COLUMBIA RIVER ESTUARY
DREDGING AND IN-WATER DISPOSAL
HANDBOOK

December 1989

Columbia River Estuary Study Taskforce

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This Project was funded by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C., through a grant made under Section 309 of the Coastal Zone Management Act of 1972, as amended, to the National Coastal Resources Research and Development Institute, Newport, Oregon.

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1. INTRODUCTION

The Columbia River Estuary contains valuable aquatic and biological resources as well as economically significant navigational facilities. Dredging and dredged material disposal are essential for maintaining the Estuary's navigation channels, turning basins, anchorages and mooring facilities. Dredging and dredged material disposal, and particularly in-water disposal of contaminated sediment, may damage aquatic and biological resources. A number of regulatory programs at the local, state and federal level seek to manage in-water disposal in a manner that minimizes damage to the aquatic environment. The regulatory programs are complex. This report describes the permit process for in-water dredged material disposal in the Columbia River Estuary, and the steps that should be followed by those seeking permits for in-water dredged material disposal.

1.1. Project Description

This report describes the regulatory process used for making permit decisions about in-water dredged material disposal in the Columbia River Estuary. The estuary is defined here as extending from the river mouth upstream to approximately river mile 45 (see Map 1). In-water disposal of dredged material includes flowlane disposal using a hydraulic dredge, or open water disposal using a barge. Local, state and federal agencies are involved in the permit process for in-water dredged material disposal.

The permit process is complex, but not just because water quality is a complex issue. Three additional complicating factors are also present. The Columbia River Estuary is a bi-state water body, so regulatory agencies from two states are involved. The Washington Department of Ecology and the Oregon Department of Environmental Quality cooperate, but their regulations and administrative procedures are not identical. Sediment quality is a relatively new area for regulatory attention, and regulations are still evolving and being developed. The passage of time will improve this situation. Finally, the Columbia River Estuary is a large and dynamic estuary. The aquatic environment in the Columbia River Estuary is significantly different from other marine and estuarine environments, and would be expected to respond differently to sediment quality problems. For these reasons and others, the permit process for in-water dredged material disposal is slow, confusing and, at times, frustrating. There is little certainty in the process. There are, however, procedures that can be followed by a permit applicant that will minimize these problems. Those procedures are described in this report.

This report is one of four documents addressing sediment quality and dredging in the Columbia River Estuary. The other three documents are:

<u>Columbia River Estuary Sediment Quality Policy Evaluation.</u> (CREST 1989)

<u>Dredging and Dredged Material Disposal Policy Evaluation.</u> (CREST 1987)

<u>Columbia River Estuary Dredged Material Management Plan.</u> (CREST 1986)

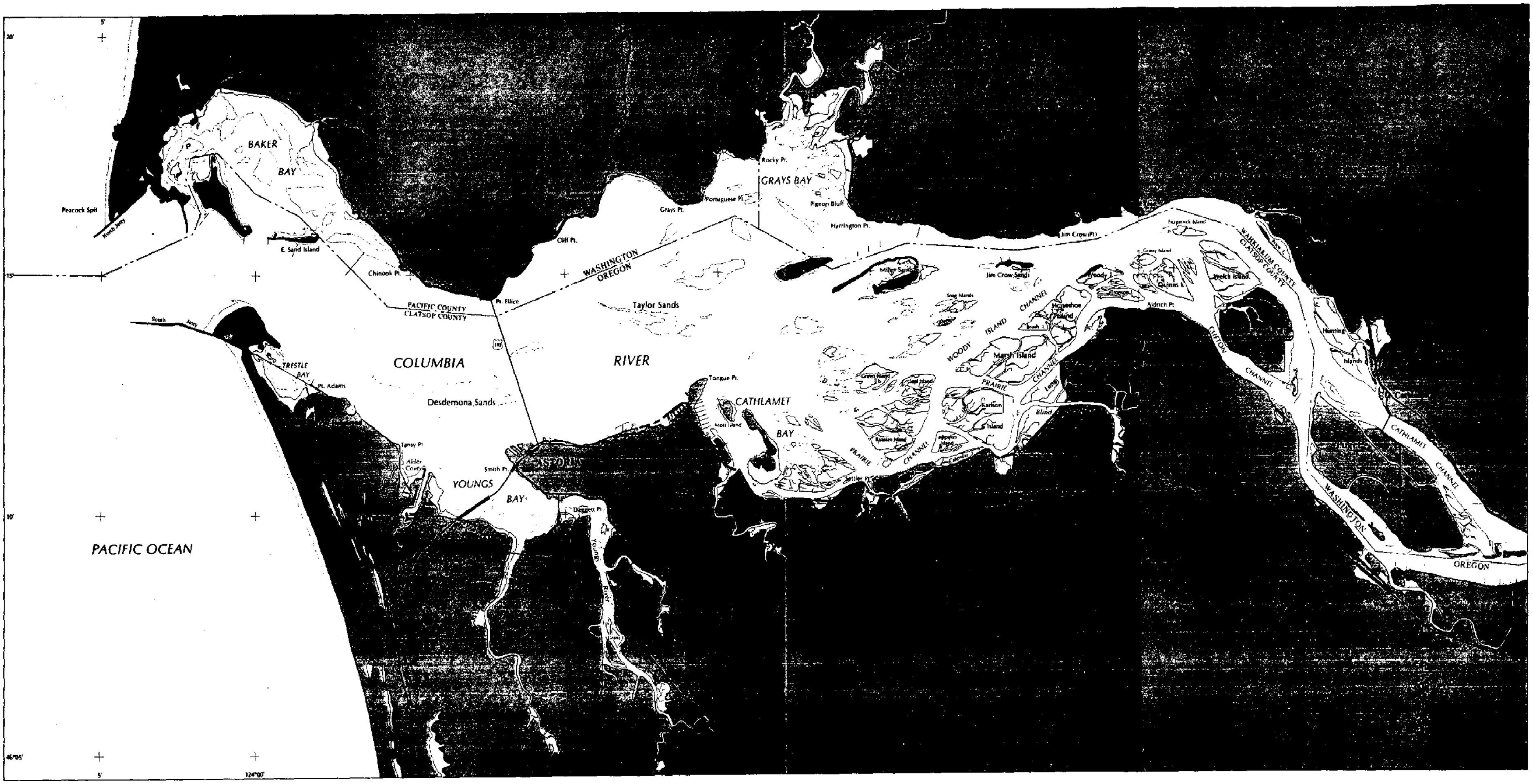
All four of these reports are prepared by the Columbia River Estuary Study Taskforce (CREST), a bi-state council of local governments serving communities on the lower Columbia River. This report, as well as the three reports cited above, were funded in whole or in part by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C., through a grant made under Section 309 of the Coastal Zone Management Act of 1972, as amended, to the National Coastal Resources Research and Development Institute, Newport, Oregon.

1.2. Contents

This report includes two principal chapters. Chapter 2, Sediment Quality, provides background information on some of the principal issues and concerns about sediment contamination in the Columbia River Estuary. It describes the procedures for providing sediment quality information needed for review of in-water disposal permits. Adequate information about the sediment proposed for in-water disposal is an essential part of the permit review process.

Chapter 3 provides procedural and substantive information about the permit process. Most in-water disposal projects on the Columbia River Estuary will require a federal permit, one or more state permits, and a local permit. For projects that occur in both states (such as dredging in Washington waters and disposal in Oregon waters), additional permit review will be required. Despite the number of permits involved, the different agencies coordinate their permit review efforts reasonably well. Permit considerations are described in Chapter 3.

A glossary of technical terms used in this report and elsewhere is included following Chapter 3, along with a list of reference documents.



Columbia River Estuary

Scale 1:160,000

0 1 2 3 4 5 6 7 8 9 10 Kilometers

0 1 2 3 4 5 6 Miles

Map produced in 1983 by Northwest Cartography, Inc.
for the Columbia River Estuary Data Development Program

Shoreline (limit of non-aquatic vegetation)

Intertidal vegetation

Shoals and flats

Lakes, rivers, other non-tidal water features

Major highways

Cities, towns

Railroads

Other cultural features

2. SEDIMENT QUALITY

The presence or absence of chemical contaminants in sediment, and their potential affects on aquatic organisms, are major considerations during review of permits for in-water dredged material disposal. Instances of severe sediment contamination have not been reported in the Columbia River Estuary, but because they have occurred in other estuaries, regulatory agencies are justifiably cautious when reviewing proposals for in-water disposal in the Columbia River.

Sediment quality can be evaluated against several different parameters. For regulatory purposes, these parameters can be broadly classified as biological, chemical, physical or locational. Data needed for evaluating sediment quality for permit review purposes is normally supplied by the permit applicant, at the applicant's expense. The types of data needed vary from project to project. This Chapter describes the types of data needed for evaluating sediment quality as well as methods for collecting and presenting the data. Section 2.1. describes the physical, locational, chemical and biological data used for evaluating sediment. Section 2.2. provides guidelines on generating the data.

2.1. Sediment Quality Data: Background Information

As mentioned in the introduction to this section, the different kinds of data reviewed by regulatory agency staff when evaluating sediment suitability for in-water disposal can be divided into four categories: locational, physical, chemical and biological. These four data types are used sequentially for evaluating sediment quality in the Columbia River Estuary. The sequential use of these data is sometimes called a tiered approach to sediment evaluation. Although there are many different ways a tiered approach might be implemented, its basic outline is relatively simple. A decision is made at each tier whether the existing sediment data at that tier criteria can support approval for in-water disposal. If the data is sufficient, there is no need to proceed to the next tier. If not, data corresponding to the next tier are required before sediment may be approved for in-water disposal. This tiered arrangement is summarized in Figure 1. The four tiers and the data associated with each tier are described below.

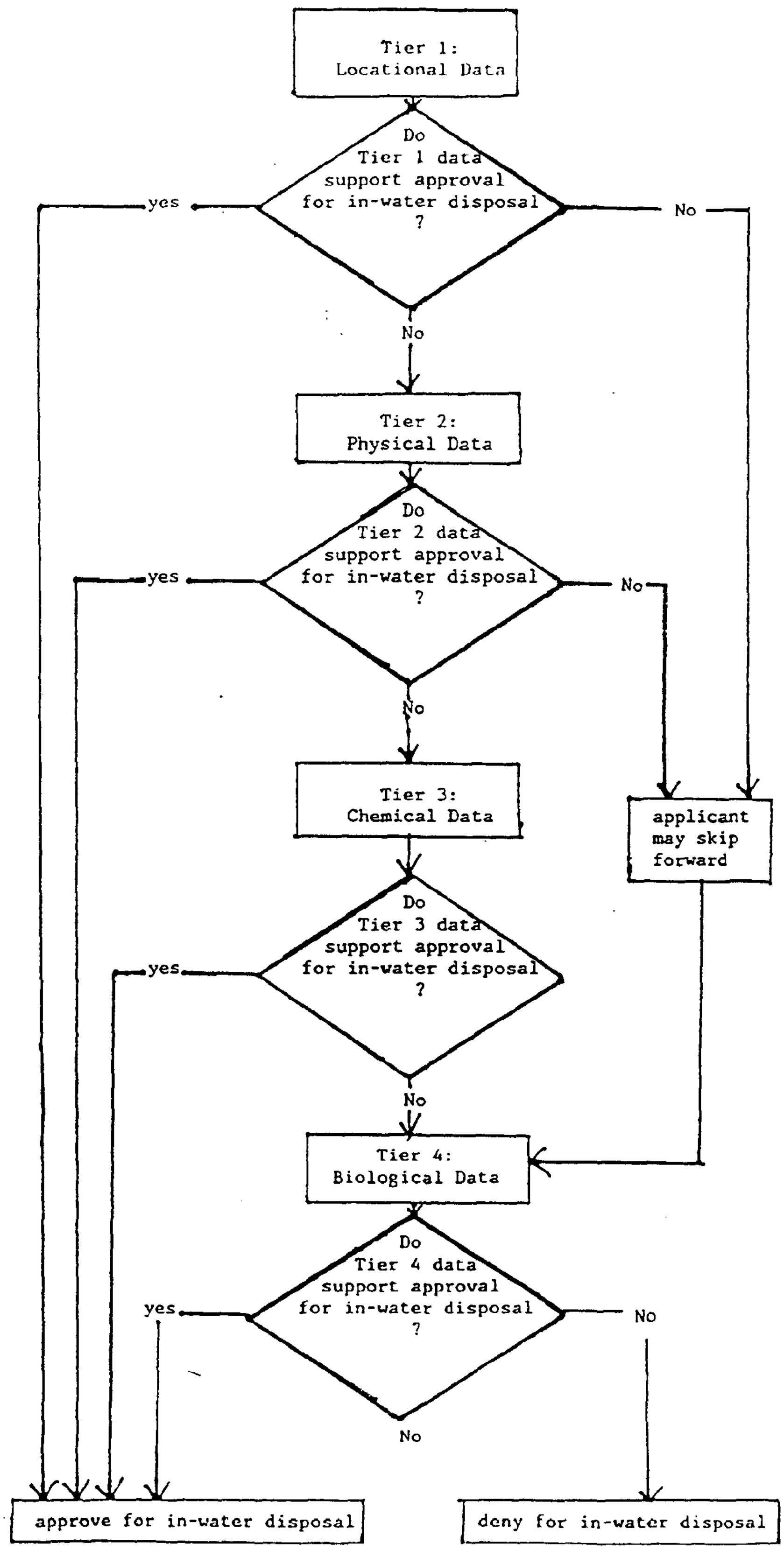
Locational Factors

A dredging site's location within the estuary can provide a significant amount of information about sediment that may be found there. This information, under some circumstances, may be useful for evaluating sediment suitability for in-water disposal. Locational data may also help guide and fine-tune other evaluative efforts. The best kind of data at this tier are physical, chemical or biological test data that have been previously collected at or near the proposed dredge site. Data that show a history of clean sediment at the proposed dredge site, plus no reason to suspect recent contamination, may speed the sediment evaluation process significantly. Sediment chemistry data are available for a number of dredging sites in the estuary, especially the main navigation channel, areas in Baker Bay, Cathlamet Bay, the Skipanon River and the Port of Astoria docks.

Areas of fine grain sediment accumulation are generally believed to be areas where sediment contaminants might be found. This is expected because many compounds have electrochemical properties that cause an affinity for fine grain sediment. Existing data tend to support this (for example, Felstul, 1986). Therefore, areas in the estuary with a predominance of coarser grain sediment are likely to be clean, and may not require further evaluation for in-water disposal. Sediment from the main navigation channel typically consists of less than twenty percent silt, clay and finer material, and often is approved for in-water disposal without detailed physical, chemical, or biological study. Fine-grain sediments accumulate in shallow areas, semi-enclosed embayments, marinas, or other areas not affected by strong currents. Sediment from these areas will probably require additional testing before approved for in-water disposal.

Some sites in the estuary are located near known or suspected sources of contamination. Activities with the potential for generating localized sediment contamination are boat and ship building and repair; marine fuel storage or dispensing; sewage treatment or storm drainage; railroad or highway bridge crossings; and sand blasting. Sediment from sites near these activities is often suspected of containing chemical contaminants, and some chemical evaluation will probably be necessary.

Figure 1: Tiered Sediment Evaluation



Historical information may be useful for evaluating sediment quality at the first tier. Tongue Point sediment, for example, is believed to be contaminated as a result of U.S. Navy activities conducted there after the Second World War. The Pacific Power and Light coal gasification plant in Astoria may be the source of coal tar contamination in a portion of Youngs Bay. Areas of the estuary where boat building or fishpacking has occurred over a long period are suspected of retaining sediment contaminants associated with these industries. The fact that these activities have occurred does not by itself imply that sediment from those areas is unsuitable for in-water disposal, however, it probably indicates additional information on physical and chemical sediment characteristics will be necessary.

Locational factors are the first tier in the tiered approach to sediment evaluation. If existing locational data adequately support a decision in favor of in-water disposal, data from the subsequent tiers are not needed. If locational data suggest that sediments at the dredge site may be contaminated, or if the data are inconclusive, unreliable, or otherwise insufficient, data from one or more of the subsequent tiers will be necessary.

Physical Factors

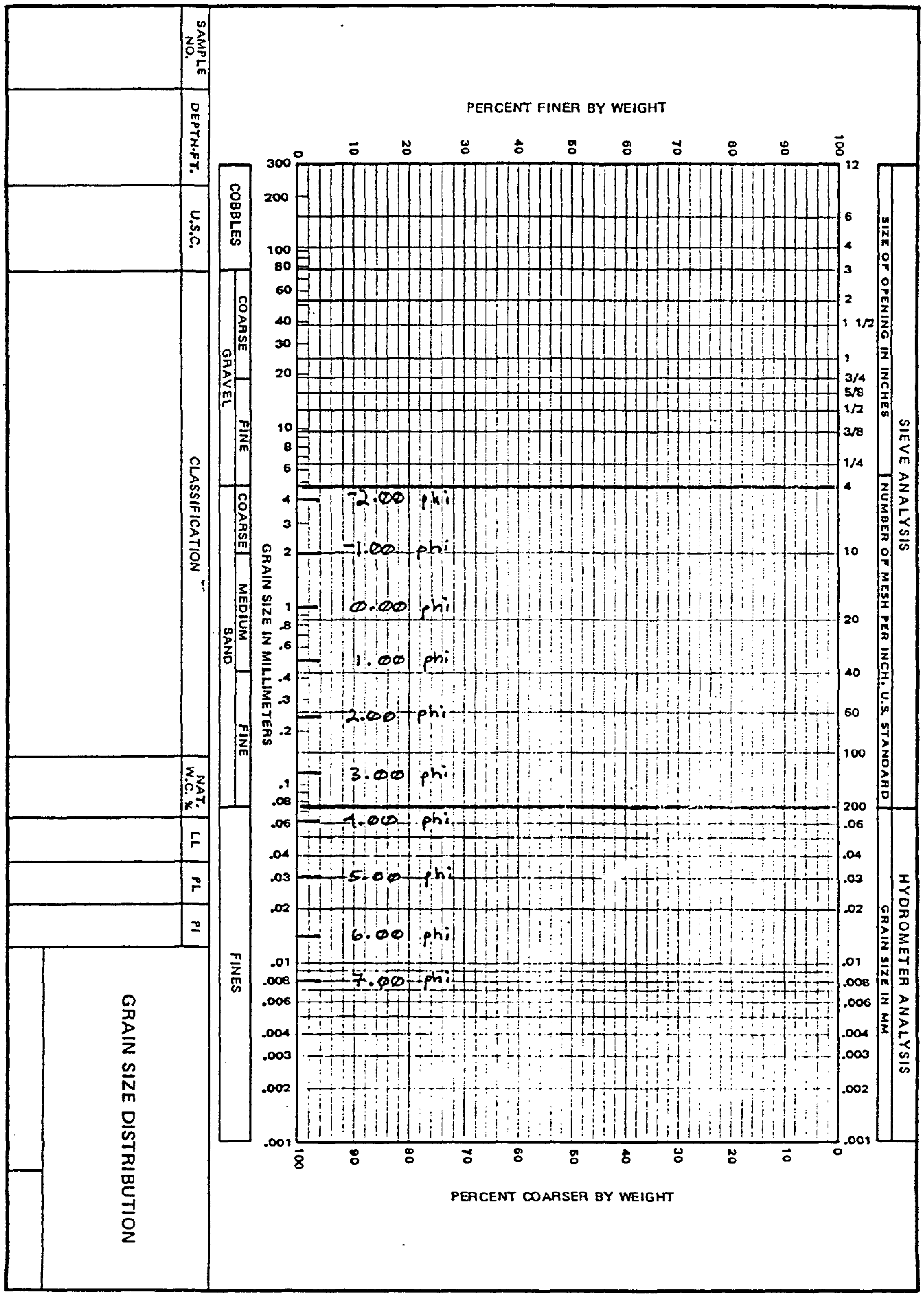
Up to twelve physical parameters are useful in determining sediment quality, although only one of them -- grain size data -- is used often. The variables described here include grain size, oil and grease, total organic carbon, volatile solids, pH, total sulfides, total nitrogen, ammonia, biochemical oxygen demand, chemical oxygen demand, petroleum hydrocarbons, and dissolved sulfides. Of these, grain size data are the most frequently measured. With the possible exception of pH, all of these tests involve laboratory analysis of samples collected in the field. The paragraphs below describe a physical sediment parameter, its uses and limitations, and typical ranges for the parameter in the Columbia River Estuary.

Grain size information are probably the most frequently collected data for sediment evaluation purposes. Sediment in the Columbia River Estuary ranges from gravel-sized material to very fine clay. A widely used classification system for sediment uses phi units, named after the 23rd letter of the Greek alphabet. Grain size decreases as phi units increase. Phi units are negative for grain sizes larger than one millimeter in diameter. Sand is between about 0.08 millimeters and 5 millimeters in diameter (4 phi and -2 phi, approximately). Finer material is silt and clay. Coarser material is gravel. Sediment grain size data are occasionally presented graphically using the graphic format shown in Figure 2.

More than 2,000 sediment samples from the Columbia River Estuary collected during different times of the year and at depths ranging from the intertidal zone to over 100 feet below MLLW were examined by the Columbia River Estuary Data Development Program in 1982. Mean grain sizes ranged from -1.12 phi (about 2.2 mm, or very fine gravel) to 8.17 phi (about 0.0035 mm, or coarse clay). The average of the mean grain sizes was about 2.5 phi (about 0.18 mm, or fine sand).

Grain size is a commonly measured sediment characteristic because it involves a relatively inexpensive test, and the results are applicable to sediment evaluation decisions. The Oregon Department of Environmental Quality

Figure 2: Grain Size Distribution Chart



disposal permits, uses a 20% silt (4 phi and finer) content threshold for further testing. Sediment with 20% or less silt and finer material would generally be approved for in-water disposal without additional testing. Sediment with a silt content exceeding 20% would require additional chemical and possibly biological testing before it could be approved by ODEQ for in-water disposal. This 20% threshold is in a draft form at this time. If adopted, it would be a guideline, and not a substitute for professional judgement on the part of ODEQ officials. Other agencies involved in the review of proposed in-water dredged material disposal are not obligated to follow this guideline, so chemical testing may be required even if the 20% silt content threshold is not adopted.

Grain size analysis is accomplished with graduated sieves for sand and coarser material (4 phi and coarser). Silt and clay fractions are measured using a technique that depends on differential settling rates among particle size classes. This test takes up to thirty hours for material finer than 10 phi (fine clay). It is usually completed in a commercial laboratory, using standardized analytical techniques. Sediment for a grain size analysis must be collected from the disposal site, and stored and transported in a manner that maintains its integrity. Sediment for grain size analysis may be stored for up to six months, and should be refrigerated. At least 100 grams of sediment are needed for the test. Sediment collection depths should normally correspond to planned dredging depths, and sample collected with a coring device may be subdivided by depth. Coring devices or grab samplers are suitable for sediment collection for grain size analysis: less sophisticated tools may also be appropriate.

Oil and grease content in sediment is typically reported in dry-weight parts per million (ppm). Oil and grease tests measure hydrocarbons, vegetable oils, animal fats, waxes, soaps, greases and related compounds. Oil and grease in Columbia River Estuary sediment may range anywhere from 0 ppm to more than 3,000 ppm. "Draft Interim Sediment Quality Guidelines" issued by the Oregon Department of Environmental Quality (ODEQ) for use in evaluating sediment quality set a limit of 1,000 ppm oil and grease for in-water disposal approval. Sediment with oil and grease in excess of 1,000 ppm may require further testing before approval for in-water disposal. Sediment samples collected for analysis of oil and grease content should be refrigerated. At least 100 grams of sediment per sample are needed. Sediment to be tested for oil and grease must be stored in glass containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one month refrigerated, and up to six months frozen.

Total organic carbon (TOC) is a measure of organic compounds (that is, compounds containing carbon) in a sediment sample. It is usually reported as milligrams per gram dry weight (mg/g) or as parts per thousand (ppt). Sediment analysis sometimes requires that the concentration of a compound in sediment be normalized to the total organic carbon content. Total organic carbon content in Columbia River Estuary sediment may exceed 100 mg/g in some cases, but probably averages between 10 and 20 mg/g. Sediment samples to be analyzed for total organic carbon content should be frozen until analysis. Only 25 grams of sediment per sample are needed. Sediment to be tested for total organic carbon may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for up to six months frozen.

Volatile solids are the solid materials in a dry sediment sample that burn or evaporate at a temperature of 550°C (1,022°F). The sediment is weighed before and after the heating: the weight loss represents total volatile solids. Volatile solids are usually reported as a percent of dry weight. Volatile solids content is a measure of a sediment sample's organic content, and may be used for normalizing other sediment contaminant concentrations to the sediment carbon content. The volatile solids content of Columbia River Estuary sediment may exceed 20 percent in some cases, but probably averages between zero and five percent. The Oregon Department of Environmental Quality (ODEQ) has issued "Draft Interim Sediment Quality Guidelines" for their use in evaluating sediment quality. The guidelines establish a limit of five percent for volatile solids. Sediment with more than five percent volatile solids is subject to additional chemical testing before it may be approved for in-water disposal. The ODEQ volatile solids limit is a guideline and subject to professional judgement on the part of ODEQ staff. Sediment samples collected for volatile solids analysis should be frozen until analysis. At least 50 grams of sediment per sample are needed. Sediment samples may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for up to six months frozen.

Sediment acidity is represented by a pH measurement. pH values between 0 and 7 indicate acidity. pH values between 7 and 14 represent alkalinity. Sediment pH is not always measured. Sediment pH for 3 samples taken at the Port of Astoria docks in 1988 ranged from 6.9 to 7.5. Its use in evaluating sediment for in-water disposal is limited. It is one of the few tests that can be performed in the field.

The amount of acid soluble H_2S, HS^-, and S^{2-} in a sample is measured as total sulfides. These compounds may be toxic and have a strong odor. Total sulfides are usually reported in units of mg/kg dry weight (ppm). A zinc acetate preservative is often added in the field to sediment samples tested for sulfides. Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for total sulfides may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one week refrigerated.

Total nitrogen values in sediment are not normally measured on the Columbia River Estuary, and no data showing representative nitrogen levels in Columbia River Estuary sediment are available. If required, sediment tests may be ordered for total nitrogen. Samples should be frozen until analysis. At least 25 grams of sediment per sample are needed. Sediment may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for up to six months frozen.

Measures of ammonia are typically represented as mg/kg dry weight for sediments, or as mg/liter for elutriates. Four sediment samples taken at Tongue Point were measured for ammonia: they ranged up to 131 mg/kg, and averaged 74 mg/kg. Sample collection methods are similar to those described for grain size analysis.

Biochemical oxygen demand is a measure of the dissolved oxygen consumed by microbial organisms while assimilating and oxidizing the organic matter in actually available to organisms, in contrast with other measures of the total amount of organic matter (e.g., total volatile solids, total organic carbon, chemical oxygen demand). Biochemical oxygen demand is typically reported as mg/kg dry weight. Sediment sample collection considerations for analysis of biochemical oxygen demand are similar to those described for grain size analysis. Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for biochemical oxygen demand may be stored in either polyethylene or glass containers. Samples may be stored for about one week refrigerated.

Chemical oxygen demand is a measure of the organic content of a sample susceptible to oxidation by a strong chemical oxidant at an elevated temperature and a reduced pH. Data are typically reported as mg/kg dry weight. Columbia River Estuary sediment measures of chemical oxygen demand are not available. Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for chemical oxygen demand may be stored in either polyethylene or glass containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one week frozen.

Measures of petroleum hydrocarbons in sediment are often needed for sediment evaluation, particularly in areas where petroleum products may have been spilled. This test measures the same compounds as the oil and grease test, minus polar compounds (vegetable oils, animal fats, soaps). Four sediment samples from Cathlamet Bay tested for petroleum hydrocarbons ranged from less than 5 mg/kg dry weight to 23 mg/kg. Measures of oil/grease and petroleum hydrocarbons for the Cathlamet Bay sites were comparable: oil and grease averaged 54.7 mg/kg dry weight for the composited samples, compared to 23.0 mg/kg dry weight petroleum hydrocarbons. Sediment samples to be analyzed for petroleum hydrocarbons should be refrigerated until analysis. Collection methods are similar to those described for grain size analysis.

Dissolved sulfide measurements are intended as an indicator of biologically available sulfide compounds in a sediment sample. The procedure for this test measures only water soluble sulfides, and should yield a smaller sulfide concentration than the total sulfides test. Dissolved sulfides are typically reported as mg/kg dry weight. Cathlamet Bay sediment analyzed was found to have an average dissolved sulfide content of 44.5 mg/kg dry weight. Sediment sample collection considerations for analysis of dissolved sulfides are the same as those for total sulfides. A zinc acetate preservative is often added in the field. Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for dissolved sulfides may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one week refrigerated.

Total solids are a measure of inorganic and organic materials remaining after a sediment sample has been completely dried. Total solids are usually reported as a percent of the sample's wet weight. This may be used to convert concentrations of other compounds in sediment from a wet weight to a dry weight basis. Drying temperatures are typically 103° C (217° F). Samples should be frozen until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for total solids may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about six months frozen.

The thirteen physical parameters described above can, singly or in combination, provide a second tier estimate of overall sediment quality. The most frequently measured of these parameters are grain size, total organic carbon and volatile solids. The other parameters may be required in specific situations. The grain size analysis is needed because it may satisfy the data requirements for this analytical tier, and result in in-water approval for the sediment without further testing. Measures of total organic carbon or volatile solids in sediment are often used to normalize the concentrations of certain organic chemicals.

Chemical Factors

Two groups of chemical parameters for sediment evaluation are covered in this subsection: metals and organic compounds. Two different kinds of chemical analysis are used for metals and organic compounds: elutriate and bulk sediment tests. Elutriate tests involve analysis of water that has been exposed to test sediment. An elutriate test is a laboratory simulation of dredging and in-water disposal. Test sediment is mixed with disposal site water and mixed. After the sediment settles, water is removed, filtered and centrifuged, and analyzed for chemical contaminants. The elutriate test is useful for estimating the impact of dredging and disposal on water quality. Results can be compared to existing state and federal water quality standards. It measures only those contaminants that are likely to enter the water column after dredging and disposal are conducted. Elutriate test results may not be appropriate for estimating the effects of disposal on benthic organisms. Elutriate test results are usually reported in units of chemical per liter of water. Specific procedures for elutriate tests have been developed, and lab reports normally document these procedures.

Bulk sediment tests measure the concentration of a chemical in a sediment sample. Water is completely removed prior to analysis. The dried sediment sample is subjected to either strong oxidation, acid digestion, or organic solvent extraction. These procedures are harsher than the elutriate test described above, and do not reproduce dredging or disposal conditions. Results of bulk sediment tests do, however, facilitate estimates of effects on benthic organisms. Bulk sediment analysis results are usually reported in units of chemical per gram (or per milligram or microgram) of dry sediment. Specific procedures for bulk sediment tests have been developed, and the laboratory test results should document these procedures.

Chemical Factors: Metals

Metals analysis focuses on metals listed by the EPA as priority pollutants. Up to 15 different metals are often targeted for analysis in Columbia River Estuary sediment. They are:

arsenic	antimony
cadmium	beryllium
chromium	iron
copper	manganese
lead	nickel
mercury	selenium
zinc	silver
	tin

The most frequently measured of these are in the left-hand column, above, but those on the right are targeted for analysis in some circumstances. All are described in the following paragraphs. Detection limits for metals are also mentioned in each paragraph. These are the lowest concentrations of each metal that can be reliably detected using standard analytical procedures.

Beryllium is a hard metal found in alloy with copper and other metals. It is not often measured in Columbia River Estuary sediment because it is not known to be present above background levels. Beryllium is not used by the Oregon Department of Environmental Quality or the Washington Department of Ecology as a sediment quality parameter in the Columbia River Estuary. When targeted, it is reported in units of µg/gram. The detection limits for beryllium in bulk sediment are 1 µg/gram. Sediment from thirteen sites in the Columbia River Estuary have been examined for beryllium. The bulk sediment tests yielded measurements at or below detection limits. Elutriate tests yielded beryllium concentrations ranging from 10 to 20 µg/liter, averaging about 12.3 µg/liter.

Chromium is occasionally measured in Columbia River Estuary sediment. It is toxic to aquatic organisms. The Oregon Department of Environmental Quality has established a limit of between 20 and 300 mg/kg for chromium in sediment. Sediment with chromium in excess of this guideline will not normally be approved for in-water disposal without further testing. There is no corresponding Washington sediment standard for chromium in Columbia River Estuary. Mainstem and side channel sediment samples have been analyzed by several researchers for chromium content. Results ranged from 1.7 to 72 mg/kg.

Manganese is not an Environmental Protection Agency priority pollutant metal, but it is occasionally included in analysis of Columbia River Estuary sediment. Researchers have found manganese in Columbia River sediment ranging between 0 and 1,100 mg/kg. Detection limits for manganese in bulk sediment are 2 mg/kg, dry weight.

Iron, like manganese, is not an Environmental Protection Agency priority pollutant. Iron concentrations in Columbia River sediment have ranged from 0 to 49,000 mg/kg dry weight.

Nickel is a metal on the Environmental Protection Agency's list of priority pollutants because of its toxicity to aquatic organisms. There is some evidence suggesting that nickel may be present in sediment due to natural sources. Nickel in Columbia River Estuary sediment has ranged from 0 to 44 mg/kg dry weight. The detection limit for nickel in bulk sediment is 0.1 mg/kg dry weight. For elutriate tests it is 1.0 µg/liter. There are no Oregon or Washington sediment quality guidelines for nickel in sediment applicable to the Columbia River Estuary. Puget Sound sediment evaluated for nickel must meet a threshold of 140 mg/kg or be subject to additional testing under the Puget Sound Dredged Disposal Analysis (PSDDA) program.

Copper is an Environmental Protection Agency priority pollutant and is included in many sediment tests due to widespread concern about its toxicity and its presence in the aquatic environment. Anti-fouling marine paints and wood preservatives often contain copper compounds. The Oregon Department of Environmental Quality's "Draft Interim Sediment Quality Guidelines" set threshold concentrations for copper. Sediment with a copper content exceeding 50 mg/kg will not be approved for in-water disposal without further evaluation. The Washington Department of Ecology has not established a sediment standard for copper in Columbia River Estuary sediment, but the PSDDA program threshold for copper in Puget Sound sediment is 81 mg/kg. Puget Sound sediment exceeding this concentration is subject to additional testing before it can be approved for in-water disposal. Researchers have found copper in Columbia River Estuary sediment ranging between 1.5 to 91 mg/kg, dry weight. Detection limits for copper in bulk sediment are 0.1 mg/kg, dry weight. For elutriates, copper detection limits are 1.0 µg/liter.

Zinc is a bluish-white metal with a number of applications in maritime industries as an anti-corrosive agent. Zinc is an Environmental Protection Agency priority pollutant and is toxic. The Oregon Department of Environmental Quality's "Draft Interim Sediment Quality Guidelines" sets a threshold concentration for zinc. Sediment with more than 250 mg zinc per kg will require additional testing before approved for in-water disposal. There is a corresponding Washington sediment quality standard for zinc in Puget Sound. PSDDA sets a threshold of 160 mg/kg for zinc in Puget Sound sediment. Puget Sound sediment with more than 160 mg zinc per kg sediment is subject to additional testing before it can be approved for in-water disposal. Zinc in Columbia River Estuary sediment has ranged from 18 mg/kg dry weight to 300 mg/kg. Detection limits for zinc in bulk sediments are 0.2 mg/kg dry weight. For elutriate tests, zinc detection limits are 1.0 µg/liter.

Arsenic is a highly toxic metalloid on the Environmental Protection Agency's priority pollutant list. The Washington Department of Ecology has not established a sediment quality guideline for arsenic applicable to the Columbia River Estuary. The PSDDA threshold for arsenic in Puget Sound sediment is 57 mg/kg. Puget Sound sediment exceeding this arsenic concentration is subject to additional testing before it can be approved for in-water disposal. The Oregon Department of Environmental Quality's "Draft Interim Sediment Quality Guidelines" sets threshold concentrations for arsenic. Sediment with 40 or more mg arsenic per kg is subject to additional testing before it can be approved for in-water disposal. Arsenic in Columbia River sediment has been found in concentrations ranging from 0 to 20.5 mg/kg dry weight. The detection limit for arsenic in bulk sediment is 0.1 mg/kg dry weight. For elutriates, the detection limit is 1.0 µg/liter.

Selenium is a toxic element on the Environmental Protection Agency's priority pollutant list. There are no data for selenium levels in Columbia River Estuary sediment. Neither the Washington Department of Ecology nor the

Oregon Department of Environmental Quality have established threshold limits for selenium in sediment.

Silver is a toxic metal on the Environmental Protection Agency's priority pollutant list. There are no state standards for silver in sediment for the Columbia River Estuary. Silver in Puget Sound sediment proposed for in-water disposal may not exceed 1.2 mg/kg without additional testing under the PSDDA program. Data on silver concentrations in Columbia River Estuary sediment could not be found. The detection limit for silver in sediment is 0.1 mg/kg dry weight. For elutriate tests, it is 0.2 µg/liter.

Cadmium is a toxic metal on the Environmental Protection Agency's priority pollutant list. The Oregon Department of Environmental Quality's "Draft Interim Sediment Quality Guidelines" for evaluating sediment quality in Oregon estuaries establishes a threshold of 1.0 mg/kg cadmium per kilogram of sediment. Sediment with cadmium concentrations in excess of 1.0 mg/kg is subject to additional testing before approval for in-water disposal. The Washington Department of Ecology has not established corresponding standards for cadmium in sediment applicable to the Columbia River Estuary: however, the PSDDA program sets an additional testing threshold of 0.96 mg/kg for in-water disposal in Puget Sound. The detection limit for cadmium in sediment is 0.1 mg/kg dry weight. For elutriate tests the detection limit is 0.1 µg/liter.

Antimony is a toxic metal that contaminates sediment and is on the Environmental Protection Agency's priority pollutant list. Antimony is not frequently measured in Columbia River Estuary sediment. Neither the Oregon Department of Environmental Quality nor the Washington Department of Ecology have established threshold limits for antimony in Columbia River Estuary sediment. Antimony in Puget Sound sediment destined for in-water disposal may not exceed 20 mg/kg without additional testing under the PSDDA program. Smelter slag is occasionally tainted with antimony. The detection limit for antimony in bulk sediment is 0.1 mg/kg. For elutriate tests the detection limit for antimony is 3.0 µg/liter.

Mercury is a highly toxic metal with well documented adverse impacts on aquatic life and human health. It is an Environmental Protection Agency priority pollutant. The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" for mercury. Sediment with mercury concentrations in excess of 0.15 mg/kg require additional testing before it can be approved for in-water disposal. The Washington Department of Ecology has not adopted sediment guidelines for mercury in Columbia River sediment. PSDDA standards for in-water disposal of Puget Sound sediment call for additional testing if mercury concentrations exceed 0.21 mg/kg. Mercury levels in the Columbia River Estuary have been recorded as high as 0.72 mg/kg. Detection limits for mercury in sediment are 0.01 mg/kg, dry weight. For analysis of elutriates, detection limits are 0.2 µg/liter.

Lead is a heavy toxic metal on the Environmental Protection Agency's priority pollutant list. It is associated with anti-fouling paints and other industrial sources in the aquatic environment. The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" for evaluation of sediment. The guidelines set threshold concentrations for lead and other compounds. Sediment with lead in excess of 40 mg/kg is subject to additional analysis before it can be approved for in-water disposal. There are no Washington sediment quality guidelines for lead applicable to the Columbia River Estuary. Lead in Puget Sound sediment must not exceed a concentration of 6.6 mg/kg under the PSDDA program. Sediment with higher lead levels is subject to additional testing before it can be approved for in-water disposal. Lead concentrations in Columbia River Estuary sediment have been recorded up to 40.0 mg/kg, dry weight. Lead detection limits using standard analytical techniques are 0.1 mg/kg dry weight for bulk analysis. For elutriate analysis, lead detection limits are 1 µg/liter.

Tin is an infrequently examined metal in Columbia River Estuary sediments. Organotin compounds are used in anti-fouling paints, so their presence in sediment is a potential problem near boat yards or marinas. The family of organotins most frequently cited as a concern are tributyltins. It is not an EPA priority pollutant, and water quality criteria are not established for it. There are no sediment quality guidelines for tin compounds in either Oregon or Washington that are applicable to the Columbia River Estuary. PSDDA establishes an additional testing threshold for tributyltin in Puget Sound sediment of 30 mg/kg.

Chemical Factors: Organics

Organic compounds are chemicals containing carbon. They include many pesticides, industrial solvents, petroleum products, and PCBs, among other compounds. Organic compounds in sediment are typically measured using a gas chromatograph/mass spectrophotometer (GC/MS). This method, and the quality control/quality assurance measures that accompany it, are well-documented by all qualified labs. Documentation should be included in the lab report on organic compounds in test sediment. Sediment samples collected for organic analysis are stored in glass containers, and refrigerated. Some of the volatile compounds begin to break down after 14 days, so analysis must begin as soon as possible after collection.

Three groups of organic compounds in sediment have drawn regulatory attention in the Columbia River Estuary: PCB, DDT, and Dioxin. Polychlorinated biphenols (PCBs) are a group of about seventy closely related organic compounds consisting of carbon, hydrogen and chlorine. PCBs are not water soluble, and can persist in the food chain. Their principal use is as an insulating fluid in electrical transmission and generating equipment. PCBs are suspected of causing cancer in humans. The insecticide DDT has been banned for use in the United States for several years, but it persists in the aquatic environment. DDD and DDE, two decomposition products of DDT, are also found in Columbia River Estuary sediment. DDT, DDE, and DDD have been implicated in the decline of the northern bald eagle population in the estuary. Dioxin is a byproduct of the bleaching process used by the pulp and paper industry. It may also enter the environment through other avenues. While PCBs and DDTs are frequently targeted in sediment analysis, dioxin content is rarely measured. Dioxin analysis is expensive compared to analysis for other organic compounds. Dioxin is highly toxic, and debate currently revolves around its fate in the aquatic environment.

The most frequently targeted organic compounds in Columbia River sediment are:

- Aldrin
- Chlordane
- DDT
- DDD
- DDE
- Methoxychlor
- 2,4-D (Silvex)
- Heptachlor
- Acenaphthene
- Phenanthrene
- PCBs

- Naphthalene
- Acenaphthylene
- Fluorene
- Phenanthrene
- Anthracene
- Methylnaphthalene
- Fluoranthene
- Pyrene
- Benzo(a)anthracene
- Chrysene
- Benzofluoranthenes
- Benzo(a)pyrene
- Indeno(1,2,3-c,d)pyrene
- Dibenzo(a,h)anthracene
- Benzo(g,h,i)perylene
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 1,2-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- Hexachlorobenzene
- Dimethyl phthalate
- Diethyl phthalate
- Di-n-butyl phthalate
- Butyl benzyl phthalate
- Bis(2-ethylhexyl)phthalate
- Di-n-octyl phthalate
- Phenol
- 2 Methylphenol
- 4 Methylphenol
- 2,4-Dimethylphenol
- Pentachlorophenol
- Benzyl alcohol
- Benzoic acid
- Dibenzofuran
- Hexachloroethane
- Hexachlorobutadiene
- N-Nitrosodiphenylamine
- Trichloroethene
- Tetrachloroethene
- Ethylbenzene
- Total xylene
- Dieldrin

The organic compounds in the left-hand column are those listed in the Oregon Department of Environmental Quality's (ODEQ) draft "Interim Sediment Quality Guidelines". Except for the herbicide silvex (2,4-D), the compounds in the left-hand column are also routinely tested in Puget Sound sediment under the Puget Sound Dredged Disposal Analysis (PSDDA). The compounds in the right-hand column are also listed by the PSDDA program, but are not listed by ODEQ.

Although the PSDDA program is not applicable to the Columbia River Estuary, Federal regulatory agencies such as the Environmental Protection Agency, and the Washington Department of Ecology will sometimes use it as a guide for sediment evaluation outside of Puget Sound.

Biological Factors

Biological testing constitutes the fourth and final tier in the tiered sediment evaluation methodology. Biological tests provide a better basis for sediment evaluation than do the other parameters described above. Bioassay and bioaccumulation studies are relatively expensive, however, and their results are subject to interpretation. Two kinds of biological studies are considered here: bioassay and bioaccumulation. A bioassay is a laboratory test used for evaluating the toxicity of a sediment sample on aquatic organisms. Behavioral, physiological, or lethal response is measured. Bioaccumulation means the build-up of chemical compounds in an organism's tissues. A bioaccumulation study exposes aquatic organisms to a test sediment in the laboratory, and then analyzes their body tissues for contaminants. A third type of biological test is disposal site monitoring. Disposal site monitoring is essentially an on-site experiment that, unlike the bioassay and bioaccumulation studies mentioned above, relies on actual site conditions and disposal conditions. It also differs from the two tests mentioned above in that the results can only be made available after dredging and disposal have been conducted. Monitoring is more likely to be a condition on an approved permit for in-water disposal, and it is not addressed in this document for that reason. Bioassay and bioaccumulation studies, the conditions under which they may be required, and the standards used for interpreting these tests, are described in this section.

A bioassay is a laboratory test that assesses sediment toxicity by measuring changes in organisms exposed to a test sediment. The test is done by a qualified lab, in aquaria. Several different kinds of bioassay tests can be designed. The principal variables are the species used as test organisms; the length of the test; the nature of exposure to test sediment; and the type of response measured.

Bioaccumulation tests measure the accumulation of sediment contaminants in a test organism's tissues. Bioaccumulation test results report the levels of contaminants in test organism tissues in units of weight of chemical per wet weight of tissue. Bioaccumulation tests help determine whether a sediment contaminant is likely to accumulate in the aquatic food chain, but do not necessarily help evaluate sediment toxicity. There are no standards for bioaccumulation tests on Columbia River Estuary sediment evaluation. The Puget Sound Dredged Disposal Analysis (PSDDA) has developed standards applicable in Puget Sound. These are summarized in the PSDDA report "Unconfined Open-water Disposal of Dredged Material, Phase II" (U.S. Army Corps of Engineers, 1989c).

