Appendix B
Engineering Narrative

Continental Steel Superfund Site – Evaluation of Lagoon Area Consolidation

PREPARED FOR: Project File

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DATE: December 6, 2005

Consolidation tests were performed on two sludge samples collected from Lagoon No. 6 in OU2 of the Continental Steel Superfund Site (CSSS) in September 2005. This memorandum presents a summary of the consolidation test results, and estimates of subsurface consolidation settlement under future construction loads.

The magnitude and rate of primary consolidation of the sludge were considered for two loading scenarios:

- A dewatering pad constructed in Lagoon No. 6, plus a single eight-foot thick layer of geotextile tubes filled with dredge slurry.
- Cover fill over the OU2 lagoons. The fill will be graded to provide positive drainage from a high point in the northeast corner of OU2. Fill height over the existing sludge will be variable, ranging from less than a foot to over 10 feet.

The consolidation test results are presented in Section 1 of this memorandum. Estimated consolidation settlement under dewatering pad loads is presented in Section 2. Estimated consolidation settlement of the cover fill is presented in Section 3.

1.0 Consolidation Test Results

Consolidation tests were performed on two sludge samples within Lagoon No. 6. The first sample was collected from Borehole B-2 (near the proposed dewatering pad sump) from 6 to 6.5 feet bgs, and the second was collected from Borehole B- 3 (northwestern portion of the dewatering pad area) from 2.3 to 3.5 feet bgs. Approximate borehole locations are shown on Figure 1. Borehole logs are presented in Attachment A. The consolidation test laboratory results are presented in Attachment B.

The laboratory test results were interpreted to estimate consolidation engineering parameters, including void ratio (e), compression index (Cc), coefficient of compression (Cce), and coefficient of consolidation (Cv). The interpretations of these parameters are shown on a copy of the results in Attachment B. Based on these interpretations, the two samples exhibit similar consolidation properties, as follows:

- Initial void ratio (e) = 1.58 to 1.65
- Compression index (Cc) = 0.52 to 0.77 [this is the decrease in void ratio per log-cycle of applied pressure]

- Coefficient of Compression (Cce): 0.158 to 0.228 [this is the compression strain per log-cycle of applied pressure]
- Coefficient of Consolidation (Cv): 0.00004 to 0.00018, average of 0.00006 cm^2/sec [this is a measure of the time-rate of consolidation]
- Sludge is normally consolidated

2.0 Consolidation Under Dewatering Pad Loads

The magnitude and time-rate of consolidation settlement was estimated using typical dewatering pad loads and the typical subsurface conditions in the dewatering pad area. Dewatering pad loads were modeled as three feet of drainage stone (at 135 pcf) and eight feet of dredged sediment in geotextile bags (at 80 pcf), for a total applied vertical load of 1045 psf across the dewatering pad area. A typical soil profile consisting of eight feet of sludge over silty sand (alluvium) was considered to represent the subsurface conditions below the dewatering pad.

2.1 Magnitude of Primary Consolidation

The magnitude of primary consolidation under dewatering pad loads was calculated using three separate methods. Since the sludge is not a native soil (though it exhibits soil-like properties), a variety of methods were used in an attempt to envelop the potential sludge consolidation behavior.

Method 1: Use of Cce: The subsurface was modeled as discrete vertical soil layers. The existing overburden pressure and the pressure under expected dewatering pad loads were both calculated for each soil layer. The Cce interpreted from the "strain-log(pressure)" charts was used to estimate primary consolidation for each layer.

Method 2: Direct measurement from the strain-log(pressure) charts: The subsurface was modeled as for Method 1. The change in strain for the expected change in effective stress for each layer was read directly from the "strain-log(pressure)" test result charts. Results were calculated separately using the two sets of consolidation test results.

Method 3: Use of Cc: The subsurface was modeled as for Method 1. The Cc interpreted from the "void ratio-log(pressure)" charts was used to estimate consolidation for each layer.

The evaluation results are presented in Attachment C, Table C-1. The calculated magnitude of primary consolidation under dewatering pad loads ranged from 0.5 to 1.4 feet (6 to 17 inches) among the three methods. The highest consolidation was calculated using Method 3. While Method 3 is a common approach for evaluating consolidation for soils, direct reading from the strain charts may be the most appropriate approach for these non-native soil sludge materials (Method 2). The strain-log(pressure) charts for both tests indicate a break in the curve at approximately 0.2 to 0.4 tsf. This break is commonly taken as the approximate preconsolidation pressure. These pressures are somewhat higher than the existing overburden pressures at the sludge sample depths - and may indicate that the sludge is slightly overconsolidated. Some overconsolidation may have developed during dry periods in the past, when the groundwater table was lower and therefore in-situ effective stresses higher. If so, the "worst-case" consolidation settlements estimated above

(for normally consolidated conditions) are likely conservative. The effects of potential overconsolidation are incorporated in the results for Method No. 2, which partially explains why this method resulted in the lowest estimated settlement.

Therefore, it is expected that the ultimate primary consolidation of the sludge materials will range from 6 to 12 inches.

2.2 Time-Rate of Consolidation

The rate of consolidation was calculated using the range in Cv interpreted from the test data. The calculation considered an eight-foot thick layer of sludge, and double-drainage (i.e., free drainage at the ground surface and to the underlying silty sand).

Results are shown in Table 2. The results indicate that only a portion of the ultimate sludge primary consolidation will develop during the design life of the dewatering pad. It is not expected that the dewatering pad will be staged with filled geotextile tubes for more than one year. The estimate of consolidation that will develop over one year varies with the range of Cv and the range of calculated ultimate primary consolidation (H). Considering the low end of the range for rate of settlement (Cv) and for ultimate H, only one inch of primary consolidation would develop within one year. However, using the most conservative values for Cv and H, up to 10 inches of consolidation may develop in one year.

Based on these results, it is expected that a few to several inches of sludge consolidation will develop during one year of loading with dredged sediments. This amount of settlement is considered acceptable for the flexible dewatering pad design components. These results are consistent with the assumptions listed in the engineering narrative for the dewatering pad design. Since most of the primary consolidation will not develop during the operation life of the dewatering pad (i.e., one year), secondary consolidation has not been considered in this evaluation.

3.0 Consolidation of Lagoon Area Cover Fill

A permeable soil cover will be constructed over the OU2 lagoons. The cover will be constructed with a minimum 0.25 percent slope to promote drainage and prevent ponding. The cover elevation will drop to the west and south, to an elevation of 792 feet above mean sea level (MSL) at the bank of Wildcat Creek. The high point of the cover will have an elevation of approximately 795 feet above MSL at the northeast corner of OU2.

3.1 Estimate of Primary Consolidation

The water level in the ponds of OU2 is approximately 788 to 790 feet above MSL, based on survey data from the mid-1990s. The top of existing sludge in the ponds varies from a few feet above the water level, to several feet below the water level. Based on boreholes advanced by ABB in 1993, the lowest top of sludge elevation was 782.4 feet bgs (at Borehole SB-10 in Lagoon No. 2). Typically, the lowest top-of-sludge elevations also correspond to the lowest thickness of sludge, but not always (for example, at SB-08 in Lagoon No. 2, top of sludge was relatively low at 783.6 feet above MSL, but eight feet of sludge were present).

Therefore, to construct the cap, a variable thickness of soil cover will need to be constructed over the existing lagoon sludges, which themselves vary in thickness. At the existing berm locations, the ground elevation is relatively high, and no compressible sludge is typically present. For these reasons, differential settlement is expected across the soil cover.

No consolidation test data is available for samples outside of Lagoon No. 6. However, if the presently submerged sludges are assumed to be normally consolidated, the test data from Lagoon No. 6 is considered representative of the consolidation properties of sludge in the other lagoons.

As an estimate of the differential settlement, consolidation settlement has been considered for two bounding cases:

Case 1 - Greatest Settlement: 10 feet of fill over 8 feet of submerged normally consolidated sludge. This represents the expected maximum settlement case - at Borehole SB-08 in Lagoon No. 2. Approximately 6 feet of the fill will be submerged, and 4 feet will be above the water table, resulting in an effective stress surcharge of approximately 925 psf (for fill unit weight of 130 pcf). Since the existing sludge is submerged at this location (as it is in most of the lagoon areas), the sludge is likely normally consolidated. Therefore, Method 3, the most conservative method described above, was used to estimate settlement. With these assumptions, **up to 20 inches of ultimate primary consolidation settlement** is estimated for this condition.

Case 2 - Least Settlement: This corresponds to regrading of the existing berms. **No consolidation settlement** is expected at these locations under cover loads.

Differential settlement is therefore likely to develop across the cover area. Given the shallow grade of the cover (0.25 percent), areas of ponding and grade reversal will likely develop in the cover surface, unless measures are taken to mitigate their development.

3.2 Recommendations to Mitigate Consolidation Settlement

Following are some recommended methods to mitigate the differential settlement, and minimize future ponding of the final cover surface:

Option 1 - Rough grade the cover soil: Allow the rough graded surface to sit for an extended period of time before final grading. For example, using the "average" rate of consolidation properties for the sludge, 80 percent of the consolidation settlement will develop within approximately 5 years of loading. Prepare final grades once the majority of the consolidation is complete.

Option 2 - Preload the lagoon areas with excess soil height. Preloading will expedite the consolidation process. For example, adding an additional 2 feet of soil to the lagoon areas would produce the same consolidation settlement as for Option 1 within 4 years, as opposed to 5 years.

Other options, such as massive dewatering, use of wick drains, and additional preload height, could also be considered. However, these solutions would be potentially costly (i.e., treatment requirements for extracted groundwater, very tight wick drain spacing to be effective, etc). Long-term staging of cover soil (and potentially a marginal preload soil height) are workable options, if sufficient time is available to allow consolidation to develop.

4.0 Limitations

This memorandum has been prepared for specific application to CSSS lagoon cover and dewatering pad development activities in accordance with generally accepted geotechnical engineering practice. No other warranty, expressed or implied, is made. These analyses and recommendations are based on data obtained at specific locations and times. Conditions between the boreholes may vary from those at the boreholes.

Sludge materials encountered at the site have been evaluated using conventional geotechnical exploration and laboratory testing methods. However, the unique consistency of the sludge could result in unexpected long-term settlement performance.

Attachment A

Borehole Logs

CH2MHILL	PROJECT NUMBER 184243.FD.01	BORING NUMBER B-1 SHEET 1 OF 1

SOIL BORING LOG

PROJECT : CSSS Dewatering Pad LOCATION : SE corn. of dewatering pad area, Lagoon No.

ELEVATION : N/A DRILLING CONTRACTOR : None

DRILLING METHOD AND EQUIPMENT USED : Hand auger with 4-inch diameter bucket

WATER LEVELS ~3 feet bgs START : 9/22/2005 END : 9/22/2005 LOGGER : MDG

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL 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. Shear Strength Measurements:
					0 - 1': SLUDGE, black to dark grey, moist, firm	
					1 - 6': SLUDGE, black to dark grey, with intervals of bright blue/teal, soft, wet.	
2						
						Su at 3.0' bgs = 26 kPa (540 psf)
						Su at 3.5' bgs = 20 kPa (410 psf)
4						Collected Shelby Tube Sample B-1 (4-6') at 1210. 13-inches recovery
6						Su at 6.0' bgs = 23 kPa (480 psf)
					6 - 7': SAND (SW), well sorted, grey, wet, loose to medium.	
					End of Boring at 7' bgs	Notes:
8						Undrained shear strength (Su) was measured with a Geonor vane shear
						GIS Coordinates (lat/long): N 40d, 28m, 21.1s W 86d, 09m, 13.8s
10						
12						

CH2MHILL	PROJECT NUMBER 184243.FD.01	BORING NUMBER B-2	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : CSSS Dewatering Pad
LOCATION : Near dewatering pad sump, Lagoon No. 6
ELEVATION : N/A
DRILLING CONTRACTOR : None
DRILLING METHOD AND EQUIPMENT USED : Hand auger with 4-inch diameter bucket
WATER LEVELS ~3 feet bgs
START : 9/22/2005
END : 9/22/2005
LOGGER : MDG

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL 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. Shear Strength Measurements:
					0 - 1': SLUDGE, black to dark grey, moist, firm	
					1 - 6.5': SLUDGE, black to dark grey, with intervals of bright blue/teal, soft, wet.	
2						Collected Shelby Tube Sample B-2 (1.5-3.5') at 1345. 24-inches recovery.
						Su at 2.5' bgs = 27 kPa (560 psf)
4						
6						Collected Shelby Tube Sample B-2 (6.0-8.0') at 1410. 14-inches recovery. Su at 6.5' bgs = 13 kPa (270 psf)
					6.5 - 7.2': SAND (SW) with gravel, wet.	
					End of Boring at 7.2' bgs	Notes:
8						Undrained shear strength (Su) was measured with a Geonor vane shear
						GIS Coordinates (lat/long): N 40d, 28m, 21.2s W 86d, 09m, 14.9s
10						
12						

CH2MHILL	PROJECT NUMBER 184243.FD.01	BORING NUMBER B-3 SHEET 1 OF 1

SOIL BORING LOG

PROJECT : CSSS Dewatering Pad LOCATION : NW corn. of dewatering pad area, Lagoon No.

