CHAPTER FOUR
ALTERNATIVES

4. ALTERNATIVES

4.1. Formulation and Screening of Alternatives

The purpose of a proposed project would be to improve the deep-draft transport of goods on the Columbia and Lower Willamette Rivers navigation channel. The formulation of alternatives involved a systematic process of identifying and analyzing the navigation needs and opportunities identified in Chapter 3. Alternatives for improving deep-draft navigation, as well as any dredging and disposal actions needed for construction and maintenance, were formulated and evaluated on the basis of technical, economic, social, and environmental criteria.

Planning constraints for the study recognized that channel improvement alternatives were limited to a maximum of 3 feet of deepening by the study's authorizing legislation. Also, improving the entrance channel at the mouth of the Columbia River was not part of the study. An initial evaluation of the entrance channel found that it would be compatible with ships having up to a 43-foot draft, except during rough wave conditions when the channel would be closed to navigation traffic.

A range of alternatives was considered in the study. These include the no action alternative (without-project condition) and a non-structural alternative to upgrade the existing river stage forecasting system to improve navigation. Three structural channel improvement alternatives were considered that alter the channel's configuration and/or depth (41, 42, or 43 feet) to improve deep-draft vessel transport. A range of disposal alternatives were also evaluated, including upland, shoreline, in-water (flowlane) and ocean disposal. An extensive evaluation of the ocean disposal site selection process is included in Appendix H. As a result of public comments for reducing the environmental impacts associated with dredging, regional port concepts also were formulated to locate deep-draft facilities closer to the mouth of the Columbia River.

One of the assumptions in the *Initial Project Management Plan* for the study was that the width of the channel in the with- and without-project conditions would be sufficient for all channel improvement alternatives. To further substantiate this assumption, the Corps conducted a ship tracking study utilizing a global positioning system. Receivers were placed on both the bow and stern of inbound and out bound vessels. Four inbound and five outbound ships were tracked. Two panamax class bulk carriers drawing 40 feet were tracked outbound from the Peavy elevator at Kalama. Two container ships were tracked both inbound and outbound, and a third was tracked outbound. The sailing lines were recorded into a computer file. The resulting sailing line plots showed the vessels were able to navigate within the limits of the existing authorized channel. This result was also confirmed for the reach from CRMs 28 to 35 in the ship simulation studies conducted for the DMMP (Corps of Engineers, 1998). It follows that no navigation aids on the Columbia River would require change.

The three channel improvement alternatives would be somewhat similar and would require dredging and disposal alternatives for construction and maintenance. The quantity of dredged material removed from the channel would vary by alternative. The mix of disposal sites would primarily distinguish the disposal alternatives rather than the availability of dredges (hopper, pipeline, or clamshell). Specific environmental and engineering criteria were developed for screening the disposal alternatives.

An ecosystem restoration component resulted from a series of workshops with federal and state resource agencies and the public. Its scope consists of restoring the hydraulic connection between the Columbia River and Shillapoo Lake and fisheries habitat restoration measures. These elements were selected from a long list of potential restoration actions as being the most appropriate to implement as a component of the structural alternatives.

This chapter describes the no action, non-structural, structural channel improvement alternatives, and the ecosystem restoration component considered in the study. It discusses the alternatives eliminated from further consideration, compares the technical, environmental and economic aspects of the alternatives carried forward for further detailed analysis, and provides the rationale for selecting a preferred alternative.

4.2. No Action Alternative

The no action alternative (without-project condition) is the most likely condition expected to prevail over the length of the planning period in the absence of the Federal Government (Corps) implementing a plan to improve deep-draft transport on the navigation channel. It is the most probable future condition and also provides the baseline for estimating direct and indirect impacts associated with the proposed alternatives.

The no action alternative assumes that the navigation channel would continue to be maintained at its existing dimensions (40 feet deep with 5 feet of AMD by 600 feet wide), and that the DMMP (Corps of Engineers, 1998) would be implemented to maintain the channel in the future. The target drafts for container ships and bulk carriers would remain at 36 feet and 40 feet, respectively. The maximum draft in the river would remain at 40 feet for all ships. There would be some changes in future maintenance dredging and disposal practices, as identified in the DMMP and summarized in the next section.

The no action disposal plan provides a flexible mix of dredging and disposal practices for maintaining the existing 40-foot channel over the next 20 years. The plan reduces the number of disposal sites that have been previously used. The plan also considers an estimated 8 mcy of ocean disposal over the next 20 years, in addition to ocean disposal of about 4.5 mcy annually from MCR entrance channel. This plan also includes construction of pile dike fields along Miller Sands Spit and Wallace Island/Jones Beach to stabilize these erosive beach nourishment sites. The NMFS has indicated concerns about the potential impact of birds feeding on juvenile salmonids around the proposed Miller Sands pile dikes. Construction of the pile dikes at Miller Sands Spit will not proceed until consultation with NMFS is completed. Flowlane (in-water) disposal would continue as an

important option under this plan. The present worth cost of the no action disposal plan is estimated at $94.3 million over the next 20 years.
The no action disposal plan relies on the use of upland sites and flowlane disposal. The plan includes 18 upland disposal sites listed in table 4-1, which total 1,165 acres.

The only beach nourishment site included in the plan would be a 151-acre site at Miller Sands Spit, which would be used in conjunction with the new pile dike field. This represents a significant reduction from the 14 beach nourishment disposal sites currently in use. All sites have been previously used for dredged material disposal. The shift to upland disposal would reduce the amount of material re-depositing in the navigation channel from erosion at beach nourishment sites.

Flowlane disposal could occur along the length of the channel and would generally be at water depths of 45 to 65 feet. This represents a deeper initial depth and narrower range of depth than current in-water disposal practices. There would be exceptions to the flowlane criteria, however. Flowlane disposal would occur in water depths of 35 to 65 feet between CRM 64 to 68 and CRM 90 to 101. Flowlane disposal also would occur in water depths over 65 feet in three other specific areas: CRM 30 to 33 in the Oregon half of the navigation channel; CRM 54 to 56.3 in the Oregon half of the navigation channel; and CRM 72.2 to 73.2 in the Washington half of the navigation channel.

Table 4-1. Upland Disposal Site Summary for the No Action Alternative

DISPOSAL SITE	NAME	USE	ACRES	SITE CAPACITY (cubic yards)	DISPOSAL VOLUME (cubic yards)	FINAL HEIGHT (feet)
O-105.0	West Hayden Island	annually	79	3,050,000	3,050,000	45
W-97.1	Fazio Sand & Gravel	every 3rd year	27	1,225,000	1,225,000	25
W-95.8	near Ridgefield NWR	4th & 15th years	13	350,000	350,000	27
O-75.8	Sandy Island	every 7th year	30	740,000	275,000	17
W-68.7	Howard Island	annually	200	6,400,000	5,450,000	28
O-65.7	Globe Quarry	annually	73	1,180,000	1,180,000	40
O-64.8	Rainier Industrial	annually	53	2,200,000	2,200,000	35
O-63.5	Lord Is. Upstream	annually	28	1,255,000	1,255,000	30
W-59.7	Hump Island	annually	69	1,400,000	1,305,000	29
O-57.0	Crims Island	annually	51	1,600,000	1,600,000	30
W-46.3	Brown Island	annually	72	3,700,000	3,192,500	38
W-45.0	White Island	annually	15	1,210,000	1,207,500	38
O-42.9	James River	every 3rd year	59	1,280,000	300,000	20
W-42.5	opposite Ft James mill	2 out of 3 years	28	1,275,000	631,000	13
O-38.3	Tenasillahe Island	annually	42	4,000,000	350,000	16
O-34.0	Welch Island	every 6th year	42	1,350,000	380,800	16
O-27.2	Pillar Rock Island	annually	56	1,500,000	1,500,000	30
W-21.0	Rice Island	annually	228	5,500,000	1,321,200	29

4.3. Non-Structural Alternative

The non-structural alternative consists of upgrading the existing river stage forecasting system (called *LoadMax*) to enable ships to determine navigable channel depths based upon projected future and real-time tide and river stage information. The forecast is generated by the National Weather Service Northwest River Forecast Center (NWS-NWRFC), a branch of the National Oceanic & Atmospheric Administration, and distributed by the Port of Portland.

An analysis of navigation practices on the Columbia River found that available water depths were not fully utilized by ships, not even by the deepest 10 percent of the fleet. Vessels sailing at the target drafts shown in table 4-2 commonly have underkeel clearances of one to four feet greater than the minimum allowable clearances. Most container lines target a 36-foot draft and only schedule enough outbound cargo to reach that draft. Because cargo is not scheduled at the dock, container ships with design drafts of 38 to 41 feet can not take advantage of the water depths that may be available at their scheduled sailing time. Bulk carriers make better use of available water depths because their sailing draft is selected just hours prior to departure. The bulk carriers can also delay departure to wait for maximum water depths. There have been limitations with the existing river stage forecasting system that have prevented shippers from making maximum use of the available water depths in the Columbia River.

- Concern about the accuracy of the river stage forecast.
- The river stage forecast is presented for only six locations, and does not present a clear picture of expected river conditions.
- Since navigation channel bed elevations are not included in the forecast, the total water depth available is not available.
- The six-day forecast does not allow enough time for container lines to schedule cargo to take full advantage of expected water depths.

Over the last two years, and as part of a national modernization effort, the NWS-NWRFC has made significant improvements to its hydrologic and hydraulic modeling that underlie the LoadMax system. At the same time, the River Forecast Center has implemented advanced technology in weather forecasting which is a key component of Columbia River flows. Also, the Port of Portland has installed technology at its river gauges to allow the pilots to call ahead from the vessel's bridge to obtain real-time river level information. The Port has improved and automated the electronic delivery of the forecast data to the commercial users and research institutions that utilize the information on a regular basis.

The NWS-NWRFC estimates that the current accuracy of the LoadMax forecast is 0.3 to 0.4 feet for the first 24 hours, increasing to 1.0 to 1.4 feet for the 6th day (the current forecast limit). A longer-range forecast might allow container lines to schedule cargo to take advantage of potential higher river stages. However, there would be even more uncertainty in the river stage forecast.

Maintaining safe underkeel clearance while maximizing draft requires knowledge and understanding of both water surface and riverbed conditions to predict the total depth of water available at any point in the navigation channel. The benefit of LoadMax as a navigation planning tool could still be enhanced if it provided controlling riverbed elevations along with the predicted river levels.

The potential benefits of additional improvements to the river stage forecast system would be difficult to judge with precision. An evaluation was conducted to estimate the deepest draft that could have been obtained on actual transits under conditions in 1991 to 1993. During this period, the potential draft benefits from an improved stage forecasting system for the deepest 240 bulk carriers (target draft 40 feet) and 67 deepest container ships (target draft 36 feet) are shown in table 4-2. Achieving these potential benefits would require a change in the regulatory environment at the Oregon Board of Maritime Pilots (OBMP).

Table 4-2. Potential Vessel Draft Benefits

Bulk Carriers			Container Ships		
Maximum Potential Draft (feet)	**Number of Ships**	**Percent of Sample**	**Maximum Potential Draft (feet)**	**Number of Ships**	**Percent of Sample**
41	45	19	37	16	24
42	13	5	38	7	10
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The maximum potential drafts are based on the estimates of the minimum water depth available during transits studied in the navigation analysis discussed in Section 2.3 and Appendix A. The potential drafts could have been accomplished without changing the ship's departure time or exceeding the minimum underkeel clearance requirements listed in table 2-2. Most of the bulk carriers with a potential to sail at 41- or 42-foot drafts (instead of 40 feet) were from the Port of Kalama. Additional draft increases may be available to container ships that could schedule departure times to take advantage of the water depth available. The potential for deeper drafts on container ships is supported by 1994 to 1995 data that shows about 30 percent of those ships sailed with drafts over the target draft of 36 feet, including nine percent that sailed with drafts over 38 feet.

The benefits of this alternative could be realized under any of the considered channel alternatives. It appears that ships that have the potential to load deeper than the target drafts could achieve an extra foot of draft about 20 percent of the time and two additional feet of draft about 5 percent of the time, based upon preliminary analysis. Additional benefits might be possible, especially with bulk commodities, if some acceptable level of delay is added into the equation. No analysis has been done, however, to show that LoadMax actually can provide these benefits. This alternative is expected to increase net benefits when added to any deepening alternative. Continuous improvement of LoadMax is an important priority for the ports, river and bar pilots, the NWS-NWRFC, and steamship line customers that utilize the projected and real-time tide and river-stage information system.

Recent enhancements have improved the LoadMax forecast and data distribution. Future upgrades, including the addition of bathymetric information, are being planned. It is estimated that future improvements to the river stage forecast system would be implemented as part of the day-to-day operations under with- or without a new project.

4.4. Structural Alternatives

4.4.1. Regional Port Alternatives

Several alternatives have been formulated which involve development on new port facilities closer to the mouth of the Columbia. An analysis of these alternatives to determine whether they would provide benefits to the nation while avoiding channel improvement costs is discussed in this section. These alternatives include construction of topping-off facilities at Astoria, close to the mouth of the river, or at Longview at CRM 66. Two other alternatives involve development of regional port facilities closer to the mouth of the Columbia River at either Astoria (CRM 13) or Longview (CRM 66). Two other alternatives involve development of regional port facilities at either Astoria or Longview to fully load any vessel that would depart the river at drafts greater than 40 feet.

The Corps is directed to analyze a variety of alternatives, including those that may be outside Corps' authority. The goal of the analysis is to establish that the selected plan maximizes benefits to the nation. The net benefits (benefits minus costs) of a regional port alternative must be higher than the net benefits for any other plan. This study is not intended to be a port development document. These alternatives have only been examined to the extent that this threshold is reached; once the analysis clearly shows that the estimated costs exceed the projected costs of the most beneficial channel deepening alternative, no further analysis is pursued.

Landside port development is a port responsibility. Should a regional port facility be constructed or planned for construction, the Corps could conduct a feasibility study and make recommendations regarding associated navigation infrastructure if authorized to do so by Congress. A deepening of the entire navigation channel does not prohibit the non-federal investments in facilities and infrastructure that would be required for a regional port, and should such investments be made, a non-federal sponsor would be in a much stronger position to ask for federal cost sharing of a navigation channel to these facilities.

There are several factors that make this analysis difficult. First, the most recent federal deep-draft navigation investment at Astoria has yet to produce any benefits. The Tongue Point project, which was planned by the State of Oregon to be an auto import center, has not had any deep draft traffic since completion in 1990; nor has there been commercial development associated with the federal and state investment in navigation improvements made at that time. This lack of commercial interest does not support the feasibility of development of a major deep draft port at Astoria.

Another factor is that container shipping has market requirements that do not fit with the concept of a topping-off facility. The idea that a container operator would make two stops on the Columbia in order to maximize cargo utilization is in conflict with the predominate concern by container carriers and shippers to meet schedules. An additional stop on the Columbia could be compared to the willingness of operators to incur delay due to tides. At this time, few operators are willing to delay for tide, and it is unlikely that many would be willing to incur a similar delay for a topping-off container facility. Given that the benefits attributable to container traffic are greater than the costs required to achieve the benefits, any alternative that does not benefit the container traffic is not going to be a net-benefit-maximizing alternative. In other words, even if a topping-off facility was beneficial to grain movements, the channel deepening would still be the recommended plan based on the strength of the container benefits.

A third complicating factor is that regional port options in the Astoria area generally rely on filling portions of the estuary. The Port of Astoria has prepared a preliminary cost estimate for a grain topping-off facility, which includes filling 375 acres of the estuary. To achieve this development in the estuary, the Port of Astoria would be required to obtain the necessary environmental clearances for the fill and related development before material could be utilized. Filling 375 acres of special aquatic sites, such as estuary areas, for upland port facility development would be inconsistent with 404(b)(1) guidelines that require the avoidance of filling to the extent possible. Based upon the effort expended to date on this channel improvement study, the conceptual estuarine fill at Astoria would require a 5 to 10 year effort to complete environmental and feasibility studies.

An estuarine fill of 375 acres would adversely effect ESA critical habitat for federally-listed salmonids. Additionally, benthic invertebrates and other fish species such as white sturgeon would lose valuable habitat. Impacts to various wildlife resources would also occur, their nature and extent dependent upon location and physical attributes of the area to be filled. Fill of this extent would be expected to have an impact on flow, circulation, and potentially estuarine salinity, which may lead to adverse impacts peripheral to the developed site(s). These attributes would require lengthy studies and modeling to ascertain their impacts to estuarine resources. Where fill material would be obtained, presumably dredged from the Columbia River, would pose further problems with regards to critical habitat, impacts to fish and benthic invertebrates, and whether the material is contaminated.

To offset estuarine fill impacts, implementation of ESA conservation measures or reasonable and prudent alternatives and mitigation for wetland fill would be required should the resource agencies consent to such a substantial estuarine fill. These mitigative actions would require the acquisition and development of habitat on a substantial acreage of land in the Astoria area. Generally, offsetting acreage would exceed impacted acreage by at least a 2:1 ratio or greater. Conceptually, this would entail acquisition of private diked lands, removal of their perimeter dikes, and restoration of these lands to the ebb and flood of the tides.

A further environmental concern associated with regional port development at Astoria arises from associated land development and necessary improvements to the transportation facilities. Associated urban and industrial development would be expected to impact wetlands and riparian habitat through additional fill along the shoreline and/or in lands behind dikes. Improvements to highway and rail corridors would be required to handle increased traffic to and from the interior. Rail improvements, particularly if another track was needed, would have substantial impacts on estuarine and riverine habitats if the additional track was paired with the existing rail line. The present rail line parallels the Columbia River shoreline on fill and cuts through wetlands and embayments on causeways. Another track would impact critical habitat for ESA salmonids and damage riparian habitat. Locating the track inland would require numerous crossings of streams and wetlands, would impact timberlands, and would need to overcome steep, unstable terrain. Enlargement of present highway corridors also appears necessary and would have comparable environmental issues and mitigation requirements as an interior aligned railroad.

4.4.1.1. Astoria Single-Stop Port Alternative

This alternative would involve constructing in Astoria all export facilities to handle vessels with drafts greater than 40-feet. New port facilities would have to be built for wheat, corn, and containers. These facilities would require hundreds of acres of land that is not currently available to handle the volume of grain and containers expected to move on vessels with design drafts greater than 40 feet. An option would be to fill the existing Astoria port area and adjacent land in Young's Bay. The railroad and highway routes into Astoria would need to be upgraded to handle the large increase in freight traffic that would occur. By 2004, over 10 million tons of grain is expected to move on vessels with a design draft of 41 feet or greater. In terms of container traffic, it is expected that about 350,000 TEUs[1] (twenty-foot equivalent units) would be loaded on vessels requiring over 40-foot drafts.

