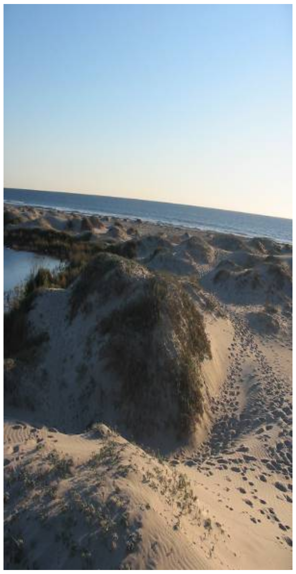
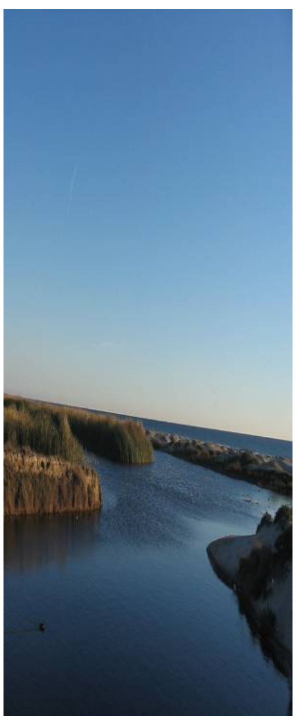


J Street Drain

Sediment Transport Study for Proposed Outlet at Ormond Beach Lagoon

Draft Final Report



August 2011

Prepared for

Ventura County Watershed Protection District
Design and Construction Division
800 South Victoria Avenue
Ventura, CA 93009-1610

Prepared by

HDR Engineering, Inc.
3230 El Camino Real, Suite 200
Irvine, CA 92602

ONE COMPANY
Many Solutions℠

TABLE OF CONTENTS

FIGURES

EXECUTIVE SUMMARY

Ventura County Watershed Protection District has designed a new J Street Drain concrete channel with an outlet about 2.5 feet lower than the existing channel outlet elevation at the Ormond Beach Lagoon. Since the lagoon bottom elevation is approximately at the same elevation as the end of the existing concrete channel, there is a concern that water will be ponded for a long time where the lowered channel meets the existing lagoon bottom elevation. The purpose of this study is to evaluate what storm event would erode the existing lagoon bottom and create an equilibrium slope that will allow the proposed J Street Drain to positively drain to the ocean.

Sediment transport modeling with HEC-RAS and known storm event hydrographs were used to identify flow conditions that would allow J Street Drain to drain to the ocean. It was determined that two consecutive 2-year flood events (occurring in one season) would eliminate the ponded condition. In addition, one 5-year event would achieve the same results.

In each case, the sediment transport modeling was started from the time of a berm breach such as occurred during January 2010. The action of ocean waves builds up a sand berm at the beach. When the berm becomes substantial, it blocks the flow of water from the lagoon into the ocean. Ventura County Watershed Protection District intends to maintain a berm elevation at a designated breach location. This will facilitate berm breaching whenever the water surface elevation in the lagoon exceeds that elevation. The elevation for the maintained berm will be determined from an inland flooding study; the Watershed Protection District has maintained the berm recently at elevation 6.5 feet ± NGVD 1929, 6 inches above the water surface elevation in the lagoon. Based on survey data taken in 2010, when the berm breaches, the elevation of the berm is reduced to about 1.0 feet ± NGVD 1929. This was the starting berm elevation used for the sediment transport modeling. Note that at the lagoon location, 0 feet NGVD 1929 = 2.42 feet NAVD 1988.

Once the lagoon bottom elevation has been reduced to the elevation of the concrete channel outlet between the channel outlet and the designated berm breach location, it is not expected that it will fill in again because the sediment load from the J Street Drain watershed is very low. However, during the time that the berm is re-built by the natural action of the ocean waves, the outlet of J Street will be inundated. In addition, because the tidal cycle peaks twice each day and the peak tide exceeds the channel outlet elevation, the channel outlet will be inundated at least twice per day even after berm breaching and erosion of the bottom material in the lagoon.

1.0 BACKGROUND AND APPROACH

The purpose of this study is to investigate the development of an equilibrium lagoon channel bottom slope between the outlet of the proposed J Street Drain channel improvements and the Pacific Ocean at Ormond Beach Lagoon. The proposed Phase 1 improvements to J Street Drain generally consist of replacement of approximately 2,800 feet of existing trapezoidal open channel with a deeper and wider-bottom concrete rectangular channel. The improvements will lower the channel outlet approximately 2.5 feet below the existing channel bottom. This will create a sump condition since the existing lagoon bottom elevation (elevation 3.0 feet ± NGVD 1929) is at about the same elevation as the outlet of the existing J Street channel. There are no plans to excavate within the lagoon beyond the project limits in order to create a slope to drain; the primary reason for not excavating is to avoid impacts to endangered tidewater goby and its critical habitat as well as to endangered California least tern foraging habitat.

This study attempts to determine what hydrologic conditions (storm event) would create sufficient flow conditions to erode the lagoon bottom and create an equilibrium slope between the end of the proposed concrete channel and the ocean. To accomplish this, a hydraulic model was created for the J Street Drain, from approximately 500 feet upstream of the concrete channel outfall to a designated lagoon outlet into the Pacific Ocean. The United States Army Corps of Engineers (USACE) Hydraulic Engineer Center River Analysis System (HEC-RAS) software was used to model the channel reach. HEC-RAS includes a module for modeling of sediment transport, which was used to determine movement of lagoon bed material during various flow events.

The natural action of the ocean waves builds up a sand berm on the beach that periodically blocks the lagoon outlet, preventing J Street drainage from reaching the ocean and preventing tidal flow from entering the lagoon. Ventura County Watershed Protection District indicated the intent to maintain a berm elevation at a designated breach location approximately 800 feet southeast of the J Street Drain concrete channel outfall. The elevation for the maintained berm will be determined from an inland flooding study; the Watershed Protection District has maintained the berm recently at elevation 6.5 feet ± NGVD 1929, 6 inches above the water surface elevation in the lagoon. Based on this, it was assumed for this study that a berm breach would occur at the identified location and exist prior to sediment model runs. HEC-RAS modeling used a combination of hydrographs representative of runoff for the J Street Drain and the Hueneme Drain (see Figure 1). The downstream water surface boundary influence was based on tidal elevations obtained from the National Oceanic and Atmospheric Administration (NOAA).