Both the bioassay and the bioaccumulation study need to be professionally interpreted. Sophisticated biostatistical analytical techniques are often applied. The lab report for a bioassay or bioaccumulation study should include test results, as well as analysis of the results.

2.2. Sediment Data Collection: Sampling and Analysis Considerations

A number of factors need to be considered when preparing to collect sediment information. Chief among these are:

quality control/quality assurance;

sampling strategies;

chemical analysis; and

biological tests.

These four factors are described in this section.

Quality Control/Quality Assurance

Appropriate quality assurance and quality control (QA/QC) procedures ensure that the resulting sediment quality data are of an acceptable level of quality, and that the level of quality attained is well-documented. Quality assurance refers to the total integrated program for assuring the reliability of monitoring and measurement data. It is a system for integrating the quality planning, quality assessment, and quality improvement efforts to meet user requirements. Quality control is the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.

Laboratories and consultants involved in the collection, analysis and interpretation of sediment quality data should document their QA/QC efforts in their reports. Some examples of such documentation include:

A chain-of-custody form that follows sediment samples from their collection point to the analytical lab;

Calibration schedules for the analytical equipment used in chemical and biological tests;

References for analytical methods used; and

Accurate records of sampling station location.

It is assumed that good QA/QC procedures have been followed. When they have not been followed, or when they can not be documented, the validity of the sediment data can be questioned.

Sampling Strategies

A number of factors should be considered when developing a sediment sampling strategy. The overall goal of the strategy should be to generate sediment quality data that are useful to the sediment evaluation process and that meet regulatory agency needs. For this reason it is essential that sediment sampling plan development be coordinated with resource agency staff. A sampling plan should consider:

The volume of sediment to be disposed of in-water;

The size of the area to be dredged;

The maximum depth of dredging; and

The type of analytical work needed (such as chemical or biological analysis).

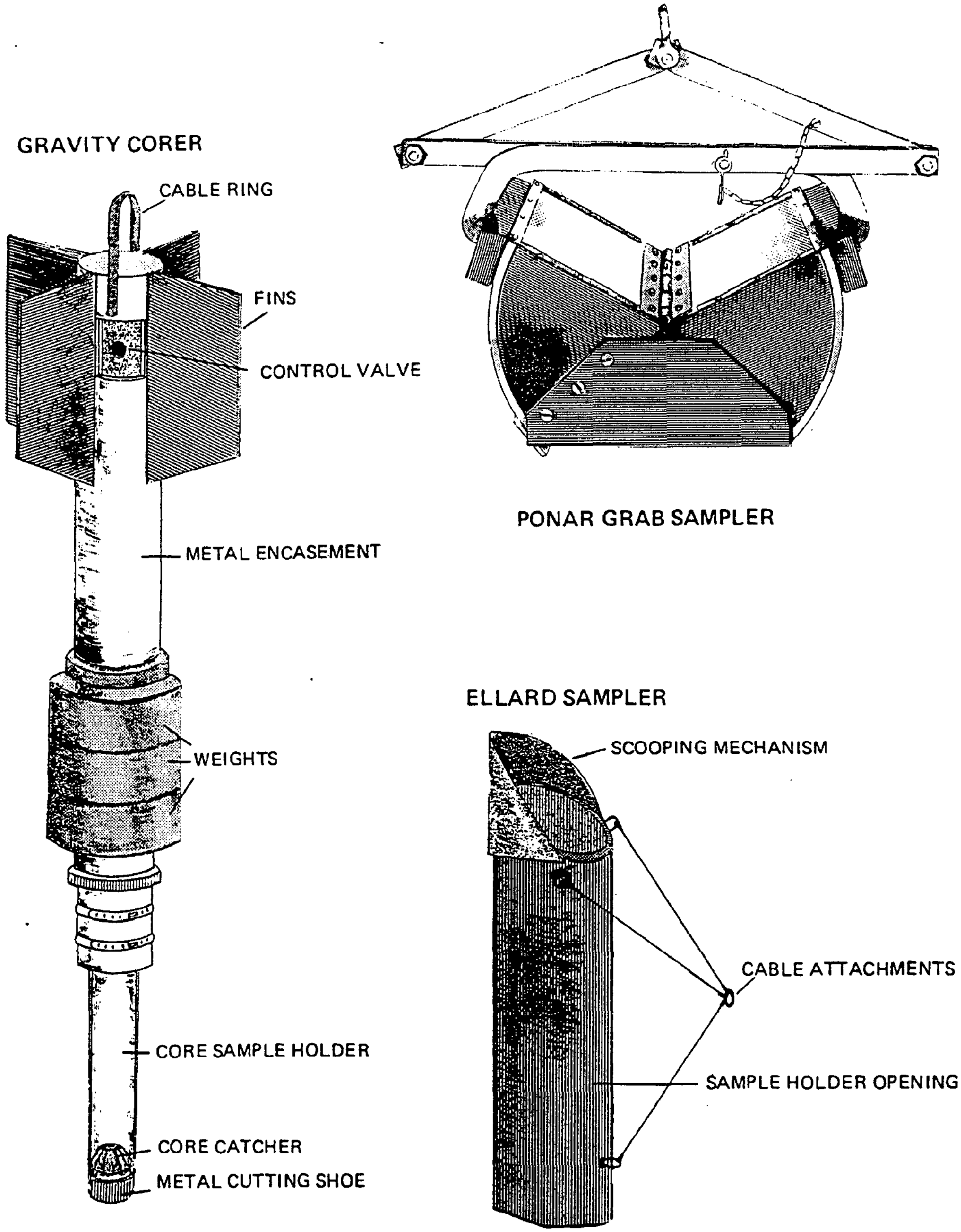
These are reviewed in the following paragraphs.

Disposal volumes and sampling requirements are closely related. Larger projects require more extensive sampling than smaller projects. The Puget Sound Dredged Disposal Analysis (PSDDA) program has established a guideline of one sediment sample for each 8,000 cubic yards of sediment to be disposed of in-water. This is a guideline, and not a regulation; and it is not applicable to dredging and disposal conditions in the Columbia River Estuary. Dredging volumes in the Columbia River Estuary are generally larger than in Puget Sound, so a ratio of one sample per 10,000 or even 20,000 cubic yards may be more representative of actual practice. Most sampling plans rely on at least three or four samples, regardless of the disposal volume.

The size of the area to be dredged is related to disposal volume and comes into consideration when determining the number of sediment samples needed, and when determining sample location. A preliminary estimate of sediment homogeneity may be helpful. If site conditions are believed to be unchanging over the entire site, a minimal number of samples may adequately characterize site sediments. If parts of the site are known or suspected to have distinctive sediment or water quality characteristics, a more thorough sampling plan may be appropriate. For a very large project, a reconnaissance sampling/analysis effort may be needed to help design the full sampling plan. The sampling density is difficult to subjectively link to the dredging site size. Statistical analysis is of little help, because it results in a prohibitively large number of samples for most projects. Sample location requirements are equally unclear. Sample locations should be evenly spread throughout the dredging area. The location of each sampling station should be accurately fixed on a dredging site map using compass bearings or LORAN readings.

Dredging depth affects the depth of the sampling effort and, at some point, the number of samples needed. Samples should be taken to the same depth as the proposed dredging. This will account for layers of sediment with differing characteristics. Dredging more than approximately 30 centimeters will require core samples rather than grab samples (see Figure 3 for the different kinds of sampling equipment) to obtain the necessary depth. It may also be necessary to subsample a core at different depths: at 30 centimeter depth increments for example. This allows comparison of sediment characteristics throughout the proposed dredging depth.

Figure 3: Sampling Equipment



The number of sediment samples collected and the number of analyses conducted is not necessarily the same. As mentioned above, a single deep sample may result in several sediment analyses, each at a different depth. Several samples from a dredging site may be mixed together in the lab for a single analysis. This is often described as "compositing" samples. Compositing has a number of potential advantages. It can result in relatively lower costs because the cost of collecting a sediment sample is often less than the cost for a single analysis. A large site may also be better characterized by, for example, ten samples composited for five analyses rather than seven samples individually analyzed. The risks involved in compositing are that differences in sediment characteristics between the sampling stations are masked. A single "hot spot" in one sample may be interpreted as wide spread low-level contamination in a composited analysis.

The analytical purpose for collecting sediment samples should be considered when developing a collection plan. Sediment for metal and organic compound analysis requires special handling methods not needed for sediment grain size analysis. The lab performing the analysis should describe collection, handling, storage and labeling procedures before collection begins. Sediment collected for grain size analysis requires fewer special handling considerations than does sediment for organics analysis or biological tests.

Chemical Analysis

State or federal resource agencies may indicate which chemicals need to be evaluated. More often, it will be up to the permit applicant or their consultant to suggest a list of target chemicals for analysis, and seek agency agreement on the list. Section 2.1. of this report lists a number of metals and organic compounds that have been targeted in Columbia River Estuary sediment tests. These lists are not exhaustive, and special circumstances may require that additional chemicals be targeted. It may be cost-effective for a permit applicant to order the full array of metals and organics tests even if the resource agencies are not requiring it. If an initial sediment analysis reveals elevated levels of, for example, mercury, resource agencies may then require a more exhaustive analysis of organic compounds. Because sediment samples have a finite shelf life, this may require collection of a second group of sediment samples.

Detection limits must be established. The lab, permit applicant, and resource agencies must all agree on detection limits for each compound. This may be difficult to achieve. The Puget Sound Dredged Disposal Analysis (PSDDA) program has established detection limits for a number of compounds of interest in Puget Sound. Labs in Washington, the Washington Department of Ecology, and federal agency staff are all aware of these detection limits. Some Oregon labs may not be familiar with the sample preparation measures needed to achieve the PSDDA detection limit. These differences must be resolved before the analyses are ordered if expensive retesting is to be avoided.

The type of chemical analysis needed -- bulk tests, elutriate tests or both -- need to be established. Bulk sediment tests are generally, but not always, preferred by the resource agencies.

Biological Tests

Data from the lower tiers may suggest that biological tests are needed. The type of biological test, the species involved, duration, and other special conditions need to be established with the resource agencies. Some of the considerations for chemical analysis apply if a bioaccumulation study is necessary: detection limits and target compounds must be established. The test organism, exposure method, and test duration must also be specified. Often additional test sediment from the dredge site will be needed, and this test sediment may need to be chemically analyzed. A bioassay test will require that some of the same kinds of decisions be made. The consultant or lab performing the biological tests may suggest appropriate test procedures to the resource agencies, or everyone may agree on one of several standard biological test protocols.

2.3. Sediment Quality, Summary

Developing adequate sediment quality data is one of the most essential, and most difficult, parts of the in-water disposal permit process. Despite the ambiguities involved in identifying agency data needs, there are measures that will improve the efficiency of the permitting processes. These are summarized below.

A sediment sampling and analysis plan should be developed prior to submitting permit applications if physical, chemical, or biological data are likely to be needed.

Sediment data collection should be structured so as to avoid repeat sample collection or analysis. In most cases, it is more cost effective to collect and analyze the largest number of sediment samples for the widest range of chemicals, rather than sample and analyze twice.

3. PERMIT PROCESS

The permit process for in-water disposal of Columbia River sediment is complex. This chapter provides procedural and substantive information about the permit process. Most in-water disposal projects on the Columbia River Estuary will require a federal permit, one or more state permits, and a local permit. For projects that occur in both states (such as dredging in Washington waters and disposal in Oregon waters), additional permit review will be required. Despite the number of permits involved, the different agencies coordinate their permit review efforts reasonably well. The permits needed for in-water dredged material in the Columbia River Estuary are described in this chapter.

3.1. Section 404 Permit

All in-water dredged material disposal in the Columbia River Estuary will require a permit issued by the US Army Corps of Engineers. These permits are issued under the Federal Water Quality Act, and are known as Section 404 permits, after the section of the Act that describes the permit process. This section provides some background and procedural information about Section 404 permits.

All Section 404 permits on the Oregon side of the Columbia River Estuary are managed by the Corps' Portland District office. The Portland District also manages Section 404 permits on the Washington side of the estuary when a port district is involved. Other Washington side permits on the Columbia River Estuary are administered through the Corps' Seattle District office. Although the review process is the same, the Portland and Seattle District use different application forms (Figures 4 and 5).

Water quality concerns associated with in-water dredged material disposal are normally addressed during review of a Section 404 permit primarily through the Section 401 water quality certification process. The Oregon Department of Environmental Quality and the Washington Department of Ecology share Section 401 water quality certification responsibilities on the Columbia River Estuary. The section 401 process certifies that the applicable state water quality standards will not be violated by the dredging or disposal of contaminated sediments. Many dredging and disposal projects in the Columbia River Estuary will affect water in both states. In these cases, water quality certification should be obtained from both Oregon and Washington. This is rarely done: more typically, only the state where the dredging or disposal actually occurs issues a Section 401 certification. Federal agencies are also involved reviewing water quality issues, particularly the U.S. Environmental Protection Agency (EPA).

Section 401 water quality certifications can be denied for lack of sufficient data, as well as when disposal would violate water quality standards. The need for decision making information for the Section 401 certification process is the impetus for most of the project-specific sediment testing, both chemical and biological, in the Columbia River Estuary. Providing sufficient data for state water quality certification may, under some circumstances, be one of the most significant and expensive obstacles for a permit applicant to overcome. Chemical analysis of sediments to be dredged biological investigations on the test sediments, pre-dredging surveys of the

JOINT APPLICATION FOR PERMIT

U.S. ARMY CORPS OF ENGINEERS
STATE OF OREGON, DIVISION OF STATE LANDS

WHEREAS Department of the Army permits for proposed work in or affecting navigable waters of the United States, the discharge of dredged or fill material into those waters, and the transport of dredged material for the purpose of dumping it into ocean waters are authorized by Section 10 of the River and Harbor Act of 1899, Section 404 of the Clean Water Act of 1977, and Section 103 of the Marine Protection Research and Sanctuaries Act of 1972, respectively, ---AND---permits for that part of those project activities which includes the removal or fill in the waterways of Oregon of rock, gravel, silt, and clay are authorized by the State of Oregon under O.R.S. 541.605 to 541.695---THIS APPLICATION WILL MEET THE REQUIREMENTS OF BOTH AGENCIES.

For Agency Use Only — Corps of Engineers # ______ Date received ______

For Agency Use Only — State of Oregon # ______ Date received ______

Name of Waterway ______ River Mile ______ Local Name ______

Section ______ Township ______ Range ______

Estimated Starting Date of Project ______ Estimated Completion Date of Project ______

NAME OF APPLICANT ______ | AUTHORIZED AGENT ______

Address ______ | Address ______

City, State, Zip Code ______ | City, State, Zip Code ______

Phone: Work Area ( ) ______ Home Area ( ) ______ | Phone: Work Area ( ) ______ Home Area ( ) ______

PROJECT SUPERVISOR ______ Phone: Work Area ( ) ______ Home Area ( ) ______

PROPERTY OWNER IF OTHER THAN APPLICANT ______ | PROJECT ADDRESS ______

Address ______ | City, County, State Zip Code ______

City, State, Zip Code ______ | Assessor's Records-- Shown on Map # ______ Tax Lot # ______

Phone: Work Area ( ) ______ Home Area ( ) ______ | Name of Subdivision ______ Lot ______ Block ______

In order to expedite the processing of this application, the following city and/or county department, which has local jurisdiction over the proposed project, has been contacted:

Name of Department: ______

Address: ______

Phone Number: ______

APPROVALS OR CERTIFICATIONS applied for or already obtained from other agencies (Federal, interstate, state, county, city, area) for any of the proposed projects described in this application:

Issuing Agency	Type of Approval	Identification #	Date of Application	Date of Approval

NPP Form 358
OCT 1980
141-31-04-80

Inclosure 1

Has any agency denied approval for the activity described herein or for any other activity directly related to it?
☐ Yes ☐ No If yes, please explain in Remarks.

ADJOINING PROPERTY ON THE WATERWAY: Give names, addresses, and phone numbers of owners and/or occupants.

PLEASE EXPLAIN IN DETAIL your plans to restore the area to its natural condition.

INFORMATION FOR FILL OR REMOVAL:

FILL WILL INVOLVE ______ cubic yards annually, and ______ cubic yards for the total project.

☐ Riprap ☐ Rock ☐ Gravel ☐ Sand ☐ Silt ☐ Clay ☐ Organic

REMOVAL WILL INVOLVE ______ cubic yards annually, and ______ cubic yards for the total project.

☐ Rock ☐ Gravel ☐ Sand ☐ Silt ☐ Clay

DESCRIBE IN DETAIL THE PROPOSED ACTIVITY---its primary purpose and secondary purpose, if any.---intended use (private, public, commercial)---type of structures and use---type of vessels using facility---facilities for handling wastes---type of conveyance and manner of extraction of any fill or removal---the quantity and composition of, and the source and disposal sites for any fill or removal. (If additional space is needed, use plain sheet of paper.)

Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that, to the best of my knowledge and belief, such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities.

______
Signature of Applicant or Authorized Agent

18 USC 1001 provides in part: "Whoever, in any manner within the jurisdiction of any department . . . of the United States knowingly and willfully falsifies . . . a material fact or makes any false . . . statement or . . . uses any false . . . document . . . shall be fined not more than $10,000 or imprisoned not more than five years, or both."

Figure 4: Portland District Corps of Engineers Section 404 Permit Application

APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT
(33 CFR 325)

OMB APPROVAL NO. 0702-0036
Expires 30 June 1989

The Department of the Army permit program is authorized by Section 10 of the River and Harbor Act of 1899, Section 404 of the Clean Water Act and Section 103 of the Marine, Protection, Research and Sanctuaries Act. These laws require permits authorizing activities in or affecting navigable waters of the United States, the discharge of dredged or fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Information provided on this form will be used in evaluating the application for a permit. Information in this application is made a matter of public record through issuance of a public notice. Disclosure of the information requested is voluntary; however, the data requested are necessary in order to communicate with the applicant and to evaluate the permit application. If necessary information is not provided, the permit application cannot be processed nor can a permit be issued.

One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application *(see sample drawings and instructions)* and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

1. APPLICATION NUMBER *(To be assigned by Corps)*

2. NAME AND ADDRESS OF APPLICANT

Telephone no. during business hours

A/C ( ) ______________ *(Residence)*
A/C ( ) ______________ *(Office)*

3. NAME, ADDRESS, AND TITLE OF AUTHORIZED AGENT

Telephone no. during business hours

A/C ( ) ______________ *(Residence)*
A/C ( ) ______________ *(Office)*

Statement of Authorization: I hereby designate and authorize ______________ to act in my behalf as my agent in the processing of this permit application and to furnish, upon request, supplemental information in support of the application.

SIGNATURE OF APPLICANT | DATE

4. DETAILED DESCRIPTION OF PROPOSED ACTIVITY

4a. ACTIVITY

4b. PURPOSE

4c. DISCHARGE OF DREDGED OR FILL MATERIAL

5. NAMES AND ADDRESSES OF ADJOINING PROPERTY OWNERS, LESSEES, ETC., WHOSE PROPERTY ALSO ADJOINS THE WATERWAY

6. WATERBODY AND LOCATION ON WATERBODY WHERE ACTIVITY EXISTS OR IS PROPOSED

7. LOCATION ON LAND WHERE ACTIVITY EXISTS OR IS PROPOSED

ADDRESS:

STREET, ROAD, ROUTE OR OTHER DESCRIPTIVE LOCATION

COUNTY STATE ZIP CODE

LOCAL GOVERNING BODY WITH JURISDICTION OVER SITE

8. Is any portion of the activity for which authorization is sought now complete? ☐ YES ☐ NO
If answer is "Yes" give reasons, month and year the activity was completed. Indicate the existing work on the drawings.

9. List all approvals or certifications and denials received from other federal, interstate, state or local agencies for any structures, construction, discharges or other activities described in this application.

ISSUING AGENCY	TYPE APPROVAL	IDENTIFICATION NO.	DATE OF APPLICATION	DATE OF APPROVAL	DATE OF DENIAL

10. Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities or I am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT | DATE | SIGNATURE OF AGENT | DATE

The application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in Block 3 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of The United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

Do not send a permit processing fee with this application. The appropriate fee will be assessed when a permit is issued.

Figure 5: Seattle District Corps of Engineers Section 404 Permit Application

disposal site, and post disposal monitoring may all be required of a Section 404 permit applicant.

The section 404 permit review process is described graphically in Figure 6. The process involves an opportunity for public and agency comment on the proposal. Sediment quality data is reviewed here. Compliance with a number of other federal and state laws is also checked at this stage.

3.2. Washington Hydraulics Project Approval

Applicants for projects on the Washington side of the estuary must apply for a permit under the Washington Hydraulic Code from the Washington Department of Fisheries. A section 404 permit application to the Seattle District Corps of Engineers office is a joint application for this permit. Review is normally concurrent with the federal review. Impacts on fish are this permit's principal focus.

3.3. Washington State Environmental Policy Act (SEPA) Review

The Washington State Environmental Policy Act (SEPA) establishes a review process for projects that may have environmental impacts in the state. In-water disposal of dredged material on the Washington side of the Columbia River Estuary is subject to SEPA requirements. The SEPA process is described in Figure 7. The process starts with completion of an environmental checklist. Review of the checklist by the lead agency, which may be Wahkiakum County, Pacific County, the Department of Ecology or Fisheries, or some other agency, results in either a Determination of Nonsignificance (DNS), or preparation of an Environmental Impact Statement (EIS). Sediment quality may be included in the EIS.

3.4. Proprietary Management of Submerged Lands in Washington

The Washington Department of Natural Resources (DNR) manages state owned submerged lands in the Columbia River Estuary and elsewhere in Washington. DNR administers a program for reviewing use of submerged lands for dredged material disposal that runs concurrently with other state and federal permit programs. In-water disposal of dredged material on the Washington side of the estuary will need to comply with this program.

3.5. Oregon Fill and Removal Permit

The Oregon Division of State Lands administers a permit program for filling and dredging in Oregon waters. In-water dredged material disposal on the Oregon side of the Estuary will require a permit under this program. The US Army Corps of Engineers Section 404 permit application form used by the Portland District office is a joint application for both the Section 404 permit and this permit. Public review and agency comment are required for this permit. The Oregon Department of Fish and Wildlife and Oregon Department of Environmental Quality are the principal commenting agencies for in-water disposal permits under this program.

Figure 6: Section 404 Permit Process

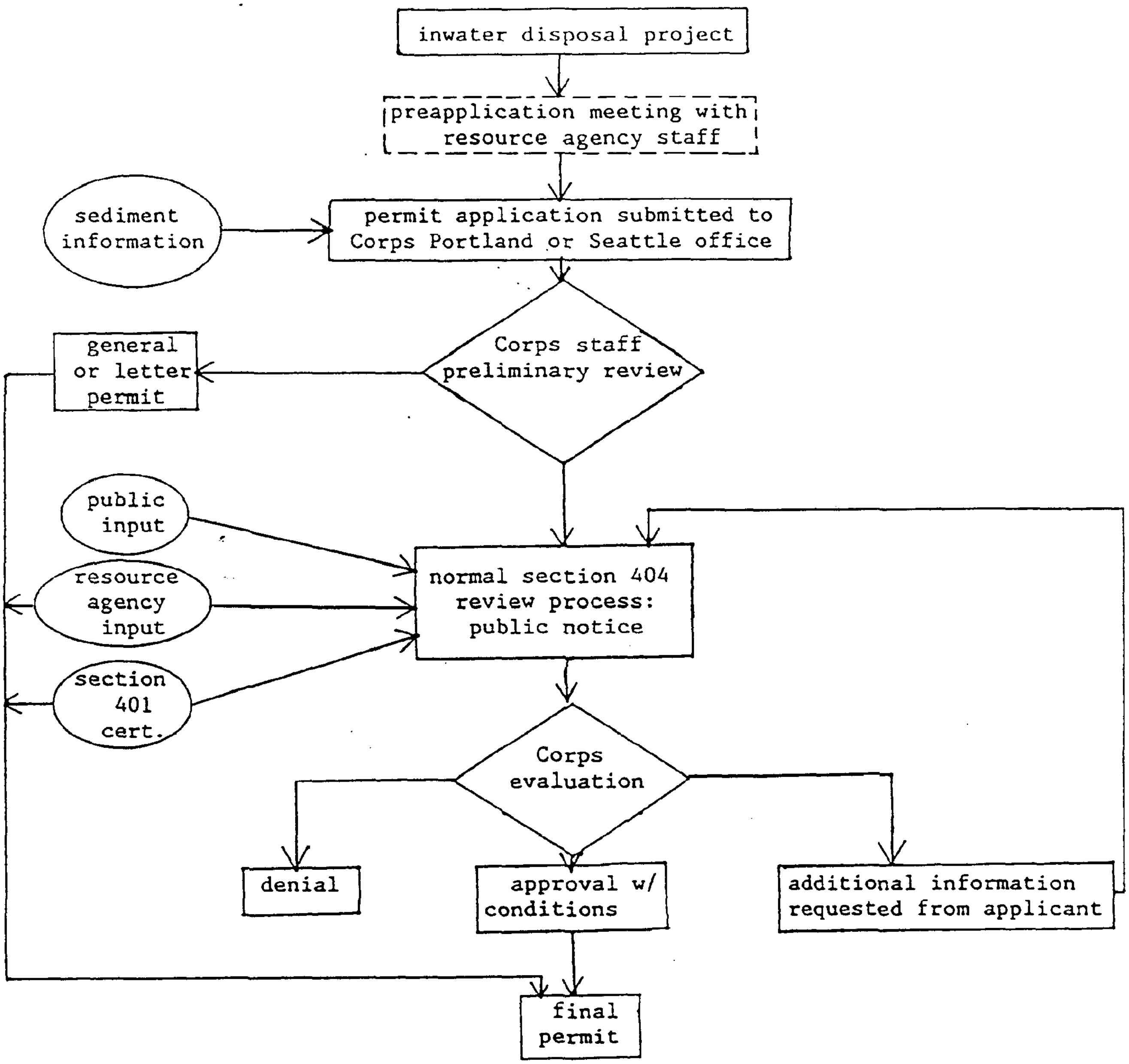
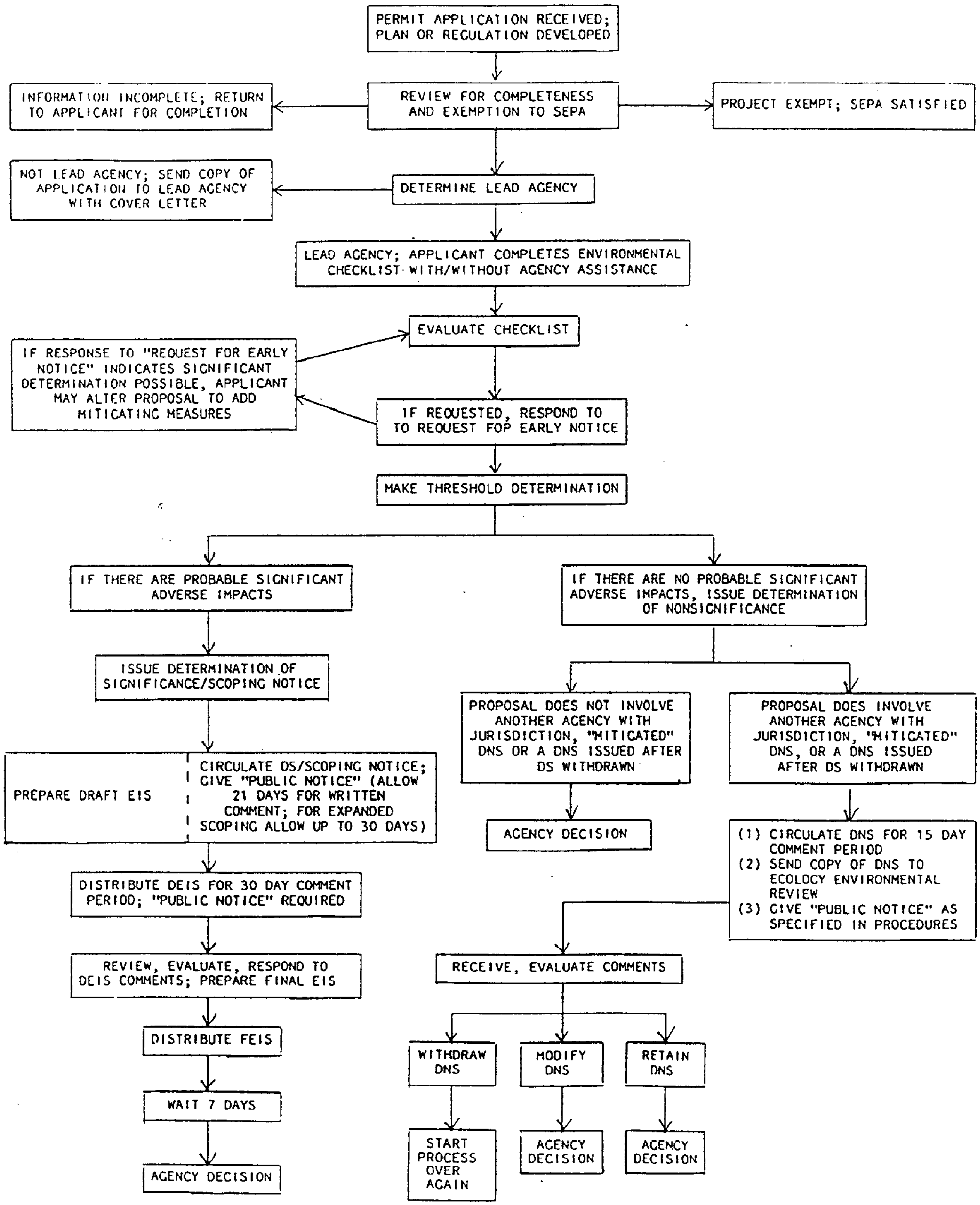


Figure 7: State Environmental Policy Act (SEPA) Review Process



source: Washington Department of Ecology, 1988

3.6. Local Permits

Both Oregon and Washington local governments on the Columbia River Estuary administer local permit processes that affect in-water dredged material disposal within their jurisdiction. Figure 7 graphically describes the basic local permit review process, although there are differences between the way each city and county handle these permits. The most significant of these differences are between Oregon and Washington local governments.

Oregon Local Governments

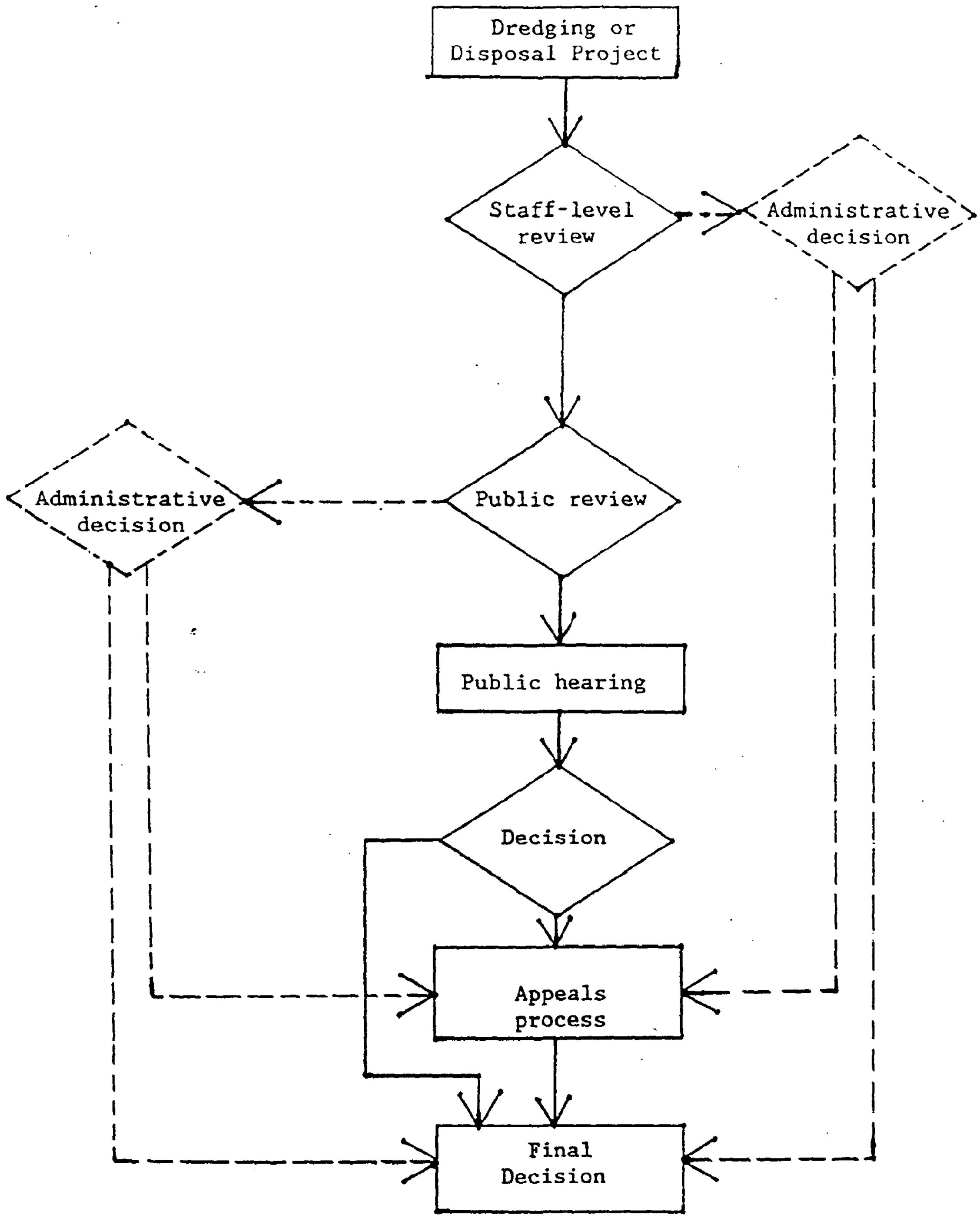
Clatsop County, Astoria, Warrenton and Hammond each administer a comprehensive plan and zoning ordinance that regulates, among a great many other things, in-water disposal of dredged material. Each jurisdiction has adopted a zoning map that designates dredged material disposal sites. These are shown in the CREST publication "Columbia River Estuary Dredged Material Management Plan" (Fox, 1986), and on local zoning maps. Some types of in-water dredged material disposal may be allowed without obtaining a local permit, particularly if it is associated with ongoing maintenance of an existing facility, and disposal occurs at a designated and regularly used site. New projects and changed maintenance disposal methods and sites will usually require approval of a local permit.

The local permit review process in Oregon starts with completion of an application form. The completed form is reviewed administratively, and a permit may be issued administratively without a public hearing in some cases. Most in-water disposal permits will require a public hearing before a planning commission. A permit is issued or denied, which can then be appealed to the city or county governing body. From there the appeal route is to the Land Use Board of Appeals (LUBA), the Court of Appeals, and finally to the State Supreme Court. There have been no LUBA appeals of dredging permits to date. The Oregon Department of Land Conservation and Development monitors local permit activity, but does not have the ability to veto a local permit.

Washington Local Permits

Pacific County, Wahkiakum County, Cathlamet and Ilwaco each administer a Shoreline Master Program that sets up a permit program for, among other things, in-water disposal of dredged material. In-water dredged material disposal sites are designated in the Shoreline Master Programs, and in the CREST publication "Columbia River Estuary Dredged Material Management Plan" (Fox, 1986). Most in-water disposal projects will require a Substantial Development Permit, issued by the county or city planning commission. Permits may be appealed to the State Shoreline Hearing Board, and from there into the State court system. The Washington Department of Ecology can veto a Substantial Development Permit it feels is not consistent with the local Shoreline Master Program. This is a tool that its Oregon counterpart, The Oregon Department of Land Conservation and Development, lacks.

Figure 8; Local Permit review Process



Note: dashed lines indicate a review route not available in all Columbia River Estuary jurisdictions.

3.7. Permit Summary

The permit process for in-water dredged material disposal in the Columbia River Estuary is complex, and there are no shortcuts to the regulatory procedure. There are, however, several courses of action open to a permit applicant that will usually avoid some of the potential problems inherent in a multi-agency regulatory environment. These are summarized below.

Local, state, and federal permits should be requested at the same time, rather than sequentially. These programs are designed to run concurrently.

Pre-application contact with resource agency staff may prove helpful, especially for large projects, or for first-time applicants.

Preparation of a sediment sampling and analysis plan should begin prior to submitting permit applications if sediment physical, chemical or biological data are likely to be needed.

The permit process may take anywhere from two to six months, depending on the complexity of the project, the degree of controversy it generates, and the permit applicant's flexibility.

4. GLOSSARY

Absorption: To be assimilated, taken in.

Accuracy: The closeness of a measured or computed value to its true value.

Acute Effect: A toxic effect on an organism occurring with in a short period of time, usually 96 hours or less.

Adsorption: Dissolved substance becomes bound to the surface of the particle.

Analyte: The specific component measured in a chemical analysis.

Apparat Effects Threshold: The sediment concentration above which statistically significant biological effects would always be expected.

Batch: Usually refers to the number of samples that can be prepared or analyzed at one time. A typical commercial batch size is 20 samples for extraction of organic compounds.

Bedload: Medium to coarse sands transported along the bed bottom.

Benthic Organisms: Organisms that live in or on the bottom of a body of water.

Bioaccumulation: Process by which a chemical accumulates in an organism's tissues.

Bioassay: Test procedure to measure response of living plants, animals or other organisms to a test sediment or elutriate.

Bulk Chemical Analyses: Chemical analyses performed on an entire sediment sample, without separating water from the solid material in a sample.

Blank-Corrected: The concentration of a chemical in a sample adjusted for the concentration of that chemical in the method blank carried through the procedure concurrently with the sample.

Calibration: The systematic standardization of either the response of instruments used for measurements or the chemical separation achieved by a laboratory cleanup procedure.

Chronic Effect: A toxic effect on an organism occurring after chemical exposure of long duration.

Coefficient of Variation: The standard deviation expressed as a percentage of the mean.

Composite: A sediment sample that consists of several samples mixed together; also, the mixing together of two or more sediment samples.

Contaminant: A substance not naturally present in the environment or present in unnaturally high concentrations which can affect the environment.

Contaminated Sediment: A sediment that contains measurable levels of contaminants; or, a sediment that contains sufficient concentrations of chemicals to produce unacceptable adverse environmental effects and thus require restrictions for dredging and disposal.

Control Limit: Defines the minimum quality of data as measured by some indicator (e.g., recovery) required to assume that the system or method is performing as expected. Exceeding a control limit triggers action by the laboratory to correct the problem before data are reported.

Dredged Material: Sediment, gravel and other solids removed from an aquatic area.

Duplicate Analysis: A second analysis made on the same (or identical) sample of material to assist in the evaluation of measurement variance.

Effluent: Water flowing out of a contained disposal facility during and immediately following a disposal operation.

Elutriate: The extract resulting from mixing water and dredged material in a laboratory test. The resulting elutriate can be used for chemical and biological testing to assess potential water column effects of dredged material disposal.

Equilibrium Partitioning: A methodology for estimating the interstitial water concentration of a sediment contaminant.

GC: Gas chromatography. An instrumental technique used to separate a complex mixture into its component compounds by partitioning the compounds between a mobile gaseous phase (under pressure) and a stationary solid or liquid phase.

GC/MS: Gas chromatography/mass spectroscopy. An instrumental technique useful for breaking organic compounds into characteristic fragments that can be used to determine the original structure of the compound.

Inorganic Chemicals: Compounds not containing carbon: includes metals, ammonia, acids used in pulp/paper processing.

Matrix: The sample material in which the chemicals of interest are found (e.g., water, sediment, tissue).

Matrix Spike: An analysis conducted by adding a known amount of chemicals of interest to an actual sample (i.e., matrix), usually prior to extraction or digestion, and then carrying the spiked sample through the analytical procedure. The final matrix spike results are reduced by the amount of each chemical found in a replicate analysis of the sample conducted without spikes. A comparison of these results with the known concentration of spike added to the sample enables an evaluation of the effect of the particular sample matrix on the recovery of compounds of interest.

Method Blank: A measure of the contribution of analytes from all laboratory sources external to the sample. The method blank value is determined by proceeding through all phases of extraction and analysis with no addition of sample.

Method Spike: A method blank to which a known amount of surrogate standards and analytes (compounds of interest) have been added.

NMFS: National Marine Fisheries Service

Noise: The electronic signal intensity attributed to instrument "background" or electronic current from chemical interferents (i.e., any part of an electrical signal that cannot be related in a known way to the electronic signal from a target compound).

ODEQ: Oregon Department of Environmental Quality

ODLCDC: Oregon Department of Land Conservation and Development

ODSL: Oregon Division of State Lands

ODFW: Oregon Department of Fish and Wildlife

Organic Chemicals: Chemicals containing carbon, including plastics, herbicides, rubber, PCB's, or petroleum - related products.

PPB: Parts per billion, or µg/gram.

PPM: Parts per million, or mg/kg, or µg/gram.

Phi: A measurement unit for sediment grain size. Phi = $-\log_2 d$, where d is the grain diameter in millimeters.

Polychlorinated Biphenyls (PCB): A group of manmade organic chemicals, including about 70 different but closely related compounds made up of carbon, hydrogen, and chlorine. If released to the environment, they persist for long periods of time and can concentrate in food chains. PCB's are not water soluble and are suspected of causing cancer in humans. PCB's are an example of an organic toxicant.

Polycyclic (Polynuclear) Aromatic Hydrocarbon (PAH): A class of complex organic compounds, some of which are persistent and cancer-causing. These compounds are formed from the combustion of organic material and are ubiquitous in the environment. PAH's are commonly formed by forest fires and by the combustion of fossil fuels. PAH's often reach the environment through atmospheric fallout, highway runoff, and oil discharge.

Precision: The degree of mutual agreement characteristic of independent measurements as the result of repeated application of a method under specified conditions.

Priority Pollutant: Toxic pollutants defined by the US EPA in 1976 that are the primary subject of regulation of the Water Quality Act. A list of these substances can be found in the Code of Federal Regulations Volume 40, Section 401.15.

PSDDA: Puget Sound Dredged Disposal Analysis

QA/QC: Quality assurance/quality control (see below).

Quality Assurance: The total integrated program for assuring the reliability of monitoring and measurement data. A system for integrating the quality planning, quality assessment, and quality improvement efforts to meet user requirements.

Quality Control: The routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.

Quantification: The determination or expression of the number or amount of a variable.

RM: River Mile

Recovery: The amount of a chemical detected in a sample extract at the end of a procedure relative to the total amount present in a sample before the procedure was begun. Also, the amount of a chemical detected in a sample relative to the amount added (i.e., spike) or known to be present (i.e., in a naturally derived standard reference material). Recovery is usually expressed as a percentage.

Replicate: One of several identical experiments, procedures, or samples. Duplicate is a special case of replicates consisting of two samples or measurements.

Reproducibility: The ability to produce the same results for a measurement. Often measured by calculation of relative percent difference or coefficient of variation.

Semivolatile Organic Compounds: Organic compounds with moderate vapor pressures that can be extracted from samples using organic solvents and analyzed by gas chromatography. Semivolatile organic compounds include the US EPA acid/base/neutral compounds (including pesticides and PCBs) as well as numerous other neutral and organic acid compounds of regional interest (e.g., carbazole, retene, coprostanol, 4-methylphenol).

Sensitivity: Capability of a method or instrument to discriminate between samples having differing concentrations of a chemical. The degree to which an instrument responds to low concentrations of a chemical.

SEPA: Washington State Environmental Policy Act

Significant Figure: A figure(s) that remains to a number or decimal after the zeros to the right or left are cancelled.

Spike: The addition of a known amount of a substance to a sample.

Standard (analytical): A substance or material, the properties of which are believed to be known with sufficient accuracy to permit its use to evaluate the same property of a sample. In chemical measurements, a standard often describes a solution of chemicals, commonly prepared by the analyst, to establish a calibration curve or the analytical response function of an instrument.

Standard (regulatory): A threshold for regulatory action. With respect to sediment evaluation, the amount of a compound that triggers a particular regulatory decision.

Surrogate Spike Compound: A known amount of a compound that has characteristics similar to that of a compound of interest, added to a sample prior to extraction. The surrogate compound can be used to estimate the recovery of chemicals in the sample. These compounds are also called "recovery internal standards".

Target Compounds: The chemicals of interest in a sample that can be quantified relative to response factors of reliable standards (in contrast to tentatively identified compounds).

Tentatively Identified Compounds: Chemicals identified in a sample on the basis of mass spectral characteristics held in common with a reference mass spectra of a known chemical. These compounds cannot be more confidently identified unless a reliable standard of the compound is obtained and is confirmed to co-elute with the tentatively identified compound and generate similar mass spectra using the same gas chromatograph/mass spectrometer.

TOC: Total Organic Carbon

Turbidity: A measure of the amount of suspended material in the water.

USEPA: United States Environmental Protection Agency

US EPA CLP: United States Environmental Protection Agency Contract Laboratory Program.

USFWS: United States Fish and Wildlife Service

Volatile Organic Compounds: Organic compounds with high vapor pressures that tend to evaporate readily from a sample. In this document, volatile organic compounds are the 29 US EPA priority pollutants considered as volatiles (e.g., benzene).

WDOE: Washington Department of Ecology

WDF: Washington Department of Fisheries

WDNR: Washington Department of Natural Resources

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COLUMBIA RIVER ESTUARY
SEDIMENT QUALITY POLICY EVALUATION

December 1989

Columbia River Estuary Study Taskforce

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COLUMBIA RIVER ESTUARY

SEDIMENT QUALITY POLICY EVALUATION

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December 1989

This Project was funded by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C., through a grant made under Section 309 of the Coastal Zone Management Act of 1972, as amended, to the National Coastal Resources Research and Development Institute, Newport, Oregon.

