Investigation of Impacts Associated with Modifying East Sand Island to Prevent Nesting of Double-Crested Cormorants

Kimberly C. Pevey, Tate O. McAlpin, and Hans R. Moritz

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Investigation of Impacts Associated with Modifying East Sand Island to Prevent Nesting of Double-Crested Cormorants

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Abstract

The U. S. Army Engineer District, Portland, is conducting an alternative analysis under an Environmental Impact Statement to determine a preferred approach to permanently modify or eliminate habitat for double-crested cormorants on East Sand Island in the Columbia River. The goal of the alternative analysis is to determine how to reduce/eliminate the habitat for the cormorants and correspondingly increase the survivability of the out-migrating salmonids without impacting the overall behavior of the system, including the stability of the island and navigation. One proposal to reduce/eliminate cormorant habitat on East Sand Island is to cause the parts of the island used by the birds to become subtidal or intertidal so that the island will not be used for nesting or roosting.

Hydrodynamic impacts associated with proposed system alterations to East Sand Island are investigated. An Adaptive Hydraulics numerical model of the Lower Columbia River produces water levels, velocities, shear stresses, and inundation information for existing conditions and one alternative condition in and around the study area.

A base versus alternative plan analysis was conducted by simulating the existing and proposed conditions for two time periods, May (high river flow) and August (low river flow) 2009. Comparisons of the existing and proposed simulations indicate the differences between the water surface elevation, velocity, and bed shear stress will be small. The system as a whole should experience minimal changes.

Based on the simulation results, the lagoons will be inundated approximately 40%-60% of the time. The May 2009 time period has slightly higher percent inundated values than the August 2009 time period. Overall, it appears from this analysis that the lagoon/atoll design will produce minimal impacts to the surrounding environment in terms of bed shear stress and based on the inundation times, will likely reduce cormorant nesting habitat.
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Preface

This study was conducted for the U.S. Army Engineer District, Portland (NWP) under a project entitled Investigation of Impacts Associated with Modifying East Sand Island to Prevent Nesting of Double-Crested Cormorants. The technical monitor was Hans R. Moritz.

The work was performed by the Estuarine Engineering Branch (HF-E) of the Flood and Coastal Storm Protection Division (CF), U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Lab (ERDC-CHL). At the time of publication, Dr. Robert McAdory was Chief, CEERD-HF-E; Dr. Ty V. Wamsley was Chief, CEERD-HF. The Deputy Director of ERDC-CHL was Dr. Kevin Barry, and the Director was José E. Sánchez.

At the time of publication, COL Bryan S. Green was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.
# Unit Conversion Factors

<table>
<thead>
<tr>
<th>Multiply</th>
<th>By</th>
<th>To Obtain</th>
</tr>
</thead>
<tbody>
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<td>cubic feet</td>
<td>0.02831685</td>
<td>cubic meters</td>
</tr>
<tr>
<td>feet</td>
<td>0.3048</td>
<td>meters</td>
</tr>
<tr>
<td>miles (U.S. statute)</td>
<td>1,609.347</td>
<td>meters</td>
</tr>
<tr>
<td>miles per hour</td>
<td>0.44704</td>
<td>meters per second</td>
</tr>
<tr>
<td>pounds (force) per square foot</td>
<td>47.88026</td>
<td>pascals</td>
</tr>
<tr>
<td>square feet</td>
<td>0.09290304</td>
<td>square meters</td>
</tr>
<tr>
<td>square miles</td>
<td>2.589998 E+06</td>
<td>square meters</td>
</tr>
</tbody>
</table>
1 Introduction

Prior to jetty construction in 1885, East Sand Island (Figures 1-1 and 1-2) was part of the tidal delta at the mouth of the Columbia River (MCR) and was continually shifting in response to unconstrained dynamics of the ocean inlet and river currents. The island’s present configuration was established during the 1920–1950 time period in an attempt to stabilize the island and adjacent morphology within the MCR. Stabilization of East Sand Island was achieved by constructing a pile dike system, riprap, and targeted placement of dredged material. East Sand Island has not been used for dredged material placement since 1984, and currently, the island shoreline is receding at some locations.

Hatchery and juvenile salmonids, protected by the Endangered Species Act, pass near East Sand Island during their migration down the Lower Columbia River (LCR). A large colony of double-crested cormorants uses the western half of East Sand Island as its primary nesting ground during March to October. The colony, which numbered approximately 14,900 breeding pairs in 2013, is considered the largest in western North America. The East Sand Island cormorants are estimated to have consumed approximately 18.9 million hatchery and juvenile salmonids in 2012 (U.S. Army Corps of Engineers, Portland District [USACE-NWP], n.d.).

Figure 1-1. Regional location of study area.
In 2008, the USACE began efforts to dissuade nesting on East Sand Island. While some efforts succeeded in reducing habitat by 70%, the colony continued to grow despite the reduction in habitat (USACE-NWP, n.d.). In 2014, the National Oceanic and Atmospheric Administration (NOAA) Fisheries released a Supplemental Biological Opinion for the operation of the Federal Columbia River Power System (FCRPS) that requires the FCRPS Action Agencies to reduce the nesting pair population on East Sand Island to no more than 5,380 to 5,939 (NOAA Fisheries 2014). To meet this requirement, NWP is conducting an analysis under an Environmental Impact Statement to permanently modify or eliminate nesting habitat for double-crested cormorants on East Sand Island (USACE-NWP, n.d.). The goal of the analysis is to determine a preferred alternative configuration, or island terrain modification, to reduce/eliminate the cormorant habitat and correspondingly increase the survivability of the out-migrating salmonids without impacting the overall behavior of the system, including the stability of the island and navigation.

Some cormorant nests are located between mean tide level (MTL) and mean higher high water (MHHW), but most are located above MHHW. One proposal to reduce or eliminate cormorant habitat on East Sand Island is to convert areas of the island used for nesting to subtidal or intertidal in order to discourage the cormorants from utilizing East Sand Island for nesting or roosting purposes.
These are the objectives for the East Sand Island terrain modification:

1. Inundate the affected area of East Sand Island for at least 2–3 hr every 2 weeks.
2. Create no adverse consequences to the stability of East Sand Island or adjacent areas.
3. Ensure that the terrain modification does not adversely affect long term stability of the MCR or the function of navigation within the MCR.
4. Develop, if possible, a modified terrain that is beneficial to other species using East Sand island and demonstrate this attribute.

