TECHNICAL MEMORANDUM

To:	**Humboldt Bay Harbor, Recreation, and Conservation District**
From:	**Moffatt & Nichol**
Date:	**April 29, 2024**
Subject:	**Redwood Marine Multipurpose Terminal Replacement Project - Tidal Hydrodynamics and Sedimentation Modeling**
M&N Job No.:	**212991-03**

Disclaimer:

This draft technical memorandum is a work-in-progress and is intended to be an internal document for use by the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project Team as a part of the conceptual design process and the ongoing permitting process. This memorandum is meant to be read as part of a comprehensive packet of technical analyses. It is not written to be a standalone document and it is assumed that the reader has substantial project knowledge and context to understand the memorandum's content. All aspects of this memorandum are subject to change and may become less accurate over time. To better understand the project, please review the more comprehensive and up to date documents posted to the Humboldt Bay Harbor District's website at https://humboldtbay.org/humboldt-bay-offshore-wind-heavy-lift-marine-terminal-project-3

1. Introduction

The Humboldt Bay Harbor, Recreation and Conservation District (Harbor District) is proposing to redevelop an approximately 180-acre site, the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project (Project) at the Port of Humboldt Bay, California, on the Samoa Peninsula. The Project would provide a new multi-purpose, heavy-lift marine terminal facility to support the offshore wind energy industry and other potential, future, coastal-dependent industries. The new marine facility would include both landside and waterside components as part of the redevelopment and would serve as a facility for the vertical integration, launching, and long-term maintenance of fully assembled wind turbine generators (WTGs). The Project does not include the planning, design, construction, or operation of offshore wind farms.

This project seeks to redevelop the existing Redwood Marine Terminal Berth 1 (RMT1) and its associated uplands on the Samoa Peninsula of Humboldt Bay to support the offshore wind industry in the Pacific Outer Continental Shelf (OCS) region. The project includes dredging three areas adjacent to the federal navigation channel to support safe navigation, berthing, and assembly of WTGs (see Figure 2-3):

- Dredging the wharf and pier berthing areas to Elevation -40 ft, Mean Lower Low Water or MLLW (west of Samoa Channel)
- Dredging a sinking basin to Elevation -38 ft, MLLW (east of Samoa Channel and west of Tuluwat Island)
- Dredging a sinking basin to Elevation -38 ft, MLLW (north of Samoa Turning Basin and south of the Bridge)

RMT1 is uniquely located with no air draft restrictions and direct access to a federally maintained deep water channel (see Table 1-1 for the federally authorized channel dimensions). RMT1 is comprised of approximately 160 acres of useable upland space. Upgrades to the existing uplands, utilities, and marine infrastructure are required for RMT1 to serve as the regional WTG staging port, and component and foundation manufacturing port. The facility's existing size, location, and direct unimpeded access to open water, as well as vicinity to the Bureau of Ocean Energy Management (BOEM) offshore wind Humboldt Call Area make it an ideal candidate to serve as an offshore wind hub (co-location of marshalling and manufacturing terminals) in this region. Figure 1-1 presents the project site and Humboldt Bay area and Figure 1-2 presents the conceptual master plan for the project.

Moffatt & Nichol (M&N) was retained by the Harbor District to conduct numerical modeling of hydrodynamics and sediment transport in support of the Project. The purpose of the numerical modeling is to evaluate potential changes of tidal hydrodynamics and sedimentation as a result of the proposed project dredging. This memorandum presents numerical modeling development, model inputs and results for tidal hydrodynamics and sedimentation.

TABLE 1-1: HUMBOLDT BAY FEDERAL NAVIGATION CHANNEL DIMENSIONS (USACE, 2021)

Navigation Channel	Depth (ft, MLLW)	Width (ft)	Length (ft)
Bar and Entrance Channels	48	500 to 1,600	8,500
North Bay Channel	38	400	18,500
Samoa Channel	38	400	8,100
Samoa Turning Basin	38	1,000	1,000
Eureka Channel	35	400	9,700
Field's Landing Channel	26	300	12,000
Field's Landing Turning Basin	26	600	800

FIGURE 1-1: OVERVIEW OF HUMBOLDT BAY NAVIGATION CHANNELS AND RMT1 PROJECT SITE

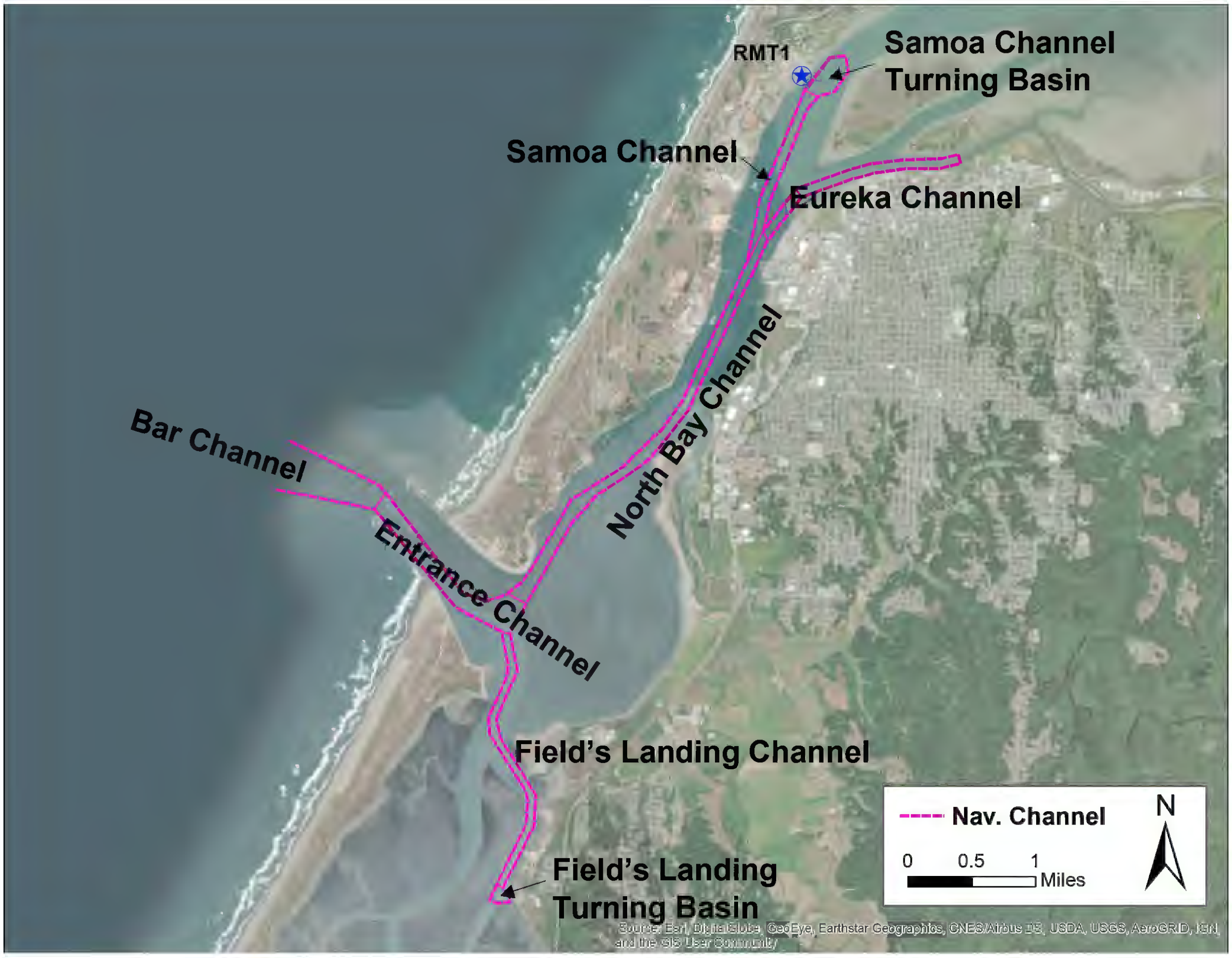
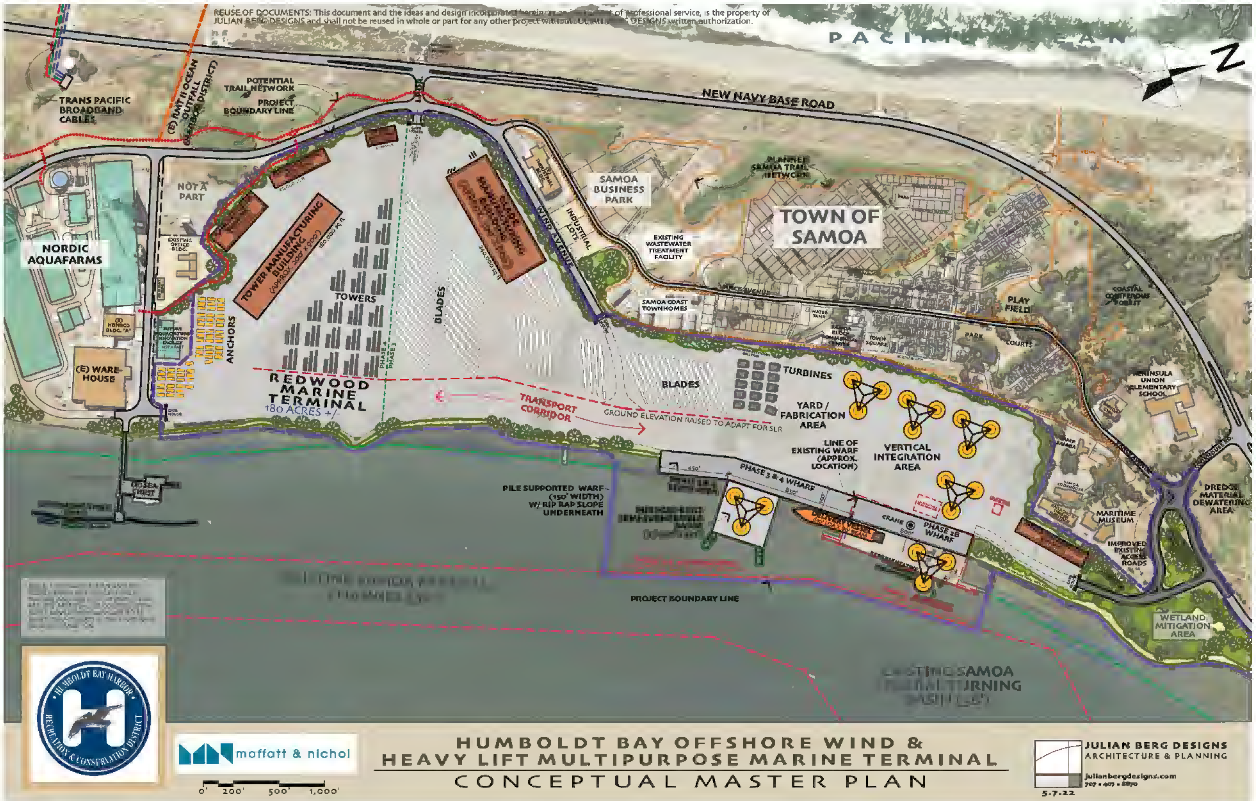


