CH2M HILL

Environmental Advisor
to the 1996
Olympic Games

May 7, 1996

130786.28.04

Mr. Richard Tedder, P.E.
Solid Waste Section
Mail Station 4565
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

RECEIVED
MAY 08 1996
Solid Waste Section

Dear Mr. Tedder:

Subject: Landfill Sideslope Subbase Design
Request for Alternate Procedure
Citrus County Central Landfill Phase 1A Expansion

Per your request in our telephone conversation on April 9, 1996, this correspondence provides additional information for the alternate landfill sideslope subbase design for the Citrus County Central Landfill Phase 1A Expansion. Your requests for additional information are restated below with our responses.

Request No. 1. *Summarize existing hydraulic conductivity data and provide a figure with the locations of the exploratory test sites.*

Response No. 1. The existing hydraulic conductivity data has been summarized in Table 1. This data is a compilation of investigations performed by Post, Buckley, Schuh & Jernigan (PBS&J) in May 1988, and Universal Engineering Testing Company in August 1988. As shown in Table 1, hydraulic conductivity test results from these investigations vary from 1.77×10^{-4} cm/sec to 1.33×10^{-7} cm/sec. The hydraulic conductivity values tend to decrease as the depth below the ground surface increases. Also included within Table 1 are the results from the recent investigation performed by CH2M HILL and Ardaman & Associates. The results from this investigation of are discussed in Response No. 2.

The locations of the exploratory test locations from the PBS&J, Universal, and CH2M HILL/Ardaman investigations are shown in Figure 1.

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Table 1
Summary of Hydraulic Conductivity Test Results

Soil Boring or Test Pit Designation	Elevation (feet, NGVD)	Sample Depth (feet)	Hydraulic Conductivity (cm/sec)	Type of Test
1[a]	117.5	63.5 to 65	2.16×10^{-6}	Falling Head
1[a]	117.5	128.5 to 130	5.08×10^{-5}	Constant Head
2[a]	133.1	18.5 to 20	1.98×10^{-4}	Triaxial
2[a]	133.1	58.5 to 60	1.14×10^{-6}	Falling Head
2[a]	133.1	73.5 to 75	4.18×10^{-5}	Falling Head
3[a]	119.5	45	5.0×10^{-7}	Falling Head
3[a]	119.5	80	6.5×10^{-6}	Constant Head
B-3[b]	Unknown	5	1.77×10^{-4}	Falling Head
B-3[b]	Unknown	20	4.36×10^{-6}	Falling Head
B-3[b]	Unknown	25	2.04×10^{-5}	Falling Head
B-4[b]	Unknown	22	2.05×10^{-6}	Falling Head
B-4[b]	Unknown	27	1.33×10^{-7}	Constant Head
B-7[b]	Unknown	5	2.41×10^{-4}	Falling Head
TP-2[c]	115	5 to 6	4.1×10^{-4}	Triaxial
TP-2[c]	115	7 to 8	3.2×10^{-4}	Triaxial

[a]Tests Performed by Post, Buckley, Schuh & Jernigan, May 1988
[b]Tests Performed by Universal Engineering Testing Company, August 1988
[c]Tests Performed by Ardaman & Associates, April 1996

Request No. 2. *Obtain additional information on the hydraulic conductivity of the on-site soils on the east and west side of the Phase 1A Expansion.*

Response No. 2. On April 23, 1996, Citrus County personnel excavated two test pits (TP-1 and TP-2) to a depth of 7 feet below ground surface. The test pits were excavated on the east and west sides of the proposed Phase 1A Expansion approximately 35 feet north of the existing landfill (see Figure 1). CH2M HILL personnel visually classified the soil within the test pits in accordance with the American Society for Testing Materials (ASTM) D 2488. Relatively undisturbed soil samples of selected materials were obtained with a 3-inch-diameter thin-walled tube sampler. Test pit logs (and a legend of the terms used on the logs) are provided in Attachment A.