An Adaptive Hydraulics (AdH) numerical model of the Lower Columbia River was created and validated to water surface elevations as part of previous work. Using the existing AdH (Berger et al. 2013) numerical hydrodynamic model (Pevey et al. 2012; Savant and McAlpin 2014), a base versus plan analysis was conducted by the U. S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), to analyze the impacts of one such proposal on water surface elevations, water velocities, bottom shear stresses, and inundation times. From these results, the AdH model will verify that the terrain modification objectives may be met, through analysis of the following list of key topics:

1. Will the conceptual design change velocity or shear at the offsite areas?
2. How often will the modified terrain be inundated?
3. What is the estimated confidence in the model results?
4. Provide, if possible, insight as to where the modified terrain may need maintenance in the future.
5. Provide, if possible, inferences from the bed shear stresses such as the stability of the modified terrain and potential for erosion or deposition within the modified terrain.
2 Model Development

2.1 East Sand Island conceptual design

The conceptual design for the proposal was developed by NWP and minimizes the hydraulic impacts to the surrounding estuary by maintaining the same island footprint while creating two interior lagoons. The yellow outline in Figure 2-1 shows the project extent. Converting the interior areas to large intertidal regions is anticipated to reduce or eliminate cormorant nesting habitat. The lagoons have an elevation of approximately 1.1 m NAVD88 with several inlets for each. A slight slope is applied to each lagoon to ensure that salmonids will not be stranded due to the falling tide. The surrounding atoll is specified as 2.2 m NAVD88. At a nearby tide gauge, the MHHW is 2.69 m NAVD88 (Astoria NOAA gauge 9439040). The eastern half of East Sand Island is to remain in its current condition.

![Figure 2-1. Conceptual design outline for East Sand Island terrain modifications.](image)

The conceptual design as implemented in the AdH mesh is shown in Figure 2-2 and illustrates the design with linear elevation contour lines to highlight the slight slopes in the lagoons (each contour line is 0.25 m).
2.2 Lower Columbia River AdH model mesh updates

The existing LCR model mesh required modification to add an appropriate level of resolution to investigate localized changes near East Sand Island. The LCR validation mesh is shown in Figure 2-3 for the East Sand Island vicinity. The mesh has a higher resolution around the pile dikes, but East Sand Island is coarsely resolved. Also noteworthy are inaccuracies in the locations of the pile dikes. The mesh was generated using location data for the pile dikes, which has since been updated.

The corrected pile dike locations for the three pile dikes near the island and additional resolution in general in and around East Sand Island were implemented in the revised East Sand Island mesh (Figure 2-4). Additional resolution was added to the eastern end of West Sand Island (seen as the left island in Figures 2-3 and 2-4) to more accurately resolve the tidal flow between the islands. The western portion of East Sand Island is now highly resolved to capture the terrain modifications. The resolution of the eastern portion of East Sand Island was also increased for this investigation. The Chinook Federal Navigation Channel has also been included in the mesh modification.
The East Sand Island mesh was then populated with two separate elevation datasets. The existing elevation dataset was populated with the most up-to-date topography and bathymetry data (USACE 2013). The proposed alternative elevation dataset was used to modify the existing dataset to reflect the conceptual design. The meshes will hereafter be described as *existing* and *proposed*.
2.3 Boundary conditions development

The LCR AdH model boundary conditions were developed from field data acquired from the NOAA and U.S. Geological Survey (USGS). The tidal and inflow data are described below.

2.3.1 Inflows

There are five inflows into the model domain: the Cowlitz, Lewis, Willamette, and Sandy Rivers, and the Bonneville L&D (Figure 2-5). Hourly discharge data (m³/s) were collected from USGS for the all river inflows, with the exception of the Lewis River where only daily discharge data were available. The station data are in Table 2-1.

The model year 2009 was chosen due to the 2 yr event (10,000 m³/s) that occurred during the spring freshet on the Columbia River. During this same time period, the Willamette River flow rates were also elevated. The inflow at Bonneville Lock and Dam (USGS 14128870) for the May and August time periods are in Figures 2-6 and 2-7, respectively.
Table 2-1. Inflow boundary condition station information.

<table>
<thead>
<tr>
<th>Station</th>
<th>Agency</th>
<th>Station ID</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Approximate River Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowlitz River</td>
<td>USGS</td>
<td>14243000</td>
<td>46° 16’ 30”</td>
<td>122° 54’ 48”</td>
<td>RM 68</td>
</tr>
<tr>
<td>Lewis River</td>
<td>USGS</td>
<td>14220000</td>
<td>45° 58’ 12”</td>
<td>122° 34’ 12”</td>
<td>RM 87</td>
</tr>
<tr>
<td>Willamette River</td>
<td>USGS</td>
<td>14207740</td>
<td>45° 21’ 00”</td>
<td>122° 37’ 12”</td>
<td>RM 101</td>
</tr>
<tr>
<td>Sandy River</td>
<td>USGS</td>
<td>14142500</td>
<td>45° 25’ 48”</td>
<td>122° 13’ 48”</td>
<td>RM 120</td>
</tr>
<tr>
<td>Bonneville L&amp;D</td>
<td>USGS</td>
<td>14128870</td>
<td>45° 37’ 48”</td>
<td>121° 57’ 00”</td>
<td>RM 145</td>
</tr>
</tbody>
</table>

Figure 2-6. Model inflow at Bonneville Lock and Dam for May time period.
2.3.2 Tidal boundary conditions

The model tidal ocean boundary (shown in Figure 2-8 with a solid red line) was specified using the NOAA-measured tidal signal at Astoria, OR (gauge 9439040). The Astoria signal was filtered to remove extraneous noise with periods less than 4 hr, and the signal was shifted by -0.027 m, phase lagged by -1.1 hr, and scaled by 0.95 to ensure that, after propagating from offshore to the Astoria gauge site, the modeled tide matched the Astoria gauge data (Pevey et al. 2012; Savant and McAlpin 2014). The analysis period includes a 2 yr river flow event (10,000 m$^3$/s at Bonneville) which occurred in 2009. The boundary condition file contains data from 1 November 2008 to 31 January 2010 to fully encompass the calendar year surrounding this event. The final applied tidal boundary conditions are found in Figures 2-9 and 2-10 for the May and August time periods, respectively.
Figure 2-8. LCR AdH mesh extents (NAVD88, SPCS Oregon North, meters).

