Exhibit 1 - Appendix C4

HDR | SHINER MOSELEY

Memo

To:	Bill Young		
From:	Joel Darnell, Robert Thomas	Project:	J-Street Drain Environmental and Preliminary Design
CC:	Jerry Hauske, Dan Heilman		
Date:	3/11/2008	Job No:	75217 (Dept. 043)

RE: Coastal Processes Assessment at Ormond Lagoon and Beach

The overall goal of the J-Street Drain Environmental and Preliminary Design project is to reduce local flooding within the City of Oxnard by increasing the capacity of J-Street Drain while minimizing environmental impacts to Ormond Lagoon. This memorandum summarizes key coastal processes affecting the episodic opening and closure of the ephemeral inlet between Ormond Lagoon and the Pacific Ocean. The analysis of coastal processes was performed to improve understanding of lagoon morphology, focus field data collection needs, refine methodologies to simulate breaching of the beach, and provide a basis for evaluating potential impacts to the coupled lagoon/beach system related to project design. Information provided in this memorandum will be integrated into the final coastal engineering report.

1.0 Description and Purpose

Ormond Lagoon (lagoon) is located in the City of Oxnard, Ventura County, CA approximately one mile southeast of Port Hueneme (Figure 1). The lagoon receives storm water from J-Street Drain, Industrial Drain and Hueneme Drain. Flooding in the City of Oxnard has been attributed to the backwater effect caused when the lagoon is closed to the ocean (URS 2005). The Ventura County Watershed Protection District is therefore pursuing alternatives that will reduce the backwater effect during design flood events. A number of scenarios have been proposed to control the water levels in the lagoon and reduce flooding, some of which may alter the lagoon's hydrodynamic and geomorphologic regime.

A considerable amount of hydrologic and hydraulic study has been conducted to document the performance of the existing drainage system upstream of the lagoon. However, studies to date have generally not included characterization of the breaching process such as key processes affecting breaching, the duration that the breach remains open, and the effect the breach has on hydrodynamics and morphology of the lagoon.

Therefore, better quantification of the existing hydrodynamics and geomorphology of the lagoon and beach are needed to provide a basis for assessing environmental impacts of the proposed J-Street Drain design alternatives. The results will aid with the environmental impact assessment and permit preparation while reducing the likelihood of adverse impacts to the lagoon by allowing quantitative comparison of existing and future conditions in the lagoon.

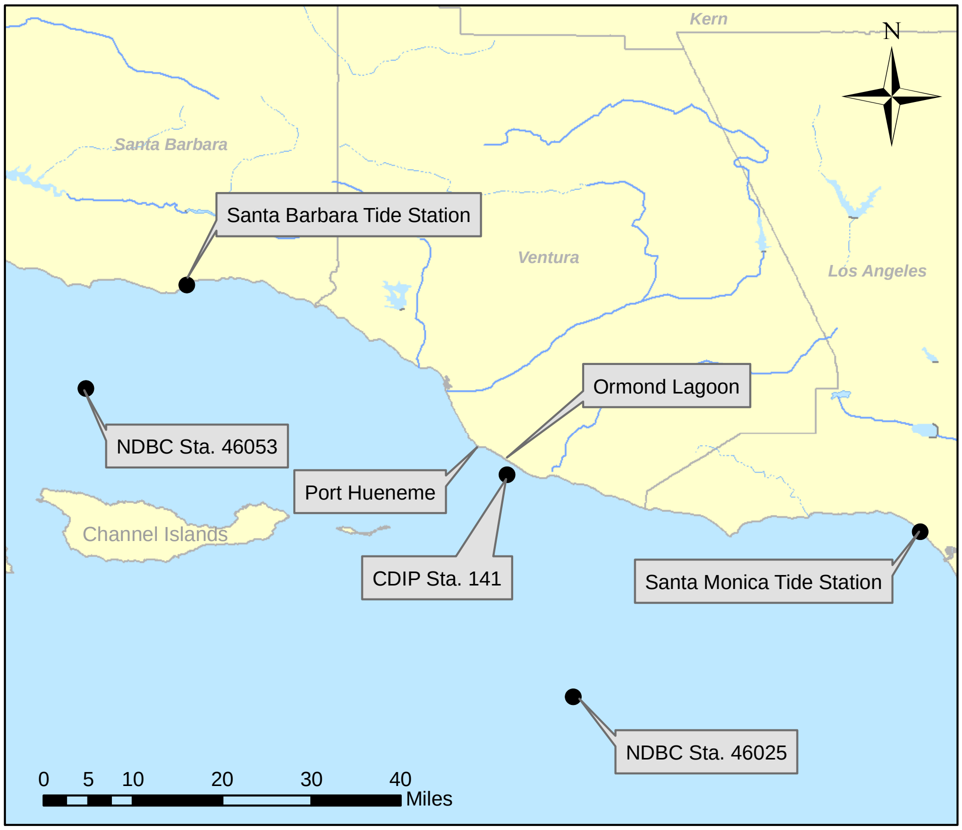

Figure 1. Location map.

2.0 Background Data

Various sources of background data were reviewed to develop an understanding of the history of the lagoon, similar systems studied by others, and key physical processes affecting the coupled drain-lagoon-beach system.

2.1 Previous Studies

Previous modeling of and reports on the drainage system including the lagoon have been conducted by the Ventura County Watershed Protection District (Su 2007), URS (2005), Tetra Tech (2005) and Pacific Advanced Civil Engineering. These efforts provide documentation of the flooding in the City of Oxnard and include different assumptions about flow and downstream boundary conditions in the lagoon.

Su's (2007) memorandum provides information on frequency of berm breaching and prior work by others. Prior to 1992, the beach at J-Street was routinely breached through mechanical means by the Ventura County Watershed Protection District, but this practice has since been halted because of environmental concerns (Su 2007). Assuming that the berm completely breaches when the storage capacity of the lagoon is reached, Su (2007) determined that the lagoon would breach during storms with a 2-year recurrence interval. During stronger storms the backwater effect of the lagoon will not substantially increase flooding because the breach occurs early in the storm. However, during weaker storms the unbreached lagoon could contribute significantly to flooding in the City of Oxnard.

URS (2005) developed a plan and preliminary design to reduce flooding in the City of Oxnard by improving flow in J-Street Drain. URS concluded that along with drainage system modifications, the backwater effect in the lagoon must be controlled to reduce flooding. URS (2005) used HEC-RAS, a one dimensional model of flow with limited sediment transport capabilities, to analyze the existing and proposed hydraulic conditions. Rather than modeling the breaching process, URS assumed that the water level in the lagoon was either a constant or that the breach was completely open to the ocean, depending on the return period of the storm considered.

Tetra Tech (2005) determined the 100-year storm event in the City of Oxnard which was partially based on a previous effort by Pacific Advanced Civil Engineering. Tetra Tech (2005) considered the flow in two dimensions using FLO-2D, a two-dimensional river flow and floodplain inundation model. They performed two dimensional modeling of the lagoon to determine at what point during a given storm the flow would breach through to the ocean. The analysis of flow in the lagoon was more detailed and likely more accurate than that performed by URS (2005), but Tetra Tech (2005) did not include erosion of the beach or an analysis of breaching processes that might elucidate potential project impacts.

