Appendix SLR

Sea Level Rise-Related Supporting Information

SLR.1 Tidal Datums and Sea Level Rise Design Basis Memorandum (Moffatt & Nichol, 2019)

moffatt & nichol

2185 N. California Blvd., Ste 500
Walnut Creek, CA 94596-3500

(925) 944-5411 Fax (925) 944-4732
www.moffattnichol.com

MEMORANDUM

To: Noah Rosen, Oakland Athletics

From: M&N (Dilip Trivedi & Mads Jorgensen)

Date: May 29, 2019

Subject: Tidal Datums and Sea Level Rise Design Basis
M&N Job No: 10114

The purpose of this memorandum is to document tidal elevations, datum conversions, existing FEMA flood zones, and sea level rise projections being used for the project, as well as the design basis for grading as related to FEMA flood zones and sea level rise.

1. Tidal Datums and FEMA Flood Zone

In the absence of long term NOAA tide gage data in the immediate vicinity of the project, flooding studies conducted by FEMA[1] were used to establish the elevation of normal and extreme tides in the vicinity of the project area; these are summarized in Table 1.

Table 1: Tidal Elevations and Datum Conversions

Tidal Plane	NAVD 88 Datum	Oakland City Datum (OCD)
Normal (Astronomical) Tides		
King Tide (Approx. Annual Maximum)	+7.50	+1.73
Mean Higher High Water (MHHW)	+6.28	+0.51
Mean High Water (MHW)	+5.70	-0.07
Mean Tide Level (MTL)	+3.34	-2.43
Mean Low Water (MLW)	+0.97	-4.80
North American Vertical Datum (NAVD, 1988)	0.00	-5.77
Mean Lower Low Water (MLLW)	-0.10	-5.87
Extreme Tides (With Storm Surge)		
10-year Return Period (RP)	+8.50	+2.73
25-year RP	+8.90	+3.13
50-year RP	+9.24	+3.47
100-year RP (FEMA BFE[2])	+9.71	+3.94

[1] AECOM, 2016. "*San Francisco Bay Tidal Datums and Extreme Tides Study*". Final Report.

[2] Estimated by the Federal Emergency Management Agency (FEMA); it represents the water level that has a 1% annual chance of occurrence in the vicinity of the project.

The FEMA Flood Insurance Rate Map shown in Figure 1 indicates that most of the site is outside of a Special Flood Hazard Area (SFHA or floodplain), except for the areas shown in blue shade. The Estuary itself and the area between Jefferson and Clay Streets is in the 100-year floodplain marked as Zone AE 10, which is rounded up from the actual BFE of +9.71' shown in Table 1 (FEMA shows only whole numbers). The tan shade, which is not a SFHA, indicates areas that are potentially vulnerable to a 500-year return period flooding event.

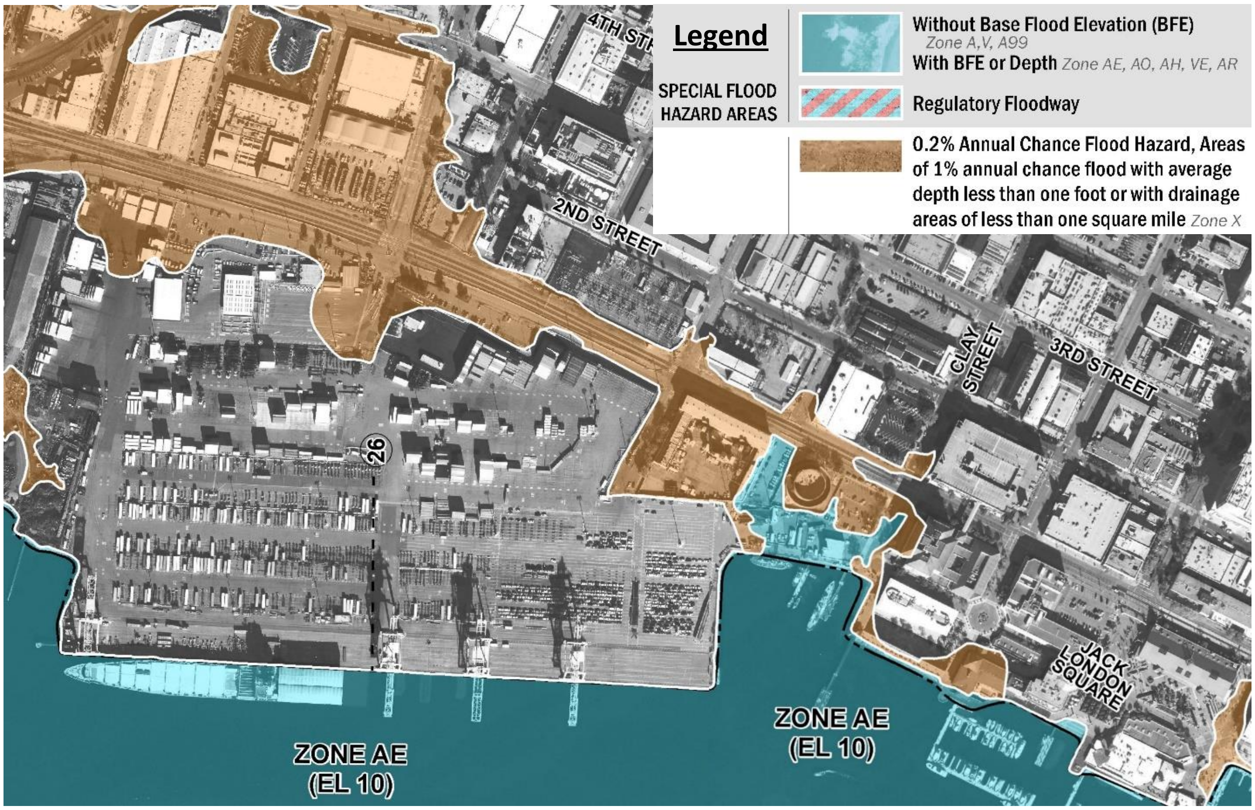

Figure 1: Flood Insurance Rate Map, FEMA
(Map 06001C0067H, Effective 12/21/2018)

2. Datum Conversions

The project datum is Oakland City Datum (OCD). However, base flood elevations from FEMA use the North American Vertical Datum, 1988 (NAVD). Based on the conversions shown in Table 1:

- To convert elevations in OCD to NAVD, add 5.77 feet
- To convert elevation in NAVD to OCD, subtract 5.77 feet

3. SLR Projections

<u>Regional Guidance</u>

Regional guidance recommended by the San Francisco Bay Conservation and Development Commission (BCDC) is to use the best available science developed by the State. The most recent guidance for California is provided by the *California Ocean Protection Council (OPC)*[3], which has been adopted for this project. The guidance recommends evaluation of SLR impacts using a scenario-based analysis. This method is founded on the approach by the Intergovernmental Panel on Climate Change *(IPCC)* to understand how SLR and other drivers interact to threaten health, safety, and resources of coastal communities. Table 2 summarizes SLR scenarios adopted from *OPC (2018)* for time horizons out to 2100. The columns outlined in bold reflects the OPC guidance for risk levels, which include low risk aversion, medium to high risk aversion, and extreme risk aversion.

Table 2: Sea-Level Rise Projections for San Francisco Bay Area, *OPC (2018)*

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...		5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 -	1.5	1.9	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.3	3.9	
High emissions	2080	1.7	1.2 -	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 -	2.1	2.8	4.7	
High emissions	2090	2.1	1.4 -	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 -	2.4	3.2	5.7	
High emissions	2100	2.5	1.6 -	3.4	4.4	6.9	10.2

For planning and design purposes, SLR projections adopted for the project are those consistent with the *High Emissions, Medium – High Risk Aversion* (0.5% probability of exceedance) scenario in Table 2. A summary of significant tidal datums for the present and with the future SLR projections are summarized in Table 3.

The tidal datums selected for planning purposes in Table 2 are the:

- *100-yr return period water level* (represents extreme flooding with a low probability of occurrence)
- *King Tide* (represents infrequent flooding with an annual occurrence of 5 to 7 times a year)
- *MHHW* (represents the highest water level experienced on average every day)

[3] California Ocean Protection Council, 2018. "*State of California Sea-Level Rise Guidance*". 2018 Update.

Table 2: Tidal Datums with Sea Level Rise

Tidal Plane	Present	2050 (1.9' SLR)	2070 (3.5' SLR)	2100 (6.9' SLR)
100-year RP	+3.94	+5.84	+7.44	+10.84
King Tide	+1.73	+3.63	+5.23	+8.63
MHHW	+0.51	+2.41	+4.01	+7.41

Local Sea Level Rise Guidance

It is also necessary to comply with Local SLR guidance that has been adopted by the City of Oakland in their *Oakland Sea Level Rise Roadmap*[4]. Figure 1 of the guidance recommends that, at a minimum, the following projections be used in planning:

- Mid Century (2050): 11 inches (most likely) to 24 inches (upper range)
- End of Century (2100): 36 inches (most likely) to 66 inches (upper range).

Since the OPC SLR projections are slightly higher than the Oakland Sea Level Rise Roadmap projections, the more conservative OPC projections will be utilized for this project.

4. Design Basis

The design basis for flood protection for proposed buildings and the ballpark is to accommodate extreme high tides (100-yr tide) plus end-of-century SLR projections, with minimal to no required adaptations, and mid-century SLR projections (at a minimum) for the roadways and open space areas.

Therefore, the project site will be elevated such that it accommodates the BFE and includes an additional allowance for Sea Level Rise as described in the OPC 2018 guidance document. A summary of proposed grades for the site is provided below:

Mixed Use Development Area

- Finish floors of proposed buildings are anticipated to be set at elevation +10 ft OCD. This indicates that there would be the need for a small amount of adaptation (less than 1-ft) near the end of the century to accommodate the 6.9-ft of SLR by 2100, which would equate to an elevation of +10.8 ft OCD;
- Roadway, park and open-space elevations, which typically have to conform to surrounding grades and where adaptations are quite feasible, will range from elevation+7 ft OCD at the existing wharf edge to about +9 ft OCD for the development footprint. This will accommodate the BFE of +3.9 ft OCD and more than the 1.9 ft of SLR projected for 2050;

[4] City of Oakland, 2017. Oakland Preliminary Sea Level Rise Road Map, Fall 2017

- Along the northern edge of the site, grades will conform to existing roadway elevations of about +4.5 OCD, which will still be above the BFE, but adaptations will be necessary to keep up with rising sea levels in the future.
- The existing wharf at Howard Terminal is at an elevation of +7.2 to +8.2 ft OCD, which implies that there is about 3 to 4 ft of SLR allowance presently, even during a 100-year flood event.

Comparing these SLR projections to the ones described in the Oakland Sea Level Rise Road Map, it is apparent that the only difference is for 2100 where the OPC projection is about 1.4 ft larger. For the year 2090, the OPC projection is about 5.6 ft, which is similar to the year 2100 SLR projection of 5.5 ft (66 inches) in the Oakland Sea Level Rise Road Map

Given the above, it can be concluded that the proposed building elevations are adequate to accommodate even worst-case SLR projections combined with extreme tides in the future, up to year 2090 and potentially beyond depending on actual SLR measurements. Adaptations for roadways, parks, and open-spaces will be needed only after sea levels have risen about 3 ft or so beyond the present. Based on the most recent science (OPC 2018), a 3 ft SLR projection is not expected to occur until about 2065 even for the High-Emissions, Medium-High risk aversion scenario.

