Final Report

Seafloor Mapping Survey, Proposed Deepwater Disposal Site, Offshore Columbia River, Oregon

Prepared for

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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, Proposed 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. DF1000 Tow fish and winch aboard *HICKSON.*

Figure 2-2. RoxAnn^{TM} system.

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™ 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™ 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™ 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™ produced from RoxAnn™ 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.

Figure 3-1. Example sonar image from Line 8 (Easting 1,064,885 ft; Northing 943,591 ft) showing possible fish schools near bottom.

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.