An ongoing restoration project at Ormond Beach that may tie into the lagoon in the future is being led by the Coastal Conservancy with partners including Aspen Engineering, Philip Williams and Associates (PWA), Everest International Consultants, and others. The Coastal Conservancy team has experience with other restoration projects at tidal lagoons including a project completed by PWA at the Crissy Field tidal inlet and beach. There, significant data were collected over at least two years to quantify the lagoon processes (Botello et al 2004).

The results of the previous modeling efforts have characterized flow into Ormond Beach Lagoon but have specifically not addressed hydrodynamic processes in the lagoon, morphology of the lagoon or the duration of the breach after the storm. These processes are critical to assessing environmental impacts because they are likely somewhat quantifiable and predictable.

2.2 Coastal Processes

2.2.1 Longshore Transport

Longshore transport is the movement of sand along a coastline forced by waves (combined with currents) approaching at some angle to the coast. Greater wave height and/or angle of approach cause greater longshore sediment transport. Longshore transport is analogous to a river of sand moving along the coast. This river of sand carries sediment from updrift sources to Ormond Beach and from Ormond Beach to downdrift areas. The net direction of sediment transport along the California coast is south from Santa Barbara to Point Mugu. Gradients in the rate of longshore transport are primarily responsible for beach erosion and accretion. Without a continuous supply of sand to Ormond Beach from the north, transport to the south would erode the beach and lagoon system within a short time.

Ormond Beach is located immediately southeast of Port Hueneme, a jettied inlet that interrupts longshore transport. Sand supply for beaches in Ventura County has historically been from Ventura and Santa Clara Rivers (Coastal Sand Management Plan 1989). Approximately 1,100,000 cubic yards (CY) of sand per year are mechanically bypassed around Port Hueneme in the direction of net longshore transport from north to south (Coastal Sand Management Plan 1989). Campbell and Benedet (2004) report that from 1959 to 1987 about 910,000 CY per year were bypassed around the Port in the direction of net transport. Weigel (1994) has also confirmed a similar magnitude of bypassing and further describes longshore transport in the area.

Longshore transport must be maintained to prevent erosion of Ormond Beach. If, for example, sand bypassing at Port Hueneme were to cease, it is likely that the Ormond Beach would switch from being a stable beach (not significantly accreting or eroding) to one with significant erosion. This erosion would likely expose the lagoon to more frequent inundation from the ocean side and significantly increase breaching.

Longshore transport can be significantly interrupted by tidal inlets, especially during the initial phases of inlet development. During a site visit to Ormond Beach on February 12, 2008, waves were breaking on an ebb shoal that had developed since the most recent breach. That shoal will be reworked into the beach system after the breach closes. When a tidal inlet first opens, ebb and/or flood shoals typically form depending on whether the inlet is ebb or flood dominated. Sediment from these shoals comes from the adjacent beach and, on a more regional scale, from the adjacent coastlines as fed by longshore transport. It appears that while the breach at Ormond Lagoon is open, some component of the longshore transport is trapped in both the ebb shoal and lagoon. The small ephemeral ebb shoal created by episodic breaching likely has no significant permanent effect on downdrift beaches but a permanent inlet may by trapping sand in the ebb shoal and/or lagoon, which is a temporary impact until natural bypassing commences, In considering future alternatives for improving J-Street Drain that include a more permanent connection between the lagoon and the ocean, measurable alterations to beach and coastal processes should be anticipated.

2.2.2 Cross Shore Transport

Cross shore transport refers to sand moving across the beach profile perpendicular to the shoreline. It is generally agreed that, on an engineering time scale, cross shore transport is limited to a conceptual depth of closure beyond which waves do not cause significant sediment transport (Dean, Kriebel, and Walton 2002). Depth of closure is a function of the sand gain size, shape of the beach profile, and waves. The depth of closure will be applied as the effective offshore boundary for sediment transport of the Ormond Beach system. According to Dean, Kriebel, and Walton (2002), depth of closure can be estimated based on an annual 12-hour exceedance significant non-breaking wave height. This definition results in a depth of closure at Ormond Beach of approximately 25 feet.

Overall, cross shore transport is a fundamental process through which the shape of the beach profile evolves. This process transports sand across the shoreface that eventually closes the breach and rebuilds the beach. The best way to quantify this process is through rigorous data collection and modeling. There appears to be no data readily available on cross shore transport at Ormond Beach. The data collection effort previously proposed for the current effort will help calibrate and verify a numerical model of the beach and lagoon system and provide the information necessary to better understand cross shore transport.

2.2.3 Aeolian Transport

Aeolian (wind-blown) sand transport is likely a significant component of the long term stability of the lagoon. Visual observations made during the February 12, 2008 site visit indicated that the beach may be significantly reformed after breach closure by aeolian transport. Aeolian transport is known to have significantly contributed to closing of inlets at other locations, such as at the Mustang Island Fish Pass in Texas (Kraus and Heilman 1997), and could contribute to filling the lagoon without the periodic breaching that flushes sediment from the lagoon.

2.2.4 Shoreline Change

Historic aerial photographs, presented in the following section, suggest that there is minimal erosion at Ormond Beach. The effects of the sediment bypassed at the Port Hueneme entrance along with the shadowing effects of the jetties and Channel Islands should provide for a region of stable shoreline downdrift of Port Hueneme. The Coastal Sand Management Plan (1989) indicates that this is the case, reporting an area of accretion down drift of Port Hueneme. Prior to construction of the Port Hueneme jetties, the net change in shoreline position at Ormond Beach was insignificant (Thompson 1994). Thompson (1994) also points out the dependence that the stable shoreline has on continued bypassing.

Shoreline change is of particular importance to the future of Ormond Beach Lagoon because the lagoon is bordered by developed lands, giving the lagoon no room to migrate landward as the shoreline retreats. Natural shorelines retreat and advance as natural forcing varies. In a beach's natural state, the width of the beach generally remains constant regardless of shoreline advance or retreat. However, when structural improvements are constructed landward of a retreating shoreline, such as at Ormond Beach, the landward boundary of the beach becomes stationary, resulting in decreasing beach width. This problem is evident around the developed world and should be considered as part of future plans for J-Street Drain.

2.2.5 Relative Sea Level Rise

The National Oceanic and Atmospheric Administration's (NOAA) Center for Operational Oceanographic Products and Services (2008) reports that relative sea level rise at the Santa Barbara tide gauge is approximately 0.91 feet per century and approximately 0.52 feet per century at Santa Monica. Relative sea level rise should be included in the long term planning of improvements at J-Street Drain, but will not significantly affect the result of short term hydrodynamic or morphologic analyses of the lagoon for the purpose of drainage design.

2.3 Historic Aerial Photography

Historic aerial photography has been obtained for the vicinity of Ormond Beach Lagoon. Aerial photographs from 1945, 1950, 1972, 1979, 1989, 1994, 2004, 2006 and 2007 were qualitatively reviewed. A shoreline survey from 1855 and navigation chart from 1945 were also reviewed. Historical conditions indicate that the lagoon was created by J-Street Drain. Continued evolution and growth of the lagoon is expected to be similar to the recent past.

