Private Fuel Storage, L.L.C.

7677 East Berry Ave., Englewood, CO 80111-2137
Phone 303-741-7009 Fax: 303-741-7806
John L. Donnell, P.E., Project Director

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

May 1, 2001

RESPONSE TO APRIL 18, 2001 MEETING ISSUES
REGARDING PFSF LICENSE APPLICATION AMENDMENT #22
DOCKET NO. 72-22 / TAC NO. L22462
PRIVATE FUEL STORAGE FACILITY
PRIVATE FUEL STORAGE L.L.C.

Reference:
1. PFS letter, Parkyn to U.S. NRC, License Application Amendment #22, dated March 30, 2001
2. April 18, 2001 meeting between PFS and the NRC in San Antonio, Texas

The purpose of this letter is to respond to various questions posed or clarifications requested during the April 18, 2001 meeting (Reference 2) with the NRC regarding License Application Amendment #22 (Reference 1). The NRC questions and requests for clarification are repeated below followed in each case by the Private Fuel Storage (PFS) response.

1. Provide a copy of the Downhole Seismic Geophysical Testing report prepared by Northland Geophysical, LLC that is referenced in SAR Chapter 2.

   PFS Response
   A copy of the requested report, "Report on Downhole Seismic Geophysical Testing," Report No. 0599602-G(PO37)-1, Revision 1, dated January 31, 2001, is enclosed.

2. Provide a figure showing the location of the test pits that were excavated at the PFSF in January 2001 for obtaining samples for soil cement laboratory testing.

   PFS Response
   A copy of the requested figure, "Location Plan – Test Pits for Soil Cement Samples," Geotechnical Sketch No. 05996.02-GSK-B-85-1, is enclosed. This figure will be included in SAR Chapter 2 in the next license amendment.

NMSS01 Public

3. Provide "logs" of these test pits.

   PFS Response
   A copy of the requested "logs" are enclosed. These test pit logs will be included in SAR Chapter 2 in the next license amendment. The sample descriptions presented on these logs are based primarily on particle size analyses and Atterberg limits tests that were performed on these samples. Solid horizontal lines are used to designate the locations of top of ground and the bottom of the test pits, as well as interfaces observed in the field between strata. The dashed horizontal lines indicate strata changes based on the results of the laboratory tests.

4. Provide an explanation (e.g., interpretation of "Tip Resistance", field data, etc) as to how the depth of eolian silt, as revised in SAR Chapter 2 of License Amendment No. 22, was determined.

   PFS Response
   In January 2001, 16 test pits were excavated at the PFSF site in the pad emplacement area to obtain soil samples for use in the laboratory analyses necessary to design the soil cement. It was observed from these test pits that the depth of the eolian silt was shallower than previously believed (approximately 2-ft on average rather than 3-ft). The borings previously performed in this area obtained soil samples at depths from grade to 2 ft and from 5 ft to 7 ft. Therefore, as later observed in the test pits, the interface between the eolian silt and the silty clay/clayey silt fell between the samples collected in the borings. The soil unit descriptions from Trench T-2 in the pad emplacement area (Plate 3, Geomatrix, 2001a) also corroborates the soil-cement test pit observations; i.e., the fine sandy silt (eolian deposit) overlying the sandy clayey silt (combic B soil horizon developed on Bonneville deep-water sediment) is not expected to extend much deeper than approximately 2 feet from the ground surface. Furthermore, these observations are verified by Atterberg limits tests that have recently been performed on the samples obtained from these test pits, which indicate that those collected below depths of 2 ft are exclusively cohesive clayey silt/silty clay with high plasticity indices.

   Our previous interpretation of the eolian silt boundary assumed that this boundary lay where the initial spike in the cone penetration tip resistance bottomed out. This assumption was made in order to obtain a conservative upper-bound estimate of the amount of soil cement required for the soil improvement of the noncohesive eolian silt. This increase in tip resistance was previously assumed to represent a layer of slightly cemented eolian silt. However, as observed in the January 2001 soil-cement test pits and in Trench T-2, the interface between the noncohesive eolian silt and the cohesive clayey silt/silty clay more closely corresponds to the initial increase in the cone tip resistance, along with an accompanying steep increase in the sleeve skin

friction resistance. These observations are consistent with the experience of soil classification using electric CPT data which indicate that sandy soils (noncohesive) tend to produce high cone resistance and low friction ratio, whereas soft clay soils (cohesive) tend to produce low cone resistance and high friction ratio (p.51, Lunne, Robertson and Powell, 1997). Therefore, it is expected that the transition from the noncohesive soil to the cohesive soil will be characterized by a steep increase of the cone skin friction resistance.

Based on the correlations and evaluations discussed above, the transitional boundary between the surficial noncohesive eolian silt and underlying cohesive clayey silt/silty clay presented in SAR Figure 2.6-5, Sheets 1 through 14, were re-interpreted to make them consistent with the soil-cement test pit observations and laboratory classification test results performed on soil samples from the test pits in the pad emplacement area. The interpretation also considered that the measurement of sleeve friction (f_s) is often less accurate and less reliable than the cone resistance (p.51, Lunne, Robertson and Powell, 1997). The boundary was re-interpreted based on consideration of the consistency between various cone penetration tests to obtain a smoothed boundary instead of interpreting each cone penetration test discretely. This re-interpretation of the eolian silt boundary reduces the estimated amount of eolian silt, resulting in the need for less soil cement under the cask storage pads (see SAR Figure 4.2-7).

The above explanation will be included in SAR Chapter 2 in the next license amendment.

5. Confirm/state that "all" eolian silt will be removed from beneath the cask storage pads.

PFS Response
Confirmed. The following will be incorporated into SAR Section 2.6.4.11 "Techniques to Improve Subsurface Conditions," in the next license amendment.

The surficial layer of eolian silt extends across the entire site, including the pad emplacement area and area surrounding the Canister Transfer Building. The eolian silt, in its *in situ* loose state, is not suitable for founding the structures at the site. The basemat of the Canister Transfer Building will be founded on the silty clay/clayey silt layer beneath the eolian silt. It was originally intended that the cask storage pads also would be founded on the silty clay/clayey silt layer. However, instead of excavating the eolian silt from the pad emplacement area and replacing it with structural fill, the eolian silt will be mixed with sufficient portland cement and water and compacted to form a strong soil-cement subgrade to support the cask storage pads. Soil cement will also be utilized around the Canister Transfer Building. The required characteristics of

the soil cement will be engineered during detailed design and constructed to meet the necessary strength requirements.

During construction of the storage pads, all eolian silt in the quadrant under construction will be excavated. The eolian silt will be mixed with cement and water and compacted to produce soil cement across the pad area, up to the design elevations of the bottoms of the storage pads. The layer of soil cement beneath the storage pads will have a minimum thickness of 12 inches and a maximum thickness of 24 inches. In the event that the eolian silt layer extends to a depth greater than 2 ft below the elevations of the bottoms of the storage pads, compacted clayey soils will be used to raise the elevation of the subgrade that will support the soil-cement layer to an elevation of 2 ft or less below the design elevations of the bottoms of the pads. This will ensure that the layer of soil cement does not exceed a thickness of 2 ft.

The soil cement underlying the pads shall have a minimum unconfined compressive strength of 40 psi to ensure that there is an adequate factor of safety against sliding of an entire column of pads (Calculation 05996.02-G(B)-4 (S&W, 2001b)). This layer of soil cement also will be tested to demonstrate that the static modulus of elasticity does not exceed 75,000 psi to ensure that the decelerations from a hypothetical storage cask tipover event do not exceed design limits (Section 3.2.11.3).

Following construction of the storage pads on top of this layer of soil cement, additional soil cement will be placed around and between the cask storage pads, up to a level that is 28 inches above the bottoms of the storage pads. The remaining 8 inches, from the top of the soil cement up to grade, will be filled with coarse aggregate, placed and compacted to be flush with the tops of the pads to permit easy access by the cask transporter. The soil cement placed around the sides of the storage pads shall have a minimum unconfined compressive strength of 340 psi to ensure sliding stability of individual pads (based on Calculation 05996.02-G(B)-4, (S&W, 2001b), as discussed in Section 2.6.1.12.1).

The Canister Transfer Building basemat will be founded on the silty clay/clayey silt layer that is below the eolian silt. Soil cement will surround the foundation mat and will extend out from the mat to a distance equal to the associated mat dimension; i.e., approximately 240 ft out from the mat in the east and west directions and approximately 280 ft out in the north and south directions. Existing soils (eolian silt and silty clay/clayey silt) will be excavated to a depth of approximately 5 ft 8 inches below grade, mixed with cement, and placed and compacted around the foundation mat. The soil cement placed around the Canister Transfer Building foundation mat will be 5 ft thick and will have a minimum unconfined compressive strength of 250

psi to ensure that there is an adequate factor of safety against sliding of the Canister Transfer Building (based on Calculation 05996.02-G(B)-13 (S&W, 2001c), as discussed in Section 2.6.1.12.2).

The top 8 inches of the profile will be filled with compacted coarse aggregate, similar to that used in the pad emplacement area.

6. Revise SAR Figure 4.2-7 to correct the strength of the soil cement layers around the cask storage pads to agree with the calculation for Stability Analysis of Cask Storage Pads 05996.02-G(B)-4 (S&W, 2001b).

   PFS Response
   A revised copy SAR Figure 4.2-7 is enclosed. This figure will be included in SAR Chapter 4 in the next license amendment.

7. SAR p 2.6-22 states with respect to the relationship of major foundations to subsurface materials:

   > "Standard Penetration Test (SPT) N-values for this layer are mostly between 8 and 20 blows per ft, with an average value of 16 blows per ft and a median value of 14 blows per ft, indicating that these are "stiff" or "medium dense" materials.

   SAR Table 2.6-5 lists several SPT N-value that are less than 8. PFS should explain the impact of the N-values that are less than 8 on the characterization of these materials as "stiff" or "medium dense" materials.

   PFS Response
   Excluding the surficial samples, which need not be considered because they will be mixed with cement to form soil cement, only a few samples that in the pad emplacement area have N-values of less than 8 blows/ft, and these were all obtained from the depth range of 5 to 7 ft. These include Samples S-2 of the following:

Samples Obtained Within Pad Emplacement Area That Have SPT N-values Less Than 8 Blows/ft (Excluding Surficial Samples, Which Will Be Replaced by Soil Cement)

Boring	N-Value (Blows/ft)	LL (Liquid limit)	PI (Plasticity Index)
B-2	5	47.4	21.8
D-2	6	46.4	15.3
C-3	6	43.1	20.7
C-4	7	69.5	25.3
D-4	4	49.3	21.6

As indicated by the index property tests presented in SAR Figure 2.6-20, the soils obtained from this depth interval (5 to 7 ft) typically are clayey silts/silty clays. Liquid limit values for these soils indicate they typically are high plasticity clays. Figure 4 of DM-7.1 (NAVFAC, 1982) indicates that clays of high plasticity with SPT N-values of 4 to 8 have unconfined compressive strengths of 1 to 2 tsf.

This result is further confirmed by the cone penetration tests performed in the pad emplacement area all demonstrate that the measured cone tip resistances, Q_t, of the soils within the depth range of 5 to 7 ft exceed 15 tsf, as shown in the plots of Q_t vs depth in Appendix A of ConeTec (1999). Using an empirical cone factor, N_{kt}, of 12.5 to estimate the undrained shear strength, these tip resistances result in undrained shear strengths that exceed 1 tsf, indicating the unconfined compressive strengths exceed 2 tsf.

Table 7.1 of Terzaghi & Peck (1967) indicates that clayey soils with strengths of 1 to 2 kg/cm^2 (~1 to ~2 tsf) are characterized as having "stiff" consistency. Therefore, existence of a few N-values that are less than 8 blows/ft for these soils do not adversely impact the characterization of these soils as "stiff".

8. Provide a drawing detailing the extent of soil cement around the Canister Transfer Building.

PFS Response
Calculation No. 05996.02–G(B)-13, entitled "Stability Analysis of the Canister Transfer Building Supported on a Mat Foundation" includes a sketch detailing the

soil cement around the Canister Transfer Building. SAR Section 2.6.4.11 also provides a detailed description of the soil cement around the Canister Transfer Building.

9. Confirm that the new steel roof beams in the Canister Transfer Building have been evaluated for the building fire scenarios discussed in SAR section 8.2.5.

   PFS Response
   The PFSF draft Fire Hazards Analysis of the Canister Transfer Building states: "The construction classification is Type II-FR per the UBC, and Type II-222 per NFPA 220. The structural steel roof support columns and steel roof support girders and beams will be fireproofed to provide the required 2-hour fire resistance rating. The UBC Construction Type II-FR is more restrictive and has higher fire resistance requirements than NFPA 220 Construction Type II-222. The building construction meets the requirements of NFPA 801, Section 3-5."

   The bounding fire for building structural considerations, discussed in SAR Section 8.2.5, is the 300 gallon diesel fuel spill that burns for 16 minutes combined with the 30 minute tire fire. Therefore, the 2-hour fire resistance rating of the fireproofing on the structural steel is more than adequate to ensure that fire scenarios discussed in SAR section 8.2.5 will not result in a structural failure.

10. Explain why a revised finite element analysis is not required to support the NRC's review of the Canister Transfer Building design revisions.

    PFS Response
    A revised finite element analysis is not required to support the NRC's review of the Canister Transfer Building design revisions because the revised analysis will be performed for the Building's design load combinations in accordance with the applicable codes and standards identified in the SAR (Section 3.2.11.4). Further, the revised analysis will follow the same general approach as the finite element analysis performed for the conceptual design configuration of the Building previously reviewed by the NRC.

    The finite element analysis performed in Revision 0 of calculation 05996.02-SC-6 and the subsequent design of reinforcing steel performed in Revision 0 of calculation 05996.02-SC-7 were submitted to the NRC with previous SAR submittals, and were reviewed by the NRC staff prior to issuance of the SER. Since that time, the building layout has changed somewhat, to accommodate increased seismic ground motions, to increase operational efficiency, and to reduce construction effort. The changes include:

- Increasing the area of the base mat. This was done to maintain the desired factor of safety against sliding and overturning for the increased seismic loads.
- Changing the strain-dependent soil properties beneath the building because of higher seismic accelerations.
- Providing, as a result of discussions with the transporter vendors, improved access to the transfer cells to avoid the 90-degree turns required with the original design to enter the transfer cells. Three additional doors were incorporated into the West wall of the transporter aisle to make access into the transfer cells easier. It was decided that the tornado missile boundary should be moved from column line A.8 (transporter aisle west wall) to column line C (transporter aisle east wall). Since it is no longer needed as a missile barrier, the concrete wall on column line A.8 was replaced with a steel frame and metal sided wall, as was the wall on column line F (office area).
- Widening the doors entering each transfer cell from the transporter aisle from 20-ft to 22-ft and the height was increased to accommodate a larger cask transporter.
- Moving the building north wall 5-ft in the North direction to accommodate crane hook approach requirements
- Changing, as the result of a constructability review, the roof beams from reinforced concrete to structural steel. The roof slabs were reevaluated and the thickness reduced from 1 foot to 8 inches, while still satisfying tornado missile protection criteria. These changes will reduce construction time and cost.
- Increasing the width of the transporter aisle by 7-ft to accommodate larger transporters.

These changes to the building require that the ANSYS finite element model be revised. However, the revised analysis will conform to the same design codes and standards as before. Further, it is expected that the results of the analysis and design will be very similar to those of the initial ANSYS finite element model previously reviewed by the NRC. Some changes to the amount of reinforcing steel are expected, but preliminary analyses show that the sizes of the existing members will be sufficient to accommodate increased loadings. The new building configuration will be evaluated for the new seismic loads, as well as all other loads, in the applicable combinations identified in SAR Section 3.2.11.4. The new finite element analysis will be documented in Revision 1 of calculation 05996.02-SC-6. The method and assumptions will be almost exactly the same as in Revision 0. The analysis will be performed using ANSYS, and the type and size of the elements will be the same. The steel roof beams will not be included in the model, but the vertical loads from the roof beams will be applied at the top of the walls in the model.

Similarly, the reinforcing steel design will have to be revised. This will be documented in Revision 1 of calculation 05996.02-SC-7, and will commence as soon as the finite element analysis is complete. The methods and assumptions will be the

same as those in Revision 0, and will address all applicable load combinations. The allowable stresses and code requirements will remain unchanged.

Two new calculations will be required. The first, 05996.02-SC-12, will design the structural steel roof beams and columns. The second, 05996.02-SC-14, will design the tornado-resistant doors on the west side of the transfer cells, and the shielding doors on the east side of the cells. These calculations will be submitted to the NRC in approximately one week.

Revisions to SC-6 and SC-7 will be submitted when they are complete, but as discussed above, they will be very similar to the previously submitted and reviewed versions and conform to the same design codes and standards.

11. Provide the NRC a copy of the letter from the crane manufacturer (EDERER) that evaluates the impact of the new seismic accelerations on the design of the cranes.

PFS Response
A copy of the requested letter is enclosed.

References:

ConeTec, 1999, Cone penetration testing report, Private Fuel Storage Facility, prepared for Stone and Webster Engineering Corp., Denver, CO, 2 volumes.

Geomatrix Consultants, Inc., 2001a, Fault evaluation study and seismic hazard assessment study-final report, Revision 1, prepared for Stone and Webster Engineering Corp., Denver, CO, 3 volumes, March 2001.

Lunne, T., Robertson, P. K., and Powell, J. J. M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academeic & Professional, London, 1997.

NAVFAC, 1982, DM 7.1, Soil Mechanics, Dept of the Navy, Naval Facilities Eng'g, Command, Alexandria, VA.

Northland Geophysical, LLC, 2001, Report No. 05996.02-G(PO37)-1, Report on Downhole Seismic Geophysical Testing, Revision 1, March 2001.

Stone & Webster, Inc. (S&W), 2001b, Calculation No. 05996.02- G(B)-4, Revision 7, Stability Analyses of Storage Pad.

Stone & Webster, Inc. (S&W), 2001c, Calculation No. 05996.02- G(B)-13, Revision 4, Stability Analysis of the Canister Transfer Building.

Terzaghi, K., and Peck, R. B., 1967, Soil Mechanics in Engineering Practice, John Wiley & Sons, New York, NY.

The PFS response to other items raised at the meeting, including calculations, will follow in approximately one week. If you have any questions or need additional information, please contact me at 303-741-7009.

Sincerely,

John L. Donnell
Project Director
Private Fuel Storage L.L.C.

Enclosure

copy to: (with enclosure)
Mark Delligatti
Scott Flanders
Asadul Chowdhury
John Parkyn
Jay Silberg
Sherwin Turk
Greg Zimmerman
Scott Northard
Richard E. Condit
John Paul Kennedy
Joro Walker
Denise Chancellor

ENCLOSURE

1. Report on Downhole Seismic Geophysical Testing, Report No. 0599602-G(PO37)-1, Revision 1, dated January 31, 2001

2. Location Plan – Test Pits for Soil Cement Samples," Geotechnical Sketch No. 05996.02-GSK-B-85-1

3. Test Pit Boring Logs, Boring TP-1 through TP-16

4. SAR Figure 4.2-7, Cask Storage Pads

5. Letter from EDERER, Incorporated dated March 23, 2001 (6 pages)

REPORT ON

DOWNHOLE SEISMIC GEOPHYSICAL TESTING

Private Fuel Storage Facility
Skull Valley, Utah

Private Fuel Storage, LLC

Northland Geophysical, LLC

	Signature	Date
Preparer:	Thomas R. Williams	1-31-2001
Lead Engineer:	Paul J. Prudeau	3/5/2001
Technical Review:	Z-M Tyrah	3/7/2001
Independent Review:	Z-M Tyrah	3/7/2001

QA CATEGORY I
IMPORTANT TO SAFETY
Copyright 2001
Stone & Webster, Inc.
Stoughton, Massachusetts

NORTHLAND GEOPHYSICAL, LLC
P.O. Box 310
Snohomish, WA 98291-0310

January 31, 2001

Mr. Jerry L. Cooper
Stone & Webster, Inc.
7677 East Berry Ave.
Greenwood Village, CO 80111

SUBJECT: **Results of Downhole Seismic Geophysical Testing**
Private Fuel Storage Facility, Skull Valley, Utah
ESSOW No. 05996.02-G011 (Rev. 1)

Dear Mr. Cooper:

This report presents the results of two downhole seismic velocity surveys which Northland Geophysical, LLC, conducted for Stone & Webster, Inc., on December 21, 2000, and January 19, 2001, at the proposed site for the Private Fuel Storage Facility (PFSF) in Skull Valley, Utah. The primary purpose of the geophysical investigation was to determine *in-situ* shear-wave (S-wave) velocities of the subsurface materials to a depth of at least 100 feet below ground surface (bgs). During the course of the investigation, the compression-wave (P-wave) velocity profile was also determined to a depth of approximately 51 feet to assist in characterization of the soils underlying the site.

The shear-wave results are presented graphically in Figures 2-4 and in a tabular form in Tables 1-6; the compression-wave results are presented graphically in Figures 5-6 and in a tabular form in Table 7. The recorded seismic waveforms are documented in Appendices B and C to this report.

FIELD PROCEDURES

The initial downhole seismic velocity survey was conducted on December 21, 2000, in Boring CTB-5(OW), which was previously constructed as a groundwater monitoring well at the PFSF site. This well is comprised of a 2" Schedule 80 flush-joint PVC casing which has been grouted from ground surface to a depth of approximately 122 feet. Because the PVC casing had been grouted and is therefore presumed to be well coupled to the surrounding soils for the uppermost 122 feet, it was thought that downhole seismic logging could be performed satisfactorily in the borehole even though the well was not constructed specifically for this purpose.

Following mobilization to Salt Lake City and then to the site in the morning and early afternoon of Wednesday, December 20, 2000, initial tests of the borehole seismic transducer were performed in the well on Wednesday afternoon. The 6"x6"x7' shear wave wood beam was brought back to Tooele, Utah, for additional preparation that evening. This preparation included the mounting of steel alloy end plates on both ends of the beam, and the addition of friction plates to the base of the beam to enhance the generation of shear-wave motion in the surficial soils.

The initial transducer tests on Wednesday afternoon indicated that the PVC well casing was not clear of obstructions to the desired logging depth of approximately 125 feet bgs. Nominally, 2" Sch. 80 PVC casing has an OD of 2.375" and an ID of 1.94". The borehole seismic transducer which was used in this investigation has a maximum diameter (across the clamping spring axis) of approximately 1.88". While the fit of the transducer inside the PVC casing was tight, I found that I could get to a total depth of 55.8 feet below the top of the casing (53.1 feet bgs) after trying several azimuthal orientations of the transducer. Furthermore, there were a number of constrictions (thought to be located at casing joints) which I was able to work past in the upper 50 feet of the well, but the constriction at a depth of 55.8 feet could not be cleared regardless of the orientation of the transducer. This constriction appeared to be in the form of a shelf or a lip, which may have resulted from a slight offset of the casing sections at a casing joint.

With the assistance of Mr. Richard Gillespie, Senior Engineering Geologist with Stone & Webster, I returned to the PFSF site on the morning of Thursday, December 21st, to perform downhole seismic logging of the upper 51 feet of Boring CTB-5(OW). The geophysical survey was performed using standard downhole seismic logging procedures. The seismic sources were located at the ground surface, and the seismic receivers were located down the borehole. The shear-wave survey was completed during the morning and early afternoon, and the compression-wave survey was completed in the latter part of the afternoon.

A diagram of the survey field configuration for Boring CTB-5(OW) is provided in Figure 1 in both plan and profile views. The S-wave energy source consisted of sequential sledge hammer impacts to the ends of a 6"x6"x7' horizontal wood beam which was positioned perpendicular to a ray from the well. The beam was offset a distance of 7.0' from the borehole to minimize coupling of the seismic energy with the borehole casing or grout, as well as to ensure that the travel path of the seismic energy was predominantly through soils which were undisturbed by the borehole preparation. The front tires of the field vehicle were driven onto the beam to provide secure coupling of the beam with the ground surface. The P-wave energy source consisted of vertical hammer impacts to a 6"x6"x1" aluminum striker plate which was positioned on the ground surface at the east end of the shear-wave beam. Triggering of the seismograph at the time of hammer impact was accomplished by attaching a Geometrics impact switch to the sledge hammer.