Compared to improving the existing channel infrastructure, this alternative would increase transportation costs. The costs of getting a ton of grain from the Portland area to the Astoria region by deep draft vessel is less than the cost of transporting grain via rail or barge. The costs of port development could exceed the $400 million[2] estimate for a comparable project, which is more than double the current estimate of the channel improvement costs.

There would also be environmental impacts due to the loss of shallow-water habitat in the estuary, transportation improvements, and the urban development triggered by the new port facilities. These were discussed in more detail in the general section on regional port facilities. These impacts are likely to be far more significant than the impacts of the additional disposal sites created for the channel improvement alternatives.

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[1] As all containers are not of equal size, an appropriate measure of traffic volume can count a 40-foot container as equivalent to two 20-foot containers.

[2] Estimated from the Port of Portland's *West Hayden Island Development Program Final Report*, which estimated costs for new grain and container facilities.

The single-stop port alternative was not carried forward for further consideration because it would require substantial efforts to complete environmental and feasibility studies, and the initial construction, transportation, and environmental costs of this alternative would be higher than those associated with channel improvement.

4.4.1.2. Astoria Topping-Off Port Alternative

In the year 2004, a topping-off facility would be expected to handle 360,000 short tons of wheat, 800,000 short tons of corn, and approximately 600,000 short tons of containers. By 2014, these numbers will increase to 800,000 short tons for wheat, 900,000 short tons for corn, and 1,000,000 short tons for containers. These commodities would have to be transported to Astoria by rail, truck, or barge rather than by deep draft vessels.

The Port of Astoria has completed a preliminary cost estimate for a grain topping-off facility at Astoria. The initial cost estimate, which does not include a mitigation plan, is currently $295 million. This does not include increased transportation costs. Mitigation costs for such a development, particularly with the extensive in-water fill requirement, would be significant. As the construction, transportation, and environmental costs of this alternative are considered much higher than those associated with channel improvement, it was not carried forward for further consideration.

4.4.1.3. Longview Single-Stop Port Alternative

This alternative would deepen the channel to Kalama and would locate large wheat and container facilities in Longview. Several new wheat elevators and a container terminal the size of the Port of Portland's T-6 would have to be built in Longview. Environmental costs associated with development at Longview would be less than for Astoria. Rail and transportation corridors are substantially in place and a land base of former industrial and undeveloped (but previously disturbed) lands are available. As with the Astoria one-stop alternative, this alternative would cost substantially more than the channel improvement alternatives, because of facilities development, and was not carried forward for further consideration.

4.4.1.4. Longview Topping-Off Port Alternative

This alternative includes deepening the channel to Kalama, using existing wheat elevators at Longview and Kalama, and building a new container terminal at Longview. No improvements would be needed to the existing railroad and highway systems. Environmental impacts would be minimized through the use of existing facilities.

The costs of this alternative include a transportation cost increase as more wheat is shipped via barge or rail to Longview rather than Portland. Assuming that container carriers would opt to make two vessel stops on the Columbia, there would need to be a substantial investment in a new container facility. Current industry cost estimates to construct container terminals generally assume a cost of about $1,000,000 per acre. This assumption may be conservative. The five most recently constructed West Coast container terminals cost an combined average $1,470,000 per acre. The Port of Portland has recently completed a study that included a cost estimate for a new container facility at Hayden Island. This facility, which includes a 190-acre container yard, is expected to cost over $325,000,000. Given these cost estimates, it can be assumed that even if the container facility at Longview is only one-quarter of this size and cost, the costs of a topping-off facility combined with the additional transportation costs (for moving containers and wheat the additional distance to Longview) would exceed the costs of the channel improvement alternatives. Based on this analysis, this alternative was not carried forward for further consideration.

4.4.2. Channel Deepening Alternatives

The three channel deepening alternatives include deepening the existing 40-foot navigation channel to 41, 42, or 43 feet. These alternatives retain the existing channel alignment from CRM 3 to CRM 105.5 and the existing 600-foot width. For the Willamette River, a narrower channel was selected because of the small volume of ship traffic that would likely exceed the existing 40-foot depth.

The channel design included allowances for overdepth and overwidth AMD. The AMD extends the time during which the project depth would be available to ships and also the time between maintenance dredging actions. Five feet of overdepth dredging (four feet of advance maintenance and one foot of dredging tolerance) was included for the Columbia River for each channel improvement alternative. In the Willamette River, two feet of overdepth dredging was included. Also in the Columbia River, an additional 100 feet of overwidth advance maintenance was included in reaches where that practice is currently used during maintenance dredging for the 40-foot channel.

The construction of the 41-, 42-, and 43-foot channels would require dredging 6.0 mcy, 11.9 mcy, and 19.5 mcy from the navigation channels, respectively. The depth and width of the dredging cut would vary with location. A few short reaches (CRMs 3 to 5, 36 to 37, 49 to 51, and 52 to 54) would not require any dredging. In other reaches (CRMs 22 to 36 and 68 to 74) dredging would be limited generally to areas along the edge of the channel. Also, nearly the entire navigation channel would need to be dredged in some reaches, such as at CRMs 10 to 13, 15 to 17, 38 to 39, 43 to 48, 63 to 68, and 88 to 100.

Construction of the 43-foot channel would also require the removal of 220,000 cubic yards of hard basalt rock and 450,000 cubic yards of cemented sand, gravel and boulders at four areas in the Columbia River and two in the Willamette River. Basalt is present at two areas at CRM 87 and WRMs 3 to 7. A softer, consolidated rock occurs at CRMs 63 to 67, CRM 105 and WRMs 10 to 11. An area with an unknown type of rock (probably basalt) is located at CRM 98. There is a high likelihood that rock in the basalt areas was fractured during the construction of the 40-foot channel. Mechanical methods such as a large clamshell dredge would be tried to see if the rock could be removed. Underwater blasting would need to be done in areas where mechanical methods are unsuccessful. Excavated rock will be placed in upland disposal sites.

Dredging requirements and disposal alternatives for the channel deepening alternatives are discussed in Section 4.4.3. Most construction dredging would be done by hopper and pipeline dredges. Each foot of deepening would allow an increase of one foot in the target drafts shown in table 2-2. The deepening would extend through the entire riverine portion of the navigation channel, including the approach to MCR from CRM 13 to CRM 3. The Bar Pilots believe that with a deeper approach channel, they would be able to transit the existing 55-foot MCR channel with the deeper draft ships. The deeper drafts are not expected to significantly increase delays at the MCR due to wave and tide conditions (see Appendix A). The institutional constraint on maximum draft in the river and at the MCR imposed by the regulatory environment at OBMP is expected to shift directly with the deepening; that is, a 43-foot channel would allow a maximum draft of 43 feet.

The main benefits of channel deepening are attributable to transportation cost savings for bulk grain carriers and container ships. Following existing practices, bulk carriers from Portland and Vancouver would load to drafts one foot less than the channel design depth. The bulk carriers from Kalama would load to the channel design depth. Container ships would continue to load shallower than the bulk carriers. The 42-foot deep channel would allow the 38-foot design draft container ships to fully load, following the current navigation practices. The 43-foot channel would allow 41-foot design draft container ships to routinely load to a 39-foot draft, and to fully load with the concurrence of a river pilot.

4.4.3. Disposal Alternatives

Implementing any of the three channel deepening alternatives would require dredging and disposal of dredged material for the construction and maintenance of the new project. The disposal of dredged material is a sensitive issue that can influence land use, natural resources, and industrial development, as well as future dredging demands. Disposal alternatives were prepared for construction and 20 years of maintenance dredging for the channel improvement alternatives considered in this study. It was necessary to estimate construction and maintenance dredging volumes to establish construction plans, disposal capacity and project costs. Maintenance dredging was forecast for a 20-year period. To make these forecasts, past dredging volumes, disposal practices, and bathymetric surveys of the riverbed were examined for each bar on the Columbia and lower Willamette Rivers.

4.4.3.1. Construction Dredging Forecast

The construction dredging volume for each channel improvement alternative was estimated from bathymetric surveys taken during winter 1994 and spring 1995. A computer design program was used to run the separate dredging templates for the alternative channel depths of -40, -41, -42 and -43 feet CRD. As described in Section 4.4.2, the channel design included allowances for overdepth and overwidth AMD. The construction dredging and rock removal volume for the 41-, 42- and 43-foot channel improvement alternatives are shown in table 4-3.

Table 4-3. Construction Dredging and Rock Removal Volume by Alternative

Alternative	Construction Dredging (mcy)		Rock Removal (mcy)		Total
(channel depth)	Columbia	Willamette	Columbia	Willamette	
41 feet	5.4	0.2	0.1	0	5.7
42 feet	11.2	0.3	0.2	0.1	11.8
43 feet	18.4	0.7	0.5	0.1	19.7

4.4.3.2. Maintenance Dredging Forecast

A significant part of the cost of a deeper navigation channel would be the increased costs for maintenance dredging. To assess the expected changes in maintenance dredging, a 20-year forecast of anticipated maintenance dredging volumes was made for the existing 40-foot channel (no action) and the 43-foot channel alternative.

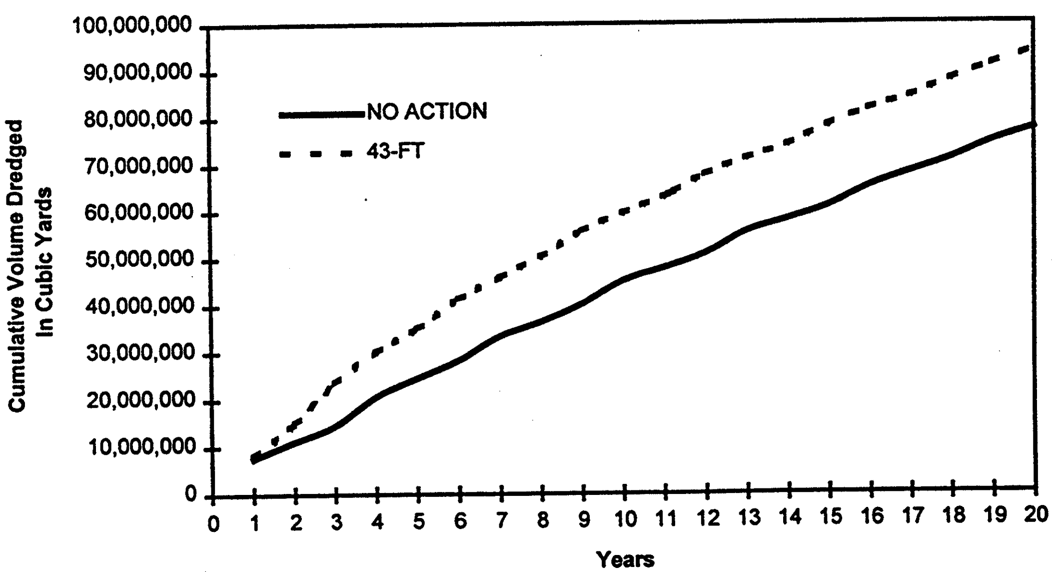
Any increase in maintenance dredging depends on the magnitude of the disturbance to the riverbed produced by any of the channel improvement alternatives. Where the navigation channel is deepened, the riverbed adjacent to the channel becomes unstable. Near the dredging cutline, the steep side-slope perpendicular to the channel causes the river's bedload to be deflected more toward the channel. The steeper the side-slope, the greater the deflection of the bedload which would cause shoaling and higher maintenance dredging. Eventually the river would re-establish equilibrium side-slope. During this period of side-slope adjustment, maintenance dredging requirements would be higher than under normal riverbed conditions, which accounts for the initial increase in maintenance dredging that would accompany a deeper channel.

A detailed forecast of future maintenance dredging for the existing 40-foot channel was made in the DMMP (Corps of Engineers, 1998). For this study, a detailed forecast was made of the potential maintenance dredging for the 43-foot channel improvement alternative because it would result in the greatest disturbance to the riverbed. The maintenance dredging volumes for the 41-foot and 42-foot channel improvement alternatives would fall between the volumes for the 40- and 43-foot channels, and were interpolated from the two detailed forecasts. The 20 year maintenance dredging forecasts for the 40-, 41-, 42-, and 43-foot channels total 78, 81, 85, and 90 mcy, respectively.

The maintenance dredging forecasts involved examining dredging volumes from 1980 to 1995 to identify the type of dredge used and trends in annual maintenance volumes. Hydrographic surveys from 1982 to 1995 were analyzed to identify significant changes in riverbed bathymetry, the source of shoal material, and the volume of sand available for shoaling. Disposal practices were reviewed to determine if dredged material was being placed in shoal material source areas or removed from the shoaling sediment supply. The flowlane disposal sites were examined to determine if material was accumulating in the disposal area. Each navigation alternative, including no action, required maintenance dredging forecasts that covered the range of available disposal options. The dredging forecasts were made using the observed dredging trends and potential sediment supplies. Where recent disposal practices have been adding to the sediment supply, two forecasts were made; one for a continuation of recent disposal practices and another that incorporated removing the dredged material from the sediment supply. A third maintenance dredging forecast was made for sites where river control structures have the potential to further reduce sediment supply. These sites include the St. Helens, Westport, Pillar Rock, and Miller Sands bars. The dredging expected at each bar was forecast based on disposal methods and/or river control structures included in the options. The individual bar forecasts were then compiled into overall river forecasts for each channel improvement alternative.

The 20-year maintenance dredging forecasts for the no action alternative and the 43-foot channel alternative are shown in figure 4-1. The initial increase in maintenance dredging is attributable to adjustments in the river bank side slopes. After 12 years, the annual maintenance dredging rates are expected to be essentially the same for the 40- and 43-foot channels. Both forecasts predict a slow decline in annual dredging over the 20-year period; this decline is related to reductions in the potential sediment supply.

Figure 4-1. Maintenance Dredging Forecasts (cumulative volume for 20 year period)



Over the first 20 years of the 43-foot channel project, the annual maintenance dredging forecast declines from around 8 mcy per year to approximately 3 mcy per year. This decline would result from the removal of sediment from the channel and shoal source areas. Shoaling would remain near current rates only in areas with sediment sources outside the channel, such as the upstream end of the channel near Hayden Island or downstream of the Cowlitz River. Most other areas of the Columbia River channel would experience only minor shoaling. The shoaling in the Willamette River would also remain near current rates because the shoal material also comes from upstream of the navigation channel.

The average annual maintenance dredging for years 21 through 50 of the project can not be forecast with any degree of certainty. Assuming the disposal practices proposed for the first 20 years are continued during the next 30 years, the average annual maintenance dredging could be in the 2 to 3 mcy per year range.

4.4.3.3. Disposal Methods

The development of alternatives for disposal focused on the suitability of upland, shoreline, in-water, and ocean disposal sites. All of these disposal methods, except ocean disposal, are currently used for maintenance of the existing 40-foot channel. The suitability of disposal sites determined which dredging practices would be considered for a specific location. The following sections discuss the disposal practices that could be utilized by any channel improvement alternative.

Upland Disposal. At upland disposal sites, dredged material would be confined within specific diked areas. Upland disposal can be done directly by pipeline dredges, by pumping from hopper dredges, or by mechanically unloading barges from a clamshell dredging operation. For this study, however, only pipeline dredging was considered in conjunction with upland disposal. Pipeline dredging/upland disposal could be a cost-effective means of removing large volumes of material from the channel. Cost effectiveness depends on the availability of disposal sites close to the dredging locations.

The upland areas along both sides of the river were surveyed for suitable disposal sites. Consideration was given to all upland disposal sites used during the past 10 years plus numerous potential new sites. Most of the upland sites were considered for long-term use and several had a potential beneficial use as port development and sand mining sites. Upland disposal would require an initial investment to acquire the site. However, upland disposal could generate offsetting long-term economic and environmental benefits by reducing future operation and maintenance dredging.

Shoreline Disposal. Shoreline disposal measures can be either permanent or temporary fills. Permanent shoreline fills would result from placing material in areas protected from erosion by natural channel features or river control structures. Permanent shoreline fills on the Columbia River have subsequently been used for industrial, port, and residential development, recreation and wildlife sites, channel constriction, and long-term disposal. Temporary shoreline fills occur when disposal sites are exposed to erosion by waves and river currents. Where shoreline disposal replaces the material previously eroded, the disposal action is commonly referred to as beach nourishment.

Like upland disposal, pipeline, hopper, or clamshell dredges could utilize shoreline disposal. For this study, however, consideration was limited to pipeline dredging. Pipeline dredges discharge directly onto the beach and adjacent shallow water areas. The fills typically extend out to water depths of 5 to 10 feet. Although shoreline disposal would be inexpensive in the short term, the material eroded from the sites can return to the channel and increase future maintenance dredging.

Historically, the Corps used more than 80 shoreline sites along the banks of the Columbia River for disposal of dredged material. Over time, the number of approved shoreline sites has been reduced from 80 to only one site at Miller Sands. The reduction resulted from concerns over protection of endangered juvenile salmon during ESA consultation with the NMFS. Another 10 previously used sites were studied in 1995 to determine their potential value as juvenile salmon rearing habitat in order to consider them for the list of approved sites. This study considered the use of the 14 approved shoreline sites and the ten additional sites studied in 1995. The least cost plan in the DMMS proposes to use one shoreline site over the next 20 years.

In-Water Disposal. The areas used for in-water (flowlane) disposal would change yearly, depending on the dredging location and river depths. In-water disposal could be used by hopper, pipeline, and clamshell dredges. Although hopper dredges could haul material several miles to a disposal site, they would be most cost-effective using nearby sites. Pipeline dredges could sidecast or pump several thousand feet of material into in-water disposal sites. A clamshell and barge operation could economically move material many miles to an in-water disposal site.

In-water disposal was considered along the length of the navigation channel. The 1998 DMMP stated that in-water disposal would be placed within and adjacent to the navigation channel primarily in water depths from 45 to 65 feet with some exceptions for disposal in depths as shallow as 35 feet and as deep as 85 feet. For this study, in-water disposal was considered for several depth zones ranging from 35 to 65 feet deep. Disposal in sites over 50 feet deep would limit the amount of sand that would return to channel shoals. In-water disposal was evaluated for pipeline and hopper dredging in the Columbia channel.

Sand and fine-grained sediment from the Willamette River could be disposed of at in-water sites in the Columbia and Willamette rivers. Material would be disposed of in the Columbia River near CRM 101.5, and in two deep-water areas in the Willamette River at WRMs 4.5 and 9.6. Maximum water depths at both Willamette sites are over 70 feet.