A number of different inflowing hydrographs were used to define either a single storm event or series of storm events that would create a channel within the lagoon with positive drainage from the J Street Drain concrete channel outfall to the Pacific Ocean. Results from those sediment transport models were reviewed to interpret the sensitivity of the model to input data and the inundation frequency of the J Street Drain outlet.

| Path | Created by: | Last Updated : 00-00-00

HDR
ONE COMPANY | *Many Solutions*℠

HEC-RAS Cross Section Layout

FIGURE 1

Ventura County | J Street Drain | Sediment Transport Study for Proposed Outlet at Ormond Beach Lagoon

2.0 SEDIMENT TRANSPORT MODELING

The USACE HEC-RAS model, version 4.1, was selected for hydraulic and sedimentation modeling of the J Street Drain and Ormond Beach Lagoon. HEC-RAS provides a seamless integration of sediment modeling modules within the widely accepted one-dimensional hydraulic modeling platform.

2.1 MODEL GEOMETRY

Aerial topography information obtained by HDR was used to create the hydraulic model. A three-dimensional surface was created from topography flown in 2008 in conjunction with bathymetric data for Ormond Beach Lagoon collected in 2008. Bathymetry data used in surface creation was obtained from the *J Street Drain Coastal Engineering 2008 Beach and Lagoon Monitoring Program* study, prepared by Coastal Frontiers Corporation for HDR. HEC Geo-RAS was used within Arc GIS to cut cross sections from the three-dimensional surface used in the hydraulic modeling. J Street Drain concrete channel and riprap dissipater geometry were obtained from *"J" Street Drain Improvements Phase I (2011)* construction plan documents, and were manually entered into HEC-RAS. A final downstream cross section was established in the Pacific Ocean assuming a wide flat plain located below mean sea level. All elevation data presented in this report is referenced to the NGVD 1929 datum, unless otherwise specified. Figure 1 illustrates the HEC-RAS cross section layout used in the modeling.

A berm breach was assumed to occur approximately 800 feet southeast of the J Street Drain concrete channel outfall. A mechanical breach location was identified in survey information from Ventura County Watershed Protection District, taken in January 2010. The modeled berm breach location was based on the same location. Modeled breach geometry was manually entered into HEC-RAS berm cross sections. Berm breach widths were established to be approximately 130 feet to 220 feet wide based on the 2010 berm breach survey. A narrow 50-foot low-flow channel was created through breach sections to maintain low flow channel continuity with the lagoon. Breach invert elevations were established at elevation 1.0 feet ±, similar to breach invert elevations identified in the 2010 survey.

Manning's roughness coefficients used in the hydraulic modeling were calculated using criteria in *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains* by the United States Department of Transportation, Federal Highway Administration (FHWA). A roughness coefficient (n value) of 0.024 was used for all bare sand channels and 0.04 for all vegetated channel and overbank areas. The Manning-Strickler equation was used to calculate the n value for the proposed riprap at the end of the J Street Drain concrete channel. Assuming 4-ton riprap with a mean diameter of 4.5 feet, the calculated n value is 0.051. An n value of 0.015 was used for all J Street Drain concrete channel.

Channel bank points were established at the top of the proposed concrete J Street Drain channel obtained from design plans. Earthen channel bank points were located at the extents of the low-flow channel created in the topographic cross sections as described above. This was done to develop consistent channel hydraulics for sediment transport calculations.

Ineffective flow areas were used to eliminate flow areas outside of the active flow path throughout the model. Flow expansion and contraction was accounted for with application of ineffective flow areas upstream and downstream of the breach location and at the earthen channel outfall into the lagoon.

2.2 BOUNDARY CONDITIONS

A steady state HEC-RAS plan was created to compare model results for the 100-year flood with results from a previously completed Water Surface Pressure Gradient (WSPG) program analysis. For the HEC-RAS modeling, a mixed flow regime was simulated with an upstream water surface elevation established at normal depth in the concrete channel and a downstream water surface elevation at mean sea level (elevation 0.16 feet NGVD). The mean sea level elevation for the downstream boundary was obtained from the NOAA Santa Monica tidal gage (Station 9410840), one of the closest tidal gages to the J Street Drain location.

Sediment transport modeling uses a “quasi-unsteady” flow regime and requires a downstream water surface boundary condition and an upstream inflowing sediment load. NOAA tidal information from the Santa Monica gage was used to create a downstream boundary tidal series. Mean higher high water, mean high water, mean low water, and mean lower low water elevations were used to represent the typical series of high and low tides. Figure 2 illustrates a representative repeating tidal series which peaks twice per day. Figure 2 was based on tidal graphs found in the Santa Monica gage station data but edited to include the high and low reference elevations just cited. Figure 2 represents the repeating cycle used for the sediment transport model downstream boundary.

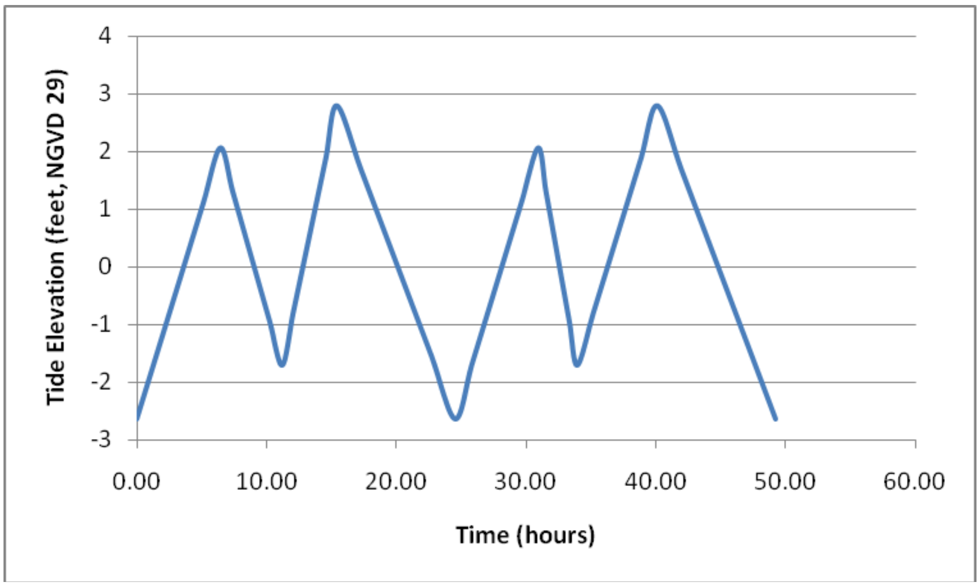


Figure 2: HEC-RAS Downstream Boundary Tidal Series

Each sediment transport model described in this report was run with a tidal series starting both at low tide (-2.63 feet) and at high tide (2.79 feet). It should be noted that when two storm events were modeled in sequence, the tide series was re-set at the appropriate high or low tide at the beginning of each storm event.