FIGURE 1-2: CONCEPTUAL MASTER PLAN OF RMT1 REDEVELOPMENT



2. Tidal Hydrodynamics

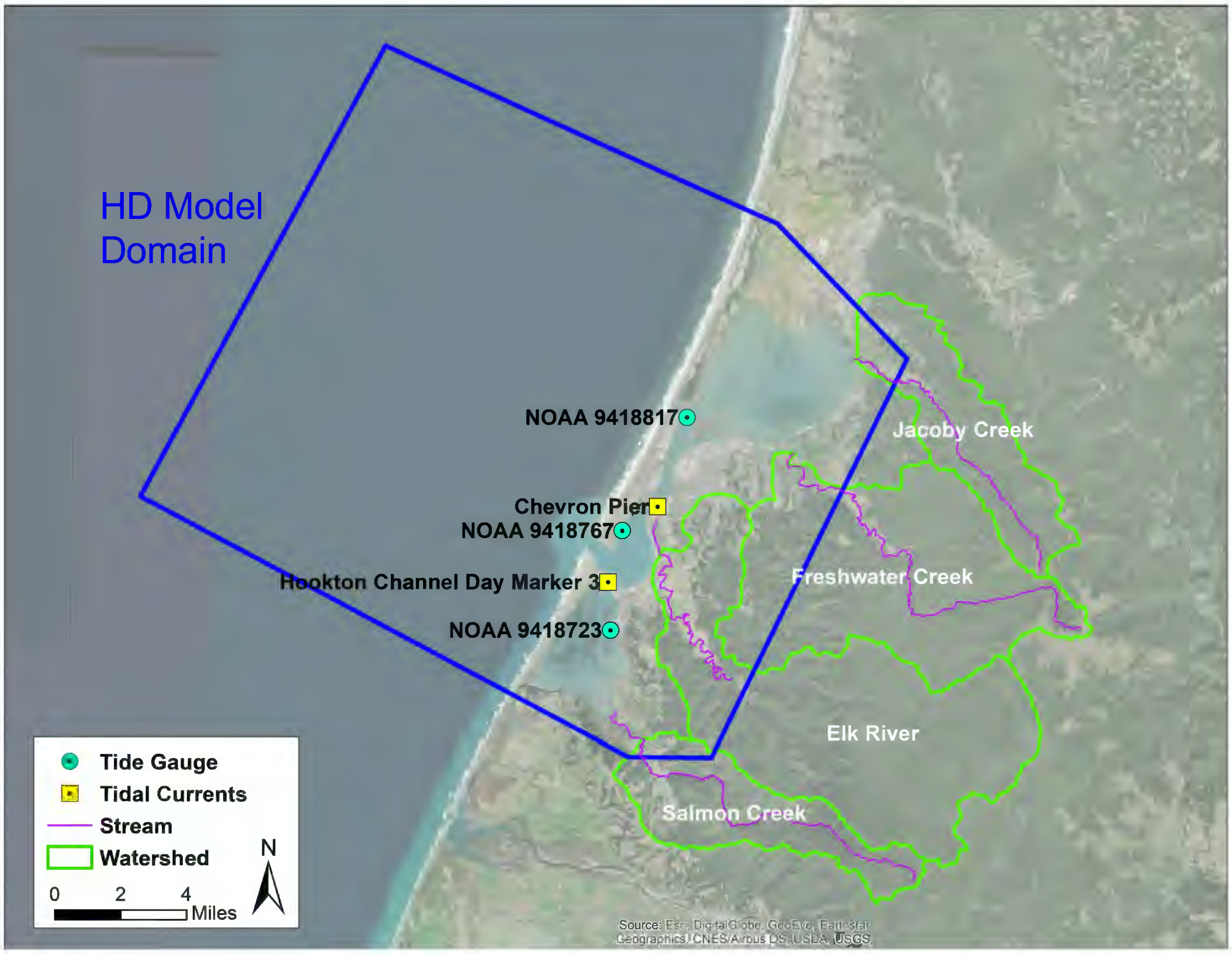
Tidal circulation within estuaries is driven primarily by ocean tides and freshwater inflow. The tidal mixing is often quantified by the tidal prism, which is the volume of water being exchanged between an estuary (enclosed bay) and the open sea over a complete tidal cycle.

Numerical modeling of tidal circulation and tidal currents for Humboldt Bay was assessed using the Danish Hydraulic Institute (DHI) MIKE-21 Hydrodynamic (HD) model. The two-dimensional HD model solves the depth-averaged shallow water equations and simulates water level variations and flows in response to a variety of forcing function (DHI, 2021). The MIKE-21 HD model has been applied extensively worldwide within ocean, coastal, and estuarine environments.

2.1. HD Model Setup

The HD model domain encompasses the entire Humboldt Bay, including South Bay in the south and Arcata Bay in the north, see Figure 2-1. The model grid consists of triangular elements with varying resolutions. The finest resolution (approximately 30 ft) is used in the vicinity of project site and numerous narrow passages. The coarsest resolution (approximately 1,100 to 1,300 ft) is used in the further offshore areas. The total number of elements in the model grid is approximately 106,000.

FIGURE 2-1: HD MODEL DOMAIN AND SURROUNDING FRESHWATER WATERSHEDS



Two primary sources of topographic/bathymetric information were incorporated to develop the model elevation. The USGS compiled CoNED topobathy Digital Elevation Model (DEM) was used for the entire model domain (OCM Partners, 2023). For the project vicinity the bathymetry was taken from the multi-beam survey conducted by eTrac Inc. in 2022 (eTrac, 2022). Model elevation was referenced to the North American Vertical Datum of 1988 (NAVD88) and is shown in Figure 2-2.

Three dredging areas are proposed outside of the existing federal navigation channel. Figure 2-3 indicates that the proposed dredging elevations are -38 ft and -40 ft MLLW (-38.72 ft and -40.72 ft, NAVD88), similar to or slightly deeper than the federally authorized depths.

To evaluate potential changes as a result of proposed project, the general approach in this study was to compare with and without project scenarios conditions. The model inputs and parameters for both scenarios were the same and the only difference was the model elevation for each scenario.

FIGURE 2-2: COMPILED MODEL ELEVATION

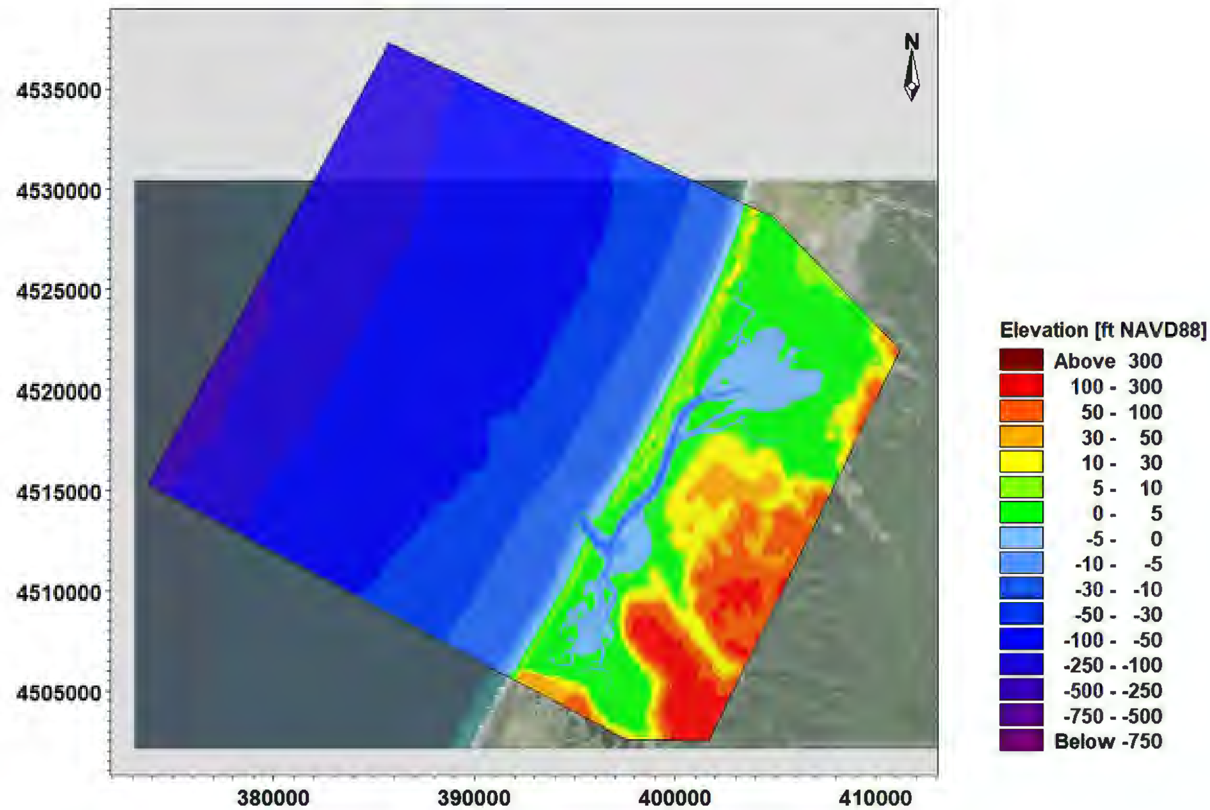
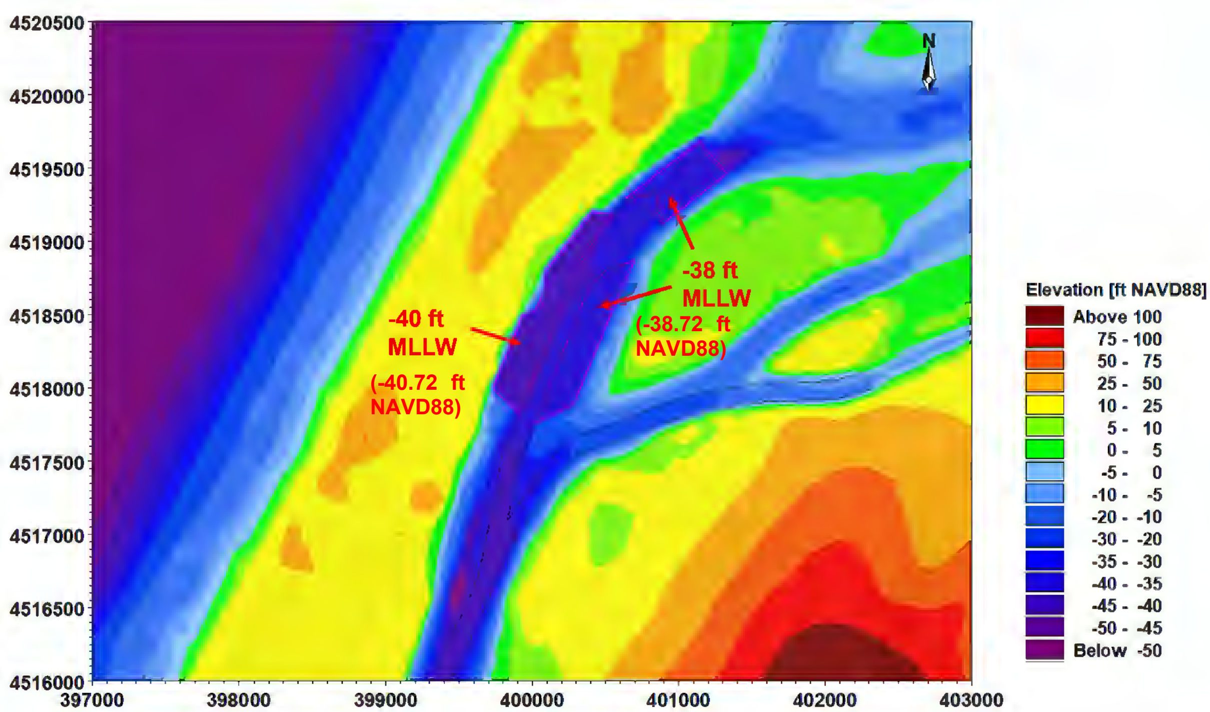


