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Test Pad Construction Certification Report

Bert Avenue Site

Chemetron Corporation
Newburgh Heights, Ohio

Project No. C1220
March 1998

Earth Sciences
Consultants, Inc.

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Earth Sciences Consultants, Inc.
One Triangle Drive
Export, PA 15632
724/733-3000
FAX: 724/325-3352

Branch Offices
Akron, Ohio
Denver, Colorado
Philadelphia, Pennsylvania

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1.0 Introduction

This report presents the construction certification for the test pad for the proposed liner and cover system material to be utilized at the Bert Avenue Site, Chemetron Corporation in Newburgh Heights, Ohio. AWS Remediation, Inc (AWS Remediation) constructed the test pad under the construction quality control (QC) oversight of Earth Sciences Consultants, Inc. (Earth Sciences), in accordance with the Ohio Environmental Protection Agency (OEPA) Ohio Administrative Code (OAC) Chapter 3745. This test pad models the liner system to be constructed at the Bert Avenue Site.

2.0 Requirements Under OEPA OAC Chapter 3745

OAC Chapter 3745-27-08 presents requirements for the construction of liner and barrier systems. The following sections outline the necessary requirements.

2.1 Material Specifications

In order to comply with the requirements stated in the OAC rule mentioned above, the liner must be constructed of a soil:

- with 100 percent of the particles having a maximum dimension not greater than 2 inches;
- with not more than 10 percent of the particles, by weight, having a maximum dimension greater than 0.75 inch;
- with not less than 50 percent of the particles, by weight, passing through the 200-mesh sieve;
- with not less than 25 percent of the particles, by weight, having a maximum dimension not greater than 0.002 millimeter; and
- with a maximum clod size of 3 inches or half the lift thickness, whichever is less.

2.2 Test Pad Specifications

Before the actual construction of the liner system, a test pad must be constructed and tested according to the following requirements:

The test pad shall:

- Be designed such that the proposed tests are appropriate and their results are valid.
- Be constructed to establish the construction details or verify or amend the construction details proposed in the approved permit.
  - Compaction must be 95 percent of the maximum Standard Proctor Density using American Society for Testing and Materials (ASTM) D 698 or at least 90 percent of the maximum Modified Proctor Density D 1557.
  - Compacted moisture must be at or wet of optimum.
- Be constructed whenever there is a significant change in soil material properties.

- Have a minimum width of three times the width of the compaction equipment and a minimum length two times the length of the compaction equipment including power equipment and any attachments.
- Be comprised of at least four lifts.
- Be tested for field permeability following the completion of the test pad construction.
- For each lift, a minimum of three tests for moisture content and density shall be performed.
- Be reconstructed as many times as necessary to meet the permeability requirement. Any amended construction details shall be noted for future soil liner or soil barrier construction.

2.3 Alterations

On February 11, 1998, Mr. Theodore G. Adams of B. Koh & Associates submitted to OEPA an alteration request concerning test pad construction and earthwork specifications. On February 17, 1998, OEPA approved the alteration request for the items listed. The alteration request and approval are enclosed in Appendix A The following items are revisions of the same found in the Test Fill Work Plan and are applicable to the methods and materials covered by this report:

1. Authorization to use clay materials in the compacted clay liner and compacted clay barrier which has less than twenty-five (25) percent, by weight, having a maximum dimension not greater than 0.002 millimeters. The material shall only be used if it shown through the means of a test pad that the material can meet 1X10-7 centimeters per second.
2. Compacted clay materials shall be compacted at a moisture content at or wet of optimum in compliance with Ohio Administrative Code (OAC) Rule 3745-27-08 (C)(1)(e).
3. In-place density and moisture testing of compacted clay materials shall be performed at a frequency of no less than five (5) tests per acre per lift in compliance with OAC Rule 3745-27-08 (C)(1)(o).
4. Deletion of the minimum liquid limit and plasticity index criteria presented in the Test Fill Work Plan.
5. Construction of the lifts using a maximum thickness of eight (8) inches in compliance with OAC Rule 3745-27-08 (C)(1)(a).
6. Cold Weather Protection of the Test Pad.

3.0 Material Properties of the Soil Liner/Barrier

Material to be used in the construction of the soil liner/barrier was obtained from the MBNA Project Site operated by Independence Excavating, Inc. of Independence, Ohio. All of the required quantity of the material has been stockpiled on or adjacent to the Bert Avenue Site. The total quantity of clay needed for the construction of the soil liner and cover has been estimated as 22,250 cubic yards as stated in the contract documents. To date, all of the material has been received and stockpiled on site. This quantity was used to determine the number of samples required in order to properly evaluate the material. The number of samples taken was 18 which exceeded the required number of 15 samples (based on the sampling frequency of 1 per 1,500 cubic yards). Grain-size distribution tests (ASTM D 422), Atterberg limits (ASTM D 4318), and soil classifications (ASTM D 2487) were performed on 16 of the 18 samples. Moisture-density tests (ASTM D 698) were performed on all of the samples taken. Laboratory permeability tests (ASTM D 5084) were performed on 3 of the samples. Table 1 presents a summary of the data obtained and Appendix B contains drawings of the stockpile and sample locations. Appendix C contains the laboratory analysis reports on the clay material. The following sections discuss in detail the results found from the tests performed.

3.1 Soil Classification and Atterberg Limits

Atterberg limits evaluations and soil classifications were performed on 16 of the 18 samples taken from the stockpile. All clay material is classified as CL according to the Unified Soil Classification System (USCS). Plasticity indices ranged from 9 to 13 and liquid limits ranged from 24 to 31.

3.2 Grain Size

A grain-size distribution test was performed on 16 of the 18 samples taken from the stockpile. Fifteen of the 16 samples had 100 percent passing the 2-inch sieve. Sample C9 had 95 percent passing the 2-inch sieve. This percentage was below the 100 percent requirement established under OAC Rule 3745-27-08. Therefore, if particles greater than 2 inches in size are present in the clay material during construction, they will be removed before compaction activities begin. This method was utilized during the construction of this test pad and determined to be effective based upon the results achieved. The percent of material passing a three-quarter-inch sieve ranged from zero to 8 percent and the percent passing a No. 200 sieve ranged from 63.4 to 73.1 percent, both of which were in accordance with the OAC rule requirements. The percent passing a 0.002-millimeter sieve ranged from 17.8 to 26.3 percent. Some of the 0.002 millimeter results fell below the 25 percent requirement established by OAC Rule 3745-27-08. The material represented by Sample C14 has 17.8 percent less than 0.002 millimeter, which is the lowest of all the samples; therefore, this material was used in the construction of the test pad. The use of this material was authorized by OEPA in their approval letter to Mr. Theodore G. Adams of B. Koh & Associates dated February 17, 1998. Table 1 summarizes the grain-size distribution information.

3.3 Moisture Content and Density

A Standard Proctor test was performed on all 18 samples obtained from the stockpile. This test produced a maximum dry density and optimum moisture content for each sample. The maximum dry densities ranged from 115.2 pounds per cubic foot to 123.6 pounds per cubic foot. The optimum moisture contents ranged from 11.4 to 15.5 percent. Table 1 presents the data for the samples obtained and tests performed. Sample C14 represented the material that was used in the construction of the test pad. This material has a maximum dry density of 116.3 pounds per cubic foot and an optimum moisture content of 15.1 percent.

3.4 Remolded Permeability

A remolded permeability test (ASTM D 5084) was performed on 3 of the 18 samples obtained. The laboratory permeabilities of Samples C16, C17, and C18 were below the maximum requirement of 1.0×10^{-7} centimeters per second (cm/sec). The laboratory permeabilities for the samples ranged from 3.80×10^{-8} to 5.60×10^{-8} cm/sec. These results are summarized in Table 1.

4.0 Test Pad Evaluation

Test pad construction began on February 16, 1998 and was completed on February 26, 1998. The construction was done in accordance with the requirements outlined in the approved Test Fill Work Plan, OAC Rule 3745-27-08, and an alteration request approved by OEPA on February 17,1998. Material used for the construction of the test pad was obtained from the same stockpile of Sample C14. This stockpile was located near the test pad area, inside the north gate of the zoned area. Sketches of the stockpiled material and sample locations are enclosed in Appendix B. The in-situ permeability testing of the test pad was performed in accordance with the draft ASTM standard for the Two-Stage Borehole Procedure.

4.1 Area Layout

A minimum test pad size must be determined by the size of the equipment to be used for its construction. According to OAC Rule 3745-27-08, the test pad must be at least twice the length and three times the width of the equipment and any attachments. The CAT D6M dozer has the maximum width of 161 inches (13 feet 5 inches). The CASE 1550 dozer with the tow-behind sheepsfoot compactor attached has the maximum length of 351 inches (29 feet 3 inches). These measurements produce a minimum test pad size of total length equals twice the length of the CAT D6M dozer which equals 322 inches (26 feet 10 inches). Total width equals three times the width of the CASE 1550 dozer with the tow-behind sheepsfoot compactor attached which equals 1,053 inches (87 feet 9 inches). Appendix D contains specifications of all equipment used to construct the test pad. Prior to the start of test pad construction, stakes were placed around the perimeter of the proposed area laying out the 60-foot-by-100-foot area in 20-foot sections.

4.2 Surveying

The floor and top of the first lift and each successive lift were surveyed by QC personnel in order to control the loose lift thickness to 8 inches. Surveys done on each lift were recorded in the daily notes contained in Appendix E.

4.3 Construction Sequence

The test pad was constructed in the containment cell area on the Groundwater Conveyance Layer (GWCL) subgrade and which has already been deemed suitable as a sufficient drainage material with a minimum permeability of 1×10^{-2} cm/sec. Therefore, no additional storm water diversion measures were deemed necessary. The GWCL was graded using a CAT D6M dozer. Prior to the construction of the initial lift, a single layer of 8-ounce geotextile fabric was placed on the GWCL subgrade to avoid infiltration of clay fines. Clay material was brought to the test pad area from the stockpile via a CAT 966F rubber-tired loader. The material used for the construction of the test pad was obtained from the west side of the stockpile located inside the zoned area near the north gate (Sample C14 area). Once the material was brought to the test pad area, a CAT D6M dozer distributed the material and reduced large soil clods. Prior to the compaction activities, each lift was graded and surveyed to control the loose lift thickness to a maximum of 8 inches. Also, particles greater than 2 inches were removed from the lift prior to compaction. A large amount of these particles (approximately 1 percent of the total test pad soil volume) existed in the material represented by Sample C14, but appear to have been effectively removed by the methods developed during construction of this test pad. A CASE 1550 dozer pulling a tow-behind sheepsfoot compactor made six two-way passes before compaction tests were performed. Once compaction was complete, the CASE 1550 dozer blade was utilized in several places to smooth out locations for the Troxler gauge to take moisture and density readings. Any holes made by the Troxler gauge were backfilled and tamped with bentonite and water. Five moisture/density tests were performed on each lift. Appendix E contains "Field Results" log sheets attached to the daily notes summarizing the moisture and density test results and test locations. A sand cone test (ASTM D 1556) was performed by Solar Testing Laboratories, Inc. once per day during test pad construction. Appendix F contains sand cone testing information. Six two-way passes of the CASE 1550 dozer and tow-behind sheepsfoot compactor were used to compact the material to the required result. Due to the wet weather conditions at the site, after the first two lifts were completed, work was halted and the test pad was covered in plastic. Once conditions became more favorable, construction resumed and the third, fourth, and fifth lifts were completed. If in the event that a density result was below the required 95.0 percent, the area was rerolled and retested. In only one instance, a moisture reading taken on Lift No. 3 resulted in a moisture content below the optimum moisture content of 15.1 percent. This result was noted by on-site QC and Dames & Moore's personnel. At that time, conditions again became unfavorable and Lift No. 3 construction ceased due to inclement weather. The following day, Lift No. 3 was recompacted and retested. All density and moisture content tests passed and Lift No. 4 construction began. Upon completion of the fifth and final lift, the surface of the test pad was graded by the CAT D6M Dozer and rolled smooth. Then a layer of plastic, approximately 6 inches of straw, and a second layer of plastic were installed over the clay to prevent the test pad from freezing.

4.4 Testing

4.4.1 In-Situ Permeability Tests

The in-situ permeability tests were conducted in accordance with the draft ASTM standard for the Two-Stage Borehole procedure included in Appendix G. Five permeameters for Stage One were installed on February 26, 1998 and allowed to hydrate overnight. After 24 hours, water was placed in the permeameters. Soon after, four of the five permeameters failed (lost water). It was determined that this failure was due to hydraulic fracturing since the top of the permeameter casing extended too high from the ground surface. All five permeameters were removed from the test pad and the remaining holes backfilled and tamped with bentonite and water. After discussions with Messrs. Gordon P. Boutwell and Dan Franklin of Soil Testing Engineers, Inc. (STE), all five permeameter casings were shortened to approximately 12 inches. This ensured that overburden pressure in each permeameter would not induce hydraulic fracturing. Five new permeameters were installed on March 4, 1998 at different locations at a sufficient distance away from the old permeameters and the sides of the test pad (refer to Appendix J). The second set of permeameters held water and readings were taken in accordance with the draft standard. As readings were taken, results were faxed to Ziad Alem of STE. On March 10, 1998, Ziad Alem of STE informed Doug Zimmer of AWS Remediation that the last of the five permeameters had stabilized and that all may be advanced to Stage Two. Each permeameter was advanced to Stage Two on March 13, 1998. For details regarding permeameter installation, see the daily notes included in Appendix E. Log sheets provided by STE for both Stage One and Stage Two readings are enclosed in Appendix H. STE performed all data reduction and interpretation of steady-state conditions. The vertical field permeability test results ranged from 1.29×10^{-8} to 3.27×10^{-8} cm/sec with an average of 2.40×10^{-8} cm/sec. The horizontal field permeability results ranged from 1.94×10^{-8} to 4.84×10^{-8} cm/sec with an average of 3.61×10^{-8} cm/sec. Therefore, all of the results have met the permeability requirement of 1.0×10^{-7} cm/sec. The report from STE is included in Appendix I. A drawing showing the test pad layout and permeameter locations is included in Appendix J.

4.4.2 Shelby Tube Sampling

Three undisturbed samples (Shelby tube) were taken from the test pad at various locations on March 19, 1998. The results from these samples will be provided when available.

5.0 Conclusions

Based on the laboratory and field results presented in this document, we conclude the following:

- The clay material stockpiled at the Bert Avenue Site is suitable for use as a recompacted soil liner or barrier layer. As stated in the Two-Stage Field Permeability Test Report prepared by Messrs. Gordon P. Boutwell and Ziad H. Alem of STE, the clay material meets the permeability requirement of 1×10^{-7} cm/sec.

- The clay material having a 17.8 percent content of material finer than a 0.002-millimeter sieve met the minimum permeability requirement and, therefore, the remaining stockpiled material having a greater than 17.8 percent material finer than 0.002-millimeter sieve content will meet the permeability requirements also.

- Equipment and methods of construction used in the preparation of the test pad produced a material permeability acceptable under OAC Rule 3745-27-08 for use as a recompacted soil liner or barrier.

- Manual or mechanical removal of particles greater than 2 inches will be necessary for some materials if they are to be used.

6.0 Recommendations

Based on the information presented in this document, we recommend the followings procedures during the placement of the recompacted soil liner/barrier system (clay) at the Bert Avenue Site in Newburgh Heights, Ohio:

- The clay should be spread in lifts not to exceed 8 inches in loose thickness and compacted with no less than six two-way passes with the CASE 1550 dozer and tow-behind sheepsfoot compactor.
- Particles greater than 2 inches should be removed from the material as each lift is placed and before compaction activities begin. If this causes an unacceptable delay in liner/barrier placement, alternative materials should be used.
- An equipment equivalency calculation for the tow-behind sheepsfoot and HYPAC C852B self-propelled tamping-foot compactors has been included in Appendix K. Contained also within this appendix are specifications for the HYPAC C852B tamping-foot compactor as well as the tow-behind sheepsfoot. The contractor (AWS Remediation) has requested that this equivalency calculation be included in this report for consideration by the agency. If approved, it would allow the use of either piece of equipment providing flexibility during the actual installation. If this equipment is used, no fewer than six two-way passes should be used.
- The clay should be compacted to at least 95.0 percent maximum dry density as determined by the Standard Proctor test (ASTM D 698) and at or wet of the optimum moisture content.

Material to be used in the construction of the recompacted soil liner/barrier systems has been stockpiled on site and sampled and tested at the frequency required by OEPA and Dames & Moore (Certifying Engineer). The clay material has been found to be acceptable and will achieve the desired permeability when placed under the conditions described above.

Table

AWS Remediation, Inc.
Bert Avenue Site
Project No.: C1220
Clay Analysis Summary - Revision

Sample No.	Sample Date	Soil Classification		Gradation Results				Atterberg Limits		Proctor Value	Optimum Moisture Content	Permeability (cm/sec)
		USCS	AASHTO	% < 2"	% > 0.75"	% passing #200 sieve	% < 0.002mm	Liquid Limit	Plasticity Index			
C1	7/31/97	NA	NA	NA	NA	NA	NA	NA	NA	121.7	13.0	-
C2	11/6/97	CL	A-6(10)	100	2	73.1	23.9	27	11	120.5	13.7	-
C3	11/6/97	CL	A-4	100	2	71.5	22.3	25	9	119.8	13.6	-
C4	11/6/97	CL	A-4	100	7.5	66.8	21.5	2[illegible]	10	119.8	12.7	-
C5	11/6/97	CL	A-4	100	4	69.4	23.1	26	10	118.6	13.1	-
C6	11/6/97	CL	A-4	100	4	68.3	21	25	9	118.8	12.7	-
C7	11/6/97	CL	A-4	100	3	68.4	23.4	25	9	120.6	12.6	-
C8	11/6/97	CL	A-4	100	4.5	64.4	19.8	25	10	120.6	12.6	-
C9	11/6/97	CL	A-1	95	7	65.4	21.1	25	9	120.7	13.7	-
C10	11/6/97	CL	A-4	100	1	71.2	24.7	26	10	122.2	12.1	-
C11	11/6/97	CL	A-4	100	3	70	22.3	26	10	118.8	12.7	-
C12	11/6/97	CL	A-6	100	8	67.8	22.7	31	13	115.6	15.5	-
C13	11/6/97	CL	A-4	100	0	72.4	21.8	25	9	118.4	13.8	-
C14	11/6/97	CL	A-6	100	2	63.4	17.8	30	11	116.3	15.1	-
C15	11/6/97	CL	A-6	100	5	67.4	19.5	28	11	115.2	15.2	-
C16*	2/2/98	-	-	-	-	-	-	-	-	121.7	12.3	3.80E-08
C17**	2/2/98	CL	-	100	2.2	72.5	26.3	24	9	123.6	11.4	5.40E-08
C18**	2/2/98	CL	-	100	1.6	70.1	25.0	25	10	120.9	12.0	5.60E-08

* Sample taken for ASTM D 5084 Permeability test only

** Sample taken to replace sample C1 for all parameters listed in addition to ASTM D 5084 Permeability

Appendix A

Alteration Request and Approval

OhioEPA
State of Ohio Environmental Protection Agency

Northeast District Office
2110 E. Aurora Road
Twinsburg, Ohio 44087-1969
(330) 425-9171 FAX (330) 487-0769

George V. Voinovich
Governor

February 17, 1998

RE: BERT AVENUE LF
CUYAHOGA COUNTY
CLOSURE PLAN ALTERATION
APPROVAL

Mr. Theodore G. Adams
Vice President
B. Koh & Associates, Inc.
11 West Main Street
Springville, NY 14141

Dear Mr. Adams:

On October 8, 1997, the Ohio Environmental Protection Agency (OEPA)-Division of Solid and Infectious Waste Management (DSIWM)-Northeast District Office (NEDO) received a Test Pad Construction Certification data package for the Bert Avenue Landfill in the Village of Newburgh Heights, Cuyahoga County, Ohio. This report was submitted by Earth Sciences Consultants on behalf B. Koh & Associates, Inc. who is representing the Chemetron Corporation in the remediation of this site. A work plan for the test pad was originally included in Appendix A of the Final Closure/ Post-Closure Plan which was approved by the OEPA on July 24, 1996.

After a review of the data package, the OEPA-DSIWM-NEDO issued a Notice of Deficiency (NOD) letter to B. Koh & Associates on November 14, 1997. In response to this letter, a Test Pad Construction Certification report was submitted in accordance with Ohio Administrative Code (OAC) Rule 3745-27-08(H) to the OEPA-DSIWM-NEDO on November 26, 1997.

Upon completing a review of this report, the OEPA-DSIWM-NEDO issued a second NOD letter on January 23, 1998. As a result of this NOD letter, a meeting was conducted with various representatives of the OEPA-DSIWM-NEDO, the Cuyahoga County Health Department (CCHD), the Nuclear Regulatory Commission (NRC), B. Koh & Associates, American Waste Services (AWS) and Earth Sciences on January 30,1998.

Due to the deficiencies that were cited in the construction of the original test pad, it was concluded during the meeting that another test pad would be constructed based upon an alteration request to be submitted to the OEPA-DSIWM-NEDO. The alteration request would revise the Test Fill Work Plan and the Earthwork Technical Specifications which are provided in Attachment A of the approved closure plan. This request was faxed to the OEPA-DSIWM-NEDO on February 12, 1998. In addition to a list of the proposed alterations which are provided below, a revised clay materials summary table along with geotechnical data was also provided.

1. Authorization to use clay materials in the compacted clay liner and compacted clay barrier which has less than twenty-five (25) percent, by weight, having a maximum dimension not greater than 0.002 millimeters. The material shall only be used if it shown through the means of a test pad that the material can meet 1X10(-7) centimeters per second.

2. Compacted clay materials shall be compacted at a moisture content at or wet of optimum in compliance with Ohio Administrative Code (OAC) Rule 3745-27-08(C)(1)(e).

3. In-place density and moisture testing of compacted clay materials shall be performed at a frequency of no less than five (5) tests per acre per lift in compliance with OAC Rule 3745-27-08(C)(1)(o).

4. Deletion of the minimum liquid limit and plasticity index criteria presented in the Test Fill Work Plan.

5. Construction of lifts using a maximum thickness of eight (8) inches in compliance with OAC Rule 3745-27-08(C)(1)(a).

6. Cold Weather Protection of the Test Pad

The OEPA-DSIWM-NEDO has completed a review of the request and has concluded that the proposed alterations are acceptable. A response to the submittal of the revised clay materials summary table along with the geotechnical data will be provided in a separate correspondence. If you have any questions, please call me at (330) 963-1186.

Sincerely,

Jerry L. Parker, R.S., E.I.T.
Division of Solid and
Infectious Waste Management

Kurt Princic, Group Leader
Division of Solid and
Infectious Waste Management

JLP:cl

cc: Ms. Katharina Snyder, OEPA-DSIWM-NEDO
Mr. John Romano, CCHD
Mr. Tim Johnson, NRC
Mr. Ross Landsman, NRC
Mr. Steve Kiiper, AWS
Mr. Herb Addison, AWS Remediation
Mr. Brien Kilkenny, AWS Remediation
Mr. Barry Koh, B. Koh & Associates
Mr. David Fannin, Sunbeam-Oster
Mayor Ed Kohlar, Village of Newburgh Heights
FILE: [LAND/BERT AVENUE LF/AUT/18]

B. KOH & ASSOCIATES, INC.
Environmental Restoration
Radioactive Waste Management

TAM/HJD/SBK/BJK/
GEW.

Principal Office
9199 Reisterstown Road, Suite 111-C
Owings Mills, Maryland 21117-4520
Telephone: (410) 356-6612
FAX: (410) 356-4213

New York Office
11 West Main Street
Springville, New York 14141-1012
Telephone: (716) 592-3431
FAX: (716) 592-3439

February 11, 1998

Mr. Jerry Parker, R.S., E.I.T.
Ohio Environmental Protection Agency
Northeast District Office
2110 East Aurora Road
Twinsburg, Ohio 44087

Re: Bert Avenue Site Remediation Project - Alteration Request for the Approved Technical Specifications and Test Fill Work Plan

Dear Jerry:

Thank you for taking the time to meet with us on January 30, 1998 concerning the test pad and other liner issues at the Bert Avenue site. Per our discussion, we respectfully request approval of the following alterations to the approved Technical Specifications and Test Fill Work Plan for the site:

1. Authorization to use clay materials for the compacted clay liner under the waste and the compacted clay barrier layer of the cover system which has less than 25 percent by weight having a maximum dimension not greater than 0.002 millimeters. This material shall only be used if it is shown through means of a test pad that the material can achieve a maximum permeability of 1x10-7 centimeters per second, and is specifically approved in writing by Ohio EPA (refer to Page 02200-2 of the Technical Specifications and Page 2 of Test Fill Work Plan).

2. Compacted clay materials shall be compacted at a moisture content at or wet of optimum (refer to Page 02200-11 and 02200-12 of the Technical Specifications) in compliance with OAC 3745-27-08(C)(1)(e).

3. In-place density and moisture testing of compacted clay materials shall be performed at a frequency of no less than five tests per acre per lift (refer to Page 02200-11 and 02200-12 of the Technical Specifications) in compliance with OAC 3745-27-08(C)(1)(o).

4. Deletion of 25% minimum liquid limit and 10% to 40% plasticity index criteria presented in the Test Fill (test pad) Work Plan and found on Page 2 of

that Plan. These indexes are used in the classification of the material under the Unified Soil Classification System (USCS).

5. Correction of the loose lift thickness of compacted clay materials found on Page 6 of the Test Fill (test pad) Work Plan to a maximum thickness of 8 inches in compliance with OAC 3745-27-08(C)(1)(a).

<u>Cold Weather Protection of the Test Pad</u> .

1. The test pad will be constructed in loose lifts of no more than 8 inches thick. A minimum of four lifts will be placed. Lifts will be compacted only when ambient temperatures are above 32 degrees Fahrenheit. If construction of the full height cannot be achieved in one day, or if temperatures fall below 32 degrees, the placed lifts shall be protected as follows.

   - The last lift placed will be sealed to prevent moisture loss by rolling 100% of the surface with rubber-tired construction equipment or, alternatively, with a smooth drum steel roller, if available.

   - If the remaining test pad lift placement is expected to be delayed for only a short period (less than approximately 3 days), the test pad will be covered with a plastic film in order to protect the top lift from morning frost. If the remaining lift placement is expected to be delayed for an extended period, the test pad will be covered with a plastic film, followed by a minimum of six inches of hay or straw and a second plastic film cover to keep the hay or straw dry. Alternatively, the test pad may be covered with construction insulation blankets.

   - Placement of subsequent lifts will be preceded by the scarification of the last placed lift using the cleats of a bulldozer.

2. Following the compaction of the last lift of the test pad, the surface will be sealed as described above. The test pad will then be insulated from cold weather effects using hay, straw, or construction insulation blankets as described above for extended delays.

3. Permeameters will be protected from freezing by placing large plastic barrels wrapped with insulation over each permeameter and the temperature effect gauge. Should temperatures drop to a level where these provisions become ineffective, the permeameters shall be drained to an elevation corresponding to the top of the compacted clay, and testing will be discontinued until temperatures allow restarting. These procedures are applicable to both Stage 1 and Stage 2 of the Two-Stage-Borehole testing.

The test pad will be constructed in the containment area over the groundwater conveyance layer in order to provide some protection from winds. Following completion of permeability testing, the clay materials used in the test pad will be removed and used for the compacted clay layer within the containment cell.

Enclosed is a revised clay materials analysis summary table along with copies of the geotechnical laboratory results from Geotechnics. The sample previously reported as "initial" has been deleted because it was sampled at the borrow source and not from stockpiles at the Bert Avenue site. Sample C1, which was previously missing USCS classification and grain size data in previous data submitted to Ohio EPA, has been replaced by Sample C17, taken from the clay stockpile. Please note that sample C9 data includes data indicating that less than 100%, by weight, of the material is less than 2 inches in any dimension. During placement of lifts of clay material, the Coordinator of Quality Assurance inspector shall not allow compaction unless he/she verifies that all particles with a dimension of 2 inches or more are removed. If the "picking" of the oversize particles becomes impracticable, the material will not be used in the compacted clay layer or barrier systems unless screened or prepared using alternate methods.

The above alterations will be incorporated into the Technical Specifications and Test Fill Work Plan and will be submitted to Ohio EPA in the certification report upon completion of the work.

As agreed to at the January 30, 1998 meeting, upon your receipt of this letter, we are planning to move forward with the installation of the test pad on February 16, 1998.

Thank you for your assistance and attention to this project.

If you have any questions regarding this letter, please contact me at (716) 592-3431.

Very truly yours,

Theodore G Adams

Theodore G. Adams
Project Manager

SGK:lj:1572
Enclosure

cc: Kurt Princic, OEPA-NEDO
John Romano, Cuyahoga County Board of Health
Ross Landsman, NRC Region 3
Herb Davidson, AWSR
Dave Fannin, Sunbeam-Oster
Mark Wetterhahn, Winston & Strawn
Tim Johnson, USNRC
Mayor Kolar, Village of Newburgh Heights
Barry Koh, B. Koh

AWS Remediation, Inc.
Bert Avenue Site
Project No.: C1220
Clay Analysis Summary - Revision

Sample No.	Sample Date	Soil Classification		Gradation Results				Atterberg Limits		Proctor Value	Optimum Moisture Content	Permeability
		USCS	AASHTO	% < 2"	% > 0.75"	% passing #200 sieve	% < 0.002mm	Liquid Limit	Plasticity Index			
C1	7/31/97	NA	NA	NA	NA	NA	NA	NA	NA	121.7	13.0	-
C2	11/6/97	CL	A-6(10)	100	2	73.1	23.9	27	11	120.5	13.7	-
C3	11/6/97	CL	A-4	100	2	71.5	22.3	25	9	119.8	13.6	-
C4	11/6/97	CL	A-4	100	7.5	66.8	21.5	26	10	119.8	12.7	-
C5	11/6/97	CL	A-4	100	4	69.4	23.1	26	10	118.6	13.1	-
C6	11/6/97	CL	A-4	100	4	68.3	21	25	9	118.8	12.7	-
C7	11/6/97	CL	A-4	100	3	68.4	23.4	25	9	120.6	12.6	-
C8	11/6/97	CL	A-	100	4.5	64.4	19.8	25	10	120.6	12.6	-
C9	11/6/97	CL	A-1	95	7	65.4	21.1	25	9	120.7	13.7	-
C10	11/6/97	CL	A-4	100	1	71.2	24.7	26	10	122.2	12.1	-
C11	11/6/97	CL	A-4	100	3	70	22.3	26	10	118.8	12.7	-
C12	11/6/97	CL	A-6	100	8	67.8	22.7	31	13	115.6	15.5	-
C13	11/6/97	CL	A-4	100	0	72.4	21.8	25	9	118.4	13.8	-
C14	11/6/97	CL	A-6	100	2	63.4	17.8	30	11	116.3	15.1	-
C15	11/6/97	CL	A-6	100	5	67.4	19.5	28	11	115.2	15.2	-
C16*	2/2/98	-	-	-	-	-	-	-	-	121.7	12.3	(1)
C17**	2/2/98	CL	-	100	2.2	72.5	26.3	24	9	123.6	11.4	(1)
C18*	2/2/98	-	-	-	-	-	-	-	-	120.9	12.0	(1)

* Samples taken for ASTM D 5084 Permeability test only

** Sample taken to replace sample C1 for all parameters listed in addition to ASTM D 5084 Permeability

(1) Samples C16, C17 & C18 permeabilities will be available at a later date

Clay Logs.xls

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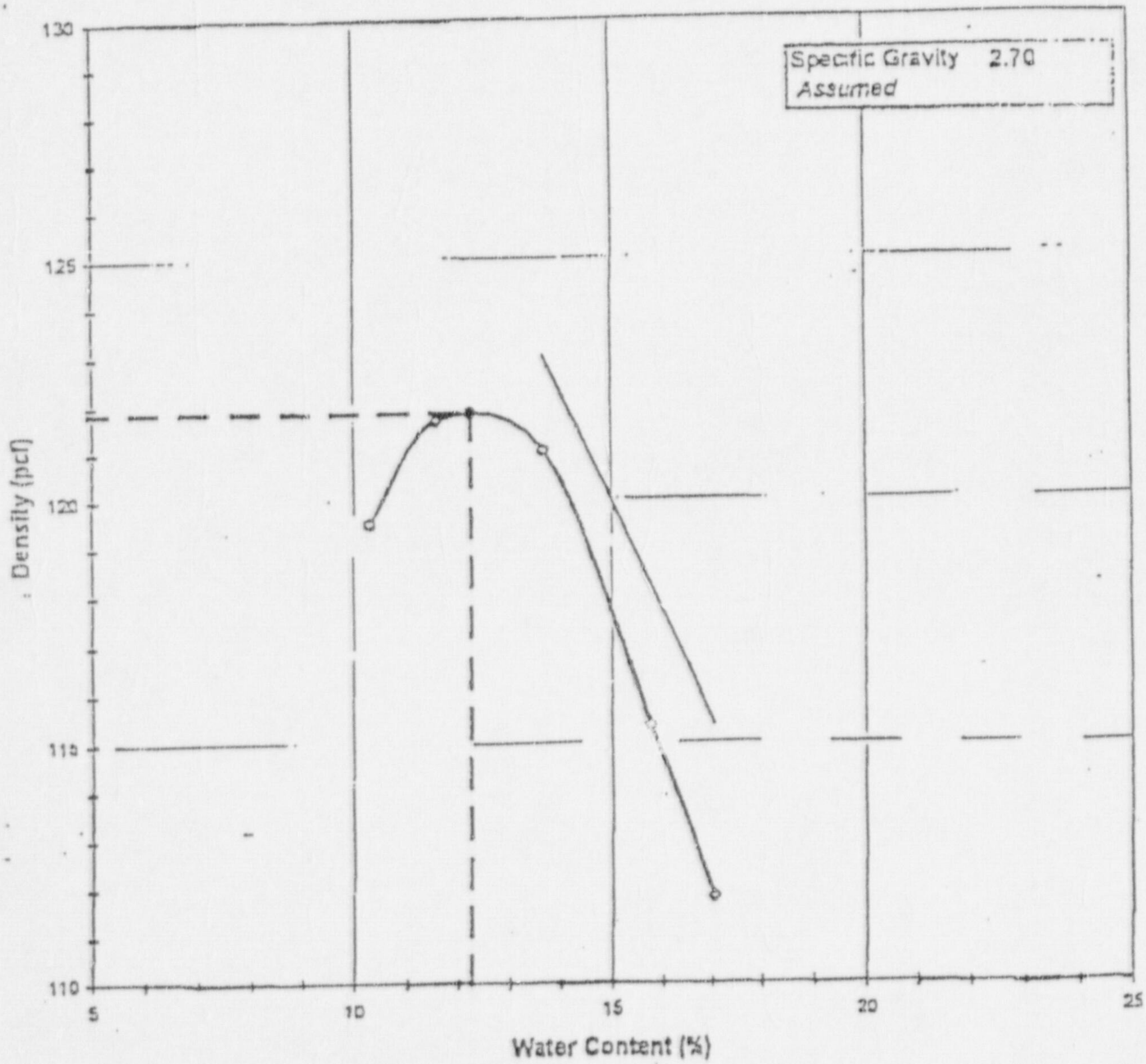
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ES[illegible]	Boring No.	NA
Client Reference	[illegible]ERT AVE.	Depth (ft)	NA
Project No.	[illegible]	Sample No.	C-16
Lab ID	[illegible]-01.001	Test Method	STANDARD

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Optimum Water Content	12.3
Maximum Dry Density	121.8



Tested By MV Date 2/4/98 Checked By Jem Date 2.6.98

 DCN:CT-S12 REVISION:2 DATE: 11/07/97

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-16
Lab ID	98040-01.001		

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	C

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G441
Mold ID	G695
Mold diameter	6
Weight of the Mold	5746
Volume of the Mold(cc)	2124

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	10233	10368	10429	10291	10201
Wt.of Mold (gm)	5746	5746	5746	5746	5746
Wt. of WS	4487	4622	4683	4545	4455
Mold Volume (cc)	2124	2124	2124	2124	2124

Moisture Content / Density

Tare Number	1126	1125	576	1734	567
Wt. of Tare & WS (gm)	355.81	445.80	474.70	428.10	565.90
Wt. of Tare & DS (gm)	330.53	408.30	427.70	381.15	495.80
Wt. of Tare (gm)	85.14	84.37	84.07	83.17	84.57
Wt. of Water (gm)	25.28	37.50	47.00	46.95	70.10
Wt. of DS (gm)	245.39	323.93	343.63	297.98	411.23

Wet Density (gm/cc)	2.11	2.18	2.20	2.14	2.10
Wet Density (pcf)	131.8	135.8	137.6	133.5	130.9
Moisture Content (%)	10.3	11.6	13.7	15.8	17.0
Dry Density (pcf)	119.5	121.7	121.0	115.4	111.8

Zero Air Voids

Moisture Content (%)	13.7	15.8	17.0
Dry Unit Weight (pcf)	123.0	118.2	115.4

Tested By MV *Date* 2/4/98 *Checked By* Jem *Date* 2-6-98

 DCN:CT-S12 REVISION:2 DATE: 11/07/97

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REVISION: 1

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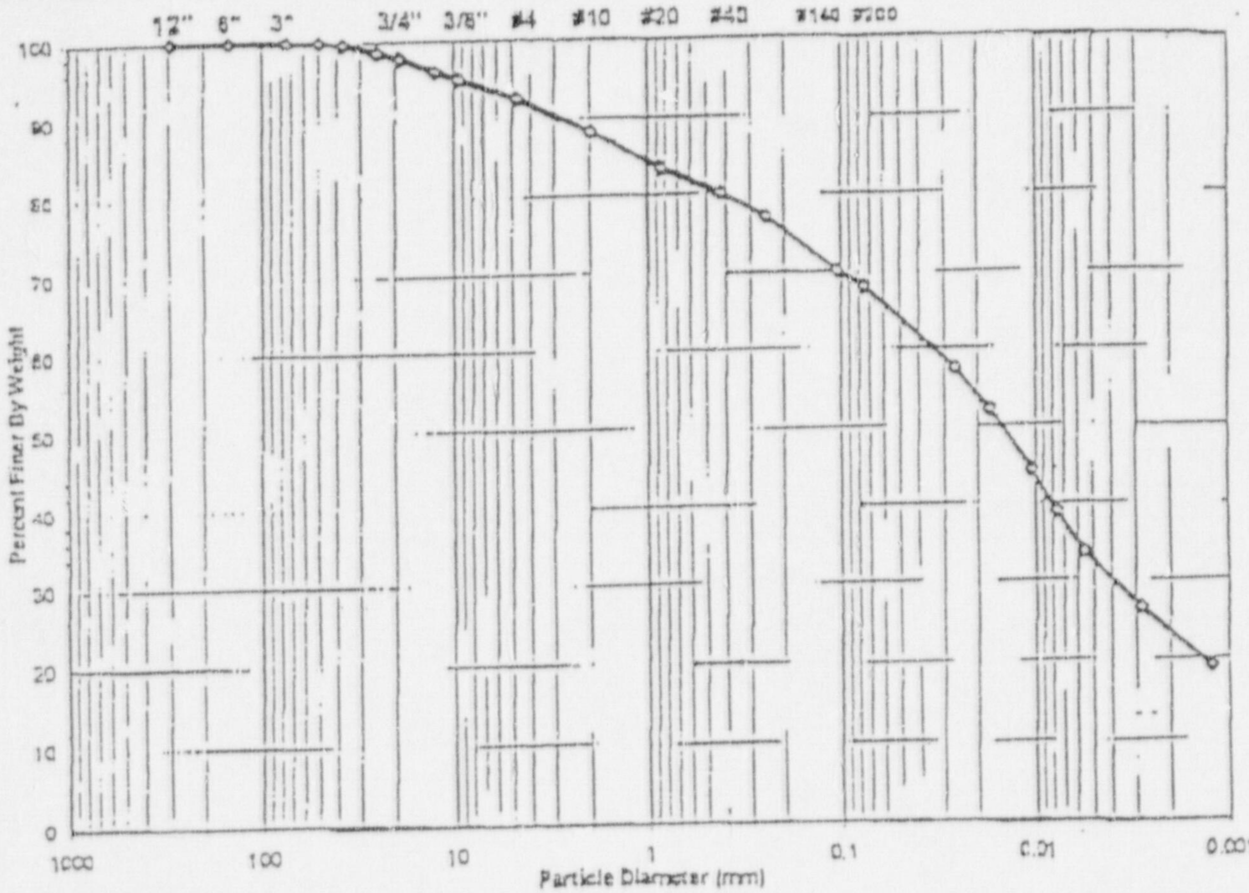
SIEVE AND HYDROMETER ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY

	SIEVE ANALYSIS			HYDROMETER
USCS	gravel	sand	silt and clay fraction	
USDA	gravel	sand	silt	clay



Sieve Size (mm)	Percent Finer	Components	Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
100	100.00	*Gravel*	11.82	0.00
2	88.18	*Sand*	24.27	27.52
0.075	68.04	*Silt*	40.72	46.18
0.05	63.91	*Clay*	23.19	26.30
0.002	23.19			

USDA Classification	*LOAM*
USCS Symbol	*CL, TESTED*
USCS Classification	*SANDY LEAN CLAY*

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DCN: D3-S3A
DATE: 11/12/98
REVISION: 1

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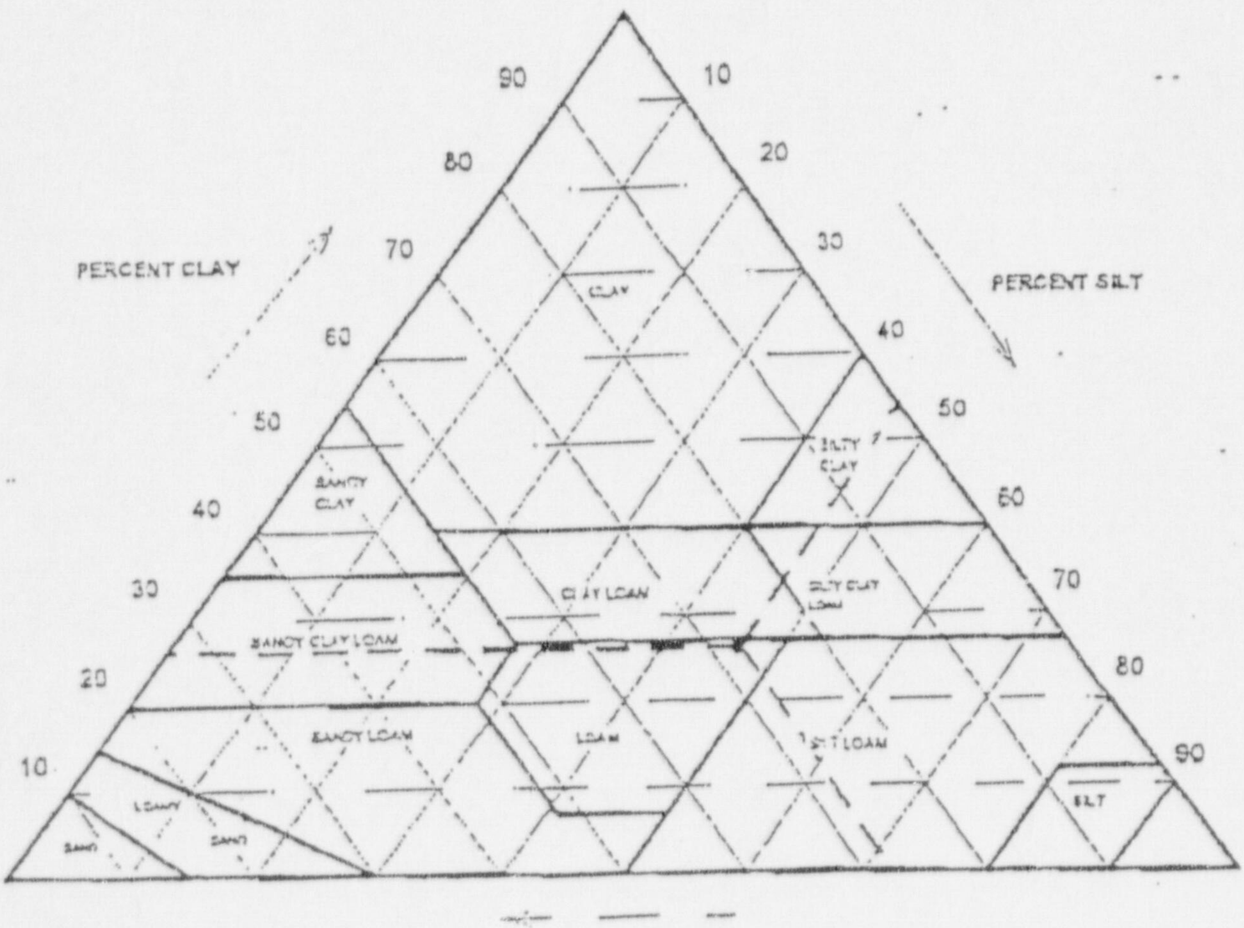
USDA CLASSIFICATION CHART

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY



Components	Corrected % of Minus 2.0 mm material for USDA Classificat.
Gravel	0.00
Sand	27.52
Silt	45.18
Clay	26.30

USDA Classification *LOAM*

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DCN: DS-S3A
DATE: 11/12/96
REVISION: 1

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WASH SIEVE ANALYSIS

ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2457	Tare No.	9
Wgt.Tare + Wet Specimen (gm)	1352.50	Wgt.Tare + Wet Specimen (gm)	425.10
Wgt.Tare + Dry Specimen (gm)	1280.40	Wgt.Tare + Dry Specimen (gm)	419.80
Weight of Tare (gm)	99.91	Weight of Tare (gm)	74.45
Weight of Water (gm)	72.10	Weight of Water (gm)	6.30
Weight of Dry Soil (gm)	1180.49	Weight of Dry Soil (gm)	345.35
Moisture Content (%)	6.1	Moisture Content (%)	1.8

Wet Weight -3/4" Sample (gm)	26564	Weight of the Dry Specimen (gm)	1180.49
Dry Weight - 3/4" Sample (gm)	25035.0	Weight of minus #200 material (gm)	821.24
Wet Weight +3/4" Sample (gm)	563.05	Weight of plus #200 material (gm)	359.25
Dry Weight + 3/4" Sample (gm)	552.96		
Total Dry Weight Sample (gm)	25587.9	J - Factor (Percent Finer than 3/4")	0.9780

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	100.00
6"	150	0.00		0.00	0.00	100.00	100.00
3"	75	0.00		0.00	0.00	100.00	100.00
2"	50	0.00	(*)	0.00	0.00	100.00	100.00
1 1/2"	37.5	75.82		0.30	0.30	99.70	99.70
1"	25	294.51		1.15	1.45	98.55	98.55
3/4"	19	192.72		0.75	2.20	97.80	97.80
1/2"	12.5	19.14		1.62	1.62	98.38	96.21
3/8"	9.5	13.81		1.17	2.79	97.21	95.07
#4	4.75	29.58		2.51	5.30	94.70	92.62
#10	2	53.61		4.54	9.84	90.16	88.18
#20	0.85	57.59	(**)	4.88	14.72	85.28	83.41
#40	0.425	40.08		3.40	18.11	81.89	80.09
#60	0.25	36.60		3.10	21.21	78.79	77.05
#140	0.106	83.69		7.09	28.30	71.70	70.12
#200	0.075	25.14		2.13	30.43	69.57	68.04
Pan	-	821.24		69.57	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/4/98 Checked By T.D. Date 2-9-98

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DCN: DS-S3A
DATE: 11/12/96
REVISION: 1

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HYDROMETER ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY

Elapsed Time (min)		R Measured	Temp. (°C)	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0	NA	NA	NA	NA	NA	NA	NA	NA
2	50.0	50.0	22.3	43.4	84.3	0.01308	0.0263	57.4
5		46.0	22.3	39.4	76.5	0.01308	0.0173	52.1
15		40.0	22.3	33.4	64.9	0.01308	0.0105	44.2
30		36.0	22.3	29.4	57.1	0.01308	0.0077	38.9
61		32.0	22.3	25.4	49.3	0.01308	0.0056	33.6
250		26.5	22.5	19.9	38.6	0.01305	0.0029	26.3
1440		21.0	22.1	14.4	27.9	0.01311	0.0012	19.0

Soil Specimen Data		Other Corrections	
Tare No.	532		
Tare + Dry Material (gm)	157.64	a - Factor	0.99
Weight of Tare (gm)	101.73	Composite Correction	6.63
Weight of Deflocculant (gm)	5.0	Percent Finer than # 200	68.04
Weight of Dry Material (gm)	50.91		
		Specific Gravity	2.7 Assumed

Note: Hydrometer test is performed on - # 200 sieve material.

Tested By TO Date 2/4/98 Checked By Jcm Date 2-9-98

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ATTERBERG LIMIT

ASTM D 4318-95 (SOP - S4)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Description	GRAY LEAN CLAY

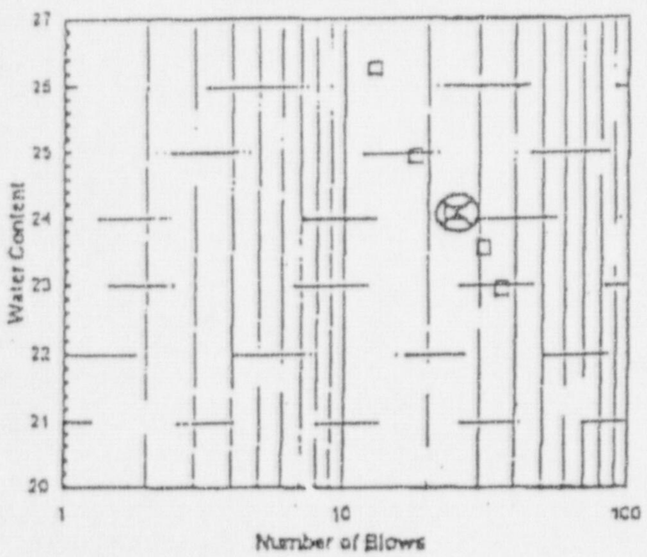
Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

Liquid Limit Test	1	2	3	4	5	MULTIPOINT
Tare Number	2317	2055	2239	2316	2080	
Wt. of Tare & WS (gm)	41.05	40.98	40.39	49.17	42.57	
Wt. of Tare & DS (gm)	36.29	36.74	35.99	43.25	37.15	
Wt. of Tare (gm)	15.55	18.75	17.71	19.53	16.52	
Wt. of Water (gm)	4.76	4.24	4.4	5.92	5.42	
Wt. of DS (gm)	20.74	17.99	18.28	23.72	20.63	
Moisture Content (%)	23.0	23.6	24.1	25.0	26.3	
Number of Blows	35	31	24	18	13	

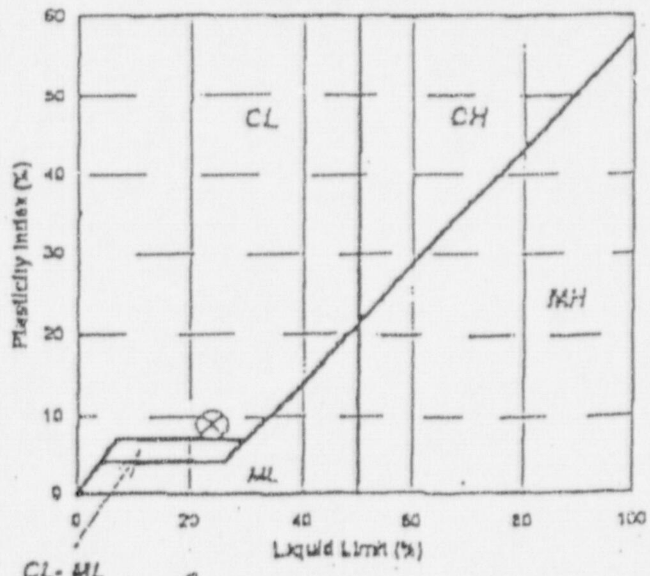
Plastic Limit Test	1	2	3
Tare Number	2047	1837	2041
Wt. of Tare & WS (gm)	21.94	24.63	24.86
Wt. of Tare & DS (gm)	21.12	23.82	23.97
Wt. of Tare (gm)	15.58	18.26	17.83
Wt. of Water (gm)	0.82	0.81	0.89
Wt. of DS (gm)	5.54	5.56	6.14
Moisture Content (%)	14.8	14.6	14.5

Test Results	
Liquid Limit (%)	24
Plastic Limit (%)	15
Plasticity Index (%)	9
USCS Symbol	CL

Flow Curve



Plasticity Chart



Tested By TO *Date* 2/9/98 *Checked By* Jcm *Date* 2.10.98

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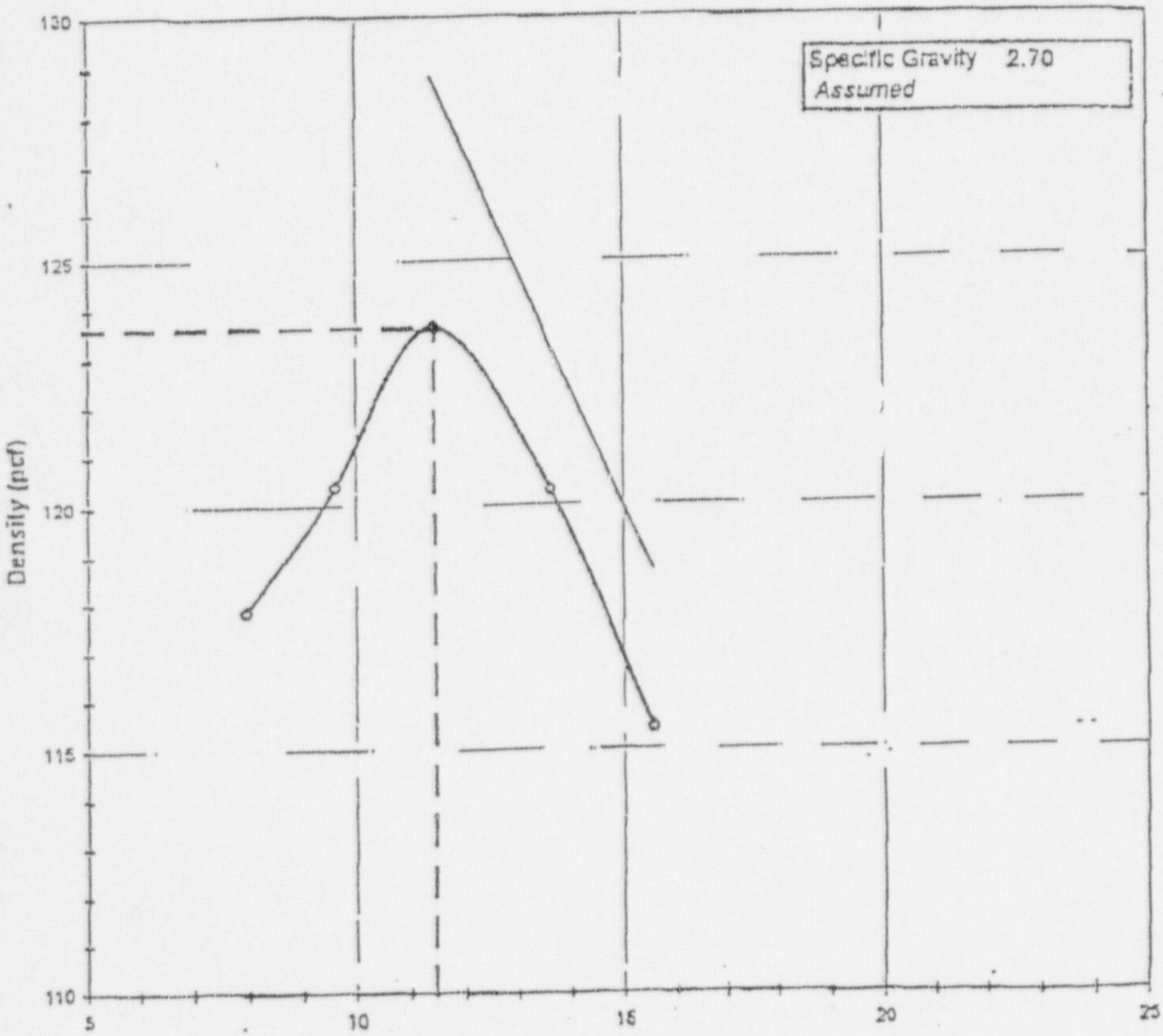
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Test Method	STANDARD

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Optimum Water Content	11.4
Maximum Dry Density	123.5



Tested By JP Date 2/4/98 Checked By Jcm Date 2-6-98

 DCN:CT-S12 REVISION:2 DATE: 11/07/97

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002		

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	C

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G441
Mold ID	G778
Mold diameter	6
Weight of the Mold	5584
Volume of the Mold(cc)	2124

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	9913	10074	10272	10236	10124
Wt.of Mold (gm)	5584	5584	5584	5584	5584
Wt. of WS	4329	4490	4688	4652	4540
Mold Volume (cc)	2124	2124	2124	2124	2124

Moisture Content / Density

Tare Number	582	569	1701	538	574
Wt. of Tare & WS (gm)	477.70	459.40	439.70	534.10	657.60
Wt. of Tare & DS (gm)	448.80	426.50	403.00	480.00	580.40
Wt. of Tare (gm)	84.13	83.36	81.34	82.15	83.72
Wt. of Water (gm)	28.90	32.90	36.70	54.10	77.20
Wt. of DS (gm)	364.67	343.14	321.66	397.85	496.68

Wet Density (gm/cc)	2.04	2.11	2.21	2.19	2.14
Wet Density (pcf)	127.2	131.9	137.7	136.7	133.4
Moisture Content (%)	7.9	9.6	11.4	13.6	15.5
Dry Density (pcf)	117.8	120.4	123.6	120.3	115.4

Zero Air Voids

Moisture Content (%)	11.4	13.6	15.5
Dry Unit Weight (pcf)	128.8	123.2	118.7

Tested By JP *Date* 2/4/98 *Checked By* Jcm *Date* 2-6-98

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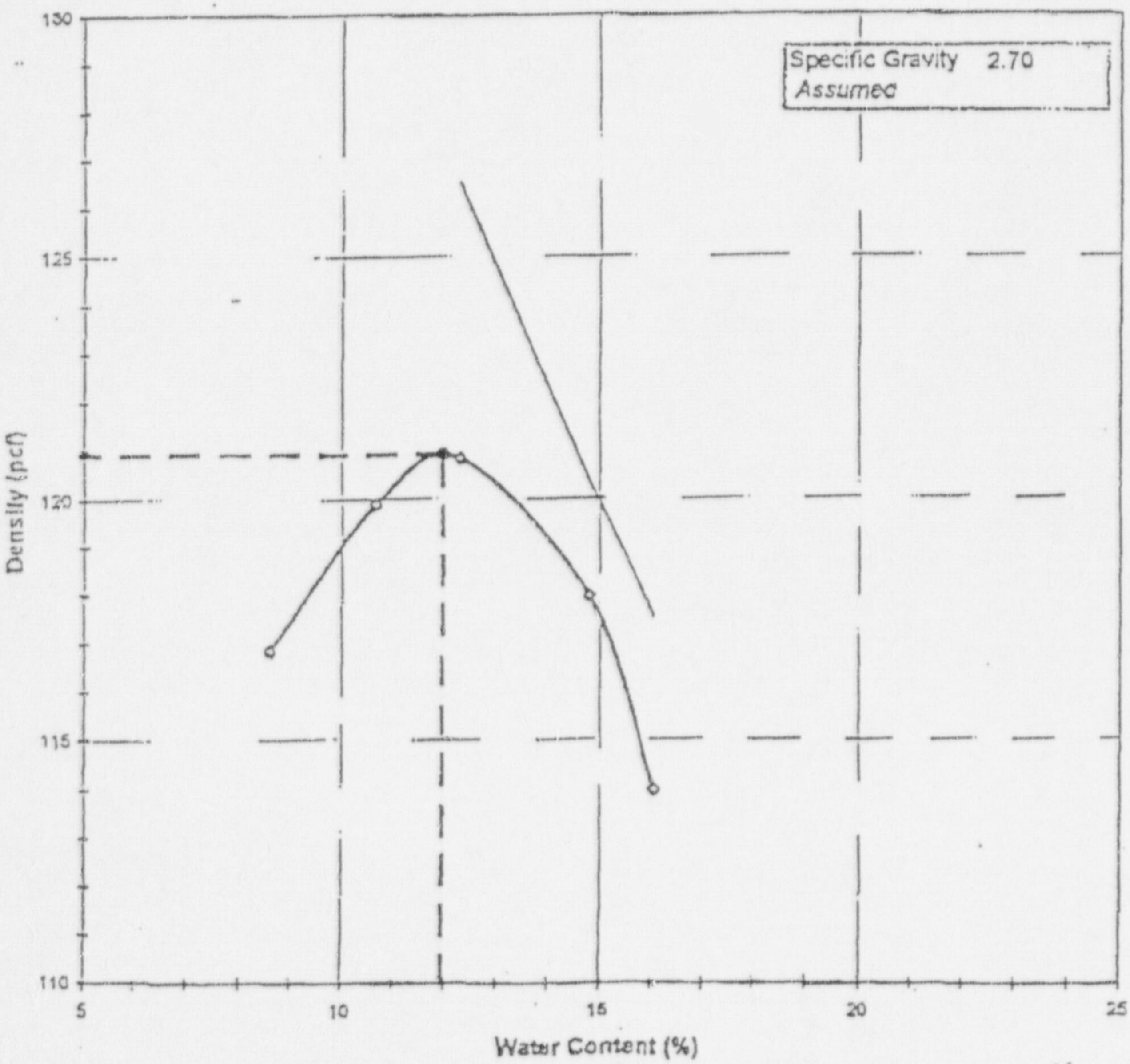
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-18
Lab ID	98040-01.003	Test Method	STANDARD

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Optimum Water Content	12.0
Maximum Dry Density	120.9



Tested By MV *Date* 2/4/98 *Checked By* [signature] *Date* 2-6-98

 DCN:CT-S12 REVISION:2 DATE: 11/07/97

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-18
Lab ID	98040-01.003		

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	C

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G441
Mold ID	G685
Mold diameter	6
Weight of the Mold	5746
Volume of the Mold(cc)	2124

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	10066	10262	10364	10356	10249
Wt.of Mold (gm)	5746	5745	5746	5746	5746
Wt. of WS	4320	4516	4618	4610	4503
Mold Volume (cc)	2124	2124	2124	2124	2124

Moisture Content / Density

Tare Number	1694	1661	1700	545	ZZ
Wt. of Tare & WS (gm)	406.20	390.32	426.50	418.70	422.60
Wt. of Tare & DS (gm)	380.73	360.79	388.56	375.41	375.86
Wt. of Tare (gm)	84.03	83.61	79.45	82.81	84.69
Wt. of Water (gm)	25.47	29.53	37.94	43.29	46.74
Wt. of DS (gm)	296.70	277.18	309.11	292.60	291.17

Wet Density (gm/cc)	2.03	2.13	2.17	2.17	2.12
Wet Density (pcf)	126.9	132.7	135.7	135.4	132.3
Moisture Content (%)	8.6	10.7	12.3	14.8	16.1
Dry Density (pcf)	116.9	119.9	120.8	118.0	114.0

Zero Air Voids

Moisture Content (%)	12.3	14.8	16.1
Dry Unit Weight (pcf)	126.5	120.4	117.5

Tested By MV *Date* 2/4/98 *Checked By* Jem *Date* 2-6-98

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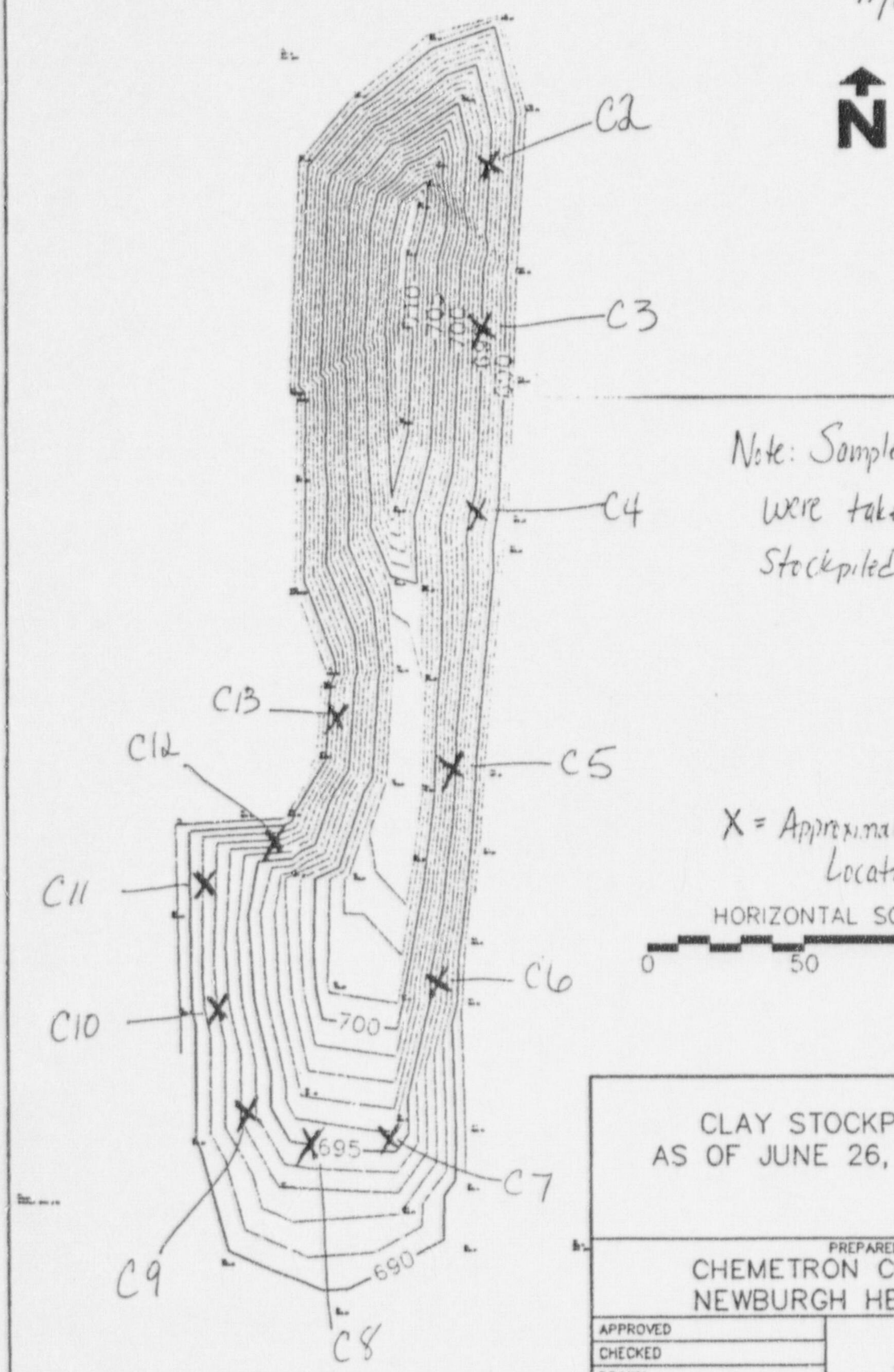
Appendix B

Clay Stockpile and Sample Location Drawings

Clay Sample Location Drawing
11/6/97



Note: Samples C14 & C15 were taken from clay stockpiled onsite

X = Approximate Sample Location

HORIZONTAL SCALE – FEET
0 50 100 150

CLAY STOCKPILE VOLUME
AS OF JUNE 26, 1997 2:00 PM

PREPARED FOR
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO

APPROVED	
CHECKED	
DRAWN	
DRAWING NUMBER	C1220A10

AWS Remediation, Inc.