ELEVATION : N/A DRILLING CONTRACTOR : None

DRILLING METHOD AND EQUIPMENT USED : Hand auger with 4-inch diameter bucket

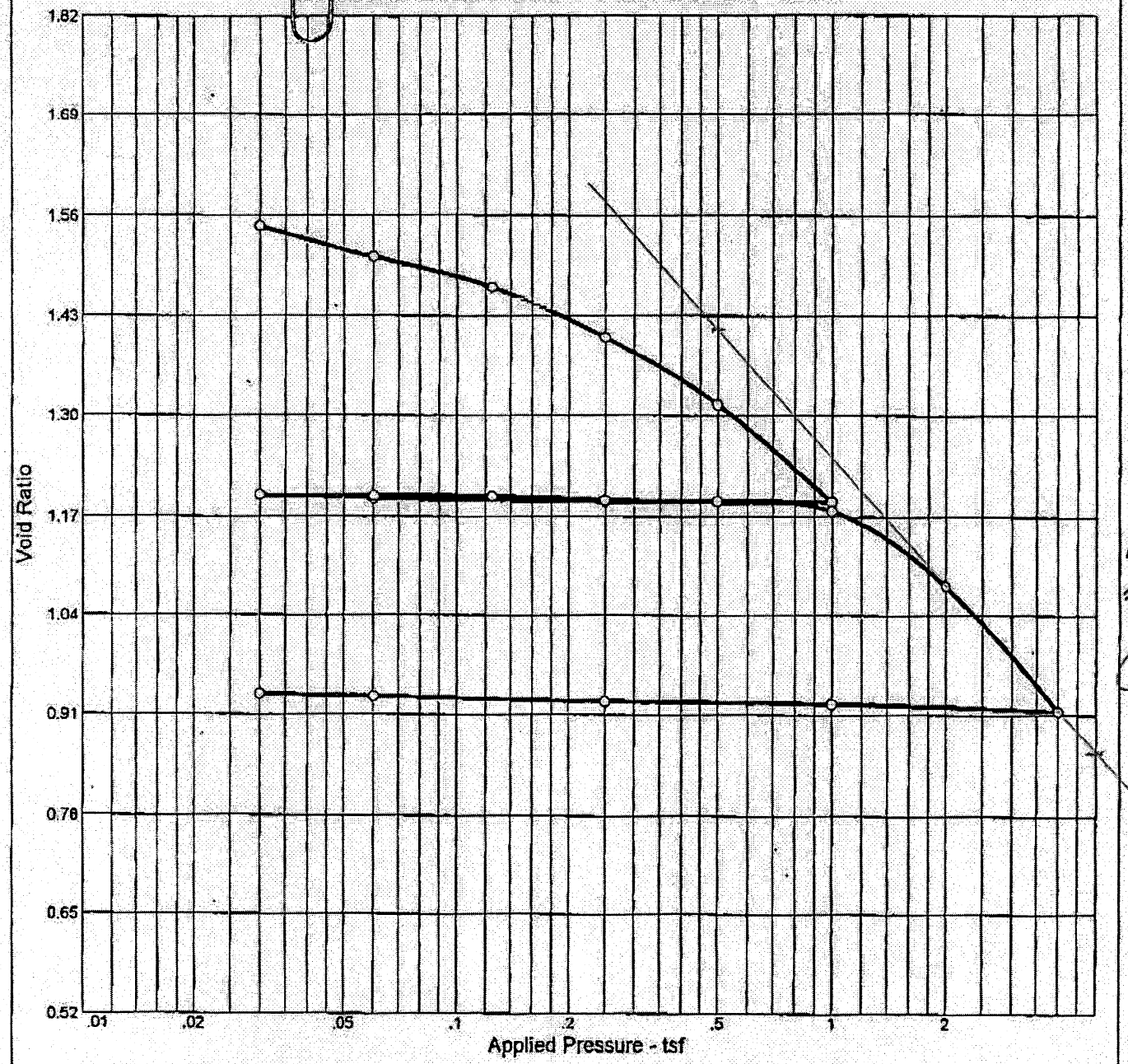
WATER LEVELS ~3 feet bgs START : 9/22/2005 END : 9/22/2005 LOGGER : MDG

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL 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. Shear Strength Measurements:
					0 - 1': SLUDGE, black to dark grey, moist, firm	
					1 - 6': SLUDGE, black to dark grey, with intervals of bright blue/teal, soft, wet.	
2						Su at 2.5' bgs = 25 kPa (520 psf)
						Collected Shelby Tube Sample B-3 (2.3-4.3') at 1435. 12-inches recovery.
4						
6						
					6 - 7': No recovery. Possibly silt or sand, firm.	
					End of Boring at 7.0' bgs	Notes:
8						Undrained shear strength (Su) was measured with a Geonor vane shear
						GIS Coordinates (lat/long): N 40d, 28m, 22.5s W 86d, 09m, 17.0s
10						
12						

Attachment B

Consolidation Test Data

CONSOLIDATION TEST REPORT



$C_c =$

$\Delta e =$

$= 1.41 -$

0.81

$= 0.5$

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
99.9 %	59.5 %	64.3			2.66			1.584

MATERIAL DESCRIPTION

Black unknwown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KanKakee

Source: Boring 2 **Elev./Depth:** 6.0'- 7.5'

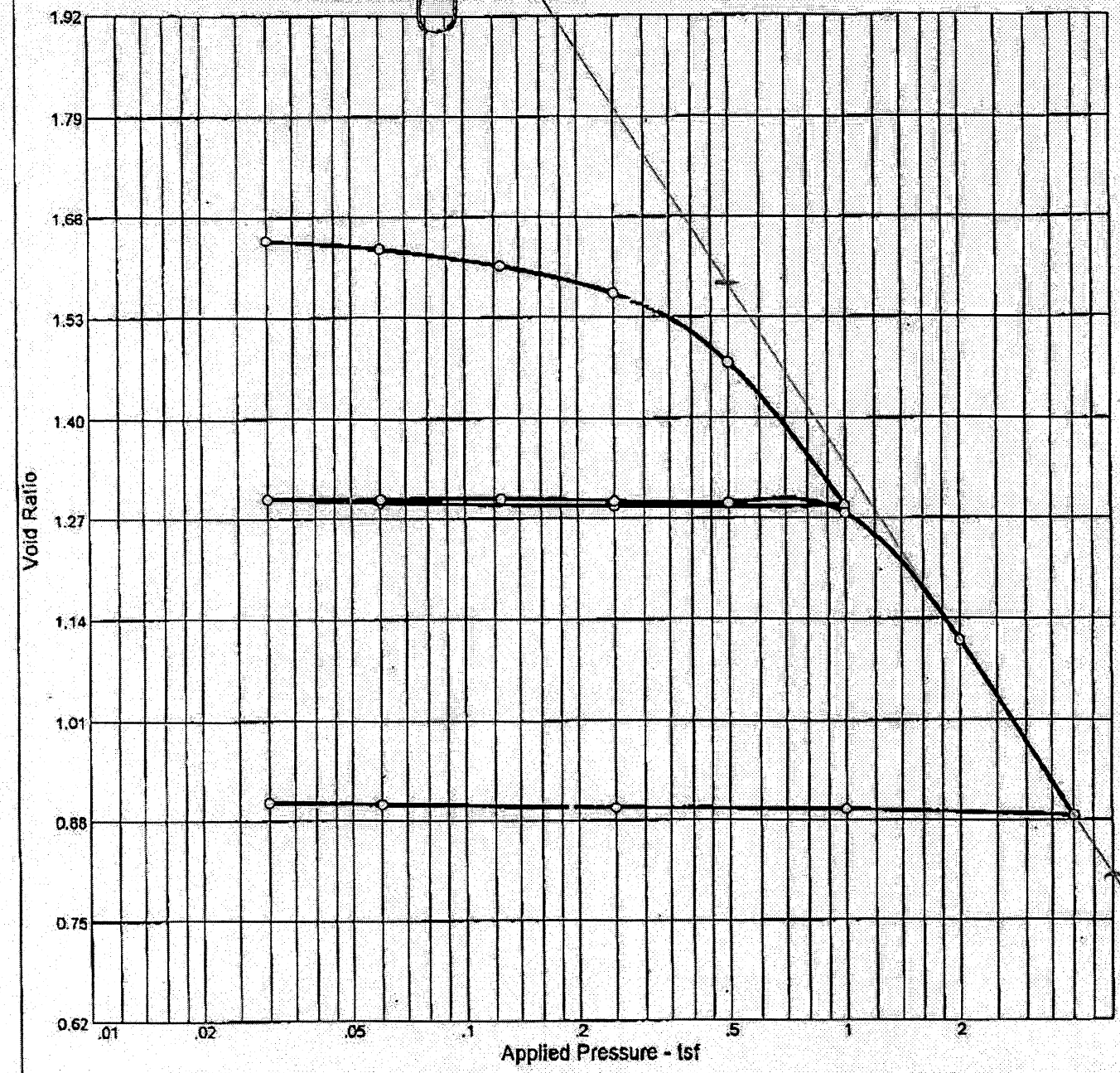
Remarks:

CONSOLIDATION TEST REPORT

TESTING SERVICE CORP

Figure

CONSOLIDATION TEST REPORT



$C_c =$

$\Delta e = 1.58 - 0.81 = 0.77$

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
100.2 %	63.2 %	61.6	50	32	2.610			1.646

MATERIAL DESCRIPTION

Black unknown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KanKakee

Source: Boring 3 **Elev./Depth:** 2.3'- 4.3'

Remarks:

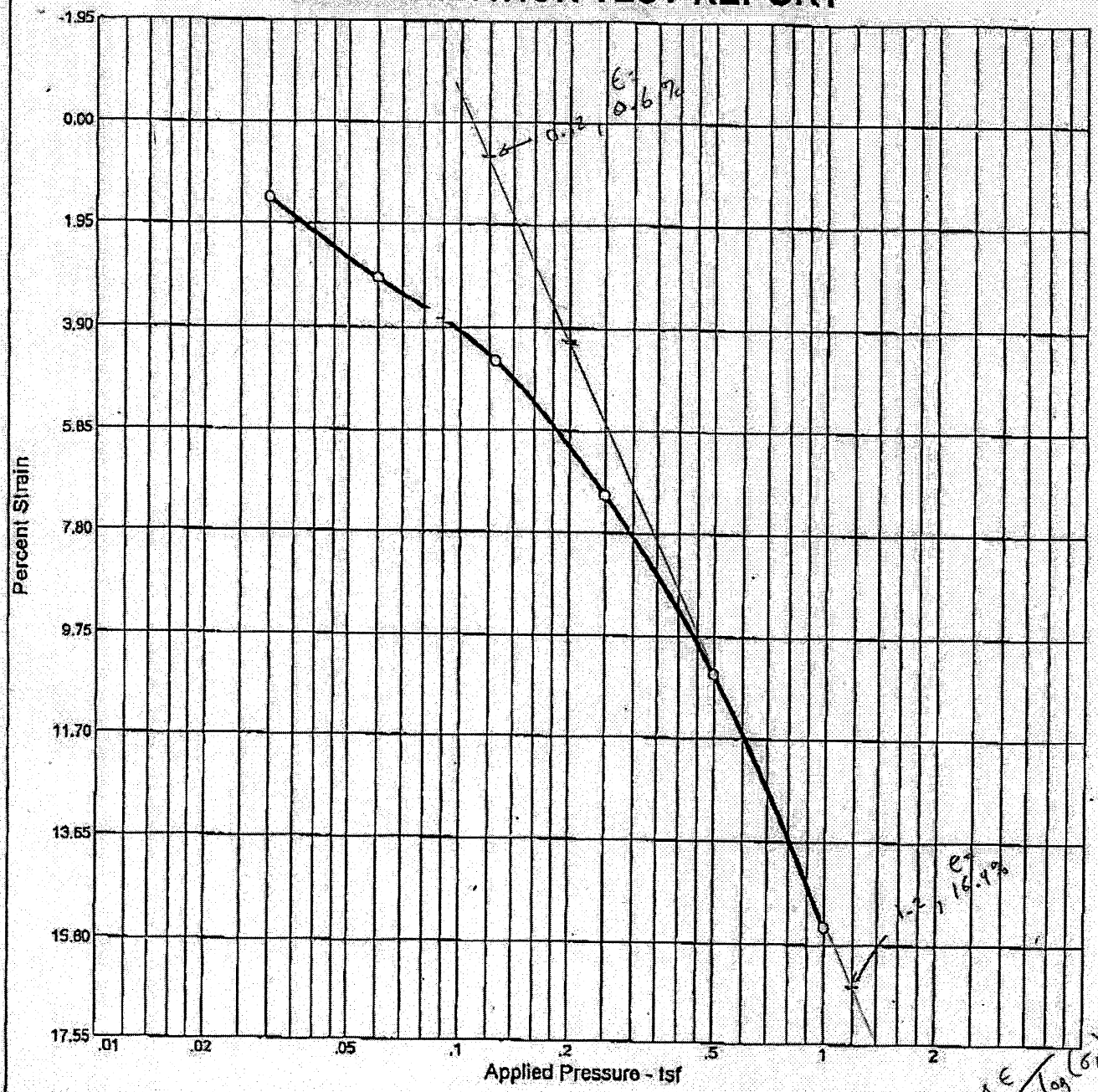
CONSOLIDATION TEST REPORT

TESTING SERVICE CORP

Figure

TEST # 2

CONSOLIDATION TEST REPORT



$\Delta\epsilon / \Delta\log(\sigma_p) = (16.4 - \epsilon) = 15.8'$

$C_{c\epsilon} = 0.158$

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
					2.744			

MATERIAL DESCRIPTION

Black unknwown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KanKakee

Source: Boring 2 **Elev./Depth:** 6.0'- 7.5'

