Port of Ilwaco and Port of Chinook Engineering Study/Solutions In Support of Maintenance Dredging

Prepared for:

Port of Ilwaco and Port of Chinook

This document was prepared by a Professional Engineer who conducted an engineering study in order to assist the Port of Ilwaco and Port of Chinook with engineering solutions and cost estimates for feasible and cost-effective measures to support maintenance dredging at the Port of Ilwaco and Port of Chinook Marinas. This document is not to be used for construction purposes.

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Technical Memorandum – Executive Summary
Port of Ilwaco and Port of Chinook Engineering Study/Solutions In Support of Maintenance Dredging

1. Introduction

The Port of Ilwaco and Port of Chinook have regularly conducted dredging in the marinas to maintain minimal required navigation depths to provide safe berthing and maneuvering operations for pleasure and commercial fishing vessels. For the last several decades, dredging at the marinas was conducted by hydraulic pipeline with placement of dredged material at the upland disposal sites. Currently, the upland disposal sites at the Port of Ilwaco and at Port of Chinook are at the limit of their capacity and likely may be available for only 2-3 more dredging cycles.

This study was conducted by Coast & Harbor Engineering, A Division of Mott MacDonald, to develop engineering solutions and cost estimates for feasible and cost-effective measures to provide long-term sustainable and navigable depths in the Port of Ilwaco and Port of Chinook marinas. The study determined the required dredging depths at both the Port of Ilwaco and Port of Chinook marinas, estimated maintenance dredging requirements, identified and evaluated dredged material disposal alternatives, selected the preferred alternative, and developed engineering cost estimates.

The current document presents a summary of the study. For more details of the study, the reader is referred to the study report: Port of Ilwaco and Port of Chinook Engineering Study/Solutions In Support of Maintenance Dredging, June 2019.

2. Dredging Depths and Dredging Requirements

For the purposes of dredging, the Port of Ilwaco Marina area is defined by two areas with navigable depths[1] at 10 ft. MLLW and 16 ft. MLLW. Figure 1a shows these areas overlayered on a 2013 bathymetric survey. Similarly, for dredging purposes, the Port of Chinook Marina is defined by three distinct areas with navigable depths at 10 ft. and 8 ft. MLLW. Figure 1b shows these areas overlayered on the 2016 depth measurements data.

The volumes of dredging for the Port of Ilwaco and Port of Chinook marinas were computed using the alignment and design depths of the areas delineated in Figure 1, and are shown in Table 1.

[1] Please note that the navigation depth does not include 1 ft. of allowable over-dredge and/or advanced maintenance dredging clearance.

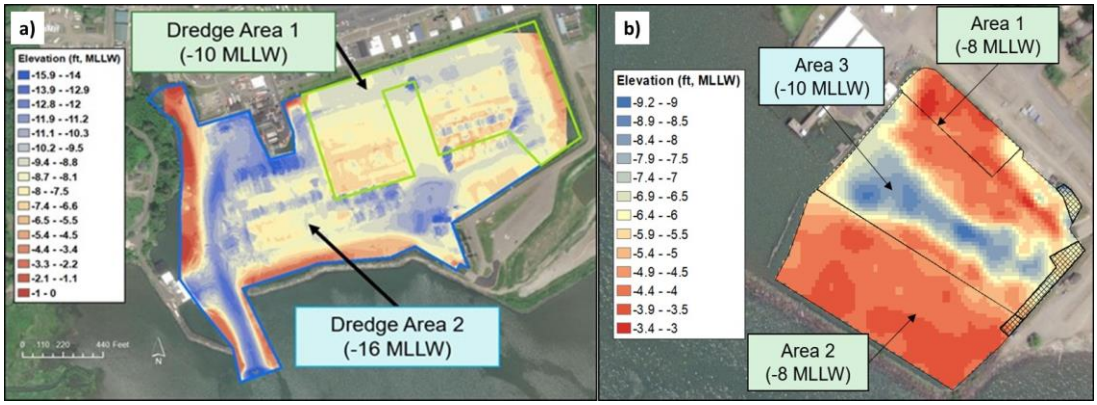

Figure 1. Dredging depths for a) Port of Ilwaco and b) Port of Chinook

Table 1. Dredging Volumes Estimates, Port of Ilwaco and Port of Chinook Marinas

	Dredging to Navigable Depths (CY)	Dredging to Navigable Depths + 1 ft OD (CY)
Port of Ilwaco Marina	400,000	450,000
Port of Chinook Marina	56,000	67,000

Analysis of sedimentation was conducted, and the average yearly rates of sediment deposition[2] for both the Port of Ilwaco and Port of Chinook Marinas were estimated. Using these rates, the volumes of yearly sediment deposition in the marinas were computed and are depicted in Table 2.

Table 2. Averaged per Year Rates of Sedimentation and Volumes of Sediment Deposution Estimates at Port of Ilwaco and Port of Chinook Marinas

	Rate of sedimentation (ft/year)	Volume of Deposition (CY/year)
Port of Ilwaco Marina	0.4	29,000
Port of Chinook Marina	0.6	9,000

Table 3 summarizes the volumes of dredging for the Port of Ilwaco and Port of Chinook Marinas to achieve the designed depths (also referenced as Capital Dredging) and maintenance dredging requirements for a 10-year period[3].

[2] Rate of sediment deposition is the thickness of accumulated sediment layer, averaged over the entire area of the marina.

[3] The table considers that the Port of Ilwaco Marina maintenance dredging will remove 58,000 cy of sediment once every two years, and the Port of Chinook Marina maintenance dredging will remove 27,000 cy of sediment once every three years.

Table 3. Summary of Dredging Volumes

Port	Capital Dredging (CY)	Yearly Maintenance (CY/yr)	Total Volume for 10 Years (CY)
Ilwaco	450,000	29,000	740,000
Chinook	67,000	9,000	157,000

3. Dredging and Dredge Material Disposal Alternatives

Analysis and development of the dredging and dredged material disposal alternatives was conducted to identify feasible and cost-effective measures that will provide long-term sustainable and navigable depths in the Port of Ilwaco and Port of Chinook Marinas. As a result, a total of five dredging and dredged material disposal alternatives for the Port of Ilwaco and three dredging and dredged material disposal alternatives for the Port of Chinook were developed and conceptually evaluated to select the preferred option(s). The evaluation was based on the following 7 (seven) criteria: performance, constructability (dredgeability), capital cost, maintenance cost, risks and uncertainties associated with environmental permitting process, use of dredged sediment for shoreline protection, and use of dredged sediment to maintain sediment budget in LCR Estuary. Initial feedback from Portland District USACE dredging experts was also considered in the evaluation of alternatives.

Based on evaluation of the analysis results and coordination with the Port of Ilwaco and Port of Chinook, two preferred alternatives[4] were selected for the Port of Ilwaco and one preferred alternative was selected for the Port of Chinook.

The preferred alternatives for the Port of Ilwaco are: Preferred Alternative 1– Dredging with a small hydraulic dredge and placement of sediment into nearshore beneficial use disposal sites; and Preferred Alternative 2– Clamshell and bottom dump barges with open water disposal and restoration of existing upland disposal site capacity.

Port of Ilwaco Preferred Alternative 1: Dredging with a small hydraulic dredge and placement of sediment into nearshore beneficial use disposal sites. The objective of this alternative is to develop an unlimited capacity nearshore disposal site with several beneficial uses including: a) minimizing shoreline erosion; and b) restoring historical levels of suspended sediment concentration in the Lower Columbia River Estuary that has apparently been depleted during the last century. Upon implementation of this alternative, no need for an upland disposal site would exist in the future. The concept of the Preferred Alternative 1 is described in Figure 2 (a and b).

[4] Two alternatives (instead of one) was selected due to the risks associated with obtaining environmental permits for the most preferred, cost-effective alternative. However, during the next phase of the project it may occur that this alternative will require a complex and lengthy process of permitting that may eventually transform this alternative into a more expensive and less preferred alternative. Thus, the funds are secured for a second preferred alternative that should be used to implement it.

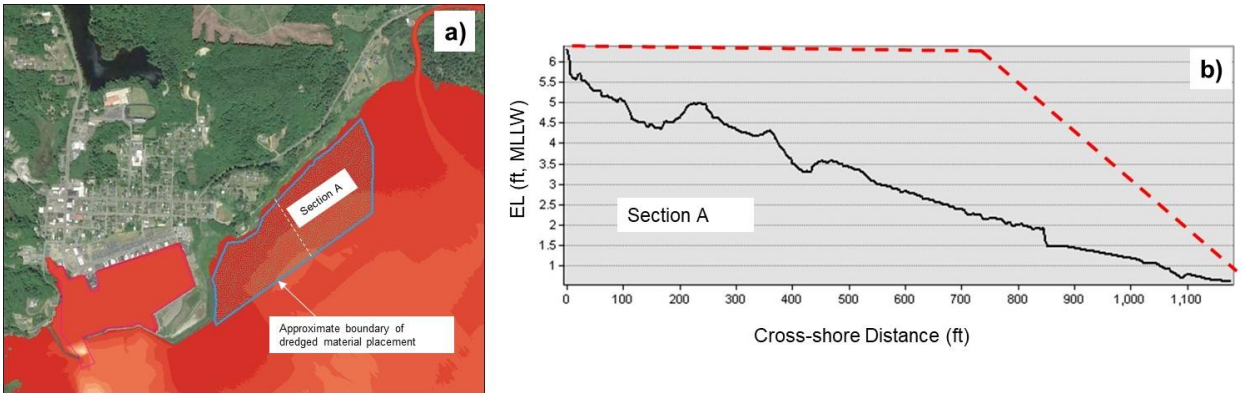

Figure 2. Port of Ilwaco Dredge Material Disposal - Preferred Alternative 1 Concept

Plate "a" of Figure 2 shows the boundary of the proposed nearshore and beneficial use dredged material placement area overlaid on the bathymetric survey data. The boundary of the landward part of the proposed placement site is aligned along the eroding shoreline and armor rock revetment that was placed at some locations to stop the shoreline erosion. Plate "b" of Figure 2 shows, in black, the existing depths (elevations) along Section A and proposed vertical limits (red-dashed line) of the dredged material placement. The geometric volume confined by the boundaries of the proposed site and existing configuration of the bed is estimated to be in excess of 600,000 cy, which would be sufficient for first-time placement and long-term maintenance dredging requirements. Please note that a steep drop of existing elevations at the landward part of the section indicates the presence of armor rock and concrete slabs that were built and maintained historically to stop shoreline erosion.

With this Preferred Alternative 1, the marina would be dredged by a small hydraulic dredge with placement of sediment through a hydraulic pipeline directly at the nearshore disposal area. No confinement for placement of dredged sediment is assumed at this time[5]. Once placed, the dredged material will be subject to erosion from energy produced by waves and tidal currents. However, by eroding and absorbing wave and tidal current energy, the dredged sediment provides protection from shoreline erosion.

Port of Ilwaco Preferred Alternative 2: Clamshell and bottom dump barges with open water disposal and restoration of existing upland disposal site capacity. This alternative includes maintenance of the existing upland disposal site, but periodically (once every 10-15 years) emptying the site using the operations discussed below. The frequency of emptying the upland disposal site would be reduced (more time between re-empty events) if there are opportunities for beneficial use of dredged material[6]. The concept of this alternative is illustrated in Figure 3 (plates "a" and "b").

[5] A final decision on the need for a confinement berm would be made during the permitting process and through consultation with the agencies and USACE.

[6] Based on information from the Port of Ilwaco, there was one example of using a limited amount dredged material (approximately 12,000 cy) from the upland disposal site of the Port for a habitat restoration project. However, long-term and regular users of the dredged material have not yet been identified.

