US Army Corps
of Engineers®
Portland District

Columbia River Channel Improvement Project

Final Supplemental Integrated Feasibility Report and Environmental Impact Statement

Volume 3

Exhibits
2 of 2

January 2003

Preface for Exhibits

The following exhibits required no updating for the Final Supplemental IFR/EIS (see the Final IFR/EIS, August 1999):

Exhibit A – Correspondence
Exhibit B – Scoping Documentation
Exhibit C – Fish and Wildlife Coordination Act Report
Exhibit D – Section 103 Evaluation
Exhibit G – Biological Assessment for Wildlife and Plants

Exhibit H required no updating and is available on the Corps web page under consultation

The following exhibits ***have been revised or are new*** for the Final Supplemental IFR/EIS:

Exhibit E - Section 404(B)(1) Evaluation (Revised)
Exhibit F - Coastal Zone Management Act Consistency Determination (Revised)
Exhibit I - Essential Fish Habitat Assessment (Revised)
Exhibit J - Columbia River Sediment Impacts Analysis (Revised)
Exhibit K
- K-1, Evaluation Report White And Green Sturgeon (Revised)
- K-2, Evaluation Report Smelt (Revised)
- K-3, Evaluation Report Fish Stranding (Revised)
- K-4, Evaluation Report Dungeness Crab (Revised)
- K-5, Wildlife And Wetland Mitigation (Revised)
- K-6, Royalty Fees For State-Owned Dredged Material (Revised)
- K-7, Evaluation Report Floodplains (Revised)
- K-8, Part I - Consistency With Critical Areas Ordinances Including Wetland Mitigation Plan (Revised)
  Part II - Wetland Mitigation Plan
- K-9, Consistency With Washington Local Shoreline Master Programs (Revised)

Exhibit L - Cost Estimate Summary (Revised)
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EXHIBIT L
COST ESTIMATE SUMMARY (REVISED)

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COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT (CRCIP)
CURRENT WORKING ESTIMATE NARRATIVE
COLUMBIA RIVER, OR/WA

Project Description

The Columbia River Channel Improvement Project (CRCIP) would consist of deepening the existing navigation channel from RM 3.0 to RM 106.5 on the Columbia River, and RM 0.0 to RM 11.6 on the Willamette River. The channel would generally be deepened from the current authorized depth of 40 feet to a new depth of 43 feet. The typical width of the navigation channel would be 600 feet, the same as the existing channel. The Willamette River dredging has been deferred until the Portland Harbor Superfund Remediation Plan is complete. At that time, the Willamette River cost estimate will be revised as appropriate and so is not included in this current working estimate. About 19.5 mcy of sand and 0.5 mcy of rock or rock-like materials would be dredged from the Columbia River, including new work and 40-foot maintenance material. Hopper, pipeline and clamshell excavation methods would be employed. Hopper dredge disposal would be at a temporary sump location adjacent to the navigation channel near CRM 18 to 20, and other flow lane sites in the Columbia River. Disposal for pipeline and clamshell dredging would be at existing and new upland disposal areas, and at three shoreline disposal sites. Three mitigation areas and eight environmental restoration projects would be constructed. The current working estimate covers only new deepening work. No operations and maintenance dredging costs are included in the current working estimate.

Estimates have been prepared for two different plans, the sponsors' plan (the proposed plan) and the least cost plan (Corps' Plan). These plans differ primarily in disposal locations. The sponsors' plan proposes the use of several upland disposal areas that would be more expensive than those included in the least cost plan, because the sponsors' plan sites are a greater distance from the river reaches to be dredged. The sponsors have proposed these more distant sites because they utilize properties already owned by the ports, avoid some environmental impacts (wetlands), and allow some beneficial reuse of dredged materials. The estimate for the proposed plan has been authorized for implementation. The sponsors have agreed to pay the difference between the proposed plan and the Corps' plan. The difference between the two plans is discussed below.

The Corps' plan uses almost all of the same disposal sites as the proposed plan. The amount of material going to any given disposal site may differ between the two plans. The proposed plan differs from the Corps' plan by placing dredged sand material from CRM 99 to 104 at Gateway site (W-101), from Oregon Slough RM 0.0 to 1.5 will be disposed at Gateway site (W-101) and CRM 89 to 94 will be disposed at Lonestar site (2.6 miles from the river). These disposal sites are a greater distance from the Columbia River than similar disposal sites in the Corps' plan for subject river miles.

For the Corps' plan the dredged sand material from CRM 101 to 104 would have been disposed at Hayden Island site (O-105), CRM 99 to 100 would have been disposed at Fazio Sand and Gravel (W-97.1), Oregon Slough RM 0.0 to 1.5 would have been disposed at Hayden Island (O-105) and CRM 89 to 94 would have been disposed at Scappoose Dairy site (0.75 mi from the river).

Basis of Design

The basis for the design of the improvement project is given in the 1999 Final Integrated Feasibility Report and Environmental Impact Statement (1999 Final IFR/EIS). Major changes in the cost estimates include: deferral of the Willamette River portion of the project; beneficial use of dredge materials previously slated for ocean disposal to create ecosystem restoration features at Lois Island embayment and Miller-Pillar; addition of five more ecosystem restoration projects; reduction in the quantity of material to be dredged; increased production rate for pipeline dredging having bank heights of less than 4 feet; and reduction in the amount of water control structures at the Shillapoo Lake ecosystem restoration project

Estimate References

ER 1110-2-1302 (Civil Works Cost Engineering), APPENDIX G (Preparation of Dredge Cost Estimates)

EP 1110-1-8 (Construction Equipment Ownership and Operating Expense Schedule)

Construction Schedule

The proposed construction schedule is given below. Dredging is assumed to begin on June 1 each year. This schedule indicates that the proposed work can be accomplished within the 2-year construction time frame.

DREDGING REACH	VOLUME	DREDGING TYPE	PLANT
		YEAR 1	
U/S of CRM 78	700,000	O&M	Hopper
CRM 42-78	6,000,000	Construction + O&M	2 - 30" pipelines
CRM 29-78	2,700,000	Construction + O&M	Hopper
CRM 3-29	6,000,000	Construction + O&M	2 - Hopper
CRM 63-67	240,000	Construction (Rock)	Clamshell

Columbia	51,000	Construction (Basalt)	Drill & Blast
CRM 101-106	203,000	Construction (Rock)	Clamshell
		YEAR 2	
U/S of CRM 78	4,300,000	Construction + O&M	2 - 30" pipelines
D/S of CRM 78	3,000,000	O&M	30" pipeline
D/S of CRM 78	4,000,000	O&M	Hopper
CRM 101-107	125,000	Construction	Clamshell

Although the construction of the Willamette River has been deferred, the costs for the Willamette River have been escalated and are shown in the total project summary sheets.

a. Overtime. Overtime would be necessary for the hopper, pipeline, and clamshell dredging. The dredges would be operating 24 hours a day 7 days a week. There would be three shifts a day for each dredge. The operation for drilling and shooting of rock would be 10 hours a day, 6 days a week.

b. Construction Windows. State and federal resource agency concerns about fishery resources have resulted in designated in-water work periods in the Columbia River for certain activities. The clamshell, pipeline and hopper dredging windows are year-round. The in-water work period for blasting in the Columbia River would run from November through February. These blasting windows would allow drilling and blasting operations to be conducted intermittently until completed. The Willamette River dredging has been delayed until the Portland Harbor Remediation Plan is complete. At that time the Willamette River cost estimate will be revised as appropriate.

c. Acquisition Plan. It is anticipated that construction would require two years to complete. Three major dredging contracts were planned, one for removal of common materials (primarily sand) by hopper, another for removal of common material by pipeline, and one for rock excavation on the Columbia River. Upland disposal site improvements would be accomplished during the dredging contracts. Separate contracts would be used to construct the mitigation and ecosystem restoration areas. The sponsors are responsible for dredging the berths at the ports. Utility owners would be responsible for accomplishing the relocations of their underwater utilities if required, however, no utility relocations are required for the Columbia River deepening.

Subcontracting Plan

No subcontracting is anticipated in any of the contracts.

General Estimating Information

a. Determination of Types of Dredging. The types of dredging equipment assumed to be used, by river mile, were determined by Corps design personnel for the least cost plan, and by sponsors' personnel for the sponsors plan. Factors considered included economics (D2M2 program), river conditions, distance to disposal areas, past practice, judgment and environmental considerations.

b. Estimating by River Mile. The cost of the dredging was estimated river mile to adjacent river mile, in order to accurately capture costs of varying quantities, depths of cut, distances to disposal sites, and types of dredging equipment.

c. Sources of Dredging Information. Sources of dredging expertise consulted in the preparation of the estimates include: John Chew of New York District, Kim Callan of Walla Walla District, Bob Parry of Seattle District, Manson, Great Lakes, Dutra, Corps personnel from San Francisco and Los Angles Districts, and Ogden Beeman & Associates, Inc., and representatives of the sponsor ports. There have been no large dredging contracts on the Columbia River in recent years except for hopper dredging. However, the historical dredging information was modified to account for the conditions anticipated on the Columbia River including river flows, traffic, current and congestion in the work area. In addition, a technical panel has reviewed the cost estimate and has determined that the assumptions and methodology used for these estimates appear to be reasonable.

d. Sources of Historical Data. Previous projects used as sources of historical data include: Coos Bay Channel Deepening, Oakland Harbor Channel Deepening, Los Angeles Harbor Deepening, and the Kill Van Kull Channel Deepening in New York Harbor. Historical information obtained for these projects included types of equipment used, labor crew makeups, production rates and difficulties encountered that might be similar to those anticipated for CRCD. Additional information was obtained from modifications to these projects, which included audited monthly equipment costs. Unit costs developed in the estimates were compared to actual costs from these projects to assess reasonableness of the estimate.

e. Hazardous, Toxic and Radioactive Waste (HTRW) Remediation Costs. No specific costs for HTRW remediation were included in the estimates. A waiver was received from higher authority, which stated that HTRW aspects did not need to be considered in the Feasibility phase, but that they must be considered in the Planning, Engineering and Design (PED) phase of the project. Costs for the HTRW explorations and analysis work, to be accomplished during PED, are considered to be included in the estimates as part of the contingencies. HTRW remediation work is expected to be minor in nature, primarily at the upland disposal sites. Therefore associated remediation costs would be relatively small.

f. Site Access. Access to the dredging areas should not be difficult, since these areas have been dredged in the past. Access to the disposal areas should not be difficult, since most of these areas have been used in the past. Access to three of the disposal areas (new upland disposal sites) and mitigation areas must be developed, but would generally not be difficult.

g. Rock Borrow Areas. Rock for the outfalls at the disposal areas would be acquired from commercial quarries. Several quarries up and down the river would be used. A representative quote for the rock materials was obtained from Goble Quarry.

h. Production Rates for New Work Dredging. The new work dredging of sand materials would likely be at a rate comparable to maintenance dredging for the existing channel.

i. Equipment/Labor Availability. Hopper, pipeline and clamshell dredge(s) of the appropriate sizes would most likely be available on the West Coast at Seattle, San Francisco or Los Angeles. Drill boats may be mobilized from the east coast (Florida) or assembled from scratch at a fabrication facility on the west coast. Appropriate crewmembers would likely come with the dredge plant.

j. Environmental Concerns. See 1999 Final IFR/EIS and Final SEIS.

k. Contingencies by Feature or Sub-Feature.

1) Construction Contingency. A contingency of 15% was used for the 09 account (hopper, pipeline and rock excavation) to cover uncertainties in all the dredging quantities, and in the unit prices for rock excavation and pipeline dredging in particular. The unit prices for hopper and clamshell dredging are more certain. The range of acceptable crew composition, operating costs, production rates, equipment availability, uncertain weather conditions, ship traffic and material variations are also covered by the construction contingency. A contingency of 25% has been used for the 09 (mitigation) and 06 (ecosystem restoration) since there are more uncertainty in the quantities and unit prices.

2) Contingencies for Functional Accounts. The contingency included in the 01 account cost is 5% for the disposal and mitigation sites and 6% for the ecosystem restoration. Contingencies of 10% were included in the 30 and 31 accounts to cover uncertainties in engineering, design and construction management related to 09 accounts discussed above.

l. Effective Dates for Labor, Equipment, Material Pricing. The effective date for all pricing is October 2001.

Quantities

a. Computation of Common Dredging Quantities. The quantities of common excavation were computed based on channel sounding data obtained primarily in the December 2001/January 2002, and on the maximum dredging pay depth (48 ft). Standard dredge quantity software was used to generate the quantities. The quantities of rock excavation were deducted from the appropriate river reaches.

b. Computation of Rock Excavation Quantities. Quantities of potential rock excavation on the Columbia River were computed initially on historical rock locations and the summation of condition surveys conducted between 1982 and 1997. The deepest depth record was assumed to be top of rock. In October 1999 geophysical exploration was conducted on potential rock areas including side scan sonar and sub-bottom profiling. Then in the summer of 2000 jet probing was conducted to better define rock areas. This was followed with core drilling from a barge and clamshell excavation to better define rock materials and quantities. Rock would be excavated several feet below the proposed new authorized depth of 43 feet in order to minimize damage to dredges during future O&M dredging operations.

Quantities of the conglomerate rock to be excavated at Slaughter's Bar, Lower Vancouver Bar and Vancouver Turning Basin, all of which are on the Columbia River, were based on a depth of 48 feet. For basalt to be blasted and removed in the Columbia River, quantities were computed to a depth of 50 feet. Only volumes inside the contour for the required excavation depth were included in the rock quantities. Quantities outside the excavation contour (50 feet depending on location) were not included.

c. Combination of O&M and New Work Quantities. Both new work and O&M quantities would be dredged under these contracts, but only the new work costs were included in the estimates. Combining these materials would lead to greater efficiency than would be accomplished by dredging the O&M materials and then the new work materials. Dredging unit costs were estimated in Cost Engineering Dredge Estimating Program (CEDEP) using the combined new work and O&M quantities, and then the new work quantities were input into Micro-computer Aided Cost Engineering System (MCACES), along with the unit prices generated in CEDEP.

d. Quantities for Dredging of Sand. Sand quantities were based on excavation to 48 feet. For purposes of this estimate, all of this quantity will probably be dredged, since a contractor might choose to maximize his pay amount by dredging all paid yardage. For hopper dredging, non-pay yardage was determined based on historical data from sand wave dredging accomplished by the dredge Newport in recent years. See paragraph above for planned overdepth in rock.

e. Quantities Along Channel Slopes (in Sand). For each river mile the total quantity of sand to be dredged included sand material above 1V to 3H side slopes. It was assumed much of this sand material would slough down the slope during deepening of the channel and be removed by the dredges.

Cost Estimating Dredge Estimating Program (CEDEP)

a. General. CEDEP was used to prepare the dredging estimates for all hopper, pipeline and clamshell dredging, including mobilization and demobilization of the dredges and associated equipment. The rock drilling and blasting, upland disposal site development, and mitigation area estimates were prepared using MCACES. All overhead, profit and bond were computed in MCACES, not in CEDEP. The Excel version of CEDEP was used for the hopper, pipeline and clamshell dredging estimates.

b. Dredging Areas. Areas to be dredged were provided by Cartography, by river mile. The areas to be dredged were used in CEDEP with the excavation quantities to determine the depth of cut, which has a very important effect on dredging costs.

Inputs to CEDEP

a. Density of Sand. All non-rock was assumed to be loosely deposited sand weighing about 1,900 grams per liter. A material factor of 1.0 was used for this loose sand material.

b. Crew Makeups. Crew makeups were modified in CEDEP, where necessary, using recent experience on large pipeline, clamshell and hopper dredging projects along the West and East Coasts.

c. Equipment Rates. CEDEP equipment rates were used in some cases, while audited equipment rates from modifications on recent dredging contracts were used in other cases.

d. Labor Rates. Labor rates were updated using recent Davis-Bacon information. A workman's compensation rate of 30% was used in CEDEP and MCACES dredging labor. This reflects longshoreman's insurance rates per review of modification estimates and discussions with SAIF personnel. Overtime percentages were computed in CEDEP and MCACES as appropriate.

e. Hydrosurveys. Hydrosurvey costs were included in CEDEP, including a survey boat and crew. Costs for pre-dredge surveys, surveys during construction and post-dredge surveys were covered.

f. Permits. No permits need to be obtained by the government because all environmental clearances would be covered by the EIS. Thus no costs associated with permits would be incurred.

g. Fuel Price. A fuel price of $0.90 per gallon for diesel fuel was used in the CEDEP program. This is the estimated price for diesel fuel in the Portland area when provided in bulk to a marine customer for the anticipated construction period.

h. Interest Rate, Economic Index. A cost-of-money rate of 5.5% per year was used. This was the rate in June 2001. An economic index of 6012, which reflects 2001 costs, was used.

i. Bank Factor. The quantity for a given reach of river in combination with area to be dredged yields a bank height, which is converted to a bank factor in CEDEP. This factor varies for the different dredge types. The greater the bank factor, the more efficient the dredging operation is, up to a maximum point where no further improvement in efficiency results.

j. Effective Working Time (EWT). Dredges would typically work 7 days a week, 24 hours a day, due to the high capital expense associated with the purchase of these machines. However, maintenance activities would reduce the actual working time somewhat, based on the type of dredge, types of material being excavated, and the condition of the equipment. An EWT percentage of 80% was used for hopper and 65% for pipeline dredging based on historical performance. For basalt rock excavation the EWT was set at 50%, due to high maintenance requirements resulting for the hardness of the rock material. The nonuniform nature of the rock material also affects the EWT. The EWT for excavating the conglomerate material using a clamshell dredge is about 52%.

Mobilization (Mob), Demobilization (Demob) and Preparatory Work

This would vary for the different contracts, depending on how the work is broken out. CEDEP has been used to compute mob and demob for each dredge contract.

a. Initial Mob and Demob.

1) Sand Dredging Contracts. This would consist of transporting three 30" pipeline dredges, one D-8 dozer, 966 loader, 70-ton crane, ramp barge and all associated equipment, and two medium sized hopper dredges. It is anticipated that this equipment would be available from various locations on the West Coast.

2) Rock Excavation Contract. This would consist of transporting 2 drill boats, one 21 CY (13 CY in rock) clamshell dredge, three 2,000 CY flat-topped barges, one 1,500 HP tug and associated equipment.

a) Mobilization and Demobilization - Drill Boats. This has been calculated in detail for the drill boats in the backup. It is anticipated that 2 drill boats would be mobilized. Mobilization was assumed to occur from Florida. Demobilization would be back to Florida. The drill boats might be assembled from scratch at some facility on the West Coast. The cost of assembling drill boats on the West Coast would be roughly the same as mobilizing-demobilizing existing drill boats from the east coast.

A full crew, and 100% ownership and operational costs, were assumed for preparation and set-up of the drill boats. For transfer of the equipment, 25% of crew and operational costs were used, along with tug costs.

A tank barge with 60,000 lb capacity would be mobed to supply pourvex. Pourvex is the liquid explosive that would be used to blast basalt.

Initial mobilization was assumed to be to the Warrior Rock reach on the Columbia River. Interim mobilizations were assumed to the remaining rock excavation sites. Demobilization was assumed from Warrior Rock reach on the Columbia River.

b) <u>Mobilization and Demobilization - Off-Loading Equipment</u>. Off-loading equipment mob/demob has also been computed in the backup. Equipment included in this activity is: 966 loader, 100-ton crane, and 16 CY rock skiff, three dump trucks and D6 cat. Equipment requirements would vary between water based off-loading and land based off-loading. Initial and interim mobs between sites were computed.

b. <u>Interim Mobs and Demobs</u>. These were the mobs/demobs from one reach of the river to another. There were four mob/demobs anticipated for the clamshell dredge (for rock excavation) and one for the hopper dredges. See the MCACES estimate for a listing of these mob/demobs, along with mileages from one reach to the next.

Hopper Dredging

The West Coast Team estimated hopper dredging. Hopper dredging is assumed for use in the lower 30 miles of the Columbia River, where rough ocean conditions predominate, and at several other locations along the Columbia Rivers where it is the more cost effective method. Disposal for hopper dredging would be accomplished at one Lois Island site and at eleven flowlane sites in the Columbia Rivers. See the drawings in the main report, section 4 for locations of disposal areas. Two medium-sized hopper dredges were assumed. The Padre Island, owned by NATCO, was used as the reference dredge. It has a capacity of 3,800 CY. Cycle times and production rates were computed based on recent projects on which the Padre Island was utilized. Hopper dredging would be performed primarily in sand waves on the channel bottom.

Pipeline Dredging

a. <u>Determination of Pipeline Dredge Sizes</u>. Pipeline dredge sizes were chosen as follows:

1) Various pipeline diameters (18”, 24” and 30”) were checked to obtain the least cost by river mile, but in the final analysis three 30-inch dredges were chosen in order to accomplish the work within the two-year construction contract period.

2) River miles were grouped together by disposal area.

3) Assured the dredging times were consistent with the project schedule, which calls for initial construction to be completed in 2 years.

It was decided to assume that all the new work pipeline dredging would be accomplished by three 30-inch pipeline dredges, working over two years. The first year, these three dredges would remove 7.7 mcy from downstream of RM 78. The second year, the three 30-inch dredges would remove 6.7 mcy from upstream from RM 78.

b. Determination of Pipeline Lengths. Pipeline lengths were determined using maps generated by Cartography. Floating pipeline was assumed at a maximum of 2,500 LF, since it is the most expensive type of pipe, and this is the maximum amount of this type of pipe that is normally mobilized on a job. All other pipe traversing water was submerged. Shore pipeline lengths were scaled off the maps. Average pipeline lengths were computed based on half the RM to be dredged, half the disposal area length, and the additional distance between the RM to be dredged and disposal area at their closest approach. A length of “Equivalent Additional Pipeline” was added to all pipeline estimates, in the amount of 1,000 feet. This covers any vertical height of pumping that might be required, as well as any abnormal pipeline losses.

c. Production Rates. Production rates for pipeline dredging were computed in CEDEP based on material type, bank height, pipeline lengths (distance to disposal areas), pumping horsepower, type of cutterhead, operator experience, effective working time, and cleanup time required. Standard production charts account for the above-listed data, and were used in CEDEP to compute production rates. Computed production rates are then compared to historical rates, as practicable, to assure reasonableness and are modified where appropriate. For the river miles (approximately 67% of the pipeline dredging) where the average bank height was less than 4 feet, the production rate (cy/hr) for the pipeline was based on the advancement rate of 50 ft/hr (30-in pipeline). An Excel spreadsheet was developed to calculate the production rate by reach based on the area to be dredged, length of the dredge area, width of the cutter head swing (300 ft), and the advancement rate of 50 ft/hr. The spreadsheet for each plan is located in the backup material.

d. Boosters. Use of boosters is sometimes necessary where pumping distances are high. The use of a booster leads to about a 15% loss in pumping efficiency per booster for the pipeline dredge, and can also be a disadvantage due to the maintenance they require. Occasionally their use is cost-effective for long pumping distances or higher heads. CEDEP runs were performed with and without boosters to determine if booster use would yield lower unit costs. Boosters were determined to be cost effective at several river miles on the sponsor plan.

e. Pipeline Dredge Labor Crews. A pipeline dredging crew comprised of 21 personnel, 22 when a booster was required, was used in CEDEP. This covers all personnel required for three 8-hour shifts per day on the dredge.

f. Pipeline Dredge Shore Crew. The shore crew is composed of personnel required at the disposal site while the pipeline is dredging. This crew is comprised of: outside equipment operator foreman, two outside equipment operators, D-8L dozer with blade and winch, 966 front end loader, hydraulic crane (4wd & 45 ton), barge with ramp, small light plant, and three deckhands.

g. Pump Horsepower. Prime and secondary horsepower associated with the pumps on a 30-inch dredge were 9,000 and 3,310 respectively. Dredge pump horsepower relates to production rates and fuel usage.

h. Modified Dredge Areas. At a few RMs, computed bank height was too low for CEDEP to accomplish an estimate using a 30-inch dredge. At these RMs, the bank height was increased slightly to obtain output from CEDEP.

i. Variable Parameters in CEDEP. Key parameters that changed from RM to RM were: quantities, areas to be dredged, bank height and pipeline lengths. All other parameters in the pipeline CEDEP runs remained constant from RM to RM.

Rock Excavation

a. General. More details on the development of the rock excavation estimate are available in the backup material. .

b. Mechanical Dredging. Removal of conglomerate rock in the Columbia River at RMs 63 to 67 and 101 to 106 would be accomplished using a clamshell dredge.

c. Blasting. Basalt in the Columbia River at RM 87 would be broken up using blasting, with removal by a clamshell.

d. Dredge Type and Size. Discussions with industry personnel indicate that a 13 CY (rock) clamshell bucket would be appropriate for digging shot basalt in the Columbia River.

e. EWT for Clamshell Dredge. Based on historical record for previous rock excavation projects, an EWT of 50% was adopted for the removal of blasted basalt. An EWT of 52% was adopted for dredging of the conglomerate materials at several other locations. The previous projects examined included: Coos Bay Channel Deepening; John Day Drawdown: Cargill Grain Loading Facility, Rock Dredging - 1/28 to 3/6/97; and SD & Lumber Rock Dredging - 2/25 to 3/2/95; and Kill Van Kull in New York.

f. Swell Factors. The swell factors used for rock are:

1) Basalt: 1.50
2) Slaughters Bar, Vancouver Turning Basin and Lower Vancouver Turning Basin Conglomerate: 1.30

Swell of the blasted basalt was computed based on the sum of the drill plus sub-drill depths. Sub-drilling (and hence the blasting) would occur to depths deeper than the design excavation depths. Thus, swelling would occur in both the rock above the design excavation depth, but also to a depth of rock (the sub-drill depth) below the design excavation depth. This additional swelling, and requisite additional excavation, is computed in the backup and accounted for in the basalt excavation estimate.

g. Disposal of Rock Materials. Disposal of rock materials would be accomplished at the following areas:

1) Slaughters Bar material would go to O-64.8.

2) Materials from areas above and including Warrior Rock would go to Austin Point (W86.5).

3) The materials from Vancouver Bar and Turning Basin would go to Hayden Island (O-105).

Materials would be hauled on flat deck steel barges towed by 1500 hp tugs. Materials would be off-loaded at the disposal sites. A Cat 966 front-end loader situated on the barge, and a 100-ton crane with a 16 CY skip based on land were assumed for off-loading the rock. Rock would be unloaded from the skip into dump trucks, which would haul materials to the actual disposal site. A D-6 dozer would spread the materials at the disposal site. The number of barges needed to allow for continuous excavation varies from site to site, as computed in the backup. CEDEP was used to assist in the computations. Fill factors, cycle times, production rates, and hauling times for each disposal site were computed in the backup and entered into CEDEP.

h. Blasting. Blasting would be used to loosen basalt materials. Drilling would be accomplished using drill boats similar to those owned by Great Lakes Dredge and Dock, or equivalent. These rigs were used recently on a project (Kill Van Kull) in New York that involved in-water blasting. The drill boats were about 150' by 120' and each has 3 drills on board. A crew of about 16 people would man each drill boat. Drilling and shooting would only occur during daylight hours, because of safety concerns expressed by the Coast Guard and OSHA. Water velocities, 4 to 7 fps in the Columbia, were similar to those experienced on the New York project, so they should be tolerable. Drilling would be accomplished on a 10' x 10' pattern, using 4.5-inch diameter holes, which are 8' to 10' in depth. Steve O'Hara of Great Lakes has indicated that the daily direct cost of one drill boat, including equipment and labor, is $17,200/day at 1997 price level. This was also confirmed by audit information from the New York harbor deepening project.

1) Blasting Materials and Supplies. The backup has calculations of the quantities and costs of the explosives, datacord, blasting caps, starters, and boosters anticipated to be used at the various rock excavation sites.

2) Drilling Production. Based on production levels achieved at New York Harbor, it is anticipated that each drill boat would drill 35 holes per day. These holes would be drilled during one 10-hour shift per day. Drilling must be accomplished during daylight hours in the winter, therefore no more than a 10-hour shift would be used.

Upland Disposal Areas

a. General. Designs for the upland disposal areas were received from Parsons Brinkerhoff contracted through the sponsors. Designs for the disposal areas include several elements, such as dikes, spillway weirs, outfall pipes, pumping systems, utility relocations, clearing and grubbing, and access work. The containment dikes would be constructed of previously dredged sands. Ditches would be provided within the disposal areas as required to facilitate adequate drainage. Clearing and grubbing would be light.

b. Containment Dikes. Assume dike construction crew would work 8 hours per day, 5 days per week. A D-8 dozer would be used for constructing dikes. The dike crew production rate is 360 LCY/hr.

c. Weirs. Quotes for weirs (spillways) were procured from Oregon Culvert of Tualatin, OR, (503) 692-0410. Weirs would cost $7,410 each, FOB jobsite, including a riser and 2' stub for each weir. Discharge pipe would cost $53.58 per linear foot, FOB jobsite for 48-inch diameter 12-gage pipe. Bands, gaskets and bolts for the discharge pipe would cost $5.13 per linear foot of pipe, FOB jobsite. About 6 hours would be required to install each weir. Rock (12-inch minus) would be placed at the end of the outfall pipes to dissipate energy from drainage water. The cost of the rock (crushed & riprap) would be $22.80/cy, FOB jobsite, as quoted by Goble Quarry, (503) 556-9049. This is considered a typical outfall rock price for various locations along the river.

d. Return Water Pumpout Systems. Pumpout systems would be required at up to three disposal sites, and would generally be comprised of 40,000 gpm pumps at 20 feet of total head, with discharge lines. Pumping costs cover rental and operation/maintenance. Costs for a settling pond, manifold and discharge pipe were also included.

Mitigation Areas

Three mitigation areas are proposed. These measures are intended to improve wildlife habitat in several areas, as mitigation for construction of the upland disposal areas. Measures proposed include excavation of wetlands, dike construction, dike breaching, blockage of ditches, site tillage, irrigation, placement of snags and root wads, planting of riparian vegetation, clearing of blackberry thickets, removal of fencing, construction of water control structures, pumping, and construction of carp excluders.

Ecosystem Restoration

This consists of establishing wetlands in the Shillipoo Lake area; replacing several tide gates on the lower Columbia River at select locations; excavating channels through spits at the upper end of Walker-Lord and Hump-Fisher Islands; Tenasillahe Island Phase 1 interim restoration (replacing two tide box structures, installing two culverts with tide gates and fish friendly inlets, installing two additional inlet culverts, and two additional outlet culverts); Tenasillahe Island Phase 2 interim restoration (relocating whitetail deer); Tenasillahe Island Phase 3 long-term restoration breaching the levee at 7 locations; treatment of Purple Loosestrife in lower Columbia River estuary; construction of timber pile groins at Miller-Pillar; and dredging of Bachelor Slough.

Developing the wetlands at Shillapoo Lake consists of constructing dikes and channels for areas or cells and installation of water control structures to regulate flow between the individual cells. The new aluminum tide gates vary in diameter from 24 to 72 inches and have a manually operated fish slide gate attached for juvenile fish passage as needed. One or more new tide gates are to be installed at Deep River (RM 20), Grizzly Slough (RM 28), Warren Creek (RM 28), Tide Creek (RM 77), and Burris Creek (RM 81). Construction of the channels at the upper end of Walker-Lord and Hump-Fisher Islands would allow Columbia River flow into the embayments adjacent to the islands thus improving circulation and lowering water temperature.

Utilities Replacement

Utility owners would be responsible for relocation of utilities affected by dredging and disposal operations. The costs of utility relocations are considered in the economic analysis, but are not included in the estimates because the utility owner must bear these costs, not the Federal Government or Sponsor.

Columbia River. Existing utilities crossing the Columbia River (RM 3.0 to RM 106.5) were investigated and verified to determine impacts from lowering the channel to a depth of 43 feet (48-foot depth for maintenance). The verification process included correspondence with the utility company/U.S. Coast Guard that would have utility lines that are potentially impacted by lowering the channel; review of drawings; and site visits. Based on this process, there are no utilities between RM 3.0 and RM 106.5 that require removal or relocation on the Columbia River.

Berth Dredging

Several of the container, wheat, corn and barley exporting facilities must be deepened. These costs were developed by the sponsor and are not part of the federal cost-sharing equation but are included in the total project costs for economic analysis.

Use of MCACES

a. General. CEDEP results (quantities and unit prices for hopper, pipeline and clamshell dredging) were entered into MCACES in a summary manner. Portions of the BCE update were directly estimated in MCACES, including rock excavation, upland disposal site construction, mitigation areas, ecosystem restoration, utilities relocations, field office overhead, home office overhead, profit and bond. No land-based positioning equipment was included in the MCACES, because a ship-based global positioning system would be used for this purpose.

b. Overhead, Profit and Bond. Field office overhead (FOOH) costs include: insurance costs, project superintendent (and/or manager), project engineer, clerical staff, project trailer, sanitary, project sign, telephone, pickups, quality control, environmental protection, and other miscellaneous items. Home office overhead (HOOH) was input as a "rule of thumb" percentage for this type and size of project. A HOOH percentage of 4% was used since all contracts would likely be over $500,000 in value. Profit was computed using the weighted guidelines sheet in MCACES. This project is not considered very risky, so the profit percentage is relatively low. Bond costs were computed using the built-in table in MCACES.

Functional Costs

The Task and/or Project Managers provided Functional costs associated with this work as follows:

a. 01 Account - Lands and Damages:

1) Right-of-Way Acreage: This is the land required for access to the disposal sites.

2) Disposal Site Acreage: This is the land required for the disposal sites.

b. 30 Account - Planning, Engineering and Design:

1) Plans and Specifications: This item covers preparing plans and specifications, District review, technical review, contract advertisement and award activities.

2) Engineering During Construction: This item consists of Planning and Engineering Branch support to Construction Branch during construction and participation in the prefinal and final inspections of the contracts.

c. <u>31 Account - Construction Management:</u> This account covers construction management for the all contracts.

******COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT TOTAL COST SUMMARY******

PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 — AUTHORIZ./BUDGET YEAR: 2000 — FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 — EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	COLUMBIA R. CHANNELS AND CANALS	56,756	8,557	15%	65,313	0.0%	56,756	8,557	65,313			63,385	9,555	72,941
09- - -	WILLAMETTE R. CHANNELS AND CANALS	17,998	2,880	16%	20,878	0.0%	17,998	2,880	20,878			25,989	4,158	30,147
06- - -	ENVIRONMENTAL RESTORATION	18,030	4,507	25%	22,537	0.0%	18,030	4,507	22,537			20,137	5,034	25,172
	TOTAL CONSTRUCTION COSTS =====>	92,784	15,944	17%	108,728	0.0%	92,784	15,944	108,728			109,511	18,748	128,259
01 - - -	LANDS & DAMAGES (Disposal & Mitigation)	16,574	862	5%	17,436	0.0%	16,574	862	17,436			17,627	916	18,542
01 - - -	LANDS & DAMAGES (Envir. Restoration)	2,500	160	6%	2,660	0.0%	2,500	160	2,660			2,742	177	2,919
30 - - -	CR ENGINEERING & DESIGN	2,097	210	10%	2,307	0.0%	2,097	210	2,307			2,287	229	2,516
30 - - -	CR ENGINEERING DURING CONSTRUCTION	319	32	10%	351	0.0%	319	32	351			363	36	399
30 - - -	CR MONITORING & EVALUATION (GNF)	9,259	926	10%	10,185	0.0%	9,259	926	10,185	Jan-06	13.4%	10,500	1,050	11,550
30 - - -	CR MONITORING & EVALUATION (Envir. Restoration)	700	70	10%	770	0.0%	700	70	770	Jan-06	13.4%	794	79	873
30 - - -	WR ENGINEERING AND DESIGN	392	39	10%	431	0.0%	392	39	431			557	56	612
30 - - -	WR ENGINEERING DURING CONSTRUCTION	1,080	108	10%	1,188	0.0%	1,080	108	1,188			1,555	156	1,711
31 - - -	CR CONSTRUCTION MANAGEMENT	7,479	748	10%	8,226	0.0%	7,479	748	8,226			8,352	834	9,186
31 - - -	WR CONSTRUCTION MANAGEMENT	506	51	10%	557	0.0%	506	51	557			729	73	802
	TOTAL COST =========>	133,689	19,149	14%	152,838	0.0%	133,689	19,149	152,838		16.1%	155,017	22,353	177,369
	UTILITY OWNER COST FOR UTILITY RELOCATIONS	11,948	1,195	10%	13,143		11,948	1,195	13,143	Nov-12	42.0%	16,966	1,697	18,663
	NON-FEDERAL DREDGE COST TO BERTHS	1,366		0%	1,366		1,366	0	1,366			1,697	0	1,697
	TOTAL COST =========>	147,003	20,344	14%	167,347	0.0%	147,003	20,344	167,347		18.2%	173,680	24,049	197,729

APPROVED:

[signature] CHIEF, ENGINEERING AND CONSTRUCTION DIVISION

[signature] CHIEF, PLANNING, PROGRAMS AND PROJECT MANAGEMENT DIVISION

[signature] For CHIEF, COST ENGINEERING SECTION

APPROVAL DATE: JAN 14 2003

******COLUMBIA RIVER COST SUMMARY******

PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 | AUTHORIZ./BUDGET YEAR: 2000 | FULLY FUNDED ESTIMATE

EFFECTIVE PRICING LEVEL: Oct-02 | EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	COLUMBIA R. CHANNELS AND CANALS	56,756	8,557	15%	65,313	0.0%	56,756	8,557	65,313			63,385	9,555	72,941
06- - -	ENVIRONMENTAL RESTORATION	18,030	4,507	25%	22,537	0.0%	18,030	4,507	22,537			20,137	5,034	25,172
	TOTAL CONSTRUCTION COSTS =====>	74,786	13,065	17%	87,850	0.0%	74,786	13,065	87,850			83,522	14,590	98,112
01 - - -	LANDS & DAMAGES (Disposal & Mitigation)	16,574	862	5%	17,436	0.0%	16,574	862	17,436			17,627	916	18,542
01 - - -	LANDS & DAMAGES (Envir. Restoration)	2,500	160	6%	2,660	0.0%	2,500	160	2,660			2,770	206	2,975
30 - - -	CR ENGINEERING & DESIGN	2,097	210	10%	2,307	0.0%	2,097	210	2,307			2,287	229	2,516
30 - - -	CR ENGINEERING DURING CONSTRUCTION	319	32	10%	351	0.0%	319	32	351			363	36	399
30 - - -	CR MONITORING & EVALUATION (GNF)	9,259	926	10%	10,185	0.0%	9,259	926	10,185	Jan-06	13.4%	10,500	1,050	11,550
30 - - -	CR MONITORING & EVALUATION (Envir. Restoration)	700	70	10%	770	0.0%	700	70	770	Jan-06	13.4%	794	79	873
31 - - -	CR CONSTRUCTION MANAGEMENT	7,479	748	10%	8,226	0.0%	7,479	748	8,226			8,352	834	9,187
	TOTAL COST =========>	113,713	16,072	14%	129,785	0.0%	113,713	16,072	129,785		11.1%	126,215	17,939	144,155
UTILITY OWNER COST FOR UTILITY RELOCATIONS		0	0	0%	0		0	0	0			0	0	0
NON-FEDERAL DREDGE COST TO BERTHS		843		0%	843		843	0	843	Jun-05	11.7%	942	0	942
	TOTAL COST =========>	114,556	16,072	14%	130,628	0.0%	114,556	16,072	130,628		11.1%	127,156	17,939	145,097

******COLUMBIA RIVER COST SUMMARY OF CONTRACTS INCLUDED IN BCR****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN DISTRICT: PORTLAND 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 AUTHORIZ./BUDGET YEAR: 2000 FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	COLUMBIA R. CHANNELS AND CANALS	56,756	8,557	15%	65,313	0.0%	56,756	8,557	65,313			63,385	9,555	72,941
06- - -	ENVIRONMENTAL RESTORATION	10,468	2,617	25%	13,085	0.0%	10,468	2,617	13,085			11,724	2,931	14,655
	TOTAL CONSTRUCTION COSTS =====>	67,224	11,174	17%	78,398	0.0%	67,224	11,174	78,398			75,109	12,486	87,596
01 - - -	LANDS & DAMAGES (Disposal & Mitigation)	16,574	862	5%	17,436	0.0%	16,574	862	17,436			17,627	916	18,542
01 - - -	LANDS & DAMAGES (Envir. Restoration)	0	0	0%	0	0.0%	0	0	0			0	0	0
30 - - -	CR ENGINEERING & DESIGN	1,345	135	10%	1,480	0.0%	1,345	135	1,480			1,436	144	1,579
30 - - -	CR ENGINEERING DURING CONSTRUCTION	146	15	10%	161	0.0%	146	15	161			163	16	179
30 - - -	CR MONITORING & EVALUATION (GNF)	9,259	926	10%	10,185	0.0%	9,259	926	10,185	Jan-06	13.4%	10,500	1,050	11,550
31 - - -	CR CONSTRUCTION MANAGEMENT	6,722	672	10%	7,395	0.0%	6,722	672	7,395			7,511	751	8,262
	TOTAL COST =========>	101,270	13,783	14%	115,054	0.0%	101,270	13,783	115,054		11.0%	112,345	15,363	127,708
UTILITY OWNER COST FOR UTILITY RELOCATIONS		0	0	0%	0		0	0	0			0	0	0
NON-FEDERAL DREDGE COST TO BERTHS		843		0%	843		843	0	843	Jun-05	11.7%	942	0	942
	TOTAL COST =========>	102,113	13,783	13%	115,897	0.0%	102,113	13,783	115,897		11.0%	113,287	15,363	128,650

******COLUMBIA RIVER COST SUMMARY OF CONTRACTS NOT INCLUDED IN BCR******

PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 | AUTHORIZ./BUDGET YEAR: 2000 | FULLY FUNDED ESTIMATE

EFFECTIVE PRICING LEVEL: Oct-02 | EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
6 - - -	ENVIRONMENTAL RESTORATION	7,562	1,890	25%	9,452	0.0%	7,562	1,890	9,452			8,413	2,103	10,517
	TOTAL CONSTRUCTION COSTS =====>	7,562	1,890	25%	9,452	0.0%	7,562	1,890	9,452			8,413	2,103	10,517
01 - - -	LANDS AND DAMAGES	2,500	160	6%	2,660	0.0%	2,500	160	2,660			2,770	206	2,975
30 - - -	ENGINEERING AND DESIGN	752	75	10%	827	0.0%	752	75	827			851	85	937
30 ---	ENGINEERING DURING CONSTRUCTION	173	17	10%	190	0.0%	173	17	190			200	20	220
30 - - -	CR MONITORING & EVALUATION (Envir. Restoration)	700	70	10%	770	0.0%	700	70	770	Jan-06	13.4%	794	79	873
31 - - -	CONSTRUCTION MANAGEMENT	756	76	10%	832	0.0%	756	76	832			841	84	925
	TOTAL COST =========>	12,443	2,289	18%	14,731	0.0%	12,443	2,289	14,731		11.7%	13,870	2,578	16,448

October 2003 Price Level
Fully Funded Estimate Table S8-1

Least Cost Disposal Plan ($1,000)

	Total
General Navigation Features (GNF)-Cost Shared	
Channel and Turning Basins	$55,438
Rock	$19,195
Mitigation Construction	$477
Contingency	$12,486
Engineering and Design	$1,758
Supervision and Administration	$8,262
Monitoring	$11,550
Total GNF	$109,166
Non-Federal	
Berths	$942
LERRDs	$18,542
Utilities (to be paid by the permit applicant)	$0
	$19,484

10% GNF =	$10,917	< LERRDs	$18,542	**No Extra 10%**

GNF

Federal = 75% GNF =	$109,166	x	0.75	=	$81,874.25
Non-Federal = 25%	$27,291	+	$19,484	=	$46,775.25

Ecosystem Restoration $16,448

Federal =	65%	=	$16,448	x	0.65	$10,690.94
Non-Federal =	35%	=	$16,448	x	0.35	$5,756.66

Per Section 210 of WRDA 1996, the Non-Federal cost for ecosystem restoration projects is 35 percent of all construction costs, including LERRDs, and 100 percent of OMRR&R.

Total Federal	**$81,874**	**+**	**$10,691**	**=**	**$92,565**	
Total Non-Federal	**$46,775**	**+**	**$5,757**	**=**	**$52,532**	
					$145,097	$0.00

Locally Preferred Disposal Plan (LPP) ($1,000)

LLP Cost =	$147,414	
Federal	$92,565	NED Cap on Federal Interest
Non-Federal	$54,849	

Non-Federal	$54,849
Berths	$942
Real Estate Already Owned	9649
Cash	$44,259
State of Washington	$22,129
State of Oregon	$22,129

******WILLAMETTE RIVER COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	17,998	2,880	16%	20,878	0.0%	17,998	2,880	20,878	Jun-13	44.4%	25,989	4,158	30,147
	TOTAL CONSTRUCTION COSTS =====>	17,998	2,880	16%	20,878	0.0%	17,998	2,880	20,878		44.4%	25,989	4,158	30,147
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	392	39	10%	431	0.0%	392	39	431	Dec-12	42.0%	557	56	612
30 - - -	ENGINEERING DURING CONSTRUCTION	1,080	108	10%	1,188	0.0%	1,080	108	1,188	Jun-13	44.0%	1,555	156	1,711
31 - - -	CONSTRUCTION MANAGEMENT	506	51	10%	557	0.0%	506	51	557	Jun-13	44.0%	729	73	802
	TOTAL COST =========>	19,976	3,077	15%	23,053	0.0%	19,976	3,077	23,053		44.3%	28,830	4,442	33,272
UTILITY OWNER COST FOR UTILITY RELOCATIONS		11,948	1,195	10%	13,143	0.0%	11,948	1,195	13,143	Nov-12	42.0%	16,966	1,697	18,663
NONFEDERAL DREDGE COST TO BERTHS		523	0	0%	523	0.0%	523	0	523	Jun-13	44.4%	755	0	755
	TOTAL COSTS	32,447	4,272		36,719		32,447	4,272	36,719			46,551	6,139	52,690

******COLUMBIA RIVER HOPPER COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 — AUTHORIZ./BUDGET YEAR: 2000 — FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 — EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	9,123	1,368	15%	10,491	0.0%	9,123	1,368	10,491	Jun-05	11.7%	10,190	1,529	11,719
	TOTAL CONSTRUCTION COSTS =====>	9,123	1,368	15%	10,491	0.0%	9,123	1,368	10,491		11.7%	10,190	1,529	11,719
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	200	20	10%	220	0.0%	200	20	220	Dec-03	6.5%	213	21	234
30 - - -	ENGINEERING DURING CONSTRUCTION	36	4	10%	40	0.0%	36	4	40	Jun-05	11.7%	40	4	44
31 - - -	CONSTRUCTION MANAGEMENT	912	91	10%	1,004	0.0%	912	91	1,004	Jun-05	11.7%	1,019	102	1,121
	TOTAL COST =========>	10,271	1,483	14%	11,755	0.0%	10,271	1,483	11,755		11.6%	11,463	1,656	13,118

******PIPELINE DREDGING COST SUMMARY******

PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	30,012	4,502	15%	34,514	0.0%	30,012	4,502	34,514	Jun-05	11.7%	33,523	5,029	38,552
	TOTAL CONSTRUCTION COSTS =====>	30,012	4,502	15%	34,514	0.0%	30,012	4,502	34,514		11.7%	33,523	5,029	38,552
01 - - -	LANDS AND DAMAGES	13,497	547	4%	14,044	0.0%	13,497	547	14,044	Dec-03	6.5%	14,374	583	14,957
30 - - -	ENGINEERING AND DESIGN	300	30	10%	330	0.0%	300	30	330	Dec-03	6.5%	320	32	351
30 - - -	ENGINEERING DURING CONSTRUCTION	36	4	10%	40	0.0%	36	4	40	Jun-05	11.7%	40	4	44
31 - - -	CONSTRUCTION MANAGEMENT	3,001	300	10%	3,301	0.0%	3,001	300	3,301	Jun-05	11.7%	3,352	335	3,688
	TOTAL COST =========>	46,846	5,383	11%	52,229	0.0%	46,846	5,383	52,229		10.3%	51,610	5,982	57,592

******COLUMBIA RIVER ROCK EXCAVATION COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:	Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:	Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER / FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - - CHANNELS AND CANALS	17,184	2,578	15%	19,762	0.0%	17,184	2,578	19,762	Jun-05	11.7%	19,195	2,879	22,074
TOTAL CONSTRUCTION COSTS =====>	17,184	2,578	15%	19,762	0.0%	17,184	2,578	19,762		11.7%	19,195	2,879	22,074
01 - - - LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - - ENGINEERING AND DESIGN	225	23	10%	248	0.0%	225	23	248	Dec-03	6.5%	240	24	264
30 - - - ENGINEERING DURING CONSTRUCTION	36	4	10%	40	0.0%	36	4	40	Jun-05	11.7%	40	4	44
31 - - - CONSTRUCTION MANAGEMENT	1,718	172	10%	1,890	0.0%	1,718	172	1,890	Jun-05	11.7%	1,919	192	2,111
TOTAL COST =========>	19,163	2,776	14%	21,939	0.0%	19,163	2,776	21,939		11.6%	21,394	3,099	24,493

******COLUMBIA RIVER MITIGATION COST SUMMARY******

PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING BRANCH

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	437	109	25%	546	0.0%	437	109	546	Jul-04	9.1%	477	119	596
	TOTAL CONSTRUCTION COSTS =====>	437	109	25%	546	0.0%	437	109	546		9.1%	477	119	596
01 - - -	LANDS AND DAMAGES	3,077	315	10%	3,392	0.0%	3,077	315	3,392	Jul-03	5.7%	3,252	333	3,585
30 - - -	ENGINEERING AND DESIGN	150	15	10%	165	0.0%	150	15	165	Jul-03	5.7%	159	16	174
30 - - -	ENGINEERING DURING CONSTRUCTION	18	2	10%	20	0.0%	18	2	20	Jul-04	9.1%	20	2	22
31 - - -	CONSTRUCTION MANAGEMENT	44	4	10%	48	0.0%	44	4	48	Jul-04	9.1%	48	5	52
	TOTAL COST =========>	3,726	445	12%	4,171	0.0%	3,726	445	4,171		6.2%	3,955	475	4,430

******COLUMBIA RIVER LOIS ISLAND DISPOSAL COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN DISTRICT: PORTLAND 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 | AUTHORIZ./BUDGET YEAR: 2000 | FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 | EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	8,630	2,158	25%	10,788	0.0%	8,630	2,158	10,788	Jun-05	11.7%	9,640	2,410	12,050
	TOTAL CONSTRUCTION COSTS =====>	8,630	2,158	25%	10,788	0.0%	8,630	2,158	10,788		11.7%	9,640	2,410	12,050
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0			0	0	0
30 - - -	ENGINEERING AND DESIGN	200	20	10%	220	0.0%	200	20	220	Dec-03	6.5%	213	21	234
30 - - -	ENGINEERING DURING CONSTRUCTION	10	1	10%	11	0.0%	10	1	11	Jun-05	11.7%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	863	86	10%	949	0.0%	863	86	949	Jun-05	11.7%	964	96	1,060
	TOTAL COST =========>	9,703	2,265	23%	11,968	0.0%	9,703	2,265	11,968		11.6%	10,828	2,529	13,357

******COLUMBIA RIVER MILLAR-PILLAR COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	1,838	460	25%	2,298	0.0%	1,838	460	2,298	Jan-06	13.4%	2,084	521	2,605
	TOTAL CONSTRUCTION COSTS =====>	1,838	460	25%	2,298	0.0%	1,838	460	2,298		13.4%	2,084	521	2,605
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	270	27	10%	297	0.0%	270	27	297	Jul-04	8.2%	292	29	321
30 - - -	ENGINEERING DURING CONSTRUCTION	10	1	10%	11	0.0%	10	1	11	Jan-06	13.4%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	184	18	10%	202	0.0%	184	18	202	Jan-06	13.4%	208	21	229
	TOTAL COST =========>	2,302	506	22%	2,808	0.0%	2,302	506	2,808		12.8%	2,596	572	3,168

******COLUMBIA RIVER SHILLAPOO LAKE COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02						AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL: Oct-02						EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	3,788	947	25%	4,735	0.0%	3,788	947	4,735	Jul-04	9.1%	4,133	1,033	5,166
	TOTAL CONSTRUCTION COSTS =====>	3,788	947	25%	4,735	0.0%	3,788	947	4,735		9.1%	4,133	1,033	5,166
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	185	19	10%	204	0.0%	185	19	204	Jul-03	5.7%	196	20	215
30 - - -	ENGINEERING DURING CONSTRUCTION	33	3	10%	36	0.0%	33	3	36	Jul-04	9.1%	36	4	40
31 - - -	CONSTRUCTION MANAGEMENT	379	38	10%	417	0.0%	379	38	417	Jul-04	9.1%	413	41	455
	TOTAL COST =========>	4,385	1,007	23%	5,391	0.0%	4,385	1,007	5,391		9.0%	4,778	1,098	5,875

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****COLUMBIA RIVER LORD/WALKER HUMP/FISHER COST SUMMARY****														PAGE 1 OF 1
PROJECT:	COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN					DISTRICT: PORTLAND								1-Oct-02
LOCATION:	COLUMBIA RIVER, OR/WA					P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION								
CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
6 - - -	ENVIRONMENTAL RESTORATION	44	11	25%	55	0.0%	44	11	55	Aug-04	9.1%	48	12	60
	TOTAL CONSTRUCTION COSTS =====>	44	11	25%	55	0.0%	44	11	55		9.1%	48	12	60
01 - - -	LANDS AND DAMAGES	25	1	5%	26	0.0%	25	1	26	Aug-04	9.1%	27	1	29
30 - - -	ENGINEERING AND DESIGN	25	3	10%	28	0.0%	25	3	28	Aug-03	5.7%	26	3	29
30 ---	ENGINEERING DURING CONSTRUCTION	5	1	10%	6	0.0%	5	1	6	Aug-04	9.1%	5	1	6
31 - - -	CONSTRUCTION MANAGEMENT	4	0	10%	5	0.0%	4	0	5	Aug-04	9.1%	5	0	5
	TOTAL COST =========>	103	16	15%	119	0.0%	103	16	119		8.3%	112	17	129

******COLUMBIA RIVER TENASILLAHE INTERIM COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN — DISTRICT: PORTLAND — 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 — AUTHORIZ./BUDGET YEAR: 2000 — FULLY FUNDED ESTIMATE

EFFECTIVE PRICING LEVEL: Oct-02 — EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	933	233	25%	1,166	0.0%	933	233	1,166	Aug-04	9.1%	1,018	254	1,272
	TOTAL CONSTRUCTION COSTS =====>	933	233	25%	1,166	0.0%	933	233	1,166	Aug-04	9.1%	1,018	254	1,272
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	368	37	10%	405	0.0%	368	37	405	Aug-03	5.7%	389	39	428
30 - - -	ENGINEERING DURING CONSTRUCTION	10	1	10%	11	0.0%	10	1	11	Aug-04	9.1%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	93	9	10%	103	0.0%	93	9	103	Aug-04	9.1%	102	10	112
	TOTAL COST =========>	1,404	280	20%	1,685	0.0%	1,404	280	1,685		8.3%	1,520	305	1,824

******COLUMBIA RIVER TENASILLAHE LONG-TERM COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	202	51	25%	253	0.0%	202	51	253	Aug-14	50.0%	303	76	379
	TOTAL CONSTRUCTION COSTS =====>	202	51	25%	253	0.0%	202	51	253		50.0%	303	76	379
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0			0	0	0
30 - - -	ENGINEERING AND DESIGN	144	14	10%	158	0.0%	144	14	158	Aug-13	45.0%	209	21	230
30 - - -	ENGINEERING DURING CNSTRUCTION	10	1	10%	11	0.0%	10	1	11	Aug-14	50.0%	15	2	17
31 - - -	CONSTRUCTION MANAGEMENT	20	2	10%	22	0.0%	20	2	22	Aug-14	50.0%	30	3	33
	TOTAL COST =========>	376	68	18%	444	0.0%	376	68	444		48.2%	557	101	658

****COLUMBIA WHITE-TAILED DEER COST SUMMARY****																PAGE 1 OF 1
PROJECT:	COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN						DISTRICT: PORTLAND									1-Oct-02
LOCATION:	COLUMBIA RIVER, OR/WA						P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION									
CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02					AUTHORIZ./BUDGET YEAR: 2000					FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02					EFFECT. PRICING LEVEL: Oct 02									
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)		OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)		FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	122	30	25%	152		0.0%	122	30	152		Jan-06	14.3%	139	35	174
	TOTAL CONSTRUCTION COSTS =====>	122	30	25%	152		0.0%	122	30	152			14.3%	139	35	174
01 - - -	LANDS AND DAMAGES	2,475	160	6%	2,635		0.0%	2,475	160	2,635		Jan-05	10.8%	2,742	177	2,920
30 - - -	ENGINEERING AND DESIGN	0	0	10%	0		0.0%	0	0	0			0.0%	0	0	0
30 - - -	ENGINEERING DURING CONSTRUCTION	5	1	10%	6		0.0%	5	1	6		Jan-06	14.3%	6	1	6
31 - - -	CONSTRUCTION MANAGEMENT	12	1	10%	13		0.0%	12	1	13		Jan-06	14.3%	14	1	15
	TOTAL COST =========>	2,614	192	7%	2,806		0.0%	2,614	192	2,806			11.0%	2,901	214	3,115

****COLUMBIA RIVER PURPLE LOOSESTRIFE COST SUMMARY****																PAGE 1 OF 1
PROJECT:	COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN						DISTRICT: PORTLAND									1-Oct-02
LOCATION:	COLUMBIA RIVER, OR/WA						P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION									
CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02					AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE					
EFFECTIVE PRICING LEVEL:		Oct-02					EFFECT. PRICING LEVEL: Oct 02									
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)		OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)	
06- - -	ENVIRONMENTAL RESTORATION	1,036	259	25%	1,295		0.0%	1,036	259	1,295	Jul-06	16.3%	1,205	301	1,506	
	TOTAL CONSTRUCTION COSTS =====>	1,036	259	25%	1,295		0.0%	1,036	259	1,295	Jul-06	16.3%	1,205	301	1,506	
01 - - -	LANDS AND DAMAGES	0	0	0%	0		0.0%	0	0	0		0.0%	0	0	0	
30 - - -	ENGINEERING AND DESIGN	10	1	10%	11		0.0%	10	1	11	Jul-03	5.7%	11	1	12	
30 - - -	ENGINEERING DURING CONSTRUCTION	100	10	10%	110		0.0%	100	10	110	Jul-06	16.3%	116	12	128	
31 - - -	CONSTRUCTION MANAGEMENT	104	10	10%	114		0.0%	104	10	114	Jul-06	16.3%	120	12	133	
	TOTAL COST =========>	1,250	280	22%	1,530		0.0%	1,250	280	1,530		16.2%	1,452	326	1,778	

****COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT TOTAL COST SUMMARY**** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 — AUTHORIZ./BUDGET YEAR: 2000 — FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 — EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	COLUMBIA R. CHANNELS AND CANALS	58,520	8,822	15%	67,342	0.0%	58,520	8,822	67,342			65,355	9,852	75,207
09- - -	WILLAMETTE R. CHANNELS AND CANALS	17,998	2,880	16%	20,878	0.0%	17,998	2,880	20,878			25,989	4,158	30,147
06- - -	ENVIRONMENTAL RESTORATION	18,029	4,507	25%	22,536	0.0%	18,029	4,507	22,536			20,136	5,034	25,170
	TOTAL CONSTRUCTION COSTS =====>	94,547	16,209	17%	110,756	0.0%	94,547	16,209	110,756			111,481	19,044	130,525
01 - - -	LANDS & DAMAGES (Disposal & Mitigation)	17,309	906	5%	18,215	0.0%	17,309	906	18,215			18,412	962	19,374
01 - - -	LANDS & DAMAGES (Envir. Restoration)	2,500	160	6%	2,660	0.0%	2,500	160	2,660			2,742	177	2,920
30 - - -	CR ENGINEERING & DESIGN	2,097	210	10%	2,307	0.0%	2,097	210	2,307			2,287	229	2,517
30 - - -	CR ENGINEERING DURING CONSTRUCTION	319	32	10%	351	0.0%	319	32	351			363	36	399
30 - - -	CR MONITORING & EVALUATION (GNF)	9,259	926	10%	10,185	0.0%	9,259	926	10,185	Jan-06	13.4%	10,500	1,050	11,550
30 - - -	CR MONITORING & EVALUATION (Envir. Resto	700	70	10%	770	0.0%	700	70	770	Jan-06	13.4%	794	79	873
30 - - -	WR ENGINEERING AND DESIGN	392	39	10%	431	0.0%	392	39	431			557	56	612
30 - - -	WR ENGINEERING DURING CONSTRUCTION	1,080	108	10%	1,188	0.0%	1,080	108	1,188			1,555	156	1,711
31 - - -	CR CONSTRUCTION MANAGEMENT	7,655	765	10%	8,420	0.0%	7,655	765	8,420			8,549	855	9,404
31 - - -	WR CONSTRUCTION MANAGEMENT	506	51	10%	557	0.0%	506	51	557			729	73	802
	TOTAL COST =========>	136,363	19,476	14%	155,840	0.0%	136,363	19,476	155,840		15.9%	157,969	22,718	180,686
UTILITY OWNER COST FOR UTILITY RELOCATIONS		11,948	1,195	10%	13,143		11,948	1,195	13,143	Nov-12	42.0%	16,966	1,697	18,663
NON-FEDERAL DREDGE COST TO BERTHS		1,366		0%	1,366		1,366	0	1,366			1,697	0	1,697
	TOTAL COST =========>	149,677	20,671	14%	170,348	0.0%	149,677	20,671	170,348		18.0%	176,632	24,414	201,046

APPROVED:

[signature] CHIEF, ENGINEERING AND CONSTRUCTION DIVISION

[signature] CHIEF, PLANNING, PROGRAMS AND PROJECT MANAGEMENT DIVISION

[signature] FOR CHIEF, COST ENGINEERING SECTION

JAN 14 2003

APPROVAL DATE: ____________

******COLUMBIA RIVER BACHELOR SLOUGH COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - CWE UPDATE CORPS PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN JUN 02: Oct-02 | AUTHORIZ./BUDGET YEAR: 2000 | FULLY FUNDED ESTIMATE

EFFECTIVE PRICING LEVEL: Oct-02 | EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	1,437	359	25%	1,796	0.0%	1,437	359	1,796	Jul-04	9.1%	1,568	392	1,960
	TOTAL CONSTRUCTION COSTS =====>	1,437	359	25%	1,796	0.0%	1,437	359	1,796		9.1%	1,568	392	1,960
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0			0	0	0
30 - - -	ENGINEERING AND DESIGN	20	2	10%	22	0.0%	20	2	22	Jul-03	5.7%	21	2	23
30 - - -	ENGINEERING DURING CONSTRUCTION	10	1	10%	11	0.0%	10	1	11	Jul-04	9.1%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	144	14	10%	158	0.0%	144	14	158	Jul-04	9.1%	157	16	172
	TOTAL COST =========>	1,611	377	23%	1,987	0.0%	1,611	377	1,987		9.1%	1,757	411	2,167

******COLUMBIA RIVER COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 — AUTHORIZ./BUDGET YEAR: 2000 — FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 — EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	COLUMBIA R. CHANNELS AND CANALS	58,520	8,822	15%	67,342	0.0%	58,520	8,822	67,342			65,355	9,852	75,207
06- - -	ENVIRONMENTAL RESTORATION	18,029	4,507	25%	22,536	0.0%	18,029	4,507	22,536			20,136	5,034	25,170
	TOTAL CONSTRUCTION COSTS =====>	76,549	13,330	17%	89,878	0.0%	76,549	13,330	89,878			85,492	14,886	100,377
01 - - -	LANDS & DAMAGES (Disposal & Mitigation)	17,309	906	5%	18,215	0.0%	17,309	906	18,215			18,412	962	19,374
01 - - -	LANDS & DAMAGES (Envir. Restoration)	2,500	160	6%	2,660	0.0%	2,500	160	2,660			2,742	177	2,920
30 - - -	CR ENGINEERING & DESIGN	2,097	210	10%	2,307	0.0%	2,097	210	2,307			2,287	229	2,517
30 - - -	CR ENGINEERING DURING CONSTRUCTION	319	32	10%	351	0.0%	319	32	351			363	36	399
30 - - -	CR MONITORING & EVALUATION (GNF)	9,259	926	10%	10,185	0.0%	9,259	926	10,185	Jan-06	13.4%	10,500	1,050	11,550
30 - - -	CR MONITORING & EVALUATION (Envir. Resto	700	70	10%	770	0.0%	700	70	770	Jan-06	13.4%	794	79	873
31 - - -	CR CONSTRUCTION MANAGEMENT	7,655	765	10%	8,420	0.0%	7,655	765	8,420			8,549	855	9,404
	TOTAL COST =========>	116,387	16,399	14%	132,786	0.0%	116,387	16,399	132,786		11.0%	129,139	18,275	147,414
UTILITY OWNER COST FOR UTILITY RELOCATIONS		0	0	0%	0		0	0	0			0	0	0
NON-FEDERAL DREDGE COST TO BERTHS		843		0%	843		843	0	843	Jun-05	11.7%	942	0	942
	TOTAL COST =========>	117,230	16,399	14%	133,629	0.0%	117,230	16,399	133,629		11.0%	130,081	18,275	148,356

******WILLAMETTE RIVER COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN DISTRICT: PORTLAND 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	17,998	2,880	16%	20,878	0.0%	17,998	2,880	20,878	Jun-13	44.4%	25,989	4,158	30,147
	TOTAL CONSTRUCTION COSTS =====>	17,998	2,880	16%	20,878	0.0%	17,998	2,880	20,878		44.4%	25,989	4,158	30,147
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	392	39	10%	431	0.0%	392	39	431	Dec-12	42.0%	557	56	612
30 - - -	ENGINEERING DURING CONSTRUCTION	1,080	108	10%	1,188	0.0%	1,080	108	1,188	Jun-13	44.0%	1,555	156	1,711
31 - - -	CONSTRUCTION MANAGEMENT	506	51	10%	557	0.0%	506	51	557	Jun-13	44.0%	729	73	802
	TOTAL COST =========>	19,976	3,077	15%	23,053	0.0%	19,976	3,077	23,053		44.3%	28,830	4,442	33,272
UTILITY OWNER COST FOR UTILITY RELOCATIONS		11,948	1,195	10%	13,143	0.0%	11,948	1,195	13,143	Nov-12	42.0%	16,966	1,697	18,663
NONFEDERAL DREDGE COST TO BERTHS		523	0	0%	523	0.0%	523	0	523	Jun-13	44.4%	755	0	755
	TOTAL COSTS	32,447	4,272		36,719		32,447	4,272	36,719			46,551	6,139	52,690

******COLUMBIA RIVER HOPPER COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN DISTRICT: PORTLAND 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	9,123	1,368	15%	10,491	0.0%	9,123	1,368	10,491	Jun-05	11.7%	10,190	1,529	11,719
	TOTAL CONSTRUCTION COSTS	9,123	1,368	15%	10,491	0.0%	9,123	1,368	10,491		11.7%	10,190	1,529	11,719
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	200	20	10%	220	0.0%	200	20	220	Dec-03	6.5%	213	21	234
30 - - -	ENGINEERING DURING CONSTRUCTION	36	4	10%	40	0.0%	36	4	40	Jun-05	11.7%	40	4	44
31 - - -	CONSTRUCTION MANAGEMENT	912	91	10%	1,004	0.0%	912	91	1,004	Jun-05	11.7%	1,019	102	1,121
	TOTAL COST =========>	10,271	1,483	14%	11,755	0.0%	10,271	1,483	11,755		11.6%	11,463	1,656	13,118

******COLUMBIA RIVER ROCK EXCAVATION COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN DISTRICT: PORTLAND 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	17,184	2,578	15%	19,762	0.0%	17,184	2,578	19,762	Jun-05	11.7%	19,195	2,879	22,074
	TOTAL CONSTRUCTION COSTS =====>	17,184	2,578	15%	19,762	0.0%	17,184	2,578	19,762		11.7%	19,195	2,879	22,074
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	225	23	10%	248	0.0%	225	23	248	Dec-03	6.5%	240	24	264
30 - - -	ENGINEERING DURING CONSTRUCTION	36	4	10%	40	0.0%	36	4	40	Jun-05	11.7%	40	4	44
31 - - -	CONSTRUCTION MANAGEMENT	1,718	172	10%	1,890	0.0%	1,718	172	1,890	Jun-05	11.7%	1,919	192	2,111
	TOTAL COST =========>	19,163	2,776	14%	21,939	0.0%	19,163	2,776	21,939		11.6%	21,394	3,099	24,493

****PIPELINE DREDGING COST SUMMARY**** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN | DISTRICT: PORTLAND | 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 | AUTHORIZ./BUDGET YEAR: 2000 | FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 | EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	31,776	4,766	15%	36,542	0.0%	31,776	4,766	36,542	Jun-05	11.7%	35,494	5,324	40,818
	TOTAL CONSTRUCTION COSTS =====>	31,776	4,766	15%	36,542	0.0%	31,776	4,766	36,542		11.7%	35,494	5,324	40,818
01 - - -	LANDS AND DAMAGES	14,558	591	4%	14,558	0.0%	14,558	591	15,149	Dec-03	6.5%	15,504	629	16,134
30 - - -	ENGINEERING AND DESIGN	300	30	10%	330	0.0%	300	30	330	Dec-03	6.5%	320	32	351
30 - - -	ENGINEERING DURING CONSTRUCTION	36	4	10%	40	0.0%	36	4	40	Jun-05	11.7%	40	4	44
31 - - -	CONSTRUCTION MANAGEMENT	3,178	318	10%	3,495	0.0%	3,178	318	3,495	Jun-05	11.7%	3,549	355	3,904
	TOTAL COST =========>	49,848	5,709	11%	54,965	1.1%	49,848	5,709	55,556		10.3%	54,907	6,344	61,252

******COLUMBIA RIVER MITIGATION COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING BRANCH

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09- - -	CHANNELS AND CANALS	437	110	25%	547	0.0%	437	110	547	Jul-04	9.1%	477	120	597
	TOTAL CONSTRUCTION COSTS =====>	437	110	25%	547	0.0%	437	110	547		9.1%	477	120	597
01 - - -	LANDS AND DAMAGES	2,751	315	11%	3,066	0.0%	2,751	315	3,066	Jul-03	5.7%	2,908	333	3,241
30 - - -	ENGINEERING AND DESIGN	150	15	10%	165	0.0%	150	15	165	Jul-03	5.7%	159	16	174
30 - - -	ENGINEERING DURING CONSTRUCTION	18	2	10%	20	0.0%	18	2	20	Jul-04	9.1%	20	2	22
31 - - -	CONSTRUCTION MANAGEMENT	44	4	10%	48	0.0%	44	4	48	Jul-04	9.1%	48	5	52
	TOTAL COST =========>	3,400	446	13%	3,846	0.0%	3,400	446	3,846		6.2%	3,610	476	4,086

******COLUMBIA RIVER LOIS ISLAND DISPOSAL COST SUMMARY******

PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	8,630	2,158	25%	10,788	0.0%	8,630	2,158	10,788	Jun-05	11.7%	9,640	2,410	12,050
	TOTAL CONSTRUCTION COSTS =====>	8,630	2,158	25%	10,788	0.0%	8,630	2,158	10,788		11.7%	9,640	2,410	12,050
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0			0	0	0
30 - - -	ENGINEERING AND DESIGN	200	20	10%	220	0.0%	200	20	220	Dec-03	6.5%	213	21	234
30 - - -	ENGINEERING AND DESIGN	10	1	10%	11	0.0%	10	1	11	Jun-05	11.7%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	863	86	10%	949	0.0%	863	86	949	Jun-05	11.7%	964	96	1,060
	TOTAL COST =========>	9,703	2,265	23%	11,968	0.0%	9,703	2,265	11,968		11.6%	10,828	2,529	13,357

******COLUMBIA RIVER MILLAR-PILLAR COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	1,837	459	25%	2,296	0.0%	1,837	459	2,296	Jan-06	13.4%	2,083	521	2,604
	TOTAL CONSTRUCTION COSTS =====>	1,837	459	25%	2,296	0.0%	1,837	459	2,296		13.4%	2,083	521	2,604
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	270	27	10%	297	0.0%	270	27	297	Jul-04	8.2%	292	29	321
30 - - -	ENGINEERING DURING CONSTRUCTION	10	1	10%	11	0.0%	10	1	11	Jan-06	13.4%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	184	18	10%	202	0.0%	184	18	202	Jan-06	13.4%	208	21	229
	TOTAL COST =========>	2,301	506	22%	2,806	0.0%	2,301	506	2,806		12.8%	2,595	572	3,167

******COLUMBIA RIVER SHILLAPOO LAKE COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	3,788	947	25%	4,735	0.0%	3,788	947	4,735	Jul-04	9.1%	4,133	1,033	5,166
	TOTAL CONSTRUCTION COSTS =====>	3,788	947	25%	4,735	0.0%	3,788	947	4,735		9.1%	4,133	1,033	5,166
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	185	19	10%	204	0.0%	185	19	204	Jul-03	5.7%	196	20	215
30 - - -	ENGINEERING DURING CONSTRUCTION	33	3	10%	36	0.0%	33	3	36	Jul-04	9.1%	36	4	40
31 - - -	CONSTRUCTION MANAGEMENT	379	38	10%	417	0.0%	379	38	417	Jul-04	9.1%	413	41	455
	TOTAL COST =========>	4,385	1,007	23%	5,391	0.0%	4,385	1,007	5,391		9.0%	4,778	1,098	5,875

******COLUMBIA RIVER LORD/WALKER HUMP/FISHER COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
6 - - -	ENVIRONMENTAL RESTORATION	44	11	25%	55	0.0%	44	11	55	Aug-04	9.1%	48	12	60
	TOTAL CONSTRUCTION COSTS =====>	44	11	25%	55	0.0%	44	11	55		9.1%	48	12	60
01 - - -	LANDS AND DAMAGES	25	1	5%	26	0.0%	25	1	26		0.0%	25	1	26
30 - - -	ENGINEERING AND DESIGN	25	3	10%	28	0.0%	25	3	28	Aug-03	5.7%	26	3	29
30 ---	ENGINEERING DURING CONSTRUCTION	5	1	10%	6	0.0%	5	1	6	Aug-04	9.1%	5	1	6
31 - - -	CONSTRUCTION MANAGEMENT	4	0	10%	5	0.0%	4	0	5	Aug-04	9.1%	5	0	5
	TOTAL COST =========>	103	16	15%	119	0.0%	103	16	119		6.3%	110	17	127

******COLUMBIA RIVER TENASILLAHE INTERIM COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	933	233	25%	1,166	0.0%	933	233	1,166	Aug-04	9.1%	1,018	254	1,272
	TOTAL CONSTRUCTION COSTS =====>	933	233	25%	1,166	0.0%	933	233	1,166	Aug-04	9.1%	1,018	254	1,272
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	368	37	10%	405	0.0%	368	37	405	Aug-03	5.7%	389	39	428
30 - - -	ENGINEERING DURING CONSTRUCTION	10	1	10%	11	0.0%	10	1	11	Aug-04	9.1%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	93	9	10%	103	0.0%	93	9	103	Aug-04	9.1%	102	10	112
	TOTAL COST =========>	1,404	280	20%	1,685	0.0%	1,404	280	1,685		8.3%	1,520	305	1,824

******COLUMBIA RIVER TENASILLAHE LONG-TERM COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 — AUTHORIZ./BUDGET YEAR: 2000 — FULLY FUNDED ESTIMATE
EFFECTIVE PRICING LEVEL: Oct-02 — EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	202	51	25%	253	0.0%	202	51	253	Aug-14	50.0%	303	76	379
	TOTAL CONSTRUCTION COSTS =====>	202	51	25%	253	0.0%	202	51	253		50.0%	303	76	379
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0			0	0	0
30 - - -	ENGINEERING AND DESIGN	144	14	10%	158	0.0%	144	14	158	Aug-13	45.0%	209	21	230
30 - - -	ENGINEERING DURING CNSTRUCTION	10	1	10%	11	0.0%	10	1	11	Aug-14	50.0%	15	2	17
31 - - -	CONSTRUCTION MANAGEMENT	20	2	10%	22	0.0%	20	2	22	Aug-14	50.0%	30	3	33
	TOTAL COST =========>	376	68	18%	444	0.0%	376	68	444		48.2%	557	101	658

******COLUMBIA WHITE-TAILED DEER COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN — DISTRICT: PORTLAND — 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA — P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	122	30	25%	152	0.0%	122	30	152	Jan-06	14.3%	139	35	174
	TOTAL CONSTRUCTION COSTS =====>	122	30	25%	152	0.0%	122	30	152		14.3%	139	35	174
01 - - -	LANDS AND DAMAGES	2,475	160	6%	2,635	0.0%	2,475	160	2,635	Jan-05	10.8%	2,742	177	2,920
30 - - -	ENGINEERING AND DESIGN	0	0	10%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING DURING CONSTRUCTION	5	1	10%	6	0.0%	5	1	6	Jan-06	14.3%	6	1	6
31 - - -	CONSTRUCTION MANAGEMENT	12	1	10%	13	0.0%	12	1	13	Jan-06	14.3%	14	1	15
	TOTAL COST =========>	2,614	192	7%	2,806	0.0%	2,614	192	2,806		11.0%	2,901	214	3,115

******COLUMBIA RIVER PURPLE LOOSESTRIFE COST SUMMARY******

PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN | DISTRICT: PORTLAND | 1-Oct-02

LOCATION: COLUMBIA RIVER, OR/WA | P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN: Oct-02 | AUTHORIZ./BUDGET YEAR: 2000 | FULLY FUNDED ESTIMATE

EFFECTIVE PRICING LEVEL: Oct-02 | EFFECT. PRICING LEVEL: Oct 02

ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	1,036	259	25%	1,295	0.0%	1,036	259	1,295	Jul-06	16.3%	1,205	301	1,506
	TOTAL CONSTRUCTION COSTS =====>	1,036	259	25%	1,295	0.0%	1,036	259	1,295	Jul-06	16.3%	1,205	301	1,506
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0		0.0%	0	0	0
30 - - -	ENGINEERING AND DESIGN	10	1	10%	11	0.0%	10	1	11	Jul-03	5.7%	11	1	12
30 - - -	ENGINEERING DURING CONSTRUCTION	100	10	10%	110	0.0%	100	10	110	Jul-06	16.3%	116	12	128
31 - - -	CONSTRUCTION MANAGEMENT	104	10	10%	114	0.0%	104	10	114	Jul-06	16.3%	120	12	133
	TOTAL COST =========>	1,250	280	22%	1,530	0.0%	1,250	280	1,530		16.2%	1,452	326	1,778

******COLUMBIA RIVER BACHELOR SLOUGH COST SUMMARY****** PAGE 1 OF 1

PROJECT: COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT - SPONSOR PLAN DISTRICT: PORTLAND 1-Oct-02
LOCATION: COLUMBIA RIVER, OR/WA P.O.C.: PAT JONES, CHIEF, COST ENGINEERING SECTION

CURRENT MCACES ESTIMATE PREPARED IN JUN 02:		Oct-02				AUTHORIZ./BUDGET YEAR: 2000				FULLY FUNDED ESTIMATE				
EFFECTIVE PRICING LEVEL:		Oct-02				EFFECT. PRICING LEVEL: Oct 02								
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06- - -	ENVIRONMENTAL RESTORATION	1,437	359	25%	1,796	0.0%	1,437	359	1,796	Jul-04	9.1%	1,568	392	1,960
	TOTAL CONSTRUCTION COSTS =====>	1,437	359	25%	1,796	0.0%	1,437	359	1,796		9.1%	1,568	392	1,960
01 - - -	LANDS AND DAMAGES	0	0	0%	0	0.0%	0	0	0			0	0	0
30 - - -	ENGINEERING AND DESIGN	20	2	10%	22	0.0%	20	2	22	Jul-03	5.7%	21	2	23
30 - - -	ENGINEERING DURING CONSTRUCTION	10	1	10%	11	0.0%	10	1	11	Jul-04	9.1%	11	1	12
31 - - -	CONSTRUCTION MANAGEMENT	144	14	10%	158	0.0%	144	14	158	Jul-04	9.1%	157	16	172
	TOTAL COST =========>	1,611	377	23%	1,987	0.0%	1,611	377	1,987		9.1%	1,757	411	2,167

EXHIBIT M
ECONOMIC ANALYSIS
(REVISED)

Table of Contents
Exhibit M
Economic Analysis (Revised)

1. Introduction

The purpose of this analysis is to revise the benefits for the 43-foot channel. This does not constitute a reformulation of the project; rather, this analysis assesses the benefits of the 43-foot channel based on current information. This analysis presents the revised benefits for only the Columbia River portion of the deepening project, and assumes that the Willamette River portion of the deepening project will be deferred.

Average annual benefits have been reduced from $34.4 million to $18.8 million. The reduction in benefits is due to a number of factors, including reductions in export projections and adjustments to fleet forecasts. Numerous other factors have been adjusted and are discussed in the analysis below.

Throughout this analysis, the original work done in the 1999 Final Integrated Feasibility Report / Environmental Impact Statement (1999 Final IFR/EIS) will occasionally be referenced as 'the original analysis' or 'the original projection'. Several of the primary updated elements are listed below, but the specific changes for each commodity group are detailed in separate sections.

- Commodity Projections. Each of the commodity projections has been updated. For all of the original commodities analyzed, exports have been down since the mid 1990's, reflecting a number of factors, starting with the Asian economic crisis. The best new information for this update is a study that has been completed by DRI-WEFA, in association with BST Associates and Cambridge Systematics. The study, *Commodity Flow Forecast Update and Lower Columbia River Cargo Forecast,* was commissioned by the Port of Portland, Metro, ODOT, the Port of Vancouver, and the Regional Transportation Council (July 2002[1]). DRI-WEFA and BST were two of the firms that worked on the original cargo forecasts used in the FEIS. This revised analysis will reference that report, which is publicly available.

- Fleet Projections. Each of the fleet projections has been updated using recent data. Vessel movements for 1999, 2000, and 2001, and available data from the beginning of 2002 were used in this analysis. The data was compiled by the Port of Portland, and was gathered from PIERS (for vessel movements), Lloyds Registry (vessel characteristics), Clarkson (vessel characteristics), and Columbia River pilots logs (departure drafts).

- The interest rate used to evaluate the project is now 5.875% (the 1999 rate was 6.625%). The interest rate is calculated in accordance with Section 80 of Public Law 93-251, and is provided in Corps of Engineers Economic Guidance Memorandum Number 03-02: Fiscal Year 2003 Interest Rates[2].

[1] http://www.portofportlandor.com/Marine/MTMP/Key_Information.htm
[2] At the time of this publication, EGM 03-02 is still in draft form.

- Vessel operating costs change every year as well, and the update of the benefits will use the current vessel operating costs. The vessel operating costs are based on 2002 price levels, and are documented in Economic Guidance Memorandum 02-06. The fiscal year (FY) 2003 interest rate has been applied to the annual capital cost calculation.

- The Willamette River. This analysis assumes that the Willamette River portion of the project is deferred, and the costs and benefits of deepening the Willamette River have been excluded from this analysis.

- The first full year that the entire project will be constructed is 2007. The majority of the construction activities will take place in FY 05 and FY 06. All costs and benefits are brought to the beginning of FY 07. In the original analysis it was assumed that the portion of the river from the mouth to Kalama would be done in the first year of construction. The revised construction schedule has the entire project completed after the second year of construction, meaning there are no longer benefits during construction. The construction period is a 24-month period from June of 2004 to July of 2006. The original analysis assumed that construction would be completed in 2004.

2. Wheat

Relative to the original analysis, the average annual transportation cost savings associated with wheat exports have decreased from $8.9 million to $2.1 million. The deferment of the Willamette River navigation channel improvements represents a 50 percent reduction in wheat benefits. Wheat export projections have decreased by approximately 20 percent. Adjustments to the fleet projections and vessel operating costs have also reduced benefits.

2.1. Wheat Export Projections

The Columbia River wheat export projections have been reduced substantially relative to the original analysis, dropping from a projected 14.5 million short tons in 2004 to a new projection of 11.5 million short tons in 2007. Exports are expected to grow at an average annual rate of 0.46 percent from 2007 to 2037. For all commodity groups, the analysis uses DRI-WEFA/BST projections that exclude interregional shifts in cargo that cannot be properly counted as NED benefits.

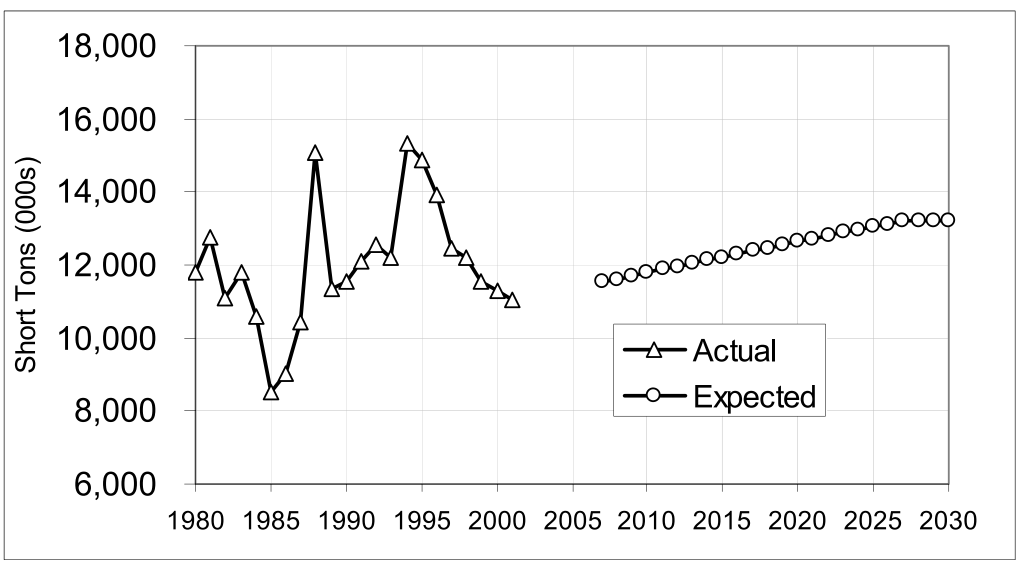
Table 1. Columbia River Wheat Projections (short tons)

Year	Original Projection	Year	Revised Projection
2004	14,518,651	2007	11,528,504
2014	14,729,680	2017	12,394,901
2024	15,972,270	2027	13,215,377
2034	19,065,140	2037	13,230,430
2044	19,427,940	2047	13,230,430
2054	19,427,940	2057	13,230,430

In comparison, wheat exports were over 12 million short tons each year from 1991 to 1998, hitting a high of 15.3 million short tons in 1994. While global demand for wheat is expected to increase over the term of the project, Columbia River exports are not expected to change appreciably from historic levels due to strong international competition.

The DRI-WEFA/BST projections present high and low forecasted growth rates that range from –0.5 percent to 1.3 percent from 2000 to 2030. This analysis has taken the midpoint of those projections. For example, in 2010, the low range of the estimate is 10.8 million short tons and the high range of the estimate is 12.8 million short tons. This update uses the midpoint of those two values, 11.8 million short tons.

Figure 1. Actual and Projected Columbia River Wheat Exports, 1980 - 2030



2.2. The Willamette Reach

Benefits associated with deepening the Willamette River have been removed from the analysis. For the purposes of this analysis, it has been assumed that all of the grain that is shipped out of the Willamette River will never benefit from the deepening of the Columbia River, and that the distribution of vessels serving various trade routes will be equally distributed across all facilities. In 2000 and 2001, about half (48 percent) of the exported wheat and barley came from Willamette River facilities, and that has been assumed to continue throughout the analysis.

It was assumed in the original analysis that the larger, benefiting grain vessels would be equally distributed across all facilities. With the deferment of the Willamette, it is possible that some greater portion of the benefiting vessels would be served by the deeper facilities on the Columbia River. For example, wheat being exported to Indonesia often moves in the maximum possible load size given the current channel constraint. With a deepening, it is possible that some portion of this tonnage will shift to existing facilities on the Columbia River, rather than being distributed across all facilities. It is difficult to quantify this potential shift, but the fleet projections should be viewed in the light that they are being applied only to 50 percent of the total tonnage, meaning that if the fleet projection for one of the trade routes predicts that 25 percent of the wheat would benefit from a channel deepening, the calculations only apply to 50 percent of the total tonnage, and only 12.5 percent of the actual tonnage will benefit.

2.3. Distance between Ports

In the original analysis, all wheat transportation costs were calculated using a uniform round-trip distance to the destination port (11,500 nautical miles), which is appropriate for countries such as Japan, but is not appropriate for Pakistan, Bangladesh, The Philippines, Yemen, etc. The number of days at sea for each trade route has been adjusted appropriately for each trade group, and has been increased to more accurately reflect actual distances. This adjustment increases the benefits of the project relative to the distances assumed in the original analysis. Voyage distances have also been adjusted to reflect that approximately 35 percent of handymax vessels have a U.S. backhaul, reducing total roundtrip voyage distances for those vessels. For all other vessels, voyage distances have been adjusted to reflect that most vessels arriving from overseas are coming from Japan, Taiwan, or South Korea, rather than making a full roundtrip voyage from further destinations.

The at-sea portion of the transportation costs for wheat moving to the Other Asia group has been changed from 34.0 days to 32.5 days for handymax vessels and 46 days for panamax vessels. Currently, the major importer in this group is The Philippines, but the group also includes Pakistan and Bangladesh. This calculation is a weighted average based on export data from 2000 and 2001.

The at-sea portion of the transportation costs for wheat moving to the Rapidly Developing Asia group has been changed from 34.0 days to 28.8 days for handymax vessels and 37.9 days for panamax vessels. The two major importers in this group are South Korea and Taiwan, but the group also includes Malaysia, Indonesia, and Thailand.

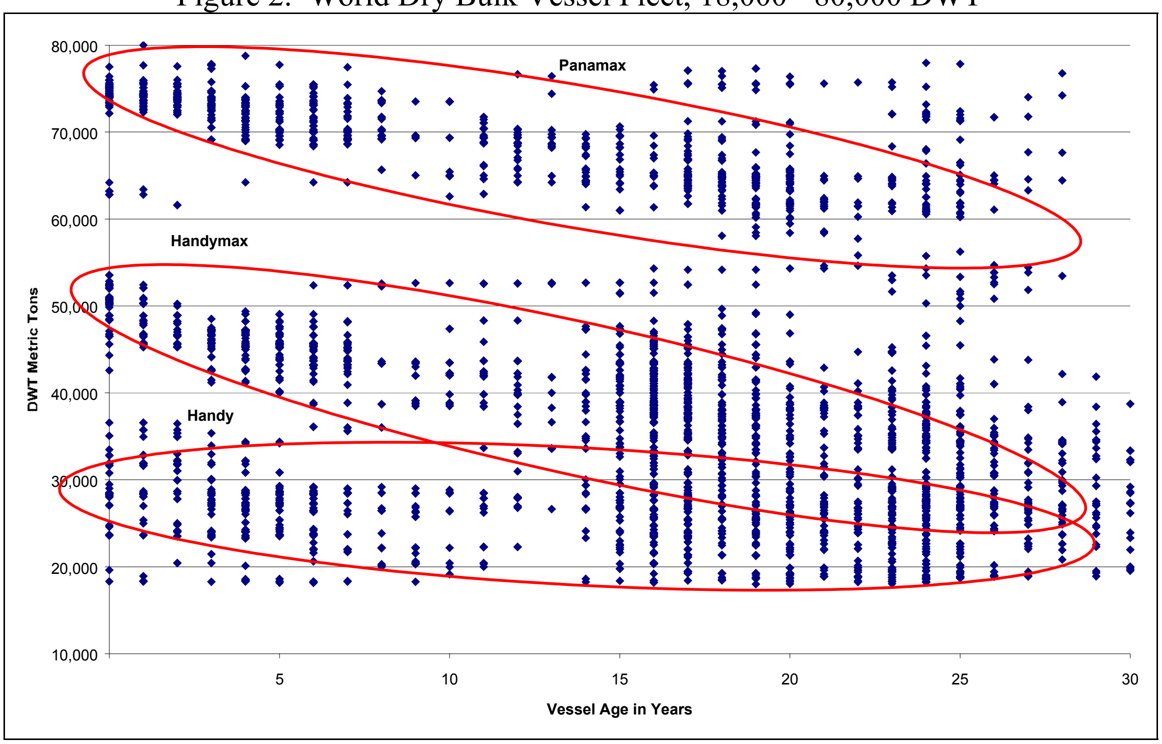
The at-sea portion of the transportation costs for wheat moving to the Other group has been changed from 34.0 days to 48.4 days (only panamax vessels benefit in this trade route). The two major importers in this group are currently Egypt and Yemen.

2.4. Wheat Fleet Projections

New vessel builds in the world bulk fleet have shown upward trends in vessel size. Figure 2 displays the trends that have developed over the last 30 years. The panamax class has grown to the point where the smallest vessels built in the last three years are 72,000 deadweight ton (dwt) vessels, much larger than the average panamax vessel built in 1990. These larger panamax vessels are calling on the Columbia River today.

The handymax class has shown a significant upward trend in size as well, and 50,000 to 53,000 dwt vessels have become common new builds, with fresh water design drafts between 40 and 41 feet. It is expected that this trend will continue, and that the trade routes that are currently using older 38-foot and 39-foot vessels will be using larger 40 and 41-foot vessels by 2017.

Figure 2. World Dry Bulk Vessel Fleet, 18,000 - 80,000 DWT



Source: Lloyd's Registry.

2.4.1. Rapidly Developing Asia

The following section describing the analysis for Rapidly Developing Asia (RDA) is presented in detail to illustrate the methodology used for all grain segments. Following the RDA section, the analyses for the other segments are presented in a summary form.

Table 2 displays the original projected wheat fleet for the RDA trade group for 2004. The fleet projections in 2004 predicted that 20 percent of the tonnage would move in vessels of design draft 40-foot or greater. The projections also show that 9 percent of the tonnage would move in vessels that could fully benefit from a 43-foot channel. The primary importers in this group are South Korea, Taiwan, Indonesia, and Thailand.

Table 2. Original Projected Wheat Fleet, 2004, Rapidly Developing Asia

Design Draft (fresh water, feet)	Projected Tonnage Distribution
31	3%
32	5%
33	10%
34	20%
35	10%
36	25%
37	7%
38	0%
39	0%
40	0%
41	5%
42	6%
43	5%
44	4%
45	0%
	100%

Table 3 displays the actual tonnage distribution by design draft for the RDA wheat fleet in 2000 and 2001. In this period, 16 percent of the tonnage moved on vessels with design drafts of 40 feet or greater, and 8 percent moved in vessels that would fully benefit from a 43-foot channel.

Table 3. Actual Fleet Distribution, Wheat, Rapidly Developing Asia, 2000-2001

Design Draft (fresh water, feet)	Actual Tonnage Distribution
32	3%
33	10%
34	3%
35	22%
36	17%
37	6%
38	13%
39	12%
40	3%
41	3%
42	1%
43	2%
45	2%
46	2%
47	2%
53	1%
(blank)	1%
Total	100%

Table 4 displays the actual tonnage distribution by departure draft. The original projected distribution and the actual distribution have some similarities. In the actual data, 22 percent of the tonnage departed at drafts of 39 or 40 feet. The projections assumed that 20 percent of the cargo would move at the channel constraint.

Table 4. Distribution of Tonnage by Departure Draft, RDA Wheat, 2000-2001

Actual Outbound Draft (feet)	Actual Tonnage Distribution
20	0%
23	1%
24	1%
25	1%
26	0%
29	1%
30	0%
31	2%
32	2%
33	8%
34	10%
35	19%
36	13%
37	9%
38	11%
39	13%
40	9%

The differences between today's fleet and the original projected fleet in 2004 are small. By 2014, however, the fleet projections assume that 25 percent of the cargo would fully benefit from a 43-foot channel, and that an additional 25 percent would gain some benefit as well, which would mean that a significant portion of the tonnage shifts from handymax vessels to panamax vessels. By 2024, it was expected that 66 percent of the tonnage would benefit to some degree with a deeper channel, and that 36 percent would take full advantage of the channel deepening.

In evaluating the reasonableness of the projections at 2014 and 2024, it is useful to look at some of the trend data. Table 5 displays the distribution of Columbia River wheat exports in 2000 and 2001. South Korea and Taiwan combine for almost three-quarters of the tonnage, with Indonesia and Thailand combining for the majority of the remaining share. This group of countries accounted for 33 percent of wheat exports over the last two years, and the calculations in the FEIS assumed that they would total 31 percent in 2004.

Table 5. Distribution of Tonnage, Wheat, RDA, 2000-2001

Country	Percent of Total
South Korea	40%
Taiwan	32%
Indonesia	14%
Thailand	11%
Malaysia	2%
Vietnam	1%

South Korea represents a large portion of this group, and is expected to continue to do so. Historically, exports to South Korea have moved in handymax vessels, with the most common design draft being about 35 feet. Over time, the average vessel size for vessels on this trade route has been increasing, but has not grown to panamax levels, and is not using even the larger vessels in the handymax class.

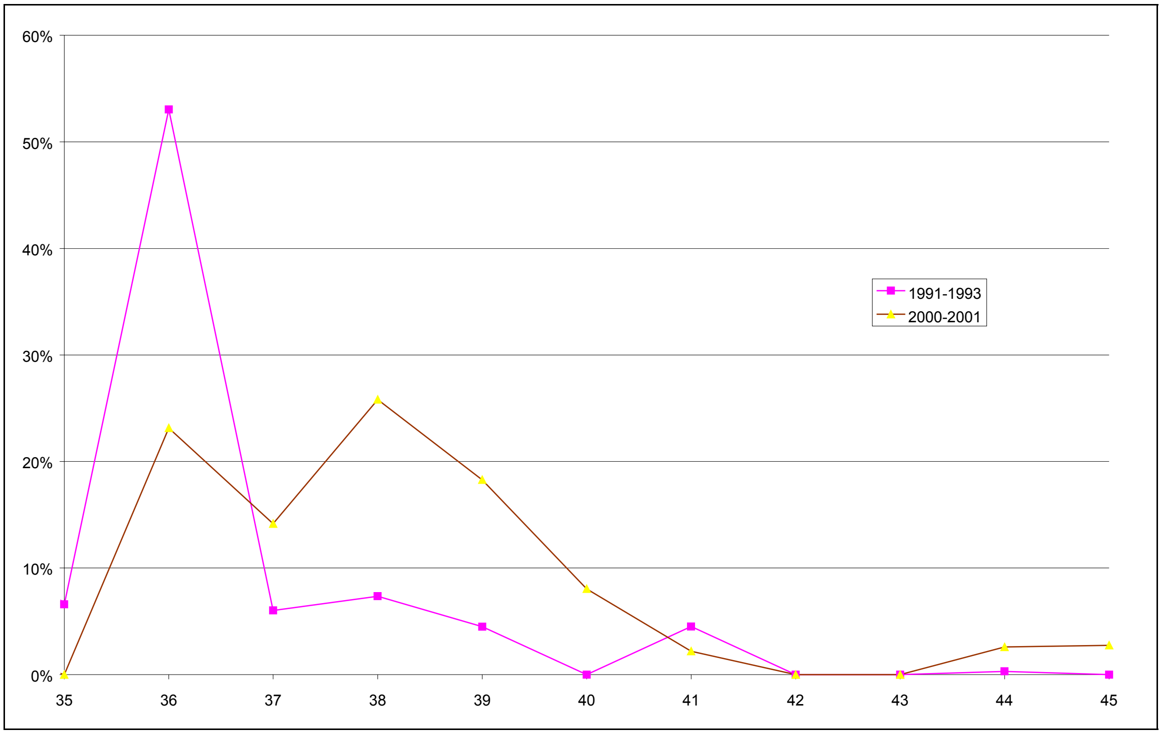
Table 6. Weighted Average Fresh Water Design Draft, Wheat to S. Korea

Year	Average Design Draft (fresh water, feet)
1991	31.0
1992	32.8
1993	34.1
2000-2001	34.6

While it is likely that exports to South Korea could shift to panamax or the larger handymax vessels at some point in the future, this analysis has adopted the conservative assumption that all of this tonnage will continue moving on smaller handymax vessels. Specifically, the revised fleet projections reflect that 40 percent of this tonnage is expected to never benefit from a channel deepening.

Taiwan is the second biggest importer of wheat in the RDA group, and, like South Korea, most of the wheat is currently moving in handymax vessels. Unlike South Korea, however, there were panamax movements in 2000 and 2001, and the majority of the tonnage is moving in the largest handymax vessels. Relative to the vessels in 1991 to 1993, the size of the vessels on this trade route has shift upward significantly. From 1991 to 1993, almost 80 percent of the tonnage on this route moved in vessels of design drafts ranging from 34 feet to 36 feet. Over the last two years, only 26 percent of the tonnage moved in that same vessel size. The average design draft has shifted from 36.2 feet to 38 feet. Figure 3 displays a comparison of the distribution of wheat exports to Taiwan by design draft.

Figure 3. Distribution of Wheat by Design Draft, Taiwan, 1991-1993 and 2000-2001



In the short term, the fleet used to ship wheat to Taiwan is expected to look much like today's fleet. In the long term, by 2017, it is expected that much of what is seen moving in 38-foot and 39-foot vessels will be moving in 40-foot and 41-foot vessels. It is expected that there will continue to be some level of panamax shipments, but that portion of the fleet will remain small.