SLR.2 Coastal Flooding, Proposed Grading Strategy, Sea Level Rise Adaptation, and Public Access on Wharf Memorandum (Moffatt & Nichol, 2021)

moffatt & nichol

2185 N. California Blvd., Ste 500
Walnut Creek, CA 94596-3500

(925) 944-5411 Fax (925) 944-4732
www.moffattnichol.com

MEMORANDUM

To: Noah Rosen, Oakland Athletics

From: Dilip Trivedi

Date: July 9, 2021 v2 (rev 9/21/21)

Subject: Coastal Flooding, Proposed Grading Strategy, Sea Level Rise Adaptation, and Public Access on Wharf
Oakland Athletics Howard Terminal Project
M&N Job No: 10114-01

The Oakland Athletics Howard Terminal project envisions a new waterfront ballpark and a mixed-use development along the Oakland Estuary. The project site is located between Clay St and Linden St, bound to the north by the Embarcadero and to the south by the Oakland Estuary. The proposed ballpark, mixed-use structures and streets, along with a significant amount of open space will be sited on land (former container yard) and the pile-supported wharf will be utilized for additional publicly accessible open space.

This document provides a summary of the following:

1. Vulnerability Assessment of issues related to coastal flooding, groundwater intrusion, and future sea level rise
2. Proposed Design Strategy to address the vulnerabilities, along with the design basis for grading as related to FEMA flood zones and sea level rise
3. Adaptation Measures to address higher amounts of sea level rise
4. Consideration of Public Access over the pile supported wharf

1. Vulnerability Assessment

1.1. Tides, Water Levels and Storm Surges

Key elements of risk associated with coastal flood hazards for any site include water levels and waves; the combination of these result in vulnerability to coastal flooding. Water levels include a wide range of influencing factors, including astronomical tides, storm surges, and El Niño effects.

Astronomical tides in San Francisco Bay occur twice each lunar day, characterized by a semidiurnal inequality (i.e., a difference in heights of successive high waters or low waters). Changes in winds and barometric conditions can cause variations in the tide level from day to day, which are not included in daily tide predictions for the area. Along the West Coast of the US, storm surges occur when there are meteorologic anomalies that result in high or low pressure systems. These anomalies result in a change in the astronomic tide range, and can be observed as a “higher than predicted” or a “lower than predicted” tidal elevation.

Typically, for projects along the SF Bay shoreline, data from tide gages in the vicinity of the project site are utilized to estimate the elevation of high, low and extreme tides. In the absence of long term NOAA tide gage data in the immediate vicinity of the proposed project, flooding studies conducted by FEMA[1] were used to establish the elevation of normal and extreme tides in the vicinity of the project area; these are summarized in Table 1. The extreme tides shown in the table below include the effects of storm surge.

Table 1: Representative Tidal Elevations for Proposed Project Site

Tidal Plane	NAVD 88 Datum	Oakland City Datum (OCD)
Normal (Astronomical) Tides		
King Tide (Approx. Annual Maximum)	+7.50	+1.73
Mean Higher High Water (MHHW)	+6.28	+0.51
Mean High Water (MHW)	+5.70	-0.07
Mean Tide Level (MTL)	+3.34	-2.43
Mean Low Water (MLW)	+0.97	-4.80
North American Vertical Datum (NAVD, 1988)	0.00	-5.77
Mean Lower Low Water (MLLW)	-0.10	-5.87
Extreme Tides (With Storm Surge)		
10-year Return Period (RP)	+8.50	+2.73
25-year RP	+8.90	+3.13
50-year RP	+9.24	+3.47
100-year RP (Base Flood Elevation, BFE)[2]	+9.71	+3.94

1.2. Datum Conversions

The vertical datum being used for the proposed project is the Oakland City Datum (OCD). However, most of the elevational data available from NOAA, FEMA, and other agencies is based on the North American Vertical Datum, 1988 (NAVD). It is therefore useful to document the datum relationship. The conversions are described below.

- To convert elevations in OCD to NAVD, add 5.77 feet
- To convert elevation in NAVD to OCD, subtract 5.77 feet

1.3. Existing Flood Hazards

The Flood Insurance Rate Map (FIRM) developed by the Federal Emergency Management Agency (FEMA) for the project vicinity is shown on Figure 1. The figure shows the extent of inundation in shaded blue that is associated with the FEMA 1% Annual Chance Base Flood (also

[1] AECOM, 2016. "*San Francisco Bay Tidal Datums and Extreme Tides Study*". Final Report.
[2] *Ibid*

called the Base Flood Event or BFE). The BFE has a probability of occurrence of about 1% in any given year. It indicates that most of the site is outside of a Special Flood Hazard Area (SFHA or floodplain), except for the areas shown in blue shade. The Estuary itself and the area between Jefferson and Clay Streets is in the 100-year floodplain marked as Zone AE 10, which is rounded up from the actual BFE of +9.71' shown in Table 1 (FEMA shows only whole numbers). The tan shade, which is not a SFHA, indicates areas that are potentially vulnerable to a 500-year return period flooding event.

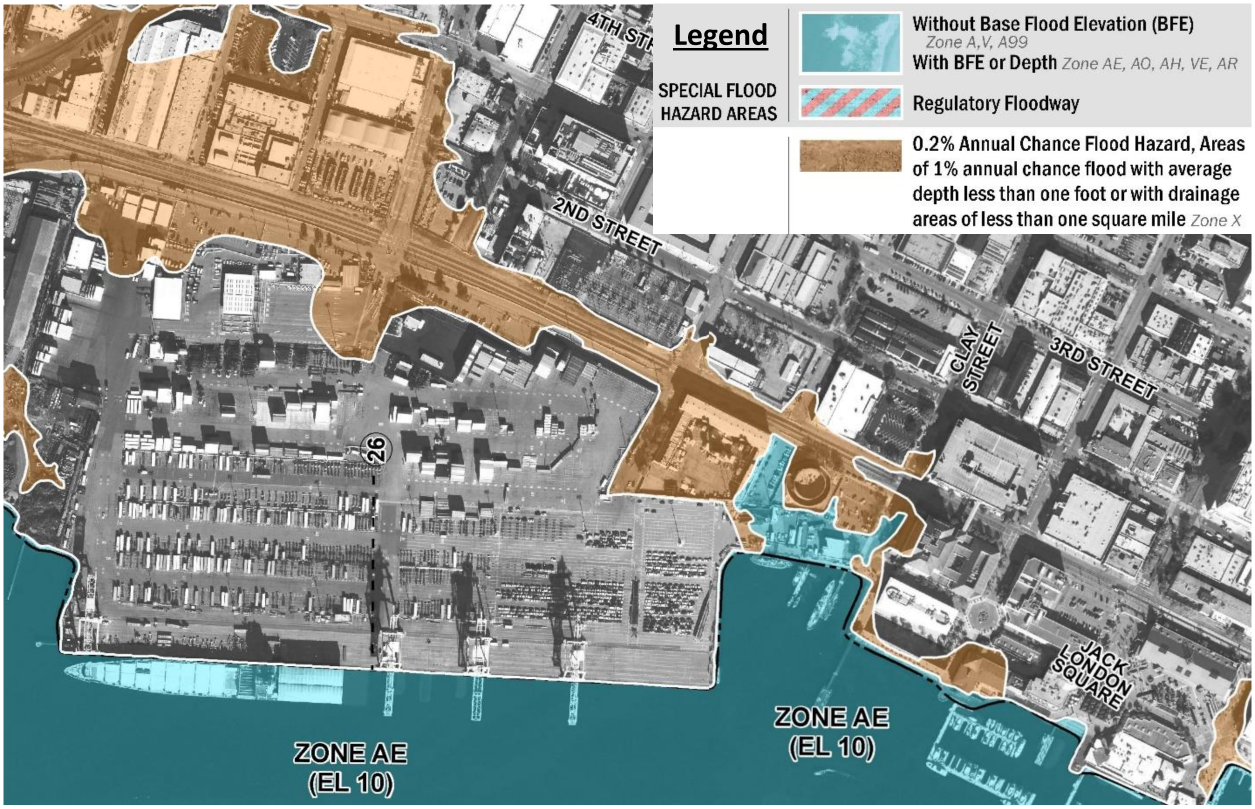

Figure 1: Flood Insurance Rate Map, FEMA
(Map 06001C0067H, Effective 12/21/2018)

The potential for significant tsunamis (either locally generated or distant seismic events) or ship-generated wake waves is very small. For the project site, waves are typically wind-generated and associated with local storm events in the Bay. However, given the narrow width of the Oakland Estuary, wave heights are significantly attenuated and the primary source of coastal inundation (persistent flooding over several hours) is tidally influenced water level (tides and storm surges).

1.4. Groundwater Table

Typically, for low-lying areas along the Bay shoreline, groundwater could also be a significant source of vulnerability if the elevation of the groundwater table is in close proximity to site elevations and is also influenced by tides in the Bay. Levee protected areas are an example of this condition, which then requires the levees to be engineered such that seepage below and through the levee does not result in groundwater induced flooding.

At the proposed project site, the elevation of the groundwater table fluctuates around an average of about -1.5’ OCD (+4.2’ NAVD) with a significantly muted tidally-influenced range of only about 1-ft[3]. Observations from data loggers in monitoring wells over a two month period (Nov to Jan 2019) at the site indicate the following:

- During a high tide of about +1.53’ OCD (+7.3’ NAVD) in the Estuary, which is approximately the King Tide, the groundwater table elevation at the site was about -1’ OCD (+4.8’ NAVD).
- During a low tide elevation of -7.3’ OCD (-1.5’ NAVD) in the Estuary, the groundwater table elevation at the site was about -2.2’ OCD (+3.6’ NAVD).

Given that existing site grades are higher than +4.2’ OCD (+10’ NAVD), changes in groundwater table does not constitute to be a source of flooding vulnerability at the present time (influence of sea level rise on the groundwater table is discussed in Section 2 of this memorandum).

1.5. Sea Level Rise

Regional guidance recommended by the San Francisco Bay Conservation and Development Commission (BCDC) is to use the best available science developed by the State. The most recent guidance for California is provided by the *California Ocean Protection Council (OPC)*[4], which has been adopted for this project. The guidance recommends evaluation of SLR impacts using a scenario-based analysis. This method is founded on the approach by the Intergovernmental Panel on Climate Change *(IPCC)* to understand how SLR and other drivers interact to threaten health, safety, and resources of coastal communities. Table 2 summarizes SLR scenarios adopted from *OPC (2018)* for time horizons out to 2100. The columns outlined in bold reflects the OPC guidance for risk levels, which include low risk aversion, medium to high risk aversion, and extreme risk aversion.

For long-term projects that have a robust adaptive capacity, defined as “the ability to adapt to future sea levels”, regional planning agencies in the SF Bay Area have recommended using the *High Emissions Scenarios,* coupled with the *Medium – High Risk Aversion* projections that has a 1-in-200 chance of being equaled or exceeded in Table 2. For shorter term projects (lifespan of 30-years or less), the 1-in-20 chance projections have been used.

Since the proposed project has a significant amount of adaptive capacity, the applicable projections to be utilized would be the estimates for High Emissions, Medium – High Risk Aversion (1.9-ft by 2050, 3.5’ by 2070, and 6.9’ by 2100).

[3] Lytle Water Solutions, 2020. *“Howard Terminal Aquifer Field Testing Report*”, February 2020.
[4] California Ocean Protection Council, 2018. “*State of California Sea-Level Rise Guidance*”. 2018 Update.