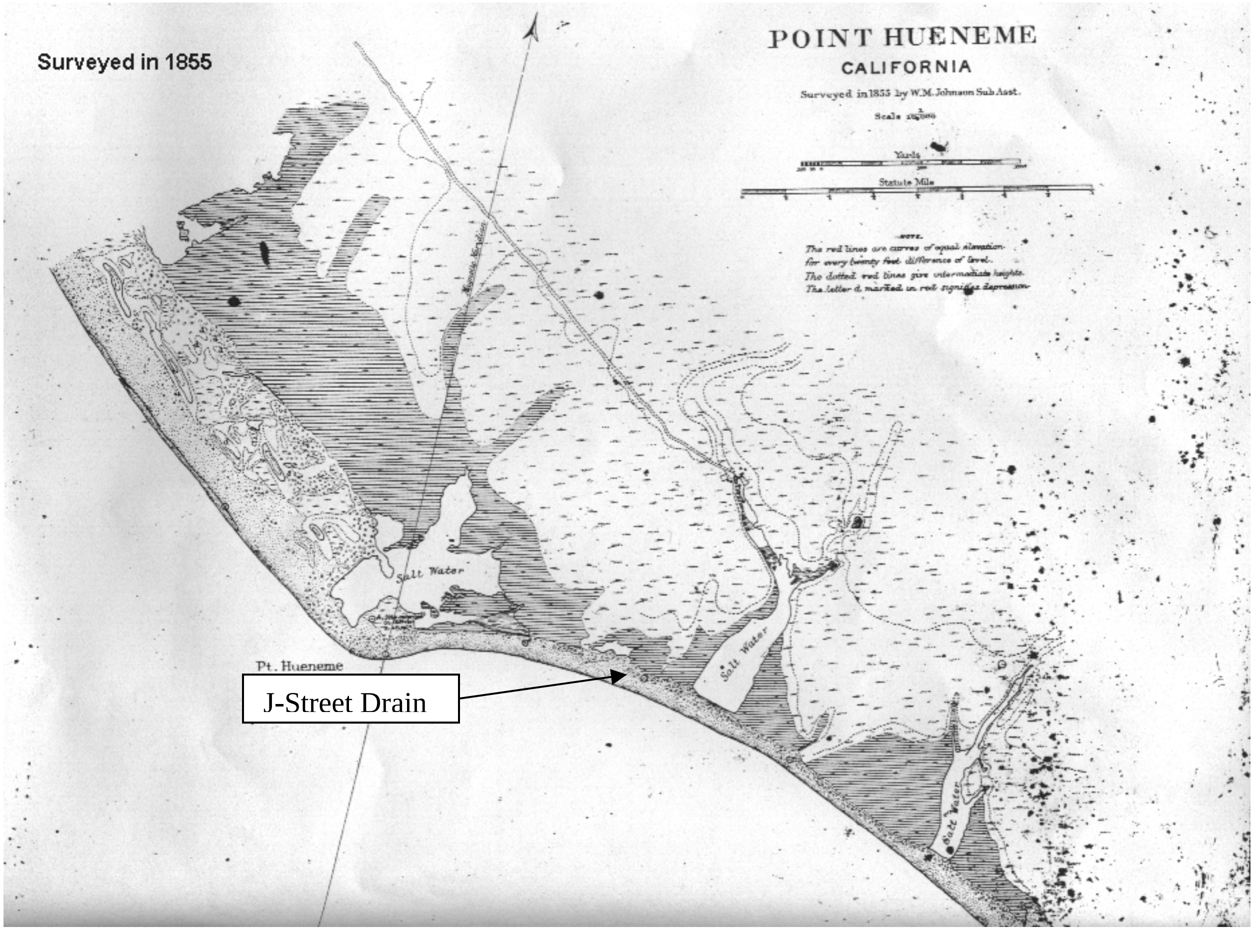

Figure 2. 1855 shoreline survey (Johnson 1855).

The 1855 survey (Figure 2) shows that three nearby lagoons existed in 1855. One of the lagoons/ponds appears to be near where J-Street is today. Another appears to be near where Industrial Drain is today. It appears that the lagoons were connected to the Pacific Ocean during large rainfall events but that the connections may not have been permanent. Historically, the connections likely remained open longer than under existing conditions because of the larger tidal prisms or surface areas available to receive tidal exchange. The large lagoons shown on this map are similar to one of the alternatives being considered by the Coastal Conservancy to restore wetland habitat in the area.

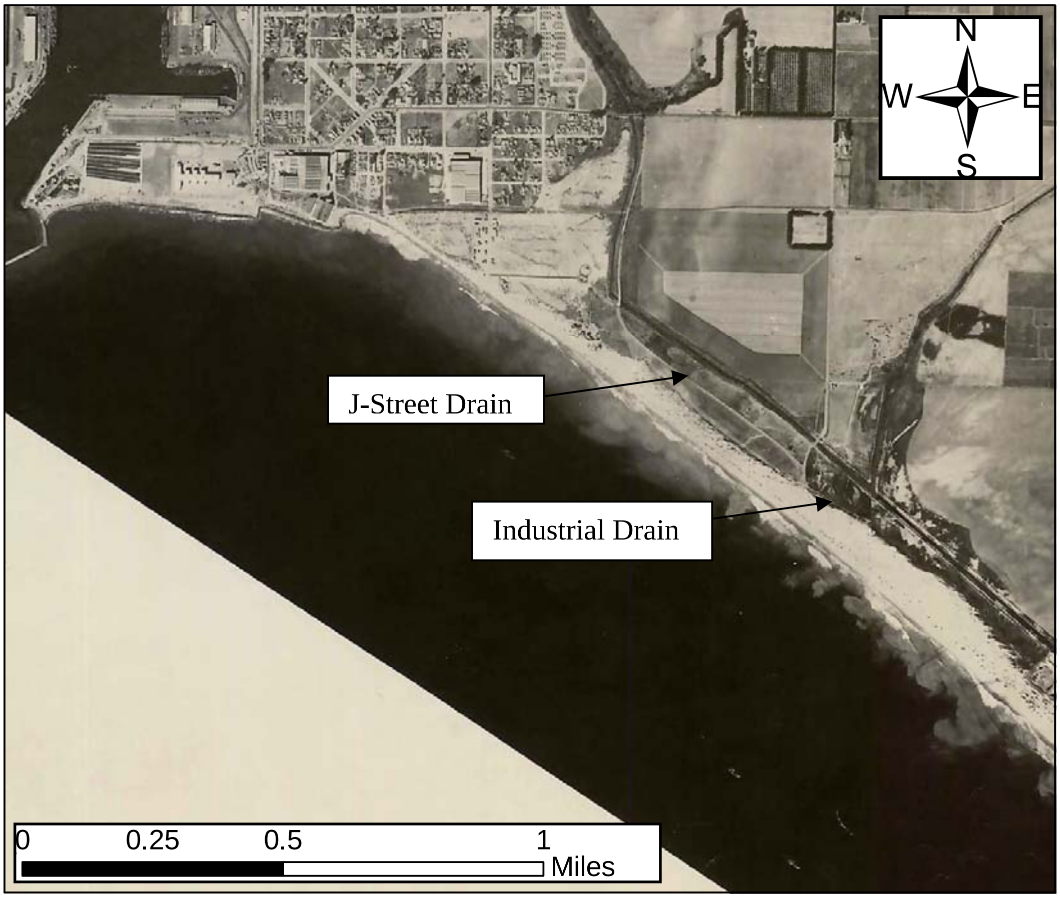

Figure 3. Aerial photograph, 1945 (unknown).