FIGURE 2-3: PROPOSED PROJECT DREDGING ELEVATIONS



2.2. Boundary Conditions

The offshore boundary conditions for the HD model, in terms of water levels and currents, were extracted from the Oregon State University (OSU) Tidal Data Inversion, specifically the TPXO8 global tidal solution with a resolution of 1/6° (Egbert and Erofeeva, 2002). The OSU global model of astronomical tides was developed assimilating the TOPEX/Poseidon global altimeter data (satellite-measured ocean surface). Additionally, meteorological tides or residuals, which are changes in expected astronomical tides caused by local meteorological conditions, were determined from the NOAA North Spit tide station and superimposed at the offshore boundary.

The inland freshwater boundaries include the Jacoby Creek, the Freshwater Creek, the Elk River, and the Salmon Creek watersheds (see Figure 2-1). To the best of our knowledge, direct measurements of discharge for these tributaries are not available. However, the daily discharge can be estimated based on gauged data for the nearby Mad River watershed (as a reference) and corresponding drainage areas. Figure 2-4 shows the estimated daily discharge during the calibration period.

$$Q_{ungaged} = Q_{gaged} \times \frac{Area_{ungaged}}{Area_{gaged}}$$

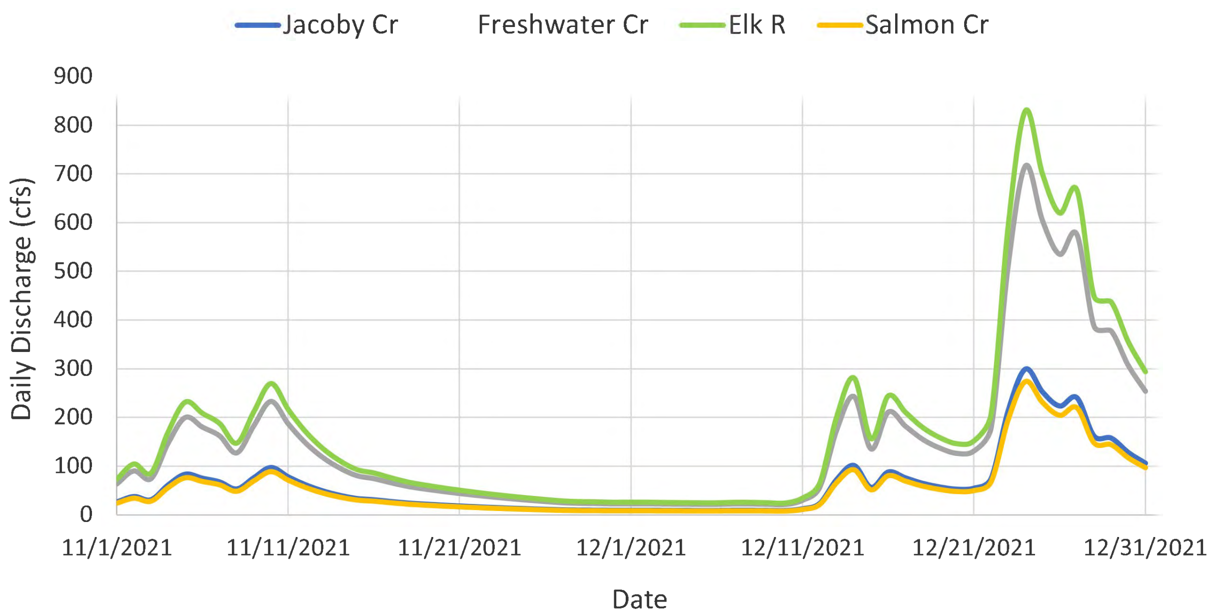
The HD model calibration period was defined as a two-month period (11/1/2021 – 12/31/2021) given measurements of both water levels and tidal current are available throughout Humboldt Bay for this period. In addition, the HD model production period was selected as a two-month period (11/1/2015 – 12/31/2015) to coincide with the most recent Very Strong El Niño (VSE) event. Because the El Niño conditions are typically associated with greater storm activity in the Eastern Pacific, greater tidal currents are expected during VSE.

TABLE 2-1: BOUNDARY CONDITIONS FOR HYDRODYNAMIC MODEL

<table>
<tr><th>Input</th><th>Source</th><th>Data & Period</th></tr>
<tr><td>Tides (offshore boundary conditions)</td><td>OSU tidal database global solution, TPXO8 1/6 resolution with adjustments based on residuals at NOAA North Spit tide gauge</td><td rowspan="2">Calibration period, 2-month from 11/1/2021 – 12/31/2021

Production period, 2-month from 11/1/2015 – 12/31/2015 (occurrence of the most recent VSE)</td></tr>
<tr><td>Freshwater discharge (inland boundary conditions)</td><td>Freshwater discharge for four tributaries: daily discharge was estimated using gauged data for Mad River and corresponding drainage areas</td></tr>
</table>

FIGURE 2-4: INLAND FRESHWATER BOUNDARIES FOR HD MODEL CALIBRATION PERIOD



2.3. HD Model Calibration

Figure 2-5 presents a comparison of water levels during the calibration period between the HD model outputs ("calculated") against the hourly measurements ("observed") at three NOAA tide stations. To evaluate the HD model's performance, several commonly used statistics were calculated and are listed in Table 2-2.

- Root-Mean-Squared (RMS) Difference $\varepsilon_{RMS} = \sqrt{\overline{(x-y)^2}}$
- Mean Absolute Error (MAE): $MAE = \overline{|x-y|}$

where *x* and *y* represent the calculated (model) and the measured (observed) data, respectively, and the ⁻ symbol represents the mean value of a parameter.

Model performance in simulating the parameter of interest can also be assessed using the index of agreement between the measured and the calculated data sets. In addition to the index of agreement, the correlation coefficient was also determined to evaluate the linear relationship between the two datasets.

- Index of Agreement $d = 1 - \frac{\overline{(x-y)^2}}{\overline{(|x-\bar{x}|+|y-\bar{x}|)^2}}$, $0 \le d \le 1$
- Correlation Coefficient $R = \frac{s_{xy}}{s_x \times s_y}$

Where S_{xy} is the covariance between the measured and the calculated data; S_x and S_y are the standard deviations of the measured and the calculated data, respectively.

Model performance evaluation results show that for the calibration period, the RMS difference for water level is less than 0.12 meters (0.4 ft), or 6 percent of the great diurnal range (e.g. 6.9 ft at North Spit).

In addition, both the index of agreement “d” and the correlation coefficient “R” are approximately equal to 0.99 at all locations, indicating the model outputs are in good agreement with the measurements.

TABLE 2-2: STATISTICS FOR WATER LEVELS PERFORMANCE

Parameter	North Spit 9418767	Samoa 9418817	Fields Landing 9418723
ε_{rms} (m)	0.097	0.116	0.116
MAE (m)	0.08	0.09	0.09
d	0.99	0.99	0.99
R	0.99	0.99	0.98

In addition, model results were compared against measured tidal currents at Chevron Pier and Hookton Channel provided by NOAA,from 2021 to the present. Figure 2-6 illustrates time series of current speed during the calibration period. Table 2-3 indicates that both the index of agreement “d” and the correlation coefficient “R” are approximately equal to 0.9 at both locations.

TABLE 2-3: STATISTICS FOR TIDAL CURRENTS PERFORMANCE

Parameter	Chevron Pier hb0401	Hookton Channel hb0302
ε_{rms} (m/s)	0.117	0.119
MAE (m/s)	0.09	0.09
d	0.92	0.93
R	0.86	0.91

FIGURE 2-5: COMPARISON OF WATER LEVELS AGAINST OBSERVATIONS AT: (TOP) NORTH SPIT; (MIDDLE) SAMOA; AND (BOTTOM) FIELDS LANDING