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1. INTRODUCTION

The Columbia River Estuary contains valuable aquatic and biological resources as well as economically significant navigational facilities. Dredging and dredged material disposal needed for maintaining the estuary's navigation channels, turning basins, anchorages and mooring facilities can degrade water quality and harm aquatic organisms. Dredging and dredged material disposal are regulated to assure that these necessary activities are conducted in a manner that minimizes damage to the aquatic environment. The regulatory programs addressing dredging and dredged material disposal are complex; particularly so with respect to in-water disposal of contaminated sediment. This report describes Columbia River Estuary sediment quality evaluation procedures and the dredged material disposal decision-making process. Also suggested are ways that this evaluation and decision-making process might be improved.

1.1. PROJECT DESCRIPTION

This report describes current information on sediment quality and dredging in the Columbia River Estuary. The estuary is defined here as extending from the river mouth upstream to approximately river mile 45 (see Map 1.1). Although Columbia River Estuary sediment is comparatively clean, there is evidence suggesting that some sediment quality problems may be present. These may be localized instances of sediment contamination, or more widespread problems associated with a particular chemical.

This report also describes the current regulatory framework for managing sediment quality in the Columbia River Estuary. Local, state and federal agencies are involved. The regulatory decision-making process for in-water dredged material disposal is complex, but not just because water quality is a complex issue. Three additional complicating factors are also present. The Columbia River Estuary is a bi-state water body, so regulatory agencies from two states are involved. The Washington Department of Ecology and the Oregon Department of Environmental Quality cooperate with each other, but their regulations and administrative procedures are not identical. Sediment quality is a relatively new area for regulatory attention, and regulations are still evolving and being developed. The passage of time will improve this situation. Finally, the Columbia River Estuary is a large and dynamic estuary, and unlike most other estuarine ecosystems in the nation. The aquatic environment in the Columbia River Estuary is significantly different from other marine and estuarine environments, and would be expected to respond differently to sediment quality problems. For these reasons and others, sediment quality regulatory programs are multilayered, evolving, and not necessarily well-matched to Columbia River Estuary environmental conditions. There are, however, procedures that can be followed that will meet all regulatory requirements. Those procedures are described in this report.

This report is one of four documents addressing sediment quality and dredging in the Columbia River Estuary. The other three documents are:

Columbia River Estuary dredging and in-water disposal handbook. (CREST 1989)

Dredging and dredged material disposal policy evaluation. (CREST 1987)

Columbia River Estuary dredged material management plan. (CREST 1986)

All four of these reports are prepared by the Columbia River Estuary Study Taskforce (CREST), a bi-state council of local governments serving communities on the lower Columbia River. This report, as well as the three reports cited above, were funded in whole or in part by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C., through a grant made under Section 309 of the Coastal Zone Management Act of 1972, as amended, to the National Coastal Resources Research and Development Institute, Newport, Oregon.

1.2. CONTENTS

This report is organized into seven chapters. Each chapter is described below, and outlined in the Table of Contents.

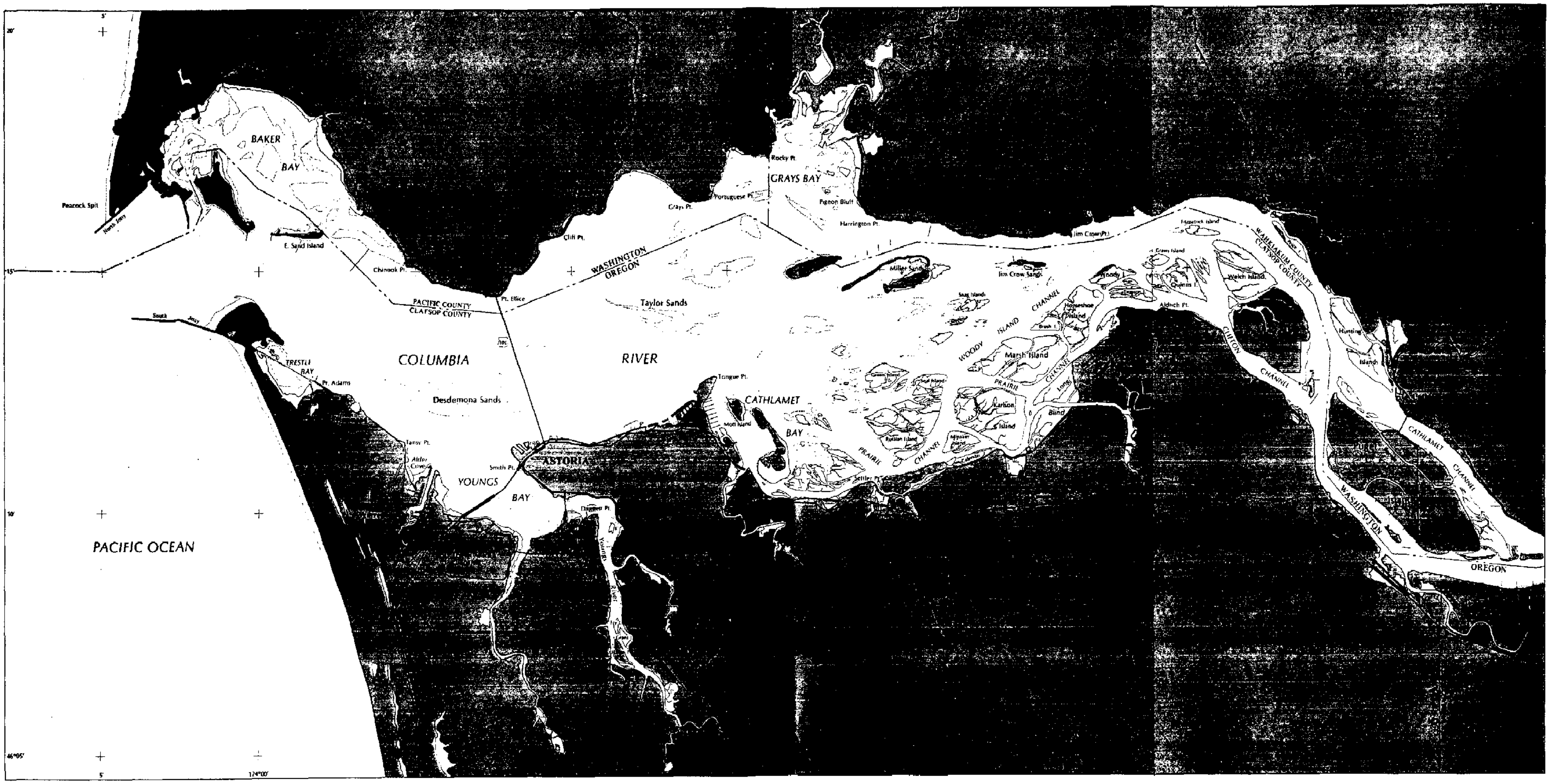
Chapter 2, Review of Dredging Practices and Impacts, summarizes dredging sites, volumes, techniques and disposal methods on the Columbia River Estuary. This chapter also briefly looks at dredging requirements and restraints of other west coast estuaries.

Chapter 3, Sediment Quality Parameters, describes the types of data used for evaluating sediment quality. This data fall into four broad categories or tiers: information about the dredging site, conventional sediment variables (such as grain size), sediment chemistry, and biological data.

Chapter 4, Sediment Analysis, describes some of the sedimentary processes, contaminant sources, contamination trends, and analytical methods germane to the Columbia River Estuary. This chapter summarizes some of the existing sediment contamination data for specific subareas of the Columbia River Estuary.

Chapter 5, Regulatory Environment, reviews existing federal, state, and local legislation and regulatory programs affecting sediment quality management on the Columbia River Estuary. The principal regulatory program is established under the Federal Clean Water Act. The Corps of Engineers Section 404 permit process and the state Section 401 water quality certification process are both products of the Clean Water Act. Several state and local regulatory programs are also relevant to sediment quality management. Chapter 5 also identifies the critical components of the regulatory environment that need to be followed for the Columbia River Estuary. This is complex because the Columbia River Estuary is a bi-state estuary, and because local governments participate in regulation of dredging and dredged material disposal.

Chapter 6 is a glossary of technical terms used in this report and elsewhere. Chapter 7 lists reference documents.



Columbia River Estuary

Scale 1:160,000

0 1 2 3 4 5 6 7 8 9 10 Kilometers

0 1 2 3 4 5 6 Miles

Map produced in 1983 by Northwest Cartography, Inc
for the Columbia River Estuary Data Development Program

Shoreline (limit of non-aquatic vegetation)

Intertidal vegetation

Shoals and flats

Lakes, rivers, other non-tidal water features

Major highways

Cities, towns

Railroads

Other cultural features

2. REVIEW OF DREDGING PRACTICES AND IMPACTS

2.1. INTRODUCTION AND CONTENT

Dredging is the removal of sediment or other material from an aquatic area for the purpose of deepening navigation channels, mooring basins or other navigational, mining or mineral extraction or obtaining fill material. Approximately 2.2 million cubic yards of sediment are dredged annually from the Columbia River Estuary. Dredging activities occur in extensively developed areas as well as in pristine areas. Some of this material is disposed of at upland sites, but a significant portion of the dredged material is disposed of in-water. Sediment contamination levels can range from below detection limits to significantly elevated concentrations. Potential adverse effects of this material on water quality and aquatic habitat raises concerns regarding the policy of in-water disposal and under what circumstances it is appropriate. Dredging and the disposal of the dredged material are generally not allowed in the Columbia River Estuary environments locally designated as Aquatic Natural, but are often permitted in Conservation, Rural, Development and Industrial Zoned Aquatic environments, subject to standards or conditional uses.

In 1986, the Columbia River Estuary Study Taskforce updated the Dredged Material Management Plan of 1979 to establish consistent policies and standards for regulating dredging and dredged material disposal in the estuary and to identify sites that can sufficiently meet projected disposal needs. The revisions were necessary to address federal, state and local changes in policy, dredging needs, and disposal site requirements. Changes in policies concerning water and sediment quality is the impetus for this report. Sediment analysis and monitoring of dredging and dredged material disposal activities are necessary to protect aquatic resources and minimize resuspension and relocation of contaminated sediments. All dredge projects are subject to federal and state regulations and local Comprehensive Plans (Oregon) or Shoreline Management Master Programs (Washington). Dredge projects are also subject to federal and state environmental regulations addressing chemical and physical contamination levels in water and sediments.

2.2. DREDGING

2.2.1 Dredging Practices

Dredge projects in the Columbia River Estuary are performed by the federal government, local governments, ports, private developers and the diking districts. In the Columbia River Estuary the US Army Corps of Engineers maintains the mouth of the Columbia River, the Columbia River Main Navigation Channel, Baker Bay West Channel (16 foot channel to Ilwaco), Chinook Channel, Channel to Hammond Boat Basin, Skipanon Channel and Skamokawa Creek Channel. Dredging of port slips, boat basins and waterward of boat ramps is the responsibility of ports and local governments. Several diking districts in the estuary repair their dikes by dredging adjacent to the repair site and disposing of the material directly on the dikes.

Dredging in the Columbia River Estuary occurs predominantly during the summer and fall months, from May to November when weather conditions and currents are most favorable. Scheduling of dredging projects must consider the weather and currents and minimize impacts on aquatic habitats, migrating and spawning fish, and drift-net fisheries. Between RM 3 and 20, hopper dredges are used exclusively to maintain the mouth of the Columbia River and main navigation channel due to the lack of upland disposal sites in the lower estuary and the large wave and swell action making conditions for pipeline dredging risky. Above RM 20 both hoppers and pipeline dredges are used for maintaining the navigation channel and other navigational projects. Hopper dredges are typically used on small shoals or rapidly forming shoals requiring immediate dredging. Pipeline dredging is limited because disposal areas must be relatively close to the dredging site, however, large volumes of material may be removed in a short period of time. Historically, bucket dredging has not been used for maintaining the deep draft navigation channel, but is used for small dredging projects in confined areas, or when disposal is on adjacent shoreland.

2.2.2 Dredging Impacts

Adverse effects of dredging can include increased turbidity, release of heavy metals, sulfides, organic materials or toxic substances, oxygen depletion, loss of benthic productivity, disruption of the food chain, and disturbance of aquatic habitat. Dredging can alter existing sediment relationships such as particle size distribution, sediment stability and organic carbon content. In areas with high concentrations of contaminants, resuspension in the water column could potentially have a devastating effect on the bioproductivity of the area and potentially expose species that have already been adversely impacted by contaminants (i.e., bald eagles and shore animals feeding on contaminated fish). Dredging in intertidal areas destroys wetlands, shallow water habitats, and migratory and feeding areas for juvenile fish. Impacts on aquatic life and habitats may also affect commercial and recreational fisheries.

2.3. DREDGED MATERIAL DISPOSAL

2.3.1 Dredged Material Disposal Practices

Dredged material from the Columbia River Estuary may be disposed of in-water, which includes flowlane disposal, sump disposal, beach nourishment, ocean disposal and estuarine water disposal. Columbia River dredged material is also disposed of on the landward side of flood control dikes, on shorelands and uplands. The Dredged Material Management Plan lists the current and potential disposal sites in the Columbia River Estuary with capacity to meet at least the disposal requirements through 1992.

The US Army Corps of Engineers follows a disposal regime of like-on-like sediments unless the best disposal alternative, considering all factors, requires mixing particle size distributions. Other factors, such as distance from the dredge site, cost, currents and scheduling requirements are important in determining not only the dredge method but also the disposal site. For example, for ocean disposal to be cost effective, dredging must occur within the first 20 miles of the Columbia River mouth but preferably within the first 10 miles. Dredging projects with proposed ocean disposal must be scheduled to end prior to mid-October. Bar transit becomes hazardous at this time and the increase in transit time and associated costs reduces overall cost efficiency. Upland disposals must not impact wetlands and preferably should occur where the dredged material will restore degraded habitat or where the site's final use will benefit from the deposition. Dredging or disposal activities should also be scheduled so as not to conflict with critical fisheries or other aquatic biological occurrences.

2.3.2. Dredged Material Disposal Impacts

Impacts resulting from disposing of dredged materials are much the same as that resulting from dredging. Additionally, there is a chance for sediments disposed of in-water to be recirculated and redistributed in the estuary resulting in increased shoaling. Material disposed of in-water at a non-dispersive site can cause smothering of organisms at the disposal site and adjacent areas. Disposal islands and beach nourishment sites experience some erosion of the disposed material back into the estuary. The like-on-like disposal regime discussed in the previous section helps to minimize sediment instability and associated adverse impacts from mixing particle sizes. Upland disposal sites must have properly designed drainage systems for adequate dewatering of materials. Spoils containing organic, chemical or other potentially toxic pollutant material must be properly contained to avoid leaching in order to minimize health and environmental hazards.

2.4. DREDGE PROJECT SITES, DISPOSAL SITES AND BIOLOGICAL CHARACTERISTICS

The following tables were compiled from information collected from the Dredged Material Management Plan (Fox 1986), the US Army Corps of Engineers Columbia River Maintenance Disposal Plan, direct communication with the US Army Corps of Engineers Operations Division and miscellaneous reports on specific projects in the Columbia River Estuary that provide information on dredging, dredged material disposal and sediment characteristics.

Table 2.1 provides information pertaining to dredging projects. The sediment volumes dredged through 1986 were obtained from the US Army Corps of Engineers Maintenance Disposal Plan and the Dredged Material Management Plan. Dredge volumes for 1987 and 1988 were provided by the US Army Corps of Engineers and from their Long Term Management Study Phase I Report. The associated sites in Table 2.1 refer to disposal sites used when dredging the referenced site. This information was obtained from the same sources. Sediment characteristics and potential contaminants were obtained from the same sources as well as other reports investigating specific contaminants or particular subareas in the Columbia River Estuary.

Table 2.2 provides information pertaining to dredged material disposal sites currently incorporated into the Columbia River Estuary Dredged Material Management Plan. Most of these sites are shoreland or beach nourishment sites. Flowlane disposal sites are not listed but include a 600 foot wide strip on either side of the Main Navigation Channel; The Environmental Protection Agency's designated ocean disposal sites are included. All dredged material disposals must comply with the dredged material policies and standards of local Comprehensive Management Plans or Shoreline Master Programs and any sediment quality policies that may be adopted by the states. The site designation for Table 2.2 is set up in the following manner:

Example:

Cc - B - 36.8
(Tenasillahe Island)

Key:

Planning Jurisdiction - Type of Disposal Site - Approximate Columbia River Mile

Jurisdiction Abbreviations:

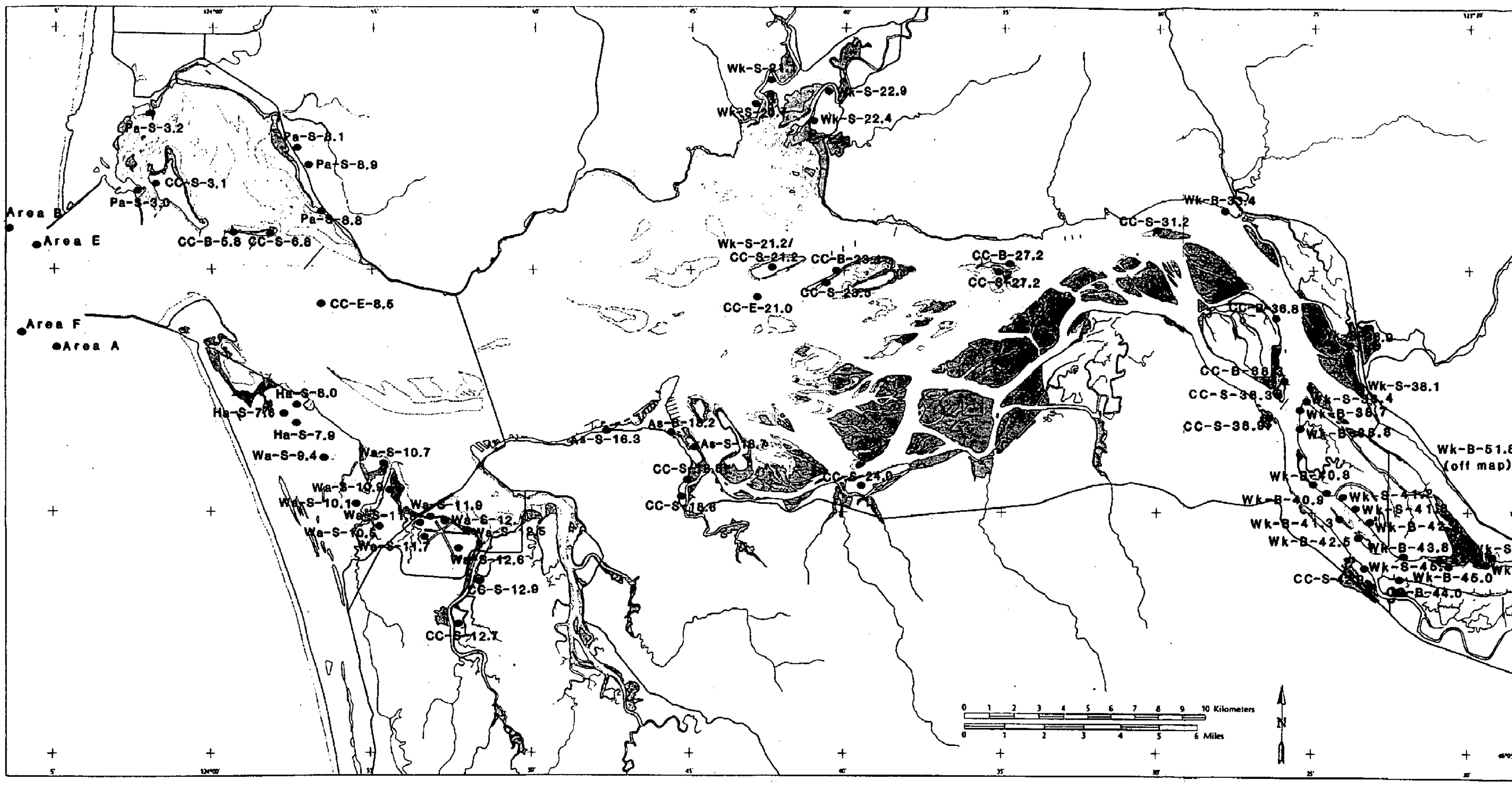
As - City of Astoria
Cc - Clatsop County
Ha - Town of Hammond
Pa - Pacific County
Wa - City of Warrenton
Wk - Wahkiakum County

Disposal Site Abbreviations:

S - Shoreline Disposal
B - Beach Nourishment
E - Estuarine In-Water Disposal
O - Ocean Disposal

Entries in the tables are consecutively ordered by river mile. A map (Map 2.1) is provided showing disposal sites.

Table 2.3 describes the biological characteristics of the disposal sites. The information is a general summary of the aquatic species, birds, mammals, and vegetation at each site or potentially impacted by disposal at the site. There will be other species found at or near the sites which are not included in the list. Many of these species can be found throughout the estuary. Much of this information was compiled from Environmental Impact Statements, the Corps' Long-Term Management Strategy Phase I Report and CREST's Oil Spill Protection Plan for Columbia River Estuary Resources.



Map 2.1: Dredged Material Disposal Sites

TABLE 2.1: DREDGE PROJECT SITES

Dredge Site	River Mile	Amount Dredged	Dredge Method	Depth	Sediment	Potential Contaminants	Associated Sites
MCR		22,056,300m cy 1984 - 1986 32,800 cy 1987	Hopper	55'	Medium to fine sands		Areas A, B, E, F
Baker Bay West	2.5	Average of 33,000 cy/yr 1982-1986	Hopper Clamshell	16'	Medium to fine sand silts and clays	lead, copper, mercury, zinc, iron, nickel	Area D, E
		1985 495,000 cy	Pipeline		West Sand Island - Fine Material		Sand Island
Desdemona Shoal	4.4-10	Approximately 350,000 cy 1985-1987	Hopper	40'	Medium sands		Area D, E
Skipanon Channel and Basin	10.1	Average of 87,000 cy/yr	Hopper Pipeine	30' main-tained at 14'	Fine organic silts	cadmium, copper, lead, chromium, nickel, zinc, wood fiber, sunken logs, jetsam	Area D - uncontaminated Sediments Tansy Point Sump
Flavel Shoal	10-13.6	Average of 600,000 cy per year	Hopper	45'	Medium to fine sands		Area D In-water disposal at Tansy Point Harrington Sump
Upper Sands Shoal	13.6-17.5	183,000 cy in 1986	Hopper	41'	Medium sands		Area D Harrington Sump
Tongue Point Crossing	17.5-21.4	Average of 300,000 cy annually 1982-1987 except for 1.5m cy in 1984	Hopper Pipeline	44'	Medium sands		Harrington Sump Rice Island
Miller Sands	21.4-22.52	675,000 cy/yr from 1982-1988	Pipeline Hopper	45'	Medium to fine sands		Northside Miller Sands Harrington Sump
Harrington Sump	21.0	1.32m cy in 2 dredgings last 5 years	Pipeline to Rice Island		Medium sands		From Harrington Sump to Rice Island

TABLE 2.1: DREDGE PROJECT SITES

Dredge Site	River Mile	Amount Dredged	Dredge Method	Depth	Sediment	Potential Contaminants	Associated Sites
Pillar Rock aka Jim Crow Sands	26.4-27.9	Average of 300,000 cy annually 1982 - 1987	Pipeline Hopper	40'	Medium sands		Jim Crow Sands Flowlane disposal Harrington Sump
Brookfield-Welch Island Reach	28.7-32.2	Average of 110,000 cy annually 1982-1986 50,000 cy in 1987	Pipeline Hopper	40'	Medium sands		Fitzpatrick Island In-water (future)
Skamokawa Bars	32.6-36.6	Average of 179,000 cy each of 3 yrs 1982-1986 2 of 5 yrs 591,000 cy each	Hopper Pipeline	45'	Medium sands		Welch Island Beach Nourishment Price Island Shoreline Replenishment
Skamokawa Creek	33.2	1985 22,000 cy	Pipeline	6.5'	very fine sands silts and clays; medium sands closer to channel	manganese, nickel	W-33.4
Puget Island Bar	37.4-38.4	Average of 181,000 cy each of 3 years 1982-1986	Hopper	40'	Coarse to medium		Tenasillahe Island Beach Nourishment
		Average of 660,000 cy remaining 2 yrs 1982-1986	Pipeline				Lower Puget Island
Wauna and Lower Westport Bars	40.8-44.5	Average of 105,000 cy each of 3 years 1982-1986	Hopper	40'	Coarse to medium		Westport Slough Beach Nourishment
		Average of 521,000 cy each of 3 years 1982-1986	Pipeline		Coarse to medium		Various others see pink book

TABLE 2.1: DREDGE PROJECT SITES

Dredge Site	River Mile	Amount Dredged	Dredge Method	Depth	Sediment	Potential Contaminants	Associated Sites
Westport Bars	44.5-48.2	Average of 560,000 each of 4 yrs 1982-1986	Hopper	40'	Coarse to medium		Sites in Columbia County
		470,000 cy in remaining year 1982-1986	Pipeline				Wk-B-45 Wk-S-45 Wk-S-46.3
Gull Island	48.2-51.9	2 of 5 yrs 67,000 cy each time	Hopper				Sites in Columbia County
Ports; Boat Basins; Boat Ramps							
Ilwaco Boat Basin	4			Channel 16' Mooring Basin 10'	Very fine sand silt and clay	mercury, nickle, cadmium	
Chinook Basin and Channel	5	Average of 26,000 cy/yr 1982-1986	Hopper	10'	Very Fine Sands, silts and clays	arsenic, copper, lead, cadmium	Area D East Sand Island
		1986-124,000 cy	Clamshell				
			Pipeline				
Hammond Boat Basin	7	1982-24,000 cy	Pipeline	10'	Very fine sands silts and clays	copper, cadmium	Ha-S-8.0
Warrenton Boat Basin	11					copper, cadmium	Ha-S-8.0
Youngs Bay	12				Very fine sands, silts and clay	Youngs Bay - nickel, cadmium, copper	

TABLE 2.1: DREDGE PROJECT SITES

Dredge Site	River Mile	Amount Dredged	Dredge Method	Depth	Sediment	Potential Contaminants	Associated Sites
Port of Astoria Slips and Dock	13				Very fine sand silt and clay Sometimes medium, coarse in river adjacent	nickel, arsenic	Flowlane
Tongue Point Channel, piers and turning basin					Fine sand, silt and clay Block of basalt off end of pier 8	cadmium, lead, zinc, nickel	

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
Pa-S-3.0	Spoils since 1979 - None	26.1 acres	420,000 cy	420,000 cy	Pipeline	Baker Bay West Channel
CC-S-3.1 (West Sand Island)	Spoils since 1979 - 420,000 cy	83.3 acres	2.5m cy	2.08m cy	Pipeline	Baker Bay West Channel
Pa-S-3.2		10.7 acres	17,000 cy/year	Stockpiled for reuse	Pipeline	Port of Ilwaco Boat Basin
CC-B-5.8 (East Sand Island)	Spoils since 1979 - None	4,100 feet	450,000 cy	450,000 cy	Pipeline	Port of Ilwaco Boat Basin
CC-S-6.8 (East Sand Island)	Spoils prior to June 1986 - 440,000 cy	18 acres	1.02m cy	580,000 cy	Pipeline (Reserved for fine grained material)	Northern portion of Chinook Channel
Ha-S-7.6	Spoils prior to June 1986 - None	9.5 acres	150,000 cy	150,000 cy	Pipeline	Hammond Boat Basin expansion
Ha-S-7.9 Ha-S-8.0	Spoils prior to June 1986 - 100,000 cy	6 acres	145,000 cy	45,000 cy	Pipeline	Hammond Boat Basin
Pa-S-8.1	Spoils prior to June 1986 - None	143 acres	2.3m cy	2.3m cy		Chinook Channel realignment
CC-E-8.5 (Area D)	Restricted to 650,000 cy/yr or 3.25m cy over 5 yrs	5,000' x 2,000' 38' deep	ACOE 3.25m cy/5yrs Non-Fed 100,000 cy/yr		Hopper fine grained	ACOE-maintenance of Desdemona Shoal, Flavel Shoal, Upper Sands Shoal, Tongue Point Crossing, Chinook Channel, Baker Bay West Channel, Skipanon Channel, Columbia River Bar, Non-federal projects
Pa-S-8.8	Spoils prior to June 1986 - None	3 acres	20,000 cy	Depends on amount removed for reuse		Chinook Channel Chinook Boat Basin

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
Pa-S-8.9	Spoils prior to June 1986 - None	15.3 acres	250,000 cy	250,000 cy		Chinook Channel Chinook Boat Basin
Wa-S-9.4	Spoils prior to June 1986 - None	26 acres	420,000 cy	420,000 cy		
Wa-S-10.1	Spoils prior to June 1986 - None	15 acres	240,000 cy	240,000 cy		Skipanon Channel Warrenton Boat Basin West Bank Skipanon Development
Tansy Point (RM 10.0I W) In-water Disposal	Spoils since 1970 - None	1,500' x 1,700' 45' deep			Hopper	
Wa-S-10.5		70 acres	1.13m cy	1.13m cy		Skipanon Channel Warrenton Boat Basin East & West Bank Skipanon Development
Wa-S-10.7	Spoils since 1979 - - None	4.8 acres	39,000 cy	39,000 cy	Trucked in disposal (possibly to high for clamshell or pipeline	West Bank Skipanon Development
Wa-S-10.9 (East Bank Skipanon Peninsula) (Site 1)	Spoils since 1979 - 300,000+cy	15.5 acres	213,000 cy	None	Pipeline	
Wa-S-10.9 (Site 2)	Spoils since 1979 - 240,000	33.6 acres	461,000 cy	221,000 cy	Pipeline	Flavel Shoal
Wa-S-10.9 (Site 3)	Spoils since 1979 - None	48.8 acres	657,000 cy	657,000 cy	Pipeline	Skipanon Channel, Warrenton Boat Basin, East and West Bank Skipanon Development

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
Wa-S-10.9 (Site 4)	Spoils since 1979 - None	40.5 acres	277,000 cy	277,000 cy	Pipeline	Flavel Shoal
Wa-S-10.9 (Site 5)	Spoils since 1979 - None	50.3 acres	650,000 cy	650,000 cy	Pipeline	Flavel Shoal, Skipanon Channel, East and West Bank Skipanon Development
Wa-S-11.7	Spoils prior to June 1986 - None	32 acres	260,000 cy	260,000 cy		Youngs Bay and River Lewis & Clark River entrance Port of Astoria Maintenance
Wa-S-11.8	Spoils prior to June 1986 - None	131 acres	1.06m cy	1.06m cy		Youngs Bay and River Lewis & Clark River entrance Port of Astoria Maintenance
Wa-S-11.9	Spoils prior to June 1986 - None	10.6 acres	170,000 cy	170,000 cy		Youngs Bay and River Lewis & Clark River entrance Port of Astoria Maintenance
Wa-S-12.1	Spoils prior to June 1986 - None	16.7 acres	135,000 cy	135,000 cy		Youngs Bay and River Lewis & Clark River entrance Port of Astoria Maintenance
Wa-S-12.5	Spoils prior to June 1986 - None	17 acres	137,000 cy	137,000 cy		Youngs Bay and River Lewis & Clark River entrance Port of Astoria Maintenance
Wa-S-12.6	Spoils prior to June 1986 - None	103 acres	831,000 cy	831,000 cy	Pipeline	Youngs Bay and River Lewis & Clark River entrance Port of Astoria Maintenance
Cc-S-12.7	Spoils prior to June 1986 - None	2.9 acres	69,000 cy	69,000 cy	Pipeline	Lewis & Clark log sort yard
Cc-S-12.9	Spoils prior to June 1986 - 2,000 cy	.5 acres	7,400 cy	5,400 cy	Pipeline Clamshell Fine sediments	AMCCO Boat Basin Maintenance
As-S-16.3 (East Mooring Basin)	Spoils from 1979 - 1986 - None	7 acres	112,000 cy	112,000 cy	Pipeline	East Mooring Basin Tongue Point Coast Guard Dock

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
As-S-18.2 (N. Tongue Point)	Spoils prior to June 1986 - None	8 acres	128,000 cy	128,000 cy	Pipeline Clamshell	Tongue Point Development
Cc-S-18.6 (John Day River)	Spoils prior to June 1986 - None	59 acres	845,000 cy	845,000 cy	Pipeline	Tongue Point Development
As-S-18.7 (S. Tongue Point)	Spoils prior to June 1986 - None	59 acres	950,000 cy	950,000 cy	Pipeline	Tongue Point Development
Cc-S-18.8	Spoils prior to June 1986 - None	1.6 acres	27,000 cy	27,000 cy		John Day Boat Ramp Maintenance
Wk-S-20.7 (Deep River)	Spoils prior to June 1986 - None	15 acres	240,000 cy	240,000 cy		Grays Bay Channel Deep River Channel
Cc-E-21.0 (Harrington Sump)	1.32m cy in 2 dredgings last 5 years removed from Harrington Sump	N/A	N/A	N/A dependent on capacity of Rice Island (pipeline from Harrington Sump)	Hopper	Flavel Shoal Upper Sands Shoal Tongue Point Crossing Shoal Miller Sands Bar Pillar Rock
Wk-S-21.1 (Deep River)	Spoils prior to June 1986 - None	22 acres	350,000 cy	350,000 cy		Deep River Channel
Wk-S-21.2 CC-S-21.2 (Rice Island)	12m cy has been disposed of here in last 25 years	250 acres	6.9m cy	To maximum height limit of 45 feet	Pipeline	Harrington Sump (Cc-E-21.0) Miller Sands Bar
Wk-S-22.4	Spoils prior to June 1986 - None	19 acres	307,000 cy	307,000 cy		Grays Bay Channel Grays River Channel
Wk-S-22.9	Spoils prior to June 1986 - None	25 acres	400,000 cy	400,000 cy		Grays River Channel

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
Cc-B-23.1 (Miller Sand Spit)		90 acres	415,000 cy	Limited by erosion	Pipeline	Miller Sands Bar
Cc-S-23.5 (Miller Sand Island)		154 acres		Limited by erosion - approximately 2.0m cy	Pipeline	Miller Sands Bar - some from Tongue Point and Pillar Rock
Cc-S-24.0 (Svenson Island)	Prior to June 1986 - 100,000 cy	282 acres	4.5m cy	4.4m cy		Port of Astoria West Mooring Basin Tongue Point Coast Guard Docks Tongue Point Development
Cc-S-27.2 (Jim Crow Sands)	Prior to June 1988 - 800,000 cy	50 acres		Limited by bank erosion	Pipeline	Pillar Rock Bar
Cc-B-27.2 (Jim Crow Sands)		5,400 feet	300,000 cy			Pillar Rock Bar
RM 27/28) (In-water disposal)	Presently used as relief for Harrington Sump					
RM 29 (B) (Woody Island)	1973 - 110,000 cy					Pillar Rock Bar
Cc-S-31.2 (Fitzpatrick Island)		26 acres	425,000 cy			Brookfield - Welch Island Bars
Wk-B-33.4 (Skamokawa)		3,300 feet	250,000 cy			Skamokawa Creek Improvement Skamokawa Bar

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
RM 34 (B) (Welch Island)	Spoils in 1986 - 435,000 cy					
Cc-B-36.8 (Tennasillahe Island)	Spoils prior to June 1986 - None	2,500 feet	90,000 cy	90,000 cy		Puget Island Bar Skamokawa Bar
Wk-S-36.9 (Elochoman Slough)		7.5 acres	120,000 cy			Elochoman Slough
Wk-S-38.1		3.6 acres	58,000 cy			Cathlamet Boat Basin
Cc-B-38.3		2,400 feet	175,000 cy			Puget Island Bar
Cc-S-38.3		37 acres	595,000 cy			Puget Island Bar
Wk-S-38.4	Spoils from 1979-1986 unknown	8 acres	128,000 cy	Depends on amount removed for reuse	Pipeline	Puget Island Bar
Wk-B-38.7 (downstream Puget Island)		2,900 feet	216,000 cy	Depends on amount removed for reuse	Pipeline	Puget Island Bar
Wk-B-38.8 (downstream Puget Island)		800 feet	62,000 cy		Pipeline	Puget Island Bar
Cc-S-38.9 (Bradwood)	Spoils prior to June 1986 - None	26 acres	420,000 cy	420,000 cy		Water Dependent Development at site Puget Island Bar
Wk-B-40.8 (near Welcome Slough)		900 feet	33,000 cy		Pipeline	Wauna/ Lower Westport Bars
Wk-B-40.9 (near Welcome Slough)		2,500 feet	92,500 cy		Pipeline	Wauna/ Lower Westport Bars

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
Wk-S-41.2 (near Welcome Slough)		5.3 acres	85,000 cy		Pipeline	Welcome Slough
Wk-B-41.3 (Coffee Pot Island)		4,000 feet	148,000 cy		Pipeline	Wauna/Lower Westport Bars
Wk-S-41.8	Spoils prior to June 1986 - None	6.2 acres	100,000 cy	100,000 cy can be used for stockpile	Pipeline	Wauna/Lower Westport Bars
Wk-B-42.4		4,200 feet	310,000 cy		Pipeline	Wauna/Lower Westport Bars
Wk-B-42.5		35 acres	560,000 cy		Pipeline	Wauna/Lower Westport Bars
Cc-S-42.9		95 acres	1.5m cy		Pipeline	Wauna/Lower Westport Bars Westport Slough
Wk-B-43.8 (Pancake Point)		3,250 feet	120,000 cy		Pipeline	Wauna/Lower Westport Bars
Cc-B-44.0 (Westport)		4,600 feet	340,000 cy		Pipeline	Wauna/Lower Westport Bars
Cc-B-45.0		28 acres	450,000 cy			Westport Bars
Wk-B-45.0 (White Island)		5,400 feet	300,000 cy		Pipeline	Westport Bars
Wk-S-46.3		60 acres	960,000 cy		Pipeline	Westport Bars
Wk-B-46.3		6,000 feet	330,000 cy		Pipeline	Westport Bars
Wk-B-51.8		3,100 feet	230,000 cy		Pipeline	Eureka Bar

TABLE 2.2: DREDGED MATERIAL DISPOSAL SITES

Site Designation	Amount Deposited	Area	Total Capacity	Remaining Capacity	Method of Disposal	Associated Sites
OCEAN DISPOSAL						
Area A	Approximately 1m cy	5,000' x 2,000' 67' deep			Hopper (Medium to fine sands)	Mouth of the Columbia River - Bar Channel
Area B	4m cy/year	5,000' x 2,000' 85' - 130' deep			Hopper (Medium to fine sands)	Mouth of the Columbia River - Bar Channel
Area E	Approximately 1m cy	4,000' x 1,000' 70' deep			Hopper (Medium to fine sands)	Baker Bay West Channel Mouth of the Columbia River - Bar Channel
Area F	1.8 mcy 1989	1,800'x 1,800'			Hopper (sandy silt)	Tongue Point Channel, Pier Heads and Turning Basin

Table 2.3: Biological Characteristics of Dredged Material Disposal Sites and Potentially Affected Adjacent Areas

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Pa-S-3.0 Cc-S-3.1 West Sand Island Cape Disappointment	Starry Flounder Salmon Dungeness Crab Northern Anchovy Pacific Herring Shiner Perch Crabs	Seabirds, including: Glaucous-Winged Gull Western Gull Waterfowl Diving Birds, including: Brown Pelicans Wading Birds, including: Great Blue Heron Shorebirds, including: Dunlin Western Sandpiper Sanderling Raptors, including: Bald Eagles	Coyotes Otter	Native sand dune plants European beach grass Hair grasses Forbes
Pa-S-3.2 Ilwaco		Shorebirds, including: Dunlin Western Sandpiper Sanderling Seabirds		
Cc-B-5.8 Cc-B-6.8 East Sand Island	Starry Flounder Salmon American Shad Northern Anchovy Pacific Herring	Seabirds, including: Glaucous-Winged Gull Western Gull Caspian Tern Waterfowl, including: Canada Goose Mallards Pintail Wigeon Surf Scoter	Harbor Seal	European beach grass Hair grasses Forbes Shrubs

Table 2.3:

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Ha-S-7.6 Ha-S-7.9 Ha-S-8.0 Hammond		Waterfowl, including: Surf Scoter Western Grebe Wading birds, including: Great Blue Heron		
Pa-S-8.1 Pa-S-8.9			Muskrat Nutria Raccoon Otter Deer	Sitka Spruce Alder
Pa-S-8.8 Port of Chinook				
Cc-E-8.5 Area D	Starry Flounder Sturgeon Pacific Herring American Shad Salmon Longfin Smelt			
Wa-S-9.4				
Wa-S-10.1				
Wa-S-10.7 West Bank Skipanon River		Water fowl Shorebirds		
Wa-S-10.9 East Bank Skipanon River		Waterfowl Shorebirds Wadingbirds		

Table 2.3:

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Wa-S-11.7 Wa-S-11.8 Wa-S-11.9 Wa-S-12.1 Wa-S-12.5 Wa-S-12.6 Airport		Wading birds, including: Great Blue Heron Waterfowl, including: Canvasback Greater Scaup Scoters Western Grebe Mallard Shorebirds, including: Sanderling Western Sandpiper	Muskrat Nutria Raccoon	Lyngby's Sedge Hairgrass Rushes
Cc-S-12.7 Cc-S-12.9 Lewis and Clark River	Salmon Steelhead		Muskrat Nutria Raccoon	Tufted Hairgrass Lyngby's Sedge
As-S-16.3 East End Mooring Basin				
As-S-18.2 As-S-18.7 Tongue Point	Starry Flounder Salmon Steelhead Cutthroat Trout	Raptors, including: Bald Eagles Osprey Waterfowl, including: Common Merganse Western Grebe Wading Birds, including: Great Blue Heron	Nutria Otter Beaver Muskrat	Lyngby's Sedge Bulrush
Cc-S-18.6 Cc-S-18.8 John Day River	Starry Flounder Salmon Steelhead Cutthroat Trout	Waterfowl, including: Common Merganser Western Grebe Shorebirds, including: Western Sandpiper Dunlin Sanderling Raptors, including: Bald Eagles Osprey	Otter Beaver Muskrat Nutria	Lyngby's Sedge Bulrush

Table 2.3:

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Wk-S-20.7 Wk-S-21.1 Deep River	Starry Flounder Salmon Steelhead	Raptors, including: Bald Eagles Waterfowl Shorebirds, including: Western Sandpiper Dunlin Sanderling	Otter Beaver Muskrat Nutria Deer	Bulrush Lyngby's Sedge Tufted Hairgrass
Cc-E-21.0 Harrington Sump	Starry Flounder Salmon Pacific Herring Cutthroat Trout Steelhead	Diving birds, including: Double-Crested Cormorant Seabirds, including: Glaucous-Winged Gull Western Gull Caspian Tern		
Wk-S-21.2 Cc-S-21.2 Rice Island	Starry Flounder Salmon Pacific Herring	Diving birds, including: Double-Crested Cormorant Seabirds, including: Glaucous-Winged Gull Western Gull Caspian Tern Waterfowl, including: Canada Goose Surf Scoter Snow Goose Western Grebe Common Merganser		Grasses
Wk-S-22.9 Wk-S-22.4 Gray's River	Starry Flounder Salmon Steelhead		Muskrat Nutria Beaver Raccoon Otter Deer	Bulrush Lyngby's Sedge Tufted Hairgrass

Table 2.3:

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Cc-B-23.1 Cc-S-23.5 Miller Sands		Diving birds, including: Double-Crested Cormorant Seabirds, including: Glaucous-Winged Gull Western Gull Caspian Tern Waterfowl, including: Canada Goose Mallard Common Merganser Western Grebe Shorebirds, including: Dunlin Western Sandpiper Sanderling	Nutria Harbor Seal	Lower End - Forbes Upper End - Lupine Velvet grass Red fescue Cottonwoods
Cc-S-24.0 Svenson Island	Starry Flounder Salmon	Raptors, including: Bald Eagles Osprey Waterfowl, including: Western Grebe Mallard Green-Winged Teal Shorebirds, including: Dunlin Western Sandpiper Sanderling Wading Birds	Otter Beaver Muskrat Nutria	Agricultural

Table 2.3:

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Cc-B-27.2 Cc-S-27.2 Jim Crow Sands	Salmon Steelhead Sturgeon Cutthroat Trout	Waterfowl, including: Canada Goose Mallard Western Grebe Common Merganser Shorebirds, including: Dunlin Western Sandpiper Sanderling Raptors, including: Bald Eagles Diving Birds, including: Double Crested Cormorants	Muskrat Nutria	Lyngby's Sedge Bulrush
RM 29 Woody Island	Salmon Steelhead Sturgeon	Shorebirds, including: Dunlin Western Sandpiper Sanderling Raptors, including: Bald Eagles Waterfowl, including: Common Merganser Mallard	Muskrat Nutria	Lyngby's Sedge Bulrush
Cc-S-31.2 Fitzpatrick Island	Salmon Cutthroat Trout	Waterfowl, including: Surf Scoter Mallard Shorebirds, including: Dunlin Western Sandpiper Sanderling Raptors, including: Bald Eagles Wading Birds, including: Great Blue Herons	Harbor Seal Muskrat Nutria	Bulrush Lyngby's Sedge

Table 2.3:

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Wk-B-33.4 Skamokawa	Salmon Cutthroat Trout	Waterfowl, including: Surf Scoter Mallard Raptors, including: Bald Eagles Shorebirds, including: Dunlin Western Sandpiper Sanderling	Beaver Muskrat Nutria	Grasses
Wk-S-38.4 Wk-S-36.9 Elochoman Slough	Salmon Steelhead Cutthroat Trout	Raptors, including: Osprey Bald Eagle	Columbia White-Tailed Deer Muskrat Nutria, Beaver	
Wk-S-38.1 Cathlamet	Salmon Steelhead Cutthroat Trout	Raptors, including: Osprey Bald Eagle	Columbia White-Tailed Deer Muskrat Nutria Beaver	
Cc-B-38.3 Cc-S-38.3 Tenasillahe Island (upper end)	Salmon Steelhead Cutthroat Trout	Waterfowl Raptors, including: Bald Eagles Wading Birds, including: Great Blue Heron	Beaver Muskrat Nutria Raccoon	
Wk-S-38.4 Wk-B-38.7 Wk-B-38.8 Puget Island	Salmon Steelhead Cutthroat Trout	Waterfowl	Columbia White-Tailed Deer	
Cc-S-38.9 Bradwood			Nutria Muskrat	

Table 2.3:

DREDGED MATERIAL DISPOSAL SITES	AQUATIC SPECIES	BIRDS	MAMMALS	VEGETATION
Wk-B-40.8 Wk-B-40.9 Wk-S-41.2 Wk-S-41.8 Wk-B-42.4 Puget Island	Salmon Steelhead Sturgeon	Shorebirds Waterfowl	Raccoon	
Wk-B-41.3 Wk-S-42.5 Coffee Pot Island	Salmon Steelhead Sturgeon	Waterfowl, including, Surf Scoter		
Wk-B-43.8 Wk-S-45 Wk-B-45 Puget Island		Wading Birds, including: Great Blue Heron	Otter Beaver Muskrat Nutria Columbia White-Tailed Deer Raccoon	
Cc-B-44 Westport	Salmon Steelhead Sturgeon	Waterfowl	Columbia White-Tailed Deer	
Wk-S-46.3 Wk-B-46.3 Brown Island	Salmon	Waterfowl Wading Birds, including: Great Blue Heron	Otter Beaver Muskrat Nutria	

Source: Data compiled from US Army Corps of Engineers' Long-Term Management Strategy, 1989; CREST Oil Spill Protection Plan for Columbia River Estuary Resources 1988; and David Fox, Paul Benoit Physical and Biological Characteristics of the Columbia River Estuary by Sub-Region, 1985.

