHRA.

Figure 2: MHRA Risk Assessment Process



The MHRA represents more than 2 years' worth of investigation across multiple disciplines. The MHRA provides the foundation for the Waterfront Resilience Program for the entire northern waterfront. With this context as a foundation, it is critical to highlight the following:

- **The MHRA is a planning-level study.** Analyses were performed at a variety of levels to produce the appropriate level of understanding for planning purposes Program-wide. The analyses draw on industry-respected models and methods where available and applicable, and many industry-respected methods are designed for regional analyses. While these models and methods were customized for this effort, the level of confidence in results should not be overestimated for individual assets or sites, as this was not the intent of this study. To better understand the performance of a specific building, site-specific analysis is required.
- **The MHRA results are intended to provide information and tools to design Proposition A projects and guidance for prioritization of Proposition A projects within the Embarcadero Seawall area.**
- **Site-specific analyses, pilot projects, and continued stakeholder engagement will be required as the program begins to develop alternatives and design projects.**
- **The MHRA is a peer-reviewed study.** The Port established an independent Seismic Peer Review Panel (SPRP) to guide the MHRA. The SPRP oversaw and commented on the complex technical work of seismic hazard analysis, building and infrastructure damage and loss predictions, and overall risk characterization using sound engineering methods. This panel met with the Port and consultant team regularly to review the in-progress work, ask questions and resolve issues during the assessment. Appendix B contains a list of SPRP members.

MHRA Overall Takeaways

What We Knew In 2016

In 2016, the Port completed the Seawall Earthquake Vulnerability Study of the Northern Seawall (GHD-GTC Joint Venture). The study was a high-level analysis of the performance of the Seawall using geotechnical data that was already in the Port's possession with the following primary findings:

"The primary findings from the study are:

- Most of the Seawall area is built over Young Bay Mud, a weak, saturated, and highly compressible marine clay that tends to amplify earthquake shaking and is susceptible to earthquake induced lateral spreading and settlement.
- Fill that was used to create the land behind the Seawall is susceptible to liquefaction, a phenomenon where the soil loses strength and behaves similarly to a liquid. This has previously been predicted, however, the Study confirms the potential based on current knowledge.
- Large earthquakes will likely cause most of the Seawall to settle and move outward toward the Bay due to a combination of weakness in the underlying Bay Mud and increased pressure from the liquefiable fill. The amount of movement varies across the waterfront, but in general, up to a foot is predicted in moderate to large earthquakes and more than several feet is predicted in a major earthquake. Complete failure of the Seawall is unlikely."

The GHD-GTC study also estimated economic damages and suggested high-level concepts to reinforce the Seawall. Given the gaps in data, the GHD-GTC study recommended that the Port conduct additional analysis to support design at specific locations.

What We Know Today

The MHRA includes new modeling of physical earthquake and coastal flood damages, recovery times, and economic loss predictions – all at four earthquake levels and water levels assuming a variety of sea level rise scenarios. This information will allow the Port to quantify the economic benefits of investment.

To produce the MHRA, the Port developed a number of important tools (sitewide subsurface soil mapping, earthquake ground shaking hazard models, advanced engineering models of the Seawall, Hazus earthquake model of Port buildings and marine structures on the Embarcadero) to carry out the MHRA that are currently being used in the design of seismic and flood risk reduction measures and alternatives.

The MHRA significantly advanced the Port's understanding of the risks and consequences associated with earthquake and flood risk. We now know:

- **Soil conditions have a big effect, creating higher and lower risk zones.** Deep Young Bay Mud is a problem in some areas, sand layers are a problem in other locations, ground shaking and settlement are Embarcadero-wide problems.
- **Earthquake risk to San Francisco's waterfront is severe and the consequences will be expensive.** We now have predicted physical damages and understand economic losses across four earthquake levels. Included in the economic loss predictions are cost of repair/replacement, loss of building related contents, business

interruption and relocation, lost wages, lost rent to the Port, and indirect and induced effects. This allows us to quantify the fiscal benefits of investment.

- **San Francisco’s waterfront is very sensitive to flood thresholds, with significant consequences.** We now have predicted coastal flood damages for all buildings and major infrastructure exposed by Seawall “overtopping,” along with the first flood-mapping of the City that includes wave action, an important contributor to flooding.

This advanced analysis gives a more accurate understanding of how flooding will affect different areas of the Port and City. We now know that the majority of long-term flood damages and disruptions are predicted to occur inland of Port jurisdiction, and that the shoreline will be a critical area of intervention to avoid long term flood damage in coordination with upland water management interventions. We also have predicted economic losses due to flooding.

- In addition, we now understand the specific consequences of earthquake and flood-related damages to:
 - disaster response systems (earthquake only);
 - maritime assets,
 - the Embarcadero Historic District and its contributing resources and other Port facilities in the northern waterfront,
 - utility systems in the Embarcadero;
 - transportation systems along the Embarcadero corridor;
 - public spaces, and
 - environmental assets.

This information will allow the Resilience Program to quantify the benefits of investment as well as any un-mitigated risk. This understanding will allow the Port to prioritize available investment in the areas where it will provide the greatest benefit (including emergency response and life safety).

MHRA Key Findings

We now know Seawall earthquake risk is high north of the Bay Bridge and moderate to low in South Beach, with the exception of a hot spot near the Ballpark (which does not impact the Ballpark itself). As described later in this report, the Resilience team is developing seismic measures designed to respond to different conditions along the waterfront with a focus on life safety and disaster response to support decision-making in early 2021 related to Proposition A projects.

Earthquake risk is very high in most bulkhead wharves (including seismically retrofitted facilities), moderate in piers, and low where piers have been retrofit or replaced. The bulkhead wharves are directly connected to the Seawall and provide flood protection to the City today. Any improvements to the Seawall will also include improvements to adjacent bulkhead wharves and/or replacement of the wharves.