REVISION	DATE	DESCRIPTION

SHEET 1 OF 1 SUBJECT Clay Stockpile & Sample Locations

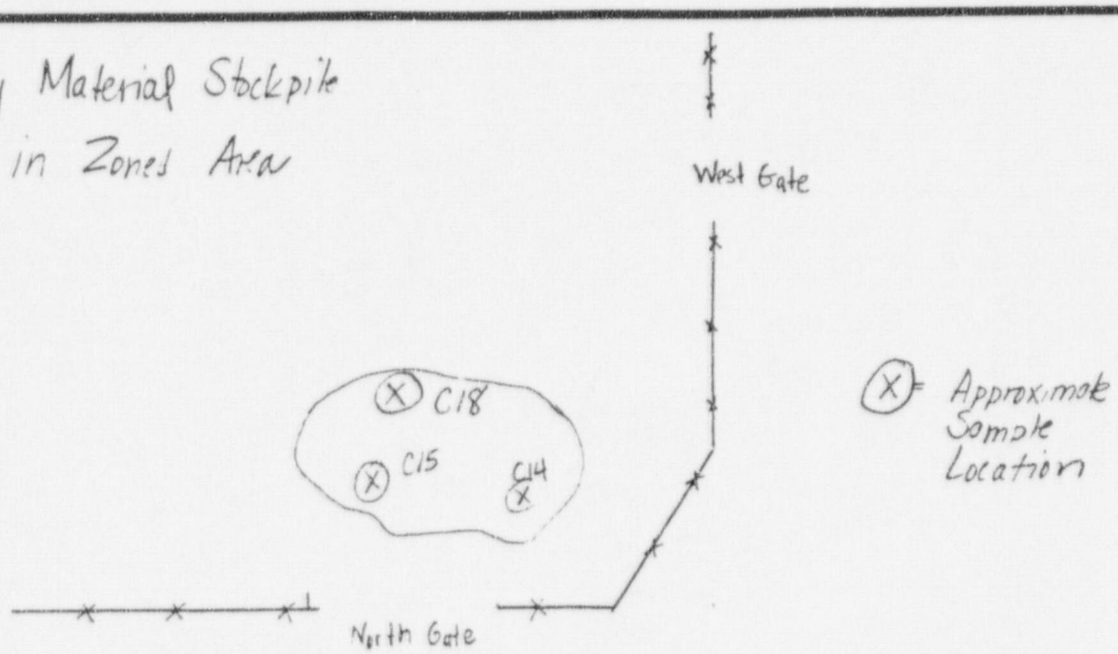
PROJECT NO. C1220-17

BY NTY DATE 3/10/98

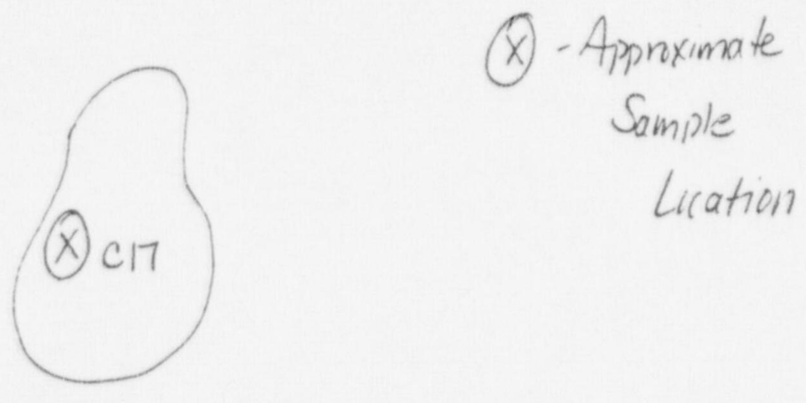
CHECKED ______ DATE ______

Earth Sciences Consultants, Inc.

Clay Material Stockpile in Zones Area



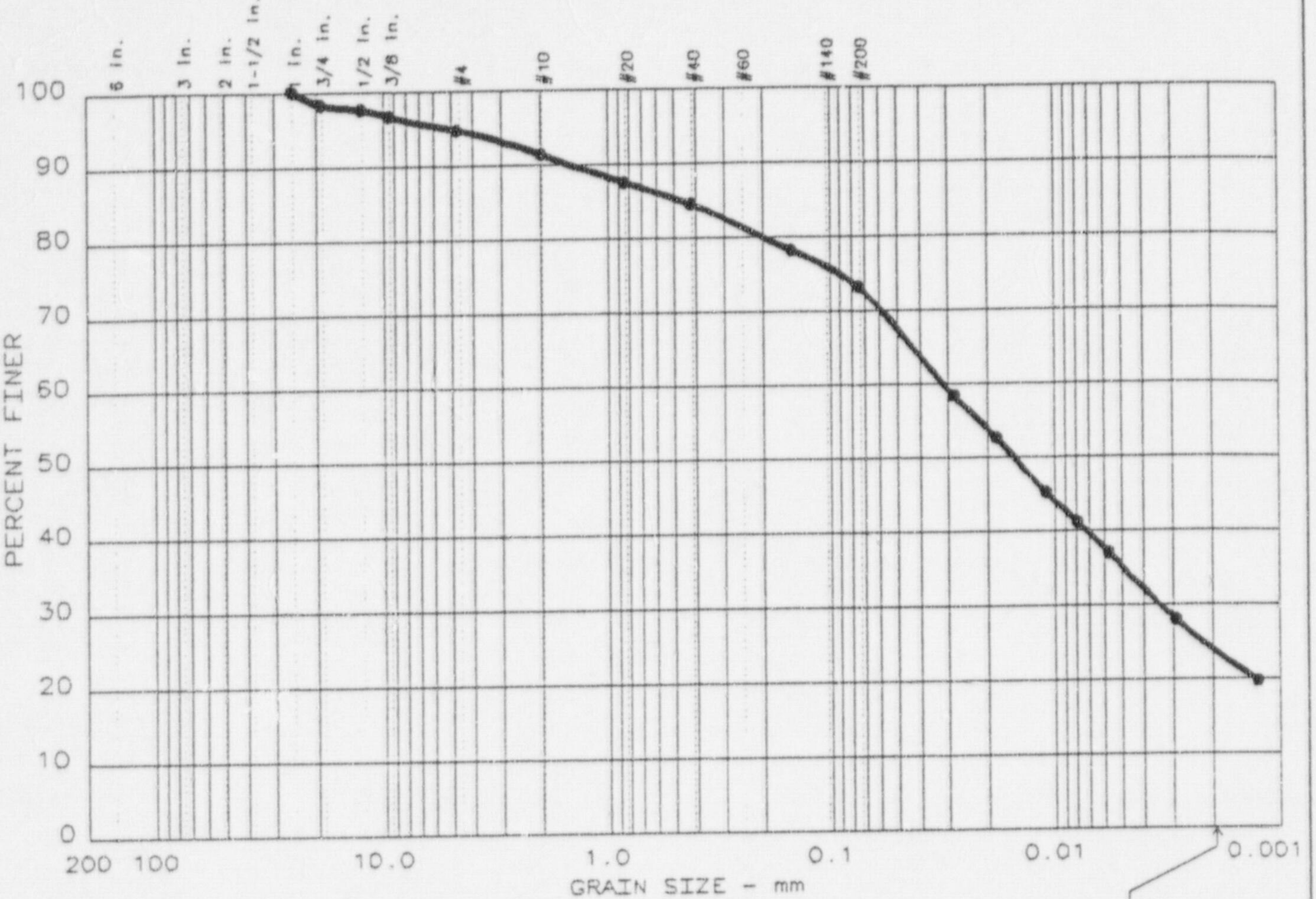
Small Clay Material Stockpile in LTV Property



Appendix C

Laboratory Data on Clay Material

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	8.7	18.2	49.2	23.9

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	27	11	1.50		0.0153	0.0034				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-6

Project No.: A97820x12

Project: Bert Ave. Site Closure

● Location: C2

Date: 11-18-1997

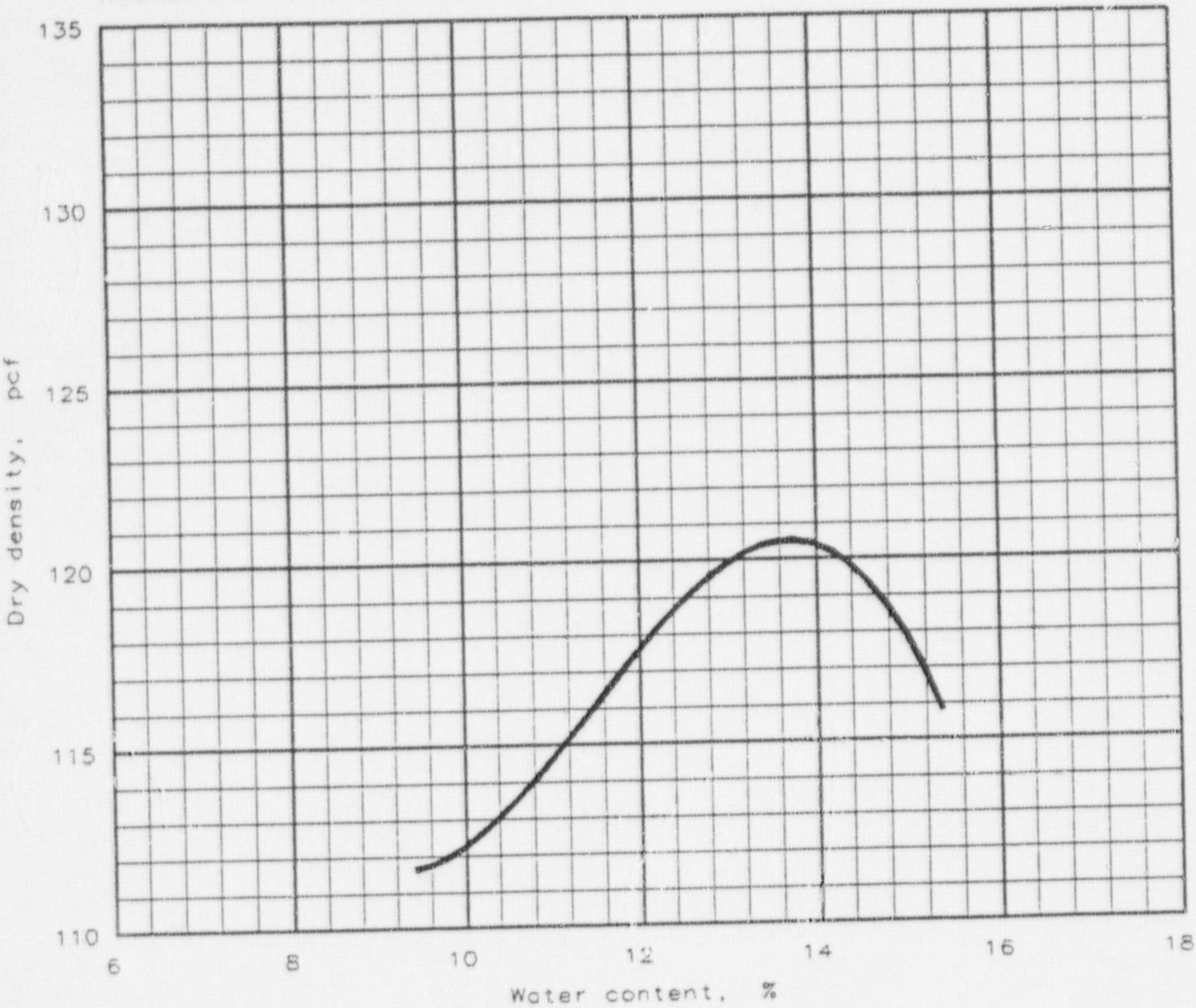
GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
			11 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 120.5 pcf Optimum moisture = 13.7 %	Gray CLAYEY SILT, little sand trace shale, gravel

Project No.: A97820x1

Project: Bert Avenue Site

Location: C2

Date: 11-14-1997

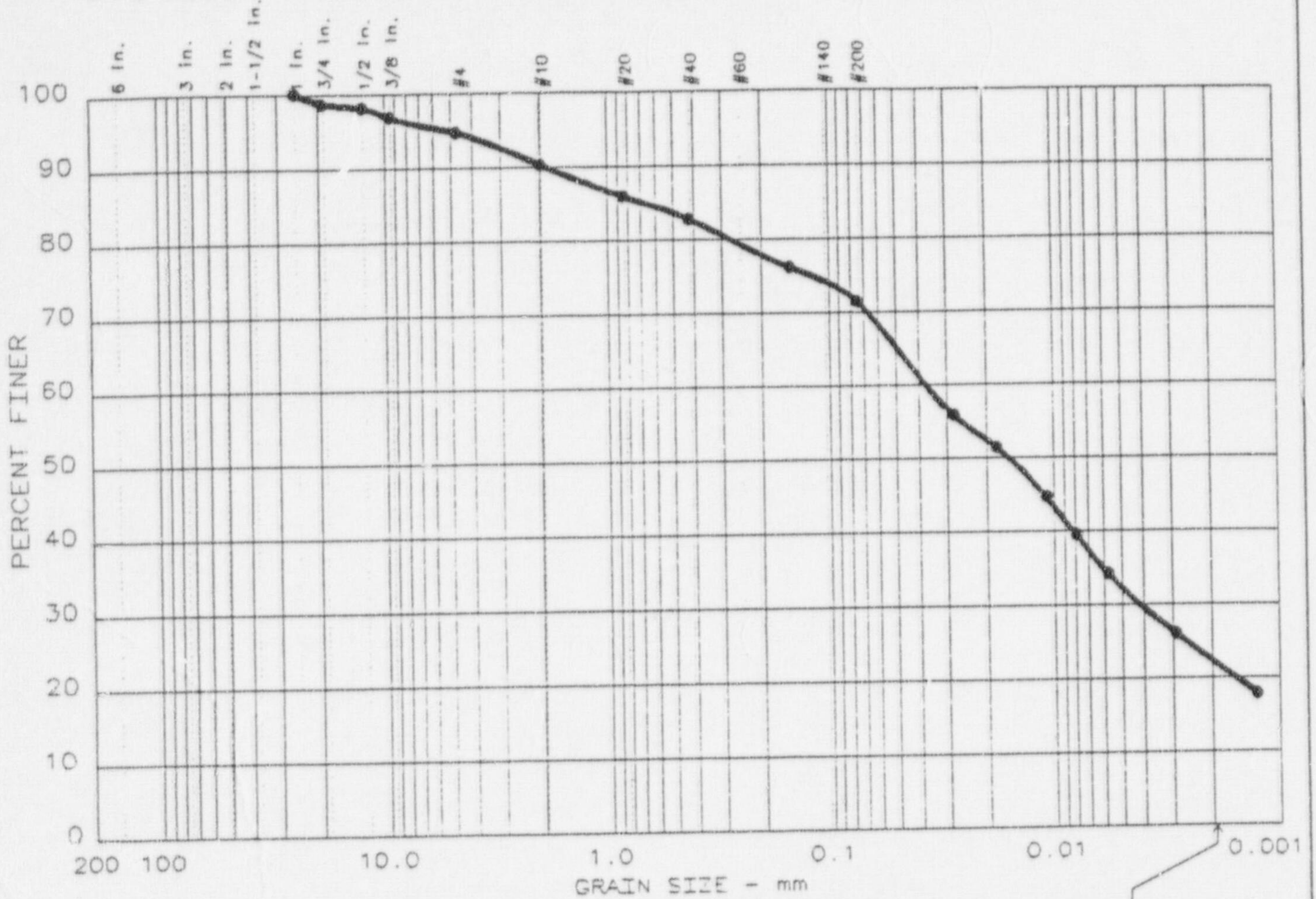
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	20	0.0	9.8	18.7	49.2	22.3

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	25	9	1.91		0.0160	0.0042				

	MATERIAL DESCRIPTION	USCS	AASHTO
●		CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C3

Date: 11-18-1997

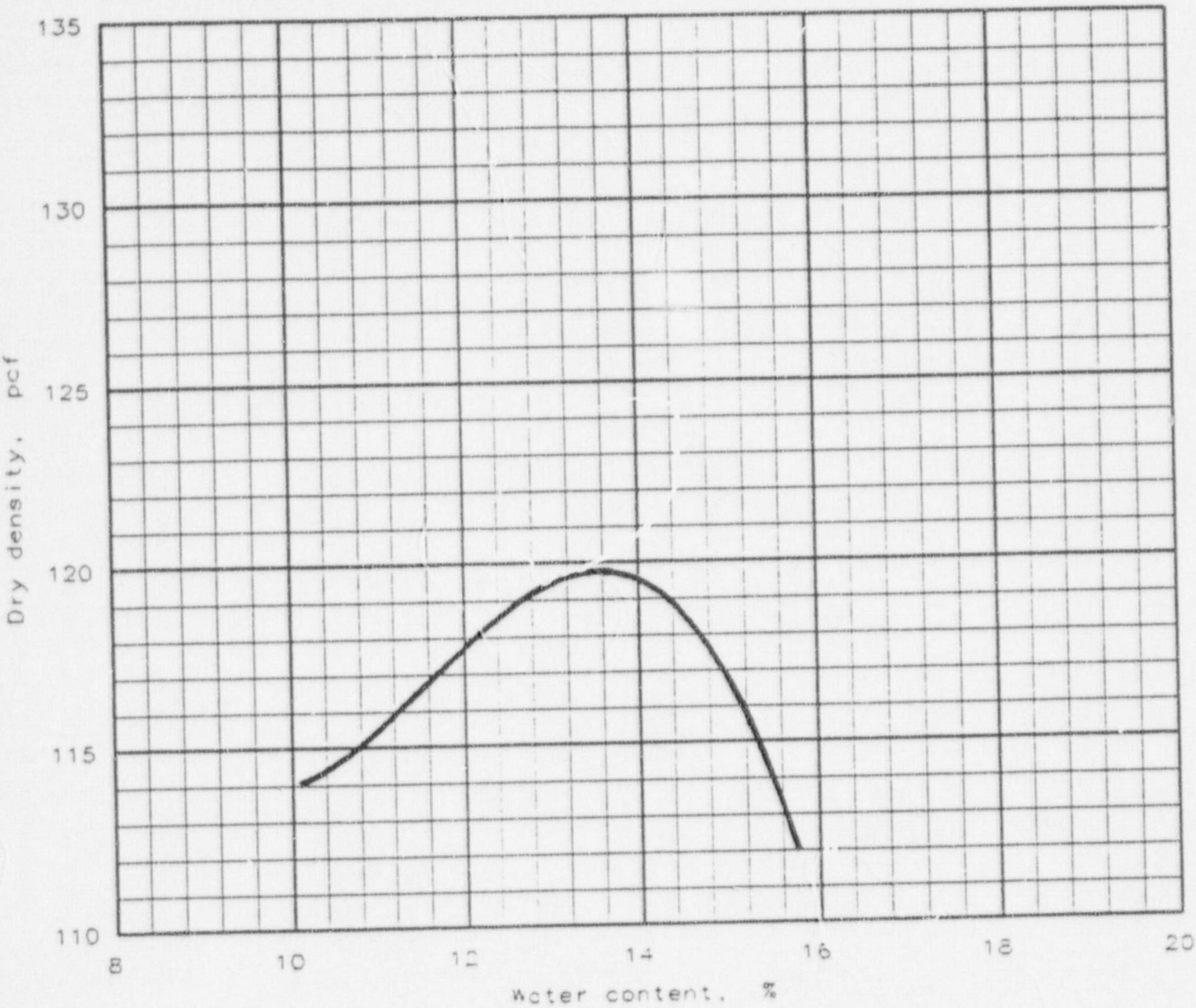
GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			9.2 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 119.8 pcf Optimum moisture = 13.6 %	Gray SILT, some clay, little sand, trace shale fragments, gravel

Project No.: E97820x1

Project: Bert Avenue Site Closure

Location: C3

Date: 11-18-1997

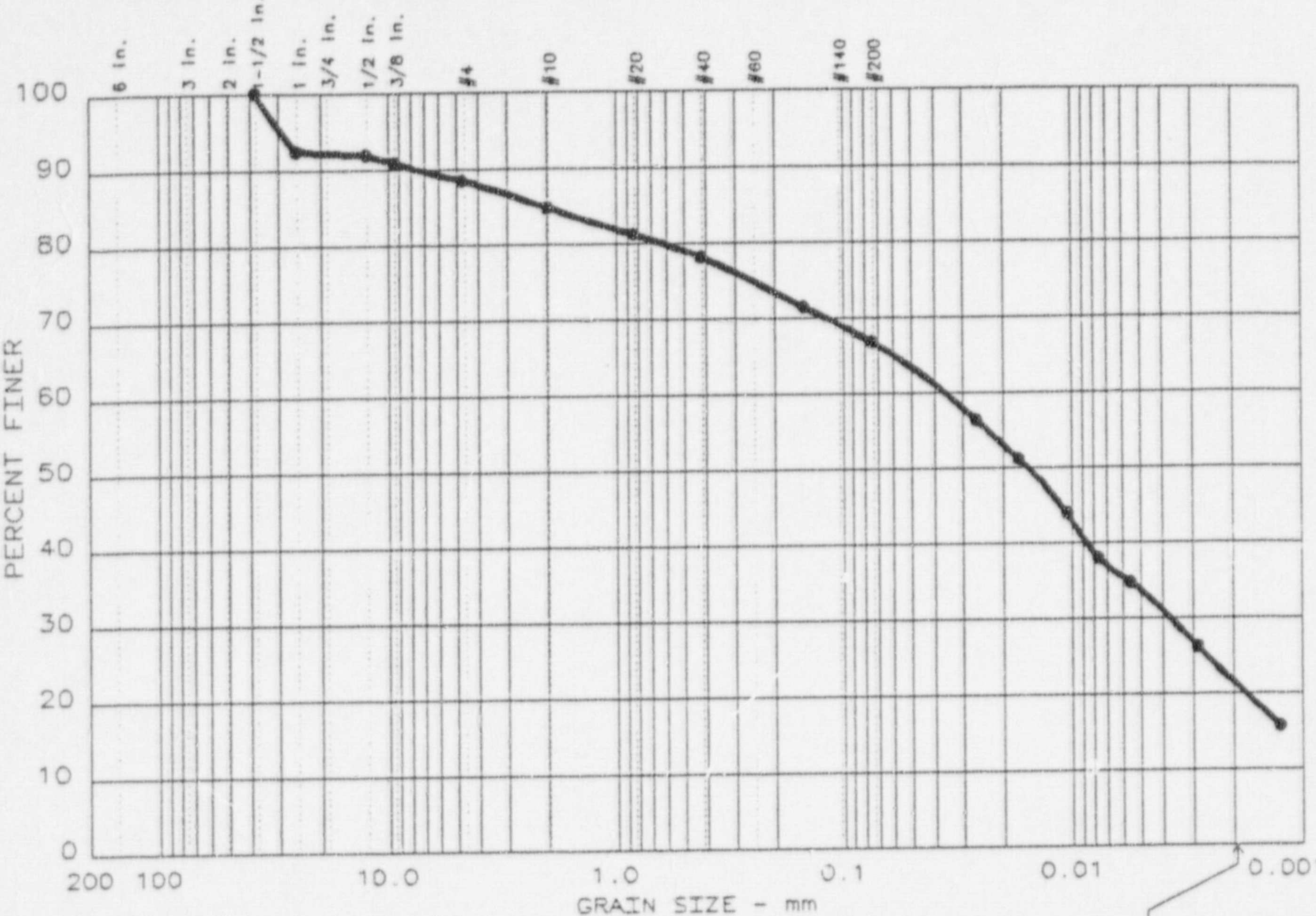
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	15.3	17.9	45.3	21.5

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	26	10	7.50		0.0157	0.0037				

	MATERIAL DESCRIPTION	USCS	AASHTO
●		CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C4

Date: 11-18-1997

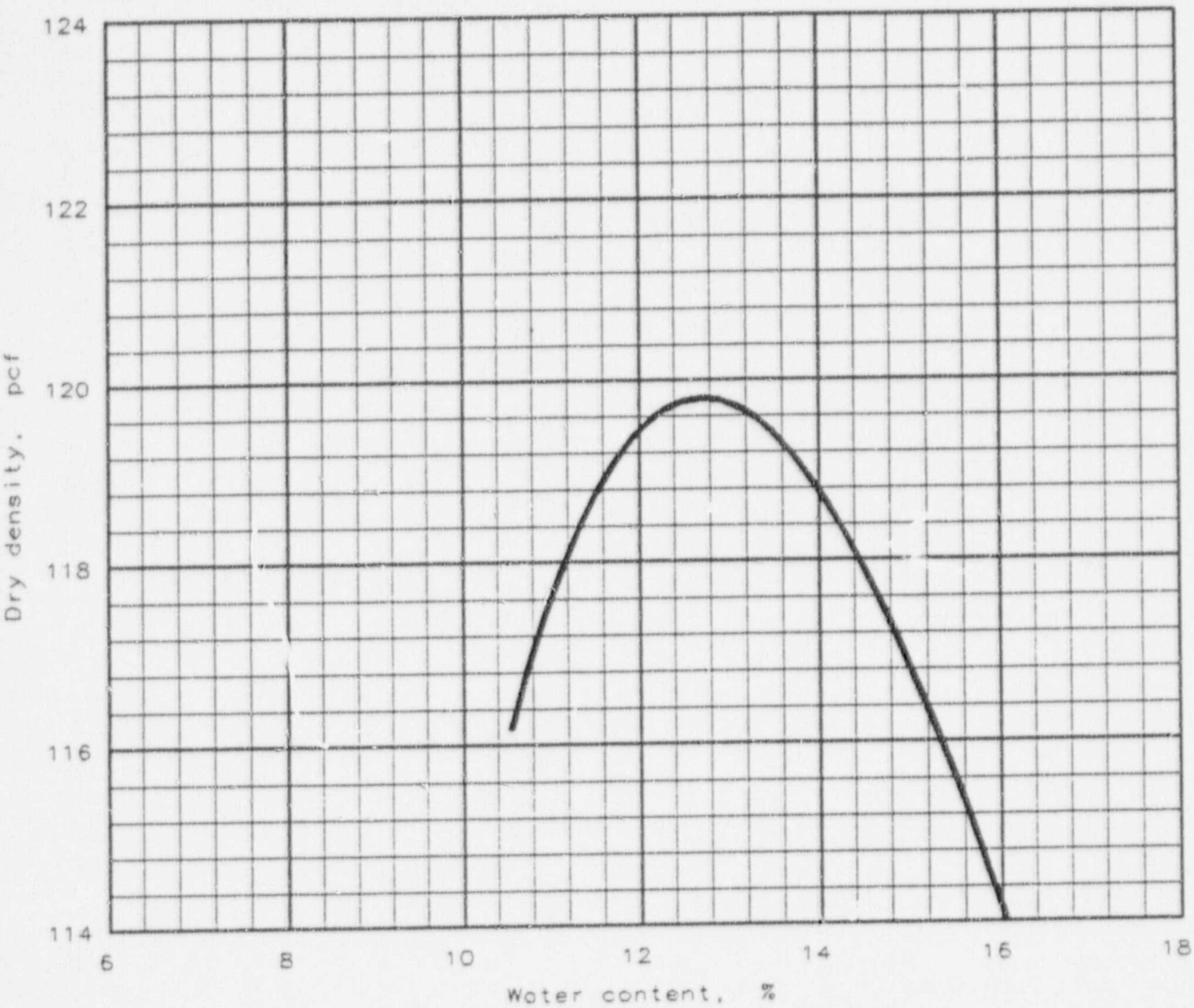
Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			10.3 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 119.8 pcf Optimum moisture = 12.7 %	Gray CLAYEY SILT , little sand, few shale fragments, trace gravel

Project No.: A97820x1

Project: Bert Avenue Site

Location: C4

Date: 11-14-1997

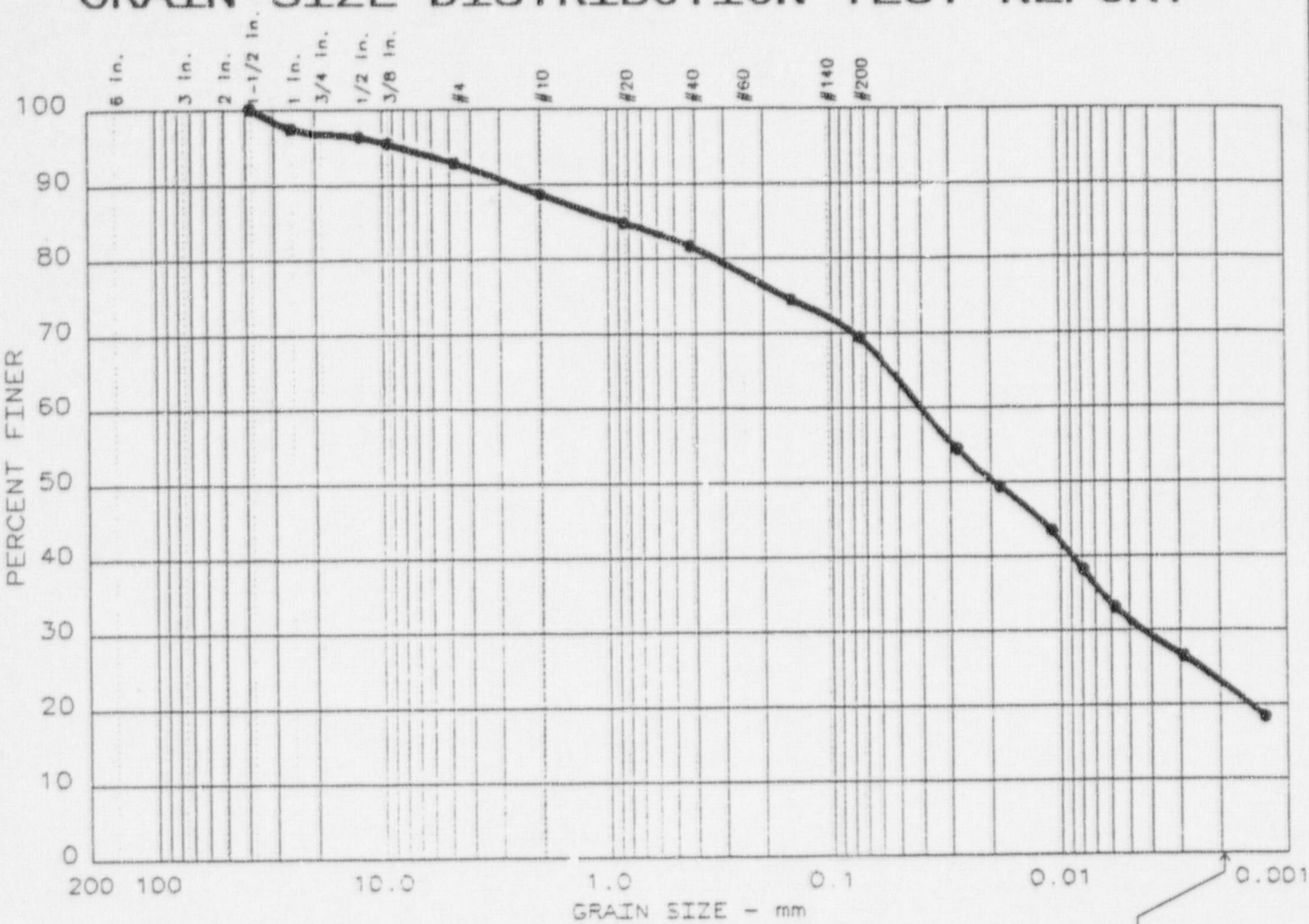
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	11	0.0	11.5	19.1	46.3	23.1

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	26	10	2.66		0.0195	0.0044				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C5

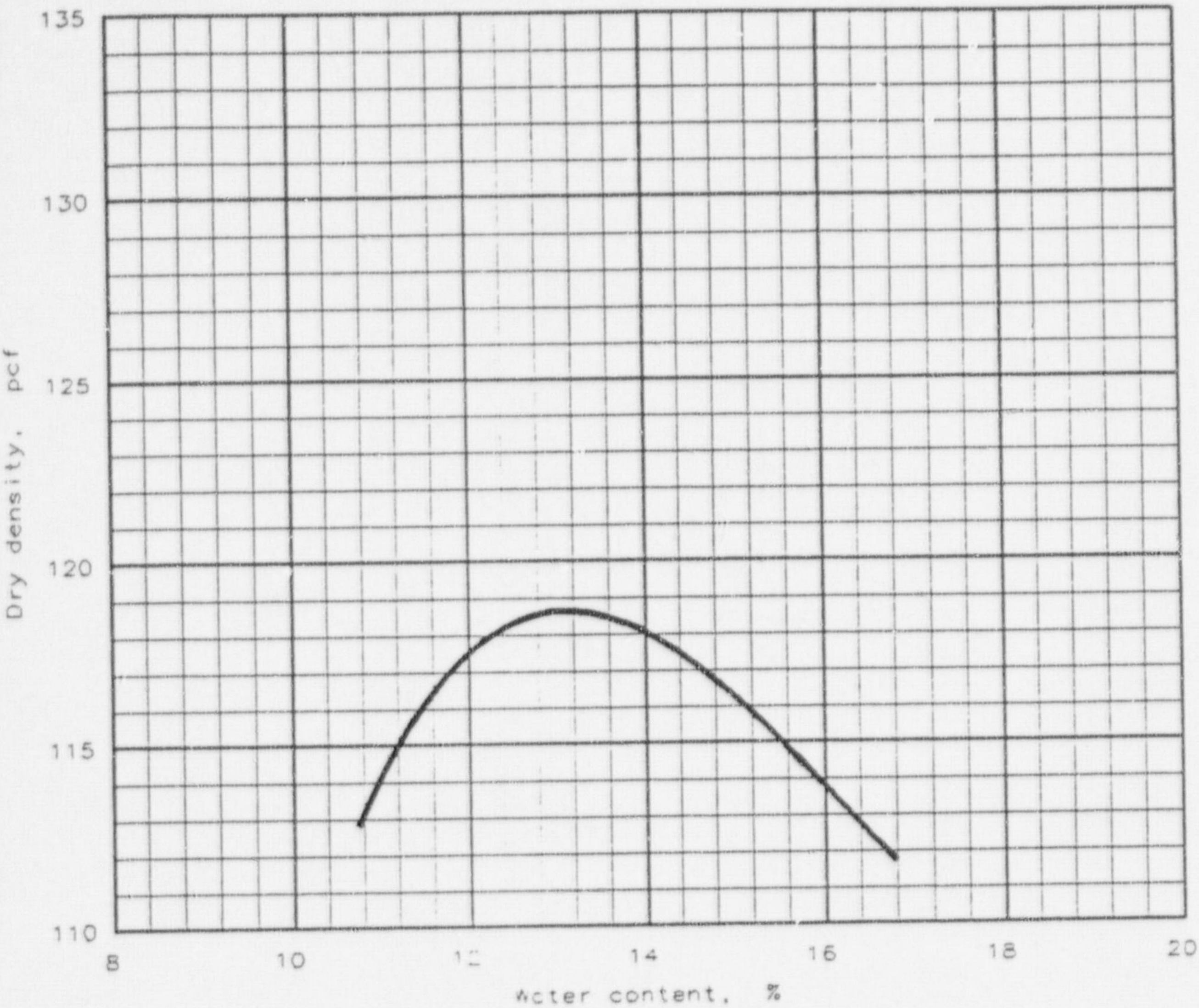
Date: 11-18-1997

GRAIN SIZE DISTRIBUTION TEST REPORT
SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification USCS	AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
			9.7 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 118.6 pcf Optimum moisture = 13.1 %	Gray Silt, some clay, little sand trace shale, gravel

Project No.: E97820x1

Project: Bert Avenue Site

Location: C5

Date: 11-19-1997

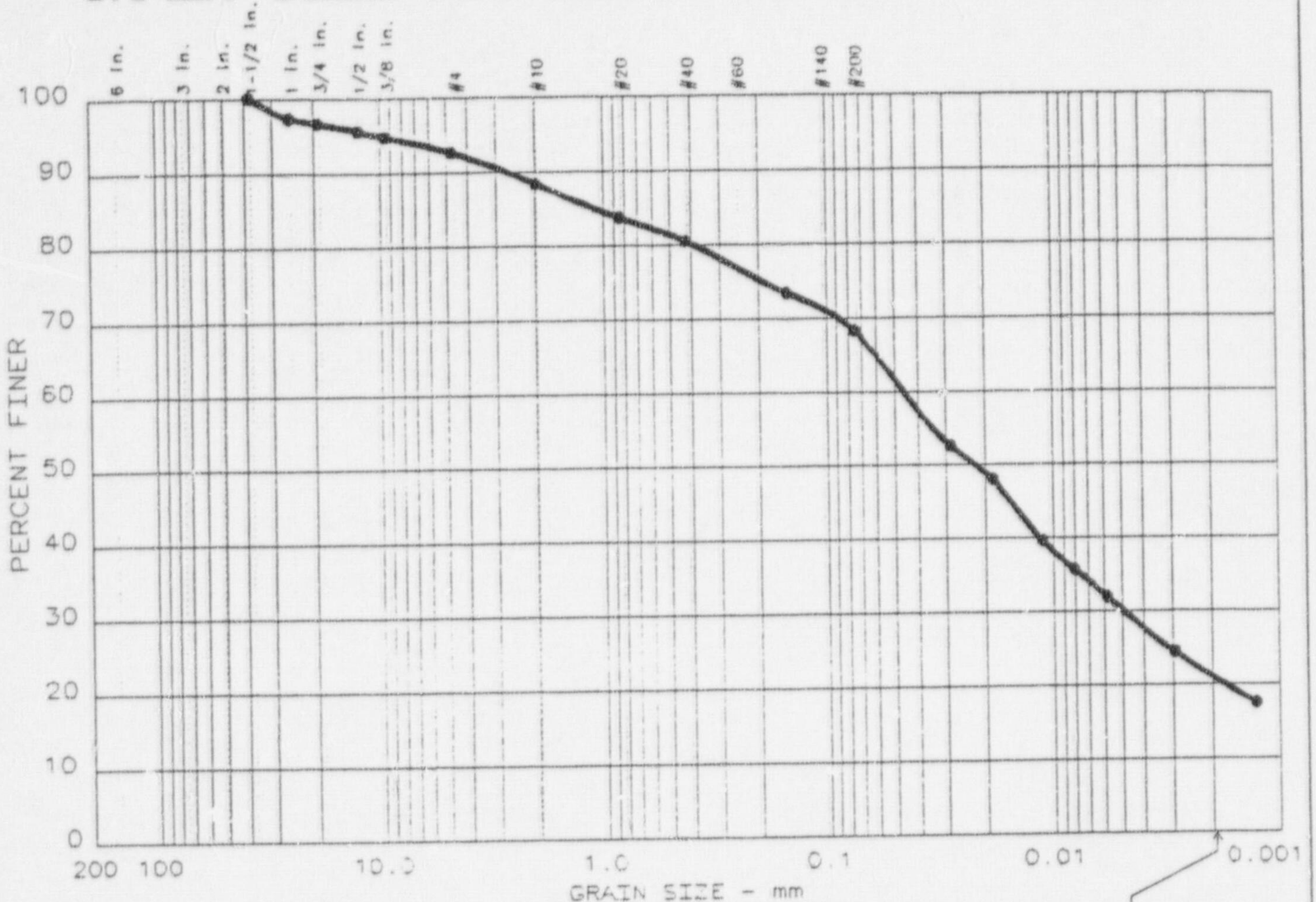
MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Remarks:

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	13	0.0	11.7	20.0	47.3	21.0

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	25	9	2.66		0.0221	0.0049				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-4

Project No.: A97820x12

Project: Bert Ave. Site Closure

● Location: C6

Date: 11-18-1997

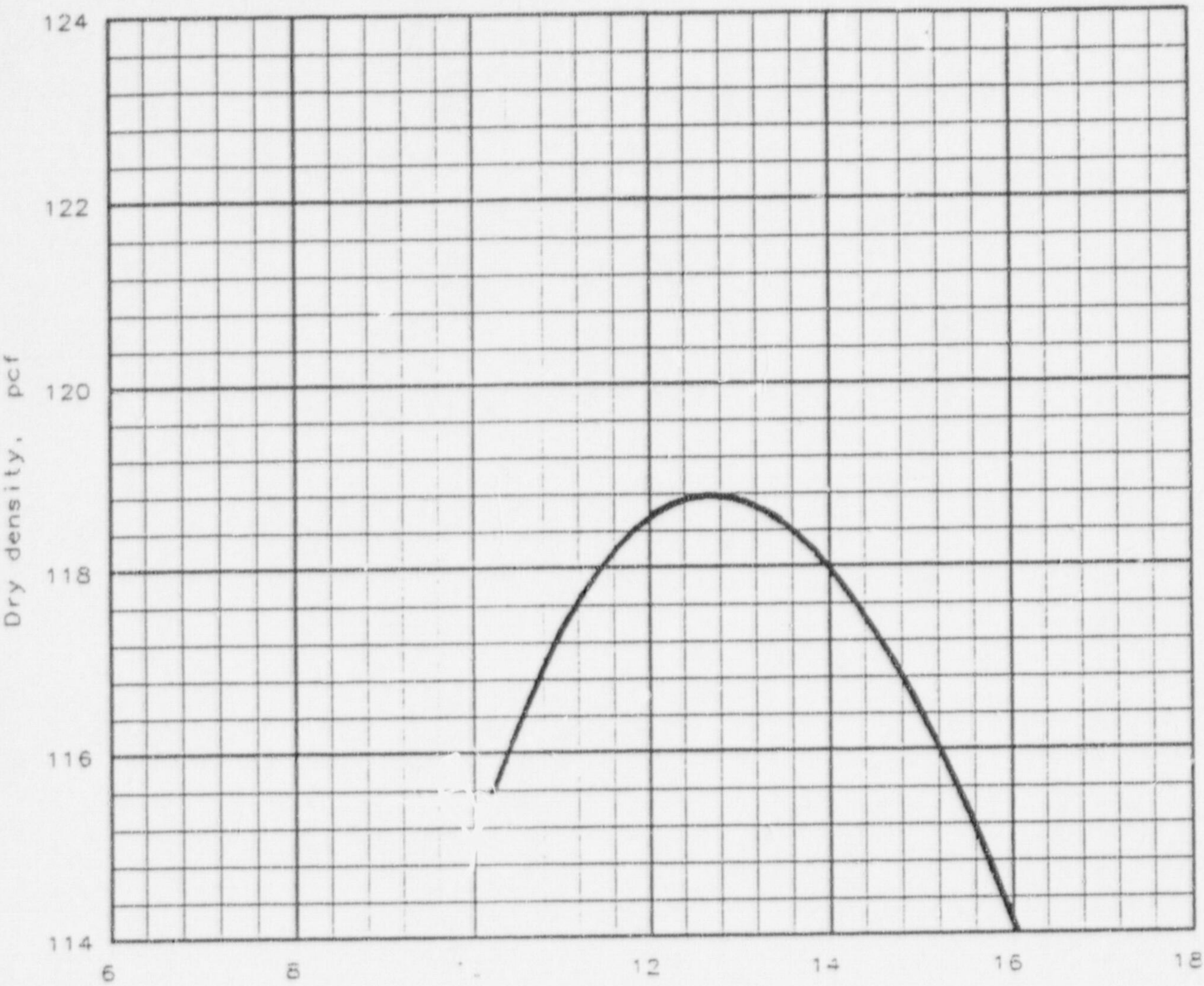
GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			9.4 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 118.8 pcf Optimum moisture = 12.7 %	Gray SILT, some clay, little sand trace gravel, shale

Project No.: E97820x1

Project: Bert Avenue Site Closure

Location: C6

Date: 11-19-1997

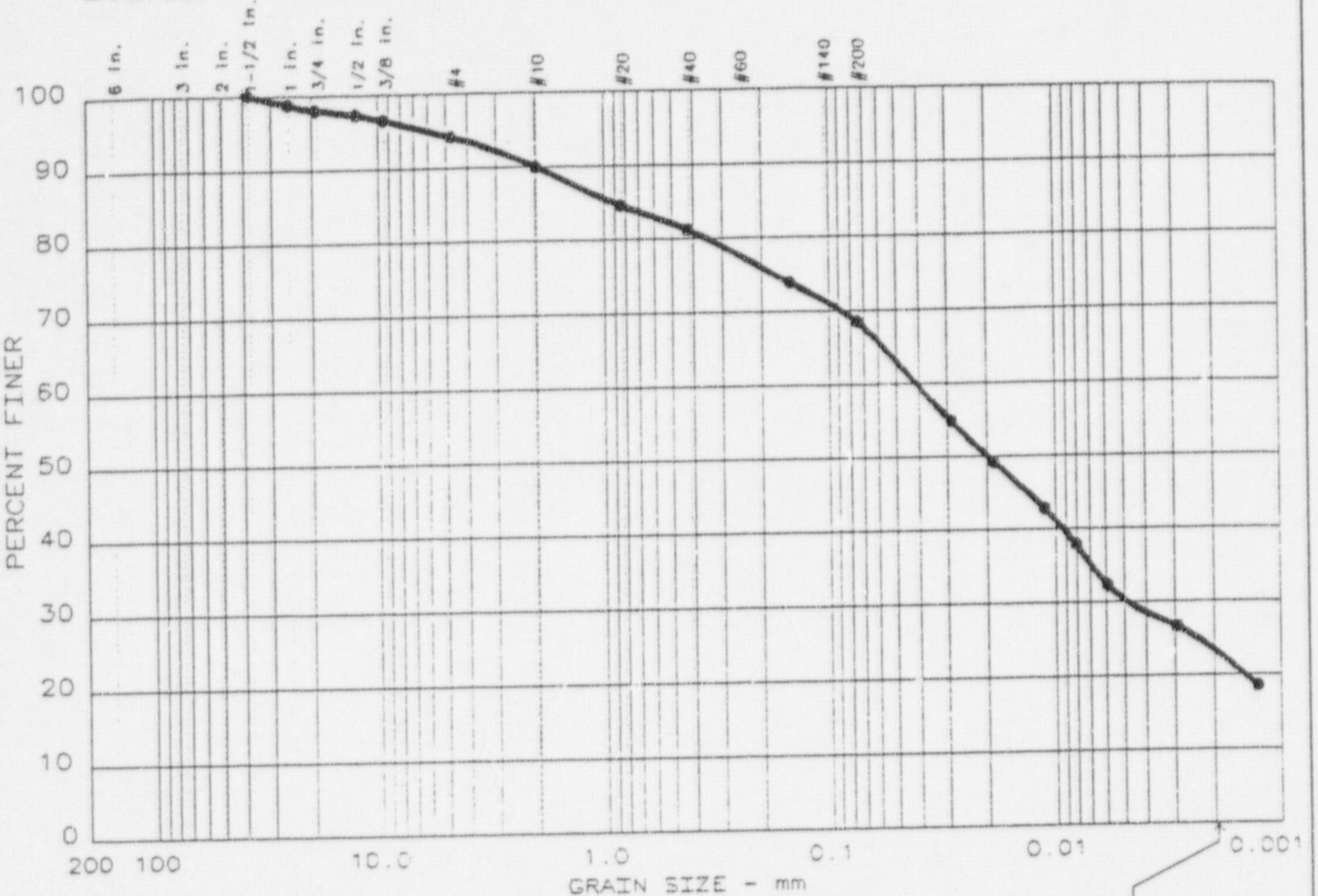
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	12	0.0	10.1	21.5	45.0	23.4

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	25	9	2.02		0.0200	0.0048				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C7

Date: 11-18-1997

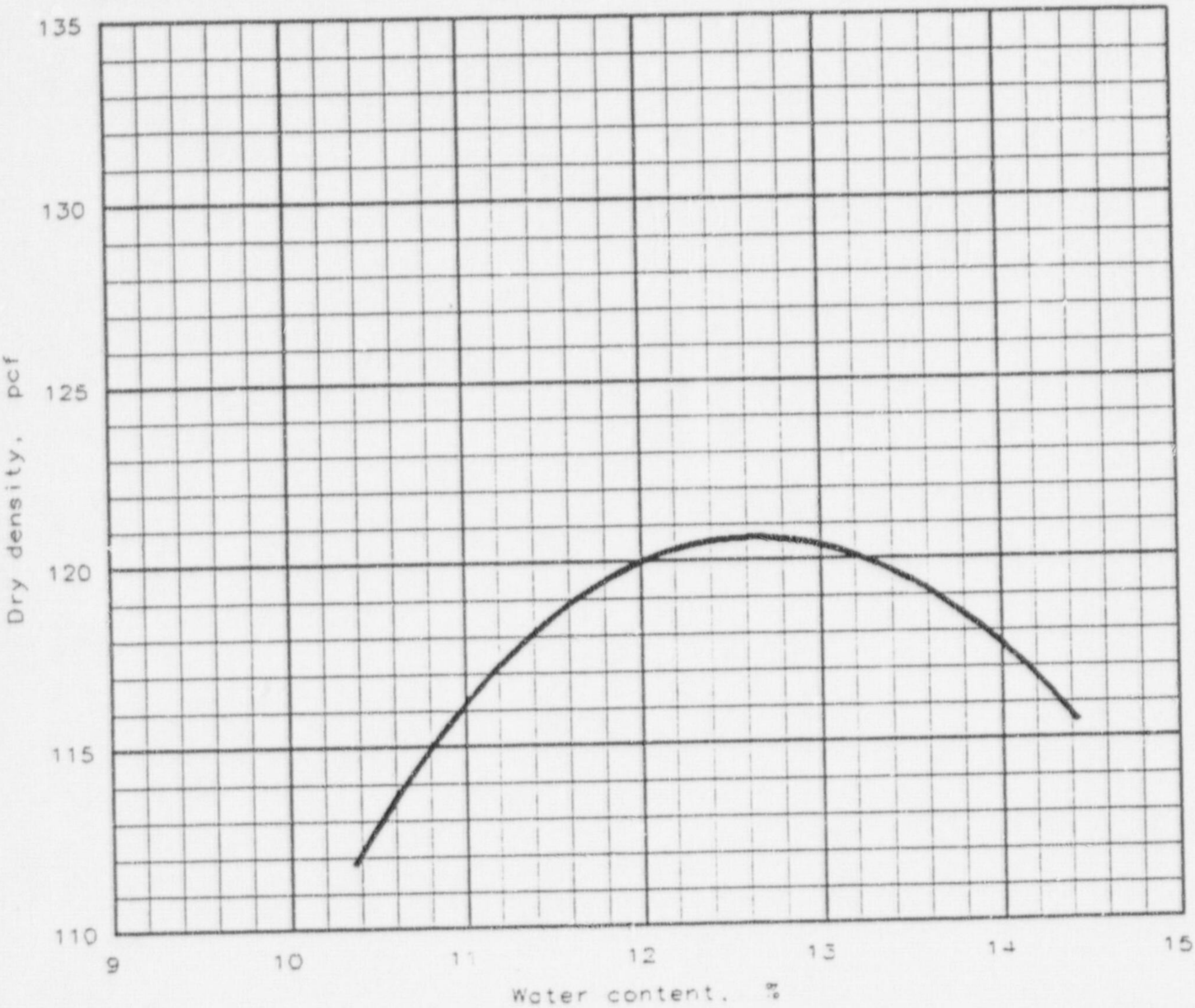
GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			10.4 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 120.6 pcf Optimum moisture = 12.6 %	Gray SILT, some clay, sand, trace shale fragments, gravel

Project No.: E97820x1

Project: Bert Avenue Site Closure

Location: C7

Date: 11-18-1997

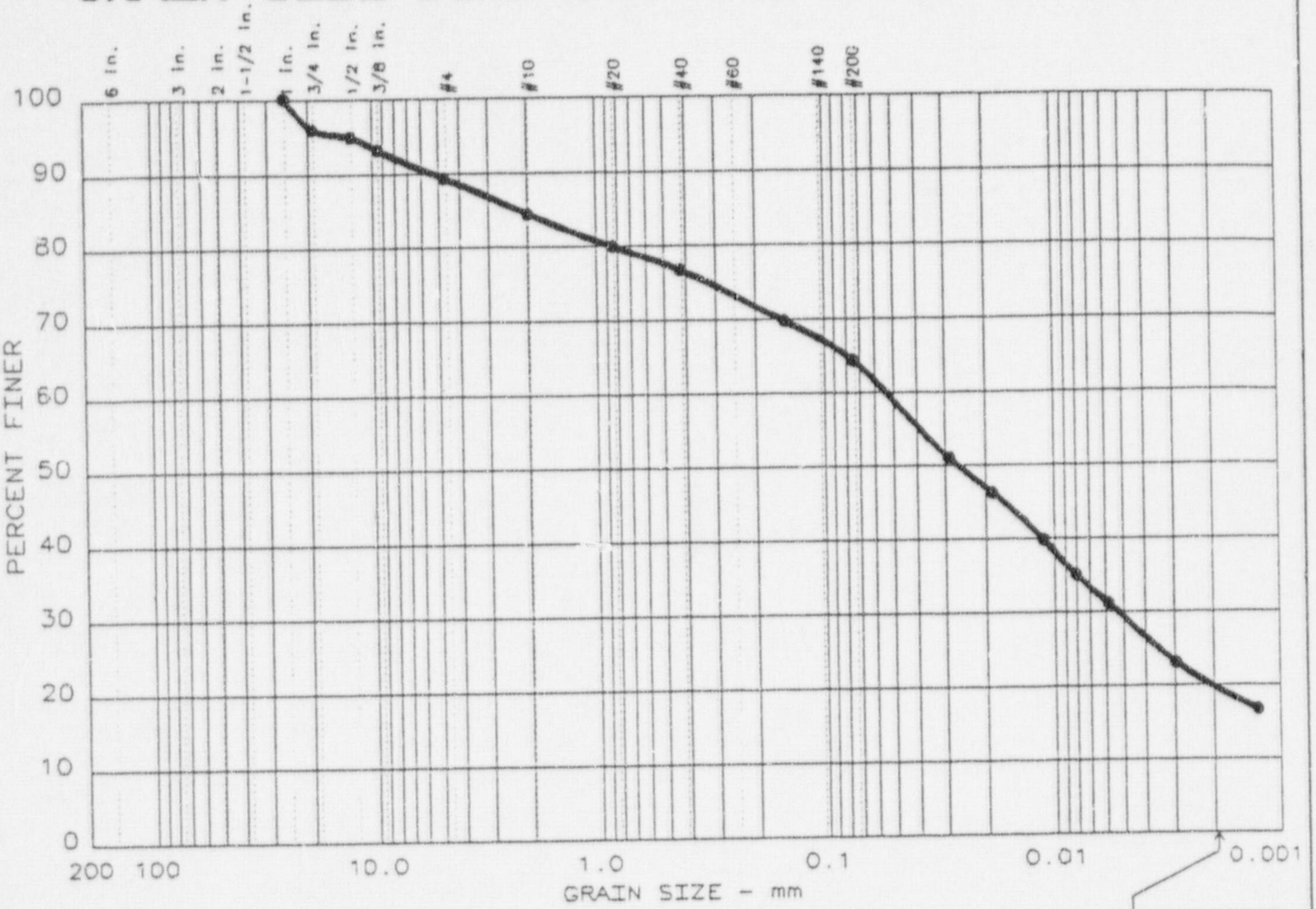
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	8	0.0	15.6	20.0	44.6	19.8

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	25	10	5.31		0.0266	0.0053				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C8

Date: 11-18-1997

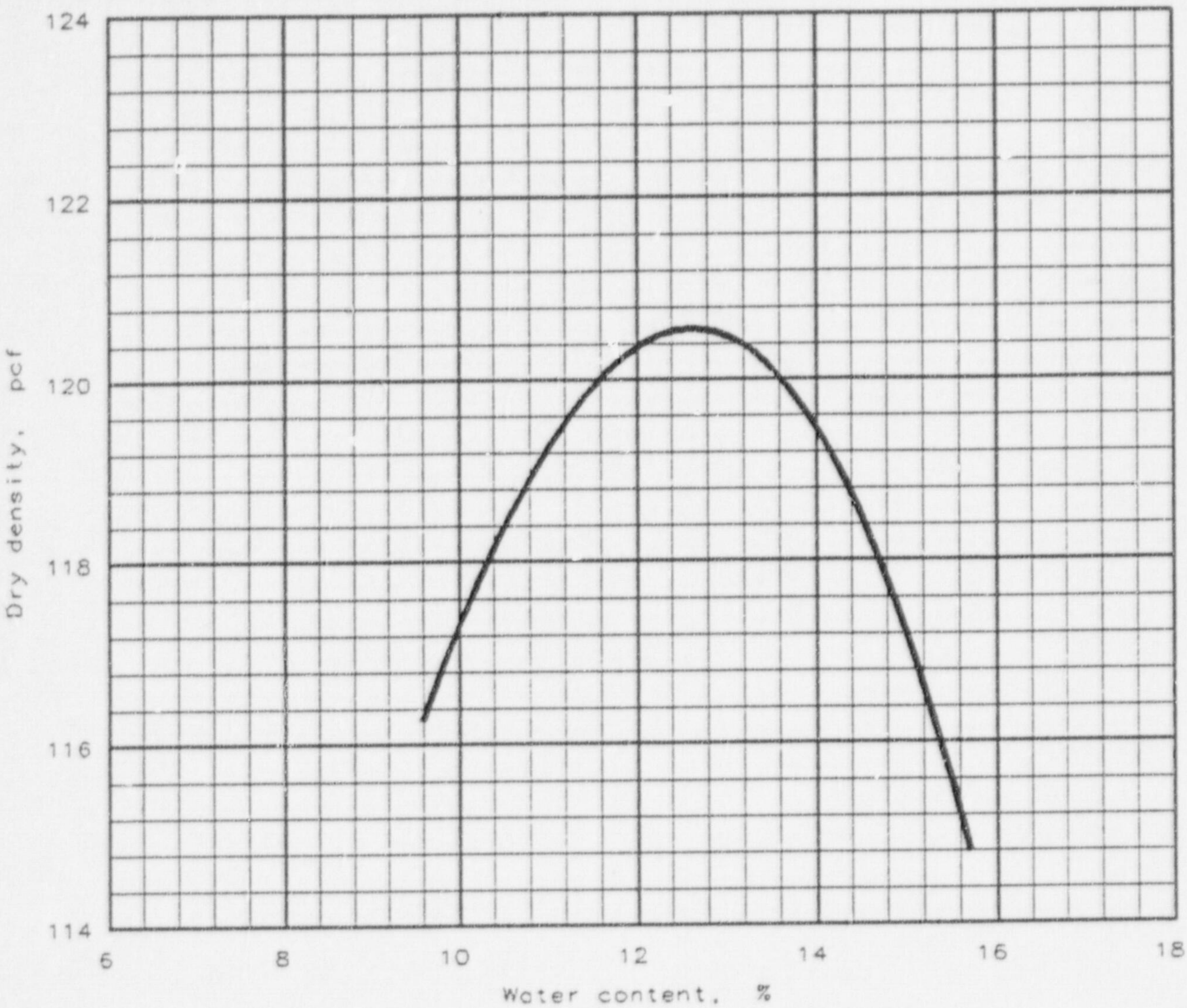
GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			12.2 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 120.6 pcf Optimum moisture = 12.6 %	Gray SILT, little sand, clay, few shale fragments, trace gravel