Indonesia receives a small portion of the wheat in this group, and imported only 970,000 short tons of wheat over the last two years, but 60 percent of that wheat moved in panamax vessels. This trend is expected to continue in the future, with likely further shifts into panamax vessels on this trade route.

Thailand is the last significant importer in this trade group, importing 11 percent of the RDA wheat total over the last two years. Approximately 95 percent of this tonnage went out in the largest handymax size vessels, with design drafts of 38 feet to 41 feet.

The current data can be used to estimate some reasonable bounds for future benefits. For example, South Korea does not show any signs of an immediate shift even to larger handymax vessels, and it is probably reasonable to project that wheat exports to South Korea are not going to benefit from a channel deepening in the near future, and that any benefit that might occur could be a decade or more away. The projections assume that 40 percent of the tonnage on this trade route will never benefit from a channel deepening.

Approximately 15 percent of the RDA wheat tonnage is moving in vessels that could benefit immediately from a channel deepening. Another 25 percent of the tonnage is moving in larger handymax vessels with design drafts of 38 and 39 feet, and has the potential to shift upward into 40 to 42-foot vessels by 2017.

The majority of the remaining 20 percent of the tonnage is moving in smaller vessels to Taiwan and Indonesia, and has some potential to benefit in the long run, but also represents that there will, for the foreseeable future, be some of this cargo that will not require a 43-foot channel.

Table 7 displays the revised fleet projections for the Rapidly Developing Asia trade group. The difference between the actual recent data and the projection for 2007 is minor, but by 2017 it is projected that much of the grain that is moving in the largest handymax vessels today will shift upward by about two feet. While this projection has been adopted as the expected future, there is a potential upside benefit if some greater portion of the tonnage shifts into the larger panamax vessels. However, the fleet projections for this revised analysis have been held constant from 2017 to 2057.

Table 7. Revised Fleet Projections, Wheat RDA

Design Draft (feet)	Actual Tonnage Distribution (2000-2001)	2007	2017
32	3%	0%	0%
33	10%	8%	8%
34	3%	5%	5%
35	22%	20%	5%
36	17%	20%	20%
37	6%	6%	20%
38	13%	11%	4%
39	12%	11%	4%
40	3%	4%	10%
41	3%	3%	10%
42	1%	3%	3%
43	2%	2%	2%
44	0%	2%	3%
45[3]	2%	5%	6%
46	2%	0%	0%
47	2%	0%	0%
53	1%	0%	0%
Per Ton Costs 40-foot Channel		$ 14.03	$ 13.62
Per Ton Costs 43-foot Channel		$ 13.87	$ 13.41
Per Ton Savings[4]		$ 0.16	$ 0.22

[3] For the purposes of calculating benefits, bulk vessels at 45' design draft and larger benefit at approximately the amounts for a three-foot deepening, and have been grouped together.
[4] This is the average reduction in transportation costs spread across the entire tonnage exported. The actual per ton benefit for the vessels that benefit is much greater. For example, the per-ton benefit for a 45' vessel is $1.33.

2.4.2. Other Asia

The primary country in the Other Asia trade group is currently The Philippines, which accounted for 72 percent of Columbia River wheat exports in this trade group. Other significant importing countries are Bangladesh, Pakistan, and North Korea. In 2000 and 2001, about 25 percent of this cargo moved in vessels that could have benefited from a channel deepening. Table 8 displays the distribution of exports to this trade group in 2000 and 2001. The large portion of the distribution at the 38-foot and 39-foot design drafts consists primarily of exports to the Philippines.

Table 8. Distribution of Wheat Exports to the Other Asia Trade Group by Design Draft, 2000-2001

Design Draft (fresh water, feet)	Distribution of Wheat Exports
31	1%
32	1%
33	0%
34	2%
35	3%
36	3%
37	8%
38	29%
39	22%
40	5%
41	7%
42	4%
44	5%
45+	10%

Exports to The Philippines have moved primarily in the largest handymax (38 and 39-foot design drafts) vessels, with a small percentage moving in panamax vessels. As was the case with Taiwan, the average vessel has grown in size over the last decade. In 1993, the average vessel carrying wheat to The Philippines had a design draft of 37 feet. From 2000 to 2001, the average grew to 38.9 feet, reflecting the trend in handymax vessels. Assuming that this trend can continue, in 2017 this tonnage could be moving on vessels that are constrained by a 40-foot channel. On the high side, there is the potential that this cargo could eventually shift into larger panamax vessels. There has been heavy investment in panamax capable grain importing facilities in The Philippines.

The revised projections for this analysis assume that the fleet in 2007 will look much like the fleet today. By 2017 a portion of this wheat will shift to the 40 and 41-foot design draft vessels that are being built today. The fleet projections are held constant after 2017.

Table 9. Revised Fleet Projections Other Asia

Design Draft (fresh water, feet)	2007	2017
33	1%	1%
34	2%	2%
35	1%	1%
36	10%	10%
37	10%	10%
38	25%	1%
39	25%	5%
40	1%	25%
41	5%	25%
42	5%	5%
43	5%	5%
44	5%	5%
45	5%	5%
Per Ton Cost 40-foot Channel	$ 14.49	$ 13.97
Per Ton Cost 43-foot Channel	$ 14.17	$ 13.59
Savings	$ 0.32	$ 0.38

2.4.3. Other

The Other trade group consists primarily of the African countries, with Egypt and Yemen making up 90 percent of the exports to this trade group from 2000 to 2001. Exports to Egypt have moved almost completely in panamax vessels, while exports to Yemen have been primarily in handymax vessels. Approximately 50 percent of the total tonnage to this trade group moved in panamax vessels in 2000 and 2001. The original projections assumed that, by 2004, 60 percent of the tonnage would move in panamax vessels. It is expected that trade to this group will continue to move in about the same mix of vessels as was observed in the recent data, meaning that the benefiting tonnage has been reduced relative to the original analysis.

Table 10 displays the actual distribution of tonnage in 2000 and 2001. Table 11 displays the revised projected fleet. This fleet has been held constant throughout the analysis. The average cost per short ton for this trade route is $18.26 in the base condition, and $17.45 with a 43-foot channel, representing a savings of approximately $0.81 per short ton.

Table 10. Distribution of Wheat Exports to the Other Trade Group by Country and Design Draft, 2000-2001

Design Draft (fresh water, feet)	Egypt	Yemen	All Other	Total
32	0%	1%	0%	1%
34	1%	0%	0%	1%
35	0%	1%	1%	2%
36	1%	5%	0%	7%
37	0%	14%	1%	15%
38	0%	13%	1%	14%
39	0%	4%	1%	5%
40	0%	3%	1%	4%
41	0%	0%	0%	0%
42	4%	1%	0%	5%
43	2%	0%	0%	2%
44	0%	0%	0%	0%
45+	39%	1%	3%	44%
Total	48%	44%	8%	100%

Table 11. Revised Fleet Projections, Wheat Other Trade Group, 2007-2057

Design Draft (fresh water, feet)	Tonnage Distribution
31	0%
32	0%
33	0%
34	0%
35	5%
36	5%
37	12%
38	12%
39	9%
40	6%
41	0%
42	5%
43	2%
44	0%
45	44%
Total	100%

3. Corn

Relative to the original analysis, the average annual transportation cost savings associated with corn exports have decreased from $7.4 million to $3.8 million. Corn export projections have decreased by approximately 36 percent. Adjustments to the fleet projections and vessel operating costs have also reduced benefits.

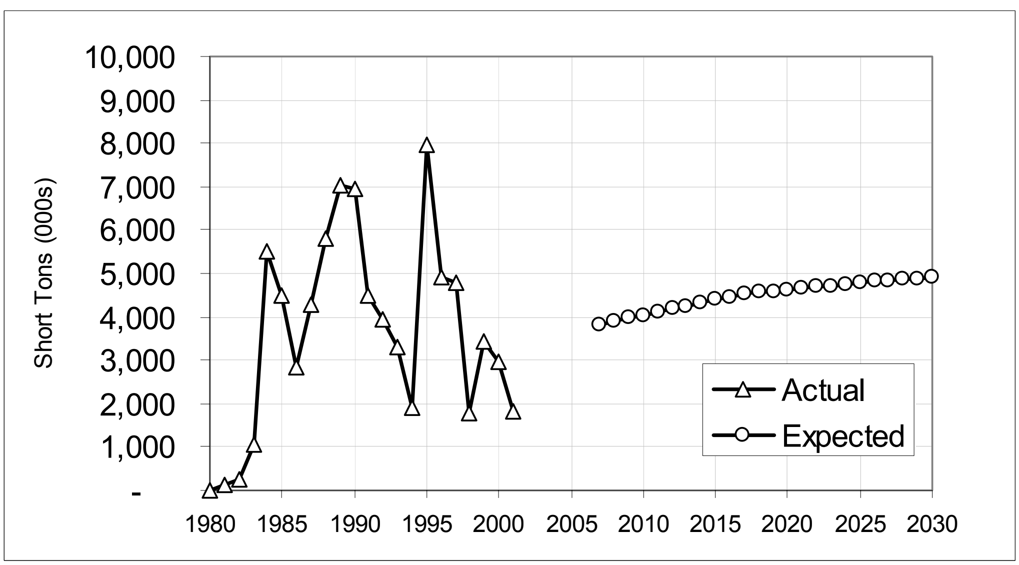
3.1. Corn Export Projections

Table 12 displays the original and revised export projections for corn on the Columbia River. The DRI-WEFA/BST study projects that Columbia River corn exports will grow at an annual rate between of 0.9 percent and 3.3 percent from 2000 to 2030. This revised analysis uses the midpoint between the low and high estimates. Over the first thirty years of the project, corn is projected to grow at an average annual rate of 0.9 percent. Figure 4 displays the actual and projected corn exports for the Columbia River from 1985 to 2030.

Table 12. Export Projections for Corn (short tons)

Year	Original Projection	Year	Revised Projection
2004	6,020,000	2007	3,832,972
2014	6,980,000	2017	4,535,873
2024	7,934,000	2027	4,841,875
2034	8,167,000	2037	5,016,538
2044	8,315,000	2047	5,016,538
2054	8,315,000	2057	5,016,538

Figure 4. Actual and Projected Columbia River Corn Exports, 1980 - 2030



3.2. Corn Fleet Projections

The fleet projections for corn are divided into two groups: 1) Japan; and 2) Rapidly Developing Asia (RDA), which, for the purposes of corn, is Taiwan and South Korea. China was originally expected to become a net corn importer at some point in the future, but has not become so yet, and is not included in this analysis. This analysis assumes that exports to Japan will experience little growth. For this revised analysis, most of the growth in the future is expected to come from exports to Taiwan and South Korea.

3.2.1. Japan

Over the last ten years, the corn fleet to Japan has decreased in terms of the portion of the tonnage moving in panamax vessels. Table 13 displays the distribution of average design draft for corn exports to Japan, comparing 1991-1993 to 2000-2001. The average design draft has not shifted very much, but the portion of the corn moving on vessels of 42-foot design draft or greater has decreased dramatically. At the same time, however, almost half of the total corn exports have shifted to the largest handymax vessels that can be used on the river.

Table 13. Distribution of Corn Exports to Japan by Design Draft

Fresh Water Design Draft	1991	1992	1993	2000 - 2001
31	0%	0%	0%	0%
32	1%	0%	0%	5%
33	1%	1%	0%	3%
34	0%	0%	0%	0%
35	2%	4%	0%	0%
36	4%	8%	16%	1%
37	23%	10%	31%	11%
38	15%	23%	13%	6%
39	5%	0%	0%	47%
40	6%	3%	0%	9%
41	3%	3%	0%	5%
42	23%	13%	6%	0%
43	3%	7%	18%	3%
44	11%	25%	12%	0%
45	3%	2%	3%	2%
46	1%	0%	0%	2%
47	0%	0%	0%	7%
Grand Total	100%	100%	100%	100%
Average	39.8	40.3	39.5	39.3
Design 42 or >	41%	48%	40%	13%
Design 39+	54%	53%	40%	73%

Table 14 displays the distribution of corn exports to Japan by departure draft for selected years. From a departure draft perspective, the majority of the corn vessels continue to leave at their maximum design draft. Recent history shows that, while the total number of vessels leaving at the authorized channel depth has dropped to 18 percent, the total tonnage departing at 39 or 40 feet has increased to 59 percent from 47 percent in 1991 and 1992, and 40 percent in 1993.

Table 14. Distribution of Corn Exports to Japan by Departure Draft

Actual Departure Draft	1991	1992	1993	2000 – 2001
24	0%	0%	0%	0%
25	0%	0%	0%	0%
26	2%	0%	0%	1%
27	0%	0%	0%	1%
28	0%	2%	0%	0%
29	0%	0%	0%	0%
30	0%	0%	0%	1%
31	0%	0%	0%	1%
32	0%	2%	0%	2%
33	2%	2%	0%	2%
34	2%	4%	3%	0%
35	0%	2%	4%	2%
36	20%	8%	28%	1%
37	25%	20%	19%	10%
38	2%	12%	6%	19%
39	5%	6%	0%	41%
40+	42%	41%	40%	19%
Grand Total	100%	100%	100%	100%
Average	38.0	37.9	37.8	38.0
Departure 39+	47%	47%	40%	59%

The future fleet is likely to see two changes. It is likely that the handymax vessels deployed to the Columbia River will continue to get larger, and what we see in 39-foot design draft vessels will likely be in 40 and 41-foot vessels by 2017. Further, it is likely that tonnage moving on this trade route will shift out of handymax and into panamax vessels with a channel deepening. Looking to the Puget Sound can be useful in estimating the range of that shift. In 2000 and 2001, 30 percent of the corn exported to Japan out of the Puget Sound moved on panamax vessels of design draft 43 feet or greater. Another six percent moved at 41 or 42 feet. Corn moving to Japan out of the

Puget Sound can be reasonably compared with corn moving out of the Columbia River. It is the same commodity, moving to the same destinations, with the same origins.

The most likely benefit for this trade route assumes that exports from the Columbia River and the Puget Sound will look more alike with a channel deepening than in the base condition.

Looking at the Pacific Northwest as one corn-exporting region, the exports out of the Puget Sound and the Columbia River can be combined to calculate an average demand for panamax lot sizes. Table 15 displays the combined exports of the two sub regions, and the portion of the combined tonnage that is moving at both greater than 41 and 42 feet, and 43 feet and greater. Based on this calculation, the initial total benefiting tonnage out of the Columbia River would be about 29 percent, much less than the original estimate of 45 percent.

Table 15. Combined Puget Sound and Columbia River Corn Exports to Japan, 2000-2001

Design Draft Range	Corn Exports (Short Tons)	Share of Total
Combined Tonnage	5,875,364	
Combined Tonnage 41, 42	325,281	6%
Combined Tonnage 43+	1,351,759	23%

Table 16 displays the revised fleet projections for corn exports to Japan in 2007 and 2017. By 2017, it is expected that the largest handymax vessels to be deployed on the Columbia River will have shifted to slightly deeper drafting vessels, resulting in a portion of the handymax fleet benefiting from the channel deepening. As in 2007, it is also expected that there will be a small shift from some of the larger handymax shipments into panamax vessels with a channel deepening. The fleet projections have been held constant after 2017.

Table 16. Revised Columbia River Fleet Projections, Corn to Japan

Design Draft (fresh water, feet)	40-foot Channel 2007	43-foot Channel 2007	40-foot Channel 2017	43-foot Channel 2017
36	8%	8%	8%	8%
37	12%	10%	12%	10%
38	6%	5%	6%	5%
39	47%	42%	5%	5%
40	9%	6%	26%	25%
41	5%	3%	25%	21%
42	0%	3%	5%	3%
43	3%	3%	3%	3%
44	0%	4%	0%	4%
45	2%	8%	2%	8%
46	8%	8%	8%	8%
$/per ton	$12.19	$11.91	$11.97	$11.59
Savings		$0.28		$0.38

3.2.2. Rapidly Developing Asia

The Rapidly Developing Asia trade group consists of South Korea and Taiwan for the purposes of revising the benefits associated with corn exports. The original analysis had assumed that growth in corn exports would eventually include other countries in this trade group, but that has not developed, and the fleet projections have been revised to reflect actual current operating practices and trade patterns.

Currently, 82 percent of this cargo moves in vessels of 42-foot design draft or greater. It was projected that only 69 percent of the cargo would be in that size group in 2004, increasing to 82 percent in 2024. Additionally, the trend in panamax vessels has been toward larger vessels, and the existing fleet is clustered around the 45-foot design draft, whereas the previous projections clustered around 43-foot design drafts.

In 1991, 88 percent of the cargo moved at 42 feet or greater. Table 17 displays the historical share of RDA corn moving in vessels of 42-foot design draft or greater, followed by the current share moving out of the Puget Sound. Today's level of cargo moving in those vessels is slightly lower than in 1992, but, unlike 1992, the corn that is moving in shallower draft vessels is moving almost exclusively in partial loads with soybean exports.

Table 17. Historical Share of Columbia River RDA Corn Exports, 42-foot+ Design Draft

Year	Share
1991	88%
1992	83%
1993	90%
1995-1996	90%
2000-2001	82%
Puget Sound 2000-2001	93%

The fleet projections have been revised to reflect the most recent levels of panamax loads, meaning closer to 82 percent rather than the higher historic levels and what is seen in the Puget Sound. The fleet projection has been held constant for the entire period of analysis. The base condition per-ton transportation costs are $12.06. With a 43-foot channel, costs are reduced to $11.04, resulting in a savings of $1.02 per short ton.

Table 18. Distribution of RDA Corn Exports by Design Draft, Actual and Projected

Fresh Water Design Draft (feet)	Actual 2000-2001	Expected Projection (2007-2057)
36	4%	4%
37	5%	5%
38	7%	5%
39	1%	4%
40	2%	0%
41	0%	0%
42	9%	8%
43	0%	0%
44	13%	14%
45	30%	30%
46	15%	30%
47	5%	0%
48	9%	0%

3.3. Corn Distribution of Tonnage

In the original analysis, 5 percent of the corn was assumed to go out of facilities on the Willamette. For this revised analysis, that has been reduced to zero percent based on recent data.

4. Barley

Relative to the original analysis, the average annual transportation cost savings associated with barley exports have decreased from $1.1 million to $185,000. The deferment of the Willamette River results in a 48 percent decrease in the benefits. Barley export projections have decreased by about 50 percent. Adjustments to the fleet projections and vessel operating costs have also reduced benefits.

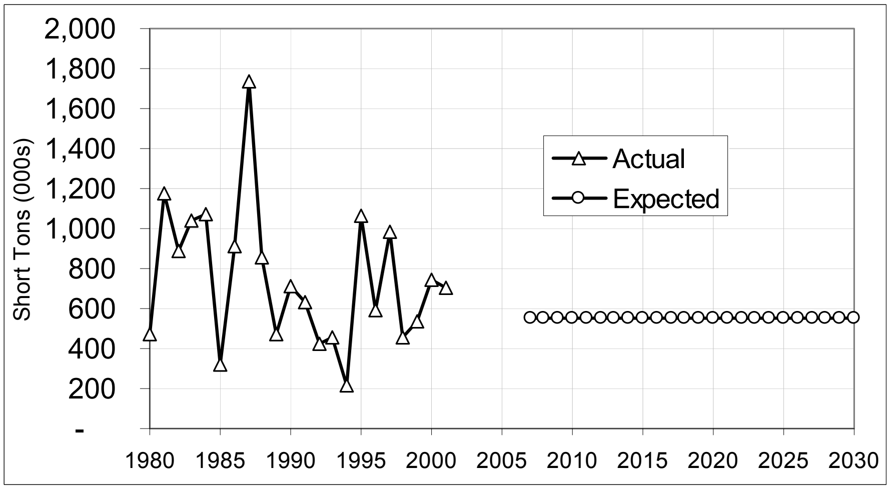
4.1. Barley Export Projections

The export projections for barley have been reduced substantially from the original analysis. The original analysis assumed that export levels would range from 900,000 to 1,000,000 short tons. The DRI-WEFA study projects that barley exports will range from 440,000 to 660,000 short tons over the period of analysis. This update adopts the midpoint, assuming a constant 550,000 short tons over the period of analysis. Approximately 48 percent of that tonnage is expected to move on the Willamette and will not benefit from a channel deepening, meaning that the actual benefiting tonnage is 287,000 short tons annually. Figure 5 displays the actual and projected Columbia River barley exports from 1980 to 2030.

Table 19. Export Projections for Barley

Year	Original Projection	Year	Revised Projection
2004	899,000	2007	550,000
2014	983,000	2017	550,000
2024	1,086,000	2027	550,000
2034	1,043,000	2037	550,000
2044	1,064,000	2047	550,000
2054	1,064,000	2057	550,000

Figure 5. Actual and Projected Barley Exports, Columbia River, 1980-2030



4.2. Fleet Projections

Over 2000 and 2001, the two primary destination countries for barley were Japan and Saudi Arabia. Movements to Japan were handy-sized vessels, and movements to S. Arabia were panamax vessels. About 40 percent of the tonnage moved in vessels that could have benefited from a channel deepening. The future fleet has been revised to reflect today's fleet, and has been held constant through the period of analysis.

Table 20. Columbia River Barley Exports by Design Draft (2000-2001)

Fresh Water Design Draft (feet)	Japan	Saudi Arabia	All Other	Total
31	5%	0%	0%	5%
32	16%	0%	0%	16%
33	1%	0%	0%	19%
34	1%	0%	2%	3%
35	1%	0%	0%	1%
36	1%	0%	0%	1%
37	2%	0%	0%	2%
38	5%	0%	2%	8%
39	3%	0%	0%	3%
40	1%	0%	0%	1%
41	2%	0%	0%	2%
42	0%	0%	4%	4%
43	0%	8%	0%	8%
44	0%	4%	0%	4%
45	0%	8%	8%	16%
46	0%	8%	0%	8%
Grand Total	57%	28%	16%	100%

Table 21. Columbia River Barley Fleet Projection (2007-2057)

Fresh Water Design Draft	Tonnage Distribution
33	39%
34	3%
35	1%
36	1%
37	2%
38	8%
39	3%
40	1%
41	2%
42	4%
43	8%
44	4%
45	24%

5. Soybeans

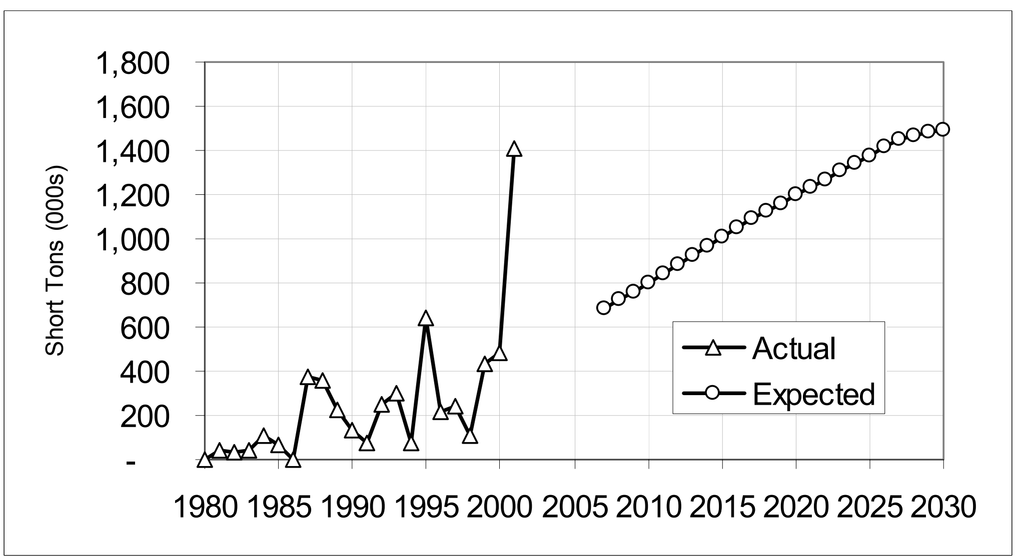
5.1. Soybean Export Projection

Soybeans are a new commodity in the benefit analysis, and were not included in the original analysis. In 2001, exports of soybeans exceeded one million short tons, and 2002 shows a similar trend. Columbia River soybean exports are projected to range between 880,000 short tons and 2.3 million short tons 2030, or at average annual rates of growth of 2.3 percent (low) and 6.6 percent (high) between 2000 and 2030. The initial range of exports is projected to be between 514,000 short tons and 846,000 short tons in 2007. Over the first 30 years of the analysis the expected average annual growth rate is 2.9 percent. Figure 6 displays the actual and projected Columbia River soybean exports from 1980 to 2030.

Table 22. Columbia River Soybean Export Projection

Year	Short Tons
2007	680,230
2017	1,088,770
2027	1,450,065
2037	1,598,677
2047	1,598,677
2057	1,598,677

Figure 6. Actual and Projected Columbia River Soybean Exports, 1980 - 2030



5.2. Fleet Projection

In 2000 and 2001, 67 percent of the soybeans exported moved in vessels that could have benefited from a deeper channel. The fleet projections for soybeans have been modeled to reflect that data. China, Taiwan and The Philippines are currently the three biggest markets for Columbia River soybean exports, combining for 85 percent of the exports in 2000 and 2001. Table 23 displays the distribution of soybean exports in 2000 and 2001 by destination and design draft.

Table 23. Distribution of Columbia River Soybean Exports by Destination and Vessel Design Draft (2000-2001)

Fresh Water Design Draft	China	Taiwan	The Philippines	All Other
31	0%	0%	0%	0%
32	0%	0%	0%	0%
35	0%	0%	0%	1%
36	0%	2%	0%	0%
37	0%	2%	2%	1%
38	0%	5%	10%	0%
39	0%	1%	6%	1%
40	0%	0%	1%	0%
42	0%	0%	0%	1%
44	6%	0%	0%	6%
45	10%	7%	1%	3%
46	10%	1%	0%	0%
47	10%	1%	0%	0%
48	7%	4%	0%	0%

Using a fleet projection that matches the vessel movements from 2000 to 2001 results in an average base condition per-ton transportation cost of $12.90. With a channel deepening, the average cost drops to $12.06 per short ton. The total transportation cost savings associated with soybean exports are $976,000 on an average annual basis. Table 24 displays the fleet projection for soybeans on the Columbia River. The fleet projection has been held constant through the period of analysis.

Table 24. Columbia River Soybean Fleet Projection (2007-2057)

Design Draft (Fresh Water, Feet)	Tonnage Distribution
33	0.0%
34	0.0%
35	2.0%
36	2.0%
37	4.5%
38	14.5%
39	7.5%
40	1.5%
41	0.0%
42	1.0%
43	0.0%
44	13.0%
45	54.0%

6. Containerized Cargo

Relative to the original analysis, average annual container transportation costs savings have been reduced from $15.7 million to $11.7 million. Container export projections have been reduced by about 25 percent over the first ten years. Benefiting tonnage has been reduced an additional 20 percent due to changes in vessel rotational patterns that have resulted in Canadian cargo being carried on Portland-calling vessels. In accordance with NED guidelines, only U.S. cargo can be used to calculate NED benefits. The average size of the vessels calling on the Columbia River has increased substantially relative to the original analysis.

In the original analysis, containerized cargo was divided into two categories, last-port and mid-port. Last-port cargo moves on vessels using the Port of Portland as their last U.S. port of call. Mid-port cargo is loaded onto vessels making at least one more stop at a U.S. port after Portland. Recent data shows little indication that there will be a benefit for mid-port cargo in the near term, and, while there is some potential for future benefits, the mid-port category has been dropped from this revised benefit analysis.

6.1. Container Export Projections

Table 25 displays the original and revised container export projections. Expectations have been reduced substantially. In the original projections, the average annual growth rate for the entire 50-year period of analysis was approximately 3 percent. In the revised projections the growth rate over the same period is 1.03 percent. The revised projections have been capped after 2030. Over the first 30 years of the analysis, the average annual growth rate is 1.73 percent. In comparison, projections produced by PIERS show an expected annual growth rate of 5.8 percent in total U.S. transpacific westbound containerized cargo from 2000 to 2010. The PIERS projections are general and not specific to the Columbia River, but they represent the expected growth in demand from the Asian economies.

The cargo projections used in this study are based on forecasts done by BST Associates with DRI-WEFA. The BST forecasts are initially based on DRI-WEFA commodity forecasts that are demand driven, meaning that they are unconstrained with respect to regional production capabilities and transportation logistics. However, export commodities may be constrained by production limitations such as changes in the inputs of production (acres in production and harvest, availability of water or other inputs). For certain commodities, this may preclude achieving the volumes forecast by DRI-WEFA based upon demand conditions overseas. BST Associates reviewed the DRI-WEFA demand forecasts on a commodity specific basis to determine where the demand forecasts exceeded realistic supply constraints. In cases where the demand forecasts appeared too high, they were ratcheted downward to reflect the potential supply constraint. This process is described in greater detail in the DRI-WEFA/BST study.

BST Associates started with the DRI-WEFA export growth rate projections for the North Pacific port range. The total demand driven annualized growth rate for the 2000 to 2030 period ranged from 2.7 percent (low) to 4.8 percent (high). Applying the supply constraints, as described above, BST Associates adjusted the annualized growth rates to a range of 1.6 percent (low) to 3.1 percent (high). These growth rates were projected for each major trade route.

BST Associates then estimated the size of the local transpacific cargo base in the Columbia River hinterland and projected how much of that hinterland market would be captured by Portland as compared to alternate ports in the Puget Sound. BST Associates also projected intermodal cargo volumes for the transpacific trade route, and export volumes for the non-transpacific routes.

In the revised analysis, the projections have been capped after 2030, but this has a minor impact on the benefit estimate due to discounting. In the original analysis, it was assumed that about 3.5 percent of the exported teu's[5] would be empty. This revised calculation excludes empties in the projections. Figure 7 displays the actual and projected Columbia River container exports (full TEUs) from 1980 to 2030.

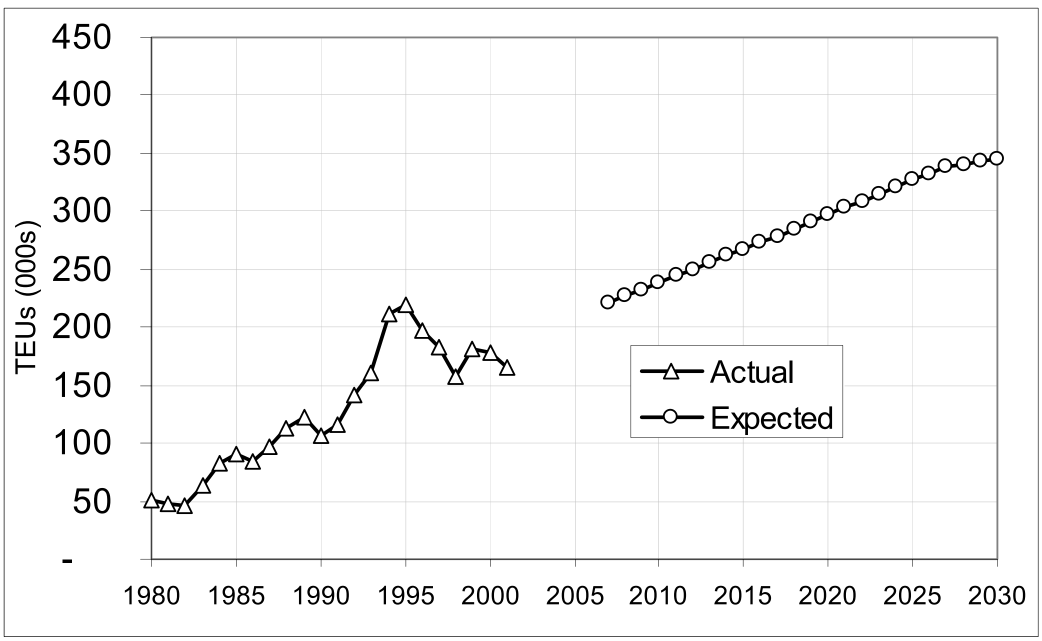
[5] A TEU is a Twenty-foot Equivalent Unit. Containers generally come in 40-foot and 20-foot varieties, and, when discussing volumes, are broken down into teu's.

Table 25. Columbia River Container Export Projections

Year	Original Projection, Outbound TEU's*	Year	Revised Projections, Full Teu's
2004	263,000	2007	221,000
2014	359,000	2017	279,000
2024	482,000	2027	339,000
2034	634,000	2037	358,000
2044	829,000	2047	358,000
2054	1,045,000	2057	358,000

* Twenty-foot Equivalent Units, full and empty.

Figure 7. Actual and Projected Columbia River Full Container Exports (TEUs) 1980 - 2030



As noted above, interregional shifts in cargo are excluded from the projections. The projections do assume that a greater share of the local Portland cargo base moves through Portland as opposed to alternative ports.

Unlike the commodity forecasts for the grains, this analysis uses an expected value that is two-thirds the difference between the low and high estimates produced in the DRI-WEFA/BST projections, reflecting a judgment by the DRI-WEFA/BST analysts that the expected case falls somewhere between the midpoint and the high forecasts[6]. In comparison to previous export levels, taking two-thirds the difference results in exports

[6] Conversation with Paul Sorenson, BST Associates.

reaching pre-Asian currency crisis levels of exports in 2007, meaning that there is expected to be a little more than a decade between the most recent peak and a recovery to that level of export. Exports hit 213,000 full teu's in 1995, and were 199,000 in 1996.

Further calculations are necessary in order to estimate the total amount of cargo that benefits from a channel deepening on the Columbia River. Table 26 displays an example of the calculation of total benefiting tonnage. Line 1 shows the projected number of full export teu's from the Port of Portland. In Line 2, the teu's are converted to short tons, using the average value calculated over the most recent two years. This value has increased from 11.8 short tons to 12.4 short tons. In Line 3, that tonnage is multiplied by 77.5 percent to estimate the amount of the tonnage that is last-port. In the original analysis only 70 percent of the cargo was moving last-port. Finally, the other cargo on board the vessels is added. This factor has been reduced from 1.026 to 0.6208, reducing the total benefiting tonnage by 20 percent, reflecting the development of increased Canadian tonnage on board the vessels. Canadian cargo has been excluded from the analysis, in accordance with NED guidelines.

In the original analysis, it was assumed that Canadian cargo comprised zero percent of the overall tonnage. In the revised analysis, taking into account recent changes in vessel rotations, the percentage of Canadian cargo has been increased to 20 percent of overall tonnage carried.

Prior to 1999, Vancouver B.C. was infrequently included on transpacific rotations calling Portland and the percentage of Canadian on-board tonnage carried on last-port Portland vessels was, on average, negligible. In recent years, with the inclusion of a Vancouver call on two Portland services, the percentage of Canadian cargo carried on last-port vessels calling Portland has increased significantly.

The revised analysis assumes that the surge in Canadian on-board tonnage is a permanent condition, even though this a very recent phenomenon. Direct transpacific container service to Vancouver B.C. has grown over the past five years as a result of favorable currency exchange rates relative to the U.S. dollar, the development of the Deltaport container terminal, improved rail service to and from eastern Canada and the U.S., and the deployment of larger vessels requiring more port calls to fill. Today, of the 23 transpacific vessel strings that call North Pacific ports, 15 call Vancouver B.C. Thus, about two out of every three North Pacific services call in Canada. This is consistent with the current service mix in Portland and the long-term assumptions made in this analysis.

Table 26. Example Calculation, Container Export Benefiting Tonnage, 2007

1	Number of Full Export Teu's	221,348
2	Conversion to Short Tons (12.4 short tons per teu)	2,744,715
3	Last Port Portion (77.5 percent)	2,127,154
4	Additional Tons on Board (U.S. Only) (0.6208)	1,320,537
5	Total Benefiting Short Tons	3,447,692

With regard to port capacity, Terminal 6, Portland's primary container facility, is a 200-acre, three-berth facility with seven container cranes and a berth length of 2,850 feet. The container storage area covers 125 acres. Vessel berth capacity at Terminal 6 is estimated to be 770,000 TEUs annually[7]; in 2001, 278,000 TEUs were loaded and discharged from vessels. Terminal 6 operates a two-stage gate (9 inbound lanes, 4 outbound lanes) that has an estimated capacity of 187 moves per hour; in 2002, the gate averaged 51 moves per hour. The terminal is served by a 53-acre on-dock intermodal rail yard with a capacity of 82 double-stack railcars. In 2001, the rail yard handled 228 moves per day on average; capacity for the rail yard is estimated to be 3,336 moves per day.

6.2. Fleet Projections

6.2.1. Vessel Size

In reviewing the fleet projections for the last-port container vessels, the most significant recent development is that vessels have gotten larger faster than was anticipated. This has a significant impact on the benefit analysis. In the original analysis, it was projected that 34 percent of the Columbia River fleet would still be 39-foot design draft vessels in 2004, and that 22 percent would still remain in 2014. Today, all last port tonnage is carried on vessels larger than 39-feet design draft. Since the original analysis, container carriers have rapidly deployed newer and larger vessels to the Port of Portland. Today's vessels have design drafts ranging from 41 to 46 feet, compared to 38 to 40-foot design drafts just a few years ago.

Present last-port services calling Portland are operated by K Line, Hyundai Merchant Marine, and Hanjin.

Table 27 displays the distribution of cargo by design draft from 1999 through the beginning of 2002.

[7] Port of Portland Marine Terminal Master Plan (draft), January 2003

Table 27. Distribution of Last-Port Container Tonnage by Design Draft, 1999-2002 and Original Fleet Projections

Design Draft	1999	2000	2001	2002	FEIS Projection 2004	FEIS Projection 2014	FEIS Projection 2054
36	0%	0%	0%	0%	1%	0%	0%
37	0%	0%	0%	0%	1%	1%	0%
38	13%	10%	0%	0%	1%	1%	1%
39	52%	13%	1%	4%	34%	22%	8%
40	31%	42%	28%	18%	13%	17%	15%
41	1%	13%	13%	13%	10%	13%	17%
42	1%	19%	46%	48%	24%	26%	30%
43	3%	3%	0%	0%	11%	13%	17%
44	0%	0%	12%	12%	3%	4%	7%
46	0%	0%	0%	6%	2%	3%	5%
Total	100%	100%	100%	100%	100%	100%	100%

Source: Clarkson Container Ship Register 2001 for design drafts, Port of Portland Terminal Management System for cargo tons.

Vessel size projections have been revised to reflect current practices (shown in Table 28). The fleet in 2007 looks much like what is expected to happen in 2003.

Table 28. Revised Columbia River Container Fleet Projections

Design Draft (fresh water, feet)	2007	2017	2027-2057
40	0%	0%	0%
41	0%	0%	0%
42	30%	0%	0%
43	0%	0%	0%
44	35%	50%	50%
45	0%	0%	0%
46	35%	50%	50%

The fleet in 2017, fifteen years from now, assumes that the smaller 42-foot vessels have been removed from the Columbia River, and only 44-foot and 46-foot vessels remain. Those portions are held constant through the remainder of the analysis.

The implication of this shift in design drafts both on the Columbia River and in the world fleet is that the pool of vessels that can fully benefit from a three-foot deepening is larger than was anticipated.

6.2.2. Operating Practices

6.2.2.1. Underkeel Clearance

Container vessels have underkeel clearance[8] requirements that reflect the schedule-driven nature of the business. Unlike bulk carriers that are able to accept any reasonable delay to depart at 40 feet in a 40-foot authorized channel (using tide and other river stage factors for underkeel clearance), container carriers are on a scheduled rotation that generally cannot facilitate significant delays. At the time of the original analysis, the most common underkeel clearance was four feet, with one carrier using one foot, and the analysis reflected those practices. Currently, there are three services calling at Portland as a last port of call, two of those services target 38 feet (two feet of underkeel clearance) as their departure draft and one has targeted 36 feet (four feet of clearance) in the past, but has switched to 38 feet recently with the arrival of a larger class of ship in 2002. It is expected that all the services will target two feet of underkeel clearance. One of the implications of this assumption is that the fleet projections will appear to have more of the vessels moving at deeper departure drafts than have been observed in the last few years. This is an assumption that reduces benefits, as a more efficient base condition reduces the incremental benefit of an equally efficient fleet with a channel deepening.

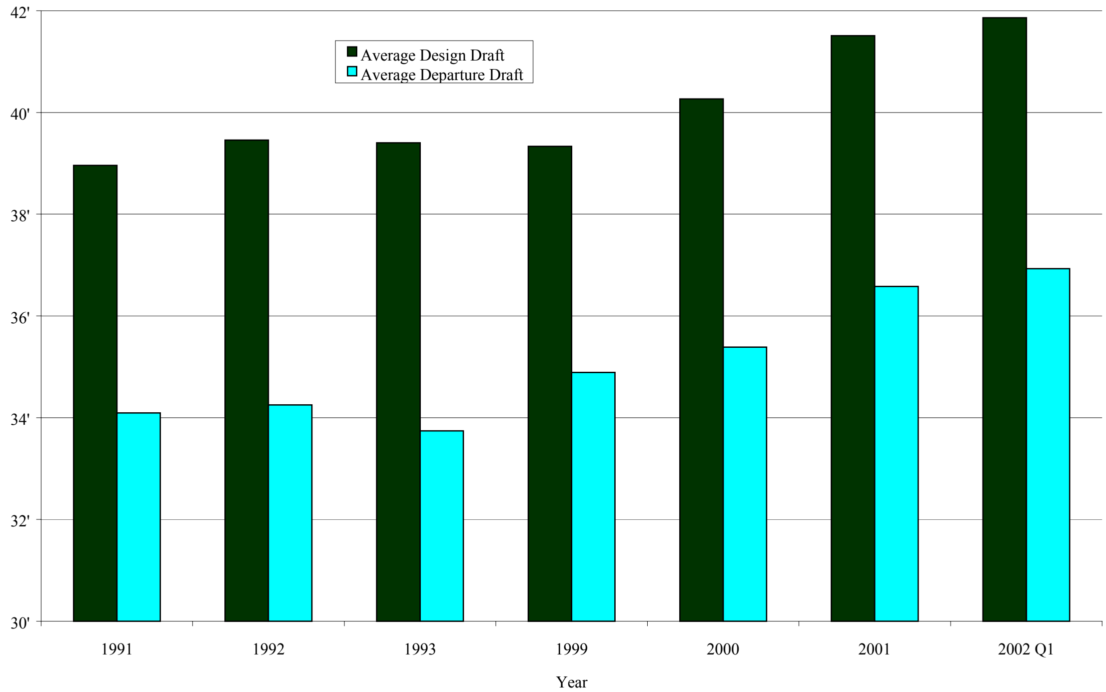
6.2.2.2. Container Vessel Efficiency

At the heart of the benefit estimate is an assumption about the degree to which container vessel operators will take advantage of the additional three feet of channel depth offered though deepening. In the original analysis, the average gain in departure draft for a three-foot deepening was only 1.5 feet. In other words, it was assumed that the vessels would only use about 50 percent of the additional draft that would be available. The FEIS fleet projections also assumed that 29 percent of the cargo would move within a foot of the authorized channel depth for the existing channel, but that share dropped to 7 percent with a 43-foot channel. This tended to reduce benefits, as the existing channel was being optimized much more than the deepened channel in terms of vessel utilization.

Figure 8 displays a comparison of design and departure drafts from 1991-1993 and 1999-2002. From 1991 to 1993 the average departure draft was 34.0 feet. In 2001 that average shifted up to 36.6 feet. Without any change in the physical constraints of the channel, average departure drafts increased by more than 1.5 feet over the last ten years.

[8] Underkeel clearance, for the purposes of the analysis, is being discussed relative to the authorized channel depth.

Figure 8. Design and Departure Drafts, Columbia River Container Fleet



Source: PIERS (for vessel movements), Lloyds Registry (vessel characteristics), and Columbia River pilots' logs (departure drafts). Includes last-port and mid-port container vessels.

This revised analysis assumes that vessel efficiencies remain essentially the same with a channel deepening. In terms of draft, efficiency can be defined as how frequently operators meet their target drafts (target draft is the authorized channel depth minus underkeel clearance). On average, over the last three years, the three existing services have come within one foot of their target drafts about 73 percent of the time. With a three-foot deepening, target drafts increase by three feet, and it can be assumed that operators will meet their new target drafts about as frequently as they do today, given a short period of adjustment.

Table 29 displays the actual and projected departure draft projections in 2007. It is expected that there will be a brief period of capacity utilization adjustment as container carriers begin to make use of the additional capacity created by the new channel depth. According to vessel operators, this adjustment period should be short (could be as short as a few months) and should not exceed a year. This analysis assumes that the initial change in departure drafts with a channel deepening is only 1.9 feet, meaning that the vessel operators only use about 65 percent of the additional draft available during the first year of the project. The average per-ton transportation costs in the first year drop from $14.30 to $12.41, a benefit of $1.89 per short ton.

Table 29. Actual and Revised Projected Container Departure Draft Distribution, 2007

Departure Draft	Actual 2000-2002 Q1	Actual 2001-2002 Q1	40-foot Channel 2007	43-foot Channel 2007
33	8%	3%	1%	1%
34	8%	7%	5%	0%
35	16%	15%	10%	5%
36	18%	16%	10%	5%
37	20%	23%	33%	6%
38	20%	26%	33%	13%
39	7%	8%	8%	13%
40	1%	2%	0%	26%
41	0%	0%	0%	25%
42	0%	0%	0%	6%
Total	100%	100%	100%	100%
Average Departure Draft	35.8	36.7	37.0	38.9

By 2008, it is expected that the operators will have fully adjusted to the new channel depth. The average departure draft shifts upward by three feet, meaning that, after a year of lower efficiencies, vessel operators are able to return to operating at current levels of efficiency. Per ton transportation costs shift from $14.30 to $11.83, a transportation cost savings of $2.48 per short ton.

Table 30. Projected Container Departure Draft Distribution, 2008

Departure Draft	40-foot Channel 2008	43-foot Channel 2008
33	1%	1%
34	5%	0%
35	10%	0%
36	10%	0%
37	33%	5%
38	33%	10%
39	8%	10%
40	0%	33%
41	0%	33%
42	0%	8%
Total	100%	100%
Average	37.0	40.0

Departure drafts are essentially the same from 2008 onward, but increases in vessel size in 2017 slightly increase the per-ton benefit from $2.48 in 2008 to $2.68 in 2017. The fleet projections are held constant after 2017.

Other factors that impact draft are expected to remain the same over the period of analysis. For example, most projections assume that U.S. imports will continue to exceed exports, which means that it will always be necessary to move empty containers back to Asia. The analysis assumes that a portion of vessel capacity will be used to carry empties, regardless of channel deepening, and no benefits are calculated for empty containers.

The analysis also assumes that cargo densities remain about the same, and that exports from the Pacific Northwest will continue to be primarily agricultural and forestry products, rather than lower density goods.

6.2.3. Calculation Details

The following paragraphs describe all of the calculations that take place in the process of estimating the benefits of deepening.

- **Vessel Characteristics and Operating Costs.** Vessel characteristics and operating costs are provided by the Corps of Engineers in *Economic Guidance Memorandum 02-06, Deep Draft Vessel Operating Costs*[9].

- **Vessel Cargo Capacity**. The analysis excludes empty containers and the weight of the containers (tare weight) from the benefiting tonnage. On average, about 80.8 percent of the tonnage loaded at the Port of Portland is cargo, with the remaining 19.2 percent consisting of the weight of the containers (both empty and full). This is assumed to be the case for all cargo loaded on the vessels.

- **Immersion Rates**. Immersion rates are also adjusted by about 80.8 percent to account for the assumption that, for every foot made available by channel deepening, a portion of the additional capacity will be taken by the weight of the containers and returning empties.

- **Distance to Destination**. The original analysis assumed that container vessels would spend about 13 days in transit to their Asian destinations. Currently, all of the services calling on the Columbia River as a last port of call use Japanese ports as their next port of call. This is approximately a 10-day transit. The analysis has reduced transit times to 10 days, which is the shortest possible transit time. The change has the effect of reducing benefits. If, as container traffic grows in the future, a carrier shifts its next port of call to any other country, benefits could

[9] http://www.usace.army.mil/inet/functions/cw/cecwp/General_guidance/EGM02-06Memo.pdf

increase substantially. Table 31 displays transit times for Pacific Northwest container services.

Table 31. Transit Days, Transpacific Container Services, PNW Ports

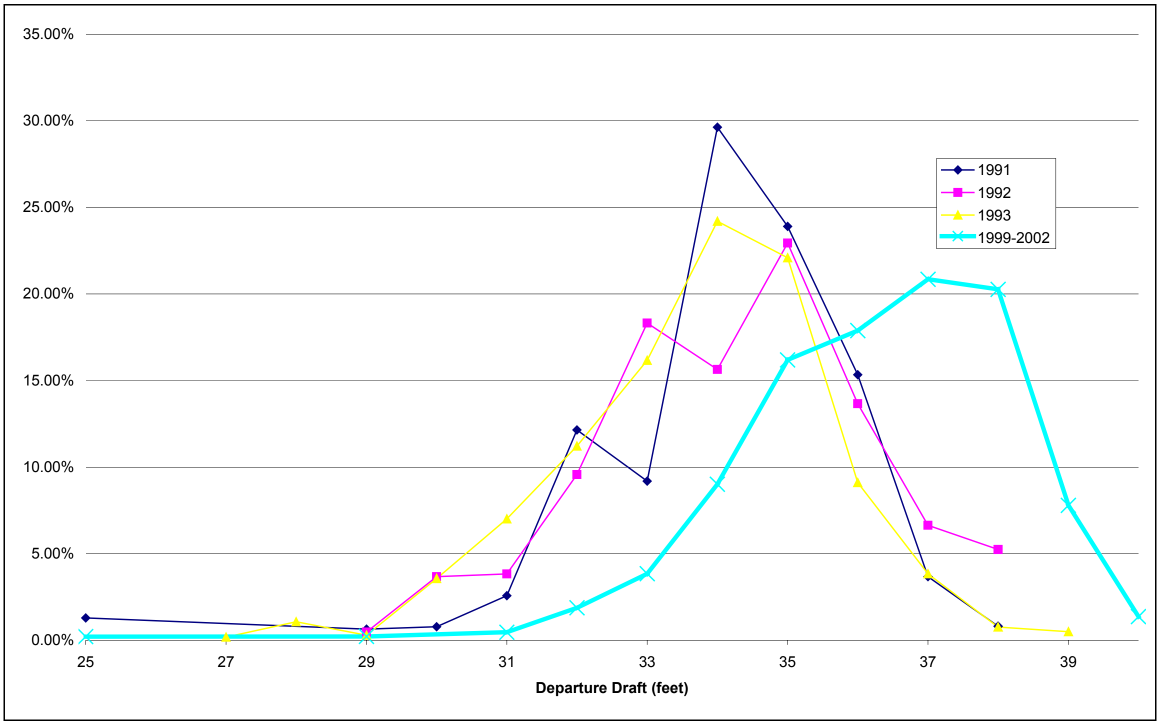
Consortium	**Service**	**Last Port-Next Port**	**Transit Days**
China Shipping	AAT	Seattle-Pusan	11
China Shipping	ZPS	Seattle-Pusan	11
CKYHS	CAX (staring August 2002)	Portland-Tokyo	10
CKYHS	NOWCO A	Portland-Tokyo	10
CKYHS	PDN	Seattle-Pusan	10
CMA-CGM	TPD1	Vancouver-Pusan	14
Columbus/Lykes	PNW	Seattle/VBC-H. Kong	14
COSCO	PNWX	Seattle-Shanghai	14
Evergreen/LT	CPN	Vancouver-Pusan	13
Evergreen/LT	TPS	Vancouver-Kaohsiung	12
Evergreen/LT	WAE	Vancouver-Tokyo	10
Global Alliance	PNW	Portland-Yokohama	10
Global Alliance	PS3	Vancouver-Tokyo	11
Grand Alliance	CKX	Seattle-Pusan	12
Grand Alliance	PNX	Seattle-Kaohsiung	14
Maersk SeaLand	TP6	Tacoma-Yokohama	10
Westwood	PNW	Seattle/VBC-Japan	14
		Average	11.8

Source: Port of Portland, Pacific Shipper (May 27, 2002) and carrier web sites.

- **One Percent Tail.** The analysis assumes that approximately one percent of the cargo will move on particularly shallow drafts regardless of the channel condition. A comparison of data from 1991 to 1993 with data from 1999 to 2002 shows that there are consistently some movements that are significantly below the channel constraint, and are unlikely to change with a channel deepening. From 1999 to 2002, approximately 0.7 percent of the containerized cargo moved at departure drafts of 31 feet or less. From 1991 to 1993, the amount of cargo moving at 31 feet or less ranged from 5 to 12 percent.

  Figure 9 displays the distribution of containerized cargo by departure draft, comparing 1991 to 1993 with 1999 to 2002. It is evident that cargo moving at the shallowest drafts in the early 1990’s has shifted upward into deeper departure drafts a decade later. The cargo that was moving at 30 and 31 feet is now moving at 32 to 34 feet, but there is a small tail of cargo throughout the entire data series.

Figure 9. Distribution of Columbia River Containerized Cargo by Departure Draft (1991-1993, 1999-2002)



- **Container Tonnage Distribution Response to Channel Improvement.** As shown in the distributions of container tonnage, 16 percent of the container cargo is expected to move at departure drafts at three or more feet less than the vessel target draft in the without-project condition (cargo moving at 35-feet or less in a 40-foot channel). This is a technical issue that has been disputed, but represents a small portion of the overall benefits.

  In the early 1990's all of the container vessels had target drafts of 36 feet. By 1999, two of three services had target drafts of 38 feet, and by 2002 the third service also shifted to a 38-foot target draft. Comparing the two distributions, it is clear that the entire tonnage distribution, rather than only the deepest segment, has shifted with the change in target drafts.

- **Service Implications of Fewer Vessel Calls.** One of the results of the method used to calculate benefits is an apparent decrease in vessel calls in the with-project condition relative to the without-project condition. This implies reduced service to Portland, which could lead to lower volumes. In the short-term, it is unlikely that the additional capacity created by channel improvement would result in existing carriers deciding to discontinue Portland service. In the long-term, it is likely that the greater utilization of the larger container vessels would have the effect of reducing the overall number of vessel calls to the Columbia River as cargo volumes increase over time. This is the same effect that was observed with the deepening of the channel from 35 feet to 40 feet. While total Columbia River cargo volumes have tripled over the 40 years since the deepening was authorized in 1962, the number of annual commercial marine vessel calls has declined slightly over that same period of time. Service frequency is a legitimate issue that arises out of the deployment of larger vessels. However, it seems unlikely that deepening the channel will have a negative impact on Portland service frequency, rather it seems more likely that a deeper channel will lead to improved service in Portland due to improved vessel operating efficiencies. It should also be noted that the analysis does not assume that vessels immediately make full use of the additional capacity created by deepening, allowing for a one-year adjustment period. A sensitivity analysis also shows that extending the adjustment period to three years has a small impact on the benefits (see Section 8.)

7. Summary of Benefits and Costs

Table 32 displays the summary of transportation cost savings for the 43-foot channel. As noted earlier, benefits for each of the commodity groups are reduced relative to the original analysis. Relative to the original analysis, container benefits have increased in proportion to the total benefit, increasing from about 50 percent to 63 percent of the total transportation cost savings.

Table 32. Revised Benefit Summary by Commodity

Commodity	Original Benefit Estimate[10]	Revised Benefit
Corn	$7,352,000	$3,842,000
Wheat	$8,901,000	$2,054,000
Barley	$1,144,000	$185,000
Soybeans	$0	$976,000
Containers Last Port	$15,671,000	$11,748,000
Container Mid Port	$911,000	$0
Total	$34,419,000	$18,806,000

Table 33 displays the delay component of the total benefits. Delay benefits are approximately 0.7 percent of total benefits.

[10] Includes both Columbia River and Willamette River transportation cost savings.

Table 33. Average Annual Transportation and Delay Benefits

	Ocean Transportation Cost Reduction	Delay Cost Reduction
Corn	$3,797,000	$45,000
Wheat	$1,977,000	$78,000
Barley	$184,000	$1,000
Soybeans	$970,000	$6,000
Containers	$11,744,000	$4,000
Total	$18,672,000	$134,000
Total Average Annual Benefit		$18,806,000

Table 34 displays the average annual costs and benefits of the project. Total first costs, including interest during construction, are $119 million. Costs are amortized over 50 years at the FY03 interest rate of 5.875 percent. Total annual Operations and Maintenance (O&M) costs are approximately $3.6 million. Total average annual costs are $11.0 million.

Table 34. Average Annual Costs and Benefits

Total First Costs	$118,924,000
Average Annual Capitol Costs	$7,414,000
Average Annual O&M Costs	$3,619,000
Total Average Annual Costs	$11,033,000
Average Annual Benefits	$18,806,000
Net Benefits	$7,773,000
Benefit to Cost Ratio	1.7

8. Risk and Uncertainty

While this analysis has attempted to present a most likely scenario, it is certain that things will happen that will be considered unlikely at the time of this analysis. In no particular order, and without identifying specific numbers of upside or downside risks, some of the potential issues that could impact the benefits are:

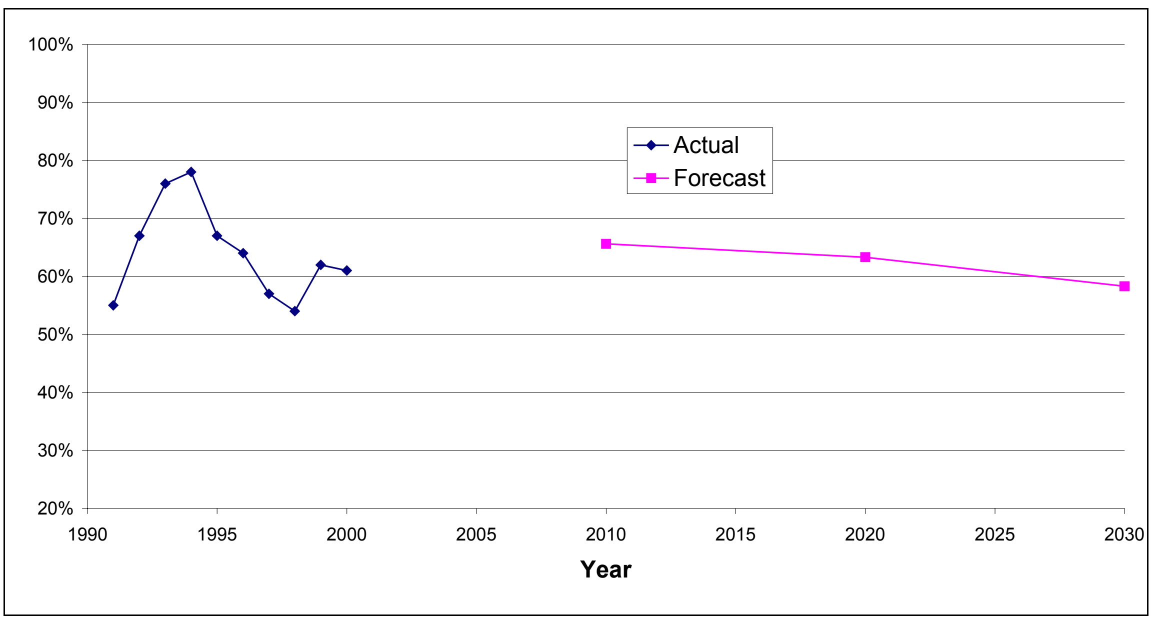
- **Bulk Fleets, upside.** For the most part, all of the bulk fleets were assumed to be the same 50 years from now as they are today. It was assumed that handymax vessels would increase in size between 2002 and 2017, but, generally speaking, the analysis assumed that the mix of handymax and panamax vessels would remain about the same over the next 50 years. This is an assumption that tends to mean that, for the bulk fleet, the benefit risk is almost completely upward relative to vessel size. Also, during the 2000 to 2001 period that was used to assess the bulk fleet, there were periods of time when vessel draft was restricted to a maximum of 38 or 39 feet due to shoaling and low water conditions. The analysis also assumed that 40-foot and 41-foot design draft handymax vessels would only gradually become common on the Columbia River over the first ten years of the analysis. Given that some of those vessels are already transiting the Columbia River today, it is possible that they will be common by 2007. Table 35 displays the impact of assuming that large handymax vessels are common on the Columbia by 2007. It should be noted that only certain trade wheat and corn routes use these vessels, resulting in a relatively small impact.

Table 35. Comparison of Alternative Large Handymax Assumptions - Average Annual Wheat and Corn Benefit

	Combined Wheat and Corn Benefit	Percentage Change
Base Value (2017 utilization of large handymax)	$5,897,000	
2007 Utilization of large handymax	$5,994,000	2%

- **Containerized Cargo volume, capture rate.** The analysis has assumed that the Columbia River loses containerized cargo market share to Puget Sound ports. Figure 10 displays the historical and forecasted Port of Portland capture rate for the Portland hinterland. At the beginning of the period of analysis, the capture rate is approximately identical to the ten-year average. Over time, the capture rate is expected to decline, dropping to 58 percent by 2030.

Figure 10. Portland Hinterland Capture Rates (1991-2000 and Projected)



Overcapacity in Pacific Northwest container terminals has been a part of the base condition of the Columbia River container market over the past decade has likely already contributed to a decline in Columbia River market share over that period. Given the expansion plans of Puget Sound ports, especially Tacoma, the concentration of Pacific Northwest container activity and terminal capacity at Puget Sound ports is expected to continue into the future and over the duration of the project. This could cause additional loss of Columbia River port market share. This reduced market share is already reflected in the project forecasts. The impact of Puget Sound port expansion on Columbia River container cargo volumes could be more or less than anticipated by the forecasts, however.

It is likely that most of the growth in container terminal capacity will occur at the Port of Tacoma. The Port of Tacoma's "2020 Vision" plans suggests an aggressive program of container terminal development over the next 20 years in response to expected growth in West Coast international container volumes. In the first phase of its development plan, the Port plans to build a 170-acre container terminal at its Pierce County terminal location. The Port is presently negotiating with Evergreen Marine to occupy the new terminal, which could be available as soon as 2005. Evergreen Marine presently occupies a 75-acre terminal at the Port of Tacoma. In addition to the redevelopment of the Pierce County Terminal, over the next twenty years, the Port of Tacoma envisions an expansion of the Maersk Sealand terminal on the Sitcum Waterway, an expansion of the Terminal 3 and 4 complex on the Blair Waterway, an expansion of the Hyundai Marine terminal on the Blair Waterway, and the creation of a new container terminal on the east side of the Blair Waterway. In December 2002, the Port of Tacoma announced plans to purchase an idled aluminum smelter and 96 acres on which it sits from Kaiser Aluminum and Chemical Corp. This land is on the east side of the Blair Waterway.

Future container development at the Port of Seattle is likely to be far more modest as compared to Tacoma's plans. In the long-term, future container cargo activity is likely to be focused on the two largest container terminals in the harbor: Terminal 5 and Terminal 18. In 2001, Hanjin Shipping signed a 10-year lease at Terminal 46. The Port has indicated that it is considering redeveloping the 88-acre terminal for non-marine cargo uses once the Hanjin lease expires. The Terminal 25/30 complex is no longer used for container cargo handling. The Port of Seattle has publicly indicated that Terminal 91, used in the past for breakbulk and automobile operations, is likely to be redeveloped for non-marine cargo uses.

There is some uncertainty in the projection of future Portland capture rates. The capture rate has fluctuated over time, and it is reasonable to consider the possibility that the capture rate could differ between the with-project and without-project conditions. Assigning values that differed from historic levels would be problematic, however. This analysis has assumed that the Portland capture rate will decline from 65.6 percent (slightly higher than the 10-year average) to 58.3 percent over the period of analysis. This represents a substantially more conservative approach than was taken in the 1999 Final IFR/EIS, in which it was assumed that the Portland market share stayed constant at the historical average over the period of analysis. The current low capture rates, particularly the low that occurred in 1998 coincide with weak overall exports, and the Portland capture rate is likely to recover with the recovery of the export market.

Table 36 displays a comparison of the container benefits under alternative assumptions. Relative to the base value, if the capture rate is held constant over the period of analysis at the 10-year average (64.1 percent), average annual container benefits increase by 2.3 percent to $12,017,000. Dropping the capture rate to 60 percent decreases container benefits by 3.1 percent, and increasing the capture rate to 66 percent increases benefits by 5.1 percent. Finally, if the Portland capture rate drops immediately to 50 percent, well below the lowest market shares observed over the last decade.

Table 36. Comparison of Alternative Capture Rate Assumptions - Average Annual Container Benefit

	Container Benefit	Percentage Change
Base Value	$11,748,000	
Capture Rate 64.1 Percent	$12,017,000	2.3%
Capture Rate 60 Percent	$11,385,000	-3.1%
Capture Rate 66 Percent	$12,348,000	5.1%
Capture Rate 50 percent	$10,157,000	-13.5%

- **Container Fleet, vessel size, upside.** It is unlikely that vessels on the Columbia River will get smaller than they are today, and the upside risk of having vessels get larger faster than is anticipated is substantial. The one last port of call service that is currently using the smallest vessels on the river today indicated that those vessels could be completely gone from the Columbia River by 2007, and, for that particular line, could be replaced by much larger 5,500 teu vessels. While the analysis should not depend on speculations about the future actions of a particular service, it is an indication that there is an upside risk in terms of vessel size. Table 37 displays the average annual container benefits assuming that the shallowest vessels (42-foot design draft) are phased out by 2007 rather than 2017, replacing them with both 44-foot and 46-foot vessels (50 percent each).

Table 37. Comparison of Alternative Vessel Design Draft Assumptions - Average Annual Container Benefit

	Container Benefit	Percentage Change
Base Value (10 day transit time)	11,748,000	
Earlier Elimination of 42' Vessels	11,959,000	2%

- **Container Fleet, vessel size, downside.** The downside potential with regard to vessel size is the potential scenario in which vessels get so large in the future that the Port of Portland loses an even greater share of local cargo, even with a channel deepening. By 2030, with a channel deepening, the DRI-WEFA forecasts assume that 45 percent of the cargo generated in the Portland hinterland will be shipped out of the Puget Sound due to vessel capacity constraints and increases in vessel size. However, as long as there are 4,000 to 6,000 teu panamax and post-panamax vessels in the transpacific trade, it is reasonable to assume that there will continue to be services that find it profitable to pick up cargo in Portland.

- **Container Fleet, transit times, upside.** As noted earlier, the transit times used for container vessels are as short as possible, representing an expectation that all of those container vessels using Portland as a last port of call are destined for Japan. If a single service changes that practice, the benefits of the project (for containerized cargo) could increase by 5 to 10 percent. The average transpacific transit time for Pacific Northwest carriers is 11.8 days. Table 38 displays the container transportation benefits assuming longer transit times. The Pacific Northwest average of 11.8 days increases container benefits by 17 percent.

Table 38. Comparison of Alternative Transit Time Assumptions - Average Annual Container Benefit

	Container Benefit	Percentage Change
Base Value (10 day transit time)	$11,748,000	
PNW Average (11.8 days)	$13,751,000	17%
11 Day transit time	$12,861,000	9%

- **Past and Projected ratios of empties to loaded containers.** There are a number of factors that have contributed to the increase in empties loaded at Portland. Empty containers comprised 24 percent of Portland export containers in 2001. This has grown from only a few percent five years ago. The increase followed the 1998 Asian economic crisis, which worsened the imbalance of transpacific trade and created the need to transport increasing volumes of empty containers back to Asia. We expect this to be a long-term situation; that is, imports will continue to grow faster than exports, and that a significant imbalance in the trade will persist.

  In addition to the imbalance, vessel size has also had an impact on the percent of empties loaded on vessels in Portland. As vessels get larger and deeper, the percentage tends to increase. This is because the vessel will reach the target outbound draft well before it "cubes" out. The vessel operator will desire to cube out the ship, and therefore will need to allocate slots and deadweight to the carriage of empties on each voyage. If the vessel is draft constrained, the percent of the vessel's cubic capacity that is empty, as measured in TEUs, will increase with the size and draft of the ship.

  An additional factor contributing to the increase in empties loaded at Portland is the extension of vessel rotations calling Portland into new port areas, especially mainland China. These are destinations that carriers must position empty equipment into to capture the higher revenue eastbound headhaul cargo.

Container carriers come to Portland to load export cargo. There is a balancing act that occurs every week for every service, balancing the need to get empties back to Asia with the need to carry enough revenue generating cargo to justify the additional time and expense of a call to Portland. The result of this balancing act is a very consistent utilization of the available draft in the Columbia River navigation channel. With the additional capacity created by channel deepening, carriers are likely to continue the trend of maximizing export cargo within the new draft constraint of the river.

The Corps' analysis assumes that the additional three feet of capacity does not change the total ratio of empties to fulls on board each vessel. Analytically, there are a few other reasonable scenarios.

- **Empties increase as a percentage in both with- and without-project conditions.** The benefits of the project increase in this case, as the total voyage costs are spread over less cargo in both conditions.
- **Empties decrease as a percentage in both with- and without-project conditions.** The benefits of the project decrease in this case, as the total voyage costs are spread over more cargo.
- **Empties decrease as a percentage in the with-project condition.** The benefits of the project increase in this case. This case essentially assumes that the average vessel cubes out in the without-project condition, and that full containers in the with-project condition displace empties.
- **Empties increase as a percentage in the with-project condition.** The benefits of the project decrease in this case, representing a scenario in which carriers choose to use the additional capacity created by channel deepening to load more empties rather than fulls.

Table 39 displays a range of benefits under alternative assumptions for total tare. Decreasing tare to 15 percent represents a scenario in which every container on board the vessel is loaded with heavy cargo, and is an extremely unlikely possibility.

Table 39. Comparison of Alternative Tare Assumptions - Average Annual Container Benefit

	Container Benefit	Percentage Change
Base Value (Tare is 19.2%)	$11,748,000	
Tare increased to 25% (with and without project)	$12,651,000	8%
Tare decreased to 15% (with and without project)	$11,164,000	-5%
With-Project Tare 17.2%	$12,327,000	5%
With-Project Tare 21.2%	$11,185,000	-5%

- **Container Vessel Adjustment Period.** The analysis assumes that a one-year period of adjustment for container vessel operators after channel deepening. Table 40 displays the impact of different assumptions regarding the container vessel transition period. A three-year adjustment period, in which operators only take advantage of 65 percent of the additional capacity created through channel deepening, results in a reduction of the benefits by 1.3 percent.

Table 40. Comparison of Alternative Adjustment Periods – Average Annual Container Benefit

	Container Benefit	Percentage Change
Base Value (One year adjustment)	$11,748,000	
Immediate Adjustment	$11,865,000	1.0%
Three Year Adjustment	$11,593,000	-1.3%

EXHIBIT N
PHYSICAL AND BIOLOGICAL STUDIES OF THE DEEP WATER AND SHALLOW WATER SITES

Table of Contents
Exhibit N
Physical and Biological Studies of the Deep Water And Shallow Water Sites

Physical and Biological Studies
of the
Deep Water and Shallow Water Sites

The attached information provide results of baseline and special studies undertaken to characterize the proposed Deep Water and Shallow Water ocean dredge material disposal sites off the mouth of the Columbia River. The 1999 Final IFR/EIS, Appendix H, Exhibit H, identified the need for additional baseline and special studies of the proposed ocean dredged material disposal sites. Identified study needs in Exhibit H, included Side Scan Sonar, Sediment Characterization, Crab Distribution and Abundance Studies, and Benthic Sampling. These studies were jointly funded and conducted by EPA, Region 10 and the USACE, Portland District to meet various requirements of the Marine Protection, Research and Sanctuaries Act with regard to required baseline designation studies.

Attachment A

The objective of the Sediment Trend Analysis (STA) and Acoustic Bottom Classification study was to develop an understanding of the mechanisms of sediment transport and inter-relationships among sediment sources and sinks associated with the mouth of the Columbia River. Over 1,200 sediment samples were collected and subjected to size analysis. Five principle Transport Environments were identified and described. In the area of the Deep Water Site sediment transport trends were dominantly landward. Material placed in the Shallow Water Site is very likely to help maintain beaches to the north.

Attachment B

The purpose of the Physical and Chemical Sediment Characterization Baseline Study was to provide sediment physical and chemical baseline information of the Deep Water Site. Samples were collected in conjunction with the STA study. Ten sediment samples were analyzed for physical and chemical properties using protocols proscribed in the Dredged Material Evaluation Framework. Grain size varied between 0.106 mm and 0.126 mm with a mean of 0.120 mm. Chemical results are provided in 8 different tables and compared to previous studies in the area.

Attachment C

Baseline physical information for the Deep Water Site was further accomplished through an acoustic seafloor mapping survey that incorporated the results of the baseline physical grain size analysis. Hydrographic surveys using side scan sonar and bathymetric systems were conducted to continuously map the seafloor in the vicinity of the proposed Deep Water Site. Side scan sonar was used to identify surface material types and boundaries, geomorphic shipwrecks or debris. Accurate depth data was collected. Sediment classification was accomplished using the RoxAnn™ operating in conjunction with the vessel's echo sounder. The sediment within the Deep Water Site can be generally characterized as a homogeneous distribution of fine sand. Acoustic reflectance presents a nearly featureless geomorphic configuration of the seabed with only a band of apparent low relief seafloor undulations in the eastern portion of the site.

Attachment D

Biological baseline studies were conducted in 2002 with a final report due in March 2003. Preliminary results have been presented and are here included in power point slides. The Deep Water Site biological baseline survey included Sediment Profiling Imagery, sediment physical analyses, benthic infauna analysis, and crab/fish analysis. Crab abundance were analyses through pot deployment and trawls. The latter were also used for fish population analysis. To assess crab and fish populations at the Shallow Water Site pots and trawls were also used.

Attachment A

Sediment Trend Analysis

and Acoustic Bottom Classification

in the Mouth of the Columbia River

(Implications to Dredged Material Disposal and Operations

and Coastal Erosion)

By

GeoSea Consulting Ltd.

Funded By

EPA, Region 10 and USACE, Portland District

2001

UNITED STATES ARMY CORPS OF ENGINEERS
CENWP-EC-HR
PORTLAND, OREGON

and

WEST CONSULTANTS
BELLEVUE, WASHINGTON

(Contract No. DACW57-00-D-0003, Task Order No.07)

A SEDIMENT TREND ANALYSIS (STA®) AND AN ACOUSTIC BOTTOM CLASSIFICATION (ABC) IN THE MOUTH OF THE COLUMBIA RIVER: *IMPLICATIONS TO DREDGE DISPOSAL OPERATIONS AND COASTAL EROSION*

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April 2001

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1.0 INTRODUCTION

1.1 Background

The US Army Corps of Engineers is responsible for the navigational maintenance of the entrance to the Columbia River, including the jetties and navigational channels (Fig.1). The latter include the mouth of the Columbia River and main stem Columbia River federal navigational channels. Dredged material from the mouth is placed offshore in EPA designated disposal sites. These have been recently enlarged and their use increased. If authorized, material from the Columbia River, including its estuary, will also be placed in offshore EPA designated sites (Ocean Dredged Material Disposal Sites; ODMDS). The fate of the material placed at these sites is of prime interest in their management and monitoring. To obtain this information GeoSea was contracted by the Corps under subcontract to West Consultants to carry out two types of studies.

The first uses a technique known as Sediment Trend Analysis (STA®), which was invented and developed by GeoSea. STA derives patterns of net sediment transport from relative changes in the grain-size distributions of bottom sediments. In addition, the technique defines the dynamic behavior of the sediments with respect to erosion, deposition or equilibrium. Such knowledge provides a clear indication of how dredged material introduced into the marine environment is likely to behave.

The second study, known as Acoustic Bottom Classification (ABC), is a method of inferring and mapping sea-bottom characteristics based on an analysis of the returning echo from a standard depth sounder. It provides complementary information to the STA, and has the advantage of more-or-less working itself during the fieldwork necessary for STA.

To encompass all disposal sites associated with the Columbia River mouth, the study area was chosen to extend from inside the river mouth seaward to the 350-foot isobath. This area is divided into three regions each with a different sampling density based upon the complexity of the bathymetry and level of interest. Area A lies between the 350 and 120-foot isobaths, thereby encompassing a proposed Deep Water Site (Fig.1). Area B includes the entire river mouth including the north and south shelves, the ebb delta, and the river itself. Finally Area C incorporates Peacock Spit, a region of specific interest given that the beaches between the North Jetty and North Head are known to be eroding. Thus the fate of material placed at the proposed shallow water site (ODMDS E) is of prime concern.

1.2 Objectives

The specific objectives of this study are as follows:

(1) Collect about 1,250 sediment grab samples from the study area.

(2) Analyze all samples for their complete grain-size distributions and input into a Geographic Information System (GIS).

(3) Classify and map, using information from the grab sampling program and the acoustic data collected from ABC, bottom types (including the area presently being affected by the ongoing disposal program) from the river to a depth of 350 feet, and include this information in the GIS.

(4) Undertake STA using proprietary software developed by GeoSea in order to establish the patterns of net sediment transport, areas of erosion, deposition, and dynamic equilibrium.

(5) Discuss (i.e., compare and contrast) the results of STA with the present understanding of processes as described in previous and ongoing work.

(6) Use the results of the grain-size analyses, ABC, and STA to:
(i) Delineate sediment transport pathways and their dynamic behavior throughout the study area;
(ii) Identify sediment sources and sinks;
(iii) Identify the areas potentially impacted by disposal operations;
(iii) Propose optimum locations for specific process measurements required to determine transport rates, if desired;
(iv) Determine the probable long-term fate of dredge material.
(v) Advise, if applicable, on disposal options to mitigate undesirable affects or, conversely, determine areas where dredge material could be placed to ensure optimum benefits such as beach replenishment on Peacock Spit.

1.3 Field Methods

Sediment grab samples were collected from Aug. 23 to Sept. 7, 2000, using *GeoSea*, a 50 foot steel motor-sailor equipped with a hydraulic winch and Shipek grab sampler. This grab sampler enables the top 10 to 15 cm of sediment to be sampled. Many of the nearshore samples were collected with a 12-foot, hard-bottom inflatable speedboat (Caribe) equipped with a depth sounder, a small electric winch, and a portable grab sampler. Positioning was achieved on the speedboat with a hand held Differential GPS (Garmin GPS75 and Garmin GBR21), providing a typical accuracy of ±5.0 m. *GeoSea* itself was equipped with Trimble DS212L GPS with a 2 to 5 m accuracy in differential mode.

In most instances, samples were obtained at predetermined locations (Fig.1); however, where shoreline structures (jetties, pilings etc.) interfered with navigation, a sample was collected as close as practical to the planned position. Representative samples from each successful grab were stored in plastic bags and transported to the GeoSea laboratory in Brentwood Bay, BC, for grain-size analysis.

Samples were collected on a regular, hexagonal grid with a spacing of 1,000 m over the deep-water region (Area A, Fig.1). Areas B and C were sampled at a spacing of 500 and 250 m respectively. A total of 1,252 sample sites were visited, at 21 of which, a sample could not be obtained. A sampling site was designated a failure after at least two drops of the grab failed to retrieve a sample. Failures were generally in deep water (typically greater than 200 ft) and were likely the result of difficult swell conditions rather than the presence of a rocky or scoured bottom. Sites where samples were unobtainable are mapped as "No Sample" (Fig.2).

During the sediment-sampling program, ABC was undertaken continuously with the vessel's echo sounder, a dual frequency SITEX CVS-108DF, and a 200kHz QTCView system. For this survey the QTCView was set up to encompass a depth range from 5 m to 100 m. The acoustic data were logged from *GeoSea* to a computer together with position and time. Classification information was merged with the results of the grab sampling program and with field notes to produce the best classification catalogue for the region. Full details of the ABC program are included in Appendix II.

1.4 Grain-Size Analyses

All samples were analyzed for their complete grain-size distribution using a Malvern MasterSizer 2000 laser particle sizer. The laser-derived distributions were combined with sieve data for particles larger than 1500 microns in diameter using a merging algorithm developed by GeoSea Consulting[1]. The size distributions were entered into a computer equipped with proprietary software to establish sediment trends and transport functions. A more complete description of the grain-size analytical technique is provided in Appendix III

2.0 STA THEORY

The technique to determine the sediment transport regime utilizes the relative changes in grain-size distributions of the bottom sediments. The derived patterns of transport are, in effect, an integration of all processes responsible for the transport and deposition of the bottom sediments. The latter may be considered as a facies that is defined by its grain-size distribution. The original theory was first published in McLaren and Bowles, 1985; a more up-to-date version is described in Appendix I, which is briefly summarized in the following paragraphs.

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[1] The grain-size data (listed in Appendix II) are supplied on a disk as an Excel worksheet containing sample locations and the complete phi distributions of the sediments.

Suppose two sediment samples (D_1 and D_2)[2] are taken sequentially in a known transport direction (for example from a river bed where D_1 is the up-current sample and D_2 is the down-current sample). The theory shows that the sediment distribution of D_2 may become finer (Case B) or coarser (Case C) than D_1; if it becomes finer, the skewness of the distribution must become more negative. Conversely, if D_2 is coarser than D_1, the skewness must become more positive. The sorting will become better (i.e., the value for variance will become less) for both Case B and C. If either of these two trends is observed, sediment transport from D_1 to D_2 can be inferred. If the trend is different from the two acceptable trends (e.g. if D_2 is finer, better sorted and more positively skewed than D_1), the trend is unacceptable and it cannot be supposed that transport between the two samples has taken place.

In the above example, where the transport direction is unequivocally known, $D_2(s)$ can be related to $D_1(s)$ by a function $X(s)$ where 's' is the grain size. The distribution of $X(s)$ may be determined by:

$$X(s) = D_2(s)/D_1(s)$$

$X(s)$ provides the statistical relationship between the two deposits and its distribution defines the relative probability of each particular grain size being eroded, transported and deposited from D_1 to D_2.

2.1 Interpretation of the X-Distribution

The shape of the X-distribution, relative to the D_1 and D_2 distributions, enables an interpretation of the dynamic behavior of bottom sediments as follows (see Fig.A-6; Appendix I):

(1) Dynamic Equilibrium: The shape of the X-distribution closely resembles the D_1 and D_2 distributions. The relative probability of grains being transported, therefore, is a similar distribution to the actual deposits. This suggests that the probability of finding a particular grain in the deposit is equal to the probability of its transport and re deposition (i.e., there is a grain by grain replacement along the transport path). The bed is neither accreting nor eroding and is, therefore, in dynamic equilibrium.

(2) Net Accretion: The shapes of the three distributions are similar, but the mode of X is finer than the modes of D_1 and D_2. Sediment must fine in the direction of

---

[2] A sample is considered to provide a representation of a sediment type (or facies). There is no direct time connotation, nor does the depth to which the sample was taken contain any significance (provided, of course, that the sample does, in fact, accurately represent the facies). For example, D_1 may be a sample of a facies that represents an accumulation over several tidal cycles, and D_2 represents several years of deposition. The trend analysis simply provides the sedimentological relationship between the two. It is unable to determine the rate of deposition at either locality, but frequently the derived patterns of transport do provide an indication of the probable processes that are responsible in producing the observed sediment types.

transport; however, more fine grains are deposited along the transport path than are eroded, with the result that the bed, though mobile, is accreting.

(3) Net Erosion: Again the shapes of the three distributions are similar, but the mode of X is coarser than the D_1 and D_2 modes. Sediment coarsens along the transport path, more grains are eroded than deposited, and the bed is undergoing net erosion.

(4) Mixed Case: A Mixed Case trend is one where the sequence of samples produces significantly acceptable statistics for both Net Erosion and Net Accretion. Such a finding is usually taken to be analogous to the case of Dynamic Equilibrium, but it may be more correctly interpreted to mean that the environment undergoes periodic accretion followed by periodic erosion, and both events have been "captured" in the samples used to make up the trend.

(5) Total Deposition (I): Regardless of the shapes of D_1 and D_2, the X-distribution more or less increases monotonically over the complete size range of the deposits. Sediment must fine in the direction of transport; however, the bed is no longer mobile. Rather, it is accreting under a "rain" of sediment that fines with distance from source. Once deposited, there is no further transport. No Total Deposition (I) – type dynamic behavior was found for the mouth of the Columbia River study.

(6) Total Deposition (II): More recently, a fifth form of the X-distribution has been discovered. Occurring only in extremely fine sediments when the mean grain-size is very fine silt or clay, the X-distribution may be essentially horizontal (Fig.A6-E). Such sediments are usually found far from their source (compared with Deposition (I) sediments in which size-sorting of the fine particles is taking place, and therefore the source is relatively close). The horizontal nature of the X-distribution suggests that their deposition is no longer related strictly to size-sorting. In other words, there is now an equal probability of all sizes being deposited. This form of the X-distribution was first observed in the muddy deposits of a British Columbia fjord and is described in McLaren, et al., 1993. Again, no X-distributions for this type of deposition were found in the mouth of the Columbia River.

2.2 Interpretation of a Trend

In reality, a perfect sequence of progressive changes in grain-size distributions is seldom observed in a line of samples, even when the transport direction is clearly known. This is due to complicating factors such as variation in the grain-size distributions of source material, local and temporal variability in the X(s) function, and a variety of sediment sampling difficulties (i.e., sample doesn't adequately describe the deposit; it's taken too deeply; not deep enough etc.).

Initially, a trend is easily determined using a statistical approach whereby, instead of searching for "perfect" changes in a sample sequence, all possible pairs contained in the sequence are assessed for possible transport direction. When one of the trends exceeds random probability within the sample sequence, we infer the direction of transport and calculate X(s). The precise statistical technique is described more fully in Appendix I. The statistical acceptance of each trend is provided in Appendix IV.

Despite the initial use of a statistical test, various other qualitative assessments must be made in the final acceptance or rejection of a trend. Included is an evaluation of R^2, a multiple correlation coefficient defining the relationship among the mean, sorting and skewness in the sample sequence (R^2 values are shown in Appendix III). If a given sample sequence follows a transport path perfectly, R^2 will approach 1.0 (i.e., the sediments are perfectly "transport-related"). A low R^2 may occur, even when a trend is statistically acceptable for the following reasons: (i) sediments on a presumed transport path are, in reality, from different facies, and valid trend statistics occurred accidentally; (ii) the sediments are from a single facies, but the chosen sequence is only a poor approximation of the actual transport path, and (iii) extraneous sediments have been introduced into the natural transport regime, as in the case of dredged material disposal. R^2, therefore, is assessed qualitatively, and when low, statistically accepted trends must be treated with caution.

To analyze for sediment transport directions over 2-dimensions, a grid of samples is required. Each sample is analyzed for its complete grain-size distribution and these are entered into a computer equipped with appropriate software to "explore" for statistically acceptable trends. The technique to explore for transport pathways is initially undertaken randomly[3] (i.e., up and down the coast, perpendicular to the coast, lines of samples running east-west, north-south etc.). As familiarity with the data increases, exploration becomes less and less random until a single and final coherent pattern of transport is obtained[4]. On completion of an interpretation, each transport line may then be used to derive a corresponding X(s) function from which the behavior of the bed material on the transport path is inferred.

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[3] The term "random" is used loosely in that it is not strictly possible to remove the element of human decision-making entirely. The important aspect of the initial search for sediment trends is that it is undertaken with no preconceived concept of transport directions. It is, however, assumed that there will be a net sediment transport pattern and that changes in the grain-size distributions throughout the study area will not be random. The derivation of the final patterns may be likened to communication theory, which in the case of extremely noisy signals, requires the "discovery" of a "message" as the proof that the message does indeed exist.

[4] At present, the approach of obtaining the final derivation of the net sediment transport pathways relies on assessing and removing "noise" qualitatively. The GeoSea trend programming is specifically designed to do this in that all sample distributions may be readily compared with one and other (and excessively noisy distributions discarded), the best sediment types can be determined for the analysis, and the relationships among all the sample pairs may be assessed. Because we are unable to know the exact nature of the "noise" that we may be confronted with, it is difficult at this stage to devise a quantitative technique to eliminate it. To do so is the subject of much on-going research both by GeoSea and at various universities.

3.0 PHYSICAL SETTING

The Columbia River, having the second largest discharge in the United States averaging 7,500 m^3s^{-1}, enters the Pacific Ocean between Washington and Oregon through an entrance largely controlled by jetties and dredging (Fig.1). With a mean tidal range of 2.0 m, peak ebb flows of 2.4 ms^{-1}, and an average annual offshore wave height of greater than 2 m, conditions at the mouth have a deservedly dangerous reputation (Moritz, et al.).

About 9.7 million metric tons of sediment is supplied to the estuary each year, most of which is carried in suspension (Simenstad et al., 1990). Sherwood and Creager (1990) modified this value to 7.6 x 10^6 mt y^{-1}, which is thought to be considerably less than historical values of 10 – 15 x 10^6 mt y^{-1} prior to dam construction. Immediately offshore of the estuary mouth, shelf circulation is influenced by the southward flowing California current augmented by surface winds that are predominantly from the north-northwest. In winter, the northward flowing Davidson Current dominates the shelf attaining maximum strength from winter storm patterns from the south (US Army Corps of Engineers, 1999). These patterns coincide with the generally accepted view that the direction of net sediment movement along the Oregon and Washington coasts is northward on both the shelf and beaches (Sherwood and Creager, 1990).

Since the late 1800's, an effort to stabilize the mouth of the Columbia River in the interests of shipping has been continuous. Construction of the South Jetty began in 1885 and an extension was completed between 1903 and 1914. The North Jetty followed and was in place by 1917. Following jetty construction, adjacent beaches grew rapidly for several decades. In recent years, however, accretion rates have not only slowed but rapid erosion is now taking place. Furthermore, upstream dams are thought to have decreased the natural Holocene sediment loads by at least 72 per cent (Nelson, et al., 1998).

Dredging actively began in 1903 (Sherwood et al., 1990). Of particular interest to this study is the presence of six dredged material disposal sites (North Jetty Site, ODMDS A, B, E and F, and a Deep Water Site. Figure 1 shows each site together with their expanded boundaries. With the exception of the Deep Water Site that has not yet been used, each of these sites has been receiving material dredged from the Columbia River mouth. According to data supplied by the US Army Corps, Portland District, nearly 100 mcy have been disposed of since 1980 at these sites. Of this total, A has received 21 %, B 32 %, E 35 %, and F the remaining 10 %. The North Jetty Site was first used in June 1999 when an additional 1.05 mcy (1%) were placed there (Fig.3). Mounding is known to have occurred at A, B, and F and has affected local wave climate; however, E is evidently located in a sufficiently high-energy area to preclude any significant degree of dredged material accumulation (US Army Corps of Engineers, 2001).

4.0 RESULTS

4.1 Acoustic Bottom Classification (ABC)

The full theory, data analysis and results for the ABC survey are described in Appendix II.

4.2 Sediment Trend Analysis

As seen from Figure 2 and Table 1, the sediments obtained from the study area are composed principally of sand. Samples containing muddy sand are scattered fairly randomly in water depths generally greater than 60 feet. A few samples could be classified as sandy mud, and these are found in water depths of more than 190 feet. The number of samples other than pure sand was insufficient to derive separate trend interpretations for each facies; the best trends were obtained by treating all the samples as a single sediment.

Table 1: Breakdown of sediment types found in the mouth of the study area (see Fig.2)

	SEDIMENT TYPE[5]	NO. OF SAMPLES	PERCENTAGE
1	Sandy Gravel	0	0
2	Gravel	0	0
3	Gravely Sand	0	0
4	Sand	1,138	91
5	Muddy Sand	88	7
6	Sandy Mud	5	0
7	Mud	0	0
9	No sample sites	21	2
	TOTAL	1,252	100

Following the calculation of numerous sample sequences to determine significant trends, a total of 186 lines were selected to provide a pattern of transport (Fig.4). The trend statistics for each line are provided in Appendix IV. The net sediment transport pathways

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[5] The sediment types use 20% and 50% as "cut-off" limits. For example, sand has less than 20% of any other size; sandy mud has greater than 20% sand, but less than 50%; muddy sand has greater than 20% mud, but less than 50%; etc. The few types of sediment containing three modes (i.e., a muddy, sandy gravel) although obviously "noisy" distributions, were still successfully included in the STA.

are shown in Figure 5. For ease of discussion, the pathways are grouped into various areas (or Transport Environments; Figure 6 and Table 2). A Transport Environment is defined as an area within which transport lines are associated by a common source and, to some extent, dynamic behavior. Generally, transport lines cannot be continued from one TE into another, and so a region in which transport lines naturally end (and begin) is a boundary between Transport Environments. Representative X-distributions[6] to illustrate the dynamic behavior derived from sample lines are referenced in Table 2, and their graphs are shown in Appendix V.

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[6] An X-distribution is a function derived from the grain-size distributions contained in a sample line. It is used to describe the dynamic behavior of the sediments along the transport pathway defined by the sample line. The X-distribution may be thought of as a function that describes the relative probability of each particle being removed from an "up-current" sediment sample, and being deposited in a "down-current" sample. The shape of the X-distribution relative to the distributions of the sediments making up the sample line is used to define dynamic behavior (see Fig.AI-6).

TABLE 2: SUMMARY OF THE SEDIMENT TRANSPORT LINES MAKING UP EACH TRANSPORT ENVIRONMENT (FIGURE 6)

TRANSPORT ENVIRONMENT (TE) (Figure 6)		1: COLUMBIA RIVER		2: NORTH JETTY		3: NEARSHORE SHELF			4: MID SHELF		5: OUTER SHELF
SUB-ENVIRONMENT	1A: SOUTH GYRE	1B: RIVER CHANNEL	1C: NORTH GYRE	-	3A: INNER SOUTH SHELF	3B: SOUTH SHELF TO NORTH SHELF	3C: OUTER SOUTH SHELF	4A: MID-SHELF SOUTH	4B: MID-SHELF CENTRAL	4C: MID-SHELF NORTH	-
LINES (Figure 4)	1 to 3	4 to 6	7 to 14	15 to 36	37 to 46	47 to 60	61 to 70	71 to 97	98 to 112	113 to 144	145 to 186
NO. OF LINES	3	3	8	22	10	14	10	27	15	32	42
MEAN R2 VALUE	0.89±0.10	0.94±0.01	0.82±0.16	0.89±0.10	0.77±0.10	0.57±0.28	0.76±0.13	0.89±0.11	0.83±0.08	0.86±0.16	0.92±0.11
NET ACCRETION NET EROSION DYNAMIC EQUILIBRIUM MIXED CASE	100% 0% 0% 0%	100% 0% 0% 0%	50% 25% 25% 0%	36% 45% 18% 0%	0% 100% 0% 0%	0% 100% 0% 0%	20% 50% 0% 30%	100% 0% 0% 0%	20% 0% 0% 80%	9% 34% 25% 31%	19% 7% 74% 0%
REPRESENTATIVE X-DISTRIBUTIONS (APPENDIX V)	Fig. AV-1	Fig. AV-2	Fig. AV-3 Fig. AV-4 Fig. AV-5	Fig. AV-6 Fig. AV-7 Fig. AV-8	Fig. AV-9 Fig. AV-10	Fig. AV-11	Fig. AV-12 Fig. AV-13	Fig. AV-14	Fig. AV-15	Fig. AV-16 Fig. AV-17 Fig. AV-18	Fig. AV-19 Fig. AV-20

4.2.1 Columbia River (TE's 1A, 1B, and 1C).

These lines indicate that sediment transport in the main channel (TE 1B) of the Columbia River is seaward (ebb-directed), with a return flow on either side (TE 1A and TE 1C). Columbia River sediments appear to be accreting in the main channel, but reach their farthest seaward extent in the region between the two jetties, after which they lose their "signature" by mixing with marine sediments defined by TE 3.

R^2 values are highest in the main channel, but drop somewhat in the north and south gyres. This is likely due to the relatively few number of samples that do not allow for the best pathways to be determined. Although Net Accretion dominates in both the gyres, there is a mix in dynamic behavior on the north side of the river where the channels to Ilwaco and into Baker Bay undoubtedly contribute to a more complex system. Further sampling would likely show a greater detail of sediment pathways and their dynamic behavior for this area.

4.2.2 North Jetty (TE 2)

These lines originate on the North Jetty Disposal Site. They show a clockwise gyre emanating from the disposal site, and circulating sediment around the bay formed between the two jetties (Jetty A and the North Jetty). The trends terminate in the Navigation Channel. It is probable that these trends all could have been part of the TE 1 (the Columbia River environment) or TE 3 (the Nearshore Shelf environment). However, the active dumping in the North Jetty disposal site appears to have created a new and extraneous source for the sediments in the bay between the jetties. Most of the trends show Net Erosion and these are confined principally to transport close to the shoreline. It appears that material is eroded from the disposal site and probably added to the deposition occurring inside the Navigation Channel. The transport lines making up the central portion of the bay tend to show Net Accretion, although the westernmost lines are in Dynamic Equilibrium. R^2 values are relatively high, but quite variable, a finding that could be expected given that the trends are likely a mix of "natural" and extraneous sediments emanating from the North Jetty Disposal Site.

4.2.3 Nearshore Shelf (TE's 3A, 3B, and 3C).

This environment encompasses the nearshore shelf on both sides of the Columbia River. Overall, transport is northwards and the trends are diverted into, and back out, of the Columbia River. TE 3 is broken into three areas. The first, (Inner Shelf; TE 3A), shows sediment rounding the South Jetty and crossing the breaker zone associated with the northwest side of Clatsop Spit. The lines join in with the Columbia River channel sediments (TE 1), where they cross over the channel to merge with the clockwise gyre associated with TE 2. Essentially all the trends show Net Erosion, reflecting high-energy transport associated with the significant breaker zone north of Clatsop Spit. R^2 values are not particularly high, probably reflecting sediment disturbances caused by channel dredging, and mixing with the Columbia River sediments of TE 1.

The second sub environment (TE 3B) consists of lines that round both the South and North Jetties, thereby providing a link between the south and north shelves. As the paths cross the Ocean Dredged Material Disposal Site located beyond the end of the North Jetty (ODMDS E; Fig.1) they veer to the north and northeast towards shore. Although there is virtually no sedimentolgical evidence for the large volumes of material disposed of in ODMDS E, the R^2 values drop significantly for these lines, probably because of the "foreign" dredged material joining into the transport paths.

The third sub-environment is located on the outer south shelf. The trend lines parallel the northward regime of TE 3B and merge into the latter in the vicinity of the navigation channel. None of these lines crosses a disposal site and as a result, R^2 values are relatively high. Like the previous environments, most of these lines also show predominantly Net Erosion, although there are two Net Accretion lines (67 and 68) in the southern portion of the area.

4.2.4 Mid Shelf (TE's 4A, 4B, and 4C)

These lines all originate in the vicinity of ODMDS B (Fig.5) where they emanate to the south, north and landwards. Broken up into 3 sub-environments, TE 4A trends south and eastwards, the latter forming a counterclockwise gyre that merges with the northerly pathways of TE 3C. All the lines show Net Accretion and R^2 values are relatively high with the exception of Lines 91 to 95 which directly cross over ODMDS A (R^2 for these lines is 0.81 ± 0.04 compared with 0.90 ± 0.11 for the remaining lines which do not cross the disposal site).

TE 4B trends eastwards up the slope to curve northwards merging with the pathways defined in TE 3B. Some of these lines (98, 99, and 100) cross ODMDS E where they terminate on Peacock Spit. They suggest that material from the disposal site is being deposited on the northern flank of Peacock Spit. Otherwise, all the lines produced Mixed Case trends. Although R^2 values are reasonably high, they are lower than those found for 4A and 4C, probably because most of the lines in 4B are associated with ODMDS E. The Lines in TE 4C trend essentially northwards and show a variety of dynamic behaviors, although Mixed Case and Dynamic Equilibrium trends dominate.

4.2.5 Outer Shelf (TE 5)

These lines show a transport regime emerging from deeper water bringing sediment towards shore to merge with the east and west lines of TE 4. R^2 values are quite high reflecting little anthropogenic influence on the sediments. The trends are mostly in Dynamic Equilibrium, although there are a few Net Accretion lines, particularly in the northern half of the regions.

5.0 DISCUSSION

5.1 Process Implications

5.1.1 Columbia River (TE 1) and North Jetty (TE 2) Transport Environments

There are few lines of evidence in the literature that provide convincing support for or against the patterns of net transport determined for these two environments. The most complete synthesis of sediment transport, based on bedform morphology, is found in Sherwood and Creager (1990); however, the overlap between the two studies is confined only to the mouth area between the North and South Jetties, landward to the eastern finish of the sampling program. Their findings showed this region to be dominated by reversing bedforms in the spring and fall, with a larger number of unidirectional, seaward bedforms occurring in winter. Some of the elements contained in the winter map of bedform distributions agree quite well with the STA pathways; but Sherwood and Creager suggested that the net of reversing transport is predominantly landwards in this area which, except in a few specific locations (e.g., adjacent to the channel side of Clatsop Spit) is contrary to the STA.

Nevertheless, the STA agrees well with several of the essential conclusions made by Sherwood and Creager. For example, TE 1 shows the source for sediments inside the main entrance to the estuary to be derived from the Columbia River. Sherwood and Creager surmised from their evidence that local and marine sources can only be minor compared with the source that the river provides. They also could not confirm that bedload sediment is transported out of the estuary (the STA suggests that it is not), and finer sediment in the deeper water may be entering and leaving the estuary through the tidally dominated entrance (again the STA shows sediment moving into and out of the estuary entrance).

The overall morphology of the river suggests that channel flow is concentrated on the south bank past Astoria and Hammond, after which it is directed northwest to impinge the north bank between Jetty A and the North Jetty. As a result, both Clatsop Spit and the channel between the two jetties have tended to migrate northwards (US Army Corps of Engineers, 2001). It appears likely that the protrusion of Jetty A into the outside of the main channel bend is causing a clockwise gyre to form between the two jetties resulting in the transport patterns determined for TE 2. In addition the flood tide will also produce a similar sediment transport pattern. Thus the directions of sediment transport within TE 2 may be the result of both flood and ebb directed currents.