Representative soil samples obtained from the test pits were analyzed in the geotechnical laboratory by Ardaman & Associates of Orlando, Florida. The soil samples were tested for vertical hydraulic conductivity in accordance with ASTM D 5084. Laboratory data results as reported by Ardaman are provided in Attachment B and summarized in Table 1. Soil samples obtained from test pit TP-1 were not analyzed since the soils within the test pits appeared to be fill from roadway and utility work and are not representative of natural subgrade soils. Due to the limited clearance on the west side of the Phase 1A Expansion, field personnel could not obtain soil samples closer to the landfill outside of the fill area.

As shown in Table 1, the results from the vertical hydraulic conductivity tests performed in a triaxial cell indicate that the on-site soils near the surface (5 to 8 feet below ground surface) will have permeabilities of approximately 4.1×10^{-4} cm/sec to 3.2×10^{-4} cm/sec. These permeability values represent an upper case limit since typically the permeability of the on-site soils tend to decrease as the depth below ground surface increases (see Table 1).

The calculations in Attachments C and D of the correspondence forwarded to your office on February 13, 1996 were re-evaluated to determine the effect of the recent hydraulic conductivity test results. The first set of calculations in Attachment C of this correspondence determines whether the alternate procedure provides an equal degree of protection for the public and the environment (Rule 62-701.310(2)(d), FAC). As determined in Attachment C of the February 13, 1996 correspondence, the expected flow per cross-sectional area through a 6-inch-thick subbase layer in accordance with Rule 62-701.400(3)(c)(1), FAC is 6.6×10^{-7} times the head on the subbase, per second. Based on a conservative thickness equal to 25 feet for the subgrade and the greatest measured hydraulic conductivity value of 4.1×10^{-4} cm/sec, the expected flow per cross-sectional area through the in place subgrade alternative is 5.38×10^{-7} times the head on the subbase, per second. Therefore, potential flow through the alternative based on the most recent hydraulic conductivity test results is expected to be less than 82 percent of the flow through a 6-inch-thick lining subbase. The proposed alternative provides a greater degree of protection to the public and the environment.

The second set of calculations in Attachment C of this correspondence demonstrates the effectiveness of the proposed alternative procedure (Rule 62-701.310(2)(e), FAC). Using the head, the size and frequency of potential lining defects, and the properties of the underlying soils as determined in Attachment D of the February 13, 1996 correspondence; the maximum expected flow through the secondary lining can be estimated. As shown in Table 1, the hydraulic conductivity of soils at the site which will underlie the secondary lining as the proposed alternative ranges from 1.3×10^{-7} to 4.1×10^{-4} cm/sec. The frequency of different ranges in hydraulic conductivity from this data was used to calculate a total maximum flow of approximately 1.4×10^{-6} gal/day through the proposed Phase 1A Expansion sideslopes. This flow is negligible, which demonstrates the effectiveness of the proposed alternative procedure for the lining subbase.

For your review, we are submitting two copies of this correspondence. We appreciate your prompt attention to this correspondence. The approval of the alternate design procedure is the last outstanding item regarding the approval of the construction permit for the Citrus County Central Landfill Phase 1A Expansion. If you have any questions concerning the additional information for the alternate landfill sideslope subbase design for the Phase 1A Expansion, do not hesitate to contact me. Please respond directly to CH2M HILL, Citrus County, and the FDEP Tampa district regarding your decision on the alternate procedure for the landfill sideslope subbase design.