2.5. THE REGULATORY ENVIRONMENT

The Columbia River Estuary, because it spans the state boundaries of Oregon and Washington, is subject to a unique policy and regulatory regime. Any action that might affect the water quality or natural resources of the Columbia River Estuary is subject to review and jurisdictional authority of both Oregon and Washington states. This means that regulatory programs of both states affect dredging, in-water dredged material disposal, water and sediment quality analyses. Yet the states have different requirements regarding permitting procedures, review criteria and allowable contamination levels.

Neither state has established sediment quality guidelines, yet both are in the process of preparing them -- separately. Oregon Department of Environmental Quality is formulating general guidelines to be utilized for testing sediments in Oregon rivers and estuaries. Draft Interim Sediment Quality Guidelines distributed in September 1989 by the Department of Environmental Quality were adapted from the Corps of Engineers Three Tiered Approach. Through the National Estuary Program, the Puget Sound Dredged Disposal Analysis program was initiated by US Army Corps of Engineers, Washington Department of Natural Resources, Washington Department of Ecology and US Environmental Protection Agency to study open water unconfined disposal sites and to develop sediment quality values for use in managing contaminated sediments in Puget Sound. Due to differing physical processes, contamination levels, and regulatory requirements and authorities between Puget Sound area and the Columbia River Estuary, these guidelines may not be appropriate for use in the Columbia River Estuary.

In addition to state jurisdiction and review, dredging and dredged material disposal on the Columbia River Estuary is also subject to federal approval by the Army Corps of Engineers and review by local city and county governments through Shoreline Management Master Programs (Washington) or Comprehensive Plans (Oregon).

The remainder of this chapter briefly summarizes physical processes, dredging requirements, and sediment quality from other west coast estuaries. This information allows a comparison for differentiating dredging needs, requirements and impacts between the Columbia River Estuary and other estuaries. These differences in requirements suggest a need for establishing effective sediment quality guidelines specific to the Columbia River Estuary.

2.6. COMPARATIVE DREDGING NEEDS AND REQUIREMENTS

Dredging maintenance needs and quantities differ from estuary to estuary. The US Army Corps of Engineers currently dredges and disposes of approximately 2.2 million cubic yards of sediment annually from the Columbia River Estuary to maintain the mainstem navigation channel from the mouth to the lower end of Puget Island (RM 39). The Washington Department of Natural Resources estimates approximately 1.13 million cubic yards are dredged annually in Puget Sound (PSWQA, 1986). San Francisco Bay area requires 9 million cubic yards of material to be dredged each year to maintain the bar, navigation channel and access to the ports and harbors (Weightman 1989). Coos Bay, Oregon and Grays Harbor, Washington have approximately 1.4 and 1.8 million cubic yards respectively, dredged annually for channel maintenance. These volumes as well as the content and composition of the dredged sediments are influenced by flow patterns, flushing, sediment transport, erosion and navigational requirements.

2.6.1 Physical Processes

Puget Sound has approximately 75 river systems draining into the Sound area for an average total of 45,000 cfs of fresh water flow. In comparison, the Columbia River Estuary has tremendous flow, discharging an average of 260,000 cfs. The central basin of Puget Sound, however is 600 feet deep, a fjord carved by glacial activity. At the north end where it connects with the Strait of Juan de Fuca there is a shallow sill of 125 feet. This relatively shallow barrier effectively prevents sediments from being carried out to the ocean. The water is diverted and recirculated back into the Sound. Suspended sediments remain in the area and are very likely to settle out. The Columbia River Estuary, however, retains very little of its suspended load.

In San Francisco Bay, tides profoundly affect water movement. The tidal motion, however, is oscillatory with horizontal motions; the motion greatly dispenses sediments, but very little is actually transported out to the ocean. Seventy percent (70%) of the Bay is less than 18 feet deep. Water residence depends on seasonal freshwater flows and is estimated to be from 2 weeks (high flow) to 5 months (low flow) (Sustar, 1982). Most new sediment enters the Bay from the Central Valley drainage basin during periods of high fluvial flow and is deposited in the shallow water areas. A large percentage of the in-flowing sediments remain within the estuary for a number of years. Wave and wind erosion recirculate and resuspend the sediment. Sediment deposited in the deeper channels is influenced more strongly by tidal flows and is eventually transported out of the estuary.

Grays Harbor, Washington is predominantly a shallow basin averaging less than 20 feet deep, although the mouth is approximately 75 feet. The 23 mile navigation channel is maintained at 30 feet. Tidal flows dominate the river flows. The Chehalis River system transports approximately 2 million cubic yards of sediments per year into the estuary. It is also estimated that a similar amount of marine sediments enters the mouth. During the winter months, periods of high fluvial flow, flushing is fairly good throughout the estuary. However, in low flow summer months, flushing and sediment transport out of the estuary is reduced. Suspended sediments tend to settle out in the central harbor. What little sediment is retained in the Columbia River Estuary tends to settle in the peripheral bays and back channels.

2.6.2 Sediment Contamination

Most dredging projects in Puget Sound occur in the active harbors. These areas have been shown to contain high chemical concentrations in the sediments. Contamination levels may be at least 100 times higher than levels found in the cleanest rural bays. The heavily industrialized areas of Seattle and Tacoma are the most contaminated areas thus far studied in the Puget Sound Basin, showing elevated concentrations of arsenic, mercury, silver, cadmium, copper, lead and zinc. High concentration levels of contaminants have been associated with adverse biological effects in fish, including fin erosion, liver tumors and reproduction failures.

The contaminated areas in San Francisco Bay are the enclosed bodies of water within the San Francisco Bay complex, which includes the harbors. Dredging is required to maintain these ports and harbors as well as the navigation channel. In these peripheral areas, the sedimentation rate is higher, energy levels are lower, and sediment composition consists of finer materials, mostly from silt and clay. Heavy metals come primarily from surface runoff as well as fluvial flow from agricultural areas. Chromium, mercury and silver concentrations in San Francisco Bay are high in particular hot spots.

The central portion of Grays Harbor, where the majority of suspended sediments settle out, accumulates contaminants as a result of low fluvial flows and poor flushing. This midreach area has had a history of poor water quality since the earliest recorded measurements. Sediment testing of the midreach area in the early 1980's indicated levels of copper, zinc and PCB's exceeded EPA criteria (AM Test, Inc., 1981).

Felstul's (1988) investigation of Oregon estuaries determined the state's estuaries with the highest metal concentrations. Coos Bay had the highest levels of lead and zinc. Tillamook Estuary had the highest levels of chromium, nickel, and cadmium. Elevated levels of arsenic were found in Chinook Channel, manganese and mercury in Cathlamet Bay, and copper in the Columbia River mainstem channel.

2.7 CONCLUSION AND SUMMARY

Dredging in the Columbia River Estuary is necessary to maintain the navigational channel, the mouth of the Columbia River, and access to the ports and mooring basins. Approximately 2.2 million cubic yards of sediment is dredged annually to preserve the Columbia River as a significant transportation and economic system. Dredging and the disposal of dredged material can have adverse effects on water quality and aquatic habitat, dependent in part on the type of dredging equipment used, disposal methods, sediment quality, and time of year of the project. Some of the adverse effects of dredging and dredged material disposal include increased turbidity, release of heavy metals, organic materials or toxic substances, oxygen depletion, loss of benthic productivity, disturbance of aquatic habitat and recirculation of sediments.

Variable riverflow discharges, tidal motions, geographical locations, industrial pursuits and other human pressures on west coast estuaries affect the amount of material required to be dredged from each estuary and the means by which the material is disposed of. These same parameters also affect the quantities and types of toxic discharges in estuarine areas with a higher probability of pollutant retention. It is important to consider when determining the impacts of dredging and dredged material disposal, the unique resources characteristic of a specific estuary and estuarine subarea as well as the potential cumulative effects and individual elements adversely impacting the estuary's resources.

3. SEDIMENT QUALITY PARAMETERS

Sediment quality can be evaluated against several different parameters. For regulatory purposes, these parameters can be broadly classified as biological, chemical, physical or locational. Sediment quality evaluative parameters are reviewed in this chapter.

Locational factors are addressed in Section 3.1. Locational factors include the wide range of information about sediment quality that can be inferred from a dredging project's location in the Columbia River Estuary. This may include old physical, chemical or bioassay analysis on sediments from the dredging site; historic information about the site's use; or other data about the dredging site that may provide clues to sediment characteristics.

Physical sediment parameters are described in Section 3.2. The principal physical characteristics are sediment grain size data. Grain size data can, within limits described below, be used for predicting chemical contamination in sediment. A number of other factors are also considered in Section 3.2.: oil and grease content, total organic carbon, ammonia content, biochemical oxygen demand, chemical oxygen demand, petroleum hydrocarbons, and dissolved sulfides. These are sometimes referred to as conventional sediment variables.

Chemical parameters are described in Section 3.3. These include metals (beryllium, aluminum, chromium, nickel, copper, zinc, arsenic, selenium, silver, cadmium, antimony, barium, mercury, tin and lead) and organic compounds (for example, insecticides and PCBs). Typically only ten or eleven of the metals are measured. The list of organic sediment contaminants covers nearly 100 compounds. A typical sediment test may examine only a few organic compounds.

Biological data are used for evaluating sediment suitability for in-water disposal. Two different kinds of tests are commonly employed: bioassay, and bioaccomulation studies. A bioassay evaluates the toxicity of a sediment or wastewater by measuring behavioral, physiological or lethal response in test organisms. A bioaccumulation study determines the amount of a chemical accumulated in a test organism's tissue as a result of exposure to a test sediment. Both of these kinds of tests can involve several different species of aquatic organisms. A third type of information focused primarily on biological effects may be obtained from post-disposal monitoring. Biological parameters are described in Section 3.4.

These four data types -- locational, physical, chemical and biological -- can be used in a sequential manner for evaluating sediment quality in the Columbia River Estuary. This sequential approach is sometimes called a tiered approach. Although there are many different ways a tiered approach might be implemented, its basic outline is relatively simple. At each tier a decision is made regarding whether the existing data are sufficient. If they are, there is no need to proceed to the next tier. If not, data at the next tier are required before sediment may be approved for in-water disposal. This tiered arrangement is summarized in Figure 3.3.

3.1. LOCATIONAL FACTORS

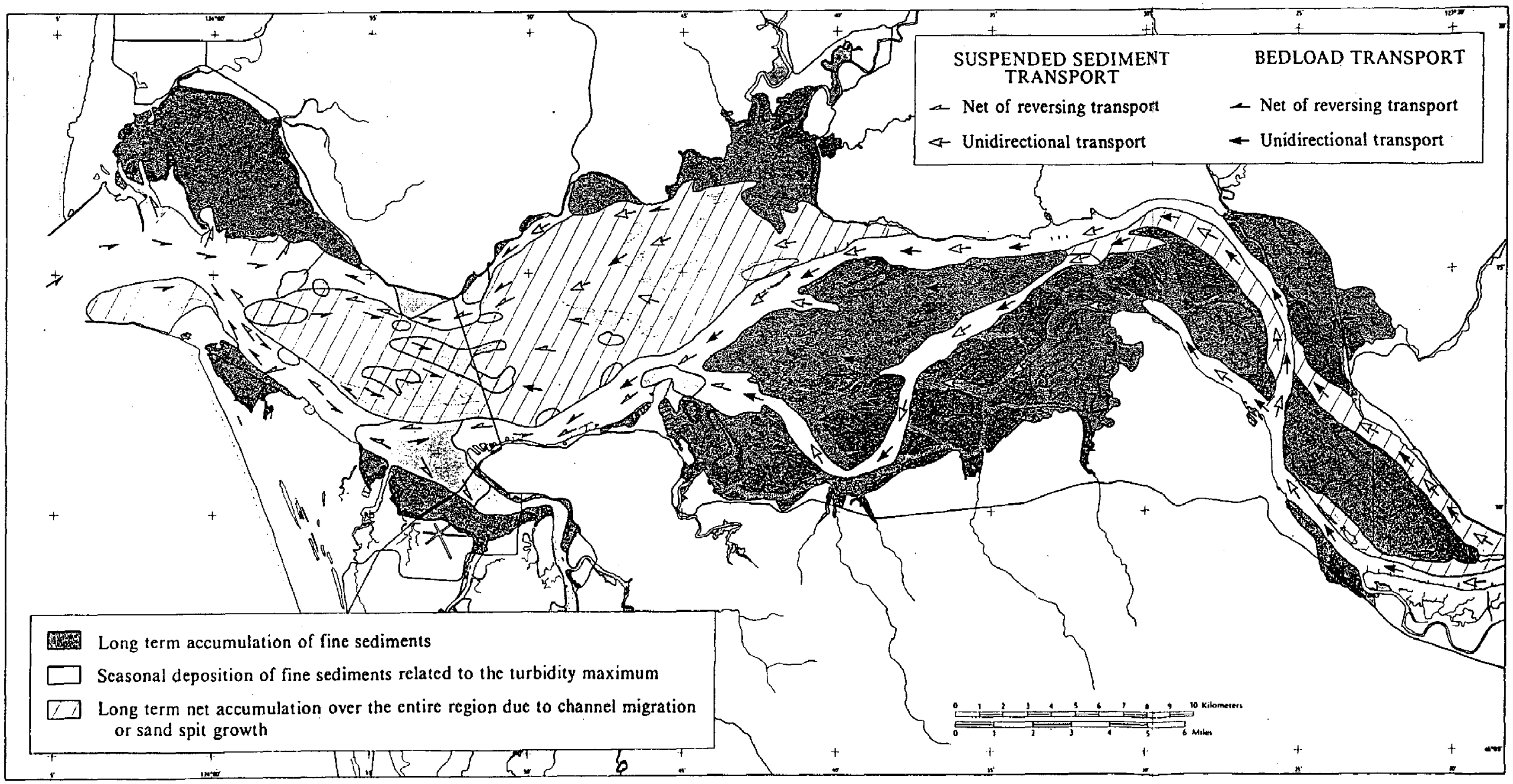
A dredging site's location within the estuary can provide a significant amount of information about the sediments that may be found there. This information, under some circumstances, may be useful for evaluating sediment suitability for in-water disposal. Locational data may also help guide and fine-tune other evaluative efforts. This section examines some locational aspects of sediment characteristics in the Columbia River Estuary for sediment quality regulatory programs.

Areas of fine grain sediment accumulation are generally believed to be areas where sediment contaminants might be found. This is expected because of physical and chemical differences between the different grain sizes: many compounds have electrochemical properties that cause an affinity for fine grain sediment. Existing data tend to support this (for example, Felstul, 1986). Therefore, areas in the estuary with a predominance of coarser grain sediment are likely to be clean, and may not require further evaluation for in-water disposal. Sediment from the main navigation channel typically consists of less than twenty percent silt, clay and finer material, and is usually approved for in-water disposal without detailed physical, chemical, or biological study. Map 3.1 shows generalized sediment characteristics in the Columbia River Estuary. Fine-grain sediments accumulate in shallow areas, semi-enclosed embayments, or other areas not affected by strong currents.

Some sites in the estuary are located near known or suspected sources of contamination. Activities with the potential for generating localized sediment contamination are boat and ship building and repair; marine fuel storage or dispensing; sewage treatment or storm drainage; railroad or highway bridge crossings; and sand blasting. The Columbia River Estuary does not have a long history of urban and industrial activity, so the incidence of sediment contamination related to a specific identifiable activity is low. Because the Columbia River Estuary is downstream from industrial and urban activities in the Portland/Vancouver area, and intensive agricultural activities further upstream, much of the sediment contamination present in the estuary may come from non-estuarine locations.

Historical information may be useful in evaluating sediment quality. Tongue Point sediment, for example, is believed to be contaminated as a result of U.S. Navy activities conducted there after the Second World War. The Pacific Power and Light coal gasification plant in Astoria may be the source of coal tar contamination in a portion of Youngs Bay. Areas of the estuary where boat building or fishpacking has occurred over a long period may be reasonably suspected of retaining sediment contaminants associated with these activities. The fact that these activities have occurred does not by itself imply that sediment from those areas is unsuitable for in-water disposal. Instead, it supports a need for additional information on physical and chemical characteristics of the sediment at the dredge site.

Locational factors are the first tier of a tiered approach to sediment evaluation (see page 3-45, and Figure 3.3). If existing locational data adequately support a decision in favor of in-water disposal, no additional tiers of data are needed. The second tier, consisting of physical parameters, must be evaluated if locational data are inadequate, or if they are unfavorable.



Map 3.1 Patterns of sediment transport and deposition in the Columbia River Estuary (Sherwood et al. 1984).

3.2. PHYSICAL PARAMETERS

Twelve conventional parameters are useful in determining sediment quality. The variables described here include grain size, oil and grease, total organic carbon, volatile solids, pH, total sulfides, total nitrogen, ammonia, biochemical oxygen demand, chemical oxygen demand, petroleum hydrocarbons, and dissolved sulfides. Of these, grain size data are the most frequently measured. With the possible exception of pH, all of these tests are conducted in a laboratory on samples collected in the field. Field sample collection considerations are described in Chapter 5 of this report, and in a separate report: Columbia River Estuary in-water disposal handbook (CREST 1989). Each subsection below describes a physical sediment parameter, its uses and limitations, and typical ranges for the parameter in the Columbia River Estuary.

3.2.1. Grain Size

Sediment in the Columbia River Estuary ranges from gravel-sized material to very fine clay. Table 3.1 summarizes a widely used classification system for sediment. The units in the right-hand column are phi units, named after the 23rd letter of the Greek alphabet. Phi units are defined as:

$$\text{phi} = -\log_2 d$$

where d is the grain size diameter in millimeters.

The phi scale is used because, for most sediment samples, a nearly normal distribution curve results from plotting each size class interval's weight against a logarithmic size scale. The log transformation used to convert diameter measurements to phi units allows a more sensitive statistical description of the size distribution curve (Sherwood, et al. 1984).

Sediment grain size data are often presented as the percent of sand (4 phi and coarser), silt (5 through 8 phi), and clay (9 phi and finer). Greater detail may be collected on the sand and silt fractions; perhaps the percent of a sample in each phi increment. These grain size data are also occasionally presented graphically, using the graphic format shown in Figure 3.1.

The distribution of grain sizes in sediment may vary with the sample location, time of year, and sample depth. Sample location influences grain size characteristics because different locations in the estuary are subject to different current regimes. Generally speaking, areas with stronger currents will have coarser sediment than backwater areas. The estuary's channels have predominantly coarse-grain sediment, while its bays and shallow areas tend toward finer sediment. Current patterns are also subject to seasonal variation, and a site may have significantly different grain size characteristics from one season to the next. The depth of a sediment sample also influences grain size characteristics. This is due to seasonal influences mentioned above, longer-term changes in the estuary's current patterns, and erosion and depositional trends.

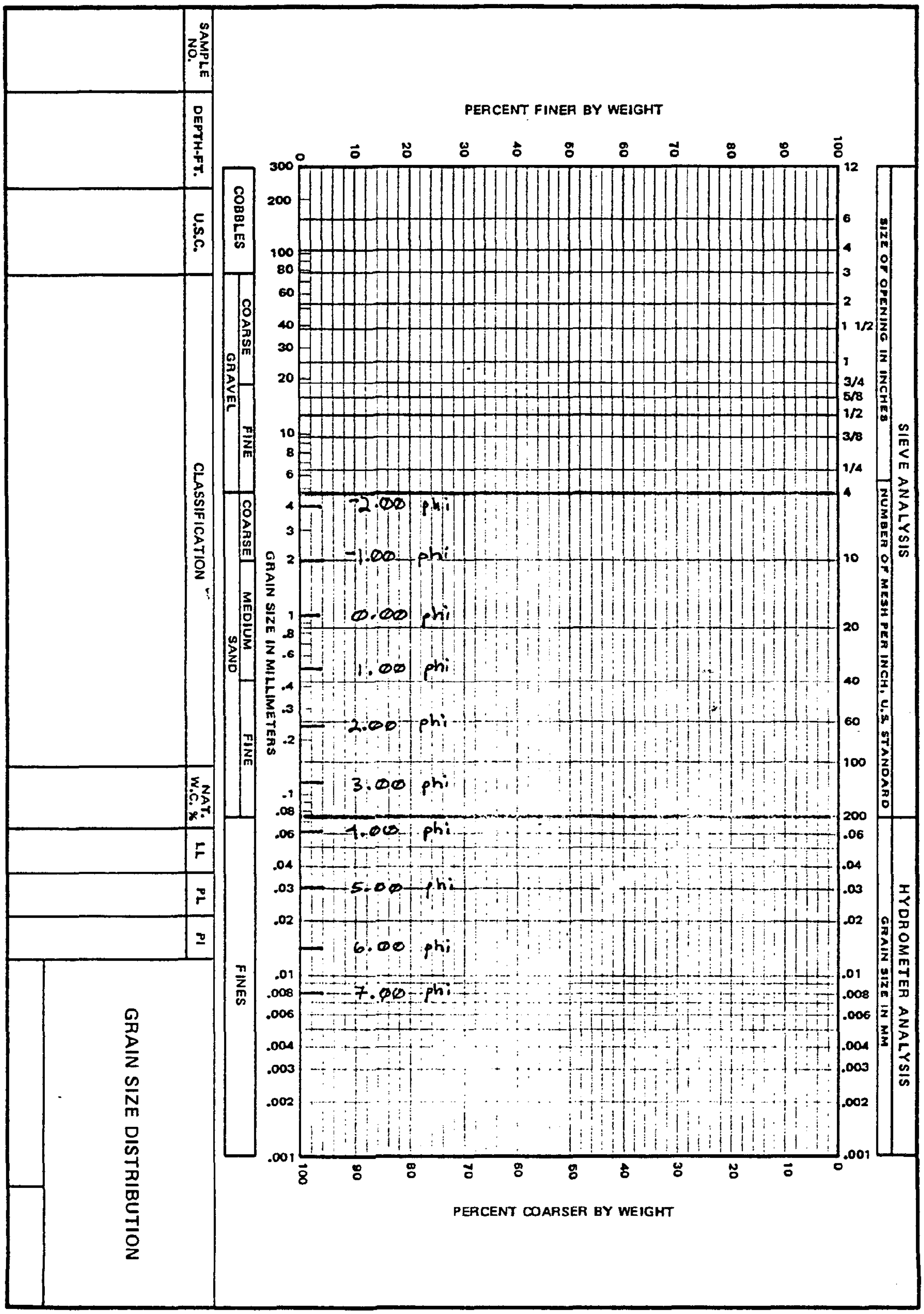
Single summary measures of sediment characteristics are sometimes used, both to investigate statistical relationships with other parameters, and to facilitate comparisons between sediment samples. Some of the measures used

Table 3.1: Grain Size Classes

CLASS NAME		METRIC UNITS (mm)	ENGLISH UNITS (inch)	PHI UNITS
Cobble	Large	256 - 128	10 - 5	-8 to -7
	Small	128 - 64	5 - 2.5	-7 to -6
Gravel	Very coarse	64 - 32	2.5 - 1.25	-6 to -5
	Coarse	32 - 16	1.25 - 0.625	-5 to -4
	Medium	16 - 8	0.625 - 0.31	-4 to -3
	Fine	8 - 4	0.31 - 0.16	-3 to -2
	Very fine	4 - 2	0.16 - 0.08	-2 to -1
Sand	Very coarse	2.000 - 1.000		-1 to 0
	Coarse	1.000 - 0.500		0 to 1
	Medium	0.500 - 0.250		1 to 2
	Fine	0.250 - 0.125		2 to 3
	Very fine	0.125 - 0.062		3 to 4
Silt	Coarse	0.062 - 0.031		4 to 5
	Medium	0.031 - 0.016		5 to 6
	Fine	0.016 - 0.008		6 to 7
	Very fine	0.008 - 0.004		7 to 8
Clay	Coarse	0.004 - 0.002		8 to 9
	Medium	0.002 - 0.001		9 to 10
	Fine	0.001 - 0.0005		10 to 11
	Very fine	0.0005 0.00024		11 to 12

Source: Sherwood, et al. 1984

Figure 3.1 Grain Size Distribution Chart



are mean grain size, median grain size, modal grain size, percent sand, percent silt, and percent clay. Measures of skewness and kurtosis are also employed. Factor analysis and cluster analysis are sometimes used in comparing sediment samples.

Felstul (1988) examined median grain size measurements for 78 sediment samples from the Columbia River Estuary. The median sediment sizes ranged from 0.006 mm (7.4 phi) to 0.410 mm (1.3 phi). The average of the medians was 0.111 mm, or 3.2 phi. Felstul reported correlation coefficients for mainstem Columbia River Estuary sediment samples between certain trace metals and five grain size measures. These are summarized in Table 3.2. Only values of r^2 greater than 0.50 are reported.

Table 3.2: Correlation Coefficients for Metals in Columbia River Sediment

Metal	% Sand	% VF Sand	% Silt	% Clay	Median Grain Size
As	-	-	-	-	-
Cd	-	-	-	-	-
Cr	-	-	-	-	-
Cu	-	-	-	-	-
Fe	-	0.60	0.59	0.65	0.65
Pb	-	-	-	-	-
Mn	-	0.52	0.51	0.68	-
Hg	-	-	-	-	-
Zn	-	0.51	-	0.64	-

Source: Felstul (1988)

Sherwood, et al. (1984) examined more than 2,000 sediment samples from the Columbia River Estuary during different times of the year and at depths ranging from the intertidal zone to over 100 feet below MLLW. Mean grain sizes ranged from -1.12 phi (about 2.2 mm, or very fine gravel) to 8.17 phi (about 0.0035 mm, or coarse clay). The average of the mean grain sizes was about 2.5 phi (about 0.18 mm, or fine sand). There was no overall correlation between grain size and depth ($r^2 = 0.10$), but Sherwood did find spatial patterns of different grain sizes using factor analysis.

Grain size analysis is accomplished with graduated sieves for sand and coarser material (4 phi and coarser). Silt and clay fractions are measured using a pipet technique that depends on differential settling rates among particle size classes. This is a time-consuming test that takes up to thirty hours for material finer than 10 phi (fine clay). The procedure for this test is outlined in Kurmbein and Pettijon (1938).

Grain size is a commonly measured sediment characteristic because it involves a relatively inexpensive test, and the results are applicable to dredged material management decisions. The Oregon Department of Environmental Quality (ODEQ) has issued "Draft Interim Sediment Quality Guidelines" for use in evaluating sediment quality. The guidelines set a 20% silt content threshold for further testing. Sediment with 20% or less silt and finer would generally be approved for in-water disposal without additional testing. Sediment with a silt content exceeding 20% would require additional chemical and possibly biological testing before they could be approved by ODEQ for in-water disposal. This 20% threshold, if finalized, would be a guideline only, and not a substitute for professional judgement on the part of ODEQ officials. Other agencies involved in the review of proposed in-water dredged material disposal are not obligated to follow this guideline.

Sediment for a grain size analysis must be collected from the disposal site, stored and transported in a manner that maintains its integrity, and handled in the laboratory according to accepted procedures. Sediment for grain size analysis may be stored for up to six months, and should be refrigerated. At least 100 grams of sediment are needed for the test. Sediment collection depths should normally correspond to planned dredging depths, and sample collected with a coring device may be subdivided by depth. Coring devices or grab samplers are suitable for sediment collection for grain size analysis: less sophisticated tools may also be appropriate.

3.2.2. Oil and Grease

Oil and grease content in sediment is typically reported in dry-weight parts per million (ppm). Oil and grease tests measure hydrocarbons, vegetable oils, animal fats, waxes, soaps, greases and related compounds. Sulphur compounds, organic dyes, and chlorophyll may also be measured, depending on the extraction solvent used.

Felstul (1988) reported oil and grease content for 86 sediment samples in Columbia River Estuary mainstem and side channel areas. They ranged from 0 ppm to 2,800 ppm. The mean oil and grease concentration was 423 ppm for these sediment samples. In the mainstem samples, Felstul found that oil and grease was only weakly correlated with sediment grain size (for example, $r^2 = .39$ for percent of very fine sand with oil and grease). He also found that oil and grease were somewhat correlated with mercury concentrations ($r^2 = .59$).

"Draft Interim Sediment Quality Quidelines" issued by the Oregon Department of Environmental Quality (ODEQ) for use in evaluating sediment quality set a limit of 1,000 ppm oil and grease for in-water disposal approval. Sediment with oil and grease in excess of 1,000 ppm require further testing before they can be approved for in-water disposal. As with the ODEQ grain size guideline described in Subsection 3.2.2., this oil and grease concentration is simply a guideline.

The U.S. Environmental Protection Agency has established quality criteria for oil and grease in water (EPA 1986). The criteria are based on affects on aquatic life. Criterion (2) states that:

Levels of oils or petrochemicals in the sediment which cause deleterious effects to the biota shall not be allowed.

Sediment sample collection considerations for analysis of oil and grease content are described in Tetra Tech (1986). Samples should be refrigerated until analysis. At least 100 grams of sediment per sample are needed. Sediment to be tested for oil and grease must be stored in glass containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one month refrigerated, and up to six months frozen.

3.2.3. Total Organic Carbon

Total organic carbon (TOC) is a measure of volatile, nonvolatile, partially volatile and particulate organic compounds in a sediment sample. It is usually reported as milligrams per gram dry weight (mg/g) or as parts per thousand (ppt). Total organic carbon content can be used to estimate the interstitial concentrations of certain non-polar organic compounds in a sediment sample using an equilibrium partitioning approach. This is described in Subsection 3.5.

Felstul (1988) examined total organic carbon measures for eighty-six sediment samples from Columbia River Estuary main channel and side channel areas. They ranged from 0 to 74.9 mg/g, and averaged 8.9 mg/g. Felstul also reported a moderate inverse correlation between total organic carbon and medium grain size (r^2 = .51) for mainstem sediment samples.

Total organic carbon measurements include some of the components of oil and grease measurements, plus many other compounds. In Felstul's data set, average TOC measurements were about 2,000 times larger than average oil and grease measurements.

Sediment sample collection considerations for analysis of total organic carbon are described in Tetra Tech (1986). Samples should be frozen until analysis. Only 25 grams of sediment per sample are needed. Sediment to be tested for total organic carbon may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for up to six months frozen.

3.2.4. Volatile Solids

Volatile solids are the fraction of total solids lost on ignition at a temperature higher than that used to determine total solids (see subsection 3.2.13.). Sediment samples are weighed, heated to 550°C (1,022°F), then re-weighed. The weight loss represents total volatile solids. Volatile solids are usually reported as a percent of dry weight. Volatile solids content is a measure of a sediment sample's organic content.

Felstul (1988) examined 86 sediment samples from Columbia River Estuary mainstem and side channel areas, with volatile solids ranging from zero to 13.8 percent, and averaging 3.0 percent. Higher volatile solids fractions are correlated with a higher percentage of very fine sand, silt and clay (r^2 =

0.64, 0.68 and 0.74), and with iron (r^2 = .71), manganese (r^2 = .66), and zinc (r^2 = .52).

The Oregon Department of Environmental Quality (ODEQ) has issued "Draft Interim Sediment Quality Guidelines" for their use in evaluating sediment quality. The guidelines establish a limit of five percent for volatile solids. Sediment with more than five percent volatile solids are subject to additional chemical testing before they may be approved for in-water disposal. The ODEQ volatile solids limit is a guideline and subject to professional judgement on the part of ODEQ staff.

Sediment sample collection considerations for analysis of volatile solids in sediment are described in Tetra Tech (1986). Samples should be frozen until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for volatile solids may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for up to six months frozen.

3.2.5. pH

Sediment acidity is represented by a pH measurement. pH is the logarithm of the reciprocal of the hydrogen ion concentration. pH values between 0 and 7 indicate acidity. pH values between 7 and 14 represent alkalinity.

Sediment pH is not always measured. Sediment pH for 3 samples taken at the Port of Astoria docks in 1988 ranged from 6.9 to 7.5. Its use in evaluating sediment for in-water disposal is limited.

3.2.6. Total Sulfides

The amount of acid soluble H_2S, HS^-, and S^{2-} in a sample is measured as total sulfides. These compounds may be toxic and have a strong odor. The hydrogen sulfide compound (H_2S) is believed to contribute more to overall sulfide toxicity than either HS^- or S^{2-}. They are indicative of anaerobic conditions in the sediment. Total sulfides are distinguished from water-soluble sulfides (see subsection 3.2.12.). Total sulfides are usually reported in units of mg/kg dry weight (ppm).

Sediment sample collection considerations for analysis of total sulfides are described in Tetra Tech (1986). A zinc acetate preservative is often added in the field. Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for total sulfides may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one week refrigerated.

The U.S. Environmental Protection Agency has established water quality criteria for sulfides in water. A long-term level of 2.0 µg/liter would constitute a hazard to aquatic life forms.

3.2.7. Total Nitrogen

Total nitrogen values in sediment are typically used to calculate carbon/nitrogen ratios. It is a parameter not normally measured on the Columbia River Estuary, and no data could be found showing representative nitrogen levels in Columbia River Estuary sediment.

Sediment sample collection considerations for analysis of total nitrogen are described in Tetra Tech (1986). Samples should be frozen until analysis. At least 25 grams of sediment per sample are needed. Sediment may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for up to six months frozen.

3.2.8. Ammonia

Measures of ammonia (NH_3) are typically represented as mg/kg dry weight for sediments, or as mg/liter for elutriates. Four sediment samples taken at Tongue Point were measured for ammonia. It ranged from below detection limits (about 14 mg/kg) to 131 mg/kg, and averaged 74 mg/kg.

Techniques for analysis of ammonia content are described in Standard Methods for the Examination of Water and Wastewater (APHA 1985). Collection methods are similar to those described for grain size analysis. The Environmental Protection Agency has established water quality criteria for ammonia that are applicable in reviewing sediment quality. The criteria for ammonia are temperature and pH dependent, and are described in the criteria (EPA 1986).

3.2.9. Biochemical Oxygen Demand

Biochemical oxygen demand is a measure of the dissolved oxygen consumed by microbial organisms while assimilating and oxidizing the organic matter in a sediment sample. It is used to estimate the amount of organic matter available to organisms, in contrast with other measures of the total amount of organic matter (e.g., total volatile solids, total organic carbon, chemical oxygen demand). In addition to oxygen used for degrading organic matter, biochemical oxygen demand may also measure oxygen used to oxidize inorganic material (e.g., sulfide, ferrous iron) and reduced forms of nitrogen. Biochemical oxygen demand is typically reported as mg/kg dry weight.

Sediment sample collection considerations for analysis of biochemical oxygen demand are described in Tetra Tech (1986). Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for biochemical oxygen demand may be stored in either polyethylene or glass containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one week refrigerated.

3.2.10. Chemical Oxygen Demand

Chemical oxygen demand is a measure of the oxygen equivalent of the organic content of a sample susceptible to oxidation by a strong chemical oxidant at an elevated temperature and a reduced pH. Data are typically reported as mg/kg dry weight.

No Columbia River Estuary sediment measures of chemical oxygen demand could be found. Fuhrer (1989) reported results of chemical oxygen demand for five Columbia River sites near Portland, Oregon. They ranged from 43,000 mg/kg to 76,000 mg/kg, and averaged 62,400 mg/kg.

Sediment sample collection considerations for analysis of chemical oxygen demand are described in Tetra Tech (1986). Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for chemical oxygen demand may be stored in either polyethylene or glass containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one week frozen.

3.2.11. Petroleum Hydrocarbons

This test measures the same compounds as the oil and grease test (subsection 3.2.2.), minus polar compounds (vegetable oils, animal fats, soaps).

Battelle Labs (1989) measured petroleum hydrocarbons in four sediment samples from Cathlamet Bay. They ranged from less than 5 mg/kg dry weight to 23 mg/kg. The two samples with 23 mg/kg petroleum hydrocarbons were actually made up of several composited samples. Measures of oil/grease and petroleum hydrocarbons for the Cathlamet Bay sites were comparable: oil and grease averaged 54.7 mg/kg dry weight for the composited samples, compared to 23.0 mg/kg dry weight petroleum hydrocarbons.

Sediment samples to be analyzed for petroleum hydrocarbons should be refrigerated until analysis. Collection methods are similar to those described for grain size analysis.

3.2.12. Dissolved Sulfides

Dissolved sulfide measurements are intended as an indicator of biologically available sulfide compounds in a sediment sample. The procedure for this test measures only water soluble sulfides, and should yield a smaller sulfide concentration than the total sulfides test (see subsection 3.2.6.). Dissolved sulfides are typically reported as mg/kg dry weight.

Cathlamet Bay sediment analyzed by Battelle Labs (1989) was found to have an average dissolved sulfide content of 44.5 mg/kg dry weight.

Sediment sample collection considerations for analysis of dissolved sulfides are the same as those for total sulfides, and are described in Tetra Tech (1986). A zinc acetate preservative is often added in the field. Samples should be refrigerated until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for dissolved sulfides may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about one week refrigerated.

The U.S. Environmental Protection Agency has established water quality criteria for dissolved sulfides. A long-term level of 2.0 µg/liter would constitute a hazard to aquatic life forms.

3.2.13. Total Solids

Total solids are a measure of inorganic and organic materials remaining after a sediment sample has been completely dried. Total solids are usually reported as a percent of the sample's wet weight. This may be used to convert concentrations of other compounds in sediment from a wet weight to a dry weight basis. Drying temperatures are typically 103° C (217° F).

Sediment sample collection considerations for analysis of total solids are described in Tetra Tech (1986). Samples should be frozen until analysis. At least 50 grams of sediment per sample are needed. Sediment to be tested for total solids may be stored in either glass or polyethylene containers. Collection methods are similar to those described for grain size analysis. Samples may be stored for about six months frozen.

3.2.14. Conventional Sediment Variables - Summary

The thirteen physical parameters described above can, singly or in combination, provide a first-order estimate of overall sediment quality. Table 3.3 summarizes information on these thirteen variables. The second column reports an approximate range of values for each parameter. These range estimates are based on sediment data for the Columbia River that must be used with caution. Because of the differences between analytical methods, data from different researchers is often not comparable. The range estimates reported in this table are based on data from several different researchers. A second cautionary note concerns the use of these range estimates. They are not regulatory thresholds and may not even be representative of sediment in the Columbia River Estuary.

Table 3.3: Conventional Sediment Variables - Summary

Parameter	Approximate Range	Notes
Grain size	4 mm - .004 mm	Oregon DEQ physical parameter
Oil and grease	0 - 2,800 ppm	Oregon DEQ physical parameter
Total organic carbon	0 - 75 mg/gram	Oregon DEQ physical parameter
Volatile solids	0 - 14%	
pH	6 - 8	based on very few samples
Total sulfides	*	
Total nitrogen	*	
Ammonia	14 - 130 mg/kg	based on very few samples
Biochemical oxygen demand	*	
Chemical oxygen demand	*	
Petroleum hydrocarbons	<5 - 25 mg/kg	
Dissolved sulfides	*	
Total solids	*	

(* An asterisk in column 2 indicates that data for this variable are not available for the Columbia River Estuary.)

Source: subsections 3.2.1 - 3.2.13

3.3. CHEMICAL PARAMETERS

Two groups of chemical parameters for sediment evaluation are covered in this subsection: metals and organic compounds.

Two different kinds of chemical analysis are described during discussion of chemical parameters: elutriate and bulk sediment tests. Elutriate tests involve analysis of water that has been exposed to test sediment. An elutriate test is a laboratory simulation of dredging and in-water disposal. A volume of test sediment is mixed with four times its volume of disposal site water and mixed for thirty minutes. Water is removed after one hour of settling, filtered and centrifuged, and analyzed for chemical contaminants. The elutriate test is useful for estimating the impact of dredging and disposal on water quality. Results can be compared to existing state and federal water quality standards. It measures only those contaminants that are likely to enter the water column after dredging and disposal are conducted. It does not measure chemicals that are tightly bonded to sediment grains, or are part of the sediment grains themselves. Elutriate test results may not be appropriate for estimating the effects of disposal on benthic organisms. Elutriate test results are usually reported in units of chemical per liter of water. Specific procedures for elutriate tests are described in Tetra Tech (1986).

Bulk sediment tests measure the concentration of a chemical in a sediment sample. Water is completely removed prior to analysis. The dried sediment sample is subjected to either strong oxidation, acid digestion, or organic solvent extraction. These procedures are harsher than the elutriate test described above, and do not reproduce dredging or disposal conditions. Results of bulk sediment tests do, however, facilitate estimates of effects on benthic organisms. Bulk sediment analysis results are usually reported in units of chemical per gram (or per milligram or microgram) of dry sediment. Specific procedures for bulk sediment tests are described in Tetra Tech (1986).

3.3.1. Metals and Metaloids

The presence and concentration of certain metals is used as a measure of sediment quality. The metals described in this subsection are the most likely to be examined in Columbia River Estuary sediment.

Metals analysis focuses on thirteen metals and metaloids listed by the EPA as priority pollutants. They are:

antimony
arsenic
beryllium
cadmium
chromium
copper
lead
mercury
nickel
selenium
silver
thallium
zinc.

These are described in the following subsections. Most subsections include information on detection limits. These are the lowest concentrations of each metal that can be reliably detected using standard analytical procedures.

Beryllium (Be)

Beryllium is a hard metal found in alloy with copper and other metals. It is not often measured in Columbia River Estuary sediment because it is not known to be present above background levels. Beryllium is not used by the Oregon DEQ as a chemical parameter in its Draft Interim Sediment Quality Guidelines. It is typically reported in units of µg/gram.

The Environmental Protection Agency has established the following water quality criteria for beryllium. Freshwater acute and chronic effects criteria are 130 and 5.3 µg/liter respectively (USEPA 1986). The detection limits for beryllium in bulk sediment are 1 µg/gram.

Fuhrer and Rinella (1987) analyzed sediment from 13 sites in the Columbia River Estuary for beryllium. The bulk sediment tests yielded measurements at or below detection limits. Elutriate tests yielded beryllium concentrations ranging from 10 to 20 µg/liter, averaging about 12.3 µg/liter.

Chromium (Cr)

Chromium is occasionally measured in Columbia River Estuary sediment. It is toxic to aquatic organisms, and the Environmental Protection Agency has established the following water quality criteria for chromium:

aquatic organisms, chronic exposure (4 day):	11 µg/L	freshwater
aquatic organisms, chronic exposure (4 day):	50 µg/L	saltwater
aquatic organisms, acute exposure (1 hour):	16 µg/L	freshwater
aquatic organisms, acute exposure (1 hour):	1,100 µg/L	saltwater

The Oregon Department of Environmental Quality has established a limit of between 20 and 300 mg/kg for chromium in sediment. Sediment with chromium in excess of this guideline will not normally be approved for in-water disposal without further testing.

Felstul (1988) examined results from analysis for 86 Columbia River Estuary mainstem and side channel sediment samples for chromium content. He found an average concentration of 19.6 mg chromium per kg sediment, with a range of 1.7 to 72.0 mg/kg. Felstul found a weak relationship between the percentage clay and the concentration of chromium in Columbia River Estuary mainstem sediment (r^2 = .38) and between chromium and iron content in Columbia River Estuary mainstem sediment (r^2 = .39).

Other researchers on the Columbia River Estuary have examined chromium in sediment and found concentrations similar to those reported by Felstul.

Eighteen sites examined by three researchers yielded chromium concentrations ranging from 2 to 72 mg/kg, averaging about 23 mg/kg (Fuhrer 1984; Fuhrer and Horowitz 1989; Fuhrer and Rinella 1983).

Manganese (Mn)

Manganese is not an Environmental Protection Agency priority pollutant metal, but it is occasionally included in analysis of Columbia River Estuary sediment as an indexing parameter. Metals from pollution sources may be selectively enriched within sediment fractions with a high manganese content. The presence of manganese may also affect the toxicity of other metals.

Felstul (1988) examined results of analysis of 86 sediment samples in the Columbia River Estuary mainstem and tributaries for manganese. The average manganese concentration was 232.7 mg/kg, ranging between 0 and 900 mg/kg. Felstul also examined the relationship between manganese concentrations and other sediment parameters. He found relatively strong correlations between manganese and the percent of very fine sand (r^2 = .52), percent of silt (r^2 = .51), percent of clay (r^2 = .68), percent volatile solids (r^2 = .66), and iron concentrations (r^2 = .73). Manganese concentrations do not correlate very well with priority pollutant metals. Felstul found correlation coefficients ranging from 0.54 for manganese and zinc to about 0.14 for manganese and mercury.