The uniqueness of TE 2 (i.e., that it is a separate Transport Environment) is likely due to the presence of disposed material in the North Jetty Site, which is providing an extraneous new sediment source. There is some evidence from the grain-size data of material leaving the disposal site and circulating in the pattern derived by the trends (e.g., see Figure 7). Had there been no disposal, it is likely that TE 2 would be merely an extension of TE 1B (Columbia River Channel) or even TE 3A (Inner South Shelf).

5.1.2 Nearshore Shelf (TE 3)

From a review of the existing literature, there seems to be general agreement that the net direction of littoral transport is northwards on the seaward side of the Columbia River mouth. This direction may be correlated with the northward flowing Davidson Current that prevails during the winter months, as well as the prevalence of the strongest storms coming from the south and southwest. Not reported in the literature, however, is the relationship between Clatsop Spit south of the entrance and Peacock Spit on the north side. If transport from south to north dominates, it follows that Peacock Spit cannot really be a spit (i.e., a coastal landform trending in the direction of the dominant littoral drift) Rather it fits the morphology of a downdrift offset where the beach on the downdrift side of the inlet is seaward to the beach on the updrift side. Downdrift offsets are formed by a combination of strong ebb currents that collide with a longshore current to produce a shoal on the downdrift side (Bruun, 1978). In this case, the shoal is the erroneously named Peacock Spit. Downdrift offsets are less common than updrift offsets and the explanation in this case is probably, at least in part, geological since the north side of the Columbia River is stabilized by bedrock (i.e., Cape Disappointment).

The suggestion that the coastal landforms found on either side of the Columbia River is a downdrift offset requires that the dynamics associated with the mouth of the Columbia River must provide a bypassing system whereby sediment is able to be transported across its entrance from south to north. That such a bypassing system exists is supported by plan views of the entrance over time. In 1844 Clatsop and Peacock Spits are evident as sand bodies, but Peacock Spit does not have the morphology of a spit. In 1876, Clatsop Spit still exists, but Peacock Spit has broken apart, forming a large bar in the middle (Fig.8). Such changes can be expected in sand bodies associated with a sediment bypassing system, simply through relatively small perturbations in river flow, storm activity and sediment supply. In 1895, the first part of the South Jetty was completed and the sand body associated with Peacock Spit totally disappeared as the breakwater temporarily blocked the northward movement of sand. By 1910 the barrier effect of the South Jetty was overcome and sand is seen again on the north side, as a sediment bypassing system becomes re-established (Fig.9). To lend further support to the concept of a sediment bypassing system crossing the mouth of the Columbia River forming a downdrift offset, similar downdrift offset morphologies (suggesting similar bypassing systems) are seen at the entrances to Willapa and Grays Harbors to the north (Fig.9).

The transport of sediments into and out of the entrance is supported by the known estuarine circulation, which is characterized by the flood favoring the southern side of the river channel (along the south jetty and Clatsop Spit) and the ebb flow dominating the northern side (Sternberg et al., 1977). On a local scale, the patterns of transport in the vicinity of ODMDS E and Peacock Spit as determined by bathymetric changes (Fig.11), agree extremely well with the findings of the STA for the same area.

5.1.3 Mid Shelf (TE 4)

The radiating pattern of sediment transport defining this environment originates out of ODMDS B (Fig.5). This location is a "sediment-parting zone", a term first introduced by Stride (1963). Such a term may, at first, seem paradoxical in that it implies an area that is able to maintain a continuous source of sediment. STA carried out in a number of estuaries and marine environments has found parting zones to be relatively common (e.g., they have been defined in the Bristol Channel, Carmarthen Bay, and Morecambe Bay in the UK, the Waddenzee tidal basins in Holland, and in Washington Narrows, Puget Sound). In these studies, it has been argued that parting zones, which clearly cannot provide a continuous supply of sediment forever, must be periodically loaded with sediments during extreme events (An obvious event in this case could be an exceptionally high sediment yield from the Columbia River), after which more "normal" transport processes distribute the sediments into the derived patterns of transport. On the other hand, this parting zone might be simply eroding into the foreslope of the Columbia River Mouth Bar that was an actively prograding feature at a time of greater sediment yields out of the Columbia River. Quite probably, the disposal of dredged material is helping to keep the parting zone replenished as mounding has been documented at the disposal site.

There are several lines of evidence to support the radiating pattern of transport found for this environment. Comparative bathymetry at ODMDS B has documented a similar radiating dispersal pattern of the mounded material (Mark Siipola, pers. comm., 2001). Early work using bottom drifters also show a similar landward transport (Morse et al., 1968, reported in US Army Corps of Engineers, 1991). It is highly likely that wave induced oscillatory currents are of sufficient strength at these depths to induce sediment motion (Sternberg and Larson, 1976). The radiating pattern may be in response to the morphology of the bar and landward moving bottom waters caused by the large amount of outflowing freshwater across the sea surface from the Columbia River.

5.1.4 Outer Shelf (TE 5)

The driving forces for the patterns of transport in TE 5 are likely similar to those described for TE 4. In this deeper water facies, the landward movement of sediment does not have a central focus, which ODMDS B at the base of the bar has provided for TE 4. In the deeper waters of TE 5, the bar morphology is no longer present, and the transport of sediment is roughly across the lines of bathymetry.

5.2 Implications for dredging and disposal operations

As is seen in Figure 5, most of the pathways cross the dredged entrance channel at an angle ranging from a few degrees to perpendicular. In general terms, the greater the angle between a dredged channel and the net transport pathways, the greater will be the trapping effect of the channel. The dredged entrance channel would, therefore, appear to be an effective trap for the sediments in TE 3 and 4B, and much of 4A (Fig.6). ODMDS A lies in TE 4A, and in 1958 this site was temporarily discontinued when it was suspected, on the basis of bottom current data, that material was being returned to the navigation channel (US Army Corps of Engineers, 1999). Certainly the findings of the STA confirms a direct route from ODMDS A back to the navigation channel (Fig.5). Most of the trends crossing the channel are either showing Net Erosion (TE 3B) or Mixed Case (TE 4B) which is both erosion and accretion occurring down the transport path. It might be expected that more Net Accretion should be present in lines associated with the channel; however, the sampling density only allowed one or two samples on any particular transport line crossing the navigation channel; an insufficient number to delineate a separate dynamic behavior from the rest of the line. Undoubtedly, a separate, dense sample grid in the channel and its immediate vicinity would reveal distinct depositional trends occurring inside the channel.

With the exception of TE 1B (the Columbia River Channel) which parallels the dredged channel, it appears that most of the deposition occurring in the mouth is the result of marine sediments in their passage from south to north. It is perhaps for this reason that there is virtually no identifiable "sedimentological signature" associated with any of the disposal sites (i.e., marine sediments are dredged and placed in marine disposal sites with very little change in their textural qualities). The ABC Analysis also failed to find a unique signature associated with either dredging or dredged material disposal (Appendix II). Another reason, and not mutually exclusive of the first, is that the environment is sufficiently dynamic to allow rapid dispersal and mixing with "natural sediments" out of the disposal sites.

The only exception is seen in the dispersal out of the North Jetty Site (TE 2). Various textural characteristics (notably sorting, Fig.7) roughly follow the patterns of transport as determined by the STA. There is evidence for seabed lowering occurring along the south side of the North Jetty (trend lines adjacent to the jetty show Net Erosion; see Lines 15 to 22, Fig.4). The dredged material disposal program has been designed to help replace this loss (US Army Corps of Engineers, 2001); however the trends also suggest that material from the disposal site may be contributing to deposition in the main navigation channel. Disposal in the North Jetty Site appears, therefore, to be a double-edged sword in that the consequences are not altogether favorable.

With respect to the desirability of using one disposal site over another, the findings of the STA suggest that all disposal sites presently being used (as shown on Fig.1) are, to some degree, dispersive. The rate of dispersion is undoubtedly depth related with material moving out of deeper sites more slowly than shallower ones. The following is a brief outline of the consequences of using each site:

ODMDS A: As discussed above, its location evidently insures the return of material back to the dredged channel. For this reason, it would seem undesirable to continue using this site.

ODMDS B: At least some of the pathways indicate a return to the dredged entrance channel, although it might be only a small proportion. If it is undesirable to have this site as one that is non-dispersive, this site should be avoided.

ODMDS E: This is the most highly dispersive site of all. Little, if any, material is being returned to the dredged entrance channel, making this probably the most desirable site (with the possible exception of ODMDS F). Again, if dispersion is undesirable, this site should not be used. It is the most favorable site to ensure replenishment of coastal sediments to the north (discussed below).

ODMDS F: There is only a very small likelihood of sediment return from this site. The amount will increase if the expanded area to the northeast is used, as more of the pathways circulate back to the dredged channel in this region.

5.3 Implications for coastal erosion

The results of the STA clearly show that the nearshore shelves and beaches on both sides of the Columbia River mouth are sediment starved (i.e., most of the lines in TE 3 are undergoing Net Erosion). The amount of sand from the Clatsop side of the river mouth is, therefore, insufficient to maintain the shelf and associated beaches on the north side. Given that Peacock Spit formed rapidly following jetty construction, it appears likely that the amount of sediment from the Columbia River able to join into the northward regime has been greater in the past. Very little sediment from the Columbia River itself is being made available to the beaches. According to Sherwood and Creager (1990), there was roughly twice the sediment yield from the river prior to dam construction. Today, the source for the coast is mainly marine, although the sediment source from the outer bar (TE 4) may have originally been Columbia River sediment.

At present there is some controversy over where to place material dredged from the navigation channel. Given the considerable erosion problems to the north, disposal in ODMDS E is clearly a desirable location. However, it must be stressed that the shelf in its entirety is sediment starved, and placing temporarily trapped material from the channel onto ODMDS E will be insufficient to replenish the beaches or to halt the erosion. Additional material, such as from the Columbia River channel, would be required.

6.0 SUMMARY AND CONCLUSIONS

(1) STA was performed on 1,231 samples taken from the Columbia River Mouth. Concurrent with the sediment sampling program, an Acoustic Bottom Classification (ABC) was carried out to water depths of 100 m. In all, nearly 850 km of sea bottom were mapped by ABC.

(2) Nearly all the samples (91%) consisted of pure sand (i.e., <20% of any other size fraction). The few muddy sand and sandy mud samples were confined mainly to water depths of >60 ft.

(3) 186 samples sequences were found to describe the sediment transport regime of the Columbia River Mouth. These were divided into 5 principal Transport Environments (TE)

(4) It was found that the Columbia River itself has a relatively minor effect on the overall sedimentation. Deposition from the river could be traced in the main channel only to a little beyond Jetty A (to about RM 2).

(5) A clockwise gyre has formed between Jetty A and the North Jetty in response to the ebb flow in the river. The same transport paths could be expected during the flood.

(6) The entrance is dominated by a nearshore/littoral transport regime extending from the south side, into and out of the entrance and onto the shelf on the north side. This pattern conforms to the concept that Peacock Spit is not a spit in the morphological sense of the word, but rather it is a downdrift offset. Historically, Peacock Spit, compared to Clatsop Spit, is an unstable sand body that easily breaks up into bars and rejoins the land depending on variations in sediment supply, waves and currents, storm activity etc. This behavior is typical of bars that are formed in a sediment bypassing system which, in this case, is from south to north across the river mouth. The driving process for this regime is likely the Davidson Current, which is strongest in winter, and storms from the south.

(7) Farther offshore at the seaward base of the ebb delta, the pathways radiate landwards. Probably coincidentally, they originate at ODMDS B, a site where mounding of disposed material is known to occur. Wave action, the outflowing freshwater from the Columbia River, and the morphology of the delta are likely responsible for the derived patterns.

(8) In the deep water portion of the study area, trends are dominantly landward.

(9) The grain-size data, the STA, and the results of the ABC all failed to find an identifiable "sedimentological signature" associated with dredging in the channel, or with the disposal sites. This suggests that the material being dredged is more or less identical to the "natural" sediments, or the dispersal of dredged material is rapid and quickly diluted with the natural sediments. These two reasons are probably not mutually exclusive of each other.

(10) At least some of the material disposed of in Sites B and A is likely to return to the navigation channel. Sites F and E, on the other hand, are located in environments where the transport pathways show that a return is unlikely.

(11) The STA shows that the nearshore shelf on both sides of the entrance is sediment starved with the result that the coasts are eroding. Material placed in ODMDS E is very likely to help maintain beaches to the north. However only material from the channel will not be sufficient to replenish beach material, or to halt erosion. A larger supply of sediment would be required from elsewhere, the Columbia River being the most obvious source.

7.0 ACKNOWLEDGMENTS

Sincere thanks are extended to Mark Siipola of the Portland District, US Army Corps of Engineers for instigating and supporting this project. The efforts of Dr. Ray Walton of West Consultants in managing GeoSea's subcontract are gratefully acknowledged.

On board help during the sampling program include Daniel Eggers and Leo Kreymborg of West Consultants, and Patrick Hill (student). Dušan Markovic of GeoSea provided field support and analyzed all the samples. Dr. Steven Hill (GeoSea) carried out the ABC portion of the project, and undertook quality control, sample design and computer support throughout the duration of the study.

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Figure 1: Location map, place names used in text, and sample locations

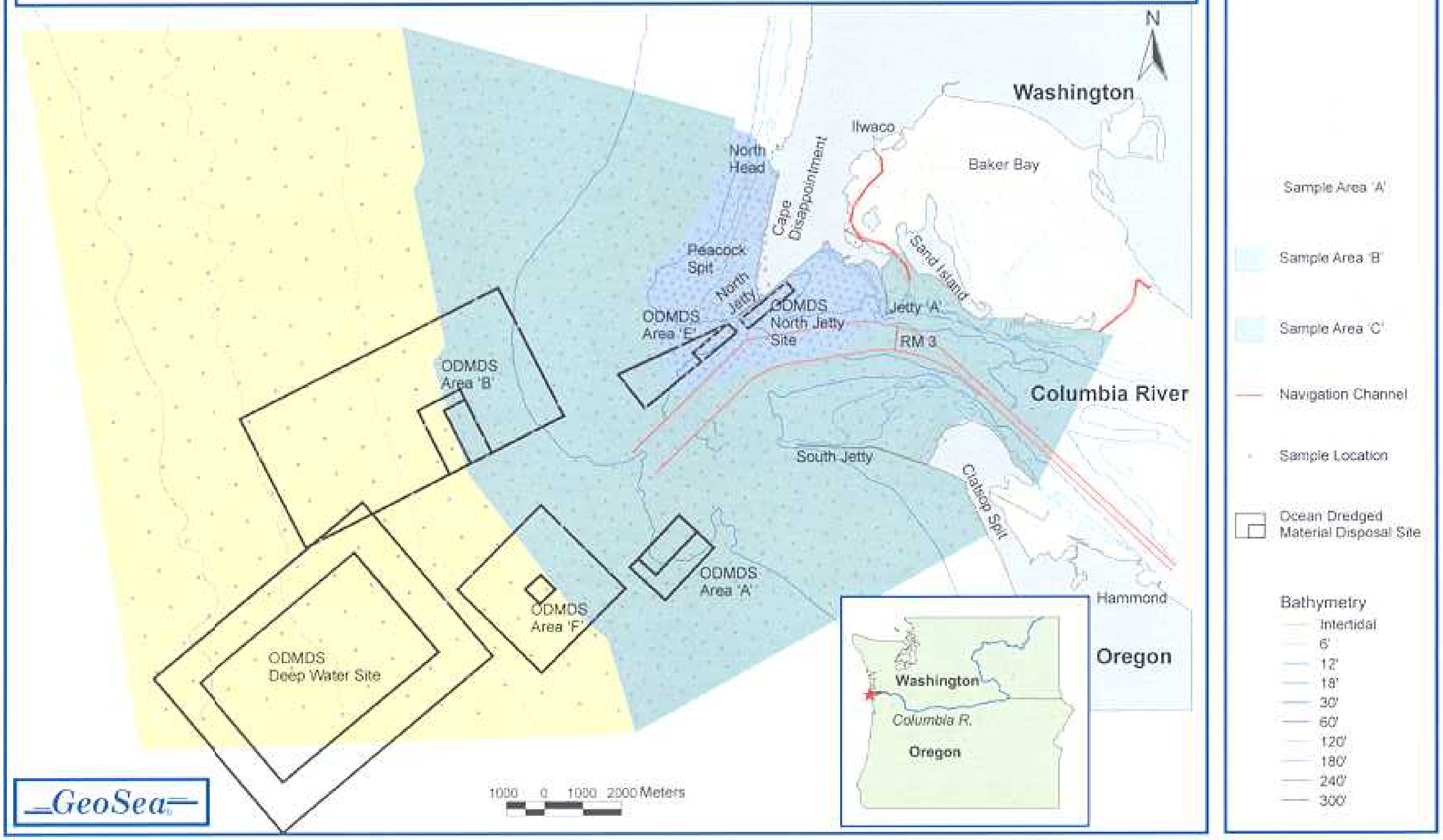
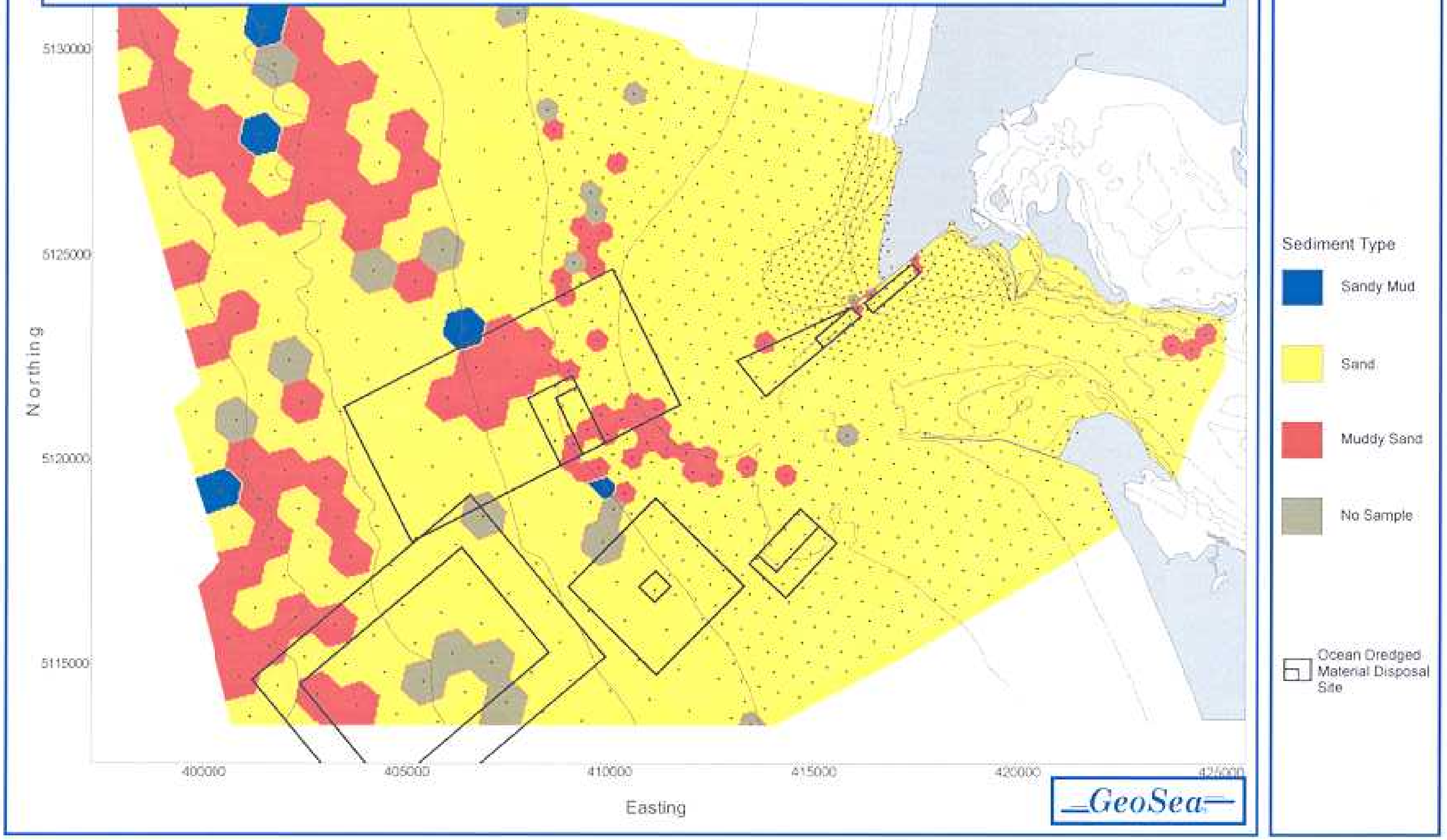


Figure 2: Sediment Types



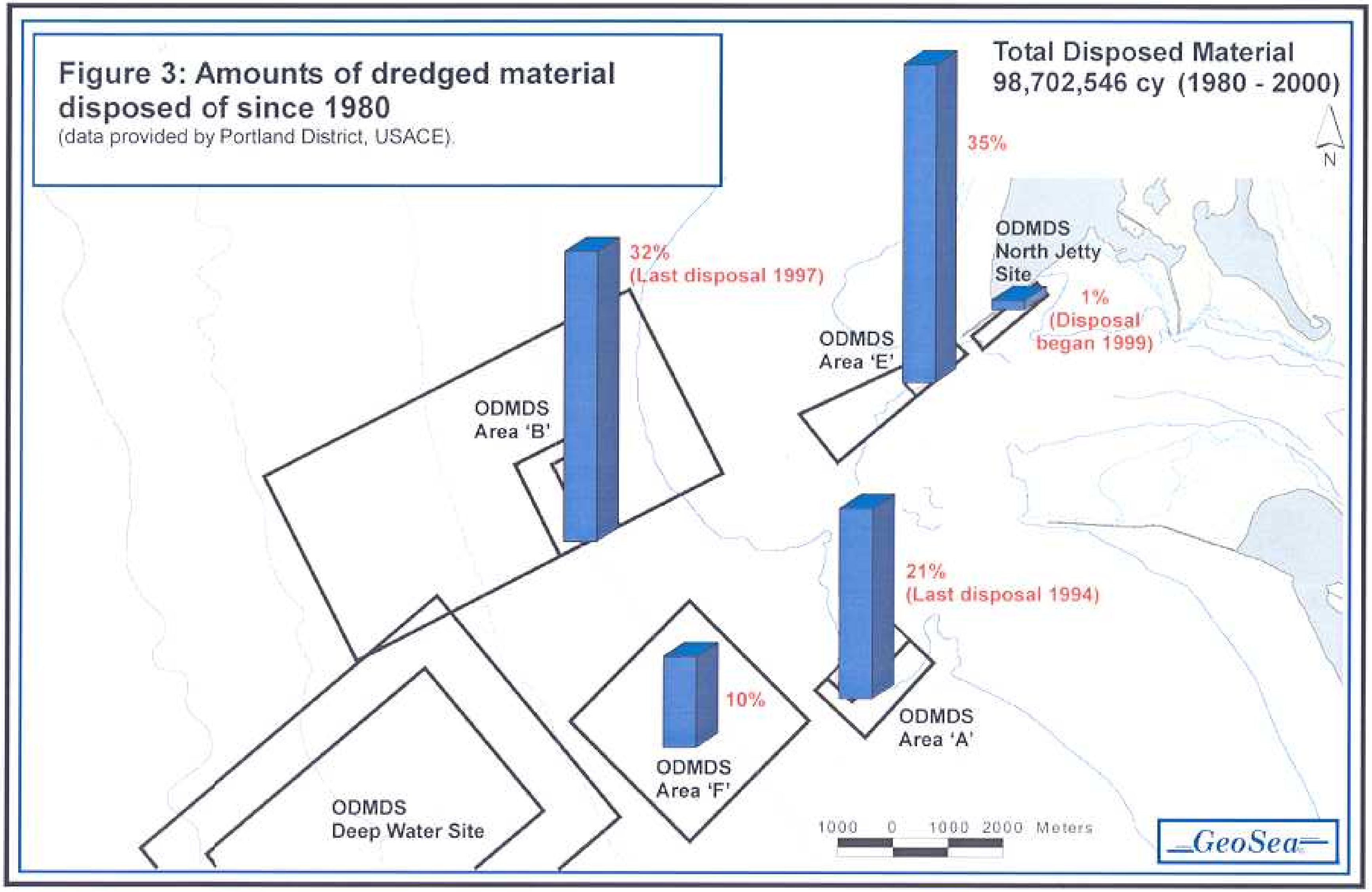


Figure 3: Amounts of dredged material disposed of since 1980
(data provided by Portland District, USACE).

Figure 4: Sample lines used to determine net sediment transport pathways

(see Appendix IV).

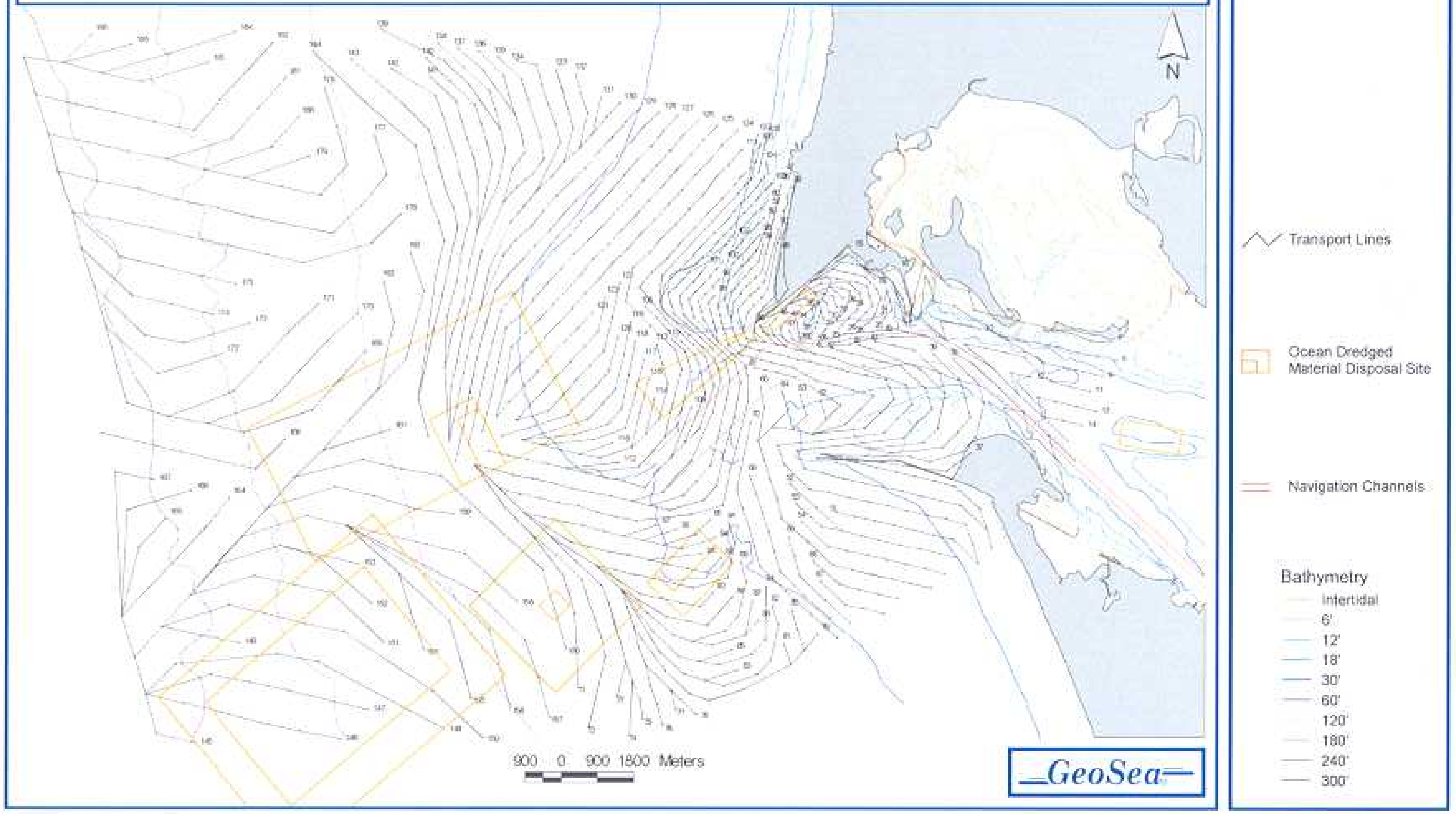


Figure 5: Net sediment transport pathways.

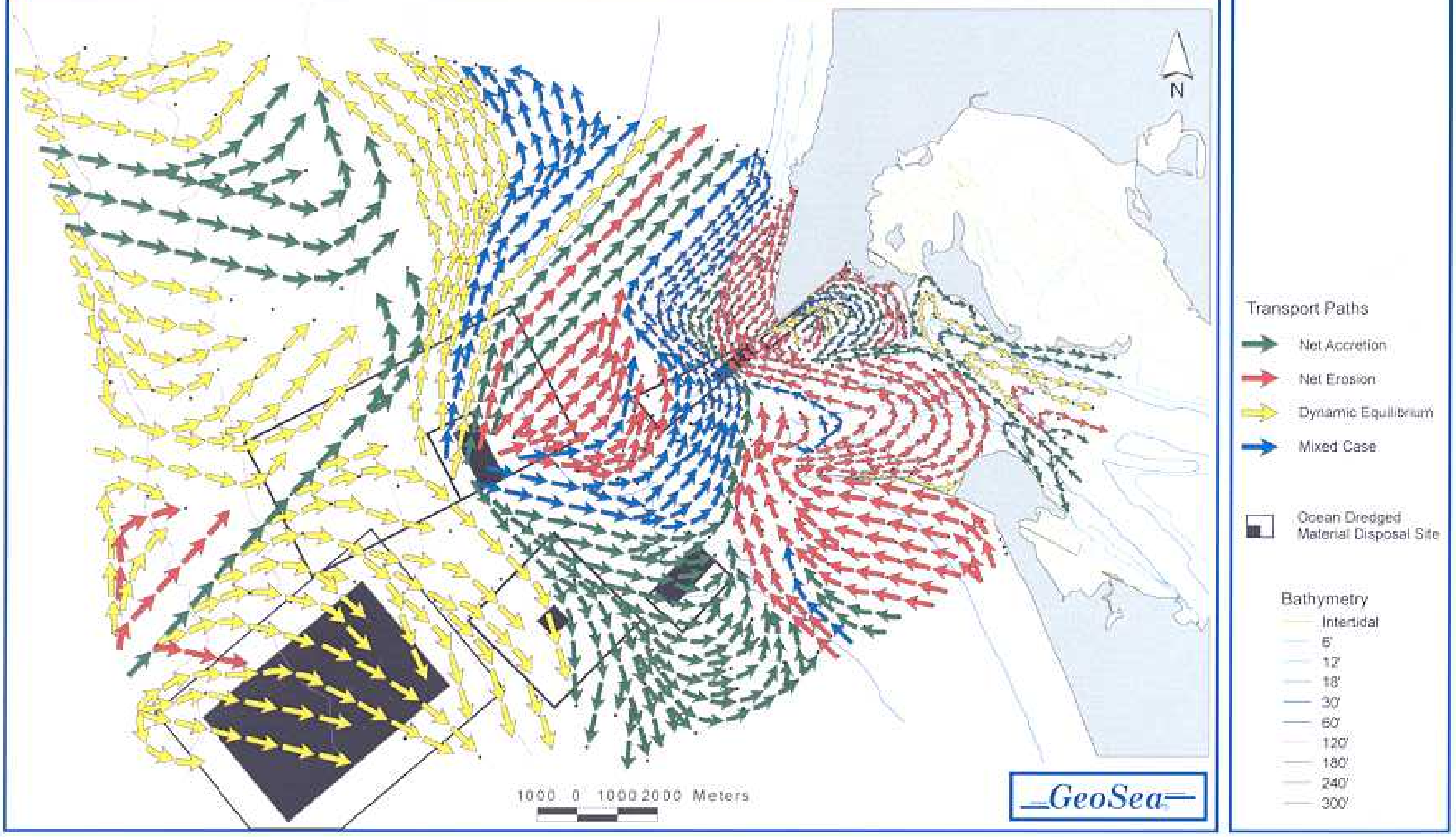


Figure 6: Sediment transport environments.

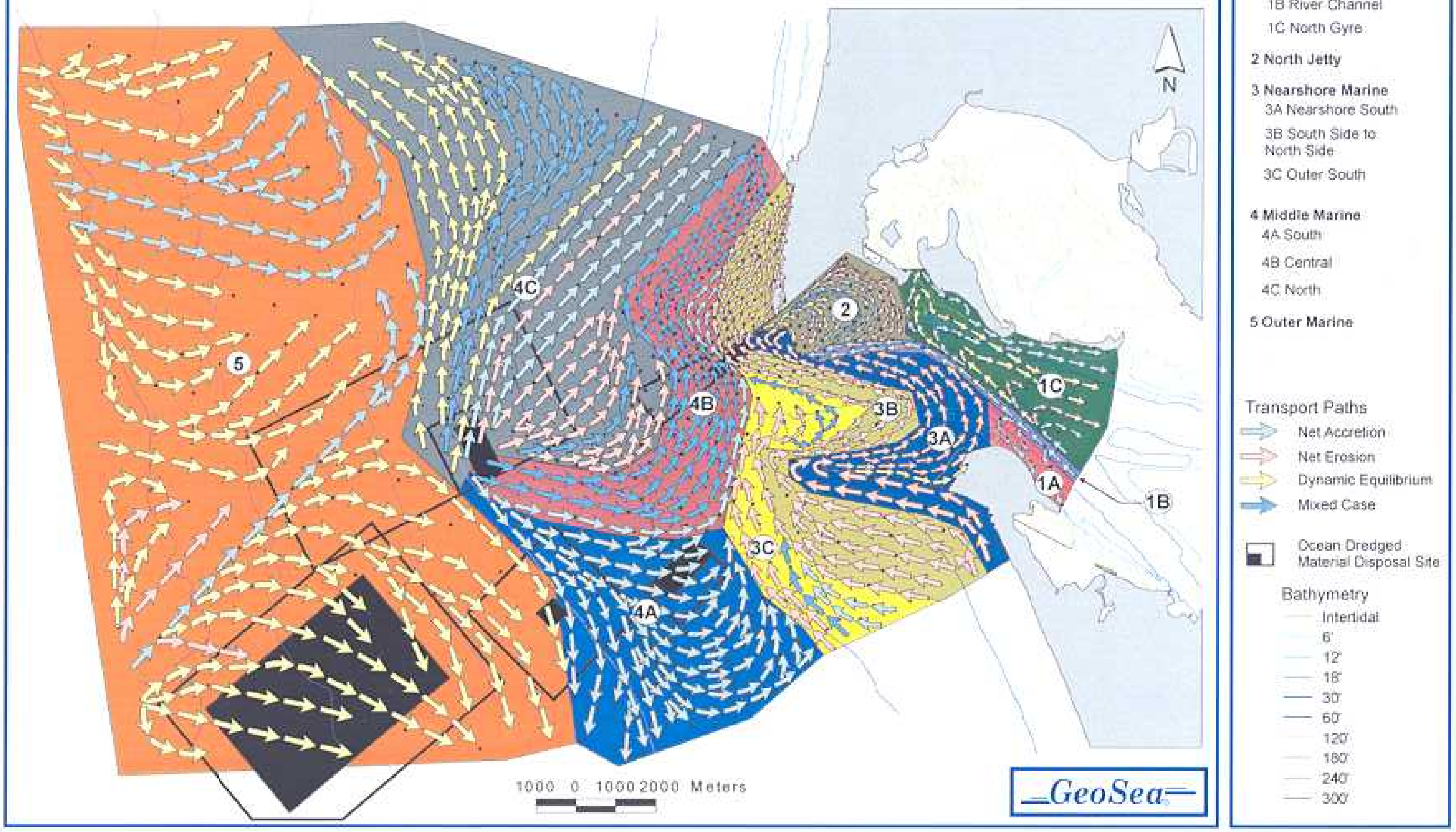


Figure 7: Map of sediment sorting suggesting that material is emanating from the North Jetty Disposal Site in a clockwise circulation.

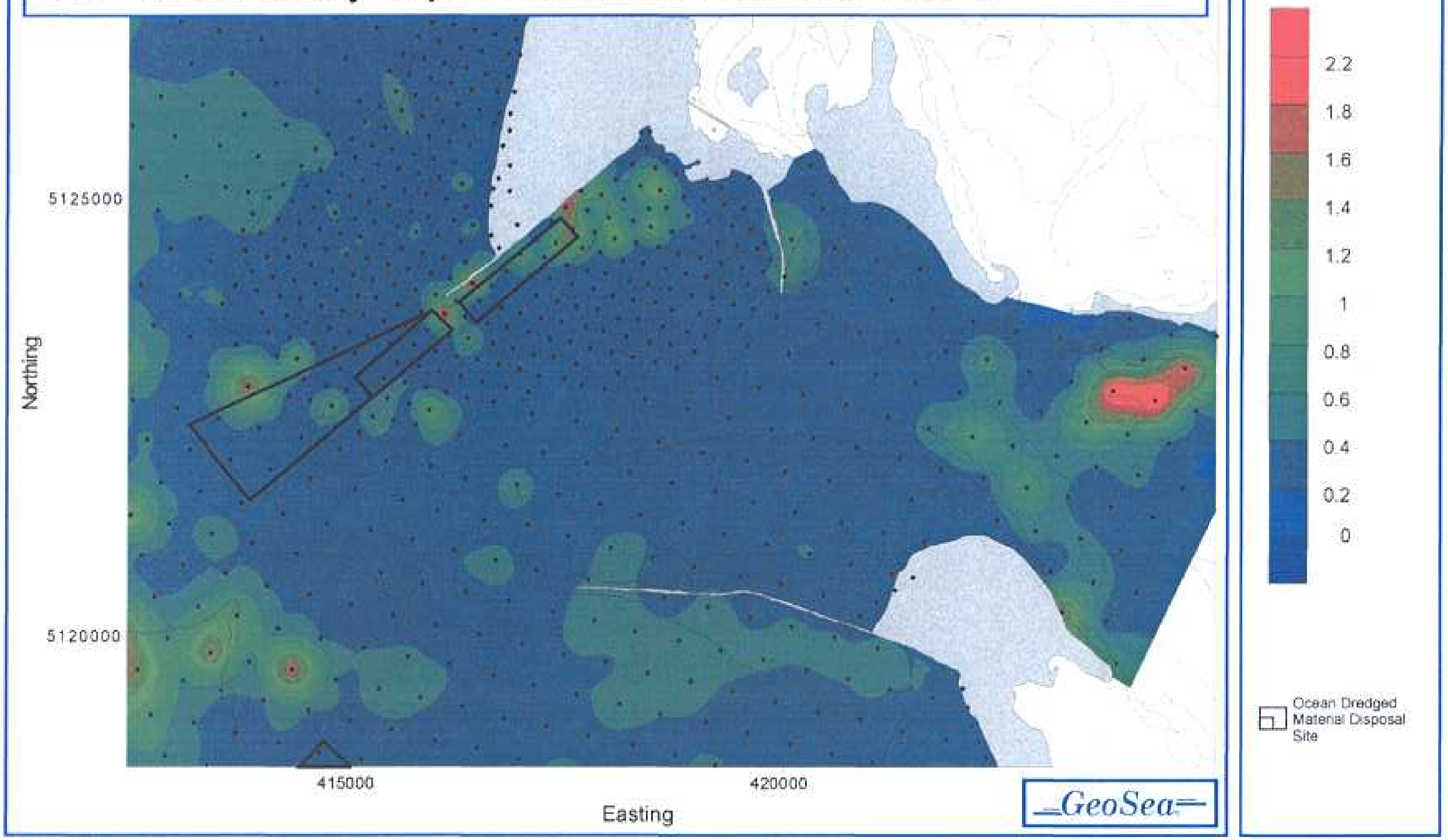
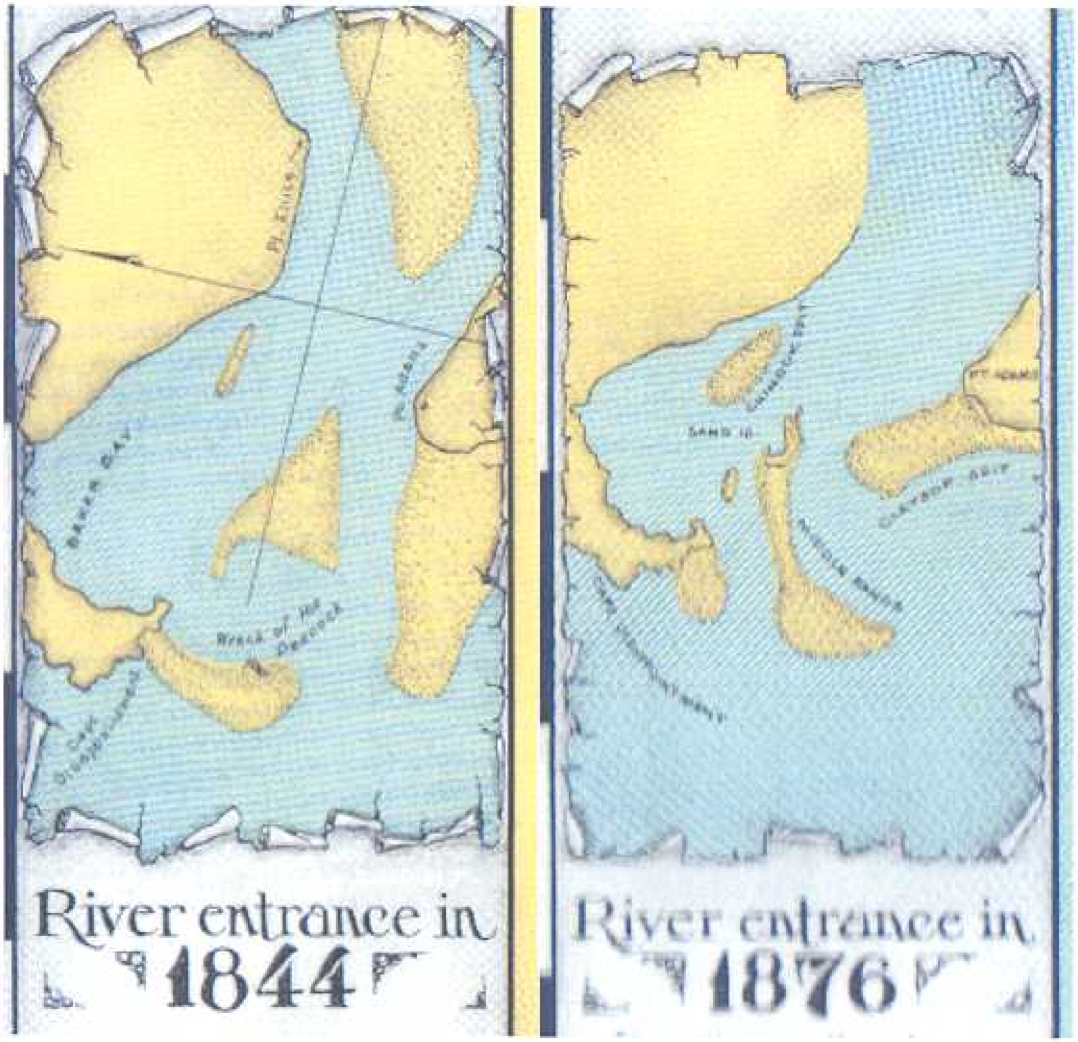
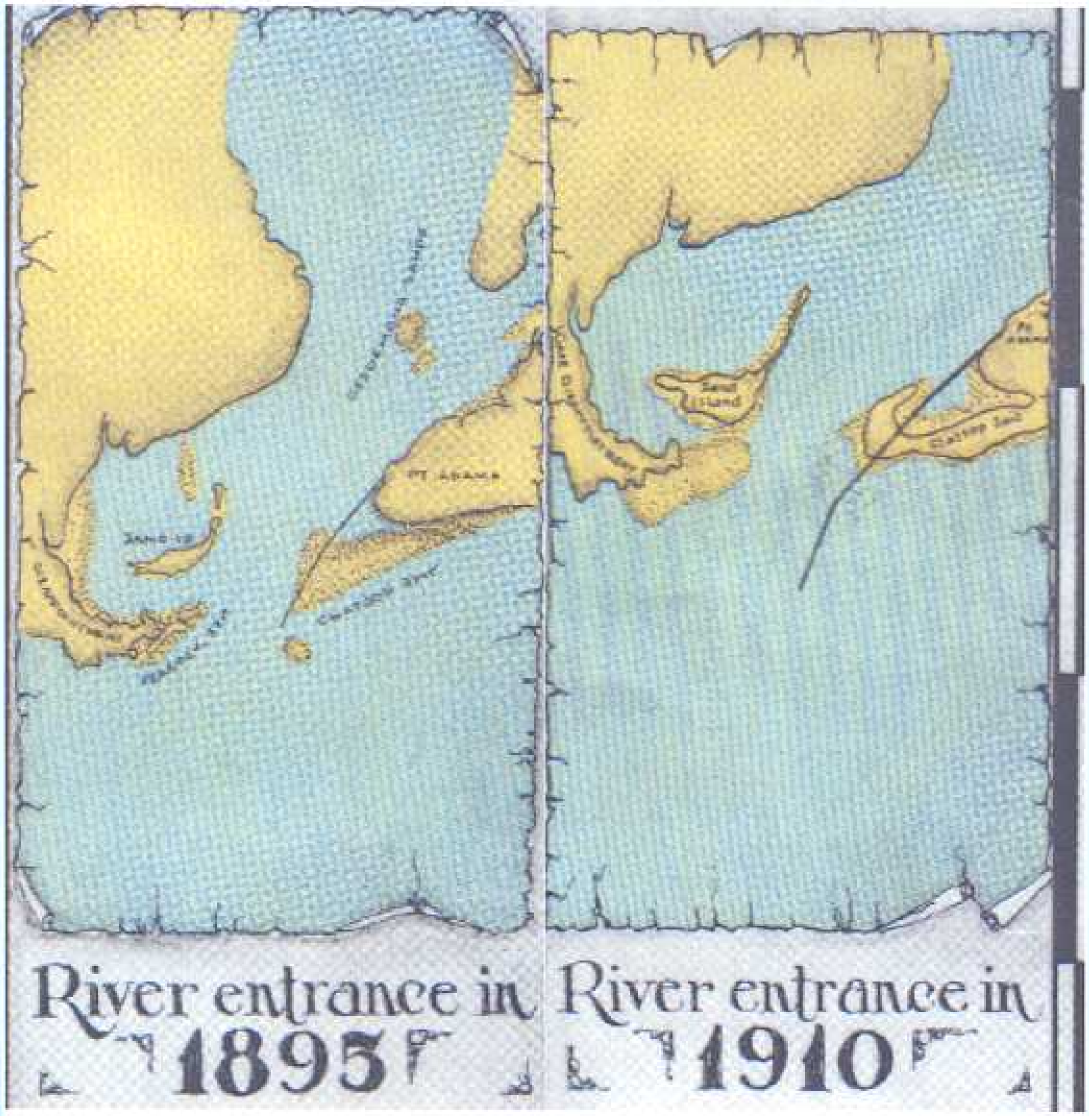


Figure 8: The river mouth in 1844 and 1876 (from McBean, 1936).
The sand body known as Peacock Spit is unstable, forming bars, or coalescing with the shoreline in response to small changes in sediment supply, flow conditions or storm activity.



GeoSea

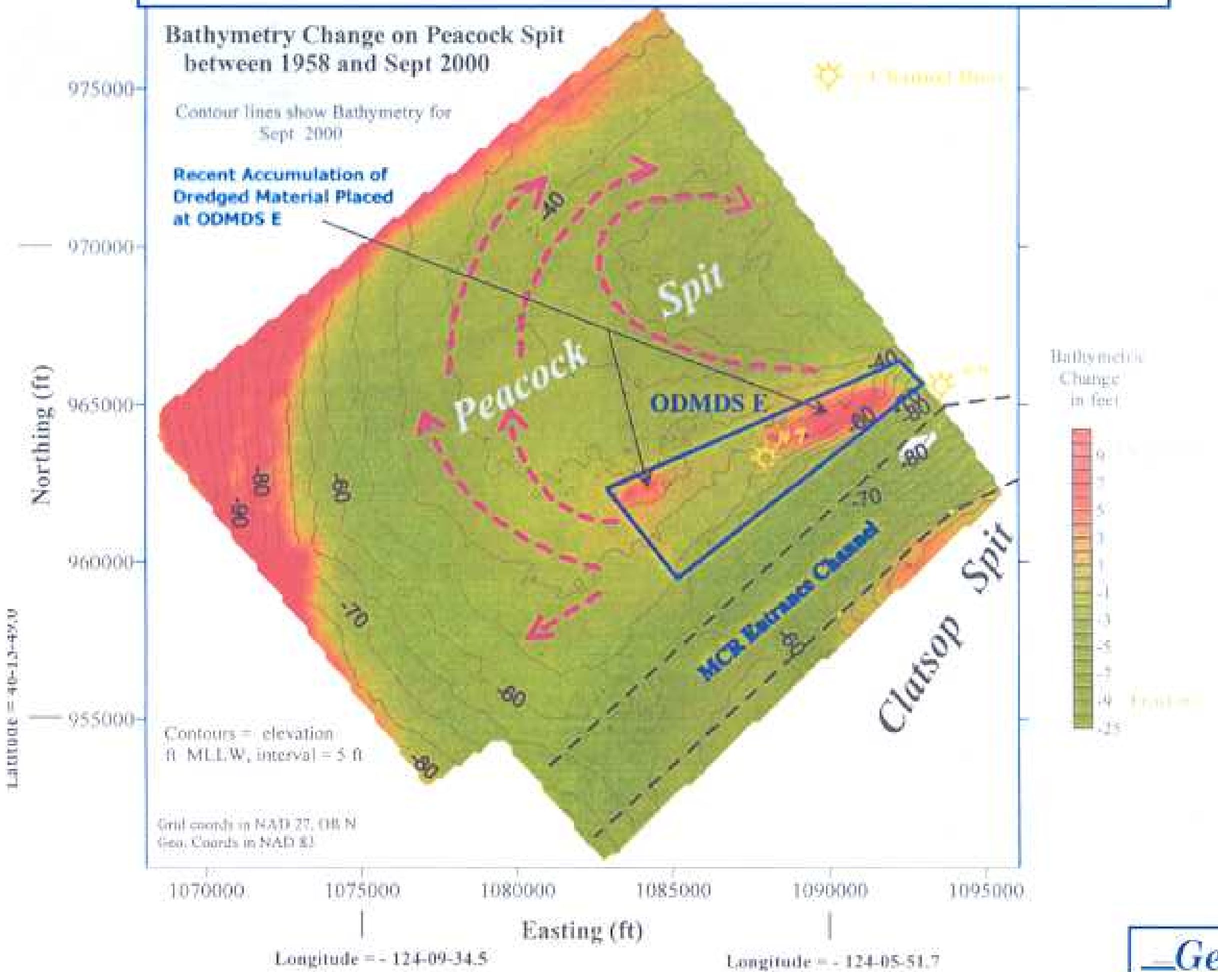
Figure 9: The river mouth in 1895 and 1910 showing the re-establishment of the sediment by-passing system from south to north following the construction of the South Jetty (maps from McBean, 1936).



GeoSea

Figure 10: Plan view of the coast of Washington showing downdrift offset morphology at Willapa and Grays Harbors.

Figure 11: Inferred directions of sediment transport on Peacock Spit.
(US Army Corps of Engineers, 2001)



APPENDIX I

Sediment Transport Model

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1 SEDIMENT TRANSPORT MODEL

The following is a brief review of the sediment transport model, a detailed analysis of which is contained in McLaren and Bowles (1985). The required information used throughout this analysis is the grain-size distribution which, for the purpose of Sediment Trend Analysis, is defined for any size class as the probability of the sediment being found in that size class. Size classes are defined in terms of the well-known ϕ (phi) unit, where d is the effective diameter of the grain in millimeters.

$$\mathrm{d(mm)} = 2^{-\phi} \text{ ; or } \log_2 \mathrm{d(mm)} = -\phi$$

Given that the grain-size distribution $g(s)$, where s is the grain size in phi units, is a probablility distribution, then

$$\int_{-\infty}^{\infty} g(s)ds = 1$$

In practice, grain-size distributions do not extend over the full range of s, and are not continuous functions of s. Instead we work with discretized versions of $g(s)$ with estimates of $g(s)$ in finite sized bins of 0.5ϕ width.

Three parameters related to the first 3 central moments of the grain-size distribution are of fundamental importance in Sediment Trend Analysis. They are defined here, both for a continuous $g(s)$ and for its discretized approximation with N size classes. The first parameter is the mean grain size (μ), defined as:

$$\mu = \int_{-\infty}^{\infty} s \cdot g(s)ds \approx \sum_{i=1}^{N} s_i \cdot g(s_i)$$

The second parameter is sorting (σ) which is equivalent to the variance of the distribution, defined as:

$$\sigma^2 = \int_{-\infty}^{\infty} (s-\mu)^2 \cdot g(s)ds \approx \sum_{i=1}^{N} (s_i - \mu)^2 \cdot g(s_i)$$

Finally, the coefficient of skewness (κ) is defined as:

$$\kappa = \frac{1}{\sigma^3} \int_{-\infty}^{\infty} (s-\mu)^3 \cdot g(s)ds \approx \frac{1}{\sigma^3} \sum_{i=1}^{N} (s_i - \mu)^3 \cdot g(s_i)$$

1.1 Case A (Development of a lag deposit)

Consider a sedimentary deposit that has a grain-size distribution *g(s)* (Figure AI- 1). If eroded, the sediment that goes into transport has a new distribution, *r(s)*, which is derived from *g(s)* according to the function *t(s)* so that:

$$r(s_i) = k \cdot g(s_i) t(s_i)$$

$$\text{or} \quad t(s_i) = \frac{r(s_i)}{k \cdot g(s_i)}$$

where $g(s_i)$ and $r(s_i)$ define the proportion of the sediment in the i^{th} grain-size class interval for each of the sediment distributions. '*k*' is a scaling factor[1] that normalizes *r(s)* so that:

$$\sum_{i=1}^{N} r(s_i) = 1$$

$$\text{thus} \quad k = \frac{1}{\sum_{i=1}^{N} g(s_i) t(s_i)}$$

With the removal of *r(s)* from *g(s)*, the remaining sediment (a lag) has a new distribution denoted by *l(s)* (Figure AI- 1) where:

$$l(s_i) = k \cdot g(s_i)[1 - t(s_i)]$$

$$\text{or} \quad t'(s_i) = \frac{l(s_i)}{k \cdot g(s_i)}$$

$$\text{where} \quad t'(s_i) = 1 - t(s_i)$$

The function *t(s)* is defined as a sediment transfer function and is described in exactly the same manner as a grain-size probability function except that it is not normalized. It may be thought of as a function that incorporates all sedimentary and dynamic processes that result in initial movement and transport of particular grain sizes.

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1 'k' is actually more complex than a simple normalizing function, and its derivation and meaning is the subject of further research. It appears to take into account the masses of sediment in the source and in transport, and may be related to the relative strength of the transporting process.

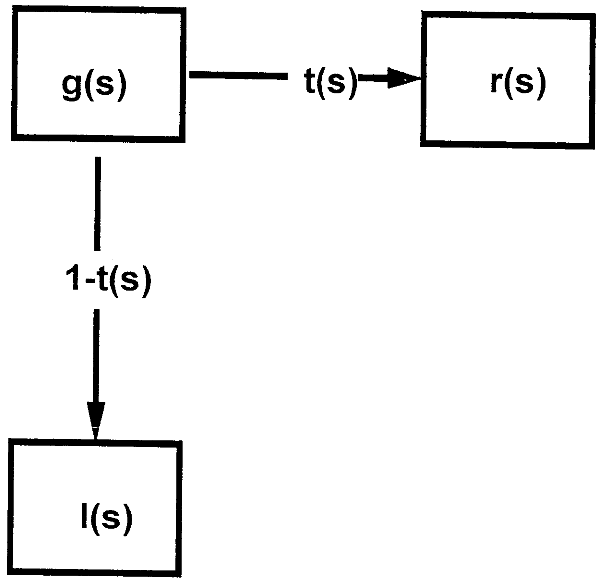


Figure AI- 1: Sediment transport model to develop a lag deposit (see the text for a definition of terms).

Data from flume experiments show that distributions of transfer functions change from having a high negative skewness to being nearly symmetrical (although still negatively skewed) as the energy of the eroding/transporting process increases. These two extremes in the shape of *t(s)* are termed low energy and high energy transfer functions respectively (Figure AI- 2). The shape of *t(s)* is also dependent, not only on changing energy levels of the process involved in erosion and transport, but also on the initial distribution of the original bed material, *g(s)*(Figure AI- 1). The coarser *g(s)* is, the less likely it is to be acted upon by a high energy transfer function. Conversely, the finer *g(s)* is, the easier it becomes for a high energy transfer function to operate on it. In other words, the same process may be represented by a high energy transfer function when acting on fine sediments, and by a low energy transfer function when acting on coarse sediments. The terms high and low energy are, therefore, relative to the distribution of *g(s)* rather than to the actual process responsible for erosion and transport.

The fact that *t(s)* appears to be mainly a negatively skewed function results in *r(s)*, the sediment in transport, always becoming finer and more negatively skewed than *g(s)*. The function *1-t(s)* (Figure AI- 1) is, therefore, positively skewed, with the result that *l(s)*, the lag remaining after *r(s)* has been removed, will always be coarser and more positively skewed than the original source sediment.

If *t(s)* is applied to *g(s)* many times (i.e., *n* times, where *n* is large), then the variance of both *g(s)* and *l(s)* will approach zero (i.e., sorting will become better). Depending on the initial distribution of *g(s)*, it is mathematically possible for variance to become greater before eventually decreasing. In reality, an increase in variance in the direction of transport is rarely observed.

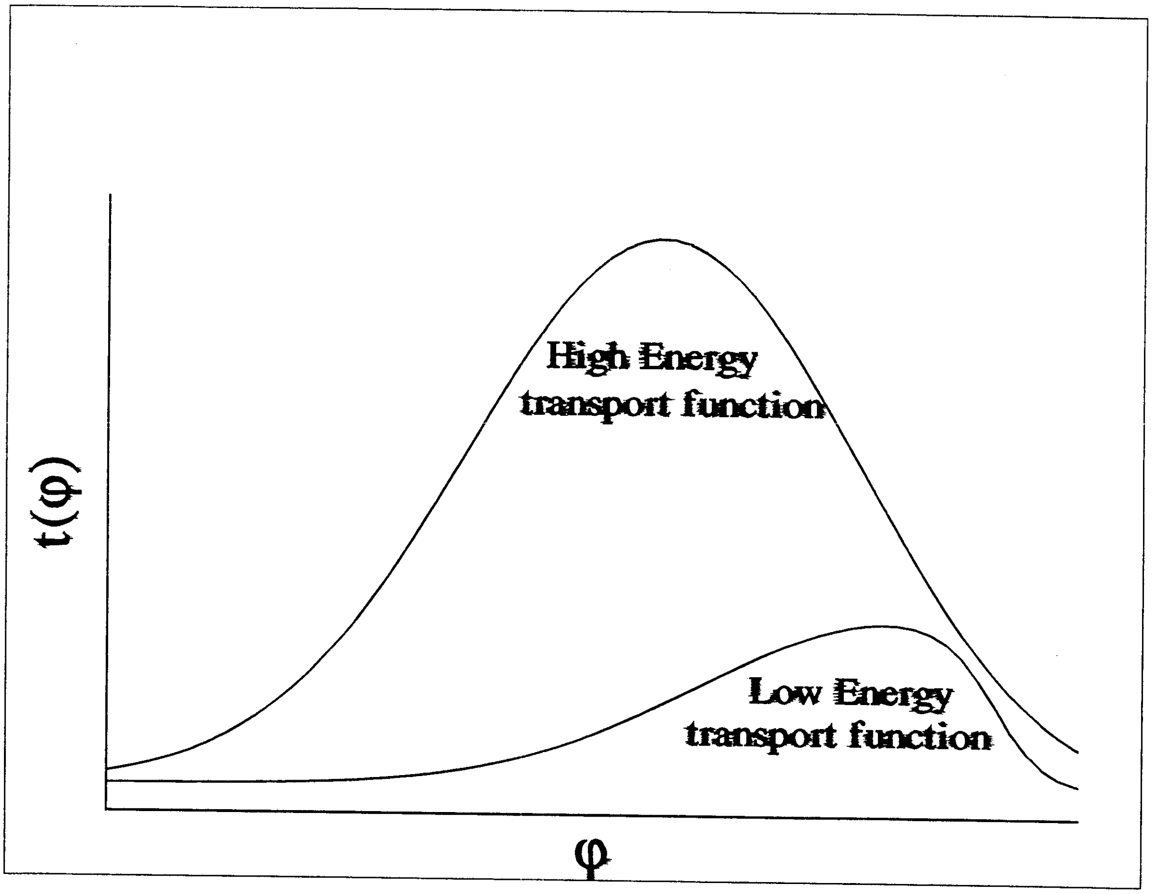


Figure AI- 2: Diagram showing the extremes in the shape of transfer functions t(φ).

Given two sediments whose distributions are, $d_1(s)$ and $d_2(s)$, and $d_2(s)$ is coarser, better sorted and more positively skewed than $d_1(s)$, it may be possible to conclude that $d_2(s)$ is a lag of $d_1(s)$ and that the two distributions were originally the same (Case A; Table AI- 1).

1.2 1.2 Case B (Sediments becoming finer in the direction of transport)

Consider a sequence of deposits ($d_1(s)$, $d_2(s)$, $d_3(s)$,...) that follows the direction of net sediment transport (Figure AI- 3). Each deposit is derived from its corresponding sediment in transport according to the "3-box model" shown in Figure AI- 1. Each $d_n(s)$ can be considered a lag of each $r_n(s)$. Thus, $d_n(s)$ will be coarser, better sorted and more positively skewed than $r_n(s)$. Similarly, each $r_n(s)$ is acted upon by its corresponding $t_n(s)$ with the result that the sediment in transport becomes progressively finer, better sorted and more negatively skewed. Any two sequential deposits (e.g., $d_1(s)$ and $d_2(s)$) may be related to each other by a function $X(s)$ so that:

$$d_s(s) = k \cdot d_1(s) \cdot X(s)$$

or $$X(s) = \frac{d_2(s)}{k \cdot d_1(s)}$$

where $$k = \frac{1}{\sum_{i=1}^{N} d_1(s_i) \cdot X(s_i)}$$

As illustrated in Figure AI- 3, $d_2(s)$ can also be related to $d_1(s)$ by:

$$d_2(s) = \frac{k \cdot d_1(s) t_1(s)[1 - t_2(s)]}{1 - t_1(s)}$$

$$= k \cdot d_1(s) X(s) \qquad (1)$$

where $$X(s) = \frac{t_1(s)[1 - t_2(s)]}{1 - t_1(s)} \qquad (2)$$

The function $X(s)$ combines the effects of two transfer functions $t_1(s)$ and $t_2(s)$ (Equation 2). It may also be considered as a transfer function in that it provides the statistical relationship between the two deposits and it incorporates all of the processes responsible for sediment erosion, transport and deposition. The distribution of the deposit $d_2(s)$ will, therefore, change relative to $d_1(s)$ according to the shape of $X(s)$ which, in turn, is derived from the combination of $t_1(s)$ and $t_2(s)$ as expressed in Equation 2. It is important to note that $X(s)$ can be derived from the distributions of the deposits $d_1(s)$ and $d_2(s)$ (Equation 1) and it provides the relative probability of any particular sized grain being eroded from d_1, transported and deposited at d_2.

Using empirically derived $t(s)$ functions, it can be shown that when the energy level of the transporting process decreases in the direction of transport (i.e., $t_2(s_i) < t_1(s_i)$) and both are low energy functions (Figure AI- 4), then $X(s)$ is always a negatively skewed distribution. This will result in $d_2(s)$ becoming finer, better sorted and more negatively skewed than $d_1(s)$. Therefore, given two sediments (d_1 and d_2) where $d_2(s)$ is finer, better sorted and more negatively skewed than $d_1(s)$, it may be possible to conclude that the direction of sediment transport is from d_1 to d_2 (Table AI- 1).

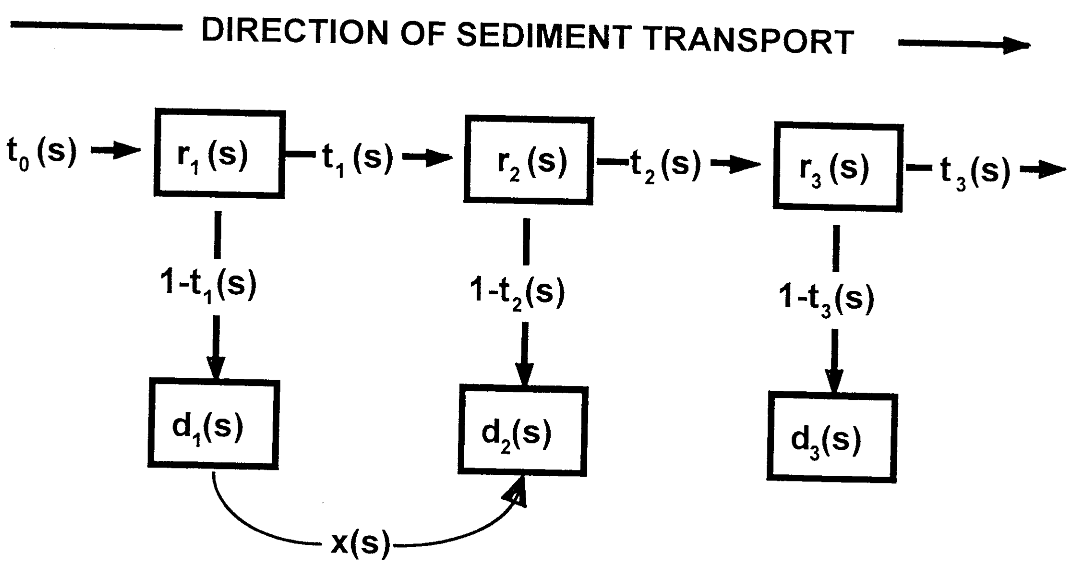


Figure AI- 3: Sediment transport model relating deposits in the direction of transport (see Appendix I for definition of terms).

1.3 1.3 Case C (Sediments becoming coarser in the direction of transport)

In the event that $t_1(s)$ is a high energy function (Figure AI- 2) and $t_2(s_i) < t_1(s_i)$ (i.e., energy is decreasing in the direction of transport), the result of Equation 2 will produce a positively skewed $X(s)$ distribution. Therefore, $d_2(s)$ will become coarser, better sorted and more positively skewed than $d_1(s)$ in the direction of transport (Figure AI- 4). When these changes occur between two deposits, it may be possible to conclude that the direction of transport is from d_1 to d_2 (Table AI- 1).

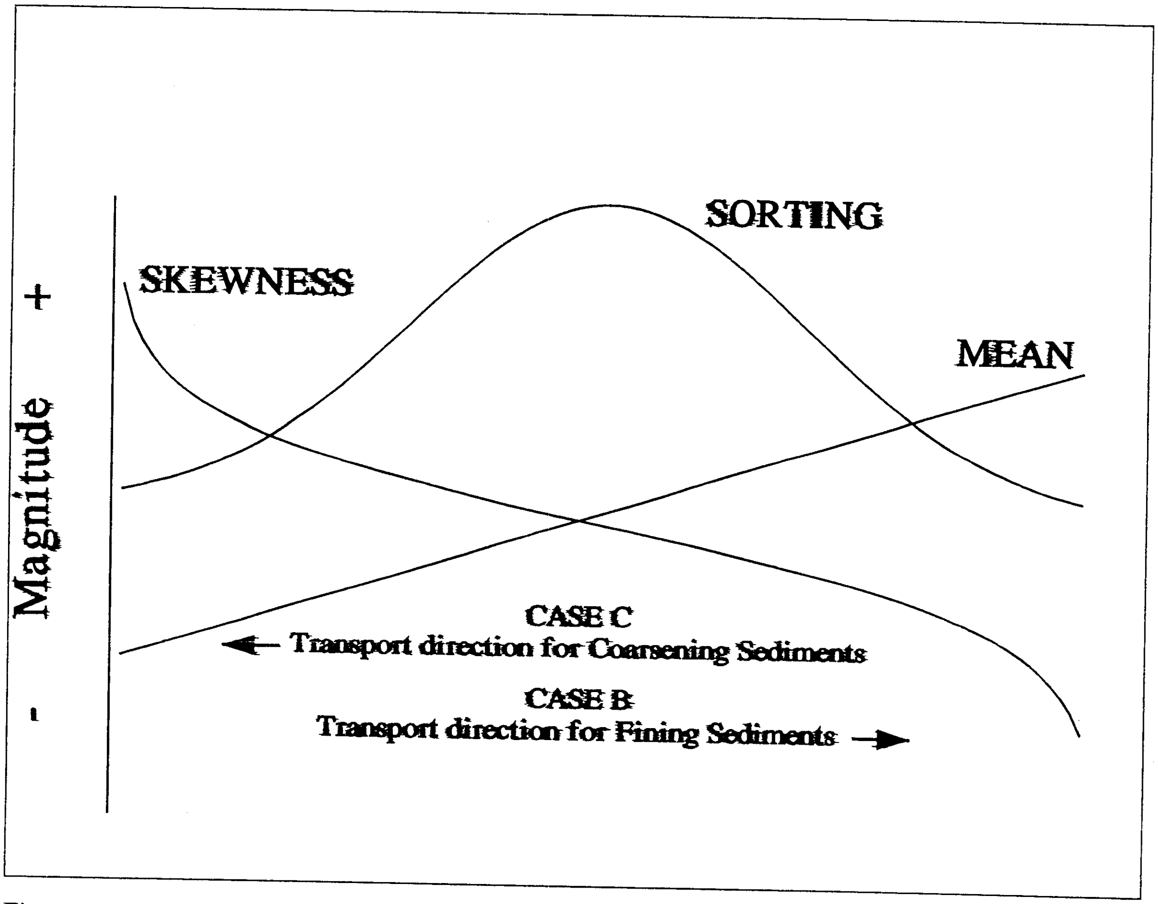


Figure AI- 4: Changes in grain-size descriptors along transport paths.

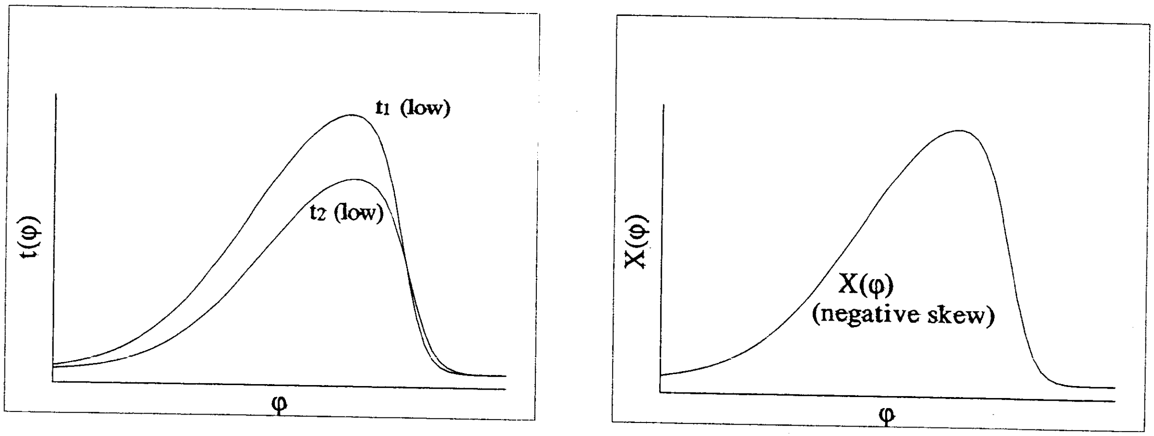
Table AI- 1: Summary of the interpretations with respect to sediment transport trends when one deposit is compared to another.

CASE	RELATIVE CHANGE IN GRAIN-SIZE DISTRIBUTION BETWEEN DEPOSIT d_2 AND DEPOSIT d_1	INTERPRETATION
A	Coarser Better sorted More positively skewed	d_2 is a lag of d_1. No direction of transport can be determined.
B	Finer Better sorted More negatively skewed	(i) The direction of transport is from d_1 to d_2. (ii) The energy regime is decreasing in the direction of transport. (iii) t_1 and t_2 are low energy transfer functions.
C	Coarser Better sorted More positively skewed	(i) The direction of transport is from d_1 to d_2. (ii) The energy regime is decreasing in the direction of transport. (iii) t_1 is a high energy transfer function and t_2 is a high or low energy transfer function (Figure AI- 5).

Sediment coarsening along a transport path will be limited by the ability of $t_1(s)$ to remain a high energy function. As the deposits become coarser, it will be less and less likely that the transport processes will maintain high energy characteristics. With coarsening, the transfer function will eventually revert to its low energy shape (Figure AI- 2) with the result that the sediment must become finer again.

Cases A and C produce identical grain-size changes between d_1 and d_2 (Table AI- 1). Generally, however, the geological interpretation of the environments being sampled will differentiate between the two Cases.

CASE B: $t_2 < t_1$; both low energy functions



CASE C: $t_2 < t_1$; t_1 is a high energy function; t_2 is high or low.

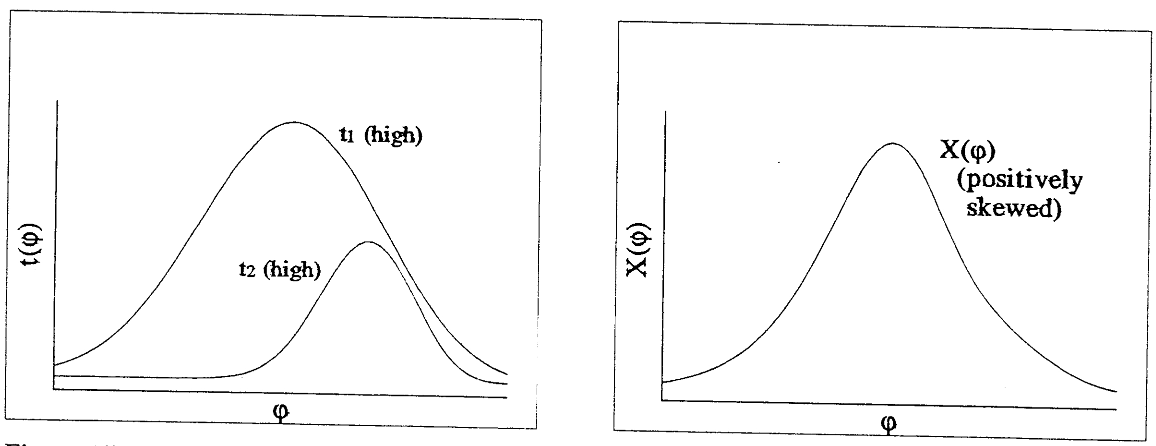


Figure AI- 5: Summary diagram of t_1 and t_2 and corresponding X-distribution (Equation 2) for Cases B and C (Table AI- 1).

2 METHOD TO DETERMINE TRANSPORT DIRECTION FROM GRAIN-SIZE DISTRIBUTIONS (SEDIMENT TREND ANALYSIS)

2.1 Uncertainties

The above model indicates that grain-size distributions will change in the direction of transport according to either Case B or Case C[2] (Table AI- 1; Figure AI- 4). Thus, if any

[2] Case A which defines the development of a lag deposit is not used to determine a sediment transport direction. There may be instances when a Case C transport direction is determined which, in fact, is not Case C transport, but rather Case A. For example, in some Arctic environments, sediments become progressively coarser, better sorted and more positively skewed from deep to shallow water. It is impossible to suppose that there is a high energy transport fumction operating on the deep water sediments resulting in Case C transport towards the shoreline. In this enviroment, ice action and currents result in the winnowing of the finer size fractions as the water shallows. Thus Case A indicating the development of a lag is the accepted Case, rather than Case C. As stated earlier, a geological interpretation may be required to differentiate between the development of a lag (Case A) and a genuine transport pathway (Case C).

two samples (d_1 and d_2) are compared sequentially (i.e., at two locations within a sedimentary facies), and their distributions are found to change in the described manner, the direction of net sediment transport may be inferred.

A Sediment Trend Analysis attempts to determine the patterns of net sediment transport over an area through the grain-size distributions of the sediments. The sampled sediments are described in statistical terms (by the moment measures of mean, sorting and skewness) and the basic underlying assumption is that processes causing sediment transport will affect the statistics of the sediments in a predictable way. Following from this assumption, the size frequency distributions of the sediments provide the data with which to search for patterns of net sediment transport.

In reality, perfect sequential changes along a transport path as determined by the model are rarely observed. This is because of a variety of uncertainties that may be introduced in sampling, in the analytical technique to obtain grain-size distributions, in the assumptions of the transport model, and in the statistics used in describing the grain-size distributions. These uncertainties may be summarized as follows:

<u>(1) The use of the log-normal distribution:</u>

Although sediments are typically described by a particle weight distribution based on the log of the grain-size (i.e., the phi scale where particle diameter in mm = $2^{-\phi}$) there is, in fact, no way to determine the "best" descriptor for all sediments. The log-normal distribution has been found useful in practice since it appears to highlight important features of naturally occurring sediments. Bias can, however, be introduced in the choice of distribution. For example, the mean of the distribution in phi space is not equal to the mean of the distribution in linear space. Using the moment measures (mean, variance and skewness) may highlight important features and suppress those that are unimportant; however, information will also be lost. There is no way to determine if the lost information is significant (Bowles and McLaren, 1985).

Whatever method is used to describe the sediments, the trend analysis requires the above model which demonstrates that transport processes will change the moment measures of sediments in a predictable way. It is hoped that future research may be able to address the possible benefits of using other distributions (e.g., the log hyperbolic distribution; Hartmann and Christiansen, 1992).

<u>(2) Assumptions in the transport model:</u>

In providing a mathematical proof for the transport model used in the Sediment Trend Analysis (McLaren and Bowles, 1985), a basic assumption is made that smaller grains are more easily transported than larger grains. As seen in the transfer functions obtained from flume experiments (Fig. AI-2), this assumption is not strictly true. The curves monotonically increase over only a portion of the available grain sizes before returning to zero. Factors such as shielding whereby the presence of larger grains may impede the transport of smaller grains, or the decreasing ability of the eroding process to carry additional fines with increasing load, demonstrate that the transport process is a complicated function related to the sediment distribution and the strength of the erosion process.

(3) Temporal fluctuations:

Sediment samples may comprise the effects of several transport processes. It is assumed that what is sampled is the "average" of all the transport processes affecting the sample site. The "average" transport process may not conform to the transport model developed for a single transport process.

In a Sediment Trend Analysis, it is assumed that a sample provides a representation of a specific sediment type (or facies). There is no direct time connotation, nor does the depth to which the sample was taken contain any significance provided that the sample does, in fact, accurately represent the facies. For example d_1 may be a sample of a facies that represents an accumulation over several tidal cycles, and d_2 represents several years of deposition. The trend analysis simply provides the sedimentological relationship between the two (see McLaren, 1981 for a more detailed discussion of sampling). The possibility also exists that different samples may result from a different suite of transport events.

(4) Sample spacing:

Sample sites may be too far apart to detect relevant transport processes. With increasing distance between sample locations there is an increasing possibility of collecting sediments unrelated by transport (i.e., different facies). Sample sites placed X m apart can only be reliable to detect transport processes with a spatial scale of 2X m or more. Transport processes with smaller spatial scales may appear as noise or spurious signals.

In practice, selection of a suitable sample spacing takes into account: (1) the number of sedimentological environments likely to be encountered; (2) the desired spatial scale of the sediment trends; and (3) the geographic shape of the study area (see below for further discussion of sample spacing).

(5) Random environmental uncertainties:

All samples will be affected by random errors. These may include unpredictable fluctuations in the depositional environment, the effects of sampling and sub-sampling a representative sediment population, and random measurement errors.

2.2 The use of the Z-score statistic

Given the above list of complicating factors that introduce uncertainties in establishing the net patterns of transport, it is rare to find sequences of samples whose distributions change exactly according to Figure AI- 4. One approach that appears to be successful in determining trends is a simple statistical method whereby the Case (Table AI- 1) is determined among all possible sample pairs contained in a specified sequence. Given a sequence of n samples, there are $\frac{n^2 - n}{2}$ directionally orientated pairs that may exhibit a transport trend in one direction, and an equal number of pairs in the opposite direction. When any two samples are compared with respect to their distributions, the mean may become finer (F) or coarser (C), the sorting may become better (B) or poorer (P), and the skewness may become more positive (+) or more negative (-). These three parameters provide 8 possible combinations (Table AI- 2).

Table AI- 2: All possible combinations of grain-size parameters

	1*	**2**	**3**	**4**
Mean Sorting Skewness	F B -	C B -	F P -	F B +
	5	**6**	**7****	**8**
Mean Sorting Skewness	C P +	F P +	C B +	C P -

* Case B (Table AI- 1)
** Case A or C (Table AI- 1)

In Sediment Trend Analysis we postulate that a certain relationship exists among the set of n samples, and that this relationship is evidenced by particular changes in sediment size descriptors between pairs of samples. Then the number of pairs for which the trend relationship occurs should exceed the number of pairs that would be expected to occur at random by a sufficient amount for us to state confidently that the trend relationship exists. Suppose the probability of any trend existing between any pair of samples, if the trend relationships were established randomly, is p. Since there are 8 possible trend relationships among 3 sediment descriptors, and we assume that each of these is equally likely to occur, the value of p is set at 0.125.

To determine if the number of occurrences that a particular Case exceeds the random probability of 0.125, the following two hypotheses are tested:

H_0: $p<0.125$, and there is no preferred direction; and
H_1: $p>0.125$, and transport is occurring in the preferred direction.

Using the Z-score statistic in a one-tailed test (Spiegel, 1961), H_1 is accepted if:

$$Z = \frac{x - Np}{\sqrt{Nqp}} \rangle 1.645 \quad \text{(0.05 level of significance)}$$

or $\rangle 2.33$ (0.01 level of significance) where x is the observed number of pairs representing a particular Case in one of the two opposing directions; and N is the total number of possible unidirectional pairs, given by $\frac{n^2 - n}{2}$. The number of samples in the sequence is n; p is 0.125; and q is $1.0 - p = 0.875$.

The Z statistic is considered valid for $N>30$ (i.e., a large sample). Thus, for this application, a suite of 8 or 9 samples is the minimum required to evaluate adequately a transport direction.

3 DERIVATION OF SEDIMENT TRANSPORT PATHWAYS

From the above it is seen that a variety of uncertainties may preclude obtaining a "perfect" sequence of progressive changes in grain-size distributions from sediment samples that follow a specific transport pathway (Figure AI- 4). In using the Z-score statistic, however, a transport trend may be determined whereby all possible pairs in a sample sequence are compared with each other. When either a Case B or Case C trend exceeds random probability within the chosen sample sequence, the direction of net sediment transport can be inferred. In using the Z-score statistic, a minimum of 9 samples should be used which indicates that, if transport pathways are to be determined over a specific area, a minimum grid of 9 by 9 samples is required (i.e., 81 samples). As suggested above, the grid spacing must be compatible with the area under study and take into account the number of sedimentological environments likely to be involved, the geographic shape of the study area, and the desired statistical certainty of the pathways. For practical purposes, it has been found that, for regional studies in open ocean environments, sample spacing should not exceed 1 km; in estuaries spacing should be reduced to 500 m. For site specific studies (e.g., to determine the transport regime for a single marina), sample spacing will be reduced so that a minimum number of samples can be taken to ensure an adequate coverage (i.e., 9 X 9 samples). Experience has also shown that extra samples should be taken over sites of specific interest (e.g., dredged material disposal sites) and, should the regular grid be insufficient, from specific bathymetric features (e.g., bars and channels).

In determining transport patterns over an area, it is useful to draw an analogy with communication systems. In the latter, information is transmitted to a distant location where a signal is received containing both the desired information as well as noise. The receiver must extract the information from the noisy signal. In theory, the information can be recovered by simply subtracting the noise from the signal, an approach that works well in communications systems because the nature of both the information and the noise is well known.

In sedimentary systems, the information is the direction of net sediment transport, and the received signal is the grain-size distributions of the sediment samples. The goal of a Sediment Trend Analysis is to extract the information from the noisy signal which, in this case, may be difficult because neither the nature of the information nor the noise is known.

There is, however, another approach that draws from communications theory. In some communications systems, the information from many sources is combined into one signal which, from a statistical viewpoint, is nothing but noise. To extract specific information the receiver assumes that the information is present and determines if that assumption is consistent with the received signal[3].

The same approach may be used in a Sediment Trend Analysis as follows: (i) assume the direction of sediment transport over an area containing many sample sites; (ii) from this assumption, predict the sediment trend that should appear along a particular sequence of samples; (iii) compare the prediction with the actual trend that is derived from the selected samples; and (iv) modify the assumed transport direction and repeat the comparison until the best fit is achieved.

The important feature of this approach is the use of many sample sites to detect a transport direction. This effectively reduces the level of noise. The principal difficulty is that the number of possible pathways in a given area may be too large to mechanize the technique, or to try them all. As a result, the choosing of trial transport directions has, as yet, not been analytically codified (research is on-going to do this). At present, the selection of trial directions is undertaken initially at random; although the term "random" is used loosely in that it is not strictly possible to remove the element of human decision-making entirely. For example, a first look at the possible transport pathways may encompass all north-south, or all east-west directions. As familiarity with the data increases, exploration for trends becomes less and less random. The number of trial trends becomes reduced to a manageable level through both experience and the use of additional information (usually the bathymetry and morphology of the area under study). Following from the communications analogy, when a final and coherent pattern of transport pathways is obtained that encompasses all, or nearly all of the samples, the assumption that there is information (the transport pathways) contained in the signal (the grain-size distributions) has been verified, despite the inability to define accurately all the uncertainties that may be present.

4 THE USE OF R^2

In order to assess the validity of any transport line, we use the *Z*-score and an additional statistic, the linear correlation coefficient R^2, defined as:

$$R^2 = \frac{\sum_i (\hat{y}_i - \bar{y})^2}{\sum_i (y_i - \bar{y})^2}; \text{ where } \hat{y} = f(x_1, x_2, \ldots); \text{ and } \bar{y} = \frac{1}{N}\sum_i y_i$$

The value of R^2 can range from 0 to 1. The definition of R^2 is based on the use of a model to relate a dependent parameter y to one or more independent parameters $(x_1, x_2, \ldots)$. In our case, the model used is a linear one, which can be written as:

$$\hat{y} = a_o + a_1 \cdot x_1 + a_2 \cdot x_2$$

[3]This is a process referred to as Code Division Multiplexing.

The data (y,x_1,x_2) are grain-size distribution statistics, and the parameters (a_0, a_1, a_2) are estimated from the data using a least-squares criterion. The dependent parameter is defined as the skewness and the independent parameters are the mean size and the sorting. We make an implicit assumption that grain size samples making up a transport line, if plotted in skewness/sorting/mean space (as in Figure AI- 4), would tend to be clustered along a straight line. The slopes of the straight line, which are the fitted parameters, would depend on the type of transport (fining or coarsening). While there is no theoretical reason to expect a linear relationship among the three descriptors, there is also no theory predicting any other kind of relationship, so using the principle of Occam's Razor[4], we choose the simplest available relationship as our model. High values of R^2 (0.8 or greater) together with a significantly high value of the Z-score give us confidence in the validity of the transport line.

A low R^2 may occur, even when a trend is statistically acceptable for the following reasons: (i) sediments on an assumed transport path are, in reality, from different facies and valid trend statistics occurred accidentally; (ii) the sediments are from a single facies, but the chosen sequence is only a poor approximation of the actual transport path; and (iii) extraneous sediments have been introduced into the natural transport regime, as in the case of dredged material disposal. R^2, therefore, is assessed qualitatively and, when low, statistically acceptable trends must be treated with caution.

5 INTERPRETATION OF THE X-DISTRIBUTION

The shape of the X-distribution is important in defining the type of transport occurring along a line (erosion, accretion, total deposition, *etc.*), and thus the computation of X is important. Let us suppose that we have defined a transport line containing N source/deposit (d_1/d_2) pairs. Then we define X as:

$$X(s) = \sum_{i=1}^{N} \frac{(d_2)_i(s)}{(d_1)_i(s)}$$

Often d_2 in one pair is d_1 in another pair, and vice versa. Mean values of d_2 and d_1 are computed through:

$$\bar{d}_1(s) = \sum_{i=1}^{N} (d_1)_i(s); \text{and } \bar{d}_2(s) = \sum_{i=1}^{N} (d_2)_i(s)$$

Note that we do not define X as the quotient of the mean value of d_2 divided by the mean value of d_1, even though the results of the two computations are often almost identical. For ease of comparison, d_1, d_2, and X are normalized before plotting in reports, although there is no reason to expect that the integral of the X distribution should be unity.

$X(s)$ may be thought of as a function that describes the relative probability of each particle being removed from d_1 and deposited at d_2. It must be emphasized that the processes responsible for the transport of particles from d_1 to d_2 are unknown; they may in one

[4] Occam's Razor: Entities ought not to be multiplied except from necessity. (Occam, 14th Century philosopher, died 1349)

environment be breaking waves, in another tidal residual currents and, in still another, incorporate the effects of bioturbation.

Examination of *X*-distributions from a large number of different environments has shown that five basic shapes are most common when compared to the distributions of the deposits $d_1(s)$ and $d_2(s)$ (Fig. AI-6). These are as follows:

(1) Dynamic Equilibrium: The shape of the X-distributions closely resembles $d_1(s)$ and $d_2(s)$. The relative probability of grains being transported, therefore, is a similar distribution to the actual deposits. Thus, the probability of finding a particular sized grain in the deposit is equal to the probability of its transport and re-deposition (i.e., there must be a grain by grain replacement along the transport path). The bed is neither accreting nor eroding and is, therefore, in dynamic equilibrium.

An X-distribution signifying dynamic equilibrium may be found in either Case B or Case C transport suggesting that there is "fine balance" between erosion and accretion. Often when such environments are determined, both Case B and Case C trends may be significant along the selected sample sequence. This is referred to as a "Mixed Case", and when this occurs it is believed that the transport regime is also approaching a state of dynamic equilibrium.

(2) Net Accretion: The shapes of the three distributions are similar, but the mode of X is finer than the modes of $d_1(s)$ and $d_2(s)$. The mode of X may be thought of as the size that is the most easily transported. Because the modes of the deposits are coarser than X, these sizes are more readily deposited than transported. The bed, therefore, must be in a state of net accretion. Net accretion can only be seen in Case B transport.

(3) Net Erosion: Again the shapes of the three distributions are similar, but the mode of X is coarser than the $d_1(s)$ and $d_2(s)$ modes. This is the reverse of net accretion where the size most easily transported is coarser than the deposits. As result the deposits are undergoing erosion along the transport path. Net erosion can only be seen in Case C transport.

(4) Total Deposition I: Regardless of the shapes of $d_1(s)$ and $d_2(s)$, the X-distribution more or less increases monotonically over the complete size range of the deposits. Sediment must fine in the direction of transport (Case B); however, the bed is no longer mobile. Rather, it is accreting under a "rain" of sediment that fines with distance from source. Once deposited, there is no further transport. The occurrence of total deposition is usually confined to cohesive, muddy sediments.

(5) Total Deposition II (Horizontal X-Distributions): Occurring only in extremely fine sediments when the mean grain-size is very fine silt or clay, the X-distribution may be essentially horizontal. Such sediments are usually found far from their source and the horizontal nature of the X-distribution suggests that their deposition is no longer related strictly to size-sorting. In other words, there is now an equal probability of all sizes being deposited. This form of the X-distribution was first observed in the muddy deposits of a

British Columbia fjord and is described in McLaren, Cretney et al., 1993. Because the trends occur in very fine sediments where any changes in the distributions are extremely small, horizontal X-distributions may be found in both Case B and Case C trends.

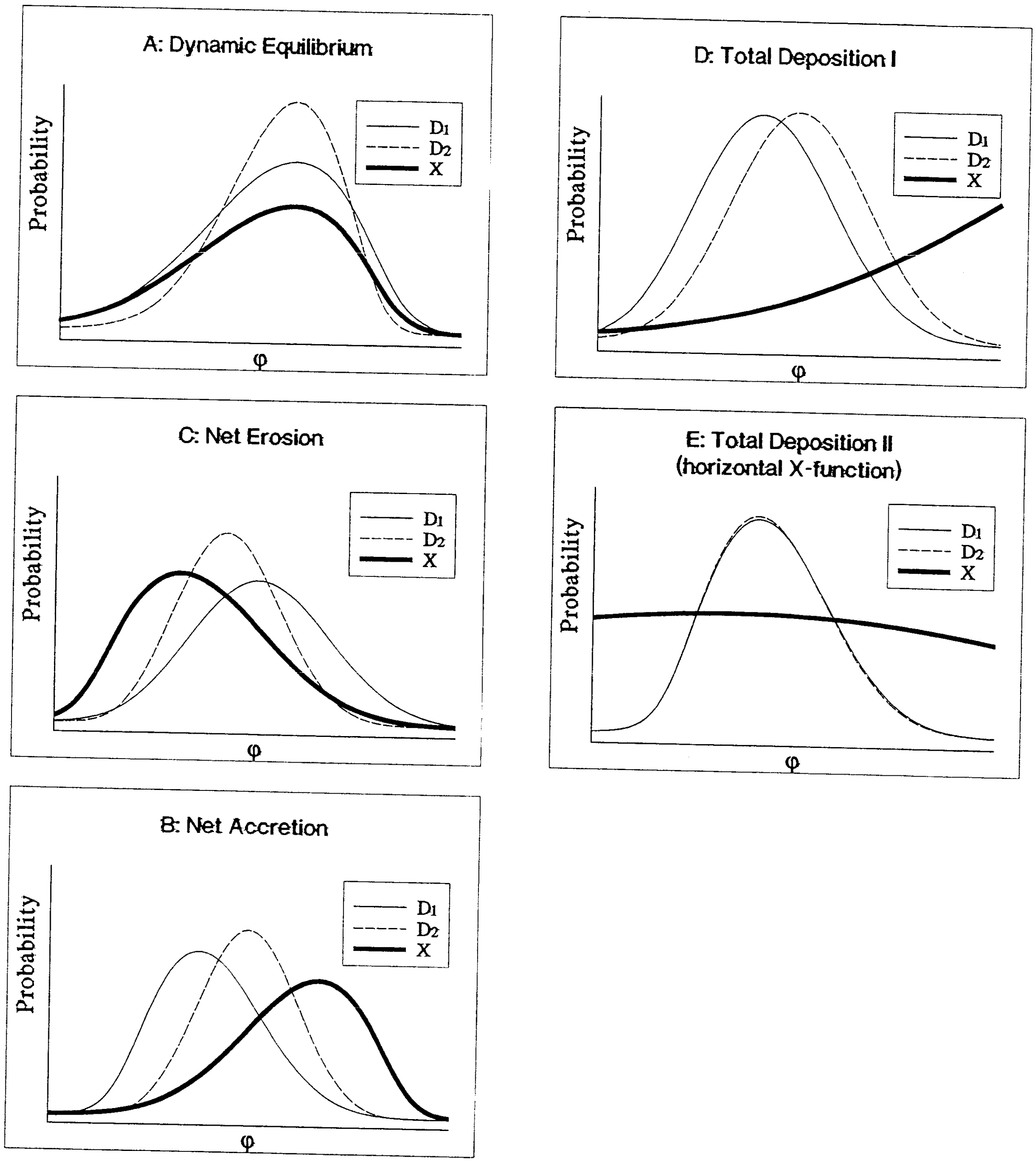


Figure AI- 6: Summary of the interpretations given to the shapes of X-distributions relative to the D1 and D2 deposits.

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APPENDIX II

Acoustic Bottom Classification Data Analysis and Results.

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Data Collection

The QTCView™ System

QTCView is a seabed classification system consisting of hardware and software developed by Quester Tangent Corp. (www.questercorp.com). The system uses acoustic information provided by a standard echo sounder to infer the properties of the seabed. Acoustic seabed classification involves the organization of sea floor echoes into "classes" based on a characteristic acoustic response. In the normal operation of a depth sounder, the acoustic pulse generated by an echo sounder travels through the water column, reflects from the seabed and returns to the transducer. There it is converted back into electrical energy and, after amplification and signal conditioning, recorded as a gray scale mark on paper or as colors of different hue and intensity on a video display. The data can also be stored as a digital time series (a set of numbers representing the amplitude of the signal in volts sampled at a regular time interval). QTCView "taps into" the electrical path between the transducer and the sounder. The detection of the transmitted signal going to the transducer is taken as the start of each record: the system then digitizes all of the data received by the transducer until such time as the signal associated with the sea bed has passed. This information constitutes a digital version of the echo trace.

Sophisticated signal processing algorithms are applied to the digitized echo, separating it into fundamental components (e.g., energy, frequency etc.). These components vary relative to each other as the signal reflects from differing sea beds. Sets of about 5 digitized traces are analyzed in this way, checked for consistency, averaged, and saved as a 166 element Full Feature Vector (FFV). These data are collected and saved during the data collection process, which occurs in tandem with grab sampling operations. The FFVs are input into a post-processing scheme that assumes echoes with similar component values come from sea beds with similar characteristics. Similar echoes are grouped into classes that may be related to the physical seabed characteristics by comparison with grab sampling results.

The Acoustics

The acoustic system used for this project is the ships echo sounder, a dual frequency SITEX CVS-108DF system. The transducer is a hull-mounted 50kHz/200kHz dual frequency unit. QTCView uses the 200 kHz signal: the half-power beam-width of the transducer at this frequency is 7°, and the beam is conical.

The Survey Area

The ABC survey covered the same area as the grab-sampling program, and in fact was carried out at the same time as the grab sampling.

The Survey Plan and Parameter Selection

The grab sampling plan covered areas with depths ranging from 5 meters to just over 100m. One of the parameters that must be defined for QTCView is the "reference depth", which is meant to be the average depth over a survey area. However, results are best if the maximum range of depths in a survey is less than 100m. Accordingly, although some of the expected depths at the outer edge of the sampling area were slightly greater than 100 meters, ABC data collection was restricted to areas with depths less than 100 meters, and used the parameters shown in Table A2-1.

Parameter	Values
	System
Base Gain (dB)	-5
Reference Depth (m)	45
Minimum Depth (m)	5
Maximum Depth (m)	100
	Sounder
Power	25W (RMS)
Pulse Length	648μs
Maximum Range(m)	80

Table A2-1: QTCVIEW parameters

Survey Operations

Details of the survey operations are detailed in Table A2-2.

Date	Km surveyed	No. of Records
23/8/2000	49.0	8,804
24/8/2000	141.4	22,789
25/8/2000	99.9	14,246
30/8/2000	56.6	7,653
31/8/2000	38.3	3,503
1/9/2000	38.6	4,958
2/9/2000	14.7	1,310
3/9/2000	73.6	9,849
5/9/2000	72.8	9,512
6/9/2000	78.7	9,718
7/9/2000	77.6	9,784
8/9/2000	26.5	2,307
10/9/2000	40.4	3,281
11/9/2000	39.8	3,964
Total	847.9	111,678

Table A2-2: Survey details.

Data Analysis

Data quality assessment and filtering

There are literally thousands of ABC records collected during a typical survey, and not all records are suitable for analysis. Records that are outside of the depth range specified by the system parameter settings must be removed, as well as "garbage" data. The most common problem is faulty depth picks. These occur when the QTCView system loses track of the bottom and then enters a search mode to find the bottom. Faulty depth picks are obvious in a plot of depth *vs.* time, and are easily removed. Faulty depth picks are rare overall, but are more common in deeper water, because of the attenuation of the acoustic signal with depth.

There were unique data quality problems with this particular survey. During the first few days of the survey in August, there were problems with the QTCVIEW "Blue Box" ceasing operations intermittently and having to be restarted during surveys. This behavior was unusual, and after discussions with Quester Tangent the problem was traced to some electrical equipment on the vessel. After the use of this equipment was discontinued the problems ceased. However, on analyzing data collected during this period, several data sets were found to be too noisy to be used. As a result, 23,949 records covering 89.5 km (10.6% of the total survey track) were discarded from the final data set. Fortunately most of these survey lines were in the northwest portion of the study area and away from the areas of greatest interest – *e.g.* Peacock Spit, Clatsop Spit, dredge disposal sites and the proposed deep water site. Details of record removal during quality assessment are shown in Table A2-3.

Description	Number
Starting number	111,678
Removed due to noise problem	23,949
Faulty depth picks, too shallow or deep	493
Final number of records	87,236

Table A2-3: Records removed during data assessment.

Unsupervised Classification

Classification may be either supervised or unsupervised. In supervised classification, local knowledge of the available bottom types specifies the classifications that will exist. The acoustic properties of these known bottom types are measured and used to form a catalogue that is employed in subsequent survey operations to classify the area. Unsupervised classification was applied to this project. An unsupervised classification is one in which no *a priori* judgments are made about the diversity of bottom types present in the survey area. FFVs are collected and analyzed after the fact to determine a reasonable division of the survey area into bottom type classes. Because a large number of bottom grab samples are collected as part of the Sediment Trend Analysis work, unsupervised classification is ideal for such projects. Nevertheless, some bottom types will classify out as different from others, although the associated grab samples may appear almost identical. This is because the properties of the acoustic return from the bottom depend on many factors, not all of which may be apparent from grab samples. The gross morphology of the bottom is a good example of how this can occur. Given a beam angle of 7° and a depth of 30m, the "acoustic footprint" on the bottom is roughly 3.7m in diameter. Two bottom types composed of exactly the same sediments, one perfectly flat and one with small sand waves due to, say, bottom currents, will have different acoustic returns. Although the grab samples may appear identical, the two regions may separate into distinct classes. Another example might be the presence of biota on the bottom. Two regions on the bottom composed of identical sediments may differ in that one is empty of biota and the other may have starfish or some other invertebrates scattered about. These invertebrates may not be evident in the grab samples, but will show up in the acoustic return.