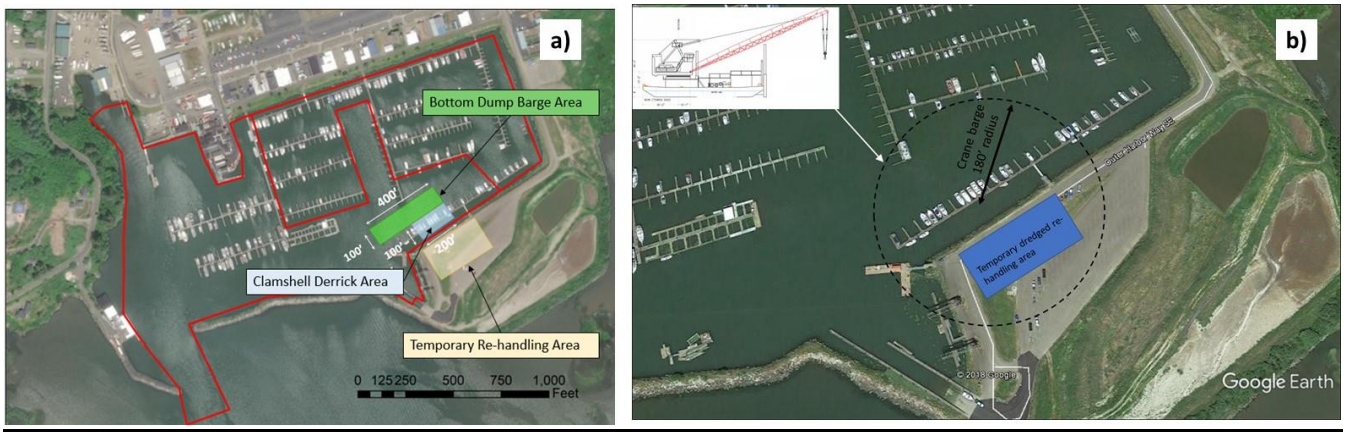

Figure 3. Port of Ilwaco Preferred Alternative 2 concept

Plate A shows the overall view of the Port of Ilwaco Marina with the existing upland site. With Alternative 1, dredged material from this upland disposal site will be periodically mechanically excavated and placed at the temporary re-handling area, also shown in the figure. It should be noted that the specific location of the re-handling facility may change due to possible remodeling of the adjacent upland area[7], but still will be within reach of the clamshell, shown schematically in Plate B. The clamshell will be able to reach the temporary re-handling facility and load the excavated sediment to the bottom dump barge, stationed at the temporary offloading facilities (Bottom Dump Barge Area), as shown in Plate A.

This alternative assumes using a clamshell and bottom dump barge with a capacity of 4,000 – 6,000 cy, with a loaded draft of 12-17 ft. that will be moored at the temporary loading facility. Additional dredging may be required at this loading facility to accommodate barge loading operations without grounding. The volume of this dredging as well as specific locations of temporary loading and re-handling facilities shall be determined upon preliminary and final design of the dredging operations, if this alternative is implemented.

Once loaded with excavated sediment, the bottom dump barge will be towed to the designated open water disposal site where sediment will be disposed. The specific open water disposal site for placement of excavated sediment shall be determined upon preliminary and final design, but likely would be one of the USACE's Columbia River Mouth sites.

Port of Chinook Preferred Alternative: Dredging with a hydraulic dredge and placement of sediment at the nearshore beneficial use disposal sites. The objective of this alternative is to develop an unlimited capacity nearshore open water disposal site, restore the eroded bottom slope, and abandon the existing upland disposal site. Also, it is believed that this alternative would beneficially contribute to restoration of historical levels of suspended sediment concentration in the Lower Columbia River Estuary that, apparently, have been depleted during the last century. The concept of the alternative is described in Figure 4.

[7] For example, as informed by the Port, the marina restroom facilities may be relocated in the vicinity of the proposed project area. Thus, if this occurs, the location of the re-handling area shown in the figure would shift appropriately.

Figure 4. Port of Chinook Preferred Dredging and Dredged Disposal Alternative

The proposed nearshore disposal area is preliminarily identified with dimensions at approximately 3,000 ft. long (along the shore) and 500 ft. wide (perpendicular to the shore), as shown in Figure 4 The location of the disposal area was selected along the nearshore bottom slope that recently has been subjected to scour and deepening (trenching), apparently from landward migration of the tidal channel. Formation of the trench at the nearshore area has contributed to acceleration of shoreline erosion; thus, several shoreline erosion measures have been undertaken at this area recently.

Under this alternative, dredging in the marina would be conducted by a hydraulic dredge. The dredged sediment would be pumped through a short length of pipeline and discharged directly at the proposed nearshore placement area, shown in the figure. The type and dimensions of the hydraulic dredge as well as detailed alignment of the pipeline should be determined during preliminary and final design. Preliminarily, it is expected that a portable hydraulic dredge of a minimum 10" and maximum 16" discharge pipe diameter would be used for the project. The length of pipeline would not exceed 4,000 ft.; thus, no need for a booster pump is assumed.

Placement of dredged material at the proposed placement site would minimize scour effects and preclude further formation of a trench. The placement area would be sufficient for placement of sediment from capital and the following maintenance dredging events.

4. Dredging and Dredged Material Disposal Alternatives Preliminary Cost Estimates

Cost estimates for implementation of each of the preferred dredging and dredged material placement alternatives were developed at the preliminary level[8] based on the general assumptions as follows:

- All dredged and excavated sediment are suitable for open water disposal.
- Open water disposal sites at the Mouth of Columbia River with be available for placement of sediment from the Port of Chinook and the Port of Ilwaco.
- Costs for permitting and related mitigation measures (if required) are not included.
- Costs for acquiring land or leases of nearshore areas (if required) are not included.
- All dredging work will be performed by the Contractor.
- All costs are in 2018 money values.
- Dredging cost estimates for hydraulic dredging work were computed using the Corps of Engineering Dredging Software (Dredging Cost Spreadsheet).

In addition to the general, the explicit assumptions are described in more detail in the study report. The results of the cost estimates are presented below in Table 4.

Table 4. Port of Ilwaco and Port of Chinook Recommended Dredging and Disposal Alternative Preliminary Cost Estimates

Port	Alternative	First-Time Dredging Costs	Design Maintenance Dredging Event Costs[9]
Ilwaco	Preferred Alternative 1	$2,800,000	$420,000
	Preferred Alternative 2	$11,000,000	$460,000
Chinook	Preferred Alternative	$3,000,000	$270,000

5. Recommendations

1. Port Ilwaco
   a. Proceed with design, permitting, and implementation for the Preferred Alternative 1 of dredging and dredged material disposal.
   b. Secure the funds for Preferred Alternative 2 ($11,000,000) in case the permitting process for Preferred Alternative 2 requires unreasonable amounts of time and resources.
   c. Bathymetric and topographic surveys of the bottom slope of Preferred Alternative 1 has been completed under this study effort and the results, xyz format survey data are

[8] The level of accuracy of the preliminary cost estimates corresponds to the opinion on the order of magnitude and is used herein for comparison analysis and selection of the preferred alternative. More accurate cost estimates would be developed during the next phases of the project; preliminary and final design.
[9] Maintenance dredging event for the Port of Ilwaco Marina is assumed once every 2 years with a volume of 58,000 cy.

stored in a separate digital file. The survey data of the disposal site are prepared to support future permitting process.

2. Port of Chinook
   a. Proceed with obtaining funds for design, permitting, and implementation of the recommended Preferred Alternative of dredging and dredged material disposal.
   b. Bathymetric and topographic surveys of the bottom slope of Preferred Alternative has been completed under this study effort and the results, xyz format survey data are stored in a separate digital file. The survey data of the disposal site and are prepared to support future permitting process.

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Technical Memorandum
Port of Ilwaco and Port of Chinook Engineering Study/Solutions In Support of Maintenance Dredging

6. Introduction

The Port of Ilwaco and Port of Chinook have regularly conducted dredging in the marinas to maintain minimal required navigation depths to provide safe berthing and maneuvering operations for pleasure and commercial fishing vessels. For the last several decades, dredging at the marinas was conducted by hydraulic pipeline with placement of dredged material at the upland disposal sites. Currently, the upland disposal sites at the Port of Ilwaco as well as at the Port of Chinook are at the limit of their capacity and likely may be available for only 2-3 dredging cycles.

This study was conducted by Coast & Harbor Engineering, A Division of Mott MacDonald, to develop the engineering solution and cost estimates for feasible and cost-effective measures to provide long-term sustainable and navigable depths in the Port of Ilwaco and Port of Chinook Marinas. The study determined the required dredging depths in both Port of Ilwaco and Port of Chinook marinas, estimated the maintenance dredging requirements, identified and evaluated the dredged material disposal alternatives, selected the preferred alternative and developed the engineering cost estimates.

7. Design Dredging Depths and Volumes of Dredged Material

7.1. Design Dredging Depths

7.1.1. Port of Ilwaco

As mentioned above, the historical practice of maintenance dredging at the Port of Ilwaco was performed to provide minimum required navigation depths to assure safe navigation of small pleasure crafts and commercial fishing vessels. Due to lack of funds, restrictions on disposal sites, and complexity/uncertainties with timely obtaining of the environment permits, the previous dredging efforts were mostly conducted in response to critical shoaling events rather than methodical advanced maintenance dredging. As a result, the dredging depths and volumes in the marinas were defined in terms of environmental permits only and not from the perspective of optimal depths/dimensions that provide maximum benefits to the commerce and the Port's future development.

For the purpose of the current project, the design depths in the Port of Ilwaco Marina were established based on a) review of general information on marina slips (number, location, dimensions, conditions), b) examination of the mix of commercial and

pleasure boats - current occupants of the marina, and c) input from the Port. As a result of the above, two areas of the marina with two different depths, -16 ft and -10 ft MLLW where identified and selected for further analysis. Figure 1 shows these areas overlayered on the bathymetry of the marina from 2013 Department of Ecology (DOE) survey. Please note that the selected design depths indicate the required navigation conditions and do not include 1 ft of allowable over-dredge and/or advanced maintenance dredging clearance. Using the alignment of these two area configurations (confirmed by the Port of Ilwaco) and 2013 DOE bathymetric survey data, the dredging volumes are computed as follows:

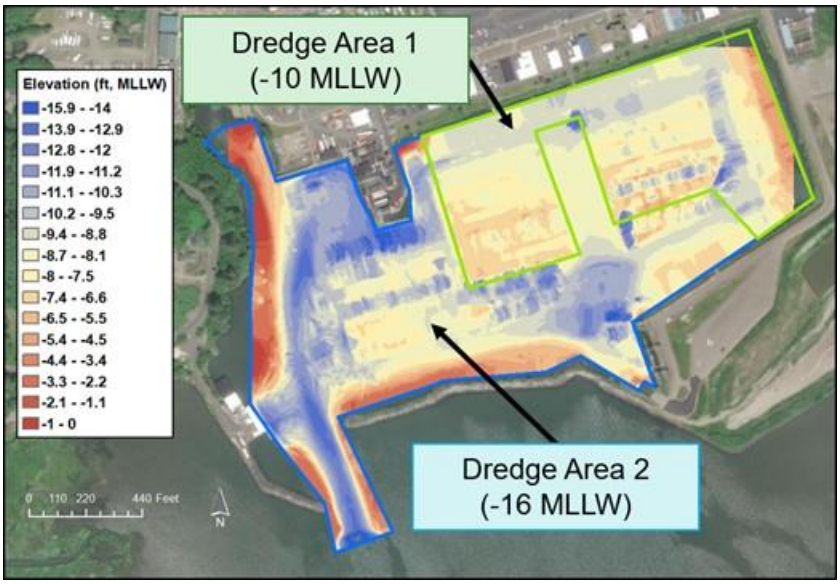

Figure 1. Dredging Depths for Port of Ilwaco

Table 1. Port of Ilwaco Dredging Volumes Estimates

	Dredging to Navigable Depths (CY)	Dredging to Navigable Depths + 1 ft OD (CY)
Dredge Area 1 to – 10 ft MLLW Dredge Area 2 to – 16 ft MLLW	400,000	450,000

7.1.2. Port of Chinook

Similar to Port of Ilwaco, the historical practice of maintenance dredging at the Port of Chinook was primarily conducted in response to critical shoaling events rather than methodical advanced maintenance dredging. As a result, the dredging depths and volumes in the marinas were not defined in terms to provide maximum benefits to the commerce and Port's future development.