Inflowing sediment load was assumed to be zero for the J Street Drain. Previous analysis completed by HDR, in *Sedimentation Study for the J Street Drain and Oxnard Industrial Drain,* based on the United States Department of Agriculture RUSLE2 computer program, identified minimal sediment delivery from the watershed through the J Street Drain. Annual sediment yield for J Street Drain and Hueneme Drain combined was approximately 17 tons per year or about 5 percent of the total estimated annual load to the lagoon. This inflowing sediment load was assumed to be insignificant to sediment transport occurring within the lagoon during a breach cycle as discussed in more detail later.

2.3 HYDROLOGY

For the steady state discharge modeling for the 100-year event, the design discharge provided by Ventura County Watershed Protection District (2,127 cfs at the outfall of the J Street Drain concrete channel) was used. This flow rate includes runoff from Hueneme Drain.

Sediment transport modeling required “quasi-unsteady” flow data, which was input as a hydrograph broken into 5-minute periods. Ventura County Watershed Protection District provided hydrograph information to HDR for the J Street Drain and Hueneme Drain for the 2-year, 5-year, 10-year, 50-year, and 100-year storm events. Flows of interest, based on sediment modeling performance, were the 2-year, 5-year, and 100-year storm events, which are shown in Figure 3, Figure 4, and Figure 5, respectively.