All seismic data were recorded on a Geometrics R24 StrataView 24-channel digital seismograph, Serial Number 75285. This instrument was calibrated and certified by Geometrics at their headquarters plant in San Jose, California, just three days prior to the December field survey (see Appendix A). During the course of the field survey, digital computer files of the waveforms were written to an internal hard drive in the seismograph. A digital sampling rate of 1/16 millisecond (0.0625 ms) and a record length of 128 ms were used throughout the recording sequence. Paper seismograms were also recorded during the survey to monitor data quality; photocopies of these paper records are reproduced in Appendix B to this report. At the conclusion of the field survey, backup electronic copies of the downhole seismic data were also created by writing the data to diskettes using the seismograph's floppy disk drive.

The downhole seismic wave arrivals were detected using a Model BHG-2 slimhole triaxial geophone transducer manufactured by Geostuff of Saratoga, California. The transducer assembly houses one vertical and two horizontal 14-Hz velocity geophones in an X-Y-Z configuration. The transducer uses a motor-driven steel spring clamp to lock the sensors in position at each recording level in the borehole. For downhole surveys, the shear-wave arrivals are recorded using the two horizontal geophones, whereas the P-wave arrivals are recorded using the vertical geophone.

The December 21st recording sequence consisted of first lowering the transducer assembly to a depth of 10 feet in the well and then recording P-wave and S-wave arrivals to determine the characteristic waveforms at the site, as well as to examine the full wavetrain for possible sources of interference. Then, the transducer was lowered to the greatest depth possible in the casing (53.5' below the top of the casing, or 50.8' bgs), and the steel spring clamp was locked into position for the deepest recording. To the extent possible, the spring clamp was left in the locked position for successive recording intervals. By sliding the entire assembly along the inside casing wall, the transducer was moved up the borehole in 2.5' increments. This procedure helps to minimize rotation of the transducer in the borehole, thus avoiding frequent changes in the orientation of the horizontal geophones. Relatively constant orientation of the horizontal geophones results in consistent and correlative waveforms in the shear-wave records. However, due to constrictions in Boring CTB-5(OW), the spring clamp had to be released and then reapplied at a number of levels to enable the passage of the BHG-2 transducer through constricted zones.

The shear-wave survey was conducted by successively recording hammer impacts to opposite ends of the shear-wave impulse beam on alternate seismograph channels in order to observe S-wave arrivals of opposing polarity at each of the two horizontal geophones in the triaxial transducer assembly. This recording technique is important for positive identification of shear-wave arrivals, particularly at shallower depths in the borehole where latter portions of the wavetrain from the higher-velocity P-wave may interfere with the shear-wave arrivals. The technique of reversing the

polarity of the shear waves is also useful for differentiating shear-wave arrivals from other types of secondary seismic events in the borehole. For each 2.5' recording level and for each polarity, a total of four hammer blows were "stacked" using the signal enhancement capability of the seismograph in order to enhance the signal-to-noise ratio of the recorded waveforms.

Due to the proximity of the PFSF site to the Utah Test and Training Range to the west and the Dugway Proving Ground to the southwest, careful attention was focused on monitoring ambient noise conditions during the course of the survey. The noise monitor on the seismograph was viewed prior to the addition of each hammer blow of the stacking sequences. In general, the background noise level was very low, but there were a few intermittent periods during the course of the downhole survey where data acquisition was temporarily halted while waiting for ground noise bursts to subside. A separate file of background noise levels was recorded every 15 feet of elevation in the borehole following the completion of each 24-channel data file. In addition to these separate noise files, the background noise level is evident in each of the seismic data traces in the portion of the trace prior to the arrival of the S-wave or P-wave generated at the borehole (see Appendix B).

Following the shear-wave survey in Boring CTB-5(OW), a compression-wave survey was conducted by lowering the seismic transducer to a depth of 50 feet once again, locking the spring clamp in place, and then successively recording P-wave arrivals at the vertical geophone in the triaxial transducer assembly as the transducer was raised in 2.5' increments.

Late in the afternoon of December 21st following completion of the downhole seismic survey to a depth of 51' in Boring CTB-5(OW), a two-person drill crew from Applied Geotechnical Engineering Consultants, Inc. (AGEC) of Salt Lake City arrived on the site with an all-terrain drill rig to attempt to remove the constrictions in the PVC casing by using an improvised drill bit. This first attempt was terminated about 8 PM that evening, but the operation was continued on Friday, Dec. 22nd, with a somewhat larger-diameter drill bit. The improvised reaming bit was augered inside the PVC casing to a depth of approximately 95 feet bgs. However, the resulting ID of the casing did not permit free entry of the BHG-2 seismic transducer into the well because of two factors: 1) the roughness of the inside casing wall caused by the reaming operation; 2) a very dense plug of PVC cuttings which blocked the borehole at a depth of approximately 27 feet. Consequently, the December seismic field operation was terminated late in the afternoon of Friday, Dec. 22nd.

In the second week of January, 2001, a tapered diamond drill bit was designed and fabricated in Salt Lake City for the purpose of boring out the PVC casing in Boring CTB-5(OW) to an inside diameter of 2 inches, in order to permit the BHG-2 borehole seismic transducer to achieve the desired logging depth of approximately 125' bgs. Using circulating water to help remove the PVC cuttings, a drill crew from AGEC was

able to auger the new diamond bit to a depth of about 94' bgs on January 16th–17th. I re-mobilized myself and the downhole seismic logging system to Salt Lake City on Thursday, January 18th, and then proceeded with the equipment to temporary quarters in Tooele, Utah, by late Thursday afternoon. While the drill crew was attempting to further clean out the PVC casing Thursday, however, the borehole became plugged again at a depth of about 60' bgs due to the soft spongy nature of the PVC cuttings.

With the seismic logging system on site in Utah, but Boring CTB-5(OW) blocked by PVC cuttings once again, the Stone & Webster project team made the decision to offset the AGEC drill rig 15.5 feet to the northeast of Boring CTB-5(OW) and auger a temporary borehole (Boring CTB-5A) using 8" OD (3.75" ID) hollow-stem auger. This decision was based on my suggestion that I could obtain the required shear-wave data by logging inside hollow-stem auger, although additional P-wave data could not be acquired because of the high-velocity steel from which the auger is constructed.

The augering operation in Boring CTB-5A was completed to a depth of 108.7' bgs by 2:30 PM on Friday afternoon, January 19, 2001. The AGEC drill crew did an excellent job of easing the hollow-stem auger into the very dense material below a depth of about 94' bgs without over-stressing the auger sections.

Shear-wave logging of the new temporary boring was conducted using the same field configuration illustrated in Figure 1 for Boring CTB-5(OW). The offset of the shear-wave beam from the new borehole was 6.2', the bottom of the beam was at the same elevation as the ground surface at the auger, and the stickup of the auger above ground surface was 2'.

Shear-wave logging of the borehole began by partially clamping the BHG-2 borehole seismic transducer inside the auger near the surface to approximately align the longitudinal geophone with the shear-wave beam. The transducer was then lowered to total depth inside the auger, and the steel spring clamp was locked into position for the deepest travel-time measurement at a depth of 106.5' bgs. The remainder of the shear-wave recording sequence was identical to that used in Boring CTB-5(OW). To the extent possible, the spring clamp was left in the locked position for successive recording intervals. By sliding the entire assembly along the inside wall of the auger, the transducer was moved up the borehole in 2.5' increments. Occasionally the spring clamp had to be released slightly and then reapplied at the hollow-stem auger joints, but we were able to maintain a relatively consistent transducer orientation throughout the logging sequence.

The shear-wave logging was continued at 2.5' intervals until a depth of 39', thereby achieving approximately a 10-foot overlap with the logging in adjacent Boring CTB-5(OW). As seen on the seismic traces plots in Figures C4 and C5 of Appendix C,

the data quality deteriorated substantially on the last two measurement levels (41.5' and 39') because of a slight decrease in the diameter of the auger sections in the upper part of the borehole. Due to this data quality deterioration, as well as the darkness and accompanying snowstorm which had descended on the field operation, the shear-wave logging was terminated at the 39' level at 5:50 PM. The next two hours were spent retrieving the hollow-stem auger from the ground, backfilling the temporary borehole, and demobilizing the entire field operation.

DATA PROCESSING

Preliminary estimates of the downhole seismic velocities were made in the field as the data were acquired during both downhole surveys. Detailed processing of the data was carried out at my home office in Washington State.

The first stage in processing of the shear-wave data was to graphically superimpose the forward and reverse polarities of the S-wave for each of the two horizontal geophones. Plots of these superimposed traces are presented in Figures C1 (transverse geophone) and C2 (longitudinal geophone) of Appendix C for Boring CTB-5(OW), and in Figures C4 (longitudinal geophone) and C5 (transverse geophone) for Boring CTB-5A. Other than trace sorting and superposition of the S-wave traces, no other processing (such as digital filtering) has been applied to the raw field data for these plots. From these plots, it can be seen that the waveforms for the transverse geophone in Boring CTB-5(OW) are excellent, whereas those for the longitudinal geophone are relatively poor. This indicates that the axis of the transverse horizontal geophone was best aligned with the shear-wave impulse beam, whereas the axis of the longitudinal horizontal geophone was approximately perpendicular to the shear-wave beam. The longitudinal geophone also exhibits much greater interference from (unwanted) P-wave energy generated by the S-wave beam due to the orientation of the geophone axis in relation to the beam. Hence, the much higher-quality data from the transverse geophone were used for the shear-wave velocity analysis for Boring CTB-5(OW). In Boring CTB-5A, the opposite was true, so that the data from the longitudinal geophone were used for the travel-time and velocity analyses.

The waveform of the S-wave generally consists of three primary lobes, a small peak (trough), followed by a large trough (peak), followed by a small peak (trough), in a butterfly-like pattern. In determining downhole travel times, it would ideally be best to "pick" (i.e., time) the very first arrival of the shear waveform. This is generally not possible, however, due to the "emergent" rather than "impulsive" character of the shear-wave arrival. Thus, the most consistent results (as well as the greatest detail regarding stratigraphic breaks and interval velocities) are usually obtained by "picking" the time of arrival of the first peak (trough) of the waveform. This is

generally taken to be the average of the forward and reverse polarities of the shear waveform.

The composite plot of the P-wave arrivals in Figure C3 indicates that the P-wave arrivals in Boring CTB-5(OW) were also generally "emergent" rather than "impulsive." Accordingly, the first major trough of the P-wave signal was "picked" to determine the downhole travel times. In the shallow part of the borehole, an interfering P-wave thought to be traveling down the casing grout was expressed as a small peak ahead of the higher-amplitude trough created by the P-wave in the soil.

The arrival times determined for the S-wave and the P-wave represent the relative travel times along the slant path between the seismic energy source and the borehole transducer (i.e., along the "Seismic Ray" in Figure 1). The next step in data processing is to convert these slant-path travel times to vertical travel times by multiplying the measured travel time by the cosine of the angle formed by the slant path and the wellbore. This conversion is greatest for the shallow measurement levels in the borehole, but becomes less of a factor at depth in the boring. Based on recent research conducted on the Yucca Mountain Project in Nevada, it is necessary to correct the measured travel times (first "peak") back to the time of first arrival of the seismic wave (first "break") before applying the cosine conversion factor. This correction is determined by observing the average time difference (in milliseconds) between the first "break" and the first "peak" on a number of seismic traces, with particular attention to the uppermost 20-30 feet of the borehole.

The conversions to vertical travel time were accomplished in a Microsoft EXCEL spreadsheet which I normally use for downhole seismic data processing. Copies of the spreadsheets for the S-wave and the P-wave data processing are reproduced in Appendix D to this report, together with a description of the column labels for the spreadsheets.

INTERPRETATION AND SURVEY RESULTS

Shear-Wave Velocities

The downhole shear-wave results are presented graphically in Figures 2-4. Figure 2 is a plot of vertical travel time versus depth in Borings CTB-5(OW) and CTB-5A (from columns 7 and 3, respectively, of the EXCEL spreadsheets reproduced in Appendix D). Superimposed on this plot is my interpretation of straight-line segments of the S-wave travel-time curves which represent seismic "layers" in the subsurface. Average velocities for these seismic "layers" have been determined by computing the inverse slopes of the travel-time segments using a linear least-squares fitting routine in the computer program GRAPHER from Golden Software of Golden, Colorado. GRAPHER was also used to generate the plots, and then to

export them to AutoCAD for the final drawings. The average shear-wave velocities posted on Figure 2 are also presented in tabular form in Tables 1 and 2.

In Figures 3 and 4, the average S-wave velocities determined for linear segments of the travel-time curve are plotted as a solid bold line representing velocity vs. depth in Borings CTB-5(OW) and CTB-5A. Superimposed on this plot in Figure 3 is a dashed line representing "interval" velocities computed over 2.5' intervals in the boreholes (from Column 8 of Tables D1 and D3 in Appendix D). These are termed "pseudo" interval velocities because they were determined from successive locations of the same geophone. In contrast, the determination of "true" interval velocities would require the use of a string of at least two tandem geophones in the borehole which simultaneously record the same hammer blow to the shear-wave beam.

There is generally a significant degree of scatter in the 2.5' interval-velocity plots because this small an interval is close to the limit of resolution of the downhole seismic method. This is due to the finite length of the waveform, the "emergent" rather than "impulsive" nature of the seismic arrivals, and timing uncertainties associated with imperfections in the seismic waveform. Nevertheless, the 2.5' interval velocity plot can be quite useful for deciding on the location of stratigraphic boundaries in the subsurface formations.

An alternative interval velocity plot, termed the "differential" velocity, is given by the dashed line in Figure 4. The differential velocity is determined by computing pseudo-interval velocities over 5' intervals in the borehole, then averaging these 5' interval velocities over intervals of 2.5' (from Columns 9 and 10 of Tables D1 and D3 in Appendix D). This is effectively a smoothing technique for averaging some of the scatter which is inherent to the 2.5' interval velocity plot. The differential velocity plot tends to "smooth" through stratigraphic boundaries, but it has been found to give a good representation of S-wave velocities within individual stratigraphic units. The character of the differential velocity plot generally agrees favorably with plots of SPT N-values in subsurface materials. I have found both types of interval velocity plots to be helpful for understanding the seismic stratigraphy in somewhat greater detail than is provided by the average S-wave velocity plots.

Compression-Wave Velocities

The compression-wave results for Boring CTB-5(OW) are presented graphically in Figures 5 and 6. Figure 5 is a plot of the P-wave vertical travel time vs. depth in the borehole (from columns 7 and 3, respectively, of Table D2 in Appendix D). Superimposed on this plot is my interpretation of linear segments of the travel-time curve and the respective average velocities of these segments computed by applying linear least-squares fits to the data. Figure 6 is a plot of these average P-wave velocities vs. depth in the borehole.

As is generally found to be the case in downhole velocity logging, the P-wave travel-time curve exhibits more scatter than the S-wave travel-time curve. The P-wave data for the third layer, in particular (with a computed velocity of 1490 feet/sec), shows a relatively high degree of scatter. The apparent stratigraphic breaks at depths of 10-11 feet and 35-36 feet appear to correlate with breaks at similar positions in the S-wave data. Interval velocities are not presented for the P-wave data since the interval velocity calculations are less meaningful because of the higher degree of data scatter.

CONCLUSIONS AND RECOMMENDATIONS

The downhole seismic velocity surveys in Borings CTB-5(OW) and CTB-5A provide *in-situ* seismic velocities to a depth of 106.5' below the PFSF site in the vicinity of Boring CTB-5(OW). In the zone of overlap of the two downhole surveys (44' to 51' bgs), the shear-wave velocity determined in Boring CTB-5A is somewhat higher than that in Boring CTB-5(OW). This may be due to a slightly higher degree of sedimentary consolidation at the offset location. Also, the steel hollow-stem auger in Boring CTB-5A provided an expedient, but less ideal well construction for shear-wave logging than the grouted PVC casing in Boring CTB-5(OW), thus leading to higher variability in the computed interval velocities. Nevertheless, the average velocity determinations for both borings are thought to be representative of the subsurface formations.

The prominent change in the slope of the shear-wave travel-time curve (Figure 2) at a depth of 94' bgs indicates that we successfully logged approximately 12' into the very dense silt which underlies the site at this depth. The interval velocity determinations suggest that this dense silt has a somewhat higher shear-wave velocity in the uppermost 5'-7' of the unit than deeper in the unit. The computed least-squares velocity of 2870 ft/sec computed over the six measurement levels in the silt is thought to provide a good representation of the overall shear-wave properties of the upper 12' of the unit.

If additional wells are constructed at the site for the purpose of downhole shear-wave logging, I recommend that the borings are cased with grooved Slope Indicator casing so that one of the two horizontal geophones can be maintained in close alignment with the shear-wave energy source by attaching a guide rod to the BHG-2 borehole transducer. Alternatively, if the PVC casing ID is increased to 3", my Model BHG-3 borehole seismic transducer could be employed for the downhole logging. The BHG-3 transducer is similar to the BHG-2, except that it includes a servo mechanism which can be used to rotate the geophone elements until one of the horizontal geophones is aligned with the shear-wave energy source. This ability to control geophone orientation optimizes the shear-wave data quality and decreases

waveform timing ambiguities which can result from rotation of the seismic transducer as the transducer is raised up the borehole.

I have appreciated the opportunity to determine *in-situ* downhole seismic velocities for Stone & Webster, Inc., for the purpose of site characterization at the Private Fuel Storage Facility. Please call if there are any questions regarding field procedures or my interpretation of the shear-wave and compression-wave velocity profiles.

Sincerely yours,

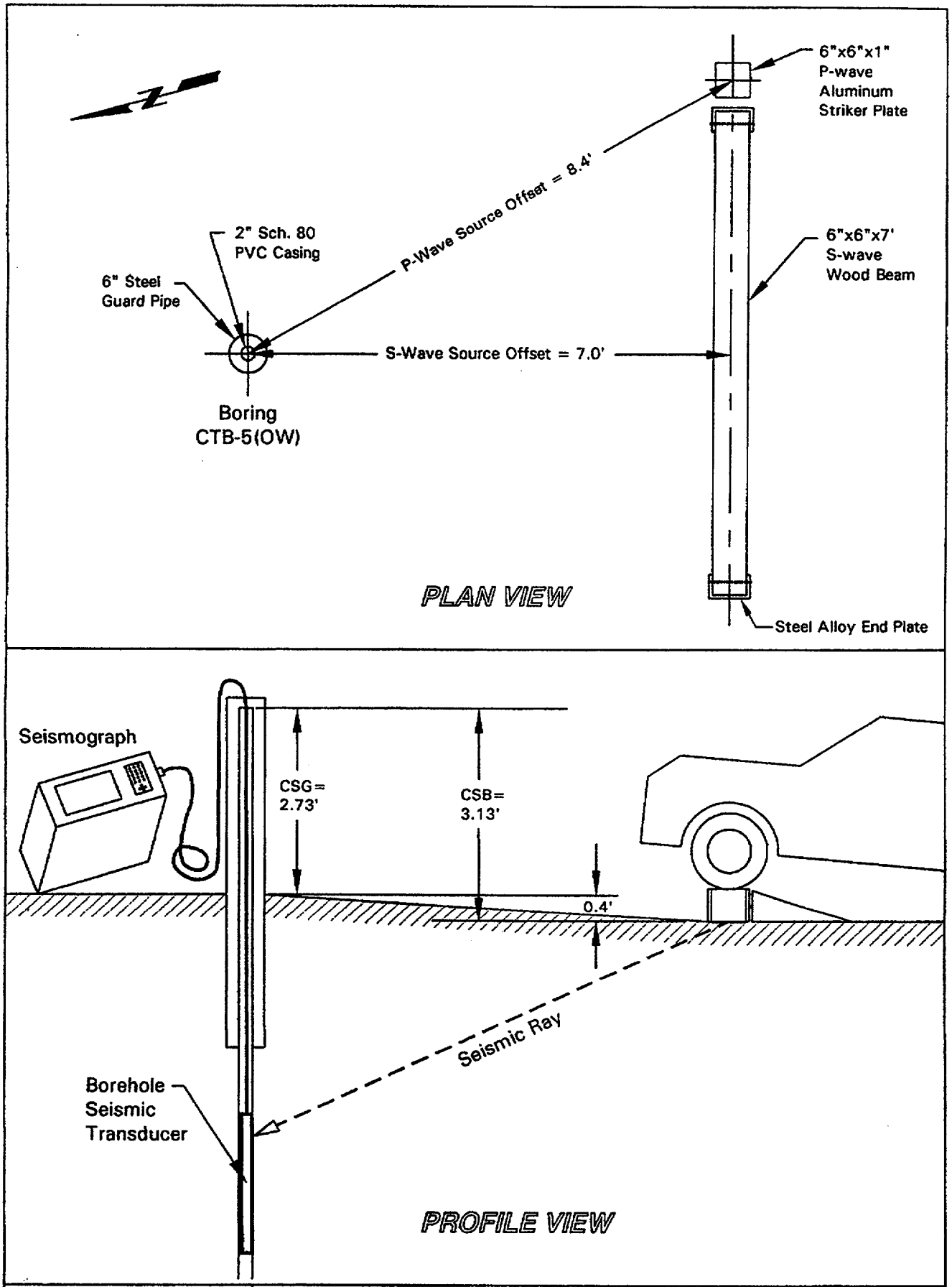
NORTHLAND GEOPHYSICAL, LLC

Thomas R. Williams

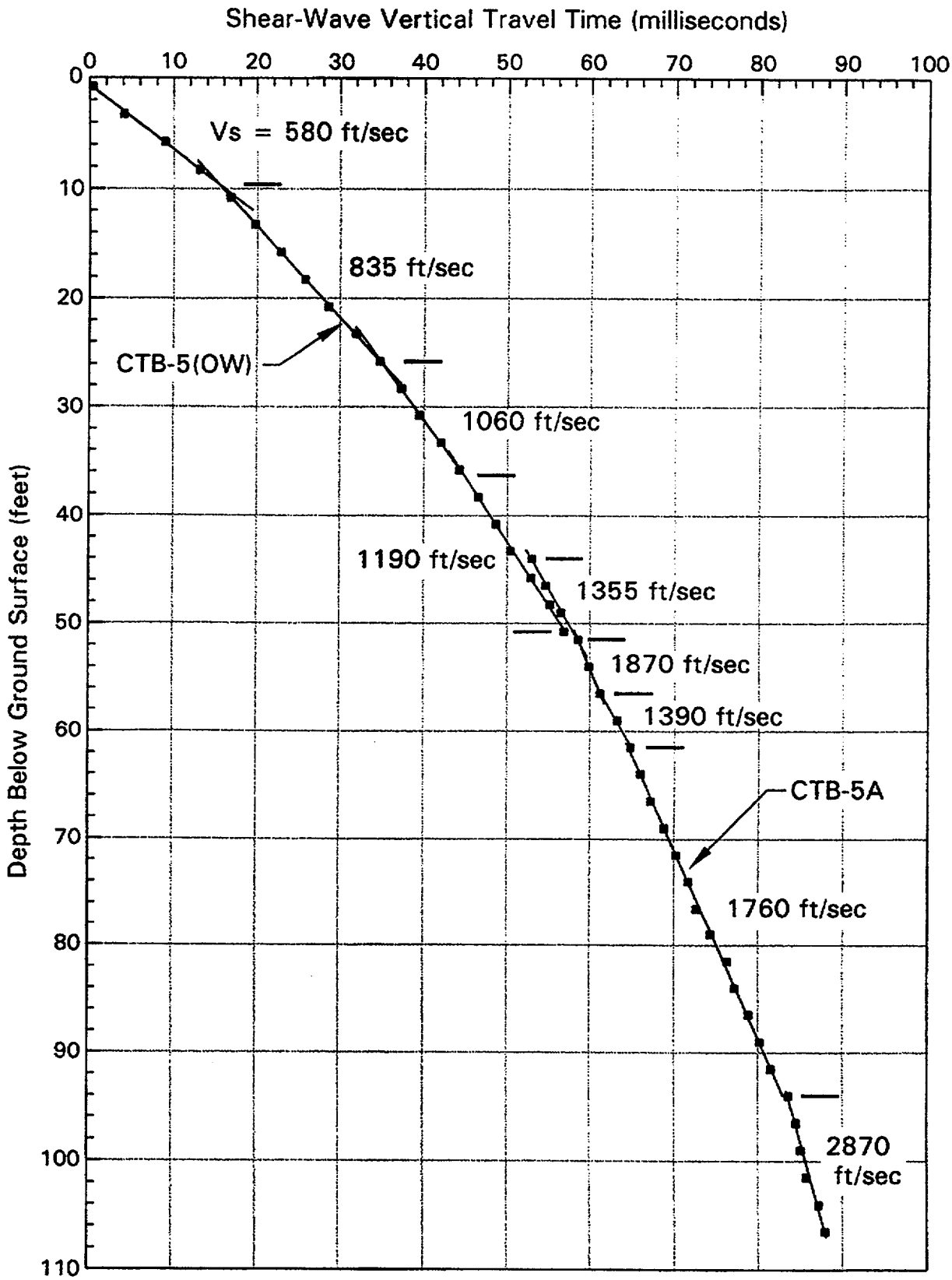
Thomas R. Williams, Member
Consulting Geophysicist