The 1945 aerial photograph shown in Figure 3 documents significant development in the region, including filling of the lagoon north of J-Street and creation of the Hueneme Drain. It appears that the lagoon at Industrial Drain is smaller compared to the 1855 survey, but it is important to note that the data provided in the 1855 survey may not be accurate. J-Street Drain had not yet been constructed in 1945. The lagoon only exists at Industrial Drain and did not extend northwest to the existing location of J-Street Drain.

Figure 4. Aerial photograph facing J-Street Drain, 1972 (Permission requested).

Figures 4 and 5 show the early formation of the lagoon at the outfall of J-Street Drain in 1972. Along with these photographs, available information suggests that during this time the breach was being periodically maintained (URS 2005) to promote flow from J-Street directly to the ocean. Prior to construction of J-Street Drain in the early 1960's, flows likely were collected within Hueneme Drain and passed south to the Industrial Drain and beyond.

In Figure 4, note that water had drained behind the dunes and within dune swales, forming what were likely ephemeral wetlands. Sediment from the dunes was likely transported from the lagoon to the ocean when connected. Comparison between the 1972 photos and the 1945 photo indicates that the J-Street Drain created the lagoon because direct flow from the drain to the ocean wasn't maintained.

Figure 5. Aerial photograph between J-Street and Industrial Drains, 1972 (Permission requested).

Figure 5 is an aerial of the area between J-Street and Industrial Drains in 1972. The backwater at J-Street Drain has not yet connected to the lagoon at Industrial Drain. Channelization of what is now Industrial Drain likely increased the capacity of the lagoon and prevented more permanent flooding of inland areas. This channelization likely increased the frequency of breaching by conveying more flow directly to the lagoon rather than allowing for local storage upland.

Figure 6. Aerial photograph facing Industrial Drain, 1972 (Permission requested).

Figure 6 shows Industrial Drain and a small lagoon including portions of Hueneme Drain. It is obvious that an overwash has occurred at the lagoon in the recent past adjacent Industrial Drain.

Figure 7. Aerial photograph showing J-Street Drain, 1979 (Permission requested).

Figure 7 reflects the dynamic nature of the lagoon system. The lagoon appeared to have been growing in 1972, but by 1979 the lagoon still had not developed to a point at which J-Street and Industrial Drains flow into what is now the Ormond Lagoon.

Figure 8. Aerial photograph showing the area between J-Street and Industrial Drain, 1979 (Permission requested).

Figure 8 shows that, in 1979, Industrial Drain had not recently flowed directly to the Ocean. The overwash features on the beach evident in 1972 are less evident, although still visible . At the time of this photograph, it had likely been at least a few months since Industrial Drain last breached.

Figure 9. Aerial photograph, 1994 (USGS 1994).

The 1994 photograph in Figure 9 shows the lagoon becoming larger between J-Street and Industrial Drain. The lagoon in 1994 exists in the basic configuration that it exists today. Flow from J-Street and Industrial Drains converge into the Ormond Beach Lagoon. The lagoon exists entirely on the beach bounded on its landward side by development and infrastructure.

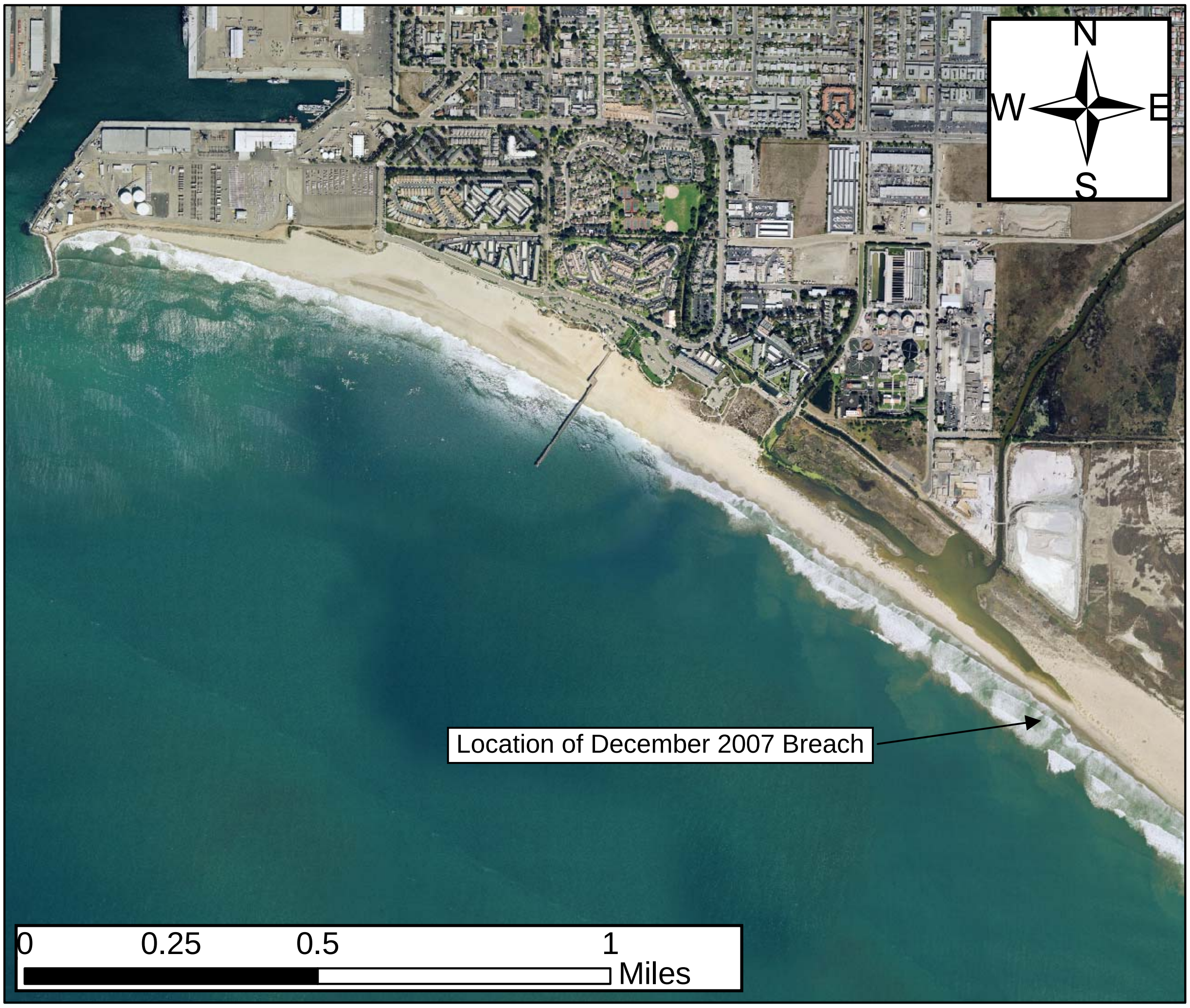

Figure 10. Aerial photograph, 2007 (VCWPD 2007).

