Appendix L

Hydrology and Water Quality Supporting Information

- India Basin Waterfront Parks and Open Space Coastal Processes and Shoreline Improvements
- India Basin Park – Concept Design Technical Memorandum
- India Basin 700 Innes & India Basin Open Space – Storm Drain Design

INDIA BASIN WATERFRONT PARKS AND OPEN SPACE

COASTAL PROCESSES AND SHORELINE IMPROVEMENTS

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1. EXECUTIVE SUMMARY

2. INTRODUCTION

2.1 Background

This report provides a review of coastal processes that influence potential shoreline uses along the India Basin shoreline. The physical setting of the project area, including site history, present uses, topography, bathymetry, and shoreline edge conditions is presented in Section 3. Hydrographic conditions including water levels, sea level rise, wind driven waves, and coastal flooding are discussed in Section 4. Coastal processes and sediment transport is discussed in Section 5, and potential improvements are discussed in Sections 6 and 7.

As co–project sponsors, BUILD and the San Francisco Recreation and Parks Department (RPD) propose to redevelop their respective adjacent parcels along the India Basin shoreline of San Francisco Bay (Bay). The project location and vicinity are shown in Figure 2-1 and Figure 2-2.

The project site encompasses publicly and privately owned parcels, including existing streets, totaling approximately 37.3 acres. The larger India Basin area also includes properties owned by FivePoint (formerly Lennar Urban), Pacific Gas & Electric Company (PG&E), and the Port of San Francisco (SF Port), which are not included in the project. Figure 2-3 illustrates the project area and parcels within its boundaries.

BUILD would develop 17.12 acres of privately owned land plus 5.94 acres of developed and undeveloped public rights-of-way (ROWs) in phases with residential, retail, commercial, office, research and development (R&D)/ laboratory and clinical care space, institutional, flex space, and recreational and art uses (Figure 2-4 and Figure 2-5). BUILD would also redevelop 6.2 acres of RPD property along the shoreline, adjacent to privately owned land, into enhanced wetlands, a boardwalk, and a beach. Two BUILD development options are being considered: the proposed residential project (a residentially focused mixed-use development, referred to herein as the “proposed project”) and the maximum commercial variant (with fewer dwelling units and more commercial development than the proposed project, referred to herein as the “variant”).

As part of both the proposed project and the variant, RPD would improve 8 acres of publicly owned parcels along the shoreline plus 1.58 acres of unimproved paper streets to create a publicly accessible network of new and/or improved parkland and open space. This new shoreline network would extend the Blue Greenway—a portion of the San Francisco Bay Trail (Bay Trail) that will ultimately connect the Embarcadero to the north and Candlestick Point to the south—and would provide pedestrian and bicycle connections to and along the shoreline, fronting the Bay.

Figure 2-4 and Figure 2-5 demonstrate the properties with the project area, and corresponding the owners and the area of each property is listed in Table 2-1. Bionic and GGN have provided design concepts for the project area (Figure 2-6). GGN designed a master plan for 900 Innes and India Basin Shoreline Park properties. The GGN master plan includes a gravel beach and floating piers in 900 Innes property, as well as a sloped lawn and another gravel beach in India Basin Shoreline Park, locating floating piers and an outfitter pavilion offshore of the property (Figure 2-7). Also, Bionic provided a detailed master plan for 700 Innes and India Basin Open Space properties, which includes a sandy beach, a kayak launch, terraced wetlands, and new tidal marshes (Figure 2-8).

2.2 Purpose

- To develop on understanding of coastal processes and provide guidelines to the project team for shoreline improvements
- To provide recommendations regarding shoreline erosion, SLR, and recreational opportunities.
- To describe potential construction activities, for potential impacts could be analyses in the EIR

Table 2-1: Proposed Projects and Property Ownership within India Basin Cove

Property	Owner	Area (Acres)
1. India Basin Open Space (IBOS)	RPD*	6.2
2. India Basin Shoreline Park (IBSP)	RPD	5.6
3. 900 Innes	RPD/CCSF	2.4
Subtotal: RPD Proposal		**14.2**
1. 700 Innes (Includes Big Green)	Build Inc.	17.12 (5.63*)
2. Right-of-Way	DPW	5.94
Subtotal: Build Proposal		**23.06**
1. Heron's Head Park (north of proposed development)	SF Port	22.69
2. Northside Park (eastern edge)	FivePoint (Lennar)	13.63
3. PG&E Hunters Point Site (western edge)	PG&E	4.66
Subtotal: Adjacent Parcels		**40.98**
Total India Basin Cove Area		**78.24**

*Big Green Area

2.3 Scope of Work

The scope of this study is analyze and discuss coastal processes that influence shoreline uses, and identify location and type of potential shoreline uses. The report provides baseline information for the study area that encompasses India Basin and Lash Lighter Cove, at a level that will support development of concept level improvement recommendations. Specific tasks undertaken include:

1. Document environmental (MetOcean) conditions
2. Analyze factors that influence shoreline stability and uses
3. Provide Guidance for Sea Level Rise (SLR) guidance for adaptation
4. Discuss potential shoreline uses/improvements
5. Describe potential construction activities.

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Figure 2-1: Location map

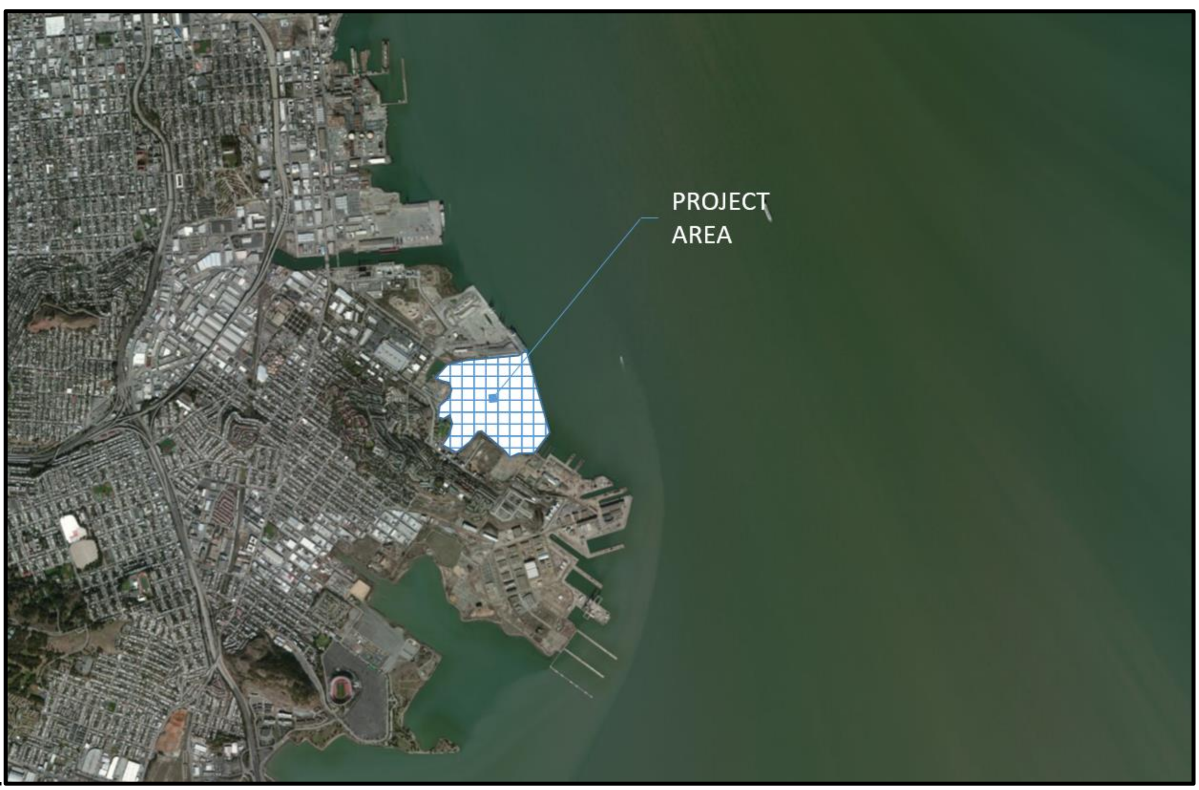

Figure 2-2: Vicinity map

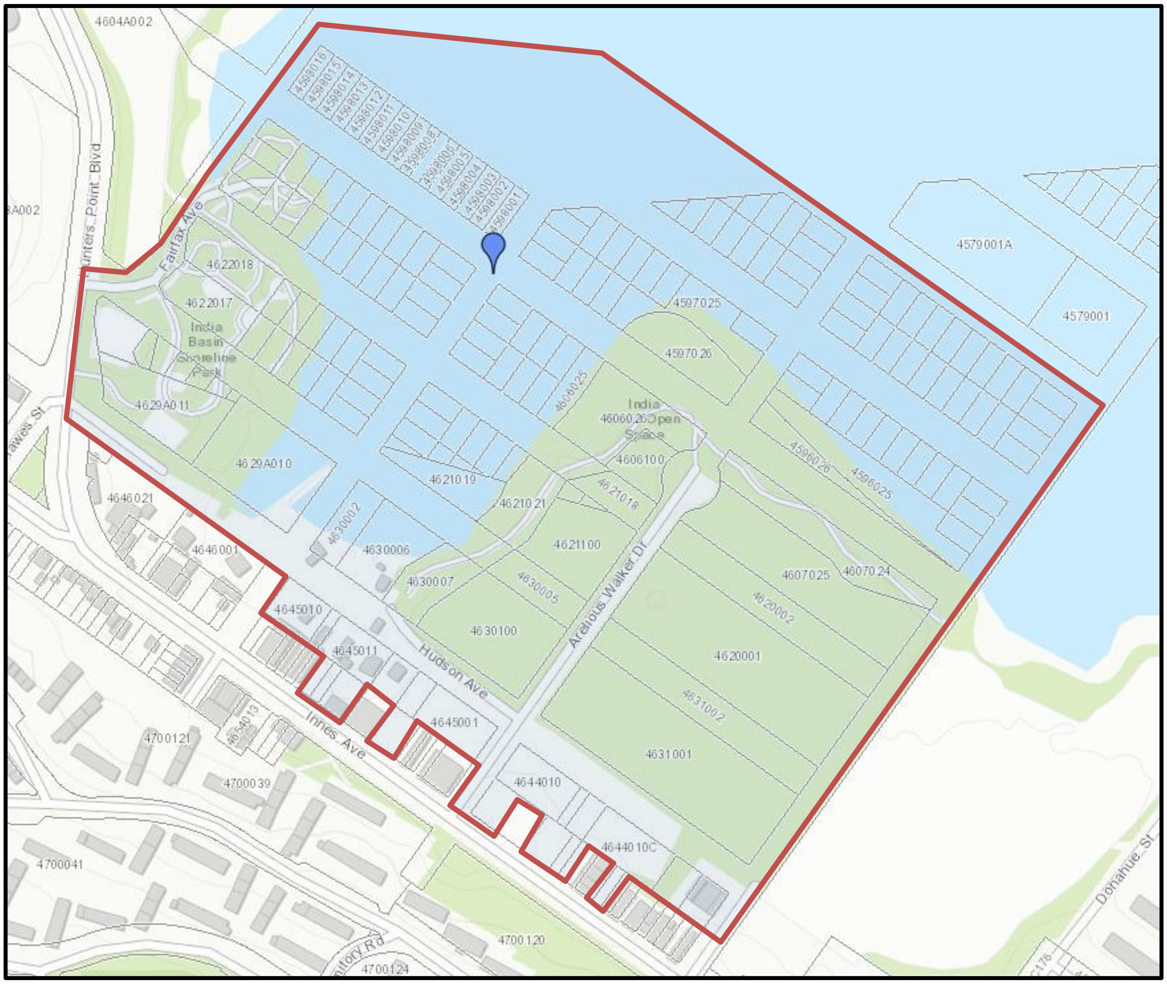

Figure 2-3: Project Site

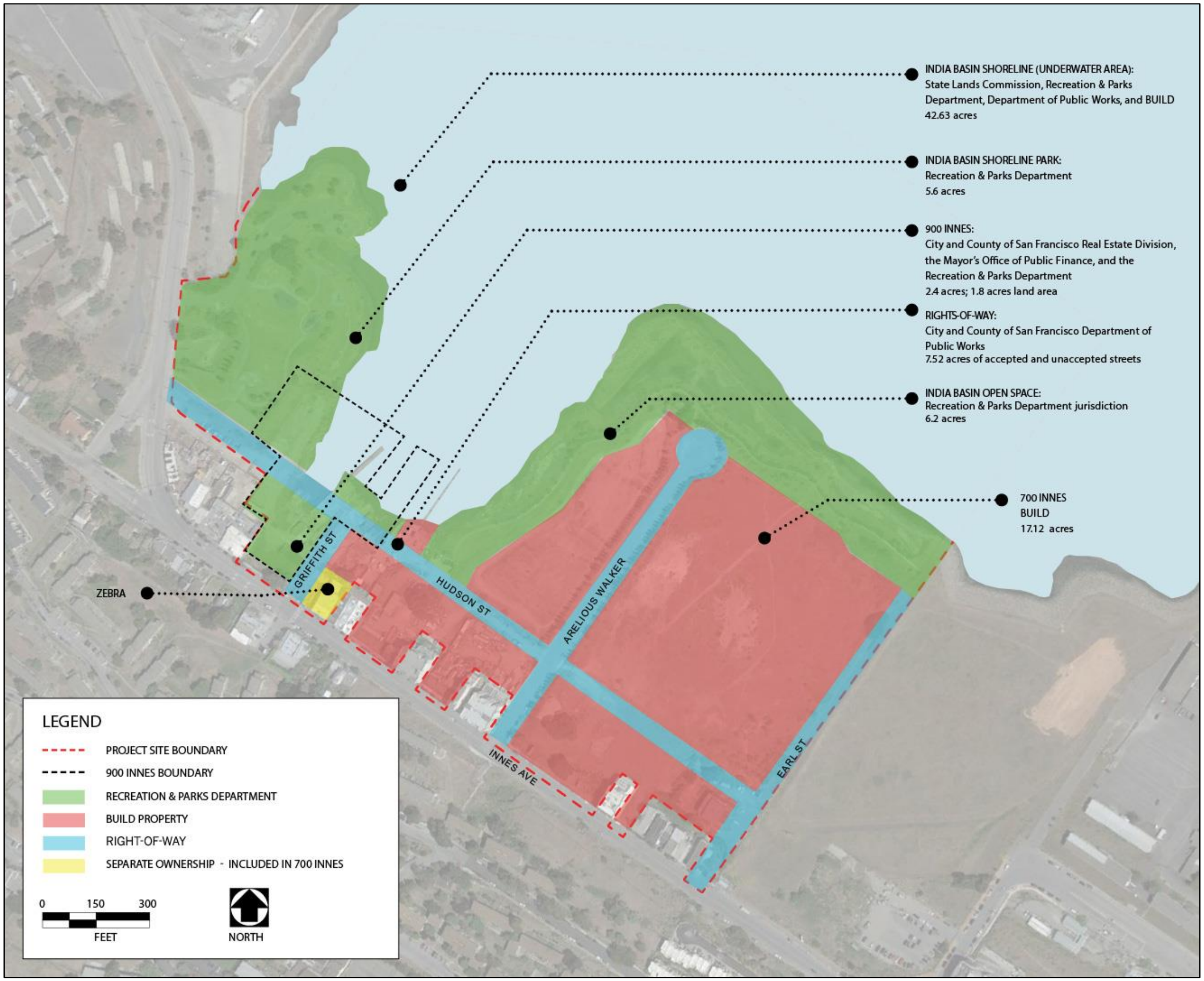

Figure 2-4: Parcels within Project Area and Ownership

Figure 2-5: Site Designations within India Basin Cove

Figure 2-6: Concept Master Plans for the Project Area

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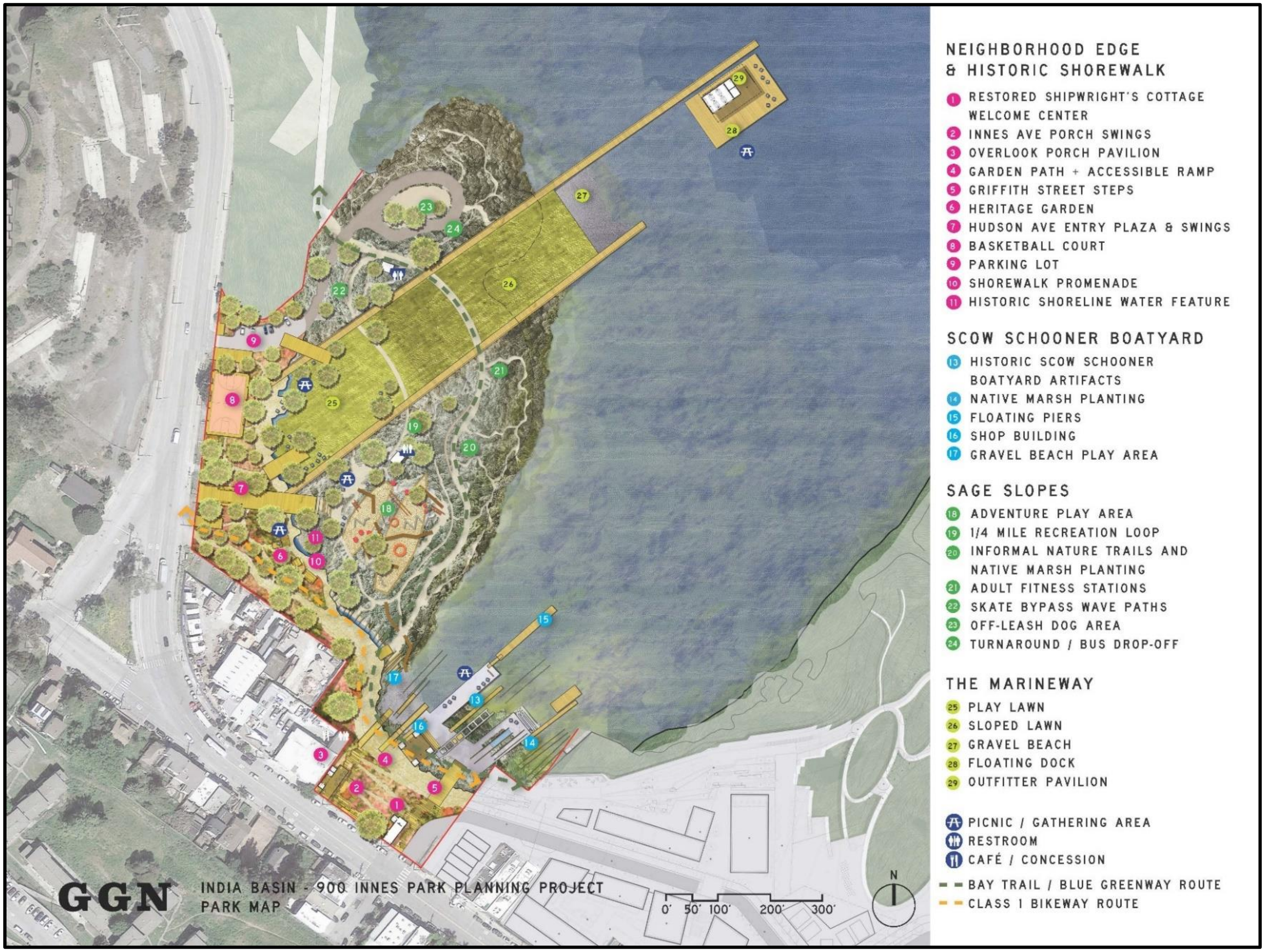

Figure 2-7: 900 Innes and India Basin Shoreline Park Project (SF Rec & Park, 2016)

Figure 2-8: 700 Innes and India Basin Open Space Project (Build, 2017)

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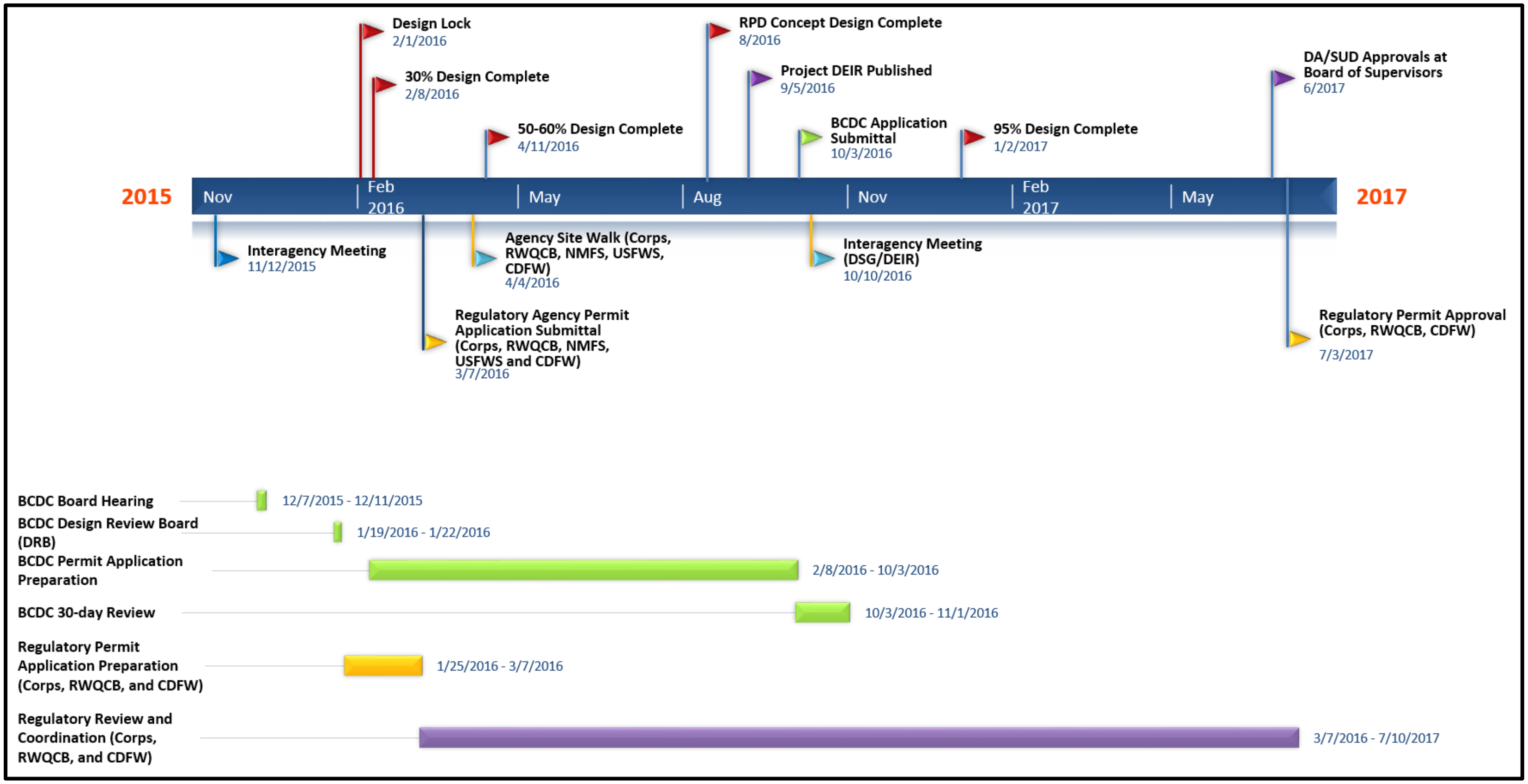

Figure 2-9: Tentative Project Schedule (Build, 2016)

3. PHYSICAL SETTING

3.1 Site History and Present Uses

A review of historic maps of the India basin area show that the project area is a combination of tidal flat and bay fill (Figure 3-1). A historic survey of the area carried out by Kelley and Verplanck Historical Resources Consulting (2008) indicates that the project site was created around 1965 when owners of several dozen water lots north of Hudson Avenue between Griffith and Earl Streets filled them with debris from the construction of Interstate 280. The primary uses of the shoreline area have been boat building. India basin was well known for building Bay scows, small shallow-draft sailing craft that transported goods from the sloughs of San Francisco Bay to the city, during the late 1800s to early 1900s. Maritime industry uses continued, including boat repair, until the 1990s. Figure 3-1 illustrate the India Basin shoreline before and after the landfill operations.

Time history of filling material is listed below

- 700 Innes/ IBOS, 1965, Interstate 280 debris
- Heron's Head Park, Early 1970s, Part of pier 98 Construction
- Expanded Marsh lands, Late 1990s, removing over 5,000 tons of concrete, asphalt, metal and other debris, created a tidal channel to improve circulation and constructed upland trails, picnic and bird-viewing areas and a fishing pier.

3.1.1 India Basin Shoreline Park Property

This 5.6-acre property is an existing RPD park located between Hunters Point Boulevard and PG&E's vacant parcels to the north and the 900 Innes property to the south (Figure 2-5). India Basin Shoreline Park has two play structures, a basketball court, landscaping, a portion of the Blue Greenway/Bay Trail, artwork by local artists and students, barbeque grills, seating areas, a water fountain, and educational signage. Vehicular access to the park is provided via Hunters Point Boulevard. Hawes Street has designated parking areas and ends at a cul-de-sac and drop-off area. The park provides informal access along the Bay shoreline, which includes some wetlands and upland plantings. Many of the amenities at India Basin Shoreline Park are outdated, require maintenance, and are used only minimally.

3.1.2 900 Innes Property (multiple parcels)

The 900 Innes property consists of seven parcels totaling 2.4 acres, 0.6 acre of which is submerged, that are located between India Basin Shoreline Park and the India Basin Open Space (Figure 2-5). The property is a former maritime industrial site that contains five structures totaling approximately 7,760 gross square feet (gsf).

A one-story, 900-square-foot wood-framed house is located on the northwestern corner of Innes Avenue and the unimproved Griffith Street ROW. This house, known as the Shipwright's Cottage, is eligible for listing in the California Register of Historical Resources and has been designated as San Francisco Landmark No. 250. The first dwelling in the India Basin vicinity, the Shipwright's Cottage was erected by boatwrights in 1875, initiating development of a boatbuilding community that crafted most of San Francisco's scow schooner fleet. It is the last known Victorian workers' cottage and one of the oldest buildings on the San Francisco waterfront. The building is in poor condition; the interior is in disrepair and uninhabitable.

Other structures on the 900 Innes property (with their dates of construction listed parenthetically) include:

- a 1,600-square-foot, steel-framed canopy building (between 1979 and 1989);
- a 1,700-square-foot, wood-framed structure (approximately 1943);
- a 1,460-square-foot shed (approximately 1930);
- a 1,350-square-foot, wood-framed shed building (1890s);
- a 750-square-foot, wood-framed office building adjoining the shed (between 1900 and 1935); and
- an approximately 120-foot-long wharf (in stages through the 1930s and 1940s).

All structures are 64–138 years old and are in poor condition. All lack utilities and three of the four are partially or almost completely collapsed.

This property also contains the India Basin Scow Schooner Boatyard, which is eligible for listing in the California Register of Historical Resources. Finally, two dilapidated piers and approximately 32 creosote-treated piles are located in the Bay, offshore from this property.

3.1.3 India Basin Open Space Property

The India Basin Open Space property is an existing 6.2-acre RPD open space that borders the Bay. This property includes a portion of the Blue Greenway/Bay Trail along its shoreline, consisting of features that improve the regionwide Bay Trail from Mission Creek on the north to the City limits on the south. The India Basin Open Space contains benches, upland habitat, tidal salt marsh, mudflats, sand dunes, and native vegetation. No offshore eelgrass beds were found in a recent survey of the India Basin vicinity. The tidal salt marsh habitat, the result of a 2002 wetlands mitigation project for San Francisco International Airport, occupies 2.5 acres of the India Basin Open Space property. Habitat management and protection areas in the India Basin Open Space are fenced from public access. A storm drain and overflow storm outfall are located on the northeastern shoreline, but are not maintained by the City and currently are not operable. The Tenth Annual Monitoring Report for the California Regional Water Quality Control Board in January 2012 found that after 10 years of monitoring wetland progress, two of the four wetland zones were underperforming per the target criterion of 80 percent salt marsh cover. To date, the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) has not proposed any alterations to the wetlands to improve their ecological performance.

Legal public access to the shoreline is limited to the Blue Greenway/Bay Trail. Two easements to the shoreline exist, but they are not paved or designated for public access. Shoreline access also occurs via informal pathways that also are not designated for public access.

3.1.4 700 Innes Property (multiple parcels)

The 700 Innes property consists of 30 parcels totaling 17.12 acres. This area is generally made of fill materials, covered by light brush, debris, dirt, and gravel mounds. Some portions of the parcels are located in the Bay. The area is mostly flat between Hudson Street and Earl Street to the India Basin Open Space boundary, which then slopes toward the Bay. There is more slope downward from Innes Avenue toward Hudson Street. The property is generally undeveloped, except for six buildings and structures. One dilapidated, wood-framed storage structure sits on the concrete wharf that fronts a wooden dock, in a western portion of the property that once was part of the Allemand Brothers Boat Yard. A second structure, built in 1935, is on the southwestern corner of the property at 702 Earl Street. This building (also known as the Heerdt Building and Repair) is a timber-framed industrial building with two stories over a basement, a compound shed, and a shallow-pitch gable roof.

The primary pedestrian entrance to the 702 Earl Street building and loading dock are on the north elevation, which is punctuated by a large vehicular opening. The fenestration includes bands of ribbon windows. A remodeled external staircase provides access to the attic level, which currently is used as a residence. A commercial building with one residential unit, at 840 Innes Avenue, is located on the southeastern corner of the property. The property also contains three temporary structures (two construction trailers and one shed), construction vehicle parking, and debris. Finally, a pier and approximately eight associated creosote-treated piles extend into the Bay from this property.

The 700 Innes property surrounds Arelious Walker Drive, a public ROW ending in a cul-de-sac, and is generally bounded by Innes Avenue to the south, Earl Street to the east, Griffith Street to the west, and the Bay to the north. The 700 Innes property is generally separated from the Bay by the 6.2-acre shoreline area owned by RPD and referred to as the India Basin Open Space (described above).

3.1.5 Public Rights-of-Way (Griffith Street, Hudson Street, Earl Street, and Arelious Walker Drive)

The existing public ROW within the project site totals 7.52 acres. Griffith Street, Hudson Street, and Earl Street are partially paved where they meet Innes Avenue, but in general, they are unpaved and/or partially paved, unimproved, and fenced from public access. Hudson Street runs north to south through the project site, starting at Hunters Point Boulevard and terminating at Earl Street. Sections of Hudson Street are paper streets. Earl Street forms the eastern boundary, running from the edge of the Bay to Innes Avenue. Griffith Street is the shortest of the streets, starting at Innes Avenue and terminating at the edge of the shoreline, bisecting the project site. Arelious Walker Drive is a paved street that runs south to north and roughly bisects the 700 Innes property, ending in a cul-de-sac.

Table 2-2 lists the existing buildings on the project site, providing their approximate gross square footage, historic status, and existing uses, and specifying whether they would remain as part of the proposed future improvements.

3.2 Topography

Figure 3-3 shows the topgraphic features of the project site. The topographic data was extracted from 2010 American Recovery and Reinvestment Act (ARRA) Lidar data. All of the low-lying areas within the project border below +25 feet (NAVD88) used to be tidal flat, and have been filled between 1965-1970 with debris material. Most of the areas in 700 Innes/IBOS and 900 Innes below +35 feet (NAVD88) are bayfill.

The IBOS shoreline is composed of an intertidal bench backed by vegetated bluffs. A summary of the elevations and slopes along the IBOS shoreline is provided in Table 3-1. In this report, the IBOS shoreline is broken into two sections described as the northeast (Reach 700-R1) and northwest (Reach 700-R2) shorelines. It is worthwhile to note that there are several locations within the project area where flatter slopes extend from the top of bluff to the high tide bench. These areas can be seen in Figure 3-4, which is an aerial picture of the project area during low-tide condtion to illustrate the extent of mudflats.

The 900 Innes property is composed of concrete structures and a vegetated bluff leading to a mudflat. Top of bank elevations range from +7 to +17 feet NAVD88, and the area beyond the vegetated bluff is approximately above +17 feet NAVD88 everywhere. The park area in IBSP is at elevations from +15 to +40 feet NAVD88, while vegetated berms, intertidal marshes, and engineered revetments are location at elevations between +5 to +17 feet NAVD88.

Table 3-1: India Basin Open Space Shoreline Elevations and Slopes

	Reach 700-R1	**Reach 700-R2**
Bluff Toe elevation	7.5 feet MLLW	8.5 to 7.5 feet MLLW
Bluff Slope	1:2.5 (V:H)	1:2.5 (V:H)
Bluff Top elevation	15.5 to 19.5 feet MLLW	15.5 to 18.5 feet MLLW
High Tide Bench slope	Flat	Flat
High Tide Bench elevation	6.5 to 7.5 feet MLLW	6.5 to 7.5 feet MLLW
High Tide Bench Width	70 to 200 feet	70 to 200 feet

3.3 Bathymetry of India Basin Cove

Meridian Surveying conducted a hydrographic survey of India Basin and Lash Lighter Cove between May 12 and May 19, 2015. Figure 3-5 provides a map of the surveyed bathymetry. Generally, within India Basin, elevations immediately offshore vary between 0 and -3 feet NAVD88, except for the eastern portion of Heron's Head Park which has elevations between -4 and -10 feet NAVD88. Within Lash Lighter Cove elevations immediately offshore generally range between -3 and -4 feet NAVD88.

Historical bathymetric surveys dating back to the 1800s show that the project area prior to development of Hunter's Point Naval Shipyard generally having elevations of -6 feet MLLW or shallower. Surveys indicate that the area maintained these depths until bay filling began both to the north and south. The filling of the bay to the north and south created a protected embayment and shoaling resulted. The 1981 survey of the area completed by NOAA shows water depths around the shoreline are fairly shallow ranging from 3-5 feet below MLLW.

Along the IBOS northeast shoreline (Reach 700-R1) depths of 3 feet or less persist for up to 1000 feet offshore while along the northwest shoreline (Reach 700-R2) deeper water is not present. A deeper channel 6-12 feet in depth is indicated on present navigation charts which comes within 150 feet of the IBSP shoreline. This is a remnant dredge channel which was maintained by a former owner in the area. The presence of this channel is questionable as it has not be maintained for some time and may have shoaled in. It should be noted that field observations indicate that the nearshore area offshore of the IBOS northwest shoreline (Reach 700-R2) is presently at approximately MLLW elevation (Figure 3-4).

Within India Basin elevations shallower than -2 feet NAVD88 and flat slopes extend for distances of greater than 200 feet offshore for the majority of the India Basin except along reach 700-R1, IBSP-R3, PGE-R3, and Heron-R-2 (Figure 3-6) in these areas elevations of -2 to -3 feet NAVD88 or deeper are noted within 50-100 feet of the shoreline.

3.4 Shoreline Edge Conditions

A summary of the existing shoreline conditions observed by Moffatt & Nichol staff during field visits on May 12 and June 19, 2015, is provided herein. Plan view maps and photographs taken during the site visits are presented in Appendix A.

3.4.1 Definitions / Notations

The following shoreline features, as shown in Figure 3-7, are used to describe the site:

- *Embankment or bluff*: a slope which may or may not be vegetated and extends from the intertidal zone up to an elevation above typical tidal influence
- *Revetment*: engineered rock slope protection which extends from the intertidal zone up to an elevation above typical tidal influence
- *Intertidal marsh*: a relatively flat intertidal slope which supports, or has adequate elevation to support, marsh habitat
- *Foreshore slope*: an intertidal slope transition between the mudflat and the intertidal marsh (if present), or relatively steep embankment/bluff/revetment
- *Mudflat*: a comparatively low intertidal habitat with minimal slope
- *Concrete ramp/slope*: a relatively steep slope typically extending above tidal influence
- *Bulkhead wall*: a vertical or near-vertical edge (typically concrete) that retains a soil embankment and protects the embankment from damage by wave action

The proposed waterfront parks plan for India Basin includes six properties: 700 Innes, India Basin Open Space, 900 Innes, India Basin Shoreline Park, PG&E Shoreline Trail and Heron's Head Park. Each property has been divided into several reaches based on shoreline orientation and existing conditions. A sketch indicating the general extent of each reach is provided in Figure 3-6.

3.4.2 700 Innes & India Basin Open Space

The 700 Innes and India Basin Open Space property is the southern-most property included in the project. The coastal reach of interest extends from the boundary of the Hunters Point Shipyard Northside Park, north to the 900 Innes Avenue property. The property is broken down into 2 reaches as shown in Figure 3-6.

In general, the shoreline is composed of vegetated bluffs fronted by an intertidal marsh. Offshore of the intertidal marsh (below Mean Tide Level [MTL]), a foreshore slope extends to mudflats. Top of bank elevations generally range from 15.5 - 19.5 feet NAVD88 with the lower elevations at the southern and northern limits of the reach where it connects to the adjacent properties.

In Reach 700-R1, which faces northeast, there is a layer of rock placed at the toe of the vegetated bluff which provides scour protection. Bayward of the intertidal marsh there is a concrete debris berm which serves as a wave break. The concrete debris berm consists of material which varies in size from approximately 2 to 6 feet in diameter. The concrete debris berm has locations where the material is sparse and has a lower top elevation compared to adjacent berm heights. The foreshore slope consists of rock and concrete debris below MTL extending to the mudflat with significant plant growth through much of the debris. There is a low vegetated sand dune at the eastern end of the reach.

Reach 700-R2 is similar to Reach 700-R1 except that the concrete debris berm is not present and the foreshore slope consists of a sandy material. A photo of the typical conditions along the shoreline is provided in Figure 3-8.

3.4.3 900 Innes

The 900 Innes property extends from 700 Innes/India Basin Open Space at the south to the India Basin Shoreline Park. The property is divided into two reaches as shown in Figure 3-6. The shoreline is composed of concrete structures (Reach 900-R1) and a vegetated bluff (Reach 900-R2) leading to a mudflat. Top of bank elevations at the concrete structures range from +7 to +9 feet NAVD88 and approximately +17 feet NAVD88 along the vegetated bluff.

In Reach 900-R1, the concrete structures consist of a deck leading to waterfront bulkhead walls and ramps. The deck shows some signs of differential settlement; The bulkhead walls are generally in fair shape with no signs of significant degradation, and the concrete ramps are in various states of degradation with much of the ramps spalling, broken or cracked. Remnant piles, of wood and steel, and timber railings run out onto the mudflat.

In Reach 900-R2, the vegetated bluff appears stable as no signs of erosion were evident along the bluff, although along a portion of the bluff large pieces of concrete debris have been placed at the toe. Photos of the typical conditions along the shoreline are shown in Figure 3-9

3.4.4 India Basin Shoreline Park

The India Basin Shoreline Park property extends from the 900 Innes site at the south to the PG&E Shoreline Trail at the north. The property is divided into 4 reaches as defined in Figure 3-6 The shoreline of India Basin Shoreline Park is composed of vegetated berms, with intertidal marshes, and engineered revetments.

The vegetated berm is found in Reach IBSP-R1 and IBSP-R2 and IBSP-R3.   In Reach IBSP-R1, the vegetated berm extends along shore approximately 300 feet from the southern limit of the property and is fronted by a foreshore slope with scattered rock and concrete debris leading to the mudflat. The top of the berm varies from approximately +9 to +10 feet NAVD88 and has signs of erosion along most of the length. In reach IBSP-R2 and IBSP-R4, the vegetated berm is fronted by intertidal marshes. The top of the berm ranges in elevation from +10 to +15 feet NAVD88. Photos showing the typical conditions are provided in Figure 3-10 and Figure 3-11.