Attachments:

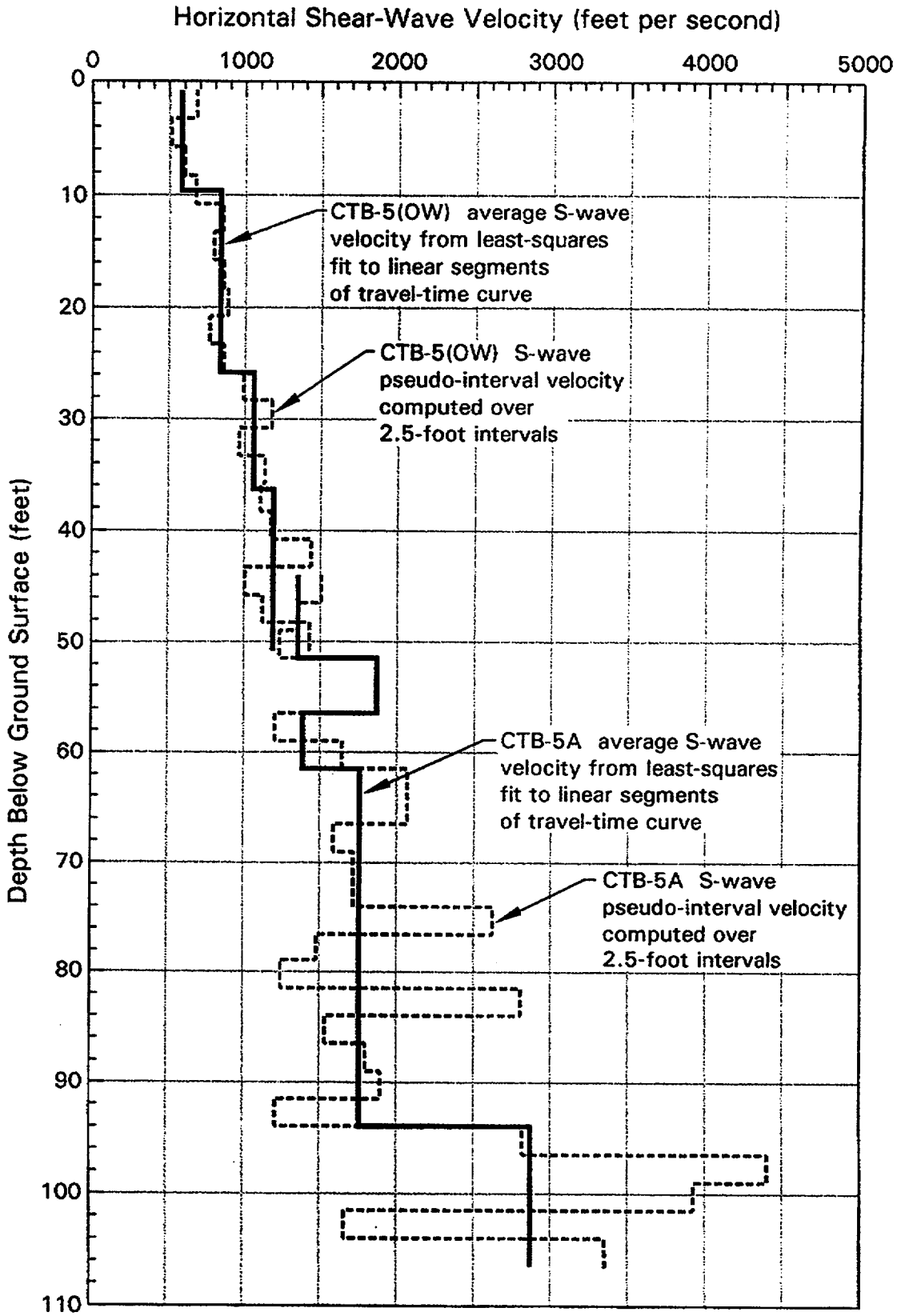
Appendix A	Seismograph Calibration
Appendix B	Downhole Seismic Field Data
Appendix C	Shear-Wave and Compression-Wave Traces
Appendix D	Downhole Seismic Data Processing Spreadsheets



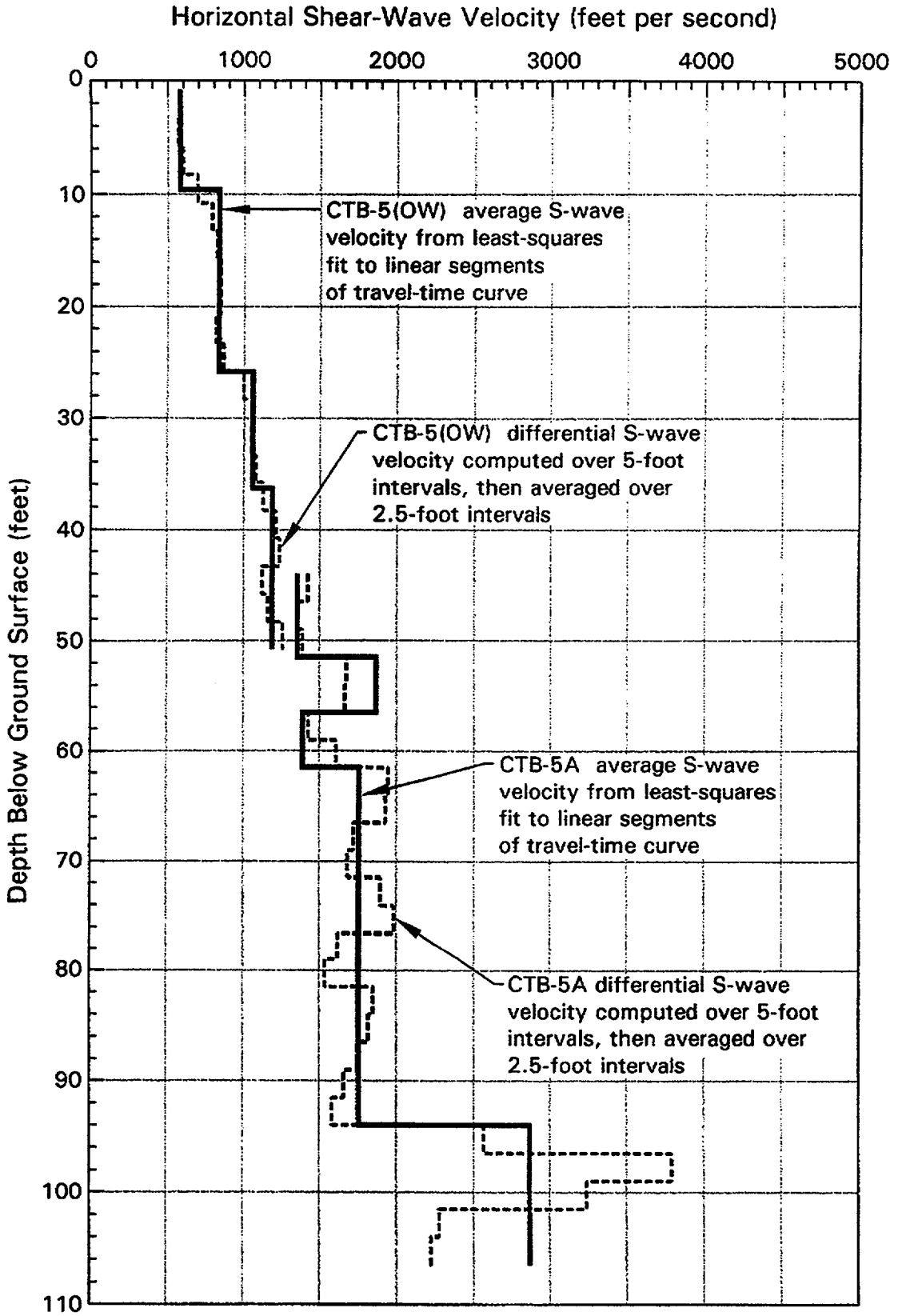
NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	DOWNHOLE SEISMIC SURVEY FIELD CONFIGURATION Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE 1



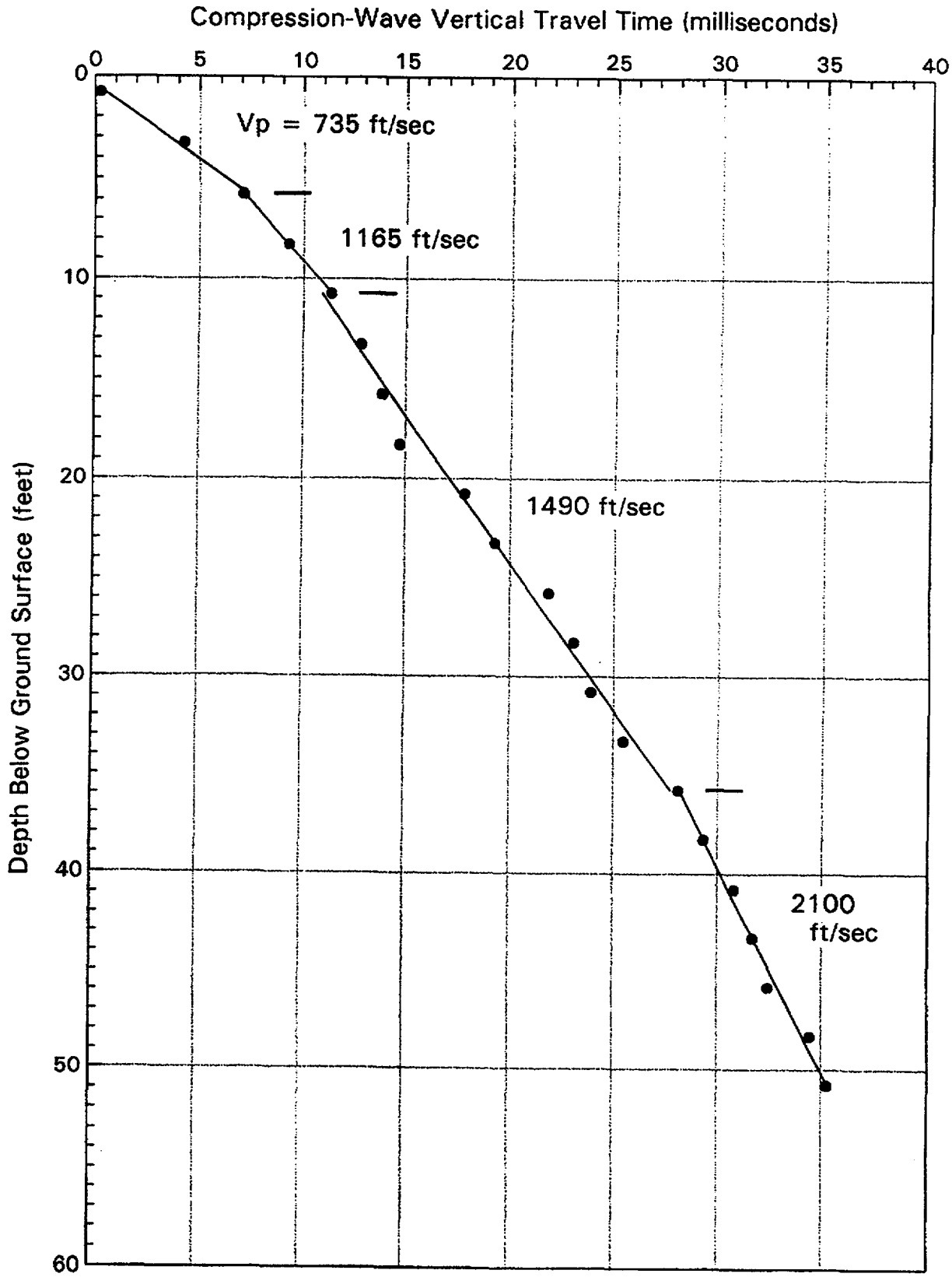
NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	S-WAVE TRAVEL TIMES and AVERAGE VELOCITIES Borings CTB-5(OW) and CTB-5A PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE 2



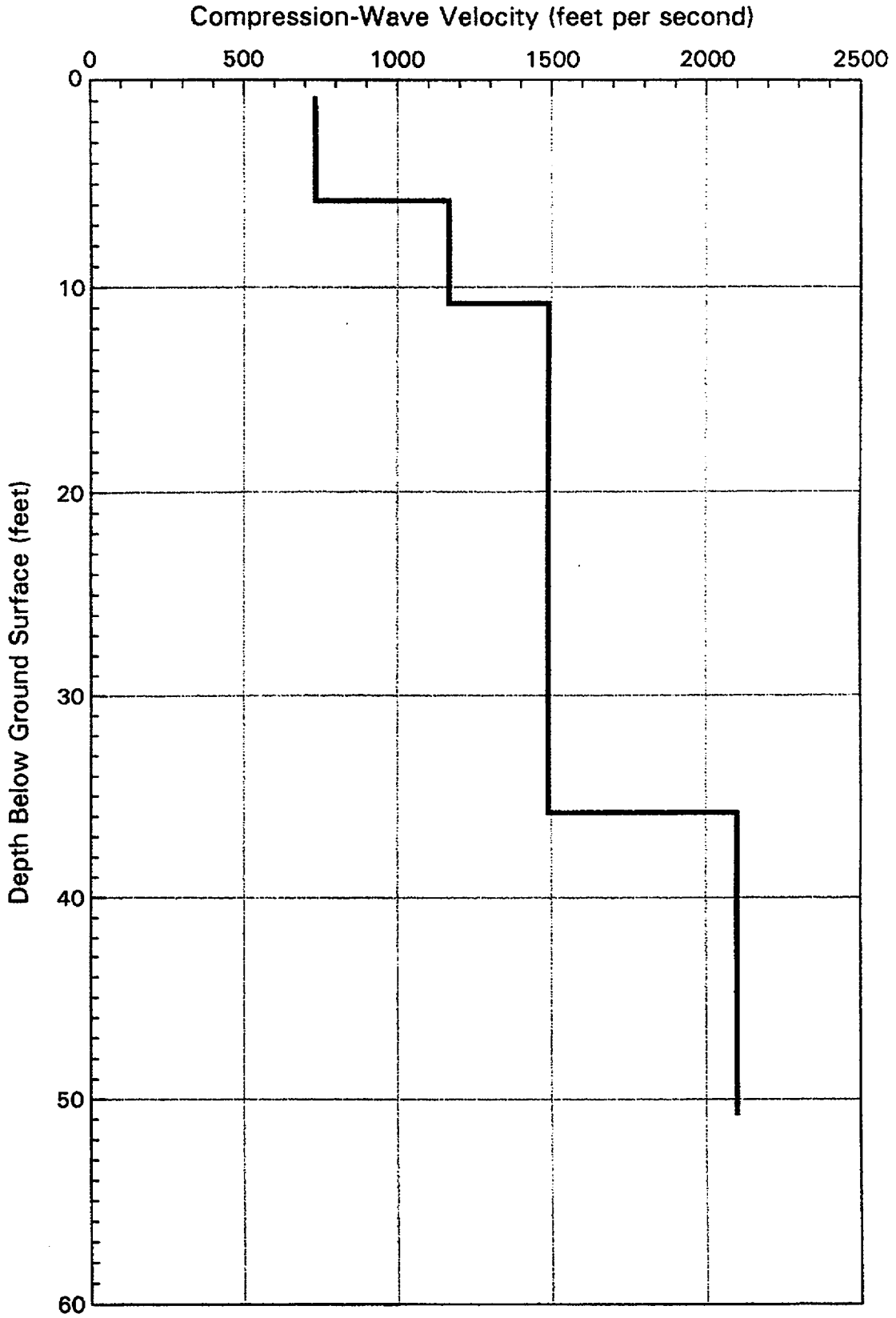
NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	S-WAVE AVERAGE and PSEUDO-INTERVAL VELOCITY Borings CTB-5(OW) and CTB-5A PRIVATE FUEL STORAGE FACILITY	January 2001
		FIGURE 3



NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	S-WAVE AVERAGE and DIFFERENTIAL VELOCITY Borings CTB-5(OW) and CTB-5A PRIVATE FUEL STORAGE FACILITY	January 2001
		FIGURE 4



NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	P-WAVE TRAVEL TIMES and AVERAGE VELOCITIES Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE 5



NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	COMPRESSION-WAVE VELOCITY Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE 6

Table 1 AVERAGE SHEAR-WAVE VELOCITY Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	
Interval Depth (feet bgs)	S-wave Velocity (feet / sec)
0.8 - 9.6	580
9.6 - 25.8	835
25.8 - 36.3	1060
36.3 - 50.8	1190

Table 2 AVERAGE SHEAR-WAVE VELOCITY Boring CTB-5A PRIVATE FUEL STORAGE FACILITY	
Interval Depth (feet bgs)	S-wave Velocity (feet / sec)
44.0 - 51.5	1355
51.5 - 56.5	1870
56.5 - 61.5	1390
61.5 - 94.0	1760
94.0 - 106.5	2870

Table 3 2.5' PSEUDO-INTERVAL SHEAR-WAVE VELOCITY Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	
Interval Depth (feet bgs)	S-wave Velocity (feet / sec)
0.8 - 3.3	680
3.3 - 5.8	513
5.8 - 8.3	603
8.3 - 10.8	673
10.8 - 13.3	853
13.3 - 15.8	791
15.8 - 18.3	858
18.3 - 20.8	885
20.8 - 23.3	768
23.3 - 25.8	862
25.8 - 28.3	992
28.3 - 30.8	1176
30.8 - 33.3	965
33.3 - 35.8	1134
35.8 - 38.3	1106
38.3 - 40.8	1173
40.8 - 43.3	1438
43.3 - 45.8	1007
45.8 - 48.3	1121
48.3 - 50.8	1429

Table 4 2.5' PSEUDO-INTERVAL SHEAR-WAVE VELOCITY Boring CTB-5A PRIVATE FUEL STORAGE FACILITY	
Interval Depth (feet bgs)	S-wave Velocity (feet / sec)
44.0 - 46.5	1506
46.5 - 49.0	1349
49.0 - 51.5	1233
51.5 - 54.0	1867
54.0 - 56.5	1871
56.5 - 59.0	1203
59.0 - 61.5	1645
61.5 - 64.0	2067
64.0 - 66.5	2070
66.5 - 69.0	1588
69.0 - 71.5	1720
71.5 - 74.0	1721
74.0 - 76.5	2623
76.5 - 79.0	1480
79.0 - 81.5	1245
81.5 - 84.0	2807
84.0 - 86.5	1536
86.5 - 89.0	1801
89.0 - 91.5	1898
91.5 - 94.0	1210
94.0 - 96.5	2817
96.5 - 99.0	4405
99.0 - 101.5	3925
101.5 - 104.0	1661
104.0 - 106.5	3352

Table 5

DIFFERENTIAL SHEAR-WAVE VELOCITY
(5' Interval Velocity Averaged Over 2.5' Intervals)

Boring CTB-5(OW)
PRIVATE FUEL STORAGE FACILITY

Interval Depth (feet bgs)	S-wave Velocity (feet / sec)
0.8 - 3.3	584
3.3 - 5.8	569
5.8 - 8.3	595
8.3 - 10.8	694
10.8 - 13.3	787
13.3 - 15.8	822
15.8 - 18.3	847
18.3 - 20.8	847
20.8 - 23.3	817
23.3 - 25.8	867
25.8 - 28.3	999
28.3 - 30.8	1068
30.8 - 33.3	1051
33.3 - 35.8	1081
35.8 - 38.3	1129
38.3 - 40.8	1215
40.8 - 43.3	1238
43.3 - 45.8	1123
45.8 - 48.3	1159
48.3 - 50.8	1257

Table 6

DIFFERENTIAL SHEAR-WAVE VELOCITY
(5' Interval Velocity Averaged Over 2.5' Intervals)

Boring CTB-5A
PRIVATE FUEL STORAGE FACILITY

Interval Depth (feet bgs)	S-wave Velocity (feet / sec)
44.0 - 46.5	1423
46.5 - 49.0	1356
49.0 - 51.5	1387
51.5 - 54.0	1677
54.0 - 56.5	1667
56.5 - 59.0	1427
59.0 - 61.5	1611
61.5 - 64.0	1950
64.0 - 66.5	1933
66.5 - 69.0	1724
69.0 - 71.5	1686
71.5 - 74.0	1900
74.0 - 76.5	1985
76.5 - 79.0	1622
79.0 - 81.5	1539
81.5 - 84.0	1855
84.0 - 86.5	1822
86.5 - 89.0	1753
89.0 - 91.5	1663
91.5 - 94.0	1586
94.0 - 96.5	2565
96.5 - 99.0	3794
99.0 - 101.5	3243
101.5 - 104.0	2278
104.0 - 106.5	2221

Table 7 AVERAGE COMPRESSION-WAVE VELOCITY Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	
Interval Depth (feet bgs)	P-wave Velocity (feet / sec)
0.8 - 5.8	735
5.8 - 10.8	1165
10.8 - 35.8	1490
35.8 - 50.8	2100

APPENDIX A

Seismograph Calibration

Borings CTB-5(OW) and CTB-5A
Private Fuel Storage Facility
ESSOW No. 05996.02-G011 (Rev. 1)

Seismograph Calibration
ESSOW No. 05996.02-G011 (Rev.1)

The Geometrics R24 StrataView 24-channel digital seismograph (Serial No. 75285) used for the downhole seismic geophysical testing in Borings CTB-5(OW) and CTB-5A at the Private Fuel Storage Site underwent calibration tests at the manufacturer's headquarters facility in San Jose, California, on Monday morning, December 18, 2000. The calibration tests were performed by Mr. George Tait of the Customer Service Department at Geometrics in the presence of Thomas R. Williams, Northland Geophysical, LLC, and Andrew J. Mills, Quality Assurance Manager, Stone & Webster, Inc.

The calibration tests were conducted with a Geometrics Portable Precision Oscillator, Model TP-1, Serial No. 79016. This oscillator is the main instrument used for final testing of new seismographs before shipment from the Geometrics plant. It is also the instrument used to test other Portable Precision Oscillators produced for sale by Geometrics. Geometrics is considered by the engineering geophysics community to be the pre-eminent manufacturer of engineering seismographs in the U.S.A. today.

The subject R24 StrataView Seismograph (S.N. 75285) has been in field service since being shipped from Geometrics to Thomas R. Williams in September, 1998. The instrument underwent stringent calibration tests as part of the Quality Assurance program at Geometrics prior to the Fall 1998 shipment. The seismograph has performed flawlessly since that time in all types of field environments on projects in Washington, Oregon, California, and Alaska.

The visit to Geometrics on December 18, 2000, was the first time the seismograph has been back to the manufacturer's plant since the 1998 purchase. The instrument passed the entire battery of calibration tests with no problem areas noted. A copy of the Certificate of Calibration is enclosed, together with a photocopy of the printout from the seismograph as the calibration tests were being performed.