For the purpose of the current project the design depths in the Port of Chinook were established based on a) review of general information on marina slips (number, location, dimensions, conditions), b) examination of the mix of commercial and pleasure boats - current occupants of the marina, and c) input from the Port. As a result of the above, three distinct areas with depths at -10 ft and -8 ft MLLW were

identified and selected for further analysis, as shown on Figure 2. Again, it should be noted that the selected design depths indicate the required navigation conditions and do not include 1 ft of allowable over-dredge and/or advanced maintenance dredging clearance. Using the alignment of these three areas (confirmed by the Port of Chinook) and Depth Measurements collected by the Port in May 2016, the dredging volumes are computed as shown in Table 2**Error! Reference source not found.**.

Table 2. Port of Chinook Dredging Volume Estimates

	Dredging Volume to Navigable Depths (CY)	Dredging Volume to Navigable Depths + 1 ft OD (CY)
Dredge Area 1 & 2 to – 8 ft MLLW Dredge Area 3 to – 10 ft MLLW	56,000	67,000

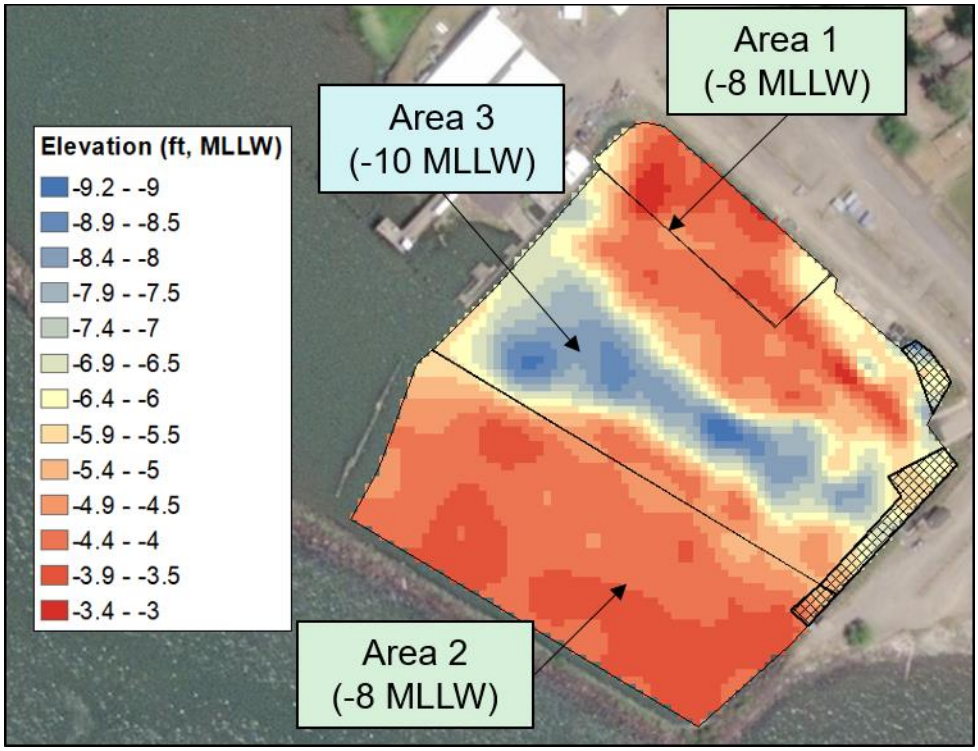

Figure 2. Dredging Depths for Port of Chinook

7.2. Sedimentation Estimates

7.2.1. General

The previous section identified the volume of dredging to bring both Port of Ilwaco and Port of Chinook to the design (desirable) depth/dimensions conditions. The next step of the study was to estimate the yearly rate of sedimentation in the marinas (of the design depths) and establish the required maintenance dredging requirements.

7.2.2. Port of Ilwaco

Estimates of sedimentation in the marina were conducted by compilation, evaluation, and extrapolation of limited data that somehow relate to the project matter, including a University of Washington study on historical bottom depth changes in Baker Bay (Creager, 1984), bathymetric surveys that overlapped in close proximity of the marina[10], and U.S. Corps of Engineers (USACE) navigation channel sedimentation study and data. It should be noted that there were no measurements or other type of data found that directly are applicable to compute rates of sediment deposition in the marina. Thus, further analysis was conducted to interpret and extrapolate available information to develop a range of possible sedimentation rates and, ultimately, select the design rate. For example, the previous UW study of bottom depth changes in Baker Bay indicates the overall trend of deposition of sediment in areas adjacent to the marina (but not inside of the breakwaters) is rounded to 1" per year. This rate of sedimentation reflects the lowest possible rate of sedimentation that may occur in the marina[11]. The other information that was used in evaluation of sedimentation was a result of the comparison of two overlapped bathymetric surveys: USACE January 2012 and DOE May 2013. Figure 3 shows the area and profile where these two surveys were compared. The area of comparison is a small bottom depression, apparently a remnant of a small tidal channel. The pattern of sediment deposition in this depression is more distinct than that of an open bay and more representative to that of confined marina. The thickness of sedimentation over this area is computed at approximately 0.2 ft per year. This rate was used as another data-point in the determination of sedimentation estimates in the marina.

And finally, the information from a sedimentation study at the Federal Navigation Channel (FNC) (USACE, 2011) and available USACE dredging records and hydrographic surveys were used to develop an upper level of estimate. Specifically, a part of FNC adjacent to the marina was used as a prototype for estimates of the upper level of sedmentation in the marina. Based on the available records, the thickness of sediment depostion at this part of the channel in averaged is estimated at 0.6 ft/year.

As a result of interpretation and extrapolation of the available data, a rate of sedimentation in the marina is estimated in a range of 0.2-0.6 ft/year. This corresponds to a maintenance dredging requirement between 15,000 and 43,000 cy/year, assuming that the marina is dredged to the allowable depths shown in Figure 1. An average and rounded rate of sedimentation of 0.4 ft per year and corresponding volume of sedimentation of 29,000 cy/year were selected and have been used for further analysis.

[10] There is only one detailed bathymetric survey, performed by WA Department of Ecology (DOE) in 2013, that is available for the marina area. No other adequate surveys of the marina have been found. Thus, no sequential surveys in the marina were found to analyze sedimentation.

[11] The marina breakwaters restrict flow dynamics inside of the marina and increase sedimentation rates relative to unconfined areas.

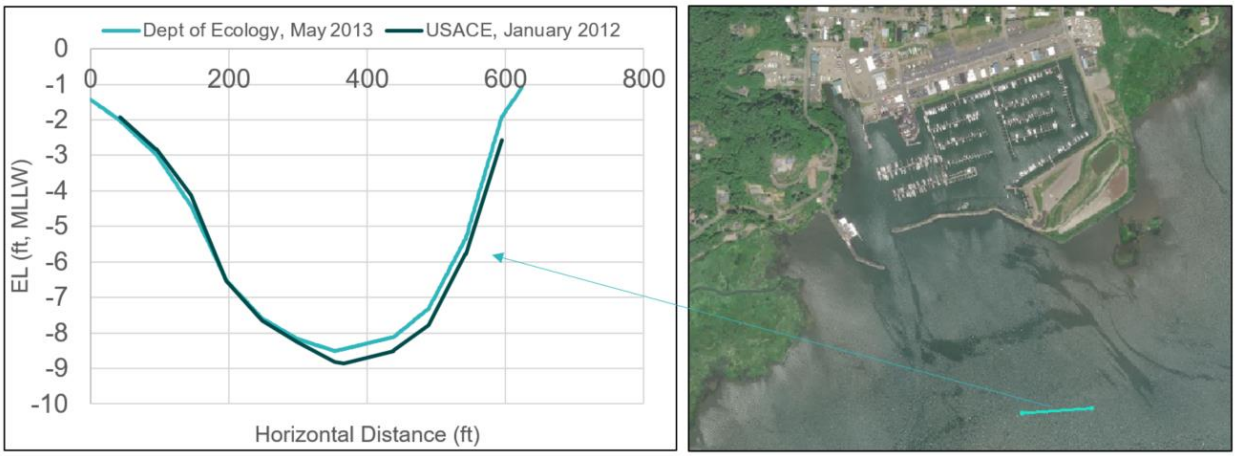

Figure 3. Sedimentation in vicinity of Port of Ilwaco Marina between May 2013 and January 2012.

7.2.3. Port of Chinook

Similar to the Port of Ilwaco analysis, an estimate of sedimentation in the Port of Chinook Marina was conducted by compilation, evaluation, and extrapolation of limited data that somehow relate to the project matter. The lowest possible rate of sedimentation was assumed to be equal to the historical bottom depth change in Baker Bay, representative of the area adjacent to the marina (but not inside of the breakwaters). This value rounds to 1" per year. The upper rate of sedimentation was assumed to be equal to the deposition of sediment in the part of the FNC located in the lee of the breakwater. A series of USACE hydrographic surveys for the period 2015-2018 was compiled and analyzed to determine the rate of sedimentation in this area. Figure 4 shows the result of comparison of two sequential USACE surveys (August 2016 and May 2017) in this part of the channel. The rate of sedimentation in this part of Federal Channel was estimated approximately in a range of 0.6-1.6 ft per year. The average value of this range, 1.1 ft per year was assumed as the upper limit for the Port of Chinook marina sedimentation. And, finally, a design level of sedimentation for further considerations and estimates herein was computed as an average between lower and upper limits that yields approximately 0.6 ft/year. This corresponds to a maintenance dredging requirement of 9,000 cy/year if the marina is dredged to the allowable depths shown in Figure 2.

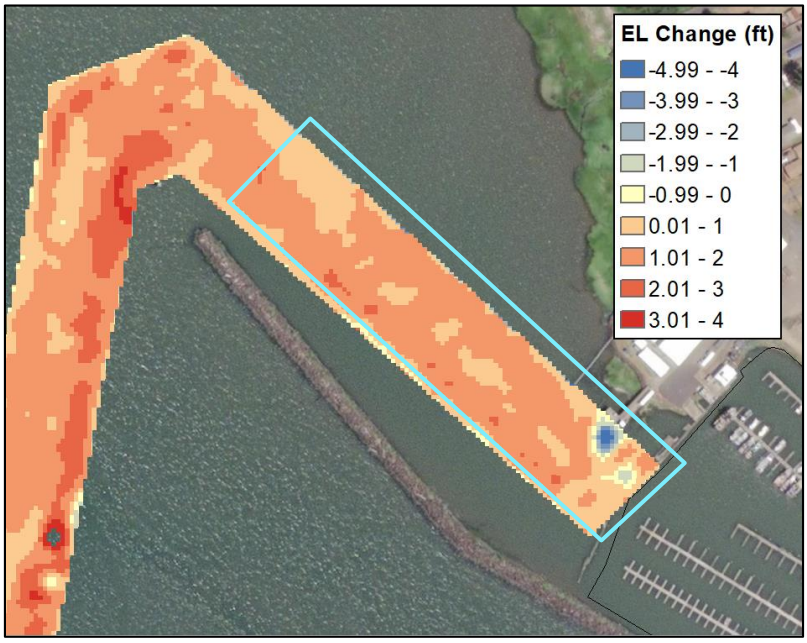

Figure 4. Elevation change between August 2016 and May 2017 USACE surveys (warm colors represent sedimentation and cool colors represent erosion)

Table 3. Estimated Sedimentation Rates for Port of Ilwaco and Port of Chinook

Port	Estimated Sedimentation Rate (CY/year)		Selected Design (CY/year)
	Lower Limit	Upper Limit	
Ilwaco	15,000	43,000	29,000
Chinook	2,000	16,000	9,000

7.3. Summary of Dredging Volumes

Table 4 summarizes the estimated volumes of dredging for the Port of Ilwaco and Port of Chinook marinas to achieve the designed depths (also referenced to as Capital Dredging) and yearly sedimentation volumes that need to be dredged to assure sustainability of these design depths. Please note that Capital volumes, depicted in Tables 1 and 2, include 1 ft over-dredge allowance. It also should be noted that this 1 ft over-dredge is in excess of estimated sedimentation rates (0.4 ft at the Port of Ilwaco and 0.6 ft at the Port of Chinook). Considering this fact and a relatively small volume[12] of sedimentation, conducting annual maintenance in the marinas is not necessary, nor economical. It is recommended that the Port of Ilwaco Marina schedule maintenance dredging of approximately 58,000 cy once every 2 years and the Port of Chinook marina schedule maintenance dredging of approximately 27,000 cy once every 3 years.