Principal Component Analysis

The first stage in data analysis is to reduce the dimensionality of the FFV data. Principal Components Analysis (PCA), a mathematical procedure (see Murtagh & Heck 1987) that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called *principal components* is used to do this. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. Usually, principal component analysis is performed on a square symmetric correlation matrix (sums of squares and cross products from standardized data). The data are standardized because the elements of any FFV can differ by several orders of magnitude. Standardizing the data ensures that all element of the FFV are equally important in the PCA procedure. The objectives of principal component analysis are:

- To discover or to reduce the dimensionality of the data set.
- To identify new meaningful underlying variables.

The mathematical technique used in PCA is called eigen-analysis: one solves for the eigenvalues and eigenvectors of a square symmetric matrix with sums of squares and cross products. The eigenvector associated with the largest eigenvalue has the same direction as the first principal component; the eigenvector associated with the second largest eigenvalue determines the direction of the second principal component; and so on. The sum of the eigenvalues equals the trace of the square matrix (which is the number of variables; in our case 166) and the maximum number of eigenvectors equals the number of rows (or columns) of this matrix. Using the first three principal components has been found to be adequate for the purposes of ABC. The eigenvalues are examined to determine the effectiveness of the first three principal components in accounting for the variance in the data.

Using the results of the PCA the 166-element FFV for each data point in the cluster analysis can be replaced by the three-element PCA vector which approximates the FFV.

The Clustering Algorithm

K-means clustering (see Hartigan 1975) is used to partition the data into several classes or "clusters". There are several variants of the k-means clustering algorithm, but most variants involve an iterative scheme that operates over a fixed number of clusters, while attempting to satisfy the following properties:

1. Each cluster has a center that is the mean position of all the samples in that cluster.
2. Each sample is in the cluster to whose center it is closest.

The algorithm works by first selecting N samples (where N is the chosen number of clusters) randomly as cluster centers. It then moves samples into the closest cluster, meanwhile recalculating the mean center of the cluster. This partition of samples into new clusters is repeated until any further movement of samples does not improve the mean square error of the partition. The space in which the classification takes place is that spanned by the three principal components, and the distance measure is Euclidean.

Determining the number of clusters to use is somewhat of an art. There is of course a practical limit to the number of clusters that can be reasonably represented in a region, based on the number of ABC records, the area covered, the assumed diversity of the environment, and the number of "ground-truth" records available. One method to determine the number of clusters is to keep track of the mean square error of the partition as the number of clusters is increased, and stop when it is judged that the mean square error of the partition does not decrease significantly with the addition of another cluster. Another method, the one used in this report, is to keep track of the Clustering Performance Index Rate (CPIR – see Kirlin and Desaji, 2000) and look for peaks. The results of this approach are shown in Figure A2-1, and show a small peak at 8 classes. The 8-cluster classification is the solution presented in this document.

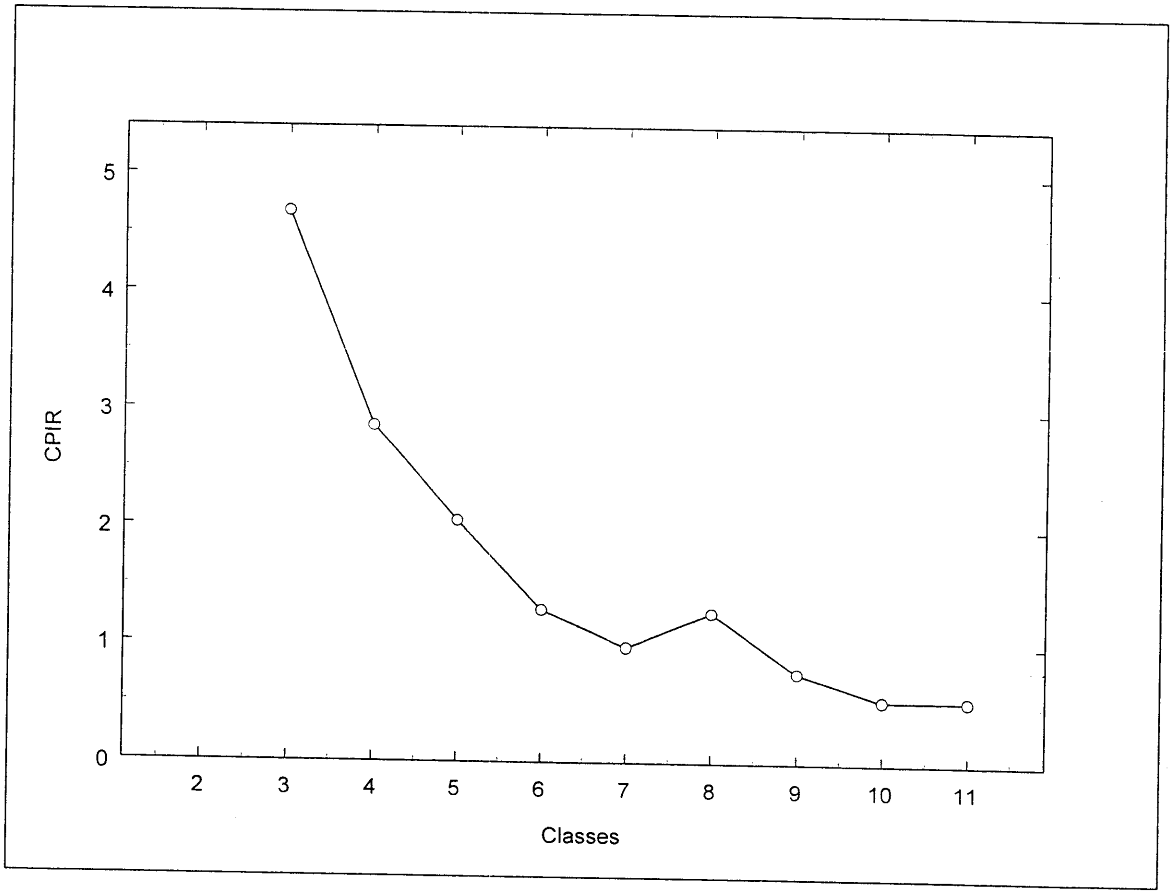


Figure A2-1: CPIR *vs.* number of classes.

Confidence Estimation

A means of assessing the confidence with which a datum is assigned to a cluster is required. Since all records are within a data space spanned by the three chosen principal components, and since the clustering algorithm uses a distance metric to assign data to clusters, a comparison of distances can be used to define confidence level. For each datum the distance D_c to its cluster center and its distance D_n to the center of the next closest cluster are calculated. Then the confidence level C, defined as a percentage, is given by:

$$C = \frac{D_n - D_c}{D_n + D_c} \cdot 100$$

Therefore, a datum that is at the center of its cluster is 100% confident, and a datum which is equally close to the next closest cluster center has a confidence level of 0%. This measure is intuitively conservative: a datum which is twice as close to its cluster center as to the next nearest cluster center has a confidence level of only 33%. To have a confidence level of 50%, a datum must be three times as close to its cluster center as to the center of the next nearest cluster.

Comparison with Collected Samples

A large number of grab samples were collected in the region surveyed for ABC, and these data can be used to help understand the meaning of the results of the unsupervised classification. To do this, the locations of all the ABC samples are compared with the locations of the grab samples and all of the ABC samples that are within a certain distance of a grab sample are selected. These ABC samples are then associated with that grab sample; this process is called *blending*. The radius within which the search for ABC samples is carried out is a variable that relates to the depth, being smaller in shallow water than in deep. In shallow water, the acoustic footprint is smaller than at deeper depths. In addition, pitch and roll of the vessel causes uncertainty in the location of the acoustic footprint on the bottom, and this uncertainty is greater in deep water than in shallow. In this project a radius of 20 meters was used.

Once the list of all the ABC samples that are close enough to the location of a grab sample to be considered is found, the statistics of that set of data can be examined. Are they all classified the same? How do the confidence levels of the classifications compare? Then some statistics of the grab samples that are in regions that are classified identically can be calculated: for example, the mean and standard deviations of the grain-size parameters (mean, sorting and skewness) of the samples. The average percentage of mud, gravel and sand, the average confidence level of the classification, and the average depth of the samples are also calculated. In addition, the anecdotal descriptions of the samples in the field records can be examined to see if there is anything consistently different among the clusters.

Results

Statistics

After noisy data removal and filtering there were 87,729, or 78.1% of the original number of FFVs suitable for input into the classification process. The results of the principal component analysis are shown in Table A2-4: nearly 60% of the variance of the data set is included in the first three eigenvectors.

Eigenvalue	1	2	3	Sum
% Variance	43.5	10.9	3.7	58.1

Table A2-4: Results of PCA of ABC data.

The data were then analyzed using k-means clustering: the results are shown in Table A2-5. Based on practical considerations, examination of the cluster sizes and the CPIR changes, a classification using 8 clusters was chosen.

Cluster	1	2	3	4	5	6	7	8	9	Sum of Squares
2	58198	29038								11,392
3	36787	27078	23371							8,119
4	30745	19348	18637	18506						4,643
5	28333	19068	14960	14949	9926					3,550
6	24549	18657	13237	12028	11765	7000				2,972
7	19367	15466	13068	11653	11331	9565	6786			2,184
8	18803	15369	10861	10799	10564	9544	9374	2422		1,876
9	15504	15244	10144	9652	9319	8979	8901	7795	1698	1,641

Table A2-5: Numbers of samples in each cluster, and sum of squares for shallow data. The cluster numbers in this table are not the actual class numbers used in the following descriptions; they are arranged in decreasing order by number of records.

The number of records in each class and the cluster centers in eigenvector space are shown in Table A2-6, where the columns refer to the eigenvector numbers (column 1 is the cluster center location on the eigenvector 1 axis). Table A2-7 shows the normalized (largest inter-cluster difference is set equal to 1) inter-cluster separations in eigenvector space. Note that class 6 has both the largest positive and the largest negative value, and appears to be a nodal point for the second and third eigenvector.

Class	Records	Vector 1	Vector 2	Vector 3
1	2422	+0.808	+0.067	-0.440
2	9374	+0.821	+0.296	-0.459
3	10799	+0.796	+0.467	-0.517
4	10861	+0.751	+0.653	-0.592
5	10564	+0.695	+0.835	-0.662
6	18303	+0.619	+1.000	-0.704
7	15369	+0.490	+0.903	-0.594
8	9544	+0.419	+0.729	-0.502

Table A2-6: Number of records in each class and cluster center locations in eigenvector space.

Class	1	2	3	4	5	6	7	8
1	0	23	41	62	82	100	92	78
2	23	0	18	39	60	78	71	60
3	41	18	0	21	41	60	54	46
4	62	39	21	0	21	39	37	36
5	82	60	41	21	0	19	23	34
6	100	78	60	39	19	0	20	40
7	92	71	54	37	23	20	0	21
8	78	60	46	36	34	40	21	0

Table A2-7: Normalized inter-cluster distance in eigenvector space, shown as a percentage.

The largest separations are between clusters 1 and 6, and clusters 1 and 7. Clusters 2 and 3 and clusters 5 and 6 are the closest together in eigenvector space, although there are several other pairs almost equally close together. Cluster 6, which is the cluster with the most records, is the furthest away from another cluster (Cluster 1) and also almost the closest to another (Cluster 5).

The space spanned by the first three eigenvectors is an artificial space: in order to get a feeling for what these classifications mean, it is necessary to look at some measured or observed characteristics of the sediments in areas classified differently. The results of *blending* can be used to do this.

The Data File

Data are provided in an ASCII format, as a comma-separated variable (CSV) file that can be read by any text editor or spreadsheet program, such as Microsoft Excel. The first line in the file is a header line that describes the content of each record. The first two records on each line are the position of the ABC record in meters of Easting and Northing in UTM Zone 10 co-ordinates (WGS84 datum). The next record is the depth of the ABC record in meters, and the next is the classification of the point, a number from 1 to 8. The final record in each line is the confidence of the classification in percent.

Blending

There were 1,238 grab sample grain-size results and 586 anecdotal descriptions available to match up with the ABC data. Using a radius of 20m and a minimum acceptable confidence level of 50% for the ABC classification, 6,506 ABC records were connected to 525 grab samples. The results of that analysis are shown in Table A2-8, Table A2-9, Table A2-10 and Table A2-11.

Class	#of records	%Sand	%Mud	Depth(m)
1	10	99.7 ± 1.0	0.3 ± 1.0	7.0 ± 0.9
2	49	99.2 ± 2.8	0.8 ± 2.8	9.8 ± 0.9
3	32	99.6 ± 2.5	0.4 ± 2.5	12.9 ± 0.7
4	24	96.7 ± 7.9	3.3 ± 7.9	19.3 ± 5.1
5	20	96.4 ± 6.9	3.6 ± 6.9	20.9 ± 2.0
6	60	96.8 ± 5.2	3.2 ± 5.2	35.3 ± 5.2
7	54	86.6 ± 10.6	13.4 ± 10.6	67.6 ± 7.5
8	45	79.1 ± 13.7	20.8 ± 13.7	90.4 ± 9.1

Table A2-8: Mean textural properties and depth of each class, shown with the 95% confidence level of the mean.

The data in Table A2-8 show that the classes are numbered by mean depth, Class 1 being the shallowest and Class 8 the deepest. The sediments are sandy: Classes 1,2 and 3 are nearly pure sands, Classes 4,5, and 6 have a trace of mud, and only classes 7 and 8 have any appreciable amount of mud.

Class	# of records	Mean	Sorting	Skewness
1	10	1.98 ± 0.22	0.54 ± 0.04	0.00 ± 0.04
2	49	2.09 ± 0.22	0.60 ± 0.15	0.11 ± 0.38
3	32	2.18 ± 0.25	0.59 ± 0.14	0.04 ± 0.27
4	24	2.34 ± 0.39	0.72 ± 0.38	0.11 ± 0.32
5	20	2.48 ± 0.36	0.71 ± 0.27	0.14 ± 0.33
6	60	2.52 ± 0.41	0.64 ± 0.15	0.28 ± 0.53
7	54	2.71 ± 0.52	1.13 ± 0.48	1.69 ± 0.59
8	45	3.08 ± 0.65	1.49 ± 0.57	1.33 ± 0.62

Table A2-9: Mean grain-size parameters (in Phi units) for each class, with standard deviations.

Class	2	3	4	5	6	7	8
1	0/0/0	*/0/0	*/0/0	**/0/0	**/*/0	**/**/**	**/**/**
2	-	0/0/0	**/0/0	**/*/0	**/0/0	**/**/**	**/**/**
3		-	0/0/0	**/*/0	**/0/*	**/**/**	**/**/**
4			-	0/0/0	0/0/0	**/**/**	**/**/**
5				-	0/0/0	0/**/**	**/**/**
6					-	*/**/**	**/**/**
7						-	**/**/**

Table A2-10: Significance ("0" = not significant, "*" = 95%, "" = 99%) from t-tests of differences in mean/sorting/skewness of each class. The table is symmetrical, so the bottom half is not filled in.**

Some comments can be made about the classes based on the textural properties. The mean grain size becomes uniformly finer (mean phi becomes bigger) with class number (and mean depth). Sorting becomes generally poorer with class number, and skewness becomes generally more positive. The tests of significance of differences in textural properties show that adjacent class numbers are not significantly different in terms of their textural properties. Of the adjacent pairs only 6/7 and 7/8 are significantly different. Class 8 is the only one that is significantly different at the 99% confidence level from all other classes for all three textural properties. Classes 1 through 6 have very similar textural properties: for example the sorting and skewness of classes 1 through 5 are statistically identical.

In order to try and differentiate these classes using some objective measure, the anecdotal reports must be used. A summary of the analysis of these data is shown in Table A2-11.

Class	N	% Firm	% Biota	% Worms	% Shell	% Molluscs
1	10	100	0	0	0	0
2	48	90	35	53	6	47
3	27	100	44	83	0	17
4	19	95	68	92	0	15
5	20	95	90	78	6	17
6	59	98	88	87	17	6
7	54	50	76	90	22	2
8	45	42	69	87	32	0

Table A2-11: Descriptive properties of the classes. The numbers are percentages, and 'N' is the number of anecdotal descriptions available for each class.

Table A2-11 shows the utility of adding the descriptive properties to the interpretation of the classes. The results in Table A2-8 indicate that Classes 1 through 6 are virtually identical insofar as some of their textural properties are concerned, but the descriptive data show that these classes differ in other ways. For example, Class 1 is the only class in which no biota were found. Class 2 is the only one of the shallowest 4 classes to have any shells or shell debris present, and had a very high incidence of live mollusks. Some general trends can be seen in the data: Classes 1 through 6 are firm in texture, likely because they contain very little mud, and Classes 7 and 8 are commonly loose in texture. Biota tend to be most common at intermediate depths; worms or worm tubes were the most common biota to be noted; mollusks are most common in shallower depths, and shells and shell debris is most common at depth.

Maps

Figure A2-2 is a map showing the classification of areas along the vessel track over the entire study area, and Figure A2-3 is a closer view of the river mouth. The colors of the classes are given in Table A2-12. The points plotted in the map are those for which the confidence of the classification is greater than 50%. Regions in which classification points are sparse are usually found at the boundary between two classes where confidence levels are low. Such regions are more common between deeper classes (*e.g.* 6 and 7 and 7 and 8).

The pattern of depth-dependence of the classes is clear in Figure A2-2. Note how the classification bands follow the bulge of the contour lines around the river mouth. Some of the deeper classes (4, 5 and 6) are found in the dredged channel and south of Jetty 'A' where depths are deeper due to dredging and scour.

There does not seem to be any ABC "signature" associated with material in the dredge disposal sites: no anomalous patterns are seen associated with these sites, and there is no evidence in the ABC of any difference between sediment at those sites and the surrounding sediments.

Class Number	Color
1	Red
2	Orange
3	Yellow
4	Green
5	Cyan
6	Blue
7	Violet
8	Purple

Table A2-12: Colors used to identify classes in the maps.

Figure A2-2: (Overleaf)Classification map of the study area.
Figure A2-3: (Overleaf)Classification map of the area around the river mouth.

Figure A2-2: Classification map of the study area.

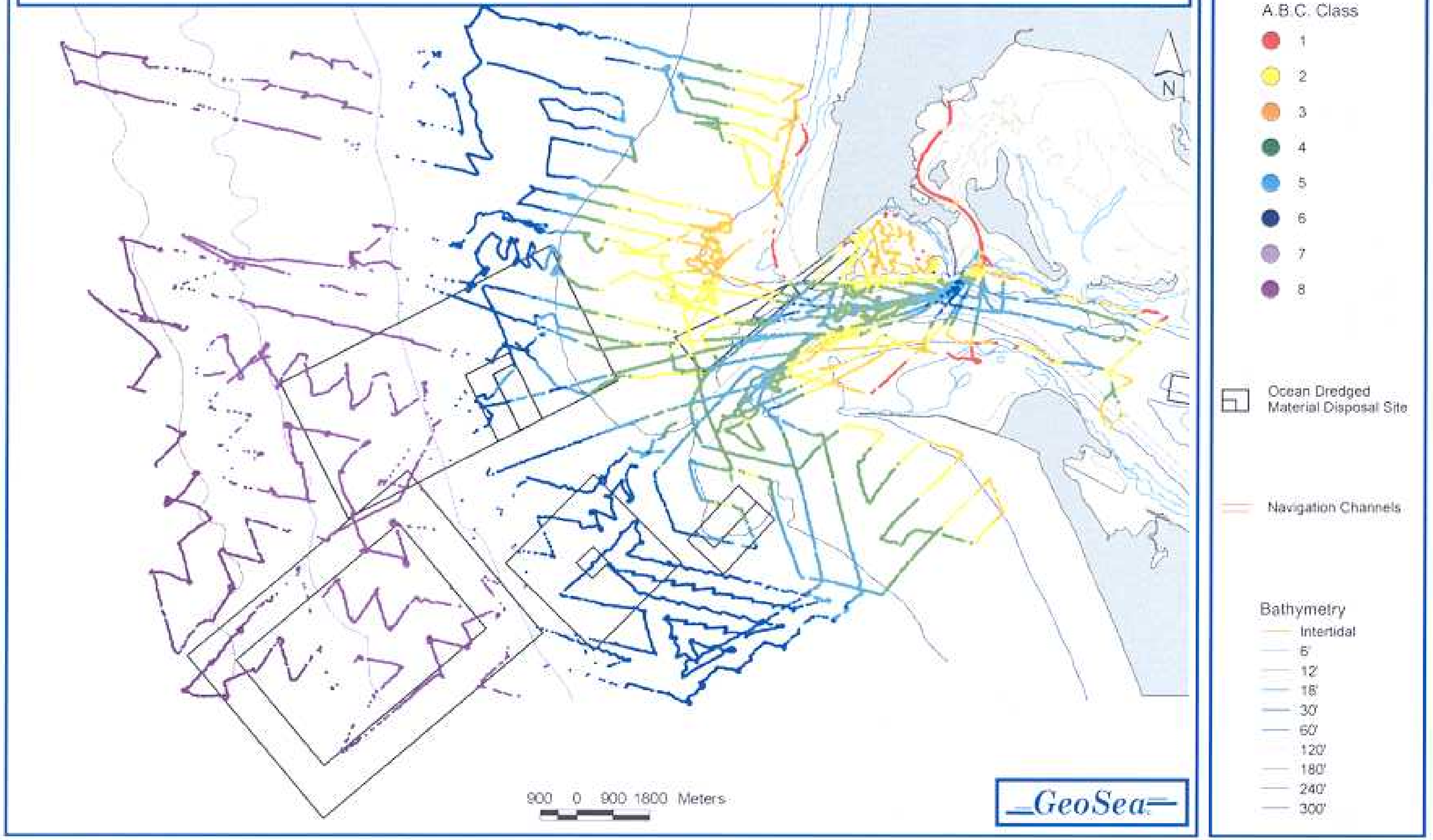
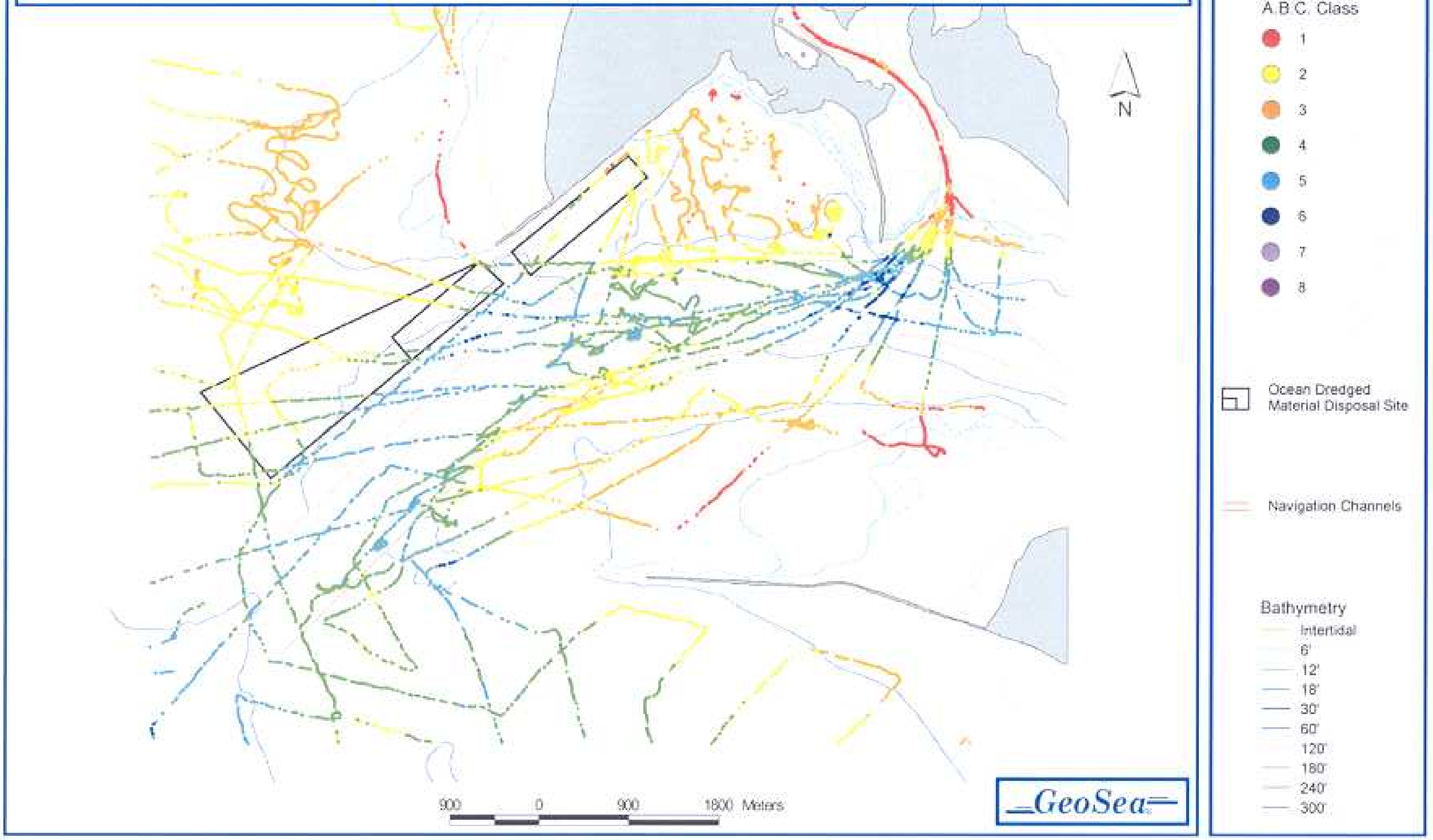


Figure A2-3: Classification map of the area around the river mouth.



Summary

The following are descriptions of each of the eight classes.

Class 1: Medium pure sand, well sorted, un-skewed. The texture is firm, with no biota present. Found close inshore near Peacock Spit, on the northern edge of Clatsop Spit, and up the channel to Ilwaco.

Class 2: Medium to fine pure sand, well sorted and un-skewed: the grain-size parameters for this class are statistically identical to those of class 1. Generally firm in texture with biota sometimes found: worms/worm tubes and live mollusks are about equally common. Shell debris found occasionally. Found inshore between the North Jetty and Jetty 'A', along the western edge of Clatsop spit, and in shallow areas north and south of the South Jetty.

Class 3:. Medium to fine pure sand, well sorted and un-skewed: the grain-size parameters for this class are statistically identical to those of class 2. Biota slightly more common than class 2, but almost exclusively worms and/or worm casings; mollusks occasionally present. Found along the edges of the dredged channel between the North Jetty and Jetty 'A' and north of the South Jetty, and in a depth-related band along the western edge of Clatsop and Peacock Spits.

Class 4: Fine sand with a trace of mud, well sorted and un-skewed: the grain-size parameters for this class are statistically identical to those of class 3. Firm in texture, two-thirds of samples had biota present, almost entirely worms and/or worm casings with occasional mollusks.

Class 5: Fine sand with a trace of mud, well sorted and un-skewed: the grain-size parameters for this class are statistically identical to those of class 4. Generally firm in texture; 90 percent of the samples contained biota, with worms and/or worm casings common, and occasional mollusks and shell debris. Found in the dredged channel and in a band spanning the study area from north to south, roughly following the depth contours and just offshore (and therefore slightly deeper) of the locations of Class 4.

Class 6: Fine sand with a trace of mud, well sorted and un-skewed: the grain-size parameters for this class are statistically identical to those of class 5. Almost all samples were firm in texture, and biota was present in 88 percent of samples. Worms and worm casings were most common, followed by shells and shell debris and lastly live mollusks. Found in a small area just south of Jetty 'A' and in a band spanning the study area from north to south, following the depth contours and offshore and deeper than Class 5.

Class 7: Fine sand with more than 10% mud. Less well sorted than the previous six classes, and positively skewed. Half the samples were loose in texture and half firm, and biota were less common than in Classes 5 and 6. Almost all samples with biota contained worms and worm casings, with occasional shells and/or shell debris. Found in a depth-related band near the western margin of the study area.

Class 8: Very fine sand with more than 10% mud. Not well sorted, and positively skewed. More than half the samples were loose in texture and the rest firm, and biota were slightly less common than in Class 7. Almost all samples with biota contained worms and worm casings, with occasional shells and/or shell debris. Found in a depth-related band at the western margin of the study area.

References

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APPENDIX III

Grain-Size Analysis Data

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

As of April 2000, GeoSea® is using a Malvern Mastersizer 2000 laser particle sizer for the grain-size analysis of sediments. This unit is state-of-the-art equipment. It is extremely accurate, the results are consistent, and it enables the determination of a large range of particle sizes using a single technique[1]. A laser particle sizer is also the most efficient way to analyze the large numbers of samples that are required in Sediment Trend Analysis. This Appendix describes the methodology used in our laboratory.

2.0 METHODOLOGY

2.1 Malvern Mastersizer 2000 laser particle sizer

The instrument is based on the principle of laser diffraction. Light from a low power helium-neon laser is used to form a collimated, monochromatic (red) beam of light which is the analyser beam. The unit also has a solid state blue light source. The shorter wavelength of the blue light allows for greater accuracy in the sub-micron range. Particles from sediment samples enter the beam via a dispersion tank that pumps the material, carried in water, through a sample cell. The resultant light scatter is incident onto the detector lens. The latter acts as a Fourier Transform Lens forming the far field diffraction patterns of the scattered light at its focal plane. Here a custom designed detector in the form of 52 concentric rings gathers the scattered light over a range of solid angles of scatter. When a particle is in the analyser beam its diffraction pattern is stationary and centred on the optical axis of the range lens. Un-scattered light is also focused onto an aperture on the detector. The total laser power exiting the optical system through this aperture enables measurement of the sample concentration.

In practice many particles are simultaneously present in the analyser beam and the scattered light measured on the detector is the sum of all individual patterns overlaid on the central axis. Our instrument is set to take 60,000 such measurements (snaps), which are then averaged to build up a light scattering characteristic for that sample based upon the population of individual particles. Applying the Mie theory of light scattering, the output from the detector is then processed by a computer, generating a final distribution.

Particles scatter light at angles related to their diameter (*i.e.*, the larger the particle, the smaller the angle of scatter and *vice versa*). Over the size range of interest, which is 0.02 micron (μ) and larger for this instrument, scattering is independent of the optical properties of the medium of suspension or the particles themselves. Through a process of constrained least squares fitting of theoretical scattering predictions to the observed data, the computer calculates a volume size distribution that would give rise to the observed scattering characteristics. No *a priori* information about the form of the size distribution

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[1] Most techniques to measure grain-size distributions require sand to be separated from the finer fractions; different analytical methods are used for each split (e.g., settling tube and sedigraph) and the two distributions are then merged together to obtain a complete distribution. Laser analysis does not require such a split, except when very coarse materials are present (coarse sand to gravel-sized fractions).

is assumed, allowing for the characterization of multi-modal distributions with high resolution.

2.2 Laboratory technique

GeoSea has developed a standard operating procedure (SOP) using the Malvern Mastersizer 2000 laser particle size analyser. This ensures that all parameters and variables will remain consistent throughout sample analysis. The methodology covers the range of sizes normally considered important in sediments, is relatively rapid and requires only small samples. No chemical pre-treatment of the samples is undertaken without prior request[2]. Our priority is to determine the size distribution of the naturally occurring sample.

Prior to every analysis, the Mastersizer 2000 automatically aligns the laser beam, and a background measurement of the suspension medium is taken. Samples are initially well mixed before obtaining a representative sub-sample for analysis. The amount of sediment required is about 2 to 4 grams for sands and 0.5 to 1 gram for silt and clay. Samples are introduced into the dispersion unit by wet sieving through a 1mm mesh, eliminating possible blockage of the pumping mechanism by particles that are too large. Disaggregation of the sample is achieved by both mechanical stirring and mild ultrasonic dispersion in the sample dispersion unit[3]. If material remains on the 1mm sieve then the weight percent for each of the coarse sizes (-2.0ϕ to 0.5ϕ[4]; 4.0mm to 0.7mm) is obtained by dry sieving at 0.5ϕ intervals.

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[2]Occasionally we are asked to remove organic matter by peroxide digestion, or carbonates by treatment with weak acid.

[3]GeoSea has conducted several experiments concerning the degree of ultrasonic dispersion that is desirable. If no ultrasonic dispersion is used, fine particles tend to remain as relatively large aggregates producing an erroneously coarse sediment distribution. With increasing ultrasonic disaggregation a distribution will tend to become increasingly finer as flocs become broken apart. Total disaggregation of the fine material may be desirable for some purposes, but for Sediment Trend Analysis we find that the flocs are best treated as part of the overall grain-size distribution. This is because flocs form particular sized particles that behave as separate entities in the transport regime, whereas total disaggregation would produce a grain-size distribution containing particle sizes that were not actually behaving independently during their transport and deposition. Although we find that increasing the degree of disaggregation changes the specific parameters of a grain-size distribution, it is insufficient to produce significant changes in the derived sediment trend statistics. The degree of ultrasonic dispersion presently used by GeoSea appears to be adequate to break apart the sediment into its component particle sizes without excessive damage to those sizes composed of flocculated material.

[4]ϕ (phi) is the unit of measure most commonly used in sediment size distributions where $\phi = -\frac{\log(mm)}{\log(2)}$.

Table 1: Grain-size scales for sediments.

U.S. Standard Sieve Mesh Number	Diameter (*mm*)	Diameter (*microns*)	Phi Value	Wentworth Size Class	Sediment Type
5	4.00		-2.00	Granule	GRAVEL
6	3.36		-1.75		
7	2.83		-1.50		
8	2.38		-1.25		
10	2.00		-1.00		
12	1.68		-0.75	Very Coarse Sand	SAND
14	1.41		-0.50		
16	1.19		-0.25		
18	1.00		0.00		
20	0.84	840	0.25	Coarse Sand	
25	0.71	710	0.50		
30	0.59	590	0.75		
35	0.50	500	1.00		
40	0.42	420	1.25	Medium Sand	
45	0.35	350	1.50		
50	0.30	300	1.75		
60	0.25	250	2.00		
70	0.21	210	2.25	Fine Sand	
80	0.177	177	2.50		
100	0.149	149	2.75		
120	0.125	125	3.00		
140	0.105	105	3.25	Very Fine Sand	
170	0.088	88	3.50		
200	0.074	74	3.75		
230	0.0625	62.5	4.00		
270	0.053	53	4.25	Coarse Silt	MUD
325	0.044	44	4.50		
	0.037	37	4.75		
	0.031	31	5.00		
	0.0156	15.6	6.00	Medium Silt	
	0.0078	7.8	7.00	Fine Silt	
	0.0039	3.9	8.00	Very Fine Silt	
	0.002	2	9.00	Clay*	
	0.00098	0.98	10.00		
	0.00049	0.49	11.00		
	0.00024	0.24	12.00		
	0.00012	0.12	13.00		
	0.00006	0.06	14.00		

(* The Clay/Silt boundary is sometimes taken at 2 microns, or 9 phi.)

2.3 Merge method

GeoSea has developed software that allows the dry-sieved weights and measurements from the laser unit to be merged into a final distribution within the range of -2.0ϕ to 15ϕ, in size bins of equal width (0.5 ϕ) in ϕ-space. The results from the Mastersizer 2000 consist of a set of 52 size bins, where the bin width is inversely proportional to the mean particle size in the bin, with the percentage of material in each bin. A summary of the merging process follows:

(1) Sieve data

Sieving is carried out at half-phi intervals from -2.0ϕ to 0.5ϕ. The weights are normalized and the percentage smaller than 0.5ϕ is used to renormalize the Malvern values using the methods described above. The portion of the lens data above 0.5ϕ is removed and replaced with sieve data.

2.4 Presentation of Results

Size distribution data are generally provided as both hard copy (Table 2) and as a PC computer file. The file format is as comma-separated ASCII values (*.csv) in which the data for each sample are contained in a single line. The first line in the file defines the variables and the phi scale, and is followed by the weight percentages for the samples. These files can be easily imported into a Microsoft Excel spreadsheet. The interpretation of the data is as follows: the weight percentage shown under a size heading is the amount of material found in a bin with size boundaries set by the previous size heading as the upper size limit and the current size heading as the lower limit. For example, the weight percent shown under the heading 1.5ϕ is the amount in the bin bounded by 1.0ϕ and 1.5ϕ. Because of the way the file is written the first size fraction in the list (-2.0ϕ) always has zero weight percent.

The hard copy (Table 2) consists of a printout of the data in spreadsheet form and, when requested, plots of each sample showing its histogram and cumulative curve in both phi and micron units.

APPENDIX III

Table 2: Grain-Size Analysis Data

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud
1	399302.8	5125738.4	317	S	2.81	1.533	1.844	0	87.44	12.56
2	400294.3	5125511.3	291	S	2.734	1.434	2.23	0	89.14	10.86
3	401298.3	5125284.4	262	S	2.407	0.987	3.188	0	95.48	4.52
4	402260.6	5125042.7	241	S	2.192	0.504	0.015	0	100	0
5	403174.8	5124837.5	206	S	2.4	1.034	3.074	0	94.9	5.1
6	404196.8	5124613.7	206	NS	0	0	0	0	0	0
7	405227.3	5124335.3	202	MS	3.722	2.039	0.383	0	61.56	38.44
8	406206.2	5124129.0	182	S	3.109	1.273	1.879	0	87.7	12.3
9	407107.8	5123899.4	162	S	3.113	1.325	1.851	0	87.33	12.67
10	408091.4	5123680.9	140	S	2.882	0.997	2.182	0	93.65	6.35
11	399621.6	5124792.7	315	MS	3.326	2.04	0.983	0	73.97	26.03
12	400558.2	5124554.9	291	S	2.481	1.105	2.999	0	94.19	5.81
13	401543.9	5124338.5	261	S	2.482	1.159	2.887	0	93.51	6.49
14	402576.2	5124088.2	236	S	2.418	1.071	3.064	0	94.57	5.43
15	403515.5	5123867.9	219	S	2.337	0.92	3.313	0	96.22	3.78
16	404471.9	5123641.7	211	S	2.749	1.492	2.002	0	87.05	12.95
17	405459.2	5123435.1	209	S	2.971	1.492	1.536	0	83.11	16.89
18	406426.5	5123205.5	178	SM	4.37	1.967	0.398	0	49.66	50.34
19	407418.7	5122987.0	160	MS	3.549	1.711	1.095	0	72	28
20	399920.5	5123780.8	313	S	2.538	1.206	2.675	0	93.18	6.82
21	400873.9	5123580.0	280	MS	3.967	2.234	0.602	0	59.26	40.74
22	401855.0	5123388.1	259	S	2.404	1.087	3.104	0	94.56	5.44
23	402827.7	5123129.8	237	S	2.422	1.014	3.097	0	95.09	4.91
24	403798.1	5122917.9	221	S	2.486	1.178	2.709	0	93.27	6.73
25	404757.6	5122686.5	207	S	2.395	1.001	3.106	0	95.28	4.72
26	405743.4	5122461.5	195	S	2.909	1.482	1.7	0	84.79	15.21
27	406733.2	5122244.7	174	MS	3.346	1.7	1.199	0	75.37	24.63
28	407727.8	5122007.5	154	MS	3.948	1.848	0.534	0	57.16	42.84
29	400176.5	5122813.5	310	MS	3.481	2.027	1.06	0	71.48	28.52
30	401203.0	5122621.1	275	S	2.683	1.473	2.104	0	87.8	12.2
31	402142.4	5122426.5	259	NS	0	0	0	0	0	0
32	403126.2	5122180.9	237	S	2.606	1.328	2.524	0	90.95	9.05
33	404070.0	5121954.9	220	S	2.463	1.194	2.84	0	93.2	6.8
34	405088.0	5121728.5	207	S	2.424	1.065	3.069	0	94.67	5.33
35	406026.5	5121504.9	194	MS	3.483	1.93	0.954	0	69.06	30.94
36	407017.3	5121240.3	178	MS	3.274	1.727	1.168	0	74.82	25.18
37	407981.3	5121071.0	144	S	2.608	1.54	1.662	0	85.24	14.76
38	400451.1	5121906.6	300	S	2.386	1.064	3.165	0	94.91	5.09
39	401450.6	5121568.4	278	S	3.03	1.758	1.563	0	80.61	19.39
40	402449.3	5121401.0	252	MS	3.24	1.932	1.266	0	75.97	24.03
41	403387.6	5121173.7	236	S	2.71	1.481	2.201	0	88.57	11.43
42	404398.4	5121008.2	218	S	2.501	1.155	2.934	0	93.76	6.24
43	405354.9	5120731.4	206	S	2.468	1.109	2.977	0	94.21	5.79
44	406343.7	5120506.2	197	S	2.556	1.224	2.61	0	92.48	7.52
45	407308.2	5120262.9	180	S	2.978	1.691	1.559	0	81.79	18.21
46	408296.6	5120114.2	157	S	2.667	1.578	1.638	0	84.52	15.48
47	399814.7	5121165.8	323	S	2.846	1.591	1.909	0	86.65	13.35
48	400842.4	5120958.5	298	NS	0	0	0	0	0	0
49	401788.1	5120686.1	277	S	2.89	1.563	1.773	0	84.06	15.94
50	402748.4	5120472.1	253	S	2.782	1.593	2.004	0	86.31	13.69
51	403675.1	5120275.5	240	S	2.418	1.084	3.049	0	94.44	5.56
52	404653.8	5120061.5	223	S	2.488	1.142	2.934	0	93.82	6.18
53	405661.1	5119827.8	209	S	2.356	1.05	3.017	0	95.38	4.62
54	406623.4	5119612.0	194	S	2.533	1.187	2.634	0	92.8	7.2
55	407641.6	5119278.9	180	S	2.688	1.418	2.153	0	88.49	11.51
56	408605.2	5119155.7	162	S	2.711	1.298	2.275	0	90.13	9.87
57	409558.8	5118953.8	144	S	2.256	1.053	2.427	0	94.75	5.25
58	400145.0	5120198.0	319	S	2.496	1.154	2.752	0	94.06	5.94
59	401102.1	5120011.5	302	MS	3.499	2.03	1.011	0	70.3	29.7
60	402034.5	5119740.4	276	MS	3.368	2.055	1.136	0	73.36	26.64
61	403036.7	5119556.2	253	MS	3.373	2.033	1.128	0	73.7	26.3
62	403992.7	5119308.8	237	S	2.556	1.293	2.668	0	91.88	8.12
63	404962.3	5119111.1	222	S	2.494	1.169	2.961	0	93.8	6.2
64	405946.1	5118877.2	210	S	2.686	1.401	2.216	0	89.21	10.79
65	406915.1	5118611.8	198	NS	0	0	0	0	0	0
66	407949.3	5118411.4	184	S	2.474	1.083	3.002	0	94.2	5.8
67	408915.3	5118177.2	167	S	2.758	1.403	2.127	0	88.26	11.74
68	409863.5	5117987.3	142	NS	0	0	0	0	0	0
69	400459.3	5119250.2	314	SM	4.402	2.113	0.196	0	48.03	51.97
70	401410.6	5119047.9	296	MS	3.448	1.965	1.103	0	72.53	27.47
71	402374.5	5118799.2	275	S	2.974	1.698	1.663	0	82.29	17.71
72	403332.2	5118589.7	253	MS	3.261	2.014	1.197	0	74.82	25.18
73	404300.8	5118373.8	237	S	2.668	1.362	2.397	0	90.45	9.55
74	405265.4	5118087.4	225	S	2.921	1.712	1.763	0	83.52	16.48
75	406240.6	5117918.0	213	S	2.852	1.521	1.968	0	86.3	13.7
76	407264.2	5117686.8	200	S	2.927	1.651	1.625	0	83	17
77	408231.7	5117467.0	186	S	2.458	1.16	2.904	0	93.48	6.52
78	409184.0	5117240.5	163	S	2.52	1.171	2.792	0	92.98	7.02
79	410207.2	5117006.0	148	S	2.047	0.842	2.763	0	97.25	2.75
80	411147.3	5116808.4	128	S	2.049	1.03	3.015	0	95.46	4.54
81	400746.4	5118340.6	316	S	2.573	1.228	2.647	0	93.06	6.94
82	401710.4	5118071.3	297	MS	3.375	1.952	1.165	0	74.03	25.97
83	402652.2	5117874.9	278	S	2.457	1.082	3.049	0	94.42	5.58
84	403666.7	5117630.1	259	MS	3.337	1.983	1.169	0	74	26
85	404651.1	5117412.1	241	S	2.682	1.419	2.36	0	89.5	10.5
86	405609.7	5117202.2	224	S	2.705	1.433	2.163	0	88.64	11.36
87	406576.5	5116952.8	215	S	2.58	1.27	2.693	0	92.12	7.88
88	407555.0	5116728.1	203	S	2.616	1.255	2.558	0	91.47	8.53
89	408522.7	5116514.3	183	S	2.546	1.197	2.777	0	92.76	7.24
90	409519.4	5116299.4	167	S	2.506	1.078	2.99	0	94.26	5.74
91	410410.3	5116066.2	153	S	1.75	0.523	0.004	0	100	0
92	411431.4	5115837.0	136	S	1.955	0.928	3.101	0	96.66	3.34
93	412418.1	5115640.9	122	S	2.506	0.574	-0.011	0	99.99	0.01
94	400997.1	5117334.1	313	MS	3.517	1.952	1.111	0	73.08	26.92
95	402026.1	5117149.9	294	S	2.422	1.092	3.001	0	94.3	5.7
96	403038.1	5116909.0	276	S	2.528	1.278	2.593	0	91.51	8.49
97	403901.6	5116713.9	260	S	2.698	1.454	2.301	0	88.89	11.11
98	404930.5	5116447.6	245	S	2.576	1.292	2.707	0	92.13	7.87
99	405885.5	5116253.1	233	S	2.452	0.966	3.167	0	95.72	4.28
100	406880.7	5115993.2	219	S	2.502	1.16	2.89	0	93.59	6.41
101	407883.9	5115807.8	205	S	2.573	1.256	2.712	0	92.29	7.71
102	408816.2	5115532.4	186	S	2.56	1.248	2.731	0	92.3	7.7
103	409799.4	5115317.0	172	S	2.24	0.501	0.012	0	100	0
104	410743.3	5115103.2	157	S	2.289	0.544	0.014	0	100	0
105	411736.4	5114876.7	142	S	2.468	0.846	3.124	0	96.77	3.23
106	412717.0	5114643.5	131	S	2.506	0.881	2.942	0	96.97	3.03
107	400320.6	5116613.7	327	MS	3.374	1.94	0.888	0	74.23	25.77
108	401319.2	5116373.2	312	S	3.073	1.652	1.58	0	83.39	16.61
109	402300.4	5116155.0	296	MS	3.433	2.038	1.097	0	72.5	27.5
110	403281.7	5115970.0	280	MS	3.885	2.204	0.67	0	61.55	38.45
111	404230.8	5115694.1	264	S	2.454	1.091	3.026	0	94.39	5.61
112	405251.2	5115506.7	246	S	2.44	1.124	2.968	0	94.01	5.99
113	406165.4	5115270.6	235	NS	0	0	0	0	0	0
114	407127.0	5115043.1	216	NS	0	0	0	0	0	0
115	408114.8	5114793.2	206	S	2.39	0.893	3.27	0	96.35	3.65
116	409074.7	5114603.4	194	S	2.465	0.959	3.172	0	95.68	4.32
117	410057.7	5114353.4	180	S	2.437	0.928	3.346	0	96.26	3.74
118	411031.1	5114139.4	163	S	2.3	0.542	0.015	0	100	0
119	412000.3	5113874.2	150	S	2.501	0.96	3.22	0	95.98	4.02
120	413020.2	5113691.1	133	S	2.498	0.881	3.055	0	96.93	3.07
121	400650.3	5115623.7	325	MS	3.388	1.909	1.007	0	74.99	25.01
122	401654.4	5115447.4	310	MS	3.642	2.074	0.823	0	69.03	30.97
123	402535.5	5115184.4	296	S	2.491	0.97	2.918	0	95.85	4.15
124	403530.9	5115006.8	281	S	2.555	1.227	2.726	0	92.49	7.51
125	404494.3	5114803.5	261	S	2.577	1.274	2.452	0	91.46	8.54
126	405462.3	5114579.6	234	NS	0	0	0	0	0	0
127	406489.9	5114322.2	234	S	2.414	0.98	3.171	0	95.55	4.45
128	407502.7	5114076.6	219	NS	0	0	0	0	0	0
129	408406.4	5113842.4	210	S	2.538	1.131	2.922	0	93.89	6.11
130	409365.0	5113625.0	198	S	2.487	0.97	3.24	0	95.73	4.22
131	400933.6	5114697.4	323	MS	3.876	2.1	0.634	0	63.74	36.26
132	401877.0	5114480.5	309	S	2.758	1.28	2.272	0	91.86	8.14

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud
133	402849.7	5114265.8	295	MS	3.58	2.052	0.931	0	69.37	30.63
134	403330.5	5113999.4	282	MS	3.167	1.846	1.409	0	79.49	20.51
135	404798.5	5113794.4	267	S	2.423	0.991	3.128	0	95.44	4.56
136	405814.0	5113595.9	250	S	3.093	1.805	1.561	0	80.94	19.06
137	401190.4	5113732.5	321	S	2.805	1.67	1.37	0	86.11	13.89
138	402154.7	5113500.7	308	S	2.904	1.418	1.836	0	89.36	10.64
139	399083.4	5126634.0	318	S	2.53	1.321	1.965	0	92.37	7.63
140	399994.9	5126455.5	292	S	2.511	1.2	2.798	0	93.48	6.52
141	401030.1	5126235.3	266	MS	3.363	1.971	1.16	0	73.54	26.46
142	401994.6	5125992.6	242	MS	3.773	2.296	0.393	0	58.69	41.31
143	402969.5	5125801.3	224	S	2.456	1.154	2.894	0	93.59	6.41
144	403948.7	5125571.0	208	MS	3.096	1.779	1.376	0	79.07	20.93
145	404869.1	5125369.4	194	S	2.738	1.223	2.363	0	91.7	8.3
146	405889.0	5125115.9	184	NS	0	0	0	0	0	0
147	406844.2	5124903.6	164	S	3.018	1.017	2.463	0	93.43	6.57
148	407857.6	5124667.1	135	S	2.677	0.559	-0.034	0	99.88	0.12
149	398710.5	5127638.2	320	S	2.811	1.665	1.357	0	84.8	15.2
150	399699.1	5127392.2	296	MS	3.553	2.052	0.956	0	69.37	30.63
151	400735.9	5127194.9	269	MS	3.318	1.947	1.166	0	74.2	25.8
152	401664.9	5126942.5	251	S	3.015	1.737	1.536	0	81.35	18.65
153	402686.4	5126732.5	230	MS	3.558	2.04	0.942	0	68.35	31.65
154	403616.9	5126496.7	215	MS	3.304	2.001	1.031	0	73.79	26.21
155	404608.0	5126289.5	200	MS	3.824	1.843	0.943	0	65.83	34.17
156	405575.9	5126103.7	184	S	3.418	1.491	1.552	0	80.76	19.24
157	406543.5	5125847.6	160	S	2.802	0.56	-0.016	0	99.27	0.73
158	407519.3	5125610.5	137	S	3.087	0.992	2.186	0	92.12	7.88
159	398475.8	5128550.6	317	MS	3.884	2.225	0.525	0	60.63	39.37
160	399459.6	5128347.2	295	MS	3.732	2.2	0.631	0	63.81	36.19
161	400454.6	5128117.9	274	MS	3.815	2.169	0.633	0	61.76	38.24
162	401402.4	5127936.9	274	SM	4.418	2.188	0.175	0	46.2	53.8
163	402352.0	5127675.7	233	MS	3.715	2.122	0.667	0	63.32	36.68
164	403372.6	5127461.8	215	MS	3.782	2.12	0.596	0	61.87	38.13
165	404333.6	5127246.2	215	S	2.768	1.212	2.254	0	92.02	7.98
166	405262.7	5127032.5	182	MS	3.793	1.689	1.054	0	69.76	30.24
167	406310.5	5126790.1	158	S	3.128	1.046	2.33	0	92.03	7.97
168	407278.7	5126563.7	135	S	3.21	1.035	2.057	0	89.5	10.5
169	398153.8	5129534.3	316	S	2.996	1.622	1.647	0	83.99	16.01
170	399173.5	5129275.5	294	MS	3.892	2.19	0.544	0	60.37	39.63
171	400110.1	5129096.4	276	S	2.808	1.49	2.062	0	87.39	12.61
172	401091.8	5128861.9	257	S	2.448	0.987	3.217	0	95.55	4.45
173	402081.6	5128641.3	237	S	2.612	1.3	2.399	0	91.09	8.91
174	403050.7	5128430.4	219	MS	3.261	1.842	1.228	0	75.87	24.13
175	404053.0	5128231.3	204	S	3.149	1.554	1.55	0	82.53	17.47
176	405006.1	5128008.2	185	MS	3.694	1.731	0.843	0	71.65	28.35
177	405945.5	5127783.6	162	S	3.041	0.817	2.104	0	94.97	5.03
178	406917.4	5127545.3	143	S	2.915	0.565	-0.018	0	98.15	1.85
179	407889.5	5127330.0	126	S	3.196	1.046	2.039	0	89.56	10.44
180	397860.1	5130456.7	305	MS	3.804	2.142	0.668	0	64.08	35.92
181	398844.1	5130305.4	287	MS	3.533	1.972	1	0	70.31	29.69
182	399781.0	5130063.9	268	S	2.546	1.16	2.713	0	93.43	6.57
183	400786.8	5129842.2	252	S	2.664	1.345	2.3	0	90.03	9.97
184	401738.4	5129635.9	237	NS	0	0	0	0	0	0
185	402739.9	5129384.4	219	MS	4.096	2.142	0.243	0	52.42	47.58
186	403732.8	5129196.6	208	MS	3.364	1.838	0.928	0	74.23	25.77
187	404716.7	5128973.0	189	S	3.372	1.211	1.938	0	85.79	14.21
188	405671.8	5128736.9	166	S	3.124	0.963	2.383	0	92.93	7.07
189	406634.4	5128500.3	142	S	2.904	0.572	-0.02	0	98.11	1.89
190	407645.8	5128257.8	127	S	3.056	0.78	1.986	0	95	5
191	399535.7	5131000.7	267	S	2.431	0.959	3.183	0	95.72	4.28
192	400524.1	5130755.8	252	S	2.746	1.4	2.04	0	88.69	11.31
193	401493.5	5130546.7	232	SM	4.49	2.078	0.177	0	45.37	54.63
194	402430.4	5130321.3	220	MS	3.611	2.047	0.77	0	67.01	32.99
195	403489.1	5130161.5	208	S	2.77	1.24	2.248	0	91.83	8.17
196	404395.6	5129922.8	192	S	3.384	1.322	1.684	0	83.02	16.98
197	405362.1	5129677.3	169	S	3.195	1.068	2.119	0	90.18	9.82
198	406366.2	5129355.7	147	S	2.971	0.774	2.01	0	95.97	4.03
199	407341.4	5129264.6	133	S	3.024	0.767	1.624	0	94.69	5.31
200	403141.5	5131067.1	205	S	3.029	1.704	1.244	0	81.15	18.85
201	404071.9	5130809.2	192	S	3.091	0.86	1.85	0	92.93	7.07
202	405074.1	5130581.9	171	S	3.133	0.858	1.836	0	92.11	7.89
203	406024.0	5130389.7	152	S	3.191	1.209	2.083	0	89.25	10.75
204	407040.8	5130158.5	132	S	2.961	0.81	2.078	0	95.61	4.39
205	406761.3	5131133.3	137	S	2.937	0.778	2.082	0	96.23	3.77
206	413499.0	5113546.7	129	NS	0	0	0	0	0	0
207	413357.8	5114090.8	129	S	2.394	0.559	0.018	0	100	0
208	413851.1	5113917.2	124	S	2.409	0.561	0.016	0	100	0
209	413277.7	5114594.2	124	S	2.408	0.56	0.014	0	100	0
210	413702.2	5114459.0	120	S	2.409	0.563	0.021	0	100	0
211	414169.8	5114316.7	116	S	2.428	0.573	0.021	0	99.99	0.01
212	414687.9	5114201.3	106	S	2.433	0.568	0.019	0	100	0
213	413087.9	5115017.8	124	S	2.334	0.554	0.03	0	100	0
214	413543.6	5114911.0	116	S	2.453	0.568	0.016	0	99.99	0.01
215	414064.2	5114806.9	110	S	2.438	0.571	0.016	0	99.99	0.01
216	414533.8	5114713.7	108	S	2.45	0.573	0.016	0	100	0
217	415005.2	5114560.2	102	S	2.367	0.525	0.021	0	100	0
218	412923.7	5115504.4	121	S	2.325	0.557	0.036	0	100	0
219	413423.4	5115414.4	114	S	2.389	0.557	0.025	0	100	0
220	413911.4	5115291.7	110	S	2.381	0.567	0.033	0	100	0
221	414376.8	5115197.9	104	S	2.437	0.576	0.024	0	100	0
222	414899.2	5115049.8	100	S	2.393	0.581	0.028	0	99.99	0.01
223	415363.7	5114926.0	95	S	2.37	0.566	0.042	0	100	0
224	415843.9	5114827.3	89	S	2.493	0.6	-0.013	0	99.99	0.01
225	412310.1	5116106.5	121	S	2.464	0.751	2.083	0	97.58	2.42
226	412796.4	5115990.7	118	S	2.341	0.555	0.039	0	100	0
227	413252.7	5115860.6	111	S	2.431	0.571	0.022	0	99.99	0.01
228	413765.9	5115751.9	107	S	2.437	0.577	0.025	0	100	0
229	414252.2	5115634.0	100	S	2.433	0.57	0.026	0	99.99	0.01
230	414743.5	5115526.3	96	S	2.38	0.569	0.031	0	100	0
231	415227.3	5115436.6	90	S	2.363	0.574	0.036	0	100	0
232	415706.3	5115303.8	86	S	2.451	0.593	0.017	0	99.99	0.01
233	416177.0	5115184.6	75	S	2.441	0.599	0.014	0	99.99	0.01
234	411649.6	5116691.9	121	S	1.997	0.947	3.079	0	96.24	3.76
235	412147.0	5116581.7	113	S	1.849	0.56	0.017	0	100	0
236	412632.8	5116436.9	113	S	2.429	0.713	1.871	0	97.99	2.01
237	413121.4	5116358.0	110	S	2.352	0.563	0.032	0	100	0
238	413611.8	5116253.9	102	S	2.448	0.575	0.016	0	100	0
239	414100.9	5116159.3	99	S	2.303	0.568	0.019	0	100	0
240	414573.2	5116024.3	91	S	2.343	0.581	0.01	0	100	0
241	415055.2	5115916.4	87	S	2.388	0.6	-0.008	0	100	0
242	415551.6	5115794.6	83	S	2.419	0.583	0.027	0	100	0
243	416039.0	5115680.3	78	S	2.399	0.583	0.035	0	99.99	0.01
244	416517.3	5115555.8	75	S	2.26	0.515	0.018	0	100	0
245	417012.6	5115436.8	73	S	2.351	0.569	0.035	0	100	0
246	411508.0	5117171.6	115	S	1.826	0.533	-0.019	0	100	0
247	411973.0	5117052.9	108	S	1.702	0.518	0.008	0	100	0
248	412504.2	5116948.2	104	S	1.754	0.512	0.009	0	100	0
249	412957.6	5116858.8	104	S	2.293	0.564	0.011	0	100	0
250	413460.8	5116712.8	100	S	2.29	0.569	0.016	0	100	0
251	413945.8	5116616.4	93	S	2.232	0.575	0.012	0	100	0
252	414433.2	5116510.1	90	S	2.159	0.596	0.015	0	100	0
253	414930.9	5116397.9	83	S	2.151	0.568	-0.011	0	100	0
254	415397.5	5116262.2	80	S	2.409	0.611	-0.012	0	99.99	0.01
255	415897.7	5116170.3	78	S	2.312	0.521	0.024	0	100	0
256	416392.7	5116061.1	75	S	2.4	0.582	0.039	0	100	0
257	416859.2	5115943.3	69	S	2.432	0.586	0.037	0	99.99	0.01
258	417355.2	5115802.0	63	S	2.31	0.577	0.03	0	100	0
259	410853.4	5117782.9	123	S	1.858	0.561	0.007	0	100	0
260	411361.5	5117637.6	116	S	1.74	0.589	-0.053	0	100	0
261	411833.7	5117537.2	111	S	2.048	0.828	2.953	0	97.25	2.75
262	412318.0	5117400.1	104	S	2.011	0.824	3.034	0	97.44	2.56
263	412820.3	5117289.1	105	S	2.423	0.745	1.497	0	98.13	1.37
264	413282.0	5117182.3	100	S	2.274	0.589	0.005	0	100	0

Diameter(Φ)	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Diameter(u)	4000	2828.4	2000	1414.2	1000	707.1	500	353.6	250	176.8	125	88.4	62.5	44.2	31.3	22.1	15.6	11	7.8	5.5	3.9	2.8	2	1.4	1	0.7	0.5	0.35	0.24	0.18	0.12	0.09	0.06	0.03	0.02
133	0	0	0	0	0	0	1.4	6.3	13.6	18.5	16.2	9.3	3.5	1.5	2.7	3.9	4.4	4.3	3.9	3.3	2.6	1.9	1.1	0.3	0	0	0	0	0	0	0	0	0	0	0
134	0	0	0	0	0	0	0.7	7.2	17.3	23.1	19.1	9.5	2.1	0.3	1.5	2.8	3.2	3	2.7	2.3	1.9	1.3	0.8	0.1	0	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0.1	5.6	24	37	23.2	5.2	0	0	0.3	1.1	0.9	0.5	0.3	0.4	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0
136	0	0	0	0	0	0	0.3	5.7	18.7	27.6	20.6	7.1	0.6	0	1.1	2.7	3.2	2.8	2.6	2.2	1.8	1.3	0.7	0.2	0	0	0	0	0	0	0	0	0	0	0
137	0	0	0	0.4	1	1.7	3.4	8	15.3	20.8	19.3	11.7	4.1	0.7	0.9	2	2.4	2.2	1.7	1.4	1	0.7	0.4	0.1	0	0	0	0	0	0	0	0	0	0	0
138	0	0	0	0.2	0.3	0.2	0.6	4.2	13.7	24.2	25.4	15.5	4.7	0.3	0.3	1.5	2.1	1.8	1.3	1	0.6	0.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0
139	0	0	0	0.2	0.5	0.7	2.4	8.8	19.8	26.6	21.3	9.7	1.9	0	0.6	1.4	1.4	1.1	0.8	0.7	0.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0.3	7.1	23.6	33	22.4	6.5	0.2	0	0.4	1.2	1.1	0.8	0.6	0.6	0.6	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0.7	7.2	16.7	21.3	16.8	8.1	2.3	1.4	2.7	3.6	3.7	3.5	3.1	2.7	2.2	1.6	1	0.3	0	0	0	0	0	0	0	0	0	0	0
142	0	0	0	0.6	1.5	2.1	3.4	6.5	10.7	12.5	10.3	6.5	4.1	4	4.9	5.5	5.6	5.3	4.7	3.9	3.1	2.2	1.3	0.4	0	0	0	0	0	0	0	0	0	0	0
143	0	0	0	0	0	0	0.2	7	25.5	35.6	20.9	4.1	0	0	0.5	1.3	1.2	0.8	0.6	0.6	0.6	0.4	0.1	0	0	0	0	0	0	0	0	0	0	0	0
144	0	0	0	0	0	0	1.2	8.2	17.9	22.6	18	8.6	2.2	1	2.3	3.3	3.4	3	2.5	2	1.5	1	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	3.9	17	30.1	26.9	11.8	1.8	0	0.4	1.7	1.9	1.4	0.9	0.6	0.5	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
147	0	0	0	0	0	0	0	0.1	5.9	21.2	32.5	24.8	8.7	0.8	0	0.5	1.6	1.5	0.8	0.4	0.2	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0
148	0	0	0	0	0	0	1	1	10.4	26.4	33.2	22.2	6.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
149	0	0	0	0.5	1	1.3	3	8.4	16.4	21.4	18.5	10.4	3.6	1.2	1.6	2.3	2.4	2.1	1.7	1.3	1	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	1.3	6.6	14.6	19	15.8	8.5	3.2	2	3	3.9	4.2	4.1	3.7	3.2	2.6	1.9	1.1	0.4	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	1.1	7.5	16.8	21.3	16.9	8.1	2.2	1.3	2.6	3.6	3.8	3.5	3.1	2.7	2.1	1.5	0.9	0.2	0	0	0	0	0	0	0	0	0	0	0
152	0	0	0	0	0	0	1	8.3	18.8	23.8	18.6	8.6	1.9	0.7	2	2.9	2.9	2.5	2.1	1.8	1.4	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0
153	0	0	0	0	0	0	1.1	6.8	14.8	18.7	15.2	8.1	3.3	2.5	3.6	4.3	4.3	4	3.5	3	2.5	1.9	1.1	0.4	0	0	0	0	0	0	0	0	0	0	0
154	0	0	0	0.3	0.5	0.5	2	7.4	15.2	19.3	16.1	8.7	3.2	1.8	2.7	3.6	3.8	3.5	3	2.6	2.1	1.5	0.9	0.3	0	0	0	0	0	0	0	0	0	0	0
155	0	0	0	0	0	0	0	2.7	8.4	14.6	17	14	8.8	5.3	4.2	4.4	4.4	4	3.4	2.8	2.2	1.7	1.1	0.4	0	0	0	0	0	0	0	0	0	0	0
156	0	0	0	0	0	0	0	0.8	7.3	17.5	23.8	20.3	10.8	3.3	1.1	2	3	2.9	2.3	1.6	1.1	0.8	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0
157	0	0	0	0	0	0	0	0.3	7.1	22.5	33.1	26.1	9.8	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
158	0	0	0	0	0	0	0	0.3	5.7	18.2	28.6	25.9	13.2	2.9	0	0.2	1.2	1.4	0.9	0.4	0.2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0
159	0	0	0	0.4	0.7	0.9	1.9	5.3	10.7	14.3	13	8.5	4.6	3.3	3.8	4.7	5.1	5.1	4.8	4.1	3.4	2.5	1.5	0.5	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0.5	0.8	0.6	1.6	5.8	12.4	16.2	13.8	7.9	3.6	2.6	3.5	4.5	4.9	4.8	4.5	3.9	3.1	2.2	1.3	0.4	0	0	0	0	0	0	0	0	0	0	0
161	0	0	0	0.2	0.2	0.2	1.5	6.1	12.7	16.2	13.4	7.4	3.4	2.9	4	4.9	5.3	5.1	4.6	4	3.1	2.2	1.3	0.4	0	0	0	0	0	0	0	0	0	0	0
162	0	0	0	0.1	0.3	0.4	1.4	4.2	8.1	10.2	9.1	6.6	5.2	5.6	6.4	7	7.1	6.8	6.1	5.1	4	2.9	1.8	0.6	0	0	0	0	0	0	0	0	0	0	0
163	0	0	0	0.3	0.4	0.4	1.7	6.2	12.6	16	13.4	7.9	4.1	3.4	4.3	5	5	4.7	4.1	3.5	2.7	1.9	1.2	0.4	0	0	0	0	0	0	0	0	0	0	0
164	0	0	0	0.4	0.7	0.7	1.7	5.3	10.9	14.4	13.1	8.9	5.4	4.4	4.7	5.1	5	4.6	4	3.4	2.7	2	1.3	0.5	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	4.4	16.1	27.4	26.3	14.1	3.4	0	0.3	1.5	1.8	1.4	0.8	0.6	0.5	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	1.1	5.8	13.7	19.6	18.2	11.2	4.8	2.6	3.4	4.5	4.5	3.7	2.6	1.8	1.1	0.7	0.1	0	0	0	0	0	0	0	0	0	0	0
167	0	0	0	0	0	0	0	0	4.3	17.9	31	27.1	11.5	1.6	0	0.4	1.6	1.7	1.1	0.5	0.3	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0
168	0	0	0	0	0	0	0	0.1	4.3	15.4	26.9	27	15.6	4.4	0.2	0.2	1.3	1.7	1.2	0.6	0.2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0
169	0	0	0	0	0	0	0.8	6.9	17	23.6	20.6	11.3	3.4	0.7	1.4	2.4	2.6	2.3	1.9	1.5	1.2	0.8	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0.3	0.5	0.5	1.5	5.3	11.3	15	13.3	8.1	4.1	3.1	3.9	4.9	5.4	5.3	4.9	4.2	3.3	2.3	1.3	0.4	0	0	0	0	0	0	0	0	0	0	0
171	0	0	0	0	0	0	0.1	5.6	20.2	30.3	22.5	7.7	0.7	0	1.1	2.2	2.2	1.8	1.5	1.2	1	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0
172	0	0	0	0	0	0	0	4.8	22.9	37.2	24.3	5.8	0.1	0	0.3	1.1	0.9	0.4	0.3	0.3	0.4	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0
173	0	0	0	0	0	0	0.4	6.9	22.2	31.5	22.3	7.1	0.5	0	0.7	1.8	1.7	1.2	0.9	0.8	0.6	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0
174	0	0	0	0	0	0	1.4	7.1	15.6	20.5	17.4	9.7	3.8	2.1	2.8	3.5	3.5	3.1	2.6	2.2	1.7	1.3	0.7	0.1	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0.1	4.4	13.5	21.8	22.2	14.5	5.8	1.6	1.6	2.7	3	2.6	1.9	1.4	1	0.7	0.4	0.1	0	0	0	0	0	0	0	0	0	0	0
176	0	0	0	0.4	0.6	0.7	0.3	0.9	4.9	12.6	19.3	19	12.3	5.2	2.2	2.8	4	4.2	3.5	2.5	1.7	1.1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0
177	0	0	0	0	0	0	0	0	3.7	17.3	32	29.1	12.5	1.6	0	0	0.9	1.2	0.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
178	0	0	0	0	0	0	0	0	4.8	18.7	31.8	29	13.5	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
179	0	0	0	0	0	0	0	0.2	4.7	15.9	26.8	26.5	15.2	4.3	0.2	0.2	1.3	1.7	1.2	0.6	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0.4	0.6	0.3	1	4.8	11.2	15.9	15	9.7	4.7	2.8	3.3	4.2	4.8	4.8	4.5	3.9	3.1	2.2	1.3	0.5	0	0	0	0	0	0	0	0	0	0	0
181	0	0	0	0	0	0	0.7	5.9	14.1	19.1	16.7	9.6	3.9	2.3	3	3.9	4.2	4	3.6	3	2.3	1.6	0.9	0.3	0	0	0	0	0	0	0	0	0	0	0
182	0	0	0	0	0	0	0.1	6.1	22.2	32.9	23.8	7.6	0.5	0	0.4	1.3	1.3	0.9	0.6	0.6	0.5	0.4	0.1	0	0	0	0	0	0	0	0	0	0	0	0
183	0	0	0	0	0	0	0.2	6.4	21.8	31.4	22.3	7.2	0.5	0	1	1.9	1.8	1.4	1	0.9	0.7	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0
184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185	0	0	0	0.5	1	1.1	1.7	4	7.8	10.5	10.4	8.3	6.6	6.1	6.4	6.6	6.4	5.8	5	4	3	2.1	1.3	0.4	0	0	0	0	0	0	0	0	0	0	0
186	0	0	0	0.5	0.9	0.8	1.4	4.6	10.8	16.6	17.5	13.1	7.4	4	3.1	3.3	3.4	3.1	2.6	2.1	1.6	1.2	0.7	0.1	0	0	0	0	0	0	0	0	0	0	0
187	0	0	0	0	0	0	0	0	3.2	13.9	25.9	26.8	15.7	4.4	0.2	0.5	2	2.4	1.8	1.1	0.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0
188	0	0	0	0	0	0	0	0	3.5	16.6	30.8	28.6	13	2	0	0.1	1.2	1.5	1	0.4	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0
189	0	0	0	0	0	0	0	0.1	5.3	19	31.6	28.5	13.3	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	3.3	16.4	31.4	29.9	13.8	2.1	0	0	0.8	1.1	0.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
191	0	0	0	0	0	0	0	5	23.2	37.3	24.3	5.5	0.1	0	0.3	1.1	0.9	0.4	0.3	0.3	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0
192	0	0	0	0	0	0	0.5	7	19.9	27.9	22.1	9.4	1.6	0.1	1.2	2.2	2.1	1.6	1.2	0.9	0.7	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	0
193	0	0	0	0.1	0.2	0.1	0.6	2.8	7.2	10.7	10.4	7.6	5.5	5.3	6.3	7.4	7.8	7.5	6.5	5.2	3.8	2.5	1.4	0.4	0	0	0	0	0	0	0	0	0	0	0
194	0	0	0	0.4	0.6	0.4	1.3	5.4	12.1	16.5	15.1	9.7	5	3.5	3.8	4.4	4.4	4.1	3.6	3	2.4	1.8	1.1	0.4	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0.1	4.6	16.5	27.3	25.8	13.8	3.4	0.1	0.3	1.4	1.8	1.4	0.9	0.7	0.5	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0
196	0	0	0	0	0	0	0	0.7	5.5	15	23.5	23.4	14.6	5.1	0.8	1	2.3	2.6	2	1.2	0.7	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0
197	0	0	0	0	0	0	0	0.1	4.5	16.2	27.9	26.9	14.4	3.2	0	0.2	1.6	1.9	1.3	0.6	0.3	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0
198	0	0	0	0	0	0	0	0	4.7	19.3	32.8	27.8	11.1	1.2	0	0	0.9	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199	0	0	0	0	0	0	0	0.1	4.7	17.6	29.7	28	14.4	2.9	0	0	0.7	1	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0.4	0.6	0.5	1.7	6.9	15.3	21	19	11.2	4.2	1.5	2	2.9	3.2	2.8	2.1	1.6	1.1	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0
201	0	0	0	0	0	0	0	0	4.4	16.7	28.8	27.9	14.9	3.4	0	0	0.9	1.3	0.8	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202	0	0	0	0	0	0	0	0	3.7	15.5	25.1	28.4	16.2	4.2	0.1	0	0.8	1.3	0.9	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
203	0	0	0	0	0	0	0	0.3	6	18.4	25.1	24.4	11.7	2.2	0	0.6	1.9	2.1	1.5	0.9	0.5	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0
204	0	0	0	0	0	0	0	0.1	5.2	20.3	32.9	26.7	10.2	1.1	0	0.1	1	1.1	0.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205	0	0	0	0	0	0	0	0.1	5.2	20.7	33.5	26.7	9.7	0.8	0	0.1	0.9	1	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
207	0	0	0	0	0	0	0	4.9	19.8	32.5	25.4	12.6	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
208	0	0	0	0	0	0	0	4.7	19.3	32.2	28.7	13.2	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
209	0	0	0	0	0	0	0	4.8	19.3	32.2	28.7	13.1	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	4.7	19.3	32.1	28.6	13.2	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
211	0	0	0	0	0	0	0	4.7	18.7	31.3	28.7	14	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212	0	0	0	0	0	0	0	4.4	18.5	31.6	29	14	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213	0	0	0	0	0	0	0	6.2	21.9	33.2	26.8	10.7	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
214	0	0	0	0	0	0	0	4	17.9	31.2	29.4	14.7	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215	0	0	0	0	0	0	0	4.4	18.3	31.3	29	14.3	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
216	0	0	0	0	0	0	0	4.2	18	31	29.1	14.7	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
217	0	0	0	0	0	0	0	4.2	20.4	35.2	28.7	10.4	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
218	0	0	0	0	0	0	0	6.4	22.2	33.1	26.4	10.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
219	0	0	0	0	0	0	0	4.9	20	32.7	28.3	12.4	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	5.5	20.3	32.2	27.7	12.4	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221	0	0	0	0	0	0	0	4.6	18.5	31.1	28.7	14.3	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
222	0	0	0	0	0	0	0.1	5.6	19.9	31.4	27.5	13	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223	0	0	0	0	0	0	0	5.7	20.7	32.4	27.4	12	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
224	0	0	0	0	0	0	0	4.3	16.7	29.1	28.9	16.5	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	0	4.3	19.4	33.3	28.1	11.1	1.1	0	0	0.7	0.8	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
226	0	0	0	0	0	0	0	6	21.7	33.2	26.9	10.8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
227	0	0	0	0	0	0	0	4.5	18.6	31.4	28.8	14	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
228	0	0	0	0	0	0	0	4.6	18.5	31.1	28.7	14.3	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
229	0	0	0	0	0	0	0	4.4	18.6	31.5	28.8	14	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	5.6	20.3	32.1	27.6	12.4	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
231	0	0	0	0	0	0	0.1	6	20.9	32.1	27	12	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
232	0	0	0	0	0	0	0	4.8	18.1	30.2	28.3	14.9	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
233	0	0	0	0	0	0	0.1	5.2	18.4	30	27.9	14.8	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
234	0	0	0	0	0	0	4.4	20.4	34.2	27	9.3	0.7	0	0.1	0.8	0.7	0.4	0.3	0.4	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0.1	5.8	21.2	33	27.2	11.2	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
236	0	0	0	0	0	0	0	4.7	20.2	33.6	27.5	10.5	1.1	0	0	0.7	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
237	0	0	0	0	0	0	0	6	21.2	32.7	27.1	11.4	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
238	0	0	0	0	0	0	0	4.4	18.1	31	29	14.6	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
239	0	0	0	0	0	0	0.3	7.3	22.7	32.7	25.6	10.1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0.3	6.7	21.3	31.9	26.5	11.6	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
241	0	0	0	0	0	0	0.4	6.3	19.7	30.5	27.1	13.3	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
242	0	0	0	0	0	0	0	5.2	19.1	31	28	13.8	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
243	0	0	0	0	0	0	0.1	5.6	19.8	31.3	27.5	13.2	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
244	0	0	0	0	0	0	0.1	6.4	24.6	36.5	25	7	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
245	0	0	0	0	0	0	0.1	6.2	21.3	32.4	26.8	11.5	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
246	0	0	0	0	0	0.1	5.4	21.6	35.2	27.5	9.4	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
247	0	0	0	0	0	0.3	8	26.7	36.3	22.8	5.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
248	0	0	0	0	0	0.1	6.3	24.8	36.8	24.9	6.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
249	0	0	0	0	0	0	0.3	7.4	23	32.9	25.5	9.7	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0.4	7.6	23.1	32.7	25.2	9.7	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
251	0	0	0	0	0	0	0.8	9.3	24.8	32.4	23.4	8.4	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
252	0	0	0	0	0	0	1.8	11.8	26.3	31.1	21	7.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
253	0	0	0	0	0	0	1.3	11.4	27.1	32.4	21	6.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
254	0	0	0	0	0	0	0.4	6.1	19.1	29.8	27.1	14.1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
255	0	0	0	0	0	0	0	5.2	22.6	36	26.9	8.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
256	0	0	0	0	0	0	0	5.5	19.8	31.3	27.6	13.2	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
257	0	0	0	0	0	0	0	5	18.7	30.8	28.1	14.2	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
258	0	0	0	0	0	0	0.3	7.3	22.5	32.3	25.6	10.5	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
259	0	0	0	0	0	0.1	5.8	20.8	32.8	27.5	11.5	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	1.2	9.4	23.6	31.8	24	9	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
261	0	0	0	0	0	0	2.6	16.7	33.4	30.5	12.5	1.3	0	0	0.7	0.7	0.3	0.1	0.2	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
262	0	0	0	0	0	0	3.1	18.1	34	29.5	11.4	1.1	0	0	0.6	0.6	0.2	0.1	0.2	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
263	0	0	0	0	0	0	0.4	6.6	20.3	30.4	25.9	12.1	2.1	0	0	0.6	0.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
264	0	0	0	0	0	0	0.7	8.6	23.3	31.7	24.5	9.8	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud	Diameter(φ)	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
											Diameter(μ)	4000	2828.4	2000	1414.2	1000	707.1	500	353.6	250	176.8	125	88.4	62.5	44.2	31.3	22.1	15.6	11	7.8	5.5	3.9	2.8	2	1.4	1	0.7	0.5	0.35	0.24	0.18	0.12	0.09	0.06	0.03	0.02
265	413762.2	5117076.9	95	S	1.994	0.586	0.015	0	100	0		0	0	0	0	0	0	3.8	16.6	30	29.5	16	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
266	414276.2	5116963.3	88	S	2.068	0.574	-0.002	0	100	0		0	0	0	0	0	0	2.4	14.1	29	31.3	18.4	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
267	414765.3	5116862.3	85	S	2.273	0.583	0.02	0	100	0		0	0	0	0	0	0	0.6	8.4	23.5	32	24.4	9.7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
268	415248.4	5116741.7	81	S	2.276	0.586	0.017	0	100	0		0	0	0	0	0	0	0.6	8.4	23.3	31.9	24.5	9.8	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
269	415721.4	5116640.4	77	S	2.417	0.59	0.032	0	99.99	0.01		0	0	0	0	0	0	0.1	5.4	19.2	30.8	27.7	13.8	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
270	416216.2	5116530.4	75	S	2.349	0.56	0.042	0	100	0		0	0	0	0	0	0	0	5.9	21.4	32.9	27	11.2	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
271	416710.6	5116414.6	73	S	2.476	0.591	0.014	0	99.99	0.01		0	0	0	0	0	0	0	4.4	17.3	29.8	28.9	15.7	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
272	417200.0	5116300.7	69	S	2.45	0.595	0.019	0	99.99	0.01		0	0	0	0	0	0	0	4.9	18.2	30	28.2	15	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
273	417681.7	5116193.4	66	S	2.281	0.572	0.015	0	100	0		0	0	0	0	0	0	0.4	7.9	23.4	32.6	24.9	9.6	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
274	418177.6	5116095.0	65	S	2.069	0.603	0.011	0	100	0		0	0	0	0	0	0	3.1	14.5	28	29.9	18.4	5.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
276	411179.8	5118146.6	107	S	1.756	0.53	-0.008	0	100	0		0	0	0	0	0	0.3	7	24.4	35.6	24.9	7.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
277	411688.1	5117983.8	106	S	2.158	0.804	2.067	0	97.63	2.37		0	0	0	0	0	0	2.6	13.5	27.7	29.9	18	5.1	0.1	0	0.4	0.7	0.5	0.2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
278	412177.8	5117886.4	101	S	2.246	1.033	2.794	0	95.12	4.88		0	0	0	0	0	0	1.8	13.1	29.2	31	16.3	3.4	0	0	0.8	1.1	0.8	0.5	0.4	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	
279	412651.0	5117780.9	100	S	2.368	1.148	2.511	0	94.2	5.8		0	0	0	0	0	0	2.2	12.1	25	28.6	19	6.5	0.5	0	0.6	1.2	1.1	0.7	0.6	0.5	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	
280	413148.1	5117663.0	96	S	2.177	0.574	0	0	100	0		0	0	0	0	0	0	1.2	10.8	26.3	32.3	21.8	7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
281	413643.3	5117560.6	78	S	1.926	0.526	0.032	0	100	0		0	0	0	0	0	0	3	18.1	34.5	30.5	12.3	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
282	414129.6	5117442.8	76	S	1.617	0.527	0.02	0	100	0		0	0	0	0	0	0.8	11	29.6	34.8	19.4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
283	414601.3	5117341.5	75	S	1.618	0.566	0.025	0	100	0		0	0	0	0	0	1.4	12.5	28.2	32.1	19.8	5.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
284	415084.4	5117219.7	75	S	2.25	0.602	-0.001	0	100	0		0	0	0	0	0	0	1.1	9.5	23.7	31.1	23.6	9.5	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
285	415572.4	5117099.7	72	S	2.258	0.559	0.022	0	100	0		0	0	0	0	0	0	0.4	8.1	24.3	33.3	24.4	8.6	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
286	416062.5	5117004.7	72	S	2.202	0.511	0.013	0	100	0		0	0	0	0	0	0	0.2	7.8	26.9	36.7	22.8	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
287	416570.3	5116874.4	67	S	2.429	0.593	0.023	0	99.99	0.01		0	0	0	0	0	0	0.1	5.3	18.8	30.5	27.9	14.3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
288	417053.6	5116768.2	67	S	2.254	0.56	0.009	0	100	0		0	0	0	0	0	0	0.7	8.8	24	32.3	24	9.1	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
289	417522.2	5116678.4	64	S	2.304	0.575	0.016	0	100	0		0	0	0	0	0	0	0.4	7.4	22.6	32.4	25.5	10.3	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
290	418006.8	5116574.8	63	S	2.226	0.604	-0.031	0	100	0		0	0	0	0	0	0	1.6	10	24	31.1	23.2	9	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
291	418499.5	5116453.7	60	S	1.898	0.62	0.03	0	100	0		0	0	0	0	0	0.4	6.6	19.7	29.7	26.4	13.6	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
292	410125.4	5118788.1	131	NS	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
293	410558.7	5118669.1	121	S	2.453	1.563	1.668	0	84.86	15.14		0	0	0	0	0	0.5	7.5	18.1	23.7	19.4	10	3.4	1.9	2.7	3	2.4	1.7	1.3	1.1	0.9	0.7	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	
294	411053.3	5118603.7	113	S	2.047	1.146	2.492	0	93.21	6.79		0	0	0	0	0	0.3	7.3	21.6	30.4	23.3	8.9	1	0	1	1.5	1.1	0.7	0.6	0.6	0.5	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
295	411552.7	5118467.2	101	S	2.44	1.502	1.956	0	83.69	11.31		0	0	0	0	0	0.4	5.8	15.9	23.9	22.7	13.9	4.9	0.8	0.7	1.5	1.8	1.6	1.4	1.2	1	0.8	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	
296	411998.5	5118355.0	94	S	2.137	0.591	0.004	0	100	0		0	0	0	0	0	0	1.9	12.3	26.9	31.2	20.4	6.6	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
297	412500.6	5118232.0	96	S	2.237	0.82	1.953	0	97.49	2.51		0	0	0	0	0	0	1.9	12.1	25.9	29.8	19.7	7	0.9	0	0.6	0.7	0.4	0.2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
298	412993.4	5118136.7	88	S	2.196	0.685	1.1	0	98.78	1.22		0	0	0	0	0	0	1.6	11.7	26.2	30.9	20.6	7	0.5	0	0.2	0.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
299	413496.4	5118031.8	77	S	1.76	0.564	0.016	0	100	0		0	0	0	0	0	0.4	8.2	24.1	33.1	24.4	8.8	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
300	413973.3	5117912.4	56	S	1.72	0.524	-0.003	0	100	0		0	0	0	0	0	0.3	7.8	25.8	35.9	23.6	6.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
301	414461.8	5117813.2	57	S	1.701	0.588	0.001	0	100	0		0	0	0	0	0	1.3	10.4	25.3	31.8	22.4	8	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
302	414943.0	5117705.1	63	S	1.613	0.524	0.018	0	100	0		0	0	0	0	0	0.8	11.1	29.8	34.9	19.3	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
303	415448.7	5117582.5	71	S	2.249	0.608	-0.014	0	100	0		0	0	0	0	0	0	1.3	9.6	23.5	30.9	23.6	9.6	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
304	415910.2	5117485.5	68	S	2.351	0.588	0.027	0	99.99	0.01		0	0	0	0	0	0	0.3	6.7	21.2	31.5	26.3	11.9	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
305	416404.4	5117364.3	63	S	2.326	0.575	0.038	0	100	0		0	0	0	0	0	0	0.2	6.9	22.1	32.3	25.9	10.9	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
306	416894.0	5117267.0	63	S	2.294	0.614	0.005	0	99.99	0.01		0	0	0	0	0	0	1	8.7	22.4	30.5	24.4	10.9	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
307	417370.6	5117132.4	62	S	2.209	0.594	0.003	0	100	0		0	0	0	0	0	0	1.3	10.4	25	31.5	22.5	8.3	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
308	417872.6	5117030.2	60	S	2.197	0.606	-0.009	0	100	0		0	0	0	0	0	0	1.7	10.8	24.9	30.9	22.2	8.3	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
309	418365.7	5116916.3	59	S	2.029	0.607	-0.017	0	100	0		0	0	0	0	0	0.1	3.9	15.5	28.4	29.4	17.3	4.9	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
310	418835.6	5116822.5	57	S	2.051	0.63	0.024	0	100	0		0	0	0	0	0	0.1	4	15.4	27.4	28.5	17.8	5.9	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
311	419333.9	5116693.7	56	S	2.019	0.595	0.01	0	100	0		0	0	0	0	0	0	3.7	15.9	29.1	29.5	16.9	4.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
312	409918.1	5119308.0	125	SM	4.24	2.136	0.216	0	47.2	52.8		0	0	0	0	0	0.3	2.9	6.7	9	8.5	6.7	8.1	6.8	7.5	7.6	7.2	6.7	6.1	5.3	4.4	3.3	2.3	1.4	0.4	0	0	0	0	0	0	0	0	0	0	
313	410397.0	5119172.8	112	MS	2.849	1.847	1.133	0	75.41	24.59		0	0	0	0	0	0.6	7.3	16.1	19.6	15.1	7.9	4.2	4.3	5	4.7	3.6	2.7	2.3	2	1.6	1.2	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	
314	410887.5	5119067.8	101	S	2.455	1.545	1.477	0	84.08	15.92		0	0	0	0	0	0.8	8.6	18.4	22.2	17	8.7	4.2	3.8	4.2	3.5	2.3	1.5	1.1	1	0.8	0.6	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	
315	411391.3	5118944.8	94	S	1.917	0.735	1.407	0	97.54	2.46		0	0	0	0	0	0.2	6.4	20.9	31.6	25.7	10.9	1.7	0	0.7	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
316	411849.5	5118876.4	89	S	2.475	1.023	1.845	0	95.12	4.88		0	0	0	0	0	0	2.1	9.8	20.1	25.5	21.5	11.9	3.9	0.7	0.5	0.9	0.9	0.6	0.4	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
317	412374.3	5118724.4	88	S	2.199	0.776	0.769	0	98.66	1.34		0	0	0	0	0	0.1	3.8	13.5	23.7	26.3	19.4	9.2	2.4	0.1	0.2	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
318	412854.5	5118618.6	81	S	2.246	0.783	1.588	0	98.01	1.99		0	0	0	0	0	0	1.9	11.6	25	29.5	20.6	7.9	1.1	0	0.2	0.6	0.5	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
319	413340.5	5118509.2	78	S	1.798	0.571	0.032	0	100	0		0	0	0	0	0	0.3	7.4	22.9	32.8	25.3	9.9	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
320	413832.9	5118387.2	65	S	2.046	0.575	-0.01	0	100	0		0	0	0	0	0	0	2.8	14.7	29.2	31	17.8	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
321	414329.7	5118306.3	47	S	1.707	0.524	0	0	100	0		0	0	0	0	0	0.4	8.1	26.3	35.9	23.1	5.8	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
322	414801.6	5118167.3	51	S	1.657	0.533	-0.015	0	100	0		0	0	0	0	0	0.8	9.8	27.8	35.1	21.2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
323	415290.1	5118078.9	59	S	1.719	0.52	0.018	0	100	0		0	0	0	0	0	0.2	7.6	26.2	36.2	23.4	6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
324	415786.8	5117961.7	63	S	2.264	0.599	0.006	0	100	0		0	0	0	0	0	0	1	9	23.4	31.3	24	9.8	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
325	416249.3	5117860.6	63	S	2.39	0.599	0.004	0	100	0		0	0	0	0	0	0	0.3	6.2	19.6	30.6	27	13.3	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
326	416749.6	5117728.0	60	S	2.262	0.607	0.004	0	100	0		0	0	0	0	0	0	1.2	9.3	23.3	30.9	23.7	9.9	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
327	417244.9	5117625.9	58	S	2.143	0.597	0.01	0	100	0		0	0	0	0	0	0	2	12.2	26.6	31	20.5	6.9	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
328	417737.1	5117512.5	58	S	2.13	0.591	0.012	0	100	0		0	0	0	0	0	0	2	12.5	27.1	31.1	20.2	6.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
329	418216.5	5117427.4	56	S	2.113	0.599	0.007	0	100	0		0	0	0	0	0	0	2.4	13.1	27.1	30.6	19.7	6.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
330	418706.0	5117292.7	55	S	2.059	0.628	0.042	0	100	0		0	0	0	0	0	0.1	3.8	15.2	27.6	28.7	17.8	6	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
331	419185.1	5117179.1	54	S	2.049	0.622	0.038	0	100	0		0	0	0	0	0	0.1	3.8	15.4	27.8	28.8	17.6	5.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
332	419685.4	5117076.5	53	S	2.13	0.634	0.017	0	100	0		0	0	0	0	0	0	3	13.3	25.8	29.1	19.9	7.6	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
334	409763.0	5119790.8	112	MS	3.053	1.807	0.81	0	71.35	28.65		0	0	0	0	0	1.4	6.8	12.8	14.9	11.9	8.1	7.1	7.9	7.9	6.2	4.1	2.6	2.1	1.8	1.5	1.1	0.7	0.3	0	0	0	0	0	0	0	0	0	0	0	
335	410259.3	5119658.9	100	S	2.508	1.656	1.476	0	82.68	17.32		0	0	0	0	0	0.9	8.9	15.7	22.2	16.5	8.1	3.7	3.3	3.8	3.3	2.4	1.8	1.6	1.4	1.1	0.8	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	
336	410755.0	5119546.7	92	S	2.38	1.305	1.204	0	88.21	11.79		0	0	0	0	0	1	8.4	17.3	20.4	16.1	10.3	7.6	6.7	5.1	2.9	1.1	0.5	0.5	0.5	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	
337	411241.6	5119433.5	86	S	2.023	0.937	1.419	0	95.99	4.01		0	0	0	0	0	0.6	8.5	20.6	26.3	21	11.2	4.8	2.6	1.8	1	0.4	0.1	0.2	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
338	411723.5	5119354.7	81	S	2.408	0.79	0.76	0	98.31	1.69		0	0	0	0	0	0	1.9	9.1	19.4	25.8	23.1	13.8	4.8	0.5	0	0.4	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
339	412217.9	5119204.4	79	S	2.829	1.443	1.258	0	85.32	14.68		0	0	0	0	0	0.8	2.9	8.2	15.1	19.5	18.3	12.8	6.9	3.3	2.2	2.2	2.1	1.7	1.1	0.7	0.5	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	
340	412689.0	5119085.4	82	S	2.63	1.023	1.533	0	94.05	5.95		0	0	0	0	0	0	1.4	7.6	16.7	23.1	22.4	15.4	7.1	2	0.5	0.6	0.9	0.7	0.5	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
341	413185.2	5118994.9	72	S	2.221	0.609	0.008	0	100	0		0	0	0	0	0	0	1.5	10.4	24.4	30.7	22.7	9	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
342	413683.0	5118881.7	65	S	1.827	0.593	0.065	0	100	0		0	0	0	0	0	0.3	7.3	22.1	31.6	25.3	11.1	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
343	414175.1	5118768.1	55	S	2.019	0.599	-0.025	0	100	0		0	0	0	0	0	0.1	3.8	15.7	28.9	29.6	17.1	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
344	414649.4	5118648.8	45	S	1.921	0.525	0.015	0	100	0		0	0	0	0	0	0	3.2	18.1	34.5	30.5	12.1	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
345	415137.0	5118570.4	49	S	1.78	0.531	0.019	0	100	0		0	0	0	0	0	0.2	6.3	23.7	35.6	25.6	8	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
346	415620.4	5118453.5	60	S	1.765	0.514	0.008	0	100	0		0	0	0	0	0	0.1	6.1	24.3	36.7	25.3	7	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
347	416111.3	5118357.9	65	S	2.226	0.579	0.016	0	100	0		0	0	0	0	0	0	0.8	9.6	24.9	32.2	23.2	8.3	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
348	416604.0	5118220.0	60	S	2.217	0.624	0.029	0	100	0		0	0	0	0	0	0	1.8	10.8	24.4	30	22.1	9.2	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
349	417101.1	5118104.8	57	S	2.122	0.589	0.012	0	100	0		0	0	0	0	0	0	2	12.7	27.4	31.2	19.9	6.2	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
350	417567.4	5118000.7	56	S	2.179	0.605	0.016	0	100	0		0	0	0	0	0	0	1.8	11.4	25.6	30.8	21.5	7.9	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
351	418065.0	5117892.1	54	S	2.044	0.574	0.003	0	100	0		0	0	0	0	0	0	2.7	14.8	29.5	30.9	17.6	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
352	418549.7	5117770.5	53	S	2.128	0.601	0.033	0	100	0		0	0	0	0	0	0	2.2	12.8	27	30.6	19.9	6.7	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
353	419037.1	5117665.1	52	S	2.228	0.621	0.001	0	100	0		0	0	0	0	0	0	1.7	10.4	23.9	30.2	22.7	9.4	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
354	419525.7	5117553.8	51	S	2.172	0.646	-0.003	0	100	0		0	0	0	0	0	0	2.8	12.3	24.5	28.9	21.1	8.7	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
355	420010.9	5117435.3	49	S	2.238	0.625	-0.048	0	100	0		0	0	0	0	0	0	1.9	10.2	23.1	30	23.4	9.9	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
356	420512.1	5117334.6	46	S	2.346	0.589	-0.059	0	100	0		0	0	0	0	0	0	0.6	6.9	20.6	31.3	26.9	12	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
357	408670.3	5120456.8	117	S	1.985	0.931	2.773	0	95.35	4.65		0	0	0	0	0	0	4.7	21.1	34.6	25.9	8.1	0.5	0	1	1.3	0.7	0.3	0.3	0.3	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
358	409133.2	5120375.4	100	MS	2.673	1.713	1.123	0	79.91	20.09		0	0	0	0	0	1.9	9.5	16.6	17.4	12.5	7.9	6.8	7	5.9	3.8	2.3	1.8	1.7	1.6	1.2	0.8	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	
359	409622.9	5120250.7	94	S	2.312	1.398	1.532	0	87.43	12.57		0	0	0	0	0	1.1	9.3	19.3	22.7	17	8.8	4.7	4.2	4.1	2.9	1.6	0.9	0.7	0.7	0.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	
360	410104.7	5120119.6	92	S	2.374	1.307	1.15	0	86.75	13.25		0	0	0	0	0	0.8	8.4	17.9	21.4	16.3	9.2	6.2	6.2	5.6	3.7	1.6	0.6	0.4	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
361	410587.0	5120032.0	86	MS	4.117	1.894	0.222	0	51.8	48.2		0	0	0	0.1	0.5	1.2	2.2	3.3	4.7	6.8	9.4	11.5	11.6	9.8	7.7	6.5	5.9	5.4	4.5	3.4	2.3	1.4	0.7	0.1	0	0	0	0	0	0	0	0	0	0	
362	411065.1	5119929.7	78	S	1.851	0.82	0.89	0	97.73	2.27		0	0	0	0	0	1.4	11.2	23.2	26.9	19.5	9.4	3.7	2	1.4	0.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
363	411566.6	5119788.3	76	S	2.515	1.082	1.261	0	92.78	7.22		0	0	0	0	0	0.1	3.5	11	18.6	21.6	18.6	12.5	6.5	2.8	1.2	0.3	0.7	0.6	0.4	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	
364	412088.6	5119687.6	74	MS	3.458	1.866	0.837	0	68.81	31.19		0	0	0	0	0	0	2.1	7.5	13.5	16.2	14.2	9.5	5.5	3.8	4.1	4.8	5	4.4	3.4	2.3	1.4	0.9	0.5	0.1	0	0	0	0	0	0	0	0	0	0	
365	412538.9	5119607.4	66	MS	3.478	1.657	0.942	0	72.07	27.93		0	0	0	0	0	0.2	1.5	4.5	9.4	14.3	16.6	14.9	10.3	6	3.9	3.6	3.7	3.4	2.7	1.8	1.2	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	
366	413060.4	5119474.8	71	S	2.4	0.754	1.281	0	98.42	1.58		0	0	0	0	0	0	0.8	7.8	20.6	29.1	24.8	12.3	2.7	0	0	0.4	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
367	413523.1	5119360.3	66	S	2.171	0.621	0.016	0	100	0		0	0	0	0	0	0	2.3	12	25.3	30	21.1	8.1	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
368	414010.6	5119251.5	58	S	2.113	0.598	0.028	0	100	0		0	0	0	0	0	0	2.3	13.3	27.4	30.5	19.5	6.3	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
369	414521.8	5119142.4	50	S	1.885	0.598	0.041	0	100	0		0	0	0	0	0	0.3	6.2	20.1	30.9	26.7	12.8	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
370	415001.7	5119014.7	44	S	1.92	0.572	0.034	0	100	0		0	0	0	0	0	0	4.7	19	31.7	28.4	13.5	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
371	415483.7	5118918.6	57	S	1.922	0.584	0.056	0	100	0		0	0	0	0	0	0.1	4.9	19.1	31.4	27.9	13.5	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
372	415991.8	5118791.2	61	S	1.767	0.571	0.025	0	100	0		0	0	0	0	0	0.5	8.3	23.9	32.7	24.4	9.1	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
373	416469.5	5118708.9	59	S	1.97	0.578	0.033	0	100	0		0	0	0	0	0	0	3.9	17.4	30.8	29.3	15.1	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
374	416957.0	5118584.8	57	S	1.978	0.583	0.012	0	100	0		0	0	0	0	0	0	4	17.1	30.3	29.4	15.5	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
375	417430.2	5118475.3	54	S	2.146	0.619	0.032	0	100	0		0	0	0	0	0	0	2.4	12.7	26	29.9	20.3	7.5	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
376	417929.7	5118358.3	54	S	2.078	0.584	-0.006	0	100	0		0	0	0	0	0	0	2.6	13.9	28.3	30.9	18.7	5.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
377	418406.6	5118245.8	52	S	2.161	0.612	0.025	0	100	0		0	0	0	0	0	0	2.1	12.1	25.9	30.3	20.9	7.7	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
378	418904.5	5118150.4	50	S	2.249	0.604	-0.012	0	100	0		0	0	0	0	0	0	1.2	9.5	23.6	31.1	23.7	9.6	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
379	419396.7	5118033.6	49	S	2.226	0.614	-0.039	0	100	0		0	0	0	0	0	0	1.8	10.2	23.7	30.6	23.1	9.3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
380	419864.6	5117923.7	50	S	2.355	0.595	-0.059	0	100	0		0	0	0	0	0	0	0.6	6.8	20.3	30.9	27	12.4	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
381	420357.2	5117806.4	43	S	2.335	0.585	-0.051	0	100	0		0	0	0	0	0	0	0.5	7	20.9	31.6	26.8	11.6	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
382	420838.7	5117692.2	39	S	2.376	0.534	-0.015	0	100	0		0	0	0	0	0	0	0	4.4	19.7	34.5	29.1	11	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
383	408500.7	5120954.3	117	S	1.865	0.657	1.679	0	98.11	1.89		0	0	0	0	0	0	4.9	22.2	35.9	26.4	8	0.4	0	0.3	0.9	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
384	408984.3	5120850.4	80	S	1.875	0.735	0.827	0	98.47	1.53		0	0	0	0	0	0.6	8.8	22.1	28.9	22.7	11	3.2	0.9	0.7	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
385	409480.9	5120722.0	70	MS	3.139	1.96	0.969	0	71.44	28.56		0	0	0	0	0	0.3	5.1	12.8	17.8	16	10	5.2	3.7	4	4.3	4.2	3.8	3.4	2.9	2.2	1.6	1	0.5	0.1	0	0	0	0	0	0	0	0	0	0	
386	409967.4	5120608.7	83	MS	3.854	1.668	0.277	0	58.28	41.72		0	0	0	0.4	1	1.4	1.6	2	3.4	6.6	11.1	14.9	15.4	12.7	8.7	5.6	3.9	3.1	2.5	2	1.4	0.9	0.5	0.1	0	0	0	0	0	0	0	0	0	0	
387	410449.9	5120498.5	80	S	2.037	0.956	0.907	0	95.34	4.66		0	0	0	0	0	1	9.9	20.8	24.2	18.1	10.2	6.2	4.6	3	1.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
388	410945.0	5120404.2	75	MS	3.52	1.713	0.701	0	69.68	30.32		0	0	0	0.1	0.4	1.1	2.4	4.5	7.5	11.1	14.5	15.2	12.3	7.9	4.6	3.5	3.4	3.3	2.7	1.9	1.3	0.8	0.4	0.1	0	0	0	0	0	0	0	0	0	0	
389	411431.4	5120278.5	70	MS	3.438	1.709	0.791	0	71.36	28.64		0	0	0	0.1	0.4	0.9	2.1	4.8	8.9	13.3	15.6	14.3	10.4	6.6	4.5	3.8	3.5	3.1	2.4	1.8	1.2	0.8	0.4	0.1	0	0	0	0	0	0	0	0	0	0	
390	411905.6	5120169.7	66	MS	3.775	1.7	0.769	0	66.38	33.62		0	0	0	0.2	0.3	0.4	0.6	1.9	5.8	11.6	16.4	16.5	12.2	7.2	4.5	4.1	4.3	4.1	3.3	2.4	1.6	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	
391	412395.3	5120069.7	62	MS	3.311	1.615	0.953	0	77.89	22.11		0	0	0	0.5	0.9	0.6	0.7	3.1	9	16.1	19.8	16.9	9.9	4.3	2.4	2.8	3.3	3.1	2.3	1.5	0.9	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	
392	412880.8	5119963.2	59	S	2.216	0.754	0.693	0	99.05	0.95		0	0	0	0	0	0	3.4	13.1	23.5	26.4	20	9.8	2.5	0	0	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
393	413394.0	5119796.7	64	MS	3.432	1.806	0.957	0	72.02	27.98		0	0	0	0	0	0.2	1.6	5.8	12.2	17.1	16.8	11.8	6.1	3.2	3.2	4.1	4.5	4.1	3.2	2.2	1.4	0.9	0.5	0.1	0	0	0	0	0	0	0	0	0	0	
394	413842.6	5119691.4	54	S	2.248	0.614	-0.046	0	100	0		0	0	0	0	0	0	1.6	9.7	23.1	30.8	23.8	9.5	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
395	414335.0	5119608.2	57	MS	3.939	2.024	0.39	0	52.35	47.65		0	0	0	0	0	0.1	2.7	7.3	10.8	10.8	8.1	6	6.1	7.5	8.4	7.9	6.6	5.1	3.7	2.8	2.1	1.6	1	0.4	0	0	0	0	0	0	0	0	0	0	
396	414838.2	5119489.7	57	S	2.033	0.592	0.046	0	100	0		0	0	0	0	0	0	3.2	15.7	29.3	29.7	17	4.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
397	415339.8	5119380.8	57	S	2.084	0.659	0.094	0	100	0		0	0	0	0	0	0	4.1	15.5	26.2	27.1	18.2	7.5	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
398	415817.4	5119284.8	60	S	2.163	0.612	0.036	0	100	0		0	0	0	0	0	0	2	12.1	25.9	30.3	20.8	7.7	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud
399	416305.1	5119182.1	57	S	1.846	0.583	0.036	0	100	0
400	416786.1	5119048.0	55	S	1.985	0.589	0.056	0	100	0
401	417277.4	5118560.8	55	S	1.87	0.537	0.012	0	100	0
402	417762.5	5118447.6	53	S	2.036	0.566	0.024	0	100	0
403	418276.3	5118742.3	52	S	1.99	0.561	0.027	0	100	0
404	418756.1	5118632.2	49	S	2.063	0.59	-0.003	0	100	0
405	419220.1	5118511.6	48	S	2.216	0.613	-0.032	0	100	0
406	419721.8	5118398.9	45	S	2.344	0.578	-0.042	0	100	0
407	420232.1	5118302.2	41	S	2.31	0.581	-0.033	0	100	0
408	420706.0	5118180.4	35	S	2.321	0.579	-0.023	0	100	0
409	421175.1	5118072.4	29	S	2.309	0.588	-0.026	0	100	0
410	421673.3	5117933.1	24	S	2.194	0.584	-0.031	0	100	0
411	408861.3	5121310.1	87	S	1.927	0.571	0.014	0	100	0
412	409332.4	5121192.8	68	S	1.819	0.57	0.033	0	100	0
413	409820.7	5121091.4	75	MS	3.038	1.768	0.862	0	73.83	26.17
414	410309.7	5120979.2	79	MS	3.823	1.811	0.24	0	57.67	42.33
415	410805.2	5120862.9	73	MS	3.329	1.62	0.654	0	74.49	25.51
416	411267.3	5120748.9	66	MS	3.494	1.569	0.824	0	72.53	27.47
417	411759.6	5120632.6	62	S	2.605	0.838	0.546	0	97.74	2.26
418	412272.2	5120545.4	53	S	2.632	0.774	1.616	0	97.61	2.39
419	412729.0	5120433.9	55	S	2.377	0.602	-0.057	0	99.99	0.01
420	413233.8	5120322.4	54	S	2.442	0.756	1.474	0	97.86	2.14
421	413702.0	5120219.3	56	S	2.742	1.205	1.59	0	92.67	7.33
422	414168.4	5120074.3	53	S	2.318	0.599	-0.052	0	100	0
423	414662.3	5119958.9	52	S	2.347	0.594	-0.053	0	100	0
424	415166.0	5119851.7	52	S	2.191	0.6	-0.002	0	100	0
425	415670.3	5119750.6	61	S	2.317	0.629	-0.067	0	99.99	0.01
426	416152.4	5119646.9	55	S	2.134	0.596	0.01	0	100	0
427	416664.9	5119536.1	55	S	1.938	0.587	0.032	0	100	0
428	417133.4	5119424.2	53	S	1.902	0.591	0.058	0	100	0
429	417629.4	5119317.9	53	S	2.001	0.592	0.022	0	100	0
430	418123.2	5119209.4	51	S	1.963	0.636	0.055	0	100	0
431	418591.8	5119100.0	48	S	1.93	0.601	0.028	0	100	0
432	419106.1	5118999.6	46	S	2.31	0.591	-0.041	0	100	0
433	419588.3	5118862.9	42	S	2.371	0.532	-0.016	0	100	0
434	420084.5	5118757.8	39	S	2.263	0.589	-0.029	0	100	0
435	420563.3	5118637.1	33	S	2.335	0.58	-0.021	0	100	0
436	421030.2	5118544.0	28	S	2.401	0.59	-0.027	0	99.99	0.01
437	421541.6	5118413.5	21	S	2.218	0.595	-0.035	0	100	0
438	422014.7	5118322.8	12	S	2.349	0.694	-0.529	0	99.99	0.01
439	408683.7	5121760.6	123	S	2.631	1.416	1.671	0	87.25	12.75
440	409174.0	5121673.9	95	S	2.495	1.207	2	0	92.41	7.59
441	409670.7	5121551.4	77	S	1.937	0.605	0.074	0	100	0
442	410168.7	5121446.2	73	S	2.739	1.405	1.438	0	87.55	12.45
443	410653.0	5121344.4	69	MS	3.457	1.645	0.636	0	71.75	28.25
444	411145.4	5121239.5	64	MS	3.604	1.834	0.613	0	68.21	31.79
445	411630.9	5121118.6	57	S	2.418	0.654	-0.064	0	99.98	0.02
446	412116.1	5121000.1	59	S	2.307	0.586	-0.037	0	100	0
447	412578.1	5120907.1	57	S	2.283	0.577	-0.017	0	100	0
448	413059.0	5120804.2	55	S	2.155	0.531	-0.019	0	100	0
449	413567.9	5120700.6	55	S	2.371	0.568	-0.031	0	100	0
450	414042.3	5120562.3	55	S	2.432	0.591	-0.057	0	100	0
451	414531.0	5120467.0	53	S	2.297	0.584	-0.051	0	100	0
452	415017.3	5120345.1	53	S	2.178	0.535	-0.017	0	100	0
453	415502.1	5120226.9	63	S	2.035	0.535	0.009	0	100	0
454	415999.1	5120101.4	60	S	1.93	0.528	0.028	0	100	0
455	416498.4	5120010.5	56	S	2.234	0.531	-0.013	0	100	0
456	416996.3	5119895.2	52	S	2.179	0.583	-0.003	0	100	0
457	417480.0	5119774.8	49	S	2.135	0.594	-0.009	0	100	0
458	417955.5	5119692.1	46	S	2.142	0.566	-0.02	0	100	0
459	418449.9	5119565.1	46	S	2.097	0.613	-0.026	0	100	0
460	418936.0	5119468.0	44	S	2.105	0.63	-0.038	0	100	0
461	419422.4	5119357.3	41	S	2.349	0.578	-0.028	0	100	0
462	419912.0	5119240.0	37	S	2.357	0.528	-0.013	0	100	0
463	420402.4	5119119.1	34	S	2.321	0.577	-0.047	0	100	0
464	420880.6	5119033.5	29	S	2.322	0.588	-0.029	0	100	0
465	421376.5	5118897.3	21	S	2.275	0.59	-0.016	0	100	0
466	421879.8	5118804.4	12	S	2.028	0.534	0.001	0	100	0
468	408545.7	5122291.7	129	MS	3.865	1.869	0.546	0	57.57	42.43
469	409014.9	5122159.2	111	MS	3.637	1.783	0.704	0	63.28	36.72
470	409548.7	5122066.6	88	S	2.425	1.278	1.401	0	88.94	11.06
471	410008.5	5121938.4	75	S	2.245	0.851	0.994	0	97.06	2.94
472	410495.1	5121835.0	64	S	2.099	0.802	0.668	0	98.81	1.19
473	410987.9	5121708.0	60	S	2.727	1.266	0.812	0	89.96	10.04
474	411471.3	5121606.8	56	S	2.501	0.626	-0.081	0	99.98	0.02
475	411966.1	5121502.5	55	S	2.266	0.591	-0.027	0	100	0
476	412451.2	5121373.3	50	S	2.678	1.516	1.647	0	85.75	14.25
477	412896.5	5121274.5	50	S	2.164	0.593	0.008	0	100	0
478	413408.2	5121154.0	54	S	2.206	0.704	1.767	0	98.13	1.87
479	413877.6	5121053.8	58	S	2.188	0.577	-0.024	0	100	0
480	414386.2	5120924.4	60	S	2.277	0.583	-0.042	0	100	0
482	415359.2	5120712.3	72	S	1.865	0.507	0.008	0	100	0
483	415839.5	5120590.1	83	MS	0			0	0	
484	416342.1	5120497.3	52	S	2.125	0.572	-0.021	0	100	0
485	416840.4	5120389.8	46	S	2.053	0.583	0.003	0	100	0
486	417355.4	5120262.4	48	S	2.095	0.578	-0.024	0	100	0
487	417829.4	5120161.2	42	S	2.061	0.659	-0.055	0	100	0
488	418302.7	5120038.6	39	S	2.028	0.647	-0.039	0	100	0
489	418802.0	5119936.0	34	S	2.127	0.645	-0.039	0	100	0
490	419282.5	5119826.5	36	S	2.07	0.664	0.003	0	100	0
491	419775.1	5119719.3	33	S	2.155	0.576	-0.041	0	100	0
492	420270.8	5119594.7	31	S	2.222	0.623	-0.082	0	100	0
493	420746.6	5119498.5	26	S	2.295	0.596	-0.048	0	100	0
494	421232.5	5119377.8	18	S	2.262	0.603	-0.061	0	100	0
495	421721.2	5119282.7	8	S	2.406	0.598	-0.03	0	100	0
496	408381.2	5122781.3	129	MS	4.144	1.995	0.178	0	50.1	49.9
497	408849.0	5122637.7	110	S	2.495	1.06	1.923	0	94.23	5.77
498	409352.9	5122526.8	88	S	2.698	1.36	1.431	0	87.04	12.96
499	409909.9	5122414.5	72	S	2.526	1.226	1.521	0	91.06	8.94
500	410362.2	5122305.0	66	S	2.164	0.861	0.73	0	97.36	2.64
501	410852.3	5122194.1	57	S	2.871	1.339	0.853	0	86.5	13.5
502	411336.3	5122082.7	53	S	2.519	0.916	0.495	0	97.22	2.78
503	411828.7	5121980.2	54	S	2.371	0.591	-0.034	0	100	0
504	412309.2	5121859.4	50	S	2.172	0.585	-0.026	0	100	0
505	412803.1	5121743.8	50	S	2.176	0.59	-0.011	0	100	0
506	413253.3	5121643.2	52	S	2.223	0.516	0.01	0	100	0
507	413745.7	5121508.7	55	S	1.898	0.524	0.03	0	100	0
508	414226.7	5121385.1	62	S	2.321	0.526	-0.02	0	100	0
509	414733.5	5121271.9	62	S	2.115	0.532	-0.019	0	100	0
510	415234.3	5121199.6	68	S	2.043	0.535	-0.017	0	100	0
511	415723.9	5121091.2	61	S	1.732	0.586	0.002	0	100	0
512	416203.0	5120970.8	52	S	1.728	0.598	-0.02	0	100	0
513	416682.9	5120855.7	45	S	1.634	0.642	0.051	0	100	0
514	417159.9	5120736.6	38	S	2.252	0.564	-0.039	0	100	0
515	417755.0	5120630.8	30	S	2.289	0.604	-0.046	0	100	0
516	418635.1	5120424.7	33	S	2.084	0.542	-0.041	0	100	0
517	419133.4	5120318.5	32	S	2.07	0.624	-0.059	0	100	0
518	419626.6	5120192.8	28	S	2.155	0.576	-0.041	0	100	0
519	420096.9	5120090.6	28	S	2.164	0.617	-0.04	0	100	0
520	420589.7	5119970.9	20	S	2.253	0.619	-0.05	0	100	0
521	421090.4	5119847.6	15	S	2.25	0.66	-0.378	0	99.99	0.01
523	408721.1	5123107.5	114	S	2.782	1.194	1.769	0	89.87	10.13
524	409198.8	5123018.2	93	S	2.547	1.032	1.399	0	93.83	6.17
525	409712.1	5122910.7	77	MS	3.586	1.741	0.611	0	66.8	33.2
526	410192.5	5122776.0	66	S	2.731	1.165	1.437	0	90.69	9.31
527	410697.5	5122667.3	61	S	2.897	1.323	0.735	0	87.8	12.2
528	411176.0	5122550.6	54	S	2.389	0.974	0.277	0	97.77	2.23
529	411662.7	5122461.3	50	S	2.337	0.663	-0.064	0	99.99	0.01
530	412166.2	5122327.1	52	S	2.202	0.599	-0.037	0	100	0
531	412645.2	5122242.7	49	S	2.081	0.622	-0.095	0	100	0
532	413132.7	5122120.1	51	S	2.244	0.518	-0.013	0	100	0
533	413615.8	5122005.3	51	S	1.762	0.522	-0.036	0	100	0

