FINAL REPORT

PHASE III
GEOPHYSICAL INVESTIGATION
OF THE DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PA

OSI REPORT NO. 94ES131C

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5 June, 1995

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1.0 INTRODUCTION

During the period 4-13 April 1995, Ocean Surveys, Inc. (OSI) conducted Phase III of a multi-phase marine geophysical survey investigation of the Delaware River. Phase III investigations were performed in the berthing areas and channel adjacent to the BP and Sun Oil terminals in Marcus Hook, PA (Figure 1). Present plans call for the widening and deepening of the Delaware River navigation channel from Philadelphia to the sea to safely accommodate larger bulk and container-type ships than can presently use the river for commerce. Similar to the preceding two phases of this investigation, Phase III geophysical investigations focused on delineating nearsurface rock underlying the river to aid in the development of an accurate cost estimate of rock removal for the proposed channel expansion project. This project was undertaken for ERM Program Management Company (ERM) working under subcontract to the U.S. Army Corps of Engineers (ACOE), Philadelphia District. For detailed discussion and analysis of data acquired during the previous phases refer to OSI Report Nos. 94ES131A & B entitled "Summary Report - Phase I" and "Final Report - Phase II", Geophysical Investigation of the Delaware River Main Channel, Philadelphia to the Sea Project - Philadelphia, PA", dated 2 January and 27 April 1995, respectively.

Following completion of the Phase III investigation and data interpretation, OSI made rock quantity estimates for Phase II Sites B and C and the Phase III site. Estimates of the

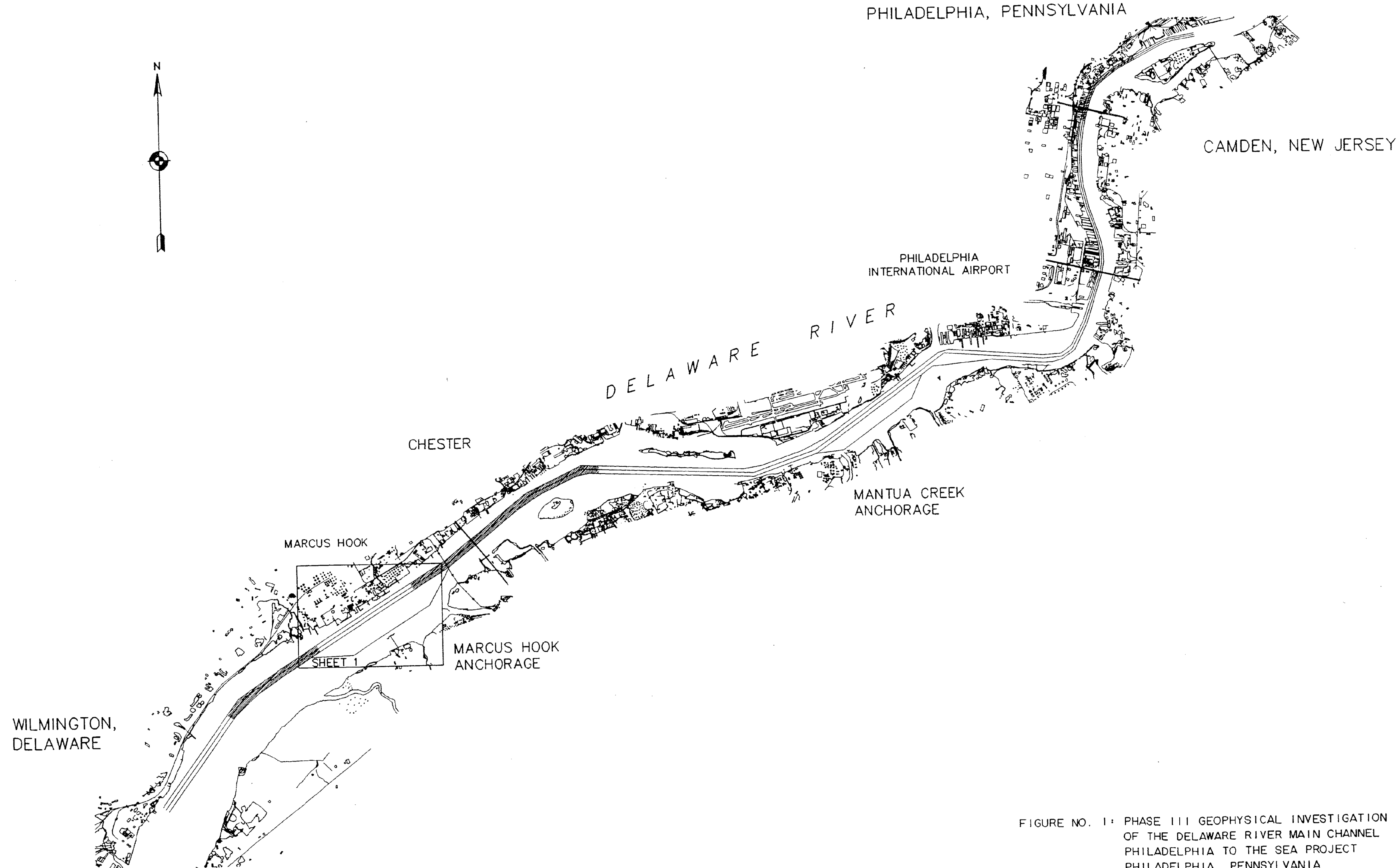

FIGURE NO. 1: PHASE III GEOPHYSICAL INVESTIGATION OF THE DELAWARE RIVER MAIN CHANNEL PHILADELPHIA TO THE SEA PROJECT PHILADELPHIA, PENNSYLVANIA volume of rock requiring removal for each site were calculated assuming that the existing channel would be dredged to a depth of 47' or 48' ACOE mean low water (MLW).

2.0 PROJECT SUMMARY

2.1 Phase III Overview

Phase I and II investigations utilized acoustical subbottom profilers to delineate near surface rock underlying the Delaware River in the channel between river stations 0+00 and 152+00, in the Mantua and Marcus Hook Anchorages, and in the BP and Sun Oil berthing areas (adjacent to the Marcus Hook Anchorage). Throughout many reaches of the river and within the anchorages and the berthing areas, nearsurface gaseous sediments inhibited or partially restricted penetration of the acoustic subbottom profiling signal which prevented the examination and mapping of the underlying geology. Following completion of the Phase I investigation, OSI personnel met with representatives from ERM and the ACOE (Philadephia District) and discussed alternative methods of investigating the gaseous sediment areas. During this meeting, ground penetrating radar (GPR) was identified as a geophysical tool that might produce subsurface data in the areas of restricted acoustic penetration. GPR, a proven land-based subsurface profiling tool that can be adapted to waterborne investigations uses electromagnetic energy rather than acoustic energy to penetrate sediments. When conditions are favorable, the electromagnetic signal has the ability to pass through gaseous sediments deposits and resolve the underlying nearsurface geology.

Following completion of the Phase II investigation, GPR was tested in the Delaware River to determine if it would be a viable subbottom profiling tool. During this test, a standard 100 MHz. radar antenna was towed on the water's surface astern of the survey vessel and was used to generate and receive the electromagnetic profiling signal. Preliminary testing of the 100 MHz. radar antenna indicated that the GPR was functional in the river, but was limited in its ability to penetrate greater than approximately 20' through the water column.

Thus, after completing the preliminary GPR tests, OSI returned to Connecticut to identify a GPR antenna that could overcome limited penetration through the water column. Initial tests focused on using a production antenna with a lower frequency range (20-80 MHz.). This antenna is very large and cumbersome, and proved to be difficult to tow from the survey vessel. It also did not gain significant penetration through the water column. Consequently, OSI developed/designed a subsurface 100 MHz. radar antenna to be towed approximately 5-10' above the river bed, thus reducing the distance the electromagnetic signal needs to pass through the water column. This antenna proved successful in penetrating nearsurface sediments at the Connecticut test site.

Following development and initial testing of the subsurface 100 MHz. antenna, OSI remobilized to the Delaware River to initiate the Phase III survey investigation. Phase III investigations focused on acquiring GPR data in the BP and Sun Oil berthing areas and channel adjacent to the Marcus Hook Anchorage between Delaware River Stations 120+000 and 131+000 (where nearsurface gaseous sediments had previously restricted subbottom penetration of the acoustical subbottom profilers).

2.2 Summary of the Phase III Field Survey

Similar to the Phase I and II investigations, Phase III survey operations were conducted from OSI's R/V Willing II, a 27' survey vessel equipped with an array of geophysical and satellite positioning equipment. Prior to surveying, a tide recorder was established at ACOE vertical control site "Quarantine Dock". The survey plan designed for Phase III consisted of acquiring hydrographic and GPR data concurrently along all survey transects. Survey tracklines were oriented parallel to the channel axis, spaced at 100' intervals, and extended across the navigation channel to the face of the BP and Sun Oil docks. Following a preliminary review of this GPR data set, additional tracklines were also run at 50' intervals between tracklines spaced at 100' intervals where initially acquired GPR data suggested rock was at or near the river bed.

As a means of providing additional subsurface information and groundtruthing of the GPR interpretation, grab samples of the river bed were acquired at 24 locations within or nearby the Phase III area. Sampling was accomplished using a Shipek bottom sampler following completion of the GPR survey.

A complete discussion of the operation of OSI's equipment and specific information regarding the acquisition, processing, and analysis of the acquired data is presented in Appendix I and should be referred to for additional detail. Primary equipment employed to complete the investigation included:

- Sea Data Inc., TDR-3A tide recorders,
- Trimble Model 4000 Differential Satellite Global Positioning System interfaced with OSI's "Maretrack II" PC-based navigation and data logging software package,
- Innerspace Model 448 precision depth sounder,
- SIR System-10 computer controlled Ground Penetrating Radar (GPR) system equipped with an OSI designed 100 MHz. subsurface towed monostatic antenna,
- Shipek bottom sampler, Model 860.

Specification sheets for primary equipment employed during the investigation are included in Appendix II.

2.3 Rock Quantity Computations

Rock quantities were calculated for Phase II sites B and C and for the Phase III site. Computations were made to estimate the quantities of rock that would require removal if the existing channel was dredged to both a depth of 47' and 48' ACOE MLW. Volume calculations were made using QuickSurf V. 5.1, a surface modeling computer program which works within AutoCad. QuickSurf uses the depths (below ACOE MLW) assigned to each rock surface contour to generate a surface model and then calculates the volume of rock which exists above a specified depth (47' or 48' ACOE MLW).

2.4 Data Products

Following completion of the Phase III field investigation, the acquired data sets were processed and interpreted at OSI's Old Saybrook, CT office. Hydrographic data were corrected for tidal and speed of sound variations and were plotted along survey tracklines. The shoreline, channel stationing, and channel prism lines were included on this plot which is presented as "Hydrographic Chart Phase III", OSI Drawing No. 94ES131C.1, Sheet 1. This drawing was then used in the subsequent task of GPR interpretation and construction of an overlay to the drawing entitled "GPR Survey Results & Rock Quantity Calculations, Phase III", OSI Drawing No. 94ES131C.2, Sheet 1. The overlay delineates the extent of surface rock and nearsurface rock and summarizes the rock quantity calculations in the Phase III site. Phase III grab sample locations were plotted and are also included on this overlay. Grab sample descriptions are included in tabular format in Appendix III and rock quantity computations for Phase II and III sites are included in tabular format in Appendix IV.

Additional data processing and interpretation for the previously surveyed Phase II sites included constructing overlays to the Phase II Drawing No. 94ES131.B, Sheets 2-4. These overlays depict 1' contours of the top of the acoustic basement in areas where the acoustic basement is expected above a depth of 50' ACOE MLW and also graphically summarize the rock quantity calculations for the Phase II sites. These overlays are entitled "Top of Acoustic Basement Above 50' ACOE MLW", OSI Drawing No. 94ES131B.2 and "Rock Quantity Calculations", OSI Drawing No. 94ES131B.3, Sheets 2-4.

The aforementioned drawing and overlay sheets were plotted at a scale of 1"=400' and are presented under separate cover in full size and in this report as reduced versions (Appendix V). AutoCad (Version 12) digital drawing files of these drawing sheets have also been generated and are provided on 3½" computer diskettes.

3.0 PHASE III GEOPHYSICAL DATA ANALYSIS AND DISCUSSION

GPR data, in conjunction with sounding data and sediment samples, provided the necessary framework of information needed to identify near surface rock in the Phase III area. Periodically during the Phase III investigation, GPR data were acquired over selected Phase II areas where nearsurface rock had previously been identified via the acoustical subbottom profilers. Each of these control runs allowed the GPR data to be correlated with the previous data sets and provided confidence in the ability of the GPR to identify nearsurface rock at the project site.

Following the conclusion of the Phase III investigation, GPR records were reviewed to evaluate the shallow subsurface stratigraphy throughout the area investigated. During this review, data were classified into three type categories. Classification was based on the ability of the GPR to penetrate the river bed, the return strength of the river bed reflector, and the appearance of the river bed reflector and those radar reflectors observed immediately underlying the river bed. In general, the GPR signal did not penetrate significantly below the river bed (possibly due to the presence of clays in the river bed sediments which strongly attenuate a GPR signal), but did provide data needed to delineate the presence of rock at or near the river bed surface. The three types of radar returns were classified as follows: Type 1 - probable rock outcrop or rock just below a thin surface veneer of sediments, Type 2 - rock expected below at least 1' of river bed surface sediments, and Type 3 - rock not detected on/or below river bed (assume a minimum of 3' of surficial river bed sediments). Figures 2 and 3, are reproductions of the GPR records depicting each of the three categories of radar returns. Type 1 and 2 categories are very similar in appearance and the distinction between these types is interpretive rather than exact. GPR data indicate that rock is present within the boundaries of the Type 1 and 2 areas identified, but due to the limited penetration of the GPR signal the upper rock surface could not be clearly traced below the river bed for more than a few feet. As a result, in some of the rock areas (more likely in the Type 2 areas), the rock identified may represent nearsurface rocks or rip-rap, remnants of

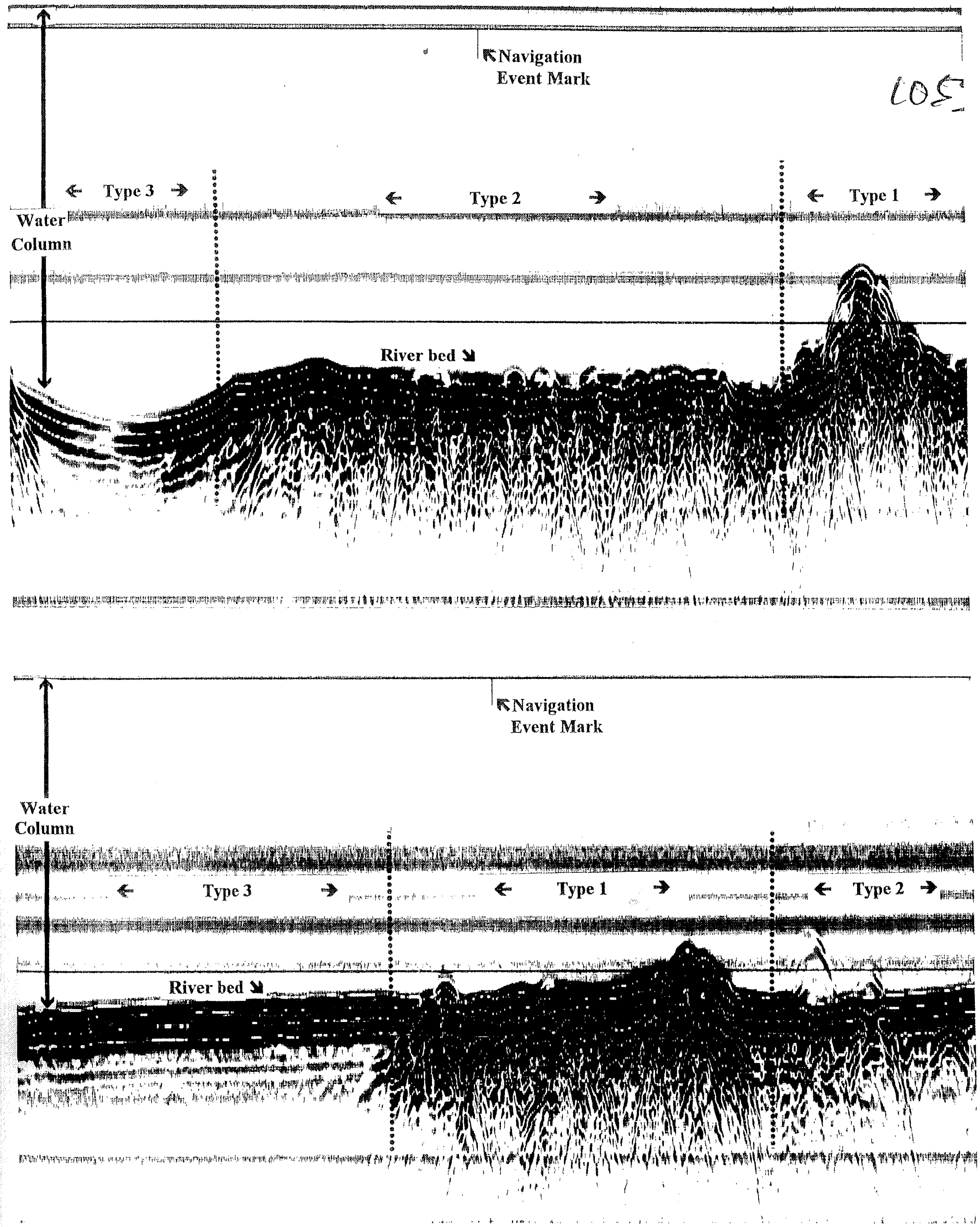

FIGURE 2 - Reproduction of ground penetrating radar profile records depicting various radar return types identified in the Phase III site.

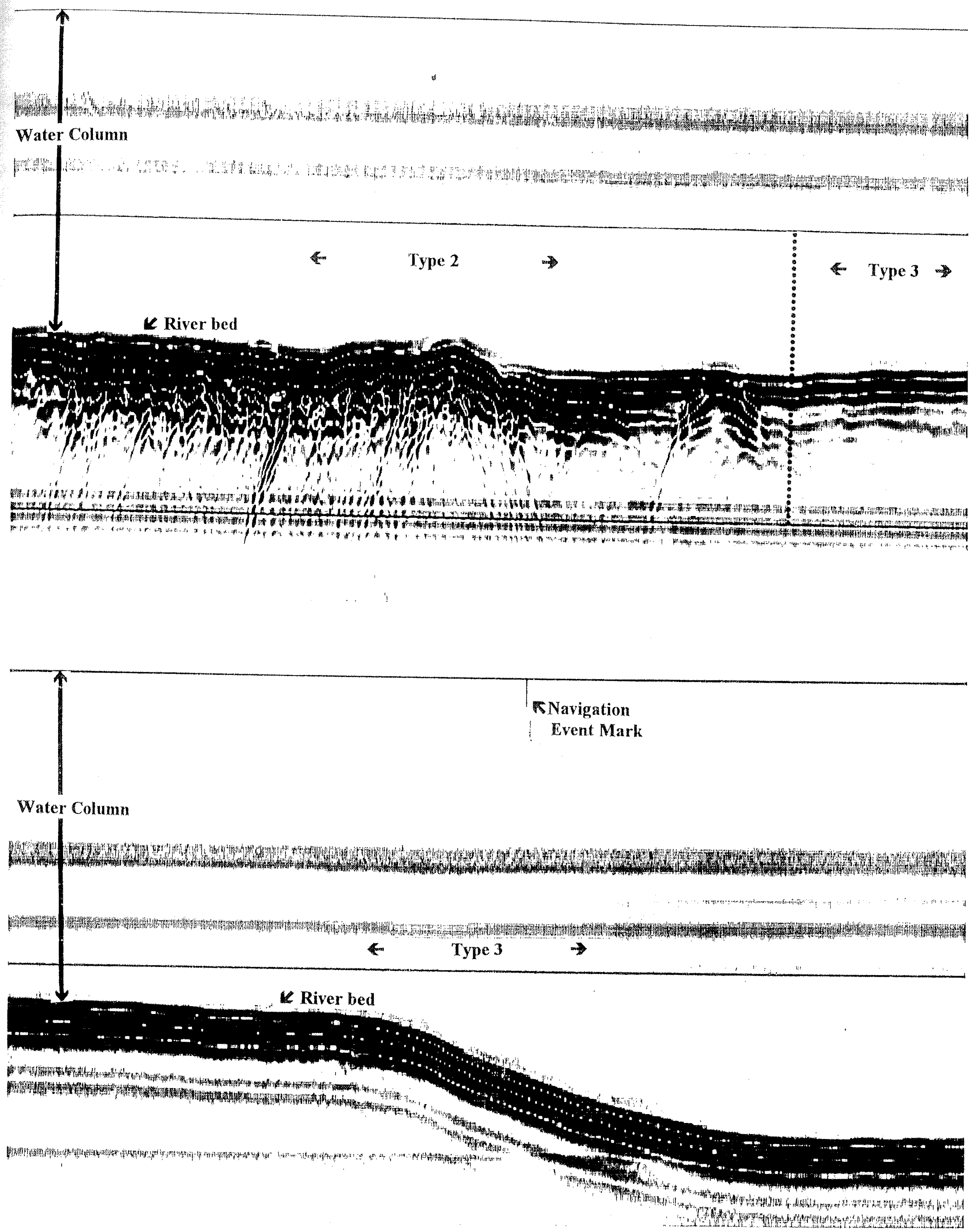

FIGURE 3 - Reproduction of ground penetrating radar profile records depicting various radar return types identified in the Phase III site.

previous excavations or dumpings in the area rather than bedrock. Likewise, rock may exist below the Type 3 areas but at a depth below detection by the GPR.