GEOMETRICS
2190 Fortune Drive, San Jose, California 95131, USA
Tel. (408) 954-0522 • FAX (408) 954-0902

CERTIFICATE OF CALIBRATION

This document certifies that the following products meet or exceed the manufacturers specifications

Date Calibrated	Manufacturer	Model
12/18/00	Geometrics	R24
Serial Number	P.O. No.	Condition
75285	Verbal	Like New
Temperature	Osc. Frequency	Timing/Delay
70 F.	N/A	N/A
Before Calibration	After Calibration	Technician G. Tait

CALIBRATION EQUIPMENT USED:

MANF.	MODEL	SER. NO.	ASSET NO.	CAL. RECALL
Geometrics	Seismic Test	79016	N/A	N/A
COMMENTS:				

CALIBRATION RECORDS ARE ON FILE.

```
TEST REPORT
DATE: 18/DEC/0   TIME:  8:43:06    INSTRUMENT SERIAL NO. 75285
TOTAL 24 CHANNELS TESTED

TITLE: StrataView R Monthly Test  V1.20  5/27/98

TEST 1 NOISE  2mS
DC OFFSET SPECIFICATION ( < 0.010000 mV )                          PASSED
AC RMS SPECIFICATION ( < 0.000800 mV )                             PASSED

TEST 2 NOISE  1/4mS
DC OFFSET SPECIFICATION ( < 0.010000 mV )                          PASSED
AC RMS SPECIFICATION ( < 0.001000 mV )                             PASSED

TEST 3 NOISE  1/16mS
DC OFFSET SPECIFICATION ( < 0.010000 mV )                          PASSED
AC RMS SPECIFICATION ( < 0.001400 mV )                             PASSED

TEST 4 THD  2mS, 23Hz NFS
HARMONIC DISTORTION SPECIFICATION ( <  0.01200 % )                 PASSED

TEST 5 THD  2mS, 23Hz Low-level
HARMONIC DISTORTION SPECIFICATION ( <  0.05000 % )                 PASSED

TEST 6 ACC/SIM  1/2mS, 190Hz
GAIN ACCURACY SPECIFICATION ( <  5.00000% )                        PASSED
GAIN SIMILARITY SPECIFICATION ( <  2.50000% )                      PASSED
PHASE SIMILARITY SPECIFICATION ( <  3.42000 DEGREE )               PASSED

TEST 7 THD  1/2mS, 190Hz NFS
HARMONIC DISTORTION SPECIFICATION ( <  0.01200 % )                 PASSED

TEST 8 XFD ODD  1mS, 190Hz
CROSS TALK REJECTION SPECIFICATION ( >  73.00 dB )                 PASSED

TEST 9 XFD EVEN  1mS, 190Hz
CROSS TALK REJECTION SPECIFICATION ( >  73.00 dB )                 PASSED

TEST 10 CMR  1mS, 190Hz
COMMON MODE REJECTION SPECIFICATION ( >  90.00 dB )                PASSED

TEST 11 TIMING  1/2mS
TIMING SPECIFICATION ( ABSOLUTE DEVIATION <     500.00 usec )      PASSED

TEST 12 BW  1/2mS
LOWER CORNER FREQ SPEC AT 3 dB ( >   2.150 Hz & <   3.550 Hz )     PASSED
UPPER CORNER FREQ SPEC AT 3 dB ( > 605.000 Hz & < 635.000 Hz )     PASSED

TEST 13 LC 25Hz FILTER 2mS
LOWER CORNER FREQ SPEC AT 3 dB ( >  24.375 Hz & <  25.625 Hz )     PASSED

TEST 14 HC 500Hz FILTER  1/8mS
UPPER CORNER FREQ SPEC AT 3 dB ( > 487.500 Hz & < 512.500 Hz )     PASSED

TEST 15 NOTCH 50Hz  2mS
NOTCH FILTER SPEC AT 3 dB (WIDTH <  20.000 Hz)                     PASSED
NOTCH FILTER SPEC AT 40 dB (UPPER >  50.250 Hz & LOWER <  49.750 Hz)  PASSED

TEST RESULT                                          ALL TESTS PASSED
```

APPENDIX B

Downhole Seismic Field Data

Borings CTB-5(OW) and CTB-5A
Private Fuel Storage Facility
ESSOW No. 05996.02-G011 (Rev. 1)

Downhole Seismic Field Data
ESSOW No. 05996.02-G011 (Rev.1)

Following are photocopies of the field seismograms generated during the downhole seismic velocity survey at Boring CTB-5(OW) on December 21, 2000, and Boring CTB-5A on January 19, 2001. The data files are numbered 5000.DAT through 5009.DAT for Boring CTB-5(OW) and 5020.DAT through 5024.DAT for Boring CTB-5A.

The even-numbered files 5000.DAT, 5002.DAT, 5004.DAT, 5006.DAT, and 5008.DAT contain background noise recordings at 15' intervals in Boring CTB-5(OW) [Chl. 1 = vertical geophone; Chl.2 = longitudinal horizontal geophone; Chl. 3 = transverse horizontal geophone].

The S-wave data for Boring CTB-5(OW) are contained in files 5001.DAT, 5003.DAT, 5005.DAT, and 5007.DAT. Each recording level in the borehole is represented by four channels in the files, so that six measurement levels are recorded in each 24-channel StrataView data file. In each group of four traces, the first two are from the longitudinal geophone and the second two are from the transverse geophone. The odd-numbered channels were used for hammer blows to the west end of the shear-wave beam; the even-numbered channels were used for hammer blows to the east end of the beam. Four hammer blows were stacked for each end of the beam at each 2.5' measurement level. The data from the longitudinal geophone are relatively poor, whereas the data from the transverse geophone are very good, thus indicating that the longitudinal geophone was oriented nearly perpendicular to the shear-wave beam, while the transverse geophone was nearly parallel to the beam. The data from the transverse geophone were therefore used for the travel-time "picks" and the velocity calculations for Boring CTB-5(OW).

The P-wave data for Boring CTB-5(OW) are contained in file 5009.DAT. In this data file, one channel was used for each measurement level, from cable depth 52.5' on Chl.24 to cable depth 2.5' on Chl. 4.

The S-wave data for Boring CTB-5A are contained in files 5020.DAT through 5024.DAT. The recording sequence for the S-wave data for this boring was identical to that for Boring CTB-5(OW), except that no separate background noise data files were recorded because of the limited time available for data acquisition after completion of the temporary boring. However, the noise monitor on the seismograph was viewed prior to the addition of each hammer blow to the data stacks to be certain that shear-wave data was not recorded during periods of high background noise levels. For this boring, the S-wave data recorded using the longitudinal horizontal geophone were used for the travel-time "picks" and the velocity calculations. No P-wave data were acquired in Boring CTB-5A due to the high-velocity steel from which the hollow-stem auger sections are constructed.

Boring CTB-5(OW)

Noise Record at 52.5'

(S-wave Survey)

GEOMETRICS StratoView

READ FROM 5000.DAT 11:11:20 21/DEC/2000

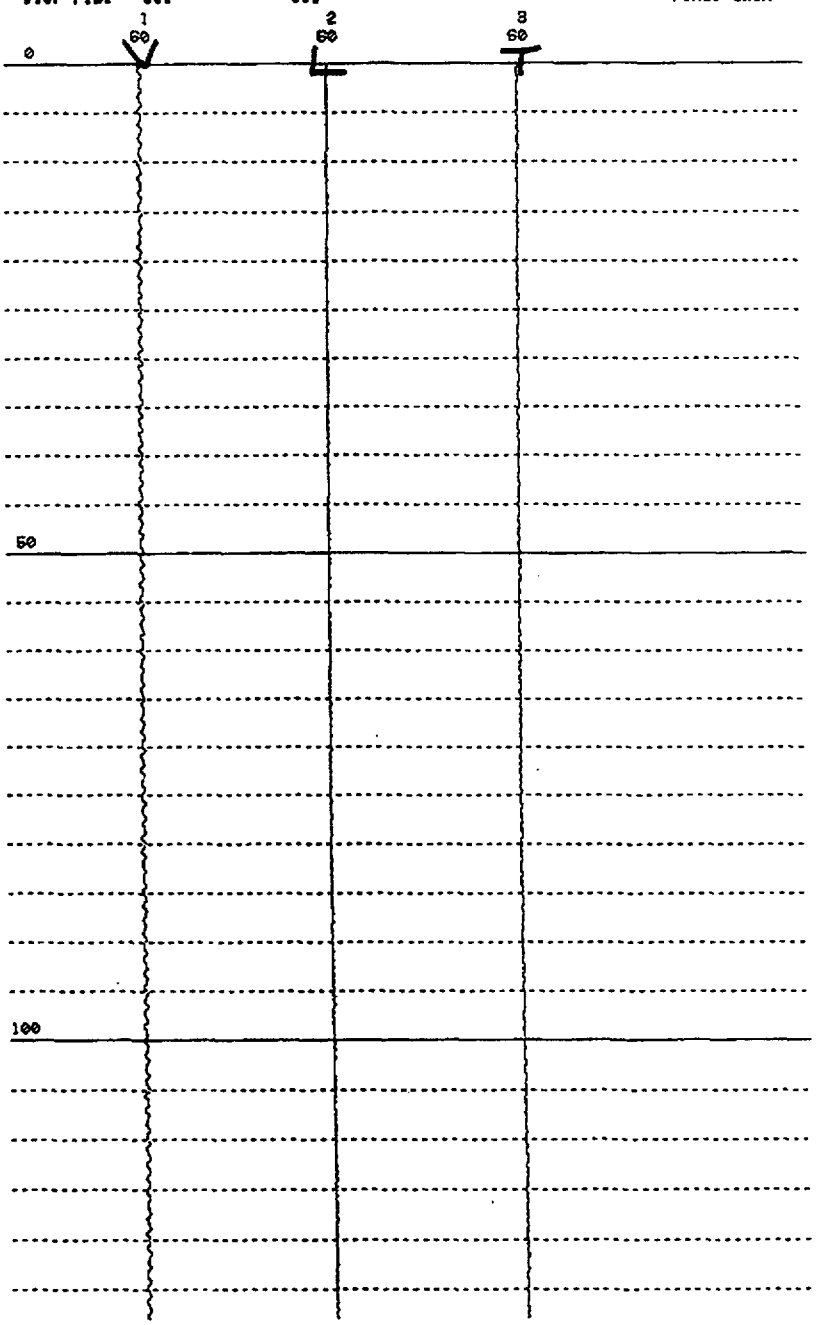
LINE NUMBER CTB5nw GROUP INTERVAL 2.50

SHOT LOC -6.90 PHONE 1 LOC ~~0.00~~ 52.5 PHONE 3 LOC ~~5.00~~ 52.5

SAMPLE INTERVAL 062 uS RECORD LEN 128 MS DELAY 0 MS

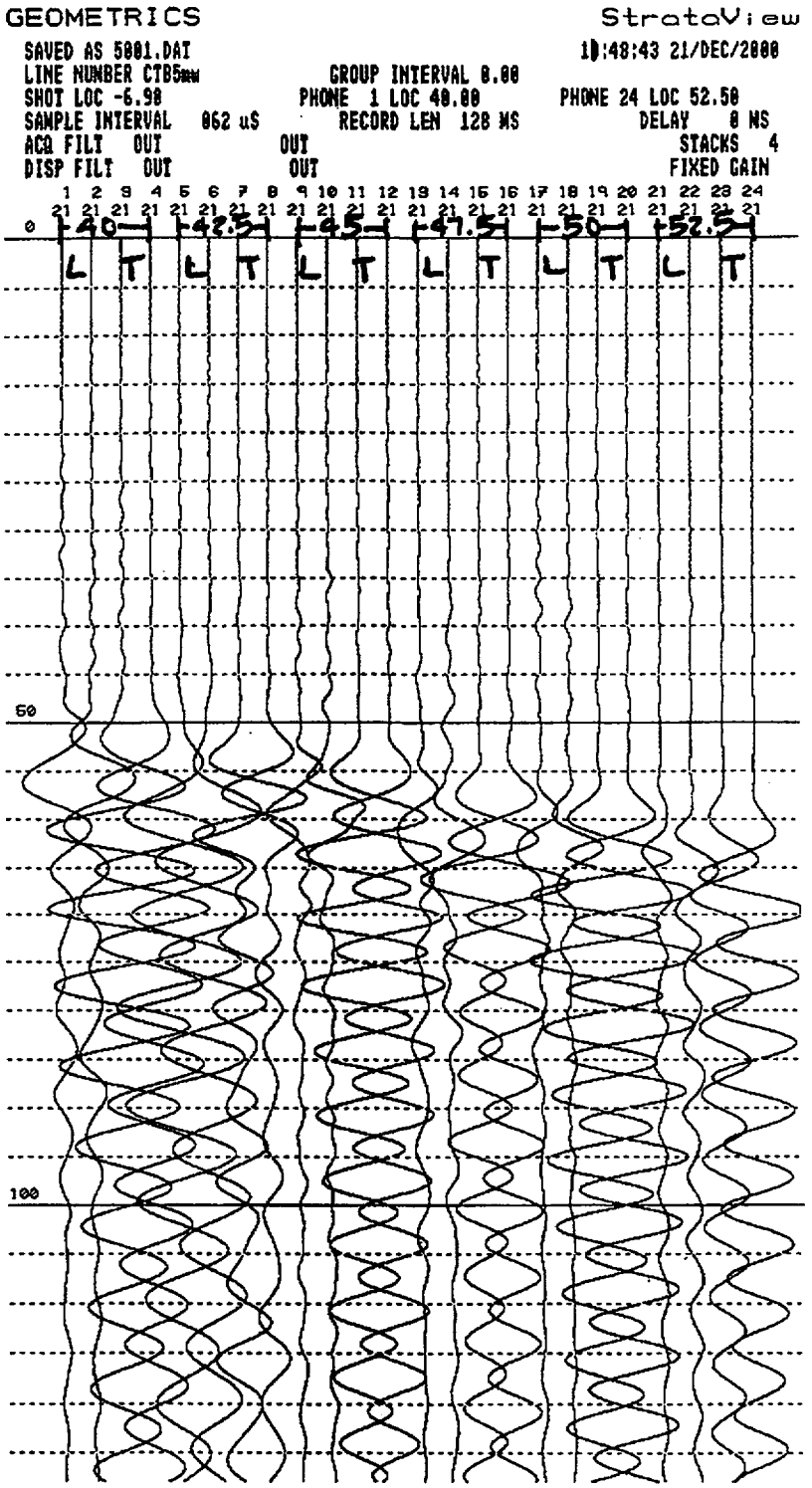
ACQ FILT LO CUT 0HZ NOTCH 0HZ STACKS 1

DISP FILT OUT OUT FIXED GAIN



Boring CTB-5 (OW)

S-wave Data, 40'-52.5'



Boring CTB-5(OW)

Noise Record at 37.5'

(S-wave Survey)

GEOMETRICS

StrataView

READ FROM 5002.DAT

10:58:44 21/DEC/2000

LINE NUMBER CTB5ow

GROUP INTERVAL 0.00

SHOT LOC -6.98

PHONE 1 LOC 37.50

PHONE 3 LOC 37.50

SAMPLE INTERVAL 062 uS

RECORD LEN 128 MS

DELAY 0 MS

ACQ FILT LO CUT 0HZ

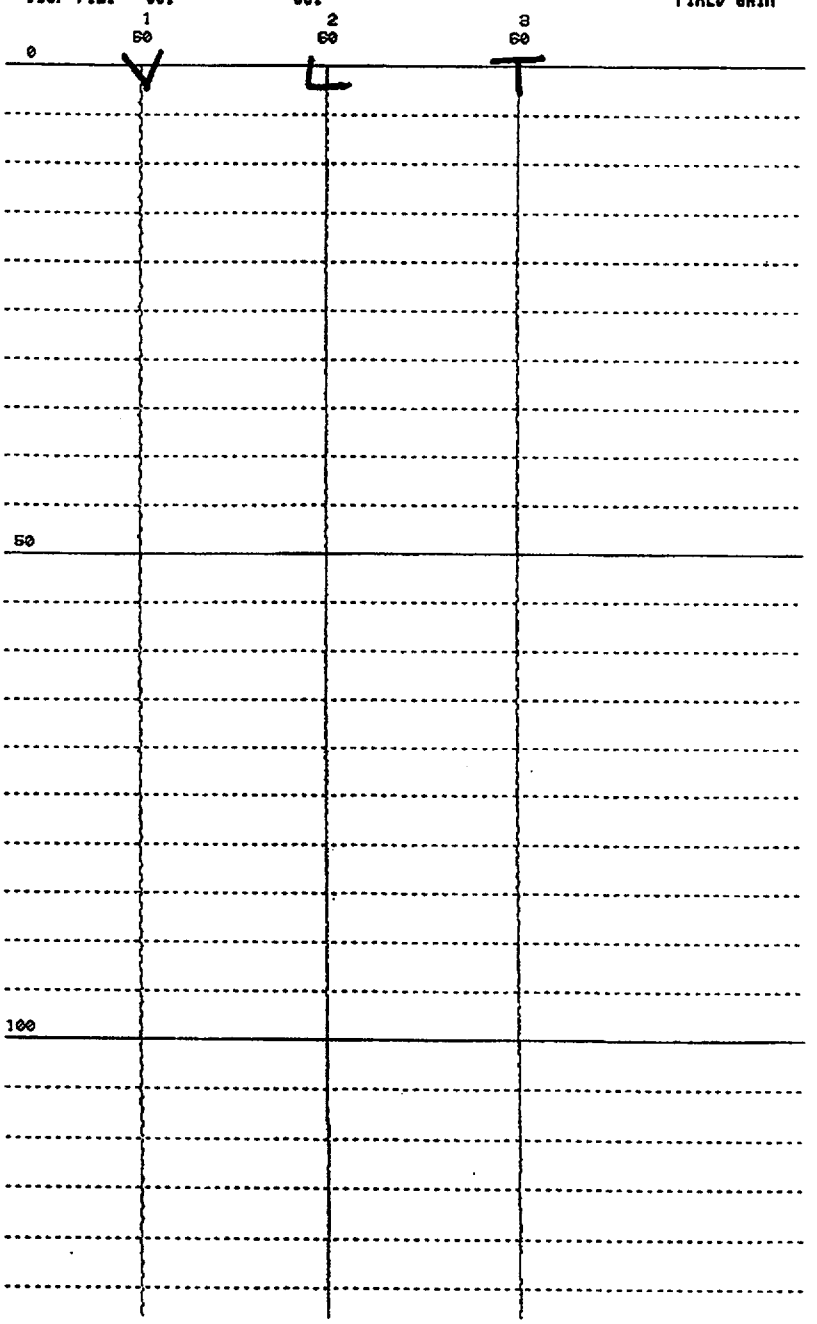
NOTCH 0HZ

STACKS 1

DISP FILT OUT

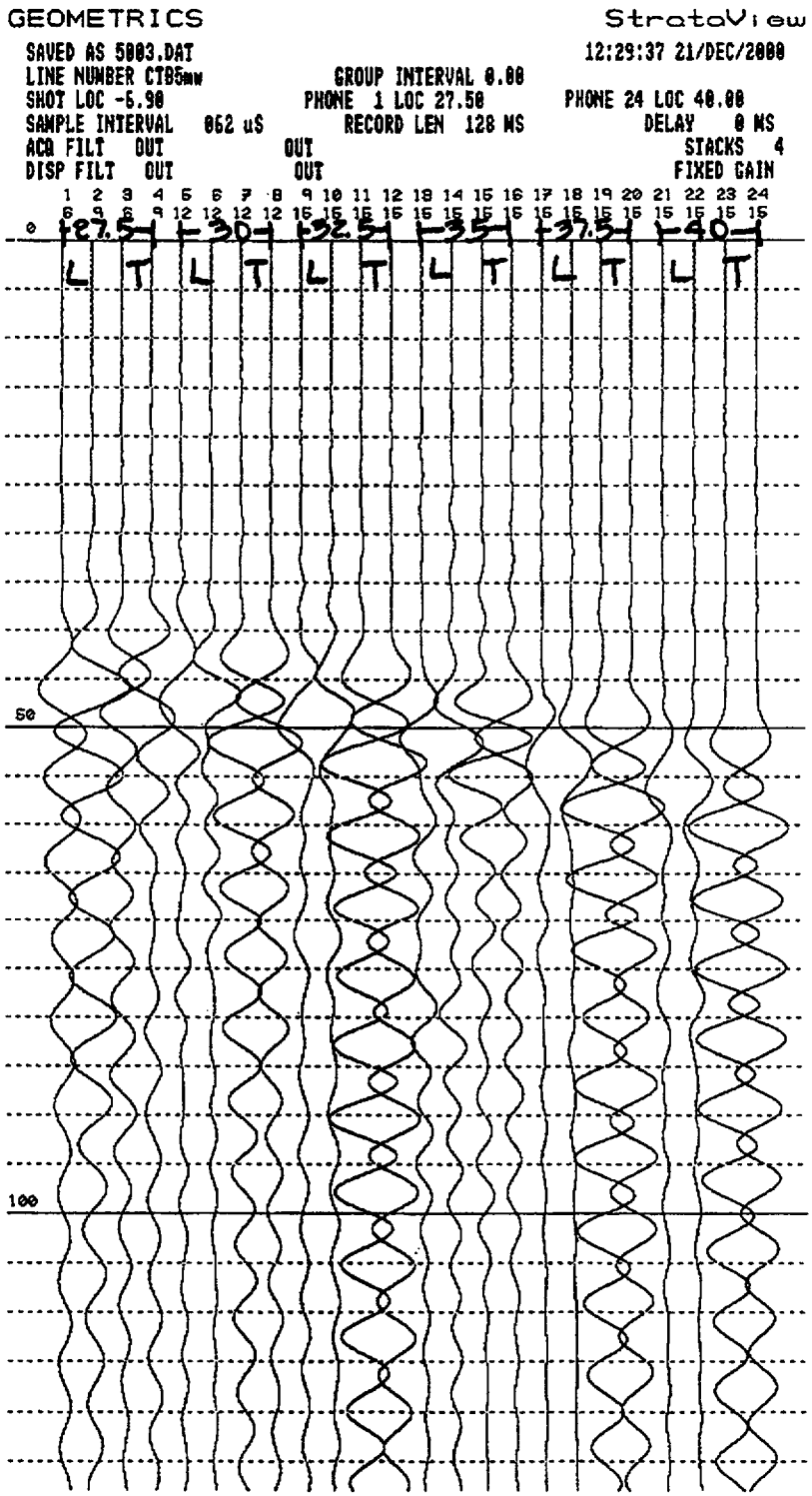
OUT

FIXED GAIN



Boring CTB-5 (OW)

S-wave Data, 27.5'-40'



Boring CTB-5 (OW)

Noise Record at 25'

(S-wave Survey)