Sincerely,

CH2M HILL

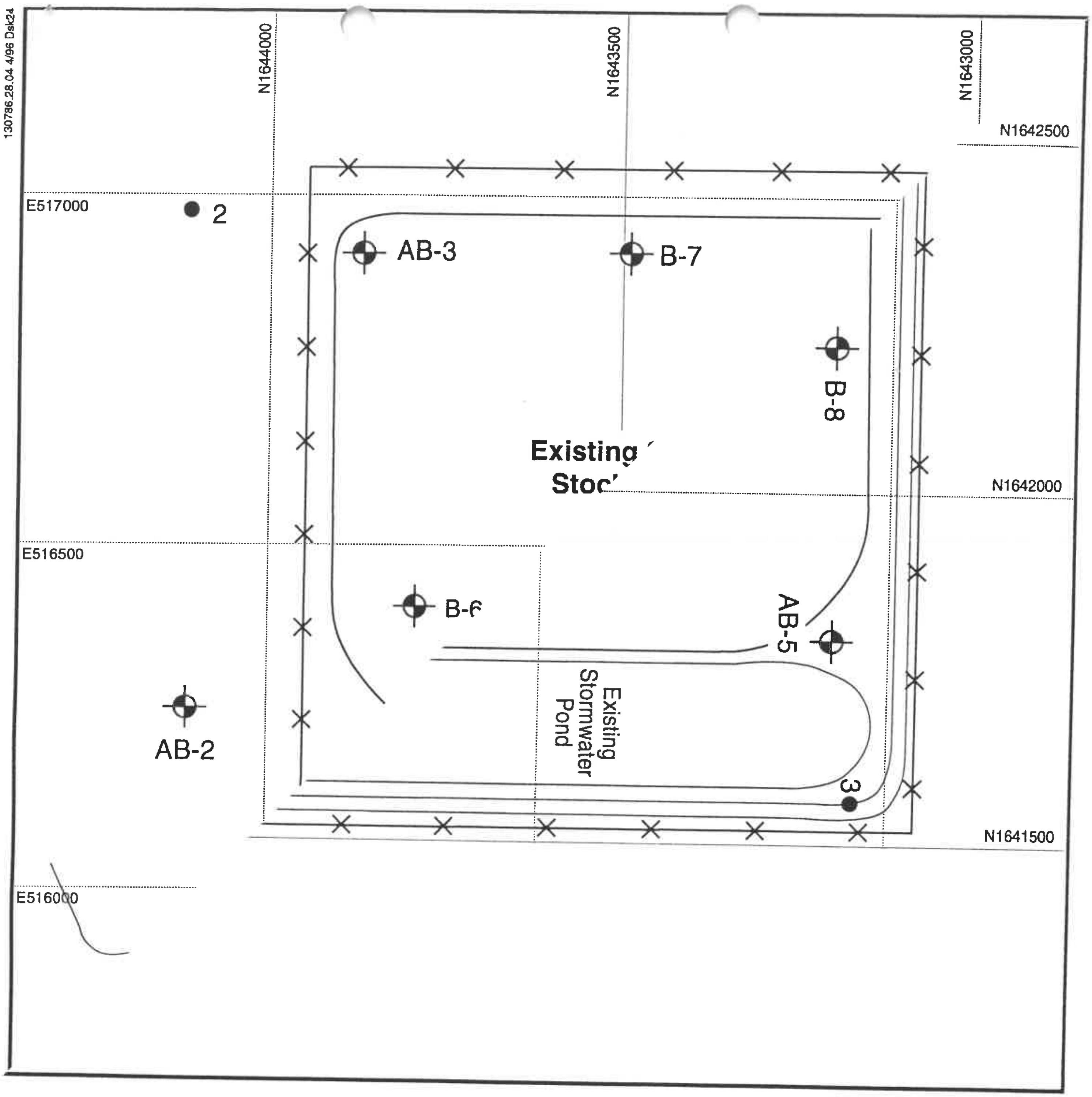
Tawny H. Olore

Tawny H. Olore, P.E.
Project Engineer

TPA/LET019.doc

c: Kim Ford, P.E. - FDEP Tampa District
Susan Metcalfe, P.G. - Citrus County
John Wood, P.E. - CH2M HILL
Gary Panozzo, P.E. - CH2M HILL
Steve Tsangaris, P.E. - CH2M HILL

Tawny H. Olore
5/7/96
No. 50059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N1644000
N1643500
N1643000
N1642500
E517000
2
AB-3
B-7
B-8
Existing
Stoc'
N1642000
E516500
B-6
AB-5
Existing
Stormwater
Pond
AB-2
3
N1641500
E516000

Attachment A

TEST PIT LOG LEGEND

SAMPLE TYPE:

ST	—	Thin–Walled Tube Sample (ASTM D1587)
S	—	Split Barrel (ASTM D1586 unless otherwise noted)
NQ	—	Core Barrel Run
J	—	Jar Sample
B	—	Bag Sample

LABORATORY AND FIELD TESTS:

PP	—	Pocket Penetrometer Reading
w	—	Natural Moisture Content Laboratory Test Result
LL	—	Liquid Limit Laboratory Test Result
PL	—	Plastic Limit Laboratory Test Result
GS	—	Grain Size Distribution Laboratory Test
γ_d	—	Dry Unit Weight Laboratory Test Result
q_u	—	Unconfined Compression Test Result
k	—	Permeability Laboratory Test Result
Ø	—	Triaxial Laboratory Test Result

NOTES:

1. The test pit logs and related information depict subsurface conditions only at the specific locations and dates indicated. Soil conditions and water levels at other locations may differ from conditions occurring at these test pit locations. Also, the passage of time may result in a change in the conditions at these locations.