Project No.: A97820x1

Project: Bert Avenue Site

Location: C8

Date: 11-13-1997

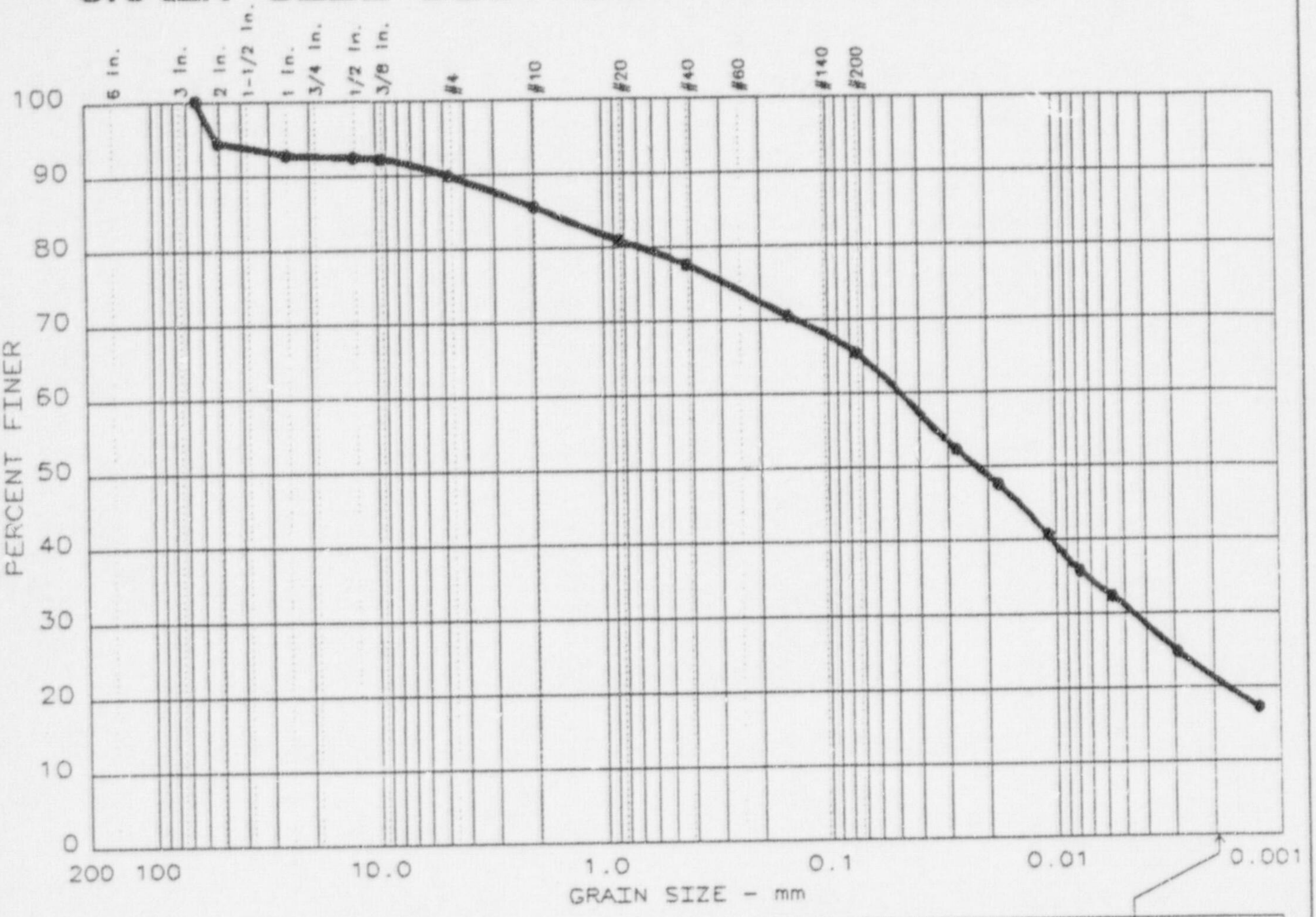
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	14.5	20.1	44.3	21.1

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	25	9	4.95		0.0224	0.0046				

	MATERIAL DESCRIPTION	USCS	AASHTO
●		CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C9

Date: 11-18-1997

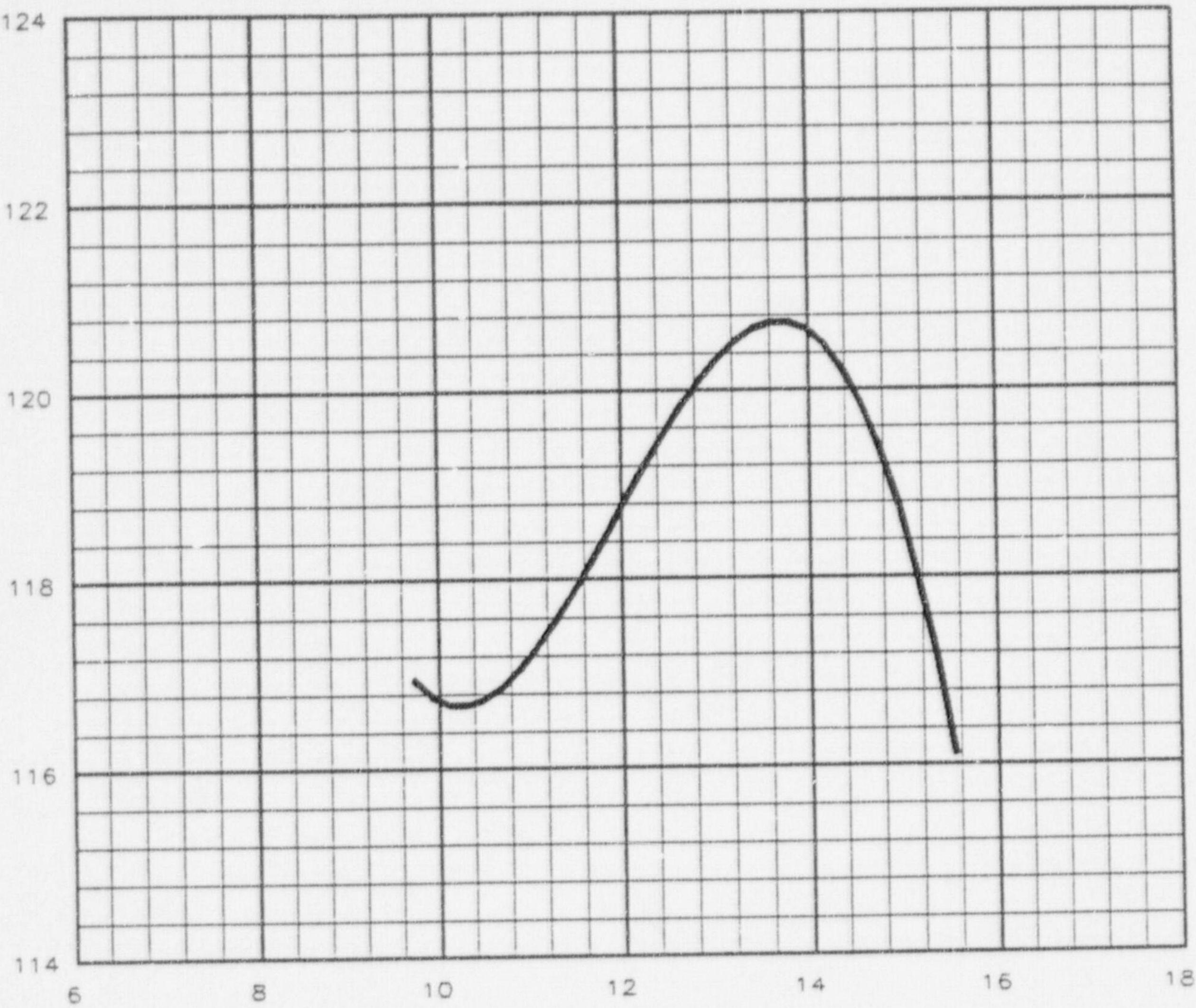
GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
			12.6 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 120.7 pcf Optimum moisture = 13.7 %	Gray SANDY,CLAYEY SILT,few shale fragments,trace gravel

Project No.: A97820x1

Project: Bert Avenue Site

Location: C9

Date: 11-13-1997

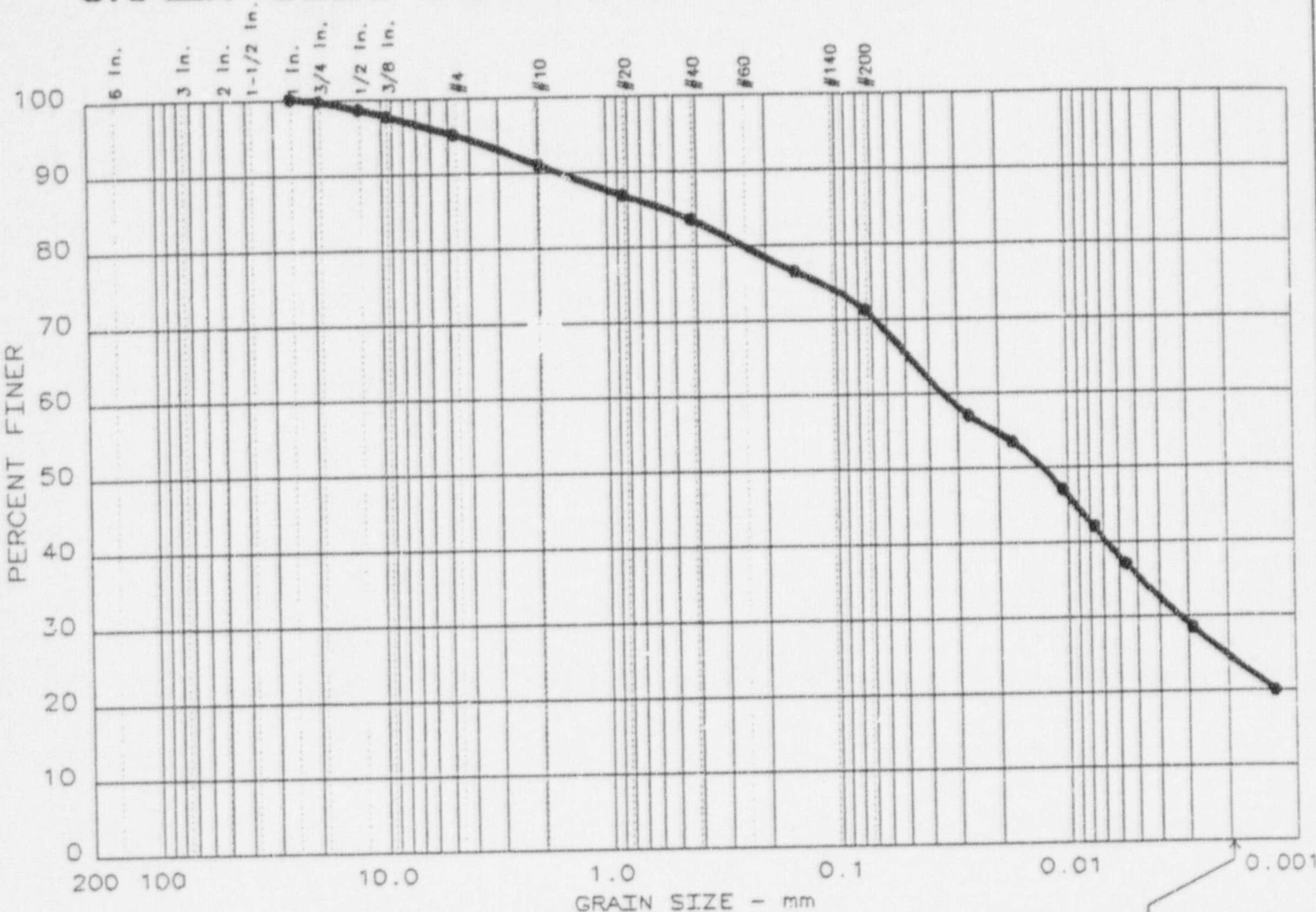
MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Remarks:

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	9	0.0	9.0	19.8	46.5	24.7

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	26	10	1.64		0.0129	0.0032				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-4

Project No.: A97820x12

Project: Bert Ave. Site Closure

● Location: C10

Date: 11-18-1997

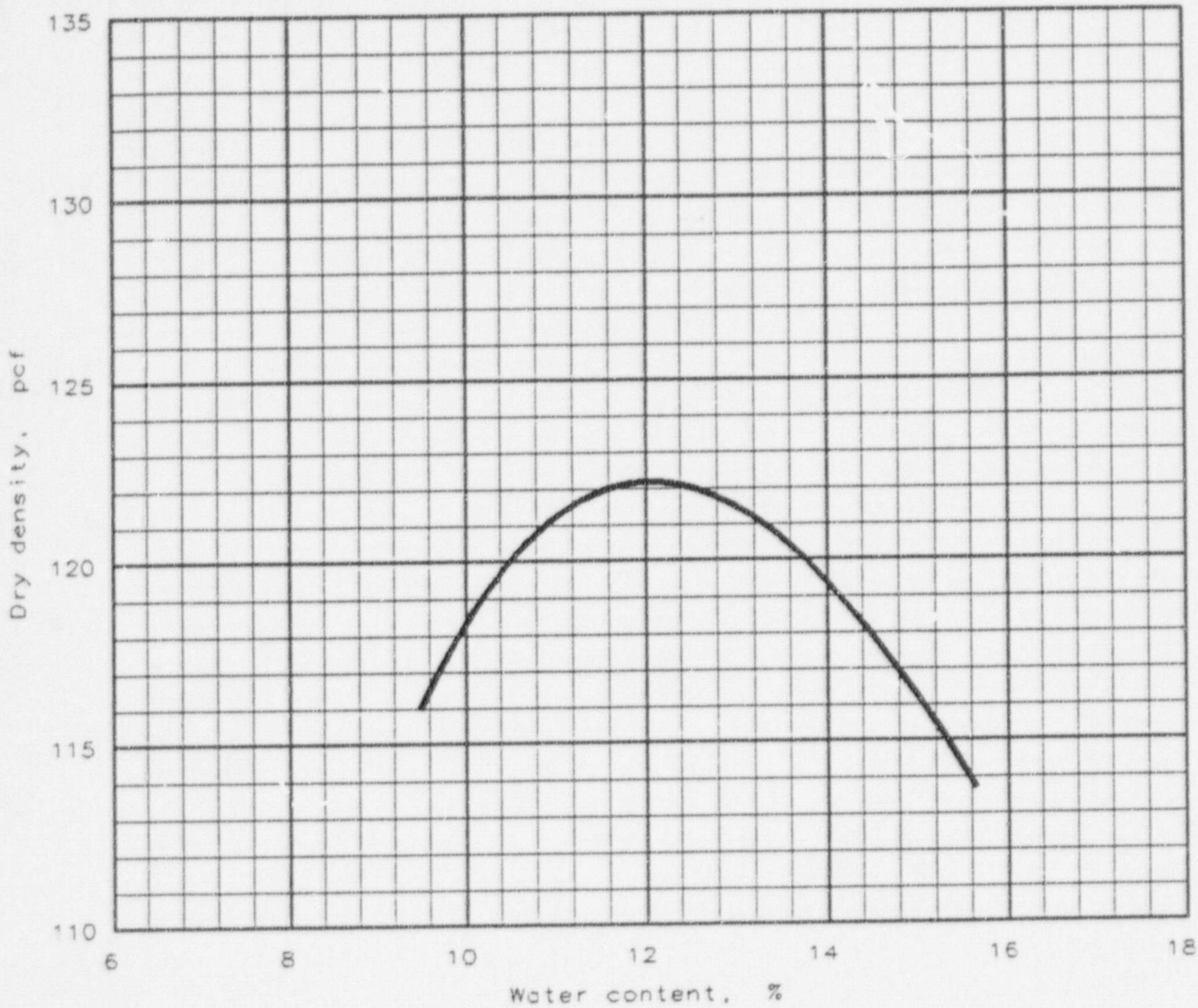
GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Remarks:

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
			7.3 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 122.2 pcf Optimum moisture = 12.1 %	Gray CLAYEY SILT, little sand, trace shale, gravel

Project No.: A97820x1

Project: Bert Avenue Site

Location: C10

Date: 11-14-1997

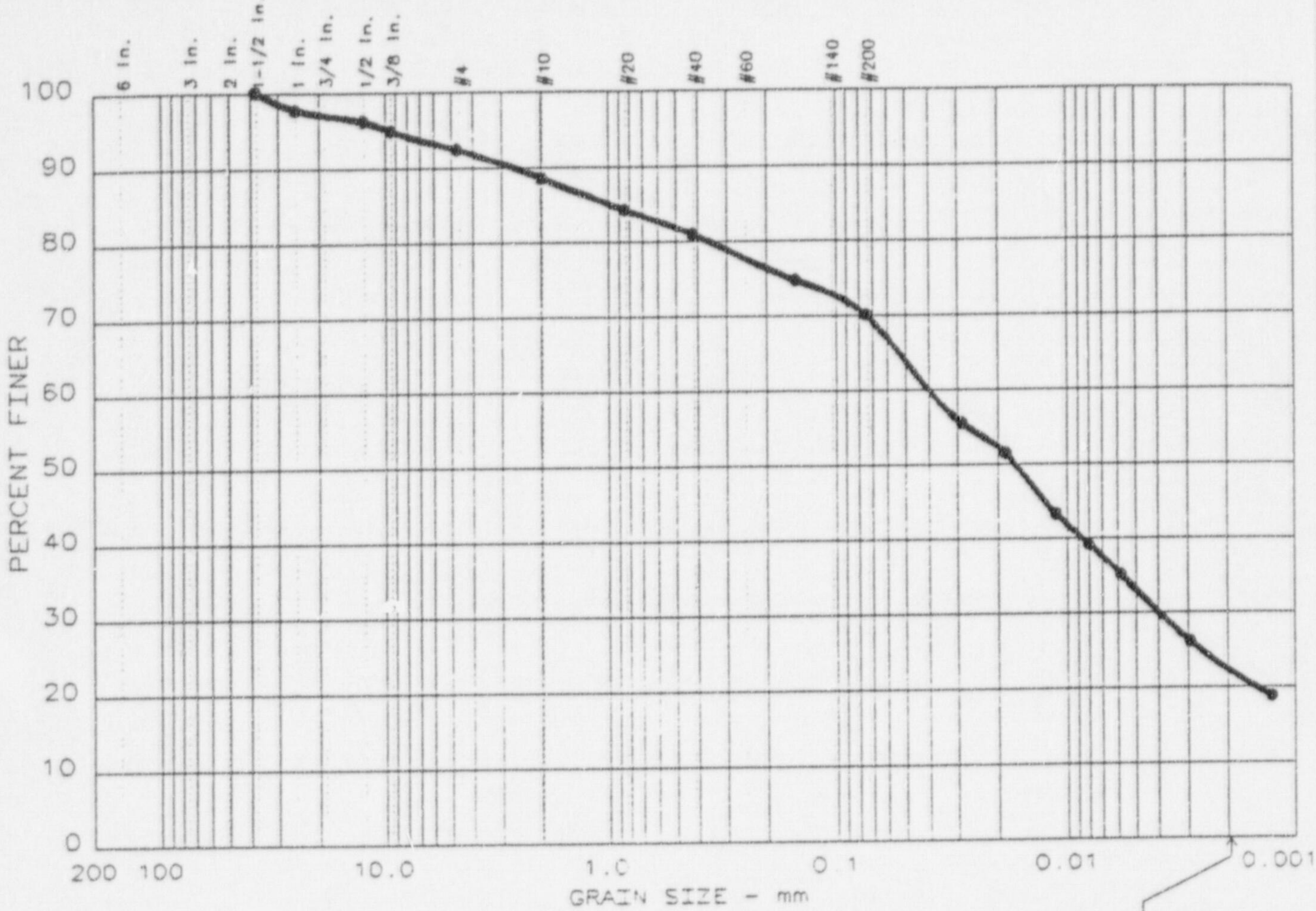
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	14	0.0	11.5	18.5	47.7	22.3

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	26	10	2.66		0.0168	0.0040				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C11

Date: 11-18-1997

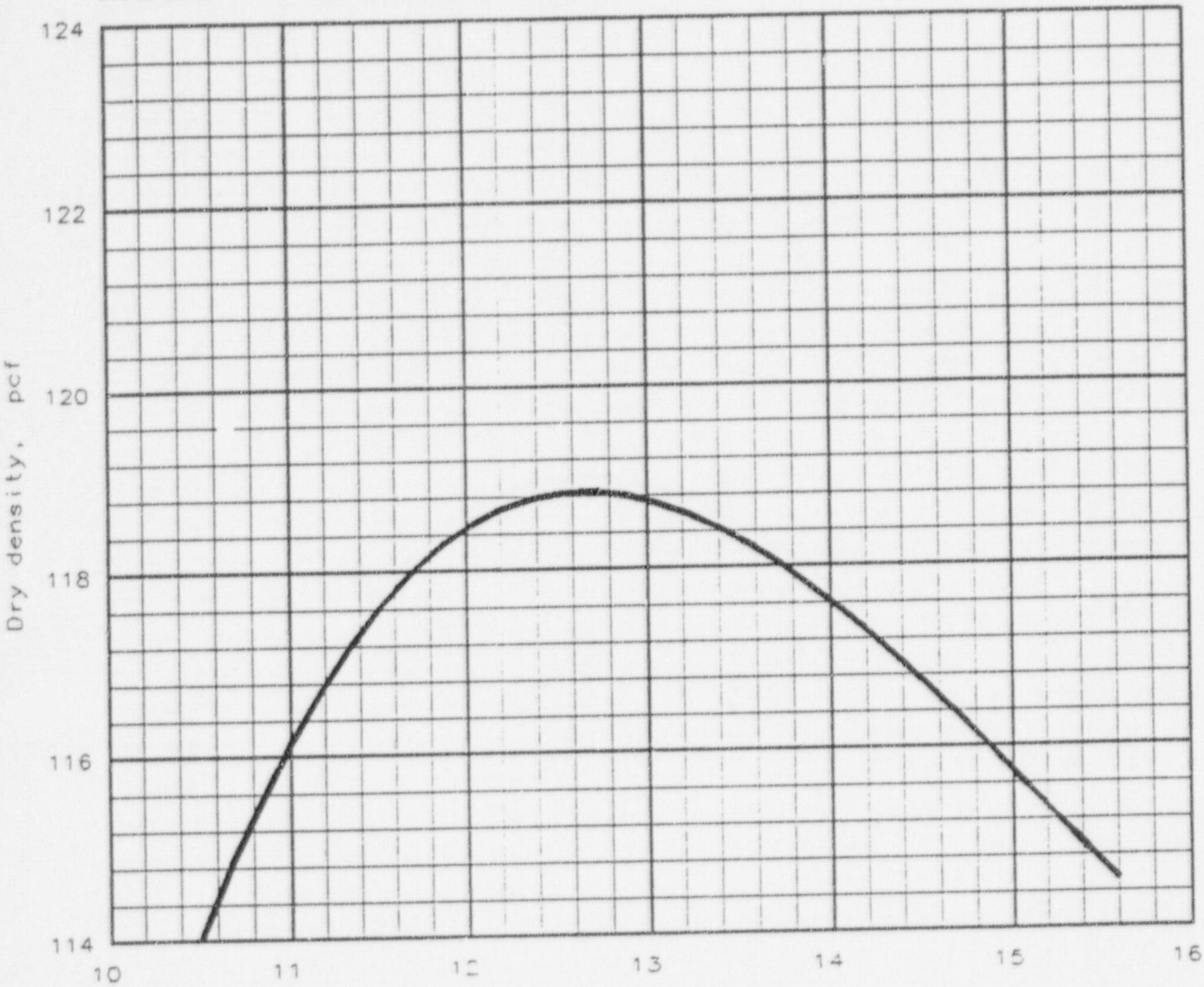
Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			8.4 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 118.8 pcf Optimum moisture = 12.7 %	Gray SILT, some clay, little sand, trace shale fragments, gravel

Project No.: E97820x1

Project: Bert Avenue Site Closure

Location: C11

Date: 11-18-1997

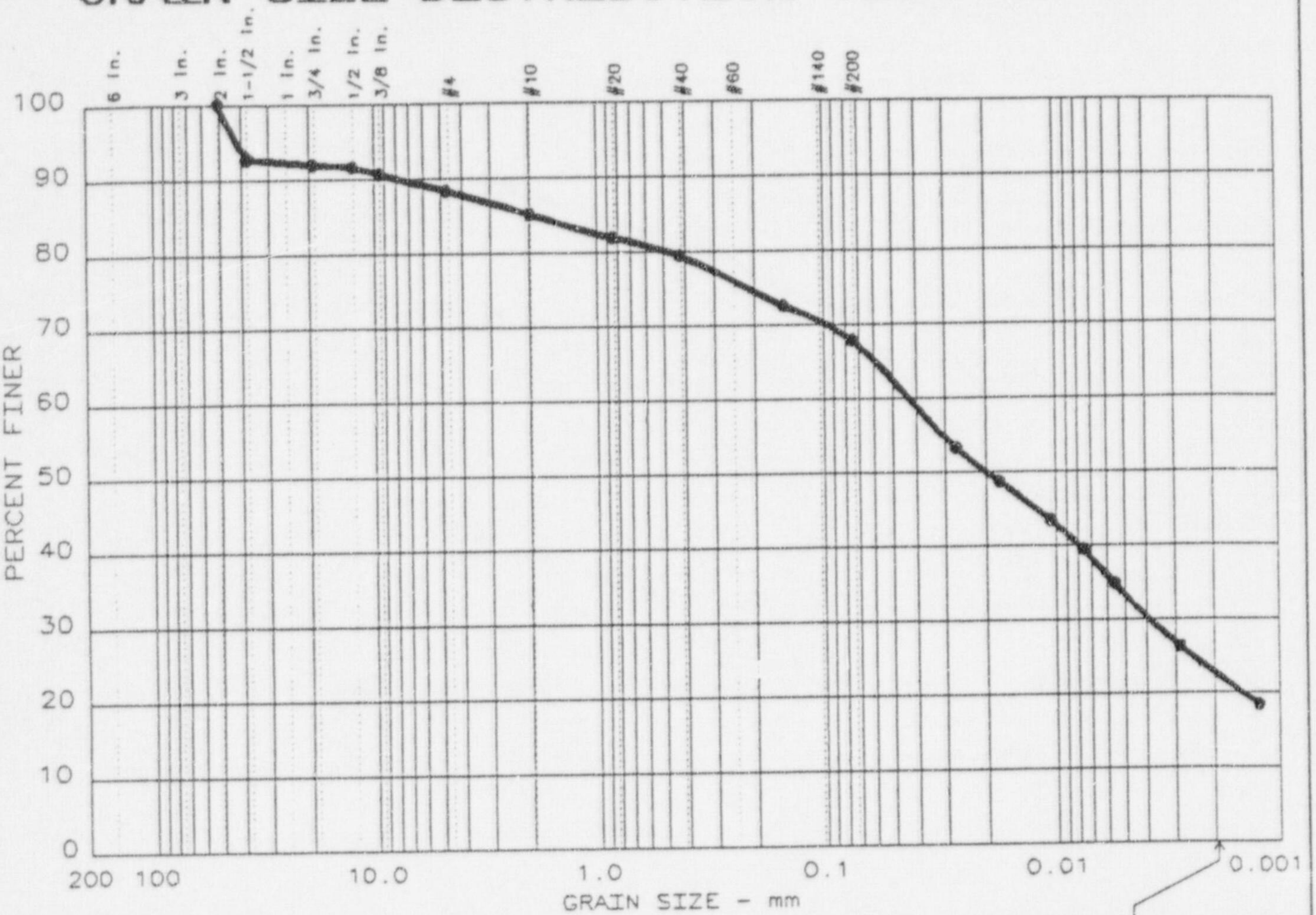
MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Remarks:

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	14.9	17.3	45.1	22.7

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	31	13	8.04		0.0202	0.0039				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-6

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C12

Date: 11-18-1997

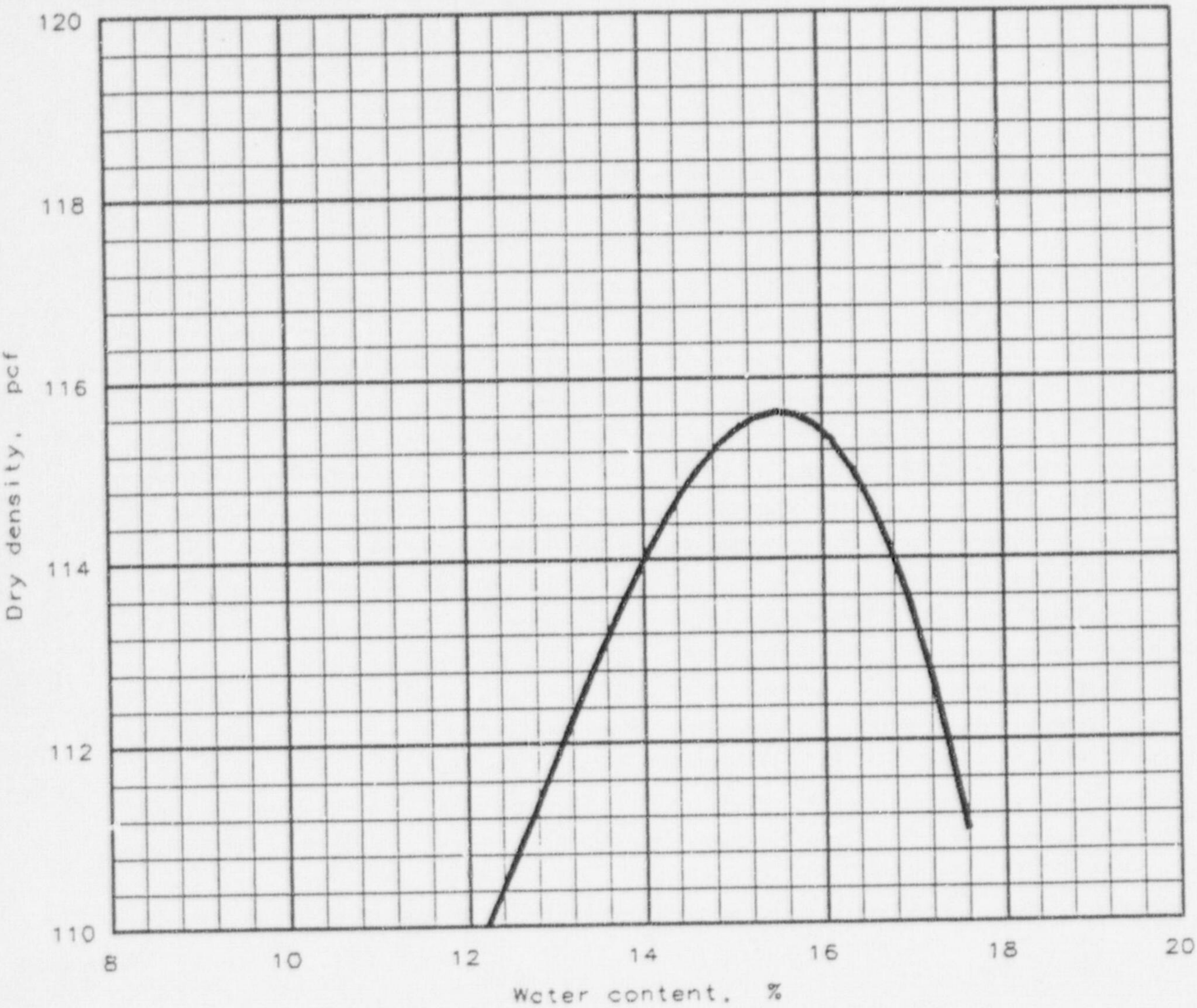
Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT

SOLAR TESTING LABORATORIES

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			13.7 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 115.6 pcf Optimum moisture = 15.5 %	Brown CLAYEY SILT, little sand, few shale fragments, trace gravel

Project No.: A97820x1

Project: Bert Avenue Site

Location: C12

Date: 11-14-1997

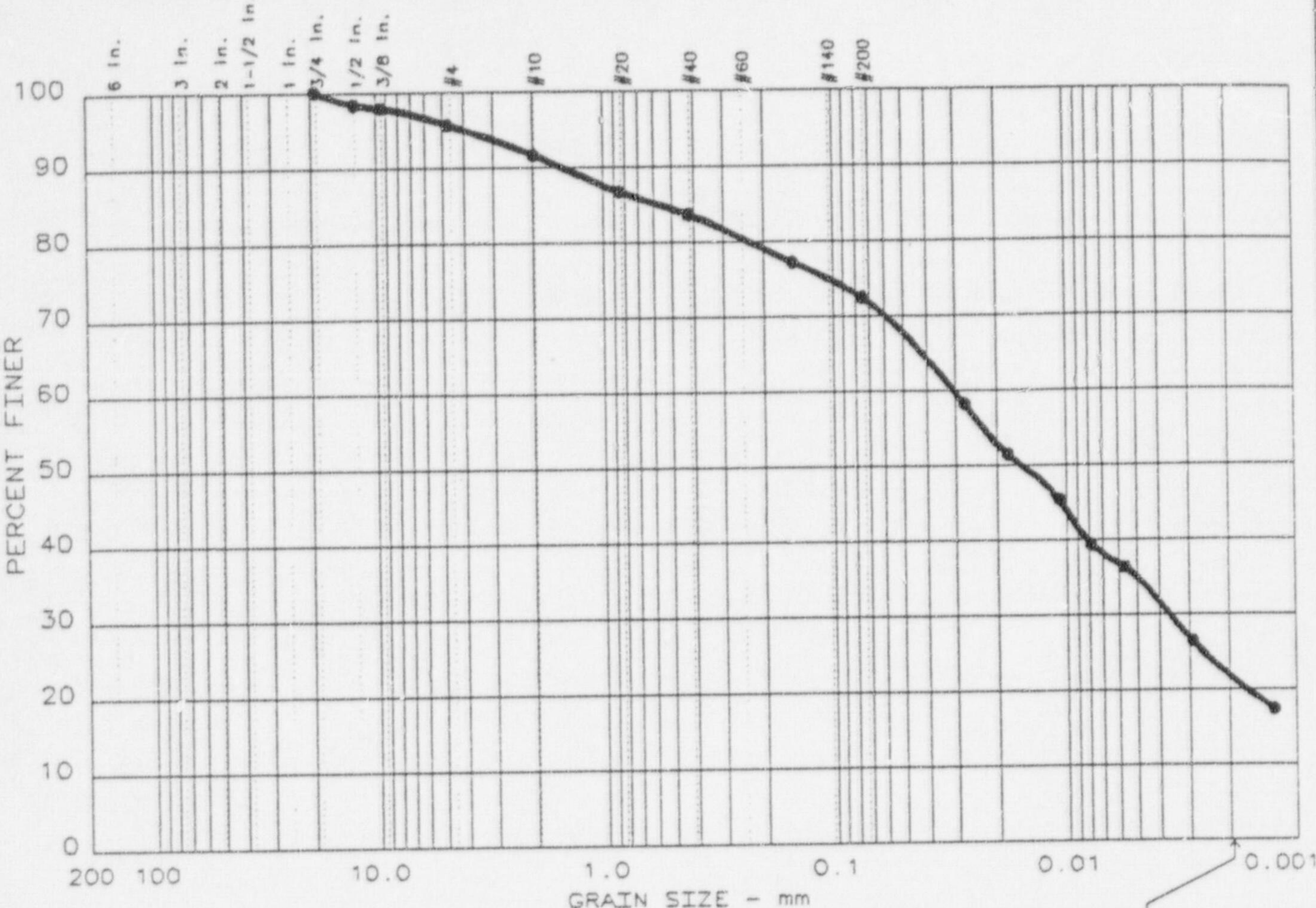
Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	7	0.0	8.4	19.2	50.6	21.8

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	25	9	1.51		0.0158	0.0036				

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-4

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C13

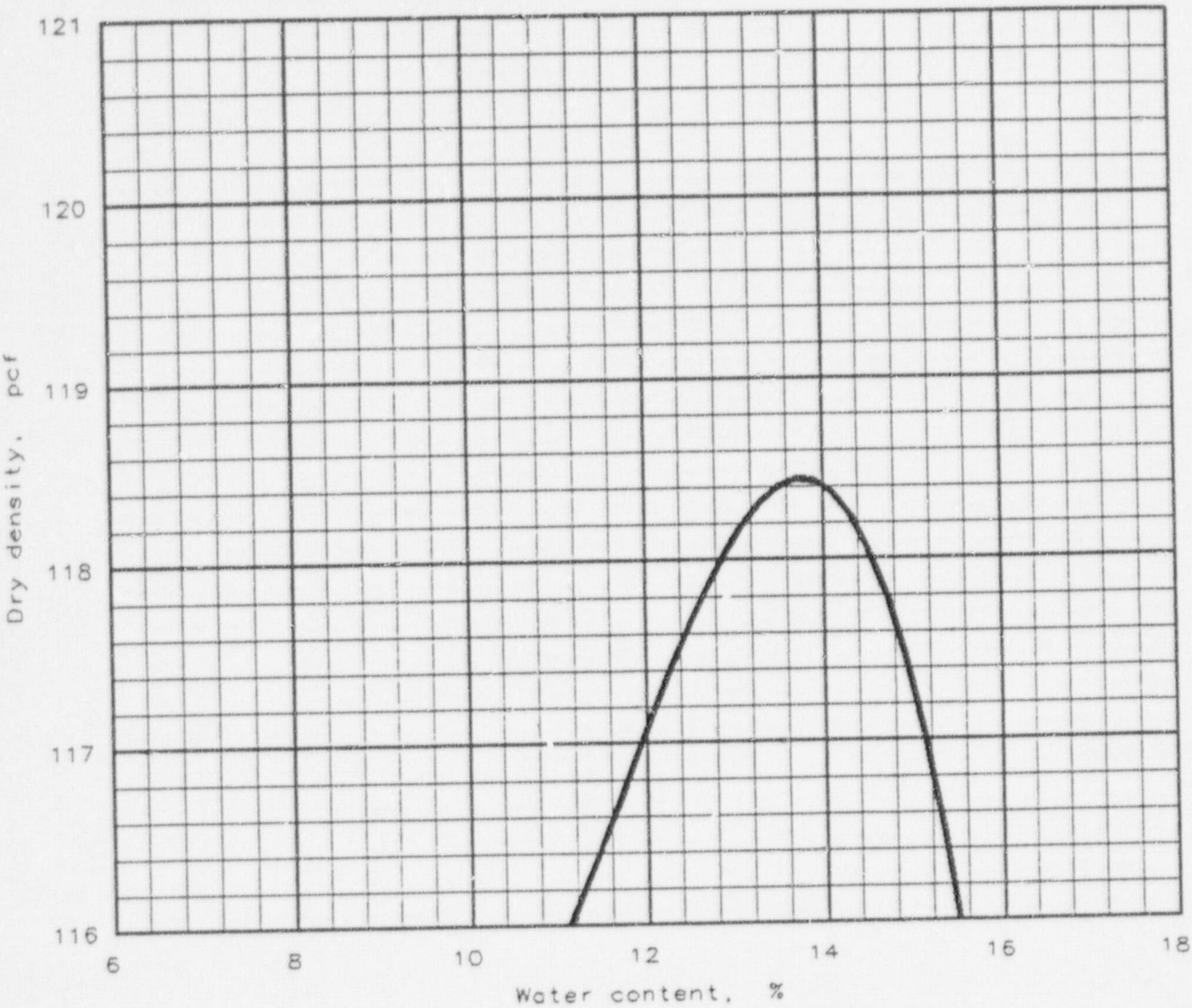
Date: 11-18-1997

Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT
SOLAR TESTING LABORATORIES

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
			12.6 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 118.4 pcf Optimum moisture = 13.8 %	Gray SILT, some clay, little sand, trace shale, gravel

Project No.: A97820x1

Project: Bert Avenue Site

Location: C13

Date: 11-13-1997

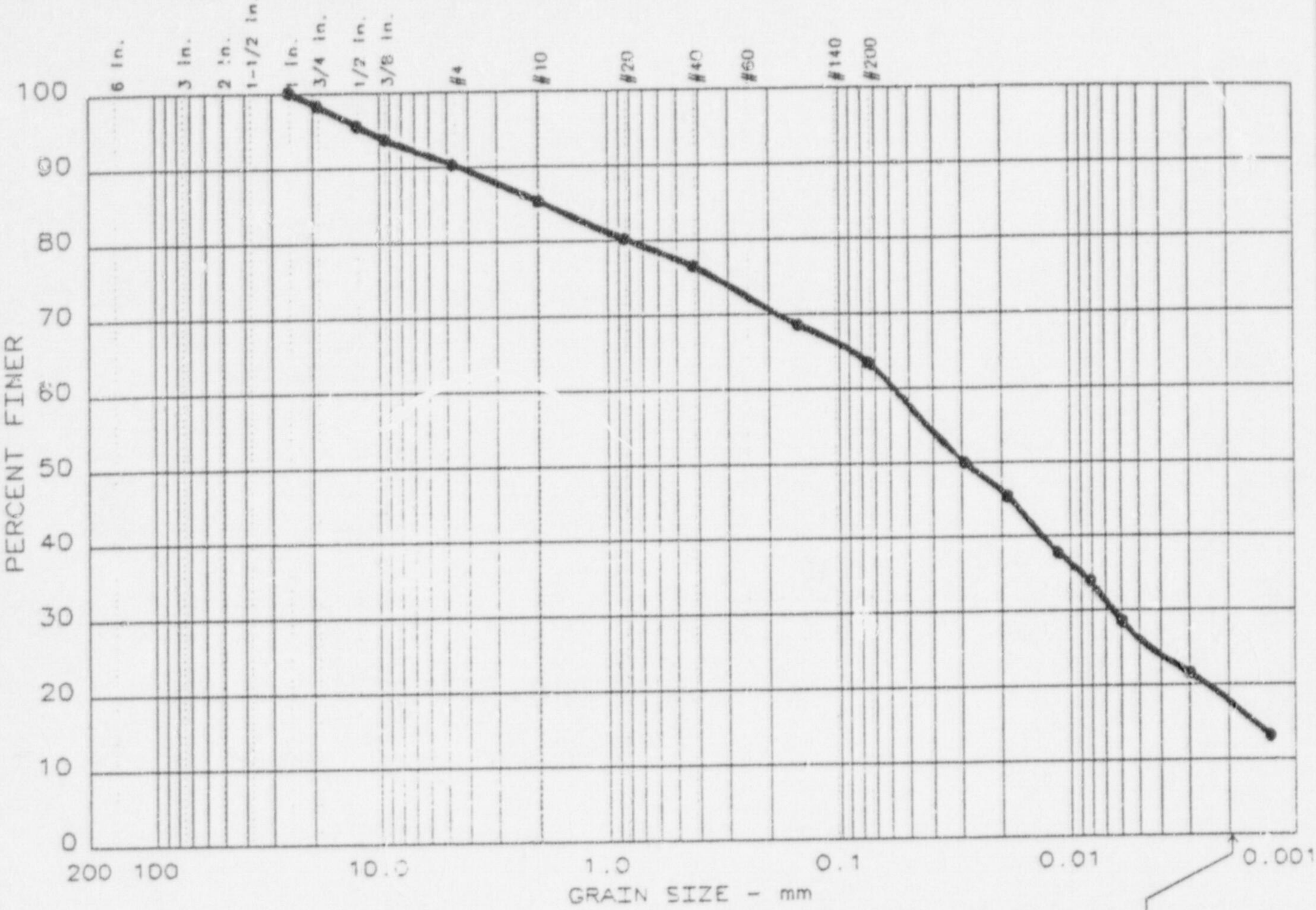
MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Remarks:

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	10	0.0	14.8	21.8	45.6	17.8

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	30	11	4.47		0.0292	0.0065	0.0015			

MATERIAL DESCRIPTION	USCS	AASHTO
●	CL	A-6

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C14

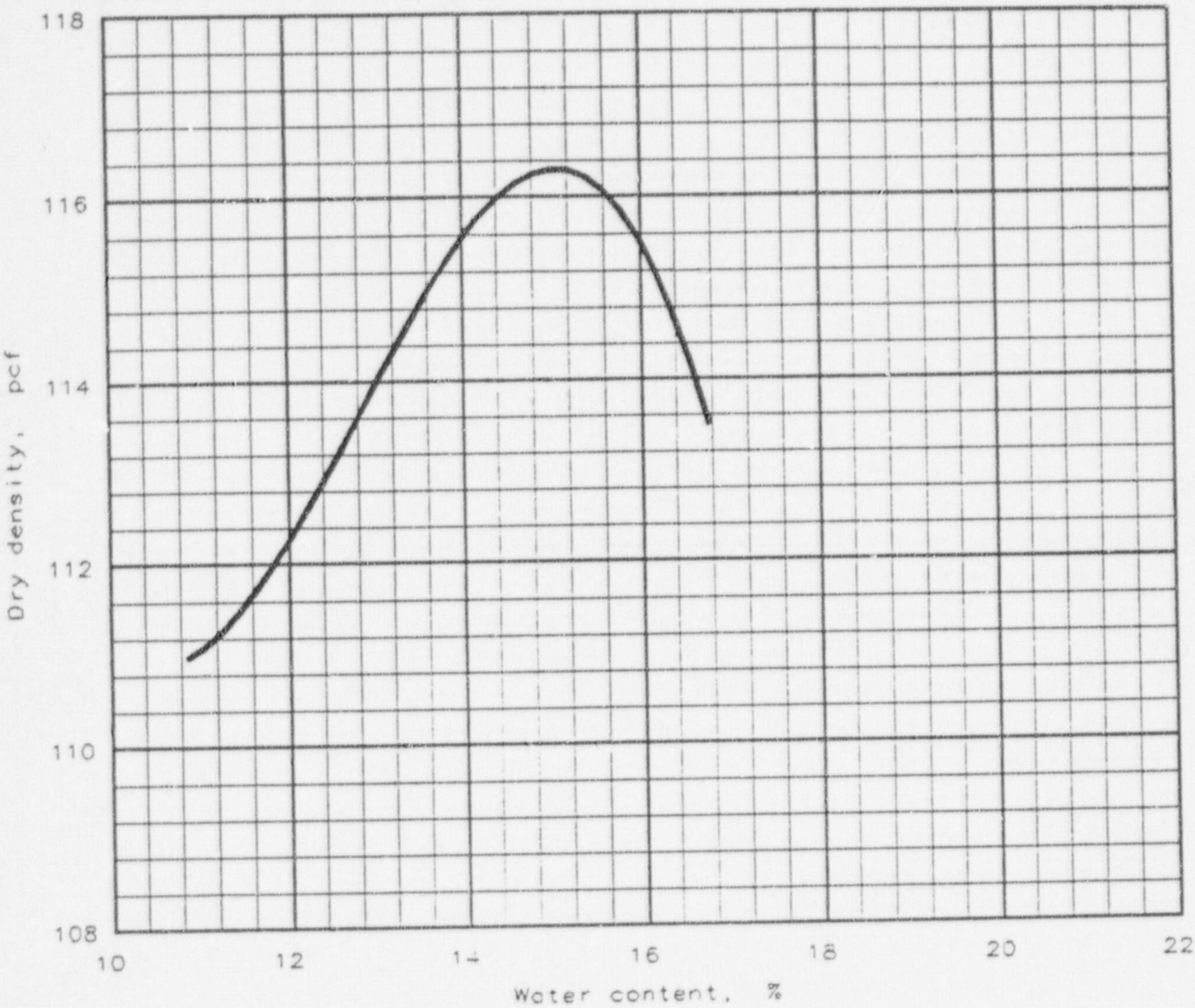
Date: 11-18-1997

Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT
SOLAR TESTING LABORATORIES

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
	USCS	AASHTO						
			13.4 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 116.3 pcf Optimum moisture = 15.1 %	Brown SILT, some sand, little clay, few shale fragments, trace gravel

Project No.: E97820x1

Project: Bert Avenue Site

Location: C14

Date: 11-18-1997

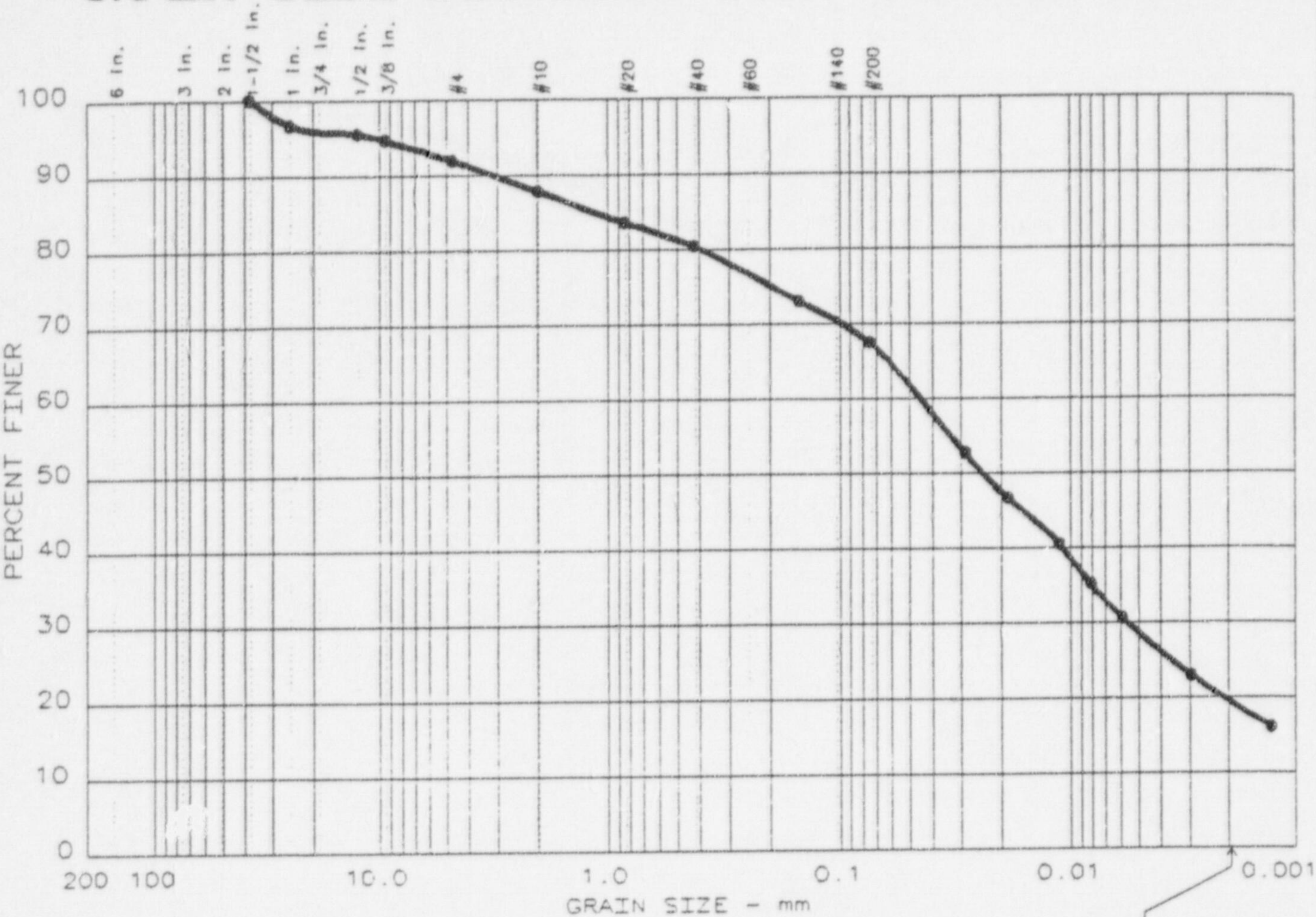
MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Remarks:

Fig. No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	12.3	20.3	47.9	19.5

	LL	PI	D_{90}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	28	11	3.16		0.0240	0.0056				

	MATERIAL DESCRIPTION	USCS	AAHSTO
●		CL	A-6

Project No.: A97820x12
Project: Bert Ave. Site Closure
● Location: C15

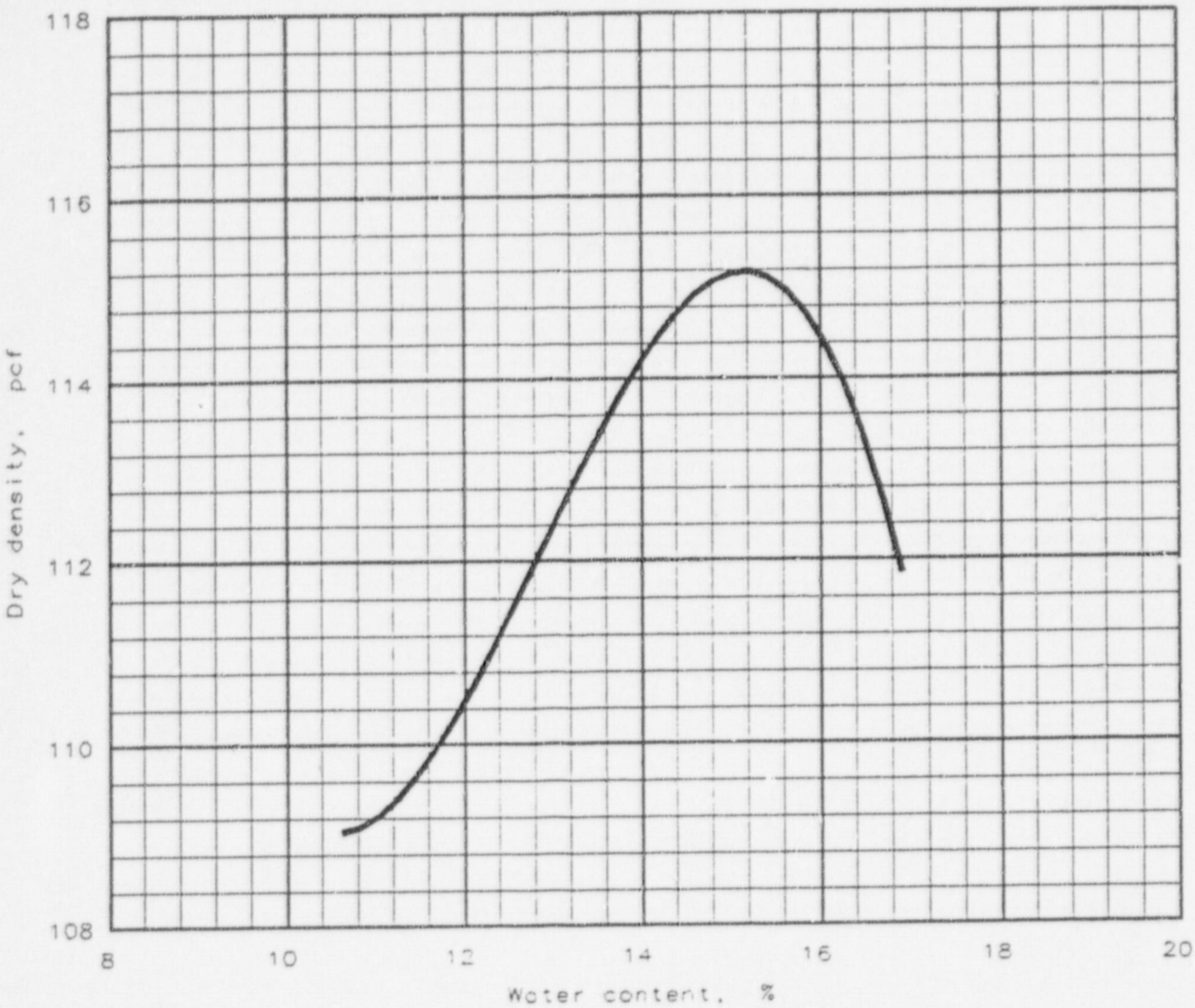
Date: 11-18-1997

Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT
SOLAR TESTING LABORATORIES

Fig. No.: ______

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure B, Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in	% < No.200
			13.1 %					

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 115.2 pcf Optimum moisture = 15.2 %	Gray SILT, little sand, clay, trace shale fragments, gravel

Project No.: E97820x1

Project: Bert Avenue Site Closure

Location: C15

Date: 11-18-1997

Remarks:

MOISTURE-DENSITY RELATIONSHIP TEST

SOLAR TESTING LABORATORIES

Fig. No. ______

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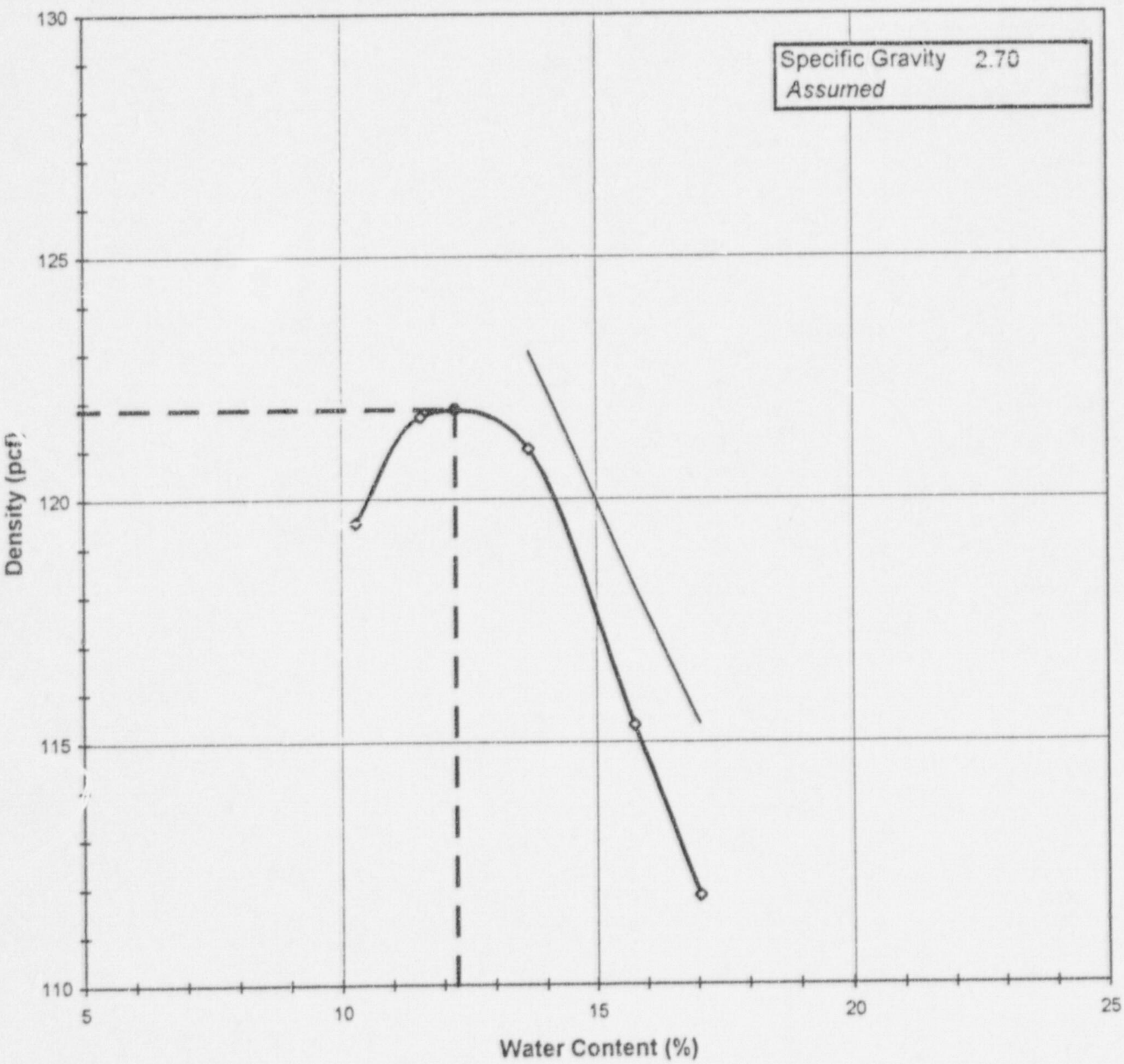
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-16
Lab ID	98040-01.001	Test Method	**STANDARD**

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Optimum Water Content **12.3**
Maximum Dry Density **121.8**



Tested By *MV* *Date* *2/4/98* *Checked By* Jcm *Date* 2-6-98

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-16
Lab ID	98040-01.001		

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	C

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G441
Mold ID	G695
Mold diameter	6
Weight of the Mold	5746
Volume of the Mold(cc)	2124

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	10233	10368	10429	10291	10201
Wt.of Mold (gm)	5746	5746	5746	5746	5746
Wt. of WS	4487	4622	4683	4545	4455
Mold Volume (cc)	2124	2124	2124	2124	2124

Moisture Content / Density

Tare Number	1126	1128	579	1734	567
Wt. of Tare & WS (gm)	355.81	445.80	474.70	428.10	565.90
Wt. of Tare & DS (gm)	330.53	408.30	427.70	381.15	495.80
Wt. of Tare (gm)	85.14	84.37	84.07	83.17	84.57
Wt. of Water (gm)	25.28	37.50	47.00	46.95	70.10
Wt. of DS (gm)	245.39	323.93	343.63	297.98	411.23

Wet Density (gm/cc)	2.11	2.18	2.20	2.14	2.10
Wet Density (pcf)	131.8	135.8	137.6	133.5	130.9
Moisture Content (%)	**10.3**	**11.6**	**13.7**	**15.8**	**17.0**
Dry Density (pcf)	**119.5**	**121.7**	**121.0**	**115.4**	**111.8**