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Table 2: Sea-Level Rise Projections for San Francisco Bay Area, *OPC (2018)*

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1.0
	2040	0.6	0.5	-	0.8	1.0	1.3	1.8
	2050	0.9	0.6	-	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	-	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	-	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	-	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	-	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	-	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	-	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	-	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	-	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	-	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	-	3.4	4.4	6.9	10.2

A summary of significant water levels for the present and with the future SLR projections are summarized in Table 3. The water levels selected for planning purposes in Table 2 are the:

- *100-yr return period water level* (represents extreme flooding with a low probability of occurrence)
- *King Tide* (represents infrequent flooding with an annual occurrence of 5 to 7 times a year)
- *MHHW* (represents the highest water level experienced on average every day)

Table 3: Water Levels with Sea Level Rise
(all elevations in Oakland City Datum)

Tidal Plane	Present	Medium – High Risk Aversion Projections*			H++ Scenario
		2050 (1.9 ft SLR)	**2070** (3.5 ft SLR)	**2100** (6.9 ft SLR)	
100-year RP	+3.9’	+5.8’	+7.4’	+10.8’	+14.1’
King Tide	+1.7’	+3.6’	+5.2’	+8.6’	+11.9’
MHHW	+0.5’	+2.4’	+4.0’	+7.4’	+10.7’

* using High Emissions Scenarios

Extreme Risk Aversion (H++) Projections

The last column in Tables 2 and 3 above shows projections for an additional *Extreme Risk Aversion Scenario,* which is called the *H++* scenario. There is no probability of occurrence or timeline associated with these projections, and the Guidance states that these should be *considered* only for projects with a design life beyond 2050 that have little to no adaptive capacity. The specific language in the OPC Guidance regarding its applicability to projects states:

> *"The Guidance also includes an extreme sea level rise scenario, the H++ scenario, which is not tied to a specific emissions trajectory but should be considered for projects with a lifespan beyond 2050 that have a low tolerance for risk, such as large power plants, major airports and roads, wastewater treatment plants, and hazardous waste and toxic storage sites."*
>
> *"The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections."*
>
> *"For highly vulnerable or critical assets that have a lifespan beyond 2050 and would result in significant consequences if damaged, the H++ scenario (extreme risk aversion projection) should be included in planning analyses."*
>
> *"For high consequence projects with a design life beyond 2050 that have little to no adaptive capacity, would be irreversibly destroyed or significantly costly to relocate/repair, or would have considerable public health, public safety, or environmental impacts should this level of sea-level rise occur, the H++ extreme scenario should be included in planning and adaptation strategies (e.g. coastal power plant)."*

Although this would indicate that the proposed project need not consider the H++ scenario, Assembly Bill 1191 (AB1191) states that parcels subject to State Lands Trust jurisdiction should consider it, regardless of adaptive capacity, and outline potential adaptation scenarios for this scenario. Since portions of the project are subject to State Lands Trust jurisdiction, water levels associated with the H++ scenario are included in the Table and adaptations shown in Appendix A.

Local Sea Level Rise Guidance

It is also necessary to comply with Local SLR guidance that has been adopted by the City of Oakland in their *Oakland Sea Level Rise Roadmap*[5]. Figure 1 of the guidance recommends that, at a minimum, the following projections be used in planning:

1. Mid Century (2050): 11 inches (most likely) to 24 inches (upper range)
2. End of Century (2100): 36 inches (most likely) to 66 inches (upper range).

Comparing these SLR projections to the ones described in OPC 2018 guidance, it is apparent that the only difference is for 2100 where the OPC projection is about 1.4 ft larger. For the year

[5] City of Oakland, 2017. Oakland Preliminary Sea Level Rise Road Map, Fall 2017

2090, the OPC projection is about 5.6 ft, which is similar to the year 2100 SLR projection of 5.5 ft (66 inches) in the Oakland Sea Level Rise Road Map

Since the OPC SLR projections are slightly higher than the Oakland Sea Level Rise Roadmap projections, the more conservative OPC projections will be utilized for this project.

2. Proposed Design Strategy

2.1. Design Basis for Site Grades

The project site will be elevated such that proposed grades include an allowance for Sea Level Rise as described in the OPC 2018 guidance document. The design basis for flood protection is as described below:

<u>Overland Flooding</u>

- For proposed *Building and Ballpark Structures*, strive to accommodate <u>end-of-century SLR projections</u> (6.9-ft for high emissions, medium-high risk aversion scenario) with minimal adaptations. Implement adaptations when the as-built SLR allowance is close to being exceeded.
- For the *Streets and Open Space Areas*, accommodate <u>mid-century SLR projections at a minimum</u> (1.9-ft for high emissions, medium-high risk aversion scenario). Implement adaptations when the as-built SLR allowance is close to being exceeded.
- For sea levels higher than those included in the initial construction, prepare an *Adaptive Management Plan* that describes adaptation strategies that could be implemented within the project boundaries for SLR that exceeds the above allowances, including the H++ scenario.
- Project improvements will not result in *Increased Offsite Flooding*, now or in the future when adaptations are constructed.

<u>Groundwater Flooding</u>

- For the *Development Areas, Ballpark, Streets, and Open Spaces*, accommodate changes to groundwater levels through <u>end-of-century</u> (no adaptation required).
- For Existing Structures or Facilities planned to remain at current elevations on the site, accommodate changes to groundwater levels through <u>mid-century</u>. Implement adaptations before groundwater levels affect the intended functions of these structures or facilities
- Describe adaptation strategies in the *Adaptive Management Plan* that could be implemented within the project boundaries for groundwater elevations that exceed the above allowances.

2.2. Proposed Site Grades

A summary of proposed grades for the site, based on the above criteria, is provided below. Adaptations for higher sea and groundwater levels are described in Section 3.

Overland Flooding

1. Finish floors of *Building Structures* will be constructed to an elevation of +10' OCD, which would accommodate the BFE through about 2095 without any adaptations. To accommodate a higher amount of SLR, adaptations will be required (see Section 3).
2. The *Ballpark* will also accommodate SLR up to +10' OCD. However, the ballfield and access ramps/entryways will likely be built to a lower elevation for reasons related to operational and functional efficiency. A below-ground cutoff wall (to control groundwater intrusion) is proposed around these lower elevation areas that will tie in to higher elevation structures to prevent overland flooding. With the cutoff wall in place, the criteria for overland flooding will be similar to the other building structures (no flooding until about 2095). To accommodate a higher amount of SLR, adaptations will be required (see Section 3).
3. The majority of *Streets and Open-Spaces* will be raised to about +9' OCD, which would accommodate about 5-ft of SLR (well beyond the 1.9-ft of SLR projected for 2050). To accommodate a higher amount of SLR, adaptations will be required (see Section 3). Where grades need to conform to surrounding grades, elevations will be lower as described below:
   - *Along the Inland Wharf Edge*, proposed open space grades will be about +7' OCD. This will accommodate about 3-ft of SLR. When SLR exceeds the 3-ft allowance, adaptations will be required (see Section 3).
   - *Along the Embarcadero and Clay Street*, grades will transition from the +9' OCD development footprint to about +4.5' OCD to conform to existing street elevations. As sea levels rise, these street connectors may see temporary flooding during extreme high tides from off-site sources (if adjacent communities have not addressed SLR). The development itself is elevated and will not be affected by it except for access to and from the site during these events. When SLR exceeds 5-ft, adaptations will be needed (see Section 3)
4. The *Concrete Wharf* along the Estuary is at an elevation of +7.2' to +8.2' OCD. Minor raising of grades to accommodate landscaping elements is also proposed over the wharf, which would accommodate even more SLR. This implies that there is over 3-ft of SLR allowance, even during a 100-year flood event (well beyond the 1.9-ft of SLR projected for 2050). To accommodate a higher amount of SLR, adaptations could be built (see Section 3).
5. *Northeast Corner*: The development block at the corner of Clay St and the Embarcadero (Block 18) will be raised to elevation +6' OCD, which will provide about 2-ft of SLR

allowance. When SLR starts impacting the block from offsite flooding sources including the Embarcadero and Jefferson, adaptations could be constructed (see Section 3)

The Peaker Plant site is not vulnerable to flooding from the 100-yr tide at the present time and will not be raised. Street grades around it will be higher and retaining walls will be built around the site to accommodate the higher grades. When SLR starts impacting the plant from offsite flooding sources including the Embarcadero and Jefferson, adaptations could be constructed (see Section 3).

6. *Offsite Flooding.* Proposed grading for all elements as described above will not result in hydrological changes in the vicinity. This is because the source of flooding is the entire waterfront of the Oakland Estuary and raising the site as proposed will not displace floodwaters such that the depth of flooding on adjacent parcels would be higher.

<u>Groundwater Flooding</u>

As summarized in Section 1.4, groundwater monitoring studies indicate that even during a King Tide in the Estuary the groundwater elevation at the site was -1' OCD (+4.8' NAVD) and the range in groundwater elevations was only about 1-ft. Groundwater analyses also indicate that combining a 1% annual chance tide with end-of-century SLR projections of 6.9-ft result in an estimated groundwater elevation of about +4.5' OCD which is well below the proposed site grades described above.

Around the lower elevation ballfield, a deep, below-ground cutoff wall is proposed that will control groundwater intrusion. The proposed cutoff wall will reduce seepage such that the elevation of the groundwater table is lower than the levels described above. The top of the cutoff wall will tie in to high ground and/or above-ground structures to prevent overland flooding, and a pumping system will be installed to address storm drainage from the ballfield area. In the event that groundwater elevations start affecting the ballfield, the pumps can be operated to lower the groundwater within the footprint of the area enclosed by the cutoff wall.

With the construction of the cutoff wall, no adaptation through 2100 and (likely beyond) is envisioned.

3. ADAPTATION STRATEGY

<u>Approach</u>

Although the project is built around a robust design strategy with an adequate amount of allowance such that even low-probability SLR scenarios will not affect it, it is prudent for a project of this magnitude to also consider higher than projected (or more rapid) sea level rise given the uncertainties in climate change. A project-specific Adaptation Strategy addresses this. The premise of such a strategy is based on the following key observations:

- the rate and amount of SLR is uncertain and it is important to have accurate data to identify and implement adaptation strategies

- adaptation strategies are site-specific and must be based on the unique vulnerabilities and risks that the site is exposed to
- changes in SLR will occur over a decadal timescale, providing sufficient time to identify and implement an adaptation strategy

Based on the above, a comprehensive Adaptation Strategy will be developed for the project. The framework for such a strategy will be based on *Monitoring* of flooding events, sea level rise, and groundwater levels; establishing *Triggers* for management actions that include planning and design of adaptations, and identifying potential *Implementation Actions* such as raising grades or installing other interventions. The objective of the strategy will be to identify specific thresholds when responses to sea levels and groundwater levels higher than those built into the initial project design need to be initiated, and what might those adaptations look like.

- *Monitoring*: After project buildout (or interim phases if sufficiently long), monitoring of sea level rise and groundwater will be implemented by the Developers. This would be based on a combination of scientific guidance/updates from a variety of credible sources (NOAA, USGS, OPC, academic publications, etc.) and measurements of groundwater increase and frequency of flooding events at the site.
- *Triggers:* When data from the monitoring program reveal that sea and/or groundwater levels are expected to exceed the allowances included in the initial design, management actions need to be implemented. Since planning, design, and review takes a significant amount of time, work will begin on the adaptations before SLR impacts become problematic.
- *Implementation:* Given that adaptations may be needed several decades in the future, a variety of adaptations can be identified now for future implementations. These would identify dependencies (for example, offsite improvements that neighboring communities may construct), constraints (for example, in-water construction that could impact sensitive resources)

<u>Adaptation Measures</u>

The project's adaptation strategy will vary in different areas based on levels of acceptable risk, requirements to maintain existing uses and connectivity to adjacent streets, and the desire to provide a variety of user experiences. The decision on which adaptations to implement will be based on a variety of factors, including applicable SLR guidance at the time, consultation with agencies and the local community, regulatory requirements, and industry best practices at the time of adaptations. Potential triggers and strategies for adaptation are described below, and shown in Appendix A.

