H.1

SUMMARY OF SUBSURFACE STRATIGRAPHY AND MATERIAL PROPERTIES (DATA PACKAGE)

SUMMARY OF SUBSURFACE STRATIGRAPHY AND MATERIAL PROPERTIES

1. INTRODUCTION

This "*Summary of Subsurface Stratigraphy and Material Properties*" package (referred to as the Data Package) was prepared in support of the stability evaluation of the In-Lake Waste Deposit (ILWD). Specifically, the purpose of the package is to provide:

- a summary of the site investigation activities conducted in the ILWD area to date;
- interpretation of subsurface stratigraphy in the ILWD area;
- interpretation of material properties (i.e., index properties, shear strength, and compressibility); and
- recommendation on material properties to be used for the stability evaluation of the ILWD area.

2. SITE INVESTIGATIONS

The ILWD area, which is adjacent to Wastebed B (WB-B), consists mainly of the area identified as Sediment Management Unit 1 (SMU 1) with limited portions of SMU 2, SMU 7, and SMU 8 (Figure 1). Extensive pre-design investigations (PDIs) were conducted in the ILWD area to characterize the subsurface conditions. These investigations included the Phase I PDI in 2005, the Phase II PDI in 2006, the Phase III PDI in 2007, and the DNAPL investigation in 2006 and 2007. Figure 2 shows the locations of soil borings drilled during the investigations. Details of the investigations were presented in the data summary reports prepared by Parsons [Parsons, 2007a, 2007b, 2009a, and 2009b].

3. SUBSURFACE STRATIGRAPHY

The subsurface stratigraphy in the ILWD area was developed based on the geotechnical information interpreted from the boring logs. Subsurface profiles at eight selected cross sections (Figure 2) are shown in Figures 3 through 10. Sections 1 through 5 represent the overall general cross sections with average slopes of about 3 to 5 degrees (i.e., 19 horizontal to 1 vertical [19H:1V] to 11H:1V) and Sections 6 through 8 represent the steeper localized cross sections with average slopes of about 20 to 27 degrees (i.e., 2.7H:1V to 2H:1V). Attachment 1 of this package provides a detailed description of how the subsurface profiles were developed.

As shown in the above cross sections, the subsurface soil in the ILWD area consists primarily of seven strata:

- Stratum I – Solvay Waste (SOLW): SOLW encountered in the ILWD area was described in the boring logs as wet, very soft, gray to dark gray, silt-like grains with mothball odor. The reported standard penetration test (SPT) N value of SOLW in the ILWD area ranges mainly from 0 to 7 (with most of the values being 0). The thickness of SOLW ranges between approximately 15 ft and 55 ft in the ILWD area.
- Stratum II – Marl: Marl encountered in the ILWD area was described in the boring logs as wet, very soft, dark gray or brown silt with shells. The reported SPT N value of Marl in the ILWD area ranges mainly from 0 to 4 (with most of the values being 0). The thickness of Marl varies from 0 ft to approximately 50 ft in the ILWD area.
- Stratum III – Silt and Clay: Silt and Clay encountered in the ILWD area was described in the boring logs as wet, very soft, dark gray or brown mixture of silt and clay. The reported SPT N value of Silt and Clay in the ILWD area is mainly 0. Only a limited number of deep borings in the ILWD area penetrated the bottom of Silt and Clay layer and the thickness of Silt and Clay was reported to be about 20 ft to 80 ft. Based on available information from the deep borings and the other relatively shallow borings, it was estimated that the thickness of Silt and Clay in the ILWD area is at least 15 ft.
- Stratum IV – Silt and Sand: Silt and Sand were encountered in several deep borings in the ILWD area. The SPT N value of Silt and Sand ranges typically from approximately 20 to 80 as reported in the boring logs.
- Stratum V – Sand and Gravel: Sand and Gravel were encountered in several deep borings in the ILWD area. The typical SPT N value for Sand and Gravel ranges from approximately 20 to greater than 100 as reported in the boring logs.
- Stratum VI – Till: Till was encountered in several deep borings in the ILWD area. The SPT N value for Till is typically greater than 100.
- Stratum VII – Shale: Shale was encountered in several deep borings in the ILWD area. The SPT N value for Shale is typically greater than 100.

