

APPENDIX D
SEISMIC REFLECTION SURVEY

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SEISMIC REFLECTION SURVEY

D1.0 INTRODUCTION

This report presents the results of a seismic reflection survey conducted between November 2 through 4, 1993, at Fort Ord, California. The survey was conducted by Carlene Merey, Steve Korbay and Rick Erdman of HLA and Rick Miller, consulting geophysicist.

The purpose of this survey was to assist the site geologic characterization effort by mapping the extent and depth of a silt unit approximately 80 feet below ground surface.

D2.0 SEISMIC REFLECTION PROFILING METHOD

Seismic reflection profiling relies on certain properties of acoustic energy. The energy is generated at a shot point by striking a metal plate with a sledgehammer or by detonating some type of explosive. The energy wave travels through the subsurface and is reflected back to the surface by interfaces or reflectors. The interfaces occur where there are changes in the elastic properties of the subsurface materials, for example, where their density changes or where water is present. The time it takes the wave to travel from the source down to the interface and back to the surface again is recorded and is typically known as two-way travel time. At receiver points on the ground surface, sensors called geophones detect the returning energy and convert it to a voltage that varies with time. This voltage is recorded by a seismograph.

By determining the variation in the reflection times to the geophones, it is possible to identify subsurface geologic features. Depth to the reflectors is calculated by using a velocity to convert travel time to distance. This velocity is known as the stacking velocity and is determined during data processing (*Dobrin, 1976*). The judicious arrangement of source and receiver locations results in a continuous profile beneath the survey transect line. The reflections can then be interpreted and utilized to map the geology beneath the line.

Unwanted signals may be caused by nearby vehicle or aircraft noise or surface noise caused by the source itself. Consequently, energy generation is repeated 6 to 12 times at each shallow seismic reflection line; redundant sampling of the subsurface reflecting points reduces spurious signals and enhances the reflections. This redundant sampling approach is denoted by "fold," e.g., 6- or 12-fold data.

D3.0 DATA ACQUISITION

Previous seismic testing at Fort Ord (*Draft Basewide Hydrogeologic Characterization Report, Fort Ord, California*, dated June 7, 1993)) has provided appropriate equipment spacing and settings. To adequately map the silt unit, a total of four lines (G through J) were selected running essentially east-west across Sites 2 and 12 (Plates D1 and D2). The locations were based on access, potential cultural interference, topographic relief, and the need to augment existing geologic data. The four lines totaled approximately 3,000 linear feet of 12-fold common-depth-point (CDP) coverage except where underground and surface obstacles decreased the fold by preventing emplacement of geophones.

All source locations were first cleared using procedures described in Part 2 of the *Draft Site Characterization, Site 34 - Fritzsche Army Airfield, Fueling Facility, Field Procedures and Analytical Data Validation, Fort Ord, California*, dated June 12, 1992. The energy source for the survey was an 18-pound sledgehammer striking an aluminum plate. The source station spacing was 4 feet. An EG&G Geometrics Model R24, 24-channel seismograph recorded the data and stored it on 1.44-megabyte floppy disks in SEG-2 format. The total record length was 256 milliseconds (msec) with a sampling interval of 0.25 msec. Floating point amplification followed by analog-to-digital (A/D) conversion of the signal resulted in 15-bit digital words.

The data were acquired using a standard CDP roll-along method. The receivers were three

L28E 20-Hz geophones configured in a 3-foot, in-line array with station spacings of 4 feet. The array was designed to reduce cultural and source-generated noise traveling approximately parallel to the line. All four seismic lines were collected with a split-spread configuration. On all four lines, the source-to-nearest-receiver distance was 8 feet, and the source-to-farthest-receiver distance was 52 feet. The geometries and receiver spacings were designed to optimize recording reflections from the target interface.

D4.0 QUALITY CONTROL PROCEDURES

The following quality control procedures were followed during the collection of the seismic data to ensure measuring consistency and the best quality results:

- Upon initial powering-up of the seismograph, internal machine tests were automatically run to check all equipment circuitry.
- Battery voltage levels were checked to verify that they were within operational limits.
- A visual inspection was made of the geophone plants to ensure that they were connected properly and were placed in the ground vertically.
- Once the geophones were planted and connected to the cables and the seismograph, the noise monitor was turned on to check ambient conditions. Most ambient noise was due to vehicle traffic. After traffic passed and the noise monitor indicated lower noise levels, recording proceeded.
- The roll switch was used to check electrical continuity for all 24 channels. Also, each channel was checked for signal level and for noise due to poor geophone plants or bad connections.
- A test fire of the trigger switch was made after each cable move to check the trigger mechanisms.
- During recording, periodic printouts of the data were made to inspect signal strength, equipment functioning, and noise levels.