[12] A small volume herein is defined in terms of the dredging Contractor. Mobilization and demobilization costs may exceed the cost of dredging if the dredging volume is small. Thus, the total cost of each maintenance dredging event would be high.

Table 4, Column 4 also includes the estimated 10-year cumulative volumes of dredging that need to be performed to maintain navigable conditions in the marinas at the design depths discussed above. Based on industry practice and knowledge, it would be very difficult (if not impossible) to develop an upland disposal site to accommodate these volumes without the possibility of beneficial use of dredged sediment or periodic re-emptying of the upland site.

Table 4. Summary of Dredging Volumes

Port	Capital Dredging (CY)	Yearly Maintenance (CY/yr)	Total Volume for 10 Years (CY)
Ilwaco	450,000	29,000	740,000
Chinook	67,000	9,000	157,000

8. Dredging and Dredge Material Disposal Alternatives

8.1. General

Analysis and development of the dredging methods and dredge material disposal alternatives were conducted to meet the main objective of the project: to identify feasible and cost-effective measures to provide long-term sustainable and navigable depths in the Port of Ilwaco and Port of Chinook Marinas. To identify and engineer these measures, the following criteria were developed and coordinated with the Port of Ilwaco and Port of Chinook:

- Dredging methods provide effective navigable depths for marina users throughout the year.
- Minimize dredging costs and optimize use of dredging equipment.
- No/minimal impact on the FNC.
- Avoid adverse environmental impacts.
- Use dredged sediment to maintain sediment budget in Lower Columbia River Estuary.
- Use dredged sediment to address localized morphology and shoreline erosion issues.

Five alternatives for the Port of Ilwaco and four alternatives for the Port of Chinook were developed and are described below that address the above criteria at different levels.

8.2. Port of Ilwaco

Five potential dredged material alternative disposal sites were developed and are discussed below to accommodate dredging at the Port of Ilwaco to the navigation condition dimensions that are discussed above in Section 2. Each alternative and method of removal is briefly described below.

Alternative 1: Clamshell and bottom dump barges with open water disposal and restoration of existing upland disposal site capacity. The objective of this alternative is to maintain the existing upland disposal site, but periodically, once it is filled up (as estimated to be once every 10-15 years), to empty the site using the operations discussed below. The frequency of emptying the upland disposal site would be reduced (more time between re-empty events) if the opportunity for beneficial use of dredged material occurs[13]. The concept of Alternative 1 is illustrated in Figure 5 (plates "a" and "b").

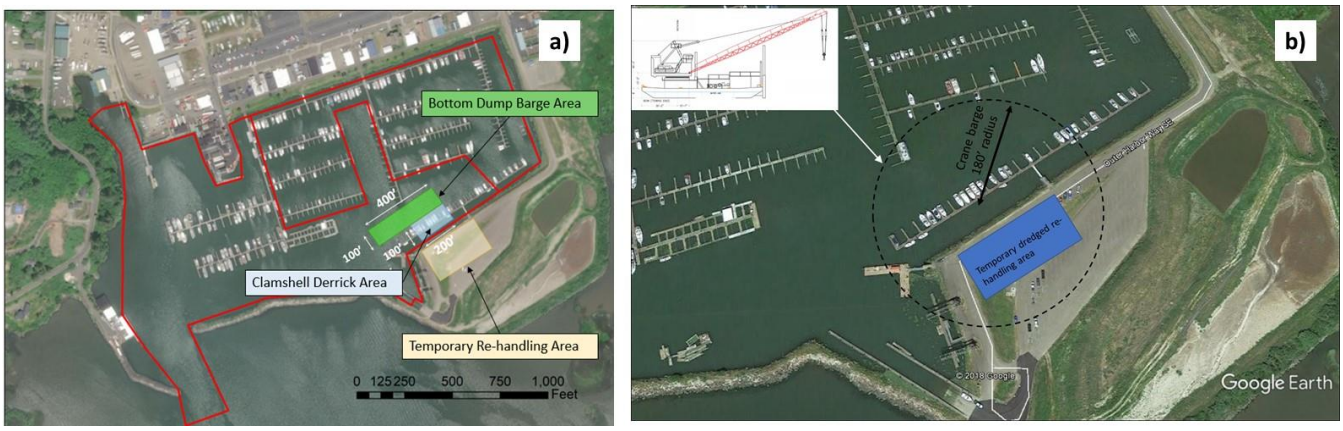

Figure 5. Port of Ilwaco Disposal Alternative 1 schematic

Plate A shows the overall view of the Port of Ilwaco Marina with existing upland site. With Alternative 1 the dredged material from this upland disposal site will be periodically mechanically excavated and placed at the temporary re-handling area, also shown in the figure. It should be noted that the specific location of the re-handling facility may change due to possible remodeling of the adjacent upland area[14], but its location will still be within reach of the clamshell, shown schematically in Figure 5b. The clamshell will be able to reach the temporary re-handling facility and load the excavated sediment to the bottom dump barge, stationed at the temporary offloading facilities (Bottom Dump Barge Area) as shown in Figure 5.

Alternative 1 assumes using a clamshell and bottom dump barge with capacity of 4,000 – 6,000 cy, with a loaded draft of 12-17 ft that will be moored at the temporary loading facility. Additional dredging may be required at this loading facility to accommodate barge loading operations without grounding. The volume of additional dredging and the specific locations of temporary loading and re-handling facilities shall be determined upon preliminary and final design of the dredging operations if Alternative 1 is implemented.

[13] Based on information from the Port of Ilwaco, there was one example of using a limited amount dredged material (approximately 12,000 cy) from the Port's upland disposal site for a habitat restoration project. However, long-term and regular users for the dredged material have not been yet identified.

[14] The Port has indicated that the marina restroom facilities may be relocated in the vicinity of the proposed project area. If this occurs, the location of the re-handling area shown in the figure would shift appropriately.

Once loaded with excavated sediment, the bottom dump barge will be towed to the designated open water disposal site, where sediment will be disposed. The specific open water disposal site for placement of excavated sediment shall be determined upon preliminary and final designs, but likely would be one of the USACE's Columbia River Mouth sites, as described in Appendix A.

Alternative 2: Hydraulic dredging and dispersive disposal at Jetty A. The concept of this alternative was recommended by specialists from the Portland District USACE during a joint project meeting in October 2018. The objective of this alternative is to develop an unlimited capacity nearshore open water disposal site and to abandon the existing upland disposal site. It is believed that this alternative would beneficially contribute to the restoration of historical levels of suspended sediment concentration in the Lower Columbia River Estuary that have apparently been depleted during the last century. The concept of Alternative 2 is described in Figure 6a and 6b.

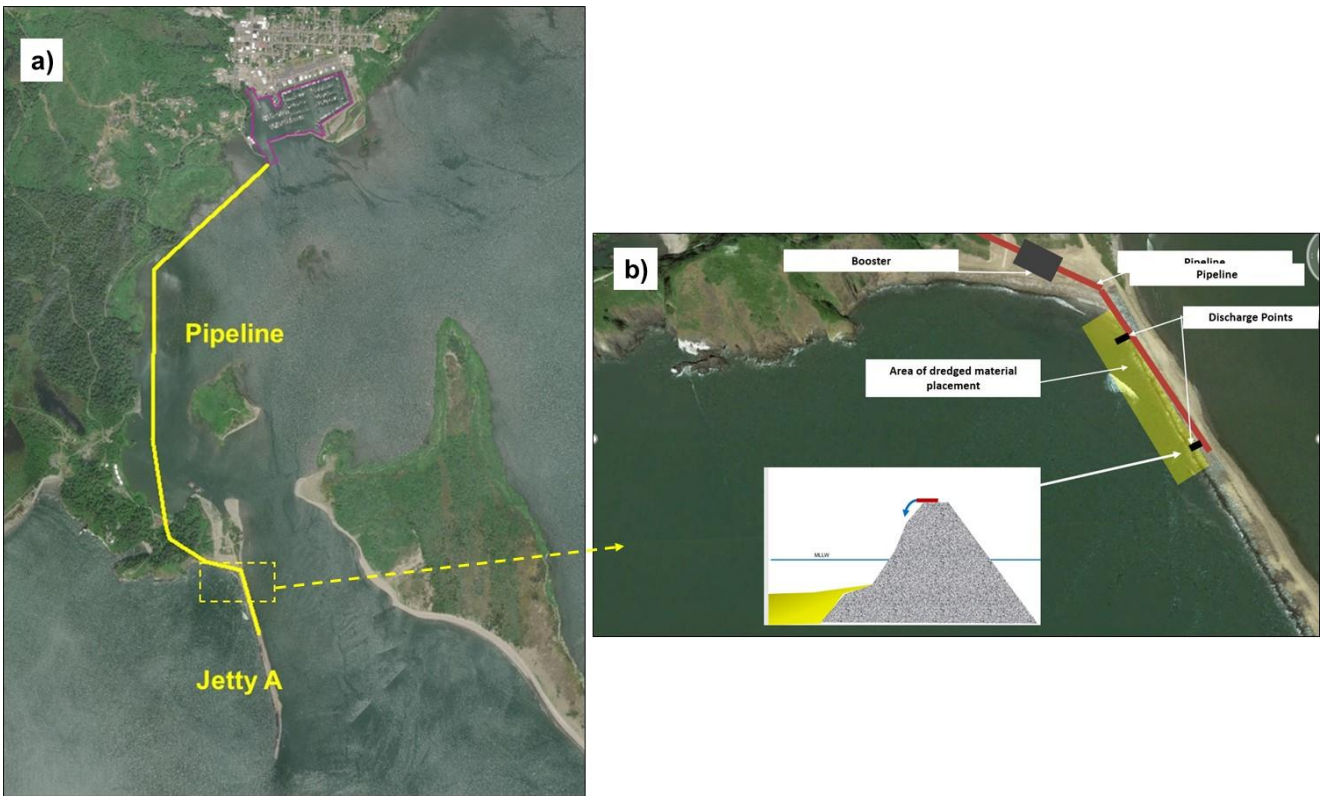

Figure 6. Port of Ilwaco Dredge Material Disposal Alternative 2 Concept

For Alternative 2 it is assumed that dredging in the marina will be conducted by a hydraulic dredge. The dredged sediment will be pumped through a partially floating and partially land-based pipeline and discharged at the nearshore area on a northwest side of Jetty A. The type and dimensions of hydraulic dredge as well as detailed alignment of the pipeline will be determined during preliminary and final designs, should this alternative be chosen. A preliminary assumption is that a portable hydraulic dredge of minimum 12" and maximum 16" discharge pipe diameter would be used for the project. The preliminary length of pipeline was estimated at

approximately 14,000 ft, which indicates a need for one booster pump. Figure 6b shows a preliminary location of the booster pump; this location is subject to modification upon further design efforts.