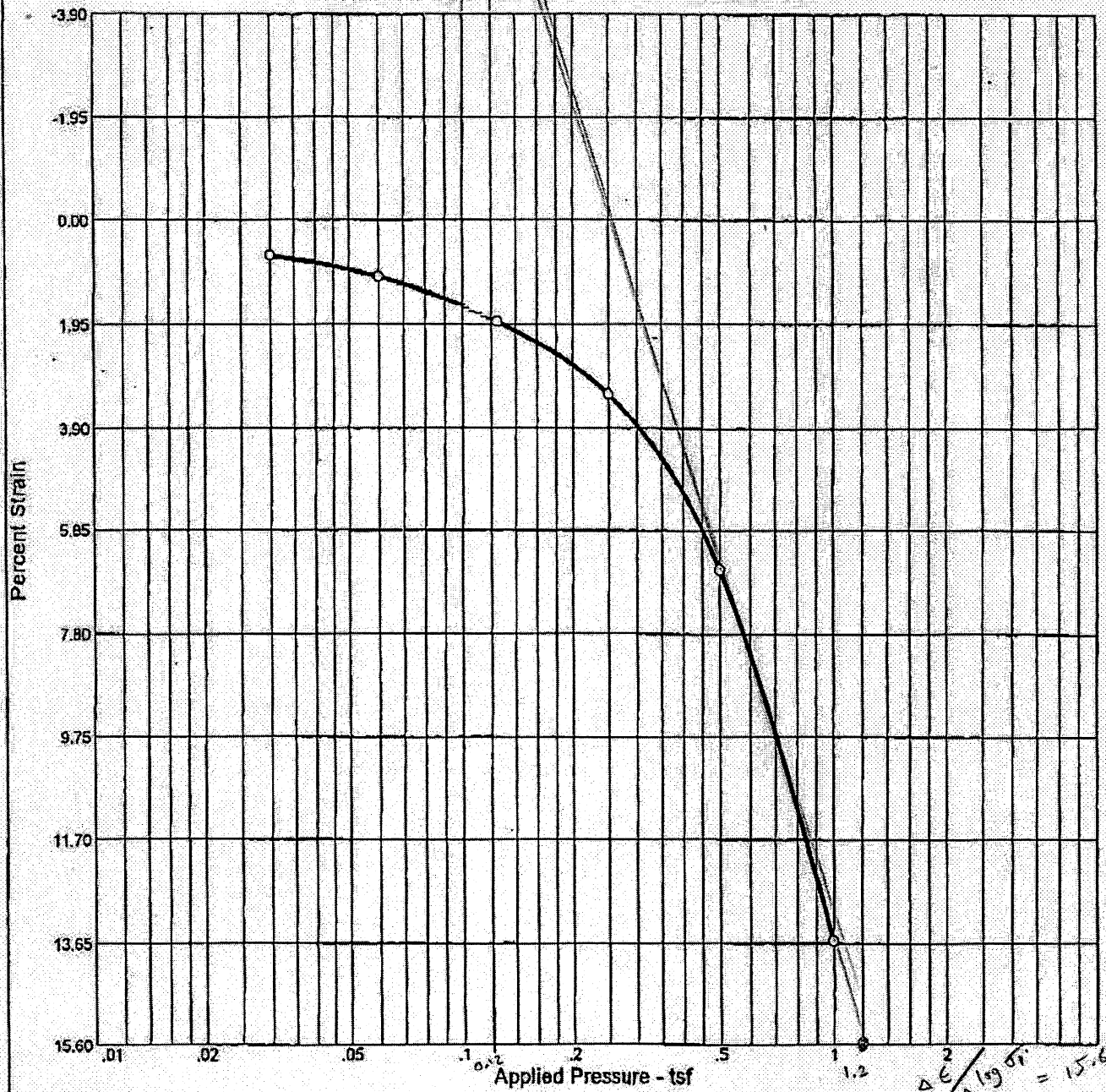
Remarks:

CONSOLIDATION TEST REPORT

TESTING SERVICE CORP

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
					2.610			

MATERIAL DESCRIPTION

Black unknown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KanKakee

Source: Boring 3 **Elev./Depth:** 2.3'- 4.3'

Remarks:

CONSOLIDATION TEST REPORT

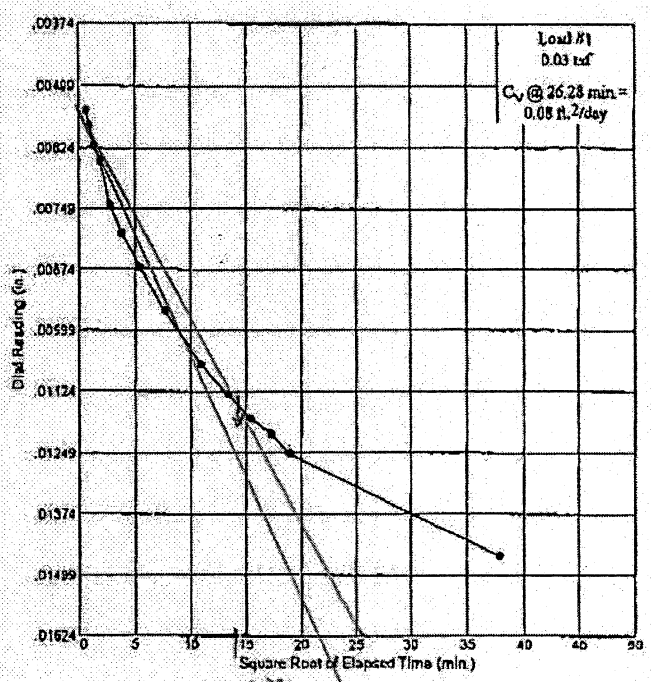
TESTING SERVICE CORP

Figure

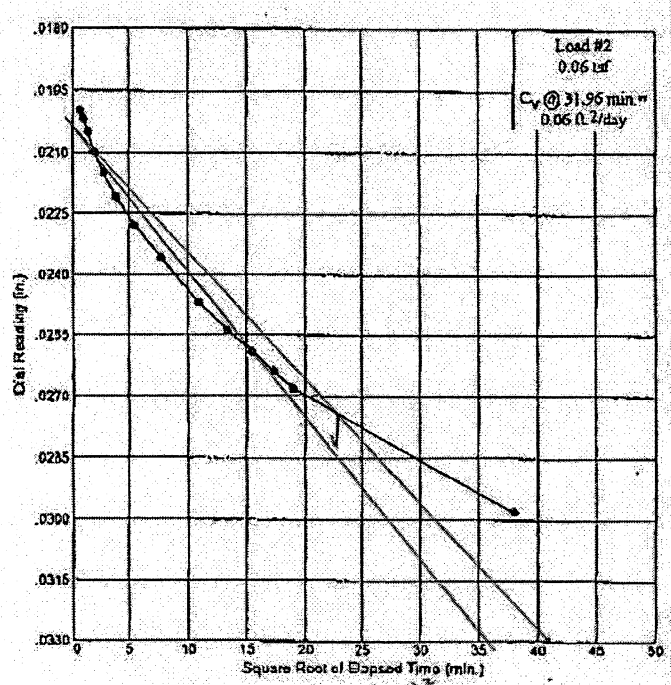
Dial Reading vs. Time

Project No.: L - 64,644
Project: CSSS KanKakee

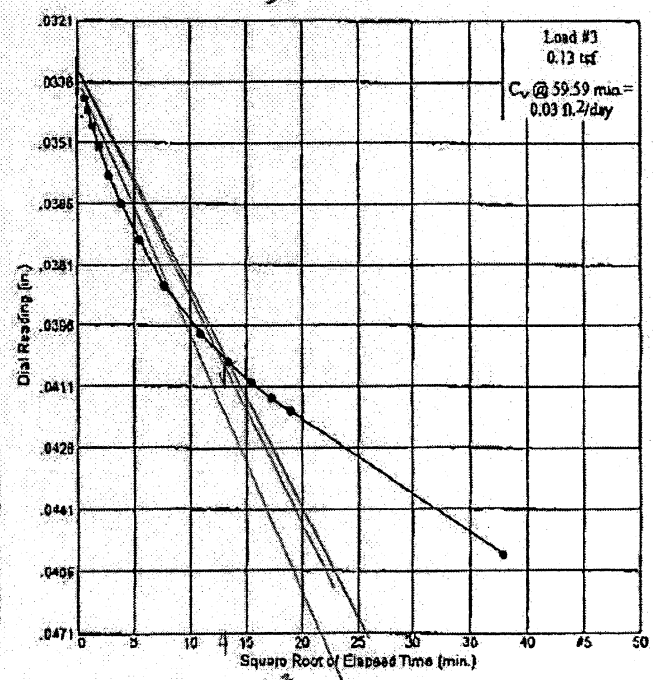
Source: Boring 2 Elev./Depth: 6.0'-7.5'