In addition to the above seven strata, isolated pockets of thin layers of silt were also noticed on top of SOLW in the ILWD area.

Figure 11 shows the historic lake water level. The lake water level was estimated to be at Elevation 363 ft above mean sea level for the purpose of the ILWD stability evaluation.

4. MATERIAL PROPERTIES

Properties of the subsurface soils were selected based on laboratory data or empirical correlations using in-situ test data when laboratory data were not available. Samples of SOLW, Marl, and Silt and Clay were collected during the investigations for laboratory testing, which included:

- Index property tests (i.e., water content, grain size, organic content, carbonate content, Atterberg limits, specific gravity, and density); and
- Performance tests (i.e., unconsolidated undrained (UU) triaxial compression tests, consolidated undrained (CU) triaxial compression tests with porewater pressure measurement, and one-dimensional consolidation tests).

Summary tables of the laboratory test results for Phase I, Phase II, Phase III, and DNAPL investigations were provided to Geosyntec by Parsons and are presented in Attachment 2 of this package. It is noted that the summary tables include data from SMU 1, SMU 2, and SMU 8. However, only the data from SMU 1 (unless specified otherwise) were considered for the ILWD stability evaluation because: (i) the ILWD area consists of only a small portion of SMU 2; and (ii) the stability evaluation is mainly focused on SMU 1 where the lake bottom slope is steeper than in SMU 8.

4.1 <u>INDEX PROPERTIES</u>

The fines (including clay and silt) content was measured in the laboratory index property tests during all four investigations. The carbonate and organic contents were also measured in the laboratory index property tests except during the Phase II investigation. The fines, carbonate, and organic contents were plotted together as a function of depth in Figure 12. Hydrometer tests were performed during the Phase I, Phase II, Phase III, and DNAPL investigations to further measure the clay content (particle size less than 0.002 mm). Based on the lab results, the clay content typically ranges from 5% to 30% for SOLW, from 20% to 43% for Marl, and from 14% to 50% for Silt and Clay. The average clay content was calculated to be 14%, 30%, and 30% for SOLW, Marl, and Silt and Clay, respectively.

The water content and Atterberg limits (i.e., plastic limit and liquid limit) were measured in the laboratory index property tests and were plotted together as a function of depth in Figure 13. Based on the measured water content and Atterberg limits, the plasticity index and liquidity index were calculated and plotted with respect to depth in Figures 14 and 15, respectively. The laboratory data were also plotted in Casagrande's plasticity chart shown in Figure 16.

The unit weights of SOLW, Marl, and Silt and Clay were measured in the laboratory index property tests except during the Phase II investigation when only disturbed sampling was performed. The results are summarized in Table 1 and also plotted in Figure 17 as a function of depth. The calculated average total unit weights recommended for the ILWD stability analysis are 81 pcf, 98 pcf, and 108 pcf for SOLW, Marl, and Silt and Clay, respectively. The unit weight of the isolated silt pockets was assumed to be the same as Marl. The unit weights of the other subsurface soils (i.e., Silt and Sand, Sand and Gravel, Till, and Shale) were assumed to be 120 pcf.

4.2 CONSOLIDATION PARAMETERS

One-dimensional consolidation tests were performed during Phase I and Phase II investigations. The results of the preconsolidation pressures ($p_c^{'}$) of SOLW, Marl, and Silt and Clay were plotted with respect to depth in Figure 18. As a comparison, data from adjacent SMU 2 were also plotted in the figure. The profile of the in-situ vertical effective stress was calculated and plotted in the same figure. The assumed representative subsurface profile in the ILWD area shown in Figure 19 was used in the calculation of the in-situ vertical effective stress. It was assumed in the representative subsurface profile that the thickness of SOLW, Marl, and Silt and Clay is 30 ft, 10 ft, and 30 ft, respectively.

