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ENGINEERING & CONSTRUCTION DIVISION
419 SOUTH SPRING ST. SUITE 800
LOS ANGELES, CA 90013
(213) 893-8202
FAX: (213) 893-8223

November 20, 1998

Peter Janicki
Closure Branch
California Integrated Waste Management Board
8800 Cal Center Drive
Sacramento, California 95814

ADDITIONAL REVISIONS TO "REVISION II OF FINAL CLOSURE PLAN" DATED OCTOBER 1998

On October 22, 1998, the Bureau of Sanitation (BOS) transmitted Revision II to Volume IV of IV Replacement Amendment to Final Closure Plan (FCP) address revising the final cover design for the slopes of Disposal Areas A and AB+ and the decks of Disposal Areas A, B and AB+ to an engineered alternative final cover that uses a monolithic soil cover.

Subsequent revisions have been made to this report to better clarify and or insert information that was inadvertently not included in the original report, (see attachments). These include:

- Revised "Summary Table of Revisions" (replace original)
- Revised Chapter 2 of FCP (replace original chapter)
- Excluded Figures 2-2,2-2(a), 2-2(b), (include into Figure section of report)
- Approval letter from LEA dated August 5, 1998 (part of Appendix G - replace original LEA letter)
- Appendix J - Alternative Final Cover Water Balance Analysis (replace in entirety)

Please make these required changes to the original October 1998 report. If you have any questions or comments regarding this submittal or the original report please contact Ms. Reina Pereira at (213) 893-8529.

Very truly yours,

For Stephen A. Fortune, Division Manager
Solid Resources Engineering and Construction Division

Attachments

c: Rod Nelson, RWQCB
Joe Maturino, LEA
Ed Kavazanjian, GeoSyntec Consultants
Kelly Gharios
Ken Redd
Reina Pereira

SUMMARY TABLE OF REVISIONS TO
VOLUME IV OF IV REPLACEMENT AMENDMENT TO
FINAL CLOSURE PLAN
Revised October 1998

The following revisions and additions to the final closure plan address the conditional approval by the CIWMB, RWQCB and LEA of an alternative final cover on the slopes of Disposal Areas A and AB+, and the decks of Disposal Areas A, B and AB+. Please ensure that these revisions are incorporated into your closure plan, and all previous sections discarded.

Sections, Details, Drawings to be Amended	Description of Change	Comment
Cover Sheet	Replace	Reflects revision dates
Summary of Revisions	Replace in Entirety	Accounts for all revisions made to this document
Table of Contents of Volume IV of IV	Replace pages ii - x	Updated to reflect revisions/additions
Section 1: "Introduction"	Replace in Entirety	Updated to reflect revisions
Section 2: "Revised Final Cover Design"	Replace in Entirety	Revised to reflect use of a monolithic cover on the slopes of Disposal Areas A and AB+, and on the decks of Disposal Areas A, B and AB+.
Section 8: "Revised Landscaping and Irrigation"	Replace in Entirety	Revised to reflect the advantages of a monolithic cover with respect to allowing for deeper rooted vegetation, and better evapotranspiration performance.
Section 9: "Revised Closure Cost Estimate"	Replace in Entirety	Revised Sections 9.2.1 and 9.3 to include corrected final cover costs.
Section 10: "Updated Implementation Schedule"	Replace in Entirety	Revised to reflect updated schedule.
Section 11: "Revised Quality Assurance Plan"	Replace in Entirety	Revised to reflect addition of monolithic soil cover CQA.
Tables	Add Table 2-3 Replace Table 9-1	Monolithic Soil Cover Testing Summary Revised Summary of Closure Cost Estimate
Figures	Add Fig. 2-0 Replace Fig. 2-2 Delete Fig. 2-2(a) Delete Fig. 2-2(b) Add Fig 2-2(a) Add Fig 2-2(b) Delete Fig. 2-2(c) Delete Fig. 2-2(d) Replace Fig. 2-3 Replace Fig. 2-3(a) Replace Fig. 2-3(b) Replace Fig. 2-4 Replace Fig. 10-1	Landfill Final Cover Configuration Final Cover on B Deck GCL on A, B and AB+ Decks GCL on A, B, AB+ and C Decks Final Cover on A and AB+ Decks Vertical well on A, B, AB+ Decks Vert. Well on A, B, AB+ Decks – prescriptive Vert. Well on A, B, AB+ Decks – GCL Final Cover on Slopes/Benches of B Canyon Final Cover on Slopes/Benches of A Canyon Final Cover on Slopes/Benches of AB+ Cny. Final Cover System under Haul Road Revised Closure Schedule

SUMMARY TABLE OF REVISIONS TO VOLUME IV OF IV REPLACEMENT AMENDMENT TO FINAL CLOSURE PLAN
Revised October 1998

(Continued)

Sections, Details, Drawings To be Amended	Description of Change	Comment
Appendix F: "Updated Closure and Post-Closure Cost Estimates"	Replace in Entirety	Reflects cost revisions pertaining to use of a monolithic cover
Appendix G: "Approval Letters from CIWMB, RWQCB and LEA"	Add additional approval letters to back of Appendi G	RWQCB and LEA's approval of monolithic cover
Appendix I: "Revised CQA Plan"	Replace in Entirety	Includes CQA for monolithic cover
Appendix J: "Proposed Engineere Alternative Final Cover on the Slopes of Disposal Areas A and AB+ and the Decks of Disposal Areas A, B and AB+	Add new Appendix J	Technical report on the feasibility of an alternative final cover
Appendix K: "Evaluation of the Phase III West Ridge as a Borrow Source for Monolithic Soil Cover	Add new Appendix K	An additional source of dirt for final closure

c:summtble.98/rp

2. REVISED FINAL COVER DESIGN

2.1 General

The final cover for Disposal Area C has been revised from the design presented in the PCP to conform to the requirements of Subtitle D, Title 27, and RWQCB Order No. 93-062 for final covers over bottom liners which include a geomembrane. This revised final cover design was submitted to the CIWMB in February 1994 and was approved on 10 October 1995. A copy of the approval is presented in Appendix G. The final cover presented in the PCP employed an infiltration barrier layer composed of compacted soil only. The revised design for Disposal Area C incorporates a geomembrane in the infiltration barrier layer in the deck and bench areas. The geomembrane was included in the deck and bench areas in accordance with the prescribed minimum construction standards of Subtitle D and Title 27. On the slopes of the waste face, an engineered alternative final cover is employed. The alternative slope final cover was designed in accordance with state and federal regulatory standards for a performance-based design of an engineered alternative final cover.

A performance evaluation of the Disposal Area C alternative slope final cover was conducted to demonstrate compliance with applicable state and federal regulations. The performance evaluation included an infiltration analysis and a slope stability assessment for the alternative slope final cover design. The performance evaluation also included a demonstration that the construction of the prescriptive final cover provided in state and federal regulations on the side slopes was burdensome and impractical and would not promote attainment of the performance goals for final covers, as required by the state regulations. A detailed presentation of the performance evaluation is contained in the Final Cover Performance Evaluation report presented as Appendix H of this addendum. A summary of the performance evaluation is presented herein.

Additionally, the final cover design for the slopes of Disposal Areas A and AB+, and the decks of Disposal Areas A, B and AB+ have been revised from the prescriptive standards outlined in Subtitle D and Title 27 to reflect an alternative engineered monolithic cover. This request was submitted to the RWQCB and LEA on April 8, 1998, and conditionally approved by the RWQCB in a letter dated July 23, 1998, and by the LEA on August 5, 1998. Copies of the approvals are shown in Appendix G.

The final cover presented in the amended FCP utilized a one foot infiltration barrier layer under a two foot vegetative layer on the slopes of Disposal Areas A and AB+, and a GCL liner under a two foot vegetative layer on the decks of Disposal Areas A, B and AB+. The revised design for these areas employs a monolithic final cover which was shown to perform better than the Title 27 prescriptive cover in controlling infiltration in a report entitled "Proposed Engineered Alternative Final Cover on the Slope of Disposal Areas A and AB+ and the Decks of Disposal Areas A, B and AB+ - Lopez Canyon Restoration Project," as presented in Appendix J.

2.2 Regulatory Framework

State of California regulations concerning design and construction of final covers for closure of municipal solid waste landfills are found in Title 27, and RWQCB Order No. 93-062. Federal regulations for final covers are provided in Subtitle D. State and federal regulations both provide a minimum prescriptive construction standard for the final cover of Municipal Solid Waste Landfills (MSWLFs) that includes a protective vegetative erosion control layer and a low-permeability soil infiltration barrier layer. State regulations are somewhat more restrictive than federal regulations with respect to these layers, requiring a thicker erosion control layer and an order of magnitude lower hydraulic conductivity for the barrier layer. The state and federal regulations both require that the final cover have a "permeability" less than or equal to that of any bottom liner or underlying material. This requirement is generally interpreted as an implied prescriptive requirement that a geomembrane be included in the final cover barrier layer above areas which incorporate a geomembrane in the bottom liner. This "permeability" requirement is also interpreted as a performance standard requiring less infiltration of surface water through the final cover than liquid flux through the base of the landfill.

Based upon the state and federal regulations and considering that Disposal Area C does have a geomembrane bottom liner, the prescriptive final cover for Disposal Area C is inferred to consist of (from top to bottom):

- a vegetative layer at least 12-in. (300-mm) thick and of greater thickness than the rooting depth of any vegetation planted on the final cover;
- a geomembrane infiltration barrier;
- a compacted soil barrier layer not less than 12-in. (300-mm) thick with a maximum hydraulic conductivity of 1×10^{-6} cm/sec;
- a foundation layer at least 24-in. (600-mm) thick; and
- a design which provides for the minimum maintenance possible.

Both federal and state regulations provide for design of an alternative to the prescriptive final cover. Federal regulations allow the director of an approved state to approve an alternative design shown to be equivalent or superior to the performance of the prescriptive design with respect to infiltration and wind and water erosion. California is an approved state.

Section 21140. of Title 27 provides for the approval of alternative final covers when the owner demonstrates that:

- "the final cover shall function with minimum maintenance and provide waste containment to protect public health and safety by controlling at a minimum, vectors, fire, odor, litter and landfill gas migration. The final cover shall also be compatible with postclosure land use."

- the engineered alternative is consistent with the performance requirements as established in 40 CFR 258.60(b), which states that the alternative final cover design shall meet or exceed the prescriptive permeability of $1x10^{-5}$ cm/sec, or less than the permeability of any bottom liner, with a minimum of 18-inches of earthen material. Additionally, provide an erosion layer that provides protection from wind and water erosion, equivalent to the prescriptive minimum of 6-inches of earthen material capable of sustaining native plant growth.

The state and federal requirement that the final cover have a "permeability" less than or equal to the bottom liner or underlying material is generally interpreted as an implied final cover infiltration performance standard that the flux through the cover should be less than the flux through the base liner. United States Environmental

Protection Agency (USEPA) has confirmed this interpretation of the implied prescriptive requirement and performance standard of the Subtitle D closure requirement in the "Final rule; corrections" for Subtitle D published in the Federal Register of 26 June 1992 (Vol. 57, No. 124, pp. 28626-28628). USEPA's comments on the prescriptive and performance standards for final cover design are discussed in detail in the Final Cover Performance Evaluation report presented in Appendix H.

The Final Cover Performance Evaluation report presented in Appendix H of this addendum contains the demonstration required by state regulations that construction of the prescriptive final cover on the slopes of the waste face of Disposal Area C is both burdensome and impractical and will not promote attainment of the performance goals for final covers. On the basis of this demonstration, an engineered alternative final cover for the Disposal Area C waste slopes was developed.

The Proposed Engineered Alternative Final Cover report presented in Appendix J shows that the monolithic soil cover model provides better infiltration control than the prescriptive standard described in Title 27, thus providing better ground water protection. Moreover, the prescriptive standard illustrates constructability that is more burdensome, quality assurance testing procedures that are more stringent, it is more susceptible to cracking, involves more labor intensive maintenance, and is significantly higher in cost of purchase and placement of material. Based on the above findings, it was determined that the engineered alternative cover developed for the slope of Disposal Areas A and AB+, and the deck of Disposal Areas A, B and AB+ would be more practical and would better promote attainment of performance goals.

2.3 Revised Final Cover Configuration

Final cover configuration for the entire landfill is shown in Figure 2-0.

2.3.1 Disposal Area C Deck/Bench Areas

The final cover on deck and bench areas of Disposal Area C satisfies the prescriptive standard in the California regulations. The deck and bench area final cover, shown in Figures 2-1 through 2-1(f), consists of the following components (from top to bottom):

- vegetative layer at least 24-in. (600-mm) thick;
- 12 oz/yd^2 (410 g/m^2) non-woven geotextile cushion;
- 40-mil (1-mm) thick very-flexible polyethylene (VFPE) geomembrane (smooth on the deck areas and textured on the bench areas). Technical specifications are shown in Table 2-1. Note that VFPE geomembranes include very low density polyethylene (VLDPE) and linear low density polyethylene (LLDPE), as noted in Appendices H and I;
- 12-in. (300-mm) thick barrier layer of compacted low-permeability soil, with a hydraulic conductivity no greater than 1 x 10^{-6} cm/s. A geosynthetic clay liner (GCL) with a hydraulic conductivity no greater than 5 x 10 $^{-9}$ cm/s may be used as a barrier layer for the deck area instead of the low-permeability soil. Technical specifications for GCL are shown in Table 2-2; and

- 24-in. (600-mm) thick foundation layer.

2.3.2 Disposal Area A, B, and AB+ Deck Areas

The final cover on the deck of Disposal Areas A, B, and AB+ has been modified from that presented in the PCP to delete the geotextile between the vegetative layer and the low-permeability soil barrier layer. It has also been modified from the original Amendment to the Final Closure Plan to delete the option of using a geosynthetic clay liner (GCL) as a low permeability barrier layer. The revised final cover comprises a three foot single layer monolithic cover of silty sand or clayey sand with a field saturated hydraulic conductivity no greater than 3×10^{-5} cm/s overlying a minimum of two foot existing foundation layer. The modified final cover is presented in Figures 2-2 through 2-2(b).

2.3.3 Disposal Area C Slope Areas

An engineered alternative final cover was developed for the slope areas of the Disposal Area C waste face. The engineered alternative was developed on the basis of the demonstration included in Appendix H of this amendment, the Final Cover Performance Evaluation report, that inclusion of a geomembrane in the slope areas of the Disposal Area C final cover would be burdensome and impractical and would not promote attainment of the performance goals of a final cover. Use of a geomembrane in the final cover on the waste slopes was deemed burdensome and impractical due to constructability, stability, and cost considerations. Furthermore, the maintenance requirements for a slope final cover incorporating a geomembrane were deemed contrary to the performance goal of minimizing final cover maintenance.

The engineered alternative final cover design for the slope areas of the Disposal Area C waste face is shown in Figure 2-3. The final cover for the slope area consists of the following components (from top to bottom):

- vegetative layer at least 24-in. (600-mm) thick;
- 12-in. (300-mm) thick barrier layer of compacted low-permeability soil with a hydraulic conductivity no greater than 1 x 10^{-6} cm/s; and
- 24-in. (600-mm) thick foundation layer.

2.3.4 Disposal Area B Slope Areas

The same final cover used on the Disposal Area C slopes will be used on the slopes of Disposal Area B. This final cover for the B slopes is different than that which was originally submitted in the PCP. The monolithic clay cover was replaced with the final cover as described in the above section. This modification was submitted to the CIWMB on 31 May 1994 and approved on 10 October 1995. A copy of the approval letter is presented in Appendix G. This final cover is shown in Figure 2-3 and described in the preceding section. As the slopes of Disposal Area B are not underlain by a geomembrane liner, the final cover for the benches in these areas do not require a geomembrane. The final cover conforms to the prescriptive design standard.

2.3.5 Disposal Areas A and AB+ Slope Areas

The final cover for the slopes of Disposal Area A has been modified from the monolithic clay cover originally submitted in the PCP, and the 2 ft (0.6m) foundation layer, 1 ft (0.3m) clay layer and two ft (0.6m) vegetative layer final cover as submitted in the June 1996 Amendment to the Final Closure Plan. The modified final cover consists of an engineered monolithic soil cover composed of a minimum 2 ft (0.6m) thick foundation layer overlain by a 3 ft (0.9m) layer of silty sand or clayey sand.

The existing interim soil cover on the slopes of Disposal Area A consists of at least 6.5 ft (2m) of silty sand or clayey sand characterized by a hydraulic conductivity of 4.6×10^{-5} cm/s. Additionally, the Proposed Engineered Alternative Final Cover report (refer to Appendix J), shows that the existing interim soil cover demonstrates less percolation than the Title 27 prescriptive cover. Therefore, the existing slope areas of Disposal Area A meet final closure specifications. Refer to Figure 2-3(a).

The final cover for the slopes of Disposal Area AB+ has also been modified from the 2 ft (0.6 m) foundation layer, 1 ft (0.3m) clay layer and two ft (0.6 m) foundation layer as submitted in the Amendment to the Final Closure Plan. The modified final cover also consists of an engineered monolithic soil cover as described for the slope areas of Disposal Area A above. However, a 3 ft (0.9m) thick layer of soil with a field hydraulic conductivity of no greater than 3×10^{-5} cm/s is required to be placed in this area to meet minimal final cover thicknesses, as illustrated in Appendix J, and shown in Figure 2-3(b).

The change in the final elevation of Disposal Area C has produced a split-deck final grading plan, with the deck of Disposal Area C at elevation 1,600 ft msl and the deck of Disposal Area AB+ at elevation 1770 ft msl. This split deck has created a need for construction of a final cover on the waste slopes of Disposal Area AB+ between the decks of Disposal Areas AB+ and C. Additionally, a portion of the haul road and perimeter channel in Disposal Area AB+ will be reconstructed to include a final cover, since refuse underlies this area. This final cover detail is shown in Figure 2-4.

2.3.6 Sources of Dirt for the Monolithic and Prescriptive Final Cover

The amount of dirt required to close the decks of Disposal Areas A, B and AB+, and the slopes of Disposal Areas AB+ with a monolithic cover, and the slopes and deck of Disposal Area C with the prescriptive vegetative layer is approximately 494,000 CY (377,910 m^3). Approximately 250,000 CY (188,955 m^3) of this dirt will be recovered from a native ridge regrade within the landfill. Appendix K presents a report entitled Evaluation of the Phase III West Ridge as a Borrow Source for Monolithic Soil Cover, that demonstrates the ridge to be a feasible borrow source of material for monolithic soil cover.

The remaining quantity is being obtained from construction contractors either free or through purchase orders.

2.4 Infiltration Analyses

Use of an engineered alternative final cover on the waste slopes of Disposal Area C requires a demonstration that the alternative design provides equivalent protection to ground water and resistance to infiltration compared to the prescriptive design. The potential for infiltration of surface water through the alternative final cover on the slopes of the waste face was evaluated using two USEPA-developed water balance models: (i) HELP Model Version 2 [USEPA; 1984 a,b]; and (ii) the SW-168 Model developed by Fenn et al. [1975]. The infiltration calculations are included in Appendix H of this addendum, the Final Cover Performance Evaluation report.

Neither the HELP nor the SW-168 Model predicted infiltration through the cover. One factor influencing the lack of infiltration is the high percentage of run-off from the 2H:1V Disposal Area C slopes. In addition, the annual precipitation is significantly less than the annual pan evaporation rate. As a result, the soil moisture storage capacity was not exceeded in either short term or long term conditions, resulting in no infiltration through the final cover barrier layer. Because there was no infiltration through the barrier layer, the engineered alternative final cover design for the Disposal Area C slopes meets the infiltration performance standard of less infiltration through the final cover than through the bottom liner.

Likewise, use of an engineered alternative final cover on the decks of Disposal Areas A, B and AB+, and the slopes of Disposal Areas A and AB+ demonstrate that the alternative design provides equivalent or better protection to ground water and resistance to infiltration compared to the prescriptive design. The infiltration performance evaluation was conducted using the LEACHM Model under existing site conditions. This infiltration water balance analysis is included in Appendix J of this report.

2.5 Final Cover Slope Stability

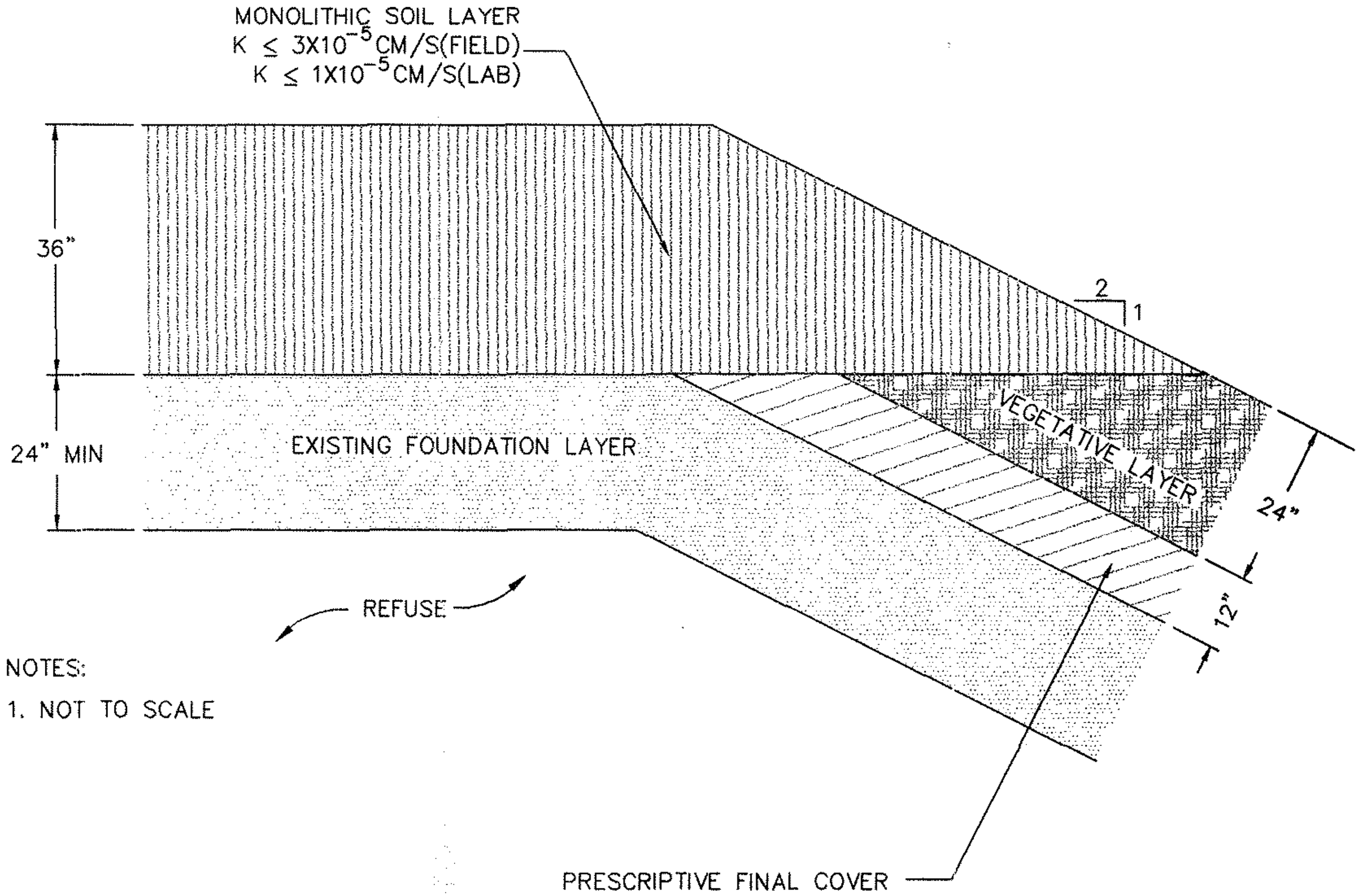
Both one-dimensional (infinite slope) and two-dimensional slope stability analyses of the Disposal Area C final cover were performed. Slope stability calculations are included in Appendix H of this report, the Final Cover Performance Evaluation report. The one-dimensional slope stability analyses were performed using the methodology suggested by Matasović [1991]. Two-dimensional slope stability analyses were performed using the computer program PC STABL 5M [Achilleos, 1988].

One-dimensional stability analyses yielded a minimum (static) factor of safety of 2.0 for a failure surface passing through the waste immediately below the existing foundation layer. The corresponding pseudo-static factor of safety for a seismic coefficient of 0.2 was 1.41. GeoSyntec considers this pseudo-static factor of safety acceptable based upon the conclusions of Seed [1979]. Based upon observations of the performance of slopes and embankments in earthquakes around the world, Seed [1979] concluded that slopes designed with a pseudo-static factor of safety of 1.15 for a seismic coefficient of 0.15 experienced "acceptable" deformations (less than 1 ft (0.3 m)) in earthquakes of all magnitudes and intensities. However, to substantiate this conclusion, maximum permanent seismic displacements were estimated using charts developed by Hynes and Franklin [1984] using Newmark analyses. Predicted displacements for the critical final cover failure surface were on the order of 2 in. (50 mm) for the design peak ground acceleration of 0.69 g. Two-dimensional slope stability analyses yielded a minimum (static) factor of safety of 2.86 and a pseudo-static factor of safety of 2.0.

The infiltration analyses indicated the potential for development of down slope seepage parallel to the face of the slope within the vegetative cover layer was negligible, even for the 100-year, 24-hour storm. However, stability analyses were conducted for the limiting case of seepage parallel to the slope. Stability analyses for the condition of seepage parallel to the slope yielded a minimum (static) factor of safety of 2.5 for this condition.

The final cover on the slopes of the Disposal Area AB+ waste face will have the same cross section as the final cover on the Disposal Area C waste face. However, the inclination of the slopes on the Disposal Area AB+ waste face is 2.5H:1V, flatter than the 2H:1V inclination of the slopes on the Disposal Area C waste face. As the final cover on the Disposal Area C waste face was demonstrated to be stable, separate stability calculations for the flatter Disposal Area AB+ final cover were not considered necessary.

The stability calculations are included in Appendix H of this addendum, the Final Cover Performance Evaluation report.



NOTES:

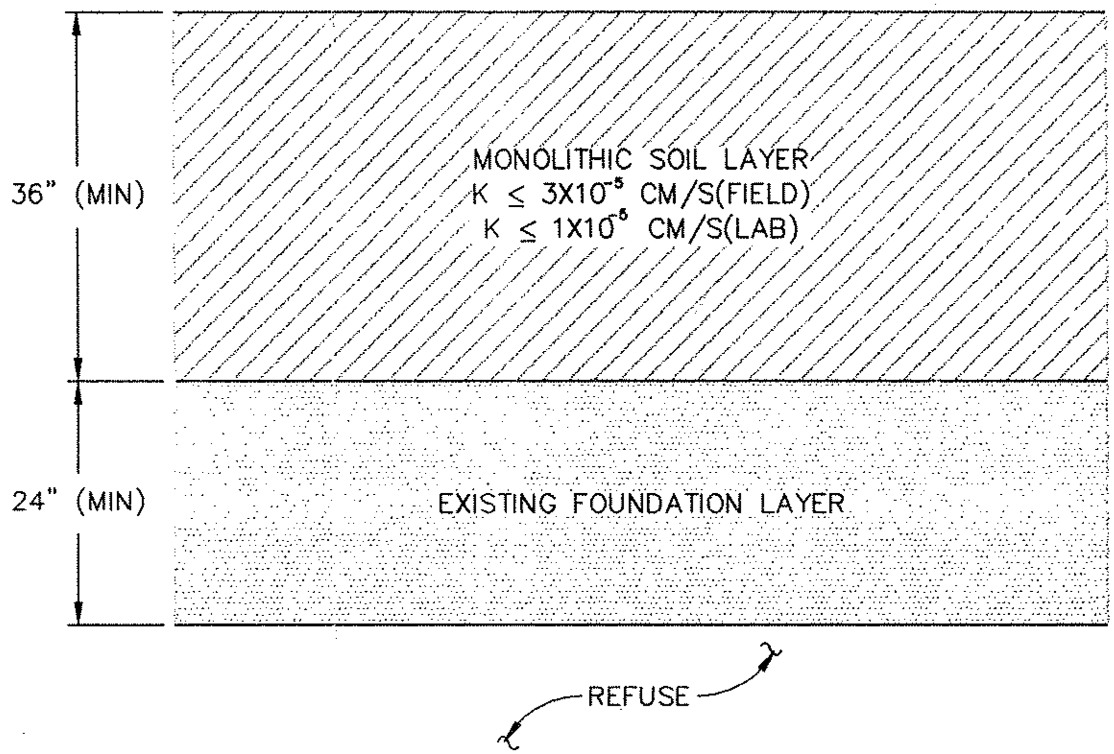
1. NOT TO SCALE

GEOSYNTEC CONSULTANTS

FINAL COVER ON DECK AREAS
DISPOSAL AREA B
LOPEZ CANYON SANITARY LANDFILL

FIGURE NO.	2-2
PROJECT NO.	CE4100-06
DATE:	NOV-18-98

DWG: 41F604-1.DWG



SCALE: 1" = 1.5'

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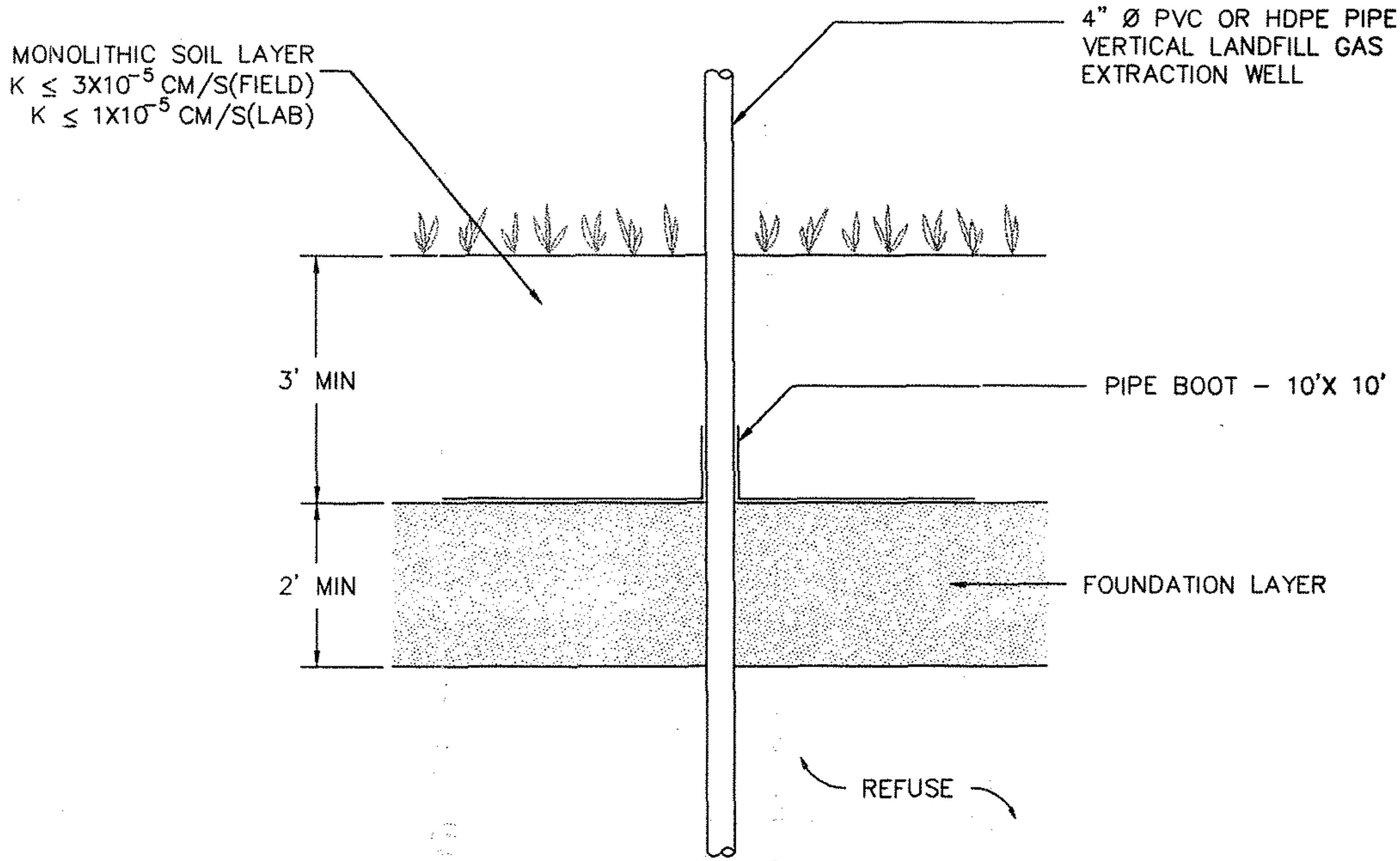
MONOLITHIC SOIL FINAL COVER DECK OF DISPOSAL AREA A, B, AND AB+ LOPEZ CANYON SANITARY LANDFILL	FIGURE NO.	2-2(a)
	PROJECT NO.	CE4100-04
	DATE:	NOV-18-98

DWG: 4100F034.DWG 199808131259 RCG

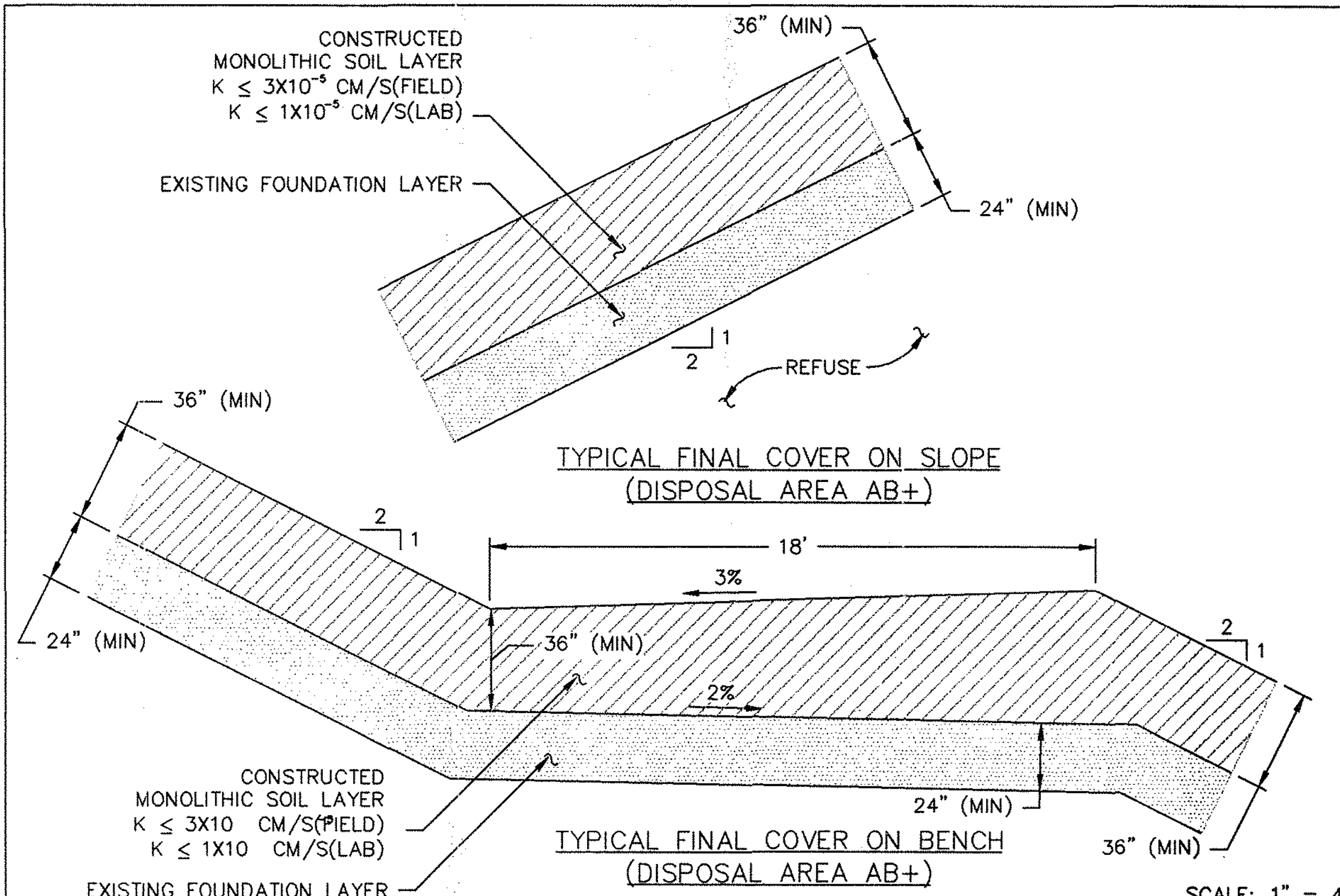


GEOSYNTEC CONSULTANTS

VERTICAL LANDFILL GAS EXTRACTION WELL PENETRATING
FINAL COVER SYSTEM ON DECK WITH
MONOLITHIC COVER SYSTEM
LOPEZ CANYON SANITARY LANDFILL

FIGURE NO.	2–2(b)
PROJECT NO.	CE4100–06
DATE:	NOV–18–98

DWG: 4100F601.DWG 199808071515 RCG

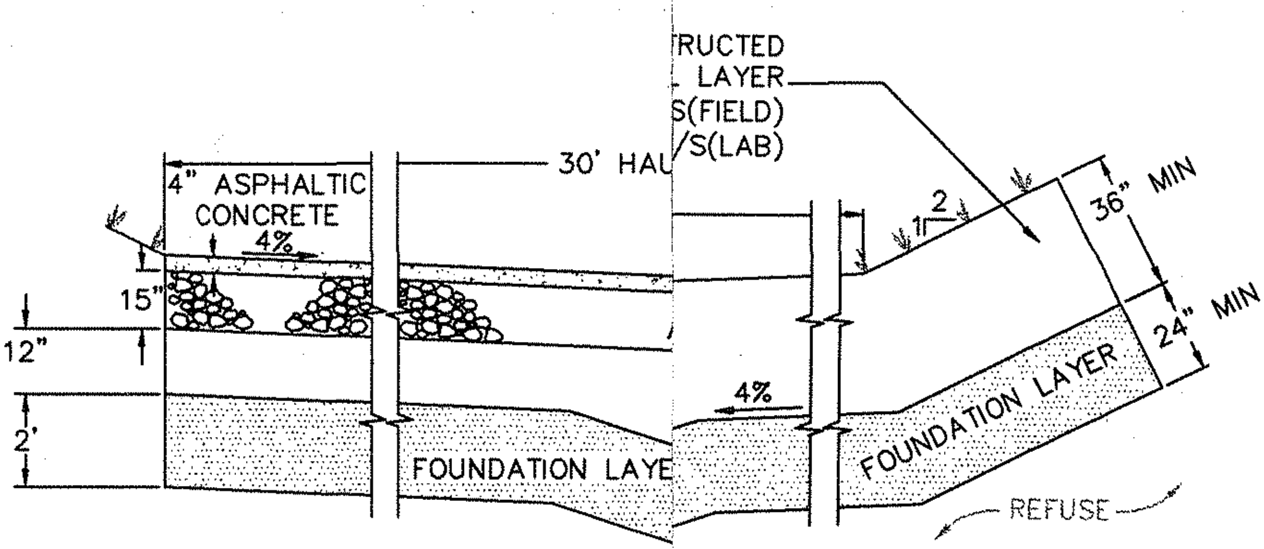


SCALE: 1" = 4'

GEOSYNTEC CONSULTANTS

MONOLITHIC SOIL FINAL COVER SLOPE/BENCH OF DISPOSAL AREA AB+ LOPEZ CANYON SANITARY LANDFILL	FIGURE NO.	2-3(b)
	PROJECT NO.	CE4100-04
	DATE:	NOV-18-98

4100F033.DWG



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4
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NOTES

1. MODIFIED 9-17-98 BY BOS TO REFLECT THE USE OF MONOLITHIC COVER

BASE DRAWING SUPPLIED BY GEOSYNTEC CONSULTANTS

FIGURE NO.	2-4
PROJECT NO.	
DATE:	NOV-18-98

DWG: 41F603-1

APPENDIX G

APPROVAL LETTERS FROM CIWMB, RWQCB AND LEA

(replace August 5, 1998 letter from LEA with attached)

ENVIRONMENTAL AFFAIRS
DEPARTMENT
L' 'IAN Y. KAWASAKI
ERAL MANAGER
201 TH FIGUEROA STREET
SUITE 200, MAIL STOP 177
LOS ANGELES, CA 90012
(213) 580-1040

CITY OF LOS ANGELES

CALIFORNIA

G -6 AM 9:34

RICHARD J. RIORDAN
MAYOR

August 5, 1998

FYI

Mr. Stephen Fortune, Division Manager
Solid Resources Engineering and Construction Division
City of Los Angeles Department of Public Works, Bureau of Sanitation
419 South Spring Street, Suite 800
Los Angeles, CA 90013

Re: Proposed Alternative Final Cover for Lopez Canyon

Dear Mr. Fortune:

The City of Los Angeles Local Enforcement Agency has received your request for conditional approval of the proposed monolithic cover design. We have reviewed the following documents submitted to us in the technical briefing meeting held on June 25, 1998 at Lopez Canyon.

1. Memorandum from E. Kavazanjian, Tarik Hadj-Hamou (GeoSyntec Consultants) to Kelly Gharios (BOS), Additional LEACHM Analyses, Engineered Alternative Final Cover Disposal Areas A, B, and AB+ Decks and Disposal Area A and AB+ Slopes, Lopez Canyon Sanitary Landfill, Lake View Terrace, CA., June 22, 1998

2. Construction Quality Assurance Plan, Final Cover Construction, Disposal Areas A, B, and AB+, Lopez Canyon Sanitary Landfill Lakeview Terrace, California, Revised June 25, 1998.

3. Initial Cost Estimate (rev. 10.89)

The LEA grants conditional approval for the use of an alternative final cover (for Deck of Disposal Areas A, B, and AB+, Slope of AB+) consisting of a three foot layer of borrow soil (k value of 1×10^{-5} cm/s) over an existing interim cover (k value of 4.5×10^{-4} cm/s, minimum two feet thick). Conditional approval is also granted for the use of the alternative final cover (existing interim cover) for the slopes of Disposal Area A. The approval is conditioned upon the following requirements:

Reviewed by: ______________________
Wayne Tsuda

Cc: Kelly Gharios (BOS)
Rod Nelson (RWQCB)
Peter Janicki (CIWMB)
Darryl Petker (CIWMB)
Ed Kavazanjian (GeoSyntec Consultants)

APPENDIX J

PROPOSED ENGINEERED ALTERNATIVE FINAL COVER ON THE SLOPES OF DISPOSAL AREAS A AND AB+ AND THE DECKS OF DISPOSAL AREAS A, B AND AB+

(replace in entirety with attached report)

ALTERNATIVE FINAL COVER
WATER BALANCE ANALYSIS
DECK OF DISPOSAL AREAS A, B, AND AB+
SLOPES OF DISPOSAL AREA A AND AB+
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

Prepared for:

Bureau of Sanitation
Resources Disposal and Engineering Division
Department of Public Works
City of Los Angeles
600 South Spring Street, Suite 600
Los Angeles, California 90014
(213) 893-8211

Prepared by:

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, California 92648
(714) 969-0800

Revision 2

13 November 1998

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TABLES

FIGURES

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FIGURES (continued)

APPENDICES

1. INTRODUCTION

1.1 Terms of Reference

This report presents a technical evaluation of the infiltration control performance of a monolithic soil cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at the Lopez Canyon Sanitary Landfill. The Lopez Canyon Sanitary landfill is an inactive California Class III municipal solid waste landfill located in the Lake View Terrace section of the City of Los Angeles, California. This report was prepared by the Huntington Beach, California office of GeoSyntec Consultants (GeoSyntec) for the City of Los Angeles Bureau of Sanitation (BOS).

This report was prepared at the request of Mr. Kelly Gharios, P.E., of BOS. The scope of services included in this report is described in the memoranda entitled Cost Estimate and Schedule for Engineering Services, Engineered Alternative Final Cover, Disposal Areas A, B, and AB+ Decks and Disposal Area AB+ Slopes, Lopez Canyon Restoration Project, dated 11 December 1997, and Cost Estimate for Engineering Services, Evaluation of Existing Soil Cover as a Monolithic Soil Final Cover on the Slopes of Disposal Area A, Lopez Canyon Restoration Project, dated 11 March 1998 from Edward Kavazanjian, Jr. and Tarik Hadj-Hamou of GeoSyntec to Mr. Gharios. The work presented in this report was performed under the GeoSyntec contract with BOS for engineering services in support of the Lopez Canyon Restoration project.

This report was prepared by Mr. Michael Reardon, Ms. Colleen Caldwell, and Dr. Tarik Hadj-Hamou, P.E., all of GeoSyntec. This report was reviewed by Dr. Edward Kavazanjian, Jr., P.E., G.E., also of GeoSyntec in accordance with the peer review policy of the firm.

1.2 Project Overview

The Lopez Canyon Sanitary Landfill is an inactive California Class III municipal solid waste landfill which is owned and was operated by the City of Los

Angeles (the City) Bureau of Sanitation (BOS). The Lopez Canyon Sanitary Landfill received waste from the mid-1970's until 1 July 1996. The Lopez Canyon Sanitary Landfill is located in the Lake View Terrace section of the City. The site location is shown in Figure 1-1.

The Lopez Canyon Sanitary Landfill covers approximately 399 acres (162 ha) of which 162 acres (65.6 ha) are designated for landfilling. The Lopez Canyon Sanitary landfill is divided into four disposal areas known as Disposal Areas A, B, AB+, and C. In order to accommodate closure of the slopes of Disposal Areas A and B in advance of final closure of the remaining disposal areas, the Final Closure Plan (FCP) [BAS, 1993] proposed that the closure of Lopez Canyon Sanitary Landfill be accomplished in two phases. Phase I closure includes the slopes of Disposal Areas A and B. Construction is currently underway on Phase I closure. Phase II closure includes the decks of Disposal Areas A, B, AB+, and C and the slopes of Disposal Areas AB+ and C. Phase II closure construction has yet to begin.

The currently proposed final cover for the decks of Disposal Areas A, B, AB+, and C and the slopes of Disposal Areas AB+ and C is described in *Final Closure Plan, Lopez Canyon Sanitary Landfill, Lakeview Terrace, Volume IV of IV, Replacement Amendment to Final Closure Plan [GeoSyntec, 1996]* and *Revision to Volume IV of IV, Replacement Amended to Final Closure Plan* [Bureau of Sanitation, 1997]. The currently proposed final cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ consist of the following components (from top to bottom):

- a vegetative layer at least 24-in. (600-mm) thick;
- a barrier layer composed of either compacted low-permeability soil with a hydraulic conductivity no greater than 1×10^{-6} cm/sec 12-in. (300-mm) thick or a geosynthetic clay liner (GCL); and
- a foundation layer at least 24-in. (600-mm) thick.

This currently proposed final cover meets or exceeds the prescriptive requirements of Section 21090(a) of Title 27 of the California Code of Regulation (27 CCR) for final covers. If compacted low-permeability soil is used as the barrier layer, the proposed cover conforms to the prescriptive requirements of 27 CCR. The use of a GCL as the barrier layer constitutes an engineered alternative to the prescriptive final cover.

State regulations provide explicit criteria that must be satisfied for approval of engineered alternatives to the prescriptive final cover in Section 20080(b) of 27 CCR. The objective of this report is to demonstrate that a monolithic soil cover is an engineered alternative that satisfies state regulations for the final cover at municipal waste landfill facilities with respect to infiltration resistance. The engineering evaluation conducted by GeoSyntec to demonstrate that a monolithic soil cover is an acceptable engineered alternative to the prescriptive final cover with respect to infiltration resistance include:

- reviewing federal and state requirements for final cover design;

- selecting an analytical model to compare the infiltration performance of the Title 27 prescriptive cover to that of the monolithic soil cover proposed as an engineered alternative;

- evaluating the geotechnical characteristics of the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+; and

- evaluating and comparing the performance of both the existing interim soil cover and a layer of compacted soil placed for the specific purpose of serving as an engineered monolithic soil cover to the Title 27 prescriptive soil cover for the site-specific conditions at the Lopez Canyon Sanitary Landfill.

- developing a performance evaluation program for the proposed monolithic soil cover, including details of the instrumentation, the monitoring frequency, and the performance evaluation methodology.

The analyses presented in this report demonstrate that the infiltration control performance of a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ can exceed the infiltration control performance of the Title 27 prescriptive cover if the monolithic soil cover has the appropriate hydraulic properties. As a monolithic soil cover can be shown to be equally effective as the prescriptive cover with respect to other final cover functions (e.g., waste isolation, erosion control), it may therefore be concluded that a monolithic soil cover with the appropriate hydraulic properties is an acceptable engineered alternative for the final cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at the Lopez Canyon Sanitary Landfill.

Analyses presented in this report indicate that the existing interim cover soil on the slopes of Disposal Area A are likely to have the appropriate hydraulic properties to serve as a monolithic soil final cover. A performance monitoring plan is provided to demonstrate that the existing interim soil cover provides satisfactory infiltration control. The analyses presented in this report also indicate that the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and on the slopes of Disposal Area AB+ do not have the appropriate hydraulic properties to serve as a monolithic soil final cover. Recommendations are provided for procurement of soil with the appropriate properties for use as a monolithic soil final cover in these areas. A monitoring program for implementation after placement of the procured soil is also provided herein to demonstrate that the infiltration performance of the monolithic soil cover exceeds that of the Title 27 prescriptive cover in these areas.

1.3 Report Organization

The remainder of this report is organized as follows:

- Section 2, *Background Information*, provides general background information regarding the Lopez Canyon Sanitary Landfill.

- Section 3, *Alternative Final Cover Requirements*, presents the relevant state and federal regulatory requirements and the proposed alternative final cover configuration.

- Section 4, *Water Balance Analysis*, describe the water mass balance equation and discusses the component of the equation. The section also describes the LEACHM computer program used to model infiltration through the alternative and prescriptive final covers and the input data required for the analyses. This section also presents the weather data selected for use in evaluating cover performance at the Lopez Canyon Sanitary Landfill.

- Section 5, *Geotechnical Evaluation of Existing Conditions*, describes the geotechnical field and laboratory investigation programs performed to assess the geotechnical characteristics of the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+.