1. *Development Areas and Ballpark*: Proposed building elevations are adequate to accommodate extreme water levels in the future, up to 2095 and potentially beyond depending on actual SLR measurements. For a higher amount of SLR, and assuming that grades along the Embarcadero, Clay Street, and adjacent parcels to the west have not been raised, adaptations will be needed. Potential adaptations could include:

- A Perimeter Floodwall around the project site (top of wall would be +12’ OCD to +14’ OCD)
- Raise Street Grades along the perimeter of the site to function as a levee (same elevations as for wall described above)

2. *Streets and Open-Spaces:* Proposed elevations for these features are adequate to accommodate 3-ft (along wharf edge) to about 5-ft (north of wharf) of SLR. Based on the 2018 Guidance, a 3-ft SLR projection is not expected to occur until about 2065 for the High-Emissions, Medium-High Risk Aversion scenario. For a higher amount of SLR, potential adaptations could include the following:
   - If SLR approaches 3-ft (by about 2065), construct a berm along the open space between the wharf and the development area to provide an additional 3-ft of SLR protection for the lower elevation open space area
   - If SLR approaches 5-ft (by about 2085), construct floodgates at street entrances to prevent street flooding from offsite sources. Open space areas would see temporary flooding during extreme high tides.
   - If SLR approaches 7-ft (by about 2100), construct a Perimeter Floodwall or Raise Street Grades as described in 1 above
3. *Wharf Edge:* The existing wharf elevation is adequate to accommodate 3-ft to 4-ft of SLR during a 1% annual chance tide, and 5-ft to 6-ft of SLR during a King Tide event. Since the wharf structure cannot be raised in place, adaptations will be needed when SLR exceeds the 3-ft allowance. Potential adaptations could include:
   - Parapet walls along the wharf edge
   - Change in programming and user experience to incorporate the temporary inundation during extreme tides
4. *Northeast Corner:* Since the development block (Block 18) and the Peaker Power Plant front the Embarcadero, Jefferson St, and Clay St needs to conform to street grades, grades are not proposed to be raised here. Adaptations such as floodwalls can be constructed along the edges and entryways reconfigured for access.

4. Public Access on Pile Supported Wharf

Much of the project site was utilized as a container terminal since the early 1980’s and it includes a pile-supported marginal wharf structure at its southern edge along the Oakland Estuary, where vessels used to berth. The wharf structure consists of prestressed concrete piles, cast-in-place pile-caps and deck, and four cranes above the deck.

The Howard Terminal Project proposes to utilize the wharf structure for open space and recreational use, which will be considered a change in use (and occupancy) from a Building Code compliance perspective. This proposed change in use from a former industrial facility to a publicly accessible park will require a detailed structural evaluation during the final design phase to demonstrate that it meets applicable building codes.

A preliminary structural review of the concrete wharf structure indicates that it was designed to meet relatively modern-era building code requirements (less than 40-years old) that also included seismic criteria. Although a detailed structural analysis to estimate it's useful remaining service life has not yet been performed, a Preliminary Assessment of structure performance, augmented by visual inspections of the structure above and below the deck confirmed that it is in relatively good condition with no visible signs of structural distress like cracks, spalls or differential settlement. The Preliminary Assessment also indicates that the existing wharf structure should be able to withstand the code forces resulting from the change in occupancy, with minor retrofits, as long as the proposed design does not introduce a significant amount of new additional loading or higher risk category uses such as emergency egress or large public assembly on the deck.

Detailed structural evaluations will be conducted during the final design phase to achieve a balance between desired park elements, structural performance, and amount of seismic retrofit such that compliance with applicable codes can be demonstrated. Such an approach, where proposed design elements and required seismic retrofits are iteratively tweaked to comply with applicable building codes, is typical of many structural rehabilitation type of projects.

Of note are two considerations that are described below.

- *Crane Retention:* If one or more of the cranes are proposed to be retained, it is conceivable that code compliance triggers the need for additional seismic retrofits. If that is the case, the extent of additional construction, resulting environmental impacts, and benefit/cost analyses may render the proposed retention of the cranes as-is (without substantial modifications) infeasible and they would be modified or removed from the structure.
- *Service Life:* Because marine structures undergo degradation of concrete and steel elements when exposed to salt water, they typically have a project service life of 50 to 70 years. They are also designed to have an elastic response to earthquakes up to a certain level of seismic activity that is code-based. If a higher-than-code level seismic event occurs, it is possible that the level of damage is still repairable or the structure may need to be demolished due to excessive damage. Since the overall condition of the structure appears to be good, it is proposed to be used for public access as part of the Ballpark project until such time that a significant seismic event damages it beyond repair. If that event were to occur, several options could be evaluated at the time including complete demolition of the structure, partial rebuild of structure, or other forms of public access such as in-water or floating structures.

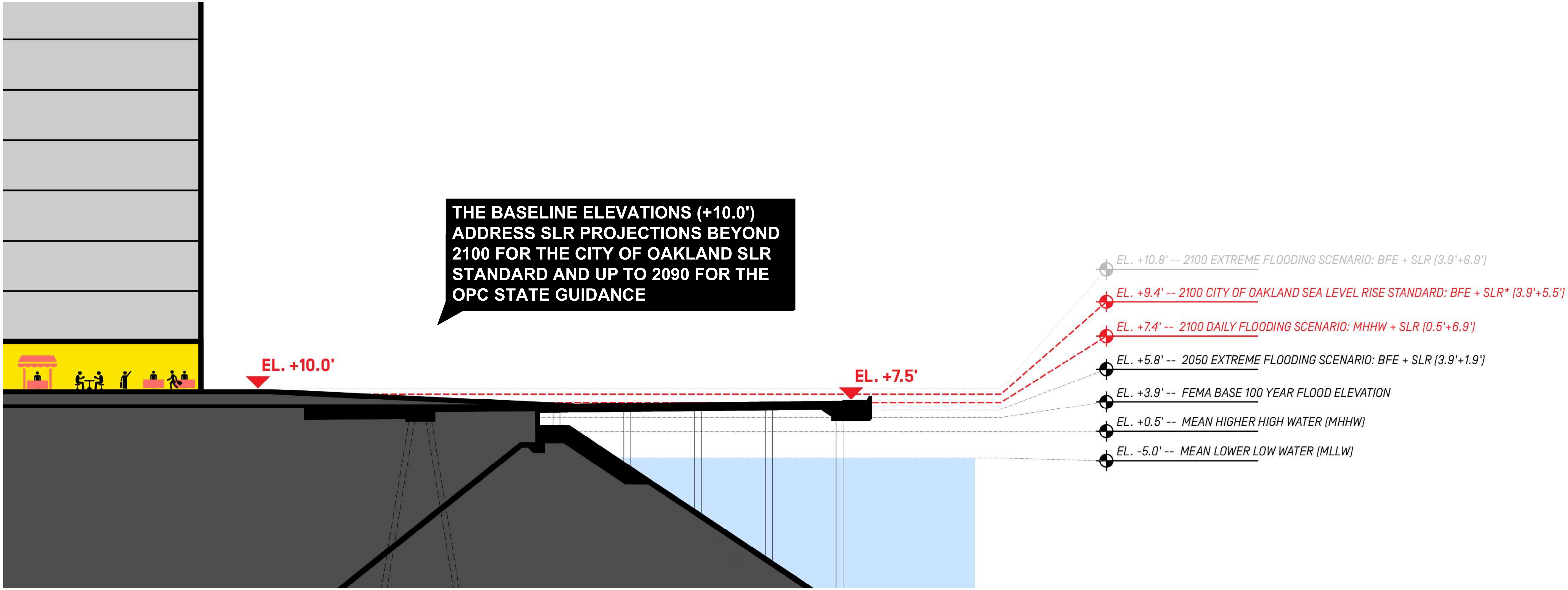
APPENDIX A

SEA LEVEL RISE ADAPTATION STRATEGIES

OAKLAND ATHLETICS
HOWARD TERMINAL MASTERPLAN

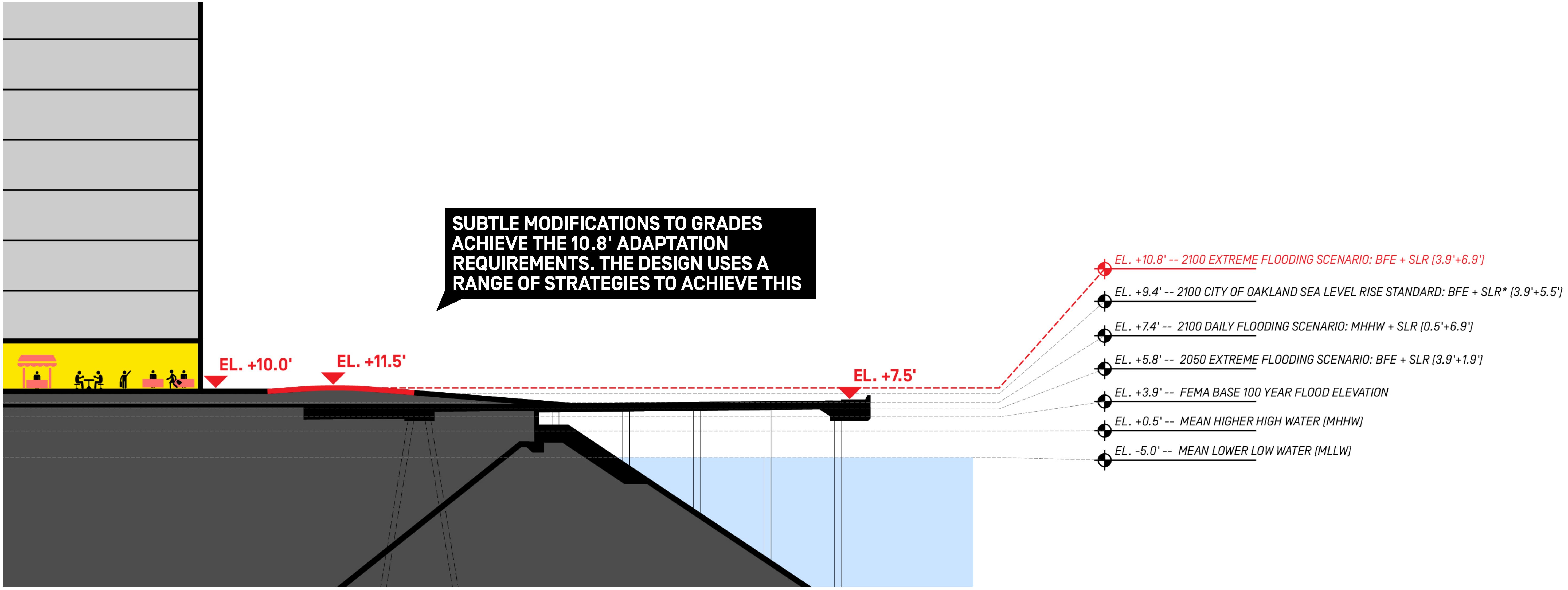
SEA LEVEL RISE ADAPTATIONS
2019-12-09

JAMES CORNER FIELD OPERATIONS Gensler CATELLUS BKF MAGNUSSON KLEMENCIC ASSOCIATES MEYERS+ ENGINEERS FEHR PEERS atelier ten