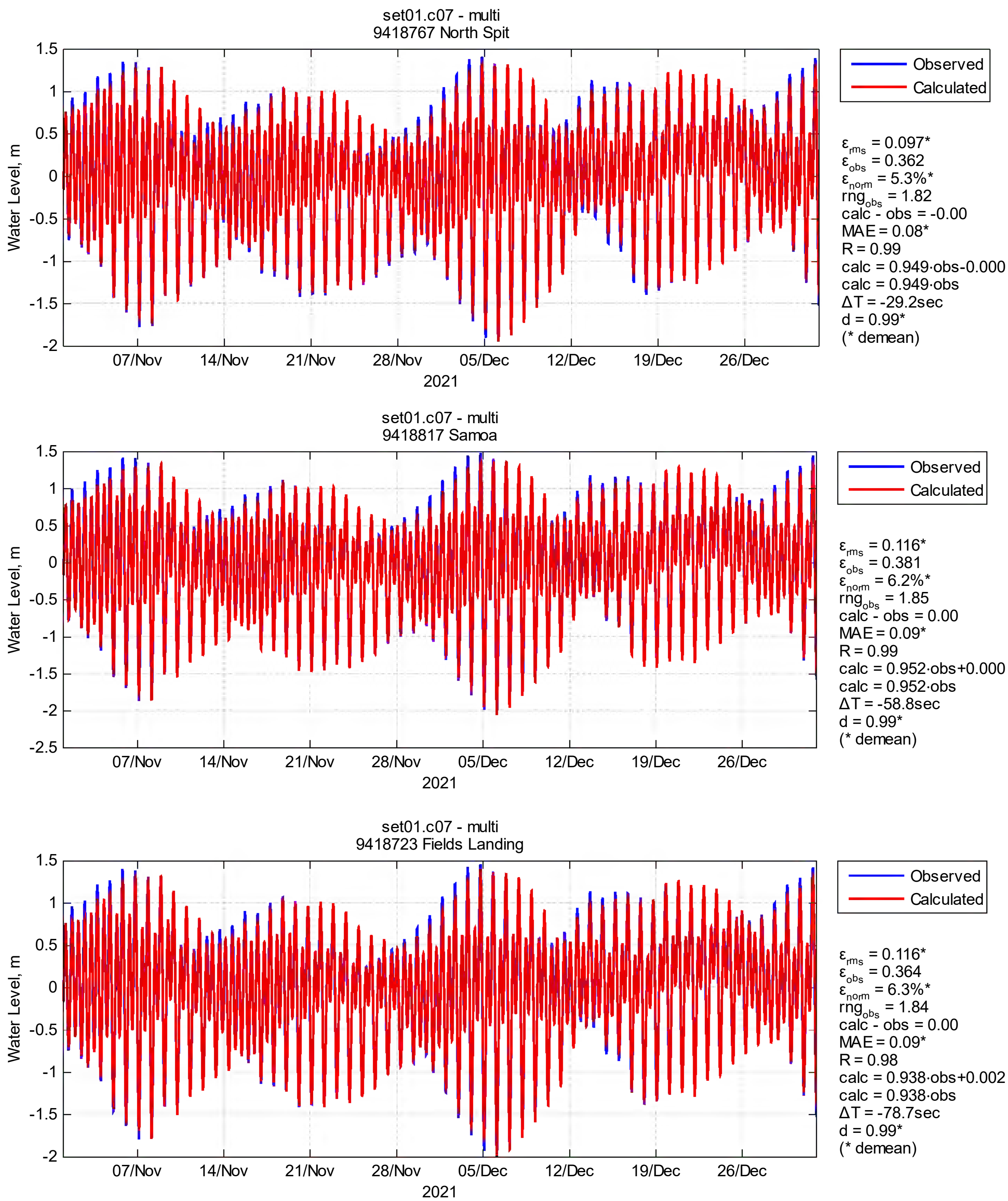
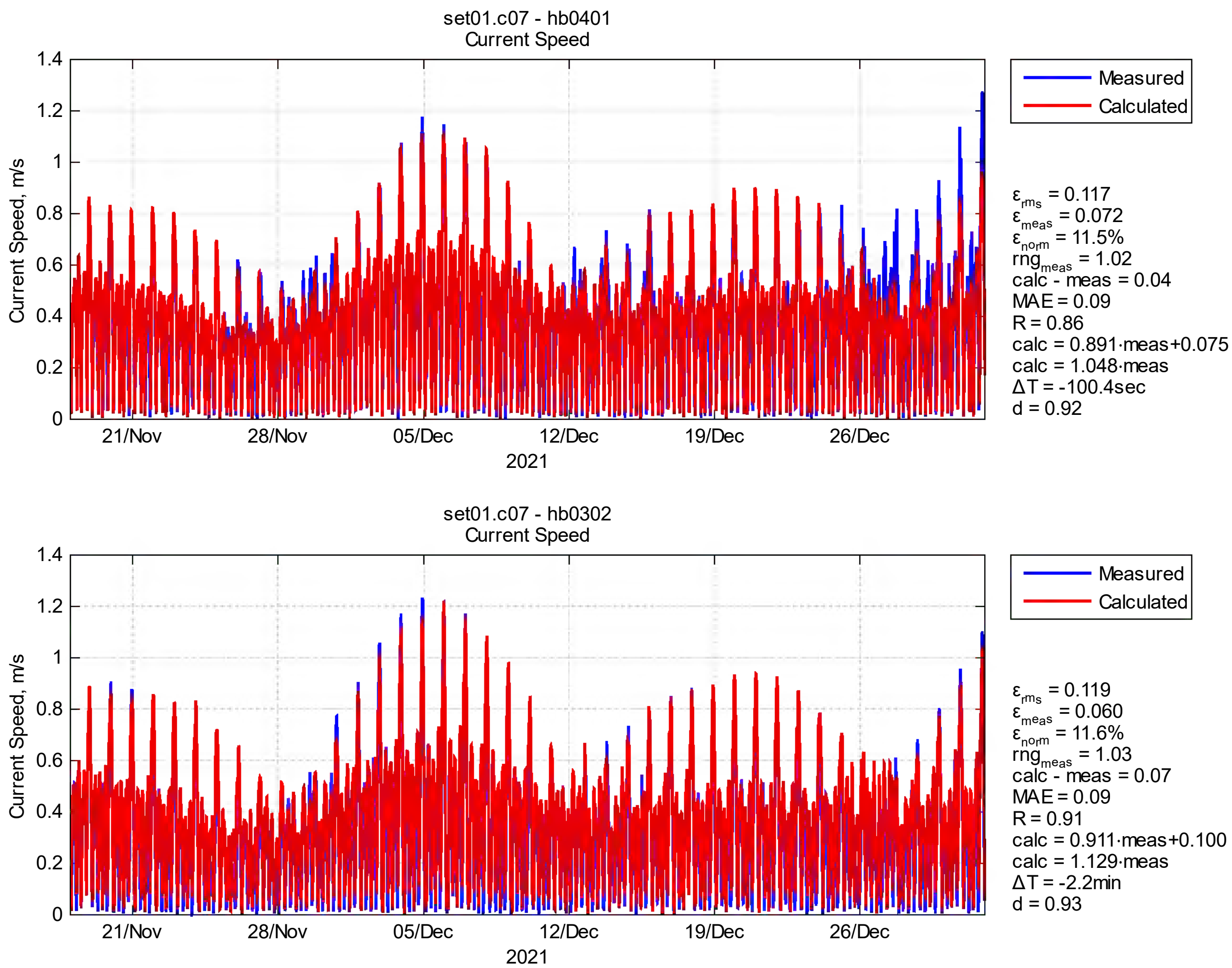


FIGURE 2-6: COMPARISON OF CURRENT SPEED AGAINST OBSERVATIONS AT: (TOP) CHEVRON PIER; AND (BOTTOM) HOOKTON CHANNEL DAY MARKER 3



2.4. HD Model Outputs

Peak flood and peak ebb currents under the existing condition in the vicinity of project site are shown in Figure 2-7. It can be observed that ebb currents are larger than flood currents and stronger currents are typically aligned with the navigation channel.

Difference in maximum and mean depth-averaged currents as a result of the proposed project dredging are shown in Figure 2-8 and Figure 2-9, respectively. The results generally show a reduction in current speed at the proposed dredging areas. The reduction in current speed is most likely due to an increase in the flow cross-sectional area by deepening the three areas. Since current speed is inversely proportional to cross-sectional area of the flow, it is expected that an increase in cross-sectional area could result in decreased current speeds.

In addition, the model predicted a slight increase of current speed (generally less than 0.3 ft/s) at some localized spots near the slope of dredging areas. These localized increases in flow speed are most likely a product of model resolution along the shoreline/capturing sharp gradients. Further refinement of the model resolution is recommended as part of the next phase of design.

FIGURE 2-7: TYPICAL PEAK CURRENT SPEED UNDER EXISTING CONDITION: (TOP) FLOOD CURRENTS; (BOTTOM) EBB CURRENTS

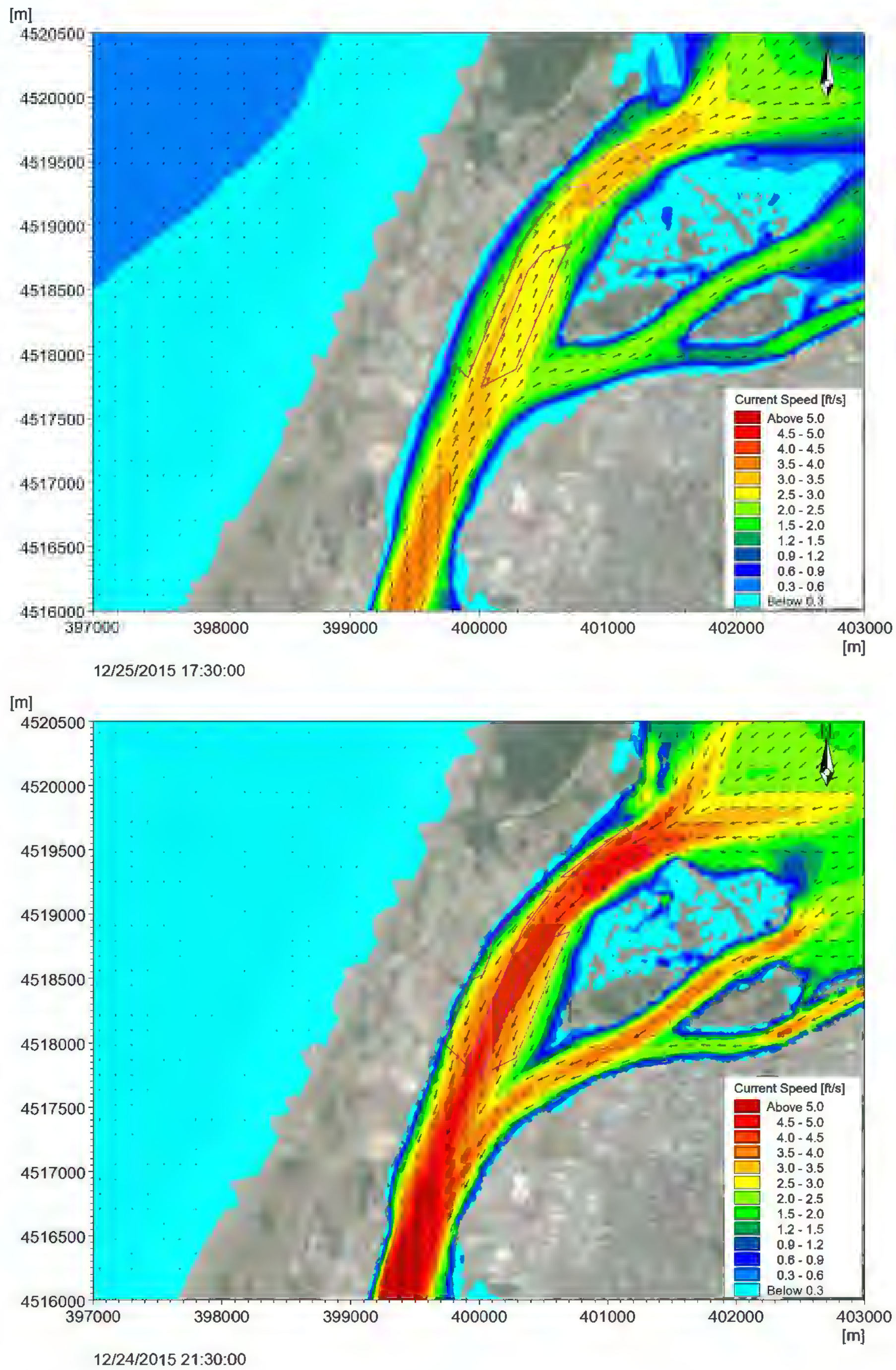
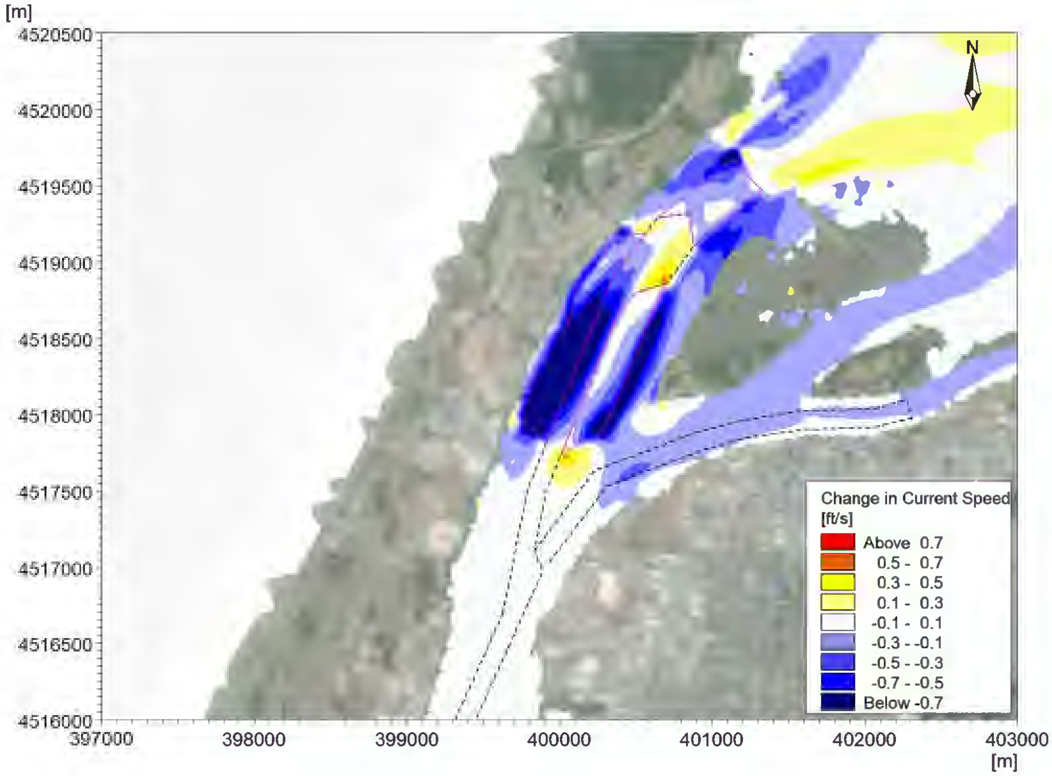