The overconsolidation ratio (*OCR*), which is the ratio of $p_c^{'}$ to the in-situ vertical effective stress, was calculated and plotted in Figure 20 as a function of depth. Figure 20 includes both SMU 1 and SMU 2 data. Based on the plot, material above 30 ft, which consists mainly of SOLW, was considered to be overconsolidated and material below 30 ft, which consists mainly of Marl and Silt and Clay, was considered to be normally consolidated. The *OCR* of SOLW was observed to vary from 1.6 to 8.2, with an average of about 4.7. An OCR value of 2.0 was selected, which is slightly higher than the lower bound of 1.6 but well below the average value of 4.7, to conservatively estimate undrained shear strengths from CU test results, as presented in the next section.

4.3 UNDRAINED SHEAR STRENGTH

Undrained shear strength (S_u) properties of SOLW, Marl, and Silt and Clay were interpreted from UU and CU tests performed as part of the Phase I, Phase III, and DNAPL investigations.

4.3.1 Interpretation of Undrained Shear Strength from UU Tests

The S_u values of SOLW, Marl, and Silt and Clay measured from the UU tests were plotted with respect to depth in Figure 21. The mean and standard deviation of the S_u were calculated and summarized in Table 2 for SOLW, Marl, and Silt and Clay. As presented in the table, the calculated average S_u of SOLW, Marl, and Silt and Clay is 247 psf, 354 psf, and 350 psf, respectively.

4.3.2 Interpretation of Undrained Shear Strength from CU Tests

During CU tests, a soil sample is usually trimmed into three specimens, and each specimen is tested under a different initial confining stress. The initial effective confining stress applied in each test should be greater than the effective overburden stress in the ground where the sample was collected to compensate for the effect of any disturbance. The S_u measured in each CU test corresponds to the initial effective confining stress applied to the specimens rather than the in-situ effective overburden stress the specimens were subjected to in the field. Therefore, the measured S_u from each CU test can not be used directly in analysis. However, a relationship between the S_u in the field and the S_u established from the CU test results can be used to calculate the "in-situ" S_u as explained below:

- Approach 1 – The undrained shear strength ratio defined as s_u / σ'_{ci} can be calculated from CU test results, where S_u is the undrained shear strength measured in the laboratory and is equal to one half of the peak deviator stress, and σ'_{ci} is the initial effective confining stress applied in the CU test. The calculated s_u / σ'_{ci} is then corrected for the overconsolidation effect by multiplying by a factor of $OCR^{0.8}$, if the sample is overconsolidated [Kulhawy and Mayne, 1990]. The s_u / σ'_{ci}, or the corrected s_u / σ'_{ci} if soil is overconsolidated, can be applied directly to a slope stability analysis program. The program will calculate the effective stress for each slice and then assign appropriate S_u based on the undrained shear strength ratio.
- Approach 2 – A best-fit straight line that passes through the origin can be developed to represent the relationship between S_u and σ'_{ci} for each specimen based on the CU tests, as illustrated in Figure 22. In this example using this best-fit line, the "in-situ" S_u for the sample can be established as the strength that corresponds to the in-situ overburden effective stress, $\sigma'_{v,in-situ}$ (see Figure 22), which is calculated according to the subsurface profile where the sample was collected. The calculated S_u is then corrected for the overconsolidation effect by multiplying by a factor of $OCR^{0.8}$, if the sample is overconsolidated [Kulhawy and Mayne, 1990].

The undrained shear strengths were interpreted from the CU test results using both approaches:

Approach 1 -- Undrained Shear Strength Ratio

The undrained shear strength ratio was calculated for each test based on the summary tables of the CU test results provided by Parsons. Figures 23, 24, and 25 present the plots of the undrained shear strength ratio versus the effective confining stress for SOLW, Marl, and Silt and Clay, respectively. The undrained shear strength ratios of SOLW presented in Figure 23 were not corrected for the overconsolidation effect (i.e., the factor of $OCR^{0.8}$ was not applied). The undrained shear strength ratio ranges mainly from 0.2 to 1.2 for SOLW, 0.25 to 0.65 for Marl, and 0.25 to 0.6 for Silt and Clay.