Other investigators have also examined manganese levels in sediment. Fuhrer (1989) found Portland harbor sediments to have between 400 and 1,200 mg manganese per kilogram sediment (dry weight). Fuhrer and Horowitz (1987) found manganese levels between 400 and 1,100 mg/kg for sites in the lower Columbia.

Detection limits for manganese in bulk sediment are set at 2 mg/kg, dry weight, by the Puget Sound Dredged Disposal Analysis (PSDDA) program.

Iron (Fe)

Iron, like manganese, is not an Environmental Protection Agency priority pollutant. It is included in some sediment tests because it may be useful as an indexing or standardizing factor. Iron may also affect the toxicity of other metals. Environmental Protection Agency water quality guidelines for iron are 300 μg/liter for domestic water supplies, and 1,000 μg/liter for freshwater aquatic life.

Fuhrer (1988) measured iron in Columbia River Estuary mainstem and tributary sediment, and found concentrations ranging from 0 to 49,000 mg/kg dry weight. The average concentration was 17,302 mg/kg dry weight. Felstul's analysis of Columbia River Estuary mainstem sediments revealed moderately strong correlation coefficients for iron and the conventional sediment variables: r^2 for iron and very fine sand was .60; for iron and silt, r^2 = .59; for iron and clay r^2 = .65; for iron and volatile solids r^2 = .71. For other metals, iron is strongly correlated only with manganese: r^2 = .73. Correlation coefficients for other metals and iron range from 0.15 for arsenic to 0.44 for zinc.

Other investigators have also examined iron in Columbia River Estuary sediment. Fuhrer and Rhinella (1983) reported average iron levels at seven Columbia River Estuary locations. These are summarized in Table 3.4.

Table 3.4: Iron in Columbia River Estuary sediment

Location	Number of Samples	Average	Maximum
Baker Bay	5	10,600 mg/kg	22,000 mg/kg
Chinook	2	10,850 mg/kg	17,000 mg/kg
Tansy Point	1	4,500 mg/kg	4,500 mg/kg
Skipanon River	1	19,000 mg/kg	19,000 mg/kg
Youngs Bay	1	11,000 mg/kg	11,000 mg/kg
Port of Astoria	1	11,000 mg/kg	11,000 mg/kg
Skamokawa	2	13,450 mg/kg	21,000 mg/kg
Total	13	11,008 mg/kg	22,000 mg/kg

Source: Fuhrer and Rhinella 1983.

Nickel (Ni)

Nickel is a metal on the Environmental Protection Agency's list of priority pollutants because of its toxicity to aquatic organisms. There is some evidence suggesting that nickel may be present in sediment due to natural sources (PSSDA), but the evidence is inconclusive.

Environmental Protection Agency water quality criteria for nickel are as follows:

aquatic organisms, chronic exposure (4 day): 160 µg/L freshwater
aquatic organisms, chronic exposure (4 day): 8.3 µg/L saltwater
aquatic organisms, acute exposure (1 hour): 1,400 µg/L freshwater
aquatic organisms, acute exposure (1 hour): 75 µg/L saltwater

The freshwater acute and chronic water quality criteria reported above are for water with a hardness of 100 mg $CaCO_3$ per liter.

Felstul (1988) evaluated nickel concentrations in 86 sediment samples from Columbia River Estuary tributaries and the main navigation channel. The nickel content ranged from 0 to 44 mg/kg dry weight, and averaged 9.16 mg/kg. The average for silty samples (greater than 50% silt) was 11.6 mg/kg, as compared to the average for sandy samples (50% or less silt) of 6.5 mg/kg.

The detection limit for nickel in bulk sediment is 0.1 mg/kg dry weight. For elutriate tests it is 1.0 µg/liter.

Copper (Cu)

Copper is an Environmental Protection Agency priority pollutant and is included in many sediment tests due to widespread concern about its toxicity and its presence in the aquatic environment. Anti-fouling marine paints and wood preservatives often contain copper compounds. Environmental Protection Agency water quality criteria for copper are as follows:

aquatic organisms, chronic exposure (4 day):	12	μg/L freshwater
aquatic organisms, chronic exposure (4 day):	2.9	μg/L saltwater
aquatic organisms, acute exposure (1 hour):	16	μg/L freshwater
aquatic organisms, acute exposure (1 hour):	2.9	μg/L saltwater

The freshwater acute and chronic water quality criteria reported above are for water with a hardness of 100 mg $CaCO_3$ per liter.

The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" that set threshold concentrations for several metals, including copper. Sediment with a copper content exceeding 50 mg/kg will not be approved for in-water disposal without further evaluation.

Felstul (1988) examined results of analysis for copper in 86 sediment samples from the Columbia River Estuary main navigation channel and some side channels. He found copper concentrations ranging from 1.5 to 91 mg/kg, dry weight, and averaging about 25.31 mg/kg. Silty sediments had an average copper content of 35.7 mg/kg, compared to an average of 13.9 for sandier sediment samples. There was a relatively weak correlation between copper and percent silt in these 86 samples: $r^2 = 0.20$. For the mainstem samples, copper was also correlated with cadmium ($r^2 = 0.52$).

Detection limits for copper in bulk sediment are 0.1 mg/kg, dry weight. For elutriates, copper detection limits are 1.0 μg/liter.

Zinc (Zn)

Zinc is a bluish-white metal with a number of applications in maritime industries as an anti-corrosive agent. Zinc is an Environmental Protection Agency priority pollutant, and is toxic. The Environmental Protection Agency water quality criteria established for zinc are as follows:

aquatic organisms, chronic exposure (4 day):	110	μg/L freshwater
aquatic organisms, chronic exposure (4 day):	95	μg/L saltwater
aquatic organisms, acute exposure (1 hour):	120	μg/L freshwater
aquatic organisms, acute exposure (1 hour):	95	μg/L saltwater

The freshwater acute and chronic water quality criteria reported above are for water with a hardness of 100 mg $CaCO_3$ per liter.

The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" that set threshold concentrations for several metals, including zinc. Sediment with more than 250 mg zinc per kg require additional testing before they are approved for in-water disposal.

Felstul (1988) examined zinc concentrations in 86 sediment samples from the Columbia River Estuary navigation channel and side channel areas. Zinc concentrations ranged from 18 mg/kg dry weight to 300 mg/kg, and averaged about 92 mg/kg. There was a tendency for finer-grain size samples to have higher zinc levels. Forty-five samples with more than 50 percent silt and finer particles had an average zinc concentration of 125.8 mg/kg, while 41 samples with 50 percent or less silt and finer material had an average zinc concentration of 55.0 mg/kg. There was a relatively strong correlation between the percent silt in a sample and its zinc concentration: $r^2 = 0.60$. Felstul found that, for mainstem samples only, zinc content was associated with percent very fine sand ($r^2 = 0.51$), percent silt ($r^2 = 0.48$), percent clay ($r^2 = 0.64$), median grain size ($r^2 = 0.49$), volatile solids ($r^2 = 0.52$), and manganese ($r^2 = 0.55$).

Detection limits for zinc in bulk sediments are 0.2 mg/kg dry weight. For elutriate tests, zinc detection limits are 1.0 µg/liter.

Arsenic (As)

Arsenic is a highly toxic metalloid on the Environmental Protection Agency's priority pollutant list. Environmental Protection Agency water quality criteria for arsenic are as follows:

aquatic organisms, chronic exposure (4 day): 190 µg/L freshwater
aquatic organisms, chronic exposure (4 day): 36 µg/L saltwater
aquatic organisms, acute exposure (1 hour): 1360 µg/L freshwater
aquatic organisms, acute exposure (1 hour): 69 µg/L saltwater

The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" that set threshold concentrations for several sediment contaminants, including arsenic. Sediment with 40 or more mg arsenic per kg is subject to additional testing before it can be approved for in-water disposal.

Felstul (1988) examined the results of sediment analysis for arsenic content in 86 Columbia River Estuary mainstem and side channel sediment samples. Arsenic values ranged from 0 to 20.5 mg/kg dry weight. The average arsenic content was 6.76 mg/kg. Samples with more than 50 percent silt or finer content averaged 8.4 mg arsenic per kg sediment. Samples with 50 percent or less silt content averaged 4.92 mg arsenic/kg sediment. Felstul measured correlation between arsenic and other sediment variables in the mainstem samples. The strongest correlation was with clay, but it was weak at $r^2 = .025$.

The detection limit for arsenic in bulk sediment is 0.1 mg/kg dry weight. For elutriates, the detection limit is 1.0 µg/liter.

Selenium (Se)

Selenium is a toxic element on the Environmental Protection Agency's priority pollutant list. There are no data for selenium levels in Columbia River Estuary sediment. The Oregon Department of Environmental Quality has not established threshold limits for selenium in sediment. The U.S. Environmental Protection Agency has established the following water quality criteria for selenium:

aquatic organisms, 24 hour average:	35 µg/L	freshwater
aquatic organisms, maximum at any time:	260 µg/L	freshwater
aquatic organisms, 24 hour average:	54 µg/L	saltwater
aquatic organisms, maximum at any time:	410 µg/L	saltwater

Silver (Ag)

Silver is a toxic metal on the Environmental Protection Agency's priority pollutant list. The Oregon Department of environmental Quality has not established threshold limits for silver in sediment. Environmental Protection Agency water quality criteria for silver are as follows:

aquatic organisms, chronic exposure (4 day):	0.12 µg/L	freshwater
aquatic organisms, acute exposure (1 hour):	4.1 µg/L	freshwater
aquatic organisms, acute exposure (1 hour):	2.3 µg/L	saltwater

The freshwater acute water quality criterion reported above is for water with a hardness of 100 mg $CaCO_3$ per liter.

Puget Sound Dredged Disposal Analysis (PSDDA) metals protocols reported average silver concentrations in Puget Sound reference sediments of 1.2 mg/kg dry weight, and ranging between 0.02 and 3.3 mg/kg dry weight (Tetra Tech Inc. 1986). No data could be found for silver in Columbia River Estuary sediment.

The detection limit for silver in sediment is 0.1 mg/kg dry weight. For elutriate tests, it is 0.2 µg/liter.

Cadmium (Cd)

Cadmium is a toxic metal on the Environmental Protection Agency's priority pollutant list. Environmental Protection Agency water quality criteria for cadmium are as follows:

aquatic organisms, chronic exposure (4 day):	1.1 µg/L	freshwater
aquatic organisms, chronic exposure (4 day):	9.3 µg/L	saltwater
aquatic organisms, acute exposure (1 hour):	3.9 µg/L	freshwater
aquatic organisms, acute exposure (1 hour):	4.3 µg/L	saltwater

The freshwater acute and chronic water quality criteria reported above are for water with a hardness of 100 mg $CaCO_3$ per liter.

The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" for evaluating sediment quality in Oregon estuaries. The draft guidelines establish a threshold of 1.0 mg/kg cadmium per kilogram of sediment. Sediment with cadmium concentrations in excess of 1.0 mg/kg is subject to additional testing before approval for in-water disposal.

Felstul (1988) examined results of analysis of 86 Columbia River Estuary mainstem and side channel sediment samples for cadmium content. There are two different analytical techniques for bulk cadmium analysis. The techniques tend to yield different values, and there is little consensus as to which technique is more appropriate. Average cadmium content using the "furnace method" of cadmium analysis was 0.26 mg/kg dry weight, compared to 0.95 mg/kg for the alternative method. Cadmium content did not correlate strongly with any other sediment variable measured by Felstul.

The detection limit for cadmium in sediment is 0.1 mg/kg dry weight. For elutriate tests the detection limit is 0.1 µg/liter.

Antimony (Sb)

Antimony is a toxic metal that contaminates sediment and is on the Environmental Protection Agency's priority pollutant list. Antimony is not frequently measured in Columbia River Estuary sediment. Environmental Protection Agency water quality criteria for antimony are as follows:

aquatic organisms, chronic toxicity:	1,600	µg/L freshwater
aquatic organisms, acute toxicity:	9,000	µg/L freshwater

Neither the Oregon Department of Environmental Quality nor the Washington Department of Ecology have established threshold limits for antimony in Columbia River Estuary sediment. Smelter slag is occasionally tainted with antimony, which is why it is of concern in Puget Sound sediment.

Puget Sound reference sediment samples have antimony ranging from 0.0 to 1.7 mg/kg, and average values ranging from 0.32 to 0.38 mg/kg, all dry weights. The detection limit for antimony in bulk sediment is 0.1 mg/kg. For elutriate tests the detection limit for antimony is 3.0 µg/liter.

Barium (Ba)

Barium is a toxic metal occasionally measured in Columbia River Estuary sediment. It is not an EPA priority pollutant. Barium water quality criteria for aquatic life are not established because barium reacts with other chemicals in the aquatic environment to form generally non-toxic compounds. Neither the Washington Department of Ecology nor the Oregon Department of Environmental Quality have established threshold limits for barium in Columbia River Estuary sediment.

Barium measurements of Columbia River Estuary sediment available to this project have always been at or below detection limits for barium in bulk sediment: 1.0 mg/kg.

Mercury (Hg)

Mercury is a highly toxic metal with well documented adverse impacts on aquatic life and human health. It is an Environmental Protection Agency priority pollutant. Environmental Protection Agency water quality criteria for mercury are as follows:

aquatic organisms, chronic exposure (4 day):	0.012	μg/L freshwater
aquatic organisms, chronic exposure (4 day):	0.025	μg/L saltwater
aquatic organisms, acute exposure (1 hour):	2.4	μg/L freshwater
aquatic organisms, acute exposure (1 hour):	2.1	μg/L saltwater.

The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" for sediment contaminants in Oregon estuaries. The guidelines set threshold limits for mercury and other compounds. Sediment with mercury concentrations in excess of 0.15 mg/kg requires additional testing before it can be approved for in-water disposal.

Mercury levels in 86 Columbia River Estuary mainstem and side channel sediment samples examined by Felstul (1988) averaged 0.07 mg mercury per kg sediment, dry weight. Mercury content ranged from 0 to 0.72 mg/kg. The average mercury concentration for samples with a silt content of 50% or more was 0.09 mg/kg, compared to 0.04 mg/kg for the sandier samples. For mainstem samples only, Felstul found mercury content correlated relatively well with oil and grease content ($r^2 = 0.59$).

Fuhrer (1982) examined three Columbia River Estuary sediment samples for mercury content. His low and high values were 0.06 and 0.01 mg/kg. The average for the three samples was 0.03 mg/kg.

Mercury at Puget Sound reference sites ranged from 0.01 to 0.28 mg/kg, and averaged about 0.08 mg/kg, dry weight (PSDDA, 1986).

Detection limits for mercury in sediment are 0.01 mg/kg, dry weight. For analysis of elutriates, detection limits are 0.2 μg/liter or, using a special gold-amalgamation-cold-vapor technique, 0.02 μg/liter (PSDDA, 1986). These detection limits do not reach the freshwater aquatic life acute water quality criterion reported above.

The PSDDA analytical protocol for mercury in sediment, and for most other metals in sediment, uses a strong acid total digestion extraction technique. This may be inappropriate for Columbia River Estuary sediments, due to the presence of mercury-bearing rocks in the upper watershed. A partial digestion method is often used for mercury analysis of Columbia River Estuary sediment.

Lead (Pb)

Lead is a heavy toxic metal on the Environmental Protection Agency's priority pollutant list. It is associated with anti-fouling paints and other industrial sources in the aquatic environment. Environmental Protection Agency water quality criteria for lead are as follows:

aquatic organisms, chronic exposure (4 day): 3.2 µg/L freshwater
aquatic organisms, chronic exposure (4 day): 5.6 µg/L saltwater
aquatic organisms, acute exposure (1 hour): 82.0 µg/L freshwater
aquatic organisms, acute exposure (1 hour): 140.0 µg/L saltwater

The freshwater acute and chronic water quality criteria reported above are for water with a hardness of 100 mg $CaCO_3$ per liter.

The Oregon Department of Environmental Quality has established "Draft Interim Sediment Quality Guidelines" for evaluation of sediment quality in Oregon estuaries. The guidelines set threshold concentrations for lead and other compounds in sediment. Sediment with lead in excess of 40 mg/kg is subject to additional analysis before it can be approved for in-water disposal.

Felstul (1988) examined analytical results of 86 sediment samples from the Columbia River Estuary mainstem and side channels for lead concentrations. He found values ranging from 0.4 mg/kg to 40.0 mg/kg, dry weight. The average value was 11.6 mg/kg. Samples with more than 50% silt had an average lead content of 14.3 mg/kg, while those with coarser sediment averaged 8.6 mg lead per kg sediment. For mainstem samples only, Felstul's analysis showed no correlation between lead and any other sediment parameter larger than r^2 = 0.32, for lead and clay content. Lead levels in Puget Sound reference sediments reported by PSDDA ranged from 0.1 to 24 mg/kg dry weight, and averaged about 9.8 mg/kg dry weight.

Lead detection limits using PSDDA protocols are 0.1 mg/kg dry weight for bulk analysis. For elutriate analysis, lead detection limits are 1 µg/liter.

Tin (Sn)

Tin is an infrequently examined metal in Columbia River Estuary sediments. Organotin compounds are used in anti-fouling paints, so their presence in sediment is a potential problem near boat yards or marinas. The family of organotins most frequently cited as a concern are tributyl tins. It is not an EPA priority pollutant, and water quality criteria are not established for it. The Puget Sound Dredged Disposal Analysis (PSDDA) sets a "screening level" of 30 ppm dry weight for tributyltin, but only for certain defined areas in Puget Sound.

3.3.2. Organic Compounds

There are a number of subcategories into which organic compounds measured in sediment may be divided. The Puget Sound Dredge Disposal Analysis (PSDDA), divides these compounds into "volatile", "semi-volatile", and "pesticides/PCBs". Other investigators have used different sub groupings:

pesticides
chlorinated hydrocarbons

low molecular weight hydrocarbons
poly-nuclear aromatic hydrocarbons (PAHs)
acid/base neutral extractables
poly-chlorinated byphenyls (PCBs)

Some of these subgroupings overlap, and the compounds included under some of these subgroupings do not strictly match their titles. Reporting conventions vary, too. Sometimes these compounds are listed by their molecular weight, or an order based on groupings with similar chemical properties. Table 3.5 lists a number of organic compounds sometimes associated with sediment contamination.

Organic compounds are typically measured using a gas chromatograph/mass spectrophotometer (GC/MS). This method, and the quality control/quality assurance measures that must accompany it, are described in Tetra Tech (1986). Sample gathering, handling and storage techniques are also described in Tetra Tech (1986). Sediment samples are stored in glass containers, and refrigerated. Some of the volatile compounds begin to break down after 14 days, so analysis must begin as soon as possible after collection.

Three groups of organic compounds have drawn the attention of researchers and regulatory personnel in recent months and years: PCB, DDT, and Dioxin. These compounds and information about their association with Columbia River Estuary sediment is discussed in the paragraphs below.

Polychlorinated biphenols (PCBs) are a group of about seventy closely related, organic compounds consisting of carbon, hydrogen and chlorine. PCBs are not water soluble,and can persist in the food chain. Their principal use is as an insulating fluid in electrical transmission and generating equipment. PCBs are suspected of causing cancer in humans.

The insecticide DDT has been banned for use in the United States for several years, but it persists in the aquatic environment. DDD and DDE, two decomposition products of DDT, are also found in Columbia River Estuary sediment. DDT, DDE, and DDD have been implicated in the decline of the northern bald eagle population in the estuary.

Dioxin is a byproduct of the bleaching process used by the pulp and paper industry. It may also enter the environment through other avenues. It is not often measured in sediment because its analysis is relatively expensive. Dioxin is highly toxic, and debate currently revolves around its fate in the aquatic environment.

3.3.3. Sediment Quality Chemical Standards

U.S. Environmental Protection Agency water quality criteria for organic compounds are listed in Table 3.5. The EPA has not established sediment quality standards for chemicals. The two state water quality agencies have taken steps in this direction. The Puget Sound Dredged Disposal Analysis (PSDDA) establishes two sets of chemical standards for Puget Sound sediment. These standards are not applicable in the Columbia River Estuary, but they are indicative of general regulatory trends in this area. The PSDDA screening levels and maximum levels are summarized in Table 3.6. The PSDDA screening

Table 3.5: Organic Compounds

Organic Compound	Priority Pollutant	Aquatic Life Water Quality Criteria
Pesticides/PCBs		
alpha-BHC	no	none established
beta-BHC	no	none established
delta-BHC	no	none established
gamma-BHC(Lindane)	no	none established
Heptachlor	yes	acute fresh: 0.52 µg/L acute marine: 0.053 µg/L chronic fresh: 0.0038 µg/L chronic marine: 0.0036 µg/L
Aldrin	yes	acute fresh: 3.0 µg/L acute marine: 1.3 µg/L
Endosulfans	yes	acute fresh: 0.22 µg/L acute marine: 0.034 µg/L chronic fresh: 0.056 µg/L chronic marine: 0.0067 µg/L
Dieldrin	yes	acute fresh: 2.5 µg/L acute marine: 0.71 µg/L chronic fresh: 0.0019 µg/L chronic marine: 0.0019 µg/L
4,4'-DDE	yes	acute fresh: 1.050 µg/L acute marine: 14 µg/L
Endrin	yes	acute fresh: 0.18 µg/L acute marine: 0.037 µg/L chronic fresh: 0.0023 µg/L chronic marine: 0.0023 µg/L
4,4'-DDD	yes	acute fresh: 0.06 µg/L acute marine: 3.6 µg/L
4,4'-DDT	yes	acute fresh: 1.1 µg/L acute marine: 0.13 µg/L chronic fresh: 0.001 µg/L chronic marine: 0.001 µg/L
2,4-D (silvex)	no	none established

Table 3.5, Continued

Methoxychlor	no	chronic fresh: 0.03 μg/L chronic marine: 0.03 μg/L
Chlordane	yes	acute fresh: 2.4 μg/L acute marine: 0.09 μg/L chronic fresh: 0.0043 μg/L chronic marine: 0.0040 μg/L
Toxaphene	yes	acute fresh: 0.73 μg/L acute marine: 0.21 μg/L chronic fresh: 0.0002 μg/L chronic marine: 0.0002 μg/L
PCBs	yes	acute fresh: 2.0 μg/L acute marine: 10.0 μg/L chronic fresh: 0.014 μg/L chronic marine: 0.03 μg/L
Volatiles		
Chloromethane	no	none established
Bromomethane	no	none established
Vinyl Chloride	yes	none established
Chloroethane	no	none established
Methylene Chloride	no	none established
Acetone	no	none established
Carbon Disulfide	no	none established
1,1-Dichloroethene	no	none established
1,1-Dichloroethane	no	none established
Chloroform	yes	acute fresh: 28,900 μg/L chronic fresh: 1,240 μg/L

Table 3.5, Continued

1,2-Dichloroethane	yes	acute fresh: 118,000 µg/L acute marine: 113000 µg/L chronic fresh: 20,000 µg/L
2-Butanone	no	none established
1,1,1-Trichloroethane	yes	acute marine: 31,200 µg/L
Carbon Tetrachloride	yes	acute fresh: 35,200 µg/L acute marine: 50,000 µg/L
Dichloropropane	yes	acute fresh: 23,000 µg/L acute marine: 10,300 µg/L chronic fresh: 5,700 µg/L chronic marine: 3,040 µg/L
Dichloropropene	yes	acute fresh: 6,060 µg/L acute marine: 790 µg/L chronic fresh: 244 µg/L
1,1,2-Trichloroethane	yes	chronic fresh: 9,400 µg/L
Benzene	yes	acute fresh: 5,300 µg/L acute marine: 5,100 µg/L chronic marine: 700 µg/L
Bromoform	no	none established
4-Methyl-2-pentanone	no	none established
2-Hexanone	no	none established
Tetrachloroethene	no	none established
Toluene	yes	acute fresh: 17,500 µg/L acute marine: 6,300 µg/L chronic marine: 5,000 µg/L
1,1,2,2-Tetrachloroethane	yes	none established
Ethyl Benzene	yes	acute fresh: 32,000 µg/L acute marine: 430 µg/L
Styreen	no	none established
Xylenes	no	none established

Table 3.5, Continued

Semivolatiles

Phenol	yes	acute fresh: 10,200 μg/L acute marine: 5,800 μg/L chronic fresh: 2,560 μg/L
bis(2-Chloroethyl) ether	yes	none established
2-Chlorophenol	yes	acute fresh: 4,360 μg/L chronic fresh: 2,000 μg/L
Benzyl alcohol	no	none established
Dichlorobenzene	yes	acute fresh: 1,120 μg/L acute marine: 1,970 μg/L chronic fresh: 763 μg/L
bis(2-Chloroisopropyl) ether	yes	none established
Hexachloroethane	no	acute fresh: 960 μg/L acute marine: 940 μg/L chronic fresh: 540 μg/L
Nitrobenzene	yes	acute fresh: 27,000 μg/L acute marine: 6,600 μg/L
Isophorone	yes	acute fresh: 117,000 μg/L acute marine: 12,900 μg/L
Nitrophenol	yes	acute fresh: 230 μg/L acute marine: 4,850 μg/L chronic fresh: 150 μg/L
2,4-Dimethylphenol	yes	acute fresh: 2,120 μg/L
Benzoic acid	no	none established
2,4-Dichlorophenol	no	acute fresh: 2,020 μg/L chronic fresh: 365 μg/L
1,2,4-Trichlorobenzene	no	none established
Napthalene	yes	acute fresh: 2,300 μg/L acute marine: 2,350 μg/L chronic fresh: 620 μg/L
4-Chloroaniline	no	none established

Table 3.5, Continued

Hexachlorobutadiene	yes	acute fresh: 90 μg/L acute marine: 32 μg/L chronic fresh: 9.3 μg/L
Parachlorometacresol	no	none established
2-Methylnaphthalene	no	none established
Hexachlorocyclopentadiene	yes	acute fresh: 7 μg/L acute marine: 7 μg/L chronic fresh: 5.2 μg/L
2,4,6-Trichlorophenol	yes	chronic fresh: 970 μg/L
2,4,5-Trichlorophenol	no	none established
2-Chloronaphthalene	no	none established
Nitroaniline	no	none established
Dimethylphthalate	yes	none established
Acenaphthene	yes	acute fresh: 1,700 μg/L acute marine: 970 μg/L chronic fresh: 520 μg/L chronic marine: 710 μg/L
2,4-Dinitrotoluene	no	none established
Acenaphthylene	no	none established
Dibenzofuran	no	none established
Diethylphthalate	yes	none established
Fluorene	no	none established
Nitroaniline	no	none established
4,6-Dinitro-2-methylphenol	no	none established
Nitrosoamines	yes	acute fresh: 5,850 μg/L acute marine: 3.3 g/L
4-Bromophenyl-phenylether	no	none established
Hexachlorobenzene	yes	none established

Table 3.5, Continued

Pentachlorophenol	yes	* acute fresh: 5.5 µg/L acute marine: 13 µg/L * chronic fresh: 3.5 µg/L chronic marine: 7.9 µg/L * at pH =6.5
Phenanthrene	no	none established
Anthracene	no	none established
Dibutylphthalate	yes	none established
Fluoranthene	yes	acute fresh: 3,960 µg/L acute marine: 40 µg/L chronic marine: 16 µg/L
Pyrene	no	none established
Butylbenzylphthalate	no	none established
Dichlorobenzidine	yes	none established
Benzo(a)anthracene	no	none established
Chrysene	no	none established
bis(2-Ethylhexyl)phthalate	no	none established
Di-n-octylphthalate	no	none established
Benzo(g,h,i)perylene	no	none established
2,3,7,8-Tetrachlorodibenzo-p-dioxin	yes	acute fresh: 0.01 µg/L acute marine: 0.00001 µg/L

Source: EPA, 1986; U.S. Army Corps of Engineers, 1989c.

Table 3.6: Sediment Chemistry Guideline Values

Chemical	PSSDA screening level	PSSDA maximum level	ODEQ draft level
Metals (PPM)			
Antimony	20	200	--
Arsenic	57	700	40
Cadmium	0.96	9.6	1.0
Copper	81	810	50
Lead	6.6	660	40
Mercury	0.21	2.1	0.15
Nickel	140		--
Silver	1.2	6.1	--
Zinc	160	1,600	250
Tributyltin	30	--	--
Chromium	--	--	20 - 300
Organics (PPB)			
Total LPAH	610	6,100	--
Naphthalene	210	2,100	--
Acenaphthylene	64	640	--
Acenaphthene	63	6,300	7,330*
Fluorene	64	6,400	--
Phenanthrene	320	3,200	1,390*
Anthracene	130	1,300	--
2-Methylnaphthalene	67	670	--
Total HPAH	1,800	51,000	--
Fluoranthene	630	6,300	--
Pyrene	430	7,300	--
Benzo(a)anthracene	450	4,500	--
Chrysene	670	6,700	--
Benzofluoranthenes	800	8,000	--
Benzo(a)pyrene	680	6,800	--
Indeno(1,2,3-c,d)pyrene	69	5,200	--
Dibenzo(a,h)anthracene	120	1,200	--
Benzo(g,h,i)perylene	540	5,400	--
Chlorinated Hydrocarbons			
1,3-Dichlorobenzene	170		--
1,4-Dichlorobenzene	26	260	--
1,2-Dichlorobenzene	19	350	--
1,2,4-Trichlorobenzene	6.4	64	--
Hexachlorobenzene	23	230	--

Table 3.6, continued

Phthalates			
Dimethyl phthalate	160	--	--
Diethyl phthalate	97	--	--
Di-n-butyl phthalate	1,400	--	--
Butyl benzyl phthalate	470	--	--
Bis(2-ethylhexyl)phthalate	3,100	--	--
Di-n-octyl phthalate	6,200	--	--
Phenols			
Phenol	120	1,200	--
2 Methylphenol	10	72	--
4 Methylphenol	120	1,200	--
2,4-Dimethylphenol	10	50	--
Pentachlorophenol	69	690	--
Miscellaneous Extractables			
Benzyl alcohol	10	73	--
Benzoic acid	216	690	--
Dibenzofuran	54	540	--
Hexachloroethane	1,400	14,000	--
Hexachlorobutadiene	29	290	--
N-Nitrosdiphenylamine	22	220	--
Volatile Organics			
Trichloroethene	160	1,600	--
Tetrachloroethene	14	210	--
Ethylbenzene	10	50	--
Total xylene	12	160	--
Pesticides			
Total DDT	6.9	69	8.28*
Aldrin	10	--	*
Chlordane	10	--	*
Dieldrin	10	--	--
Heptachlor	10	--	1.10*
Lindane	10	--	1.57*
Methoxy chlor	--	--	*
2,4-D (Silvex)	--	--	*
Total PCBs	130	2,500	500

Source: U.S. Army Corps of Engineers, 1989c; ODWQ, 1989: USEPA 1988.

*: established using Equilibrium Partitioning (USEPA 1988) with a total organic carbon level of 1% and assuming fresh water conditions.

level identifies chemical concentrations below which there is no reason to believe that in-water disposal would result in unacceptable adverse impacts. No biological evaluation is needed to approve these sediments for in-water disposal in Puget Sound. The PSDDA maximum level corresponds to the concentration above which there is reason to believe that the material would be unsuitable for in-water disposal. These guidelines are implemented as follows:

(1) all chemicals are below their screening levels: sediment may be approved for in-water disposal without biological testing.

(2) one or more chemicals are between their screening and maximum levels: standard PSDDA biological evaluation is required before the sediment can be approved for in-water disposal.

(3) a single chemical exceeds its maximum level by less than 100%: standard PSDDA biological testing is required before the sediment may be approved for in-water disposal.

(4) a single chemical exceeds its maximum level by more than 100%, or two or more chemicals are above their maximum levels: special PSDDA biological testing is required before the sediment can be approved for in-water disposal.

The Oregon Department of Environmental Quality Draft Sediment Criteria in Table 3.6 are similar in their implementation: sediment within the draft DEQ level may be approved for in-water disposal without biological testing. Bioassay or bioaccumulation testing is required for in-water disposal if any of the guideline values are exceeded.

3.4. BIOLOGICAL PARAMETERS

Biological testing provides a better basis for sediment evaluation than do any of the other parameters described above. Bioassay and bioaccumulation studies are relatively expensive, however, and their results are subject to interpretation.

Three kinds of biological studies are considered here: bioassay, bioaccumulation, and disposal site monitoring. A bioassay is a laboratory test used for evaluating the toxicity of a sediment sample on aquatic organisms. Behavioral, physiological, or lethal response is measured.

Bioaccumulation means the buildup of chemical compounds in an organism's tissues. A bioaccumulation study exposes aquatic organisms to a test sediment in the laboratory, and then analyzes their body tissues for contaminants.

Disposal site monitoring is essentially an on-site experiment that, unlike the bioassay and bioaccumulation studies mentioned above, relies on actual site conditions and disposal conditions. It also differs from the two tests mentioned above in that the results can only be made available after dredging and disposal have been conducted.

These three types of tests, the conditions under which they may be required, and the standards used for interpreting these tests, are described in this section.

3.4.1. Bioassay Studies.

A bioassay is a laboratory test that assesses sediment toxicity by measuring changes in organisms exposed to a test sediment. This is accomplished in aquaria, in a controlled laboratory environment. Several different kinds of bioassay tests can be designed. The principal variables are the species used as test organisms; the length of the test; the nature of exposure to test sediment, and the type of response measured.

Bioassay test organisms include oyster larvae (*Crassostrea gigas*), amphipods (such as *Rhepoxinius abronius*, *Eohaustarius estuarius*, or *Grandidierella japonica*), polychaetes (such as *Abarenicola pacifica* , *Neanthes arenaceodentata*, *Nephtys caecoides*), clams (such as *Macoma balthica* or *M. nasuta*) and other species. Some of these species do not occur at Columbia River Estuary dredged material disposal sites, so the applicability of these tests to actual disposal site biological conditions is subject to interpretation.

Bioassay tests are time consuming. A ten-day exposure period is commonly used to measure acute toxicity in the solid phase test (US Army Corps of Engineers 1989c; Battelle Marine Sciences Laboratory 1988).

Two basic kinds of exposure to test sediments are commonly used: suspended phase and solid phases. In a solid phase evaluation the test sediment is allowed to settle on the bottom of the aquarium. The suspended phase test uses water and suspended test sediment. The suspended phase test simulates conditions during and immediately after in-water disposal. The suspended phase acute mortality test using the oyster larvae Crassostrea gigas is conducted for 48 or 96 hours.

Several different types of response are measured. These are sometimes characterized as lethal and sublethal responses. A lethal response is recorded when a test organism is dead after the test period. Sublethal responses include retarded growth, physical abnormalities, reduced reproductive vitality, or lack of response to stimuli when compared to control organisms.

There are no standards for interpreting bioassay tests for in-water disposal sediment evaluation in the Columbia River Estuary. The Puget Sound Dredged Disposal Analysis (PSDDA) program has developed interpretation standards for bioassay tests on Puget Sound Sediments. They are not applicable to Columbia River Estuary dredging or disposal conditions, but they are indicative of general regulatory trends. Figure 3.2 shows a summary of the PSDDA bioassay review process. The Oregon Department of Environmental Quality (ODEQ) does not have any standards for evaluating bioassays. ODEQ staff rely on professional judgement for evaluating bioassay tests in the Columbia River Estuary and elsewhere in Oregon. The Washington Department of Ecology will also rely on professional judgement, while using the PSDDA guidelines as a rough bench mark.

3.4.2. Bioaccumulation

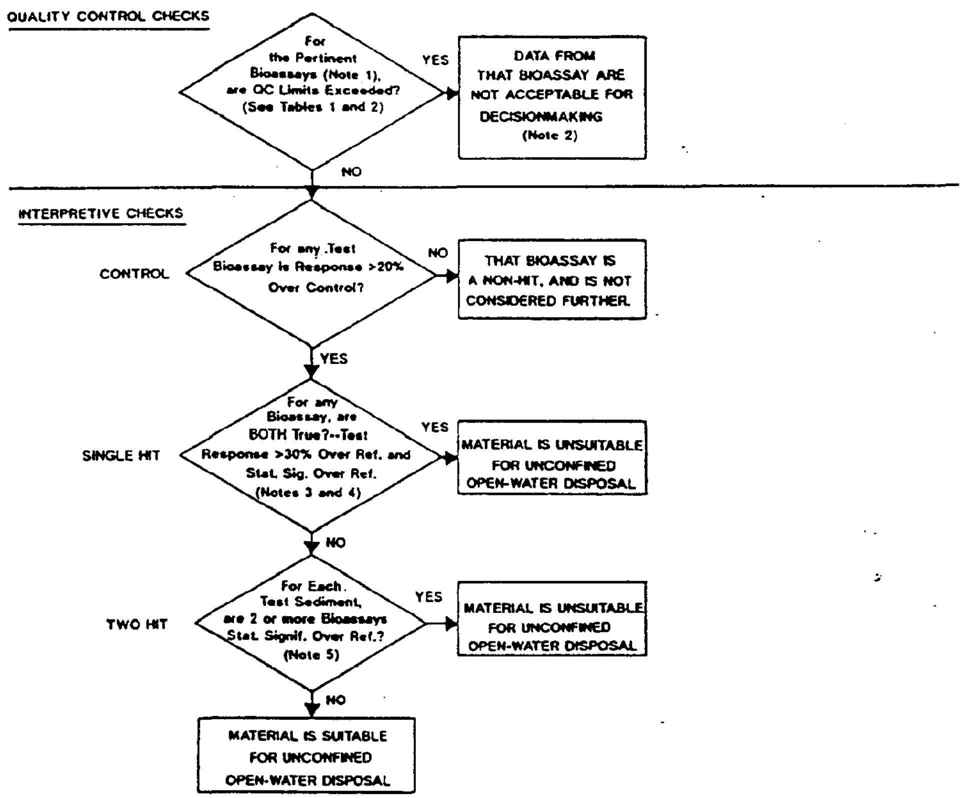
Bioaccumulation tests measure the accumulation of sediment contaminants in a test organism's tissues. Test organisms include some of the organisms listed under section 3.4.2. Bioaccumulation test results report the levels of contaminants in test organism tissues in units of weight of chemical per wet weight of tissue. Bioaccumulation tests help determine whether a sediment contaminant is likely to accumulate in the aquatic food chain, but do not necessarily help evaluate sediment toxicity.

There are no standards for bioaccumulation tests on Columbia River Estuary sediment evaluation. The Puget Sound Dredged Disposal Analysis (PSDDA) has developed standards applicable in Puget Sound. The PSDDA bioaccumulation studies are used to determine impacts on human health. Table 3.7 summarizes PSDDA standards for bioassay studies. The first column in Table 3.7 shows the threshold for conducting bioaccumulation tests expressed in terms of chemical content of the sediment. A test sediment exceeding one or more of these test thresholds must be subjected to a bioaccumulation study before it can be approved for in-water disposal in Puget Sound. The second column includes tissue guidelines, which are intended as a human health protection threshold. Test organism tissues with a level exceeding a guideline value are indicators that the test sediment is unsuitable for in-water disposal.

Figure 3.2: Summary of PSDDA Bioassay Requirements

TABLE 1 Control Limits, Amphipod and Juvenile Infaunal Species mortality ≤10% absolute. Larval Sediment Test T_{final} mortality plus abnormality in Seawater Control must be ≤50% of $T_{initial}$ Seawater Control.

TABLE 2 Reference Limits, For all Tests; ≤20% Over Control. In the Case of the Amphipod, >20% may be Accepted by the PSDDA Agencies on a Case-by-Case Basis for Sediments with High Fines.



NOTE 1 At this Step in the Flow Chart, the 404 Bioassays are Amphipod and Juvenile Infaunal Species; the 401 Bioassays include Those Tests Plus the Sediment Larval Bioassay. The 404 Water Column Bivalve Larval Bioassay is Not in This Flow Chart [Microtox, a 401 Test, Enters in a Later Step (Two Hit)].

NOTE 2 If any Bioassay Fails QC Limits, it Generally Must be Rerun, Unless the PSDDA Agencies Decide to Interpret Suitability Based on Remaining Test Results.

NOTE 3 Generally a Single-tailed Student's T comparison of Mean Test Sed. response versus Mean Reference Sed. response (Ho: they are equal), alpha level of ≤.05

NOTE 4 This decision block refers to Nondispersive Sites (Commencement Bay, Port Gardner, Elliott Bay, Anderson-Ketron Is. and Bellingham Bay). For Dispersive Sites (Port Angeles, Port Townsend and Rosario Straits),The Single Hit rule is >10% over Reference and Statistically Significant for the Amphipod and Juvenile Infaunal Species Test, and >15% over Reference and Statistically Significant for the Sediment Larval Test.

NOTE 5(This applies to Nondispersive Sites and the Two Hit case)-Microtox is an additional 401 Test that Must be Considered at This Point. Microtox Results of the Test Sediments Must be Statistically Significant from Reference Results and >20% Below Control Response to Count as a Hit.

Source: U.S. Army Coprs of Engineers, 1989c

Table 3.7 PSSDA Bioaccumulation study summary

Chemical	Threshold for conducting bioaccumulation tests (dry weight)	Tissue guidelines (wet weight)
Antimony	126.0 ppm	5,600.0 ppm
Arsenic	393.1 ppm	10.1 ppm
Mercury	1.5 ppm	1.0 ppm
Nickel	504.0 ppm	20,000.0 ppm
Silver	4.6 ppm	200.0 ppm
Fluoranthene	4,600 ppb	8,400.0 ppm
Benzo(a)pyrene	4,964 ppb	1.2 ppm
1,2-Dichlorobenzene	37 ppb	300.0 ppm
1,3-Dichlorobenzene	1,241 ppb	300.0 ppm
1,4-Dichlorobenzene	190 ppb	300.0 ppm
Dimethyl phthalate	1,168 ppb	300,000.0 ppm
Di-n-butyl phthalate	10,220 ppb	30,000.0 ppm
Bis (2-ethylhexyl) phthalate	13,870 ppb	18,000.0 ppm
Hexachloroethane	1,022 ppb	98.0 ppm
Hexachlorobutadiene	212 ppb	180.0 ppm
Phenol	876 ppb	3,000.0 ppm
Pentachlorophenol	504 ppb	900.0 ppm
Ethylbenzene	27 ppb	600.0 ppm
N-Nitrosodiphenylamine	161 ppb	2,845.0 ppm
Hexachlorobenzene	168 ppb	180.0 ppm
Tributyltin	219 ppb	-----
Trichloroethene	1,168 ppb	127.0 ppm
Tetrachloroethane	102 ppb	27.0 ppm

Table 3.7, Continued

Total DDT	50 ppb	41.0 ppm
Aldrin	37 ppb	1.2 ppm
Chlordane	37 ppb	8.7 ppm
Dieldrin	37 ppb	.046 ppm
Heptachlor	37 ppb	4.2 ppm
Total PCBs	38 ppb	2.0 ppm

Source: U. S. Army Corps of Engineers. 1989c.

3.4.3. Site Monitoring

Disposal site monitoring is essentially an on-site experiment that, unlike the bioassay and bioaccumulation studies mentioned above, relies on actual site conditions and disposal conditions. It also differs from the other tests in that the results can only be made available after dredging and disposal have been conducted.

Disposal site monitoring may involve a number of activities, and would typically be conducted for a year or more. A monitoring program would be designed to collect data that allows comparison of pre-disposal with post-disposal conditions. Bathymetry, sediment grain size and chemical data, and benthic organism communities are of interest.

There are no standards for conducting disposal site monitoring. A monitoring plan would normally be developed at the request of resource agencies. A pre-disposal site survey is conducted. This provides the baseline data against which subsequent post disposal data are evaluated. surveys of the disposal site are conducted after the disposal operation is completed, and the data are compared.

There are no standards for evaluating disposal site monitoring data. Oregon Statewide Planning Goal 16, dealing with estuarine resources, states that monitoring is carried out "to assume that estuarine sedimentation is consistent with the resource capabilities and purposes of affected natural and conservation management units".

3.5. CONCLUSION AND RECOMMENDATION

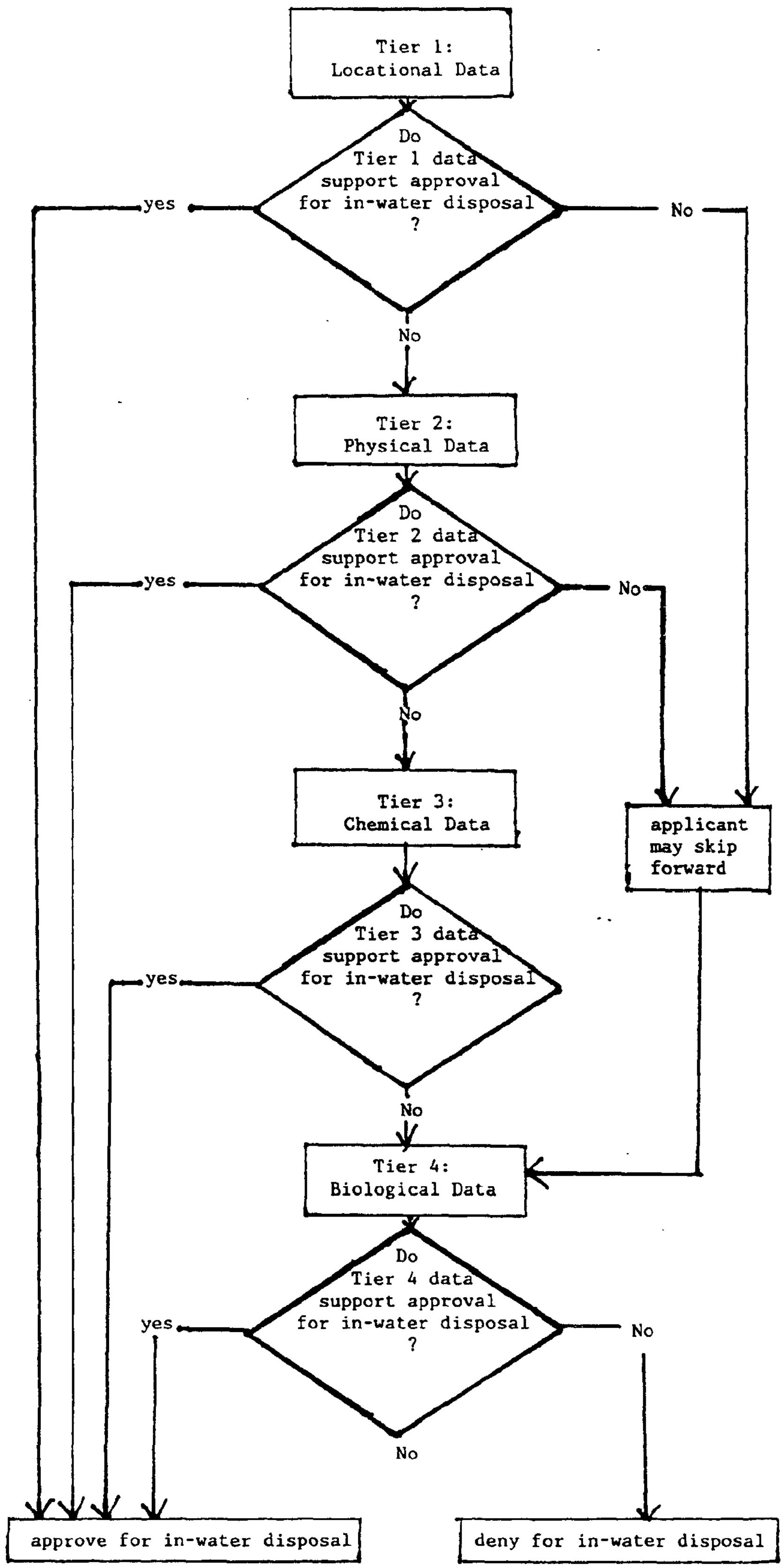
Locational, physical, chemical and biological sediment data are all useful for evaluating sediment suitability for in-water disposal. However, each has significant drawbacks. Table 3.8 summarizes each parameter's principle advantages and disadvantages.