D5.0 DATA PROCESSING

Data processing was done on an Intel-80486-based microcomputer using Eavesdropper, a proprietary set of algorithms developed by the Kansas Geological Survey (*Somanas et al., 1987*). The processing flow was similar to that used in petroleum exploration: the principal distinctions relate to the conservative application of correlation statistics, the precision of the analysis of near-surface velocity, and more sensitive muting operations. Data processing included the use of low-cut filtering and dip filtering to enhance reflections.

The following is a list of the processing applied to the raw seismic data (A complete explanation of these processing steps is not included here. For a thorough description, please see *The Encyclopedic Dictionary of Exploration Geophysics* [Sheriff, 1989].):

- Automatic edit where signal-to-noise ratio is greater than 0.15
- Trace balance
- First arrival mute
- Manual trace edit
- Source/receiver geometries
- Sort CDP
- Datum correction
- Surface consistent statics (maximum 1 msec shift)
- Normal moveout correction (stretch mute greater than 20 percent)
- Stacking velocities ranged from 1,600 to 2,000 ft/sec
- Secondary editing
- Residual statics (maximum shift less than 2 msec)
- Digital filter

- CDP stack
- Automatic Gain Control (AGC) scaling

Each seismic line was converted to a depth profile by multiplying half the two-way travel time at selected points along each reflection by the stacking velocity. Once the reflections were converted to depths, a correction factor was applied to "flatten" the water table reflection. In other words, each reflection below the water table was moved up or down to maintain relative spacing vertically between it and the water table, and to have the water table end up flat across the line. This was done because it was an easier way to simulate real conditions than to have the seismic processing mimic them. If we had flattened on the water table during processing, we would have precluded arriving at other interpretations and perhaps artificially homogenized the data. With this approach, the original character and relationships of the seismic data are preserved.

D6.0 RESULTS

The results for each seismic line are discussed in the following sections. Geologic interpretations were made on the basis of reflection character, selected borehole data, and the interpreted geologic cross section presented in Plate 12.

In the following discussions, locations on the seismic lines are referenced horizontally by shot point number and vertically by two-way travel times (msec) as shown on Plate D3.

Line G was the easternmost seismic line collected. The predominant reflection is interpreted to be the top of the water table (85 to 95 msec across the line). A portion of the water table multiple (a multiple is caused by energy that travels down to the water table, up to the surface, back down to the water table, and finally back up to the surface receivers) can be seen between shot points 565 and 545 at 185 msec.

Two reflectors beneath the water table reflection have been identified. The lower most one is interpreted as the top of the silt unit. The other is not easily correlated with any lithologic change noted in the boreholes. It may represent a slight, yet seismically noticeable, change within the dune sands, perhaps indicative of a paleosol.

The silt unit was identified across the three easternmost lines and appears to be continuous across this region. The surface of the silt unit has quite a bit of topographic relief. Some of this is due to the exaggeration of the chosen plotting scale, and some is due to flattening the water table. Regardless, this unit is continuous and is not flat and could indicate preferential flow paths.

Lines H and I show similar reflectors and have been interpreted accordingly. Line I suffers in data quality, perhaps because the site had been disturbed in the past by the construction of outfalls, utility corridors, and possibly the emplacement of a concrete slab. All these things contribute to a jumbled near-surface, which can scatter out going and returning seismic energy. No deep borehole information was available for these areas.

Line J continues to show two reflectors beneath the water table, yet neither of these now represent the silt unit. Near shot point 320, MW-02-07-180 and PZ-02-01-180 record the silt unit at an elevation of approximately 75 feet below MSL. The seismic data do not show a coherent reflection at this depth, perhaps due to insufficient energy penetration or due to the coarsing of the unit westward. Another silty clay horizon noted in those boreholes is imaged by the seismic data at 90 msec. Unfortunately, Highway 1 prevents continuous data collection to determine the fate of the silt unit between Line I and Line J. However, the topographic variation of the reflections that were identified still may indicate preferential flow paths.

D7.0 SUMMARY

The results of a seismic reflection survey conducted at four locations at Fort Ord, California, were of good quality. The water table was the predominant reflector mapped. A silt unit was identified across Lines G, H, and I at 50 to 75 feet below MSL. The nature of this layer is continuous and gently rolling. Line J also showed reflectors with rolling dips, but did not penetrate deep enough to pick up the silt unit. Those reflectors that were imaged in Line J will still provide future remediators with important information about low areas that may act as preferential flow paths.