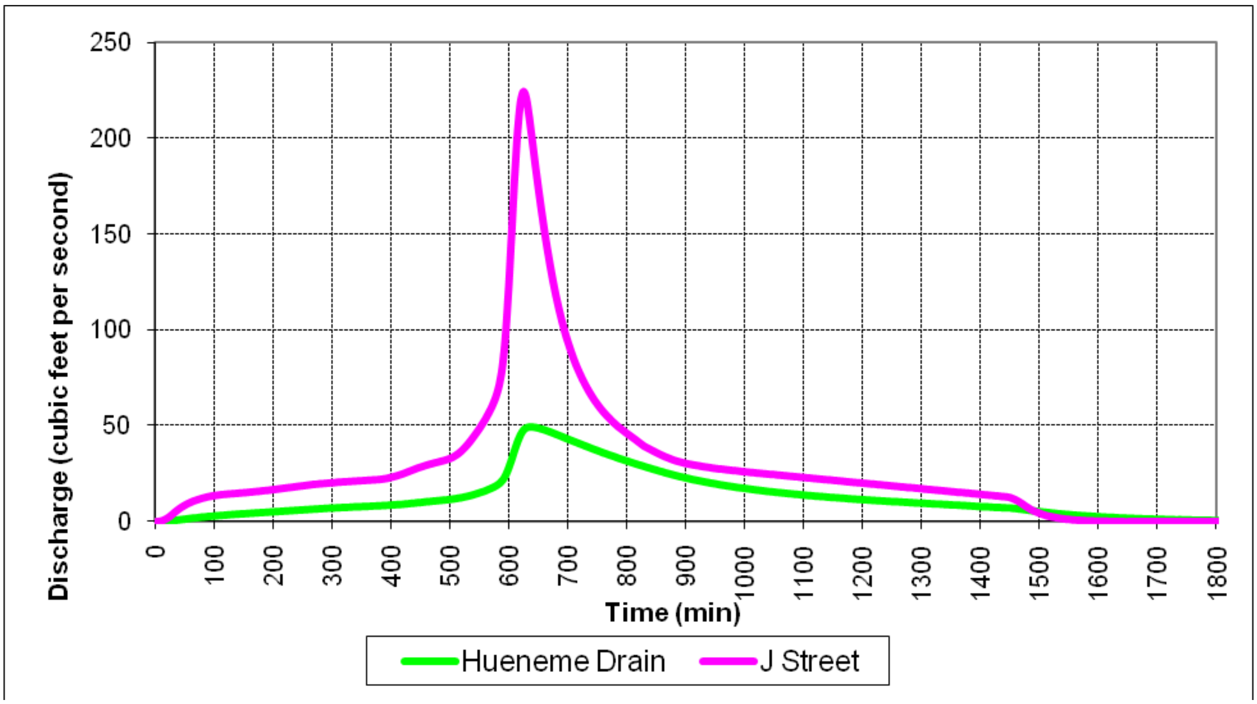


Figure 3: 2-Year Storm Hydrograph

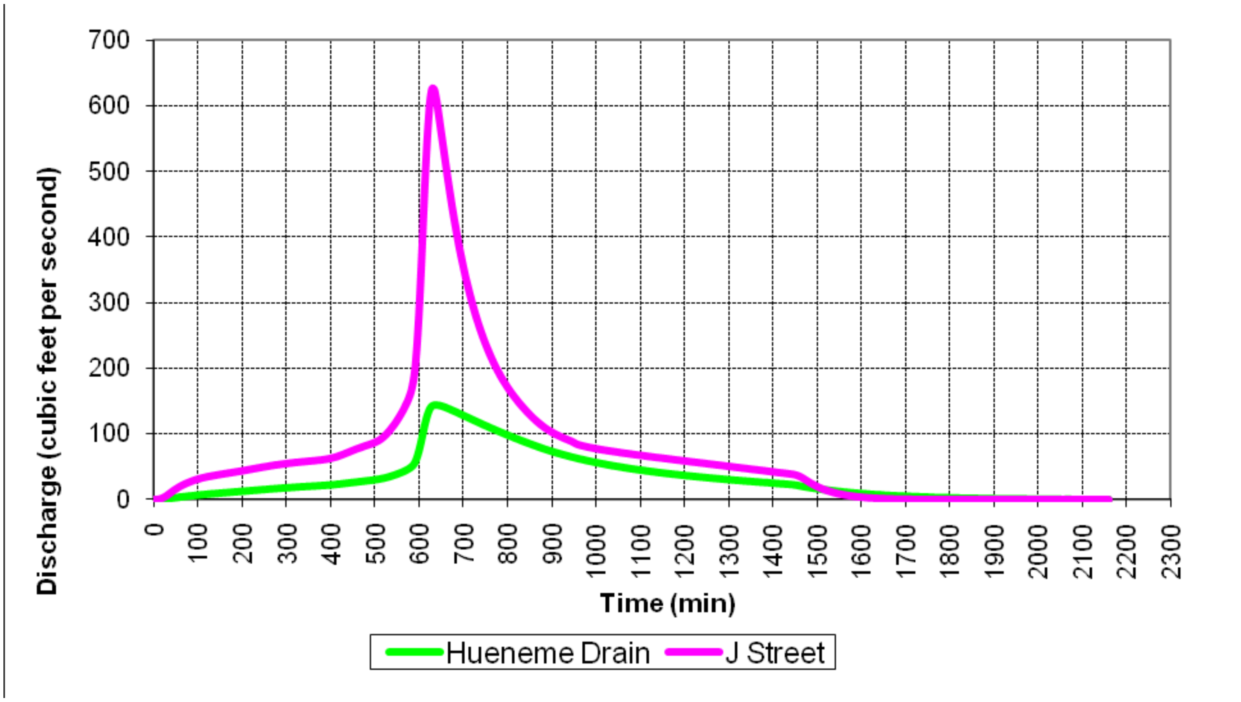


Figure 4: 5-Year Storm Hydrograph

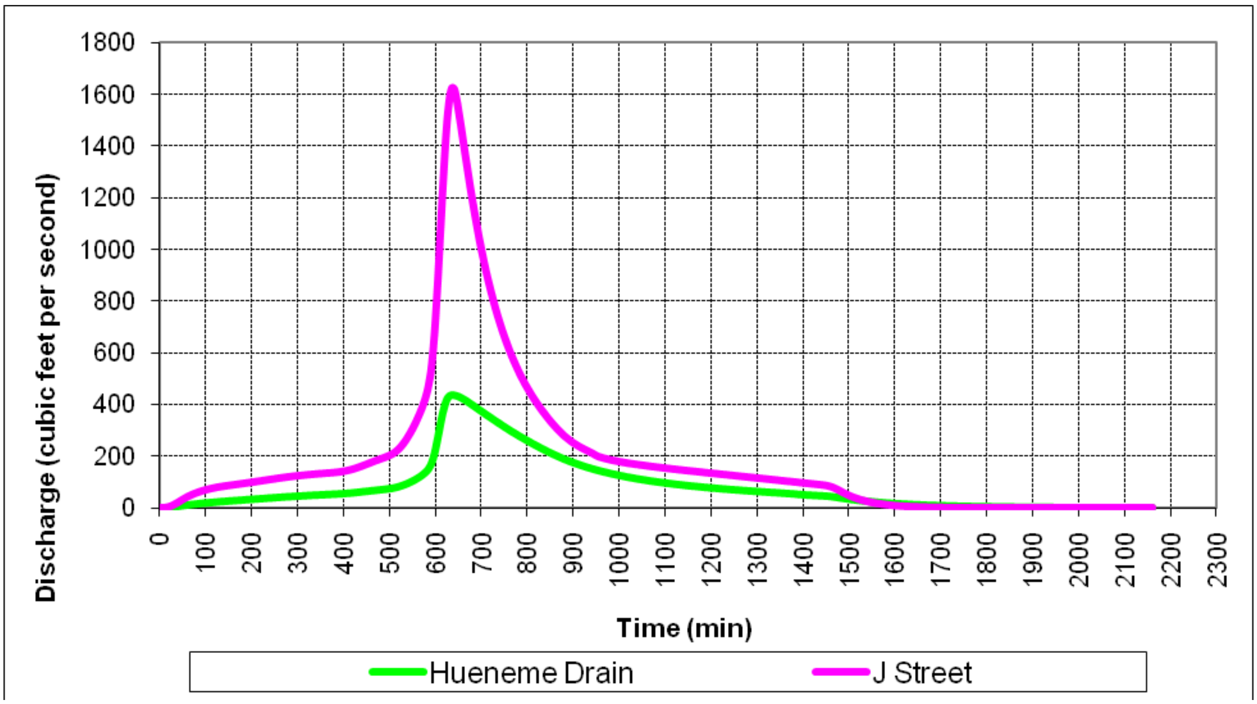


Figure 5: 100-Year Storm Hydrograph

The J Street Drain hydrograph was input into the upstream HEC-RAS river station 1813. Hueneme Drain flows were input into the model as a lateral flow series at river station 1407. Hueneme Drain and J Street Drain hydrographs were allowed to combine with coincident peaks, to be consistent with the hydrograph plots provided by the Watershed Protection District.

2.4 BED GRADATIONS AND SEDIMENT MODELING

Sediment sampling and analyses were reported in the *J Street Drain Coastal Engineering 2008 Beach and Lagoon Monitoring Program* study prepared by Coastal Frontiers for HDR. This data was used to identify grain size distributions representative of the outlet of J Street Drain channel in the lagoon and the beach berm area. Berm area grain size distributions were taken from Transect OL01 data in the report. Figure 6 is a screen capture of the grain size distribution used in sediment modeling for the J Street Drain outlet in the lagoon and Figure 7 is a screen capture of the grain size distribution used to represent the berm area. Lagoon J Street Drain outlet grain size distributions were applied between river station 503 and river station 1273. Transect OL01 berm grain size distributions were applied between river station -82 and 293.