Zero Air Voids

Moisture Content (%)	13.7	15.8	17.0
Dry Unit Weight (pcf)	123.0	118.2	115.4

Tested By MV *Date* 2/4/98 *Checked By* Jcm *Date* 2-6-98

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PERMEABILITY TEST

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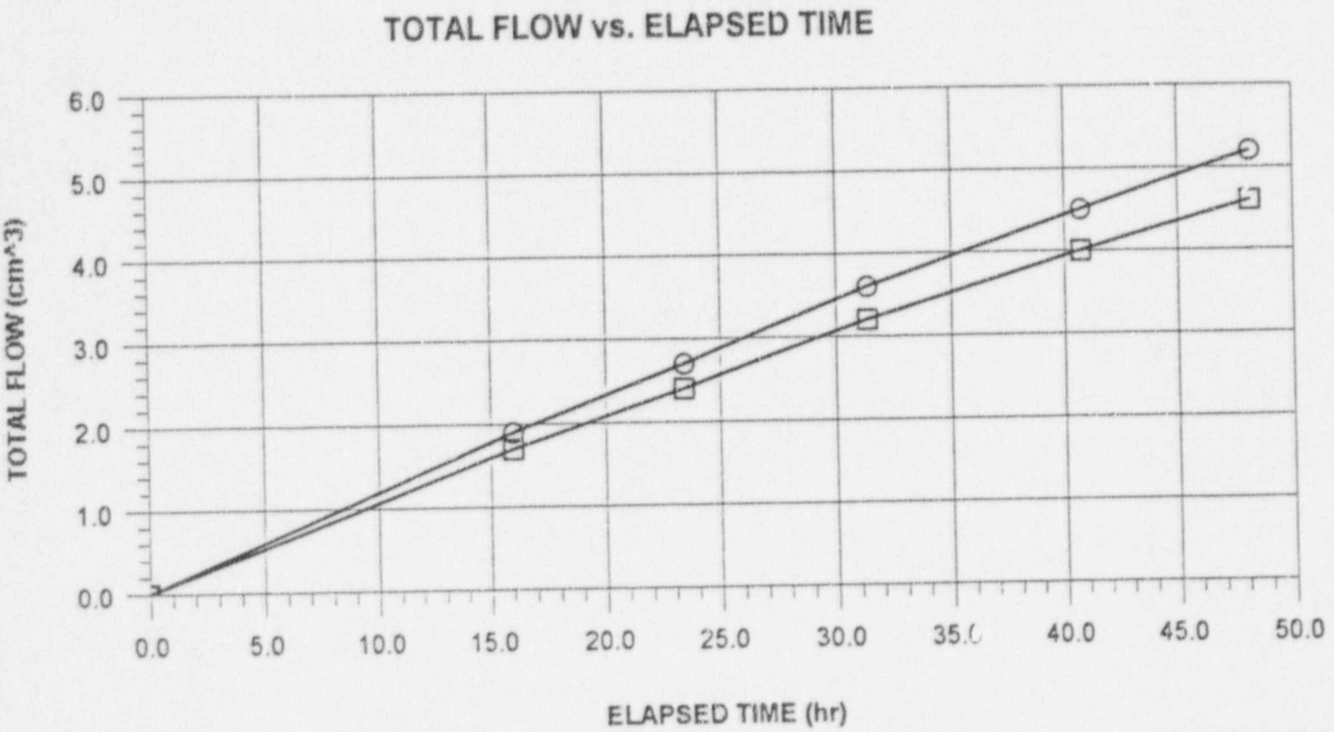
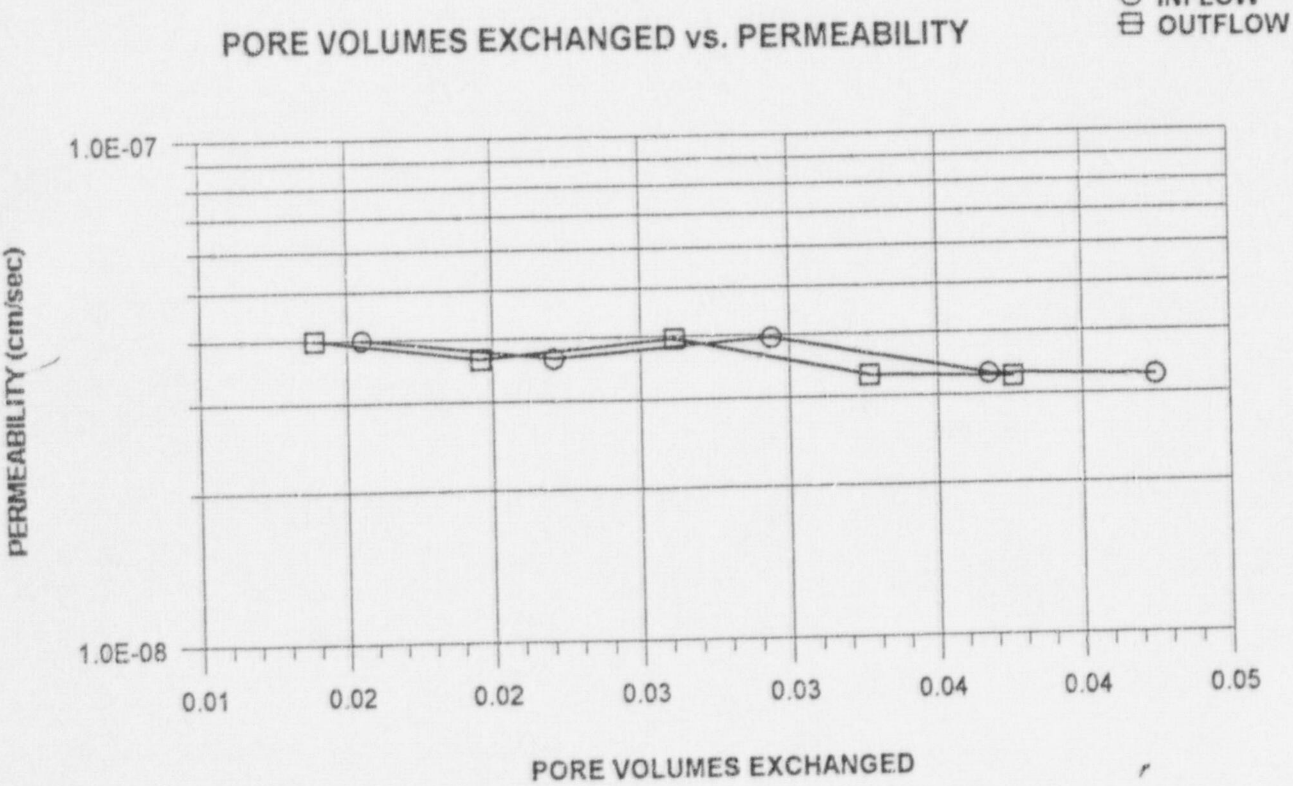
Client	ESC	Boring No.	NA
Client Project	C1220 BERT AVE.	Depth(ft.)	NA
Project No.	98040-01	Sample No.	C-16

AVERAGE PERMEABILITY = 3.5E-08 cm/sec @ 20°C
AVERAGE PERMEABILITY = 3.5E-10 m/sec @ 20°C





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PERMEABILITY TEST

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Client	ESC	Tested By	JCM	Date	02-09-98
Client Project	C1220 BERT AVE.	Checked By	GO	Date	2-13-98
Project No.	98040-01				
Boring No.	NA	Specific Gravity	2.70 ASSUMED		
Depth(ft.)	NA	Sample Condition	REMOLDED		
Sample No.	C-16				

Visual Description GRAY CLAY

MOISTURE CONTENT	BEFORE TEST	AFTER TEST
Tare Number	2	1709
Wt. Tare & WS(gm.)	302.74	549.50
Wt. Tare & DS(gm.)	271.60	488.50
Wt. Water(gm.)	31.14	61.00
Wt. Tare(gm.)	45.01	83.25
Wt. DS(gm.)	226.59	405.25
Moisture Content(%)	13.7	15.1

UNIT WEIGHT		
Wt. Tube & WS.(gms.)	2251.90	NA
Wt. Of Tube(gms.)	1352.50	NA
Wt. Of WS.(gms.)	899.40	909.8
Length 1 (in.)	4.000	3.918
Length 2 (in.)	4.000	3.924
Length 3 (in.)	4.000	3.942
Top Diameter (in.)	2.870	2.866
Middle Diameter (in.)	2.870	2.864
Bottom Diameter (in.)	2.870	2.868
Average Length (in)	4.00	3.93
Average Area (in^2)	6.47	6.45
Sample Volume(cc.)	423.94	415.26
Unit Wet Wt.(gms/cc)	2.12	2.19
Unit Wet Wt.(pcf.)	132.4	136.7
Unit Dry Wt.(pcf.)	116.4	118.8
Unit Dry Wt.(gms/cc)	1.87	1.90
Void Ratio,e	0.45	0.42
Porosity, n	0.31	0.29
Pore Volume(cm^3)	131.1	122.4

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PERMEABILITY TEST

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Client	ESC	Tested By	JCM	Date	02-09-98
Client Project	C1220 BERT AVE.	Checked By	GO	Date	2-13-98
Project No.	98040-01				
Boring No.	NA				
Depth(ft.)	NA				
Sample No.	C-16				
Visual Description	GRAY CLAY				

Pressure Heads (Constant)		Final Sample Dimensions	
Top Cap (psi)	27.5	Sample Length (cm.), L	9.98
Bottom Cap (psi)	30.0	Sample Diameter (cm.)	7.28
Cell (psi)	35.0	Sample Area (cm.^2), A	41.62
Total Pressure Head (cm)	175.8	Inflow Burette Area, (cm.^2), a-in	0.91
		Outflow Burette Area, (cm.^2), a-out	0.96
		B Parameter	97%

AVERAGE PERMEABILITY = 3.5E-08 cm/sec @ 20°C
AVERAGE PERMEABILITY = 3.5E-10 m/sec @ 20°C

DATE mon-dy-yr	TIME hr	TIME min	ELAPSED TIME (t) hr	TOTAL INFLOW cm^3	TOTAL OUTFLOW cm^3	TOTAL HEAD (h) cm	FLOW 0 FLOW 1 STOP	TEMP °C	INCREMENTAL PERMEABILITY @ 20°C cm/sec
02-10-98	15	15	0.0	0.0	0.0	187.3	0	20.0	NA
02-11-98	7	15	16.0	1.9	1.7	183.4	0	20.5	4.0E-08
02-11-98	14	40	23.4	2.7	2.4	181.8	0	20.5	3.6E-08
02-11-98	22	35	31.3	3.6	3.2	180.0	0	20.0	4.0E-08
02-12-98	8	0	40.8	4.5	4.0	178.2	0	20.7	3.3E-08
02-12-98	15	25	48.2	5.2	4.6	176.8	1	20.5	3.3E-08

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DCN: DS-S3A
DATE: 11/12/96
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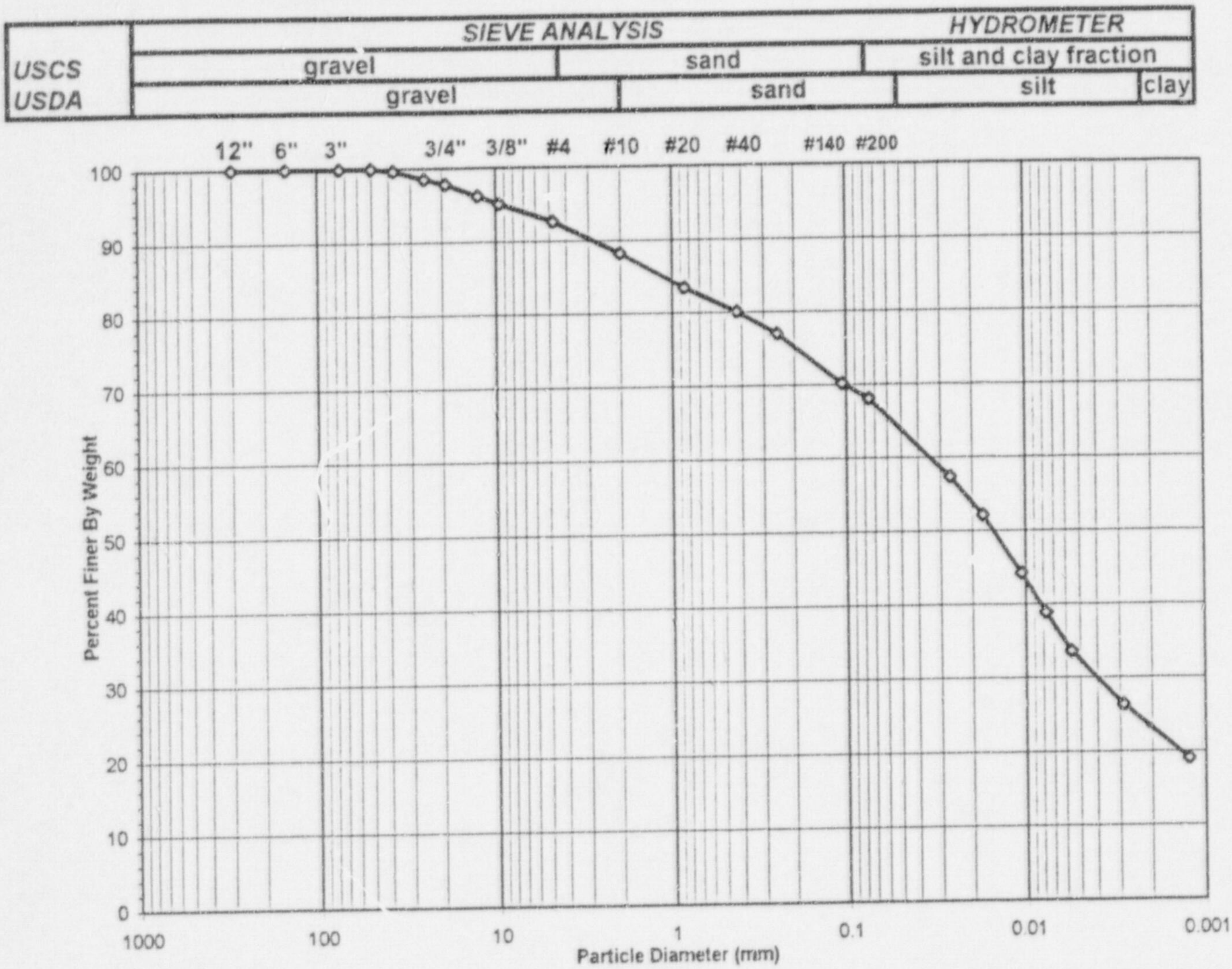
SIEVE AND HYDROMETER ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY



Sieve Size (mm)	Percent Finer	Components	Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
100	100.00	*Gravel*	11.82	**0.00**
2	88.18	*Sand*	24.27	**27.52**
0.075	68.04	*Silt*	40.72	**46.18**
0.05	63.91	*Clay*	23.19	**26.30**
0.002	23.19			

USDA Classification *LOAM*

USCS Symbol *CL, TESTED*

USCS Classification *SANDY LEAN CLAY*

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DATE: 11/12/96
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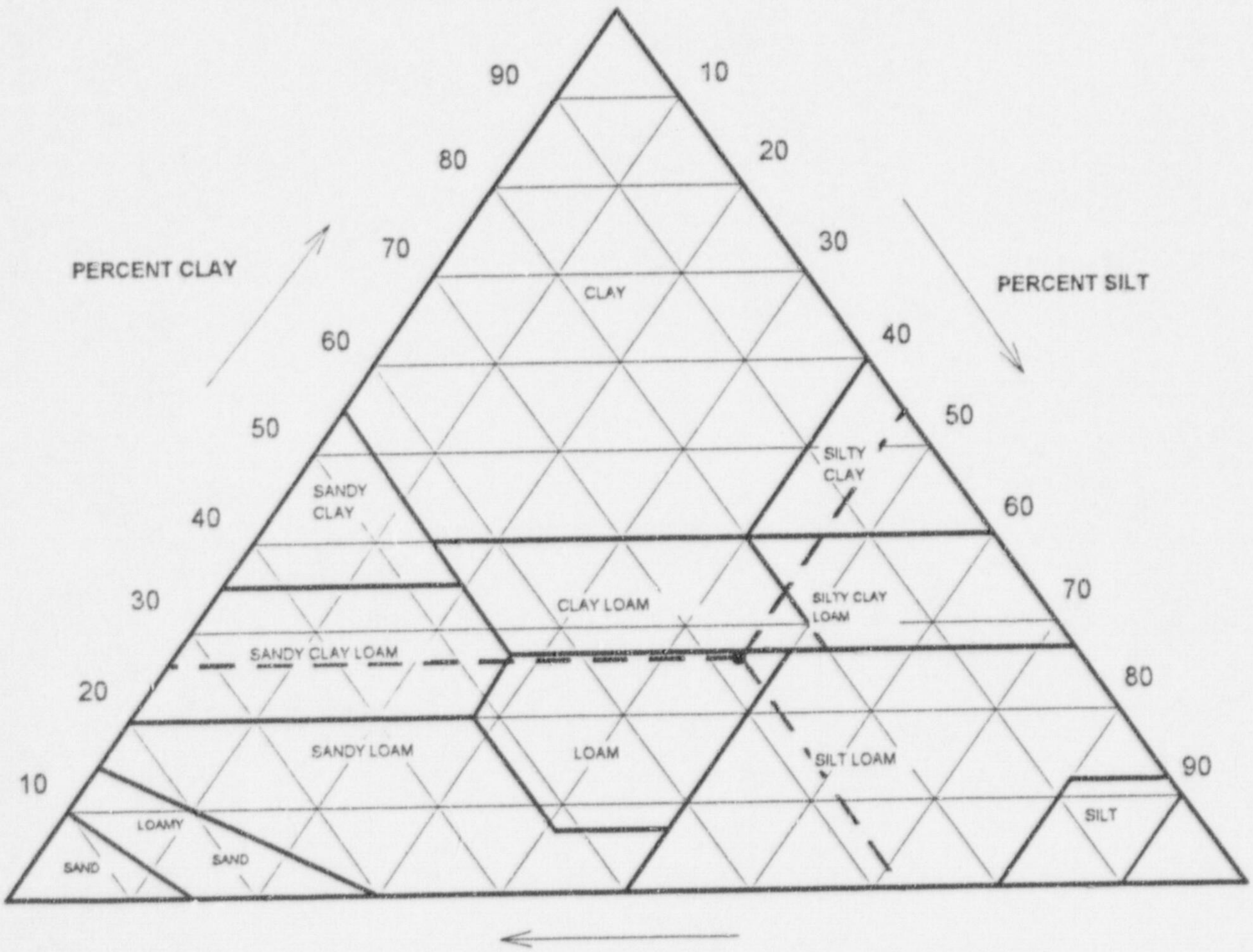
USDA CLASSIFICATION CHART

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY



Components	Corrected % of Minus 2.0 mm material for USDA Classificat.
Gravel	0.00
Sand	27.52
Silt	46.18
Clay	26.30

USDA Classification ***LOAM***

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DATE: 11/12/96
REVISION: 1

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WASH SIEVE ANALYSIS

ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	2457	Tare No.	9
Wgt.Tare + Wet Specimen (gm)	1352.50	Wgt.Tare + Wet Specimen (gm)	426.10
Wgt.Tare + Dry Specimen (gm)	1280.40	Wgt.Tare + Dry Specimen (gm)	419.80
Weight of Tare (gm)	99.91	Weight of Tare (gm)	74.45
Weight of Water (gm)	72.10	Weight of Water (gm)	6.30
Weight of Dry Soil (gm)	1180.49	Weight of Dry Soil (gm)	345.35
Moisture Content (%)	**6.1**	**Moisture Content (%)**	**1.8**

Wet Weight -3/4" Sample (gm)	26564	Weight of the Dry Specimen (gm)	1180.49
Dry Weight - 3/4" Sample (gm)	25035.0	Weight of minus #200 material (gm)	821.24
Wet Weight +3/4" Sample (gm)	563.05	Weight of plus #200 material (gm)	359.25
Dry Weight + 3/4" Sample (gm)	552.96		
Total Dry Weight Sample (gm)	25587.9	**J - Factor (Percent Finer than 3/4")**	**0.9780**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	75.82		0.30	0.30	99.70	**99.70**
1"	25	294.51		1.15	1.45	98.55	**98.55**
3/4"	19	192.72		0.75	2.20	97.80	**97.80**
1/2"	12.5	19.14		1.62	1.62	98.38	**96.21**
3/8"	9.5	13.81		1.17	2.79	97.21	**95.07**
#4	4.75	29.58		2.51	5.30	94.70	**92.62**
#10	2	53.61		4.54	9.84	90.16	**88.18**
#20	0.85	57.59	(**)	4.88	14.72	85.28	**83.41**
#40	0.425	40.09		3.40	18.11	81.89	**80.09**
#60	0.25	36.60		3.10	21.21	78.79	**77.05**
#140	0.106	83.69		7.09	28.30	71.70	**70.12**
#200	0.075	25.14		2.13	30.43	69.57	**68.04**
Pan	-	821.24		69.57	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By JP Date 2/4/98 Checked By TO Date 2-9-98

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HYDROMETER ANALYSIS

ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Color	GRAY

Elapsed Time (min)		R Measured	Temp. (°C)	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0	NA	NA	NA	NA	NA	NA	NA	NA
2	50.0	50.0	22.3	43.4	84.3	0.01308	0.0263	**57.4**
5		46.0	22.3	39.4	76.6	0.01308	0.0173	**52.1**
15		40.0	22.3	33.4	64.9	0.01308	0.0105	**44.2**
30		36.0	22.3	29.4	57.1	0.01308	0.0077	**38.9**
61		32.0	22.3	25.4	49.3	0.01308	0.0056	**33.6**
250		26.5	22.5	19.9	38.6	0.01305	0.0029	**26.3**
1440		21.0	22.1	14.4	27.9	0.01311	0.0012	**19.0**

Soil Specimen Data		Other Corrections	
Tare No.	532		
Tare + Dry Material (gm)	157.64	a - Factor	0.99
Weight of Tare (gm)	101.73	Composite Correction	6.63
Weight of Deflocculant (gm)	5.0	Percent Finer than # 200	68.04
Weight of Dry Material (gm)	50.91	Specific Gravity	2.7 Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 2/4/98 Checked By Jcm Date 2-9-98

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ATTERBERG LIMIT

ASTM D 4318-96 (SOP - S4)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Soil Description	**GRAY LEAN CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

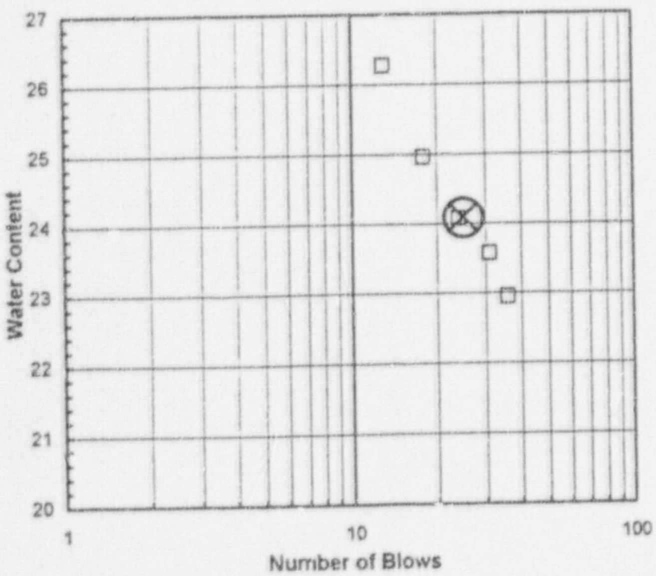
(Minus No. 40 sieve material, Airdried)

Liquid Limit Test	1	2	3	4	5	MULTIPOINT
Tare Number	2317	2055	2239	2316	2060	
Wt. of Tare & WS (gm)	41.05	40.98	40.39	49.17	42.57	
Wt. of Tare & DS (gm)	36.29	36.74	35.99	43.25	37.15	
Wt. of Tare (gm)	15.55	18.75	17.71	19.53	16.52	
Wt. of Water (gm)	4.76	4.24	4.4	5.92	5.42	
Wt. of DS (gm)	20.74	17.99	18.28	23.72	20.63	
Moisture Content (%)	**23.0**	**23.6**	**24.1**	**25.0**	**26.3**	
Number of Blows	**36**	**31**	**24**	**18**	**13**	

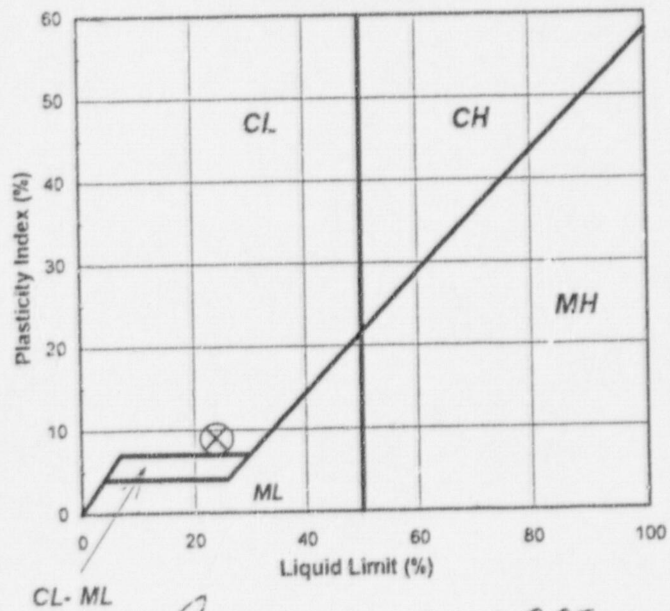
Plastic Limit Test	1	2	3
Tare Number	2047	1837	2041
Wt. of Tare & WS (gm)	21.94	24.63	24.86
Wt. of Tare & DS (gm)	21.12	23.82	23.97
Wt. of Tare (gm)	15.58	18.26	17.83
Wt. of Water (gm)	0.82	0.81	0.89
Wt. of DS (gm)	5.54	5.56	6.14
Moisture Content (%)	**14.8**	**14.6**	**14.5**

Test Results	
Liquid Limit (%)	**24**
Plastic Limit (%)	**15**
Plasticity Index (%)	**9**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



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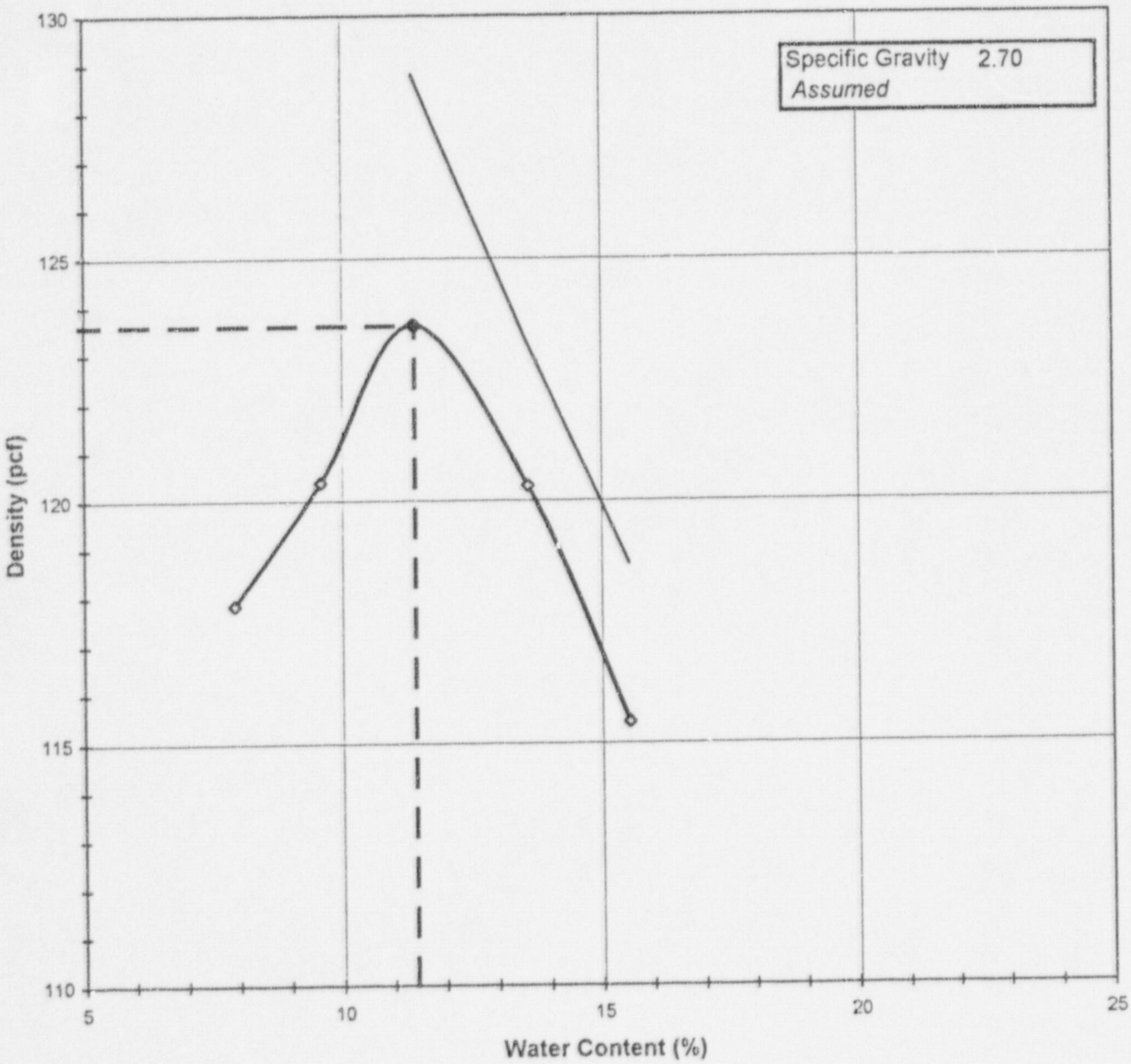
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002	Test Method	STANDARD

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Optimum Water Content **11.4**
Maximum Dry Density **123.6**



Tested By JP *Date* 2/4/98 *Checked By* Jcm *Date* 2-6-98

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 S(P-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-17
Lab ID	98040-01.002		

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	C

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G441
Mold ID	G778
Mold diameter	6
Weight of the Mold	5584
Volume of the Mold(cc)	2124

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	9913	10074	10272	10236	10124
Wt.of Mold (gm)	5584	5584	5584	5584	5584
Wt. of WS	4329	4490	4688	4652	4540
Mold Volume (cc)	2124	2124	2124	2124	2124

Moisture Content / Density

Tare Number	582	569	1701	538	574
Wt. of Tare & WS (gm)	477.70	459.40	439.70	534.10	657.60
Wt. of Tare & DS (gm)	448.80	426.50	403.00	480.00	580.40
Wt. of Tare (gm)	84.13	83.36	81.34	82.15	83.72
Wt. of Water (gm)	28.90	32.90	36.70	54.10	77.20
Wt. of DS (gm)	364.67	343.14	321.66	397.85	496.68

Wet Density (gm/cc)	2.04	2.11	2.21	2.19	2.14
Wet Density (pcf)	127.2	131.9	137.7	136.7	133.4
Moisture Content (%)	**7.9**	**9.6**	**11.4**	**13.6**	**15.5**
Dry Density (pcf)	**117.8**	**120.4**	**123.6**	**120.3**	**115.4**

Zero Air Voids

Moisture Content (%)	11.4	13.6	15.5
Dry Unit Weight (pcf)	128.8	123.2	118.7

Tested By JP *Date* 2/4/98 *Checked By* Jcm *Date* 2-6-98

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PERMEABILITY TEST

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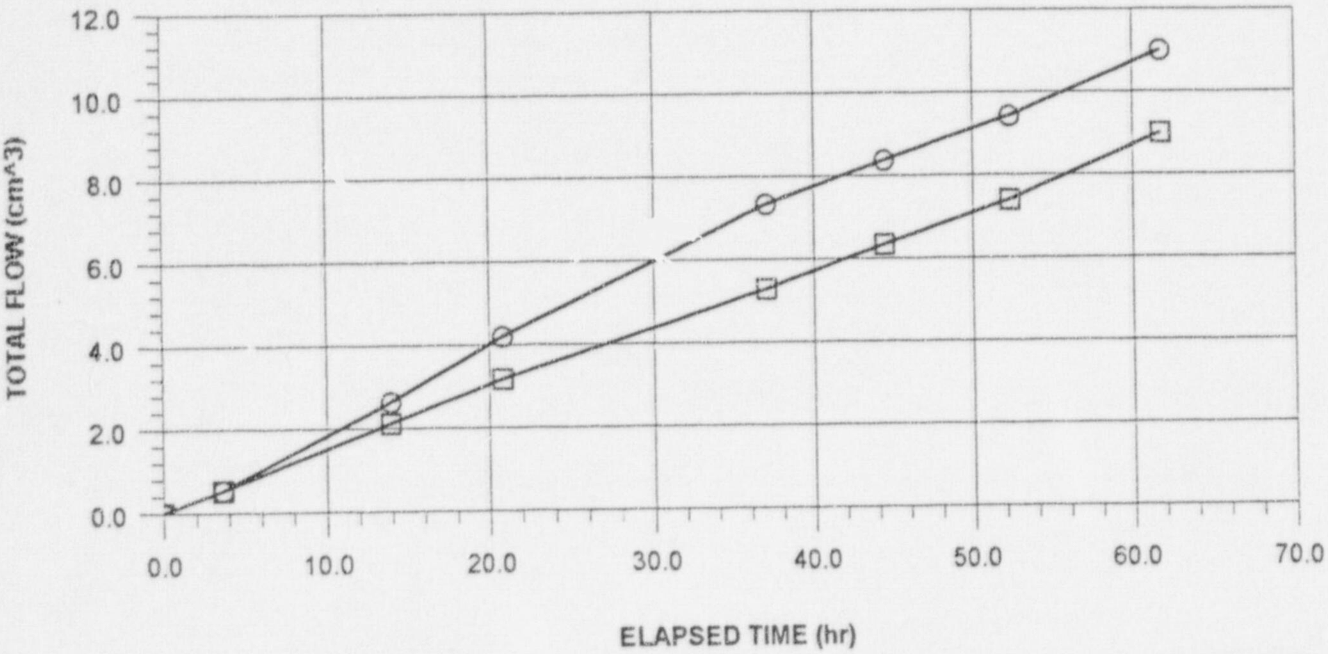
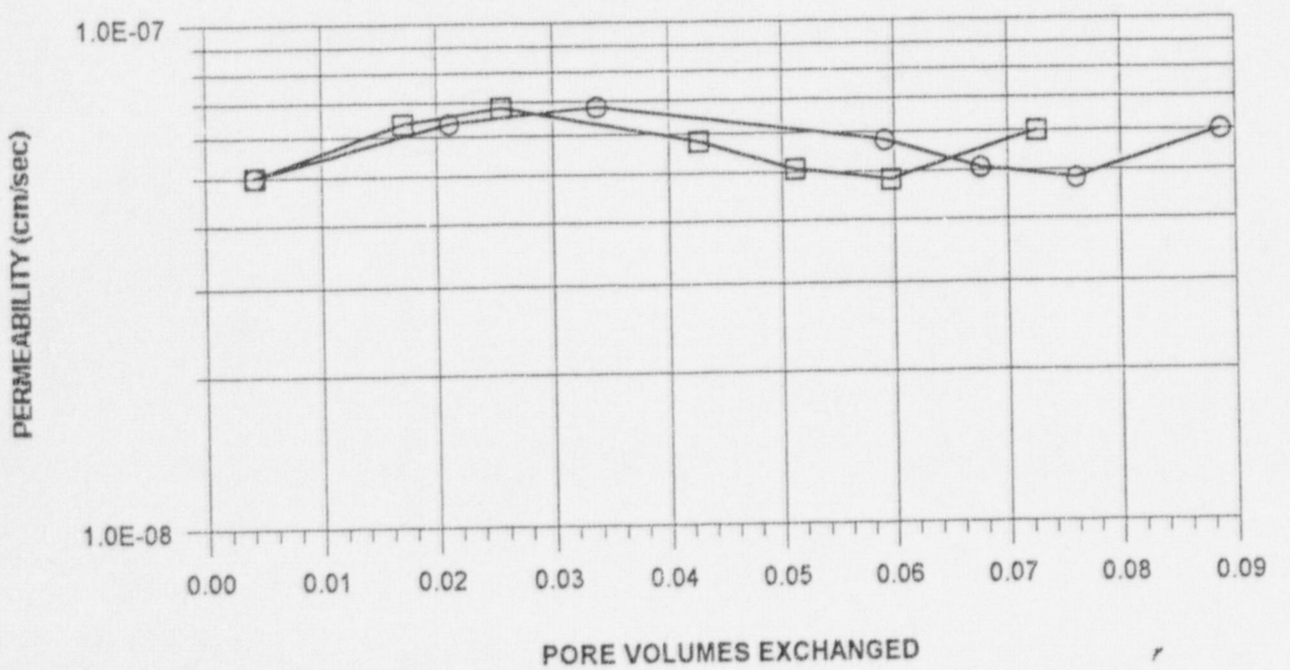
Client	ESC	Boring No.	NA
Client Project	C1220 BERT AVE.	Depth(ft.)	NA
Project No.	98040-01	Sample No.	C-17

AVERAGE PERMEABILITY = 5.4E-08 **cm/sec @ 20°C**
AVERAGE PERMEABILITY = 5.4E-10 **m/sec @ 20°C**

TOTAL FLOW vs. ELAPSED TIME



PORE VOLUMES EXCHANGED vs. PERMEABILITY



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PERMEABILITY TEST

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Client	ESC	Tested By	JCM	Date	02-09-98
Client Project	C1220 BERT AVE.	Checked By	GU	Date	2-13-98
Project No.	98040-01				
Boring No.	NA	Specific Gravity	2.70 ASSUMED		
Depth(ft.)	NA	Sample Condition	REMOLDED		
Sample No.	C-17				

Visual Description GRAY CLAY

MOISTURE CONTENT	BEFORE TEST	AFTER TEST
Tare Number	444	558
Wt. Tare & WS(gm.)	373.11	617.80
Wt. Tare & DS(gm.)	340.44	549.90
Wt. Water(gm.)	32.67	67.90
Wt. Tare(gm.)	99.87	81.46
Wt. DS(gm.)	240.57	468.44
Moisture Content(%)	13.6	14.5

UNIT WEIGHT

Wt. Tube & WS.(gms.)	2258.80	NA
Wt. Of Tube(gms.)	1352.50	NA
Wt. Of WS.(gms.)	906.30	913.6
Length 1 (in.)	4.000	3.964
Length 2 (in.)	4.000	3.968
Length 3 (in.)	4.000	3.977
Top Diameter (in.)	2.870	2.867
Middle Diameter (in.)	2.870	2.864
Bottom Diameter (in.)	2.870	2.864
Average Length (in)	4.00	3.97
Average Area (in^2)	6.47	6.45
Sample Volume(cc.)	423.94	419.37
Unit Wet Wt.(gms/cc)	2.14	2.18
Unit Wet Wt.(pcf.)	133.4	135.9
Unit Dry Wt.(pcf.)	117.4	118.7
Unit Dry Wt.(gms/cc)	1.88	1.90
Void Ratio,e	0.43	0.42
Porosity, n	0.30	0.30
Pore Volume(cm^3)	128.4	123.8

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PERMEABILITY TEST

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Client	ESC	Tested By	JCM	Date	02-09-98
Client Project	C1220 BERT AVE.	Checked By	GU	Date	2-13-98
Project No.	98040-01				
Boring No.	NA				
Depth(ft.)	NA				
Sample No.	C-17				
Visual Description	GRAY CLAY				

Pressure Heads (Constant)	
Top Cap (psi)	27.5
Bottom Cap (psi)	30.0
Cell (psi)	35.0
Total Pressure Head (cm)	175.8

Final Sample Dimensions	
Sample Length (cm.), L	10.08
Sample Diameter (cm.)	7.28
Sample Area (cm.^2), A	41.59
Inflow Burette Area, (cm.^2), a-in	4.74
Outflow Burette Area, (cm.^2), a-out	4.71
B Parameter	95%

AVERAGE PERMEABILITY = 5.4E-08 cm/sec @ 20°C
AVERAGE PERMEABILITY = 5.4E-10 m/sec @ 20°C

DATE mon-dy-yr	TIME hr	TIME min	ELAPSED TIME (t) hr	TOTAL INFLOW cm^3	TOTAL OUTFLOW cm^3	TOTAL HEAD (h) cm	FLOW 0 FLOW 1 STOP	TEMP °C	INCREMENTAL PERMEABILITY @ 20°C cm/sec
02-09-98	18	15	0.0	0.0	0.0	188.9	0	20.5	NA
02-09-98	21	55	3.7	0.5	0.5	188.7	0	21.0	5.0E-08
02-10-98	8	10	13.9	2.6	2.1	187.9	0	20.5	6.3E-08
02-10-98	15	5	20.8	4.2	3.2	187.4	0	20.0	6.8E-08
02-11-98	7	15	37.0	7.3	5.3	186.3	0	20.5	5.8E-08
02-11-98	14	40	44.4	8.4	6.3	185.8	0	20.5	5.1E-08
02-11-98	22	35	52.3	9.4	7.4	185.4	0	20.0	4.8E-08
02-12-98	8	0	61.8	11.0	9.0	184.7	1	20.7	6.0E-08

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DCN: DS-S3A
DATE: 11/12/96
REVISION: 1

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SIEVE AND HYDROMETER ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-02	Sample No.	C-18
Lab ID	98040-02.001	Soil Color	BROWN

	SIEVE ANALYSIS		*HYDROMETER*	
USCS	gravel	sand	silt and clay fraction	
USDA	gravel	sand	silt	clay

Sieve Size (mm)	Percent Finer	Components	Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
100	100.00	*Gravel*	11.97	**0.00**
2	88.03	*Sand*	25.67	**29.16**
0.075	67.52	*Silt*	40.32	**45.80**
0.05	62.36	*Clay*	22.04	**25.04**
0.002	22.04			

USDA Classification	***LOAM***
USCS Symbol	***CL, TESTED***
USCS Classification	***SANDY LEAN CLAY***

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DCN: DS-S3A
DATE: 11/12/96
REVISION: 1

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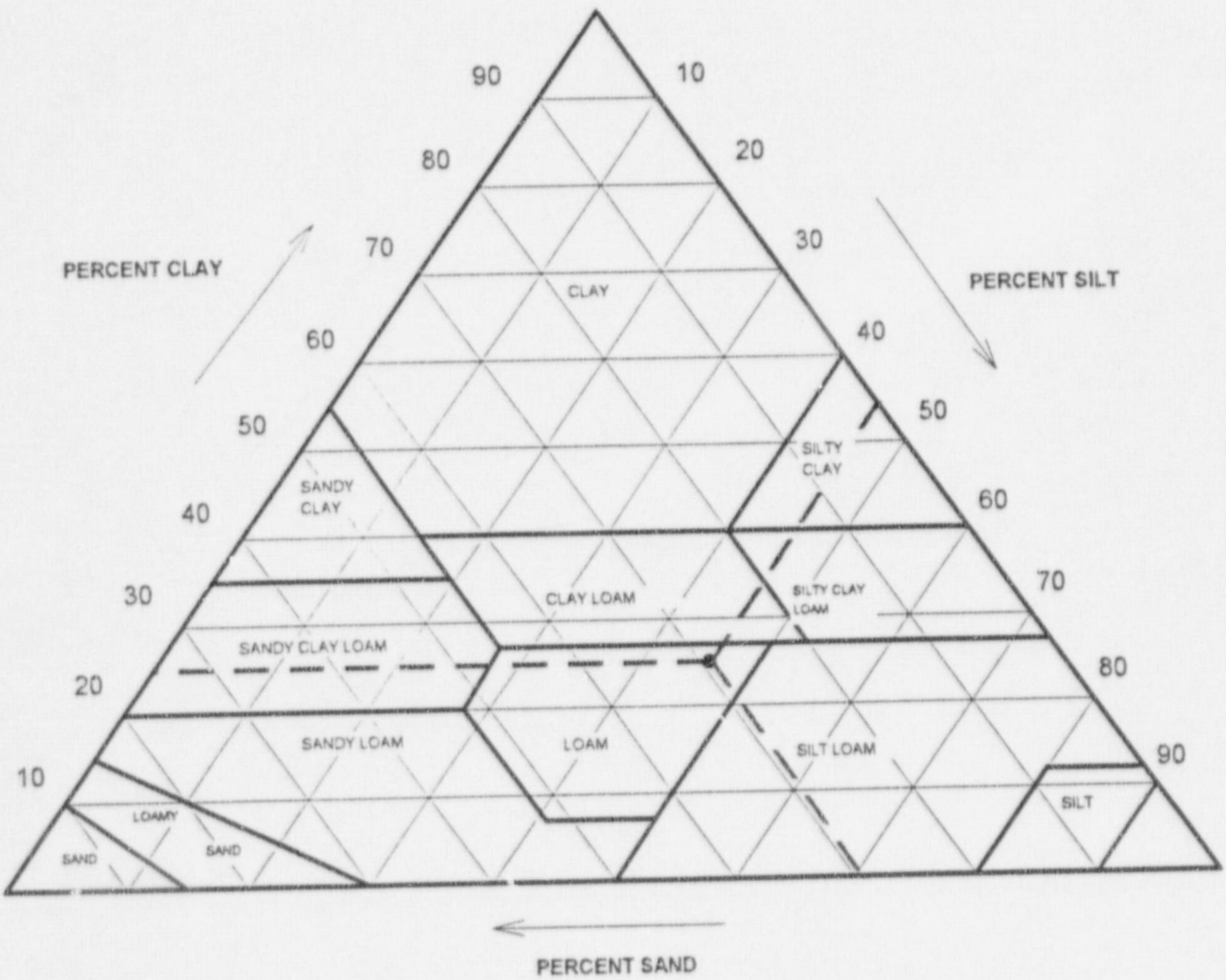
USDA CLASSIFICATION CHART

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-02	Sample No.	C-18
Lab ID	98040-02.001	Soil Color	BROWN



Components	Corrected % of Minus 2.0 mm material for USDA Classificat.
Gravel	0.00
Sand	29.16
Silt	45.80
Clay	25.04
USDA Classification	***LOAM***

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DCN: DS-S3A
DATE: 11/12/96
REVISION: 1

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WASH SIEVE ANALYSIS

A... D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-02	Sample No.	C-18
Lab ID	98040-02.001	Soil Color	BROWN

Moisture Content of Passing 3/4" Material		Water Content of Retained 3/4" Material	
Tare No.	526	Tare No.	567
Wgt.Tare + Wet Specimen (gm)	1175.30	Wgt.Tare + Wet Specimen (gm)	443.90
Wgt.Tare + Dry Specimen (gm)	1128.60	Wgt.Tare + Dry Specimen (gm)	439.50
Weight of Tare (gm)	101.38	Weight of Tare (gm)	84.60
Weight of Water (gm)	46.70	Weight of Water (gm)	4.40
Weight of Dry Soil (gm)	1027.22	Weight of Dry Soil (gm)	354.90
Moisture Content (%)	**4.5**	**Moisture Content (%)**	**1.2**

Wet Weight -3/4" Sample (gm)	23227	Weight of the Dry Specimen (gm)	1027.22
Dry Weight - 3/4" Sample (gm)	22217.0	Weight of minus #200 material (gm)	704.82
Wet Weight +3/4" Sample (gm)	359.63	Weight of plus #200 material (gm)	322.40
Dry Weight + 3/4" Sample (gm)	355.23		
Total Dry Weight Sample (gm)	22572.2	**J - Factor (Percent Finer than 3/4")**	**0.9841**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	Accumulated Percent Finer (%)
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00		0.00	0.00	100.00	**100.00**
1"	25	210.79		0.93	0.93	99.07	**99.07**
3/4"	19	148.84		0.66	1.59	98.41	**98.41**
1/2"	12.5	12.16		1.18	1.18	98.82	**97.24**
3/8"	9.5	6.73		0.66	1.84	98.16	**96.60**
#4	4.75	37.27		3.63	5.47	94.53	**93.03**
#10	2	52.12		5.07	10.54	89.46	**88.03**
#20	0.85	46.82	(**)	4.56	15.10	84.90	**83.55**
#40	0.425	35.33		3.44	18.54	81.46	**80.16**
#60	0.25	35.35		3.44	21.98	78.02	**76.78**
#140	0.106	74.54		7.26	29.24	70.76	**69.64**
#200	0.075	22.08		2.15	31.39	68.61	**67.52**
Pan	-	704.82		68.61	100.00	-	-

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Specimen*

Tested By GU Date 2/12/98 Checked By Jcm Date 2-20-98

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HYDROMETER ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-02	Sample No.	C-18
Lab ID	98040-02.001	Soil Color	BROWN

Elapsed Time (min)		R Measured	Temp. (°C)	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0	NA	NA	NA	NA	NA	NA	NA	NA
2	47.5	47.5	22	40.7	80.8	0.01313	0.0271	**54.6**
5		45.0	22	38.2	75.8	0.01313	0.0175	**51.2**
15		39.0	22	32.2	63.9	0.01313	0.0107	**43.2**
30		34.5	22	27.7	55.0	0.01313	0.0078	**37.1**
66		31.0	22.1	24.2	48.1	0.01311	0.0054	**32.5**
250		25.0	21.8	18.2	36.2	0.01316	0.0029	**24.4**
1440		21.0	21.5	14.2	28.2	0.01321	0.0012	**19.1**

Soil Specimen Data		Other Corrections	
Tare No.	522		
Tare + Dry Material (gm)	154.3	a - Factor	0.99
Weight of Tare (gm)	99.4	Composite Correction	6.78
Weight of Deflocculant (gm)	5.0	Percent Finer than # 200	67.52
Weight of Dry Material (gm)	49.9		
		Specific Gravity	2.7 Assumed

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 2/13/98 Checked By Jom Date 2-20-98

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ATTERBERG LIMIT

ASTM D 4318-96 (SOP - S4)

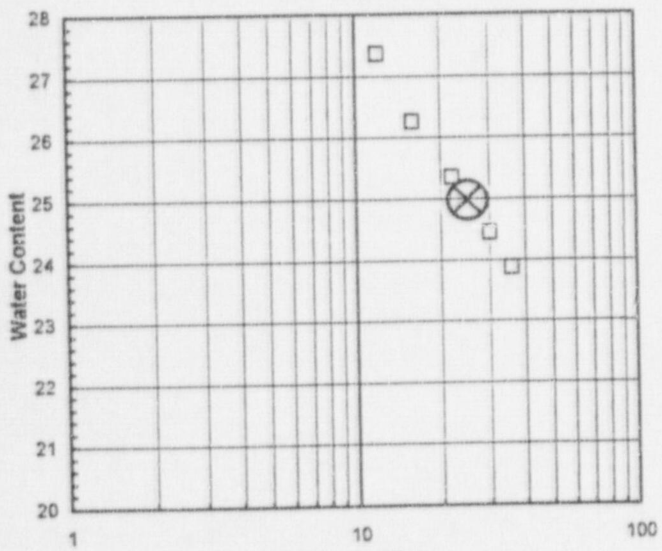
Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-02	Sample No.	C-18
Lab ID	98040-02.001	Soil Description	**BROWN LEAN CLAY**

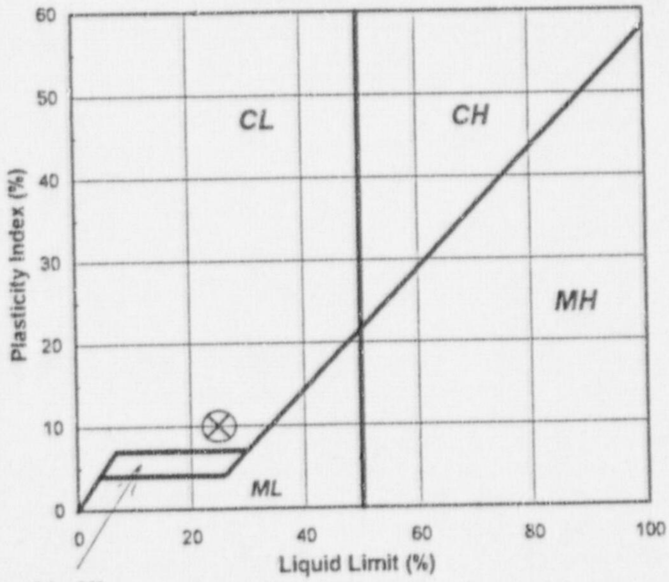
Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

Liquid Limit Test	1	2	3	4	5	MULTIPOINT
Tare Number	47	53	23	71	2275	
Wt. of Tare & WS (gm)	53.15	44.65	45.71	51.03	46.40	
Wt. of Tare & DS (gm)	46.33	39.26	39.80	44.20	39.72	
Wt. of Tare (gm)	17.76	17.21	16.49	18.19	15.31	
Wt. of Water (gm)	6.82	5.39	5.91	6.83	6.68	
Wt. of DS (gm)	28.57	22.05	23.31	26.01	24.41	
Moisture Content (%)	**23.9**	**24.4**	**25.4**	**26.3**	**27.4**	
Number of Blows	**36**	**30**	**22**	**16**	**12**	

Plastic Limit Test	1	2	3
Tare Number	2296	2062	2239
Wt. of Tare & WS (gm)	25.55	25.58	24.33
Wt. of Tare & DS (gm)	24.72	24.74	23.47
Wt. of Tare (gm)	19.06	19.00	17.70
Wt. of Water (gm)	0.83	0.84	0.86
Wt of DS (gm)	5.66	5.74	5.77
Moisture Content (%)	**14.7**	**14.6**	**14.9**

Test Results	
Liquid Limit (%)	**25**
Plastic Limit (%)	**15**
Plasticity Index (%)	**10**
USCS Symbol	**CL**





Tested By TO *Date* 2/17/98 *Checked By* Jcm *Date* 2-20-98

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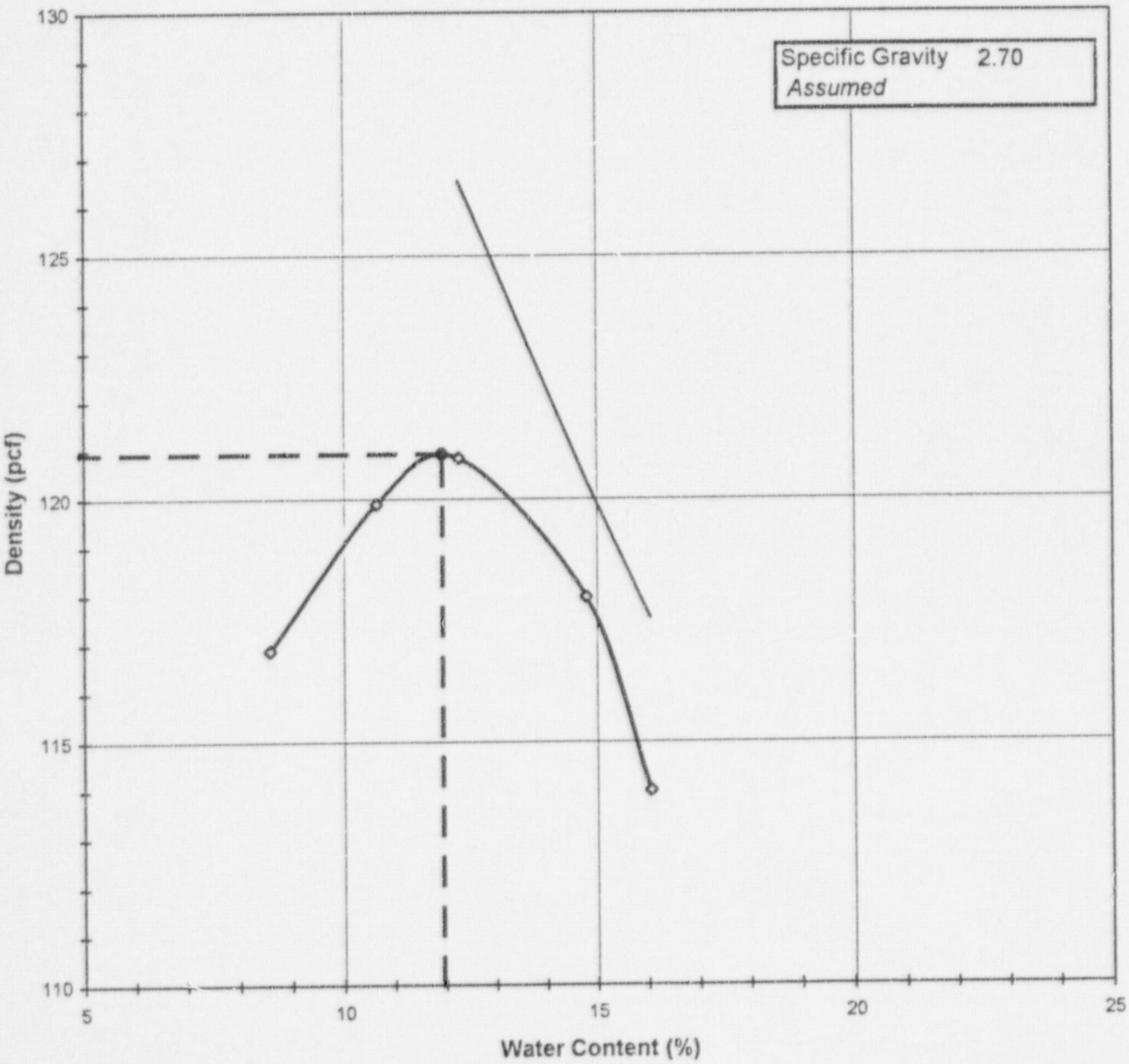
MOISTURE DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-18
Lab ID	98040-01.003	Test Method	**STANDARD**

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Optimum Water Content	**12.0**
Maximum Dry Density	**120.9**



Tested By MV *Date* 2/4/98 *Checked By* Jem *Date* 2-6-98

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MOISTURE - DENSITY RELATIONSHIP

ASTM D698-91 SOP-S12

Client	ESC	Boring No.	NA
Client Reference	C1220 BERT AVE.	Depth (ft)	NA
Project No.	98040-01	Sample No.	C-18
Lab ID	98040-01.003		

Visual Description GRAY CLAY WITH ROCK FRAGMENTS

Total Weight of the Sample (gm)	NA
As Received Water Content(%)	NA
Assumed Specific Gravity	2.70
Percent Retained on 3/4"	NA
Percent Retained on 3/8"	NA
Percent Retained on #4	NA
Oversize Material	Not included
Procedure Used	C

TestType	STANDARD
Rammer Weight (lbs)	5.5
Rammer Drop (in)	12
Rammer Type	MECHANICAL
Machine ID	G441
Mold ID	G695
Mold diameter	6
Weight of the Mold	5746
Volume of the Mold(cc)	2124

Mold / Specimen

Point No.	1	2	3	4	5
Wt. of Mold & WS (gm)	10066	10262	10364	10356	10249
Wt.of Mold (gm)	5746	5746	5746	5746	5746
Wt. of WS	4320	4516	4618	4610	4503
Mold Volume (cc)	2124	2124	2124	2124	2124

Moisture Content / Density

Tare Number	1694	1691	1700	545	ZZ
Wt. of Tare & WS (gm)	406.20	390.32	426.50	418.70	422.60
Wt. of Tare & DS (gm)	380.73	360.79	388.56	375.41	375.86
Wt. of Tare (gm)	84.03	83.61	79.45	82.81	84.69
Wt. of Water (gm)	25.47	29.53	37.94	43.29	46.74
Wt. of DS (gm)	296.70	277.18	309.11	292.60	291.17

Wet Density (gm/cc)	2.03	2.13	2.17	2.17	2.12
Wet Density (pcf)	126.9	132.7	135.7	135.4	132.3
Moisture Content (%)	**8.6**	**10.7**	**12.3**	**14.8**	**16.1**
Dry Density (pcf)	**116.9**	**119.9**	**120.8**	**118.0**	**114.0**

Zero Air Voids

Moisture Content (%)	12.3	14.8	16.1
Dry Unit Weight (pcf)	126.5	120.4	117.5

Tested By MV *Date* 2/4/98 *Checked By* Jem *Date* 2-6-98

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PERMEABILITY TEST

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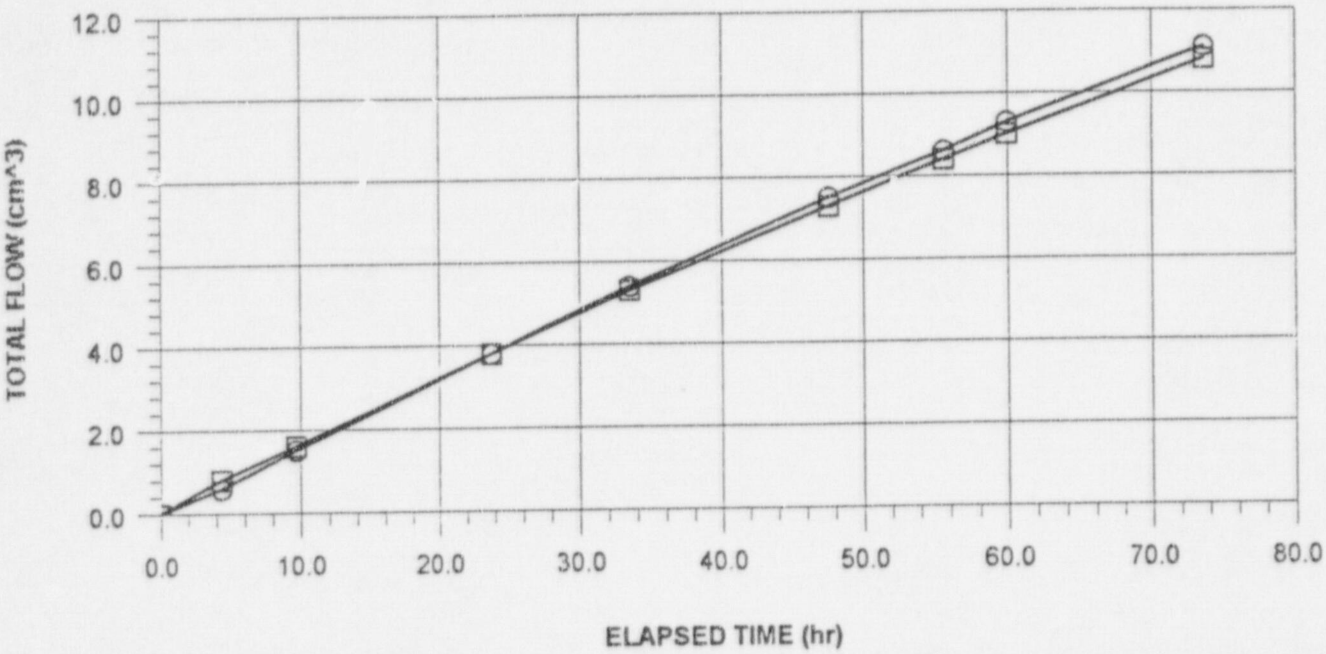
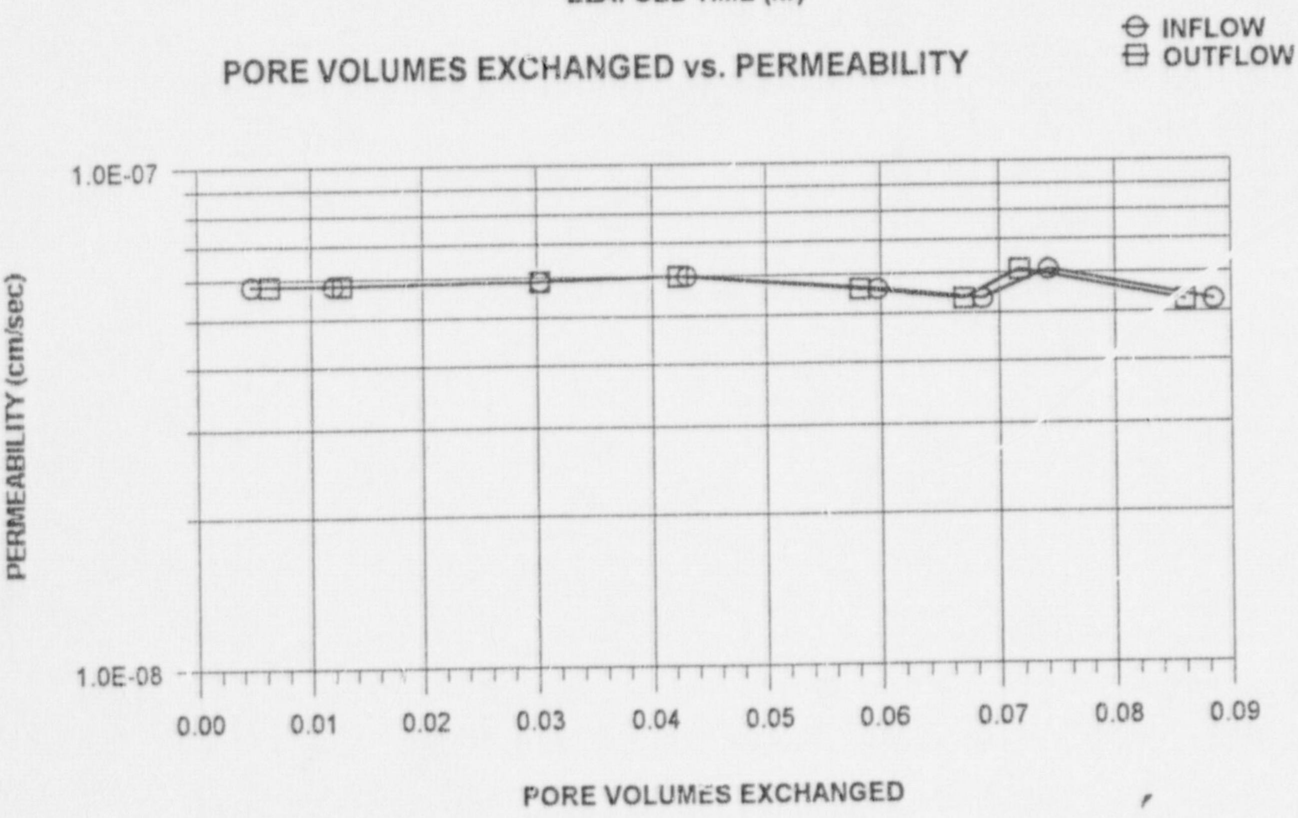
Client	ESC	Boring No.	NA
Client Project	C1220 BERT AVE.	Depth(ft.)	NA
Project No.	98040-02	Sample No.	C-18 REMOLDED TO 96% STD.PROCTOR AT +2.1% WC.