Single or multiple discharge points are proposed along Jetty A to provide slurry discharge on the armor rock slope and toe of the jetty. Based on experience with similar projects, such type of discharge would result in high dispersion of placed sediment. No accumulation of dredged sediment is expected to occur in the nearshore areas[15]. The mobilization of hydraulic dredge, booster pump, installation of pipeline and discharge points, etc. should occur during each dredging event, including capital dredging of 450,000 cy as well as maintenance dredging of 58,000 cy every two years. This mobilization contributes significantly to the dredging cost discussed below in Section 5. However, the expenses of mobilization may be reduced if permanent pipeline and discharge points are secured by the Port and/or the disposal site and methods are used by the USACE for dredging of the FNC.

Alternative 3: Dredging with a small hydraulic dredge and placement of sediment into bottom dump barge with further open water disposal. The objective of this alternative is to abandon the existing upland disposal site and use the unlimited capacity of the existing open water disposal sites. The concept of Alternative 3 is described in Figure 7 (plates "a" and "b").

Figure 7a shows the bottom depths in the vicinity of the Port of Ilwaco Marina in color format. Red color indicates shallower depths, while yellow and blue colors indicate deeper depths. The figure shows a localized and relatively deep-water area (17 ft MLLW and deeper), located not far (approximately 2,000 ft) from the entrance to the marina. The location of this deep-water area is adjacent to the FNC. Based on review of the dredging data, this area has not been dredged previously, meaning that the deep-water area represents a natural bottom depression that likely has been maintained by strong localized tidal currents[16].

Alternative 3 consists of dredging the marina by small hydraulic dredge and pumping dredged sediment through a floating pipeline to the bottom dump barge, stationed in the bottom depression area, as shown in Figure 7b. Once filled up to capacity with dredged sediment, the barge is towed to the designated open water disposal site where said sediment is released from the bottom dump barge. A specific open water disposal site for placement of excavated sediment shall be determined upon preliminary and final design, but likely would be one of USACE's Columbia River Mouth designated disposal sites, as described in Appendix A.

[15] For example, the Port of Orford, OR has conducted disposal of dredged material on the slope of a breakwater exposed to the ocean waves for more than a decade, and no accumulation of sediment has been observed.
[16] It was confirmed by further analysis (See Section 4).

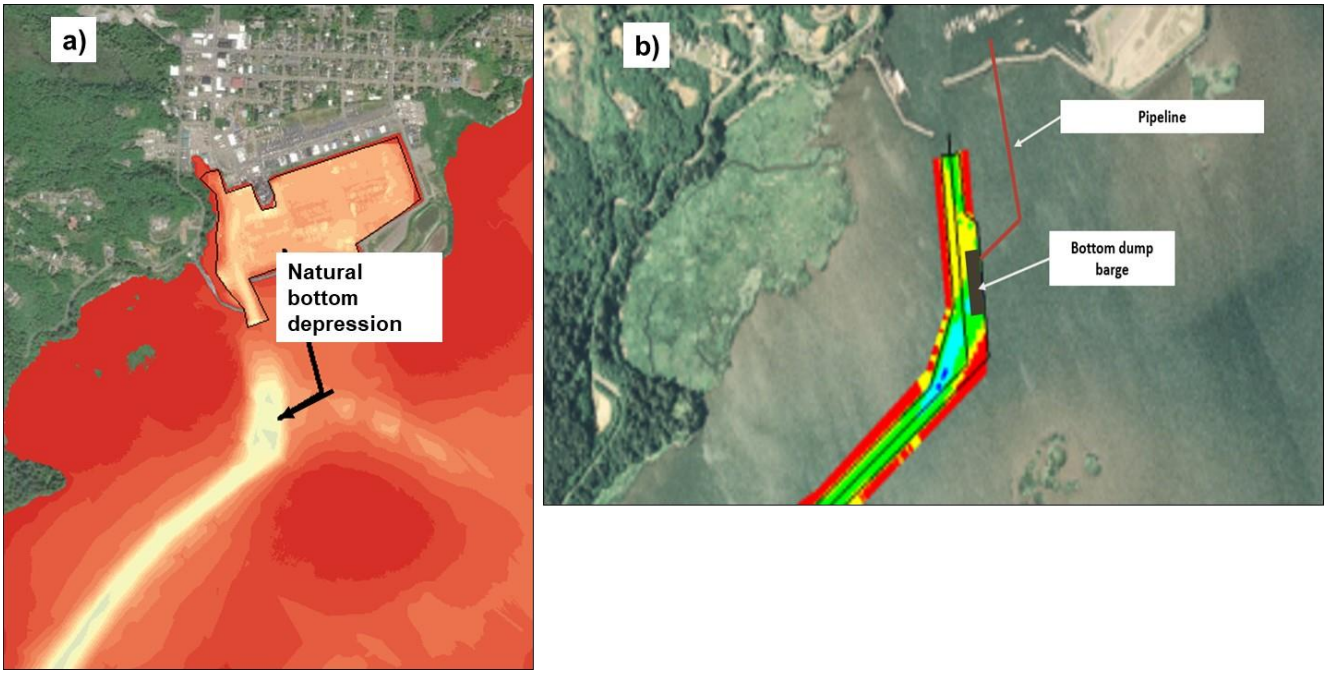

Figure 7. Port of Ilwaco Dredge Material Disposal Alternative 3 Concept

Alternative 4: Dredging with small hydraulic dredge and placement of sediment into nearshore beneficial use disposal site. The objective of this alternative is to develop an unlimited capacity nearshore open water disposal site with several beneficial uses including: a) minimize shoreline erosion and b) restore historical level of suspended sediment concentration in the Lower Columbia River Estuary that has apparently been depleted during the last century. With Alternative 4, there is no need to maintain the upland disposal site, and this site could be abandoned. The concept of Alternative 4 is described in Figure 8 (a and b).

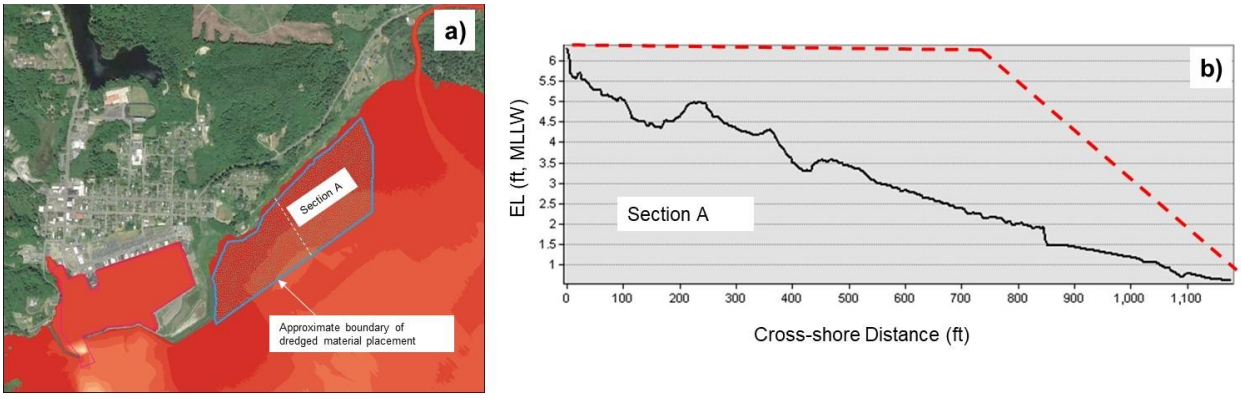

Figure 8. Port of Ilwaco Dredge Material Disposal Alternative 4 Concept

Figure 8a shows the boundary of the proposed nearshore and beneficial use dredged material placement area overlaid on the bathymetric survey data. The boundary of the landward part of the proposed placement site is aligned along the eroding shoreline and armor rock revetment that was placed at some locations to stop the shoreline

erosion. Figure 8b shows in black the existing depths (elevations) along Section A and proposed vertical limits (red dashed line) of the placement the dredged material. The geometric volume confined by the boundaries of the proposed site and existing configuration of the bed is estimated in excess of 600,000 cy, which would be sufficient for first time placement and long-term maintenance dredging requirements. Please note a steep drop of existing elevations at the landward part of the section that indicates the presence of armor rock and concrete slabs that were built and maintained historically to stop shoreline erosion at this site.

With Alternative 4, the marina would be dredged by small hydraulic dredge with placement of sediment through hydraulic pipeline directly at the nearshore disposal area. No confinement for placement of dredged sediment is assumed at this time[17]. Once placed, the dredged material will be subject to erosion from energy produced by waves and tidal currents. However, by eroding and absorbing wave and tidal current energy, the dredged sediment provides protection from shoreline erosion. In other words, placement of dredged material at the proposed Alternative 4 site should be considered as a sacrificial measure to minimize shoreline erosion and to avoid the need to place armor rock. It is expected that sediment to be placed at the Alternative 4 Disposal Site would be constantly eroding, providing space and capacity for upcoming maintenance dredging events.

Alternative 5: Dredging with hydraulic dredge and Sand Island disposal. The objective of this alternative is to abandon the existing upland disposal site and form a new, unlimited capacity nearshore disposal site. The concept of Alternative 5 is described in Figure 9 (plates "a" and "b").

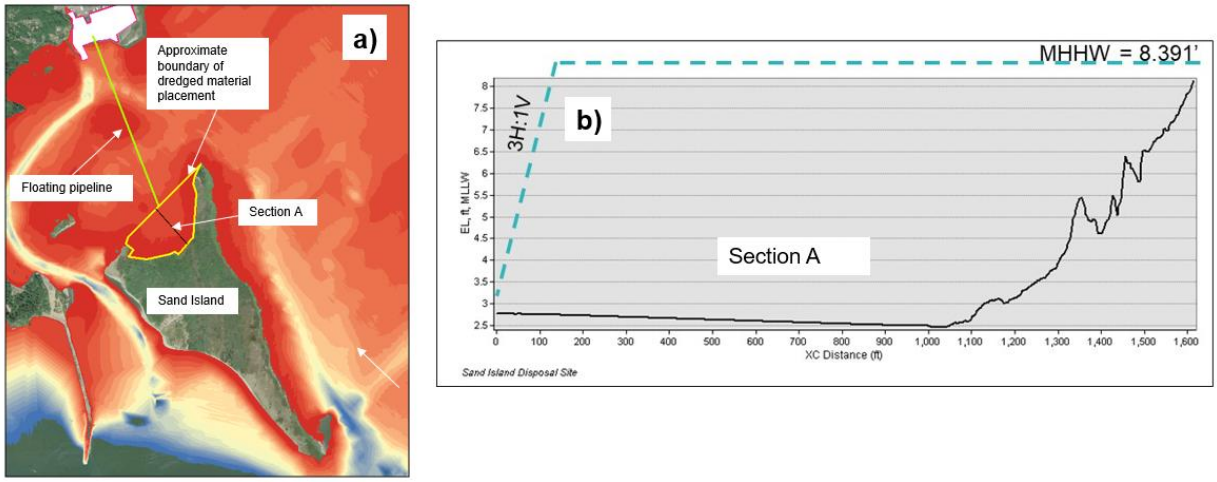

Figure 9. Port of Ilwaco Dredge Material Disposal Alternative 5 concept

Figure 9a shows the boundary of the proposed Sand Island nearshore placement area overlaid on bathymetric survey data. Figure 9b shows in black the existing depths (elevations) along Section A and proposed vertical limits (blue dashed line) of the dredged material placement. The geometric volume confined by the boundaries of the

[17]The final decision regarding the need of a confinement berm would be made during the permitting process and upon consultation with the agencies and USACE.

proposed site and existing configuration of the bed is estimated in excess of 600,000 cy, which would be sufficient for first time placement and long-term maintenance dredging requirements.

With Alternative 5, dredging in the marina would be conducted by a hydraulic dredge. The dredged sediment would be pumped through a floating pipeline and discharged directly at the proposed nearshore placement area of Sand Island. The type and dimensions of the hydraulic dredge and detailed alignment of the pipeline should be determined during preliminary and final design, if this alternative is selected. Preliminarily, it is expected that a portable hydraulic dredge of a minimum 12" and maximum 16" discharge pipe diameter would be used for the project. The length of pipeline was estimated at approximately 7,000 ft, which indicates a possible need for one booster pump. The need for a booster pump and specific location would be determined during the next phase of design.