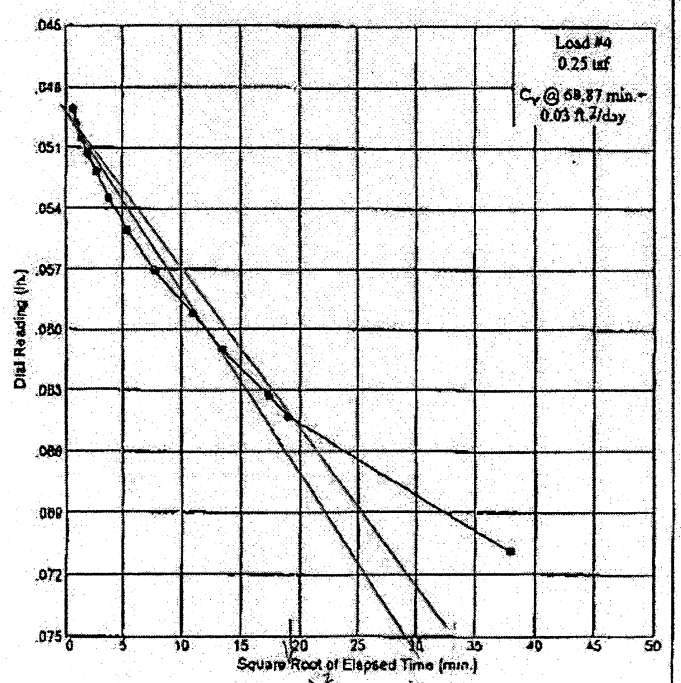
$t_{90} = (14)^2 = 196$ min



$t_{90} = (23)^2 = 529$ min



$t_{90} = (13)^2 = 169$ min



$t_{90} = (19)^2 = 361$ min

Dial Reading vs. Time

TESTING SERVICE CORP

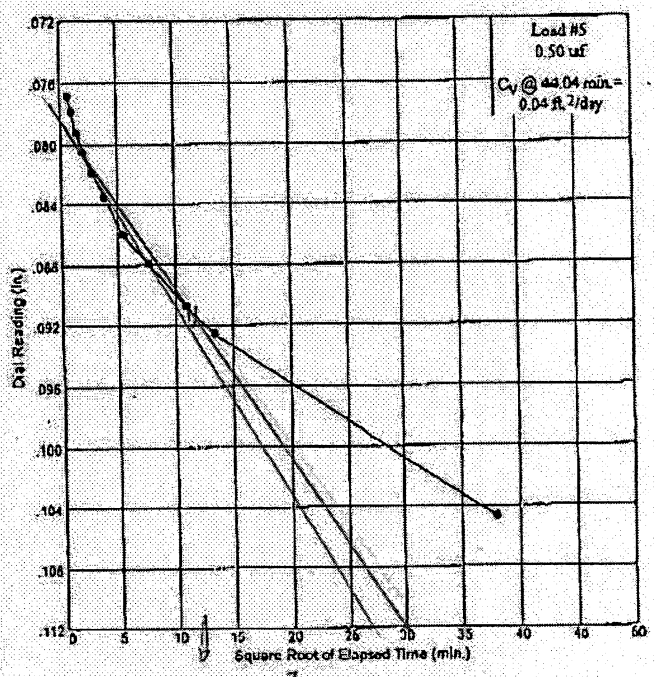
Figure

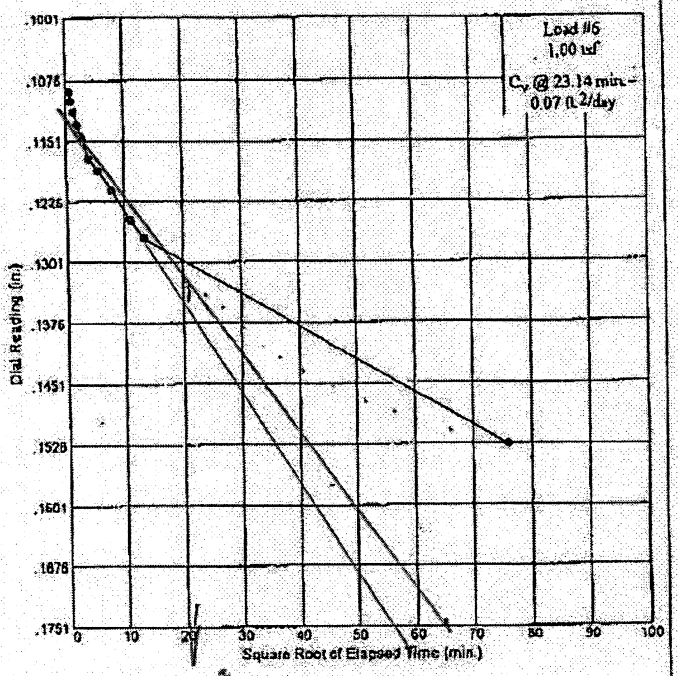
Dial Reading vs. Time

Project No.: L - 64,644
Project: CSSS KanKakee

Source: Boring 2

Elev./Depth: 6.0'-7.5'





$t_{90} = (12)^2 = 144$ min

$t_{90} = (21)^2 = 441$ min

$T_{90} = 0.848$

$H_{DR} = 1$ inch (APPROX)

t_{90} (AVG) = 306 min

t_{90} (MIN) = 144

t_{90} (MAX) = 529

$$C_v = \frac{T_{90}\left(H_{DR}/2\right)^2}{t_{90}}$$

$$C_v(AVG) = \frac{0.848\left(2.54/2\right)^2}{306\,(60)} \quad \frac{cm^2}{sec}$$

C_v(AVG) = 0.000745 cm²/sec

C_v(MAX) = 0.00016

C_v(MIN) = 0.000043

B-2,
6 - 7.5'
bgs =

Dial Reading vs. Time

TESTING SERVICE CORP

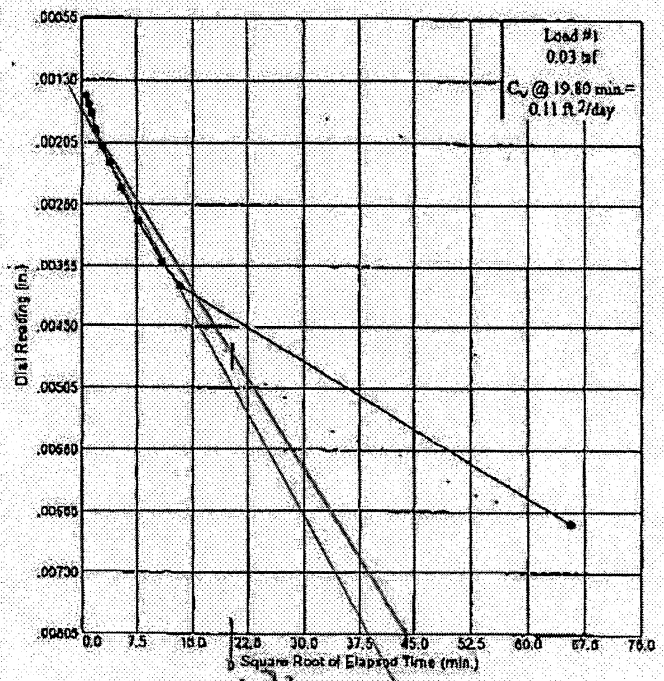
Figure

Dial Reading vs. Time

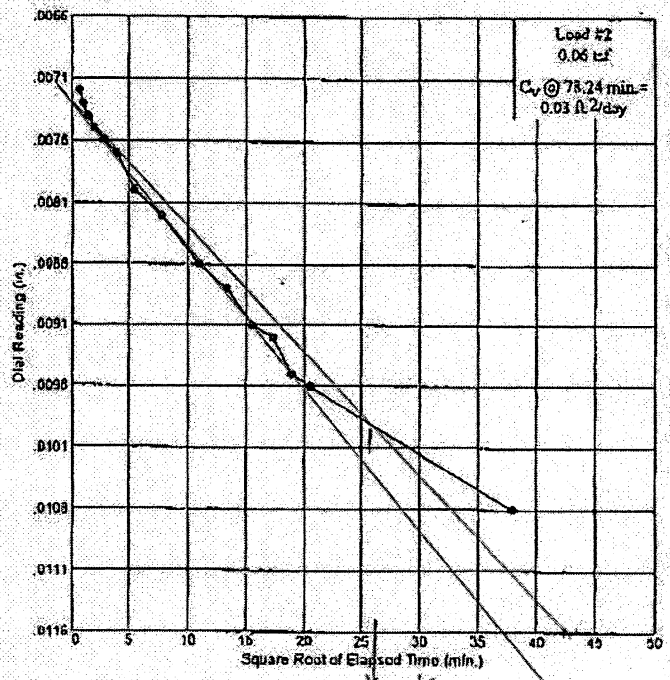
Project No.: L - 64,644
Project: CSSS KanKakee

Source: Boring 3

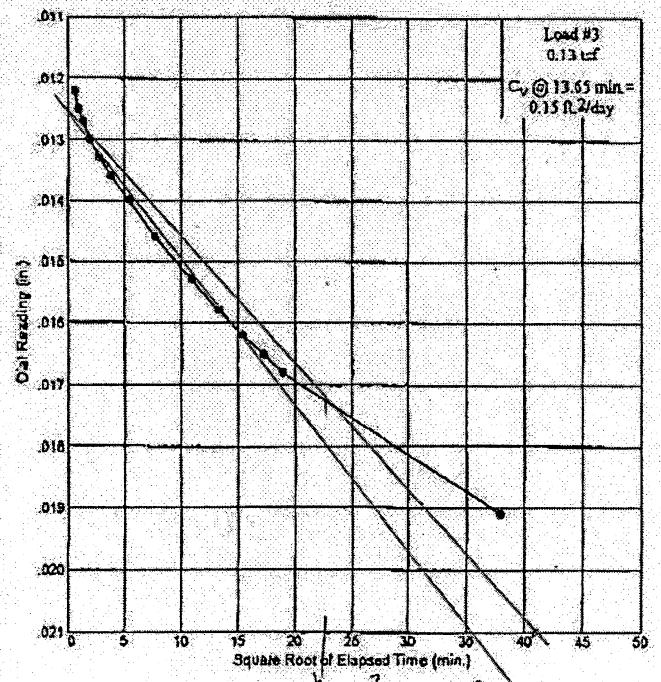
Elev./Depth: 2.3'- 4.3'



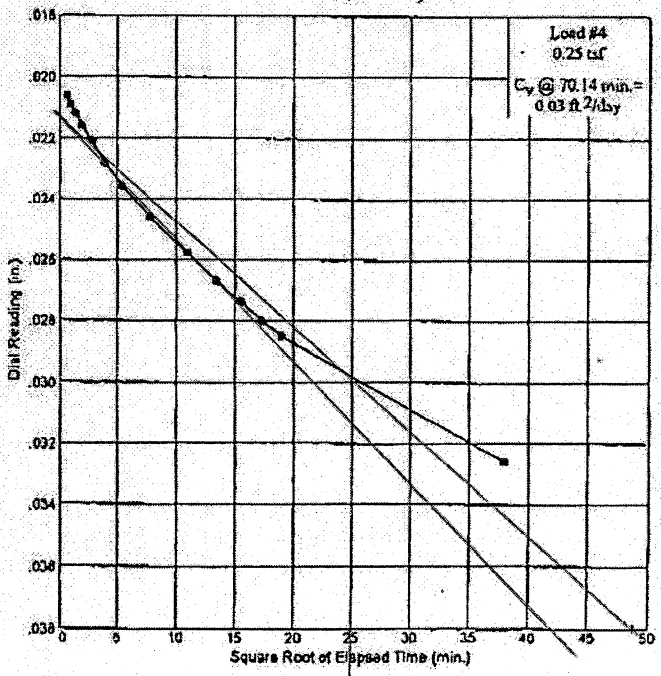
$t_{90} = (19)^2 = 361$ min



$t_{90} = (26)^2 = 676$ min



$t_{90} = (23)^2 = 529$ min



$t_{90} = (25)^2 = 625$ min

Dial Reading vs. Time

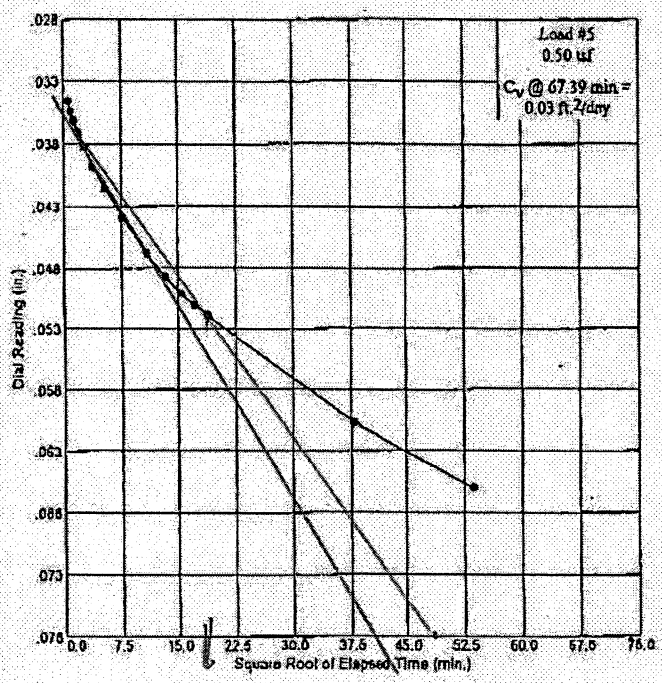
TESTING SERVICE CORP

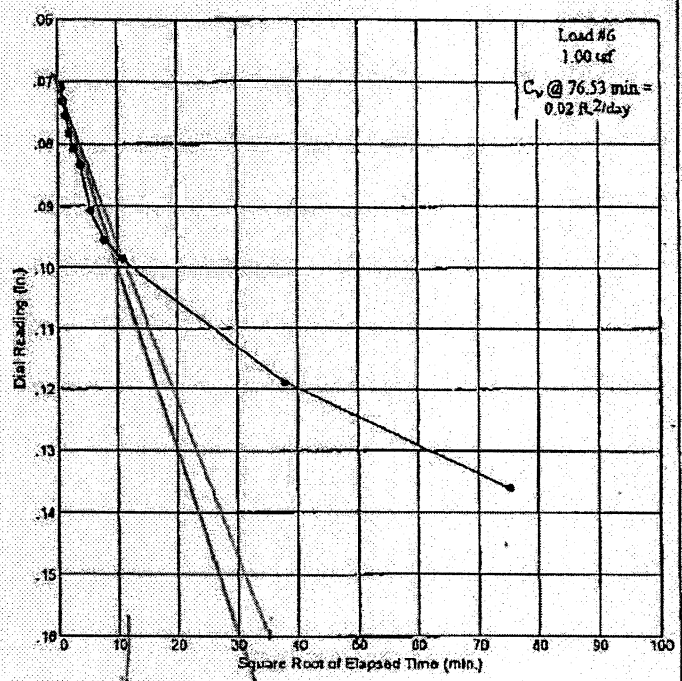
Figure

Dial Reading vs. Time

Project No.: L - 64,644
Project: CSSS KanKakee

Source: Boring 3 Elev./Depth: 2.3'- 4.3'





$t_{90} = (19)^2 = 361$ min

$t_{90} = (11)^2 = 121$ min

$$C_v = \frac{T_{90}\left(H_{DR}/2\right)^2}{t_{90}}$$

$T_{90} = 0.848$

$H_{DR} = 1$ INCH (APPROX)

t_{90} (AVG) = 445 min

min = 121

MAX = 625

$$C_{v(AVG)} = \frac{0.848\left(\frac{2.54}{2}\right)^2}{(445)(60)} \ \mathrm{cm^2/sec}$$