FIGURE 2-8: DIFFERENCE IN MAXIMUM CURRENTS AS A RESULT OF PROPOSED PROJECT DREDGING: (TOP) FLOOD CURRENTS; (BOTTOM) EBB CURRENTS



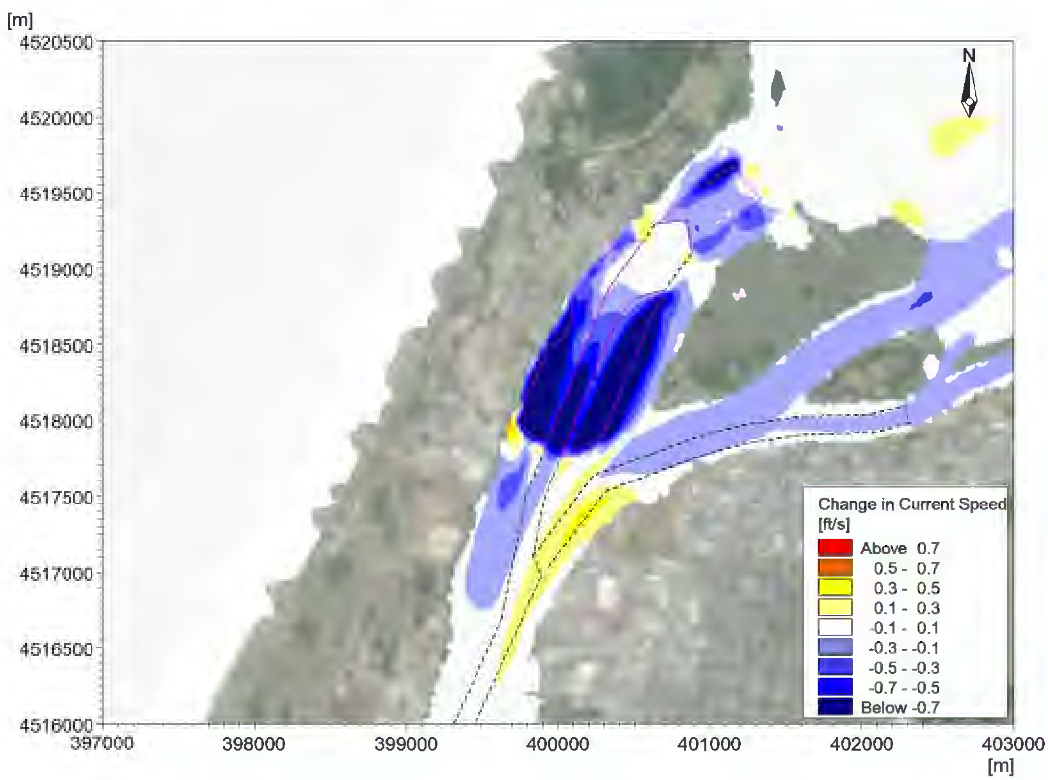
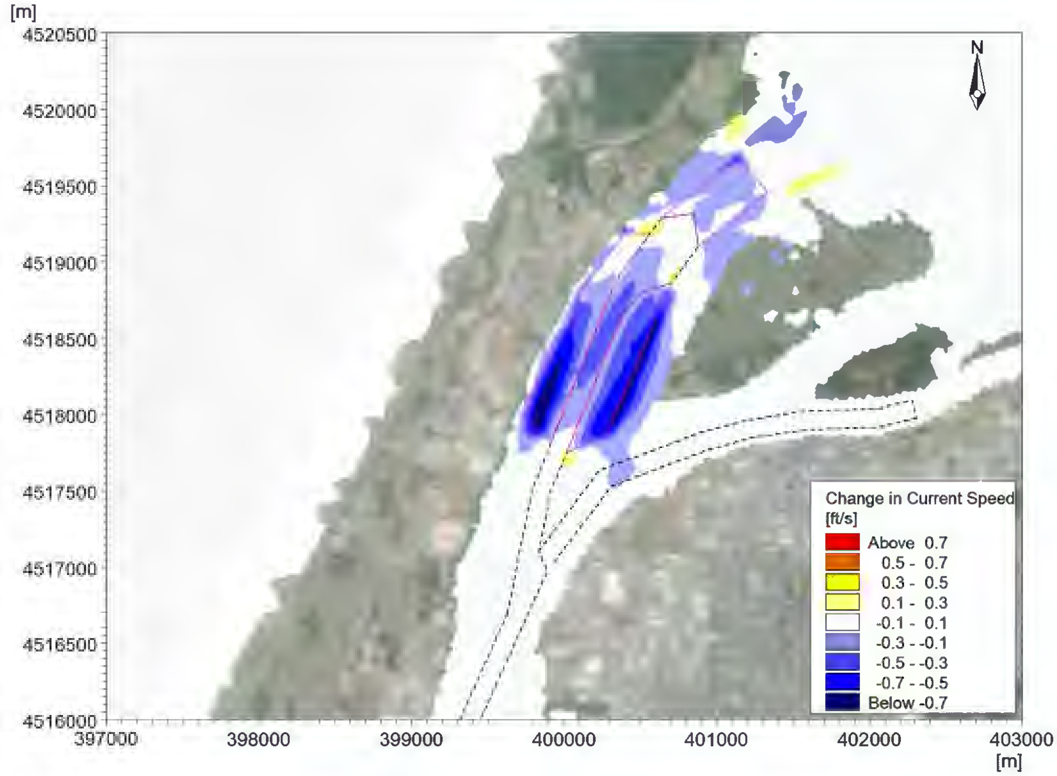
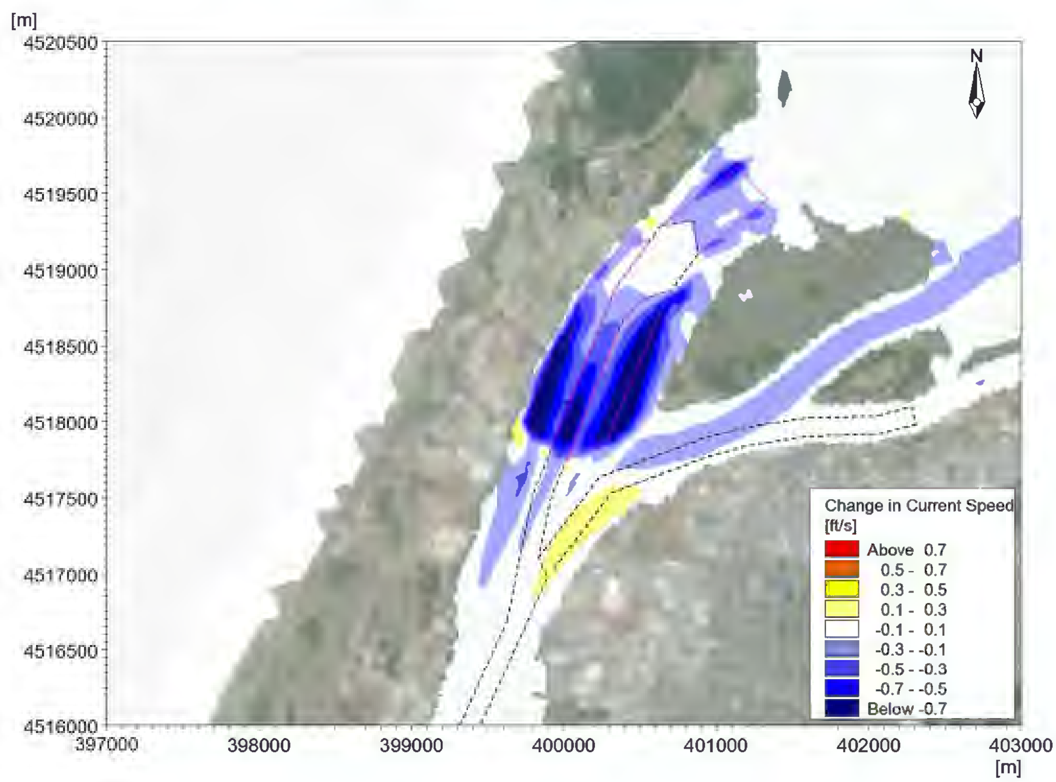


FIGURE 2-9: DIFFERENCE IN MEAN CURRENTS AS A RESULT OF PROPOSED PROJECT DREDGING: (TOP) FLOOD CURRENTS; (BOTTOM) EBB CURRENTS





3. Sediment Transport (ST) Modeling

This section describes sediment transport (ST) modeling and potential changes in ST as a result of the proposed project dredging.

3.1. ST Model Setup

Sediment transport modeling within Humboldt Bay was conducted using the DHI MIKE-21 model suite, with coupled hydrodynamic and sand transport (ST) modules. Erosion, transport, and deposition of sand under the action of currents are taken into account by the ST module.