Figure 10 shows that in December 2007, it had been some time since the system breached to the Ocean as evidenced by the lack of overwash features. In mid December 2007 the beach breached, connecting the lagoon to the ocean near Industrial Drain. Figure 11 shows a photograph of the breach taken on December 22, 2007. The photograph reflects significant beach erosion since December, 2007.

The historical aerial photographs support the assumption that Ormond Beach Lagoon developed as a result of flow from J-Street and Industrial Drains ponding on the back side of the beach until a catastrophic breach occurs. Flow during the breaching events is likely strong enough across the entire lagoon area to transport sand from the dunes to the ocean. That periodic flow appears to have caused the gradual formation of a semi-permanent lagoon.

Without strong flow within the lagoon during breaching, much of the lagoon area would likely never have developed. It's probable that if both drains provided permanent, constricted flow pathways to the beach, the lagoon would rapidly decrease in size, ultimately resulting in short channels across the beach instead of a lagoon.

Figure 11. Breach on December 22, 2007 (photo from site visit 2/12/2008).

3.0 Literature Review of Coastal Breaching

A review of available literature was conducted to provide background on work completed at other sites and methods applied to analyze lagoon breaching dynamics. The literature reviewed will aid in the upcoming numerical modeling phase, particularly the literature that specifically describes breaching models and sediment transport. This documentation of the literature review is not intended to educate the reader on the specifics of each paper, but rather to direct interested parties to the sources of specific knowledge.

Coastal breaching models have been developed by Basco and Shin (1999), Kraus (2003), Tuan, Verhagen, and Visser (2006), Tuan (2007), Mohamed (2001), Faeh (2007), Srinivas and Dean (1996) and Odd, Roberts, Visser (1998) and Maddocks (2000). Applicable general sediment transport work has been conducted by Madsen and Wood (2002), Myrhaug and Holmedal (2003), Fredsøe and Deigaard (1992), Davies *et al* (2002), Baldock *et al* (2005), Ogston and Sternberg (2002), Smith (2002), Soulsby and Damgaard (2005), and Yu, Sternberg, and Beach (1993).

Case studies evaluating lagoon and beach breaching on the California coast and around the world have been conducted in detail by Kraus (2002), Hansen *et al* (2007) and others. Most of the literature relevant to coastal breaching focuses on a breach occurring during extreme weather events from elevated storm surge levels so that water is flowing from the ocean rather than to the ocean. Stone Lagoon (Kraus 2002) is one example of a case similar to that at Ormond Beach Lagoon in that it breaches seaward.

Big Lagoon and Stone Lagoon in California are connected to several small streams and are prone to breach during or near the end of the rainy season (Joseph 1958). The combined water volume from the stream discharge and runoff during the rainy season gradually raise the water level and cause breaching from the lagoon to the ocean by seepage and failure. The surface area of these lagoons is too small to maintain the necessary velocity for the breach gorge to be self-scouring. A breach occurs in Big Lagoon when the water elevation reaches approximately 3 to 4 m above MSL; however, it does not breach as often as Stone Lagoon because of the larger drainage area at Stone Lagoon.

4.0 Meteorological and Oceanographic Data

Data required to interpret the physical processes forcing morphological development at Ormond Beach lagoon are identified and summarized in the following section.

4.1 Wind

Wind plays a primary role in the lagoon's development through driving nearshore waves, surface currents and aeolian transport. Wind data was obtained from the NOAA's National Data Buoy Center (NDBC). Average hourly winds were analyzed for NDBC Station 46053 offshore Santa Barbara (Figure 12) for the period of 1996 through 2007 and NDBC Station 46025 offshore Santa Monica (Figure 13) for the period of 1997 through 2007. Daily average winds at Naval Base, Port Hueneme (Figure 14) were analyzed for the period from 1996 through 2008 with significant gaps in coverage. Wind directions are displayed following standard meteorological convention.

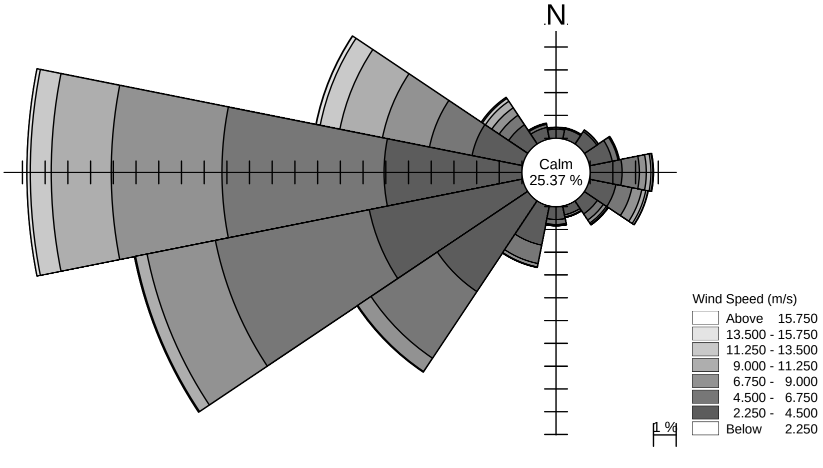

Figure 12. Wind rose for Santa Barbara, Station 46053.

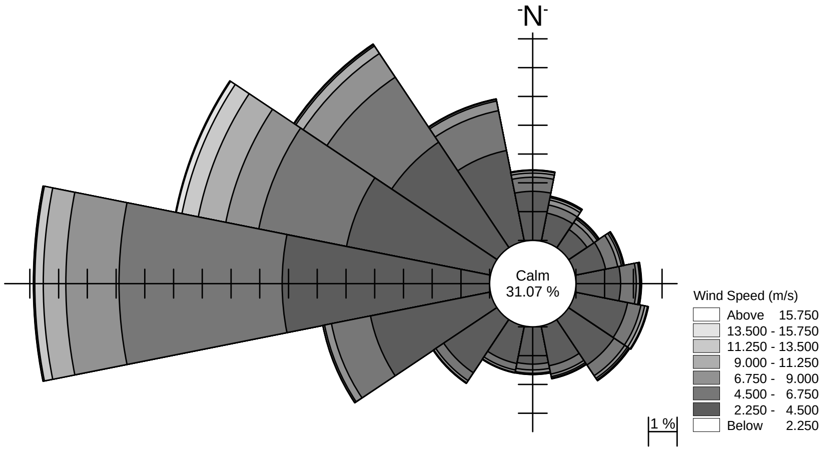

Figure 13. Wind rose for Santa Monica, Station 46025.