GEOMETRICS StrataView

READ FROM 5004.DAT 12:40:56 21/DEC/2000

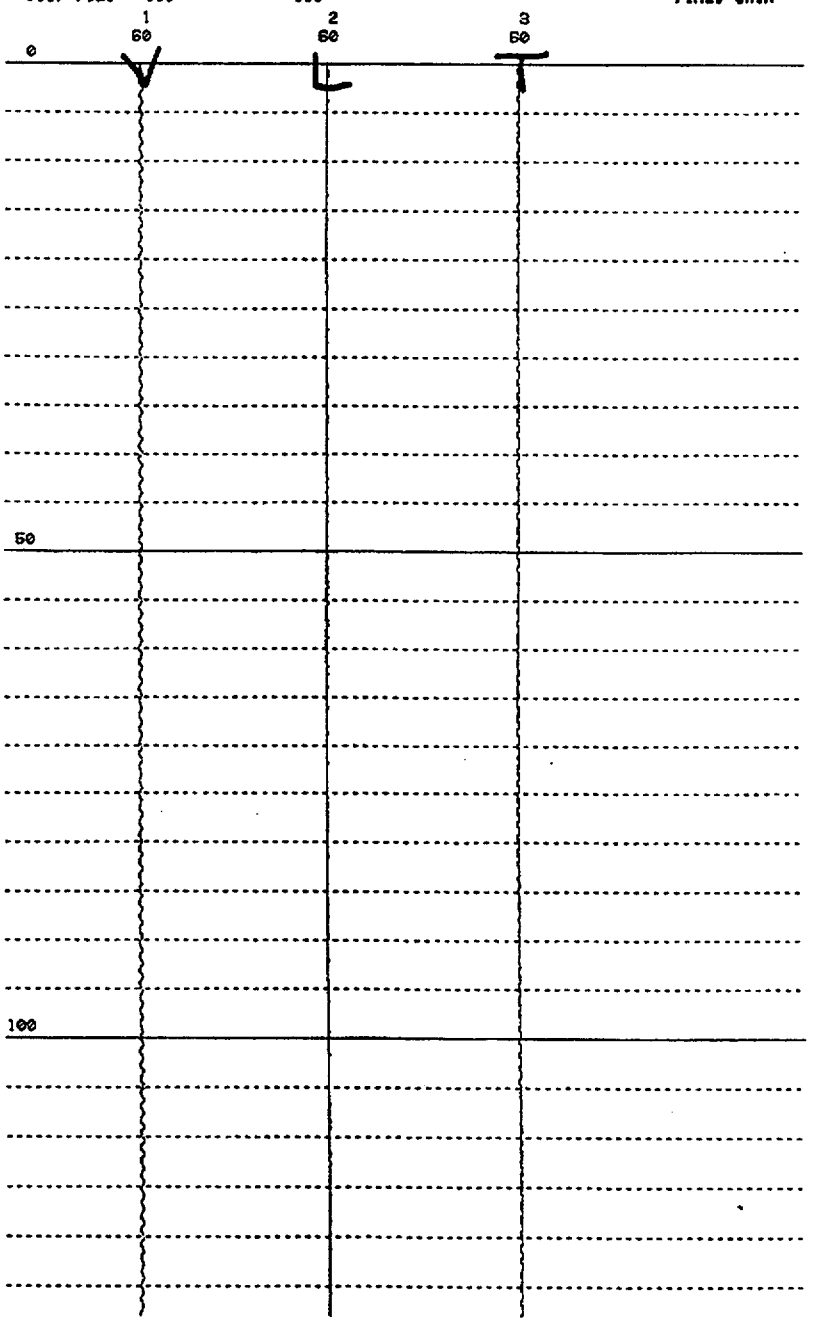
LINE NUMBER CTB5ow GROUP INTERVAL 0.00

SHOT LOC -6.90 PHONE 1 LOC 25.00 PHONE 3 LOC 25.00

SAMPLE INTERVAL 062 uS RECORD LEN 128 MS DELAY 0 MS

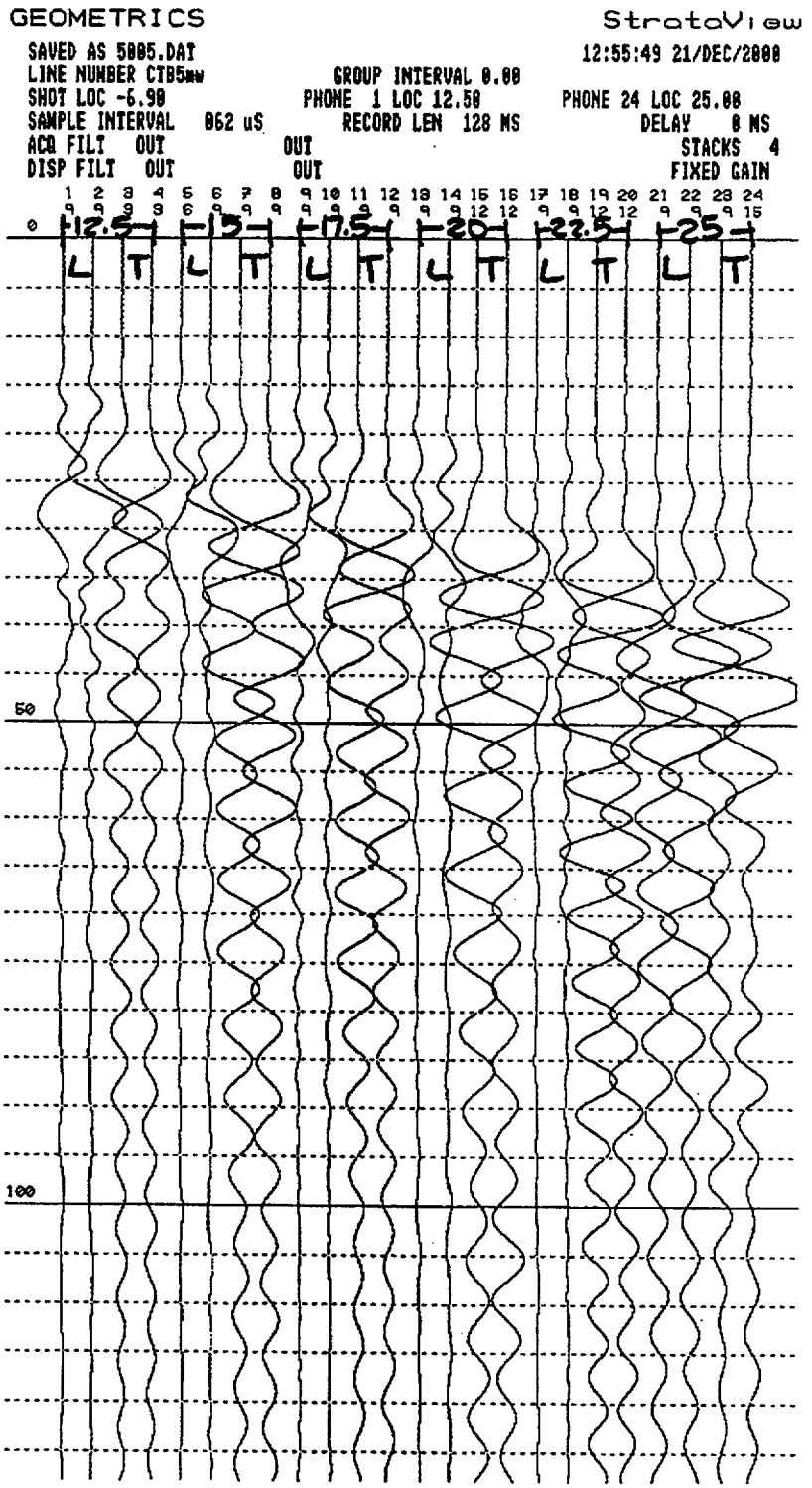
ACQ FILT LO CUT 0HZ NOTCH 0HZ STACKS 1

DISP FILT OUT OUT FIXED GAIN



Boring CTB-5(OW)

S-Wave Data, 12.5'-25'



Boring CTB-5 (OW)

Noise Record at 10'

(S-wave Survey)

GEOMETRICS StratoView

READ FROM 5006.DAT 13:00:49 21/DEC/2000

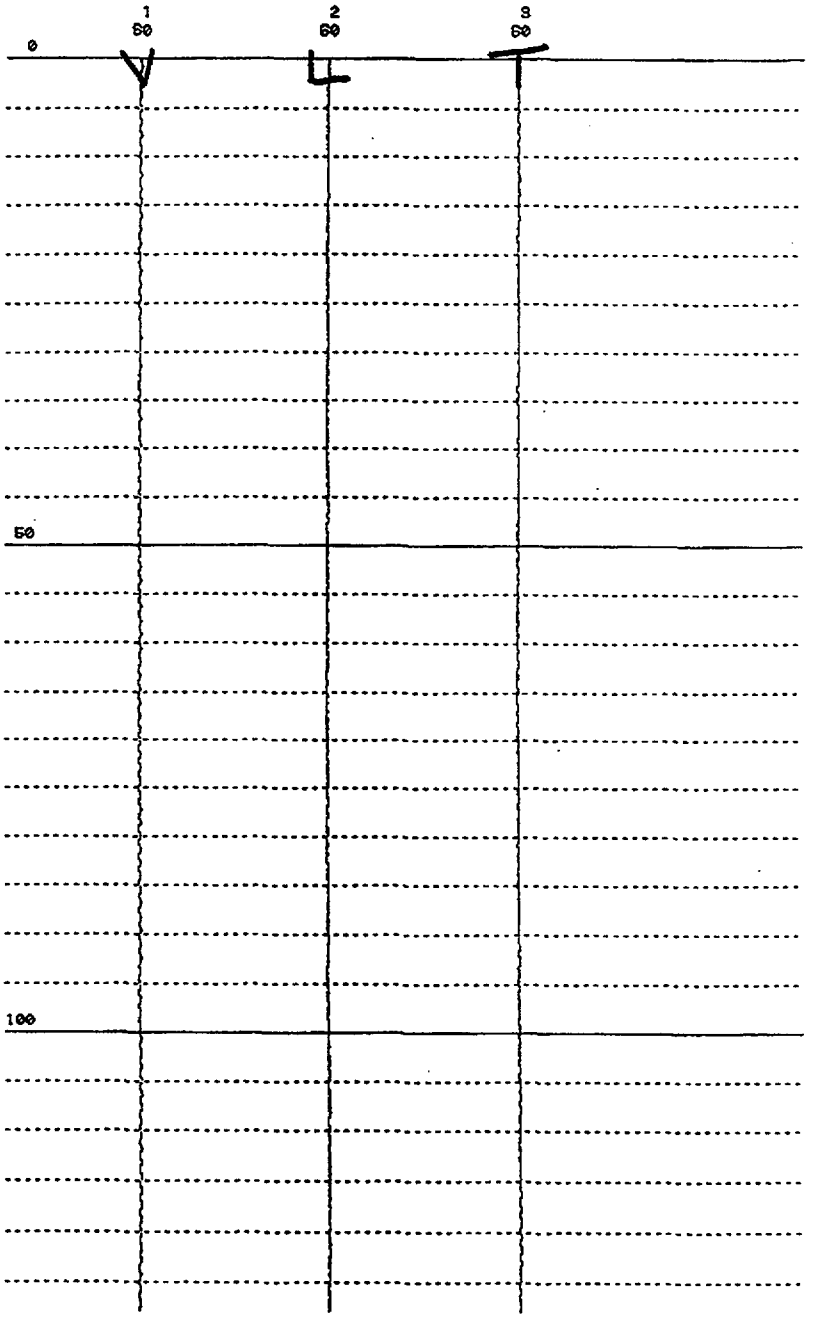
LINE NUMBER CTB5nw GROUP INTERVAL 0.00

SHOT LOC -6.90 PHONE 1 LOC 10.00 PHONE 3 LOC 10.00

SAMPLE INTERVAL 062 uS RECORD LEN 128 MS DELAY 0 MS

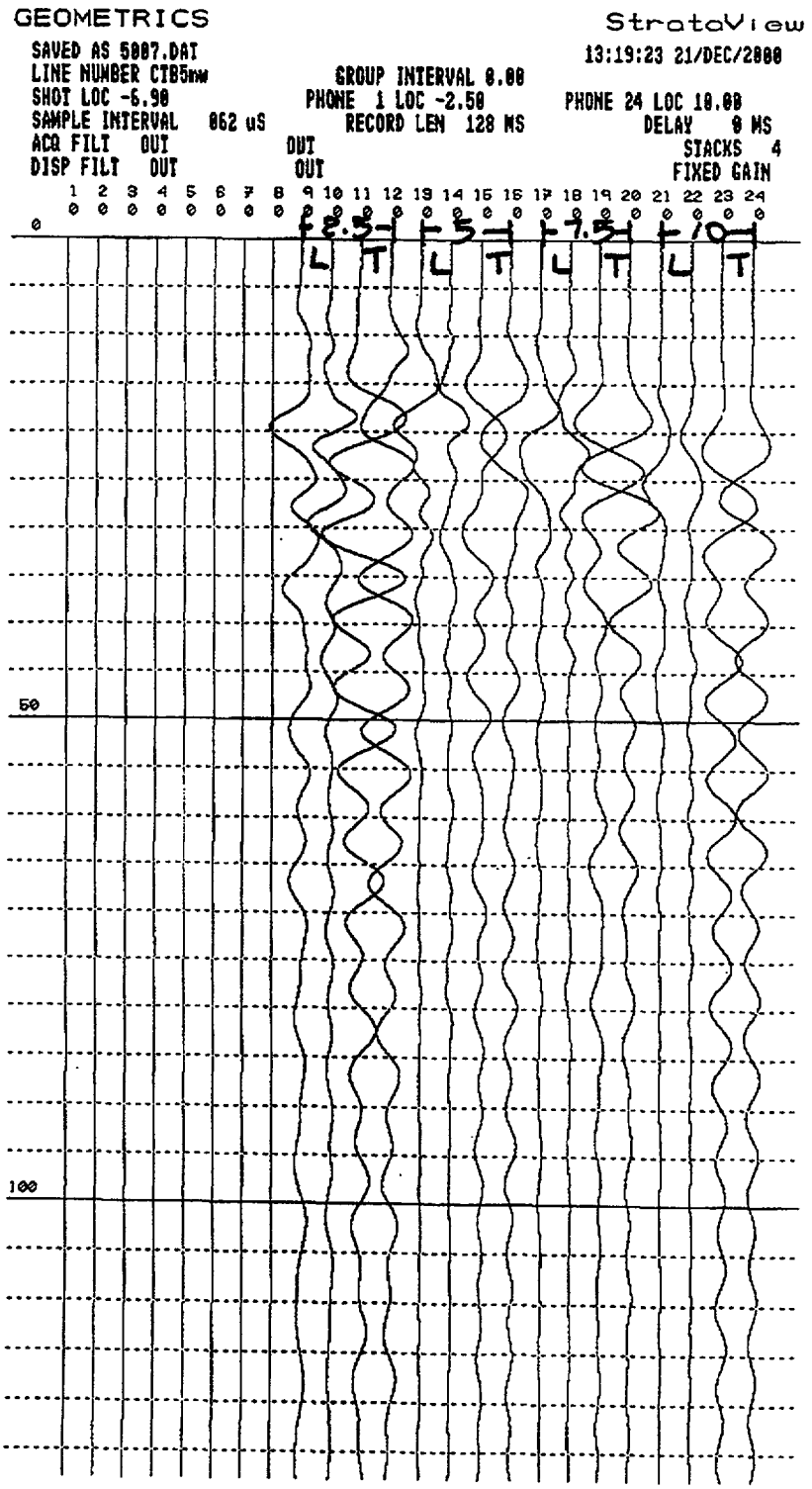
ACQ FILT LO CUT 0HZ NOTCH 0HZ STACKS 1

DISP FILT OUT OUT FIXED GAIN



Boring CTB-5 (OW)

S-wave Data, 2.5'-10'



Boring CTB-5(OW)

Noise Record at 52.5'

(P-wave Survey)

GEOMETRICS StrataView

READ FROM 5008.DAT 14:12:31 21/DEC/2000

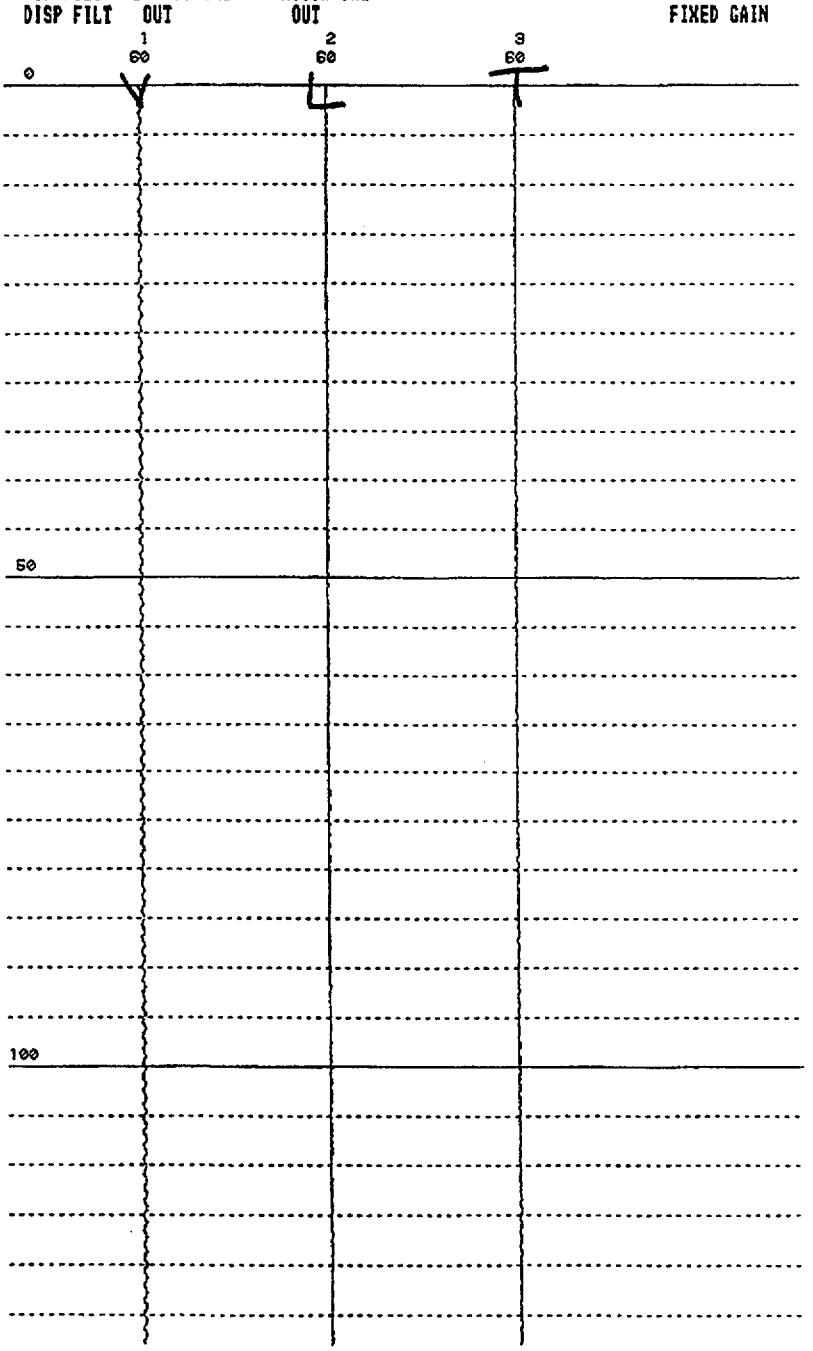
LINE NUMBER CTB5mw GROUP INTERVAL 2.50

SHOT LOC -8.40 PHONE 1 LOC 52.50 PHONE 3 LOC 52.50

SAMPLE INTERVAL 062 uS RECORD LEN 128 MS DELAY 0 MS

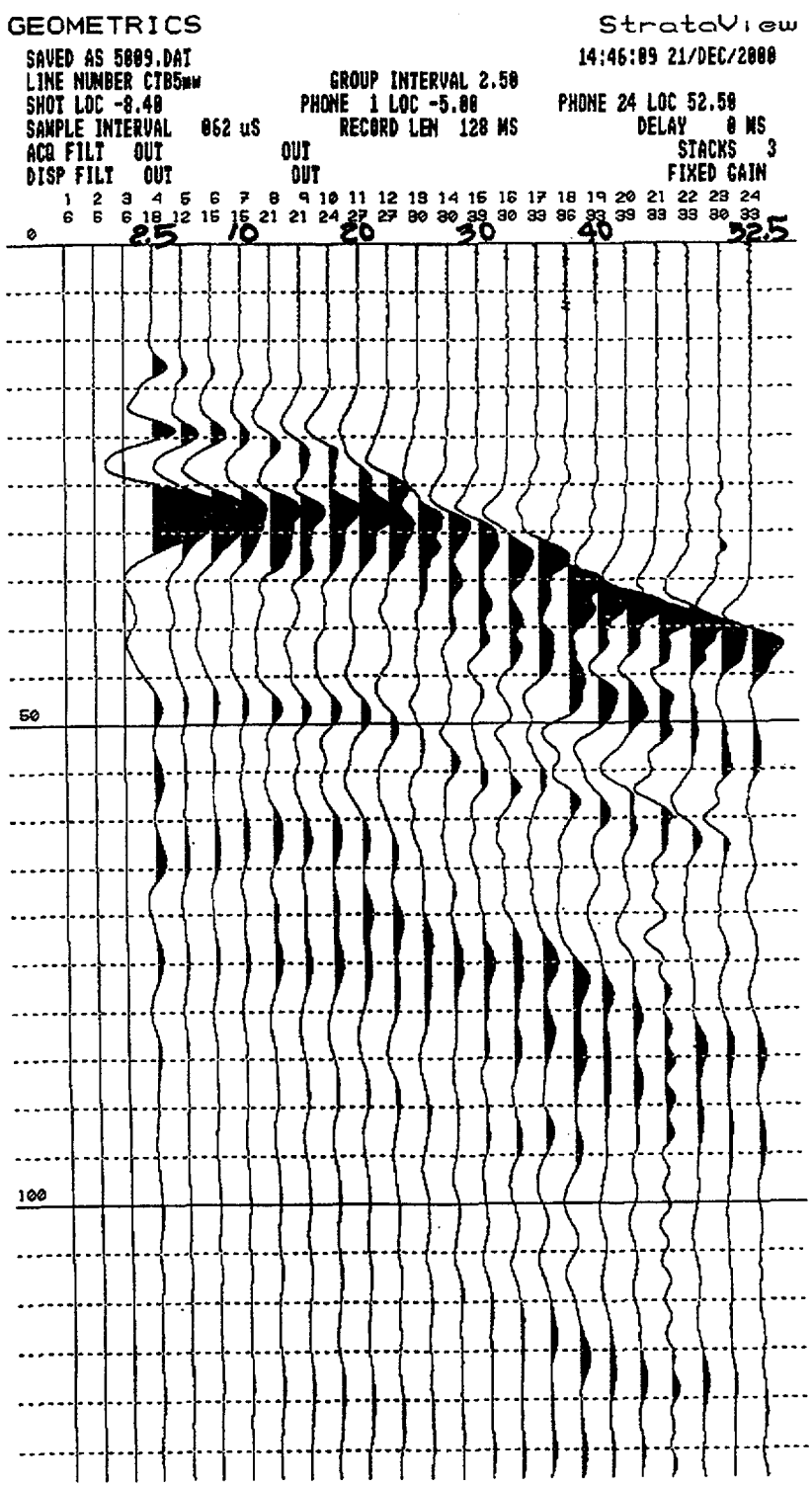
ACQ FILT LO CUT 0HZ NOTCH 0HZ STACKS 1

DISP FILT OUT OUT FIXED GAIN

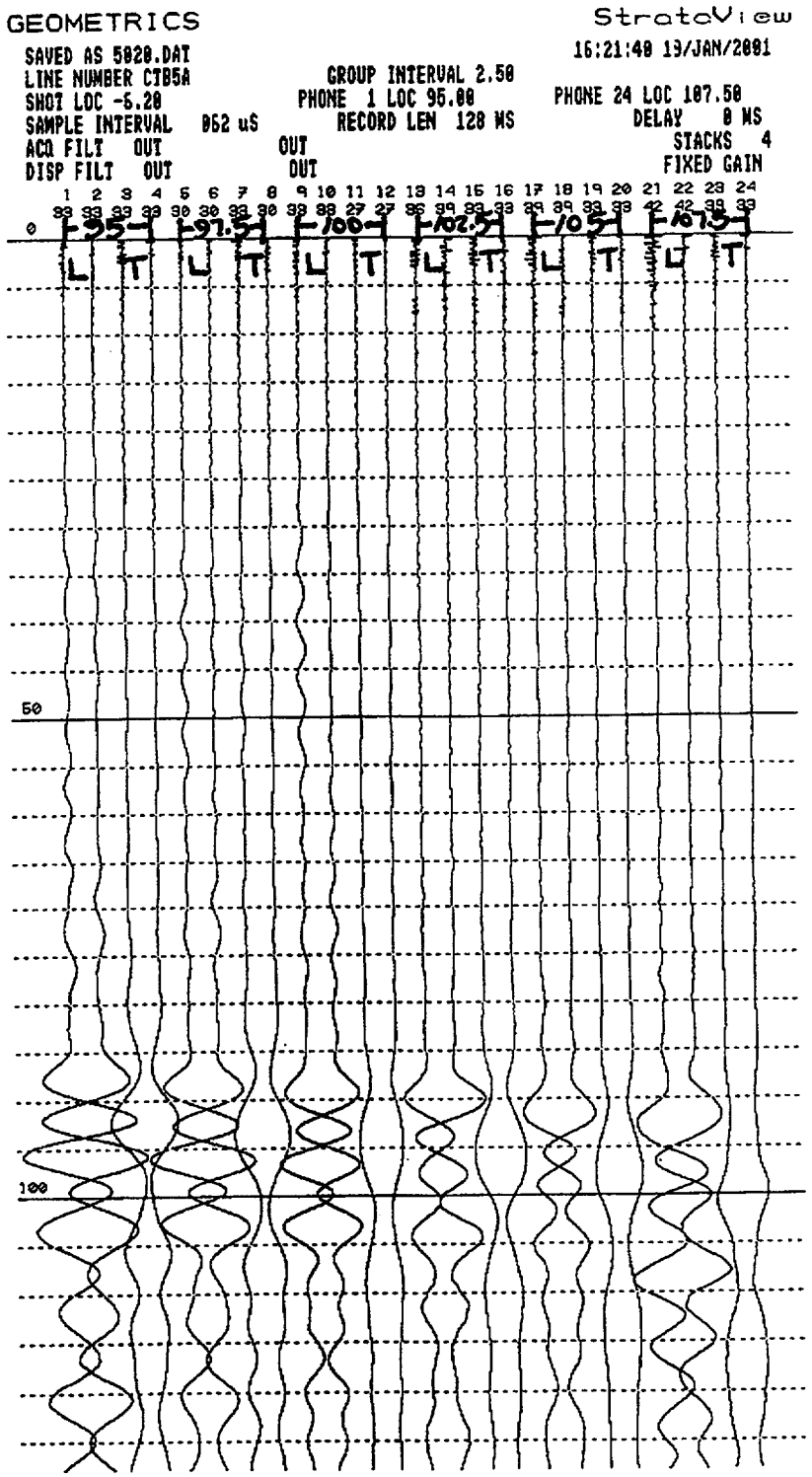


Boring CTB-5(OW)