The model grids (i.e. existing condition and the proposed project dredging) and boundary conditions (in terms of tides and freshwater discharge) were the same as that used for the tidal hydrodynamics.

3.2. ST Model Inputs

Primary input parameters for the ST model are listed in Table 3-1. These parameters were selected through ST model calibration efforts.

TABLE 3-1: INPUT PARAMETERS FOR ST MODEL

Parameter	Value	Comment
Bedload Formula	Van Rijn	Selected from four bedload formulae available in MIKE-21 ST: Engelund & Fredsøe, Engelund & Hansen, Van Rijn, Meyer-Peter and Müller
Suspended Load Formula	Van Rijn	Selected from three suspended load formulae available in MIKE-21 ST: Engelund & Fredsøe, Engelund & Hansen, Van Rijn
Bedload/Suspended Load Factor	0.31/0.31	Selected based on ST model calibration

3.2.1. Grain Size Measurements

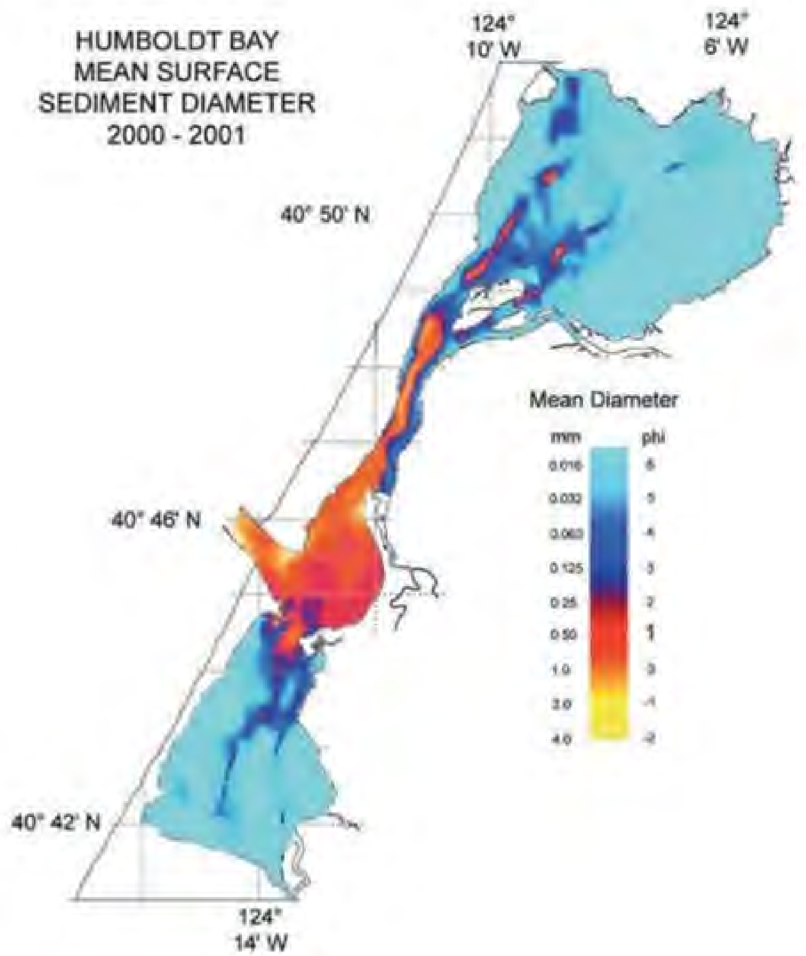
Borgeld and Stevens (2004) collected and analyzed surface sediments (i.e. upper 5 centimeters of the surface) in Humboldt Bay between year 2000 and 2001. Figure 3-1 illustrates the mean sediment diameter. The key findings are:

- The sediment diameter reduces in grain size with increased distance from the Entrance Channel.
- Coarse material (sand/gravel) typically originates from marine sources while fine material (silt/clay) originates from inland watersheds. The silt/clay fraction tends to remain in suspension.

- The vast majority of sediment is transported through the Entrance Channel. A volume of 60,000 tons per year was estimated from inland watersheds, and 1 to 2 million tons per year was dredged from the channels.

- The watershed-origin sediment has increased over historic levels, but little evidence of its physical effects within the Humboldt Bay.

FIGURE 3-1: MEAN SURFACE SEDIMENT DIAMETER IN HUMBOLDT BAY, 2000 – 2001 (BORGELD AND STEVENS, 2004)



3.2.2. Historical Dredging Volumes

Table 3-2 lists the historical dredging volumes by fiscal year per U.S. Army Corps of Engineers (USACE, 2012 & 2021). The dredging records indicate that the Bar and Entrance Channels were dredged annually, with an average of 1 million cubic yards (CY) per year. The interior channels (combined the North Bay, Samoa, Eureka, and Field's Landing Channels) were dredged irregularly (i.e. 12 times in the last two decades and 3 times in the last decade), with an average of 101,000 CY per year. It is noted that the records did not distinguish volumes from individual interior channels. The annual average values were used for the ST model calibration.

TABLE 3-2: HUMBOLDT BAY CHANNEL RECENT DREDGING VOLUMES (USACE, 2012 & 2021)

Fiscal Year	Bar and Entrance Channels (CY)	Interior Channels* (CY)	Total Volume (CY)
2001	1,128,681	158,474	1,287,155
2002	1,007,158	197,052	1,204,210
2003	1,504,757	289,798	1,794,555
2004	1,177,706	190,570	1,368,276
2005	918,722	211,751	1,130,473
2006	978,274	197,310	1,175,584
2007	1,101,125	173,697	1,274,822
2008	1,094,392	217,266	1,311,658
2009	955,224	107,512	1,062,737
2010	553,278	--	553,278
2011	1,165,398	154,881	1,320,279
2012	1,182,620	---	1,182,620
2013	674,928	---	674,928
2014	432,490	---	432,490
2015	715,296	---	715,296
2016	1,588,906	20,777	1,609,683
2017	1,115,051	---	1,115,051
2018	759,625	---	759,625
2019	1,181,388	---	1,181,388
2020	1,047,669	110,834	1,158,503
Annual Average	1,014,000	101,000	1,115,000

* Includes the North Bay, Samoa, Eureka, and Field's Landing Channels.

3.2.3. Observed Sedimentation Pattern

In addition, the USACE has been conducting hydrographic surveys (both condition surveys and pre-/post-dredge surveys) for the Humboldt Bay navigation channels on an annual basis (USACE, 2022). These surveys were processed to determine sedimentation pattern. Sedimentation patterns are shown inn the following figures where deposition is depicted with the warm (yellow-orange-red) colors and sediment erosion is depicted with cool colors. It should be noted that the focus of this study is more on understanding the qualitative sedimentation patterns (i.e. distribution and rate of sediment deposition or erosion), rather than the actual quantity. Figure 3-2 and Figure 3-3 show sedimentation pattern in the Samoa Channel and the North Bay Channel, respectively.

FIGURE 3-2: OBSERVED SEDIMENTATION PATTERN IN SAMOA CHANNEL

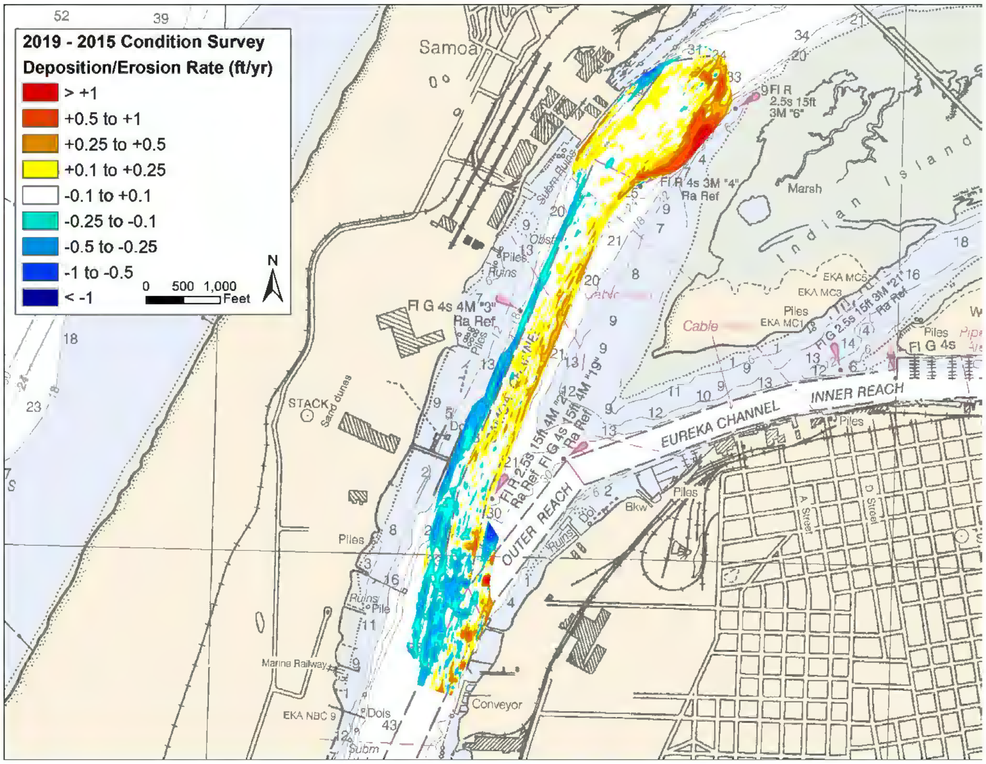
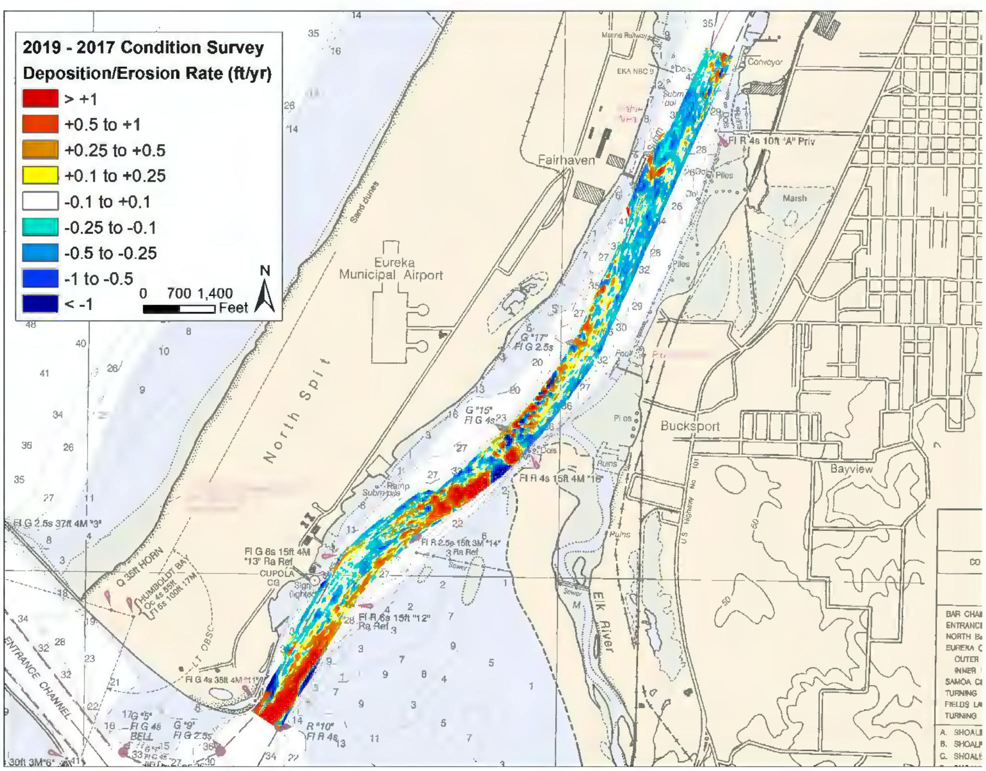