No confinement for placement of dredged sediment is assumed at this time[18]. It is expected that sediment to be placed at the Sand Island Disposal Site would be constantly eroding, providing space and capacity for upcoming maintenance dredging events.

8.3. Port of Chinook

Three potential disposal sites were considered for sediments dredged from the Port of Chinook. Each alternative is briefly described below.

Alternative 1: Clamshell and bottom dump barges with open water disposal and restoration of existing upland disposal site capacity. The objective of this alternative is to maintain the existing upland disposal site, but periodically, once it is filled up (estimated once every 10-15 years) to empty the site using the operations discussed below. The concept of Alternative 1 is described in Figure 10.

With Alternative 1, dredged material from this upland disposal site will be periodically mechanically excavated and placed at the temporary re-handling area, also shown in Figure 10. It should be noted that the specific location of the re-handling facility may change due to possible remodeling of the adjacent upland area, but will still be within reach of the clamshell to be used for the project. The clamshell shall be able to reach the temporary re-handling facility and load the excavated sediment to the bottom dump barge, stationed at the temporary offloading facility (over-dredge area) shown in the figure.

[18]The final decision regarding the need for a confinement berm would be made during the permitting process and upon consultation with the agencies and USACE.

Figure 10. Port of Chinook Disposal Alternative 1 schematic

Alternative 1 assumes the use of a middle or large-scale clamshell and bottom dump barge with a capacity of 2,000 – 6,000 cy, with a loaded draft of 10-17 ft that will be moored at the temporary loading facility. Additional dredging may be required at this loading facility to accommodate barge loading operations without grounding. The volume of additional dredging and the specific locations of temporary loading and re-handling facilities shall be determined upon preliminary and final design of the dredging operations, if Alternative 1 is implemented for Port of Chinook.

Once loaded with excavated sediment, the bottom dump barge will be towed to the designated open water disposal site and sediment will be disposed. The specific open water disposal site for placement of excavated sediment shall be determined upon preliminary and final design, but likely would be one of USACE's Columbia River Mouth sites, as described in Appendix A.

Alternative 2: The objective of this alternative is to develop an unlimited capacity nearshore open water disposal site with beneficial use of dredged material to minimize bottom scour in the vicinity of the USACE Pile Dike. Upon implementation of Alternative 2 there would be no need for the upland disposal site currently in use, and the upland disposal site would be abandoned. As discussed above, it is believed that placement of sediment at the Pile Dike site would also help to restore historical levels of suspended sediment concentration in the Lower Columbia River Estuary that have apparently been depleted during the last century. The concept of Alternative 2 is described in Figure 11.

Figure 11. Port of Chinook Disposal Alternative 2 schematic

With Alternative 2, dredging in the marina would be conducted by a hydraulic dredge. The dredged sediment would be pumped through a floating pipeline and discharged at the proposed placement area eastward of the pile-dike structure. The type and dimensions of hydraulic dredge as well as detailed alignment of the pipeline would be determined during preliminary and final design. Preliminarily, it is expected that a portable hydraulic dredge of a minimum 10" and maximum 16" discharge pipe diameter would be used for the project. The length of pipeline was estimated at approximately 6,500 ft, which indicates a possible need for one booster pump. The need for a booster pump and specific location (if needed) would be determined during the next phase of design.

The proposed area of placement is located in close proximity to the USACE Pile Dike. It is very likely (based on previous experience) that a scour hole has been formed and has progressed along at least some length of the toe, which is detrimental to the Pile Dike's integrity and performance. Placement of dredged material at the Alternative 2 Disposal Area would minimize scour effects and may be beneficial for the stability and performance of the Pile Dike. The proposed Alternative 2 Disposal Area is preliminarily identified with dimensions 4,000' x 1,000' that would be sufficient for placement of sediment from the capital and subsequent maintenance dredging events.

Alternative 3: Dredging with hydraulic dredge and placement of sediment at the nearshore beneficial use disposal sites. The concept of this alternative was recommended by specialists from the Portland District USACE during a joint project meeting in October 2018. The objective of this alternative is to develop an unlimited capacity nearshore open water disposal site, restore the eroded bottom slope, and abandon the existing upland disposal site. Also, as discussed above, it is believed that this alternative would beneficially contribute to restoration of historical levels of suspended sediment concentration in the Lower Columbia River Estuary that apparently have been depleted during last century. The concept of Alternative 3 is described in Figure 12.

Figure 12. Port of Chinook Disposal Alternative 3 schematic

The Alternative 3 Nearshore Disposal Area is preliminary identified with dimensions at approximately 3,000 ft long (along the shore) and 500 ft wide (perpendicular to the shore) as shown on Figure 12. The location of the disposal area was selected along the nearshore bottom slope that has recently been subjected to scour and deepening (trenching) as a result of landward migration of the tidal channel. Formation of the trench in the nearshore area has contributed to an acceleration of shoreline erosion, thus several erosion mitigation measures have recently been undertaken at this site.

With Alternative 3 dredging in the marina would be conducted by a hydraulic dredge. The dredged sediment would be pumped through a short length of pipeline and discharged directly at the proposed nearshore placement area, shown in Figure 12. The type and dimensions of the hydraulic dredge as well as detailed alignment of the pipeline would be determined during preliminary and final design. Preliminarily, it is expected that a portable hydraulic dredge of a minimum 10" and maximum 16" discharge pipe diameter would be used for the project. The length of pipeline would not exceed 4,000 ft; thus, it is assumed that a booster pump would not be needed.

Placement of dredged material at the proposed placement site for Alternative 3 would minimize scour effects and preclude further formation of a trench. The placement area would be sufficient for placement of sediment from capital and subsequent maintenance dredging events.

9. Environmental Permit and Regulatory Requirements Considerations

9.1. General Overview

A conceptual level investigation of permitting requirements and possible regulatory concerns has been conducted for the purpose of evaluating the developed dredging

and dredged material disposal alternatives and selection of the preferred option(s)[19]. The regulatory-related investigation was conducted by specialists from BergerABAM and a full report on this investigation is attached (Appendix A).

In general, the report has identified a scope of regulatory studies and requirements that shall be completed and addressed during the process of obtaining the environmental permits as follows:

- Clean Water Act Section 404b1- Alternatives Analysis: This analysis is required for dredging or filling of waters of the United States. This evaluation assumes that alternatives analysis would not be required if the alternative is using existing permitted disposal sites. Establishing a new in-water disposal site or beneficial use site is assumed to require the 404b1 analysis.
- Section 408 review: Section 408 review by the USACE Navigation group is needed for all in-water work to evaluate potential impacts to the FNCs. A checklist is submitted for USACE review. Additional analysis is typically required if any activities will occur within or near a FNC, including hydraulic analysis, sediment fate and transport evaluation and/or other studies as determined by USACE.
- Existing Upland Disposal Site Restoration: Relocation of previously dredged material from the existing marina upland disposal site to an open-water site may trigger additional dredged material characterization by the DMMP.
- Beneficial Use: Establishing a new in-water beneficial use site will likely require 404b1 analysis, baseline studies of the proposed site, documentation of the benefits (i.e., beach nourishment or erosion control), sediment fate and transport analysis and use/lease agreements with DNR or other owners.

The investigation also pointed out possible complexities and uncertainties with obtaining the environmental permits, including potential needs for specific additional studies that may affect permitting difficulty, schedule, and cost. Tables 1 and 2 of Appendix A summarize the permitting requirements, relative permitting difficulty, and anticipated regulatory review timelines estimated for each alternative at the Port of Ilwaco and at the Port of Chinook. The color scheme in the table indicates the category of difficulty (or uncertainty) associated with the permitting process for each alternative- yellow color indicates more complexities and uncertainties.

In general, the tables indicate that alternatives which include dredged material disposal at non-established disposal sites are generally more difficult to permit than those alternatives which use active and established disposal sites. For example, the Port of Ilwaco Alternatives 2, 4, and 5, and Port of Chinook Alternatives 2 and 3 may require a step further in the Section 408 process by providing a hydraulic analysis demonstrating sediment fate and transport. It should be noted that Section 408 is a relatively new regulatory permit and there are uncertainties with the requirements related to this process. In order to assess and minimize possible risks in the future, a simplified level of hydraulic analysis was performed for the alternatives ranked (by

[19] It should be noted that assessments and preparation of environmental permits is not a part of the scope of work for the current project. However, upon meetings and consultations with the Portland District USACE (predominately with specialists from Engineering and Navigation Branches) a concern has been raised that some of the alternatives, though technically feasible and economical, may be viewed differently by environmental regulatory bodies.

BergerABAM specialists) as being more complex and uncertain from the perspective of the Section 408 permitting process. Alternative 4 for the Port of Ilwaco, dredging with small hydraulic dredge and placement of sediment into nearshore beneficial use disposal sites, was selected for this analysis. The location of the dredged sediment placement site for this alternative is the shortest distance to the FNC (in comparison to other alternatives); thus, a more rigorous USACE regulatory branch review is expected.

9.2. Alternative 4, Port of Ilwaco, Section 408 Related Hydraulic Analysis

The Port of Ilwaco FNC extends from Fort Canby (RM 01+50) to the Port of Ilwaco (RM 03+10), with a total length of 1.3 miles and is maintained by the USACE at a depth of -16 ft MLLW (with advanced maintenance dredging to -18 ft MLLW) and a width of 150 ft (USACE, 2016a). Figure 13 shows the location of the Port of Ilwaco FNC and the boundaries of the proposed Alternative 4 nearshore beneficial use disposal site.

A part of the FNC near the entrance to the Port (further referenced as "entrance channel") of approximately 1,000 ft long, from RM 03+00 to RM 03+10, is located in close proximity to the proposed placement site and would be at the highest risk of impact. The Port of Ilwaco FNC has been subjected to sedimentation and was regularly dredged by the USACE. For example, between August 11 and September 4, 2015, the Corps dredged 92,104 cy of material from the Port of Ilwaco FNC (USACE, 2016a). Review of hydrographic survey data indicates that the thickness of deposition (prior to the dredging) was in a range of 2-5 ft in average over the width of the channel.

The possible impact analysis was evaluated thorough review and analysis of morphology, hydrodynamics, and lithology (sediment composition) at the adjacent bottom slope.