Ocean Disposal. Currently, there are four EPA designated ocean dredged material disposal sites at the mouth of the Columbia River. The ocean disposal sites have been evaluated (Appendix H) with a proposal for designation and use of two ocean dredged material disposal sites (figure 4-2). Historically, the majority of the material placed at these sites has been dredged material from the MCR entrance channel. Dredging quantities disposed at the sites are currently averaging about 4.5 mcy annually. Significant mounding has occurred at two existing sites in recent years and remaining site capacity is not adequate for long-term maintenance of the entrance channel. In 1992, the Corps and EPA Region 10 determined that long-term new site designation studies would be required. To address short-term disposal needs, sites were expanded on a temporary basis in 1993 and 1997.

This feasibility study addresses both the long-term disposal needs for continued maintenance of the mouth of the Columbia River project, maintenance of the existing 40-foot channel, and the ocean disposal requirements for construction and maintenance of the channel deepening alternatives.

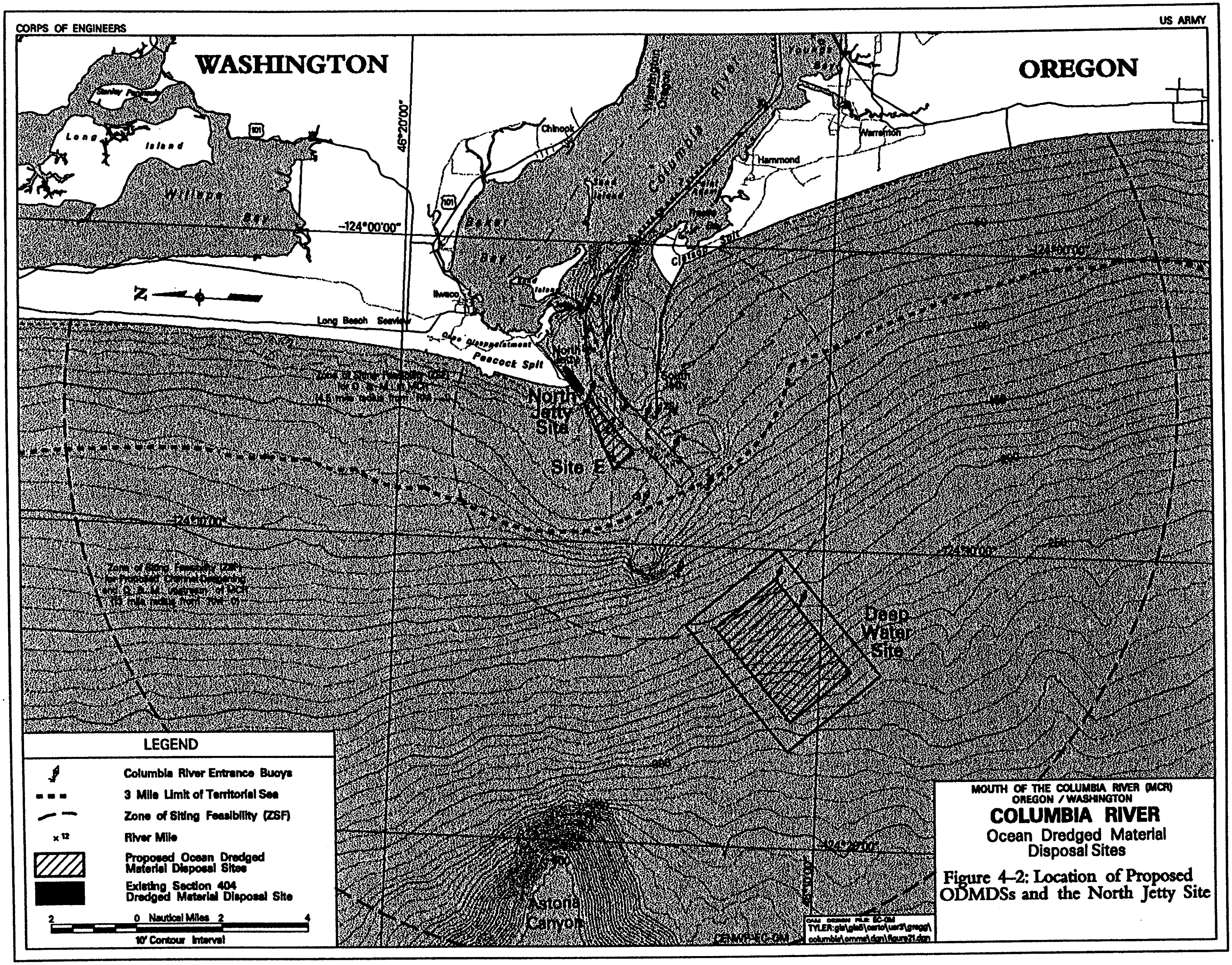


Figure 4-2: Location of Proposed ODMDSs and the North Jetty Site

The estimated ocean disposal volumes for maintaining the mouth of the Columbia River project, maintaining the existing 40-foot channel, and for the 43-foot channel improvement alternative (construction and maintenance) are shown below.

- MCR maintenance: annual average 4.5 mcy – 50-year estimate is 225 mcy
- 40-foot channel maintenance: year 1 to 20 is 8 mcy – year 21 to 50 is 12 mcy
- 43-foot channel construction: 7 mcy (includes 40-foot channel maintenance volume)
- 43-foot channel maintenance: year 1 to 20 is 9 mcy – year 21 to 50 is 21 mcy

The Corps, in cooperation with EPA, initiated an ocean dredged material disposal site study to identify new sites for the MCR and the navigation channel. Many other agencies and stakeholders participated in the study. Through a series of workshops, candidate ocean disposal sites were identified and refined to two sites with adequate offshore disposal capacity for both the MCR and the river channel. Detailed discussion of the study process and results, including a site management and monitoring plan, are included in Appendix H, *Columbia River Ocean Dredged Material Disposal Sites*.

River Control Structures. The only river control structures considered for this study were pile dike fields. Island creation and channel constrictions were judged unacceptable because of their potentially significant environmental impacts. Construction of new pile dike fields could stabilize eroding sites and reduce future maintenance dredging. Pile dike fields at two sites, between Miller Sands Spit and Pillar Rock Island (Miller/Pillar) and Sand Island near St. Helens were evaluated for inclusion in a new project.

4.4.3.4. Upland Disposal Site Screening

An initial list of 157 potential disposal sites were developed based on the 25 sites previously used for Columbia River maintenance dredging, the 1991 Columbia River Maintenance Disposal Plan, and staff determinations (table 4-4: note that 17 sites had two disposal options, but were counted only once). Unconfined in-water disposal in or adjacent to the channel was counted as one site for the length of the river regardless of the initial disposal depth identified. Twenty-nine new sites, not previously proposed were included in this initial list. Disposal history for each potential disposal site was identified to the extent possible. As discussed below, this initial list was further refined by applying six environmental and engineering criteria to each disposal site. To the extent possible, only sites that passed all the environmental and engineering criteria were given further consideration for inclusion in the disposal alternative.

Environmental Criteria. Environmental issues related to endangered species and wetlands are especially sensitive in the lower Columbia River study area. The six environmental criteria were considered significant enough to restrict or prohibit disposal actions that might adversely impact them. Each potential disposal site was screened against the criteria determine its environmental suitability. To the extent possible, the six environmental criteria were applied as follows:

1. ESA critical habitat. No disposal action would occur within the 300-foot riparian zone (critical habitat) for ESA Snake River salmonids as established by the NMFS. Existing disposal sites or sites where natural habitat values had been lost were exempted from application of this criterion. Riparian inclusions at existing disposal sites within the 300-foot critical habitat zone, per discussion with the NMFS, would be avoided during disposal actions. Application of this criterion was intended to preclude impacts to these federally listed species.

2. Near bald eagle sites. No disposal would be targeted to occur within 1,500 feet of any known bald eagle nesting site. Application of this criterion was intended to preclude impacts to this federally listed species, principally disturbance to nesting pairs.

3. Productive shallow-water habitat. Shallow-water habitat, defined as depths less than 20 feet, was not targeted for disposal in order to protect areas considered productive for benthic invertebrates and juvenile salmonids, including federally listed species.

4. Beach nourishment sites not currently cleared, or studied and determined to be productive for benthic invertebrates. Beach nourishment sites were limited to the 14 sites cleared by NMFS in the December 1993 biological opinion for maintenance dredging. An additional 10 sites were evaluated to determine their productiveness for benthic invertebrates. Sites determined to be productive were not included further and/or the disposal was shifted to upland.

5. Impact to wetlands. Wetland habitat would be avoided to the extent practicable.

6. No disposal inside state/federal wildlife refuges or management areas (except currently used sites). This criterion was established to avoid land management conflicts on public lands designated for wildlife management purposes. Existing sites within the Lewis and Clark National Wildlife Refuge remained in consideration, however.

Engineering Criteria. The initial list of potential disposal sites contained many that had not been recently used for disposal. These sites were evaluated for disposal suitability based on site conditions and dredging requirements. Six engineering criteria were used for screening the sites. These criteria focused on physical factors that would limit a site's usage for long-term disposal. The six engineering criteria used to eliminate sites from detailed evaluation were:

1. Insufficient capacity available/required. Small sites that did not have sufficient capacity to handle the expected 20-year disposal volume, or sites where the potential disposal requirements could be better met by other nearby sites.

2. Disposal site not in proximity to dredging site. Disposal sites that do not require pipeline dredging and upland disposal.

3. Placement of material results in re-handling or creation of a shoal. These sites would require dredging the material a second time to place it in a stable disposal site or have been determined to be sources for adjacent channel shoals that would increase future maintenance dredging requirements.

4. Incompatible with future development/land use. Sites planned for intensive use that would be prohibited by disposal, such as those for commercial or industrial development.

5. Insufficient volume for pipeline use to upland site. Shoaling volumes expected in the vicinity would not justify use of a pipeline dredge and upland disposal.

6. High costs. Site use would be unusually expensive due to identifiable issues, such as real estate values, wildlife mitigation requirements, high pumping costs, or hazardous, toxic, radioactive waste cleanup.

4.4.3.5. Disposal Site Screening Results

Application of the environmental and engineering criteria produced a subset of acceptable disposal sites. Disposal sites that could be considered a beneficial use site were given additional review to determine whether they should be included in the new project.

Table 4-4 identifies all the disposal sites considered in the feasibility study, along with the type of disposal practice, a determination on whether the site has been used and the applicable environmental and engineering screening criteria. Following the table, figure 4-3 shows the locations of the disposal sites.

Table 4-4. Disposal Site Screening Summary

SITES CONSIDERED 1/	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY 2/	ENVIRONMENTAL 3/						ENGINEERING 4/					
			1	2	3	4	5	6	1	2	3	4	5	6
CRM 98-105 > 50' of depth in and adjacent to channel	Unconfined In-water	Used[1,2,3]												
CRM 98-105 > 35' of depth in and adjacent to channel	Unconfined In-water	Used[1,2,3]									X			X
O-106.0	Upland	Used[3]							X			X		X
West Hayden Is. O-105.0	Upland /Beach Nourishment	Used[1,2,3]												
W-103.7	Upland	Not Used										X		
W-103.6	Upland	Used[2]										X		
Gateway 3	Upland	New		X										
W-102.1	Upland	Not Used											X	
W-102.0	Upland	Not Used											X	
W-101.3	Upland	Not Used											X	
Gateway 5	Upland	New		X										
W-101.2	Upland	Not Used											X	
W-101.1	Upland	Not Used											X	
W-101.0	Beach Nourishment	Used[3]	X		X	X								
O-100.8	Beach Nourishment	Used[3]	X		X	X								
O-99.9	Beach Nourishment	Used[3]			X	X								
O-98.9	Beach Nourishment	Used[3]			X	X								
Sump-1	Unconfined In-water	New							X		X			X
Sauvie 1	Upland	New												
Cereghino	Upland	New												
O-97.3	Upland/Beach Nourishment	Used[3]		X		X			X					
W-97.3	Beach Nourishment	Used[3]	X			X					X			
W-97.1	Upland	Used[1,2,3]												
W-96.9	Upland	New/Used[3]												
W-96.7	Upland	Not Used					X		X					X
W-96.6	Beach Nourishment	Used[3]	X		X	X								
W-96.5	Upland	Not Used												X
O-95.9	Beach Nourishment	Used[3]			X	X								
W-95.8	Beach Nourishment	Used[3]	X			X					X			
W-95.8	Upland	Not Used							X					
W-95.7	Upland	Not Used					X							
W-95.1	Upland	Not Used						X						

Table 4-4 (continued). Disposal Site Screening Summary

Sites Considered[1/]	Type of Disposal Site	Disposal History[2/]	Environmental[3/]						Engineering[4/]					
			1	2	3	4	5	6	1	2	3	4	5	6
O-94.6	Beach Nourishment	Used[3]	X			X			X					
Sauvie 94	Upland	New					X							X
O-93.5	Beach Nourishment	Used[3]	X			X					X			
Lonestar	Gravel Pit	New								X				X
O-91.6	Beach Nourishment	Used[3]	X		X	X								
Dairy	Upland	New					X							
W-91.0	Beach Nourishment	Used[3]												X
O-90.4	Beach Nourishment	Used[3]	X			X					X			
O-89.8	Beach Nourishment	Used[3]	X			X					X			
W-89.1	Beach Nourishment	Used[3]	X			X					X			
Railroad Corridor	Upland	Used[3]												X
O-87.0	Beach Nourishment	Used[3]	X		X	X								
W-86.9	Beach Nourishment	Used[3]	X			X					X			
W-86.5	Beach Nourishment	Used[3]	X			X					X			
Austin Point	Upland	Used[3]												X
O-86.2	Beach Nourishment	Used[2,3]									X			X
W-85.5	Beach Nourishment	Used[3]	X		X									
O-85.0	Beach Nourishment	Used[3]	X		X	X			X					
O-85.0	Upland	Not Used							X			X		
W-83.0	Upland	Used[3]							X					
O-82.8	Beach Nourishment	Used[2,3]	X			X					X			
O-82.8	Upland	Not Used							X					
W-82.6	Beach Nourishment	Used[3]	X			X			X		X			
O-82.6	Upland	Used[3]							X					
O-82.0 & O-82.3	Beach Nourishment	Used[3]	X		X	X								
W-82.0	Upland	Used[3]												
O-80.9	Beach Nourishment	Used[2,3]	X		X	X								
Morse Bros	Gravel Pit	New								X				X
Martin Island	Upland	New	X				X							X
W-80.3	Beach Nourishment	Used[3]	X			X					X			
O-78.4	Beach Nourishment	Used[3]	X		X	X								
O-77.0	Beach Nourishment	Used[1,2,3]	X			X					X			
O-77.0	Upland	Used[3]												

Table 4-4 (continued). Disposal Site Screening Summary

Sites Considered 1/	Type of Disposal Site	Disposal History 2/	Environmental 3/ 1	2	3	4	5	6	Engineering 4/ 1	2	3	4	5	6
W-77.0	Upland	Used[2,3]												X
W-76.0	Beach Nourishment	Used[3]				X					X			
O-75.8	Beach Nourishment	Used[2,3]									X			
O-75.8	Upland	Used[1]												
O-74.5	Beach Nourishment	Used[2,3]	X			X					X			
W-74.1	Upland	Used[2]					X		X					
W-73.5D	Upland	Used[2,3]												
Peavey Oval	Upland	Used[2,3]												
W-72.2	Upland	Used[2,3]										X		
W-71.9	Upland	Used							X			X		
W-71.9	Beach Nourishment	Used[2,3]	X		X	X			X					
O-71.4	Beach Nourishment	Used[2,3]			X	X						X		
O-70.2	Beach Nourishment	Used[3]	X		X	X			X					
W-70.1 (Cottonwood Is)	Upland	Used[2,3]												
W-69.0	Upland	Used[2,3]								X				X
W-68.7	Upland	Used[2,3]												
W-68.2	Upland	Used[2]	X						X	X				
W-68.0	Upland	Used[2]							X	X				
Pac Fiber	Upland	New					X					X		
Longview Fiber	Upland	New										X		X
Int'l Paper Rehandle	Upland	Used[2]							X					
Rainier Beach	Upland	Used[3]												X
Rainier Log Yard	Upland	Used[3]										X		X
W-67.5	Upland	Used[1,2]							X					X
W-66.8	Upland	Not Used							X			X		X
Rainier Inlet	Shoreline Fill	New	X		X	X								
O-65.9	Upland	Not Used								X				X
O-65.7	Beach Nourishment	Used[1,2,3]									X			
O-65.7	Upland	Used[1,2]												
O-64.8	Beach Nourishment	Used[1,2,3]	X								X			
O-64.8	Upland	Used[2]												
W-63.5	Upland	Used[1,2,3]							X					
O-63.5	Upland	Used[1,2,3]												

Table 4-4 (continued). Disposal Site Screening Summary

SITES CONSIDERED [1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY [2/]	ENVIRONMENTAL [3/]						ENGINEERING [4/]					
			1	2	3	4	5	6	1	2	3	4	5	6
Mt Solo (W-62.0)	Upland	Not Used					X			X				X
O-61.8	Beach Nourishment	Used[3]	X			X					X			
W-61.3	Beach Nourishment	New	X		X	X			X				X	
O-60.8	Beach Nourishment	Used[3]	X			X					X			
Barlow Point	Upland	New								X			X	X
W-59.7	Beach Nourishment	Used[1,2,3]	X								X			
W-59.7	Upland	Not Used	X											
W-58.7	Beach Nourishment	Used[3]	X			X			X					
W-58.0	Upland	New					X							X
W-57.8	Beach Nourishment	Used[1,2,3]									X			
O-57.0	Beach Nourishment	Used[1,2,3]			X	X								
O-57.0	Upland	Used[1]												
W-56.8	Beach Nourishment	Used[3]	X		X	X								
Crims Island	Upland	Used[3]	X				X							
Bradbury Slgh	Upland	New					X					X		
Port Westward 2	Upland	New								X				
Port Westward 1	Upland	Used[3]					X			X				
O-54.9	Beach Nourishment	Used[1,2,3]			X	X								
O-54.9	Upland	Used[3]											X	
O-53.5	Upland	Not Used								X				X
Sump 2	Unconf. In-water	New	X	X							X			X
W-51.3	Beach Nourishment	Used[3]	X			X					X			
O-50.9	Beach Nourishment	Used[3]	X		X	X								
O-47.8	Beach Nourishment	Used[2,3]				X					X			
O-47.8	Upland	Used[2]							X					
Westport 4	Upland	New					X							X
W-47.5	Beach Nourishment	Used[3]	X				X		X					
O-46.8	Beach Nourishment	Used[1,2,3]									X	X		
O-46.8	Upland	Used[2]							X			X		
W-46.0/46.3	Beach Nourishment	Used[1,2,3]									X			
W-46.0/46.3	Upland	Not Used												
O-46.2	Beach Nourishment	Used[3]	X			X					X			
O-44.0/45.1	Beach Nourishment	Used[2,3]				X					X			
Westport Slgh 3	Upland	New					X							X