Sample ID	Diameter(Φ) Diameter(μ)	-2 4000	-1.5 2828.4	-1 2000	-0.5 1414.2	0 1000	0.5 707.1	1 500	1.5 353.6	2 250	2.5 176.8	3 125	3.5 88.4	4 62.5	4.5 44.2	5 31.3	5.5 22.1	6 15.6	6.5 11	7 7.8	7.5 5.5	8 3.9	8.5 2.8	9 2	9.5 1.4	10 1	10.5 0.7	11 0.5	11.5 0.35	12 0.24	12.5 0.18	13 0.12	13.5 0.09	14 0.06	14.5 0.03	16 0.02
399		0	0	0	0	0	0.3	6.6	21.4	31.9	26.2	11.6	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
400		0	0	0	0	0	0	3.9	17.2	30.2	28.9	15.5	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
401		0	0	0	0	0	0	4.5	20.2	34.5	28.6	10.8	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
402		0	0	0	0	0	0	3.1	15.4	29.3	30.1	17.3	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
403		0	0	0	0	0	0	3.7	16.8	30.3	29.5	15.8	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
404		0	0	0	0	0	0	2.9	14.5	28.4	30.4	18.3	5.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
405		0	0	0	0	0	0	1.8	10.5	24	30.5	22.8	9	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
406		0	0	0	0	0	0	0.4	6.6	20.8	31.9	27	11.6	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
407		0	0	0	0	0	0	0.6	7.5	21.9	32	26	10.7	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
408		0	0	0	0	0	0	0.5	7.2	21.7	32	26.2	11	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
409		0	0	0	0	0	0	0.6	7.7	22	31.7	25.7	10.8	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
410		0	0	0	0	0	0	1.4	10.5	25.3	31.9	22.5	7.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
411		0	0	0	0	0	0.1	4.5	18.5	31.7	28.9	13.7	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
412		0	0	0	0	0	0.2	6.9	22.2	32.7	26	10.4	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
413		0	0	0	0	0	1.6	6	11.4	14.4	13.6	10.9	8.5	7.1	6.1	5.1	4	3.1	2.4	1.9	1.4	0.9	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	
414		0	0	0	0.4	1.1	1.9	2.5	3.2	4.5	7	10.4	13	13.3	11.3	8.3	5.8	4.3	3.5	2.9	2.3	1.6	1	0.5	0.1	0	0	0	0	0	0	0	0	0	0	
415		0	0	0	0.5	1.1	1.6	2.1	3.7	7.1	12	16.2	16.7	13	7.9	4.3	2.8	2.5	2.3	1.9	1.4	0.9	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	
416		0	0	0	0.2	0.5	0.6	0.5	2.4	6.8	13.3	18	17.3	12.1	6.9	4.3	3.7	3.6	3	2.2	1.5	0.9	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	
417		0	0	0	0.4	0.6	0.3	0.3	3.3	13.1	25.8	29.2	18.7	5.7	0.2	0	0.3	0.9	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
418		0	0	0	0	0	0	0	3.2	14	27.5	29.9	18	4.7	0	0	0.4	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
419		0	0	0	0	0	0	0.6	6.6	19.6	30.4	27.3	13.1	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
420		0	0	0	0	0	0	0.8	7.3	19.6	28.7	25.3	12.9	2.9	0	0	0.6	0.8	0.4	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
421		0	0	0	0.3	0.4	0.2	1.2	5.8	14.4	22.4	23.7	16.7	7.1	1.2	0	0.9	1.5	1.3	0.8	0.5	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	
422		0	0	0	0	0	0	0.8	7.7	21.4	31.1	25.9	11.4	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
423		0	0	0	0	0	0	0.6	7	20.6	31.1	26.7	12.1	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
424		0	0	0	0	0	0	1.6	11	25.2	31.1	22	8.1	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
425		0	0	0	0	0	0	1.4	8.4	21	29.7	25.2	12	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
426		0	0	0	0	0	0	2.1	12.5	26.8	30.9	20.3	6.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
427		0	0	0	0	0	0.1	4.8	18.5	30.8	28.3	14.3	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
428		0	0	0	0	0	0.1	5.6	19.8	31.2	27.2	13.1	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
429		0	0	0	0	0	0	3.9	16.5	29.6	29.3	16.3	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
430		0	0	0	0	0	0.3	5.7	18	28.6	26.8	15.3	4.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
431		0	0	0	0	0	0.2	5.4	18.7	30.2	27.6	14.3	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
432		0	0	0	0	0	0	0.7	7.8	21.8	31.5	25.8	10.9	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
433		0	0	0	0	0	0	0	4.5	19.9	34.6	29	10.8	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
434		0	0	0	0	0	0	0.9	8.8	23.3	31.8	24.5	9.5	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
435		0	0	0	0	0	0	0.4	6.9	21.3	31.9	26.5	11.3	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
436		0	0	0	0	0	0	0.3	5.8	19.2	30.8	27.9	13.5	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
437		0	0	0	0	0	0	1.4	10	24.4	31.6	23.1	8.5	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
438		0	0	0	0.2	0.4	0.3	1.4	7.3	18.9	28.2	25.9	13.8	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
439		0	0	0	0	0	0.1	3.6	11.8	20.3	22.5	16.9	8.5	3.1	1.8	2.2	2.3	1.9	1.4	1	0.7	0.5	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	
440		0	0	0	0	0	0	2.5	11.3	21.6	25.3	19.4	9.5	2.5	0.5	1	1.5	1.4	1	0.7	0.5	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	
441		0	0	0	0	0	0	5.5	19.1	29.8	27.2	14.5	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
442		0	0	0	0	0	0.5	4.1	10.2	16.1	18.8	17.4	12.8	7.2	3.2	1.6	1.4	1.5	1.4	1.1	0.7	0.5	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	
443		0	0	0	0.5	1.1	1.3	1.4	2.8	6.5	12	16.4	16.6	12.7	7.9	4.7	3.4	3.1	2.7	2.2	1.6	1.1	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	
444		0	0	0	0.5	1.1	1.2	1.3	2.9	7.2	13.1	16.4	14.6	9.5	5.4	4.1	4.4	4.6	4.1	3.2	2.3	1.6	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	
445		0	0	0	0	0	0	0.9	7.3	18.5	27.4	26.1	15.3	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
446		0	0	0	0	0	0	0.6	7.7	21.9	31.7	25.8	10.7	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
447		0	0	0	0	0	0	0.6	8	23	32.3	25.2	9.8	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
448		0	0	0	0	0	0	0.4	9.9	27.9	35.1	21.2	4.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
449		0	0	0	0	0	0	0.4	6.3	20	31.2	27.3	12.6	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
450		0	0	0	0	0	0	0.3	5.2	18	30.3	28.7	14.6	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
451		0	0	0	0	0	0	0.8	7.8	22.1	32	25.7	10.3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
452		0	0	0	0	0	0	0.7	9.3	27.1	35.1	22	5.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
453		0	0	0	0	0	0	1.9	14	31.6	33	16.5	2.8	0	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
454		0	0	0	0	0	0	3.1	17.9	34.3	30.5	12.5	1.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
455		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
456		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
457		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
458		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
459		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
460		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
461		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
462		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
463		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
464		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
465		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
466		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
468		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.4	2.6	2	1.4	0.8	0.1	0	0	0	0	0	0	0	0	0	0	0	
469		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.7	2.1	1.5	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	
470		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.6	0.5	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	
471		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
472		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
473		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.5	0.3	0.2	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
474		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
475		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
476		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.3	0.9	0.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	
477		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
478		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
479		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
480		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
482		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
483		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
484		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
485		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
486		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
487		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
488		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
489		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
490		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
491		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
492		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
493		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
494		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
495		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
496		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.6	3.5	2.4	1.6	0.9	0.2	0	0	0	0	0	0	0	0	0	0	0	
497		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.4	0.3	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
498		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9	0.6	0.4	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
499		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.7	0.4	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	
500		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
501		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.8	0.5	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
502		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
503		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
504		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
505		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
506		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
507		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
508		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
509		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
510		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
511		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
512		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
513		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
514		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
515		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
516		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
517		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
518		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
519		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
520		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
521		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
523		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.6	0.4	0.3	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
524		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.4	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
525		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.9	2	1.3	0.6	0.4	0.1	0	0	0	0	0	0	0	0	0	0	0	
526		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.7	0.4	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
527		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	0.5	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
528		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
529		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
530		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
531		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
532		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
533		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud
534	414079.2	5121895.7	57	S	2.149	0.568	-0.017	0	100	0
535	414541.8	5121791.4	65	S	2.344	0.522	-0.006	0	100	0
536	415067.9	5121670.2	67	S	2.292	0.513	-0.004	0	100	0
537	415601.9	5121543.3	61	S	1.924	0.532	0.012	0	100	0
538	416009.1	5121423.2	43	S	1.902	0.528	0.006	0	100	0
539	416547.2	5121312.4	41	S	1.923	0.521	-0.008	0	100	0
540	417055.3	5121257.2	38	S	1.763	0.54	-0.04	0	100	0
541	417525.5	5121128.1	37	S	2.134	0.524	-0.019	0	100	0
542	418011.4	5120994.0	42	S	2.15	0.63	-0.45	0	100	0
543	418498.4	5120878.9	28	S	2.235	0.591	-0.037	0	100	0
544	418972.5	5120788.0	25	S	2.171	0.586	-0.006	0	100	0
545	419505.8	5120668.3	23	S	2.138	0.58	0.004	0	100	0
546	419975.0	5120576.9	20	S	2.17	0.57	0.007	0	100	0
547	420460.6	5120447.1	15	S	2.088	0.531	0.024	0	100	0
549	423845.9	5119683.3	27	S	1.916	0.957	3.47	0	95.67	4.33
550	408565.8	5123612.7	121	S	2.739	1.102	2.265	0	93.71	6.29
551	409052.3	5123501.2	99	S	2.84	1.18	1.56	0	88.25	11.75
552	409578.5	5123375.9	87	S	2.865	1.154	1.027	0	88.12	11.88
553	410041.4	5123273.1	71	S	2.502	0.94	1.318	0	95.96	4.04
554	410549.9	5123151.2	60	S	2.793	1.174	0.775	0	91.49	8.51
555	411028.3	5123032.7	55	S	2.591	1.04	0.762	0	94.67	5.33
556	411520.1	5122923.0	50	S	2.784	1.407	1.573	0	86.83	13.17
557	412002.4	5122812.3	49	S	2.62	1.218	1.785	0	90.95	9.05
558	412471.3	5122690.5	48	S	2.235	0.598	-0.039	0	100	0
559	412984.4	5122595.0	48	S	2.26	0.525	-0.029	0	100	0
560	413477.8	5122478.9	46	S	2.103	0.524	0.012	0	100	0
561	413952.3	5122370.2	52	S	1.787	0.471	0.012	0	100	0
562	414431.1	5122263.9	54	S	1.758	0.474	0.018	0	100	0
563	414882.1	5122128.3	65	S	2.197	0.522	-0.014	0	100	0
564	415413.2	5121990.9	63	S	2.154	0.524	-0.003	0	100	0
565	415929.3	5121929.2	59	S	2.055	0.516	-0.002	0	100	0
566	416339.2	5121796.5	38	S	1.901	0.472	0	0	100	0
567	416930.4	5121718.6	39	S	1.745	0.718	1.365	0	98	2
568	417403.3	5121608.0	42	S	1.828	0.466	0.001	0	100	0
569	417888.2	5121493.4	33	S	2.126	0.519	-0.002	0	100	0
570	418357.2	5121365.5	44	S	2.138	0.584	-0.068	0	100	0
571	418835.9	5121277.5	38	S	2.07	0.584	-0.023	0	100	0
572	419315.8	5121154.9	37	S	2.291	0.58	-0.022	0	100	0
573	419806.4	5121035.1	22	S	2.158	0.589	-0.012	0	100	0
574	420296.0	5120922.6	25	S	2.184	0.606	0.015	0	100	0
575	420781.8	5120810.2	20	S	2.14	0.573	-0.016	0	100	0
576	421248.2	5120697.5	6	S	1.677	0.588	-0.045	0	100	0
577	423215.2	5120260.5	11	S	2.757	1.715	1.544	0	81.34	18.66
578	423728.2	5120164.1	33	S	1.329	0.422	-0.006	0	100	0
579	408437.8	5124041.5	123	S	2.624	0.576	-0.024	0	99.84	0.16
580	408906.3	5123986.5	109	MS	3.398	1.751	0.452	0	69.57	30.43
581	409416.0	5123874.9	93	S	2.983	1.151	1.261	0	86.35	13.65
582	409917.0	5123751.3	75	S	2.726	1.168	1.261	0	91.43	8.57
583	410407.2	5123627.2	62	S	2.404	0.856	0.988	0	97.31	2.69
584	410884.6	5123524.2	57	S	2.377	0.824	0.946	0	98.05	1.95
585	411394.1	5123419.7	50	S	2.16	0.763	0.675	0	99.16	0.84
586	411870.8	5123298.3	50	S	2.183	0.657	0.021	0	100	0
587	412361.3	5123186.3	47	S	2.57	1.188	1.954	0	92.74	7.26
588	412853.9	5123076.7	47	S	2.298	0.578	-0.012	0	100	0
589	413348.2	5122967.8	48	S	2.301	0.553	0.003	0	100	0
590	413817.1	5122845.7	48	MS	3.354	1.922	0.791	0	68.41	31.59
591	414292.0	5122731.5	50	S	1.986	0.468	0.01	0	100	0
592	415755.3	5122410.1	68	S	1.88	0.521	0.022	0	100	0
593	416263.4	5122290.0	59	S	1.653	0.516	0.009	0	100	0
594	416794.9	5122171.4	39	S	1.616	0.47	0.006	0	100	0
595	417232.7	5122082.3	40	S	1.768	0.476	0.011	0	100	0
596	417737.0	5121964.6	39	S	1.84	0.474	-0.006	0	100	0
597	418233.9	5121853.0	34	S	2.068	0.466	0.015	0	100	0
598	418718.0	5121744.6	30	S	2.184	0.506	0.016	0	100	0
599	419210.5	5121640.3	27	S	2.114	0.519	0.006	0	100	0
600	419657.2	5121514.6	26	S	2.148	0.528	-0.013	0	100	0
601	420133.4	5121397.5	27	S	2.206	0.588	0.005	0	100	0
602	420662.2	5121279.1	22	S	2.183	0.533	-0.012	0	100	0
603	421148.5	5121172.7	11	S	1.99	0.463	0.003	0	100	0
604	421617.1	5121070.1	11	S	1.824	0.514	-0.018	0	100	0
605	423076.7	5120727.3	32	S	1.805	0.464	-0.004	0	100	0
606	423573.3	5120610.1	37	S	1.068	0.737	3.161	0	99.18	0.82
607	424077.2	5120486.4	53	S	0.899	0.546	-0.431	0.87	99.13	0
608	408317.6	5124542.5	124	S	3.036	0.987	2.024	0	92.11	7.89
609	408836.9	5124387.4	115	MS	3.532	1.535	0.695	0	69.91	30.09
610	409293.2	5124315.2	99	S	2.917	1.057	1.361	0	89.28	10.72
611	409792.7	5124179.6	79	S	2.637	0.998	0.586	0	94.41	5.59
612	410285.3	5124072.4	63	S	2.459	0.796	0.744	0	98.42	1.58
613	410751.0	5123981.1	58	S	2.514	0.938	1.364	0	95.92	4.08
614	411224.9	5123868.0	52	S	2.123	0.684	0.479	0	99.11	0.89
615	411719.2	5123763.1	48	S	2.094	0.675	0.072	0	99.99	0.01
616	412215.4	5123652.2	45	S	2.298	0.617	-0.04	0	100	0
617	412707.2	5123543.2	46	S	2.322	0.595	-0.055	0	100	0
618	413140.9	5123412.7	41	S	2.284	0.58	-0.027	0	100	0
619	413680.5	5123331.5	46	S	2.237	0.528	-0.049	0	100	0
620	414150.6	5123192.9	43	S	2.239	0.502	0.009	0	100	0
621	414710.7	5122534.4	62	S	1.675	0.429	-0.01	0	100	0
622	417620.8	5122449.4	42	S	1.562	0.463	0.011	0	100	0
623	418083.2	5122347.7	46	S	1.747	0.431	0.001	0	100	0
624	418561.2	5122210.4	43	S	1.778	0.466	0.003	0	100	0
625	419054.2	5122081.9	31	S	1.698	0.518	-0.009	0	100	0
626	419574.5	5121999.3	26	S	2.155	0.471	0.025	0	100	0
627	420019.3	5121869.4	25	S	2.041	0.511	0.001	0	100	0
628	420523.7	5121761.1	19	S	2.06	0.518	-0.016	0	100	0
630	421469.7	5121544.7	9	S	1.925	0.463	0.001	0	100	0
632	422459.9	5121315.1	20	S	1.577	0.466	0.001	0	100	0
633	422905.0	5121190.2	36	S	1.385	0.677	3.476	0	99.29	0.71
634	423418.6	5121108.7	55	S	0.759	0.644	-0.02	0	100	0
635	423899.6	5120973.9	53	S	1.193	0.569	0.076	0	100	0
636	408147.5	5125009.2	127	S	2.968	0.759	1.549	0	95.19	4.81
637	408682.1	5124906.0	118	S	3.16	1.075	1.522	0	86.05	13.95
638	409129.3	5124796.1	108	NS	0	0	0	0	0	0
639	409645.9	5124674.1	88	MS	3.451	1.382	0.759	0	71.21	28.79
640	410135.3	5124591.1	69	S	2.471	0.865	0.503	0	97.53	2.47
641	410596.8	5124464.8	58	S	2.598	0.835	1.043	0	97.27	2.73
642	411084.0	5124331.5	54	S	2.317	0.728	1.156	0	98.66	1.34
643	411569.0	5124241.6	50	S	2.009	0.654	0.098	0	100	0
644	412073.9	5124131.2	47	S	1.993	0.657	0.073	0	100	0
645	412561.3	5124012.7	45	S	2.051	0.585	0.029	0	100	0
646	413017.6	5123896.9	39	S	1.98	0.602	0.034	0	100	0
647	413518.5	5123793.1	40	S	2.135	0.605	-0.039	0	100	0
648	417937.0	5122813.6	51	S	1.464	0.51	0.011	0	100	0
649	418407.2	5122693.1	59	S	1.187	0.521	0.041	0	100	0
650	418893.8	5122589.4	60	S	1.756	0.511	0.009	0	100	0
651	419372.1	5122477.0	47	S	1.715	0.467	0.004	0	100	0
652	419858.0	5122353.1	40	S	1.872	0.426	0.018	0	100	0
653	420339.4	5122255.0	32	S	2.253	0.509	0.002	0	100	0
654	420836.4	5122149.6	21	S	1.917	0.429	0.004	0	100	0
655	421338.2	5122029.9	15	S	1.805	0.463	0.004	0	100	0
656	421807.2	5121898.1	18	S	1.806	0.427	0.001	0	100	0
657	422303.8	5121794.0	35	S	1.534	0.504	-0.009	0	100	0
658	422798.0	5121687.0	63	S	2.195	1.224	2.153	0	92.79	7.21
659	423278.9	5121577.8	68	S	1.591	0.564	0.035	0	100	0
660	423772.6	5121471.5	44	S	2.147	0.5	0.024	0	100	0
661	424260.5	5121352.1	36	S	1.824	0.469	0	0	100	0
662	408498.8	5125391.5	122	S	3.173	1.299	0.819	0	83.62	16.38
663	408983.1	5125289.9	102	S	3.14	1.094	1.485	0	86.08	13.92
664	409477.9	5125165.6	102	MS	3.333	1.367	1.321	0	78.53	21.47
665	409968.9	5125069.5	82	S	2.862	1.135	0.984	0	89.73	10.27
666	410434.2	5124948.3	64	S	2.567	0.682	-0.077	0	99.22	0.78
667	410937.9	5124847.9	53	S	2.4	0.77	-0.492	0	99.59	0.41
669	411890.3	5124602.8	42	S	2.227	0.628	-0.026	0	100	0

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud
670	412390.6	5124496.3	43	S	2.124	0.634	0.01	0	100	0
671	412902.7	5124416.5	37	S	2.072	0.596	0.009	0	100	0
672	413380.3	5124277.8	39	S	1.843	0.593	0.047	0	100	0
673	418765.7	5123062.7	74	S	1.525	0.461	0.021	0	100	0
674	419229.3	5122941.5	78	S	1.349	0.538	-0.007	0	100	0
675	419714.2	5122830.8	66	S	1.211	0.498	0.022	0	100	0
676	420220.9	5122746.6	64	S	1.503	0.459	0.021	0	100	0
677	420716.9	5122626.9	66	S	1.593	0.472	0.003	0	100	0
678	421197.4	5122499.7	68	S	1.645	0.47	-0.005	0	100	0
679	421673.8	5122365.4	66	S	1.895	0.705	1.546	0	100	0
680	422173.4	5122270.8	78	S	1.991	1.261	1.665	0	98.15	1.85
681	422635.6	5122161.8	78	S	1.055	0.755	0.284	0	93.88	6.12
682	423147.5	5122052.2	60	S	1.092	0.62	-0.376	0	99.92	0.08
683	423605.5	5121932.6	46	S	0.899	0.594	-0.298	0.66	99.34	0
684	424091.9	5121835.9	41	S	1.11	0.695	-0.187	0.39	99.61	0
685	424604.2	5121690.7	36	S	1.556	0.459	0.009	0	100	0
686	408363.2	5125905.4	116	S	3.034	0.807	1.585	0	100	0
687	408820.1	5125794.2	20	S	2.788	0.584	-0.024	0	93.5	6.5
688	409293.4	5125653.6	103	MS	3.311	1.26	0.731	0	98.95	1.05
689	409832.3	5125550.4	88	MS	3.501	1.357	0.481	0	78.47	21.53
690	410317.3	5125436.3	71	S	2.599	0.816	1.05	0	70.65	29.35
691	410803.0	5125330.9	57	S	2.36	0.697	-0.056	0	97.19	2.81
692	411288.7	5125217.9	47	S	2.33	0.634	-0.08	0	99.85	0.15
693	411805.7	5125083.1	44	S	2.406	0.612	-0.058	0	100	0
694	412258.9	5124985.3	39	S	2.281	0.622	-0.05	0	100	0
695	412759.8	5124858.3	37	S	2.272	0.596	-0.042	0	100	0
696	413243.8	5124763.7	40	S	2.074	0.59	-0.032	0	100	0
697	419574.5	5123310.1	92	S	1.558	0.567	0.015	0	100	0
698	420050.1	5123219.8	100	S	1.634	0.516	0.005	0	100	0
699	420539.9	5123110.3	85	S	1.3	0.541	-0.034	0	100	0
700	421056.5	5122988.5	86	S	1.386	0.461	0.007	0	100	0
701	421514.6	5122882.5	82	S	1.363	0.506	0.009	0	100	0
702	422024.8	5122777.0	80	S	1.506	0.476	0.006	0	100	0
703	422486.9	5122659.6	68	S	1.027	0.647	-0.807	0	100	0
704	422962.2	5122542.8	63	S	0.919	0.542	-0.058	1.29	98.71	0
705	423484.0	5122437.8	62	S	1.228	1.339	1.388	0	100	0
706	423965.8	5122305.4	54	S	0.82	0.826	-0.681	3.28	91.47	5.24
707	424444.6	5122197.6	48	S	1.14	0.536	-0.013	3.83	96.17	0
708	408240.5	5126348.9	120	S	3.017	0.722	1.762	0	100	0
709	408700.0	5126249.2	116	S	3.046	0.963	2.045	0	95.79	4.21
710	409192.4	5126154.2	101	S	2.774	0.588	-0.038	0	92.46	7.54
711	409671.0	5126011.3	96	NS	0	0	0	0	99.05	0.95
712	410127.3	5125911.3	83	S	2.848	1.088	0.553	0	0	0
713	410630.7	5125786.3	67	S	2.586	0.805	0.876	0	90.99	9.01
714	411108.2	5125687.6	55	S	2.413	0.753	-0.6	0	97.32	2.68
715	411603.0	5125580.6	49	S	2.302	0.607	-0.038	0	99.73	0.27
716	412086.0	5125461.4	40	S	2.331	0.635	-0.057	0	100	0
717	412560.0	5125350.9	39	S	2.336	0.607	-0.042	0	100	0
718	413080.6	5125248.2	41	S	2.224	0.739	-0.07	0	100	0
719	413550.1	5125124.2	31	S	2.243	0.605	-0.057	0	99.98	0.02
720	419908.5	5123644.3	100	S	1.606	0.476	0.008	0	100	0
721	420386.5	5123554.0	85	S	1.686	0.468	-0.007	0	100	0
722	420864.6	5123460.8	87	S	1.349	0.518	-0.006	0	100	0
723	421306.6	5123367.4	80	S	1.546	0.465	0.005	0	100	0
724	421854.7	5123253.7	79	S	1.445	0.475	-0.003	0	100	0
725	422338.1	5123155.1	89	S	1.604	0.939	3.153	0	100	0
726	422823.5	5123020.8	76	S	1.308	0.515	0.009	0	96.61	3.39
727	423313.3	5122903.8	62	S	1.423	0.524	-0.004	0	100	0
728	423797.8	5122792.2	55	MS	2.294	2.384	1.222	0	100	0
729	424283.6	5122684.2	63	MS	3.006	2.457	0.561	0.37	76.48	23.15
730	424761.4	5122563.9	40	S	1.075	0.595	-0.074	0	64.41	35.59
731	408039.1	5126853.8	121	S	2.967	0.759	1.559	0	100	0
732	408558.3	5126728.0	113	S	3.086	0.985	1.989	0	95.46	4.54
733	409036.2	5126584.9	111	S	3.072	0.933	1.476	0	91.5	8.5
734	409540.3	5126508.2	101	NS	0	0	0	0	90.15	9.85
735	410010.7	5126353.5	91	S	3.065	0.945	1.141	0	0	0
736	410542.0	5126282.6	78	S	2.775	1.041	0.429	0	88.21	11.79
737	411001.0	5126157.7	65	S	2.39	0.81	1.034	0	92.79	7.21
738	411503.2	5126048.5	54	S	2.294	0.649	-0.034	0	98.09	1.91
739	411974.3	5125937.8	48	S	2.266	0.726	-0.091	0	99.99	0.01
740	412455.0	5125825.1	43	S	2.159	0.641	-0.012	0	99.98	0.02
741	412945.2	5125707.1	40	S	2.187	0.613	-0.012	0	100	0
742	413481.1	5125598.6	37	S	2.146	0.618	-0.022	0	100	0
743	413920.8	5125474.4	37	S	2.05	0.614	-0.001	0	100	0
744	420235.5	5124022.2	43	S	1.524	0.573	0.028	0	100	0
745	420722.6	5123927.6	39	S	2.085	0.508	0.013	0	100	0
746	421231.5	5123826.8	39	S	1.712	0.57	-0.03	0	100	0
747	421706.1	5123727.2	46	S	1.786	0.462	0.005	0	100	0
748	422175.2	5123583.5	46	S	1.726	0.466	-0.003	0	100	0
749	422673.3	5123473.4	32	S	1.468	0.429	-0.013	0	100	0
750	423167.7	5123395.0	16	S	1.708	0.464	0.006	0	100	0
751	423650.0	5123279.9	21	S	2.013	0.515	0.015	0	100	0
752	424142.3	5123160.5	13	S	1.619	0.751	3.858	0	100	0
753	424626.0	5123055.0	20	MS	3.374	2.088	0.789	0	98.92	1.08
754	425119.3	5122953.5	16	S	2.301	1.204	2.573	0	65.67	34.33
755	408373.6	5127242.2	116	S	3.009	0.743	1.469	0	94.07	5.93
756	408895.5	5127066.8	111	S	3.055	0.849	1.721	0	94.97	5.03
757	409385.6	5127028.1	101	S	3.101	0.936	1.466	0	93.02	6.98
758	409838.2	5126858.5	100	S	2.964	0.761	1.434	0	89.62	10.38
759	410345.4	5126760.7	86	S	2.979	0.915	1.316	0	94.93	5.07
760	410838.9	5126646.6	79	S	2.788	0.872	1.132	0	91.18	8.82
761	411313.0	5126533.4	68	S	2.592	0.848	1.045	0	94.16	5.84
762	411784.3	5126396.4	57	S	2.372	0.632	-0.048	0	96.71	3.29
763	412300.3	5126262.9	49	S	2.335	0.611	-0.028	0	99.99	0.01
764	412784.5	5126160.6	47	S	2.261	0.608	-0.017	0	99.99	0.01
765	413258.6	5126065.9	45	S	2.166	0.607	-0.022	0	100	0
766	413759.3	5125956.0	39	S	2.13	0.616	-0.013	0	100	0
767	414241.2	5125839.7	34	S	2.104	0.603	-0.009	0	100	0
768	414732.7	5125729.9	32	S	1.95	0.585	0.031	0	100	0
769	420074.2	5124522.1	8	S	1.818	1.042	3.279	0	100	0
770	420571.9	5124420.8	20	S	1.667	0.425	0.001	0	95.32	4.68
771	421061.4	5124294.6	19	S	1.623	0.463	0.009	0	100	0
772	421563.2	5124189.8	17	S	1.798	0.507	0.011	0	100	0
773	423988.0	5123622.0	4	S	2.065	0.514	0.008	0	100	0
774	424465.8	5123438.5	2	S	2.333	0.6	-0.039	0	100	0
775	424988.3	5123428.4	6	S	1.696	0.461	0.004	0	100	0
776	408240.3	5127697.3	115	S	3.025	0.801	1.745	0	100	0
777	408742.5	5127547.2	116	S	3.015	0.787	1.639	0	94.49	5.51
778	409207.8	5127480.2	104	S	2.979	0.787	1.528	0	94.51	5.49
779	409719.8	5127342.1	100	S	3.026	0.869	1.741	0	94.67	5.33
780	410167.1	5127227.2	71	MS	3.614	1.499	1.259	0	93.21	6.79
781	410658.6	5127125.1	82	S	2.798	0.87	1.394	0	73.24	26.76
782	411170.5	5127021.6	74	S	2.675	0.857	1.291	0	94.83	5.17
783	411636.7	5126894.6	65	S	2.429	0.68	-0.023	0	95.98	4.02
784	412155.7	5126729.0	53	S	2.259	0.611	-0.013	0	99.71	0.29
786	413131.6	5126531.8	46	S	2.205	0.596	-0.035	0	100	0
787	413618.4	5126420.5	42	S	2.226	0.601	-0.034	0	100	0
788	414125.4	5126310.0	39	S	2.097	0.592	-0.022	0	100	0
789	414602.2	5126215.6	35	S	2.029	0.585	0.017	0	100	0
790	415082.4	5126105.7	36	S	2.141	0.585	-0.015	0	100	0
791	420326.0	5125035.1	2	S	1.583	0.423	-0.005	0	100	0
792	420436.7	5124869.1	6	S	1.544	0.433	-0.011	0	100	0
793	420948.6	5124779.6	10	S	1.461	0.516	-0.001	0	100	0
794	421433.3	5124664.2	14	S	1.72	0.476	0.008	0	100	0
795	408115.0	5128183.9	118	S	3.274	1.099	1.711	0	100	0
796	408632.7	5128035.7	117	MS	3.627	1.488	1.322	0	85.58	14.42
797	409084.6	5127975.6	104	S	2.851	0.893	-0.161	0	74.73	25.27
798	409559.0	5127815.1	100	S	3.02	0.815	1.665	0	95.97	4.03
799	410067.2	5127681.6	92	S	3.025	0.915	1.468	0	93.95	6.05
800	410587.6	5127573.3	87	S	2.881	0.795	1.479	0	91.49	8.51
801	411044.3	5127491.6	65	S	2.822	0.757	1.258	0	95.48	4.52
802	411544.7	5127371.1	68	S	2.488	0.666	-0.019	0	96.34	3.66

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud	Diameter(Φ) / Diameter(μ)	-2 / 4000	-1.5 / 2828.4	-1 / 2000	-0.5 / 1414.2	0 / 1000	0.5 / 707.1	1 / 500	1.5 / 353.6	2 / 250	2.5 / 176.8	3 / 125	3.5 / 88.4	4 / 62.5	4.5 / 44.2	5 / 31.3	5.5 / 22.1	6 / 15.6	6.5 / 11	7 / 7.8	7.5 / 5.5	8 / 3.9	8.5 / 2.8	9 / 2	9.5 / 1.4	10 / 1	10.5 / 0.7	11 / 0.5	11.5 / 0.35	12 / 0.24	12.5 / 0.18	13 / 0.12	13.5 / 0.09	14 / 0.06	14.5 / 0.03	15 / 0.02
803	412028.9	5127247.0	63	S	2.492	0.76	1.196	0	98.28	1.72		0	0	0	0	0	0	0.7	6	17.7	28	26.7	14.9	4	0.1	0	0.3	0.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
804	412513.8	5127143.6	60	S	2.307	0.609	-0.022	0	100	0		0	0	0	0	0	0	0.9	8.3	21.8	30.6	25.1	11.2	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
805	413008.4	5127004.5	49	S	2.342	0.589	-0.032	0	100	0		0	0	0	0	0	0	0.5	7	20.9	31.4	26.6	11.8	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
806	413466.8	5126900.3	47	S	2.303	0.599	-0.045	0	100	0		0	0	0	0	0	0	0.9	8	21.9	31.2	25.4	10.9	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
807	413951.5	5126807.4	43	S	2.268	0.592	-0.03	0	100	0		0	0	0	0	0	0	0.9	8.3	23.1	31.6	24.6	9.8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
808	414464.8	5126682.4	40	S	2.194	0.6	-0.017	0	100	0		0	0	0	0	0	0	1.7	10.9	25	31.1	22.2	8.1	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
809	414929.8	5126601.7	36	S	2.11	0.6	-0.013	0	100	0		0	0	0	0	0	0	2.6	13.2	27	30.5	19.8	6.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
810	420290.7	5125387.6	21	S	1.538	0.461	0.002	0	100	0		0	0	0	0	0	0.5	11.2	34.9	37.7	14.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
811	407965.0	5128651.4	121	S	2.929	0.584	0.001	0	97.36	2.64		0	0	0	0	0	0	0	0.1	5.1	18.5	30.8	23.5	14.2	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
812	408469.7	5128528.8	117	NS	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
813	408933.5	5128417.2	110	S	2.861	0.584	-0.015	0	98.28	1.72		0	0	0	0	0	0	0	0.3	6.5	20.5	31.5	27.1	12.2	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
814	409421.2	5128298.8	102	S	3.122	1.018	2.069	0	90.72	9.28		0	0	0	0	0	0	0	0.4	5.8	17.4	27.2	25.5	14.1	3.9	0.2	0.2	1.1	1.4	1	0.5	0.2	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	
815	409884.1	5128177.4	92	S	3.074	0.964	2.008	0	91.84	8.16		0	0	0	0	0	0	0	0.4	6.1	18.1	27.9	25.4	13.6	3.5	0.1	0.2	1.1	1.3	0.8	0.3	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	
816	410368.7	5128092.8	88	S	2.931	0.789	1.519	0	95.03	4.97		0	0	0	0	0	0	0	0.5	7.2	20.6	29.9	25	11.6	2.2	0	0.3	1	0.8	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
817	410844.6	5127948.7	83	S	2.802	0.783	1.534	0	96.4	3.6		0	0	0	0	0	0	0	1.3	10.2	23.8	30	22	8.8	1.2	0	0.3	0.8	0.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
818	411344.3	5127863.4	79	S	2.797	0.815	0.994	0	94.84	5.16		0	0	0	0	0	0	0	2.9	11.7	22.2	26.5	20.8	10.4	2.8	0.3	0.4	0.7	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
819	411870.9	5127691.9	69	S	2.809	1.135	1.819	0	92.02	7.98		0	0	0	0	0	0	0.6	5.2	14.1	22.5	23.9	17.3	8	2	0.4	0.9	1.4	1.2	0.8	0.4	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	
820	412364.8	5127607.1	63	S	2.666	0.748	1.279	0	97.75	2.25		0	0	0	0	0	0	0	3	13.1	26	29.4	19.4	6.5	0.5	0	0.3	0.7	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
821	412839.9	5127518.1	59	S	2.44	0.585	-0.02	0	100	0		0	0	0	0	0	0	0.1	4.9	18	30.5	28.8	14.6	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
822	413331.4	5127401.8	52	S	2.301	0.581	-0.023	0	100	0		0	0	0	0	0	0	0.6	7.7	22.3	32	25.7	10.4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
823	413826.4	5127279.7	52	S	2.35	0.595	-0.033	0	100	0		0	0	0	0	0	0	0.6	7	20.6	31	26.6	12.1	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
824	414289.1	5127175.8	44	S	2.277	0.586	-0.015	0	100	0		0	0	0	0	0	0	0.7	8.4	23	31.8	24.8	9.9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
825	414815.1	5127057.7	44	S	2.213	0.598	-0.02	0	100	0		0	0	0	0	0	0	1.5	10.3	24.5	31.3	22.9	8.5	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
826	415282.8	5126031.1	38	S	2.282	0.588	-0.02	0	100	0		0	0	0	0	0	0	0.8	8.3	22.8	31.8	24.9	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
827	408310.3	5129006.6	114	S	2.89	0.581	0.017	0	97.88	2.12		0	0	0	0	0	0	0	0.1	5.8	19.8	31.4	27.6	12.9	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
828	408789.8	5128883.4	111	S	3.072	0.833	1.655	0	92.69	7.31		0	0	0	0	0	0	0	0.2	5	16.8	27.9	27.1	15.4	4.2	0.2	0	0.7	1	0.7	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
829	409277.0	5128791.6	101	S	3.136	0.839	1.74	0	91.83	8.17		0	0	0	0	0	0	0	0	3.8	15.1	27.4	28.4	16.9	4.8	0.2	0	0.6	1.1	0.8	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
830	409763.3	5128657.9	96	S	3.018	0.85	1.765	0	93.6	6.4		0	0	0	0	0	0	0	0.2	6	18.7	29	26.1	13.3	3	0	0.1	0.9	1.1	0.7	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
831	410296.4	5128520.0	83	S	3	0.956	2.009	0	93.26	6.74		0	0	0	0	0	0	0	0.6	7.3	20.2	29.1	24.4	11.4	2.1	0	0.3	1.2	1.4	0.9	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
832	410765.9	5128440.4	79	S	2.915	0.792	1.506	0	95.05	4.95		0	0	0	0	0	0	0	0.6	7.6	21.1	29.9	24.5	11.2	2.2	0	0.4	1	0.8	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
833	411260.4	5128321.3	80	S	2.72	0.778	1.579	0	97.1	2.9		0	0	0	0	0	0	0	2	12.1	25.8	30	20	6.8	0.5	0	0.4	0.9	0.7	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
834	411746.8	5128201.4	74	S	2.692	0.741	1.183	0	97.38	2.62		0	0	0	0	0	0	0	2.5	12.7	25.7	29.2	19.7	7.3	0.9	0	0.3	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
835	412205.1	5128103.0	72	S	2.705	0.824	1.184	0	96.06	3.94		0	0	0	0	0	0	0	4	13.8	24	26.4	19.1	8.5	1.7	0	0.5	0.8	0.6	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
836	412688.5	5127996.8	65	S	2.577	0.766	1.385	0	97.75	2.25		0	0	0	0	0	0	0.1	4.3	15.9	27.8	28.1	16.5	4.7	0.2	0	0.5	0.8	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
837	413179.6	5127902.3	58	S	2.472	0.575	-0.008	0	100	0		0	0	0	0	0	0	0	4.1	17.1	30.5	29.7	15.4	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
838	413661.3	5127771.4	55	S	2.435	0.578	-0.018	0	99.99	0.01		0	0	0	0	0	0	0.1	4.8	18.1	30.9	29	14.3	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
839	414152.7	5127660.8	50	S	2.353	0.577	-0.008	0	100	0		0	0	0	0	0	0	0.3	6.4	20.8	31.9	27	11.8	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
840	414622.5	5127533.3	44	S	2.295	0.588	-0.016	0	100	0		0	0	0	0	0	0	0.7	8	22.4	31.7	25.3	10.4	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
841	415128.2	5127471.7	41	S	2.355	0.586	-0.005	0	100	0		0	0	0	0	0	0	0.3	6.6	20.8	31.4	26.8	12.1	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
842	415598.7	5127307.3	34	S	2.347	0.583	-0.024	0	100	0		0	0	0	0	0	0	0.4	6.7	20.8	31.7	26.8	11.8	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
843	408142.3	5129491.2	116	S	2.872	0.574	0.016	0	98.27	1.73		0	0	0	0	0	0	0	0.1	5.9	20.4	31.9	27.4	12.2	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
844	408651.0	5129354.6	112	S	3.011	0.765	1.601	0	94.87	5.13		0	0	0	0	0	0	0	0.1	5.1	17.8	29.6	27.7	14.3	2.9	0	0	0.6	0.9	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
845	409126.6	5129263.3	102	S	2.951	0.584	-0.02	0	97.15	2.85		0	0	0	0	0	0	0	0.1	4.7	17.6	30.4	29.1	15	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
846	409638.5	5129147.4	102	S	2.971	0.827	1.789	0	94.77	5.23		0	0	0	0	0	0	0	0.3	6.5	19.8	29.8	25.8	12.3	2.2	0	0.1	0.9	1.1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
847	410121.3	5129037.9	90	S	2.954	0.945	2.405	0	94.6	5.4		0	0	0	0	0	0	0	0.3	6.8	22.1	32.3	24.3	8.7	0.8	0	0.3	1.2	1.3	0.8	0.3	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	
848	410596.2	5128912.3	90	NS	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
849	411133.9	5128805.4	90	S	2.593	0.566	-0.012	0	99.98	0.02		0	0	0	0	0	0	0	1.8	13.2	28.6	31.9	19.2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
850	411587.4	5128690.9	80	S	2.719	0.734	1.369	0	97.45	2.55		0	0	0	0	0	0	0	1.7	11.7	25.8	30.4	20.4	7.1	0.7	0	0.3	0.8	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
851	412063.6	5128563.7	74	S	2.825	0.937	1.479	0	93.29	6.71		0	0	0	0	0	0	0	3.3	12.4	22.4	25.7	19.6	9.6	2.6	0.4	0.7	1	0.8	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
852	412550.2	5128462.2	65	S	2.861	0.893	1.195	0	92.84	7.16		0	0	0	0	0	0	0	2.6	11.3	21.3	25.6	20.7	11	3.4	0.7	0.7	0.9	0.7	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
853	413038.0	5128364.2	58	S	2.6	0.733	1.268	0	98.08	1.92		0	0	0	0	0	0	0	3.7	15	27.5	28.8	17.5	5.3	0.3	0	0.3	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
854	413519.6	5128220.6	55	S	2.531	0.595	-0.012	0	99.92	0.08		0	0	0	0	0	0	0	3.6	15.4	28.7	29.9	17.4	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
855	414001.0	5128135.1	49	S	2.457	0.576	0.002	0	100	0		0	0	0	0	0	0	0	4.3	17.6	30.8	29.4	15	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
856	414491.4	5128017.5	45	S	2.385	0.577	0.001	0	100	0		0	0	0	0	0	0	0.1	5.7	19.9	31.6	27.7	12.7	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
857	414978.2	5127899.0	41	S	2.389	0.575	-0.009	0	100	0		0	0	0	0	0	0	0.1	5.6	19.7	31.7	28	12.8	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
858	415447.5	5127785.9	36	S	2.378	0.573	-0.01	0	100	0		0	0	0	0	0	0	0.2	5.8	20	31.9	27.8	12.5	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
859	408000.0	5129962.2	116	S	3.012	0.822	1.795	0	94.3	5.7		0	0	0	0	0	0	0	0.1	5.5	18.7	29.7	26.7	13.3	2.7	0	0	0.8	1.1	0.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
860	408487.8	5129854.3	118	S	3.122	0.97	2.081	0	91.49	8.51		0	0	0	0	0	0	0	0.1	5.1	17.1	28	26.5	14.4	3.6	0.1	0.1	1.1	1.4	1	0.4	0.2	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	
861	408988.1	5129752.0	107	S	3.007	0.8	1.643	0	94.27	5.73		0	0	0	0	0	0	0	0.2	5.7	18.4	29.2	26.7	13.8	3.1	0	0	0.7	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
862	409466.6	5129623.4	102	S	2.991	0.766	1.559	0	94.94	5.06		0	0	0	0	0	0	0	0.1	5.6	18.5	29.6	27	13.7	2.6	0	0	0.6	0.9	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
863	409965.0	5129501.4	94	S	2.906	0.737	1.559	0	96.41	3.59		0	0	0	0	0	0	0	0.2	6.7	21	31.3	25.8	11.1	1.5	0	0.1	0.8	0.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
864	410441.0	5129406.6	91	S	2.901	0.825	1.805	0	95.51	4.49		0	0	0	0	0	0	0	0.6	7.9	21.8	30.5	24.2	10.2	1.4	0	0.2	1	1	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
865	410933.3	5129290.7	85	S	2.739	0.573	0.006	0	99.36	0.64		0	0	0	0	0	0	0	0.7	9.1	24.5	32.5	23.7	8.5	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
866	411431.7	5129181.1	81	S	3.032	1.223	1.791	0	88.21	11.79		0	0	0	0	0	0	0	2.6	11.2	21.1	24.6	19	9.4	2.7	0.9	1.4	1.9	1.7	1.1	0.7	0.4	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	
867	411929.4	5129061.2	76	S	2.769	0.826	1.185	0	94.99	5.01		0	0	0	0	0	0	0	2.7	12.5	23.7	27	19.8	9	2.1	0.4	0.7	0.9	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
868	412399.0	5128961.6	72	S	2.707	0.83	1.757	0	96.41	3.59		0	0	0	0	0	0	0	2.5	13.2	26.5	29.2	18.6	6.2	0.6	0	0.6	1	0.7	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
869	412881.7	5128836.8	58	S	2.67	0.811	1.647	0	96.92	3.08		0	0	0	0	0	0	0	3.1	14	26.7	28.7	18.2	6	0.5	0	0.5	0.9	0.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
870	413336.7	5128743.3	60	S	2.603	0.722	1.34	0	98.2	1.8		0	0	0	0	0	0	0	3.2	14.7	28	29.6	17.6	4.9	0.1	0	0.3	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
871	413819.1	5128622.8	54	S	2.688	0.732	1.352	0	97.77	2.23		0	0	0	0	0	0	0	2.1	12.5	26.2	30.1	19.9	6.6	0.4	0	0.3	0.7	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
872	414303.8	5128509.5	50	S	2.563	0.583	-0.006	0	99.92	0.08		0	0	0	0	0	0	0	2.7	14.4	28.7	30.8	18.3	4.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
873	414800.9	5128394.2	45	S	2.439	0.577	-0.009	0	99.99	0.01		0	0	0	0	0	0	0	4.6	18	31	29.1	14.4	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
874	415277.3	5128273.4	39	S	2.452	0.57	-0.001	0	99.99	0.01		0	0	0	0	0	0	0	4.2	17.7	31.1	29.5	14.7	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
875	415778.2	5128170.2	34	S	2.43	0.526	-0.011	0	100	0		0	0	0	0	0	0	0	3.2	17.6	34.1	31	12.6	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
876	407883.2	5130429.6	124	S	2.97	0.772	1.994	0	95.93	4.07		0	0	0	0	0	0	0	0	4.7	19.4	32.7	27.7	11.2	1.3	0	0	0.8	1	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
877	408345.6	5130350.8	111	S	2.856	0.575	0.014	0	98.44	1.56		0	0	0	0	0	0	0	0.1	6.4	20.9	32	27	11.6	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
878	408841.6	5130196.6	102	S	2.93	0.777	1.663	0	95.71	4.29		0	0	0	0	0	0	0	0.3	6.7	20.5	30.5	25.7	11.6	1.8	0	0.1	0.8	0.9	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
879	409319.0	5130109.3	95	S	2.841	0.572	0.016	0	98.64	1.36		0	0	0	0	0	0	0	0.1	6.7	21.4	32.2	26.7	11.3	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
880	409834.7	5129987.0	90	S	3.028	0.887	1.907	0	93.48	6.52		0	0	0	0	0	0	0	0.2	6	18.8	29.1	26	13.1	2.7	0	0.1	1	1.2	0.8	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
881	410284.0	5129901.5	84	S	2.919	0.773	1.674	0	95.91	4.09		0	0	0	0	0	0	0	0.3	6.9	20.9	30.8	25.5	11.2	1.6	0	0.1	0.8	0.9	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
882	410797.3	5129769.3	82	S	2.904	0.772	1.679	0	96.08	3.92		0	0	0	0	0	0	0	0.3	7.2	21.3	31	25.2	10.8	1.4	0	0.1	0.9	0.9	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
883	411286.5	5129656.7	79	S	2.898	0.903	1.931	0	94.49	5.51		0	0	0	0	0	0	0	0.9	9	22.7	29.7	22.6	9.3	1.4	0	0.5	1.3	1.1	0.6	0.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	
884	411776.7	5129536.9	77	S	2.724	0.737	1.355	0	97.18	2.82		0	0	0	0	0	0	0	1.5	11.6	26	30.5	20.3	7	0.7	0	0.6	0.8	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
885	412262.0	5129428.7	69	S	2.697	0.734	1.404	0	97.62	2.38		0	0	0	0	0	0	0	1.9	12.3	26.4	30.3	19.9	6.6	0.5	0	0.3	0.8	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
886	412741.9	5129310.3	66	S	2.721	0.734	1.275	0	97.49	2.51		0	0	0	0	0	0	0	1.9	11.7	25.3	30	20.7	7.6	0.8	0	0.2	0.7	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
887	413239.4	5129197.2	60	S	2.677	0.73	1.298	0	97.82	2.18		0	0	0	0	0	0	0	2.3	12.8	26.3	29.9	19.6	6.6	0.5	0	0.3	0.7	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
888	413726.2	5129088.6	54	S	3.049	1.29	1.64	0	88.09	13.91		0	0	0	0	0	0	0	3.5	12	20.9	23.4	17.4	8.5	2.8	1.5	2.1	2.4	1.9	1.2	0.7	0.4	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	
889	414182.6	5129007.5	50	S	2.533	0.583	-0.007	0	99.98	0.02		0	0	0	0	0	0	0	3.2	15.3	29.2	30.3	17.3	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
890	414676.4	5128864.1	46	S	2.538	0.573	-0.008	0	99.99	0.01		0	0	0	0	0	0	0	2.9	15.1	29.3	30.7	17.5	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
891	415161.7	5128747.2	46	S	2.525	0.566	-0.012	0	99.99	0.01		0	0	0	0	0	0	0	2.8	15.3	30	31.1	17	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
892	415650.9	5128629.8	38	S	2.558	0.564	-0.014	0	99.99	0.01		0	0	0	0	0	0	0	2.3	14.2	29.4	31.7	18.1	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
893	407741.8	5130889.4	122	NS	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
894	408203.4	5130796.8	115	S	2.84	0.562	0.012	0	98.87	1.13		0	0	0	0	0	0	0	0.1	6.3	21.5	32.8	26.9	11.1	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
895	408678.0	5130668.9	108	S	3.005	0.869	1.916	0	94.08	5.92		0	0	0	0	0	0	0	0.2	6.1	19.4	29.7	25.9	12.4	2.3	0	0.1	1	1.2	0.8	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
896	409194.5	5130600.4	100	S	2.862	0.767	1.696	0	96.5	3.5		0	0	0	0	0	0	0	0.5	8.1	22.6	31.2	24.1	9.7	1.1	0	0.1	0.9	0.8	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
897	409681.6	5130452.3	94	S	2.917	0.804	1.752	0	95.57	4.43		0	0	0	0	0	0	0	0.4	7.4	21.1	30.2	24.9	11.2	1.8	0	0.1	0.8	0.9	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
898	410157.0	5130354.1	92	S	3.155	1.114	2.104	0	89.96	10.04		0	0	0	0	0	0	0	0.3	5.9	18.1	27.7	24.9	12.9	3.1	0.1	0.4	1.5	1.8	1.3	0.7	0.4	0.2	0.2	0	0	0	0	0	0	0	0	0	0	0	
899	410659.7	5130248.0	85	S	2.847	0.574	0.018	0	98.52	1.48		0	0	0	0	0	0	0	0.1	8.6	21.2	32.1	26.7	11.5	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
900	411144.6	5130121.2	81	S	2.84	0.781	1.715	0	96.48	3.52		0	0	0	0	0	0	0	0.7	8.8	23.3	31.1	23.3	9	0.9	0	0.2	0.9	0.8	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
901	411647.0	5130002.7	79	S	2.767	0.754	1.59	0	97.11	2.89		0	0	0	0	0	0	0	1.1	10.4	25.1	31.1	21.6	7.5	0.6	0	0.3	0.9	0.7	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
902	414820.8	5122370.6	64	S	1.729	0.472	0.019	0	100	0		0	0	0	0	0	0	5.2	26.2	40.3	23.8	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
903	415102.3	5122327.3	67	S	2.228	0.51	0.007	0	100	0		0	0	0	0	0	0	0.1	7	25.9	36.8	23.9	5.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
904	414531.6	5122685.2	51	S	1.849	0.567	0.046	0	100	0		0	0	0	0	0	0.1	6	21.5	32.7	26.7	11.2	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
905	414783.5	5122624.5	36	S	2.075	1.117	2.812	0	94.04	5.96		0	0	0	0	0	0.1	4.8	20.1	33	26	9	0.7	0	0.5	1.2	1	0.7	0.5	0.6	0.5	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	
906	415021.1	5122548.4	64	S	1.656	0.51	0.028	0	100	0		0	0	0	0	0	0.3	9.1	28.8	36.4	20.8	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
907	415259.5	5122500.4	70	S	2.097	0.852	1.871	0	97.81	2.19		0	0	0	0	0	0.6	4.9	15.4	26.5	27.5	16.9	5.3	0.3	0	0.3	0.6	0.4	0.2	0.1	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
908	415502.4	5122455.9	71	S	1.877	0.574	-0.004	0	100	0		0	0	0	0	0	0.2	5.7	20.1	32	27.7	12.4	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
909	414461.8	5122931.8	47	S	1.81	0.524	-0.01	0	100	0		0	0	0	0	0	0.1	5.4	22.3	35.9	27	8.6	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
910	414711.9	5122855.0	45	S	1.916	0.501	0.01	0	100	0		0	0	0	0	0	0	2.5	18	36.1	31.2	11.2	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
911	414953.9	5122808.7	55	S	2.014	0.475	0.014	0	100	0		0	0	0	0	0	0	0.8	12.7	35.3	36	13.8	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
912	415206.7	5122750.9	65	S	1.894	0.509	0.012	0	100	0		0	0	0	0	0	0	3.1	19.1	35.9	30.2	10.8	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
913	415430.2	5122707.9	75	S	2.047	0.712	1.125	0	98.62	1.38		0	0	0	0	0	0.2	4.3	16	28.4	28.7	16.4	4.3	0.1	0	0.4	0.6	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
914	415679.5	5122644.8	77	S	2.081	0.513	0.01	0	100	0		0	0	0	0	0	0	0.9	11.8	31.1	35.1	17.9	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
915	415916.3	5122572.4	75	S	2.209	1.367	1.814	0	91.45	8.55		0	0	0	0	0.3	2.8	8.7	17.1	22.5	20.5	12.7	5.1	1.4	0.9	1.4	1.5	1.2	1	0.8	0.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	
916	414378.7	5123166.1	44	S	2.683	1.379	2.125	0	88.41	11.59		0	0	0	0	0	0	0.4	6.9	22	30.8	21.3	6.4	0.3	0.1	1.6	2.5	2.2	1.5	1.1	0.8	0.7	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	
917	414620.9	5123102.5	45	S	1.819	0.463	-0.004	0	100	0		0	0	0	0	0	0	2.9	21.4	40.7	28.5	6.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
918	414873.2	5123045.9	42	S	1.743	0.516	0.02	0	100	0		0	0	0	0	0	0.1	6.8	25.3	36.5	24.4	6.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
919	415100.8	5122987.3	48	S	1.733	0.474	0.007	0	100	0		0	0	0	0	0	0	5.2	25.8	40.1	24.1	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
920	415382.6	5122938.7	60	S	1.649	0.527	0.002	0	100	0		0	0	0	0	0	0.7	10	28.3	35.3	20.8	4.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
921	415624.9	5122887.0	78	S	1.259	0.621	0.02	0	100	0		0	0	0	0	1.3	9.8	23.3	30.2	23.3	10.1	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
922	415870.0	5122836.0	83	S	2.178	0.523	0.003	0	100	0		0	0	0	0	0	0	0.5	8.9	27.5	35.7	21.8	5.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
923	416103.2	5122773.7	79	S	1.843	0.51	-0.004	0	100	0		0	0	0	0	0	0	4.2	21	36.4	28.5	9.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
924	416353.4	5122714.9	66	S	2.133	0.516	0.006	0	100	0		0	0	0	0	0	0	0.6	10.1	29.3	35.7	20	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
925	416657.2	5122664.0	64	S	1.988	0.471	0.004	0	100	0		0	0	0	0	0	0	1	13.6	36.3	35.4	12.6	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
926	414046.8	5123472.7	43	S	2.249	0.514	-0.006	0	100	0		0	0	0	0	0	0	0.1	6.6	24.9	36.6	24.8	6.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
927	414298.1	5123406.3	41	S	2.18	0.518	-0.02	0	100	0		0	0	0	0	0	0	0.5	8.6	27.3	36.2	22.1	4.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
928	414565.2	5123346.5	41	S	2.052	0.503	0.012	0	100	0		0	0	0	0	0	0	0.9	12.5	32.5	35.1	16.6	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
929	414810.5	5123285.8	40	S	1.975	0.463	0.005	0	100	0		0	0	0	0	0	0	0.9	13.9	37.3	35.3	11.7	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
930	415049.5	5123232.4	44	S	1.678	0.52	-0.003	0	100	0		0	0	0	0	0	0.4	8.8	27.4	36	22	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
931	415291.5	5123170.0	42	S	1.54	0.529	-0.019	0	100	0		0	0	0	0	0	1.7	13.7	31.4	33.6	16.8	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
932	415541.4	5123123.1	55	S	1.726	0.571	-0.015	0	100	0		0	0	0	0	0	0.8	9.3	24.8	32.7	23.5	8.1	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
933	415783.2	5123079.2	75	S	1.488	0.507	0.012	0	100	0		0	0	0	0	0	1.6	15.2	34.1	33.3	14.1	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
934	416023.0	5123016.3	86	S	2.104	0.513	0.02	0	100	0		0	0	0	0	0	0	0.7	11	30.5	35.5	18.7	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud	Diameter(Φ) Diameter(μ)	-2 4000	-1.5 2828.4	-1 2000	-0.5 1414.2	0 1000	0.5 707.1	1 500	1.5 353.6	2 250	2.5 176.8	3 125	3.5 88.4	4 62.5	4.5 44.2	5 31.3	5.5 22.1	6 15.6	6.5 11	7 7.8	7.5 5.5	8 3.9	8.5 2.8	9 2	9.5 1.4	10 1	10.5 0.7	11 0.5	11.5 0.35	12 0.24	12.5 0.18	13 0.12	13.5 0.09	14 0.06	14.5 0.03	15 0.02
935	416274.1	5122962.8	80	S	1.717	0.474	-0.007	0	100	0		0	0	0	0	0	0.1	5.7	26.5	40.1	23.4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
936	416523.9	5122903.9	68	S	1.688	0.466	-0.012	0	100	0		0	0	0	0	0	0	2	18	39.3	31.7	8.6	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
937	416803.2	5122838.8	62	S	1.822	0.522	-0.027	0	100	0		0	0	0	0	0	0.1	5.1	21.7	35.9	27.7	8.9	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
938	417065.1	5122777.5	51	S	1.596	0.476	0.002	0	100	0		0	0	0	0	0	0.4	9.6	32	38.3	17.5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
939	413975.9	5123684.7	36	S	2.261	0.518	-0.018	0	100	0		0	0	0	0	0	0	0.2	6.5	24.2	36.3	25.4	7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
940	414256.2	5123660.2	37	S	2.194	0.517	-0.01	0	100	0		0	0	0	0	0	0	0.4	8.2	26.9	36.3	22.6	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
941	414482.6	5123579.5	38	S	2.234	0.509	0.009	0	100	0		0	0	0	0	0	0	0.1	6.8	25.6	36.9	24.2	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
942	414755.3	5123517.3	37	S	2.094	0.509	0.027	0	100	0		0	0	0	0	0	0	0.7	11.2	31	35.5	18.3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
943	414981.3	5123466.5	36	S	2.075	0.506	0.014	0	100	0		0	0	0	0	0	0	0.8	11.8	31.6	35.4	17.6	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
944	415193.7	5123423.0	40	S	1.908	0.466	-0.001	0	100	0		0	0	0	0	0	0	1.7	17.1	38.9	32.5	9.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
945	415451.9	5123343.7	42	S	1.685	0.516	-0.009	0	100	0		0	0	0	0	0	0.4	8.5	27.1	36.3	22.4	4.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
946	415733.9	5123325.5	50	S	1.61	0.514	-0.002	0	100	0		0	0	0	0	0	0.7	10.8	30	35.6	19.2	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
947	415982.4	5123255.9	72	S	1.632	0.511	0	0	100	0		0	0	0	0	0	0.6	10	29.3	36.1	20.1	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
948	416230.9	5123194.1	82	S	1.981	0.59	-0.044	0	100	0		0	0	0	0	0	0.2	4.3	16.6	29.8	29.6	15.9	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
949	416458.7	5123156.4	80	S	2.172	0.518	-0.02	0	100	0		0	0	0	0	0	0	0.5	8.8	27.6	38.1	21.8	4.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
950	416708.5	5123101.7	66	S	1.989	0.528	-0.015	0	100	0		0	0	0	0	0	0	2.3	15.4	32.8	32.5	14.8	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
951	416947.6	5123043.6	59	S	1.857	0.51	-0.002	0	100	0		0	0	0	0	0	0	3.9	20.5	36.2	29	9.6	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
952	417171.5	5122968.4	62	S	1.947	0.515	0.003	0	100	0		0	0	0	0	0	0	2.5	16.9	34.6	31.8	12.8	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
953	417470.7	5122935.8	59	S	1.531	0.519	-0.006	0	100	0		0	0	0	0	0	1.5	13.8	32.1	33.8	16.2	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
954	417672.9	5122858.5	61	S	1.595	0.426	0.005	0	100	0		0	0	0	0	0	0.1	7	33.9	42.4	15.5	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
955	413671.6	5123999.8	35	S	2.082	0.582	-0.01	0	100	0		0	0	0	0	0	0	2.4	13.7	28.3	31.1	18.9	5.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
956	413913.2	5123947.1	34	S	2.128	0.582	-0.033	0	100	0		0	0	0	0	0	0	2	12.4	27	31.5	20.5	6.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
957	414179.7	5123873.7	34	S	2.165	0.577	-0.038	0	100	0		0	0	0	0	0	0	1.5	11.1	26.2	32.1	21.7	6.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
958	414412.5	5123842.2	38	S	2.272	0.521	-0.022	0	100	0		0	0	0	0	0	0	0.2	8.3	23.7	36.1	25.8	7.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
959	414662.4	5123756.5	36	S	2.21	0.514	0.01	0	100	0		0	0	0	0	0	0	0.2	7.7	26.5	36.5	23.1	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
960	414908.2	5123712.5	33	S	1.94	0.464	0.002	0	100	0		0	0	0	0	0	0	1.2	15.6	38.2	33.9	10.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
961	415147.7	5123662.1	35	S	1.692	0.429	0.004	0	100	0		0	0	0	0	0	0	4.3	28.1	44.3	21.1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
962	415381.7	5123589.7	35	S	1.628	0.429	0.005	0	100	0		0	0	0	0	0	0	6.1	31.9	43.1	17.4	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
963	415631.5	5123538.5	43	S	1.562	0.528	-0.021	0	100	0		0	0	0	0	0	1.5	12.9	30.8	34.1	17.6	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
964	415887.6	5123489.1	59	S	1.699	0.477	-0.005	0	100	0		0	0	0	0	0	0.1	8.3	27.3	39.7	22.5	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
965	416130.4	5123426.6	70	S	1.732	0.519	-0.017	0	100	0		0	0	0	0	0	0.3	7.2	25.3	36.4	24.2	6.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
966	416360.3	5123399.8	74	S	0.827	0.928	-0.456	8.07	91.59	0.34		2.9	2.3	2.7	3.5	5.8	13.9	24.9	22.7	14.1	5.3	0.8	0	0.1	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
967	416642.3	5123342.8	70	S	2.109	0.471	0.007	0	100	0		0	0	0	0	0	0	0.3	8.8	31.7	38.9	18	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
968	416850.2	5123285.9	60	S	2.114	0.466	0.006	0	100	0		0	0	0	0	0	0	0.2	8.5	31.5	39.3	18.2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
969	417115.3	5123211.2	61	S	2.265	0.472	0.011	0	100	0		0	0	0	0	0	0	0	4.4	24.4	40.2	25.6	5.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
970	417344.9	5123180.3	58	S	2.124	0.461	0.016	0	100	0		0	0	0	0	0	0	0.1	7.9	31.4	39.9	18.5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
971	417605.2	5123106.1	60	S	1.951	0.528	-0.032	0	100	0		0	0	0	0	0	0	3	16.6	33.6	31.7	13.4	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
973	418000.9	5123008.0	58	S	1.49	0.515	0.002	0	100	0		0	0	0	0	0	1.8	15.3	33.5	33	14.4	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
974	413860.8	5124164.7	35	S	1.925	0.535	0.017	0	100	0		0	0	0	0	0	0	3.4	18.1	33.9	30.2	12.6	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
975	414100.4	5124097.2	33	S	2.07	0.589	-0.002	0	100	0		0	0	0	0	0	0	2.8	14.3	28.3	30.5	13.5	5.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
976	414345.3	5124062.0	36	S	2.125	0.567	-0.002	0	100	0		0	0	0	0	0	0	2	12.6	27.2	31.2	20.2	6.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
977	414589.4	5124015.0	35	S	2.109	0.529	-0.009	0	100	0		0	0	0	0	0	0	1	11.3	29.6	34.7	19.3	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
978	414835.4	5123954.4	34	S	2.179	0.527	-0.015	0	100	0		0	0	0	0	0	0	0.6	9	27.2	35.5	22.1	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
979	415032.1	5123878.2	32	S	2.085	0.507	0.001	0	100	0		0	0	0	0	0	0	0.8	11.4	31.1	35.6	18.1	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
980	415290.6	5123855.6	36	S	1.881	0.464	-0.006	0	100	0		0	0	0	0	0	0	2	18.3	39.6	31.4	8.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
981	415540.5	5123774.7	30	S	1.591	0.47	0.013	0	100	0		0	0	0	0	0	0.3	9.5	32.5	38.5	17.1	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
982	415815.8	5123704.7	50	S	1.324	0.47	0.006	0	100	0		0	0	0	0	0	3.1	21.4	40	28.5	6.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
983	416085.7	5123673.0	66	MS	3.664	2.284	0.285	0	53.49	46.51		0	0	0	0	0	2.3	8	12.8	12.5	7.8	3.4	2.4	3.5	5.7	6.9	7.3	7.1	6.3	4.9	3.5	2.2	1.3	0.7	0.1	0	0	0	0	0	0	0	0	0	0	
984	416321.1	5123646.6	64	S	1.908	0.469	0.002	0	100	0		0	0	0	0	0	0	1.8	17.2	38.7	32.3	9.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
985	416577.2	5123566.1	64	S	1.77	0.523	0	0	100	0		0	0	0	0	0	0.2	6.3	24	36.1	25.5	7.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
986	416804.4	5123521.3	66	S	2.008	0.514	0.003	0	100	0		0	0	0	0	0	0	1.6	14.4	33.2	33.6	15.1	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
987	417057.6	5123468.9	57	S	2.124	0.466	0.01	0	100	0		0	0	0	0	0	0	0.2	8.2	31.1	39.5	18.6	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
988	417300.5	5123391.7	60	S	2.235	0.468	0.012	0	100	0		0	0	0	0	0	0	0	4.9	25.8	40.6	24.1	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
989	417538.2	5123362.0	56	S	2.084	0.465	0.007	0	100	0		0	0	0	0	0	0	0.3	9.5	33	38.7	16.7	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
990	417767.9	5123281.7	62	S	1.937	0.463	0.002	0	100	0		0	0	0	0	0	0	1.2	15.6	38.4	33.8	10.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
991	418012.3	5123237.7	58	S	1.828	0.469	-0.003	0	100	0		0	0	0	0	0	0	3	21.1	40.1	28.8	6.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
992	418262.4	5123185.0	65	S	1.51	0.532	-0.024	0	100	0		0	0	0	0	0	2.2	14.8	32	32.9	15.7	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
993	418516.8	5123125.0	69	S	1.6	0.524	0.009	0	100	0		0	0	0	0	0	0.9	11.5	30.1	34.8	18.5	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
994	413764.7	5124398.8	34	S	2.067	0.577	-0.007	0	100	0		0	0	0	0	0	0	2.5	14.1	28.5	31.1	18.4	4.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
995	414031.1	5124329.6	33	S	1.927	0.577	0.024	0	100	0		0	0	0	0	0	0	3.1	16	34.4	30.5	12.4	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
996	414279.8	5124324.0	33	S	2.026	0.576	0.016	0	100	0		0	0	0	0	0	0	2.9	15.5	29.9	30.5	16.9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
997	414538.4	5124241.7	34	S	2.176	0.534	-0.008	0	100	0		0	0	0	0	0	0	0.7	9.3	27.2	35	21.9	5.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
998	414783.9	5124173.9	35	S	2.274	0.598	-0.07	0	100	0		0	0	0	0	0	0	0.9	8.7	23	31.3	24.5	10.1	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
999	415029.7	5124122.2	30	S	1.876	0.534	0.015	0	100	0		0	0	0	0	0	0	4.3	20	34.6	28.8	10.9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1000	415247.5	5124062.5	31	S	2.043	0.585	-0.009	0	100	0		0	0	0	0	0	0	3.1	14.9	29	30.4	17.7	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1001	415503.5	5124007.7	30	S	1.832	0.529	0.004	0	100	0		0	0	0	0	0	0.1	5	21.6	35.4	27.6	9.4	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1002	415746.3	5123947.7	30	S	1.609	0.514	0.012	0	100	0		0	0	0	0	0	0.7	10.9	30.1	35.4	19.1	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1003	415983.3	5123888.4	25	NS	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1004	416225.0	5123814.7	85	S	0.807	0.812	-1.342	11.99	88.01	0		6.4	2.6	2.9	2.7	2.9	7.4	33	28	12.1	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1005	416484.3	5123821.9	57	S	1.862	0.468	-0.007	0	100	0		0	0	0	0	0	0	2.4	19.3	39.7	30.4	7.8	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1006	416739.2	5123746.3	54	S	2.04	0.517	0.006	0	100	0		0	0	0	0	0	0	1.4	13.4	32.2	34.1	16.3	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1007	416962.4	5123677.7	62	S	1.921	0.508	-0.004	0	100	0		0	0	0	0	0	0	2.7	17.8	35.4	31.3	11.7	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1008	417201.9	5123626.2	58	S	2.072	0.528	-0.021	0	100	0		0	0	0	0	0	0	1.4	12.4	30.6	34.3	17.9	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1009	417438.7	5123581.9	56	S	1.759	0.514	0.013	0	100	0		0	0	0	0	0	0.1	6.3	24.7	36.6	25	6.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1010	417719.1	5123523.8	40	S	1.897	0.527	-0.008	0	100	0		0	0	0	0	0	0	3.7	18.9	34.7	29.9	11.4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1011	417924.0	5123483.3	56	S	2.032	0.507	-0.001	0	100	0		0	0	0	0	0	0	1.2	13.3	32.8	34.6	15.9	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1012	418184.9	5123415.0	64	S	1.828	0.471	0.012	0	100	0		0	0	0	0	0	0	3	21.2	40	28.5	6.9	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1013	418459.8	5123346.3	66	S	1.747	0.427	0.01	0	100	0		0	0	0	0	0	0	2.9	24.8	44.9	24.2	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1014	418691.0	5123324.2	65	S	1.585	0.471	-0.005	0	100	0		0	0	0	0	0	0.4	9.8	32.5	38.4	17	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1015	418962.4	5123238.5	75	S	1.506	0.512	0.007	0	100	0		0	0	0	0	0	1.6	14.6	33.4	33.5	14.9	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1016	413755.7	5124630.2	34	S	2.072	0.605	-0.021	0	100	0		0	0	0	0	0	0	3.2	14.3	27.6	30	18.7	5.6	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1017	413959.0	5124599.2	33	S	2.151	0.6	0.005	0	100	0		0	0	0	0	0	0	2	12.1	26.2	30.8	20.9	7.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1018	414231.7	5124527.1	32	S	1.903	0.574	0.001	0	100	0		0	0	0	0	0	0.1	5.2	19.3	31.7	28.2	13.1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1019	414472.9	5124455.4	34	S	1.931	0.589	0.03	0	100	0		0	0	0	0	0	0.1	5	18.7	30.9	28.1	14	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1020	414710.0	5124411.6	34	S	1.906	0.596	0.017	0	100	0		0	0	0	0	0	0.2	5.8	19.3	30.7	27.4	13.6	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1021	414944.1	5124353.5	33	S	1.723	0.601	-0.008	0	100	0		0	0	0	0	0	1.4	10.1	24.3	31.3	23	8.8	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1022	415188.6	5124307.2	30	S	1.964	0.576	0.045	0	100	0		0	0	0	0	0	0	3.9	17.7	31.1	29.1	14.8	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1023	415428.7	5124237.1	30	S	1.899	0.525	0.006	0	100	0		0	0	0	0	0	0	3.8	18.9	34.8	29.9	11.4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1024	415664.9	5124189.1	28	S	1.883	0.535	0.016	0	100	0		0	0	0	0	0	0	4.2	19.7	34.6	29	11.1	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1025	415925.0	5124127.7	26	S	1.697	0.516	0.002	0	100	0		0	0	0	0	0	0.3	8.2	26.9	36.3	22.7	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1026	416150.4	5124077.5	28	S	1.666	0.513	0.021	0	100	0		0	0	0	0	0	0.4	8.9	28.2	36.3	21.3	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1027	416407.7	5124024.5	61	MS	3.638	2.169	0.455	0	59.27	40.73		0	0	0	0	0	1.6	5.6	10	12.3	11.2	8.1	5.5	4.6	4.9	5.5	5.9	6	5.5	4.6	3.4	2.3	1.4	0.7	0.1	0	0	0	0	0	0	0	0	0	0	
1028	416627.5	5123985.1	50	S	1.827	0.56	-0.003	0	100	0		0	0	0	0	0	0.2	6.4	21.8	33.1	26.7	10.5	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1029	416907.7	5123942.5	48	S	1.886	0.514	-0.005	0	100	0		0	0	0	0	0	0	3.5	19.3	35.6	30	10.7	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1030	417145.0	5123880.9	50	S	2.02	0.515	-0.013	0	100	0		0	0	0	0	0	0	1.6	13.9	32.7	33.9	15.6	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1031	417386.9	5123817.4	45	S	1.969	0.532	-0.014	0	100	0		0	0	0	0	0	0	2.8	16.2	33.1	31.8	14.1	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1032	417606.8	5123751.8	47	S	1.97	0.476	0.008	0	100	0		0	0	0	0	0	0	1.2	14.6	36.6	34.4	12.1	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1033	417850.6	5123721.9	56	S	1.915	0.469	0.001	0	100	0		0	0	0	0	0	0	1.7	16.9	38.5	32.6	9.7	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1034	418094.6	5123619.5	55	S	1.766	0.514	-0.027	0	100	0		0	0	0	0	0	0.2	6.2	23.9	36.7	25.7	6.9	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1035	418319.3	5123612.8	51	S	1.854	0.463	-0.005	0	100	0		0	0	0	0	0	0	2.4	19.7	40.2	30.1	7.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1036	418609.4	5123526.8	64	S	1.623	0.472	-0.004	0	100	0		0	0	0	0	0	0.3	8.4	30.9	39.2	18.8	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1037	418877.9	5123472.5	66	S	1.734	0.471	0.013	0	100	0		0	0	0	0	0	0	5	25.9	40.4	24	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1038	419082.6	5123416.2	72	S	1.307	0.539	-0.002	0	100	0		0	0	0	0	0.2	6.2	22.1	34.7	26.9	9.1	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1039	413867.4	5124816.6	32	S	2.051	0.624	-0.012	0	100	0		0	0	0	0	0	0.2	4	15	27.5	29	18	5.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1040	414156.4	5124750.0	30	S	2.018	0.595	-0.015	0	100	0		0	0	0	0	0	0.1	3.7	15.7	29.1	29.7	17	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1041	414403.9	5124722.9	35	S	2.115	0.591	-0.001	0	100	0		0	0	0	0	0	0	2.2	12.9	27.3	31	19.8	6.2	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1042	414638.8	5124645.7	35	S	2.102	0.538	-0.006	0	100	0		0	0	0	0	0	0	1.3	11.7	29.5	34	19	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1043	414877.0	5124588.7	33	S	1.866	0.587	-0.004	0	100	0		0	0	0	0	0	0.3	6.4	20.4	31.5	27	12.3	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1044	415104.3	5124553.9	33	S	1.998	0.604	0.026	0	100	0		0	0	0	0	0	0.1	4.2	16.7	29.3	28.7	16.2	4.4	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1045	415342.6	5124472.5	30	S	2.033	0.589	0.033	0	100	0		0	0	0	0	0	0	3.2	15.6	29.3	29.8	17.1	4.7	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1046	415585.6	5124417.9	29	S	1.786	0.591	0.022	0	100	0		0	0	0	0	0	0.8	8.9	23.5	31.7	24.1	9.6	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1047	415822.8	5124368.7	28	S	1.852	0.58	0.055	0	100	0		0	0	0	0	0	0.2	6.4	21.3	32	26.3	11.6	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1048	416072.4	5124303.3	26	S	1.793	0.572	0.043	0	100	0		0	0	0	0	0	0.3	7.6	23.2	32.7	25	9.8	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1049	416328.7	5124264.0	23	S	1.948	0.533	0.022	0	100	0		0	0	0	0	0	0	2.9	17.2	33.7	30.9	13.3	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1050	416799.1	5124162.2	45	S	1.842	0.517	-0.007	0	100	0		0	0	0	0	0	0	4.5	21.1	36	28.3	9.4	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1051	417072.5	5124111.4	45	S	1.915	0.579	-0.033	0	100	0		0	0	0	0	0	0.2	5.2	18.6	31.2	28.6	13.7	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1052	417296.2	5124079.7	45	S	2.14	0.571	-0.084	0	100	0		0	0	0	0	0	0	1.8	11.3	26.7	32.7	21.2	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1053	417559.1	5124014.8	37	S	1.701	0.474	0.018	0	100	0		0	0	0	0	0	0.1	6	27.5	39.9	22.4	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1054	417805.1	5123955.4	36	S	1.948	0.511	0.005	0	100	0		0	0	0	0	0	0	2.3	16.8	34.8	32	12.7	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1055	418026.8	5123878.5	38	S	1.962	0.468	0.011	0	100	0		0	0	0	0	0	0	1.1	14.7	37.4	34.5	11.4	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1056	418263.4	5123829.8	41	S	1.94	0.464	-0.002	0	100	0		0	0	0	0	0	0	1.3	15.5	38.2	33.9	10.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1057	418514.7	5123805.2	50	S	1.896	0.456	-0.002	0	100	0		0	0	0	0	0	0	1.6	17.5	39.8	32.2	8.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1058	418704.2	5123719.1	48	S	1.879	0.467	0.001	0	100	0		0	0	0	0	0	0	2.1	18.5	39.5	31.1	8.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1059	419021.9	5123673.9	62	S	1.805	0.471	0.02	0	100	0		0	0	0	0	0	0	3.4	22.4	40.3	27.4	6.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1060	419241.7	5123593.5	65	S	1.602	0.467	0.015	0	100	0		0	0	0	0	0	0.2	8.9	32.1	39	17.6	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1061	419497.4	5123542.4	75	S	1.623	0.475	0.008	0	100	0		0	0	0	0	0	0.3	8.6	30.9	38.8	18.8	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1062	413808.5	5125065.6	36	S	2.123	0.618	-0.022	0	100	0		0	0	0	0	0	0	2.8	13	26.2	30	20.1	7	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1063	414050.5	5125006.9	31	S	2.135	0.611	0	0	100	0		0	0	0	0	0	0	2.5	12.7	26.2	30.2	20.4	7.1	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1064	414324.8	5124959.0	34	S	2.095	0.592	0.002	0	100	0		0	0	0	0	0	0	2.5	13.6	27.7	30.7	19.2	5.8	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1065	414571.0	5124884.5	35	S	2.113	0.596	0.001	0	100	0		0	0	0	0	0	0	2.4	13.1	27.2	30.7	19.8	6.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1066	414816.3	5124826.8	35	S	2.128	0.62	0.024	0	100	0		0	0	0	0	0	0	2.7	13.1	26.4	29.7	19.9	7.2	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1067	415050.6	5124761.6	33	S	1.92	0.533	0.022	0	100	0		0	0	0	0	0	0	3.4	18.3	34.1	30.1	12.3	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud	Diameter(Φ) Diameter(μ)	-2 4000	-1.5 2828.4	-1 2000	-0.5 1414.2	0 1000	0.5 707.1	1 500	1.5 353.6	2 250	2.5 176.8	3 125	3.5 88.4	4 62.5
1068	415269.5	5124723.9	33	S	1.87	0.588	0.024	0	100	0		0	0	0	0	0	0.2	8.3	20.5	31.4	26.8	12.3	2.1	0
1069	415542.5	5124666.5	30	S	1.852	0.578	0.027	0	100	0		0	0	0	0	0	0.2	6.4	21.1	32.1	26.6	11.6	1.7	0
1070	415752.0	5124602.8	29	S	1.945	0.61	0.039	0	100	0		0	0	0	0	0	0.2	5.3	18.4	29.8	27.4	14.7	3.8	0
1071	416005.4	5124570.1	27	S	2.087	0.536	0.001	0	100	0		0	0	0	0	0	0	1.4	12.2	30.1	33.9	18.4	3.8	0
1072	416268.3	5124499.1	24	S	2.224	0.58	0.007	0	100	0		0	0	0	0	0	0	0.9	9.7	24.9	32.1	23.2	8.4	0.6
1073	416619.8	5124570.0	0	S	1.972	0.516	0.011	0	100	0		0	0	0	0	0	0	2.1	15.9	34	32.4	13.7	1.5	0
1074	416961.7	5124358.5	45	S	2.247	1.236	2.184	0	91.37	8.63		0	0	0	0	0	0.1	5	17.3	27.9	25.4	12.7	2.7	0
1075	417241.9	5124318.3	42	S	1.931	0.586	0.007	0	100	0		0	0	0	0	0	0.1	5	18.5	30.8	28.4	14.2	2.7	0
1076	417496.7	5124230.8	43	S	2.252	0.521	-0.044	0	100	0		0	0	0	0	0	0	0.3	6.8	24.3	38.2	25.1	6.8	0.1
1077	417736.5	5124174.6	35	S	1.643	0.519	0.036	0	100	0		0	0	0	0	0	0.5	9.9	29.1	35.6	20.3	4.3	0	0
1078	417938.4	5124139.3	32	S	1.915	0.47	-0.011	0	100	0		0	0	0	0	0	0	1.7	16.8	38.4	32.7	9.7	0.3	0
1079	418220.3	5124050.4	33	S	2.039	0.473	0.004	0	100	0		0	0	0	0	0	0	0.7	11.6	34.4	36.9	14.8	1.3	0
1080	418436.4	5124021.1	31	S	1.954	0.517	-0.013	0	100	0		0	0	0	0	0	0	2.5	16.5	34.2	32.1	13.1	1.3	0
1081	418685.1	5123963.3	38	S	1.924	0.471	-0.002	0	100	0		0	0	0	0	0	0	1.6	16.5	38.2	33	10.1	0.4	0
1082	418929.9	5123887.2	40	S	1.941	0.47	0.003	0	100	0		0	0	0	0	0	0	1.4	15.7	37.8	33.7	10.7	0.5	0
1083	419176.1	5123859.1	48	S	1.867	0.46	-0.001	0	100	0		0	0	0	0	0	0	2	19	40.2	30.7	7.6	0.1	0
1084	419414.5	5123779.0	55	S	1.803	0.509	0.023	0	100	0		0	0	0	0	0	0	4.9	22.9	36.9	26.8	7.9	0.3	0
1085	419642.4	5123726.5	67	S	1.673	0.557	0.014	0	100	0		0	0	0	0	0	0.8	10.6	26.8	33.1	21.8	6.4	0.2	0
1086	414215.2	5125159.2	31	S	1.993	0.622	0.062	0	100	0		0	0	0	0	0	0.1	4.7	17.2	28.8	27.8	15.9	4.8	0.3
1087	414481.1	5125141.0	34	S	1.992	0.577	0.015	0	100	0		0	0	0	0	0	0	3.6	16.6	30.3	29.8	15.9	3.4	0
1088	414736.5	5125073.6	35	S	1.993	0.582	0.012	0	100	0		0	0	0	0	0	0	3.7	16.6	20.1	29.7	16	3.6	0
1089	414981.8	5125021.9	34	S	1.987	0.583	0.042	0	100	0		0	0	0	0	0	0	3.8	17	30.3	29.3	15.6	3.7	0
1090	415209.8	5124950.7	34	S	1.935	0.569	0.038	0	100	0		0	0	0	0	0	0	4.3	18.5	31.6	28.9	14	2.4	0
1091	415432.1	5124909.5	33	S	1.958	0.582	0.044	0	100	0		0	0	0	0	0	0	4.2	17.9	30.8	23.8	14.7	3.2	0
1092	415697.4	5124838.5	30	S	1.785	0.592	0.013	0	100	0		0	0	0	0	0	0.7	8.4	22.9	31.7	24.7	10.1	1.3	0
1093	415893.8	5124777.9	27	S	2.026	0.598	0.007	0	100	0		0	0	0	0	0	0	3.6	15.7	28.9	29.5	17.1	4.7	0.1
1094	416193.8	5124736.8	23	S	2.108	0.586	-0.001	0	100	0		0	0	0	0	0	0	2.2	13.1	27.7	31.1	19.6	5.9	0.2
1095	416413.9	5124687.3	18	S	2.167	0.657	-0.024	0	100	0		0	0	0	0	0	0.1	3.1	12.6	24.3	28.2	21	9	1.3
1096	417140.5	5124520.0	41	S	1.872	0.509	-0.001	0	100	0		0	0	0	0	0	0	3.6	19.8	36.2	29.6	10	0.5	0
1097	417366.6	5124484.2	43	S	2.702	1.594	1.583	0	84.35	15.65		0	0	0	0	0	0.1	3.9	12.5	21.1	22.6	15.7	6.6	1.4
1098	417674.1	5124422.8	40	S	2.442	0.968	2.792	0	95.63	4.37		0	0	0	0	0	0	0.3	6.5	22.4	33.7	24.6	7.6	0.3
1099	417876.8	5124369.9	33	S	2.256	0.51	-0.028	0	100	0		0	0	0	0	0	0	0.1	6.3	24.4	36.9	25.3	6.5	0.1
1100	418135.0	5124275.4	31	S	2.274	0.471	0.004	0	100	0		0	0	0	0	0	0	0	4.1	23.8	40.3	26.1	5.4	0
1101	418377.3	5124250.8	31	S	2.23	0.521	-0.039	0	100	0		0	0	0	0	0	0	0.3	7.3	25.2	36.2	24.3	6.3	0.1
1102	418636.0	5124191.7	32	S	2.119	0.508	0.016	0	100	0		0	0	0	0	0	0	0.5	10.3	30.1	36	19.4	3.4	0
1103	418861.6	5124133.0	30	S	2.143	0.519	0.012	0	100	0		0	0	0	0	0	0	0.6	9.9	28.9	35.6	20.5	4.3	0
1104	419092.1	5124099.6	32	S	1.971	0.521	0.017	0	100	0		0	0	0	0	0	0	2.3	16.1	33.8	32.1	13.8	1.7	0
1105	419335.0	5124017.6	37	S	1.769	0.506	0.013	0	100	0		0	0	0	0	0	0	5.7	24.3	37.2	25.5	6.8	0.1	0
1106	419578.0	5124016.5	49	S	1.614	0.479	-0.013	0	100	0		0	0	0	0	0	0.4	9.1	30.9	38.5	18.5	2.3	0	0
1107	419828.7	5123931.5	56	S	1.692	0.432	0.004	0	100	0		0	0	0	0	0	0	4.4	28.1	44	21.1	2.1	0	0
1108	414416.9	5125363.5	31	S	2.08	0.603	0.014	0	100	0		0	0	0	0	0	0	3	14.3	27.7	29.9	13.7	5.8	0.3
1109	414643.7	5125317.5	35	S	1.967	0.603	0.036	0	100	0		0	0	0	0	0	0.1	4.7	17.7	29.8	28.2	15.2	3.9	0
1110	414883.1	5125270.6	31	S	1.981	0.587	0.043	0	100	0		0	0	0	0	0	0	4	17.2	30.3	29	15.5	3.7	0
1111	415134.7	5125199.2	30	S	2.04	0.591	0.035	0	100	0		0	0	0	0	0	0	3.1	15.4	29.1	29.8	17.3	4.8	0.1
1112	415367.7	5125122.6	30	S	1.903	0.579	0.014	0	100	0		0	0	0	0	0	0.1	5.3	19.4	31.5	28	13.2	2.2	0
1113	415613.2	5125088.2	29	S	2.052	0.597	0.025	0	100	0		0	0	0	0	0	0	3.2	15	28.6	29.8	17.8	5.2	0.2
1114	415865.5	5125038.2	24	S	2.028	0.578	0.006	0	100	0		0	0	0	0	0	0	3.1	15.4	29.6	30.4	17.1	4.1	0
1115	416105.8	5124981.9	18	S	1.981	0.52	0.002	0	100	0		0	0	0	0	0	0	2.1	15.6	33.6	32.6	14.2	1.7	0
1117	416617.8	5124906.0	0	S	2.123	0.528	0.012	0	100	0		0	0	0	0	0	0	0.8	10.9	29.3	34.7	19.7	4.2	0
1118	417317.7	5124725.1	25	S	1.636	0.465	0.012	0	100	0		0	0	0	0	0	0.1	7.7	30.6	39.8	19.2	2.3	0	0
1119	417565.9	5124639.5	37	MS	3.081	1.834	1.072	0	73.99	26.01		0	0	0	0	0	0.1	3.5	11.1	18.4	19.2	13.1	5.8	2.3
1120	417816.1	5124601.2	36	S	2.016	0.625	-0.066	0	100	0		0	0	0	0	0	0.3	4.7	15.8	27.6	28.7	17.5	5.1	0.1
1121	418048.8	5124529.2	33	S	2.745	1.552	1.606	0	84.37	15.63		0	0	0	0	0	0	2.8	11.5	20.7	23	16.6	7.4	2
1122	418296.3	5124485.1	31	S	2.149	0.534	-0.023	0	100	0		0	0	0	0	0	0	0.9	10.1	28	34.9	21	4.8	0
1123	418547.8	5124431.9	29	S	2.326	0.517	-0.026	0	100	0		0	0	0	0	0	0	0	4.9	21.6	36	27.9	8.9	0.3
1124	418774.7	5124361.9	28	S	2.239	0.527	-0.04	0	100	0		0	0	0	0	0	0	0.4	7.3	24.8	35.8	24.6	6.7	0.1
1125	419031.8	5124316.7	26	S	1.84	0.574	0.03	0	100	0		0	0	0	0	0	0.2	6.5	21.6	32.3	26.4	11.2	1.5	0
1126	419269.8	5124250.1	33	S	1.614	0.52	0.001	0	100	0		0	0	0	0	0	0.8	10.9	29.7	35.3	19.4	3.8	0	0
1127	419559.0	5124109.0	45	S	1.665	0.469	0.007	0	100	0		0	0	0	0	0	0.1	7	29.1	39.9	20.7	2.9	0	0
1128	419757.7	5124157.2	30	S	1.586	0.503	-0.766	0.69	99.31	0		0.3	0.1	0.1	0.4	0.6	0.9	10.7	28.6	34.4	19.4	3.8	0	0
1129	420001.3	5124101.6	34	S	1.829	0.918	3.315	0	96.28	3.72		0	0	0	0	0	0.1	6.9	27.1	37.5	20.9	3.5	0	0
1130	414584.6	5125562.2	37	S	2.135	0.64	-0.002	0	100	0		0	0	0	0	0	0.1	3.1	13.1	25.5	29	20.1	7.6	0.9
1131	414809.7	5125509.5	34	S	1.902	0.6	0.017	0	100	0		0	0	0	0	0	0.3	6	19.4	30.5	27.2	13.5	2.7	0
1132	415048.4	5125462.7	34	S	1.936	0.533	0.025	0	100	0		0	0	0	0	0	0	3.1	17.7	33.9	30.6	12.8	1.6	0
1133	415303.1	5125385.2	33	S	1.927	0.577	0.05	0	100	0		0	0	0	0	0	0	4.7	18.9	31.5	28.3	13.7	2.6	0
1134	415542.2	5125332.4	29	S	2.059	0.595	0.001	0	100	0		0	0	0	0	0	0	3.1	14.7	28.3	30.1	18.1	5.2	0.1
1135	415780.5	5125282.6	27	S	2.019	0.582	0.006	0	100	0		0	0	0	0	0	0	3.4	15.7	29.6	30.1	16.8	4	0
1136	416019.5	5125227.5	20	S	2.006	0.534	0.015	0	100	0		0	0	0	0	0	0	2.2	15	32.3	32.4	15.4	2.4	0
1137	416279.7	5125156.5	17	S	2.41	0.698	-0.883	0	99.99	0.01		0	0	0	0.5	0.7	0.2	0.5	5.4	17	28.4	28.1	15.5	3.3
1138	416641.8	5125105.0	0	S	2.008	0.514	0.013	0	100	0		0	0	0	0	0	0	1.6	14.5	33.3	33.4	15	1.9	0
1139	417480.7	5124883.3	36	MS	4.059	2.077	0.357	0	52.62	47.38		0	0	0	0	0	0	2.1	6.5	10.4	11.2	9.2	6.9	5.9
1140	417733.3	5124853.1	39	S	2.142	0.577	-0.022	0	100	0		0	0	0	0	0	0	1.7	11.8	26.9	32	20.9	6.3	0.1
1141	417977.8	5124767.7	31	S	2.47	1.335	2.009	0	90.87	9.13		0	0	0	0	0	0	3.8	13.5	22.8	24.3	17.1	7.4	1.5
1142	418256.7	5124731.6	31	S	2.197	0.534	-0.02	0	100	0		0	0	0	0	0	0	0.6	8.8	26.4	35.1	22.8	6	0.1
1143	418462.7	5124664.3	29	S	2.912	1.459	1.644	0	85.19	14.81		0	0	0	0	0	0	0.7	6.7	16.9	24	21.4	11.8	3.5
1144	418704.9	5124610.1	28	S	2.113	0.6	-0.025	0	100	0		0	0	0	0	0	0	2.6	13.1	26.8	30.5	20	6.4	0.2
1145	418940.2	5124557.5	27	S	1.777	0.522	0.006	0	100	0		0	0	0	0	0	0.1	6.1	23.7	36.1	25.7	7.6	0.3	0
1146	419229.2	5124482.7	27	S	1.74	0.516	-0.005	0	100	0		0	0	0	0	0	0.2	6.9	25.1	36.6	24.5	6.3	0.1	0
1147	419450.5	5124457.3	30	S	1.656	0.531	-0.013	0	100	0		0	0	0	0	0	0.8	9.8	27.9	35.2	21.2	4.9	0	0
1148	419685.8	5124416.3	23	S	1.781	0.475	-0.003	0	100	0		0	0	0	0	0	0	4.2	23.4	40	26.4	5.6	0	0
1149	419833.5	5124293.3	12	S	1.812	0.517	-0.001	0	100	0		0	0	0	0	0	0	5.1	22.3	36.3	27.2	8.4	0.4	0
1150	415004.2	5125674.3	37	S	2.026	0.589	0.014	0	100	0		0	0	0	0	0	0	3.4	15.6	29.3	29.9	17.1	4.4	0
1151	415236.8	5125603.7	32	S	2.068	0.598	0.012	0	100	0		0	0	0	0	0	0	3	14.5	28.2	30.1	18.3	5.4	0.2
1152	415466.0	5125560.0	33	S	2.046	0.572	0.009	0	100	0		0	0	0	0	0	0	2.6	14.8	29.6	31	17.6	4.2	0
1153	415720.2	5125499.9	29	S	2.078	0.58	0.003	0	100	0		0	0	0	0	0	0	2.4	13.9	28.5	31	18.7	5.1	0.1
1154	415948.9	5125447.2	23	S	2.136	0.581	0.002	0	100	0		0	0	0	0	0	0	1.7	12.2	27.2	31.6	20.5	6.3	0.2
1155	416198.4	5125402.1	16	S	1.93	0.536	-0.005	0	100	0		0	0	0	0	0	0	3.4	17.8	33.7	30.5	12.8	1.5	0
1156	416699.8	5125220.0	0	S	1.917	0.472	0.002	0	100	0		0	0	0	0	0	0	1.7	16.9	38.3	32.6	9.9	0.4	0
1157	417660.7	5125080.5	29	S	2.545	1.675	1.636	0	83.65	16.35		0	0	0	0	0	0.3	6.7	17.4	23.8	20.3	10.7	3.1	0.8
1158	417890.5	5125030.6	35	S	1.94	1.088	2.628	0	94.93	5.07		0	0	0	0	0	0.8	9.3	23.4	30	21.8	8.3	1	0
1159	418152.1	5124976.8	30	S	1.675	0.556	0.042	0	100	0		0	0	0	0	0	0.7	10.4	27.1	33.3	21.5	6.4	0.2	0
1160	418440.8	5124870.9	27	S	2.446	0.879	2.013	0	96.83	3.17		0	0	0	0	0	0	0.8	7.5	20.4	29.4	24.9	11.6	1.9
1161	418640.4	5124883.7	56	S	2.076	0.707	0.956	0	98.97	1.03		0	0	0	0	0	0.1	4	15.5	27.5	28.2	17.3	5.6	0.5
1162	418887.9	5124787.4	27	S	1.832	0.69	1.324	0	98.57	1.43		0	0	0	0	0	0.4	7.9	23	31.9	24.4	9.7	1.1	0
1163	419119.6	5124730.2	26	S	1.866	0.521	0.012	0	100	0		0	0	0	0	0	0	4.1	20.2	35.5	28.9	10.2	0.7	0
1164	419396.0	5124674.2	28	S	1.873	0.586	0.036	0	100	0		0	0	0	0	0	0.2	6.1	20.5	31.8	26.9	12.3	2.1	0
1165	419610.6	5124634.9	22	S	1.914	0.524	0.004	0	100	0		0	0	0	0	0	0	3.3	18.3	34.6	30.5	11.9	1.1	0
1166	419767.3	5124480.2	15	S	1.905	0.52	0.006	0	100	0		0	0	0	0	0	0	3.3	18.6	35.1	30.3	11.4	1	0
1167	415155.6	5125867.8	38	S	2.032	0.603	0.001	0	100	0		0	0	0	0	0	0	3.7	15.6	28.6	29.4	17.3	4.9	0.1
1168	415390.4	5125807.3	37	S	2.11	0.592	0	0	100	0		0	0	0	0	0	0	2.3	13.2	27.4	30.8	19.7	6.1	0.2
1169	415641.3	5125740.0	31	S	2.173	0.606	-0.003	0	100	0		0	0	0	0	0	0	1.9	11.6	25.5	30.7	21.5	7.8	0.7
1170	415894.0	5125695.4	26	S	2.173	0.575	-0.035	0	100	0		0	0	0	0	0	0	1.4	10.8	26.1	32.3	22	7	0.2
1171	416132.3	5125644.4	20	S	1.857	0.54	-0.005	0	100	0		0	0	0	0	0	0.1	4.9	20.5	34.5	28.2	10.5	1	0
1172	416364.2	5125590.6	16	S	1.727	0.513	-0.001	0	100	0		0	0	0	0	0	0.2	7.1	25.8	36.7	23.9	5.9	0.1	0
1173	416748.8	5125594.0	0	S	1.703	0.473	0.007	0	100	0		0	0	0	0	0	0.1	6	27.3	40.1	22.6	3.7	0	0
1174	418050.7	5125200.9	31	S	1.659	0.548	0.03	0	100	0		0	0	0	0	0	0.7	10.7	27.8	33.6	21.2	5.8	0.1	0
1175	418341.9	5125135.2	29	S	2.007	1.19	2.262	0	93.43	6.57		0	0	0	0	0	1	10.6	22.6	27	20.1	9.2	2.2	0.3
1176	418571.1	5125087.8	28	S	2.461	1.48	2.005	0	87.8	12.2		0	0	0	0	0	0	3.9	15.3	26.3	25.2	13.5	3.2	0
1177	418838.0	5125011.4	27	S	1.942	0.529	0.009	0	100	0		0	0	0	0	0	0	3	17.3	33.9	31.1	13	1.5	0
1178	419068.0	5124974.8	26	S	1.88	0.473	-0.007	0	100	0		0	0	0	0	0	0	2.3	18.6	39	31	8.6	0.3	0
1179	419305.9	5124924.9	25	S	1.952	0.527	0.009	0	100	0		0	0	0	0	0	0	2.7	16.9	33.8	31.4	13.3	1.6	0
1180	419531.9	5124875.6	19	S	1.787	0.53	0.029	0	100	0		0	0	0	0	0	0.1	6.1	23.5	35.6	25.7	8.1	0.5	0
1181	415325.4	5126040.0	36	S	2.128	0.595	0	0	100	0		0	0	0	0	0	0	2.2	12.6	26.9	30.9	20.2	6.6	0.3
1182	415576.2	5125994.9	32	S	2.217	0.606	-0.017	0	100	0		0	0	0	0	0	0	1.6	10.4	24.3	30.9	22.8	8.9	0.9
1183	415816.6	5125930.2	30	S	2.222	0.591	-0.034	0	100	0		0	0	0	0	0	0	1.3	9.9	24.3	31.6	23.3	8.6	0.6
1184	416052.6	5125873.3	23	S	1.98	0.573	0.022	0	100	0		0	0	0	0	0	0	3.7	17	30.7	29.8	15.5	3.1	0
1185	416296.0	5125827.0	18	S	2.4	0.599	-0.071	0	100	0		0	0	0	0	0	0	0.5	6	18.9	30.2	27.9	13.9	2.3
1186	416647.8	5125852.0	0	S	1.785	0.534	0.004	0	100	0		0	0	0	0	0	0.2	6.3	23.3	35.3	25.8	8.2	0.4	0
1187	418243.2	5125387.8	25	S	1.779	0.514	-0.009	0	100	0		0	0	0	0	0	0.1	5.8	23.6	36.7	26	7.3	0.2	0
1188	418506.8	5125340.1	26	S	1.92	0.852	2.851	0	96.82	3.18		0	0	0	0	0	0.1	5.4	22.1	34.7	25.7	8.1	0.5	0
1189	418746.0	5125279.4	21	S	1.712	0.47	0.001	0	100	0		0	0	0	0	0	0	5.6	26.8	40.4	23.1	3.8	0	0
1190	419274.3	5125121.0	16	S	1.824	0.524	-0.004	0	100	0		0	0	0	0	0	0.1	5.1	21.8	35.8	27.5	9	0.5	0
1191	419594.8	5125237.0	0	S	2.015	0.58	0.024	0	100	0		0	0	0	0	0	0	3.2	16	29.9	30	16.6	4	0
1192	415508.7	5126214.7	34	S	2.131	0.606	0	0	100	0		0	0	0	0	0	0	2.4	12.8	26.4	30.4	20.3	6.9	0.5
1193	415731.1	5126167.4	32	S	2.222	0.593	-0.022	0	100	0		0	0	0	0	0	0	1.3	10	24.4	31.5	23.2	8.6	0.7
1194	415994.3	5126131.0	26	S	2.199	0.535	-0.018	0	100	0		0	0	0	0	0	0	0.6	8.7	26.3	35.1	22.8	6	0.1
1195	416223.2	5126065.9	26	S	2.038	0.539	0.006	0	100	0		0	0	0	0	0	0	1.9	14	31.3	32.9	16.7	3	0
1196	416477.0	5126007.5	26	S	1.808	0.53	0.003	0	100	0		0	0	0	0	0	0.1	5.6	22.5	35.5	26.7	8.7	0.5	0
1197	416708.5	5125964.0	0	S	1.85	0.523	-0.016	0	100	0		0	0	0	0	0	0	4.5	20.7	35.5	28.5	9.8	0.6	0
1198	418409.3	5125576.0	12	S	1.738	0.508	0	0	100	0		0	0	0	0	0	0.1	6.6	25.4	37.1	24.4	6	0.1	0
1199	418640.0	5125420.9	15	S	1.557	0.431	0	0	100	0		0	0	0	0	0	0.2	8.8	35.7	40.7	13.8	0.7	0	0
1200	415437.3	5126443.8	35	S	2.229	0.6	-0.024	0	100	0		0	0	0	0	0	0	1.4	9.9	24	31.2	23.3	9	0.9