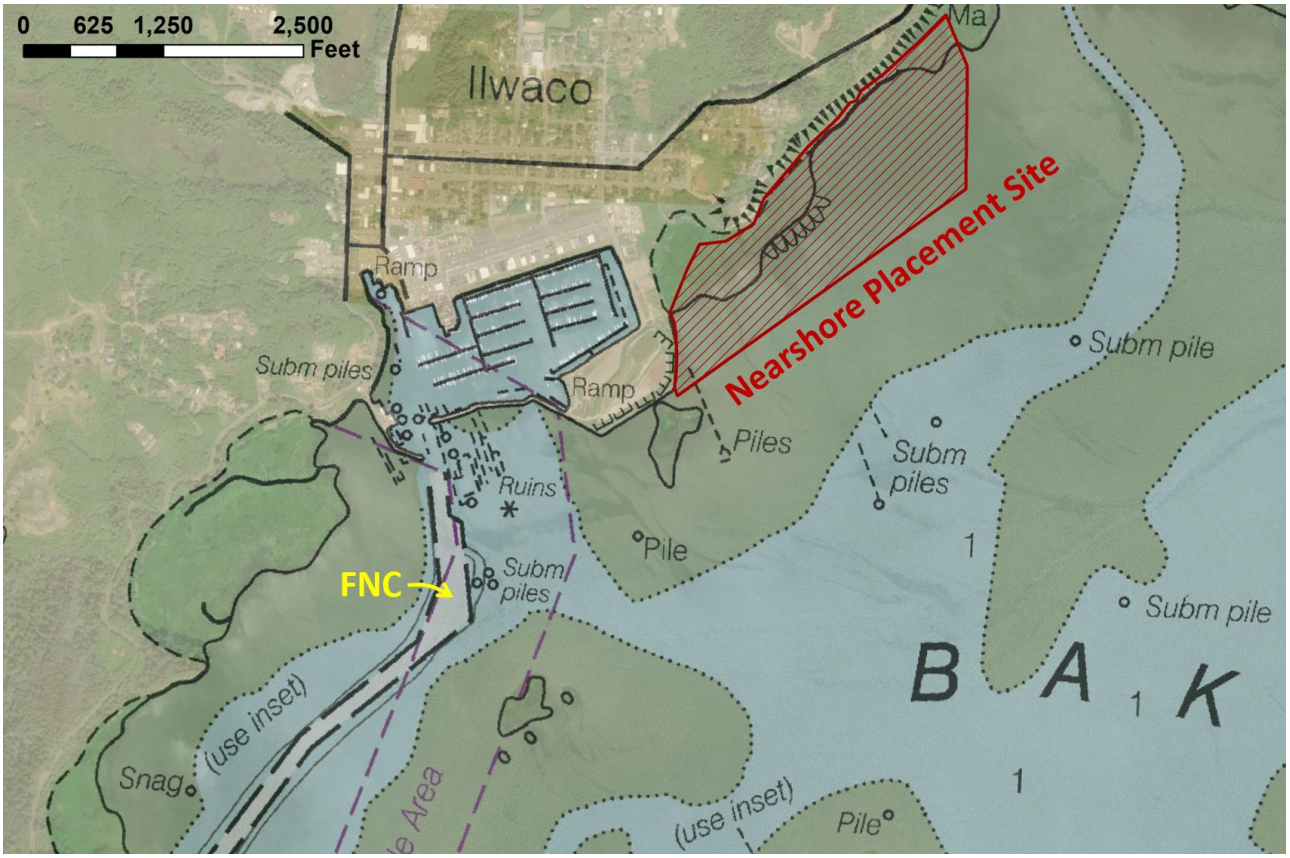

Figure 13. Location of proposed nearshore disposal site relative to FNC

Hydrodynamics: Hydrodynamic conditions described herein are governed by tidal circulation and Columbia River flows and do not include the local wave component. Analysis of hydrodynamic conditions was conducted based on results of numerical modeling by USACE (USACE, 2019). Figure 14 shows a snapshot of this numerical modeling that was provided by USACE to describe the representative ebb tide conditions in the vicinity of the Port of Ilwaco FNC. A location of the proposed beneficial use disposal site is also plotted in the figure.

The figure shows a spatial distribution of apparently depth-averaged velocities over an area of the FNC and proposed location of disposal site. Results of the modeling demonstrate low velocities at the proposed nearshore disposal site that, at peak values, are less than 10 cm/s. At the same time, the figure shows high velocities (> 80 cm/s) at the areas adjacent to the FNC. The current flow of these high velocities is aligned close to perpendicular to the Entrance Channel. While currents are crossing the channel, the flow velocity reduces dramatically to a negligible value.

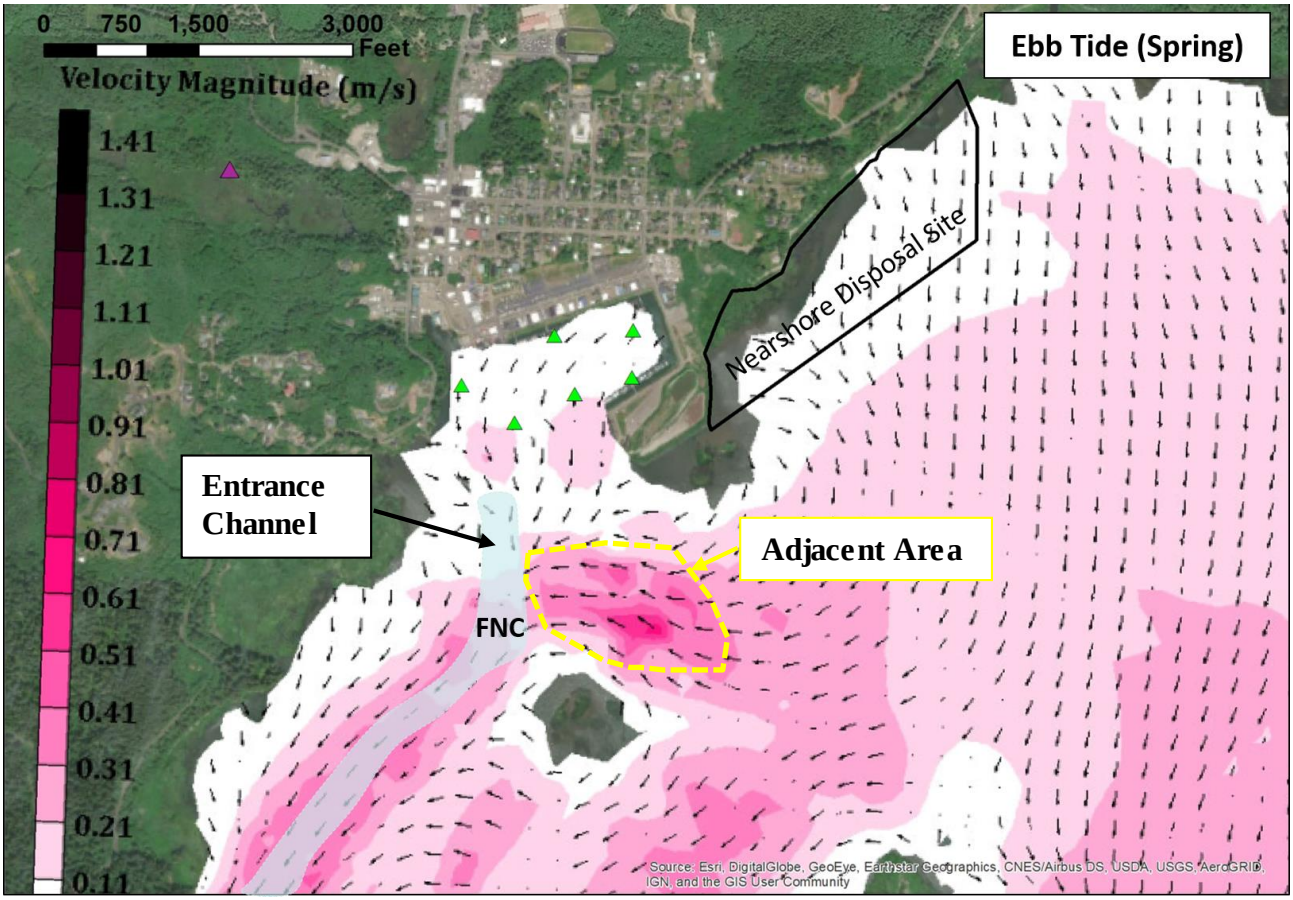

Figure 14. Results of USACE hydrodynamic numerical modeling during spring ebb tide

Interpretation of the modeling results suggests the following: a) High velocities resuspend bottom sediment in the vicinity of the channel; b) Reduction of flow velocity, while crossing the channel results in deposition of resuspended sediment. Considering the significant gradient of flow velocities crossing the channel area it is likely that most of resuspended nearby sediments are deposited in the channel cut. In other words, most of the material contributing to sedimentation in the FNC originates in the adjacent areas; c) Flow velocities at the proposed beneficial use site are insufficient to resuspend any significant amount of sediment. Sediment that can be resuspended by such small velocities (less than 10 cm/s) would be very fine (small) with no, or limited, ability to settle in the Adjacent Area and FNC. In other words, based on hydrodynamic conditions, it is unlikely that the proposed beneficial use disposal site would result in an increase of sedimentation in the FNC of any detectable amount.

Morphology: The proposed beneficial use disposal site is separated from the Entrance Channel by a headland-type feature that is composed of an extensive tidal flat and a shallow mass of land jutting out seawards, as shown in Figure 15. This morphological feature would preclude direct sediment transport (if any may occur) from the proposed disposal site towards the FNC. As shown above, tidal currents traveling from the proposed Placement Site toward the channel are weak and would

not be able to transport any significant amount of sediment from the disposal site (if indeed this sediment is resuspended during a wave storm event).

In addition, the path through the bifurcated channel (from the proposed disposal site to the FNC) is over 1 mile; therefore, the risk of significant alternation of sediment transport conditions at the FNC due to placed sediment at the Nearshore Site is low.

Figure 15. Google Earth Aerial (2016) image showing shoal between proposed nearshore placement site and FNC at Ilwaco

Lithology: The data on sediment characteristics at the nearshore bottom area of Baker Bay is limited and not sufficient to directly predict possible sediment pathways from the proposed beneficial use site. For this purpose, an indirect comparison of dredged sediment at the Port of Ilwaco Marina (sediment to be placed at the proposed disposal site) and sediment currently dredged from the FNC was conducted. The Port of Ilwaco Marina dredged sediment consists predominately (> 99%) of silt and clay. The amount of sand in the sediment grain size composition is minimal, less than 1%. On the other hand, the sediment deposited in the FNC includes significant amount of sand particles. Depending on the location of the sediment samplings, it may be up to 80-90%, as shown in Figure 16, which is taken from Table 5 of the USACE Sediment Quality Evaluation Report, July 2016.

SAMPLE ID:	080315-BBWC-COMP-01	Q	080315-BBWC-COMP-02	Q	101615-BBWC-PG-1.1	Q	101615-BBWC-PG-1.2	Q	101615-BBWC-PG-1.3	Q	101615-BBWC-PG-2.1	Q	101615-BBWC-PG-2.2	Q	101615-BBWC-PG-2.3	Q	101615-BBWC-PG-2.4	Q
DMMU/NSM ID:	DMMU 1		DMMU 2		DMMU 1		DMMU 1		DMMU 1		DMMU 2		DMMU 2		DMMU 2		DMMU2	
Conventional Parameters																		
Total Organic Carbon (%)	2.20		0.04	J	--		--		--		--		--		--		--	
Total Solids (%)	43.6		80.9		38.9		44.6		49.8		76.8		77.3		49.2		78.7	
Total Sulfides (mg/kg)	--		--		--		--		--		--		--		--		--	
Ammonia (NH3) as Nitrogen(N) (mg/kg)	--		--		--		--		--		--		--		--		--	
Particle Size (% retained)																		
Gravel (>2.00 mm)	0.00		0.08		0.00		0.00		0.00		0.00		0.00		0.00		0.00	
Sand, Very Coarse (1.00 to 2.00 mm)	0.07		0.02		0.00		0.00		0.03		0.03		0.03		0.01		0.01	
Sand, Coarse (0.500 to 1.00 mm)	0.08		0.43		0.03		0.03		0.17		2.62		1.52		1.31		2.72	
Sand, Medium (0.250 to 0.500 mm)	0.09		64.37		0.03		0.27		0.62		65.31		62.82		61.61		66.81	
Sand, Fine (0.125 to 0.250 mm)	0.38		33.59		0.28		1.20		3.92		30.24		33.67		35.55		29.00	
Sand, Very Fine (0.0625 to 0.125 mm)	8.16		0.14		0.50		2.70		5.00		0.06		0.15		0.12		0.10	
Silt (0.039 to 0.0625 mm)	82.24		0.09		2.50		9.20		14.70		0.00		0.00		0.00		0.00	
Clay (<0.0039 mm)	18.10		0.39		97.16		89.3		80.56		1.99		2.05		10.41		8.75	
% Sand	8.78		98.55		0.84		4.20		9.74		98.26		98.19		98.6		98.64	
% Fines	100.34		0.48		99.66		98.5		95.26		1.99		2.05		10.41		8.75	

Figure 16. Table 5 of USACE report Sediment Quality Evaluation Report, July 2016

Other information used in the evaluation of possible sediment pathways from the Nearshore Disposal site and possible deposition in the FNC is based on modeling results with the Particle Tracing Model[20] (PTM) from the USACE report: *Assessment of Sedimentation in the Federally Maintained Channels for the Ports of Chinook and Ilwaco*, 2011. The PTM modeling results (relevant to the current project) indicate that only a small amount of sediment resuspended from the bottom of Baker Bay would settle in the Ilwaco FNC. For example, Figure 14, from the USACE report (Figure 17 in this report) shows results of PTM modeling of sediment that was released into the system just upstream of Baker Bay. Sediments deposited in the bed are depicted by red color. Blue color indicates sediment that is active and was not deposited during the 5-day simulation period. The figure shows non-detectable sediment deposition in FNC Entrance Channel. Most sediment shown on the figure (even inside of FNC) is the "active" sediment, those that move through the channel area without settling. An interpretation of the Port of Ilwaco Marina and FNC dredged sediment composition in combination with PTM modeling results suggest that placement of dredged sediment at Nearshore Disposal Site would not result in additional sedimentation in the FNC of any significance.