FIGURE 3-3: OBSERVED SEDIMENTATION PATTERN IN NORTH BAY CHANNEL



3.3. ST Model Calibration

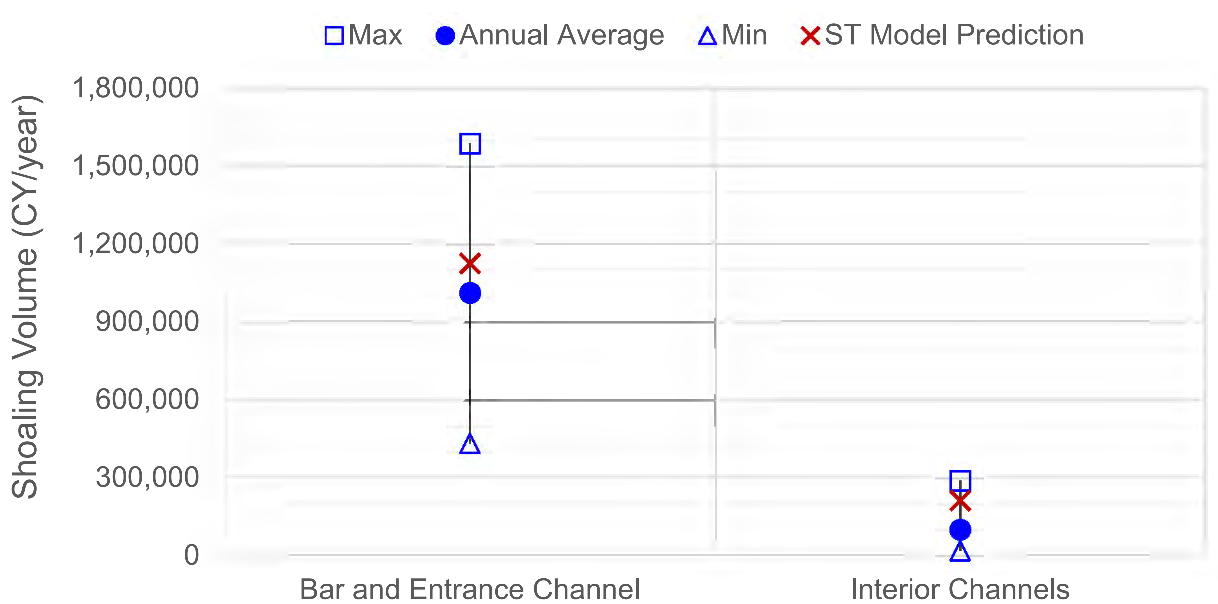
3.3.1. Predicted Shoaling Volumes

ST Model was calibrated by adjusting model parameters to find the best match between model results in terms of sediment deposition and average annual dredge volume based on USACE records for the Bar and Entrance Channels as well as interior channels. ST Model calibration period was defined as as 12-month period. Table 3-3 and Figure 3-4 compare the ST model's predicted shoaling volumes with the USACE dredge records. Comparison of Observed and Modeled dredge volumes indicate that for the Bar and Entrance Channel, the model's predicted volume is within 11% of the annual average. Although the model over-predicts shoaling volume for the Interior Channels, the value still falls within the historical range.

TABLE 3-3: LIST OF DREDGING VOLUMES

Parameter	Bar and Entrance Channels (CY/yr)	Interior Channels (CY/yr)
USACE Minimum	432,000	21,000
USACE Annual Average	1,014,000	101,000
USACE Maximum	1,589,000	290,000
ST Model Prediction	1,126,000	213,000

FIGURE 3-4: COMPARISON OF PREDICTED SHOALING VOLUMES VS. USACE DREDGING RECORDS



3.3.2. Simulated Sedimentation Pattern

Figure 3-5 and Figure 3-6 compare the ST model's simulated sedimentation pattern in the Samoa Channel and the North Bay Channel with the USACE surveys. Some observations and noticeable patterns are noted on the figures. Overall, the simulated sedimentation pattern qualitatively agrees with the measured data (obtained by comparison of USACE surveys) for the most part.

FIGURE 3-5: COMPARISON OF SEDIMENTATION PATTERN IN SAMOA CHANNEL: (LEFT) DIFFERENCE IN USACE SURVEYS; (RIGHT) ST MODEL OUPUT

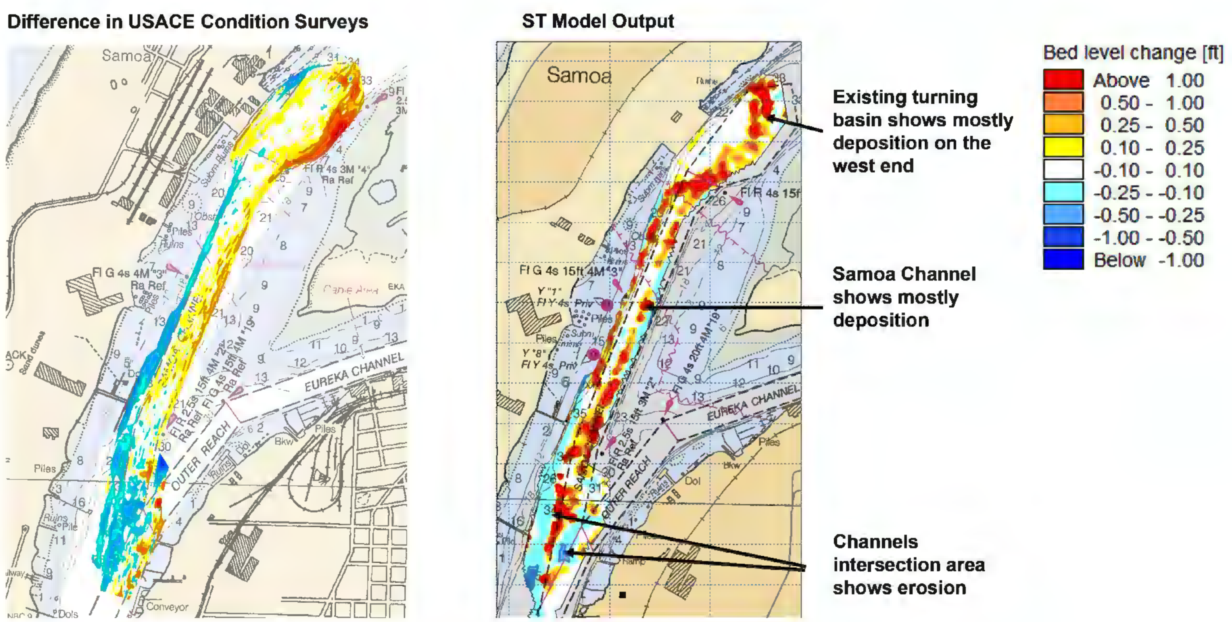
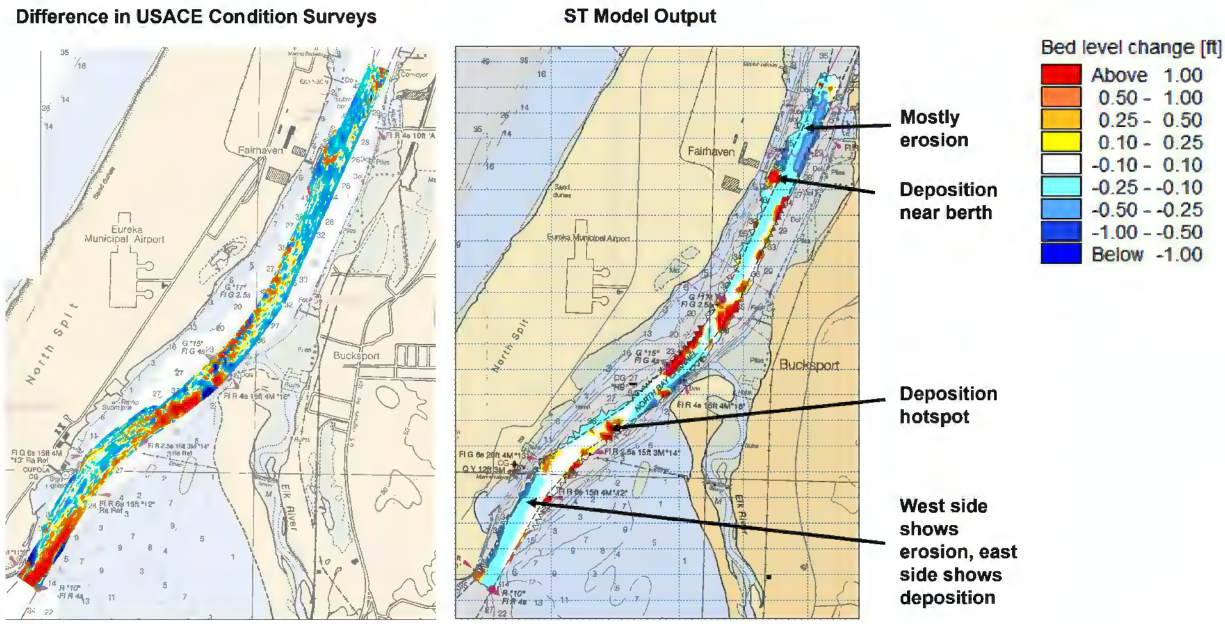


FIGURE 3-6: COMPARISON OF SEDIMENTATION PATTERN IN NORTH BAY CHANNEL: (LEFT) DIFFERENCE IN USACE SURVEYS; (RIGHT) ST MODEL OUPUT



3.4. ST Model Outputs

Difference in bed level change as a result of the proposed project dredging for lower Humboldt Bay and in the vicinity of project site are shown in Figure 3-7 and Figure 3-8, respectively. In general, the change in current speed affects the occurrence of sedimentation (both deposition and erosion). Near the project site, sand deposition was found to occur primarily at the three project dredging areas due to the reduced current speed in those areas. Erosion was found to occur around side slopes of dredging areas where the hydrodynamic modeling predicts a slight increase of current speed.

