How the Project is Technically Feasible and will be Effective in Reducing the Risk of Coastal Flooding

The proposed Menlo Park SAFER Bay Project will provide coastal flood protection to the PG&E Ravenswood Substation at the edge of the San Francisco Bay, and construct additional adjacent reaches of levees and floodwalls from the SAFER Bay program along the margin of the Bay (**Attachment 4 - Menlo Park SAFER Bay Site Plans and Sections**).

Although a network of existing embankments already provides some degree of protection from coastal flooding, these embankments are not currently certifiable as per FEMA's 44 Code of Federal Regulations (CFR) Section 65.10. The crest elevations are below FEMA's 1% Annual Chance Event (ACE) coastal flood event freeboard requirements and they do not meet FEMA's geotechnical requirements.

The proposed project will construct flood protection levees and floodwalls that will meet freeboard requirements to protect against FEMA's 1% ACE coastal flood event, plus 3.5 feet of sea level rise, and will account for settlement of levees after construction due to the compressible foundation soils. The design criteria that will be used to guide the project are described below.

Levee Design Criteria

Project geotechnical design criteria will be established to evaluate the levees for acceptable performance with respect to levee height and settlement, stability, and underseepage. The criteria used will be based on published federal and state regulations and technical guidance documents.

For levees to be accredited by FEMA, evidence must be provided that adequate design and operation and maintenance (O&M) systems are in place to provide reasonable assurance that protection from the 1% ACE flood exists. These requirements are outlined in the Code of Federal Regulations, 44CFR65.10 (FEMA, 2006), and in the California Code Regulations (CCR), Title 23 (CVFPB, 2009).

In general, the United States Army Corps of Engineers (USACE) criteria will be followed for the design of levees, as presented in USACE Engineering Manual 1110-2-1913 *Design and Construction of Levees* (USACE, 2000), based on the requirements of 44CFR65.10. State guidelines, as presented in the State of California Department of Water Resources (DWR) Urban Levee Design Criteria (2012), will also be referenced. These include design criteria for levee height/settlement, stability, through seepage and underseepage, summarized as follows.

Levee Height and Settlement

Levees are to be designed to achieve a minimum levee crest height to meet FEMA 1% ACE freeboard requirements, plus an additional 3.5 feet for sea level rise. As settlement is expected over time, levees will be evaluated for additional overbuild heights, such that the post-settlement crest elevation still meet the hydraulic criteria.

1% Annual Chance Flood Event

In Table 1, FEMA's 1% ACE still water level (SWL) is shown to be between 10.8 feet at Reach 2 and 10.9 feet at Reach 5 (DHI, 2013), measured using the standard North American Vertical Datum of 1988 (NAVD).). A preliminary estimate to account for shoreline wave effects increases the 100-year design water levels to 10.8 feet NAVD at Reach 2 and 14 feet NAVD at Reach 5.

To provide a margin of safety, FEMA requires that the crest top elevation of a certified levee be built above the 1% ACE water level by an additional amount of freeboard. The FEMA freeboard requirement for coastal levees is a minimum of two feet above the SWL and higher if either of the following two wave-influenced elevations exceeds two feet: one foot above the 1% ACE wave crest elevation, or one foot above the maximum wave runup elevation or total water level (TWL). Table 1 indicates which case governs for each project reach, and shows that to meet present-day FEMA requirements, the levee elevations would need to be between 12.8 feet NAVD at Reach 2 and 15 feet NAVD at Reach 5.

3.5 Feet of Sea Level Rise

The Menlo Park SAFER Bay Project will be designed for 3.5 feet sea level rise based on recent guidance from the California Ocean Protection Council's statewide strategy (OPC, 2020). Incorporating 3.5 feet of sea level rise into the design is consistent with the Menlo Park SAFER Bay project time frame and the range of sea level rise projections over this time (OPC, 2018).

Foundation Settlement

The proposed project is located along the southwestern fringe of San Francisco Bay. A review of published information on geologic and geotechnical conditions in the site area indicate that the area is underlain by soil deposits commonly referred to as Young Bay Mud. This soil is soft, weak, and highly compressible.