The Agriculture Building and wood pile-supported structures in Fisherman’s Wharf are vulnerable to both ground shaking and lateral spreading. Some older waterfront structures are vulnerable to ground shaking in earthquakes whether or not the Seawall adjacent to these structures moves bayward. **As noted above, the MHRA is a planning-level study and further site-specific analysis will provide better information about the performance of specific**

structures. Program staff will use MHRA results to brief Port tenants about seismic and flood risks and discuss opportunities for making these facilities safer.

Earthquake risk to The Embarcadero is due to a combination of Seawall instability and liquefaction of the ground beneath The Embarcadero. Widespread and damaging liquefaction is expected to occur at earthquakes larger than 1989 but smaller than 1906. Damage is expected to both the Roadway, light rail and local telecommunication, gas, electric and water lines within the roadway. The Port has worked closely with other City and regional transportation and utility providers on the MHRA and these agencies have reviewed and commented on the MHRA results for the Embarcadero and transit and utility infrastructure in the Roadway. More interagency coordination is needed to determine next steps for this vital corridor.

Flood risk is highest between Rincon Park and Pier 7, centered on the Ferry Building area. Anticipated sea level rise between 2 and 3 feet, expected to occur between 2050 and 2080, represents a tipping point where the Port will no longer be able to function and damages within the City begin to rapidly escalate.

We know now that the Ferry Building area is the entry point for water and that flooding extends along the Embarcadero Roadway. Knowing that the critical threshold for flooding damages is 2-3 feet of sea level rise allows the Port and the City to plan and implement shoreline improvements to reduce risks in the most effective and efficient way: phased flood risk reduction at the shoreline to reduce flood risk to a large part of the City.

With no action, we could see up to \$30 billion in present value damages by 2100. The Port is communicating these risks to our tenants so they can make informed decisions.

The MHRA findings will provide important information to guide alternatives development, decision-making and prioritization of projects, funding and action along the San Francisco waterfront.

EMBARCADERO SEAWALL COMMUNITY ENGAGEMENT

Since 2017, the Port's WRP has connected with tens of thousands of people through robust community engagement efforts to advance work on the Embarcadero Seawall. This engagement included community members, businesses and merchants, advisory committees, non-profit groups and others. The engagement was designed to ensure that the findings from the MHRA including the hazards, risks and consequences would be accompanied by an understanding of the priorities, concerns and issues that mattered to community members and other stakeholders.

All community engagement offered the public an opportunity to provide the Port key feedback on WRP priorities as the Port and its consultants worked with City partners and others to advance the MHRA. The engagement included the assets and services within the Program area and the nature and consequences of the risks. The stakeholder engagement approach included:

- Embarcadero Seawall community meeting series;
- Participation in and hosting of community events like mixers, walking tours, and boat tours throughout the waterfront;
- Online engagement through the Waterfront Resilience Program website (sfportresilience.com); and

- Presentations to and discussions with advisory committees and boards.

An overview of all Program stakeholder and community engagement, including descriptions of community meetings, hosted events, digital engagement, presentations to advisory boards, and more can be found on the Waterfront Resilience Program website³.

Lessons Learned

Based on this robust engagement, the Port heard the following key messages across the waterfront:

- Prioritize life safety, emergency response and critical facilities
 - Community members consistently prioritize life safety, emergency response and critical facilities
 - The Embarcadero Promenade and the Ferry Building are two of the most consistently beloved assets along the waterfront
- Bay ecology, the Bay as an open space, Bay views and nature and ecology are important to everyone along the waterfront
- The public also prioritizes transportation and utilities
- Community members consistently stated that the focus of the Program should be on City and Port assets that serve the whole City
- There is a strong desire for a robust and waterfront wide pedestrian and bicycle corridor that provides safe and enjoyable access for commuting, recreating and travelling across the whole waterfront
- Jobs and economy are important throughout the waterfront and preserving and enhancing job centers such as Fisherman’s Wharf and the Financial District was important to many

While community feedback heard over the last two and a half years carried many universal themes, there were some specific concerns related to each geography along the waterfront. What follows is what we heard that resonated as distinct feedback for the Embarcadero area:

- The community affirmed the Port’s focus on life safety and emergency response
- Key community-prioritized assets include: Muni Tunnel, Ferry Building, Exploratorium, Fisherman’s Wharf
- We heard the importance of increased transportation options, open space and parks, and more family friendly activities
- We heard a desire to preserve and enhance jobs and diversity of jobs along the Embarcadero
- The Embarcadero Promenade is viewed as a critical asset and there is a strong desire to preserve and enhance it

EMBARCADERO SEAWALL WORK IN PROGRESS

Concurrent with work to finalize the MHRA, the Waterfront Resilience Program team has pivoted to using the results of the risk assessment to lay the ground work for developing Proposition A projects to address earthquake and flood risks. This section of this report describes the following workstreams, all of which will feed into an Alternatives Formulation

³ <https://www.sfportresilience.com/resilience-library>

process described below. Through the Alternatives Formulation process, the Resilience team will develop a range of alternatives for potential Proposition A funding for consideration by the Port Commission and the public later this Fall. Current workstreams include:

- **Envision** – What are potential scenarios for a Port of San Francisco shoreline that would be resilient to 3 to 7 feet (or more) of sea level rise expected by 2100, and how should these scenarios influence the design of adaptation measures developed today?
- **Bulkhead Wharf Elevation Scenarios** – The wharves in the Embarcadero Historic District which are connected to the Seawall provide flood protection to the Embarcadero today, but they are aging and are exposed to significant seismic risk. If they are rebuilt, can they be constructed at a higher elevation to increase sea level rise flood protection for the City, and can this be accommodated consistent with historic preservation and Americans with Disabilities Act standards?
- **Seismic Measures Development** – Given the unique soil conditions and structures at various points along the Embarcadero, what are the engineering solutions that can reduce lateral spreading and protect structures and infrastructure near the Seawall? What do these approaches cost, what are the associated construction impacts, how effective are these solutions at mitigating risks, and how can they be part of sea level rise adaptation?
- **Flood Measures Development** – Through the USACE Flood Resiliency Study, the Resilience team and USACE are developing flood measures for the Port's entire waterfront. For the Embarcadero Seawall area, what are the most effective measures that can also improve seismic performance and what are the costs of these measures?