The tiered approach to sediment evaluation, using locational, physical, chemical and biological data as needed in a sequential manner, is a reasonable compromise between two competing demands on the sediment evaluation process. On the one hand is the need to protect valuable Columbia River Estuary aquatic resources from preventable adverse impacts, and the associated high costs of making a permit decision that results in avoidable damage to those resources. On the other hand are the high costs of gathering sediment data, particularly at the biological tier, and the need to maintain essential navigation facilities in a cost-effective manner. The tiered approach to sediment evaluation, summarized graphically in Figure 3.3, provides a framework for making decisions on in-water disposal that has the potential for meeting resource protection and navigation needs on the Columbia River Estuary.

Table 3-8: Summary of Sediment Evaluation Criteria Advantages and Disavantages

Parameter	Advantages	Disadvantages
Locational data:	lowest cost	sensitive to unknown quality of historic data;
		assumes that impacts on aquatic habitat can be predicted from existing data.
Physical data grain size:	relatively low cost	assumes a strong relationship between grain size and chemistry exists;
other physical data:	relatively low cost fast (two - six weeks).	assumes strong relationship between grain size and sediment chemistry.
Chemical data:	moderate cost: less costly than biological testing;	does not provide information about biological response;
	provides accurate data that can be compared to existing standards.	statistically unsound (hot spots ignored).
Biological data:	provides direct data on impacts to aquatic organisms.	generally does not use on site organisms;
		expensive;
		slow;
		"laboratory effects" are hard to account for.

Figure 3.3. Tiered Sediment Evaluation



4. SEDIMENT ANALYSIS

4.1. INTRODUCTION

This section provides a brief summary of the sedimentary process of the Columbia River and means by which these sediments and the water column may become contaminated. Common sediment analysis methods used by testing labs are summarized. Specific subareas and contaminants discovered during sediment sampling of those subareas since 1980 are also discussed. The end of this section describes various sediment quality assessment methods used in other estuaries, and some of the advantages and disadvantages for each method.

4.2. PHYSICAL PROCESSES

Prior to extensive damming of the mainstem Columbia River and its tributaries as well as increased water diversion demands, the discharge from the Columbia River ranged from 65,000 cubic feet per second (cfs) to as much as 1.2 million cfs. Spring freshets due to snow melts significantly impacted flow regime and sedimentary deposits. Currently, the average discharge of the Columbia River is approximately 260,000 cfs. Spring freshets now have minimal impacts on flows and channel formations because of upstream storage and flow regulations. Tidal flows are the largest influencing factor of hydraulic conditions and sediment transport in the lower estuary. Although tidal influence extends upstream to Bonneville Dam (RM 145), upriver from Tongue Point (RM 18) fluvial flows dominate sediment transport.

According to previous studies, the Columbia River drains annually 667,000 square kilometers total of igneous, sedimentary and metamorphic rocks and extensive alluvial and eolian surficial deposits (Creagor, 1984). The majority of the sediment in the Columbia River Estuary is comprised of fine to medium grained sand. Sediment transport in the Columbia River Estuary consists of suspended fine sediments (which are mostly discharged out to sea) and bedload transport of medium grained sands. The estimated average of the total suspended load in the Columbia River Estuary is 10 million tons per year. The small fraction of fine grained suspended sediments retained in the estuary is usually found in peripheral bays and back channels. Whereas the Columbia River Basin previously was the major source of bedload materials, due to upstream reservoirs, primary sources of bedload are now from volcanic eruption, channel meandering, beach erosion and channel slope adjustments. These bedload sediments are transported through and deposited in the main navigation channel. The bedload supply is estimated at approximately 1 million tons per year. It is this bedload transport that is the key to erosion and deposition of sediments in the estuary. Flow regime, sediment transport, seasonal fluctuations and historical uses are important components to be considered when developing a plan for determining under what circumstances sediment analysis should occur.

4.3. SOURCES OF CONTAMINANTS

Sediments in aquatic environments can be contaminated from airborne polluted particles settling on the water surface and dissolving or from precipitation washing the particles into streams, storm drains, and ground water supplies which eventually drain into the Columbia River. Contaminants are also directly discharged into water as a result of human activities and development. Point sources include industrial outlets, sewers and storm drains directly discharging into the river. Other activities potentially contributing localized sediment contamination include shipbuilding and repair, marine fuel dispensing or storage areas, sand blasting, and bridge painting. Non-point sources such as boating activities, agricultural and forest uses and ground runoff from roads and septic systems can contribute a significant amount of contaminants to rivers and estuaries. Point source discharges often have limits placed on their effluents to minimize contaminant discharges. However, non-point sources are not so easily controlled and more difficult to regulate. Pesticides and herbicides used in agriculture and forest practices can be limited and regulated to minimize time of use and quantity but the ground absorption, runoff, and overall region-wide use is less controllable. High contamination levels in urban estuaries and bays are probably most associated with industrial outputs, but a significant amount of pollutants also enter the river from storm drains and through ground runoff where solid waste and automobile fluids collect and are transported to the water. High levels of sediment contamination may also be as a result of historical uses. For example, sediments located near the piers of Tongue Point are believed to contain "hot spots" of pollutants as a result of U.S. Naval activities occurring at Tongue Point after World War II.

Dredging is necessary in the Columbia River Estuary in order to maintain shipping facilities and services but it is a means by which contaminants re-enter the estuary. Dredging and the disposal of the dredged material recirculates contaminants that have settled out in the bottom sediments. This increase in turbidity and potential release of metals, organic substances and other toxic materials can cause serious adverse effects on water quality, aquatic resources and habitats. Thus sediment testing is vitally important in order to determine potential impacts of dredging or dredged material disposal, and to minimize these potential impacts.

4.4. REVIEW OF SEDIMENT ANALYSIS METHODS

Federal and state agencies have developed quantitative assessment methods for evaluating levels of contamination in dredge material sediments. Earlier methods based analysis on comparisons of chemical concentrations in sediments from the contaminated area to those of a control site. More recent evaluation methods consider impacts of contamination levels in dredged sediments on the biological resources at the dredge site as well as at the dredged material disposal site.

The main impetus for sedimentological research is the requirement to maintain navigational access. Since such a large quantity of material is being displaced, contamination levels in those sediments must be determined and evaluated to estimate potential effects. Trace metals bonded to sediments are present in various physical and chemical forms, each form capable of having different biological availability. During in-water disposal of dredged material, those metals that deposited and settled at the dredge site accumulate at the surface/water interface resulting in potential adverse impacts on benthic deposit feeders. Potential effects will vary, dependent on concentrations of and reactions to other metals or contaminants, organic matter content, oxidation-reduction, pH and salinity conditions of the sediment (US Army Corps of Engineers, 1983). The following paragraphs generally describe the methods used to analyze sediment composition and content.

4.4.1. Biological Tests

Bioassay

Bioassay tests are used to determine the effects of contaminants on biological organisms. Test organisms are exposed to dredged material for a specific period of time. Following exposure, response of the organism is determined by observation and by chemically testing tissues of the organisms to determine if contaminants from the dredged material were incorporated or bioaccumulated.

Two types of bioassays may be performed: a suspended-particulate phase and a solid phase. The suspended-particulate phase introduces a predetermined mixture of disposal site water and dredged material to three sensitive resident species. Effects on the species are determined for various quantities of the mixture. The solid phase requires the placement of a layer of dredged material over a layer of clean material and impacts of the benthic organisms are measured. In both cases, impacts are determined by the survival rates.

Bioassays reflect the cumulative influence of all contaminants and provide an indication of potential overall biological effects of a dredged material discharge. Bioassays can be conducted in situ or in controlled laboratory conditions. This kind of test cannot be used to characterize or delineate specific chemicals, metals, or other contaminants. A bioassay is useful however, in determining problem sediments and developing dose-response relationships.

Indigenous Biota

Evaluations of indigenous biota usually focus on benthic macroinvertebrates. These organisms are preferred because they are bottom-dwelling, are relatively stationary, can be sampled quantitatively and exhibit more predictable responses to environmental stress (PTI, 1989). Since benthic organisms are continuously exposed to contaminants in the sediment and have varying sensitivities to toxicity, they provide an estimate of combined effects of acute and chronic exposure to toxic chemicals. These organisms are evaluated for changes in abundance of individuals, abundance of species and bioaccumulation.

This method is advantageous because effects are evaluated in natural conditions rather than controlled laboratory situations, and are subjected to varying environmental conditions. However, the research may be costly for the same reason, in addition to the extensive data and taxa identification requirements.

4.4.2. Chemical Analysis

Water Column

Contaminants in the sediments and suspended in the water column are present in various physical and chemical forms. There may be unequal distribution of contaminants dependent on the physical/chemical conditions of the surface sediments and overlying water column. Contaminants that settle and bond to the surface bottom sediments usually remain dissolved but become absorbed or adsorbed to the sediment as ionized constituents, form organic complexes or participate in oxidation-reduction reactions (US Army Corps of Engineers, 1983). Elutriate tests are used to simulate the conditions of the dredging and disposal process and to measure chemicals released from the agitated sediments. Predetermined amounts of water and sediments from the dredge site are mixed together to approximate the dredged material slurry. The material is chemically analyzed to determine contaminant concentrations. Concentrations should be compared to background levels and to state water quality objectives to determine the potential impact of the material during dredging and discharge.

Elutriate tests are also performed using predetermined amounts of sediment from the dredge site and water from the disposal site. This combination allows an analysis of the amount of metal concentrations contributed from the sediment by subtracting from the mixture chemical concentrations in the water. Mixing sediment and water from each site also provides another means to evaluate potential reactions and impacts during disposal operations. Elutriate tests only register pollutants that dissolve or resuspend out of sediments. Pollutants that are bound to sediments, i.e., DDT, are likely to remain undetected during an elutriate test, yet still have the potential to cause adverse impacts. Elutriate test results also must be reviewed concerning consequences of dissolved oxygen depletion during the testing procedure especially if the disposal site is well oxygenated. Depletion could effect measured metal concentrations and evaluations of environmental impacts (Fuhrer and Horowitz, 1988). Other factors which could influence elutriate test results include sediment-water ratio, shaking time, settling time, method of agitation and salinity of the water (Schroeder 1977).

Sediments

Bulk sediment or total sediment analysis measures the presence of a contaminant in the sediment and compares the chemical similarity between sediments at the dredge site and sediments at the disposal site. The sediment sample is digested using hydrofluoric acid to break down silicate matrices of the sediment and release the chemical constituents.

4.5. SEDIMENT ANALYSIS OF METALS IN COLUMBIA RIVER ESTUARY

Felstul (1988) examined 86 Columbia River mainstem channel and tributary samples determining grain size, percent of sand, silt and clay and the concentrations of heavy metals, oil and grease, volatile solids, total organic content and ammonia in each sample. The samples were collected by the U.S. Geological Survey and the U.S. Army Corps of Engineers from 1980 to 1987. The 86 Columbia River mainstem channel and tributary samples investigated by Felstul are part of a larger project that includes over 160 samples collected along the Oregon coastline. For purposes of this project, the data for the 86 lower Columbia River Estuary sampling sites was separated from the overall Oregon estuary database in order to analyze sediment samples specifically from the Columbia River Estuary. This estuary-wide analysis of sediments and contaminants will allow comparisons between areas within the estuary, between other estuaries and other regions in the country. The analysis will also identify areas or projects with potential regulatory conflicts and provide a foundation for developing a coordinated sediment quality management plan for the Columbia River Estuary.

It is believed that the distribution of metals and organic compounds is dependent on the association with fine grained particles. Therefore, it is important to investigate correlations in the Columbia River Estuary between certain metals and grain size distribution to determine if this is the case for the Columbia River Estuary. Felstul investigated correlations between concentrations of contaminants and sediment grain size distribution. He found that as his sample site narrowed geographically, his correlations improved. For example, correlations between heavy metals and grain size distribution in Chinook Channel were higher than correlations in the Columbia River mainstem channel which were higher than correlations using data from all Oregon estuaries. Chinook Channel has a greater percent of silt/clay sediments than does the Columbia River mainstem channel. The higher correlations between heavy metals and grain size distribution in Chinook Channel seems consistent with the concept linking elevated levels of contaminants with finer sediments. This result might also suggest that each project site has its own unique characteristics; physical parameters specific to each site should be established for each project and used as part of the evaluation criteria during sediment analysis.

The following sections describe contamination levels specific to smaller geographical areas in the Columbia River Estuary. Felstul's data was sorted and analyzed according to the following areas: Chinook Channel, Skipanon Channel and Basin, Ilwaco Channel, Columbia River Mainstem Channel to river mile 18.5, Baker Bay, and Cathlamet Bay. Felstul and Fuhrer and Rinella analyzed one sample from Hammond, Astoria, Tansy Point, Youngs Bay and Skamokawa. Maps 4.1 through 4.4 show the generalized areas where samples were collected. Information from other reports that analyzed sediments in the Columbia River Estuary, including the Port of Astoria docks, is also used in the discussions below.

Columbia River Main Channel and Tributaries n=86	Arsenic (As)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Nickle (Ni)	Zinc (Zn)	Cadmium (cd Flame)	Cadmium (cd Furn)
Average (mg/kg)	6.76	19.63	25.31	17,302	11.60	232.70	.07	9.16	92.08	.94	.26
Standard Deviation (mg/kg)	4.78	14.13	16.34	12,054	6.93	196.48	.09	10.78	53.15	1.33	.39
r^2	.116942	.066982	.529961	.021457	.207608	.000664	.118330	.102785	.599160	.004033	.161129

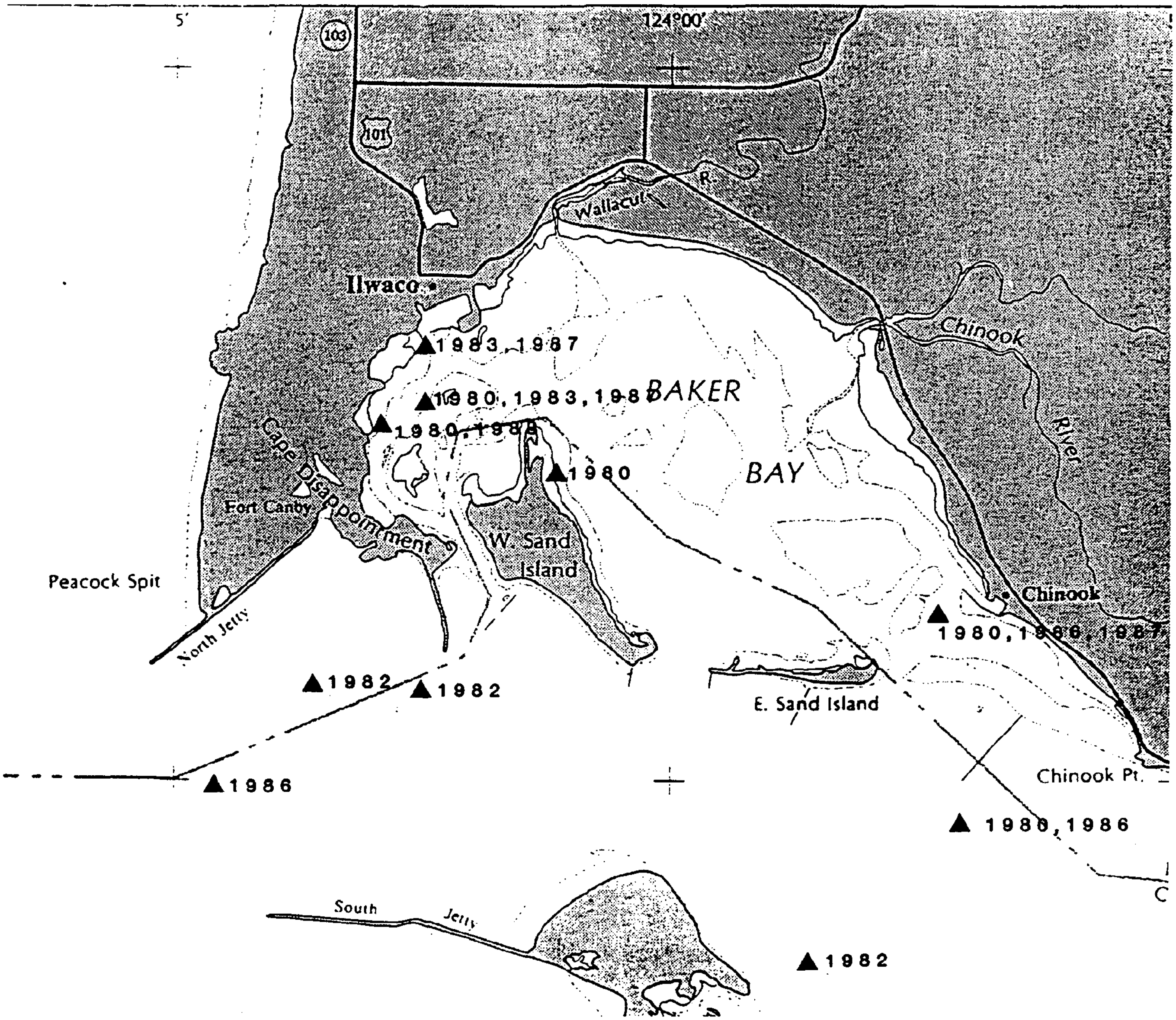
TABLE 4.1b: Average Metal Concentrations in Samples With Over 50% Silt/Clay Composition

Samples With Greater Than 50% Silt n=45	Arsenic (As)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Nickle (Ni)	Zinc (Zn)	Cadmium (cd Flame)	Cadmium (cd Furn)
Average (mg/kg)	8.44	22.15	35.7	17,842.22	14.31	223.18	.09	11.59	125.83	1.05	.40
Minimum (mg/kg)	0.0	10.0	8.3	0.0	4.20	0.0	0.0	0.0	54	0.0	0.0
Maximum (mg/kg)	20.5 (Chinook Channel)	72.0 (Skipanon Channel)	56.9	49,000 (Skipanon Channel)	40.0 (Baker Bay)	700.00	.31	44 (Skipanon Channel)	300 (Skipanon Channel)	8.0 (Chinook Channel)	1.83 (Skipanon Channel)
Standard Deviation (mg/kg)	4.66	12.90	10.05	12,884.45	7.68	179.19	.07	11.81	49.64	1.72	.49

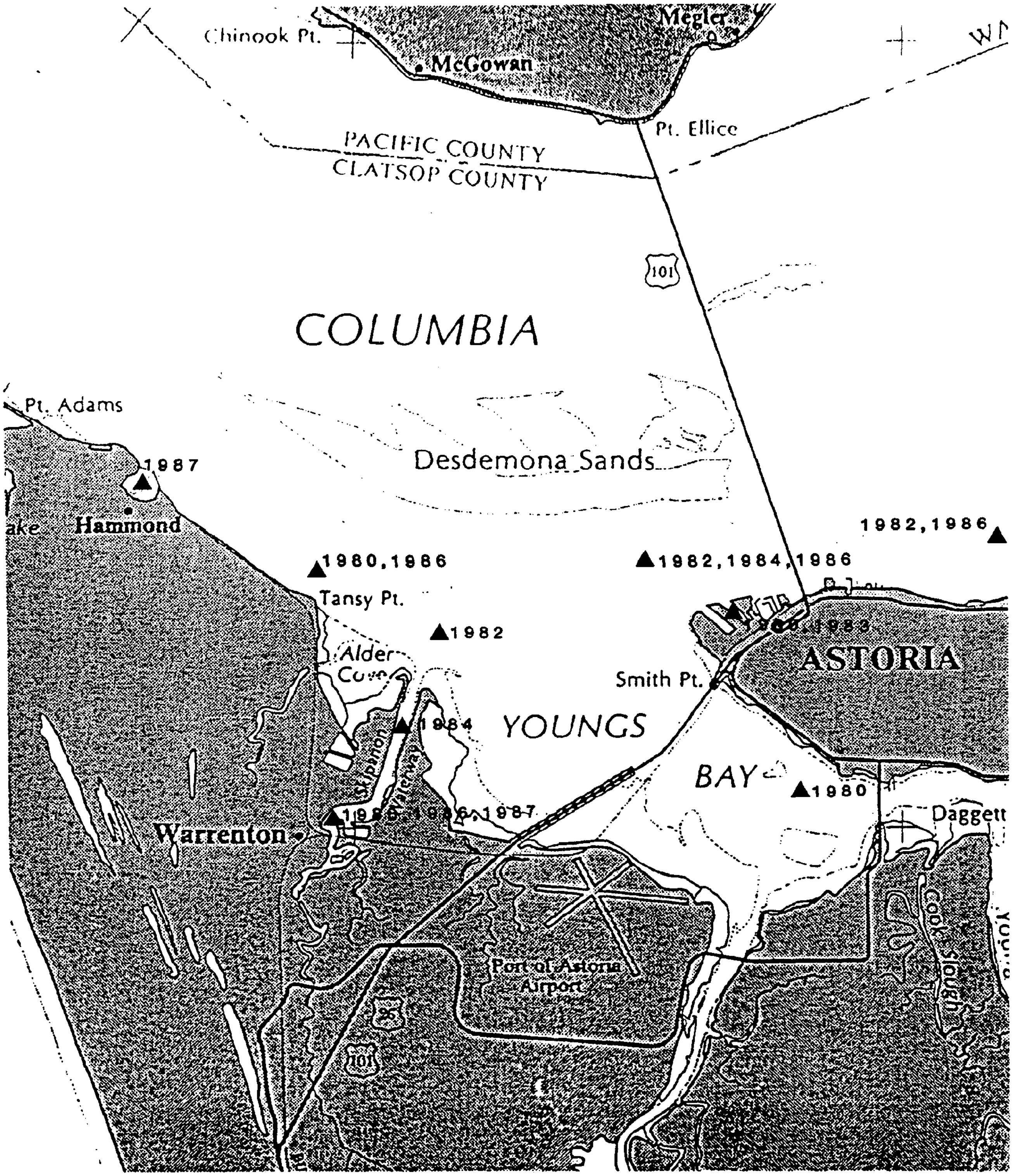
TABLE 4.1c: Average Metal Concentrations in Samples With Over 50% Sand Composition

Samples With Greater Than 50% Sand n=41	Arsenic (As)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Nickle (Ni)	Zinc (Zn)	Cadmium (cd)	Cadmium (cd Furn)
Average (mg/kg)	4.92	16.85	13.90	16,709.76	8.62	243.16	.04	6.5	55.04	.84	.11
Minimum (mg/kg)	0.0	1	1.5	0.0	.40	0.0	0	0	18.00	0	0
Maximum (mg/kg)	16.00	57.00	91.00 (Columbia River Channel)	41,000	20.00	900.00 (Cathlamet Bay)	.72 (Cathlamet Bay)	27.00	126.00	2.3	.43
Standard Deviation (mg/kg)	4.19	14.88	14.17	11,040.83	4.37	213.37	.11	8.77	24.46	.66	.11

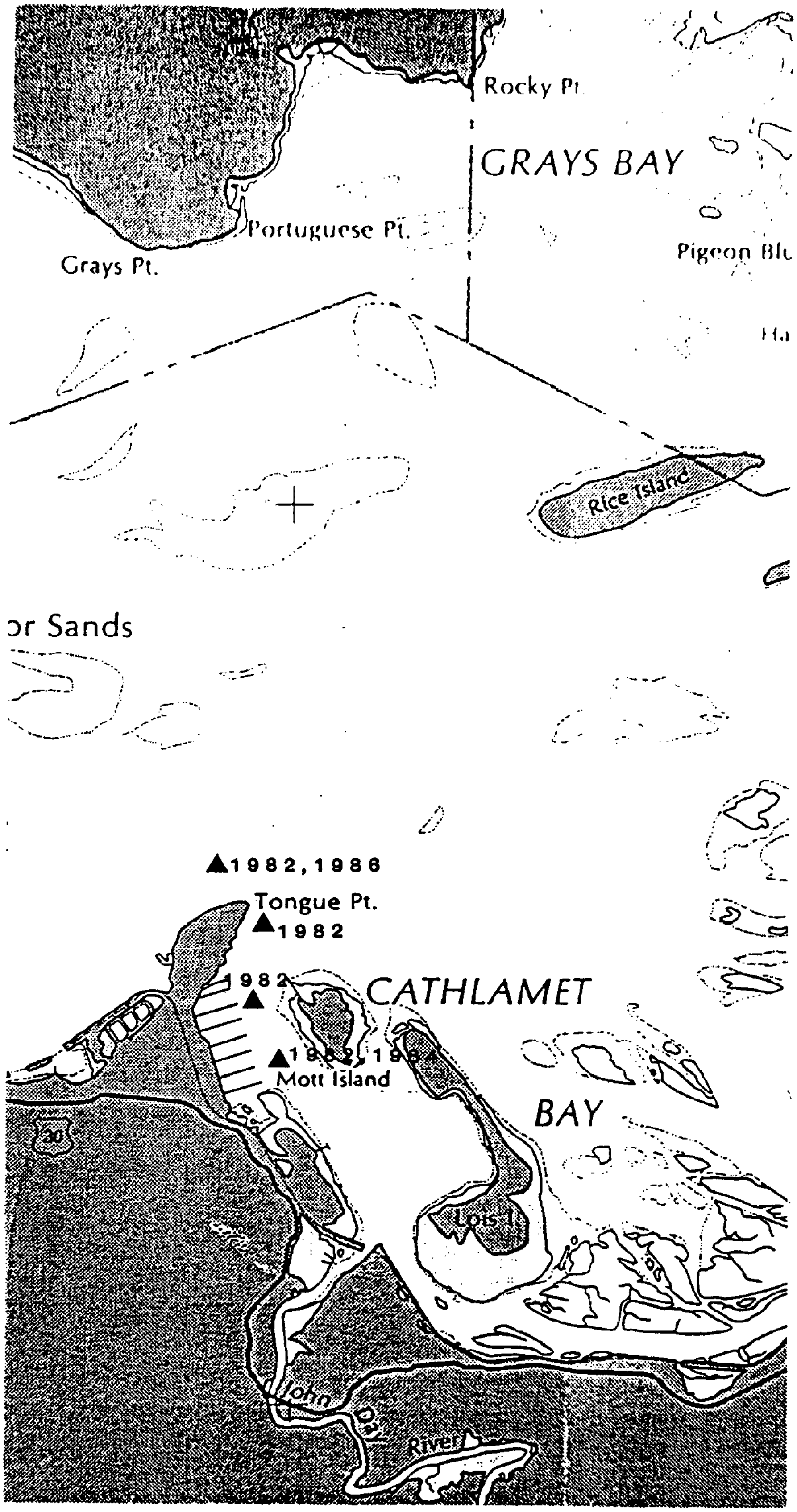
Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", Corps of Engineers, 1988.



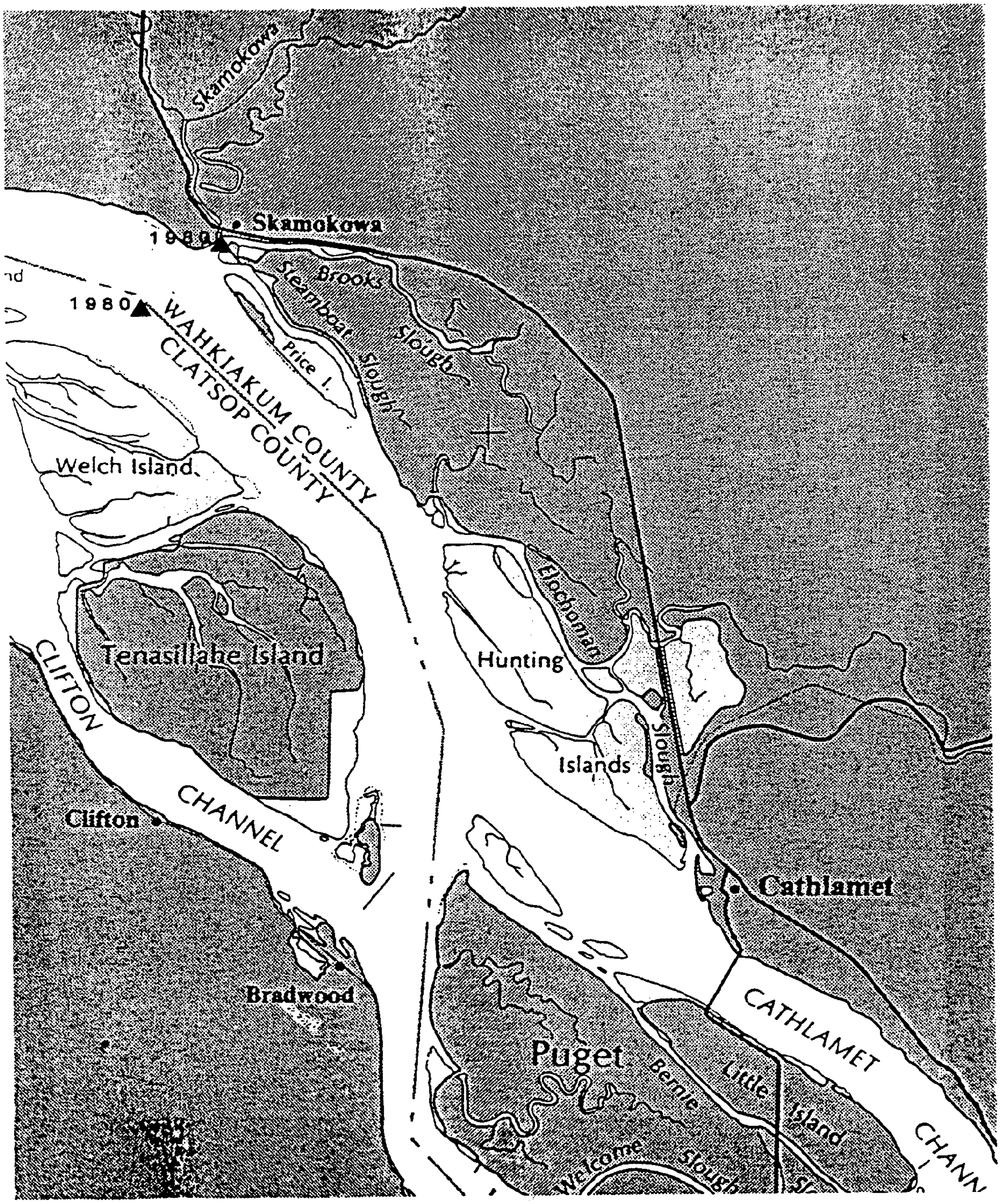
Map 4.1: General Sampling Areas for Columbia River, Baker Bay, Ilwaco Channel and Chinook Channel



Map 4.2 : General Sampling Areas for Columbia River, Hammond Boat Basin, Skipanon River, Youngs Bay and Port of Astoria's Docks



Map 4.3: General Sampling Areas for Columbia River and Cathlamet Bay



Map 4.4: General Sampling Areas for Columbia River and Skamokawa River

Pertinent information specific to each individual metal is discussed in Chapter Three. In the following sections, the contamination levels for the Columbia River Estuary, determined by combining all 86 Columbia River mainstem channel and tributary samples, are reviewed first. Table 4.1a-c summarizes metal concentrations estuary wide. Correlation coefficients derived for 10 metals show the relationship between the concentration of metal, as found estuary wide, and the sediment grain size distribution. Smaller geographical areas are then discussed individually and compared to the combined data for the entire estuary. Tables are presented which show the estuary-wide average. A metal is considered elevated in this chapter if the contamination level exceeds one standard deviation fron the estuary-wide average concentration for that metal. When discussing a subarea's mostly silt samples, a metal is considered elevated if the contamination level exceeds one standard deviation for the metal for all Columbia River Estuary samples of mostly silt. The same method applies for sandy samples. The smaller Tables in this chapter are descriptive of a specific subarea and should be used in conjunction with Table 4.1a-c.

4.5.1. Metal Correlations in the Columbia River Estuary

When comparing concentrations of each of the 10 metals from all 86 Columbia River Estuary samples to sediment grain size composition, only two metals, copper and zinc, showed a strong relationship between high concentration levels and fine grained particles (Table 4.1a). The correlation coefficient r^2 was over 0.5 for both: copper r^2=.5299 and zinc r^2=.5991. The remaining correlations were under r^2=0.2.

However, as the sample site narrows geographically, correlations improve somewhat. For example, correlations between metal concentrations and the 29 sediment samples for the Columbia River mainstem subarea show stronger correlations (r^2=0.5 or more) for iron, manganese and zinc (Table 4.2).

Likewise, correlations between high metal concentrations and fine grained particles for Chinook Channel reveal even stronger correlations specific to this subarea (Table 4.3). This could be due in part to higher quantities of the fine grained particles that are found in the peripheral bays than in the main channel. In Chinook Channel, lead, manganese and nickel are the only metals having higher correlations with sandy sediments rather than with finer sediments. Additional descriptions of sediments particular to specific subareas within the Columbia River Estuary are discussed in the following sections.

Table 4.2:

COLUMBIA RIVER MAINSTEM CHANNEL
Correlation Coefficient for Metals and Grain Size Distribution

METAL	% VERY FINE SAND	% SILT	% CLAY	MEDIAN GRAIN SIZE
Fe	.60	.59	.65	.65
Mn	.52	.51	.68	--
Zn	.50	--	.64	--

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

Table 4.3:

CHINOOK CHANNEL
Correlation Coefficient for Metals and Grain Size Distribution

METAL	% SAND	% VERY FINE SAND	% SILT	% CLAY	MEDIAN GRAIN SIZE
Cr	.78	.89	.97	.97	.89
Cu	.77	.76	.83	.87	.76
Fe	.78	.89	.97	.97	.89
Pb	.62	--	.50	.58	--
Mn	.89	.69	.66	.66	.69
Hg	--	.62	.66	.57	.61
Ni	.76	.53	.59	.59	.53
Zn	.52	.69	.78	.76	.72

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

4.5.2. Baker Bay

Felstul (1988) examined five samples that were collected in Baker Bay in July of 1980 (see Map 4.1). Two of the samples had a grain size distribution consisting of over 90% silt and clay. The remaining three samples consisted of sands. The two samples consisting of silt and clay consistently exhibited higher levels of metals than the samples of mostly sand, with concentrations of lead, mercury, nickel and zinc exceeding one standard deviation limit in one or both samples (see Table 4.4). One of the silt samples exhibited the highest concentration of lead, 40 mg/kg, of all 86 Columbia River Estuary samples analyzed. This concentration is right at the threshold level established by the Oregon Department of Environmental Quality in the "Draft Interium Sediment Quality Guidelines" at which additional analysis would be required for in-water disposal of dredged materials. One of the samples consisting of mostly sand also showed a concentration of lead (20 mg/kg) which exceeded one standard deviation. Felstul indicated that additional samples were taken in 1987 (although not part of this database) also showing elevated levels of lead. The higher levels of lead could be due in part to leaded fuels.

Table 4.4: Metals in Baker Bay with Concentrations Higher than one Standard Deviation from the Average of all Columbia River Estuary Samples and Samples Consisting of >50% Silt and Clay, and samples with >50% sand.

ELEVATED METALS IN BAKER BAY
Columbia River Estuary Samples
n=86

METAL	AVERAGE CONCENTRATION IN CRE (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF BAKER BAY SAMPLES EXCEEDING SD
Zn	92.08	53.15	2
Ni	9.16	10.78	1
Hg	.07	.09	2
Pb	11.6	6.93	2
Cu	25.31	16.34	1

Columbia River Estuary Samples Of >50% Silt and Clay
n=45

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SILT (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF BAKER BAY SAMPLES EXCEEDING SD
Zn	125.83	49.64	1
Ni	11.59	11.81	1
Hg	.09	.07	2
Pb	14.31	7.68	2

Columbia River Estuary Samples Of >50% Sand
n=41

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SAND (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF BAKER BAY SAMPLES EXCEEDING SD
Pb	8.62	4.37	1

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

Other investigators examined trace metal concentrations in Baker Bay using a soft digestion (1N HCl) extraction of bottom material. Fuhrer (1986) examined six bottom material samples taken form Baker Bay in 1983. Two samples had concentrations of cadmium (flame) (1.9 and 2.2 mg/kg) above the average concentration (.95 mg/kg) determined by Felstul for 86 Columbia River Estuary samples, but just within one standard deviation. One of these same samples also had higher levels of manganese and zinc compared to Felstul's averages, but within standard deviations. Lead concentration for one sample (31.8 mg/kg) exceeded the standard deviation for lead from all 86 Columbia River Estuary samples.

Total organic carbon (TOC) content was elevated in Baker Bay sediments consisting of >50% silt and clay. Measures in Baker Bay ranged below the average of 8.9 mg/g for all Columbia River Estuary sediments up to 18.7 and 19.7 mg/g for the two Baker Bay samples from Felstul's data of mostly silt and clay. Fuhrer (1986) found, however, that higher levels of TOC were in sandier sediment samples. He attributes this factor to the possible presence of discrete heavy fragments of organic detritus material. Ammonia concentrations were much higher in siltier samples, measuring over 130 mg/kg compared to under 5 mg/kg for Baker Bay samples consisting of mostly sand. Measures for volatile solids for all Baker Bay samples ranged from 0 to 5.53 percent.

4.5.3. Chinook Channel

Twenty-one sediment samples were included in Felstul's database for Chinook Channel. One sample was taken in 1980, fourteen in December 1986 and six samples in July of 1987 (see Map 4.1). Fifteen samples consisted of over 50% silt and clay.

Eleven samples of arsenic and eight samples of copper exhibited concentrations higher than one standard deviation for each metal from the 86 samples analyzed in the Columbia River Estuary. Three of the arsenic samples were above one standard deviation limit for Felstul's 45 samples consisting of greater than 50% silt and clay and 2 samples consisting of greater than 50% sand were above the limit. The one site sampled in 1980 was resampled in 1986 resulting in some considerable differences. Concentration of arsenic doubled to 20.5 mg/kg being the sample with the largest concentration of arsenic of all 86 sites sampled in the Columbia River Estuary. This level of arsenic is below the threshold level (40 mg/kg) established by the Oregon Department of Envioronmental Quality at which additional sediment analysis would be required for in-water disposal.

Of the eight samples exhibiting elevated levels of copper, one sample, consisting of 56.9 mg/kg of copper also exceeded Oregon's Department of Environmental Quality threshold level (50 mg/kg) established in the "Draft Interim Sediment Quality Guidelines." Cadmium showed a marked decrease from being the highest concentration in the Columbia River Estuary in 1980 at 8 mg/kg to being well below the average concentration of .26 mg/kg. There was also a decrease in the concentration of lead from 30 mg/kg to 11 mg/kg. Three sites consisting of mostly silt were sampled in December of 1986 and again 6 months later in July of 1987. Concentration levels for arsenic decreased in that time period but levels of chromium, copper and lead increased. This increase could in part be due to lower river flows, more turbidity from dredging activities during the summer months and increased boating activities.

Chinook Channel sediments consisting of over 50% silt and clay had higher measures of Total Organic Carbon content (TOC) than did Chinook Channel sediment samples consisting of mostly sand. Measures ranged from .28 mg/g to 26.6 mg/g. The average TOC content however, was the same 8.9 mg/g as the average TOC of all 86 Columbia River Estuary sediments. Measures of volatile solids ranged from .50 percent of dry weight to 6.6 percent.

Table 4.5: Metals in the Chinook Channel with Concentrations Higher than One Standard Deviation from the Average of all Columbia River Estuary Samples, Samples with >50% Silt and Clay, and Samples with >50% Sand

ELEVATED METALS IN CHINOOK CHANNEL
Columbia River Estuary Samples
n=86

METAL	AVERAGE CONCENTRATION IN CRE (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CHINOOK SAMPLES EXCEEDING SD
As	6.76	4.78	11
Cd (furn)	.26	.39	1
Cu	25.31	16.34	8
Pb	11.60	6.93	1
Zn	92.08	53.15	1

Columbia River Estuary Samples of >50% Silt and Clay
n=45

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SILT (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CHINOOK SAMPLES EXCEEDING SD
As	8.44	4.66	3
Cd (furn)	.40	.49	1
Cu	35.7	10.05	1
Pb	14.31	7.68	1
Mn	223.18	179.19	1

Columbia River Estuary Samples of >50% Sand
n=41

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SAND (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CHINOOK SAMPLES EXCEEDING SD
As	4.92	4.19	2
Cd (furn)	.11	.11	1

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

4.5.4. Ilwaco Channel

Felstul examined eight samples in Ilwaco Channel that were collected in 1987 (see Map 4.1). Five of the samples were comprised of a grain size distribution of greater than 65% silt. Two of the remaining samples consisted of at least 50% sand and only one sample was almost 80% coarser than medium sand. One of the samples comprised of mostly silts had concentrations of mercury (.184 mg/kg), nickel (22.6 mg/kg) and cadmium (1.13 mg/kg) (furnace) higher than one standard deviation for those metals for all 86 Columbia River Estuary samples. These concentrations for mercury and cadmium slightly exceed the threshold level (.15 mg/kg and 1.0 mg/kg respectively) established by the Oregon Department of Environmental Quality in the "Draft Interim Sediment Quality Guidelines." The samples consisting mostly of sand had much lower concentrations of metals than those comprised of silts and clays. However, the one sample consisting of coarser sands showed a slight increase in concentration levels for most metals than the other two mostly sand samples, but well within one standard deviation.

Table 4.6: Metals in the Ilwaco Channel with Concentrations Higher than one Standard Deviation from the Average of all Columbia River Estuary Samples and Samples Consisting of >50% Silt and Clay

ELEVATED METALS IN ILWACO CHANNEL
Columbia River Estuary Samples
n=86

METAL	AVERAGE CONCENTRATION IN CRE (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF ILWACO SAMPLES EXCEEDING SD
Hg	.07	.09	1
Ni	9.16	10.78	1
Cd (furnace)	.26	.39	2

COLUMBIA RIVER ESTUARY SAMPLES of >50% SILT AND CLAY
n=45

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SILT (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF ILWACO SAMPLES EXCEEDING SD
Hg	.09	.07	1
Cd (furnace)	.40	.49	1

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

Ilwaco sediment samples consisting of more than 50% silt and clay had elevated amounts of total organic carbon compared to Ilwaco sediment samples consisting of mostly sand. Measures of TOC ranged from 7.63 mg/g to 13.10 mg/g for samples of mostly silt and clay. Samples consisting of mostly sand had a TOC content under .55 mg/g. The same pattern held true for the percent of volatile solids in the sediment. Measures of TOC ranged from .6 percent (sandy sample) to 6.03 percent (silt and clay samples).

4.5.5. Skipanon Channel and Basin

Skipanon Channel and Basin proved to have high concentrations of most metals. The high levels of contaminants were probably due to development and industrial outputs. Felstul analyzed fourteen samples taken from the Skipanon area. Seven sites in the channel were sampled in 1984, and seven sites in the basin area from 1980 to 1987 (see Map 4.2). All sites sampled except for two consisted of very fine sediments. Twelve of the 14 samples had a grain size distribution of 50% or more silt sediments and seven of those consisted of more than 20% clay. Neither of the two samples that consisted of sandier sediments had concentrations of metals exceeding one standard deviation. Three of the samples had the highest concentrations of a metal of all Columbia River Estuary samples. One sample had the highest concentration of chromium (72 mg/kg), iron (49,000 mg/kg) and nickel (44 mg/kg). Another sample was determined to have the highest level of zinc at 300 mg/kg and a third sample had the highest level of cadmium (furnace) at 1.83 mg/kg. These concentrations of zinc and cadmium both exceed threshold levels (250 mg/kg and 1.0 mg/kg respectively) established by the Oregon Department of Environmental Quality in the "Draft Interim Sediment Quality Guidelines".

The samples with grain size distribution of more than 50% silt and clay consistently had a total organic carbon (TOC) content higher than the average TOC content for all 86 Columbia River Estuary samples. TOC measures ranged from 0.0 mg/g to 74.9 mg/g. The average amount of TOC for sediment samples in Skipanon Channel and boat basin was 17.75 mg/g compared to the average TOC of 8.9 mg/g for all 86 Columbia River Estuary sites. Measures for volatile solids in the Skipanon Channel and boat basin ranged from 0.0 to 13.79 percent.