AVERAGE PERMEABILITY = 5.6E-08 cm/sec @ 20°C
AVERAGE PERMEABILITY = 5.6E-10 m/sec @ 20°C

TOTAL FLOW vs. ELAPSED TIME



PORE VOLUMES EXCHANGED vs. PERMEABILITY



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PERMEABILITY TEST

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Client	ESC	Tested By	JCM	Date	02-13-98
Client Project	C1220 BERT AVE.	Checked By	TO	Date	2-23-98
Project No.	98040-02				
Boring No.	NA	Specific Gravity	2.70 ASSUMED		
Depth(ft.)	NA	Sample Condition	REMOLDED		

Sample No. C-18 REMOLDED TO 96% STD. PROCTOR AT +2.1% WC.

Visual Description GRAY CLAY

MOISTURE CONTENT	BEFORE TEST	AFTER TEST
Tare Number	1439	541
Wt. Tare & WS(gm.)	221.01	521.10
Wt. Tare & DS(gm.)	199.21	462.60
Wt. Water(gm.)	21.80	58.50
Wt. Tare(gm.)	44.06	82.97
Wt. DS(gm.)	155.15	379.63
Moisture Content(%)	14.1	15.4

UNIT WEIGHT		
Wt. Tube & WS.(gms.)	2252.40	NA
Wt. Of Tube(gms.)	1352.50	NA
Wt. Of WS.(gms.)	899.90	910.6
Length 1 (in.)	4.000	3.939
Length 2 (in.)	4.000	3.979
Length 3 (in.)	4.000	3.948
Top Diameter (in.)	2.870	2.861
Middle Diameter (in.)	2.870	2.864
Bottom Diameter (in.)	2.870	2.868
Average Length (in)	4.00	3.96
Average Area (in^2)	6.47	6.44
Sample Volume(cc.)	423.94	417.66
Unit Wet Wt.(gms/cc)	2.12	2.18
Unit Wet Wt.(pcf.)	132.5	136.1
Unit Dry Wt.(pcf.)	116.1	117.9
Unit Dry Wt.(gms/cc)	1.86	1.89
Void Ratio,e	0.45	0.43
Porosity, n	0.31	0.30
Pore Volume(cm^3)	131.7	125.4

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PERMEABILITY TEST

Client	ESC	Tested By	JCM	Date	02-13-98
Client Project	C1220 BERT AVE.	Checked By	T.O	Date	2-23-98
Project No.	98040-02				
Boring No.	NA				
Depth(ft.)	NA				
Sample No.	C-18 REMOLDED TO 96% STD. PROCTOR AT +2.1% WC.				
Visual Description	GRAY CLAY				

Pressure Heads (Constant)		Final Sample Dimensions	
Top Cap (psi)	27.5	Sample Length (cm.), L	10.05
Bottom Cap (psi)	30.0	Sample Diameter (cm.)	7.28
Cell (psi)	35.0	Sample Area (cm.^2), A	41.57
Total Pressure Head (cm)	175.8	Inflow Burette Area, (cm.^2), a-in	0.91
		Outflow Burette Area, (cm.^2), a-out	0.96
		B Parameter	97%

AVERAGE PERMEABILITY = 5.6E-08 **cm/sec @ 20°C**
AVERAGE PERMEABILITY = 5.6E-10 **m/sec @ 20°C**

DATE mon-dy-yr	TIME hr	TIME min	ELAPSED TIME (t) hr	TOTAL INFLOW cm^3	TOTAL OUTFLOW cm^3	TOTAL HEAD (h) cm	FLOW 0 FLOW 1 STOP	TEMP °C	INCREMENTAL PERMEABILITY @ 20°C cm/sec
02-18-98	7	35	0.0	0.0	0.0	184.0	0	20.6	NA
02-18-98	11	55	4.3	0.6	0.8	182.5	0	20.6	5.8E-08
02-18-98	17	15	9.7	1.5	1.6	180.7	0	20.6	5.8E-08
02-19-98	7	20	23.8	3.8	3.8	175.9	0	21.0	5.9E-08
02-19-98	17	5	33.5	5.4	5.3	172.5	0	21.0	6.0E-08
02-20-98	7	10	47.6	7.5	7.3	168.1	0	21.0	5.6E-08
02-20-98	15	15	55.7	8.6	8.4	165.8	0	21.0	5.3E-08
02-20-98	19	30	59.9	9.3	9.0	164.4	0	21.0	6.1E-08
02-21-98	9	15	73.7	11.1	10.8	160.5	1	21.0	5.3E-08

544 Braddock Avenue · East Pittsburgh, PA 15112 · Phone (412) 823-7600 · Fax (412) 823-8999

Appendix D

Equipment Specifications

Equipment Specification

CAT D6M LGP Dozer

Engine

Four-stroke cycle, six cylinder 3116 turbocharged diesel engine.

Ratings at 2200 RPM*	kW	HP
Gross power	114	153
Net power	104	140

The following ratings apply at 2200 RPM when tested under the specific standard conditions for the specified standard:

NET POWER	kW	HP	PS
Caterpillar	104	140	—
ISO 9249	104	140	—
EEC 80/1269	104	140	—
SAE J1349	104	140	—
DIN 70020	—	—	145

Dimensions		
Bore	105 mm	4.13 in
Stroke	127 mm	5.0 in
Displacement	6.6 liters	403 cu in

*Power rating conditions

- based on standard air conditions of 25°C (77°F) and 99 kPA (29.32 in Hg) dry barometer
- used 35° API gravity fuel having an LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 30°C (86°F) [ref. a fuel density of 838.9 g/L (7.001 lb/U.S. gal)]
- net power advertised is the power available at the flywheel when engine is equipped with fan, air cleaner, muffler and alternator
- no derating required up to 2300 m (7500 ft) altitude

Features

- direct injection fuel system with individual adjustment-free unit injectors
- 3-ring forged steel crown pistons with aluminum skirts
- heat resistant sil-chrome steel intake and stellite-faced exhaust valves
- forged steel connecting rods
- one-piece cylinder head designed with cast intake manifold
- cast cylinder block with oil cooler cavity cast into block
- induction-hardened, forged crankshaft that is dynamically balanced
- direct electric 24-volt starting and charging system
- two 12-volt, 100 amp-hour, 750 CCA, maintenance-free batteries
- 70-amp alternator
- plate-type, water-cooled oil cooler
- vertical-flow, steel-fin, tube-type radiator
- dry-type, radial-seal air cleaner with primary and secondary elements

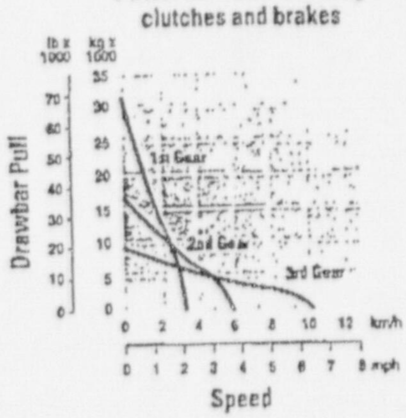
Transmission

Three-speed planetary power shift, remotely mounted from engine.

Speeds with power shift transmission approximate

		km/h	MPH
Forward	1	3.4	2.1
	2	6.0	3.7
	3	10.3	6.4
Reverse	1	4.2	2.6
	2	7.5	4.6
	3	12.8	7.9

Power shift with steering clutches and brakes



Hydraulic Controls

Load-sensing, variable displacement piston pump.

Pump output at 2200 RPM and maximum pressure	119 liters/min	31.5 gpm

Relief valve setting		
XL	24 804 kPa	3600 psi
LGP	24 804 kPa	3600 psi

Control positions
- lift cylinders — raise, hold, lower, float
- tilt cylinder — left, right, hold
- angle cylinders — left, right, hold
- ripper cylinder — raise, hold, lower

Final Drive

Single reduction final drives.

Features
- isolated from ground-impact and blade-induced loads
- modular design reduces removal and installation time
- segmented sprocket simplifies replacement

Cab

Caterpillar cab and Rollover Protective Structure (ROPS). ROPS canopy required in U.S.A.

Features
- meets OSHA and MSHA limits for operator and sound exposure with doors and windows closed (according to ANSI/SAE J1166 JUL87)
- ROPS meets the following criteria:
  - SAE J395
  - SAE J1040 APR88
  - ISO 3471-1 1986
  - ISO 3471-1 1994
- also meets the following criteria for Falling Objects Protective Structure:
  - SAE J231 JAN81
  - ISO 3449 1992 Level II

Note
When properly installed and maintained, the cab offered by Caterpillar, when tested with doors and windows closed according to ANSI/SAE J1166 MAY90. meets OSHA and MSHA requirements for operator sound exposure limits in effect at time of manufacture. The operator sound pressure level is 77 dB(A) when measured per ISO 6394 and 79 dB(A) when measured per ISO 6396

Choice of Lever Steering or Finger Tip Control System meets SAE J1026 APR90.

Features — Lever steering
- hand-lever steering/braking controls
- oil-cooled, hydraulically actuated multiple-disc steering clutches and brakes
- single brake pedal brakes both tracks without disengaging steering clutches
- mechanically actuated, spring applied parking brake

Features — Finger Tip Control
- Finger Tip Control of transmission and steering clutches and brakes
- oil-cooled, electro-hydraulically actuated multiple-disc steering clutches and brakes
- single brake pedal brakes both tracks without disengaging steering clutches
- electro-hydraulically actuated, spring applied parking brake

Service Refill Capacities

	Liters	Gallons
Fuel tank	311	82.2
Crankcase and filter	26	6.9
Transmission, bevel gear and steering clutch (includes torque converter)	122	32.2
Final drives (each side)	7	1.8
Cooling system	48.4	12.8
Implement hydraulic system (includes hydraulic tank)	69.2	18.3
Hydraulic tank	29.2	7.7
Recoil spring compartment	29.5	7.8

Pivot Shaft and Equalizer Bar

Pivot shaft and pinned equalizer bar oscillation system.

Features
- pivot shaft transmits ground impact loads directly to main frame
- protects power train components
- pinned equalizer bar keeps track roller frame in proper alignment
- system provides smooth machine underside
- prevents collection of mud and debris

Heavy Duty Sealed and Lubricated Track

Heavy duty design for superior track life.

Features
- improved sealability and link rail wear life
- wider bushing strap provides improved bushing retention and resistance to bore stretching and cracking
- wider pin boss and longer pin improves pin-to-link retention
- more rail material increases link and roller system wear life
- extends undercarriage maintenance intervals
- reduces overall undercarriage operating costs

Track Roller Frame

Tubular design resists torsional loads.

Features

- Lifetime Lubricated rollers and idlers are directly mounted to roller frame
- oscillating roller frames attach to tractor by pivot shaft and pinned equalizer bar
- large pivot bushings operate in an oil reservoir
- equalizer bar saddle connection is low-friction bushing with remote lube line
- recoil system fully sealed and lubricated

	XL		LGP	
Oscillation:				
front and rear idlers at gauge line	245 mm	9.6"	270 mm	10.6"
at pivot shaft	±2.8°		±2.5°	
Number of rollers (each side)	7		8	
Number of shoes (each side)	40		46	
Width of:				
standard shoes	600 mm	24"	860 mm	34"
optional shoes	560 mm	22"	710 mm	28"
self-cleaning shoes	—		865 mm	34"
Length of track on ground	2550 mm	100"	3102 mm	122"
Track gauge	1890 mm	74"	2160 mm	85"
Ground contact area with:				
560 mm (22") shoes	2.86 m²	4427 in²	—	
600 mm (24") shoes	3.06 m²	4743 in²	—	
710 mm (30") shoes	—		4.40 m²	6820 in²
860 mm (34") shoes	—		5.34 m²	8277 in²
self cleaning 865 mm (34") shoes	—		5.37 m²	8324 in²
Ground Pressure:				
560 mm (22") shoes	.53 kg/cm²	7.49 psi	—	
600 mm (24") shoes	.49 kg/cm²	6.99 psi	—	
710 mm (28") shoes	—		.38 kg/cm²	5.36 psi
860 mm (34") shoes	—		.31 kg/cm²	4.43 psi
self cleaning 865 mm (34") shoes	—		.31 kg/cm²	4.40 psi

Winch

Rugged PA55 winch with freespool.*

Features

- hydraulically actuated multiple-disc wet clutch and brake
- single lever control of clutch and brake functions
- separate lever for freespool operation

Weight	1276.4 kg	2814 lb
Winch length	1120 mm	44.1"
Winch case width	975 mm	38.4"
Flange diameter	504 mm	19.8"
Drum width	330 mm	13"
Drum diameter	254 mm	10"
Cable size:		
Recommended	19 mm	0.75"
Optional	22 mm	0.87"
Drum capacity:		
Recommended cable	122 m	400'
Optional cable	88 m	289'
Oil capacity	74 L	19.55 gal
Cable/ferrule sizes (OD x length)	54 mm x 65 mm	2.13" x 2.56"

*PA55 winch is manufactured for Caterpillar by PACCAR Inc.

Weight (approximate)

Shipping weight

Includes VPAT blade, three-valve hydraulic control, lubricants, coolant, ROFS canopy, track end guiding guards, rigid drawbar, forward warning horn, precleaner, 5% fuel, decelerator and standard shoes.

	XL		LGP	
Power shift	14 750 kg	32,500 lb	16 200 kg	35,700 lb

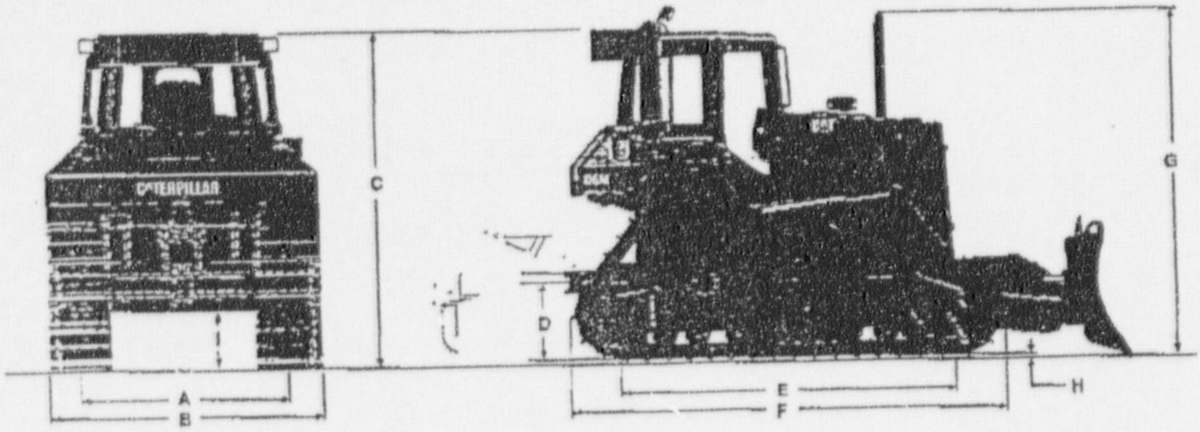
Operating weight

Includes above plus operator and full fuel tank.

	XL		LGP	
Power shift	15 050 kg	33,200 lb	16 500 kg	36,400 lb

Dimensions

(approximate)



Tractor Dimensions

	XL		LGP	
A. Track gauge	1890 mm	74"	2160 mm	85"
B. Width of tractor (standard shoes, no blade)	2490 mm	98"	3020 mm	119"
C. Machine height from tip of grouser with the following equipment:				
ROPS canopy	3022 mm	119"	3136 mm	123"
ROPS cab	3080 mm	121"	3194 mm	126"
D. Drawbar height (center of clevis) from ground face of shoe	595 mm	23.4"	710 mm	27.9"
E. Length of track on ground	2550 mm	100"	3082 mm	121"
F. Length of basic tractor (with drawbar)	3740 mm	147"	4149 mm	163"
With the following attachments, add to basic tractor length:				
Ripper	1016 mm	40"	1016 mm	40"
PA55 winch	381 mm	16"	381 mm	15"
SU blade	1180 mm	46.5"	—	
VPAT blade	1057 mm	41.6"	1244 mm	49"
G. Height over stack from tip of grouser	3152 mm	124"	3266 mm	129"
H. Height of grouser	57 mm	2.2"	57 mm	2.2"
I. Ground clearance from ground face of shoe (per SAE J1234)	424 mm	16.7"	538 mm	21.2"

Bulldozer Specifications

	(XL) 6 VPAT Blade		(XL) 6SU Blade		(LGP) 6 VPAT Blade	
Blade capacity (SAE J1265)	3.18 m³	4.16 yd³	4.26 m³	5.57 yd³	3.16 m³	4.11 yd³
Blade width (over end bits)	3274 mm	129"	3190 mm	125.6"	4080 mm	161"
Blade width (angled 25°)	2967 mm	116.8"	—	—	3698 mm	145.6"
Blade height	1195 mm	47"	1244 mm	49"	1025 mm	40.4"
Digging depth	444 mm	17.5"	520 mm	20.5"	433 mm	17.0"
Ground clearance	925 mm	36.4"	983 mm	38.7"	1024 mm	40.3"
Maximum tilt	497 mm	20"	665 mm	26.2"	598 mm	23.5"
Weight (without hyd. controls)	2372 kg	5229 lb	2427 kg	5351 lb	2819 mm	6215 lb
Total operating weight (with blade)	15 050 kg	33.200 lb	15 105 kg	33,230 lb	16 500 kg	36,400 lb

Ripper

Multi-shank parallelogram design lets you choose one, two or three shanks to match job conditions.

	XL		LGP	
Beam width	2202 mm	86.7"	2202 mm	86.7"
Cross section	216 x 254 mm	8.5 x 10"	216 x 254 mm	8.5 x 10"
Ground clearance under beam (raised)	1090 mm	42.9"	1205 mm	47.4"
(Under tip at full raise)	391.7 mm	15.4"	505.7 mm	19.9"
Number of pockets (teeth)	3		3	
Max. penetration	473.5 mm	18.6"	359.5 mm	14.2"
Max. pryout force	12 600 kg	27,780 lb	12 600 kg	27,780 lb
Max. penetration force (VPAT blade equipped — power shift)	6023 kg	13,278 lb	7198 kg	15,869 lb
Weight				
With three teeth	1406 kg	3100 lb	1406 kg	3100 lb
Each tooth	78 kg	172 lb	78 kg	172 lb

Standard Equipment

Standard and optional equipment may vary. Consult your Caterpillar dealer for specifics.

Air cleaner, dry-type, with precleaner
Air cleaner service indicator
Air intake heater
Alternator, 70-amp
Automatic shifting features (Finger Tip Control models only)
- Auto-kickdown (auto-downshift)
- Auto shift (2R-1F, 2R-2F)

Back up alarm
Batteries
Blower fan
Brake system, service, parking and emergency
Canopy, ROPS (depending on region)
Computerized Caterpillar Monitoring System on Finger Tip Control models. Electronic Monitoring system on Lever Steering models.
Decelerator
Diagnostic connector (Finger Tip Control models)
Drawbar, rigid
Dual fuel filters
Ecology drains
Electric hour meter
Electric starting, 24-volt direct
Engine, 3116 turbocharged diesel engine
Engine enclosures, lockable
Front pull device
Fuel gauge
Fuel priming pump
Gauge package, temperature
- Coolant
- Hydraulic oil (Finger Tip Control models)
- Power Train oil

Guards:
- Crankcase, normal service
- End guiding
- Instrument panel (OROPS)
- Radiator, hinged
- Rear

Horn
Hydraulics, three-valve for VPAT bulldozer
IMRM radiator
Lifetime Lubricated rollers and idlers
Lockable storage compartment
Mirror, rearview
Muffler
Precleaner
Seat, vinyl suspension with adjustable armrests
Seat belt
Segmented sprocket
Single key start
Steering system:
- Lever Steering or
- Finger Tip Control

Track:
- Adjusters, hydraulic
- Carrier rollers
- Heavy Duty Sealed and Lubricated Track
  - with single grouser track shoes
  - XL — 40-section, 600 mm (24")
  - LGP —46-section, 860 mm (34")
  - Center track guiding guards
- Two-piece master link

Transmission, power shift
Vandalism protection
Water separator

Optional Equipment

Approximate changes in operating weights.

	Kg	Lb
Air conditioner	130	287
Armrest, electric adjustable for Finger Tip Control		
Back up alarm (std. in U.S.A.)	2	5
Bulldozers	(see page 17 for weights)	
Cab – ROPS sound suppressed with heater	364	802
Fan, reversible	8	18
Grill, heavy duty hinged radiator	32	92
Guards:		
Center section track guiding (XL)	72	159
Extreme service crankcase	62	137
Precleaner	7	16
Radiator core protector grid	16	35
Rear screen (for ROPS cab)	53	117
Rear screen (for use with air conditioner)	46	101
Rear screen (for ROPS canopy)	64	142
Fuel tank (for ROPS cab or canopy)	106	234
Track roller, full length	289	637
Heater, dash mounted (for ROPS canopy)	34	75
Hydraulics:		
Two valve for 6SU (XL) bulldozer	254	560
Three valve for 6SU (XL) and ripper	281	620
Four valve for 6P bulldozer and ripper	295	650
Lighting system, six lights:		
For use with ROPS cab	16	35
For use with ROPS canopy	16	35
Precleaner with prescreener	5	11
Ripper, parallelogram (with three curved teeth)*	1406	3100
Each tooth	78	172

	Kg	Lb
Starting aids:		
Ether starting aid	3	7
Engine coolant heater (dealer installed)	1	2
Heavy duty batteries	42	94
Suspension seat, contour (vinyl for canopy)	10	22
Sound suppression (European)	72	158
Sweeps (for ROPS canopy)	224	494
Tool kit (dealer installed)	15	33
Track, pair, Heavy Duty Sealed and Lubricated		
XL arrangement, 40-section:		
560 mm (22") MS/HD	-116	-256
560 mm (22") MS/RBT	-136	-300
560 mm (22") ES/HD	80	176
600 mm (24") MS/RBT	-20	-44
600 mm (24") ES/HD	214	472
LGP arrangement, 46-section:		
710 mm (28") MS/HD	-406	-895
710 mm (28") MS/RBT	-428	-944
865 mm (34") MS/RBT	-22	-49
860 mm (34") self cleaning/HD	-293	-646
Track rollers, high flange track guiding arrangement		
XL	27	60
LGP	30	66
Winch (standard and low speed)	1140	2513
Winch fairlead		
3 Roller	293	645
4 Roller	320	704

ES = Extreme service shoes, MS = Moderate service shoes, HD = Heavy duty link track, RBT = Rotating bushing track.

*Straight teeth available for ripper.

Model Comparisons

Former Model	kW	HP	Current Model
D5H	89	120	D6M 104 kW(140 hp)
D5H Series II Standard	89	120	
D5H Series II XL & LGP	97	130	
D6C	104	140	
D6D	104-119	140-160	
D6E	116	155	

Equipment Specification

CAT 966F Rubber-Tired Loader

Engine

Four-stroke cycle, six cylinder 3306 turbocharged diesel engine.

Ratings at 2200 RPM	kW	HP
Gross power	175	235
Flywheel power	164	220
DIN 70020	170	228
ISO 1585	164	220
ISO 3046-2	164	220
EEC 80/1269	164	220
ISO 9249	164	220

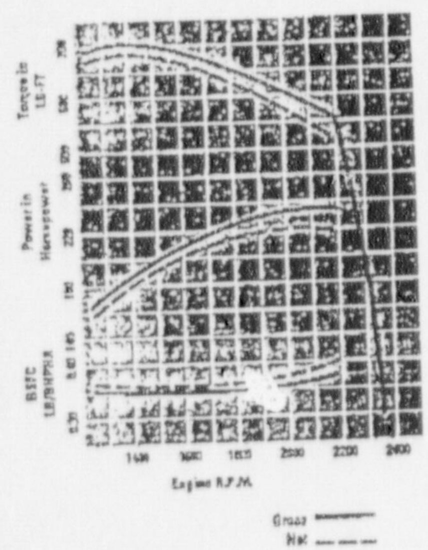
Dimensions		
Bore	120.7 mm	4.75 in.
Stroke	152.4 mm	6.0 in.
Displacement	10.5 liters	638 cu in.

Exhaust emissions

The 3306 DITA meets the following emissions requirements:

- EEC JUL 1997
- US EPA JAN 1996
- Japan MOC APRIL 1997

	g/kWh	g/hp-hr
Hydrocarbons (HC)	0.50	0.37
Carbon monoxide (CO)	1.74	1.30
Nitrogen oxides (NO_x)	8.35	6.23



Power rating conditions

- based on SAE J1349 standard conditions of 25°C (77°F) and 100 kPa (29.6")
- used 35° API, 16°C (60°F), gravity fuel
- fuel had LHV of 42 780 kJ/kg (18,390 Btu/lb) when used at 29°C (85°F)
- fuel density of 838.9 g/L (7.001 lb/gal)
- flywheel power ratings are for engine equipped with fan, alternator, air cleaner, water pump, fuel pump, muffler, and lubricating oil pump
- no derating required up to 2286 m (7500 ft) altitude

Features

- direct-injection fuel system with individual adjustment-free injection pumps and valves
- 3-ring aluminum-alloy pistons, cam-ground, tapered and cooled by oil spray
- spiral ground, stellite faced valves
- tapered connecting rods
- one-piece cylinder head design with integrally cast intake manifold
- deep-skirted cast cylinder block
- induction-hardened, forged crankshaft
- gear driven water pump, air compressor and power steering pump
- direct-electric 24-volt starting and charging system with 12-volt, 100 amp-hour batteries
- standard ether starting aid
- standard oil cooler

Transmission

Planetary power shift transmission with four speeds forward and reverse.

Maximum travel speeds (standard 26.5-25 tires)

		km/h	MPH
Forward	1	7.3	4.5
	2	13.0	8.1
	3	22.5	14.0
	4	38.8	24.1
Reverse	1	8.3	5.2
	2	14.8	9.2
	3	25.6	15.9
	4	43.9	27.3

Features

- automatic shift capability
- Quick Gear Kickdown Switch
- single lever to control both speed and direction
- single-stage, single-speed torque converter
- optional extreme service transmission is available (recommended for millyard/logging applications)

Axles

Fixed front, oscillating rear (±13°).

Features
- maximum single-wheel rise and fall: 495 mm (19.5")
- differentials, enclosed brakes and final drives included
- threaded nuts to set bearing pre-load
- Duo-Cone Seals between axle and housing
- uses SAE 30W (oil change interval: 2000 hours or 1 year)

Brakes

Meets the following standards: OSHA, SAE J1473 DEC84, ISO 3450-1985.

Service brake features
- full-hydraulic wet disc brakes
- completely enclosed and sealed
- adjustment-free
- separate circuits for front and rear axles
- dual pedal braking system with switchable left pedal

Parking brake features
- mechanical, shoe-type brake
- mounted on transmission output shaft for manual operation

Secondary brake features
- Computerized Monitoring System alerts operator if pressure drops and automatically applies parking brake

Final Drives

Planetary final drives consist of ring gears and planetary carrier assemblies.

Features
- ring gears are pressed in and doweled to axle housings
- carrier assemblies include:
  - planet gears with full-floating bronze sleeve bearings
  - planet shafts
  - retaining pins
  - bearings
  - sun gear shafts
  - planetary carriers

Loader Hydraulic System

Open-centered, interrupted series system with full-flow filtering. System is completely sealed. Pilot-operated controls.

Implement system, vane-type pump		
Output at 2092 RPM and 6900 kPa (1000 psi) with SAE 10W oil at 66°C (150°F)	302 liters/min	79 gpm
Relief valve setting	20 700 kPa	3000 psi
Cylinders, double acting: lift, bore and stroke	178 x 759 mm	7.00 x 29.8"
Cylinders, double acting: tilt, bore and stroke	210 x 535 mm	8.25 x 21.0"

Pilot system, vane-type pump		
Output at 2092 RPM and 6900 kPa (1000 psi) with SAE 10W oil at 66°C (150°F)	21.0 liters/min	5.5 gpm
Relief valve setting	2525 kPa	366 psi

Hydraulic cycle time	
Raise	7.1
Dump	2.0
Lower, empty, float down	2.4
Total	11.5 seconds

Features
- completely enclosed system
- low effort, pilot-operated controls
- full-flow filtering
- reusable couplings with O-Ring Face Seals

Cab

Caterpillar cab and Rollover Protective Structure (ROPS) are standard in North America, Europe and Japan.

Features

- meets OSHA and MSHA limits for operator sound exposure with doors and windows closed (according to ANSI/SAE J1166 JUL87)
- ROPS meets the following criteria:
  - SAE J394
  - SAE 1040 APR88
  - ISO 3471-1986
- also meets the following criteria for Falling Objects Protective Structure:
  - SAE J231 JAN81
  - ISO 3449-1984

Note

When properly installed and maintained, the cab offered by Caterpillar when tested with doors and windows closed according to ANSI/SAE J1166 MAY90, meets OSHA and MSHA requirements for operator sound exposure limits in effect at time of manufacture. The operator sound pressure level is 75 dB(A) when measured per ISO 6394 or 86/662/EEC.

Tires

Tubeless, nylon, loader design tires.

Choice of

- 26.5-25, 14 PR (L-2) standard
- 26.5-25, 20 PR (L-3)
- 26.5-R25 GP-2B(L-2/3) radial
- 26.5-R25 XHA (L-3) radial
- 23.5-25, 16 PR (L-2)
- 23.5-25, 16 PR (L-3)
- 23.5-25, 24 PR (L-3)
- 23.5-R25 GP-2B (L-2/3) radial
- 23.5-R25 XHA (L-3) radial

Note

In certain applications (such as load-and-carry work) the loader's productive capabilities might exceed the tires' tonnes-km/h (ton-MPH) capabilities. Caterpillar recommends that you consult a tire supplier to evaluate all conditions before selecting a tire model. Other special tires are available on request.

Steering

Full hydraulic power steering.

Ratings

Minimum turning radius (over tire)	6779 mm (22'3")
Steering angle, each direction	35°
Hydraulic output at 2092 RPM and 6900 kPa (1000 psi)	189 liters/min (50 gpm)
Relief valve setting	20 700 kPa (3000 psi)

Features

- center-point frame articulation
- hydraulic neutralizer steering stops
- dedicated hydraulic steering pump
- front and rear wheels track
- flow-amplified, open-center, pressure-compensated system
- steering-wheel operated metering pump controls flow to steering cylinders
- full-flow filtering
- adjustable steering column

Bucket Controls

Pilot-operated lift and tilt circuits.

Lift circuit features

- four positions: raise, hold, lower and float
- can adjust automatic kickout from horizontal to full lift

Tilt circuit features

- three positions: tilt back, hold, and dump
- can adjust automatic bucket positioner to desired loading angle
- does not require visual spotting

Controls

- two-lever control standard
- optional single-lever control available
- both types of controls available with three-valve hydraulic system

Service Refill Capacities

	L	Gallons
Fuel tank	377	99.6
Cooling system	41	11.0
Crankcase	28	7.3
Transmission	59	15.0
Differentials and final drives		
front	47	12.4
rear	47	12.4
Hydraulic system (including tank)	205	54.2
Hydraulic tank	140	37.0

		General purpose bucket							
Rated bucket capacity	m³ yd³	3.8 5.0		3.6 4.75			3.5 4.5		
		Bolt-on edges	Teeth & segments	Teeth	Bolt-on edges	Teeth & segments	Teeth	Bolt-on edges	Teeth & segments
Struck capacity	m³ yd³	3.25 4.26	3.25 4.26	3.04 3.95	3.18 4.17	3.18 4.17	2.76 3.59	2.91 3.81	2.91 3.81
Width	mm in	3059 120	3107 122	3107 122	3059 120	3107 122	3107 122	3059 120	3107 122
Dump clearance at full lift and 45° discharge	mm ft/in	2981 9'9"	2845 9'4"	2845 9'4"	2981 9'9"	2845 9'4"	2845 9'4"	3055 10'0"	2921 9'7"
Reach at full lift and 45° discharge	mm ft/in	1275 4'2"	1398 4'7"	1398 4'7"	1275 4'2"	1398 4'7"	1398 4'7"	1227 4'0"	1352 4'5"
Reach at 45° discharge and 2130 mm (7 ft 0 in) clearance	mm ft/in	1832 6'0"	1892 6'2"	1892 6'2"	1832 6'0"	1892 6'2"	1892 6'2"	1814 5'11"	1883 6'2"
Reach with lift arms horizontal and bucket level	mm ft/in	2583 8'6"	2764 9'1"	2764 9'1"	2583 8'6"	2764 9'1"	2764 9'1"	2493 8'2"	2674 8'9"
Digging depth	mm in	82 3.2	82 3.2	52 2.0	82 3.2	82 3.2	52 2.0	82 3.2	82 3.2
Overall length	mm ft/in	8303 27'3"	8506 27'11"	8506 27'11"	8213 26'11"	8506 27'11"	8506 27'11"	8213 26'11"	8416 27'7"
Overall height with bucket at full raise	mm ft/in	5589 18'4"	5589 18'4"	5589 18'4"	5589 18'4"	5589 18'4"	5589 18'4"	5515 18'1"	5515 18'1"
Loader clearance circle with bucket in carry position	mm ft/in	14 722 48'4"	14 876 48'10"	14 876 48'10"	14 722 48'4"	14 876 48'10"	14 876 48'10"	14 674 48'2"	14 828 48'8"
Static tipping load straight**	kg lb	14 130 31,157	14 372 31,690	14 275 31,476	14 094 31,077	13 960 30,782	14 293 31,516	14 249 31,419	14 056 30,993
Static tipping load full 35° turn**	kg lb	12 854 28,343	13 057 28,791	12 987 28,636	12 818 28,264	12 684 27,968	13 005 28,676	12 966 28,590	12 772 28,162
Breakout force***	kN lb	201.0 45,187	200.2 45,007	215.5 48,446	201.1 45,209	201.0 45,187	215.9 48,536	216.6 48,693	214.9 48,311
Operating weight**	kg lb	20 732 45,714	20 905 46,096	20 751 45,756	20 725 45,699	20 898 46,080	20 744 45,741	20 672 45,582	20 845 45,963

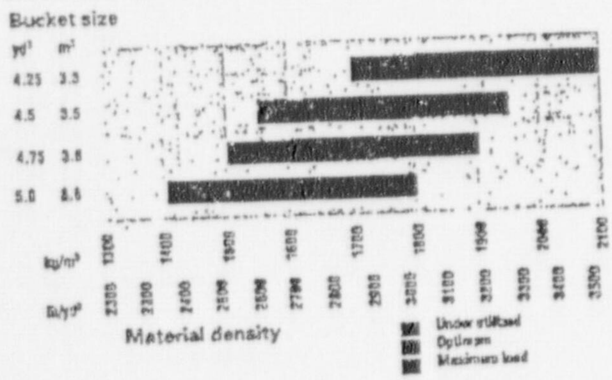
* All buckets shown can be used on high lift arrangement. High lift column shows changes in specifications from standard lift to high lift. Add or subtract as indicated to or from specifications given for appropriate bucket to calculate high lift specifications.

** Static tipping load and operating weight shown include sound-suppression cab and ROPS, 26.5-25 tires, full fuel tank, coolant, lubricants and operator.

*** Measured 102 mm (4.0"): behind tip of cutting edge with bucket hinge pin as pivot point in accordance with SAE J732c.

	Penetration bucket	Rock bucket		High Lift Arrangement*
3.3 4.25	3.6 4.75	3.5 4.5		same same
Teeth	Teeth	No teeth	Bottom strap teeth	
2.76 3.62	3.12 4.09	2.94 4.51	2.94 4.51	same same
3107 122	3128 123	3085 121	3085 121	same same
2921 9'7"	2769 9'1"	3016 9'11"	2801 9'2"	+600 +23.6"
1352 4'5"	1318 4'4"	1358 4'5"	1523 5'0"	+37 +1.5"
1883 6'2"	1774 5'10"	1930 6'4"	1995 6'6"	+497 +19.6"
2674 8'9"	2786 9'2"	2616 8'7"	2877 9'5"	+465 +18.3"
52 2.0	52 2.0	52 2.0	52 2.0	same same
8416 27'7"	8491 27'10"	8311 27'3"	8630 28'4"	+576 +22.7"
5515 18'1"	5589 18'4"	5610 18'5"	5610 18'5"	+600 +23.6"
14 828 48'8"	14 880 48'10"	14 748 48'5"	14 926 49'0"	+251 +9.9"
14 433 31,825	14 184 31,276	14 377 31,701	14 303 31,538	-468 -1030
13 137 28,967	12 898 28,440	13 080 28,841	13 005 28,676	-554 -1220
233.6 52,515	215.1 48,356	196.1 44,123	197.0 44,325	-24.5 -5,513
20 691 45,624	20 810 45,886	20 768 45,793	20 834 45,939	+1202 +2645

Bucket Size Selector

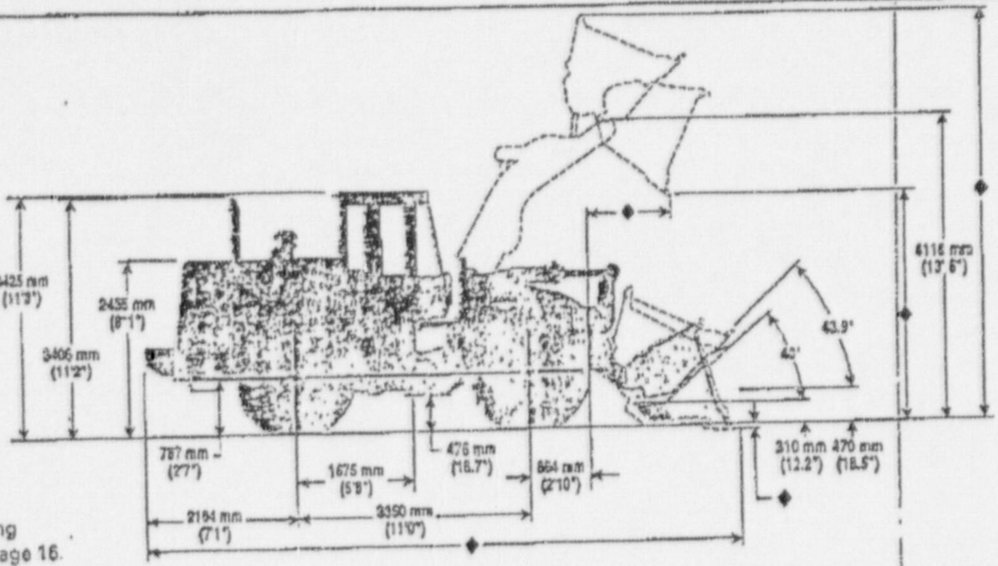


Typical material densities-loose

	kg/m³	lb/yd³
Basalt	1960	3300
Bauxite, Kaolin	1420	2394
Clay		
natural bed	1660	2799
dry	1480	2495
wet	1660	2799
Clay and gravel		
dry	1420	2394
wet	1540	2596
Decomposed rock		
75% rock, 25% earth	1960	3305
50% rock, 50% earth	1720	2900
25% rock, 75% earth	1570	2647
Earth		
dry, packed	1510	2546
wet, excavated	1600	2698
Granite		
broken	1660	2799
Gravel		
pitrun	1930	3254
dry	1510	2546
dry, 6-50 mm (.2-2")	1690	2849
wet, 6-50 mm (.2-2")	2020	3406
Gypsum		
broken	1810	3052
crushed	1600	2698
Limestone		
broken	1540	2596
crushed	1540	2596
Sand		
dry, loose	1420	2394
damp	1690	2849
wet	1840	3102
Sand and clay		
loose	1600	2698
Sand and gravel		
dry	1720	2900
wet	2020	3406
Sandstone	1510	2546
Shale	1250	2107
Slag		
broken	1750	2950
Stone		
crushed	1600	2698

Dimensions

All dimensions are approximate.



◆ Dimensions vary with bucket. Refer to operating specifications chart on page 16.

Tread width for all tires 2200 mm (86.6")

	Width over tires		Ground clearance		Change in vertical dimensions	
	mm	inches	mm	inches	mm	inches
26.5-25, 14 PR (L-2) standard	2942	115.9	476	18.7	—	—
26.5-25, 20 PR (L-3)	2949	116.1	497	19.6	+21	+0.8
26.5-R25 GP-2B (L-2/3) radial	2938	115.6	497	19.6	+21	+0.8
26.5-R25 XHA (L-3) radial	2940	115.7	482	19.0	+6	+0.2
23.5-25, 16 PR (L-2)	2865	112.8	437	17.2	-39	-1.5
23.5-25, 16 PR (L-3)	2862	112.7	434	17.1	-42	-1.7
23.5-25, 24 PR (L-3)	2862	112.7	434	17.1	-42	-1.7
23.5-R25 GP-2B (L-2/3) radial	2875	113.2	438	17.2	-38	-1.5
23.5-R25 XHA (L-3) radial	2877	113.3	419	16.5	-57	-2.2

Supplemental Specifications

	Change in Operating Weight		Change in Articulated Static Tipping Load	
	kg	lb	kg	lb
Remove cab only, ROPS remains	-177	-390	-150	-331
26.5-25, 20 PR (L-3)	+350	+772	+234	+516
26.5-R25, GP-2B, (L-2/3) radial	+526	+1160	+352	+776
26.5-R25, XHA (L-3) radial	+561	+1237	+376	+829
23.5-25, 16 PR (L-2)	-419	-924	-281	-620
23.5-25, 16 PR (L-3)	-257	-567	-172	-379
23.5-25, 24 PR (L-3)	-130	-287	-88	-194
23.5-R25, GP-2B (L2/3) radial	-103	-227	-69	-152
23.5 R25, XHA (L-3) radial	-19	-42	-13	-29
Tire ballast 23.5-25 bias ply tires	+752	+1658	+1007	+2220
Tire ballast 26.5-25 bias ply tires	+1516	+3342	+2032	+4481

Note: Tire options include tires and rims.

Standard Equipment

Standard and optional equipment may vary. Consult your Caterpillar dealer for specifics.

- Alternator (50-amp)
- Automatic bucket positioner
- Automatic lift kickout
- Back up alarm
- Batteries (two 12-volt, 100 amp-hour)
- Brake system (service, parking, secondary)
- Cab with sound suppression, canopy and rollover protective structure (ROPS)
- Computerized Monitoring System *
- Coolers (engine oil, hydraulic oil and transmission oil)
- Diagnostic connector
- Drawbar hitch pin
- Fenders
- Gauges (coolant temperature, fuel level, tachometer, speedometer)
- Heater/defroster/pressurizer
- Horn, electric
- Indicators (engine air filter and service hour meter)
- Key (single key for cab and access doors)
- Lights (front and rear), Halogen
- Lock (hydraulic implement control levers)
- Muffler
- Radiator, multi-row modular
- Rearview mirrors, interior
- Seat, suspension (fully adjustable)
- Seat belt, retractable
- Sight gauge (for engine coolant and hydraulic tank)
- Starting and charging system (24-volt)
- Tires (26.5-25) 14 PR (L-2)
- Windshield washers/wipers (front and rear), front intermittent

***Functions analyzed by Computerized Monitoring System**

Category I: Fuel level

Category II: Coolant, hydraulic oil and transmission oil temperatures

Category III: Engine oil and brake air pressures, parking brake engaged, supplemental steering if so equipped, low hydraulic oil level indicator.

Optional Equipment

With approximate changes in operating weights.

	kg	lb
Air conditioning (R134a Refrigerant)	73	161
Alternator (75 amp)	0	0
Axle seal guard	10	21
Brake Oil Cooler		
Buckets		see page 16
Cab removed, ROPS remains	-177	-390
Differentials:		
NoSpin	-2	-4
Limited slip	16.8	37
Ether starting aid, canister not included		
Extreme service transmission	18	40
Fender Extension Package		
Flexxaire fan	23	50
Guards:		
Crankcase	45	99
Power train	102	224
Hydraulic arrangement, three valve	91	200
Logging arrangement	130	287
Mirrors, outside mounted	28	62
Millyard and woodchip arrangement	—	—
Payload Measurement System	26	57
Ride Control System	91	200

	kg	lb
Seat, air suspension	32	71
Signal lights, directional	10	22
Single lever bucket controls, lift and tilt	0	0
Starting aids		
Engine coolant heater, 120-volt	1.4	3
Receptacle, 120-volt	1.4	3
Steering, supplemental	122	269
Tires	see pages 15 & 18	
Waste handling arrangement	—	—
Field installed attachments and kits:		
Guard, crankcase		
Guard, power train		
Engine coolant heater, 120-volt		
Lighting system, warning (rotating beacon)		
Mirrors rearview		
Emergency starting receptacle		
Radio, AM/FM cassette (fixed mounting and quick release versions)		
Payload Measurement System kit		
Ride Control kit		
Prelube 42 mt kit		
Flexxaire fan kit		

Equipment Specification

CASE 1550 Dozer

1550 Basic Tractor

Engine

Make and model ....Case 6T-830
Type of fuel...............No. 2 diesel
No. of cylinders....................6
Bore and stroke ....4.49" x 5.32" (114 mm x 135 mm)
Displacement...........505 in³ (8.3L)
Compression ratio 17.3:1
Fuel induction ....Injectors (6)
Fuel supply ....Injection pump
Air cleaner....Dry type — dual element with service indicator
Oil filter ....Full flow, replaceable spin-on cartridge
Lubrication ....Positive pressure
Cooling system ...Pressurized — 15 psi (103 kPa)

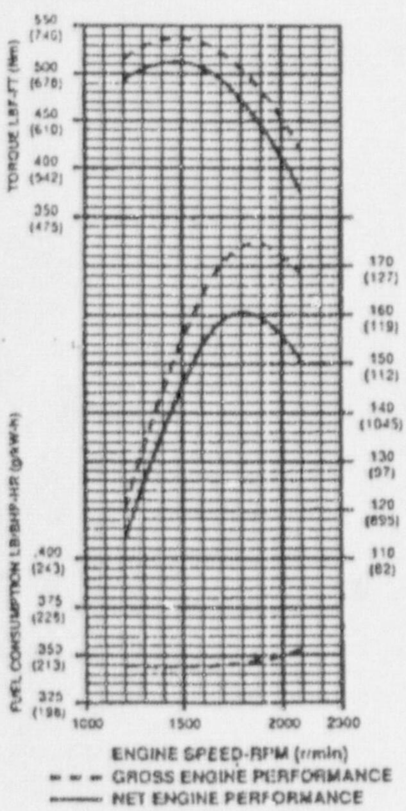
Horsepower

(1) Gross .... 168 @ 2100 rpm (125 kW @ 2100 r/min)
(2) SAE Net .... 150 @ 2100 rpm (112 kW @ 2100 r/min)

Max torque lbf-ft
(1) Gross .... 538 @ 1500 rpm (729 Nm @ 1500 r/min)
(2) SAE Net .... 511 @ 1500 rpm (693 Nm @ 1500 r/min)

(1) Gross engine horsepower or torque at flywheel per SAE Standard J1349
(2) Net engine horsepower or torque at flywheel per SAE Standard J1349

Power Curve



Electrical

System voltage ....24-volt, negative ground
Batteries (2)...12-volt, low maintenance 950 cold cranking amps @ 0°F (−18°C)
Alternator ....24 volt, 45 amp

Steering

Steering controlled by independent hydrostatic power. Infinitely variable speed to each track is controlled by foot pedal.

Power Train

Transmission: Dual path hydrostatic transmission.

Brakes: Two multiple-disc spring applied, hydraulically released brakes. Over-center hand control for parking and center pedal foot control for inching.

Final Drives: Double reduction with planetary output.

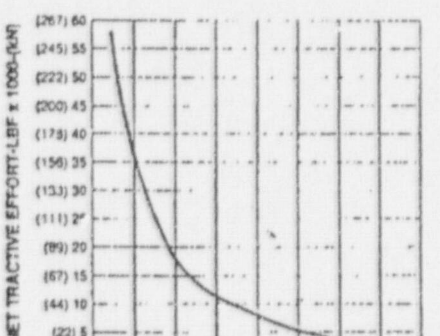
Filtration: Three pressure spin-on cartridges rated $B_2=10$. Inlet line strainer, 200 mesh.

Cooling: Side by side radiator cooling, air-to-oil.

Travel Speeds—mph (km/h)

Engine at full throttle
Forward/Reverse — Infinite from 0 to 6.0 (0 to 9.7)

Drawbar Pull



Undercarriage
Standard

Sealed and lubricated track standard. Hydraulic track adjusters. Track rollers, carrier rollers, drum type idlers permanently lubricated. Segmented hunting tooth sprockets. Reinforced box section track roller frame.

Track frame ....Equalizer beam suspension
Track rollers (each side) 6
Carrier rollers (each side)...........2
Track gauge ....74" (1.88 m)
Length of track on ground ..94" (2.39 m)
Shoes per track (each side) 36
Track shoe widths available....22", 24" (559 mm, 610 mm)
Area of track on ground
22" (559 mm)...4136 in² (26 684 cm²)
24" (610 mm) ... 4512 in² (29 110 cm²)
Ground pressure (Angle/tilt/pitch dozer)
22" (559 mm) .... 8.1 psi (56 kPa)
24" (610 mm)........7.5 psi (52 kPa)
Height of track shoe
Heavy-duty grouser ... 2.81" (71 mm)

Undercarriage
LGP

Sealed and lubricated track standard. Permanently sealed and lubricated track rollers, carrier rollers, drum-type idlers. Hydraulic track adjusters. Segmented hunting tooth sprockets. Reinforced box section track roller frame.

Track frame ....Equalizer beam suspension
Track rollers (each side) 7
Carrier rollers (each side)...........2
Track gauge.............78" (1.98 m)
Length of track on ground........106" (2.69 m)
Shoes per track (each side) 39
Max. track shoe width ....36" (914 mm)
Area of track on ground
22" (559 mm) ..4664 in² (30 090 cm²)
24" (610 mm)...5088 in² (32 826 cm²)
36" (914 mm)...7632 in² (49 239 cm²)

Ground pressure (Angle/tilt dozer)
22" (559 mm) ....7.5 psi (52 kPa)
24" (610 mm)........6.9 psi (48 kPa)
36" (914 mm) ....4.8 psi (33 kPa)
Height of track shoe
Single bar...........2.36" (60 mm)
Self cleaning...........3" (76 mm)

1550 Basic Tractor

Undercarriage

Long Track

Sealed and lubricated track standard. Hydraulic track adjusters. Track rollers, carrier rollers, drum type idlers permanently lubricated. Segmented hunting tooth sprockets. Reinforced box section track roller frame.

Track frame ....Equalizer beam suspension
Track rollers (each side) 7
Carrier rollers (each side) 2
Track gauge ....74" (1.88 m)
Length of track on ground . 106" (2.69 m)
Shoes per track (each side) 39
Track shoe widths available....22", 24" (559 mm, 610 mm)
Area of track on ground
  22" (559 mm) ..4664 in² (30 090 cm²)
  24" (610 mm)...5088 in² (32 826 cm²)
Ground pressure
  22" (559 mm) ....7.5 psi (52 kPa)
  24" (610 mm)........6.9 psi (48 kPa)
Height of track shoe
  Heavy-duty grouser ...2.81" (71 mm)

Dozer Hydraulic System

Full hydraulic control of blade lift, lower, angle, tilt and pitch functions. Positive-hold "float" position in lift circuit.

Pump: Gear type, driven from engine, 42 gpm @ 2100 rpm (159 L/min @ 2100 r/min)

Control valve: Open center, parallel with pressure compensation.

System relief pressure ......2500 psi (17 237 kPa)

Cylinders

Tilt and Semi-U Dozers

Lift: (2) ....3.5" dia x 37" stroke, 2" rod (89 mm dia x 940 mm stroke, 51 mm rod)

Tilt: (2) .....6" dia x 6.7" stroke, 3" rod (152 mm dia x 170 mm stroke, 76 mm rod)

Mechanical Angle Dozer

Lift: (2) 3.5" dia x 35.6" stroke, 2" rod (89 mm dia x 904 mm stroke, 51 mm rod)

Mechanical Angle/Power Tilt Dozer

Lift: (2) 3.5" dia x 35.6" stroke, 2" rod (89 mm dia x 904 mm stroke, 51 mm rod)

Tilt: (2) 5" dia x 4.5" stroke, 2.5" rod (127 mm dia x 114 mm stroke, 64 mm rod)

Angle/Tilt Dozer

Lift: (2) 3.5" dia x 35" stroke, 2" rod (89 mm dia x 889 mm stroke, 51 mm rod)

Angle: (2) 5.5" dia x 17" stroke, 2.75" rod (140 mm dia x 432 mm stroke, 70 mm rod)

Tilt: (2) 5.5" dia x 5.4" stroke, 2.75" rod (140 mm dia x 137 mm stroke, 70 mm rod)

Angle/Tilt/Pitch Dozer

Lift: (2) ...3.5" dia x 35.6" stroke, 2" rod (89 mm dia x 904 mm stroke, 51 mm rod)

Angle: (2) .... 4" dia x 54.95" stroke, 2.25" rod (102 mm dia x 1.40 m stroke, 57 mm rod)

Tilt, Pitch: (2) .... 5" dia x 4.5" stroke, 2.5" rod (127 mm dia x 114 mm stroke, 64 mm rod)

Service Capacities

	U.S. Gal	Liters
Fuel tank	76	287.7
Hydraulic system (refill)	20.7	78.4
Transmission (total)	28	106
(refill)	14.7	55.6
Engine crankcase	6	22.7
Final drive (each side)	15 qt	14.2
Cooling system	6.5	24.6

Standard Equipment

Alternator and voltage regulator • Backup alarm • Crankcase guard • Drawbar • Dry-type dual element air cleaner with service indicator • Electronic instrumentation • Engine side shields • Full bottom transmission guard • Horn* • Hydraulic track adjusters • Lock-up kit • Master disconnect switch • Muffler • Neutral safety start mechanism • Permanently lubricated track rollers • Radiator guard • Rear transmission guard • Reversible fan • ROPS canopy with 2" (51 mm) seat belt • Sealed and lubricated track • Spring-applied, hydraulically released parking brake • Suspension seat • Track guides

*Standard after January 1, 1991

Optional Equipment

Approximate add-on weight

	lb	kg
Air conditioning	310	141
Brush screen	13	5.9
Cab	1700	771
Counterweight, front	900	408
Counterweight, rear	2100	953
End bits (H.D. ILO Std.)**	36	16
Ether starting kit	4	2
Final drive seal guard	10	5
Front pull hook	20	9
Lights (front and rear)	18	8
Hydraulic - assist blade controls	30	14
Ripper	3000	1361
Rock guard center section	220	100
ROPS - front sweeps	170	77.1
rear screen	57	25.9
side screens	185	83.9
Track shoes, each 1" less than 24" for std undercarriage	−147	−67
for LT undercarriage	−158	−72

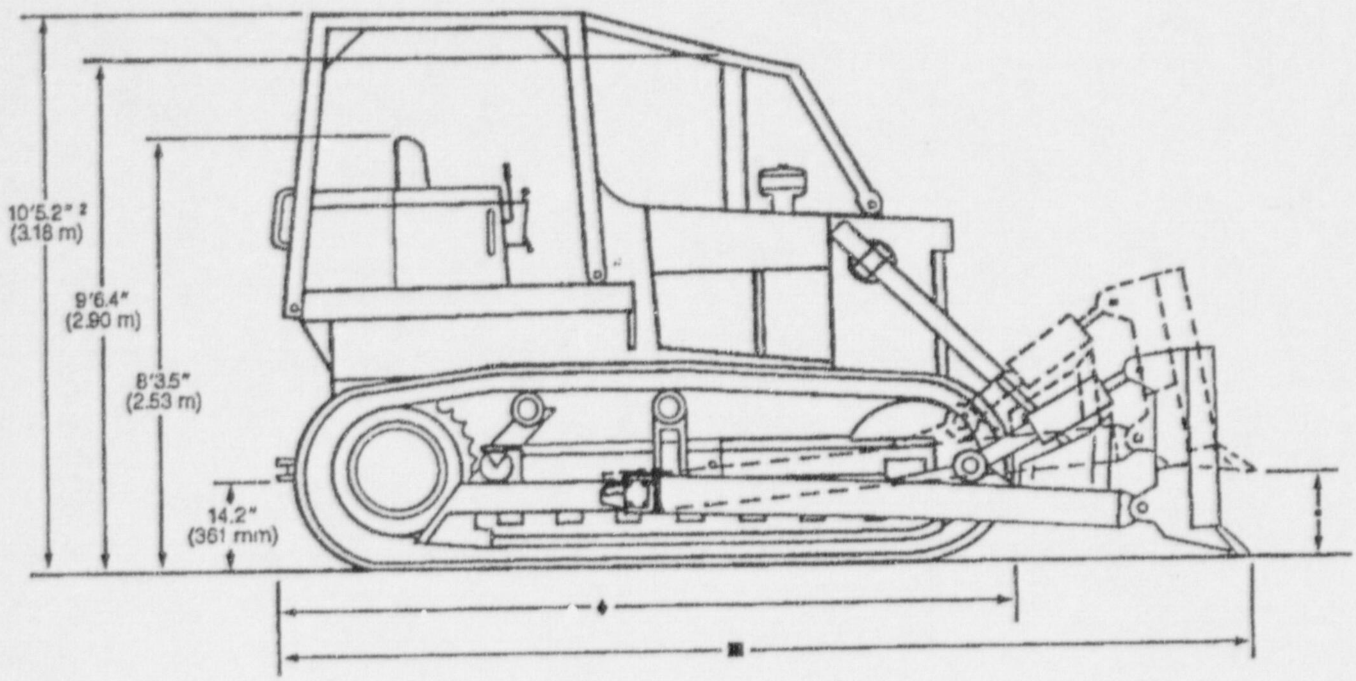
**Not applicable for Semi-U Dozers

Ripper***

Overall width ....78.1" (1.98 m)
Maximum penetration ...18.1"(460 mm)
Ground clearance
  (at carry) ....10.9" (277 mm)
Number of shanks ....3 std., 4 or 5 opt.
Shank spacing
  Inner ....17.75" (450 mm)
  Outer ....19.25" (489 mm)
Ripper tips ....Replaceable
Hydraulic cylinders (2) .... 4" dia x 10" stroke, 2" rod (102 mm dia x 254 mm stroke, 51 mm rod)
Weight ....3000 lb (1361 kg)

***Not usable w/36" (914 mm) track shoes

Dimensional Data—Outside Push Beam



Track Type	Standard and Long Track[1] Mechanical angle	Standard Angle/tilt/pitch	Standard and Long Track[1] Semi-U	Standard and Long Track[1] Tilt
Dozer Blade				
Width	148" (3.76 m)	148" (3.76 m)	122" (3.1 m)	121" (3.1 m)
Height	40" (1.02 m)	40" (1.02 m)	47" (1.19 m)	44.5" (1.13 m)
• Lift above ground[4]	39" (991 mm)	38" (965 mm)	40" (1016 mm)	40" (1016 mm)
Drop below ground[4]	20" (508 mm)	20" (508 mm)	20" (508 mm)	20" (508 mm)
Angle - both directions	0 - 25°	0 - 25°	—	—
Tilt - either end	15" (381 mm)	15" (381 mm)	15" (381 mm)	15" (381 mm)
Pitch - both directions	—	0 - 5°	—	—
Push beam type	Outside	Outside	Outside	Outside
SAE blade capacity	3.9 yd³ (3.0 m³)	3.9 yd³ (3.0 m³)	5.5 yd³ (4.2 m³)	4.1 yd³ (3.1 m³)
Tractor Dozer Dimensions				
■ Overall length[1]				
With ripper raised	19'9" (6.02 m)	19'6" (5.89 m)	19'7" (5.97 m)	18'10" (5.69 m)
With blade straight (with drawbar)	16'7" (5.05 m)	16'7" (5.05 m)	16'9" (5.11 m)	15'10" (4.82 m)
With blade angled (with drawbar)	19'3" (5.87 m)	19'3" (5.87 m)	—	—
♦ Less "C" frame and blade	11'5" (3.48 m)	11'5" (3.48 m)	11'5" (3.48 m)	11'5" (3.48 m)
Maximum grouser width	24" (610 mm)	24" (610 mm)	24" (610 mm)	24" (610 mm)
Overall width				
With blade straight	148" (3.76 m)	148" (3.76 m)	122" (3.1 m)	121" (3.1 m)
With blade angled	137" (3.48 m)	137" (3.48 m)	—	—
At track with maximum shoes	98" (2.49 m)	98" (2.49 m)	98" (2.49 m)	98" (2.49 m)
Turning clearance circle (counterrotating)[4]	24' (7.32 m)	24' (7.32 m)	21'11" (6.68 m)	21'7" (6.58 m)
Ground clearance	14" (356 mm)	14" (356 mm)	14" (356 mm)	14" (356 mm)
Operating weight w/max width shoes[3]				
Standard Track	32,644 lb (14 807 kg)	33,684 lb (15 279 kg)	32,904 lb (14 956 kg)	32,174 lb (14 594 kg)
Long Track	34,332 lb (15 573 kg)	— —	34,592 lb (15 691 kg)	33,862 lb (15 360 kg)

[1]For LT overall lengths, add 12" (305 mm)

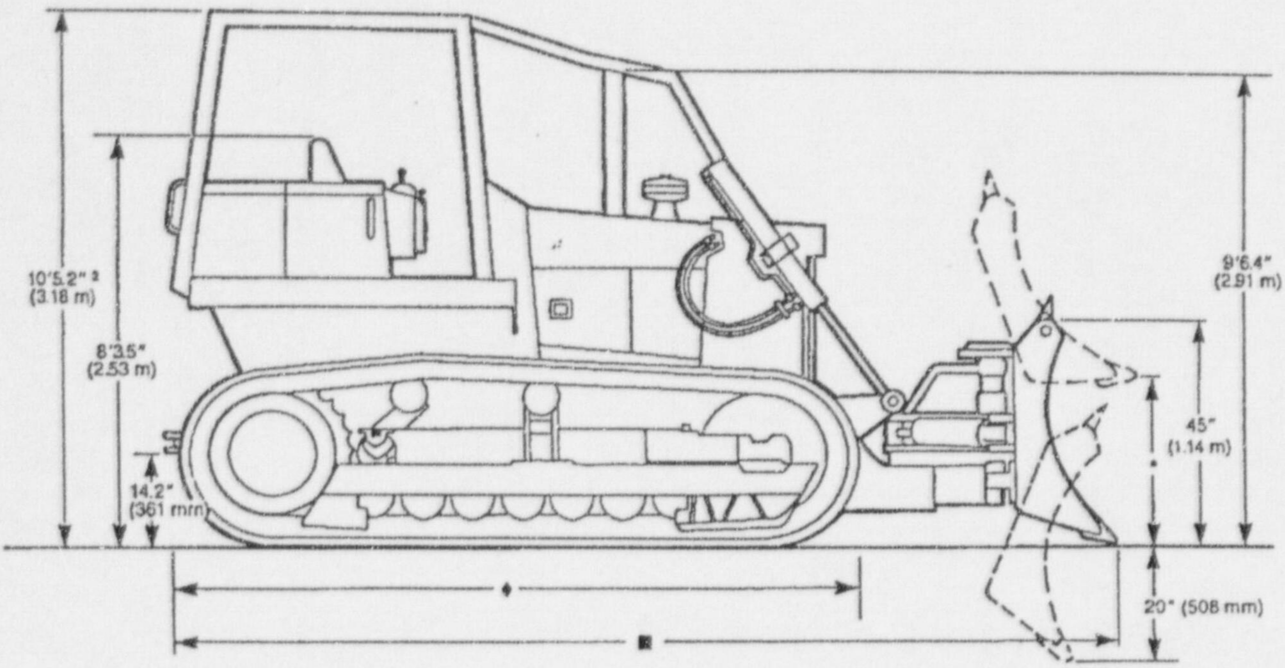
[2]Height over cab is 10'11" (3.34 m).