Current work underway is described in more detail below.

Envision (May – November 2020)

While the Resilience team has heard important public feedback on values for a waterfront of 2100, the Port is still engaged in the process of developing options for a waterfront that is resilient to 2100 conditions by understanding the critical assets, systems and services that must remain along the waterfront and the range of sea level rise scenarios are projected for the end of the century. The Resilience team is working to develop draft concepts that are resilient to this range of potential 2100 water levels, which according to current State of California and City guidance is from 3.4 feet to approximately 7 or more feet of sea level rise.

Staff will share these concepts for public consideration in Fall 2020, with final concepts due for consideration in Winter 2020. The Resilience team will develop Envision concepts that demonstrate that the actions planned as part of Proposition A-funded projects are adaptable to future conditions including California Ocean Protection Council (OPC) high (1:200) projection and share how we might adapt into future concepts of the waterfront. These concepts are intended to help guide near term actions and long-range planning, and will be updated over time to reflect changing science, priorities, and strategies.

Bulkhead Wharf Elevation Scenarios (July – September 2020)

The historic wharves in the Embarcadero Historic District currently provide flood protection to the City today. Early results from the MHRA indicate substantial seismic risk in the bulkhead

wharf zone. The condition of the soils, the wharves and the structures all combine to make the bulkhead wharf zone a critical seismic safety hazard along the waterfront. In addition to the seismic risk associated with the bulkhead wharves, these wharves also present an entry point for future flood risk and a challenge when considering how to raise the entire San Francisco waterfront to reduce increasing current and future flood risks.

This study will provide concepts for how seismically-strengthened, raised bulkhead wharves could provide increased coastal flood management method for the City to address sea level rise and improved seismic performance, including analysis of whether this approach is consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties and the Americans with Disabilities Act.

Seismic Measures Development (April – August 2020)

Concurrent with the completion of the final subtasks in the MHRA, Resilience team engineers and geotechnical experts started a technical task – Seismic Measures Development – to support identifying Proposition A projects through the Alternatives Development process described below.

This task includes developing a range of measures applicable to the unique areas of the Embarcadero Seawall based on subsurface conditions, marine structure type, and landside infrastructure type and configurations. The work includes conceptual engineering design, performance, constructability, service life considerations, and cost estimating. This work supports development of complete alternatives, alternatives evaluation, and selection of Proposition A projects.

Seismic Measures Development Background

Early in the development of the MHRA, the Resilience team, with approval from the Port Commission, implemented a geotechnical exploration program from Fisherman's Wharf to Mission Creek to collect high quality engineering data to support decision-making and project design. CH2M/Arcadis and its subconsultants Fugro and Simpson, Gumpertz & Heger (SGH) used the data collected through this effort to develop advanced soil/structure analytical models at key sections along the entire Embarcadero Seawall to better inform the Resilience team's understanding of Seawall behavior.

This high-quality information produced design level engineering in the MHRA phase of the Program, enabling more effective assessment and more information to support development of seismic measures. Staff considered this approach necessary due to the extreme variability along the 3-mile Seawall and Roadway and the sensitivity of earthquake behavior and solutions to the engineering assumptions. This approach was endorsed by the independent Seismic Peer Review Panel.

Staff selected the geotechnical exploration program locations/data and CH2M/Arcadis, Fugro and SGH developed analytical soil/structure models for assessment considering the tools needed to develop and refine the seismic risk reduction approaches. The Resilience team made it a key requirement that the same models be suitable for developing seismic measures, thereby shortening the time needed for development of seismic measures. The Resilience team is using these models to test the efficacy of engineering concepts developed as part of this task.

In October 2019, as the assessment work began to yield results, the engineering team started interpreting results and considering the types of engineering approaches that would be effective

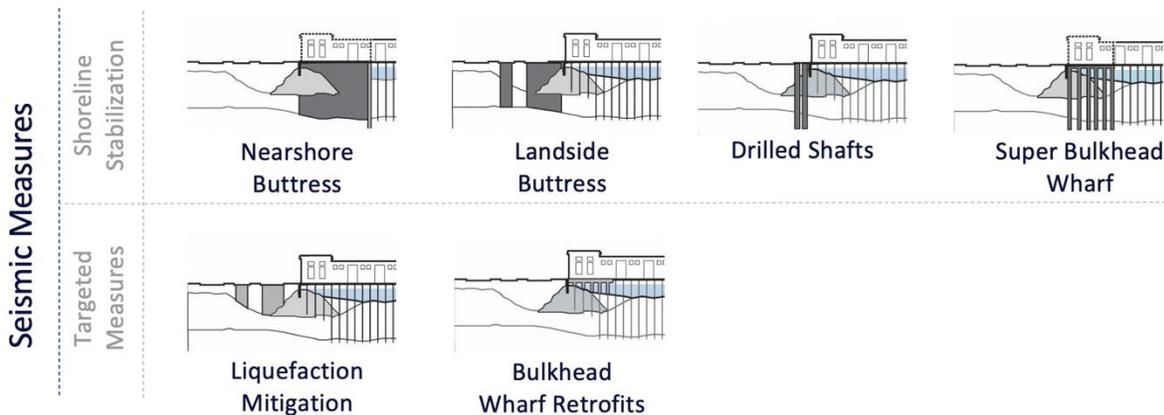
in the different areas. In April 2020, the analytical assessment work was largely complete, and the team turned its attention to seismic measures in earnest.