Table 4.7: Metals in the Skipanon Channel with Concentrations Higher than One Standard Deviation from the Average of all Columbia River Estuary Samples and Samples Consisting of >50% Silt and Clay

ELEVATED METALS IN SKIPANON CHANNEL
Columbia River Estuary Samples
n=86

METAL	AVERAGE CONCENTRATION IN CRE (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF SKIPANON SAMPLES EXCEEDING SD
Cd (furnace)	.26	.39	8
Cr	19.63	14.13	2
Cu	25.31	16.34	8
Fe	17302.00	12054.00	4
Pb	11.60	6.93	4
Mn	232.70	196.48	1
Hg	.07	.09	6
Ni	9.16	10.78	7
Zn	92.08	53.15	9

Table 4.7, Continued

Columbia River Estuary Samples of >50% Silt and Clay
n=45

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SILT (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF SKIPANON SAMPLES EXCEEDING SD
Cd (furnace)	.40	.49	8
Cr	22.15	12.90	2
Cu	35.70	10.05	5
Fe	17842.22	12884.45	4
Pb	14.31	7.68	3
Mn	223.18	179.19	1
Hg	.09	.07	6
Ni	11.59	11.81	3
Zn	125.83	49.64	5

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

4.5.6. Cathlamet Bay

Felstul examined six samples collected from Cathlamet Bay in 1984 (see Map 4.3). Only one sample consisted of more than 50% silt and clay. All samples tested had very high levels of chromium, iron, manganese and nickel, exceeding one standard deviation above average concentrations. Two different samples, both consisting of mostly sand, had the highest concentrations of manganese and mercury (900 mg/kg and .72 mg/kg, respectively) of all 86 samples examined by Felstul in the Columbia River Estuary. Mercury exceeded the Oregon Department of Environmental Quality threshold level of .15 mg/kg established in "Draft Interim Sediment Quality Guidelines" above which additional analysis would be required for in-water disposal.

Fuhrer (1984) collected three sediment samples from Cathlamet Bay in 1982. He found all metal concentrations were within one standard deviation of the average for each metal as determined by Felstul for all 86 Columbia River Estuary samples except for cadmium. A sample collected at the tip of Tongue Point had a cadmium (flame) concentration of 10 mg/kg.

Total organic carbon (TOC) content in Cathlamet Bay sediment samples examined by Felstul ranged from 3.2 to 13.3 mg/g. The average TOC in Cathlamet Bay, 7.86 mg/g is just under the average 8.9 mg/g for all 86 Columbia River Estuary samples.

Table 4.8: Metals in Cathlamet Bay with Concentrations Higher than One Standard Deviation from the Average of all Columbia River Estuary Samples, Samples consisting of >50% Silt and Clay, and Samples Consisting of >50% Sand

ELEVATED METALS IN CATHLAMET BAY
Columbia River Estuary Samples
n=86

METAL	AVERAGE CONCENTRATION IN CRE (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CATHLAMET BAY SAMPLES EXCEEDING SD
Cr	19.63	14.13	6
Fe	17302.00	12054.00	6
Mn	232.7	196.48	6
Ni	9.16	10.78	6
Hg	.07	.09	1

Columbia River Estuary Samples of >50% Silt and Clay
n=45

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SILT (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CATHLAMET BAY SAMPLES EXCEEDING SD
Mn	223.18	179.19	1

Columbia River Estuary Samples of >50% Sand
n=41

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SAND (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CATHLAMET BAY SAMPLES EXCEEDING SD
Cr	16.85	14.88	6
Fe	16709.00	11040.00	6
Mn	243.16	213.37	6
Ni	6.5	8.7	6
Hg	.04	.11	1
Zn	55.04	24.46	3

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

4.5.7. Columbia River Channel

Twenty-nine sites in the Columbia River mainstem channel to RM 18.5, and one additional site at RM 32.7, were sampled and analyzed by Felstul (1988)(see Maps 4.1 - 4.4). Twenty-five samples were collected in 1986, two each in 1980 and 1984. Only eight samples consisted of more than 50% silt and clay. Seven samples consisted of sediments in which over 50% were coarser than fine to medium sand.

Two 1984 sediment samples from RM 12.5 consistently showed high concentrations of iron, manganese, chromium and nickel. Only one sample, consisting of mostly sand from RM 5.5, had an elevated concentration of copper, 91 mg/kg, the highest concentration of all 86 Columbia River Estuary samples analyzed. This concentration exceeded the threshold level of 50 mg/kg established by Oregon Department of Environmental Quality. Cadmium (furnace) concentrations in eight samples taken between RM .5 and 16.5 exceeded one standard deviation of the metal for Columbia River Estuary sediments consisting of >50% sand, but remained within one standard deviation for the metal combining all 86 Columbia River Estuary samples. Elevated concentrations for arsenic were also detected in eight samples between RM 5.5 and 16.5. Three of these samples exceeded one standard deviation for silt samples and four samples exceeded one standard deviation for sand samples. However they were well under the threshold level of 40 mg/kg established by Oregon Department of Environmental Quality. Manganese concentrations greater than one standard deviation of the metal for sediments of mostly silts were detected in four samples between RM 10.5 and 18.5.

Fuhrer (1984) examined seven additional sediment samples from the Columbia River collected in August of 1982. He found that soft digestion procedures on bulk-samples yielded concentrations similar to Felstul's estuary-wide averages for most metals.

Table 4.9: Metals in the Columbia River Mainstem Channel with Concentrations Higher than One Standard Deviation from the Average of all Columbia River Estuary Samples; Samples Consisting of >50% Silt and Clays; and, Samples Consisting of >50% Sand

ELEVATED METALS IN THE COLUMBIA RIVER MAINSTEM CHANNEL
Columbia River Estuary Samples
n=86

METAL	AVERAGE CONCENTRATION IN CRE (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CR CHANNEL SAMPLES EXCEEDING SD
As	6.76	4.78	8
Cr	19.63	14.13	3
Cu	25.31	16.34	1
Fe	17302.00	12054.00	2
Ni	9.16	10.78	2
Pb	11.60	6.93	1
Mn	232.70	196.48	6

Table 4.9 Continued

Columbia River Estuary Samples of >50% Silt and Clay
n=45

METAL	AVERAGE CONCENTRATION FOR CRE SAMPLES >50% SILT (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CR CHANNEL SAMPLES EXCEEDING SD
As	8.44	4.66	3
Cr	22.15	12.90	2
Fe	17842.22	12884.45	1
Ni	11.59	11.811	1
Pb	14.31	7.68	1
Mn	223.18	179.19	4

Columbia River Estuary Samples of >50% Sand
n=41

METAL	AVERAGE FOR CRE SAMPLES >50% SAND (mg/kg)	STANDARD DEVIATION (SD) (mg/kg)	# OF CR CHANNEL SAMPLES EXCEEDING SD
As	4.92	4.19	5
Cd (furn)	.11	.11	8
Cr	16.85	14.88	1
Cu	13.9	14.17	1
Fe	16709.76	11040.83	1
Ni	6.5	8.77	1
Pb	8.62	4.37	5
Mn	243.16	213.37	1

Source: Compiled from Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Quality", 1988.

Total organic carbon content of sediments from the Columbia River Mainstem Channel ranged from 0 mg/g to 23 mg/g. The average TOC for the Columbia River Channel, 5.47 mg/g, was under the average 8.9 mg/g for all 86 Columbia River Estuary samples. The percentage of volatile solids in Columbia River Mainstem Channel samples ranged from 0 to 4.3 percent.

4.5.8. Port of Astoria Docks

In 1988, the Port of Astoria contracted with Farr, Friedman and Bruya, Inc. to analyze toxicity of sediment samples at the port slips in preparation for dredging and disposing of this material. Bulk sediment analysis was performed on two samples from Slip One. One sample was actually a composite sample of three different sample sites. All samples consisted of fine grained "muddy" sediments.

The samples had very high concentrations of arsenic, 55.6 and 63.8 mg/kg compared to the average of 6.76 mg/kg reported for 86 Columbia River Estuary samples by Felstul. These concentrations also exceed the threshold level (40 mg/kg) established by Oregon Department of Environmental Quality in the "Draft Interim Sediment Quality Guidelines" at which additional analysis is required for in-water disposal. Copper, lead, mercury and zinc concentrations were also higher than Felstul's estuary-wide averages.

Bulk sediment analysis by Coffey Laboratories in 1987 of seven samples at the Port of Astoria Docks only showed lead in elevated contamination levels, the highest concentration being 95 mg/kg. This exceeds the Oregon Department of Environmental Quality threshold level of 40 mg/kg of lead.

Fuhrer and Rinella (1983) collected nine samples from the Port of Astoria's docks in 1980. Eight of those samples were dissolved in native water and elutriates. One sample was analyzed by bulk sediment analysis. Three of the elutriate samples had concentrations of iron over 2,000 Ug/L, the highest concentration being 4300 Ug/L. Five of the elutriate samples had concentrations of manganese between 5,500 Ug/L and 10,000 Ug/L. The bottom material sample had only one heavy metal (nickel) exceeding one standard deviation as determined by Felstul. Nickel was found to be at 20 mg/kg.

Fuhrer (1986) again examined two sediment samples collected in 1983 from between piers 1 and 2 at the Port of Astoria docks. Bulk analysis yielded metal concentrations similar to the averages determined by Felstul for 86 Columbia River Estuary samples.

4.5.9. Tongue Point

In 1988, Battelle/Marine Sciences laboratory conducted solid-phase bioassays to provide technical data to the US Army Corps of Engineers for evaluation of sediments at Tongue Point. The Oregon Department of Economic Development was seeking to develop the site for commercial shipping. Samples were collected and analyzed from stations at the ends of piers three through eight at North Tongue Point. The metal concentrations found in Tongue Point sediments were compared to concentrations in shale and basalt soils world wide, with sediments from the disposal site, and to a Columbia River Estuary reference point. Battelle found that the metal concentrations with the exception of zinc and cadmium were average or comparable to concentrations of metals found in shale soils world wide. However, when compared to basalt soils world wide, metals were generally at elevated levels.

The results from Battelle's study were similar to Felstul's (1988) findings for Columbia River mainstem and tributary sediment (see Table 4.10). Concentrations of cadmium, lead, zinc and nickel sampled by Battelle exceeded by more than one standard deviation of the average concentration for all samples analyzed by Felstul in the Columbia River Estuary. Battelle's results also confirmed in part a previous analysis of sediments in the same area conducted one year earlier in 1987 by Enviro Science. Enviro Science reported elevated concentrations oflead and cadmium at the ends of the piers.

Table 4.10: Average Concentrations of Metals at North Tongue Point (Solid Phase Bioassay)

Metal	End of Piers 3, 4 and 5 (Battelle) mg/kg	End of Piers 3, 4 and 5 (Enviro) mg/kg	End of Piers 6, 7 and 8 (Battelle) mg/kg	End of Piers 6, 7 and 8 (Enviro) mg/kg	CRE Average (Felstul) mg/kg	SD (Felstul) mg/kg
As	5.43	--	5.18	--	6.76	4.78
Cd	1.16*	.87*	1.21*	.69*	.26	.39
Cr	25.00	15.90	22.80	14.60	19.63	14.13
Cu	30.80	22.20	35.10	19.50	25.31	16.34
Hg	.143	--	.16	--	.07	.09
Ni	23.00	--	22.40*	--	9.16	10.78
Pb	18.38	16.70	20.52*	13.30	11.60	6.93
Zn	134.60	111.00	161.80*	101.10	92.08	53.15

* - indicates exceeds one standard deviation as determined by Felstul's (1988) report

Source: Compiled from the Oregon estuarine database used by David R. Felstul in "An Evaluation of Oregon Sediment Evaluation" 1988; Data collected by Enviro Science, Inc., "Tongue Point Project: Sediment Evaluation," 1987; Data collected by Battelle, Confirmatory Chemical Analyses and Solid Phase Bioassays on Sediment from the Columbia River Estuary at Tongue Point, Oregon, 1988.

4.5.10. Other Sediment Samples

Only one bottom material sample from the Hammond area, collected in 1987, was included in Felstul's database. The sample sediment composition was over 70% silt and clay. The sample had elevated concentrations of copper (43.1 mg/kg) and cadmium (furnace)(.94 mg/kg), exceeding one standard deviation of the metal for all 86 Columbia River Estuary samples analyzed.

The one bottom material sample collected near Tansy Point in 1980 and analyzed by Felstul consisted of sediments approximately 70% coarser than medium to fine sands. The metals tested had concentrations below or similar to the average concentrations for all Columbia River Estuary samples.

Fuhrer and Rinella (1983) examined one bottom material sample collected in 1980 from Youngs Bay at the confluence at Columbia River mile 12.0. The sample was analyzed using a two-step extraction procedure on bulk samples. They reported elevated levels of cadmium, copper and nickel. The copper concentration was 180 mg/kg, substantially exceeding amounts of copper in sediments examined by Felstul and exceeding the threshold value of 50 mg/kg established by the Oregon Department of Environmental Quality.

Fuhrer and Rinella (1983) examined one bottom material sample from Skamokawa Creek. Bulk sediment analysis yielded high levels of manganese (400 mg/kg) and nickel (30 mg/kg).

4.6. REVIEW OF EXISTING SEDIMENT QUALITY ASSESSMENT METHODS

Assessing sediment quality of a site is a critical step before deciding the level of regulatory or managerial action needed to minimize environmental impacts. At the very minimum, sediment evaluation should determine the existing contaminants and the potential for the sediments, if contaminated, to cause adverse environmental impacts. To be able to determine the potential for adverse effects however, consistent standards and criteria for sediment quality testing specific to the Columbia River Estuary must be established. Uniform testing methods and threshold concentration levels of contaminants above which more complex sediment analysis would be required, are vitally important components of a regional sediment quality plan appropriate specifically for the Columbia River Estuary.

Through the National Estuary Program, sediment quality testing methods and protocols were developed for the Puget Sound area. The Puget Sound Dredged Disposal Analysis (PSDDA) program was designed to specifically address the circumstances and sediment contamination problems in Puget Sound. These same guidelines are probably not appropriate for the Columbia River Estuary because of differences in environmental conditions between Puget Sound and the Columbia River Estuary (e.g., Columbia River's dynamic hydraulic regime involving large tidal fluctuations and high seasonal fluvial flow). PSDDA guidelines were formed for the more polluted waters of Puget Sound and are probably not restrictive enough to adequately protect Oregon estuaries from potential degradation (Felstul 1988). Oregon sediments, excepting Portland harbor, should pass PSDDA standards. There are also differences in regulatory approaches, management of resources and accepted contamination levels between Oregon and Washington state agencies. This is further indication of the need for a cohesive regional sediment quality plan.

Ten methods for assessing sediment quality are summarily reviewed here. Six methods rely more heavily on field based data while the remaining rely on laboratory analysis. The PSDDA program uses the apparent effects threshold (AET) approach to establish sediment quality values for Puget Sound and will be reviewed first.

4.6.1. Apparent Effects Threshold (AET)

The AET approach attempts to determine the concentration of contaminants in sediments above which statistically significant biological effects would always be expected to occur (PTI Environmental Services, 1989). AET uses data from sediment chemistry, benthic infaunal effects and sediment bioassays to determine a single quantitative index identifying the threshold concentration level.

The AET approach identifies the concentration of contaminants in sediments established as contaminated, but does not show cause-effect relationships between contaminants and effects. The AET approach requires extensive data collection for chemical variables as well as biological indicators.

4.6.2. Field Bioassay

This approach exposes test organisms to field collected sediment for the purposes of comparing mortality or sublethal effects to effects observed from using reference sediments. The combined effect of all contaminants in the sediments is measured as a mixture. This is an advantage in one sense in that chemical data is not required to identify a sediment as being contaminated and adversely impacted; however, the bioassay only measures the combined effect, providing no chemical characterization or delineation. This approach is useful in identifying problem sediments and developing dose-response relationships, but another approach would be required to determine chemical-specific sediment quality values.

4.6.3. Screening Level Concentration Approach (SLC)

This approach correlates the presence of a specific benthic species in field samples to sediment concentrations of a specific contaminant. The SLC is determined as the sediment contaminant concentration in which 95% of the benthic species enumerated for testing were able to survive. This method has extensive data requirements: 20 testing stations and 10 enumerated taxa for each calculation, sampling stations arranged to cover a wide range of contaminant concentrations and taxa identified to genus level. Given a large database, this approach provides a conservative estimate of the highest organic-carbon-normalized concentrations of contaminants that can be tolerated by 95% of the benthic influna, which data can also be extrapolated to other areas.

4.6.4. Sediment Quality Triad

The sediment quality triad testing method involves analyzing relationships between sediment concentrations of chemical contaminants, sediment bioassay end points (toxicity) and in situ (infauna) studies. This approach allows a variety of bioassay species and endpoints, including species lethality, alteration in respiration rate, development abnormalities and mutagenicity and cytotoxicity, to be used. Common in situ measurements used in this approach involve community structure expressed as biomass, total abundance, species richness, diversity or taxa/taxa ratios (Battelle, 1988). Combining analysis of in situ studies with chemical bioassays that use a variety of end points, different contaminants and various community structure measures, provides an assessment of sediment quality which focuses on the extent of biological damage contributed by chemical contamination. The biological effects associated with sediment contamination may be differentiated from naturally caused or laboratory induced effects.

This approach is extremely data intensive. The data for chemical analysis, bioassays and in situ effects, although from the same geographical area, may not be from the same sample or station. Sediment quality values also include subjective determinations rather than solely statistical criteria.

4.6.5. Reference Area Approach

The reference area approach compares chemical concentrations at a given site to the concentration levels at a previously chosen reference site. The reference area may be a pristine or relatively undisturbed area or an area with known low levels of contaminants and adverse biological impacts. Often, comparisons are made using historical data for reference areas. A problem with this approach is the subjectivity inherent in arbitrarily choosing the reference site. The chemical concentrations at the reference area are used to derive sediment quality values of the project site, whether the concentration levels are below or above the level at which adverse biological effects occur. Only chemical concentration levels are compared; no consideration is given to the sensitivity of organisms to various contaminants. This approach establishes regional comparisons specific to sample sites. The values obtained from reference area analysis would not be applicable to other areas.

4.6.6. Infauna Community Structures

A sediment quality assessment based on either an indicator organism or on infauna community structure is sometimes used to qualify changes of an ecosystem due to contaminants or other stress related factors. These approaches require precise taxonomic identification and should be used in conjunction with chemical analysis for a larger picture of causes and effects.

Indicator organisms are used to measure biotic indices on the premise that certain organisms are more sensitive or tolerant than others to particular metals, organics, or pesticides. Such a measure is restricted to narrow geographical areas because indicator organisms vary geographically. There are other factors in addition to levels of contaminants that can alter the value of the indice. Consideration must be given to organism movement, seasonal variations and patchiness.

The community structure approach based on a diversity indice looks at the number of species in a community as well as the number of individuals within each species. This approach is criticized however, because summarizing the community structure in only one parameter reduces the information available of overall community patterns. Measuring similar indices of a community structure compares joint species present or the proportional abundance of species. These measurements may be useful in identifying gaps caused by contaminants in communities of varying distances from pollutant sources.

4.6.7. Water Quality Criteria Approach

Concentrations of contaminants in interstitial water are compared with EPA water quality criteria. Comparisons are made relying on existing EPA toxicological database. Biological effects are not measured in this approach nor are the effects of chemical mixtures. Comparisons are made chemical-by-chemical with an additional limitation that EPA standards have been developed for only 10 metals and 9 organic chemicals (PTI Environmental Services, 1989). There are also no established procedures for collecting, analyzing and validating water samples.

4.6.8. Equilibrium Partitioning Approach (Sediment-Water)

This approach describes the equilibrium partitioning of a contaminant between sedimentary organic matter and interstitial water with little consideration or reliance on other physical or chemical factors. The sediment concentration, normalized to organic carbon content and corresponding with interstitial water concentration equivalent to EPA water quality criterion for the contaminant, is the sediment quality value for the contaminant. (Battelle Ocean Sciences 1988).

This method is advantageous in that it uses existing EPA water quality criteria database. It does not require the collection of biological data however, this raises uncertainties regarding the application of data for water column toxicity tests to organisms that may ingest sediments. This approach also ignores the effects of chemical mixtures and assumes that there is always equilibrium at the sediment water interface.

4.6.9. Spiked Sediment Bioassay

This approach consists of developing dose-response relationships by exposing an indicator organism to sediments containing known level of contaminants. This approach can be used to determine cause-effect relationships between a specific chemical or mixture and biological responses. The results are laboratory findings and must be extrapolated to reflect field conditions.

4.6.10. Army Corps of Engineers Three Tiered Approach

The tiered sediment quality approach provides a systematic procedure for conducting appropriate tests specific to the proposed action. This systematic approach establishes a project-specific design where physical, chemical and biological tests are conducted only as the need is demanded by preceding tier test results. The tiered approach, as implemented by the US Army Corps of Engineers will study and analyze sediment from each project approximately every five years. Where elevated levels of contaminated sediments are found and handled, testing will occur more frequently. For any dredge project, available information necessary for predicting sediment quality (including contaminant sources, historic uses, natural mineral deposits and rock characteristics) is collected, reviewed and environmental concerns are identified. Based on this information one or more tiers are entered.

Tier one analyzes basic physical/chemical properties of the sediments. Criteria regarding grain size distribution, organic content, oil and grease levels and the available information. If one or more of these criteria is exceeded or in the case of the available information, lacking, then tier two testing is required.

Tier two investigates chemical contaminant levels for total organic carbon, heavy metals; pesticides, PCB's, and additional compounds as the need is indicated. If detrimental effects on biota could be expected to occur, tier three is entered.

Tier three determines biological effects by testing using acute toxicity bioassays, bioacculumation tests and chronic effects tests.

4.7. CONCLUSION AND SUMMARY

Dredging and dredged material disposal can recirculate contaminants that have settled out in the sediments. Thus the testing of this material is an important data gathering step that provides a portion of the information necessary for making management decisions concerning proper dredging and disposal methods.

The peripheral bays of the Columbia River Estuary retain fine grained sediments. Certain metals and contaminants are often associated with these finer particles. Felstul, in his examination of 89 Columbia River Estuary sediment samples found that as his sample site narrowed geographically and focused on a particular estuarine subarea, higher levels of contaminants and fine grained particles improved.

Felstul examined 86 bottom material samples. He found that elevated levels of zinc (contamination levels exceeding one standard deviation of all 86 Columbia River Estuary samples) were found in Baker Bay, Chinook Channel, Skipanon Channel and boat basin, and Cathlamet Bay and the mainstem Columbia River; mercury was found in high levels in Baker Bay, Ilwaco Channel, Skipanon Channel and boat basin and Cathlamet Bay; elevated levels of lead was found in Baker Bay, Chinook Channel, Skipanon Channel and boat basin and the mainstem Columbia River; only Chinook Channel and mainstem Columbia River had high levels of arsenic; cadmium (furnace) was found in high levels in Chinook Channel, Skipanon Channel and boat basin and the mainstem Columbia River; and, elevated levels of manganese, iron and chromium were found in Skipanon Channel and boat basin, Cathlamet Bay and the mainstem Columbia River.

Each of these subareas differ in contaminants found and levels of contaminants as well as in dredging and requirements. These subareas also may be found in different jurisdictions under varying state and local regulation authority. However, impacts from recirculation contaminants affect the estuary as a whole. This necessitates the need for a uniform sediment quality assessment method or testing protocols throughout the estuary.

5. REGULATORY ENVIRONMENT

5.1. INTRODUCTION AND CONTENT

This chapter reviews federal, state and local regulation of dredging and dredged material disposal. The principal goals of this chapter are to describe these programs' effect on sediment quality management and describe a unified method for meeting sediment quality regulatory requirements. The different sediment quality regulatory programs in effect on the Columbia River Estuary are relatively complex, both procedurally and substantively. Significant differences exist between the manner in which the various programs address Columbia River Estuary sediment quality. The common theme among these programs is their goal of assuring that dredging is conducted in a way that minimizes damage to the aquatic environment.

The principal federal regulations affecting sediment quality are examined in Subsection 5.2. The 1987 Water Quality Act is the most significant of the federal programs. Other federal components of the sediment quality regulatory framework are the Rivers and Harbors Act (Section 10); the Fish and Wildlife Coordination Act; Fishery Conservation and Management Act; Marine Protection, Research and Sanctuaries Act; Endangered Species Act; National Environmental Policy Act; and the Coastal Zone Management Act. Programs under these federal laws either directly or indirectly address sediment quality in the Columbia River Estuary.

Subsection 5.3. examines state-level programs in Washington that affect dredging and disposal decisions. The Washington Department of Ecology (WDOE) implements state regulations promulgated under Section 303 of the federal Water Quality Act. These regulations are chiefly implemented through state water quality certifications issued for Federal Section 404 or Section 10 permits. The Washington Hydraulics Project Act (HPA) also affects dredging and dredged material disposal decision-making. These programs and others (such as the State Environmental Policy Act, the Shorelines Management Act, and proprietary regulation of submerged lands) are reviewed in Subsection 5.3.

Oregon sediment quality programs are examined in Subsection 5.4. Like Washington, Oregon administers state water quality regulations under Section 303 of the federal Water Quality Act. These water quality programs are managed by the Oregon Department of Environmental Quality (ODEQ). The state's Fill and Removal Law, administered by the Oregon Division of State Lands, is also applicable to sediment quality in the Columbia River Estuary. These two state programs, along with others germane to sediment quality, are examined in Subsection 5.4.

City and County governments along the Columbia River Estuary administer programs that affect dredging, dredged material disposal and sediment quality. These local requirements are the product of state programs under the federal Coastal Zone Management Act (CZMA). Three counties and five cities administer locally developed Shoreline Management Master Programs (Washington) and Comprehensive Plans (Oregon) that address dredging and dredged material disposal. They are described in Subsection 5.5.

Subsection 5.6. summarizes the key components of local, state and federal regulatory programs. The major substantive and procedural differences between the programs are identified, as well as their effects on dredging, dredged material disposal, and sediment quality in the Columbia River Estuary. Also described is a unified method for meeting the different program requirements.

5.2. FEDERAL REGULATIONS

The major federal regulations and programs affecting dredging, dredged material disposal, and sediment quality in the Columbia River Estuary are examined in this subsection. Programs under the following federal laws are applicable:

1987 Water Quality Act
Rivers and Harbors Act
Fish and Wildlife Coordination Act
Fishery Conservation and Management Act
Marine Protection, Research and Sanctuaries Act
Ocean Dumping Act
Endangered Species Act
National Environmental Policy Act
Coastal Zone Management Act.
Resource Conservation and Recovery Act

This subsection also describes how the different federal programs are administered through the Corps of Engineers Section 10/Section 404 permit process.

The legal and philosophical underpinnings of federal regulatory intervention in dredging and dredged material disposal are relatively simple. The waters of the Columbia River belong to the United States: protection of these waters from degradation is, therefore, a federal concern. Federal agencies such as U.S Fish and Wildlife Service and National Marine Fisheries Service have stewardship responsibilities over living resources in the Columbia River Estuary. The federally maintained navigation channel is essential for interstate as well as international commerce: an obvious federal concern. The federal government also has a long history of involvement in Columbia River dredging. The U.S. Army Corps of Engineers has been, and continues to be, the sponsor of most dredging on the River. These factors cumulatively support a strong federal role in dredging and dredged material disposal regulation.

5.2.1. Water Quality Act

Federal legislation known as the 1987 Water Quality Act is actually a package of amendments to the Clean Water Act of 1977, which was itself an amendment of the original Water Pollution Control Act of 1948. Sections 404 and 401 of the Water Quality Act provide for public review of and comment on dredging and dredged material disposal projects, as well as other in-water activities. Section 404 is implemented through a permit process administered by the US Army Corps of Engineers. Section 401 of the Water Quality Act ensures that activities under federal permits (such as the Section 404 permits) do not violate state or federal water quality regulations. Section 401 is administered by the states through a certification process that, in the case of dredging and disposal, is triggered through the Section 404 permit process. Section 304 requires the development of water quality standards. These standards are applicable for evaluating in-water disposal.

The Section 404 permit process and the Section 401 water quality certification are major components of the sediment quality regulatory framework. For this reason they are described in some detail in this subsection.

Section 404 of the Clean Water Act is titled "Permits for Dredged or Fill Material". The Section 404 permit process is administered by the US Army Corps of Engineers. All Section 404 permits on the Oregon side of the Columbia River Estuary are managed by the Corps' Portland District office. The Portland District also manages Section 404 permits on the Washington side of the estuary when a port district is involved. Other Washington side permits on the Columbia River Estuary are administered through the Corps' Seattle District office.

Section 404 permits are required for all discharges of dredged material into waters of the United States. The Columbia River Estuary and all tributaries to the head of tide are waters of the Unites States. Most non-tidal wetlands along the Columbia River Estuary shoreline are also waters of the United States and subject to the Section 404 permit program.

In-water disposal of contaminated or potentially contaminated sediment raises a number of water quality concerns. These concerns, discussed in Chapters 2 and 3, include turbidity, chemical contamination, and degradation of aquatic ecosystems. These are normally addressed during review of a Section 404 permit primarily through the Section 401 water quality certification. The Oregon Department of Environmental Quality and the Washington Department of Ecology share Section 401 water quality certification responsibilities on the Columbia River Estuary. The section 401 process certifies that the applicable state water quality standards will not be violated by the dredging or disposal of contaminated sediments. These state water quality standards are described in subsections 5.3 and 5.4. Many dredging and disposal projects in the Columbia River Estuary will affect water in both states. In these cases, water quality certification should be obtained from both Oregon and Washington. This is rarely done: more typically, only the state where the dredging or disposal will actually occurs issues a Section 401 certification. Federal agencies are also involved reviewing water quality issues, particularly the U.S. Environmental Protection Agency (EPA).

Disposal of contaminated or potentially contaminated sediment at an upland site is not covered by the Section 404 permit process, yet disposal site runoff could have unwanted impacts on estuarine water quality and, possibly, violate state water quality standards. The Section 401 certification process does not come into play for non-404 dredging operations.

Section 401 water quality certifications can be denied for lack of sufficient data, as well as when disposal would violate water quality standards. The need for decision-making information for the Section 401 certification process is the impetus for most of the project-specific sediment testing in the Columbia River Estuary and elsewhere. Providing sufficient data for state water quality certification may, under some circumstances, be one of the most significant and expensive obstacles for a permit applicant to overcome. Chemical analysis of sediments to be dredged, biological investigations on the test sediments, pre-dredging surveys of the disposal site, and post disposal monitoring may all be required of a Section 404 permit applicant.

Section 404 permits are circulated by the Corps for public comment and resource agency input. The Environmental Protection Agency, National Marine Fisheries Service, U.S. Fish and Wildlife Service, U.S. Coast Guard and other interested federal agencies routinely comment on these public notices. In addition, state and local agencies receive public notices of Section 404 permits and comment to the Corps on them. The Corps reviews the public comments and makes a decision to either:

approve the proposal as submitted;

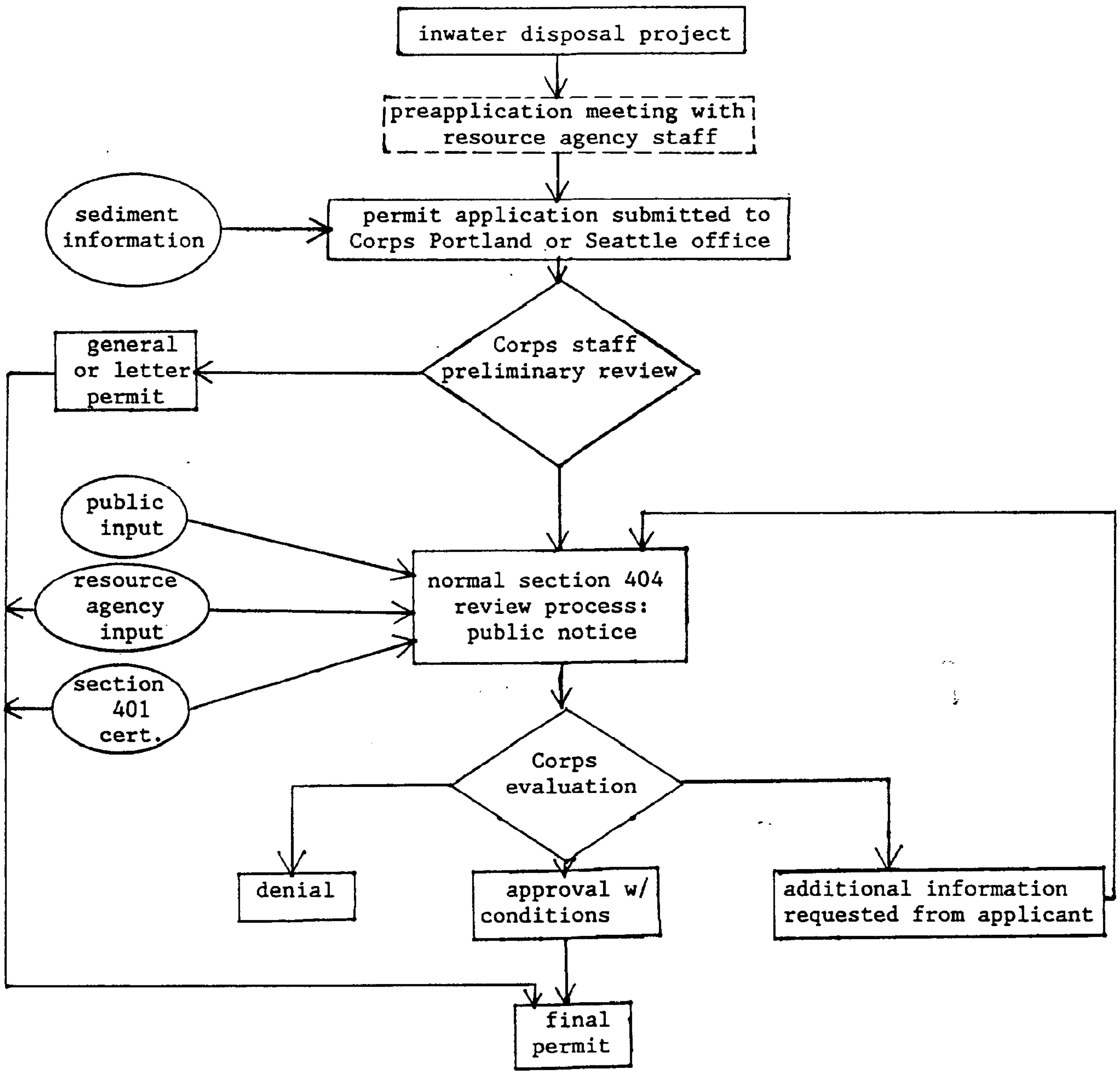
approve the proposal with special conditions to meet resource agency or public concerns;

request additional information from the applicant addressing concerns raised by commenting agencies and citizens; or

deny the permit.

Requesting additional information from the applicant will often require that the public notice be recirculated. A schematic representation of the Corps of Engineers Section 404 permit process is shown in Figure 5.1.

Figure 5.1   Section 404 Permit Process



5.2.2. Rivers and Harbors Act

The 1899 Rivers and Harbors Act ensures that navigable waters are not obstructed. The Act applies to dredging and dredged material disposal, in addition to other actions in, over or affecting navigable waters. The Columbia River Estuary is a navigable waterway, so the Act is applicable. Permits under Section 10 of the Act are reviewed by the US Army Corps of Engineers in a manner similar to Section 404 permits described above. The Rivers and Harbors Act does not directly address water quality or contaminated sediment. However, review of Section 10 permits may reveal potential water quality or sediment quality concerns that can be addressed under other regulatory programs.

5.2.3. Fish and Wildlife Coordination Act

This federal legislation is implemented by the US Fish and Wildlife Service (CUSFWS) and National Marine Fisheries Service (NMFS), and ensures that project impacts on fish and wildlife resources are considered in the permit decision-making process. The Act's requirements are typically fulfilled through a report prepared by USFWS or NMFS describing affected fish and wildlife resources, the project's potential impact on those resources, and recommended mitigation measures. The report is used, for example, by the US Army Corps of Engineers in its decision-making process on Section 404 and Section 10 permits.

For most Columbia River Estuary projects, Coordination Act reports are prepared by the USFWS' Portland Field Office. For a project involving dredging or disposal of contaminated or potentially contaminated sediments, a Coordination Act report would address the likely affects of the action on aquatic organisms, and recommend ways of reducing negative impacts. These recommendations might include changes in the proposed dredging methods and timing, restrictions on disposal locations and timing, or similar recommendations. These recommendations may become conditions of the Section 404 or Section 10 permit. Physical, chemical or biological data on the dredged material may be evaluated by USFWA or NMFS in the course of preparing a Coordination Act report.

5.2.4. Fishery Conservation and Management Act.

The Fishery Conservation and Management Act is only peripherally related to in-water dredged material disposal. The Act give the National Marine Fisheries Service the responsibility of protecting fisheries resources. NMFS reviews in-water disposal proposals for their potential impact on fisheries resources, and comments to the permitting agency.

5.2.5. Marine Protection, Research and Sanctuaries Act

This act addresses, among other things, ocean disposal of dredged material. There are four designated ocean dredged material sites offshore of the Columbia River Estuary. These are referred to as Disposal Areas A, B, E and F, and are located immediately outside of the river mouth (see Map 2.1). Ocean disposal of dredged material is generally subject to more intense scrutiny than in-water disposal in the estuary. Ocean dredged material disposal involves the U.S. Environmental Protection Agency (EPA) in a direct regulatory role. Section 103 of the Act requires that all ocean dredged material disposal be evaluated under EPA rules.

5.2.6. Endangered Species Act

This federal law does not directly affect contaminated sediments, but can come into play because of the presence of endangered or threatened species in the Columbia River Estuary. The endangered Peregrine falcon migrates through the area. Threatened northern bald eagles are present in the estuary area both as permanent and seasonal residents. Dredging and disposal of contaminated sediment can result in toxins entering the food chain and affecting organisms protected by the Endangered Species Act. Section 7 of the Act establishes a consultation process that is often employed in the Columbia River Estuary.

The U.S. Fish and Wildlife Service assumes a special role during review of Section 404 permit if an endangered specie is present. The Act requires that activities that adversely affect threatened species be avoided, or if unavoidable, be fully mitigated.

5.2.7. National Environmental Policy Act

The National Environmental Policy Act (NEPA) is applicable to major federal actions that have significant adverse environmental impacts. This can include water quality impacts caused by dredging or disposal of contaminated sediment. No project in the Columbia River Estuary to date has resulted in preparation of an Environmental Impact Statement under NEPA. The environmental assessment, prepared under NEPA, results in either preparation of an Environmental Impact Statement (EIS), or a Finding of No Significant Impact (FONSI).

Two key phrases in NEPA are noted here in connection with Columbia River Estuary sediment quality. NEPA applies only to major activities: many dredging and disposal projects are relatively minor in nature, and would not require NEPA review. NEPA also is applicable only to federal actions. Although there is some non-federal dredging in the Columbia River Estuary, this is covered by NEPA because the federal permits (under Section 404 or Section 10) are considered federal activities. The end result is that NEPA covers almost all dredging in the Columbia River Estuary, but rarely goes beyond the environmental assessment step.

5.2.8. Coastal Zone Management Act

The Federal Coastal Zone Management Act (CZMA) resulted in the adoption of Washington's Shorelines Management Act and Oregon's Coastal Land Use Planning Goals. The key elements of this act for dredging and disposal of contaminated or potentially contaminated sediment are the local plans, described under Section 5.5. Shoreline Management Master Programs in Washington and Comprehensive Plans in Oregon are the local government expression of the federal Coastal Zone Management Act.

5.3. STATE REGULATIONS - WASHINGTON

The principal Washington state regulations and programs affecting dredging, dredged material disposal, and sediment quality in the Columbia River Estuary are examined in this subsection. The following programs and laws are briefly examined.

Puget Sound Water Quality Programs
State Hydraulic code
Shoreline Management Act
State Environmental Policy Act

5.3.1. Puget Sound Water Quality Programs

The Puget Sound Dredged Disposal Analysis (PSDDA) has developed a detailed regulatory program addressing Puget Sound sediment quality. The PSDDA program is not applicable to the Columbia River Estuary, or to any other waterbody except Puget Sound. However, the PSDDA program follows the general framework used elsewhere (a tiered approach to sediment evaluation), and relies on existing permit programs that also pertain to the Columbia River Estuary (Section 404, Hydraulics Permit, Shorelines Permit). Some of the PSDDA guidelines are described in Chapter 3. This section describes the PSDDA program's impact on Columbia River Estuary sediment evaluation.

The PSDDA program and related research and regulatory efforts are needed in Puget Sound to address several water and sediment quality problems in the Sound. Although it would be premature to judge PSDDA program's effectiveness in addressing Puget Sound water and sediment contamination, their affect on existing regulatory program operation is clear: clear and objective standards for evaluating Puget Sound sediment quality exist, while other water bodies are managed without such standards. Many of the federal and Washington state regulatory staff assigned to review Columbia River Estuary dredging and disposal permits are familiar with the PSDDA standards, and will refer to the PSDDA guidelines when reviewing Columbia River Estuary sediment data. Contract laboratories that handle sediment testing in the northwest are familiar with the sediment and biological testing protocols developed under PSDDA, and the list of target chemicals examined in Puget Sound sediment and bioaccumulation tests. For these reasons, PSDDA's influence extends well beyond Puget Sound, and the program affects sediment evaluation in the Columbia River Estuary.

5.3.2. Hydraulics Project Approval

The State Hydraulic Code (RCW 75.20.100) establishes a permit process designed to assure that the state's fisheries resources are protected from potentially harmful in-water construction-related activities. Dredging and in-water dredged material disposal are subject to the Hydraulic Code's permit process, called the Hydraulic Project Approval (HPA). The Washington Departments of Fisheries and Wildlife share administration of the program statewide, but the Department of Fisheries is usually the lead agency for HPA permits for in-water disposal on the Columbia. The HPA permit process usually runs simultaneously with the Corps Section 404 permit process. The HPA permit is closely coordinated with the State Environmental Policy Act process (see subsection 5.3.4.).

5.3.3. Shoreline Management Act

Washington's Shoreline Management Act (SMA) establishes a statewide framework for local Shoreline Master Programs everywhere in Washington. Pacific County, Wahkiakum County, Ilwaco and Cathlamet in the Columbia River Estuary area administer their own Shoreline Master Programs under the SMA. These are described in more detail in Section 5.5. At the state level, the SMA gives the Washington Department of Ecology (DOE) authority to veto local permits issued under their Master Programs. DOE could use this permit veto authority on projects that, in their opinion, are mistakenly approved at the local level.

5.3.4. State Environmental Policy Act

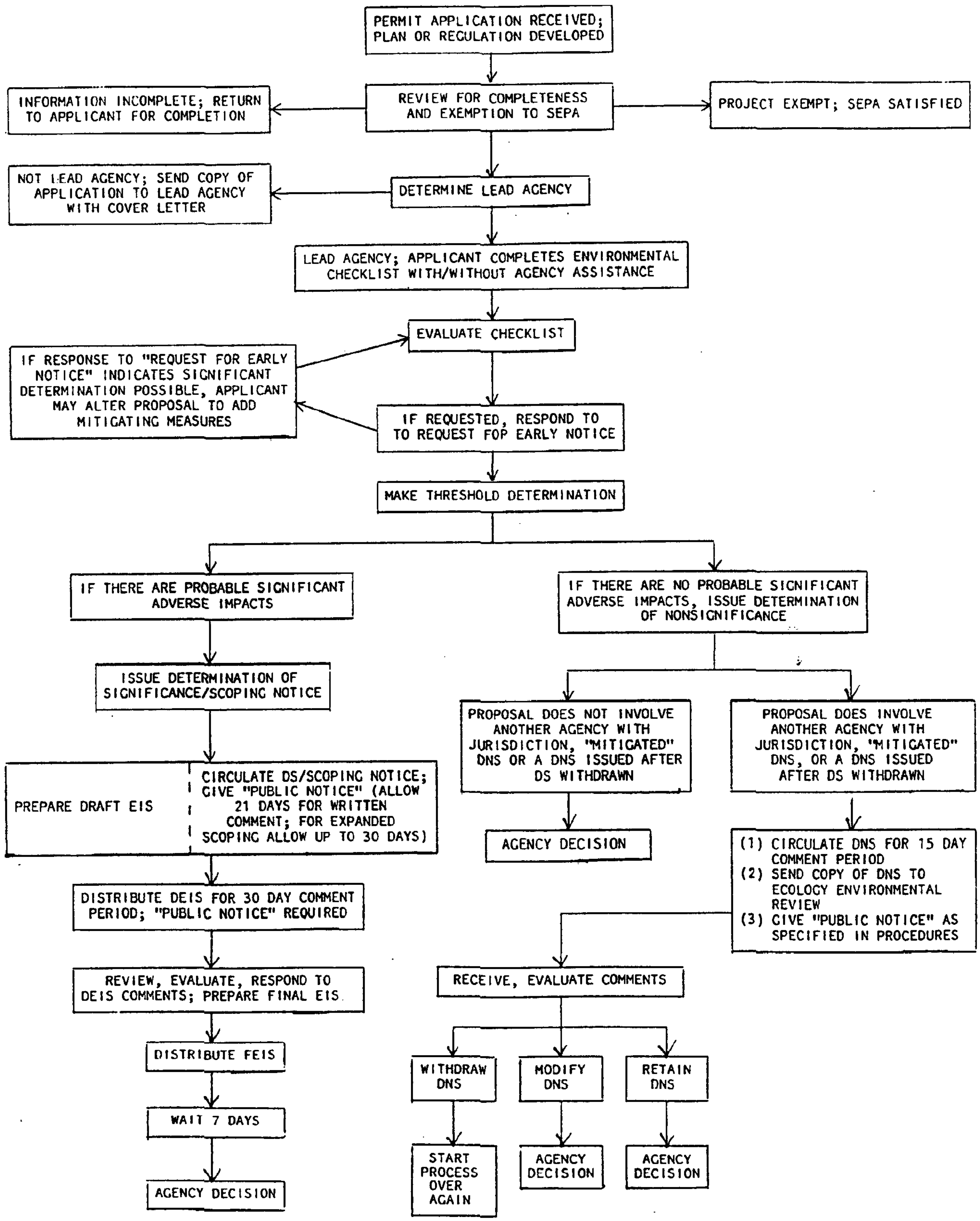
The Washington State Environmental Policy Act (SEPA) is a state-level version of the National Environmental Policy Act (NEPA: see Section 5.2.7.). SEPA establishes a process of environmental review. Most in-water disposal of dredged material will probably be covered under SEPA. The SEPA review process is diagramed in Figure 5.2. An "environmental checklist" is prepared for the project. This is basically an inventory of the project's anticipated environmental impacts on several different resources, including aquatic resources. The checklist is reviewed by the lead agency, which can be a local government or a state agency, and a threshold determination is made based on the checklist. If the threshold determination is that the project will have no probable significant adverse impacts, a determination of non-significance (DNS) is made, ending the SEPA process. If the threshold determination is that there are probable significant adverse impacts, an environmental impact statement is prepared. This is relatively thorough process, involving extensive opportunities for public involvement and a wide-ranging review of environmental impacts.