B-3, 2.3- 4.3' bgs:

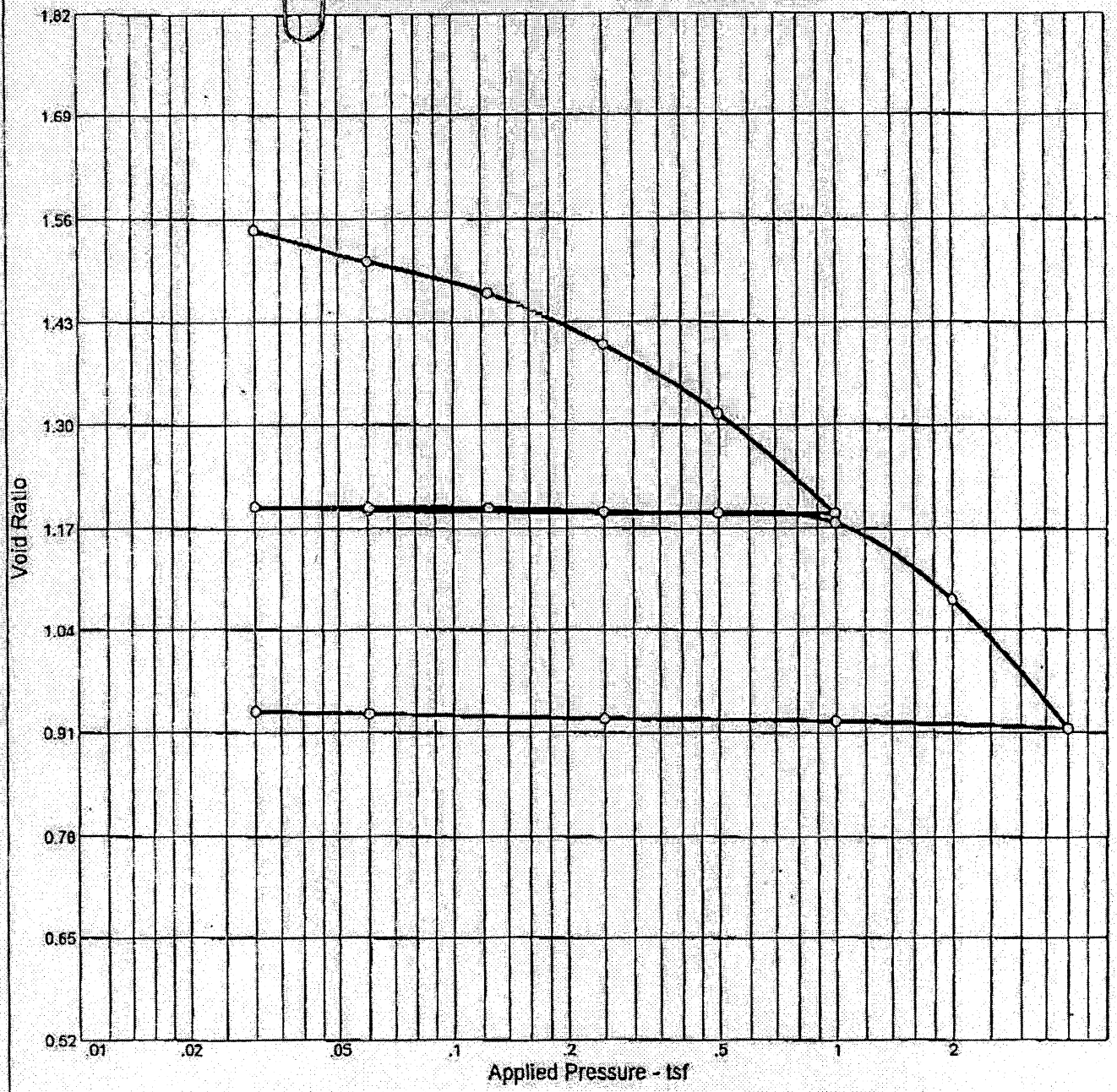
$C_{v(AVG)}$	= 0.000051	cm^2/sec
$C_{v(MAX)}$	= 0.00018	"
$C_{v(MIN)}$	= 0.000036	"

Dial Reading vs. Time

TESTING SERVICE CORP

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
99.9 %	59.5 %	64.3			2.66			1.584

MATERIAL DESCRIPTION

Black unknwown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KanKakee

Source: Boring 2 **Elev./Depth:** 6.0'- 7.5'

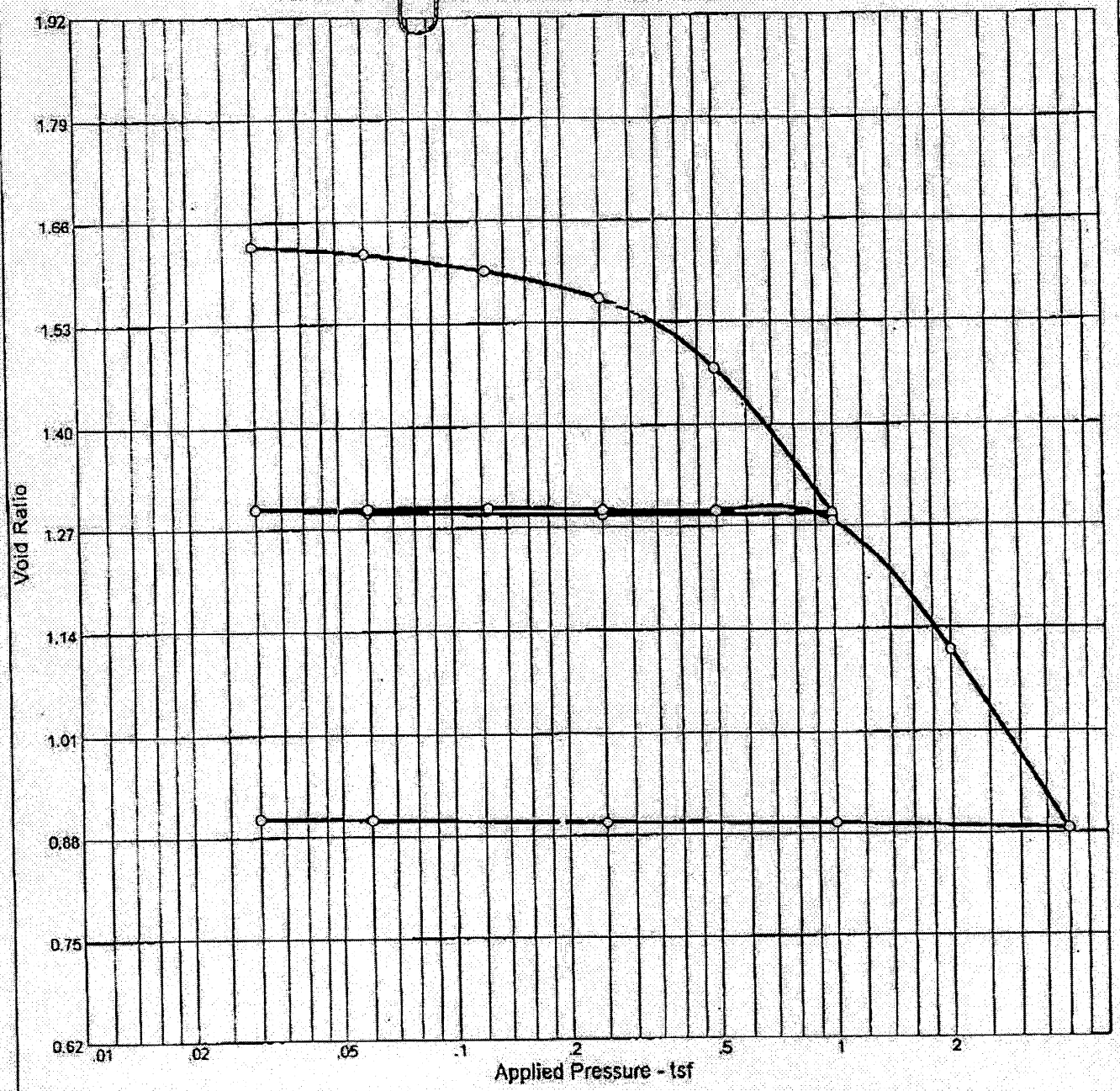
Remarks:

CONSOLIDATION TEST REPORT

TESTING SERVICE CORP

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
100.2 %	63.2 %	61.6	50	32	2.610			1.646

MATERIAL DESCRIPTION

Black unknown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KanKakee

Source: Boring 3 **Elev./Depth:** 2.3'- 4.3'

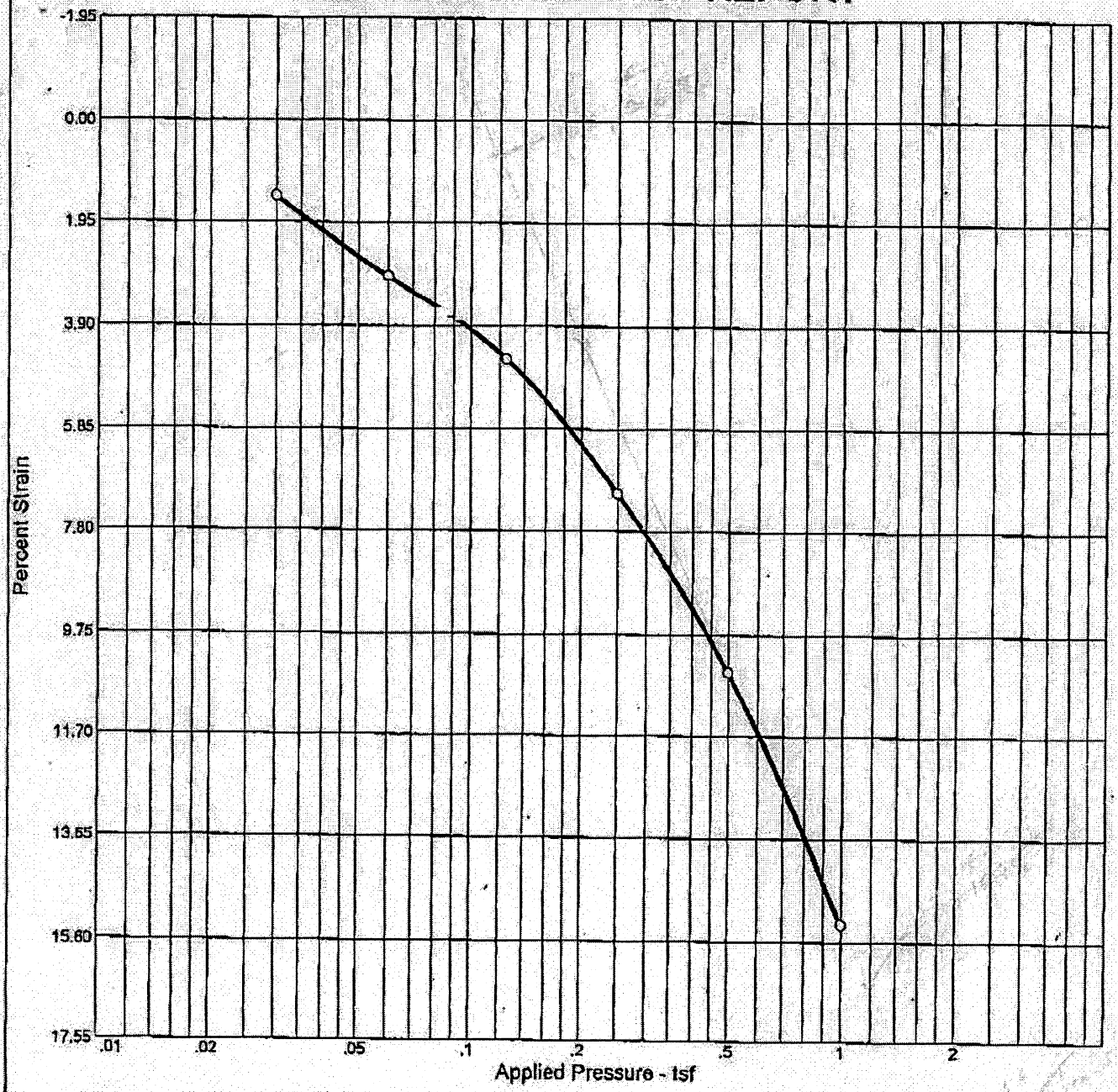
Remarks:

CONSOLIDATION TEST REPORT

TESTING SERVICE CORP

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
					2.744			

MATERIAL DESCRIPTION

Black unknowown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KanKakee

Source: Boring 2 **Elev./Depth:** 6.0'- 7.5'