- Section 6, *Monolithic Soil Final Cover Evaluation*, presents the infiltration control performance evaluation for the existing interim cover soil and of a layer of additional soil placed as a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and on the slopes of Disposal Areas A and AB+. This section also presents a comparison of the infiltration control performance of the Title 27 prescriptive cover to the existing interim cover and to an engineered monolithic soil cover at the Lopez Canyon Sanitary Landfill.

- Section 7, *Performance Evaluation Program,* presents recommendations for instrumentation and performance monitoring of the monolithic soil cover and the performance evaluation methodology.

- Section 8, *Summary and Recommendations*, summarizes the work described in the report and presents GeoSyntec's recommendations with respect to the use of a monolithic soil cover as an engineered alternative final cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at the Lopez Canyon Sanitary Landfill.

Tables, figures, and appendices are included at the end of this report.

2. BACKGROUND INFORMATION

2.1 General

The Lopez Canyon Sanitary Landfill is owned by the City of Los Angeles and is located at 11950 Lopez Canyon Road in Lakeview Terrace, California. The Lopez Canyon Sanitary Landfill received waste from mid-1970's until it closed on 1 July 1996. Closure construction work at Lopez Canyon Sanitary Landfill started on the slopes of Disposal Areas A and B on 7 July 1996. As of 31 December 1997, 17 acres of the slopes of Disposal Area B have been closed in accordance with the prescriptive requirements.

2.2 Climate

The Lopez Canyon Sanitary Landfill is located within, but on the margin of, the Los Angeles basin. The Los Angeles basin area climate can best be described as relatively mild, with cool, wet winters and warm, dry summers, both moderated by sea breezes. This climatic pattern is caused by a semi-permanent high pressure system from the eastern Pacific Ocean. During the summer months, this high pressure system is generally located in a northern position and prevents storms from moving across the region.

The climate in the area of the Lopez Canyon Sanitary Landfill is characterized as semi-arid. The 100-year mean rainfall in the vicinity of the site is approximately 16 in. (406 mm). This precipitation falls predominately during the winter months (November through March). Typical daily high temperatures for the area range from approximately 60° F (15.5° C) in the winter to 95° F (35° C) in the summer. Typical daily low temperatures for the area range from approximately 40° F (4.5° C) in the winter to 60° F (15.5° C) in the summer.

2.3 Existing Conditions

The Lopez Canyon Sanitary Landfill is divided into four disposal areas, denoted as Disposal Areas A, B, AB+, and C. The limits of these four disposal areas are shown in Figure 2-1. Closure construction has already commenced on the slopes of Disposal Areas A and B. The final cover in these areas is the prescriptive final cover contained in California Title 27 regulations and is composed of a 2-ft (0.6-m) vegetative soil layer underlain by 1 ft (0.3 m) of low-permeability soil with a hydraulic conductivity less than or equal to 1×10^{-6} cm/s underlain by a foundation soil layer at least 2 ft (0.6 m) thick. The final closure plan currently calls for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ to be covered with either the same final cover as the slopes of Disposal Areas A and B (i.e., the Title 27 prescriptive final cover) or an alternative final cover that uses a GCL composed of 0.25 in. (6.25 mm) of bentonite soil with a saturated hydraulic conductivity less than or equal to 5×10^{-9} cm/s in lieu of the 1-ft (0.3-m) layer of compacted low-permeability soil. The infiltration resistance of the GCL has been shown to be superior to that of the prescriptive clay barrier layer in satisfaction of the regulatory requirements for an alternative final cover.

The decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ are currently covered with an interim soil cover. Test pits excavated on the existing interim cover on the slopes of Disposal Areas A and AB+ and on the decks of Disposal Areas A, B, and AB+ indicate that the thickness of the existing interim cover in these areas ranges from a minimum of 2 ft (0.6 m) to over 18 ft (5.5 m).

2.4 Proposed Alternative Cover

Monolithic soil covers are being used with increasing frequency in southern California as an alternative to the Title 27 prescriptive cover for California Class III municipal solid waste landfills. The increasing popularity of the monolithic soil cover can be attributed to both lower cost and superior performance. The monolithic soil cover alternative is cheaper than the prescriptive final cover because the monolithic soil cover is generally cheaper to procure, is cheaper and easier to construct, and is cheaper to maintain and repair. The performance of the monolithic soil cover, if properly configured, is superior to that of the Title 27 prescriptive soil cover because, in the semi-arid to arid southern California climate, it can have superior infiltration resistance and it is less susceptible to degradation (e.g., cracking during and after construction from desiccation and/or differential settlement). Due to the potential for enhanced performance at a lower cost, the BOS requested that GeoSyntec perform the analyses described herein to determine the range of soil properties and cover thicknesses within which the infiltration resistance of the monolithic soil cover exceeds that of the Title 27 prescriptive cover at the Lopez Canyon Landfill.

3. ALTERNATIVE FINAL COVER REQUIREMENTS

3.1 Regulatory Considerations

3.1.1 Federal Regulations

The federal regulations for closure of municipal solid waste landfills are found in Section 258.60 of 40 Code of Federal Regulations (CFR) Subpart F - Closure and Post Closure (Subtitle D). The federal regulations provide that the final cover of a municipal solid waste landfill shall:

- be designed to minimize percolation and erosion;
- include a barrier layer with a minimum thickness of 18 in., a maximum permeability (saturated hydraulic conductivity) of 1×10^{-5} cm/s, and a permeability less than or equal to the bottom liner system and natural subsoils present; and
- include an erosion layer, a minimum of 6-in. thick, capable of sustaining native plant growth.

The federal regulations allow the director of an approved state, such as California, to approve an alternative design to the prescriptive final cover design provided that the performance of the barrier layer and erosion layer are shown to be equivalent or superior to the performance of the prescribed layers with respect to percolation and wind and water erosion.

3.1.2 State Regulations

The state of California regulations for design and construction of final covers for closure of municipal solid waste landfills are found in Title 27 of the California Code of Regulations (27 CCR). These are the same regulations formerly contained in 14 CCR and 23 CCR.

Section 21090(a) of 27 CCR, provides the following requirements for the final cover, called herein the "Title 27 prescriptive cover":

- a foundation layer of at least 2 ft, unless the Regional Board finds that differential settlement of the waste and ultimate land use allow for a lessor thickness without impacting the integrity of the cover;

- a "low hydraulic-conductivity" layer not less than one-foot thick with a minimum permeability of 1×10^{-6} cm/s and a permeability equal to or less than any bottom liner or underlying natural materials;

- a vegetative layer containing no waste or leachate, placed on top of the barrier layer, not less than one foot and of greater thickness than the rooting depth of any vegetation planted on the cover; and

- design and construction which provides for the minimum maintenance possible.

State regulations also allow engineered alternatives to the Title 27 prescriptive cover. Criteria are provided for both Regional Water Quality Control Board (RWQCB) and California Integrated Waste Management Board (CIWMB) approval of an engineered alternative final cover. Sections 20080(b) and (c) of Title 27 provide the criteria for approval of an engineered alternative by the RWQCB. These criteria are:

- The prescriptive standard is not feasible because it is unreasonable and unnecessarily burdensome and will cost substantially more than alternatives which meet criteria, or the prescriptive standard is not feasible because it is impractical and will not promote attainment of applicable performance standards; and

- There is a specific engineered alternative that is consistent with the performance goal of the prescriptive standard and affords equivalent protection against water quality impairment.

Section 21140 of 27 CCR provides criteria for CIWMB approval. This section allows for alternative covers provided the design will function with minimum maintenance and provide waste containment to protect public health and safety by controlling at a minimum, vectors, fire, odor, liter and landfill gas migration. The alternative final cover shall also be compatible with post-closure land use.

It should be noted that the RWQCB and CIWMB have already approved an alternative final cover for the decks of Disposal Areas A, B, and AB+ in which a GCL is used in lieu of the low hydraulic conductivity layer of the Title 27 prescriptive cover on the basis of superior infiltration resistance.

3.2 Proposed Alternative Final Cover Configuration

The monolithic soil final cover is an engineered alternative final cover which has been previously approved by the RWQCB for other sites in the region on a conditional basis. The monolithic soil cover design concept utilizes a single layer of soil several feet thick to serve the combined functions of the vegetative layer and the barrier layer in the Title 27 prescriptive cover. The monolithic soil cover is typically vegetated with native plants that live on the natural seasonal precipitation. The monolithic soil cover controls infiltration by the following mechanism: rain water percolates into the monolithic soil cover and is stored by capillary tension in the soil until removed by evaporation and transpiration. The monolithic soil cover must have sufficient storage capacity to retain the infiltrating water until the storage capacity of the soil is restored by evaporation. The conditional approvals granted to date by the RWQCB have required performance monitoring of monolithic soil covers after construction to demonstrate their effectiveness.

3.3 Technical Approach for Demonstrating Compliance

Monolithic soil covers have been approved as alternative final covers on the following basis. There is essentially no difference between the erosion resistance of a monolithic soil cover and the Title 27 prescriptive cover. Furthermore, in arid and semi-arid environments, the ability of the Title 27 prescriptive cover to control infiltration may be impaired due to desiccation and cracking due to differential settlement. This cracking may result in a diminished ability of the Title 27 prescriptive cover to attain the applicable performance standard. The monolithic soil cover will also be less expensive to construct and should require less maintenance than the Title 27 prescriptive cover. Therefore, if the infiltration control performance of a monolithic soil cover in the semi-arid climate of the Lopez Canyon Sanitary Landfill can be shown equivalent or superior to the infiltration control performance of the Title 27 prescriptive cover under the as-designed conditions, the monolithic soil cover may be said to afford superior protection against water quality impairment and the monolithic soil cover should be acceptable as an engineered alternative final cover per the governing regulations.

The technical approach used to demonstrate that a monolithic soil cover performs as well or better than a Title 27 prescriptive cover with respect to infiltration control consists of water balance analyses of the two final cover concepts under similar, representative climate conditions. The water balance analyses are used to show that the percolation through a monolithic soil cover is less than the percolation through a Title 27 prescriptive cover for the climatic conditions found at the landfill site. The technical approach includes the following steps:

- Selection of a Water Balance Model.
- Evaluation of Material Properties.
- Evaluation of Climate Data.
- Evaluation of the Vegetation Properties.
- Monolithic Soil Cover Design.
- Water Balance Evaluation and Comparison.
- Instrumentation and Monitoring of Monolithic Soil Cover.
- Calibration of Water Balance Model.
- Final Water Balance Evaluation and Comparison.

The nine steps of the above technical approach are employed in the remainder of this report.

4. WATER BALANCE ANALYSIS

4.1 Introduction

The water balance analysis presented in this report uses an unsaturated flow computer code. The computer code employs a mass balance finite difference based approach to predict unsaturated flow. A description of the components of the mass balance equation used in the computer code is presented in Section 4.2. Details of the computer code and specific input used in the computer simulations are provided in Section 4.3.

4.2 Water Balance Equation

The computer code used in the analyses presented in this report employs a mass balance finite difference based calculation to track infiltration (percolation) through the cover. The mass balance equation presented below represents the conceptual approach taken by the computer model in predicting the hydrologic performance of the final cover system.

Water Balance Equation:

$$Perc = P - Of - \Delta S - (E+T)$$

Where: Perc = Percolation that has passed through the cover,
P = Precipitation falling on the cover,
Of = Overland flow, or precipitation runoff,
ΔS = Change in soil storage of infiltration,
E = Evaporation, and
T = Transpiration of vegetation.

The following sections define the various components of the mass balance equation, and how they may affect an earthen cover system performance.

4.2.1 Percolation

Percolation is the result of the mass balance calculation. Percolation is defined as the quantity of water, typically expressed as volume per unit time, that exits the base or bottom layer of the cover system. Water that enters, or infiltrates the cover but does not exit the cover is termed infiltration. Percolation may consist of water that either infiltrates the cover by rainfall, snowmelt or that is released from the cover soil storage component. Water is released from soil storage when the soil is placed at a water contents higher than the soils natural equilibrium water content with the atmosphere.

4.2.2 Precipitation

Precipitation, for purposes of this report, is defined as rainfall that lands on the cover surface. (In areas of colder climates the water equivalent of snowfall must also be included.) Of significance to an earthen cover's hydraulic performance is both the total magnitude and distribution of precipitation.

4.2.3 Overland Flow

Overland flow is defined as precipitation that falls on the cover but does not infiltrate. There is a maximum rate at which a soil profile can absorb water. When the rate of precipitation exceeds this maximum rate, overland flow is generated.

4.2.4 Soil Storage

Soil storage is defined as the volume of water that is held in the pore spaces of the soil. A change in soil storage corresponds to a change in soil water content. The maximum storage capacity of a soil is the storage capacity at saturation. The soil may approach saturation, and thus the storage capacity of soil may become depleted, with repeated rainfall events. A period of dry weather may restore the storage capacity of the soil. The water contained in a soil layer can move downward as percolation driven by the unsaturated hydraulic conductivity and potential gradient present in the soil. Water contained in a soil layer can be removed by evaporation and transpiration. Upward movement is also driven by suction gradients created in the soil when a lower moisture content exists at an upper depth, usually created by evaporative or transpirative losses. All of these water movements can affect soil storage capacity (i.e., change the water content of the soil).

4.2.5 Evaporation

For the purposes of this report, evaporation is defined as water held in soil storage that is converted from the liquid to the gas phase. The energy required for the phase change comes primarily from solar radiation and the relative humidity of the atmospheric air above the soil cover. Comparatively, evaporative losses from the upper soil layers are greater in dry, warm, sunny days, than on cloudy, rainy, or cool days. Evaporation is a factor in restoring soil cover storage. Water lost from the soil layers by evaporation combined with the water losses from plants (transpiration) is termed evapotranspiration. The following section discusses transpiration.

4.2.6 Transpiration

Water lost due to the action of plants on the soil cover is termed transpiration. Water flows through the plant, from the soil to the air, along a gradient of decreasing water potential. The water movement through the plant is driven a potential gradient created by solar powered evaporation at the leaf surface, which maintains a low water potential in leaves. This potential gradient enables roots to extract water from the soil in proportion to their rooting depth during the daylight hours. Cohesion and adhesion of water molecules to holds the microscopic water column inside the plant stems together.

The gradients that are created by evaporation at the leaf surface are only strong enough to extract water at a certain maximum soil suction. The soil suction at which plant roots can no longer extract water is termed the wilting point. The roots of a plant must also exert a suction themselves to prevent water loss from the root to the soil if the soil dries and the soil suction becomes less than the wilting point. A minimum root water potential less than the wilting point is created by osmotic suctions in the root cells to prevent these losses. Roots also become less efficient in the uptake of water at greater depths due to a decrease in the driving gradient. A root resistance factor, with a value greater than one, approximates this occurrence. Transpiration and evaporation both work to remove soil water from storage, creating upward suction gradients and acting to dry out the soil profile. This drying action restores the soil storage capacity for future rain events. These processes are enhanced by prolonged periods of dry, warm, and sunny weather.

4.3 LEACHM Model

LEACHM (Leachate Estimation and Chemistry Model) [Hutson and Wagenet, 1992], a one-dimensional finite-difference computer program, was selected as the water balance model for comparison of the performance of the monolithic soil cover to that of a Title 27 prescriptive cover. LEACHM was selected because it has already been accepted by several southern California RWQCB's as the basis for conditional regulatory approval of monolithic soil covers (pending performance monitoring of the as-constructed cover). LEACHM simulates water and solute transport through unsaturated soils to a maximum depth of 6.6 ft (2 m). LEACHM uses Richards' equation [Richards, 1931] to simulate flow of water in unsaturated soils. The model has algorithms to predict evaporation from the soil surface and transpiration of plants from the root zone. Precipitation in excess of the infiltration capacity of the profile is shed as overland flow.

LEACHM models the unsaturated hydraulic conductivity of soil at a given water content using Campbell's prediction function [Campbell, 1974]. LEACHM uses a soil-water retention fitting program to compute fitting parameters for Campbell's soil-water retention function from engineering and index properties of the soil. Site specific measured soil parameters and weather data can be used for model input. The specific input file variables are discussed in more detail in the following section.

4.4 Input Parameters

4.4.1 General

The input file parameters and variables for LEACHM include soil properties, weather data, vegetation data, finite-difference nodal arrangement, initial conditions and boundary conditions. The following sections discuss the selection process for the input parameters.

4.4.2 Soil Properties

Soil properties input for LEACHM consist of saturated hydraulic conductivity and fitting parameters for the Campbell's soil-water retention function.

The fitting parameters for the Campbell's soil water retention function can be derived in two ways using LEACHM. The first way is to directly input measured moisture content and soil suction values into the model's curve fitting program. The measured values are typically evaluated in the laboratory using pressure plate apparatus [ASTM D 2325]. The second way is to use one of the several regression equations integrated in the curve fitting program to calculate the retention fitting parameters. The input to the regression equations consist of grain size distribution parameters, bulk density, and one match point of hydraulic conductivity and soil suction. This match point is usually specified as the saturated hydraulic conductivity at zero suction.

Both of the methods described above were used to obtain retention fitting parameters for soils used in evaluations presented in this report. Soil water retention properties were directly evaluated from laboratory testing data for the existing interim cover soils. Figure 4-1 shows the result of the moisture retention test (ASTM D 2325) conducted on a sample collected in Test Pit A-6. The figure shows the variation of volumetric moisture content, θ, as a function of suction, h. The figure also shows the Campbell's soil water retention function fit through the data obtained in the laboratory test. The Campbell's soil water retention function relates the suction, h, to the volumetric moisture content, θ and is defined by the following two equations:

$$h = a\left(\frac{\theta}{\theta_s}\right)^{-b} \quad \text{for } \theta > \theta_c$$

$$h = a\,\frac{\left[\dfrac{\theta_s - \theta}{\theta_s}\right]^{1/2}\left[\dfrac{\theta_c}{\sigma_c}\right]^{-b}}{\left[\dfrac{\theta_s - \theta_c}{\theta_s}\right]} \quad \text{for } \theta_c > \theta > \theta_s$$

with

$$\theta_c = \frac{2b\,\theta_s}{(1+2b)}$$

where a and b are the parameters of Campbell's soil water retention function, θ_s is the volumetric moisture content at saturation, and θ_c is the volumetric moisture content separating the domain of validity of each equation used to define the moisture retention curve. The Campbell's soil water retention curve fit through the data obtained from the laboratory test in sample for Test Pit A-6 is characterized by a = 0.26, b = 9.703, θ_c = 0.3624, and θ_s = 0.3811.

The curve fitting method was used to develop soil properties for potential import soils. Further description of the soil sampling and laboratory testing of the existing interim cover soils can be found in Section 5 of this report. Input values used in the LEACHM analysis for the properties of the generic import and existing cover soils are presented in Section 6 of this report.

4.4.3 Weather Data

Weather data for LEACHM include daily precipitation, daily minimum and maximum air temperatures, and pan evaporation rates. However, in the absence of pan evaporation data, the pan evaporation rate can be calculated by LEACHM using the Linacre equation [Hutson and Wagenet, 1992] and data about location of the site (latitude, elevation) and weather (temperature, precipitation). LEACHM can perform infiltration simulations for durations of up to 10 years. Simulations performed for the Lopez Canyon Sanitary Landfill used 10 years of actual weather data selected as indicated below.

Weather data used for the Lopez Canyon Sanitary Landfill simulations was obtained through the use of a weather database published by EarthInfo, Inc. EarthInfo, Inc. obtains data from the National Climatic Data Center (NCDC) for weather stations nationwide [EarthInfo, 1996].

A search of the EarthInfo, Inc. data base revealed that seven weather stations lay within an approximate radius of 17 miles (10.6 km) of the Lopez Canyon Sanitary Landfill. Table 4-1 lists these stations and summarizes their characteristics. Of particular importance is the station elevation, number of record years, percent coverage (or data completeness), the average rainfall for the period of record, and distance from Lopez Canyon Sanitary Landfill.

Precipitation is one of the major factors affecting cover performance. Annual precipitation totals and statistics for the entire period of record consisting of the average and standard deviation were studied for each weather station in comparison to available Lopez Canyon Sanitary Landfill statistics. Generally, as stations increase in elevation temperatures become cooler and precipitation increases. Likewise, as elevations decrease temperature extremes drop and precipitation decreases. The disposal areas of Lopez Canyon Sanitary Landfill under consideration for monolithic soil cover are at an approximate elevation of 1500 ft (450 m) mean sea level. The station that best approximates this elevation and is the closest to Lopez Canyon Sanitary Landfill is the Sunland station.

The Sunland station has an annual average precipitation of 16.18 in. (410 mm) per year for the period of record (18 years). The 100-year mean rainfall for the Lopez Canyon Sanitary Landfill is approximately 16 in. (406 mm) per year. The time period of 1951 through 1962 for the Sunland station has an average annual precipitation of approximately 18.1 in. (460 mm) per year and includes several wet years of 35.43, 19.97, and 19.8 in. (900, 507, 503 mm) of precipitation. Thus, the 10-year period 1951 to 1962 from the Sunland weather station was deemed a conservative representation of a 10-year weather pattern of the Lopez Canyon Sanitary Landfill. The daily precipitation and daily minimum and maximum temperature values from the Sunland station for the time period of 1951 through 1962 were used for weather data input to LEACHM. Figure 4-2 displays a plot of the cumulative annual precipitation values from the Sunland station from 1951 through 1962. Also shown in Figure 4-2 is the 100-year average rainfall at Lopez Canyon Sanitary Landfill.

4.4.4 Vegetation Data

Plant data for LEACHM include:

- root depth and root distribution;
- plant growth options of constant vegetation and "growing" vegetation;
- wilting point;
- minimum root potential;
- maximum ratio of actual to potential transpiration;
- root resistance; and
- germination, emergence, maturity, and harvest dates.

Grasses planted and established on alternative final covers can have an average root depth of up to 18 in. (200 to 450 mm). However, to be conservative, a root depth of 12 in. (30 cm) was used in the model. A vegetation growth option of constant vegetation was selected. Vegetation percent coverage was input at 75 percent for the LEACHM simulations. A wilting point of 1,500 kPa and a minimum root potential 3,000 kPa were input to the program. The maximum ratio of actual to potential transpiration and root resistance were set at 1.1 and 1.05, respectively. These are typical values recommended by Dr. Hutson for southern California [personal communication, 1996] in the absence of species-specific information. The values for the germination, emergence, and maturity dates of vegetation are overridden when the constant vegetation option is selected.

4.4.5 Finite-Difference Nodal Arrangement

The LEACHM model has the capacity to simulate the vertical water regime in a saturated or partially saturated soil profile up to 6.6 ft (2 m) thick. The soil profile to be simulated is divided into a number of horizontal layers of equal thickness. Soil properties are specified for each layer. Soil properties may vary from layer to layer to simulate layered profiles. Nodes are situated at the center of each layer for finite difference calculations. Two additional nodes are required for boundary conditions, one above the surface and one below the lowest depth.

For the covers simulated at Lopez Canyon Sanitary Landfill the profiles were divided into 20 to 25 layers depending on the thickness of the cover. Nodal spacing was kept constant at 2.4 in. (60 mm) for all simulations. Each layer was assigned specific properties according to the soil it models. The maximum time step for iteration was set at 0.05 day. LEACHM reduces this time step, depending on the rate of precipitation, to gain added accuracy in the water balance calculation.

4.4.6 Initial and Boundary Conditions

Initial conditions for LEACHM are specified by assigning the initial head or water content to each node in the finite-difference nodal grid. Initial water content conditions are either volumetric water contents corresponding to optimum conditions, as defined by Proctor compaction tests, for assumed borrow source soils, representative in-situ moisture contents for in-place cover soils, or published literature values for soils used in the Title 27 prescriptive cover design. The values used for model input are given in Section 6, Monolithic Soil Cover Evaluation.

The boundary condition at the bottom of the soil column can be selected as a fixed water table, free drainage (or unit gradient), zero flux, or lysimeter boundary. The simulations were conducted by using the lower boundary as a unit gradient boundary. This boundary condition allows water to flow through the bottom of the cover in an unsaturated condition at less than field capacity.

5. GEOTECHNICAL EVALUATION OF EXISTING INTERIM COVER

5.1 Introduction

A geotechnical investigation of the characteristics of the existing interim cover was conducted on the slopes of Disposal Areas A and AB+ and the decks of Disposal Areas A, B, and AB+. The purpose of the geotechnical investigation was to evaluate the thickness of the existing interim cover and to assess the material properties of the soils in the existing interim cover for use in LEACHM analyses.

The geotechnical investigation consisted of a field investigation and a laboratory testing program. The field investigation included the excavation of test pits, logging of the test pits, in-situ measurement of unit weight and moisture content of the existing interim cover, and collection of bulk samples for laboratory testing.

The test pits were excavated by the on-site City operations crew using a John Deere 892 ELC excavator with a 4 ft (1.2 m) wide bucket. Test pit excavations were performed in Level D PPE (including half-mask respirators) in accordance with GeoSyntec's Site Health and Safety Plan. Air monitoring during excavations was performed by on-site gas inspectors in accordance with the Lopez Canyon Sanitary Landfill Health and Safety Plan for excavations in waste. Following completion of each test pit excavation, the test pit was backfilled with the excavated material. The backfilled material was compacted by track-walking with the excavator. The test pits were logged by Colleen Caldwell, GeoSyntec staff engineer. Detailed test pit logs are provided in Appendix A.

The in-situ unit weight and moisture content of the interim existing cover were measured using a Troxler 3440 nuclear density moisture gauge [ASTM D 2922]. In-situ unit weight testing was limited to shallow surfaces (depth of 8 in. (200 mm)) due to disturbance caused by excavation at depths greater than 1 ft (0.3 m). In-situ testing for unit weight was further limited by presence of gravel and cobbles in the top 6 to 8-in. (150 to 200 mm) of the existing interim cover on the deck of Disposal Areas A and AB+ and by the stockpile present on the decks of Disposal Areas A and B.

Bulk samples were collected from each excavated test pit. The bulk samples were visually classified at the Huntington Beach laboratory of GeoSyntec. Representative samples of the different types of soil encountered during the excavation were shipped to GeoSyntec's Geomechanics and Environmental Laboratory (GEL) in Atlanta, Georgia for testing.

The remainder of this section presents the results of the field investigations on the slopes of Disposal Areas A and AB+ and the decks of Disposal Areas A, B, and AB+.

5.2 Deck of Disposal Area AB+

A total of 15 test pits, designated AB-1 through AB-13, AB-24, and AB-25, were excavated during the field investigation of Disposal Area AB+ deck. The locations of the test pits are reported in Figure 5-1.

The thickness of the existing interim cover on the deck of Disposal Area AB+ varies from 2 ft (0.6 m) to 11 ft (3.3 m). Table 5-1 summarizes the elevation of existing interim cover and thickness of interim existing cover at each test pit. The detailed logs for the test pits are provided in Appendix A.

The soils found in the test pits were visually classified as being predominantly silty sands with gravel and cobbles in test pits AB-1 through AB-8, AB-10 through AB-13, and AB-25. In test pit AB-3, a layer of darker brown sandy-clayey silt was found at depth 0 to 4 ft (0 to 1.2 m). Based on discussion with the City operations crew, it was decided that this represents a mix of various stockpiles placed after the landfill had reached final grade. Bulk samples from AB-3, AB-4, AB-7, AB-10, and AB-25 were selected as representative of the range of soils found in the existing interim cover on the decks of Disposal Area AB+ and were shipped to GEL for laboratory testing.

The in-situ unit weight of the existing interim cover was evaluated using the nuclear gauge method [ASTM D 2922]. The in-situ dry unit weight was measured at test pits AB-1, AB-2, AB-10, AB-11, and AB-25 and was found to range from 76 to

98 percent of maximum dry unit weight obtained from ASTM D 1557 (76 to 98 percent relative compaction), with an average value of 88.6 percent relative compaction. The presence of gravel and cobbles within the top 10 in. (250 mm) of the existing interim cover impaired the installation of the nuclear gauge at other test pit locations for measurement of in-situ dry density. In addition, it was not possible to reliably measure the dry density at depth greater than about 1 ft (0.3 m) because of the disturbance to the soil caused by the excavator bucket. Consequently, it was decided on site to assume that the in-situ unit weight of the existing cover soil was on the order of 85 percent of maximum dry unit weight as obtained from ASTM D1557. Based upon GeoSyntec's experience in evaluating interim soil covers at southern California landfills, this is a reasonable value.

5.3 Slopes of Disposal Area AB+

A total of ten test pits designated AB-14 through AB-23, were excavated on the slopes of Disposal Area AB+. The thickness of the existing interim cover on the slopes of Disposal Area AB+ averaged 3 to 10 ft (0.9 to 3 m) on the lower slopes and 2 to 3 ft (0.6 to 0.9 m) on the upper slopes. The locations of the test pits are shown on Figure 5-1. The thickness of existing soil cover at each test pit is reported in Table 5-2. Detailed logs of the test pits are provided in Appendix A.

The existing interim cover soils on the slopes of Disposal Area AB+ were visually classified as silty sands with gravel and cobbles (Test pits AB-14, AB-16, AB-19, and AB-23) and sandy-clayey silts (AB-17, AB-18, AB-20, AB-21, and AB-22). According to City Operations personnel, the soil placed on the slopes of Disposal Area AB+ are a combination of both daily cover soils and/or cover fills employed for hot spot repairs.

5.4 Deck of Disposal Area A

A total of five test pits designated A-1 through A-5, were excavated on the deck of Disposal Area A. The locations of the test pits are reported in Figure 5-1 and detailed logs are provided in Appendix A. At the time of the investigation, The laboratory testing program included:

- soil classification per ASTM D 2487, including associated index testing (sieve analysis ASTM D 422, hydrometer, moisture content ASTM D 422, Atterberg limits ASTM D 4318);
- modified Proctor compaction tests (ASTM D 1557); and
- saturated hydraulic conductivity tests (ASTM D 5084; and
- moisture retention tests (ASTM D 2325).

A summary of the laboratory test results performed on representative bulk samples is presented in Table 5-5. Complete laboratory testing result are presented in Appendix B.

5.7.2 Laboratory Testing Results

A summary of the results of laboratory testing performed on representative bulk samples obtained during the interim final cover field investigation are presented in Table 5-5. As shown in this table, the existing interim cover soils on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ classify primarily as clayey sand or silty sand (SC or SM) according to the Unified Soil Classification System (ASTM D 2487).

The saturated hydraulic conductivity was measured on two representative samples of soil collected on the deck of Disposal Area AB+. The saturated hydraulic conductivity tests (ASTM D 5084) were performed on remolded samples. Based on field observation and result of in-situ measurements, a dry density of about 85 to 90 percent of maximum dry density measured in accordance with ASTM D 1557 was deemed representative of in-situ conditions of the existing interim cover on the decks of Disposal Area AB+. Consequently, two hydraulic conductivity tests were performed. The first test was performed on a sample from test pit AB-10 compacted to a dry density of 85 percent of maximum dry density at a moisture content equal to 2 percent greater than the optimum water content obtained from ASTM D 1557. The second test was performed on a sample from test pit AB-25 compacted to a dry density of 90 percent of the maximum dry density at a moisture content equal to 2 percent greater than the optimum moisture content obtained from ASTM D 1557.

The saturated hydraulic conductivity were measured to be 4.5×10^{-4} cm/s on the remolded sample from test pit AB-10 and 7.6×10^{-5} cm/s on the sample from test pit AB-25. A saturated hydraulic conductivity of 4.5×10^{-4} cm/s was then used to characterize the existing interim cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ for further engineering evaluations. The heterogeneity of the soils composing the existing interim cover and the presence of gravel within the silty sand and clayey sand favored the use of the higher value of saturated hydraulic conductivity measured in the laboratory for these subsequent analyses.

To further characterize the existing interim cover on the decks of Disposal Area AB+, a moisture retention test (ASTM D 2325) was performed on a sample from test pit AB-10. The results of this test are provided in Appendix B. The results from the moisture retention test were used to characterize the foundation layer in the water balance evaluation of the monolithic soil cover and Title 27 prescriptive cover.

The saturated hydraulic conductivity was measured on the four samples of soil collected on slopes of Disposal Area A. The saturated hydraulic conductivity tests (ASTM D 5084) were performed on remolded samples. Based on field observation and result of in-situ measurements, a dry density of about 90 percent of maximum dry density measured in accordance with ASTM D 1557 was deemed representative of in-situ conditions of the existing interim cover on the slopes of Disposal Area A. Consequently, the hydraulic conductivity tests were performed. Samples from test pits A6, A8, A9, and A10 compacted to dry densities of 90 percent of maximum dry density at a moisture content equal to 2 percent greater than the optimum water content obtained from ASTM D 1557.

The saturated hydraulic conductivity on the four samples from the slopes of Disposal Area A were measured to range from 3.6×10^{-6} cm/s to 8.6×10^{-5} cm/s. An average saturated hydraulic conductivity of 4.6×10^{-5} cm/s was then used to characterize the existing interim cover on the slopes of Disposal Area A for further engineering evaluations.

To further characterize the existing interim cover on the slopes of Disposal Area A, a moisture retention test (ASTM D 2325) was performed on a sample from test pit A6. The results of this test are provided in Appendix B. The results from the moisture retention test were used to characterize the existing soil cover in the water balance evaluation of the monolithic soil cover and Title 27 prescriptive cover.

6. MONOLITHIC SOIL FINAL COVER EVALUATION

6.1 Vegetation

An important factor governing the performance of the monolithic soil cover is evapotranspiration. Evapotranspiration of infiltration water from the cover soil requires the establishment of vegetation on the cover. The vegetation type selected should have the ability to establish itself and survive on the natural seasonal precipitation of the site and should display rooting depths of at least 12 to 18 in. (200 to 450 mm).

A seeding program should include vegetation that will establish quickly, provide a percent coverage as great as possible, and will be self sustaining. The main variables to be controlled for a successful seeding program in the Southern California interior area consist of the time of planting, the method of planting, and the type of species that are planted. Only plant species that can survive on the natural precipitation should be considered for vegetating the slopes of the Lopez Canyon Sanitary Landfill. These requirements are consistent with the seed mix currently established for the final cover at Lopez Canyon.

The time of planting should be in the fall prior to the natural seasonal rains. This timing allows the plants to achieve rapid seeding and sufficient biomass to sustain them through the summer months. Seeding at other times of the year may be performed with some degree of success if irrigation is used during the establishment period. However, some species of grasses may be more susceptible to summer funguses when not fully mature. Generally only 10 to 11 in. (250 to 275 mm) of rainfall is required to sustain the perennial grasses found in the area of the Lopez Canyon Sanitary Landfill, eliminating the need for irrigation if planted during the fall. Therefore, it is recommended to plant during the fall [Paul Albright, 1997].

Hydroseeding is a proven method for planting seeds over large open areas that involves spraying the seeds onto the desired areas with water as the transport medium. Hydroseeding will be utilized for the Lopez Canyon Sanitary Landfill seeding program. The hydroseeding process can be used to deliver nutrients, pesticides, or fungicides along with the seeds. A nutrient analysis of the final cover soil could be performed to asses whether or not there exist any gross nutrient deficiencies. Specific additives should be per the recommendation of the seed supplier.

Following hydroseeding the placement of a protective cover or mulch may be used. A protective cover or mulch helps prevent erosion of soil by reducing the effects of rainfall impact and runoff, and wind while providing a suitable environment for the development of the vegetative cover. Types of covers or mulch consist of plastic sheeting, hay, straw, chipped wood, and synthetic or natural nettings and blankets.

The specific species to be planted consist of mostly grasses that can survive on the natural precipitation of the area. Table 6-1 lists the seed mix recommended for Lopez Canyon Sanitary Landfill. This mix is designed for fast vigorous establishment of a final cover of native vegetation that reseeds itself. The recommended application density is on the order of 72 lb per acre (0.79 kN/ha).

6.2 Existing Interim Soil Cover Performance Evaluation

6.2.1 Decks of Disposal Areas A, B, and AB+ and Slopes of Disposal Area AB+

The characteristics of the existing interim cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ were established through the field investigation and laboratory testing program described in Section 5.2, 5.3, 5.5, 5.6, and 5.7. The thickness of the existing interim cover was found to vary from 2 ft (0.6 m) to 11 ft (3.3 m) over decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+. The soils found in the existing interim cover in these areas range from silty sand to clayey sand with gravel.

The in-situ dry density of the existing interim cover soils on the decks of Disposal Areas A, B, and AB+ and on the slopes of Disposal Area AB+ was measured to range from 76 to 98 percent of maximum dry density obtained from ASTM D 1557. The saturated hydraulic conductivity measured in that range of dry density was on the order of 4.5×10^{-4} cm/sec. Water balance analyses indicate that, in its current condition, the existing interim cover on the decks of Disposal Area A, B, and AB+ and on the slopes of Disposal Area AB+ does not perform as well as the Title 27 prescriptive cover. However, the existing interim cover can still be integrated into a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas AB+ as the foundation layer.

6.2.2 Slopes of Disposal Area A

The characteristics of the existing interim cover on the slopes of Disposal Area A were established through the field investigation and laboratory testing program described in Section 5.5 and 5.7. The thickness of the existing interim cover was found to vary from 7 ft (2.1 m) to 18 ft (5.5 m) over the slopes of Disposal Area A. The soils found in the existing interim cover on the slopes of Disposal Area A include silty sand, clayey sand, and sandy silt.

The in-situ dry density of the existing interim cover soils on the slopes of Disposal Area A was measured to range from 86 to 94 percent of maximum dry density obtained from ASTM D 1557. The saturated hydraulic conductivity measured at that range of dry density was on the order of 4.6×10^{-5} cm/sec.

Water balance simulations using LEACHM were performed for a period of 10 years using the weather data from the Sunland weather station for the time period 1951 to 1962. Cumulative percolations predicted by LEACHM for the Title 27 prescriptive cover and for the existing interim soil cover on the slopes of Disposal Area A using the input parameters listed in Table 6-2 are shown in Figure 6-1. The water balance components predicted by LEACHM for the Title 27 prescriptive cover and the existing interim soil cover are summarized in Table 6-3. Figure 6-1 shows that the percolation through the existing interim soil cover on the slopes of Disposal Area A is less than that through the Title 27 prescriptive cover.

Based on the results of the water balance analyses, the performance of the existing interim soil cover exceeds the performance of the Title 27 prescriptive cover. The existing interim soil cover on the slopes of Disposal Area A can therefore be considered to be an engineered alternative cover to the Title 27 prescriptive cover.

6.3 Engineered Monolithic Cover Evaluation

6.3.1 Engineered Monolithic Cover Configurations

Water balance analysis were performed to evaluate the performance of an engineered monolithic soil cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ consisting of a combination of existing cover soil and imported borrow soil. Two alternative configurations were simulated in the water balance analyses. Both configurations employed the existing interim cover soil as the foundation layer. However, two different types of imported borrow soil were used in the configurations, as described below.

Alternative 1 consists of 2 ft (0.6 m) of existing interim cover soil overlain by 3 ft (1 m) of an assumed low plasticity silt (SC). The low plasticity silt is characterized by a grain size distribution such that about 75 percent of the material passes the number 200 sieve (opening of 0.075 mm) and with a clay content of about 8 percent. The plasticity index for this soil should not exceed 15.

Alternative 2 consists of 2 ft (0.6 m) of existing interim cover soil overlain by 3 ft (1 m) of an assumed silty or clayey sand (SM or SC). The silty sand or clayey sand are characterized by grain size distribution such that about 40 to 50 percent of the material passes through the number 200 sieve (opening of about 0.075 mm). The Atterberg limits for the fines in the material should be characterized by a plastic limit less than 15. The cross section of these alternative cover designs is illustrated in Figure 6-2. Since both alternatives have the same configuration they are illustrated by the same cross section.

Laboratory testing provided input parameters for the foundation layer composed of existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+. Curve fitting was performed to establish the input parameters for the imported borrow soils. Hydraulic conductivity parameters for the existing interim cover soil were obtained from the laboratory tests on the samples remolded to representative densities. The initial moisture contents of these remolded samples corresponded to optimum moisture contents evaluated by modified Proctor tests based upon the assumption that the foundation layer will be re-worked at optimum moisture content prior to placement of the imported borrow soil. A value for hydraulic conductivity of 4.5×10^{-4} cm/s was input for the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+. A hydraulic conductivity of 1×10^{-5} cm/s was assumed for the imported borrow soils (SC, ML, and SM). Soil property values input to LEACHM are summarized in Table 6-2.

6.3.2 Title 27 Prescriptive Cover Configuration

The Title 27 prescriptive cover was modeled as a 4 ft thick cover section. This cover section consisted of a 1 ft (0.3 m) thick vegetative layer underlain by a 1 ft (0.3 m) thick compacted clay layer, underlain by a 2 ft (0.6 m) thick foundation layer. The cross section of the Title 27 prescriptive cover is illustrated in Figure 6-2.

Soil properties input for the Title 27 prescriptive soil cover are summarized in Table 6-2. The vegetative layer was assumed to have a saturated hydraulic conductivity equal to 1×10^{-4} cm/s. The compacted clay layer was modeled with a saturated hydraulic conductivity equal to 1×10^{-6} cm/s. The foundation layer was assumed to have a saturated hydraulic conductivity equal 1×10^{-4} cm/s, a value considered typical of native sandy silt and silty sand soil often use for structural fill. Campbell's fitting parameters were obtained from soil water retention data measured for silty soils by Khire et al. [1994, 1996] and Benson et al. [1994] for the vegetative, clay, and foundation layers. Initial water contents were assumed from data for typical silt and clay soils used in constructing Title 27 prescriptive cover in southern California.

Vegetation of the same rooting depths, percent coverage, and growth option was input for the simulation of the Title 27 prescriptive cover as for the simulation of the monolithic soil cover.

6.3.3 Results of the Water Balance Analysis

Water balance simulations using LEACHM were performed for a period of ten years using the weather data from the Sunland weather station for the time period

6.3.4.2 Variability of Hydraulic Conductivity

The first series of sensitivity analyses were performed to evaluate the effect of the saturated hydraulic conductivity on the performance of the monolithic soil cover. Figure 6-4 compares the cumulative percolation through the "Alternative 1" monolithic soil cover for the deck areas as a function of the saturated hydraulic conductivity of the soil to the cumulative percolation through the prescriptive final cover with established vegetation on top. Based on the results of this sensitivity analysis, a field saturated hydraulic conductivity of 3×10^{-5} cm/s is required for the infiltration performance of the monolithic soil cover to surpass that of the Title 27 prescriptive cover.

6.3.4.3 Monolithic Soil Covers

The second series of sensitivity analyses were performed over the three different monolithic soil cover configurations (Alternative 1, Alternative 2, and A Slope) to evaluate the consequence of degradation of the saturated hydraulic conductivity of the top foot of the cover. For each of these configurations, the saturated hydraulic conductivity for the top 1 ft (0.3 m) was increased by up to an order of magnitude (e.g. from 1×10^{-5} cm/sec to 1×10^{-4} cm/sec). Figure 6-5 compares the 10-year cumulative percolation through the three alternative monolithic soil covers as designed to the percolation through the percolation through the monolithic soil cover with a degraded saturated hydraulic conductivity in the top foot of the cover profile. A description of the legend for Figure 6-5 is presented below:

<u>Alt1:</u>

Monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

<u>Alt2:</u>

Monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

1951 to 1962. Cumulative percolations predicted by LEACHM for the Title 27 prescriptive cover and for the two monolithic soil cover alternatives are shown in Figure 6-3. The water balance components predicted by LEACHM for the Title 27 prescriptive cover and for the two monolithic soil cover alternatives are summarized in Table 6-4. Figure 6-3 shows that for the first year the percolation through the Title 27 prescriptive cover and through the monolithic soil covers are comparable. This comparable percolation is due to the migration of construction moisture from the foundation layer into the waste. Figure 6-3 clearly shows that after the first year, percolation predicted by LEACHM, for both monolithic soil cover alternatives is significantly less than the percolation predicted for the Title 27 prescriptive cover.

The water balance simulations performed using the model LEACHM indicate that predicted percolation from the monolithic soil cover alternatives presented in the previous sections is less than from Title 27 prescriptive cover. Therefore, based on modeling results, performance of the proposed monolithic soil cover exceeds the performance of the Title 27 prescriptive cover.

6.3.4 Sensitivity Analysis

6.3.4.1 General

To evaluate the impact of variability in soil properties on percolation through the final cover, four series of sensitivity analyses were performed on the monolithic soil covers designed in Section 6.3. The sensitivity analyses were carried out using the computer program LEACHM. The sensitivity analyses were performed to evaluate the effect of the saturated hydraulic conductivity on the performance of the monolithic soil cover, the effects of the saturated hydraulic conductivity degradation, and the absence of vegetation on the 10 year cumulative percolation through the monolithic soil cover compared to percolation through the Title 27 prescriptive cover. The following sections describe and present the results of the sensitivity analyses.

A Slope:

Monolithic soil cover on slopes of Disposal Area A with the design saturated hydraulic conductivity of $k = 4.6 \times 10^{-5}$ cm/s

Alt1 deg:

Monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the saturated hydraulic conductivity of the top foot increased to $k = 1 \times 10^{-4}$ cm/s due to degradation of the soil

Alt2 deg:

Monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the saturated hydraulic conductivity of the top foot set at $k = 1 \times 10^{-4}$ cm/s due to degradation of the soil

A Slope deg:

Monolithic soil cover on slopes of Disposal Area A with the saturated hydraulic conductivity of the top foot set at $k = 1 \times 10^{-4}$ cm/s due to degradation of the soil

A second series of sensitivity analyses were carried out to evaluate the effect of vegetation on the performance of the monolithic soil covers. Figure 6-6 compares the 10-year cumulative percolation through the three alternative monolithic soil covers as designed with vegetation and without vegetation. A description of the legend for Figure 6-6 is presented below:

Alt1:

vegetated monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

Alt2:

Vegetated monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s

A Slope:

Vegetated monolithic soil cover on slopes of Disposal Area A with the design saturated hydraulic conductivity of $k = 4.6 \times 10^{-5}$ cm/s

Alt1 no veg:

Monolithic soil cover Alternative 1 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s and no vegetation

Alt2 no veg:

Monolithic soil cover Alternative 2 for the deck of Disposal Areas A, B, and AB+ with the design saturated hydraulic conductivity of $k = 1 \times 10^{-5}$ cm/s and no vegetation

A Slope no veg:

Monolithic soil cover on slopes of Disposal Area A with the design saturated hydraulic conductivity of $k = 4.6 \times 10^{-5}$ cm/s and no vegetation

6.3.4.4 Title 27 Prescriptive Cover

A third series of sensitivity analyses was performed to evaluate the effect of degradation of the hydraulic conductivity of the 21 ft (0.3 m) thick compacted clay layer and the effect of vegetation on the percolation through the Title 27 prescriptive cover. Water balance analyses were performed assuming that the saturated hydraulic conductivity of the compacted clay layer degraded from the prescriptive maximum value of 1×10^{-6} cm/sec to 2×10^{-6} cm/sec and 5×10^{-6} cm/sec. The water balance analyses were performed for each value of hydraulic conductivity for both the vegetated and the no vegetation case. Figure 6-7 shows the effects of degradation and of vegetation on the 10-year cumulative percolation through a Title 27. A description for the legend of Figure 6-7 is provided below:

prsc:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer equal to $k = 1 \times 10^{-6}$ cm/s and well established vegetation on the cover

prsc n/veg :

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer equal to $k = 1 \times 10^{-6}$ cm/s and no vegetation on the cover prsc k2e6 :

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer increased to $k = 2 \times 10^{-6}$ cm/s due to degradation and established vegetation

prsc k2e6 n/veg:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer of increased to $k = 2 \times 10^{-6}$ cm/s due to degradation and no vegetation on the cover

prsc k5e6:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer increased to $k = 5 \times 10^{-6}$ cm/s due to degradation and established vegetation

prsc k5e6 n/veg:

Title 27 prescriptive cover with the hydraulic conductivity of the compacted clay layer of increased to $k = 5 \times 10^{-6}$ cm/s due to degradation assuming no vegetation on the cover.

6.3.4.5 Evaluation of the results

Several noteworthy observations can be made regarding the results of the sensitivity analyses.

Figure 6-4 shows that the performance of the monolithic soil cover with respect to surface infiltration meets or exceeds that of the Title 27 prescriptive cover if the in-place saturated hydraulic conductivity of the monolithic soil cover is no greater than 3×10^{-5} cm/s.

As shown on Figure 6-7, the performance of the Title 27 prescriptive cover with respect to surface water infiltration is not particularly sensitive to the presence of vegetation. However, the percolation through the Title 27 prescriptive cover doubles if the saturated hydraulic conductivity of the compacted clay layer degrades by one-half an order of magnitude. If the compacted clay layer does desiccate or crack, assuming a one-half order of magnitude increase in saturated hydraulic conductivity may actually be conservative.

As shown on Figure 6-5 and 6-6, increase of the saturated hydraulic conductivity in the top foot of the monolithic soil covers by up to one order of does result in a significant increase of the 10-year cumulative percolation. However, this increase is approximately equal to the increase in percolation through the Title 27 prescriptive cover when the hydraulic conductivity of the compacted clay layer has been degraded by only one half an order of magnitude. Figure 6-6 illustrates that even without vegetation, the infiltration performances of Alternative 1 and Alternative 2 is superior to the performance of the Title 27 prescriptive cover as long as the saturated hydraulic conductivity is maintained at the target value. However, the A Slope configuration is more sensitive to a loss of compared to Alternatives 1 and 2. Even without degradation of the saturated hydraulic conductivity the percolation through the A-slope configuration is above that of the Tittle 27 prescriptive cover if vegetation is not established.

6.3.4.6 Summary

In summary, results of the sensitivity analyses illustrate different cover maintenance approaches that may be taken to maintain the performance of the monolithic final cover alternatives. For monolithic Alternatives 1 and 2 (deck areas) the sensitivity analyses indicates that it would be better to strip the vegetation and rework the top one foot of cover soil if degradation in the saturated hydraulic conductivity occurs than to keeping the vegetation intact and allowing the saturated hydraulic conductivity of the soil to degrade. Conversely, the sensitivity analysis indicates that for the A-slope monolithic alternative it is better to allow the vegetation to remain as opposed to reworking the upper layers of the cover soil to counteract degradation the saturated hydraulic conductivity.

7. PERFORMANCE EVALUATION PROGRAM

7.1 Methodology

The objective of the performance evaluation program is to demonstrate that the infiltration control performance of a monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ can exceed the infiltration control performance of the Title 27 prescriptive cover if the monolithic soil cover has the appropriate hydraulic properties.