[20] PTM model is governed by combined tidal currents and wave hydrodynamics.

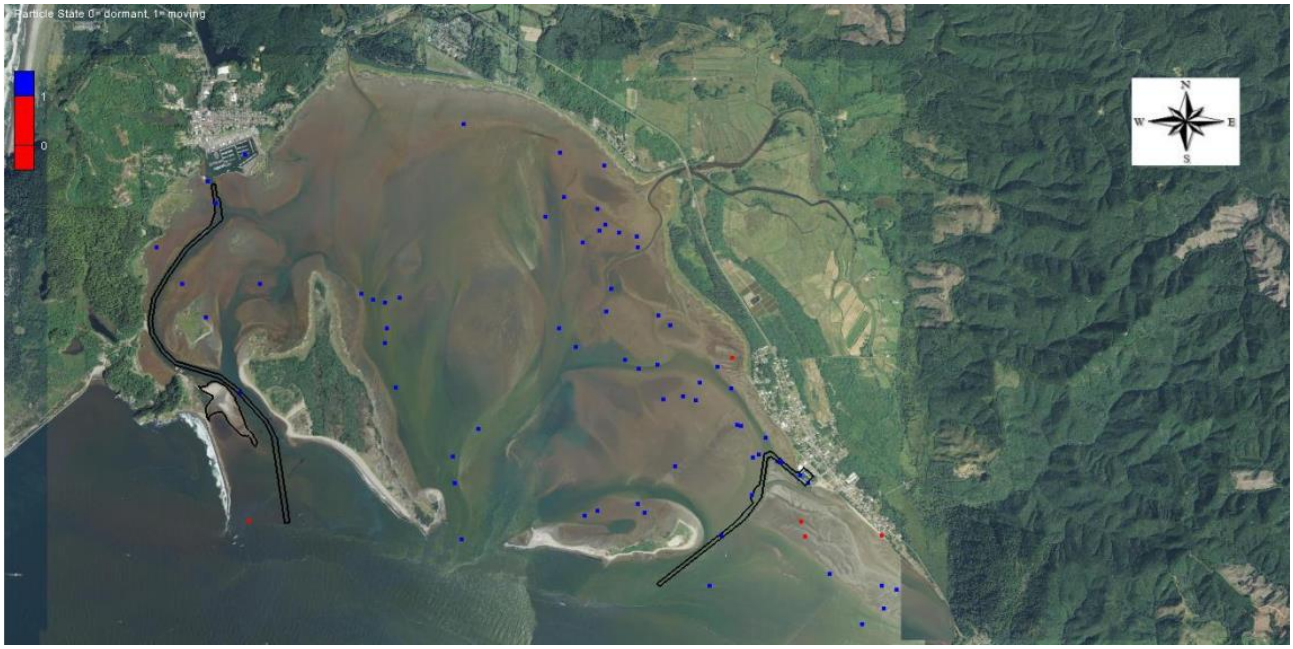

Figure 17. Results of 5 days PTM modeling at Baker Bay (from USACE's *Assessment of Sedimentation in the Federally Maintained Channels for the Ports of Chinook and Ilwaco, Baker Bay, WA* Report, Figure 14)

In summary, three methods of analysis, directly or non-directly, have indicated that placement of sediment from the Port of Ilwaco Marina at the Nearshore Disposal site would most likely not significantly increase the existing level of sedimentation and maintenance dredging requirements at the FNC. As discussed above, analysis of impact was conducted for the alternative that was ranked as more complex and uncertain from the perspective of the Section 408 permitting process. Thus, the results of this analysis may be applicable to all other dredging/disposal alternatives, excluding Port of Ilwaco Alternative 3 and Port of Chinook Alternative 2. Upon meetings with the Portland District USACE, it was pointed out that the Port of Ilwaco Alternative 3 involves temporary stationing of the barge in the FNC. The location of this stationing is of concern to the engineering staff of USACE and most likely will require a thorough Section 408 review. Similarly, the Port of Chinook Alternative 2 disposal site is located in the vicinity of the pile dike and in close proximity to the FNC. Thus, these concerns may require additional Section 408 studies. All other alternatives would likely be able to sustain review of a Section 408 permit, if required.

The data and conclusions of this section are applied below in the evaluation and selection of the preferred alternative, and would also be helpful in the future during a Section 408 review process (if required) of the preferred alternative[21].

[21] It should be understood that conclusions in this section do not warrant a decision of the USACE regulatory branch on the likelihood of a Section 408 review process or (if required) do not warrant a simple and straightforward obtaining of this permit.

10. Port of Ilwaco and Port of Chinook Dredging and Dredged Material Disposal Alternatives Preliminary Cost Estimates

The cost estimates for implementation of each of the above dredging and dredged material placement alternatives were developed at the preliminary level[22] based on the general assumptions as follows:

- All dredged and excavated sediment are suitable for open water disposal.
- Open water disposal sites at the Mouth of Columbia River with be available for placement of sediment from the Port of Chinook and the Port of Ilwaco.
- Costs for permitting and related mitigation measures (if required) are not included.
- Costs for acquiring land or leases of nearshore areas (if required) are not included.
- All dredging work will be performed by the Contractor.
- All costs are in 2018 money values.
- Dredging cost estimates for hydraulic dredging work were computed using the Corps of Engineering Dredging Software (Dredging Cost Spreadsheet).

In addition to these general assumptions, the following explicit assumptions were used in developing the preliminary level of cost estimates:

- Port of Ilwaco Alternative 1: Cost estimate for capital dredging consists of two elements: 1) Dredging and open water disposal of 450,000 of sediment to bring the marina to the design depth conditions indicated by Figure 1 above and 2) Excavate 250,000 cy of sediment from the upland disposal to provide capacity for next 10-15 years of maintenance dredging events.
- Port of Chinook Alternative 1: Cost estimate for capital dredging consists of two elements: 1) Dredging and open water disposal of 67,000 cy of sediment to bring the marina to the design depth conditions indicated by Figure 1 and 2) Excavate 40,000 cy of sediment from the upland disposal to provide capacity for next 10-15 years of maintenance dredging events.
- Port of Ilwaco Alternative 1: Maintenance dredging includes dredging of 58,000 cy one time per 2 years with small hydraulic dredge and placement of dredging sediment at the upland disposal site. No expenses on construction and maintenance of upland disposal site are included.
- Port of Chinook Alternative 1: Maintenance dredging includes dredging of 27,000 cy one time per 3 years with small hydraulic dredge and placement of dredging sediment at the upland disposal site. No expenses on construction and maintenance of upland disposal site are included.
- Port of Ilwaco Alternatives 2, 3, and 5, and Port of Chinook Alternative 2 maintenance dredging events cost estimates include mobilization/demobilization similar to capital dredging works of pipeline.

The results of cost estimates are presented in Tables 5 and 6.

[22] Level of accuracy of preliminary cost estimates corresponds to an order of magnitude and is used herein for comparative analysis and selection of the preferred alternative. More accurate cost estimates will be developed during the next phases of the project, preliminary and final design.

Table 5. Port of Ilwaco Dredging and Disposal Alternatives Preliminary Cost Estimates

Alternative	First Time Dredging Costs	Design Maintenance Dredging Event Costs[23]
1. Clamshell dredging and restoration the existing upland site capacity	$11,000,000	$460,000
2. Hydraulic dredging and Jetty A disposal	$6,300,000	$1,200,000
3. Hydraulic dredge, bottom dump barge, and open water disposal	$7,100,000	$1,400,000
4. Small hydraulic dredge and nearshore beneficial use disposal site	$2,800,000	$420,000
5. Hydraulic dredge and Sand Island disposal	7,600,000	$1,100,000

Table 6. Port of Chinook Dredging and Disposal Alternatives Preliminary Cost Estimates

Alternative	First Time Dredging	Design Maintenance Dredging Event Costs
1. Clamshell dredging and restoration the existing upland site capacity	$3,000,000	$270,000
2. Hydraulic dredging with placement at the Corps pile dike	$1,000,000	$650,000
3. Hydraulic dredge and nearshore disposal	$500,000	$250,000

11. Summary of Alternative Evaluation

The dredging and dredge material disposal alternatives were developed based on data collected and analyzed throughout the project and the alternative development criteria discussed in Section 3. In addition, the evaluation and selection of the preferred alternatives included preliminary feedback obtained from the USACE specialists during two joint meetings in Portland, October 1, 2018 and January 19, 2019. The evaluation criteria were organized and tabulated in Tables 7 and 8.

Considering the complexity and diversity of the evaluation criteria, a color scheme of three colors was applied to objectively evaluate the various alternatives: green color means "preferred," yellow color means "moderately preferred," and red color means "less preferred." Using this color scheme, the evaluation of the alternatives was conducted in a matrix form in Tables 7 and 8.

Based on review of the tables and upon consultation with the Ports, the following two alternatives were selected as preferred and are recommended for implementation:

- Port of Ilwaco: Alternative 4 and/or Alternative 1
- Port of Chinook: Alternative 3

[23] Maintenance dredging event for the Port of Ilwaco Marina is assumed 1 time per 2 years with volume of 58,000 cy

The approach of selecting two preferred alternatives for the Port of Ilwaco is justified by the risks associates with obtaining environmental permits. In the case that Alternative 4 requires a complex and lengthy process of permitting, the funds secured should be used to implement Alternative 1.

Table 7. Port of Ilwaco Marina

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Performance[14]					
Constructability[15]					
Capital Cost[16]					
Maintenance Cost					
Environmental Permit Risks and Uncertainties					
USACOE Dredging Experts Initial Feedback[17]					
Use dredged sediment for shoreline protection					
Use dredged sediment to maintain sediment budget in LCR Estuary					

Table 8. Port of Chinook Marina

	Alternative 1	Alternative 2	Alternative 3
Performance[14]			
Constructability[15]			
Capital Cost[16]			
Maintenance Cost			
Environmental Permit Risks and Uncertainties			
USACOE Dredging Experts Initial Feedback[17]			
Use dredged sediment for shoreline protection			
Use dredged sediment to maintain sediment budget in LCR Estuary			

12. Recommendations

Port Ilwaco

a. Proceed with design, permitting, and implementation for the Preferred Alternative 1 (early referenced as Alternative 4) of dredging and dredged material disposal.
b. Secure the funds for Preferred Alternative 1 ($11,000,000) in case the permitting process for Preferred Alternative 2 (early referenced as Alternative 1) requires unreasonable amounts of time and resources.
c. Bathymetric and topographic surveys of the bottom slope of Preferred Alternative 1 has been completed under this study effort and the results, xyz format survey data are stored in a separate digital file. These survey data of the disposal site are prepared to support future permitting process.

Port of Chinook

a. Proceed with obtaining funds for design, permitting, and implementation of the recommended Preferred Alternative (early referenced as Alternative 3) of dredging and dredged material disposal.
b. Bathymetric and topographic surveys of the bottom slope of Preferred Alternative has been completed under this study effort and the results, xyz format survey data are stored in a separate digital file. These survey data of the disposal site are prepared to support future permitting process.

13. References

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