The Resilience team is developing conceptual seismic measures in this task based on the MHRA Findings. For each conceptual seismic measure, the Resilience team is preparing the following engineering feasibility assessments:

- Conceptual level cost estimates (level 5);
- Seismic performance, e.g., to what extent does the measure either reduce or withstand lateral spreading;
- Construction methods and staging, including traffic rerouting, if necessary;
- Production rates; and
- Preliminary analysis of sea level rise adaptability.

Figure 3 below depicts the seismic measures developed by the Resilience team.

Figure 3: Seismic Measures



The seismic measures developed through this task include:

- **Landside Structural Stabilization Measure:** This measure consists of very large and deep drilled shafts or driven piles installed just inboard of the bulkhead wall to stabilize the rock dike and reduce lateral spreading of the Embarcadero.
- **Landside Ground Improvement Buttress:** This is a deep and wide block of improved soil constructed in the Embarcadero Roadway that buttresses the shoreline, eliminates liquefaction of the fill, and provides highly reliable earthquake performance for landside infrastructure.
- **New Super Bulkhead Wharf:** This measure replaces the existing bulkhead wall and wharves with new robust structures that are sized to stabilize the rock dike and reduce lateral spreading.
- **New Nearshore Seawall:** This measure replaces the existing bulkhead wall and wharves with new improved land and a bayward seawall.

- **Seismic Retrofits of Bulkhead Walls and Wharves:** Where the Seawall is stabilized, most of the existing bulkhead walls and wharves will still require some retrofitting of the deck and piles to resist earthquake ground shaking.
- **Liquefaction Mitigation of the Embarcadero Fill:** This measure seeks to limit the liquefaction potential of the fill through “light touch” ground improvements that can be implemented while preserving the existing infrastructure, such as compaction grouting or polymer injection.

Table 2 below summarizes the Resilience team’s current analysis of the shoreline instability and liquefaction hazards, and applicability and effectiveness of the measures described above in mitigating these hazards and their consequences.

Table 2: Hazards by Area and Applicability and Effectiveness of Seismic Measures									
	Oracle Ballpark	South Beach	Rincon	Ferry Building	P1/2 to P7	P9 to P17	P19 to P27	P29 to P35	Fisher man’s Wharf
HAZARD									
Shoreline Instability Hazard	●	○	●	●	●	●	●	○	●
Embarcadero Fill Liquefaction Hazard	●	●	●	●	●	●	●	●	●
SEISMIC MEASURE APPLICABILITY									
Landside Structural Stabilization	-	-	✓	✓	✓	✓	✓	✓	✓
Super Bulkhead Wharf	-	-	-	-	✓	✓	✓	✓	✓
Landside Geotechnical Buttress	-	-	✓	✓	✓	✓	✓	✓	✓
Nearshore Seawall	✓	-	✓	✓	✓	✓	✓	✓	✓
Targeted Ground Improvement at Seawall	✓	✗	✗	✗	✗	✗	✓	✓	✓
Wharf Retrofits	✓	✓	-	✓	✓	✓	✓	✓	✓
Fill Liquefaction Mitigation	✓	✓	✓	✓	✓	✓	✓	✓	✓
SHORELINE STABILIZATION MEASURES, EFFECTIVENESS									
Landside Structural Stabilization	-	-	-	○	○	○	●	●	●
Super Bulkhead Wharf	-	-	-	○	○	○	●	●	●
Landside Geotechnical Buttress	-	-	-	○	○	●	●	●	●
Nearshore Seawall	●	-	-	○	○	●	●	●	●
Targeted Ground Improvement at Seawall	●	-	-	○	-	-	○	○	○
Fill Liquefaction Mitigation (primarily for Embarcadero performance)	-	-	-	○	○	○	○	○	○

Key
 - N/A ✓ Yes ✗ No ✓ Maybe ○ Low ○ Moderate ● High

The seismic measures and associated costs and impacts developed through this task will be utilized in the alternatives formulation process described below to arrive at proposed Proposition A projects.

Flood Measures Development (Focused Array: June – November 2020)

The Resilience team, through its work with USACE, is also developing a comprehensive set of flood measures for potential Embarcadero Seawall and Port wide application through the Flood Resiliency Study. This Fall, WRP staff will provide an update to the Port Commission about the Flood Resiliency Study, including public engagement.