It should be noted that specimens that were tested in an overconsolidated stress state (i.e., the initial effective confining stress in the laboratory is less than the in-situ effective overburden stress) and specimens with abnormal results (i.e., laboratory test report shows abnormal behavior of the stress-strain relation) were removed from the plots for SOLW, Marl, and Silt and Clay. The intent of removing data for specimens that were tested in an overconsolidated stress state is to remove data for which overconsolidation was artificially created in the lab, rather than limiting the data to normally consolidated samples. An example of this situation is shown in Figure 26 for the Silt and Clay samples, where the test results removed from the data set are circled. The in-situ effective overburden stresses were calculated based on the assumed representative subsurface profiles in the ILWD area illustrated in Figure 19. The calculated in-situ effective stress was compared to the initial effective confining stress in the laboratory to identify the overconsolidated samples.

Approach 2 -- Undrained Shear Strength as a Function of Depth

Using Approach 2 described before and illustrated in Figure 22, the in-situ effective overburden stress calculated using the assumed representative subsurface profile in Figure 19 was used to establish the "in-situ" S_u for each sample. The resulting S_u is plotted with respect to the sample depth in Figure 27. The mean and standard deviation of the interpreted S_u from the CU tests are summarized in Table 2. As presented in the table, the calculated average S_u is 140 psf, 492 psf, and 612 psf for SOLW, Marl, and Silt and Clay, respectively. Because SOLW is overconsolidated, the average S_u of SOLW was adjusted by a factor of $OCR^{0.8}$ with OCR being 2.0 as discussed before. The adjusted S_u for SOLW was calculated to be approximately 240 psf. It is noticed that the S_u of Marl and Silt and Clay increases with depth. A line with $s_u / \sigma_v' = 0.35$ was found to fit the S_u data well for Marl and Silt and Clay.

4.3.3 Recommended Undrained Shear Strength for Design

Comparison of S_u interpreted from UU and CU test results is shown in Figure 28. In general, S_u from CU tests are close to S_u from UU tests for SOLW and Marl at shallow depths, and S_u from CU tests are greater than S_u from UU tests for Marl and Silt and Clay at deep depths. This observation is consistent with the evidence found in literature [e.g., Sabatini et al., 2002], where UU tests tend to underestimate the actual shear strength for samples collected at depths greater than 6 m (or 18 ft) for normally consolidated samples and greater than 12 m (or 36 ft) for overconsolidated soils.

Based on the interpretation results, it is recommended that the adjusted average S_u of SOLW from the CU tests, which was calculated to be 240 psf, be used for the ILWD stability analysis. It is also recommended that the undrained shear strength ratio of 0.35 be used for Marl and Silt and Clay because their S_u appears to increase with depth. For the liquefaction analysis, an undrained shear strength ratio of 0.35 is recommended for the SOLW. This value is considered conservative because it is not adjusted to account for overconsolidation.

4.4 DRAINED SHEAR STRENGTH

The effective stress friction angles (ϕ') of SOLW, Marl, and Silt and Clay were estimated based on the CU test results. The ϕ' was calculated using the effective stress Mohr circle at failure for each CU test as illustrated in Figure 29. The calculated ϕ' is plotted in Figure 30 as a function of the effective normal stress for SOLW, Marl, and Silt and Clay. The mean value and the standard deviation of the ϕ' for SOLW, Marl, and Silt and Clay are summarized in Table 3. As shown in Figure 30, there is considerable scatter in the data for the near surface material (i.e., at low effective normal stress). It is unknown if the scatter is due to material variability or difficulty in testing at low normal stresses. For this reason, it is recommended that the "Mean minus one standard deviation or slightly lower" values of the ϕ' be used at low effective normal stresses for SOLW in the ILWD stability analysis, which was calculated to be 37 degrees. It is noted that the standard deviation for the deeper materials, primarily Marl and Silt and Clay layers, indicates less scatter than for the near surface materials. While it may be appropriate to use the mean value, the mean minus standard deviation was used for consistency, which was calculated to be 32 degrees and 30 degrees for Marl and Silt and Clay, respectively.

Initial slope stability analyses were performed using mean and standard deviation values calculated from the initial data that was available. When more data (i.e., Phase III data) became available, the values were recalculated. Since the recalculated mean values were greater than or equal to the initial values and the standard deviations were less than or equal to the initial values, the slope stability analyses were not updated because the original strength values were considered to be conservative. This is the rationale behind the term *"Mean minus one standard deviation or slightly lower"*.