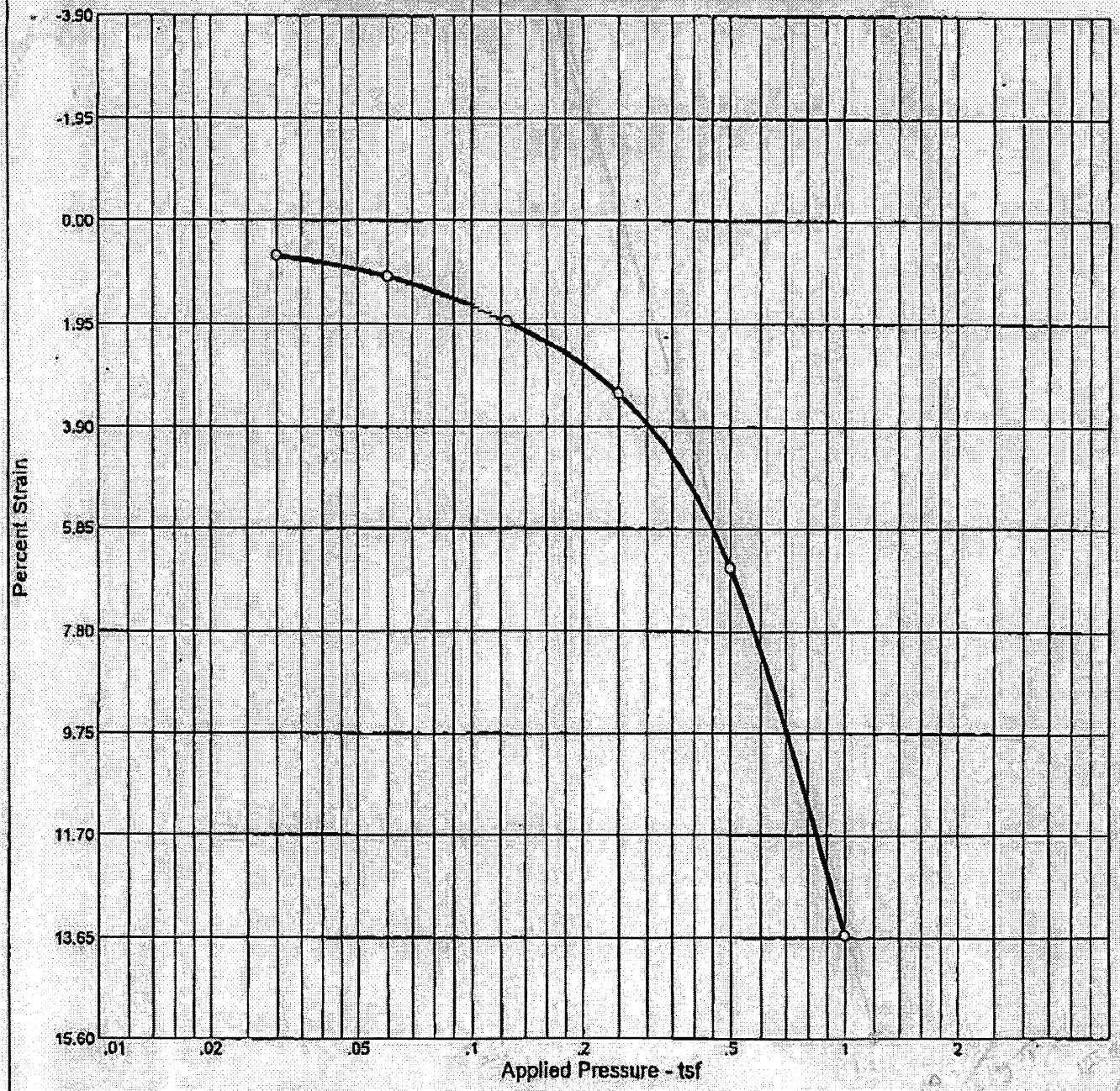
Remarks:

CONSOLIDATION TEST REPORT

TESTING SERVICE CORP

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
					2.610			

MATERIAL DESCRIPTION

Black unknown material

Project No. L - 64,644 **Client:** CH2M Hill, Inc.

Project: CSSS KonKakee

Source: Boring 3 **Elev./Depth:** 2.3'- 4.3'

Remarks:

CONSOLIDATION TEST REPORT

TESTING SERVICE CORP

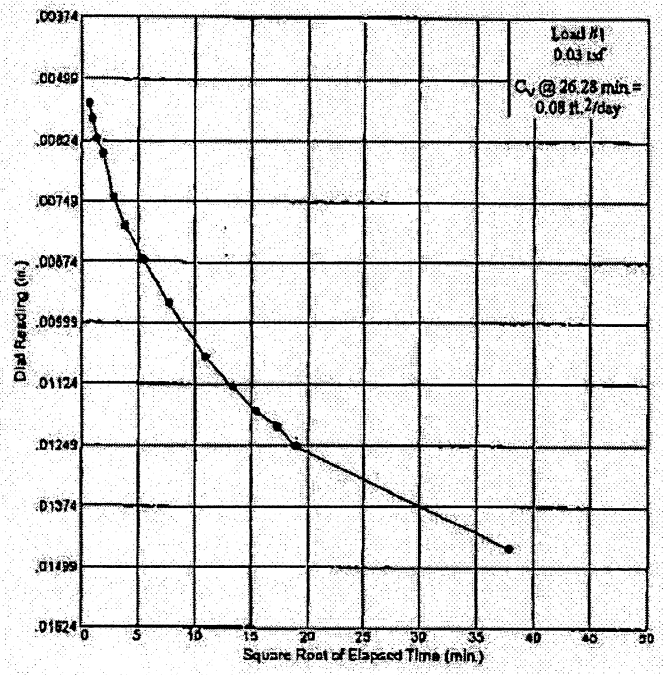
Figure

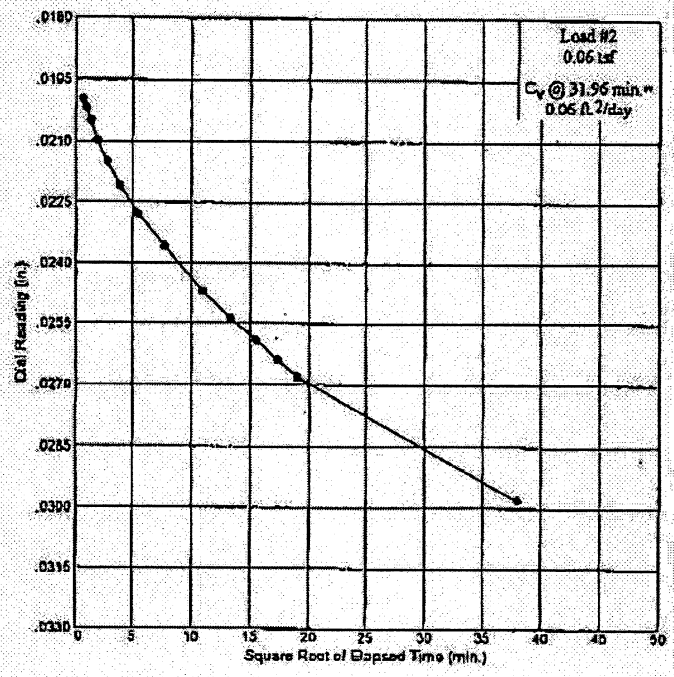
Dial Reading vs. Time

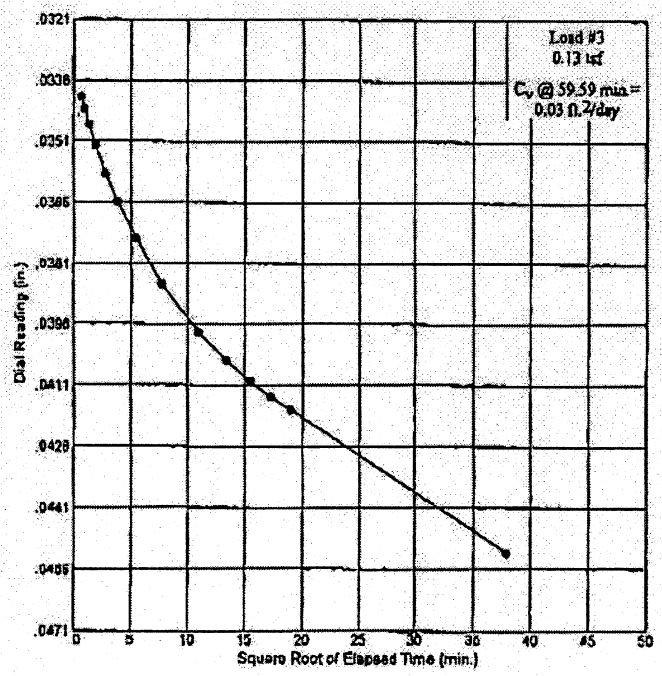
Project No.: L - 64,644
Project: CSSS KanKakee

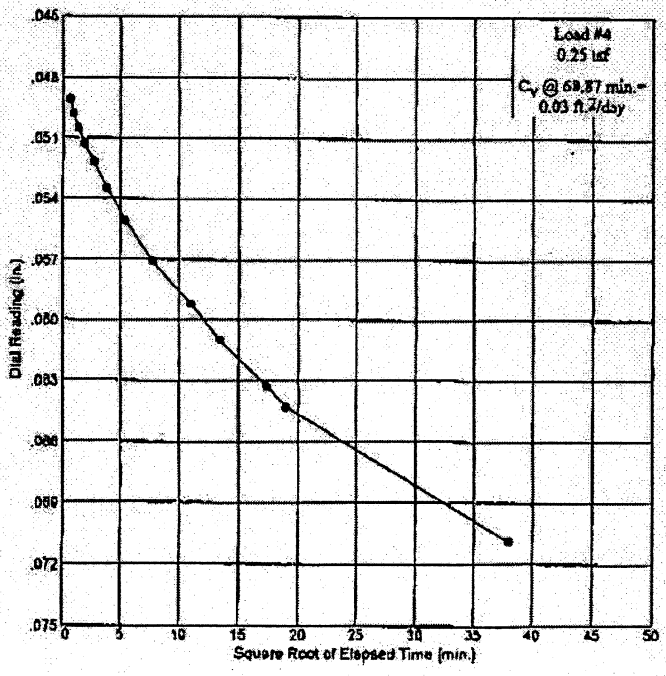
Source: Boring 2

Elev./Depth: 6.0'- 7.5'









Dial Reading vs. Time

TESTING SERVICE CORP

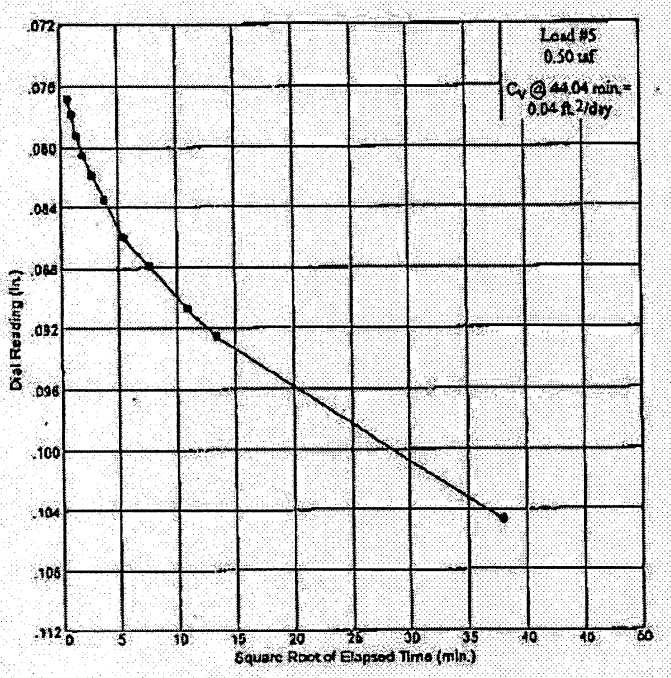
Figure

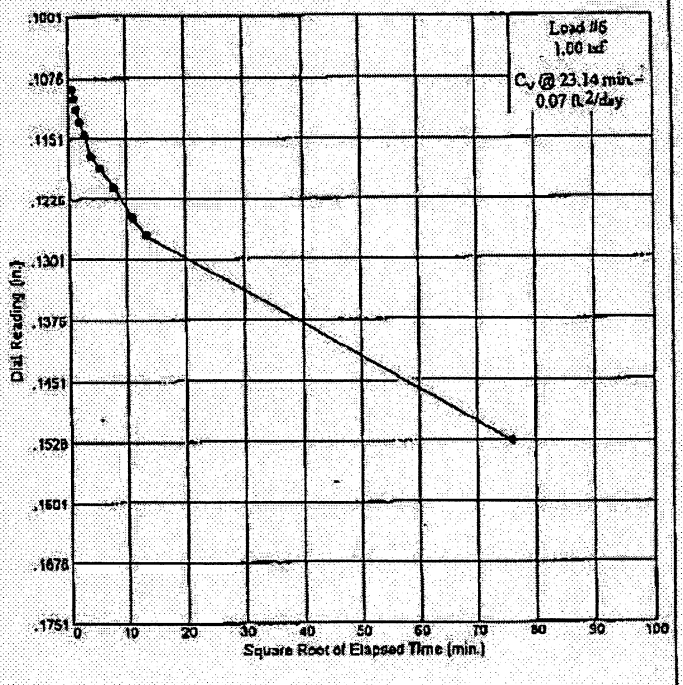
Dial Reading vs. Time

Project No.: L - 64,644
Project: CSSS KanKakee

Source: Boring 2

Elev./Depth: 6.0'- 7.5'