[3]Includes ROPS canopy, full fuel tank, 170 lb (77 kg) operator and maximum width shoes.

[4]LT values are:

Blade type	148" (3.76 m) MA	122" (3.1 m) Semi-U	121" (3.1 m) PT
Lift above ground	44.0" (1118 mm)	45.0" (1143 mm)	45.0" (1143 mm)
Drop below ground	22" (546 mm)		
Turning clearance circle	24'10" (7.57 m)	22'11" (6.99 m)	22'4" (6.81 m)

Dimensional Data— Inside Push Beam



Track Type

	Long Track Angle/tilt	LGP Angle/tilt
Dozer Blade		
Width	130" (3.30 m)	130" (3.30 m)
Height	45" (1.14 m)	45" (1.14 m)
• Lift above ground	40" (1016 mm)	40" (1016 mm)
Drop below ground	20" (508 mm)	20" (508 mm)
Angle - both directions	0 - 25°	0 - 25°
Tilt - either end	15" (381 mm)	15" (381 mm)
Push beam type	Inside	Inside
SAE blade capacity	4.1 yd³ (3.1 m³)	4.1 yd³ (3.1 m³)
Tractor Dozer Dimensions		
■ Overall length		
With ripper raised	20'8" (6.29 m)	20'8" (6.29 m)
With blade straight (with drawbar)	17'8" (5.38 m)	17'8" (5.38 m)
With blade angled (with drawbar)	19'9" (6.02 m)	19'9" (6.02 m)
♦ Less "C" frame and blade	12'5" (3.78 m)	12'5" (3.78 m)
Maximum grouser width	24" (610 mm)	36" (914 mm)
Overall width		
With blade straight	130" (3.30 m)	130" (3.30 m)
With blade angled	120" (3.05 m)	127" (3.23 m)
At track with maximum shoes	98" (2.49 m)	114" (2.90 m)
Turning clearance circle (counterrotating)	22'10" (6.96 m)	22'10" (6.96 m)
Ground clearance	14" (356 mm)	14" (356 mm)
Operating weight (approx.) w/max width shoes	35,182 lb (15 959 kg) ³	36,360 lb (16 493 kg)³,⁵

²Height over cab is 10'11" (3.34 m)
³Includes ROPS canopy, full fuel tank, 170 lb (77 kg) operator and maximum width shoes.
⁵Operating weight with 24" (610 mm) shoes is 35,245 lb (15 987 kg).

Equipment Specification

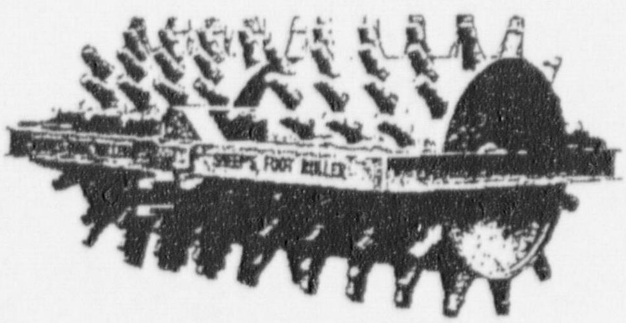
Tow-Behind Sheepsfoot Compactor

LeTOURNEAU-WESTINGHOUSE W SHEEP'S FOOT ROLLER SPECIFICATIONS

Specifications are subject to change without notice or obligation.

MODEL	W
Number of Drums	2
DRUM DIMENSIONS	
Length	4' (1,22 m)
Diameter (less feet)	3' 6" (1,06 m)
Diameter (including feet)	4' 10" (1,47 m)
Thickness of Rim Plates	½" (127 mm)
Interval between Drums	8" (17,78 cm)
BEARINGS	Tapered Roller
Number of Feet per Drum	88
Number of Feet per Row	4
Distance Center to Center between Feet in Row	12" (30,48 cm)
OVERALL MEASUREMENTS	
Length	13' 3" (4,04 m)
Width	9' 5" (2,87 m)
Height	4' 10" (1,47 m)
FOOT MATERIAL	Heat Treated Alloy Steel
FOOT DIMENSIONS	
Base (at drum) Elliptical	5" x 4" (12,7 cm x 10,16 cm)
Tamping Surface, Diameter	2.54" (6,45 cm)
Area of Foot Face in Square Inches (cm²)	5.06" (12,85 cm)
Length (Drum to Tamping Surface)	8" (20,32 cm)
TYPE OF FRAME CONSTRUCTION	Patented Box Beam
APPROXIMATE TAMPING WEIGHTS	
Empty	6,040 lbs. (2740 kg)
*Loaded with water	10,240 lbs. (4645 kg)
*Loaded with saturated sand	13,440 lbs. (6096 kg)
GROUND PRESSURE PER SQUARE INCH (PER SQUARE CM)	
Empty	149 lbs. (10,475 kg/cm²)
*Loaded with water	254 lbs. (17,858 kg/cm²)
*Loaded with saturated sand	333 lbs. (23,413 kg/cm²)

*May be loaded with 2100 lbs. (953 kg) of water or 3700 lbs. (1678 kg) of saturated sand per drum.



Rear view of Model W Roller showing hitch block

WABCO LeTOURNEAU-WESTINGHOUSE COMPANY

Peoria, Illinois U.S.A. · A Subsidiary of Westinghouse Air Brake Co.

Appendix E

Daily Notes

DAILY QUALITY CONTROL REPORT

Report #:

Project No.: C1220 Date: 2/16/98

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: Overcast Average Temp: high 30's

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

Jack Bodner · Brien Kilkenny · ~~Vince Shilobod~~ · Herb Davidson · ~~Larry Weisert~~ · ~~Stephen Wisniewski~~
~~Lester Eaton~~ · ~~Harry Moyer~~ · ~~David Wilding~~ · ~~Tom Malatesta~~ · ~~Gerry Williams~~ · John Duffy
Bruce Gulisek · ~~Dave Seidel~~ · Doug Zimmer · ~~Tim Miller~~ · ~~Donna Wilson~~ · Nora Yanes

Contractor's Visitors (name & company):
J. Parker, OEPA Ron Zitek, AWS, American Landfill Dames & Moore Representative

General Work Performed

Excavation Activities: none

Construction Activities: Test Pad lifts #1 & #2 placed and compacted.

Material Deliveries/Inspections: none

Other: none

Quality Control Activities Performed *

Observations: Clay material lifts placed in ≤ 8" lifts with CAT D6M Dozer. CAT 966F loader transported clay from C14 stockpile to test pad area. Rocks & particles > 2" removed from each lift. Six two-way passes w/ CASE 1550 Dozer & tow behind sheepsfoot compactor. D6M Dozer scarifies lift before new material is placed.

Field Test Information: Moisture density tests on lifts #1 & #2. Results attached. One test failed - area was rerolled and retested - Passed. Sand cone taken. Results available at a later date. Surveyed loose & compacted lifts. Results attached.

Sample Information: Max dry density of Sample C14 is 116.3 pcf & Optimum moisture content is 15.1%.

Submittal Information: none

Other Remarks: Many particles ≥ 2" had to be removed during placement, spreading and compaction. Holes made in clay due to Troxler gauge were backfilled & tamped w/ bentonite. One layer of geotextile placed on GMCL before clay was placed.

Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

Nora T. Yanes ESC, QC Engineer
Quality Control Representative

* Attach additional sheets if necessary

Field Test Results
Compaction and Moisture Content

Material: Clay (C14) Date: 2/16/98

Applicable Proctor Value: 116.3

Applicable Percent Compaction: 95%

Optimum Moisture Content: 15.1%

Gauge Standardized: 1030
MS=654= 0.2% Pass
DS=3336= -0.4% Pass

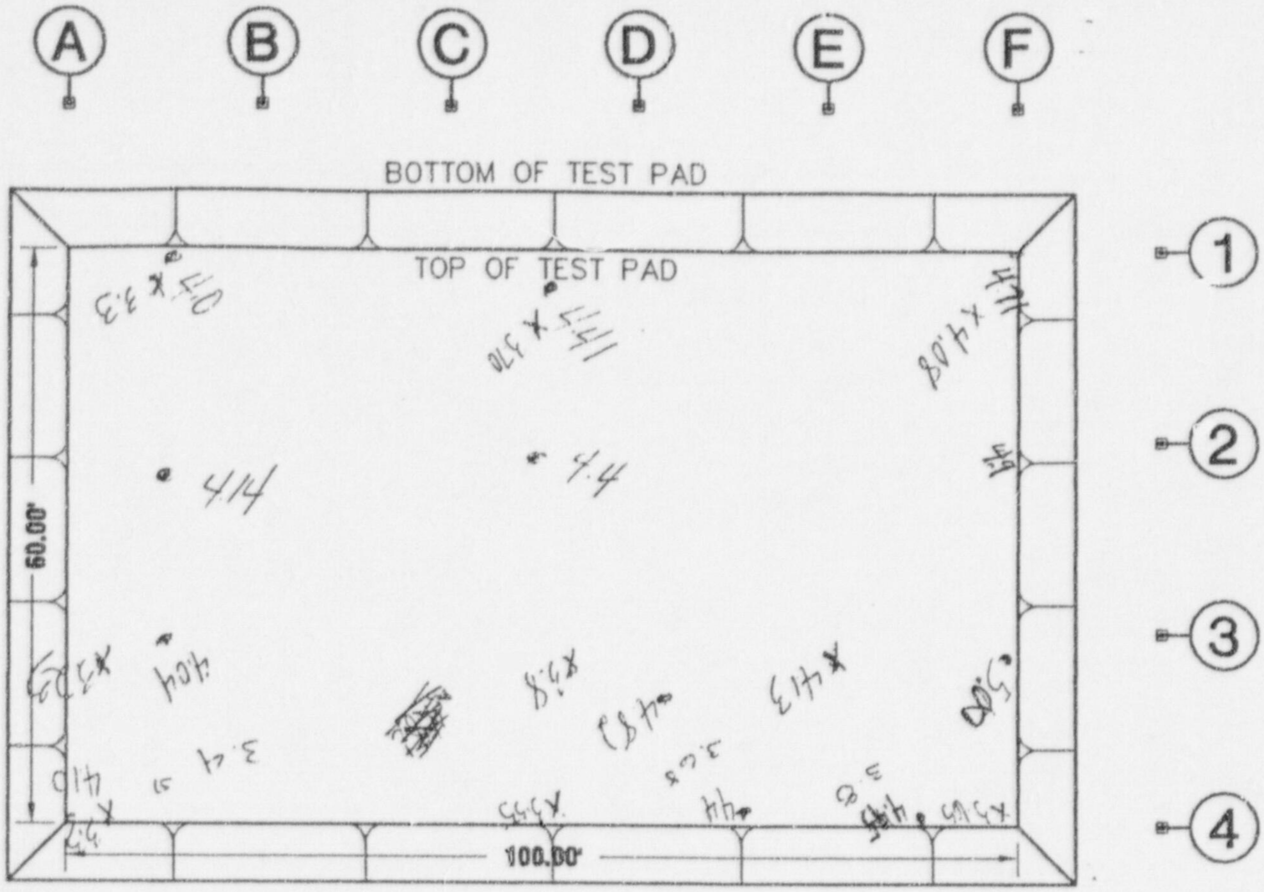
NOTE: Indicate flat or slope area, lift number & any other pertinent info

General Location	Test No.	Dry Density	% Compaction	Moisture Content	Pass/Fail	Comments
Test Pad	1	111.5	95.9	16.9	P	Sand cone same location
Lift #1	2	115.9	99.6	15.6	P	
See drawing	3	114.9	98.8	15.1	P	
attached.	4	108.9	93.6	15.3	F	ReRoll
	5	112.9	97.1	16.0	P	
	4R	112.0	96.3	16.2	P	Retest.
Lift #2	1	110.7	95.2	15.1	P	
	2	114.1	98.1	15.1	P	
	3	111.2	95.6	15.3	P	
	4	112.5	96.7	15.6	P	
	5	114.1	98.1	15.9	P	

Tester's Signature: Nora W. Yance

QC Engineer's Signature: Nora W. Yance

Field Test Results Sheet.xls



DAILY ACTIVITIES NOTES

•Survey of liner (geotextile on subgrade). 10.35

+1st lift survey 1350 (Loose lifts)

Q.C. ENGINEER [signature] date 2/16/98

DAMES & MOORE
SITE ENGINEER ______________ date ________

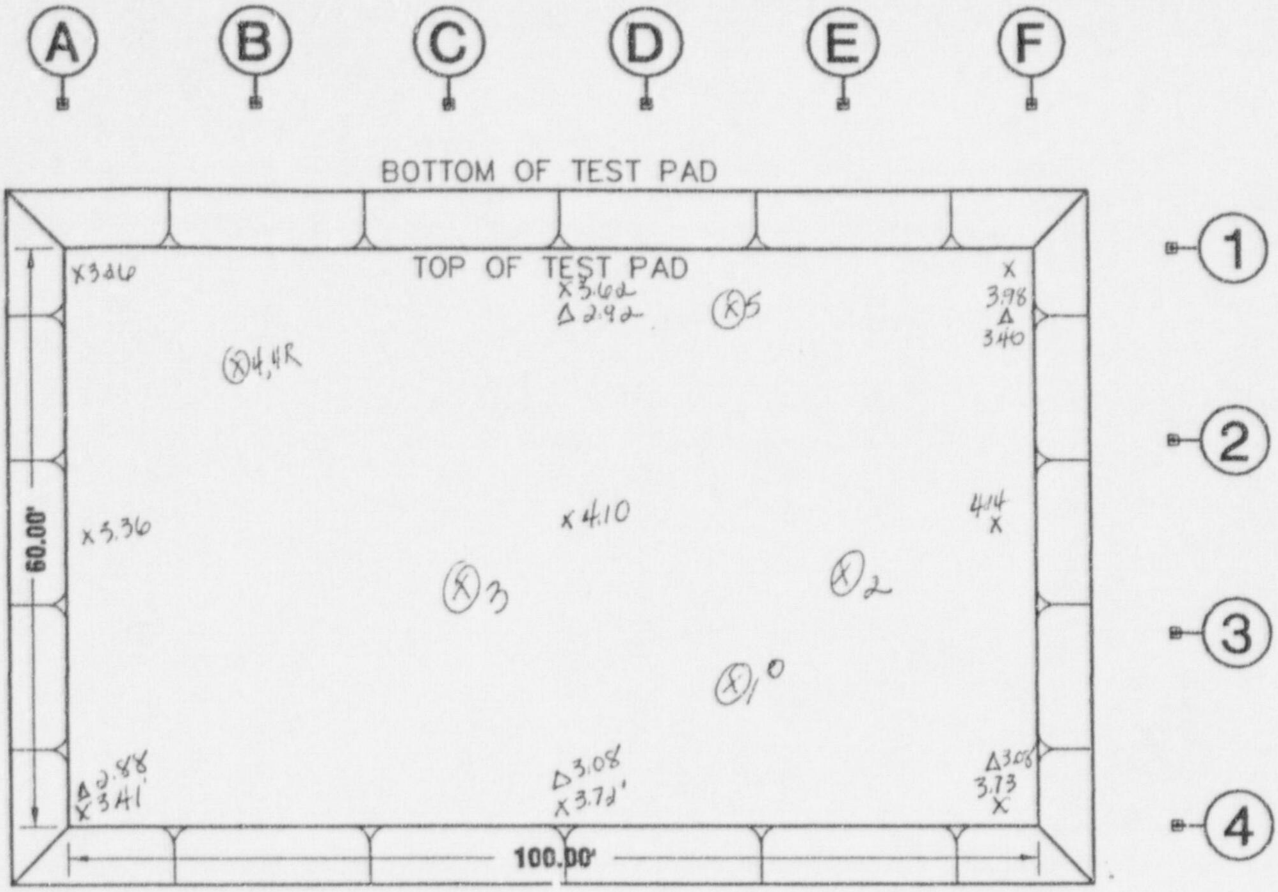
X
X

HORIZONTAL SCALE - FEET

0 20 40 60

PREPARED FOR
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO

			APPROVED	Earth Sciences Consultants, Inc
			CHECKED	
			DRAWN	
			DRAWING NUMBER C1220015	
REVISION	DATE	DESCRIPTION		



DAILY ACTIVITIES NOTES

Ⓧ Lift #1 Trotter MD tests

0 Sand Cone Sample Location

X Lift #1 Survey after compaction

Δ Lift #2 Survey loose lifts

Q.C. ENGINEER Nora J. Yanez date 2/16/98.

DAMES & MOORE
SITE ENGINEER ________ date ______

X
X

HORIZONTAL SCALE - FEET

0 20 40 60

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CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO

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C1220015

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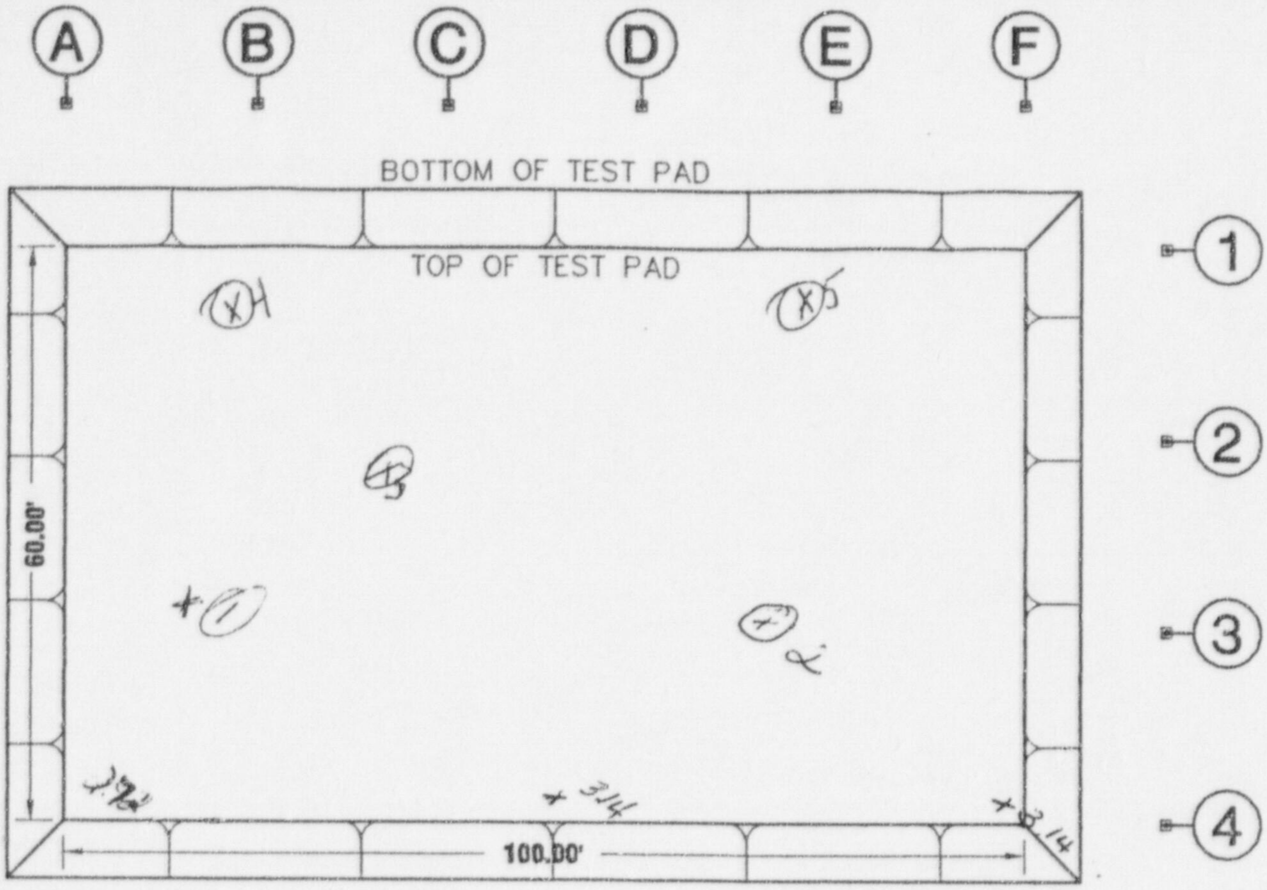

DAILY ACTIVITIES NOTES

(F) Troxler-Test Lift #2

x Survey of compacted lift #2 } Did not finish surveying due to weather

Q.C. ENGINEER Nora J. Yanez date 2/16/98

DAMES & MOORE
SITE ENGINEER ____________ date ______

X
X

HORIZONTAL SCALE - FEET

0 20 40 60

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NEWBURGH HEIGHTS, OHIO

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CHECKED	
DRAWN	
DRAWING NUMBER C1220015	Earth Sciences Consultants, Inc.

REVISION	DATE	DESCRIPTION

Report #:

DAILY QUALITY CONTROL REPORT

Project No.: C1220 **Date:** 2/17/98

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: Light rain **Average Temp:** low 40's

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

Jack Bodner	Brien Kilkenny	~~Vince Shilobod~~ Jeff Karp	~~Herb Davidson~~	~~Larry Weisert~~	~~Stephen Wisniewski~~
~~Lester Exton~~	~~Harry Moyer~~	David Wilding	Tom Malatesta	~~Gerry Williams~~	John Duffy
Bruce Gulisek	~~Dave Seidel~~	Doug Zimmer	~~Tim Miller~~	~~Donna Wilson~~	Nora Yanes

Contractor's Visitors (name & company):

General Work Performed

Excavation Activities: none

Construction Activities: Started placing lift #3

Material Deliveries/Inspections: none

Other: none

Quality Control Activities Performed *

Observations: Clay material placed in ≤ 8" lifts with CAT D6M dozer. CAT 966F loader transported clay from CH stockpile to test pad area. Rocks & particles > 2" removed from each lift. Six two-way passes of the CASE 1550 dozer & tow behind sheepsfoot compactor. Dozer (CAT D6M) scarifies previous lift before new material is placed.

Field Test Information: No testing done to inclement weather.

Sample Information: none

Submittal Information: none

Other Remarks: Activities stopped early morning (1030) due to heavy rain. Lift #3 not complete. Pad covered with plastic.

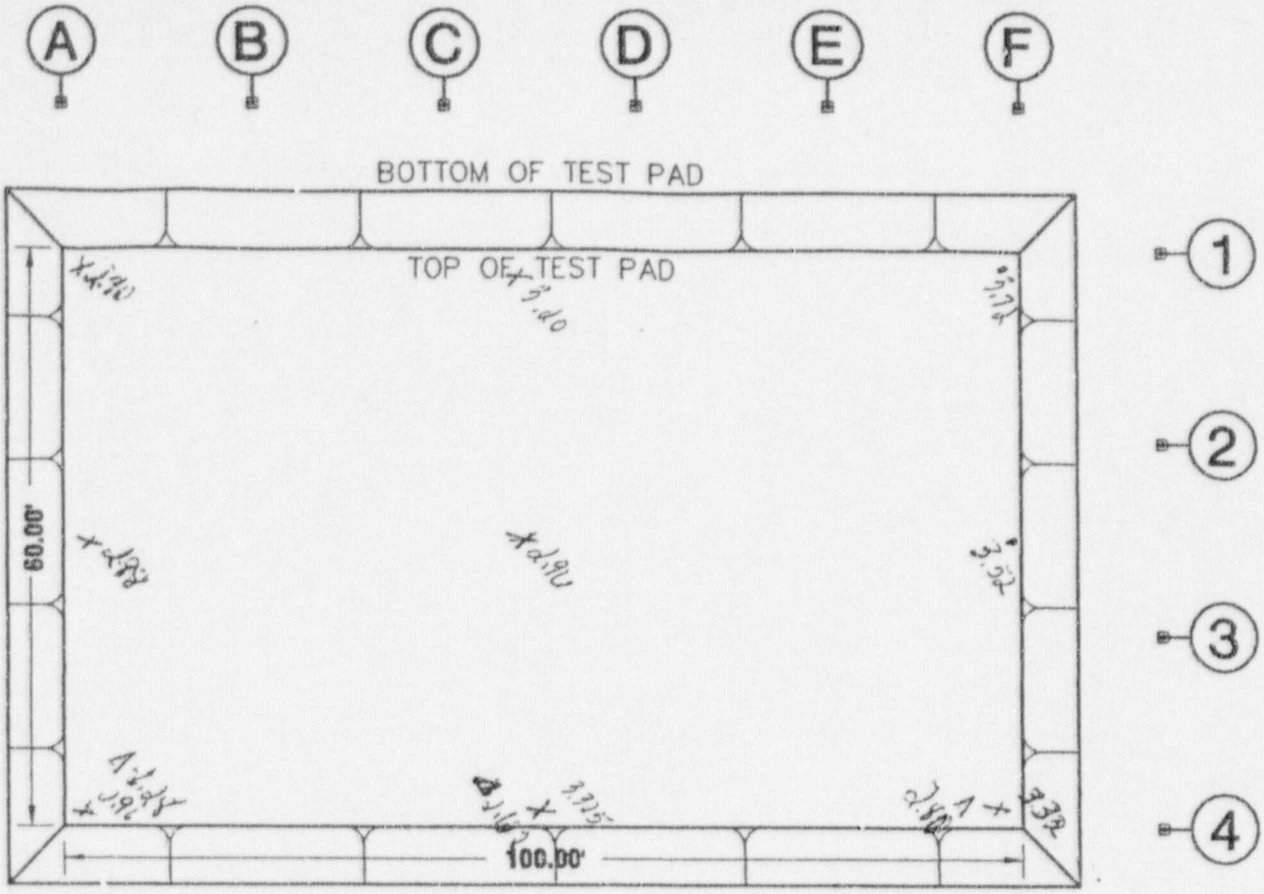
Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

Nora J. Yanes ESC, QC Engineer

Quality Control Representative

* Attach additional sheets if necessary



DAILY ACTIVITIES NOTES

* Survey of Compacted Lift #2

△ survey of loose lift #3

☆ note: south end clay placed. stopped operations 1030 due to inclement weather.

Q.C. ENGINEER Nora J. Yaw date 2/17/98

DAMES & MOORE SITE ENGINEER ____________ date ______

X
X

HORIZONTAL SCALE - FEET

0 20 40 60

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NEWBURGH HEIGHTS, OHIO

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DRAWN	
DRAWING NUMBER C1220015	Earth Sciences Consultants, Inc.

REVISION	DATE	DESCRIPTION

Report #:

DAILY QUALITY CONTROL REPORT

Project No.: C12. J

Date: 2-24-98

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: OVERCAST

Average Temp: LOW 30°s

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

Jack Bodner	Brien Kilkenny	~~Vince Shillobod~~	~~Herb Davidson~~	~~Larry Weisert~~	Stephen Wisniewski
~~Lester Exton~~	~~Harry Moyer~~	~~David Wilding~~	Tom Malatesta	~~Gerry Williams~~	John Duffy
Bruce Gulisek	~~Dave Seidel~~	Doug Zimmer	~~Tim Miller~~	~~Donna Wilson~~	~~Nora Yanes~~

Contractor's Visitors (name & company):

DAN PETERS DAMES - MOORE

General Work Performed

Excavation Activities: NONE

Construction Activities: TEST PAD COMPLETE LIFT # 3

Material Deliveries/Inspections: NONE

Other: NONE

Quality Control Activities Performed *

Observations: PRIOR TO PLACING 2ND HALF OF LIFT # 3 AREA IS SCARIFIED. CLAY BEING PLACED IN ≈ 8" LOOSE LIFTS. ORGANICS - ROCK > 2" BEING REMOVED DURING PLACEMENT OF CLAY. CLAY BEING PUSHED TO GRADE WITH CAT D6M DOZER. AFTER CLAY IS PUSHED TO GRADE IT IS COMPACTED WITH CASE 1550 DOZER - PULL BEHIND SHEEPSFOOT (6 - 2WAY PASSES

Field Test Information:
→ PRIOR TO PLACING 2ND CLAY ON NORTH SIDE OF TEST PAD TEST WERE TAKEN TO ENSURE COMPACTION SEE ATTACHED

Sample Information: NONE

Submittal Information: NONE

Other Remarks: CAT 966F LOADER KEPT OFF TEST PAD AS NOT TO RUT UP TEST PAD. WORK HALTED AT 11:50 DUE TO MOISTURE IN CLAY. LIFT THICKNESS MONITORED DURING PLACEMENT

Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

JOHN C DUFFY ESC QC TECH
Quality Control Representative

* Attach additional sheets if necessary

Field Test Results
Compaction and Moisture Content

Material: CLAY   Date: 2-24-98

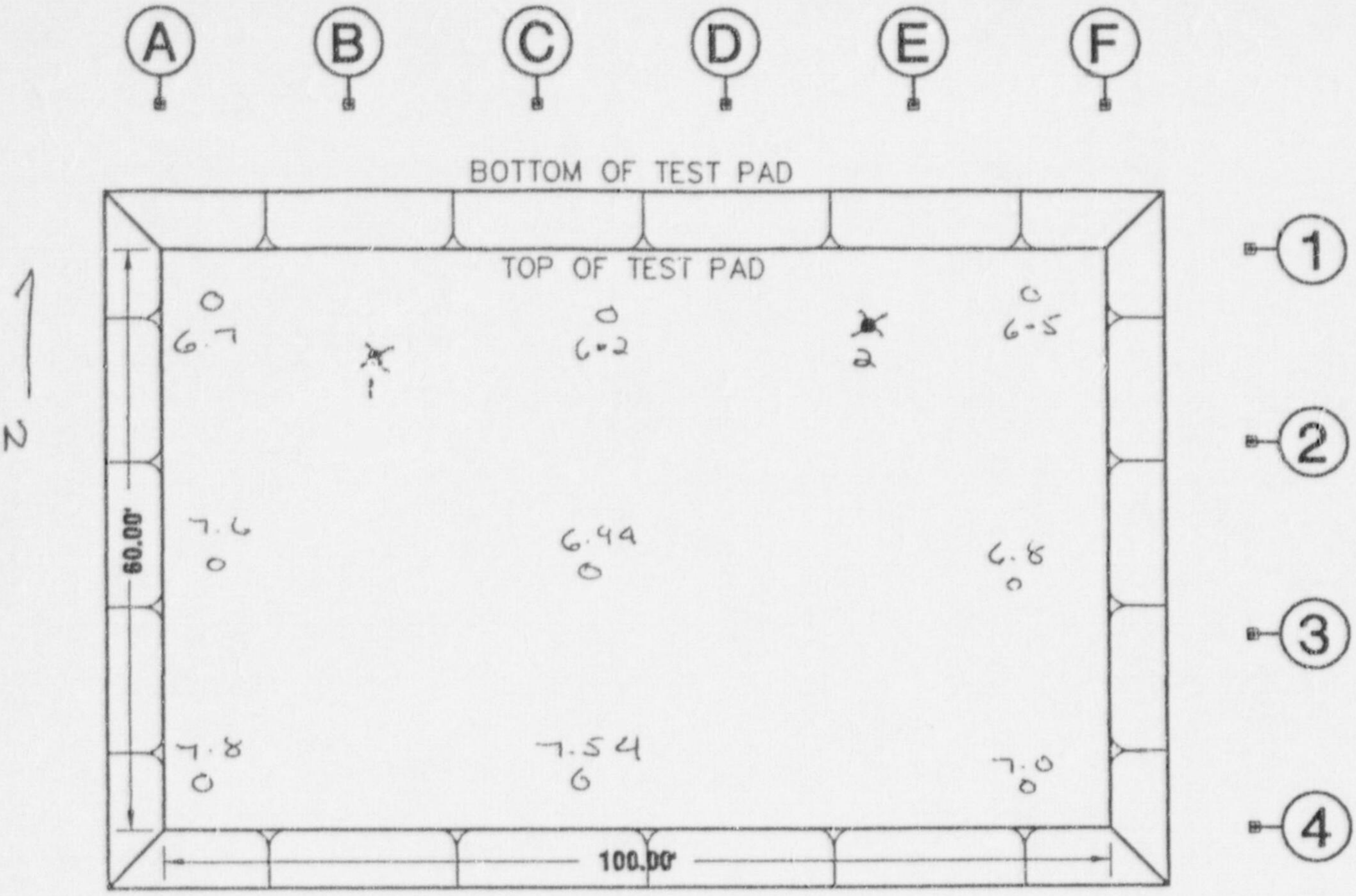
Applicable Proctor Value: 116.3
Applicable Percent Compaction: 95%
Optimum Moisture Content: 15.1

NOTE: Indicate flat or slope area, lift number & any other pertinent info

General Location	Test No.	Dry Density	% Compaction	Moisture Content	Pass/Fail	Comments
25' Ø STAKE B	1	110.7	95.2	16.3	P	
20' Ø STAKE D/E	2	114.6	98.5	14.9	P	OK DAMES-MOORE

Tester's Signature: [signature]

QC Engineer's Signature: [signature]



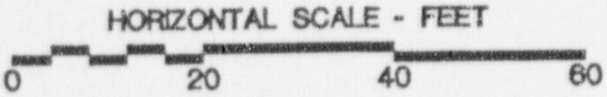
DAILY ACTIVITIES NOTES

- ✱ TROXLER TEST LOCATIONS
- ○ TEST ELEVATION PRIOR TO PLACEMENTS

Q.C. ENGINEER JOHN DUFFY date 2-24-98

DAMES & MOORE
SITE ENGINEER ______________________ date ________

X
X



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NEWBURGH HEIGHTS, OHIO

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DRAWING NUMBER
C1220015

Earth Sciences Consultants, Inc.

Report #:

DAILY QUALITY CONTROL REPORT

Project No.: C1220 **Date:** 2-25-98

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: CLOUDY **Average Temp:** MID 40'S

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

Jack Bodner	Brien Kilkenny	~~Vince Shilobod~~	~~Herb Davidson~~	Larry Weisert	Stephen Wisniewski
~~Lester Exton~~	~~Harry Meyer~~	~~David Wilding~~	Tom Malatesta	~~Gerry Williams~~	John Duffy
Bruce Gulisek	~~Dave Seidel~~	Doug Zimmer	~~Tim Miller~~	~~Donna Wilson~~	~~Nora Yanes~~

Contractor's Visitors (name & company):
STEVE KILPER AWS
DAMES + MOORE REP

General Work Performed

Excavation Activities: NONE

Construction Activities: REWORK - COMPACT LIFT #3 AND PLACE LIFT #4

Material Deliveries/Inspections: NONE

Other: NONE

Quality Control Activities Performed *

Observations: AREA OF LIFT #3 INSPECTED FOR ROCK 72" + ORGANICS PRIOR TO COMPACTION. AFTER TESTING LIFT #3, LIFT #4 BEGINS TO BE PLACED USING STANDARD CONSTRUCTION PRACTICE. ONCE AGAIN ROCKS 72" AND ORGANICS ARE BEING REMOVED. MAT'L BEING PUSHED TO GRADE WITH CAT D6M DOZER AND COMPACTED WITH CASE 1550 DOZER WITH PULL BEHIND SHEEPS FOOT

~~**Field Test Information:**~~ 6 2WAY PASSES
TEST DATA - TEST LOCATIONS ATTACHED - SOLAR TESTING PERFORMS SAND RESULTS PROVIDED AT LATER DATE

Sample Information: NONE

Submittal Information: NONE

Other Remarks: AFTER LEAVING LIFT #3 TO DRY OVERNIGHT LIFT WAS RECOMPACTED AND TEST. ALSO CAT 966F LOADER IS NOT PERMITTED ON TEST PAD. LIFT THICKNESS MONITORED DURING PLACEMENT

Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

JOHN C DUFFY ESC QC TECH
Quality Control Representative

* Attach additional sheets if necessary

Field Test Results
Compaction and Moisture Content

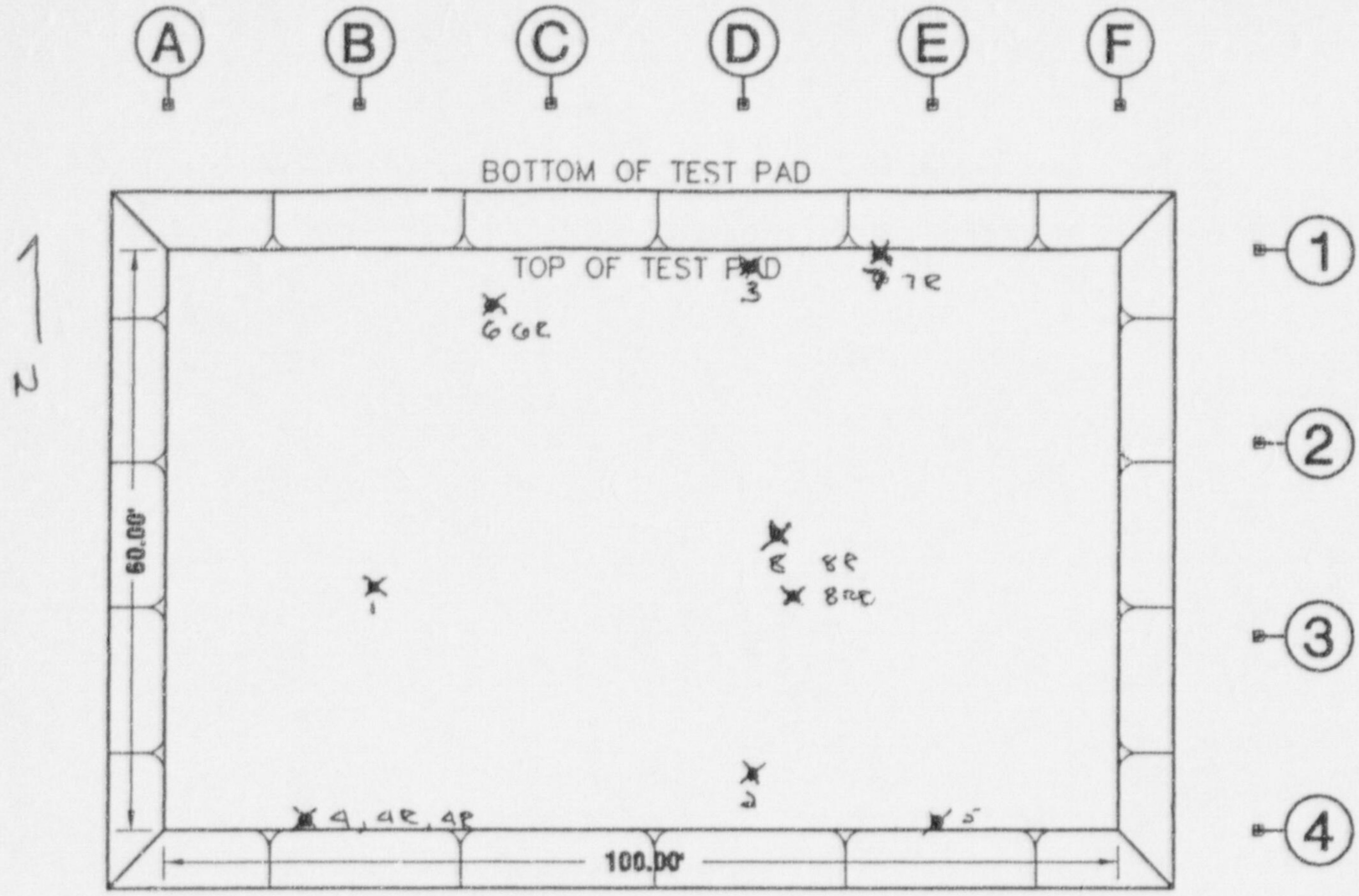
Material: CLAY　　　Date: 2-25-98

Applicable Proctor Value: 116.3
Applicable Percent Compaction: 95%
Optimum Moisture Content: 15.1

NOTE: Indicate flat or slope area, lift number & any other pertinent info

General Location	Test No.	Dry Density	% Compaction	Moisture Content	Pass/Fail	Comments
55' Ø STAKE B	1	112.5	96.8	15.3	P	TEST 1-8 LIFT 3
70' Ø STAKE D	2	114.2	98.2	15.7	P	
15' Ø STAKE D	3	116.6	100	15.1	P	
85' Ø STAKE B/C	4	106.4	91.5	19.4	F	REROLL
" "	4R	107.1	92.1	18.0	F	AFTER REROLL
75' Ø STAKE E	5	110.9	95.4	17.5	P	
85' Ø STAKE B/C	4R	110.9	95.4	16.3	P	RETEST 18 PASS'S
20' Ø STAKE B/C	6	106.3	91.4	16.4	F	REROLL
15' Ø STAKE D/E	7	105.8	91.0	16.4	F	
45' Ø STAKE D	8	110.1	94.7	17.1	F	
20' Ø STAKE B/C	6R	113.3	97.4	17.8	P	
15' Ø STAKE D/E	7R	111.9	96.2	16.8	P	
45' Ø STAKE D	8R	108.3	93.1	17.2	F	REROLL
50 Ø STAKE D	8RR	113.8	97.8	16.2	P	
30' Ø STAKE A	9	111.7	96.0	17.6	P	LIFT # 4 9-13
65' Ø STAKE D	10	114.6	98.5	15.3	P	
40' Ø STAKE C	11	114.3	98.3	17.6	P	
25' Ø STAKE B	12	113.6	97.6	16.3	P	
30' Ø STAKE E	13	114.5	98.5	17.5	P	

Tester's Signature: [illegible]
QC Engineer's Signature: [illegible]



DAILY ACTIVITIES NOTES

TEST ✱ LOCATIONS TROXLER

LIFT #3

Q.C. ENGINEER JOHN DUFFY date 2-25-98

DAMES & MOORE
SITE ENGINEER ______________________ date ________

X
X

HORIZONTAL SCALE - FEET

0 20 40 60

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NEWBURGH HEIGHTS, OHIO

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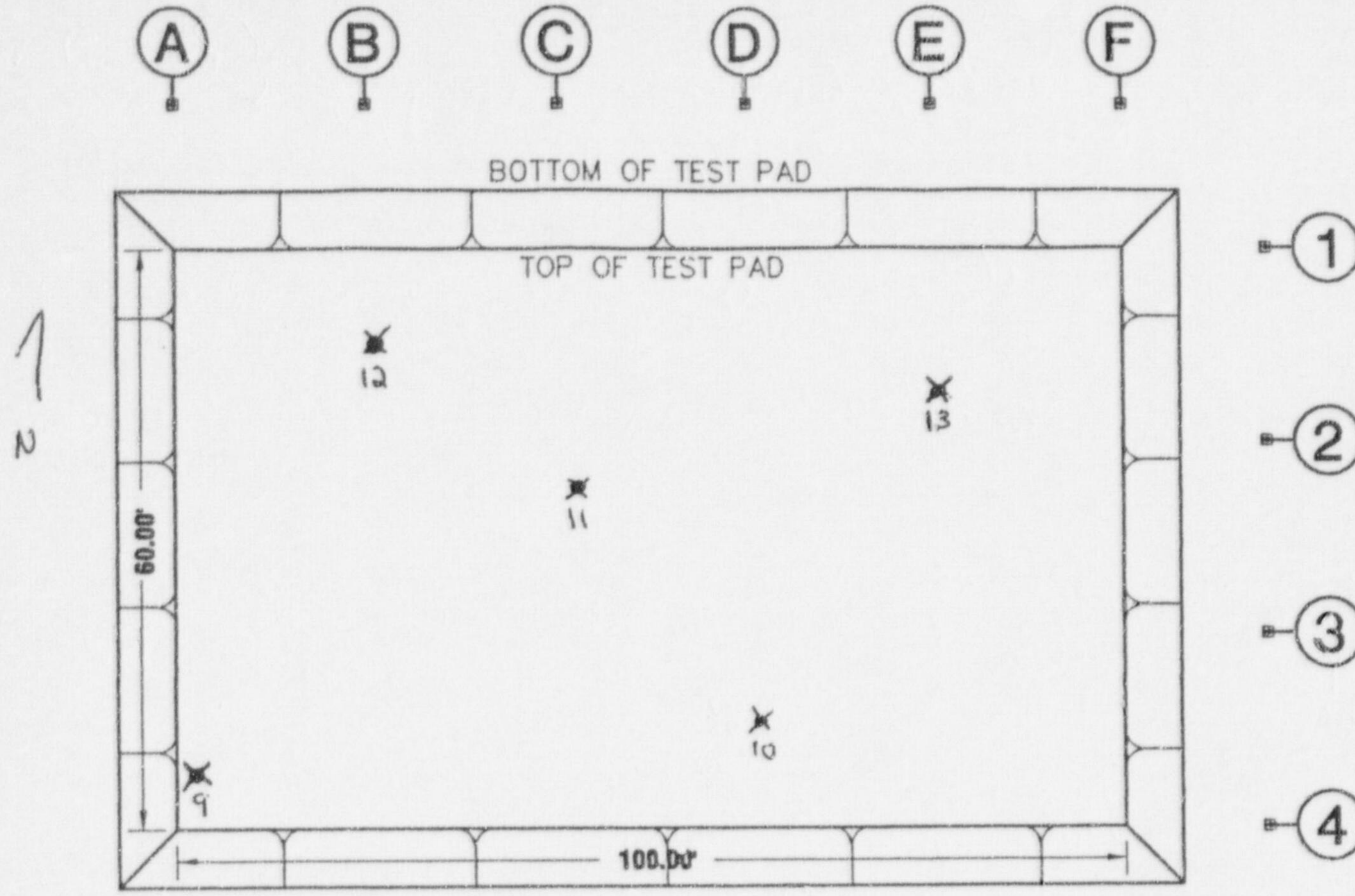
DRAWING NUMBER	C1220015

Earth Sciences Consultants, Inc.

REVISION	DATE	DESCRIPTION



DAILY ACTIVITIES NOTES

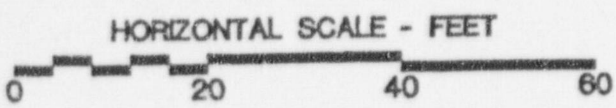
☒ TEST LOCATIONS TROXLER

LIFT #4

Q.C. ENGINEER JOHN DUFFY date 2-25-98

DAMES & MOORE
SITE ENGINEER ____________ date ________

X
X



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NEWBURGH HEIGHTS, OHIO

APPROVED	
CHECKED	
DRAWN	
DRAWING NUMBER	C1220015

Earth Sciences Consultants, Inc.

REVISION	DATE	DESCRIPTION

DAILY QUALITY CONTROL REPORT

Report #:

Project No.: C1220 **Date:** 2/26/98 pg. 1 of 2

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: Overcast **Average Temp:** high 30's

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

Jack Bodner	Brien Kilkenny	~~Vince Sh…bod~~	~~Herb Davidson~~	~~Larry Weisert~~	~~Stephen Wisniewski~~ present
~~Lester Exton~~	~~Harry Moyer~~	~~David W…lding~~	~~Tom Malatesta~~	~~Gerry Williams~~	John Duffy
Bruce Gulisek	~~Dave Seidel~~	Doug …immer	~~Tim Miller~~	~~Donna Wilson~~	Nora Yanes

Contractor's Visitors (name & company):

General Work Performed

Excavation Activities: none

Construction Activities: Finished placing lift #5 and compacted lift #5.

Material Deliveries/Inspections: none

Other: None

Quality Control Activities Performed *

Observations: Clay material placed in ≤8" lifts with CAT D6M dozer. CAT 966F loader transported clay from C14 stockpile to test pad area. Rocks & particles ≥2" removed from each lift. Six two-way passes of the CASE 1550 Dozer & tow-behind compactor (sheepsfoot). D6M Dozer scarifies previous lift before new material is placed.

Field Test Information: Moisture/density tests performed on lift #5. Results attached. Sand cone test performed. Results available at a later date.

Sample Information: Max dry density of C14 116.3 pcf & optimum moisture content is 15.1 %.

Submittal Information: none.

Other Remarks: Many particles 2" & greater had to be removed from the lift. Any holes made in lift due to Troxler gauge were back filled w/ bentonite & tamped.

Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

Nora I Yanes ESC, QC Engineer

Quality Control Representative

* Attach additional sheets if necessary

Field Test Results
Compaction and Moisture Content

Material: CLAY

Date: 2-26-98

MS 056
DS 3216

Applicable Proctor Value: 116.3

Applicable Percent Compaction: 95%

Optimum Moisture Content: 15.1

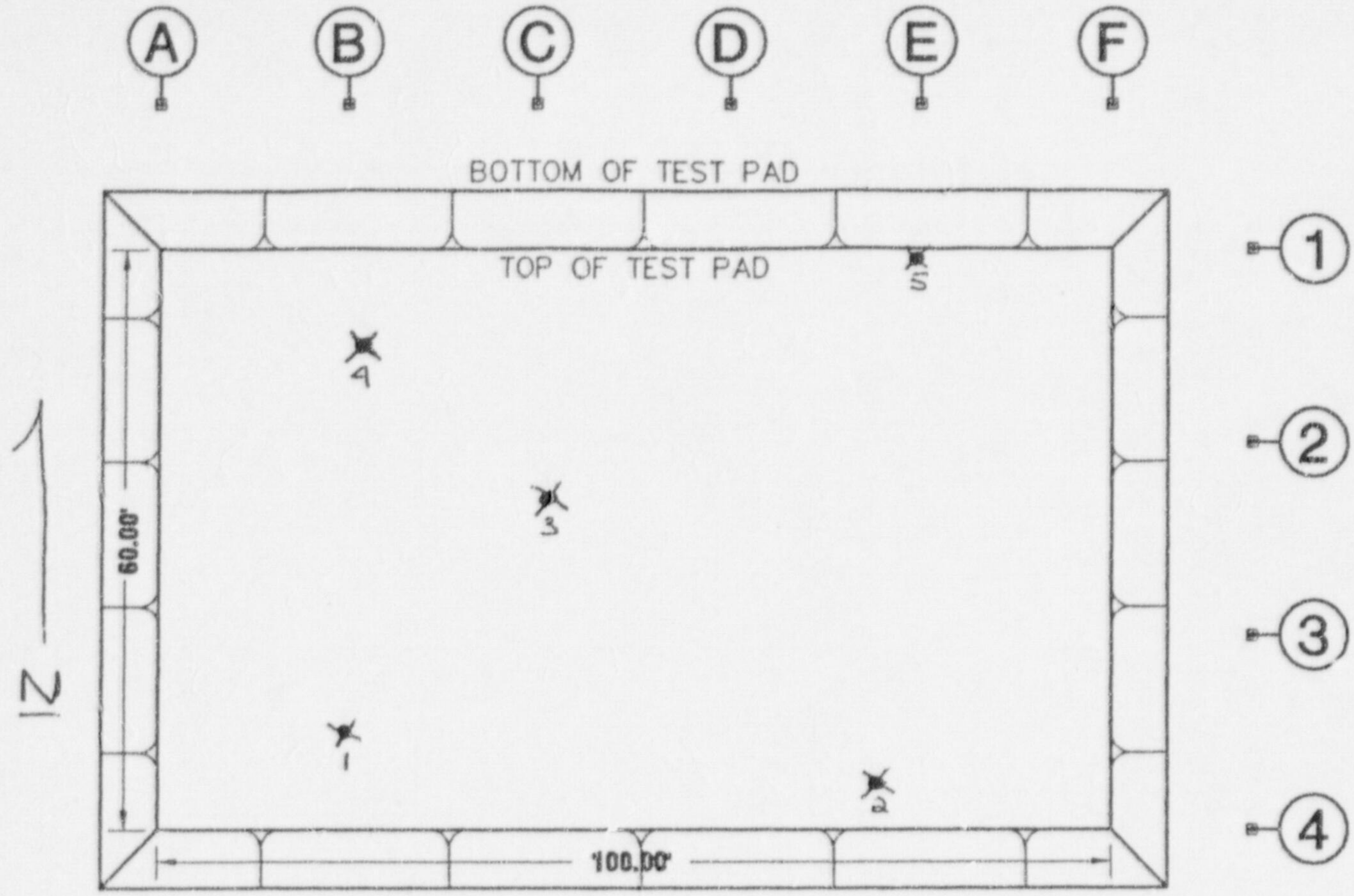
NOTE: Indicate flat or slope area, lift number & any other pertinent info

General Location	Test No.	Dry Density	% Compaction	Moisture Content	Pass/Fail	Comments
65' Ø STAKE B	1	115.9	99.7	15.1	P	LIFT #5
70' Ø STAKE D/E	2	111.6	95.9	15.2	P	↓
40 Ø STAKE C	3	118.3	100.0	15.5	P	↓
25 Ø STAKE B	4	111.5	95.9	17.4	P	↓
15 Ø STAKE E	5	114.0	98.1	15.8	P	↓

Tester's Signature: [signature]

QC Engineer's Signature: [signature]

Field Test Results Sheet.xls



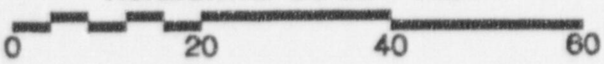
DAILY ACTIVITIES NOTES

☒ TROXLER TEST LOCATIONS

Q.C. ENGINEER JOHN DUFFY date 2-26-98

DAMES & MOORE
SITE ENGINEER ____________ date ______

X
X



PREPARED FOR
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO

APPROVED	
CHECKED	
DRAWN	
DRAWING NUMBER C1220015	Earth Sciences Consultants, Inc.

REVISION	DATE	DESCRIPTION

DAILY QUALITY CONTROL REPORT

Report #:

Project No.: C1220 **Date:** 2/26/98 pg. 2 of 2

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: Overcast **Average Temp:** high 30's

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

Jack Bodner, Brien Kilkenny, ~~Vince Shilobod~~, ~~Herb Davidson~~, ~~Larry Weisert~~, Stephen Wisniewski
~~Lester Exton~~, ~~Harry Moyer~~, ~~David Wilding~~, ~~Tom Malatesta~~, ~~Gerry Williams~~, John Duffy
Bruce Gulisek, ~~Dave Seidel~~, Doug Zimmer, ~~Tim Miller~~, ~~Donna Wilson~~, Nora Yanes

Contractor's Visitors (name & company):

General Work Performed

Excavation Activities: none.

Construction Activities: Installed permeameters and TEG for Phase I of Boutwell Test.

Material Deliveries/Inspections: None

Other: none.

Quality Control Activities Performed *

Observations: Gas powered auger bored hole to approx. 8". Flat bottom reamer, reamed hole 2". Hole cleaned out w/ shop vac. Permeameter placed in center of hole. Two "1" lifts of bentonite (granular) placed in hole & tamped w/ water. Successive 1" lifts of pelletized bentonite w/ water was tamped in to seal permeameter in place. Procedure same for all permeameters.

Field Test Information: All permeameters allowed to hydrate overnight.

Sample Information: None.

Submittal Information: none.

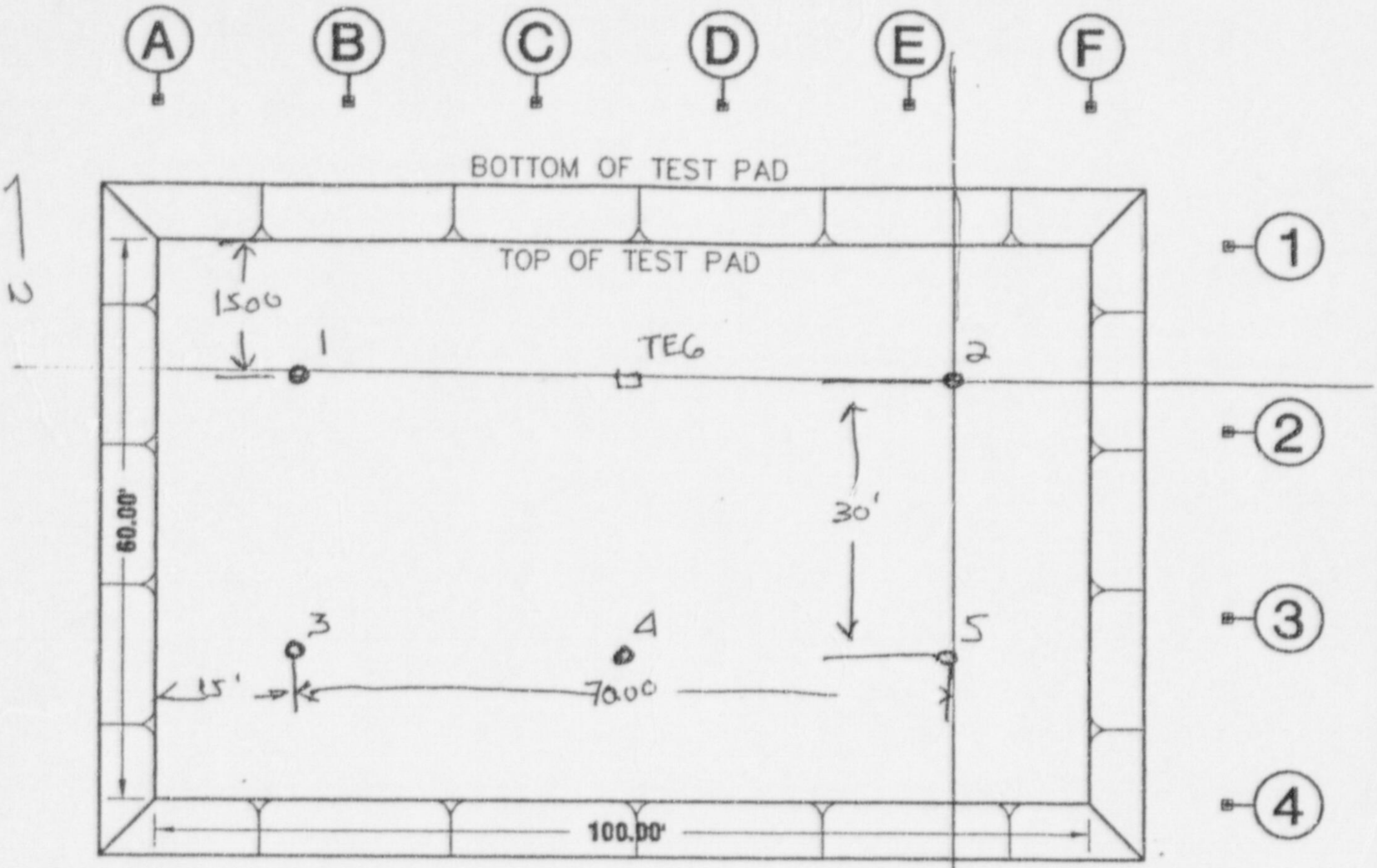
Other Remarks: Permeameter location and TEG location shown on drawing attached. All finished permeameter depths were 10".

Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

Nora J. Yanes E&E: QC Engineer
Quality Control Representative

* Attach additional sheets if necessary



DAILY ACTIVITIES NOTES

Permeameter Locations (approx.)

Q.C. ENGINEER Nora J. [illegible] date 2/26/98

DAMES & MOORE
SITE ENGINEER ______ date ______

X
X

HORIZONTAL SCALE - FEET

0 20 40 60

PREPARED FOR
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO

APPROVED	
CHECKED	
DRAWN	
DRAWING NUMBER 01220015	Earth Sciences Consultants, Inc.

REVISION	DATE	DESCRIPTION

DAILY QUALITY CONTROL REPORT

Report #:

Project No.: C1220

Date: 2/27/98

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: Cloudy

Average Temp: high 40's

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

~~Jack Bodner~~	~~Brien Kilkenny~~ present	~~Vince Shilobod~~	~~Herb Davidson~~	Larry Weisert	~~Stephen Wisniewski~~
~~Lester Exton~~	~~Harry Moyer~~	~~David Wilding~~	~~Tom Malateste~~	~~Gerry Williams~~	~~John Duffy~~
~~Bruce Gulisek~~	~~Dave Seidel~~	~~Doug Zimmer~~ - present	~~Tim Miller~~	~~Donna Wilson~~	Nora Yanes

Contractor's Visitors (name & company):

General Work Performed

Excavation Activities: none

Construction Activities: Covered test pad with plastic then 6" straw then plastic again for freeze protection.

Material Deliveries/Inspections: none

Other: none.

Quality Control Activities Performed *

Observations: Permeameters filled w/ water. (1800). Boutwell test started.

Field Test Information: none

Sample Information: none

Submittal Information: none

Other Remarks: ~~None~~ nty Insulated drums available onsite for freeze protection if necessary.

Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

Nora J. Yanes

Quality Control Representative

* Attach additional sheets if necessary

Report #:

DAILY QUALITY CONTROL REPORT

Project No.: C1220 **Date:** 3/4/98

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: Cloudy **Average Temp:** mid 30's

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

~~Jack Bouner~~	Brien Kilkenny	~~Vince Shilobod~~	~~Herb Davidson~~	Larry Weisert	~~Stephen Wisniewski~~
~~Lester Exton~~	~~Harry Moyer~~	~~David Wilding~~	~~Tom Malatesta~~	Gerry Williams	~~John Duffy~~
~~Bruce Gulicek~~	~~Dave Seidel~~	Doug Zimmer	Tim Miller	~~Donna Wilson~~	Nora Yanes

Contractor's Visitors (name & company):

General Work Performed

Excavation Activities: none

Construction Activities: Reinstalled permeameters.

Material Deliveries/Inspections: none.

Other: none

Quality Control Activities Performed *

Observations: Gas powered auger bored holes to 8". Flat bottom auger reamed hole to 10". Hole cleaned out with shop vac. Permeameter placed in center. Two - 1/2" lifts of granular bentonite placed in hole & tamped w/ water. Successive lifts of granular bentonite (1") was tamped w/ water to seal permeameters. Procedure same for all permeameters.

Field Test Information: Small amounts of water placed in each permeameter to help hydrate overnight.

Sample Information: none

Submittal Information: none

Other Remarks: Permeameters allowed to hydrate overnight. Boutwell Test Stage I will start 3/5/98. Insulated drums & lights available to provide freeze protection.