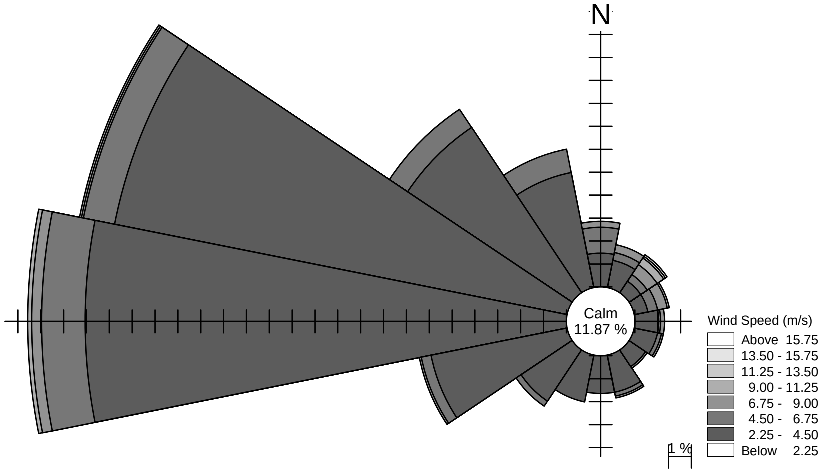

Figure 14. Wind rose for Port Hueneme.

4.2 Waves

Waves were characterized offshore of the proposed project site. Waves drive longshore and cross shore transport at Ormond Beach. These processes coupled with tides and flow from the drainage system force closure of the breach. Wave data will be applied to force the numerical model and estimate the rate at which the breach closes for alternative designs.

Ten years of historical wave data were collected from the NDBC Station 46053 in 1,370-ft deep water offshore of Santa Barbara and Station 46025 in 2,900-ft deep water offshore in the Santa Monica Basin. Wave direction data are not available for Stations 46053 and 46025. Directional wave measurements are available for a one year historical wave record from the Coastal Data Information Program (CDIP) Station 141 in 67-ft deep water offshore of Port Hueneme; these data are plotted in Figure 15. The Port Hueneme buoy was commissioned in 2007. Typically, a longer record is preferred for wave analysis. Data at CDIP Station 141 were compared and applied with the data at NDBC 46053 and 46025 to develop the statistical distribution of waves at the site.

Wave Information Studies (WIS) hindcast data at Station 91 in 14,500-ft deep water are available for the period from 1981 through 2004 (Tracy 2004). As plotted in Figure 16, the WIS data show that the waves offshore are predominantly from the northwest. Wave transformation from offshore is complicated by the shoreline geometry along this section of the California coastline and presence of the Channel Islands.

Local wave direction at Ormond Beach does not typically match that of offshore waves. An obvious reason for this is the shape of the coast from Point Conception to the Mexican border. Waves from the north are limited to local generation by the sheltering effect from the coastline. Waves from the west are also limited by the Channel Islands. Winds are predominantly from the west but the longest available fetch is from the southwest. The Channel Islands also cause waves from the west to refract, increasing the percentage of time waves are from the southwest. Models of waves developed for the breaching model will account for these effects.

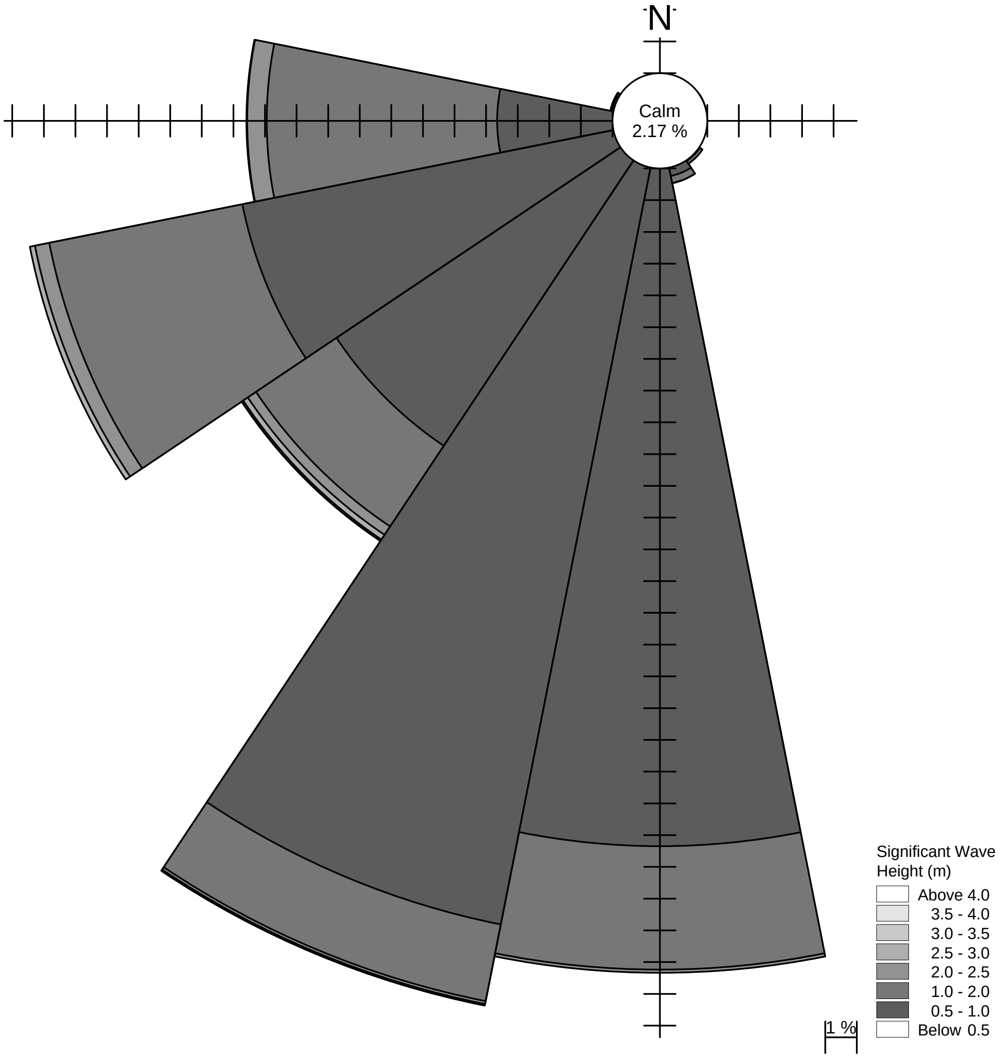

Figure 15. Wave rose for CDIP Station 141.