Table 4-4 (continued). Disposal Site Screening Summary

SITES CONSIDERED [1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY [2/]	ENVIRONMENTAL [3/]						ENGINEERING [4/]					
			1	2	3	4	5	6	1	2	3	4	5	6
Westport Slgh 2	Upland	New					X							X
W-45.0	Beach Nourishment	Used [2,3]	X								X			
W-45.0	Upland	Not Used												
W-44.0	Upland	New												X
Westport Slgh 1	Upland	New					X							X
W-43.8	Beach Nourishment	Used [2,3]			X	X								
O-42.9	Upland	Used [1,2,3]												
W-42.5	Beach Nourishment	Used [2,3]	X		X	X								
W-42.5	Upland	Not Used												
W-41.8	Upland	Used [3]										X		X
W-41.3	Beach Nourishment	Used [2,3]	X			X					X			
W-41.0	Upland	New											X	
W-40.9	Beach Nourishment	Used [2,3]				X								
O-40.8	Upland	Used [1,2,3]							X					
Red Fern	Upland	New												
W-39.0	Upland	New												
O-38.9	Upland	Used [3]							X					
W-38.7 Puget Island	Beach Nourishment	Used [1,2,3]									X			
O-38.3	Beach Nourishment	Used [1,2,3]	X								X			
O-38.3	Upland	Not Used												
O-37.6 Tenasillahe Is.	Upland	Not Used					X	X						
W-37.0 Hunting Island	Beach Nourishment	Not Used	X		X	X	X	X						
O-36.8	Beach Nourishment	Not Used	X		X	X								
O-35.8	Upland	New	X					X						
W-34.4	Beach Nourishment	Used [3]	X			X		X			X			
O-34.0 Welch Island	Beach Nourishment	Used [2,3]			X	X								
O-34.0 Welch Island	Upland	Not Used												
W-33.4	Beach Nourishment	Used [2,3]							X					
Fitzpatrick Island (O-31.2)	Beach Nourishment	Used [3]	X		X			X	X					
W-28.2	Beach Nourishment	Used [3]		X		X			X					
O-27.2 Pillar Rock Island	Upland/Beach Nourishment	Used [1,2,3]												
Miller/Pillar	Unconf. In-water	New												

Table 4-4 (continued). Disposal Site Screening Summary

SITES CONSIDERED 1/	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY 2/	ENVIRONMENTAL 3/						ENGINEERING 4/					
			1	2	3	4	5	6	1	2	3	4	5	6
O-23.5 Miller Sands	Beach Nourishment	Used[1,2,3]	X avoid								X			
W-21.0 Rice Island	Beach Nourishment Upland	Used[1,2,3]	X avoid											
Harrington Point Sump	Unconfined In-water	Used[1,2,3]												
Lois/Mott Embayment	In-water Fill	New												
SK-81	Upland	Used[3]								X				X
SK-82	Upland	Used[3]								X				X
Area D	Designated Open Water	Used[1,2,3]							X					
SI-0.5	Upland	Used[3]								X				X
SI-0.4	Upland	Used[3]								X				X
SI-0.2	Upland	Used[3]								X				X
SI-1.0	Upland	Used[3]								X				X
Ocean	Designated Open Water	Used[1,2,3]												

Table Legend:

1/ <u>**Sites Considered**</u>: "W"/"O" refer to the Washington or Oregon shoreline; the number refers to approximate river mile on the navigation channel

2/ <u>**Disposal history *based on 1995 information***</u>:
1 - Site has been used within the last 2 years
2 - Site has been used within the last 10 years
3 - Site was used over 10 years ago

3/ <u>**Environmental Criteria**</u>
1. ESA critical habitat
2. Near bald eagle site
3. Productive shallow-water habitat
4. Beach nourishment site not currently cleared, or studied and determined to be productive for benthic invertebrates
5. Impact to wetlands
6. Inside wildlife refuge or management area

4/ **Engineering <u>Criteria</u>**
1. Insufficient capacity available/required
2. Site not in proximity to dredging site
3. Placement of material would result in re-handling of material or creation of a shoal
4. Incompatible with future development/land use
5. Insufficient volume for pipeline use to site
6. High costs

X= Site did not meet criteria

4.4.3.6. Beneficial Uses

It is recognized that from time to time dredged material could be made available for beneficial uses, such as borrow material, development of county or state park lands, industrial development, erosion abatement, and environmental enhancement. Corps guidance directs that beneficial use sites be considered when available (table 4-5). If a beneficial use site would not be in the best interest of the Federal Government, for example, it would cost more than the least cost alternative, the owner would be responsible for obtaining environmental clearances for its use as a dredged material disposal site.

If part of a recommended navigation alternative, a beneficial use site would be incorporated into the project's operation and maintenance program. If not part of a recommended alternative, the site would be pursued under relevant authorities and separate funding sources. Study costs for these sites, beyond the reconnaissance study level, would be either a non-federal or shared federal/non-federal responsibility depending on the type of beneficial use as shown below:

- Restoration and protection of environmental resources: cost share 75 percent federal/25 percent non-federal.
- Placement of material on beaches for hurricane and storm protection: cost share 50 percent federal/50 percent non-federal.
- Other beneficial uses, land creation or enhancement, development purposes, placing material on beaches not meeting criteria for Corps participation: all costs required for the base plan must be paid by non-federal interests.

On the Columbia River, there are several privately owned beneficial use sites. These sites have been used and have complied with necessary environmental requirements. When available and dredging is necessary and in close proximity, material could be disposed at these beneficial use sites. These sites must meet the beneficial use criteria and save capacity in the proposed sites.

Some beneficial use sites that would likely be used in the next 20 years include (this is not a complete list): sites W-73.5 and 72.2 on Port of Kalama property which are partially developed; site W-67.5 between the Port of Longview and the Longview Fibre Company; site W-63.5 directly on the Columbia River on property owned by Reynolds Aluminum; site O-40.8 owned by James River Corporation next to their paper mill at Wauna; site O-46.8, the Jones Beach recreation site; site O-82.8 owned by the Port of St. Helens and is diked and ready to receive dredged material; site O-86.2 (Sand Island), the marine park on the island across from the City of St. Helens; site O-18.2, North Tongue Point which is owned by the state of Oregon; O-13.0, a port development and environmental remediation area owned by the Port of Astoria; and O-11.0 (SK-107), the Skipanon site which also is owned by the Port of Astoria. Another potential beneficial use could be the placement of sand along Pacific Ocean beaches to replace eroded sands, especially along the Washington shoreline. Local sponsors would need to be identified for future consideration of these beneficial use actions.

Table 4-5. Potential Beneficial Use Sites

SITES CONSIDERED[1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY[2/]	ENVIRONMENTAL[3/] 1	2	3	4	5	6	ENGINEERING[4/] 1	2	3	4	5	6
0-105.0 Hayden	Upland/Beach Nourish	Used[1,2,3]												
W-102.1	Upland	Not Used											X	
W-102.0	Upland	Not Used											X	
W-101.3	Upland	Not Used											X	
W-101.2	Upland	Not Used											X	
W-101.1	Upland	Not Used											X	
W-97.1	Upland	Used[1,2,3]												
W-96.9	Upland	New/Used[3]												
Lonestar	Gravel Pit	New								X				X
O-86.2	Beach Nourishment	Used[2,3]									X			X
Morse Bros.	Gravel Pit	New								X				X
Austin Point	Upland	Used[3]												X
W-73.5D & Peavey Oval	Upland	Used[2,3]												
O-82.8	Upland	Not Used							X					
W-77.0	Upland	Used[2,3]												X
W-72.2	Upland	Used[2,3]										X		
O-71.4	Beach Nourishment	Used[2,3]			X	X						X		
O-65.7	Upland	Used[1,2]												
O-64.8	Upland	Used[2]												
W-62.0	Upland	Used											X	X
W-63.5	Upland	Used[1,2,3]							X					
W-67.5	Upland	Used[1,2]							X					X
Longview Fiber	Upland	New										X		X
W-68.0	Upland	Used[2]							X	X				
W-66.8	Upland	Not Used							X			X		X
W-57.8	Beach Nourishment	Used[1,2,3]									X			
O-44.0/45.1	Beach Nourishment	Used[2,3]				X					X			
O-46.8	Upland	Used												
O-53.5	Upland	Not Used							X	X				X
W-43.8	Beach Nourishment	Used[2,3]			X	X								
W-38.7 Puget Is.	Beach Nourishment	Used[1,2,3]									X			
W-33.4	Beach Nourishment	Used[2,3]							X					

Table 4-5 (continued). Potential Beneficial Use Sites

SITES CONSIDERED[1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY[2/]	ENVIRONMENTAL[3/] 1	2	3	4	5	6	ENGINEERING[4/] 1	2	3	4	5	6
O-40.8	Upland	Used 1,2,3							X					
O-23.5 Miller Sands	Beach Nourishment	Used 1,2,3	X								X			
O-18.2	Upland & Confined in-water	New	X	X	X		X		X					X
O-13.0	Upland & Confined in-water	New	X		X		X		X					X
O-11.0 (SK-107)	Upland	Used					X		X					X
Miller/Pillar	Unconfined in-water	New												
Pacific Ocean beaches	Beach Nourishment	New												

Table Legend:

1/ **Sites Considered**: "W"/"O" refer to the Washington or Oregon shoreline respectively; the number refers to approximate river mile on the navigation channel

2/ **Disposal History *based on 1995 information***:
1 - Site has been used within the last 2 years
2 - Site has been used within the last 10 years
3 - Site was used over 10 years ago

3/ **Environmental Criteria**
1. ESA critical habitat
2. Near bald eagle site
3. Productive shallow-water habitat
4. Beach nourishment site not currently cleared, or studied and determined to be productive for benthic invertebrates
5. Impact to wetlands
6. Inside wildlife refuge or management area

4/ **Engineering Criteria**
1. Insufficient capacity available/required
2. Site not in proximity to dredging site
3. Placement of material would result in re-handling of material or creation of a shoal
4. Incompatible with future development/land use
5. Insufficient volume for pipeline use to site
6. High costs

X = Site did not meet criteria

4.4.3.7. Least Cost Disposal Alternative

This alternative provides disposal capacity adequate for construction and 20 years of maintenance dredging at the least practical cost, while meeting the environmental and engineering criteria. The least cost disposal alternative was developed for the 43-foot channel improvement alternative because it has the largest volume of dredging and disposal. Disposal for the 41-foot and 42-foot alternatives would be similar to that of the 43-foot alternative. Because of the uncertainties in maintenance dredging volumes, land use changes, environmental regulations and technical advances, only a general concept is provided for disposal during years 21 to 50 of the proposed project.

The methods used to evaluate potential disposal sites were the same as those used in the DMMP, or no action alternative. The need for disposal capacity for construction and maintenance of a deeper channel, and reduced in-water disposal capacity were the main factors that caused differences between the least cost and no action alternatives. Both alternatives rely on upland and flowlane disposal, and minimize the use of shoreline disposal.

Upland Disposal. The least cost disposal alternative utilizes the 31 upland disposal sites for construction and maintenance during the first 20 years of the project. Those sites are listed in table 4-6, and have a total area of 1,897 acres. Fifteen of the eighteen upland sites in the no action alternative are also included in the least cost alternative. Eight upland sites have not been used previously for disposal and 23 were used for disposal in the past.

In-water Disposal. The least cost disposal alternative involves a variety of in-water (flowlane) disposal actions during the first 20 years. There would be two beach nourishment sites (O-23.5 and O-86.2), an in-water fill at CRM 25 to 27, and flowlane disposal along the length of the navigation channel. There would also be ocean disposal during construction and maintenance dredging.

Flowlane disposal would be used over the 50-year life of the project. Flowlane disposal would generally occur in water depths of 50 to 65 feet. However, there would be several exceptions to the general flowlane criteria. Flowlane disposal could occur in areas with depths of 35 to 65 feet between CRM 64 and 68, and between CRM 90 and 101. Flowlane disposal would occur in water over 65 feet deep in six areas: downstream of CRM 5; CRM 29 to 35; CRM 36.5 to 37.5; CRM 39 to 40; CRM 54 to 56.3 in the Oregon half of the channel; and CRM 72.2 to 73.2 in the Washington half of the channel. In-water disposal from the 43-foot alternative would include 3 mcy of construction and 24 mcy of maintenance material during the first 20 years.

Clean sediments from the Willamette River would be disposed of in unconfined in-water sites near CRM 101 and near WRMs 4.5 and 9.6. In-water disposal from the Willamette River would involve one mcy of construction and three mcy of maintenance material over 20 years. Chemical test results from 1997 indicated some Willamette River sediments to be dredged during construction exceeded screening levels for one or more contaminants and may not be suitable for unconfined in-water disposal. In accordance with the regional testing manual, *Dredge Material Evaluation Framework, Lower Columbia River Management Area*, these sediments would require biological testing prior to a suitability determination. Any material not determined to be suitable for unconfined in-water disposal would need to be managed appropriately; for example, placed in the proposed Willamette River sites and then capped with clean material. A suitable cap would be designed to isolate the contaminated sediment.

Table 4-6. Least Cost Disposal Alternative Sites

Disposal Site *	Disposal History**	Location/Name	Use in 20-Year Term	Site Acres	Site Capacity (cu yds)	Disposal Volume (cu yds)	Final Height (feet)
O-105.0	DMMS	West Hayden Island	2003-2022	102	5,750,000	5,330,000	58
O-98.5	New	Sauvie Island	2003-2022	48	2,323,000	1,542,000	40
W-97.1	DMMS	Fazio Sand & Gravel	2003-2009	27	650,000	650,000	25
W-96.9	New	Adjacent Fazio	2003-2022	17	475,000	475,000	44
W-96.5	New	N. Dike Field	2006-2022	25	1,098,000	1,098,000	53
W-95.7	New		2003-2006	25	1,080,000	650,000	38
O-90.6	New	Scappoose Dairy	2003-2022	107	5,350,000	5,307,400	51
W-86.5	Used	Austin Point	2003-2022	26	1,645,000	1,645,000	65
O-86.2	Used	Sand Island (beach nourish.)	2003-2022	28	1,250,000	1,250,000	15
W-82.0	Used	Martin Bar	2003-2006	32	1,500,000	1,500,000	65
W-80.0	New	Martin Island	2003-2022	80	3,850,000	2,946,000	36
O-77.0	Used	Lower Deer Island	2003-2021	29	1,498,000	1,100,000	64
O-75.8	DMMS	Sandy Island	2003-2020	30	1,100,000	1,100,000	53
W-73.5	Used	Peavy Rail Oval	2003-2022	43	900,000	1,220,000	34
W-70.1	Used	Cottonwood Island	2003-2022	50	3,225,000	2,506,000	54
W-68.7	DMMS	Howard Island	2003-2022	200	6,400,000	3,710,000	37
O-67.0	Used	Rainier Beach	2003-2004	52	1,095,000	1,095,000	36
O-65.7	DMMS	Globe Quarry	2003-2019	73	2,950,000	2,950,000	60
O-64.8	DMMS	Rainier Industrial	2004-2022	53	2,235,000	2,235,000	65
O-63.5	DMMS	Lord Island Upstrm.	2003-2015	46	1,255,000	1,255,000	41
W-63.5	Used	Reynolds Aluminum	2003	13	500,000	500,000	35
W-62.0	New	Mt. Solo	2003-2022	50	2,420,000	2,230,000	34
W-59.7	DMMS	Hump Island	2003-2010	69	1,400,000	1,400,000	40
O-57.0	DMMS	Crims Island	2003-2022	51	1,600,000	1,600,000	48
O-54.0	Used	Port Westward	2003-2022	50	1,875,000	1,875,000	46
W-46.3	DMMS	Whites Island	2003-2022	72	3,700,000	3,700,000	42
W-44.0	New	Puget Is. (Vik Prop.)	2003-2022	100	3,200,000	3,200,000	33
O-42.9	DMMS	James River	2003-2022	59	1,280,000	1,106,000	42
O-38.3	DMMS	Tenasillahe Island	2004-2044	42	2,100,000	2,100,000	53
O-34.0	DMMS	Welch Island	2018-2022	42	446,000	446,000	25
O-27.2	DMMS	Pillar Rock Island	2004-2022	56	2,555,000	2,540,000	52
O-23.5	DMMS	Miller Sands (beach nourish.)	2004-2022	151		1,405,600	
W-21.0	DMMS	Rice Island	2004-2022	228	5,500,000	5,500,000	45

* "W" and "O" refer to the Washington or Oregon shoreline, respectively. The number refers to the approximate river mile on the navigation channel.

** DMMS = site is in the no action alternative (existing 40-foot channel maintenance)
New = site is new for this study
Used = site previously used by Corps for disposal

Ocean Disposal. During construction of the 43-foot alternative, about 7 mcy (5 mcy new work plus 2 mcy for the 40-foot channel maintenance) of material would be disposed of in ocean disposal sites. An additional 9 mcy for channel maintenance would be placed in the ocean sites during the 20-year period.

Long Term Disposal. After 20 years of channel maintenance under the proposed dredging and disposal plan for the 43-foot alternative, the average annual maintenance dredging volumes are expected to decrease to less than 3 mcy per year. During years 21 through 50 of the project, disposal is expected to total approximately 85 mcy. Most of the long-term channel shoaling is expected to be sand waves or cutline shoals that could be removed by hopper dredges. The smaller volumes would be suitable for flowlane disposal and it would be used over the length of the channel.

The need for ocean disposal is anticipated to continue during years 21 to 50. Some estuary disposal sites are expected to reach capacity and dredged material would need to be disposed of in the ocean. About 7 to 10 mcy of material from the estuary may be placed in an ocean disposal site.

High maintenance volumes are likely to support continued upland disposal near Hayden Island and in the vicinity of the Cowlitz River. Disposal capacity may be available at Hayden Island (O-105.0) if earlier disposal material is used for port development or sold for commercial uses. Howard Island (W-68.7) would have capacity remaining, but other sites in the vicinity of Longview would have to be expanded or new sites developed. Some of the other sites listed in table 4-6 would have limited capacity remaining and the demand for commercial sand may also provide capacity for future upland disposal.