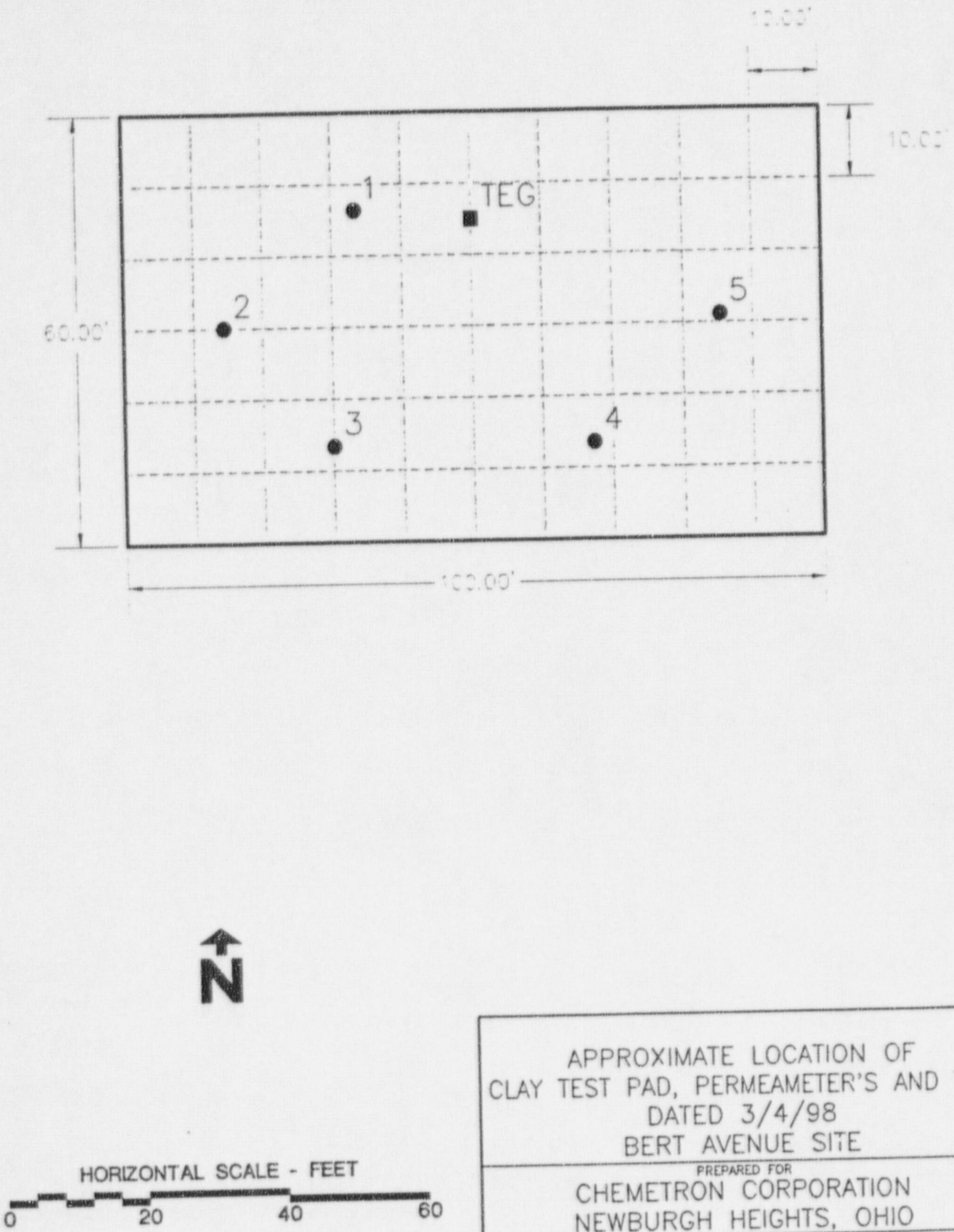
Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

Nora T. Yanes EIT - QC Engineer

Quality Control Representative

* Attach additional sheets if necessary



APPROXIMATE LOCATION OF
CLAY TEST PAD, PERMEAMETER'S AND TE(
DATED 3/4/98
BERT AVENUE SITE

PREPARED FOR
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO

APPROVED	NG 3/10/98
CHECKED	NG 3/10/98
DRAWN	

DRAWING NUMBER
C1220014

Earth Sciences Consultants, In

REVISION	DATE	DESCRIPTION
REV1	3/17/98	MOVED PERMEAMETER LOCATIONS

Report #:

DAILY QUALITY CONTROL REPORT

Project No.: C1220 **Date:** 3/13/98

Project Title & Location: Bert Avenue Remediation, 4000 E 27th St. Newburgh Heights, OH 44105

Weather Conditions: Cloudy **Average Temp:** mid 30's

Personnel Onsite

Contractor (AWSR) Personnel (cross out if not present):

~~Jack Bodner~~	Brien Kilkenny	~~Vince Shilobod~~	~~Herb Davidson~~	~~Larry Weisert~~	~~Stephen Wisniewski~~
~~Lester Exton~~	~~Harry Moyer~~	~~David Wilding~~	~~Tom Malatesta~~	~~Gerry Williams~~	~~John Duffy~~
~~Bruce Gulisek~~	~~Dave Seidel~~	Doug Zimmer	~~Tim Miller~~	~~Donna Wilson~~	Nora Yanes

Contractor's Visitors (name & company): Joe Gonda, Mahoning Landfill, AWS

General Work Performed

Excavation Activities: none

Construction Activities: Advanced permeameters to Stage Two.

Material Deliveries/Inspections: None

Other: none

Quality Control Activities Performed *

Observations: Removed water from permeameter. Advanced borehole w/ 4" hand auger. Flat bottom auger reamed hole flat. Wire brush used to scarify sides of hole. Placed geofabric socks w/ pea gravel inside bored hole to prevent collapse. Same procedure for all five permeameters. Filled all permeameters w/ water to start Stage Two.

Field Test Information: Permeameter #2 advanced 4". Permeameter #1 advanced to 5". Permeameter #3 advanced to 5". Permeameter #4 advanced to 5 1/2". Permeameter #5 advanced to 5 1/2".

Sample Information: none

Submittal Information: None.

Other Remarks: Lights & drums available for insulation to prevent permeameter from freezing.

Contractor's Certification

On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications, to the best of my knowledge, except as may be noted above.

Nora J. Yanes ESC, QC Engineer
Quality Control Representative

* Attach additional sheets if necessary

Appendix F

Sand Cone Information

SOLAR TESTING LABORATORIES, INC.
5399 Lancaster Drive, Brooklyn Heights, Ohio 44131
Telephone: (216) 741-7007 • FAX: (216) 741-7011

February 19, 1998

Ms. Nora Yanes
EARTH SCIENCES CONSULTANTS, INC.
One Triangle Drive
Export, PA 15632

RE: SAND CONE TESTING (ASTM D 1556-90)/ CLAY TEST PAD
BERT AVENUE SITE CLOSURE
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO
STL PROJECT NO. A97820x21

Dear Ms. Yanes

On February 16, 1998 we conducted an in place density test by sand cone methods per ASTM D 1556-90 at one location on the first lift of the test pad at the above subject site. The results are as follows:

Test No.	Dry Density by Sand Cone / w%	Dry Density by Nuclear methods / w%
1	101.6 pcf / 16.9%	111.5 pcf / 16.9%

Optimum Moisture 15.1%
Maximum Dry Density 116.3 pcf
w% - denotes moisture content

The sand cone test indicates a failing result for compaction.

If you have any questions. please do not hesitate to contact me.

Sincerely yours,

SOLAR TESTING LABORATORIES, INC.

Douglas J. Perisutti, P.E., CPG
Environmental Project Engineer

DJP/mjb

SOLAR TESTING LABORATORIES, INC.
5399 Lancaster Drive, Brooklyn Heights, Ohio 44131
Telephone: (216) 741-7007 • FAX: (216) 741-7011

March 2, 1998

Ms. Nora Yanes
EARTH SCIENCES CONSULTANTS, INC.
One Triangle Drive
Export, PA 15632

RE: SAND CONE TESTING (ASTM D 1556-90)/ CLAY TEST PAD
BERT AVENUE SITE CLOSURE
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO
STL PROJECT NO. A97820x21

Dear Ms. Yanes

We have completed an in place density test by sand cone methods per ASTM D 1556-90 at two locations on the test pad and a one point proctor at the above subject site. The results are as follows:

Test No.	Date	Dry Density by Sand Cone / w%
2	2/25/98	110.2 pcf / 16.6%
3	2/26/98	105.7 pcf / 17.2%

Test No.	Date	One-Point Proctor Dry Density / w%
1	2/25/98	112.5 pcf / 16.9%

w% - denotes moisture content

If you have any questions. please do not hesitate to contact me.

Sincerely yours,

SOLAR TESTING LABORATORIES, INC.

Douglas J. Perisutti, P.E., CPG
Environmental Project Engineer

DJP/mjb

Appendix G

Draft ASTM Standard for the Two-Stage Borehole Procedure (Boutwell)

Standard Test Method for Field Measurement of Hydraulic Conductivity Limits of Porous Materials Using Two Stages of Infiltration from a Borehole[1]

This standard is issued under the fixed designation D ____; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers field measurement of limiting values for vertical and horizontal hydraulic conductivities (also referred to as *coefficients of permeability*) of porous materials using the two-stage, cased borehole technique. These limiting hydraulic conductivity values are the maximum possible for the vertical direction, and minimum possible for the horizontal direction. Determination of actual hydraulic conductivity values requires further analysis by qualified personnel.

1.2 This test method may be utilized for compacted fills or natural deposits, above or below the water table, that have a mean hydraulic conductivity less than or equal to $1x10^{-5}$ m/s ($1x10^{-3}$ cm/sec).

1.3 Hydraulic conductivity greater than $1x10^{-5}$ m/s may be determined by ordinary borehole tests, e.g., U.S. Bureau of Reclamation 7310. However, the resulting value is an apparent conductivity.

1.4 For this field test method a distinction must be made between "saturated" (K_s) and "field-saturated" (K_{fs}) hydraulic conductivity. True saturated conditions seldom occur in the vadose zone except where impermeable layers result in the presence of perched water tables. During infiltration events or in the event of a leak from a lined pond, a "field-saturated" condition develops. True saturation does not occur due to entrapped air **(1)**.[2] The entrapped air prevents water from moving in air-filled pores that, in turn, may reduce the hydraulic conductivity measured in the field by as much as a factor of two compared to conditions when trapped air is not present **(2)**.[2] This field test method simulates the "field-saturated" condition.

1.5 Experience with this method has been predominately in materials having a degree of saturation of 70% or more, and where the stratification or plane of compaction is relatively horizontal. Its use in other situations should be considered experimental.

1.6 As in the case of all tests for hydraulic conductivity, the results of this test pertain only to the volume of soil permeated. Extending the results to the surrounding area requires both multiple tests and the judgement of qualified personnel. The number of tests required depends on among other things: the size of the area, the uniformity of the material in that area, and the variation in data from multiple tests.

1.7 The values stated in SI units are to be regarded as the standard, unless other units

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[1]This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.04 on Hydrologic Properties of Soil and Rocks.
Current edition approved ____________. Published

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[2]The boldface numbers in parentheses refer to a list of references at the end of the text.
[3]*Annual Book of ASTM Standards*, Vols. 04.08 and 04.09.

are specifically given. By tradition in U.S. practice, hydraulic conductivity is reported in centimeters per second, although the common SI units for hydraulic conductivity are meters per second.

1.8 *This standard does not purport to address the safety or environmental protection problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards*

D653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

D1452 Soil Investigation and Sampling by Auger Borings[3]

D1587 Thin-Walled Tube Geotechnical Sampling of Soils[3]

D2937 Density of Soil In Place by the Drive-Cylinder Method[3]

D3740 Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction[3]

D5084 Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter[3]

D5092 Design and Installation of Ground Water Monitoring Wells in Aquifers[3]

D5126 Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone[3]

2.2 *USBR Standards*

E18 Field Permeability Tests in Boreholes (**3**)[2]

3. Terminology

3.1 *Description of Terms Specific to This Standard*

3.1.1 *hydraulic conductivity, k*-the rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions (20°C).

DISCUSSION-The term *coefficient of permeability* is often used instead of *hydraulic conductivity*, but *hydraulic conductivity* is used exclusively in this test method. A more complete discussion of the terminology associated with Darcy's law is given in the literature (**4**). It should be noted that both natural soils and recompacted soils are usually not isotropic with respect to hydraulic conductivity. Except for unusual materials, $k_h > k_v$.

3.1.2 *vertical conductivity, k_v* - The hydraulic conductivity in (approximately) the vertical direction.

3.1.3 *horizontal conductivity, k_h* - The hydraulic conductivity in (approximately) the horizontal direction.

3.1.4 *limiting vertical conductivity, K1* - The hydraulic conductivity as determined in Stage 1 of this test procedure assuming the tested medium to be isotropic. For ordinary soils, both compacted and natural, this is the maximum possible value for k_v.

3.1.5. *limiting horizontal conductivity, K2* - The hydraulic conductivity as determined in Stage 2 of this test procedure assuming the tested medium to be isotropic. For ordinary soils, both compacted and natural, this is the minimum possible value for k_h.

3.1.6 *test diameter* - The inside diameter (ID) of the casing.

3.2 *Other Terms.* For definitions of other terms used in this test method, see Terminology D653.

4. Summary of Test Method

4.1 The rate of flow of water into soil through the bottom of a sealed, cased borehole is measured in each of two stages, normally with a standpipe in the falling-head procedure. The standpipe can be refilled as necessary.

4.2 In Stage 1, the bottom of the borehole is flush with the bottom of the casing for maximum effect of k_v. The test is continued until the flow rate becomes quasi-steady.

4.3 For Stage 2, the borehole is extended below the bottom of the casing for maximum effect of k_h. This stage of the test is also continued until the flow rate becomes quasi-steady.

4.4 The direct results of the test are the limiting hydraulic conductivities K1 and K2. The actual hydraulic conductivities k_v and k_h can be calculated from these values(**5**).

5. Significance and Use

5.1 This test method provides a means to measure both the maximum vertical and minimum horizontal hydraulic conductivities, especially in the low ranges associated with fine-grained clayey soils, 1×10^{-7} m/s to 1×10^{-11} m/s.

5.2 This test method is particularly useful for measuring liquid flow through soil moisture barriers such as compacted clay liners or covers used at waste disposal facilities, for canal and reservoir liners, for seepage blankets, and for amended soil liners such as those used for retention ponds or storage tanks. However, the thickness of the unit tested must be at least 6 times the test diameter. This requirement must be increased to 8 test diameters if the barrier is not underlain by a drainage blanket or by a material far less permeable than the barrier being tested.

5.3 The soil layer being tested must have sufficient cohesion to stand open during excavation of the borehole.

5.4 This test method provides a means to measure infiltration rate into a moderately large volume of soil. Tests on large volumes of soil can be more representative than tests on small volumes of soil. Multiple installations properly spaced provide a greater volume and an indication of spatial variability.

5.5 The data obtained from this method are most useful when the soil layer being tested has a uniform distribution of hydraulic conductivity and of pore space, and when the upper and lower boundary conditions of the soil layer are well-defined.

5.6 Changes in water temperature can introduce significant errors in the flow measurements. Temperature changes cause fluctuations in the standpipe levels which are not related to flow. This problem is most pronounced when a small diameter standpipe is used in soils having hydraulic conductivities of 5×10^{-8} cm/sec or less.

5.7 The effects of temperature changes are taken into account by the use of a dummy installation, the temperature effect gauge (TEG). The base of the TEG must be sealed to prevent flow. The fluctuations of the TEG are due solely to ambient changes, and are used to correct the readings at the flowing tests.

5.8 If the soil being tested will later be subjected to increased overburden stress, then the hydraulic conductivities can be expected to decrease as the overburden stress increases. Laboratory hydraulic conductivity tests or these tests under varying surface loads are recommended for studies of the influence of level of stress on the hydraulic properties of the soil.

6. Apparatus

6.1 *Boring/Reaming Tools*

6.1.1 *Drilling Equipment* - Equipment must be available to advance the borehole to the desired test level. This borehole diameter must be at least 5 cm (2 inches) larger than the outside diameter of the casing. The auger or bit used to advance the borehole below the casing for Stage 2 shall have a diameter about 1 cm (1/2 inch) less than the inside diameter of the casing. For tests in compacted materials above the water table, and wherever else possible, the borehole shall be advanced by dry augering. Either hand or mechanical augers are acceptable.

6.1.2 *Flat Auger* - The flat auger (Fig. 1) is used to prepare the borehole for casing installation. It shall be capable of reaming the bottom of the borehole to a level plane perpendicular to the borehole axis. The flat auger shall have a diameter about 5 cm (2 inches) larger than the outside diameter of the casing.

6.1.3 *Reamer* - The reamer (Fig. 1) is used to complete the Stage 2 cavity. The base of the reamer shall be capable of reaming the bottom of the advanced borehole to a level plane, perpendicular to the borehole axis, and having the inside diameter of the casing. The bottom plate of the reamer shall have a diameter about 0.1 cm (0.04 inch) less than the inside diameter of the casing. The vertical side of the cutting plate shall be serrated.

6.1.4 *Scarifier* - A bent fork, wire brush, or similar roughener small enough to fit easily within the casing and having a handle long enough to reach the bottom of Stage 2, is used to roughen the walls of the Stage 2 cavity.

6.2 *Borehole Casing*

6.2.1 *Casing* - The casing shall be watertight, but may be of any material or diameter. Its minimum ID shall be 10 cm (4 inches) unless the clearance provisions of Section 7.7 cannot be met. In such cases only, the ID may be reduced to 7.5 cm (3 inches). The wall thickness shall be adequate to prevent collapse under the lateral pressure of the overburden and swelling bentonite. Standard 10 cm (4 inch) ID Schedule 40 PVC threaded pipe is satisfactory. The bottom of the casing shall be cut off smooth and square. The casing shall have flush threads; external couplers interfere with sealing the annulus and internal couplers with advancing the borehole for Stage 2. Neither shall be used. The top of the casing shall be provided with a means of attaching the top assembly. Typical modifications include threading the top or attaching a flange. When threads are used, they must be flush. When a flange is used, the diameter shall be minimal so as not to interfere with sealing the annulus. Any casing joints and joint between top assembly and casing shall be provided with an O-Ring or other device to ensure watertightness.

6.2.2 *Top Assembly* - This consists of a cap attached (normally by gluing) to a short piece of threaded casing, as illustrated on Figure 2. The cap shall be domed or slanted upwards to minimize air entrapment. It shall be fabricated so as to receive the flow control system with a watertight joint. Provisions for bleeding any entrapped air shall be made. For the TEG (only), the top assembly may also be provided with a watertight fitting for the thermometer or thermocouple leads.

6.2.3 *Annular Sealant* - Bentonite is normally used to seal the annulus between the wall of the borehole and the wall of the casing. All sealants should be compatible with ambient geologic and geohydrologic conditions. Do not introduce any sealants into the casing.

6.2.3.1 *Directly Placed Sealant* - The annular sealant is best placed in the borehole dry and tamped for shallow installations. Bentonite should be granular or pelletized, sodium montmorillonite furnished in sacks or buckets from a commercial source and free of impurities which adversely impact the sealing process. Pellets consists of roughly spherical or disk shaped units of compressed bentonite powder. Granules consist of coarse particles of unaltered bentonite, typically smaller than 0.2 in. (5 mm). The diameter of pellets or granules selected should be less than one fifth the width of the annular space into which they are placed to reduce the potential for bridging. The directly placed sealant shall extend to the ground surface or to a minimum of 1 meter (3 feet) above the bottom of the casing, whichever is lesser. Either the placed sealant or the grouted sealant shall extend to the ground surface.

6.2.3.2 *Grouted Sealant*. The annular space may be grouted above the placed sealant. Any of the grouting methods of ASTM D5092 may be used.

6.2.3.3 *Sock* - The sock protects the soil at the bottom of the casing from disturbance when water is introduced and prevents collapse of the Stage 2 cavity. It is a cylinder composed of a semi-rigid, porous sidewall and bottom (such as a geogrid), lined with a geotextile, and filled with pea gravel or other highly pervious material. The hydraulic conductivity of all sock materials shall be at least 10 times the anticipated hydraulic conductivity of the tested stratum in the horizontal direction. The outer diameter is 0.6 cm (1/4 inch) less than the inner diameter of the casing. The length is approximately 8 cm (3 inches) longer than will be the borehole extension for Stage 2. Wires or other suitable means for retrieving the sock should be provided.

6.3 *Pressure/Flow System*

6.3.1 *Flow Control System* - The plumbing for the flow control system is illustrated on Figure 2. It can be composed of metal or plastic components. The system shall have sufficient flow area so that the unrestricted flow is at least 10 times the anticipated flow rate during the test. Nominal 13 mm (0.5 inch) components have been satisfactory for 10 cm (4 inch) diameter tests.

6.3.2 *Standpipe* - The standpipe, also shown on Figure 2, should be only as tall as needed to apply a maximum head (measured at the bottom of the casing) equal to or less than the head allowable by hydraulic fracturing considerations; the hydraulic head at the bottom of the casing should not exceed 1.5 times the total overburden pressure at that level. The standpipe must be transparent and strong enough to withstand wind forces. Clear Schedule 40 PVC has been found satisfactory. Inside diameters of 1 to 2 cm (0.5 to 0.75 inches) have been satisfactory for 10 cm (4 inch) diameter tests. Provisions shall be made to prevent precipitation from entering the standpipe and to minimize evaporation from it, while allowing equalization of air pressure. One satisfactory method is to set a 90° elbow on the top of the standpipe, cover the elbow's outlet with aluminum or similar foil, and prick a small (1mm±) hole in the foil for air pressure equalization.

6.3.3 *Scale* - The standpipe should be graduated or a scale affixed; either must have a resolution of 1 mm (1/16 inch). If a scale is used, its base should be on a known reference point of the flow control system which can be readily reestablished.

6.3.4 *Watch* - Readable to ls.

6.3.5 *Miscellaneous Hand Tools* - Adjustable and pipe wrenches, knife, strap wrenches (2) to fit casing, silicone grease such as automotive fan belt lubricant, PTFE (polytetrafluoroethylene) tape, refill hose, funnel to fit refill hose, 100 ml plastic cylinder flask.

6.4 *Temperature System* - A thermometer or thermocouple, readable to 0.5°C with a range sufficient to cover the anticipated air and water temperatures during the test and long enough to extend to the bottom of the TEG.

6.5 *Survey Equipment* - Surveyor's level and rod, and a 15 - 30 meter (50 - 100 foot) tape.

6.6 *Miscellaneous*

6.6.1 *Plastic Sheeting* - Clear or white plastic sheeting, nominal thickness at least 0.1 mm (5 mils). Provide one 3x3 m (10x10 foot) sheet per test, including the TEG.

6.6.2 *Water Supply* - Preferably water of the same quality as that involved in the problem being examined, but having a Turbidity of 5 NTU or less. Only potable water should be used if there is a possibility that the introduced water could enter the groundwater regime. All water to be introduced into the test apparatus shall be allowed to stand open at least 12 hours prior to use for deairing. See also Section 8.3.3 for temperature requirements.

6.6.3 *Antifreeze* - Where air temperatures below freezing are anticipated, an antifreeze solution may be used as the permeating fluid in lieu of water. The temperature-kinematic viscosity relation of the solution must be determined and used in the appropriate equations of Section 9 - Calculations. Ethanol (ethyl alcohol) in potable form has been used as follows:

Table 1 - Ethanol Proportions

Minimum Temperature (°C)	Proportion Water/Ethanol
-5	5 : 1
-10	3 : 1
-15	2.3 : 1
-20	1.8 : 1
-25	1.5 : 1

Ethanol at concentrations of 1:1 or stronger can cause structural changes in the soil and should not be used.

However, it is the responsibility of the user to obtain any necessary regulatory approval for the solution used, since groundwater pollution may result from antifreeze compounds. The user is advised that soil freezing/thawing will change its hydraulic conductivity.

6.6.4 *Vacuum Cleaner (Optional)* - An industrial-type vacuum cleaner can be used to clear cuttings, etc., from the bottoms of Stages 1 and 2.

6.6.5 *Aluminum Foil* - 1 roll.

6.6.6 *Rubber Bands* -

6.6.7 *Flashlight* -

7. Test Site

7.1 On a compacted fill, each individual test requires an area approximately 4x4 m (13x13 feet). Tests shall not be located closer than 40 test diameters center-to-center. A group of at least 5 tests is suggested for evaluation of a typical test pad (up to 20x25m) for waste-retention structures. Larger areas may require more tests and the program should be designed on a sound statistical basis.

7.2 The layer being tested must maintain its full thickness at least 30 test diameters horizontally in all directions from the center of the test.

7.3 Stratification or the plane of compaction should be essentially horizontal.

7.4 If a compacted fill is being tested, the test area shall be covered with clear or white plastic immediately after the final lift is placed.

7.5 Compacted fills are typically underlain by either a permeable layer (such as a drainage blanket or an impermeable layer (such as a geomembrane). Such conditions shall be recorded, together with the phreatic surface (if any) within the fill. See, e.g., Section 4.4 of D1452 for determining the phreatic surface. Where no such bottom condition exists, the nature of the underlying soil and depth to the groundwater phreatic surface shall be furnished. The thickness of the tested material near each test location shall be determined to the nearest 2cm (1 inch) by before-and-after survey or post-test borings.

7.6 In natural deposits, the stratigraphic sequence to at least 10 test diameters below the proposed bottom level for Stage 2 shall be determined by borings and/or test pits and the position of the phreatic surface in the tested stratum also determined. Borings or test pits shall not be made within 3.6 m (12 feet) of the test location before the test; any borings within 10 m (30 feet) of the test location shall be grouted prior to testing. Any test pits within this distance shall be backfilled prior to testing. Test pits shall not be made closer to the test location than half the test pit depth.

7.7 The minimum allowable thickness for the layer being tested depends on the boundary conditions. Minimum allowable test geometries are given below for typical cases. Here, "relatively pervious" means having a vertical permeability at least 10 times that of the layer being tested, and "relatively impervious" means having a permeability less than 1/10 that of the layer being tested.

7.7.1 Where the layer being tested extends to the ground surface and is underlain by either a relatively pervious or relatively impervious layer, the thickness of the layer being tested shall not be less than 6 times the test diameter. The casing shall extend at least 2.5 test diameters below the top of the ground surface and the bottom of Stage 2 shall be at least 2.0 test diameters above the bottom of the stratum being tested, leaving room for a Stage 2 extension of 1.5 test diameters. If the underlying material does not meet the criteria of Section 7.7, the bottom of Stage 2 shall be at least 4.0 test diameters above the bottom of the stratum being tested. The casing embedment remains the same, so that the required thickness of the layer being tested becomes 8.0 test diameters.

7.7.2 Where the layer being tested does not extend to the ground surface but is overlain by a relatively pervious material, the clearances of Section 7.7.1 shall apply except that the casing shall extend at least 2.5 test diameters below the top of the stratum being tested. If the overlying stratum is relatively impervious, the casing shall extend at least 5.0 diameters below the top of the stratum being tested, for a minimum test layer thickness of 8.5 to 10.5 test diameters.

8. Procedures

8.1 *Set and Seal Casing* - This is the single most important step in the entire procedure and must be done with care.

8.1.1 *Drill Borehole* - Drill the borehole in a direction perpendicular to the stratification or plane of compaction, which may or may not be perpendicular to the ground surface. The angle of inclination, if any, shall be measured and reported. The hole must be at least 5 cm (2 inches) larger in diameter than the outside diameter of the casing. Stop the borehole when its maximum depth (usually the point of the auger or bit) is at least 2.5 cm (1 inch) above the desired bottom-of-casing level.

8.1.2 *Ream Borehole* - Using the flat auger, ream the borehole to depth and to a diameter about 5 cm (2 inches) larger than the outside diameter of the casing. The bottom shall be smooth, flat, and free from cuttings and/or particles exceeding 1/4 the test diameter. An industrial-type vacuum cleaner can be used for this cleaning.

8.1.3 *Insert Casing* - Set the casing within and parallel to the axis of the borehole, centered as much as possible, with a minimum 2.5 cm (1.0 inch) annular space between the wall of the borehole and the outside of the casing. The top of the casing should be as close to ground surface as possible, but not less than 2 cm (1 inch) for internally threaded casing or 2 cm (1 inch) plus the length of the threaded section for an externally-threaded casing. Seat the casing firmly by hand. Measure the depth from top-of-casing to bottom-of-hole to ensure proper depth and seating.

8.1.4 *Seal Casing (Dry Holes)* - For dry holes, first crush bentonite to form a well-graded mixture ranging from powder to about 0.2 cm (1/16 inch) in a sufficient quantity to fill to a depth of about 1 cm (0.5 inch) of the annulus. Pour this mixture into the annulus with a uniform distribution. Then, add sufficient dry crushed or pelletized bentonite to fill the annulus another 1 cm (0.5 inch). Tamp this layer lightly with a wooden dowel or equivalent, smaller than the minimum annulus. Introduce water until it is just visible at the top of the bentonite. Note and record whether or not water has entered the interior of the casing. Add 2.5 cm (1 inch) of dry crushed or pelletized bentonite, tamp as before, and add water as before. Continue in these 2.5 cm (1 inch) increments to the ground surface, or a minimum of 1 meter (3 feet) above the bottom of the casing for deep installations. Sealing above that level shall extend to the ground surface, and may be with the same procedure or by grouting following Standard Practice D5092. Upon completion of sealing, note and record whether water has entered the interior of the casing, and remeasure the depth from top-of-casing to bottom-of-hole to ensure that the casing has not moved.

8.1.5 *Seal Casing (Wet Holes)* - The following procedure shall be used where there is seepage of groundwater into the borehole at or above test level. The casing shall be pushed (not driven) approximately 2 cm (1 inch) into the soil at the bottom of the borehole. Sufficient bentonite pellets to fill approximately 8 cm (3 inches) of the annular space shall be placed and tamped. Additional bentonite layers shall be placed in the same manner until the seal reaches at least 1 meter (3 feet) above the bottom-of-casing level. Hydration water shall be added if the top of the seal rises above the water level in the annulus. Sealing above the 1 meter (3 foot) level may be by the same procedure or by grouting following Standard Practice D5092. After the seal has hydrated a minimum of 12 hours, empty the casing, and use the reamer to advance the borehole to exactly the bottom-of-casing level. If the tested stratum is pervious, empty the casing only to groundwater level to avoid disturbance of the tested stratum from water flow into the casing. Set the sock, then introduce and remove water as necessary to remove suspended solids.

Note 1 - Sealing in wet holes cannot be controlled as well as in dry holes and the results may be somewhat less representative.

8.1.6 *Surface Protection* - For tests in compacted fills, replace the clear or white plastic square around the casing. Use sand, gravel, sandbags, or other weights to keep the plastic in-place during high winds. Place a cap over the casing top to prevent desiccation or rainfall entry during the hydration period.

8.1.7 *Hydration* - Allow the bentonite (and grout, if any) to hydrate a minimum of 12 hours before applying head to the test.

8.1.8 *Temperature Effect Gauge* - This unit is to be set in the same manner as described above, except that the borehole is slightly deeper to accommodate the bottom cap, it is not necessary to ream the hole bottom flat, and crushing bentonite for the bottom 1 cm (0.5 inch) of the seal can be omitted.

8.2 *Assemble Flow Control System and Standpipe* - The cap, flow control system and standpipe should be assembled as illustrated on Figure 2. PTFE tape and silicone grease should be used to waterproof all joints. Check the assembly for leaks by attaching it to a spare TEG casing and filling with water. No leakage can be tolerated.

8.3 *Conduct Stage 1*

8.3.1 *Check Embedment* - Recheck the casing to ensure the correct embedment has been maintained. Also, note and record the presence or absence of water inside the casing; if present, record the depth.

8.3.2 *Insert Sock* - Place the sock to the bottom of the casing, unless done previously. Tying the retrieval wires to a small (half the casing diameter or less) float aids in their recovery.

8.3.3 *Fill Casing* - Fill the casing slowly with water, but no higher than 2 cm (1 inch) below the base of any internal threads. Introduce the water in such a manner that it does not erode the exposed soil at the bottom of the casing. The water should be warmer than the soil in the tested zone, or groundwater if present above bottom-of-casing, to prevent air bubbles from coming out of solution.

8.3.4 *Add Flow Control System and Standpipe* - Screw the top assembly with these items onto the casing, sealing the joint with the O-Ring, PTFE tape, and silicone grease. Prevent casing rotation with a strap wrench while tightening the top assembly. Attach the scale to the standpipe with clear wrapping tape or equivalent means, with the zero down. Measure and record the distance from the bottom of the casing to the zero point on the scale.

8.3.5 *Fill and Check Test System* - Open the valve (Fig. 2) and fill the remainder of the casing, flow control system, and standpipe with water, making sure that no air bubbles are trapped in the cap or flow control system.. The maximum water level should not exceed that which produces the theoretical hydraulic fracturing pressure at the bottom of the casing. All filling should be via the refill hose, not down the standpipe, so as to avoid having water droplets above the water level in the standpipe. Close the filling valve. Check the casing/cap joint and all other joints carefully for water leaks by wiping the joints dry and watching for the formation of water drops at the joints. No leakage can be tolerated.

8.3.6 *Begin Stage 1 of the Test* - Record the date and time (to 1s), plus the scale reading corresponding to the bottom of the meniscus of the water in the standpipe. Take additional such readings at least according to the schedule in Table 2, using whichever method produces the greater number of readings:

Table 2 - Reading Intervals

Elapsed Time (hours)	Total Change in Scale Reading (cm)	(in)
0.5	2	1
1.0	5	2
2.0	10	4

4.0	20	8
8.0	40	16

Thereafter, the frequency of readings will depend on the behavior of the test. In soils of low hydraulic conductivity, daily or twice-daily readings may be adequate after 2 to 3 days. At each reading of the test, record the scale reading and bottom water temperature of the TEG. A typical form for recording test data is given as Figure 3.

8.3.7 *Refills* - One standpipe full of water may not be adequate for a full Stage. When the water level in the standpipe becomes low, refill in the same manner as the initial filling of the standpipe. Record the new water level and its associated time, TEG reading, and TEG temperature and note as "Refill". When the person conducting the test will be away for some length of time, such as overnight, check the drop rate against the expected time to determine whether or not refilling is necessary.

8.3.8 *Criteria for Termination* - Each stage may be terminated when a plot of log (limiting conductivity) vs log (time) fluctuates about a stable value of apparent conductivity. This is achieved when arithmetic time-weighted averages (see Equations 10 and 11) neither fluctuate by more than 20% nor show an upward or downward trend with time. These averages must maintain the above behavior for at least the time spans listed in Table 3.

Table 3 - Minimum Stable Time Spans

Limiting Conductivity K1 or K2 (m/sec)	Stable Time Span (hrs.)
$>10^{-8}$	12
10^{-8} - 10^{-9}	24
10^{-9} - 10^{-10}	48
10^{-10} - 10^{-11}	72

8.4 *Conduct Stage 2*

Note 2 - If the test is solely to verify that the actual vertical hydraulic conductivity k_v is less than some specified value and the limiting vertical conductivity K1 is less than that value, Stage 2 may be omitted.

8.4.1 *Empty the Casing* - Remove the top assembly with its attached equipment. Siphon, vacuum, and/or bail all water from within the casing for tests where the casing was set in a dry hole. Otherwise, siphon/vacuum/bail to the groundwater level of the stratum being tested. Remove the sock.

8.4.2 *Advance the Borehole* - Extend an open borehole having the same diameter as the inside of the casing to a depth below bottom-of-casing not less than 1.0 test diameters nor more than 2.5 test diameters. The soil being tested shall continue for at least the clearances listed in Section 7.7. It is desirable to secure an undisturbed sample of the tested zone with a thinwall sampler (D1587 or D2937), but this is not recommended for soils containing gravel-sized particles. The thinwall sampler or auger/bit shall have a diameter 1 cm (0.5 inch) or more smaller than the casing ID, and sampling or drilling shall be terminated with the deepest point being at least 2 cm (1 inch) above the proposed bottom of the borehole.

8.4.3 *Ream the Borehole* - Ream the borehole to the desired depth and diameter using the reamer to minimize sidewall smear. Roughen the inside walls using the scarifier discussed in 6.1.4. The bottom should be prepared as outlined in Section 8.1.2.

8.4.4 *Replace the Sock* - Place the sock to the bottom of the borehole. Alternatively, but only where an inclusion of high-conductivity material in the tested stratum is of no consequence, the hole may be filled to 8 cm (3 inches) above the casing bottom with pea gravel.

8.4.5 *Reassemble the System* - Refill the casing with water as described in Section 8.3.3, reattach and seal the top assembly with its equipment, and refill the standpipe through the refill hose. Concurrently, empty and refill the TEG with water having the same temperature (within 1°C) as that used in the test.

8.4.6 *Perform Stage 2* - Conduct this portion of test as outlined previously for Stage 1. The termination criteria are the same. See Figure 3 for a typical form for recording the data.

8.5 *Demobilization* - Remove and store the top assembly with its attached systems. For tests in compacted fills, empty the casing, remove sock and casing, then backfill the resulting hole with layers of tamped and wetted bentonite pellets or as directed. Casings for tests in natural deposits can be left as piezometers or plugged and abandoned like monitoring wells, as directed.

9. Calculation

9.1 *Equations* - The data from the tests shall be calculated using the following equations:

9.1.1 *Stage 1*

$$K1 = R_t\, G1\, Ln(H1/H2')/(t_2-t_1) \qquad (1)$$

where

$$G1 = (\pi d^2/11D_1)[1+a(D_1/4b_1)] \qquad (2)$$

R_t = ratio of kinematic viscosity of permeant at temperature of test permeant during time increment t_1 to $_2$t to that of reference fluid and temperature. For most tests, this means water at 20°C (68°F) - See Table 1 of Test Method D5084 for water as the permeant.

d = Inside diameter (ID) of standpipe (cm)

D_1 = effective diameter of Stage 1 (cm), equals inside diameter of casing under dry hole conditions when no inward seepage was noted when setting casing, otherwise equals outside diameter of casing

a = +1 for impermeable base at b_1
= 0 for infinite (+20D_1) depth of tested material.
= -1 for permeable base at b_1

b_1 = thickness of tested layer between bottom of casing and top of underlying stratum (cm).

H1 = effective head at beginning of time increment (cm), equal to distance from top of water in standpipe to top of underlying stratum or groundwater, whichever is shallower. For calculation purposes, H1 shall not exceed the height of the water column above the bottom of the casing plus 20 test diameters

H2' = corrected effective head (cm) at end of time increment, calculated in the same manner as H1, = H2 - c

c = change in TEG scale reading between times t_1 and t_2 (cm). An increase in the height of water in the TEG standpipe is positive

t_1 = time at beginning of increment (s)

t_2 = time at end of increment (s)

9.1.2 *Stage 2*

$$K2 = R_t\, G2\, Ln(H1/H2')/(t_2-t_1) \qquad (3)$$

$$G2 = (d^2/16FL)G3 \qquad (4)$$

$$G3 = 2Ln(G4)+a\, Ln(G5) \qquad (5)$$

$$G4 = L/D + [1+(L/D)^2]^{1/2} \qquad (6)$$

$$G5 = \frac{[4b_2/D+L/D]+[1+(4b_2/D+L/D)^2]^{1/2}}{[4b_2/D-L/D]+[1+(4b_2/D-L/D)^2]^{1/2}} \qquad (7)$$

$$F = 1 - 0.5623\, Exp\,(-1.566\, L/D) \qquad (8)$$

where:

L = length of Stage 2 extension below bottom of casing (cm)

D = inside diameter of Stage 2 extension (cm). It shall be equal to the casing ID.

b_2 = distance from center of Stage 2 extension to top of underlying stratum or groundwater (cm).

The other terms are as previously defined.

9.2 Calculate K1 for each time increment of Stage 1 using Equation (1).

9.3 Calculate cumulative infiltration volume (V1) through the end of each Stage 1 time increment using Equation (9).

$$V = (\pi d^2/4)\ \Sigma\,(H1\text{-}H2') \qquad (9)$$

9.4 Calculate the time-weighted average K1' of the K1 values of Stage 1 for its quasi-steady period only using Equation (10).

$$K1' = \Sigma K1_i(t_2\text{-}t_1)i/\Sigma(t_2\text{-}t_1)i \qquad (10)$$

where:

i denotes a specific time increment

9.5 Calculate K2 for each time increment of Stage 2 using Equation (3).

9.6 Calculate cumulative infiltration volume (V2) through the end of each Stage 2 time increment using Equation (9).

9.7 Calculate the time-weighted average K2' of the K2 values of Stage 2 for its quasi-steady period only using Equation (11).

$$K2' = \Sigma\ K2_i(t_2\text{-}t_1)i/\Sigma(t_2\text{-}t_1)i \qquad (11)$$

10. Report

10.1 Report the following information:

10.1.1 A data sheet such as the one shown in Figure 3 for each Stage (including project identification and test location),

10.1.2 A log-log plot of limiting hydraulic conductivity versus time such as that shown in Figure 4,

10.1.3 The time-weighted average values, K1' and K2',

10.1.4 Thickness of layer tested,

10.1.5 A description of material beneath the layer tested,

10.2 Additional optional information that can be presented in the report includes the following:

10.2.1 Total and dry density of the layer tested,

10.2.2 Initial water content of the layer tested,

10.2.3 Initial degree of saturation,

10.2.4 Water contents of samples taken after termination of test, with locations and depths referenced to the test,

10.2.5 Classification data on the layer tested,

10.2.6 Laboratory tests for hydraulic conductivity on the layer tested.

11. Precision and Bias

11.1 *Precision* - Due to the nature of the soil or rock materials tested by this test method, it is either not feasible or too costly at this time to produce multiple specimens which have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or other testing variations. Subcommittee D18.04 welcomes proposals that would allow for development of a valid precision statement.

11.2 *Bias* - There is no accepted reference value for this test method, therefore, bias cannot be determined.

12. Keywords

12.1 In-place hydraulic conductivity, vertical hydraulic conductivity, horizontal hydraulic conductivity.

References

(1) Bouwer, H. "Rapid Field Measurement of Air Entry Value and Hydraulic Conductivity of Soil as Significant Parameters in Flow System Analysis" Water Resources Research, Vol. 2, No. 4, 1966, pp. 729-738.

(2) Reynolds, D. and Elrick, D.E. "A Method for Simultaneous *In-Situ* Measurement in the Vadose Zone of Field-Saturated Hydraulic Conductivity, Sorptivity and the Conductivity-Pressure Head Relationship" Groundwater Monitoring Review, Vol. 6, No. 4, 1986, pp. 84.

(3) U.S. Department of the Interior, Bureau of Reclamation, Earth Manual, Part 2, Third Edition, 1990.

(4) Bouwer, H. "Intake Rate: Cylinder Infiltrometer". Methods of Soil Analysis, Part 1: Physical and Mineralogical Methods, Agronomy Monograph No. 9, American Society of Agronomy, Madison, WI, 1986, pp. 825-844.

(5) Trautwein, S., and Boutwell, G., "In Situ Hydraulic Conductivity Tests for Compacted Soil Liners and Caps", Hydraulic Conductivity and Waste Contaminant Transport in Soils, ASTM STP 1142, 1994.

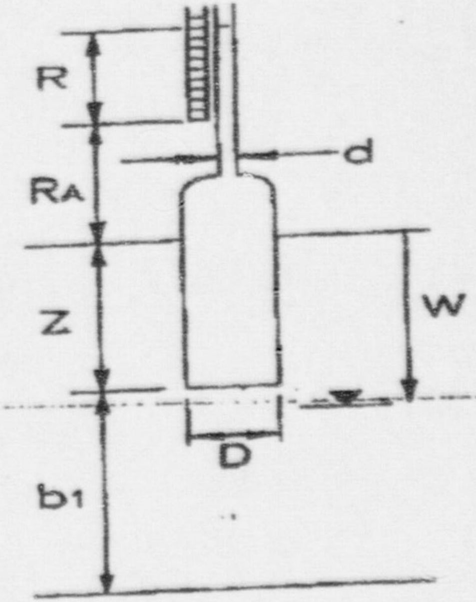
Appendix H

Log Sheets from Boutwell Test

STEI Two Stage Field Perm

Project:	
File No.	
[redacted]	
Techn.	

Date	Time	Reading "R"	Remarks
3-5-98	1430	16.00	
	1500	16.00	
	1600	15.90	
	1800	15.50	
	2200	15.40	
	2400	15.35	
3-6-98	0600	15.20	
	1200	15.00	
	1800	14.30	
	2400	14.05	
3-7-98	0600	13.55	
	1200	13.00	
	1800	12.20	
	2400	11.40	
3-8-98	0600	10.55	
	1200	9.60	
	1800	9.20	
	2400	8.90	
3-9-98	0600	8.53	
	1200	8.30	
	1800	8.00	
	2400	7.70	
3-10-98	0600	– Top half of standpipe froze	
	1800	9.10	– 1800 hrs. Filled to 9.10
	2400	8.95	
	0600	8.80	



d =	13/16"	(inside dia. of stand pipe)
D =	4"	(effective dia. of Stage 1 ID or OD)
Z -	10"	(ground surface to bottom of casing)
RA -	9.5"	(ground surface to "0" mark)
b1 -	>20"	(depth of test soil below btm of casing)
Zw=		(depth to groundwater)

NOTES:
* If groundwater is below the bottom of test pad, use Zvb = Zw
* If system is shallower than [illegible]

STAGE ONE DATA SHEET

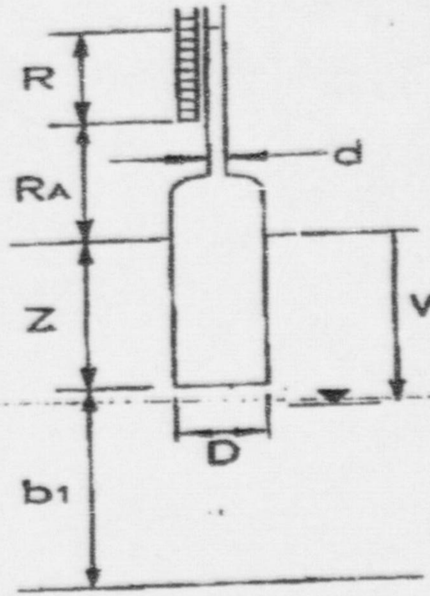
Page___ of___

Test No. #1

STEI Two Stage Field Perm

Project:	
File No.	
[redacted]	
Techn.	

Date	Time	Reading "R"	Remarks
3-11-98	0600	8.80	
	1200	8.70	
	1800	8.60	
	2400	8.45	
3-12-98	0600	8.30	



d =		(inside dia. of stand pipe)
D =		(effective dia. of Stage 1 ID or OD)
Z =		(ground surface to bottom of casing)
RA =		(ground surface to "0" mark)
b1 =		(depth of test until below btm of casing)
Zw =		(depth to groundwater)

NOTES:
* If groundwater is below the bottom of test pool, use Zb as Zw
* If system is thicker than 20D use 20D as Zw

STAGE ONE DATA SHEET

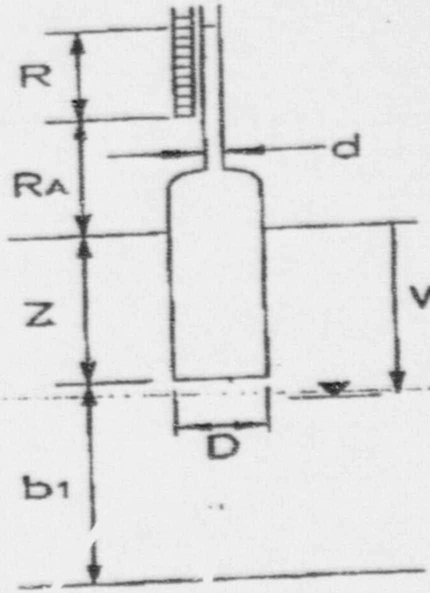
Page____of____

Test No. #1

STEI Two Stage Field Perm

Date	Time	Reading "R"	Remarks
3-5-98	1430	16.00	
	1500	16.00	
	1600	15.80	
	1800	15.20	
	2200	15.00	
	2400	14.90	
3-6-98	0600	14.65	
	1200	14.30	
	1800	13.90	
	2400	13.40	
3-7-98	0600	12.90	
	1200	12.45	
	1800	12.00	
	2400	11.70	
3-8-98	0600	11.35	
	1200	11.00	
	1800	10.50	
	2400	10.20	
3-9-98	0600	9.80	
	1200	9.40	
	1800	9.15	
	2400	8.90	
3-10-98	0600	8.60	
	1200	8.50	
	1800	8.40	
	2400		

Project:	
File No.	
[redacted]	
Techn.	



d =	13/16"	(inside dia. of stand pipe)
D =	4"	(effective dia. of Stage 1 (D = OD))
Z -	10"	(ground surface to bottom of casing)
RA -	8.5"	(ground surface to "0" mark)
b1 -	>20"	(depth of test matl below btm of casing)
Zw=		(depth to groundwater)

NOTES:
* If groundwater is below the bottom of test pad, use Z/b as Zw
* If stratum is thicker than 2SD use 2SD as Zw

STAGE ONE DATA SHEET

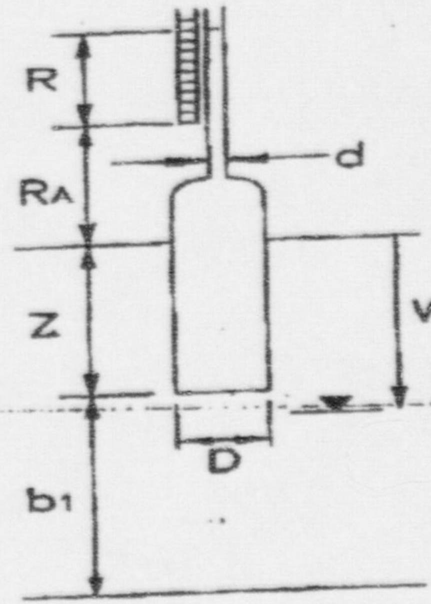
Page____of____

Test No. # 2

STEI Two Stage Field Perm

Project:	
File No.	
[redacted]	
Techn.	

Date	Time	Reading "R"	Remarks
3-10-98	2400	8.30	
3-11-98	0600	8.15	
	1200	8.00	
	1800	7.85	
	2400	7.65	
3-12-98	0600	7.50	



d = ____ (inside dia. of stand pipe)
D = ____ (effective dia. of Stage 1 ID or OD)
Z = ____ (ground surface to bottom of casing)
RA = ____ (ground surface to "0" mark)
b1 = ____ (depth of test unit below btm of casing)
Zw = ____ (depth to groundwater)

NOTES: [illegible]

STAGE ONE DATA SHEET

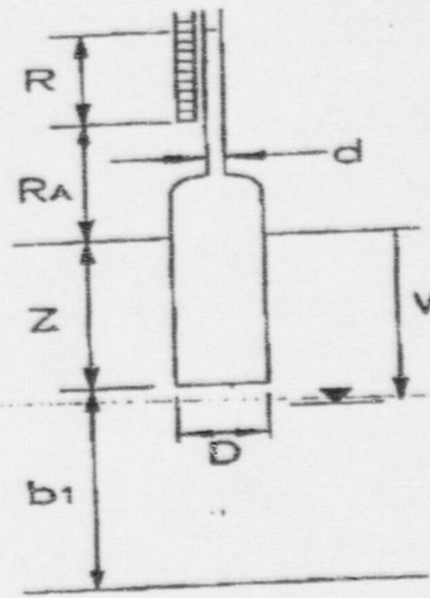
Page____of____

Test No. #2

STEI Two Stage Field Perm

Project:	
File No.	
[redacted]	
Techn.	

Date	Time	Reading "R"	Remarks
3-5-98	1430	16.00	
	1500	14.90	
	1600	14.60	
	1800	14.20	
	2200	13.60	
	2400	13.30	
3-6-98	0600	12.25	
	1200	11.15	
	1800	10.50	
	2400	10.05	
3-7-98	0600	9.65	
	1200	9.30	
	1800	9.00	
	2400	8.75	
3-8-98	0600	8.50	
	1200	8.30	
	1800	8.00	
	2400	7.80	
3-9-98	0600	7.55	
	1200	7.35	
	1800	7.10	
	2400	6.85	
3-10-98	0600	6.65	



d =	13/16"	(inside dia. of stand pipe)
D =	4"	(effective dia. of Stage 1 ID or OD)
Z =	10"	(ground surface to bottom of casing)
RA =	8"	(ground surface to "0" mark)
b1 =	>20"	(depth of test soil below btm of casing)
Zw =		(depth to groundwater)

NOTES:
- If groundwater is below the bottom of test pad, use Z+b1 as Zw
- If stratum is thicker than 2RD use 2RD as Zw

STAGE ONE DATA SHEET

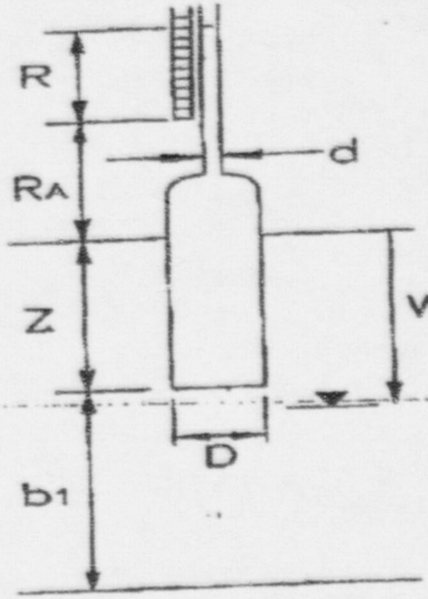
Page___ of___

Test No. #3

STEI Two Stage Field Perm

Project:	
File No.	
[redacted]	
Techn.	

Date	Time	Reading "R"	Remarks
3-5-98	1430	16.00	
	1500	16.00	
	1600	15.80	
	1800	15.60	
	2200	15.50	
	2400	15.45	
3-6-98	0600	15.35	
	1200	15.20	
	1800	14.40	
	2400	14.30	
3-7-98	0600	14.20	
	1200	14.05	
	1800	13.90	
	2400	13.80	
3-8-98	0600	13.65	
	1200	13.50	
	1800	13.40	
	2400	13.30	
3-9-98	0600	13.25	
	1200	13.20	
	1800	13.10	
	2400	12.95	→ cracked standpipe..... will repair.
3-10-98	0600		



d =	13/16"	(inside dia. of stand pipe)
D =	4"	(effective dia. of Stage 1 (ID or OD))
Z =	10"	(ground surface to bottom of casing)
RA =	9"	(ground surface to "0" mark)
b1 =	720"	(depth of tstd soil below btm of casing)
Zw=		(depth to groundwater)

NOTES:
* If groundwater is below the bottom of test pad, use Z+b as Zw
* Kaystone is thicker than 20D use 20D as Zw

STAGE ONE DATA SHEET

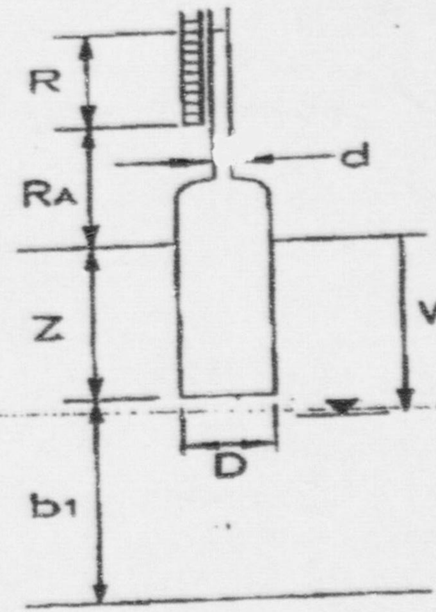
Page____of____

Test No. #4

STEI Two Stage Field Perm

Project:	
File No.	
[redacted]	
Techn.	

Date	Time	Reading "R"	Remarks
3-5-98	1430	16.00	
	1500	15.50	
	1600	14.90	
	1800	14.30	
	2200	13.20	
	2400	12.70	
3-6-98	0600	11.30	
	1200	9.80	
	1800	9.30	
	2400	8.70	
3-7-98	0600	8.10	
	1200	7.60	
	1800	7.20	
	2400	6.90	
3-8-98	0600	6.65	
	1200	6.40	
	1800	6.20	
	2400	6.00	
3-9-98	0600	5.85	
	1200	5.70	
	1800	5.45	
	2400	5.25	
3-10-98	0600	5.00	



d =	13/16"	(inside dia. of stand pipe)
D =	4"	(effective dia. of Stage 1 ID or OD)
Z =	10"	(ground surface to bottom of casing)
R_A =	6"	(ground surface to "0" mark)
b_1 =	>20"	(depth of [illegible] below btm of casing)
Zw =		(depth to groundwater)

NOTES:
- * If groundwater is below the bottom of test pad, use Z+b1 as Zw
- * If system is shallower than 20D use 20D as Zw

STAGE ONE DATA SHEET

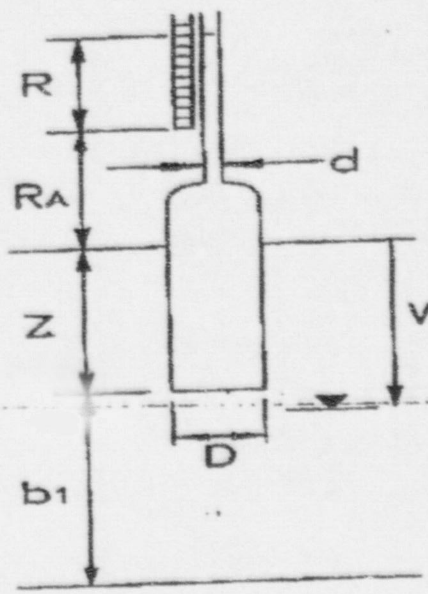
Page____of____

Test No. #5

STEI Two Stage Field Perm

Date	Time	Reading "R"	Remarks
3-5-98	1430	4.8°C	28.00
	1500	4.7°C	28.00
	1600	4.3°C	27.70
	1800	4.1°C	27.55
	2200	3.9°C	27.40
	2400	3.7°C	27.40
3-6-98	0600	4.0°C	27.50
	1200	6.0°C	27.60
			cut standpipe
			in half / level
			at 12.70"
	1800	6.0	12.80"
	2400	4.8°	12.70
3-7-98	0600	3.1°	12.50
	1200	8.5°	12.10
	1800	9.9°	12.20
	2400	7.0°	12.10
3-8-98	0600	6.2°	12.00
	1200	9.9°	12.00
	1800	9.6°	11.90
	2400	9.4°	11.90
3-9-98	0600	8.8°	11.90
	1200	8.9°	11.80
	1800	7.8°	12.00
	2400	5.0°	12.30

Project:	
File No.	
[redacted]	
Techn.	



d =		(inside dia. of stand pipe)
D =		(effective dia. of Stage 1 ID or OD)
Z =		(ground surface to bottom of casing)
RA =		(ground surface to "0" mark)
b1 =		(depth of test cavity below btm of casing)
Zw =		(depth to groundwater)

NOTES:
- * If groundwater is below the bottom of test pad, use Z+b as Zw
- * If Zw is thicker than 20D use 20D as Zw

STAGE ONE DATA SHEET

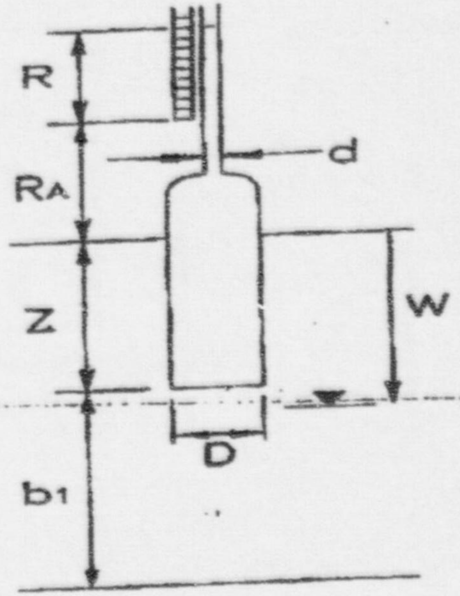
Page____of____

Test No. T.E.G.

STEI Two Stage Field Perm

Date	Time	Reading "R"	Remarks
3-10-98	0600	4.4°	12.5"
	1200	.8°	12.[illegible]
	1800	.5°	12.8"
	2400	.4°	12.9"
3-11-98	0600	.5	12.9
	1200	.9	12.8
	1800	.7	12.6
	2400	.3°	12.4
3-12-98	0600	.4°	12.5

Project:	
File No.	
[redacted]	
Techn.	



d =		(inside dia. of stand pipe)
D =		(effective dia. of Stage 1 (ID or OD))
Z -		(ground surface to bottom of casing)
RA -		(ground surface to "0" mark)
b1 -		(depth of test soil below base of casing)
Zw =		(depth to groundwater)

NOTES:
- If groundwater is below the bottom of test perf, use Z+b as Zw
- If system is shallower than 10D use 10D as b1

STAGE ONE DATA SHEET

Page____of____

Test No. T.E.G.

Appendix I

Soil Testing Engineer, Inc. Report

STE
Soil Testing Engineers, Inc.
316 HIGHLANDIA DRIVE (70810) • P.O. BOX 83710 (70884) • BATON ROUGE, LOUISIANA
PHONE (504) 752-4790 • FAX (504) 752-4878

GORDON P. BOUTWELL, JR., Ph.D.
DANIEL FRANKLIN, JR., MS
RONALD H. JONES, ME
CHARLES S. HEDGES, MS
CHING N. TSAI, MS
DANIEL J. HOLDER, MS
KENNETH A. FLUKER, MS
ZIAD H. ALEM, MS
REGISTERED PROFESSIONAL ENGINEERS

VERNON C. ASHWORTH, MS
MICHAEL J. ALLEN
BOBBY J. BAILEY
CERTIFIED PROFESSIONAL GEOLOGISTS
BRADLEY J. WEAVER, BS Geology
BILLY L. SINGLETON, BS Geology

March 18, 1998

Earth Sciences Consultants
1 Triangle Drive
Export, Pennsylvania

Attn: Nora Yanes

Re: Two-Stage Field Permeability Tests
Bert Avenue Project
Newburgh Heights, Ohio
STE File: 98-1025

Dear Ms. Yanes:

As you requested, Soil Testing Engineers, Inc. (STE) has reduced the data from the two-stage field permeability tests that AWS Remediation conducted at this facility between March 5 and March 17, 1998. The analysis followed the recommendations stated in:

A. "*The STE Two-Stage Borehole Permeability Test*," ASCE/Houston, 12 May 92.

B. Draft "*Standard Test Method for Field Measurement of Hydraulic Conductivity of Porous Material using Two Stages of Infiltration from a Borehole*," ASTM Draft/Committee Level 1998.

C. "*In-Situ Hydraulic Conductivity Tests for Compacted Soil Liners and Caps*," ASTM, 1994.

The vertical permeability (k_v) governs flow and is always less than the horizontal permeability (k_h) in compacted soils. Hence, the vertical permeability (k_v) must be less than the Stage 1 apparent permeability (K1) in such a case. The first stage apparent permeabilities (K1) were all less than 1.0 x 10^{-7} cm/sec (see Table 1 for long term averages and Appendix A for details). Therefore, the (k_v) values from all five tests are known to be below 1.0 x 10^{-7} cm/sec even without performing the second stage. Reference (B) allows terminating the test after the first stage if all (K1) values are below the required value for vertical permeability. Detailed test results are shown in Appendix A. Table 1 shows the time weighted average values for each individual test. Table 2 summarizes the results of the analyses. The following paragraphs describe the rationale for the analyses.

GEOTECHNICAL, ENVIRONMENTAL & MATERIALS CONSULTANTS
LAKE CHARLES, LOUISIANA • (318) 474-1340

The tests had (K2/K1) ratios ranging from 0.48 to 1.35. These values indicate only moderate smear on the sidewalls during second stage testing, within the typical range observed on other compacted soil liners. Therefore, the vertical (k_v) and horizontal (k_h) permeabilities of these tests were computed using the results of both Stage 1 and Stage 2 testing; see Tables 1 and 2. Smear factors ranging from 3 to 15 were used to analyze the tests. The (k_h/k_v) ratios of these tests range from 1.3 to 1.9 with an average value of approximately 1.5. The resulting (k_v) value for test FP-4 was significantly lower than those from the other tests. Therefore, the reported value for FP-4 is that using the "Stage 1 Oonly" method with (k_h/k_v = 1.5) for conservatism.

As a check, all tests were also analyzed using the "Stage 1 Only" method with various (k_h/k_v) values. Details are presented in Table 2. The final results are tabulated below for convenience.

Test	Permeability (cm/sec)	
	Vertical	Horizontal
FP - 1	1.88×10^{-8}	3.53×10^{-8}
FP - 2	2.36×10^{-8}	3.13×10^{-8}
FP - 3	3.27×10^{-8}	4.84×10^{-8}
FP - 4	1.29×10^{-8}	1.94×10^{-8}
FP - 5	3.20×10^{-8}	4.60×10^{-8}
Arith. Mean	2.40×10^{-8}	3.61×10^{-8}
Log Mean	2.27×10^{-8}	3.43×10^{-8}
Std. Dev.	0.170	0.159

EPA's "*Technical Guidance Document - Quality Assurance and Quality Control for Waste Containment Facilities*" (EPA/600/R-93/182) states that the requirement for the two-stage borehole tests is "... all five of the measured vertical hydraulic conductivities would be less than or equal to the required maximum hydraulic conductivity for the soil liner." As seen in the above table, the vertical hydraulic conductivity of the test pad is lower than the required value at all five test locations. Since the vertical hydraulic conductivity is the controlling value, it is our opinion that the results of the test program on this pad meet the requirement of 1.0×10^{-7} cm/sec or less. Additionally, all horizontal hydraulic conductivities are all less than 1.0×10^{-7} cm/sec also.