Sample ID	4.5 44.2	5 31.3	5.5 22.1	6 15.6	6.5 11	7 7.8	7.5 5.5	8 3.9	8.5 2.8	9 2	9.5 1.4	10 1	10.5 0.7	11 0.5	11.5 0.35	12 0.24	12.5 0.18	13 0.12	13.5 0.09	14 0.06	14.5 0.03	15 0.02
1068	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1069	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1072	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1073	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1074	0.6	1.8	1.9	1.4	0.9	0.7	0.5	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	
1075	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1076	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1077	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1078	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1079	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1081	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1082	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1083	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
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1088	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
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1091	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1092	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1093	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1094	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1097	0.9	2.2	2.9	2.8	2.2	1.6	1.1	0.8	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	
1098	0	0.3	1.1	1	0.5	0.3	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1119	2.6	4.1	4.7	4.3	3.4	2.5	1.7	1.1	0.7	0.4	0	0	0	0	0	0	0	0	0	0	0	
1120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1121	1.3	2.4	2.9	2.6	2	1.4	1	0.7	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	
1122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1129	0.4	0.9	0.6	0.2	0.3	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	
1130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1139	6.1	6.5	6.6	6.6	6.1	5.2	4	2.3	1.8	1	0.2	0	0	0	0	0	0	0	0	0	0	
1140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1141	0.3	1.2	1.8	1.7	1.3	0.9	0.7	0.5	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	
1142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1143	0.5	1.8	3	2.9	2.1	1.4	0.9	0.7	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	
1144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1157	1.6	2.5	2.7	2.4	2	1.7	1.3	0.9	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	
1158	0.4	1	0.9	0.7	0.6	0.5	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	
1159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1160	0	0.6	1	0.6	0.3	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1161	0	0.1	0.5	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1162	0.1	0.6	0.5	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1163	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1171	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1175	0.8	1.2	1.1	0.9	0.6	0.6	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	
1176	0.6	1.9	2.2	2	1.6	1.3	1	0.7	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	
1177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1178	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1179	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1188	0.4	0.9	0.6	0.2	0.2	0.3	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	
1189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1193	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1194	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1198	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Sample ID	Easting	Northing	Depth (ft)	Type	Mean	Sorting	Skewness	% Gravel	% Sand	% Mud	Diameter(Φ)	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
											Diameter(u)	4000	2828.4	2000	1414.2	1000	707.1	500	353.6	250	176.8	125	88.4	62.5	44.2	31.3	22.1	15.6	11	7.8	5.5	3.9	2.8	2	1.4	1	0.7	0.5	0.35	0.24	0.18	0.12	0.09	0.06	0.03	0.02
1201	415664.7	5126417.5	35	S	2.282	0.589	-0.022	0	100	0		0	0	0	0	0	0	0.8	8.4	22.8	31.7	25	10.1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1202	415910.7	5126367.1	30	S	2.271	0.578	-0.023	0	100	0		0	0	0	0	0	0	0.7	8.4	23.3	32.3	24.9	9.5	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1203	416150.8	5126310.7	23	S	2.139	0.534	-0.015	0	100	0		0	0	0	0	0	0	0.9	10.4	28.4	34.8	20.5	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1204	416393.8	5126238.8	20	S	2.189	0.536	-0.031	0	100	0		0	0	0	0	0	0	0.7	9	26.5	35	22.6	5.8	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1205	416687.8	5126210.0	0	S	1.883	0.474	-0.004	0	100	0		0	0	0	0	0	0	2.3	18.5	38.8	31.1	8.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1206	415588.5	5126648.7	35	S	2.281	0.588	-0.024	0	100	0		0	0	0	0	0	0	0.8	8.4	22.8	31.8	24.9	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1207	415834.5	5126597.0	22	S	2.291	0.577	-0.014	0	100	0		0	0	0	0	0	0	0.5	7.8	22.7	32.3	25.4	10	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1208	416068.4	5126534.2	27	S	2.191	0.527	-0.021	0	100	0		0	0	0	0	0	0	0.5	8.6	26.7	35.6	22.5	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1209	416328.1	5126484.7	21	S	2.214	0.575	-0.023	0	100	0		0	0	0	0	0	0	1	9.7	25	32.4	23.2	8	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1210	416549.0	5126410.2	12	S	1.677	0.51	-0.002	0	100	0		0	0	0	0	0	0	3.5	19.6	36	29.7	10.3	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1211	416804.9	5126386.1	0	S	1.939	0.472	-0.011	0	100	0		0	0	0	0	0	0	1.5	15.8	37.6	33.6	10.7	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1212	415762.2	5126837.1	35	S	2.323	0.576	-0.019	0	100	0		0	0	0	0	0	0	0.4	7	21.7	32.2	26.4	10.9	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1213	416007.6	5126780.0	30	S	2.326	0.571	-0.021	0	100	0		0	0	0	0	0	0	0.3	6.8	21.6	32.4	26.6	10.9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1214	416258.0	5126709.8	24	S	2.045	0.576	-0.002	0	100	0		0	0	0	0	0	0	2.8	14.8	29.3	30.8	17.7	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1215	416495.6	5126671.4	20	S	2.169	0.533	-0.021	0	100	0		0	0	0	0	0	0	0.7	9.5	27.4	35.1	21.7	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1216	416806.8	5126642.0	0	S	1.769	0.467	0.016	0	100	0		0	0	0	0	0	0	4.1	24.1	40.7	25.8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1217	415684.1	5127079.0	38	S	2.374	0.57	-0.005	0	100	0		0	0	0	0	0	0	0.1	5.8	20.2	32.1	27.8	12.3	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1218	415918.5	5126993.5	33	S	2.299	0.57	-0.007	0	100	0		0	0	0	0	0	0	0.4	7.4	22.6	32.6	25.7	10	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1219	416178.1	5126967.3	27	S	2.285	0.574	-0.018	0	100	0		0	0	0	0	0	0	0.5	7.9	22.9	32.4	25.3	9.8	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1220	416420.3	5126907.9	21	S	2.064	0.533	-0.004	0	100	0		0	0	0	0	0	0	1.5	12.9	30.8	33.8	17.6	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1221	416655.7	5126862.4	14	S	1.868	0.533	0.007	0	100	0		0	0	0	0	0	0	4.4	20.2	34.8	28.7	10.6	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1222	416901.3	5126808.3	0	S	1.633	0.43	0	0	100	0		0	0	0	0	0	0	6	31.6	43.1	17.7	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1223	415835.0	5127260.0	37	S	2.373	0.568	0.005	0	100	0		0	0	0	0	0	0	0.1	5.7	20.3	32.2	27.7	12.2	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1224	416121.2	5127218.5	33	S	2.375	0.566	-0.007	0	100	0		0	0	0	0	0	0	0.1	5.6	20.2	32.2	27.9	12.2	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1225	416352.8	5127168.8	26	S	2.119	0.57	-0.006	0	100	0		0	0	0	0	0	0	1.7	12.5	27.9	32	20	5.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1226	416579.8	5127116.2	22	S	2.141	0.575	-0.027	0	100	0		0	0	0	0	0	0	1.6	11.9	27	32	20.9	6.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1228	415740.3	5127473.5	36	S	2.341	0.573	-0.017	0	100	0		0	0	0	0	0	0	0.3	6.5	21.2	32.3	26.9	11.3	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1229	416016.3	5127430.9	34	S	2.32	0.573	-0.018	0	100	0		0	0	0	0	0	0	0.4	7	21.8	32.4	26.3	10.7	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1230	416252.2	5127400.9	29	S	2.416	0.523	-0.007	0	100	0		0	0	0	0	0	0	0	3.3	18.2	34.6	30.7	12	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1231	416500.1	5127334.3	22	S	1.974	0.524	0.018	0	100	0		0	0	0	0	0	0	2.3	16.1	33.7	32	13.9	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1232	416741.5	5127280.9	13	S	1.86	0.526	0.008	0	100	0		0	0	0	0	0	0	4.3	20.5	35.3	28.6	10.2	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1233	416997.8	5127230.4	0	S	1.705	0.463	0.006	0	100	0		0	0	0	0	0	0	5.5	27.3	40.8	22.7	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1234	415980.9	5127683.9	36	S	2.373	0.568	-0.006	0	100	0		0	0	0	0	0	0	0.1	5.7	20.2	32.2	27.8	12.2	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1235	416109.6	5127628.7	22	S	2.369	0.52	-0.007	0	100	0		0	0	0	0	0	0	0	4.1	20	35.4	29.3	10.3	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1236	416428.2	5127577.3	26	S	2.25	0.527	0.002	0	100	0		0	0	0	0	0	0	0.2	7	24.8	35.7	24.6	7.1	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1239	416117.6	5127858.8	35	S	2.308	0.567	-0.016	0	100	0		0	0	0	0	0	0	0.4	7.1	22.3	32.7	26.1	10.2	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1240	416365.3	5127839.9	30	S	2.461	0.518	-0.007	0	100	0		0	0	0	0	0	0	0	2.4	16.4	34	32.2	13.4	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1243	416040.9	5128107.2	37	S	2.342	0.525	-0.014	0	100	0		0	0	0	0	0	0	0	4.8	21	35.4	28.3	9.6	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1247	416221.6	5128296.7	36	S	2.507	0.511	-0.008	0	100	0		0	0	0	0	0	0	0	1.6	14.5	33.2	33.7	15	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1251	416157.2	5128516.8	30	S	2.403	0.561	0.003	0	100	0		0	0	0	0	0	0	0	4.9	19.3	32.2	28.7	12.9	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1252	416384.7	5128470.4	33	S	2.491	0.515	-0.004	0	100	0		0	0	0	0	0	0	0	1.9	15.1	33.5	33.1	14.5	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1500	416975.8	5127585.0	0	S	1.759	0.465	0.003	0	100	0		0	0	0	0	0	0	4.3	24.5	40.9	25.4	4.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1501	417107.8	5127490.0	0	S	1.723	0.481	-0.006	0	100	0		0	0	0	0	0	0.1	5.8	26.1	39.5	23.7	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1502	416890.8	5127025.0	0	S	1.705	0.468	0.005	0	100	0		0	0	0	0	0	0	5.7	27.3	40.5	22.7	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1503	416942.8	5126633.0	0	S	1.668	0.432	0.003	0	100	0		0	0	0	0	0	0	5	29.5	43.7	19.8	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1504	416880.8	5126208.0	0	S	1.775	0.425	0.002	0	100	0		0	0	0	0	0	0	2.4	23	45	26	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1505	416835.8	5125963.0	0	S	1.628	0.463	0.009	0	100	0		0	0	0	0	0	0.1	7.9	31	39.8	18.8	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1506	416826.8	5125768.0	0	S	1.627	0.428	-0.002	0	100	0		0	0	0	0	0	0	8.1	31.9	43.2	17.3	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1507	416831.8	5125369.0	0	S	1.525	0.469	0.006	0	100	0		0	0	0	0	0	0.6	12	35.1	36.8	14.1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1508	416830.8	5125078.0	0	S	1.754	0.512	0.014	0	100	0		0	0	0	0	0	0.1	6.3	24.8	36.8	24.9	6.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1509	416335.8	5124898.0	0	S	1.612	0.461	0.009	0	100	0		0	0	0	0	0	0.2	8.3	31.8	39.7	18	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1510	416919.8	5124689.0	0	S	1.669	0.512	0.015	0	100	0		0	0	0	0	0	0.3	8.8	28.1	36.4	21.5	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1511	416712.8	5124425.0	0	S	1.965	0.515	0.016	0	100	0		0	0	0	0	0	0	2.1	16.2	34.3	32.2	13.4	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1512	418342.8	5125740.0	0	S	1.593	0.472	-0.009	0	100	0		0	0	0	0	0	0.4	9.5	32.1	38.6	17.4	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1513	418445.8	5125753.0	0	S	1.493	0.464	-0.003	0	100	0		0	0	0	0	0	0.8	13.2	36.4	36	12.6	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1514	421493.8	5120657.0	0	S	1.804	0.472	0.006	0	100	0		0	0	0	0	0	0	3.5	22.3	40.1	27.5	6.2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1515	420681.8	5120216.0	0	S	2.141	0.463	0.021	0	100	0		0	0	0	0	0	0	0.1	7.5	30.5	39.9	19.4	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1516	422073.8	5119391.0	0	S	2.088	0.507	0.018	0	100	0		0	0	0	0	0	0	0.7	11.3	31.2	35.6	18.1	7.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1517	421290.8	5120509.0	0	S	2.058	0.427	0.011	0	100	0		0	0	0	0	0	0	0.1	8.5	35.9	40.9	13.6	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1518	421073.8	5120375.0	0	S	2.117	0.516	0.023	0	100	0		0	0	0	0	0	0	0.6	10.6	30	35.4	19.3	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1519	422264.8	5118786.0	0	S	2.134	0.475	0.02	0	100	0		0	0	0	0	0	0	0.2	8.3	30.5	38.9	19.3	2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1520	422339.8	5118600.0	0	S	2.08	0.51	0.022	0	100	0		0	0	0	0	0	0	0.8	11.7	31.4	35.2	17.8	2.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1521	422176.8	5118971.0	0	S	2.21	0.516	0.014	0	100	0		0	0	0	0	0	0	0.2	7.8	26.5	38.3	23.1	5.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1523	422133.8	5119174.0	0	S	2.089	0.473	0.012	0	100	0		0	0	0	0	0	0	0.4	9.7	32.5	38.2	17.1	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

APPENDIX IV

Sediment Trend Statistics for All Selected Sample Lines (see Fig. 4)

Definitions:

(i) R^2 = multiple correlation coefficient derived from the mean, sorting and skewness of each sample pair making up a significant trend. This is a relative indication of how well the samples are related by transport.

(ii) Case B: Sediments becoming finer, better sorted and more negatively skewed in the direction of transport.

(iii) Case C: Sediments becoming coarser, better sorted and more positively skewed in the direction of transport.

(iv) N = number of possible pairs in the line of samples.

(v) X = number of pairs making a particular trend in a specific direction.

(vi) X = Z-score statistic: ** are those trends significant at the 99% level. * are those trends significant at the 95% level. (Only trends at the 99% level are accepted.)

(vii) Down = transport in the "down-line" direction.
Up = transport in the "up-line" direction.

(viii) Status defines the dynamic behaviour of the sediments making up the line of samples (i.e., Net Erosion, Net Accretion, Dynamic Equilibrium etc.) See Appendix I for a complete explanation.

Line		R2	N	X	Z	Interpretation
1	B Down:	0.78	10	4	2.63**	Net Accretion
	Up:		10	1	-0.24	
	C Down:		10	0	-1.20	
	Up:		10	1	-0.24	
2	B Down:	0.92	6	4	4.01**	Net Accretion
	Up:		6	2	1.54	
	C Down:		6	0	-0.93	
	Up:		6	0	-0.93	
3	B Down:	0.97	21	7	2.89**	Net Accretion
	Up:		21	1	-1.07	
	C Down:		21	0	-1.73	
	Up:		21	1	-1.07	
4	B Down:	0.94	45	18	5.58**	Net Accretion
	Up:		45	3	-1.18	
	C Down:		45	0	-2.54	
	Up:		45	2	-1.63	
5	B Down:	0.95	66	30	8.10**	Net Accretion
	Up:		66	4	-1.58	
	C Down:		66	2	-2.33	
	Up:		66	3	-1.95	
6	B Down:	0.94	55	22	6.17**	Net Accretion
	Up:		55	4	-1.17	
	C Down:		55	0	-2.80	
	Up:		55	6	-0.36	
7	B Down:	0.45	91	31	6.22**	Net Accretion
	Up:		91	3	-2.65	
	C Down:		91	3	-2.65	
	Up:		91	17	1.78*	
8	B Down:	0.84	136	44	7.00**	Net Accretion
	Up:		136	7	-2.59	
	C Down:		136	1	-4.15	
	Up:		136	19	0.52	
9	B Down:	0.82	105	33	5.86**	Dynamic Equilibrium
	Up:		105	18	1.44	
	C Down:		105	0	-3.87	
	Up:		105	5	-2.40	
10	B Down:	0.91	28	14	6.00**	Net Accretion
	Up:		28	2	-0.86	
	C Down:		28	0	-2.00	
	Up:		28	4	0.29	
11	B Down:	0.94	55	13	2.50**	Dynamic Equilibrium
	Up:		55	8	0.46	
	C Down:		55	1	-2.40	
	Up:		55	0	-2.80	

Line		R2	N	X	Z	Interpretation
12	B Down:		10	0	-1.20	Net Erosion
	Up:		10	2	0.72	
	C Down:	0.93	10	4	2.63**	
	Up:		10	1	-0.24	
13	B Down:		15	4	1.66*	Net Erosion
	Up:		15	2	0.10	
	C Down:	0.85	15	5	2.44**	
	Up:		15	3	0.88	
14	B Down:	0.85	6	5	5.25**	Net Accretion
	Up:		6	0	-0.93	
	C Down:		6	0	-0.93	
	Up:		6	0	-0.93	
15	B Down:		36	2	-1.26	Net Erosion
	Up:		36	2	-1.26	
	C Down:	0.70	36	15	5.29**	
	Up:		36	4	-0.25	
16	B Down:		66	4	-1.58	Net Erosion
	Up:		66	2	-2.33	
	C Down:	0.56	66	21	4.75**	
	Up:		66	9	0.28	
17	B Down:		91	7	-1.39	Net Erosion
	Up:		91	7	-1.39	
	C Down:	0.82	91	33	6.85**	
	Up:		91	9	-0.75	
18	B Down:		91	4	-2.34	Net Erosion
	Up:		91	13	0.52	
	C Down:	0.88	91	21	3.05**	
	Up:		91	15	1.15	
19	B Down:		91	5	-2.02	Net Erosion
	Up:		91	11	-0.12	
	C Down:	0.85	91	25	4.32**	
	Up:		91	15	1.15	
20	B Down:		105	13	-0.04	Net Erosion
	Up:		105	7	-1.81	
	C Down:	0.78	105	29	4.68**	
	Up:		105	14	0.26	
21	B Down:		66	3	-1.95	Net Erosion
	Up:		66	6	-0.84	
	C Down:	0.92	66	15	2.51**	
	Up:		66	7	-0.47	
22	B Down:		45	5	-0.28	Net Erosion
	Up:		45	2	-1.63	
	C Down:	0.88	45	16	4.68**	
	Up:		45	7	0.62	

Line		R2	N	X	Z	Interpretation
23	B Down:	0.75	105	24	3.21**	Net Accretion
	Up:		105	7	-1.81	
	C Down:		105	11	-0.63	
	Up:		105	11	-0.63	
24	B Down:	0.92	105	31	5.27**	Net Accretion
	Up:		105	10	-0.92	
	C Down:		105	8	-1.51	
	Up:		105	5	-2.40	
25	B Down:	0.92	66	15	2.51**	Mixed Case
	Up:		66	2	-2.33	
	C Down:	0.65	66	19	4.00**	
	Up:		66	13	1.77*	
26	B Down:	0.76	28	11	4.29**	Net Accretion
	Up:		28	0	-2.00	
	C Down:		28	1	-1.43	
	Up:		28	3	-0.29	
27	B Down:	0.94	66	18	3.63**	Net Accretion
	Up:		66	2	-2.33	
	C Down:		66	8	-0.09	
	Up:		66	4	-1.58	
28	B Down:	0.97	15	6	3.22**	Dynamic Equilibrium
	Up:		15	0	-1.46	
	C Down:		15	0	-1.46	
	Up:		15	1	-0.68	
29	B Down:	0.98	21	8	3.55**	Net Accretion
	Up:		21	0	-1.73	
	C Down:		21	0	-1.73	
	Up:		21	2	-0.41	
30	B Down:	0.98	15	6	3.22**	Dynamic Equilibrium
	Up:		15	0	-1.46	
	C Down:		15	1	-0.68	
	Up:		15	0	-1.46	
31	B Down:	0.96	21	9	4.21**	Net Accretion
	Up:		21	3	0.25	
	C Down:		21	4	0.91	
	Up:		21	3	0.25	
32	B Down:		28	7	2.00*	Net Erosion
	Up:		28	1	-1.43	
	C Down:	0.93	28	9	3.14**	
	Up:		28	4	0.29	
33	B Down:		21	5	1.57	Net Erosion
	Up:		21	0	-1.73	
	C Down:	0.98	21	8	3.55**	
	Up:		21	5	1.57	

Line		R2	N	X	Z	Interpretation
34	B Down:	0.85	21	8	3.55**	Net Accretion
	Up:		21	0	-1.73	
	C Down:		21	0	-1.73	
	Up:		21	4	0.91	
35	B Down:	1.00	6	3	2.78**	Dynamic Equilibrium
	Up:		6	0	-0.93	
	C Down:		6	0	-0.93	
	Up:		6	2	1.54	
36	B Down:	0.96	10	5	3.59**	Dynamic Equilibrium
	Up:		10	0	-1.20	
	C Down:		10	0	-1.20	
	Up:		10	3	1.67*	
37	B Down:		91	8	-1.07	Dynamic Equilibrium
	Up:		91	4	-2.34	
	C Down:	0.72	91	41	9.39**	
	Up:		91	14	0.83	
38	B Down:		136	11	-1.56	Net Erosion
	Up:		136	11	-1.56	
	C Down:	0.87	136	74	14.78**	
	Up:		136	14	-0.78	
39	B Down:		210	25	-0.26	Net Erosion
	Up:		210	30	0.78	
	C Down:	0.80	210	99	15.18**	
	Up:		210	11	-3.18	
40	B Down:		210	24	-0.47	Net Erosion
	Up:		210	35	1.83*	
	C Down:	0.84	210	108	17.06**	
	Up:		210	11	-3.18	
41	B Down:		190	25	0.27	Net Erosion
	Up:		190	29	1.15	
	C Down:	0.85	190	92	14.97**	
	Up:		190	12	-2.58	
42	B Down:		253	29	-0.50	Net Erosion
	Up:		253	23	-1.64	
	C Down:	0.85	253	138	20.22**	
	Up:		253	18	-2.59	
43	B Down:		210	25	-0.26	Net Erosion
	Up:		210	31	0.99	
	C Down:	0.69	210	91	13.51**	
	Up:		210	7	-4.02	
44	B Down:		276	31	-0.64	Net Erosion
	Up:		276	39	0.82	
	C Down:	0.64	276	127	16.84**	
	Up:		276	10	-4.46	

Line		R2	N	X	Z	Interpretation
45	B Down:		325	37	-0.61	Net Erosion
	Up:		325	51	1.74*	
	C Down:	0.60	325	145	17.51**	
	Up:		325	10	-5.14	
46	B Down:		325	36	-0.78	Net Erosion
	Up:		325	38	-0.44	
	C Down:	0.81	325	156	19.35**	
	Up:		325	7	-5.64	
47	B Down:		666	73	-1.20	Net Erosion
	Up:		666	97	1.61	
	C Down:	0.43	666	335	29.50**	
	Up:		666	26	-6.71	
48	B Down:		528	61	-0.66	Net Erosion
	Up:		528	61	-0.66	
	C Down:	0.72	528	257	25.13**	
	Up:		528	56	-1.32	
49	B Down:		741	76	-1.85	Net Erosion
	Up:		741	99	0.71	
	C Down:	0.46	741	359	29.59**	
	Up:		741	48	-4.96	
50	B Down:		595	54	-2.53	Net Erosion
	Up:		595	88	1.69*	
	C Down:	0.52	595	293	27.10**	
	Up:		595	42	-4.01	
51	B Down:		28	3	-0.29	Net Erosion
	Up:		28	6	1.43	
	C Down:	0.98	28	12	4.86**	
	Up:		28	5	0.86	
52	B Down:		36	4	-0.25	Net Erosion
	Up:		36	4	-0.25	
	C Down:	1.00	36	22	8.82**	
	Up:		36	4	-0.25	
53	B Down:		36	4	-0.25	Net Erosion
	Up:		36	4	-0.25	
	C Down:	0.97	36	25	10.33**	
	Up:		36	1	-1.76	
54	B Down:		21	0	-1.73	Net Erosion
	Up:		21	5	1.57	
	C Down:	0.93	21	9	4.21**	
	Up:		21	1	-1.07	
55	B Down:		946	69	-4.84	Net Erosion
	Up:		946	86	-3.17	
	C Down:	0.39	946	287	16.59**	
	Up:		946	123	0.47	

Line		R2	N	X	Z	Interpretation
56	B Down:		820	66	-3.85	Net Erosion
	Up:		820	72	-3.22	
	C Down:	0.42	820	247	15.26**	
	Up:		820	122	2.06*	
57	B Down:		903	87	-2.60	Net Erosion
	Up:		903	69	-4.41	
	C Down:	0.30	903	248	13.60**	
	Up:		903	135	2.23*	
58	B Down:		861	72	-3.67	Net Erosion
	Up:		861	67	-4.19	
	C Down:	0.37	861	256	15.29**	
	Up:		861	119	1.17	
59	B Down:		780	82	-1.68	Net Erosion
	Up:		780	53	-4.82	
	C Down:	0.25	780	193	10.34**	
	Up:		780	118	2.22*	
60	B Down:		741	80	-1.40	Net Erosion
	Up:		741	56	-4.07	
	C Down:	0.29	741	182	9.93**	
	Up:		741	109	1.82*	
61	B Down:	0.68	210	41	3.08**	Mixed Case
	Up:		210	12	-2.97	
	C Down:	0.54	210	89	13.09**	
	Up:		210	4	-4.64	
62	B Down:	0.74	136	28	2.85**	Mixed Case
	Up:		136	12	-1.30	
	C Down:	0.72	136	58	10.63**	
	Up:		136	2	-3.89	
63	B Down:		120	16	0.28	Net Erosion
	Up:		120	12	-0.83	
	C Down:	0.72	120	57	11.59**	
	Up:		120	1	-3.86	
64	B Down:		105	12	-0.33	Net Erosion
	Up:		105	19	1.73*	
	C Down:	0.53	105	54	12.06**	
	Up:		105	1	-3.58	
65	B Down:		91	12	0.20	Net Erosion
	Up:		91	12	0.20	
	C Down:	0.82	91	49	11.93**	
	Up:		91	1	-3.29	
66	B Down:	0.83	10	5	3.59**	Net Accretion
	Up:		10	0	-1.20	
	C Down:		10	2	0.72	
	Up:		10	0	-1.20	

Line		R2	N	X	Z	Interpretation
67	B Down:	0.92	6	3	2.78**	Net Accretion
	Up:		6	0	-0.93	
	C Down:		6	0	-0.93	
	Up:		6	2	1.54	
68	B Down:	0.96	10	4	2.63**	Mixed Case
	Up:		10	0	-1.20	
	C Down:	0.81	10	6	4.54**	
	Up:		10	0	-1.20	
69	B Down:		28	1	-1.43	Net Erosion
	Up:		28	3	-0.29	
	C Down:	0.77	28	16	7.14**	
	Up:		28	3	-0.29	
70	B Down:		36	5	0.25	Net Erosion
	Up:		36	3	-0.76	
	C Down:	0.64	36	11	3.28**	
	Up:		36	9	2.27*	
71	B Down:	0.50	21	7	2.89**	Net Accretion
	Up:		21	0	-1.73	
	C Down:		21	2	-0.41	
	Up:		21	1	-1.07	
72	B Down:	0.71	45	12	2.87**	Net Accretion
	Up:		45	1	-2.08	
	C Down:		45	3	-1.18	
	Up:		45	5	-0.28	
73	B Down:	0.92	55	25	7.39**	Net Accretion
	Up:		55	3	-1.58	
	C Down:		55	9	0.87	
	Up:		55	1	-2.40	
74	B Down:	0.92	66	32	8.84**	Net Accretion
	Up:		66	3	-1.95	
	C Down:		66	9	0.28	
	Up:		66	1	-2.70	
75	B Down:	0.91	55	23	6.57**	Net Accretion
	Up:		55	0	-2.80	
	C Down:		55	10	1.27	
	Up:		55	5	-0.76	
76	B Down:	0.97	66	32	8.84**	Net Accretion
	Up:		66	0	-3.07	
	C Down:		66	12	1.40	
	Up:		66	7	-0.47	
77	B Down:	0.96	66	31	8.47**	Net Accretion
	Up:		66	1	-2.70	
	C Down:		66	10	0.65	
	Up:		66	6	-0.84	

Line		R2	N	X	Z	Interpretation
78	B Down:	0.96	66	32	8.84**	Net Accretion
	Up:		66	0	-3.07	
	C Down:		66	11	1.02	
	Up:		66	6	-0.84	
79	B Down:	0.96	91	37	8.12**	Net Accretion
	Up:		91	3	-2.65	
	C Down:		91	16	1.47	
	Up:		91	9	-0.75	
80	B Down:	0.94	120	45	8.28**	Net Accretion
	Up:		120	3	-3.31	
	C Down:		120	17	0.55	
	Up:		120	14	-0.28	
81	B Down:	0.95	91	38	8.44**	Net Accretion
	Up:		91	2	-2.97	
	C Down:		91	14	0.83	
	Up:		91	11	-0.12	
82	B Down:	0.95	91	37	8.12**	Net Accretion
	Up:		91	2	-2.97	
	C Down:		91	13	0.52	
	Up:		91	12	0.20	
83	B Down:	0.97	45	21	6.93**	Net Accretion
	Up:		45	1	-2.08	
	C Down:		45	7	0.62	
	Up:		45	1	-2.08	
84	B Down:	0.97	78	33	7.96**	Net Accretion
	Up:		78	8	-0.60	
	C Down:		78	13	1.11	
	Up:		78	3	-2.31	
85	B Down:	0.97	45	21	6.93**	Net Accretion
	Up:		45	2	-1.63	
	C Down:		45	10	1.97*	
	Up:		45	2	-1.63	
86	B Down:	0.94	66	24	5.86**	Net Accretion
	Up:		66	0	-3.07	
	C Down:		66	12	1.40	
	Up:		66	10	0.65	
87	B Down:	0.92	66	25	6.23**	Net Accretion
	Up:		66	0	-3.07	
	C Down:		66	11	1.02	
	Up:		66	10	0.65	
88	B Down:	0.93	78	28	6.25**	Net Accretion
	Up:		78	0	-3.34	
	C Down:		78	10	0.09	
	Up:		78	11	0.43	

Line		R2	N	X	Z	Interpretation
89	B Down:	0.91	55	20	5.35**	Net Accretion
	Up:		55	1	-2.40	
	C Down:		55	12	2.09*	
	Up:		55	1	-2.40	
90	B Down:	0.83	45	13	3.32**	Net Accretion
	Up:		45	1	-2.08	
	C Down:		45	6	0.17	
	Up:		45	5	-0.28	
91	B Down:	0.80	78	23	4.54**	Net Accretion
	Up:		78	4	-1.97	
	C Down:		78	13	1.11	
	Up:		78	10	0.09	
92	B Down:	0.79	66	15	2.51**	Net Accretion
	Up:		66	1	-2.70	
	C Down:		66	9	0.28	
	Up:		66	1	-2.70	
93	B Down:	0.88	36	13	4.28**	Net Accretion
	Up:		36	0	-2.27	
	C Down:		36	7	1.26	
	Up:		36	1	-1.76	
94	B Down:	0.80	66	17	3.26**	Net Accretion
	Up:		66	1	-2.70	
	C Down:		66	9	0.28	
	Up:		66	3	-1.95	
95	B Down:	0.77	66	16	2.88**	Net Accretion
	Up:		66	1	-2.70	
	C Down:		66	8	-0.09	
	Up:		66	5	-1.21	
96	B Down:	0.88	45	16	4.68**	Net Accretion
	Up:		45	0	-2.54	
	C Down:		45	9	1.52	
	Up:		45	5	-0.28	
97	B Down:	0.93	36	13	4.28**	Net Accretion
	Up:		36	2	-1.26	
	C Down:		36	7	1.26	
	Up:		36	2	-1.26	
98	B Down:	0.71	231	45	3.21**	Net Accretion
	Up:		231	18	-2.16	
	C Down:		231	33	0.82	
	Up:		231	7	-4.35	
99	B Down:	0.71	253	55	4.44**	Net Accretion
	Up:		253	22	-1.83	
	C Down:		253	31	-0.12	
	Up:		253	14	-3.35	

Line		R2	N	X	Z	Interpretation
100	B Down:	0.80	325	78	6.27**	Net Accretion
	Up:		325	38	-0.44	
	C Down:		325	41	0.06	
	Up:		325	27	-2.29	
101	B Down:	0.87	351	83	6.31**	Mixed Case
	Up:		351	17	-4.34	
	C Down:	0.72	351	115	11.48**	
	Up:		351	49	0.83	
102	B Down:	0.85	435	102	6.90**	Mixed Case
	Up:		435	42	-1.79	
	C Down:	0.64	435	123	9.95**	
	Up:		435	63	1.25	
103	B Down:	0.82	630	154	9.07**	Mixed Case
	Up:		630	63	-1.90	
	C Down:	0.65	630	152	8.82**	
	Up:		630	67	-1.42	
104	B Down:	0.75	630	200	14.61**	Mixed Case
	Up:		630	51	-3.34	
	C Down:	0.70	630	136	6.90**	
	Up:		630	69	-1.17	
105	B Down:	0.77	378	117	10.85**	Mixed Case
	Up:		378	17	-4.70	
	C Down:	0.67	378	86	6.03**	
	Up:		378	47	-0.04	
106	B Down:	0.80	351	86	6.80**	Mixed Case
	Up:		351	12	-5.14	
	C Down:	0.61	351	84	6.48**	
	Up:		351	44	0.02	
107	B Down:	0.82	496	82	2.72**	Mixed Case
	Up:		496	36	-3.53	
	C Down:	0.74	496	210	20.09**	
	Up:		496	75	1.76*	
108	B Down:	0.85	210	38	2.45**	Mixed Case
	Up:		210	24	-0.47	
	C Down:	0.78	210	112	17.89**	
	Up:		210	16	-2.14	
109	B Down:	0.91	66	19	4.00**	Mixed Case
	Up:		66	4	-1.58	
	C Down:	0.77	66	26	6.61**	
	Up:		66	3	-1.95	
110	B Down:	0.89	105	22	2.62**	Mixed Case
	Up:		105	5	-2.40	
	C Down:	0.66	105	59	13.54**	
	Up:		105	4	-2.69	

Line		R2	N	X	Z	Interpretation
111	B Down:	0.86	253	44	2.35**	Mixed Case
	Up:		253	15	-3.16	
	C Down:	0.81	253	100	13.00**	
	Up:		253	28	-0.69	
112	B Down:	0.99	15	5	2.44**	Mixed Case
	Up:		15	1	-0.68	
	C Down:	0.99	15	7	4.00**	
	Up:		15	2	0.10	
113	B Down:		55	2	-1.99	Net Erosion
	Up:		55	4	-1.17	
	C Down:	0.82	55	39	13.10**	
	Up:		55	2	-1.99	
114	B Down:		28	0	-2.00	Net Erosion
	Up:		28	1	-1.43	
	C Down:	0.98	28	25	12.29**	
	Up:		28	0	-2.00	
115	B Down:		28	0	-2.00	Net Erosion
	Up:		28	0	-2.00	
	C Down:	0.98	28	25	12.29**	
	Up:		28	0	-2.00	
116	B Down:		10	0	-1.20	Net Erosion
	Up:		10	0	-1.20	
	C Down:	0.98	10	9	7.41**	
	Up:		10	0	-1.20	
117	B Down:		15	2	0.10	Net Erosion
	Up:		15	1	-0.68	
	C Down:	0.99	15	11	7.12**	
	Up:		15	0	-1.46	
118	B Down:	0.92	15	5	2.44**	Mixed Case
	Up:		15	1	-0.68	
	C Down:	0.97	15	8	4.78**	
	Up:		15	0	-1.46	
119	B Down:		21	0	-1.73	Net Erosion
	Up:		21	3	0.25	
	C Down:	0.97	21	13	6.85**	
	Up:		21	0	-1.73	
120	B Down:		21	6	2.23*	Net Erosion
	Up:		21	0	-1.73	
	C Down:	1.00	21	9	4.21**	
	Up:		21	0	-1.73	
121	B Down:		28	2	-0.86	Net Erosion
	Up:		28	4	0.29	
	C Down:	0.69	28	12	4.86**	
	Up:		28	1	-1.43	

Line		R2	N	X	Z	Interpretation
122	B Down:		28	5	0.86	Net Erosion
	Up:		28	1	-1.43	
	C Down:	0.68	28	10	3.71**	
	Up:		28	3	-0.29	
123	B Down:		28	1	-1.43	Net Erosion
	Up:		28	1	-1.43	
	C Down:	0.99	28	9	3.14**	
	Up:		28	6	1.43	
124	B Down:	0.84	171	74	12.17**	Net Accretion
	Up:		171	1	-4.71	
	C Down:		171	31	2.23*	
	Up:		171	26	1.07	
125	B Down:	0.88	136	47	7.78**	Net Accretion
	Up:		136	3	-3.63	
	C Down:		136	10	-1.81	
	Up:		136	7	-2.59	
126	B Down:		136	15	-0.52	Net Erosion
	Up:		136	4	-3.37	
	C Down:	0.78	136	43	6.74**	
	Up:		136	20	0.78	
127	B Down:	0.82	153	43	5.84**	Net Accretion
	Up:		153	1	-4.43	
	C Down:		153	20	0.21	
	Up:		153	12	-1.74	
128	B Down:		153	26	1.68*	Dynamic Equilibrium
	Up:		153	6	-3.21	
	C Down:	0.22	153	36	4.13**	
	Up:		153	14	-1.25	
129	B Down:	0.87	120	38	6.35**	Mixed Case
	Up:		120	2	-3.59	
	C Down:	0.82	120	31	4.42**	
	Up:		120	19	1.10	
130	B Down:	0.68	91	28	5.27**	Mixed Case
	Up:		91	3	-2.65	
	C Down:	0.43	91	24	4.00**	
	Up:		91	4	-2.34	
131	B Down:	0.79	78	23	4.54**	Mixed Case
	Up:		78	2	-2.65	
	C Down:	0.57	78	34	8.30**	
	Up:		78	6	-1.28	
132	B Down:	0.75	91	25	4.32**	Mixed Case
	Up:		91	1	-3.29	
	C Down:	0.52	91	45	10.66**	
	Up:		91	5	-2.02	

Line		R2	N	X	Z	Interpretation
133	B Down:	0.73	91	23	3.68**	Mixed Case
	Up:		91	1	-3.29	
	C Down:	0.14	91	27	4.95**	
	Up:		91	5	-2.02	
134	B Down:	0.58	91	26	4.64**	Mixed Case
	Up:		91	0	-3.61	
	C Down:	0.37	91	19	2.42**	
	Up:		91	4	-2.34	
135	B Down:	0.99	78	22	4.19**	Mixed Case
	Up:		78	4	-1.97	
	C Down:	0.40	78	17	2.48**	
	Up:		78	8	-0.60	
136	B Down:	1.00	78	18	2.82**	Mixed Case
	Up:		78	3	-2.31	
	C Down:	0.59	78	23	4.54**	
	Up:		78	10	0.09	
137	B Down:	1.00	66	16	2.88**	Mixed Case
	Up:		66	2	-2.33	
	C Down:	0.70	66	18	3.63**	
	Up:		66	8	-0.09	
138	B Down:		78	13	1.11	Dynamic Equilibrium
	Up:		78	1	-3.00	
	C Down:	0.96	78	24	4.88**	
	Up:		78	10	0.09	
139	B Down:		66	13	1.77*	Dynamic Equilibrium
	Up:		66	0	-3.07	
	C Down:	0.92	66	22	5.12**	
	Up:		66	9	0.28	
140	B Down:		78	12	0.77	Dynamic Equilibrium
	Up:		78	2	-2.65	
	C Down:	0.93	78	29	6.59**	
	Up:		78	11	0.43	
141	B Down:		66	9	0.28	Dynamic Equilibrium
	Up:		66	1	-2.70	
	C Down:	0.96	66	21	4.75**	
	Up:		66	13	1.77*	
142	B Down:		66	4	-1.58	Dynamic Equilibrium
	Up:		66	1	-2.70	
	C Down:	0.91	66	16	2.88**	
	Up:		66	11	1.02	
143	B Down:		78	14	1.46	Dynamic Equilibrium
	Up:		78	1	-3.00	
	C Down:	0.95	78	18	2.82**	
	Up:		78	12	0.77	

Line		R2	N	X	Z	Interpretation
144	B Down:		45	7	0.62	Dynamic Equilibrium
	Up:		45	2	-1.63	
	C Down:	0.94	45	15	4.23**	
	Up:		45	7	0.62	
145	B Down:		3	0	-0.65	Dynamic Equilibrium
	Up:		3	0	-0.65	
	C Down:	1.00	3	3	4.58**	
	Up:		3	0	-0.65	
146	B Down:		15	0	-1.46	Dynamic Equilibrium
	Up:		15	1	-0.68	
	C Down:	0.99	15	10	6.34**	
	Up:		15	4	1.66*	
147	B Down:		10	0	-1.20	Dynamic Equilibrium
	Up:		10	1	-0.24	
	C Down:	0.99	10	6	4.54**	
	Up:		10	3	1.67*	
148	B Down:		10	0	-1.20	Dynamic Equilibrium
	Up:		10	0	-1.20	
	C Down:	1.00	10	7	5.50**	
	Up:		10	2	0.72	
149	B Down:		6	0	-0.93	Net Erosion
	Up:		6	2	1.54	
	C Down:	0.94	6	3	2.78**	
	Up:		6	0	-0.93	
150	B Down:		28	0	-2.00	Dynamic Equilibrium
	Up:		28	0	-2.00	
	C Down:	0.99	28	24	11.71**	
	Up:		28	2	-0.86	
151	B Down:		21	0	-1.73	Dynamic Equilibrium
	Up:		21	1	-1.07	
	C Down:	0.98	21	14	7.51**	
	Up:		21	6	2.23*	
152	B Down:		21	0	-1.73	Dynamic Equilibrium
	Up:		21	0	-1.73	
	C Down:	0.97	21	13	6.85**	
	Up:		21	6	2.23*	
153	B Down:		15	1	-0.68	Dynamic Equilibrium
	Up:		15	0	-1.46	
	C Down:	0.90	15	9	5.56**	
	Up:		15	4	1.66*	
154	B Down:		45	2	-1.63	Dynamic Equilibrium
	Up:		45	3	-1.18	
	C Down:	0.90	45	21	6.93**	
	Up:		45	10	1.97*	

Line		R2	N	X	Z	Interpretation
155	B Down:		55	6	-0.36	Dynamic Equilibrium
	Up:		55	3	-1.58	
	C Down:	0.97	55	28	8.61**	
	Up:		55	9	0.87	
156	B Down:		55	9	0.87	Dynamic Equilibrium
	Up:		55	4	-1.17	
	C Down:	0.93	55	20	5.35**	
	Up:		55	4	-1.17	
157	B Down:		55	9	0.87	Dynamic Equilibrium
	Up:		55	2	-1.99	
	C Down:	0.93	55	15	3.31**	
	Up:		55	5	-0.76	
158	B Down:		45	2	-1.63	Dynamic Equilibrium
	Up:		45	2	-1.63	
	C Down:	0.66	45	21	6.93**	
	Up:		45	7	0.62	
159	B Down:		45	2	-1.63	Dynamic Equilibrium
	Up:		45	3	-1.18	
	C Down:	0.82	45	18	5.58**	
	Up:		45	10	1.97*	
160	B Down:		91	4	-2.34	Dynamic Equilibrium
	Up:		91	11	-0.12	
	C Down:	0.77	91	32	6.54**	
	Up:		91	15	1.15	
161	B Down:		36	5	0.25	Dynamic Equilibrium
	Up:		36	3	-0.76	
	C Down:	0.97	36	14	4.79**	
	Up:		36	9	2.27*	
162	B Down:	0.88	66	18	3.63**	Net Accretion
	Up:		66	2	-2.33	
	C Down:		66	9	0.28	
	Up:		66	14	2.14*	
163	B Down:	0.77	66	15	2.51**	Net Accretion
	Up:		66	3	-1.95	
	C Down:		66	3	-1.95	
	Up:		66	7	-0.47	
164	B Down:		21	0	-1.73	Net Erosion
	Up:		21	1	-1.07	
	C Down:	0.90	21	16	8.83**	
	Up:		21	2	-0.41	
165	B Down:		10	0	-1.20	Dynamic Equilibrium
	Up:		10	1	-0.24	
	C Down:	0.99	10	6	4.54**	
	Up:		10	2	0.72	

Line		R2	N	X	Z	Interpretation
166	B Down:		10	0	-1.20	Net Erosion
	Up:		10	2	0.72	
	C Down:	1.00	10	4	2.63**	
	Up:		10	3	1.67*	
167	B Down:		10	0	-1.20	Dynamic Equilibrium
	Up:		10	0	-1.20	
	C Down:	1.00	10	6	4.54**	
	Up:		10	3	1.67*	
168	B Down:		10	0	-1.20	Dynamic Equilibrium
	Up:		10	0	-1.20	
	C Down:	0.99	10	8	6.45**	
	Up:		10	2	0.72	
169	B Down:		120	1	-3.86	Dynamic Equilibrium
	Up:		120	6	-2.48	
	C Down:	0.43	120	30	4.14**	
	Up:		120	20	1.38	
170	B Down:		120	13	-0.55	Dynamic Equilibrium
	Up:		120	5	-2.76	
	C Down:	0.84	120	62	12.97**	
	Up:		120	23	2.21*	
171	B Down:		105	1	-3.58	Dynamic Equilibrium
	Up:		105	6	-2.10	
	C Down:	0.78	105	58	13.24**	
	Up:		105	21	2.32*	
172	B Down:		45	0	-2.54	Dynamic Equilibrium
	Up:		45	0	-2.54	
	C Down:	0.98	45	35	13.24**	
	Up:		45	9	1.52	
173	B Down:		45	1	-2.08	Dynamic Equilibrium
	Up:		45	1	-2.08	
	C Down:	0.84	45	28	10.09**	
	Up:		45	7	0.62	
174	B Down:		36	0	-2.27	Dynamic Equilibrium
	Up:		36	0	-2.27	
	C Down:	0.99	36	31	13.35**	
	Up:		36	3	-0.76	
175	B Down:		36	0	-2.27	Dynamic Equilibrium
	Up:		36	0	-2.27	
	C Down:	0.99	36	23	9.32**	
	Up:		36	2	-1.26	
176	B Down:	0.84	36	11	3.28**	Net Accretion
	Up:		36	0	-2.27	
	C Down:		36	4	-0.25	
	Up:		36	8	1.76*	

Line		R2	N	X	Z	Interpretation
177	B Down:	0.91	55	29	9.02**	Net Accretion
	Up:		55	0	-2.80	
	C Down:		55	3	-1.58	
	Up:		55	11	1.68*	
178	B Down:	0.80	55	22	6.17**	Net Accretion
	Up:		55	1	-2.40	
	C Down:		55	11	1.68*	
	Up:		55	12	2.09*	
179	B Down:		21	3	0.25	Net Accretion
	Up:		21	0	-1.73	
	C Down:	0.99	21	13	6.85**	
	Up:		21	3	0.25	
180	B Down:		21	1	-1.07	Net Accretion
	Up:		21	0	-1.73	
	C Down:	0.99	21	16	8.83**	
	Up:		21	3	0.25	
181	B Down:		21	2	-0.41	Net Accretion
	Up:		21	0	-1.73	
	C Down:	0.99	21	15	8.17**	
	Up:		21	3	0.25	
182	B Down:		28	6	1.43	Dynamic Equilibrium
	Up:		28	0	-2.00	
	C Down:	0.96	28	14	6.00**	
	Up:		28	7	2.00*	
183	B Down:		10	0	-1.20	Dynamic Equilibrium
	Up:		10	0	-1.20	
	C Down:	0.97	10	5	3.59**	
	Up:		10	3	1.67*	
184	B Down:		10	1	-0.24	Dynamic Equilibrium
	Up:		10	0	-1.20	
	C Down:	0.96	10	6	4.54**	
	Up:		10	3	1.67*	
185	B Down:		3	0	-0.65	Dynamic Equilibrium
	Up:		3	0	-0.65	
	C Down:	1.00	3	3	4.58**	
	Up:		3	0	-0.65	
186	B Down:		3	0	-0.65	Dynamic Equilibrium
	Up:		3	0	-0.65	
	C Down:	1.00	3	3	4.58**	
	Up:		3	0	-0.65	

APPENDIX V

Representative D_1, D_2 and X-functions
(see Fig. AI-6 in Appendix I)

Fig. AV-1: D1,D2 and X-distributions for Line 3

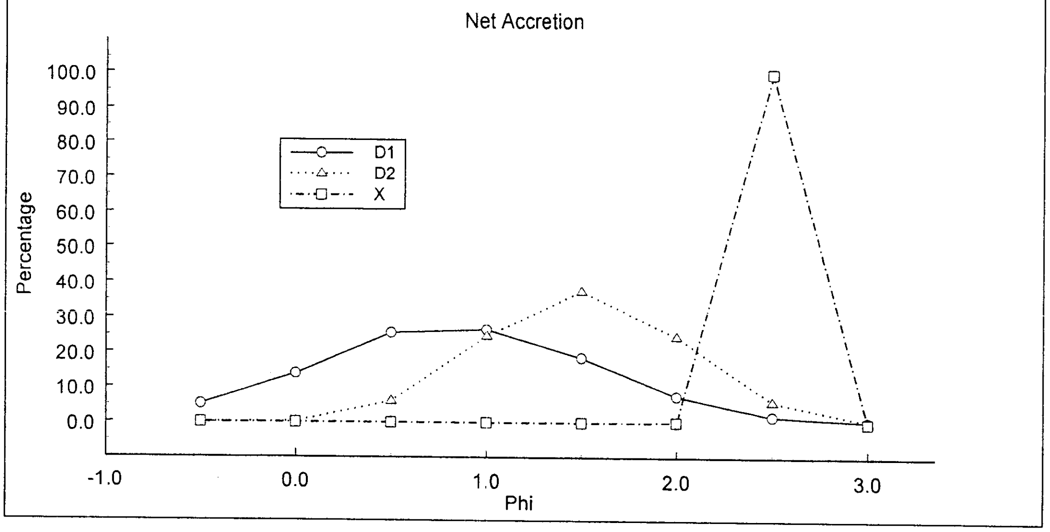
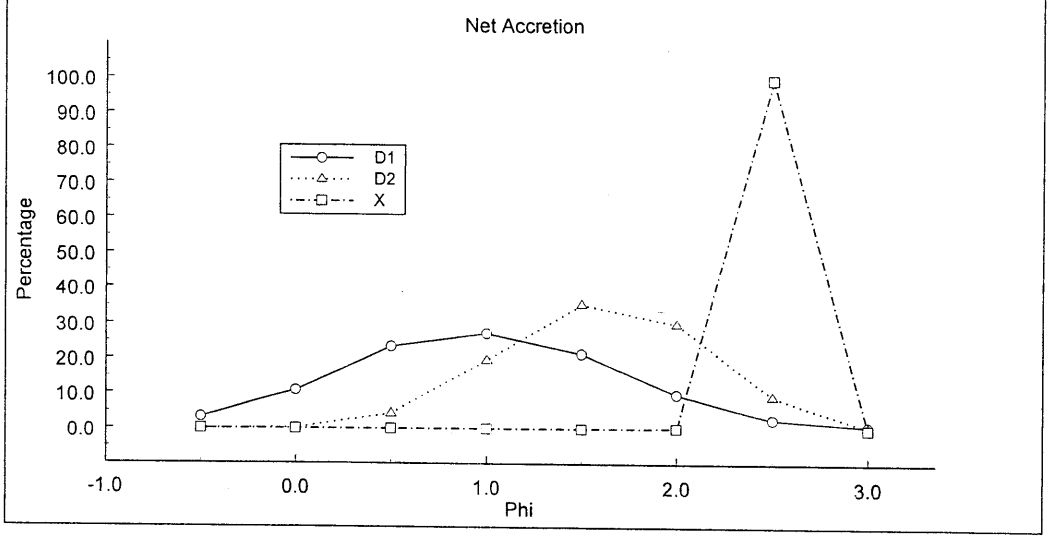


Fig. AV-2: D1,D2 and X-distributions for Line 5



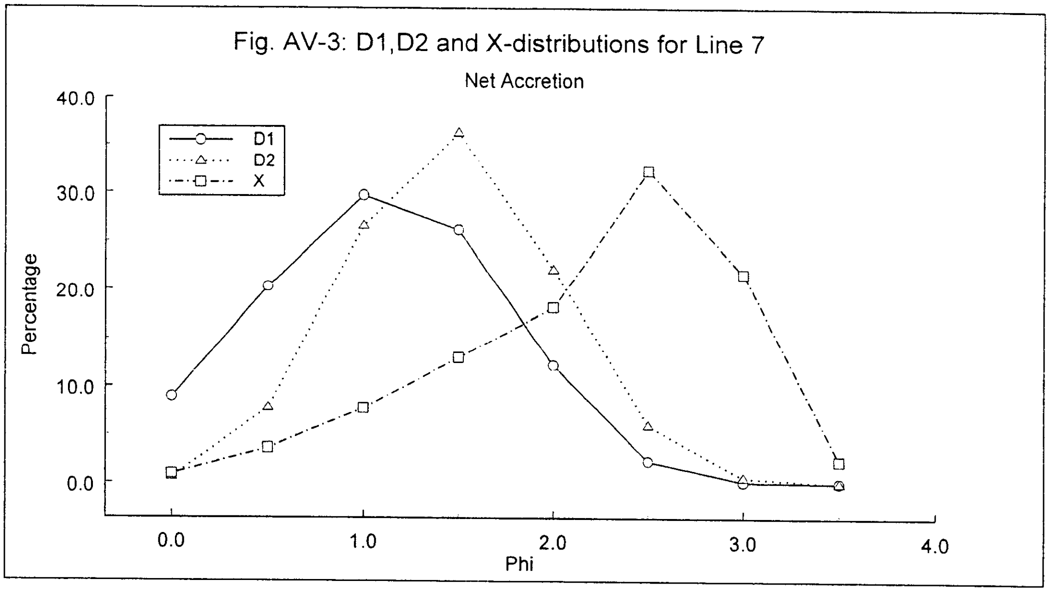


Fig. AV-3: D1,D2 and X-distributions for Line 7
Net Accretion
D1
D2
X
Percentage
40.0
30.0
20.0
10.0
0.0
0.0
1.0
2.0
3.0
4.0
Phi

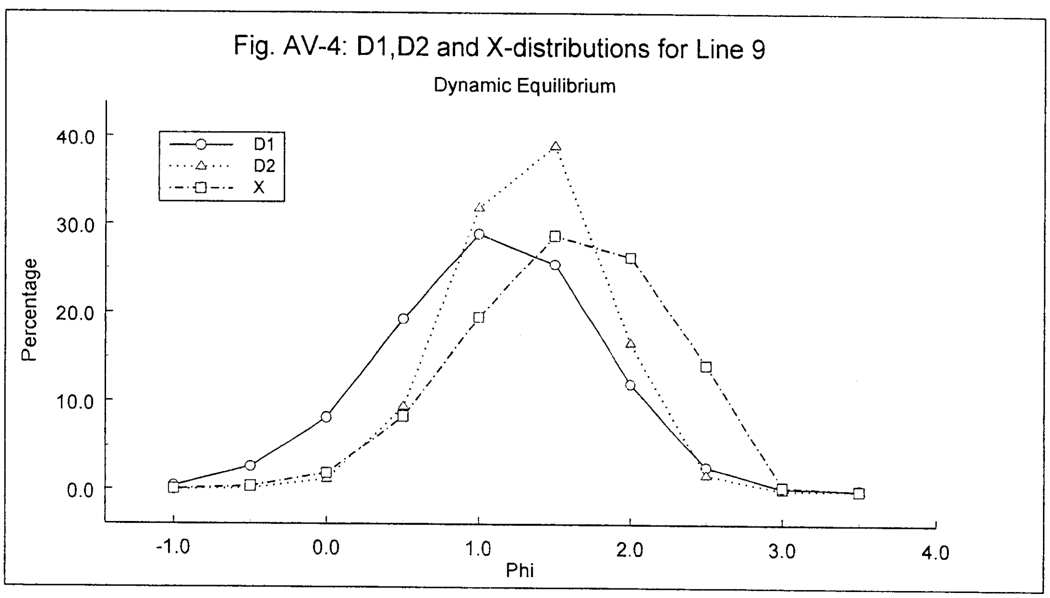


Fig. AV-4: D1,D2 and X-distributions for Line 9
Dynamic Equilibrium
D1
D2
X
Percentage
40.0
30.0
20.0
10.0
0.0
-1.0
0.0
1.0
2.0
3.0
4.0
Phi

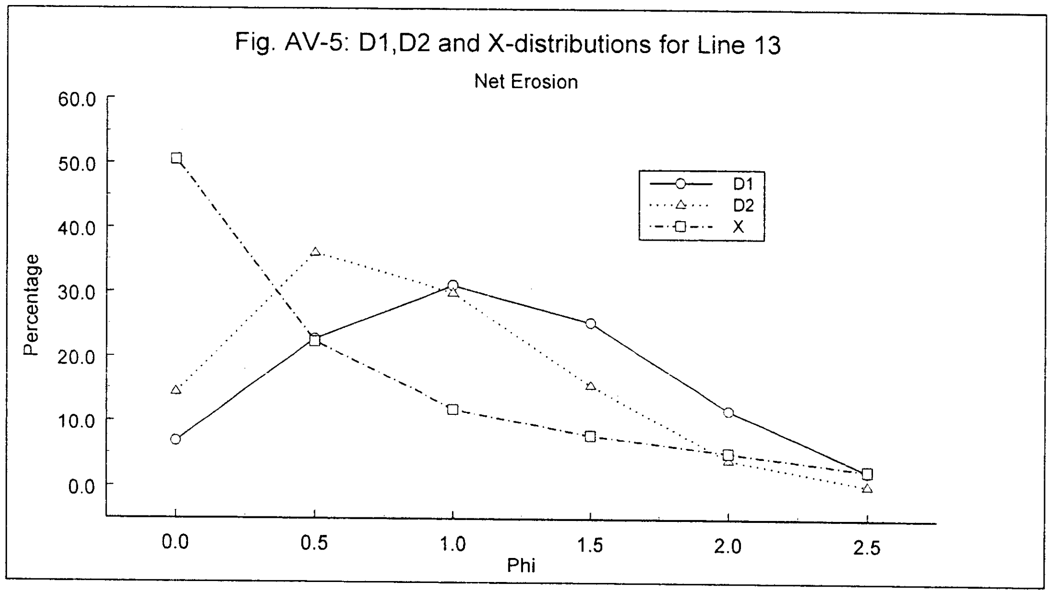


Fig. AV-5: D1,D2 and X-distributions for Line 13
Net Erosion
Percentage
60.0
50.0
40.0
30.0
20.0
10.0
0.0
D1
D2
X
0.0
0.5
1.0
1.5
2.0
2.5
Phi

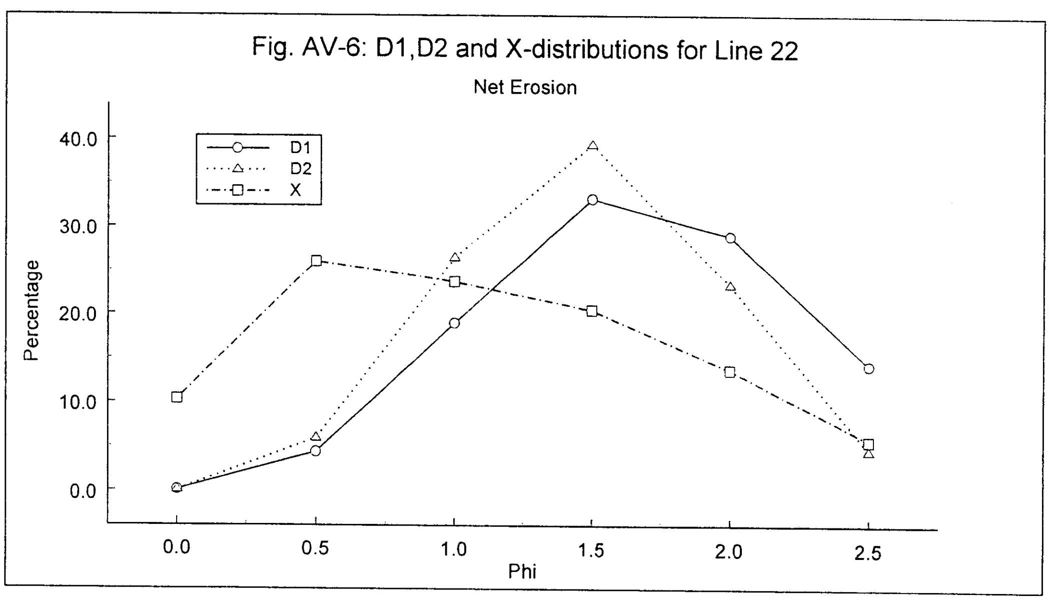


Fig. AV-6: D1,D2 and X-distributions for Line 22
Net Erosion
Percentage
40.0
30.0
20.0
10.0
0.0
D1
D2
X
0.0
0.5
1.0
1.5
2.0
2.5
Phi

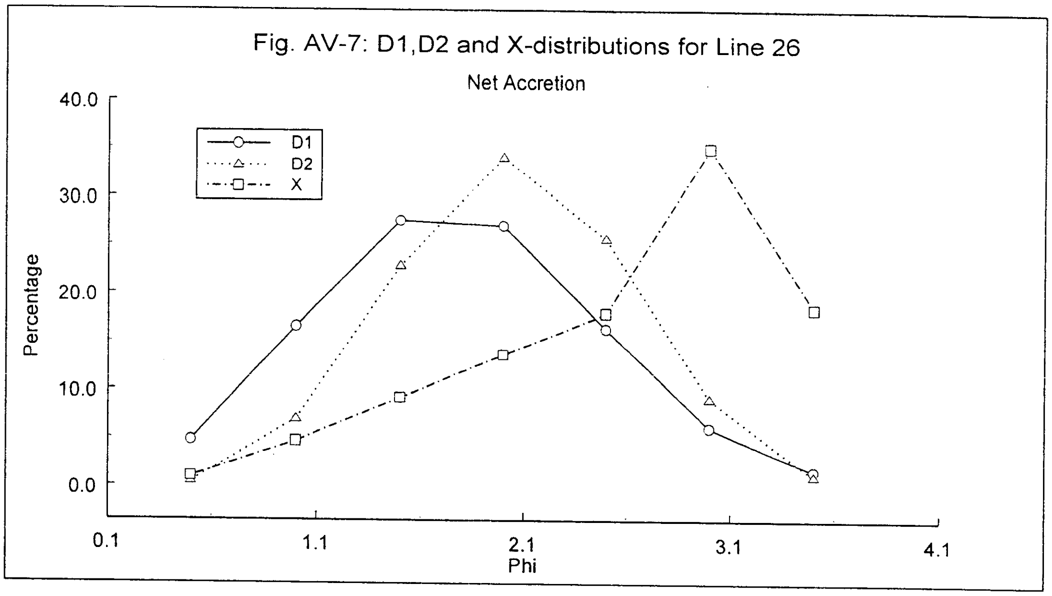


Fig. AV-7: D1,D2 and X-distributions for Line 26
Net Accretion
D1
D2
X
40.0
30.0
20.0
10.0
0.0
Percentage
0.1
1.1
2.1
3.1
4.1
Phi

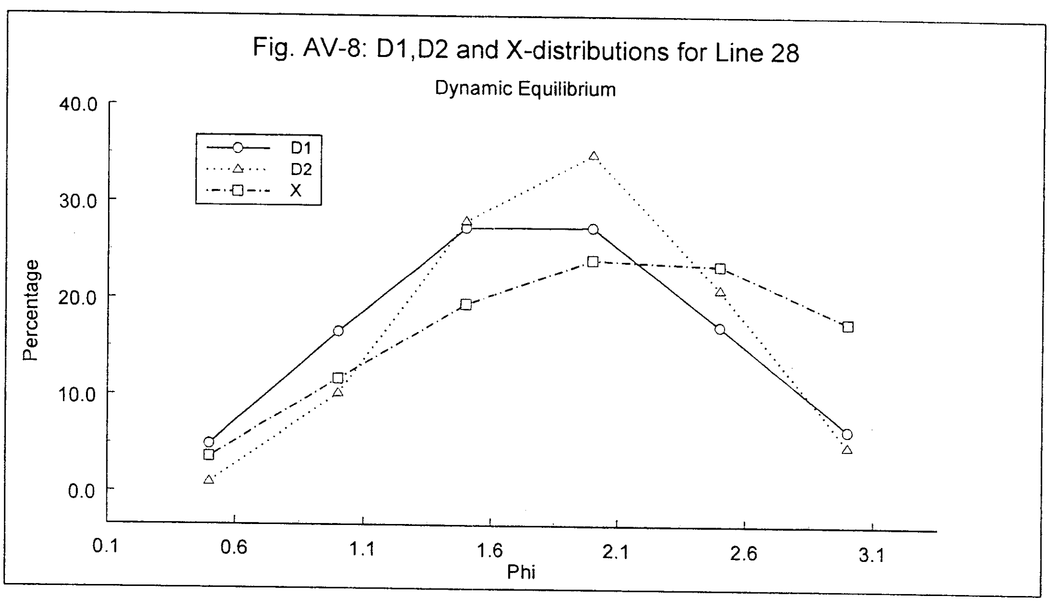


Fig. AV-8: D1,D2 and X-distributions for Line 28
Dynamic Equilibrium
D1
D2
X
40.0
30.0
20.0
10.0
0.0
Percentage
0.1
0.6
1.1
1.6
2.1
2.6
3.1
Phi

Fig. AV-9: D1,D2 and X-distributions for Line 37

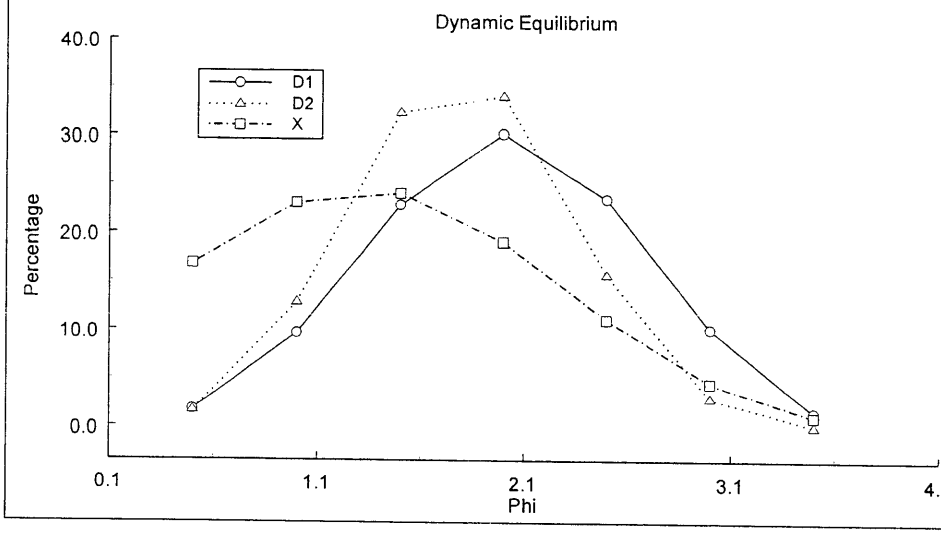
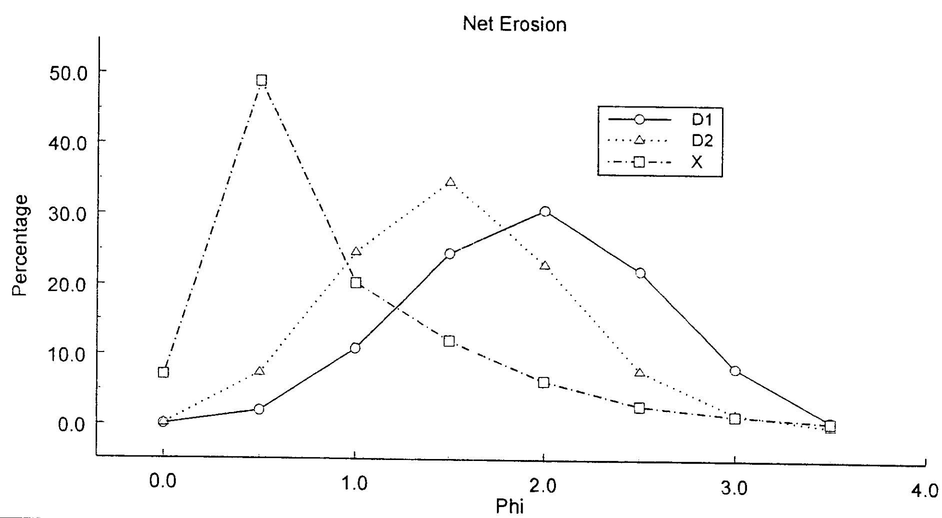


Fig. AV-10: D1,D2 and X-distributions for Line 41



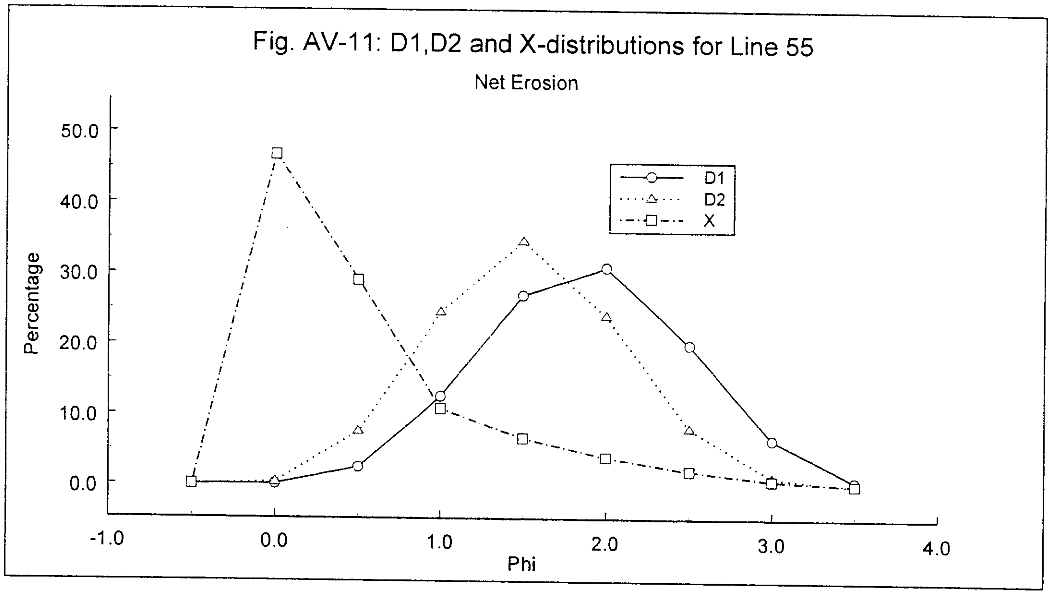


Fig. AV-11: D1,D2 and X-distributions for Line 55
Net Erosion
Percentage
50.0
40.0
30.0
20.0
10.0
0.0
-1.0
0.0
1.0
2.0
3.0
4.0
Phi
D1
D2
X

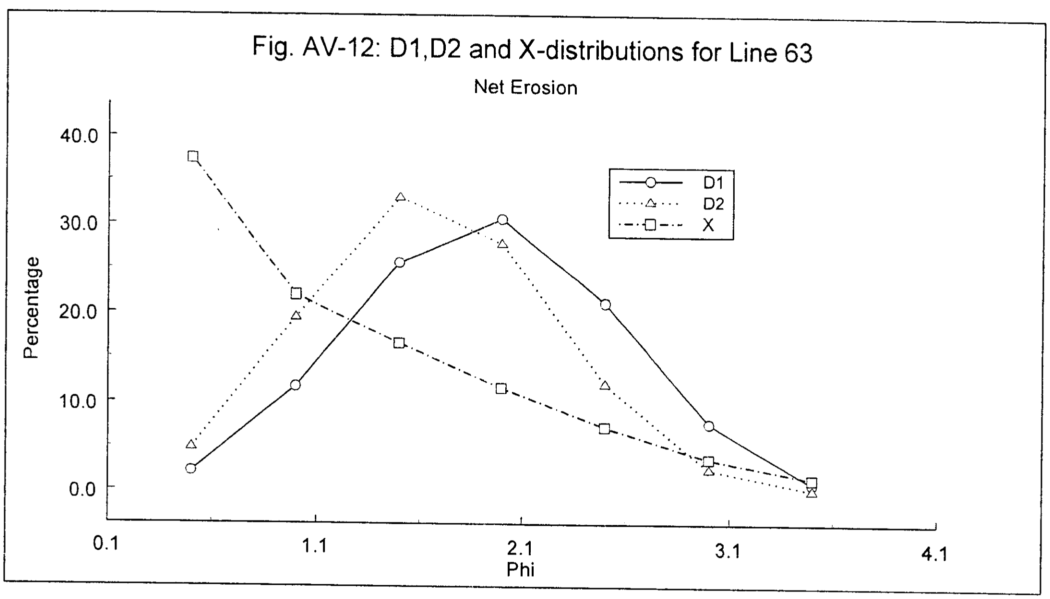


Fig. AV-12: D1,D2 and X-distributions for Line 63
Net Erosion
Percentage
40.0
30.0
20.0
10.0
0.0
0.1
1.1
2.1
3.1
4.1
Phi
D1
D2
X

Fig. AV-13: D1,D2 and X-distributions for Line 66

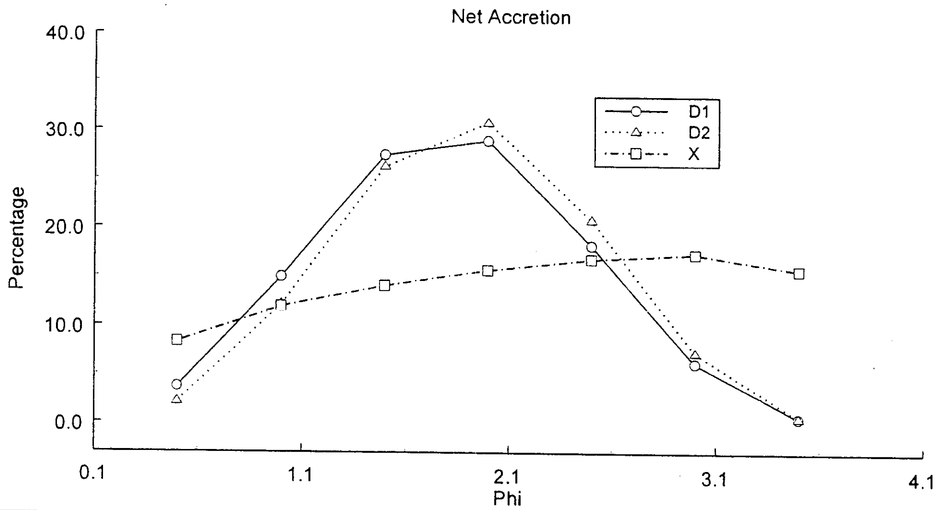
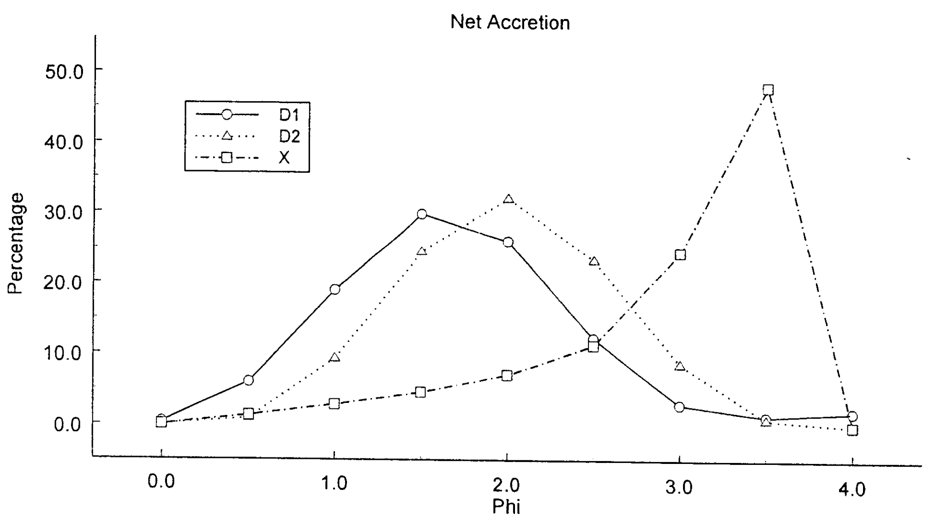


Fig. AV-14: D1,D2 and X-distributions for Line 89



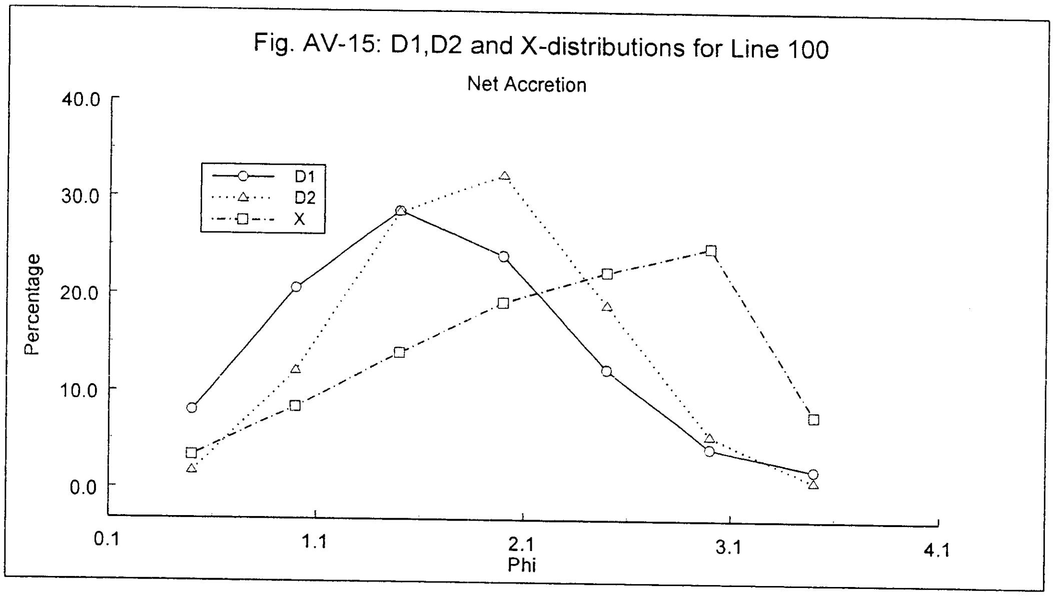


Fig. AV-15: D1,D2 and X-distributions for Line 100
Net Accretion
D1
D2
X
Percentage
40.0
30.0
20.0
10.0
0.0
0.1
1.1
2.1
3.1
4.1
Phi

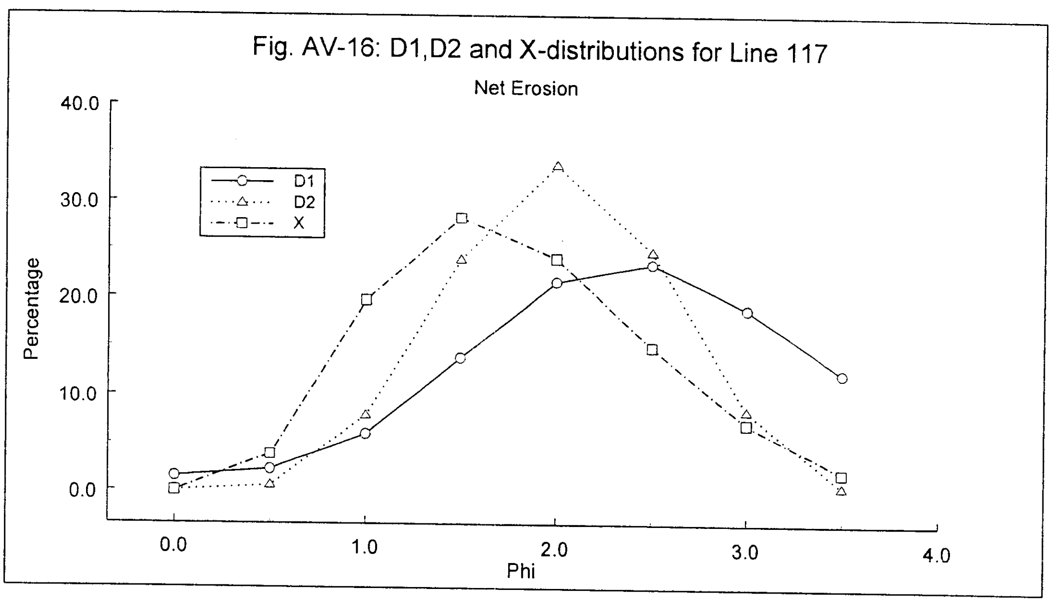


Fig. AV-16: D1,D2 and X-distributions for Line 117
Net Erosion
D1
D2
X
Percentage
40.0
30.0
20.0
10.0
0.0
0.0
1.0
2.0
3.0
4.0
Phi

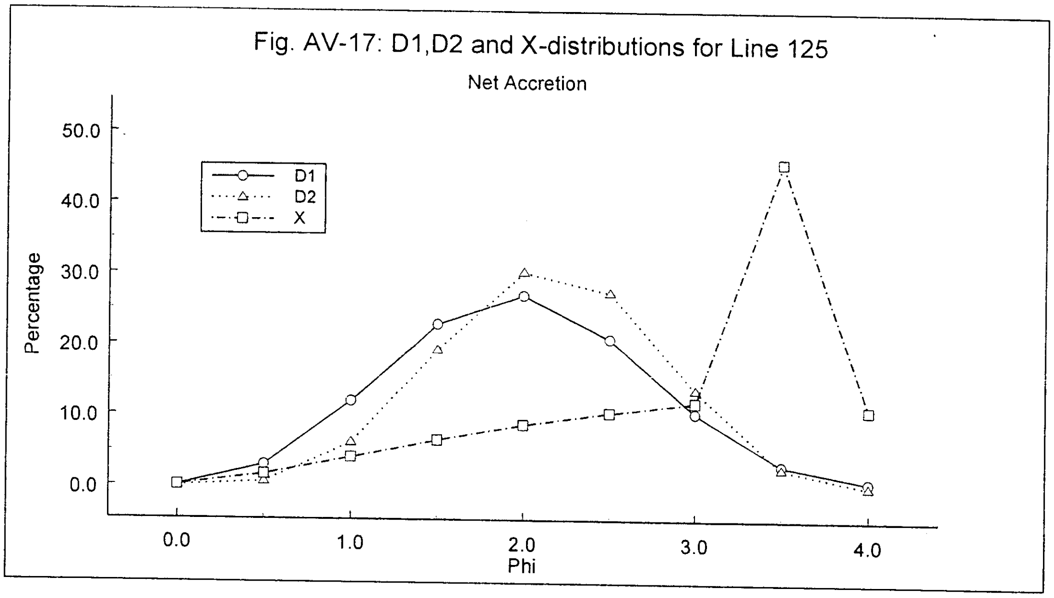


Fig. AV-17: D1,D2 and X-distributions for Line 125
Net Accretion
D1
D2
X
Percentage
50.0
40.0
30.0
20.0
10.0
0.0
0.0
1.0
2.0
3.0
4.0
Phi

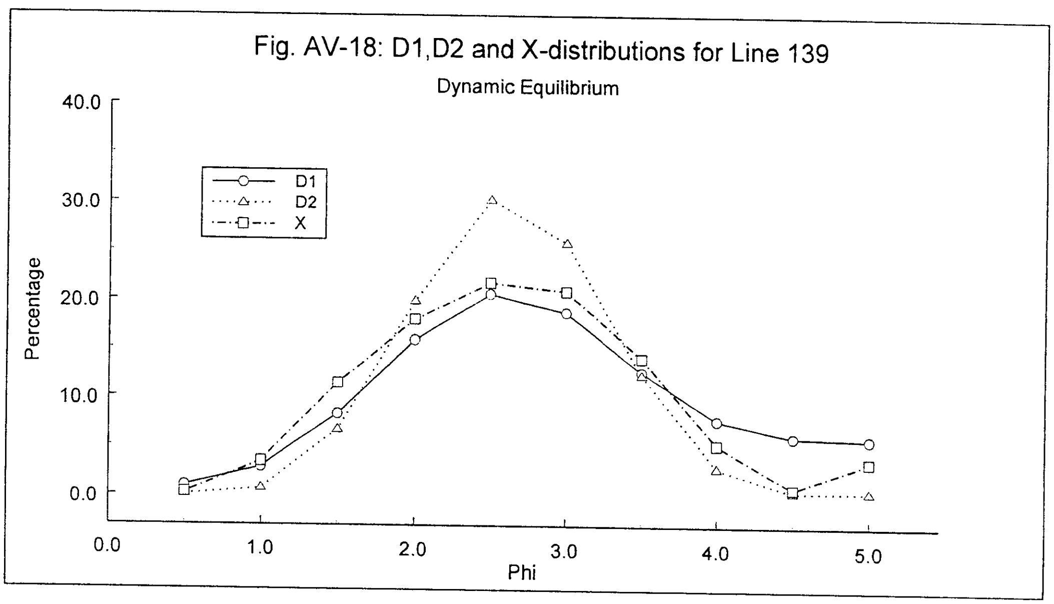


Fig. AV-18: D1,D2 and X-distributions for Line 139
Dynamic Equilibrium
D1
D2
X
Percentage
40.0
30.0
20.0
10.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
Phi

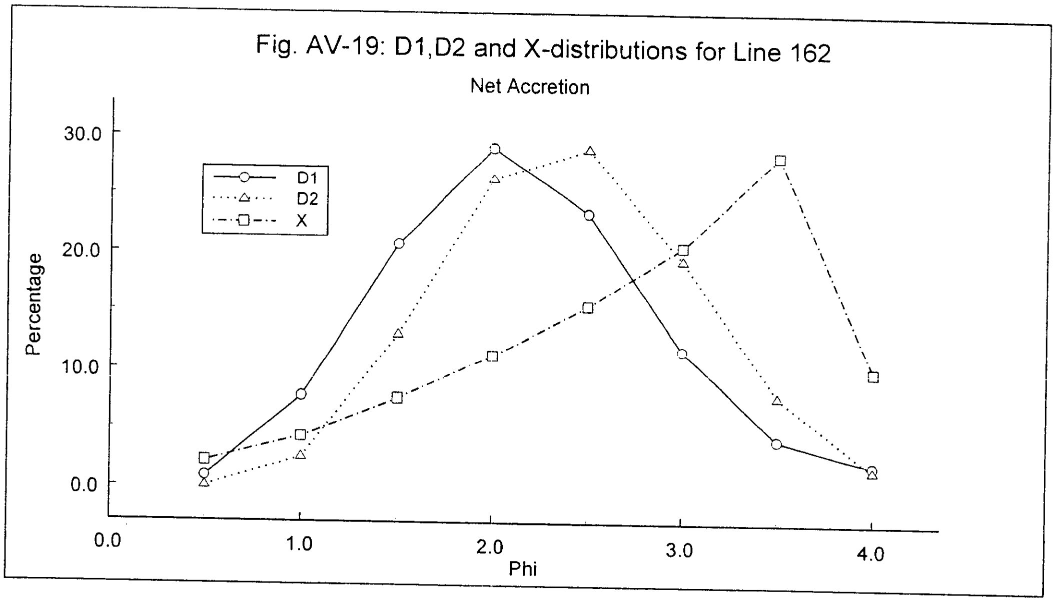


Fig. AV-19: D1,D2 and X-distributions for Line 162
Net Accretion
30.0
20.0
10.0
0.0
Percentage
D1
D2
X
0.0
1.0
2.0
3.0
4.0
Phi

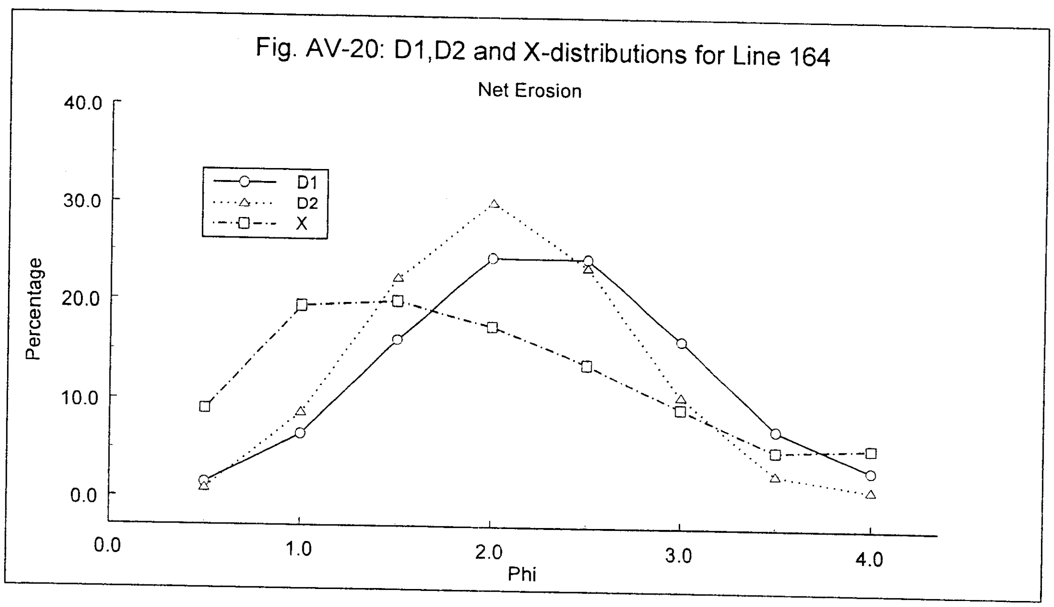


Fig. AV-20: D1,D2 and X-distributions for Line 164
Net Erosion
40.0
30.0
20.0
10.0
0.0
Percentage
D1
D2
X
0.0
1.0
2.0
3.0
4.0
Phi

Attachment B

Physical Baseline Study

Sediment Characterization

Deep Water Site

By

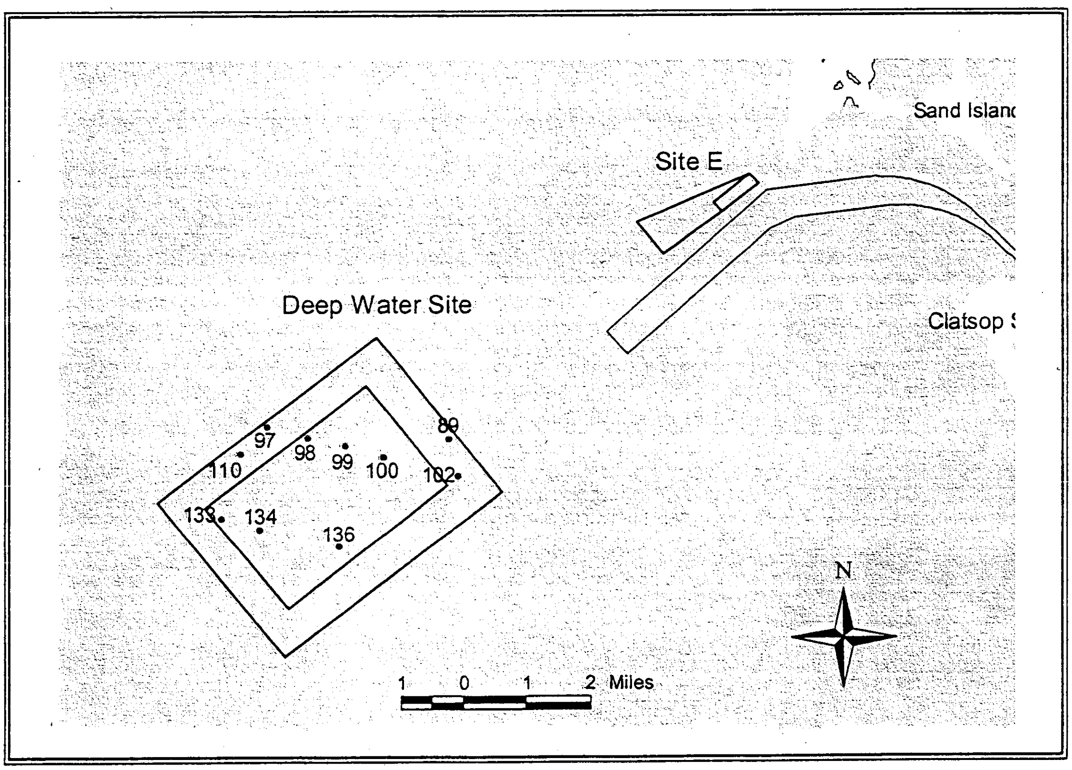
EPA, Region 10 and USACE, Portland District

2001

US Army Corps
of Engineers ®
Portland District

EPA
Region 10

MCR ODMDS DEEP WATER SITE BASELINE SEDIMENT CHARACTERIZATION STUDY



March 2001

MCR ODMDS DEEP WATER SITE

BASELINE SEDIMENT

CHARACTERIZATION STUDY

Portland District

U.S. ARMY CORPS OF ENGINEERS

FINAL REPORT

By Laura Hamilton, Environmental Engineer

MARCH 2001

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MCR ODMDS DEEP WATER SITE
BASELINE SEDIMENT CHARACTERIZATION STUDY

INTRODUCTION:
Sediment and water quality analyses of ocean dredge material disposal sites (ODMDS) are required to adequately address general criterion (b) and specific factors 4, 9, and 10 of 40 CFR 228.5 and 228.6. The lack of adequate baseline data for the MCR Deep Water Site was noted in Appendix H, Volume I: Ocean Dredged Material Disposal Sites Main Report and Technical Exhibits Integrated Feasibility Report for Channel Improvements and Environmental Impact Statement, Columbia and Lower Willamette River Federal Navigation Channel (USACE, 8/99), pg H-5. To supply this lack, ten samples were collected on September 12, 2000 in the Deep Water Site and physical and chemical analyses are performed to establish baseline conditions. Using these analyses, this report provides the baseline conditions for the MCR Deep Water Site, which is being considered as a possible ODMDS site for Columbia River dredge materials. The sediment and water quality analyses of the proposed dredge material are not addressed in this report, since this information is available in other studies.