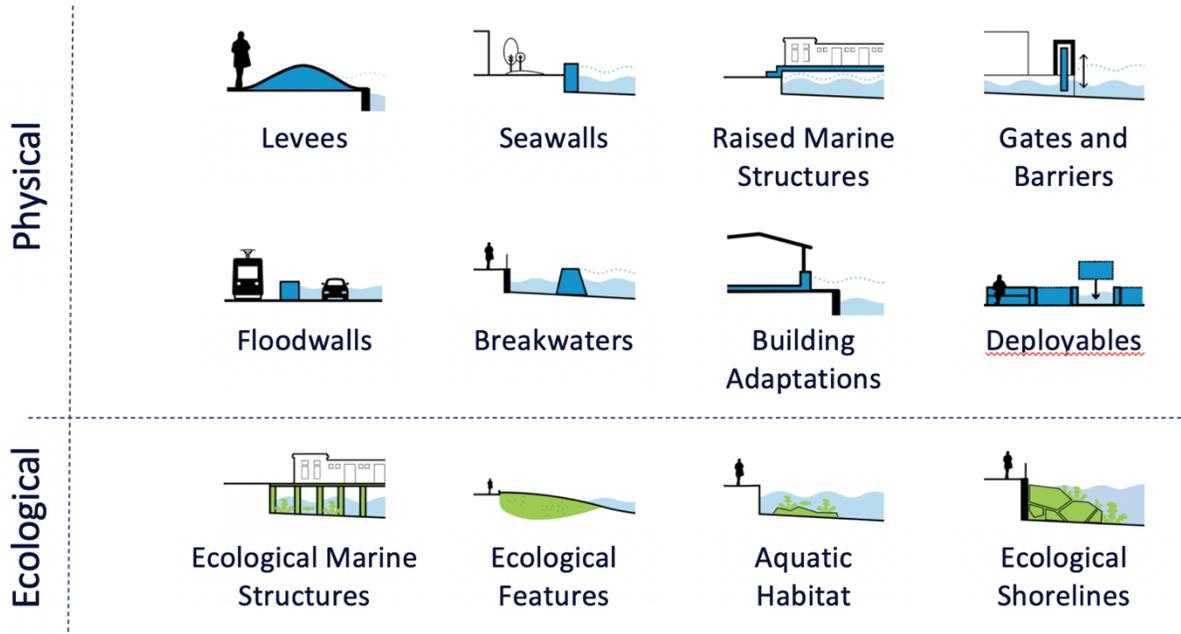
Focused Array

The Resilience team has developed the following work products to develop flood measures for the City's waterfront from Aquatic Park to Heron's Head Park, including the Embarcadero Seawall area. To support development of measures that respond to and account for Port and city functions in each distinct area of the waterfront, the team divided the waterfront into 15 subareas.

- **Problems, Objectives, Opportunities, Constraints, and Considerations (POOCCs):** With the USACE process, POOCCs are foundational to alternatives development and evaluation. During the focused array iteration, Resilience team members developed draft POOCCs for each of the 15 subareas. In-reach on the draft POOCCs was conducted with Port Division staff (designees from each Division), as well as with the Planning Department. The Resilience team will post the POOCCs for public comment along with the Focused Array.
- **Flood Risk Profiles:** Resilience team members developed Flood Risk Profiles for each subarea of the waterfront. Staff developed these Flood Risk Profiles to make information about flooding thresholds and tipping points more tangible for problem definition and alternatives development. Each Flood Risk Profile includes the following information:
 - Subarea Description and Asset Locations:
 - Timing of Exposure of the shoreline and identified assets and landmarks
 - Depiction of the flood progression
 - Adaptation Focus, including a description of shoreline vulnerabilities (e.g., overtopping locations) and flood pathways when select Bay water elevations occur, priority shoreline locations for adaptation responses, and a Description of adaptation considerations
- **Measures:** During the focused array iteration, the USACE/Port Project Delivery Team (PDT) developed a more robust list of flood risk reduction measures (Figure 4) for consideration, with particular attention to adding non-structural (policy and zoning) and nature-based measures. The PDT completed a detailed screening of measures by subarea, to complete a documented screening of measures not considered applicable at the subarea scale. To support alternatives development and stakeholder engagement, Measures Profiles were developed to define measures and support alternatives development.
- **Alternatives Development:** During the Focused Array iteration, the PDT used a subarea approach to formulate flood risk mitigation alternatives. The PDT determined that dividing the Port's waterfront into 15 subareas provides a street-scale approach that responds to the complexity and constraints of the Port's shoreline. To support the development of unique alternatives, the PDT used the concept of "themes" to drive brainstorming. Through a series of webinars, the PDT identified flood risk mitigation measures for each location along the waterfront for each of six themes (seismic safety and disaster response, historical and cultural preservation, transportation and mobility,

community cohesion, ecological assets and services, and non-structural (policy and zoning). The next step in this process is to solicit input on the measures and POOCs. Concurrently, the Resilience team will work with USACE staff to incorporate the recent MHRA and engineering feasibility findings described above to develop alternatives that more completely address the combined seismic and flood risks and respond to the POOCs. The alternatives produced through this process will be shared with the Commission and the public for input and refinement.

Figure 4: Flood Measures



- Cost estimating:** The Resilience team has developed a framework for cost estimation for the Waterfront Resilience Program and is leading cost estimation for the alternatives in the Focused Array. In addition to the measures being costed under Seismic Measures Development, the Resilience team is developing conceptual cross sections and unit costs for flood risk mitigation. This approach will provide nimble capabilities for costing alternatives developed within the Waterfront Resilience Program and the Flood Resiliency Study. The initial measures for which unit costs are under review include those within Seismic Measures Development, as well as landside floodwalls on sheet pile foundation, revetment, planted berms/levees, and gates. The Resilience team also completed an initial evaluation of systemic and project-specific cost estimating risks, in support of the USACE risk-informed planning approach.

The Resilience team will present the alternatives in the Focused Array to the Port Commission and the public this Fall. With public comment and direction the team will advance to a more detailed Final Array of alternatives over the next 18 months.

WATERFRONT RESILIENCE PROGRAM LBE SUBCONTRACTING UPDATE

Combined WRP Contracts

The progress of the program into new workstreams and a focus on incorporation of LBE firms to the effort has seen Contract payments to LBE firms increase 5% from 13.3% to 18.2% since September 2019. A breakdown of the payments between LBE, LBE-MBE, LBE-OBE and LBE-WBE is included in Table 3.