5.3.5. Water Quality Programs; Washington Department of Ecology

The Washington Department of Ecology (DOE) is the state's water quality agency, and is responsible for administering state water quality standards in the Columbia River Estuary and elsewhere in Washington. This responsibility includes issuing the state water quality certification needed for approval of federal Section 404 permits (see Section 5.2.1). All in-water disposal proposals affecting the Washington side of the Columbia River Estuary will require certification. Because the aquatic environment in the Columbia River Estuary is so dynamic, most in-water disposal in the Columbia River Estuary will affect both Oregon and Washington. It is reasonable to assume that both Washington and Oregon must approve water quality certifications for a Section 404 permit in the Columbia River Estuary. This has not occurred, though WDOE will comment on an Oregon permit on the Columbia River if it believes that Washington waters might be threatened.

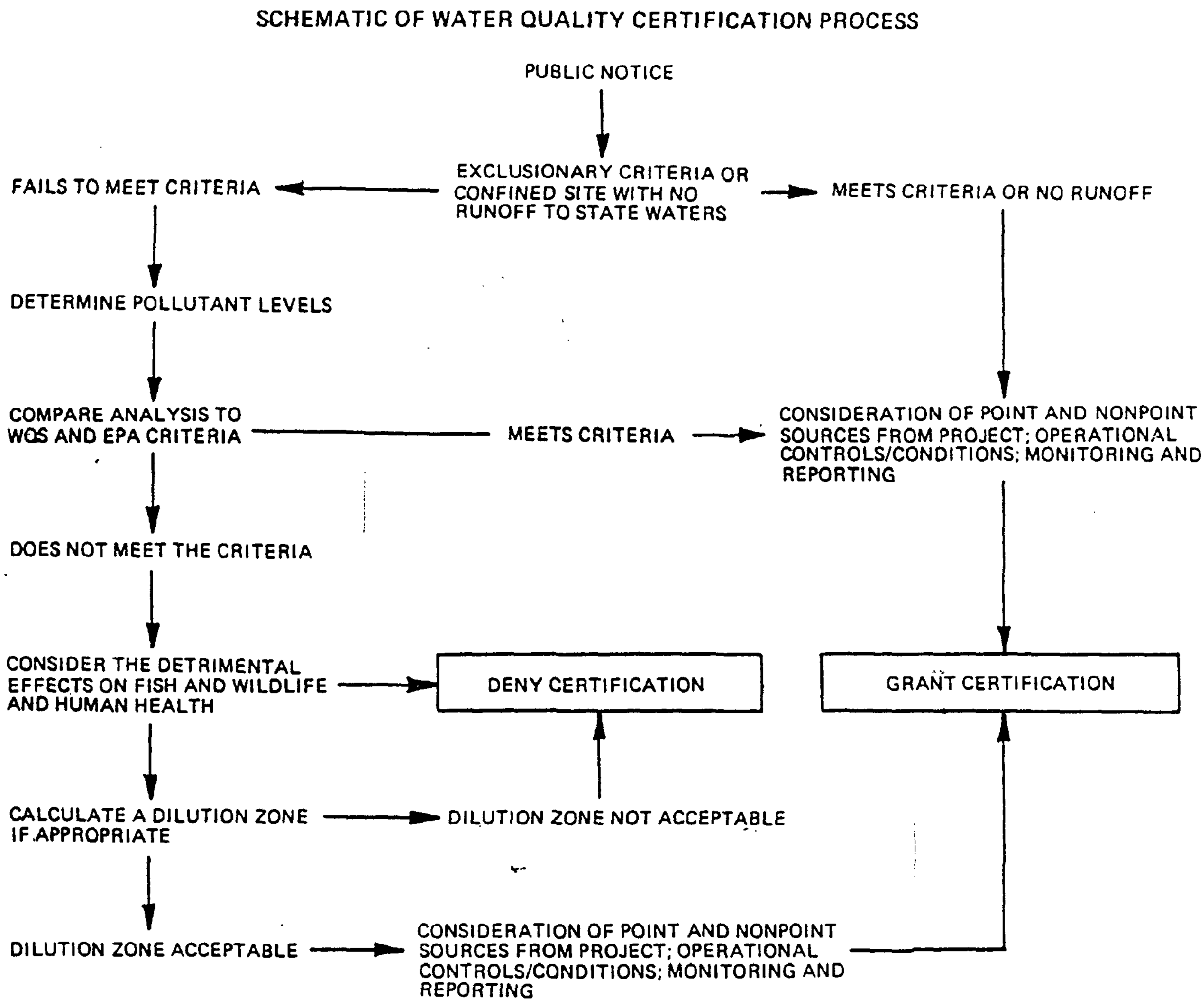
WDOE follows their publication <u>Guidelines for Issuing Water Quality Certifications for Dredging and Discharge or Dredged Material Disposal</u> (Washington Department of Ecology, 1982). Although somewhat dated, these guidelines provide a good general overview of the water quality certification process in Washington. Figure 5.3 is a diagram of the process.

Figure 5.2. State Environmental Policy Act (SEPA) Review Process



source: Washington Department of Ecology, 1988

Figure 5.3. Water Quality Certification Process.



source: Washington Department of Ecology, 1982

5.3.6. Proprietary Regulation of In-water Disposal

The Washington Department of Natural Resources (DNR) manages state-owned submerged lands, including most designated in-water disposal sites on the Washington side of the Columbia River Estuary. DNR's authority is principally of a proprietary nature, and may not include environmental concerns. The regulations covering DNR's management of submerged lands for in-water dredged material disposal are in WAC 332-30-166. The following subsections of the code are particularly applicable to sediment evaluation:

> (3) Application for use of an established site must be for dredged material that meets the approval of federal and state agencies and for which there is no practical alternative upland disposal site or beneficial use such as beach enhancement.
>
> (4) The department (DNR) will only issue authorization for use of the site after:
>
> > (a) The environmental protection agency and department of ecology notify the department that, in accordance with Sections 404 and 401, respectively, of the Federal Clean Water Act, the dredged materials are suitable for in-water disposal and do not appear to create a threat to human health, welfare, or the environment; and
> >
> > (b) All necessary federal, state, and local permits are acquired.

5.4. STATE REGULATIONS - OREGON

The principal Oregon State regulations and programs affecting dredging, dredged material disposal, and sediment quality in the Columbia River Estuary are examined in this subsection. The following programs and laws are briefly described:

Oregon Fill and Removal Law

Statewide Land Use Planning Goal 16

Water Quality Programs, Oregon Department of Environmental Quality

Proprietary Regulation of In-water Disposal

5.4.1. Oregon Fill and Removal Law

The Oregon Division of State Lands (ODSL) administers a permit program for dredging and disposal in Oregon waters and wetlands, including the Columbia River Estuary. The States's Fill and Removal Law (ORS 541.605 through 541.990) creates the permit program, which is run in tandem with Portland District Section 404 permits. Proposed fill and removal permits are circulated for public notice among the State resource agencies, local governments, and interested citizens. State agencies, particularly the Oregon Department of Fish and Wildlife, Department of Environmental Quality, and Department of Land Conservation and Development, frequently comment on public notices involving in-water dredged material disposal. Their suggestions may become conditions on a permit granted under the Fill and Removal Law.

5.4.2. Statewide Land Use Planning Goal 16 - Estuarine Resources

Local governments administer plans and ordinances prepared under Statewide Land Use Planning Goal 16, with the supervision of the Oregon Department of Land Conservation and Development (ODLCD). These are described in more detail in subsection 5.5. The actual goals of the Estuarine Resources Goal are:

> To recognize and protect the unique environmental, economic, and social values of each estuary and associated wetlands; and
>
> To protect, maintain, where appropriate develop, and where appropriate restore the long-term environmental, economic, and social values, diversity and benefits of Oregon's estuaries.

The state's role in administering Goal 16 is limited primarily to federal dredging projects. Permits for non-federal dredging projects are administered by local governments. Federal dredging projects must be consistent with Goal 16 because Goal 16 is part of the Oregon's Coastal Zone Management Program. The federal agency proposing in-water disposal (or other activity covered under the state's Coastal Zone Management Program) reviews its proposal against the relevant requirements. The federal agency involved is usually the Corps of Engineers, and the applicable Coastal Zone Management Program requirements are usually an elaboration of Goal 16 found in local plans (see Subsection 5.5).

The federal agency will then ask ODLCD for concurrence with its consistency determination.

With the exception of federal consistency determinations, state involvement in in-water disposal decision-making under Goal 16 is limited. Goal 16 is primarily implemented through local governments.

5.4.3. Water Quality Programs: Oregon Department of Environmental Quality

The Oregon Department of Environmental Quality (ODEQ) is involved in the decision making process for in-water disposal principally through the Section 401 water quality certification process. ODEQ manages its certification process in much the same way as does Washington's Department of Ecology (see subsection 5.3.5).

ODEQ has no sediment quality standards to use for water quality certification, though draft ones are being developed. Table 5.1 summarizes existing water quality standards and draft sediment quality guidelines developed by ODEQ.

5.4.4. Proprietary Regulation of In-water Disposal

The Oregon Division of State Lands (ODSL) manages state-owned submerged land on the Oregon side of the Columbia River Estuary. ODSL does not manage a formalized program like the one administered by its Washington counterpart, the Department of Natural Resources (see Section 5.3.6). Virtually all in-water disposal projects will require a state fill and removal permit from ODSL, and proprietary concerns are addressed through this permit process.

Table 5.1 Water and Sediment Quality Standards and Guidelines

Chemical	Water Quality Standard (mg/Liter)	Sediment Quality Guidelines
Mercury	—	0.15
Arsenic	0.01	40.0
Barium	1.0	—
Boron	0.5	—
Cadmium	0.003	1.0
Chromium	0.02	20 -300
Copper	0.005	50.0
Cyanide	0.005	—
Fluoride	1.0	—
Iron	0.1	—
Lead	0.05	40.0
Manganese	0.05	—
Zinc	0.01	250.0
Phenols (total)	0.001	—
Dissolved solids	500.0	—
Pesticides and other organic toxic substances	EPA quality criteria for water.	See Table 3.6.

Source: ODEQ 1989; ODEQ 1986

5.5. LOCAL PROGRAMS

Eight local governments along the Columbia River Estuary administer programs that affect dredging and dredged material disposal. Dredging involving the main navigation channel occurs mainly in Clatsop or Wahkiakum counties. Smaller projects are spread throughout the region's cities and counties. Shoreline Master Programs and Comprehensive Plans in the Columbia River Estuary area are required by state law to include program elements that address dredging and dredged material disposal. The normal permit process for local government dredging and disposal permits is outlined in Figure 5.4.

5.5.1. Oregon Local Governments

Oregon local governments develop and implement dredging regulations in their local comprehensive plans and zoning ordinances at the direction of the Oregon Department of Land Conservation and Development (ODLCD). The State requirement behind these local regulations is in Statewide Planning Goal 16; Estuarine Resources:

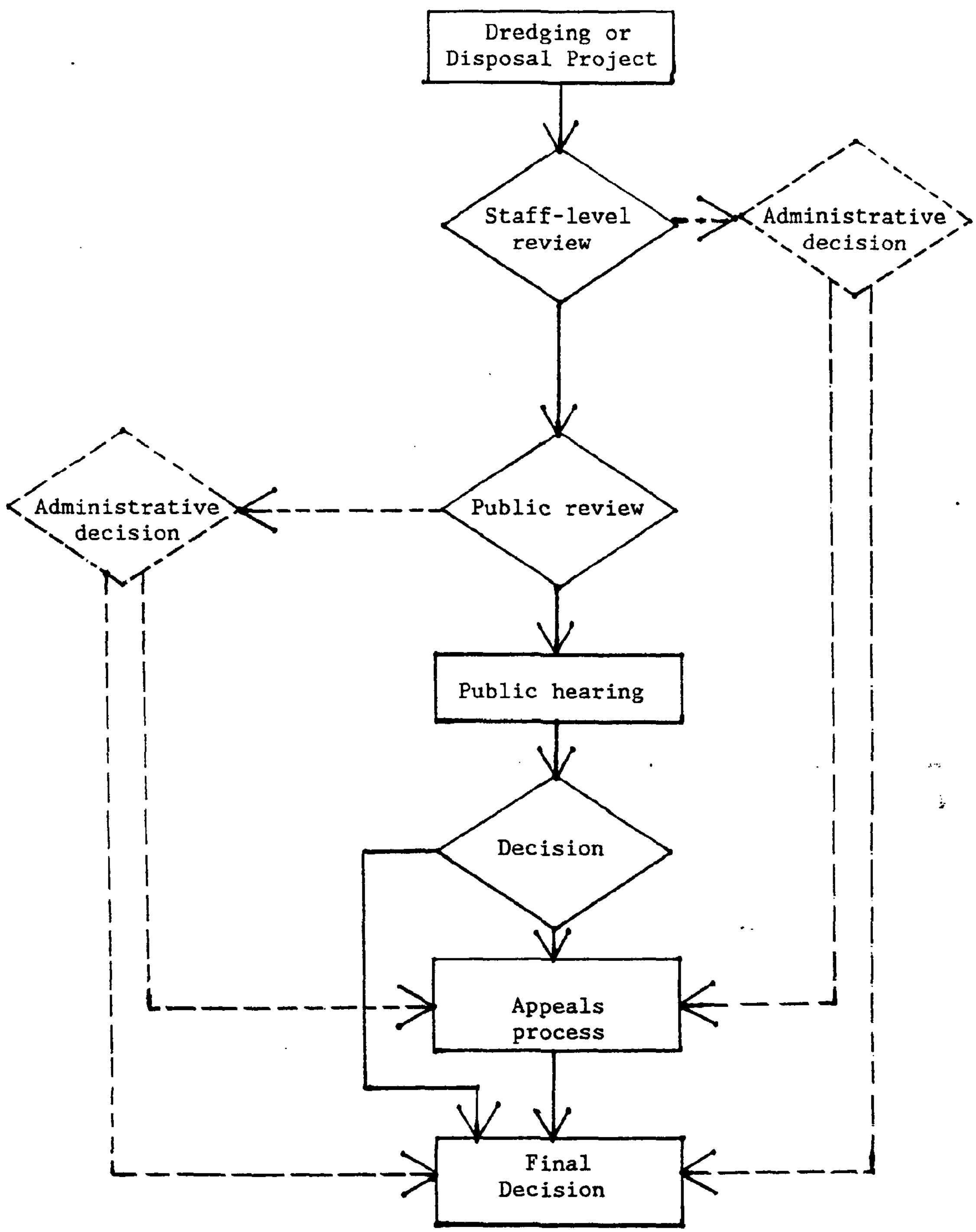
> "Unless fully addressed during the development and adoption of comprehensive plans, actions which would potentially alter the estuarine ecosystem shall be preceded by a clear presentation of the impacts of the proposed alteration. Such activities include dredging, fill, effluent discharge, flow-lane disposal of dredged material, and other activities which could affect the estuary's physical processes or biological resources."

> "Dredging and/or filling shall be allowed only:
>
> A. If required for navigation or other water-dependent uses that require and estuarine location or if specifically allowed by the applicable management unit requirements of this goal; and,
>
> b. if a need (i.e., a substantial public benefit) is demonstrated and the use or alteration does not unreasonably interfere with public trust rights; and
>
> c. if no feasible alterative upland locations exist; and,
>
> d. if adverse impacts are minimized."

> "Local government and state and federal agencies shall develop comprehensive programs, including specific sites and procedures for disposal and stockpiling of dredged materials. These programs shall encourage the disposal of dredged material in uplands or ocean waters, and shall permit disposal in estuary waters only where such disposal will clearly be consistent with the objectives of this goal and state and federal law. Dredged material shall not be disposed in intertidal or tidal marsh estuarine areas unless part of an approved fill project."

The Oregon requirements cited above are implemented through policies in Clatsop County's, Warrenton's, Astoria's and Hammond's Comprehensive Plans, and through development standards in their zoning ordinances. Oregon local

Figure 5.4 : Local Permit review Process



Note: dashed lines indicate a review route not available in all Columbia River Estuary jurisdictions.

governments have each adopted a zoning scheme that restricts in-water dredged material disposal to only a few selected sites (see Section 2.4).

5.5.2 Washington Local Governments

Washington local governments in the Columbia River Estuary area (Pacific County, Wahkiakum County, Cathlamet and Ilwaco) implement state regulations under Washington's Shoreline Management Act. The local regulations concerning dredging and dredged material disposal are in local Shoreline Master Programs. The state regulations governing development of local Shoreline Master Programs establish the following guidelines about dredging, from WAC 173-16-060(16):

> "a. Local governments should control dredging to minimize damage to existing ecological values and natural resources of both the area to be dredged and the area for deposit of dredged materials."
>
> "b. Local master programs must include long-range plans for the deposit and use of spoils on land. Spoil deposit sites in water areas should also be identified by local government in cooperation with the state departments of natural resources, game and fisheries. Depositing of dredge material in water areas should be allowed only for habitat improvement, to correct problems of material distribution affecting adversely fish and shellfish resources, or where the alternatives of depositing material on land is more detrimental to shoreline resources than depositing it in water areas."
>
> "c. Dredging of bottom materials for the single purpose of obtaining fill material should be discouraged."

5.5.3. Permit Administration

Estuary area governments on both sides of the River administer permit programs that facilitate implementation of their dredging and dredged material disposal policies and standards. The permits are reviewed and approved or denied by local planning commissions or, for some kinds of permits, by administrative decision. In Oregon, local permit decisions can be appealed to the Oregon Land Use Board of Appeals. There have been no LUBA appeals to date involving dredging. Washington local Shorelines Permits may be appealed to the State Shorelines Hearing Board, or may be administratively vetoed by the Department of Ecology. A number of dredging permits have been appealed, principally in the Puget Sound area.

Federal dredging projects are sometimes handled outside of the normal local permit process. The Federal Coastal Zone Management Act requires that federal projects in the Coastal Zone, which includes the estuary, be consistent with the approved state management programs, but only to the "maximum extent practicable". Federal dredging and disposal projects in the Columbia River Estuary have generally been fully consistent with Coastal Zone Management plans. The process for determining consistency of a federal project is, in Washington jurisdictions, simply the local permit process. Oregon jurisdictions handle federal consistency in a slightly different manner, relying on coordination between the appropriate federal agency (usually the U.S. Army Corps of Engineers), the Oregon Department of Land Conservation and Development, and the affected local government.

5.6. UNIFIED REGULATORY PROGRAM

This section summarizes the key components of local, state and federal sediment quality programs, and identifies the essential program elements from the permit applicants's perspective. These are drawn together in the form of a unified method for meeting sediment evaluation requirements in the Columbia River Estuary.

Section 404 Permit

All inwater dredged material disposal in the Columbia River Estuary will require a permit issued by the US Army Corps of Engineers. These permits are issued under the Federal Water Quality Act, and are known as Section 404 permits, after the section of the Act that describing the permit process. Background and procedural information about Section 404 permits.

All Section 404 permits on the Oregon side of the Columbia River Estuary are managed by the Corps' Portland District office. The Portland District also manages Section 404 permits on the Washington side of the estuary when a port district is involved. Other Washington side permits on the Columbia River Estuary are administered through the Corps' Seattle District office. The review process is the same. Copies of Portland District and Seattle District application forms are shown in Figures 5.5 and 5.6.

Water and sediment quality concerns associated with inwater dredged material disposal are normally addressed during review of a Section 404 permit primarily through the Section 401 water quality certification process. The Oregon Department of Environmental Quality and the Washington Department of Ecology share Section 401 water quality certification responsibilities on the Columbia River Estuary. The section 401 process certifies that the applicable state water quality standards will not be violated by the dredging or disposal of contaminated sediments. Many dredging and disposal projects in the Columbia River Estuary will affect water in both states. In these cases, water quality certification should be obtained from both Oregon and Washington. This is rarely done: more typically, only the state where the dredging or disposal actually takes place will issue a Section 401 certification. Federal agencies are also involved reviewing water quality issues, particularly the US Environmental Protection Agency (EPA), the US Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS).

Section 401 water quality certifications can be denied for lack of sufficient data, as well as when disposal would violate water quality standards. The need for decision making information for the Section 401 certification process is behind most of the project-specific sediment testing, both chemical and biological, in the Columbia River Estuary. Providing sufficient data for state water quality certification may, under some circumstances, be one of the most significant and expensive obstacles for a permit applicant to overcome. Chemical analysis of sediments to be dredged, biological investigations on the test sediments, pre-dredging surveys of the disposal site, and post disposal monitoring may all be required of a Section 404 permit applicant.

The section 404 permit review process includes an opportunity for public and agency comment on the proposal. Sediment quality data are reviewed here. Compliance with a number of other federal and state laws is also checked at this stage. Section 404 permits will either not be issued until all state and local approvals are completed, or will be issued with a condition requiring compliance with state and local permit requirements. A section 404 permit will not be issued if a corresponding state or local permit has been denied.

Hydraulics Project Approval

Applicants for projects on the Washington side of the estuary must apply for a permit under the Washington Hydraulic Code from the Washington Department of Fisheries. A section 404 permit application to the Seattle District Corps of Engineers office is a joint application for this permit. Review is normally concurrent with the federal review. Impacts on fish resources are this permit's principal focus. A copy of the Hydraulics Project Application is shown in Figure 5.7.

State Environmental Policy Act (SEPA) Review

The Washington State Environmental Policy Act (SEPA) establishes a review process for projects that may have environmental impacts in the state. Inwater disposal of dredged material on the Washington side of the Columbia River Estuary is subject to SEPA requirements. The SEPA process is described in Figure 5.2. The process starts with completion of an environmental checklist. Review of the checklist by the lead agency, which may be Wahkiakum County, Pacific County, the Department of Ecology or Fisheries, or some other agency, results in either a Determination of Nonsignificance (DNS), or preparation of an Environmental Impact Statement (EIS). Sediment quality information may be included in the EIS.

Proprietary Management of Submerged Lands

The Washington Department of Natural Resources (DNR) manages state owned submerged lands in the Columbia River Estuary and elsewhere in Washington. DNR administers a program for reviewing use of submerged lands for dredged material disposal that runs concurrently with other state and federal permit programs. Inwater disposal of dredged material on the Washington side of the estuary must comply with this program.

Oregon Fill and Removal Permit

The Oregon Division of State Lands administers a permit program for filling and dredging in Oregon waters. Inwater dredged material disposal on the Oregon side of the Estuary will require a permit under this program. The US Army Corps of Engineers Section 404 permit application form used by the Portland District office is a joint application for both the Section 404 permit and this permit. Public review and agency comment are required for this permit. The Oregon Department of Fish and Wildlife and Oregon Department of

APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT

(33 CFR 325)

OMB APPROVAL NO. 0702-0036
Expires 30 June 1989

The Department of the Army permit program is authorized by Section 10 of the River and Harbor Act of 1899, Section 404 of the Clean Water Act and Section 103 of the Marine, Protection, Research and Sanctuaries Act. These laws require permits authorizing activities in or affecting navigable waters of the United States, the discharge of dredged or fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Information provided on this form will be used in evaluating the application for a permit. Information in this application is made a matter of public record through issuance of a public notice. Disclosure of the information requested is voluntary; however, the data requested are necessary in order to communicate with the applicant and to evaluate the permit application. If necessary information is not provided, the permit application cannot be processed nor can a permit be issued.

One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application *(see sample drawings and instructions)* and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

1. APPLICATION NUMBER *(To be assigned by Corps)*

2. NAME AND ADDRESS OF APPLICANT

Telephone no. during business hours

A/C ( ) ____________ *(Residence)*
A/C ( ) ____________ *(Office)*

3. NAME, ADDRESS, AND TITLE OF AUTHORIZED AGENT

Telephone no. during business hours

A/C ( ) ____________ *(Residence)*
A/C ( ) ____________ *(Office)*

Statement of Authorization: I hereby designate and authorize ____________ to act in my behalf as my agent in the processing of this permit application and to furnish, upon request, supplemental information in support of the application.

SIGNATURE OF APPLICANT | DATE

4. DETAILED DESCRIPTION OF PROPOSED ACTIVITY

4a. ACTIVITY

4b. PURPOSE

4c. DISCHARGE OF DREDGED OR FILL MATERIAL

5. NAMES AND ADDRESSES OF ADJOINING PROPERTY OWNERS, LESSEES, ETC., WHOSE PROPERTY ALSO ADJOINS THE WATERWAY

6. WATERBODY AND LOCATION ON WATERBODY WHERE ACTIVITY EXISTS OR IS PROPOSED

7. LOCATION ON LAND WHERE ACTIVITY EXISTS OR IS PROPOSED

ADDRESS:

STREET, ROAD, ROUTE OR OTHER DESCRIPTIVE LOCATION

COUNTY　　STATE　　ZIP CODE

LOCAL GOVERNING BODY WITH JURISDICTION OVER SITE

8. Is any portion of the activity for which authorization is sought now complete? ☐ YES ☐ NO
If answer is "Yes" give reasons, month and year the activity was completed. Indicate the existing work on the drawings.

9. List all approvals or certifications and denials received from other federal, interstate, state or local agencies for any structures, construction, discharges or other activities described in this application.

ISSUING AGENCY	TYPE APPROVAL	IDENTIFICATION NO.	DATE OF APPLICATION	DATE OF APPROVAL	DATE OF DENIAL

10. Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities or I am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT　　DATE　　SIGNATURE OF AGENT　　DATE

The application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in Block 3 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of The United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

Do not send a permit processing fee with this application. The appropriate fee will be assessed when a permit is issued.

Figure 5.5: Seattle District Corps of Engineers Section 404 Permit Application

JOINT APPLICATION FOR PERMIT

U.S. ARMY CORPS OF ENGINEERS
STATE OF OREGON, DIVISION OF STATE LANDS

WHEREAS Department of the Army permits for proposed work in or affecting navigable waters of the United States, the discharge of dredged or fill material into those waters, and the transport of dredged material for the purpose of dumping it into ocean waters are authorized by Section 10 of the River and Harbor Act of 1899, Section 404 of the Clean Water Act of 1977, and Section 103 of the Marine Protection Research and Sanctuaries Act of 1972, respectively. ---AND---permits for that part of those project activities which includes the removal or fill in the waterways of Oregon of rock, gravel, silt, and clay are authorized by the State of Oregon under O.R.S. 541.605 to 541.695---THIS APPLICATION WILL MEET THE REQUIREMENTS OF BOTH AGENCIES.

For Agency Use Only	For Agency Use Only
Corps of Engineers # ________	State of Oregon # ________
________	________
Date received ________	Date received ________

Name of Waterway ________ River Mile ________ Local Name ________

Section ________ Township ________ Range ________

Estimated Starting Date of Project ________ Estimated Completion Date of Project ________

NAME OF APPLICANT ________	AUTHORIZED AGENT ________
Address ________	Address ________
City, State, Zip Code ________	City, State, Zip Code ________
Phone: Work (Area) ________ Home (Area) ________	Phone: Work (Area) ________ Home (Area) ________
PROJECT SUPERVISOR ________	Phone: Work (Area) ________ Home (Area) ________
PROPERTY OWNER IF OTHER THAN APPLICANT ________	PROJECT ADDRESS ________
Address ________	City, County, State, Zip Code ________
City, State, Zip Code ________	Assessor's Records-- Shown on Map # ________ Tax Lot # ________
Phone: Work (Area) ________ Home (Area) ________	Name of Subdivision ________ Lot ________ Block ________

In order to expedite the processing of this application, the following city and/or county department, which has local jurisdiction over the proposed project, has been contacted:

Name of Department: ________

Address: ________

Phone Number: ________

APPROVALS OR CERTIFICATIONS applied for or already obtained from other agencies (Federal, interstate, state, county, city, area) for any of the proposed projects described in this application:

Issuing Agency	Type of Approval	Identification #	Date of Application	Date of Approval

NPP Form 358
OCT 1980
141-31-04-80 Inclosure 1

Has any agency denied approval for the activity described herein or for any other activity directly related to it?
☐ Yes ☐ No If yes, please explain in Remarks.

ADJOINING PROPERTY ON THE WATERWAY: Give names, addresses, and phone numbers of owners and/or occupants.

PLEASE EXPLAIN IN DETAIL your plans to restore the area to its natural condition.

INFORMATION FOR FILL OR REMOVAL:

FILL WILL INVOLVE ________ cubic yards annually, and ________ cubic yards for the total project.

☐ Riprap ☐ Rock ☐ Gravel ☐ Sand ☐ Silt ☐ Clay ☐ Organic

REMOVAL WILL INVOLVE ________ cubic yards annually, and ________ cubic yards for the total project.

☐ Rock ☐ Gravel ☐ Sand ☐ Silt ☐ Clay

DESCRIBE IN DETAIL THE PROPOSED ACTIVITY---its primary purpose and secondary purpose, if any,---intended use (private, public, commercial)---type of structures and use---type of vessels using facility---facilities for handling wastes---type of conveyance and manner of extraction of any fill or removal---the quantity and composition of, and the source and disposal sites for any fill or removal. (If additional space is needed, use plain sheet of paper.)

Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that, to the best of my knowledge and belief, such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities.

____
Signature of Applicant or Authorized Agent

18 USC 1001 provides in part: "Whoever, in any manner within the jurisdiction of any department . . . of the United States knowingly and willfully falsifies . . . a material fact or makes any false . . . statement or . . . uses any false . . . document . . . shall be fined not more than $10,000 or imprisoned not more than five years, or both."

Figure 5.6: Portland District Corps of Engineers Section 404 Permit Application

Figure 5.7: Hydraulic Project Application, Washington

DEPARTMENT OF GAME

600 Capitol Way North
Olympia, Washington 98504
(206) 753-5897

HYDRAULIC PROJECT APPLICATION

(R.C.W. 75.20.100)

PLEASE PRINT OR TYPE

DO NOT WRITE IN SHADED AREA

DEPARTMENT OF FISHERIES

General Admin. Bldg.
Olympia, Washington 98504
(206) 753-6650

[10] LAST NAME / FIRST / [18] CONTACT PHONE(S)	[1] 1 2 3 4 [2] [3]
[19] STREET OR RURAL ROUTE	[7] [8] [9] WRIA A B C D
CITY / STATE / ZIP	
[12] WATER / TRIBUTARY TO	[14] [15] [16] F G [17]
[13] QUARTER SECTION / SECTION / TOWNSHIP / RANGE (E-W) / COUNTY	[11] TYPE OF PROJECT

DESCRIPTION OF WORK, METHOD, AND EQUIPMENT

PROPOSED STARTING DATE | PROPOSED FINISHING DATE

[20] SEPA AGENCY/DATE OF DETERMINATION

[21] OTHER PERMITS

IT IS UNDERSTOOD THAT NO WORK WILL BE STARTED UNTIL A SIGNED APPROVAL IS RECEIVED

TIME LIMITATIONS:

GAM 111 (Rev. 9/77) -771-

Local Permits

Both Oregon and Washington local governments on the Columbia River Estuary administer local permit processes that affect inwater dredged material disposal within their jurisdiction. Figure 5.4 graphically describes the basic local permit review process, although there are differences between the way each city and county handle these permits. The most significant of these differences are between Oregon and Washington local governments.

Clatsop County, Astoria, Warrenton and Hammond each administer a comprehensive plan and zoning ordinance that regulates, among a great many other things, inwater disposal of dredged material. Each jurisdiction has adopted a zoning map that designates dredged material disposal sites. These are shown in the CREST publication "Columbia River Estuary Dredged Material Management Plan (Fox, 1986), and on local zoning maps. Some types of inwater dredged material disposal may be allowed without obtaining a local permit, particularly if it is associated with ongoing maintenance of an existing facility, and disposal occurs at a designated and regularly used site. New projects and changed maintenance disposal methods and sites will usually require approval of a local permit. The local permit review process in Oregon starts with completion of an application form. The completed form is reviewed administratively, and a permit may be issued administratively without a public hearing in some cases. Most inwater disposal permits will require a public hearing before a planning commission. A permit is issued or denied, which can then be appealed to the city or county governing body. From there the appeal route is to the Land USe Board of Appeals (LUBA), the Court of Appeals, and finally to the State Supreme Court. There have been no LUBA appeals of dredging permits to date. The Oregon Department of Land Conservation and Development monitors local permit activity, but does not have the ability to veto a local permit.

Pacific County, Wahkiakum County, Cathlamet and Ilwaco each administer a Shoreline Master Program that sets up a permit program for, among other things, inwater disposal of dredged material. Inwater dredged material disposal sites are designated in the Shoreline Master Programs, and in the CREST publication "Columbia River Estuary Dredged Material Management Plan (Fox, 1986). Most inwater disposal projects will require a Substantial Development Permit, issued by the county or city planning commission. Permits may be appealed to the State Shoreline Hearing Board, and from there into the State court system. The Washington Department of Ecology can veto a Substantial Development Permit it feels is not consistent with the local Shoreline Master Program. This is a tool that its Oregon counterpart, the Oregon Department of Land Conservation and Development, lacks.

Conflicts Among Permitting Programs

One of the most significant causes of frustration with the permit process for both applicants and permit reviewers are the inconsistencies between different permit programs with generally similar goals. For inwater dredged material disposal permits, these inconsistencies are in the area of sediment chemistry evaluation. They involve the following specific regulatory elements:

What are the target chemicals for sediment analysis;

What are the standards against which sediment chemical data will be reviewed; and

Under what circumstances are bioassay and bioaccumulation studies needed.

These three regulatory conflicts are briefly described in the following paragraphs.

Conflicts: Target Chemicals

Agreement among the resource agencies about which chemicals should be targeted for examination in Columbia River Estuary sediment is not always achieved. The Oregon Department of Environmental Quality's Draft Interim Sediment Quality Guidelines lists seven metals and ten organic compounds as targets for sediment chemistry analysis. In analysis of sediment for its own dredging projects, the Corps of Engineers has tested a changing number of chemicals. In tests conducted on Elochoman Slough sediment, the Portland District Corps targeted nine metals and 34 organic compounds. The Washington Department of Ecology has sometimes recommended that Columbia River Estuary inwater disposal permit applicant consider testing for the nine metals and 48 organic compounds that the Puget Sound Dredged Disposal Analysis (PSDDA) has set standards for.

This conflict would be resolved by developing a uniform target chemical menu for the Columbia River Estuary. Short of this solution, individual permit applicants must determine the scope of chemical analysis for their project by contacting several different agencies. This will result in compilation of an aggregate list of chemicals of concern.

Conflicts: Evaluation Standards

Standards for evaluating results of sediment chemistry tests are lacking in the Columbia River. The Oregon Department of Environmental Quality's Draft Interim Sediment Quality Guidelines is in a draft form as of the date of this report. It relies on a method for setting standards for some organic compounds, known as equilibrium partitioning, that the EPA may not accept. The Puget Sound sediment standards developed under the Puget Sound Dredged Disposal Analysis (PSDDA) rely on an Apparent Effects Threshold method for determining sediment standards that is not readily transferable to other aquatic environments without additional research. The considerable investment in sediment chemical tests is partially wasted because of the lack of evaluative standards.

This conflict could be resolved by development and adoption of uniform evaluation standards. A substantial amount of biological research would be required to establish these standards, even if all of the agencies could agree on a methodology for establishing standards. Short of uniform standards, the applicant's lab or consultant should be prepared to interpret and circulate the results of sediment analysis.

Conflicts: Biological Testing

Related to the lack of sediment chemistry standards is the lack of threshold standards for requiring biological testing; the possibility that standard bioassay and bioaccumulation tests may not be applicable to environmental conditions in the Columbia River Estuary, and the lack of standards for evaluating biological test results. The first of these problems would be resolved for Oregon if the Department of Environmental Quality's Draft Interim Sediment Quality Guidelines were finalized. But a potential conflict still exists unless federal and Washington state agencies agree with the thresholds established under the Draft ODEQ Guidelines. The standardized biological tests for sediment evaluation are designed for marine conditions, and use marine organisms that may not be present in the Columbia River Estuary. The applicability of these tests to local environmental conditions has not been established. An estuary bioassay test has been developed (cite), but is not widely applied. Standards for evaluating biological tests are needed. Like chemical tests, biological tests are expensive. The investment in these tests would be more effective if the results were evaluated against a standard.

This conflict could be resolved by developing biological test protocols for the Columbia River Estuary. This has not been attempted, nor is there a sufficient demand for biological testing in the Columbia River Estuary to justify the effort. The labs that perform biological investigations can address this problem by providing detailed evaluations and interpretations of their results for the resource agencies.

6. GLOSSARY

Absorption: To be assimilated, taken in.

Accuracy: The closeness of a measured or computed value to its true value.

Acute Effect: A toxic effect on an organism occurring with in a short period of time, usually 96 hours or less.

Adsorption: Dissolved substance becomes bound to the surface of the particle.

Analyte: The specific component measured in a chemical analysis.

Apparat Effects Threshold: The sediment concentration above which statistically significant biological effects would always be expected.

Batch: Usually refers to the number of samples that can be prepared or analyzed at one time. A typical commercial batch size is 20 samples for extraction of organic compounds.

Bedload: Medium to coarse sands transported along the bed bottom.

Benthic Organisms: Organisms that live in or on the bottom of a body of water.

Bioaccumulation: Process by which a chemical accumulates in an organism's tissues.

Bioassay: Test procedure to measure response of living plants, animals or other organisms to a test sediment or elutriate.

Bulk Chemical Analyses: Chemical analyses performed on an entire sediment sample, without separating water from the solid material in a sample.

Blank-Corrected: The concentration of a chemical in a sample adjusted for the concentration of that chemical in the method blank carried through the procedure concurrently with the sample.

Calibration: The systematic standardization of either the response of instruments used for measurements or the chemical separation achieved by a laboratory cleanup procedure.

Chronic Effect: A toxic effect on an organism occurring after chemical exposure of long duration.

Coefficient of Variation: The standard deviation expressed as a percentage of the mean.

Composite: A sediment sample that consists of several samples mixed together; also, the mixing together of two or more sediment samples.

Contaminant: A substance not naturally present in the environment or present in unnaturally high concentrations which can affect the environment.

Contaminated Sediment: A sediment that contains measurable levels of contaminants; or, a sediment that contains sufficient concentrations of chemicals to produce unacceptable adverse environmental effects and thus require restrictions for dredging and disposal.

Control Limit: Defines the minimum quality of data as measured by some indicator (e.g., recovery) required to assume that the system or method is performing as expected. Exceeding a control limit triggers action by the laboratory to correct the problem before data are reported.

Dredged Material: Sediment, gravel and other solids removed from an aquatic area.

Duplicate Analysis: A second analysis made on the same (or identical) sample of material to assist in the evaluation of measurement variance.

Effluent: Water flowing out of a contained disposal facility during and immediately following a disposal operation.

Elutriate: The extract resulting from mixing water and dredged material in a laboratory test. The resulting elutriate can be used for chemical and biological testing to assess potential water column effects of dredged material disposal.

Equilibrium Partitioning: A methodology for estimating the interstitial water concentration of a sediment contaminant.

GC: Gas chromatography. An instrumental technique used to separate a complex mixture into its component compounds by partitioning the compounds between a mobile gaseous phase (under pressure) and a stationary solid or liquid phase.

GC/MS: Gas chromatography/mass spectroscopy. An instrumental technique useful for breaking organic compounds into characteristic fragments that can be used to determine the original structure of the compound.

Inorganic Chemicals: Compounds not containing carbon: includes metals, ammonia, acids used in pulp/paper processing.

Matrix: The sample material in which the chemicals of interest are found (e.g., water, sediment, tissue).

Matrix Spike: An analysis conducted by adding a known amount of chemicals of interest to an actual sample (i.e., matrix), usually prior to extraction or digestion, and then carrying the spiked sample through the analytical procedure. The final matrix spike results are reduced by the amount of each chemical found in a replicate analysis of the sample conducted without spikes. A comparison of these results with the known concentration of spike added to the sample enables an evaluation of the effect of the particular sample matrix on the recovery of compounds of interest.

Method Blank: A measure of the contribution of analytes from all laboratory sources external to the sample. The method blank value is determined by proceeding through all phases of extraction and analysis with no addition of sample.

Method Spike: A method blank to which a known amount of surrogate standards and analytes (compounds of interest) have been added.

NMFS: National Marine Fisheries Service

Noise: The electronic signal intensity attributed to instrument "background" or electronic current from chemical interferents (i.e., any part of an electrical signal that cannot be related in a known way to the electronic signal from a target compound).

ODEQ: Oregon Department of Environmental Quality

ODLCDC: Oregon Department of Land Conservation and Development

ODSL: Oregon Division of State Lands

ODFW: Oregon Department of Fish and Wildlife

Organic Chemicals: Chemicals containing carbon, including plastics, herbicides, rubber, PCB's, or petroleum - related products.

PPB: Parts per billion, or µg/gram.

PPM: Parts per million, or mg/kg, or µg/gram.

Phi: A measurement unit for sediment grain size. Phi = $-\log_2 d$, where d is the grain diameter in millimeters.

Polychlorinated Biphenyls (PCB): A group of manmade organic chemicals, including about 70 different but closely related compounds made up of carbon, hydrogen, and chlorine. If released to the environment, they persist for long periods of time and can concentrate in food chains. PCB's are not water soluble and are suspected of causing cancer in humans. PCB's are an example of an organic toxicant.

Polycyclic (Polynuclear) Aromatic Hydrocarbon (PAH): A class of complex organic compounds, some of which are persistent and cancer-causing. These compounds are formed from the combustion of organic material and are ubiquitous in the environment. PAH's are commonly formed by forest fires and by the combustion of fossil fuels. PAH's often reach the environment through atmospheric fallout, highway runoff, and oil discharge.

Precision: The degree of mutual agreement characteristic of independent measurements as the result of repeated application of a method under specified conditions.

Priority Pollutant: Toxic pollutants defined by the US EPA in 1976 that are the primary subject of regulation of the Water Quality Act. A list of these substances can be found in the Code of Federal Regulations Volume 40, Section 401.15.

PSDDA: Puget Sound Dredged Disposal Analysis

QA/QC: Quality assurance/quality control (see below).

Quality Assurance: The total integrated program for assuring the reliability of monitoring and measurement data. A system for integrating the quality planning, quality assessment, and quality improvement efforts to meet user requirements.

Quality Control: The routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.

Quantification: The determination or expression of the number or amount of a variable.

RM: River Mile

Recovery: The amount of a chemical detected in a sample extract at the end of a procedure relative to the total amount present in a sample before the procedure was begun. Also, the amount of a chemical detected in a sample relative to the amount added (i.e., spike) or known to be present (i.e., in a naturally derived standard reference material). Recovery is usually expressed as a percentage.

Replicate: One of several identical experiments, procedures, or samples. Duplicate is a special case of replicates consisting of two samples or measurements.

Reproducibility: The ability to produce the same results for a measurement. Often measured by calculation of relative percent difference or coefficient of variation.

Semivolatile Organic Compounds: Organic compounds with moderate vapor pressures that can be extracted from samples using organic solvents and analyzed by gas chromatography. Semivolatile organic compounds include the US EPA acid/base/neutral compounds (including pesticides and PCBs) as well as numerous other neutral and organic acid compounds of regional interest (e.g., carbazole, retene, coprostanol, 4-methylphenol).

Sensitivity: Capability of a method or instrument to discriminate between samples having differing concentrations of a chemical. The degree to which an instrument responds to low concentrations of a chemical.

SEPA: Washington State Environmental Policy Act

Significant Figure: A figure(s) that remains to a number or decimal after the zeros to the right or left are cancelled.

Spike: The addition of a known amount of a substance to a sample.

Standard (analytical): A substance or material, the properties of which are believed to be known with sufficient accuracy to permit its use to evaluate the same property of a sample. In chemical measurements, a standard often describes a solution of chemicals, commonly prepared by the analyst, to establish a calibration curve or the analytical response function of an instrument.

Standard (regulatory): A threshold for regulatory action. With respect to sediment evaluation, the amount of a compound that triggers a particular regulatory decision.

Surrogate Spike Compound: A known amount of a compound that has characteristics similar to that of a compound of interest, added to a sample prior to extraction. The surrogate compound can be used to estimate the recovery of chemicals in the sample. These compounds are also called "recovery internal standards".

Target Compounds: The chemicals of interest in a sample that can be quantified relative to response factors of reliable standards (in contrast to tentatively identified compounds).

Tentatively Identified Compounds: Chemicals identified in a sample on the basis of mass spectral characteristics held in common with a reference mass spectra of a known chemical. These compounds cannot be more confidently identified unless a reliable standard of the compound is obtained and is confirmed to co-elute with the tentatively identified compound and generate similar mass spectra using the same gas chromatograph/mass spectrometer.

TOC: Total Organic Carbon

Turbidity: A measure of the amount of suspended material in the water.

USEPA: United States Environmental Protection Agency

US EPA CLP: United States Environmental Protection Agency Contract Laboratory Program.

USFWS: United States Fish and Wildlife Service

Volatile Organic Compounds: Organic compounds with high vapor pressures that tend to evaporate readily from a sample. In this document, volatile organic compounds are the 29 US EPA priority pollutants considered as volatiles (e.g., benzene).

WDOE: Washington Department of Ecology

WDF: Washington Department of Fisheries

WDNR: Washington Department of Natural Resources

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