PLATES

NO. DATE

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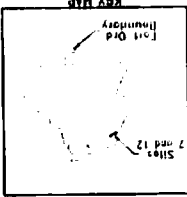
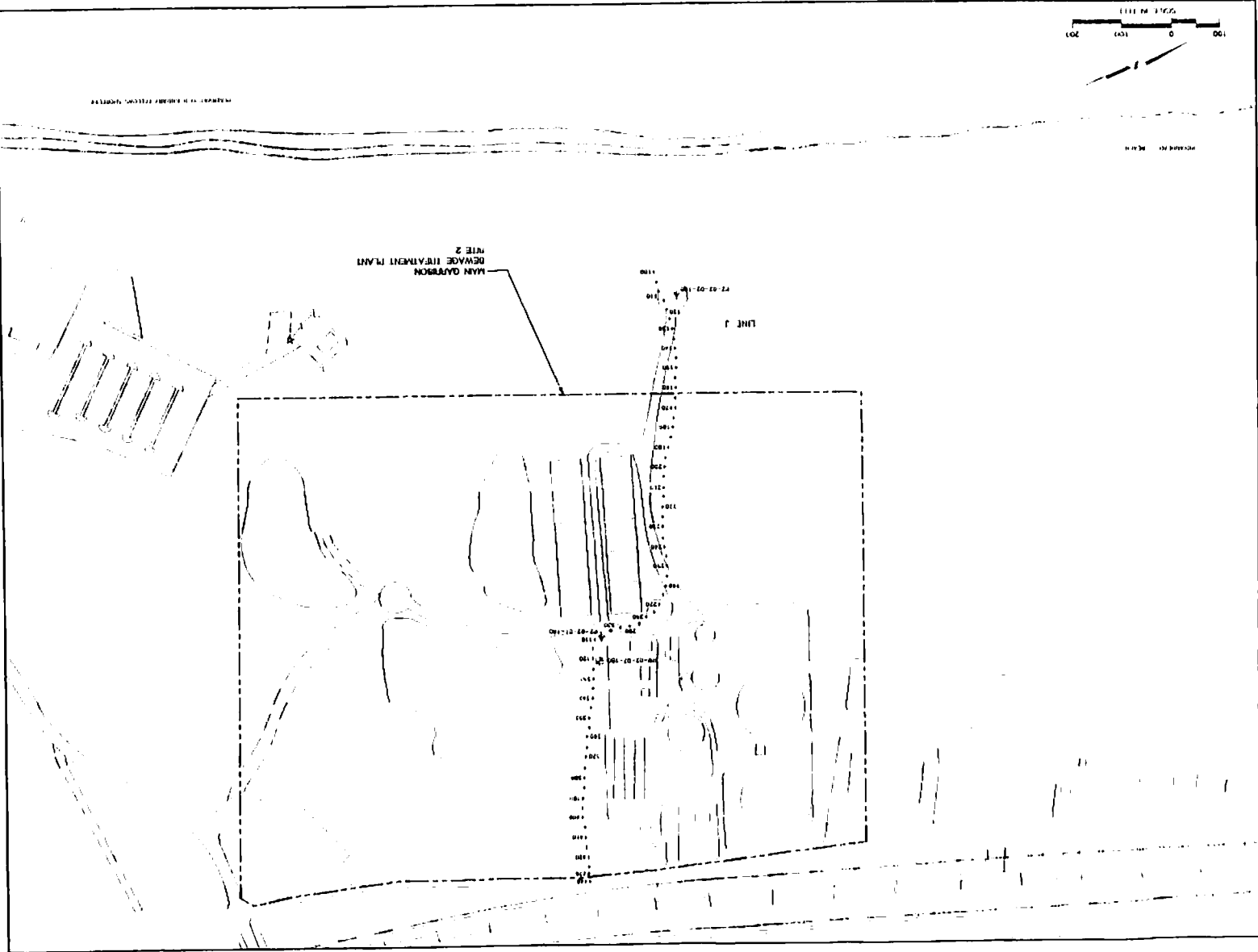
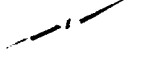
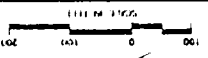
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- EXPLANATION
- AREA BOUNDARY
 - - - SITE BOUNDARY
 - FENCE
 - - - IMPASSIBLE
 - + STAKES (500) ELEV.
 - + (PI) COUNTER (100) (ELEV.)
 - LAMPING MOUNT (ELEV.)