Distribution of the three radar type returns throughout the Phase III area was variable. Type 3 (areas not shaded on the GPR survey results & rock quantity calculations overlay) was the most frequently encountered return in the Phase III area. The remaining two types (shaded areas on the GPR survey results & rock quantity calculations overlay) were sparsely distributed throughout the Phase III area, and were most common just offshore and downriver of the Sun Oil dock. Figure 4, a reproduction of the GPR records acquired offshore of the Sun dock in probable rock outcrop Area 9 depicts the most pronounced rock feature identified in the Phase III site. This feature appears to extend 3 feet off of the river bed and generally trends northwest/southeast.

Sediments ranging in size from clay to large cobbles were recovered by the grab sampler in the Phase III area. In general, the grab sampler recovered a full sample of clay and mud in the Type 3 radar return areas. In the Type 1 and 2 radar return areas the sampler generally recovered a limited sample (less than full recovery in the sampler) which was typically composed of coarse-grained deposits. Occasionally, there was no sample recovery in the Type 1 and 2 areas. The limited sample recovery at many of the Phase III sampling locations, suggests that a hard bottom (i.e. rock or compact cobbles and/or gravel) exists just below a surface veneer of unconsolidated sediments. In the Phase II areas, similar coarse-grained sediment assemblages and partial sample recoveries using the grab sampler, also typically coincided with nearsurface rock areas.

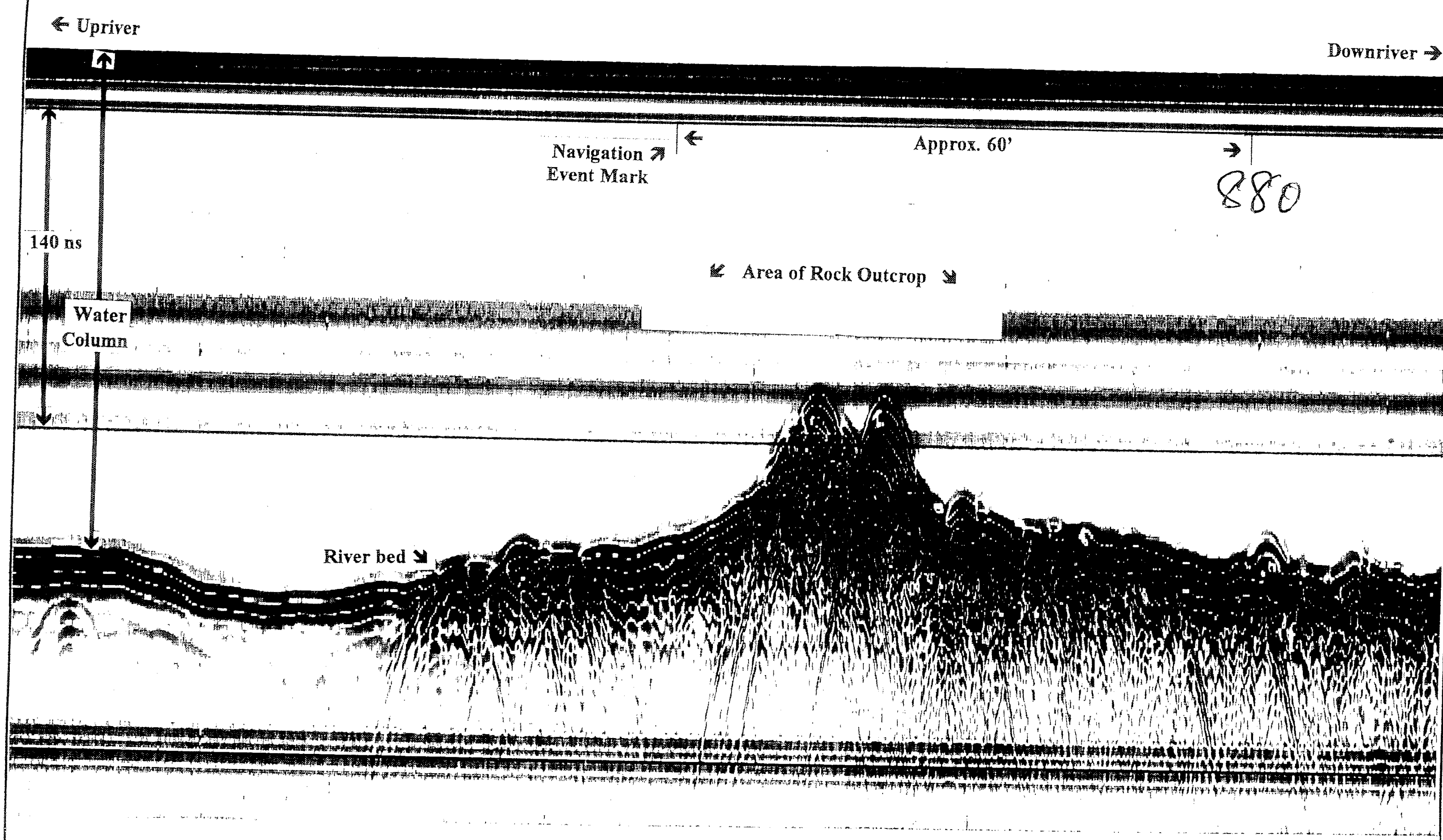

FIGURE 4 - Reproduction of ground penetrating radar profile records acquired offshore and downriver of the SUN oil dock. Record depicts rock outcrop identified in "probable rock outcrop area 9".

4.0 ROCK QUANTITY CALCULATIONS

4.1 Overview

The primary data sources for estimating rock quantities in the Phase II Sites B and C were the boomer and pinger subbottom profiler records, whereas the primary source of data for the Phase III site was the GPR records. Two different computational methodologies were used to estimate rock quantities in the Phase II and the Phase III sites, primarily because the data sets generated for each site varied in resolution and presentation.

To estimate the volume of rock present in the Phase II sites, a detailed representation of the acoustic basement surface was constructed. This was accomplished by first identifying all areas where the top of the acoustic basement was shallower than 50' ACOE MLW. Within each of these areas, the Phase II boomer and pinger records were reexamined along with historic ACOE test pit and boring log data and surface grab samples to construct one foot contours (above a depth of 50' ACOE MLW) depicting the top of the acoustic basement surface. In many of these areas, subbottom data clearly indicated that the acoustic basement surface represented the top of rock surface. These areas have been designated as "Rock" areas. Areas where it was unclear whether the acoustic basement actually represented the top of rock or a sediment interface were classified as "? Rock" areas. In gaseous sediment areas (referred to as "Gas" areas), test pit, boring and sample data provided insight as to the presence of rock at or near the surface and the thickness of any overlying sediments. This information was used along with water depth information to construct an interpretive surface indicating the minimum depth where rock might exist. This interpretive surface was used (similar to the preceding areas) to estimate rock removal volumes in the Gas areas. Rock volumes were calculated for each of the individual "Rock", "? Rock" , and "Gas" areas with each area assigned an individual number designation for reference.

To estimate the volume of rock existing above the depths of 47' and 48' ACOE MLW in the Phase III area, a different procedure was followed. The Phase III GPR data set provided insight as to the elevation of rock at the surface or very nearsurface, however its resolution of the depth below the riverbed was limited. Consequently, the GPR functioned more as a surface and near surface mapping tool, rather than a subbottom profiler and did not provide the detailed information needed to generate contours of the upper surface of the underlying rock. Areas of "rock outcrop" and "rock expected below river bed" were delineated and together with the acquired water depth information, were used to calculate expected volumes of rock using the surface modeling program. The volume for each area was based on a modeled surface of the river bed. For example, given an area of rock outcropping on the river bed of approximately 1000 sq. ft and a flat river bed surface at a depth of 45' ACOE MLW, the volume of rock above a depth of 47' ACOE MLW would be 2 ft X 1,000 sq. ft = 2,000 cu ft. Volume calculations were performed for three assumed depths of rock below the river bed for the "rock outcrop areas" and "rock expected below river bed areas". In the "rock outcrop" areas, volume calculations were made assuming 0, 1', and 2' of sediment cover overlying the rock. In the "rock expected below river bed" areas volume calculations were made assuming 1', 2', and 3' of sediment cover overlying the rock. This method provided a means of bracketing rock volume estimates and examining the impact of modifying the GPR interpretation for each of the individual areas identified.

Appendix IV presents the rock quantity calculations for Phase II sites B and C and the Phase III site in tabular format. Rock quantities were calculated in both cubic feet and cubic yards. Tables summarize the volume of rock expected in each of the isolated Phase II "Rock", "? Rock", and "Gas" areas that are delineated on the "Top of Acoustical Basement Above 50' ACOE MLW" and "Rock Quantity Calculations" drawing overlays to OSI Drawing No. 94ES131B.1 (Sheets 2-4).

Similarly, a table was generated for the Phase III site which summarizes the volume of rock expected in each of the "rock outcrop" and "rock expected below river bed" areas.

The "GPR Survey Results & Rock Quantity Calculations" overlay delineates these areas within the Phase III site. A summary table precedes each of the rock calculation tables for the Phase II and Phase III sites. These tables provide a quick overview of expected rock volumes in each site.

The border lines which encompass each of the "Rock" and "? Rock" areas on the Phase II rock quantity calculations overlay drawings represent the 50' ACOE MLW depth contour line. The actual areas in which volume calculations were performed encompass a smaller area (because rock volume calculations were performed on the areas encompassed by the 47' and 48' ACOE MLW depth contours, respectively). Gaseous areas are illustrated on the top of acoustic basement above 50' ACOE MLW overlays as shaded regions. Rock volumes were not calculated in gaseous areas where rock was estimated to be deeper than 50' ACOE MLW. The remaining gas areas where rock was estimated shallower than 50' ACOE MLW were included in the rock quantity calculations as depicted on the rock quantity calculation overlays.

4.2 Results

The largest quantity of rock identified during the investigation is located in Phase II Site B (between Delaware River Stations 96+000 and 120+000). In Site B, it is estimated that approximately 202,000 cubic yards of rock will be encountered if the channel is dredged to a depth of 47' ACOE MLW and 318,000 cubic yards of rock will be encountered if the channel is dredged to a depth of 48' ACOE MLW. A little greater than 50% of these estimated volumes are comprised of gaseous sediment areas, which are common along the channel margins in this site.

In Phase II Site C (between Delaware River Stations 131+000 and 144+000), it is estimated that approximately 18,000 cubic yards of rock will require removal if the channel is dredged to a depth of 47' ACOE MLW. If the channel is dredged to a depth of 48' ACOE MLW it is estimated that approximately 38,000 cubic yards of rock will require removal. Approximately 98% of the rock volumes estimated for Site C were based on areas were rock was clearly identified. In Site C, rock was not identified shallower than a depth of 50' ACOE MLW in any of the gaseous sediment areas. The sum totals of rock identified in both Phase II sites (B and C) were 220,000 and 356,000 cubic yards for a channel dredge depth of 47 and 48' ACOE MLW, respectively. It is estimated that by dredging the channel the additional one foot from a depth of 47' to 48' ACOE MLW, approximately 62% more rock will have to be removed.

In the Phase III area (between Delaware River Stations 120+000 and 131+000), approximately 82,000 cubic yards of rock will require removal if the channel and the BP and Sun Oil berthing areas are dredged to a depth of 47' ACOE MLW. Approximately 100,000 cubic yards of rock will require removal if the channel is dredged to a depth of 48' ACOE MLW. It is estimated that 70% of these rock volumes exist in areas where rock was interpreted to be one foot below the river bed. If rock exists two or three feet below the river bed surface these estimates could decrease by 10,000-20,000 cubic yards. Likewise in the "rock outcrop" areas, if rock exists below a surface veneer of sediments rather than outcropping on the river bed or the rock identified is not bedrock but just surface rock, rock removal estimates may decrease significantly.

5.0 SUMMARY

Phase III of a multi-phase marine geophysical survey investigation of the Delaware River was accomplished in the BP and Sun Oil berthing areas and channel adjacent to the Marcus Hook Anchorage. Similar to the preceding two phases, this investigation focused on delineating nearsurface rock underlying the river to aid in the development of an accurate cost estimate of rock removal for the proposed Army Corps. of Engineers "Philadelphia to the Sea" channel expansion project. This investigation made use of a ground penetrating radar (GPR) system, rather than an acoustic subbottom profiler as had been used in the previous phases. GPR was used as an alternative technology in an attempt to develop information through gaseous sediment deposits which had previously inhibited acoustic subbottom profiling in the Phase III site.

In general, the GPR data set acquired in the Phase III site provided insight as to the elevation of rock at the surface or very nearsurface of the river bed. However, resolution and depth of signal penetration below the river bed was limited mostly likely due to an abundance of clay in the river bed sediments. GPR data were classified into three return type categories. Type 1 and 2 categories are specifically related to the presence of rock in the nearsurface. Clear distinction between these types is interpretive rather than exact. Due to the limited penetration attained by the GPR it is possible that some of the rock identified in these two categories may be deposits of isolated rocks (i.e. rip-rap, remnant of previous excavations or dumpings in the area) and not bedrock. Distribution of the three radar return types throughout the Phase III site was variable with Type 3 being the most common and most widely distributed. The remaining two types were distributed sparsely throughout the site, and were most common just offshore and downriver of the Sun Oil dock.

Rock quantities were calculated for Phase II Sites B and C and the Phase III site using a computer surface modeling program. Computational methodologies differed between the Phase II and Phase III sites, primarily due to the differences in depths of penetration and resolution attained by each of the subsurface profiling systems. It is estimated that approximately 220,000 cubic yards of rock will require removal in the Phase II Sites B and C if the channel is dredged to a depth of 47' ACOE MLW and approximately 356,000 cubic yards of rock will require removal if the channel is dredged to a depth of 48' ACOE MLW. In the Phase III area, it is estimated that approximately 82,000 cubic yards and 100,000 cubic yards of rock will require removal if the channel is dredged to a depth of 47' and 48' ACOE MLW, respectively. In the Phase III site, a large fraction of the rock quantities estimated come from the Type 2 areas (where rock was identified at least 1' below the river bed). If the rock in these areas is deeper than 1' below the river bed or it is determined that the rock identified is comprised of individual pieces of rock and not bedrock, these rock estimates could decrease significantly.

6.0 RECOMMENDATIONS

The survey efforts and subsequent data interpretation involved in this investigation have resulted in the ability to estimate the approximate quantities of rock which will require removal if the Delaware River channel is deepened. These quantities are order of magnitude estimates and should be used as guidance in determining the budget for the deepening project. Under ideal conditions, the resolution of the subbottom profiling system used during Phases I and II is 1-3 feet. Therefore, the minimum resolution limit of the subbottom profiler was approached by attempting to construct 1 foot contours to estimate rock quantities present above a depth of 47' and 48' ACOE MLW. In addition, rock quantity estimates were made for the gaseous sediment areas encountered in the Phase II sites based on limited data. Therefore, the actual conditions within the gas areas could vary significantly and reasonable allowances for encountering unexpected rock in these areas should be considered.

In the Phase III site it is relatively certain that rock will be encountered in the Type 1 and 2 areas. A higher level of confidence is placed on the delineation of the Type 1 areas (where rock was identified cropping out on the river bed) than in the Type 2 areas. It is unclear whether the rock identified in these areas (more so in the Type 2 areas) will be surface rocks or bedrock due to the limited penetration attained by the GPR and the limited groundtruthing data. As a result, rock quantity estimates for the Phase III site may be high rather than low.

Borings and test pits conducted in areas where rock was identified at the surface or in the gas areas would be extremely useful in groundtruthing the geophysical interpretation. Implementing an extensive boring and test pit program to support the findings of this investigation would be beneficial but time consuming and expensive. Therefore, a jet sled program is recommended as an alternative to a boring/test pitting program to provide groundtruthing of the geophysical interpretation and additional data in the gaseous sediment areas (as discussed during the post Phase I meeting). A significant amount of data can be acquired at a reduced cost (relative to implementing a full scale boring or test pit program) by using a jet sled that can rapidly probe the bottom with minimum effort while being towed behind a survey vessel.

GPR did prove successful in identifying nearsurface rock in the gaseous sediment areas. Future investigations in areas of gaseous sediments should consider the use of GPR as an alternative technology to acoustic subbottom profiling, to aid in the identification of nearsurface rock. Additionally, future investigations might consider the use of side scan sonar. A side scan sonar survey in the river could quickly identify and delineate the extents of rock cropping out on the river bed, deposits of gravel, and/or any obstructions which might exist on the river bed. The side scan would also identify these features should they be situated between survey lines.

APPENDIX I

SURVEY INSTRUMENTATION AND PROCEDURES

Appendix I

SURVEY INSTRUMENTATION AND PROCEDURES

The following sections outline the equipment and procedures used during Phase III of the ACOE Delaware River marine geophysical investigation. Specification sheets for all instrumentation employed are included in Appendix II and should be referenced for additional information.

VERTICAL CONTROL

Water depth measurements made during all phases of this investigation were referenced to ACOE mean low water (MLW). Prior to acquiring sounding and GPR data during Phase III, OSI installed a Sea Data, Inc. TDR-3A solid-state, digital tide recorder at ACOE vertical control station "Quarantine Dock" which is located between the BP and Sun Oil docks. The tide recorder was referenced to the ACOE tide board located on the dock and set to record water levels at 5-minute intervals for the duration of the survey. Periodically during each survey day, OSI measured tide heights from the tide board adjacent to the recorder as a cross-check/verification to the digital tide recordings to insure data quality and proper calibration of the instrument.

NAVIGATION

OSI "Maretrack II" Trackline Control and Data Logging System

Survey vessel trackline control and position fixing were obtained by utilizing an OSI PC-based hydrographic software package in conjunction with a "Trimble" Differential Global Positioning System (DGPS) onboard the survey vessel. The OSI Maretrack II system consists of a portable personal computer and color monitor with a modified version of Coastal Oceanographic's HYPACK software installed. The OSI Maretrack II system receives geographical coordinate data from the DGPS and in real-time converts these to New Jersey State Plane, NAD 83 X,Y coordinates. These X,Y data are used to guide the survey vessel accurately along preselected tracklines and are logged on computer disk for post-processing and plotting. In addition, vessel positions are displayed on the video monitor allowing the helmsman to visualize actual tracklines being surveyed. Pre-survey tracklines along with digitized representations of the shoreline, buoys, and channel centerlines are also projected on the video monitor relative to the location of the survey vessel.

Trimble Model 4000 RS/DS GPS Receiver/Magnavox MX-50R Beacon Receiver

The 4000 RS/DS (Reference/Differential Surveyor) GPS receiver interfaced with the MX-50R Beacon Receiver provides a reliable, high-precision satellite positioning/navigation system for a wide variety of operations and environments. In operation, the MX-50R continuously receives differential satellite correction factors via radio link from a DGPS Coast Guard Beacon. During Phase III of this investigation USCG Station Cape Henlopen, DE was used to provide differential corrections to the onboard GPS receiver. The 4000 RS/DS continuously tracks up to 8 satellites, accepts the correction factors via the MX-50R interface, and applies the corrections to obtain a high-accuracy real-time position fix. A second interface on the 4000 RS/DS enables the operator to output corrected position fixes and raw measurement data at the rate of one fix per second to a personal computer and interface it with a navigation system (OSI Maretrack II software package).

The Trimble Surveyor system typically demonstrates a 2-dimensional fix accuracy better than 2-5 meters with differential corrections provided to it at an adequate rate. Periodically during the investigation, OSI occupied the ACOE horizontal control point "Fort 2 1987" and found the 2-dimensional GPS fix solution to be accurate within 1 meter of the published coordinates of the point.

HYDROGRAPHIC MEASUREMENTS

Precision water depth measurements were obtained employing an Innerspace Model 448 digital depth sounder. The 448 sounder operates at a frequency of 208 kHz. utilizing a narrow beam (8 degree) transducer. The microprocessor controlled sounder contains a solid state thermal printer and also provides means for transmitting digital depth to portable hydrographic survey systems. During survey operations digital depths are output from the 448 and merged with navigation data via the Maretrack II program and saved for post-processing. Relevant supporting information (line number, project name, date, time, and navigation event mark/number) pertaining to each line surveyed are automatically annotated on the graphic records via the computer interface.

The 448 incorporates both tide and draft corrections plus calibration capability for local water mass sound speed. Calibration for local water mass sound speed was accomplished by performing "bar checks" at the beginning and end of each survey day. The bar check procedure consisted of lowering an acoustical target on a graduated sounding line. The 448 speed of sound control is adjusted so that the target is printed precisely at its known depth. The target is then raised to successively shallower depths and chart readings noted at these depths. Variations which exist in the indicated depths at these calibration points are incorporated into the hydrographic data analysis procedure to yield maximum accuracy in the resulting depth data.