The engineered rock revetment makes up the rest of Reach IBSP-R1 and Reach IBSP-R3. Its top elevation is at +9 to +10 feet NAVD88. The revetment is under laid with filter fabric. In some areas, large portions of rock are missing, and the filter fabric is exposed. In Reach IBSP-R3 there is a small sandy slope in between two sections of the revetment where storm water from the parking lot discharges to the Bay. Photos showing the typical conditions are provided in in Figure 3-10 and Figure 3-11.

3.4.5 PG&E shoreline trail (Not in project Boundary)

The PG&E Shoreline Trail property extends from the India Basin Shoreline Park at the south to Heron's Head Park at the north. The property is divided into four reaches as shown in Figure 3-6. This shoreline is characterized by embankments either vegetated or covered in rock and concrete debris. The top of bank along the shoreline ranges in elevation from +12' to +19 feet NAVD88. Erosion of the embankment exists along the majority of this shoreline.

Reaches PGE-R1 and PGE-R3 are composed of the vegetated embankments fronted by sandy beaches and small scattered rock and concrete debris while in Reach PGE-R2 and PGE-R4 the vegetated slopes have large slabs of concrete randomly placed on slope. At the northern end of Reach PGE-R4, there is a stretch of bulkhead wall adjacent to the PG&E power plant site. Photos of the typical shoreline conditions are presented in Figure 3-12.

3.4.6 Heron's Head Park (Not in project Boundary)

Heron's Head Park extends from PG&E Shoreline Trail at the south power to the northern limit of Heron's Head Park at Pier 98. The property is divided in 3 reaches as shown in Figure 3-6. The shoreline along Heron's Head Park consists of vegetated embankment, tidal marsh, and rock revetments. The top of bank along the shoreline ranges in elevation from +10 to +15 feet NAVD88.

Reach Heron-R1 is composed of a vegetated embankment fronted by shell beaches, small rock, and concrete debris. Erosion was noted along most of the vegetated embankment. At the western limit of the reach, there is a small area of rock revetment which protects and overlook structure. Reach Heron-2 is primarily tidal marsh. Photos of the typical shoreline condition is provided in Figure 3-13.

At the eastern limit of Reach Heron-R2 and all of Heron-R3, the shoreline is composed of scattered rock on the foreshore slope and rock placed on the upper portion of the shoreline which acts as scour protection. Photos of the typical shoreline condition are provided in Figure 3-13.

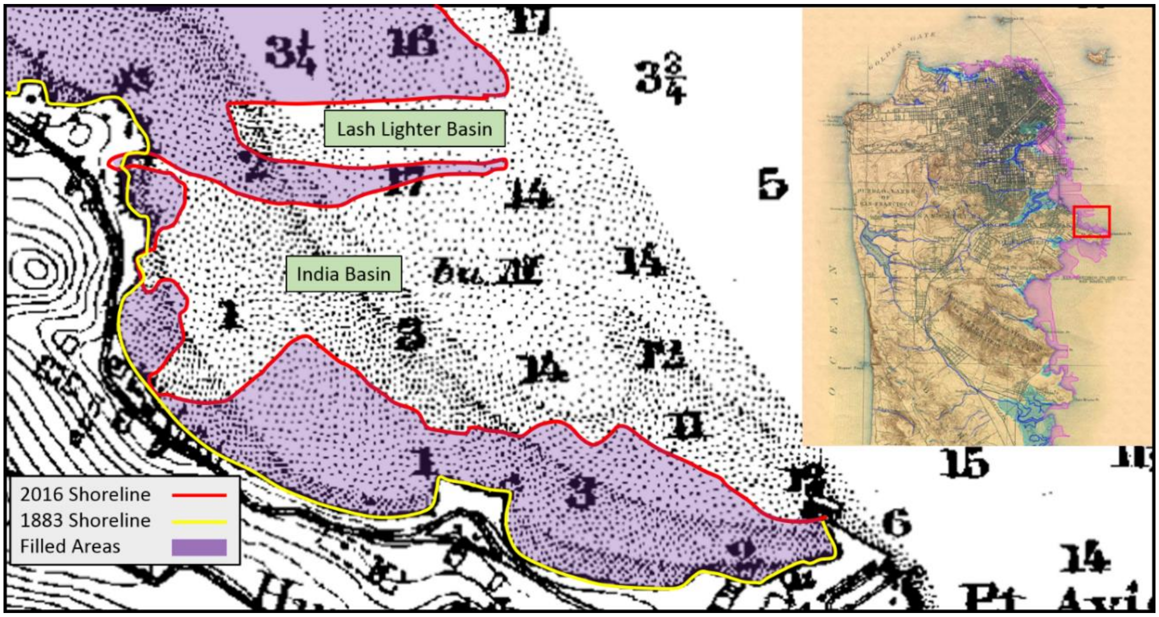

Figure 3-1: India Basin surrounding area from 1883 U.S. Coast survey map. Values show depth in feet (shaded area), and fathoms (clear area).

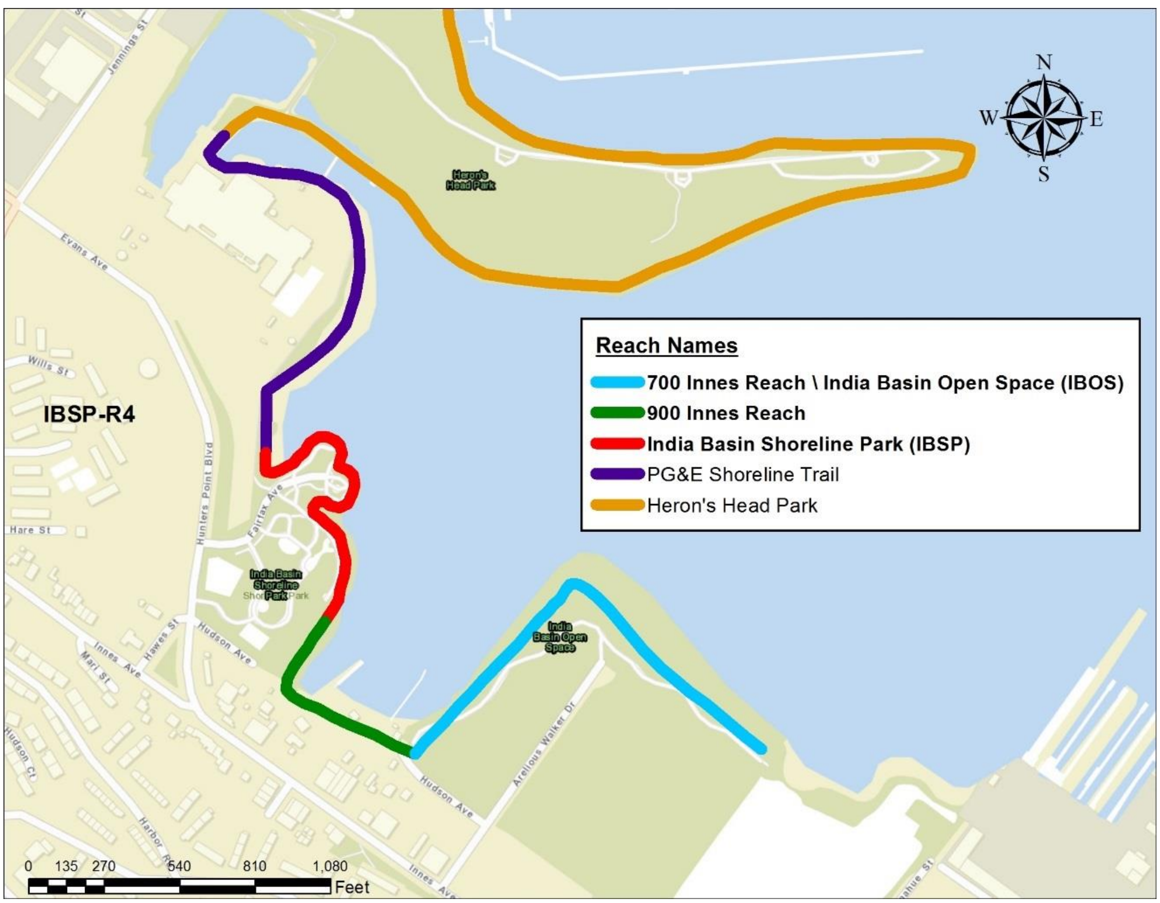

Figure 3-2: Reach definition sketch

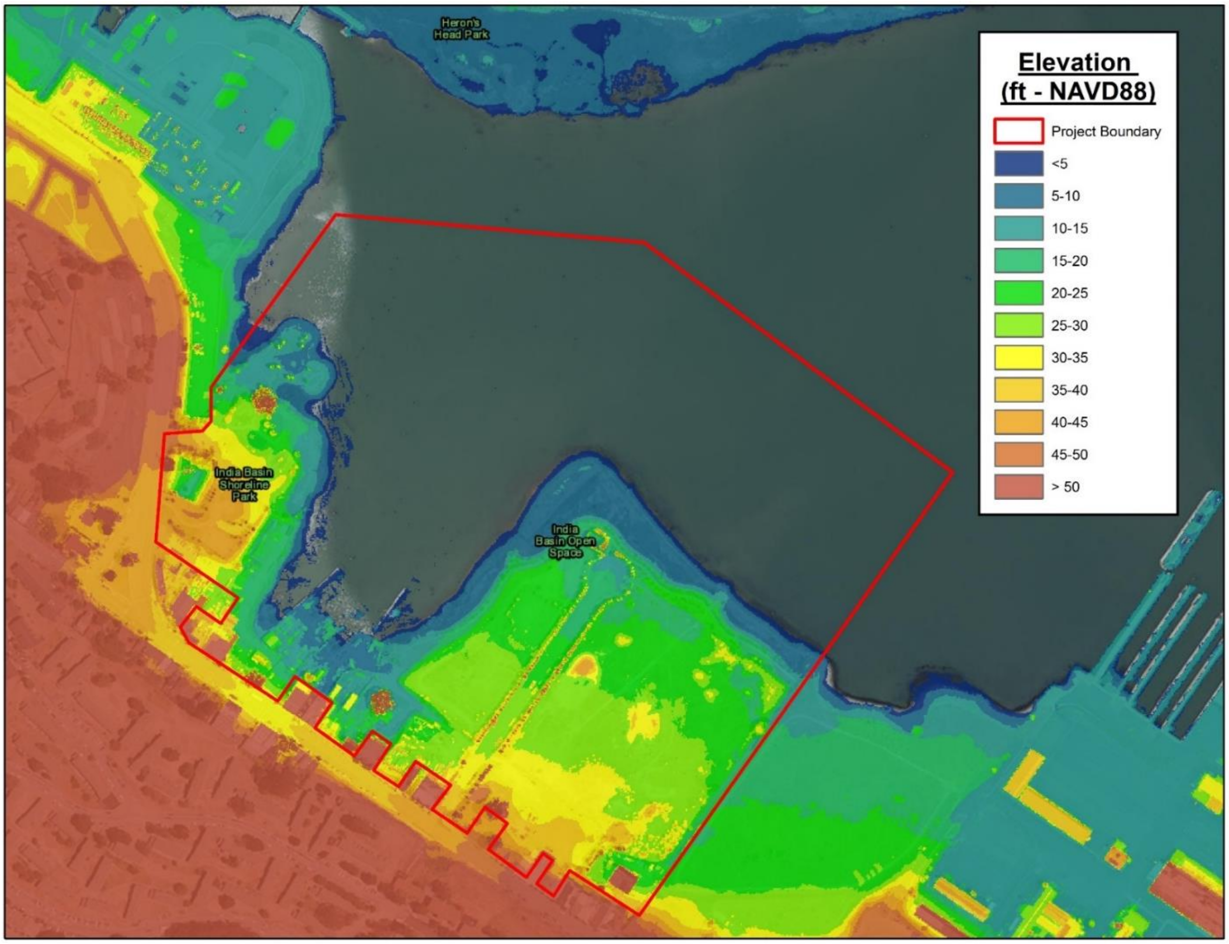

Figure 3-3: Topography of the project site (From ARRA Lidar data)

Figure 3-4: Aerial picture showing low-tide conditions (©Google 6/2012)

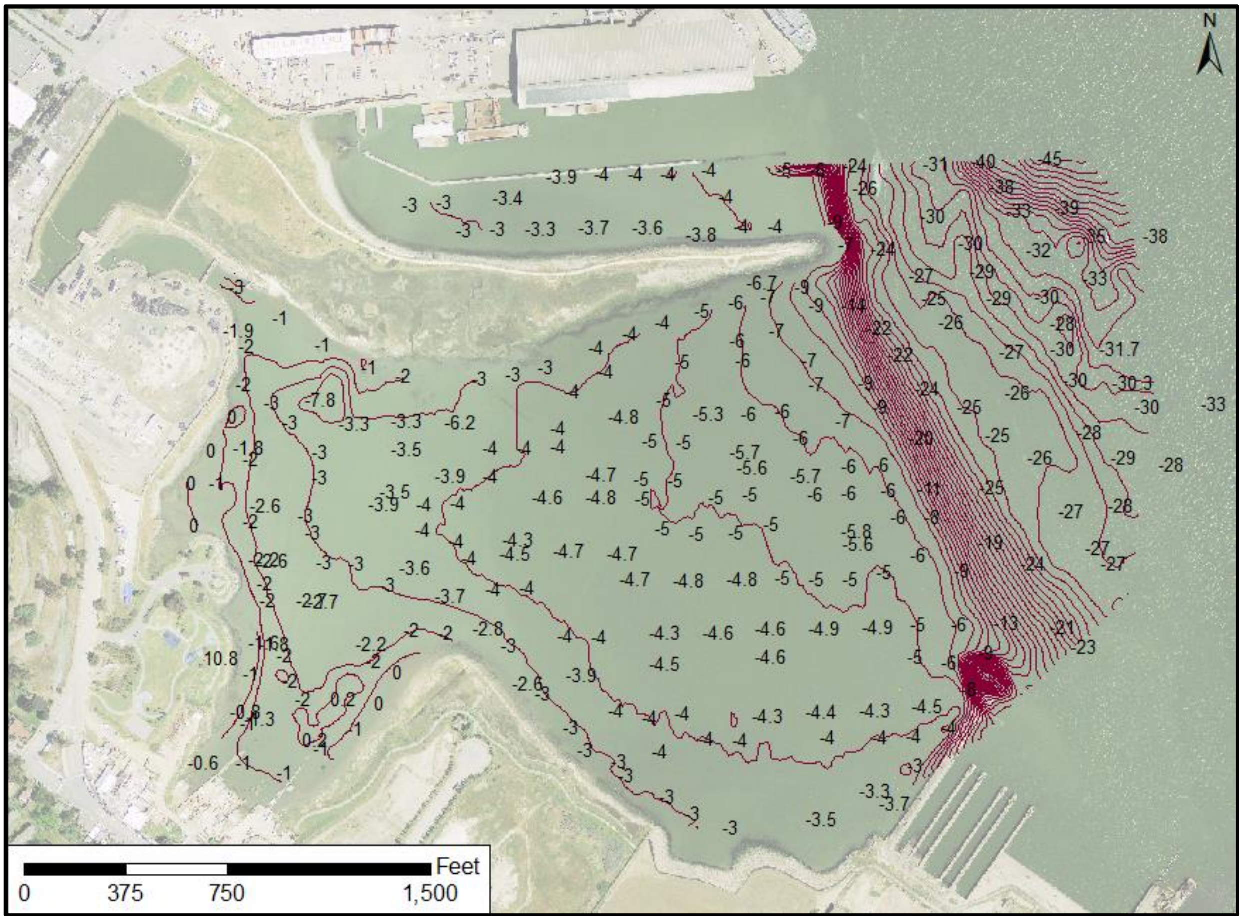

Figure 3-5: Bathymetric survey data 2015 (NAVD88, Feet)

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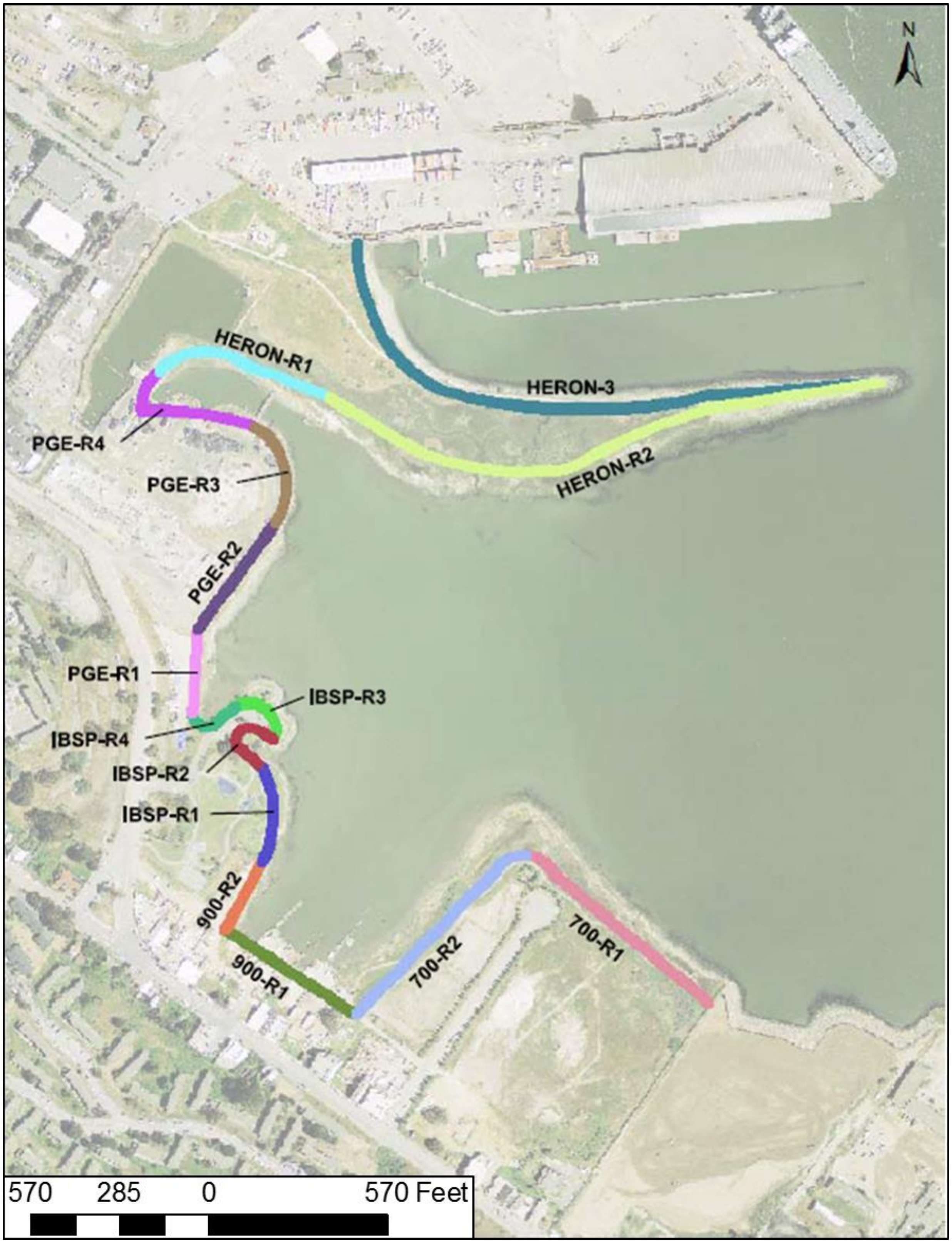

Figure 3-6: Key map for reaches

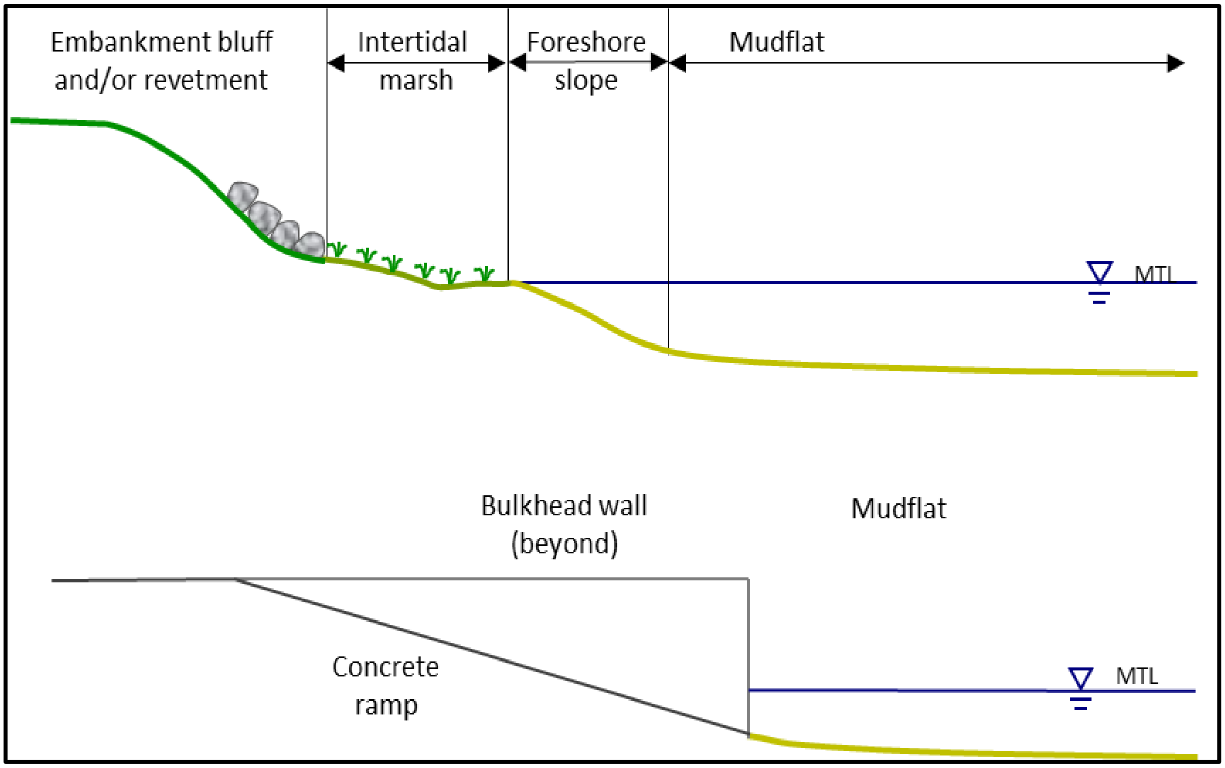

Figure 3-7: Shoreline terminology definition sketch

Figure 3-8: Typical conditions along Reach 700-R2 (left) and Reach 700-R1 (right)

Figure 3-9: Typical condtions along Reach 900-R1 (left) and Reach 900-R2 (right)

Figure 3-10: Typical conditions along Reach IBSP-R1 (left) and Reach IBSP-R4 (right)

Figure 3-11: Typical condtions along Reach IBSP-R2 (left) and IBSP-R3 (right)

Figure 3-12: Typical conditions along Reach PGE-R1, R2 (left) and Reach PGE-R3, R4 (right)

Figure 3-13: Typical condtions along Reach Heron-R1 (top left) and western portion of Heron-R2 (top right), as well as Reach Heron-R2 (bottom left) and Reach Heron-R3 (bottom right)

4. HYDROGRAPHIC CONDITIONS

4.1 Water levels

Water levels at the project site are dominated by a mixed semi-diurnal tide, which has two unequal highs and lows each tidal day. Tidal datum elevations in the project vicinity were obtained from the National Oceanic and Atmospheric Administration (NOAA) long-term station at Alameda, CA (#9414750). Tidal elevations are summarized in Table 4-1. Figure 4-1 depicts the depth values within India Basin when the water level is at MLLW datum elevation (-0.23 ft. NAVD88).

Table 4-1: Tidal datum at Alameda, CA

	MLLW (feet)	NAVD88 (feet)	CCSF (feet)
Highest Observed Water Level (12/03/1983)	9.65	9.42	-1.7
Mean Higher High Water	6.59	6.37	-4.8
Mean High Water	5.97	5.75	-5.4
Mean Tide Level	3.55	3.32	-7.8
Mean Low Water	1.13	0.90	-10.2
North American Vertical Datum 1983	0.23	0.00	-11.1
Mean Lower Low Water	0.00	-0.23	-11.4
Lowest Observed Water Level (01/11/2009)	-2.57	-2.80	-13.9

Extreme water levels were developed for the period of January 1970 through December 2012 for the Alameda tidal station. Extremal analysis was based on the selection of annual maximum water levels for the 43 years record of observations. We utilized the Generalized Extreme Value Distribution (GEVD) that uses the maximum likelihood approach to provide the best fit to the selected data. The Gumbel 2-parameter distribution method was used to provide extreme water levels for 2, 5, 10, 25, 50 and 100-year return periods, shown in Table 4-2.

The water levels shown in Table 4-2 represent the Still Water Level (SWL), which include astronomical tide, storm surge, and tsunamis over the period of observation. It represents a static water level that persists for a prolonged period (several minutes to hours at a time). Embankments which are overtopped by the SWL elevation present an inundation or large-scale flooding hazard.

Table 4-2: Extreme water levels for 2-, 5-, 10-, 25-, 50-, and 100-year return periods

Return Period	MLLW (feet)	NAVD88 (feet)
2	8.7	8.5
5	9.0	8.8
10	9.2	9.0
25	9.5	9.3
50	9.7	9.5
100	9.9	9.7

4.2 Sea Level Rise

In March 2013, the Sea-Level Rise Task Force of the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT) released their State of California Sea-Level Rise Guidance Document based on the National Academy of Sciences (NAS) Report Sea-Level Rise for the Coasts of California, Oregon, and Washington. The NAS document contains sea level rise projections for the years 2030, 2050, and 2100 relative to year 2000. CO-CAT recommends the use of these projections for the planning of waterfront projects and that sea level rise values for planning be selected based on risk tolerance and adaptive capacity. This guidance has been largely adopted by state agencies including the Bay Conservation and Development Commission (BCDC) in formulating their policies for adaptation to sea level rise. In 2016, the City and County of San Francisco published an executive summary for sea level rise action plan. They excluded lower range projections of NAS (2012) sea level rise in the report, as low projections are not recommended for planning purposes. Figure 4-2 illustrates Sea Level Rise projections for San Francisco relative to year 2000 based on NAS (2012) data.

Table 4-3 summarizes the Sea Level Rise projections, including the most likely and upper range values, for the San Francisco Bay area provided in NAS (2012) and CCSF (2016).

Table 4-3: Sea Level Rise Projections for San Francisco, California (Inches)

Time Period	Most Likely	Upper Range
2000-2030	6	12
2000-2050	11	24
2000-2100	36	66

4.3 Wind-driven Waves

Wind data for the India Basin area was collected from Alameda, CA (#9414750), approximately 4.5 miles east of the project site. We selected measured wind data at Alameda as it is representative of conditions over the central bay. The Alameda wind gauge provides hourly observations of wind speed and direction since 1945.

Annual and seasonal wind roses based from Alameda, CA are provided in Figure 4-3 and Figure 4-4. The annual wind rose shows that winds are predominately from the west. The seasonal roses show that there is some variation in predominant wind direction throughout the year. The winter wind rose exhibits increased frequency of winds from the north, northeast, southeast and south associated with winter storms.

Prevailing wind conditions give an idea of daily and seasonal conditions, while extreme wind information can be used to determine design conditions for wind waves. For India Basin winds from the north through southeast are of primary concern for wind wave development. Extremal analysis was undertaken based on the selection of annual maximum winds for the 68 years record of observations, from 1945 to 2013. Similar to water level extremal analysis, we selected the Generalized Extreme Value Distribution to provide the best fit to the data. Table 4-4 shows the wind speed return period values at Alameda for the north, northeast, east, and southeast directions.

Table 4-4: 2-, 5-, 10-, 25-, 50-, and 100-year return Wind Speeds (Alameda, 2-min average knots, 1945-2013 period)

Return Period (years)	Wind Speed at 10 m Standard Elevation (knots)			
	N	NE	E	SE
2	23.9	18.2	15.2	28.6
5	28.4	22.5	19.7	34.1
10	31.0	25.0	23.0	37.2
25	33.9	27.7	27.4	40.6
50	35.8	29.5	31.0	42.9
100	37.5	31.1	34.8	45.0

Wind waves within India Basin were analyzed using the Mike 21- spectral wave (SW) model. The model simulates both the growth of waves due to wind stress and wave transformation in the nearshore environment due to shoaling, refraction, and diffraction. The model calculates both direction and frequency spectral wave parameters over a flexible mesh computational grid. This allows for the use of high-resolution model bathymetry at the shoreline and in the nearshore areas of the project site while remaining computationally efficient.

The model domain was chosen to cover all areas of the San Francisco Bay where wind generated waves propagate towards the shoreline of India Basin. Figure 4-5 shows the extent of the model domain, which includes all of the Central and South Bay and excludes areas outside of the Golden Gate and north of Point Richmond. Bathymetry for the model was compiled from the NOAA Estuarine Bathymetry data set for the San Francisco Bay, available USGS Lidar Data (USGS 2011), and the recently completed hydrographic survey of India Basin by the Meridian Surveying. Figure 4-5 shows the model bathymetry for the entire domain and Figure 4-6 shows the model bathymetry of India Basin.

Wind wave analysis was conducted for 2-, 5-, 10-, 25- and 50-year return period wind events for the north, northeast, east and southeast directions. Each model run assumed a water surface elevation of Mean Higher High Water (MHHW). Maximum significant wave heights, provided in Table 4-5, along each shoreline reach were selected to illustrate how the wave heights can vary along the shoreline of India Basin and Lash Lighter Cove. Sample model outputs for the 2-year and 50-year return period events are presented in Figure 4-7 to Figure 4-10 for all four directions.

Table 4-5: Wave Heights within India Basin and Lash Lighter Cove

Property	Reach	Wave Height (feet) 2-yr	10-yr	50-yr
700 Innes & India Basin Open Space	700-R1	1.3	2.2	2.7
	700-R2	0.6	0.9	1.1
900 Innes	900-R1	0.4	0.7	1.0
	900-R2	0.7	1.2	1.5
India Basin Shoreline Park	IBSP-R1	1.0	1.7	2.1
	IBSP-R2	1.2	1.9	2.3
	IBSP-R3	1.4	2.2	2.7
	IBSP-R4	1.3	2.1	2.5

In general, wave heights within India Basin are significantly reduced compared to waves within the main portion of San Francisco Bay. For the 2-yr return period wave, event wave heights along the majority of the India Basin shoreline are between 0.4 and 1.4 feet in height while for a design level event (50-year return period) wave heights are between 1.0 and 2.7 feet. The shoreline of 900 Innes and reach 700-R2 exhibit the lowest wave heights (Less than 1.0 feet for the 2-year event and less than 1.5 feet for the design level event).

4.4 Coastal Flooding

4.4.1 Inundation due to Wave Runup

One percent chance wave runup elevations are calculated to consider storm-related flooding along the proposed shoreline features of the project area. Based on insights from past projects, to produce conservative estimates of 1% annual chance wave runup we have used the greater of the following combinations to determine the runup elevations,

i. 25 Year return wave conditions and 10 year return tidal levels
ii. 10 Year return wave conditions and 25 year return tidal levels

At these return period water levels depth limited wave breaking is not anticipated over the intertidal marsh; therefore, wave runup analysis can be conducted using Van der Meer equation. The wave heights along the coastline for 25 and 10 year events were imported from Mike 21- spectral wave (SW) model results, which was discussed in the previous section. Figure 4-11 shows the locations where wave attributes were recorded within India Basin during simulation time. These values were used to calculate Iribarren number (surf-similarity parameter), to be inserted in the modified Van der Meer equation (FEMA, 2005, D.4.5-19). to calculate wave runup for 5 different locations within India Basin.

i. India Basin Open Space (IBOS) northeastern shoreline (Reach 700-R1)
ii. IBOS northwestern shoreline (Reach 700-R2)

iii. 900 Innes (Reach 900-R1)
iv. India Basin Shoreline Park (IBSP) Southern Marsh Area (Reach ISBP-R1)
v. IBSP Gravel Beach (Reach ISBP-R2)
vi. IBSP Northern Marsh Area (Reach ISBP-R4)

There are four reduction factors in the Van der Meer to incorporate the influence of surface roughness (γ_r), berm (γ_b), angled wave attack (γ_β), and structure permeability (γ_p). However, beside surface roughness reduction factor (γ_r), all other reduction factors were conservatively assumed to be 1.0. The resulting 1% annual chance wave runup (Total Water Level-TWL) for different reaches mentioned above is given in Table 4-6.

Table 4-6: 1% Total Water Level (TWL) for proposed designs in different reaches.

Reach	TWL
IBOS northeastern shoreline (Reach 700-R1)	12.0
IBOS northwestern shoreline (Reach 700-R2)	11.0
900 Innes (Reach 900-R1)	10.0
IBSP Southern Marsh Area (Reach ISBP-R1)	12.0
IBSP Gravel Beach (Reach ISBP-R2)	11.0
IBSP northern Marsh Area (Reach ISBP-R4)	12.0

In addition, FEMA has provided two sets of different inundation maps for coastal flooding, Flood Insurance Rate Maps (FIRM) (Figure 4-12), and preliminary flood plain maps for 100-year and 500-year events (Figure 4-13). A summary of FEMA base flood elevations is presented in Table 4-7.

Table 4-7: FEMA Base Flood Elevations

Property	Zone Designation	NAVD88 (feet)
India Basin Open Space/ 700 Innes Avenue	AE*	10
	AE	12
900 Innes Avenue	AE	10
India Basin Shoreline Park	AE	10
	VE**	12

* Zone AE are areas that have a 1-percent probability of flooding every year (also known as the “100-year floodplain”)
** Zone VE areas are subject to a 1-percent annual chance flood event with additional hazards due to storm-induced velocity wave action.

4.4.2 Inundation due to Tsunamis

There have been approximately 51 cases of recorded or observed tsunamis within San Francisco Bay, generated both locally and along the Pacific Rim, which has made tsunami hazard analysis in San Francisco Bay subject of several studies during the past decades. Several studies have provided either inundation maps, or flood elevations values either for India Basin or its neighboring regions. A summary related to potential tsunami induced coastal flooding follows.

Garcia and Houston (1975) analyzed tsunami propagation within San Francisco Bay to develop 100- and 500-year return period tsunami water levels along the shoreline. They used a probabilistic approach, based on historic measured tsunami data, and considered the combined effect of the astronomical tide and tsunami wave propagation on water levels. They presented a 8.92 feet (NAVD88) flooding condition for 100-year event in the surrounding area of the India Basin, as well as 12.92 feet (NAVD88) runup estimate for 500-year event (Figure 4-14). However, although the model methodology and their description of the underlying seismogenic events is now considered to be outdated, many of the tsunami-risk studies for California have acknowledged that the Garcia and Houston (1975) study has reproduced historic tsunamis well, and are a good basis for planning. However, both Garcia and Houston's (1975) 100-year and 500-year recurrence estimates are only based on 20th century events, which are not sufficient for the tsunami recurrence analysis, and they must be estimated using the available paleoseismic data (Borrero et al., 2006).

In recent years, modeling efforts have been conducted to determine the wave runup resulting from tsunami propagation into the Bay. Borrero et al. (2006) modeled both near- and far-field tsunami sources and studied their propagation and inundation inside San Francisco Bay. Far-field sources were large magnitude earthquakes in the Cascadia subduction zone, the Alaska and Aleutian Islands, Kuril Islands, Japan and the South American subduction zone. They reported that a 9.15 magnitude earthquake in Aleutias Subduction Zone generated a tsunami which was the worst case scenario for the project area compared to the other sources they modeled. They did not provide return periods of the tsunami events they modeled. In 2008, the San Francisco Emergency Response Plan (Tsunami Response Annex) estimated the potential "worst-case" tsunami run-up for the project area to be 3.77 feet based on the Borrero et al. (2006) study of Tsunami effects at Marine oil Terminals in San Francisco Bay (Figure 4-15).

In 2009 California Emergency Management Agency (CalEMA) developed inundation maps for emergency planning for the State of California based on results of a series of numerical model simulations conducted by University of Southern California (USC). They have modeled several far-field and near field tsunami sources, including earthquakes in Cascadia Subduction Zone, Kuril Islands, Central Aleutias Subduction zone, Point Reyes Thrust Fault, as well as some historical tsunamis generated by 1960 Chile and 1964 Alaska earthquakes. Based on CalEMA and USC tsunami inundation mapping study, the northern tip and northeastern shoreline of the India Basin Shoreline Park property, almost the entire 900 Innes property, the shoreline edge of the India Basin Open Space property, and the southwestern edge of the 700 Innes property are mapped within the tsunami hazard zone (Figure 4-16). This is similar to the area mapped by FEMA in the preliminary FIRM as within the 100-year flood hazard zone (FEMA, 2015), except that more of the 900 Innes property is included in the tsunami inundation zone. Discussions with the USC Tsunami Research Center related to the return period associated with the Cal EMA maps indicate that ongoing probabilistic modelling has shown that the CalEMA inundation line has a return period of the order of 1,000 years.

More recently, in 2013, the U.S. Geological Survey's Science Application for Risk Reduction (SAFRR) project modeled a hypothetically large but possible tsunami at high tide generated by an earthquake with a moment magnitude of 9.1 occurring along the Alaska Peninsula. Similar to the work conducted by USC and Cal-EMA, the SAFRR study mapped inundation along the coast of California for emergency, mitigation, and evacuation purposes (Figure 4-17). For both the Cal-EMA and SAFRR maps the inundation limits are defined as an aggregate of the maximum runup caused by simulating historical and hypothetical tsunami events assuming a tide level equal to or greater than Mean High Water (MHW). Although Cal-EMA has provided tsunami inundation mapping for India Basin, the SAFRR tsunami inundation study does not extend as far inland as Cal-EMA's inundation line in the India Basin area. However, SAFRR have reported the possibility of 3 feet flooding as result of tsunami in India Basin (Figure 4-18). Based on other recent studies conducted for other sites (M&N 2016), the return period of the inundation associated with the SAFFR scenario is between 200 and 250 years.

It is possible that a tsunami event with a return period of 750 years or higher inundate the project site if the tsunami coincides with extreme still water levels, which themselves have a low chance of occurrence. However, this is considered well beyond what is appropriate for design. Tsunami inundation in not a hazard thread to the reaches within India Basin compared to wind-generated wave runup, which is discussed in the previous section.

4.4.3 Inundation due to Sea Level Rise

Figure 4-19 shows the inundation area for existing (No-Project) conditions at the present time, based on 1% annual chance flood hazard elevations as described in Table 4-6. To consider Sea Level Rise (SLR) impacts on the project site, the following SLR scenarios were considered.

1) Most likely SLR projection of 1-ft for 2050
2) Maximum SLR projection of 2-ft for 2050
3) Most likely SLR projection of 3-ft for 2100
4) Maximum SLR projection of 5.5-ft for 2100

SLR projection values were added to TWL elevations to generate 1% annual flood inundation maps for existing and proposed conditions. Figure 4-20 through Figure 4-23 presents the inundation due to SLR on the project area for existing condition for the four SLR scenarios described above. A summary of the inundation over time for No-Project conditions is shown on Figure 4-24.