2. Test pits were logged in the field by a CH2M HILL engineer or hydrogeologist. Samples were examined and visually classified in approximate accordance with the ASTM D 2488.

CH2M HILL	PROJECT NUMBER 130786.28.04	TEST PIT NUMBER TP-1 SHEET 1 OF 1

TEST PIT LOG

PROJECT : Citrus County Central Landfill Phase 1A Expansion LOCATION : See Figure 1
ELEVATION : Approx. 115 ft, NGVD DRILLING CONTRACTOR : Citrus County Personnel
DRILLING METHOD AND EQUIPMENT USED : Backhoe
WATER LEVELS : Not Encountered START : 4/23/96 END : 4/23/96 LOGGER : T. Olore

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	CORE DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION.
				POORLY GRADED SAND (SP), fine to medium, light brown, mottled with CLAYEY SAND (SC), fine to medium, orange, moist, fill	
1					
2					
3					
4					
5	5.0				
		1.0	ST-1	POORLY GRADED SAND (SP), fine to medium, light brown, mottled with CLAYEY SAND (SC), fine to medium, orange, moist, fill	
6	6.0				Root matter at 6.0 feet
7	7.0				
		1.0	ST-2	POORLY GRADED SAND (SP), fine to medium, dark brown, moist, fill	
8	8.0				
				End of Test Pit at 8.0 feet	

PROJECT NUMBER	TEST PIT NUMBER	
130786.28.04	TP-2	SHEET 1 OF 1

TEST PIT LOG

PROJECT : Citrus County Central Landfill Phase 1A Expansion LOCATION : See Figure 1
ELEVATION : Approx. 115 ft, NGVD DRILLING CONTRACTOR : Citrus County Personnel
DRILLING METHOD AND EQUIPMENT USED : Backhoe
WATER LEVELS : Not Encountered START : 4/23/96 END : 4/23/96 LOGGER : T. Olore

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	CORE DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION.
0–5	5.0			CLAYEY SAND (SC), fine to medium, orange and light brown, moist	
5–6	6.0	1.0	ST-1	CLAYEY SAND (SC), fine to medium, orange and light brown, moist	k = 4.1 x 10^{-4} cm/sec GS(17 percent passing no. 200 sieve) γ_d = 105.9 lb/ft^3 w = 10.2 percent
6–7	7.0				
7–8	8.0	1.0	ST-2	CLAYEY SAND (SC), fine to medium, orange and light brown, moist	k = 3.2 x 10^{-4} cm/sec GS(17 percent passing no. 200 sieve) γ_d = 107.6 lb/ft^3 w = 13.1 percent
				End of Test Pit at 8.0 feet	

Attachment B

Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

May 6, 1996
File Number 96-068

RECEIVED
1996
CH2M HILL
TAMPA, FLORIDA

CH2M Hill
P.O. Box 21647
Tampa, FL 33622

Attention: Ms. Tawny Olore

Subject: Laboratory Permeability Test Results, Citrus County Central Landfill

Ms. Olore:

As requested, permeability tests have been completed on two Shelby tube soil samples obtained by Ardaman & Associates, Inc. under your direction at the Citrus County Central Landfill on April 24, 1996. The samples were labelled TP-2/Sample 1 and TP-2/Sample 2. The permeability tests were performed in general accordance with ASTM Standard D 5084 "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible-Wall Permeameter" using the falling-head method (Method C).