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Boswell R/T/S
Fort Ord, California

Harding Lawson Associates
Engineering and
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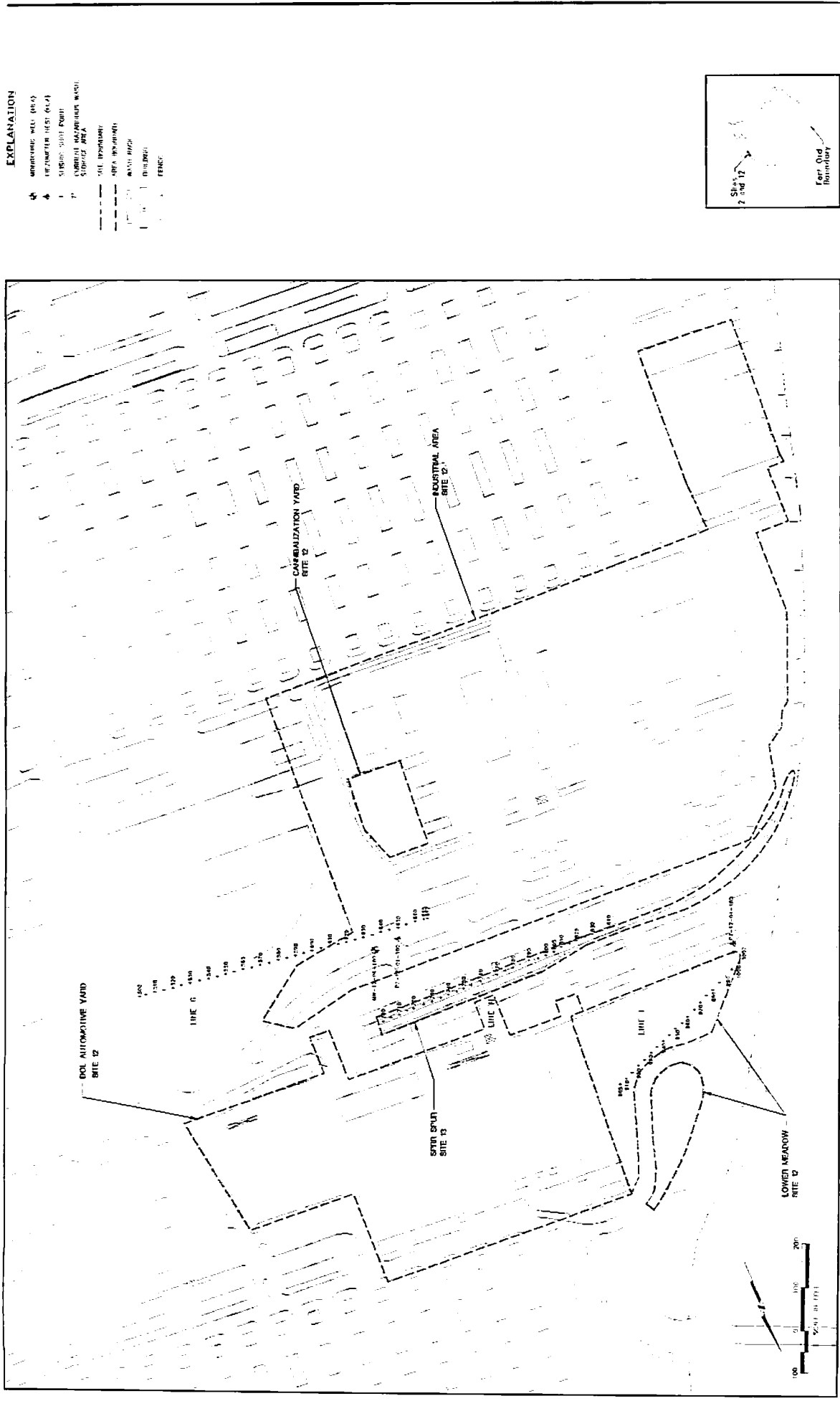
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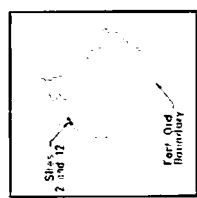
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D1

PLACE



- EXPLANATION**
- 4 HYDRAULIC WELL (HW-0)
 - 4 HYDRAULIC TEST (HT-0)
 - 1 SURFACE WATER POINT
 - 7 UNBUILT MAINTENANCE WASH STATION AREA
 - SOIL BOUNDARY
 - AREA BOUNDARY
 - WATER PUMP
 - DRAINAGE
 - FENCE



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Soils
 Site 12

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