Figure 4-25 shows the inundation area for Proposed Project conditions at the end of construction (2020 +/-), based on 1% annual chance flood hazard elevations. Figure 4-26 through Figure 4-29 show inundation due to SLR for post-project conditions for the four SLR scenarios. A summary of the inundation over time for Post-Project conditions is shown on Figure 4-30. The proposed project would improve the project site response to SLR, especially in the area between 700 Innes and 900 Innes properties. Also, through comparing flood areas shown in Figure 4-24 and Figure 4-30, flooding in IBSP and Reach 700-R1 would be significantly smaller for proposed conditions at the end of the century.

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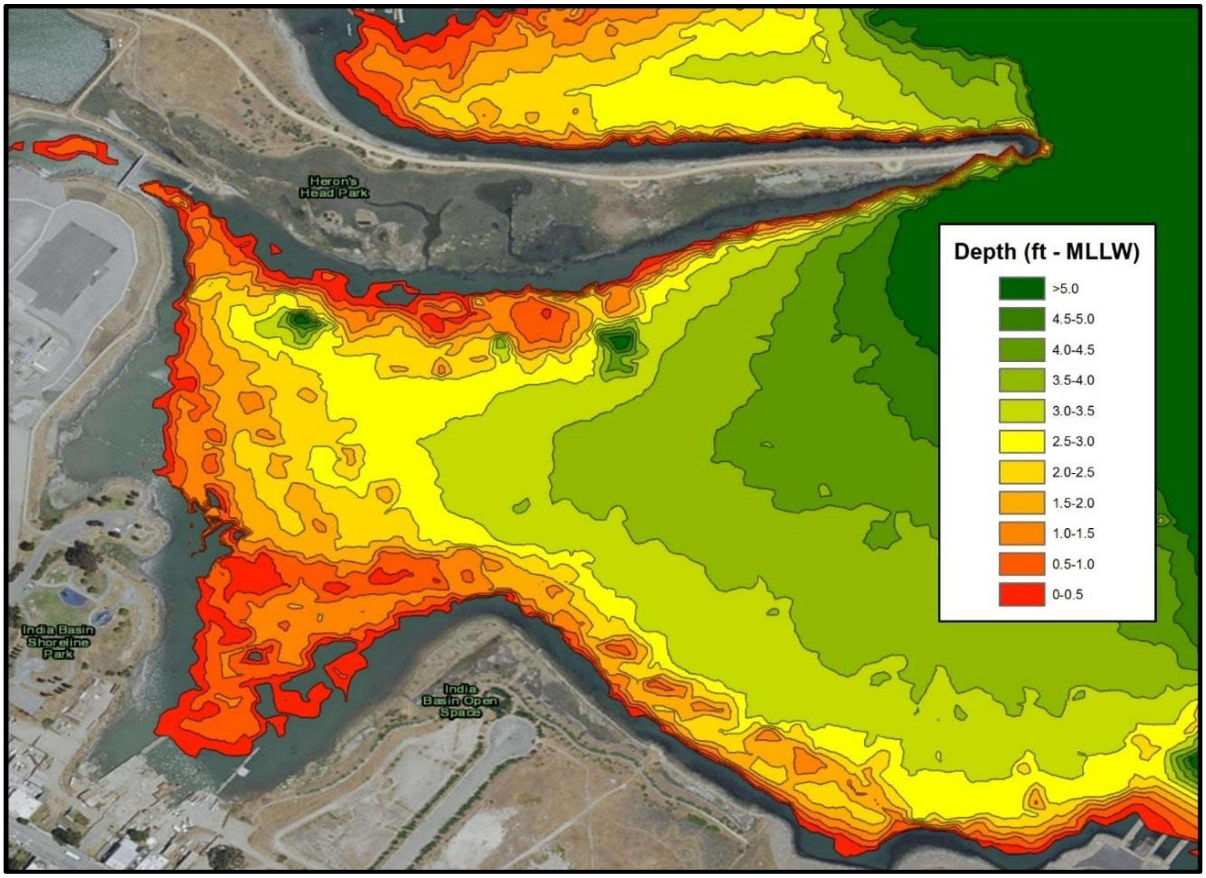

Figure 4-1: India Basin Depths (MLLW datum)

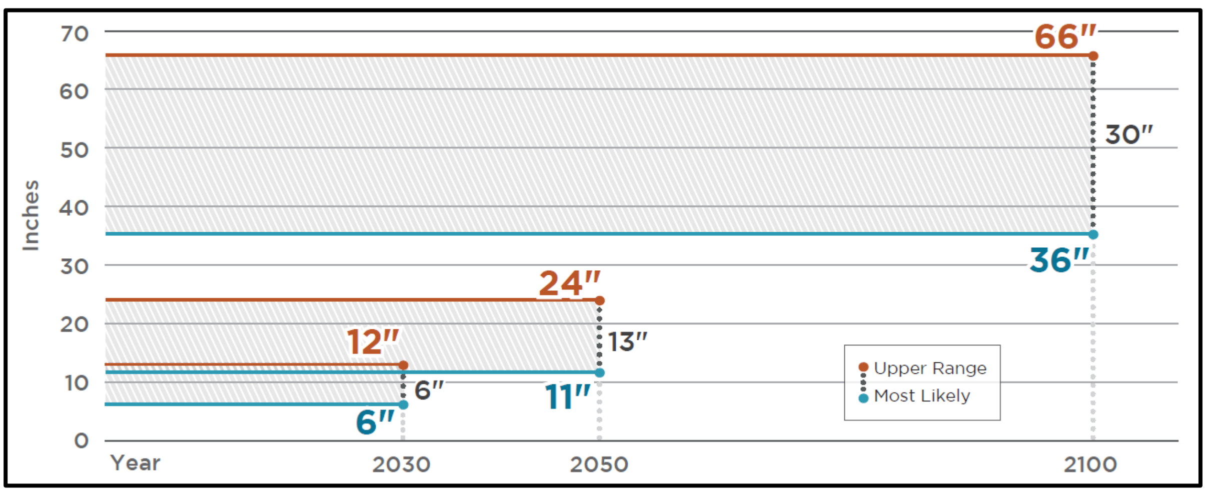

Figure 4-2: Sea Level Rise Projections for San Francisco Relative to Year 2000.

(Source: San Francisco Sea Level Rise action plan, 2016)

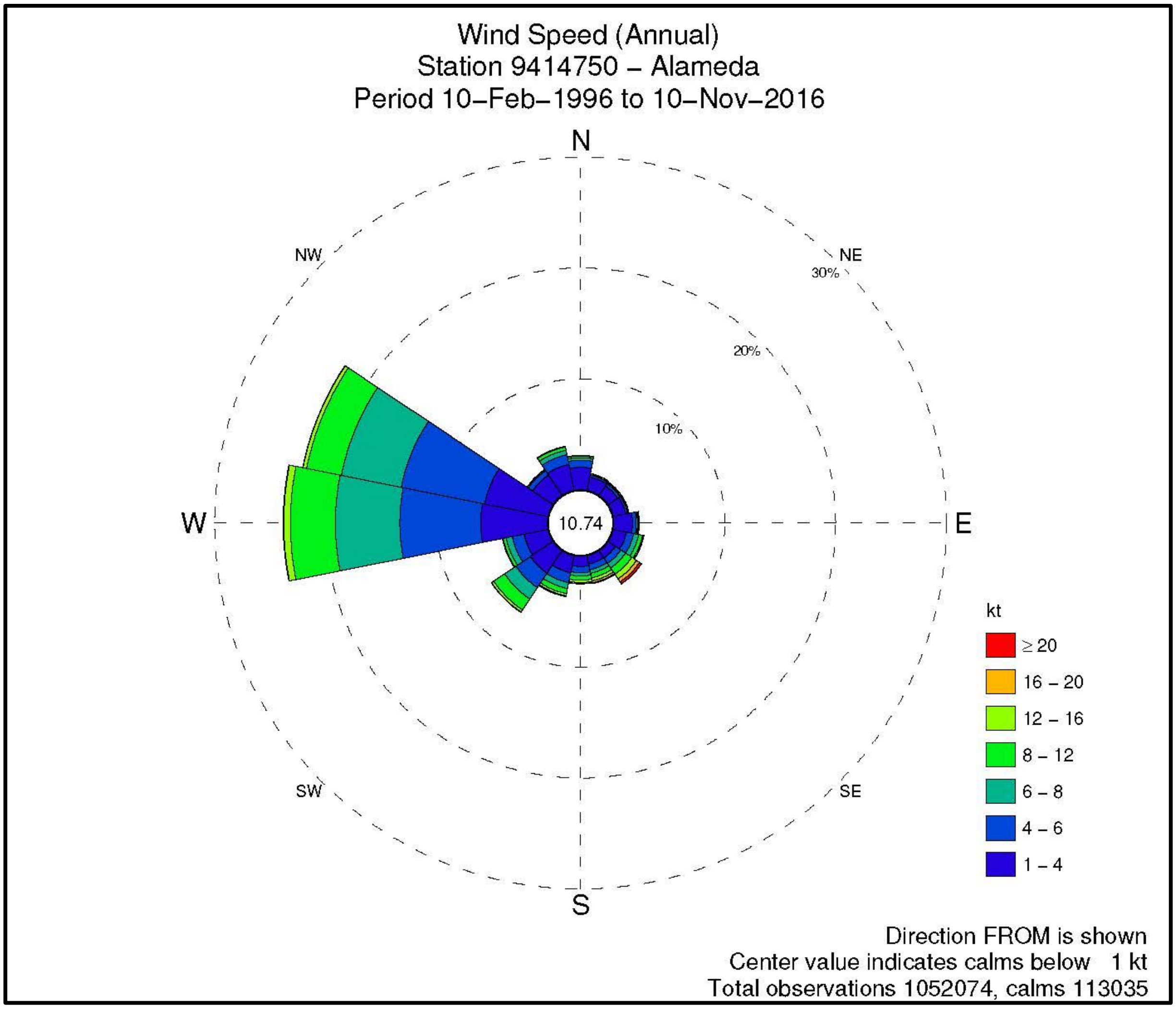

Figure 4-3: Annual Wind Rose Alameda, CA

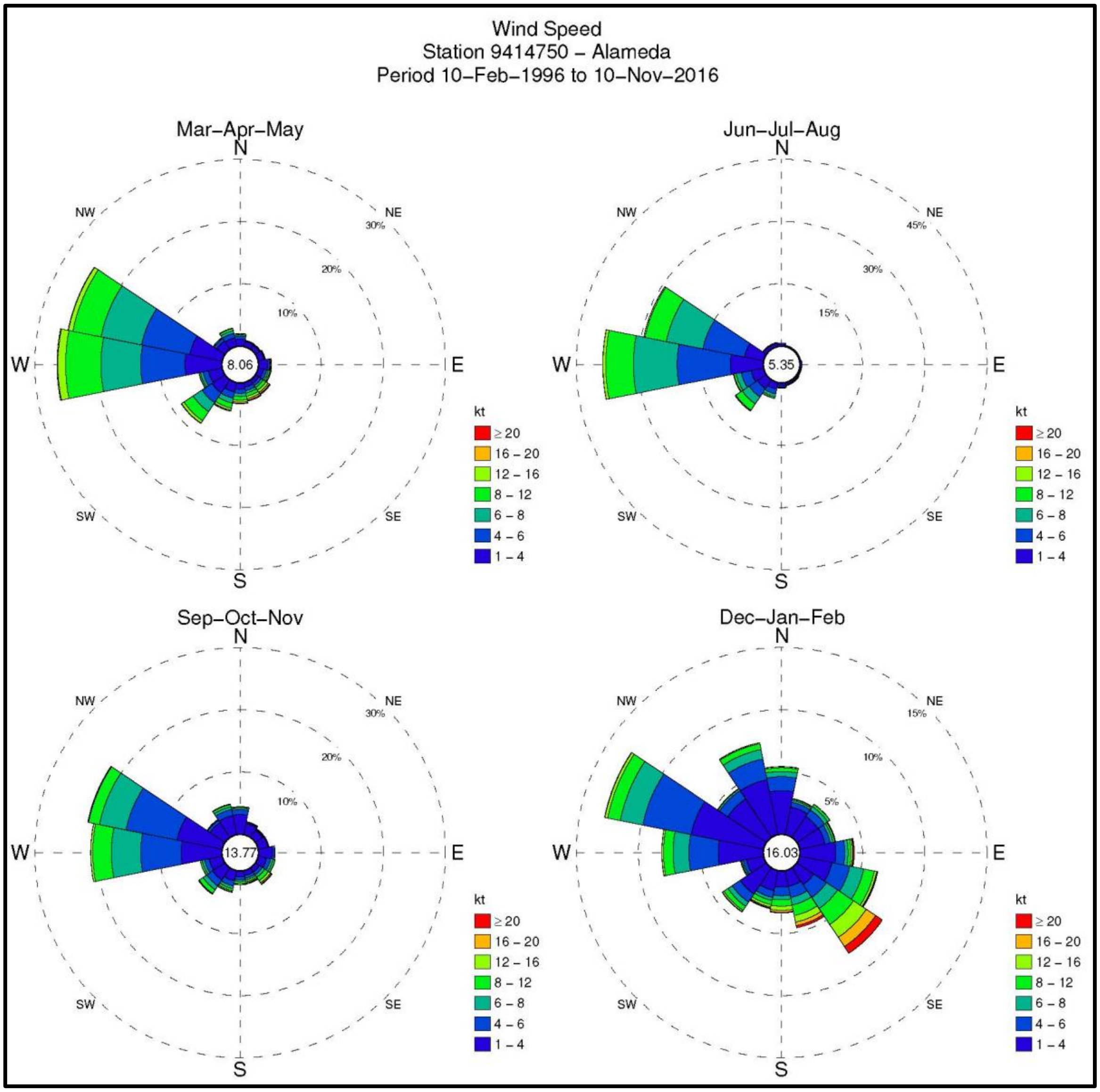

Figure 4-4: Seasonal Wind Roses Alameda, CA

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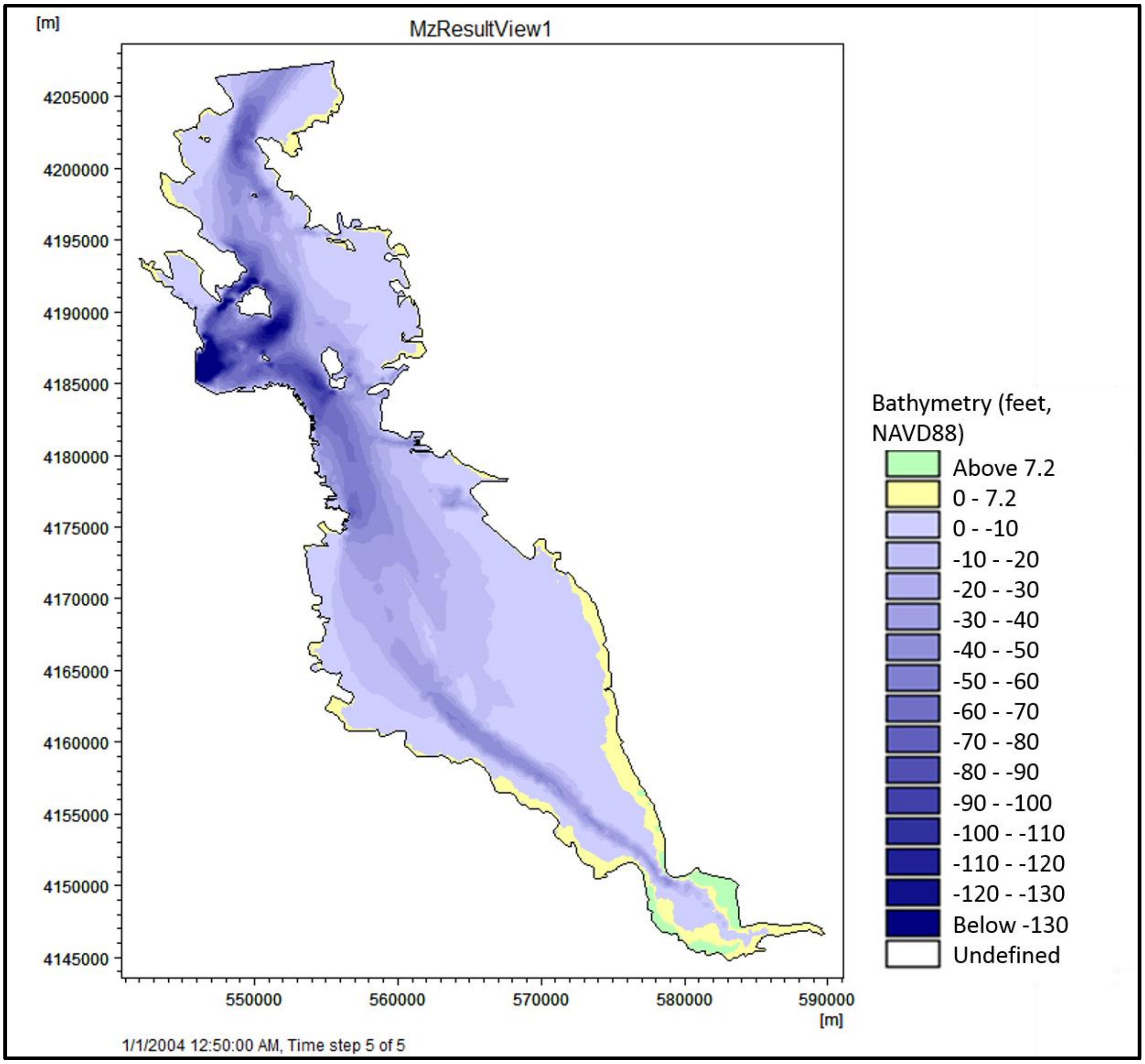

Figure 4-5: MIKE 21 Spectral Wave Model Mesh Extent

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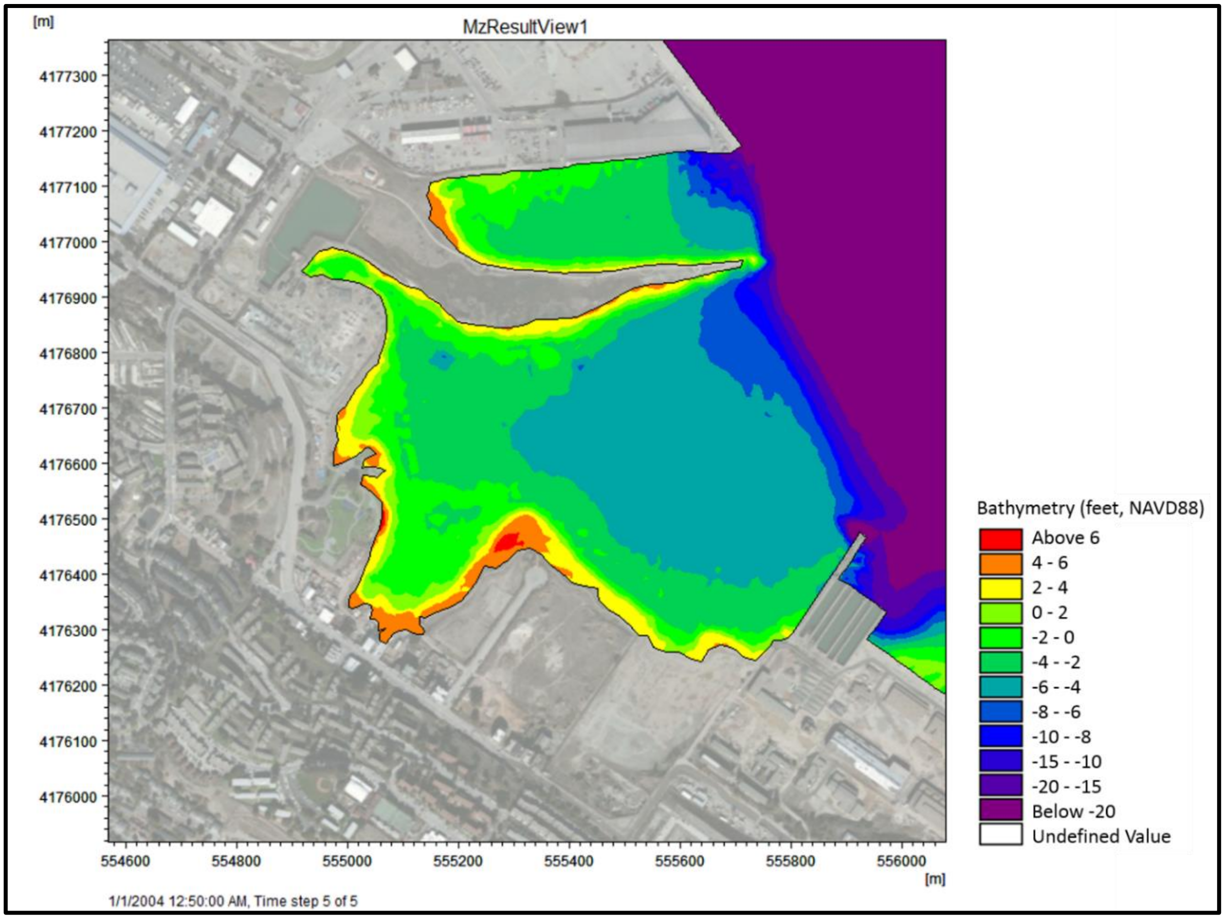

Figure 4-6: Mike 21 SW Model Project Vicinity Bathymetry

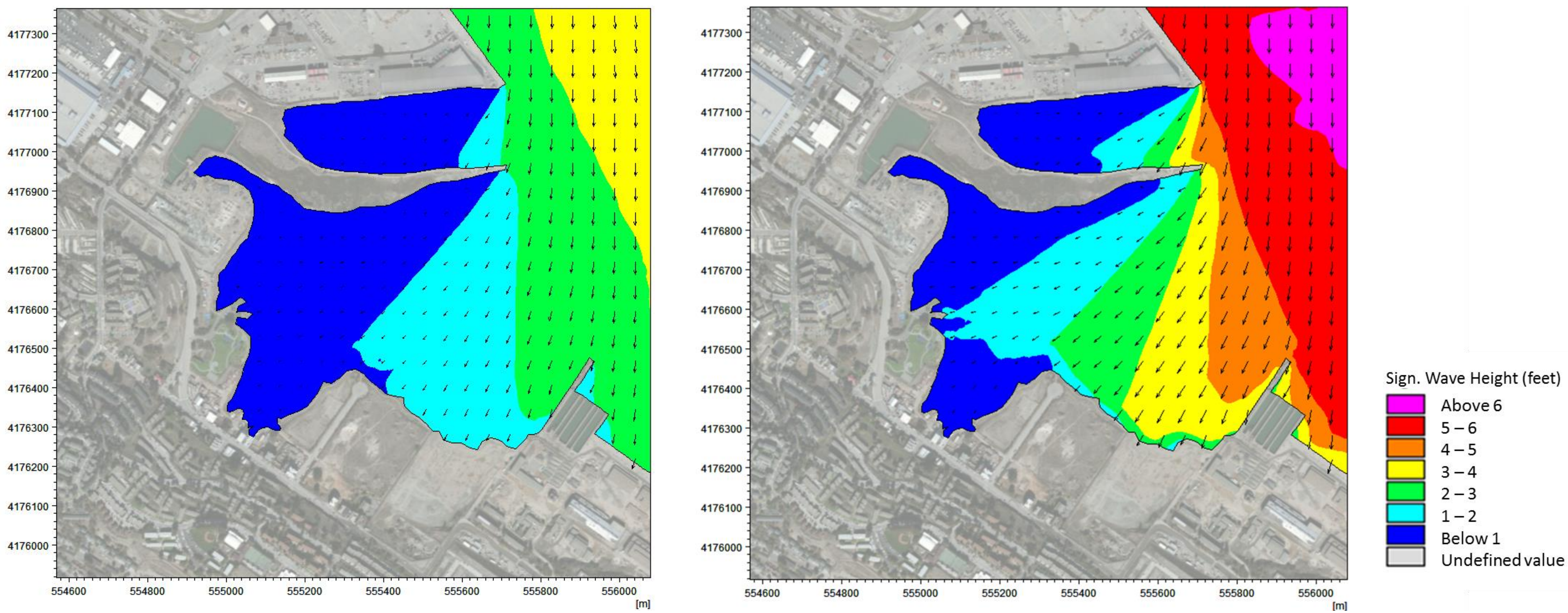

Figure 4-7: Wind Wave Results North Winds, 2-Year Return period (left), 50-Year Return Period (right)

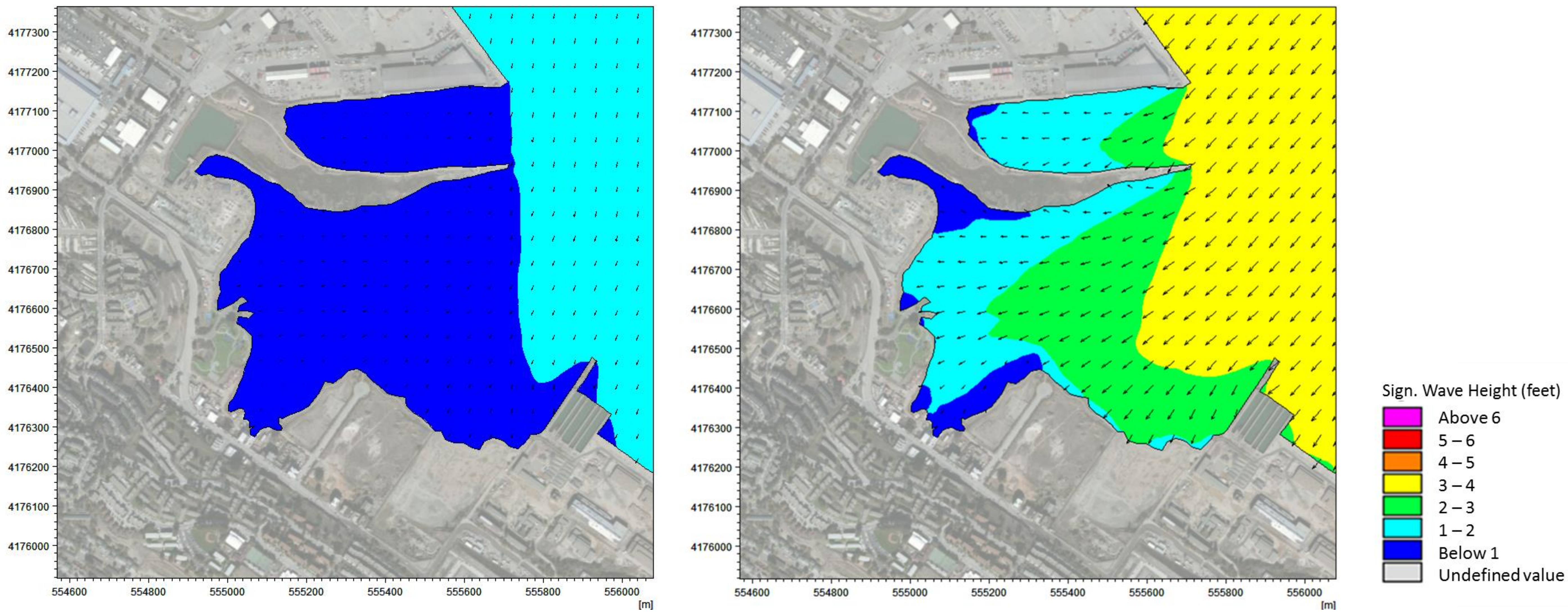

Figure 4-8: Wind Wave Results Northeast Winds, 2-Year Return Period (left), 50-Year Return Period (right)

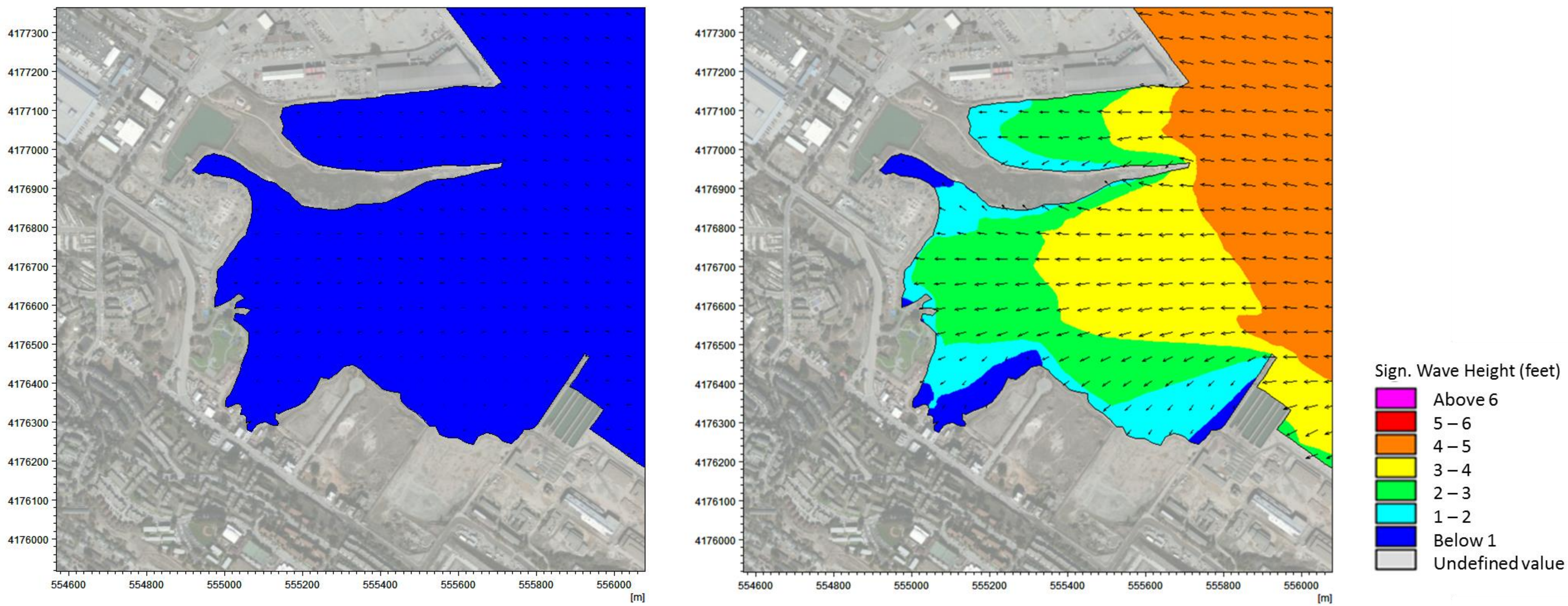

Figure 4-9: Wind Wave Results East Winds, 2-Year Return Period (left), 50-Year Return Period (right)

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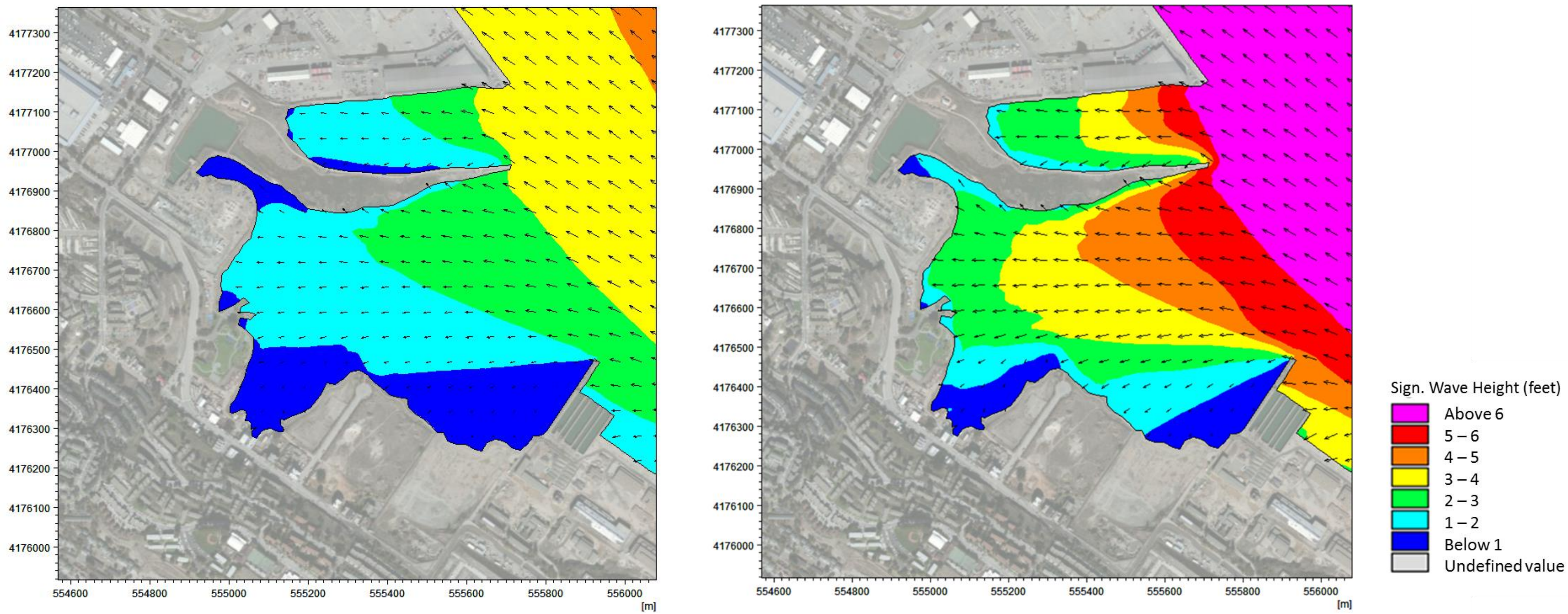

Figure 4-10: Wind Wave Results Southeast Winds, 2-Year Return Period (left), 50-Year Return Period (right)

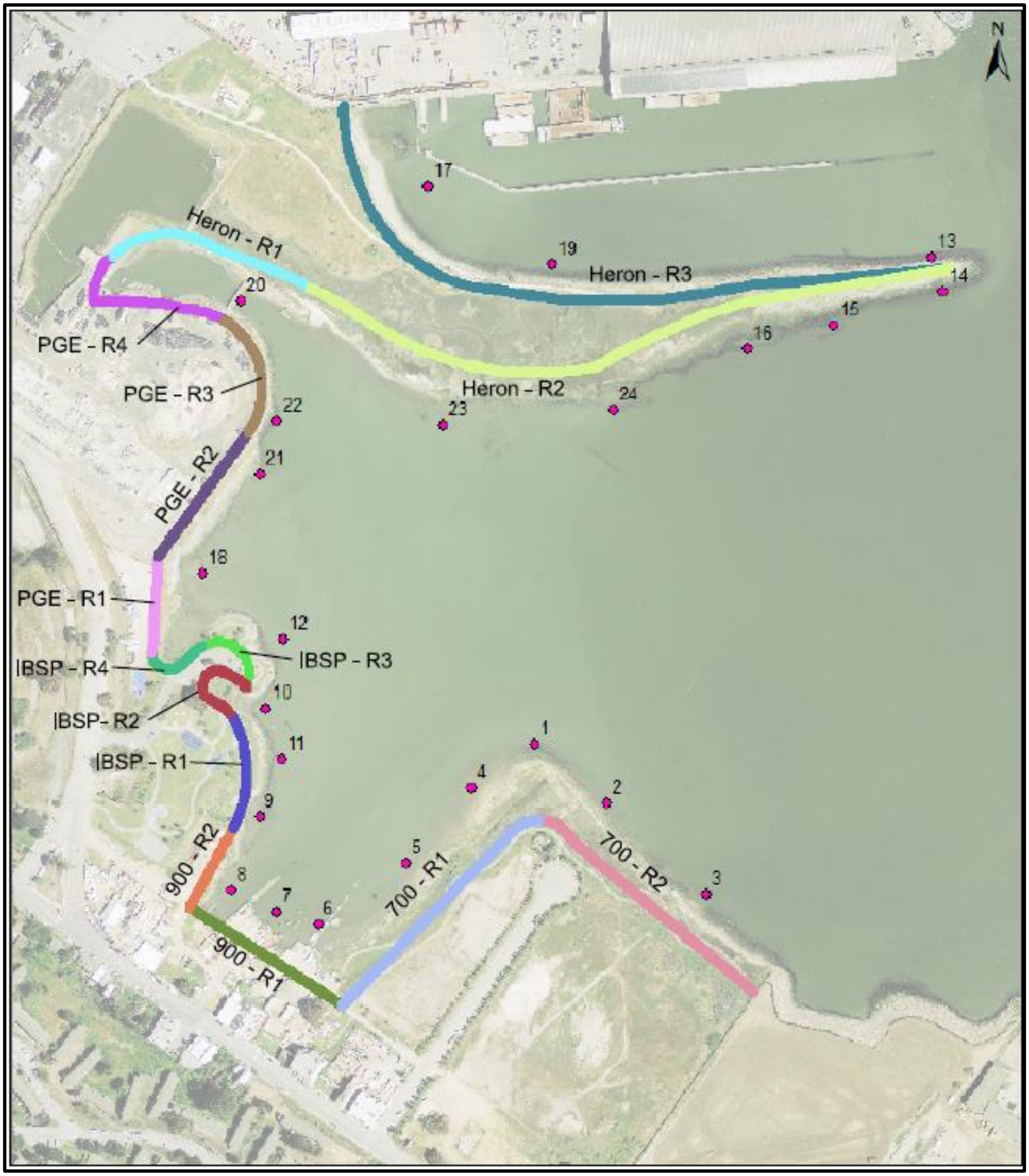

Figure 4-11: Wind Wave Model Extract Location

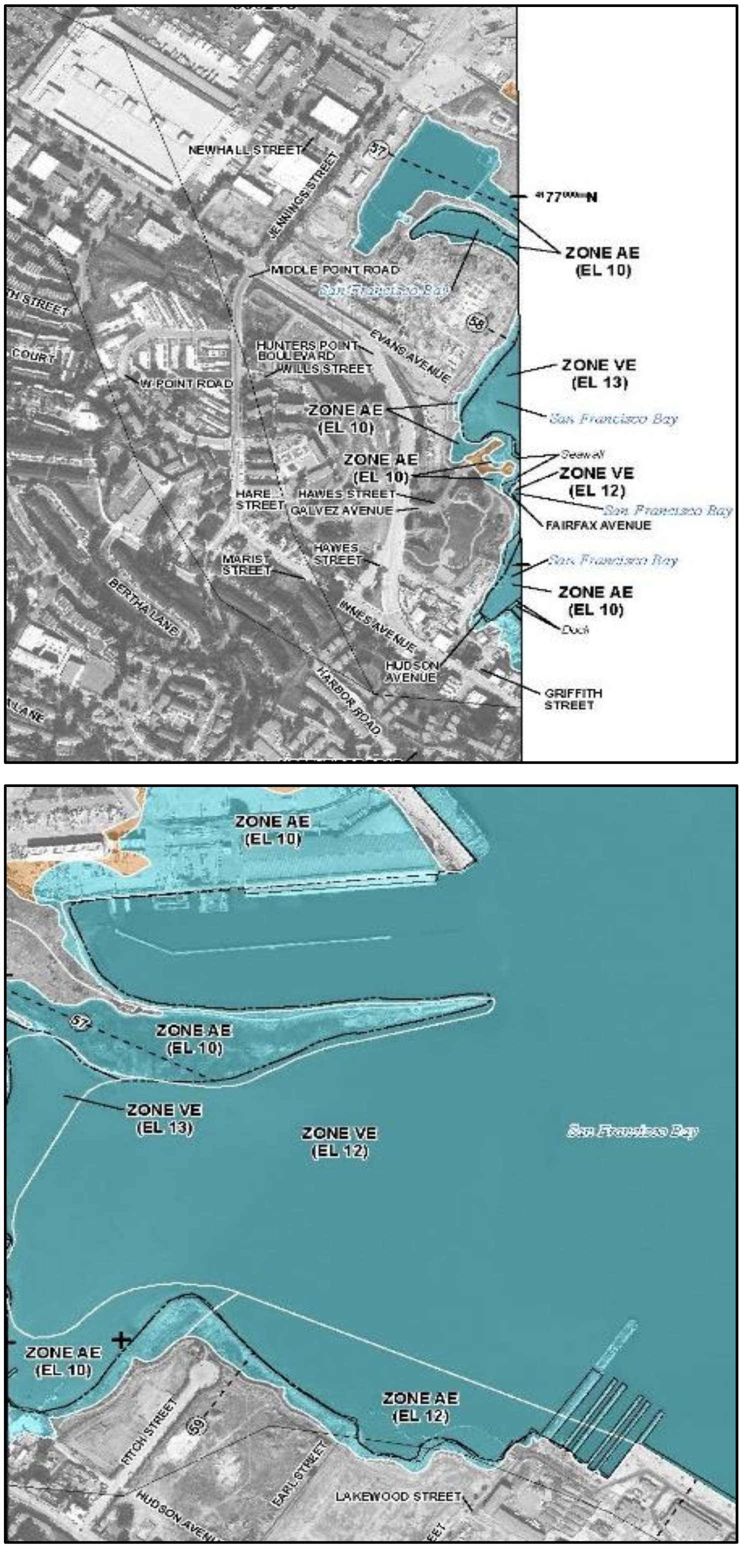

Figure 4-12: Preliminary Flood Insurance Rate Map (FEMA, 2012)

Figure 4-13: Preliminary Flood Insurance Rate Map (FEMA Nov. 2015)

100-year (Blue) and 500-year (Orange).