An empirical relation between ϕ' and SPT N value, as shown in Table 4 [Kulhawy and Mayne, 1990], was used to estimate ϕ' of Silt and Sand, Sand and Gravel, Till, and Shale. Using an estimated average SPT N value of 30 for Silt and Sand and Sand and Gravel, their ϕ' was conservatively estimated to be 32 degrees. The ϕ' of Till and Shale was estimated to be 40 degrees as their SPT N values are typically greater than 100.

4.5 SUMMARY OF RECOMMENDED MATERIAL PROPERTIES

The material properties (i.e., unit weight and undrained and drained shear strengths) recommended for the ILWD stability analysis are summarized in Table 5.

5. REFERENCES

Kulhawy, F.H. and Mayne, P.W. (1990). "Manual on Estimating Soil Properties for Foundation Design", EPRI EL-6800, Project 1493-6, August 1990.

Parsons (2007a). "Onondaga Lake Pre-Design Investigation Phase I Data Summary Report", March 2007.

Parsons (2007b). "Draft Willis-Semet Interim Remedial Measure Causeway DNAPL Investigation", December 2007.

Parsons (2009a). "Draft Onondaga Lake Pre-Design Investigation Phase II Data Summary Report", 2009.

Parsons (2009b). "Draft Onondaga Lake Pre-Design Investigation Phase III Data Summary Report", 2009.

Sabatini P.J., Bachus, R.C., Mayne, P.W., Schneider, J.A., and Zettler, T.E. (2002). " Geotechnical Engineering Circular No. 5: Evaluation of Soil and Rock Properties", FHWA-IF-02-034, Federal Highway Administration, Washington, DC, April 2002.

TABLES

Table 1. Summary of measured total unit weight

Material	Average value (pcf)	Standard Deviation (pcf)
SOLW	81	6
Marl	98	9
Silt and Clay	108	9

Note:
See Table 5 for the final recommended material properties to be used for the ILWD stability analysis.

Table 2. Summary of measured/interpreted undrained shear strength

Material	Based on UU tests		Based on CU tests		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean adjusted for overconsolidation
SOLW	247	149	140	44	244
Marl	354	127	492	166	$S_u/\sigma_v' = 0.35$
Silt and Clay	350	136	612	183	$S_u/\sigma_v' = 0.35$

Note:
See Table 5 for the final recommended material properties to be used for the ILWD stability analysis.

Table 3. Summary of interpreted effective friction angle from CU tests

Material	Mean (degrees)	Standard deviation (degrees)	Mean – Standard deviation (degrees)
SOLW	48	8	40
Marl	39	6	33
Silt & Clay	36	6	30

Note:
See Table 5 for the final recommended material properties to be used for the ILWD stability analysis.

Table 4. Empirical relation between friction angle and SPT N value

N Value (blows/ft or 305 mm)	Relative Density	Approximate $\bar{\phi}_{tc}$ (degrees) (a)	Approximate $\bar{\phi}_{tc}$ (degrees) (b)
0 to 4	very loose	< 28	< 30
4 to 10	loose	28 to 30	30 to 35
10 to 30	medium	30 to 36	35 to 40
30 to 50	dense	36 to 41	40 to 45
> 50	very dense	> 41	> 45

a - Source: Peck, Hanson, and Thornburn (12), p. 310.
b - Source: Meyerhof (13), p. 17.