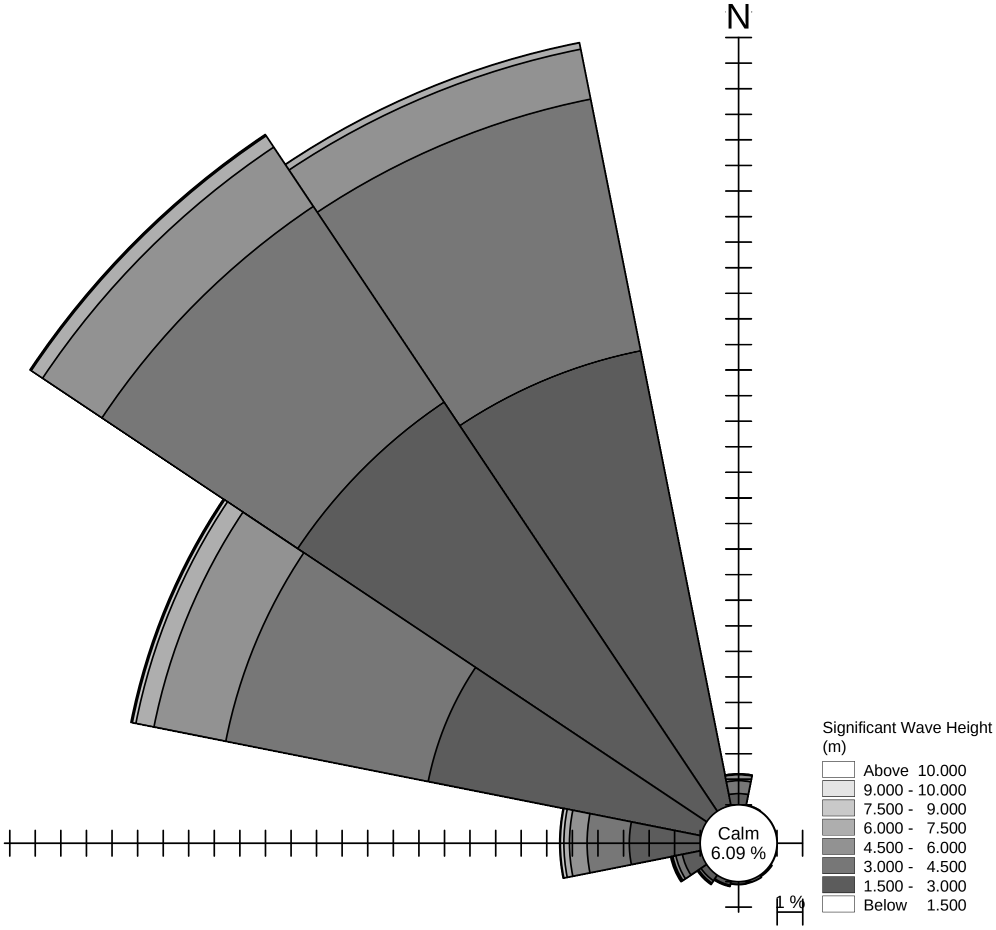

Figure 16. Wave rose for WIS Station 91.

4.3 Tides

Tidal elevation and datum information were obtained from the NOAA tide gauge in Santa Barbara, CA and at the NOAA tide gauge in Santa Monica, CA. The water level analysis, shown in Figure 17, is based on four years of verified historical data at Santa Barbara, and ten years of verified historical data from Santa Monica. Water level statistics were calculated using the average hourly water level reported at each station. Based on these data, percent exceedance of water level was calculated. Tides in the region are predominately semi-diurnal, with two high tides and two low tides occurring per day. Tidal datums and the greater diurnal tidal range, defined as the difference between MHHW (mean higher high water) and MLLW (mean lower low water), at both gauges are summarized in Table 1.

Water level data will be collected inside the lagoon to compare with water level at the tide gauges and to calibrate the numerical model. The water level data inside the lagoon may provide a time history of flow into the lagoon depending on the weather during deployment. Water level in the ocean is generally much lower than the elevation of the beach crest, discussed in more detail in Section 5.0.

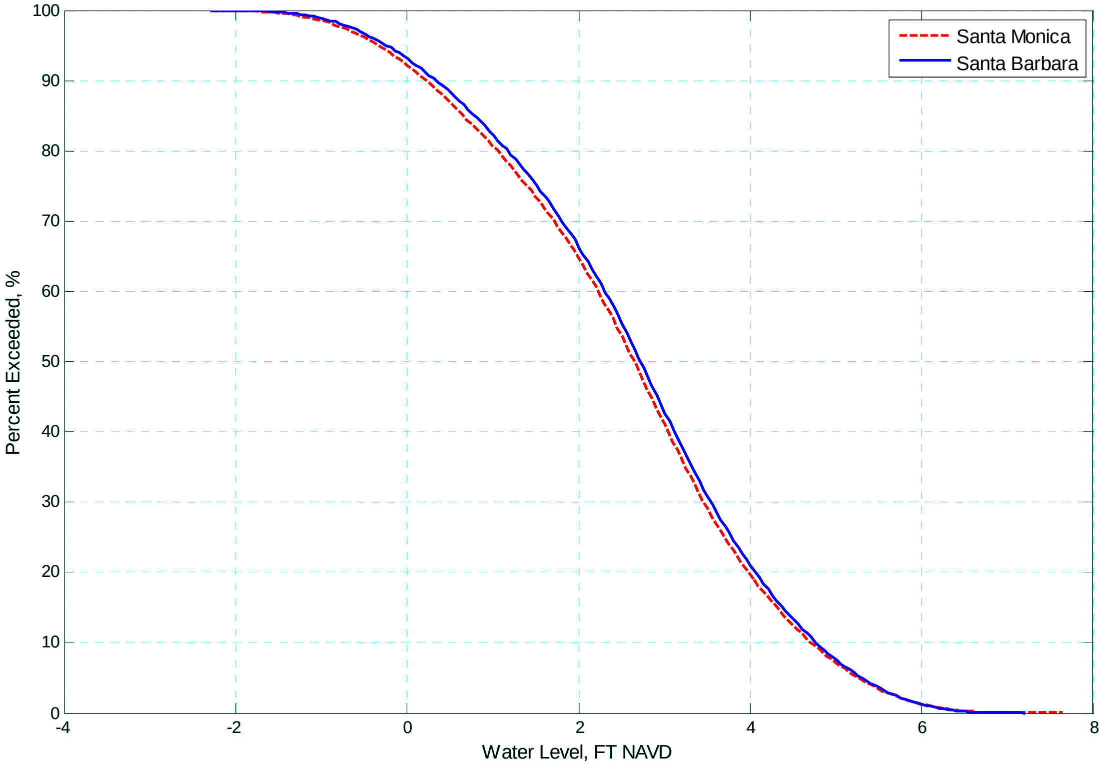

Figure 17. Water level frequency of exceedance.

Table 1. Tidal datums and range.						
Station Name	**MHHW FT (NAVD)**	**MHW FT (NAVD)**	**MSL FT (NAVD)**	**MLW FT (NAVD)**	**MLLW FT (NAVD)**	**Tide Range FT**
Santa Barbara	5.30	4.54	2.69	0.89	-0.09	5.39
Santa Monica	5.24	4.50	2.60	0.74	-0.19	5.43

4.4 Salinity

Some water conductivity data have been provided by Mark Pumford with the City of Oxnard. Salinity in the lagoon is controlled primarily by freshwater inflow, evaporation, and tidal inflow. When the breach is open, salinity in the lagoon is probably the same as the Ocean (averaging around 33 parts per thousand (PPT)). After the breach closes, salinity varies with environmental forcing. Salinity data will be collected to calibrate the numerical models and to calibrate data collected by the City of Oxnard.