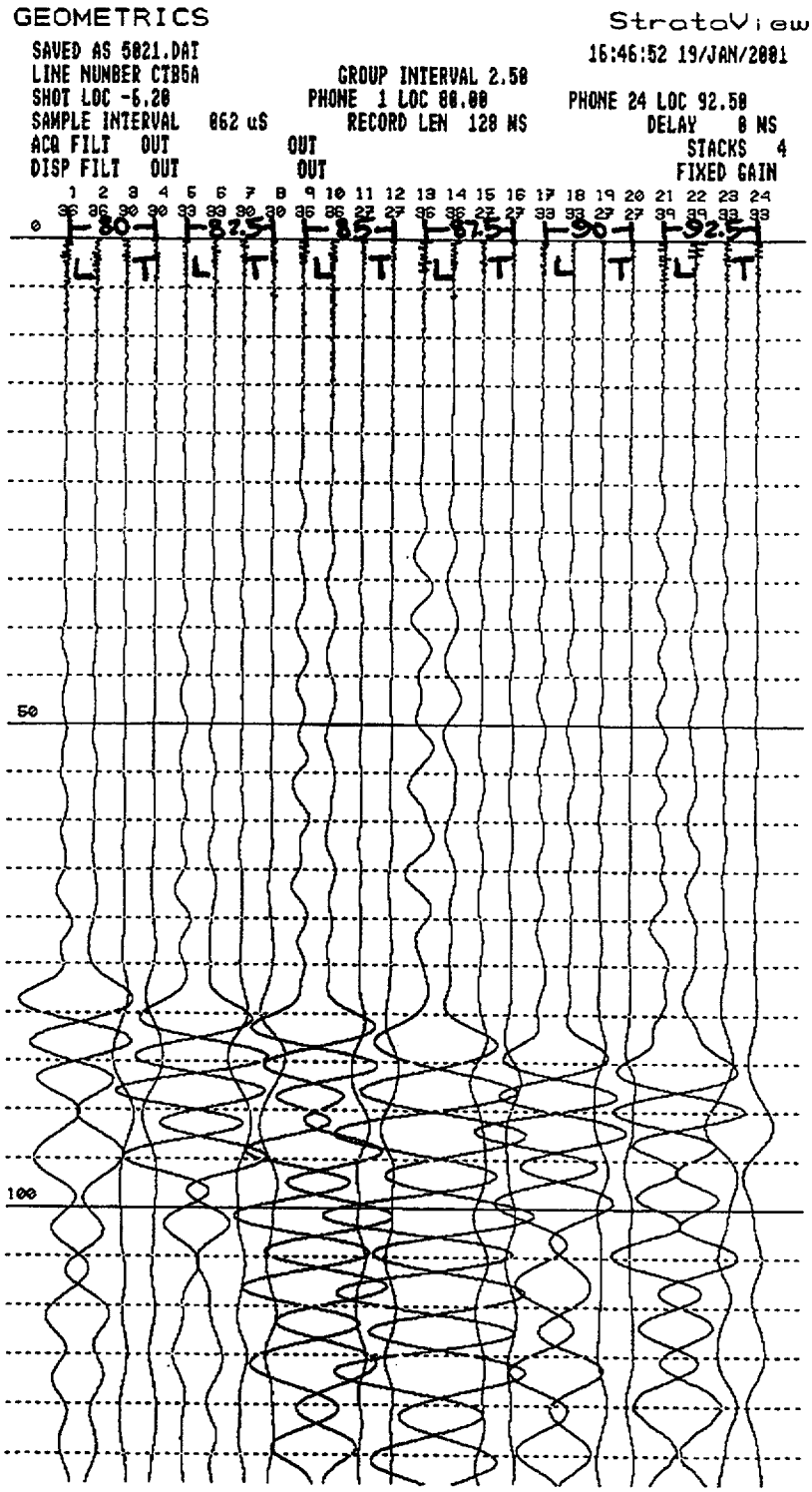
P-wave Data, 2.5'-52.5'



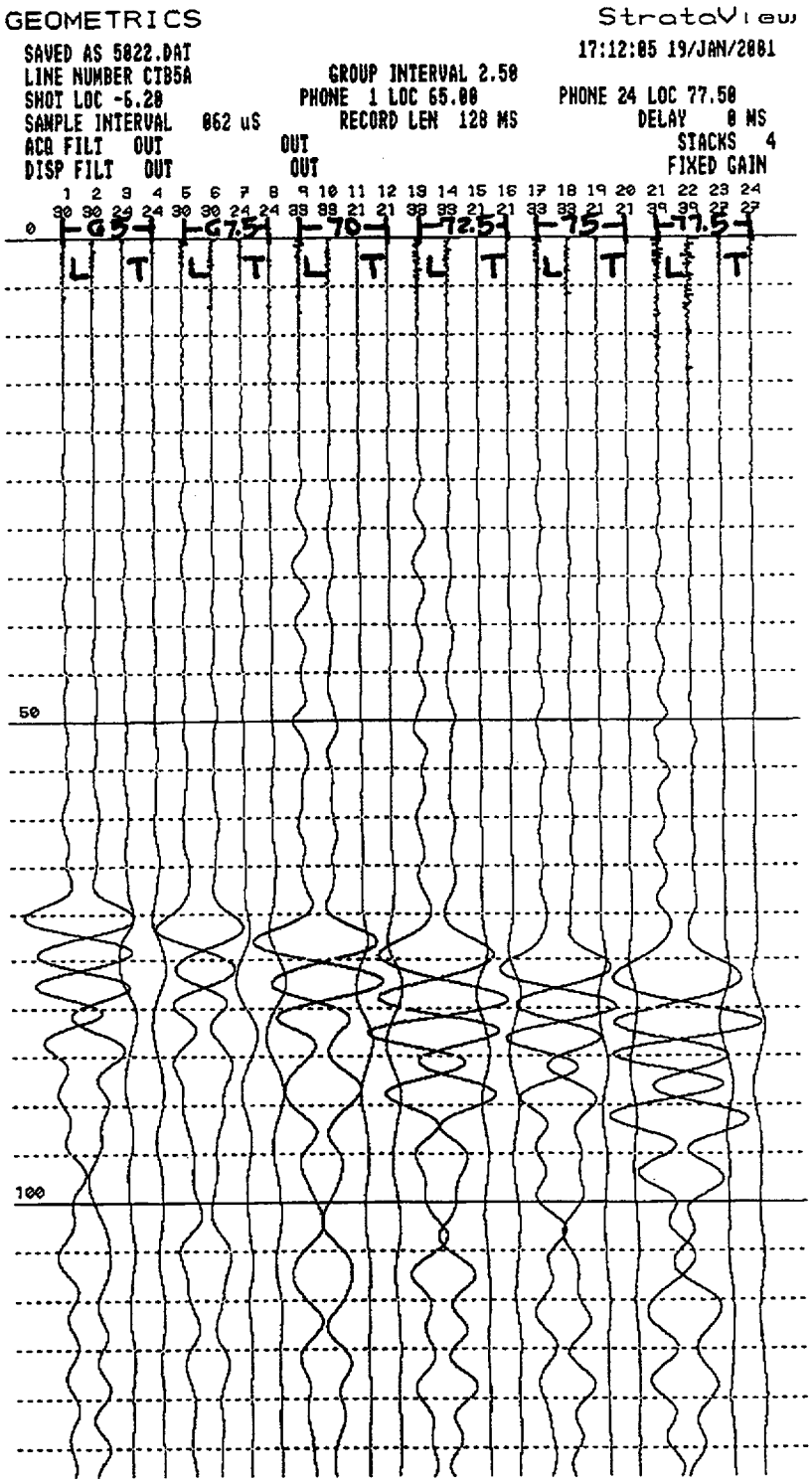
Boring CTB-5A
S-wave Data, 95'-107.5'



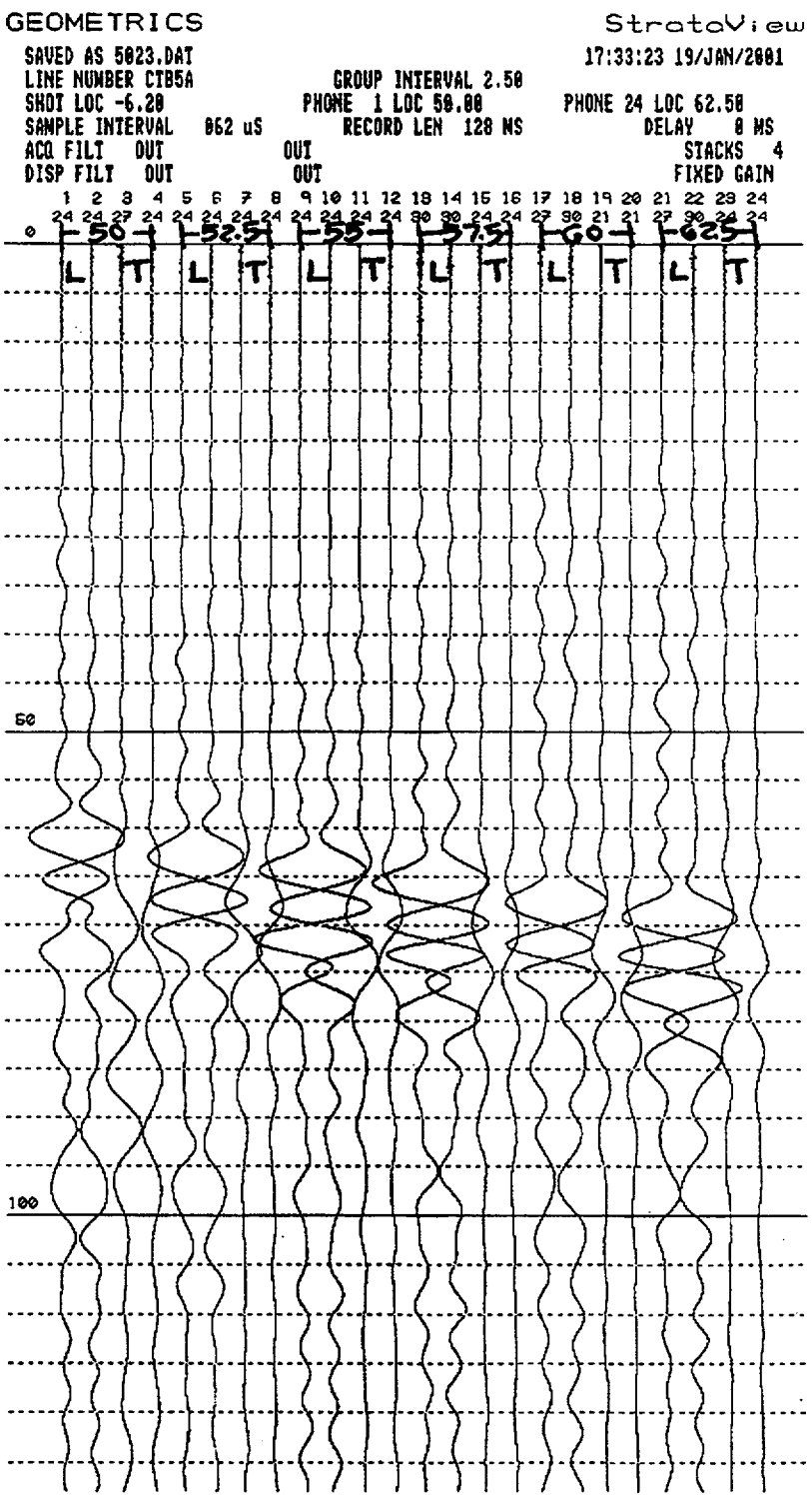
Boring CTB-5A
S-Wave Data, 80'-92.5'



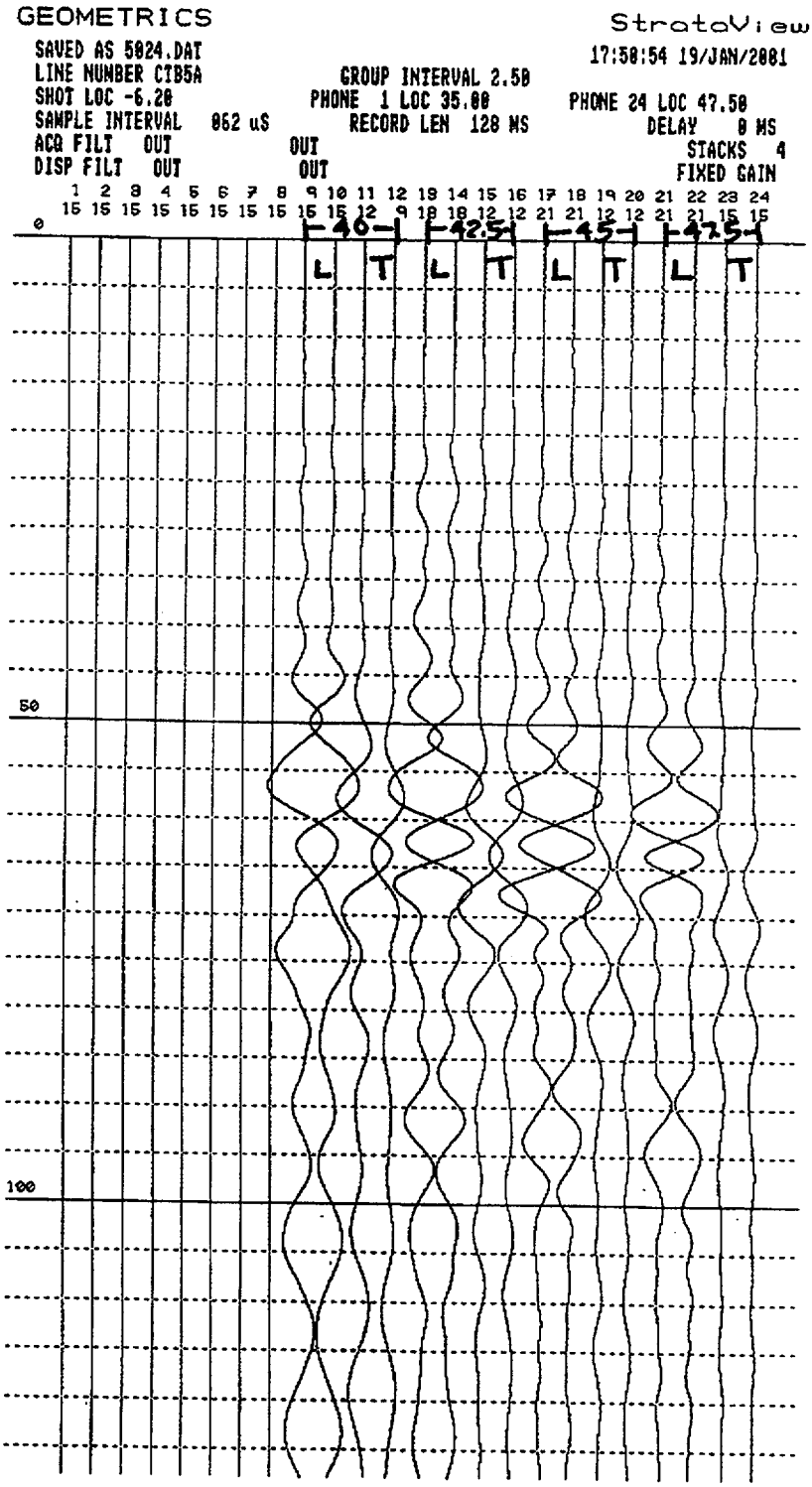
Boring CTB-5A
S-Wave Data, 65'-77.5'



Boring CTB-5A
S-wave Data, 50'-62.5'



Boring CTB-5A
S-wave Data, 40'-47.5'



APPENDIX C

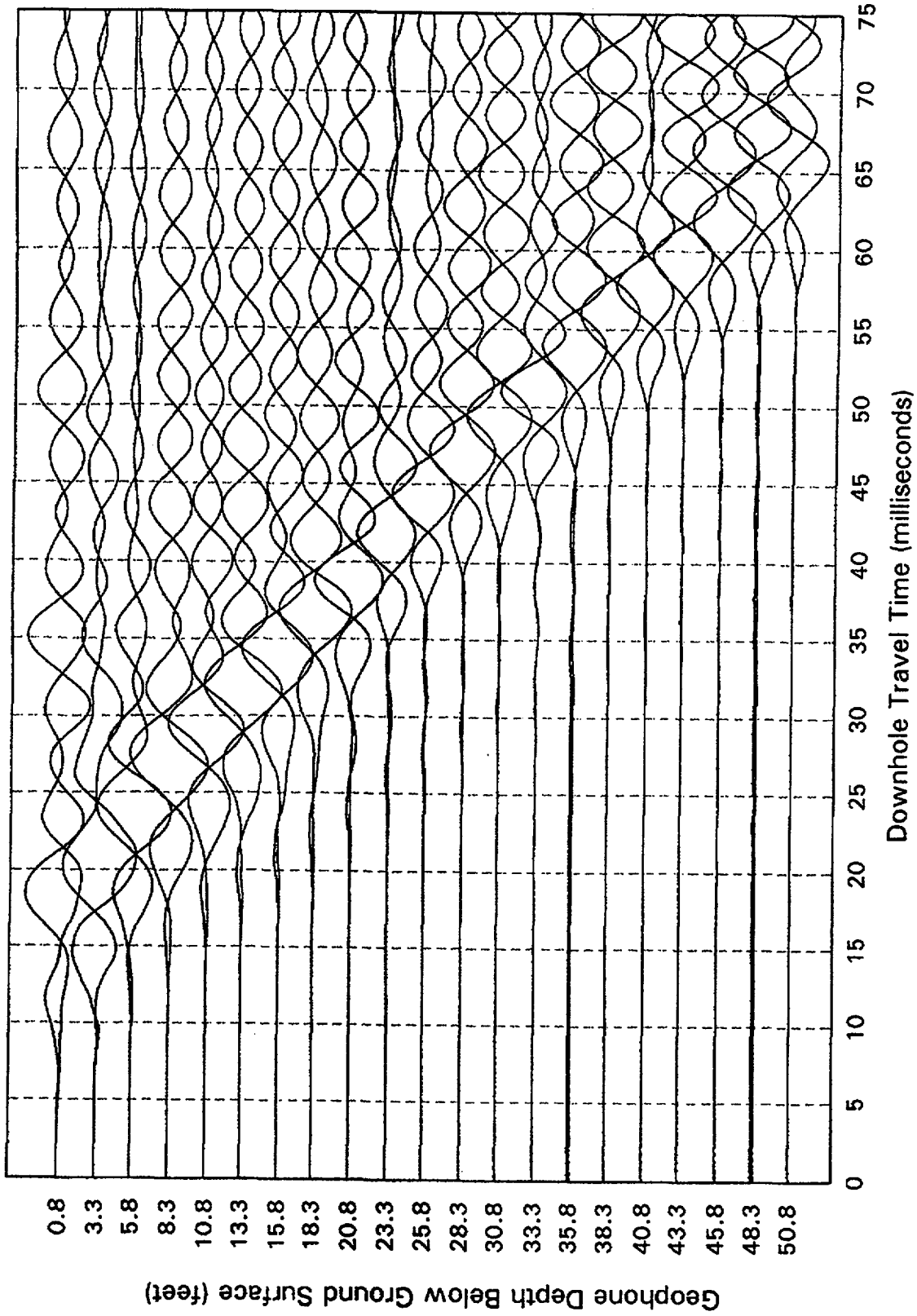
Shear-Wave and Compression-Wave Traces

Borings CTB-5(OW) and CTB-5A
Private Fuel Storage Facility
ESSOW No. 05996.02-G011 (Rev. 1)

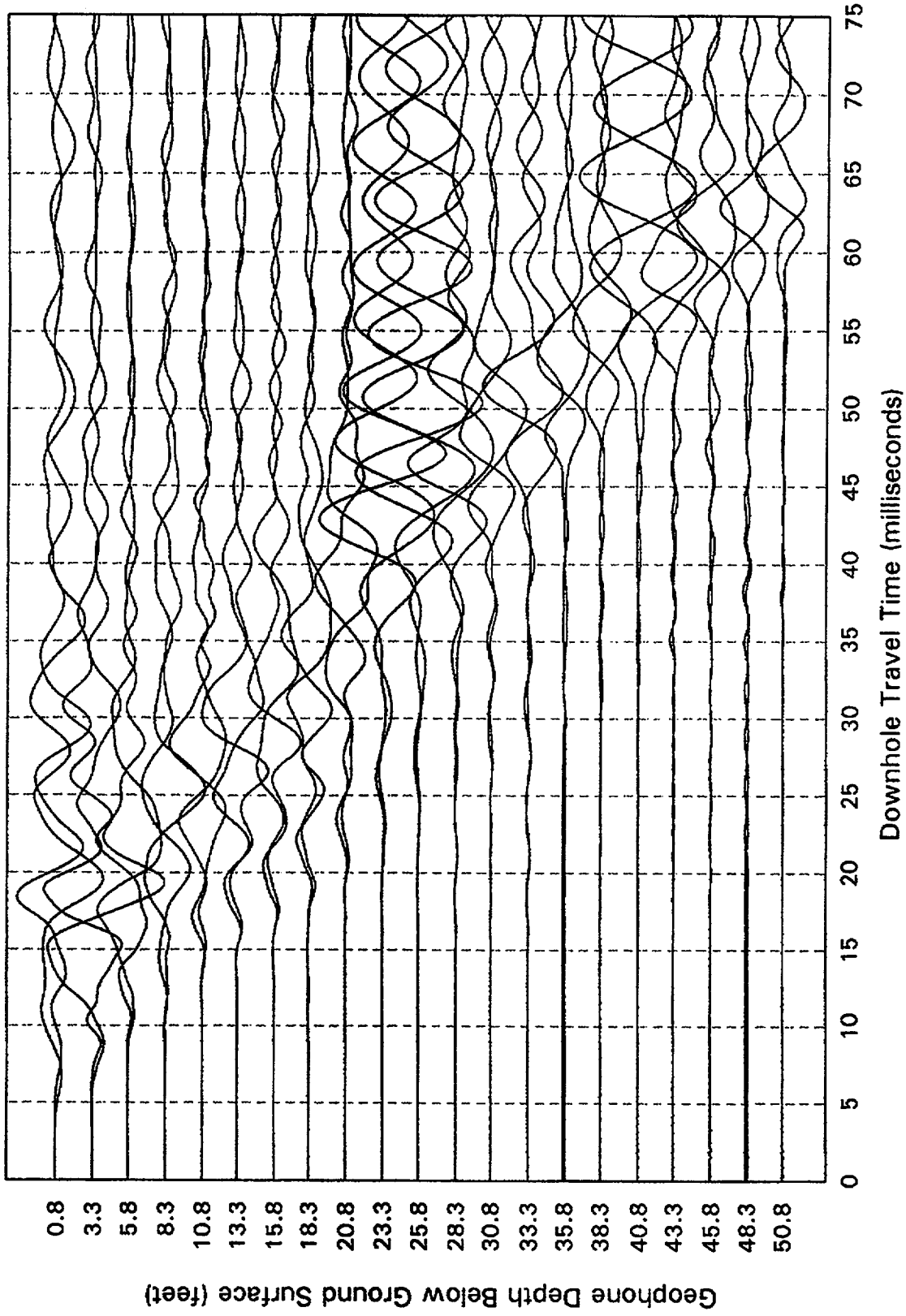
Shear-Wave and Compression-Wave Traces
ESSOW No. 05996.02-G011 (Rev.1)

The recorded shear-wave and compression-wave traces from the downhole seismic velocity survey in Boring CTB-5(OW) are compiled in Figures C1 through C3 for each of the three orthogonal geophones in the BHG-2 borehole transducer assembly. The forward- and reverse-polarity shear-wave traces have been superimposed for the two horizontal geophones, whereas the compression-wave traces recorded using the vertical geophone have been displayed as single traces at their proper depths in the borehole. Other than sorting with respect to individual geophones and the S-wave superposition, no other digital processing of the raw traces from the field records in Appendix B has been performed.