Dial Reading vs. Time

TESTING SERVICE CORP

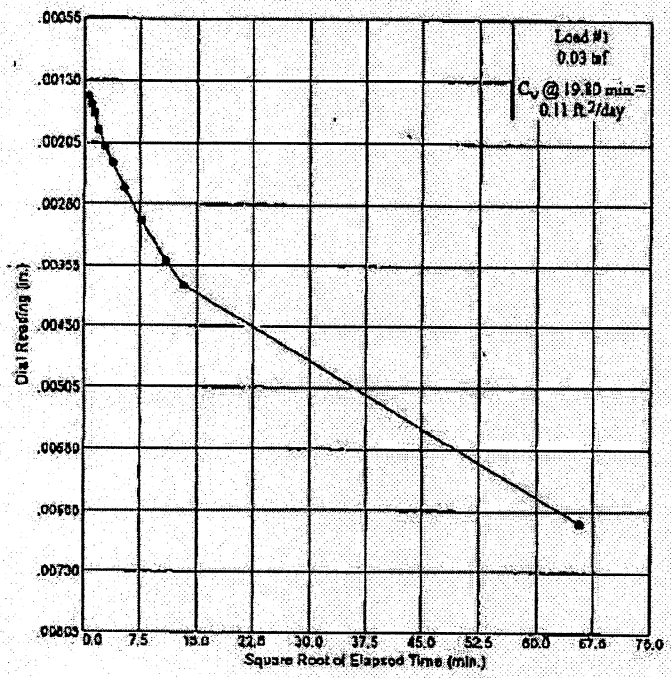
Figure

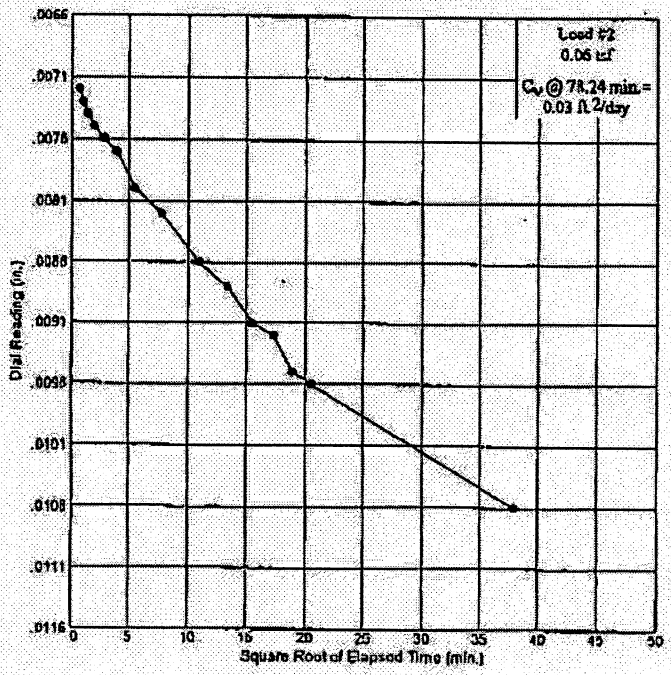
Dial Reading vs. Time

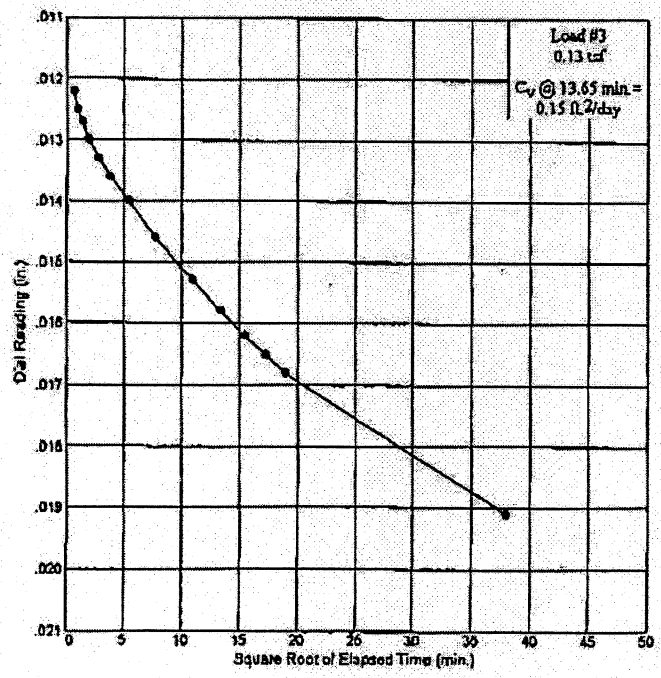
Project No.: L - 64,644
Project: CSSS KanKakee

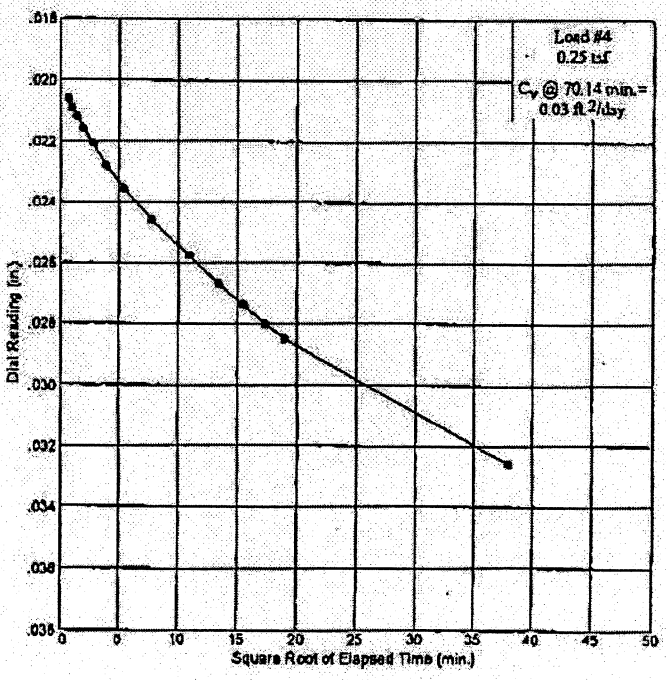
Source: Boring 3

Elev./Depth: 2.3'- 4.3'









Dial Reading vs. Time

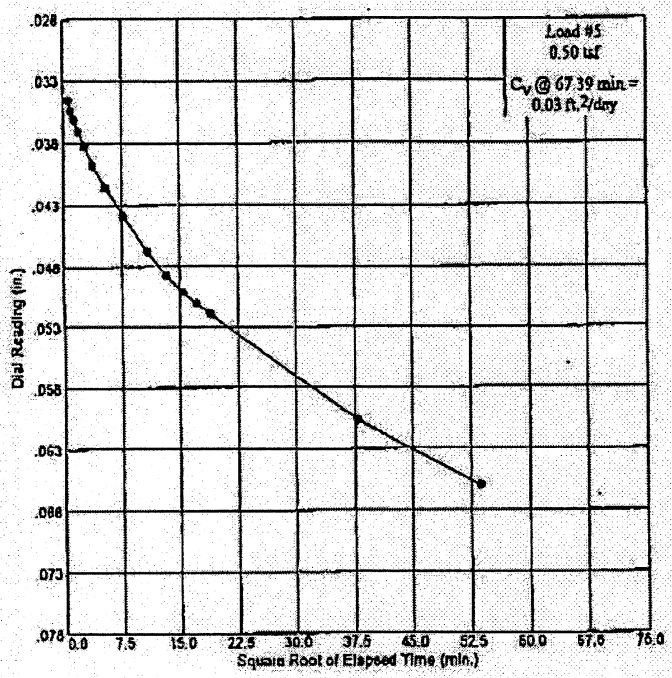
TESTING SERVICE CORP

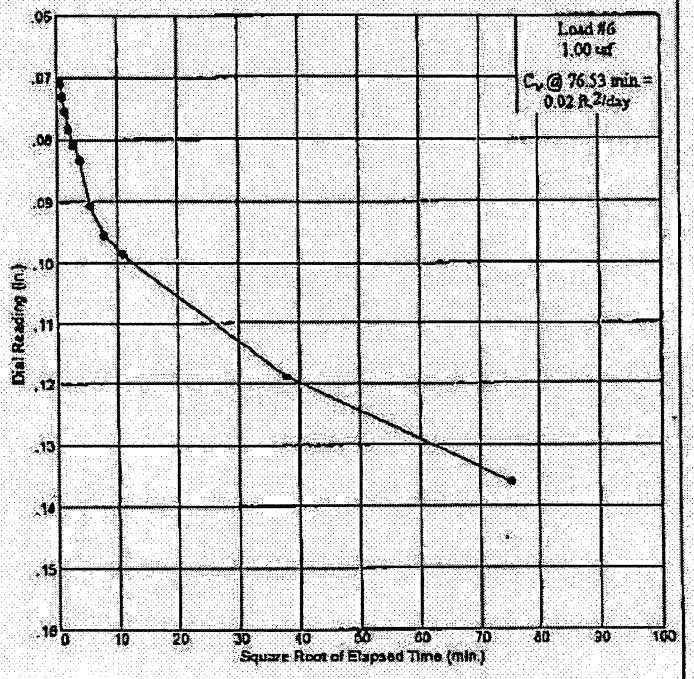
Figure

Dial Reading vs. Time

Project No.: L - 64,644
Project: CSSS KanKakee

Source: Boring 3 Elev./Depth: 2.3'- 4.3'





Dial Reading vs. Time

TESTING SERVICE CORP

Figure

Attachment C

Calculations

Table C-1
Approximate Consolidation Settlement of Sludge under Dewatering Pad Loads - 3 Methods
Continental Steel Superfund Site - Lagoon Area

Water Table Depth = **1 ft bgs**
Applied Overburden Load = **1045 psf** <== 3 ft gravel @135 pcf, plus 8 ft slurry @80 pcf

Method 1 - Use of coefficient of compression (Cce)

Interval	Depth Top (ft)	Depth Bottom (ft)	Moist Density (pcf)	Cce [1]	Existing Overburden (psf)	Effective Overburden (psf)	Effective Stress Under Load (psf)	Compression (feet)
1	0	1	90	0	45	45.0	1090.0	0
2	1	2	90	0.22	135	103.8	1148.8	0.23
3	2	4	95	0.22	275	275.0	1320.0	0.30
4	4	6	100	0.158	470	220.4	1265.4	0.24
5	6	8	105	0.158	675	300.6	1345.6	0.21
								0.97 feet
								11.7 inches

Assume upper foot non-compressible
Assume normally consolidated

[1] Cce = Coefficient of compression [d(strain) / d(log cycle stress)]

Method 2 - Direct measurement from strain - log P charts

Interval	Depth Top (ft)	Depth Bottom (ft)	Moist Density (pcf)	Existing Overburden (psf)	Effective Overburden (psf)	Effective Stress Under Load (psf)	d(Strain) [2] TEST 1 (%)	d(Strain) TEST 2 (%)	Compression TEST 1 (ft)	Compression TEST 2 (ft)
1	0	1	90	45	45.0	1090.0	6.2	9.0	0.062	0.090
2	1	2	90	135	103.8	1148.8	6.4	9.0	0.064	0.090
3	2	4	95	275	150.2	1195.2	6.5	8.2	0.130	0.164
4	4	6	100	470	220.4	1265.4	6.5	7.8	0.130	0.156
5	6	8	105	675	300.6	1345.6	6.7	7.8	0.134	0.156
									0.52	0.66 feet
									6.2	**7.9 inches**

Assume COMPRESSIBLE

[2] d(Strain) = strain (%) measured directly from the strain-log P test charts for the load increment considered

Method 3 - Use of Compression Index (Cc)