The methodology for evaluation of the performance of the monolithic final cover consists of the following:

- Monitoring the soil moisture content and environmental conditions in two test sections for a period of two years;
- Calibrating the analytical numerical model (LEACHM) for infiltration and moisture migration based upon the first year monitoring data;
- Validating the analytical numerical model using the second year monitoring data;
- Demonstrating that the infiltration performance control of the monolithic soil cover exceeds that of Title 27 prescriptive cover using the validated numerical model.

In this cover performance evaluation program, characteristic soil properties will be directly measured and the analytical model will be calibrated based upon the first year of field data. The calibrated model will then be used to predict moisture movement in the soil cover during the second year of monitoring. Comparison of predicted moisture movement during the second year to actual field observations will be used to validate the analytical model. The validated model will then be used to compare the performance of the monolithic soil cover to the performance of the Title 27 prescriptive cover. In the evaluation program, the final cover performance will be monitored at two locations: one on the deck of Disposal Area AB+ and one on the slopes of Disposal Area A. Figure 7-1 shows the proposed monitoring locations.

In order to test the validity of the analytical model for an extreme precipitation even, if at the end of the 2-year monitoring period a storm with a rainfall intensity which exceeds 75 percent of the intensity of the 100-year 24-hour rainfall has not occurred, a temporary irrigation will be set up adjacent to the monitoring stations to artificially induce the 100-year, 24-hour rainfall for monitoring purposes.

7.2 Data Requirements

The data required to perform the cover performance evaluation include:

- data on the soil used to construct the monolithic soil cover;
- data on weather conditions; and
- data on moisture content in the monolithic soil cover.

Data on the soil used to construct the monolithic soil cover include soil type, in-situ density, and hydraulic properties such as saturated hydraulic constructivity and moisture retention curves. This data will be obtained from laboratory testing on soils collected during construction of the monolithic soil cover. Data on weather conditions include records of precipitation and temperatures and irrigation if used. Data from the Sunland weather station and data from an on-site weather station will be collected. Data on moisture content in the monolithic soil cover will be obtained using the monitoring system described in Section 7.3 of this report.

7.3 Proposed Soil Moisture Monitoring System

7.3.1 Introduction

For the Lopez Canyon Landfill monolithic soil cover monitoring, it is proposed to use Time Domain Reflectometry (TDR) probes for soil moisture monitoring and a site weather station to gather accompanying weather data. TDR probes have been selected due to their automated data collection abilities, minimal disturbance installation methods, and prior successful use on similar projects in southern California. A TDR monitoring probe system consists of a segmented profiling probe for monitoring multiple depths, transmission cables, a battery power supply, and an integral data logger.

The configuration and type of soil moisture monitoring probe system for the Lopez Canyon Landfill monolithic soil cover is designed to provide flexibility so that it can be modified to accommodate whatever frequency, quality, and quantity of data is required for monitoring.

7.3.2 Soil Moisture Monitoring Probe

It is proposed to use a segmented profiling probe containing five individual probes for monitoring at depths of 6, 12, 20, 30, and 42 in. (152, 305, 508, 762, and 1067 mm, respectively) for the test section on the deck of Disposal Area AB+ where the total thickness of the proposed monolithic final cover, including the foundation layer, is 60 in. (1,500 mm).

It is proposed to use a segmented profiling probe containing seven individual probes for monitoring at depths of 6, 12, 20, 30, 42, 54, and 66 in. (152, 305, 508, 762, 1067, 1372, and 1677 mm, respectively) for the test section on Disposal Area A, where the total thickness of the proposal monolithic final cover is 78 in. (1,950 mm). A 6-in. (152-mm) spacing in the upper 1-ft (0.3 m) of the cover is required to better quantify cover performance.

Two probes will be installed in the test section on the deck of Disposal Area AB+ and two probes will be installed on the test section of the slopes of Disposal Area A.

The final location of the probes will be decided in the field and submitted for approval to the RWQCB. The probes will be connected to data loggers and a power supply will be installed in the field. Soil moisture readings from the probes will be automatically taken daily and stored in the data loggers. Data will be downloaded with a lap top computer. It is anticipated that data will be downloaded and analyzed once a month.

7.3.3 Data Logging System

Each probe will be connected to a data logger unit. The data logger interrogates the probe at user specified sampling intervals and then measures, interprets, and stores the sensor values in the non-volatile memory. Each data record will be time and date stamped. The data loggers will be powered by either solar or AC current and will be enclosed in a rugged enclosure which protects the electronics from the atmosphere and other damage. The data logger will be equipped with an RS-232 port which enables data to be downloaded with a personal computer (PC). A laptop PC will be used for data downloading. The data will be downloaded to the laptop PC using the probe manufacturers supplied software.

7.3.4 Weather Station

A self-contained weather station capable of recording wind speed, wind direction, relative humidity, rainfall, solar radiation, and air temperature will be installed and connected to the data logger. Weather data will be downloaded at the same time as the soil moisture data with the lap top PC. The weather station will be located at one of the test sections.

7.4 Vegetation

Following construction of the monolithic soil and installation of the performance monitoring system the monolithic soil cover will be hydroseeded using the seed mix designed for Lopez Canyon Landfill.

If the seeds are planted in the fall, no irrigation will be needed to establish the vegetation. If the seeds are planted at any other time, irrigation will be required during the initial stages of vegetation establishment. Once established, the vegetation will have the ability to survive on the natural seasonal precipitation of the area. Therefore, once the vegetation has been established, the need for irrigation should be minimal, if at all. If any irrigation is applied, the daily volume will be monitored and recorded.

7.5 Performance Modeling

Hydrologic performance modeling of the monolithic soil cover will be performed using the model LEACHM [Hutson and Wagenet, 1992] discussed in Section 4.3 of this report. The weather data and moisture migration data gathered during the first year of performance monitoring period will be used to simulate the performance of the monolithic soil cover over the second year of monitoring.

7.6 Reporting

Three reports will be prepared for submission to the RWQCB during the final cover performance evaluation:

- an installation report;
- a model calibration report; and
- a performance evaluation report.

The installation report will be submitted within 12 weeks of completion of installation of the test sections. This report will document moisture probe installation, soil test data, and initial probe readings. The report will include a record drawing presenting surveyed probe locations, manufacturers' product information on the probes and data logging equipment, field logs from probe installation, and laboratory data sheets and summary tables.

The model calibration report will be submitted 15 months after probe installation. The model calibration report will include the weather and moisture content data for the first 12 months of operation at each test section. The report will also include a preliminary evaluation of the performance of the monolithic soil cover in comparison to the Title 27 prescriptive cover.

The performance evaluation report will be submitted 27 months after test section installation. The performance evaluation report will include weather and moisture content data collected in the second 12 months of monitoring, a forecast of moisture migration over the second 12 months using LEACHM calibrated using the data collected over the first 12 months, a comparison of forecast and observed moisture migration, a description of any alterations or enhancements to the model required to obtain agreement between observed and predicted moisture migration in the second year of operation, and final evaluation of the performance of the monolithic soil cover as an engineered alternative to the Title 27 prescriptive cover. If the monolithic soil cover does not perform as well as the Title 27 prescriptive cover, the report will include recommendations for measures required to achieve equivalent Title 27 prescriptive cover performance for the monolithic soil cover.

8. SUMMARY AND RECOMMENDATIONS

8.1 Summary

This report describes water balance conducted to demonstrate that a monolithic soil cover is an acceptable engineered alternative to Title 27 prescriptive cover for the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at Lopez Canyon Sanitary landfill.

The work conducted included a field investigation, a laboratory testing program, and water balance analyses. The field investigation and laboratory testing program were conducted to characterize the existing interim soil cover. The water balance analyses were used to demonstrate that the performance of the monolithic soil cover met or exceeded the performance of the Title 27 prescriptive cover with respect to infiltration control.

The field investigation consisted of excavating and logging test pits, collecting bulk samples from the existing interim cover soil, and in-situ measurements of the density of the existing interim cover soil. A total of 44 test pits were excavated on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Areas A and AB+ at Lopez Canyon Sanitary landfill. The test pits logs indicate that the existing interim cover soils consist mostly of silty sand and clayey sand mixed in some areas with gravel and cobbles. The thickness of the existing interim cover ranges from 2 ft (0.6 m) to 18 ft (5.5 m) with an in-situ dry density ranging from 76 to 98 percent of maximum dry density as obtained from ASTM D1557. Reliable measurement of in-situ dry density was impaired by the presence of gravel and cobbles and the disturbance caused by the excavation activity.

Laboratory testing was conducted on selected bulk samples to classify the soil according to the Unified Soil Classification System and to obtain compaction characteristics, hydraulic conductivity values, and moisture retention relationships for the interim cover soils. The soils forming the existing interim soil covers ranged in classification from silty sand (SM) to clayey sand (SC) and include some low plasticity silts (ML). The representative hydraulic conductivity of the in place soils of the existing interim soil cover was set at 4.5×10^{-4} cm/s on the decks of Disposal Areas A, B, and

AB+ and slopes of Disposal Area AB+ the larger of two values measured in the laboratory, due to the heterogeneity of the encountered soil. The representative hydraulic conductivity of the in-place soils of the existing interim soil cover was set at 4.6×10^{-5} cm/s for the slopes of Disposal Area A, the average of the four values measured in the laboratory.

The water balance analyses were conducted using the computer program LEACHM. Input data for LEACHM includes the soil profile to be modeled, soil properties, weather data, and vegetation data. The soil profiles analyzed included the Title 27 prescriptive cover, the existing interim soil cover, and two different engineered monolithic soil covers. The Title 27 prescriptive cover consisting of a 1 ft (0.3 m) thick vegetative soil layer, a 1 ft (0.3 m) thick compacted clay layer, and a 2 ft (0.6 m) thick foundation layer. The engineered monolithic soil covers consisted of a 3 ft (0.9 m) thick layer of either a silty sand or a silty clay and a 2 ft (0.6 m) thick foundation layer.

The soil properties for the existing interim soil cover were established from the laboratory testing program conducted on the samples collected at the test pits. Soil properties for the clay layer, vegetative layer, silty sand layer, and clayey sand layer were estimated from published data. Weather data from the Sunland station were used for the water balance analyses. The Sunland station is located 3.5 miles (5.6 km) from Lopez Canyon Sanitary Landfill at a comparable elevation. A 10-year period was selected for the water balance analysis. The 10-year period exhibits an average annual rainfall of 18.1 in. (460 mm), compared to the 16 in. (406 mm) 100-year average rainfall at Lopez Canyon Sanitary Landfill. The 10-year period also includes several wet years and was deemed to be representative of the weather conditions at Lopez Canyon Sanitary Landfill. The vegetation data used in the water balance analyses is representative of the vegetation mix approved for use on the final cover at Lopez Canyon Sanitary Landfill.

The results of the water balance analyses indicate that the percolation through the existing interim soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ exceeds that through the Title 27 prescriptive cover. The results of the water balance analyses indicate that the predicted percolation from the existing interim cover on the slopes of Disposal Area A is about 68 percent less than that from the Title 27 prescriptive cover over the 10 year period modeled. The results of the water balance analyses indicate that predicted percolation from the engineered monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ is about 75 percent less than that from the Title 27 prescriptive cover over the 10-year period modeled. The results of the water balance analyses indicate that the predicted percolation from the existing interim cover on the slopes of Disposal Area A is about 68 percent less than that from the Title 27 prescriptive cover over the 10 year period modeled.

8.2 Recommendations

The work presented in this report demonstrate that a "properly configured" monolithic soil cover performs better than the Title 27 prescriptive cover infiltration control at the Lopez Canyon Landfill. Properly configured covers include the engineered monolithic soil cover on the decks of Disposal Areas A, B, and AB+ and the slopes of Disposal Area AB+ and the existing interim soil cover on the slopes of Disposal Area A. The engineered monolithic soil cover consists of a 2 ft (0.6 m) thick layer of foundation soil composed of the existing interim cover soil overlain by a 3 ft (1 m) thick layer of silty sand or clayey sand with an in-place saturated hydraulic conductivity no greater than 3×10^{-5} cm/s. In lieu of constructing a test pad with the imported monolithic soil cover and performing a sealed double ring infiltrometer (SDRI) test, the specifications will require a laboratory saturated hydraulic conductivity of 1×10^{-5} cm/s on imported monolithic soil cover. Specifying a value of laboratory saturated hydraulic conductivity three times less than the in-place saturated hydraulic conductivity will compensate for the differences between laboratory measured values and in-place values. To mitigate the potential for cracking due to desiccation or differential settlement, the plasticity index of the engineered monolithic soil cover should not exceed 15. The existing interim soil cover on the slopes of Disposal Area A consists of at least 6.5 ft (2 m) of silty sand or clayey sand characterized by a hydraulic conductivity of 4.6×10^{-5} cm/s.

Because the monolithic soil cover has the same erosion resistance as the prescriptive cover and can be constructed more economically than the prescriptive cover, and because the use of the prescriptive cover may not promote attainment of the water quality objectives of a final cover, the monolithic soil cover should be acceptable as an alternative final cover in accordance with state and federal regulations. However, because it is likely that performance monitoring will be required by the RWQCB to demonstrate acceptable performance of the proposed monolithic soil cover, a performance monitoring program has been developed. This performance monitoring program includes two monitoring stations on the slopes of Disposal Area A, where the monolithic soil cover already exists, and one monitoring station on the decks of Disposal Areas A, B, and AB+, where a monolithic soil cover will be constructed. The recommended monitoring program employs time-domain-reflectometry probes and an automated weather station. The recommended performance monitoring program includes two years of monitoring, with model calibration after year one and model validation after year two. The monitoring program is expected to result in final regulatory approval of the monolithic soil final cover for the slopes of Disposal Areas A and AB+ and the decks of Disposal Areas A, B, and AB+.

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TABLES

TABLE 4-1

PROXIMAL WEATHER STATIONS
LOPEZ CANYON SANITARY LANDFILL

Station Name	Number of Years	Percent Coverage	Latitude	Longitude	Elevation (ft)	Distance (miles)	Average Rainfall (in.)
LOPEZ CANYON LANDFILL	100		N34:17:30	W118:21:30	1600-1800		aprox. 16[(1)]
CANOGA PARK PIERCE C	46	100	N34:11:00	W118:34:00	790	14.0	15.84
DRY CANYON RESERVOIR	43	78-94	N34:29:00	W118:32:00	1455	16.7	13.88
NEWHALL	6	100	N34:22:00	W118:34:00	1400	13.1	19.53
PASADENA	68	95-99	N34:09:00	W118:09:00	864	15.0	19.47
SAN FERNANDO	48	96-99	N34:17:00	W118:28:00	971	7.3	16.39
SUNLAND	18	99-100	N34:16:00	W118:18:00	1460	3.5	16.18
TUJUNGA	22	96-97	N34:16:00	W118:17:00	1819	4.3	20.85

Notes: (1) 100 year mean rainfall from RDSI dated September 1995

TABLE 5-1

TEST PIT SUMMARY
DECK OF DISPOSAL AREA AB+
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
AB-1	1774.4	9.5	1764.9
AB-2	1768.4	5	1763.4
AB-3	1763.9	5	1758.9
AB-4	1759.7	4	1755.7
AB-5	1759.9	>8	<1752
AB-6	1766.2	>9	<1757
AB-7	1755.6	6	1749.6
AB-8	1755.9	6	1749.9
AB-9	1749.1	1.5	1747.6
AB-10	1761.5	4	1757.5
AB-11	1763.3	4	1759.3
AB-12	1759.4	>7	<1752
AB-13	1767.4	>11	<1756
AB-24	1773.5	9	1764.5
AB-25	1762.1	>9	<1751

TABLE 5-2

TEST PIT SUMMARY
SLOPES OF DISPOSAL AREA AB+
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
AB-14	1742.0	6	1736.0
AB-15	1759.9	8.5	1751.4
AB-16	1698.5	2.5	1696.0
AB-17	1700.0	2	1698.0
AB-18	1685.2	2	1683.2
AB-19	1691.9	5	1686.9
AB-20	1622.0	2.5	1619.5
AB-21	1730.8	3.5	1727.3
AB-22	1744.1	3	1741.1
AB-23	1737.8	10	1727.8

TABLE 5-3

TEST PIT SUMMARY
DECK OF DISPOSAL AREA A
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
A-1	1745.2	6.5	1738.7
A-2	1741.32	6	1735.32
A-3	1741	5	1736
A-4	1732.93	6	1726.93
A-5	1744.16	5	1739.16

TABLE 5-4

TEST PIT SUMMARY
SLOPES OF DISPOSAL AREA A
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
A-6	1738.2	7-14	1731.2
A-7	1721.2	8-18	1713.2
A-8	1678.8	>9	1669.8
A-9	1659.2	>14	1645.2
A-10	1610.0	7	1603.0
A-11	1570.5	11	1559.5

TABLE 5-5

TEST PIT SUMMARY
DECK OF DISPOSAL AREA B
LOPEZ CANYON SANITARY LANDFILL

TEST PIT NO.	EXISTING INTERIM FINAL COVER EL. (ft)	EXISTING COVER SOIL THICKNESS (ft)	REFUSE EL. (ft)
B-1	1707.44	3	1704.44
B-2	1719.02	2	1717.02
B-3	1732.1	3	1729.1
B-4	1741.8	3.5	1738.3
B-5	1727.7	5	1722.7
B-6	1743.5	>8	1735.5
B-7	1727.57	6	1721.6
B-8	1741.7	5	1736.7

TABLE 5-6

SUMMARY OF LABORATORY TEST RESULTS
LOPEZ CANYON SANITARY LANDFILL

Site Sample ID	Lab Sample No	As-Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size: ASTM D 422 Sieve Figure No	Grain Size: ASTM D 422 Hydrom Figure No.	Atterberg Limits ASTM D 4318: LL (%)	Atterberg Limits ASTM D 4318: PL (%)	Atterberg Limits ASTM D 4318: PI (-)	Soil Classification ASTM D 2487	Compaction, Modified Proctor ASTM D 1557: Max. Dry Unit Weight (pcf)	Compaction, Modified Proctor ASTM D 1557: Optimum Moisture Content (%)	Compaction: Fig. No	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Dry Unit Weight (pcf)	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Moisture Content (%)	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Consol. Pressure (psi)	Hydraulic Conductivity (cm/s)	Remarks
AB-3	98A86		46.6	1	1	35	18	17	SC - Clayey Sand								
AB-4	98A87		39.9	2	2	31	21	10	SC - Clayey Sand with Gravel								
AB-7	98A88		43.5	3	3	40	25	15	SC - Clayey Sand with Gravel								
	98A89		46.4	4	4	40	28	12	SM - Silty Sand with Gravel								
AB-10	98B32									122.5	11.3	5					Not corrected for over-sized particles
										125.7	10.1	6					
	98B32-1												104.2	13.2	1.5	4.5E-4	Moisture Retention see Fig. 13
AB-25 B	98B34									124.4	11.2	7					Not corrected for over-sized particles
										128.9	9.4	8					
	98B34-1												112.0	10.9	1.5	7.6E-5	
B-3	98B15		52.4	9		37	20	17	CL - Sandy Lean Clay								
B-6	98A90		61.9	10	10	39	30	9	ML - Sandy Silt								

TABLE 5-6 (continued)

SUMMARY OF LABORATORY TEST RESULTS
LOPEZ CANYON SANITARY LANDFILL

Site Sample ID	Lab Sample No	As-Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size: ASTM D 422 Sieve Figure No.	Grain Size: ASTM D 422 Hydrom. Figure No.	Atterberg Limits ASTM D 4318: LL (%)	PL (%)	PI (-)	Soil Classification ASTM D 2487	Compaction, Modified Proctor ASTM D 1557: Max. Dry Unit Weight (pcf)	Optimum Moisture Content (%)	Fig. No.	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Dry Unit Weight (pcf)	Moisture Content (%)	Consol. Pressure (psi)	Hydraulic Conductivity (cm/s)	Remarks
A-6	98865		37.6	1	1	34	24	10	SM - Silty Sand	126.0	10.5	2	113.3	12.2	1.5	7.8E-5	Not corrected for over-sized particles
										128.2	9.7	3					Moisture Retention see Fig. 12
A-8	98866		46.1	4	4	36	24	12	SC - Clayey Sand	122.0	11.5	5	110.0	13.1	1.5	8.8E-5	
A-9	98867		50.6	6	6	44	28	16	ML - Sandy Silt	116.2	14.3	7	102.9	17.0	1.5	1.4E-5	Not corrected for over-sized particles
										118.7	13.2	8					
A-10	98868		53.2	9	9	48	30	18	ML - Sandy Silt	119.5	12.0	10	107.4	14.8	1.5	3.6E-6	Not corrected for over-sized particles
										122.7	10.9	11					

TABLE 6-1

POTENTIAL MONOLITHIC SOIL COVER SEED MIX
LOPEZ CANYON SANITARY LANDFILL

PLANT SPECIES	PURITY/ GERMINATION	POUNDS/ ACRE
Artemesia Californica (Sagebrush)	15/60	2
Encelia Califonica (Bush Sunflower)	40/60	3
Eriogonum Fasciculatum (California Buckeye)	50/10	4
Lotus Scoparius (Deer Weed)	90/60	6
Mimulus Longiflorus (Monkey Flower)	2/55	2
Salvia Apiana (White Sage)	70/50	3
Salvia Mellifera (Black Sage)	85/50	4
Salvia Leucophylla (Purple Sage)	75/70	3
Trifolium Hirtum (Clover)	95/85	10
Vulpia Myuros	90/80	3
Stipa Cernua (Feather Grass)	80/50	8
Hordeum Californica	90/80	8
Bromux Carinatus (California Brome)	95/80	6
Eschscholzia Californica (California Poppy)	98/75	2
Lupinus Bicolor (Lupine)	98/80	4

Source: S&S Seeds

TABLE 6-2

SOIL PROPERTIES INPUT TO LEACHM
LOPEZ CANYON SANITARY LANDFILL

SOIL	SATURATED HYDRAULIC CONDUCTIVITY INPUT TO LEACHM (cm/s)	CAMPBELL'S SOIL WATER RETENTION FITTING PARAMETER: AIR ENTRY VALUE (a)	CAMPBELL'S SOIL WATER RETENTION FITTING PARAMETER: EXPONENT (b)	INITIAL WATER CONTENT (Volumetric)
Decks of Disposal Areas A, B, And AB+, Slopes of Disposal Area AB+ Existing Cover	4.5×10^{-4}	-1.34	8.783	0.22
Slopes of Disposal Area A Existing Cover	4.6×10^{-5}	-0.26	9.703	0.25
Alternative 1 Borrow - ML	1.0×10^{-5}	-2.66	3.640	0.22
Alternative 2 Borrow - SM OR SC	1.0×10^{-5}	-1.15	4.725	0.25
Prescriptive Vegetative	1×10^{-4}	-4.89	3.720	0.19
Prescriptive Clay layer	1×10^{-6}	-1.88	5.973	0.30

Notes:
For Silty and Clayey Sand Borrow Soil, initial water content equals optimum water content based on Proctor compaction tests
For Chapter 15 Soils, initial water contents assumed from data for typical silty soils.
For Existing Cover, initail moisture content equals optimum based on Proctor compaction tests.
a and b are the designation of the air entry value and exponent in Campbell's equation used in LEACHM

TABLE 6-3

SUMMARY OF WATER BALANCE PREDICTION USING LEACHM
SLOPES OF DISPOSAL AREA A
LOPEZ CANYON SANITARY LANDFILL

Simulation	Saturated Hydraulic Conductivity (cm/s)	Cover Thickness (feet)	Root Depth (in.)	Evapotranspiration (mm/yr, %)[3]	Overland Flow (mm/yr, %)[3]	Change In Cover Storage (mm/yr)	Percolation (mm/yr, %)[3]
Prescriptive[1]	$10^{-4}/10^{-6}/10^{-4}$	2/1/1	12	351.7 (76.7%)	99.0 (21.6%)	-6.4 (-1.4%)	13.8 (3.0%)
A-Slope, Alternative, (Avg-K)[2]	4.6×10^{-5}	6.5	12	229.9 (50.1%)	229.6 (50.1%)	-7.0 (-1.53%)	4.4 (1.0%)

Note: Values are annual average based on a 10-year simulation
(1) Title 27 prescriptive cover
(2) Alternative monolithic cover.
(3) Totals do not necessarily add to 100% due to rounding.

TABLE 6-4

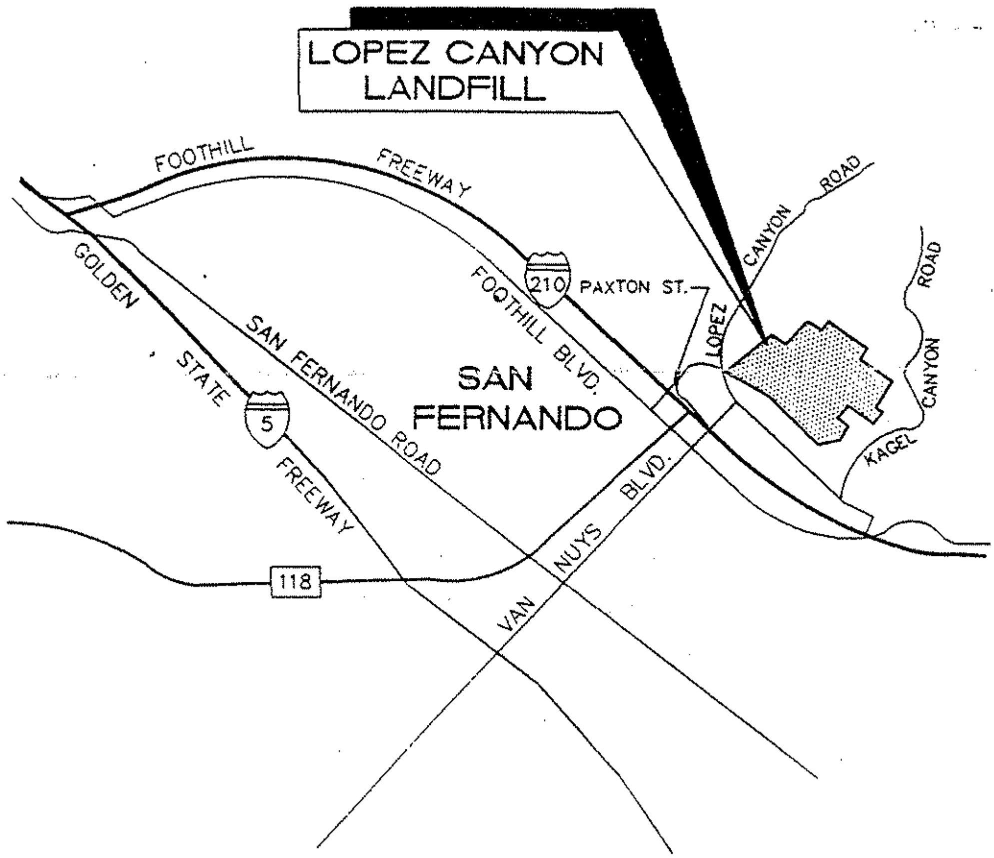
SUMMARY OF WATER BALANCE PREDICTION USING LEACHM
DECKS OF DISPOSAL AREAS A, B, AND AB+ AND SLOPES OF DISPOSAL AREA AB+
LOPEZ CANYON SANITARY LANDFILL

Simulation	Saturated Hydraulic Conductivity (cm/s)	Cover Thickness (feet)	Root Depth (in.)	Evapotranspiration (mm/yr, %)[3]	Overland Flow (mm/yr, %)[3]	Change In Cover Storage (mm/yr)	Percolation (mm/yr, %)[3]
Prescriptive[1]	$10^{-4}/10^{-6}/10^{-4}$	2/1/1	12	351.7 (76.7%)	99.0 (21.6%)	-6.4 (-1.4%)	13.8 (3.0%)
Alternative 1[2]	$4.5 \times 10^{-4}/10^{-5}$	2 / 3	12	255.2 (55.6%)	208.5 (45.5%)	-8.7 (-1.89%)	3.2 (0.7%)
Alternative 2[2]	$4.5 \times 10^{-4}/10^{-5}$	2 / 3	12	143.7 (31.3%)	319.9 (69.8%)	-8.7 (-1.89%)	3.4 (0.7%)

Note: Values are annual average based on a 10-year simulation
(1) Title 27 prescriptive cover
(2) Alternative monolithic cover
(3) Totals do not necessarily add to 100% due to rounding

FIGURES

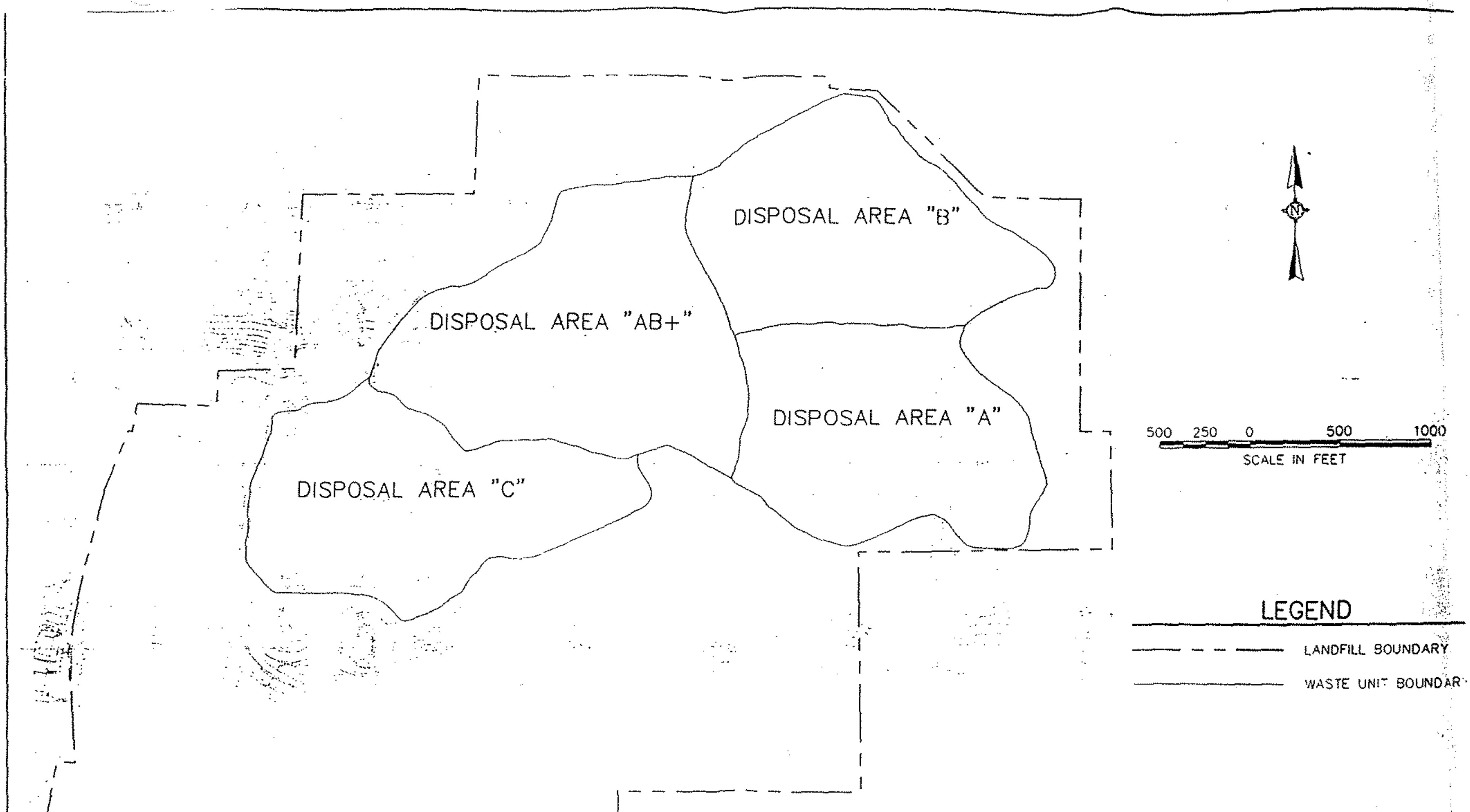
FIGURES



GeoSyntec Consultants

SITE LOCATION MAP LOPEZ CANYON SANITARY LANDFILL LAKEVIEW TERRACE, CALIFORNIA	FIGURE NO.	1-1
	DOCUMENT NO.	LPZ98-13.RPT
	PROJECT NO.	CE4100-04
	DATE:	5 MARCH 1998

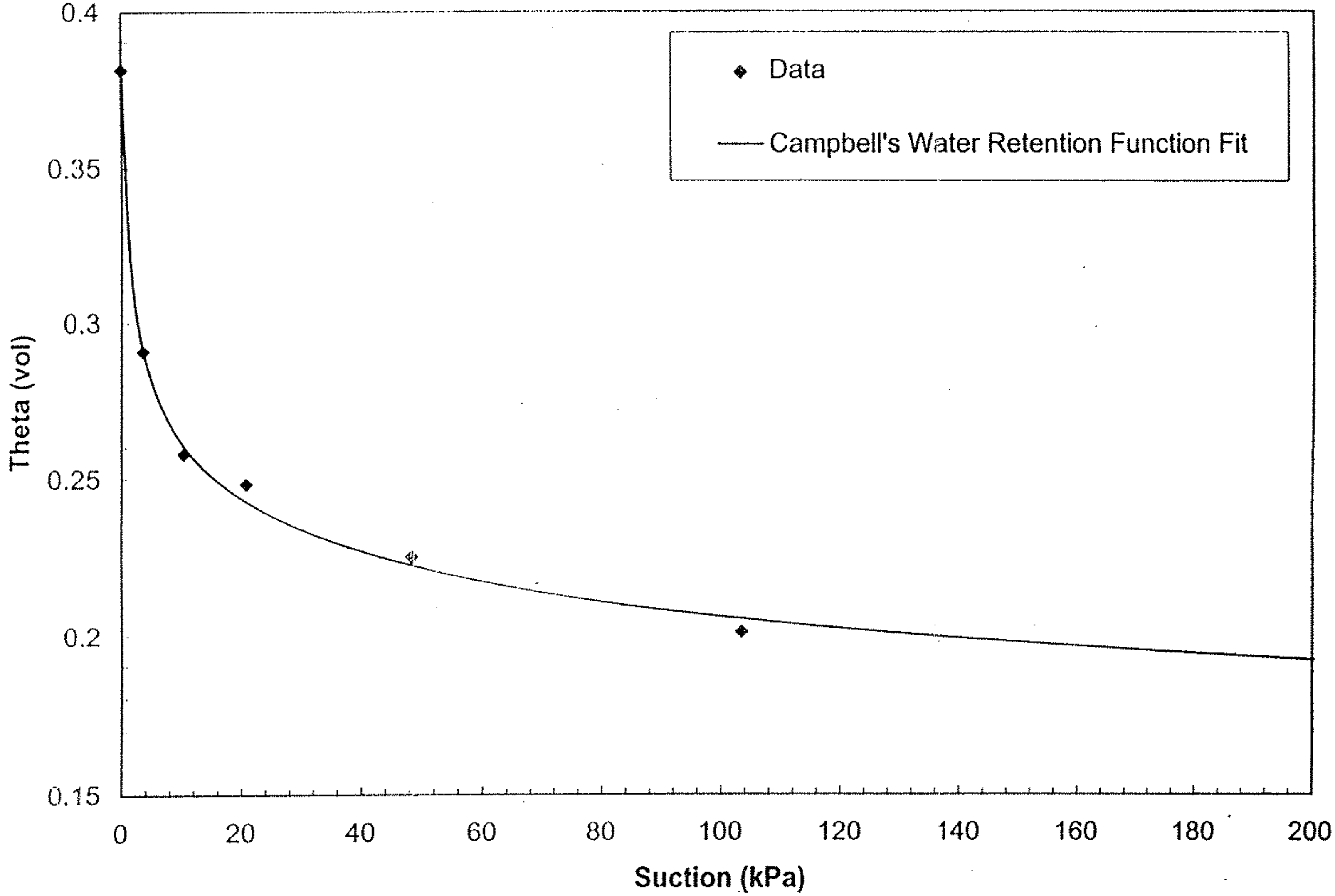
DWG: 4100F705.DWG 199803051603 RCG



GeoSyntec Consultants

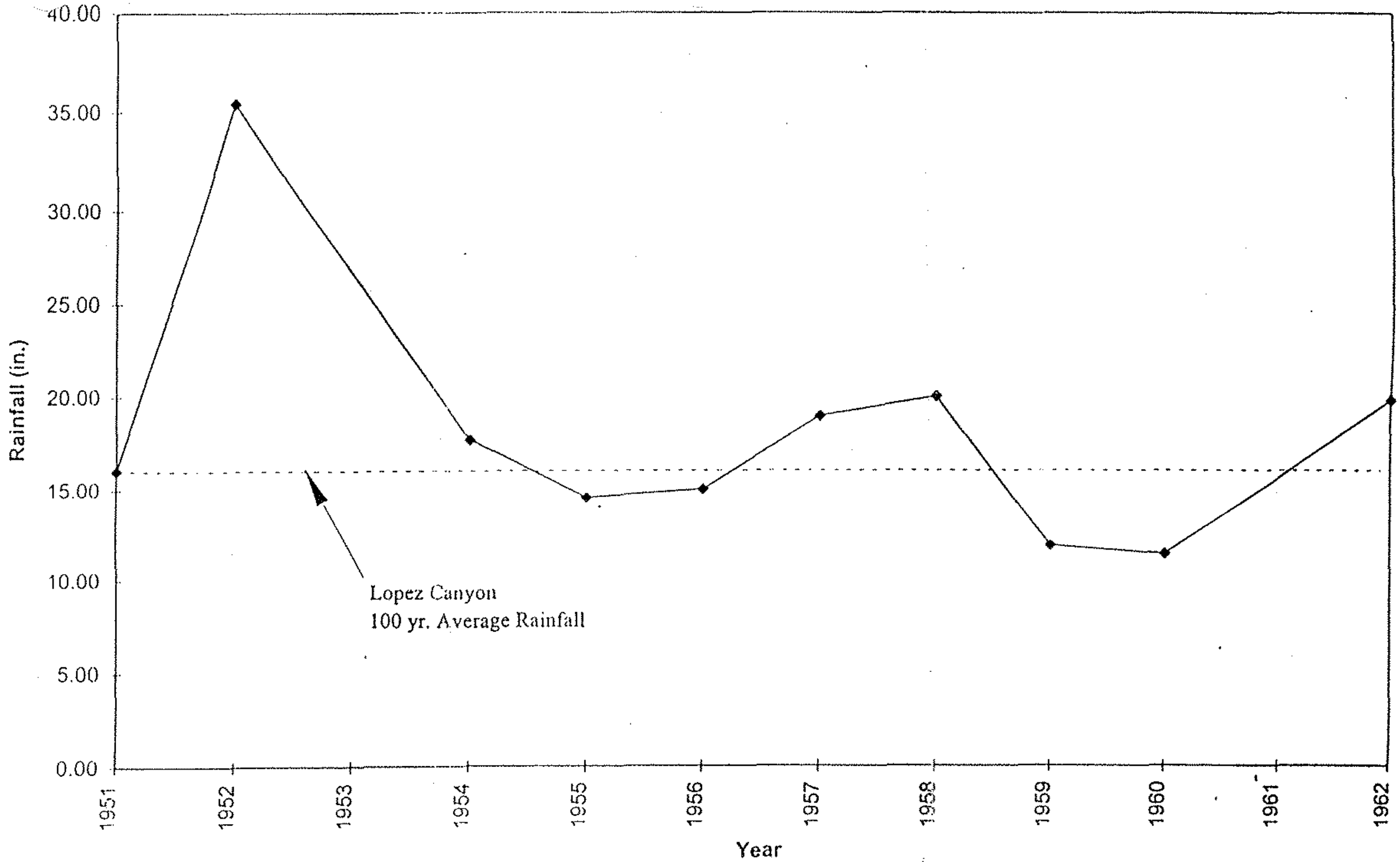
SITE PLAN
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	2-1
PROJECT NO.	CE4100-04
DOCUMENT NO.	LPZ98-13.RPT
DATE	5 MARCH 1998



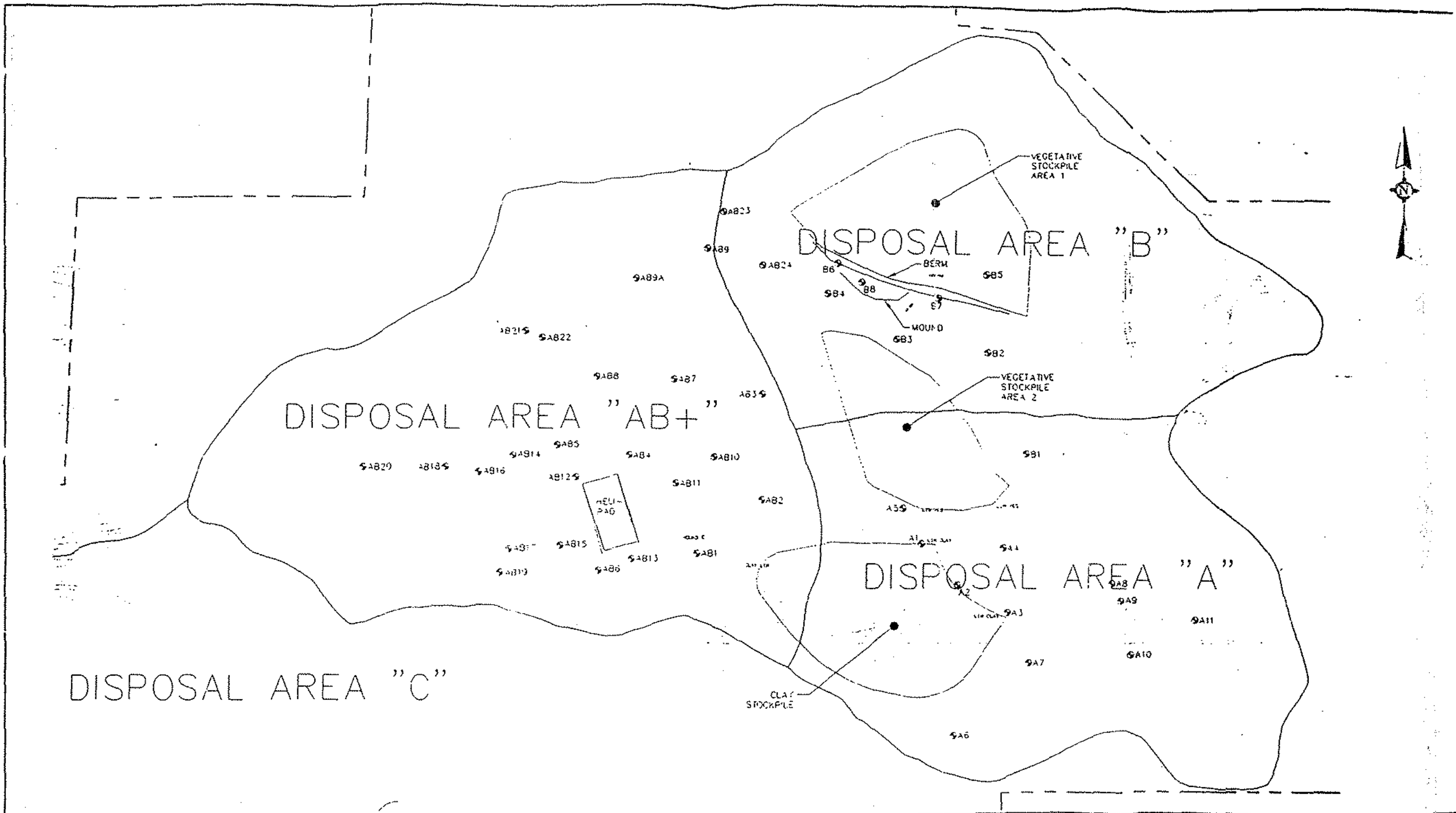
GEOSYNTEC CONSULTANTS

SUCTION DATA FOR SAMPLE A-6 LOPEZ CANYON SANITARY LANDFILL LAKEVIEW TERRACE, CALIFORNIA	FIGURE NO.	4-1
	PROJECT NO.	CE4100-04
	DATE:	5 MARCH 1998



GEOSYNTEC CONSULTANTS

SUNLAND WEATHER STATION PRECIPITATION DATA FOR MODELING LOPEZ CANYON SANITARY LANDFILL LAKEVIEW TERRACE, CALIFORNIA	FIGURE NO.	4-2
	PROJECT NO.	CE4100-04
	DATE:	5 MARCH 1998



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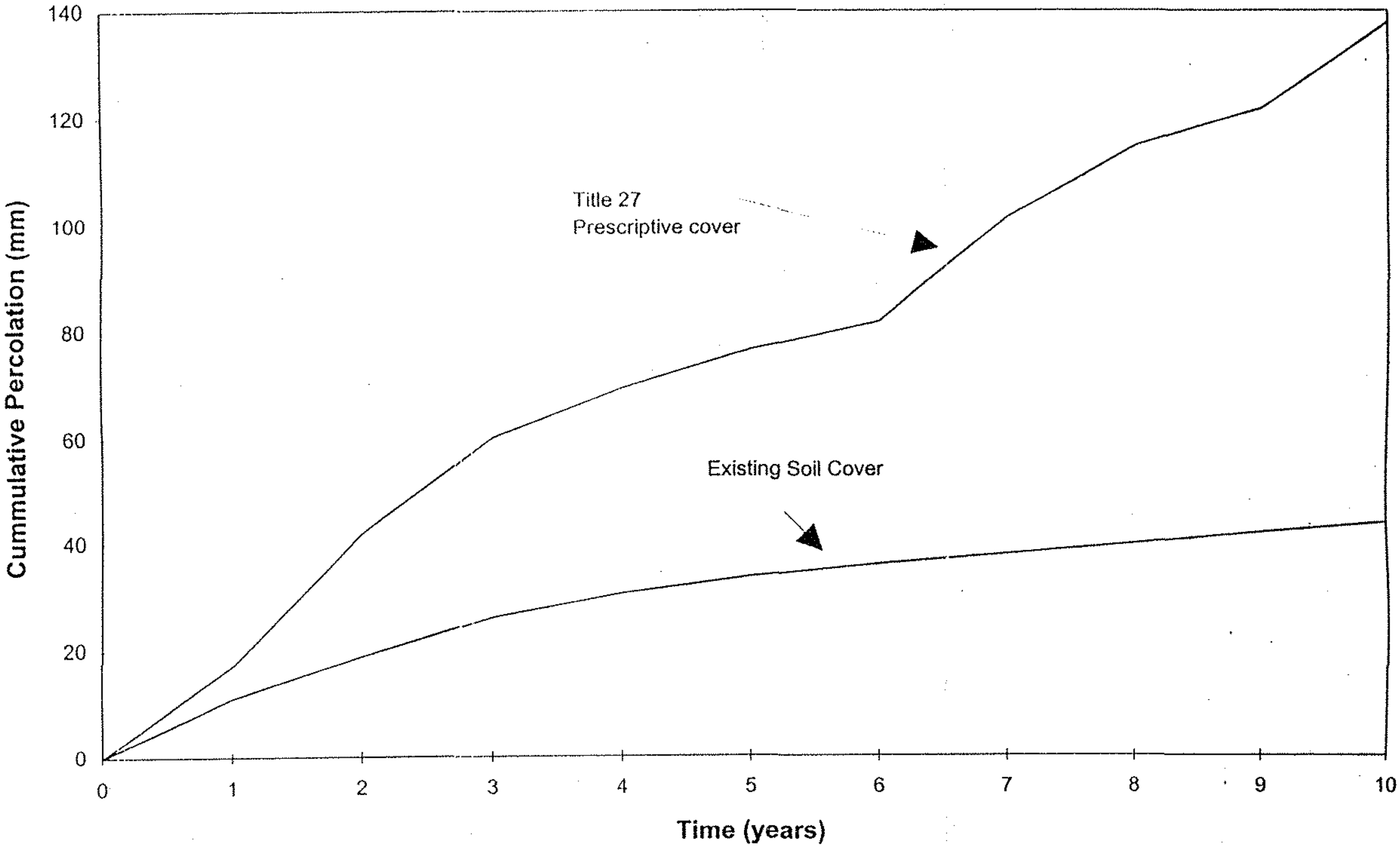
TEST PIT LOCATIONS

LOPEZ CANYON SANITARY LANDFILL

LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	5-
PROJECT NO.	GE4100-
DOCUMENT NO.	LP238-
DATE:	5 MARCH