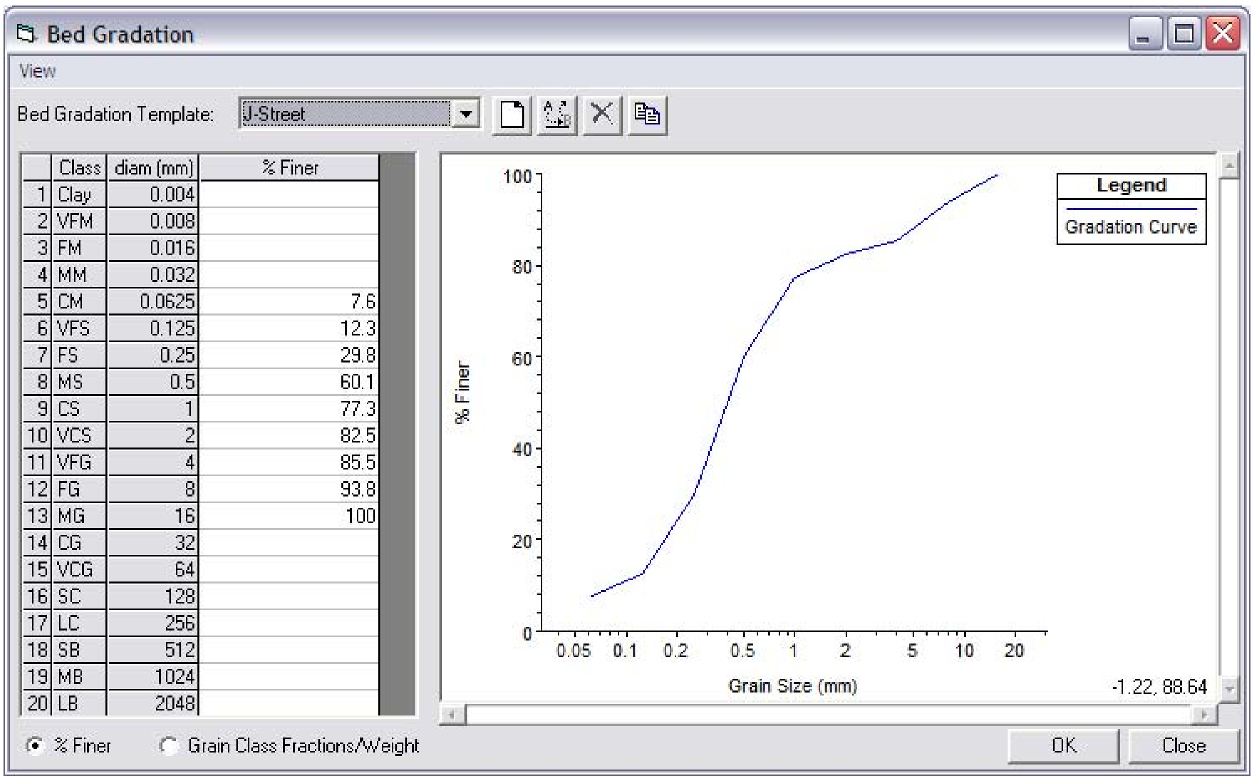


Figure 6: Lagoon J Street Drain Outlet Grain Size Distribution

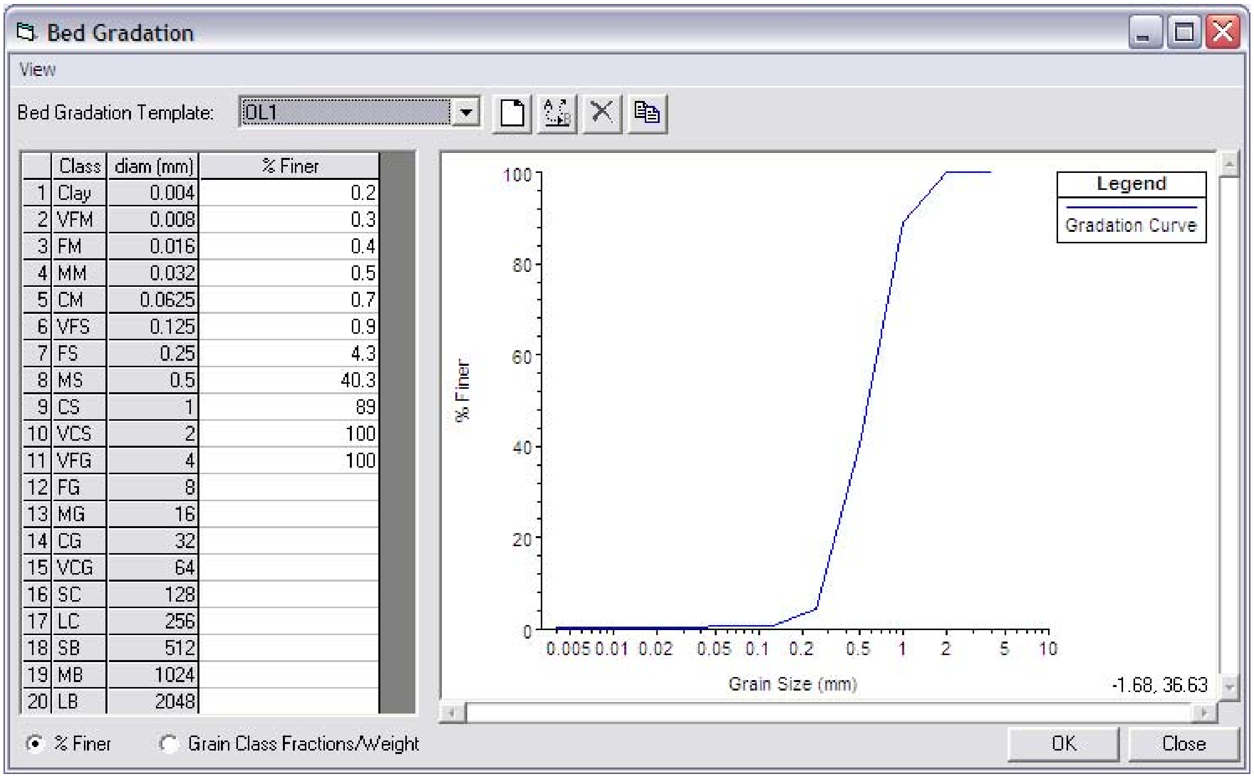


Figure 7: Transect OL01 Berm Grain Size Distribution

Various sediment transport equations were investigated to determine the appropriate equation for the J Street Drain sediment transport study. Ultimately, the Laursen-Copeland method was determined to represent the system most accurately. This transport method is the only option available in HEC-RAS which accounts for silt sized material. Bed sorting calculations were completed using the Exner 5 method. Particle fall velocity was calculated using the Report 12 method. The Report 12 method is the undocumented fall velocity default method in HEC-RAS. It computes fall velocity as a function of particle shape factor. Cross section weighting was set to 100 percent on the main cross section, rather than averaging hydraulic parameters from surrounding cross sections. This option appeared to improve model stability. A pass through boundary was established at the model outlet (river station -82) to eliminate unrealistic deposition of material in the ocean.

Erosion and deposition limits were defined at the bank station points as discussed in Section 2.1 of this report. The focus of this analysis was on the development of a low-flow channel through the lagoon to maintain positive drainage, which supported the selection of erosion and deposition limits in the model. The concrete and riprap portions of the J Street Drain were erosion-limited by application of a 0-foot sediment reservoir depth. Stations downstream of river station 1306 were assigned a sediment reservoir depth of 10 feet below initial invert elevations.

3.0 MODELING RESULTS

3.1 STEADY STATE

HEC-RAS modeling was initiated with a steady state plan to verify hydraulic result agreement with previous analyses. A 100-year water surface elevation at the outfall of the J Street Drain was calculated to be elevation 7.9 feet ±. Previous WSPG software analyses, used in J Street channel design, calculated a water surface elevation at the outfall of 7.4 feet ±. Approximately 500 feet upstream of the J Street Drain outfall, the HEC-RAS water surface elevation was 8.0 feet ±, and the WSPG water surface was 7.9 feet ±. Minor variations in results likely exist due to more refined downstream geometry for the HEC-RAS modeling, variation in starting water surface elevation, as well as differing methods in the programs for calculation of rapidly varied flow conditions and expansion and contraction of flow. However, the results converge within acceptable limits and indicate HEC-RAS results are similar to previous analyses.