Figure 2-9. Tidal boundary condition for May time period.
USGS water surface elevation data at Bonneville and additional NOAA tide gauge data were used to analyze model results. The station location information is included in Table 2-2, and a graphical representation of the gauge locations within the mesh can be found in Figure 2-11. The water surface elevation datum was NAVD88, units were in meters, and the time stamp was PST.

Table 2-2. NOAA tide gauge station information.

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Agency</th>
<th>Station ID</th>
<th>Latitude</th>
<th>Longitude</th>
<th>State Plane East, m</th>
<th>State Plane North, m</th>
<th>River Mile</th>
</tr>
</thead>
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<td>NOAA</td>
<td>9439040</td>
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<td>123° 46' 06&quot;</td>
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<td>287548.5</td>
<td>RM 8</td>
</tr>
<tr>
<td>Skamokawa</td>
<td>NOAA</td>
<td>9440569</td>
<td>46° 16' 00&quot;</td>
<td>123° 27' 06&quot;</td>
<td>2272473.4</td>
<td>293031.7</td>
<td>RM 34</td>
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<tr>
<td>Longview</td>
<td>NOAA</td>
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<td>46° 06' 18&quot;</td>
<td>122° 57' 12&quot;</td>
<td>2310340.5</td>
<td>273845.7</td>
<td>RM 66</td>
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<td>St Helens</td>
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<td>122° 47' 48&quot;</td>
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<td>246853.9</td>
<td>RM 86</td>
</tr>
<tr>
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<td>USGS</td>
<td>14128870</td>
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<td>121 57' 39&quot;</td>
<td>2386107.8</td>
<td>219541.0</td>
<td>RM 145</td>
</tr>
</tbody>
</table>
2.4 Validation

After the original LCR mesh was completed and validated, several projects arose in which localized mesh modifications were made. To ensure that the mesh modifications did not adversely impact the hydrodynamics, a comparison of validation simulations between the updated and refined existing condition mesh and the previous validation mesh was made. These comparisons indicated the additional resolution from the East Sand Island project (including resolution from previous projects) did not have a significant effect on the validation results in the East Sand Island area of interest (see Appendix A). Localized effects due to the relocation of the pile dikes near East Sand Island were slight. More details on the results of this comparison can be found in Appendix A. Although the LCR mesh is a schematized version of the real-world environment, the validation results indicate that a reasonable level of confidence may be placed on the results.
3 Results

3.1 Hydrodynamic comparisons

Existing and proposed condition simulations were executed, and comparisons between the two were completed. The velocity and water surface elevation were compared at seven far-field points (points 1–7) and five near-field points (points 8–12) (Figure 3-1). Analysis of the results involved comparing the minimum, maximum, and average at each point, as well as the differences between the existing and plan condition, and plotting the time series of water surface elevation and current velocity magnitude. The maximum velocity magnitudes for each calculation point over the simulation period are shown in Figures 3-2 and 3-3. The tabular results for May and August water surface elevation and velocity magnitude are found in Table 3-1 and Table 3-2, respectively, where a positive difference value indicates a higher value for the proposed conditions. Time series plots for points 1–12 are in Appendix B.

![Figure 3-1. Observation points for simulation comparisons.](image-url)
Figure 3-2. Maximum velocity for 10–31 May 2009.

Figure 3-3. Maximum velocity for 10–31 August 2009.
Table 3-1. Water surface elevation comparisons for existing versus proposed simulations.

<table>
<thead>
<tr>
<th>Point</th>
<th>Water Surface Elevation (m, NAVD88)</th>
<th>10–31 May 2009</th>
<th>10–31 August 2009</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td>Existing Condition</td>
<td>Proposed Design</td>
</tr>
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<td>-0.30</td>
</tr>
<tr>
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<td>Maximum</td>
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<td>2.90</td>
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<td></td>
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<td>1.33</td>
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<td>-0.29</td>
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<td>2.90</td>
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<td>-0.31</td>
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<td>2.91</td>
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<td>2.91</td>
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<td>1.31</td>
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<td>2.92</td>
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### Point Water Surface Elevation (m, NAVD88)

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<th>Point</th>
<th>Water Surface Elevation (m, NAVD88)</th>
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<th>Proposed Design</th>
<th>Difference</th>
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<th>10–31 May 2009</th>
<th>10–31 August 2009</th>
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<td>Existing</td>
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<td>Condition</td>
<td>Design</td>
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Table 3-2. Velocity magnitude comparisons for existing versus proposed simulations.

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<th>Difference</th>
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<td>6</td>
<td>Minimum</td>
<td>0.03</td>
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<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
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<td>1.91</td>
<td>0.02</td>
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<tr>
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<td>0.87</td>
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</table>
The analyses show that the hydrodynamic differences between the existing condition and the proposed design are small (±0.009 m for water surface elevation and ±0.02 m/s for velocity magnitude). All hydrodynamic differences arise from overtopping of the island (which only happens during the proposed design condition), the exchange of water between the East Sand Island lagoons and Baker Bay, and the variations in eddy formations off the western edge of the island. There were no changes in velocity direction between the existing and proposed simulations. Overall, it appears that the lagoon/atoll design will produce minimal impacts to the surrounding environment in terms of velocity magnitude and water surface elevation.

The typical flood and ebb flow patterns for the updated existing condition simulation near East Sand Island are in Figures 3-4 and 3-5, respectively.
3.2 Bed shear stress comparisons

The AdH code is coupled with the sediment transport code SEDLIB (Brown 2012a,b), enabling sediment transport, shoaling, erosion, and bed evolution studies to be performed. Performing such a study is beyond the scope of the work presented here, but the AdH-SEDLIB linked code can be used to calculate shear stresses in the vicinity of East Sand Island that are
useful in understanding the relative size and distribution of bottom shear stresses in the area of interest.