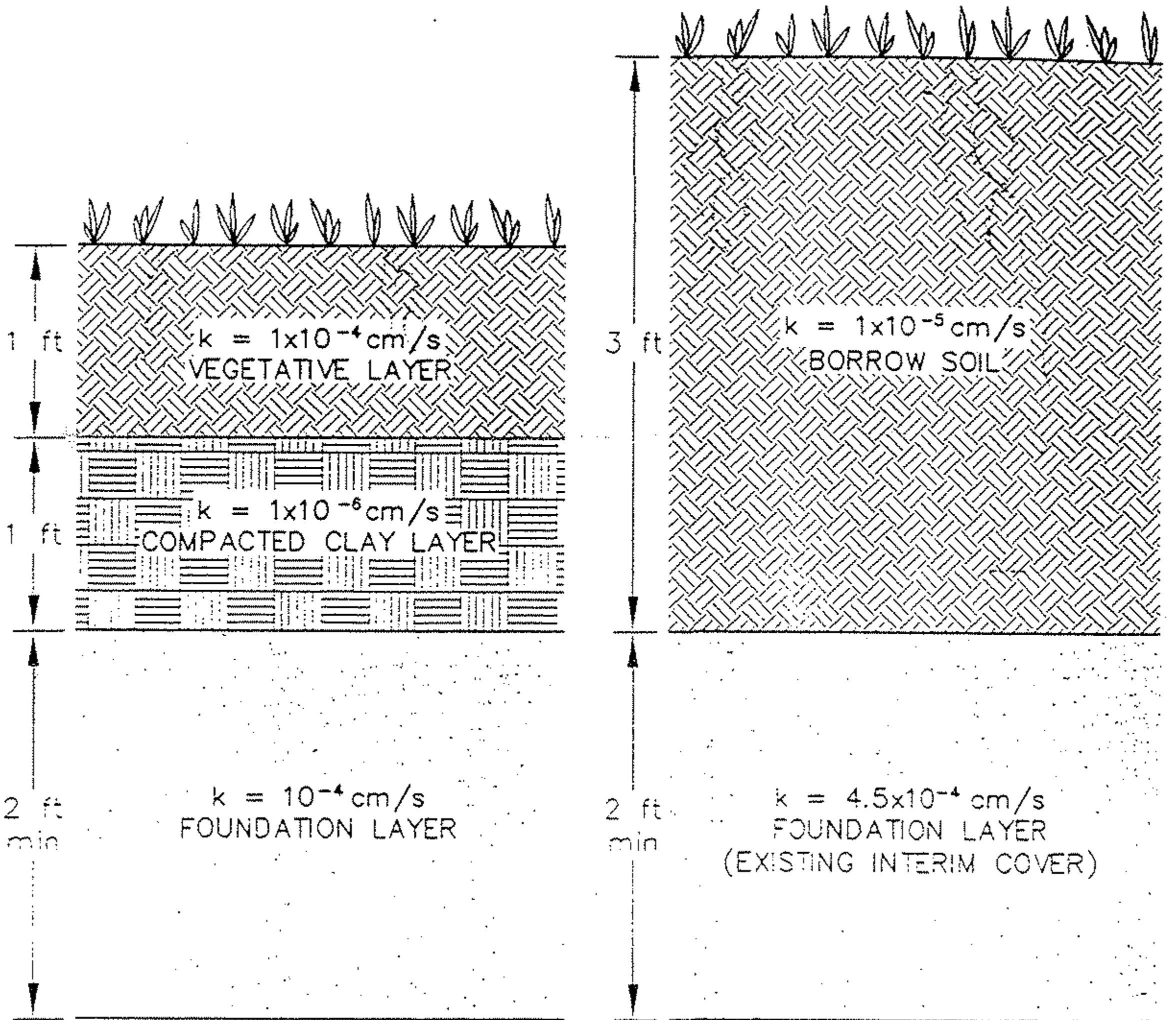
DWG 4100F703.DWG



GEOSYNTEC CONSULTANTS

PREDICTED CUMULATIVE PERCOLATION
SLOPES OF DISPOSAL AREA A
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	6-1
PROJECT NO.	CE4100-04
DATE:	5 MARCH 1998



TITLE 27 "PRESCRIPTIVE" COVER CROSS-SECTION

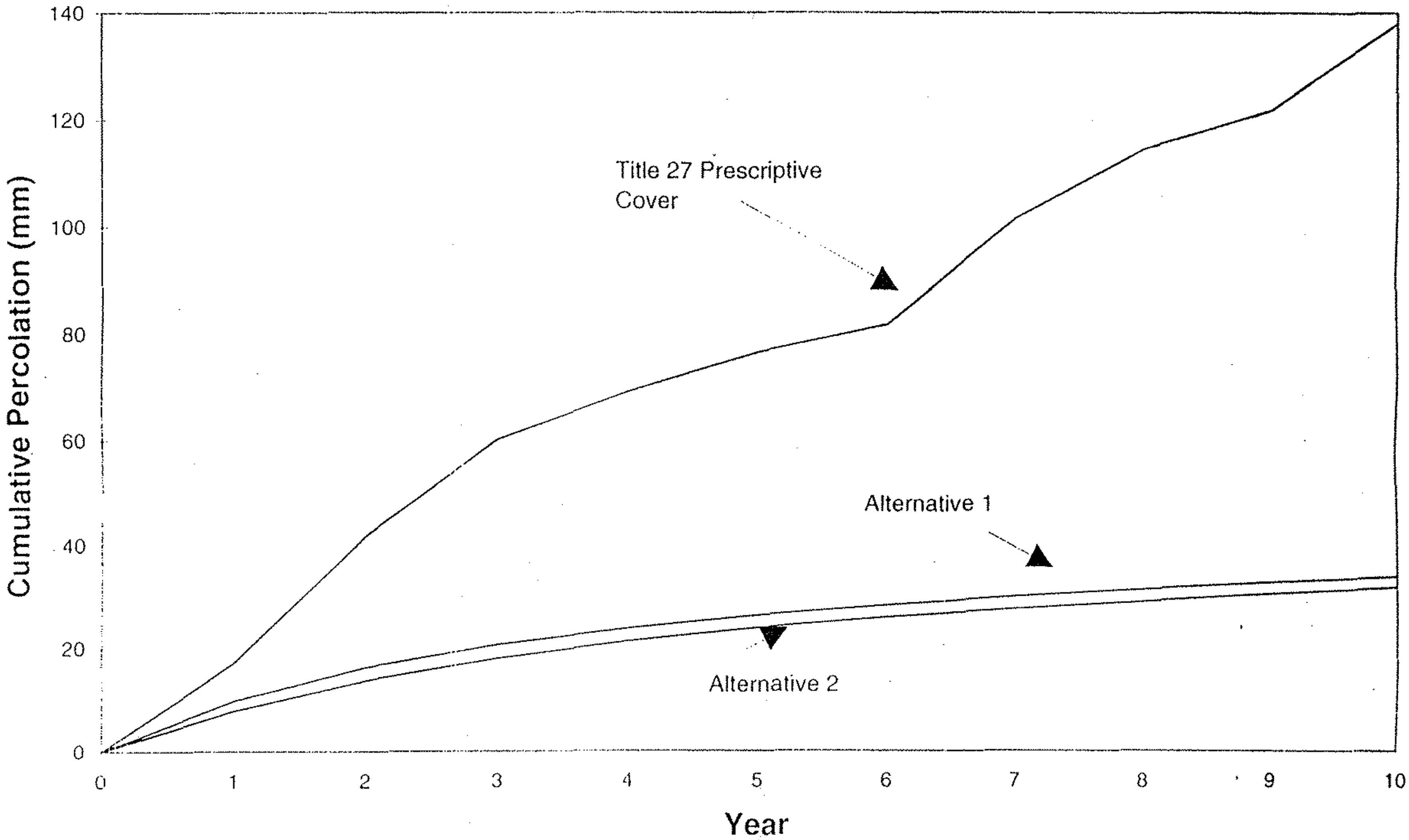
MONOLITHIC COVER CROSS-SECTION ALTERNATIVES 1 AND 2

GEOSYNTEC CONSULTANTS

FINAL COVER CROSS-SECTIONS MODELED
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

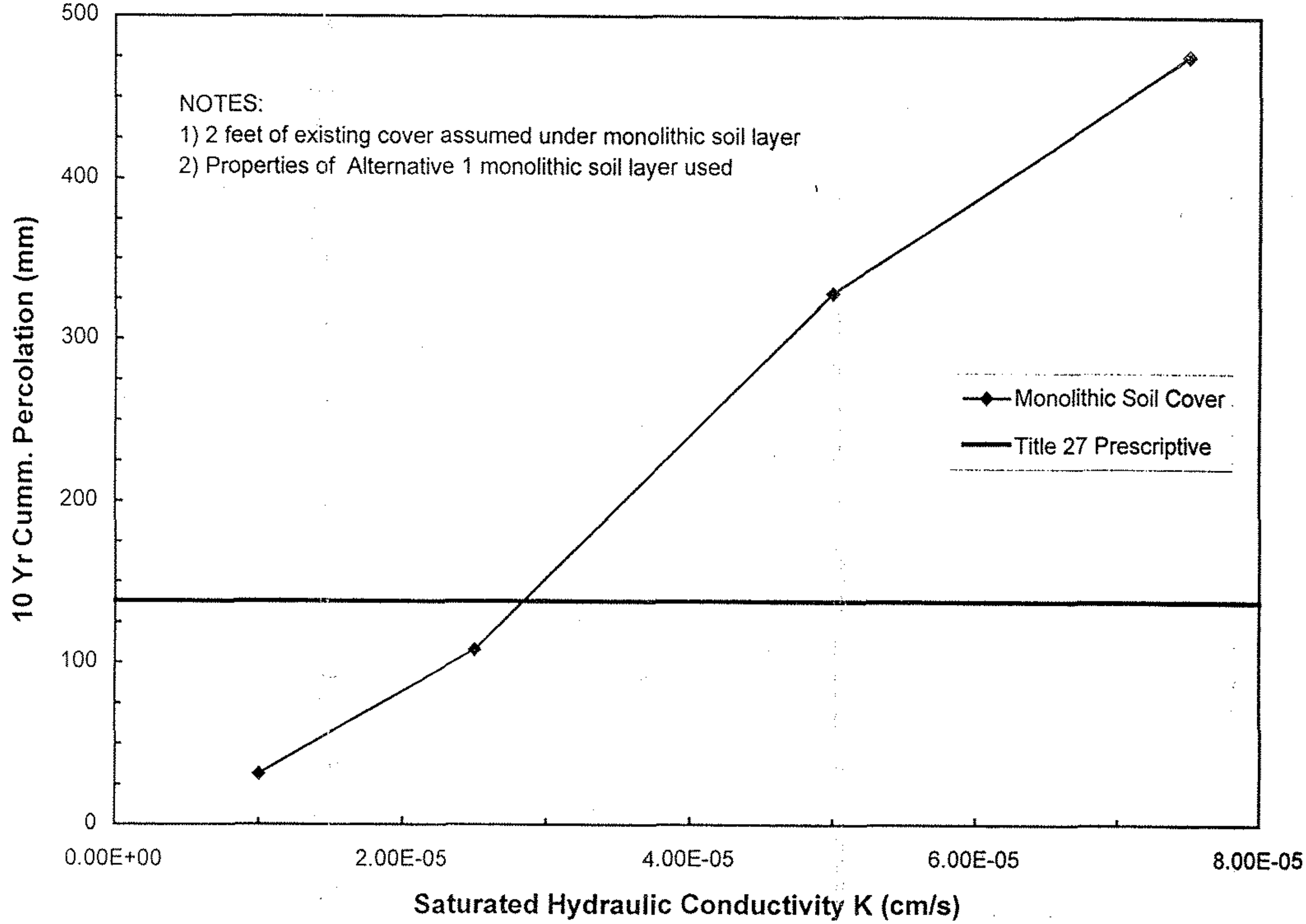
FIGURE NO.	6-2
DOCUMENT NO.	LPZ98-13.RPT
PROJECT NO.	CE4100-04
DATE:	5 MARCH 1998

DWG: 4100F704.DWG 199804060851 AC



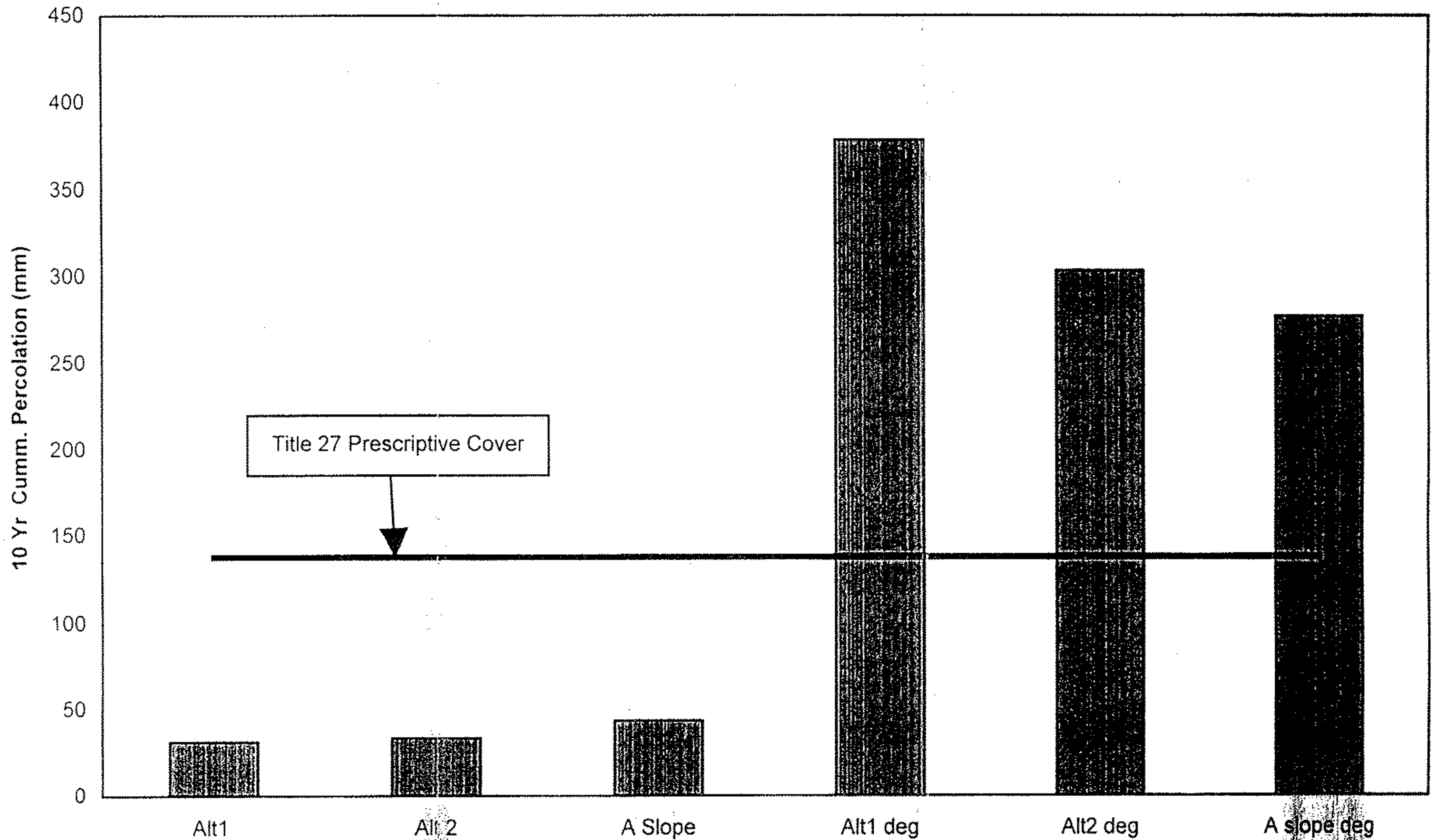
GEOSYNTEC CONSULTANTS

PREDICTED CUMULATIVE PERCOLATION FOR ALTERNATIVE AND PRESCRIPTIVE COVERS LOPEZ CANYON SANITARY LANDFILL LAKEVIEW TERRACE, CALIFORNIA	FIGURE NO.	6-3
	PROJECT NO.	CE4100-04
	DATE:	5 MARCH 1998



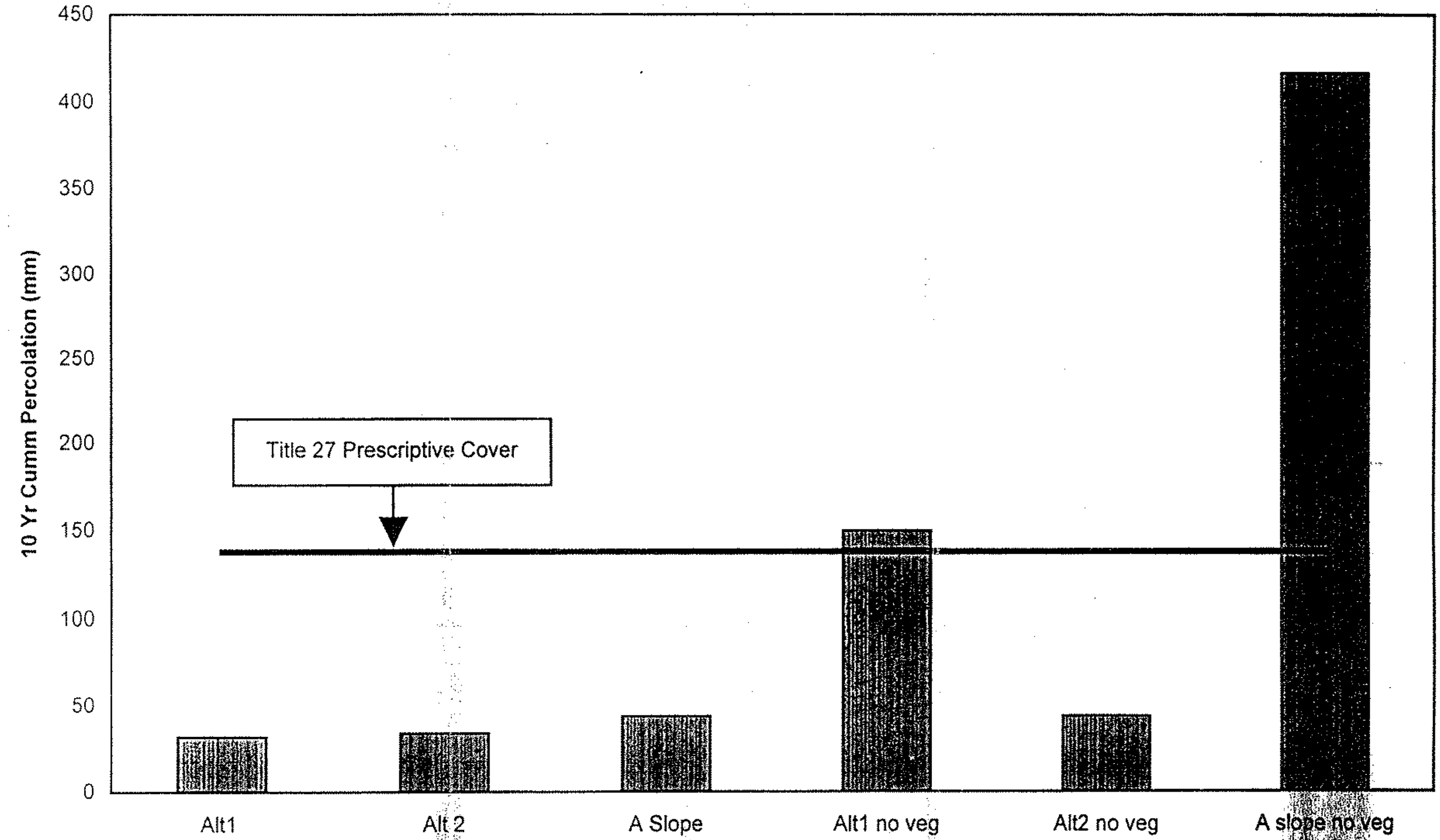
GEOSYNTEC CONSULTANTS

SENSITIVITY ANALYSIS SATURATED HYDRAULIC CONDUCTIVITY MONOLITHIC SOIL COVER LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	6-4
	PROJECT NO.	CE4100-04
	DATE:	11 SEPTEMBER 1998



GEOSYNTEC CONSULTANTS

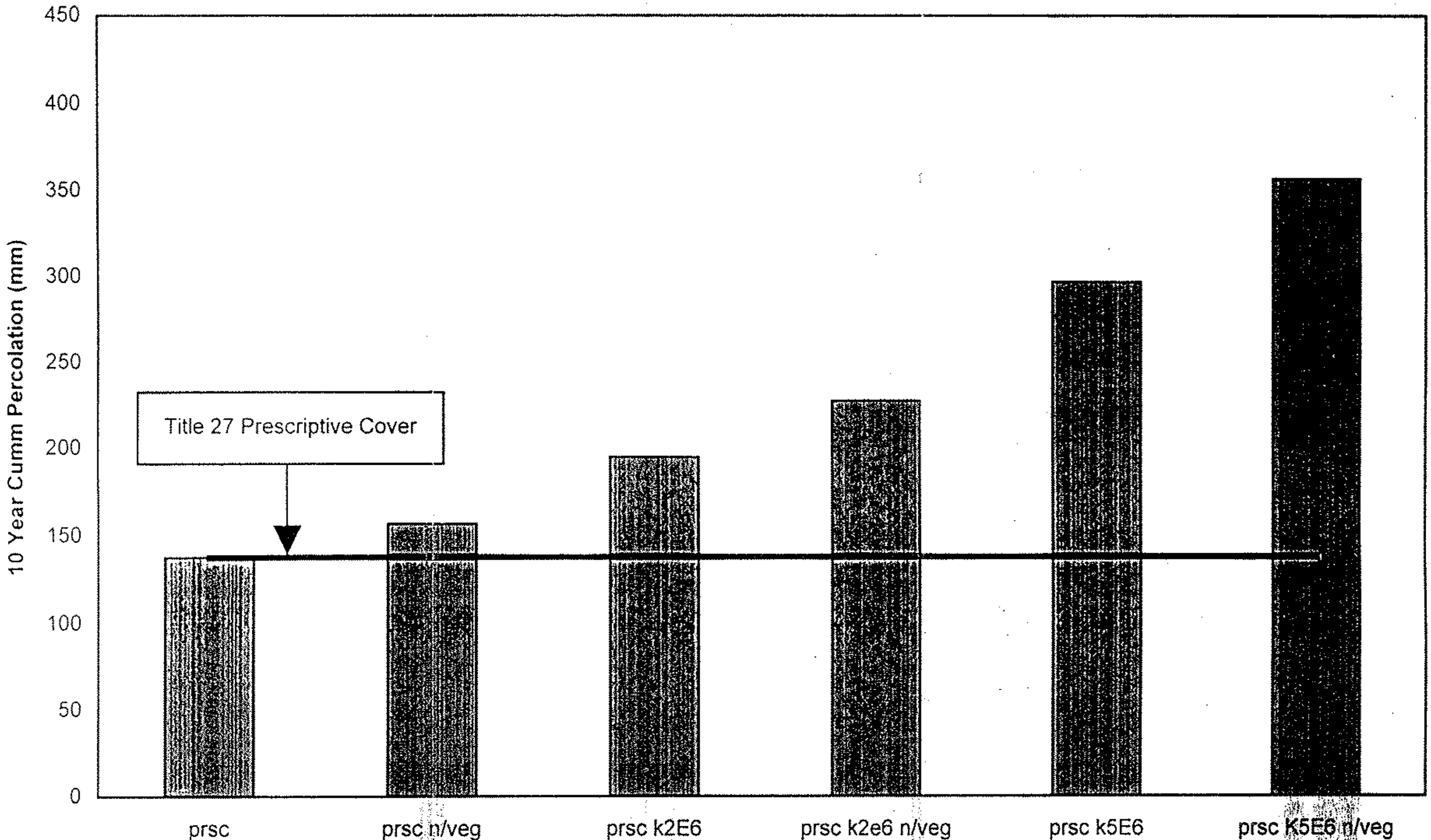
SENSITIVITY ANALYSIS DEGRADED SATURATED HYDRAULIC CONDUCTIVITY MONOLITHIC SOIL COVER LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	6-5
	PROJECT NO.	CE4100-04
	DATE:	11 SEPTEMBER 1998



GEOSYNTEC CONSULTANTS

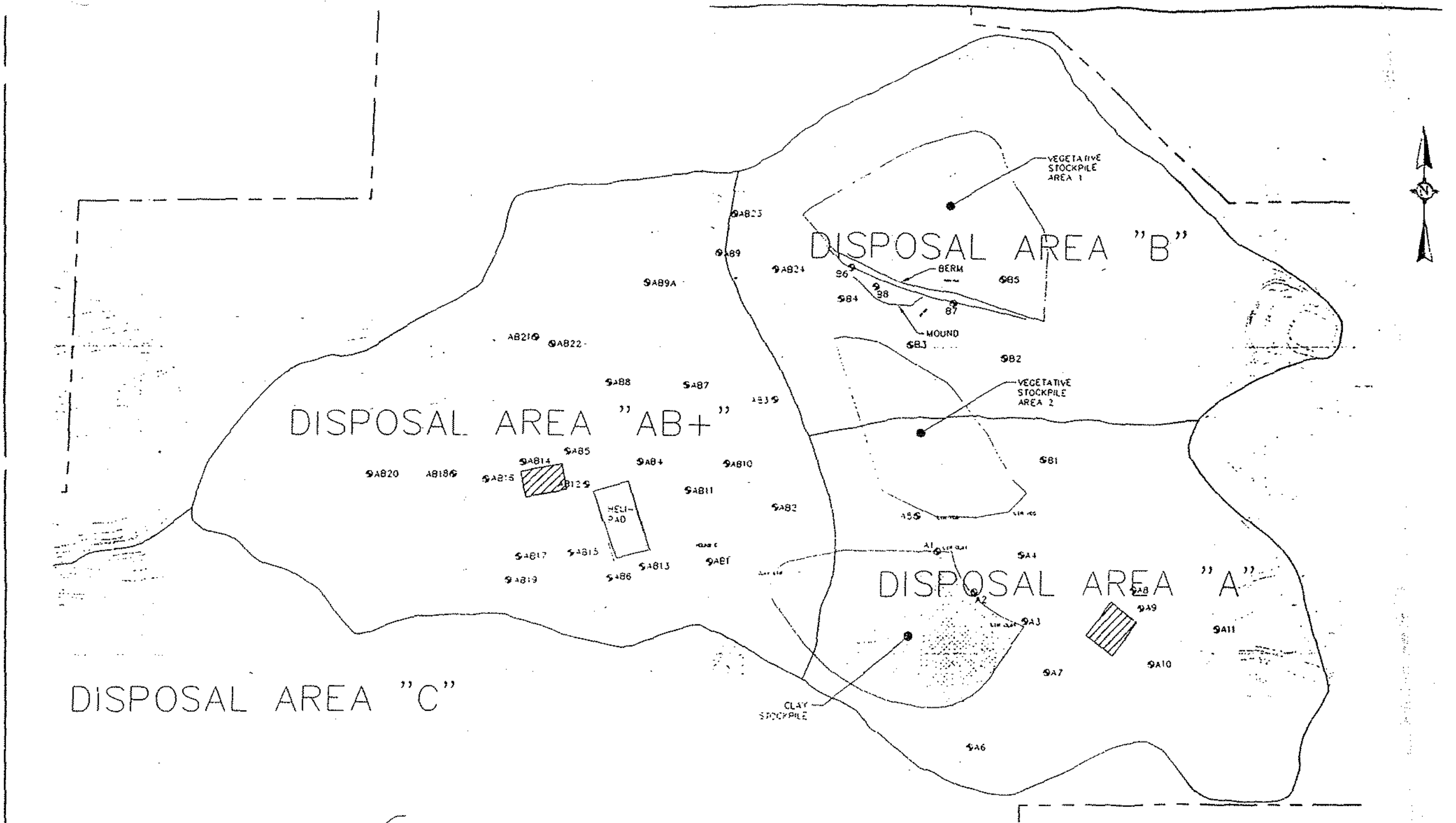
SENSITIVITY ANALYSIS
VEGETATION
MONOLITHIC SOIL COVER
LOPEZ CANYON SANITARY LANDFILL
LAKE VIEW TERRACE, CALIFORNIA

FIGURE NO.	6-6
PROJECT NO.	CE4100-04
DATE:	11 SEPTEMBER 1998



GEOSYNTEC CONSULTANTS

SENSITIVITY ANALYSES VEGETATION AND DEGRADED HYDRAULIC CONDUCTIVITY TITLE 27 PRESCRIPTIVE COVER LOPEZ CANYON SANITARY LANDFILL LAKE VIEW TERRACE, CALIFORNIA	FIGURE NO.	6-7
	PROJECT NO.	CE4100-04
	DATE:	11 SEPTEMBER 1998



PROPOSED TEST LOCATIONS

300 150 0 300 600
SCALE IN FEET

GeoSyntec Consultants

LOCATION OF MONITORING TEST SECTIONS
LOPEZ CANYON SANITARY LANDFILL
LAKEVIEW TERRACE, CALIFORNIA

FIGURE NO.	7-1
PROJECT NO.	CE4100-04
DOCUMENT NO.	LPZ98-13
DATE:	7 APRIL 199

DWG 4100F705.DWG 19980407(5) A

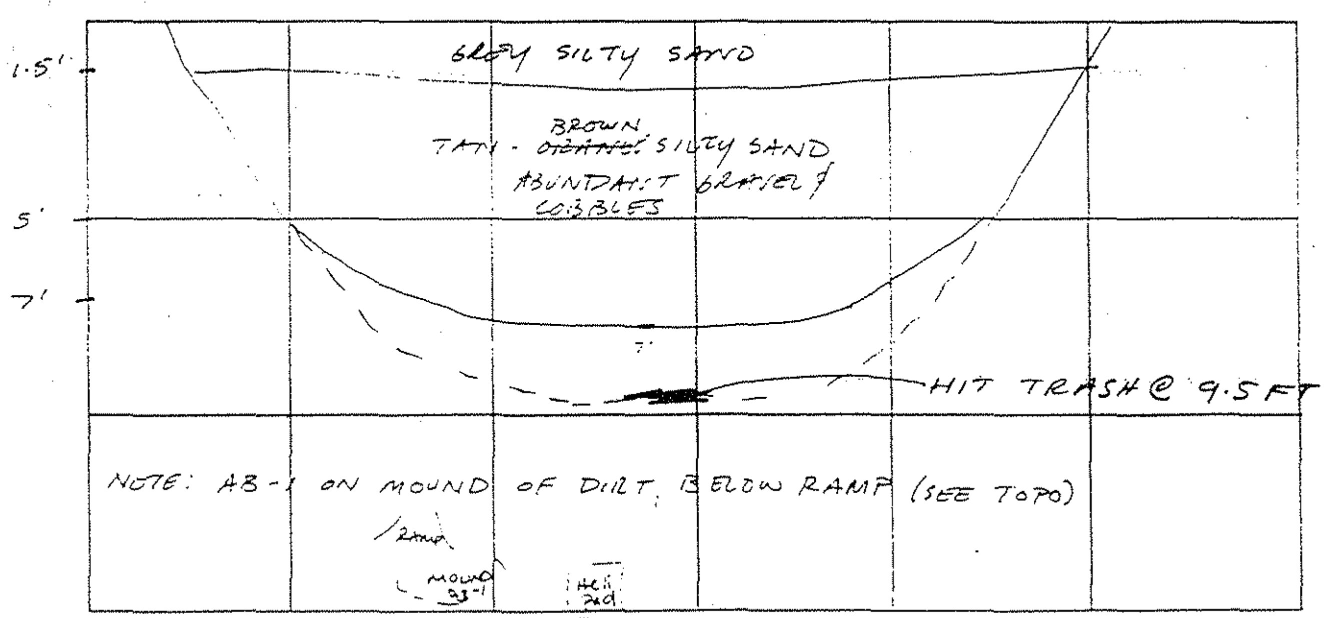
APPENDIX A:
FIELD LOGS FROM TEST PITS

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF) *	γ_w
		1.5	GREY SILTY SAND (STAINED)		12.4	110.5	124.2
			LT. TAN-~~ORANGE~~ BROWN SILTY SAND W/ GRAVEL & COBBLES TO 6"	AB-1			
		7'	NO TRASH ENCOUNTERED				
		9.5	1-16-98 RE-EXCAVATED TRENCH, HIT TRASH @ 9.5 FT				

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE * USED CURVE γ_{DMAX} = 118.5

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + DECK DATE: 1-12-98 & 1-16-98 (RE-DUG TRENCH @ SAME LOCATION)

ELEVATION: 1774 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-1

FIGURE NO.

GeoSyntec Consultants

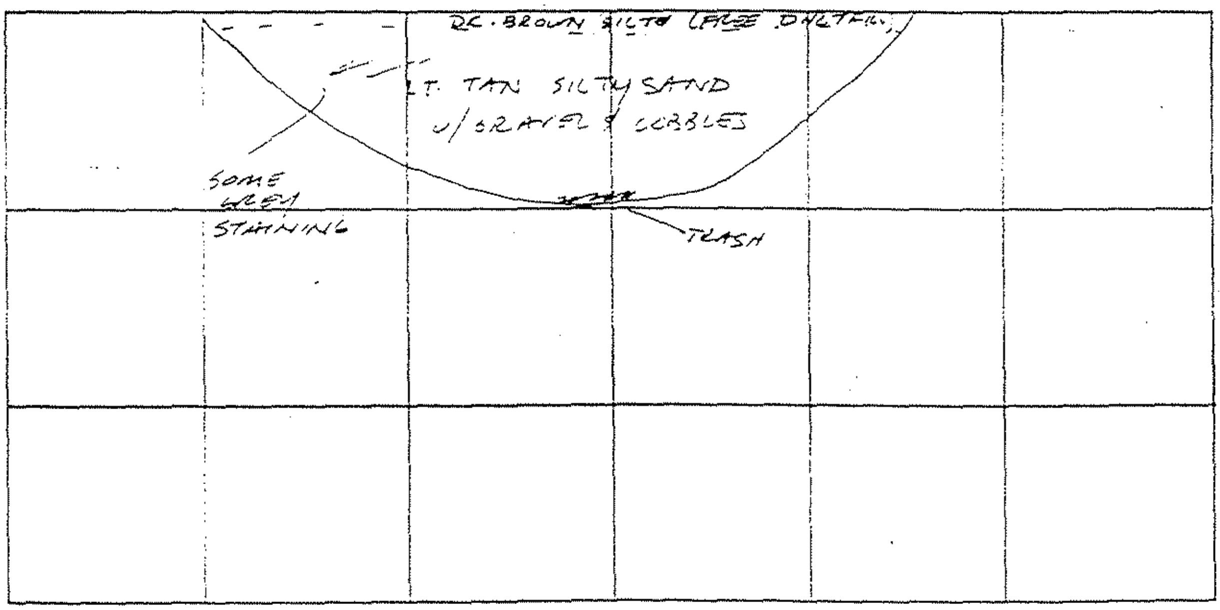
REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE* CONTENT (%)	DRY DENSITY (PCF)
		3-4"	DARK BROWN SANDY SILT		15.4	112.8
			LT. TAN SILTY SAND w/ GRAVEL & COBBLES			
		5'	HIT TRASH AT 5 FT. (PLASTIC BAGS)			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

* TOP 6", RAINED .5" OVER WEEKEND.

SCALE 1" =   BEARING =   TRENCH WALL:

5'



LOCATION: AB & PERK   DATE: 1-12-98

ELEVATION: 1768   EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY: CC

LOG OF TEST PIT NO. AB-2

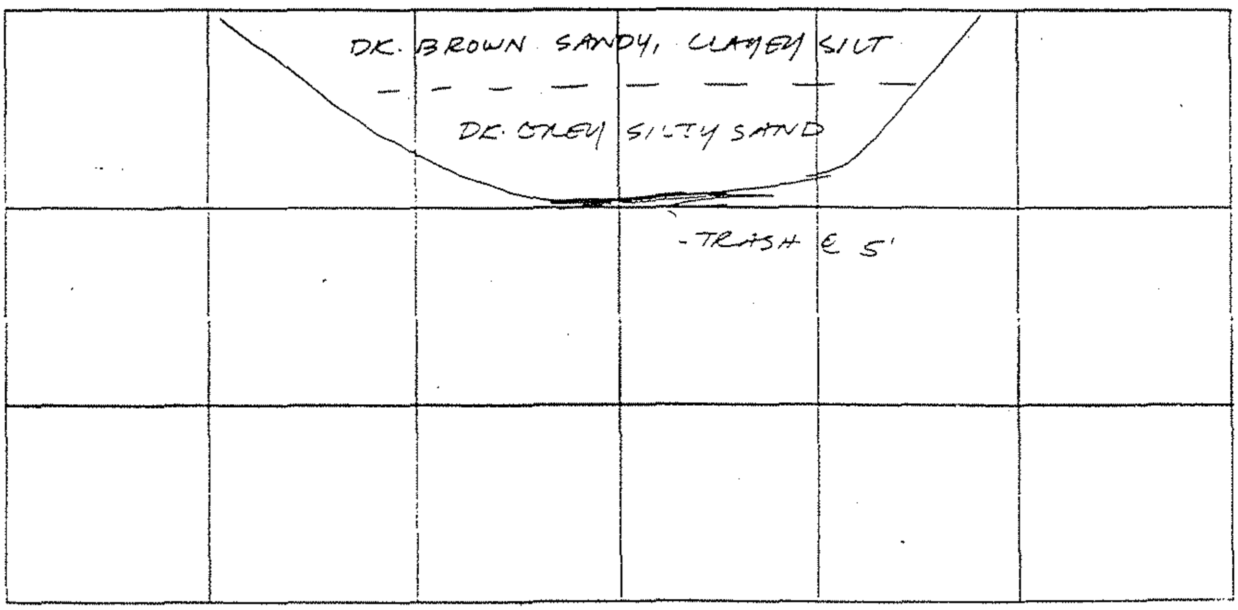
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		2FT	DK. BROWN SANDY SILT, SOME CLAYEY FINES (SAMPLED) -FREE DIRT FILL	AB-3		
		5'	GREY (STAINED) SILTY SAND w/ GRAVEL & COBBLES TO 6"			
			HIT TRASH @ 5 FT.			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-13-98

ELEVATION: 1764 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-3

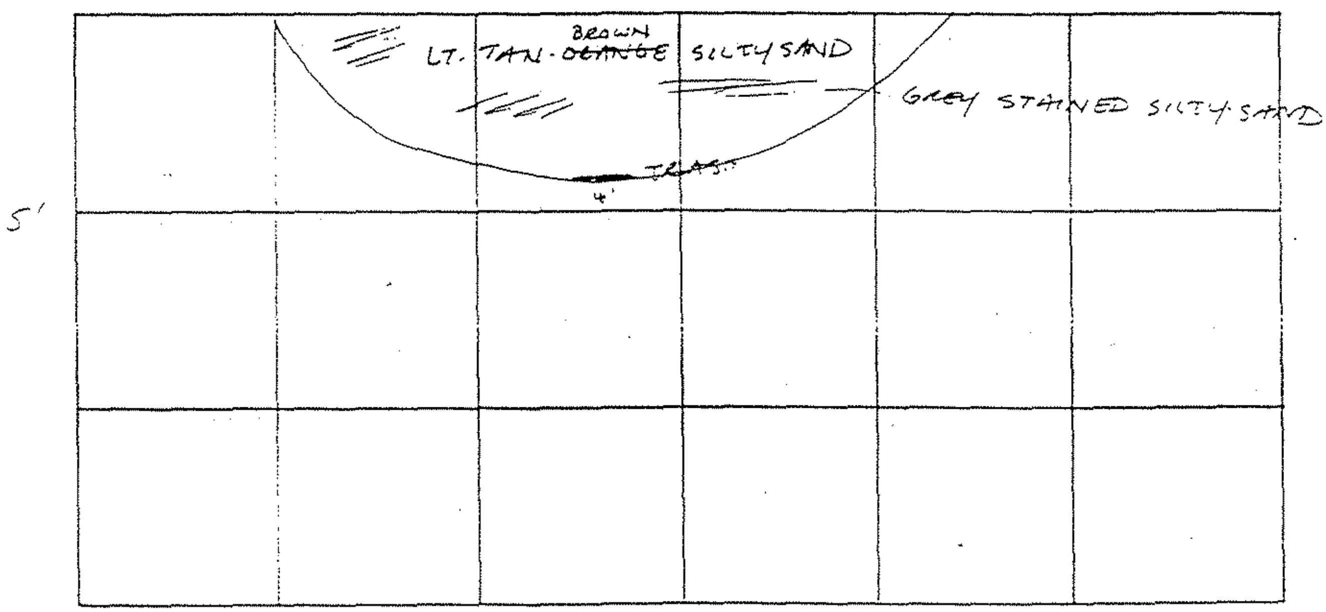
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. TAN - ~~ORANGE~~ BROWN SILTY SAND, GREY STREAKS (STAINING) W/GRAVEL & COBBLES - AS AB-11			
		4' -	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + DECK DATE: 1-12-98

ELEVATION: 1760 EQUIPMENT: EXCAVATOR

WATER LEVEL. LOGGED BY: CC

LOG OF TEST PIT NO. AB-4

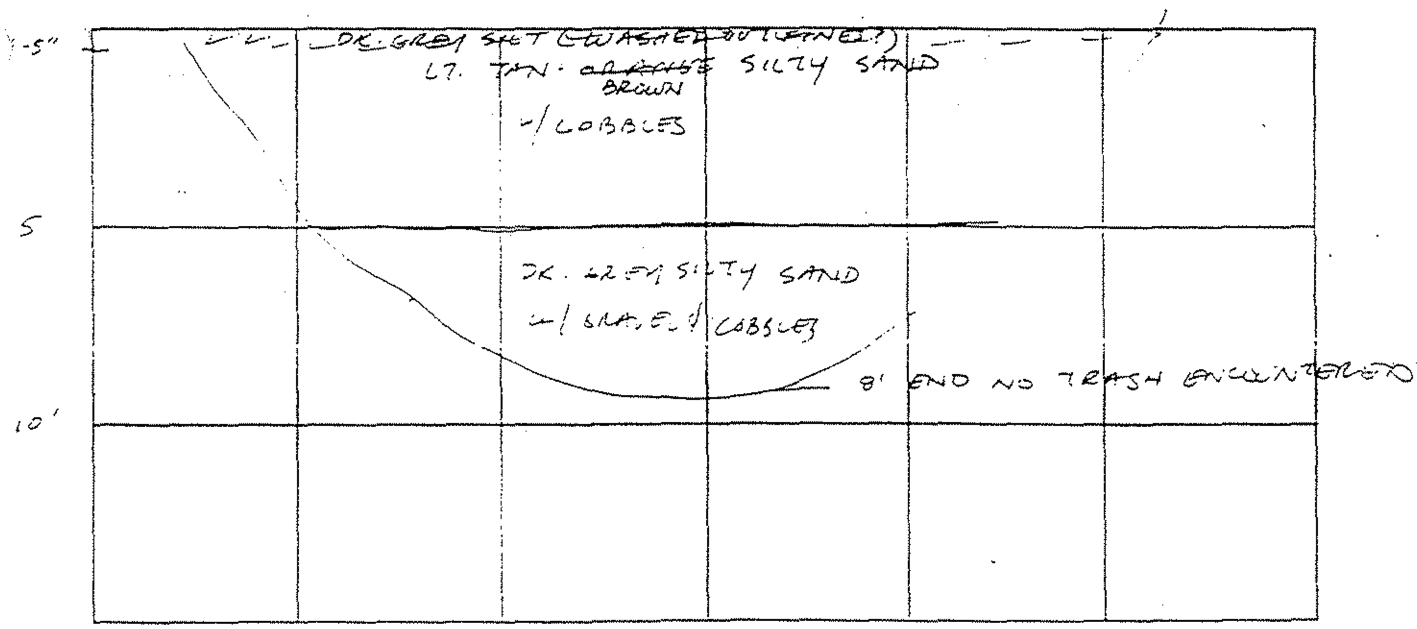
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		4.5"	MOIST DK. GREY SILT			
			LT. TAN-~~ORANGE~~ BROWN SILTY SAND W/ COBBLES TO 6"			
		5'	DK GREY (STAINED?) SILTY SAND W/ GRAVEL & COBBLES TO 6"			
		8'	NO TRASH ENCOUNTERED, END TESTPIT.			

B - BULK SAMPLE　　T - TUBE SAMPLE　　D - DRIVE SAMPLE

SCALE 1" =　　BEARING =　　TRENCH WALL:



LOCATION: AB-? DECK　　DATE: 1-12-93

ELEVATION: 1760　　EQUIPMENT: EXCAVATOR

WATER LEVEL:　　LOGGED BY: CC

LOG OF TEST PIT NO. AB-5

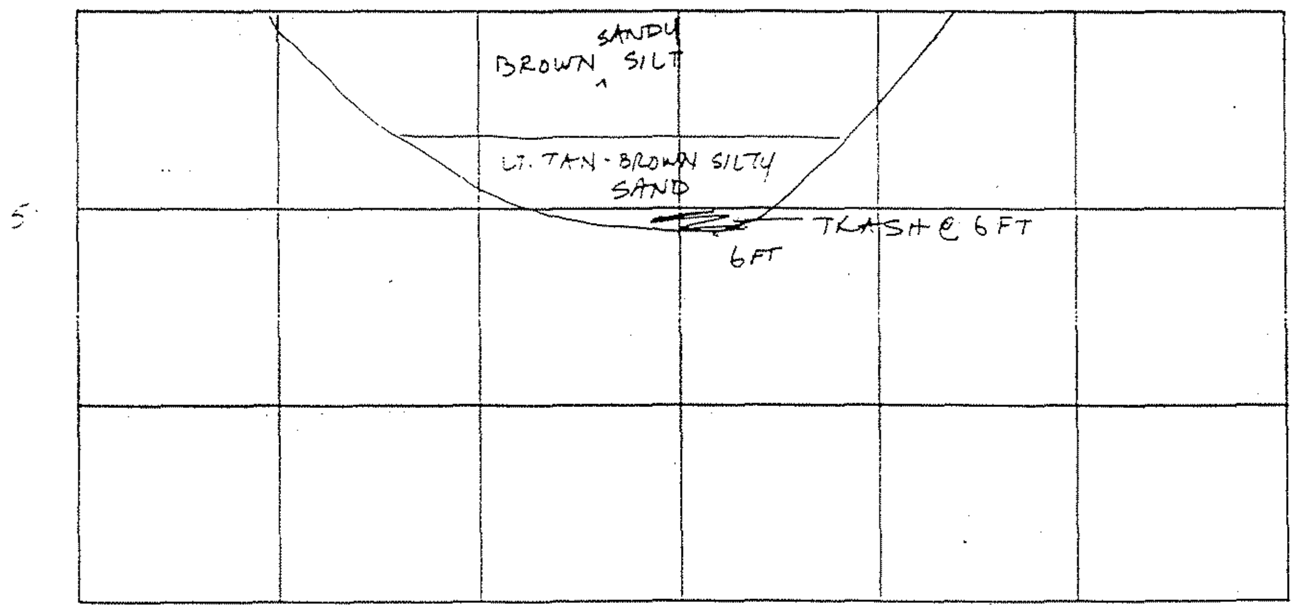
FIGURE NO. ____

A Recycled and Recyclable Paper

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SANDY SILT w/ GRAVEL & COBBLES TO 4"			
		3'	(FREE DIRT FILL ?)			
			LT. TAN/BROWN SILTY SAND w/ GRAVEL & COBBLES - GREY STAINING			
		6'	HIT TRASH			

B - BULK SAMPLE　　T - TUBE SAMPLE　　D - DRIVE SAMPLE

SCALE 1" =　　BEARING =　　TRENCH WALL:



LOCATION: AB+ DECK　　DATE: 1 - 13 - 98

ELEVATION: 1755　　EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A　　LOGGED BY: CL

LOG OF TEST PIT NO. AB - 8

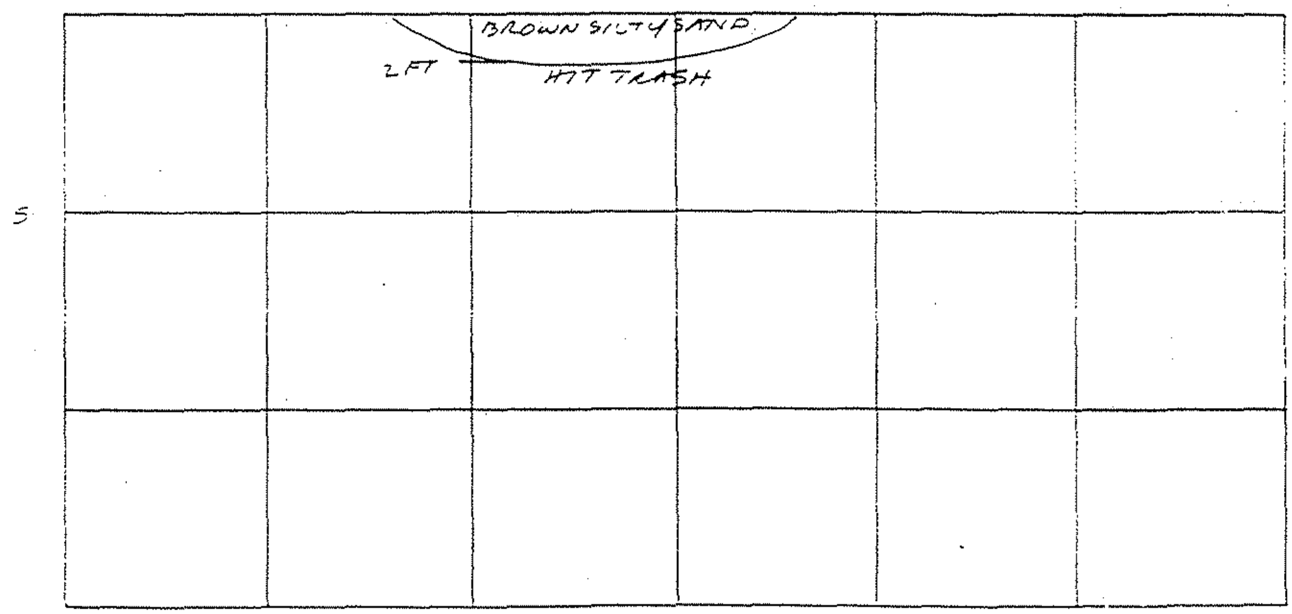
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND			
		2' —	TRASH (IN FIRST BUCKET EXCAVATED) @ 1.5 - 2 FT.		-	

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + DECKS DATE: 1 - 13 - 98

ELEVATION: 1749 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

* MOVED AB-9 LOCATION TO LOW-SPOT, AS ORIGINALLY ON 6-9 FT FREE DIRT FILL

LOG OF TEST PIT NO. AB-9A *

FIGURE NO.