The soil samples were extruded from the Shelby tubes, and a representative portion of each sample was selected for testing. Each permeability test specimen was maintained at the Shelby tube diameter, trimmed to a length of 5 to 6 cm, and mounted in a flexible-wall type permeameter. The specimens were confined using an average isotropic effective consolidation stress of 10 lb/in^2 and permeated with deaired water under a backpressure of 95 lb/in^2. The head water and tailwater levels were monitored with time, and the coefficient of permeability was calculated for each recorded set of readings. The tests were continued until steady-state flow conditions were obtained, as evidenced by an outflow/inflow ratio between 0.75 and 1.25, and until relatively stable values of the coefficient of permeability were measured. The permeability test results are presented in Table 1. Upon completion of testing, the particle-size distribution of each specimen was determined in general accordance with ASTM Standard D 422. The particle-size distributions are presented in Figure 1.

If you have any questions or require additional testing services, please contact us.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Shawkat Ali

Shawkat Ali, Ph.D.
Geotechnical Engineer

Thomas S. Ingra

Thomas S. Ingra, P.E.
Senior Project Engineer
Florida Registration No. 31987

TSI/ed

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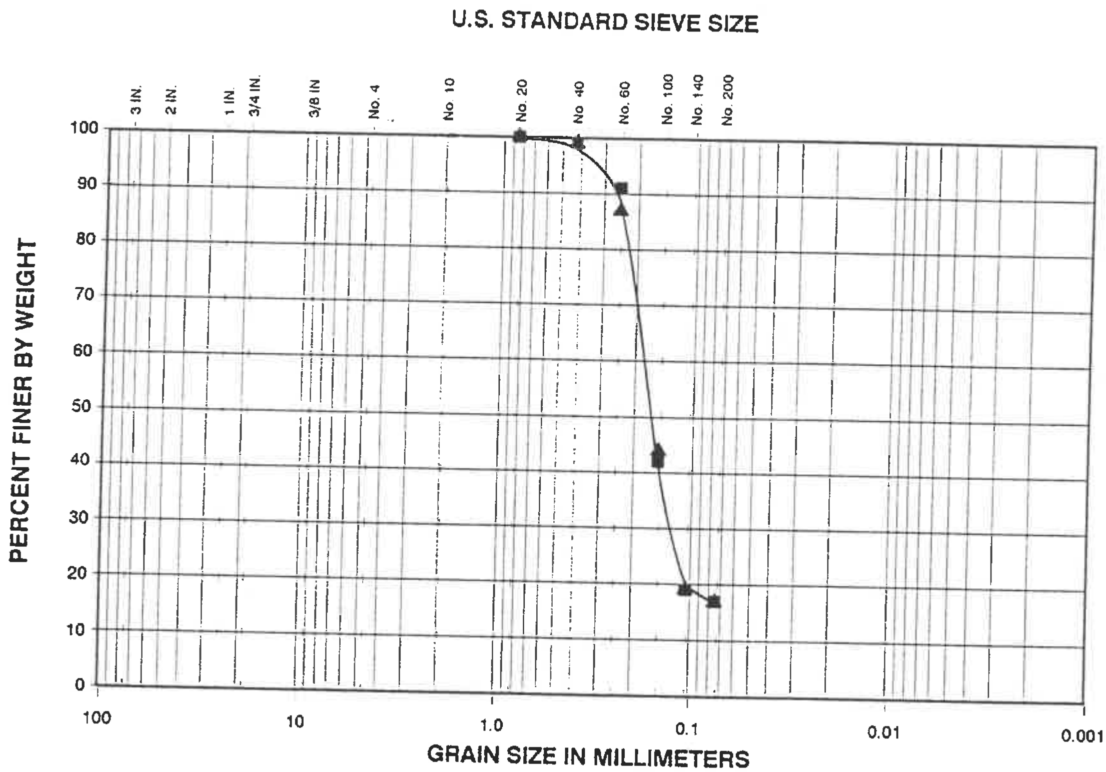
CH2M Hill
File Number 96-068
May 6, 1996

Table 1

PERMEABILITY TEST RESULTS

Sample	Initial Conditions					$\bar{\sigma}_c$ (lb/in^2)	u_b (lb/in^2)	Range of Hydraulic Gradient	Final Conditions				Fines Content (%)	Coefficient of Permeability (cm/sec)
	L (cm)	D (cm)	w_c (%)	γ_d (lb/ft^3)	S (%)				w_c (%)	γ_d (lb/ft^3)	S (%)	$\Delta V/V_o$ (%)		
1	4.95	7.30	10.2	105.9	48	10	95	1.0-5.4	19.2	108.0	95	-2.0	17	4.1×10^{-4}
2	5.77	7.23	13.1	107.6	64	10	95	1.5-4.8	18.6	108.0	92	-0.3	17	3.2×10^{-4}