The available information indicates that the thickness of the Young Bay Mud layer is on the order of 10 to 20 feet throughout much of the alignment area. The thickness of the Young Bay Mud is greater in the area of the proposed project's Reach 5 near the PG&E substation, possibly on the order of 40 feet or more. The additional loading from new levees will cause settlement over time due to the consolidation of the underlying Young Bay Mud. Levees will need to be initially built to heights greater than their final elevations, to meet the required final design crest elevations.

In the early stages of project design, field investigations will be undertaken to define the project foundation characteristics and confirm the required amount of overbuild for settlement. At this stage of conceptual design, based on field investigations made at other locations along the SAFER Bay alignment, it has been estimated that the levees along the project reach will experience between 1 and 2.5 feet of settlement over time.

Table 1 shows that incorporating 3.5 feet of sea level rise and the estimated allowance for post-construction settlement requires that the project levees be constructed to between 17.3 feet NAVD at Reach 2 and 21 feet NAVD at Reach 5. Cross sections showing conceptual levee designs to these elevations are in the attached file - **Attachment 4 - Menlo Park SAFER Bay Site Plans and Sections.**

Table 1. Derivation of Elevations for Top of Flood Control Levees and Floodwalls.

Project Reach	Representative FEMA Transect	1% SWL (ft. NAVD)	Shoreline Effects	FEMA Freeboard		SLR (ft.)	Overbuild for Settlement (ft.)	Construction Top of Flood Control
			Max Wave Runup (ft. NAVD)	1% SWL + 2 ft.	Max R + 2 ft.			
2	1014	10.8	10.8	12.8	11.8	3.5	1.0	17.3
3	1015	10.8	14.1	12.8	15.1	3.5	1.0	19.6
4								19.7*
5 West	1016	10.8	12.8	12.8	13.8	3.5	2.5	19.8
5 East	1017	10.9	14	12.9	15	3.5	2.5	21.0

*Construction top of Flood Control for Reach 4 is taken as the average of Reaches 3 and 5 West.

Levee Stability

Levee stability analyses will be performed for the following conditions and for the required minimum factors of safety:

- End of construction: minimum factor of safety of 1.3;
- During a flood event, with the water level set at FEMA 1% ACE flood elevation plus 3.5 feet for sea level rise and steady-state seepage conditions: minimum factor of safety of 1.4; and
- For rapid drawdown conditions, where the water level drops from FEMA 1% ACE flood elevation plus 3.5 feet for sea level to the waterside ground surface elevation: minimum factor of safety of 1.0.

Levee Through Seepage and Underseepage

If the phreatic surface daylights on the landside levee slope during an analysis of steady-state seepage conditions (also referred to as breakout), it may indicate that there is a potential for through seepage. Potential detrimental effects of through seepage include a reduction in slope stability,

sloughing and erosion of the landside levee slope surface, and internal erosion through piping. Low-plasticity soils are more susceptible to erosion than soils with medium to high plasticity. The project will establish the material property requirements and levee geometries such that the average exit gradient at the landside levee toe is 0.5 or less, for a flood event with the water level set at FEMA 1% ACE flood elevation plus 3.5 feet for sea level rise, and steady-state seepage conditions.

References

California Department of Water Resources, 2012, “Urban Levee Design Criteria,” May 2012.

Central Valley Flood Protection Board (CVFPB). (2009). California Code of Regulations (CCR), Title 23: Waters, Subdivision 1.

Danish Hydraulics Institute (DHI). 2013. Regional Coastal Hazard Modeling Study for South San Francisco Bay Final Draft Report. Prepared for FEMA Region IX.

Federal Emergency Management Agency (FEMA). (2006). “44 CFR Section 65.10: Mapping of Areas Protected by Levee Systems.” October, 2006 Edition.

Ocean Protection Council (OPC). 2018. State of California Sea-Level Rise Guidance.

USACE (2000), Design and Construction of Levees. Engineer Manual No. 1110-2-1913. April 2000.

Ocean Protection Council (OPC). 2020. Strategic Plan to Protect California’s Coast and Ocean 2020–2025.