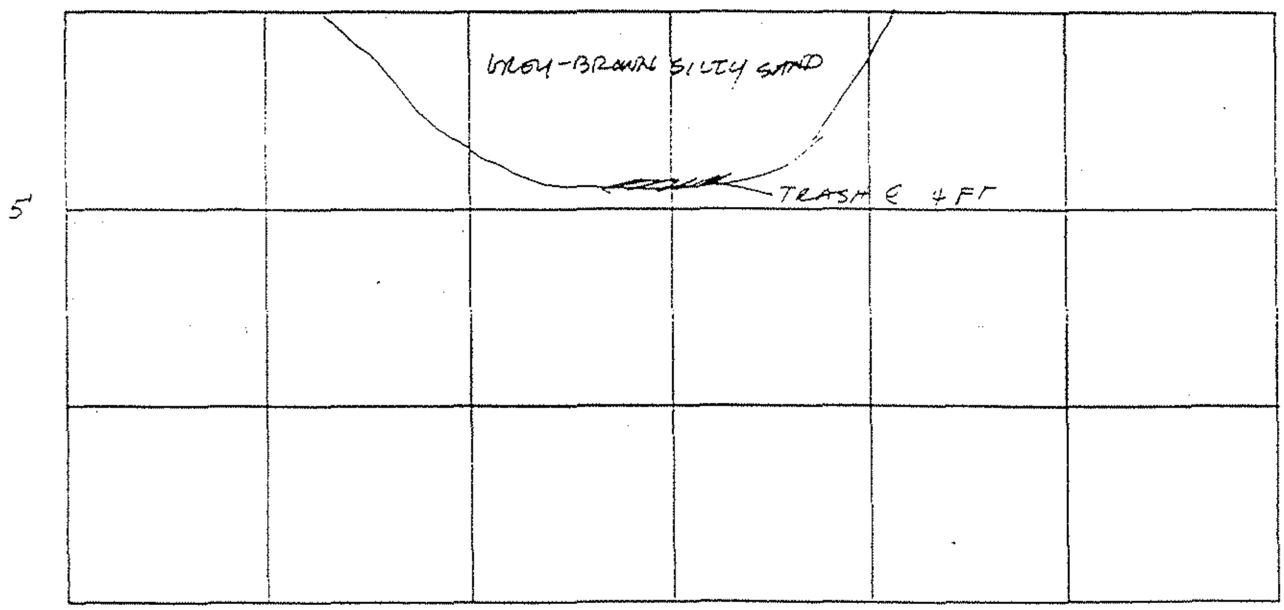
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY-BROWN SILTY SAND W/ GRAVEL & COBBLES TO 4"			
		4'	— HIT TRASH @ 4 FT. STOPPED			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB4 DECK DATE: 1 - 13 - 98

ELEVATION: 1761.5 EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY:

LOG OF TEST PIT NO. AB-10

FIGURE NO.:

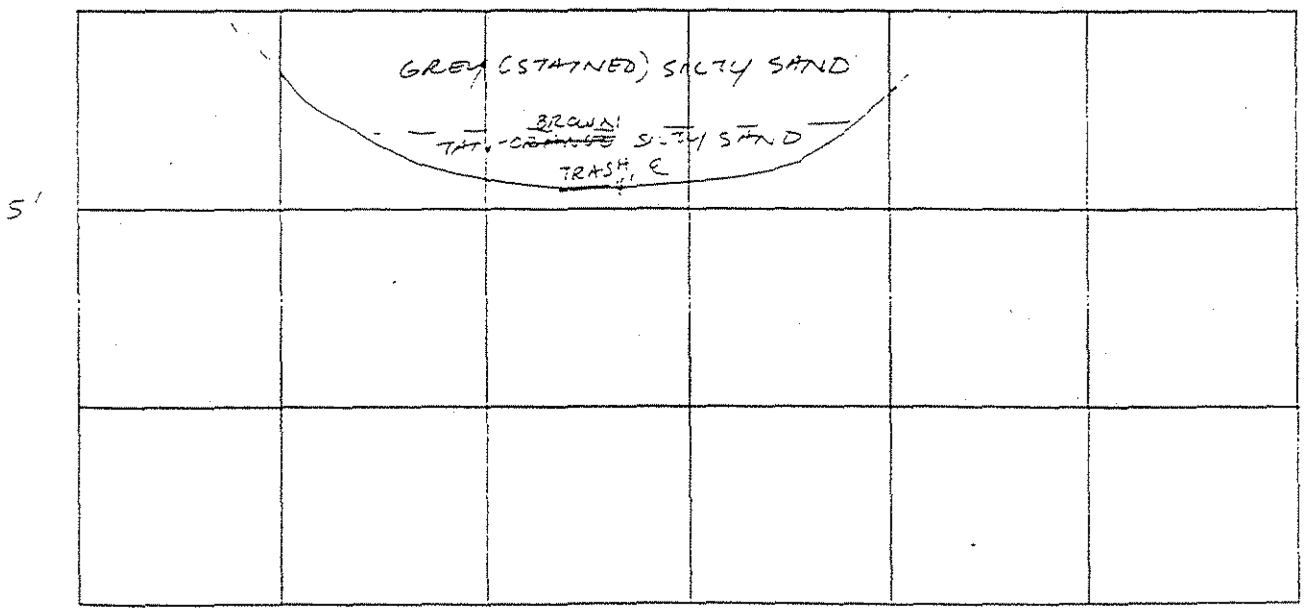
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY SILTY SAND w/ GRAVEL (STAINED) (SAMPLED)	AB-11	18.5	92.7
		3'	LT. TAN-~~ORANGE~~ BROWN SILTY SAND w/ GRAVEL			
		4'	HIT TRASH AT 4 FT.			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

STAINED 1.5" OVER WEEKEND, TOP 3-4" VERY MOIST.

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 1-12-98

ELEVATION: 1763 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-11

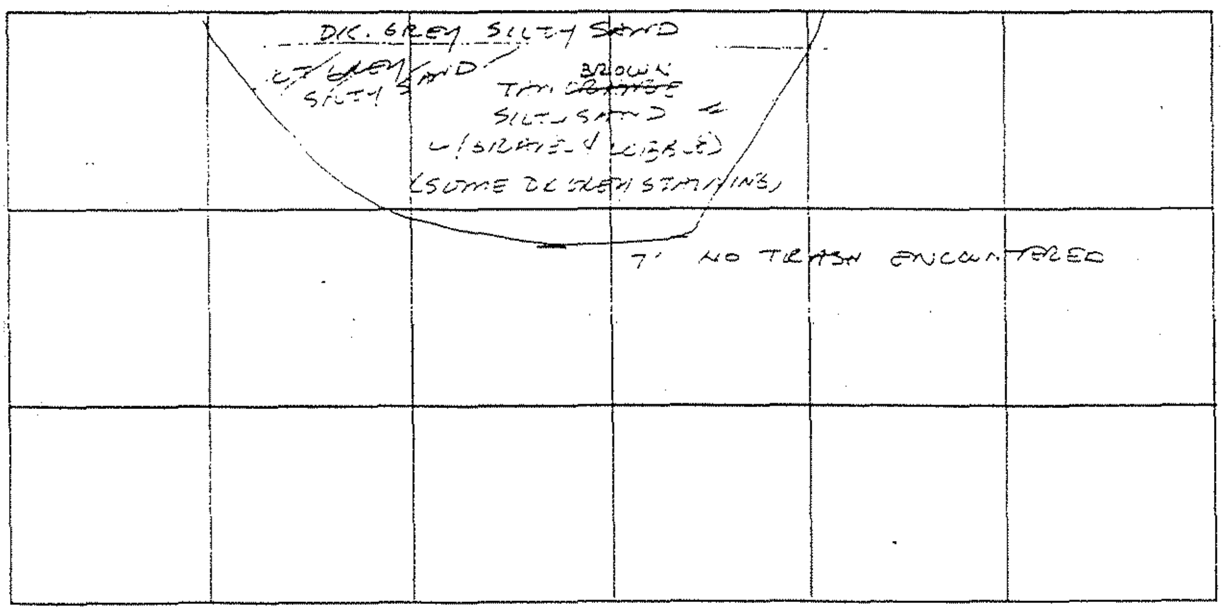
FIGURE NO. ____

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. GREY SILTY SAND			
		2'				
		3'	LT GREY SILTY SAND			
			LT. TAN ~~ORANGE~~ BROWN SILTY SAND W/GRAVEL & COBBLES DK. GREY STREAKS			
		7'	NO TRASH ENCOUNTERED, END TESTPIT @ ~~8~~ 7 FT.			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



* ADDED AB-12 BECAUSE DIDN'T FIND TRASH @ AB-5, ATTEMPTING TO GET EL. OF TRASH IN THIS CORNER (SEE LOCATION MAP)

LOCATION AB + DECK DATE: 1-12-99

ELEVATION: 1759 EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY: CC

LOG OF TEST PIT NO. AB-12

FIGURE NO. ____

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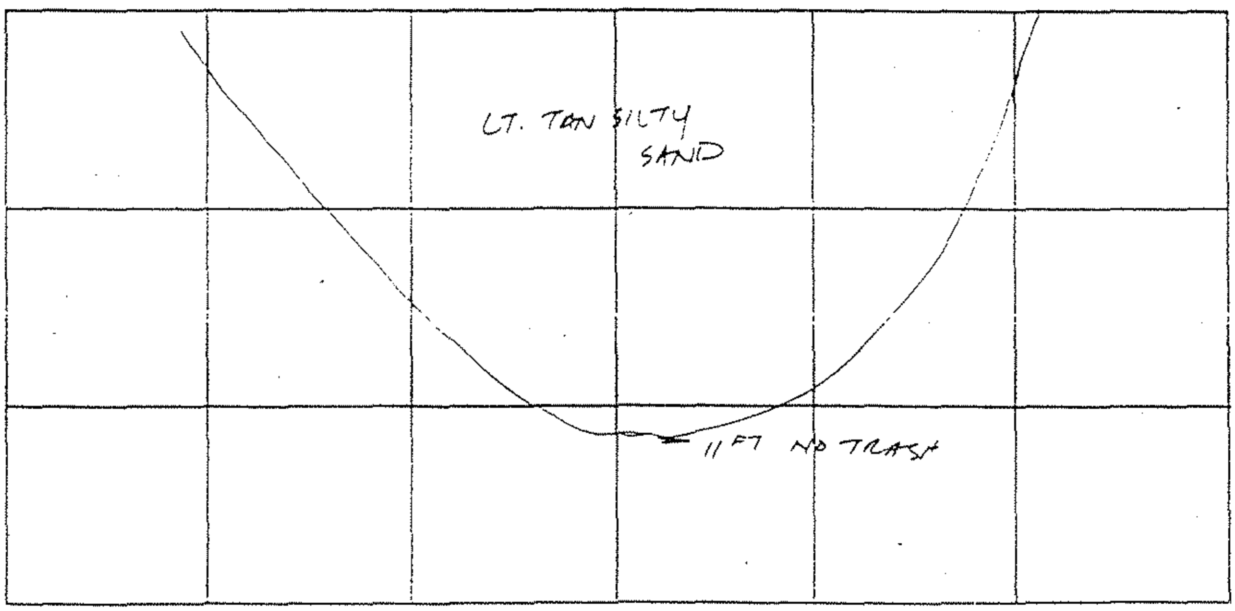
GeoSyntec Consultants

REF. NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. TAN SILTY SAND w/ GRAVEL & COBBLES			
		11'	— NO TRASH ENCOUNTERED			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

SCALE 1" =   BEARING =   TRENCH WALL:



LOCATION: ABT DECK   DATE: 1-13-93

ELEVATION: 1767   EQUIPMENT: EXCAVATOR

WATER LEVEL: LOGGED BY:

LOG OF TEST PIT NO. AB-13

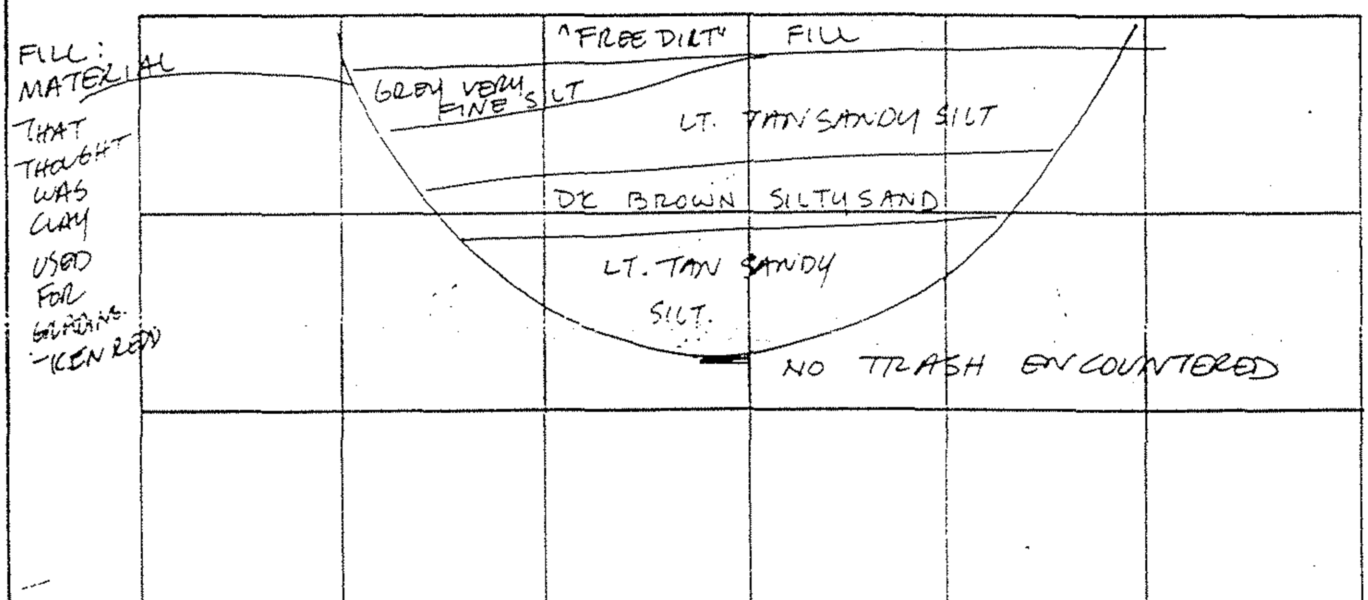
FIGURE NO. ____

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SANDY SILT W/CLAY (FREE DIRT FILL) (WET)		20.0	105.6
		6"	GREY VERY FINE SILT (SAMPLED)	AB25-A	-	
		1'	LT. TAN SANDY SILT		-	
		3'	DARK BROWN SILTY SAND (FILL)			
		5'	TAN/ LT. BROWN SILTY SAND W/ COBBLES.	AB25-B		
		9'				

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ DECK DATE: 2-5-98

ELEVATION: 1762 EQUIPMENT: J.D. 892ELC

WATER LEVEL: N/A. LOGGED BY: CC

LOG OF TEST PIT NO. AB-25 ~~(RE-DUG)~~

FIGURE NO.

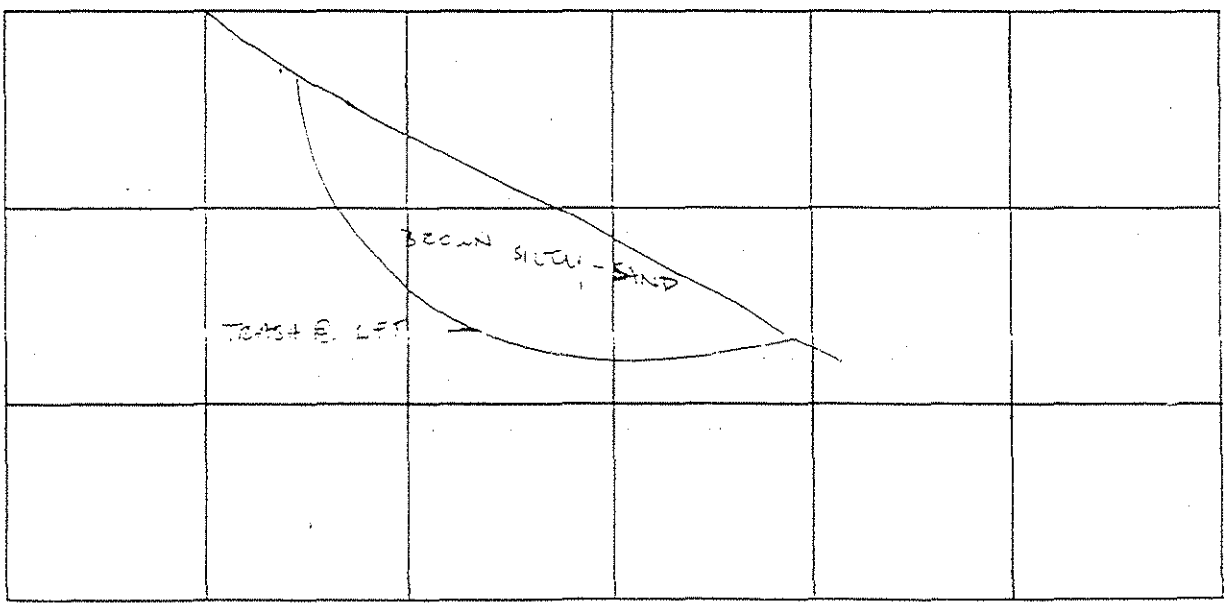
Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND (LOTS OF GRAVEL & COBBLES - TO BOULDERS (PT ϕ) STAINED/STREAKED WITH GREY			
		6'	- HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-15-98

ELEVATION: 1742.4 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

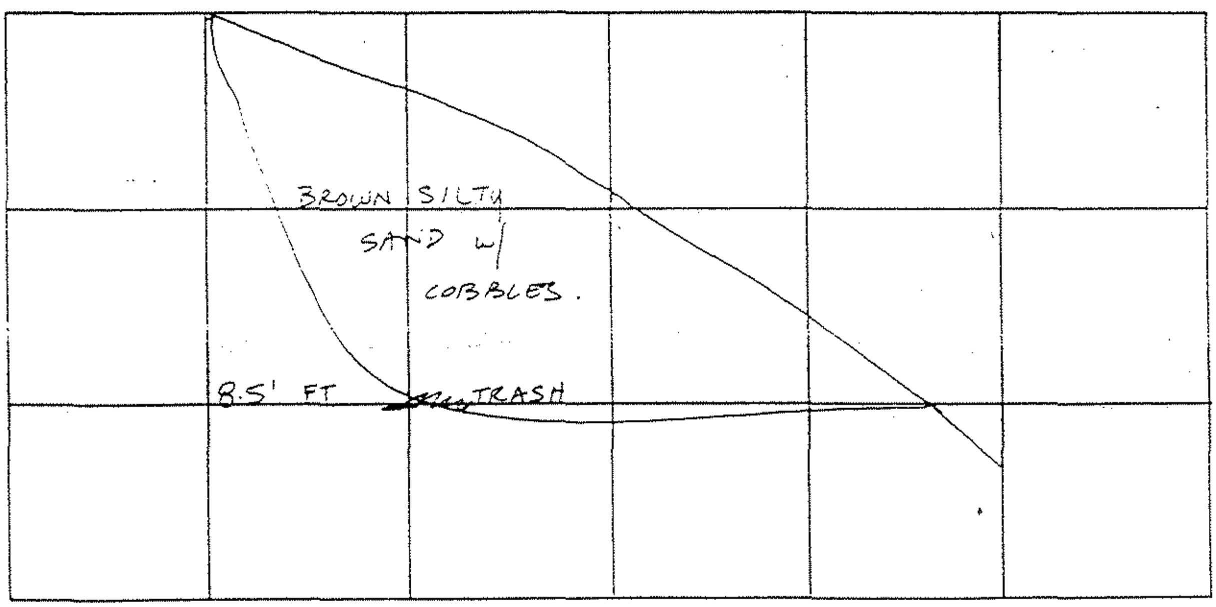
LOG OF TEST PIT NO. AB-14

FIGURE NO. ____

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND w/ COBBLES			
		8.5	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB SLOPES DATE: 1-15-93

ELEVATION: 1759.9 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-15

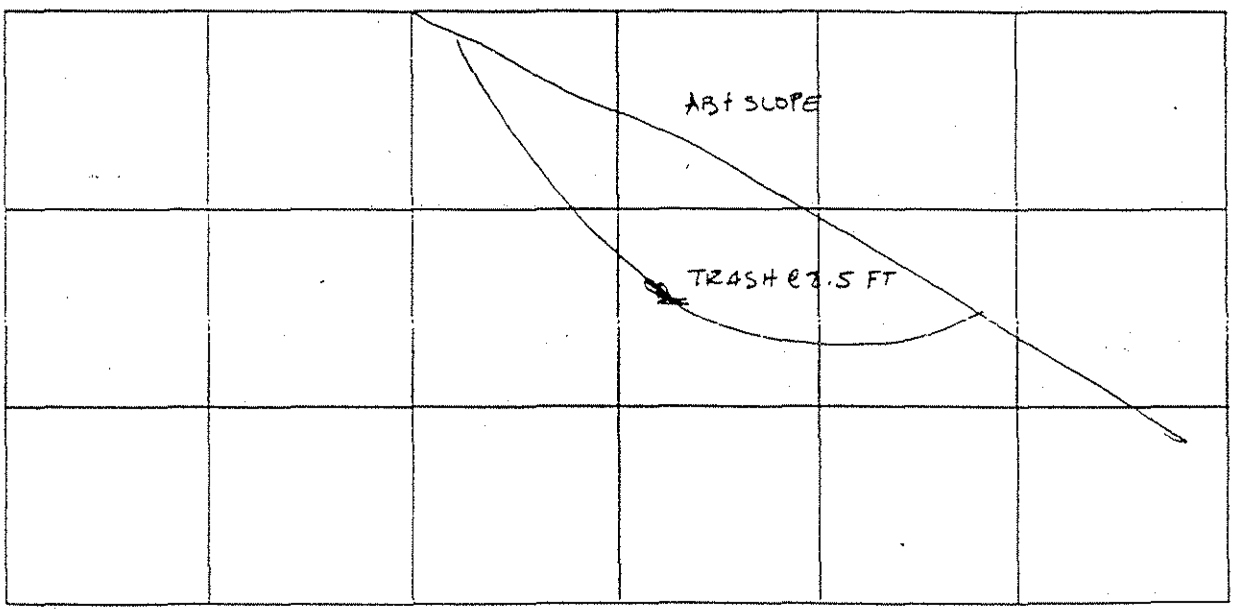
FIGURE NO. ____

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND, SOME GREY STAINING			
		2.5	TRASH @ 2.5 - 3 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-15-98

ELEVATION: 1698.5 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-16

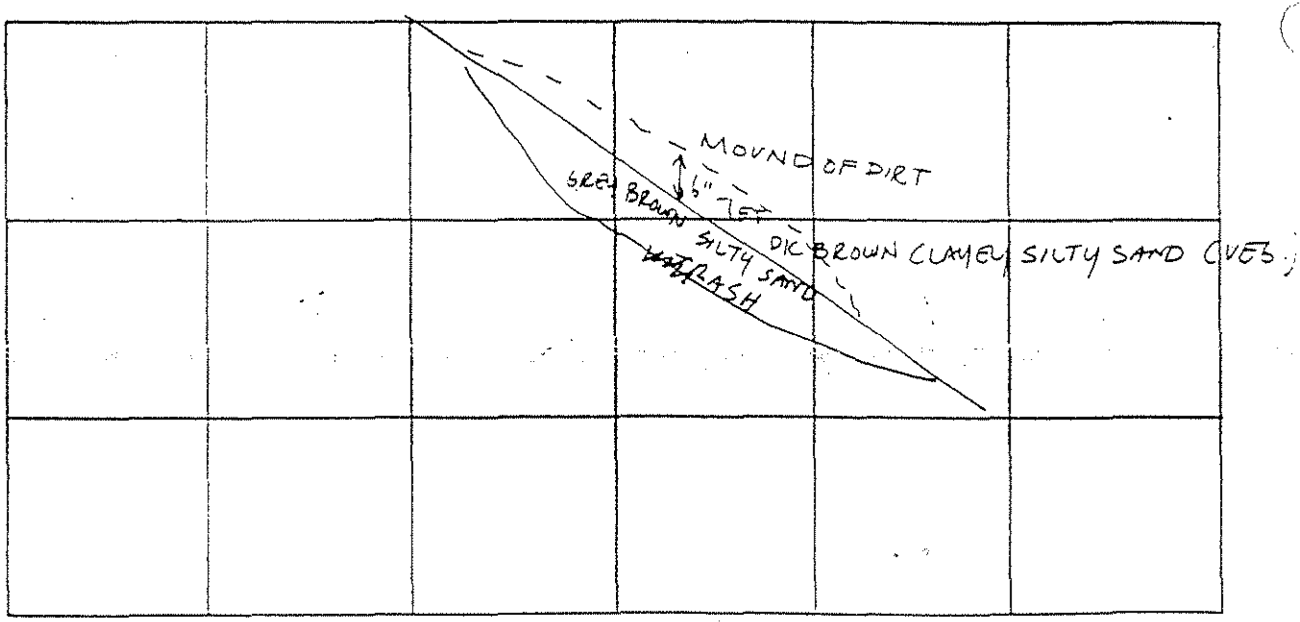
FIGURE NO.

GeoSynTec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN CLAYEY, SILTY SAND (VEG) MOUNDED. (HOT SPOT)			
		6"	GREY (STAINED) - BROWN SILTY SAND		-	
		2'	TRASH @ 1 FT - 2 FT		-	

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-15-98

ELEVATION: 1700 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CL

LOG OF TEST PIT NO. AB-17

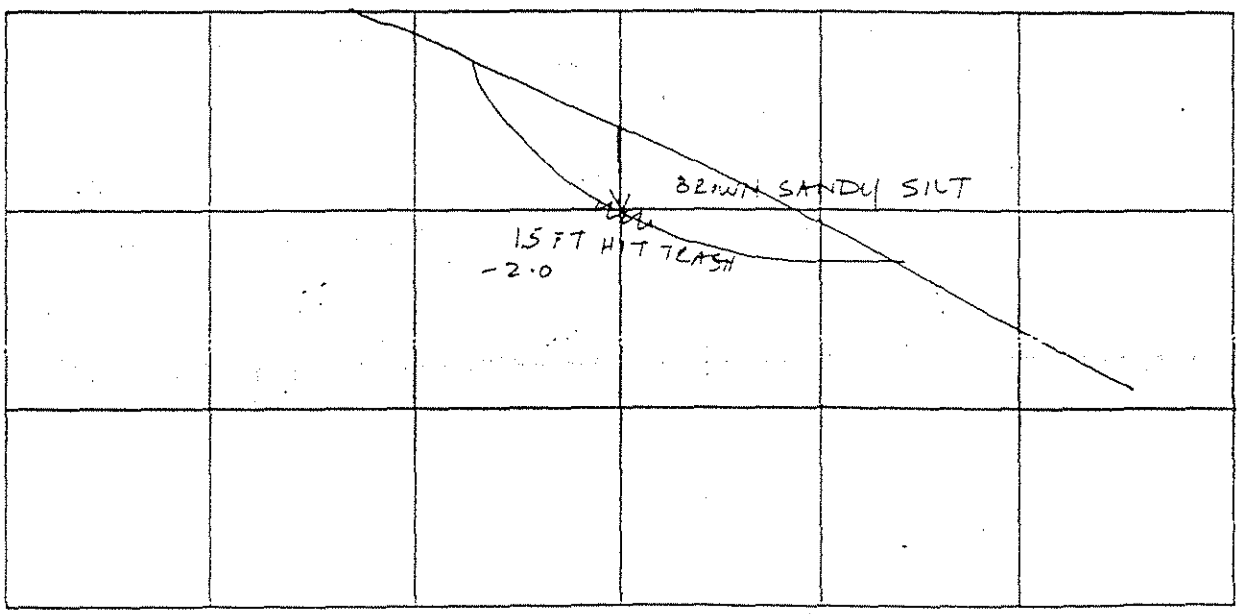
FIGURE NO. ___

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SANDY SILT (SAMPLED) ROOTS & VEGETATION	AB-18		
		1.5	HIT TRASH (~~[illegible]~~ IN 1st BUCKET)			
		2.0				

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-16-98

ELEVATION: 1685 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-18

FIGURE NO. ____

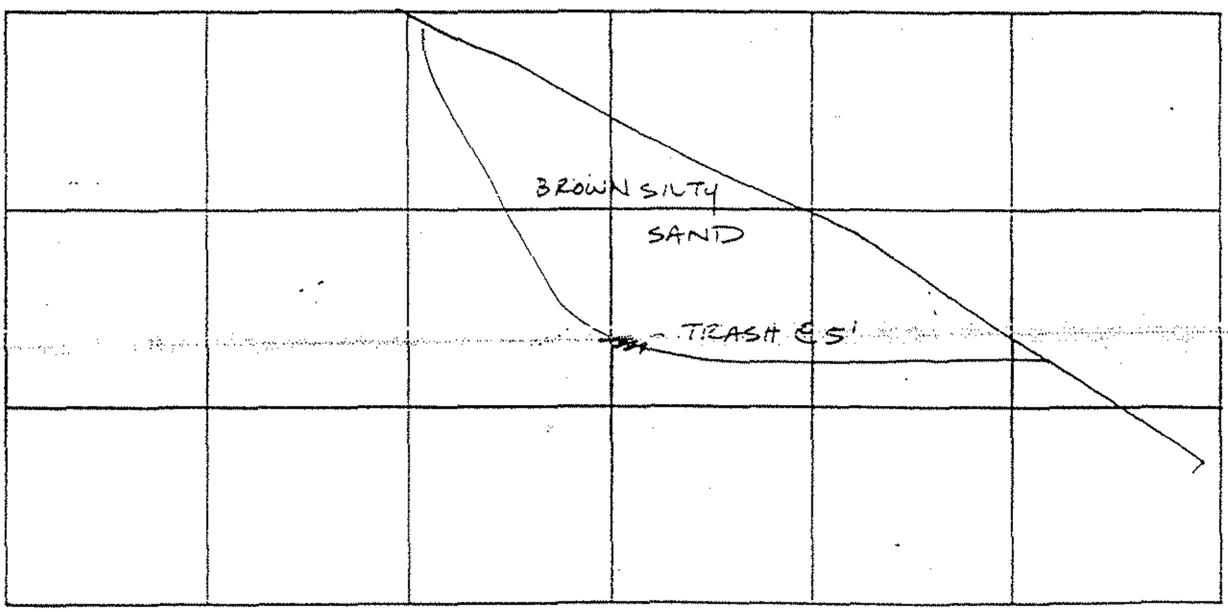
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN SILTY SAND			
		5'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-16-98

ELEVATION: 1691.9 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-19

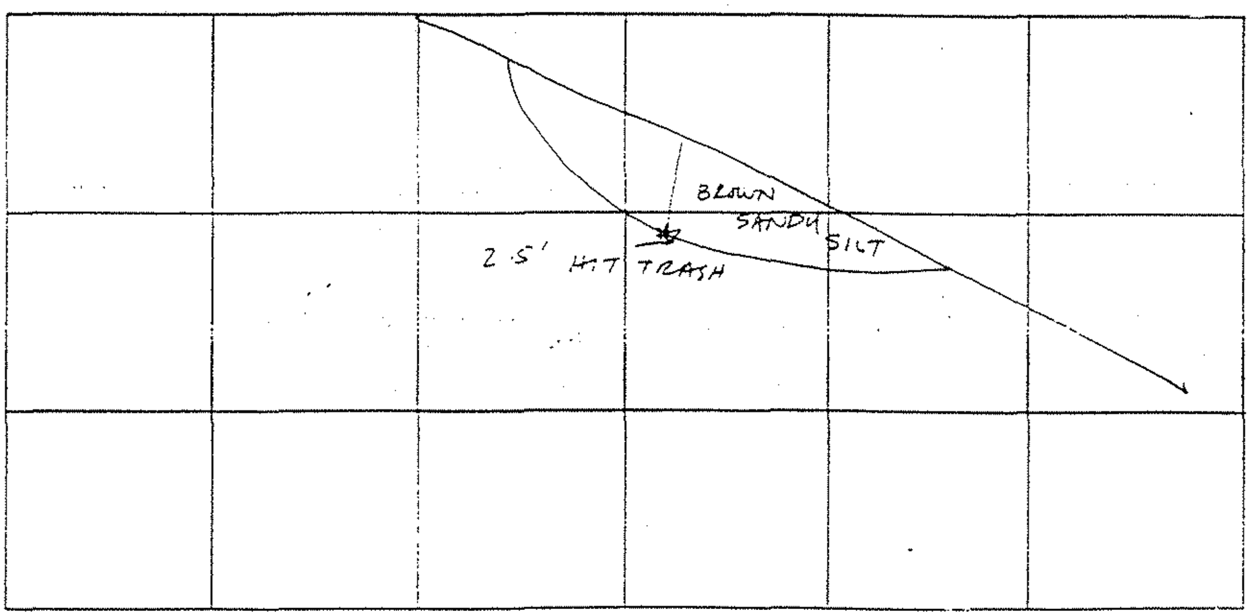
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN & GREY (STAINED) SANDY SILT			
		2.5	2.5 - 3 FT HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ SLOPES DATE: 1-16-98

ELEVATION: 1622 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. TB-20

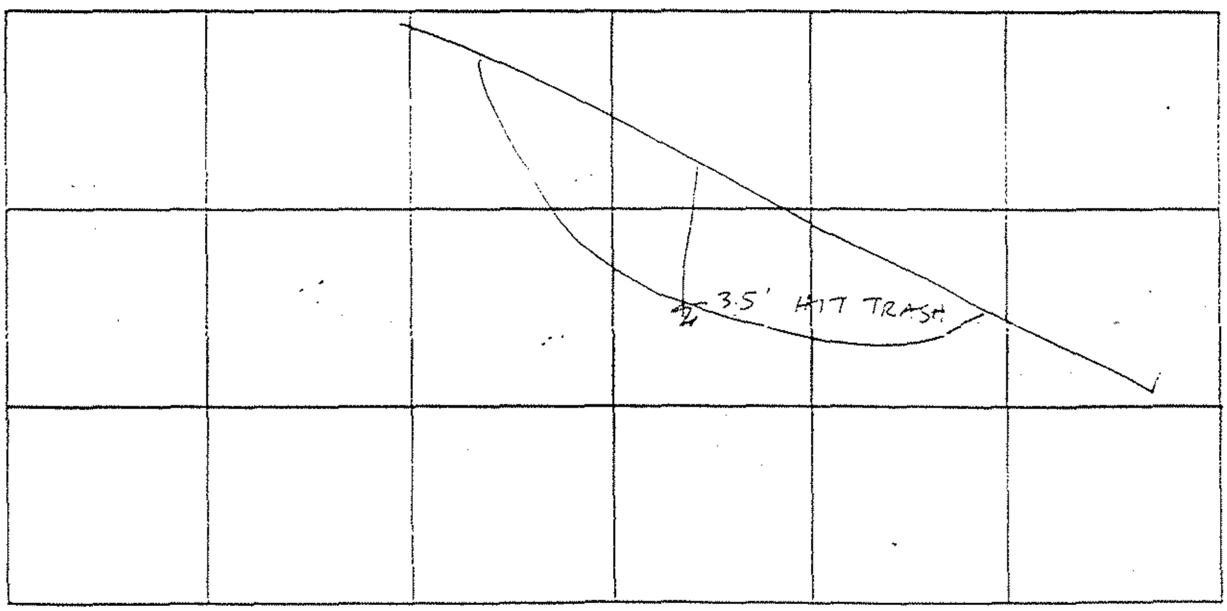
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SANDY SILT			
		3.5	HIT TRASH			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

SCALE 1" =   BEARING =   TRENCH WALL:



LOCATION: AB + SLOPES   DATE: 1-16-98

ELEVATION: 1730.7   EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A   LOGGED BY: CC

LOG OF TEST PIT NO. AB-21

FIGURE NO.

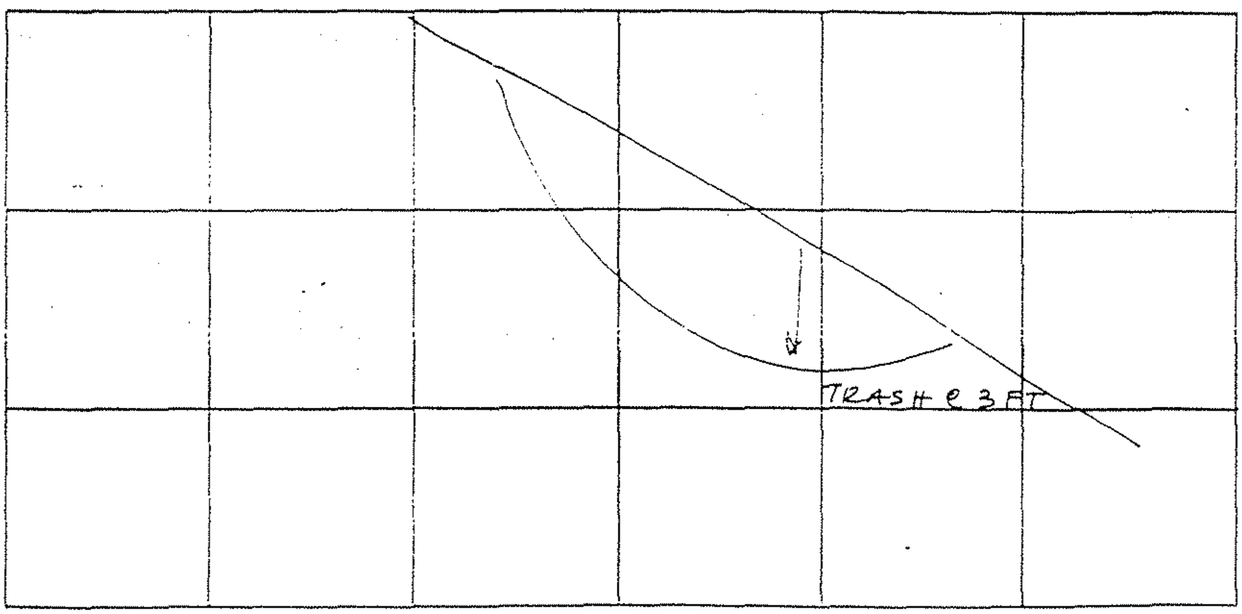
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		4''	DK BROWN SANDY SILT (VEG OVER HOTSPOTS)			
			GREY-BROWN SILTY SAND			
		3'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB + SLOPES DATE: 1-16-98

ELEVATION: 1744.0 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. AB-22

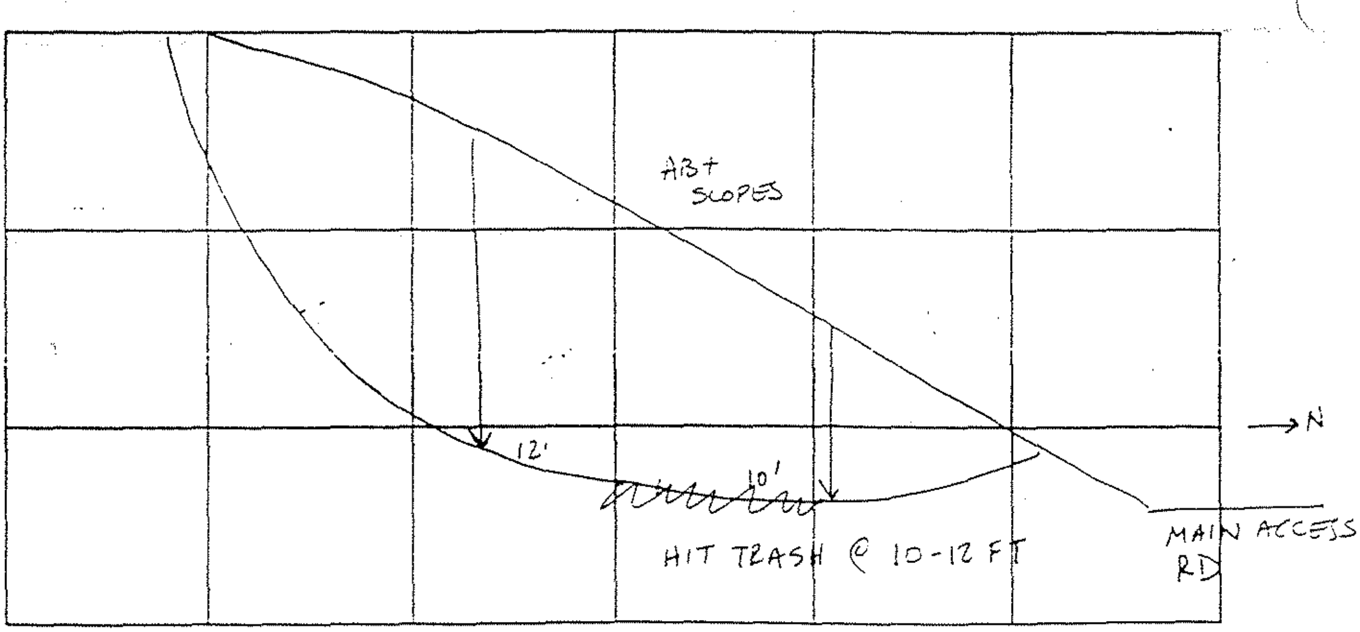
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND (SAMPLED)	AB-23	-	
			NO GREY STAINING		-	
		10'	— HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: AB+ SLOPES DATE: 1-16-98

ELEVATION: 1737.8 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

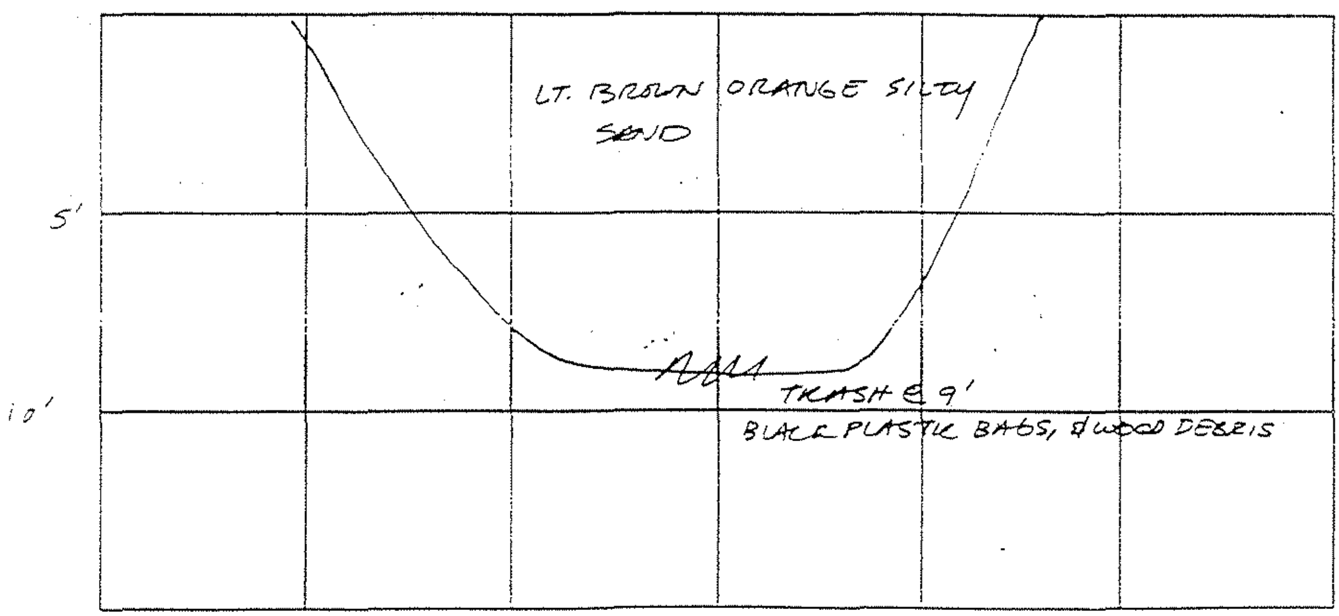
LOG OF TEST PIT NO. AB-23

FIGURE NO. ____

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN / ORANGE SILTY SAND W/ GRAVEL & COBBLES SOME GREY STREAKS / STAINING			
		9'	— TRASH @ 9 FT			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

SCALE 1" =   BEARING =   TRENCH WALL:



@ "MOUND" el stake on GPS SURVEY

LOCATION: AB + DECK   DATE: 1-16-98

ELEVATION: 1773   EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A   LOGGED BY: CC

LOG OF TEST PIT NO. AB-24

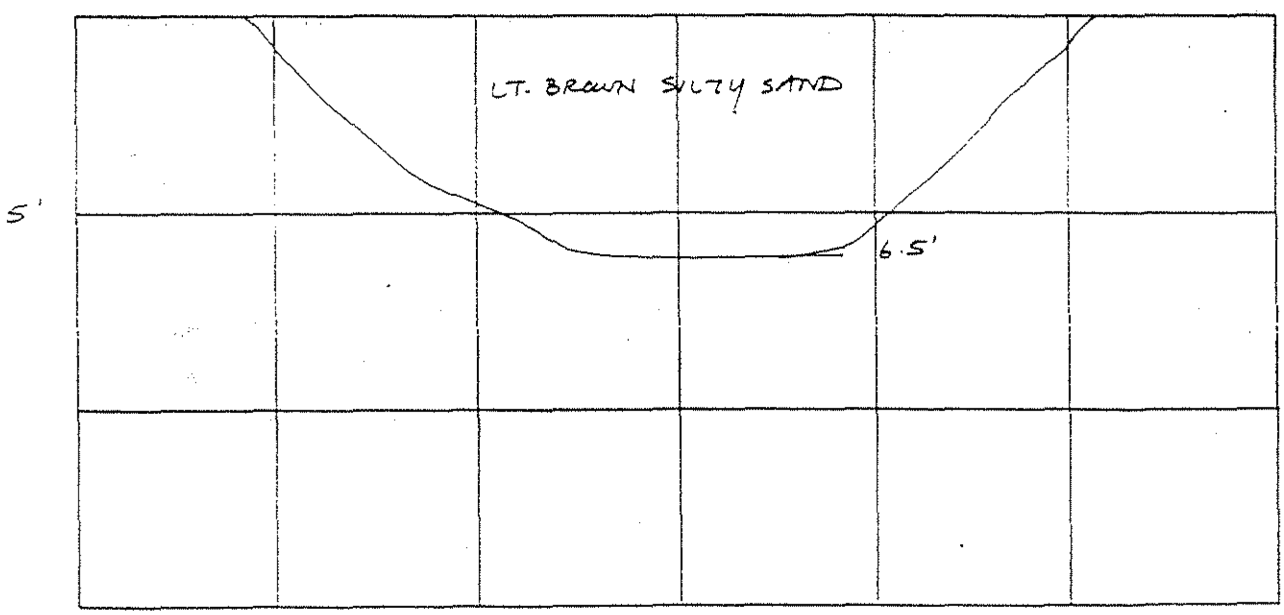
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN SILTY SAND (TAN/ORANGE - SAME AS A-4)			
			SOME GRAVEL & COBBLES			
		6.5'	NO TRASH ENCOUNTERED			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

SCALE 1" =   BEARING =   TRENCH WALL:



LOCATION: A-DEL R   DATE: 1-14-98

ELEVATION: 1745.42   EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A   LOGGED BY: CC

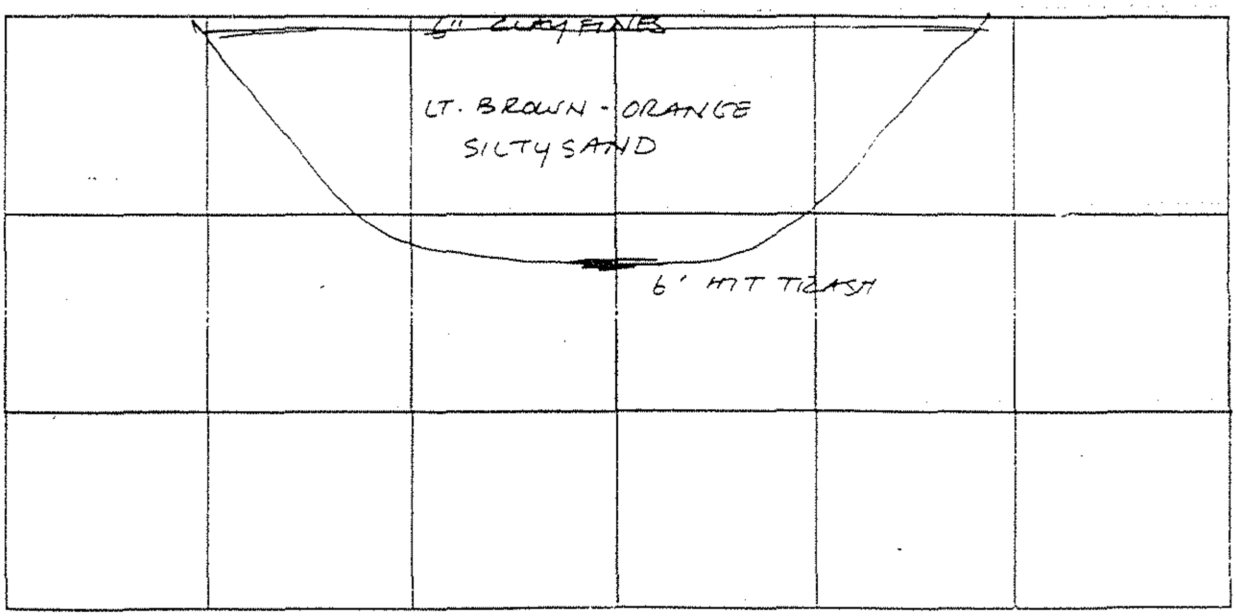
LOG OF TEST PIT NO. A-1

FIGURE NO. ____

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		6"	CLAY (WASHED OFF STOCKPILE)			
			LT. BROWN - ORANGE SILTY SAND (GREY STAINING) w/ GRAVEL & COBBLES TO 6"			
		6'	HIT TRASH @ 6FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: A-DECK DATE: 1-14-98

ELEVATION: 1741 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

* @ TOE OF CLAY STOCKPILE

LOG OF TEST PIT NO. A-2*

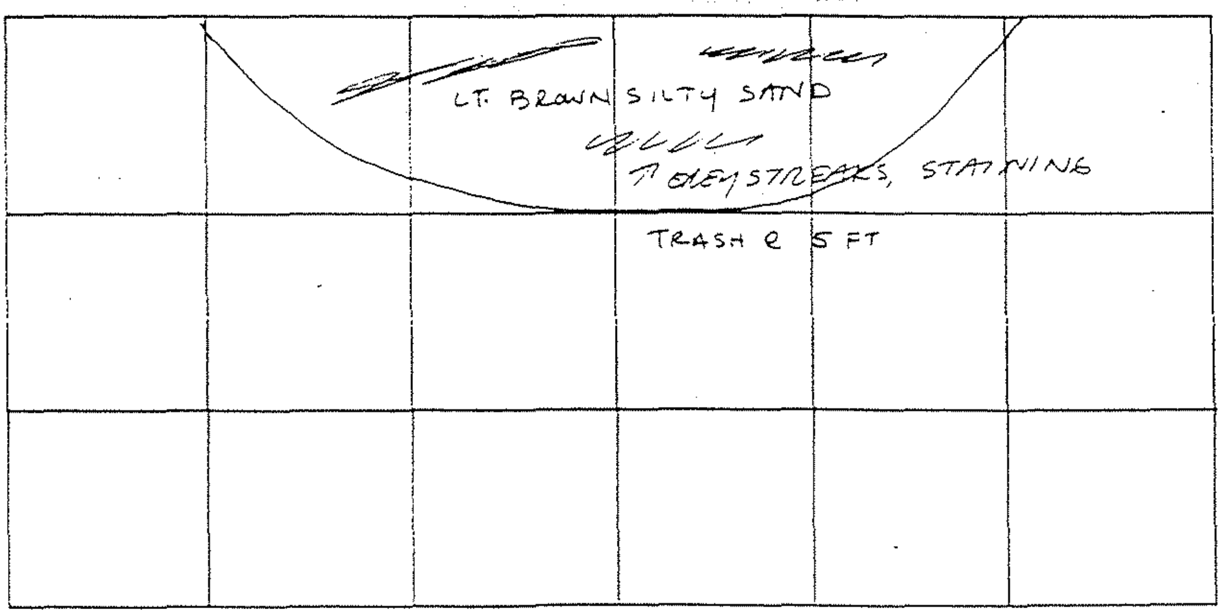
FIGURE NO.