4.4.3.8. Sponsor's Preferred Disposal Alternative

In addition to the standard Corps planning guidelines, the sponsoring ports applied the following guidelines during the selection of their preferred disposal plan:

- Utilize Columbia River sand for port purposes and other beneficial uses.
- Substitute transportation costs for environmental costs.
- Minimize acquisition costs and enhance feasibility by avoiding controversial sites.

The sponsors were willing to incur some additional project cost to satisfy the above local guidelines. Alternatives considered by the sponsors included double-handling dredged material to dispose of it in fewer but larger disposal sites; maximize use of sponsor-owned property; and use of existing sand and gravel mining operations. The sponsor's preferred disposal alternative would be similar to the least cost alternative, except for seven of the upland disposal sites as shown in table 4-7. The sponsor's alternative trades some of the sites in the least cost alternative that would require mitigation, for more costly sites that provide material for future commercial and industrial uses or do not require mitigation. Of the seven alternate upland disposal sites included in the sponsor's alternative, four sites are located on or near port land at Vancouver, St. Helens, Kalama and Longview. Two other sponsor's sites are at active sand and gravel mining operations, and one site was used for disposal over 10 years ago.

Table 4-7. Disposal Sites Not in Common

Least Cost Disposal Plan	**Sponsor's Disposal Plan**
Sauvie Island O-98.5	Gateway 3 W-101.0
Adjacent Fazio W-96.9	Lonestar Gravel Pit O-91.5
N. Dike Field W-96.5	Railroad Corridor O-87.8
W-95.7	Reichold O-82.6
Scappoose Dairy O-90.6	Northport W-72.2
Martin Island W-80.0	International Paper W-67.5
Rainier Beach O-67.0	

The sponsor's disposal alternative uses 29 upland sites encompassing 1,755 acres. Fifteen of the eighteen upland sites in the no action alternative are also included in the sponsor disposal alternative. Three of the proposed upland sites and the gravel pit have not been used for disposal and the remaining 26 were used for disposal in the past. The site differences between the no action, least cost, and sponsor's preferred disposal alternatives are summarized in table 4-8; the sites are shown in figure 4-4.

Table 4-8. Summary of Disposal Alternatives

SITES CONSIDERED[1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY[2/]	ALTERNATIVES NO ACTION	LEAST COST	SPONSOR
CRM 3-106 35'-65' deep in or adjacent to channel	Open Water, Unrestrained	Used[1,2,3]	45-65' deep in or adjacent to channel	50-65' deep in or adjacent to channel	50-65' deep in or adjacent to channel
Hayden O-105.0	Upland/ Beach Nourish	Used[1,2,3]	79 acres Upland	102 acres Upland	102 acres Upland
Gateway 3 W-101.0	Upland	New			69 acres
Sauvie Island O-98.5	Upland	New		48 acres	
Fazio S & G W-97.1	Upland	Used[2,3]	27 acres	27 acres	27 acres
Adjacent Fazio W-96.9	Upland	New		17 acres	
N. Dike Field W-96.5	Upland	New		25 acres	
W-95.7	Upland	New		25 acres	
W-95.8	Upland	Used[3]	13 acres		
Lonestar O-91.5	Gravel Pit	New			45 acres
Scappoose Dairy O-90.6	Upland	New		107 acres	
RR Corridor O-87.8	Upland	Used[3]			12 acres
Austin Point W-86.5	Upland	Used[3]		26 acres	26 acres
Sand Island O-86.2	Beach Nourish	Used[2,3]		28 acres Beach Nourish	28 acres Beach Nourish
Reichold O-82.6	Upland	Used[3]			49 acres
Martin Bar W-82.0	Upland	Used[3]		32 acres	32 acres
Morse Bros. O-80.0	Gravel Pit	New			27 acres
Martin Island W-80.0	Upland	New		80 acres	
Lower Deer Is. O-77.0	Upland	Used[3]		29 acres	29 acres
Sandy Island O-75.8	Beach Nourish/ Upland	Used[2,3]	30 acres Upland	30 acres Upland	30 acres Upland
Peavey Oval W-73.5	Upland	Used[2,3]		43 acres	43 acres
Northport W-72.2	Upland	Used[2,3]			24 acres
Cottonwood Is. W-70.1	Upland	Used[2,3]		50 acres	50 acres
Howard Is. W-68.7	Upland	Used[2,3]	200 acres	200 acres	200 acres
International W-67.5	Upland/	Used[1,2]			8 acres
Rainier Beach O-67.0	Upland	Used[3]		52 acres	
Goble Quarry O-65.7	Beach Nourish/ Upland	Used[1,2,3]	73 acres Upland	73 acres Upland	73 acres Upland
Rainier Industrial O-64.8	Beach Nourish/ Upland	Used[1,2,3]	53 acres Upland	53 acres Upland	53 acres Upland

Table 4-8 (continued). Summary of Disposal Alternatives

SITES CONSIDERED[1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY[2/]	ALTERNATIVES NO ACTION	LEAST COST	SPONSOR
Lord Island O-63.5	Upland	Used[1,2,3]	28 acres	46 acres	46 acres
Reynolds Alum. W-63.5	Upland	Used[1,2,3]		13acres	13 acres
Mt. Solo W-62.0	Upland	New		50 acres	50 acres
Hump Island W-59.7	Upland	Used[1,2,3]	69 acres	69 acres	69 acres
Crims Island O-57.0	Beach Nourish/ Upland	Used[1,2,3]	51 acres Upland	40 acres Upland	40 acres Upland
Port Westward O-54.0	Upland	Used[3]		50 acres	50 acres
Brown Island W-46.0/46.3	Beach Nourish/ Upland	Used[1,2,3]	72 acres Upland	72 acres Upland	72 acres Upland
W-45.0	Beach Nourish/ Upland	Used[2,3]	15 acres Upland		
Puget Is. (Vik) W-44.0	Upland	New		100 acres	100 acres
James River O-42.9	Upland	Used[1,2,3]	59 acres	59 acres	59 acres
W-42.5	Beach Nourish/ Upland	Used[2,3]	28 acres Upland		
Tenasillahe Is. O-38.3	Beach Nourish/ Upland	Used[1,2,3]	42 acres Upland	42 acres Upland	42 acres Upland
Welch Island O-34.0	Beach Nourish/ Upland	Used[2,3]	42 acres Upland	42 acres Upland	42 acres Upland
W-31+40	Open Water, Unrestrained	New		76 acres	76 acres
W/O-30+00	Open Water, Unrestrained	New		124 acres	124 acres
Pillar Rock Is. O-27.2	Upland/Beach Nourishment	Used[1,2,3]	56 acres Upland	56 acres Upland	56 acres Upland
Miller/Pillar O-26.0	Open Water, Unrestrained	New 162 acres		New 162 acres	New 162 acres
Miller Sands O-23.5	Beach Nourish	Used[1,2,3]	151 acres BN with Pile Dikes	151 acres BN with Pile Dikes	151 acres BN with Pile Dikes
Rice Island W-21.0	Beach Nourish/ Upland	Used[1,2,3]	228 acres Upland	228 acres Upland	228 acres Upland
CRM 21.0 Harrington Point Sump	Open Water, Unrestrained	Used[1,2,3]	118 acres Open Water, Unrestrained	118 acres Open Water, Unrestrained	118 acres Open Water, Unrestrained
Ocean	Designated Open Water	New	Designated Open Water	Designated Open Water	Designated Open Water
WRKE-1	Open Water, Unrestrained	New		New 82 acres	New 82 acres
WRKE-2	Open Water, Unrestrained	New		New 38 acres	New 38 acres

Table Legend:

1/ Sites Considered: "W"/"O" refer to the Washington or Oregon shoreline respectively; the number refers to approximate river mile on the navigation channel.

2/ Disposal History Based on 1995 information:

1 - Site has been used within the last 2 years
2 - Site has been used within the last 10 years
3 - Site was used over 10 years ago

4.4.3.9. Disposal Plan Modifications Following Draft Review

Both the least cost and sponsor's disposal plans have changed since the preparation of the draft report. The changes are the result of physical changes in the river, land use changes, and environmental issues raised during review of the draft report. There was a significant reduction in the required construction dredging in the vicinity of CRMs 97 to 101 that allowed for the removal of two disposal sites, Sauvie Island (O-98.5) and the North Dike Field (W-96.5) from the least cost plan. Expansion of facilities at Morse Sand and Gravel allowed elimination of the Morse Pit (O-80.0) and expanded use of the Reichold site (O-82.6) in the sponsor's plan. That change, plus environmental concerns at Martin Island (W-80.0) resulted in the elimination of the Martin Island disposal site in the least cost plan.

Peavy Oval (W-73.5) also was dropped from both plans because of environmental concerns. The 27-acre Northport site (W-71.9) and a 12-acre addition to the Cottonwood Island site (W-70.1) are proposed to offset the loss of Peavy Oval for disposal purposes. The Goble Quarry site (O-65.7) in Rainier was eliminated from both plans because of planned industrial development and replaced with an expanded International Paper site (W-67.5) in both plans. The sponsor's plan added a beach nourishment site at Skamokawa (W-33.4), to be used as a sand source for Wahkiakum County. The final change was the removal of the Millar-Pillar in-water fill that was part of both disposal plans and the ecosystem restoration plan.

The modified least cost and sponsor's disposal plans are summarized in table 4-9. The net result of the changes has been a reduction in overall disposal area, and the least cost and sponsor's plans are more similar and only differ in two areas. The sponsor's plan replaces site W-95.7 and some in-water disposal with site W-101.0 (Gateway 3), and substitutes O-91.5 (Lonestar gravel pit) for O-90.6 (Scappoose Dairy).

Future ocean disposal volumes increased because of the elimination of the proposed Miller/Pillar in-water fill. During the first 20 years of channel maintenance, ocean disposal would total 9 mcy. There would be an additional 21 mcy in years 21 to 50. In the draft EIS, two large sites, the North Site and the South Site, were proposed where dredged sediments still could be placed within the more dynamic littoral zone nearshore (-60 to -40 feet MLLW) or dumped into deeper water. Due to their size, disposal capacity was considered unlimited. As a result of comments received on the draft EIS and subsequent work group meetings, a single Deep Water Site was located and sized to accommodate almost a 50-year disposal capacity (225 mcy). This proposed Deep Water Site replaces the previously proposed North Site and South Site in the federal government's preferred action for management of dredged material at the mouth of the Columbia River.

Due to the large number of comments from the public review of the draft EIS received from members of the Ocean Disposal Site Designation Working Group (Working Group), resource agencies, and the public, the Corps and EPA convened additional meetings to discuss further refinements to the proposed ocean disposal sites. An initial series of five meetings was held with sub-groups of the Working Group. The purpose of these smaller meetings was to explain how the COE and EPA used the input from the Working Group in selecting the proposed ocean disposal sites circulated in the draft EIS, and to get input for subsequent meetings of the Working Group.

Working Group members expressed concern that the spatial extent of the North Site and South Site was too large and disposal in the sites may unacceptably interfere with the crab fishing industry. The specific criteria for site selection established by the EPA provide that interference of disposal with other legitimate uses of the ocean, including fishing, must be considered. Furthermore, the general criteria for site selection provide that dumping will be permitted only at sites selected to minimize this interference, with special emphasis placed on avoiding areas of existing fisheries or shell fisheries. Considering these regulatory requirements and the difficulty in scientifically quantifying actual interference with the fishery, the Corps and EPA determined that the concerns expressed by these members, including crab fishermen themselves, warranted revision to the proposed North Site and South Site. Site E as described in the DEIS has not been altered.

The Corps and EPA revised the proposed North Site and South Site by reducing the size of the North Site and the South Site. The deep water portion of the South Site would be used in the event that weather conditions or wave climate prevented access by the dredge to the nearshore sites while allowing for predominantly nearshore placement of material. The revised sites were still large enough to limit the impact from an individual dredging season to small areas on a rotational basis. This revision was presented to the Working Group on April 14, 1999. Many of the Working Group representatives felt that the spatial extent of the proposed revised North Site and South Site was still too large and impacts to the crab fishing industry would still be unacceptable. As a result, the North and South Sites were dropped from further consideration, and a new Deep Water Site was found to accommodate ocean dredged material disposal. The new Deep Water Site is located about 4.5 miles west of the entrance and extends further westerly to about 7 miles. Water depths vary from 200 to 300 feet deep. Overall site dimensions are 17,000 feet by 23,000 feet and consists of an inner rectangle that measures 11,000 feet by 17,000 feet, surrounded on all sides by a 3,000-foot buffer. The site encompasses 8,980 acres. Disposal of dredged material would only be allowed within the inner dumping or target zone. The inner placement area of the site has a total area of 4,293 acres and a static disposal capacity of 225 mcy. Material placed at this site is expected to create a mound approximately 40 feet high within the target zone over the estimated 50-year life of the site. No direct disposal of dredged material would be allowed anywhere in the buffer; however, dredged material sloughing off the developing mound may extend into the buffer zone.

The proposed Site E would replace the existing EPA Section 102 designated Site E to include the Corps' previously selected "Expanded Site E". The site is located off the end of the North Jetty and would be about two miles long and expand from 1,054 feet to over 3,600 feet wide, encompassing an area of 670 acres. Water depths in the site range from 40 to 70 feet. The site has a static capacity (maximum volume within the site boundaries) of 2.1 mcy and a dynamic (dispersive) capacity (volume that could be transported away from the site by waves and currents) of 2.3 mcy per year. Most of the sand that would erode away from Site E is expected to move north toward Peacock Spit.

Table 4-9. Summary of Modified Disposal Plans

SITES CONSIDERED[1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY[2/]	ALTERNATIVES		
			NO ACTION	LEAST COST	SPONSOR
CRM 3 to 106 (in or adjacent to channel)	Open Water, Unrestrained	Used[1,2,3]	45-65' deep	50-65' deep	50-65' deep
Hayden O-105.0	Upland	Used[1,2,3]	79 acres	102 acres	102 acres
Gateway 3 W-101.0	Upland	New			69 acres
Fazio S & G W-97.1	Upland	Used[2,3]	27 acres	27 acres	27 acres
Adjacent Fazio W-96.9	Upland	New		17 acres	17 acres
W-95.7	Upland	New		25 acres	
W-95.8	Upland	Used[3]	13 acres		
Lonestar O-91.5	Gravel Pit	New			45 acres
Scappoose Dairy O-90.6	Upland	New		107 acres	
RR Corridor O-87.8	Upland	Used[3]		12 acres	12 acres
Austin Point W-86.5	Upland	Used[3]		26 acres	26 acres
Sand Island O-86.2	Beach Nourish	Used[2,3]		28 acres	28 acres
Reichold O-82.6	Upland	Used[3]		49 acres	49 acres
Martin Bar W-82.0	Upland	Used[3]		32 acres	32 acres
Martin Is Mitig. W-80.0	In-water	New		34 acres	34 acres
Lower Deer Is. O-77.0	Upland	Used[3]		29 acres	29 acres
Sandy Island O-75.8	Upland	Used[2,3]	30 acres	30 acres	30 acres
Northport W-71.9	Upland	Used[2,3]		27 acres	27 acres
Cottonwood Is. W-70.1	Upland	Used[2,3]		62 acres	62 acres
Howard Is. W-68.7	Upland	Used[2,3]	200 acres	200 acres	200 acres
International W-67.5	Upland	Used[1,2]		29 acres	29 acres
Rainier Beach O-67.0	Upland	Used[3]		52 acres	52 acres
Rainier Indust. O-64.8	Upland	Used[1,2,3]	53 acres	53 acres	53 acres
Lord Is. Upstrm O-63.5	Upland	Used[1,2,3]	28 acres	46 acres	46 acres
Reynolds Alum. W-63.5	Upland	Used[1,2,3]		13acres	13 acres
Mt. Solo W-62.0	Upland	New		50 acres	50 acres
Hump Island W-59.7	Upland	Used[1,2,3]	69 acres	69 acres	69 acres
Crims Island O-57.0	Upland	Used[1,2,3]	51 acres	40 acres	40 acres
Port Westward O-54.0	Upland	Used[3]		50 acres	50 acres
Brown Is. W-46.0/46.3	Upland	Used[1,2,3]	72 acres	72 acre	72 acres
W-45.0	Upland	Used[2,3]	15 acres		
Puget Is. (Vik) W-44.0	Upland	New		100 acres	100 acres

Table 4-9 (continued). Summary of Modified Disposal Plans

SITES CONSIDERED[1/]	TYPE OF DISPOSAL SITE	DISPOSAL HISTORY[2/]	ALTERNATIVES NO ACTION	LEAST COST	SPONSOR
James River O-42.9	Upland	Used[1,2,3]	59 acres	59 acres	59 acres
W-42.5	Upland	Used[2,3]	28 acres		
Tenasillahe Is. O-38.3	Upland	Used[1,2,3]	42 acres	42 acres	42 acres
Welch Island O-34.0	Upland	Used[2,3]	42 acres	42 acres	42 acres
W-33.4	Beach Nourish	Used[2,3]		11 acres	11 acres
Pillar Rock Is. O-27.2	Upland	Used[1,2,3]	56 acres	56 acres	56 acres
Miller Sands O-23.5	Beach Nourish	Used[1,2,3]	151 acres	151 acres	151 acres
Rice Island W-21.0	Upland	Used[1,2,3]	228 acres	228 acres	228 acres
CRM 21.0 Harrington Point Sump	Open Water, Unrestrained	Used[1,2,3]	118 acres	118 acres	118 acres
Ocean	Designated Open Water	New	Designated Open Water	Designated Open Water	Designated Open Water
WRKE-1	Open Water, Unrestrained	New		82 acres	82 acres
WRKE-2	Open Water, Unrestrained	New		38 acres	38 acres

Table Legend:

1/ Sites Considered: "W"/"O" refer to the Washington or Oregon shoreline respectively; the number refers to approximate river mile on the navigation channel.

2/ Disposal History Based on 1995 information:
1 - Site has been used within the last 2 years
2 - Site has been used within the last 10 years
3 - Site was used over 10 years ago

4.5. Comparison of Alternatives

This section provides an evaluation of the alternatives selected for further detailed evaluation in the study. These alternatives are:

- No Action Alternative
- 41-foot Channel Improvement Alternative
- 42-foot Channel Improvement Alternative
- 43-foot Channel Improvement Alternative
  - Least Cost Disposal Alternative
  - Sponsor's Preferred Disposal Alternative
- Ocean Disposal Site Alternatives (these are discussed in detail in Appendix H, *Ocean Dredged Material Disposal Site Evaluation*)

As discussed previously, the non-structural alternative (LoadMax) would marginally enhance navigation benefits to all channel alternatives being considered, including the no action alternative. The structural channel improvement alternatives would likely make the most significant improvement to the problems associated with current deep-draft navigation conditions.