3.2 SEDIMENTATION ANALYSIS

A number of hydrologic series were run through the HEC-RAS model to determine a storm event which would erode and transport enough material from the existing lagoon bed to create positive drainage to the Pacific Ocean following an initial berm breach. All storm series were run with the tide series beginning at both low tide and high tide. After a number of model iterations, it was determined that positive drainage of the J Street Drain was achieved with two consecutive 2-year storms. Figure 8 illustrates the sediment transport results of two consecutive 2-year storm events for both high and low tide starting conditions. The phrase “two consecutive storms” implies that the storm events occur in one season. It is assumed that once breached, the berm does not build up again until the end of the storm season.

For the purpose of this study, the two 2-year storms were run consecutively over a 70-hour period. The plotted 2-year consecutive storm sequence assumes that the breach condition exists prior to the storm event and throughout the duration of the approximatley 70-hour two-storm hydrologic series. Minor variations in results can be seen, resulting from the variation in tidal downstream control sequencing. Tidal sequencing can be completed for infinite initial conditions; however, the high and low tide initial conditions provide a good representation of model bounds. There is a high point of elevation 0.68 feet ± at river station 1096 in the high tide scenario; however, due to the complex nature of sediment modeling, this result was still viewed as a reasonable indicator for positive drainage.

To recap, the sediment tranport simulation was based on two consecutive 2-year storms run consecutively in the model over a 70-hour period. It is expected that the results would be similar for two storms separated within a single season if the berm did not build up between the storms. Although not modeled explicitly, it is also judged that if the first 2-year storm occurred after a berm breach and then the berm reformed, a second 2-year storm in a later year would be able to achieve the equilibrium slope in the lagoon if the berm was breached prior to the second 2-year event.

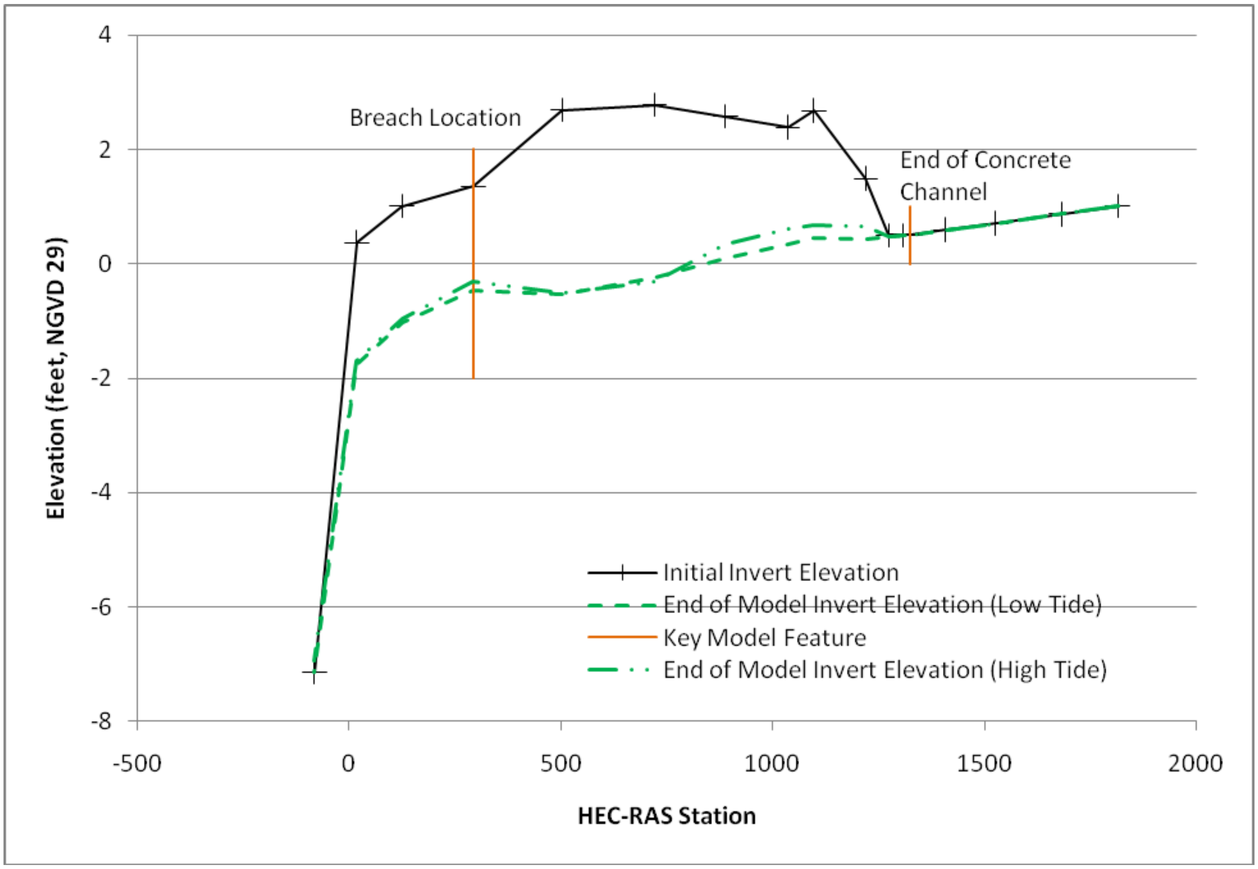


Figure 8: Sediment Transport Modeling Results: Two Consecutive 2-Year Storm Events

A single 5-year storm also created positive drainage through the lagoon for the J Street Drain and Hueneme Drain outfalls. Figure 9 illustrates the sediment transport model results for both high and low tide initial conditions. Modeled results assume an initial breached condition, which is maintained throughout the approximately 36-hour single-storm hydrologic series. Minor variations in sediment results between high and low tide initial conditions are illustrated. Bed elevations are slightly higher on the berm compared to the lagoon at the breach location due to changes in bed material gradations and modeling refinement limitations. The one-dimensional sediment transport model is generally considered an erosion and deposition trend indicator as opposed to a method to produce precise and accurate bed elevations over time or at the end of a simulation.