Table 3: Waterfront Resilience Program LBE Contract % Comparison: September 2019 to July 2020

Through September 2019

Contract Type	Total Payments	Local Business Enterprise							
		Prime Payments	Sub Payments	Total LBE Payments	Overall %	MBE %	OBE %	WBE %	Sub %
Planning, Engineering & Environmental Services	\$14,029,742	\$4,110,051	\$9,919,691	\$1,705,133	12.2%	6.1%	0.0%	6.0%	17.2%
Communications	\$1,102,798	\$616,874	\$485,924	\$303,861	27.6%	7.7%	12.3%	7.6%	62.5%
Total	\$15,132,540	\$4,726,925	\$10,405,615	\$2,008,994	13.3%	6.2%	0.9%	6.2%	19.3%

Through July 2020

Contract Type	Total Payments	Local Business Enterprise							
		Prime Payments	Sub Payments	Total LBE Payments	Overall %	MBE %	OBE %	WBE %	Sub %
Planning, Engineering & Environmental Services	\$20,929,614	\$6,365,448	\$14,564,165	\$3,579,923	17.1%	6.6%	0.0%	10.5%	24.6%
Communications	\$1,289,467	\$651,306	\$638,161	\$456,098	35.4%	7.8%	18.4%	9.2%	71.5%
Total	\$22,219,081	\$7,016,754	\$15,202,327	\$4,036,021	18.2%	6.7%	1.1%	10.4%	26.5%

The following sections provide a detailed breakdown for each contract.

CH2M Hill Contract

The Port executed a contract agreement with CH2M HILL Engineers, Inc. (\$36,349,740) to provide planning, engineering, and environmental services for the Embarcadero Seawall Program on October 1, 2017. The Local Business Enterprise (“LBE”) subcontracting requirement for the agreement was 21% (\$7,633,456).

The Port executed a contract amendment on April 20, 2020 to amend the contract scope and increase the contact amount to \$55,684,130, following Port Commission approval on September 24, 2019 and the Board of Supervisor’s approval on November 19, 2019. The LBE subcontracting participation requirement after the executed amendment increased to 22.9% (\$12,746,097).

For services completed after the Port Commission approval of the contract amendment, from October 2019 to July 2020, the Port paid CH2M \$6.9M, with \$1.8M (27.2%) paid for services completed by LBE subconsultants. This increased the cumulative LBE payments on the contract from 12.1% to 17.1% between September 2019 and July 2020.

Table 4 below shows the total amount invoiced to date under the CH2M Hill contract.

Table 4: CH2M Hill Engineers Planning, Engineering, Environmental Services Invoiced to Date

Supplier Name	LBE	MBE OBE WBE	Ethnicity (CMD Code)	Approved Contract to Date	Percent of Contract	Invoiced to Date	Percent Invoiced
CH2M HILL ENGINEERS INC (PRIME)				15,698,979	28.2%	6,365,448.25	30.4%
ARCADIS U.S. INC				8,300,567	14.9%	2,998,522	14.3%
BERGERABAM INC				23,054	0.0%	23,054	0.1%
CA DAVIS ENGINEERING				139,315	0.3%	33,539	0.2%
CAROLLO ENGINEERS PC				1,696,128	3.0%	433,261	2.1%
CMG LANDSCAPE ARCHITECTURE				2,807,812	5.0%	1,073,782	5.1%
FUGRO USA LAND INC				6,069,634	10.9%	4,550,812	21.7%
GEHL ARCHITECTS APS				65,540	0.1%	65,080	0.3%
HR&A ADVISORS INC				9,280	0.0%	-	0.0%
ICF JONES & STOKES INC				4,754,916	8.5%	168,842	0.8%
KEARNS & WEST INC				125,954	0.2%	125,954	0.6%
MGE ENGINEERING				88,300	0.2%	46,877	0.2%
MOFFAT NICHOL				72,256	0.1%	33,166	0.2%
MOZAIK				-	0.0%	-	0.0%
NEW ALBION GEOTECHNICAL INC				169,035	0.3%	154,280	0.7%
SIMPSON GUMPERTZ & HEGER INC				1,401,809	2.5%	865,025	4.1%
TD O'ROURKE				89,000	0.2%	69,718	0.3%
TEF ARCHITECTURE & INTERIOR DESIGN INC				439,987	0.8%	149,216	0.7%
THE ALLEN GROUP			African American	-	0.0%	-	0.0%
W R A INC				916,845	1.6%	123,492	0.6%
WHERE THE BUFFALO ROAM				69,622	0.1%	69,622	0.3%
A G S INC	LBE	MBE	Asian American	278,421	0.5%	-	0.0%
BAYCAT	LBE	OBE	Non-Minority	55,684	0.1%	7,839	0.0%
CHS CONSULTING GROUP	LBE	MBE	Asian American	278,421	0.5%	-	0.0%
CIVIC EDGE CONSULTING LLC	LBE	WBE	Non-Minority	556,841	1.0%	731,827	3.5%
COPYMAT	LBE	MBE	Arab American	105,800	0.2%	2,873	0.0%
GEOTECHNICAL CONSULTANTS INC	LBE	MBE	Asian American	1,113,683	2.0%	407,713	1.9%
HOLLINS CONSULTING	LBE	MBE	African American	1,670,524	3.0%	635,429	3.0%
INTERETHNICA	LBE	WBE/MBE	Latino American	189,326	0.3%	-	0.0%
LOWERCASE PRODUCTIONS	LBE	OBE	Non-Minority	-	0.0%	-	0.0%
R D J ENTERPRISES LLC	LBE	MBE	African American	278,421	0.5%	141,107	0.7%
SAYLOR CONSULTING GROUP	LBE	WBE	Non-Minority	723,894	1.3%	25,624	0.1%
SEDWAY CONSULTING INC	LBE	WBE	Non-Minority	111,368	0.2%	139,002	0.7%
SILVESTNUM CLIMATE ASSOCIATES	LBE	WBE	Non-Minority	50,116	0.1%	322,830	1.5%
SITELAB URBAN STUDIOS	LBE	WBE	Non-Minority	707,188	1.3%	288,855	1.4%
SQAURE ONE PRODUCTIONS	LBE	MBE	Asian American	111,368	0.2%	-	0.0%
STRUCTUS INC	LBE	MBE	Asian American	2,115,997	3.8%	194,114	0.9%
TELAMON ENGINEERING CONSULTANTS INC	LBE	WBE/MBE	Asian American	4,399,046	7.9%	682,710	3.3%
LBE TOTALS				12,746,097.36	22.9%	3,579,923.39	17.1%
MBE TOTALS				5,952,634	10.7%	1,381,237	6.6%
OBE TOTALS				55,684	0.1%	7,839	0.0%
WBE TOTALS				6,737,780	12.1%	2,190,847	10.5%
TOTALS				55,684,130	100.0%	20,929,614	100.0%