4.5.1. Environmental Comparison

4.5.1.1. Physical Impacts

The channel improvement alternatives would result in incrementally greater impacts with increasing depth. Compared to the no action alternative, dredging quantities would increase by as much as 20 mcy for initial construction of the 43-foot channel, and 12 mcy of maintenance dredging. In addition to using existing disposal sites, the additional dredged material would be placed in 5 new upland sites totaling about 300 acres for the least cost plan or 4 new upland sites (236 acres) and one gravel pit (45 acres) under the sponsors' plan. Maintenance dredging practices would shift from primarily in-water (flowlane) disposal to primarily upland disposal. Compared to the no action alternative, the 20-year estimate for the 43-foot alternative shows an increase of 28 mcy to 56 mcy for upland disposal and a decrease of 41 mcy to 24 mcy for flowlane disposal. Dredging a deeper channel would lead to very slight increases in estuarine salinity under low river flow conditions. Estuarine circulation would essentially be unchanged. Overall sediment budget or sedimentation patterns also would not change to any perceptible degree. Water quality impacts would increase in the short term from dredging a deeper channel. Long term water quality impacts may actually decrease, as less material would be disposed at in-water locations. Shoreline erosion from currents, wind waves and ship wake is expected to remain near current levels.

Ocean disposal material has traditionally come from shoals forming at the MCR and consists primarily of marine sand transported into the entrance. The material is clean, contain no contaminants of concern in excess levels, far removed from known sources of contaminants, and acceptable for unconfined open-water disposal. Over the next 20 years, it is estimated that there would be about 90 mcy of ocean disposal from the MCR project. Material proposed for ocean disposal from the 43-foot channel alternative (CRMs 3 to 30) includes 7 mcy (5 mcy new work plus 2 mcy from 40-foot channel maintenance) during construction and 9 mcy from maintenance dredging during the first 20 years. Columbia River channel sediments consist of sand with a low percent of silts and clays or organic material. The material has been evaluated and found acceptable for unconfined open-water disposal. Appendix H further describes the ocean disposal siting process, physical and biological conditions, and the selected ocean dredged material disposal sites.

4.5.1.2. Biological Impacts

Dredging a deeper channel would impact more benthic habitat. However, the majority of this habitat is at depths greater than 35 feet and is not considered highly productive. In-water disposal would be less than current practices which would likely result in reduced impact to aquatic organisms. The 43-foot channel alternative may require rock removal in limited reaches of the river. This may require blasting which would result in short term adverse effects on aquatic organisms and wildlife. The proposed ocean disposal would result in increased impacts to marine organisms. Based on studies evaluating the effects of current ocean disposal practices, these impacts are not expected to be significant.

Upland disposal would be greatly increased over current practice and result in additional impacts to wildlife habitat, particularly for waterfowl such as Canada geese. For the sponsors' plan, new upland disposal sites would affect about 200 acres of farmland, 20 acres of wetlands and 67 acres of riparian habitat. The least cost plan would impact about 256 acres of farmland, 28 acres of wetlands and 67 acres of riparian habitat.

Two threatened or endangered species, the bald eagle and Columbian white-tailed deer, may be adversely impacted by channel deepening actions. These adverse impacts would be offset through implementation of conservation measures as outlined in the biological assessment submitted to the U.S. Fish and Wildlife Service, and measures that may result from the formal consultation process. The proposed wildlife mitigation plan is designed to offset wildlife habitat losses and is separate from conservation measures proposed for listed species.

Aquatic resources of the ocean disposal sites are described in detail in Appendix H, Exhibit A. The proposed ocean disposal sites have many pelagic organisms occurring in the water column over them. These include zooplankton (copepods, euphausiids, pteropods, and chaetognaths) and meroplankton (fish, crab and other invertebrate larvae). These organisms generally display seasonal changes in abundance. Since they are present over most of the coast, those from the MCR are not critical to the overall coastal population. Based on evidence from previous zooplankton and larval fish studies, it appears that there will be no impacts to organisms in the water column (Sullivan and Hancock, 1978).

The listed stocks of salmonids in the Columbia River currently include the Snake River fall and spring/summer runs of chinook, Snake River run of sockeye, upper and lower Columbia/Snake River runs of steelhead, lower Columbia/upper Willamette River chinook salmon, upper Columbia River spring chinook run, Columbia River chum salmon, middle Columbia/upper Willamette steelhead. Proposed stocks include lower Columbia coho salmon and Columbia coastal cutthroat trout. A Biological Assessment containing more detailed information on these species and their use of the study area is located in Exhibit C. Although the biological assessment for this action has been submitted to the NMFS, their Biological Opinion has not been received. Their Biological Opinion will be available during the next phase of design (PED) and their opinion will be fully considered prior to the Record of Decision.

The ocean disposal sites are located in areas that generally do not contain unique or limited populations of species of benthic infauna. However, areas offshore beyond the 200-foot depth contour, and in areas of fine-grained sediment associated with the "mud hole" (the area where fines transported out the mouth of the Columbia River settle) have consistently had higher densities and number of species. Benthic infaunal samples were collected at the locations shown in Appendix H, Exhibit A.

The ocean disposal sites are located in areas off the mouth of the Columbia River which support a variety of pelagic and demersal fish species as well as shellfish and Dungeness crab. Pelagic species include anadromous salmon, steelhead, cutthroat trout, striped bass, lamprey, smelt, herring, sturgeon, and shad that migrate through the estuary to upriver spawning areas. Juveniles of these species are present in the area following their migration out of the river or estuary into the ocean. Some remain in the nearshore area for various periods of time feeding and rearing, while others move directly offshore.

4.5.1.3. Socio-Economic Impacts

Channel deepening alternatives would result in some minor impact to aesthetics, recreation and land use. Use of additional upland disposal sites would modify aesthetic value from primarily rural farm condition to bare sand disposal mounds. Recreation impacts would likewise result from increased upland disposal, adversely affecting some activities such as wildlife viewing and bird watching. Land use at new disposal sites would change from primarily agricultural/open space to dredged material disposal sites. No cultural resources would be impacted by either dredging or disposal actions. Comparison of economic impacts is discussed in Section 4.5.2.

The ocean disposal sites could adversely affect commercial fishing activities off the mouth of the Columbia River by impacting the following: commercial navigation routes, fishing gear, and harvest. Navigation hazards have the potential to occur due to mounding. Significant and persistent mounding can result in adverse wave conditions causing a potentially hazardous situation to navigation. One management concern at the ocean disposal sites is to avoid mounding that would adversely impact wave heights at the sites. Bathymetric surveys will be taken routinely to insure this hazard does not occur. Disposal operations could directly impact crab fishing by burial of crab pots, cutting of crab lines, or restricting crabbing areas. Coordination with local fishing groups and publishing site locations in the *Notice to the Mariners* will help to prevent these problems. It is expected that an overall reduction to damaged and/or lost gear would occur because the ocean disposal sites avoid fishing areas determined as important by local fishing groups.

Commercial fishermen have expressed concerns with disposal burying crabs and altering habitat. The dredged material to be placed in the ocean disposal sites is mostly sand, which is similar to the bottom material at these sites. Consequently, it is not expected to significantly alter benthic habitat or communities. The ocean disposal sites minimize the use of areas depicted by local fishing groups as high income producing locations.

Table 4-10 summarizes and compares the anticipated environmental impacts of the alternatives carried forward for further detailed analysis. A detailed discussion of these impacts is included in Chapter 6, *Environmental Consequences*.

Table 4-10. Summary Comparison of Environmental Impacts by Alternative

Affected Resources	ALTERNATIVES No Action	43-foot Channel (Least Cost Disposal)	42-foot Channel	41-foot Channel	Proposed Disposal (Sponsor's Preferred)	Ecosystem Restoration
Physical						
Salinity Intrusion	No effect	Increase salinity by less than 1 ppt under low flow conditions	Same as 43-foot	Same as 43-foot	Same as 43-foot	No effect
Shoreline Erosion	Erosion at former shoreline disposal sites	Same as no action	Same as no action	Same as no action	Same as no action	No effect
Sediment Quality	All dredged material suitable for unconfined in-water disposal	Some sediments in the Willamette would require Tier III testing	Same as 43-foot	Same as 43-foot	Same as 43-foot	No effect
Water Quality	Minor turbidity & sediment suspension created by dredging/disposal	Increase in turbidity & sediment suspension from initial deepening	Same as 43-foot	Same as 43-foot	Same as 43-foot	Minor local improvement
Ocean	Ocean disposal from MCR averages 4.5 mcy per year. This results in temporary bathymetric & sediment changes over a 3,500 acre area.	Slight increase in the depth of deposits at ocean dredged material disposal sites. Bathymetric and sediment changes over 4,963 acre area.	Same as 43-foot	Same as 43-foot	Same as 43-foot	No effect
Biological						
Riverine Aquatic	Habitat alteration & disturbance from dredging/disposal	Additional 1,463 acres of bottom habitat disturbed by dredging	Slight decrease from 43-foot	Slight decrease from 42-foot	Same as 43-foot	Improve water circulation at two locations
Ocean	Ocean disposal from MCR affects 3,500 acres of benthic habitat and impacts commercial fishing	Additional bottom habitat affected by disposal. Reduced impact on commercial fishing.	Same as 43-foot	Same as 43-foot	Same as 43-foot	No change
Riparian	Minor effects to riparian fringes at some upland disposal sites	67 acres of riparian habitat would be affected at disposal sites	Same as 43-foot	Same as 43-foot	same as 43-foot	no change
Wetland	No effect	About 28 acres would be removed at 3 new disposal sites	Same as 43-foot	Same as 43-foot	8 less acres of wetland removed	Restore 1250 acres of wetlands
General Wildlife	About 1,165 acres of upland habitat affected by past/current disposal actions	Minor additional impact at new disposal sites	Same as 43-foot	Same as 43-foot	Same as 43-foot	Restore 1250 acres of wildlife habitat
Mitigation	None required	Mitigation for 256 acres farmland, 67 acres riparian, & 28 acres wetland losses	Same as 43-foot	Same as 43-foot	Slightly less mitigation than 43-foot	None required

Table 4-10 (Continued). Summary Comparison of Environmental Impacts by Alternative

Affected Resources	ALTERNATIVES No Action	43-foot Channel (Least Cost Disposal)	42-foot Channel	41-foot Channel	Proposed Disposal (Sponsor's Preferred)	Ecosystem Restoration
Socio-Economic						
Cultural Resources	No effect	No effect	No effect	No effect	No effect	No effect
Land Use	Use existing disposal sites only. Port/industrial land uses unchanged.	Woodland/open space changed to disposal site use. Agricultural land changed to disposal site use at 5 locations. No change in port-industrial use.	Same as 43-foot	Same as 43-foot.	Expedites conversion of 193 acres of agricultural land to port-industrial lands	Converts agriculture to fish & wildlife use
Recreation	Minor impacts to recreational fishery.	Same as no action	Same as no action	Same as no action	Same as no action	Slight fishery & waterfowl hunting improvement
Aesthetics	Minor impact from upland disposal actions.	Minor additional impact in rural agricultural setting	Same as 43-foot	Same as 43-foot	Same as no action	Change from agriculture to riparian & wetland
Air Quality	Minor impact from wind borne sand and dredge operation.	Minor additional impact at new upland disposal sites	Same as 43-foot	Same as 43-foot	Same as 43-foot	No change
Noise	Minor impact from dredge operation.	Minor additional impact from dredge operation	Same as 43-foot	Same as 43-foot	Same as 43-foot	No change

4.5.2. Economic Comparison

The benefits of improving the navigation channel would result from reductions in transportation costs for each benefiting commodity. As shown in the fleet projections (Chapter 3, *Needs and Opportunities*), there are a number of vessels that load at less than their maximum capacity due to current channel depth constraints. For those vessels, a 3-foot deepening would essentially allow an increase in capacity of 6,000 to 7,400 tons.

For example, a bulk carrier with a 43-foot maximum draft typically has a maximum cargo capacity of approximately 60,000 tons. In a 40-foot channel, the capacity of this vessel is reduced to 54,000 tons. One-way vessel operating costs for a vessel carrying a load of wheat or corn out of the Columbia River average $750,000 per trip. Therefore, a 3-foot deepening can reduce transportation costs from $13.90 to $12.60 per ton, or $1.30 per ton.

As shown in the fleet projections, each commodity and trade route combination is expected to make varying use of the deepening. For wheat, the additional 3-foot channel depth would result in an average transportation cost per-ton reduction of four to five percent, or a saving of $0.75 to $1.10 per ton. Corn is projected to take greater advantage of the deepening, with cost reductions averaging six to eight percent, which typically amounts to a saving of $1.00 to $1.20 per ton. Container transportation benefits are slightly greater than for bulk commodities, with cost reductions averaging 11 to 13 percent, or a saving of $2.50 to almost $3.00 per ton.

Table 4-11 displays the average annual transportation benefits for the 43-foot channel alternative by commodity and trade route. The annual benefits for this alternative total almost $33.98 million. Container traffic provides slightly less than two-thirds of the benefits, with corn and wheat benefits making up most of the remainder.

Table 4-11. Average Annual Transportation Benefits, 43-foot Alternative

Commodity	Rapidly Developing Asia	Japan	China	Other	Other Asia	All	Total
Corn	5,224,000	916,000	1,212,000				7,352,000
Wheat	2,734,000			1,697,000	4,470,000		8,901,000
Barley						1,144,000	1,144,000
Containers-Mid Port						911,000	911,000
Containers-Last Port						15,671,000	15,671,000
Totals	**7,958,000**	**916,000**	**1,212,000**	**1,697,000**		**17,726,000**	**33,979,000**

For the purposes of incremental analysis the channel can be divided into three reaches. The first reach stretches from the mouth of the Columbia to Kalama, where the majority of corn benefits and some wheat benefits are realized. The channel from Kalama to the confluence of the Willamette and Columbia Rivers is the second reach, where the container benefits are realized. The third reach consists of the Willamette River, in which more than half of the wheat and barley benefits are realized. For each commodity, historical exports have been used to determine the share of benefits allocated to each reach as displayed in table 4-12. Table 4-13 displays the total transportation and delay benefits by channel depth and reach.

Table 4-12. Allocation of Benefits by Reach

Commodity	Mouth to Kalama/Longview	Kalama/Longview to Willamette	Willamette
Corn	95%	0	5%
Wheat	8%	35%	57%
Barley	20%	5%	75%
Mid-Port Containers	0	100%	0
Last Port Containers	0	100%	0

Table 4-13. Incremental Transportation and Delay Benefits

Incremental Depths	Mouth to Kalama/Longview	Kalama/Longview to Willamette	Willamette	Total
41 feet	$3,054,000	$7,007,000	$2,810,000	$12,871,000
42 feet	$2,724,000	$6,870,000	$2,247,000	$11,841,000
43 feet	$2,083,000	$6,228,000	$1,396,000	$9,707,000
Totals	$7,861,000	$20,105,000	$6,453,000	$34,419,000

4.6. Plan Selection

Table 4-14 compares the estimated costs and benefits of all the alternatives, using the least cost disposal plan.

Table 4-14. Estimated Costs and Benefits by Alternative

Category	No Action	41-foot Alternative	42-foot Alternative	43-foot Alternative
First Cost	---	61,524,000	99,367,000	188,664,000
Annualized First Costs	---	4,388,000	7,087,000	13,455,000
Annual Operation and Maintenance Cost*	$8,987,000	1,187,000	2,283,000	3,885,000
Total Average Annual Cost*	$8,987,000	5,575,000	9,370,000	17,340,000
Benefits	---	12,871,000	24,712,000	34,419,000
Benefit/Cost Ratio	---	2.3	2.6	2.0
Net Benefits	---	7,296,000	15,342,000	17,079,000

* Note: Costs for alternatives represent the incremental cost over the No Action Alternative

All of the alternatives yielded benefit-to-cost ratios above unity. The 43-foot alternative is the alternative that maximizes net benefits. It is selected for federal implementation as it maximizes the benefits to the nation and the return on the investments. The total costs for the 43-foot channel improvement alternative using the least cost disposal plan are shown in table 4-15.

Table 4-15. 43-foot Channel Alternative Costs with Least Cost Disposal Plan

First Costs	
Item	**Total Cost ($)**
Construction	161,173,000
Berthing Areas	1,200,000
Utility Removal and Replacement*	13,800,000
Interest During Construction	12,491,000
Total First Cost (rounded)	**188,664,000**
Annualized Costs	
First Costs (6 7/8%, 50 years)	13,322,000
O&M Dredging	3,600,000
Mitigation Site Management/Monitoring	250,000
Real Estate required throughout O&M	35,000
Total Average Annual Costs	**17,340,000**

* Paid for by the owner of the utility

The costs of the 43-foot channel alternative include costs for turning basins, anchorages, and berthing areas that must be deepened in order to achieve the benefits of the project. These three components are discussed in the sections that follow.

4.6.1. Turning Basins

As a part of the analysis of the navigation channel, each of the turning basins on the Columbia has been evaluated in terms of adequacy of dimension and usefulness. Table 4-16 displays each turning basin (existing and proposed) and indicates if the turning basin would need to be deepened. The evaluation on which turning basins to modify is based on current operating practices in which vessels, for safety and control reasons, are typically turned only after loading has been completed.

Beginning at the mouth of the Columbia and moving upstream, the first turning basin is located near Astoria at CRM 15. This turning basin is approximately 800 feet wide and 4,250 feet long. This turning basin is located in an area of the river that has been dredged to depths greater than 50 feet to provide fill for land development purposes, and no new work will be required under any alternatives.

The next turning basin is located at Longview at CRM 66.5. This turning basin is 1,200 feet wide and 5,500 feet long, and will remain at a depth of 40 feet in all alternative conditions. Currently, no commodities requiring vessel drafts greater than 40 feet are being shipped through Longview. If this situation changes, then the turning basin will be reconsidered in terms of adequacy of depth, width, and length. The next turning basin on the Columbia is located at Kalama near CRM 73.5. This basin is approximately 700 feet wide and 4,100 feet long. This turning basin will be deepened, but is otherwise considered to be of adequate dimensions. This turning basin services two grain facilities, one of which is the primary corn exporting terminal on the Columbia. In order to achieve the benefits of the channel deepening associated with the corn and wheat exports at Kalama, this turning basin will need to be deepened. The cost of the deepening the turning basin is $230,000. As there are no other turning options near this location, the benefits of the turning basin are also the benefits of deepening the channel for this reach, approximately $6.1 million on average annual basis.