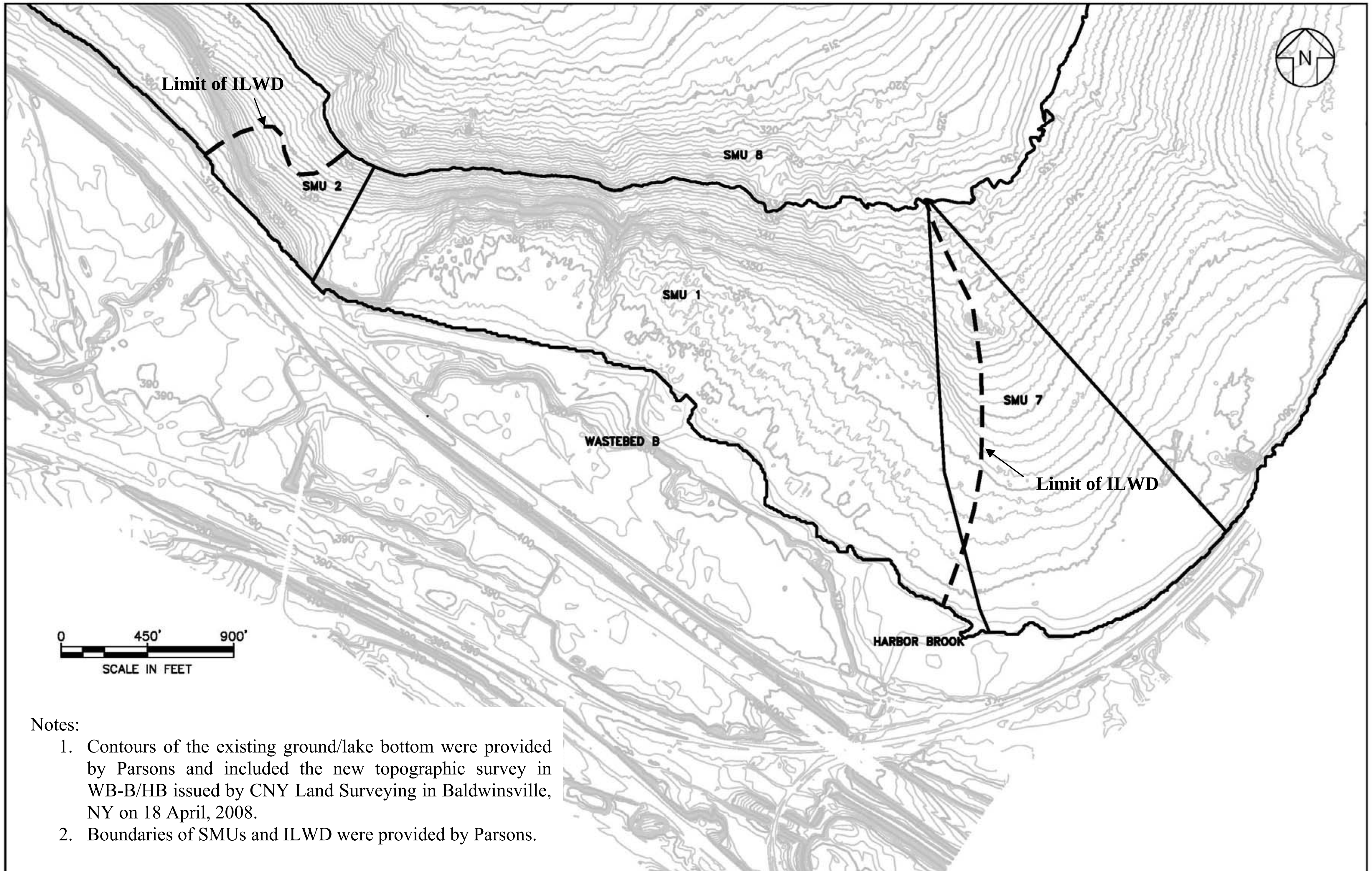
Table 5. Material properties recommended for the ILWD slope stability analysis

Material	Total Unit Weight (pcf)	Drained Shear Strength		Undrained Shear Strength[1] (psf)	
		c’	ϕ’	From UU	From CU
Silt[2]	98	0	32	N/A[3]	N/A
SOLW	81	0	37[4]	245	240[5]
Marl	98	0	32[6]	350	$S_u/\sigma'_v = 0.35$[7]
Silt and Clay	108	0	30	350	$S_u/\sigma'_v = 0.35$[7]
Silt and Sand	120	0	32	N/A	N/A
Sand and Gravel	120	0	32	N/A	N/A
Till	120	0	40	N/A	N/A
Shale	120	0	40	N/A	N/A

Notes:

1. Undrained shear strength obtained from CU tests is recommended to be used for the ILWD stability analysis for undrained loading conditions. Values of the undrained shear strength were rounded down to the nearest 5 or 10.
2. Properties of Marl were used for the isolated Silt on top of SOLW.
3. N/A = Not Applicable
4. As presented in Table 3, the “mean minus one standard deviation” value for SOLW is 40 degrees. However, based on initially available data, a value of 37 degrees was calculated and used in slope stability analyses. Because it is conservative, the recommended shear strength value was not changed to 40 degrees after the new data became available.
5. Undrained shear strength of SOLW from CU tests has been adjusted by multiplying a factor of $OCR^{0.8}$ (with OCR being 2.0) to account for the overconsolidation effect.
6. As presented in Table 3, the “mean minus one standard deviation” value for Marl is 33 degrees. However, based on initially available data, a value of 32 degrees was calculated and used in slope stability analyses. Because it is conservative, the recommended shear strength value was not changed to 33 degrees after the new data became available.
7. The laboratory undrained shear strength data of Marl and Silt and Clay shows a trend of increase with depth. An undrained shear strength ratio of 0.35 was found to fit the data well.

FIGURES



Notes:

1. Contours of the existing ground/lake bottom were provided by Parsons and included the new topographic survey in WB-B/HB issued by CNY Land Surveying in Baldwinsville, NY on 18 April, 2008.
2. Boundaries of SMUs and ILWD were provided by Parsons.

Figure 1. ILWD site layout

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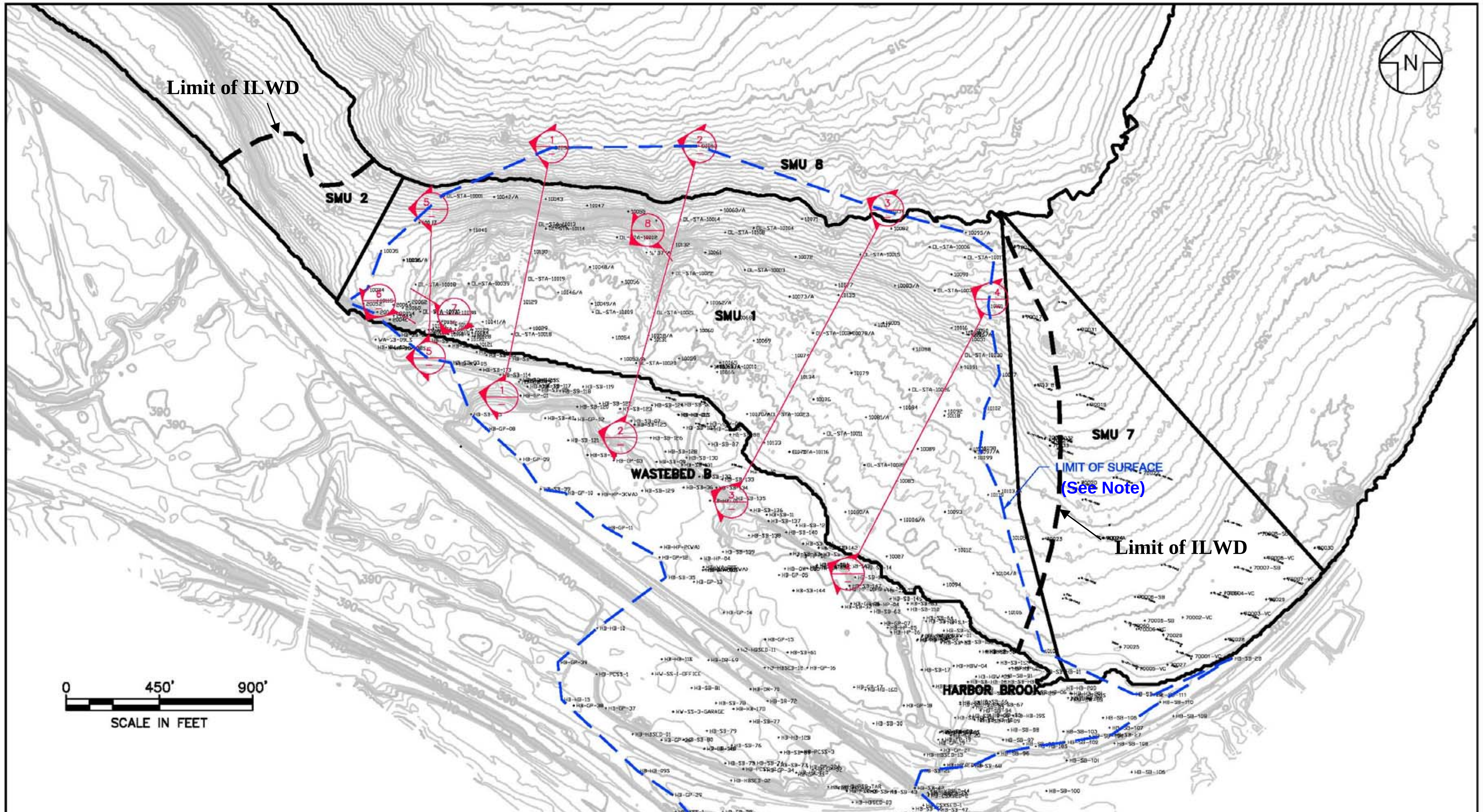
Client: **Honeywell** Project: **Onondaga Lake ILWD Stability** Project/ Proposal No.: **GJ4204** Task No.: **01**