GROUND PENETRATING RADAR

Subsurface profiling was accomplished using a Geophysical Survey Systems Inc. (GSSI) Subsurface Interface Radar (SIR) System-10. The SIR System-10 is a computer controlled ground penetrating radar system consisting of four primary components: a MF-10 (main frame) computer equipped with an EXABYTE digital tape drive, a control display unit, an electromagnetic wave generator mounted in a 100-MHz. center frequency underwater antenna, and a thermal graphic recorder.

In operation, the control unit transmits power and a synchronizing signal to the wave generator which radiates short pulses of radio-frequency electromagnetic energy. As these energy signals propagate downward, they are partially reflected at the water-sediment interface back to the antenna, while the balance of the signal continues downward into the subsurface. As the downward propagating signals encounter successive interfaces of differing dielectric properties, a series of similar partial reflections correlative with time/depth occur which are also reflected back to the antenna. (The relative dielectric permittivity is a measure of the capacity of a material to store a charge when an electric field is applied to it, relative to the same capacity in a vacuum.)

Once received by the antenna, the radio-frequency signal is converted to an audio frequency signal by the SIR-10 and sent to the graphic recorder and digital tape drive for display and archiving. In the graphic display, the vertical axis is "time" (two-way propagation time of the electromagnetic wave) which is proportional to the depth of each sequential reflection, and the horizontal axis (controlled by adjusting the paper advance speed) is proportional to survey vessel speed. As the intensity of the printed reflections are proportional to the intensity of the energy reflected from each dielectric interface, the resulting subbottom profile is analogous to a geological cross-section along each survey trackline.

The principal limiting factor in depth of penetration of the GPR signal is attenuation of the electromagnetic wave in the water and earth. The attenuation losses result from spherical spreading of the signal, signal scatter, conversion of electromagnetic energy to thermal energy, and from diffusion of the GPR signal in clay-type minerals.

During data acquisition, all records were annotated with relevant supporting information, field observations, line number, run number, navigation event marks and numbers for later interpretation and correlation with vessel position data.

SEDIMENT SAMPLING

Sediment sampling was accomplished by means of a Shipek grab sampler. The Shipek sampler is used primarily to sample unconsolidated materials from soft mud to cobbles, and is capable of retrieving a relatively undisturbed, unwashed sample from the river bed. In unconsolidated sediments the sampler can be expected to recover an approximate 8-10" sample.

The unit is composed of two concentric half cylinders, heavy duty torque springs, and a large weight. Prior to sampling, the inner half cylinder (sample bucket), is rotated against the torque springs into the outer half cylinder (sampler housing) and held in place by a spring loaded stopping mechanism. This sets the sampler for sampling. Upon contact with the river bed, the sampler is automatically triggered releasing the spring loaded stopping mechanism and the torque springs. Once triggered the sample is instantly scooped into the sample bucket as the recoiling springs force the bucket closed.

After the sampler triggered it is recovered onboard by means of a lifting winch. Once on deck, the sample is examined and described by the project geologist. At each sample location a position fix is recorded along with a sample description.

DATA PROCESSING AND PRESENTATION

Following field operations, all acquired data were brought back to OSI's regional office (Old Saybrook, Connecticut) for processing. The following sections summarize how each data set was reviewed and subsequently presented to aid the final data analysis.

Survey Trackline Reconstruction

Survey tracklines were reconstructed from the X-Y coordinates logged at each 1-second "fix" point and saved to the Maretrack II computer. Once reconstructed on the computer these tracklines were adjusted for sensor layback and offsets relative to the "DGPS" antenna and used for the subsequent task of interpretation and construction of the plan view presentations included with this report.

Sounding Data

Digitally recorded depth data were first checked against the sounding strip charts for verification of depth quality. Depths were then adjusted for changes in water mass sound speed as determined from the bar check information and referenced to ACOE MLW by applying water level corrections obtained during the survey via the TDR-3A tide recorder. This adjusted data set was then plotted in plan view along vessel tracklines (OSI Drawing No. 94ES131C.1, Sheet 1) and used in the subsequent task of calculating rock quantities and constructing the "GPR Survey Results & Rock Quantity Calculations" overlay drawing sheet.

GPR Data

GPR records were reviewed to evaluate the shallow subsurface stratigraphy throughout the area investigated. During this review, GPR data were examined along with depth and sample data and classified into three unique type categories. Classification was based on the ability of the GPR to penetrate the river bed, the return strength of the river bed reflection, and the appearance of the river bed reflector and those radar reflectors observed immediately underlying the river bed. Based on this interpretive classification scheme, unique shading patterns were incorporated onto the Phase III drawing to provide a distribution overlay which was subsequently used in calculating rock quantities.

Rock Quantity Computations

Rock quantity computations were performed using the computer software package "QuickSurf" V. 5.1 (Schreiber Instruments, Inc. (1994). QuickSurf is a general purpose surface modeling system that operates within AutoCad. A suite of sophisticated tools allows the user to manipulate modeled surfaces into high-quality finished maps and perform a variety of engineering computations.

In QuickSurf, two primary methods of modeling are available: grid and triangulated irregular network (TIN). The grid method of surface modeling is an indirect technique which generates a regularly spaced (rectangular grid) data set in which the grid node contains the "z" value derived from interpolation from the nearest original input data points. Several variables, including user-defined grid size, search pattern and the data weighting method, affect the outcome of the surface generated. The surface generated by the grid method is comprised of average "z" values, based on, but not always honoring the original input values. The TIN method is a direct modeling technique which generates a surface based on triangles connecting original data points according to the Delauney criterion (any three points are "natural neighbors" when they are on a circle containing no other points). Lines drawn between natural neighbors create what is referred to as Delauney triangles representing the primary foundation of this modeling technique. Surfaces generated by the TIN modeling routine honor all original input data points.

Volume calculations were accomplished in QuickSurf by calculating cut and fill volumes between the data surface and design surfaces (i.e. rock surface and proposed dredge depths). Volume calculations were determined using the TIN surface routine because, by generating a surface which honors all data points in the input data set, it is capable of calculating capacities with a higher degree of confidence.

APPENDIX II

EQUIPMENT SPECIFICATION SHEETS

Sea Data, Inc.

TDR-3A

TIDE RECORDER

TDR3A.DS.1286

12/86

The TDR-3A Tide Recorder is a low-cost digital pressure and temperature recorder designed for the precise measurement of water level. The instrument can be moored on the ocean bottom or attached to a structure where it will record pressure data with an accuracy of one centimeter per 15 meters of water. Recorded data are available in engineering units for output to a printer or terminal. The TDR-3A can also be configured for use as a real-time tide monitoring instrument. The measurement rate is switch selectable in 16 increments ranging from five seconds to one hour.

The TDR-3A Tide Recorder belongs to a group of Sea Data instruments known as Microloggers, and is the solid-state recording replacement for the TDR-2 Tide Recorder. The TDR-3A stores up to 21,000 pressure/temperature data pairs in its standard 92 kilobyte memory.

Solid-state storage eliminates the need for an expensive tape reader for data playback. Data can be downloaded to any compatible computer in any of four formats, including formatted engineering units. Second-order calibration coefficients stored in the EEPROM of the TDR-3A assure that engineering unit output reflects actual pressures and temperatures. The instrument is powered by the main system battery; a five-year memory back-up battery protects against data loss in the event of main battery failure.

TIDE MODE

The TDR-3A features an operating mode where frequent pressure samples are averaged (128 averaged pressure measurements are taken over a 160 second interval) to reveal only tide-induced changes in the water level. This rapid sample and average technique eliminates wave-induced fluctuations from the water level data without the need for a stilling well. First introduced by Sea Data in 1979, this technique is now a standard for the National Oceanic and Atmospheric Administration (NOAA) and the National Oceanographic Survey (NOS) for their next generation tide gauges. The TDR-3A will also record raw pressure/temperature data in situations where wave influence is insignificant. A DIP switch is used to select or deselect tide mode.

GENERAL DESCRIPTION

The standard TDR-3A is equipped with two data channels for pressure and temperature. The pressure sensor is a strain gauge with a creep-relieved stainless diaphragm and a vacuum reference chamber sealed with electron beam welding. Each sensor is individually temperature compensated with custom, wire-wound precision resistors for truly superior pressure accuracy.

The standard temperature sensor is externally mounted on the bulkhead of the TDR-3A and has a time constant of 20 seconds in water. Temperature range is set at the factory: −5 to +35°C is standard; 25 to 80°C and 0 to 20°C ranges are also available. The standard TDR-3A Tide Recorder includes a 92 kilobyte RAM storage memory, battery pack, and PVC pressure housing rated to 750 psi (150 meters). PVC pressure housings are individually pressure tested by special order. The TDR-3A will operate either in averaging tide mode or in single-sample mode.

DEPLOYMENT DURATION

The flexible TDR-3A accommodates a wide range of experiment lengths, from short-term deployments with high sampling rates. to unattended deployments of more than a year. The following table shows several possible deployment durations. For each configuration of data channels and scanning intervals, the table shows the time it takes to completely fill the 92K memory, and the number of deployments that can be completed before the battery must be replaced.

FEATURES

- **Solid-state recording; 92 kilobytes with 5 year memory**
- **RS-232 output; no reader needed**
- **Engineering unit output**
- **Special tide mode to eliminate wave noise**
- **0.15cm Accuracy: 0.5cm Resolution**
- **0.1°C Accuracy; 0.01°C Resolution**
- **Switch-selectable scanning rates**

COMMUNICATION AND DATA PLAYBACK

The TDR-3A communicates with the user via RS-232 signals. The RS-232 port on the TDR-3A is used to initialize storage and to play back stored data. Commands are issued from a terminal, modem or computer; commands compatible with the Sea Data Microreader are included in the command set. The TDR-3A also has a built-in enhanced command set for advanced data logging, annotation, segmentation and playback.

Five minutes is all it takes to download stored data and to reinitialize the TDR-3A in the field. Plug a computer with an RS-232 port into the Micrologger; choose from among four output formats (engineering units, formatted or unformatted Microreader output or compressed format); and dump the data to a computer for processing or for immediate display.

Built-in hardware and software safety features protect valuable data against loss in the unlikely event of a system crash. Special memory mapping is implemented in hardware to facilitate access to the storage memory, while eliminating the possibility of overwriting previously recorded data.

Sea Data, Inc. • A Pacer Systems Co. • One Bridge Street, Newton, MA 02158 USA • 617-244-8191 • Tlx:951107 • Fax:617-244-3624

OPTIONS

Aluminum Pressure Housing: Aluminum pressure housing rated to 10,000 psi (6800 meters) for deep ocean applications. Housing is anodized and overcoated with polyurethane paint for protection against corrosion.

Backup Recorder: Wafer tape recorder system formerly used in all versions of the Micrologger. Can be used as a backup recorder. *

Pressure Testing: Standard PVC pressure housing pressure tested to 750 psi (150 meters).

In-line Mooring Cage: Two-piece stainless steel cage for use in in-line tension mooring. Model TDR-3A/SC.

Endcap with Underwater Data Connector: Allows for real-time data monitoring. Model TDR-3A/EC.

Additional Data Channels: Two additional data channels (for a total of four) to accommodate other temperature sensors, conductivity sensor, etc. Consult factory for details.

Other Pressure Sensors: Pressure sensors that can be used to a greater depth, or that go to the same depth with less accuracy.

OTHER VERSIONS

The following instruments are part of the Sea Data family of Microloggers:

TDR-3: Temperature and depth recorder for non-tidal applications.

CTR-3A: Conductivity and temperature recorder for tidal applications.

CTDR-3: Conductivity, temperature and depth recorder for non-tidal applications.

TR-3: A series of temperature recorders with sensors in a variety of configurations. Refer to separate data sheet.

MAXIMUM DEPLOYMENT TIME AT VARIOUS SWITCH SETTINGS
(Capacity based on 92K RAM)

SCAN INTERVAL	DATA CHANNELS 1	DATA CHANNELS 2 **	Tide Mode
5 seconds	60 hours (45)	30 hours (50)	---
1 minute	30 days (10)	15 days (20)	15 days (2)
6 minutes	180 days (3)	90 days (5)	90 days (1.5)
1 hour	900 days (0.7)	450 days (1)	450 days (0.6)

Number of full-duration deployments possible with one battery shown in ( ).
* Unattended deployments of more than a year in length reqauire a high power battery pack. Deployment times can be extended by disabling temperature sampling on the DIP switch.
** Normal mode, no tide averaging.

ORDERING INFORMATION

Contact your Sea Data sales representative to place an order. Be sure to specify any non-standard temperature or depth requirements at the time of order.

GENERAL SPECIFICATIONS

TIMEBASE

Type	32.768 Hz quartz crystal oscillator
Stability	5ppm/year, 40ppm over -5 to +40°C

PRESSURE

Sensor	Strain gauge with a creep-relieved stainless diaphragm vacuum reference chamber sealed with electron-beam welding
Range	20 m; tolerates up to 80 m of overranging
Accuracy	1 cm (with corrections)
Resolution	0.5 cm (one part in 4096)

TEMPERATURE

Sensor	30K Ohm bulkhead-mounted precision thermistor
Range	-5 to +35°C
Accuracy	0.15°C
Resolution	0.01°C (one part in 4096)
Time Constant	20 seconds in water

MEASUREMENT RATE

Switch-selectable from five seconds to one hour:
5, 10, 15, 30 sec, 1, 1.5, 2, 3, 5, 6, 7.5, 10, 15, 20, 30 and 60 min

DATA STORAGE

Media	CMOS solid-state static RAM with backup power supply
Playback	via RS-232; 300 to 9600 baud
Capacity	21,000 pressure/temperature data pairs
Format	record length, model number, S/N, record number, time, time since last record, pressure/temperature data

POWER

Battery	Sea Data BP-7 10.5 V, 6 AHr alkaline battery pack; good for six months, 1.5 full tide memories
Data Backup	Built-in 160 mAhr memory backup battery to prevent data loss in event of BP-7 failure

CURRENT DRAIN

RAM Recorder	less than 5 uA at 20°C or 20 uA at 40°C (typical)
Processor	15 mA when recording; 17 mA in tide mode, 0.3 mA in standby
Sensors	Normal Mode: 2.6 x 10-6 Ahr per pressure and temperature measurement. Tide Mode: 0.8 x 10-4 Ahr per 64-sample pressure measurement, 1.5 x 10- for temperature plus 128-sample pressure measurement.

PROCESSOR

Type	64180 CPU at 3.072 MHz with EPROM, RAM and oscillator self-test procedu
Memory	32 kilobytes of EPROM, 96 kilobytes of CMOS RAM storage

HOUSING

Material	PVC rated to 750 psi (500m)with stainless steel fittings (pressure tested by request only)
Size	14 cm (5.5") diameter by 41.5 cm (16.25") long
Weight	13 lbs in air, 2 lbs in water

Sea Data reserves the right to change specifications without advance notice.

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OCEAN SURVEYS, INC.

MARETRACK-MAREPLOT II

The OSI Maretrack/Mareplot system is the result of more than a decade of integrated software/hardware evolution and development. Initially starting as a programmable calculator-based system, capability has been progressively increased with greatly expanded task abilities, processing speed, expanded display of real-time data, simultaneous multi-terminal output, redundant real-time data logging and most recently a full stand-alone remote site data processing ability.

The present version of the OSI Maretrack/Mareplot II survey vessel navigation, trackline control, data logging and post-processing system operates on high speed AT and 80386-based portable micro-computers. The OSI Maretrack® system accepts position data input from an extensive range of instrumentation including:

Racal "Micro-Fix" Falcon
Motorola "IV"
Del Norte "540"
Cubic "Autotape"
Navitrack "Rho-Theta"
Krup Atlas "Polarfix"
IMC "Hydro I"
Northstar 800 Loran-C
Trimble 4000 GPS
Magnavox 1101& 4200 GPS

and offers the following real-time outputs:

Numerical Outputs

Line number and azimuth/heading
Distance to go start/end of line
Depth, Fix No., Vessel Speed, Time
Range data (R1, R2, R3, R4,...R8)
Data Acquisition Status (on/off)

Graphical Outputs

- Labelled tracklines with fixes and vessel location
- Vessel icon shown on selectable scale left/right "off-line" bar display
- Grid North Arrow

Post processing capability include full data analysis and editing through generation of both profile and "boat" or "smooth" sheet presentations at any desired scale, complete drawing labelling including graphic scales and title blocks, project location and survey site inset and generation of ASCII or DFX format (AutoCad) 5¼" or 3½" IBM diskettes.

HYDROGRAPHIC DATA COLLECTION/PROCESSING SYSTEM

HARDWARE

- 80286 Portable Computer Featuring:
  - 30 Mb Shock mounted hard disk
  - 1.2 Mb Floppy disk
  - 720Kb 3.5" Fixed disk
  - 10MHz Turbo Mode
  - RGB graphics monitor with external option
  - Special 4 Port Serial I/O card for system peripherals
  - Operates with MS-DOS 3.2 (IBM Compatible!)

HY87 — HYDROGRAPHIC DATA COLLECTION

- Range/Range or Range/Azimuth
- Supports up to 16 ranges
- Interfaces to support:
  - Digital Echosounders
  - Plotters
  - Event Markers
  - Remote left/right indicators
  - Printer
  - Remote Graphics Display
- Supports the following grids:
  - Transverse Mercator
  - Universal Transverse Mercator
  - Lambert Conformal Conic
  - Engineering
- On-Line Screen Graphics displaying:
  - Boat Track
  - Survey Lines
  - Digitized Shoreline Data
  - Adjustable Left/Right indicator
  - Positioning Information
- On-Line Plotting of Boat Track and/or Corrected Soundings
- Keyboard interrupts to change program parameters while on-line
- Keyboard entry mode for processing manually collected data
- System Configuration selected from software
- Records data on hard disk and 3.5" fixed disk

TIDE — PREDICTED HARMONIC TIDE

- Calculates and stores predicted tide corrections
- Accessed by HY87 for on-line depth reduction
- Provides a printed summary of corrections
- Screen graphics provide a tide graph

DEPDIG — DEPTH DIGITIZATION

- Provides for digitization of echograms and tide charts
- DEPDIG data is merged with positions from HY87 for processing

SHORE — SHORELINE FEATURE DIGITIZATION

- For digitizing shoreline and hydrographic features
- Information is displayed on graphics screen of HY87
- Information can be plotted on boat and smooth sheets
- Separate symbols for:

Shorelines and buildings	Wrecks
Geodetic Marks	Tanks
Exposed Rocks	Spires
Tide Gauges	Bouys
Grid and Magnetic North	Antennae
Text	Boats

DCORR — DEPTH AND POSITION CORRECTION

- Provides graphic displays of depth and positions for on-screen editing
- Provides for entry of final tide, draft, and zero corrections
- Builds final data file for input into HYPLOT

HYPLOT — HYDROGRAPHIC PLOTTING

- Plots and labels grids
- Plots boat's track from either HY87 or DCORR files
- Plots soundings in the following styles:
  - Decimal point on the mark (Corps of Engineers format)
  - Centered sounding with small lowered fraction (IHB format)
- Soundings can be oriented either:
  - Perpendicular to track
  - At a fixed angle to sheet
- Additional plot features:
  - Range/Range nets
  - Range/Azimuth nets
  - Plots Shoreline and Hydrographic Features
  - Plots Lines and Points
- Standard Title Blocks Include:
  - Plotting Record
  - Work Record
  - Smooth Sheet Record
  - Tidal Information Block

GEOD — Geodetic Support

- GP to UTM Conversions
- UTM to GP Conversions
- Forward GP
- Grid Traverse

OCEAN SURVEYS, INC. OSI

OLD SAYBROOK, CONNECTICUT

TEL: (203)388-4631 TLX: 966429

MEMBER The Hydrographic Soci

4000RS™ & 4000DS™

DGPS Reference Surveyor and Differential Surveyor

The DGPS solution for real-time sub-meter accuracy utilizing L1 C/A code.