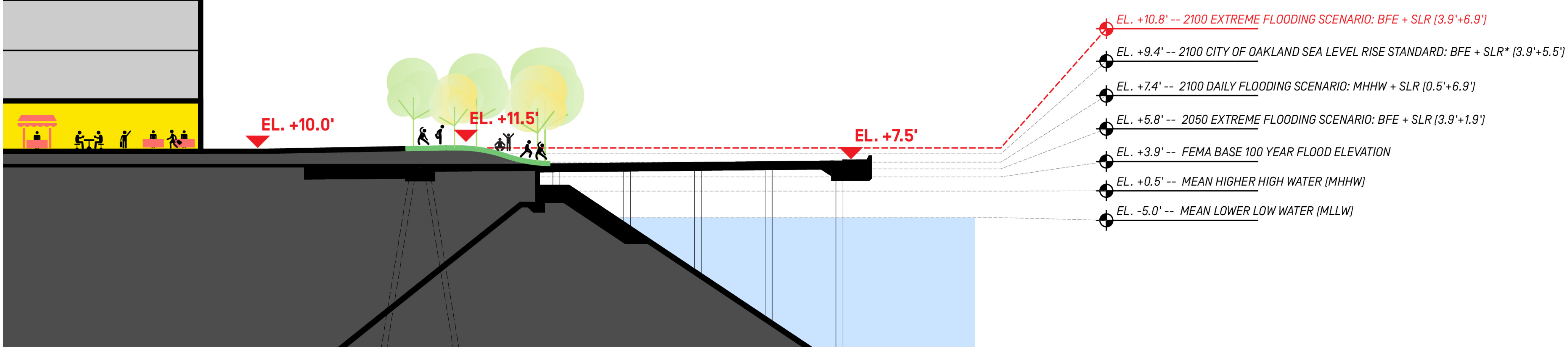
2100 UPPER RANGE PER CITY OF OAKLAND ROADMAP

BASELINE SCENARIO



2100 UPPER RANGE PER CITY OF OAKLAND ROADMAP

MODIFIED-BASELINE SCENARIO

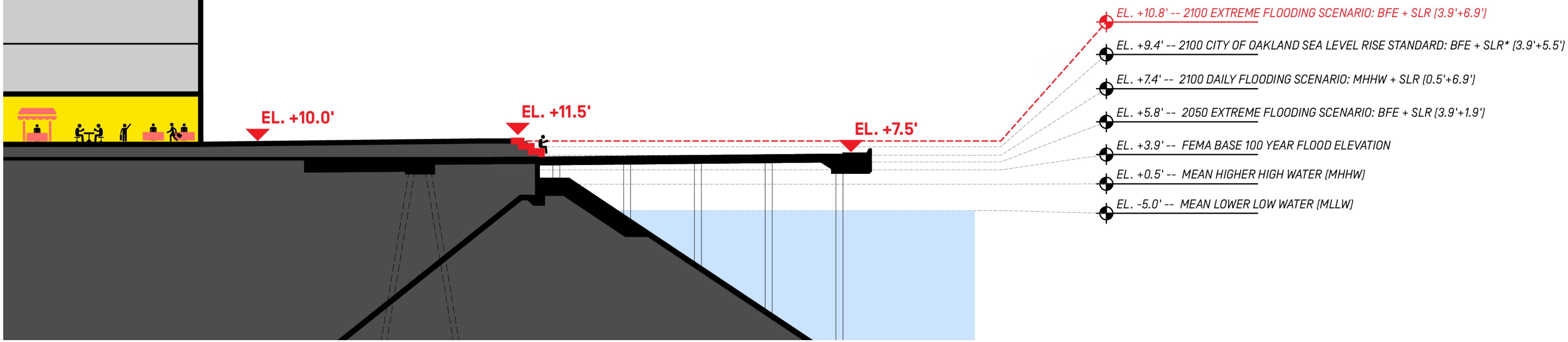


THE BIG U (BIG) - NEW YORK CITY

2100 UPPER RANGE PER OPC GUIDANCE

STRATEGY 1 - LANDSCAPE BERM

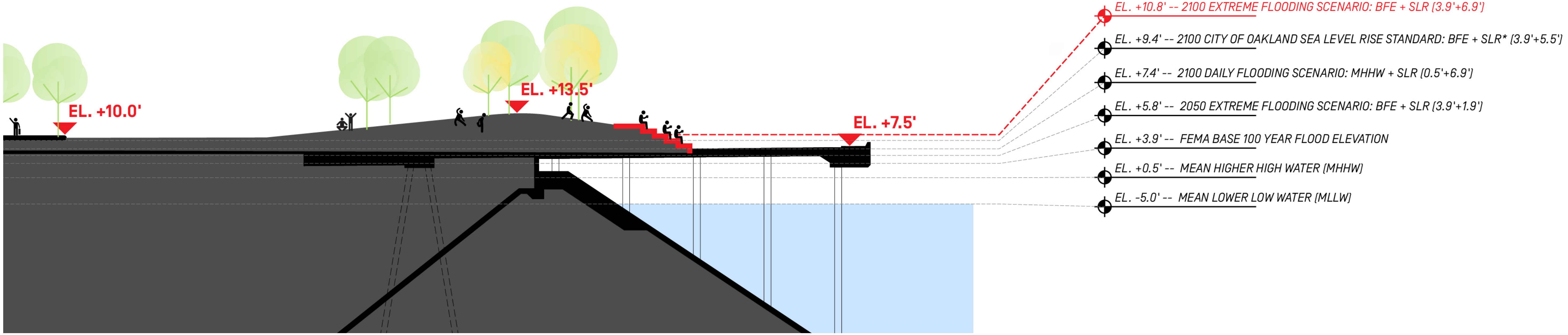
CHICAGO RIVERWALK



2100 UPPER RANGE PER OPC GUIDANCE

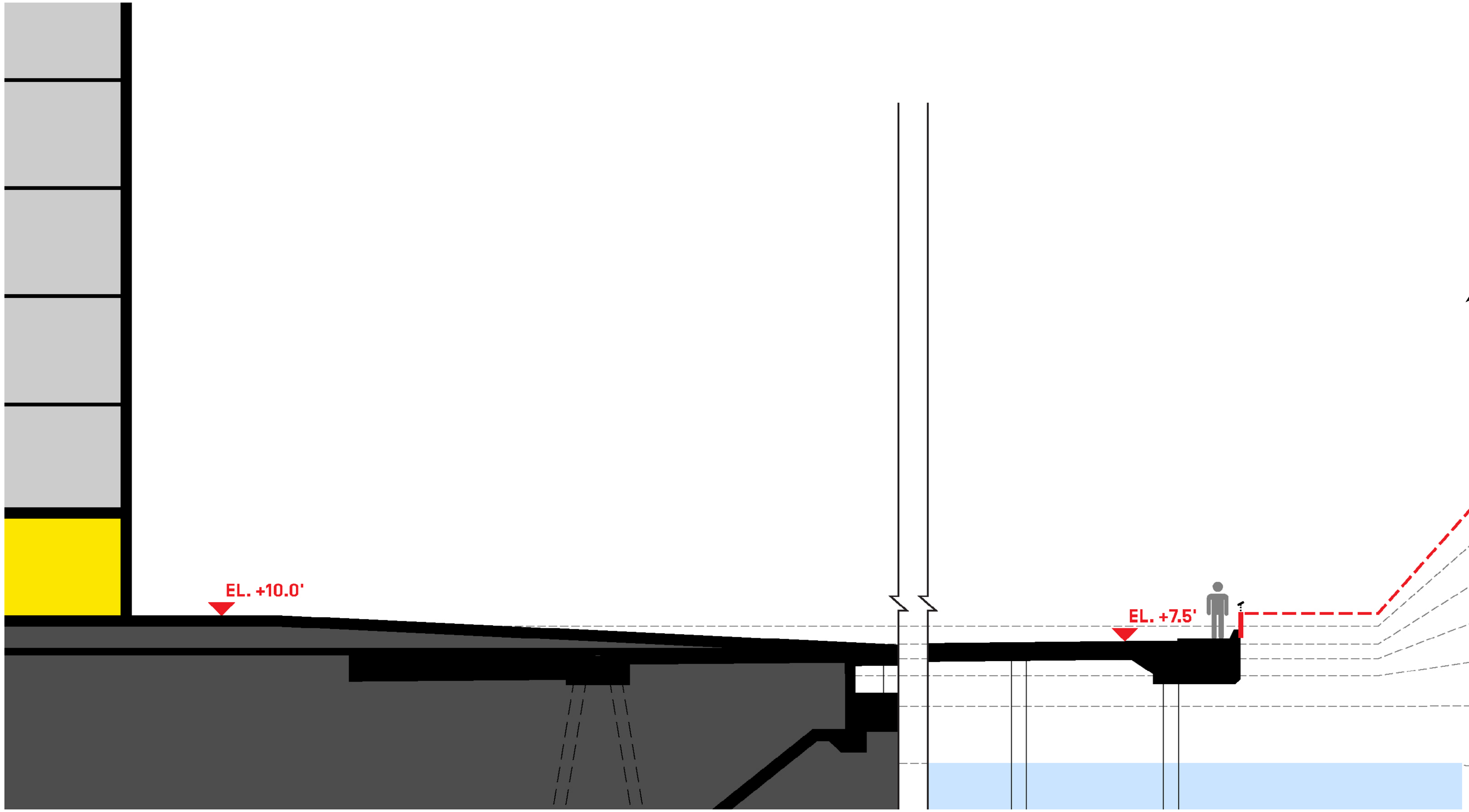
STRATEGY 2 - STEPS & TERRACES

RIVER'S EDGE PARK, OMAHA



2100 UPPER RANGE PER OPC GUIDANCE

STRATEGY 3 - OVERLOOKS & AMPHITHEATRES



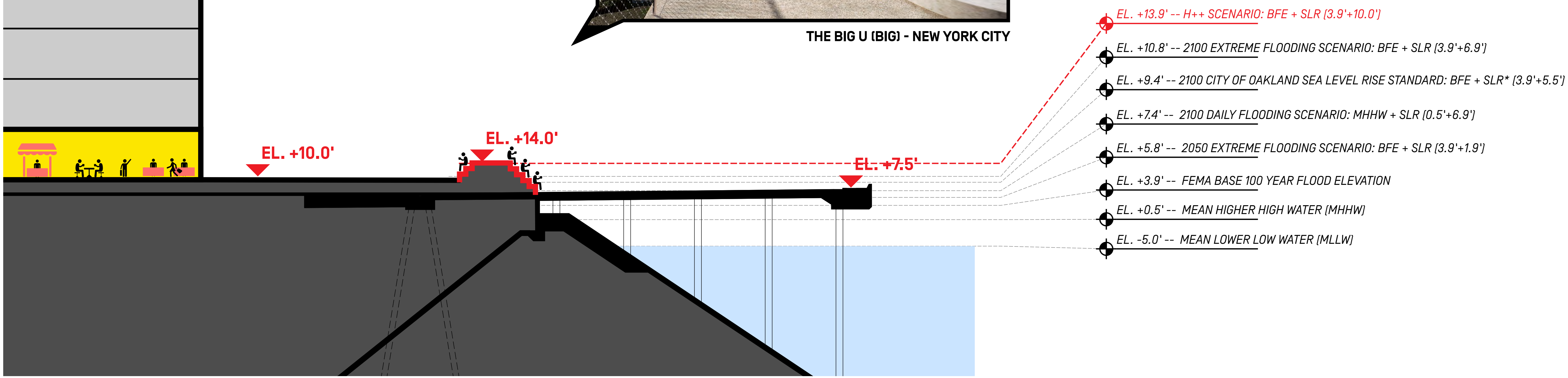
AVENUE OF STARS PROMENADE (JCFO) - HONG KONG