SEDLIB uses the following equations to calculate the bottom shear stress that a particle will feel; if the particle is small enough, it will experience incipient motion:

$$\tau_x = \frac{1}{2} \rho C_D u U$$  \hspace{1cm} \text{Equation 3-1}$$

$$\tau_y = \frac{1}{2} \rho C_D v U$$  \hspace{1cm} \text{Equation 3-2}$$

$$U = \sqrt{u^2 + v^2}$$  \hspace{1cm} \text{Equation 3-3}$$

$$C_D = 2 \left( \frac{0.4 \beta}{(\beta+1)(\ln(\beta+1)-1)+1} \right)^2$$  \hspace{1cm} \text{Equation 3-4}$$

$$\beta = \frac{29.7 h}{3d_{90}}$$  \hspace{1cm} \text{Equation 3-5}$$

where $\tau$ is shear stress, $\rho$ is water density, $u$ and $v$ are the x and y velocity components, respectively, $h$ is the water depth, and $d_{90}$ is grain diameter for which 90% of the grains are finer (American Society of Civil Engineers [ASCE] 2008). The constant, 0.4, in Equation 3-4 is an approximate value for the von Kármán constant. The value $3d_{90}$ in Equation 3-5 is an approximation of Nikuradse’s equivalent sand roughness height for an alluvial bed, given by van Rijn (van Rijn 1982). If a full sediment study were performed, the initial grain size distribution for the system would be specified, the $d_{90}$ calculated from that distribution, and the local velocities, $u$ and $v$, used to calculate $\tau$ for that time step. As time proceeds, the bed algorithm in SEDLIB would keep up with the evolving sediment distribution, and the process would repeat itself for ensuing time steps.

In this case, the known $d_{90}$ is used for the East Sand Island vicinity, medium sand (0.4 mm) (Jay et al. 1990; McAnally et al. 1983; Sherwood and Creager 1990) to calculate a shear stress from Equations 3-1 to 3-5. Calculations were performed for both the existing and proposed conditions for the entire hydrodynamic simulation, and the differences in bed shear stress between
the existing and proposed conditions were analyzed by comparing minimum, maximum, and averages, as well as analyzing the time series plots. Results for the 12 comparison points of Figure 3-1 are provided for both May and August in Table 3-3. Time series comparisons are found in Appendix C.

Table 3-3. Bed shear stress comparisons between existing and proposed design simulations.

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</thead>
<tbody>
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<td></td>
<td>Existing Condition</td>
<td>Proposed Design</td>
<td>Difference</td>
<td>Existing Condition</td>
<td>Proposed Design</td>
<td>Difference</td>
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</tr>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>0.034</td>
<td>0.037</td>
<td>0.003</td>
<td>0.042</td>
<td>0.045</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>0.004</td>
<td>0.004</td>
<td>-0.001</td>
<td>0.004</td>
<td>0.004</td>
<td>-0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The shear stresses for the proposed design are almost always higher than those of the existing condition, though the differences are small. As mentioned previously, all hydrodynamic differences arise from overtopping of the island (which only happens during the proposed condition), the exchange of water between the East Sand Island lagoons and Baker Bay, and the variations in eddy formations. These slight hydrodynamic differences can account for the minor bed shear stress differences.

Overall, this analysis shows that the lagoon/atoll design will produce minimal impacts to the surrounding environment in terms of bed shear stress. Percentile analyses of the bed shear stress are in Section 3.3. A more in-depth look at the estimated bed shear stress at the inlets is discussed in Section 3.4.

### 3.3 Full island bed shear stress percent exceedance

Using the time-series shear stress results of Section 3.2, the percent exceedance for bed shear stress was calculated for the May and August time periods (for the proposed design only). As expected, the inlets have a higher bed shear than the lagoons. The inlets are examined in greater detail in Section 3-4. The remaining areas of the lagoons have an extremely low shear stress for the majority of the simulations. Selected spatial results of the exceedance analysis are shown in Figures 3-6 through 3-11.
Figure 3-6. Proposed design maximum bed shear stress (Pa) for 10–31 May 2009.

Figure 3-7. Proposed design maximum bed shear stress (Pa) for 10–31 August 2009.
Figure 3-8. Proposed design bed shear stress (Pa) 10% exceedance for 10–31 May 2009.

Figure 3-9. Proposed design bed shear stress (Pa) 10% exceedance for 10–31 August 2009.
Based on the maximum bed shear for both time periods, a minimum grain size required to prevent bed movement was calculated using Shield’s parameter in Equation 3-6:
\[ \tau_{bs} = \Theta \rho g (s - 1)d \]  
Equation 3-6

where \( \tau_{bs} \) is critical shear stress, \( \Theta \) is Shield’s parameter (taken as 0.05), \( \rho \) is water density, \( s \) is the specific gravity of the sediment (2.65), and \( d \) is the sediment grain diameter (ASCE 2008).

The maximum shear stress can be used in Equation 3-6 to solve for the maximum incipient grain size (i.e., grains this size or smaller are likely to move). The spatial variation in these grain sizes were developed for 10–31 May 2009 (Figure 3-12) and 10–31 August 2009 (Figure 3-13). The 0.2 mm grain size threshold is shown as a dotted black line in Figures 3-12 and 3-13. Note that these grain sizes are based solely on the May and August simulation times using estimated grain parameters. It was assumed that the maximum bed shear is the critical shear stress for incipient motion for the given particles (i.e., the maximum grain size that would be moved under the computed maximum shear stress as shown in Figure 3-6 and Figure 3-7). For determination of minimum grain size required for bank/bed stabilization and other engineering needs, a comprehensive sediment transport study should be considered; such a study would include storm and flood events, processes such as waves, and an appropriate grain size sediment type distribution. Figures 3-12 and 3-13 are for demonstration purposes, but they provide insights into the behavior of the proposed plan.

The maximum calculated bed shear stress during the May and August time periods was highest for the western-most inlet at approximately 0.25 Pa. Using Shield’s equation to calculate a shear stress corresponding to a threshold grain size indicates that roughly 0.35 mm sand (medium sand) will prevent bed movement during these periods. However, as noted above, this is an estimate based solely on simulation results, and the placement material will need to be able to withstand significant events. Sediment sizes smaller than those reported will be eroded, and it is expected larger sediment sizes could be eroded as well given that the model is reproducing an average time period without any significant energetic events.