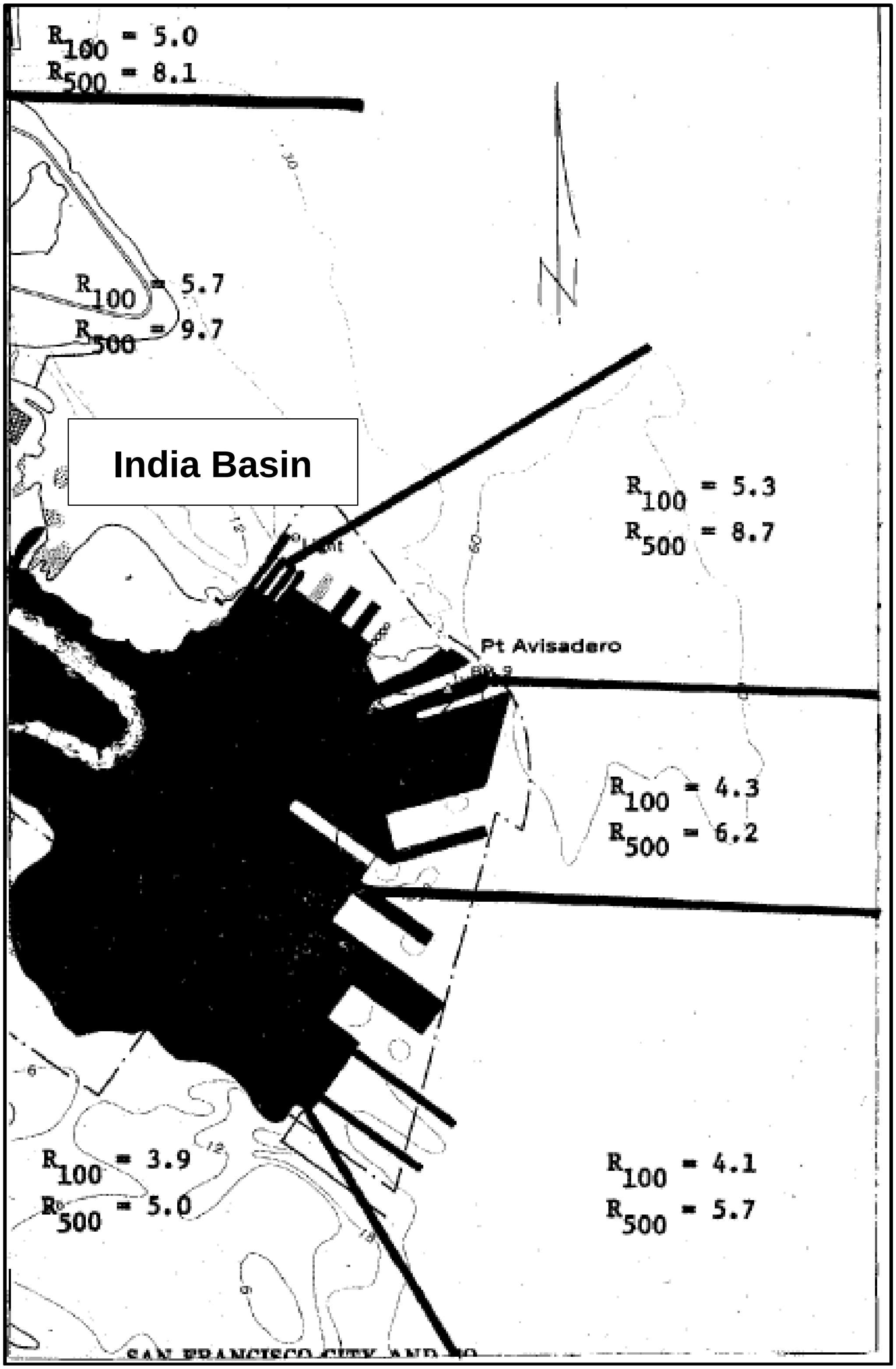

Figure 4-14: Tsunami Runup (feet, MSL) for 100-year and 500-year Tsunamis

(Garcia and Houston, 1975).

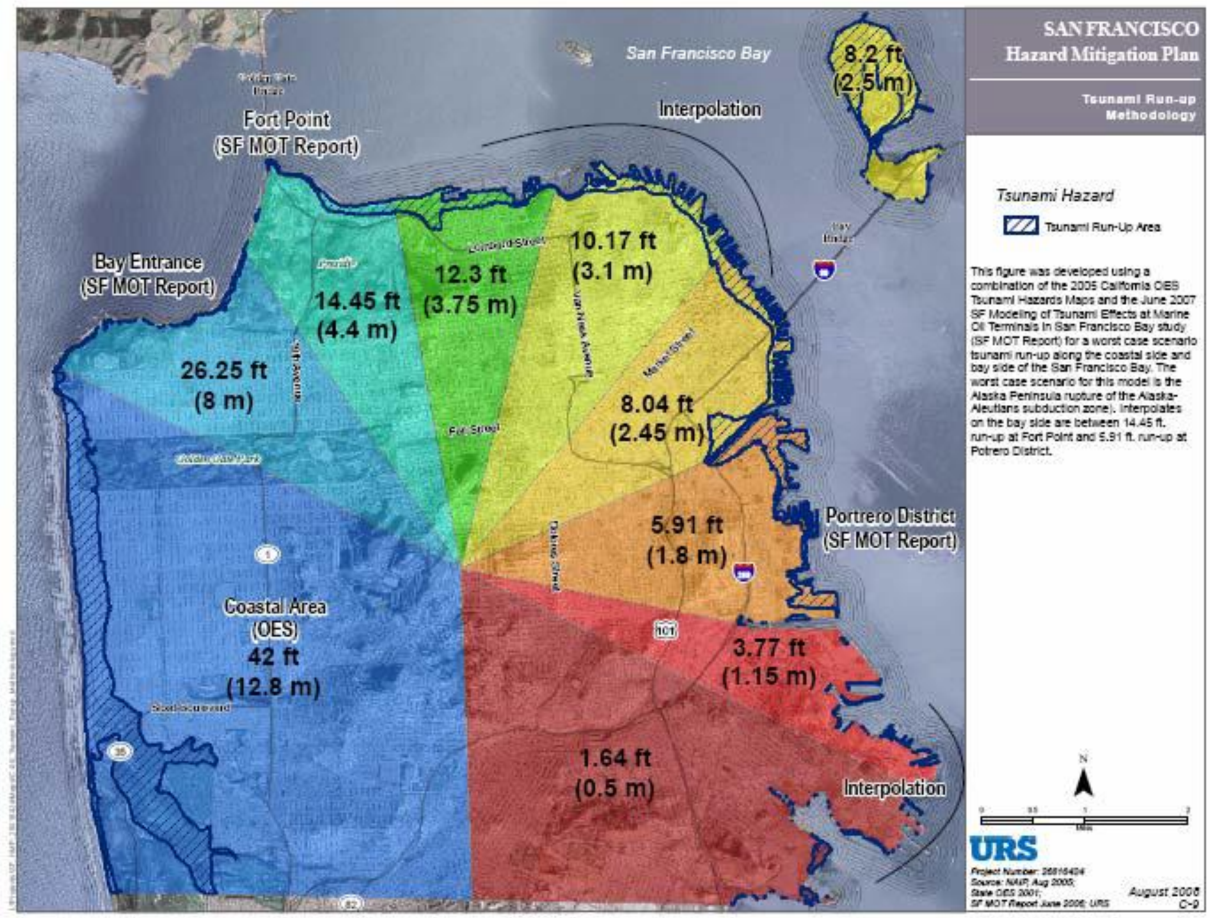

Figure 4-15: Coastal Tsunami Inundation Map for City and County of San Francisco

(Source: Emergency Response Plan; Tsunami Response Annex, 2008)

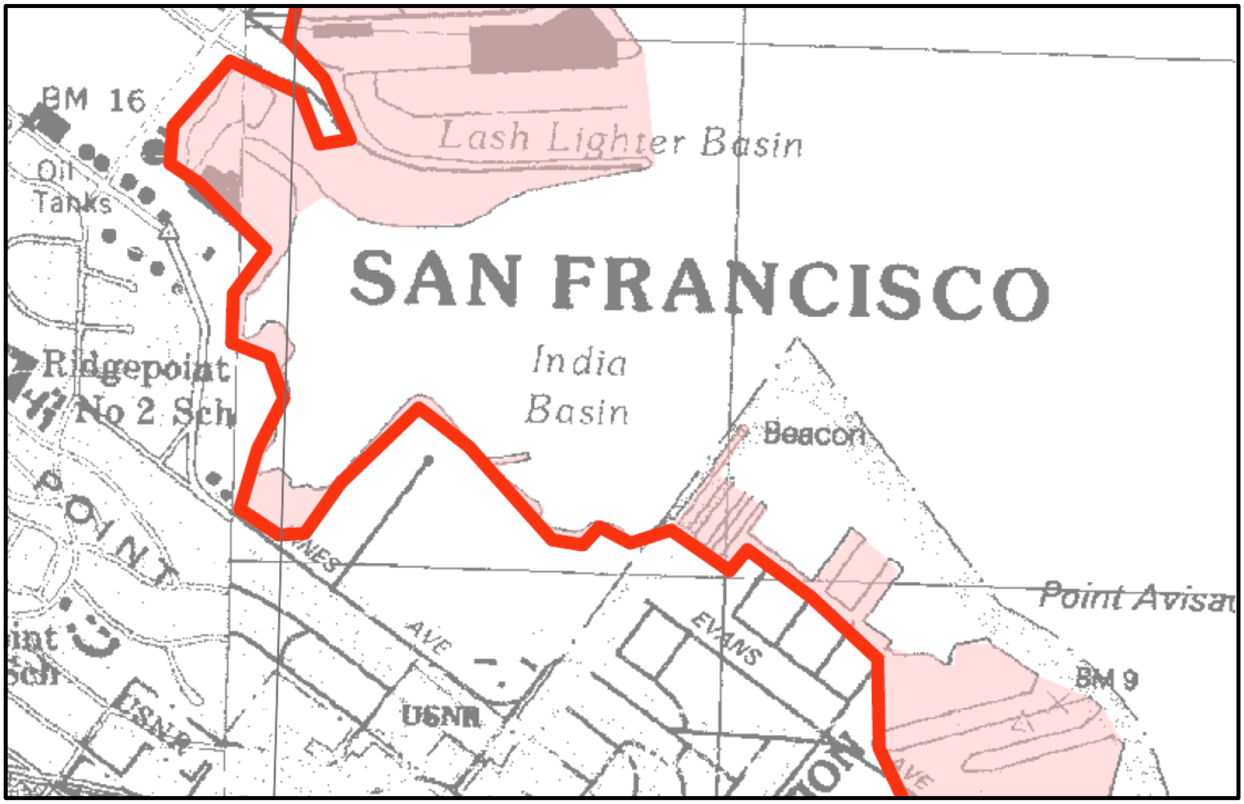

Figure 4-16: Tsunami Inundation Map for City and County of San Francisco

(CalEMA, 2009)

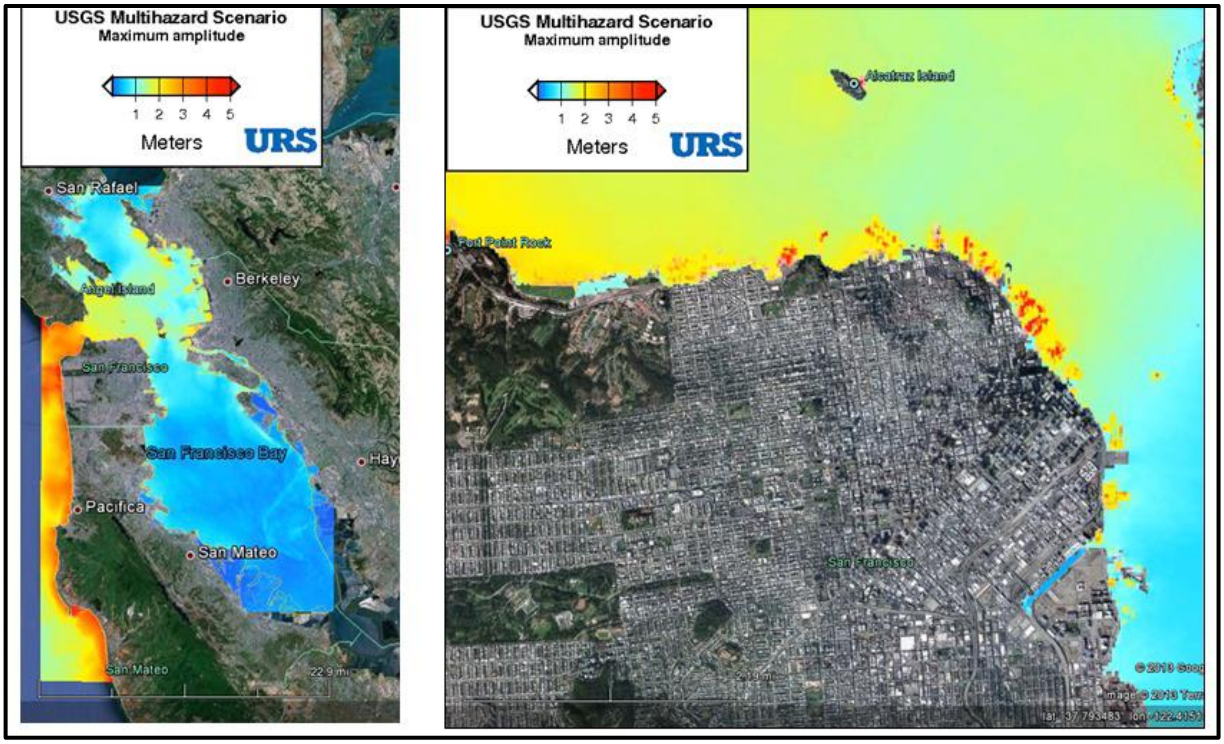

Figure 4-17: Wave Amplitudes for SAFRR Tsunami Scenario (USGS, 2013).

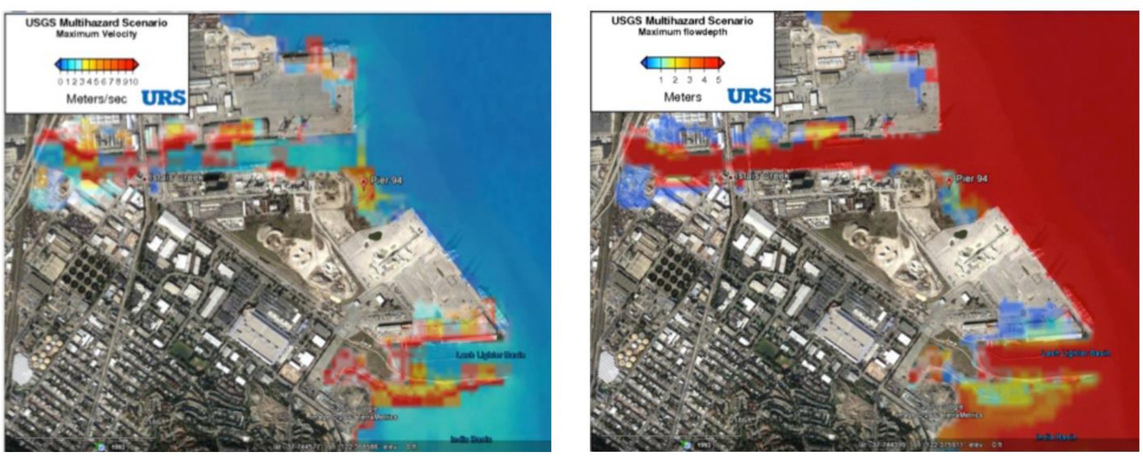

Figure 4-18: Velocities (left) and Flow Depth (right) for SAFRR Tsunami Scenario (USGS, 2013).

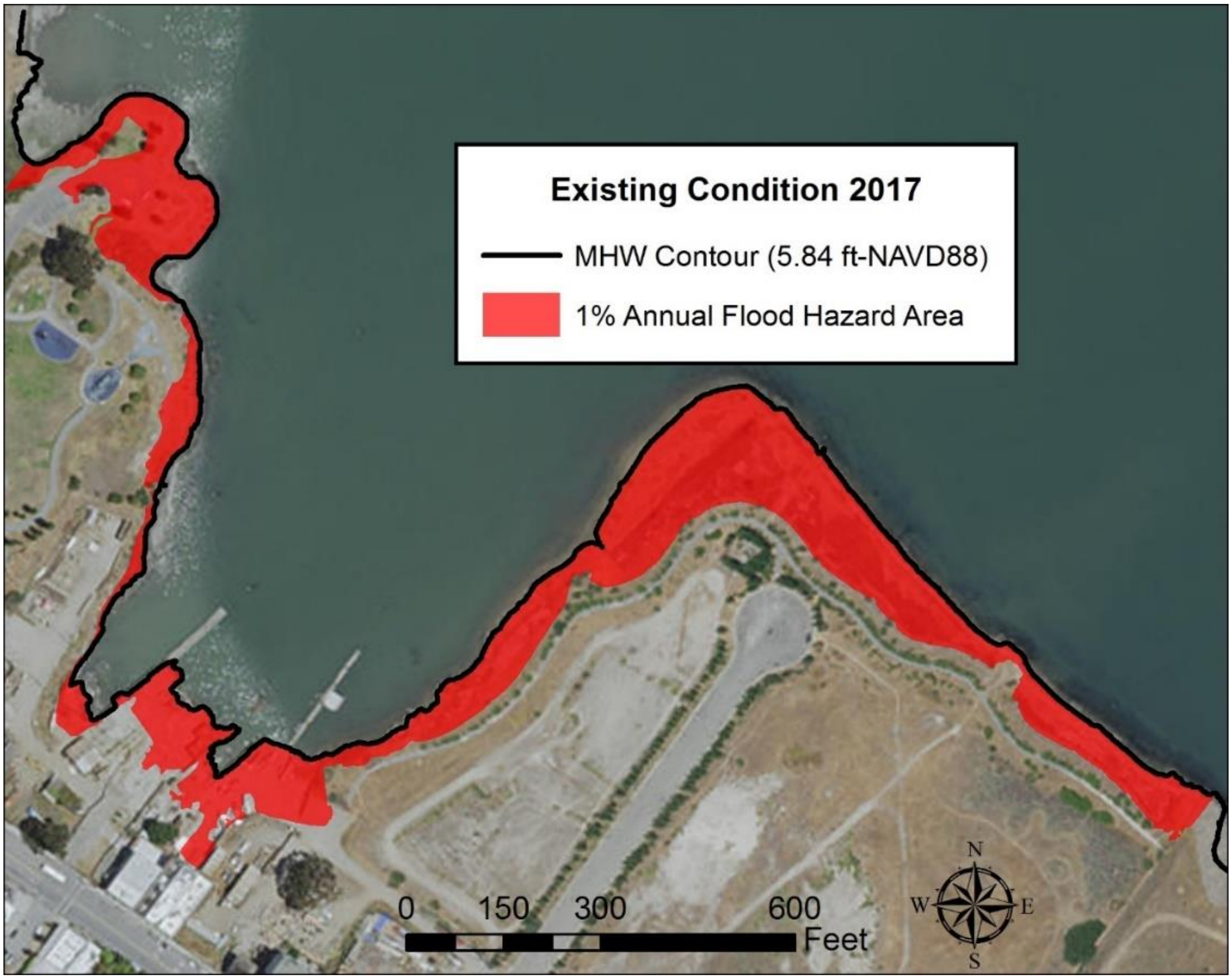

Figure 4-19: Inundation for 1% Flood (No-Project Condition, 2017)

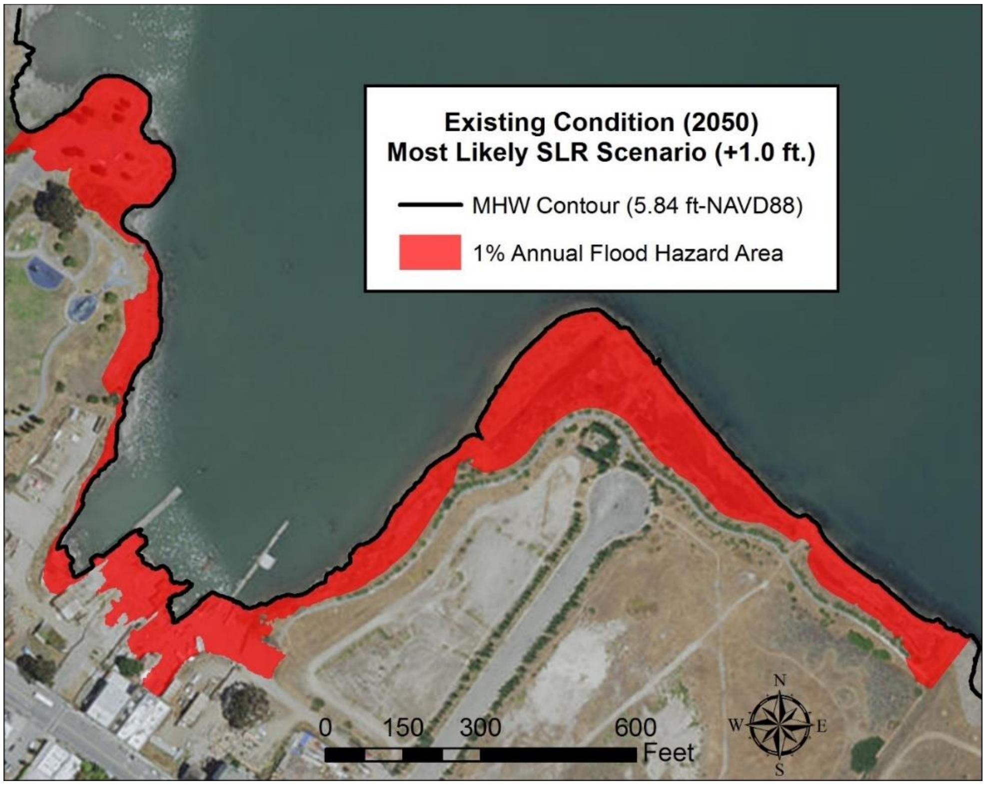

Figure 4-20: Inundation for 1% Flood (No-Project Condition, 2050 most likely SLR)

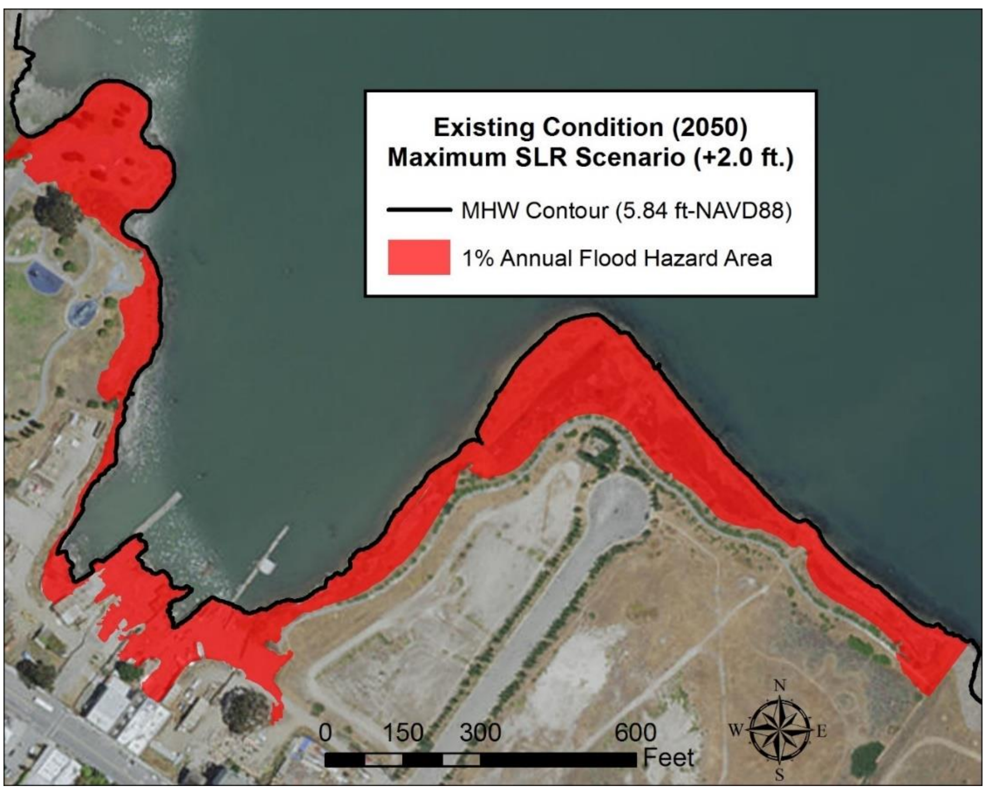

Figure 4-21: Inundation for 1% Flood (No-Project Condition, 2050 maximum SLR)

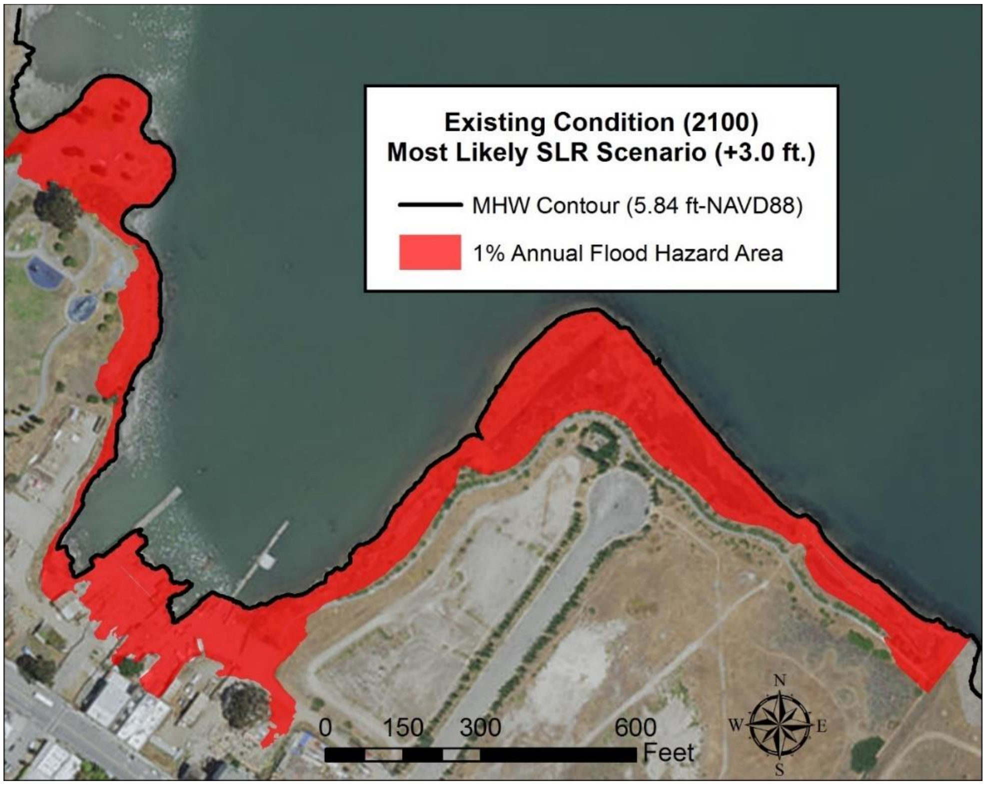

Figure 4-22: Inundation for 1% Flood (No-Project Condition, 2100 most likely SLR)

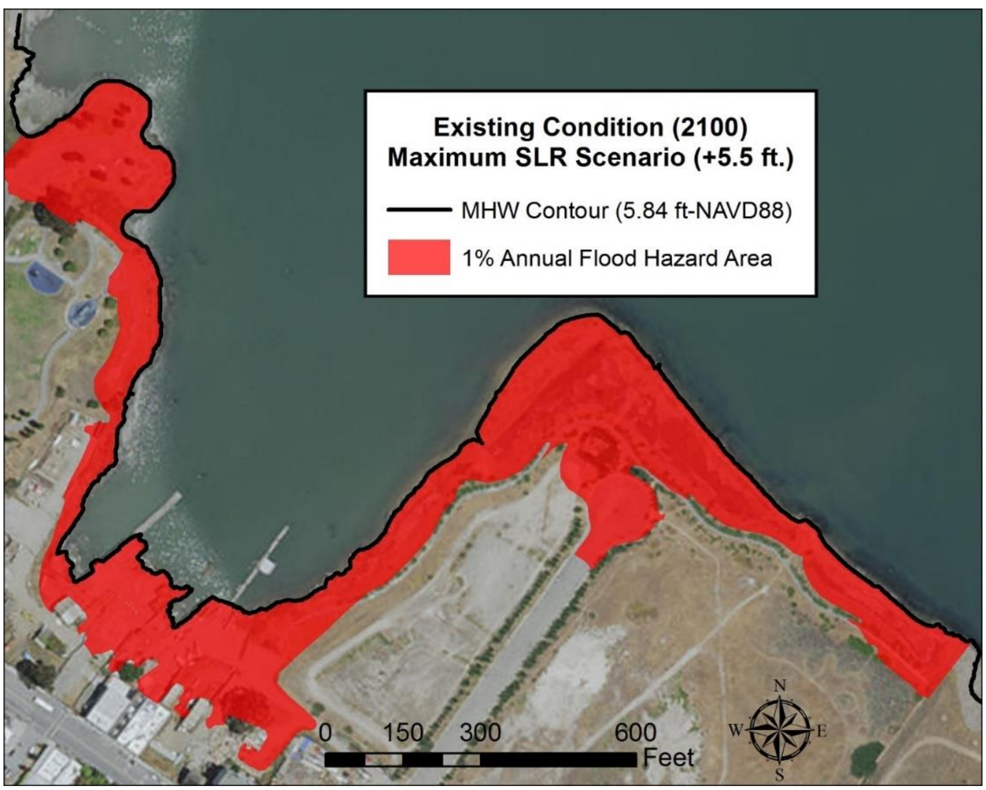

Figure 4-23: Inundation for 1% Flood (No-Project Condition, 2100 maximum SLR)

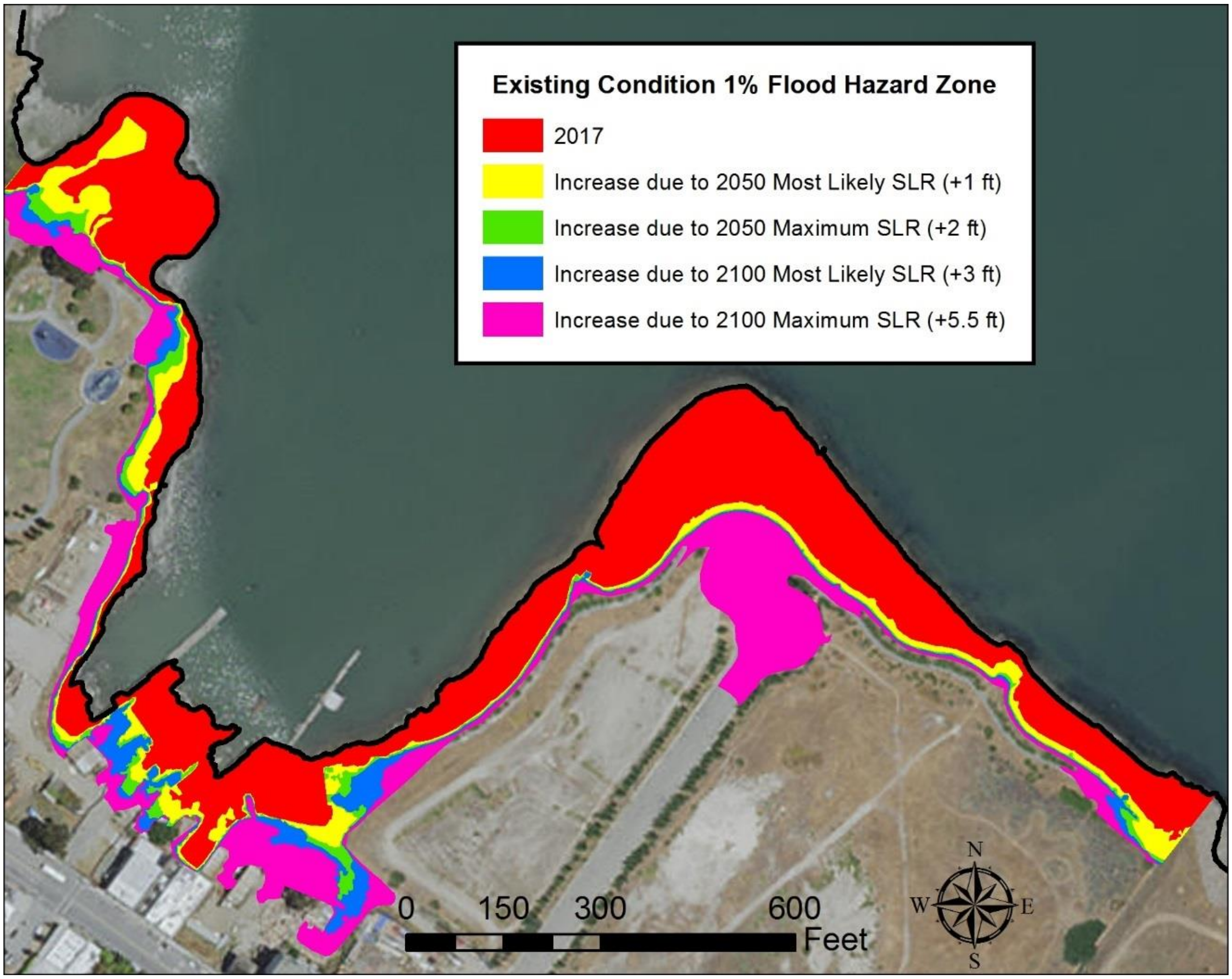

Figure 4-24: Summary of Inundation Over Time for No-Project Conditions

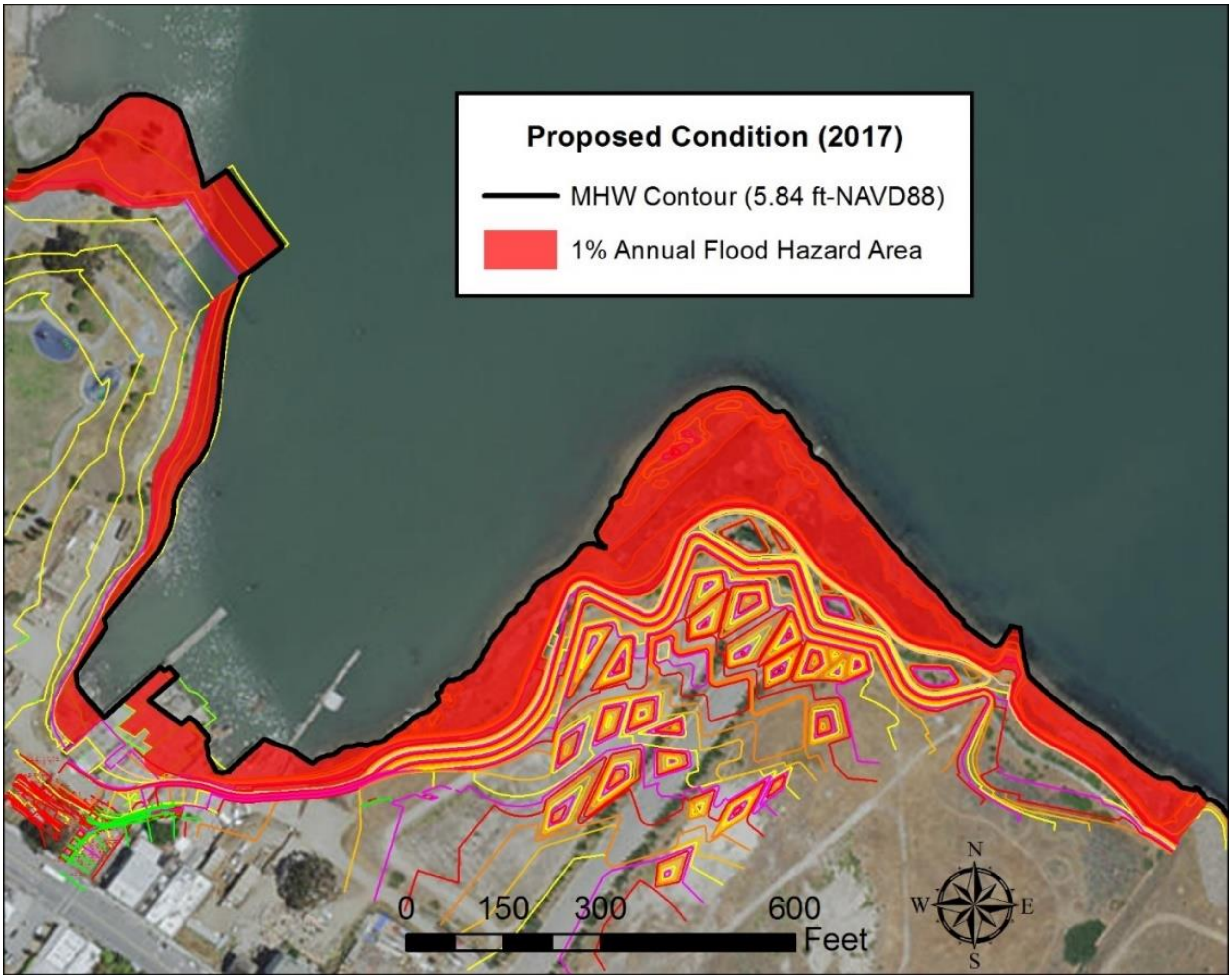

Figure 4-25: Inundation for 1% Flood (Post-Project Condition, approx. 2020)