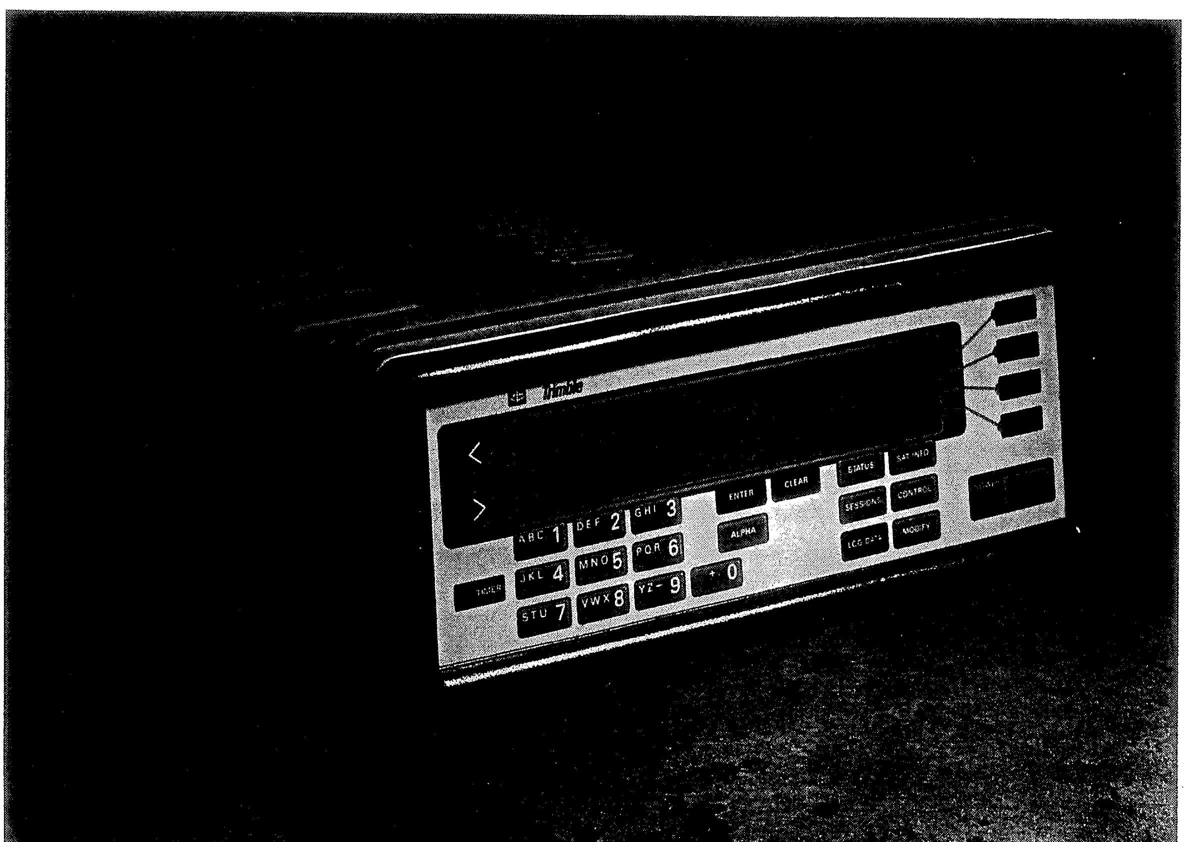
The 4000RS Reference Surveyor and 4000DS Differential Surveyor, built with Trimble's most advanced GPS processor, use carrier-smoothed C/A code measurements to achieve real-time DGPS sub-meter position accuracy. Both receivers feature 9-channels of continuous satellite tracking (12 channels optional), a lightweight, rugged, weatherproof housing, and low-power consumption for extended field operation time from batteries.

The 4000RS and 4000DS are ideal for hydrographic and navigation systems, vessel tracking and other dynamic surveying applications. The 4000RS operates as an autonomous reference station, calculating DGPS corrections in the RTCM SC-104 standard format for transmission to mobile GPS receivers. Advanced carrier aided filtering and smoothing techniques applied to exceptionally low noise C/A code measurements are used to provide the highest performance available in GPS positioning.

The 4000DS is designed to use DGPS corrections in the RTCM SC-104 standard format broadcast by the 4000RS. The receiver applies the DGPS corrections to its precise C/A code measurements to generate real-time, sub-meter positions at up to a 2 Hz. rate — even under the most challenging operating conditions.

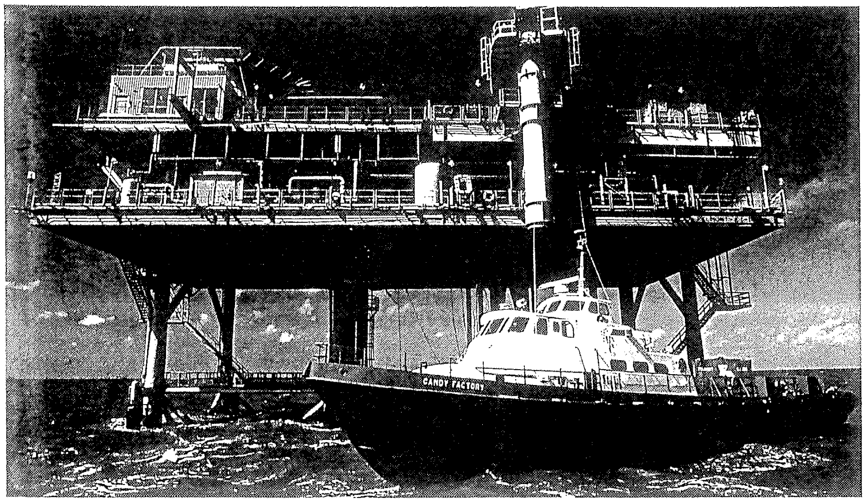
The 4000DS receiver's standard NMEA-0183 version 2 messages, navigation firmware, data and 1PPS outputs allow for optimal flexibility for system integration and interfacing with other instruments. The navigation functions enable waypoint-based route planning with displays for cross track error, steering indicator, and bearing and distance to next waypoint.

While operating, the 4000RS and 4000DS can output binary and ASCII data for archiving or post-mission analysis. In addition, the 4000RS can operate as a mobile receiver with the same features, functionality and options as the 4000DS. For optimum DGPS positioning, combine the receivers with any of Trimble's data communications systems and QA/QC firmware to ensure the integrity of positioning accuracy.



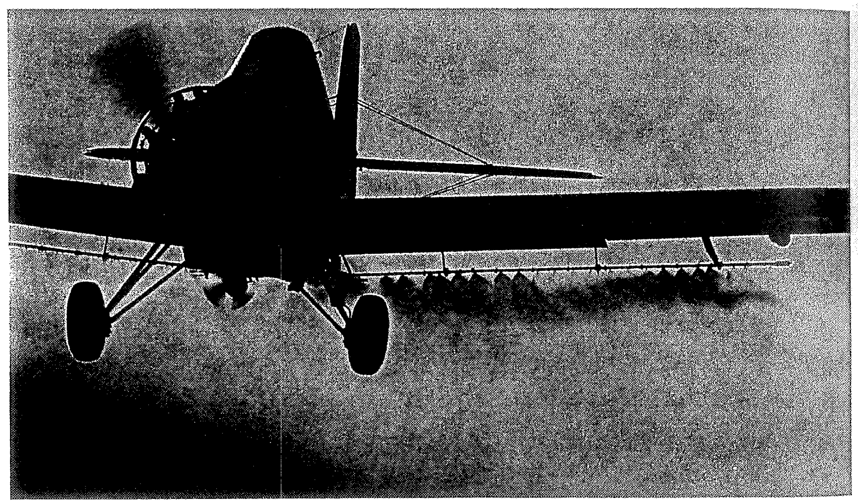
Applications:

Precision GPS Positioning on the ground, at sea and in the air.



HYDRO/DGPS Trimble's HYDRO software provides a totally integrated field-to-finish product that combines your DGPS position with other survey sensors such as echosounders, compasses, sidescan sonar, tide gauges and acoustic positioning equipment. HYDRO also provides navigation and has post-processing capabilities to produce high-quality plots. Additional modules include contouring, profiles, volumes and digitizing. HYDROseismic and HYDROrig have specialized features for the exploration industry's requirements for surveying and rig positioning.

Airborne Applications Traditionally, aerial applications have required multiple pilots as well as numerous human flaggers and associated ground crews. Using TRIMFLIGHT™, a precise DGPS airborne navigation and mapping system, crops can be sprayed effectively and consistently—without flaggers or ground assistance, providing the pilot with graphical proof of where he has sprayed. The system can also be used for a wide variety of other aerial applications, such as geophysical exploration, photogrammetry, GIS data capture and search & rescue.



Tracking Trimble's Barge Monitoring System has taken DGPS one step further by using two-way radio communications. While DGPS corrections are transmitted to vessels for navigation, positions and other status information are reported back to the reference site for display. The system is being used for environmental policing to ensure that the barges dump the material in legal dump sites. If a dump occurs outside these sites, the system will warn the controller.

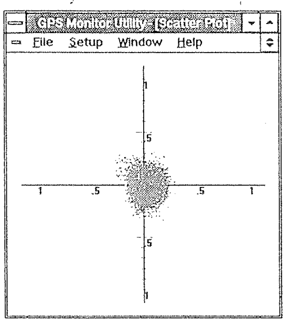
System Integration Components

Data Communications Systems

Trimble offers optimized telemetry systems. The real-time DGPS data communication systems include short-range "license-free" telemetry for line-of-sight environments such as ports, rivers, and coastal regions. For mid-range applications, there are proven HF, VHF and UHF systems for various conditions and licensing requirements. For long-ranges (up to 500 km), Trimble offers MF ground-wave systems. All telemetry components and accessories are tested to ensure system reliability.

GPS Monitor Utility™

The new GPS Monitor Utility is a Microsoft Windows® PC-based DGPS monitoring software tool. This performance analysis package is included with all 4000 Reference Surveyor and Differential Surveyor receivers, and is also available separately.



QA/QC Real-time Quality Assurance

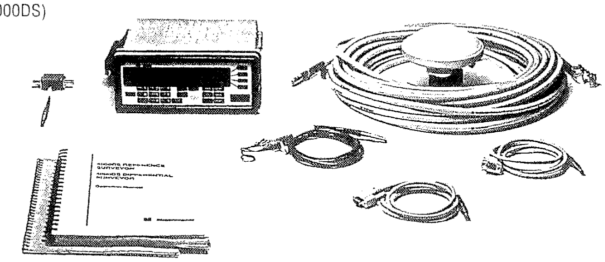
The QA/QC firmware option enables the user to verify the positioning integrity in real-time. QA/QC includes real-time position quality assurance displays, a position quality alarm with definable levels, and data output of quality related information. It provides unprecedented real-time assurances of the receiver's position accuracy so that the operator knows whether the required position quality is being met. If the accuracy falls below acceptable levels, an audible alarm notifies the operator.

Universal Reference Station™

The Universal Reference Station (URS™) is a PC-based software system that works as a dedicated, programmable DGPS reference station for broadcasting corrections to an unlimited number of users. URS collects data from all satellites in view, including pseudo ranges, carrier phase and ephemeris data, and outputs the data and corrections for transmission to mobile receivers that are being used anywhere in range. URS also can also be programmed to collect data for post-processed applications.

Standard Configuration

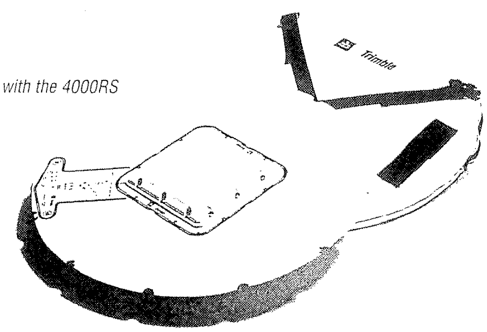
a. Series 4000 GPS receiver (4000DS)
b. Compact dome antenna
c. 30m antenna cable
d. Operating manual
e. Lemo to dual BNC cable
f. 5 pin Lemo to DB9 cable
g. 7 pin Lemo to DB9 cable
h. Dual power input cable



Geodetic Antenna Option

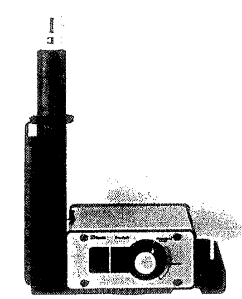
a. Ground plane geodetic antenna
b. Soft case carrying case

The Geodetic Antenna Option is standard with the 4000RS and is optional for the 4000DS.



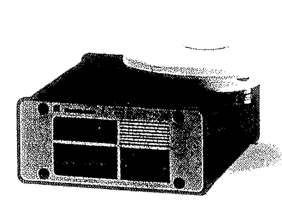
TRIMTALK Series Radio Link Options

TRIMTALK radios are available in various application-specific configurations for reference site, repeater and mobile use. Frequency options are tailored to operation worldwide, including *license-free* in many countries.



NavBeaconXL Option

The NavBeaconXL is designed specifically to receive the differential GPS correction broadcasts from DGPS/MSK radio beacons. Availability of these differential correction broadcasts is increasing rapidly worldwide.



For information about additional options, contact your Trimble sales representative.

4000 RS™ & 4000 DS™

Differential GPS Reference Surveyor and Differential Surveyor

4000 RS Features

Autonomous operation; Filtered and carrier-smoothed RTCM differential corrections (versions 1.0 and 2.0); 0.5 second measurement rate; Data integrity provision; Data link flow control on RTCM port; Triple DC input; L1 geodetic antenna; 30m antenna cable; Automatic mode restoration after power-off; Dual RS-232 I/O ports for data recording; Low power; Lightweight; Portable; Environmentally protected; 1 PPS output; NMEA-0183 outputs; RTCM input and output; 1-year warranty.

4000 DS Features

Less than 1 meter accuracy with Trimble 4000RS; Real-time operation; 0.5 second measurement rate; Data integrity provision; Triple DC input; Compact dome antenna; 30m antenna cable; Automatic mode restoration after power off; Extra RS-232 I/O port for data recording; Low power; portable; Environmentally protected; 1 PPS output; Navigation firmware; NMEA-0183 outputs; Weighted least squares solution; RTCM input; 1-year warranty.

Options

- Firmware update service—4 years
- L1 carrier phase
- 12 channels
- Rack mount
- Event marker
- QA/QC firmware
- Internal memory for datalogging
- Extended hardware warranty
- 4 serial I/O ports

Optional Accessories

- L1 Geodetic antenna
- 30m antenna cable extension, with in-line amplifier
- Office support module: OSM or OSM II
- AC power adapter, 50/60 Hz, 120V or 240V
- Receiver transport case
- TRIMTALK Series radio links
- NavBeacon XL MSK receiver

Physical Characteristics

Size:	9.8"W x 11.0"D x 4.0"H (standard receiver) (24.8cm x 28.0cm x 10.2cm) 16.8"W x 16"D x 5.25"H (rack-mount receiver) (42.7cm x 40.6cm x 13.3cm)
Weight:	6 lbs. (2.7kg) standard receiver 15lbs. (6.8kg) rack-mount receiver 0.5 lbs. (0.2kg) compact dome antenna 5.7 lbs. (2.6kg) L1 geodetic antenna
Power:	Nominal 10.5 to 35 VDC, 7 watts
Operating temp:	-20°C to +55°C
Storage temp:	-30°C to +75°C
Humidity:	100%, fully sealed, buoyant (standard receiver) 95% non-condensing (rack-mount receiver)

Technical Specifications

4000 RS

Peudorange correction accuracy:	Typically less than 30cm RMS: Low multipath environment
Compatibility:	Corrections may be applied to all differential-equipped GPS receivers

4000 DS

Accuracy:	Typically less than 1m RMS: Assumes at least five satellites and PDOP less than 4
Compatibility:	Accepts RTCM SC-104 corrections Version 1.0 or 2.0

4000 RS and 4000 DS

Tracking:	9 channels of L1 C/A
Start-up time:	Less than 2 minutes from power-on to tracking
Antenna:	External antenna with 30m RG213 cable
RS-232 data link rates:	50-57.6K baud
RTCM message output:	Types 1, 2, 3, 6, 9, 16
NMEA-0183:	ALM, BWC, GGA, GLL, GSA, GSV, RMB, RMC, VTG, WPL, XTE, ZDA
Ports:	Dual serial; Triple power inputs; Antenna; and 1PPS output
Display:	Backlit LCD with four lines of forty alphanumeric characters; Large, easy-to-read characters—2.8mm x 4.9mm; Total viewing area: 32cm²; Adjustable backlight and viewing angle
Keyboard:	Alphanumeric, function, and softkey entry

Specifications subject to change without prior notice.

Trimble

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Magnavox GPS

MX 50R DGPS Beacon Reciever

INCREASED ACCURACY

Through the simple addition of a Magnavox MX-50R Beacon Receiver, any mobile differential GPS navigator can take full advantage of the DGPS corrections broadcast by marine beacons. With such a system, accuracies on the order of 5 meters or better can be achieved economically. The MX-50R operates with beacons broadcasting in the 283.5 to 325.0 KHz band. The beacon's direction finding signal is modulated with DGPS corrections using MSK (Minimum Shift Keying) modulation. The MX-50R receives and demodulates the signal to recover correction messages.

SUPERIOR SIGNAL RECEPTION

A fully digital receiver, the MX-50R features a state-of-the-art signal processor. The digital implementation of MSK data demodulation uses a dual Costas loop detection algorithm to decrease bit errors. The patented active preamp and proprietary noise blanker ensure reception even in poor signal conditions. The MX-50R also contains error detection and correction capabilies.

INTERNATIONAL STANDARD

After several years of studying the distribution of DGPS corrections using radio beacons, IALA (International Association of Lighthouse Authorities) has established an international standard for DGPS beacon broadcasts. Magnavox has worked closely with IALA and the U.S. Coast Guard to ensure that the MX-50R adheres to all their standards and requirements.

AUTOMATIC BEACON SELECTION

The almanac message broadcast by DGPS beacons contains the location, frequency, and output power of beacons in the vicinity. This information is maintained in the GPS navigator, so the MX-50R can be automatically tuned to the nearest beacon.

EASE OF OPERATION

A single serial port provides for control of both the MX-50R and output of DGPS corrections. When teamed with a Magnavox DGPS Navigator such as the MX 4200D or MX 200, the MX-50R is automatically controlled by the navigator. The MX-50R signal strength and SNR are continuously output to the navigator.

COMPACT SIZE

The MX-50R is housed in a case identical to the popular MX 4200 GPS receiver. Compact size, single connection to the GPS receiver, and small 50 cm whip antenna simplify installation. The MX-50R is powered by 10-30 VDC and draws less than 4.5 watts.

SPECIFICATIONS

MX 50R DGPS Beacon Reciever

SIGNAL PROCESSING

Frequency Range:	283.5 - 325.0 KHz
Frequency Resolution:	500 Hz
Minimum Signal Strength:	14 dB (5uV/M)
Dynamic Range:	5 uV/M - 100 mV/M (86 dB)
Minimum SNR:	6 dB (1 bit per 1000 error rate in presence of Gaussian noise)
Adjacent Channel Rejection:	26 dB (500 Hz offset)
Acquisition Time:	5 sec typical (8 dB SNR)
Noise Blanker:	Removes impulse spikes up to 100 microseconds in duration
Signal Detection:	Digital signal processing and filtering using a TMS320 signal processor
Antenna Preamp:	Patented active preamp with integral bandpass filter minimizes detuning due to near by metallic objects and increases RF immunity

DATA PROCESSING

Demodulation:	MSK (Minimum Shift Keying)
Data Decoding:	Digital processing with dual Costas loops
RF Bit Rate (selectable):	25, 50, 100, 200 bps

POWER REQUIREMENTS

Input Voltage:	10-32 VDC
Power Consumption:	4.5 watts (Max)

DATA PORT

Control/ data port:	RS-422 or RS-232 (jumper selectable) Bi-directional serial port (9600 baud)
Connector:	DB9S

ENVIRONMENTAL

Operating Temperature

Receiver:	0° to 50°C
Antenna/ Preamp:	-40° to +50°C

Relative Humidity

Receiver:	95% non-condensing
Antenna/ Preamp:	100%

SIZE AND WEIGHT

Receiver:

Height:	46 mm (1.8 in)
Width:	140 mm (5.5 in)
Depth:	172 mm (6.8 in)
Weight:.	8 Kg (1.8 lbs)

Preamp:

Diameter:	83 mm (3.25 in)
Height:	178 mm (7.0 in)
Weight:	.3 Kg (0.6 lbs)

Antenna:	50 cm (19.7 in) Whip
Cable:	30M RG-6 Coax

STATUS INDICATORS

Power LED

Signal detect LED

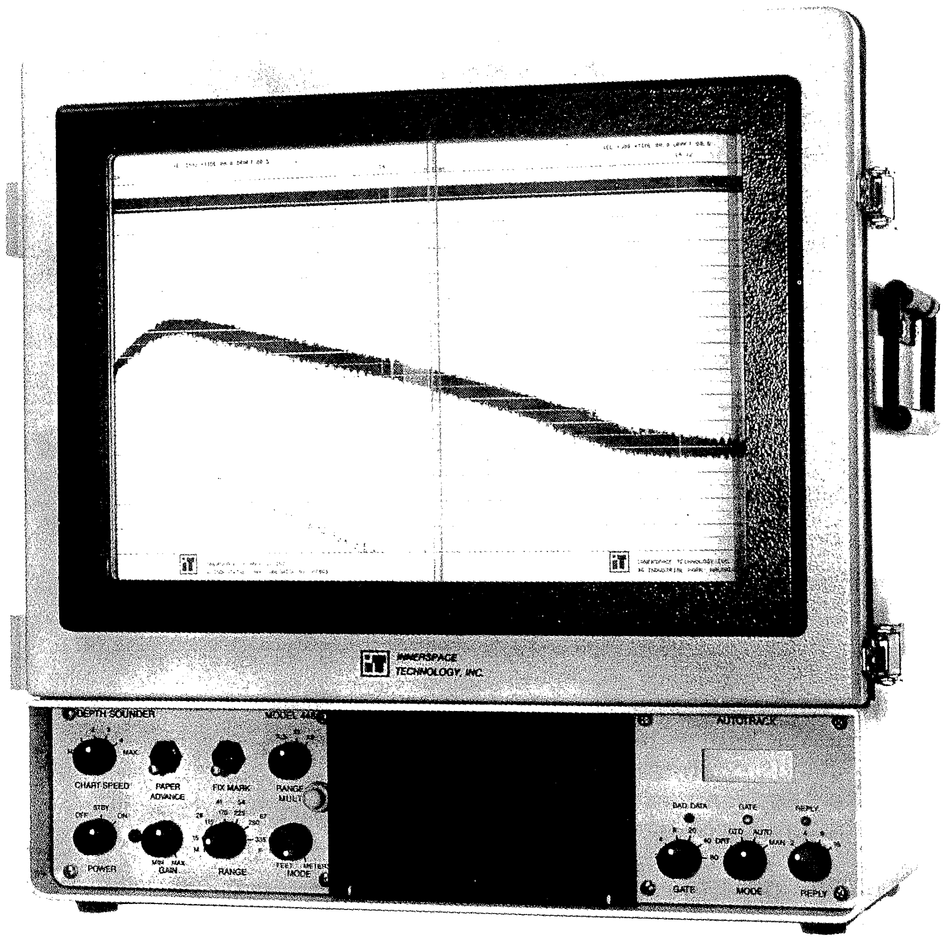
Magnavox GPS

Engineering The Evolution

MAGNAVOX, 2829 MARICOPA STREET, TORRANCE, CALIFORNIA 90503 U.S.A., TELEPHONE (213) 618-1200, FAX (213) 618-7001

INNERSPACE

THERMAL DEPTH SOUNDER RECORDER
MODEL 448



DESCRIPTION

The Innerspace Technology Model 448 Thermal Depth Sounder Recorder provides survey precision, high resolution depth recordings using SOLID STATE THERMAL PRINTING. The lightweight, portable unit is designed for use in small boat surveying as required for nautical chart production, engineering surveys, harbor and channel maintenance, pre and post dredge surveys, etc. The Model 448 TDSR uses a thermal printing technique pioneered by Innerspace for depth sounding which provides the high resolution and accuracy required by groups such as the U.S. Army Corps of Engineers, dredging companies, survey companies, port administrations, etc. The state of the art design allows integration into portable hydrographic survey systems.