The Port and CH2M continue to look for opportunities to increase LBE participation as Task Order scopes are developed. This month, CH2M will be issuing a new task order for Workforce Development and LBE Support Services to support workforce development programs and LBE outreach so that underserved San Francisco residents and businesses are well-positioned for future economic opportunities in the Waterfront Resilience Program, including Proposition A projects. This scope of work was included in the contract amendment with a budget of \$1.2M. To support this effort, Program staff worked with the Contract Monitoring Division to add an additional LBE subconsultant

Davis & Associates Communications, Inc. Other firms participating in this effort include the Allen Group and RDJ Enterprises LLC.

Civic Edge Contract

The Port executed a contract agreement with Civic Edge Consulting (\$1,695,205) to provide public relations, communications, media and related services for the Embarcadero Seawall Program on September 17, 2017. The Local Business Enterprise (“LBE”) subcontracting requirement for the agreement is 36% (\$610,274).

Table 5 below shows the total amount invoiced to date under the Civic Edge Consulting contract.

Table 5: Civic Edge Public Relations, Communications, Media Contract Invoiced to Date

A Supplier Name	B LBE	C MBE OBE WBE	D Ethnicity (CMD Code)	E Approved Contract to Date	F Percent of Contract	G Invoiced to Date	H Percent Invoiced
CIVIC EDGE CONSULTING (PRIME)*	LBE	WBE	Non-Minority	671,566	39.6%	651,306	50.5%
CIRCLEPOINT				32,139	1.9%	32,100	2.5%
CARIBOU				10,500	0.6%	10,468	0.8%
FM3				81,750	4.8%	81,750	6.3%
KATZ & ASSOCIATES				57,750	3.4%	57,746	4.5%
BONNER COMMUNICATIONS	LBE	WBE/MBE	African American	150,000	8.8%	7,013	0.5%
COPYMAT	LBE	MBE	Arab American	100,000	5.9%	43,906	3.4%
D&A COMMUNICATIONS	LBE	WBE/MBE	African American	25,000	1.5%	4,690	0.4%
INTERETHNICA	LBE	WBE/MBE	Latino American	147,000	8.7%	106,516	8.3%
JBR	LBE	MBE	African American	77,000	4.5%	23,400	1.8%
LOWERCASE PRODUCTIONS	LBE	OBE	Non-Minority	153,500	9.1%	95,733	7.4%
RDJ ENTERPRISE	LBE	MBE	African American	77,000	4.5%	33,819	2.6%
SLOW CLAP	LBE	OBE	Non-Minority	102,000	6.0%	141,021	10.9%
SPICE IT UP	LBE	MBE/WBE	African American	10,000	0.6%	-	0.0%
LBE TOTALS				841,500	49.6%	456,098	35.4%
MBE TOTALS				264,000	15.6%	101,125	7.8%
OBE TOTALS				255,500	15.1%	236,754	18.4%
WBE TOTALS				322,000	19.0%	118,219	9.2%
TOTALS				1,695,205	100.0%	1,289,467	100.0%

*Civic Edge is an LBE but as the Prime their participation does not count towards the LBE requirement

Program and CMD staff continue to monitor payments to LBEs to ensure that Resilience Program consultants honor their contract commitments and contact achieves or exceeds its LBE contracting goals.

EMBARCADERO SEAWALL NEXT STEPS

Alternatives Development Process (August to November 2020)

From August to November, the Resilience team will use the information from the MHRA, public outreach to date, City department engagement and the seismic and flood measures described above to develop conceptual project alternatives for the entire Embarcadero Seawall Program with a focus on identifying the Proposition A projects.

With the information available and building on the work to develop flood and seismic measures, the Program Staff and consultant team will prepare 2-3 project alternatives per subarea – incorporating seismic and flood risk reduction wherever possible – for the Embarcadero Seawall area. As the team develops these alternatives, staff will work closely with Port divisions to confirm that proposed alternatives are consistent with the Port’s Strategic Plan, Port operations, the Historic Piers Rehabilitation Program and related Port planning efforts.

The high-level schedule for this work is:

- Alternatives development and evaluation – September/October
- Synthesis/Executive Sponsor review/Recommendations – November/December
- Port Commission staff reports/presentations – December/January

Adaptive Decision Making Framework

The Resilience team is recommending an adaptive decision making framework, subject to Port Commission review, comment and ultimate approval including:

- **Evaluation and Screening Criteria:** using public feedback from Community Meeting #4 (June 2019) and other public engagement, staff is refining and the Program’s draft evaluation criteria for consideration by the Port Commission to ensure that solutions, including the first Proposition A projects, are determined through thoughtful and transparent analysis.
- **Program Prioritization and Funding Guidelines:** staff is developing draft funding guidelines for Port Commission consideration to guide decisions on where to spend Proposition A funding and other funding where available. These guidelines will be applied after alternatives are selected for the entire Embarcadero Seawall Program area.
- **Adaptation Design Guidelines:** staff is developing draft Program Adaptation Design Guidelines to establish guiding principles and adaptation design strategies that incorporate existing Port design guidelines. The goal of this effort will be to develop holistic adaptation guidelines to guide project design and implementation over time.