Where: L = Length; D = Diameter; w_c = Moisture content; γ_d = Dry density; $\bar{\sigma}_c$ = Average isotropic effective confining stress; u_b = Backpressure; S = Calculated degree of saturation using an assumed specific gravity of 2.66; and $\Delta V/V_o$ = Volume change (- denotes consolidation).



GRAVEL		SAND			SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE	SYMBOL	DESCRIPTION
TP-2 Sample-1	■	Orange silty fine sand (SM)
TP-2 Sample-2	▲	Orange-brown silty fine sand (SM)

PARTICLE-SIZE ANALYSES

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

CH2M HILL
CITRUS COUNTY CENTRAL LANDFILL

DRAWN BY: SA	CHECKED BY: SA	DATE: 05-06-96
FILE NO.: 96-068	APPROVED BY: Thomas D. [signature]	FIGURE: 1

Attachment C

Determine flow in place subgrade soil alternate ?

Using Darcys Law

for Darcian Flow!

$Q_{ALT} = KIA$

From calculations in Attachment C of 2/13/96 correspondence.

I = hydraulic gradient $\Delta H / \Delta L$?

= $\frac{\text{change in head } (\Delta H)}{L = (\text{ranges from 25 to 113}')}$

Assume $L = 25'$ ← ΔL? (conservative)

K = ranges from 1.3×10^{-7} cm/sec to 4.1×10^{-4} cm/sec

assume 4.1×10^{-4} cm/sec (conservative)

$$Q_{ALT} = \left(4.1 \times 10^{-4} \text{ cm/sec}\right)\left(\frac{\Delta H}{25 \cdot 12 \cdot 2.54}\right) A$$

$$Q_{ALT} = \frac{5.38 \times 10^{-7} \; \Delta H \cdot A}{\text{sec}}$$

From Attachment D of the February 13, 1996 correspondence, rate of leakage through a composite liner

$$Q = 0.21\, a^{.1}\, h^{.9}\, k_s^{.74}$$ for good contact

where Q = rate of leakage through one hole in the geomembrane component of a composite liner
a = head of leachate on top of geomembrane (m^2) AREA - Not Volume
k_s = hydraulic conductivity of the low-permeability soil underlying the geomembrane

From Attachment D, 2/13/96 correspondence
$a = 3 \times 10^{-6}\ m^2$
$h = 1.25 \times 10^{-8}\ m$

- To determine Q through a composite liner, the frequency of permeability values were determined based on the number of permeability tests conducted on onsite soils and the results of the tests.

For each value, Q (m^3/s/acre) was determined using the above equation. The Q was then multiplied by the percent frequency, and the total acreage of the 2.5:1 side slope.

The Q's for each of the permeability values were added to determine the total amount of leakage through the composite liner system. The attached spreadsheet presents the results of the analysis.

As shown on the spreadsheet, the amount of leakage through the composite liner is approximately 1.42×10^{-6} gal/day which is negligible.

Rate of Leakage Through Secondary Liner

k_s (m/sec)	Data Range (cm/sec)	Number of Tests	Percent Frequency	a (m^2)	h (m)	Q (m^3/sec/acre)	acres	Q (m^3/sec)	Q (gal/day)
1E-06	5E-5 to 4E-4	6	40%	3.00E-06	1.25E-08	1.65E-13	0.34	5.54E-14	1.27E-06
1E-07	5E-6 to 4E-5	3	20%	3.00E-06	1.25E-08	3.00E-14	0.17	5.04E-15	1.15E-07
1E-08	5E-7 to 4E-6	5	33%	3.00E-06	1.25E-08	5.46E-15	0.28	1.53E-15	3.49E-08
1E-09	5E-8 to 4E-7	1	7%	3.00E-06	1.25E-08	9.93E-16	0.06	5.56E-17	1.27E-09
Total		15	100%				0.84	6.20E-14	1.42E-06