2100 UPPER RANGE PER OPC GUIDANCE

STRATEGY 4 - POTENTIAL WHARF EDGE ENHANCEMENTS

H++ Scenario

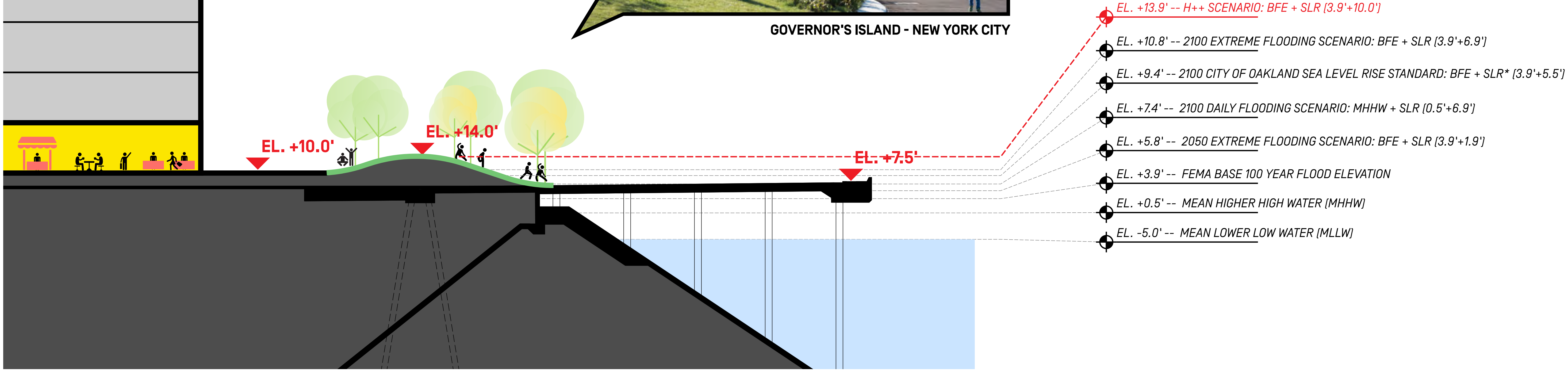
THE BIG U (BIG) - NEW YORK CITY



H++ SCNEARIO

STRATEGY 1 - URBAN STEPS

GOVERNOR'S ISLAND - NEW YORK CITY



H++ SCNEARIO

STRATEGY 2 - LANDSCAPE BERM

OAKLAND ATHLETICS

JAMES CORNER FIELD OPERATIONS | Gensler | CATELLUS | BKF | MAGNUSSON KLEMENCIC ASSOCIATES | MEYERS+ ENGINEERS | FEHR PEERS | atelier ten

SLR.3 Potential Extents of Inundation Memorandum (Moffatt & Nichol, 2021)

moffatt & nichol
2185 N. California Blvd., Ste 500
Walnut Creek, CA 94596-3500
(925) 944-5411 Fax (925) 944-4732
www.moffattnichol.com

MEMORANDUM

To: Noah Rosen, Oakland Athletics

From: Dilip Trivedi

Date: September 27, 2021

Subject: Potential Extents of Inundation
Oakland Athletics Howard Terminal Project
M&N Job No: 10114-01

The Oakland Athletics Howard Terminal project envisions a new waterfront ballpark and a mixed-use development along the Oakland Estuary. One of the requirements for obtaining environmental and regulatory approvals for the project is to describe changes to the extent of inundation associated with future Sea Level Rise for the No Project or *"existing"* condition and the Post Project or *"proposed"* condition.

This memorandum provides exhibits showing the extent of Inundation for the No-Project and Post-Project Conditions. The No-Project exhibits are based on prior Local and Regional Vulnerability Assessments conducted for the project vicinity; the Port-Project exhibits are based on analyses completed for the Ballpark project. The following exhibits, and the assumptions/sources that the exhibits are based on, are included:

NO-PROJECT CONDITIONS

1. **Inundation at Extreme High Tide by 2050 (Adapting to Rising Tides Project)**

   The exhibit is from the 2011 *Adapting to Rising Tides* (ART) project that was funded by MTC, Caltrans and BCDC. It represents inundation associated with a 100-year water level combined with 16-inches of SLR. At the time of the assessment, SLR was projected to be about 16-inches by 2050. It shows that the proposed site is not affected (no inundation).

2. **Inundation at Extreme High Tide by 2100 (Adapting to Rising Tides Project)**

   The exhibit is also from the ART Project. It represents inundation associated with a 100-year water level combined with 55-inches of SLR. At the time of the assessment, SLR was projected to be about 55-inches by 2100. It shows that most of the site, as well as adjacent properties, would be inundated under this scenario.

3. **Daily Inundation for 4-ft and 6-ft of SLR (Oakland Preliminary Sea Level Rise Road Map)**

   The exhibit is from the 2017 *Oakland SLR Road Map*. It represents a level of inundation that could occur daily after 4-ft and 6-ft of SLR has occurred. A Mean Higher High Water (MHHW) tide has been used to represent Daily inundation. The exhibit shows that the site would be inundated on a daily basis after about 6-ft of SLR has occurred.

   To compare this to the other exhibits that use inundation during an extreme high tide, the 4-ft scenario represents a timeframe of approximately 2030 (100-year water level + 0.8-ft SLR). The 6-ft SLR scenario represents a timeframe of approximately 2065 (100-year water level + 3-ft SLR).

POST-PROJECT CONDITIONS

4. **Inundation at Extreme High Tide by 2025 (OPC Projections)**

   The exhibit was prepared assuming the site is graded per proposed project plans. It represents inundation associated with a 100-year water level at the time project construction is complete (about 2025). A SLR allowance of 6-inches was used, based on the OPC 2018 Guidance Report for the year 2030. It shows that the site would not be affected (no inundation).

5. **Inundation at Extreme High Tide by 2050 (OPC Projections)**

   The exhibit represents inundation associated with a 100-year water level combined with a SLR projection of 1.9-ft per the OPC *Medium to High Risk Aversion* scenario for 2050. It is based on an assumption that certain adaptations have been implemented (Phase 1 Improvements) to secure the site against flooding from adjacent areas that are low-lying. The adaptations consist of three floodgates along the Embarcadero and one at the foot of Clay St that would operate during high tides. Three areas of temporary inundation (during extreme high tides) are also marked in red.

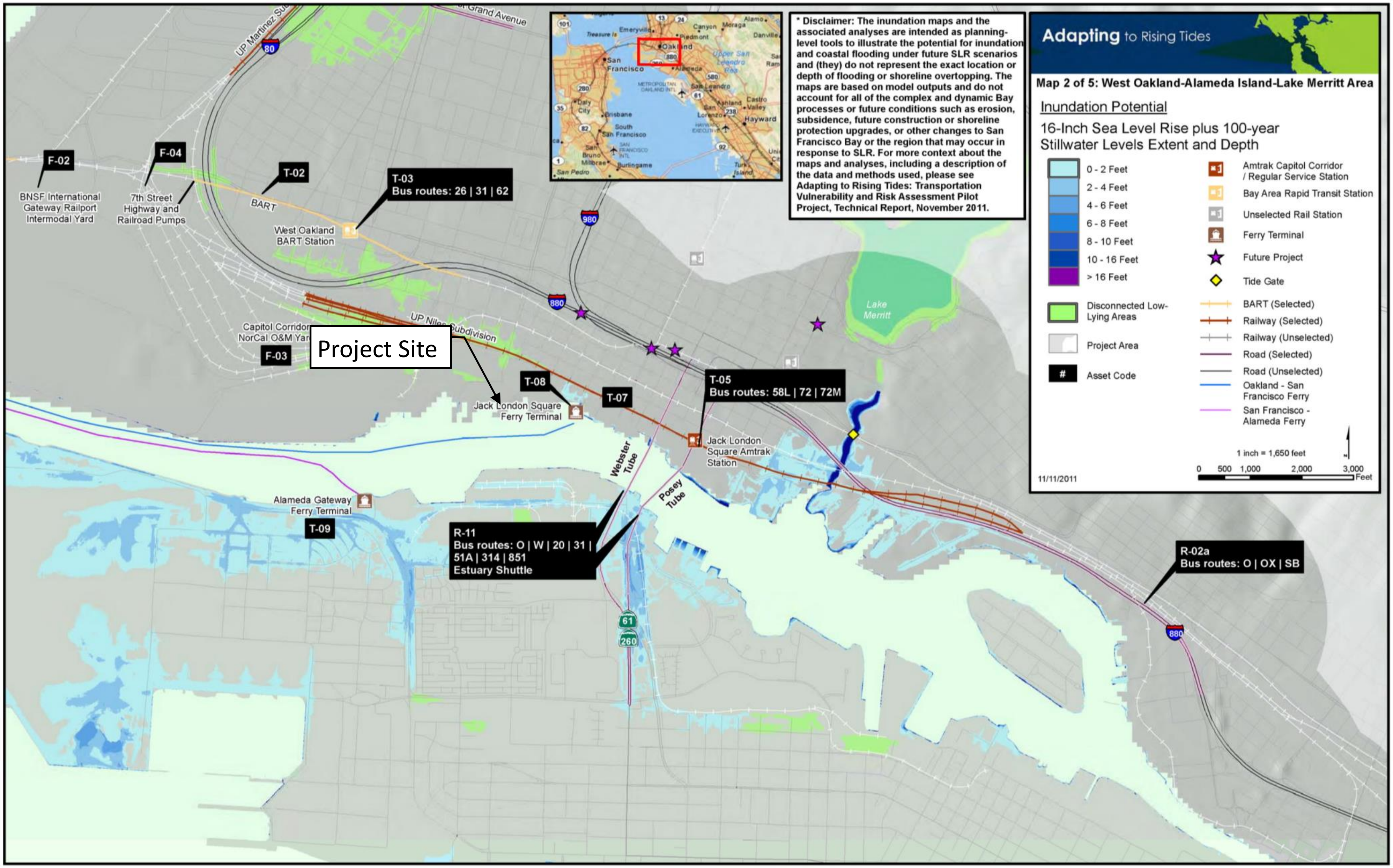
6. **Inundation at Extreme High Tide by 2025 (OPC Projections)**

   The exhibit represents inundation associated with a 100-year water level combined with a SLR projection of 6.9-ft per the OPC *Medium to High Risk Aversion* scenario for 2100. It is based on an assumption that additional adaptations have been implemented (Phase 2 Improvements) to secure the site against flooding from adjacent low-lying areas as well as over the concrete Wharf along the Estuary. The adaptations consist of one additional floodgate along the Embarcadero, a perimeter floodwall along the Embarcadero and along the Schnitzer parcel to the west, and improvements (raising) the perimeter berm along the open space edge between the development and the Wharf. The portions of the site inundated during extreme high tides are shown in red.