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SILT			
		6"	LT. BROWN SILTY SAND (GREY STREAKS - STAINING) (SAME AS A-4)			
		5'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:

5'



LOCATION: A-DECK DATE: 1-14-98

@ TOE OF CLAY STOCKPILE

ELEVATION: EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. A-3

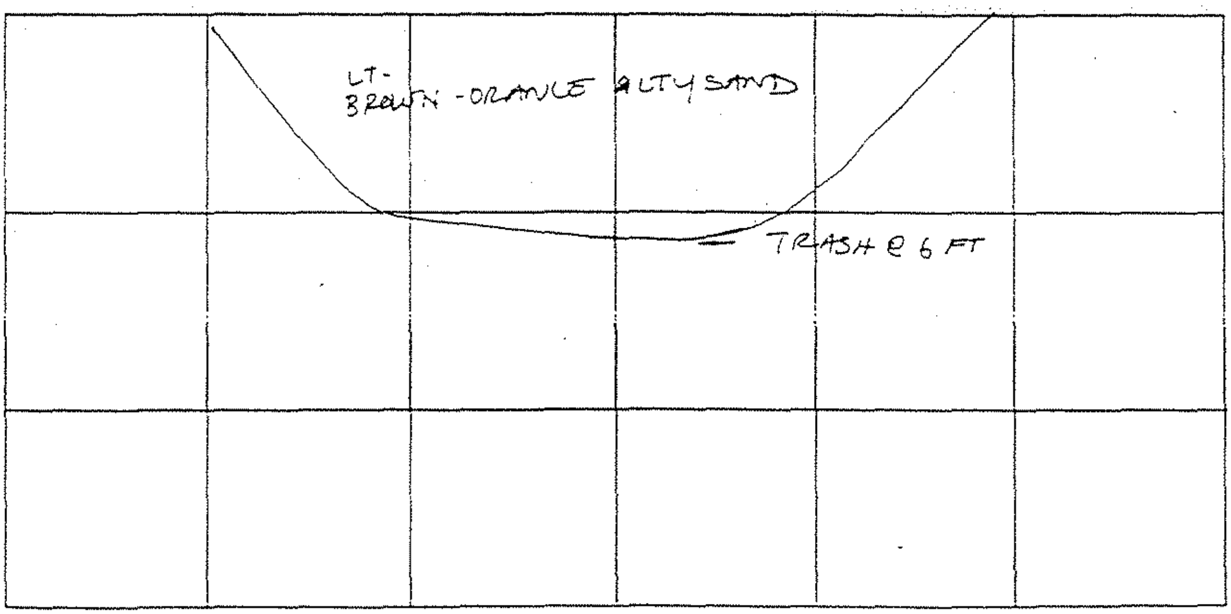
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			LT. BROWN - ORANGE SILTY SAND (SAMPLED)	A-4		
		6'	TRASH @ 6FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: A - PECK DATE: 1-14-98

ELEVATION: 1733 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. A-4

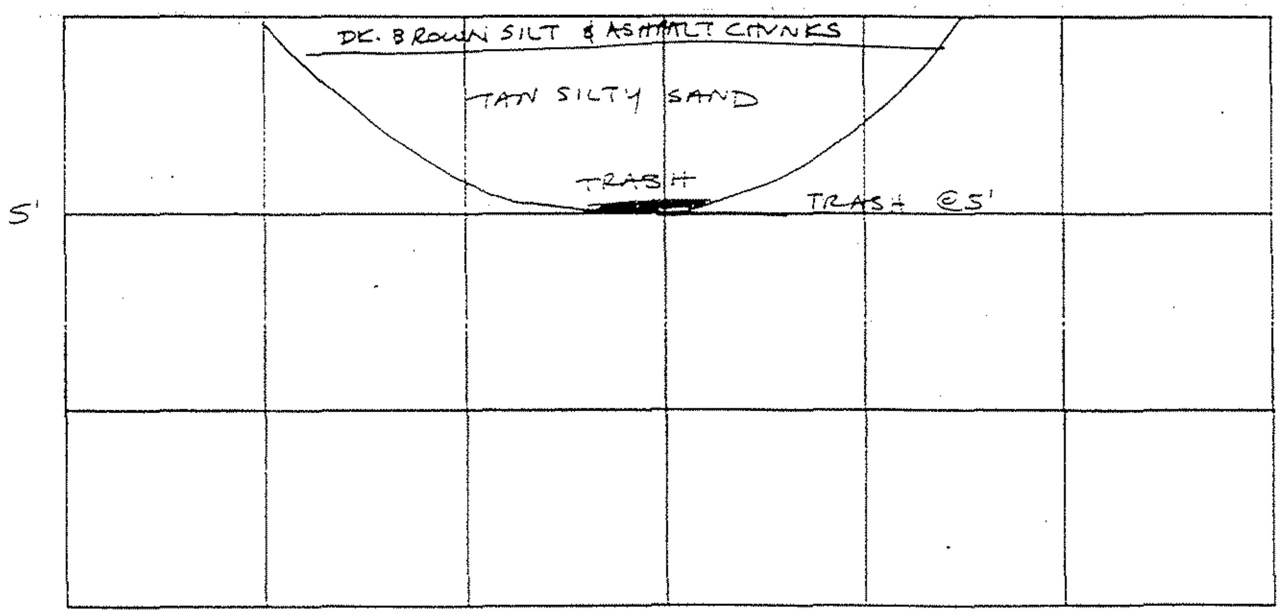
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SILT & ASPHALT CHUNKS			
		6"				
			TAN SILTY SAND			
		5'	TRASH @ 5 FT (L.A. RIOT - BURNED DEBRIS.)			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: A-DECK DATE: 1-14-98

ELEVATION: 1744 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

* RE-LABELLED A-7 AS A-5
GPS SURVEYED A-5 ON MID VEG STOCKPILE, CURRENTLY DUMP

LOG OF TEST PIT NO. A-5*

FIGURE NO. ____

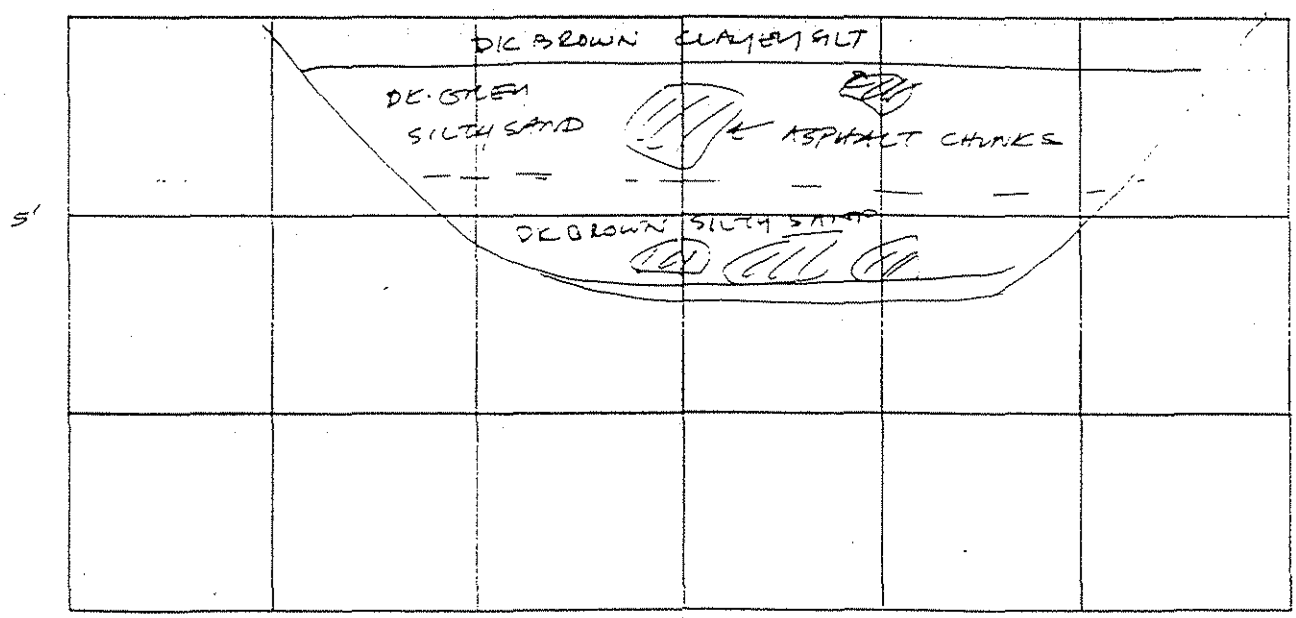
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		1	6"-1 FT DK BROWN CLAYEY SILT (AS B-3)			
			DK. GREY SILTY SAND (STAINED)			
		3'	@ 3' LARGE CHUNKS ASPHALT & CONCRETE *			
		7'	DK. BROWN SILTY SAND MIXED WITH LARGE ASPHALT CHUNKS			
			* NO OTHER TRASH (IE. PLASTIC)			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

* ACCORDING TO OPERATOR, THIS AREA OF B-DECK SOLID "WINTER" FILL ASPHALT & CONCRETE DEBRIS

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B-DECK DATE: 1-14-98

ELEVATION: 1707. EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. B-1

FIGURE NO. ____

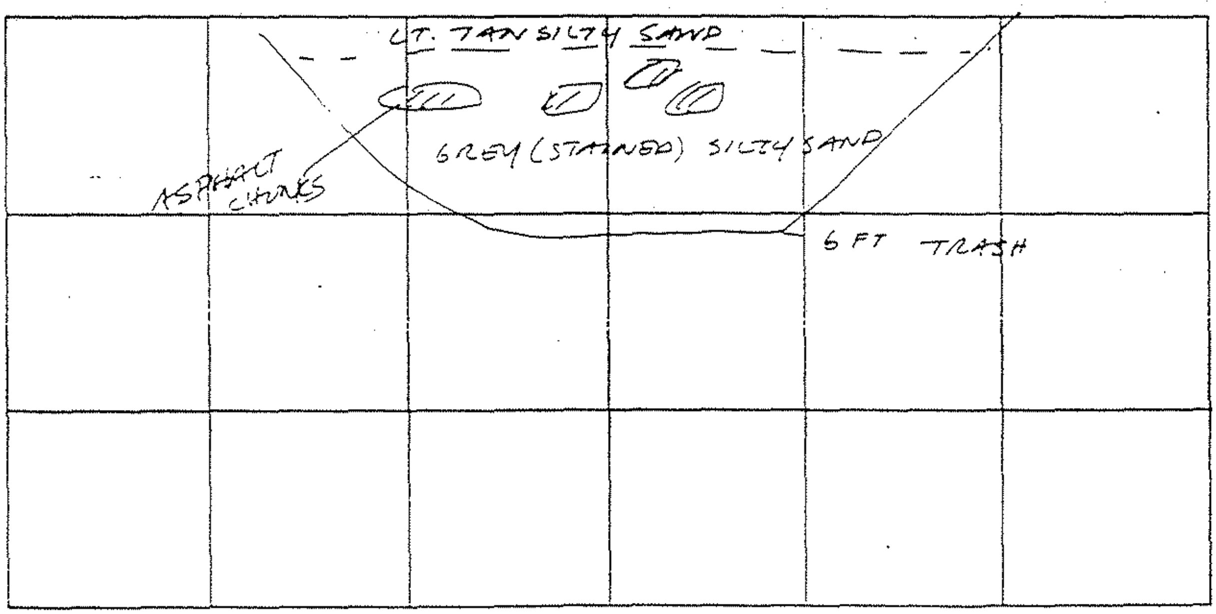
A Recycled and Recyclable Paper

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			OUT OF DK. BROWN CLAYEY SILT (AS B-3)			
		1.5	0 - 1.5' LT. TAN SILTY SAND w/ GRAVEL & COBBLES TO 6"			
		2'	LARGE CHUNKS ASPHALT & GREY (STAINED) SILTY SAND			
		6FT	TRASH @ 6 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B-DECC DATE: 1-14-98

ELEVATION: 1719 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. B-2

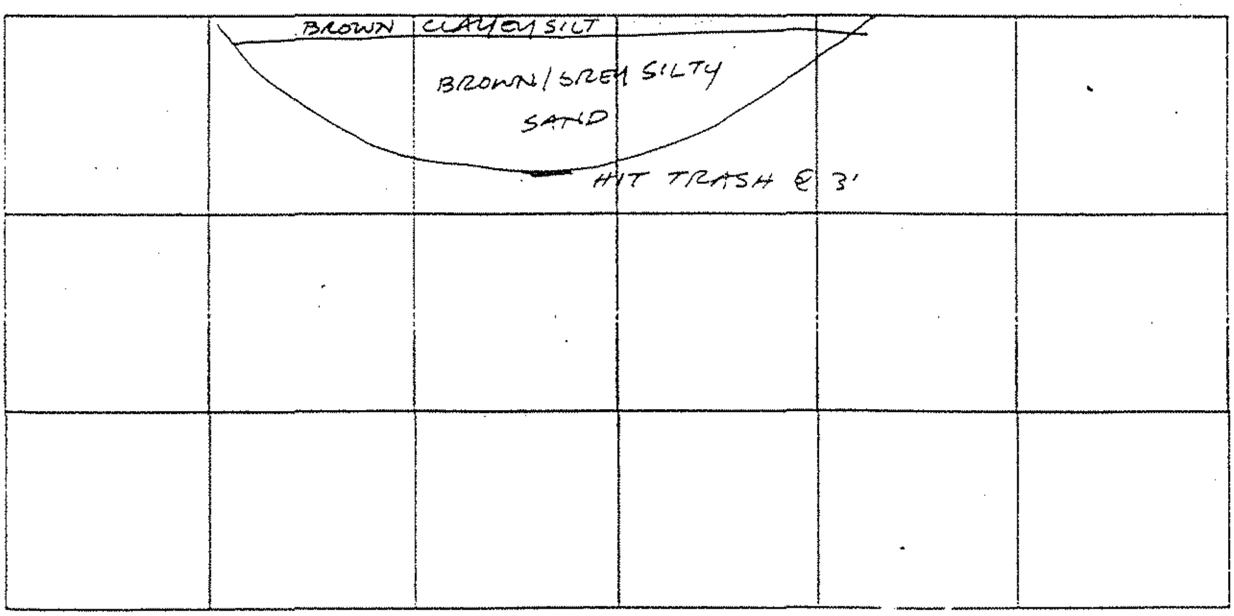
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
		1'	DK. BROWN CLAYEY SILT (SAMPLED)	B-3		
			BROWN SILTY SAND, STAINED GREY			
		3'	HIT TRASH			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B - DECK DATE: 1-14-98

ELEVATION: 1732 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC

LOG OF TEST PIT NO. B-3

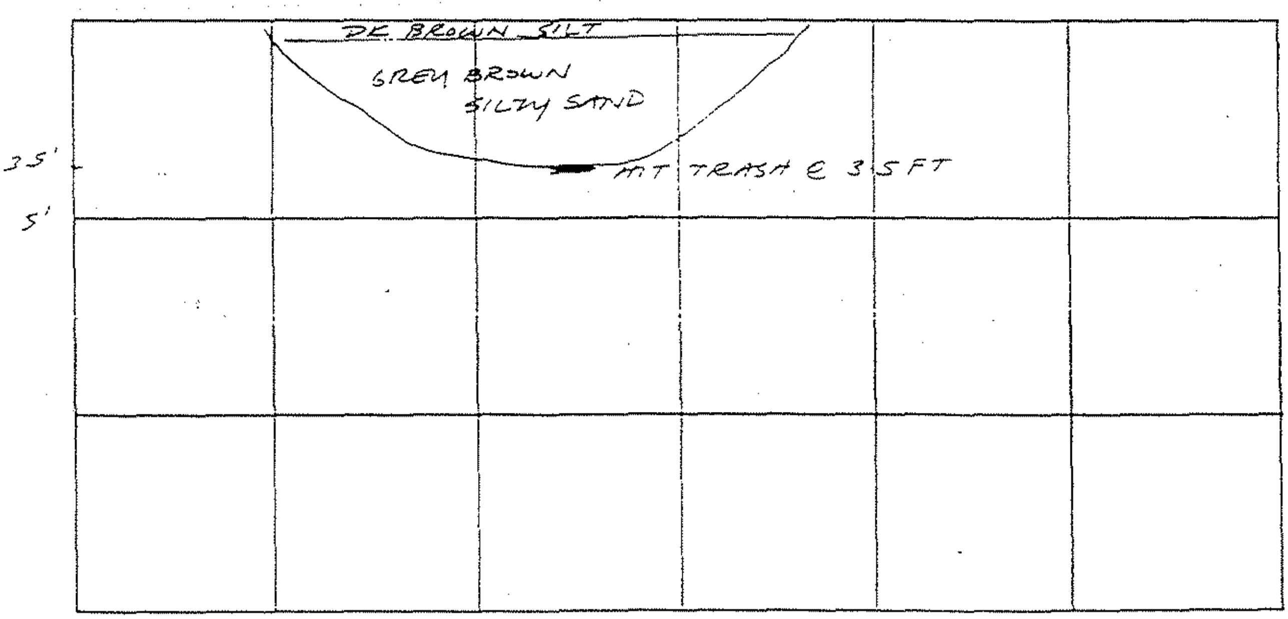
FIGURE NO. ____

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			DK. BROWN SILT			
		1'	GREY/BROWN ~~SANDY SILT~~ SILTY SAND (SAME AS B-6)		-	
		3.5'	HIT TRASH @ 3.5'			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: B DECK DATE: 1-14-98

* MOVED B-4 OFF RAMP UP TO VEG. (RESURVEYED BY ONSITE CREW)

ELEVATION: EQUIPMENT: EXCAVATOR

LOG OF TEST PIT NO. B-4A*

WATER LEVEL: N/A LOGGED BY: CC

A Recycled and ...

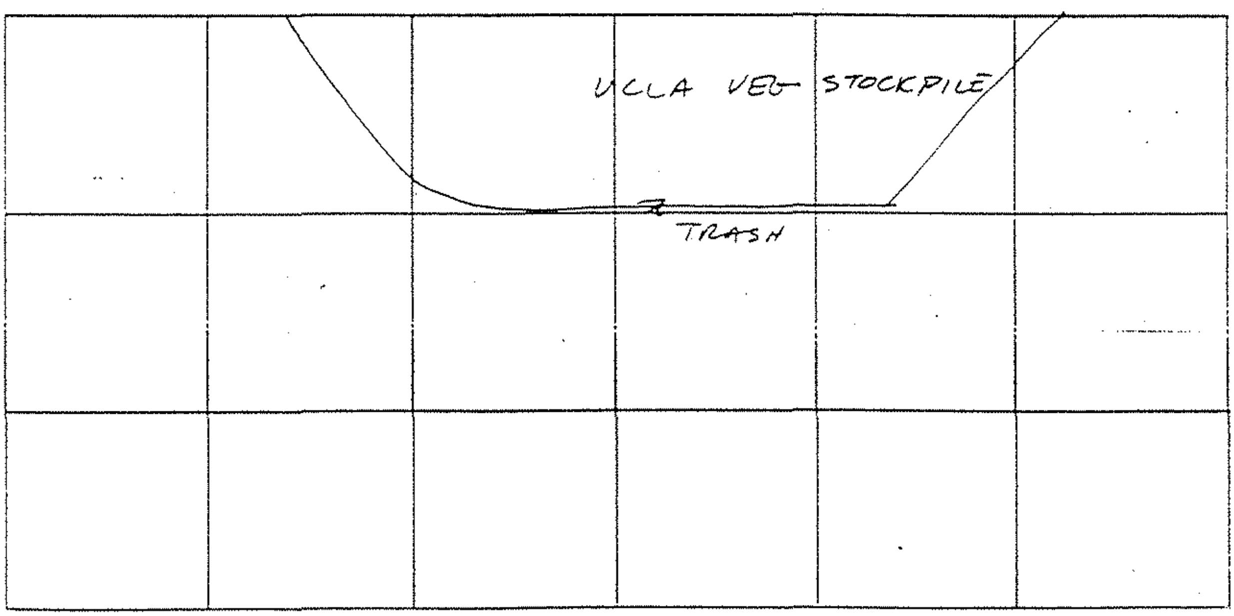
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY, CLAYEY SAND (VEG. COVER-UCLA)			
		5'	HIT TRASH @ 5 FT			

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



* VEG STOCKPILE 10-15 THICK @ THICKEST PART, UNDERNEATH DIRECTLY TO GRADING PLAN.

LOCATION: B-DECK DATE: 1-14-98
ON VEG STOCKPILE - LOWEST POINT

ELEVATION: 1729 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: cc

LOG OF TEST PIT NO. B-5

FIGURE NO.: ____

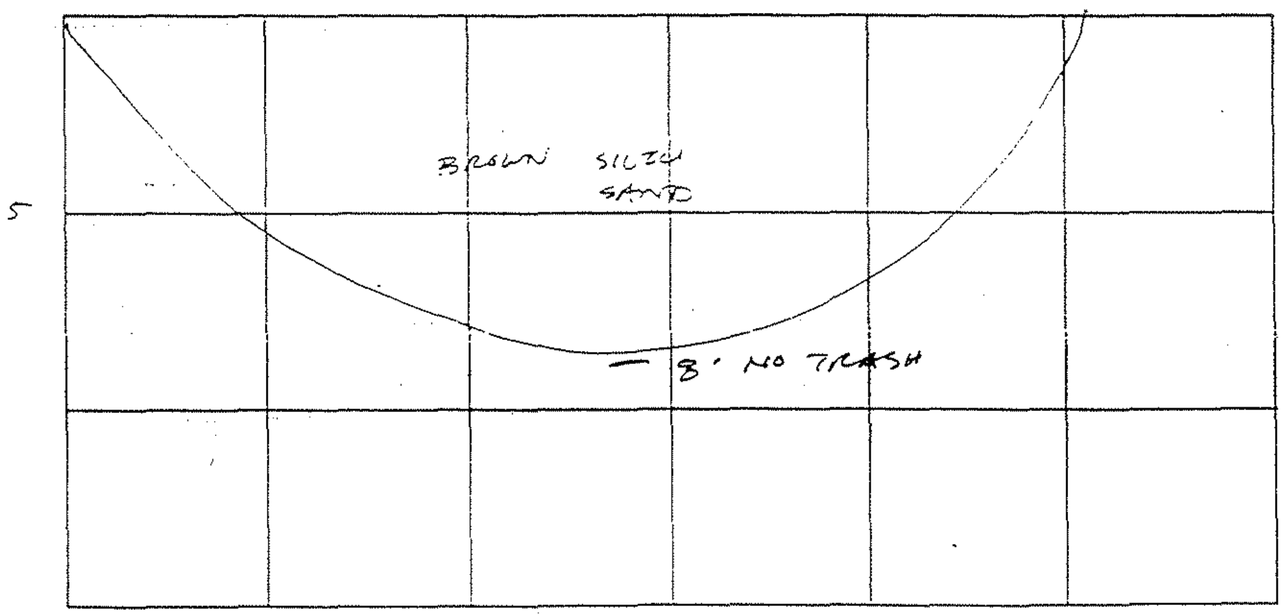
GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			BROWN SILTY SAND PATCHES/ STREAKS OF GREY STAINING SOME GRAVEL			
		8' —	NO TRASH STOPPED TRENCH.			
			(LOCATION B-6 ON RAMP UP TO VED STOCKPILE.)			

MOVED B-4, & ADDED B-7, & B-8 TO FIND TRASH BELOW BERM.

B - BULK SAMPLE T - TUBE SAMPLE D - DRIVE SAMPLE

SCALE 1" = BEARING = TRENCH WALL:



LOCATION: LOPEZ B-DECK DATE: 1-14-98

ELEVATION: 1743 5 EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A LOGGED BY: CC.

LOG OF TEST PIT NO. B-6

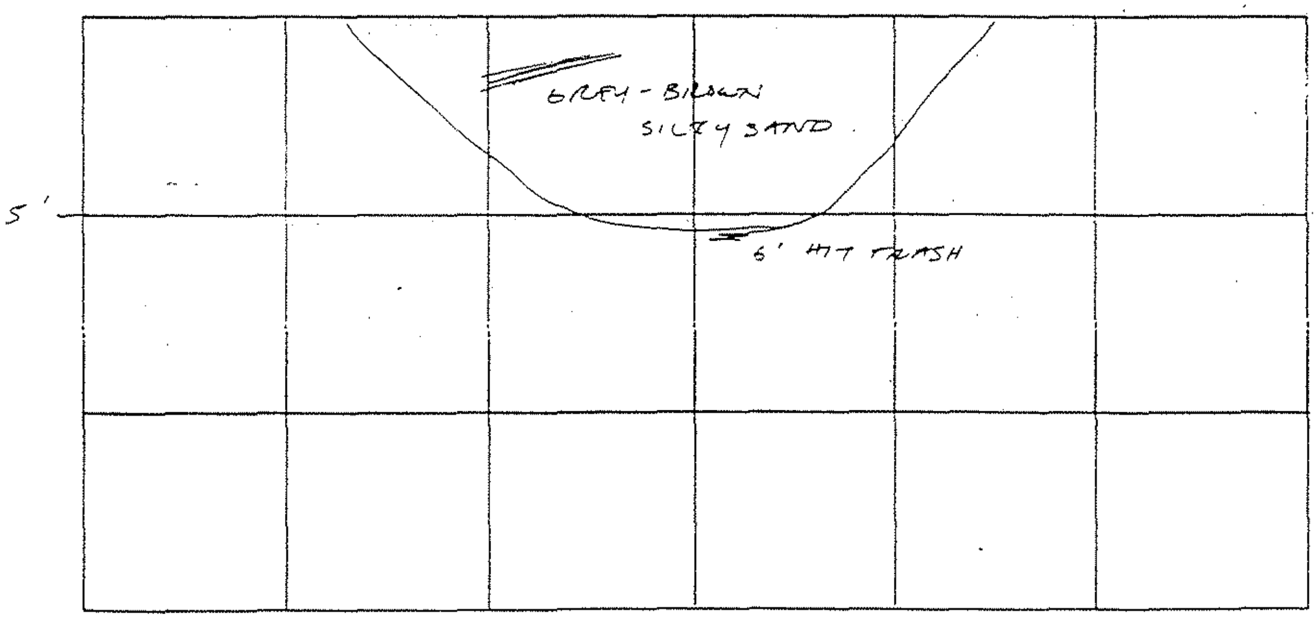
FIGURE NO. ____

Recycled and Recyclable Paper

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY-BROWN SILTY SAND			
		6'	— HIT TRASH			

B - BULK SAMPLE   T - TUBE SAMPLE   D - DRIVE SAMPLE

SCALE 1" =   BEARING =   TRENCH WALL:



LOCATION: B-DECK   DATE: 1-14-98

ELEVATION: 1727.5   EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A   LOGGED BY: CC

LOG OF TEST PIT NO. B-7

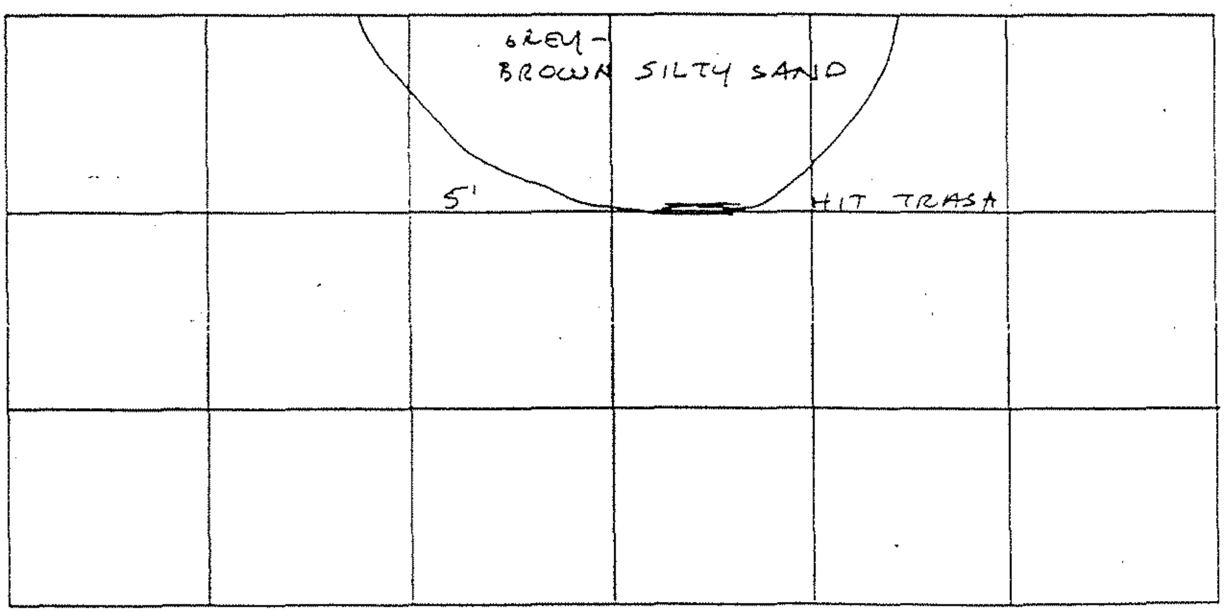
FIGURE NO.

GeoSyntec Consultants

REF NO.	BEDDING STRIKE/ DEPTH	DEPTH (FEET)	DESCRIPTION	SAMPLE NO.	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
			GREY (STAINED) - BROWN			
			SILTY SAND			
			SOME GRAVEL & COBBLES TO 6'			
		5'	— HIT TRASH @ 5'			

B - BULK SAMPLE　　T - TUBE SAMPLE　　D - DRIVE SAMPLE

SCALE 1" =　　BEARING =　　TRENCH WALL:



LOCATION: B-DECK　　DATE: 1-14-98

ELEVATION:　　EQUIPMENT: EXCAVATOR

WATER LEVEL: N/A　　LOGGED BY: CC

* ADDED, ON MOUND, OF TRASH BELOW BERM
ON-SITE CREW TO SURVEY + MOUND

LOG OF TEST PIT NO. B-8*

FIGURE NO. ____

APPENDIX B:
RESULTS FROM LABORATORY TESTING

ATTACHMENT A

Sample Identification, Handling, Storage and Disposal

Laboratory Test Standards

Application of Test Results

GEOSYNTEC CONSULTANTS
Geomechanics and Environmental Laboratory

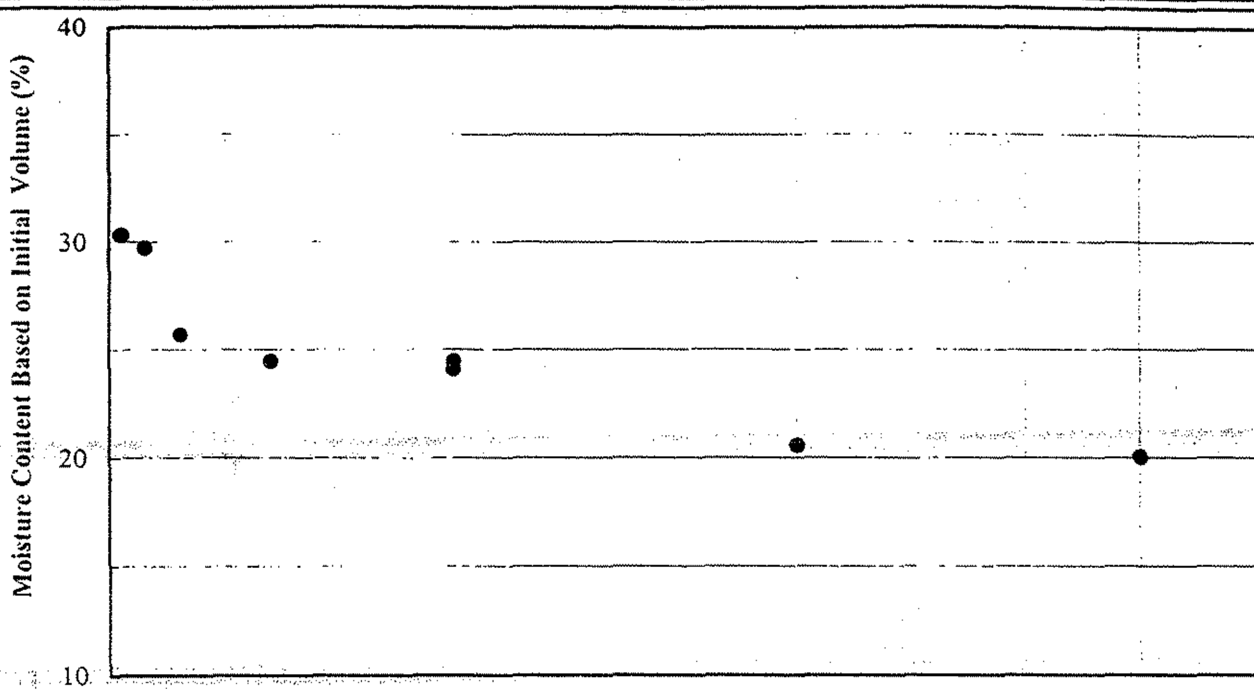
FIGURE 13

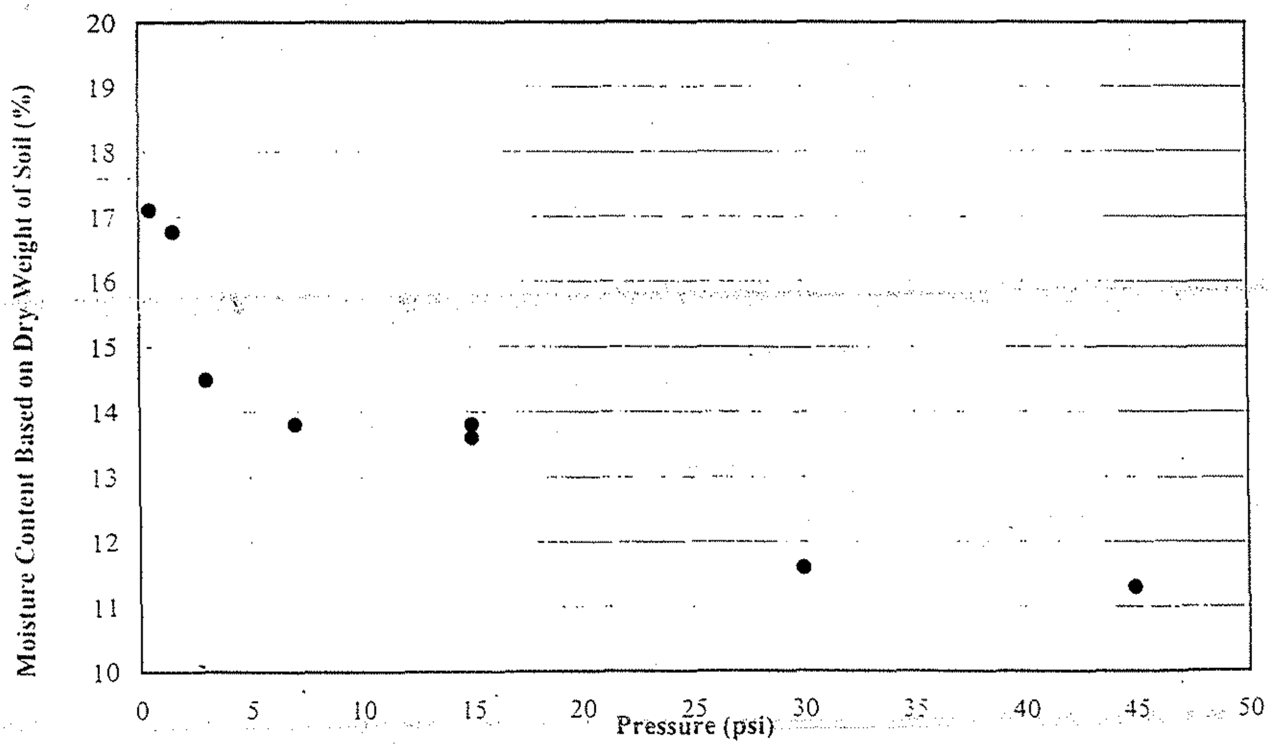
Project Name: Lopez Canyon Landfill
Project No.: CE4100

File Name: 98B32.xls

MOISTURE RETENTION TEST

ASTM D 2325





Note(s): Site Sample ID: AB - 10
Lab Sample No.: 98B32

GEO SYNTEC CONSULTANTS
Geomechanics and Environmental Laboratory
Atlanta, Georgia

FIGURE 12

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 02/26/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-8

SITE SAMPLE ID	VG021398
LAB. SAMPLE NO.	98B69
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	123.6
OPTIMUM MOISTURE CONTENT (%)	10.3
IN SITU MOISTURE CONTENT (%)	

NOTES:

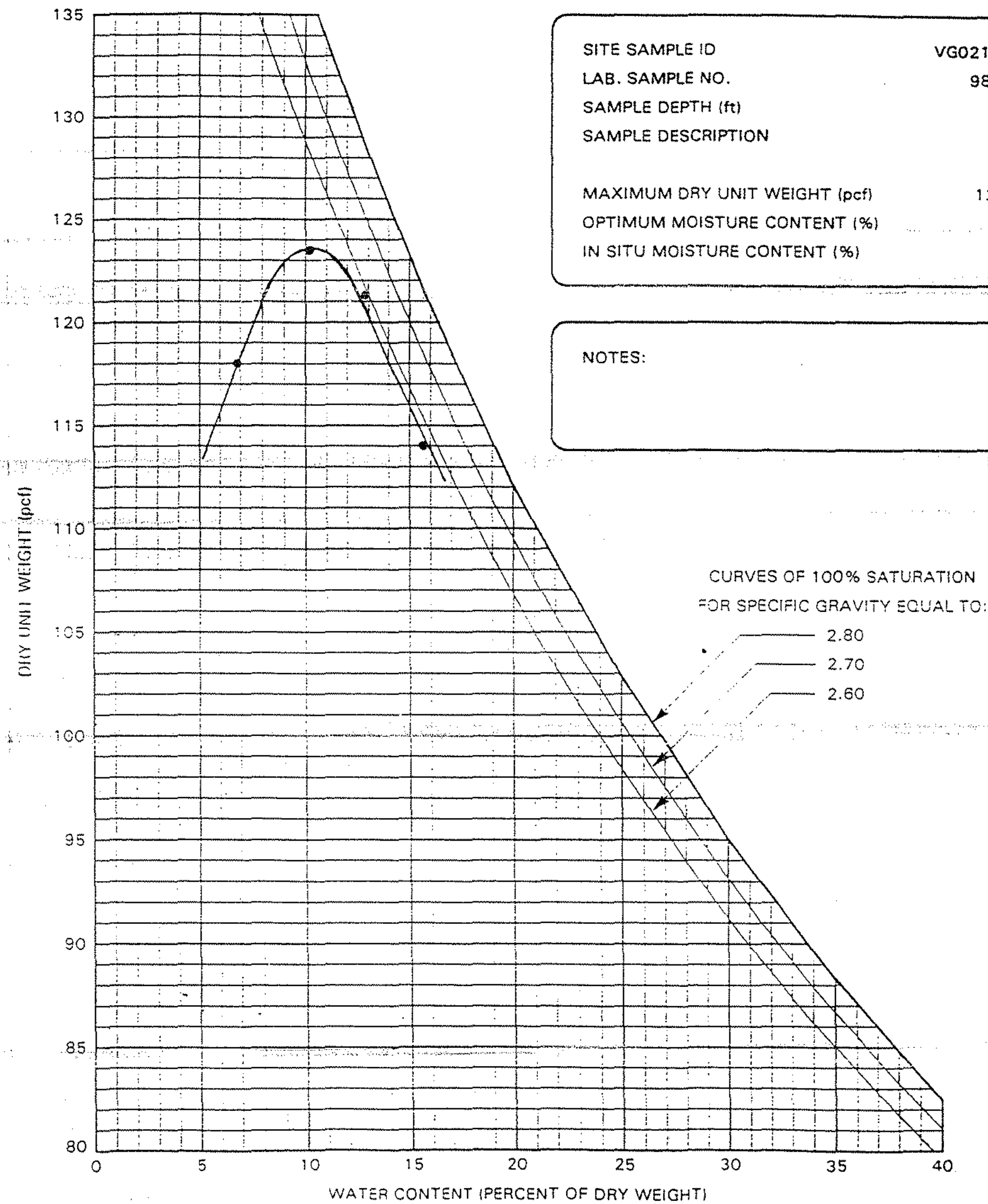


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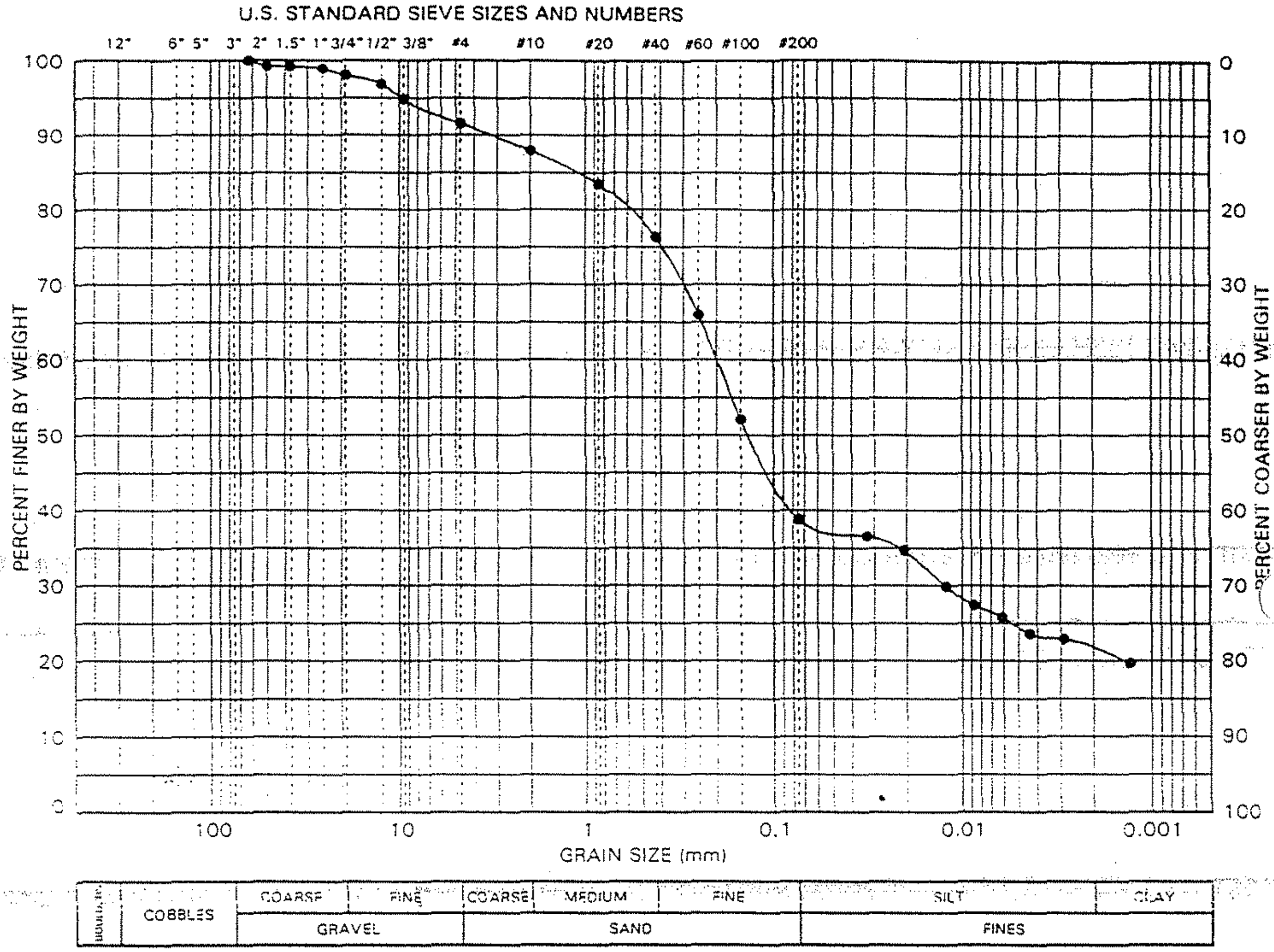
FIGURE 11

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM:
4PS2 02/27/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487
D 3042 AND D 4318



SITE SAMPLE ID VG021398	LIQUID LIMIT (%)	SOIL FRACTIONS	GRAVEL (%)	8.5
LAB. SAMPLE NO. 98869	PLASTIC LIMIT (%)		SAND (%)	52.7
SAMPLE DEPTH (ft)	PLASTICITY INDEX		FINES (%)	38.8
SOIL CLASSIFICATION:			SILT (%)	17.4
			CLAY(%)	21.4
			COEFF. UNIFORMITY (Cu)	
			COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.
100	99	99	99	98	97	95	92	88	83	76	66	52	39	38	34	24	21	

NOTES:

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Atlanta, Georgia

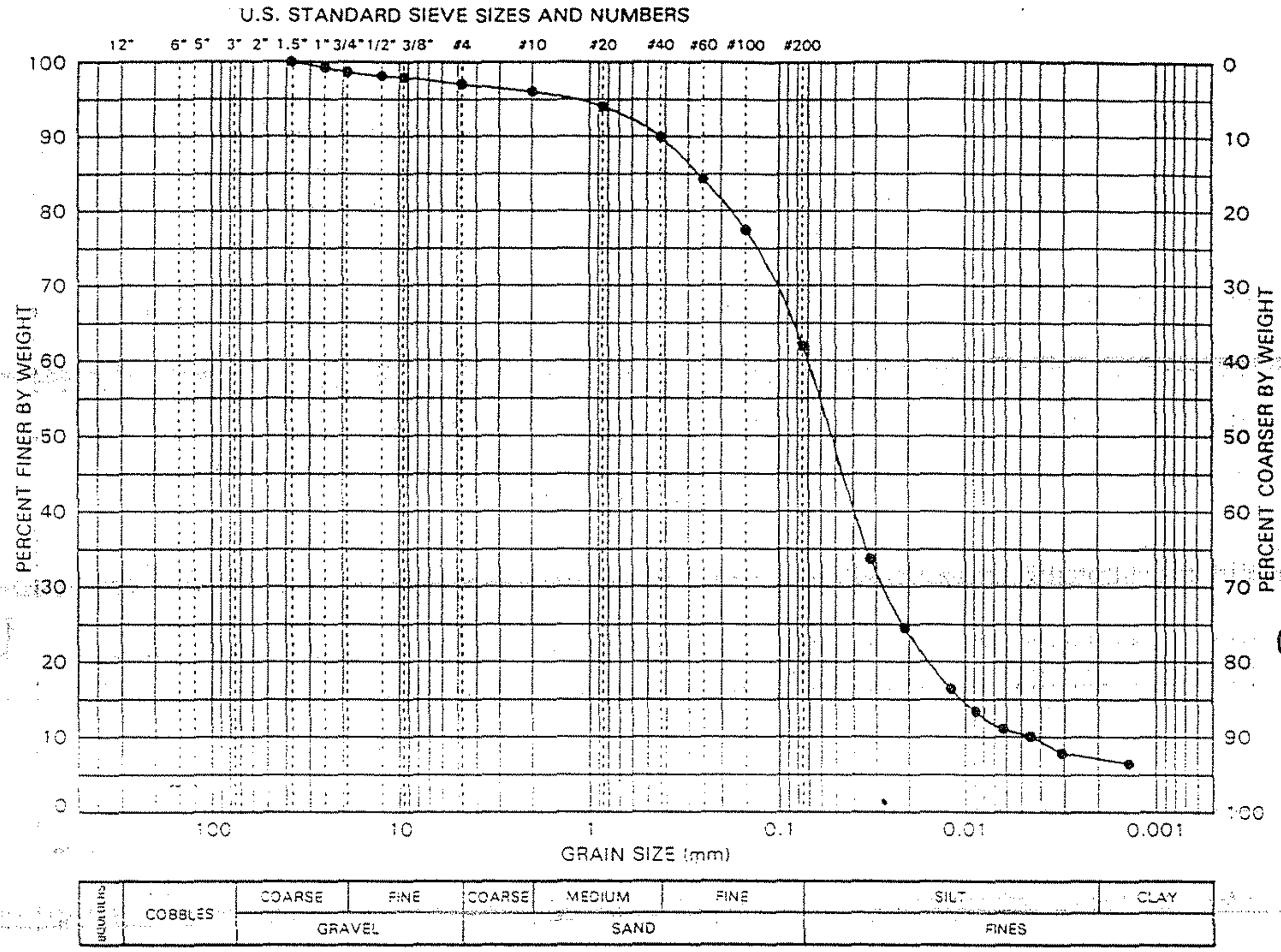
FIGURE 10

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	B-6	LIQUID LIMIT (%)	39	GRAVEL (%)	3.0
LAB. SAMPLE NO.	98A90	PLASTIC LIMIT (%)	30	SAND (%)	35.1
SAMPLE DEPTH (ft)		PLASTICITY INDEX	9	FINES (%)	61.9
SOIL CLASSIFICATION:				SILT (%)	54.8
ML - Sandy Silt				CLAY(%)	7.1
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

(SOIL FRACTIONS)

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	99	99	98	98	97	96	94	90	84	77	62	48	24	10	7	

NOTES:

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Atlanta, Georgia

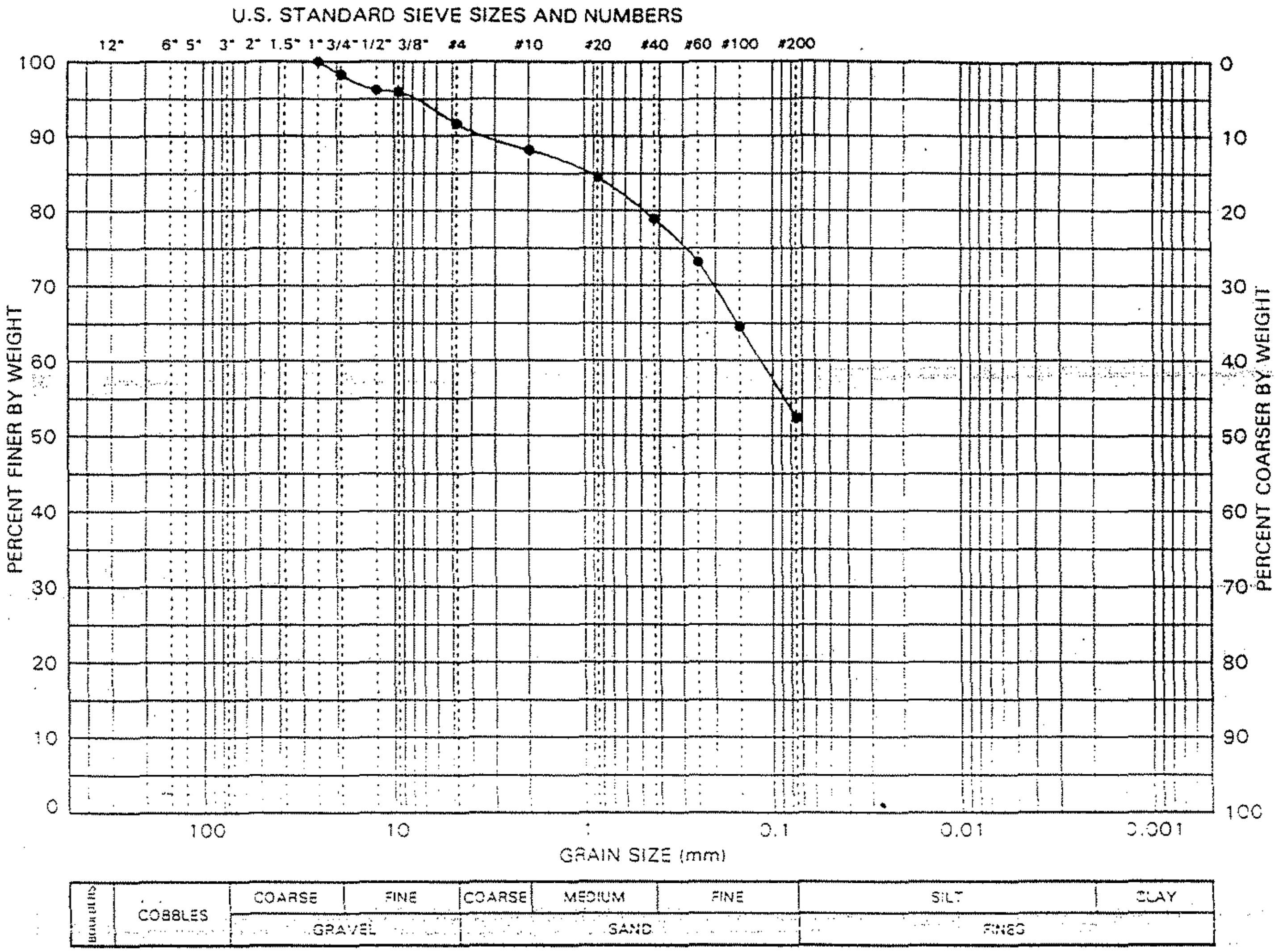
FIGURE 9

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/17/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	B-3	LIQUID LIMIT (%)	37	GRAVEL (%)	8.4
LAB. SAMPLE NO.	98B15	PLASTIC LIMIT (%)	20	SAND (%)	39.2
SAMPLE DEPTH (ft)		PLASTICITY INDEX	17	FINES (%)	52.4
SOIL CLASSIFICATION:				SILT (%)	
CL - Sandy Lean Clay				CLAY(%)	
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	100	98	96	96	92	88	85	79	73	65	52					

NOTES:

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Atlanta, Georgia

FIGURE 8

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM:
4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B

SITE SAMPLE ID	AB-25-B
LAB. SAMPLE NO.	98B34.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	128.9
OPTIMUM MOISTURE CONTENT (%)	9.4
IN SITU MOISTURE CONTENT (%)	

NOTES:

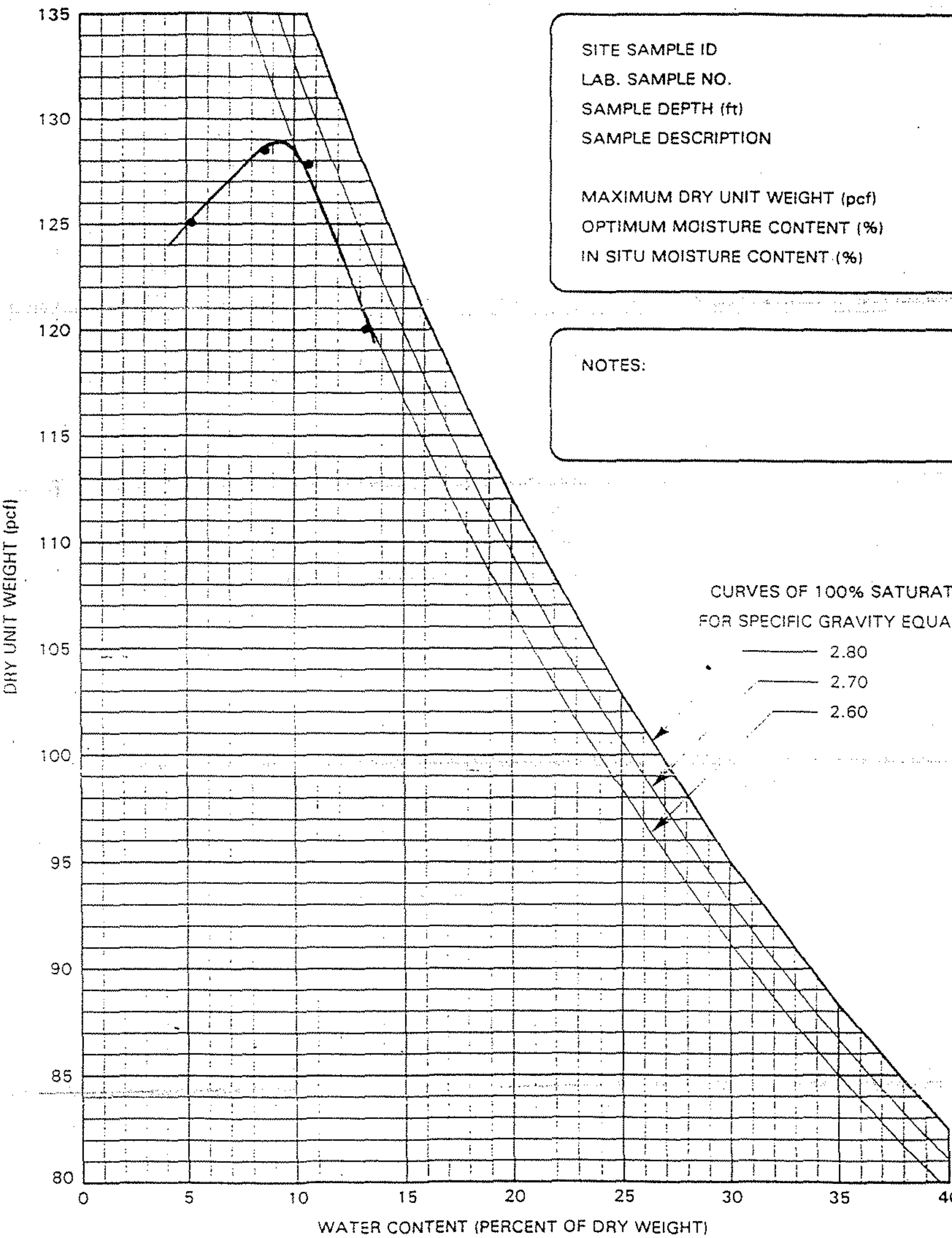

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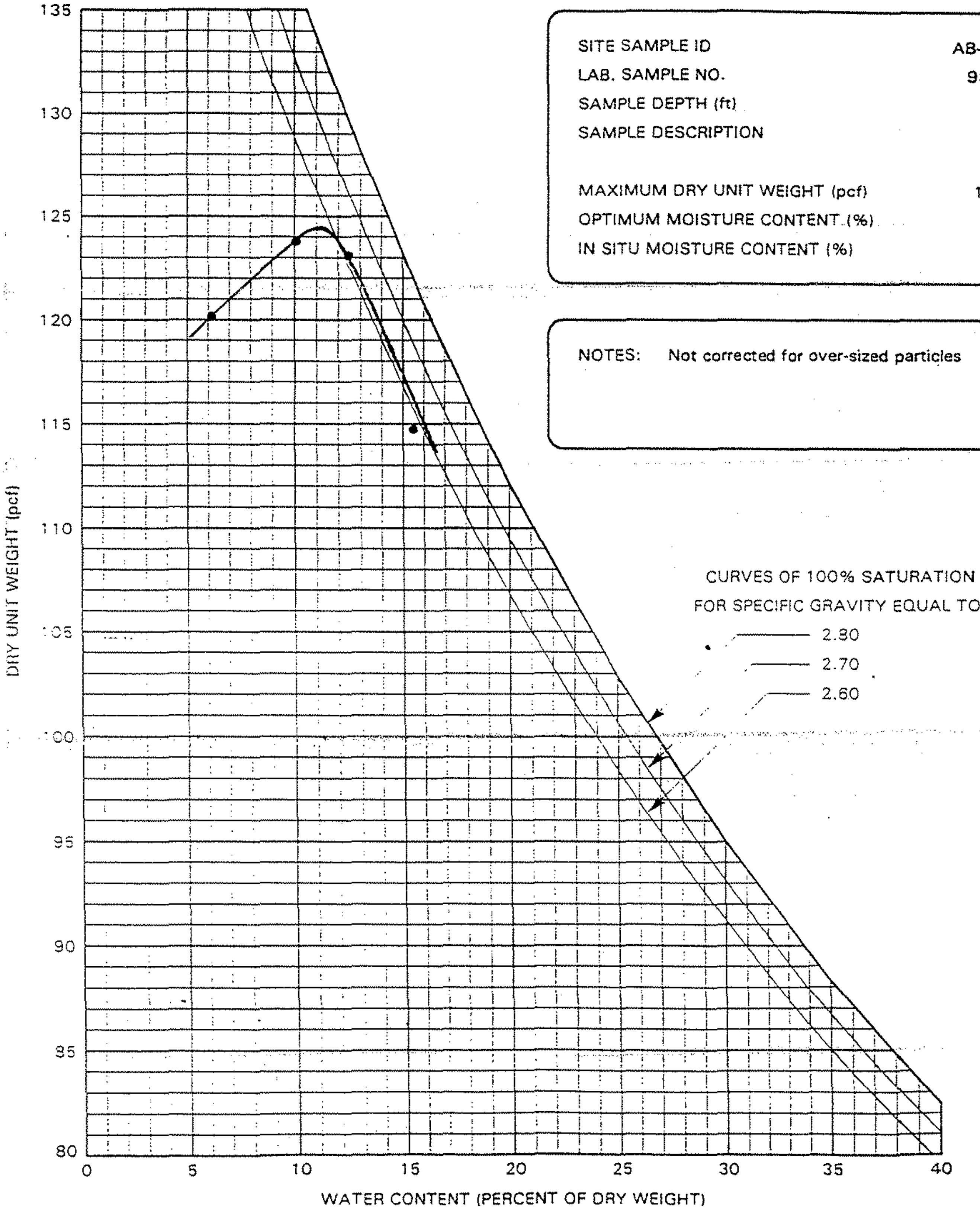
FIGURE 7

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B



SITE SAMPLE ID	AB-25-B
LAB. SAMPLE NO.	98B34
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	124.4
OPTIMUM MOISTURE CONTENT (%)	11.2
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

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Atlanta, Georgia

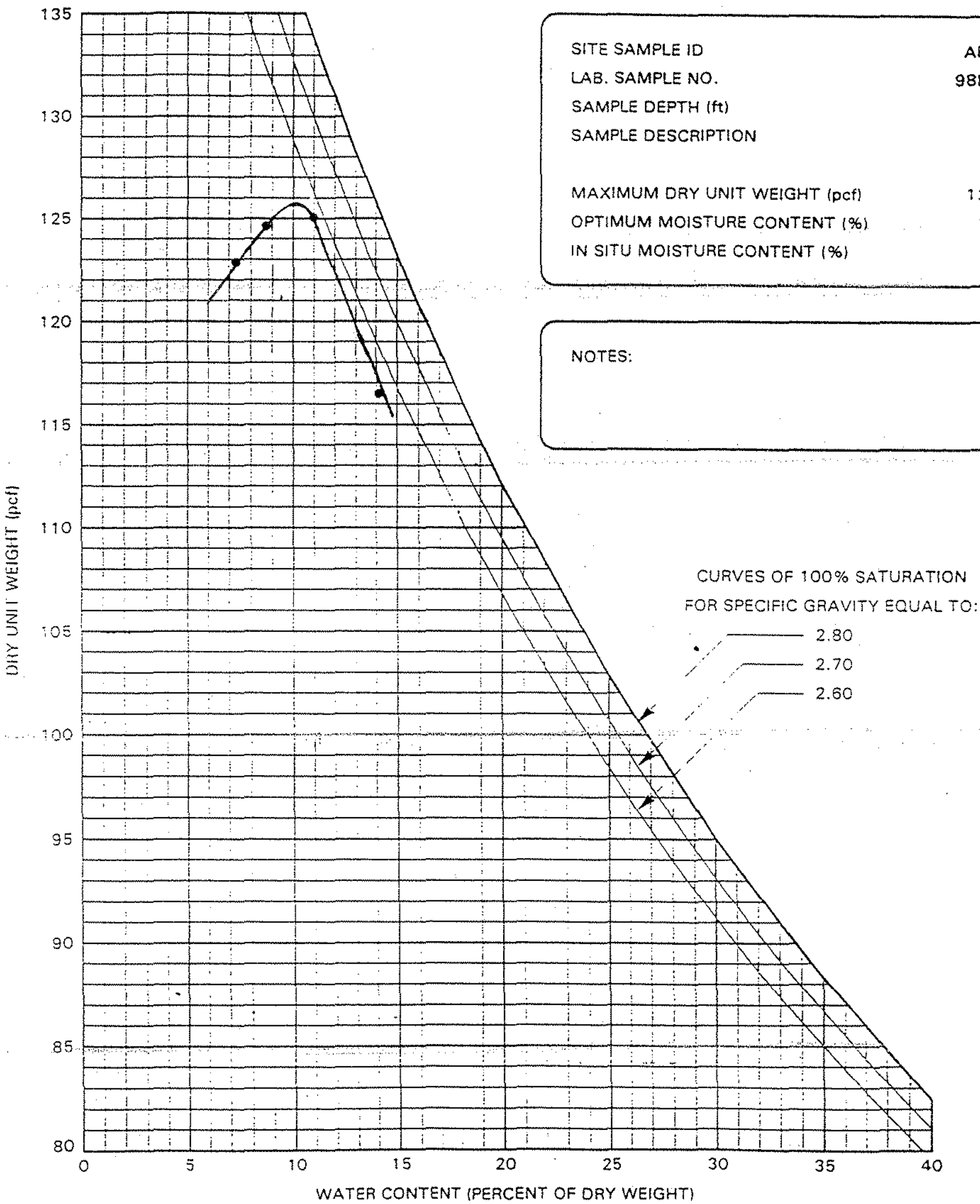
FIGURE 6

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B



SITE SAMPLE ID	AB-10
LAB. SAMPLE NO.	98832.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	125.7
OPTIMUM MOISTURE CONTENT (%)	10.1
IN SITU MOISTURE CONTENT (%)	

NOTES:

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Atlanta, Georgia

FIGURE 5

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

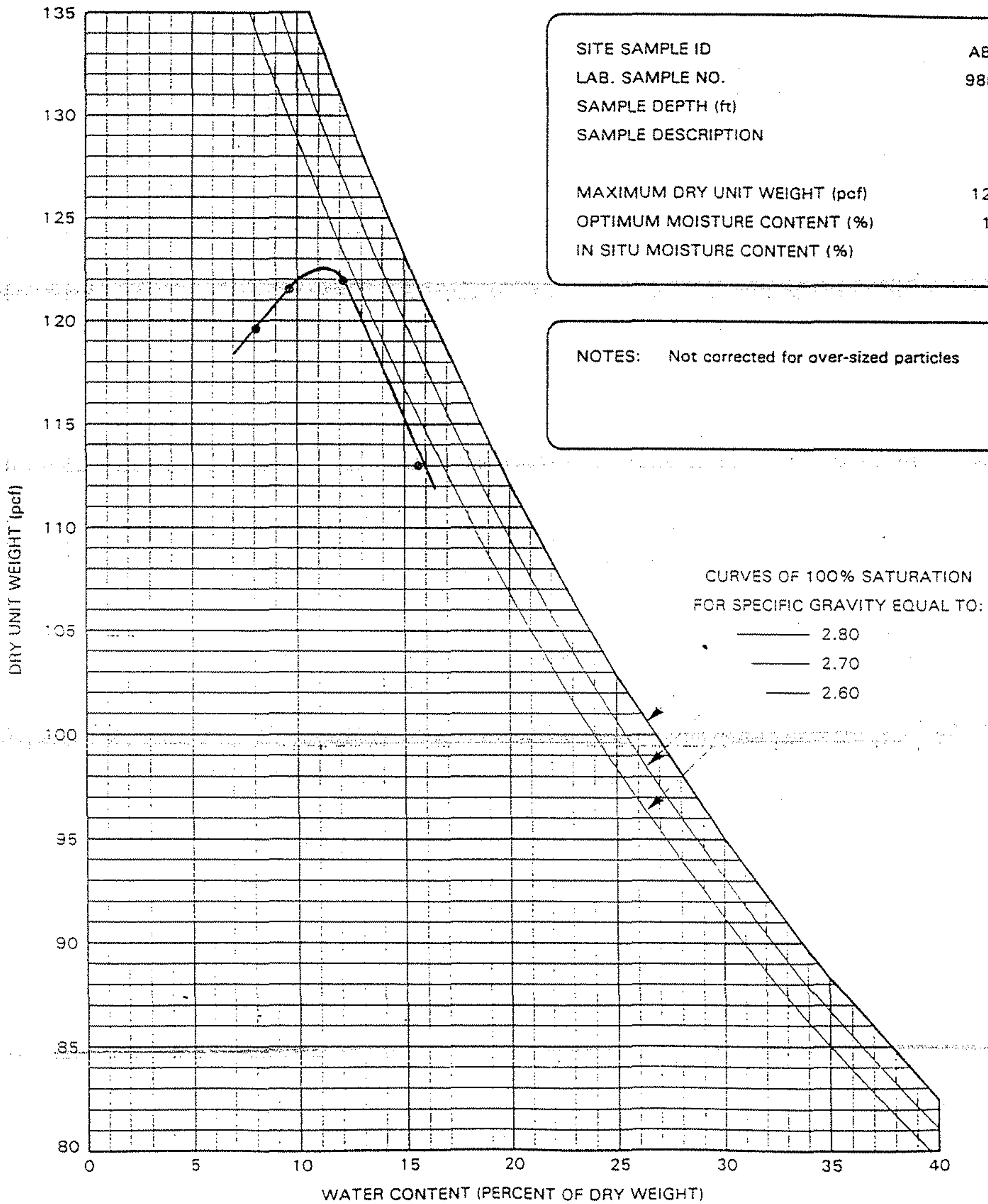
GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-8

SITE SAMPLE ID	AB-10
LAB. SAMPLE NO.	98832
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	122.5
OPTIMUM MOISTURE CONTENT (%)	11.3
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles



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Atlanta, Georgia

FIGURE 4

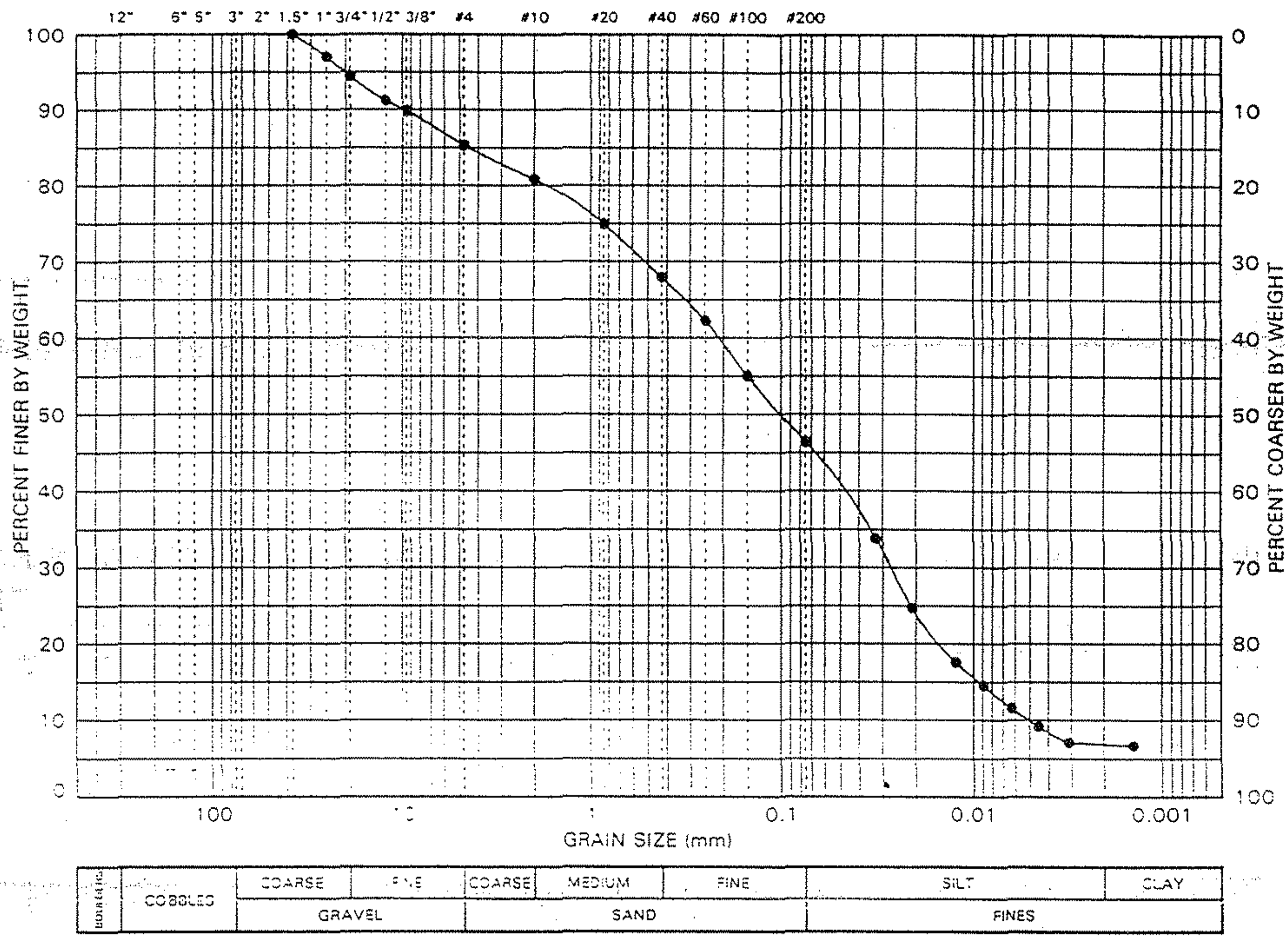
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318

U.S. STANDARD SIEVE SIZES AND NUMBERS



SITE SAMPLE ID	AB-10	LIQUID LIMIT (%)	40	GRAVEL (%)	14.7
LAB. SAMPLE NO.	98A89	PLASTIC LIMIT (%)	28	SAND (%)	38.9
SAMPLE DEPTH (ft)		PLASTICITY INDEX	12	FINES (%)	46.4
SOIL CLASSIFICATION:				SILT (%)	39.5
SM - Silty Sand with Gravel				CLAY(%)	6.9
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	97	94	91	90	85	81	75	68	62	55	46	40	24	10	7	

NOTES:

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Atlanta, Georgia

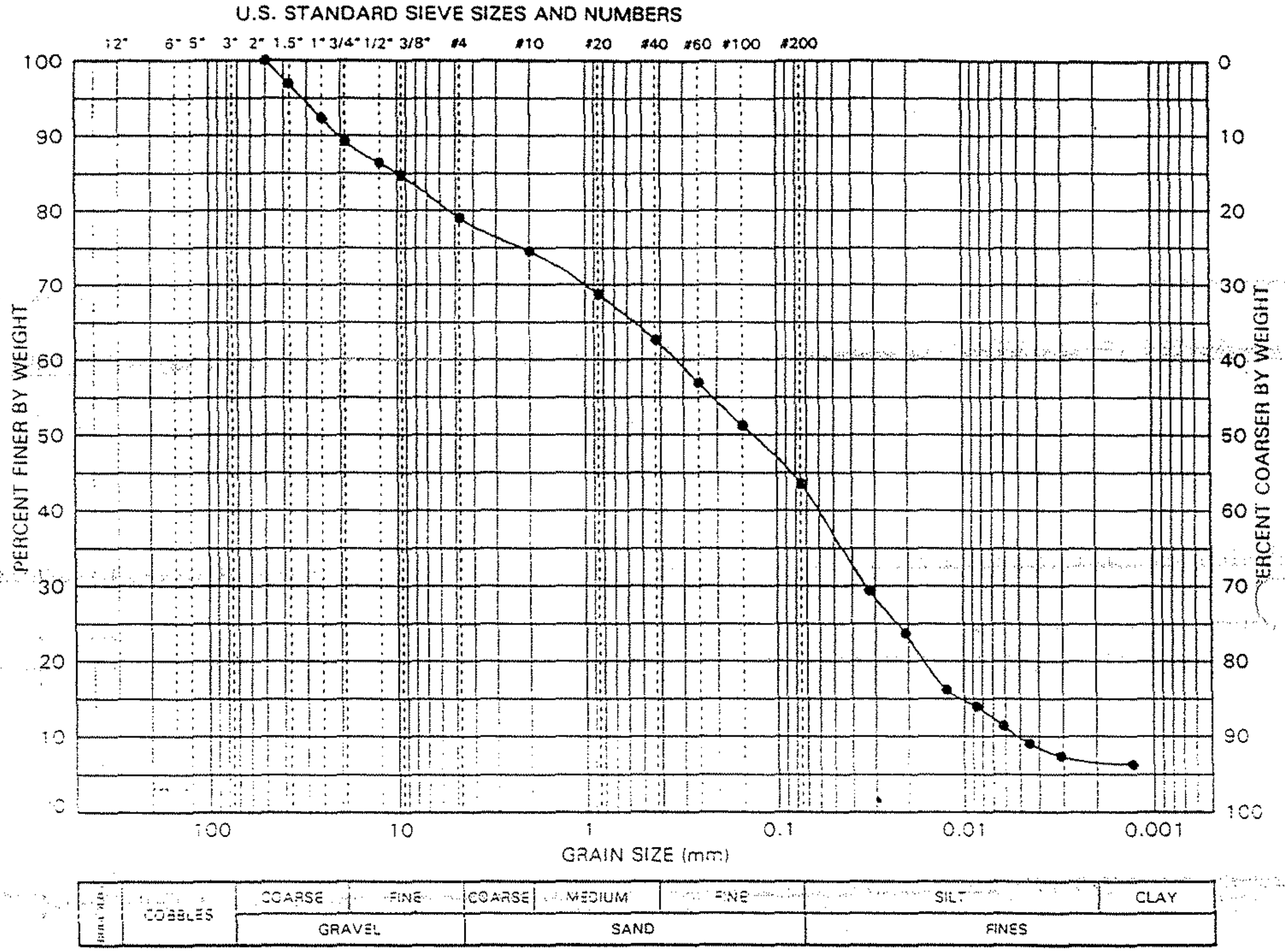
FIGURE 3

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	AB-7	LIQUID LIMIT (%)	40	SOIL FRACTIONS	GRAVEL (%)	21.0
LAB. SAMPLE NO.	98A88	PLASTIC LIMIT (%)	25		SAND (%)	35.5
SAMPLE DEPTH (ft)		PLASTICITY INDEX	15		FINES (%)	43.5
SOIL CLASSIFICATION: SC - Clayey Sand with Gravel					SILT (%)	36.7
					CLAY(%)	6.8
					COEFF. UNIFORMITY (Cu)	
					COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER ~~THAN HYDROMETER~~				
3"	2"	1.5"	1"	3/4"	1/2"	~~3/8"~~	~~#4~~	~~#10~~	~~#20~~	~~#40~~	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0
100	100	97	92	89	86	85	79	75	69	63	57	51	44	37	23	10	7	

NOTES:

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Atlanta, Georgia

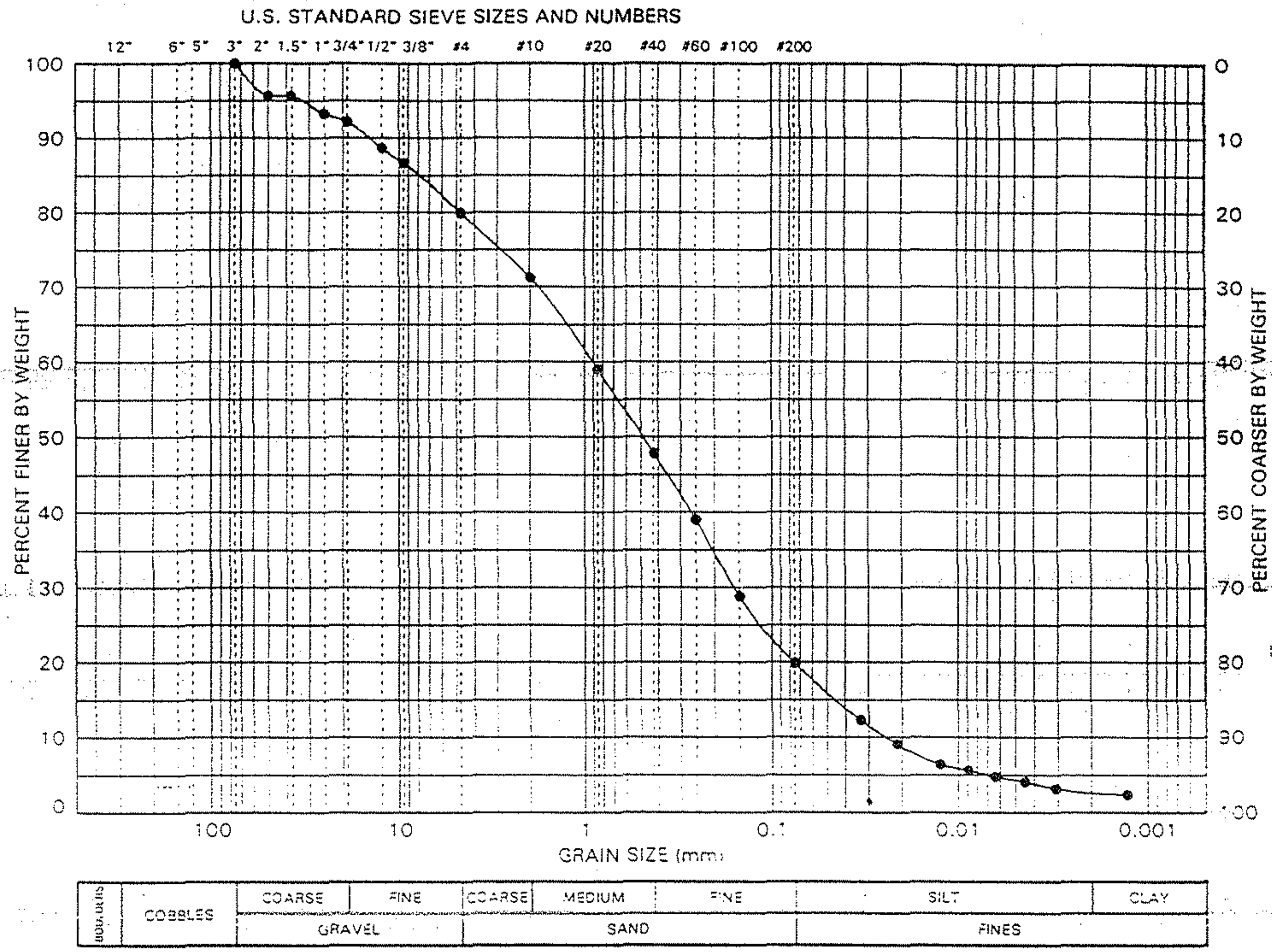
FIGURE 2

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/03/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	AB-4	LIQUID LIMIT (%)	31	SOIL FRACTIONS	GRAVEL (%)	20.1
LAB. SAMPLE NO.	98A87	PLASTIC LIMIT (%)	21		SAND (%)	60.0
SAMPLE DEPTH (ft)		PLASTICITY INDEX	10		FINES (%)	19.9
SOIL CLASSIFICATION:					SILT (%)	17.1
SC - Clayey Sand with Gravel					CLAY(%)	2.8
					COEFF. UNIFORMITY (Cu)	
					COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	96	96	93	92	89	87	80	71	59	48	39	29	20	16	9	4	3	

NOTES:

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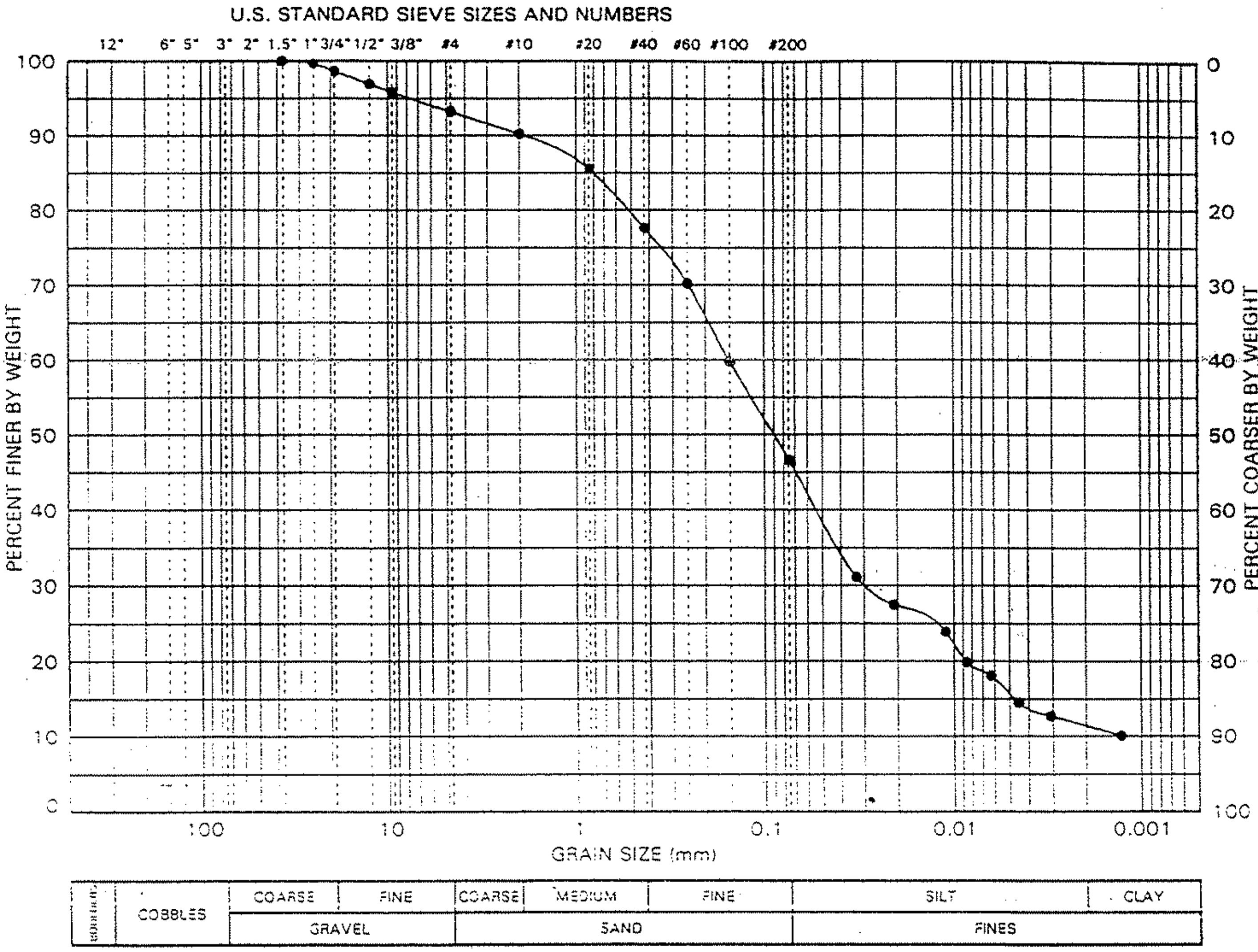
GEO SYNTEC CONSULTANTS Geomechanics and Environmental Laboratory Atlanta, Georgia	**FIGURE 1** PROJECT: LOPEZ CANYON LANDFILL PROJECT NO.: CE4100 DOCUMENT NO.:

GS FORM: 4PS2 02/03/98	PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES	ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	AB-3	LIQUID LIMIT (%)	35	GRAVEL (%)	6.8
LAB. SAMPLE NO.	98A86	PLASTIC LIMIT (%)	18	SAND (%)	46.6
SAMPLE DEPTH (ft)		PLASTICITY INDEX	17	FINES (%)	46.6
SOIL CLASSIFICATION:				SILT (%)	35.2
SC - Clayey Sand				CLAY(%)	11.4
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.(
100	100	100	100	99	97	96	93	90	86	78	70	60	47	39	27	16	11	

NOTES:

TABLE 1

LABORATORY TEST RESULTS

BUREAU OF SANITATION - CITY OF LOS ANGELES
LOPEZ CANYON LANDFILL

Site Sample ID	Lab Sample No	As Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size: ASTM D 422 Sieve Figure No	Grain Size: ASTM D 422 Hydrom. Figure No	Atterberg Limits ASTM D 4318 LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI ( )	Soil Classification ASTM D 2487	Compaction: Modified Proctor ASTM D 1557 Max. Dry Unit Weight (pcf)	Compaction: Optimum Moisture Content (%)	Compaction: Fig. No	Hydraulic Conductivity ASTM D 5084: Test Specimen Initial Conditions Dry Unit Weight (pcf)	Moisture Content (%)	Consol. Pressure (psi)	Hydraulic Conductivity (cm/s)	Remarks
AB-3	98A86		46 6	1	1	35	18	17	SC - Clayey Sand								
AB-4	98A87		19 9	2	2	31	21	10	SC - Clayey Sand with Gravel								
AB -7	98A88		43 5	3	3	40	25	15	SC - Clayey Sand with Gravel								
	98A89		46 4	4	4	40	28	12	SM - Silty Sand with Gravel								
AB -10	98B32									122.5	11.3	5					Not corrected for over-sized particles
										125.7	10.1	6					
	98B32 1												104.2	13.2	1.5	4.5E-4	Moisture Retention see Fig. 13
AB -25-B	98B34									124.4	11.2	7					Not corrected for over-sized particles
										128.9	9.4	8					
	98B34 1												112.0	10.9	1.5	7.6E-5	
B-3	98B15		52 4	9		37	20	17	CL - Sandy Lean Clay								
B-6	98A90		61 9	10	10	39	30	9	ML - Sandy Silt								
VGO21398	98B69		38 8	11	11					123 6	10.3	12	111.3	12 6	1 5	7.5E-5	

Note:

1. Moisture Retention test ongoing; test results will be presented in a revised report

SAMPLE IDENTIFICATION, HANDLING, STORAGE AND DISPOSAL

Test materials were sent to GeoSyntec Consultants (GeoSyntec) Geomechanics and Environmental Laboratory in Atlanta, Georgia by the client or its representative(s). Samples delivered to the laboratory were identified by client sample identification (ID) numbers which had been assigned by representative(s) of the client. Upon being received at the laboratory, each sample was assigned a laboratory sample number to facilitate tracking and documentation.

Based on the information provided to GeoSyntec by the client or its representative(s) and, when applicable, procedural guidelines recommended by an industrial hygiene consultant, the following Occupational Safety and Health Administration (OSHA) level of personal protection was adopted for handling and testing of the test materials:

[X] test materials were not contaminated, no special protection measures were taken;
[ ] level D
[ ] level C
[ ] level B

In accordance with the health and safety guidelines of GeoSyntec, contaminated materials are stored in a designated containment area in the laboratory. Non-contaminated materials are stored in a general storage area in the laboratory.

GeoSyntec Geomechanics and Environmental Laboratory will return contaminated materials to the client or designated representative(s), at the clients' cost, 30 days following the completion of the testing program, unless special arrangements for proper disposal have been made with the laboratory. Materials which are not contaminated will be discarded 90 days after they were received at the laboratory, unless long-term storage arrangements are specifically made with GeoSyntec Geomechanics and Environmental Laboratory.

LABORATORY TEST STANDARDS

At the request of the client, the laboratory testing program was performed utilizing the guidelines provided in the following test standards:

[X] **moisture content** - American Society for Testing and Materials (ASTM) D 2216 "*Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures*";

[ ] **moisture content** - ASTM D 4643 "*Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Method*";

[X] **particle-size analysis** - ASTM D 422, "*Standard Method for Particle-Size Analysis of Soils*";

[X] **percent passing No. 200 sieve** - ASTM D 1140, "*Standard Test Method for Amount of Material in Soil Finer Than No. 200 (75 microns) sieve*";

[X] **Atterberg limits** - ASTM D 4318, "*Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*";

[X] **soil classification** - ASTM D 2487, "*Standard Test Method for Classification of Soils for Engineering Purposes*";

[ ] **soil pH** - ASTM D 4972, "*Standard Test Method for pH of Soils*";

[ ] **soil pH** - United States Environmental Protection Agency (USEPA) SW-846 Method 9045, Revision 1, 1987, Standard Test Method for Measurement of "*Soil pH*";

[ ] **specific gravity** - ASTM D 854, "*Standard Test Method for Specific Gravity of Soils*";

[ ] **carbonate content** - ASTM D 3042, "*Standard Test Method for Insoluble Residue in Carbonate Aggregates*";

[ ] **carbonate content** - ASTM D 4373, "*Standard Test Method for Calcium Carbonate Content of Soils*";

[ ] **acid reactivity** - ASTM D 2488, "*Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*".

[ ] **soundness** - ASTM C 88, "*Standard Test Method for Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate*";

[ ] **loss-on-ignition (LOI)** - ASTM D 2974, "*Test Methods for Moisture, Ash, and Organic Matter of Peat and Other*

Organic Soils";

[ ] **standard Proctor compaction** - ASTM D 698, "*Standard Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop*";

[X] **modified Proctor compaction** - ASTM D 1557, "*Standard Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop*";

[ ] **maximum relative density** - ASTM D 4253, "*Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table*";

[ ] **minimum relative density** - ASTM D 4254, "*Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density*";

[ ] **unit weight** - ASTM D 2937, "*Standard Test Method for Density of Soil In Place by the Drive-Cylinder Method*";

[ ] **unit weight, void ratio, porosity, and degree of saturation** - U. S. Army Corps of Engineers (USCOE); EM-1110-2-1906, "*Unit Weight, Void Ratio, Porosity, and Degree of Saturation, Appendix II*";

[ ] **mass per unit area** - ASTM D 3776, "*Standard Test Method for Mass Per Unit Area (weight) of Woven Fabric*";

[ ] **thickness measurement** - ASTM D 1777, "*Standard Test Method for Measuring Thickness of Textile Materials*";

[ ] **free swell** - United States Pharmacopoeia National Formulary (USP-NF) XVII, "*Swell Index of Clay*";

[ ] **swell of clay in GCL's** - Geosynthetic Research Institute (GRI) GCL-1, "*Standard Test Method for Swell Measurement of the Clay Component of GCL's*";

[ ] **fluid loss** - American Petroleum Institute (API) RP 13B, "*Section 4, Bentonite*";

[ ] **marsh funnel** - API RP 13B, "*Section 4, Field Testing of Oil Mud Viscosity and Gel Strength*";

[ ] **pinhole dispersion** - ASTM D 4647, "*Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test*";

[ ] **gradient ratio** - ASTM D 5101, "*Standard Test Method for Measuring the Soil-Geotextile System Clogging Potential by the Gradient Ratio*";

[ ] **hydraulic conductivity ratio (HCR)** - ASTM D 5567, "*Standard Test Method for Hydraulic Conductivity Ratio (HCR) Testing of Soil/Geotextile Systems*";

[ ] **hydraulic transmissivity** - ASTM D 4716, "*Standard Test Method for Constant Head Hydraulic Transmissivity (In-plane flow) of Geotextiles and Geotextile Related Products*";

[ ] **one-dimensional consolidation** - ASTM D 2435, "*Standard Test Method for One-Dimensional Consolidation Properties of Soil*";

[ ] **one-dimensional swell/collapse** - ASTM D 4546, "*Standard Test Method for One-Dimensional Swell or Settlement Potential of Cohesive Soils*";

[ ] **unconfined compressive strength (UCS)** - ASTM D 2166, " *Standard Test Method for Unconfined Compressive Strength of Cohesive Soil*".

[ ] **triaxial compressive strength (ICU)** - ASTM D 4767, "*Standard Test Method for Triaxial Compression Test on Cohesive Soils*";

[ ] **triaxial compressive strength (UU)** - ASTM D 2850, "*Standard Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression*";

[ ] **rigid wall constant head hydraulic conductivity** - ASTM D 2434, "*Standard Test Method for Permeability of Granular Soils (Constant Head)*".

[ ] **rigid wall constant head hydraulic conductivity** - USCOE, EM-1110-2-1906, "*Standard Test Method for Permeability Tests, Appendix VII*";

[X] **flexible wall falling head hydraulic conductivity** - ASTM D 5084, *"Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter"*;

[ ] **flexible wall falling head hydraulic conductivity** - USCOE; EM-1110-2-1906, *"Standard Test Method for Permeability Tests, Appendix VII"*;

[ ] **index flux of GCL** - proposed ASTM method rough draft # 1, 6/18/94, *"Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter"*;

[ ] **flexible wall falling head hydraulic conductivity** - GRI GCL-2, *"Standard Test Method for Permeability of Geosynthetic Clay Liners (GCLs)"*;

[ ] **permeability/compatibility** - USEPA Method 9100 SW-846, Revision 1, 1987, Standard Test Method for Measurement of *"Saturated Hydraulic Conductivity, Saturated Leachate Conductivity and Intrinsic Permeability"*;

[ ] **permeability** - API RP 27, *"Recommended Practice for Determining Permeability of Porous Media"*;

[X] **capillary-moisture** - ASTM D 2325, *"Standard Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus"*;

[ ] **capillary-moisture** - ASTM D 3152, *"Standard Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-Membrane Apparatus"*;

[ ] **paint filter liquids** - USEPA Method 9095, SW-846, Revision 1, 1987, *"Paint Filter Liquids Test"*; and

[ ] **slump** - ASTM C 143-90a, *"Standard Test Method for Slump of Hydraulic Cement Concrete"*.

APPLICATION OF TEST RESULTS

The reported test results apply to the field materials inasmuch as the samples sent to the laboratory for testing are representative of these materials. This report applies only to the materials tested and does not necessarily indicate the quality or condition of apparently identical or similar materials. The testing was performed in accordance with the general engineering standards and conditions reported. The test results are related to the testing conditions used during the testing program. As a mutual protection to the client, the public, and GeoSyntec, this report is submitted and accepted for the exclusive use of the client and upon the condition that this report is not used, in whole or in part, in any advertising, promotional or publicity matter without prior written authorization from GeoSyntec.