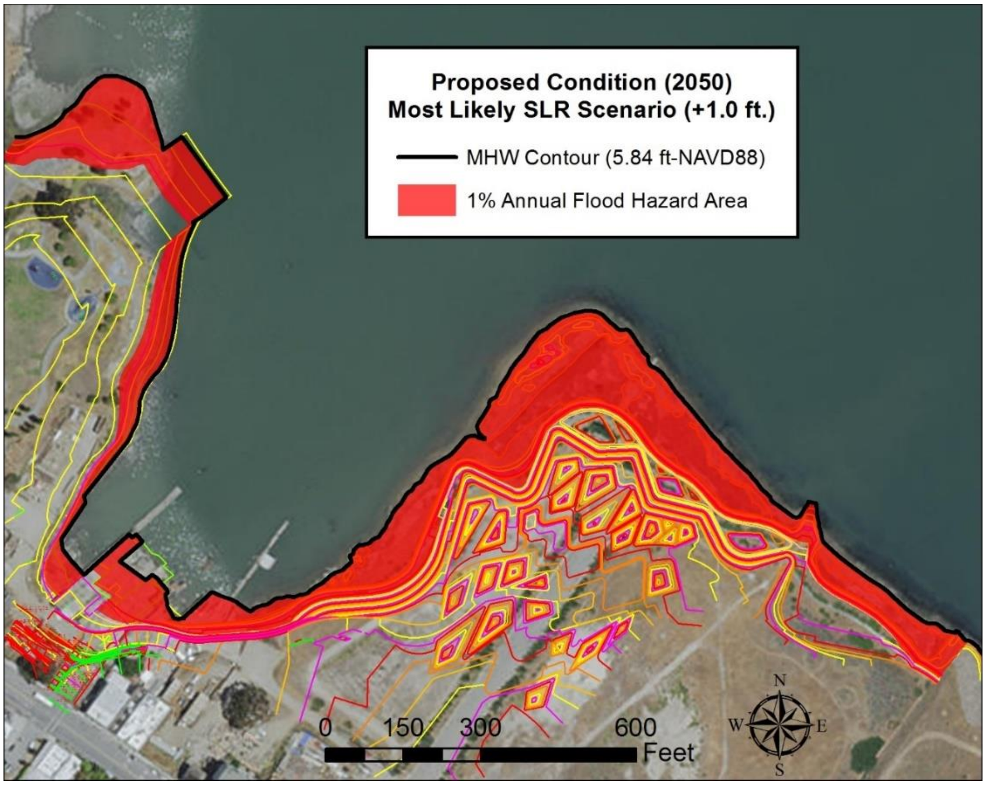

Figure 4-26: Inundation for 1% Flood (Post-Project Condition, 2050 most likely SLR)

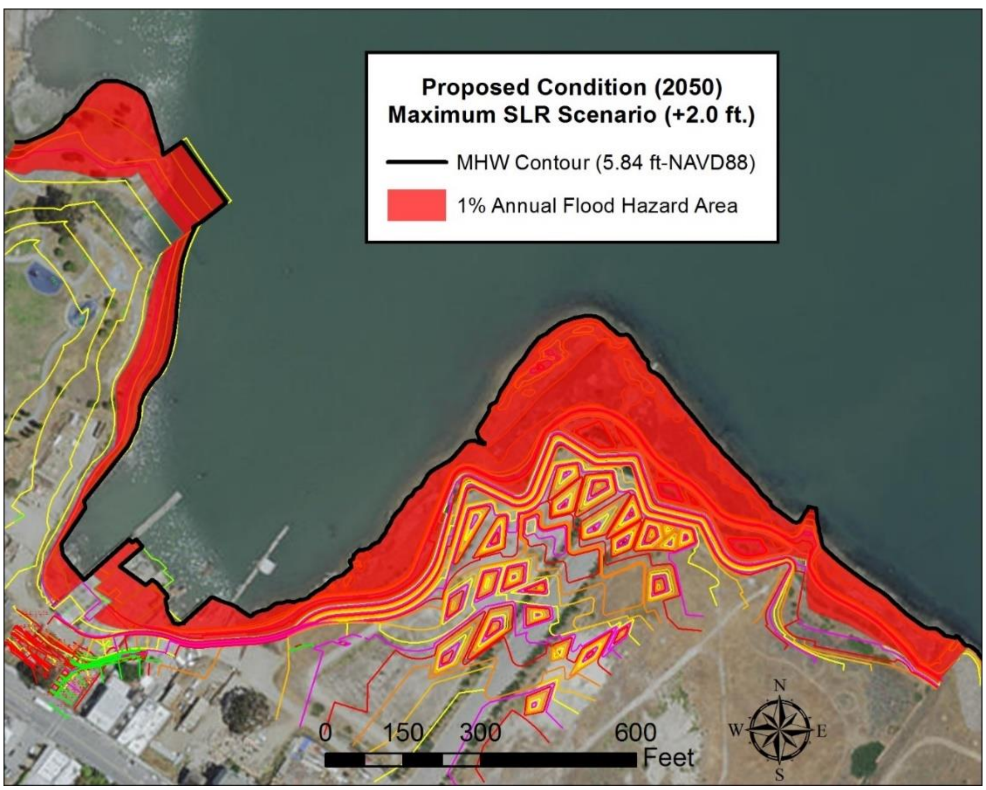

Figure 4-27: Inundation for 1% Flood (Post-Project Condition, 2050 maximum SLR)

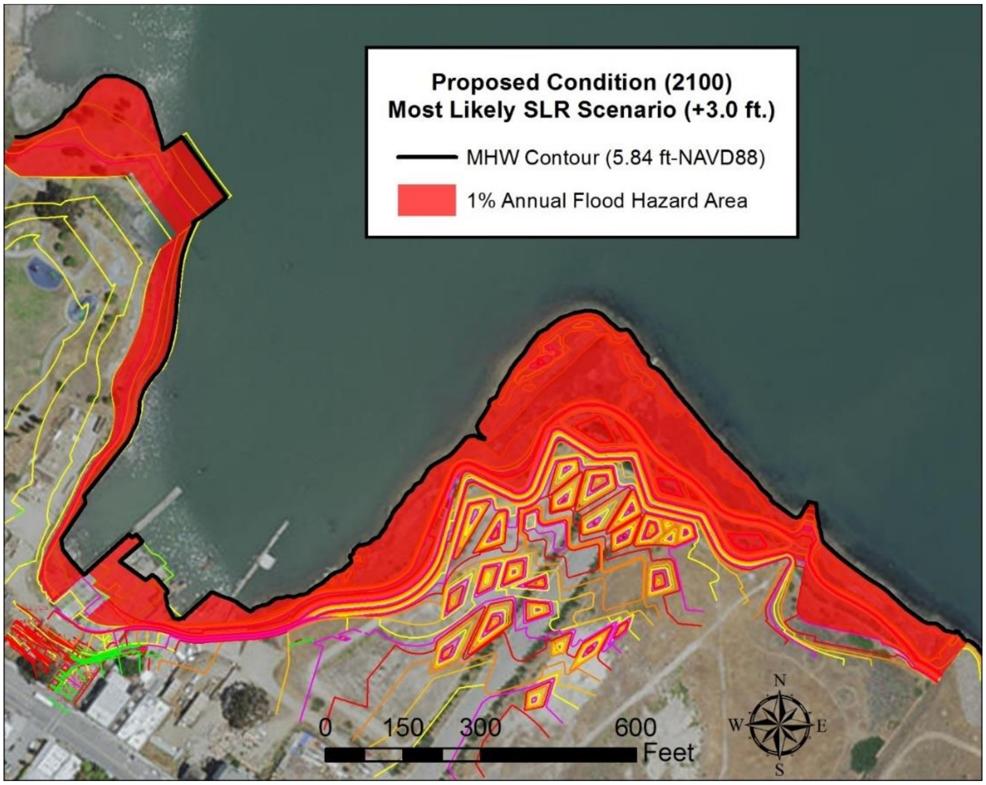

Figure 4-28: Inundation for 1% Flood (Post-Project Condition, 2100 most likely SLR)

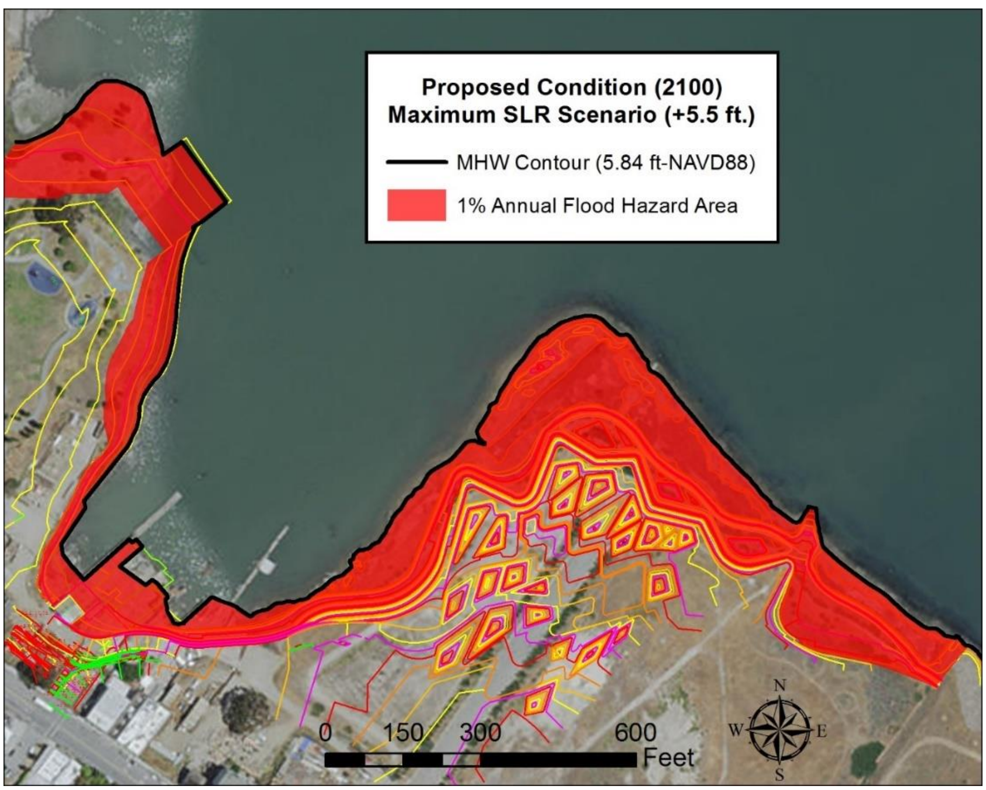

Figure 4-29: Inundation for 1% Flood (Post-Project Condition, 2100 maximum SLR)

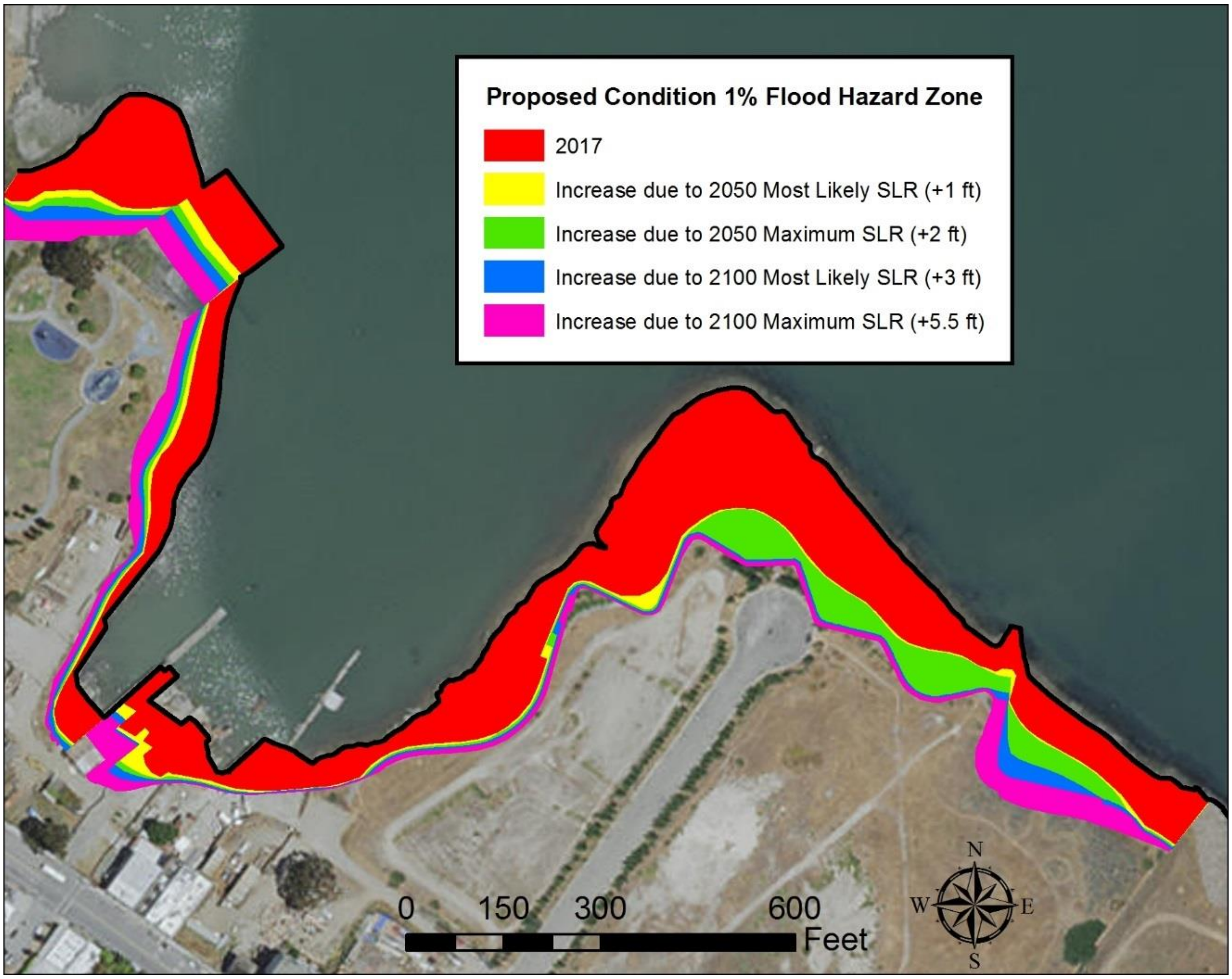

Figure 4-30: Summary of Inundation Over Time for Post-Project Conditions.

5. COASTAL PROCESSES AND SEDIMENT TRANSPORT

5.1 Historic Changes in Bathymetry

We evaluated the long-term changes within India Basin through a comparison of bathymetric surveys. The following bathymetric surveys were used in this analysis:

- US Coast and Geodetic hydrographic surveys obtained from NOAA for the years 1942, 1954, 1979, and 1981
- Meridian Surveying hydrographic survey 2015

The 1942, 1954 and 2015 surveys provided good coverage of the entire basin area. The 1979 survey covered the southern half of India Basin while the 1981 survey covered Lash Lighter Cove and the northern half of India Basin. Overtime, significant filling into the bay has taken place to create India Basin as it is today. A review of historic aerial photography indicates that the 700 Innes and India Basin Open Space site was constructed through filling of the Bay around 1968 and that filling for the construction of Pier 98 and Heron's Head Park was completed in 1977 (BCDC 1993, PORT 1993, and PORT 1994).

The historic surveys from 1945 and 1954 indicate that the area has historically been shallow. Significant shoaling has occurred well offshore of the present shorelines of 700 Innes/India Basin Open Space, 900 Innes and India Basin Shoreline Park in response to the construction of Pier 98 and Heron's Head Park. The nearshore areas of India Basin Shoreline Park, 900 Innes and Reach 700-R2 of 700 Innes/India Basin Open Space have shoaled 1-2 feet since 1954, and the nearshore area of Reach 700-R1 of 700 Innes/India Basin Open Space has shoaled 3-4 feet.

We compared the bathymetric surveys between 1954 and 2015 to estimate historic long-term shoaling rates. The 1954 and 2015 surveys were selected as they provided the most complete coverage of the existing basins. Figure 5-1 illustrate the results of this comparison in inches per year. In general, long term shoaling rates in the majority of India Basin range between 0-2 inches/year, while within Lash Lighter Cove long-term shoaling rates range between 2-4 inches/year. The higher shoaling rate in the offshore portion of India Basin represents expansion of the shallow mudflats towards deeper water. Isolated locations which were above present day elevations in 1954 have very slowly eroded over time to the present day elevations of around -1 feet NAVD88 (light blue locations in Figure 5-1).

A comparison of the 1981/1979 surveys to the 2015 survey provides some information regarding how the basin may respond to increases in elevation as well as deepening. The 1979/1981 surveys show the conditions of the basin just after the end of filling operations at Heron's Head Park and Pier 98. Figure 5-2 shows the deep areas which have significantly filled in (depositional areas) and the high spots which have significantly eroded, to reach present day elevations. The depositional areas were previously dredged 16 to 18 feet deeper than present day elevations while the erosional areas around Heron's Head Park were 3-6 feet higher.

The depositional areas filled in at a rate of 3-8 inches per year with the deeper locations filling at a higher rate than shallower areas. Erosional areas deepened at a rate of 1-3 inches/year with higher areas eroding faster than locations which were closer to adjacent elevations. As these locations were equilibrating to the surrounding depth, the adjacent areas exhibited sedimentation rates similar to the long-term rates discussed earlier.

Future sedimentation in India Basin can be expected to continue at a rate in line with the long-term rates of 0-2 inches/year for the shallow areas and 2-4 inches/year for the deeper portions further offshore, dependent on the availability of sediment.

Increasing depths significantly in India basin for a dredge channel can be anticipated to fill in at a rate of 3-8 inches/year depending on the depth of dredging while significant increases in elevations will likely eroded at a rate of 1-3 inches per year depending on exposure to wave action.

5.2 Sediment Transport

India Basin was not subject to any notable geomorphologic study. The few studies that were conducted over the past years provide insights into the geomorphological processes. Some of these studies are listed below,

- Hunters Point Shipyard Parcel F, Sediment Dynamics Report (Woods Hole and Battelle, 2004).
- Soil Characterization Study (Northgate, 2016)

As discussed in the previous section, Moffatt & Nichol (2015) conducted a bathymetric analysis, and the results are comparable with the results of the measurements done by Woods Hole and Battelle (2004). They performed a radioisotope analysis on two sets of core samples from the basin floor, each sample about 8 ft. long, and concluded that an average shoaling rate of 0.92 inches/year occurred from 1951 to 2000 inside India Basin. Woods Hole Group and Battelle (2004) prepared a sediment dynamics report for surrounding region of Hunters Point Shipyard (including India Basin) for the U.S. Navy, using time-series measurements of waves, tides, currents, and suspended sediment concentrations recorded over one-month periods during winter and summer of 2001. They reported increases in near-bottom currents and wave velocities due to winter storms near India Basin. Also, they performed a 2D regional hydrodynamic and sediment transport modeling and calibrated their model with field measurements.

In this section, we discuss different processes that possibly contribute to long-term and short-term bathymetric changes within India Basin.

5.2.1 Sediment Type inside India Basin

The sediment type inside India Basin is mainly mud with few sandy regions (Moffat and Nichol, 2015; Woods Hole and Battelle, 2004). The Woods Hole and Battelle (2004) analysis of two samples inside India Basin concluded that India Basin bottom mainly consists of silty clay (mud) with a homogenous texture. However, some sandy regions exist inside the basin, especially around 700 Innes and India Basin Open Space Reach shorelines, as well as some parts of 900 Innes and India Basin Shoreline Park. Northgate (2016) performed a soil characterization study for India Basin Open Space region based on several soil samples. They reported poorly graded sandy regions along the 700 Innes\India Basin Open Space (Reach 700-R1 and Reach 700-R2), with finer sediments (silt and clay) on its neighboring areas (e.g. 900 Innes Reach). Navigation charts also report that India Basin floor consists of mud-type sediment. Although all the surrounding regions of India Basin consist of fine sediment (mud), there is a sandy area next to the tip of the Hunters Point just south of the India Basin (Figure 5-3), which is gradually eroding due to strong ebb tidal current (Jaffe and Foxgrover, 2006). This scour hole can possibly be the origin of some of the sand observed inside the India Basin.

5.2.2 Wave-induced Sediment Transport

Regional wind roses around India Basin (SFO, Alameda, and San Francisco Pier) indicate that local winds are dominantly from the west and northwest; however, the strongest winds typically occur during winter storms from southeast, resulting in wave generation, sediment suspension, and basin-wide circulation. Wave driven transport occurs when breaking waves cause sediment to be suspended into the water column which are then transported by the resultant wave-induced currents. The overall direction of this transport is a result of the predominant wave direction and the orientation of the shoreline. Due to the varied shoreline orientation and predominant wave direction within India Basin, the wave-driven transport of sediment will also vary.

The predominant wave direction for the India Basin Shoreline are:

- Northeast - 700 Innes/India Basin Open Space, 900 Innes, and the north shoreline of Heron’s Head Park(Reach Heron-R3)
- East - India Basin Shoreline Park and the PG&E Shoreline
- Southeast - south shoreline of Heron’s Head Park (Reach Heron-R2)

Based on the predominant wave direction and shoreline orientations the overall wave driven sediment transport directions are shown in Figure 5-4. Generally, wave driven sediment transport moves available sediment into the northwest corner the basin between Heron’s Head Park and the PG&E Shoreline Trail, the cove at the northern limit of India Basin Shoreline Park, and towards 900 Innes. Reach IBSP-R3 has a mixed transport direction indicated by the dashed line with two arrows. This means that available sediment here can be transported in either direction due to the variable orientation of the shoreline and wave exposure. These patterns indicate where sediment introduced into India Basin is likely to be transported by wave action unless measures are taken to stabilize or contain them.

5.2.3 Tidal Current Transport

In the South Bay, tidal currents typically exceed 1 m/s in the channel and 0.4 m/s on the shoals, causing a clockwise sediment transport pattern inside the South Bay (Schoellhamer, 1996). India Basin is located on the west side of the South Bay, near the deepest parts of the tidal channel where tide-induced sediment transport is northward, and mainly mud dominated (Barnard et al., 2015).

Tidal current patterns were developed from a Mike 21 Flexible Mesh Hydrodynamic Model. A two-week tidal series which covered a spring-neap tidal cycle was simulated. As no calibration data is available for India Basin, the results were utilized to develop an understanding of the general tidal current propagation pattern. A general pattern of tidal ebb and flood currents is presented in Figure 5-5.

Flood currents are generally shore perpendicular along 900 Innes, India Basin Shoreline Park and PG&E Shoreline Trail, while shore parallel for 700 Innes/India Basin Open Space and Heron’s Head Park. Ebb Tides are a reversal of the flood currents and have been found to typically be stronger than flood currents in San Francisco Bay. Tidal currents typically carry suspended sediments on flood tide and deposit sediment during high or low tide when tidal currents are at their weakest.

The shore perpendicular flood currents will likely deposit suspended sediments along the shorelines of 900 Innes, India Basin Shoreline Park, and the PG&E Shoreline Trail. The shore parallel currents along Heron’s Head Park and 700 Innes/India Basin Open Space will transport suspended sediment towards the northwest corner the basin between Heron's Head Park and the PG&E Shoreline Trail and towards 900 Innes.

Woods Hole Group and Battelle (2004) reported that along the India Basin tidal currents were relatively strong and ebb-dominated, causing a rotating flow-field in the clockwise direction during flood tide, and counterclockwise during ebb tide (Figure 5-6) near the entrance of the India Basin along San Francisco Bay tidal channel. These tidal currents and their consequent flow-fields are the primary cause for the long-term shoaling inside India Basin (Figure 5-1). While the tidal currents are powerful enough to suspend mud-type sediment near the tidal channel (1-1.5 m/s), the suspended sediment deposits in the nearshore area sheltered from significant tide-induced currents inside the basin.

5.2.4 Combined Wave and Tidal Transport

It is important to consider wave effect on the shear stresses within shallow areas of San Francisco Bay, knowing that sediment suspension is typically controlled by wave-induced bottom stresses. During winter storms, local waves become significant, and in combination with tidal currents, they modify areas of erosion and deposition inside India Basin. To study the effect of wave-tide interaction on sediment transport, Woods Hole and Battelle (2004) modeled 1998 El Nino storm and tidal current in the surrounding areas of the Hunters Point Shipyard, including India Basin. Figure 5-7 shows calculated erosion flux during a maximum ebb flow combined with southeast waves. Woods Hole and Battelle (2004) concluded that erosion patterns and magnitudes showed no significant change in the deeper waters (> 10 ft) compared to tide only condition, but the wave effects on the erosion flux are important in the shallower areas. Short-term bathymetric changes in shallow areas (Figure 5-2) are possibly caused by relatively large south and southeast coming waves during winter storms which penetrate India Basin.

Moffatt & Nichol (2015) concluded that under combined wave and tidal current action, sediment deposited within India Basin will be transported toward the cove between the PG&E Shoreline Trail and Heron's Head Park, the cove at the northern end of India Basin Shoreline Park, or 900 Innes. As a result of these transport processes extensive mudflats have developed at the northern end of India Basin Shoreline Park and 900 Innes while deeper depths are found closer to shore along Reach 700-R2, IBSP-R3 and PGE-R3.

5.2.5 Summary of Sediment Transport Processes in the Project Area

Although no significant sediment transport occurs due to tidal currents inside India Basin, the observed long-term erosion (Figure 5-1) inside the nearby tidal channel is probably caused by the strong ebb-dominated tidal currents (1-1.5 m/s) near Hunters Point. On the other hand, significant erosion of sediments in India Basin should be only expected in high wave conditions, with a direction favoring propagation into the basin (i.e., from the southeast). This could happen during winter storms, where winds from south and southeast generates large waves in South San Francisco Bay that propagate into India Basin. The observed erosion rate of 3-8 inches/year around Heron's Head Park (Figure 5-2) is caused by these winter storms. Heron's Head is probably the most vulnerable location to erosion inside the India Basin, because it is not sheltered from south and southeast coming waves. Also, the northeastern side of India Basin Open Space is exposed to the refracted waves coming from northeast into the basin, which are more common than south and southeast waves throughout the year. However, these waves are not as strong as south and southeast coming waves and do not cause significant sediment action within India Basin. The northeast waves that penetrate inside the India Basin refract around Heron's Head and propagate shore-normal toward reach

700-R1. However, these waves are probably only powerful enough to suspend fine sediment (mud), and transport it to depositional reaches like 900-R1.

Field observations show that the sediment type inside and around the India Basin is typically mud, with few exceptions of sandy regions. Although coarser sediments in the deeper channel next to Hunters Point Shipyard (Point Avisadero, Figure 5-3) can be a possible sand source for the basin; the rate of this sand transport is probably negligible. The observed sand inside the basin probably originates to local sources (e.g. filling debris), or to erosion in the areas with more active wave field like reach ISBP-R2, where fine sediment (mud) is transported to the low-energy regions (like reach 900-R1), leaving poorly graded sand behind.

Figure 5-8 shows dominant sediment transport regime within India Basin, demonstrating possible erosion and deposition regions. These regions are defined based on a combination of considerations, such as dominant erosional behavior due to waves south and southeast coming waves during winter (Figure 4-4 and Figure 5-4), tidal current regime with the basin (Figure 5-5 and Figure 5-6), and combined wave-tide condition (Figure 5-7). Heron's head park shoreline is exposed to dominant winter storm waves coming from south and southeast (Figure 4-9 and Figure 4-10), and consequently experience the largest erosional wave-induced currents (2-3 feet wave heights) within India Basin. IBOS northeast shoreline (Reach 700-R1) is also exposed to erosional wave field. However, because the IBOS shoreline is not directly exposed to southeast and south coming waves in comparison to Heron's Head Park southern shoreline (1-2 feet wave heights), wave-induced erosional current are weak and incapable of moving coarse (Sand or Gravel) sediment. On the other hand, 900 Innes and IBSP either have stable shorelines, or fall into depositional regions within the basin, while the depositing sediment is mainly mud.

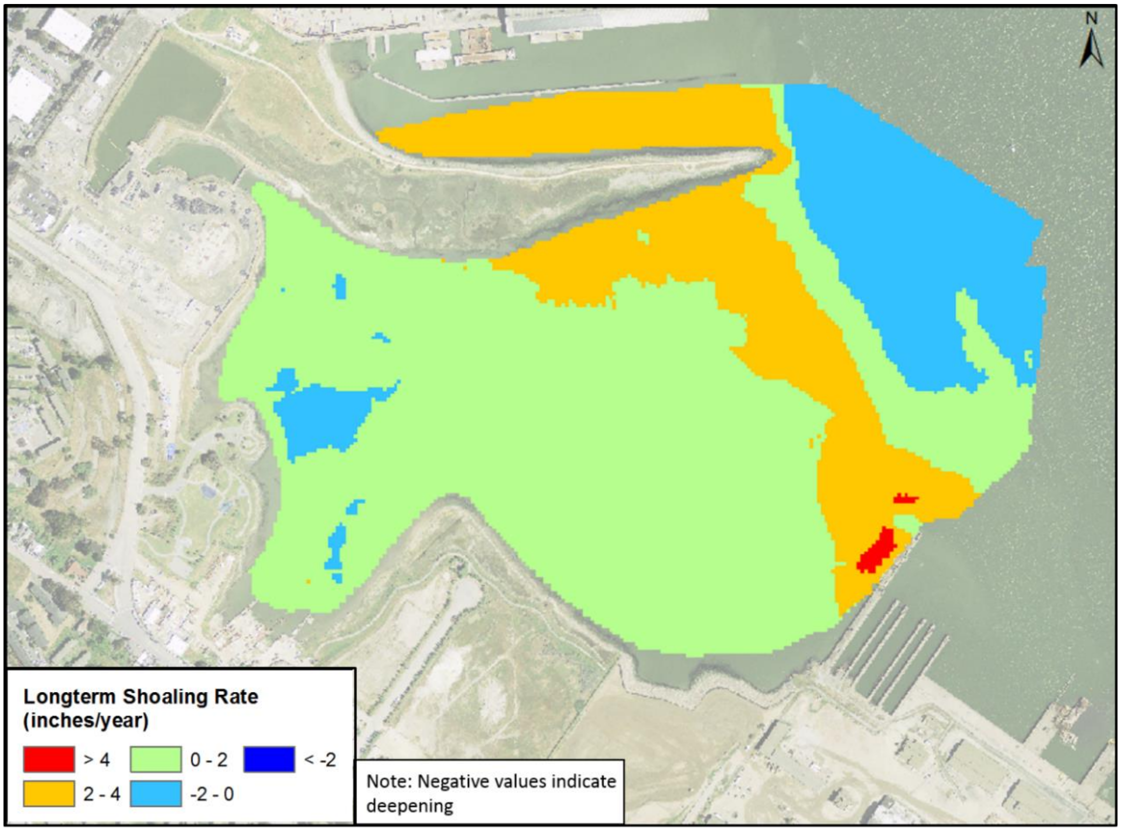

Figure 5-1: Long-term Shoaling Rates (1954-2015)

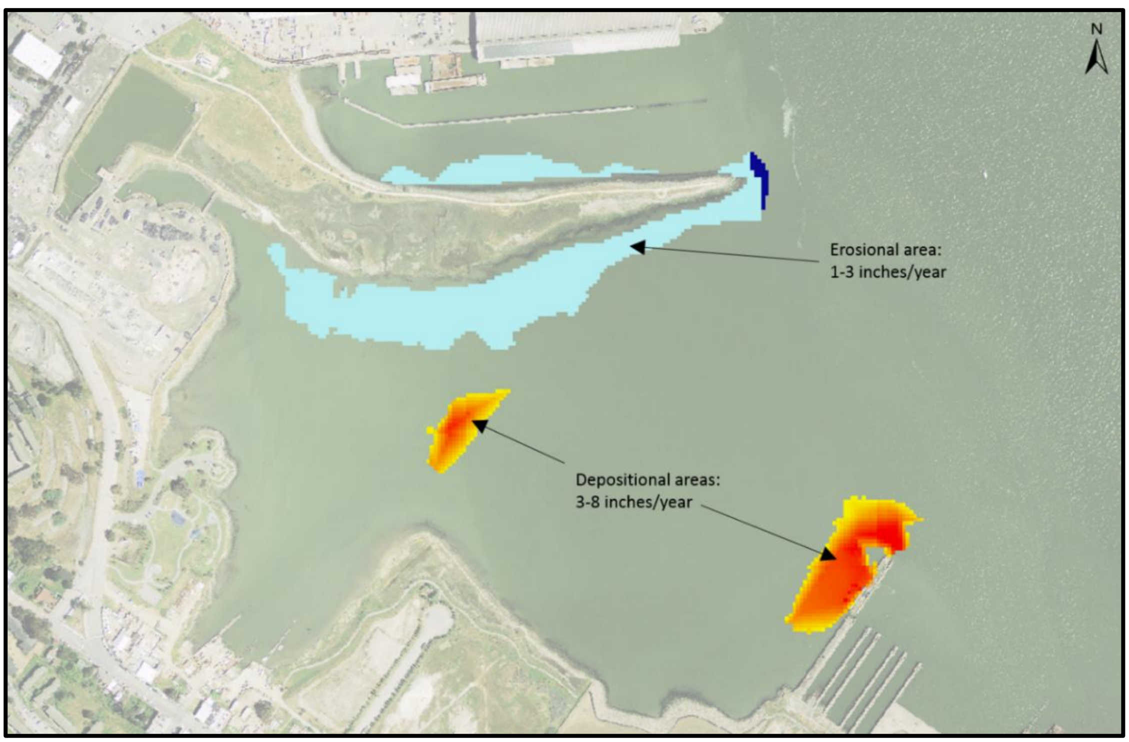

Figure 5-2: Erosional and Depositional Areas since 1979/1981

Figure 5-3: Wave-Driven Sediment Transport Pattern

Figure 5-4: Tidal-currents Driven Sediment Transport Pattern

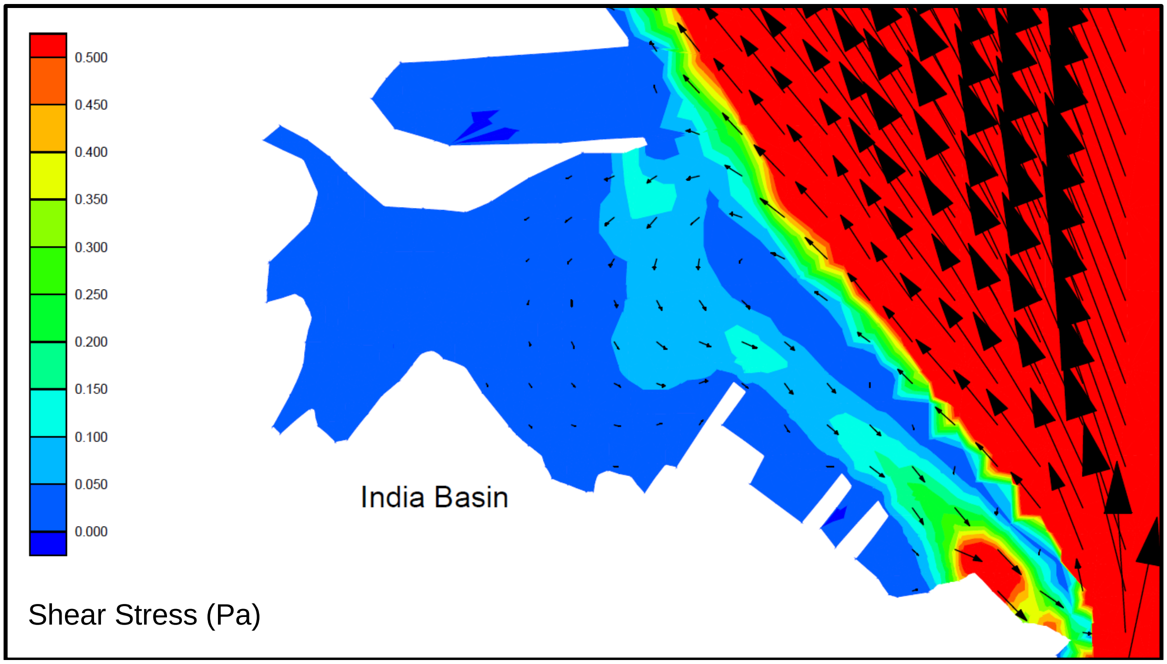

Figure 5-5: Maximum Shear Stresses and Velocity Vectors due to Currents

(Source: Woods Hole and Battelle, 2004)

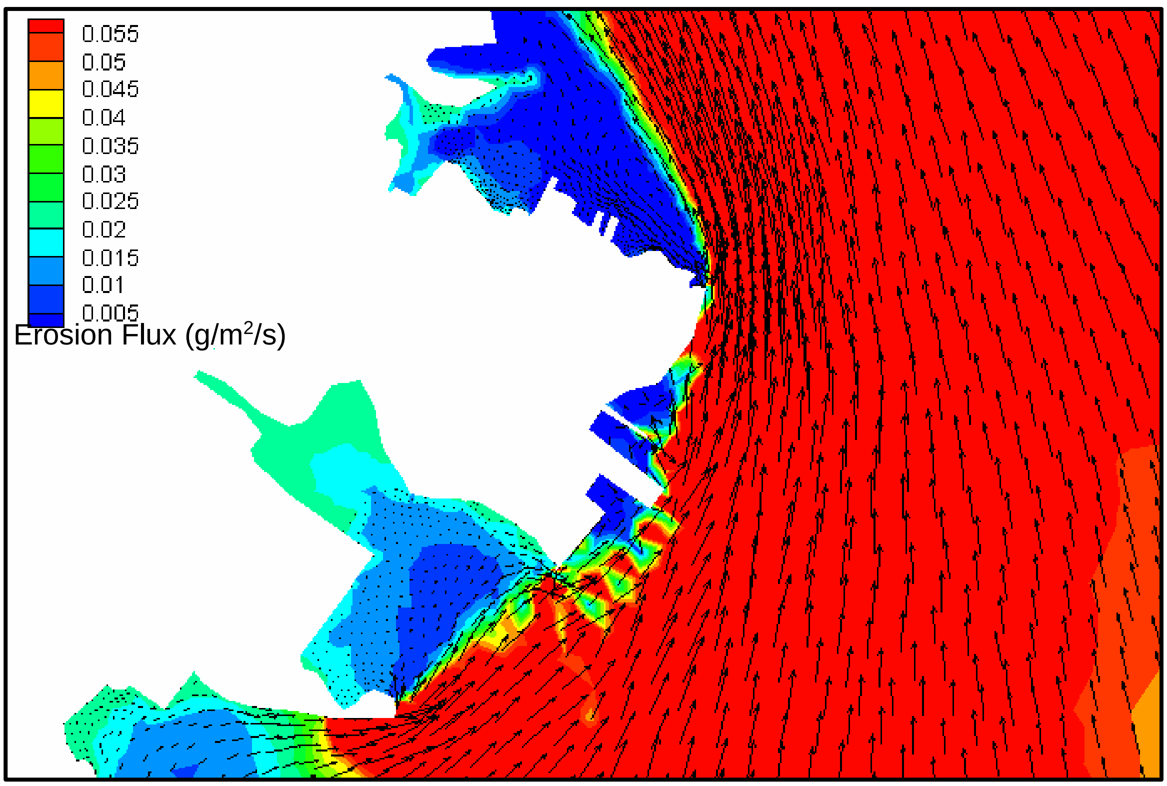

Figure 5-6: Extreme Erosion Flux From Waves And Currents

(Source: Woods Hole and Battelle, 2004)

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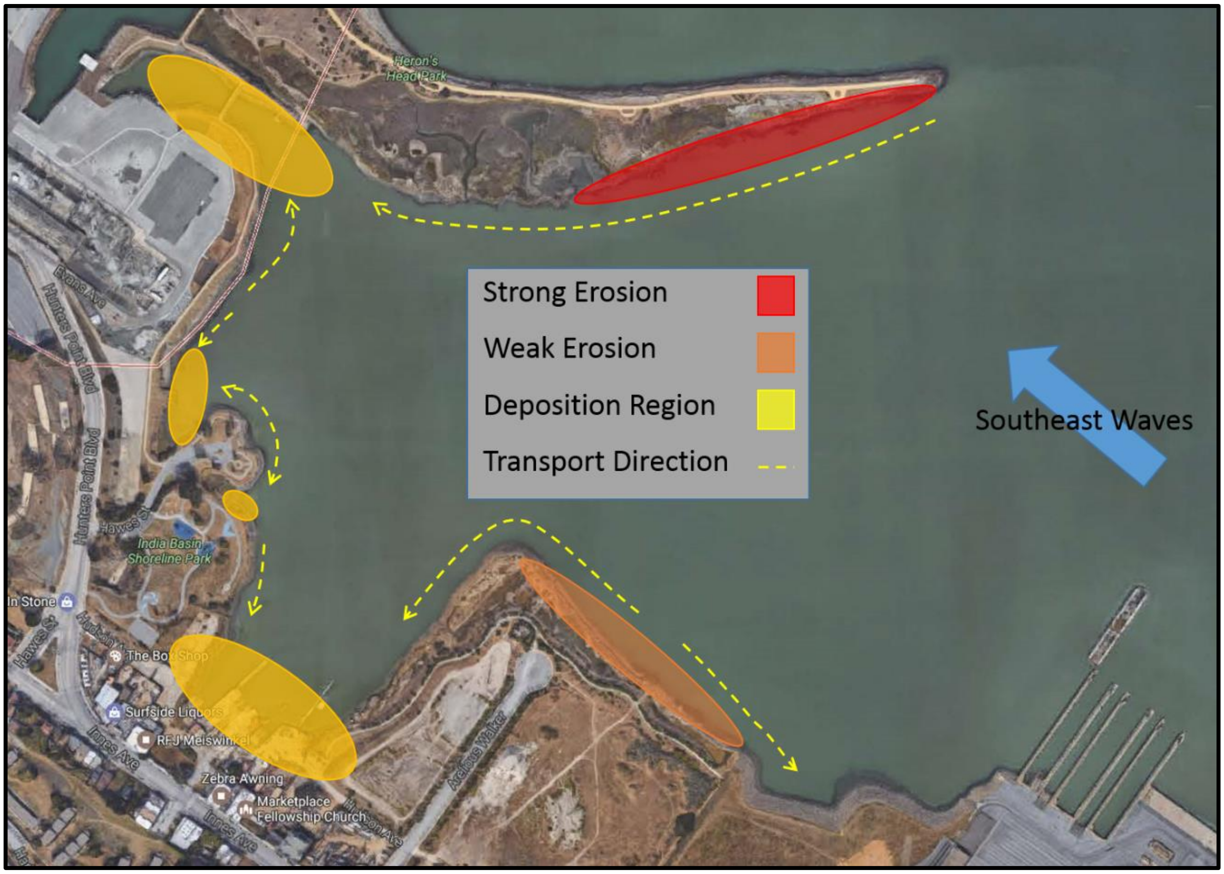

Figure 5-7: Summary of Sediment Transport Patterns, India Basin

6. PROPOSED SHORELINE IMPROVEMENTS

6.1 Project Goals for Shoreline Area

Overall goals for uses along the project shoreline include the following:

- Provide public access to the shoreline areas including trails, a range of upland pathways, boardwalks, and ramps, stairs, and terraces from the upland to the shoreline. It also may include beaches for people and dogs, water access, and human powered boat launches, drop-off/pick-up area, and spaces for sightseeing, fishing, kayak launching.
- Create a publicly accessible human powered boat launch and beach/sandy area.
- Create new tidal marsh where feasible.
- Mitigate for impacts created by the shoreline design on-site to the greatest extent possible before mitigating off-site.
- Create demonstration living shoreline projects where feasible.
- Develop a robust adaptation plan for the shoreline areas to address Sea Level Rise in the short and long-term.