INNERSPACE TECHNOLOGY, INC.

36 INDUSTRIAL PARK ▪ WALDWICK, NEW JERSEY 07463 ▪ (201) 447-0398 TWX 710-988-5628

OPERATION

The Model 448 TDSR utilizes the highest resolution, solid state, fixed thermal print head available for depth sounding. Blank white, high contrast thermal paper is used to print the selected range scale along with the depth. The depth is always read directly from the scale printed, thereby avoiding the possible confusion encountered when examining outmoded, preprinted, multi-scaled charts. Built-in chart annotation is standard and includes printing of numerical values for Speed of Sound, Tide and Draft. Time and event marks are numerically annotated and the chart is automatically labeled FEET or METERS as determined by the MODE switch.

Operator controls are provided on a gasketed, splashproof front panel. Thumbwheel switch settings are behind a splashproof access cover on the front panel, and the digitizer controls and display are provided on a front panel plug in module.

The microprocessor controlled sounder/recorder utilizes plug in printed circuit boards, a modular plug in power supply and plug in modular digitizer. Minimum wiring connections help provide an extremely reliable and serviceable unit. A preprogrammed test routine and diagnostic LED indicators provide valuable assistance for the operator and/or electronics technician. The single package portable unit may be used vertically or horizontally and can be powered from either an AC or DC source.

FEATURES

- **LOW COST**
- **RELIABLE**
- **THERMAL PRINTING** fixed head—no stylus to replace
- **CLEAN** operation—no carbon dust residue
- **QUIET** operation—no rotating stylus, no arcing
- **ODORLESS** operation—no burned paper
- **LARGE VIEWING** area with sliding window
- **LARGE CHART** standard format—high resolution
- **BLANK PAPER** is high contrast black on white and low in cost
- **PORTABLE** and lightweight for small boat operation
- **MICROPROCESSOR** controlled
- **SCALE SELECTED** is the only one printed
- **FEET or METERS** operation—switch selectable
- **THUMBWHEEL SETTINGS** for speed of sound, tide and draft
- **ANNOTATION** of all parameters appear on recordings in chart margin Speed of Sound, Tide, Draft, Event, Time and Mode of Operation
- **TVG** (time varied gain) minimizes gain adjustments
- **INTERNAL** micro controlled depth digitizer
- **EXTERNAL** depth digitizer connector on rear panel
- **NO ADJUSTMENTS** for zero line or call line are required

OPTIONS

CUSTOM LOGO—Programs recorder to repetitively print, in the lower chart margin, customer specified information such as user's logo, name, address, etc.

FREQUENCY—Choice of either 208 kHz or 125 kHz

POWER—Allows operation from either 110/120, 220/240 VAC or (not including) 12, 24 VDC

SPECIFICATIONS—SINGLE FREQUENCY TDSR MODEL 448

PRINTING	Thermal solid state fixed head thick film
CHART PAPER	8-¾ inches x 200 feet
PAPER SPEEDS	.5,1,2,4 or 8 inches/min. (Depends on scale selected)
DEPTH RANGES	0 to 335 feet or 0 to 80 meters. 6 overlapping phases of 60 feet or 15 meters A x 2 SWITCH multiplies each range by a factor of 2 and A x .5 SWITCH multiplies each range by a factor of .5
ACCURACY	± .1 foot or meter timing and printing resolution
SPEED OF SOUND	Thumbwheel switch selectable 4550 to 5050 feet/sec. or 1350 to 1550 meters/sec. Precision crystal referenced frequency synthesizer using a phase locked loop provides exact calibration.
TIDE	Thumbwheel switch selectable from 0 to ± 25.0 feet or meters
DRAFT	Thumbwheel switch selectable from 0 to + 99.9 feet or meters
EVENT MARK	Front panel switch or remote, increments internal counter
TIME	Internal clock with battery backup
SOUNDER FREQUENCY	208 kHz or 125 kHz standard or others optional
TRANSDUCERS	208 kHz 8 degree beamwidth at—3db 208 kHz 3 degree beamwidth at —3db (optional) 125 kHz 14 degree beamwidth at —3db (optional)
PULSE LENGTH	.15 to .6 ms. Automatically determined by frequency and depth range selected
PULSE POWER	250 watts RMS
SOUNDING RATE	1,200 soundings per minute max
TIME VARIED GAIN (TVG)	Automatically compensates for spreading loss and attenuation over depth range
GAIN CONTROL	Provides manual gain adjustment
STANDBY MODE	Allows transceiver and digitizer (if used) to operate without running chart paper
OUT OF PAPER SENSOR	Indicated by blinking front panel light. Paper motion stops, but sounding continues.
RAPID PAPER ADVANCE	Front panel switch allows for the rapid advance of blank paper
ANNOTATION	The numerical value of Speed of Sound, Tide, Draft, Time and Event are permanently recorded above the chart record periodically

DIGITIZER OUTPUT	In addition to the built in depth digitizer, Start/Stop pulses are available for use with external digitizers such as Innerspace Models 410, 412 and 445.
POWER	Either 12, 24 V DC or 120, 240 V AC (Must be specified AC or DC)
DIMENSIONS	17 in. W x 17¼ in. H x 9¼ in. D
WEIGHT	45 pounds
ENCLOSURE	Coated aluminum, corrosion resistant and splashproof. Sliding window for chart access and settings door for easy access to thumbwheel switches.

SPECIFICATIONS—INTERNAL MICROPROCESSOR DIGITIZER

OPERATING MODES

Either a DIRECT, GATED, AUTO or MANUAL mode may be chosen

- DIRECT — No gate present
- GATED — Gate width doubles, then quadruples automatically to reacquire the bottom reply
- AUTO — Gate width doubles, quadruples then goes to non-gated automatically to reacquire the bottom reply
- MANUAL — Fixed gate as preset on initial depth thumbwheel

GATE WIDTH	Selectable 2, 4, 8, 20, 40 or 80 via rotary switch. Gate width in feet or meters, determined by the recorder MODE switch setting
MISSED REPLIES	REPLY switch selects 2, 4, 8 or 16 missed replies, before reacquisition of bottom reply, in AUTO mode.
DISPLAY	Four digit LCD 7 segment. Resolution to 0.1 feet or meters, determined by the recorder MODE switch setting.
INDICATORS	Three LED's representing BAD DATA, REPLY and depth GATE
INITIAL DEPTH	Three station thumbwheel switch allows entry of an initial depth gate position
ALARM	A switched audible alarm indicates loss of track
OUTPUTS	BCD—8421 TTL compatible 5V positive logic. Buffered outputs with data hold, inhibit, strobe and flag lines. IEEE488 GPIB—4 digits with proper protocol and selectable address switches (optional) EIA RS232C—4 digits with selectable baud rates (optional). A bad data flag is available and can optionally set the output number to all zeros.

INNERSPACE TECHNOLOGY, INC.

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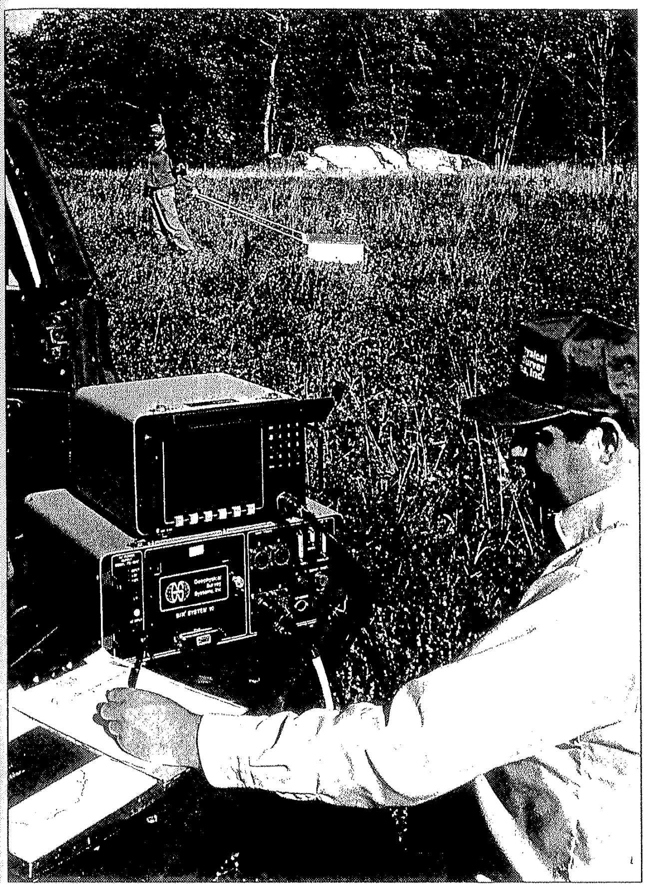
SIR® SYSTEM-10
SUBSURFACE INTERFACE RADAR

Engineered for non-destructive, rapid, subsurface investigations.



In the fields of civil engineering, construction, geology, hydrogeology, archeology and environmental protection, what you can't see often causes huge problems. Whether shallow or deep.

The SIR System-10 provides a detailed look at what's beneath the surface. Designed to interface with Geophysical Survey Systems Inc.'s entire line of state-of-the-art transducers, it is the first system to offer leading-edge, ground-penetrating radar (GPR) technology with full digital control of all setup parameters and multi-channel color display.

Widespread applications.

With the capability of performing at depths of more than 30 meters, the portable SIR System-10 is extremely effective in the earth's most critical zone to man: 0-10 meters below the surface. And as the SIR System-10 continues to prove itself in the field, users continue to find new cost-effective solutions to subsurface problems.

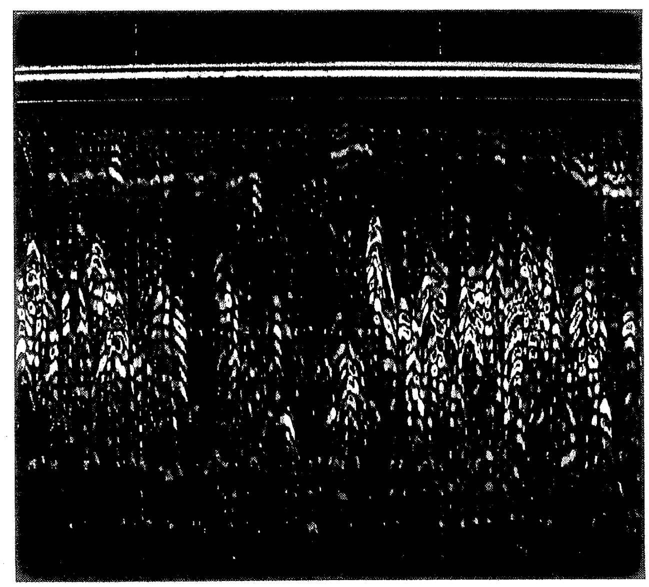
Civil engineers use the SIR System-10 to examine the infrastructure of roads, bridges and buildings; and to locate bedrock, pipes, tanks, sink holes and other underground obstructions. Geophysicists are mapping underground water tables, analyzing soil stratigraphy, profiling lake and river bottoms, and studying rock formations.

Also, environmental remediation experts are using the SIR System-10 to locate underground storage tanks and buried drums; delineate landfill boundaries and burial trenches; and in some cases, to identify hydrocarbon plumes that are leaching into neighboring soil and water supplies. Those are just some of the system's capabilities.

Instant display of subsurface data. Real-time processing and signal enhancement.

High resolution profiles are collected by pulling the appropriate GSSI transducer along the line being surveyed. Real-time digital signal enhancement and color display provide the user with immediate, on-site results. Data can be stored digitally on tape for complete post-processing and/or automatically recorded in real time with an optional thermal printer.

Powered by a DSP-56001 processor running at 20 MHz, the SIR System-10 uses our proprietary, menu-driven software to facilitate rapid 16-bit processing. Interactive and user-friendly, the software allows the operator to quickly optimize system settings for the particular task at hand. The result is exceptionally accurate and targeted data, without altering or harming the material being scanned.



This real-time data profile taken with the SIR System-10 shows individual drums buried in a trench at a hazardous waste disposal site.

SYSTEM SPECIFICATIONS

Software

CHANNELS: Can record 1, 2 or 4 data channels simultaneously.

DISPLAY MODES: Linescan, Wiggle Plot and Oscilloscope. When in linescan display, 16 color bins are used to represent the amplitude and polarity of the signal.

RANGE GAIN: Manual adjustment from -26 to +120 dB. Gain curve can be from one to eight straight-line segments over time range. Number of segments is user-selectable. Option to apply automatic gain to equalize the power over the scan.

VERTICAL FILTERS: Filter the scans in the time domain. Low and high pass, Infinite Impulse Response (IIR), Finite Impulse Response (FIR) and Triangular filter types are available.

Filtering single scans in the time domain.

Low Pass IIR	1 to 4 poles
High Pass IIR	1 to 4 poles
Low Pass FIR	3 to 63 taps
High Pass FIR	3 to 63 taps
Low Pass Triangle	3 to 63 taps
High Pass Triangle	3 to 63 taps

HORIZONTAL FILTERS: Filter the scans in the spatial domain. Stacking, background removal, IIR, FIR, Boxcar and Triangular types are available, as are Static Stacking models.

Filtering or averaging sequential scans in spatial domain.

IIR Stacking	1 to 16383 scans
IIR Background Removal	1 to 16383 scans
Boxcar Stacking	3 to 63 scans
Boxcar Background Removal	3 to 63 scans
Triangle Stacking	3 to 63 scans
Triangle Background Removal	3 to 63 scans
Static Stacking	2 to 16384 scans
Static Background Removal	3 to 63 scans

INPUTS/OUTPUTS:

- 2 Transducer channels (4 optional)
- 1 3.5" disk drive (1.44 MB)
- 1 Exabyte 8mm, 2.3-gigabyte cassette tape drive
- 1 PC/AT-compatible Centronics parallel printer port
- 1 PC/AT-compatible serial port (RS-232C)
- 1 SCSI port for external hard disk
- 1 Analog port for GSSI Graphic and Tape Recorders
- 1 Marker input
- 1 PC/AT-compatible extended keyboard
- 1 GSSI color monitor and keypad (Control/Display Module)
- 1 12 VDC or Optional 120/220 VAC input power
- 1 Survey wheel
- 1 Marker input

Electrical

TRANSDUCERS: Operates with any GSSI model transducer and can handle up to 4 transducer inputs simultaneously.

RESOLUTION: 50 picoseconds

RANGE: 0-10,000 nanoseconds full scale, selectable

PULSE REPETITION RATE: 2 to 78 KHz

ANALOG QUANTIZATION: 8- or 16-bit, selectable

ANALOG TO DIGITAL SAMPLING: 128, 256, 512 or 1024 sample/scan, selectable

CLOCK SYNCHRONIZATION: Internal crystal

SCAN RATE: 0.2 to 128 scans/second, selectable

INPUT POWER: 12 volts DC nominal with operating range of 11-15 volts, 200 watts; or 115/230 volts AC with operating range of 100-200 volts AC or 200-240 volts AC, 50/60 Hz, 200 watts

Mechanical

MODEL MF-10
30.5 cm x 29.2 cm x 21.6 cm
10.5 Kg

MODEL CD-10
44.1 cm x 38.1 cm x 17.8 cm
18.0 Kg

Thermal

MAIN SYSTEM

OPERATING TEMPERATURE: -10°C to 40°C external

RELATIVE HUMIDITY: < 90% non-condensing

EXABYTE CARTRIDGE TAPE SUBSYSTEM

MAXIMUM TEMPERATURE VARIATION: Less than 1°C per minute, not more than 10°C per 30 minutes.

STORAGE TEMPERATURE: -40°C to 60°C

Hardware

COMPUTER BOARD: 286 processor with 80287 math co-processor (386 optional)

RADAR PROCESSOR: Motorola DSP-56001, 20 MHz

ARRAY PROCESSOR: Sky 321-Plus Array Processor Card

RAM MEMORY: 4 MB (Expandable to 8, 12, and 20 MB)

MASS STORAGE: 2.3 GB Exabyte 8mm cartridge tape drive

112-meter tape stores 2.3 GB
54-meter tape stores 1024 MB
15-meter tape stores 256 MB

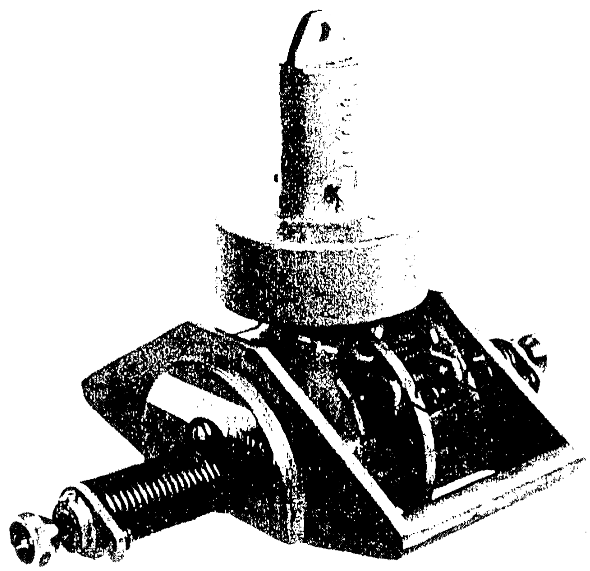
FLOPPY DISK DRIVE: 3.5" inch (8.9 cm), 1.44 MB

EXTERNAL INTERFACE: Standard SCSI connector for external hard disk

DISPLAY: 19 cm color monitor, 640 by 350 pixels, 21.8 KHz non-interlaced

Hydro Products
A TETRA TECH COMPANY

SHIPEK SEDIMENT SAMPLER
MODEL 860



FEATURES

- UNDISTURBED SAMPLES
- UNLIMITED DEPTHS
- AUTOMATIC ACTUATION
- FOOLPROOF OPERATION

DESIGN

This advanced concept in bottom samplers is based upon the patented design of the late Carl J. Shipek, noted oceanographer. Specifically designed for sampling unconsolidated sediment, from soft ooze to hard-packed course sand, the device is capable of bringing virtually undisturbed, unwashed samples to the surface from any depth.

The Shipek sampler is designed to take a sample 1/25 square meter in surface area and approximately 4 inches deep at the center. It is therefore particularly well adapted for pickup of benthos organisms living at or immediately below the water bottom interface.

PERFORMANCE

Basically the unit is composed of 2 concentric half cylinders. The inner semi-cylinder, or sample bucket, is rotated at high torque by 2 helically wound external springs. Upon contact with the bottom it is automatically triggered by the inertia of a self-contained weight upon a sear mechanism. At the end of its 180° travel the sample bucket is stopped and held at the closed position by residual spring torque.

After closure the sample is given optimum protection from washout during the return trip by the cylindrical configuration of the unit. Unlike many types of samplers, closure of the unit is made at the side, rather than at the bottom. Therefore, if complete closure is prevented by a rock or some other consolidated substance, it is improbable that the entire sample will be lost.

Based on in situ experience, special attention has been given to ease of removal of the sample from the unit. Once on deck, the sample bucket may be disengaged from the rest of the device by releasing two retaining latches at each end of the upper semi-cylinder. The sample is then readily accessible for immediate study or transport to off-site laboratory facilities. Any number of interchangeable sample buckets may be purchased for use with a single actuating mechanism. The Shipek Sediment Sampler is covered by U.S. Patent No. 3,165,935, dated January 19, 1965.