There are two turning basins adjacent to the Vancouver docks. The upper turning basin, at approximately CRM 107, has an existing depth of 35 feet, and will not be considered for deepening, as it primarily services vessels that do not require deeper depths. The lower Vancouver turning basin at about CRM 105.5 is 3,000 feet long and 1,000 feet wide. This turning basin services the United Grain facility, which typically handles 35 percent of Columbia River wheat exports. In 1993, this terminal loaded almost 4.5 million short tons of wheat on 160 vessels. If this turning basin is not deepened, it is possible that vessels could be backed down the river to the confluence of the Willamette and Columbia, which is about three miles downstream. The river pilots have indicated that this option raises serious safety concerns relating to the number of vessels that are typically anchored outside the navigation channel in this reach of the river. Vessels backing down the river requires the use of three tugs (at $2,520 per hour each) to turn and back the vessel down the river, taking an additional hour (and an additional tug) to completely turn the vessel. Thus, the additional cost of backing a vessel down the river is at least $11,300 per vessel[3].

[3] The $11,300 includes approximately $600 for one hour of deep draft vessel in-port operating costs, but does not include any costs to account for additional navigational risks.

In 1993, 24 out of a total of 160 vessels departed the United Grain terminal at a draft of 38 feet or greater. Assuming this number is representative of the number of vessels that would immediately take advantage of future deepening actions, the total average annual benefits of this turning basin would likely be greater than $270,000 on an average annual basis, or $3.7 million in net present value terms, which is far greater than the estimated costs of deepening the turning basin. Therefore this turning basin will be deepened.

The Willamette reach of the navigation channel is 11.6 miles long. For much of this reach, the navigation channel has been defined as being bank to bank. Due to concerns regarding rock, potential contaminants, and overall costs, the navigation channel in the Willamette reach will be narrowed from WRM 5.0 to 11.0 in all deepening alternatives. There are three authorized turning basins in this 11.6-mile stretch of the Willamette. The first turning basin, moving upstream from the confluence of the Willamette and Columbia rivers, is located near WRM 4, adjacent to the Port of Portland's Terminal 4, a grain export facility, and will be deepened to facilitate deep draft grain vessels. If this turning basin is not deepened, then vessels will likely need to be backed four miles down the river to the confluence of the Willamette and Columbia rivers. Again, there are substantial costs involved with backing a vessel down the river, and, as with the lower Vancouver turning basin, the costs per vessel would amount to at least $11,300. At Terminal 4, in 1993, 11 out of 55 vessels left at depths greater than or equal to 38 feet. Assuming, for the purposes of this analysis, that this reflects the number of vessels which would immediately take advantage of a deeper channel, the benefits of deepening this turning basin amount to at least $125,000 on an average annual basis, or $1.7 million in net present value terms.

The second turning basin is located at WRM 10, adjacent to Port of Portland's Terminal 2, a general cargo facility. This turning basin will be designated as deepened, although, due to past mining activities, actual dredging work is expected to be minimal.

Table 4-16. Turning Basins, Columbia River Deep Draft Navigation Channel

Turning Basin	Existing Dimensions (feet)	Deepened	Quantity (cubic yards)	Cost
CRM 15	800 x 4,250	Yes	90,000	$285,000
CRM 66.5	1,200 x 5,500	No		
CRM 73.5	700 x 4,100	Yes	65,000	$230,000
CRM 105.5	1,000 x 3,000	Yes	285,000	$405,000
CRM 107	800 x 2,000	No		
WRM 4	5,000 x 1,000	Yes	15,000	$35,000
WRM 10	1,500 x 1,000	Yes	100,000	$125,000
WRM 11.7	1,500 x 1,000	Yes	80,000	$100,000

4.6.2. Anchorages

There are two Corps-designated anchorages (one for shallow draft traffic, one for deep draft traffic) along the navigation channel, both of which are located at approximately CRM 103. The deep draft anchorage will be designated as being deepened in all deepening alternatives, although due to natural depths and mining, construction dredging will be minimal. The other anchorage has an authorized depth of 25 feet, which will not be altered in any of the study alternatives.

4.6.3. Berthing Areas

In order to achieve the benefits of any channel-deepening alternative, docks at each of the container, wheat, corn, and barley exporting facilities must be deepened. These costs have been included as part of the NED cost estimate, but are not part of the federal cost-sharing equation. Table 4-17 displays the costs of the eight facilities that must be deepened.

Table 4-17. Columbia River Deep Draft Berths Deepening Costs

Terminal	Cost
Harvest States in Kalama	250,000
Peavy in Kalama	---
United Grain in Vancouver	---
Terminal 6 - Containers, in Portland	490,000
Columbia Grain in Portland	39,400
Cargil Grain (Berth 401) in Portland	419,000
Irving Street Terminal, Cargil, in Portland	---
Louis Dreyfus Corp. in Portland	---
Total	$1,198,400

4.7. Selected Plan

The selected plan for the Columbia River is the structural alternative that deepens the navigation channel to 43 feet. The proposed disposal plan to be used for this structural alternative is the sponsor's preferred disposal plan, which is summarized in table 4-18. Disposal actions would occur in-water, at three beach nourishment locations, at new and previously used upland locations, and offshore in the ocean at proposed Site E and the new Deep Water Site. In-water disposal would occur throughout the project area in and adjacent to the navigation channel. The proposed disposal plan focuses on upland disposal and would use 29 upland disposal locations plus one gravel pit. Four of these upland sites have not been previously used for disposal purposes. These four new sites encompass about 200 acres of lands primarily used for agricultural practices. Wildlife mitigation actions will be implemented to address impacts to wildlife resources and their habitats.

The proposed plan for the Willamette River is to deepen a limited width channel to 43 feet. However, implementation is being delayed until the State of Oregon completes a contaminated sediment management plan for Portland Harbor. An engineering evaluation of the proposed channel configuration will be conducted, and a dredging and disposal plan will be prepared following completion of the State's management plan. Disposal alternatives would depend on the outcome of the management plan. One alternative could be in-water disposal with capping actions in the Willamette River wherein clean, sandy dredged material will be placed over contaminated sediments. This type of disposal could enhance environmental protection in the river.

The Water Resource Development Act of 1986 provided for non-federal cost sharing for navigation projects. Cost sharing provides the sponsors with the option to pay incremental cost differences to deviate from the least cost disposal plan. Cost allocation and apportionment of the implementation costs associated with the selected plan are discussed in Section 8.2.

The total costs for the selected plan with the proposed disposal plan are shown below.

First Costs	**Total Cost ($)**
Construction	118,955,000
Berthing Areas	1,200,000
LERRD	
Disposal Sites Real Estate	15,415,000
Mitigation Sites Real Estate	2,490,000
Utility Removal and Replacement*	13,763,000
Environmental Restoration	3,505,000
Subtotal	**142,263,000**
E&D	2,400,000
S&A	7,348,000
Total Construction Cost (rounded)	**150,729,000**
Contingency	23,245,000
Total Cost (rounded)	**188,400,000**

Note: Incremental increase in O&M dredging = $564,500

Table 4-18. Proposed Disposal Plan

Disposal Site *	Disposal History**	Location/Name	Use in 20-year Term (fiscal years)	Site Acres	Site Capacity (cu yds)	Disposal Volume (cu yds)	Final Height (feet)
In-water	DMMS	CRM 3-106 - 50'-65' deep, in or adjacent to channel***	2002-2021	NA	NA	58,000,000	NA
WRKE 1 & 2 In-water	New	Willamette RMs 4-5 & 9-10	2002-2021	120	NA	4,000,000	NA
O-105.0	DMMS	West Hayden Island	2002-2021	102	5,750,000	4,940,000	58
W-101.0	New	Gateway	2002-2021	69	3,000,000	2,800,000	55
W-97.1	DMMS	Fazio Sand & Gravel	2002-2021	27	650,000	290,000	25
W-96.9	New/Used	Adjacent to Fazio	2002-2021	17	475,000	200,000	25
O-91.5	New	Lonestar	2002-2021	45	5,350,000	5,307,400	NA
O-87.8	New	RR Corridor	2002-2003	12	540,000	520,000	20
W-86.5	Used	Austin Point	2002-2021	26	1,645,000	1,980,000	65
O-86.2	Used	Sand Island	2002-2021	28	1,250,000	910,000	15
O-82.6	Used	Reichold	2002-2021	49	1,285,000	2,100,000	NA
W-82.0	Used	Martin Bar	2002-2021	32	1,500,000	1,230,000	65
W-80.0	New	Martin Is. Mitigation	2002-2005	34	1,100,000	1,070,000	20
O-77.0	Used	Lower Deer Island	2002-2020	29	1,498,000	1,100,000	64
O-75.8	DMMS	Sandy Island	2002-2019	30	1,100,000	1,280,000	53
W-71.9	Used	Northport	2002-2021	27	900,000	1,560,000	34
W-70.1	Used	Cottonwood Is.	2002-2021	62	3,225,000	1,680,000	40
W-68.7	DMMS	Howard Island	2002-2021	200	6,400,000	3,710,000	37
O-67.0	Used	Rainier Beach	2002-2003	52	1,095,000	1,095,000	36
W-67.5	Used	International Paper	2002-2021	29	1,000,000	2,950,000	60
O-64.8	DMMS	Rainier Industrial	2003-2021	53	2,235,000	2,235,000	65
O-63.5	DMMS	Lord Island Upstrm.	2002-2014	46	1,255,000	1,255,000	41
W-63.5	Used	Reynolds Aluminum	2002	13	500,000	500,000	35
W-62.0	New	Mt. Solo	2002-2021	50	2,420,000	2,230,000	34
W-59.7	DMMS	Hump Island	2002-2009	69	1,400,000	1,400,000	40
O-57.0	DMMS	Crims Island	2002-2021	40	1,600,000	1,600,000	48
O-54.0	Used	Port Westward	2002-2021	50	1,875,000	1,875,000	46
W-46.3/ 46.0	DMMS	Brown Island	2002-2021	72	3,700,000	3,700,000	42
W-44.0	New	Puget Is. (Vik Prop.)	2002-2021	100	3,200,000	3,200,000	33
O-42.9	DMMS	James River	2002-2021	59	1,280,000	1,106,000	42
O-38.3	DMMS	Tenasillahe Island	2003-2022	42	2,100,000	2,100,000	53
O-34.0	DMMS	Welch Island	2017-2021	42	446,000	446,000	25
W-33.4	Used	Skamokawa	2002-2021	11	250,000	205,000	15
O-27.2	DMMS	Pillar Rock Island	2003-2021	56	2,555,000	2,540,000	52
O-23.5	DMMS	Miller Sands	2003-2021	151	NA	1,405,600	NA
W-21.0	DMMS	Rice Island	2003-2021	228	5,500,000	5,500,000	45
Proposed Site E	Used	Ocean	2002-2021	580	NA	MCR O&M(1)	NA
Deep Water Site	New	Ocean	2002-2021	8,980	225,000,000	16,000,000(2)	40

(1) Between 2.0-2.5 mcy per year in Site E and North Jetty Site per year.
(2) Construction plus 20 years channel project only; additional material from MCR O&M as needed. Fifty year volume 37 mcy.

* "W" and "O" refer to the Washington or Oregon shoreline. The number refers to the approximate river mile on the navigation channel.
** DMMS = site is in the no action alternative (existing 40-foot channel maintenance)
New = site is new for this study Used = site previously used by Corps for disposal
*** Disposal would occur in depths over 65' at CRMs 5, 29-35, 36.5-37.5, 39-40, 54-56.3, and 72.2 - 73.2

This measure would require more detailed scheduling of transits to avoid ships meeting in the one-way reaches. At typical transit speeds, ships would need around 15 minutes to transit the four-mile, one-way reaches and 30 minutes for the eight-mile reach. The eight and six mile reaches between the one-way reaches would allow about 30 and 20 minutes for meeting and passing. The Columbia River pilots felt that the restrictions this alternative placed on transits would be unworkable. The pilots indicated that the establishment of a Vessel Traffic System would be required to coordinate the movements of all ships on the river in order to make this alternative work. They stated that even with this system, it may not be possible to schedule ships to meet at precise locations because ships must maintain a minimum amount of headway to retain maneuverability. The scheduling problem is especially difficult if several ships were sailing in both directions during a tide cycle. Because of these objections from the Columbia River Pilots, the one-way reach configuration was dropped from further consideration.

Non-Uniform Depth Channel. The navigation channel currently has a non-uniform depth, with a minimum depth of -40 feet CRD. Due to the effects of ocean tides and river discharges on river stages, ships experience a wide range of water depths and underkeel clearances during each river transit. It could be possible to design and construct a channel that took advantage of the extra water depth available during the tide cycle to reduce the channel depth and the amount of dredging required for construction and maintenance. The analysis of navigation practices was performed to determine the potential water depth available. The analysis was done separately for container ships departing Portland, bulk wheat carriers departing Portland/Vancouver, and bulk corn carriers departing Kalama. The minimum river stage that was exceeded at least 95 percent of the time and the resulting channel depths for four reaches of the Columbia channel are shown in table 4-19.

Table 4-19. Minimum Stages and Channel Depths, 43-foot Alternative (feet)

Columbia River Mile	Portland Containers		Portland Bulk Carriers		Kalama Bulk Carriers	
	Minimum Stage	Channel Depth (feet)	Minimum Stage	Channel Depth (feet)	Minimum Stage	Channel Depth (feet)
0 to 25	0	43 MLLW*	0	43 MLLW	1	42 MLLW
25 to 50	0	-43 CRD	0	43 CRD	0	-43 CRD
50 to 75	2	-41 CRD	2	41 CRD	1	-42 CRD
75 to 105	1	-42 CRD	1	42 CRD	---	---

* mean lower low water

There would be a difference in departure timing between Portland/Vancouver and Kalama because of the transit times and tide cycle. There would be more flexibility in scheduling a departure from Kalama because the transit need only encounter one low tide stage. To meet the needs of all the ports, the non-uniform channel would have to be 43 feet deep from CRM 0 to 50 and then reduced to 42 feet deep from CRM 50 to 105. While this would reduce costs, there would be no significant environmental benefits from this channel configuration. The potential savings were not considered significant enough to warrant the sailing restrictions that would be required. Therefore, the non-uniform depth channel measure was dropped from further consideration.

4.8. Ecosystem Restoration Plan

For the Corps Civil Works Program, ecosystem restoration actions are broadly supported by various federal acts or legislation. The Corps has established guidance on implementation of ecosystem restoration activities in Engineering Circular 1105-2-210. Ecosystem restoration activities are separate from the fish and wildlife mitigation actions proposed in this EIS. Fish and wildlife mitigation actions compensate for unavoidable adverse environmental impacts resulting from new project construction and operation. Ecosystem restoration activities are separate studies that examine the condition of existing ecosystems, or portions thereof, and determine the feasibility of restoring degraded ecosystem structure, function, and dynamic processes to a more natural condition. Ecosystem restoration actions can be pursued as a separable element in conjunction with General Investigation studies as is the case with the Columbia River Channel Improvement Study. Otherwise, planning studies for ecosystem restoration would be authorized in the same manner as flood damage reduction and navigation projects using individual study authorities, Congressional resolutions, or favorable reconnaissance studies initiated under Section 216 of the River and Harbor and Flood Control Act of 1970. Linkage with an ongoing General Investigation study represents a fast track to implementation rather than waiting for Congressional authorization and appropriation for a specific ecosystem restoration study. The Corps will submit a broader scale ecosystem restoration study along the lower Columbia River in the President's 2001 budget.

Throughout the lower Columbia River, substantial alteration of fish and wildlife habitat has occurred since settlement (table 2-3). The construction of dikes and associated drainage channels and pump stations has led to the conversion of substantial acres of riparian and wetland habitat to agricultural and industrial uses. Dredging operations, for construction and maintenance of the navigation channel, have contributed to habitat losses and land development in some locations. Highways, urban development, and railroads have also contributed to the habitat loss. These losses have been incremental in fashion and are substantial in aggregate.

The Corps and sponsoring ports for this study are aware of the environmental concerns for the fish and wildlife habitat left along the lower Columbia River. This awareness, in conjunction with the knowledge that ecosystem restoration measures can be coupled with an ongoing feasibility study, prompted the Corps and the local sponsors to incorporate an ecosystem restoration plan into this study effort. The ecosystem restoration actions include restoring wetland and riparian habitat at Shillapoo Lake, tide gate retrofits at selected locations along the lower Columbia River for salmonid passage, and improved embayment circulation at two island complexes along the lower river.

The draft EIS also included an ecosystem restoration action at Miller Sand and Pillar Rock Islands that consisted of constructing a pile dike field to restore shallow water habitat for salmonids. During the review of the draft EIS, concerns were raised about the potential for birds to use the shallow water area to feed on migrating juvenile salmonids. Because of this concern, this action has been removed from the Ecosystem Restoration Plan.

The ecosystem restoration actions were formulated as the result of a series of workshops with federal and state resource agencies and the public, plus their comments on the draft EIS, and are incorporated into the selected plan. They were chosen from a list of potential actions as being the most appropriate to implement concurrently with the selected plan.

Ecosystem restoration on the lower Columbia River can not be accomplished by any single action. Rather, restoration would occur through implementation of a diverse array of measures over an extended period of time. Conceptually, restoration could entail structural modifications to existing features, habitat development, removal and/or placement of dredged material, or changes in operational practices on specific parcels of land. Standard incremental analysis has been performed on the Shillapoo Lake portion of the analysis. The other two actions attempt to improve salmon passage, and are difficult to quantify in terms of benefits. The salmon-related actions have not been assigned habitat units, and are not included in any incremental cost comparison. The benefits and costs for each measure are described in the following sections.

4.8.1. Shillapoo Lake

The concept of restoration of wetland and riparian habitat through breaching of levees provides an excellent opportunity to recover lost habitat. Shillapoo Lake near Vancouver was selected as the best overall site for implementation under the Corps' ecosystem restoration authority. The lake currently lies behind protective dikes and is drained annually for farming. Four alternatives were investigated to accomplish restoration of wetland habitat at Shillapoo Lake (Northwest Hydraulic Consultants, Inc. and Ogden Beeman & Associates, Inc., 1998). Their report contains detailed hydrological information on the Columbia and Lake Rivers and the wetland development alternatives considered. Alternatives considered were the existing condition, natural condition, gravity supply and combined pump/gravity supply. The existing condition consists of a 22.3 cfs discharge pump, 36-inch and 42-inch culverts and tidegates for discharge of water, and use of interior runoff for filling of Shillapoo Lake. The natural condition represented restoration of historical connections to the Columbia River. The gravity condition entailed obtaining water supply via gravity feed from Lake River and the Columbia River in conjunction with the development of wetland cells in the Shillapoo Lakebed. The combined pump/gravity supply alternative would include a water supply pump with a low-level connection to the Columbia River, retention of a 22.3 cfs discharge pump and the 36-inch and 42-inch culverts, and tidegates for discharge or intake of water and development of wetland cells in Shillapoo Lake.