6.2 Shoreline Morphology and Potential Opportunities

Potential shoreline uses are typically a function of existing shoreline morphology (elevation, slope), wave exposure, and desired uses. Potential opportunities for a variety of shoreline uses that could be implemented along the study area, given the above goals and the prevailing coastal processes described in the previous section, are described in Table 6-1 below.

Table 6-1: Shoreline Type and Potential Opportunities

Shoreline Morphology	Potential Uses/Constraints
Steep Frontal Slopes with High Wave Exposure	• Requires shoreline protection such as engineered revetments, seawalls, or breakwaters • Recreational features have to be set back from the shoreline, and can include trails, boardwalks, perched beaches
Shallow Frontal Slopes/Depths with Moderate Wave Exposure	• Potential exists for living shoreline elements such as marshes protected by bioengineered breakwater, sand dunes, or vegetated slopes • Potential exists for water-oriented recreation like beaches or kayak access • Larger boat access possible with docks extending to adequate depths
Depositional Areas with Low to Moderate Wave Exposure	• Potential exists for living shoreline elements such as marshes, mudflats, or vegetated slopes

A discussion about each of the potential shoreline uses is provided below; locations within the project area where these uses are possible to implement are also referenced:

Recreational Beaches (see Figure 6-1)

Beaches can provide many different types of recreational uses and also serve as a flood protection mechanism. The stability and long-term performance of a beach is dependent on the wave environment and wave driven sediment transport along the shoreline. Sea level rise will also impact the long-term use of the beach.

Beaches can function in a variety of wave environments. Typically, desirable areas will have prevailing wave conditions that prevent fine sediments such as muds from settling but design events that are low enough to prevent severe beach erosion. Wave driven sediment transport plays a significant role in the function of a beach over time. Typically, desirable conditions are areas where wave driven sediment transport is near net zero over long stretches of the shoreline.

Sea level rise over time will cause recession of the beach and movement of sediment offshore. This is can be an important consideration when selecting potential locations for a beach as the movement of this material has the potential to impact other features.

Recreational Boating (Figure 6-2)

Human powered boat access, such as kayak, canoe or standup paddle boarding, are dependent on depths, wave conditions, and sediment transport while sea level rise will impact access over time. For the types of boat being considered water depths of at least 2-3 feet are desirable. Wave conditions should be typically low to minimum as launching activities require sedimentation rates to be low to minimize the need for dredging. Access structures, if needed, need to consider direction of wave driven and tidally driven sediment transport as they have the potential to block transport which can effect access as well as the stability of adjacent shorelines.

Marshes and Living Shorelines (Figure 6-3)

Marshes require specific elevations, typically around high tide, a low wave environment and deposition of fine sediments, which will allow the marsh to accrete over time in response to sea level rise. Areas where wave-driven and tidally driven sediment transport patterns converge from other portions of the shoreline are ideal. If sediments are not available for sedimentation, then marsh areas should have space to retreat in response to sea level rise.

Living shorelines are sometimes discussed within the broader topic of shoreline protection, and can be designed as individual improvements or designed together as a system of improvements (e.g. oyster beds, tidepools, bioengineered breakwaters, etc) that can provide protection to marsh areas from wave action. Factors influencing the sustainability of living edges include substrate, water depths, water temperature, and turbidity.

Engineered Shorelines (Figure 6-4)

Greater exposure to wave action drives the need for hardened shorelines. Hardened shorelines are largely unaffected by sediment transport unless they project out perpendicular to the shoreline which then creates an impediment to wave driven transport. Sea level rise generally has minor impacts to steep, hardened shorelines, though consideration should be taken in the ability to extend, vertically, the protection provided by the hardened shoreline as sea level rises.

Hardened shorelines, such as rock revetments or bulkheads, serve to stabilize a shoreline from erosion or retain filled areas. While many different types of materials can be used depending on shoreline slopes, wave conditions and topography generally drive the selection of type and materials.

6.3 Proposed Shoreline Uses – India Basin Open Space

Figure 6-3 and Figure 6-4 depict several cross-sections along IBOS/700 Innes shoreline, showing the difference between the proposed and the existing grading. The locations of these cross-sections are demonstrated in Figure 6-5 and Figure 6-6.

6.3.1 Tidal Wetlands

The site currently includes 2.5 acres of constructed mitigation wetlands (2.1 acres of new wetlands and 0.4 acres of enhanced wetlands) that were created in 2002 in response to a 1999 order from the RWQCB associated with an expansion project at the San Francisco International Airport. Monitoring found that after 10 years, only 2 of the 4 wetland zones were meeting the target criterion of 80% salt marsh cover. The performance of the wetlands may be limited by existing elevations, wave energy, soil quality, continued and increased inundation, etc.

At a minimum, the previously constructed mitigation wetlands need to be retained since any negative impacts or alterations to the existing wetlands will require mitigation. However, the kayak launch and spur trail will result in some fill and minor impacts to the existing wetlands, which will require mitigation. Although the site has limited space for creating new tidal marsh areas, a portion of the shoreline to the northwest in the “cove” is at higher elevations, is not currently tidal marsh, and/or is a concrete pier.

Tidal marsh will be created in the cove by removing existing rubble, remove the existing concrete pier, cutting into the bank, and adapting elevations for proper tidal marsh elevations.

6.3.2 Seasonal Wetlands

The 700 Innes project currently has 0.31 acres of upland seasonal wetlands that need to be replaced. It is preferred that the seasonal wetlands are replaced and mitigated for on-site where feasible. The proposed seasonal wetlands will be created close to the top of existing bank along the 700 Innes parcel, and fed by storm runoff from the development project. Section D-D’ and E-E’ in Figure 6-7 and Figure 6-8 show the grading and elevations of proposed seasonal wetlands.

The seasonal wetlands are intended to serve as mitigation until such time that the fronting tidal marsh is inundated by SLR; when sea levels are higher, the seasonal wetlands will inundated periodically eventually functioning as tidal marshes.

6.3.3 Sandy Beach

Section B-B’ in Figure 6-7 is across the proposed sandy beach and the beach deck on the south of the Reach 700-R1. The hazard elevation at current sea levels is 12 feet NAVD 88 for this area. The proposed sandy beach would be located above 13 feet NAVD88. Therefore, it would not be subject to inundation at least until 2050 (most likely SLR scenario of 1 foot). For higher SLR, the beach would be temporarily inundated during storms. By 2100, the sandy beach would be completely inundated unless adaptations are implemented to either relocate the beach to higher elevations or the substrate is amended so it could function as a marsh.

6.3.4 Kayak Launch

The proposed kayak launch would result in minor fill and could function up to about mid-century levels of SLR, after which time it could be relocated to higher elevations.

6.3.5 Boardwalk and Spur Trails

Figure 6-5 shows the proposed pathways for the IBOS/700 Innes property in the form of boardwalks, spur trails, and stairways as part of the Blue Greenway/Bay Trail. If the boardwalk is located along the top of bank, it would be outside of the flood hazard area until at least mid-century. Some portions would be temporarily inundated at higher levels of SLR, but adaptations such as raising it in place would be relatively simple to construct. The spur trails will be higher to avoid flooding, since their proposed locations are within the 1% annual flood hazard area for current sea levels.

6.3.6 Living Shoreline Demonstration Elements

San Francisco Bay is in the piloting stage of living shoreline projects, and the presence of the India Basin Stewardship Trust allows for monitoring, maintenance, and research of a variety of landscape systems that comprise living shorelines. It also offers opportunities for education, permitting advancement, habitat creation, and marketing.

Existing tidal wetlands along the IBOS shoreline will likely be lost due to SLR. Given the shallow tidal flats fronting the shoreline and moderate wave exposure, it provides an opportunity to create a bioengineered shoreline protection edge by replacing the riprap/concrete protection at mid-tide with materials that have been tested at various other locations. Examples from other regions such as native oyster reefs, oyster balls, or oyster bags will be researched and tested at this site.

Eel grass has been found in the past to exist within the India Basin project area. This will be tested again offshore of the IBOS shoreline.

In addition, the potential for vegetated reaches of shoreline as well as floating wetlands will be tested.

6.4 Proposed Shoreline Uses – 900 Innes Avenue

On the 900 Innes property, the proposed boatyard would feature areas of shoreline planting, a small water feature, areas for seating and picnic tables, a small gravel beach, and restored artifacts from the boatyard like the marineway rails. Wherever possible, much of the existing concrete surface would remain in place at the boatyard, and selective demolition of areas of concrete would be implemented.

900 Innes has the lowest 1% annual flood hazard elevation (10 feet NAVD88) within the project site, and the proposed design will significantly improve its response to sea level rise. A comparison between inundation maps for existing and proposed condition (Figure 4-24 and Figure 4-30) indicates that the proposed design will significantly improve flood hazard control by the mid- and end of the century.

The bay trail and public access must be elevated above 12 feet NAVD88 to ensure functionality by the mid-century, considering 2 feet of sea level rise (maximum projected SLR). By the end of the century the most likely flood elevation will be 13 feet NAVD88 while the maximum projected SLR is 15.5 feet NAVD88.

6.5 Proposed Shoreline Uses – India Basin Shoreline Park

Most of the current shoreline, composed of riprap and vegetated berm, would be removed and replaced and restored as 0.9 acres of improved tidal marsh wetlands. Potential project elements for this property include improved and upgraded playground and recreational facilities; restrooms; additional trees; improved lawn areas; a promenade; event areas; a water feature; barbeque pits; drinking fountains; a pier and dock with human-powered boat launch ramp, art installations, fishing areas, and lighting; restrooms; and an exercise or cross-training course. The existing surface parking, vehicular access, and drop-off and loading zones also may be improved. In addition, 0.83 acre of tidal marsh and wetlands would be created along the shoreline.

Similar to the IBOS shoreline, this sgment is located in an area which has a dynamic current-wave field, and a gravel beach would function effectively. The wave-current field is dynamic enough to keep fine sediment in suspension and prevent deposition on the beach. Gravel beaches are different from sandy beach in terms of their response to sea level rise; they can act as a dynamic revetment, and would not erode like sandy beaches normally do.

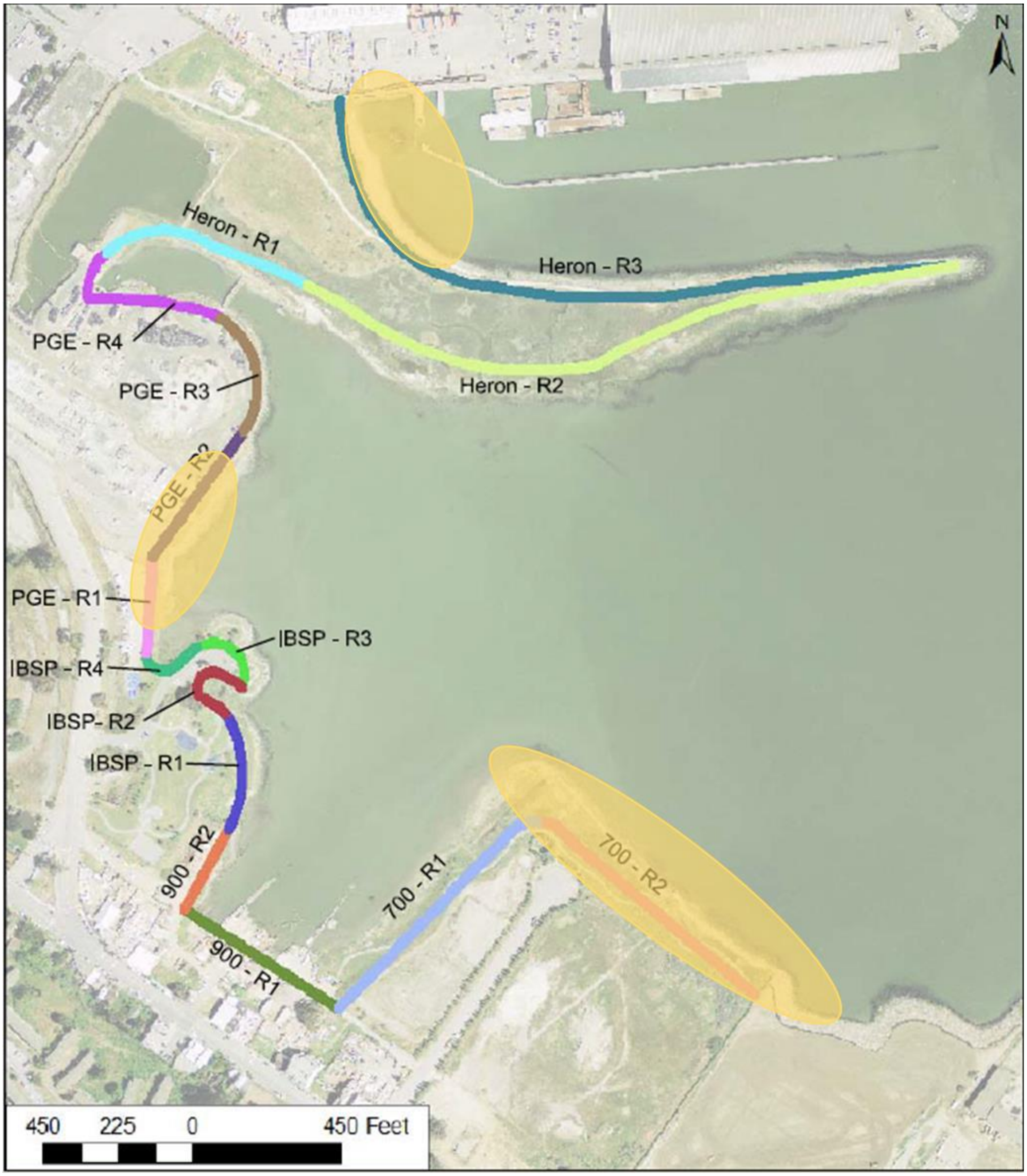

Figure 6-1: Potential Locations For Beaches

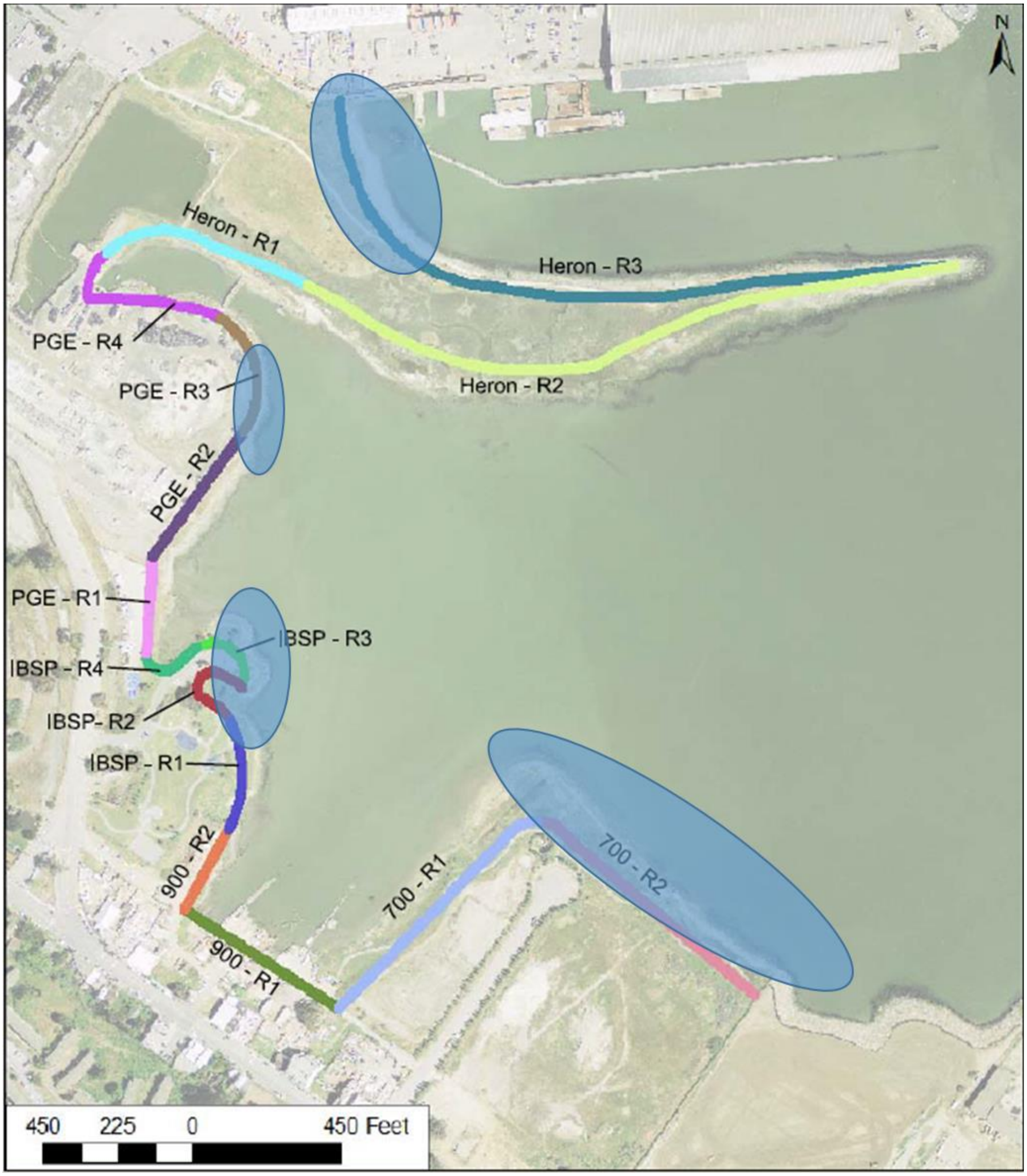

Figure 6-2: Potential Locations for Human Powered Boat Access

Figure 6-3: Potential Locations For Soft Edge Treatment or Marshes

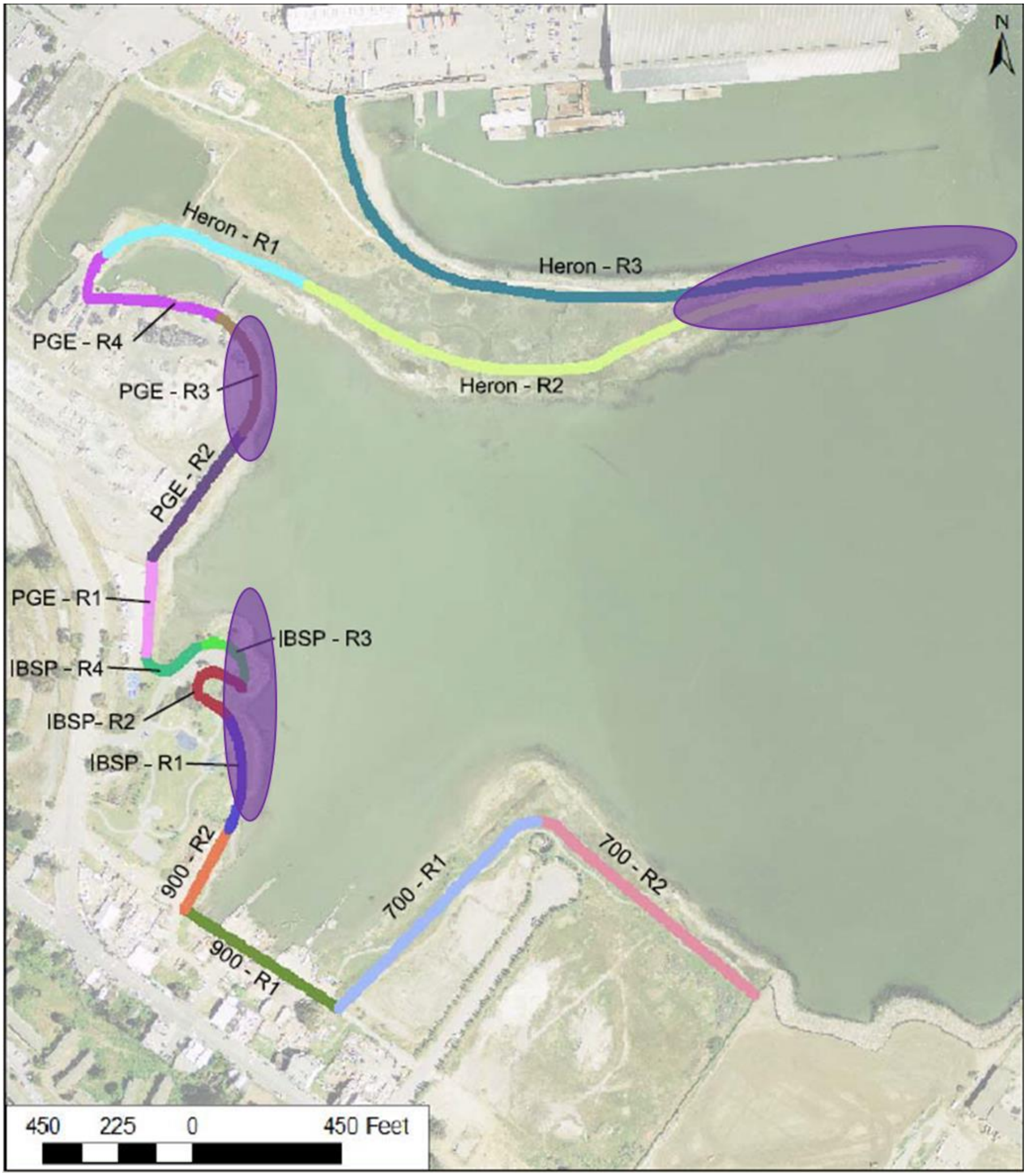

Figure 6-4: Potential Locations For Engineered Shoreline Protection

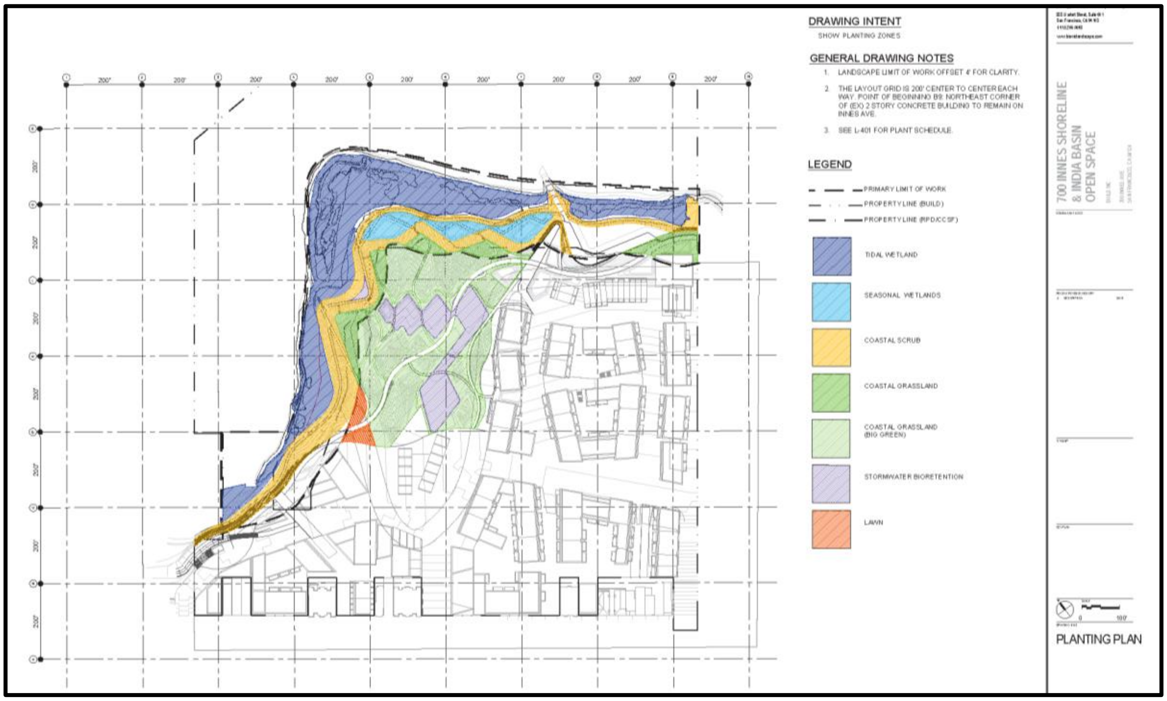

Figure 6-5: Proposed shoreline improvement for IBOS/700 Innes.

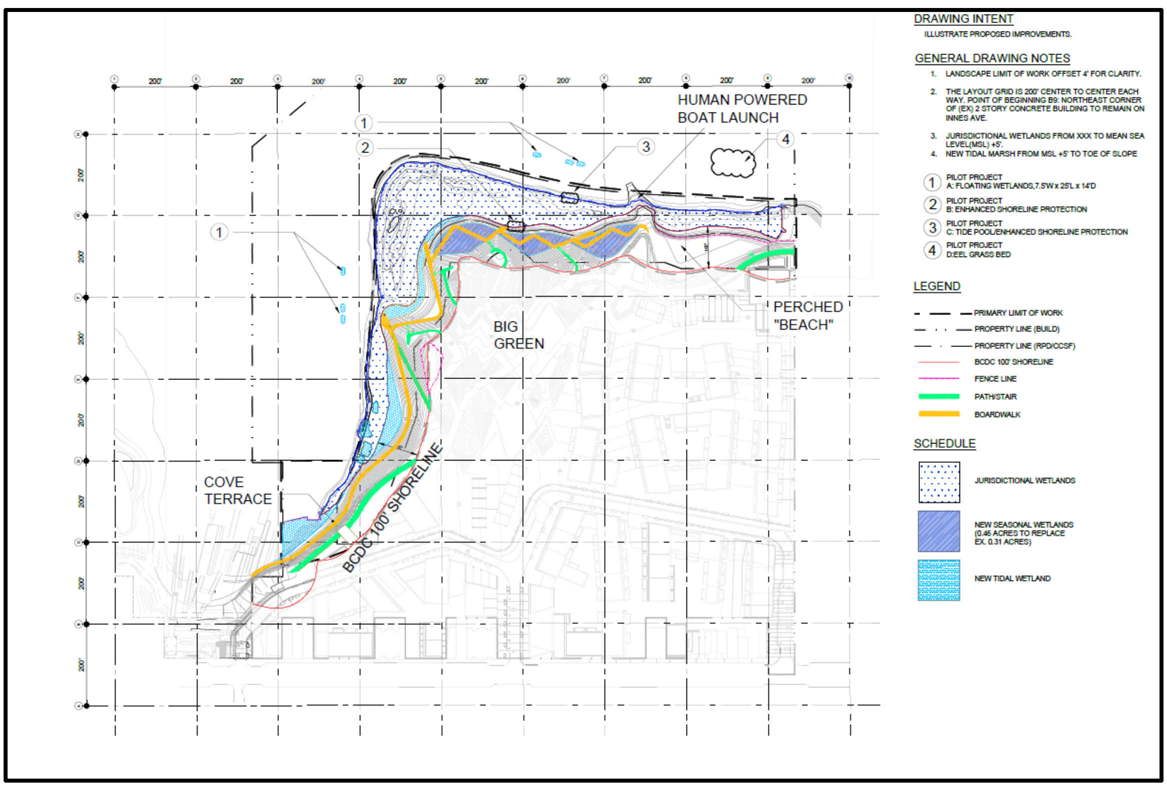

Figure 6-6: Proposed shoreline improvements for IBOS/700 Innes.

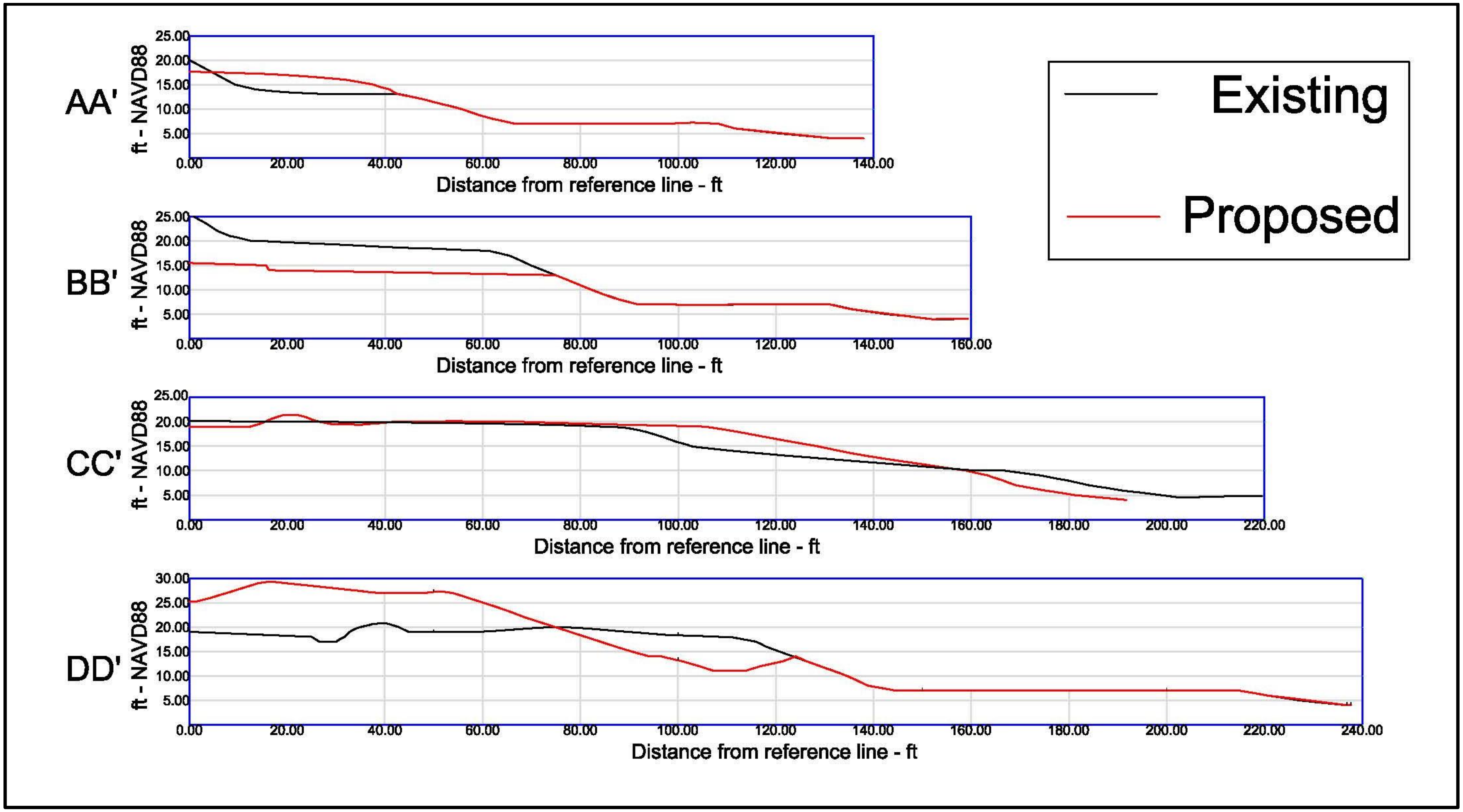

Figure 6-7: Cross-Sections along IBOS Northeast Shoreline (see Figure 6-9 for location of cuts)

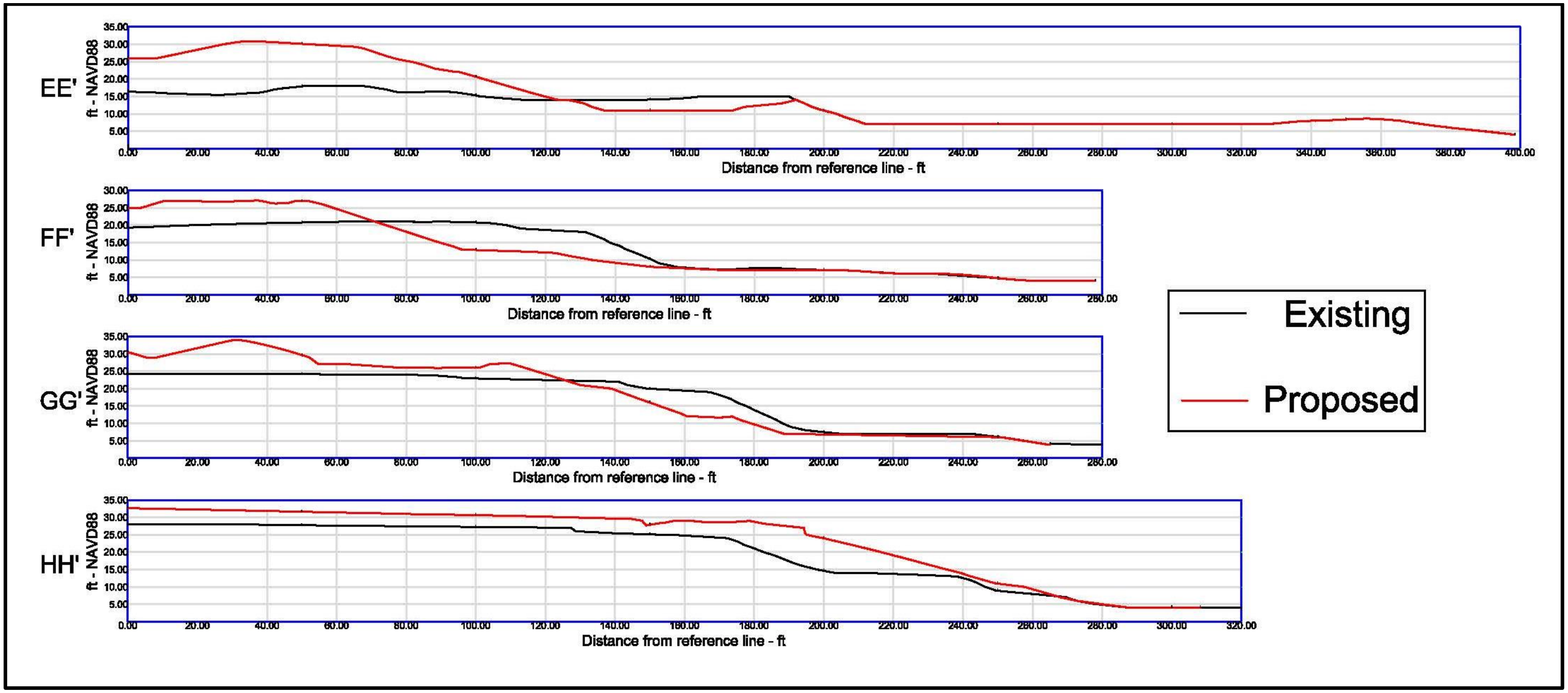

Figure 6-8: Cross-Sections along IBOS Northwest Shoreline (see Figure 6-9 for location of cuts)

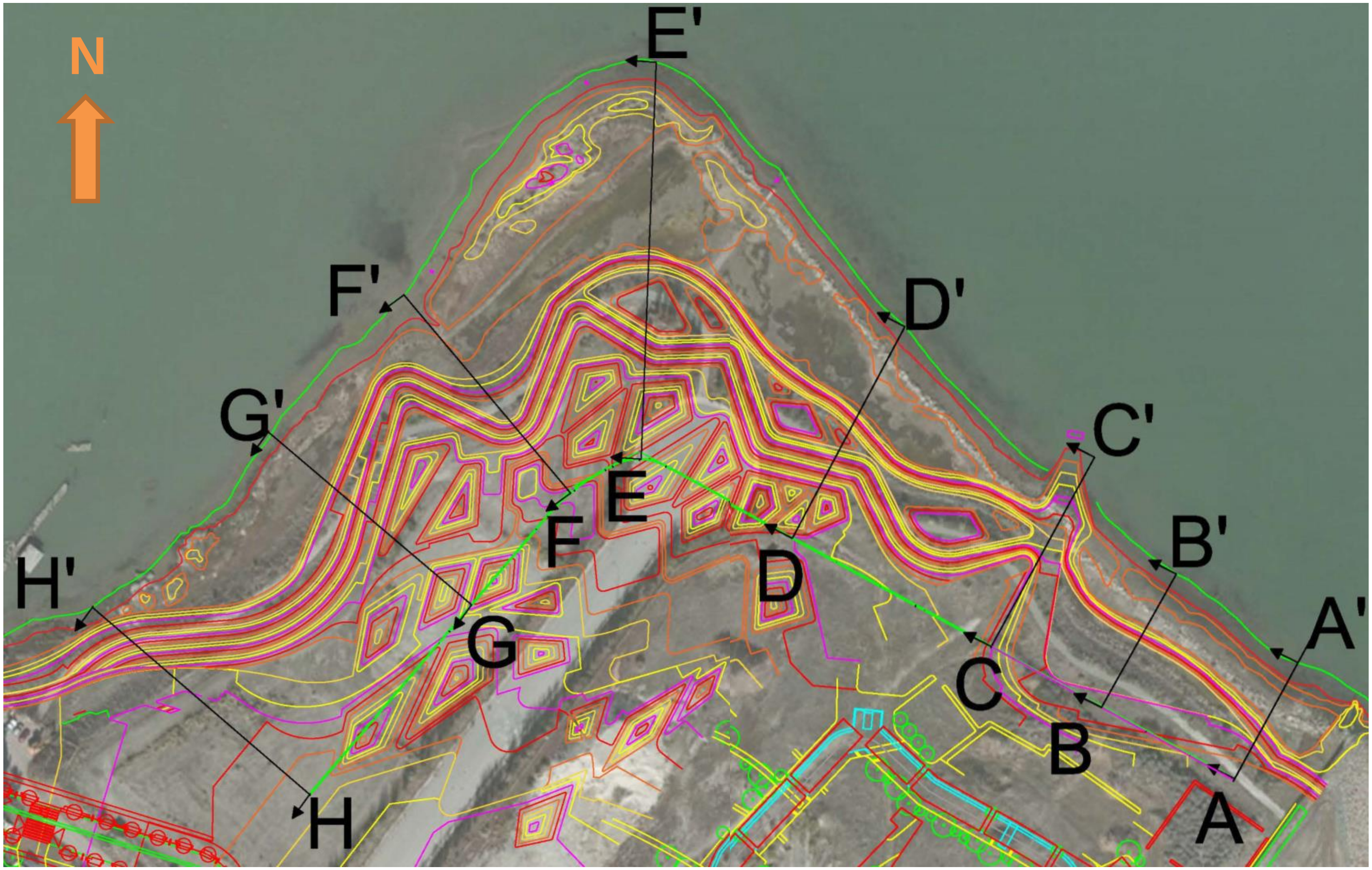

Figure 6-9: Location of Cross-Sections along IBOS Shoreline

7. CONSTRUCTION ACTIVITIES

See attached tables…

7.1 Permitting

Provided below are a list of the agencies which will require permits for the shoreline improvements and their respective jurisdictional boundaries:

- *U S Army Corps of Engineers Individual Permit* (under Section 10 of the Rivers and Harbors Act and Section 404 of Clean Water Act)

  Jurisdiction: Below High Tide Line (Sec 404) and Below MHW (Section 10)

- *BCDC Major Permit* (under McAteer Petris Act)

  Bay Jurisdiction: Below Mean High Water (if no wetlands) ; Up to MSL + 5-ft (if wetlands present)

  Shoreline Band Jurisdiction: Up to 100 feet inland of Bay Jurisdiction

- *SFRWQCB Water Quality Certification* (under Section 401 of the Clean Water Act)

  Jurisdiction: Below Mean High Water

In addition, the Corps of Engineers will consult several resource agencies (Fish & Wildlife Service, Fish & Game, and NOAA Fisheries) prior to issuing a permit.