TABLE 1

LABORATORY TEST RESULTS

BUREAU OF SANITATION - CITY OF LOS ANGELES
LOPEZ CANYON LANDFILL

Site Sample ID	Lab Sample No	As-Received Moisture Content ASTM D 2216 (%)	Grain Size: Percent Passing #200 Sieve ASTM D 1140 (%)	Grain Size ASTM D 422: Sieve Figure No	Grain Size ASTM D 422: Hydrom Figure No	Atterberg Limits ASTM D 4318: LL (%)	Atterberg Limits ASTM D 4318: PL (%)	Atterberg Limits ASTM D 4318: PI ( )	Soil Classification ASTM D 2487	Compaction, Modified Proctor ASTM D 1557: Max. Dry Unit Weight (pcf)	Compaction, Modified Proctor ASTM D 1557: Optimum Moisture Content (%)	Compaction: Fig. No	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Dry Unit Weight (pcf)	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Moisture Content (%)	Hydraulic Conductivity ASTM D 5084, Test Specimen Initial Conditions: Consol. Pressure (psi)	Hydraulic Conductivity (cm/s)	Remarks
A-6	98B65		37.6	1	1	34	24	10	SM - Silty Sand	126.0	10.5	2	113.3	12.2	1.5	7.8E-5	Not corrected for over-sized particles
										128.2	9.7	3					Moisture Retention see Fig. 12
A-8	98B66		46.1	4	4	36	24	12	SC - Clayey Sand	122.0	11.5	5	110.0	13.1	1.5	8.8E-5	
A-9	98B67		50.6	6	6	44	28	16	ML - Sandy Silt	116.2	14.3	7	102.9	17.0	1.5	1.4E-5	Not corrected for over-sized particles
										118.7	13.2	8					
A-10	98B68		53.2	9	9	48	30	18	ML - Sandy Silt	119.5	12.0	10	107.4	14.8	1.5	3.6E-6	Not corrected for over-sized particles
										122.7	10.9	11					

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Atlanta, Georgia

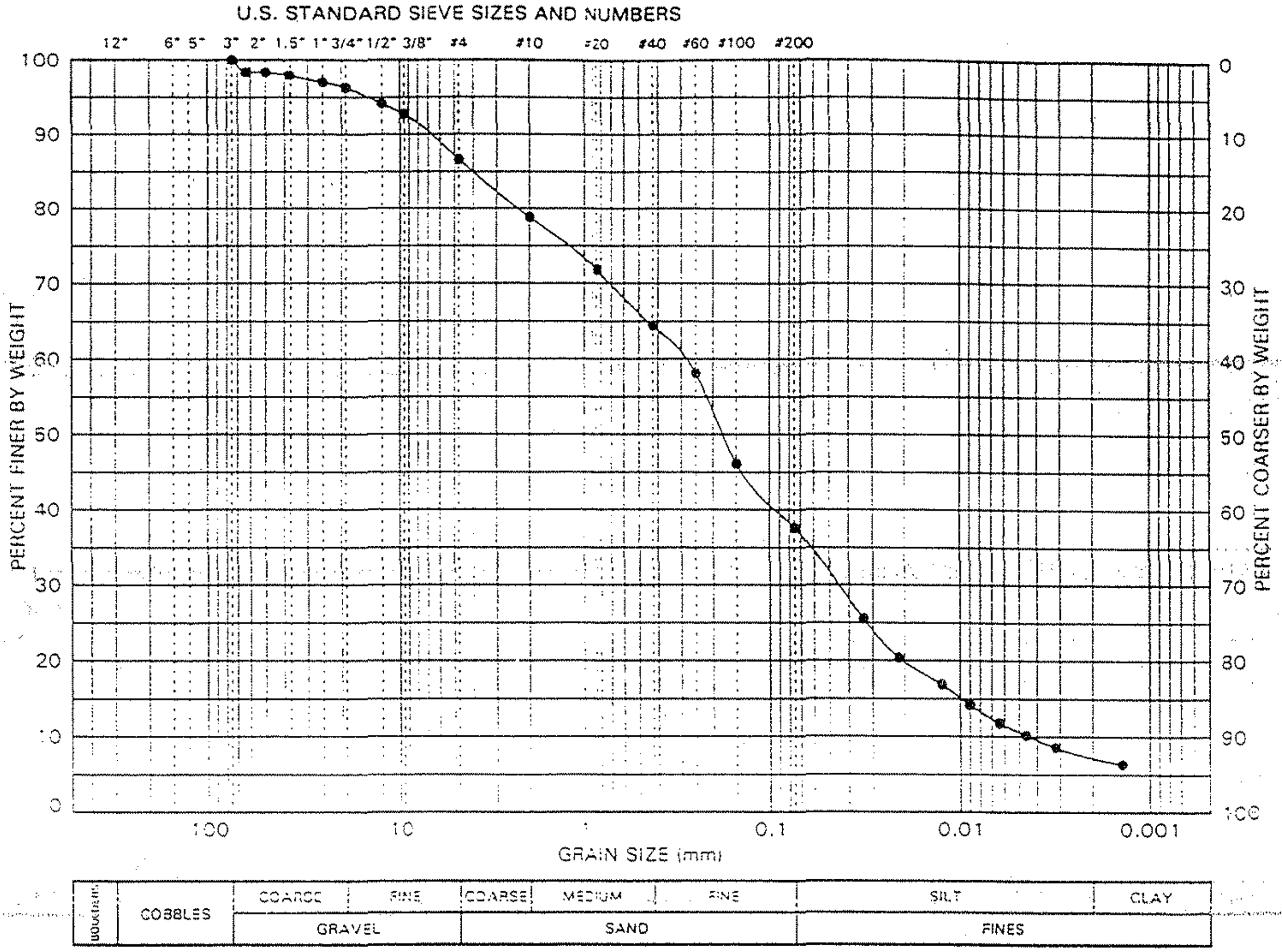
FIGURE 1

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 03/12/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	A-6	LIQUID LIMIT (%)	34	GRAVEL (%)	13.4
LAB. SAMPLE NO.	98B65	PLASTIC LIMIT (%)	24	SAND (%)	49.0
SAMPLE DEPTH (ft)		PLASTICITY INDEX	10	FINES (%)	37.6
SOIL CLASSIFICATION: SM - Silty Sand				SILT (%)	30.3
				CLAY(%)	7.3
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	98	98	97	96	94	93	87	79	72	64	58	46	38	31	20	11	7	

NOTES:

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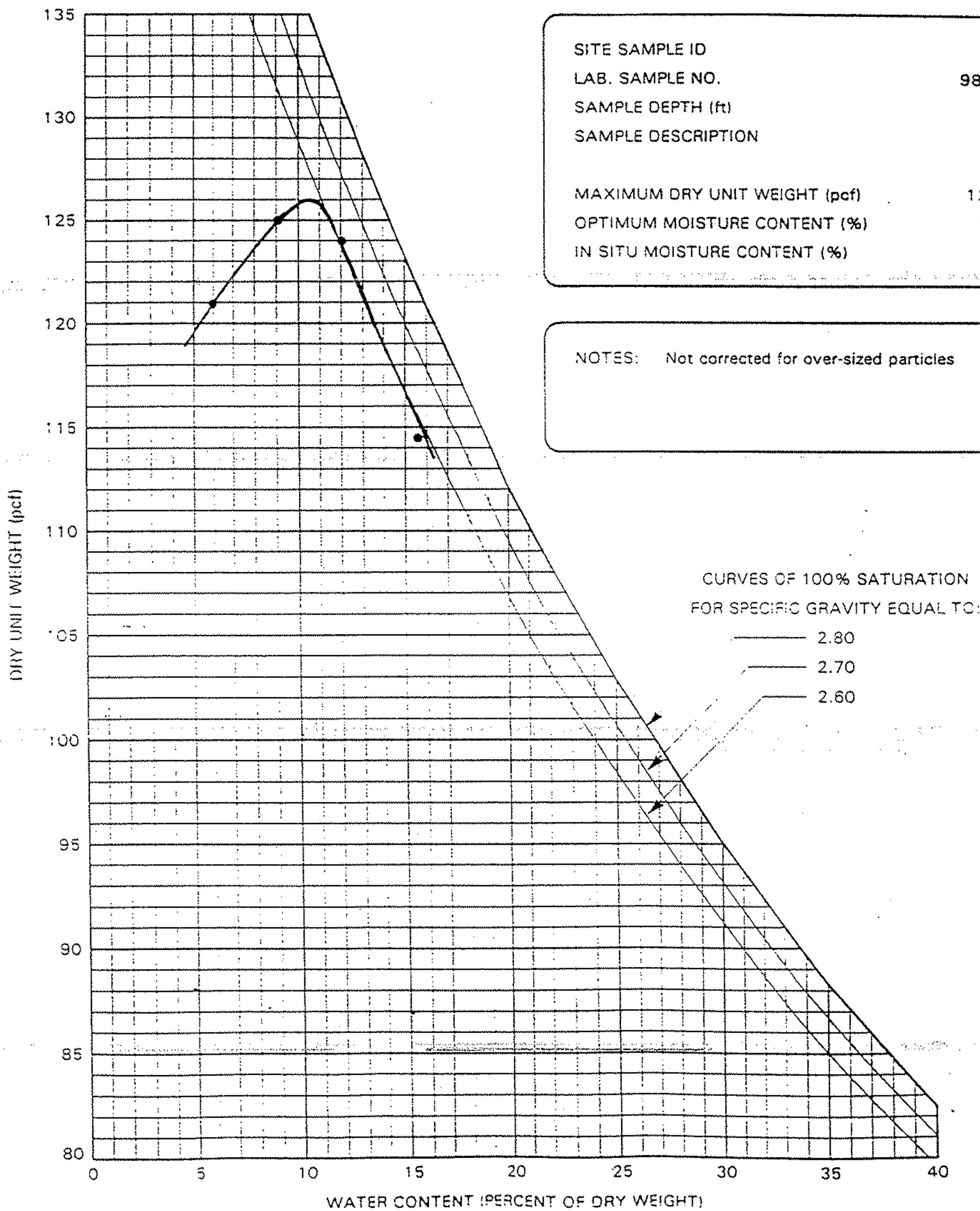
FIGURE 2

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM:
4MD1 03/04/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B



SITE SAMPLE ID	A-6
LAB. SAMPLE NO.	98865
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	126.0
OPTIMUM MOISTURE CONTENT (%)	10.5
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

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FIGURE 3
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-B

SITE SAMPLE ID	A-6
LAB. SAMPLE NO.	98865.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	128.2
OPTIMUM MOISTURE CONTENT (%)	9.7
IN SITU MOISTURE CONTENT (%)	

NOTES:

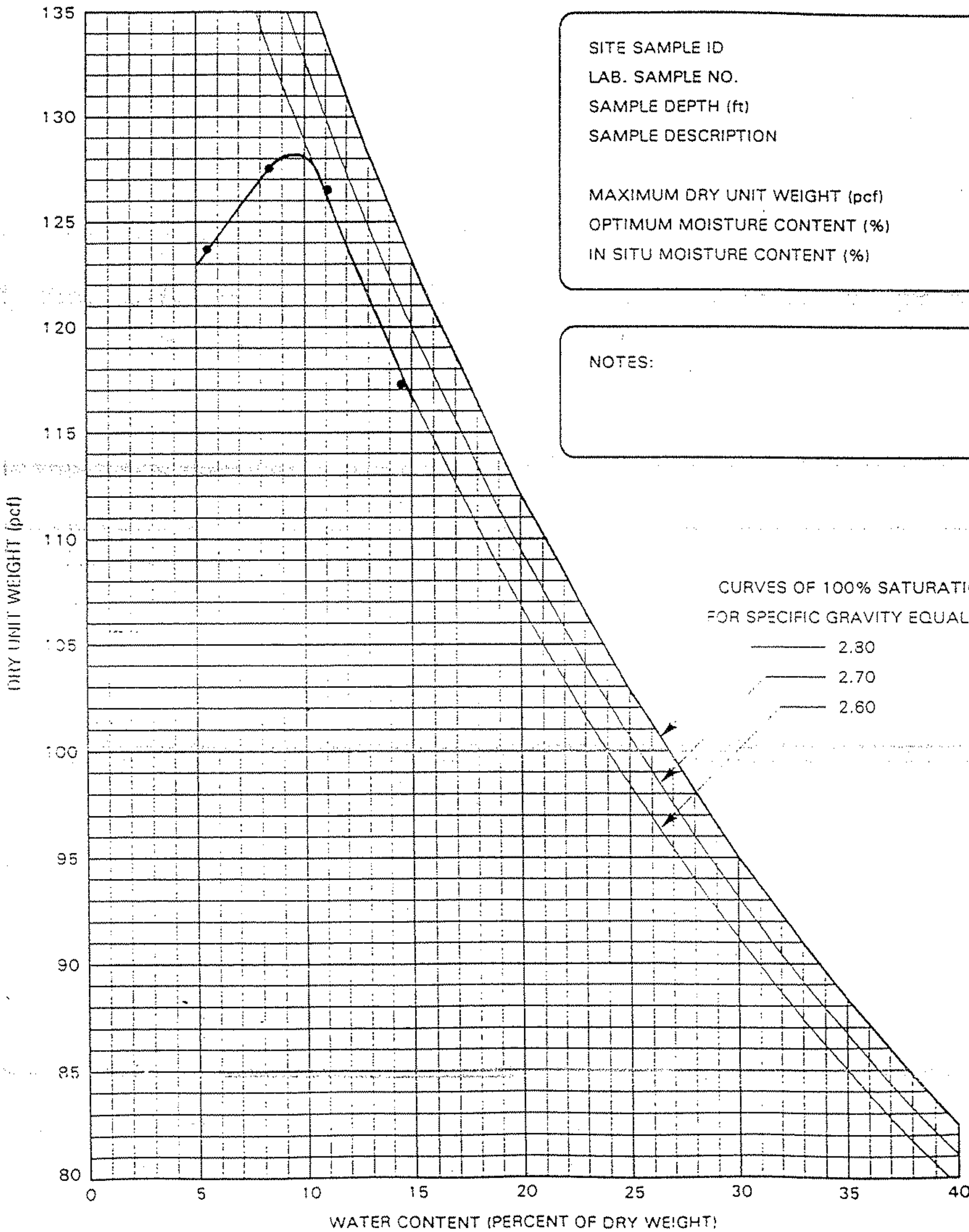

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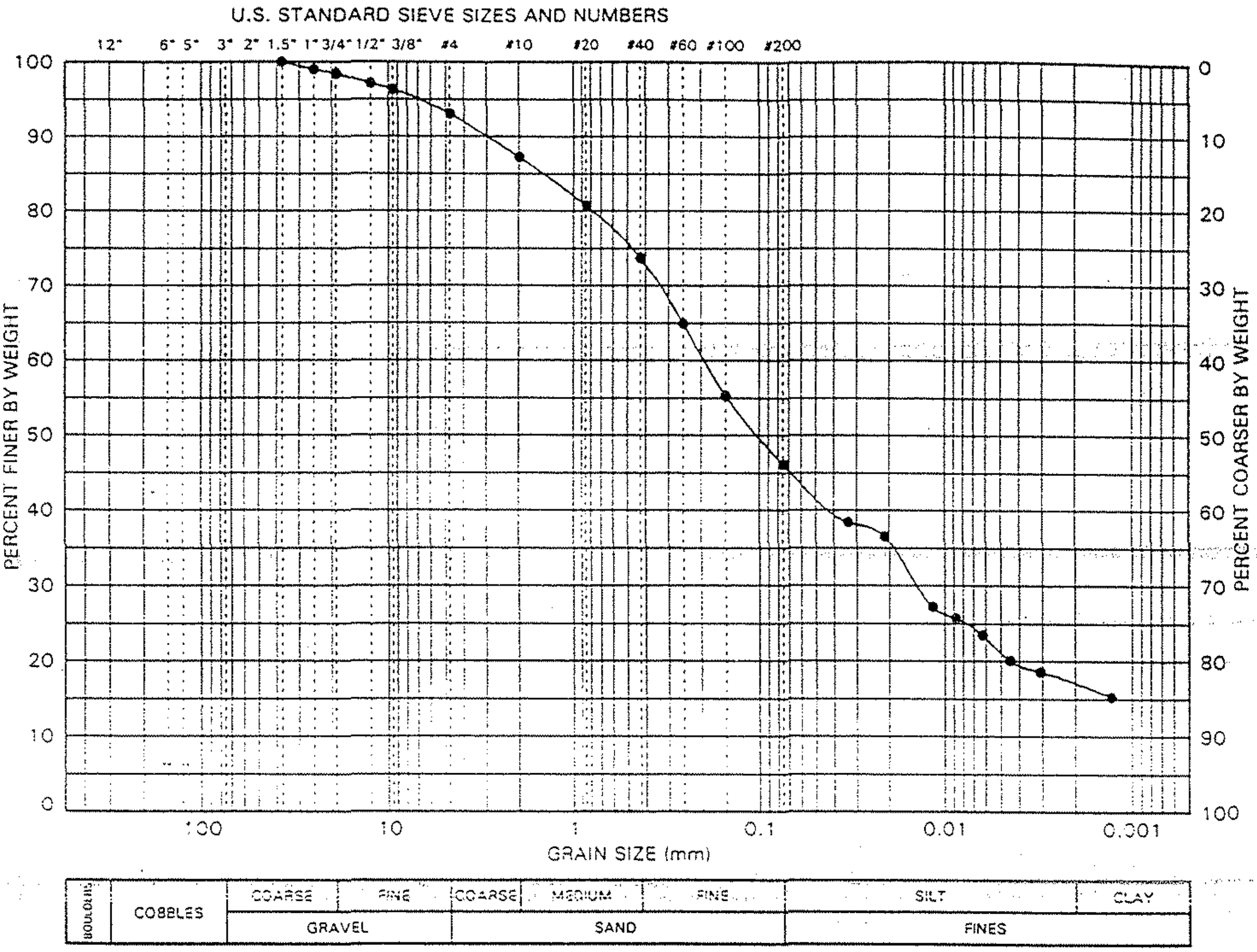
FIGURE 4

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/26/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	A-8	LIQUID LIMIT (%)	36	GRAVEL (%)	7.0
LAB. SAMPLE NO.	98B66	PLASTIC LIMIT (%)	24	SAND (%)	46.9
SAMPLE DEPTH (ft)		PLASTICITY INDEX	12	FINES (%)	46.1
SOIL CLASSIFICATION: SC - Clayey Sand				SILT (%)	29.2
				CLAY(%)	16.9
				COEFF. UNIFORMITY (Cu)	
				COEFF. CURVATURE (Cc)	

SOIL FRACTIONS

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.0[illegible]
100	100	100	99	98	97	96	93	87	81	74	65	55	46	42	36	21	17	

NOTES:

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FIGURE 5

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM:
4MD1 02/27/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-8

SITE SAMPLE ID	A-8
LAB. SAMPLE NO.	98B66
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	122.0
OPTIMUM MOISTURE CONTENT (%)	11.5
IN SITU MOISTURE CONTENT (%)	

NOTES:

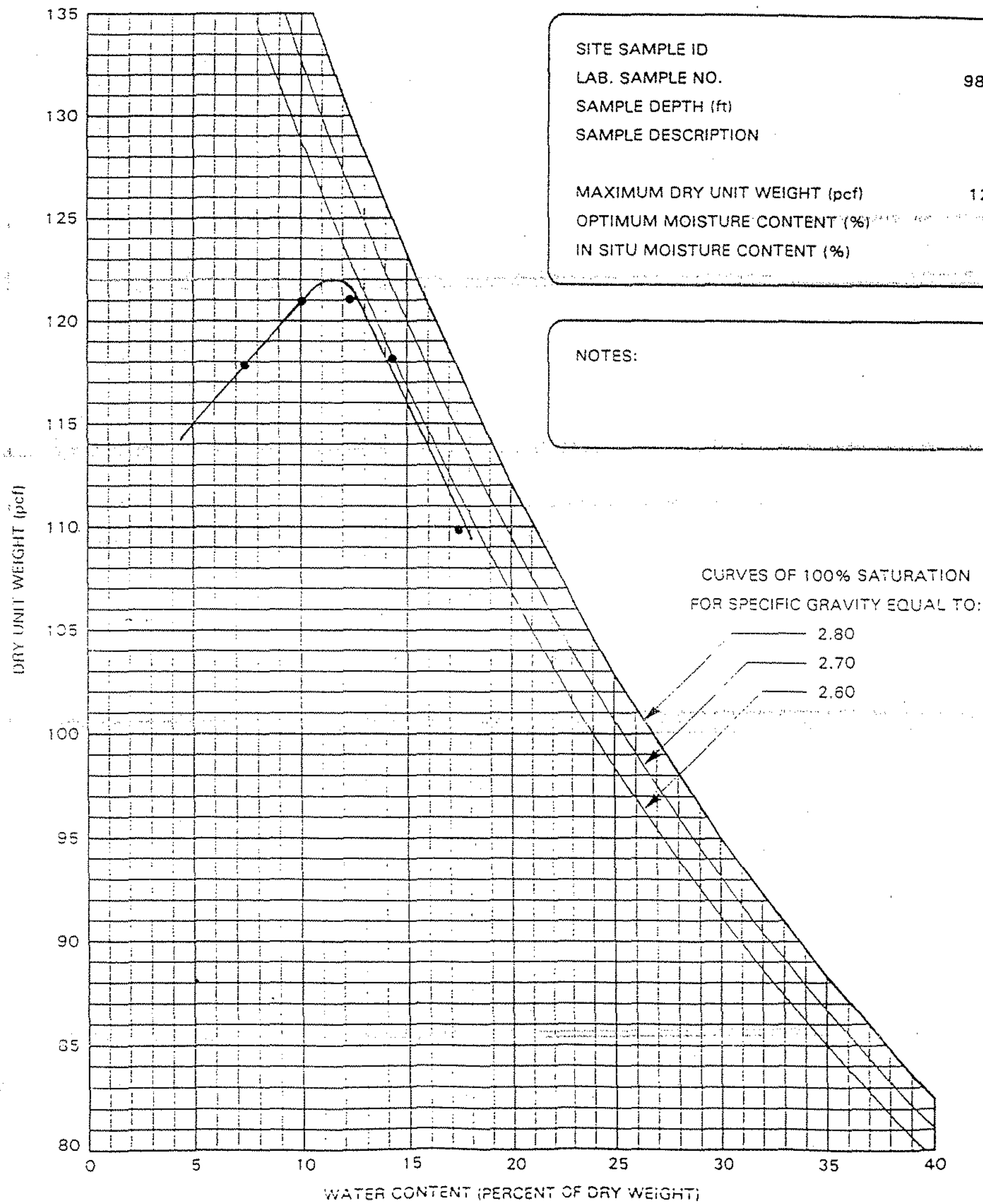

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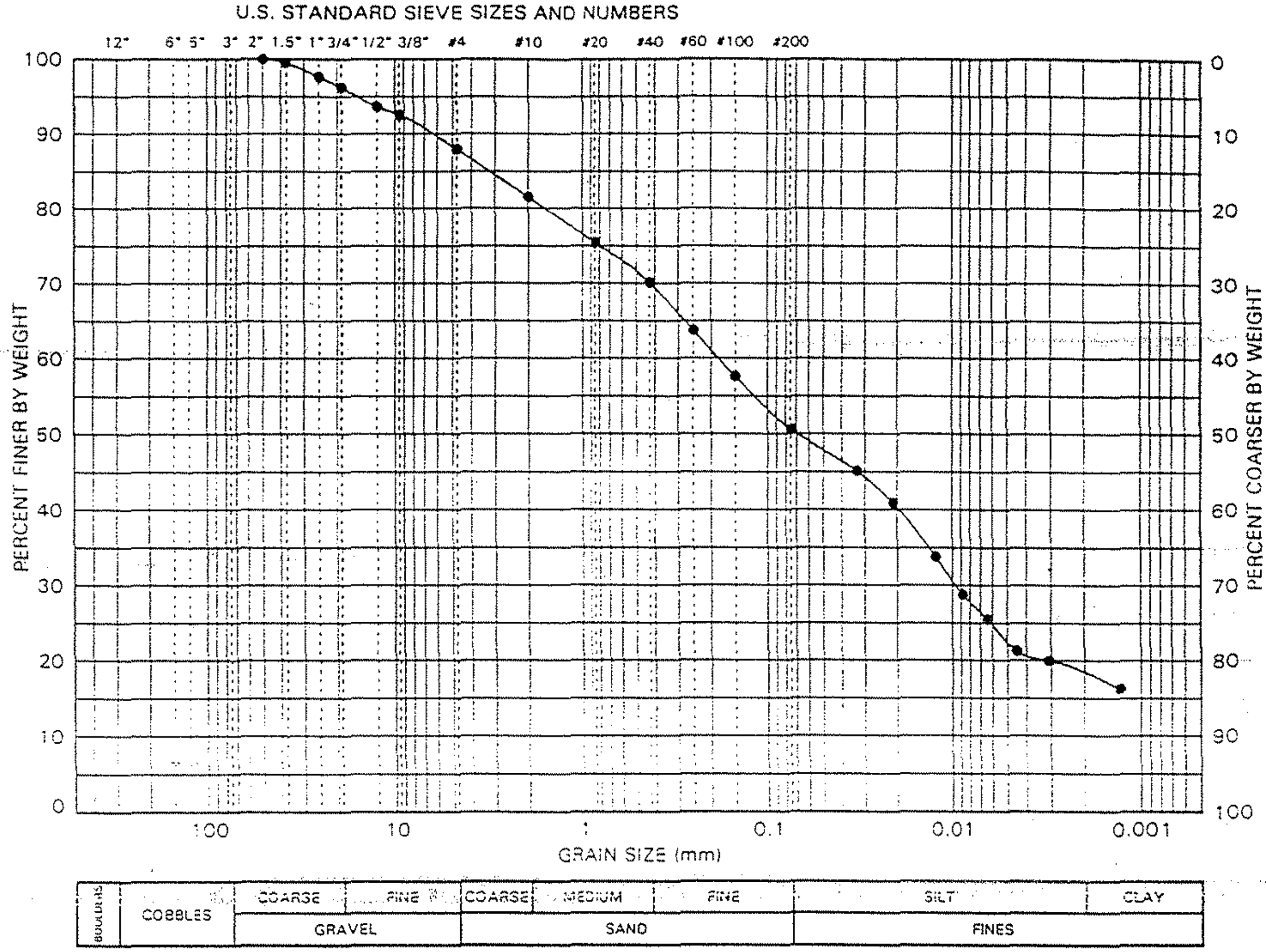
FIGURE 6

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4PS2 02/27/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487 D 3042 AND D 4318



SITE SAMPLE ID	A-9	LIQUID LIMIT (%)	44
LAB. SAMPLE NO.	98B67	PLASTIC LIMIT (%)	28
SAMPLE DEPTH (ft)		PLASTICITY INDEX	16

SOIL CLASSIFICATION:
ML - Sandy Silt

SOIL FRACTIONS	
GRAVEL (%)	12.1
SAND (%)	37.3
FINES (%)	50.6
SILT (%)	32.5
CLAY(%)	18.1
COEFF. UNIFORMITY (Cu)	
COEFF. CURVATURE (Cc)	

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)														PARTICLE DIAMETER (mm)				
75	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.00
100	100	100	98	96	94	93	88	82	75	70	64	58	51	48	40	23	18	

NOTES:

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FIGURE 7

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B

SITE SAMPLE ID	A-9
LAB. SAMPLE NO.	98867
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	116.2
OPTIMUM MOISTURE CONTENT (%)	14.3
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

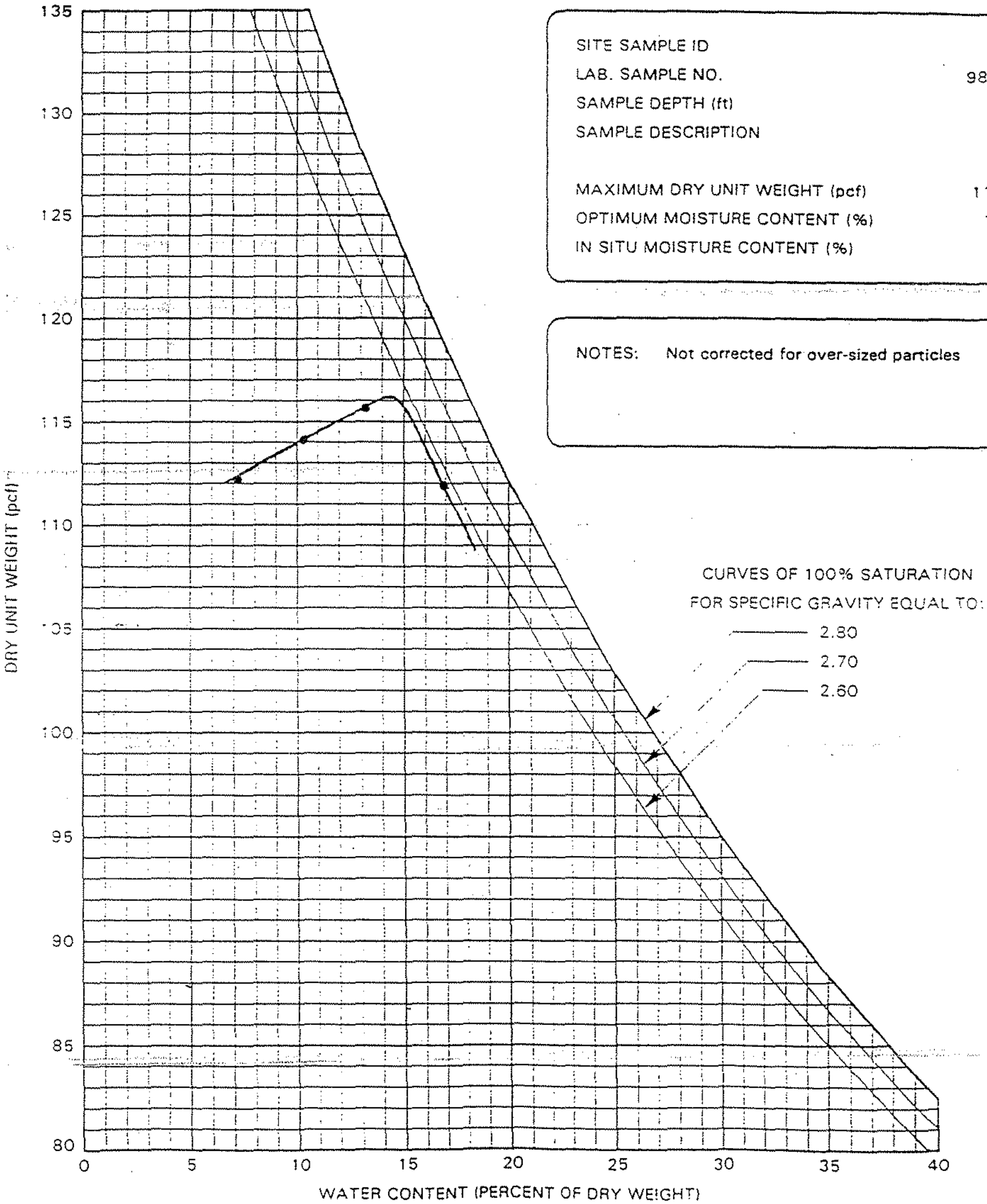

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FIGURE 8

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-8

SITE SAMPLE ID	A-9
LAB. SAMPLE NO.	98867.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	118.7
OPTIMUM MOISTURE CONTENT (%)	13.2
IN SITU MOISTURE CONTENT (%)	

NOTES:

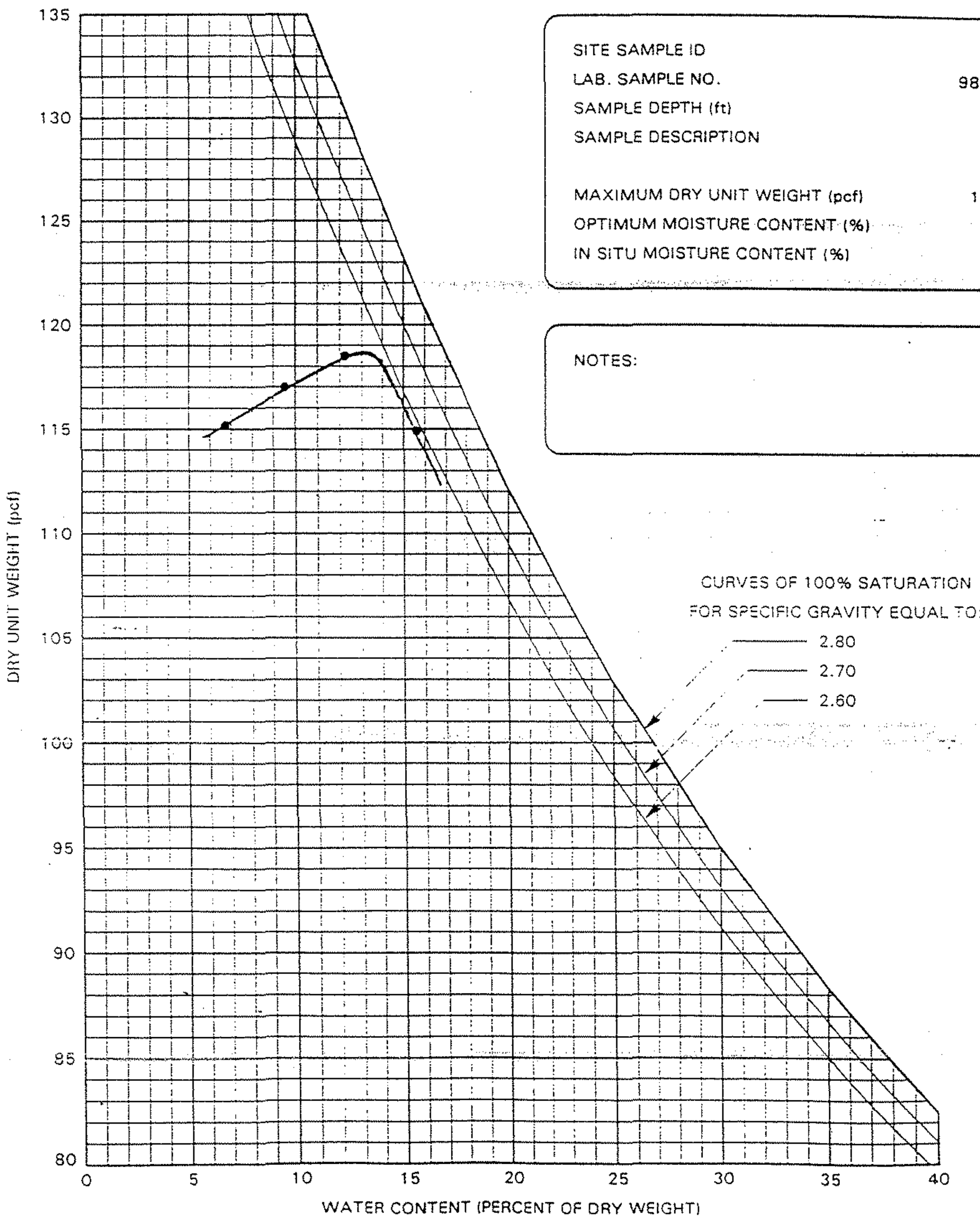

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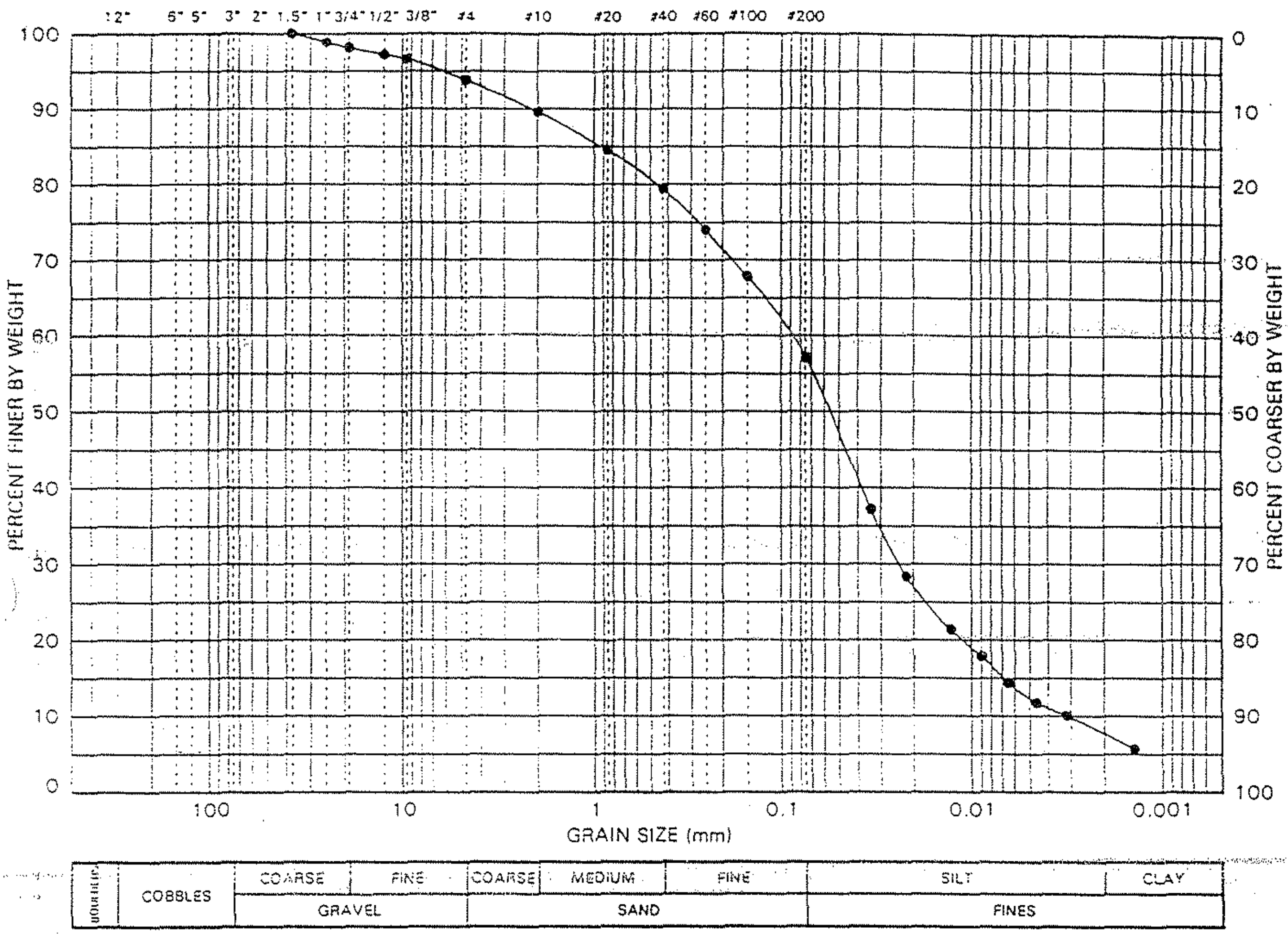
FIGURE 9
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM:
4PS2 03/04/98

PARTICLE SIZE DISTRIBUTION AND PHYSICAL PROPERTIES

ASTM C 136, D 422, D 2487
D 3042 AND D 4318

U.S. STANDARD SIEVE SIZES AND NUMBERS



SITE SAMPLE ID	A-10	LIQUID LIMIT (%)	48	GRAVEL (%)	6.2
LAB. SAMPLE NO.	98B68	PLASTIC LIMIT (%)	30	SAND (%)	36.7
SAMPLE DEPTH (ft)		PLASTICITY INDEX	18	FINES (%)	57.1
				SILT (%)	49.5
				CLAY(%)	7.6

SOIL FRACTIONS

SOIL CLASSIFICATION:
ML - Sandy Silt

COEFF. UNIFORMITY (Cu)
COEFF. CURVATURE (Cc)

PERCENT PASSING U.S. STANDARD SIEVE SIZES AND NUMBERS														PERCENT FINER THAN HYDROMETER PARTICLE DIAMETER (mm)				
3"	2"	1.5"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200					
PERCENT PASSING SIEVE SIZES (mm)																		
[illegible]	50	37.5	25	19	12.5	9.5	4.75	2.00	0.850	0.425	0.250	0.150	0.075	0.050	0.020	0.005	0.002	0.001
100	100	100	99	98	97	97	94	90	85	79	74	68	57	47	27	12	8	

NOTES: The bulk sample contained some particles greater than 3 in. (75 mm) diameter.
The soil classification should include "with Cobbles".

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FIGURE 10

PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM:
4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D-1557-B

SITE SAMPLE ID	A-10
LAB. SAMPLE NO.	98868
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	119.5
OPTIMUM MOISTURE CONTENT (%)	12.0
IN SITU MOISTURE CONTENT (%)	

NOTES: Not corrected for over-sized particles

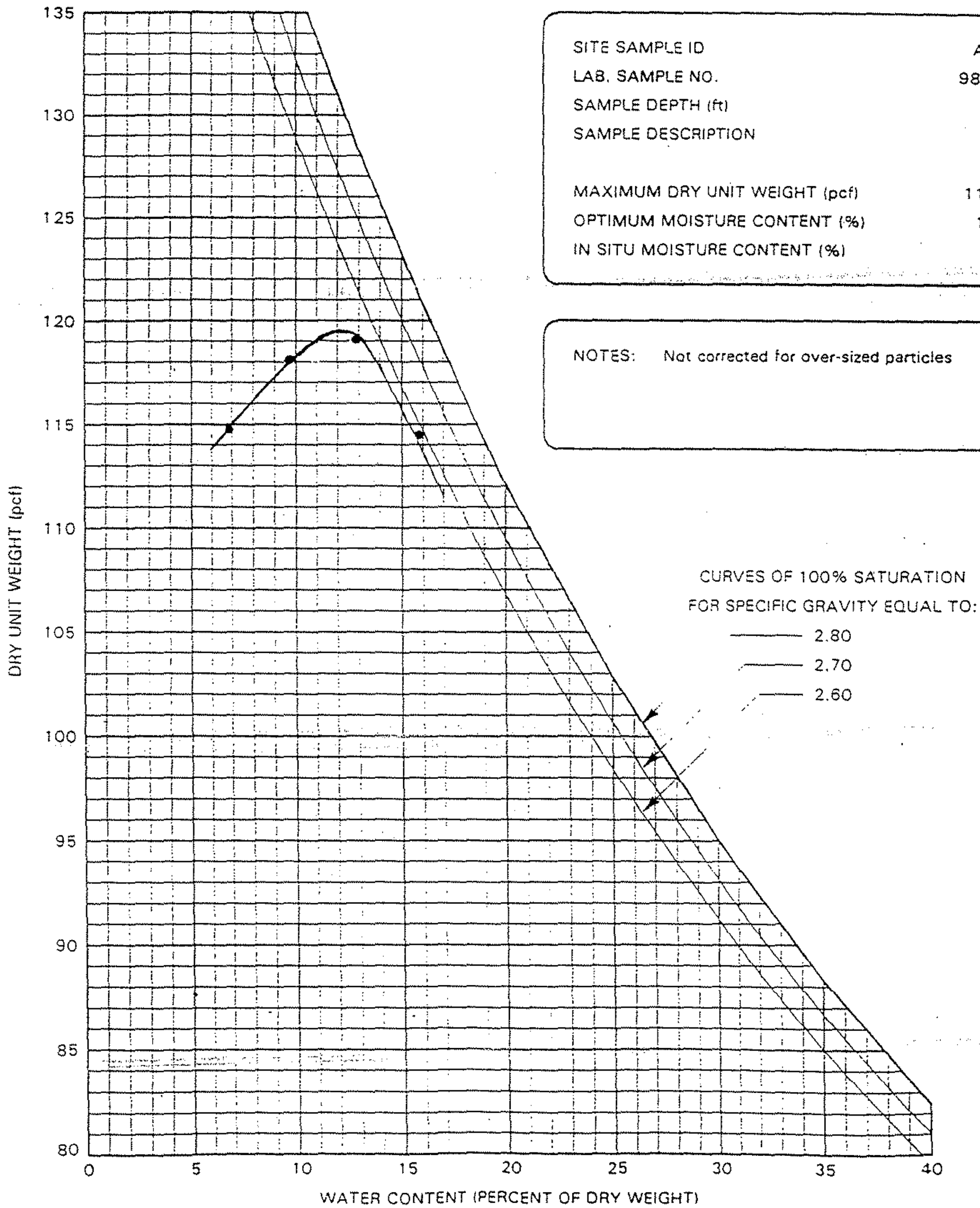

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FIGURE 11
PROJECT: LOPEZ CANYON LANDFILL
PROJECT NO.: CE4100
DOCUMENT NO.:

GS FORM: 4MD1 03/03/98

MOISTURE-DENSITY RELATIONSHIP, COMPACTION TESTING

ASTM D 4178 correction applied
ASTM D-1557-8

SITE SAMPLE ID	A-10
LAB. SAMPLE NO.	98B68.
SAMPLE DEPTH (ft)	
SAMPLE DESCRIPTION	
MAXIMUM DRY UNIT WEIGHT (pcf)	122.7
OPTIMUM MOISTURE CONTENT (%)	10.9
IN SITU MOISTURE CONTENT (%)	

NOTES:

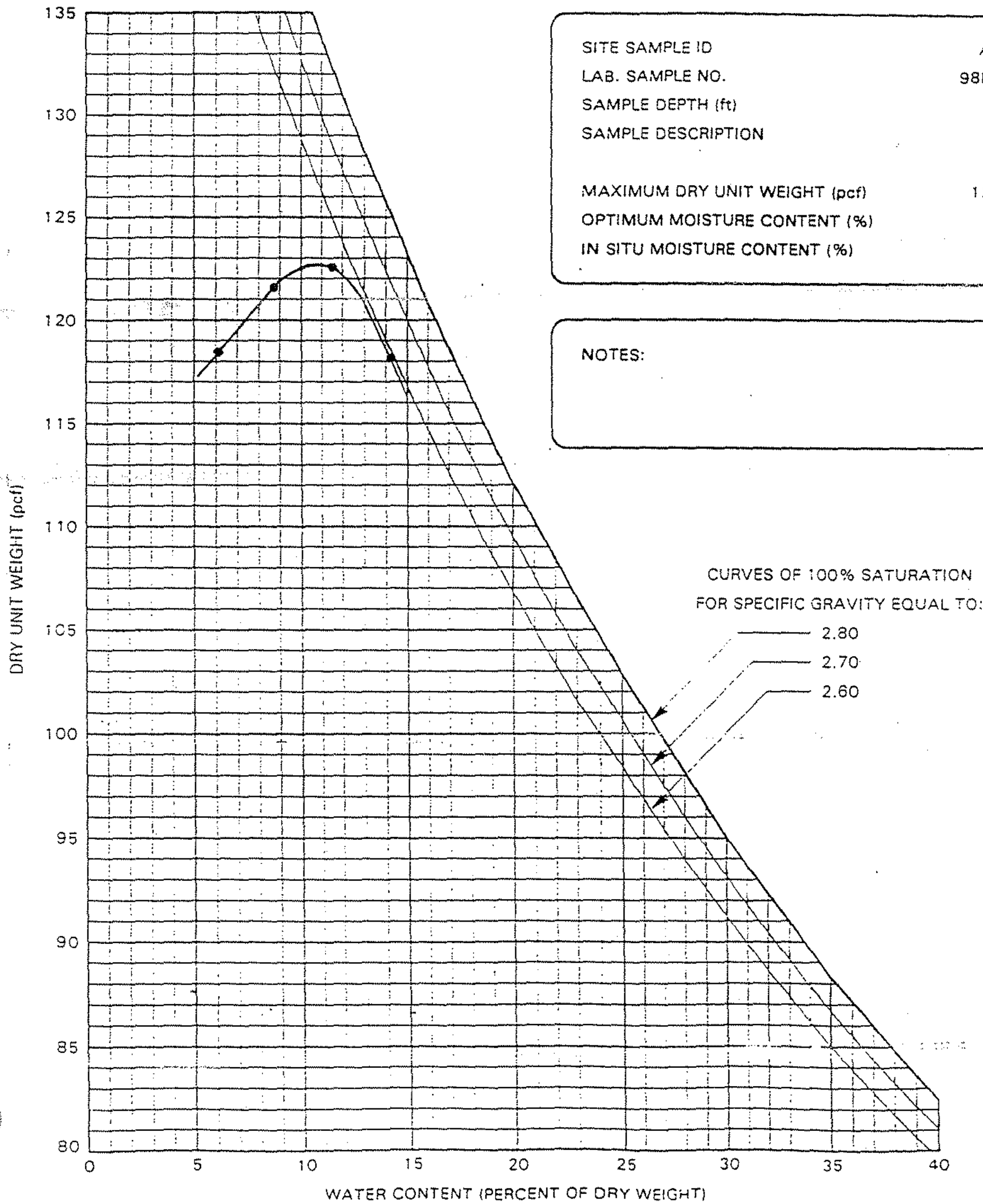

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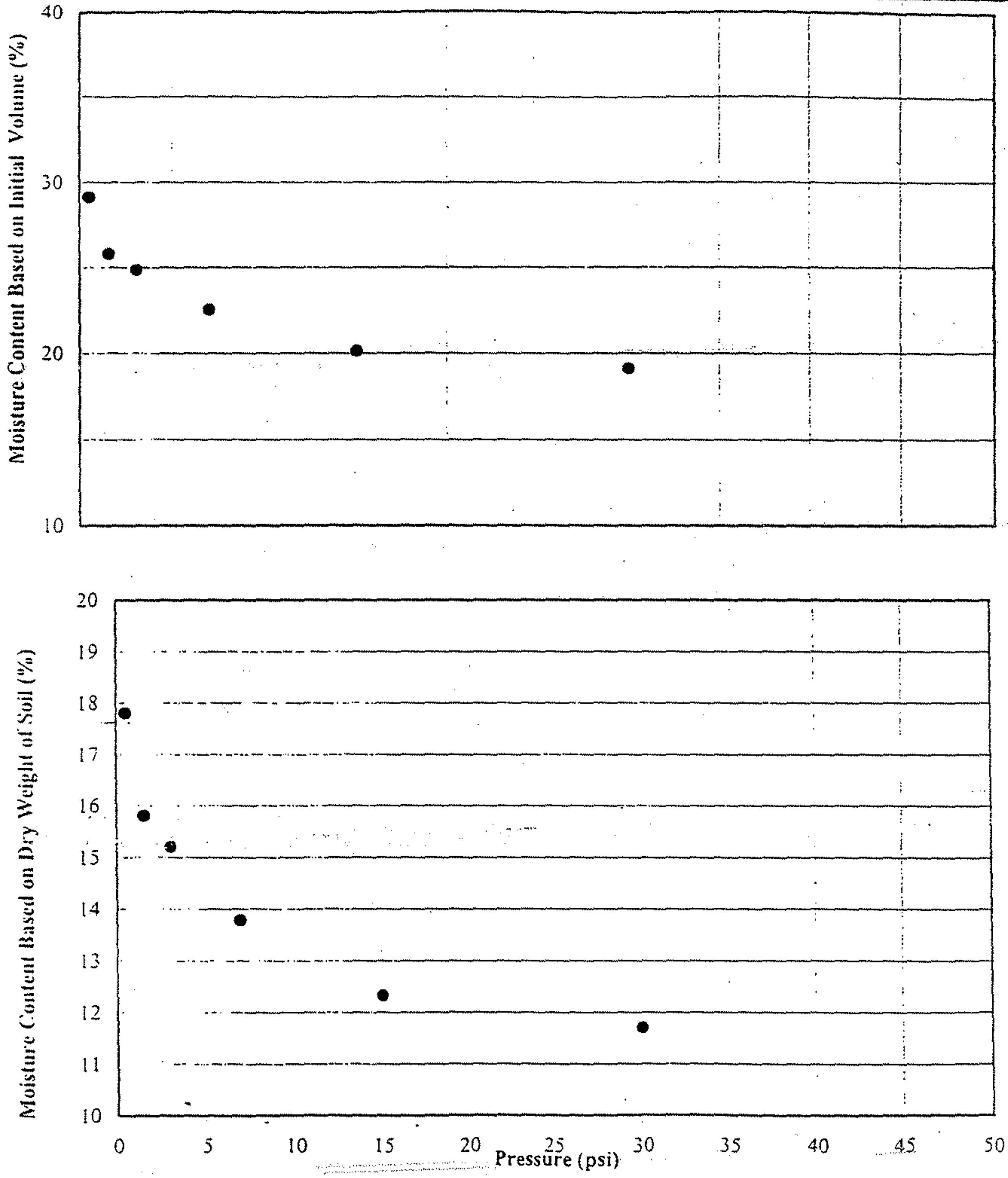
FIGURE 12
Project Name: Lopez Canyon Landfill
Project No.: CE4100

File Name: 98B65.xls

MOISTURE RETENTION TEST

ASTM D 2325



Note(s): Site Sample ID: A - 6
Lab Sample No.: 98B65