Neither the existing condition nor the natural condition alternatives were able to accomplish target water level regimes for Shillapoo Lake with any degree of reliability (Northwest Hydraulic Consultants, Inc. and Ogden Beeman & Associates, Inc. 1998). Interior runoff was not reliable on an annual basis to fill Shillapoo Lake to desired levels. For the natural condition alternative, low water years on the Columbia River compromised fill capabilities for Shillapoo Lake and drainage of the lake to desired levels was not attainable. The gravity supply alternative would allow for shallow flooding of Shillapoo Lake in low flow years for the Columbia River but would not allow for flooding of the northern portion of the management area in low flow years.

The combined pump/gravity supply alternative improves the flexibility of water management in dry years at Shillapoo Lake, meeting both fill and drainage objectives and allows wetland management to occur in the northern unit. This latter alternative was selected as the most flexible for wetland development and management and for attaining desired levels of habitat units for wildlife.

The proposed action would involve construction of water supply and control structures to allow for filling Shillapoo Lake to desired levels for moist soil wetland plant communities and control of reed canarygrass (figure 4-5). These structures would also allow for drainage of the lake in a timely manner in late spring for moist soil plant community development thus ensuring the quantity and quality of forage resources desired for wintering waterfowl and other wildlife. Eight diked cells would be constructed within the project area to enable WDFW to better manage water levels and wetland habitat development, including control of reed canarygrass. Water would be conveyed to and from the management units via channels connected to a water control structure on Lake River. A water expulsion pump and tidegate (existing) are located at the Lake River water control structure. The facilities at Lake River would also be adapted to for water supply purposes, including the presence of a porous rock dike to preclude fish from entering the management area. Each cell would have up to four water control structures to enable managers to drain or fill an individual cell, manage for specific water levels, and/or convey water to and from adjacent cells. An existing WDFW pump would be used to provide additional water to the cells if river stage was inadequate for filling cells to desired levels.

The objective is to develop moist soil plant communities on approximately 1,248 acres for wintering waterfowl. The proposed action would also provide habitat for shorebirds, raptors, wading birds and other wildlife species. Calkins (1996) assessed future habitat values for the three private ownerships in the Shillapoo Lake ecosystem project area.

The analysis of benefits for the Shillapoo Lake ecosystem project is predicated upon habitat evaluation procedure (HEP) results from Calkins (1996). He estimated 3,089 habitat units of credit would be developed on 1,252 acres or an average of 2.5 habitat units per acre. The management practices to be implemented for the Shillapoo Lake restoration project dovetail with those management practices upon which Calkins (1996) based his projection of habitat unit production. Consequently, benefits for the restoration project were based upon a production figure of 2.5 habitat units per acre.

Incremental analysis was performed on the eight cells making up the Shillapoo project in an effort to identify the costs and benefits of each cell. Cells 4 and 5 are relatively independent in terms of both costs and benefits. The remaining cells, with the exception of cell 8, are dependent on cells 4 and 5 for water supply and drainage. Cell 8 is completely independent, and depends on no other cell for water supply or drainage. Table 4-20 displays the incremental costs and benefits for each cell. In a typical incremental analysis, the cells would be shown ordered by cost-per-unit. In the case of this project, due to the dependencies of the cells, the table is arranged in logical order of construction and dependence.

Table 4-20. Incremental Costs and Benefits, Shillapoo Lake Restoration Project

Cell	Incremental Cost ($)*	Incremental Habitat Units	$/Unit	Cumulative Habitat Units	Cumulative Cost ($)	Cumulative Cost ($) per Habitat Unit
4	44,000	238	185	238	44,000	185
3	33,000	285	116	523	77,000	147
2	15,000	440	34	963	92,000	96
1	32,000	535	60	1,498	124,000	83
5	60,000	220	273	220	60,000	273
6	16,000	483	33	703	76,000	108
7	13,000	433	30	1,135	89,000	78
8	59,000	488	121	488	59,000	121
Totals	**$272,000**	**3,120**	**$87**			

* Note: These costs include maintenance and life cycle replacement costs.

The first four cells on the table are cells 1 to 4, which share levee boundaries and water control structures. Cells 5, 6, and 7 also share common levees and water control structures. In each of the two groups of cells (1 to 4 and 5 to 7), the first cell bears the majority of the water control structure and levee costs. These costs are necessary in order to achieve any of the benefits of the project. For those first two cells, the costs, on a per-habitat-unit basis, are quite high. As additional cells are added to each group, the average cost per habitat unit drops, as more acres of land benefit from the initial project investment. For each of the two groups of cells, the average annual cost per habitat unit eventually drops to $83 and $78, respectively.

Cell 8, being relatively independent, has fewer acres of habitat over which to spread the initial costs required to achieve benefits, but still produces almost 500 habitat units at an average annual cost of $121 per habitat unit. The total first cost of Shillapoo effort is approximately $3,180,000, producing 3,120 habitat units at an average annual cost of $87 per habitat unit.

The costs listed in this table are only those costs that will be cost-shared. The project is dependent upon acquisition of these lands by the WDFW, which is expected to occur regardless of the implementation of this ecosystem restoration effort. Therefore, real estate costs have not been included in this incremental analysis. However, since the habitat analysis compares habitat units under current practices with habitat units under the ecosystem restoration project, it is prudent to consider that the NED costs of this project would include an estimated first cost of $3,500 per acre in real estate costs, or about $1,400 per habitat unit for all cells.

It is proposed that all eight cells be constructed. Of the first two groupings of cells, it is most logical to complete each grouping of cells once the initial investment in the first cell is made. Cell 8, which stands alone, spreads its initial costs over less land than in the first two groups of cells, but still represents a valuable investment in wetlands and riparian habitat for the lower Columbia River area which has incurred a substantial loss of these habitats over time.

4.8.2. Tide Gate Retrofits for Salmonid Passage

The construction of dikes along the lower Columbia River has resulted in the partial or complete blockage of small tributaries to the Columbia River or other rivers. These streams supported runs of salmon, steelhead and cutthroat trout. Tide gates installed in these dikes allow for drainage of water from blocked streams. Currently, the tide gates may not be open at the appropriate times for juvenile or adult fish passage.

The ecosystem restoration action would entail installation of fish slides. A fish slide is a rectangular opening of approximately 12 inches by 15 inches in size that can be manually operated by opening or closing a slide gate. The slide gate and opening are constructed on the existing tidegate. The fish slide, when open, allows water to continuously flow through the tidegate thus allowing for upstream and downstream passage of salmonids without delays imposed by normal tidegate operations. The fish slide can be closed off during flood events.

The ecosystem restoration action would entail retrofitting existing tide gates at identified diking districts along the lower Columbia River where salmonid runs occur or potentially could occur if reintroduced. The ODFW provided maps of anadromous salmonid rearing and spawning habitat along the lower Columbia River. Through correlation of the ODFW salmonid maps with maps of known diking districts, three Oregon tributary streams where fish passage may be either blocked or impeded by tidegates were identified. These streams were Tide Creek in the Deer Island Drainage District, Grizzly Slough in Clatsop County Drainage District No. 1, and Fertile Valley Creek (also known as Hall or Warren Creek) in Clatsop County Diking District No. 12.

Tide Creek has about 11.5 miles of stream, including tributaries, upstream of Deer Island-Highway 30 which, barring natural barriers, would be available to salmonids for spawning and rearing use. Stream miles available for salmonids were approximated from review of USGS topographic maps. Fertile Valley Creek has potentially 5.5 miles of stream available for spawning and rearing habitat (barring natural barriers). Grizzly Slough contains about 10 miles of habitat for salmonids, principally rearing or overwintering habitat with less than one mile of stream potentially useful for spawning habitat.

The WDFW identified three streams where fish passage improvement could be an appropriate action. Streams identified were Gee and Burris Creeks and Deep River. The Gee Creek location does not contain a dike or tidegate structure. Gee Creek is located in the Lake River delta and its outlet to Lancaster Lake flows through a 36-foot corrugated metal pipe. Since the Gee Creek location does not involve a tidegate and the fish passage problem is undefined, it was dropped from further consideration.

Burris Creek is located in Cowlitz County Consolidated Diking Improvement District No. 2 near Woodland, Washington (figure 4-6). The WDFW identified tidegates on Deep River tributaries below the old log dumpsite near the town of Deep River as the third location. The dikes at the Deep River locations were apparently privately constructed as no information was located in Corps records. These dikes, in concert with Highway 4, which is a raised roadbed at this location, block Rangila Slough and upstream portions of Deep River and associated tributaries.

Deep River and tributaries upstream of the dike closure contain about five miles of stream, which barring natural barriers would be available to salmonids for spawning and rearing use. About one mile of stream is associated with Rangila Slough. Burris Creek contains about five miles of streambed available to salmonids for spawning and rearing activities, barring natural barriers.

The number of fish benefiting from the proposed action would vary annually and is dependent upon many variables external to the project area. Provision of restored fish passage at the tide gates would allow salmon and steelhead improved access to spawning habitat and could ensure juvenile out-migration at the appropriate times. Benefits, principally increased run size for each species at each tributary, would be anticipated from the proposed action.

In total, the eleven tide gates (figure 4-6) will be retrofitted, at a cost of approximately $200,000. These modifications are expected to have a functional life of 25 years, and minimal incremental maintenance is expected over the period of analysis. The average annual cost of the tide gates is approximately $16,200. The total linear amount of stream area that would benefit from tidegate retrofit is 38 miles. Average annual costs per stream-mile are approximately $425.00.

4.8.3. Improved Embayment Circulation

Historic dredged material disposal has created several island and embayment complexes along the lower Columbia River. At some of these islands, the flow into the embayments is restricted, typically by small or blocked channels at their upstream end. This causes poor circulation, elevated water temperatures and reduced water quality in the embayments. Circulation is impeded as water can only enter at the downstream end of the embayments and flows do not travel from upstream to downstream through the embayments. This leads to sediment in-filling of the embayments. The shallow embayments, where direct flows from the mainstream are either limited or blocked, tend to become warmer than the mainstream. These warm shallow waters affect species composition of benthic invertebrates and fish, being more conducive to carp than juvenile salmonids as temperatures increase. Fish access to embayments, particularly by juvenile salmonids may also be restricted. Embayments can provide excellent rearing habitat for juvenile salmonids.

The ecosystem restoration action would entail construction of connecting channels at the upstream end of Walker-Lord and Hump-Fisher Islands as shown on figure 4-7. These connecting channels would allow for Columbia River flows to enter at the upstream end of the embayments, increasing water circulation and through flow. Embayment water temperatures would also be reduced. The opportune time to construct channels through the old disposal sites, which close off these embayments, would be in September and October during low flow periods in the Columbia River. This also corresponds to a low abundance of out-migrant fish in the river. Adjustments in embayment water temperature and flow should occur rapidly. Consequently, any adjustments in embayment water temperatures and flow would occur well before the beginning of the next out-migrant period.

An estimated 77 acres would be restored at the Lord-Walker Island complex and about 258 acres at the Fisher-Hump Island embayment. The cost of this measure is approximately $20,000. Future maintenance costs are expected to be minimal. The average annual cost is approximately $1,375.

4.8.4. Restore Shallow Water Habitat

This ecosystem restoration action at Miller Sand and Pillar Rock Islands has been removed from the Ecosystem Restoration Plan. During the review of the draft EIS, concerns were raised about the potential for birds to use the shallow water area to feed on migrating juvenile salmonids. The riverbed south of the navigation channel between Miller Sand and Pillar Rock Islands has been eroding for many years. This erosion has converted formerly productive, shallow subtidal (about -6 feet CRD) habitat into less productive, deep sub-tidal (-25 to -30 feet CRD) habitat. A loss of benthic productivity was identified in sampling results by the NMFS for the eroded, deepened areas in comparison to the adjacent shallow subtidal habitat. Juvenile salmonid rearing or foraging during passage through the estuary would benefit most from the area being restored to a shallow subtidal, productive habitat.

This plan consisted of constructing a pile dike field between Miller Sands and Pillar Rock Islands and backfilling eroded areas with dredged material from channel maintenance to restore shallow water habitat for salmonids. Six pile dikes, each 500 feet in length and approximately 1,200 feet apart, would be necessary to stabilize the fill in this highly erosive area. About 250 acres would be filled to historic depths and benthic productivity allowed to naturally reestablish. Reestablishment of benthic productivity benefits fisheries resources, particularly juvenile salmonids that forage and rear in shallow water habitat during their out-migration to the ocean. The first costs of this measure were about $2,800,000. The pile dikes would be relatively maintenance free for the first five years of the project. Starting at year five, annual maintenance, generally consisting of replacement of piles as they deteriorate, may be needed at an average cost of $6,500 per year. The total average annual cost of the pile dikes, including maintenance, would be $197,000.

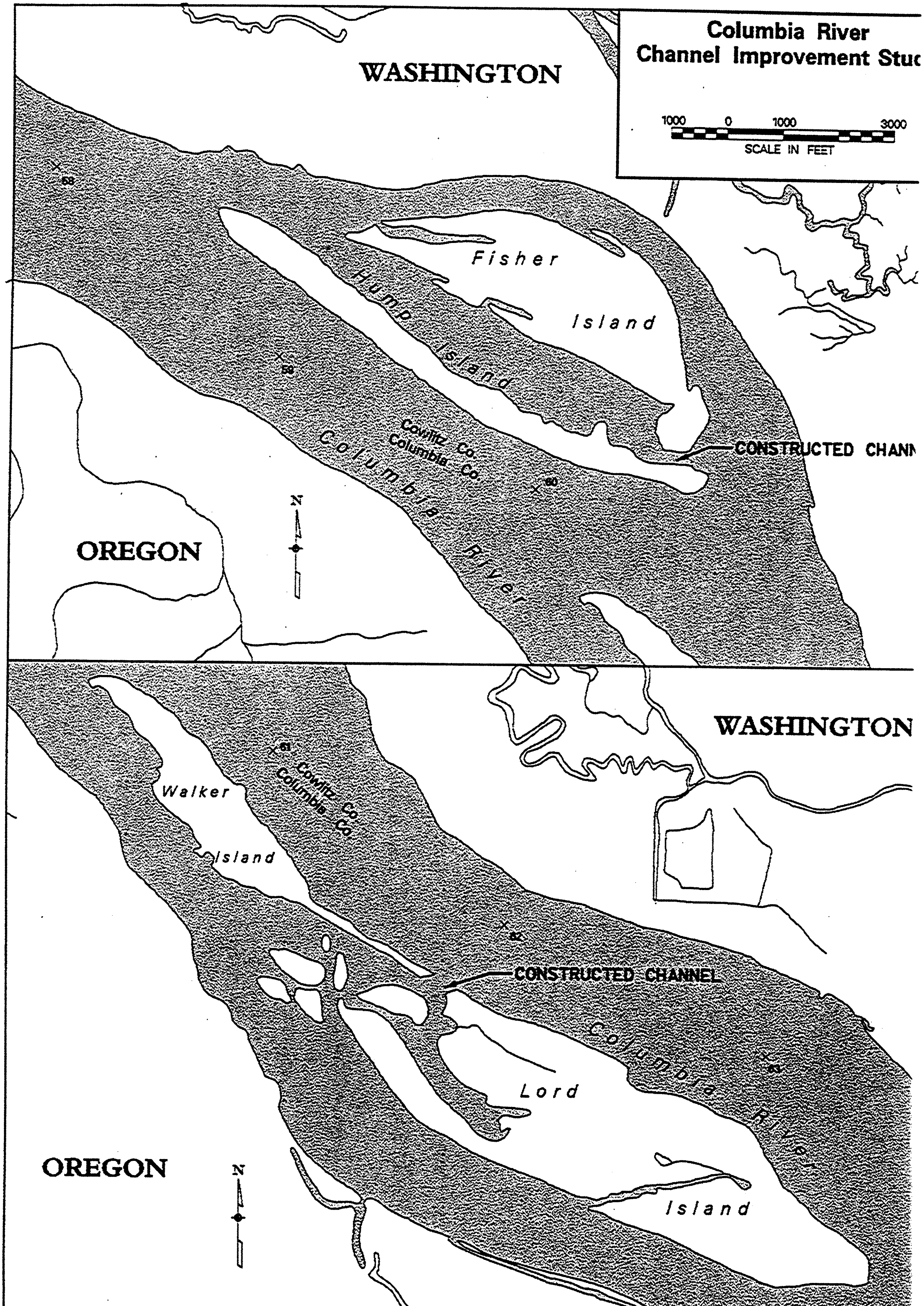
4.8.5. Summary

The restoration measures included in the ecosystem restoration plan provide substantial habitat benefits for fish and wildlife resources. They also represent important contributions to the recovery of ESA listed and proposed salmonid stocks in the Columbia River. At Shillapoo Lake, almost 1,250 acres of valuable wetland and riparian habitat would be restored. Wetland and riparian habitats have significantly declined along the lower Columbia River since the 1880s as a result of agricultural and urban/industrial development. The two other measures would improve salmonid habitat conditions by restoring adult fish access to tributary spawning grounds and improving juvenile out-migration in the mainstem Columbia River. While much has been done to improve salmon passage at Columbia River dams, relatively little has been done to improve juvenile salmonid rearing habitat, and therefore survival, on the Columbia River below the dams.

Table 4-21 summarizes the three measures included in this ecosystem restoration plan. The total average annual cost of the plan is approximately $289,575, and would improve the condition of over 1,550 acres of habitat along the lower Columbia River.

Table 4-21. Summary of Ecosystem Restoration Measures

Restoration Measure	Benefit	Average Annual Cost	Cost Per Benefit Unit
Shillapoo Lake	Restore 3,120 habitat units	$272,000	$87 per habitat unit
Tide Gate Retrofits	Improved fish passage at 38 miles of stream spawning grounds	$16,200	$425 per steam mile
Improved Embayment Circulation	335 acres of improved habitat for juvenile migrating salmonids	$1,375	$4.10 per acre
Total Average Annual Cost		**$289,575**	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