Provided in Table 7-1 are permit related quantities: At this time the shoreline improvements on the India Basin Open Space/700 Innes Avenue property have been developed in sufficient detail to approximate impact to the various jurisdictional waters. As such, only the permit quantities related to the improvements within the India Basin Open Space/700 Innes Avenue are presented in the table below. Typical sections for the proposed improvements are provided in .

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APPENDIX A:

VISUAL RECONNAISSANCE SURVEY

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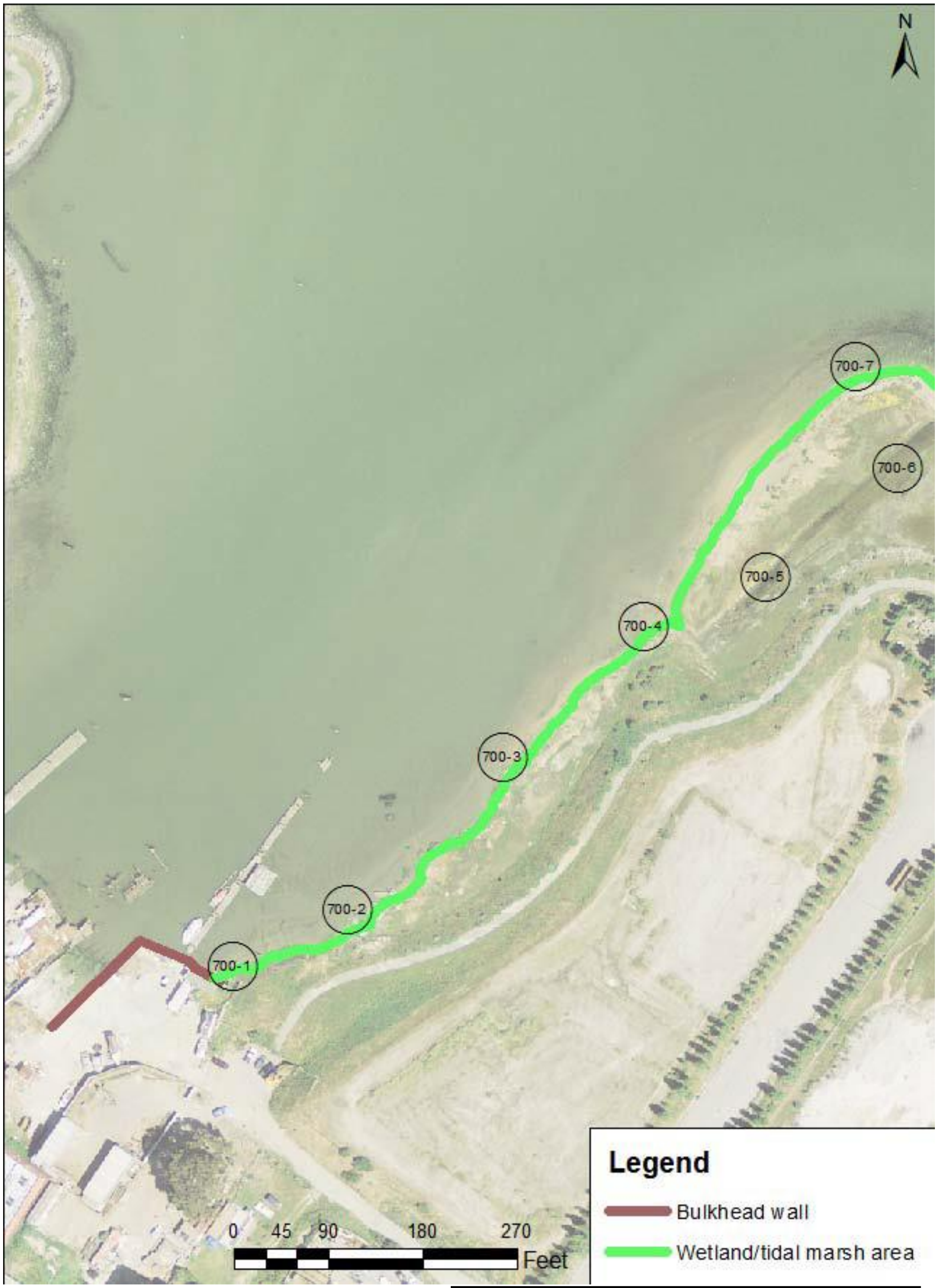

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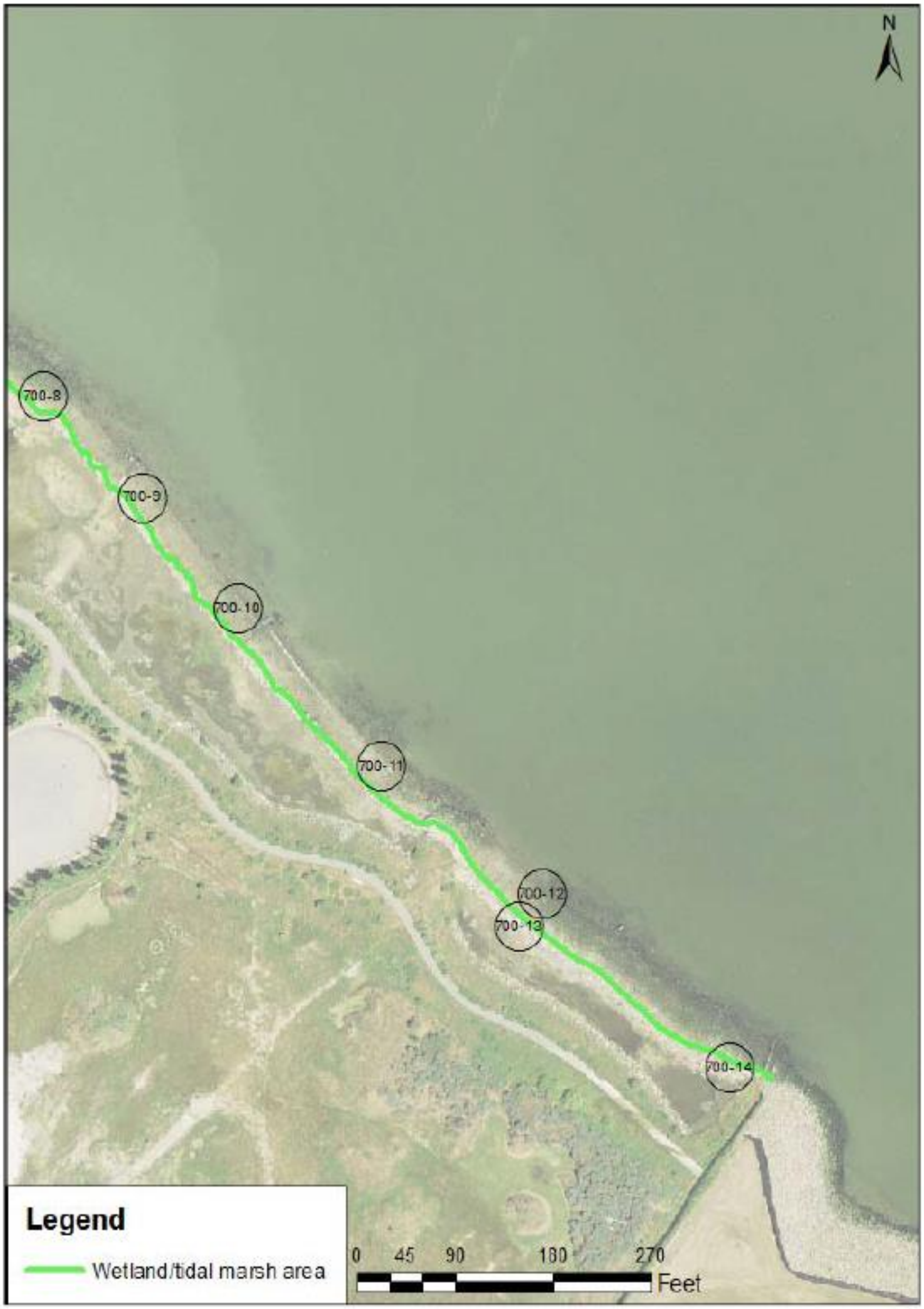

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India Basin Coastal Processes Study – Appendix A

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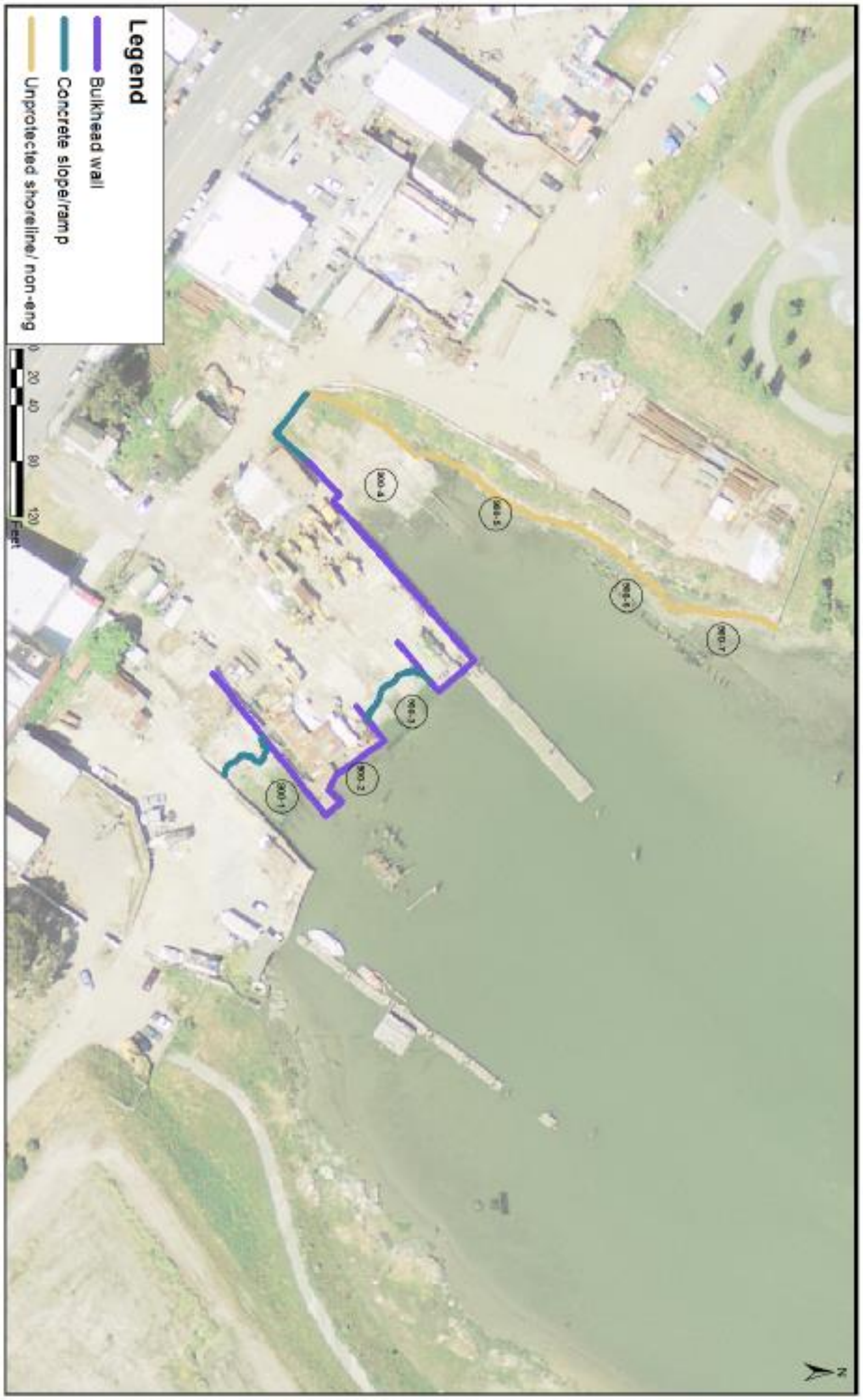

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India Basin Coastal Processes Study – Appendix A

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India Basin Coastal Processes Study – Appendix A

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ISBP-3

ISBP-4

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ISBP-5

ISBP-6

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ISBP-7

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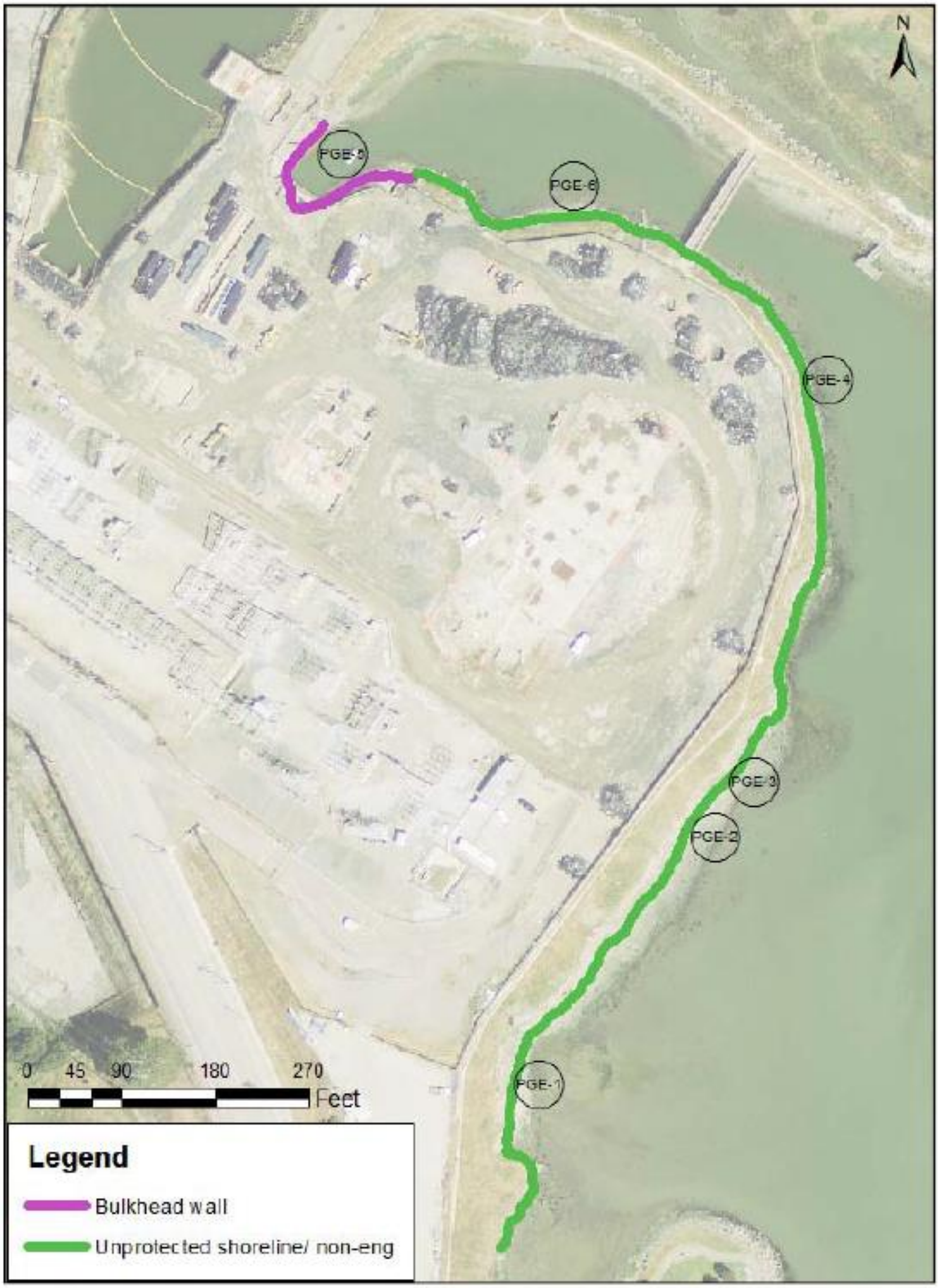

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India Basin Coastal Processes Study – Appendix A

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PGE-2

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PGE-5

PGE-6

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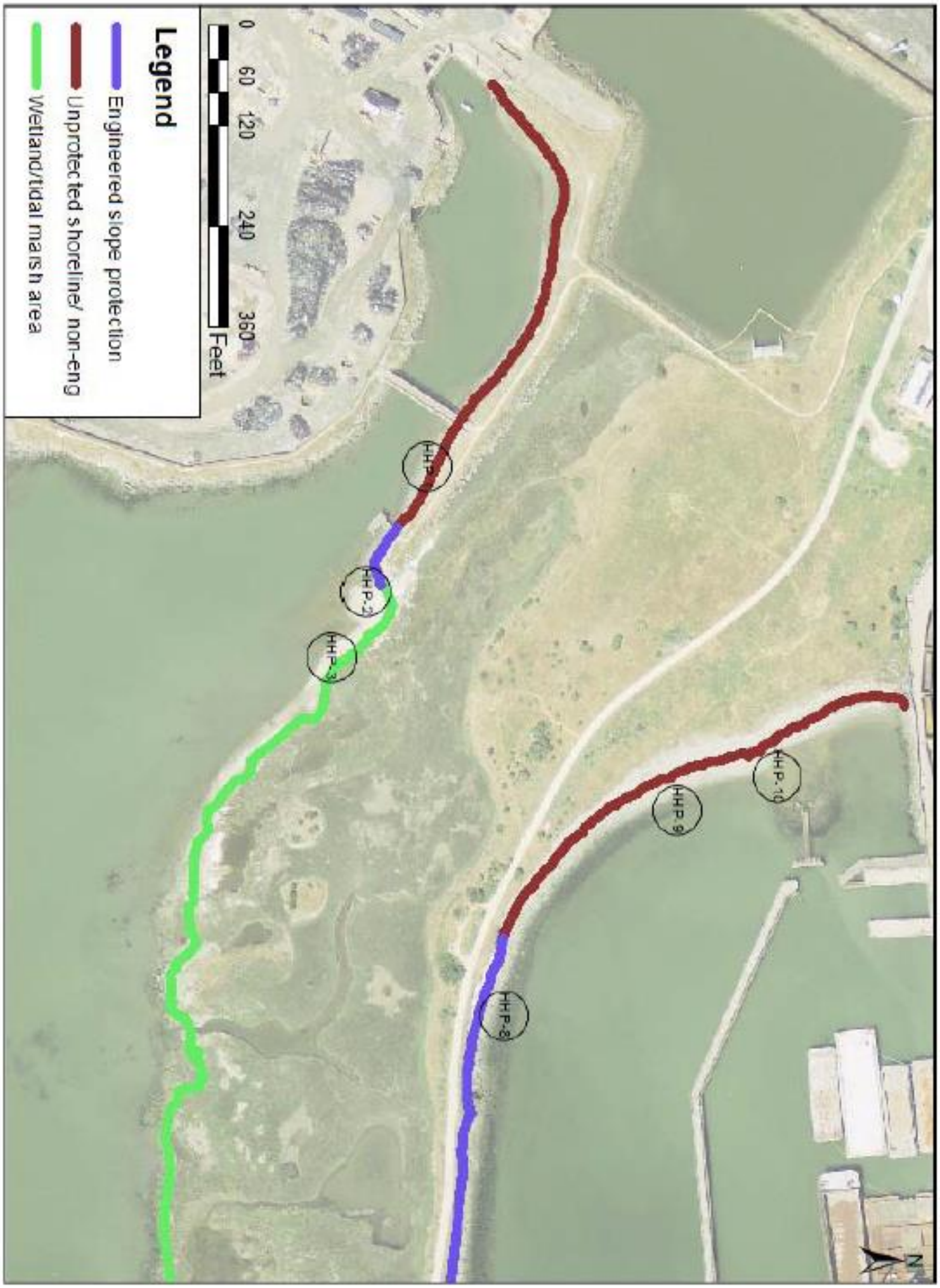

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India Basin Coastal Processes Study – Appendix A

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HHP-1

HHP-2

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HHP-3

HHP-8

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HHP-9

HHP-10

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India Basin Coastal Processes Study – Appendix A

DRAFT

HHP-7

HHP-4

moffatt & nichol

DRAFT

HHP-5

HHP-6

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APPENDIX B:

Detailed Wave Characteristics for All Reaches

India Basin Open Space/700 Innes

Return Period	700 - R1		700 - R2	
	Significant Wave height (feet)	Peak Wave Period (sec)	Significant Wave height (feet)	Peak Wave Period (sec)
North				
2	1.3	3.6	0.5	3.6
5	1.7	4.0	0.7	4.0
10	2.0	4.3	0.8	4.3
25	2.4	4.6	0.9	4.6
50	2.6	4.8	1.0	4.8
Northeast				
2	0.7	2.4	0.3	1.9
5	1.3	2.9	0.6	2.9
10	1.8	3.1	0.8	3.1
25	2.3	3.5	1.0	3.4
50	2.6	3.6	1.1	3.6
East				
2	0.5	2.0	0.3	1.9
5	1.0	2.7	0.5	2.6
10	1.5	3.2	0.7	3.2
25	2.1	3.6	0.9	3.6
50	2.5	4.0	1.1	4.0
Southeast				
2	1.3	4.0	0.2	4.1
5	1.9	4.5	0.2	4.6
10	2.2	4.7	0.3	4.8
25	2.5	5.1	0.3	5.1
50	2.7	5.2	0.3	5.3

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Significant Wave Heights and Peak Wave Period India Basin 900 Innes

Return Period	900 - R1		900 - R2	
	Significant Wave height (feet)	Peak Wave Period (sec)	Significant Wave height (feet)	Peak Wave Period (sec)
North				
2	0.4	3.6	0.3	3.6
5	0.5	4.0	0.4	4.0
10	0.5	4.3	0.4	4.3
25	0.6	4.5	0.5	4.6
50	0.7	4.8	0.5	4.8
Northeast				
2	0.3	1.8	0.2	1.8
5	0.5	2.9	0.5	2.9
10	0.7	3.0	0.6	3.0
25	0.9	3.3	0.9	3.3
50	1.0	3.6	0.9	3.6
East				
2	0.1	1.8	0.2	1.8
5	0.4	2.6	0.4	2.6
10	0.6	3.1	0.6	3.1
25	0.8	3.6	0.8	3.6
50	1.0	4.0	0.9	4.0
Southeast				
2	0.4	4.1	0.4	4.1
5	0.6	4.6	0.6	4.6
10	0.7	4.8	0.7	4.8
25	0.8	5.1	0.8	5.1
50	0.9	5.3	0.8	5.3

DRAFT

Significant Wave Heights and Peak Wave Period India Basin Shoreline Park

Return Period	IBSP - R1		IBSP - R2		IBSP - R3		IBSP - R4	
	Significant Wave height (feet)	Peak Wave Period (sec)	Significant Wave height (feet)	Peak Wave Period (sec)	Significant Wave height (feet)	Peak Wave Period (sec)	Significant Wave height (feet)	Peak Wave Period (sec)
North								
2	0.4	2.3	0.5	2.4	0.5	2.2	0.3	2.8
5	0.6	3.0	0.6	3.0	0.6	3.1	0.3	4.1
10	0.7	3.6	0.7	4.4	0.7	4.4	0.4	4.4
25	0.8	4.7	0.9	4.7	0.9	4.7	0.4	4.7
50	0.9	4.8	1.0	4.9	0.9	4.8	0.5	4.8
Northeast								
2	0.4	1.8	0.4	1.8	0.4	1.8	0.2	1.8
5	0.9	2.9	1.0	2.9	1.1	2.9	0.5	2.9
10	1.1	3.0	1.2	3.0	1.3	3.0	0.6	3.1
25	1.5	3.3	1.6	3.3	1.6	3.3	0.8	3.4
50	1.7	3.6	1.7	3.6	1.7	3.6	0.8	3.6
East								
2	0.4	1.9	0.5	2.0	0.6	2.0	0.3	2.0
5	0.8	2.7	0.9	2.7	1.0	2.7	0.5	2.8
10	1.2	3.1	1.3	3.2	1.5	3.2	0.8	3.3
25	1.7	3.6	1.8	3.6	2.1	3.7	1.0	3.7
50	2.0	4.0	2.2	4.0	2.5	4.0	1.1	4.0
Southeast								
2	1.0	4.1	1.2	4.0	1.4	4.0	0.8	4.0
5	1.4	4.6	1.6	4.5	1.9	4.5	1.0	4.5
10	1.7	4.8	1.9	4.8	2.2	4.7	1.1	4.8
25	1.9	5.1	2.2	5.1	2.5	5.1	1.2	5.1
50	2.1	5.3	2.3	5.2	2.7	5.2	1.2	5.2

Memo

MAGNUSSON KLEMENCIC ASSOCIATES

Structural + Civil Engineers

1301 Fifth Avenue, Suite 3200 Seattle Washington 98101-2699 T: 206 292 1200 F: 206 292 1201 W: www.mka.com

TO	Ashley Ludwig - GGN	**DATE**	8/19/2016
FROM	Drew Gangnes	**PAGE**	**1 OF 4**
PROJECT	**India Basin Park**	**PROJECT #**	A2960.50
SUBJECT	Concept Design Technical Memorandum		

Introduction

Magnusson Klemencic Associates (MKA) has been assisting Gustafson Guthrie Nichol (GGN) with civil engineering planning level input to their concept design for India Basin Park. MKA's conceptual engineering focus has been on water resource strategies and grading and earthwork analyses. This Technical Memorandum summarizes MKA's input to the conceptual design.

The conceptual design effort for India Basin Park covers two adjacent properties: the existing India Basin Shoreline Park (IBSP) and the 900 Innes site, see Figure 1. While the conceptual design is a holistic, new India Basin Park covering both of these two properties, information in this memo is organized by property to aid environmental permitting processes.

Existing Conditions

This section describes the existing water resources situation at each property.

<u>IBSP</u>

IBSP is an operating city park.

Domestic Water

There is domestic water service on site serving irrigation controllers. There does not appear to be any other existing water demands on the site. A map of the City water system is shown in Figure 2.

Sanitary Sewer

There are no sanitary sewer demands on the site. Existing restroom service is via portable toilets. A map of the city wastewater collection system is shown in Figure 3.

Storm Drainage

The property is in the City's Separate Sewer Area, see Figure 4.

Figure 5 indicates the existing storm drainage situation at the site. There is one storm drain inlet within the turnaround that is conveyed to an outfall. Some portions of the site overland flow to this inlet while the remainder of the site sheet flows to the shoreline. A combined sewer overflow pipe runs under Hudson Avenue under the IBSP site but no area of the site is connected to it.

900 Innes

900 Innes is a former boat maintenance and repair facility that is currently out of use and fenced off from public access.

Domestic Water

There are no current water demands on the site. However, it is presumed the Shipwrights Cottage (and potentially other buildings) utilized municipal water when they were in service. A map of the City water system is shown in Figure 2.

Sanitary Sewer

There are no current sanitary sewer demands on the site. However, it is presumed the Shipwrights Cottage (and potentially other buildings) may have utilized municipal sewer service when they were in service. A city wastewater line runs through a portion of the 900 Innes site which seems to be in a location that could have allowed for gravity collection of the Shipwrights Cottage and some of the other onsite buildings, see Figure 3.

Storm Drainage

Figure 5 indicates the existing storm drainage situation at the site. The combined sewer overflow pipe in Hudson Avenue outfalls within the 900 Innes property but none of the property is connected to the pipe. The entire site sheet flows to the shoreline.

While this property is not currently mapped in the City's GIS system as part of the Separated Sewer Area, we have learned from SFPUC that this is because it has no inlet/outlet infrastructure (only sheet flows to the shoreline), see Figure 4.

Proposed Concepts

This section describes the proposed water resources and earthwork concepts for the new park by property.

IBSP

Domestic Water

MKA provided estimated project water demands by property in a memo dated July 12, 2016. This memo is attached in Appendix A.

Sanitary Sewer

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The sanitary sewer demands from the park can be inferred from the Water Demand Memo in Appendix A. All water demands aside from Irrigation, Water Feature Top-off and Drinking Fountains will become sanitary sewer flows. Another infrequent sanitary sewer demand will be twice yearly draining of the water feature for routine maintenance, this will entail draining down 3,330 cubic feet of water.

Storm Drainage

The proposed storm drainage for the project is shown in Figure 6. Storm drainage will be managed per the SFPUC storm drainage code. Swale, bioretention or constructed wetland Best Management Practices (or a combination of these) will be used to manage runoff from new impervious surfaces. The concept design breaks down topographically into two basins within the IBSP property. Figure 6 shows a concept for utilizing constructed wetlands to manage the runoff in each sub-basin. The northern sub-basin will utilize the existing outfall near the turnaround and the southern sub-basin will require a new outfall.

Recycle Water

The project plans to create recycled water for park irrigation and potentially toilet flushing by mining wastewater from the combined sewer pipeline in Hunters Point Blvd and treating it in an onsite wastewater treatment system, see Figure 7.

Earthwork

The anticipated earthwork for the project is indicated in Figure 8.

<u>900 Innes</u>

Domestic Water

MKA provided estimated project water demands by property in a memo dated July 12, 2016. This memo is attached in Appendix A.

Sanitary Sewer

The sanitary sewer demands from the park can be inferred from the Water Demand Memo in Appendix A. All water demands aside from Irrigation, Water Feature Top-off and Drinking Fountains will become sanitary sewer flows. Another infrequent sanitary sewer demand will be twice yearly draining of the water feature for routine maintenance, this will entail draining down 1,770 cubic feet of water.

Storm Drainage

The proposed storm drainage for the project is shown in Figure 6. Storm drainage will be managed per the SFPUC storm drainage code. Swale, bioretention or constructed wetland Best Management Practices (or a combination of these) will be used to manage runoff from new impervious surfaces. The concept design breaks down

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topographically into a single basin within the 900 Innes property. Figure 6 shows a concept for utilizing a constructed wetland to manage the runoff for the property. This property will utilize a new outfall that will be jointly used by 900 Innes and the abutting Build Inc development.

Recycle Water

The project plans to create recycled water for park irrigation and potentially toilet flushing by mining wastewater from the combined sewer pipeline in Hunters Point Blvd and treating it in an onsite wastewater treatment system on the IBSP property, see Figure 7. Recycled water will be piped from that property for use at the 900 Innes property.

Earthwork

The anticipated earthwork for the project is indicated in Figure 8.