OCEAN SURVEYS, INC. OSI

OLD SAYBROOK, CONNECTICUT

June 1973

SPECIFICATIONS

SIZE:	18.6 in. x 17.4 in. x 25.1 in. (47.2 x 44.2 x 65.8 cm)
WEIGHT:	134 lbs. (to.8 kg(net; 200 lbs. (90.8 kg) shipping weight
MATERIALS:	Sampler: Cast Iron Springs: Tempered stainless steel
FINISH:	International Orange epoxy paint applied over inert primer coat
SAMPLE SIZE:	Surface area: 8 in. x 8 in. (1/25 square meter) Depth: 4 in. (10.2 cm) at center

ORDERING INFORMATION

The Model 860 Shipek Sediment Sampler is shipped from the factory in a re-useable packing crate, complete with one sample bucket and one hand cocking wrench. Complete operating instructions and handling recommendations are also provided. For ease in carrying, handles are affixed to the unit.

The complete crate measures 21.5 in. x 21 in. x 29.75 in. (54.6 x 43.3 x 75.6 cm), and will hold the sampler cocking wrench and extra sample buckets. Net weight of the Model 860 is 134 lbs., with a shipping weight of 200 lbs.

GUARANTEE

The Shipek Sediment Sampler is unconditionally guaranteed against all defects in material, workmanship, or operation for a period of one year from the date of sale. This guarantee is voided only if the sampler is obviously misused or modified by the customer.

DIMENSIONAL DRAWING OF THE SHIPEK SEDIMENT SAMPLER MODEL 860

Hydro Products
A TETRA TECH COMPANY
POST OFFICE BOX 2528 · SAN DIEGO, CALIFORNIA · TE :ONE (714) 453-2345 · TWX 910-322-1133

APPENDIX III

TABLE OF GRAB SAMPLE LOCATIONS AND RESULTS

APPENDIX III

TABLE OF GRAB SAMPLE LOCATIONS AND RESULTS

SAMPLE	NORTHING*	EASTING*	STATION OFFSET**	DESCRIPTION
DR-1	358134'	237854'	122+880, 750' west	Grey clay with no sand, full sample.
DR-2	357302'	236647'	124+390, 609' west	Grey clay, semi-stiff with no sand, full sample.
DR-3	355805'	234319'	127+220, 650' west	Grey clay intermixed with fine-coarse sand and gravel, full sample.
DR-4	356328'	235522'	125+860', 460' west	Grey Clay, no sand, full sample.
DR-5	353829'	231870'	130+300, 270' west	Grey clay, no sand, full sample.
DR-6	354257'	231903'	130+000, 620' west	Fine to med. sand with wood fragments and clay, sampler 3/4 full.
DR-7	353601'	230543'	131+580, 780' west	2" of gravel and sand, no clay present, sampler 1/5 full.
DR-8	352788'	230339'	132+160, 210' west	3" of very stiff clay, sampler 1/5 full.
DR-9	355299'	233311'	128+280,750' west	1-2" of grey clay overlies coarse sand and gravel, full sample.
DR-10	354884'	233105'	128+700, 515' west	No sample recovery, grey clay noted on side of sampler.
DR-11A	354594'	232874'	129+45, 390' west	Approx. 3" of stiff grey clay with trace of sand, sampler 1/4 full.
DR-12	359402'	239845'	120+550, 780' west	Grey-brown clay intermixed with sand, gravel and rocks, sampler 1/4 full.
DR-13	360258'	241694'	118+560, 180' west	Medium sand with pebbles and gravel, sampler 1/5 full.
DR-14♦	359847'	241646'	118+830, 180' west	3" of grey clay overlies medium sand, full sample.
DR-15	353247'	230331'	131+950, 600' west	Medium sand intermixed with pebbles, cobbles and gravel, sampler 1/6 full.
DR-16	358483'	239023'	121+780,420' west	Grey clay with no sand, full sample.
DR-17♦	361863'	244253'	115+550, 510' west	No sample, sampler bounces on very hard bottom interpreted as rock.
DR-18♦	359500'	241498'	119+130, 20' west	2" of grey mud overlies sand and gravel, full sample.
DR-19♦	359704'	241913'	118+680, 70' east	Sand with pebbles and cobbles, trace of materials in sampler.
DR-20♦	358699'	240920'	120+050, 400' east	1-2" stiff grey clay overlies medium sand, sampler 1/3 full.
DR-21	356810'	237657'	123+815, 270' east	Grey clay with no sand, full sample.

DR-22	354704'	234321'	127+760, 280' east	Grey clay overlies cobbles and pebbles, sampler 1/4 full.
DR-23	353158'	231863'	130+660, 290' east	Very stiff grey clay, sampler 1/5 full.
DR-24	352481'	231042'	131+730, 420' east	5" of stiff grey clay overlie sand and gravel, sampler 1/3 full

* Coordinates refer to New Jersey State Plane Coordinate System, NAD 83.

** Station and offset are approximate and are measured from ACOE Delaware River Channel centerline.

⌖ Denotes sample was acquired outside Phase III limits.

APPENDIX IV

Rock Quantity Calculation Tables

OCEAN SURVEYS, INC.

ROCK QUANTITY CALCULATIONS DELAWARE RIVER CHANNEL
SUMMARY OF PHASE II ESTIMATES - SITES B & C

SUMMARY OF "ROCK" AREAS

	VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS) ABOVE 47'	VOLUME (CUBIC YDS) ABOVE 48'
SITE B	2,466,779	4,224,689	91,362	156,470
SITE C	471,420	997,010	17,460	36,926
TOTAL	2,938,199	5,221,699	108,822	193,396

SUMMARY OF "? ROCK" AREAS

	VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS) ABOVE 47'	VOLUME (CUBIC YDS) ABOVE 48'
SITE B	26,626	69,183	986	2,562
SITE C	5,360	19,063	199	706
TOTAL	31,986	88,246	1,185	3,268

SUMMARY OF GAS AREAS WHERE ROCK IS EXPECTED

	VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS) ABOVE 47'	VOLUME (CUBIC YDS) ABOVE 48'
SITE B	2,960,242	4,303,112	109,639	159,375
SITE C	0	0	0	0
TOTAL	2,960,242	4,303,112	109,639	159,375

	VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS) ABOVE 47'	VOLUME (CUBIC YDS) ABOVE 48'
Sum Site B	5,453,647	8,596,984	201,987	318,407
Sum Site C	476,780	1,016,073	17,659	37,632
SUM TOTAL SITES B & C PHASE II	5,930,427	9,613,057	219,645	356,039

OCEAN SURVEYS, INC.

ROCK QUANTITY CALCULATIONS DELAWARE RIVER CHANNEL				
SITE B	PHASE II			
	VOLUME (CUBIC FT) ABOVE 47'	VOLUME (CUBIC FT) ABOVE 48'	VOLUME (CUBIC YDS) ABOVE 47'	VOLUME (CUBIC YDS) ABOVE 48'
"ROCK" AREAS				
1	46,925	76,138	1,738	2,820
2	47,909	117,633	1,774	4,357
3	14,820	24,167	549	895
4	10,688	29,038	396	1,075
5	2,685	11,212	99	415
6	10,338	30,697	383	1,137
7	8,694	17,010	322	630
8	109,028	199,956	4,038	7,406
9	407,600	584,493	15,096	21,648
10	2,425	6,835	90	253
11	125,083	212,987	4,633	7,888
12	18,744	44,805	694	1,659
13	153,703	240,343	5,693	8,902
14	41,438	65,204	1,535	2,415
15	507	6,225	19	231
16	18,727	30,831	694	1,142
17	49,366	83,213	1,828	3,082
18	9,833	16,873	364	625
19	396,144	586,212	14,672	21,712
20	0	1,137	0	42
21	0	361	0	13
22	3,477	6,570	129	243
23	110,404	191,015	4,089	7,075
24	3,421	7,828	127	290
25	0	403	0	15
26	725,209	1,258,654	26,860	46,617
27	0	1,180	0	44
28	4,308	41,024	160	1,519
29	0	318	0	12
30	27,377	47,831	1,014	1,772
31	1,479	3,234	55	120
32	49,454	106,366	1,832	3,939
33	12,992	71,337	481	2,642
34	51,307	96,148	1,900	3,561
35	0	52	0	2
36	12	1,642	0	61
37	2,682	5,440	99	201
38	0	277	0	10
SUM CUBIC FEET	2,466,779	4,224,689		
SUM CUBIC YARDS			91,362	156,470

OCEAN SURVEYS, INC.

ROCK QUANTITY CALCULATIONS DELAWARE RIVER CHANNEL					
SITE B	PHASE II				
		VOLUME	VOLUME	VOLUME	VOLUME
		(CUBIC FT)	(CUBIC FT)	(CUBIC YDS)	(CUBIC YDS)
"?ROCK" AREAS		ABOVE 47'	ABOVE 48'	ABOVE 47'	ABOVE 48'
	1	25,717	28,147	952	1,042
	2	909	41,036	34	1,520
SUM CUBIC FEET		26,626	69,183		
SUM CUBIC YARDS				986	2,562

ROCK QUANTITY CALCULATIONS DELAWARE RIVER CHANNEL					
SITE B	PHASE II				
		VOLUME	VOLUME	VOLUME	VOLUME
		(CUBIC FT)	(CUBIC FT)	(CUBIC YDS)	(CUBIC YDS)
"GAS" AREAS		ABOVE 47'	ABOVE 48'	ABOVE 47'	ABOVE 48'
	1	98,111	194,524	3,634	7,205
	2	53,345	84,138	1,976	3,116
	3	1,806	8,044	67	298
	4	494,870	976,876	18,329	36,181
	5	2,312,110	3,039,530	85,634	112,575
SUM CUBIC FEET		2,960,242	4,303,112		
SUM CUBIC YARDS				109,639	159,375

OCEAN SURVEYS, INC.

ROCK QUANTITY CALCULATIONS DELAWARE RIVER CHANNEL					
SITE C	PHASE II				
	VOLUME	VOLUME	VOLUME	VOLUME	
	(CUBIC FT)	(CUBIC FT)	(CUBIC YDS)	(CUBIC YDS)	
"ROCK" AREAS	ABOVE 47'	ABOVE 48'	ABOVE 47'	ABOVE 48'	
1	7,147	23,803	265	882	
2	43,295	85,257	1,604	3,158	
3	1,057	2,822	39	105	
4	0	80	0	3	
5	0	103	0	4	
6	30,449	58,995	1,128	2,185	
7	17,392	29,902	644	1,107	
8	363,300	781,388	13,456	28,940	
9	8,780	14,660	325	543	
SUM CUBIC FEET	471,420	997,010			
SUM CUBIC YARDS			17,460	36,926	
	VOLUME	VOLUME	VOLUME	VOLUME	
	(CUBIC FT)	(CUBIC FT)	(CUBIC YDS)	(CUBIC YDS)	
"?ROCK" AREAS	ABOVE 47'	ABOVE 48'	ABOVE 47'	ABOVE 48'	
1	5,360	18,055	199	669	
2	0	858	0	32	
3	0	150	0	6	
SUM CUBIC FEET	5,360	19,063			
SUM CUBIC YARDS			199	706	
	VOLUME	VOLUME	VOLUME	VOLUME	
	(CUBIC FT)	(CUBIC FT)	(CUBIC YDS)	(CUBIC YDS)	
"GAS" AREAS	ABOVE 47'	ABOVE 48'	ABOVE 47'	ABOVE 48'	
NO "GAS" AREAS FOR VOLUME CALCULATIONS WITHIN SITE					
SUM CUBIC FEET	0	0			
SUM CUBIC YARDS			0	0	

OCEAN SURVEYS, INC.

ROCK QUANTITY CALCULATIONS DELAWARE RIVER CHANNEL					
SUMMARY OF PHASE III ESTIMATES					
SUMMARY OF "PROBABLE ROCK OUTCROP" AREAS					
		VOLUME	VOLUME	VOLUME	VOLUME
		(CUBIC FT)	(CUBIC YDS)	(CUBIC FT)	(CUBIC YDS)
		ABOVE 47'	ABOVE 47'	ABOVE 48'	ABOVE 48'
IF ROCK @ SURF		683,328	25,308	803,539	29,761
IF ROCK 1' BELOW		565,252	20,935	683,328	25,308
IF ROCK 2' BELOW		453,814	16,808	565,252	20,935
AVG. ROCK 0-1'		624,290	23,122	743,434	27,535
AVG. ROCK 0-1'-2'		567,465	21,017	684,040	25,335
SUMMARY OF "ROCK EXPECTED BELOW SURFACE" AREAS					
		VOLUME	VOLUME	VOLUME	VOLUME
		(CUBIC FT)	(CUBIC YDS)	(CUBIC FT)	(CUBIC YDS)
		ABOVE 47'	ABOVE 47'	ABOVE 48'	ABOVE 48'
IF ROCK 1' BELOW		1,529,694	56,655	1,909,954	70,739
IF ROCK 2' BELOW		1,196,600	44,319	1,529,694	56,655
IF ROCK 3' BELOW		907,400	33,607	1,196,600	44,319
AVG. ROCK 1-2'		1,363,147	50,487	1,719,824	63,697
AVG. ROCK 1'-2'-3'		1,211,231	44,860	1,545,416	57,238
SUMMARY OF ROCK EXPECTED IN PHASE III AREA					
(ASSUME ROCK AT SURFACE IN "PROBABLE ROCK OUTCROP" AREAS					
AND ROCK 1' BELOW SURFACE IN "ROCK EXPECTED BELOW SURFACE" AREAS)					
		VOLUME	VOLUME	VOLUME	VOLUME
		(CUBIC FT)	(CUBIC YDS)	(CUBIC FT)	(CUBIC YDS)
		ABOVE 47'	ABOVE 47'	ABOVE 48'	ABOVE 48'
SUM TOTAL		2,213,022	81,964	2,713,493	100,500
PHASE III					

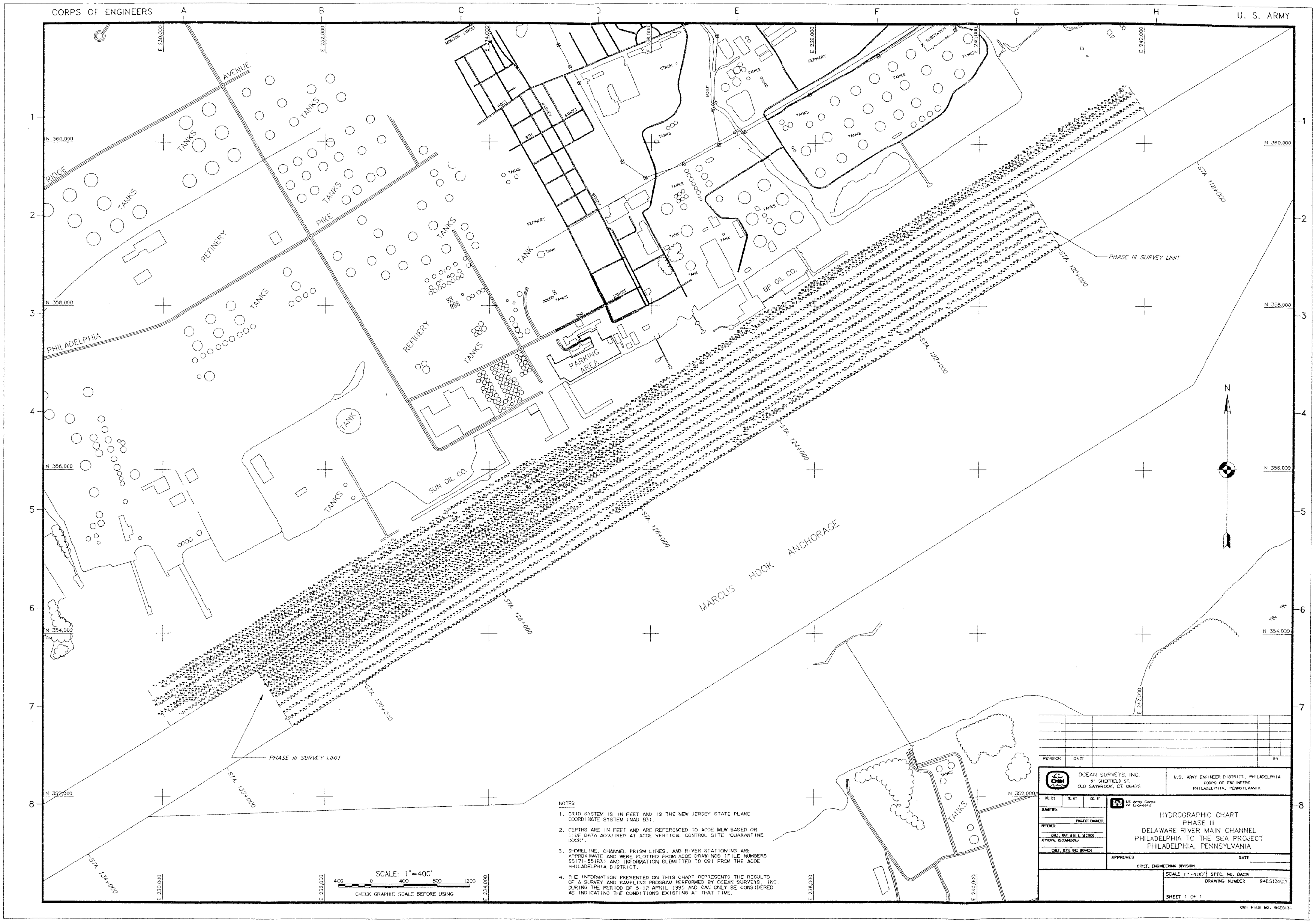
ROCK QUANTITY CALCULATIONS DELAWARE RIVER CHANNEL
PHASE III

PROBABLE ROCK OUTCROP AREAS	IF ROCK @ SURF VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC YDS)	IF ROCK @ SURF VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS)	IF ROCK 1' BELOW VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC YDS)	IF ROCK 1' BELOW VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS)	IF ROCK 2' BELOW VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC YDS)	IF ROCK 2' BELOW VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS)
1	54,876	2,032	59,504	2,204	50,248	1,861	54,876	2,032	45,621	1,690	50,248	1,861
2	19,090	707	22,060	817	16,120	597	19,090	707	13,151	487	16,120	597
3	116,608	4,319	125,572	4,651	107,643	3,987	116,608	4,319	98,679	3,655	107,643	3,987
4	35,050	1,298	37,450	1,387	32,651	1,209	35,050	1,298	30,251	1,120	32,651	1,209
5	85,626	3,171	104,411	3,867	66,842	2,476	85,626	3,171	48,057	1,780	66,842	2,476
6	26,611	986	31,620	1,171	21,601	800	26,611	986	16,592	615	21,601	800
7	23,297	863	29,099	1,078	17,495	648	23,297	863	11,693	433	17,495	648
8	8,760	324	10,535	390	6,986	259	8,760	324	5,211	193	6,986	259
9	82,491	3,055	115,203	4,267	49,779	1,844	82,491	3,055	20,765	769	49,779	1,844
10	13,688	507	20,269	751	7,107	263	13,688	507	1,237	46	7,107	263
11	41,792	1,548	48,290	1,789	35,294	1,307	41,792	1,548	28,796	1,067	35,294	1,307
12	40,901	1,515	44,192	1,637	37,609	1,393	40,901	1,515	34,318	1,271	37,609	1,393
13	104,146	3,857	113,706	4,211	94,586	3,503	104,146	3,857	85,027	3,149	94,586	3,503
14	30,392	1,126	41,628	1,542	21,291	789	30,392	1,126	14,416	534	21,291	789
SUM (CUBIC FEET)	683,328		803,539		565,252		683,328		453,814		565,252	
SUM (CUBIC YDS)		25,308		29,761		20,935		25,308		16,808		20,935

ROCK EXPECTED BELOW SURFACE AREAS	IF ROCK 1' BELOW VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC YDS)	IF ROCK 1' BELOW VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS)	IF ROCK 2' BELOW VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC YDS)	IF ROCK 2' BELOW VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS)	IF ROCK 3' BELOW VOLUME (CUBIC FEET) ABOVE 47'	VOLUME (CUBIC YDS)	IF ROCK 3' BELOW VOLUME (CUBIC FEET) ABOVE 48'	VOLUME (CUBIC YDS)
1	119,990	4,444	124,358	4,606	115,623	4,282	119,990	4,444	111,255	4,121	115,623	4,282
2	48	2	4,241	157	0	0	48	2	0	0	0	0
3	16,258	602	19,221	712	13,295	492	16,258	602	10,333	383	13,295	492
4	70,477	2,610	85,050	3,150	55,904	2,071	70,477	2,610	41,330	1,531	55,904	2,071
5	4,198	155	31,408	1,163	0	0	4,198	155	0	0	0	0
6	198,492	7,352	264,330	9,790	132,901	4,922	198,492	7,352	71,877	2,662	132,901	4,922
7	82,109	3,041	98,218	3,638	65,999	2,444	82,109	3,041	49,890	1,848	65,999	2,444
8	92,543	3,428	118,707	4,397	66,379	2,458	92,543	3,428	40,215	1,489	66,379	2,458
9	39,887	1,477	49,711	1,841	30,062	1,113	39,887	1,477	20,237	750	30,062	1,113
10	96,587	3,577	140,872	5,217	52,375	1,940	96,587	3,577	18,278	677	52,375	1,940
11	87,909	3,256	162,150	6,006	33,341	1,235	87,909	3,256	3,601	133	33,341	1,235
12	243,229	9,008	279,221	10,342	207,238	7,675	243,229	9,008	171,246	6,342	207,238	7,675
13	373,704	13,841	413,458	15,313	333,950	12,369	373,704	13,841	294,196	10,896	333,950	12,369
14	104,263	3,862	119,009	4,408	89,533	3,316	104,263	3,862	74,942	2,776	89,533	3,316
SUM (CUBIC FEET)	1,529,694		1,909,954		1,196,600		1,529,694		907,400		1,196,600	
SUM (CUBIC YDS)		56,655		70,739		44,319		56,655		33,607		44,319