Potential maintenance concerns may include inlet channel maintenance, terrain stability, and possible infilling of the lagoons. However, without a comprehensive sediment transport study including gradation of bed materials and suspended sediment concentrations along with specifications of the inlet armoring material, quantification of these maintenance concerns is not possible.
Figure 3-12. Maximum incipient grain size (mm) based on 10–31 May 2009.

Figure 3-13. Maximum incipient grain size (mm) for 10–31 August 2009.
3.4 Percent exceedance inlet analysis

The results were also analyzed at each lagoon inlet (Figure 3-14) for the proposed design. Percent exceedance curves were developed for velocity magnitude and bed shear stress at these locations and are presented in Figure 3-15 though Figure 3-18. Figure 3-15, for example, shows that point C experiences a velocity magnitude greater than 0.05 m/s 40% of the time during the May period. At the same point C during May, the shear stress, as calculated in Section 3.2, is greater than approximately 0.01 Pa 10% of the time (Figure 3-17).

Figure 3-14. Analysis point locations for inlet analysis.
Figure 3-15. Percent exceedance of velocity magnitude for the lagoon inlets for 10–31 May 2009.

Figure 3-16. Percent exceedance of velocity magnitude for the lagoon inlets for 10–31 August 2009.
Figure 3-17. Percent exceedance of bed shear stress for the lagoon inlets for 10–31 May 2009.

Figure 3-18. Percent exceedance of bed shear stress for the lagoon inlets for 10–31 August 2009.
3.5 Depth percent exceedance

The percent exceedance for depth was calculated for Points 13 and 14 located within the west and east lagoon, respectively (Figure 3-19), for the proposed design condition. For a given depth, one can observe in Figure 3-20 (10–31 May 2009 period) and Figure 3-21 (10–31 August 2009 period) the percentage of time the given depth was exceeded. Each lagoon has a slight bottom slope; therefore, the results from the depth percent exceedance will vary based on the location of each point within the lagoon.

Figure 3-19. Observation point locations within lagoons.
Figure 3-20. Proposed design depth percent exceedance for 10–31 May 2009.

Figure 3-21. Proposed design depth percent exceedance for 10–31 August 2009.
3.6 Percent inundated

The objective of the conceptual design is to reduce or eliminate the cormorant nesting habitat on the western half of East Sand Island. The likelihood of cormorants nesting on a given area is directly related to the percentage of time the area is inundated, making it perhaps the best overall indicator of future success for the project.

The percent inundation results for 10–31 May 2009 for the west and east lagoons are found in Figures 3-22 and 3-23, respectively, and the results for 10–31 August 2009 for the west and east lagoons are found in Figures 3-24 and 3-25, respectively.

The simulations indicate the lagoons will be inundated approximately 40-60% of the time. The differences in inundation time are due to the sloped elevations for the lagoons. For example, in Figure 3-22, the inlets (1.0 m NAVD88) are inundated over 60% of the time while the back/southern portion of the lagoon (1.4 m NAVD88) is inundated approximately 40% of the time.
Figure 3-22. West lagoon percent time inundated, 10–31 May 2009.

Figure 3-23. East lagoon percent time inundated, 10–31 May 2009.
Figure 3-24. West lagoon percent time inundated, 10–31 August, 2009.

Figure 3-25. East lagoon percent time inundated, 10–31 August 2009.
3.7 Computational conditions

Each AdH model simulation was run on 512 processors on the ERDC HPC Garnet (Cray XE6 – 1.5 PFLOPS). The average model computation rate was 114 model simulated hours per 1 clock hour. Two time periods were examined, 10–31 May 2009 and 10–31 August 2009. Each simulation was run with a 3-week spin-up period in order to allow the tidal energy to propagate throughout the system.
4 Conclusion

The LCR AdH mesh was modified to examine the effects of the East Sand Island lagoon/atoll design concept on tidal conditions. Two meshes were completed for a base (existing condition) versus plan (proposed design condition) assessment. The existing condition contains the updated bathymetry and topographical data. The proposed design condition modified the updated bathymetry and topography to reflect the lagoon/atoll design elevations.

Hydrodynamic variables (water surface elevation and velocity) and bed shear stress were compared for existing and proposed conditions. For the proposed conditions, percent exceedance analyses were performed for bed shear stress, velocity magnitude, and depth. In addition, percent inundation was calculated for the proposed conditions.

Comparisons of the existing and proposed simulations indicate small differences around the island for the water surface elevation, velocity, and bed shear stress. The system as a whole should experience minimal changes. Choosing the proper bed materials and inlet reinforcement will ensure that the conceptual design can withstand tidal fluctuations and extreme weather events without degradation.

The maximum bed shear during the May and August time periods was highest for the western-most inlet at approximately 0.25 Pa. Using multiple assumptions (no waves, no storm surges, uniform noncohesive sediments, etc.), this shear stress corresponds to minimum grain size of approximately 0.35 mm (medium sand) to prevent bed movement at all locations during these periods. This grain size could be substantially higher when major storm events are considered. These results should only be used to identify a minimal possible potential sediment size. It is expected that a much larger sediment size will be required to maintain inlet stability. Before implementing terrain modification, additional evaluation of proper bed materials and inlet protection is required to ensure that the conceptual design can withstand extreme weather events and inlet fluctuations without degradation.
Based on the model simulation results, the lagoons will be inundated approximately 40%–60% of the time. The May 2009 time period has slightly higher percent inundated values than the August 2009 time period. Additionally, the lagoons were modeled with a slight slope imposed that causes the inlets to be wetted more often than the interior of the lagoons. Though the inundation times vary across the lagoons, the cormorant nesting habitat will likely be reduced.

To explicitly address the key topics listed in Section 1:

1. Will the conceptual design change velocity or shear at the offsite areas? This analysis shows that the lagoon/atoll design will produce minimal impacts to the surrounding environment in terms of velocity and bed shear stress (Section 3.1 and Section 3.2).

2. How often will the modified terrain be inundated? Based on the model simulation results, the lagoons will be inundated approximately 40%–60% of the time, which is more often than the 2-3 hours every 2 weeks required by the design objectives (Section 3.6).