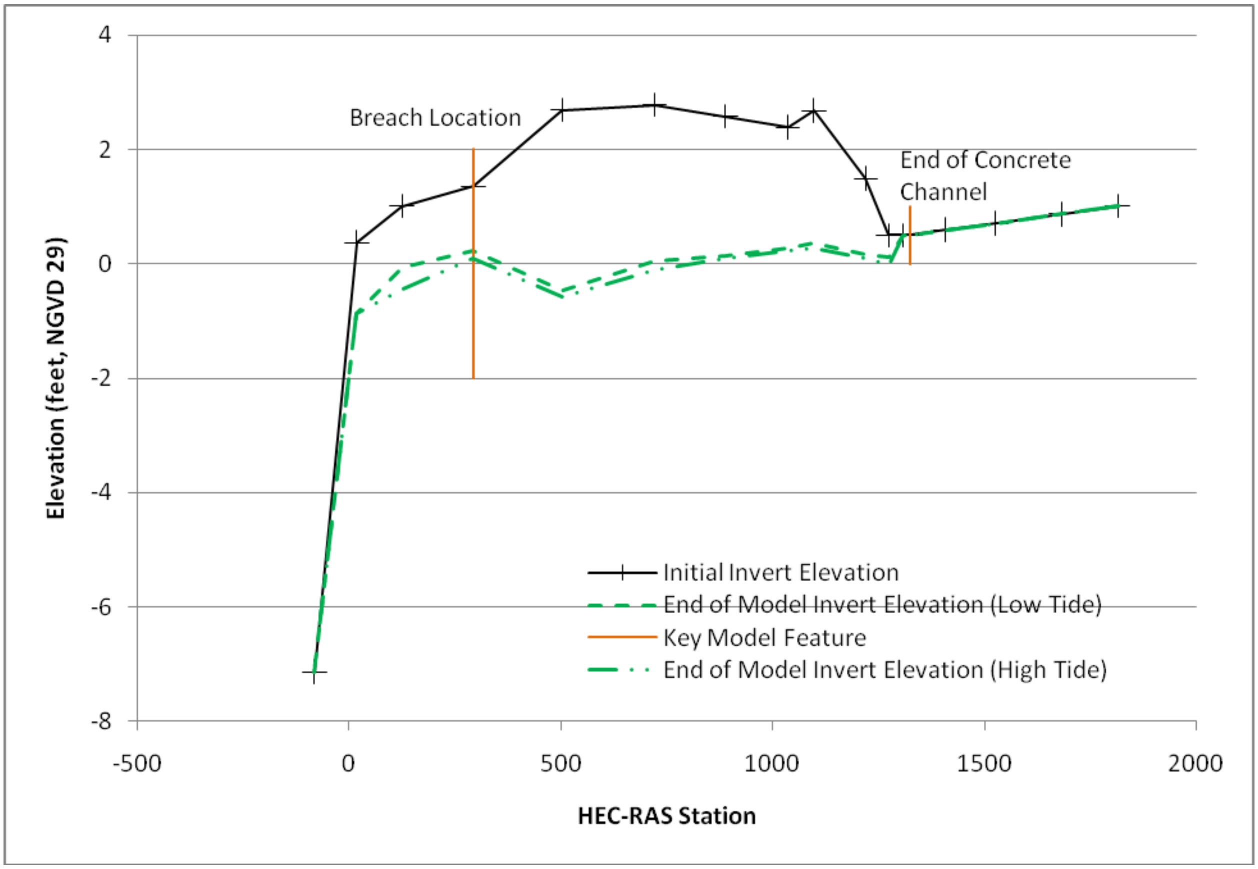


Figure 9: Sediment Transport Modeling Results: 5-year Storm Event

Finally, a flow series consisting of a 5-year storm followed immediately by a 100-year storm was modeled to simulate an extreme scour condition. This configuration represents a situation where existing sediment above the proposed J Street Drain outfall elevation has been washed out of the lagoon and a high-flow flood event occurs immediately thereafter. Figure 10 illustrates both the high and low tide initial condition results for the 5-year storm followed by the 100-year storm series.

The resulting maximum scour invert elevation in the lagoon is at elevation -4.2 feet ±. It is noted that the end of simulation invert elevations at the breach location are higher than in the lagoon, but it should be recognized that the model is primarily configured for low-flow events. It is expected that extensive time spent on modeling refinements would most likely result in a smoother profile with somewhat less overall scour elevation results.