5.0 Topography and Bathymetry

LIDAR data for Ormond Beach obtained from TOWILL surveying, mapping and GIS services in July 2001 have been reviewed. Based on this topography, the minimum continuous elevation of the beach seaward of the lagoon is over +10 feet, NAVD. In the area of the preferred breach, south of Industrial Drain, the beach width appears to be less and the elevations are somewhat lower. There is a narrow strip of missing data that may indicate that the beach was breached during the time of the survey.

Observations made during the February 12, 2008 site visit indicate the beach is much lower in the vicinity of the breach, but new are required to quantify the difference.

In general, the data show smooth, parallel contours along the beach. The topographic data do not cover wet areas of the lagoon. Additional aerial survey data are anticipated, but limited surveying within the lagoon should also be performed to define flow paths and for use in hydrodynamic modeling of the lagoon.

Bathymetric data are available for the California coastline including nearshore Ormond Beach from the NOAA National Geophysical Data Center (NGDC) (2008). The data were collected between 1933 and 2001. Data are not available very near the shoreline and in the surf zone. The Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) profiles have been reported to be available but have not yet been obtained. Beach profile survey data should be collected to characterize the near shore beach profile to closure depth.

6.0 Breaching Process Overview

Breaching at the Ormond Lagoon is caused by buildup of water originating from J-Street, Hueneme and Industrial Drains, referred to herein as seaward breaching. Most research into breaching of a beach or barrier island is forced by high coastal water levels and wave induced erosion during severe coastal storms. Except at the existing breach area, the tide must exceed +10 feet NAVD before shoreward breaching is likely to occur. The tide level has not reached the dune crest elevation during the available tide record starting at 1933 when the Santa Barbara gauge was installed. The maximum tide recorded at the Santa Barbara gauge was +7.26 feet NAVD. Under a very extreme event, large waves could overtop the dunes, but they are unlikely to cause a breach unless associated with significant rainfall. Further analysis of waves during the modeling phase will help quantify this possibility; regardless, the dominant breaching process is seaward and is caused by storm water flooding.

Tuan (2007), following Gordon (1990), describes the breaching process of coastal lagoon barriers due to overflow induced by heavy rain, as follows:

> “The lagoon breakout stage is observed to consist of three distinct stages. In the first stage, a preferred scour channel (initial channel) is formed and cuts backwards across the barrier. The flow is subcritical in the breach section and supercritical on the down slope. The second stage commences when a crescent-shaped weir forms in the main sand plug followed by a series of steps in the channel. The breach width increases rapidly as the breach flow is highly turbulent and supercritical. Once the main sand plug has been washed out completely, the final stage begins with a slower rate of breach deepening and widening.”

After the breach is completely established, tidal exchange between the lagoon and ocean acts to maintain the breach. Waves transport sediment onshore and the varying tide and wave run-up distribute the sediment along the shoreface. Swash transport, similar to transport under a small bore, effectively carries sediment into the breach. When tidal flow in the inlet is insufficient to remove all of the sand being transported by the waves, the breach will begin to close.

Visual observation of Ormond Beach Lagoon suggests that the description provided by Tuan (2007) and Gordon (1990) generally describes the breaching process. The challenge now is to quantify how breaching induces morphologic change in the lagoon and how cross shore processes close the breach and modify the lagoon.

7.0 Conceptual Assessment of Lagoon Morphology

Ormond Beach Lagoon is a dynamic system with morphology forced by upstream inflow, waves, tides, aeolian transport, and anthropogenic factors. A lagoon appears to have been historically present as part of the natural drainage system of the now channelized Industrial Drain. That lagoon did not extend to the limits of the current lagoon between J-Street and Industrial Drains.

Hydrodynamics in the lagoon are forced by inflow from the three drains prior to breaching. During this period it is likely that flow into the lagoon at the transition from the drain to the lagoon is significant during heavy rainfall. This flow appears adequately described by previous models. The flow in the lagoon during this time is probably insignificant and not capable of mobilizing and transporting sediment except very near the drains.

During the breaching process, flow is likely at its greatest everywhere in the lagoon. This period of high velocity everywhere will only last until the water surface in the lagoon has equilibrated with the ocean.

After the water surface in the lagoon is at the same level as the ocean, flow is controlled by the tides and flow from the drains. Areas of high transport (velocity) are probably confined to the breach and narrow sections (channels) in the lagoon. Over a very long period with the breach open, it is likely that channels would form, rather than the shallow lagoon system.

Flow from J-Street, Hueneme, and Industrial Drains created the lagoon in its current state through catastrophic breaching events. Those events enabled sufficient velocity in all parts of the lagoon to encourage sediment transport, effectively creating the environmental habitat that is at issue. Available data suggest that if the lagoon were to be breached permanently, channels would predominantly convey the flow and sand would fill the shallow areas, significantly changing the character of the lagoon from it's current state to resemble the photos from the 1970's (see Figures 4 through 8).

The existing data and previous studies have enabled this qualitative assessment of the breaching process and lagoon morphology and, as such, its accuracy is dependent on the limited data presented. The planned numerical model of hydrodynamics and morphology of the lagoon will help to quantify the breaching process and provide the necessary information on which reliable estimates of environmental impact can be formulated for considered design alternatives.

8.0 Findings and Recommendations

The following findings and recommendations are provided for consideration during permitting, design, and analysis of potential impacts.

1. Limited topographic data and site data are available for the lagoon.
    - Sufficient far field data are available from various sources including topography and bathymetry away from the site.
    - Environmental forcing data away from the site are also available. Analysis must be conducted to adequately transform available data to the project site.
    - Bathymetric and topographic data must be collected to accurately describe the beach/lagoon system. Aerial data will be applied to fill the space between topographic data with the topographic data being applied to rectify the aerial data.
    - Water level, salinity, total suspended solids and grain size distribution of beach sediments must be collected to help describe processes at the site and calibrate models to accurately assess existing conditions and impacts of proposed alternatives.

2. Site data (such as Aerial photographs, limited survey data, limited salinity data, etc.) are available, but there has been limited study by others on lagoon dynamics to date.
    - The lagoon has typically been considered as a boundary condition in the numerous upstream efforts that focused on evaluating flooding; the system has not been analyzed with the goal of assessing impacts to the lagoon.
    - Previous efforts have quantified flow from the drainage system into the lagoon.
    - Planned coastal modeling and data collection efforts will quantify the existing lagoon hydrodynamics and morphology sufficiently to assess potential impacts of project alternatives to the lagoon.

3. Lagoon evolution has been driven by drainage system modifications.
    - Historically the lagoon did not exist as it does today. Seaward breaching processes have created the lagoon.
    - Lagoon evolution is a dynamic process; the lagoon will likely continue to evolve dependent on environmental forcing.
    - Drainage system modifications are primarily responsible for creation of the lagoon.
    - Even minor changes in flow could result in major impacts to the lagoon.
    - Upstream flow drives breaching events, making identification of appropriate accurate current and future hydrographs essential.
    - Coastal modeling and data collection will provide information necessary to accurately predict how proposed alternatives will impact the lagoon.

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