Staff plans to bring alternatives for potential Proposition A funding to the Port Commission with the target of January 2021 and walk through how each alternative meets the goals and how each measures up against the evaluation and screening criteria. Staff plans to seek Port Commission endorsement of Proposition A projects by the end of March 2021.

After project alternatives have been vetted by the Port Commission, the public and City department partners, staff will utilize Program goals, evaluation and screening criteria and Program Prioritization and Funding Guidelines as the basis for recommendations for Proposition A funded projects to the Port Commission.

The goal of this integrated alternatives development and evaluation process is to ensure that risk reduction actions are aligned, effective, and offer the highest return on investment for the public.

Upcoming Community Engagement and Meetings

Port Tenants

Program staff understands that many Port tenants – including small businesses that have invested significantly in Port facilities – are struggling with COVID-19 and the current economic climate. The Resilience team is engaging a phased tenant outreach program in consultation with the Port’s Real Estate and Development Division to share the finding of the MHRA in detail and describe next steps in Program, including formulating alternatives to address seismic and flood risk along the Port’s shoreline.

Staff wishes to emphasize that this outreach is the continuation of a longer-term dialogue.

Embarcadero Community Meetings

The stakeholder engagement plan developed in 2017 includes upcoming meetings in the community meeting series:

- Embarcadero Community Meeting #6: The MHRA and the development of alternatives. *Meeting tentatively scheduled for September 2020.*
- Embarcadero Community Meeting #7: Present refined alternatives based on input received at Community Meeting #6. Share Envision concepts. *Meeting tentatively scheduled for Fall 2020.*
- Embarcadero Community Meeting #8: Present proposed Proposition A projects. Present next steps for the program including additional priorities that were identified in the alternatives development process. *Meeting tentatively scheduled for First Quarter 2021.*

Anticipated Schedule of Port Commission Meetings (subject to change)

Program staff needs regular engagement and direction from the Port Commission as we move through this vital and creative phase of the Program. Below is a tentative schedule for Commission engagement.

Engaging Decision-Makers – Program Decision-Making Framework, October 2020

Includes feedback on:

- Seismic and flood performance standards for designing alternatives
- Evaluation and screening criteria for recommending alternatives
- Adaptation design guidelines
- Proposition A funding guidelines

Envision Concepts: Fall, 2020

USACE Focused Array: Fall, 2020

Decision-Making Framework Fall, 2020

End of March 2021 Proposition A Project Selection

Spring 2021 Additional recommendations based on alternatives development

2022 USACE Final Array and Tentatively Selected Plan

Prepared by: Lindy Lowe, Resilience Officer
Steven Reel, Embarcadero Seawall Program Manager
Matt Wickens, Seawall Program Engineering Lead
Brad Benson, Waterfront Resilience Director

Exhibit A: Embarcadero Seawall Multi-Hazard Risk Assessment

Exhibit B: Seismic Peer Review Panel Members

Embarcadero Seawall Program Seismic Peer Review Panel	
Panel Member	Expertise
Shahriar Vahdani, Ph.D., P.E., SPRP Co-Chair	<p>Geotechnical/Earthquake Engineering/Advanced numerical modeling/Foundations</p> <p>Performed ground motion, site response, seismic soil-structure interaction, dynamic slope deformation, and liquefaction-related ground failure studies for major transportation structures including highways and commute rails, dams, tunnels, port facilities, high-rise buildings, bridges, and pipelines</p> <p>Serves on the San Francisco Tall Buildings Study, Project Technical Committee</p> <p>Serves on many Peer Review Panels in San Francisco, often as a chair</p>
Steve Dickenson, Ph.D., P.E., SPRP Co-Chair	<p>Geotechnical/Seismology/Port Engineering foundation systems and earth systems</p> <p>Led post-earthquake reconnaissance investigations focused on ports, harbors, coastal infrastructure, and major bridges (for example, 1989 Loma Prieta, 1995 Kobe, 2001 Nisqually, 2007 Kashiwazaki, and 2011 Tohoku earthquakes)</p> <p>Research leader on dynamic site response, liquefaction susceptibility of sand and silt deposits, seismic slope stability, and dynamic soil-foundation-structure interaction</p> <p>Active member in American Society of Civil Engineers Port seismic design committees</p>
Professor Thomas Denis O'Rourke, Ph.D., Cornell University	<p>Thomas R. Briggs Professor of Engineering, Cornell University</p> <p>Expertise – leading researcher on earthquake performance of lifelines in U.S.</p> <p>Runs earthquake testing lab at Cornell University for pipeline development</p> <p>Member, U.S. National Academy of Engineering</p> <p>Former President of Earthquake Engineering Research Institute</p>
Professor Jonathan D. Bray, Ph.D., P.E., UC Berkeley	<p>Faculty Chair in Earthquake Engineering Excellence</p> <p>Expertise – seismic performance of earth structures, seismic site response, liquefaction and ground failure and its effects on structures, earthquake fault rupture propagation, and post-event reconnaissance</p> <p>Member U.S. National Academy of Engineering</p> <p>Authored more than 350 research publications</p> <p>Active in University of California seismic program</p> <p>Formerly worked for USACE</p>
Mark Salmon, SE	<p>Expertise – structural engineering, earthquake engineering, risk assessment, design and assessment of major civil works</p> <p>BART Earthquake Safety Program, lead engineer</p> <p>Engineer of record for many complex infrastructure projects</p>
Daryl English, SE	<p>Expertise – Marine structural engineering, earthquake engineering, design and assessment of marine structures</p> <p>Engineer of record for many significant marine structures</p>