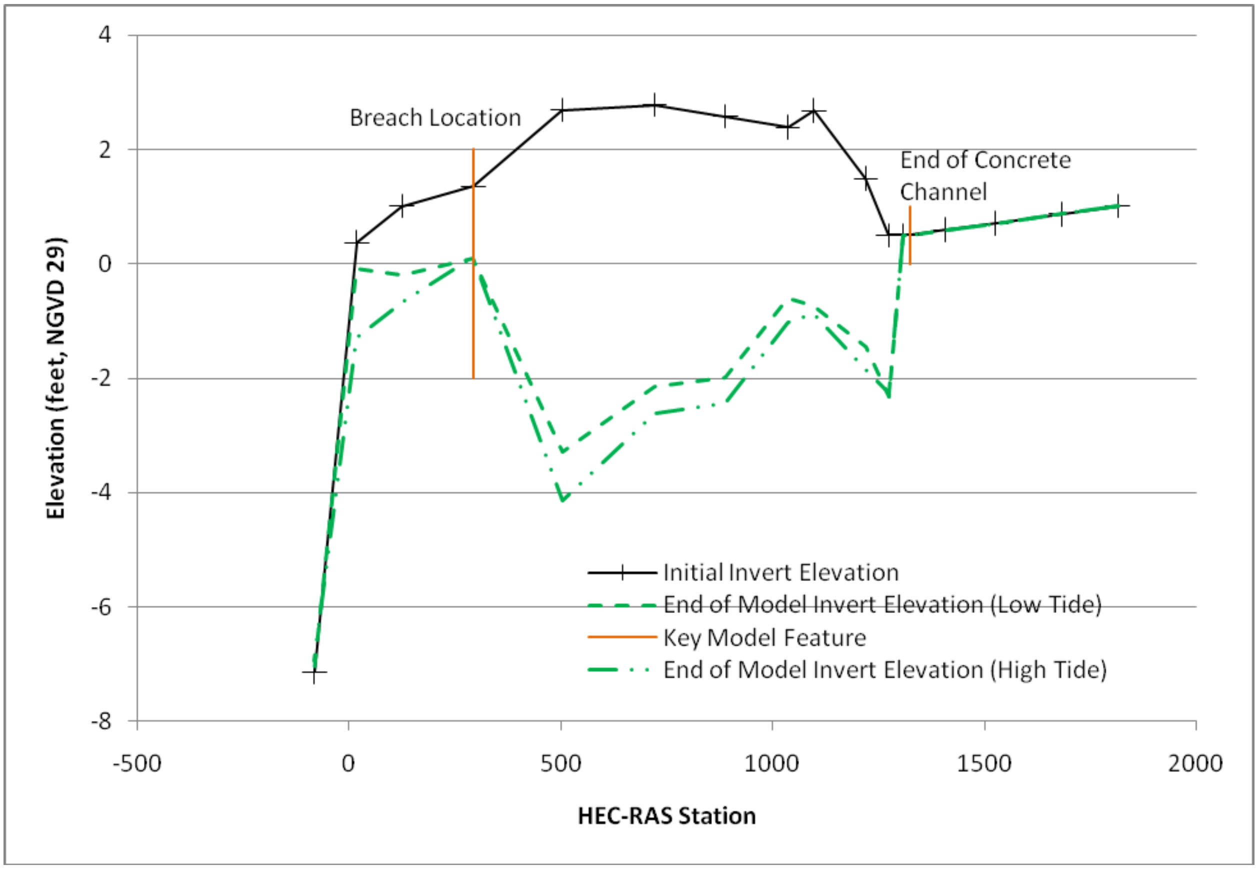


Figure 10: Sediment Transport Modeling Results: Consecutive 5-Year and 100-Year Storm Events

3.4 DISCUSSION

Sediment transport modeling identified two threshold conditions at which the lagoon bottom downstream of the proposed J Street Drain concrete channel outfall would erode to maintain positive drainage for the proposed improvements. Either two consecutive 2-year storm series or a single 5-year storm series would create a low-flow channel capable of maintaining positive drainage. The probability of a 2-year flood event in a given year is 50 percent. The probability of two consecutive 2-year storms occurring in any given year is approximately 25 percent. The probability of a 5-year storm occurring in a given year is 20 percent. The probability of a 5-year flood event occurring within a 3-year period is approximately 50 percent.

Sediment transport modeling results are highly dependent on several key assumptions. In all modeling, an initial berm breach condition was assumed. Without intervention, a breach condition is highly variable depending on flow conditions within the lagoon and the development of the beach berm by the ocean waves. A controlled breach location with a maintained elevation will facilitate conditions similar to those used in the modeling. It should also be noted that scour from tidal flows in and out of the lagoon through the breach was not considered for this analysis.

Given the proximity of the proposed J Street Drain outfall elevation to mean sea level, tidal cycles have a large impact on sediment transport capacity of the system. Even in a fully-breached lagoon berm condition, the J Street Drain will likely be inundated twice a day from tidal action. When a berm is present, the channel is also likely to be inundated to some extent over a long period, from lagoon backwater.

Based on previous analyses discussed in *Sedimentation Study for the J Street Drain and Oxnard Industrial Drain*, a total inflowing load potential of 17 tons per year was calculated for J Street Drain and Hueneme Drain. This load is insignificant compared to the total load (5,000 tons) leaving the sediment transport model in the two consecutive 2-year storm series. Annual inflowing load represented approximately 0.30 percent of the out-flowing storm sediment load, and as such, was assumed to be negligible.

Peak storm event modeling for an extreme scour condition resulted in a maximum scour elevation of -4.2 feet ±. This would indicate potential for general scour degradation of approximately 5 feet at the toe of the J Street Drain outfall riprap pad. It is recommended to provide scour protection of at least 10 feet for the toe of the riprap.

4.0 CONCLUSIONS

The proposed improvements to J Street Drain will lower the existing channel outlet to an elevation of 0.5 feet NGVD 1929. The current Ormond Beach Lagoon bottom at the channel outlet is at elevation 3.0 feet ±. Without excavating a drainage outlet in the lagoon, the lagoon bottom will be higher than the channel outlet after project construction. This will create a condition where J Street Drain will not be able to completed drain through the lagoon. Sediment transport modeling illustrates that if a breached berm condition exists for Ormond Beach Lagoon, it is possible for a new low-flow channel to form in the lagoon. This new low-flow channel would effectively lower portions of the lagoon bottom and maintain positive drainage from the J Street Drain outfall to the Pacific Ocean. Both cases of either two consecutive 2-year storm series or a single 5-year storm series were found to create this low-flow channel. These results are based on a breached condition existing throughout the storm hydrograph. In a maintained breach scenario, and following either storm series just mentioned, the J Street Drain outlet would likely only be inundated until the lagoon elevation exceeds elevation 6.0 feet, during storm events, and twice a day during tidal action.

5.0 REFERENCES

Coastal Frontiers (2008). *J Street Drain Coastal Engineering 2008 Beach and Lagoon Monitoring Program*, dated April 2008.

Federal Highway Administration (1984). *Guide for Selecting Manning's Roughness Coefficients for Natural Channel and Flood Plains.* FHWA-TS-84-204.

HDR, Inc (2008). *Sedimentation Study for the J Street Drain and Oxnard Industrial Drain*, dated March 2008.

NOAA Tides and Currents - Home. National Oceanic and Atmospheric Administration, 03 Aug. 2011. Web. 04 Aug. 2011. <http://tidesandcurrents.noaa.gov/geo.shtml?location=9410840>.

TetraTech, Inc. (2005). *City of Oxnard Floodplain Analysis Industrial Drain, Rice Road Drain, J Street Drain, Hueneme Drain, and Ormond Lagoon*, dated November 2005.

U.S. Army Corps of Engineers (2010a). HEC-RAS Program Software Version 4.1 (Build Date January 2010). Available at http://www.hec.usace.army.mil/software/hec-ras/.

U.S. Army Corps of Engineers (2010b). HEC-RAS River Analysis System User's Manual, January 2010. http://www.hec.usace.army.mil/software/hec-ras/.

U.S. Army Corps of Engineers (2010c). HEC-RAS River Analysis System Hydraulic Reference Manual, January 2010. http://www.hec.usace.army.mil/software/hec-ras/.

Ventura County Watershed Protection District (2008a). AutoCAD topographic data for J Street Drain.

Ventura County Watershed Protection District (2008b). Bathymetry point file for Ormond Lagoon.

Ventura County Watershed Protection District (2010) Hydrographs for J Street Drain, Hueneme Drain, and Oxnard Industrial Drain.

Ventura County Watershed Protection District (2010). "J" Street Drain Field Survey January 20, 2010. VCFB 2010-005.

Ventura County Watershed Protection District (2011). "J" Street Drain Improvements Phase 1 Construction Design Plans.