The Marine Protection, Research and Sanctuaries Act (MPRSA) require that five general criteria and eleven specific factors be addressed during the designation process (40CFR 228.5 and 228.6). These criteria and factors have been interpreted as 27 different "areas of consideration" that cover the proposed ODMDS site and the dredged material it receives. These areas of consideration are listed in an ODMDS conflict matrix, which is used to evaluate each candidate site on its compliance with the requirements for disposal site designation. The conflict matrix is listed in Tables 4-12 of Appendix H of the Integrated Feasibility Report for Channel Improvements and Environmental Impact Statement, Columbia and Lower Willamette River (USACE, 8/99), pg H45-55. The results of the candidate ODMDS conflict matrixes are compared with each other, and are used to select the best ODMDS. The areas of consideration involving sediment quality in this study are:

1. Physical and chemical sediment compatibility,
2. Water column chemistry and physical characteristics,
3. Influence of past disposal,
4. Degraded areas
5. Potential for Cumulative Effects

No past disposal of dredge material has occurred within the boundaries of the Deep Water Site. No degraded areas were identified. No impacts due to sediment quality are expected. Dredged material is expected to mound. This report will discuss the physical and chemical sediment compatibility, and water column chemistry and physical characteristics.

BASELINE SEDIMENT QUALITY STUDIES:
The baseline sediment quality data for the MCR Deep Water Site was collected from seven studies offshore of the Mouth of the Columbia River area spanning from 1974 to September 2000. All seven studies covered various locations offshore, such as ODMDS

Areas A, B, E, F and Southwestern Washington Inner Continental Shelf.

The September 1, 2000 sampling event was conducted specifically to establish baseline physical and chemical conditions at the MCR Deep Water Site. There were ten sample stations strategically located across the Deep Water Site to gain the best coverage of the site, as shown on Figure 3. The samples were tested for all Tier II analyses as defined by the Dredged Material Evaluation Framework (DMEF) (USACE, 1998). The DMEF manual defines the Tier II testing to include physical sediment analysis, and chemical analysis for metals; organometallic compounds; and organics. The organic analyses include chlorinated hydrocarbons, phthalates; phenols; pesticides; polynuclear aromatic hydrocarbons (PAHs); miscellaneous extractables; and other organics. The September 1, 2000 samples' physical and chemical analyses are shown on Tables 2 through 10.

The October/November 1995 and June 1996 studies were conducted to identify the benthic infauna and sediment characteristics offshore from the Columbia River (Hinton, S., 1998). There were a total of 39 stations, each sampled twice for physical analyses and biological analyses.

The August 1994 and July 1993 studies were conducted to identify the benthic infauna and sediment characteristics offshore from the Columbia River (Hinton, S., 1996) There were a total of 30 stations, each sampled twice for physical analyses and biological analyses.

The Tongue Point 1989 – 1992 monitoring program study (Siipola, M, R., 1993) supports these conclusions. The Tongue Point study was performed to assess environmental impacts of disposing dissimilar sediments to the coarser ambient sediments at disposal site F. As shown on Figure 1, disposal site F is very close to the Deep Water Site. The Tongue Point samples at Site F were collected over four years at depths ranging from 147 to 168 ft. All samples showed a low percent fines, TOC, and metals. There were no concentrations above the detection limit for phenols, LPAHs, HPAHs, and phthalates. These results correspond to the results from the six September 1, 2000 samples that were taken at similar depths.

The July 1992 study (Siipola, M, 1992) that the US Army Corps of Engineers (USACE) and National Marine Fisheries Service (NMFS) conducted also supports these conclusions. The July 992 USACE/NMFS study was conducted to identify benthic invertebrate and sediment characteristics over a large area offshore of the Columbia River. Sample 40 was taken at a depth of 255 ft and had higher percent fines (15.6%) and TOC (2.2%), with corresponding higher concentrations of copper (8.9 ppm) than the other July 1992 samples.

The earliest and most extensive sampling event was the 1974-1976 Aquatic Disposal Field Investigations of the Columbia River Disposal conducted as part of the US Army Engineers Dredged Material Research Program (Holton, R. 1978). This study was performed as part of a comprehensive nationwide study to provide more definitive information on the environmental impact of dredging and dredge material disposal operations and to develop new or improved dredged material disposal practices. This multidisciplinary study also was to characterize the baseline physical, chemical, and biological aspects of the nearshore zone. According to Table C-IA from Appendix C of the study, a total of 391 stations were sampled during the field study. Samples were collected at each station and analyzed for physical analyses of the sediments, chemical analyses of the water column and biological analyses.

A summary of tests results for the seven studies are shown on Tables 2 through 10 and will be discussed in the following section. Figures 1 shows a general overview of the MCR ODMDS disposal sites. Figure 2 shows the sample locations for various studies at or near MCR ODMDSs. Figures 3-9 show the sampling station locations for the seven individual studies with stations in or near the Deep Water Site. Basic information about these studies and their maps are listed in summary Table 1 shown below.

TABLE 1
SUMMARY OF STUDIES
AT THE DEEP WATER SITE

DATE	SAMPLE NAMES in this report	TOTAL # OF SAMPLES	WHO PERFORMED	NAME OF REPORT	MAP
9/1/00	89, 97-100, 102, 110, 133-4, 136	10	USACE	This report.	Figure 3
1997-8	67-8; 46	Attempted 100 stations, but obtained only 95.	USGS; WDOE	Sidescan-sonar Surface Sidement Samples, and Surficial Geologic Interpretation of the SW WA. Inner Continental Shelf Based on Data Collected During Corliss Cruises 97007 and 98014	Figure 4
6/96	32-36	39	USACE and NMFS	Benthic infauna and Sediment Characteristics offshore from the Columbia River, Oct/Nov. 1995 and June 1996 by NMFS. There is additional data is in the raw data file.	Figure 5
10-11/ 95	32-36	39	USACE and NMFS	Benthic infauna and Sediment Characteristics offshore from the Columbia River, Oct/Nov. 1995 and June 1996 by NMFS. There is additional data is in the raw data file.	Figure 5
8/94	52-60; A4 A7& B2	30	USACE and NMFS	Benthic Infauna and Sediment Characteristics offshore from the Columbia River, Aug. 1994 By NMFS. There is additional data is in the raw data file.	Figure 6
7/93	52-60; A4 A7& B2	30	USACE and NMFS	Benthic Infauna and Sediment Characteristics offshore from the Columbia River, Aug. 1994 By NMFS. There is additional data is in the raw data file.	Figure 6
7/92	40-42, 44-46	50	USACE and USEPA	Reconnaissance Level Benthic Infaunal, Sediment, and Fish Study offshore of the Columbia River, July, 1992	Figure 7
1989-92	A1, A4, A7; B2, B3, B5 and B6	29	USACE and NMFS	Tongue Point Monitoring Program 1989-1992 Final Report	Figure 8
1974-76	12-19, 47, 54-56, 69-70	391*	USACE – Waterways Experiment Station	Aquatic Disposal Field Investigations Columbia River Disposal Site, Oregon.	Figure 9

*Based on Table C-IA "Station Data for Smith-McIntyre Grab Samples" from Appendix C

SEDIMENT QUALITY PARAMETERS:
In order to adequately assess the areas of consideration, seven sediment studies were performed over 17 years and in the various locations offshore of the Columbia River and MCR ODMDS. These sediment studies provided information that can be used to establish the baseline conditions for the Deep Water Site. The sediment quality analytical data covers nine general categories:

1. Physical Analyses
2. Metals
3. Phenols
4. Pesticides and Insecticides
5. Low Polynuclear Aromatic hydrocarbons
6. High Polynuclear Aromatic hydrocarbons
7. Chlorinated hydrocarbons
8. Miscellaneous extractables
9. Phthalates

The sediment quality analytical data is summarized in nine tables (Tables 2 through 10). Screening levels (SL) and bioaccumulation triggers (BT) as established in the 1998 DMEF (USACE/USEPA/WDNR/WDOE, 1998) are provided in the tables for references. The nine general categories that cover ODMDS baseline sediment quality analytical data will be discussed below.

PHYSICAL BASELINE:

Physical Analyses:
There is a considerable amount of sediment physical analyses at the Deep Water Site as Table 2 shows. All seven studies have physical analyses of the sediments, which assist in establishing baseline conditions for the site. The physical analyses are addressed in two main categories: The September 1, 2000 data and samples close to each other.

<u>1. September 1, 2000 Data:</u>
The September 1, 2000 sediment physical analyses at the Deep Water Site shows a mean grain size between 0.106 and 0.126 mm, with an average of 0.120 mm. The median grain size ranges from 0.14 to 0.31mm, with an average median grain size of 0.185 mm. This is larger than the estimated 0.15 mm median grain size for in native situ materials at existing ODMDSs described in the Appendix H, Integrated Feasibility Report of Channel Improvements and Environmental Impact Statement (USACE, 8/99).

The September 1, 2000 sample mean and median grain sizes vary from the other six studies' average mean and median grain sizes. The other six studies' shows a mean grain size between 0. 094 and 0.233 mm, with an average mean grain size of 0.16 mm. This shows a wider distribution of grain size and a larger mean grain size than the 0.120 mm associated with the September 1, 2000 samples. Figure 11 shows the relationship of the mean grain size to depth for five studies. As this graphic shows, there is a strong correlation between the mean grain size and the depth. Based on the graphic mean grain size, it becomes smaller with the greater depths. All five studies showed the same trend. The smaller grain size seen in the September 1, 2000 samples reflect an increase in percent fines with greater sample depths. Figure 12 shows the relationship of the median grain size to depth for five studies and it also shows the same trend of smaller grain size increases with depth. Figure 10 shows the relationship between the sample depth and the percent fines for five studies. As this graph shows, there is a strong correlation between sample depth and percent fines. Figure 10 also shows that at about 225 ft, the percent fines significantly increase with the greater depth.

The data on the Deep Water Site shows the site to have fine to medium marine sand, with a moderate percent of silts and clays, varying from station to station, as shown in Table 2. The percent fines increased with the increased distance from shore and depth, as shown on Figure 10. This is understandable since wave action exerts a decreasing influence from shore to 250 ft, depending on the median grain size and extent of the storm. According to Appendix H, Integrated Feasibility Report of Channel Improvements and Environmental Impact Statement (USACE, 8/99 pg 42), the extreme seaward limit for wave-induced sediment motion with a median sediment grain size of 0.15 mm is 250 ft and 200 ft for 0.25 mm grain size. At depths less than 59 ft, the wave current action can transport sediments easily. Wave actions working with ocean currents can wash the sand; suspend fines, carry them away and deposit them in places with calmer, deeper waters.

Previous studies of document these conclusions. The Continental Shelf Study the USGS performed in 1997 found that the amount of silt, clay and very fine sand increased as the distance from shore increased. The report states "The sediment samples, by contrast, show a progressive offshore fining of the surface sediments. On the lower beach face, surface sediments are primarily fine sand. On the inner shelf, the very fine sand fraction increases from 45% in 59 ft to 62% in 58 water depth." (Twichell, D., 2000). This is logical since the beach receives constant wave action, causing fines to go into suspension and carried them toward sea. Once the fines reach the more tranquil water offshore, the fines fall out of suspension and are deposited in various locations. This accounts for areas of progressive higher percent fines from shore, which is documented in Appendix H, Integrated Feasibility Report of Channel Improvements and Environmental Impact Statement (USACE, 8/99 pg H-58, Figure 17), which is included as Figure 13 of this report. As Figure 13 shows, the percent fines increase with distance from shore and from southern to northern direction.

2. Comparison of Sediment Characteristics Over Time:

There are three sets of samples that provide a comparison of sediment characteristics at one location over time. They were collected between 1992 and 1997 and within 800 ft of each other:

A. Sample 40 take on 7/92 shown on Figure 7 and 35 taken on 10/95 and 6/96 shown on Figure 5.
B. Sample 41 taken on 7/92 shown on Figure 7 and samples 17/56 taken in 1974-1975 shown on Figure 9.

C. Sample 68 taken on 9/97 shown on Figure 4 and sample 47 taken in 1974 shown on Figure 9.

A. Sample 40 and 35:
Sample 40 collected in July 1992 as part of the Reconnaissance Level Benthic Infaunal, Sediment, and Fish Study offshore of the Columbia River (Siipola, M., 1992) is within 710 ft of sample 35 collected in October 1995 and again in June 1996 as part of Benthic infauna and Sediment Characteristics offshore from the Columbia River, Oct/Nov. 1995 and June 1996 (Hinton, S, A., 1998). These three samples were taken at about the same depth (255 to 249 respectively) and have very similar physical characteristics: 28 to 32% very fine sand with 16 to 18 % fines. The sand gradation is also very similar, even though there were several years between the samplings. These facts suggest that the sediment in the area is fairly stable and not subject to significant change.

B. Samples 41 and 17/56:
Sample 41 collected in July 1992 as part of the Reconnaissance Level Benthic Infaunal, Sediment, and Fish Study offshore of the Columbia River (Siipola, M., 1992) is within 110 ft of samples 17 and 56, which were sampled during the 1974- 1976 Aquatic Disposal Field Investigations of the Columbia River Disposal Site study. Sample 41 had a 0.16 mm median grain size and a 0.15 mean grain size. As shown on Figure 11, a 0.15 mean grain size is approximately the average at 200 ft. The mean grain size was not reported for samples 17 and 56.

Sample 41 had a 9.1 percent fines, which is slightly higher than the average sample at 200 ft. As shown on Figure 10, percent fines range between 3 and 10 percent, with an average at approximately 6 percent. Sample 17 had 1 percent fines and sample 56 had 10 and 4 percent fines. Although the percent fines for samples 17 and 56 vary from each other and sample 41, the overall average for this location is approximately 5 percent fines, which is close to the average percent fines at 200 ft. In a general sense, these results are in agreement with the trends shown on Figure 10.

C. Samples 68 and 47:
Sample 68 collected in September 1997 as part of the Continental Shelf Study the USGS (Twichell, D, A., 2000) is within 800 ft of sample 47 collected during the 1974- 1976 Aquatic Disposal Field Investigations of the Columbia River Disposal Site study. There is a 59 ft difference between the depth of sample 68 (239ft) and sample 47 (298 ft). Although this may seem like a minor difference in depth, according to Figure 10, its influence would be significant. At 239 ft, Figure 10 shows the percent fines could vary from 4 to 14 percent and at 295 ft, percent fines could vary from 20 to 37 percent. All lab results from sample 68 and 47 are close to the range that Figure 10 predicts. Sample 68 had 16.4 percent fines, which is close to the predicted range of 4 to 14 percent at 239 feet. Sample 47 had 21 and 47 percent fines, which is close to the range of 20 and 37 % at 295 ft.

SEPTEMBER 1, 2000 CHEMICAL BASELINE:

1. Elemental Metals: Concentrations of arsenic, cadmium, copper, lead, nickel, zinc and silver were detected in all ten September 1, 2000 samples. Mercury was detected in only sample C110 at a concentration of 0.038 ppm. As mentioned previous, of all the September 2000 samples, C133 had the highest detected arsenic (7.2 ppm) and the highest nickel (25ppm). Of all the September 2000 samples, C110 had the highest detected copper (15 ppm), lead (8.0 ppm) mercury (0.038) and cadmium (0.89 ppm). Although none of these concentrations are considered high, it is significant that these two samples have the highest concentrations of all available samples collected in the vicinity of the Deep Water Site. Both are among the deepest samples collected during the September 1, 2000 study. The northwest corner of the Deep Water Site which samples C133 and C110 represent has finer sediment.

2. Phenols: Phenols analyses were performed on the Deep Water Site samples and the results are shown on Table 4. Sample C97 showed a concentration of 20 ppb of phenol and 12 ppb of 4-methylphenol. Sample C133 showed a concentration of 140 ppb of phenol and 37 ppb of 4-methylphenol. Sample C110 showed a concentration of 6.2 ppb of 4-methylphenol. Samples C97, C133 and C110 are located in the deepest area of the Deep Water Site. Phenols occur naturally in bark and are associated with decaying vegetation, log rafting and forest product wastes. When these materials degrade, they commonly become part of the fines found in rivers and harbors. From this perspective, rivers and harbors typically have more of these materials than the ocean. But with the higher percent fines, phenols could appear as seen on Table C-4. Phenols are highly soluble in water and in high concentrations are bactericidal, but in lower concentrations may be rapidly degraded by bacteria.

3. Pesticides and PCBs: Pesticides and PCBs analyses were performed on Deep Water Site. As shown on Table 5, neither pesticides nor PCBs were detected.

4. Low Polynuclear Aromatic hydrocarbons(LPAH): A concentration of 7.0 ppb of phenanthrene was detected in sample C133 as shown on Table 6. This is the only LPAH detected and sample C133 was the only sample with a concentration above the 0.9 ppb detection limit. Sample C133 was collected at a depth of 295 ft. These results agree with the 1989-1992 Tongue Point (Siipola, M.1993) samples, which had no LPAHs detected.

5. High Polynuclear Aromatic hydrocarbons(HPAH): Sample C133 had concentrations of fluoranthene (9.8 ppb), pyrene (11 ppb), benz(a) anthracene (3.8 ppb), chrysene (3.2 ppb), benzo(a) pyrene (5.2 ppb) and benzo(g,h,I) perylene (4.3 ppb). It had the most detected LPAHs of all the September 2000 samples, with C100 the second most as shown on Table 7. Sample C100 had concentrations of fluoranthene (6.5 ppb), pyrene (8.1 ppb), benz(a) anthracene (4.3 ppb), benzofluoranthenes (b+k) (6.2 ppb), and benzo(a) pyrene (3.8 ppb). Sample C110 had a 3.5 ppb concentration of pyrene. All of these samples were taken at depths between 219 and 295 ft.

6. Chlorinated Hydrocarbons: As shown on Table 8, none were detected.

7. Miscellaneous Extractables: As shown on Table 9, none were detected.

8. Phthalate Compounds: All samples had concentrations of at least one phthalate compound. Bis(2-ethylhexyl) phthalate was detected in all ten samples, with concentrations varying from 27 ppb to 64 ppb are shown on Table 10. Sound Analytical Labs flagged these results with the B1 qualifier, which means, "This analyte was detected in the associated method blank. The analyte concentration was determined not to be significantly higher than the associated method blank (less than ten times the concentration reported in the blank)." The same qualifier flagged the Di-nbutyl phthalate concentrations, which ranged between 18 to 27 ppb on seven samples. The Di-nbutyl phthalate concentrations were also flagged with the J qualifier, which means, "The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quantity." Since the Di-nbutyl phthalate and Bis(2-ethylhexyl) phthalate concentrations are estimated and/or qualified, a clear conclusion can not be drawn from these results. These are common laboratory contaminates.

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TABLE 2
MCR ODMDS DEEP WATER SITE
PHYSICAL ANALYSES

Location	Sample	Date	Grain Size Mean mm	Grain Size Median mm	Grain Size Distribution Sand % finer (passes 60 s.)	Vf Sand % Fines (passes 120 s.)	Silt % finer (passes 230 s.)	Clay %	TVS %	TOC %	Depth (ft)
BASELINE (Deep Water Site)											
COE Deep Water Site Sampling	C89	9/1/2000	0.12	0.18	96.24	13.17	2.56	1.66	1.10	1.40	183
COE Deep Water Site Sampling	C97	9/1/2000	0.12	0.17	94.52	19.05	9.57	4.22	2.10	4.90	260
COE Deep Water Site Sampling	C98	9/1/2000	0.13	0.18	94.35	16.18	6.41	2.31	0.67	2.20	245
COE Deep Water Site Sampling	C99	9/1/2000	0.12	0.18	95.89	16.16	4.03	1.51	1.36	2.20	233
COE Deep Water Site Sampling	C100	9/1/2000	0.12	0.17	93.93	15.31	5.23	2.97	0.82	2.70	219
COE Deep Water Site Sampling	C102	9/1/2000	0.12	0.19	96.29	13.93	3.41	1.62	1.19	1.90	186
COE Deep Water Site Sampling	C110	9/1/2000	0.11	0.17	92.93	27.09	16.14	5.25	2.71	6.80	280
COE Deep Water Site Sampling	C133	9/1/2000	0.11	0.14	93.93	38.43	18.21	5.12	3.05	6.40	295
COE Deep Water Site Sampling	C134	9/1/2000	0.12	0.17	94.8	26.09	12.3	3.22	2.43	3.80	282
COE Deep Water Site Sampling	C136	9/1/2000	0.12	0.16	96.16	19.47	5.79	3.22	1.70	2.70	250
SW WA Sidescan-Sonar Study	46	9/1/1997	0.13	0.15	99.04	27.97	8.43	1.35	---	---	230
SW WA Sidescan-Sonar Study	67	9/1/1997	0.21	0.21	67.79	4.79	1.315	0.08	---	---	151
SW WA Sidescan-Sonar Study	68	9/1/1997	0.11	0.15	96.98	26.76	16.42	3.72	---	---	239
NMFS's Benthic Infauna Study	32	6/1/1996	0.15	0.16	98.70	23.40	10.20	3.00	1.00	---	180
NMFS's Benthic Infauna Study	33	6/1/1996	0.13	0.15	98.20	31.60	21.70	8.10	1.00	---	200
NMFS's Benthic Infauna Study	34	6/1/1996	0.15	0.16	97.00	23.00	11.20	5.50	1.00	---	225
NMFS's Benthic Infauna Study	35	6/1/1996	0.13	0.15	98.60	31.60	17.90	7.60	1.90	---	249
NMFS's Benthic Infauna Study	36	6/1/1996	0.11	0.12	98.00	50.80	30.90	7.60	2.60	---	294
NMFS's Benthic Infauna Study	32	10/1/1995	0.16	0.16	98.90	22.80	9.50	2.90	1.30	---	180
NMFS's Benthic Infauna Study	33	10/1/1995	0.16	0.16	98.30	23.40	8.90	3.00	1.50	---	200
NMFS's Benthic Infauna Study	34	10/1/1995	0.15	0.16	97.80	24.00	9.40	4.10	1.70	---	225
NMFS's Benthic Infauna Study	35	10/1/1995	0.14	0.15	98.00	28.00	15.70	4.10	1.60	---	249
NMFS's Benthic Infauna Study	36	10/1/1995	0.09	0.09	96.90	65.80	33.70	9.80	3.70	---	294
NMFS's Benthic Inf. & Sed. Study	52	8/1/1994	0.14	0.15	98.00	30.30	15.50	0.00	0.40	---	190
NMFS's Benthic Inf. & Sed. Study	55	8/1/1994	0.15	0.16	98.30	25.10	8.30	0.00	1.20	---	217
NMFS's Benthic Inf. & Sed. Study	56	8/1/1994	0.16	0.16	98.50	25.70	6.60	3.10	0.10	---	161
NMFS's Benthic Inf. & Sed. Study	58	8/1/1994	0.16	0.16	98.60	22.40	7.40	3.00	1.30	---	220
NMFS's Benthic Inf. & Sed. Study	59	8/1/1994	0.16	0.16	99.90	24.90	3.80	1.80	0.60	---	175
NMFS's Benthic Inf. & Sed. Study	A4	8/1/1994	0.23	0.21	65.20	4.80	2.40	0.00	0.80	---	150
NMFS's Benthic Inf. & Sed. Study	A7	8/1/1994	0.16	0.16	97.20	22.30	2.00	0.00	0.50	---	150
NMFS's Benthic Inf. & Sed. Study	B2	8/1/1994	0.16	0.16	95.60	22.90	5.40	0.00	1.00	---	148
NMFS's Benthic Inf. & Sed. Study	B6	8/1/1994	0.21	0.19	76.20	7.50	3.40	0.00	0.50	---	140
NMFS's Benthic Inf. & Sed. Study	52	7/29/1993	0.18	0.16	90.40	25.10	13.80	0.00	3.40	---	190
NMFS's Benthic Inf. & Sed. Study	55	7/29/1993	0.17	0.17	97.60	16.20	4.80	0.00	1.20	---	217
NMFS's Benthic Inf. & Sed. Study	56	7/29/1993	0.16	0.16	98.10	17.10	2.30	0.00	1.10	---	161
NMFS's Benthic Inf. & Sed. Study	58	7/29/1993	0.17	0.17	96.90	15.50	4.10	0.00	1.50	---	220
NMFS's Benthic Inf. & Sed. Study	59	7/29/1993	0.16	0.16	98.90	21.30	2.50	0.00	1.00		175
NMFS's Benthic Inf. & Sed. Study	A4	7/29/1993	0.20	0.19	81.00	10.70	1.50	0.00	1.10	---	150
NMFS's Benthic Inf. & Sed. Study	A7	7/29/1993	0.17	0.17	97.40	16.10	2.20	0.00	1.10	---	150
NMFS's Benthic Inf. & Sed. Study	B2	7/29/1993	0.17	0.17	94.80	17.80	3.20	0.00	1.10	---	148
NMFS's Benthic Inf. & Sed. Study	B6	7/29/1993	0.19	0.19	81.00	11.10	2.10	0.00	0.80	---	140

TABLE 2- Continuation
MCR ODMDS DEEP WATER SITE
PHYSICAL ANALYSES

Location	Sample	Date	Grain Size		Grain Size Distribution						
			Mean mm	Median mm	Sand % finer (passes s.60)	Vf Sand % Fines (passes s.120)	Silt % finer (passes s.230)	Clay %	TVS %	TOC %	Depth (ft)
BASELINE (Deep Water Site)											
Tongue Pt - ODMDS Site F	A1	7/1/1992	0.16	0.16	98.20	23.50	8.10	2.50	1.00	0.57	168
Tongue Pt - ODMDS Site F	A4	7/1/1992	0.16	0.16	97.90	17.50	1.30	0.00	1.00	0.17	162
Tongue Pt - ODMDS Site F	A7	7/1/1992	0.16	0.15	96.70	30.70	0.10	0.00	1.00	1.20	156
Tongue Pt - ODMDS Site F	B2	7/1/1992	0.17	0.16	95.20	18.70	1.60	0.00	0.70	0.17	153
Tongue Pt - ODMDS Site F	B3	7/1/1992	0.14	0.14	97.50	41.00	0.90	0.00	0.60	0.11	150
Tongue Pt - ODMDS Site F	B5	7/1/1992	0.16	0.16	97.60	20.40	1.00	0.00	0.80	0.13	150
Tongue Pt - ODMDS Site F	B6	7/1/1992	0.16	0.16	97.80	23.10	0.90	0.00	0.40	0.10	147
NMFS's Benthic Infauna Study	40	7/27/1992	0.14	0.15	98.70	30.10	15.60	5.30	0.71	2.2	255
NMFS's Benthic Infauna Study	41	7/27/1992	0.15	0.16	98.80	24.60	9.10	3.60	1.50	0.64	202
NMFS's Benthic Infauna Study	42	7/27/1992	0.18	0.17	86.90	18.00	0.50	0.00	0.50	0.06	85
NMFS's Benthic Infauna Study	44	7/27/1992	0.14	0.13	98.60	44.50	7.40	3.30	1.30	0.27	220
NMFS's Benthic Infauna Study	45	7/27/1992	0.16	0.16	98.70	24.30	0.50	0.00	0.70	0.2	159
NMFS's Benthic Infauna Study	46	7/27/1992	0.14	0.13	98.20	43.50	0.40	0.00	0.60	0.09	104
Tongue Pt - ODMDS Site F	A1	7/9/1991	0.17	0.17	95.60	16.40	2.20	0.00	0.90	1.30	168
Tongue Pt - ODMDS Site F	A4	7/9/1991	0.15	0.14	97.50	38.80	0.70	0.00	1.00	0.95	162
Tongue Pt - ODMDS Site F	A7	7/9/1991	0.16	0.16	98.10	19.50	0.30	0.00	0.90	1.20	156
Tongue Pt - ODMDS Site F	B2	7/9/1991	0.15	0.14	92.50	37.60	2.00	0.00	0.90	1.00	153
Tongue Pt - ODMDS Site F	B3	7/9/1991	0.14	0.13	96.70	44.10	0.90	0.00	0.80	0.94	150
Tongue Pt - ODMDS Site F	B5	7/9/1991	0.16	0.15	95.60	31.70	0.50	0.00	0.70	1.10	150
Tongue Pt - ODMDS Site F	B6	7/9/1991	0.16	0.16	96.80	21.70	1.20	0.00	0.80	1.30	147
Tongue Pt - ODMDS Site F	A1	6/27/1990	0.16	0.16	97.90	17.50	0.90	0.00	1.00	---	168
Tongue Pt - ODMDS Site F	A4	6/27/1990	0.16	0.16	97.40	26.80	2.50	0.00	1.00	0.16	162
Tongue Pt - ODMDS Site F	A7	6/27/1990	0.16	0.16	97.80	24.60	0.40	0.00	0.80	---	156
Tongue Pt - ODMDS Site F	B2	6/27/1990	0.17	0.16	91.60	24.70	1.30	0.00	0.70	0.06	153
Tongue Pt - ODMDS Site F	B3	6/27/1990	0.16	0.16	97.70	25.20	0.60	0.00	0.80	---	150
Tongue Pt - ODMDS Site F	B5	6/27/1990	0.15	0.15	97.20	33.00	0.60	0.00	0.80	---	150
Tongue Pt - ODMDS Site F	B6	6/27/1990	0.15	0.15	97.80	34.70	0.40	0.00	0.90	0.04	147
Tongue Pt - ODMDS Site F	A1	3/1/1990	0.16	0.16	97.40	23.40	1.70	0.00	0.90	---	168
Tongue Pt - ODMDS Site F	A4	3/1/1990	0.16	0.16	98.00	18.30	0.60	0.00	0.70	0.07	162
Tongue Pt - ODMDS Site F	A7	3/1/1990	0.16	0.16	96.70	20.80	0.60	0.00	0.80	---	156
Tongue Pt - ODMDS Site F	B2	3/1/1990	---	0.11	97.50	54.30	26.00	0.00	1.90	0.29	153
Tongue Pt - ODMDS Site F	B3	3/1/1990	0.17	0.17	95.90	15.80	0.30	0.00	0.60	---	150
Tongue Pt - ODMDS Site F	B5	3/1/1990	0.16	0.16	97.80	28.40	3.10	0.00	1.10	---	150
Tongue Pt - ODMDS Site F	B6	3/1/1990	0.16	0.16	98.60	23.70	0.60	0.00	0.70	0.07	147
Tongue Pt - ODMDS Site F	A7	7/10/1989	0.16	0.16	98.30	22.50	0.40	0.00	0.80	---	156
Tongue Pt - ODMDS Site F	B2	7/10/1989	0.16	0.16	98.10	25.00	1.20	0.00	0.60	0.06	153
Tongue Pt - ODMDS Site F	B3	7/10/1989	0.16	0.15	98.40	27.10	0.80	0.00	0.60	---	150
Tongue Pt - ODMDS Site F	B5	7/10/1989	0.15	0.14	97.90	40.30	0.70	0.00	0.60	---	150
Tongue Pt - ODMDS Site F	B6	7/10/1989	0.15	0.14	98.10	36.10	0.50	0.00	0.60	0.08	147

TABLE 2-Continuation
MCR ODMDS DEEP WATER SITE
PHYSICAL ANALYSES

Location	Sample	Date	Grain Size Mean mm	Grain Size Median mm	Grain Size Distribution Sand % finer (passes 60 s.)	Vf Sand % Fines (passes 120 s.)	Silt % finer (passes 230 s.)	Clay %	TVS %	TOC %	Depth (ft)
BASELINE (Deep Water Site)											
Aquatic Disposal Field Investigation.	12	12/8/1974	---	---	99.00	41.00	2.00	1.00	---	---	115
Aquatic Disposal Field Investigation.	12	12/11/1975	---	---	99.00	40.00	2.00	1.00	---	---	115
Aquatic Disposal Field Investigation.	13	9/12/1975	---	---	98.00	40.00	1.00	1.00	---	---	167
Aquatic Disposal Field Investigation.	13	12/11/1975	---	---	97.00	38.00	1.00	1.00	---	---	167
Aquatic Disposal Field Investigation.	14	9/12/1975	---	---	99.00	42.00	2.00	1.00	---	---	230
Aquatic Disposal Field Investigation.	14	10/1/1975	---	---	99.00	42.00	2.00	1.00	---	---	230
Aquatic Disposal Field Investigation.	15	9/12/1975	---	---	99.00	48.00	1.00	0.00	---	---	266
Aquatic Disposal Field Investigation.	15	10/1/1975	---	---	99.00	43.00	2.00	1.00	---	---	266
Aquatic Disposal Field Investigation.	15	12/11/1975	---	---	98.00	40.00	2.00	1.00	---	---	266
Aquatic Disposal Field Investigation.	16	12/1/1974	---	---	99.00	43.00	2.00	1.00	---	---	252
Aquatic Disposal Field Investigation.	16	9/12/1975	---	---	99.00	45.00	2.00	1.00	---	---	252
Aquatic Disposal Field Investigation.	16	10/1/1975	---	---	99.00	46.00	2.00	1.00	---	---	252
Aquatic Disposal Field Investigation.	17	12/8/1974	---	---	99.00	42.00	1.00	1.00	---	---	203
Aquatic Disposal Field Investigation.	17	12/11/1975	---	---	94.00	26.00	1.00	1.00	---	---	203
Aquatic Disposal Field Investigation.	18	12/8/1974	---	---	97.00	35.00	1.00	1.00	---	---	131
Aquatic Disposal Field Investigation.	18	12/12/1974	---	---	99.00	35.00	2.00	1.00	---	---	131
Aquatic Disposal Field Investigation.	18	7/8/1975	---	---	99.00	44.00	2.00	1.00	---	---	131
Aquatic Disposal Field Investigation.	18	12/11/1975	---	---	96.00	32.00	1.00	1.00	---	---	131
Aquatic Disposal Field Investigation.	19	12/8/1974	---	---	98.00	29.00	1.00	1.00	---	---	85
Aquatic Disposal Field Investigation.	19	7/8/1975	---	---	97.00	29.00	2.00	2.00	---	---	85
Aquatic Disposal Field Investigation.	47	9/28/1974	---	---	96.00	53.00	46.00	15.00	---	---	298
Aquatic Disposal Field Investigation.	47	11/1/1974	---	---	88.00	40.00	21.00	4.00	---	---	298
Aquatic Disposal Field Investigation.	54	9/28/1974	---	---	97.00	75.00	58.00	16.00			282
Aquatic Disposal Field Investigation.	54	11/1/1974	---	---	99.00	92.00	59.00	6.00	---	---	282
Aquatic Disposal Field Investigation.	54	8/1/1975	---	---	98.00	96.00	81.00	12.00	---	---	282
Aquatic Disposal Field Investigation.	55	1/25/1975	---	---	99.00	65.00	13.00	1.00	---	---	252
Aquatic Disposal Field Investigation.	55	4/19/1975	---	---	99.00	75.00	26.00	2.00	---	---	252
Aquatic Disposal Field Investigation.	55	7/23/1975	---	---	100.00	85.00	32.00	22.00	---	---	252
Aquatic Disposal Field Investigation.	55	9/12/1975	---	---	100.00	97.00	79.00	13.00	---	---	252
Aquatic Disposal Field Investigation.	56	12/8/1974	---	---	99.00	70.00	10.00	1.00	---	---	203
Aquatic Disposal Field Investigation.	56	1/25/1975	---	---	96.00	57.00	4.00	1.00	---	---	203
Aquatic Disposal Field Investigation.	56	12/11/1975	---	---	96.00	50.00	3.00	1.00	---	---	203
Aquatic Disposal Field Investigation.	69	9/28/1974	---	---	100.00	74.00	14.00	1.00	---	---	223
Aquatic Disposal Field Investigation.	69	1/25/1975	---	---	100.00	88.00	28.00	1.00	---	---	223
Aquatic Disposal Field Investigation.	69	4/19/1975	---	---	100.00	80.00	18.00	1.00	---	---	223
Aquatic Disposal Field Investigation.	69	7/23/1975	---	---	100.00	82.00	15.00	1.00	---	---	223
Aquatic Disposal Field Investigation.	69	9/12/1975	---	---	100.00	83.00	26.00	4.00	---	---	223
Aquatic Disposal Field Investigation.	70	9/28/1974	---	---	100.00	76.00	13.00	1.00	---	---	167
Aquatic Disposal Field Investigation.	70	1/25/1975	---	---	100.00	69.00	11.00	1.00	---	---	167

TABLE 3

MCR ODMDS DEEP WATER SITE

TOTAL METALS ANALYSES OF SEDIMENTS in ppm

Location	Sample	Date	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Silver
BASELINE (Deep Water Site)											
COE Deep Water Site Sampling	C89	9/1/2000	3.90	0.39	---	7.70	4.30	<0.02	14.00	44.00	0.07
COE Deep Water Site Sampling	C97	9/1/2000	4.70	0.69	---	10.00	5.40	<0.02	14.00	45.00	0.1
COE Deep Water Site Sampling	C98	9/1/2000	4.70	0.52	---	8.30	4.70	<0.02	15.00	45.00	0.081
COE Deep Water Site Sampling	C99	9/1/2000	5.00	0.43	---	7.70	4.30	<0.02	15.00	42.00	0.067
COE Deep Water Site Sampling	C100	9/1/2000	5.60	0.38	---	9.30	5.10	<0.02	16.00	48.00	0.098
COE Deep Water Site Sampling	C102	9/1/2000	3.90	0.40	---	8.00	4.10	<0.02	14.00	40.00	0.065
COE Deep Water Site Sampling	C110	9/1/2000	6.20	0.89	---	15.00	8.00	0.038	18.00	55.00	0.16
COE Deep Water Site Sampling	C133	9/1/2000	7.20	0.85	---	13.00	7.60	<0.02	25.00	57.00	0.12
COE Deep Water Site Sampling	C134	9/1/2000	6.40	0.73	---	11.00	6.80	<0.02	18.00	50.00	0.12
COE Deep Water Site Sampling	C136	9/1/2000	5.40	0.54	---	8.90	5.50	<0.02	17.00	45.00	0.081
NMFS's Benthic Infauna Study	40	7/1/1992	3.70	0.06	29.00	8.90	4.50	0.02	14.00	58.00	<0.01
NMFS's Benthic Infauna Study	41	7/1/1992	2.10	0.04	30.00	5.10	4.00	0.015	13.00	54.00	<0.01
NMFS's Benthic Infauna Study	42	7/1/1992	1.20	0.01	35.00	4.40	<2.00	0.011	15.00	62.00	<0.01
NMFS's Benthic Infauna Study	44	7/1/1992	2.20	0.02	32.00	2.90	4.00	<0.013	15.00	47.00	0.01
NMFS's Benthic Infauna Study	45	7/1/1992	2.30	0.02	32.00	2.80	<2.0	<0.013	14.00	45.00	<0.01
NMFS's Benthic Infauna Study	46	7/1/1992	1.10	0.01	84.00	5.70	<2.0	<0.009	18.00	120.00	<0.01
Tongue Point - Site F	B2	########	5.40	<0.050	27.00	6.30	5.00	0.04	0.00	52.00	---
Tongue Point - Site F	B6	########	5.40	<0.030	25.00	6.30	3.70	<0.030	0.00	45.00	---
Tongue Point - Site F	A4	3/1/1990	2.70	0.04	19.50	4.75	4.59	0.02	14.50	38.90	<0.01
Tongue Point - Site F	B2	3/1/1990	4.20	0.02	18.50	10.70	4.83	0.03	14.00	50.80	0.02
Tongue Point - Site F	B6	3/1/1990	4.30	0.02	19.70	4.60	4.87	0.02	14.00	37.80	<0.01
Tongue Point - Site F	B2	7/1/1992	3.00	<0.050	18.00	7.00	4.00	<0.02	14.00	42.00	<0.01
Tongue Point - Site F	B6	7/1/1992	3.00	<0.050	22.00	6.00	5.00	<0.02	15.00	43.00	<0.01
Screening Levels			**57**	**5.1**		**390**	**450**	**0.41**	**140**	**410**	---
Bioaccum. Trigger			**507.1**	---	---	---	---	**1.5**	**370**	---	---

TABLE 4
MCR ODMDS DEEP WATER SITE
PHENOLS COMPOUNDS ANALYSES in ppb

Location	Sample	Date	Phenol	2-methylphenol	4-methylphenol	2,4-dimethylphenol	Pentachlorophenol
BASELINE (Deep Water Site)							
COE Deep Water Site Sampling	C89	9/1/2000	<4.7	<1.9	<3.4	<3.3	<1.7
COE Deep Water Site Sampling	C97	9/1/2000	**20.00**	<2.0	**12.00**	<3.5	<1.8
COE Deep Water Site Sampling	C98	9/1/2000	<5.0	<2.0	<3.6	<3.6	<1.8
COE Deep Water Site Sampling	C99	9/1/2000	<4.7	<1.9	<3.4	<3.3	<1.7
COE Deep Water Site Sampling	C100	9/1/2000	<5.0	<2.0	<3.6	<3.5	<1.8
COE Deep Water Site Sampling	C102	9/1/2000	<4.5	<1.8	<3.2	<3.2	<1.7
COE Deep Water Site Sampling	C110	9/1/2000	<5.4	<2.2	**6.20**	<3.8	<2.0
COE Deep Water Site Sampling	C133	9/1/2000	**140.00**	<2.2	**37.00**	<3.8	<1.9
COE Deep Water Site Sampling	C134	9/1/2000	<4.7	<1.9	<3.4	<3.3	<1.7
COE Deep Water Site Sampling	C136	9/1/2000	<4.7	<1.9	<3.4	<3.3	<1.7
Screening level			420	63	670	29	400
Bioacc. Trigger			876	---	---	---	504

TABLE 5
MCR ODMDS DEEP WATER SITE
PESTICIDES AND PCBs ANALYSIS in ppb

Location	Sample	Date	Total BHC	Aldrin	Alpha-Chlordane	Dieldrin	DDD	DDE	DDT	Endosulfan I, II & Sulfate	Endrin	Endrin aldehyde	Heptachlor	Heptachlor epoxide	Lindane g-BHC	Methoxychlor	Toxaphene	Total PCB
BASELINE (Deep Water Site)																		
COE Deep Water Site Sampling	C89	9/1/2000	<0.28	<0.12	<8.5	<0.38	<0.14	<0.17	<0.21	<0.36	<0.38	<0.45	<0.13	<0.22	<0.23	<1.0	<15	<8.3
COE Deep Water Site Sampling	C97	9/1/2000	<0.33	<0.15	<10	<0.35	<0.17	<0.20	<0.25	<0.43	<0.45	<0.53	<0.16	<0.26	<0.27	<1.2	<17	<9.9
COE Deep Water Site Sampling	C98	9/1/2000	<0.31	<0.14	<9.5	<0.33	<0.16	<0.19	<0.24	<0.40	<0.42	<0.50	<0.15	<0.24	<0.26	<1.1	<16	<9.3
COE Deep Water Site Sampling	C99	9/1/2000	<0.18	<0.13	<9.2	<0.32	<0.15	<0.19	<0.23	<0.39	<0.41	<0.48	<0.15	<0.24	<0.25	<1.1	<16	<8.7
COE Deep Water Site Sampling	C100	9/1/2000	<0.19	<0.13	<9.3	<0.33	<0.16	<0.19	<0.23	<0.40	<0.42	<0.49	<0.15	<0.24	<0.25	<1.1	<16	<9.1
COE Deep Water Site Sampling	C102	9/1/2000	<0.29	<0.13	<8.8	<0.31	<0.15	<0.18	<0.22	<0.37	<0.39	<0.47	<0.14	<0.23	<0.24	<1.1	<15	<8.6
COE Deep Water Site Sampling	C110	9/1/2000	<0.33	<0.15	<10.0	<0.36	<0.17	<0.21	<0.25	<0.43	<0.46	<0.54	<0.16	<0.26	<0.28	<1.2	<18	<15.0
COE Deep Water Site Sampling	C133	9/1/2000	<0.19	<0.13	<9.4	<0.33	<0.16	<0.19	<0.23	<0.40	<0.42	<0.49	<0.15	<0.24	<0.25	<1.1	<16	<9.1
COE Deep Water Site Sampling	C134	9/1/2000	<0.18	<0.13	<9.1	<0.32	<0.15	<0.18	<0.23	<0.39	<0.41	<0.48	<0.14	<0.23	<0.25	<1.1	<16	<8.9
COE Deep Water Site Sampling	C136	9/1/2000	<0.19	<0.13	<9.2	<0.32	<0.16	<0.19	<0.23	<0.39	<0.41	<0.49	<0.15	<0.24	<0.25	<1.1	<16	<8.8
NMFS's Benthic Infauna Study	42	7/1/1992	---	<0.53	<0.53	<0.71	<0.89	<0.71	<1.8	---	---	---	<0.53	---	**0.96**	---	---	<8.8
NMFS's Benthic Infauna Study	44	7/1/1992	---	<0.60	<0.60	<0.80	<1.0	<0.80	<2.0	---	---	---	<0.60	---	**0.64**	---	---	<10
NMFS's Benthic Infauna Study	45	7/1/1992	---	<0.58	<0.58	<0.78	<0.97	<0.78	<1.9	---	---	---	<0.58	---	**1.4**	---	---	<9.7
NMFS's Benthic Infauna Study	46	7/1/1992	---	<0.53	<0.53	<0.70	<0.88	<0.70	<1.8	---	---	---	<0.53	---	**0.89**	---	---	<8.8
Tongue Point - Site F	B2	#######	---	<1.0	<1.0	<2.0	<2.0	<2.0	<2.0	<1.0	<2.0	---	<1.0	---	<1.0	<4.0	<150	<20.0
Tongue Point - Site F	B3	#######	---	<1.0	<1.0	<2.0	<2.0	<2.0	<2.0	<1.0	<2.0	---	<1.0	---	<1.0	<4.0	<150	<20.0
Tongue Point - Site F	A4	3/1/1990	---	<3.0	<4.0	<6.0	<6.0	<6.0	<6.0	<3.0	<6.0	---	<3.0	---	<3.0	<12.0	<450.0	<60.0
Tongue Point - Site F	B2	3/1/1990	---	<3.0	<4.0	<6.0	<6.0	<6.0	<6.0	<3.0	<6.0	---	<3.0	---	<3.0	<12.0	<450.0	<60.0
Tongue Point - Site F	B6	3/1/1990	---	<3.0	<4.0	<6.0	<6.0	<6.0	<6.0	<3.0	<6.0	---	<3.0	---	<3.0	<12.0	<450.0	<60.0
Tongue Point - Site F	B2	7/1/1992	---	<2.0	<10	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	---	<2.0	---	<2.0	<4.0	<30.0	<10.0
Tongue Point - Site F	B6	7/1/1992	---	<2.0	<10	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	---	<2.0	---	<2.0	<4.0	<30.0	<10.0
Screening level				**10**	**10**	**10**								**10**	**10**			**130**
Bioacc. Trigger				37	37	37								37	---			38

TABLE 6
MCR ODMDS DEEP WATER SITE
LOW POLYNUCLEAR AROMATIC HYDROCARBONS ANALYSES in ppb

Location	Sample	Date	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	2- Methyl-naphthalene	Total LPAHs
BASELINE (Deep Water Site)										
COE Deep Water Site Sampling	C89	9/1/2000	<2.5	<1.0	<0.91	<1.0	<0.85	<1.2	<1.8	ND
COE Deep Water Site Sampling	C97	9/1/2000	<2.6	<1.1	<0.94	<1.1	<0.88	<1.3	<1.9	ND
COE Deep Water Site Sampling	C98	9/1/2000	<2.7	<1.1	<0.97	<1.1	<0.9	<1.3	<2.0	ND
COE Deep Water Site Sampling	C99	9/1/2000	<2.5	<1.0	<0.90	<1.0	<0.84	<1.2	<1.8	ND
COE Deep Water Site Sampling	C100	9/1/2000	<2.7	<1.1	<0.98	<1.1	<0.9	<1.3	<1.9	ND
COE Deep Water Site Sampling	C102	9/1/2000	<2.4	<1.0	<0.87	<1.0	<0.81	<1.2	<1.8	ND
COE Deep Water Site Sampling	C110	9/1/2000	<2.9	<1.2	<1.0	<1.2	<0.97	<1.4	<2.2	ND
COE Deep Water Site Sampling	C133	9/1/2000	<2.9	<1.2	<1.0	<1.2	**7.0**	<1.4	<2.2	**7.0**
COE Deep Water Site Sampling	C134	9/1/2000	<2.5	<1.0	<0.90	<1.0	<0.84	<1.2	<1.9	ND
COE Deep Water Site Sampling	C136	9/1/2000	<2.5	<1.0	<0.91	<1.0	<0.85	<1.2	<1.8	ND
Tongue Point - Site F	B2	7/10/1989	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	---	ND
Tongue Point - Site F	B3	7/10/1989	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	---	ND
Tongue Point - Site F	A4	3/1/1990	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	---	ND
Tongue Point - Site F	B2	3/1/1990	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	---	ND
Tongue Point - Site F	B6	3/1/1990	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	---	ND
Tongue Point - Site F	B2	7/1/1992	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	---	ND
Tongue Point - Site F	B6	7/1/1992	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	---	ND
Screening level			**2,100**	**560**	**500**	**540**	**1,500**	**960**	**670**	**5,200**
Bioacc. Trigger			---	---	---	---	---	---	---	---

TABLE 7
MCR ODMDS DEEP WATER SITE
HIGH POLYNUCLEAR AROMATIC HYDROCARBONS ANALYSES in ppb

Location	Sample	Date	Fluoranthene	Pyrene	benz(a)-anthracene	Chrysene	Benzofluor-anthenes (b+k)	Benzo (a)-pyrene	Indeno (1,2,3-c,d) pyrene	Dibenz(a,h) anthracene	Benzo(g,h,i) perylene	Total HPHAH
BASELINE (Deep Water Site)												
COE Deep Water Site Sampling	C89	9/1/2000	<0.82	<0.73	<0.82	<1.1	<0.86	<1.1	<0.96	<0.6	<0.39	ND
COE Deep Water Site Sampling	C97	9/1/2000	<0.85	<0.76	<0.85	<1.1	<0.76	<1.1	<1.0	<0.62	<0.4	ND
COE Deep Water Site Sampling	C98	9/1/2000	<0.88	<0.78	<0.88	<1.1	<0.78	<1.1	<1.0	<0.64	<0.41	ND
COE Deep Water Site Sampling	C99	9/1/2000	<0.82	<0.73	<0.82	<1.1	<0.73	<1.1	<0.96	<0.6	<0.39	ND
COE Deep Water Site Sampling	C100	9/1/2000	**6.5**	**8.1**	**4.3**	<1.1	**6.2**	**3.8**	<1.0	<0.63	<0.41	**28.9**
COE Deep Water Site Sampling	C102	9/1/2000	<0.79	<0.70	<0.79	<1.0	<0.70	<1.0	<0.92	<0.57	<0.37	ND
COE Deep Water Site Sampling	C110	9/1/2000	<0.94	**3.5**	<0.94	<1.2	<0.84	<1.2	<1.1	<0.69	<0.44	**3.5**
COE Deep Water Site Sampling	C133	9/1/2000	**9.8**	**11**	**3.8**	**3.2**	<0.83	**5.2**	<1.1	<0.68	**4.3**	**37.3**
COE Deep Water Site Sampling	C134	9/1/2000	<0.81	<0.72	<0.81	<1.1	<0.72	<1.1	<0.95	<0.59	<0.38	ND
COE Deep Water Site Sampling	C136	9/1/2000	<0.82	<0.73	<0.82	<1.1	<0.85	<1.1	<0.96	<0.6	<0.36	ND
Tongue Point - Site F	B2	7/10/1989	<30.0	<30.0	<30.0	<30.0	<50.0	<60.0	<130.0	<130.0	<130.0	ND
Tongue Point - Site F	B3	7/10/1989	<30.0	<30.0	<30.0	<30.0	<50.0	<60.0	<130.0	<130.0	<130.0	ND
Tongue Point - Site F	A4	3/1/1990	<150.0	<50.0	<50.0	<50.0	<150.0	<150.0	<200.0	<200.0	<200.0	ND
Tongue Point - Site F	B2	3/1/1990	<150.0	<50.0	<50.0	<50.0	<150.0	<150.0	<200.0	<200.0	<200.0	ND
Tongue Point - Site F	B6	3/1/1990	<150.0	<50.0	<50.0	<50.0	<150.0	<150.0	<200.0	<200.0	<200.0	ND
Tongue Point - Site F	B2	7/1/1992	<20.0	<20.0	<20.0	<20.0	<40.0	<20.0	<20.0	<20.0	<20.0	ND
Tongue Point - Site F	B6	7/1/1992	<20.0	<20.0	<20.0	<20.0	<40.0	<20.0	<20.0	<20.0	<20.0	ND
Screening level			**1,700**	**2,600**	**1,300**	**1,400**	**3,200**	**1,600**	**600**	**230**	**670**	**12,000**
Bioacc. Trigger			**4,600**	---	---	---	---	**3,600**	---	---	---	---

TABLE 8
MCR ODMDS DEEP WATER SITE
CHLORINATED HYDROCARBONS ANALYSES in ppb

Location	Sample	Date	1,3-Dichlorobenzene	1,4- Dichlorobenzene	1,2-Dichlorobenzene	1,2,4- Trichlorobenzene	Hexachlorobenzene (HCB)
BASELINE (Deep Water Site)							
COE Deep Water Site Sampling	C89	9/1/2000	<3.6	<3.0	<2.6	<1.7	<2.8
COE Deep Water Site Sampling	C97	9/1/2000	<3.8	<3.1	<2.7	<1.8	<3.4
COE Deep Water Site Sampling	C98	9/1/2000	<3.9	<3.2	<2.7	<1.8	<3.5
COE Deep Water Site Sampling	C99	9/1/2000	<3.6	<3.0	<2.6	<1.7	<3.2
COE Deep Water Site Sampling	C100	9/1/2000	<3.8	<3.2	<2.7	<1.8	<3.4
COE Deep Water Site Sampling	C102	9/1/2000	<3.5	<2.9	<2.5	<1.6	<2.7
COE Deep Water Site Sampling	C110	9/1/2000	<4.2	<3.5	<3.0	<2.0	<3.7
COE Deep Water Site Sampling	C133	9/1/2000	<4.1	<3.4	<2.9	<1.9	<3.7
COE Deep Water Site Sampling	C134	9/1/2000	<3.6	<3.0	<2.5	<1.7	<3.2
COE Deep Water Site Sampling	C136	9/1/2000	<3.6	<3.0	<2.6	<2.5	<3.2
Screening level			**170**	**110**	**35**	**31**	**22**
Bioacc. Trigger			**1,241**	**120**	**37**	**---**	**168**

TABLE 9
MCR ODMDS DEEP WATER SITE
MISCELLANEOUS EXTRACTABLES ANALYSES in ppb

Location	Sample	Date	Benzyl alchohol	Benzoic Acid	Dibenzo furan	Hexachloro-ethane	Hexachloro-Butadiene	N-Nitrosodi-phenylamine
BASELINE (Deep Water Site)								
COE Deep Water Site Sampling	C89	9/1/2000	<3.9	<1.4	<2.6	<3.2	<2.8	<0.95
COE Deep Water Site Sampling	C97	9/1/2000	<4.0	<1.5	<2.7	<4.0	<2.9	<0.99
COE Deep Water Site Sampling	C98	9/1/2000	<4.1	<1.5	<2.8	<4.1	<3.0	<1.0
COE Deep Water Site Sampling	C99	9/1/2000	<3.9	<1.4	<2.6	<3.8	<2.8	<0.95
COE Deep Water Site Sampling	C100	9/1/2000	<4.1	<1.5	<2.7	<4.1	<2.9	<1.0
COE Deep Water Site Sampling	C102	9/1/2000	<3.7	<1.4	<2.5	<3.1	<2.7	<0.92
COE Deep Water Site Sampling	C110	9/1/2000	<4.5	<1.6	<3.0	<4.4	<3.2	<1.1
COE Deep Water Site Sampling	C133	9/1/2000	<4.4	<1.6	<2.9	<4.4	<3.1	<1.1
COE Deep Water Site Sampling	C134	9/1/2000	<3.8	<1.4	<2.7	<3.8	<2.7	<0.94
COE Deep Water Site Sampling	C136	9/1/2000	<3.9	<1.4	<2.6	<3.9	<2.8	<0.95
Screening level			**57**	**650**	**540**	**1,400**	**29**	**28**
Bioacc. Trigger			**---**	**---**	**---**	**10,220**	**212**	**130**

TABLE 10
MCR ODMDS DEEP WATER SITE
PHTHALATES ANALYSES in ppb

Location	Sample	Date	Dimethyl phthalate	Diethyl phthalate	Di-n-butyl phthalate	Butyl Benzyl phthalate	bis(2-Ethylhexyl) phthalate	Di-n-octyl phthalate
BASELINE (Deep Water Site)								
COE Deep Water Site Sampling	C89	9/1/2000	<4.0	<2.7	**18-J B1**	<1.9	**31-B1**	<3.1
COE Deep Water Site Sampling	C97	9/1/2000	<4.2	<2.8	**19-J B1**	<2.0	**27-B1**	<3.2
COE Deep Water Site Sampling	C98	9/1/2000	<4.3	<2.9	**24-J B1**	<2.0	**37-B1**	<3.3
COE Deep Water Site Sampling	C99	9/1/2000	<4.0	<2.7	<16	<1.9	**37-B1**	<3.1
COE Deep Water Site Sampling	C100	9/1/2000	<4.3	<2.9	**23-J B1**	<2.0	**27-B1**	<3.2
COE Deep Water Site Sampling	C102	9/1/2000	<3.9	<2.6	**23-J B1**	**5.9**	**64-B1**	<2.9
COE Deep Water Site Sampling	C110	9/1/2000	<4.6	<3.1	<18	<2.2	**42-B1**	<3.5
COE Deep Water Site Sampling	C133	9/1/2000	<4.6	<3.1	**23-J B1**	<2.1	**38-B1**	<3.5
COE Deep Water Site Sampling	C134	9/1/2000	<4.0	<2.7	<16	<1.9	**39-B1**	<3.0
COE Deep Water Site Sampling	C136	9/1/2000	<4.0	<2.7	**27-B1**	<1.9	**31-B1**	<3.1
Screening level			**1,400**	**1,200**	**5,100**	**970**	**8,300**	**6,200**
Bioacc. Trigger			**1,400**	---	**10,220**	---	**13,870**	---

B1 = This analyte was detected in the associated method blank. The analyte concentration was determined not to be significantly higher than the associated method blank (less than ten times the concentration reported in the blank).

J = The analyte was analyzed for and positively identified, but the associated numerical value is an estimated quanity.

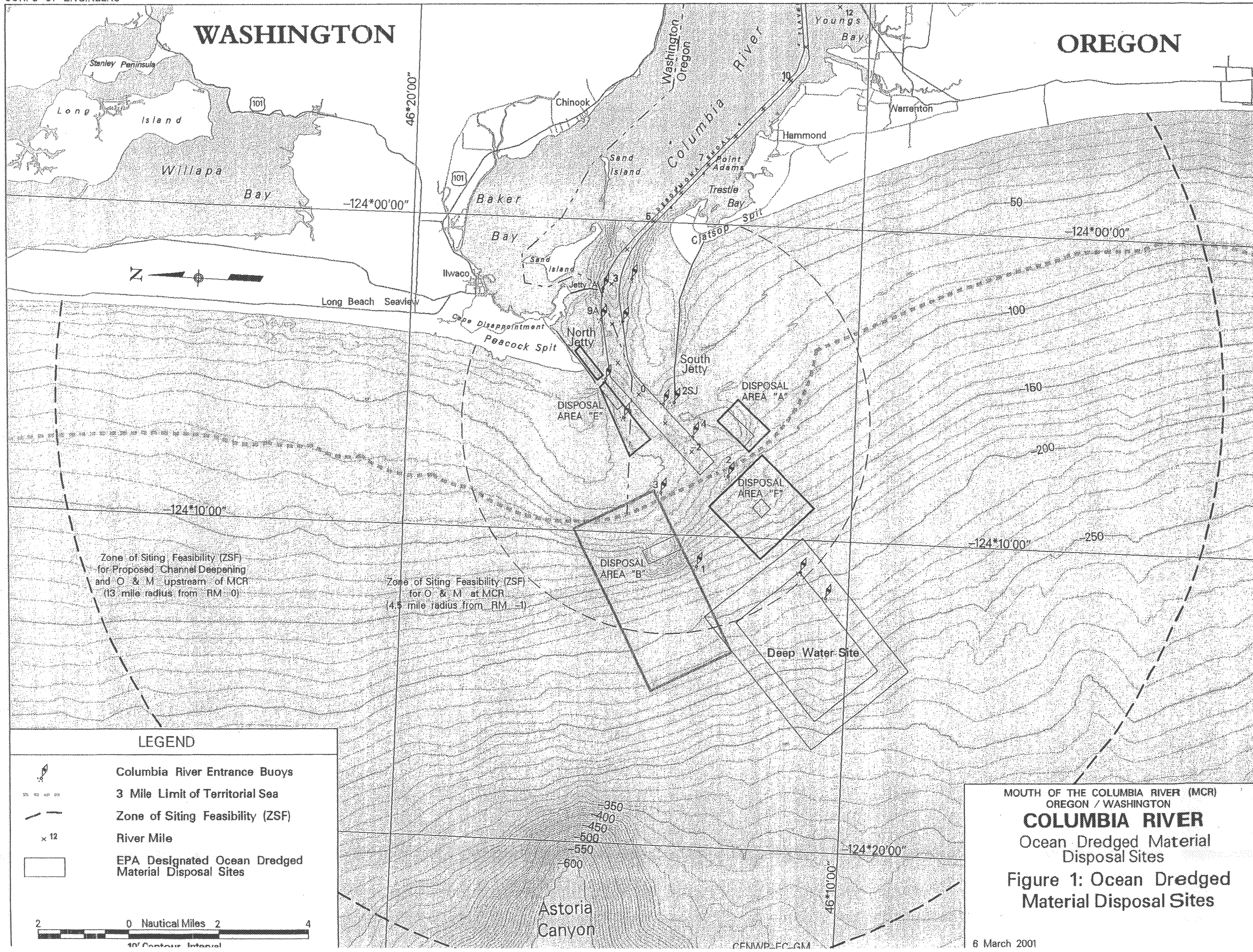


Figure 1: Ocean Dredged Material Disposal Sites

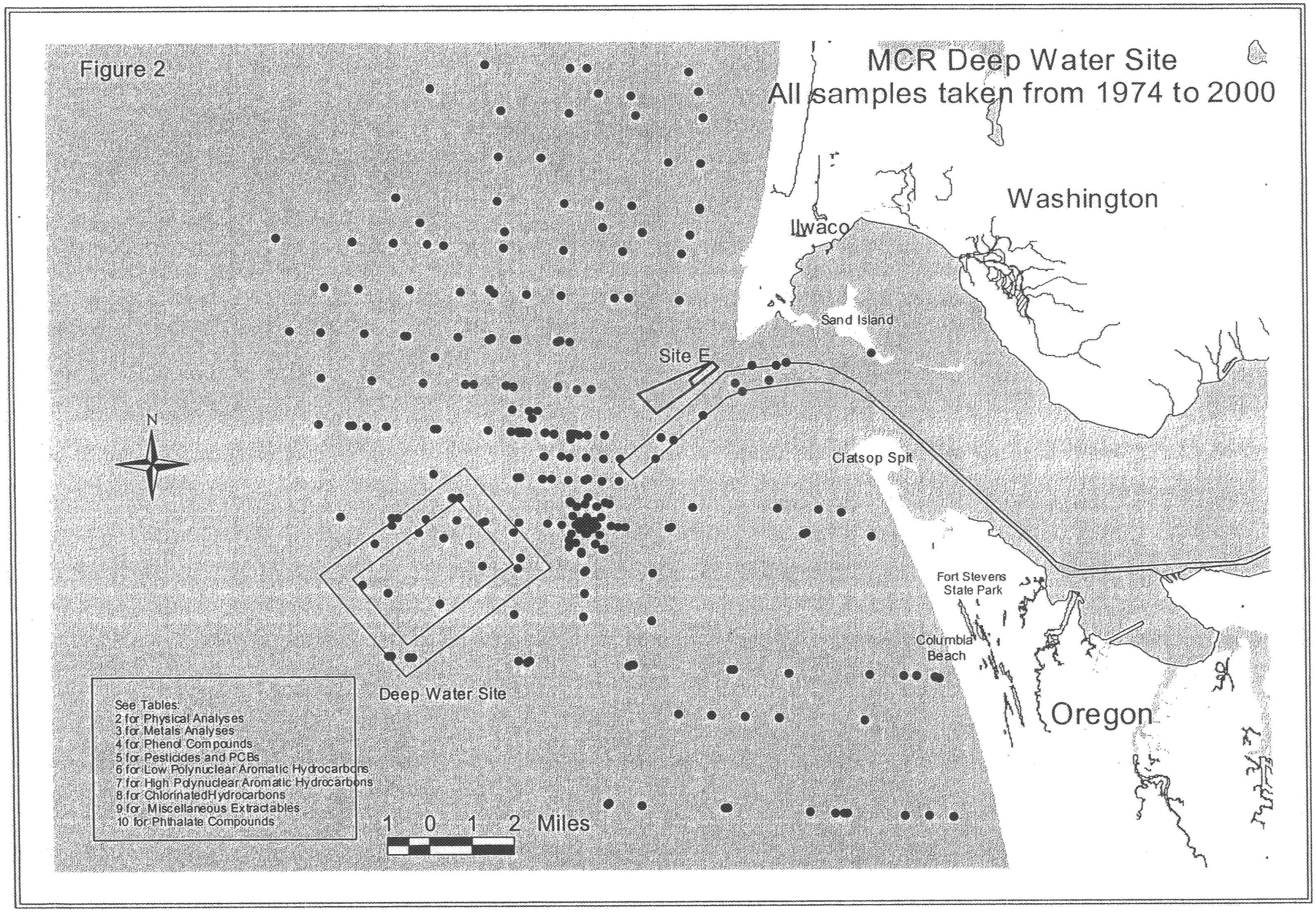


Figure 2
MCR Deep Water Site
All samples taken from 1974 to 2000
Washington
Ilwaco
Sand Island
Site E
N
Clatsop Spit
Fort Stevens
State Park
Columbia
Beach
Oregon
Deep Water Site
See Tables:
2 for Physical Analyses
3 for Metals Analyses
4 for Phenol Compounds
5 for Pesticides and PCBs
6 for Low Polynuclear Aromatic Hydrocarbons
7 for High Polynuclear Aromatic Hydrocarbons
8 for ChlorinatedHydrocarbons
9 for Miscellaneous Extractables
10 for Phthalate Compounds
1 0 1 2 Miles

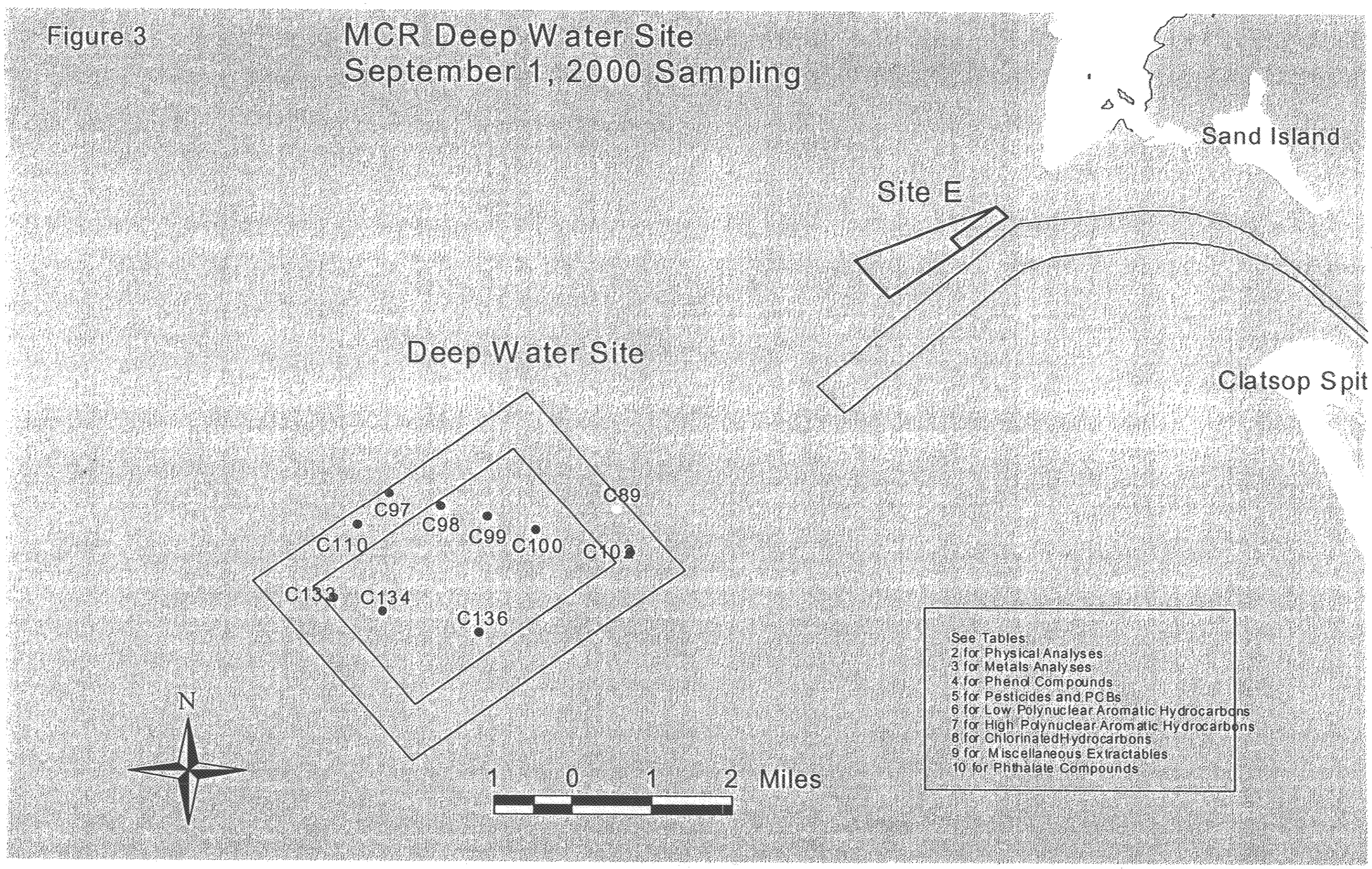


Figure 3
MCR Deep Water Site
September 1, 2000 Sampling
Sand Island
Site E
Deep Water Site
Clatsop Spit
C89
C97
C98
C99
C100
C110
C102
C133
C134
C136
N
1 0 1 2 Miles
See Tables.
2 for Physical Analyses
3 for Metals Analyses
4 for Phenol Compounds
5 for Pesticides and PCBs
6 for Low Polynuclear Aromatic Hydrocarbons
7 for High Polynuclear Aromatic Hydrocarbons
8 for ChlorinatedHydrocarbons
9 for Miscellaneous Extractables
10 for Phthalate Compounds

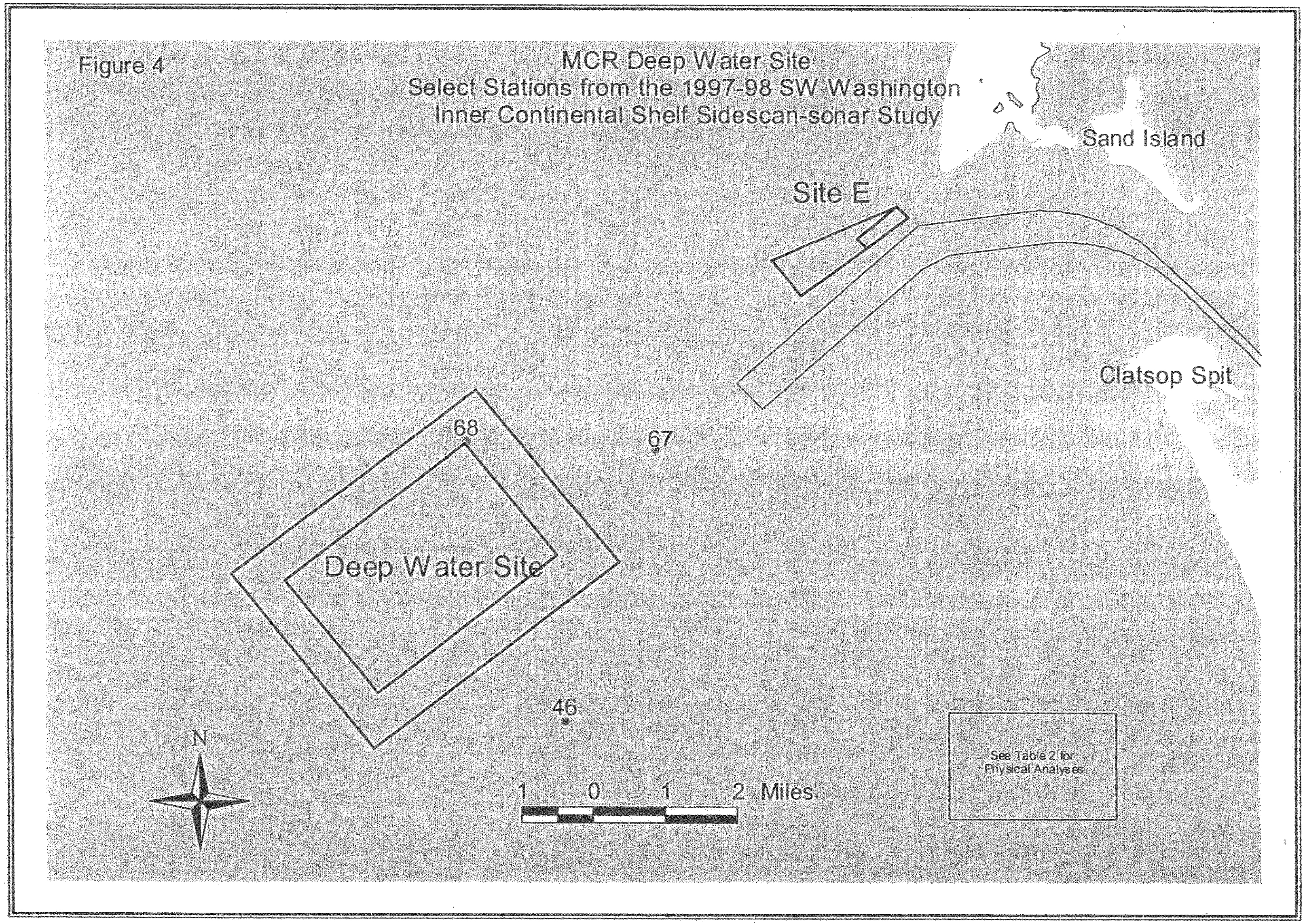


Figure 4
MCR Deep Water Site
Select Stations from the 1997-98 SW Washington
Inner Continental Shelf Sidescan-sonar Study
Sand Island
Site E
Clatsop Spit
68
67
Deep Water Site
46
N
1 0 1 2 Miles
See Table 2 for
Physical Analyses

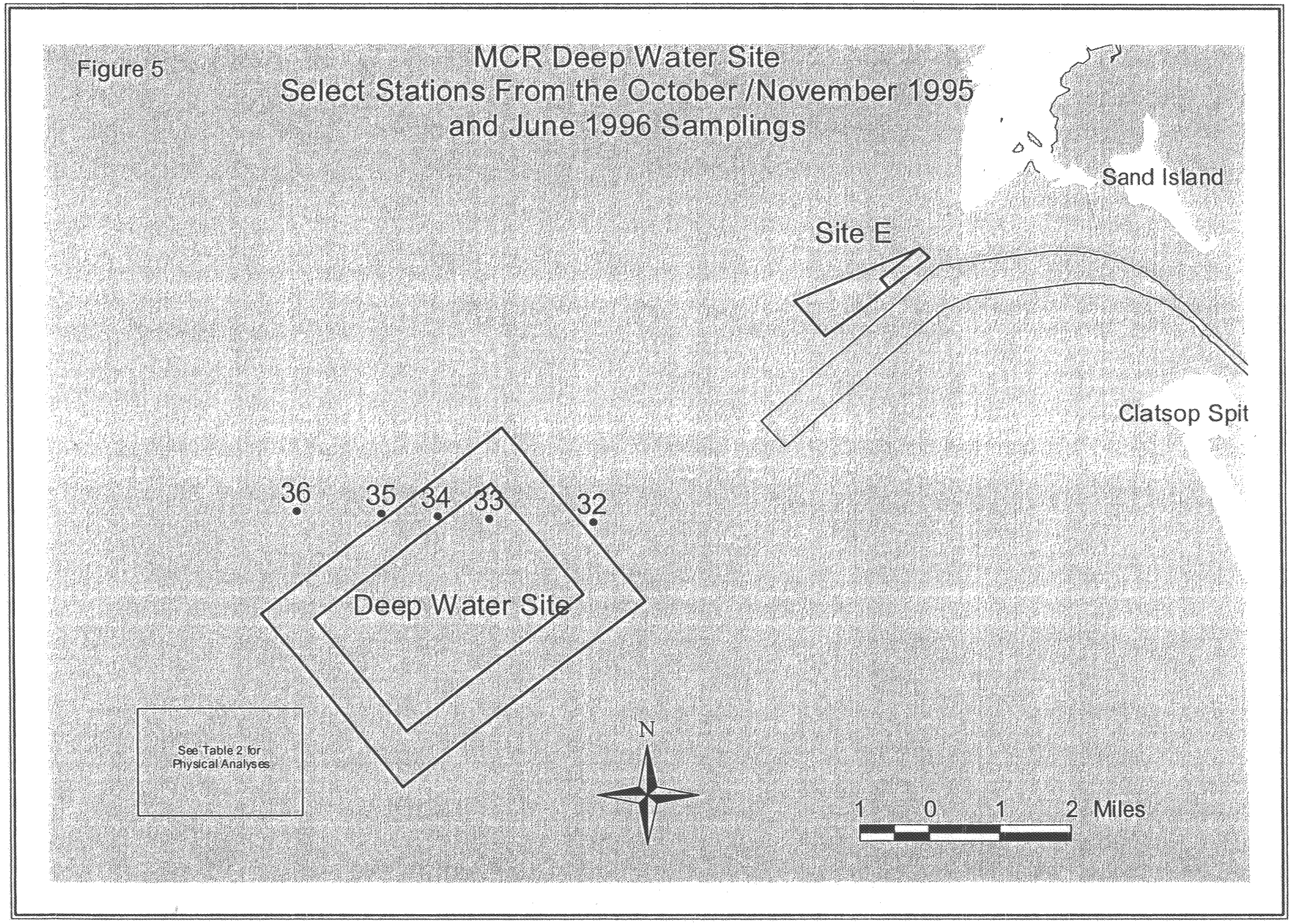


Figure 5
MCR Deep Water Site
Select Stations From the October /November 1995
and June 1996 Samplings
Sand Island
Site E
Clatsop Spit
36
35
34
33
32
Deep Water Site
See Table 2 for
Physical Analyses
N
1 0 1 2 Miles

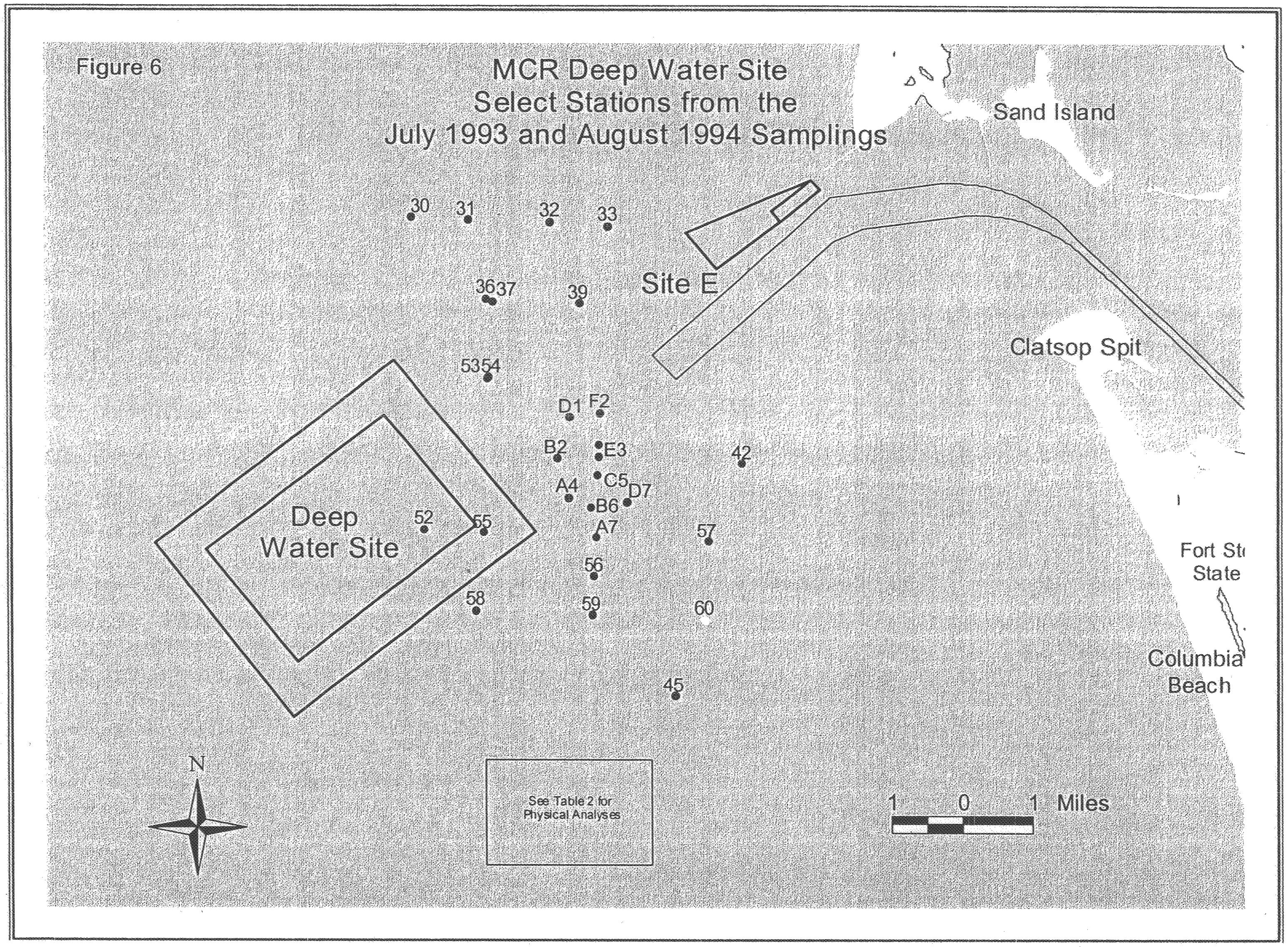


Figure 6
MCR Deep Water Site
Select Stations from the
July 1993 and August 1994 Samplings
Sand Island
30
31
32
33
Site E
36
37
39
Clatsop Spit
53
54
D1
F2
B2
E3
42
A4
C5
D7
B6
A7
57
Deep
Water Site
52
55
56
58
59
60
Fort St
State
Columbia
Beach
45
N
See Table 2 for
Physical Analyses
1 0 1 Miles

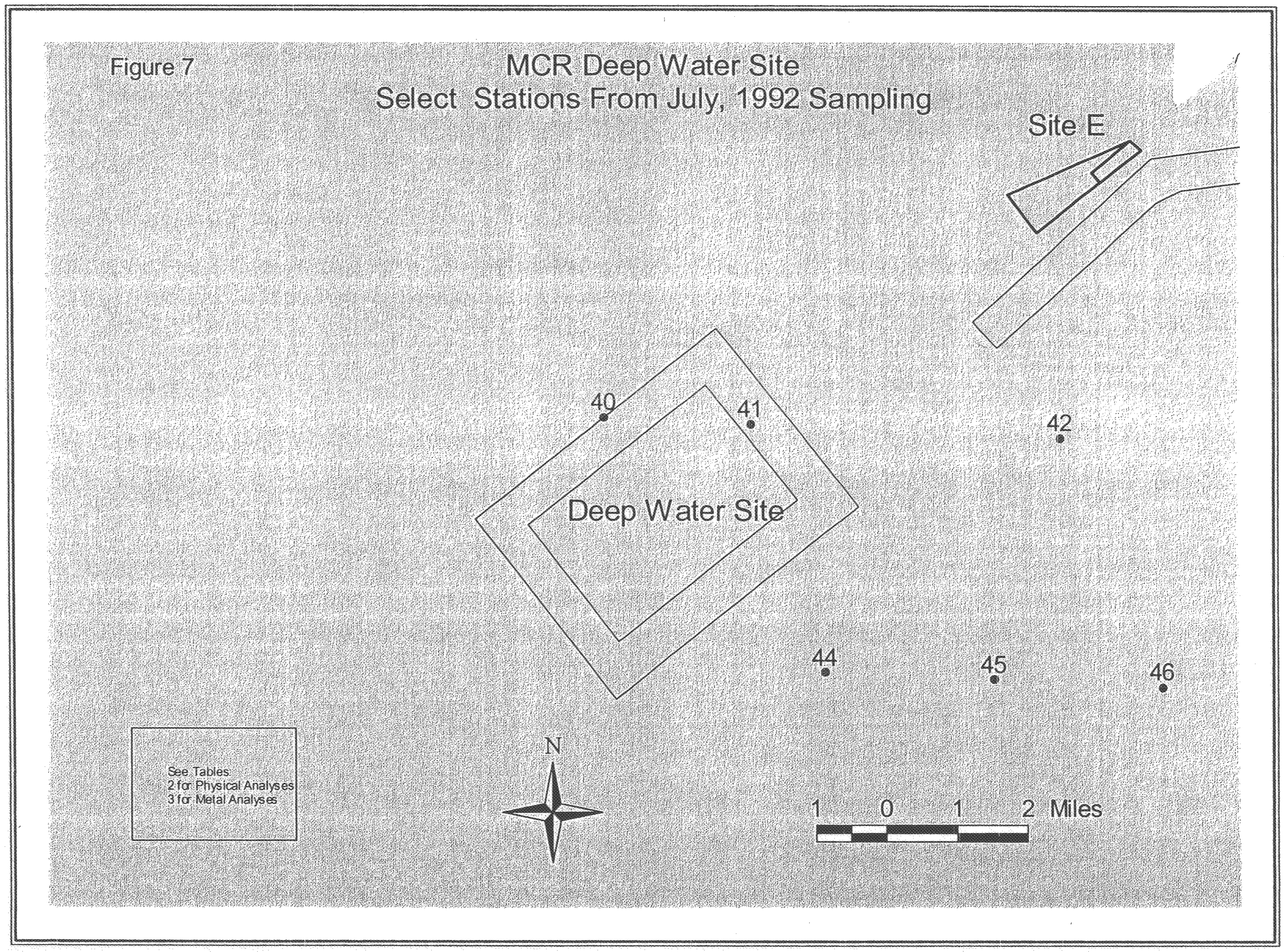
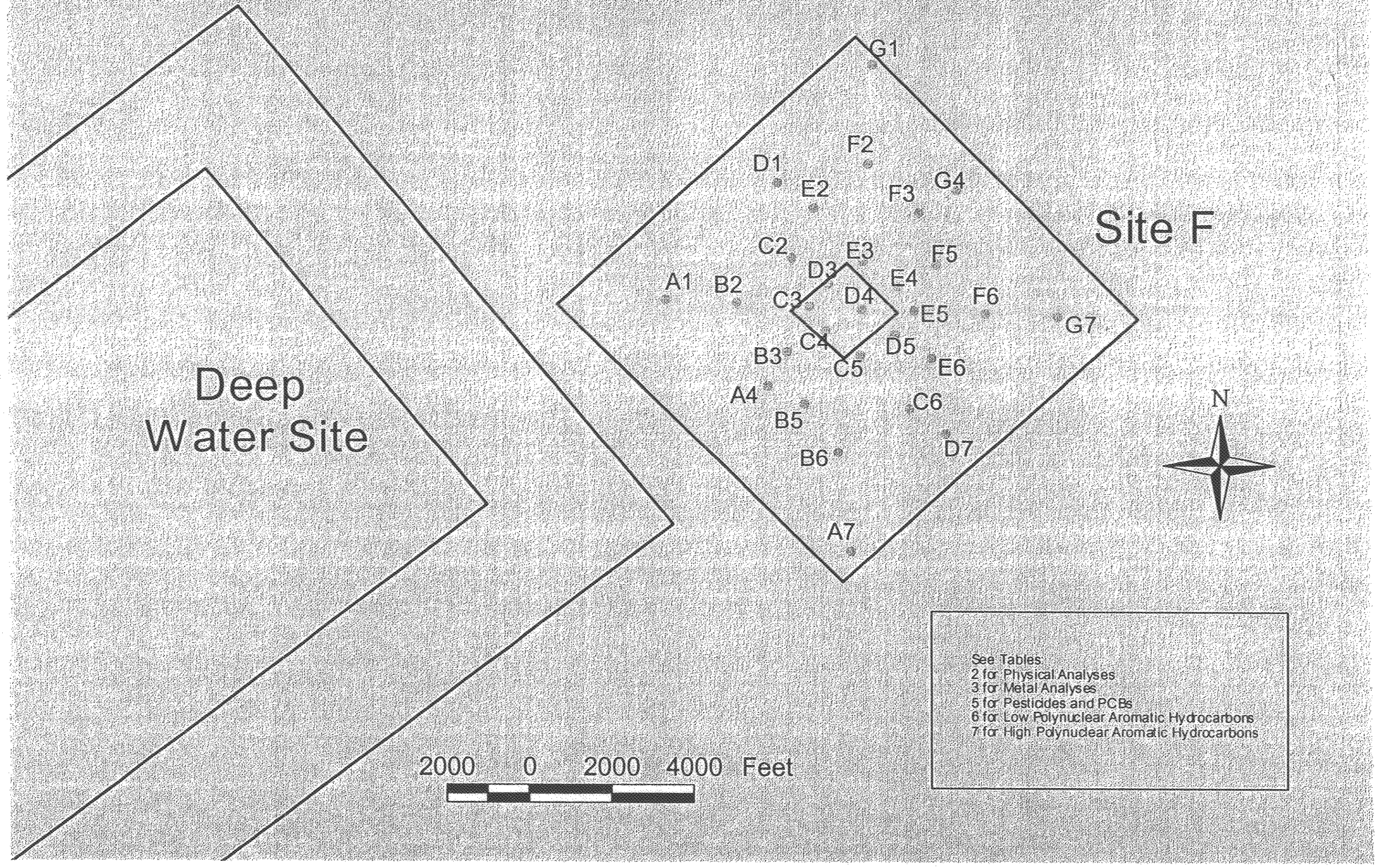