In addition, the results indicate that sedimentation also occurs at the entrance. Outside of the project dredging areas and the entrance, the majority of the navigation channel and shallow-water habitats show minor to no changes (i.e. -0.1 to 0.1 ft) because the project has very little effect on the tidal hydrodynamics at these locations.

FIGURE 3-7: DIFFERENCE IN BED LEVEL CHANGE AS A RESULT OF PROPOSED PROJECT DREDGING, LOWER HUMBOLDT BAY

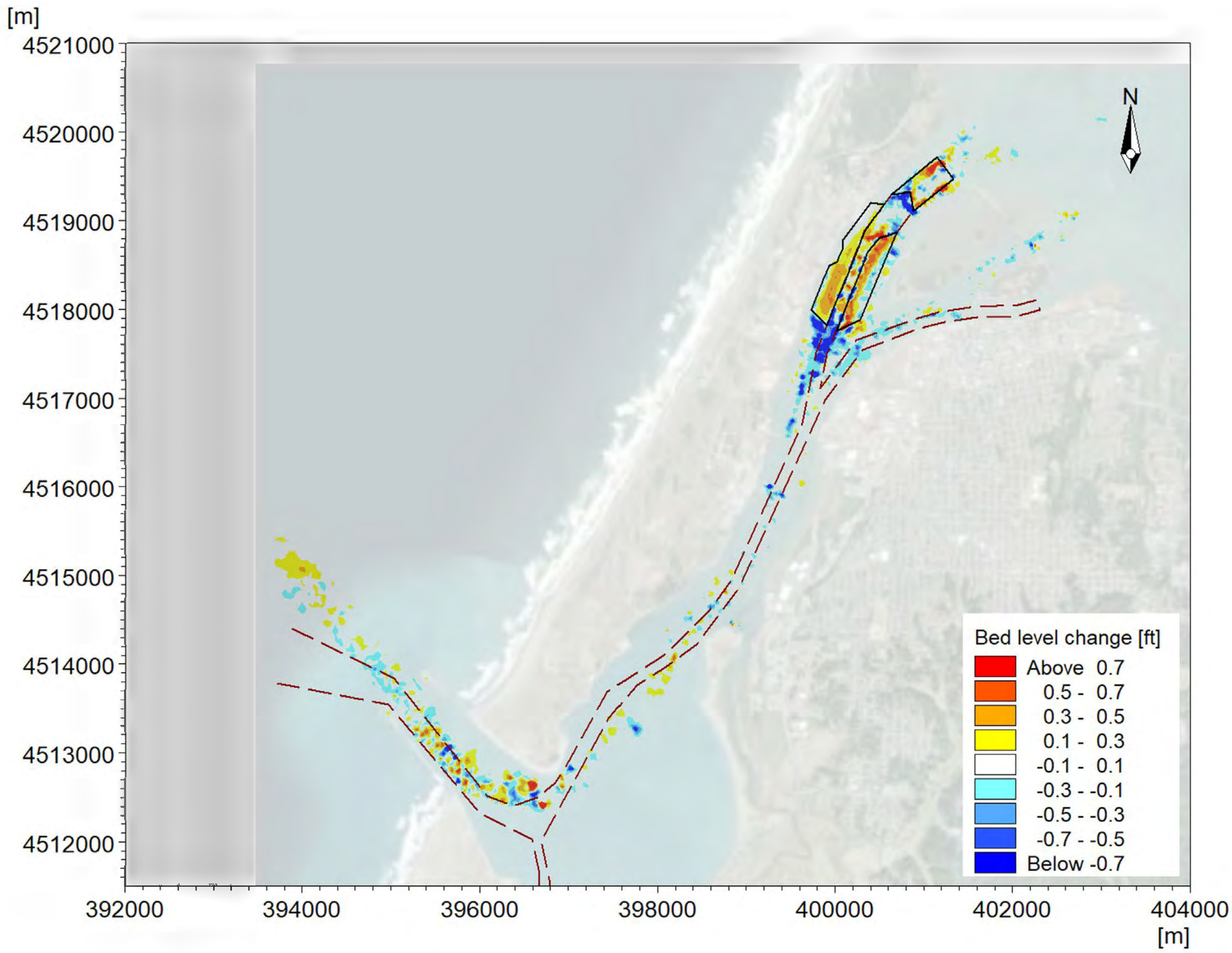
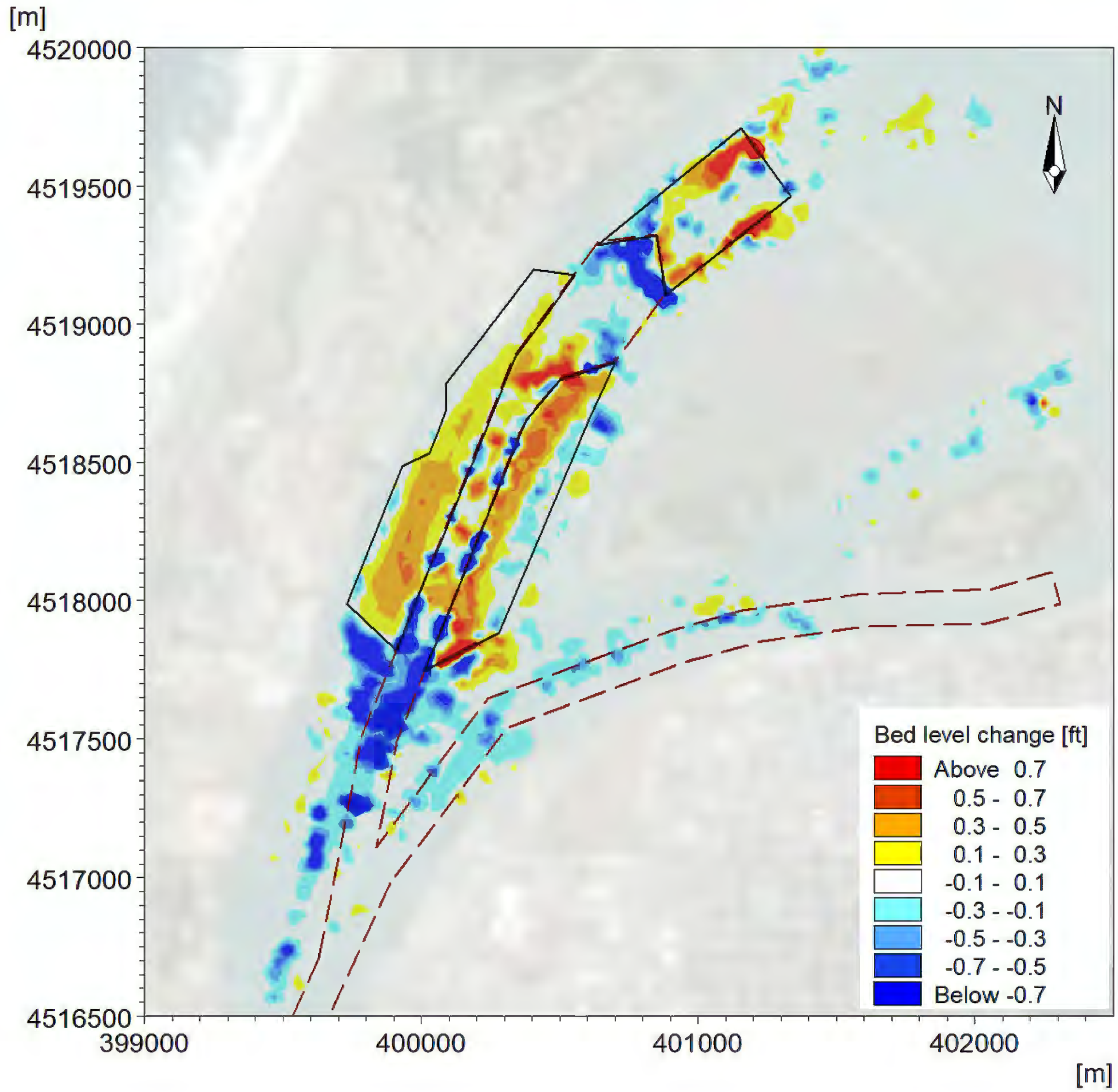


FIGURE 3-8: DIFFERENCE IN BED LEVEL CHANGE AS A RESULT OF PROPOSED PROJECT DREDGING, A ZOOMED-IN VIEW AT PROJECT SITE



Estimates of future operations and maintenance (O&M) dredging in the federal navigation channels and in the proposed project dredging areas are provided in Table 3-4 and Table 3-5, respectively.

Model results indicate that the O&M dredge volume is predicted to decrease by approximately 32,000 cubic yards (CY) annually within the footprint of the federal navigation channels as a result of the proposed project dredging. The future O&M of 1,083,000 CY is calculated by combining the modeled decrease in shoaling with the current annual average O&M.

In addition, a total of 48,000 CY annual shoaling is predicted in the project dredging areas.

TABLE 3-4: ESTIMATED CHANGE IN SHOALING (IN BRACKET) AND FUTURE O&M DREDGING WITHIN FEDERAL NAVIGATION CHANNELS

Scenario	Estimated O&M Dredging (CY/year)		
	Bar and Entrance Channels	Interior Channels	Total Federal
Existing	1,014,000	101,000	1,115,000
With-Project Dredging	[-6,000] 1,008,000	[-26,000] 75,000	[-32,000] 1,083,000

TABLE 3-5: ESTIMATED O&M DREDGING IN PROJECT DREDGING AREAS

Scenario	Estimated O&M Dredging (CY/year)			
	West Area	East Area	North Area	Total
With-Project Dredging	6,000	23,000	19,000	48,000

4. Summary of Findings and Recommendations for Next Steps

M&N conducted numerical simulation of tidal hydrodynamics and sedimentation to evaluate potential changes in hydrodynamics and sediment transport as a result of the proposed project dredging.

The results of the hydrodynamic modeling generally show a reduction in current speed at the proposed dredging areas. The reduction is most likely due to an increase in the flow cross-sectional area by deepening the three dredging areas. In addition, the model predicted a slight increase of current speed (generally less than 0.3 ft/s) at a few localized spots along the toe of dredging areas.

Sediment transport model results indicate that, additional deposition is expected to occur primarily at the three project dredging areas due to the reduced current speed there. Erosion was found to occur along side slopes of dredging areas where the hydrodynamic modeling predicts a slight increase of current speed. In addition, the results indicate that sedimentation also occurs at the entrance. Outside of the project dredging areas and the entrance, the majority of the navigation channel and shallow-water habitats show minor to no changes (i.e. -0.1 to 0.1 ft) given the project has very little effect on the tidal hydrodynamics at these locations.

Estimates of future operations and maintenance (O&M) dredging indicate a decrease of 32,000 CY per year within the footprint of the federal navigation channels. In addition, a total of 48,000 CY annual shoaling is predicted in the project dredging areas.

4.1. Recommendations for Next Steps

It is recommended to update this analysis at the next phase of design and further evaluate potential adverse impacts on nearby shoreline including Tuluwat Island shoreline. It is additionally recommended to advance this evaluation by directly incorporating transport of fine sediment (silt and clay) at the next phase of design.

5. References

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