APPENDIX V

Reduced Versions of
OSI Drawing No. 94ES131C.1 & .2, Sheet 1
OSI Drawing No. 94ES131B.2 &.3, Sheets 2-4


CORPS OF ENGINEERS
U. S. ARMY
HYDROGRAPHIC CHART
PHASE III
DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PENNSYLVANIA
OCEAN SURVEYS, INC.
91 SHEFFIELD ST.
OLD SAYBROOK, CT. 06475
U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
US Army Corps of Engineers
REVISION
DATE
BY
DR. BY
TR. BY
CK. BY
SUBMITTED:
PROJECT ENGINEER
REVIEWED:
APPROVAL RECOMMENDED
CHIEF, TECH. ENG. BRANCH
APPROVED
DATE
CHIEF, ENGINEERING DIVISION
SCALE 1"=400'
SPEC. NO. DACW
DRAWING NUMBER 94ES131C.1
SHEET 1 OF 1
OSI FILE NO. 94E8131
NOTES
1. GRID SYSTEM IS IN FEET AND IS THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NAD 83).
2. DEPTHS ARE IN FEET AND ARE REFERENCED TO ACOE MLW BASED ON TIDE DATA ACQUIRED AT ACOE VERTICAL CONTROL SITE "QUARANTINE DOCK".
3. SHORELINE, CHANNEL PRISM LINES, AND RIVER STATIONING ARE APPROXIMATE AND WERE PLOTTED FROM ACOE DRAWINGS (FILE NUMBERS 55171-55183) AND INFORMATION SUBMITTED TO OSI FROM THE ACOE PHILADELPHIA DISTRICT.
4. THE INFORMATION PRESENTED ON THIS CHART REPRESENTS THE RESULTS OF A SURVEY AND SAMPLING PROGRAM PERFORMED BY OCEAN SURVEYS, INC. DURING THE PERIOD OF 5-12 APRIL 1995 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME.
SCALE: 1"=400'
400 0 400 800 1200
CHECK GRAPHIC SCALE BEFORE USING
MARCUS HOOK ANCHORAGE
PHASE III SURVEY LIMIT
STA. 118+000
STA. 120+000
STA. 122+000
STA. 124+000
STA. 126+000
STA. 128+000
STA. 130+000
STA. 132+000
STA. 134+000
SUN OIL CO.
BP OIL CO.
PARKING AREA
REFINERY
TANKS
TANK
AVENUE
PIKE
RIDGE
PHILADELPHIA
N
N 360,000
N 358,000
N 356,000
N 354,000
N 352,000
E 230,000
E 232,000
E 234,000
E 238,000
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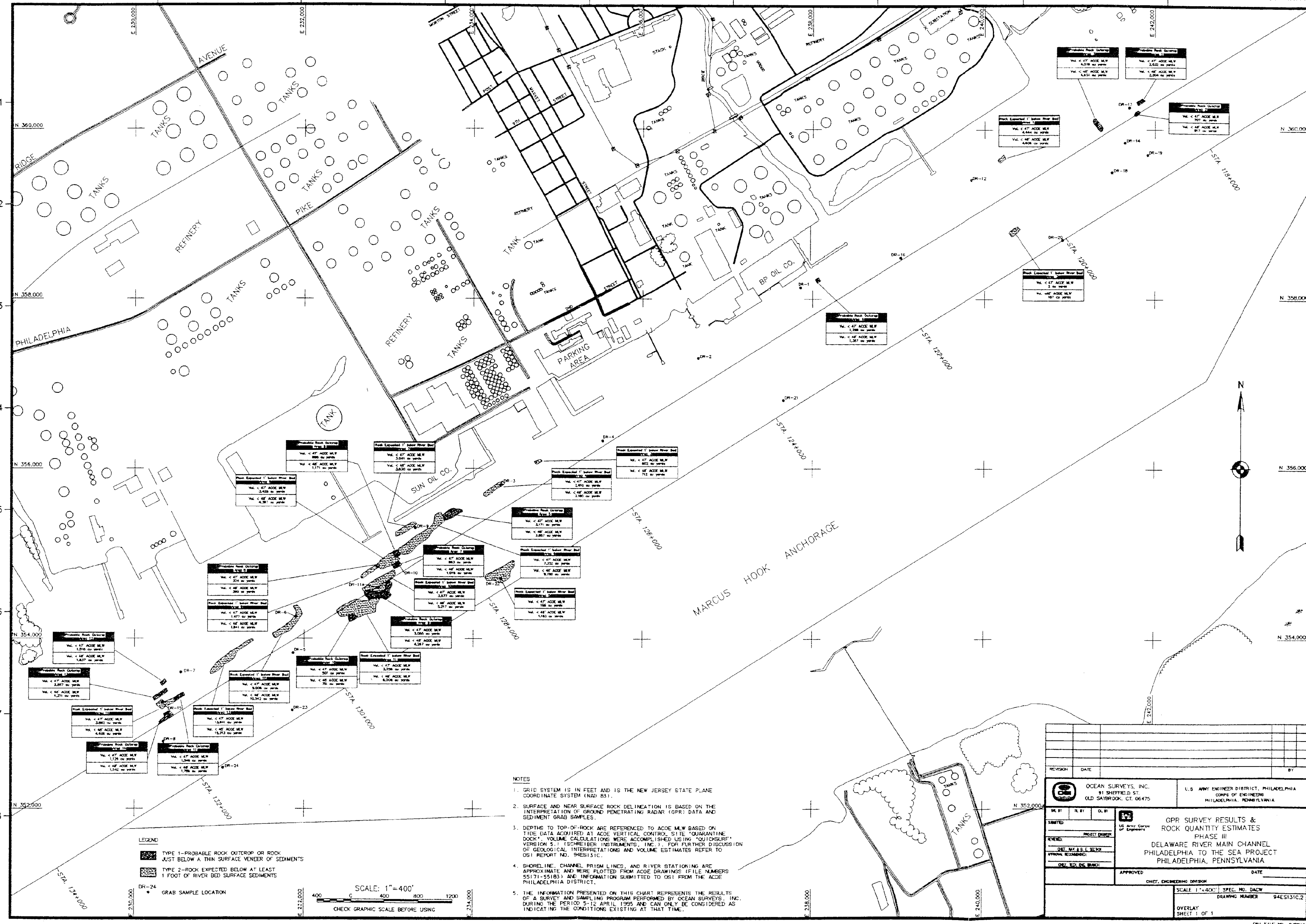


NOTES

1. GRID SYSTEM IS IN FEET AND IS THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NAD 83).
2. SURFACE AND NEAR SURFACE ROCK DELINEATION IS BASED ON THE INTERPRETATION OF GROUND PENETRATING RADAR (GPR) DATA AND SEDIMENT GRAB SAMPLES.
3. DEPTHS TO TOP-OF-ROCK ARE REFERENCED TO ACOE MLW BASED ON TIDE DATA ACQUIRED AT ACOE VERTICAL CONTROL SITE "QUARANTINE DOCK". VOLUME CALCULATIONS WERE ACCOMPLISHED USING "QUICKSURF" VERSION 5.1 (SCHREIBER INSTRUMENTS, INC.). FOR FURTHER DISCUSSION OF GEOLOGICAL INTERPRETATIONS AND VOLUME ESTIMATES REFER TO OSI REPORT NO. 94ES131C.
4. SHORELINE, CHANNEL PRISM LINES, AND RIVER STATIONING ARE APPROXIMATE AND WERE PLOTTED FROM ACOE DRAWINGS (FILE NUMBERS 55171-55183) AND INFORMATION SUBMITTED TO OSI FROM THE ACOE PHILADELPHIA DISTRICT.
5. THE INFORMATION PRESENTED ON THIS CHART REPRESENTS THE RESULTS OF A SURVEY AND SAMPLING PROGRAM PERFORMED BY OCEAN SURVEYS, INC. DURING THE PERIOD 5-12 APRIL 1995 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME.

REVISION | DATE | BY

OCEAN SURVEYS, INC.
91 SHEFFIELD ST.
OLD SAYBROOK, CT. 06475

U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

DR. BY | TR. BY | CK. BY

SUBMITTED: PROJECT ENGINEER
REVIEWED: CHIEF, NAV. & B. E. SECTION
APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

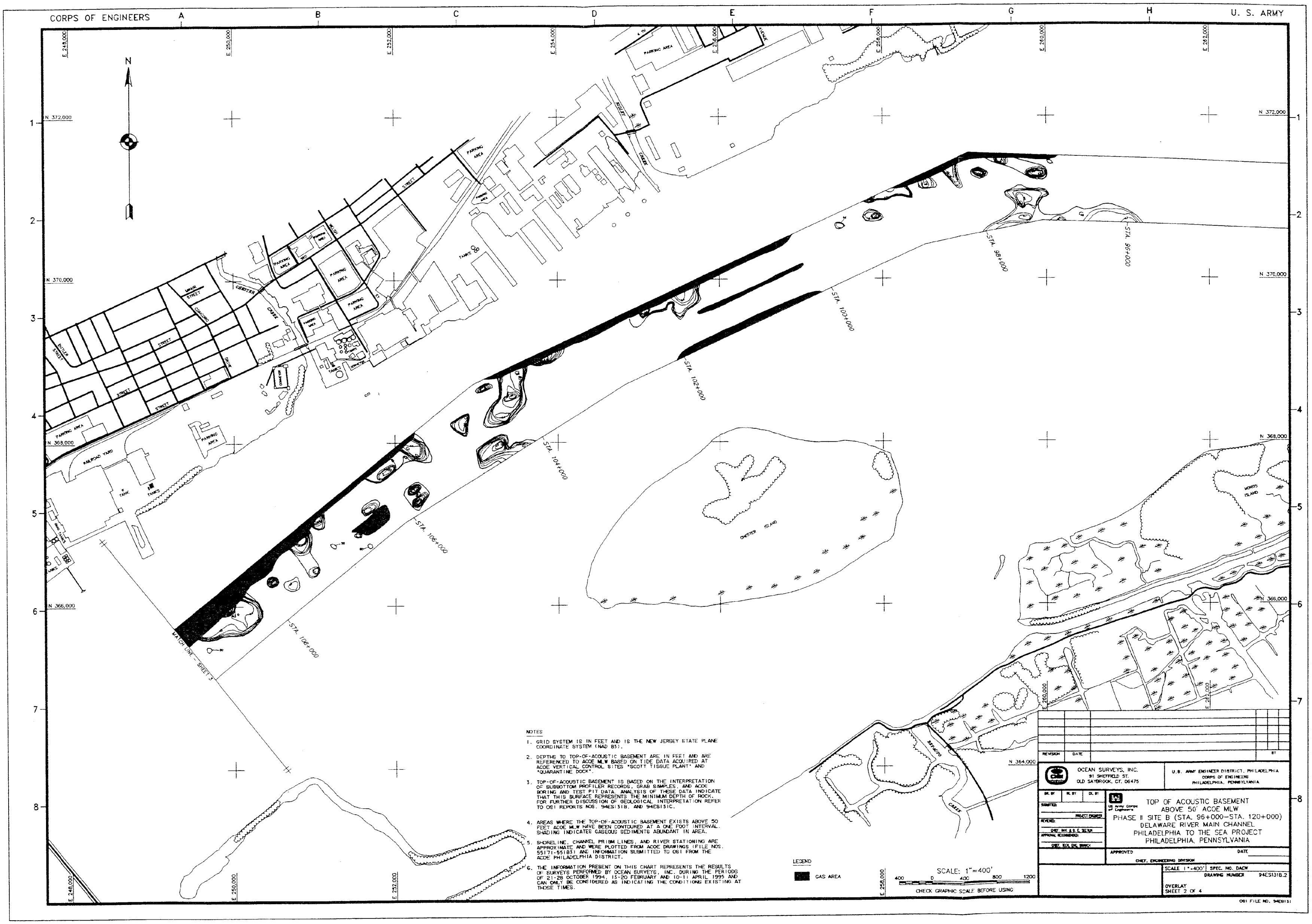
US Army Corps of Engineers

GPR SURVEY RESULTS &
ROCK QUANTITY ESTIMATES
PHASE III
DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PENNSYLVANIA

APPROVED ____ DATE ____
CHIEF, ENGINEERING DIVISION

SCALE 1"=400' | SPEC. NO. DACW
DRAWING NUMBER 94ES131C.2
OVERLAY
SHEET 1 OF 1

OSI FILE NO. 94EB131



NOTES

1. GRID SYSTEM IS IN FEET AND IS THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NAD 83).
2. DEPTHS TO TOP-OF-ACOUSTIC BASEMENT ARE IN FEET AND ARE REFERENCED TO ACOE MLW BASED ON TIDE DATA ACQUIRED AT ACOE VERTICAL CONTROL SITES "SCOTT TISSUE PLANT" AND "QUARANTINE DOCK".
3. TOP-OF-ACOUSTIC BASEMENT IS BASED ON THE INTERPRETATION OF SUBBOTTOM PROFILER RECORDS, GRAB SAMPLES, AND ACOE BORING AND TEST PIT DATA. ANALYSIS OF THESE DATA INDICATE THAT THIS SURFACE REPRESENTS THE MINIMUM DEPTH OF ROCK. FOR FURTHER DISCUSSION OF GEOLOGICAL INTERPRETATION REFER TO OSI REPORTS NOS. 94ES131B, AND 94ES151C.
4. AREAS WHERE THE TOP-OF-ACOUSTIC BASEMENT EXISTS ABOVE 50 FEET ACOE MLW HAVE BEEN CONTOURED AT A ONE FOOT INTERVAL. SHADING INDICATES GASEOUS SEDIMENTS ABUNDANT IN AREA.
5. SHORELINE, CHANNEL PRISM LINES, AND RIVER STATIONING ARE APPROXIMATE AND WERE PLOTTED FROM ACOE DRAWINGS (FILE NOS. 55171-55183) AND INFORMATION SUBMITTED TO OSI FROM THE ACOE PHILADELPHIA DISTRICT.
6. THE INFORMATION PRESENT ON THIS CHART REPRESENTS THE RESULTS OF SURVEYS PERFORMED BY OCEAN SURVEYS, INC. DURING THE PERIODS OF 21-28 OCTOBER 1994, 15-20 FEBRUARY AND 10-11 APRIL 1995 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THOSE TIMES.

REVISION	DATE		BY

OCEAN SURVEYS, INC.
91 SHEFFIELD ST.
OLD SAYBROOK, CT. 06475

U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

DR. BY | TR. BY | CK. BY

SUBMITTED: PROJECT ENGINEER

REVIEWED: CHIEF, INV. & B. E. SECTION

APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

US Army Corps of Engineers

TOP OF ACOUSTIC BASEMENT
ABOVE 50' ACOE MLW
PHASE II SITE B (STA. 96+000–STA. 120+000)
DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PENNSYLVANIA

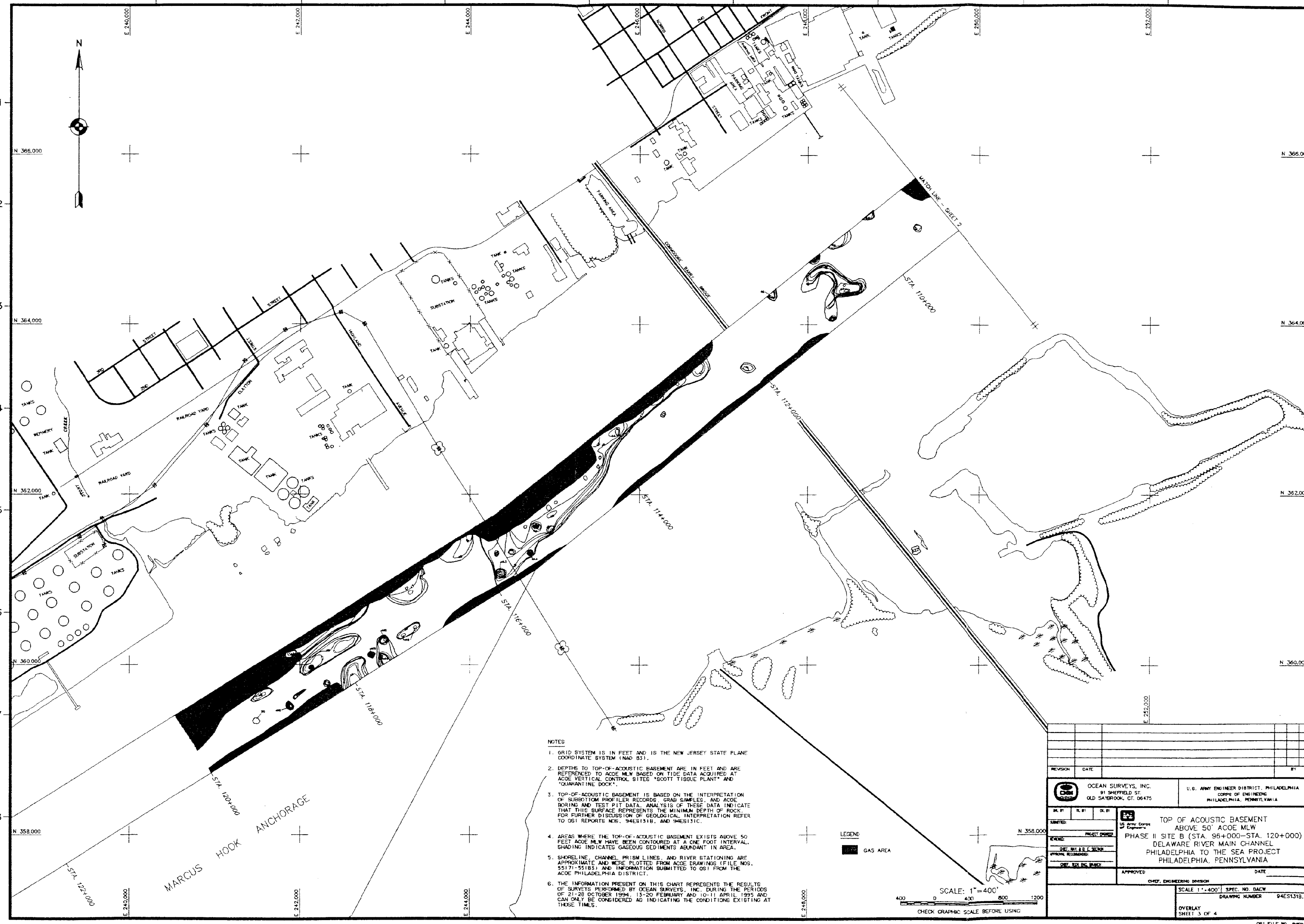
APPROVED — CHIEF, ENGINEERING DIVISION — DATE

SCALE 1"=400' | SPEC. NO. DACW

DRAWING NUMBER 94ES131B.2

OVERLAY
SHEET 2 OF 4

OSI FILE NO. 94ES131



NOTES

1. GRID SYSTEM IS IN FEET AND IS THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NAD 83).
2. DEPTHS TO TOP-OF-ACOUSTIC BASEMENT ARE IN FEET AND ARE REFERENCED TO ACOE MLW BASED ON TIDE DATA ACQUIRED AT ACOE VERTICAL CONTROL SITES "SCOTT TISSUE PLANT" AND "QUARANTINE DOCK".
3. TOP-OF-ACOUSTIC BASEMENT IS BASED ON THE INTERPRETATION OF SUBBOTTOM PROFILER RECORDS, GRAB SAMPLES, AND ACOE BORING AND TEST PIT DATA. ANALYSIS OF THESE DATA INDICATE THAT THIS SURFACE REPRESENTS THE MINIMUM DEPTH OF ROCK. FOR FURTHER DISCUSSION OF GEOLOGICAL INTERPRETATION REFER TO OSI REPORTS NOS. 94ES131B, AND 94ES131C.
4. AREAS WHERE THE TOP-OF-ACOUSTIC BASEMENT EXISTS ABOVE 50 FEET ACOE MLW HAVE BEEN CONTOURED AT A ONE FOOT INTERVAL. SHADING INDICATES GASEOUS SEDIMENTS ABUNDANT IN AREA.
5. SHORELINE, CHANNEL PRISM LINES, AND RIVER STATIONING ARE APPROXIMATE AND WERE PLOTTED FROM ACOE DRAWINGS (FILE NOS. 55171-55183) AND INFORMATION SUBMITTED TO OSI FROM THE ACOE PHILADELPHIA DISTRICT.
6. THE INFORMATION PRESENT ON THIS CHART REPRESENTS THE RESULTS OF SURVEYS PERFORMED BY OCEAN SURVEYS, INC. DURING THE PERIODS OF 21-28 OCTOBER 1994, 13-20 FEBRUARY AND 10-11 APRIL 1995 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THOSE TIMES.