3. What is the estimated confidence in the model results? As discussed in Section 2.4, the model results are acceptable for the level of accuracy necessary in this study.

4. Provide, if possible, insight as to where the modified terrain may need maintenance in the future. Potential maintenance concerns may include inlet channel maintenance, terrain stability, and possible infilling of the lagoons.

5. Provide, if possible, inferences from the bed shear stresses such as the stability of the modified terrain and potential for erosion or deposition within the modified terrain. As discussed in Section 3.2 and Section 3.3, this study may be used to make general inferences of minimum grain sizes. However, a more detailed study including the modeling of winds and waves from a design storm event would be required to accurately produce appropriate grain sizing. The erosion and deposition of the modified terrain are dependent on the grain sizes chosen for the project.
References


Brown, G. L. 2012a. A quasi-3D suspended sediment model using a set of correction factors applied to a depth averaged advection diffusion equation. In *Proceedings of the 3rd International Shallow Flows Symposium 4-6 June 2012 at IIHR at the University of Iowa in Iowa City, IA.*

Brown, G. L. 2012b. Modification of the bed sediment equations of Spasojevic and Holly (1993) to account for variable porosity, variable grain specific gravity, and nonerodable boundaries. In *Proceedings of the 3rd International Shallow Flows Symposium 4-6 June 2012 at IIHR at the University of Iowa in Iowa City, IA.*


Appendix A

A.1  Calibration/Validation comparison to existing condition

Since the calibration/validation mesh was updated and resolution increased in several regions (Crim’s Island, Sandy River delta, Stock Ranch, East Sand Island) (Figure 1-2), a comparison was made between the updated mesh simulations for East Sand Island and the calibration/validation mesh simulations.

The updated mesh contains improved resolution, bathymetry, friction specifications, adjusted pile dike locations, and includes alternate flow paths that were not previously being modeled. These changes improve the representation of the physical environment locally, but they do not have an impact on East Sand Island vicinity (points R1, R2, and R3 of Figure A-1).

Listed in Table A-1 are the minimum, maximum, and average water surface elevations for the August and May time periods, respectively, for the points shown in Figure A-1. A selection of water surface elevation time series comparison plots for 10–31 May 2009 and for 10–31 August 2009 are shown in Figure A-2 through Figure A-13 and Figure A-14 through A-25, respectively. These representative points include points R1, R2, R3, R6, R10, and R13 from Figure A-1. All points are located in the Columbia River Navigation Channel.

Figure A-1. Point locations for water surface elevation locations.
<table>
<thead>
<tr>
<th>Point</th>
<th>Water Surface Elevation (m, NAVD88)</th>
<th>10–31 May 2009</th>
<th>10–31 August 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Validation</td>
<td>Improved</td>
<td>Difference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resolution</td>
<td>Validation</td>
</tr>
<tr>
<td>R1</td>
<td>Minimum</td>
<td>-0.38</td>
<td>-0.36</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>2.89</td>
<td>2.85</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>1.30</td>
<td>1.30</td>
</tr>
<tr>
<td>R2</td>
<td>Minimum</td>
<td>-0.31</td>
<td>-0.32</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>2.92</td>
<td>2.90</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>1.32</td>
<td>1.31</td>
</tr>
<tr>
<td>R3</td>
<td>Minimum</td>
<td>-0.31</td>
<td>-0.30</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>3.01</td>
<td>3.02</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>1.39</td>
<td>1.39</td>
</tr>
<tr>
<td>R4</td>
<td>Minimum</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>3.17</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>1.56</td>
<td>1.56</td>
</tr>
<tr>
<td>R5</td>
<td>Minimum</td>
<td>1.01</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
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<td>3.33</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2.07</td>
<td>2.06</td>
</tr>
<tr>
<td>R6</td>
<td>Minimum</td>
<td>1.55</td>
<td>1.56</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>3.52</td>
<td>3.51</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2.46</td>
<td>2.44</td>
</tr>
<tr>
<td>R7</td>
<td>Minimum</td>
<td>1.78</td>
<td>1.77</td>
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<td></td>
<td>Maximum</td>
<td>3.61</td>
<td>3.58</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2.64</td>
<td>2.61</td>
</tr>
<tr>
<td>R8</td>
<td>Minimum</td>
<td>2.41</td>
<td>2.40</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>3.95</td>
<td>3.91</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>3.16</td>
<td>3.13</td>
</tr>
<tr>
<td>R9</td>
<td>Minimum</td>
<td>2.81</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>4.21</td>
<td>4.18</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>3.52</td>
<td>3.49</td>
</tr>
<tr>
<td>R10</td>
<td>Minimum</td>
<td>3.47</td>
<td>3.45</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>4.81</td>
<td>4.77</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>4.15</td>
<td>4.11</td>
</tr>
<tr>
<td>Point</td>
<td>Water Surface Elevation (m, NAVD88)</td>
<td>Validation</td>
<td>Improved Resolution</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------</td>
<td>------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>R11</td>
<td>Minimum</td>
<td>4.52</td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>5.99</td>
<td>5.96</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>5.30</td>
<td>5.27</td>
</tr>
<tr>
<td>R12</td>
<td>Minimum</td>
<td>4.91</td>
<td>4.88</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>6.52</td>
<td>6.46</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>5.80</td>
<td>5.75</td>
</tr>
<tr>
<td>R13</td>
<td>Minimum</td>
<td>5.26</td>
<td>5.23</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>7.00</td>
<td>6.95</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>6.26</td>
<td>6.21</td>
</tr>
</tbody>
</table>
Figure A-2. Water surface elevation comparison for 10–31 May 2009 for Point R1.

Figure A-3. Box plot comparison for 10–31 May 2009 for Point R1.
Figure A-4. Water surface elevation comparison for 10–31 May 2009 for Point R2.

Figure A-5. Box plot comparison for 10–31 May 2009 for Point R2.
Figure A-6. Water surface elevation comparison for 10–31 May 2009 for Point R3.

Figure A-7. Box plot comparison for 10–31 May 2009 for Point R3.
Figure A-8. Water surface elevation comparison for 10–31 May 2009 for Point R6.