Layer No.	Depth Top (ft)	Depth Bot (ft)	Thickness (ft)	Below W.T.? (n=0, y=1)	Soil Type	Unit Wt. (pcf)	Existing Overburden (psf)	Water Pressure (psf)	Effective Overburden (psf)	Cc [3]	Cr	Pc' (psf)	Init. Void Ratio (%)	Stress Increase (psf)	Settlement (ft)
1	0	1	1	0	Sludge	90	45	0	45	0	0.05	45	1.6	1045	0.000
2	1	2	1	1	Sludge	90	135	31.2	103.8	0.77	0.05	103.8	1.6	1045	0.309
3	2	3	1	1	Sludge	95	227.5	93.6	133.9	0.77	0.05	133.9	1.6	1045	0.280
4	3	4	1	1	Sludge	95	322.5	156	166.5	0.77	0.05	166.5	1.6	1045	0.255
5	4	5	1	1	Sludge	100	420	218.4	201.6	0.54	0.05	201.6	1.65	1045	0.161
6	5	6	1	1	Sludge	100	520	280.8	239.2	0.54	0.05	239.2	1.65	1045	0.149
7	6	7	1	1	Sludge	105	622.5	343.2	279.3	0.54	0.05	279.3	1.65	1045	0.138
8	7	8	1	1	Sludge	105	727.5	405.6	321.9	0.54	0.05	321.9	1.65	1045	0.128
															1.4 feet
															17.0 inches

[3] Cc = Compression Index [d(void ratio) / d(log-cycle stress)]
Assume upper foot non-compressible

Prepared by: Matt Gavin, 11/2/2005
Checked by:

Table C-2
Time Rate of Consolidation Under Dewatering Pad Loads
Continental Steel Superfund Site - Lagoon Area

Percent Consolidation	T-factor	Cv (cm^2/sec) min	Cv (cm^2/sec) average	Cv (cm^2/sec) max	Time to Achieve % Consolidation, t (days) min.	Time to Achieve % Consolidation, t (days) average	Time to Achieve % Consolidation, t (days) max.	Under Dewatering Pad Loads Total Settlement at Time t (inch) Method 1	Under Dewatering Pad Loads Total Settlement at Time t (inch) Method 2	Under Dewatering Pad Loads Total Settlement at Time t (inch) Method 3	
		0.000036	0.00006	0.00016				*11.70*	*7.06*	*17.04*	<=== *Ultimate Primary Consolidation (inch)*
0	0	0.000036	0.00006	0.00016	0	0	0	0.00	0.00	0.00	
10	0.048	0.000036	0.00006	0.00016	52	138	229	1.17	0.71	1.70	
20	0.09	0.000036	0.00006	0.00016	97	258	430	2.34	1.41	3.41	
30	0.115	0.000036	0.00006	0.00016	124	330	550	3.51	2.12	5.11	
40	0.207	0.000036	0.00006	0.00016	223	594	989	4.68	2.82	6.82	
50	0.281	0.000036	0.00006	0.00016	302	806	1343	5.85	3.53	8.52	
60	0.371	0.000036	0.00006	0.00016	399	1064	1773	7.02	4.23	10.22	
70	0.488	0.000036	0.00006	0.00016	525	1399	2332	8.19	4.94	11.93	
80	0.652	0.000036	0.00006	0.00016	701	1870	3116	9.36	5.64	13.63	
90	0.933	0.000036	0.00006	0.00016	1003	2675	4459	10.53	6.35	15.33	
100	---	0.000036	0.00006	0.00016	---	---	---	11.70	7.06	17.04	

Notes:

Cv values corresponding to min., average, and max. time of settlement are interpreted from strain-(time)^0.5 plots for the two consolidation tests.

Time to Achieve % Consolidation, t (days) is calculated assuming 8-foot thick sludge layer, double drainage, and the range of Cv values listed.

Total Settlement at Time t (inch) are calculated for each of the 3 methods used to estimate ultimate primary consolidation

--- = time to 100 percent settlement is approached asymtotically.

Assume drainage layer thickness is 8 feet thick, double drainage.

Prepared by: Matt Gavin, 11/2/2005
Checked by:

Table C-3
Approximate Consolidation Settlement of Sludge under Lagoon Cover Fill
Continental Steel Superfund Site - Lagoon Area

Water Table Depth = **0 ft bgs**
Applied Overburden Load = **925.6 psf** 10 feet fill, with 6 feet submerged

Method 3 - Use of Compression Index (Cc)

Layer No.	Depth Top (ft)	Depth Bot (ft)	Thicknes s (ft)	Below W.T.? (n=0, y=1)	Soil Type	Unit Wt. (pcf)	Existing Overburden (psf)	Water Pressure (psf)	Effective Overburden (psf)	Cc [3]	Cr	Pc' (psf)	Init. Void Ratio (%)	Stress Increase (psf)	Settlement (ft)
1	0	1	1	1	Sludge	90	45	31.2	13.8	0	0.05	13.8	1.6	925.6	0.000
2	1	2	1	1	Sludge	90	135	93.6	41.4	0.77	0.05	41.4	1.6	925.6	0.405
3	2	3	1	1	Sludge	95	227.5	156	71.5	0.77	0.05	71.5	1.6	925.6	0.339
4	3	4	1	1	Sludge	95	322.5	218.4	104.1	0.77	0.05	104.1	1.6	925.6	0.295
5	4	5	1	1	Sludge	100	420	280.8	139.2	0.54	0.05	139.2	1.6	925.6	0.184
6	5	6	1	1	Sludge	100	520	343.2	176.8	0.54	0.05	176.8	1.6	925.6	0.165
7	6	7	1	1	Sludge	100	620	405.6	214.4	0.54	0.05	214.4	1.6	925.6	0.151
8	7	8	1	1	Sludge	100	720	468	252	0.54	0.05	252	1.6	925.6	0.139
															1.7 feet
															20.1 inches

[3] Cc = Compression Index [d(void ratio) / d(log-cycle stress)]
Assume upper foot non-compressible

Prepared by: Matt Gavin, 11/2/2005
Checked by:

Appendix C
M-CACES Cost Estimate

Lagoon Area(OU2) Remedial Action
Continental Steel Superfund
Site (CSSS)
Kokomo, Indiana
Plans/Tech Specs Dated Apr. 2006

Designed By: CH2M HILL
Estimated By: CH2M HILL

Prepared By: CH2M HILL

Preparation Date: 01/17/06
Effective Date of Pricing: 01/17/06

Sales Tax: 0.00%

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SUMMARY REPORTS SUMMARY PAGE

PROJECT DIRECT SUMMARY - Task.....1

DETAILED ESTIMATE DETAIL PAGE

01. Preconstruction Submittals.....1
02. Field Management for Cover.....1
03. Mobilize Equipment/Site Prep.....1
04. Soil Erosion Sediment Control.....1
05. Water Treatment Plant Demolition.....1
06. Soil Excavation.....1
07. Confirm.Sediment Smplng&Analysis.....1
08. Excavation and Grading.....2
09. Preloading.....2
10. Settlement Monitoring.....2
11. Final Grading.....2
12. Demobilize.....2
13. Subcontractor Costs.....2
14. Payment/Performance Bonds.....2
15. Project Management Costs.....2
16. 2

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

		QUANTY	UOM	UNIT COST	TOTAL COST
Preconstruction Submittals					
	Safety Supply Allowance	1.00	LS	6250.00	6,250
	Submittals	1.00	LS	30000.00	30,000
Field Management for Cover					
	Project Manager	6.00	MO	9580.00	57,480
	Superintendent	6.00	MO	12000.00	72,000
	Field Engineer	6.00	MO	6600.00	39,600
	Health & Safety Officer	6.00	MO	12000.00	72,000
	Field Office/Util/Porta-Johns	6.00	MO	2975.00	17,850
	Fuel Storage	6.00	MO	250.00	1,500
	Oiler/Fuel Truck	6.00	MO	5200.00	31,200
	Fire Protection	1.00	LS	2500.00	2,500
	Spill Prevention Emerg Response	1.00	LS	2000.00	2,000
	Site Vehicles	6.00	MO	5600.00	33,600
	Small Tools Allowance	1.00	LS	10000.00	10,000
	Mechanic with Truck	6.00	MO	6700.00	40,200
Mobilize Equipment/Site Prep					
	Mobilize Equipment	1.00	LS	25000.00	25,000
	Construct Employee Parking Area	1.00	LS	5000.00	5,000
	Maintain Haul Road/Access Road	6.00	MO	1900.00	11,400
	Traffic Cntrl-Trucks at Markland	6.00	MO	6200.00	37,200
	Traffic Control Signage	1.00	LS	3000.00	3,000
	Orange Safety Fencing	900.00	LF	3.50	3,150
	Construction Survey Crew	6.00	MO	12000.00	72,000
	Geotech CQC Svcs/Onsite Lab	2.00	MO	21000.00	42,000
	Equipment Storage Trailers/Rent	6.00	MO	460.00	2,760
	Provide Clean H2O for Cvr Const	1.00	LS	5000.00	5,000
	Fence Removal/Replacement	500.00	LF	10.00	5,000
	Well Abandonment	500.00	LF	3.00	1,500
Soil Erosion Sediment Control					
	Install Silt Fence-Berm Perim.	2000.00	LF	2.70	5,400
	Straw Bales (Sediment Control)	1.00	LS	4500.00	4,500
Water Treatment Plant Demolition					
	Dewatering	1.00	LS	10000.00	10,000
	Asbestos/Lead Survey	1.00	LS	7000.00	7,000
	Water Treatment Plant Bldg Demo	216000	CF	0.27	58,320
	Clarifier Demolition (2)	235619	CF	0.27	63,617
	Sludge Removal	3000.00	CY	12.50	37,500
	Sludge Transp. & Disposal	4500.00	TN	37.00	166,500
	NonhazUnsalvDebrisTrnsp&Disposal	500.00	TN	50.00	25,000
	Haz Waste Transp & Disposal	20.00	TN	125.00	2,500
Soil Excavation					
	Excavate VOC-Contaminated Soils	19140	CY	5.50	105,270
	Haz Waste Transp & Disposal	28710	TN	125.00	3,588,750
	Import General Fill	28710	TN	6.00	172,260
	Place/Compact General Fill	19140	CCY	2.00	38,280
Confirm.Sediment Smplng&Analysis					
	Labor	40.00	HR	60.00	2,400

		QUANTY	UOM	UNIT COST	TOTAL COST
Excavation and Grading					
Preloading	Excavate Soil & Sludge	112095	CY	5.50	616,523
	Dewatering	3.00	MO	10000.00	30,000
	Solidfy/Place/CompactSoil&Sludge	112095	CCY	5.00	560,475
	Import General Fill	176685	TN	6.00	1,060,110
	Place/Compact General Fill	117790	CCY	2.00	235,580
	Dust control	6.00	MO	8200.00	49,200
	Seed/Fertilize/Mulch Cover	50.00	AC	1376.00	68,800
Settlement Monitoring	Settlement Plates	6.00	EA	1000.00	6,000
	Preloading Topographic Survey	3.00	EA	4000.00	12,000
	Maintenance-Erosion Cntrl Meas.	1.00	LS	10000.00	10,000
Final Grading	Import General Fill Material	160500	TN	6.00	963,000
	Compact General Fill	107000	CCY	2.00	214,000
	Dust Control	2.00	MO	8200.00	16,400
	Seed/Fertilize/Mulch Cover	50.00	AC	1376.00	68,800
Demobilize	Record Drawings/Topo Information	6.00	MO	2000.00	12,000
	Project Closeout	1.00	LS	17500.00	17,500
	Demobilize Equipment	1.00	LS	15000.00	15,000
Subcontractor Costs	Subcontractor G&A (11%)	1.00	LS	975906.00	975,906
	Subcontractor Fee (4%)	1.00	LS	354875.00	354,875
Payment/Performance Bonds	Payment/Performance Bonds (3.5%)	1.00	LS	357093.00	357,093
Project Management Costs	Engineering (10%)	1.00	LS	1020000.00	1,020,000
	Contingency (15%)	1.00	LS	1530000.00	1,530,000
TOTAL	Lagoon Area(OU2) Remedial Action	1.00	EA	13109748.63	13,109,749

		QUANTITY	UOM	UNIT COST	TOTAL COST
01	Preconstruction Submittals	1.00	EA	36250.00	36,250
02	Field Management for Cover	1.00	EA	379930.00	379,930
03	Mobilize Equipment/Site Prep	1.00	EA	213010.00	213,010
04	Soil Erosion Sediment Control	1.00	EA	9900.00	9,900
05	Water Treatment Plant Demolition	1.00	EA	370437.13	370,437
06	Soil Excavation	1.00	EA	3904560.00	3,904,560
07	Confirm.Sediment Smplng&Analysis	1.00	EA	2400.00	2,400
08	Excavation and Grading	1.00	EA	616522.50	616,523
09	Preloading	1.00	EA	2004165.00	2,004,165
10	Settlement Monitoring	1.00	EA	28000.00	28,000
11	Final Grading	1.00	EA	1262200.00	1,262,200
12	Demobilize	1.00	EA	44500.00	44,500
13	Subcontractor Costs	1.00	EA	1330781.00	1,330,781
14	Payment/Performance Bonds	1.00	EA	357093.00	357,093
15	Project Management Costs				2,550,000
TOTAL	Lagoon Area(OU2) Remedial Action	1.00	EA	13109748.63	13,109,749

No errors detected...

* * * END OF ERROR REPORT * * *