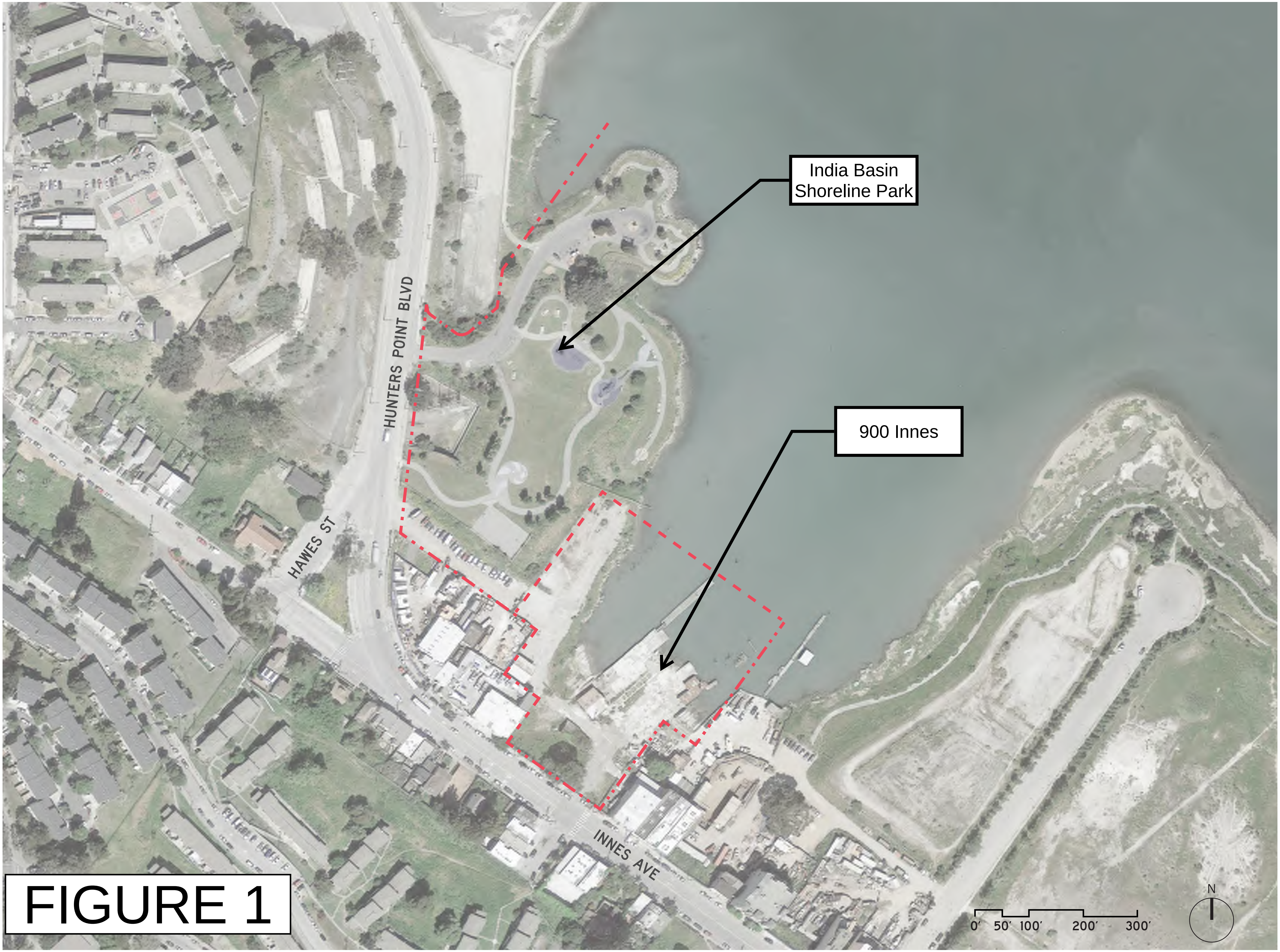

India Basin Shoreline Park
900 Innes
HUNTERS POINT BLVD
HAWES ST
INNES AVE
0' 50' 100' 200' 300'
N

FIGURE 1

City Distribution Potable Water and Auxillary Water Supply

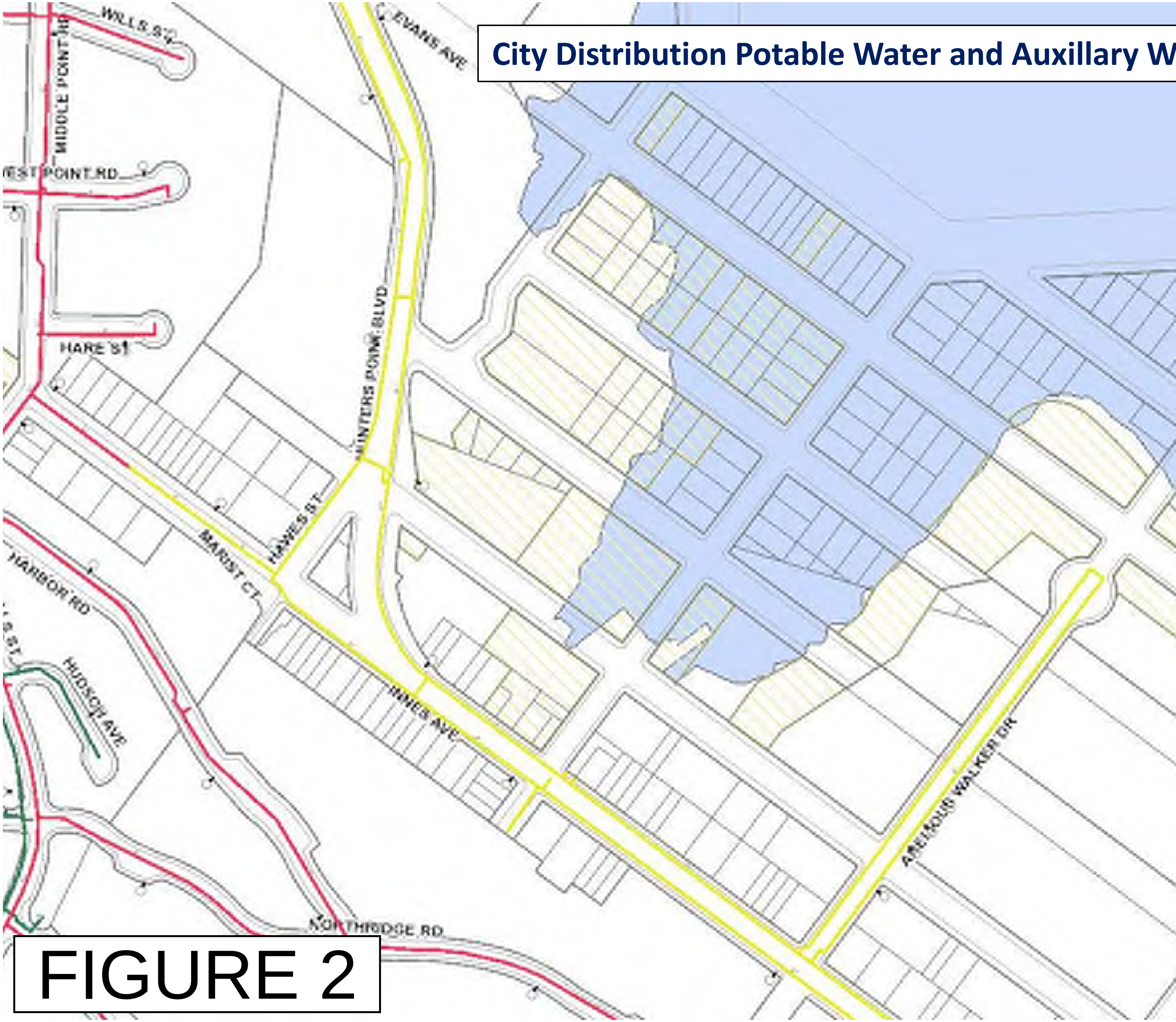
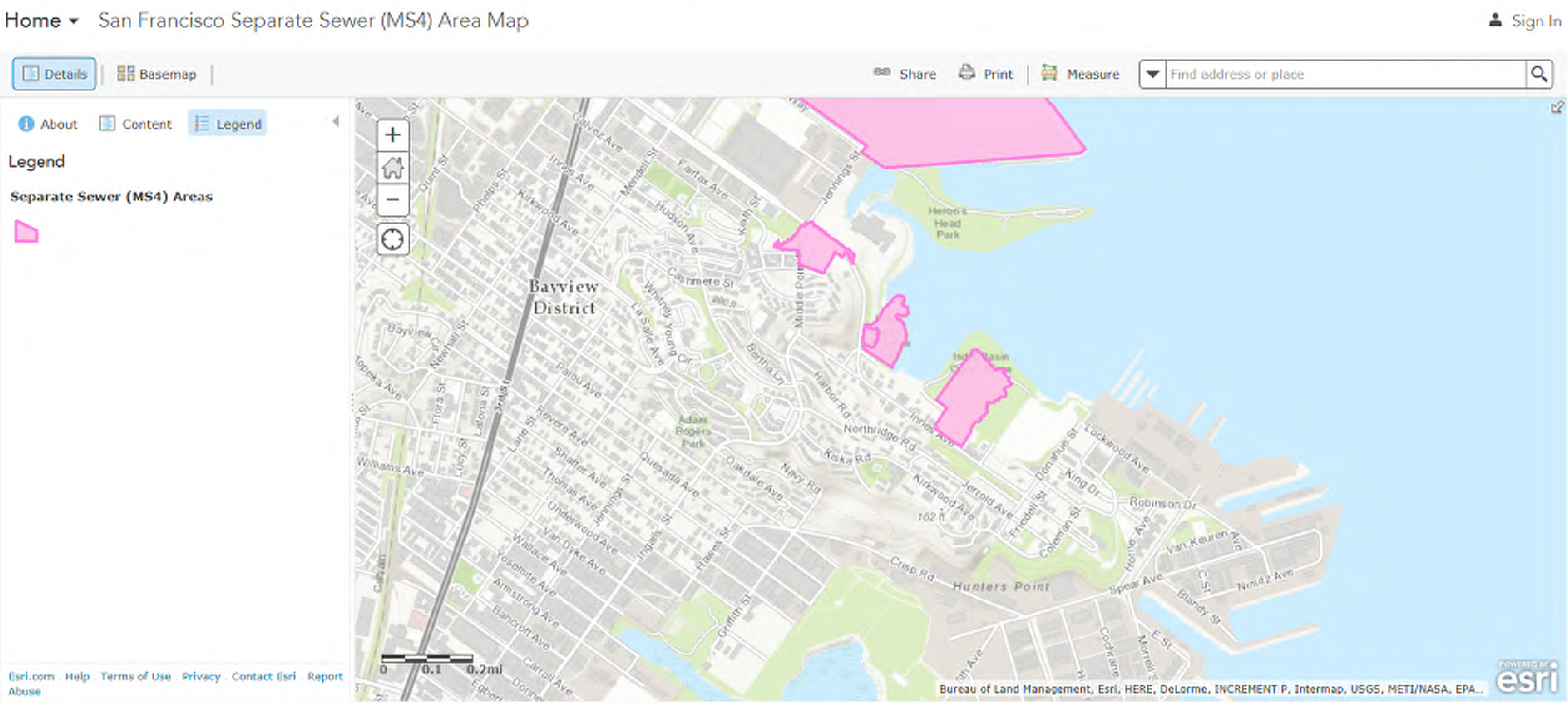


FIGURE 2

Wastewater Enterprise, Collection System Division

FIGURE 3



Home
San Francisco Separate Sewer (MS4) Area Map
Sign In
Details
Basemap
Share
Print
Measure
Find address or place
About
Content
Legend
Legend
Separate Sewer (MS4) Areas
Bayview District
Hunters Point
Heron's Head Park
Adam Rogers Park
Calvert Ave
Innes Ave
Kirkwood Ave
Fairfax Ave
Hudson Ave
Cashmere St
Middle Point Rd
Whitney Young Cir
La Salle Ave
Bertha Ln
Harbor Rd
Northridge Rd
Kiska Rd
Navy Rd
Oakdale Ave
Palou Ave
Revere Ave
Shafter Ave
Thomas Ave
Underwood Ave
Van Dyke Ave
Wallace Ave
Yosemite Ave
Armstrong Ave
Bancroft Ave
Carroll Ave
Williams Ave
Quesada Ave
Jerrold Ave
Lockwood Ave
King Dr
Robinson Dr
Van Keuren Ave
Spear Ave
Nimitz Ave
Crisp Rd
162 ft
0 0.1 0.2mi
Esri.com . Help . Terms of Use . Privacy . Contact Esri . Report Abuse
Bureau of Land Management, Esri, HERE, DeLorme, INCREMENT P, Intermap, USGS, METI/NASA, EPA...
esri

FIGURE 4

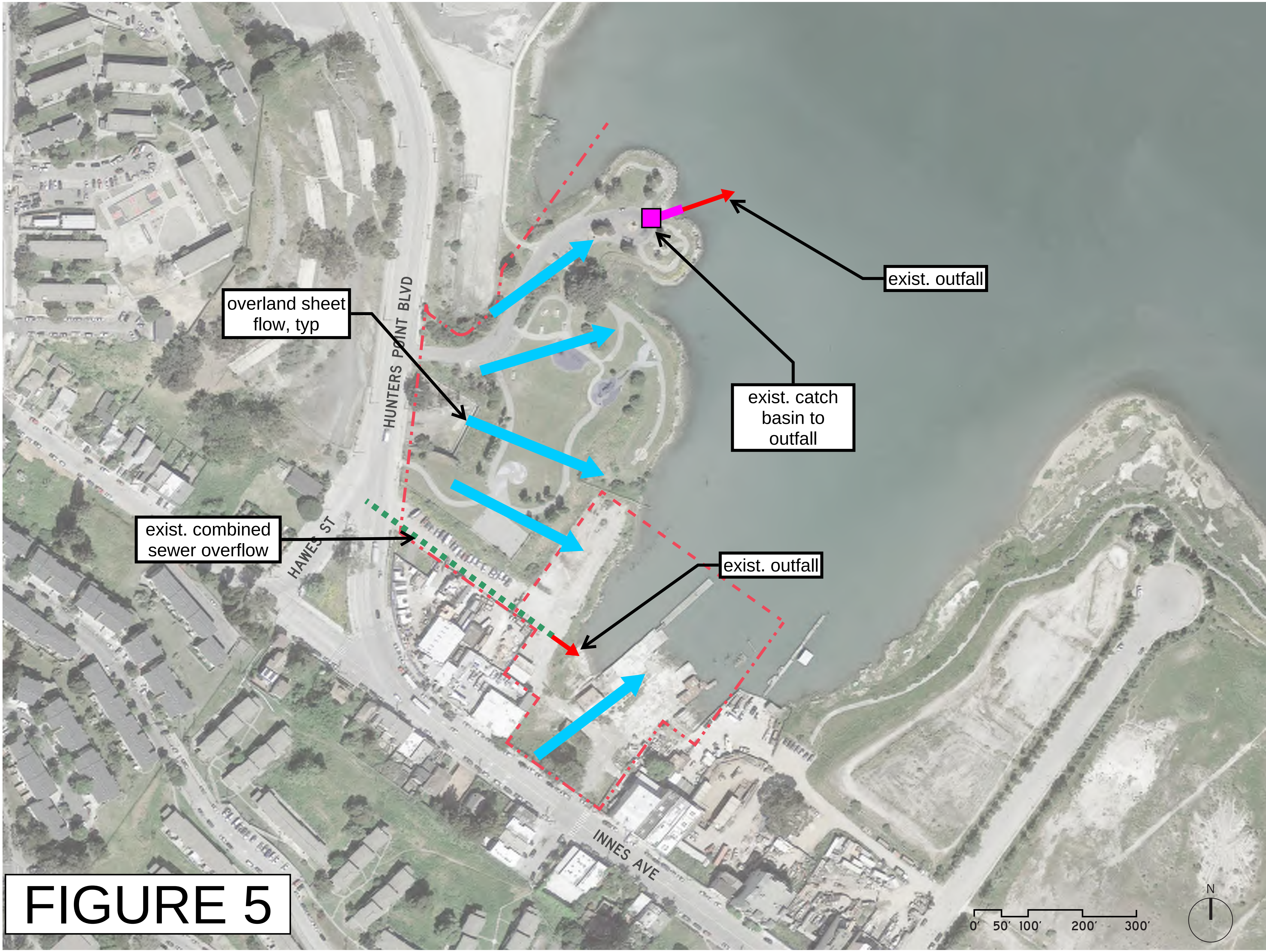
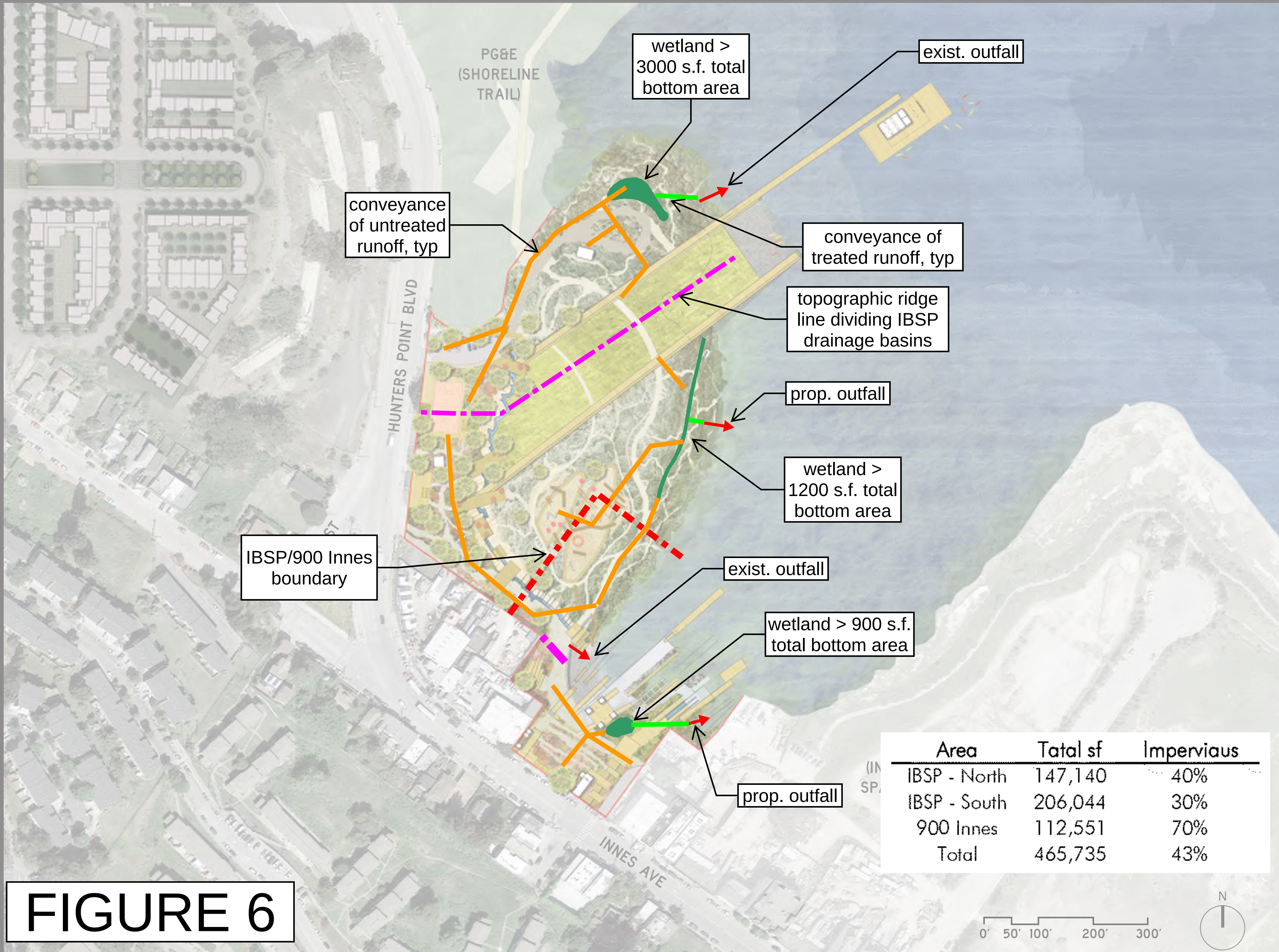

overland sheet flow, typ
exist. outfall
exist. catch basin to outfall
exist. combined sewer overflow
exist. outfall
HUNTERS POINT BLVD
HAWES ST
INNES AVE
0' 50' 100' 200' 300'
N

FIGURE 5



Area	Total sf	Impervious
IBSP - North	147,140	40%
IBSP - South	206,044	30%
900 Innes	112,551	70%
Total	465,735	43%

FIGURE 6

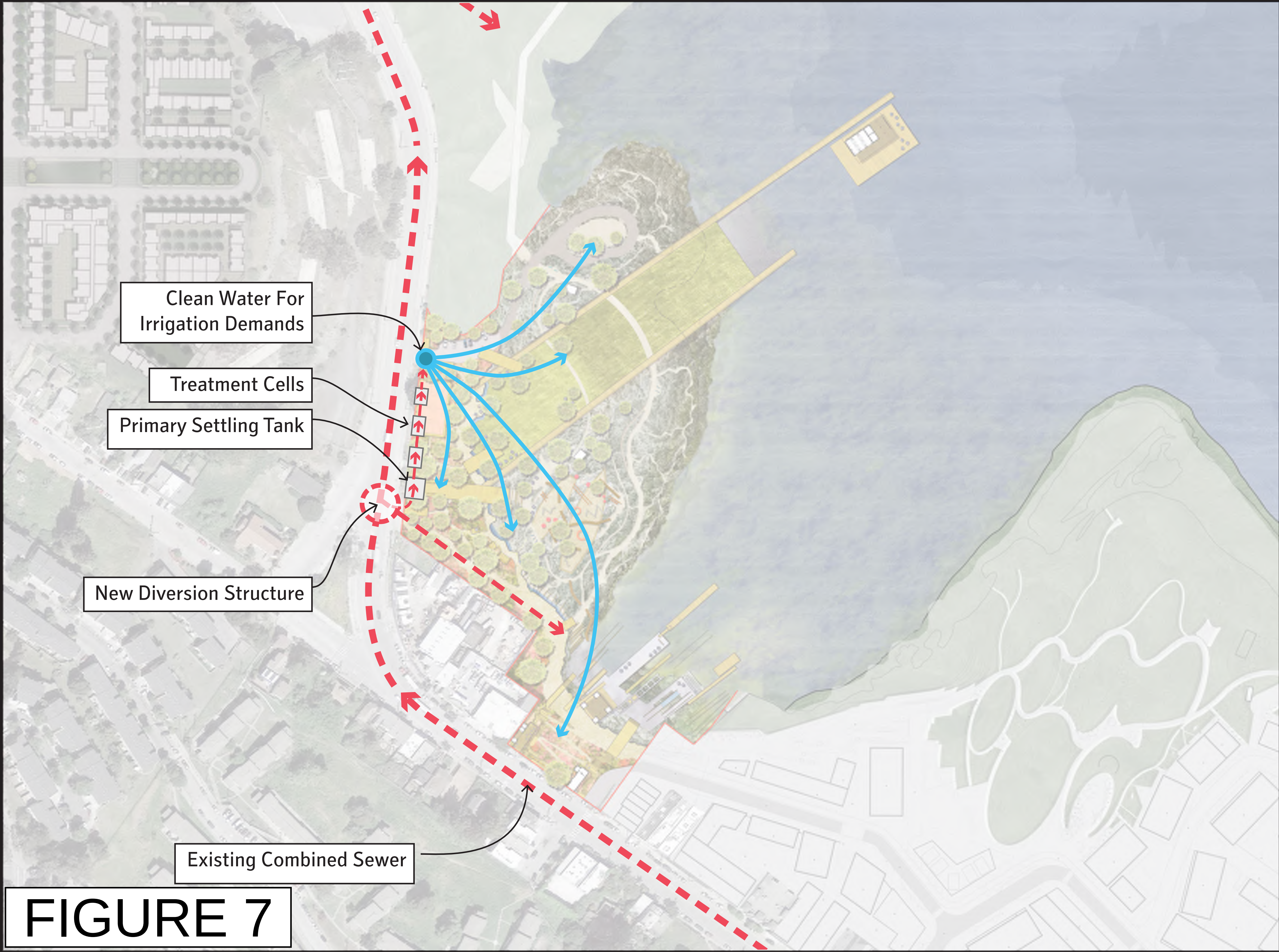
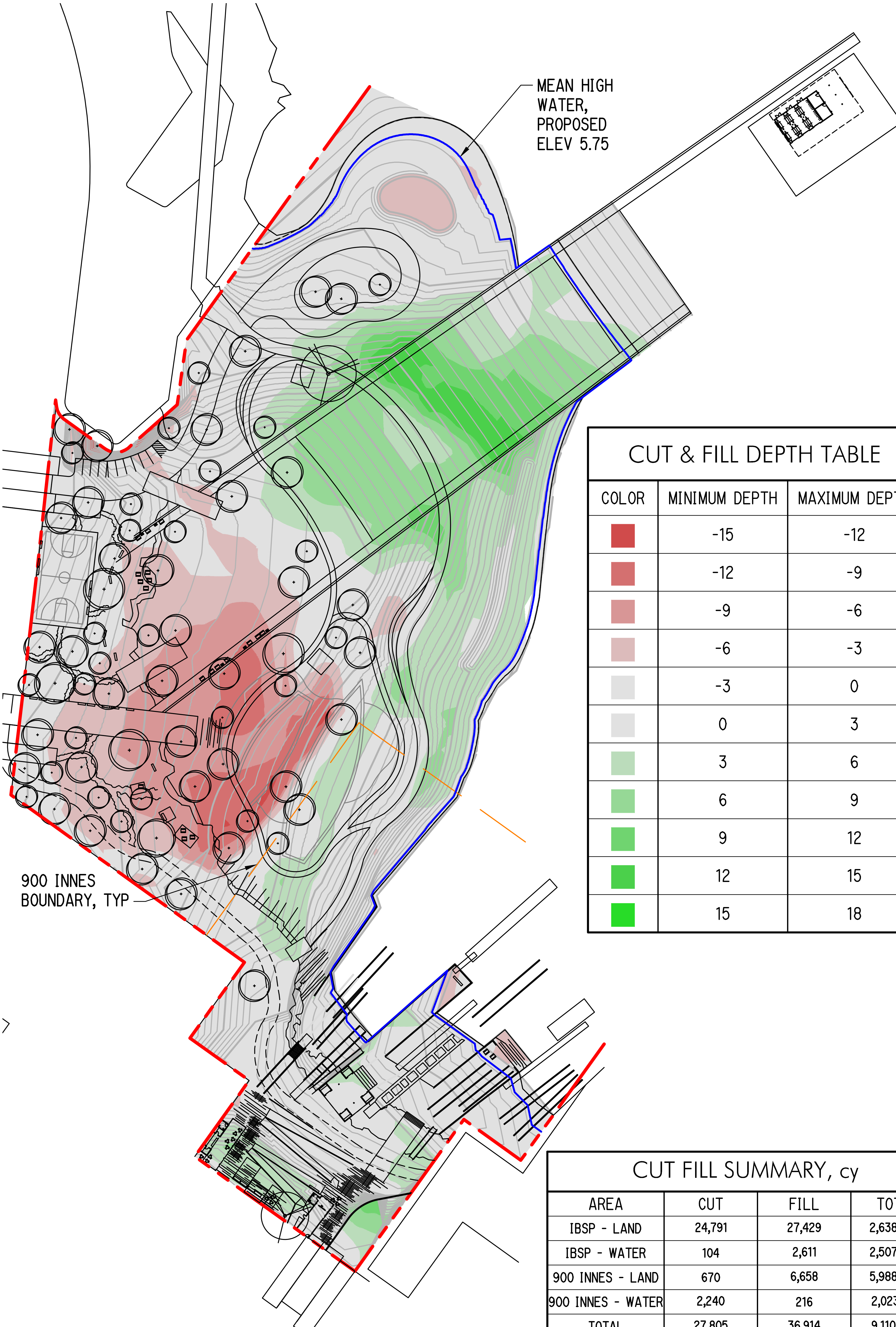

Clean Water For Irrigation Demands
Treatment Cells
Primary Settling Tank
New Diversion Structure
Existing Combined Sewer

FIGURE 7



CUT & FILL DEPTH TABLE		
COLOR	MINIMUM DEPTH	MAXIMUM DEPTH
	-15	-12
	-12	-9
	-9	-6
	-6	-3
	-3	0
	0	3
	3	6
	6	9
	9	12
	12	15
	15	18

CUT FILL SUMMARY, cy			
AREA	CUT	FILL	TOTAL
IBSP - LAND	24,791	27,429	2,638 FILL
IBSP - WATER	104	2,611	2,507 FILL
900 INNES - LAND	670	6,658	5,988 FILL
900 INNES - WATER	2,240	216	2,023 CUT
TOTAL	27,805	36,914	9,110 FILL

INDIA BASIN PARK: CUT FILL EXHIBIT

8/11/2016

100 50 0 100 200

scale 1" = 100' feet

FIGURE 8

Appendix A - MKA Water Demand Memo

Memo

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Structural + Civil Engineers

1301 Fifth Avenue, Suite 3200 Seattle Washington 98101-2699 T: 206 292 1200 F: 206 292 1201 W: www.mka.com

TO	Ashley Ludwig - GGN	DATE	7/12/2016
FROM	Drew Gangnes	PAGE	1 OF 1
PROJECT	**India Basin Park Concept Design**	PROJECT #	A2960.50
SUBJECT	Preliminary Water Demands		

This memo summarizes MKA's preliminary assessment of water demands for the new India Basin Park project.

Background

MKA has been providing civil engineering consulting to GGN as they prepare the conceptual design for a new India Basin Park. The new park will encompass the combined land area of the existing India Basin Shoreline Park (IBSP) and the 900 Innes site. The water demands noted in this memo are based on the conceptual park design and program provided by GGN.

Preliminary Water Demands

Table 1 summarizes the preliminary water demands for the project, with a breakdown by IBSP and 900 Innes sites. The "potable" column is an accounting of which demands must be served by potable, city water vs those that might be served by recycled water in the event that recycled water is available at the site.

Table 1. Preliminary Water Demands

Park Component	Total *gal/year*	IBSP *gal/year*	900 INNES *gal/year*	Potable
Irrigation	927,344	805,029	122,315	N
Water Feature Top-off	83,516	69,117	14,399	Y
Restrooms Flow	19,800	13,200	6,600	Y
Restrooms Flush	112,200	74,800	37,400	N
Concession Stand	99,000	0	99,000	Y
Drinking Fountains	24,000	19,200	4,800	Y
Kayak Station	660,000	660,000	0	Y
Fish Station	270,000	270,000	0	Y
Water Play		0	TBD	Y
Totals	2,195,860	1,911,346	284,514	

Basis of Calculations

Irrigation demands were computed using the SFPUC Water Demand Calculator which takes into account different weather data, the areas of planting and species factors. The water feature top-off was computed based on the

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water feature area and weather data. Water demands for the other park components were calculated based on the assumptions noted in Table 2.

Table 2. Water Demand Assumptions

Park Component	count	gpm	hr/day	day/yr	gal/yr	gal/d
Hose Bib - Kayak	2	10	2	275	660,000	1,808
Hose Bib - Fish	1	10	2	300	270,000	740
Drinking Fountain		0.13	2	300	24,000	66
	vis/day	**gal/vis**	**day/yr**	**gal/yr**	**Flow**	**Flush**
Restrooms	100	4	330	132,000	19,800	112,200
	vis/day	**gal/vis**	**day/yr**	**gal/yr**		
Concession	100	3	330	99,000		

EXISTING SITES

IBSP - EXISTING survey calcs			
ZONE		AREA (SF)	% OF TOTAL ON GRADE AREA
TOTAL EXISTING SITE AREA		291,419	100.00%
PERVIOUS SURFACES (softscape, on grade)		202,801	69.59%
IMPERVIOUS SURFACES (hardscape, on grade)		88,617	30.41%
	RIP RAP	8,234	
	DRIVE / TURNAROUND	19,963	
	PATHS	34,767	
	PLAYGROUND	7,053	
	BASKETBALL	5,626	
	CONCRETE PADS	659	
	ROCK PILES	667	
	PAVING (assumed to be asphalt)	11,649	

900 INNES EXISTING survey calcs			
ZONE		AREA (SF)	% OF TOTAL ON GRADE AREA
TOTAL EXISTING SITE AREA (on grade)		110,331	100.00%
PERVIOUS SURFACES (softscape, on grade)		34,103	30.91%
IMPERVIOUS SURFACES (hardscape, on grade)		76,229	69.09%
	BUILDINGS	5,831	
	CONCRETE (excluding building footprints)	25,470	S
	PAVING (assumed to be asphalt)	44,928	
FLOATING DOCKS (over water)		1,596	n/a

IBSP + 900 INNES COMBINED survey calcs		
ZONE	AREA (SF)	% OF TOTAL ON GRADE AREA
TOTAL EXISTING SITE AREA (on grade)	401,750	100.00%
PERVIOUS SURFACES (softscape, on grade)	236,904	58.97%
IMPERVIOUS SURFACES (hardscape, on grade)	164,846	41.03%
FLOATING DOCKS (over water)	1,596	n/a
TOTAL EXISTING SITE (on grade + over water)	403,345	n/a

PROPOSED DESIGNS

IBSP proposed design calcs			
ZONE		AREA (SF)	% OF TOTAL ON GRADE AREA
TOTAL PROPOSED IBSP AREA (on grade)		275,266	100.00%
PERVIOUS SURFACES (softscape, on grade)		175,941	63.92%
	LAWN	50,403	18.31%
	GARDEN	26,734	9.71%
	NATIVE SAGE	90,259	32.79%
	WETLAND	8,545	3.10%
IMPERVIOUS SURFACES (hardscape, on grade)		99,325	36.08%
	rails + deck (on existing land)	13,239	4.81%
	path + shorewalk	36,727	13.34%
	basketball courts w/ buffers & dog park	12,227	4.44%
	drive & turnaround	16,326	5.93%

	playground	20,806	7.56%
TOTAL IBSP OVER WATER		69,254	n/a
	marsh (over water)	18,015	
	lawn (over water)	17,116	n/a
	rails + deck (over water)	34,123	n/a
TOTAL PROPOSED IBSP (on grade + over water)		344,520	n/a
900 INNES proposed calcs			
ZONE		AREA (SF)	% OF TOTAL ON GRADE AREA
total 900 Innes (on grade)		79,468	100.00%
PERVIOUS SURFACES (softscape, on grade)		32,509	40.91%
	LAWN	0	0.00%
	GARDEN	15,836	19.93%
	NATIVE SAGE	13,650	17.18%
	WETLAND	3,023	3.80%
IMPERVIOUS SURFACES (hardscape, on grade)		46,959	59.09%
	main paths	0	0.00%
	basketball courts w/ buffers	0	0.00%
	boatyard concrete + rails	36,333	45.72%
	Griffith st stair	2,459	3.09%
	garden path	4,151	5.22%
	buildings (not on concrete)	4,016	5.05%
	playground	0	0.00%
total 900 Innes over water		11,775	n/a
	softscape - marsh (over water)	10,336	
	impervious - floating docks	1,439	n/a
TOTAL PROPOSED 900 INNES (on grade + over water)		91,243	n/a
IBSP + 900 INNES COMBINED proposed calcs			
TOTAL PROPOSED SITE AREA (on grade)		354,734	100.00%
TOTAL PERVIOUS SURFACES (softscape, on grade)		208,450	58.76%
TOTAL IMPERVIOUS SURFACES (hardscape, on grade)		146,284	41.24%

TOTAL PROPOSED OVER WATER	81,029	n/a

TOTAL PROPOSED SITE (on grade + over water)	435,763	n/a

TOTAL LAWN (on grade and over water)	67,519	15.49%
TOTAL MARSH (on grade and over water)	39,919	9.16%

MEMORANDUM

To: AECOM
From: Sherwood Design Engineers on Behalf of Build SF
Re: India Basin 700 Innes & India Basin Open Space - Storm Drain Design
Date: September 28, 2016

1. Introduction

This memorandum describes existing and future stormwater conditions for Build SF's proposed India Basin Development (the "Project). The Project is s located on an approximately 23.1 acre site in the Bayview Hunters Point neighborhood of San Francisco. The site is bordered by San Francisco Bay to the north and northwest, Candlestick-Hunters Point Shipyard Development to the east, Innes Avenue to the south, and the 900 Innes/India Basin Shoreline Park Development to the west.[1]

The Project site consists of a number of private parcels and platted streets, which will be collectively referred to in this report as 700 Innes (16.9 acres) and India Basin Open Space (6.2 acres). 700 Innes includes all the upland portions of the site, while the India Basin Open Space encompasses an approximately 200 foot wide band along the Project's Bay shoreline. The open space portion consists of approximately 2.5 acres of wetlands that were enhanced as offsite mitigation during the 1997 San Francisco Airport expansion, plus another 3.7 acres that extend landward from the wetlands to the BCDC 100 foot shoreline offset boundary. Current plans call for the development of public roads, residential units, commercial uses, parking, and additional open space on the 700 Innes portion of the site, while the India Basin Open Space is to be dedicated to the San Francisco Recreation and Parks Department (SFRPD). The Project does not include adjacent SFRPD properties totaling approximately 15.5 acres (900 Innes Avenue and India Basin Shoreline Park) that are also being reviewed in the same EIR. Refer to documentation prepared by MKA Engineers for stormwater conditions within these areas.

2. Existing Conditions

The Project site is primarily undeveloped. Existing improvements are limited to a few residential and commercial buildings along Innes Avenue and a single developed public street, Arelious Walker Drive, which runs north from Innes to a cul-de-sac a short distance before the Bay. All existing buildings will be demolished, except for a single family residence that will be relocated on the site. A short section of the Arelious Walker Drive right of way will be retained north of Innes, but the entire street and its improvements will be demolished in accordance with the proposed site plan. Total impervious cover on the existing site (roofs plus pavement) is estimated to be 10 percent, with sparse vegetative cover on the remaining pervious areas.

The entire site slopes north from Innes Avenue toward the Bay. This slope varies from five to ten percent between Innes and the currently vacant right of way of Hudson Avenue, where it then flattens to between one and two percent. The dry land portions of the site end at an eight to ten

[1] For the purposes of this report, it is assumed Innes Avenue runs in an east-west direction. Its actual orientation is southeast to northwest.

foot high embankment at the edge of the Bay. Within the flatter area below Hudson, there are several small mounds of dumped fill that rise between 15 and 20 feet above the surrounding terrain, all located on the east side of Arelious Walker Drive.

According to the Project's geotechnical report, the lower portions of the site, which have all been filled, are likely susceptible to liquefaction and lateral spreading. As a result, it is being conservatively assumed that concentrated infiltration of stormwater or other water sources could worsen these conditions, so all water quality treatment ponds (as described in a following Section) will be lined. Water that percolates through the upper soil layers in these ponds will be collected in underdrains and discharged to the Bay.

Approximately half of the Project site, including all of Arelious Walker Drive, is located within a Separate Sewer (MS4) Area, as designated by the SFPUC. The only storm drain improvements on the site are a series of catch basins and 12-inch storm drain line in Arelious Walker Drive. This line flows downhill to an assumed pump station inside a locked utility fence adjacent to the Bay, from which the project survey indicates a 14-inch force main conveys stormwater up to the Innes Avenue sewer at the intersection with Arelious Walker Drive. The existence of the pump station could not be confirmed, but a large, concrete overflow structure is visible inside the fence. It is expected stormwater flows the pump station cannot accommodate exit this structure and spill down the nearby shoreline embankment into the Bay. Because a pumped stormwater connection to the City sewer is not consistent with the SFPUC Separate Sewer (MS4) Area designation that covers nearly half of the Project site, including all of Arelious Walker Drive, it is assumed the designation was made since these improvements were constructed. The new designation would apply to all new development within the portions of the site that it covers.

The Arelious Walker storm drain system is the only existing facility on the undeveloped portions of the site, so the majority of rainfall is either absorbed into the ground or runs off as overland sheetflow to the Bay shoreline. There are no records of storm drain connections for the existing improved properties, but it is assumed the runoff from building roofs and front yard areas is discharged through lateral connections to the Innes Avenue sewer. Because the terrain drops away sharply from Innes, the rear portions of these lots most likely drain north to the vacant part of the site and the Bay.

3. Proposed Conditions

The proposed project consists of multiple blocks of mixed use development, with residential and commercial buildings surrounding courtyards built on podia. These improvements, which include new public roadways on both existing and reconfigured rights of way, will be spread along the entire Innes Avenue frontage and extend almost to the Bay along the site's easterly boundary. The remainder of the Project will be a combination of public and privately owned open space covering a total of about 11.8 acres along the Bay shoreline and in the northwestern part of the site. Because the planned courtyard landscaping will be over structures, only the open spaces and unpaved portions of the public roadways can be considered as pervious for the estimation of stormwater runoff. The following table summarizes these planned changes in land use and infiltration conditions.

Land Cover in acres – Residential and Commercial Variant

		Pervious Area		Impervious Area		Total Area	
		acres	%	acres	%	acres	%
700 Innes	Existing	15.4	91%	1.7	10%	16.9	100%
	Proposed	1.2	7%	15.9	94%	16.9	100%
India Basin Open Space	Existing	5.9	95%	0.3	5%	6.2	100%
	Proposed	5.9	95%	0.3	5%	6.2	100%

Notes:

Existing areas per ALTA/ACSM Land Title Survey prepared by Martin Ron & Associates, March 2014

Proposed areas per site plan by Bionic Landscape August 2016

The areas and percentages listed in the table apply equally to both the residential and the commercial project variants as currently proposed. Building sizes and locations will be slightly modified, but there will be no significant changes in roadway layout, area to be constructed over podium or total building footprint.

The Project plans to collect all stormwater runoff in a publicly owned storm drain network for discharge to the Bay, which will require a modification of the site's existing MS4 boundary. Stormwater will be treated prior to discharge, primarily through biofiltration, in accordance with SFPUC and Regional Water Quality Control Board requirements. Because of the previously described concerns related to concentrated infiltration, the biofiltration areas will be lined with underdrains that will discharge all runoff to the Bay after treatment. These treatment facilities, which will also treat runoff from the proposed public streets, will be owned and maintained by a future property owners' association. Treatment areas for the development block located north of the proposed New Hudson Street will be scattered throughout internal courtyards, while treatment for the public streets and for the areas between Innes Avenue and New Hudson Street will be located within the private open space in the northwest quadrant of the site. Per the SFPUC guidelines, it is expected the total area needed for biofiltration will be between four and five percent of the total Project site, or between 1 and 1.2 acres.

Each treatment cell will be designed to capture and treat the first 0.75 inches of rainfall from its contributing watershed, as required by the SFPUC. Higher flows will bypass the treatment and be discharged directly to the Bay. The San Francisco Department of Public Works (SFDPW) typically requires public storm drain improvements to be designed with capacity for a 5-year recurrence interval storm, with flows generated by higher intensity storms carried within overland flow routes on the surface. The peak projected discharge rate under these pipe sizing criteria, for both existing and proposed conditions, is estimated as follows using the Rational Method:

Site Peak Runoff Rates

		Total Area acres	Weighted Runoff Coefficient C	Rainfall Intensity (5yr 10min storm) in / hr	Peak runoff Rate (5yr 10min storm) cfs	Peak runoff Rate Increase %
Total site: 700 Innes & India Basin Open Space	Existing	23.3	0.44	2.32	23.94	69%
	Proposed	23.3	0.75	2.32	40.41	

Notes:

Areas per table above

Runoff coefficients; pervious = 0.4, impervious = 0.9

Estimated Time of Concentration = 10 minutes

Rainfall intensity from SFDPW

Rational Formula: Peak Runoff (cfs) = Coefficient x Intensity x Area

The location of catch basins and drainage inlets within public streets, as well as minimum pipe sizes, will be in accordance with SFDPW requirements. Overland flow routes will be designed to carry the 100-year storm away from all buildings and improvements, for discharge to the Bay.

Refer to memorandum presented by MKA for information on storm drain design for 900 Innes and India Basin Shoreline Park.