REVISION | DATE | BY

OCEAN SURVEYS, INC.
91 SHEFFIELD ST.
OLD SAYBROOK, CT. 06475

U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

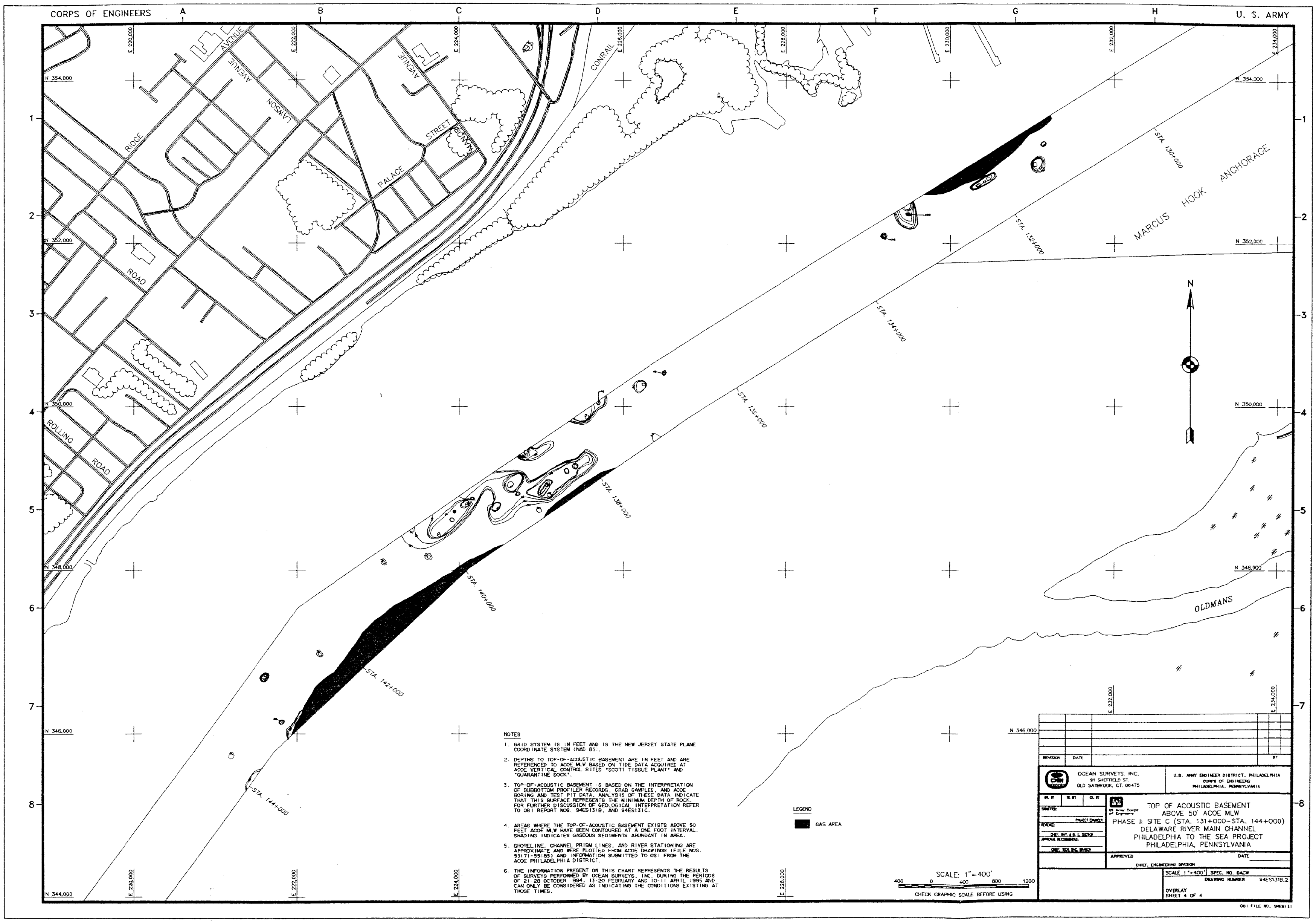
US Army Corps of Engineers

TOP OF ACOUSTIC BASEMENT
ABOVE 50' ACOE MLW
PHASE II SITE B (STA. 96+000–STA. 120+000)
DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PENNSYLVANIA

SUBMITTED: PROJECT ENGINEER
REVIEWED: CHIEF, NAV. & D. C. SECTION
APPROVAL RECOMMENDED: CHIEF, TECH ENG. BRANCH
APPROVED: CHIEF, ENGINEERING DIVISION DATE

SCALE 1"=400' | SPEC. NO. DACW
DRAWING NUMBER 94ES1318.2
OVERLAY
SHEET 3 OF 4

OSI FILE NO. 94EB131



NOTES

1. GRID SYSTEM IS IN FEET AND IS THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NAD 83).

2. DEPTHS TO TOP-OF-ACOUSTIC BASEMENT ARE IN FEET AND ARE REFERENCED TO ACOE MLW BASED ON TIDE DATA ACQUIRED AT ACOE VERTICAL CONTROL SITES "SCOTT TISSUE PLANT" AND "QUARANTINE DOCK".

3. TOP-OF-ACOUSTIC BASEMENT IS BASED ON THE INTERPRETATION OF SUBBOTTOM PROFILER RECORDS, GRAB SAMPLES, AND ACOE BORING AND TEST PIT DATA. ANALYSIS OF THESE DATA INDICATE THAT THIS SURFACE REPRESENTS THE MINIMUM DEPTH OF ROCK. FOR FURTHER DISCUSSION OF GEOLOGICAL INTERPRETATION REFER TO OSI REPORT NOS. 94ES131B, AND 94ES131C.

4. AREAS WHERE THE TOP-OF-ACOUSTIC BASEMENT EXISTS ABOVE 50 FEET ACOE MLW HAVE BEEN CONTOURED AT A ONE FOOT INTERVAL. SHADING INDICATES GASEOUS SEDIMENTS ABUNDANT IN AREA.

5. SHORELINE, CHANNEL PRISM LINES, AND RIVER STATIONING ARE APPROXIMATE AND WERE PLOTTED FROM ACOE DRAWINGS (FILE NOS. 55171-55183) AND INFORMATION SUBMITTED TO OSI FROM THE ACOE PHILADELPHIA DISTRICT.

6. THE INFORMATION PRESENT ON THIS CHART REPRESENTS THE RESULTS OF SURVEYS PERFORMED BY OCEAN SURVEYS, INC. DURING THE PERIODS OF 21-28 OCTOBER 1994, 13-20 FEBRUARY AND 10-11 APRIL 1995 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THOSE TIMES.

REVISION | DATE | BY

OCEAN SURVEYS, INC.
91 SHEFFIELD ST.
OLD SAYBROOK, CT. 06475

U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

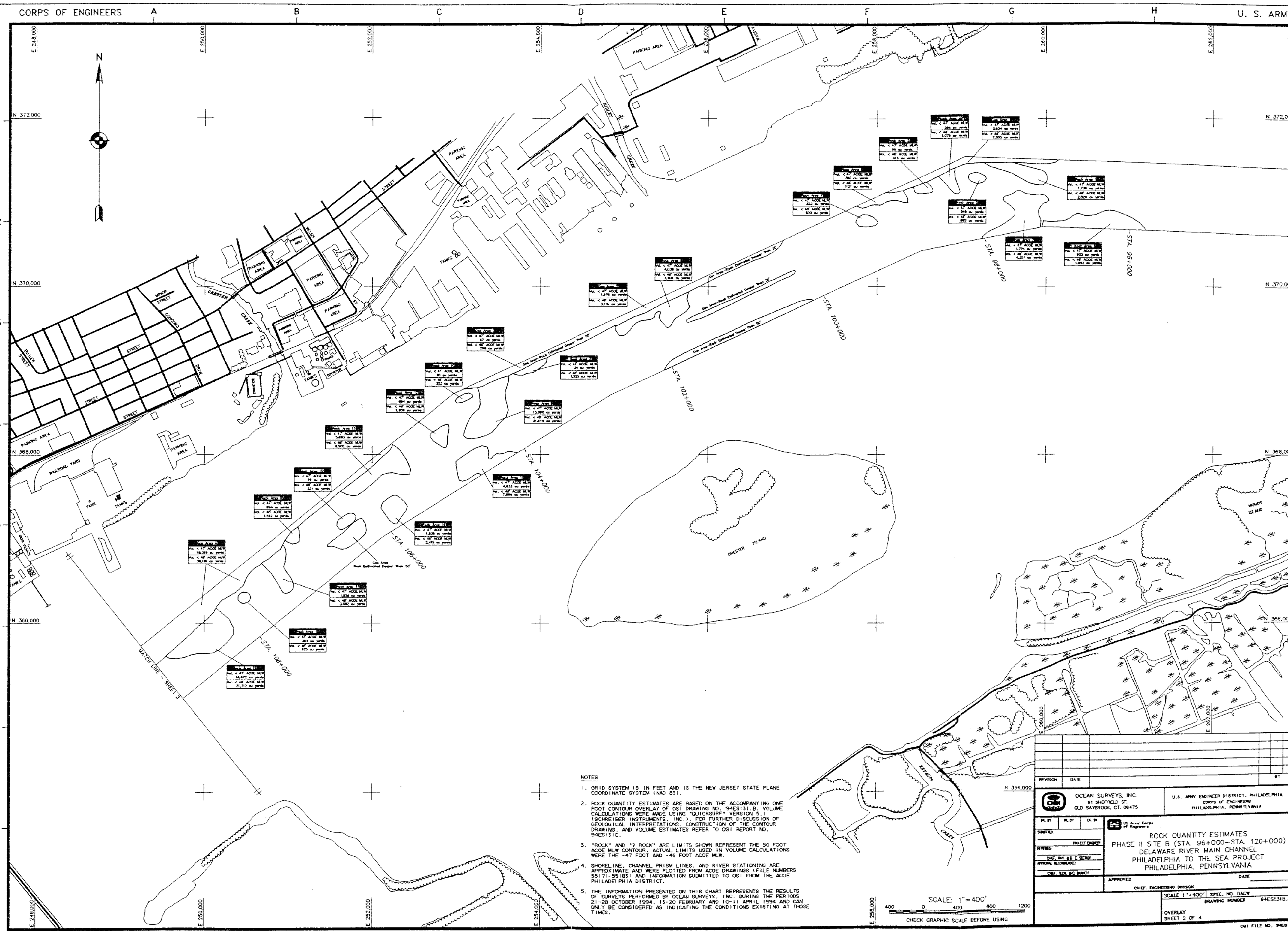
US Army Corps of Engineers

TOP OF ACOUSTIC BASEMENT
ABOVE 50' ACOE MLW
PHASE II SITE C (STA. 131+000-STA. 144+000)
DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PENNSYLVANIA

SUBMITTED: PROJECT ENGINEER
REVIEWED: CHIEF, NAV. & B. E. SECTION
APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH
APPROVED: CHIEF, ENGINEERING DIVISION
DATE

SCALE 1"=400' | SPEC. NO. DACW
DRAWING NUMBER 94ES131B.2
OVERLAY
SHEET 4 OF 4

OSI FILE NO. 94ES131



NOTES

1. GRID SYSTEM IS IN FEET AND IS THE NEW JERSEY STATE PLANE COORDINATE SYSTEM (NAD 83).

2. ROCK QUANTITY ESTIMATES ARE BASED ON THE ACCOMPANYING ONE FOOT CONTOUR OVERLAY OF OSI DRAWING NO. 94ES131.B. VOLUME CALCULATIONS WERE MADE USING "QUICKSURF" VERSION 5.1 (SCHREIBER INSTRUMENTS, INC.). FOR FURTHER DISCUSSION OF GEOLOGICAL INTERPRETATIONS, CONSTRUCTION OF THE CONTOUR DRAWING, AND VOLUME ESTIMATES REFER TO OSI REPORT NO. 94ES131C.

3. "ROCK" AND "? ROCK" ARE LIMITS SHOWN REPRESENT THE 50 FOOT ACOE MLW CONTOUR. ACTUAL LIMITS USED IN VOLUME CALCULATIONS WERE THE -47 FOOT AND -48 FOOT ACOE MLW.

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U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
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PHILADELPHIA, PENNSYLVANIA

DN. BY | TR. BY | CK. BY

SUBMITTED: PROJECT ENGINEER

REVIEWED: CHIEF, NAV. & B. E. SECTION

APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

US Army Corps of Engineers

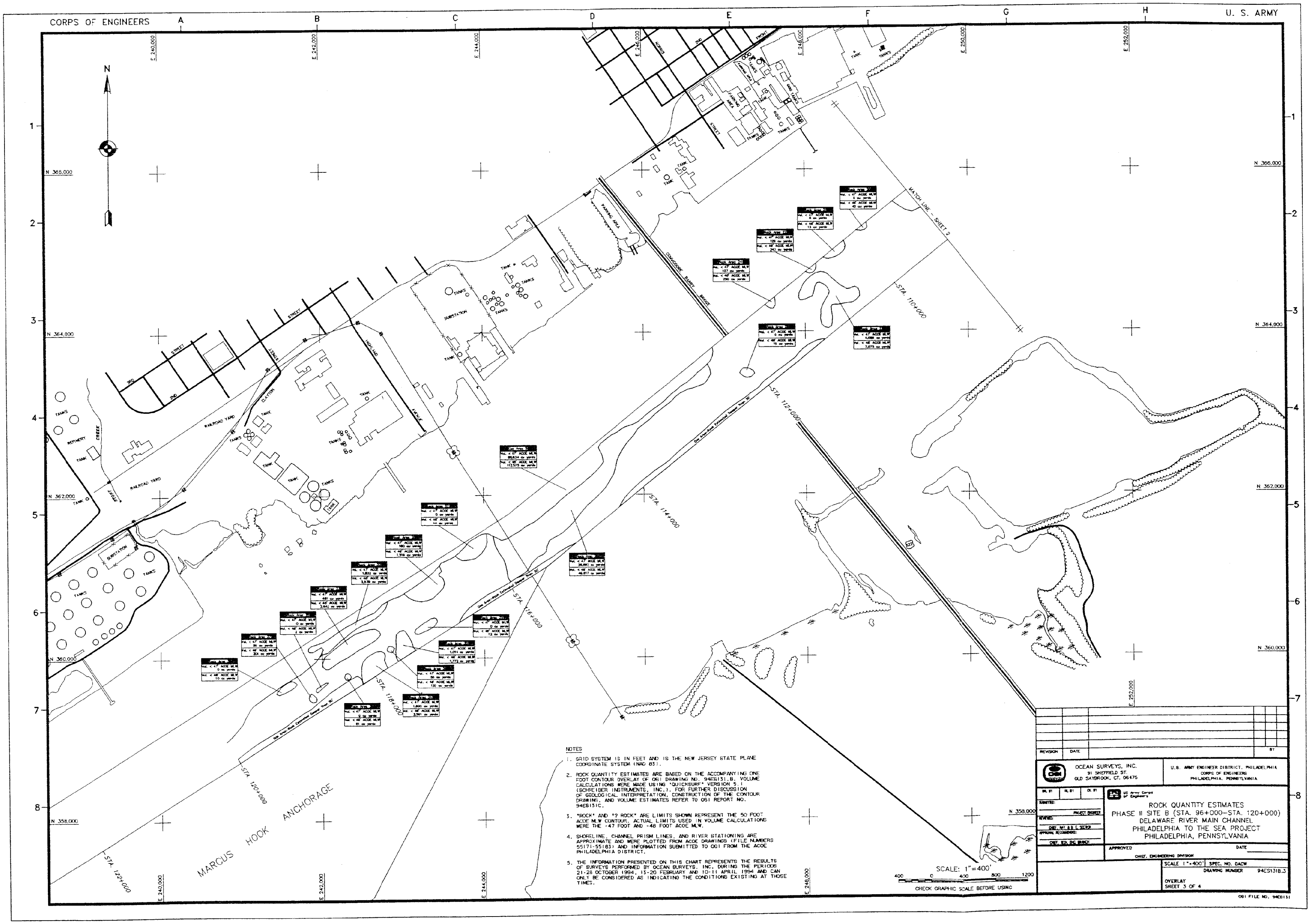
ROCK QUANTITY ESTIMATES
PHASE II SITE B (STA. 96+000–STA. 120+000)
DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PENNSYLVANIA

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

SCALE 1"=400' | SPEC. NO. DACW
DRAWING NUMBER 94ES131B.3

OVERLAY
SHEET 2 OF 4

OSI FILE NO. 94ES131



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U.S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA

DR. BY | RL. BY | CK. BY

SUBMITTED: PROJECT ENGINEER
REVIEWED: CHIEF, NAV. & B. E. SECTOR
APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

US Army Corps of Engineers

ROCK QUANTITY ESTIMATES
PHASE II SITE B (STA. 96+000--STA. 120+000)
DELAWARE RIVER MAIN CHANNEL
PHILADELPHIA TO THE SEA PROJECT
PHILADELPHIA, PENNSYLVANIA

APPROVED CHIEF, ENGINEERING DIVISION DATE

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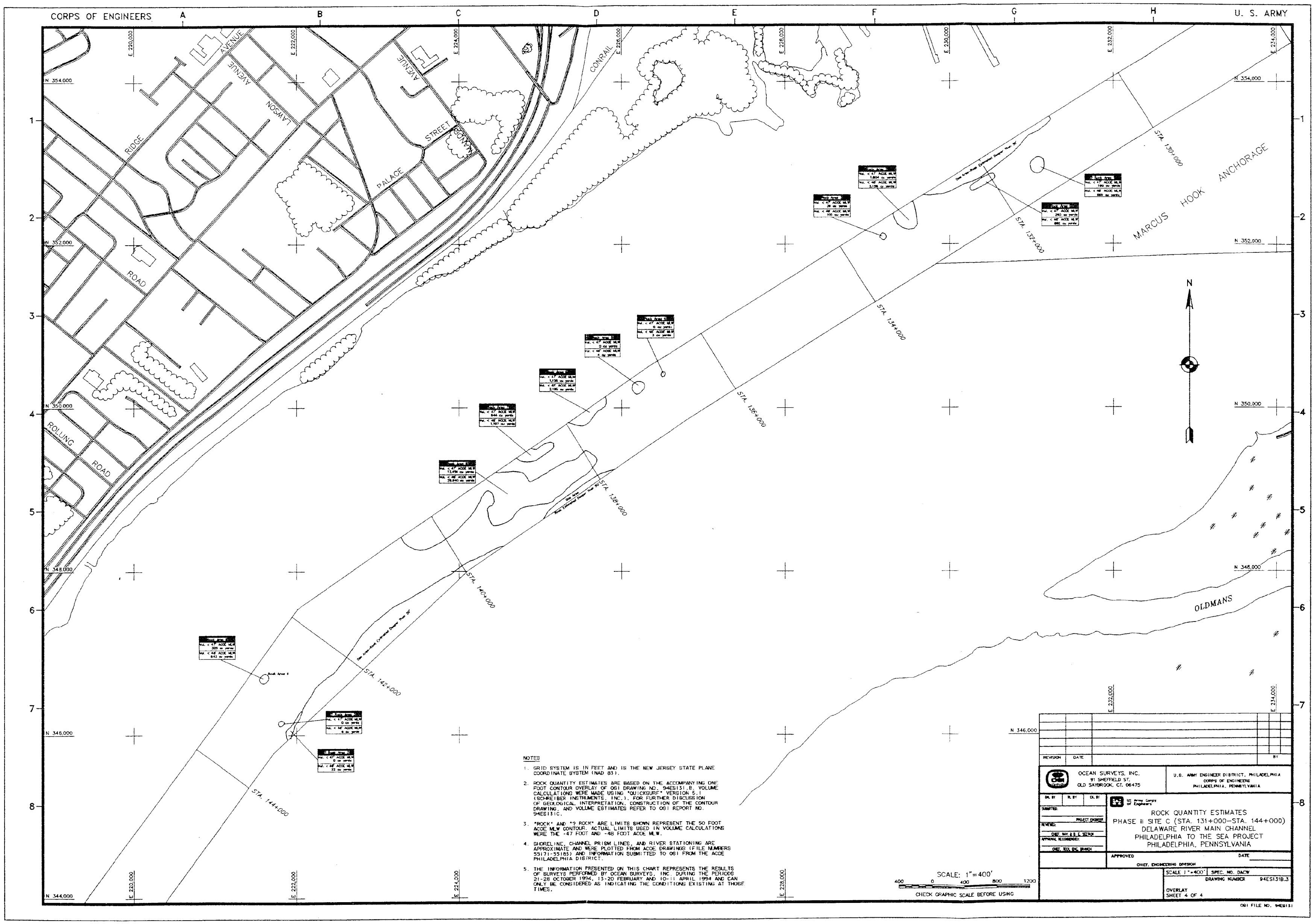
OSI FILE NO. 94ES131



CORPS OF ENGINEERS
U. S. ARMY
CONRAIL
RIDGE
ROAD
LAWSON
AVENUE
STREET
PALACE
ROLLING
ROAD
MARCUS HOOK ANCHORAGE
OLDMANS
N
STA. 130+000
STA. 132+000
STA. 134+000
STA. 136+000
STA. 138+000
STA. 140+000
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400 0 400 800 1200
CHECK GRAPHIC SCALE BEFORE USING
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