Should you have any questions regarding this report, please do not hesitate to call our offices. STE appreciates the opportunity to be of service to Earth Sciences Consultants, and look forward to working with you in the future.

Sincerely,
Soil Testing Engineers, Inc.

Ziad H. Alem, LA P.E. # 26365

Gordon P. Boutwell, LA P.E.# 9329

ZHA/GPB/zha

TWO-STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE 1
TWO-STAGE FIELD PERMEABILITY TESTS
DATA REDUCTION

Test No.	Stage 1		Stage 2	
	Period (hours)	K1' (cm/sec)	Period (hours)	K2' (cm/sec)
FP-1	0.0 - 7.5	7.04E-08	0.0 - 1.5	1.92E-07
	7.5 - 21.5	2.53E-08	1.5 - 10.0	8.25E-08
	21.5 - 45.5	7.35E-08	10.0 - 28.0	3.77E-08
	45.5 - 69.5	1.21E-07	28.0 - 40.0	2.86E-08
	69.5 - 87.5	5.00E-08	40.0 - 64.0	2.56E-08 *
	87.5 - 105.5	4.62E-08	64.0 - 82.0	2.20E-08 *
	105.5 - 135.5	2.85E-08 *		
	135.5 147.5	1.89E-08 *		
	147.5 159.5	2.88E-08 *		
	ATWA	2.54E-08	ATWA	2.40E-08
FP-2	0.0 - 3.5	2.05E-07	0.0 - 1.5	1.46E-07
	3.5 - 27.5	4.86E-08	1.5 - 3.5	3.61E-08
	27.5 - 87.5	5.97E-08	3.5 - 28.0	2.55E-08
	87.5 - 111.5	4.69E-08	28.0 - 40.0	2.25E-08 *
	111.5 - 129.5	1.92E-08 *	40.0 64.0	1.83E-08 *
	129.5 147.5	2.96E-08 *	64.0 82.0	2.28E-08 *
	147.5 159.5	3.50E-08 *		
	ATWA	2.70E-08	ATWA	2.08E-08
FP-3	0.0 - 27.5	1.93E-07	0.0 - 1.5	1.97E-07
	27.5 - 39.5	7.50E-08	1.5 - 10.0	3.04E-08
	39.5 - 51.5	5.43E-08	10.0 - 46.0	2.24E-08
	51.5 - 69.5	3.95E-08 *	46.0 58.0	1.94E-08 *
	69.5 87.5	4.10E-08 *	58.0 70.0	1.80E-08 *
	87.5 111.5	3.82E-08 *	70.0 82.0	1.39E-08 *
	ATWA	3.94E-08	ATWA	1.90E-08
FP-4	0.0 - 1.5	1.18E-07	0.0 - 1.5	3.81E-07
	1.5 - 3.5	8.96E-08	1.5 - 10.0	3.21E-08
	3.5 - 21.5	2.00E-08	10.0 - 52.0	2.62E-08 *
	21.5 - 39.5	4.83E-08	52.0 - 64.0	2.22E-08 *
	39.5 - 69.5	1.94E-08 *	64.0 - 82.0	2.01E-08 *
	69.5 105.5	1.26E-08 *		
	ATWA	1.56E-08	ATWA	2.10E-08
FP-5	0.0 - 1.5	6.89E-07	0.0 - 1.5	2.15E-07
	1.5 - 39.5	1.83E-07	1.5 - 7.5	6.10E-08
	39.5 - 45.5	8.86E-08	7.5 - 10.0	5.19E-08
	45.5 - 57.5	5.73E-08	10.0 - 34.0	3.53E-08
	57.5 - 93.5	3.39E-08 *	34.0 58.0	3.29E-08 *
	93.5 111.5	4.30E-08 *	58.0 70.0	2.71E-08 *
			70.0 82.0	2.42E-08 *
	ATWA	3.69E-08	ATWA	2.93E-08

ATWA: Arithmetic Time-weighted Average
*: Data Used in Calculating ATWA

TWO-STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE 2
TWO-STAGE FIELD PERMEABILITY TESTS
DATA REDUCTION

Test No.		FP-1	FP-2	FP-3	FP-4	FP-5	Mean
K1' (cm/sec)		2.54E-08	2.70E-08	3.94E-08	1.56E-08	3.69E-08	2.74E-08
K2' (cm/sec)		2.40E-08	2.08E-08	1.90E-08	2.10E-08	2.93E-08	2.26E-08
K2'/K1'		0.94	0.77	0.48	1.35	0.79	0.87
IMAGE EQUATIONS							
p = 3	k_v	1.88E-08 *	NC	NC	5.66E-08	NC	NA
	k_h	3.53E-08 *	NC	NC	4.60E-08	NC	NA
p = 5	k_v	1.44E-08	2.36E-08 *	NC	NC	1.20E-08	NA
	k_h	4.69E-08	3.13E-08 *	NC	NC	4.30E-08	NA
p = 8	k_v	1.11E-08	1.67E-08	NC	NC	3.20E-08 *	NA
	k_h	6.15E-08	4.54E-08	NC	NC	4.60E-08 *	NA
p = 10	k_v	9.78E-08	1.43E-08	NC	NC	2.60E-08	NA
	k_h	7.04E-08	5.36E-08	NC	NC	5.70E-08	NA
p = 15	k_v	NC	NC	3.27E-08 *	NC	1.50E-08	NA
	k_h	NC	NC	4.84E-08 *	NC	1.00E-07	NA
STAGE 1 ONLY							
$k_h/k_v = 1.5$	k_v	2.09E-08	2.23E-08	3.25E-08	1.29E-08 *	3.04E-08	2.26E-08
$k_h/k_v = 2$	k_v	1.82E-08	1.94E-08	2.83E-08	1.12E-08	2.65E-08	1.97E-08
$k_h/k_v = 5$	k_v	1.17E-08	1.24E-08	1.81E-08	7.18E-09	1.70E-08	1.26E-08

k_h,k_v in cm/sec
* Recommended values
NC: No Calculations
NA: Not Applicable

98-1025

APPENDIX A
Direct Readings

d=	2.06 cm
D=	10.16 cm
Z=	25.40 cm
Ra=	24.13 cm
ZW=	76.20 cm
L=	0.00 cm
B=	76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-1
DIRECT READINGS
TEST FP-1
STAGE 1

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K1 (cm/sec)	TC (cm)	H2c (cm)	K1c (cm/sec)	Temp	Temp Factor	K1tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/5	14:30	40.64	-	-	140.97	-	0.00	140.97	-	41	-	-	0.00	0.0	Start
	22:00	39.12	27000	140.97	139.45	4.56E-08	0.00	139.45	4.56E-08	39	1.54	7.04E-08	7.50	5.1	
3/6	6:00	38.61	28800	139.45	138.94	1.44E-08	0.00	138.94	1.44E-08	39	1.56	2.25E-08	15.50	6.8	
	12:00	38.10	21600	138.94	138.43	1.92E-08	0.00	138.43	1.92E-08	43	1.51	2.91E-08	21.50	8.5	
	18:00	36.83	21600	138.43	137.16	4.84E-08	0.00	137.16	4.84E-08	43	1.47	7.09E-08	27.50	12.7	
3/7	0:00	35.69	21600	137.16	136.02	4.39E-08	0.00	136.02	4.39E-08	41	1.49	6.56E-08	33.50	16.5	
	6:00	34.42	21600	136.02	134.75	4.92E-08	0.00	134.75	4.92E-08	38	1.56	7.69E-08	39.50	20.7	
	12:00	33.02	21600	134.75	133.35	5.47E-08	0.00	133.35	5.47E-08	47	1.48	8.07E-08	45.50	25.4	
	18:00	30.99	21600	133.35	131.32	8.06E-08	0.00	131.32	8.06E-08	50	1.33	1.07E-07	51.50	32.2	
3/8	0:00	28.96	21600	131.32	129.29	8.18E-08	0.00	129.29	8.18E-08	45	1.36	1.11E-07	57.50	38.9	
	6:00	26.80	21600	129.29	127.13	8.84E-08	0.00	127.13	8.84E-08	43	1.44	1.27E-07	63.50	46.1	
	12:00	24.38	21600	127.13	124.71	1.01E-07	0.00	124.71	1.01E-07	50	1.38	1.39E-07	69.50	54.2	
	18:00	23.37	21600	124.71	123.70	4.29E-08	0.00	123.70	4.29E-08	49	1.31	5.63E-08	75.50	57.6	
3/9	0:00	22.61	21600	123.70	122.94	3.24E-08	0.00	122.94	3.24E-08	49	1.32	4.28E-08	81.50	60.1	
	6:00	21.72	21600	122.94	122.05	3.81E-08	0.00	122.05	3.81E-08	48	1.34	5.09E-08	87.50	63.1	
	12:00	21.08	21600	122.05	121.41	2.74E-08	0.00	121.41	2.74E-08	48	1.35	3.69E-08	93.50	65.2	
	18:00	20.32	21600	121.41	120.65	3.30E-08	0.00	120.65	3.30E-08	40	1.44	4.75E-08	99.50	67.7	
3/10	0:00	19.56	21600	120.65	119.89	3.32E-08	0.00	119.89	3.32E-08	33	1.63	5.43E-08	105.50	70.3	
	18:00	23.11	64800	-	123.44	-	0.00	123.44	-	33	-	-	123.50	70.3	Restart
3/11	0:00	22.73	21600	123.44	123.06	1.62E-08	0.00	123.06	1.62E-08	33	1.75	2.84E-08	129.50	71.5	
	6:00	22.35	21600	123.06	122.68	1.63E-08	0.00	122.68	1.63E-08	33	1.75	2.85E-08	135.50	72.8	
	12:00	22.10	21600	122.68	122.43	1.09E-08	0.00	122.43	1.09E-08	33	1.74	1.89E-08	141.50	73.7	
	18:00	21.84	21600	122.43	122.17	1.09E-08	0.00	122.17	1.09E-08	33	1.74	1.89E-08	147.50	74.5	
3/12	0:00	21.46	21600	122.17	121.79	1.64E-08	0.00	121.79	1.64E-08	33	1.75	2.87E-08	153.50	75.8	
	6:00	21.08	21600	121.79	121.41	1.64E-08	0.00	121.41	1.64E-08	33	1.76	2.89E-08	159.50	77.0	

d=	2.06 cm
D=	10.16 cm
Z=	25.40 cm
Ra=	24.13 cm
ZW=	76.20 cm
L=	12.70 cm
B=	76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-1
DIRECT READINGS
TEST FP-1
STAGE 2

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	[illegible] (cm/sec)	TC (cm)	H2c (cm)	K2c (cm/sec)	Temp	Temp Factor	K2tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/13	14:00	40.64	-	-	140.97	-	0.00	140.97	-	51	-	-	0.00	0.0	Start
	14:30	38.86	1800	140.97	139.19	3.13E-07	0.00	139.19	3.13E-07	51	1.29	4.03E-07	0.50	5.9	
	15:30	38.10	3600	139.19	138.43	[illegible]	0.00	138.43	6.78E-08	52	1.27	8.62E-08	1.50	8.5	
	17:30	37.34	7200	138.43	137.67	[illegible]	0.00	137.67	3.41E-08	53	1.25	4.27E-08	3.50	11.0	
	21:30	35.94	14400	137.67	136.27	3.15E-08	0.00	136.27	3.15E-08	49	1.29	4.07E-08	7.50	15.7	
3/14	0:00	32.26	9000	136.27	132.59	1.35E-07	0.00	132.59	1.35E-07	48	1.34	1.81E-07	10.00	28.0	
	6:00	30.35	21600	132.59	130.68	2.98E-08	0.00	130.68	2.98E-08	48	1.34	4.00E-08	16.00	34.4	
	12:00	28.58	21600	130.68	128.91	2.82E-08	0.00	128.91	2.82E-08	48	1.34	3.79E-08	22.00	40.4	
	18:00	26.92	21600	128.91	127.25	2.65E-08	0.00	127.25	2.65E-08	50	1.33	3.52E-08	28.00	45.9	
3/15	0:00	25.53	21600	127.25	125.86	2.27E-08	0.00	125.86	2.27E-08	50	1.31	2.97E-08	34.00	50.6	
	6:00	24.26	21600	125.86	124.59	2.09E-08	0.00	124.59	2.09E-08	48	1.32	2.76E-08	40.00	54.8	
	12:00	23.11	21600	124.59	123.44	1.90E-08	0.00	123.44	1.90E-08	50	1.33	2.51E-08	46.00	58.6	
	18:00	21.97	21600	123.44	122.30	1.91E-08	0.00	122.30	1.91E-08	46	1.34	2.57E-08	52.00	62.4	
3/16	0:00	20.96	21600	122.30	121.29	1.72E-08	0.00	121.29	1.72E-08	44	1.41	2.41E-08	58.00	65.8	
	6:00	19.81	21600	121.29	120.14	1.95E-08	0.00	120.14	1.95E-08	47	1.40	2.72E-08	64.00	69.7	
	12:00	18.80	21600	120.14	119.13	1.75E-08	0.00	119.13	1.75E-08	57	1.26	2.21E-08	70.00	73.1	
	18:00	17.78	21600	119.13	118.11	1.76E-08	0.00	118.11	1.76E-08	53	1.20	2.12E-08	76.00	76.5	
3/17	0:00	16.76	21600	118.11	117.09	1.78E-08	0.00	117.09	1.78E-08	50	1.27	2.26E-08	82.00	79.9	

d= 2.06 cm
D= 10.16 cm
Z= 25.40 cm
Ra= 21.59 cm
ZW= 76.20 cm
L= 0.00 cm
B= 76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-2
DIRECT READINGS
TEST FP-2
STAGE 1

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K1 (cm/sec)	TC (cm)	H2c (cm)	K1c (cm/sec)	Temp	Temp Factor	K1tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/5	14:30	40.64	-	-	138.43	-	0.00	138.43	-	41	-	-	0.00	0.0	Start
	18:00	38.61	12600	138.43	136.40	1.33E-07	0.00	136.40	1.33E-07	39	1.54	2.05E-07	3.50	6.8	
	22:00	38.10	14400	136.40	135.89	2.95E-08	0.00	135.89	2.95E-08	39	1.56	4.60E-08	7.50	8.5	
3/6	0:00	37.85	7200	135.89	135.64	2.96E-08	0.00	135.64	2.96E-08	39	1.57	4.64E-08	9.50	9.3	
	6:00	37.21	21600	135.64	135.00	2.47E-08	0.00	135.00	2.47E-08	43	1.52	3.76E-08	15.50	11.5	
	12:00	36.32	21600	135.00	134.11	3.48E-08	0.00	134.11	3.48E-08	43	1.47	5.10E-08	21.50	14.4	
	18:00	35.31	21600	134.11	133.10	4.00E-08	0.00	133.10	4.00E-08	41	1.49	5.98E-08	27.50	17.8	
3/7	0:00	34.04	21600	133.10	131.83	5.05E-08	0.00	131.83	5.05E-08	38	1.56	7.89E-08	33.50	22.1	
	6:00	32.77	21600	131.83	130.56	5.10E-08	0.00	130.56	5.10E-08	47	1.48	7.52E-08	39.50	26.3	
	12:00	31.62	21600	130.56	129.41	4.63E-08	0.00	129.41	4.63E-08	50	1.33	6.17E-08	45.50	30.2	
	18:00	30.48	21600	129.41	128.27	4.67E-08	0.00	128.27	4.67E-08	45	1.36	6.36E-08	51.50	34.0	
3/8	0:00	29.72	21600	128.27	127.51	3.14E-08	0.00	127.51	3.14E-08	43	1.44	4.52E-08	57.50	36.5	
	6:00	28.83	21600	127.51	126.62	3.68E-08	0.00	126.62	3.68E-08	50	1.38	5.08E-08	63.50	39.5	
	12:00	27.94	21600	126.62	125.73	3.71E-08	0.00	125.73	3.71E-08	49	1.31	4.87E-08	69.50	42.5	
	18:00	26.67	21600	125.73	124.46	5.35E-08	0.00	124.46	5.35E-08	49	1.32	7.06E-08	75.50	46.7	
3/9	0:00	25.91	21600	124.46	123.70	3.23E-08	0.00	123.70	3.23E-08	48	1.34	4.32E-08	81.50	49.3	
	6:00	24.89	21600	123.70	122.68	4.34E-08	0.00	122.68	4.34E-08	48	1.35	5.86E-08	87.50	52.7	
	12:00	23.88	21600	122.68	121.67	4.38E-08	0.00	121.67	4.38E-08	48	1.35	5.90E-08	93.50	56.1	
	18:00	23.24	21600	121.67	121.03	2.76E-08	0.00	121.03	2.76E-08	46	1.37	3.77E-08	99.50	58.2	
3/10	0:00	22.61	21600	121.03	120.40	2.77E-08	0.00	120.40	2.77E-08	41	1.45	4.01E-08	105.50	60.3	
	6:00	21.84	21600	120.40	119.63	3.34E-08	0.00	119.63	3.34E-08	40	1.53	5.10E-08	111.50	62.9	
	12:00	21.59	21600	119.63	119.38	1.12E-08	0.00	119.38	1.12E-08	33	1.63	1.83E-08	117.50	63.7	
	18:00	21.34	21600	119.38	119.13	1.12E-08	0.00	119.13	1.12E-08	33	1.74	1.95E-08	123.50	64.6	
3/11	0:00	21.08	21600	119.13	118.87	1.12E-08	0.00	118.87	1.12E-08	33	1.75	1.97E-08	129.50	65.4	
	6:00	20.70	21600	118.87	118.49	1.69E-08	0.00	118.49	1.69E-08	33	1.75	2.96E-08	135.50	66.7	
	12:00	20.32	21600	118.49	118.11	1.70E-08	0.00	118.11	1.70E-08	33	1.74	2.95E-08	141.50	68.0	
	18:00	19.94	21600	118.11	117.73	1.70E-08	0.00	117.73	1.70E-08	33	1.74	2.95E-08	147.50	69.2	
3/12	0:00	19.43	21600	117.73	117.22	2.28E-08	0.00	117.22	2.28E-08	33	1.75	3.99E-08	153.50	70.9	
	6:00	19.05	21600	117.22	116.84	1.71E-08	0.00	116.84	1.71E-08	33	1.76	3.02E-08	159.50	72.2	

d= 2.06 cm
D= 10.16 cm
Z= 25.40 cm
Ra= 21.59 cm
ZW= 76.20 cm
L= 12.70 cm
B= 76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-2
DIRECT READINGS
TEST FP-2
STAGE 2

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K2 (cm/sec)	TC (cm)	H2c (cm)	K2c (cm/sec)	Temp	Temp Factor	K2tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/13	14:00	40.64	-	-	138.43	-	0.00	138.43	-	51	-	-	0.00	0.0	Start
	14:30	39.37	1800	138.43	137.16	2.28E-07	0.00	137.16	2.28E-07	51	1.29	2.93E-07	0.50	4.2	
	15:30	38.74	3600	137.16	136.53	5.73E-08	0.00	136.53	5.73E-08	52	1.27	7.29E-08	1.50	6.4	
	17:30	38.10	7200	136.53	135.89	2.88E-08	0.00	135.89	2.88E-08	53	1.25	3.61E-08	3.50	8.5	
	21:30	37.21	14400	135.89	135.00	2.03E-08	0.00	135.00	2.03E-08	49	1.29	2.62E-08	7.50	11.5	
3/14	0:00	36.70	9000	135.00	134.49	1.86E-08	0.00	134.49	1.86E-08	48	1.34	2.49E-08	10.00	13.2	
	6:00	35.69	21600	134.49	133.48	1.56E-08	0.00	133.48	1.56E-08	48	1.34	2.10E-08	16.00	16.6	
	12:00	34.29	21600	133.48	132.08	2.17E-08	0.00	132.08	2.17E-08	48	1.34	2.91E-08	22.00	21.2	
	18:00	33.02	21600	132.08	130.81	1.99E-08	0.00	130.81	1.99E-08	50	1.33	2.64E-08	28.00	25.5	
3/15	0:00	31.88	21600	130.81	129.67	1.81E-08	0.00	129.67	1.81E-08	50	1.31	2.36E-08	34.00	29.3	
	6:00	30.86	21600	129.67	128.65	1.62E-08	0.00	128.65	1.62E-08	48	1.32	2.14E-08	40.00	32.7	
	12:00	29.97	21600	128.65	127.76	1.43E-08	0.00	127.76	1.43E-08	50	1.33	1.89E-08	46.00	35.7	
	18:00	29.21	21600	127.76	127.00	1.23E-08	0.00	127.00	1.23E-08	46	1.34	1.66E-08	52.00	38.2	
3/16	0:00	28.45	21600	127.00	126.24	1.24E-08	0.00	126.24	1.24E-08	44	1.41	1.74E-08	58.00	40.8	
	6:00	27.56	21600	126.24	125.35	1.45E-08	0.00	125.35	1.45E-08	47	1.40	2.03E-08	64.00	43.8	
	12:00	26.42	21600	125.35	124.21	1.89E-08	0.00	124.21	1.89E-08	57	1.26	2.38E-08	70.00	47.6	
	18:00	25.40	21600	124.21	123.19	1.69E-08	0.00	123.19	1.69E-08	53	1.20	2.04E-08	76.00	51.0	
3/17	0:00	24.26	21600	123.19	122.05	1.92E-08	0.00	122.05	1.92E-08	50	1.27	2.44E-08	82.00	54.8	

d= 2.06 cm
D= 10.16 cm
Z= 25.40 cm
Ra= 20.32 cm
ZW= 32.54 cm
L= 0.00 cm
B= 32.54 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-3
DIRECT READINGS
TEST FP-3
STAGE 1

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K1 (cm/sec)	TC (cm)	H2c (cm)	K1c (cm/sec)	Temp	Temp Factor	K1tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/5	14:30	40.64	-	-	93.50	-	0.00	93.50	-	41	-	-	0.00	0.0	Start
	15:00	37.85	1800	93.50	90.71	1.30E-06	0.00	90.71	1.30E-06	40	1.52	1.98E-06	0.50	9.3	
	16:00	37.08	3600	90.71	89.94	1.81E-07	0.00	89.94	1.81E-07	40	1.54	2.78E-07	1.50	11.9	
	18:00	36.07	7200	89.94	88.93	1.22E-07	0.00	88.93	1.22E-07	39	1.55	1.89E-07	3.50	15.3	
	22:00	34.54	14400	88.93	87.40	9.26E-08	0.00	87.40	9.26E-08	39	1.56	1.45E-07	7.50	20.4	
3/6	0:00	33.78	7200	87.40	86.64	9.38E-08	0.00	86.64	9.38E-08	39	1.57	1.47E-07	9.50	22.9	
	6:00	31.12	21600	86.64	83.98	1.12E-07	0.00	83.98	1.12E-07	39	1.57	1.75E-07	15.50	31.9	
	12:00	28.32	21600	83.98	81.18	1.21E-07	0.00	81.18	1.21E-07	43	1.51	1.83E-07	21.50	41.2	
	18:00	26.67	21600	81.18	79.53	7.34E-08	0.00	79.53	7.34E-08	43	1.47	1.08E-07	27.50	46.7	
3/7	0:00	25.53	21600	79.53	78.39	5.17E-08	0.00	78.39	5.17E-08	41	1.49	7.72E-08	33.50	50.6	
	6:00	24.51	21600	78.39	77.37	4.66E-08	0.00	77.37	4.66E-08	38	1.56	7.28E-08	39.50	54.0	
	12:00	23.62	21600	77.37	76.48	4.13E-08	0.00	76.48	4.13E-08	47	1.48	6.09E-08	45.50	56.9	
	18:00	22.86	21600	76.48	75.72	3.58E-08	0.00	75.72	3.58E-08	50	1.33	4.77E-08	51.50	59.5	
3/8	0:00	22.23	21600	75.72	75.09	3.01E-08	0.00	75.09	3.01E-08	45	1.36	4.10E-08	57.50	61.6	
	6:00	21.59	21600	75.09	74.45	3.03E-08	0.00	74.45	3.03E-08	43	1.44	4.37E-08	63.50	63.7	
	12:00	21.08	21600	74.45	73.94	2.44E-08	0.00	73.94	2.44E-08	50	1.38	3.37E-08	69.50	65.4	
	18:00	20.32	21600	73.94	73.18	3.70E-08	0.00	73.18	3.70E-08	49	1.31	4.85E-08	75.50	68.0	
3/9	0:00	19.81	21600	73.18	72.67	2.49E-08	0.00	72.67	2.49E-08	49	1.32	3.29E-08	81.50	69.7	
	6:00	19.18	21600	72.67	72.04	3.13E-08	0.00	72.04	3.13E-08	48	1.33	4.15E-08	87.50	71.8	
	12:00	18.67	21600	72.04	71.53	2.53E-08	0.00	71.53	2.53E-08	48	1.33	3.35E-08	93.50	73.5	
	18:00	18.03	21600	71.53	70.89	3.18E-08	0.00	70.89	3.18E-08	46	1.33	4.22E-08	99.50	75.6	
3/10	0:00	17.40	21600	70.89	70.26	3.21E-08	0.00	70.26	3.21E-08	41	1.33	4.26E-08	105.50	77.7	
	6:00	16.89	21600	70.26	69.75	2.59E-08	0.00	69.75	2.59E-08	40	1.33	3.43E-08	111.50	79.4	

d=	2.06 cm
D=	10.16 cm
Z=	25.40 cm
Ra=	20.32 cm
ZW=	76.20 cm
L=	12.70 cm
B=	76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-3
DIRECT READINGS
TEST FP-3
STAGE 2

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K2 (cm/sec)	TC (cm)	H2c (cm)	K2c (cm/sec)	Temp	Temp Factor	K2tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/13	14:00	40.64	-	-	137.16	-	0.00	137.16	-	51	-	-	0.00	0.0	Start
	14:30	39.12	1800	137.16	135.64	2.76E-07	0.00	135.64	2.76E-07	51	1.29	3.55E-07	0.50	5.1	
	15:30	38.10	3600	135.64	134.62	9.28E-08	0.00	134.62	9.28E-08	52	1.27	1.18E-07	1.50	8.5	
	17:30	37.59	7200	134.62	134.11	2.33E-08	0.00	134.11	2.33E-08	53	1.25	2.93E-08	3.50	10.2	
	21:30	36.45	14400	134.11	132.97	2.64E-08	0.00	132.97	2.64E-08	49	1.29	3.41E-08	7 50	14.0	
3/14	0:00	35.94	9000	132.97	132.46	1.89E-08	0.00	132.46	1.89E-08	48	1.34	2.53E-08	10.00	15.7	
	18:00	38.61	64800	132.46	135.13	-	0.00	135.13	-	50	-	-	28.00	15.7	restart
3/15	0:00	37.47	21600	135.13	133.99	1.75E-08	0.00	133.99	1.75E-08	50	1.31	2.28E-08	34.00	19.5	
	6:00	36.32	21600	133.99	132.84	1.76E-08	0.00	132.84	1.76E-08	48	1.32	2.33E-08	40.00	23.4	
	12:00	35.31	21600	132.84	131.83	1.58E-08	0.00	131.83	1.58E-08	50	1.33	2.09E-08	46.00	26.8	
	18:00	34.42	21600	131.83	130.94	1.39E-08	0.00	130.94	1.39E-08	46	1.34	1.87E-08	52.00	29.7	
3/16	0:00	33.66	21600	130.94	130.18	1.20E-08	0.00	130.18	1.20E-08	44	1.41	1.69E-08	58.00	32.3	
	6:00	32.64	21600	130.18	129.16	1.61E-08	0.00	129.16	1.61E-08	47	1.40	2.25E-08	64.00	35.7	
	12:00	31.75	21600	129.16	128.27	1.42E-08	0.00	128.27	1.42E-08	57	1.26	1.80E-08	70.00	38.7	
	18:00	30.99	21600	128.27	127.51	1.23E-08	0.00	127.51	1.23E-08	53	1.20	1.48E-08	76.00	41.2	
3/17	0:00	30.35	21600	127.51	126.87	1.03E-08	0.00	126.87	1.03E-08	50	1.27	1.30E-08	82.00	43.3	

d=	2.06 cm
D=	10.16 cm
Z=	25.40 cm
Ra=	22.86 cm
ZW=	76.20 cm
L=	0.00 cm
B=	76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWTON, ILLINOIS

TABLE A-4
DIRECT READINGS
TEST FP-4
STAGE 1

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K1 (cm/sec)	TC (cm)	H2c (cm)	K1c (cm/sec)	Temp	Temp Factor	K1tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/5	14:30	40.64	-	-	139.70	-	0.00	139.70	-	41	-	-	0.00	0.0	Start
	16:00	40.13	5400	139.70	139.19	7.67E-08	0.00	139.19	7.67E-08	40	1.53	1.18E-07	1.50	1.7	
	18:00	39.62	7200	139.19	138.68	5.78E-08	0.00	138.68	5.78E-08	39	1.55	8.96E-08	3.50	3.4	
	22:00	39.37	14400	138.68	138.43	1.45E-08	0.00	138.43	1.45E-08	39	1.56	2.26E-08	7.50	4.2	
3/6	0:00	39.24	7200	138.43	138.30	1.45E-08	0.00	138.30	1.45E-08	39	1.57	2.28E-08	9.50	4.7	
	6:00	38.99	21600	138.30	138.05	9.68E-09	0.00	138.05	9.68E-09	39	1.57	1.52E-08	15.50	5.5	
	12:00	38.61	21600	138.05	137.67	1.46E-08	0.00	137.67	1.46E-08	43	1.51	2.20E-08	21.50	6.8	
	18:00	36.58	21600	137.67	135.64	7.83E-08	0.00	135.64	7.83E-08	43	1.46	1.15E-07	27.50	13.6	
3/7	6:00	36.07	43200	135.64	135.13	9.88E-09	0.00	135.13	9.88E-09	38	1.53	1.51E-08	39.50	15.3	
	12:00	35.69	21600	135.13	134.75	1.49E-08	0.00	134.75	1.49E-08	47	1.48	2.19E-08	45.50	16.6	
	18:00	35.31	21600	134.75	134.37	1.49E-08	0.00	134.37	1.49E-08	50	1.33	1.99E-08	51.50	17.8	
3/8	6:00	34.67	43200	134.37	133.73	1.25E-08	0.00	133.73	1.25E-08	43	1.38	1.72E-08	63.50	20.0	
	12:00	34.29	21600	133.73	133.35	1.50E-08	0.00	133.35	1.50E-08	50	1.38	2.07E-08	69.50	21.2	
3/9	0:00	33.91	43200	133.35	132.97	7.53E-09	0.00	132.97	7.53E-09	49	1.32	9.91E-09	81.50	22.5	
	6:00	33.66	21600	132.97	132.72	1.01E-08	0.00	132.72	1.01E-08	48	1.34	1.35E-08	87.50	23.4	
	12:00	33.53	21600	132.72	132.59	5.04E-09	0.00	132.59	5.04E-09	48	1.35	6.79E-09	93.50	23.8	
	18:00	33.27	21600	132.59	132.33	1.01E-08	0.00	132.33	1.01E-08	46	1.37	1.38E-08	99.50	24.6	
3/10	0:00	32.89	21600	132.33	131.95	1.52E-08	0.00	131.95	1.52E-08	41	1.45	2.20E-08	105.50	25.9	

d= 2.06 cm
D= 10.16 cm
Z= 25.40 cm
Ra= 22.86 cm
ZW= 76.20 cm
L= 12.70 cm
B= 76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-4
DIRECT READINGS
TEST FP-4
STAGE 2

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K2 (cm/sec)	TC (cm)	H2c (cm)	K2c (cm/sec)	Temp	Temp Factor	K2tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/13	14:00	40.64	-	-	139.70	-	0.00	139.70	-	51	-	-	0.00	0.0	Start
	14:30	36.58	1800	139.70	135.64	7.29E-07	0.00	135.64	7.29E-07	51	1.29	9.38E-07	0.50	13.6	
	15:30	35.69	3600	135.64	134.75	8.12E-08	0.00	134.75	8.12E-08	52	1.27	1.03E-07	1.50	16.6	
	17:30	34.93	7200	134.75	133.99	3.50E-08	0.00	133.99	3.50E-08	53	1.25	4.39E-08	3.50	19.1	
	21:30	33.91	14400	133.99	132.97	2.35E-08	0.00	132.97	2.35E-08	49	1.29	3.03E-08	7.50	22.5	
3/14	0:00	33.40	9000	132.97	132.46	1.89E-08	0.00	132.46	1.89E-08	48	1.34	2.53E-08	10.00	24.2	
	18:00	39.12	64800	132.46	138.18	-	0.00	138.18	-	50	-	-	28.00	24.2	
3/15	0:00	37.72	21600	138.18	136.78	2.09E-08	0.00	136.78	2.09E-08	50	1.31	2.73E-08	34.00	28.9	
	6:00	36.32	21600	136.78	135.38	2.11E-08	0.00	135.38	2.11E-08	48	1.32	2.80E-08	40.00	33.6	
	12:00	35.18	21600	135.38	134.24	1.74E-08	0.00	134.24	1.74E-08	50	1.33	2.31E-08	46.00	37.4	
	18:00	33.91	21600	134.24	132.97	1.96E-08	0.00	132.97	1.96E-08	46	1.34	2.63E-08	52.00	41.6	
3/16	0:00	32.89	21600	132.97	131.95	1.58E-08	0.00	131.95	1.58E-08	44	1.41	2.22E-08	58.00	45.0	
	6:00	31.88	21600	131.95	130.94	1.59E-08	0.00	130.94	1.59E-08	47	1.40	2.22E-08	64.00	48.4	
	12:00	30.86	21600	130.94	129.92	1.60E-08	0.00	129.92	1.60E-08	57	1.26	2.03E-08	70.00	51.8	
	18:00	29.85	21600	129.92	128.91	1.62E-08	0.00	128.91	1.62E-08	53	1.20	1.95E-08	76.00	55.2	
3/17	0:00	28.83	21600	128.91	127.89	1.63E-08	0.00	127.89	1.63E-08	50	1.27	2.07E-08	82.00	58.6	

d=	2.06 cm
D=	10.16 cm
Z=	25.40 cm
Ra=	15.24 cm
ZW=	76.20 cm
L=	0.00 cm
B=	76.20 cm

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

TABLE A-5
DIRECT READINGS
TEST FP-5
STAGE 1

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K1 (cm/sec)	TC (cm)	H2c (cm)	K1c (cm/sec)	Temp	Temp Factor	K1tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/5	14:30	40.64	-	-	132.08	-	0.00	132.08	-	41	-	-	0.00	0.0	Start
	15:00	39.37	1800	132.08	130.81	6.11E-07	0.00	130.81	6.11E-07	40	1.52	9.31E-07	0.50	4.2	
	16:00	37.85	3600	130.81	129.29	3.70E-07	0.00	129.29	3.70E-07	40	1.54	5.69E-07	1.50	9.3	
	18:00	36.32	7200	129.29	127.76	1.87E-07	0.00	127.76	1.87E-07	39	1.55	2.91E-07	3.50	14.4	
	22:00	33.53	14400	127.76	124.97	1.75E-07	0.00	124.97	1.75E-07	39	1.56	2.73E-07	7.50	23.8	
3/6	0:00	32.26	7200	124.97	123.70	1.61E-07	0.00	123.70	1.61E-07	39	1.57	2.53E-07	9.50	28.0	
	6:00	28.70	21600	123.70	120.14	1.54E-07	0.00	120.14	1.54E-07	39	1.57	2.41E-07	15.50	39.9	
	12:00	24.89	21600	120.14	116.33	1.70E-07	0.00	116.33	1.70E-07	43	1.51	2.57E-07	21.50	52.7	
	18:00	23.62	21600	116.33	115.06	5.78E-08	0.00	115.06	5.78E-08	43	1.47	8.48E-08	27.50	56.9	
3/7	0:00	22.10	21600	115.06	113.54	7.02E-08	0.00	113.54	7.02E-08	41	1.49	1.05E-07	33.50	62.0	
	6:00	20.57	21600	113.54	112.01	7.12E-08	0.00	112.01	7.12E-08	38	1.56	1.11E-07	39.50	67.1	
	12:00	19.30	21600	112.01	110.74	6.00E-08	0.00	110.74	6.00E-08	47	1.48	8.86E-08	45.50	71.4	
	18:00	18.29	21600	110.74	109.73	4.85E-08	0.00	109.73	4.85E-08	50	1.33	6.47E-08	51.50	74.8	
3/8	0:00	17.53	21600	109.73	108.97	3.67E-08	0.00	108.97	3.67E-08	45	1.36	5.00E-08	57.50	77.3	
	6:00	16.89	21600	108.97	108.33	3.08E-08	0.00	108.33	3.08E-08	43	1.44	4.43E-08	63.50	79.4	
	12:00	16.26	21600	108.33	107.70	3.10E-08	0.00	107.70	3.10E-08	50	1.38	4.27E-08	69.50	81.6	
	18:00	15.75	21600	107.70	107.19	2.49E-08	0.00	107.19	2.49E-08	49	1.31	3.27E-08	75.50	83.3	
3/9	0:00	15.24	21600	107.19	106.68	2.50E-08	0.00	106.68	2.50E-08	49	1.32	3.31E-08	81.50	85.0	
	6:00	14.86	21600	106.68	106.30	1.88E-08	0.00	106.30	1.88E-08	48	1.34	2.52E-08	87.50	86.2	
	12:00	14.48	21600	106.30	105.92	1.89E-08	0.00	105.92	1.89E-08	48	1.35	2.55E-08	93.50	87.5	
	18:00	13.84	21600	105.92	105.28	3.17E-08	0.00	105.28	3.17E-08	46	1.37	4.33E-08	99.50	89.6	
3/10	0:00	13.34	21600	105.28	104.78	2.55E-08	0.00	104.78	2.55E-08	41	1.45	3.69E-08	105.50	91.3	
	6:00	12.70	21600	104.78	104.14	3.20E-08	0.00	104.14	3.20E-08	40	1.53	4.89E-08	111.50	93.5	

TWO STAGE BOREHOLE PERMEABILITY TEST
BERT AVENUE PROJECT
NEWBURGH HEIGHTS, OHIO

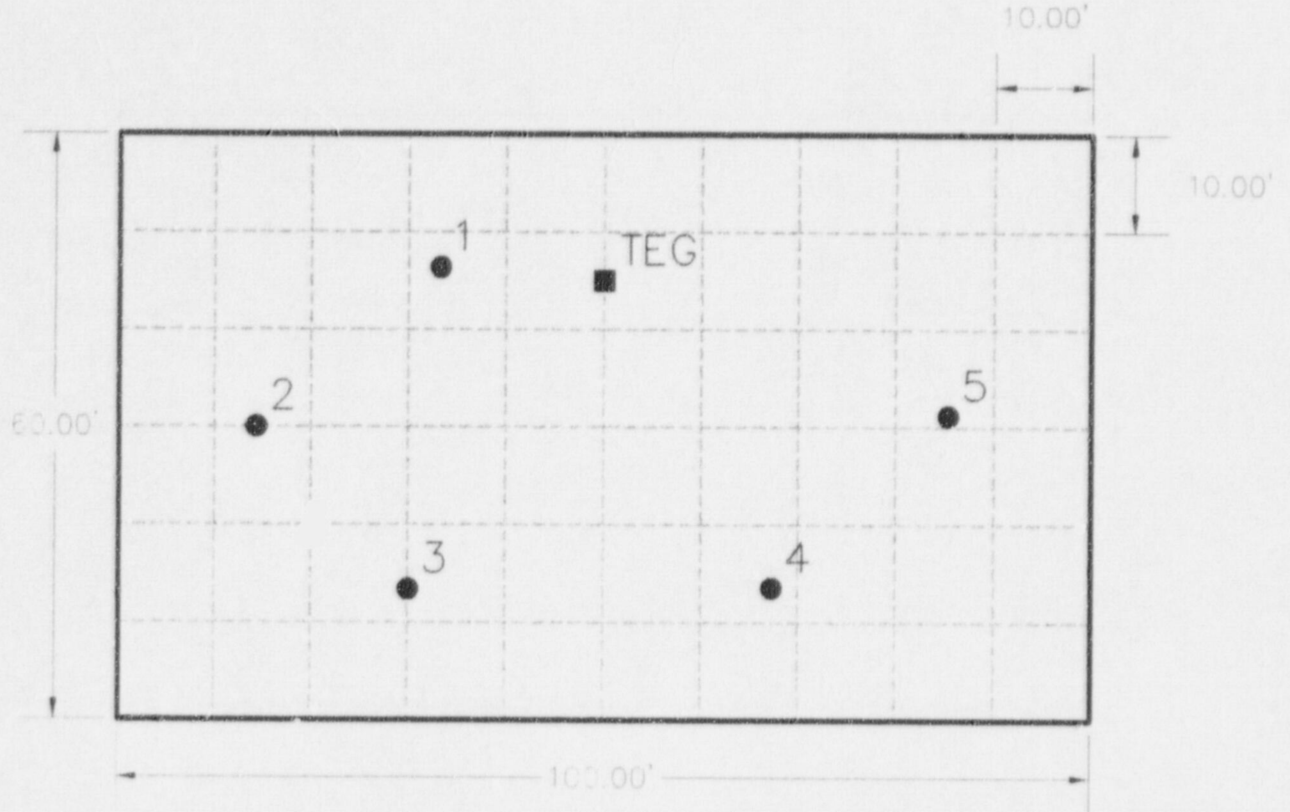
d= 2.06 cm
D= 10.16 cm
Z= 25.40 cm
Ra= 15.24 cm
ZW= 76.20 cm
L= 12.70 cm
B= 76.20 cm

TABLE A-5
DIRECT READINGS
TEST FP-5
STAGE 2

DATE	TIME	READING (cm)	TIME (sec)	H1 (cm)	H2 (cm)	K2 (cm/sec)	TC (cm)	H2c (cm)	K2c (cm/sec)	Temp	Temp Factor	K2tc (cm/sec)	Cum. Hrs.	Cum. Volume (cu. cm.)	Remarks
3/13	14:00	49.64	-	-	132.08	-	0.00	132.08	-	51	-	-	0.00	0.0	Start
	14:30	38.99	1800	132.08	130.43	3.11E-07	0.00	130.43	3.11E-07	51	1.29	3.99E-07	0.50	5.5	
	15:30	37.97	3600	130.43	129.41	9.66E-08	0.00	129.41	9.66E-08	52	1.27	1.23E-07	1.50	8.9	
	17:30	36.96	7200	129.41	128.40	4.87E-08	0.00	128.40	4.87E-08	53	1.25	6.10E-08	3.50	12.3	
	21:30	34.93	14400	128.40	126.37	4.92E-08	0.00	126.37	4.92E-08	49	1.29	6.36E-08	7.50	19.1	
3/14	0:00	34.29	9000	126.37	125.73	2.49E-08	0.00	125.73	2.49E-08	48	1.34	3.33E-08	10.00	21.2	
	18:00	25.40	64800	125.73	116.84	-	0.00	116.84	-	50	-	-	28.00	51.0	restart
3/15	0:00	23.88	21600	116.84	115.32	2.70E-08	0.00	115.32	2.70E-08	50	1.31	3.53E-08	34.00	56.1	
	6:00	22.61	21600	115.32	114.05	2.28E-08	0.00	114.05	2.28E-08	48	1.32	3.02E-08	40.00	60.3	
	12:00	21.21	21600	114.05	112.65	2.54E-08	0.00	112.65	2.54E-08	50	1.33	3.36E-08	46.00	65.0	
	18:00	19.81	21600	112.65	111.25	2.57E-08	0.00	111.25	2.57E-08	46	1.34	3.45E-08	52.00	69.7	
3/16	0:00	18.54	21600	111.25	109.98	2.36E-08	0.00	109.98	2.36E-08	44	1.41	3.32E-08	58.00	73.9	
	6:00	17.53	21600	109.98	108.97	1.91E-08	0.00	108.97	1.91E-08	47	1.40	2.67E-08	64.00	77.3	
	12:00	16.38	21600	108.97	107.82	2.17E-08	0.00	107.82	2.17E-08	57	1.26	2.74E-08	70.00	81.1	
	18:00	15.37	21600	107.82	106.81	1.95E-08	0.00	106.81	1.95E-08	53	1.20	2.35E-08	76.00	84.5	
3/17	0:00	14.35	21600	106.81	105.79	1.97E-08	0.00	105.79	1.97E-08	50	1.27	2.50E-08	82.00	87.9	

Appendix J

Test Pad Layout and Permeameter Location Drawings



N

HORIZONTAL SCALE - FEET

0 20 40 60

APPROXIMATE LOCATION OF
CLAY TEST PAD, PERMEAMETER'S AND TEG
DATED 3/4/98
BERT AVENUE SITE

PREPARED FOR
CHEMETRON CORPORATION
NEWBURGH HEIGHTS, OHIO

APPROVED [illegible] 3/20/98
CHECKED [illegible] 3/20/98
DRAWN

DRAWING NUMBER
C1220014

Earth Sciences Consultants, Inc.

REVISION	DATE	DESCRIPTION
REV1	3/17/98	MOVED PERMEAMETER LOCATIONS

Appendix K

Compaction Equipment Equivalency Determination

Prepared by: CAB Date: 3/25/98
Checked by: [signature] Date: 3/25/98
Approved by: [signature] Date: 3/25/98

Bert Avenue
Comparative Assessment of Compactive Effort for Test Pad

Purpose:
Evaluate the potential compactive effort (i.e., contact pressure) of several types of compaction equipment to determine that which is most appropriate to use during closure activities.

Approach:
The contact pressure exerted by each compactor can be determined by using the operating weight and contact area of the drum(s) or feet. A comparison can be made based on the number of passes required to achieve the same compactive effort for each piece of equipment.

References:
1. LeTourneau-Westinghouse Model W Specifications, included as Attachment A.
2. Compaction America, Hypac Footed Drum Compactor C852 Specifications, included as Attachment B.

Assumptions:
1. The operating aspects of both compactors are equivalent in relation to compactive effort, with the exception of the parameters compared herein.
2. The teeth on the drum do not effect compaction during the initial pass over uncompacted soils. The initial pass compaction is acheived by the base of the drum indenting the clay ½". Alternatively, compaction is provided on all subsequent passes by the feet, rather than the drum base. This is because, on subsequent passes, the compactor has been observed to "walk out" of the lift such that the bottoms of the feet only are in contact with the soil. Therefore, the contact area is reduced, with a calculated increase in the contact pressure.
3. The drum rollers for the LeTourneau-Westinghouse machine are filled with saturated sand to achieve the greatest ground pressure. Filling of the drum is not an option for the Hypac unit.

Evaluation:
The method of analysis includes two discrete scenarios: the initial pass using a smooth drum analysis equivalent, and all subsequent passes evaluating the contact pressure exerted by the teeth.

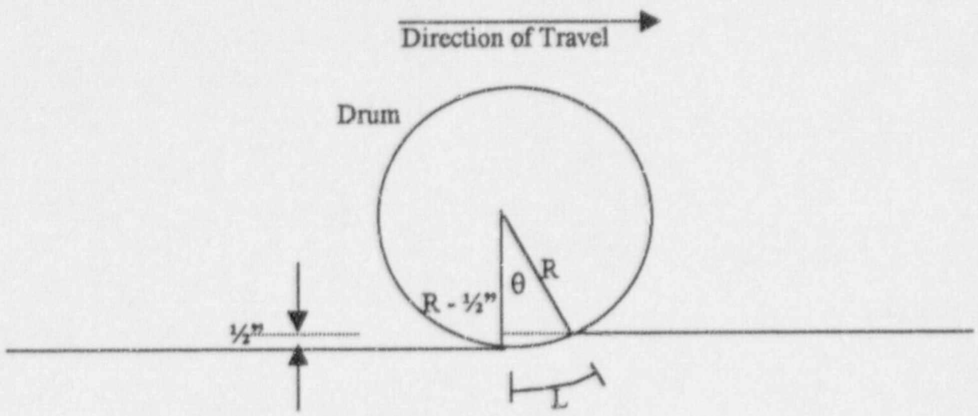
A. Initial Pass:
The contact pressure exerted by the drum can be predicted by the equation:

$$\text{Contact Pressure} = \frac{\text{Operating Weight}}{\text{Contact Area}}$$

Where:

Operating Weight = dead weight of equipment assuming saturated sand loading in roller drum(s)
Contact Pressure = pressure exerted by the drum or pressure exerted by the teeth

Contact Area = Area of drum in contact with the uncompacted soil, evaluated as follows:



Drum Schematic (*first pass*)

Where:

$\cos\theta = \frac{R - ½"}{R}$

L = R (θ° x π/180)

Width of drum, W = 48"

A = L x W

B. Subsequent Passes:
The contact pressure exerted by the drum can be predicted by the equation:

Contact Pressure = $\frac{\text{Operating Weight}}{\text{Contact Area}}$

Where:

Operating Weight = dead weight of equipment assuming saturated sand loading in roller drum(s)
Contact Pressure = pressure exerted by the drum or pressure exerted by the teeth
Contact Area = Area of feet in contact with the uncompacted soil, evaluated as follows:

A = Area of foot face x number of feet; or,
Contact area as provided by the Manufacturer

LeTourneau-Westinghouse Sheep's Foot Roller First Pass

Width of drum, W = 48"
R = 21"

$$\theta = \cos^{-1}\left[\frac{21" - 1/2"}{21"}\right] = 12.5°$$

L = 21" (12.5° x π/180) = 4.6"

Contact Area (*first pass*) = L x W x 2 (two drums per roller)
= 4.6" x 48" x 2
= 441.6 in^2

Contact Pressure (*first pass*) = $\frac{13,440 \text{ lbs}}{441.6 \text{ in}^2}$ = 30.4 lb/in^2

LeTourneau-Westinghouse Sheep's Foot Roller Subsequent Passes

No. of feet per row, N = 8 (*4 per drum)*
Area per foot face, A_f = 5.06 in^2

Contact Area = N x A_f
= 8 x 5.06 in^2
= 40.48 in^2

Contact Pressure = $\frac{13,440 \text{ lbs}}{40.48 \text{ in}^2}$ = 332 lb/in^2

LeTourneau-Westinghouse Sheep's Foot Roller Cumulative Contact Pressure (P_t); Six Passes

P_t = 30.5 psi + (5 x 332 psi) = 1691 psi

Hypac C852 Vibratory Drum First Pass

Width of drum, W = 84"
R = 33.5"

$$\theta = \cos^{-1}\left[\frac{33.5" - 1/2"}{33.5"}\right] = 9.9°$$

L = 33.5" (9.9° x π/180) = 5.8"

Contact Area (*first pass*) = L x W
= 5.8" x 84
= 487.2 in^2

Contact Pressure (*first pass*) $= \frac{13{,}400 \text{ lbs}}{487.2 \text{ in}^2} = 27.5 \text{ lb/ in}^2$

Hypac C852 Vibratory Drum Subsequent Passes

Total number of feet, N = 112
Contact Area per foot, A_t = 30.25 in^2
No. of feet in contact, N = 112(θ/360)
= 112(9.9°/360)
= 3.08

Contact Area = 3.08 x 30.25
= 93.17 in^2

Contact Pressure $= \frac{13{,}400 \text{ lbs}}{93.17 \text{ in}^2} = 144 \text{ lb/in}^2$

Hypac C852 Vibratory Drum Cumulative Contact Pressure (P_t): Six Passes

P_t = 27.5 psi + (5 x 144 psi) = 747.5 psi

Number of passes required for Equal Compactive Effort:

Passes required of Hypac Unit to equal LeTourneau – Westinghouse:

$n = 6 + \frac{(1691 \text{ psi} - 747.5)}{144 \text{ psi}} = 12.55$ (*say 13*)

Summary:

Based on six passes, and on the above methodology, the compactive effort of the LeTourneau – Westinghouse Sheeps Foot Compactor is greater than the Hypac C852B Tamping Foot Compactor by a ratio of 2.26. Despite the compactors having practically the same weight, it is apparent that the compactor with less feet and contact area will exert a greater contact pressure on the lift as it "walks out" of the soil.

If the Hypac unit is intended for use, then 13 passes on each lift will be required to be equivalent to the LeTourneau – Westinghouse machine.

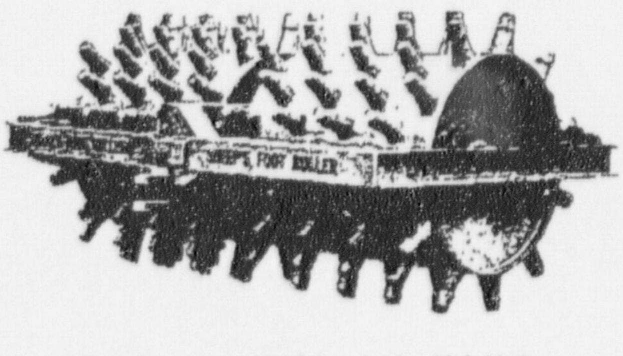
Attachment A

LeTOURNEAU-WESTINGHOUSE W SHEEP'S FOOT ROLLER SPECIFICATIONS

Specifications are subject to change without notice or obligation.

MODEL	W
Number of Drums	2
DRUM DIMENSIONS	
Length	4' (1,22 m)
Diameter (less feet)	3' 6" (1,06 m)
Diameter (including feet)	4' 10" (1,47 m)
Thickness of Rim Plates	½" (127 mm)
Interval between Drums	8" (17,78 cm)
BEARINGS	Tapered Roller
Number of Feet per Drum	88
Number of Feet per Row	4
Distance Center to Center between Feet in Row	12" (30,48 cm)
OVERALL MEASUREMENTS	
Length	13' 3" (4,04 m)
Width	9' 5" (2,87 m)
Height	4' 10" (1,47 m)
FOOT MATERIAL	Heat Treated Alloy Steel
FOOT DIMENSIONS	
Base (at drum) Elliptical	5" x 4" (12,7 cm x 10,16 cm)
Tamping Surface, Diameter	2.54" (6,45 cm)
Area of Foot Face in Square Inches (cm^2)	5.06" (12,85 cm)
Length (Drum to Tamping Surface)	8" (20,32 cm)
TYPE OF FRAME CONSTRUCTION	Patented Box Beam
APPROXIMATE TAMPING WEIGHTS	
Empty	6,040 lbs. (2740 kg)
*Loaded with water	10,240 lbs. (4645 kg)
*Loaded with saturated sand	13,440 lbs. (6096 kg)
GROUND PRESSURE PER SQUARE INCH (PER SQUARE CM)	
Empty	149 lbs. (10,475 kg/cm^2)
*Loaded with water	254 lbs. (17,858 kg/cm^2)
*Loaded with saturated sand	333 lbs. (23,413 kg/cm^2)

*May be loaded with 2100 lbs. (953 kg) of water or 3700 lbs. (1678 kg) of saturated sand per drum.



Rear view of Model W Roller showing hitch block

WABCO LeTOURNEAU-WESTINGHOUSE COMPANY

Attachment B

HYPAC

FOOTED-DRUM VIBRATORY COMPACTORS

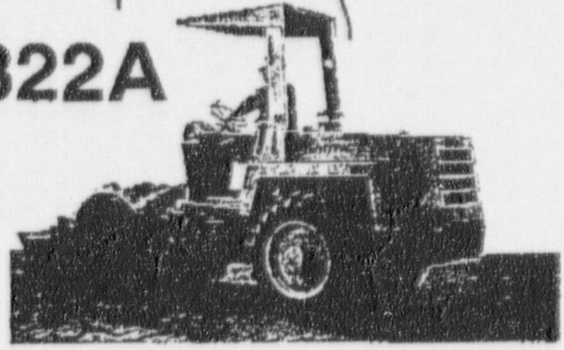
with tamping foot design for compaction of cohesive or semi-cohesive materials.

C852B

Power, hp (kW)	38 (28.3)	75 (56)	107 (80)	149 (111)	149 (111)
Model	Deutz F3L1011	Cummins 4B3.9	Cummins 4BTA3.9	Cummins 6BT5.9	Cummins 6BT5.9
Speeds					
mph (kmph) low	0-5.5 (0-9)	0-4.3 (0-6.9)	0-5 (0-8.0)	0-5 (0-8.0)	0-5.2 (0-8.4)
high	—	0-5.6 (0-9)	0-9 (0-14.5)	0-11 (0-17.7)	0-10.3 (0-16.6)
D/D low	—	—	0-3 (0-4.9)	0-3 (0-4.9)	0-3.4 (0-5.5)
D/D high	—	—	0-4 (0-6.4)	0-4 (0-6.4)	0-5.0 (0-8.0)
Tires	7.50 x 16 bar	12.4 x 24/6PR bar	14.9 x 24/R1 bar	23.1 x 26/R1 bar	23.1 x 26/R1 bar
Drum					
Shell diameter, in (mm)	26.8 (680)	41.0 (1041)	48 (1219)	59 (1499)	59 (1499)
Diameter, over feet, in (mm)	31 (790)	48.1 (1224)	54 (1372)	67 (1702)	67 (1702)
Width, in (mm)	47 (1200)	56.1 (1426)	66.5 (1689)	84 (2134)	84 (2134)
Tamping feet, number	70	84	112	112	112
Centrifugal Force					
Max. lbs (kN)	10,060 (44.7)	15,475 (68.8)	27,800 (123.7)	55,600 (247.3)	55,600 (247.3)
@ vpm (Hz)	2480 (41.3)	1950 (32.5)	1900 (31.6)	1900 (31.6)	1900 (31.6)
Frequency Range					
vpm	2480	1950	1300-1900	1200-1900	1200-1900
Amplitude					
in (mm)	0.064 (1.6)	0.042 (1.06)	0.055 (1.4)	0.062 (1.57)	0.062 (1.57)
Operating Weight					
lbs (kg)	5,990 (2717)	12,479 (5665)	15,350 (6969)	23,000 (10433)	25,650 (11638)

Leveling blade optional

C832B



C822A

Leveling blade optional

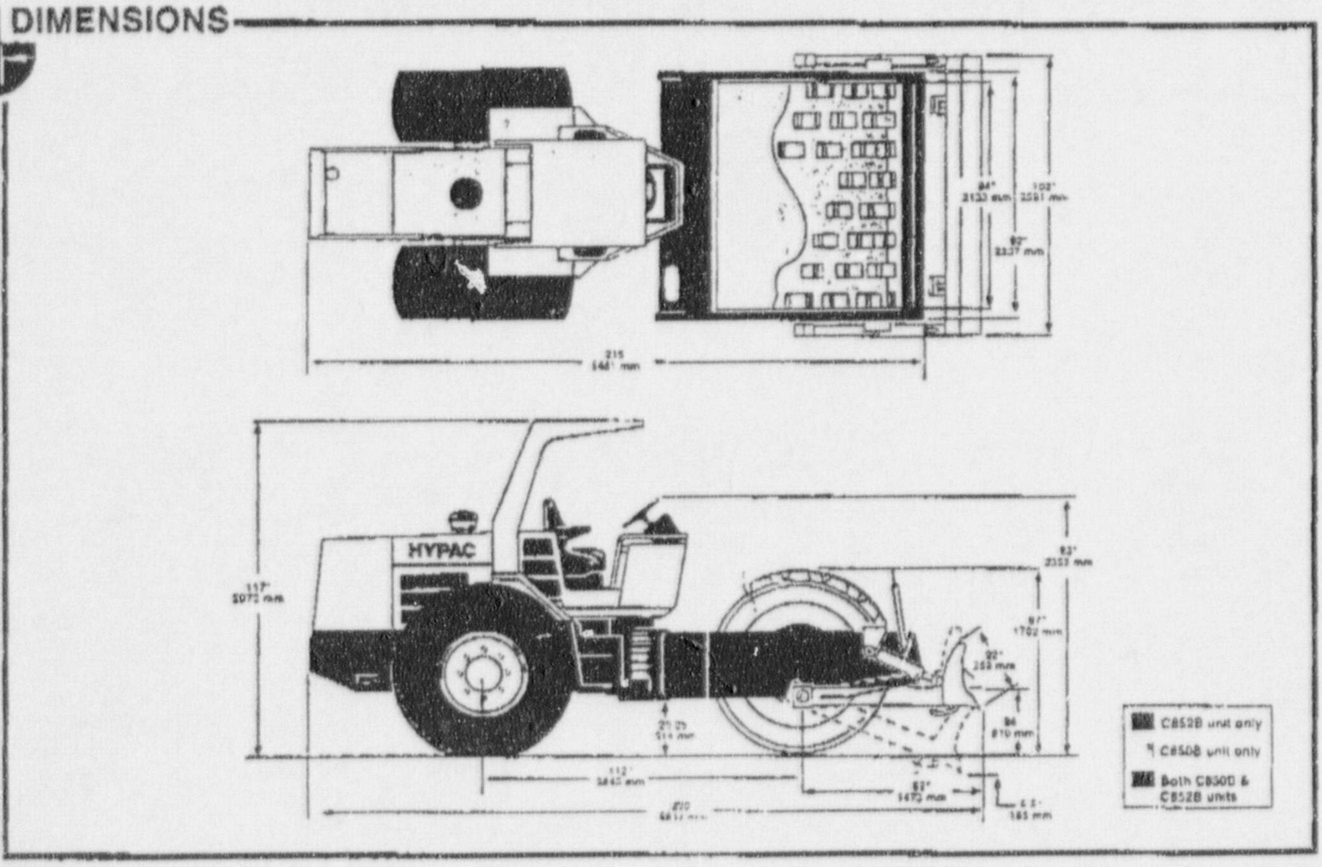
C812A

30.25

HYPAC C850B, C852B

HYPAC VIBRATORY SOILS & TAMPING COMPACTORS

DIMENSIONS



WEIGHTS

	C850B	C852B
Shipping Weight	20,350 lbs (9239 kg)	22,500 lbs (10206 kg)
Drum End (Front)	11,350 lbs (5153 kg)	13,400 lbs (6078 kg)
Tire End (Rear)	9,000 lbs (4082 kg)	9,100 lbs (4128 kg)
Operating Weight	20,850 lbs (9466 kg)	23,000 lbs (10433 kg)
w/optional Cab, add	340 lbs (154 kg)	340 lbs (154 kg)
w/optional Leveling Blade, add		1,200 lbs (544 kg)

STANDARD EQUIPMENT

- Cummins 6BT5.9 Diesel Engine
- Inside and Outside drum Cleaners
- Vandal Protection
- Hydrostatic Drum Drive
- Independent Hydrostatic Rear Wheel Drives
- 84" Smooth Drum (C850B)
- 84" Footed Drum, With 112 Tamping Feet (C852B)
- 23.1 x 26-R3 Diamond Tires (C850B)
- 23.1 x 26-R1 Cleated Tires (C852B)
- FOPS/ROPS with Seat Belt
- Horn
- Traction Valve
- Vibrator Pressure Gauge
- Backup Alarm

OPTIONAL EQUIPMENT

- All-weather Steel Cab
- Headlights (Front and Rear)
- Secondary/Park Brake Release Pump
- Engine Compartment Side Shields
- Special Paint, 1 Color Enamel
- 23.1 x 26-R1 Cleated Tires - C850B Only
- Drum Assembly (Footed) - for C850B
- Drum Assembly (Smooth) - for C852B
- Leveling Blade Package - C852B Only

Compaction America
A United Dominion Company
2000 Kentville Road
Kewanee, IL 61443

ISO 9001 SGS