Figure A-9. Box plot comparison for 10–31 May 2009 for Point R6.
Figure A-10. Water surface elevation comparison for 10–31 May 2009 for Point R10.

Figure A-11. Box plot comparison for 10–31 May 2009 for Point R10.
Figure A-12. Water surface elevation comparison for 10–31 May 2009 for Point R13.

Figure A-13. Box plot comparison for 10–31 May 2009 for Point R13.
Figure A-14. Water surface elevation comparison for 10–31 August 2009 for Point R1.

Figure A-15. Box plot comparison for 10–31 August 2009 for Point R1.
Figure A-16. Water surface elevation comparison for 10–31 August 2009 for Point R2.

Figure A-17. Box plot comparison for 10–31 August 2009 for Point R2.
Figure A-18. Water surface elevation comparison for 10–31 August 2009 for Point R3.

Figure A-19. Box plot comparison for 10–31 August 2009 for Point R3.
Figure A-20. Water surface elevation comparison for 10–31 August 2009 for Point R6.

Figure A-21. Box plot comparison for 10–31 August 2009 for Point R6.
Figure A-22. Water surface elevation comparison for 10–31 August 2009 for Point R10.

Figure A-23. Box plot comparison for 10–31 August 2009 for Point R10.
Figure A-24. Water surface elevation comparison for 10–31 August 2009 for Point R13.

Water Surface Elevation Point Comparisons

Figure A-25. Box plot comparison for 10–31 August 2009 for Point R13.
Appendix B

B.1  Water surface elevation time series comparisons between existing and proposed conditions

The following are the water surface elevation time series comparisons between the existing condition and the proposed design condition for the 12 points shown in Figure 3-1 in the vicinity of East Sand Island. Figure B-1 through Figure B-24 are for the 10–31 May 2009 period; Figure B-25 through Figure B-48 are for the 10–31 August 2009 period. Note that the elevation of Point 10 is such that it wets and dries during the simulations.
Figure B-1. Water surface elevation comparisons for 10–31 May 2009 for Point 1.

Figure B-2. Box plot comparison for 10–31 May 2009 for Point 1.
Figure B-3. Water surface elevation comparisons for 10–31 May 2009 for Point 2.

Figure B-4. Box plot comparison for 10–31 May 2009 for Point 2.
Figure B-5. Water surface elevation comparisons for 10–31 May 2009 for Point 3.

Figure B-6. Box plot comparison for 10–31 May 2009 for Point 3.
Figure B-7. Water surface elevation comparisons for 10–31 May 2009 for Point 4.

Figure B-8. Box plot comparison for 10–31 May 2009 for Point 4.
Figure B-9. Water surface elevation comparisons for 10–31 May 2009 for Point 5.

Figure B-10. Box plot comparison for 10–31 May 2009 for Point 5.
Figure B-11. Water surface elevation comparisons for 10–31 May 2009 for Point 6.

Figure B-12. Box plot comparison for 10–31 May 2009 for Point 6.
Figure B-13. Water surface elevation comparisons for 10–31 May 2009 for Point 7.

Figure B-14. Box plot comparison for 10–31 May 2009 for Point 7.
Figure B-15. Water surface elevation comparisons for 10–31 May 2009 for Point 8.

Figure B-16. Box plot comparison for 10–31 May 2009 for Point 8.
Figure B-17. Water surface elevation comparisons for 10–31 May 2009 for Point 9.

Figure B-18. Box plot comparison for 10–31 May 2009 for Point 9.
Figure B-19. Water surface elevation comparisons for 10–31 May 2009 for Point 10.

Figure B-20. Box plot comparison for 10–31 May 2009 for Point 10.
Figure B-21. Water surface elevation comparisons for 10–31 May 2009 for Point 11.

Figure B-22. Box plot comparison for 10–31 May 2009 for Point 11.
Figure B-23. Water surface elevation comparisons for 10–31 May 2009 for Point 12.

Figure B-24. Box plot comparison for 10–31 May 2009 for Point 12.
Figure B-25. Water surface elevation comparison for 10–31 August 2009 for Point 1.

Figure B-26. Box plot comparison for 10–31 August 2009 for Point 1.
Figure B-27. Water surface elevation comparison for 10–31 August 2009 for Point 2.

Water Surface Elevation Point Comparisons

Figure B-28. Box plot comparison for 10–31 August 2009 for Point 2.
Figure B-29. Water surface elevation comparison for 10–31 August 2009 for Point 3.

Figure B-30. Box plot comparison for 10–31 August 2009 for Point 3.
Figure B-31. Water surface elevation comparison for 10–31 August 2009 for Point 4.

Figure B-32. Box plot comparison for 10–31 August 2009 for Point 4.
Figure B-33. Water surface elevation comparison for 10–31 August 2009 for Point 5.

Figure B-34. Box plot comparison for 10–31 August 2009 for Point 5.
Figure B-35. Water surface elevation comparison for 10–31 August 2009 for Point 6.

Figure B-36. Box plot comparison for 10–31 August 2009 for Point 6.
Figure B-37. Water surface elevation comparison for 10–31 August 2009 for Point 7.

Figure B-38. Box plot comparison for 10–31 August 2009 for Point 7.
Figure B-39. Water surface elevation comparison for 10–31 August 2009 for Point 8.

Figure B-40. Box plot comparison for 10–31 August 2009 for Point 8.
Figure B-41. Water surface elevation comparison for 10–31 August 2009 for Point 9.

Figure B-42. Box plot comparison for 10–31 August 2009 for Point 9.
Figure B-43. Water surface elevation comparison for 10–31 August 2009 for Point 10.

Figure B-44. Box plot comparison for 10–31 August 2009 for Point 10.
Figure B-45. Water surface elevation comparison for 10–31 August 2009 for Point 11.

Figure B-46. Box plot comparison for 10–31 August 2009 for Point 11.
Figure B-47. Water surface elevation comparison for 10–31 August 2009 for Point 12.

Figure B-48. Box plot comparison for 10–31 August 2009 for Point 12.
B.2 Velocity comparisons between existing and proposed conditions

The following are the velocity magnitude time series comparisons between the existing condition and the proposed design condition for the points shown in Figure 3-1 in the vicinity of East Sand Island. Figure B-49 through Figure B-60 are for the 10–31 May 2009 period; Figure B-61 through Figure B-72 are for the 10–31 August 2009 period.
Figure B-49. Velocity magnitude comparison for 10–31 May 2009 for Point 1.