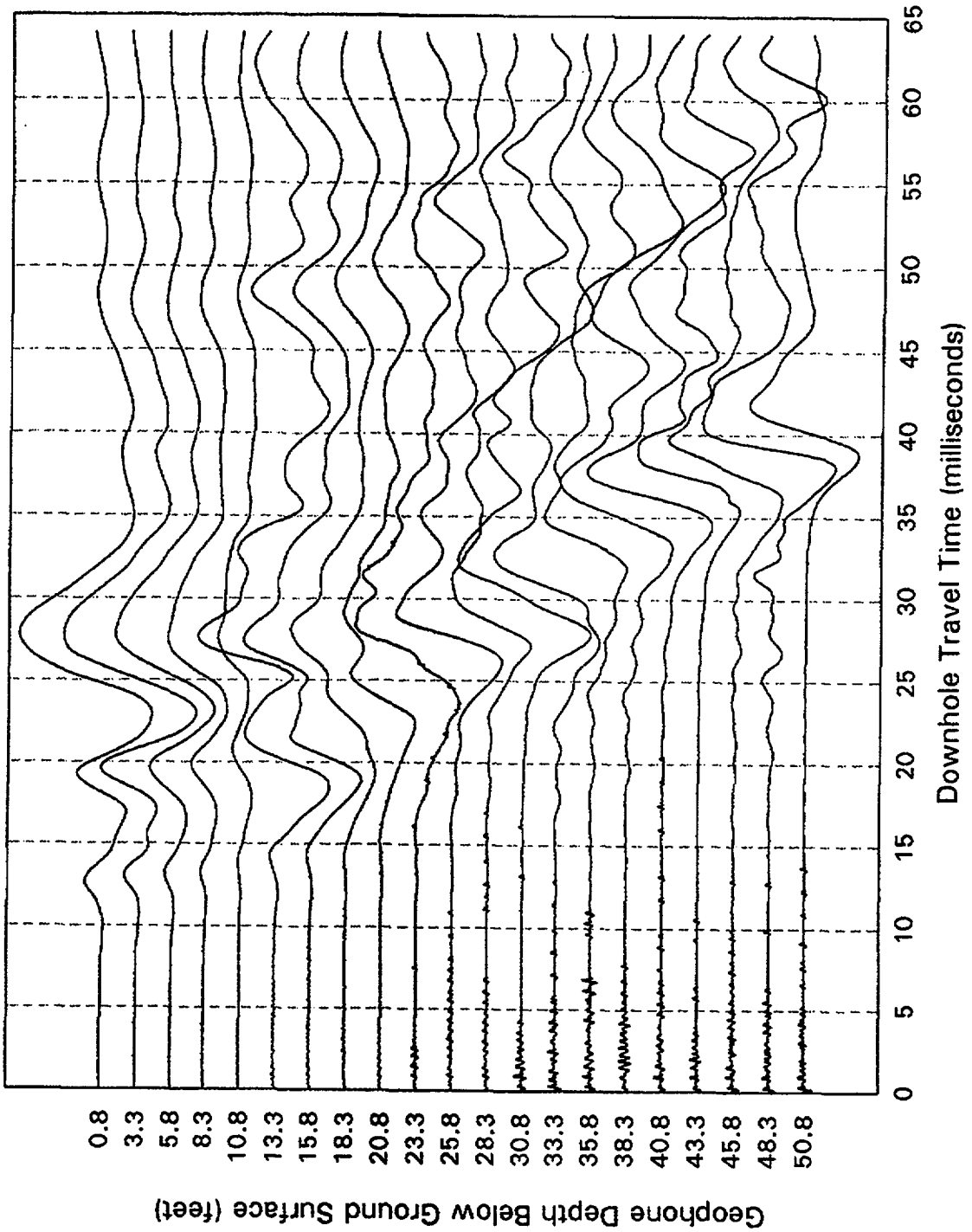
The recorded shear-wave traces from the downhole velocity survey in Boring CTB-5A are compiled in Figures C4 and C5 for the longitudinal horizontal geophone and the transverse horizontal geophone, respectively. No P-wave data were recorded in this boring.



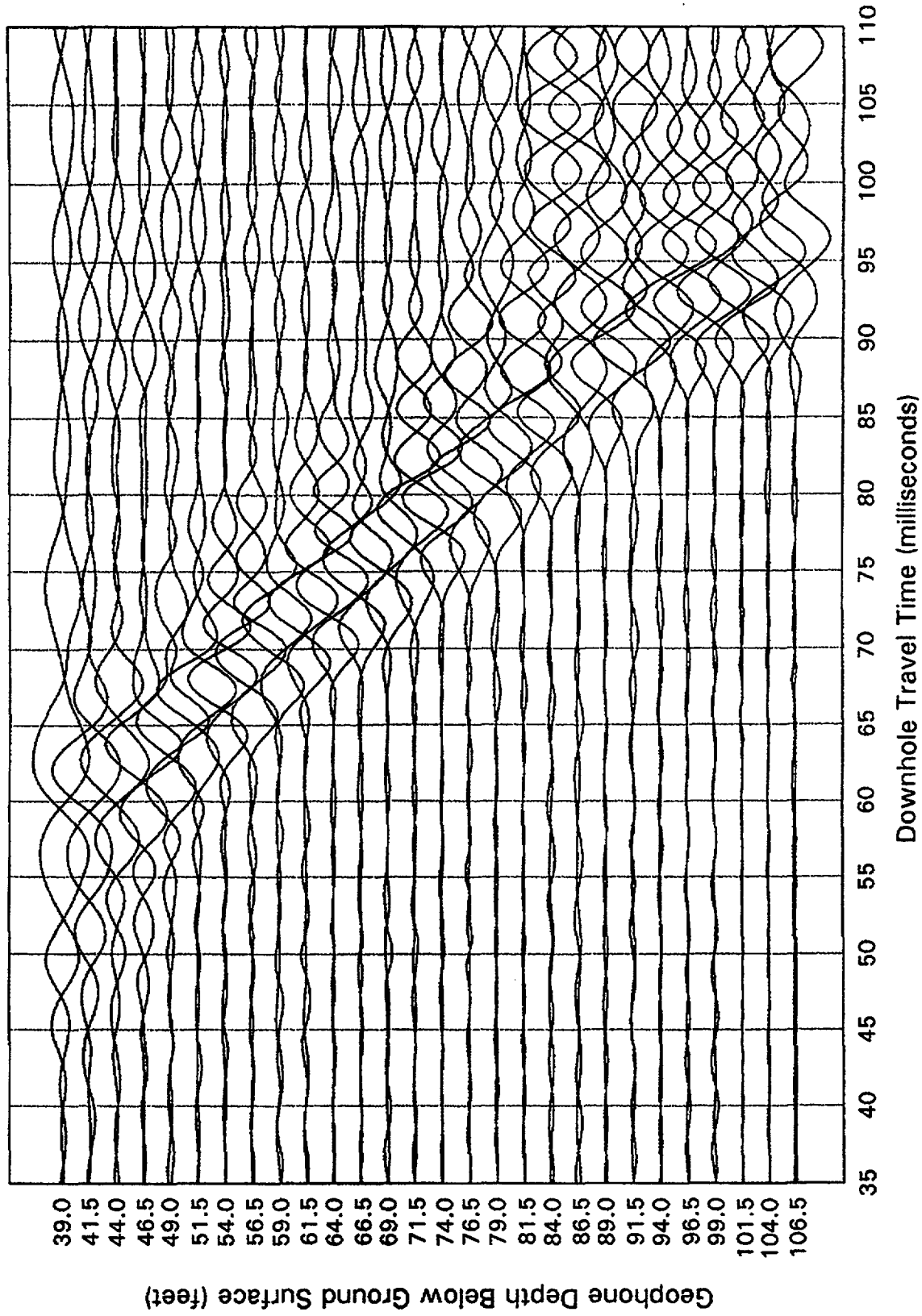
NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	S-WAVE TRACES (TRANSVERSE GEOPHONE) Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	January 2001
		FIGURE C1



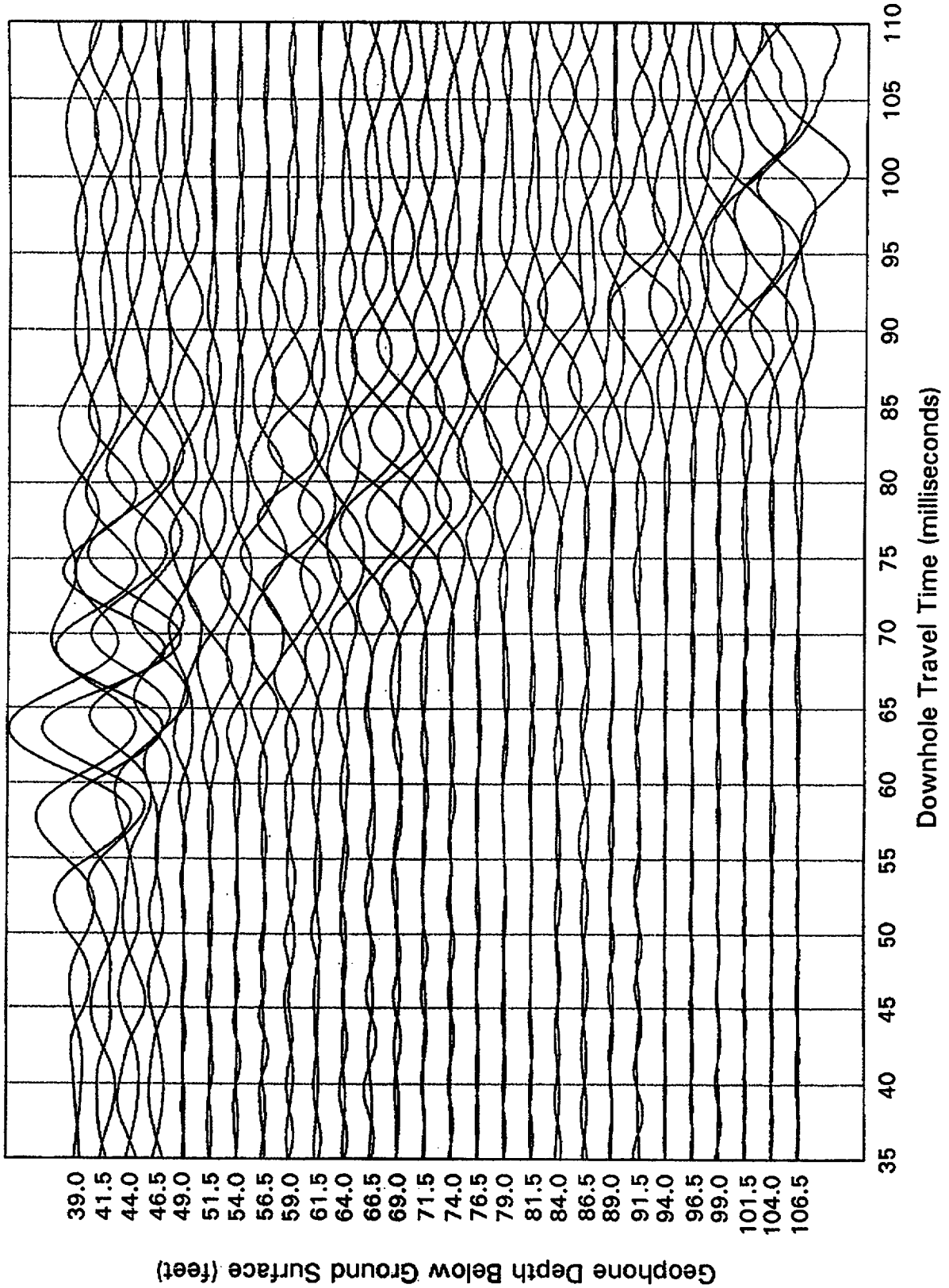
NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	S-WAVE TRACES (LONGITUDINAL GEOPHONE) Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE C2



NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	P-WAVE TRACES (VERTICAL GEOPHONE) Boring CTB-5(OW) PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE C3



NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	S-WAVE TRACES (LONGITUDINAL GEOPHONE) Boring CTB-5A PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE C4



NORTHLAND GEOPHYSICAL, LLC P.O. Box 310, Snohomish, WA 98291	S-WAVE TRACES (TRANSVERSE GEOPHONE) Boring CTB-5A PRIVATE FUEL STORAGE FACILITY	January 2001 FIGURE C5

APPENDIX D

Downhole Seismic Data Processing Spreadsheets

Borings CTB-5(OW) and CTB-5A
Private Fuel Storage Facility
ESSOW No. 05996.02-G011 (Rev. 1)

Downhole Seismic Data Processing Spreadsheets
ESSOW No. 05996.02-G011 (Rev.1)

The Microsoft EXCEL spreadsheets for shear-wave and compression-wave data processing are given in Tables D1 through D3 of this appendix. The main functions of the spreadsheets are as follows: 1) to adjust the measurement depths to depth below ground surface (bgs) based on casing stickup; 2) to convert slant-path seismic travel times to vertical travel times; and 3) for the shear wave, to calculate interval velocities based on the vertical travel times. A detailed description of the spreadsheet contents follows.

The second row of the spreadsheet gives the boring number, the seismic mode (S-wave or P-wave), the specific geophone in the BHG-2 triaxial geophone array which was used to record the data, and the portion of the waveform which was timed.

Rows 4-8, Columns 1-2 of the spreadsheet give the geometry which was used for the computations. The source offset is the horizontal distance of the seismic energy source (S-wave wood beam or P-wave striker plate) from the center of the casing. "CSB" ("CSP") is the PVC casing stickup above the ground surface at the location of the seismic energy source. "CSG" is the PVC casing stickup above the ground surface at the well. "GS elevation" is the assumed elevation of the ground surface at the well for purposes of presentation. "Phone offset" is the offset of the triaxial geophone assembly below the "zero" mark on the downhole seismic cable based on the molded markers installed on the cable at the factory.

The column labels for the computations portion of the spreadsheet are as follows:

"Cable Z" =	Depth marker on the downhole cable at the top of the PVC casing.
"Z beam" = (Z plate)	Depth of the triaxial geophone assembly relative to ground surface at the base of the S-wave beam (P-wave plate).
"Z bgs" =	Depth of the triaxial geophone assembly below ground surface at the well.
"Slant Path TT" =	Measured seismic travel time on the field records for the slant path from the base of the seismic energy source to the triaxial geophone assembly (see Figure 1 of the report).
"Slant TT– 4ms" =	The slant path TT corrected for the difference between the first arrival of the seismic wave and the portion of the waveform which was timed. It is necessary to correct back to the time of first arrival in order to apply the cosine correction

for the offset of the seismic source from the borehole.

"cos factor" = The cosine of the angle formed by the centerline of the well bore and the slant path of the seismic ray. Multiplying the slant path travel time by the cosine factor corrects for the offset of the seismic energy source from the borehole. The slant path of the seismic ray forms the hypotenuse of the right triangle used to compute the cosine, whereas the depth of the geophone below the base of the seismic source (Z beam or Z plate) forms the vertical leg of this triangle.

"Vertical TT" = The vertical seismic travel time is the time it would take the seismic energy to travel down to the borehole transducer if the seismic source was located directly over the borehole. The vertical travel time is used for subsequent velocity calculations.

"IV 2.5ft" = The "pseudo"-interval velocity calculated over 2.5' intervals. This is simply the interval (2.5') divided by the difference in Vertical TT over that interval.

"IV 5ft" = The "pseudo"-interval velocity calculated over 5' intervals. The 5' interval velocities are calculated every 2.5'.

"5ft ave" = A method for smoothing the normal scatter in the calculation of 2.5' interval velocities. It is derived from the previous column of 5' interval velocities (IV 5ft) by averaging these velocities over the 2.5' intervals in which the 5' interval velocities overlap.

The calculation of average velocities for linear segments of the travel-time curves was performed using the linear least-squares routines in the program GRAPHER by Golden Software, rather than in the EXCEL spreadsheets. The data inputs for GRAPHER were simply the two columns Zbgs (depth below ground surface) and Vertical TT (vertical travel time). On the spreadsheets the segments used for the least-squares fits are noted as S1-S4 on Table D1, P1-P4 on Table D2, and S1-S5 on Table D3.

Table D1
Shear-Wave Data Processing for Private Fuel Storage Facility

	Well Name	Boring CTB-5(0W) S-Wave (Transverse Horizontal Geophone) 1st Peak less 4ms								
	Source offset	7								
	CSB +up	3.13								
	CSG +up	2.73								
	GS elevation	0								
	phone offset	1								
	Cable Z	Z beam	Z bgs	Slant Path TT	Slant TT-4ms	cos factor	Vertical TT	IV 2.5ft	IV 5ft	5ft ave
S1	2.5	0.37	0.77	12	8	0.052783	0.42	680	584	584
	5	2.87	3.27	14.81	10.81	0.379353	4.10	513	554	569
	7.5	5.37	5.77	18.75	14.75	0.608669	8.98	603	636	595
	10	7.87	8.27	21.56	17.56	0.7472	13.12	673	752	694
S2	12.5	10.37	10.77	24.31	20.31	0.828839	16.83	853	821	787
	15	12.87	13.27	26.5	22.5	0.878469	19.77	791	823	822
	17.5	15.37	15.77	29.19	25.19	0.910062	22.92	858	871	847
	20	17.87	18.27	31.75	27.75	0.931112	25.84	885	822	847
	22.5	20.37	20.77	34.31	30.31	0.945718	28.66	768	812	817
	25	22.87	23.27	37.38	33.38	0.956212	31.92	862	922	867
S3	27.5	25.37	25.77	40.12	36.12	0.963979	34.82	992	1076	999
	30	27.87	28.27	42.5	38.5	0.969876	37.34	1176	1060	1068
	32.5	30.37	30.77	44.5	40.5	0.974451	39.47	965	1042	1051
	35	32.87	33.27	47	43	0.978067	42.06	1134	1120	1081
	37.5	35.37	35.77	49.12	45.12	0.980973	44.26	1106	1138	1129
S4	40	37.87	38.27	51.31	47.31	0.983342	46.52	1173	1292	1215
	42.5	40.37	40.77	53.38	49.38	0.985298	48.65	1438	1185	1238
	45	42.87	43.27	55.06	51.06	0.98693	50.39	1007	1061	1123
	47.5	45.37	45.77	57.5	53.5	0.988306	52.87	1121	1257	1159
	50	47.87	48.27	59.69	55.69	0.989477	55.10	1429	0	1257
	52.5	50.37	50.77	61.4	57.4	0.990481	56.85	0	0	0

Table D2
P-Wave Data Processing for Private Fuel Storage Facility

Well Name	Boring CTB-5(OW)	P-Wave (Vertical Geophone)		1st Trough less 3ms		
Source offset	8.4					
CSP +up	3.33					
CSG +up	2.73					
GS elevation	0					
phone offset -	1					
Cable Z	Z plate	Z bgs	Slant Path TT	Slant TT - 3ms	cos factor	Vertical TT
2.5	0.17	0.77	16.88	13.88	0.020234	0.28
5	2.67	3.27	17.06	14.06	0.302923	4.26
7.5	5.17	5.77	16.5	13.5	0.524154	7.08
10	7.67	8.27	16.81	13.81	0.67429	9.31
12.5	10.17	10.77	17.75	14.75	0.77101	11.37
15	12.67	13.27	18.44	15.44	0.833464	12.87
17.5	15.17	15.77	18.88	15.88	0.874836	13.89
20	17.67	18.27	19.31	16.31	0.903144	14.73
22.5	20.17	20.77	22.31	19.31	0.923145	17.83
25	22.67	23.27	23.56	20.56	0.937699	19.28
27.5	25.17	25.77	26.06	23.06	0.94857	21.87
30	27.67	28.27	27.12	24.12	0.956879	23.08
32.5	30.17	30.77	27.81	24.81	0.963358	23.90
35	32.67	33.27	29.31	26.31	0.968499	25.48
37.5	35.17	35.77	31.88	28.88	0.972643	28.09
40	37.67	38.27	33.06	30.06	0.976028	29.34
42.5	40.17	40.77	34.5	31.5	0.978828	30.83
45	42.67	43.27	35.31	32.31	0.981169	31.70
47.5	45.17	45.77	36	33	0.983145	32.44
50	47.67	48.27	38	35	0.984827	34.47
52.5	50.17	50.77	38.75	35.75	0.986271	35.26

P1
P2
P3
P4

Table D3
Shear-Wave Data Processing for Private Fuel Storage Facility

	Well Name	Boring CTB-5A S-Wave (Longitudinal Horizontal Geophone) 1st Peak less 4 ms								
	Source offset	6.2								
	CSB +up	2								
	CSG +up	2								
	GS elevation	0								
	phone offset +	1								
	Cable Z	Z beam	Z bgs	Slant Path TT	Slant TT-4ms	cos factor	Vertical TT	IV 2.5ft	IV 5ft	5ft ave
	45	44	44	57.5	53.5	0.990218	52.98	1506	1423	1423
S1	47.5	46.5	46.5	59.12	55.12	0.991228	54.64	1349	1288	1356
	50	49	49	60.94	56.94	0.99209	56.49	1233	1485	1387
	52.5	51.5	51.5	62.94	58.94	0.992831	58.52	1867	1869	1677
S2	55	54	54	64.25	60.25	0.993473	59.86	1871	1464	1667
	57.5	56.5	56.5	65.56	61.56	0.994033	61.19	1203	1389	1427
S3	60	59	59	67.62	63.62	0.994524	63.27	1645	1832	1611
	62.5	61.5	61.5	69.12	65.12	0.994957	64.79	2067	2069	1950
	65	64	64	70.31	66.31	0.99534	66.00	2070	1797	1933
	67.5	66.5	66.5	71.5	67.5	0.995682	67.21	1588	1651	1724
	70	69	69	73.06	69.06	0.995987	68.78	1720	1721	1686
	72.5	71.5	71.5	74.5	70.5	0.996261	70.24	1721	2079	1900
	75	74	74	75.94	71.94	0.996509	71.69	2623	1892	1985
S4	77.5	76.5	76.5	76.88	72.88	0.996732	72.64	1480	1352	1622
	80	79	79	78.56	74.56	0.996935	74.33	1245	1725	1539
	82.5	81.5	81.5	80.56	76.56	0.997119	76.34	2807	1985	1855
	85	84	84	81.44	77.44	0.997287	77.23	1536	1658	1822
	87.5	86.5	86.5	83.06	79.06	0.997441	78.86	1801	1848	1753
	90	89	89	84.44	80.44	0.997582	80.25	1898	1478	1663
	92.5	91.5	91.5	85.75	81.75	0.997712	81.56	1210	1693	1586
	95	94	94	87.81	83.81	0.997832	83.63	2817	3436	2565
	97.5	96.5	96.5	88.69	84.69	0.997942	84.52	4405	4151	3794
S5	100	99	99	89.25	85.25	0.998045	85.08	3925	2334	3243
	102.5	101.5	101.5	89.88	85.88	0.99814	85.72	1661	2221	2278
	105	104	104	91.38	87.38	0.998228	87.23	3352	0	2221
	107.5	106.5	106.5	92.12	88.12	0.99831	87.97	0	0	0