SEA LEVEL RISE INUNDATION EXHIBITS

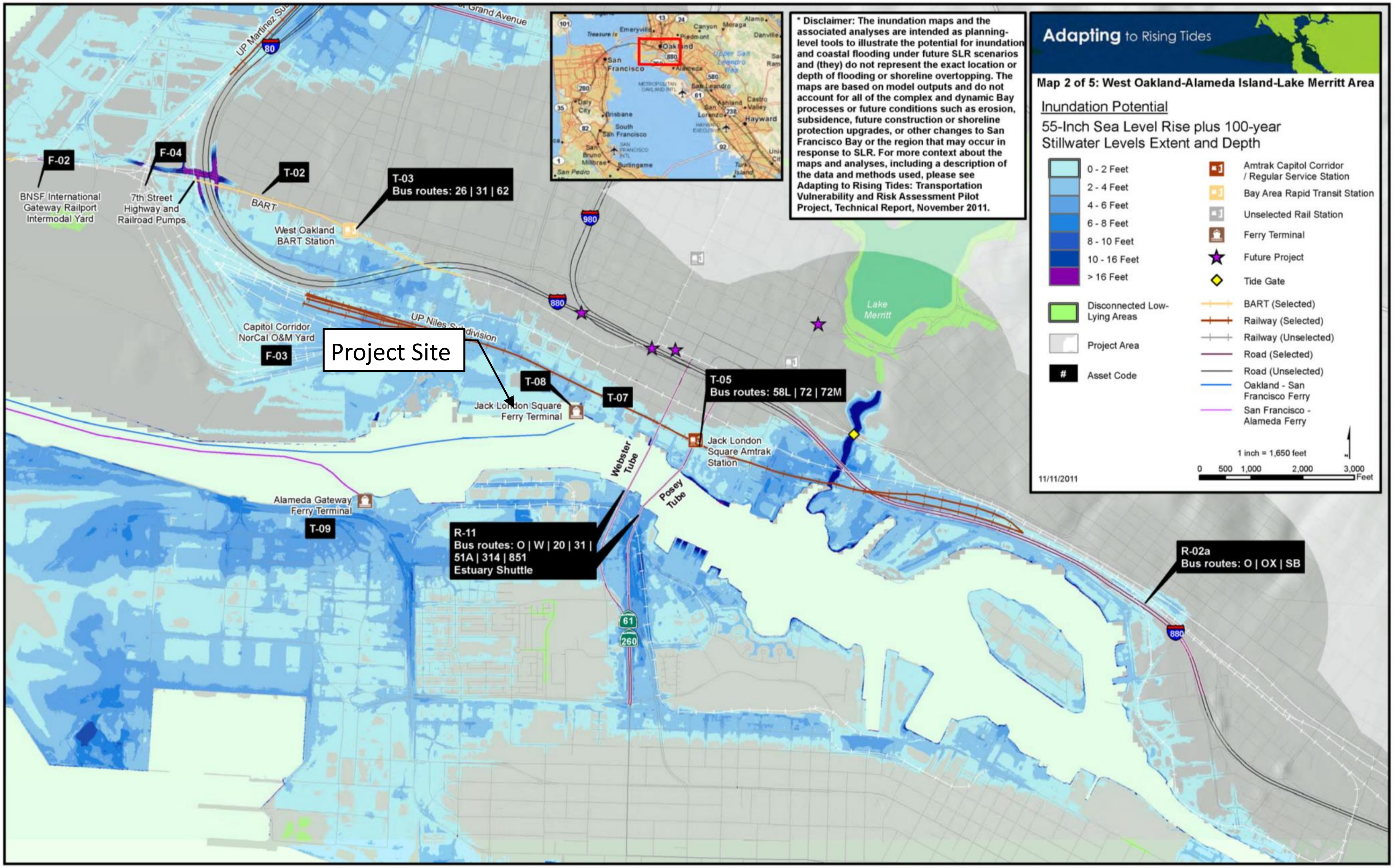
1. Inundation at Extreme High Tide, 2050 (No Project)
(16" SLR, 100-Year Tide)

Source: *Adapting to Rising Tides Transportation Vulnerability and Risk Assessment Pilot Project*, Briefing Book, November 2011, Metropolitan Transportation Commission, Caltrans, SF BCDC



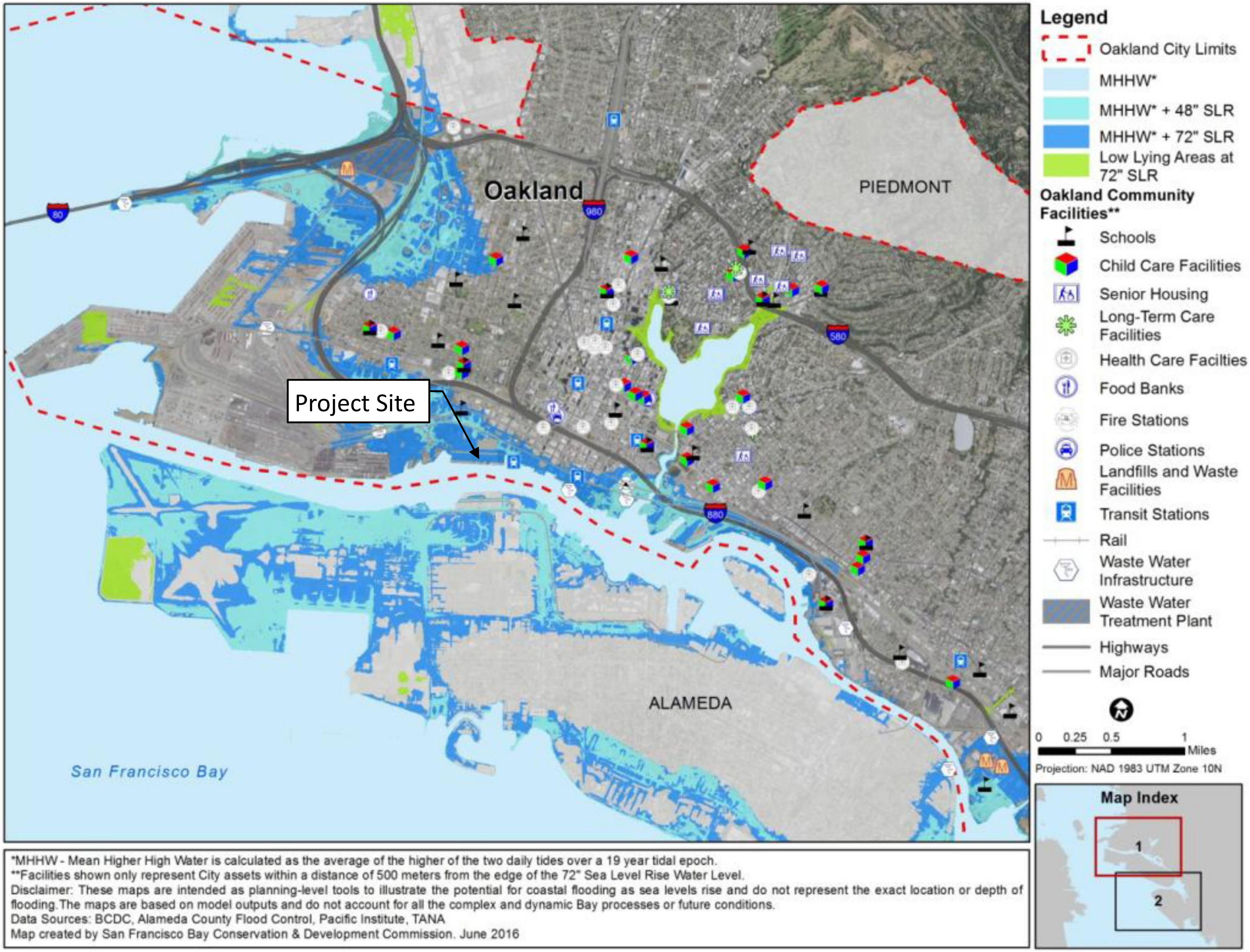
2. Inundation at Extreme High Tide, 2100 (No Project)
(55" SLR, 100-Year Tide)

Source: *Adapting to Rising Tides Transportation Vulnerability and Risk Assessment Pilot Project*, Briefing Book, November 2011, Metropolitan Transportation Commission, Caltrans, SF BCDC



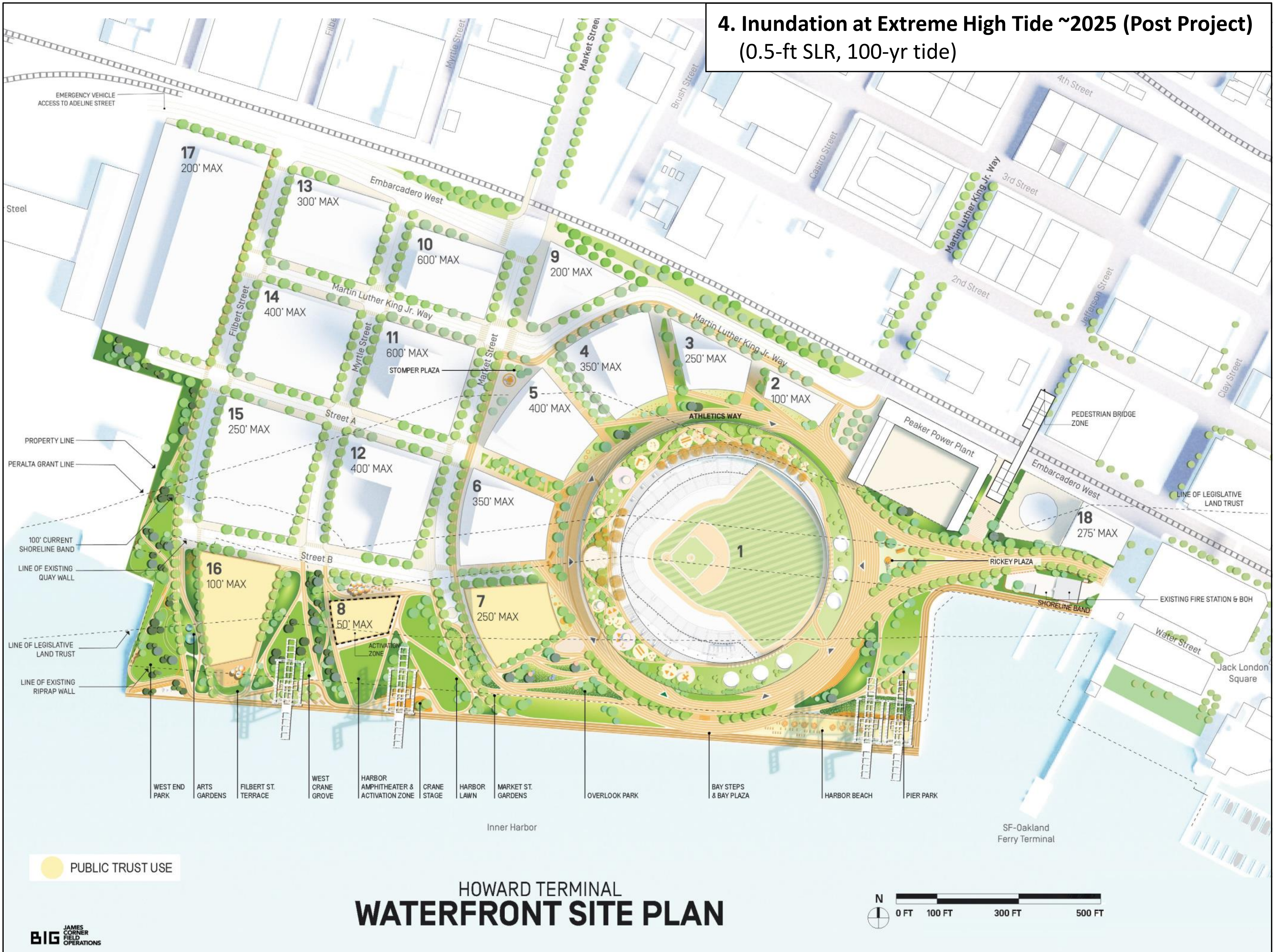
Source: *Oakland Preliminary Sea Level Rise Road Map,* Fall 2017