Figure B-50. Velocity magnitude comparison for 10–31 May 2009 for Point 2.
Figure B-51. Velocity magnitude comparison for 10–31 May 2009 for Point 3.

Figure B-52. Velocity magnitude comparison for 10–31 May 2009 for Point 4.
Figure B-53. Velocity magnitude comparison for 10–31 May 2009 for Point 5.

Figure B-54. Velocity magnitude comparison for 10–31 May 2009 for Point 6.
Figure B-55. Velocity magnitude comparison for 10–31 May 2009 for Point 7.

Figure B-56. Velocity magnitude comparison for 10–31 May 2009 for Point 8.
Figure B-57. Velocity magnitude comparison for 10–31 May 2009 for Point 9.

Figure B-58. Velocity magnitude comparison for 10–31 May 2009 for Point 10.
Figure B-59. Velocity magnitude comparison for 10–31 May 2009 for Point 11.

Figure B-60. Velocity magnitude comparison for 10–31 May 2009 for Point 12.
Figure B-61. Velocity magnitude comparison for 10–31 August 2009 for Point 1.

Figure B-62. Velocity magnitude comparison for 10–31 August 2009 for Point 2.
Figure B-63. Velocity magnitude comparison for 10–31 August 2009 for Point 3.

Figure B-64. Velocity magnitude comparison for 10–31 August 2009 for Point 4.
Figure B-65. Velocity magnitude comparison for 10–31 August 2009 for Point 5.

Figure B-66. Velocity magnitude comparison for 10–31 August 2009 for Point 6.
Figure B-67. Velocity magnitude comparison for 10–31 August 2009 for Point 7.

Figure B-68. Velocity magnitude comparison for 10–31 August 2009 for Point 8.
Figure B-69. Velocity magnitude comparison for 10–31 August 2009 for Point 9.

Figure B-70. Velocity magnitude comparison for 10–31 August 2009 for Point 10.
Figure B-71. Velocity magnitude comparison for 10–31 August 2009 for Point 11.

Figure B-72. Velocity magnitude comparison for 10–31 August 2009 for Point 12.
Appendix C

C.1 Shear stress comparisons

The following are the shear stress time series comparisons between the existing condition and the proposed design condition for the points shown in Figure 3-1 in the vicinity of East Sand Island. Figure C-1 through Figure C-12 are for the 10–31 May 2009 period; Figure C-13 through Figure C-24 are for the 10–31 August 2009 period.
Figure C-1. Shear stress comparison for 10–31 May 2009 for Point 1.

Figure C-2. Shear stress comparison for 10–31 May 2009 for Point 2.
Figure C-3. Shear stress comparison for 10–31 May 2009 for Point 3.

Figure C-4. Shear stress comparison for 10–31 May 2009 for Point 4.
Figure C-5. Shear stress comparison for 10–31 May 2009 for Point 5.

Figure C-6. Shear stress comparison for 10–31 May 2009 for Point 6.
Figure C-7. Shear stress comparison for 10–31 May 2009 for Point 7.

Figure C-8. Shear stress comparison for 10–31 May 2009 for Point 8.
Figure C-9. Shear stress comparison for 10–31 May 2009 for Point 9.

Figure C-10. Shear stress comparison for 10–31 May 2009 for Point 10.
Figure C-11. Shear stress comparison for 10–31 May 2009 for Point 11.

Figure C-12. Shear stress comparison for 10–31 May 2009 for Point 12.
Figure C-13. Shear stress comparison for 10–31 August 2009 for Point 1.

Figure C-14. Shear stress comparison for 10–31 August 2009 for Point 2.
Figure C-15. Shear stress comparison for 10–31 August 2009 for Point 3.

Figure C-16. Shear stress comparison for 10–31 August 2009 for Point 4.
Figure C-17. Shear stress comparison for 10–31 August 2009 for Point 5.

Figure C-18. Shear stress comparison for 10–31 August 2009 for Point 6.
Figure C-19. Shear stress comparison for 10–31 August 2009 for Point 7.

Figure C-20. Shear stress comparison for 10–31 August 2009 for Point 8.
Figure C-21. Shear stress comparison for 10–31 August 2009 for Point 9.

Figure C-22. Shear stress comparison for 10–31 August 2009 for Point 10.
Figure C-23. Shear stress comparison for 10–31 August 2009 for Point 11.

Figure C-24. Shear stress comparison for 10–31 August 2009 for Point 12.
Investigation of Impacts Associated with Modifying East Sand Island to Prevent Nesting of Double-Crested Cormorants

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The U.S. Army Engineer District, Portland, is conducting an alternative analysis under an environmental impact statement to determine a preferred approach to permanently modify or eliminate habitat for double-crested cormorants on East Sand Island in the Columbia River. The goal of the alternative analysis is to determine how to reduce/eliminate the habitat for the cormorants and correspondingly increase the survivability of the out-migrating salmonids without impacting the overall behavior of the system, including the stability of the island and navigation. One proposal to reduce/eliminate cormorant habitat on East Sand Island is to cause the parts of the island used by the birds to become subtidal or intertidal so that the island will not be used for nesting or roosting.

Hydrodynamic impacts associated with proposed system alterations to East Sand Island are investigated. An Adaptive Hydraulics numerical model of the Lower Columbia River produces water levels, velocities, shear stresses, and inundation information for existing conditions and one alternative condition in and around the study area.

A base versus alternative plan analysis was conducted by simulating the existing and proposed conditions for two time periods, May (high river flow) and August (low river flow) 2009. Comparisons of the existing and proposed simulations indicate the differences between the water surface elevation, velocity, and bed shear stress will be small. The system as a whole should experience minimal changes. Based on the simulation results, the lagoons will be inundated approximately 40%-60% of the time. The May 2009 time period has slightly higher percent inundated values than the August 2009 time period. Overall, it appears from this analysis that the lagoon/atoll design will produce minimal impacts to the surrounding environment in terms of bed shear stress and based on the inundation times, will likely reduce Cormorant nesting habitat.