STONE & WEBSTER ENGINEERING CORPORATION

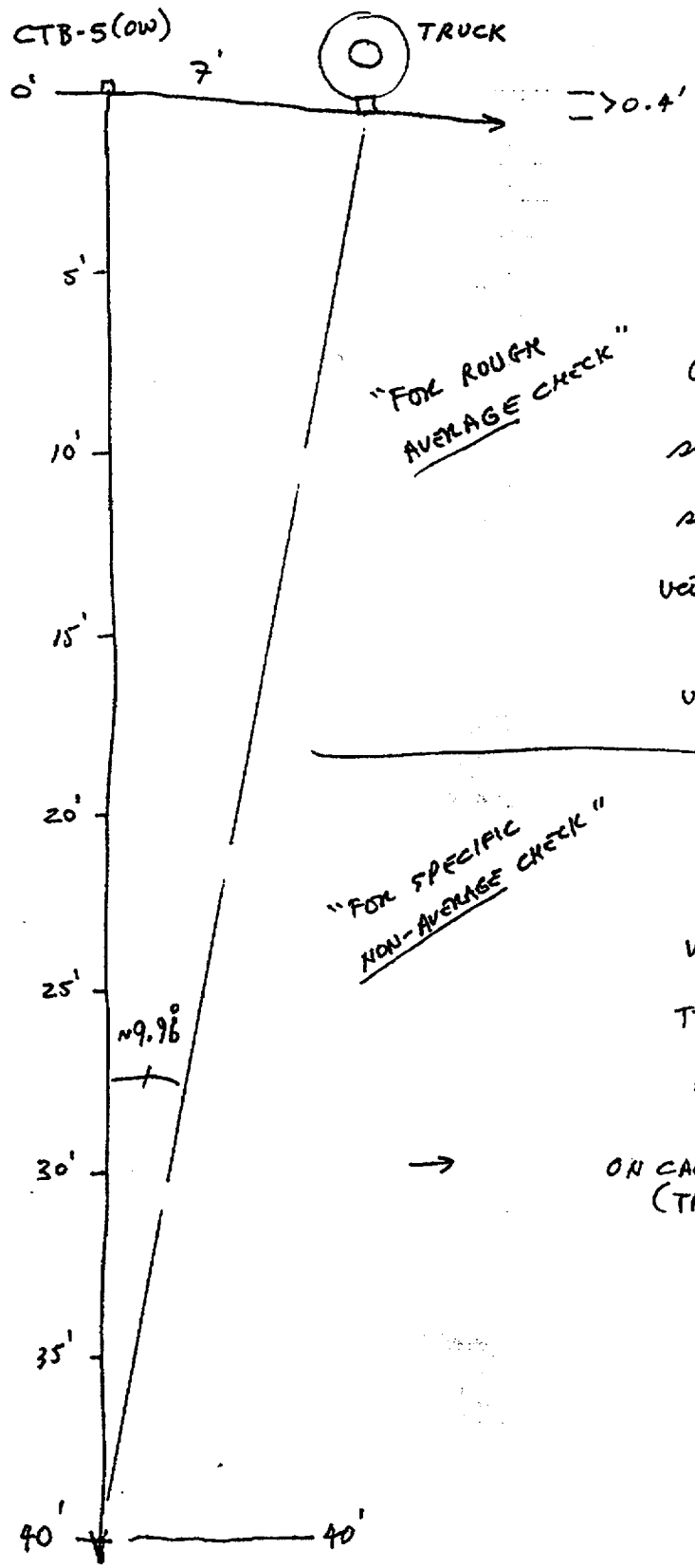
CALCULATION SHEET

▲5010.65

CALCULATION IDENTIFICATION NUMBER				PAGE E1/1
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.02-G011				

REPORT 05996.02-G(R037)-1, REV. 1 APP E 01-15-01

PRIVATE FUEL STORAGE FACILITY (PFSF), SKULL VALLEY, UT



"FOR ROUGH AVERAGE CHECK"

AT ~40' BGS (40.77')

Vertical feet = 40'

slant feet = 40.15'

angle ≈ 9.96°

Cosine of 9.96° = 0.9849

slant time ≈ 45 mSec

slant vel ≈ 892 ft/sec

vertical travel time = 45 mSec × 0.9849
= 44.3 mSec

vertical vel = 903 ft/sec

"FOR SPECIFIC NON-AVERAGE CHECK"

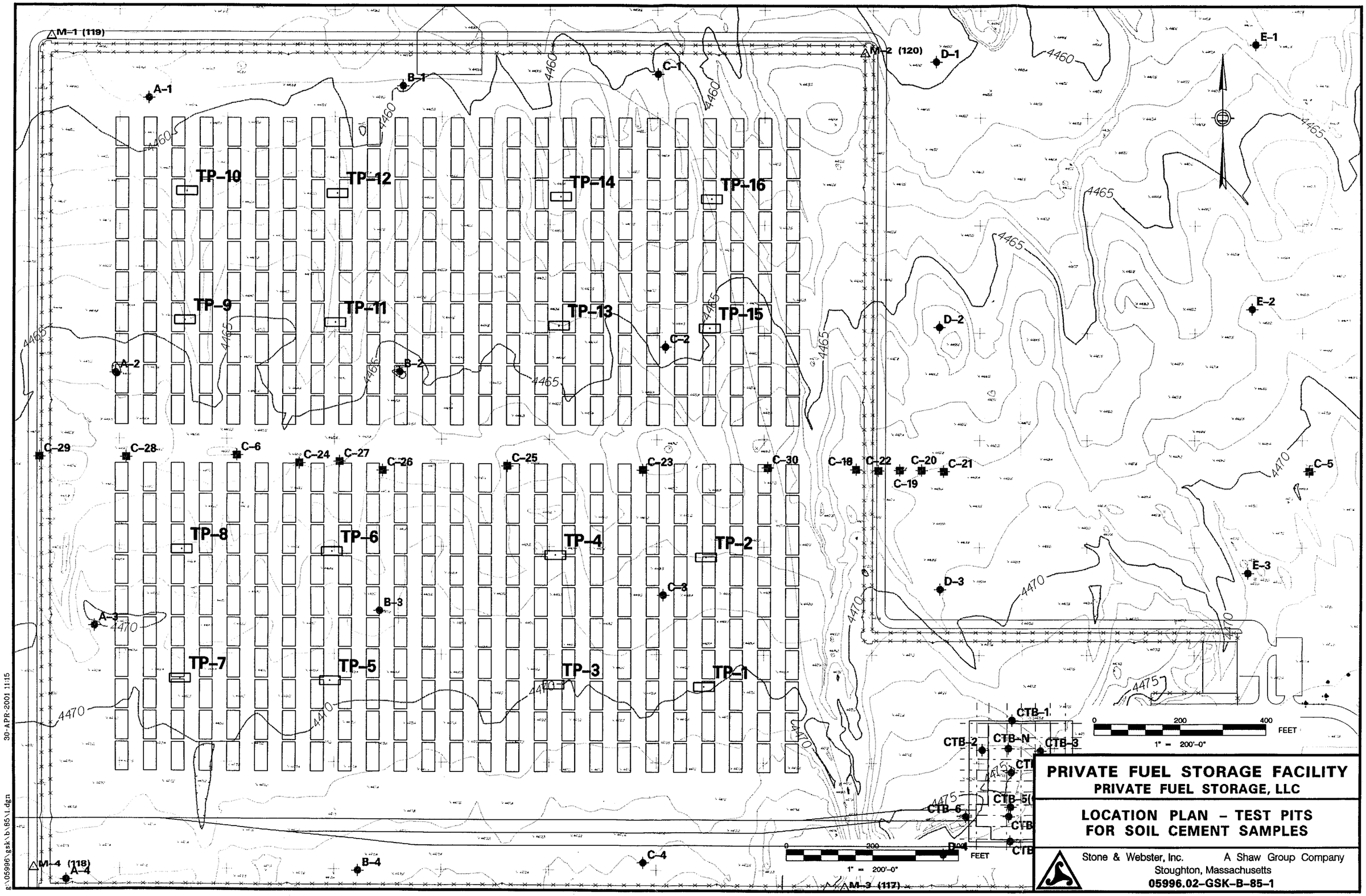
AT ~40' BGS (40.77')

VERTICAL INTERVAL = 2.5

TT = 2.26

VELOCITY = 1106 ft/s

→ ON CALC SHEET = 1106 ft/s
(TABLE D1)



PRIVATE FUEL STORAGE FACILITY
PRIVATE FUEL STORAGE, LLC

LOCATION PLAN – TEST PITS FOR SOIL CEMENT SAMPLES

Stone & Webster, Inc. A Shaw Group Company
Stoughton, Massachusetts
05996.02-GSK-B-85-1

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-1 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,176 E 1,281,860**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4470 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 0.5-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			ML	SILT, moist, brown.
		G	2			MH	ELASTIC SILT, moist, pale-brown.
		G	3			CL	LEAN CLAY, moist, light brownish-grey.
4465	5						

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-2 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,476 E 1,281,865**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4468 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 0.5-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			CH	FAT CLAY with sand, moist, dark yellowish-brown.
		G	2			MH	ELASTIC SILT, moist, light grey.
4465							
		G	3			CL	LEAN CLAY, moist, light brownish-grey.
	5						
4460							

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-3 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,181 E 1,281,510**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4470 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 0.5-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			ML	SILT with sand, moist, yellowish-brown.
		G	2			MH	ELASTIC SILT, moist, light yellowish-brown.
		G	3			CL	LEAN CLAY, moist, light olive-brown.
4465	5						

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-4 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,481 E 1,281,515**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4469 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 0.5-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			ML	SILT with sand, moist, yellowish-brown.
		G	2			CH	FAT CLAY, moist, light yellowish-brown.
4465		G	3			CL	LEAN CLAY, moist, light yellowish-brown.
	5						

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P.J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-5 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,188 E 1,280,990**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4470 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			ML	SILT with sand, moist, brown.
		G	2			MH	ELASTIC SILT, moist, light olive-brown.
		G	3			CL	LEAN CLAY, moist, greyish-brown.
4465	5						

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P.J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-6 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,488 E 1,280,995**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4468 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			ML	SILT, moist, yellowish-brown.
4465		G	2			CL	LEAN CLAY, moist, light yellowish-brown.
		G	3			CL	LEAN CLAY, moist, light brownish-grey.
	5						
4460							

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-7 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,193 E 1,280,641**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4469 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			ML	SANDY SILT, moist, dark yellowish-brown.
						ML	CLAYEY SILT, moist, light brown.
		G	2			CL	LEAN CLAY, moist, light brownish-grey.
4465		G	3			CL	LEAN CLAY, moist, light grey.
	5						

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-8 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,322,493 E 1,280,645**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/16/01 - 01/16/01**
Ground Elevation: **4468 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****	0	G	1			ML	SILT with sand, moist, yellowish-brown.
4465		G	2			MH	ELASTIC SILT, moist, light yellowish-brown.
		G	3			CL	LEAN CLAY, moist, light brownish-grey.
	5						
4460							

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-9 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,028 E 1,280,652**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/01**
Ground Elevation: **4464 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			MH	SANDY ELASTIC SILT, moist, brown.
		G	2			CL	LEAN CLAY, moist, greyish-brown.
4460							
	5	G	3			MH	ELASTIC SILT, moist, light yellowish-brown.

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-10 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,328 E 1,280,656**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/01**
Ground Elevation: **4461 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			ML	SILT with sand, moist, dark yellowish-brown.
4460							
		G	2			CL	LEAN CLAY, moist, light olive-brown.
		G	3			CH	FAT CLAY, moist, light grey.
	5						
4455							

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-11 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,023 E 1,281,002**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/07**
Ground Elevation: **4463 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			MH	ELASTIC SILT with sand, moist, yellowish-brown.
						ML	CLAYEY SILT, moist, light brown.
		G	2			CL	LEAN CLAY, moist, light olive-brown.
4460							
		G	3			MH	ELASTIC SILT, moist, light yellowish-brown.
	5						
4455							

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P.J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-12 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,323 E 1,281,006**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/01**
Ground Elevation: **4462 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			CL	LEAN CLAY with sand, moist, dark yellowish-brown.
4460		G	2			CL	LEAN CLAY, moist, light olive-brown.
		G	3			MH	ELASTIC SILT, moist, light yellowish-brown.
	5						
4455							

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-13 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,016 E 1,281,522**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/01**
Ground Elevation: **4464 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			MH	SANDY ELASTIC SILT, moist, yellowish-brown.
						ML	CLAYEY SILT, moist, light brown.
		G	2			CL	LEAN CLAY, moist, light olive-brown.
4460		G	3			CL	LEAN CLAY, moist, light grey.
	5						

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-14 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,316 E 1,281,526**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/01**
Ground Elevation: **4462 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			CH	FAT CLAY, moist, yellowish-brown.
4460		G	2			CL	LEAN CLAY, moist, light olive-brown.
		G	3			CH	FAT CLAY, moist, light olive-brown.
	5						
4455							

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-15 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,011 E 1,281,872**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/01**
Ground Elevation: **4465 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			CL	LEAN CLAY with sand, moist, dark yellowish-brown.
		G	2			CH	FAT CLAY, moist, light olive-brown.
		G	3			CL	LEAN CLAY, moist, light grey.
4460	5						

Legend/Notes

- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

Approved	Date
P. J. Trudeau	04/30/01

Stone & Webster Engineering Corporation	BORING LOG	Boring TP-16 J.O. 05996.02 Sheet 1 of 1

Site: **Private Fuel Storage Facility**
Client: **Private Fuel Storage, L.L.C.**
Coordinates: **N 7,323,311 E 1,281,876**
Groundwater Depth:
Contractor: **AGEC**

Logged by: **P. J. Trudeau**
Date Start - Finish: **01/17/01 - 01/17/01**
Ground Elevation: **4463 ft**
Depth to Bedrock:
Total Depth Drilled: **6 ft**
Driller:
Rig Type:

Methods:
Drilling Soil:
Sampling Soil: **Test pits excavated with backhoe. Grab samples obtained at 2-ft intervals.**
Drilling Rock:

Casing Used:

Comments: **Coord's refer to Modified Project Datum and were measured using a Garmin III-Plus GPS, accurate to ~10 ft. Elev's estimated based on topo from aerial survey.**

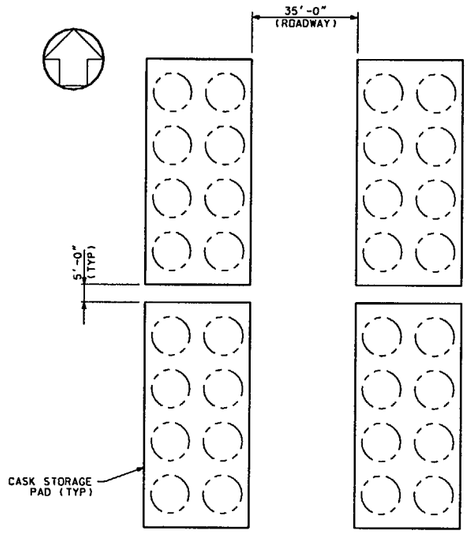
Elev (ft)	Depth (ft)	Sample Type	Sample No.	Blows or Recovery / RQD	SPT N Value	USC Symbol	Sample Description
*****							
	0	G	1			CH	FAT CLAY, moist, dark yellowish-brown.
		G	2			MH	ELASTIC SILT, moist, yellowish-brown.
4460							
		G	3			CL	LEAN CLAY, moist, light olive-brown.
	5						
4455							

Legend/Notes

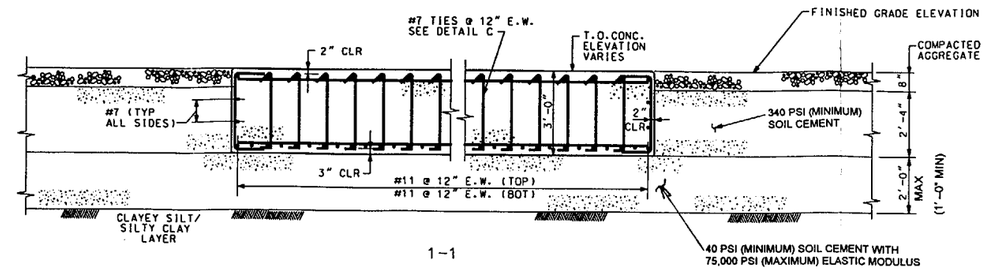
- Datum is 1929 NGVD.
- ▽ indicates groundwater level.
- ▌ indicates location of samples.
- Blows = number of blows required to drive 2" O.D. sample spoon 6" or distance shown using 140 pound hammer falling 30".
- ( ) = inches of sample recovery.
- Recovery = % rock core recovery.
- RQD = Rock Quality Designation.
- SPT N = Standard Penetration Test resistance to driving, blows/ft.
- USC = Unified Soil Classification system.
- * indicates use of 300 pound hammer.

- Sample Type:
  G = Grab sample

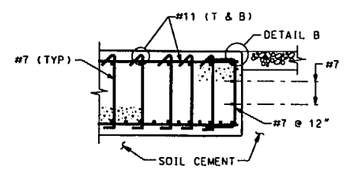
Approved	Date
P. J. Trudeau	04/30/01



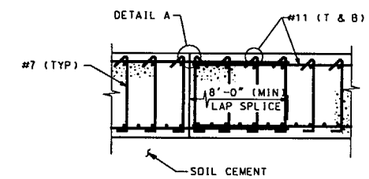
PARTIAL PLAN
TYPICAL CASK STORAGE PAD SPACING



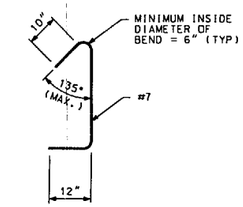
1-1



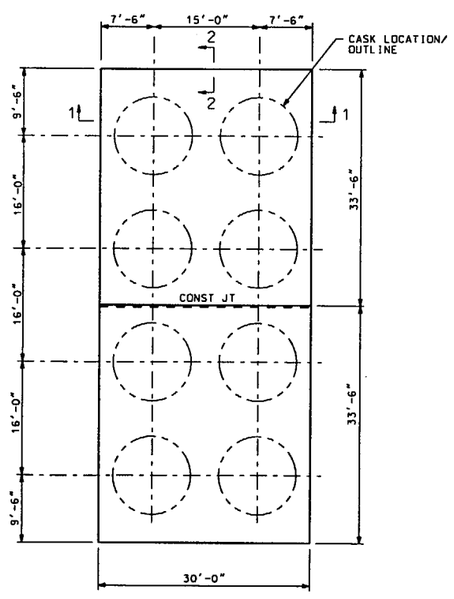
2-2



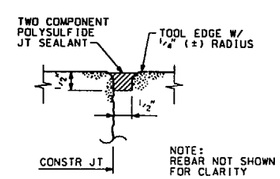
TYP CONSTRUCTION JT
CASK STORAGE PAD



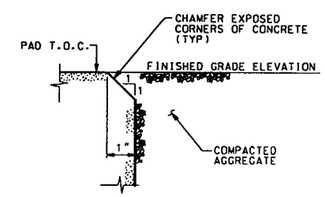
DETAIL C
TYPICAL TIE DETAIL



PLAN
CASK STORAGE PAD
(500 REQD)



DETAIL A



DETAIL B

Figure 4.2-7
CASK STORAGE PADS

PRIVATE FUEL STORAGE FACILITY
SAFETY ANALYSIS REPORT

EDERER INCORPORATED

ISO 9001 CERTIFIED

Date:	23 March, 2001	Doc #	F2621L004SH
To:	Wayne Lewis	From:	Steve Hertel
CC:	Stone & Webster	Title:	Project Manager
Fax No:	303-741-7806	Tele:	(206) 622-4421 Fax: (206)340-2628

Pages transmitted, including this sheet: 13 cc:

Ederer Project F2621/22 Private Fuel Storage Facility

Re: Revised Letter for SAR

Attached is a letter summarizing the anticipated impacts of the revised seismic requirements upon our Phase I design for the bridge and gantry cranes. As discussed, it will be possible to redesign the crane structures to accommodate the new accelerations. While both cranes will generally fit into the same envelope, both cranes' girder sections will deepen. We will report the actual revised dimensions as we proceed with the design.

Please call if you have any questions.

Yours Truly,
EDERER INCORPORATED

Steve Hertel
Project Manager

Ederer Incorporated
Post Office Box 24708
Seattle, WA 98124-0708

Via Express :
2925 1st Avenue South
Seattle, WA 98134

The phase I. Initial Detailed Engineering for Ederer Job Nos. F2621 (200T Bridge Crane) and F2622 (150T Semi Gantry crane) was carried out using the response spectra curves per the original specification attachment 9. Revised curves are dated 3/19/01 and are included in Appendix A. Table 1a gives a comparison between the original and revised curves on the basis of peak acceleration, frequency and percent increase (or decrease) in peak acceleration. Tables 2 and 3 list the maximum percentages of allowable stress for the various components analyzed in the seismic analysis that was originally done on these cranes. Since the peak accelerations occur at relatively low frequencies ($\approx$ 3-5.5 hz horizontal, and $\approx$5-13 hz vertical) and, these frequencies are close to typical crane structural natural frequencies, a dynamic analysis would have to be done to really define how the structural loading might vary. This would be especially true if a particular mode were close to either the increasing or decreasing side of the response curve. Comparison of the static peak accelerations will however, give an indication of the results of a dynamic analysis.

For the 200T bridge crane, the vertical change is +52%. The N-S lateral forces are governed by wheel slip and will remain constant. Since the bridge girders, trolley trucks, trolley girder and equalizing sill are at approximately 90% or more of the allowable stress and this margin should be maintained, the section moduli would have to increase approximately 52%. The bridge trucks will be also affected by the large E-W horizontal peak change (+94%). They are however at a lower % allowable stress of $\approx$72%. The section modulus for the trucks would then have to increase approximately 10%. Our conclusion is that the bridge crane will still fit in the same envelope as shown on PA 2189, Rev. C except that the girders will be deeper and heavier.

EDERER CRANES STAR CRANES WASHINGTON CRANES EDERER SERVICES

For the 150T gantry crane the vertical peak change is +52% on the west end +8% on the east end. The N-S lateral forces are governed by wheel slip and will remain constant. The E-W lateral peak change is +94% on the west end and –4% on the east end. The equalizing sill, end tie, and gantry trusses are at low enough % allowable stress that they should remain unchanged. The bridge girder, trolley truck and trolley girder section moduli would increase by approximately 30%. The gantry leg section modulus would increase approximately 50% at the top end and remain the same at the bottom. The joints at the girder/leg interface and the girder/truck interface would have to increase in strength to handle the increased E-W lateral loading. The bridge trucks will be affected by the vertical peak change and the large E-W horizontal peak change at elevation 170 ft. They are however at a % allowable stress of ≈75% , similar to the bridge crane. The section modulus for the trucks would then have to increase approximately 10%. In conclusion, we expect that the semi gantry crane will still fit in the same envelope as shown on PA 2190, Rev. D but the girders will be deeper and heavier.

This analysis deals with technical issues, commercial issues will be dealt with in separate correspondence.

Fred Langford, C.E. Mechanical
3/23/01

By FSL Date 3/22/01

Chkd. Date

Subject Table 1A

Sheet No. ___ of ___

Job No. F3264A F3622A

			Attach. 9		3/22/01		3/22 Δ %	8/31 Δ %
			Peak	f	Peak	f		
(Y)	Vert peak	170'	2.9	6 hz	4.4	5.2-13	52	14
(X)	N-S	100'	3.95	3 hz	5.8	4.6-5.5	47	16
(Z)	E-W	100'	6.8	3 hz	13.2	2.8-3.6	94	100
(Y)	Vert peak	100'	2.7	6 hz	2.92	5.1-10	8	8
(X)	N-S	100'	3.6	3 hz	4.5	3.8-5.5	25	8
(Z)	E-W	100'	4.1	3 hz	3.95	3.8-4.1	-4	-17

EDERER SERVICES INCORPORATED
A WHOLLY OWNED SUBSIDIARY OF EDERER INC.
2323 FIRST AVENUE SO. SEATTLE, WA 98134 • P.O. BOX 24700, SEATTLE, WA 98124
TEL: (206) 622-4421 • FAX: (206) 622-4883

Rev.	Description	Date	By	Chkd.

By FEL Date 8/31/99 Sheet No. ___ of ___

Chkd. ___ Date ___ Job No. [illegible]

Subject: Table 2 150T Gantry

Report Page	Member	Trolley	Load/hook	Max % Allow.
4-18	Bridge girder	midspan	150T/Hl	86.2
4-13	Equalizing sill	midspan	150T/Hl	39.7
4-3	Trolley truck	1/4 span	150T/Hl	96.3
4-3	Trolley girder	1/4 span	150T/Hl	98.8
4-13	Bridge truck	1/4 span	150T/Hl	75.3
4-13	End tie	1/4 span	150T/Hl	55.9
4-13	Gantry leg	1/4 span	150T/Hl	96.3
4-12	Gantry cross	1/4 span	No load	54.9

ESI EDERER SERVICES INCORPORATED
A WHOLLY OWNED SUBSIDIARY OF EDERER INC.
2828 FIRST AVENUE S. SEATTLE, WA 98134 - P. O. BOX 24798, SEATTLE, WA 98124
TEL: (206) 622-4481 - FAX: (206) 623-6383

Rev.	Description	Date	By	Chkd.

By FEL Date 8/21/99 Sheet No. ___ of ___

Chkd. ___ Date ___ Job No. 5621/22

Subject: Table 3

Report Page	Member	Trolley	Load/hook	Max % Allow
4-17	Bridge girder	midspan	200T/HC	96.2
4-17	Equalizing Srd	midspan	200T/HC	89.1
4-7	Trolley Truck	W end	200T/HC	98.8
4-7	Trolley girder	W end	200T/HC	98.7
4-7	Bridge truck	W end	200T/HC	71.9

ESI EDERER SERVICES INCORPORATED
A WHOLLY OWNED SUBSIDIARY OF EDERER INC.
2323 FIRST AVENUE S. SEATTLE, WA 98134 - P. O. BOX 24708, SEATTLE, WA 98124
TEL: (206) 623-4471 - FAX: (206) 623-0648

Rev.	Description	Date	By	Chkd.