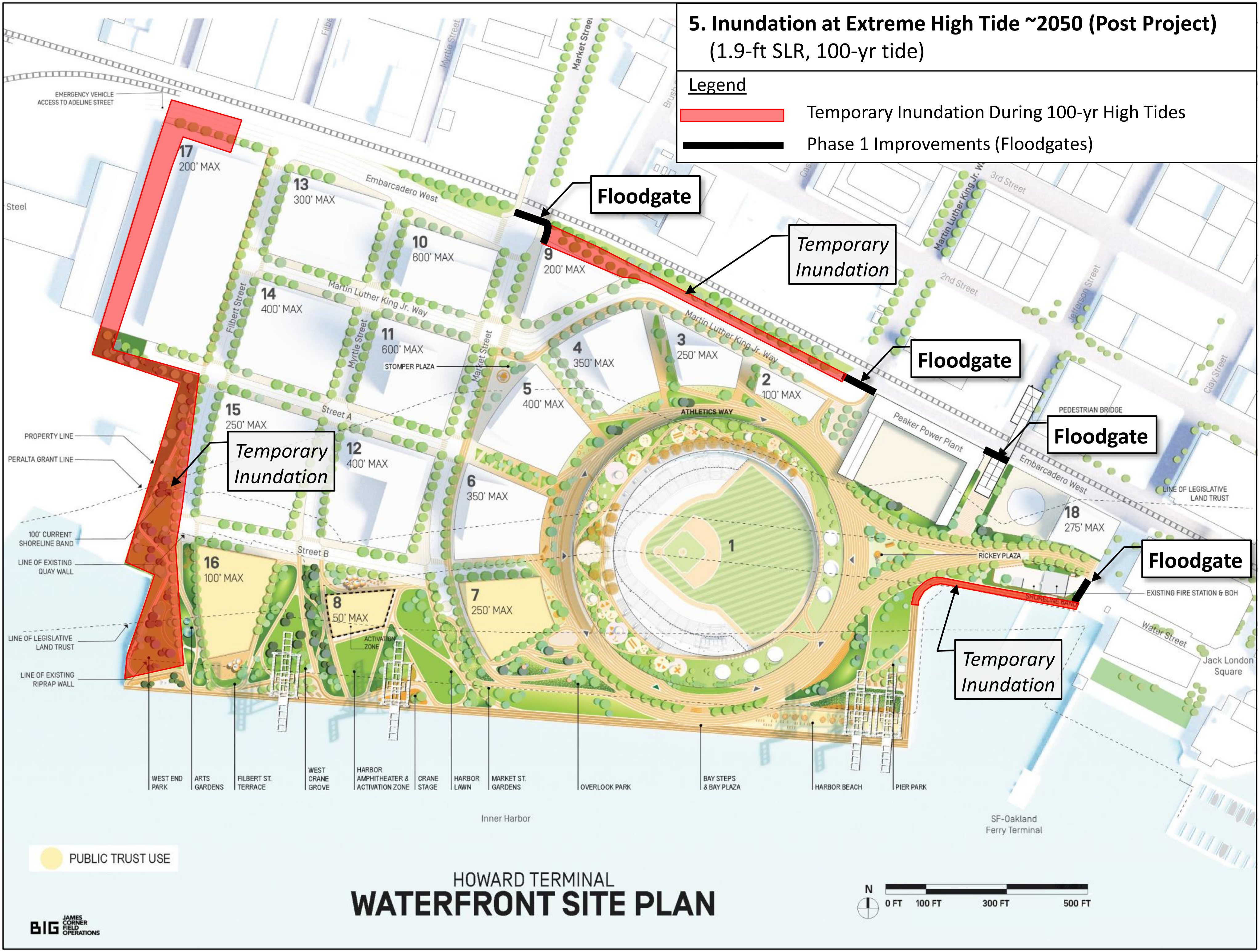
3. Daily Inundation With Sea Level Rise (No Project)
(4-ft and 6-ft SLR, MHHW Tide)

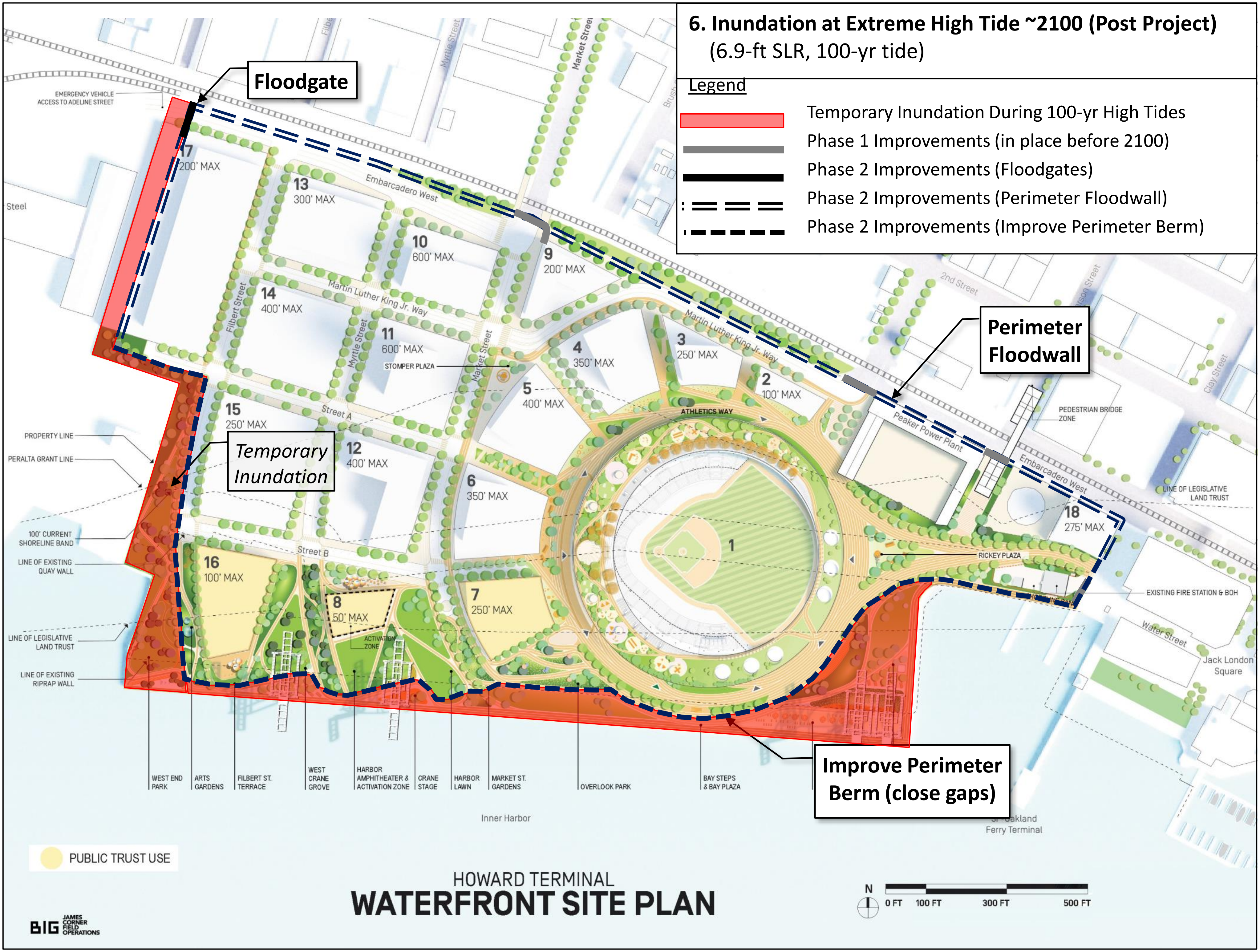


*MHHW - Mean Higher High Water is calculated as the average of the higher of the two daily tides over a 19 year tidal epoch.
**Facilities shown only represent City assets within a distance of 500 meters from the edge of the 72" Sea Level Rise Water Level.
Disclaimer: These maps are intended as planning-level tools to illustrate the potential for coastal flooding as sea levels rise and do not represent the exact location or depth of flooding. The maps are based on model outputs and do not account for all the complex and dynamic Bay processes or future conditions.
Data Sources: BCDC, Alameda County Flood Control, Pacific Institute, TANA
Map created by San Francisco Bay Conservation & Development Commission. June 2016

4. Inundation at Extreme High Tide ~2025 (Post Project)
(0.5-ft SLR, 100-yr tide)




5. Inundation at Extreme High Tide ~2050 (Post Project)
(1.9-ft SLR, 100-yr tide)
Legend
Temporary Inundation During 100-yr High Tides
Phase 1 Improvements (Floodgates)
Floodgate
Floodgate
Floodgate
Floodgate
Temporary Inundation
Temporary Inundation
Temporary Inundation
EMERGENCY VEHICLE ACCESS TO ADELINE STREET
Steel
17 200' MAX
13 300' MAX
10 600' MAX
9 200' MAX
14 400' MAX
11 600' MAX
4 350' MAX
3 250' MAX
2 100' MAX
5 400' MAX
15 250' MAX
12 400' MAX
6 350' MAX
1
18 275' MAX
16 100' MAX
8 50' MAX
7 250' MAX
Embarcadero West
Martin Luther King Jr. Way
Filbert Street
Myrtle Street
Market Street
Street A
Street B
3rd Street
2nd Street
Jefferson Street
Clay Street
Water Street
STOMPER PLAZA
ATHLETICS WAY
Peaker Power Plant
PEDESTRIAN BRIDGE
RICKEY PLAZA
EXISTING FIRE STATION & BOH
SHORELINE BAND
LINE OF LEGISLATIVE LAND TRUST
ACTIVATION ZONE
PROPERTY LINE
PERALTA GRANT LINE
100' CURRENT SHORELINE BAND
LINE OF EXISTING QUAY WALL
LINE OF LEGISLATIVE LAND TRUST
LINE OF EXISTING RIPRAP WALL
WEST END PARK
ARTS GARDENS
FILBERT ST. TERRACE
WEST CRANE GROVE
HARBOR AMPHITHEATER & ACTIVATION ZONE
CRANE STAGE
HARBOR LAWN
MARKET ST. GARDENS
OVERLOOK PARK
BAY STEPS & BAY PLAZA
HARBOR BEACH
PIER PARK
Jack London Square
Inner Harbor
SF-Oakland Ferry Terminal
PUBLIC TRUST USE
HOWARD TERMINAL
WATERFRONT SITE PLAN
N
0 FT
100 FT
300 FT
500 FT
BIG
JAMES CORNER FIELD OPERATIONS


6. Inundation at Extreme High Tide ~2100 (Post Project)
(6.9-ft SLR, 100-yr tide)
Legend
Temporary Inundation During 100-yr High Tides
Phase 1 Improvements (in place before 2100)
Phase 2 Improvements (Floodgates)
Phase 2 Improvements (Perimeter Floodwall)
Phase 2 Improvements (Improve Perimeter Berm)
Floodgate
Perimeter Floodwall
Temporary Inundation
Improve Perimeter Berm (close gaps)
EMERGENCY VEHICLE ACCESS TO ADELINE STREET
Steel
Embarcadero West
Martin Luther King Jr. Way
Filbert Street
Myrtle Street
Market Street
Street A
Street B
2nd Street
Clay Street
Water Street
Peaker Power Plant
17
200' MAX
13
300' MAX
10
600' MAX
9
200' MAX
14
400' MAX
11
600' MAX
4
350' MAX
3
250' MAX
2
100' MAX
5
400' MAX
15
250' MAX
12
400' MAX
6
350' MAX
16
100' MAX
8
50' MAX
7
250' MAX
1
18
275' MAX
STOMPER PLAZA
ATHLETICS WAY
ACTIVATION ZONE
RICKEY PLAZA
PEDESTRIAN BRIDGE ZONE
LINE OF LEGISLATIVE LAND TRUST
EXISTING FIRE STATION & BOH
PROPERTY LINE
PERALTA GRANT LINE
100' CURRENT SHORELINE BAND
LINE OF EXISTING QUAY WALL
LINE OF LEGISLATIVE LAND TRUST
LINE OF EXISTING RIPRAP WALL
WEST END PARK
ARTS GARDENS
FILBERT ST. TERRACE
WEST CRANE GROVE
HARBOR AMPHITHEATER & ACTIVATION ZONE
CRANE STAGE
HARBOR LAWN
MARKET ST. GARDENS
OVERLOOK PARK
BAY STEPS & BAY PLAZA
Jack London Square
Inner Harbor
SF-Oakland Ferry Terminal
PUBLIC TRUST USE
HOWARD TERMINAL
WATERFRONT SITE PLAN
N
0 FT
100 FT
300 FT
500 FT
BIG
JAMES CORNER FIELD OPERATIONS