Figure 7
MCR Deep Water Site
Select Stations From July, 1992 Sampling
Site E
40
41
42
Deep Water Site
44
45
46
See Tables
2 for Physical Analyses
3 for Metal Analyses
N
1 0 1 2 Miles

Figure 8

MCR Deep Water Site
Tongue Point Monitoring Program from 1989- 1992



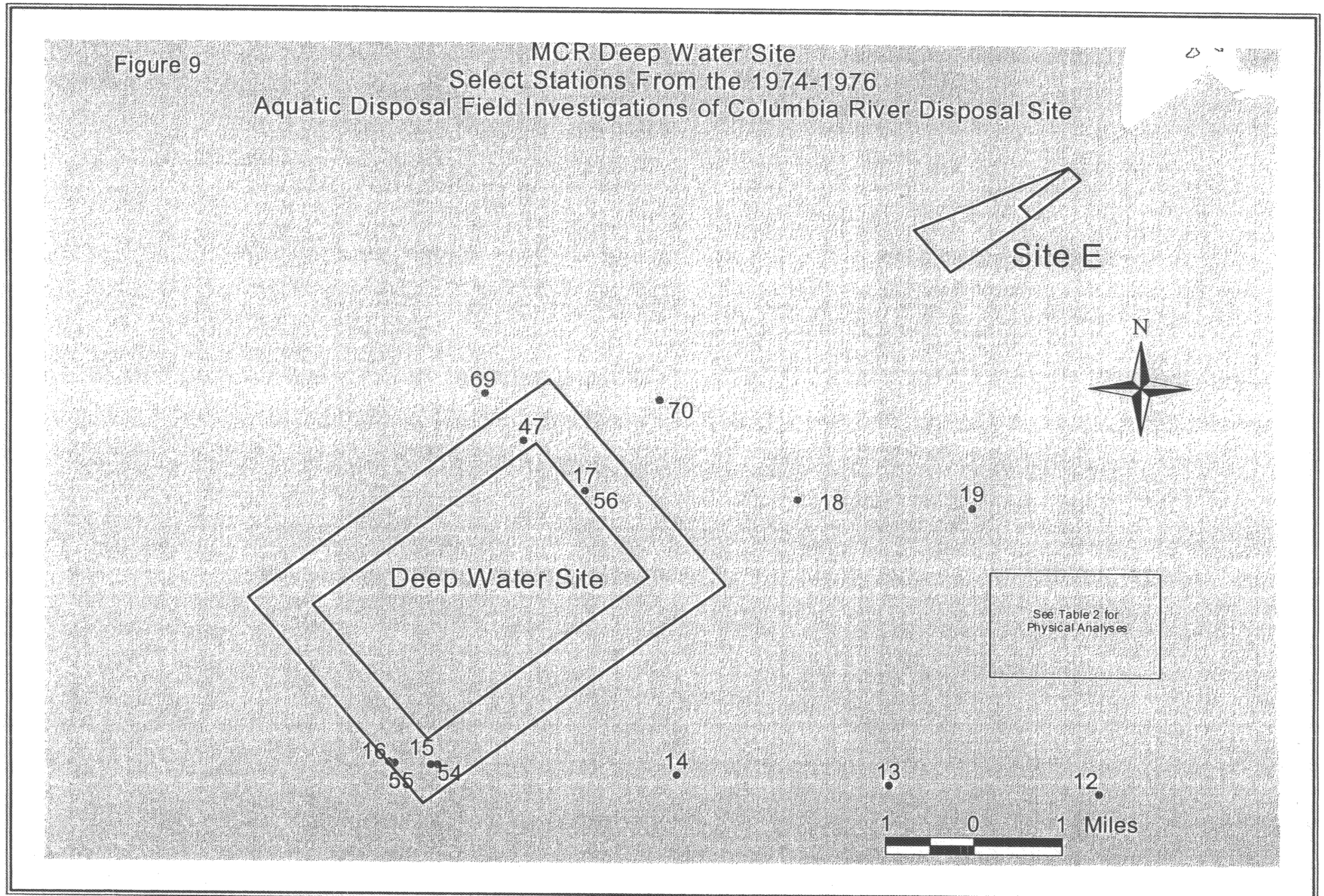
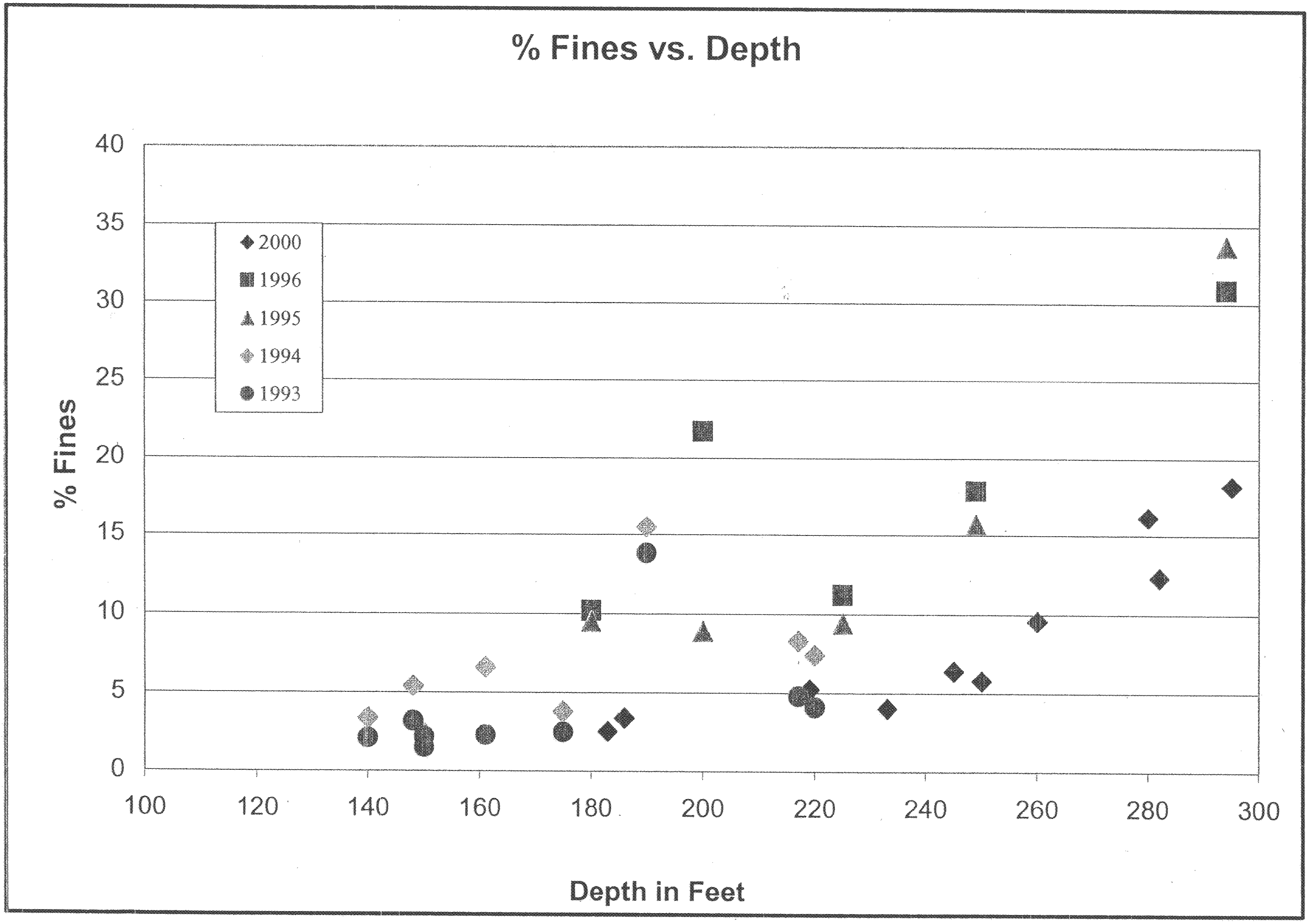


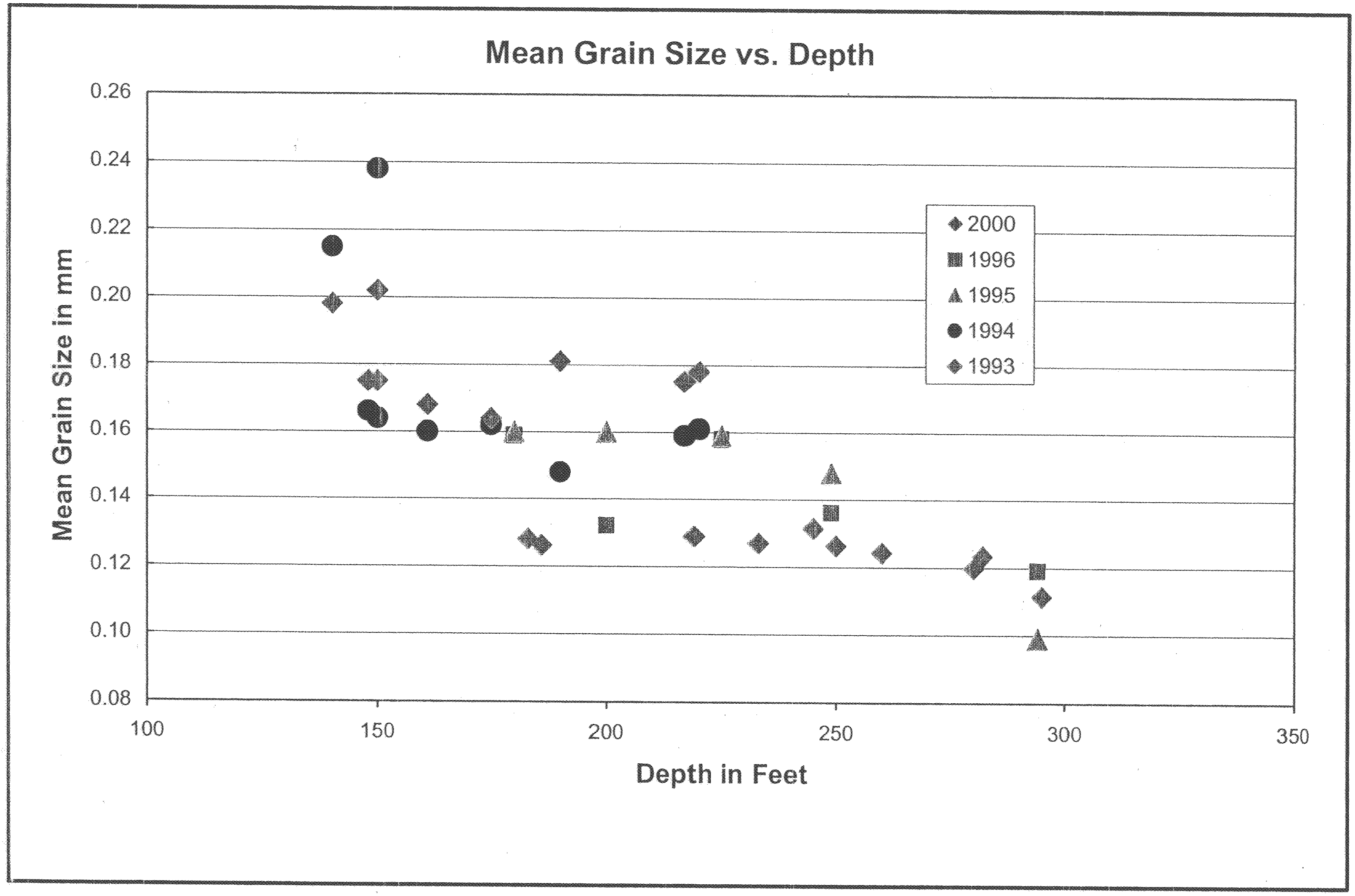
Figure 9
MCR Deep Water Site
Select Stations From the 1974-1976
Aquatic Disposal Field Investigations of Columbia River Disposal Site
Site E
N
69
70
47
17
56
18
19
Deep Water Site
See Table 2 for Physical Analyses
16
15
55
54
14
13
12
1 0 1 Miles

Figure 10



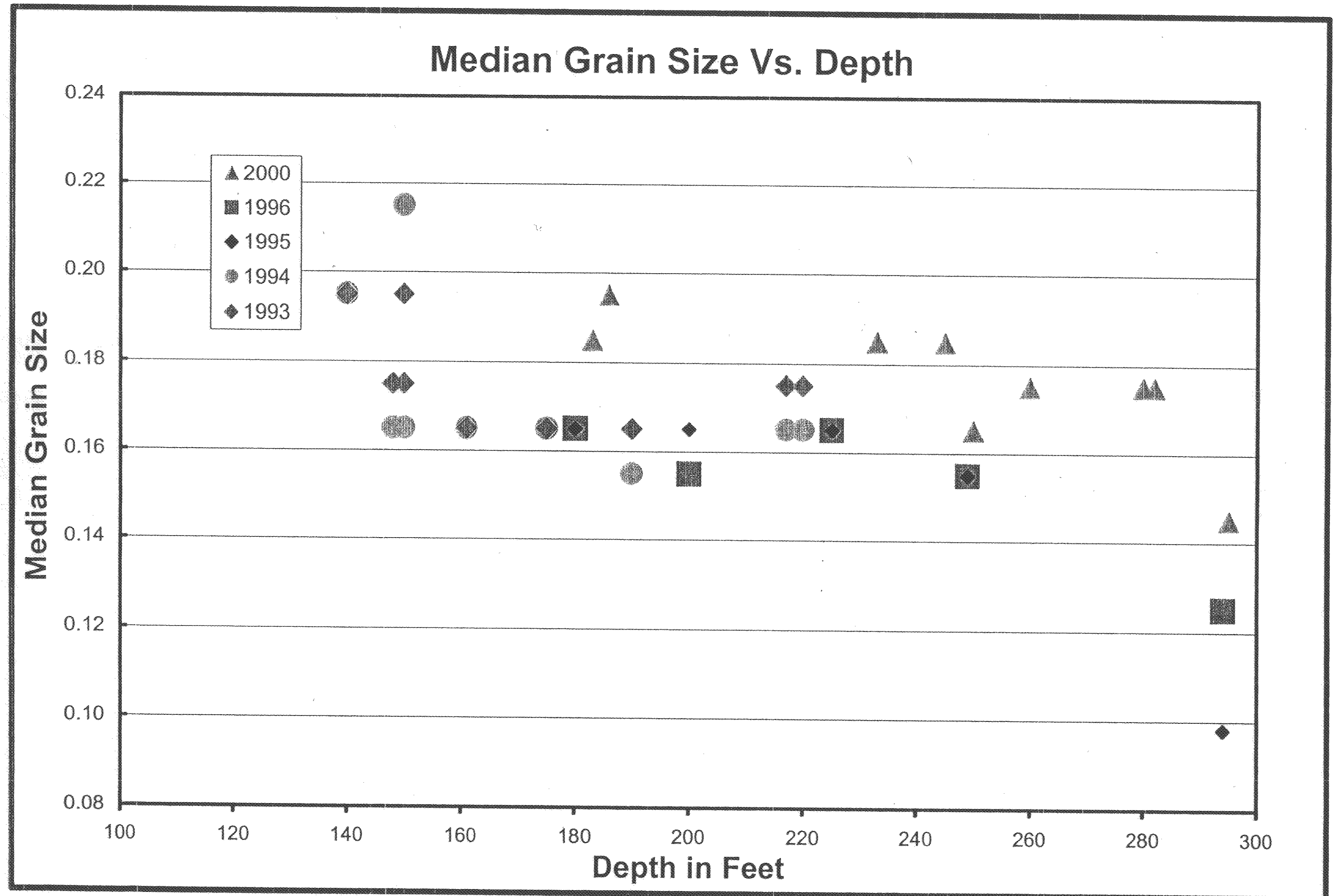
% Fines vs. Depth
% Fines
Depth in Feet
0
5
10
15
20
25
30
35
40
100
120
140
160
180
200
220
240
260
280
300
2000
1996
1995
1994
1993

Figure 11

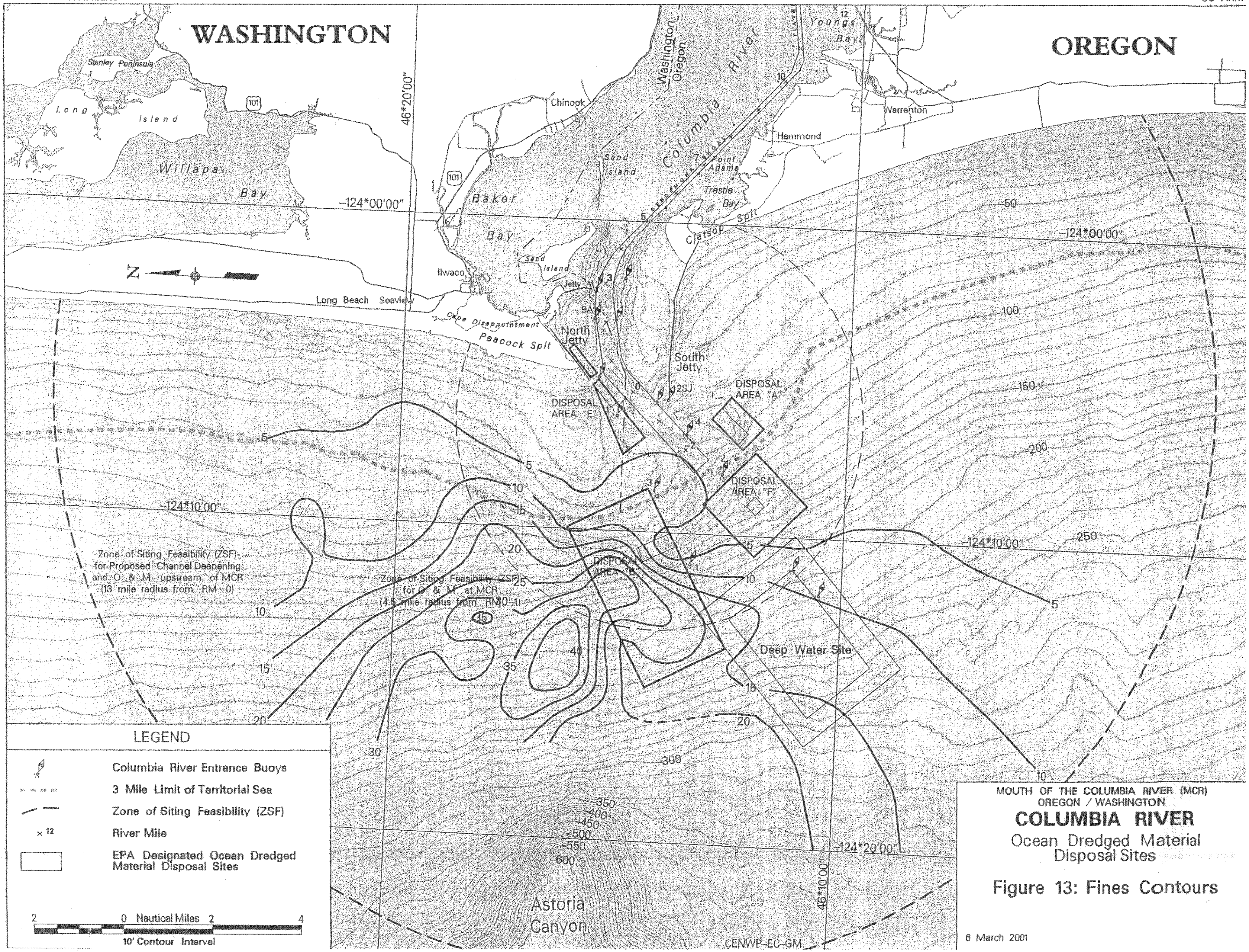


Mean Grain Size vs. Depth
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
Mean Grain Size in mm
100
150
200
250
300
350
Depth in Feet
2000
1996
1995
1994
1993

Figure 12



Median Grain Size Vs. Depth
2000
1996
1995
1994
1993
Median Grain Size
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
100
120
140
160
180
200
220
240
260
280
300
Depth in Feet



MOUTH OF THE COLUMBIA RIVER (MCR)
OREGON / WASHINGTON

COLUMBIA RIVER

Ocean Dredged Material Disposal Sites

Figure 13: Fines Contours

6 March 2001

Attachment C

Physical Baseline Study

Seafloor Mapping Survey

(Side Scan Sonar and Acoustic Sediment Classification)

Deep Water Site

By

Parametirx, Inc.

Funded By

EPA, Region 10 and USACE, Portland District

2001

Final Report

Seafloor Mapping Survey, Proposed Deepwater Disposal Site, Offshore Columbia River, Oregon

Prepared for

US Army Corps of Engineers
Portland District
PO Box 2946
Portland, Oregon 97208-2946

Prepared by

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February 2001
Project No. 553-3978-001

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1. INTRODUCTION

The Portland District , U.S. Army Corps of Engineers (COE) is conducting baseline studies of ocean dredge material disposal sites for disposal of material dredged from the Columbia River mouth (MCR) and navigation channel. The identification of existing materials on the ocean floor is a necessary part of this study. To meet these objectives, hydrographic surveys using side scan sonar (SSS) and bathymetric systems were conducted to continuously map the seafloor in the vicinity of the proposed Deepwater Disposal Site. Side scan sonar was used to identify surface material types and boundaries, geomorphic features such as location and size of sand waves and rock outcrops; and any cultural resources such as shipwrecks or debris. Accurate depth data was collected as part of the survey to provide updated bathymetric mapping of the site. Sediment classification was accomplished using the RoxAnn™ Seabed Classification System (RoxAnn™) operating in conjunction with the vessel's echosounder. Surficial seabed sediments were successfully classified by material type using the low (33 kHz) frequency of the dual frequency echosounder. The following report describes the procedures and results of this survey conducted to characterize seabed conditions at the proposed Deepwater Disposal Site.

1.1 AREA OF INVESTIGATION

The area surveyed is the proposed Deep Water Disposal Site defined by the Portland District. The site is located approximately 6 to 9 miles offshore of the MCR jetties as shown by Figure 1-1. The Deep Water Site encompasses an area approximately 4 miles by 3 miles oriented in a Northeast to Southwest direction along the longest dimension. Water depth ranges between approximately 200 and 300 feet, sloping at a fairly uniform rate away from shore.

1.2 PREVIOUS INVESTIGATIONS

Sediment samples used in conjunction with the RoxAnn™ seabed classification were collected by GeoSea Consulting under a separate contract. Physical analysis was conducted by the COE's contract laboratory and information provided to Parametrix for inclusion in this report. The sediment samples were collected between September 1-3, 2000 using a Shiptek grab sampler and represent surface sediments at the sample location.

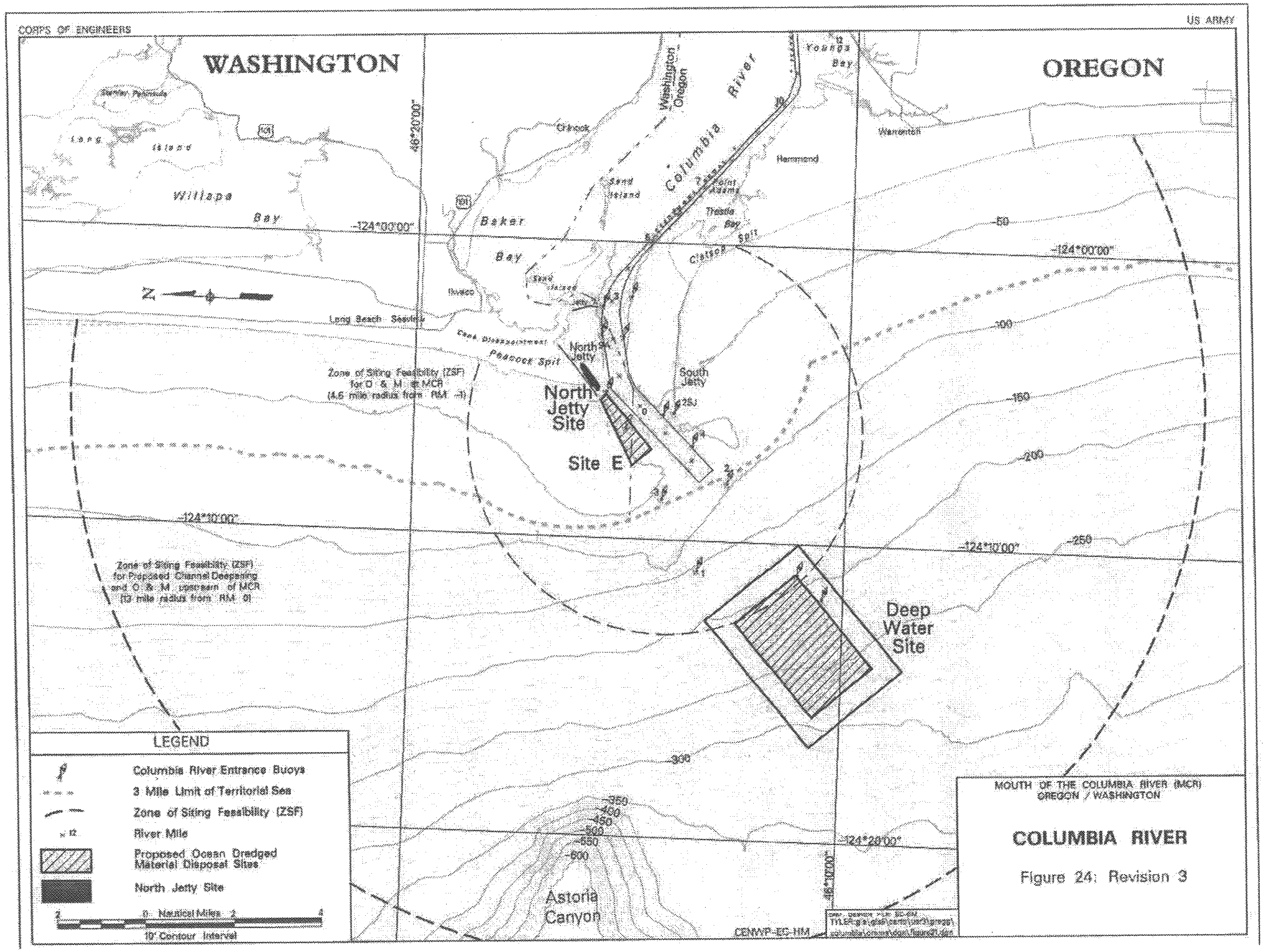


Figure 1-1
Vicinity Map, Deep Water Disposal Site

2. SURVEY, EQUIPMENT, AND PROCEDURES

The survey was conducted October 2 – 7, 2000, aboard the COE survey vessel *HICKSON*. In addition to the *HICKSON*, the COE provided horizontal positioning and depth measurements. The vessel returned to dock at the Tongue Point facility each day after surveys.

2.1 SURVEY

All surveys, i.e., SSS, RoxAnn™, and bathymetry, were conducted concurrently along identical survey tracks. A total of 31 survey lines oriented in a Northwest-Southeast direction (short dimension of the site) and spaced approximately 750 ft apart were required to completely map the entire area. This orientation allowed for optimum survey conditions with the prevailing seas. Actual survey track lines coincide with the sediment tracks presented in the sediment classification map discussed later in this report (Figure 3-4).

2.2 EQUIPMENT AND PROCEDURES

The survey consisted of three specific acoustic systems: precision echo sounding to determine bathymetry, SSS, and the RoxAnn™ acoustic signal processing unit to determine surficial sediment conditions. Table 2-1 lists the instruments used.

Table 2-1 Instrumentation

System	Model	Comments
Navigation	Ashtec Differential Global Positioning System	Position accuracy ± 3 ft.
Navigation Software	HYPACK™	Position logging and survey control for all systems
Precision Echosounder	Krupp DESO 17	Dual freguency single beam bathymetry and RoxAnn™. System vertical accuracy of ± 0.5 ft.
RoxAnn Seabed Classification System	Marine MicroSystems Stereo System	Receiver connected in parallel with low frequency (33-kHz) DESO17. Data collected at 1-sec intervals. Vertical accuracy ± 1-ft.
Side Scan Sonar	Edgetech DF1000	Dual frequency (100/500 kHz). Survey conducted at 100-kHz.
Sonar Acquisition System	Triton-Elics ISIS System	Side scan data collection and processing.

Following is a short description of selected instrument items and procedures for their operation as utilized for this survey.

2.2.1 Survey Vessel.

The COE survey vessel *HICKSON* was mobilized to perform all acoustic surveys for the MCR Deep Water Site study. The precision echosounder and navigation systems aboard the *HICKSON* were used for navigation and bathymetry information. The SSS and RoxAnn™ systems were mobilized just prior to the surveys. The SSS tow fish was deployed off the stern using the ship's davit and a marine winch as shown in Figure 2-1. The RoxAnn™ system was also installed during mobilization and attached in parallel with the echosounder.

2.2.2 Navigation.

An Ashtec Differential Global Positioning System (DGPS) was used for positioning. Real-time differential corrections were obtained automatically using the strongest detected differential correction transmission. Survey navigation control and data acquisition was accomplished with the HYPACK™ surveying package by Coastal Oceanographics. This system received data from the positioning system and fathometer, performed the appropriate geodetic transformations, and then transmitted corrected position and depth information to other instrument packages aboard the *HICKSON*. Coordinates used for this investigation are Oregon State Plane, North Zone, NAD27 datum.

2.2.3 Precision Fathometer.

A Krupp Atlas DESO17 dual frequency echosounder, operating at frequencies of 210- and 33-kHz was used for all precision bathymetric work. COE personnel post-processed all bathymetric data and provided Parametrix the tide-corrected depth data for mapping.

2.2.4 RoxAnn Seabed Classification System.

The RoxAnn™ system is an entirely automatic signal processing unit designed to supply seabed sediment hardness (similar to acoustic impedance) and sediment texture, or topographical roughness, information derived from fathometer soundings. The RoxAnn™ Stereo receiver and signal processing unit, shown aboard the *HICKSON* in Figure 2-2 was connected in parallel with the onboard 33-kHz fathometer frequency at the transducer terminals. Operational inefficiencies with the onboard 210-kHz frequency prevented successful interfacing of the RoxAnn™ system with the DESO17. A second echosounder was brought onboard for the high-frequency measurements. An Odom Hydrotrac, operating at 205-kHz was successfully interfaced with the RoxAnn™ with the transducer deployed over the starboard side of the vessel. The RoxAnn™ signal processing unit operates automatically providing E1 and E2 index values (roughness and hardness values, respectively), and depth data to an interface computer via RS-232C communications for data acquisition and display.

RoxAnn™ derives its information from the first and second echoes of a single transmission from a single beam echosounder. The index E1 is derived from the first echo and is the direct reflection from the seabed. Index E2 is produced from the second echo, or first multiple, and is hence related to the hardness of the seabed. The E1 and E2 values are normally presented as the 'y' and 'x' coordinates, respectively, on a Cartesian graph referred to typically as the RoxAnn™ Square. The RoxAnn™ Square for the Deep Water Site is presented later in this text as Figure 2-3. Since every sediment material has a unique signature, correlation of E1 and E2 data is accomplished through appropriate sediment sampling, or ground truthing. The RoxAnn™ Square is then edited to present sediment types as unique colors. The sediment classification can become as simple or complex as is required.

Figure 2-1. DF-1000 Tow fish and winch aboard *Hickson*.

Figure 2-2. RoxAnn Seabed Classification System in operation aboard *Hickson.*

As stated in the above paragraph, we encountered considerable difficulty in interfacing the RoxAnn™ Stereo system with the *HICKSON's* echosounding equipment. The high-frequency channel did not operate at sufficient signal strength to trigger the RoxAnn™ receiver. Field evaluations of the DESO17's performance revealed that the actual operating voltage across the transducer terminals was below the threshold level required by RoxAnn™. This could be the result of a possible impedance mismatch between the transducers and the DESO17 power amplifier. In addition, excessive high-frequency noise was measured on the signal further prevented good signal detection by RoxAnn™. It was decided the best solution was to use a different echosounder, even though that would require re-tuning the oscillator on the RoxAnn™ head amplifier to match the operating frequency of the new echosounder. This was successfully accomplished and seemed to work quite well in the shallow waters east of the jetties. Once the vessel reached waters greater than 85 ft in depth, the RoxAnn™ receiver was not able to properly detect seabed reflections. Sound pressure levels were not adequate with the nominal 200-kHz systems available for this survey to conduct a dual-frequency survey in the water depths at the Deep Water Site. The low frequency (33-kHz) system operated successfully the entirety of the survey.

2.2.4.1 *RoxAnn™ Calibration*

The RoxAnn™ operates as a passive receiver of acoustic signals generated by a standard single beam echosounder and modified by the seabed. RoxAnn™ discriminates between seabed types by identifying the differences in the modification of a signal by the seabed. This signal modification is represented by two unique parameters, E1, representing seabed roughness, and E2 loosely termed as hardness. Changes in E1 and E2 occur because seabed materials of different types reflect sound from the echosounder transducer slightly differently. These differences are measured voltage differences, measured as E1 and E2, in the strength of the returned echo.

In order to provide meaningful E1 and E2 data for a given survey area, the RoxAnn™ requires an initial calibration to adjust to the specifics of the echosounder and its transducer. This is carried out over known seabed conditions in a specific range of water depths. The type of seabed required for calibration depends on the frequency of operation. The manufacturer's recommendation for the 33-kHz low frequency system was to perform the calibration over a sandy bottom in a water depth between 100 to 175 feet.

For this survey, the low frequency RoxAnn™ calibration was performed near the eastern portion of the Deep Water Site over a known sandy bottom. System amplifier gain was adjusted to provide sufficient signal amplification to insure good detection of seabed echoes. Resulting E1 and E2 values were appropriate for this seabed type. The purpose and result of this onsite calibration of the electronics was to provide invariable raw E1 and E2 values suitable as reference data. After calibration, no further adjustments to either the echosounder operational settings or the RoxAnn™ receiver gain were allowed. Actual seabed classification was performed by correlating calibrated E1 and E2 values with known seabed data.

2.2.4.2 *RoxAnn™ Data Collection*

RoxAnn™ data was collected continuously along all survey tracks as shown by the sediment classification map accompanying this report. No stereo data was collected; i.e., only low frequency 33-kHz data was obtainable during the survey (refer to paragraph 2.2.4.). Data was collected at a 1-second interval during the survey. No averaging of the data was necessary due to the isotropic nature of the seabed.

2.2.4.3 *Seabed Classification using the RoxAnn™ Square*

Seabed classification is performed using the RoxAnn™ Square, a Cartesian (x, y) display of E1 values on the y axis and E2 values on the x axis, in conjunction with available sediment information. The data from a limited number of sediment samples, collected and analyzed under a separate field program, were provided by the Corps of Engineers to assist in classification of the seabed. These sample locations are shown on both the sonar mosaic and the sediment characterization maps included with this report. A summary of the sample analysis is provided in the following table.

Table 2-2. Sediment Sample Data

		Grain Size Distribution			Grain Size (mm)		Textural Classification	RoxAnn™ Values	
Sample ID	Depth (Feet)	Gravel	Sand	Clay/Silt	Mean	D50	Wentworth Scale	E1	E2
89	183	0	97.44	2.56	0.1230	0.16	Fine Sand	0.133	0.400
97	260	0	90.43	9.57	0.1192	0.16	Fine Sand	0.139	0.437
98	245	0	93.59	6.41	0.1263	0.16	Fine Sand	0.130	0.394
99	233	0	95.97	4.03	0.1219	0.16	Fine Sand	0.106	0.386
100	219	0	94.77	5.23	0.1239	0.17	Fine Sand	0.105	0.379
102	186	0	96.59	3.41	0.1211	0.16	Fine Sand	0.147	0.378
110	280	0	83.86	16.14	0.1147	0.15	Silty Fine Sand	0.158	0.451
133	295	0	81.79	18.21	0.1063	0.13	Silty Fine Sand	0.124	0.467
134	282	0	87.70	12.30	0.1183	0.15	Fine Sand	0.131	0.473
136	250	0	94.21	5.79	0.1212	0.15	Fine Sand	0.146	0.421

All samples within the limits of the Deep Water Site are uniformly classified as fine sand. Samples 97, 110, 133, and 134, retrieved from the deeper, west end of the site show increased percentages of clay/silts; i.e., greater than about 10% silt content. The remaining samples contain less than about 6% fine material. This translates into a computed grain size difference of about 0.01 mm reported as either the mean or as the D50 size (refer to Table 2-2).

To establish the RoxAnn™ Square parameters for classifying sediments, RoxAnn™ E1 and E2 data from the vicinity of the sample sites were used to match the sediment type to the plotted x/y location of the E1 and E2 values on the RoxAnn™ Square. Due to apparent sediment homogeneity, a large RoxAnn™ data subsample was used for the classification process. Data was gathered from within a 1000-ft diameter buffer around each sample location shown in Figure 3-4 accompanying this report and statistically evaluated. The arithmetic mean of the E1 and E2 values from each sample site is listed in Table 2-2. Interestingly, the two sediment groupings presented by the samples (fine sand and silty fine sand) showed an apparent measured difference in the E2 parameter. The average E2 value was 0.46 for silty fine sand (samples 97, 110, 133, and 134) as compared to an average of 0.39 for the remaining samples of fine sand. This seems to indicate that the silty fine sand areas are slightly 'harder' than the uniform sands. This is a reasonable response since the fines would introduce physico-chemical bonding forces within the sediment frame structure, effectively increasing the modulus of elasticity of the sediment and hence increasing acoustic impedance slightly.

Combinations of values for E1 and E2 that represent specific seabed types occupy specific areas within the RoxAnn™ Square. Figure 2-3 presents the RoxAnn™ Square developed for the Deep Water Site. The square was edited by assigning seabed types to areas occupied by the E1 and E2 values for that sediment. For the Deep Water Site, there are only two unique sediment types that were sampled allowing calibrated classification for echo responses within these two categories only. Other areas of the square were assigned specific seabed types based on experience and expected acoustic response. For example, in general soft smooth materials such as mud and silt have low E1 and E2 values that occupy the bottom left area of the square. Conversely, rough, hard materials have characteristically high E1 and E2 values that normally occupy the top right of the square.

2.2.4.4 *RoxAnn™ Seabed Mapping*

After establishing the classification model (RoxAnn™ Square) using the sample data, all E1 and E2 pairs measured for the entire survey were assigned a seabed type. Survey position information is recorded by the RoxAnn™ system simultaneously with each RoxAnn™ E1 and E2 value providing accurate mapping of the seabed. All post-processed RoxAnn™ data was compiled into an electronic database. The database is provided in both Excel and ASCII formats by survey track line number and is for surface sediments only. Each survey track line of data is presented as a separate worksheet in the Excel file. Individual ASCII files were created for each line. The file structure is as follows (one row for each data point):

Latitude, Longitude, Northing, Easting, Depth, Sediment Type, E1, E2.

Northing and Easting values are Oregon State Plane North, NAD27 and are in feet. Depth, reported in the database in units of meters, is not tide-corrected and is the detected value from the RoxAnn™ receiver. The sediment value is an arbitrary number assigned to represent a specific seabed type. A sediment definition table is included with the files. The E1 and E2 values are the RoxAnn™ texture and hardness parameters, respectively.

2.2.5 Side Scan Sonar

The Edgetech DF1000 dual-frequency side-scan sonar (SSS), shown in Figure 2-1, was operated at 100-kHz throughout the survey and was towed aft of the vessel. A layback of about 700-ft was required to lower the tow fish to an optimum height of approximately 65 feet (approximately 20 percent of total water depth) above the seafloor at a survey speed of approximately 4 knots. Actual layback was measured with a digital cable counter and recorded concurrently with the sonar data. The ISIS shipboard data acquisition and image processing system was used to acquire, store, and process all SSS and related data. Corrected position data was sent directly to the ISIS from HYPACK™. Actual tow fish position was calculated within ISIS using this position data, the tow fish layback value and measured survey heading. Real-time coverage maps were displayed during surveys to insure complete coverage of the seabed.

The ISIS system was also used to post process and mosaic the SSS imagery data. Signal processing involved smoothing of the navigation data, slant-range corrections and water column removal, and time-varied gain compensation. Compilation of individual geo-corrected sonar tracks into a single mosaic image was accomplished with TEI's DelphMap mosaicking and mapping package. The final sonar mosaic image was converted to a Tag(ged) Image File Format (TIFF) for mapping, presentation, and archiving.

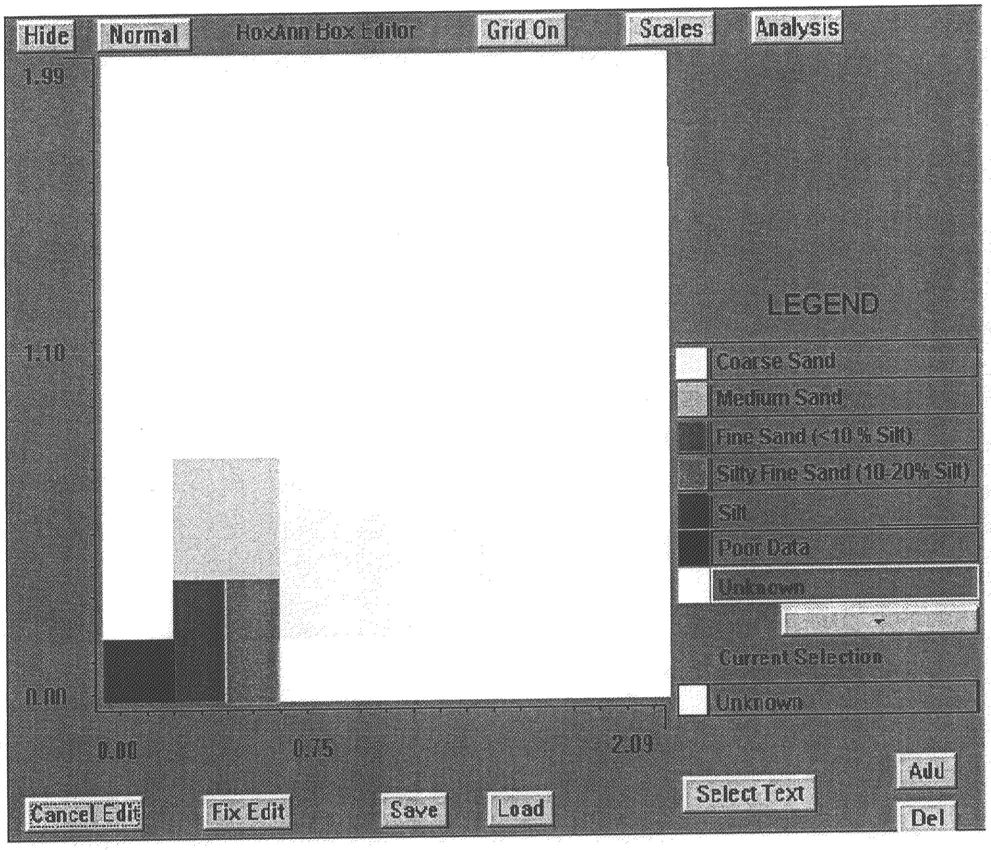


**Figure 2-3
RoxAnn Square,
Deep Water Site**

3. SURVEY RESULTS AND MAPPING

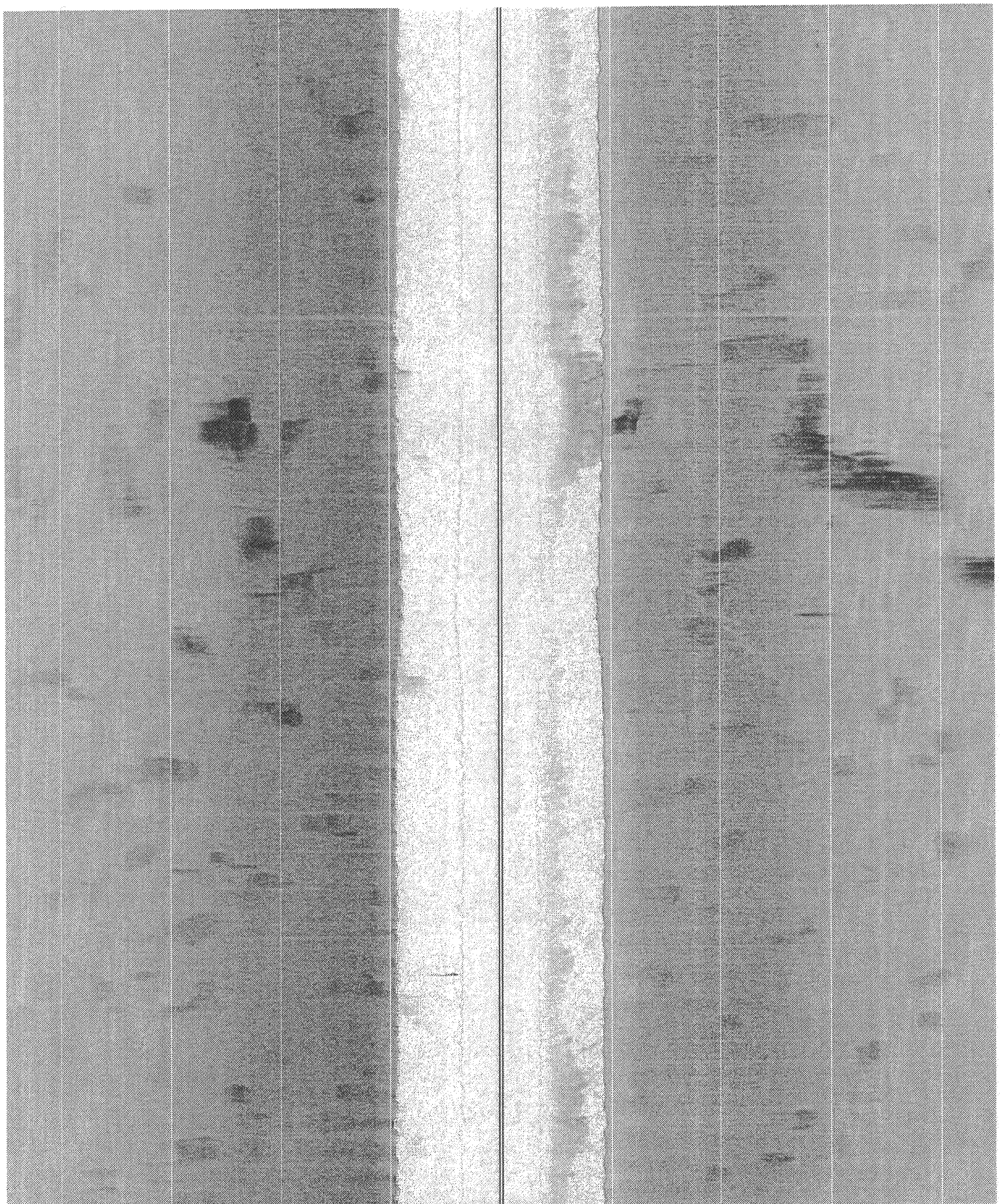
All data analysis, mapping, and presentation of results were accomplished within GIS. As directed by COE, electronic mapping products are provided in GIS format compatible for viewing in Arcview. Final mapping products accompanying this report include the *Side Scan Sonar and Bathymetric Survey* mosaic map (Figure 3-2), the *Sonar Interpretation* map of seabed conditions (Figure 3-3), and the *Sediment Classification* map derived from the RoxAnn^{TM} survey (Figure 3-4). Sediment sample locations and bathymetric contours are included with each plan view map.

3.1 OVERVIEW OF SEDIMENT CONDITIONS

Surface sediments within the Deep Water Site can be generally characterized as a homogeneous distribution of fine sand. Both the SSS and RoxAnn^{TM} data support this assessment. In general, acoustic reflectance, as shown by the sonar mosaic, presents a nearly featureless geomorphic configuration of the seabed. The smooth, even tone of the mosaic indicates no detectable differentiation in material type. The only apparent geomorphic feature within the surveyed area is a band of apparent low relief seafloor undulations in the eastern portion of the site (refer to sonar interpretation map). This feature, oriented North-South, may be an artifact of localized near-bottom currents. These features may not be seabed features at all, but rather returns from schools of fish hovering near the bottom. Field observations noted apparent heavy biological activity in the water column in this area during the time of survey. Figure 3-1 is a small section of sonar data taken from Line 8 showing the effect of fish schools on the sonar record. A number of large schools of fish of unknown type were detected throughout the survey area and their contacts identified on the interpretation map.

No significant cultural features or anthropogenic debris were identified within the boundaries of the Deep Water Site.

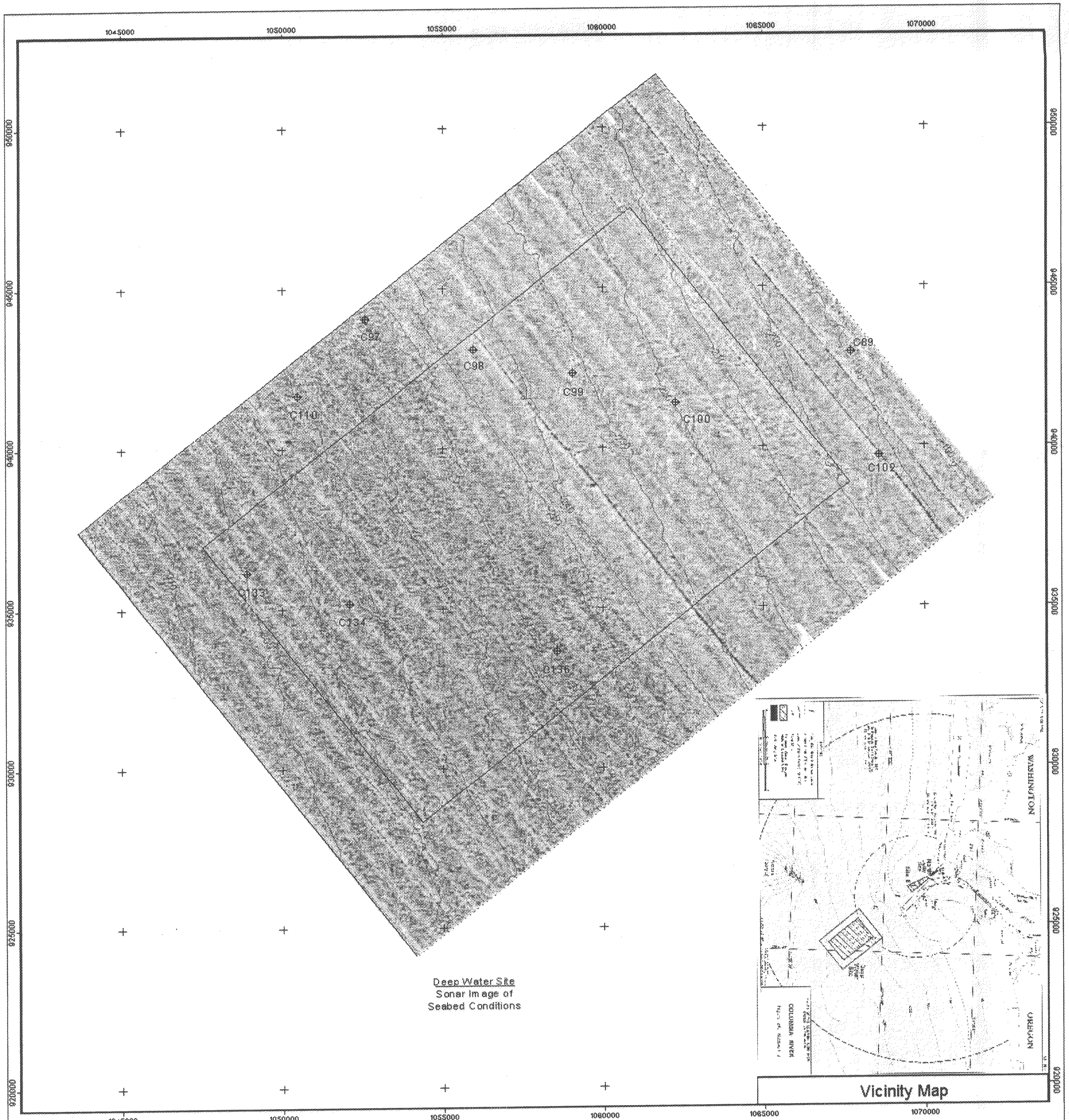
Only two sediment types were identified within the Deep Water Site; poorly graded fine sand (< 10 percent silt/clay fraction) and silty fine sand (> 10% silt/clay fraction). Sediments in the northern half of the site (above elevation –260 ft MLLW), as indicated by the sample data, consist primarily of fine sands containing only trace amounts of silt/clay material; i.e., less than approximately 6 percent silt/clay. Below this elevation the samples show increased percentages of silt/clays (12-16 %) in the sediments. As discussed in section 2.2.4.3, a measurable difference in acoustic response with the RoxAnn^{TM} between the fine sand and silty fine sand allowed the mapping of the distribution of both sediment types over the survey area. The seabed sediment classification map, RoxAnn^{TM} produced from RoxAnn^{TM} data, shows the sediments below elevation –260 ft MLLW to be mostly silty fine sand and sediments above this elevation to be poorly graded fine sand only.



Parametrix, Inc.

G:\DATA\working\3978\Report\Figure 2-3.doc

Figure 3-1
Example Sonar Image, Line 8
(Easting 1,064885, Northing 943,591)
Showing Possible Fish Schools
Near Bottom



Sediment Sample Data

Sample ID	Depth (ft, mllw)	Grain Size Distribution (%)			Grain Size (mm)		Textural Classification
		Gravel	Sand	Clay/Silt	Mean	D50	Wentworth Scale
89	183	0	97.44	2.56	0.1230	0.16	Fine Sand
97	260	0	90.43	9.57	0.1192	0.16	Fine Sand
98	245	0	93.59	6.41	0.1263	0.16	Fine Sand
99	233	0	95.97	4.03	0.1219	0.16	Fine Sand
100	219	0	94.77	5.23	0.1239	0.17	Fine Sand
102	186	0	96.59	3.41	0.1211	0.16	Fine Sand
110	280	0	83.86	16.14	0.1147	0.15	Silty Fine Sand
133	295	0	81.79	18.21	0.1063	0.13	Silty Fine Sand
134	282	0	87.70	12.30	0.1183	0.15	Fine Sand
136	250	0	94.21	5.79	0.1212	0.15	Fine Sand

Notes:
1. Mosaic boundary coincides with boundary of proposed Deep Water Site. Inner boundary shown is area designated as the Deep Water Placement Area.
2. All depths shown in feet relative to mean lower low water (MLLW).
3. Sediment samples were collected on September 1-3, 2000.

Acoustic Equipment:
1. Seafloor mosaic data from Edgtech DF-1000 Side Scan Sonar operated at 100-kHz.
2. Bathymetry data collected with Krupp DESO 17 operated at 200-kHz.

Legend

Bathymetric Contour

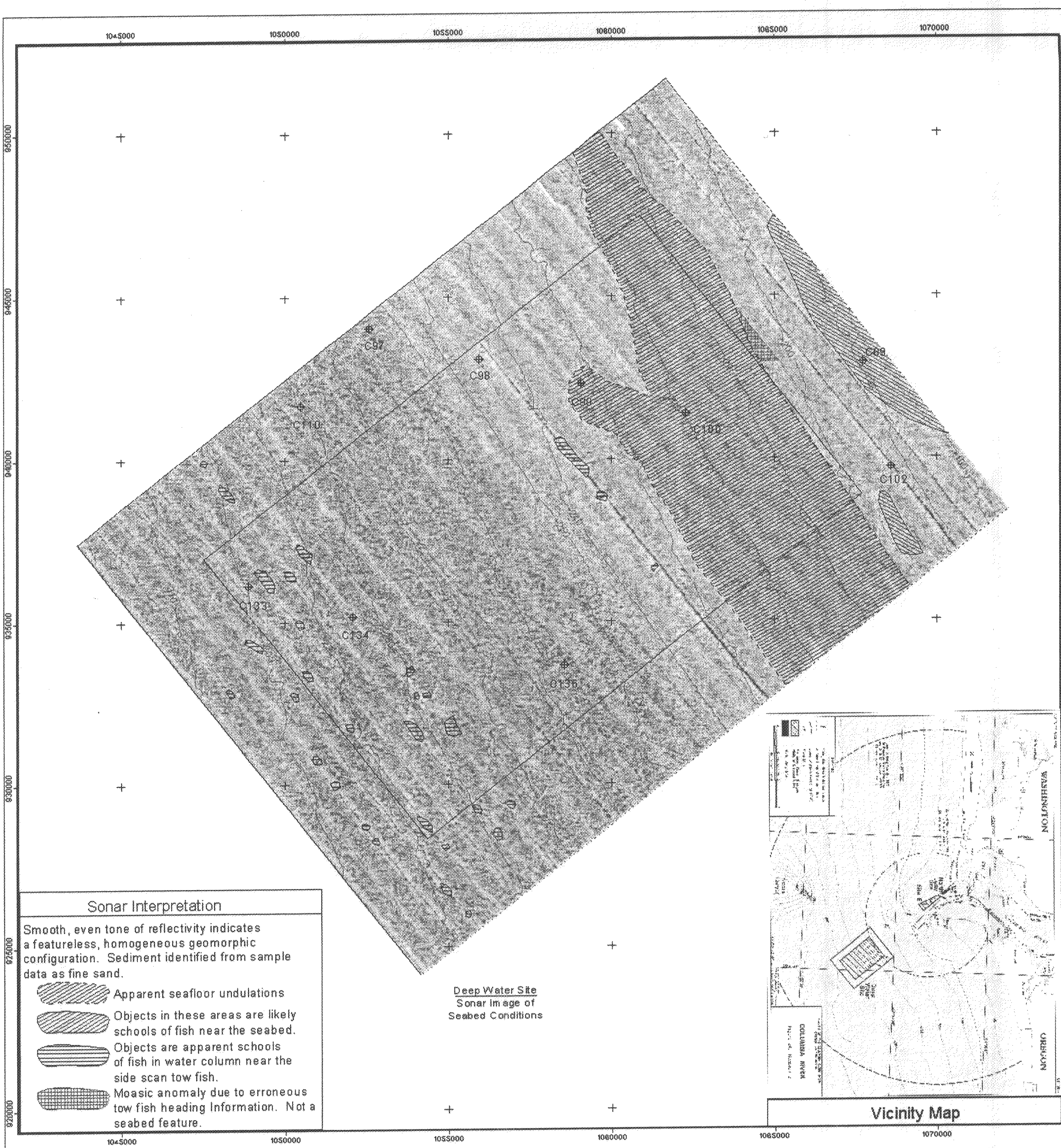
Sediment Sample Locations

Parametrix, Inc.
5808 Lake Washington Blvd. N.E.
Suite 200
Kirkland, WA 98033-7350
PH. (425) 822-8880

Figure 3-2
Side Scan Sonar and Bathymetric Survey

Proposed Deep Water Disposal Site
Offshore Columbia River, Oregon

Navigation System: ASHTEC DGPS
Projection: Oregon State Plane
Zone: North
Datum: NAD 27
Units: Feet
Survey Date: October 2-7, 2000
Scale: 1" = 1500
Drawn By: R. Rosario
Surveyed By: R. McGee
Interpretation By: R. McGee
Revised By: R. McGee
Checked By: R. McGee
Date: February 2001
Job No.: 555-3075-001
Filename: MCR.apr
Sheet No.: 1 of 1



Sediment Sample Data

Sample ID	Depth (ft, mllw)	Grain Size Distribution (%) Gravel	Sand	Clay/Silt	Grain Size (mm) Mean	D50	Textural Classification Wentworth Scale
89	183	0	97.44	2.56	0.1230	0.16	Fine Sand
97	260	0	90.43	9.57	0.1192	0.16	Fine Sand
98	245	0	93.59	6.41	0.1263	0.16	Fine Sand
99	233	0	95.97	4.03	0.1219	0.16	Fine Sand
100	219	0	94.77	5.23	0.1239	0.17	Fine Sand
102	186	0	96.59	3.41	0.1211	0.16	Fine Sand
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133	295	0	81.79	18.21	0.1063	0.13	Silty Fine Sand
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136	250	0	94.21	5.79	0.1212	0.15	Fine Sand

Notes:
1. Mosaic boundary coincides with boundary of proposed Deep Water Site. Inner boundary shown is area designated as the Deep Water Placement Area.
2. All depths shown in feet relative to mean lower low water (MLLW).
3. Sediment samples were collected on September 1-3, 2000.

Acoustic Equipment:
1. Seafloor mosaic data from Edgtech DF-1000 Side Scan Sonar operated at 100-kHz.
2. Bathymetry data collected with Krupp DESO 17 operated at 200-kHz.

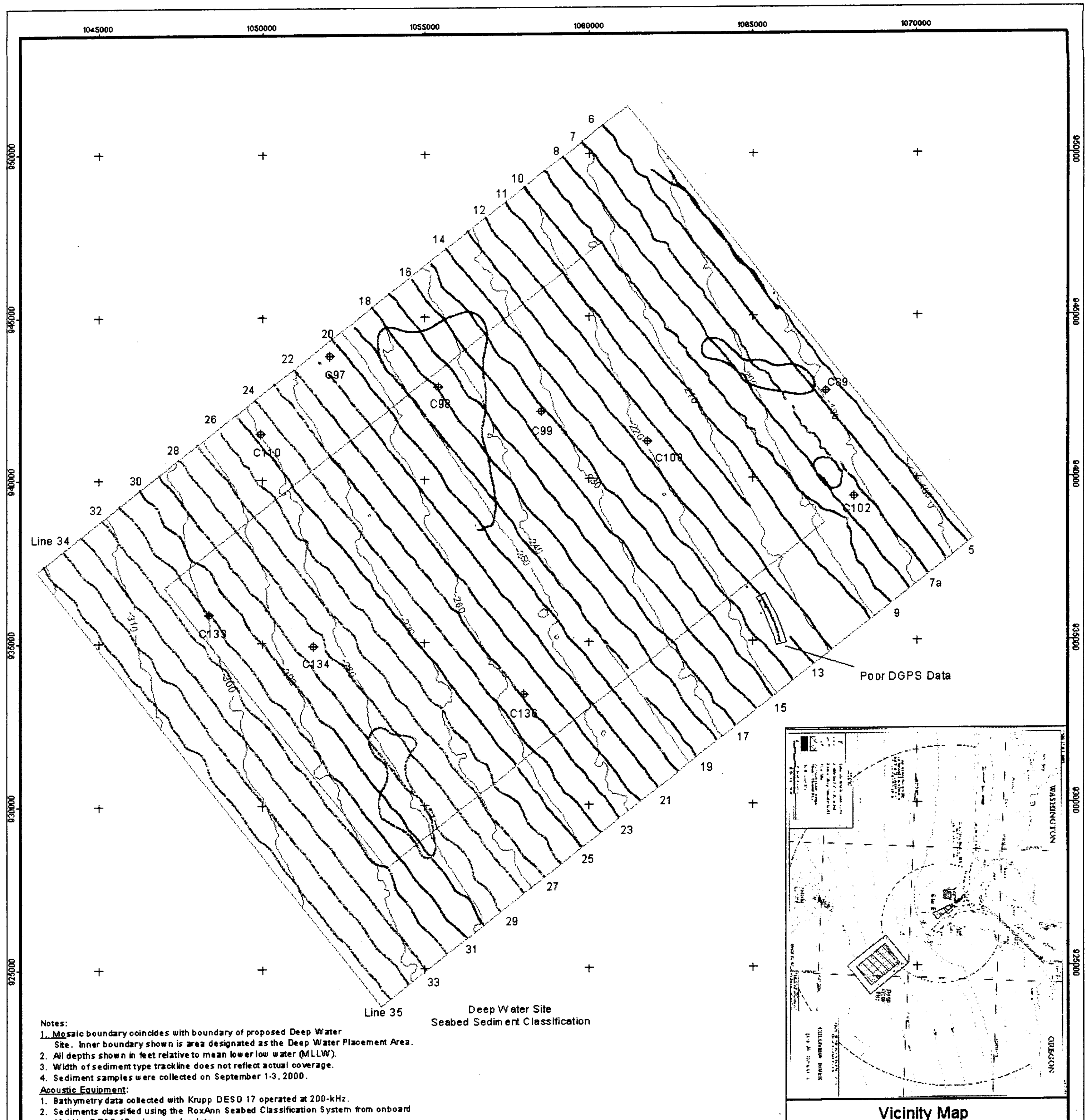
Legend
Bathymetric Contour
Sediment Sample Locations

Parametrix, Inc.
5808 Lake Washington Blvd. N.E.
Suite 200
Kirkland, WA 98033-7350
Ph. (425) 822-8880

Figure 3-3
Side Scan Sonar and Bathymetric Survey
Sonar Interpretation

Proposed Deep Water Disposal Site
Offshore Columbia River, Oregon

Navigation System: NS-TBC DGPS			
Projection: Oregon State Plane			
Zone: North			
Datum: NAD 27			
Units: Feet			
Survey Date: October 2-7, 2000	Surveyed By: R. McGee		Job No. 555-3078-001
Scale: 1" = 1500	Interpretation By: R. McGee	Checked By: R. McGee	Filename: MCR.apr
Drawn By: R. Rozario	Revised By: R. McGee	Date: February 2001	Sheet No. 1 of 1



Notes:
1. Mosaic boundary coincides with boundary of proposed Deep Water Site. Inner boundary shown is area designated as the Deep Water Placement Area.
2. All depths shown in feet relative to mean lower low water (MLLW).
3. Width of sediment type trackline does not reflect actual coverage.
4. Sediment samples were collected on September 1-3, 2000.

Acoustic Equipment:
1. Bathymetry data collected with Krupp DESO 17 operated at 200-kHz.
2. Sediments classified using the RoxAnn Seabed Classification System from onboard 33-kHz, DESO 17 echo sounder data.

1000 0 1000 Feet

Sediment Sample Data

Sample ID	Depth (ft, mllw)	Grain Size Distribution (%) Gravel	Sand	Clay/Silt	Grain Size (mm) Mean	D50	Textural Classification Wentworth Scale
89	183	0	97.44	2.56	0.1230	0.16	Fine Sand
97	260	0	90.43	9.57	0.1192	0.16	Fine Sand
98	245	0	93.59	6.41	0.1263	0.16	Fine Sand
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134	282	0	87.70	12.30	0.1183	0.15	Fine Sand
136	250	0	94.21	5.79	0.1212	0.15	Fine Sand

Legend

- Bathymetric Contour
- Sediment Sample Locations

Sediment Classification

	D50:mm	Description
	0.07 - 0.15	Silty Fine Sand (10-20% Silt)
	0.15 - 0.25	Fine Sand (< 10% Silt)
	-	Poor Data

' Grain Size Classification, Wentworth Scale

Parametrix, Inc.
5808 Lake Washington Blvd. N.E.
Suite 200
Kirkland, WA 98033-7350
Ph. (425) 822-8880

Figure 3-4
Sediment Classification

Proposed Deep Water Disposal Site
Offshore Columbia River, Oregon

Navigation System: AGNTBC DGPS	Surveyed By: R. McGee		Job No. 556-2078-001
Projection: Oregon State Plane	Interpretation By: R. McGee	Checked By: R. McGee	Filename: MCR.apr
Zone: North	Revised By: R. McGee	Date: February 2001	Sheet No. 1 of 1
Datum: NAD27			
Units: Feet			
Survey Date: October 2-7, 2000			
Scale: 1" = 1500			
Drawn By: R. Rosario			

4. LESSONS LEARNED

Should the COE consider additional surveys of this type in this area, it is recommended that the following suggestions be taken into consideration. These recommendations were developed based on actual project conditions at the Deep Water site and on the contractor's general experience in conducting surveys of this kind. The systems used did provide the required results, i.e., sediment classification and seabed geomorphic configuration.

4.1 RoxAnn™ SURVEY

As stated in this report, the 200-kHz echosounders available for this survey were not suitable for deep water surveys, e.g., water depths greater than approximately 150 ft. The 200-kHz band of the DESO 17 system installed on the *HICKSON* was found to be operating at very low efficiency and was not operable with the RoxAnn™ system (refer to paragraph 2.2.4) in any water depth. The auxiliary echosounder, a 205-kHz Odom Hydrotrac system, performed well in shallow water up to about 80-ft depths with the RoxAnn™, but failed to operate in the deeper waters at the site. Although both systems accurately recorded depth data at the site, the signal strength of the reflected signals was assumed to be below the detection threshold of the RoxAnn™ head amplifier.

The dual frequency RoxAnn™ system may not be the most effective approach for determining thickness of sediment units. High-resolution subbottom profiling systems, such as the Chirp-type systems, are specifically designed for this purpose, providing accurate sediment thicknesses relative to the same bandwidth. There is a high probability that a sediment thickness will be reported using dual frequency systems even in vertically homogeneous sediment environments due to the difference in resolution between the two frequencies. This was actually observed during sea trials in shallow water during survey mobilization. The RoxAnn™ system does not allow any operational control of the internal detector circuits within the receiver to adjust or select actual seabed reflections. Also, sediment characterization using the RoxAnn™ approach would require sediment cores into the substrate for calibration of subsurface sediments. Subbottom systems provide for the assessment of subbottom sediment types through analytical processes, requiring only minimum subsurface ground truth data.

If characterization of surficial sediments is all that is needed, the RoxAnn™ system is recommended due to it's ease of use and reproducible operability. For follow-on monitoring surveys of surficial sediment conditions at this site, a single frequency, 33-kHz RoxAnn™, is recommended.

Recommendations:

- Inspect and possibly repair the apparent malfunction of the 210-kHz channel of the DESO 17 unit.
- Deploy a higher source level 200-kHz echosounder with a longer pulse width and greater transmit power level if this frequency information is deemed a requirement.
- For subsurface sediment assessment, a Chirp Subbottom Profiler is recommended. An operating bandwidth of 2- to 16-kHz is further recommended for this environment.

- For follow-on monitoring surveys using RoxAnn™, the operational parameters defined for this survey should be followed exactly. This information is available from the survey field logs maintained at Parametrix.

4.2 SIDE SCAN SONAR SURVEY

The primary recommendation for future sonar surveys is to require the tow fish to be flown at an altitude not to exceed about 20 percent of the total water depth. For this survey a tow fish altitude of about 70 ft above the seafloor is recommended. An additional requirement may be to limit survey speed to a maximum of 4-5 knots. However, this is dependent on actual survey sea conditions and sonar system used.

Attachment D

Biological Baseline Study

Deep Water Site

And

Crab Abundance Study

Shallow Water Site

By

MEC Analytical Systems, SAIC, and EHI

Funded By

EPA, Region 10 and USACE, Portland District

2002

SCOPE OF WORK

1. PROJECT DESCRIPTION.

Portland District is working with the Environmental Protection Agency in their process of designating two ocean disposal sites off the mouth of the Columbia River. While the sites can be used by other entities or individuals, (through the Corps Regulatory permitting process) for dredged material disposal, the sites would primarily be used by the Corps for disposal of material dredged from the entrance channel to the Columbia River. One of the sites, the Deep Water Site, is new and was selected after a several year process with federal and states agencies as well as interested private groups. The site was selected using existing information and was located in an area that the group felt would be least impacting to the resources and fisheries in the area as well as having a capacity for the 50 year planning life of the disposal action. The site is located approximately 10 miles offshore of the Columbia River mouth in water depths of 200-300 feet. The second site is an expansion of a historic site (Site E) at the tip of the Columbia River north jetty. It is doubled in size to the west and is now referred to as the Shallow Water Site. It is a highly erosive area that is generally believed to be unproductive except for possibly Dungeness crabs in the late summer. It is located in water depths of 40-80 feet in an extremely high energy environment. A limited amount of biological and sediment sampling has been done at the deep water site[1]. Results of this study has indicated that the site has moderately high benthic productive and is primarily fine grained sand. No previous sampling has been done at the shallow water site. A detailed description of the site selection process and available data is provided in Appendix H, Vol.1 and 2 to the Final Environmental Impact Statement for the Columbia River Channel Improvement Project which has been added to the CD for Solicitation DACW57-02-R-0010, <u>Environmental Studies at Two Ocean Disposal Sites Off the Mouth of the Columbia River</u>.

2. CONTRACTOR REQUIREMENTS

The contractor will be required to design an acceptable biological baseline study, conduct the study and prepare a final report that describes the study, the method of analysis and the final results. A comparison of these study results to previous studies in the area will also be required. This comparison will be used to assess the uniqueness of the site compared to rest of the coastal area. The proposed requirement will be issued by Request for Proposal, subject to availability of funds. The potential award date will be late spring to early summer in order that the sampling can begin in June of this year. Two seasons of sampling are envisioned, one in early summer and one in the late fall. The data analysis and report preparation will be completed by March 2003.

3. STUDY DESIGN CONSIDERATIONS.

It is envisioned that the study will be designed to adequately characterize the disposal sites from both a physical and biological standpoint. The study will involve an adequate physical and biological sampling of the sites. The data gathered will be used to establish baseline conditions as required by the site designation process so that a management and monitoring program can be developed. Sampling methodology as well as location and distribution of stations will be the responsibility of the contractor to design and recommend in the proposal. The sampling plan should be statistically credible as well as comparable with previous studies done in the area.

1. Hinton, S.A. 1998. Benthic infauna and sediment characteristics offshore from the Columbia River, October/November 1995 and June 1996. National Marine Fisheries Service, Seattle, WA

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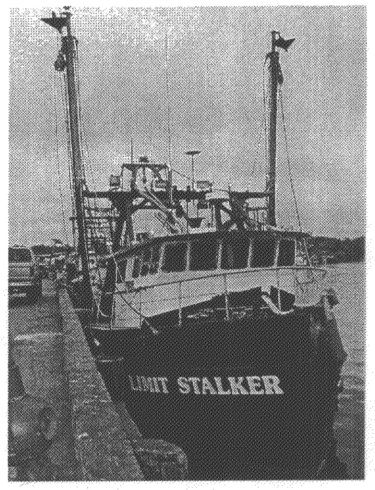
[1] Hinton, S.A. 1998. Benthic infauna and sediment characteristics offshore from the Columbia River, October/November 1995 and June 1996. National Marine Fisheries Service, Seattle, WA

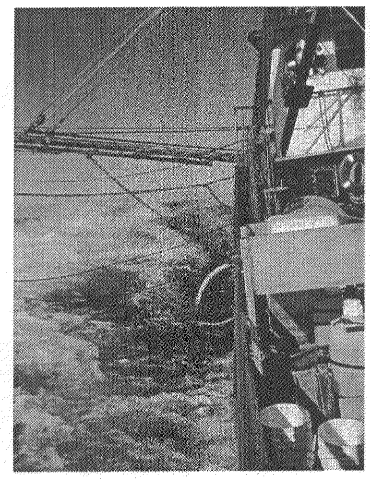
Methodologies should also be compatible with the "Revised Procedural Guide for Designation Surveys of Ocean Dredged Material Disposal Sites" Tech Report D-90-8, Water ways Experiment Station, Corps of Engineers, Vicksburg MS. http://www.wes.army.mil/el/dots/pdfs/trd90-8/preface.pdf . The contractor can propose other methodologies but sufficient justification must be provided to insure statistical validity as well as comparability with historic data. Collection of data on Dungeness crab populations will be particularly suitable to innovative approaches. Data will be analyzed using recognized statistical techniques to adequately describe the populations of organisms at the site. Finally the study should be designed in a manner that the results can be compared to previous studies and an overall assessment of how the site fits into the coastal community. An evaluation will be done of pelagic fish, in particular juvenile salmonids' use at water column over disposal sites.

MCR Ocean Disposal Sites

Preliminary Results on July 2002 Survey

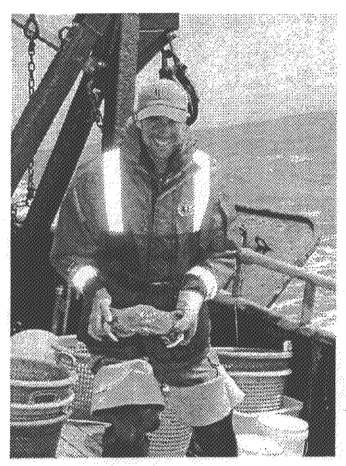
MEC Analytical Systems, SAIC and EHI





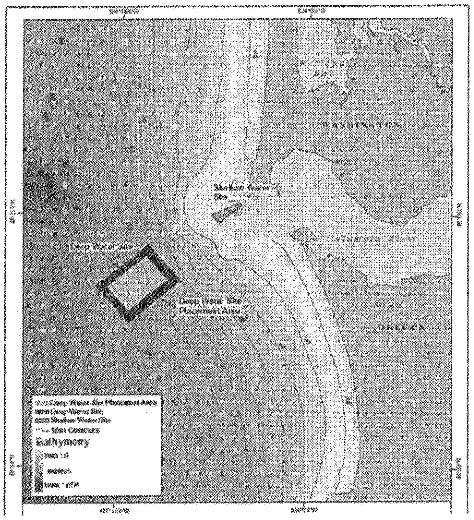
Presentation Objectives

- Overview of study objectives
- Overview of planned and accomplished sampling activities
- Preliminary data results
- Brief summary of September survey



Study Objectives

- Evaluate The **RELATIVE** Abundance Of Fishery And Ecological Resources **WITHIN AND BETWEEN** Alternative Disposal Sites.



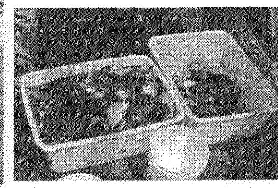
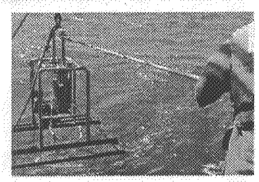
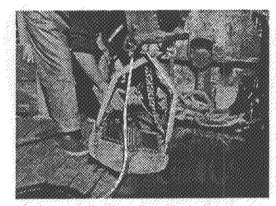
SAMPLING OBJECTIVES

SHALLOW WATER DISPOSAL SITE

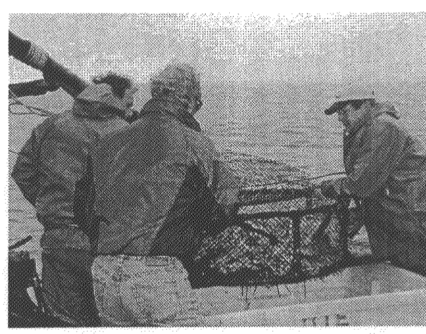
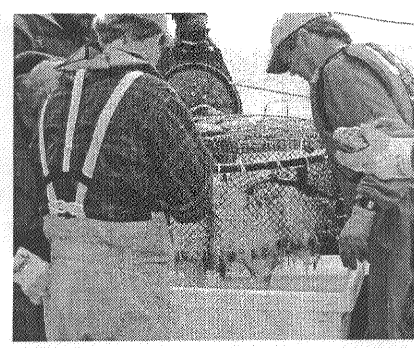
- Trappable Dungeness Crab Assessment Using Modified Commercial Crab Pots
- Demersal Fish and Invertebrate Assessment Using a Modified Willis Otter Trawl.

SAMPLING OBJECTIVES
DEEP WATER DISPOSAL SITE

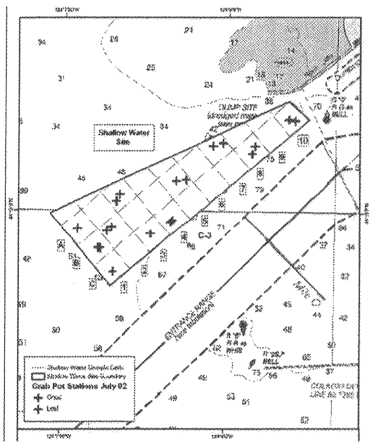
- Trappable Dungeness Crab Assessment Using Modified Commercial Crab Pots
- Demersal Fish and Invertebrate Assessment Using a Modified Willis Otter Trawl
- Distinguish Benthic Habitat Types Using Sediment Profile Imaging (SPI)
- Compare Benthic Community Structure and Function Within Deep Water Habitat Types Using Benthic Grab Samplers (Modified Double Van Veen Grabs)

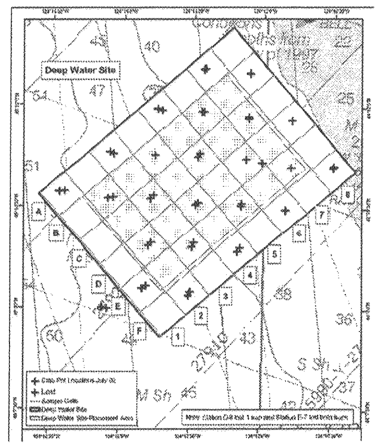





MODIFIED COMMERCIAL CRAB POT SURVEYS

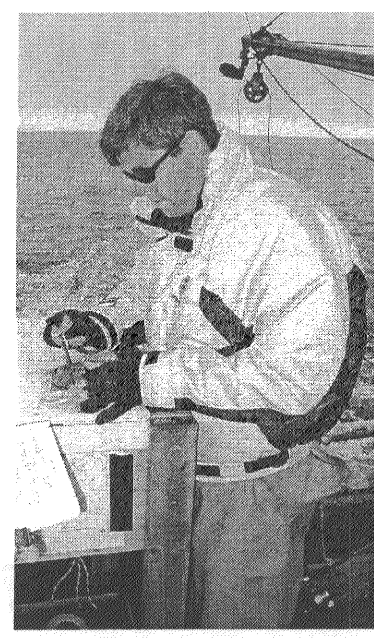



CRAB POT SURVEY LOCATIONS





CRAB POT DATA SUMMARY



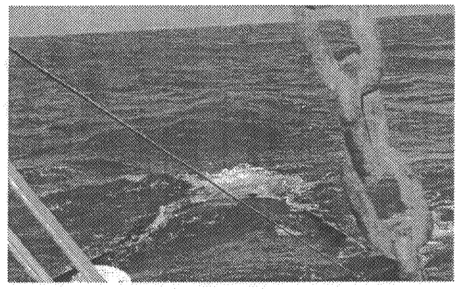
Shallow Water Site

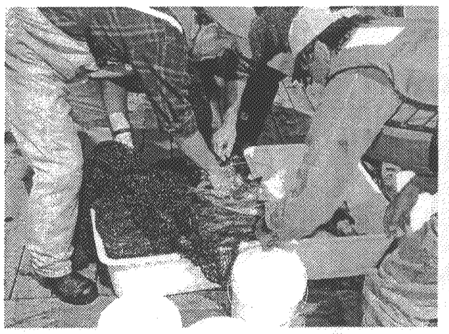
- <77 Crab/24 hour soak
- 18/22 deployments recovered
- 451 crab recovered = ~25/pot/24 h soak
- Average carapace length = 5.1 inch
- Majority were female (~75%) and < legal size
- Majority were relatively soft (merus deflection with slight pressure)

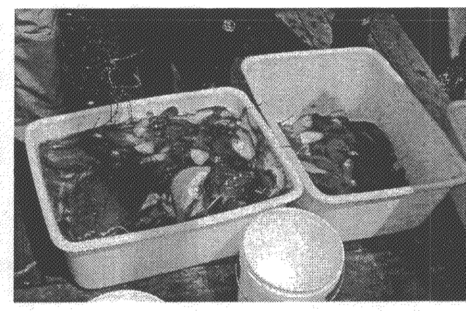
Deep Water Site

- <10 crab in one 24 hour soak
- 46/48 deployments recovered
- 82 crab recovered = <2/pot/24 h soak
- Average carapace length – 5.5 inch
- Majority were female (~80%)
- Majority were hard
- **Deep water crab were harder and larger on average but much fewer (>10-fold)**

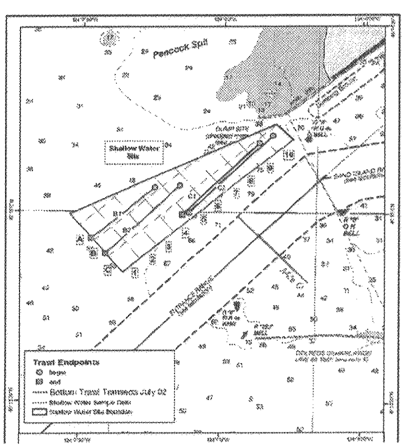
MODIFIED OTTER TRAWL SURVEYS

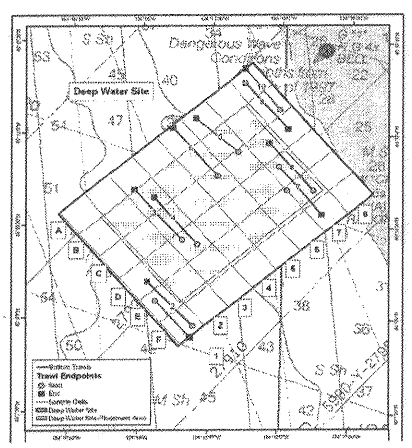






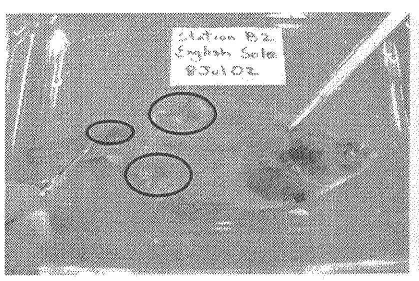
MODIFIED OTTER TRAWL SURVEYS

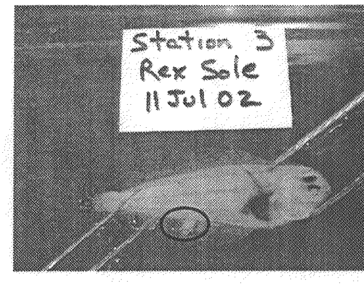


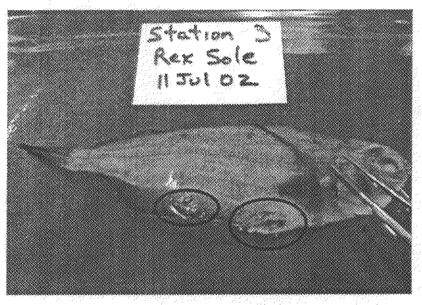


MODIFIED OTTER TRAWL SUMMARY OF SURVEYS

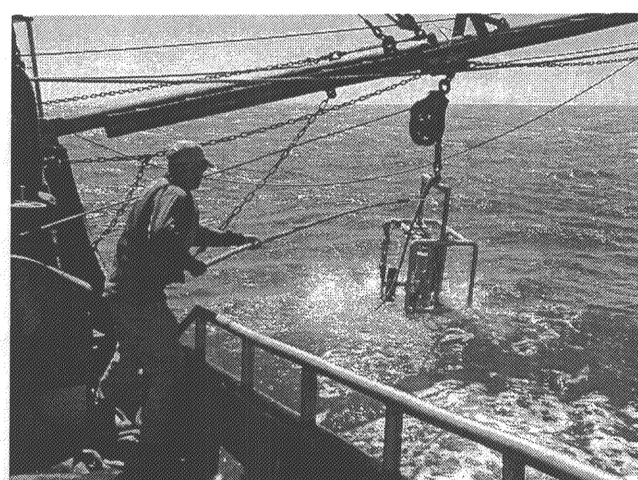
- Shallow Water Disposal Site – **(Round Fish and Crab)**
  - **No. Species** – 1-14 fish, 1-5 of invertebrates
    - Dominant type of species – round fish, shrimp
  - **Abundance** – 5-762 fish; 82-149 invertebrates
    - Most abundant – Tom Cod (<228)/Eulachon (<356); Crangon nigrocauda (<149)
  - **Biomass** - <1-78 kg fish; < 50 kg of inverts
    - Highest biomass – Big Skate (<48 kg); Dungeness Crab **(< 50 kg-estimated)**
  - **Diversity** – 0-1.96 Margalef fish;
  - English Sole with **tumors** (~10%)
- Deep Water Disposal Site - **(Flatfish and echinoderms)**
  - **No Species** – 5-11 fish; 5-12 inverts
    - Dominant type of species – flatfish/starfish; shrimp; anemones
  - **Abundance** – 43-1179 fish; 12-110 inverts
    - Most abundant – Pacific Sandab (<1072) or Rex Sole (<168); Crangon spp (<89); Luidia (<37); Metridium (<20)
  - **Biomass** – 2-52 kg fish; <5kg inverts
    - Highest biomass – Pacific Sandab (<34kg); Metridium/Pycnopodia/Rathbunaster (<1.5kg)
  - **Diversity** – 1.4 – 1.8 Margalef fish;
  - Rex Sole with **tumors** (~15%)



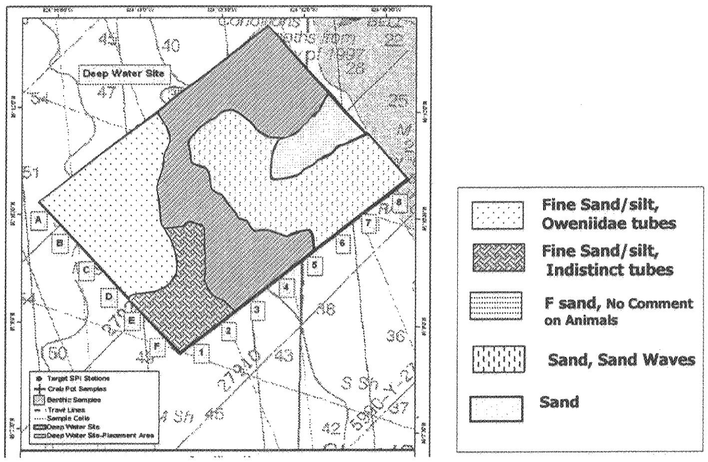




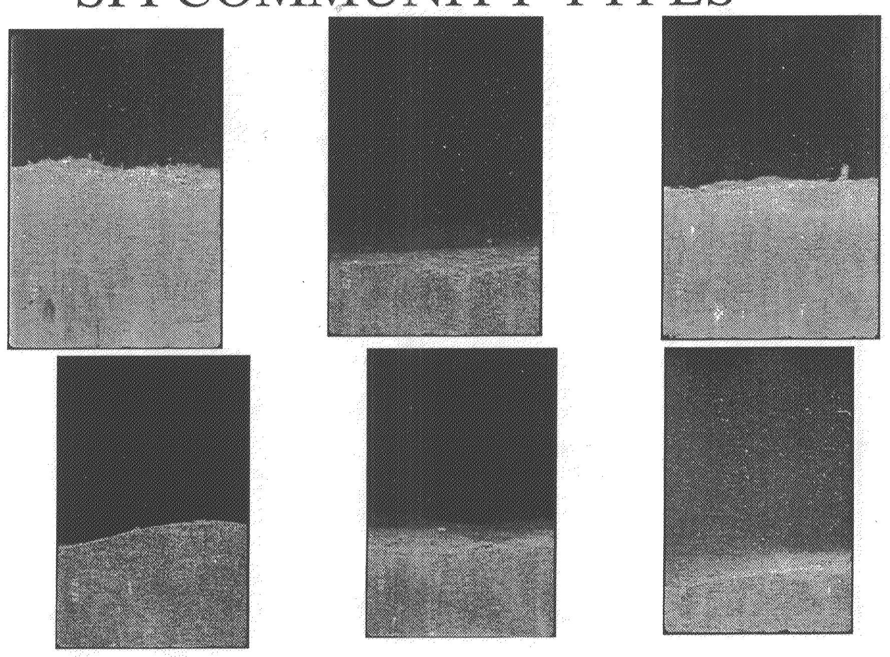
BENTHIC HABITAT TYPES USING SEDIMENT PROFILE IMAGING (SPI)



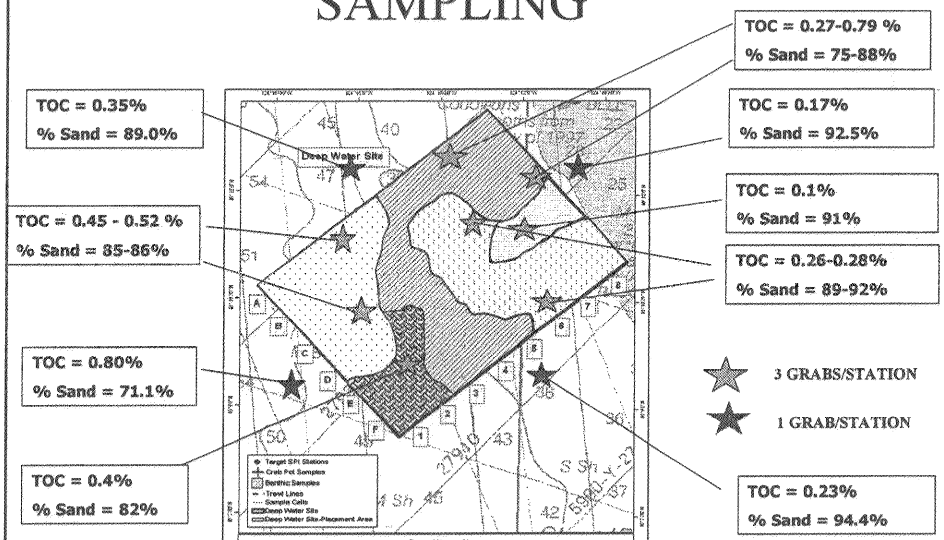
BENTHIC HABITAT TYPES USING SEDIMENT PROFILE IMAGING (SPI)



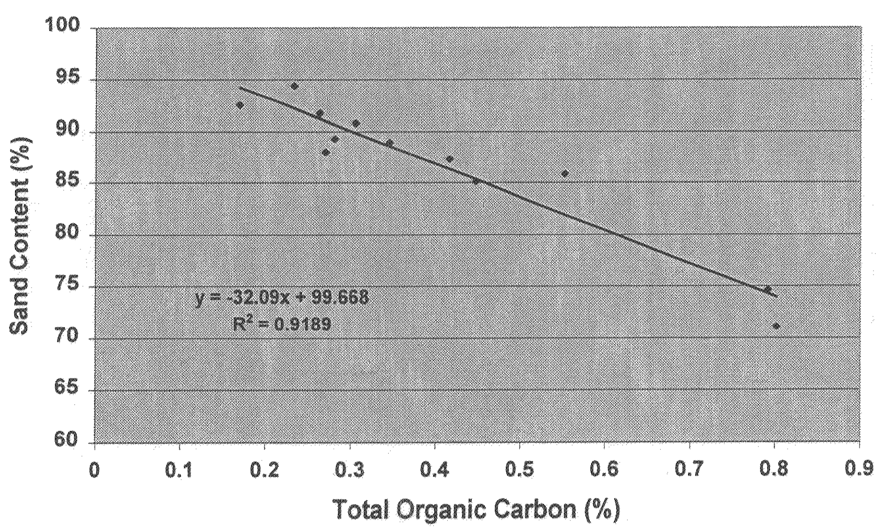
SPI COMMUNITY TYPES



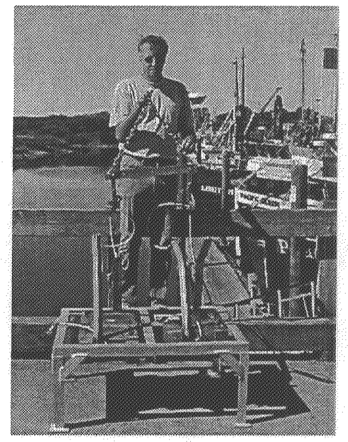
SPI SELECTION FOR BENTHIC SAMPLING

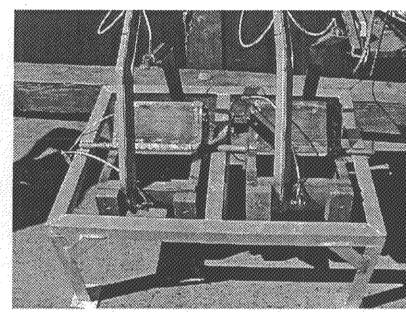


Relationships of Sediment characteristics

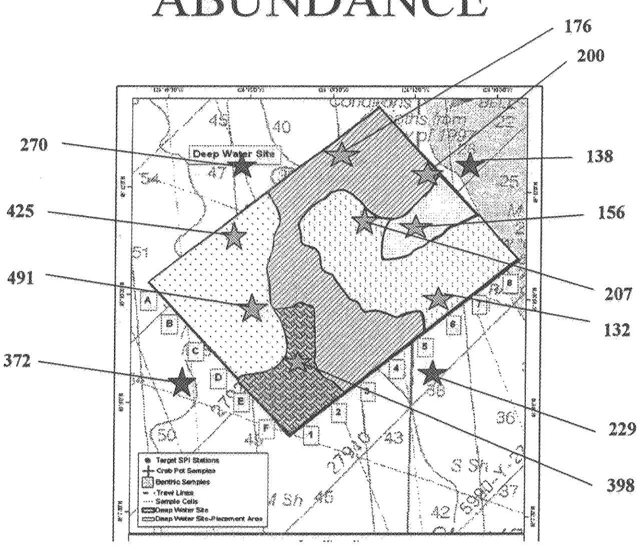


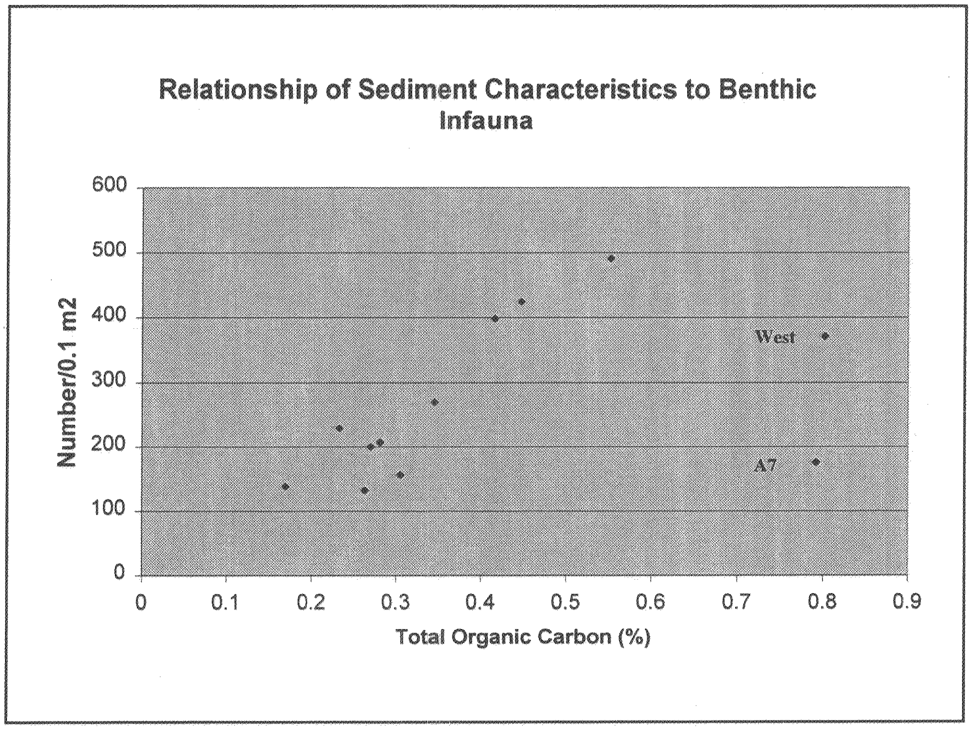
BENTHIC INFAUNA





BENTHIC INFAUNA ABUNDANCE




Relationship of Sediment Characteristics to Benthic Infauna
Number/0.1 m2
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Total Organic Carbon (%)
West
A7