Note:
3-D surfaces of subsurface layers were developed using the geotechnical information interpreted from the borings shown in this figure. 3-D surfaces for subsurface layers beyond the limit are currently not available and may be developed later, if needed.

Figure 2. Locations of borings and selected cross sections

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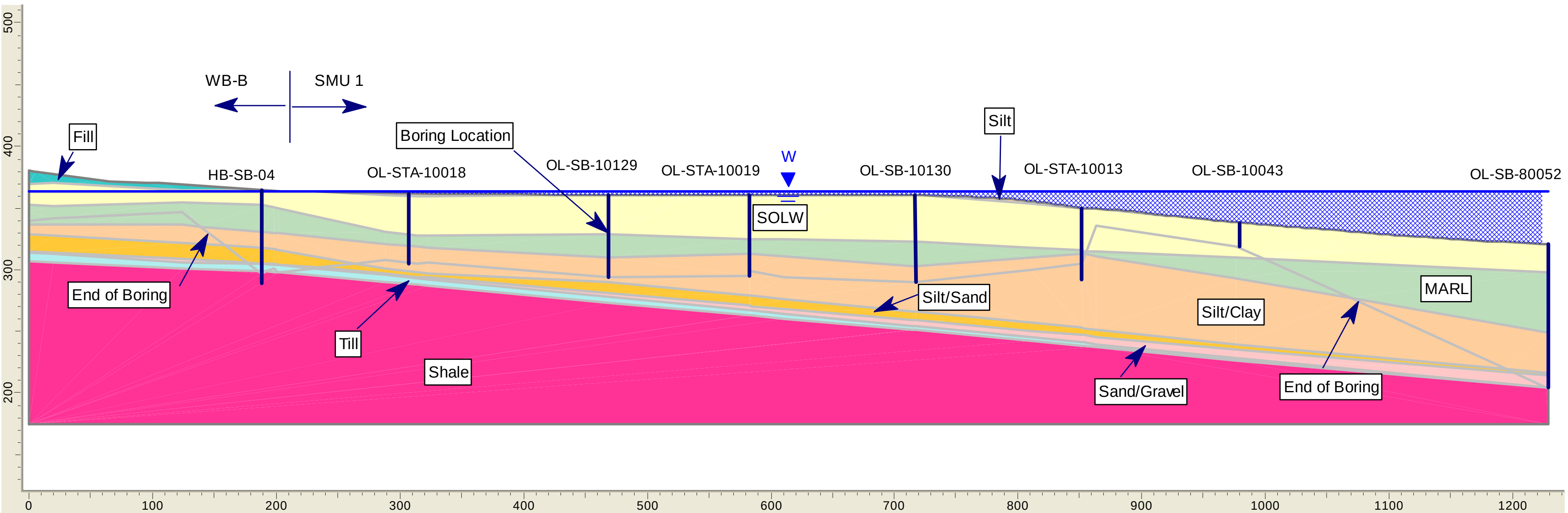

Figure 3. Geometry of cross section 1

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. Borings HB-SB-04 and OL-STA-10013 are offset from the cross section line. Therefore, the end of the boring shown in the figure does not match the line of end of boring for these two borings.
3. Subsurface layer elevations above the end of boring at the boring locations shown in the figure were checked and found to match well with the available elevations reported in the boring logs.

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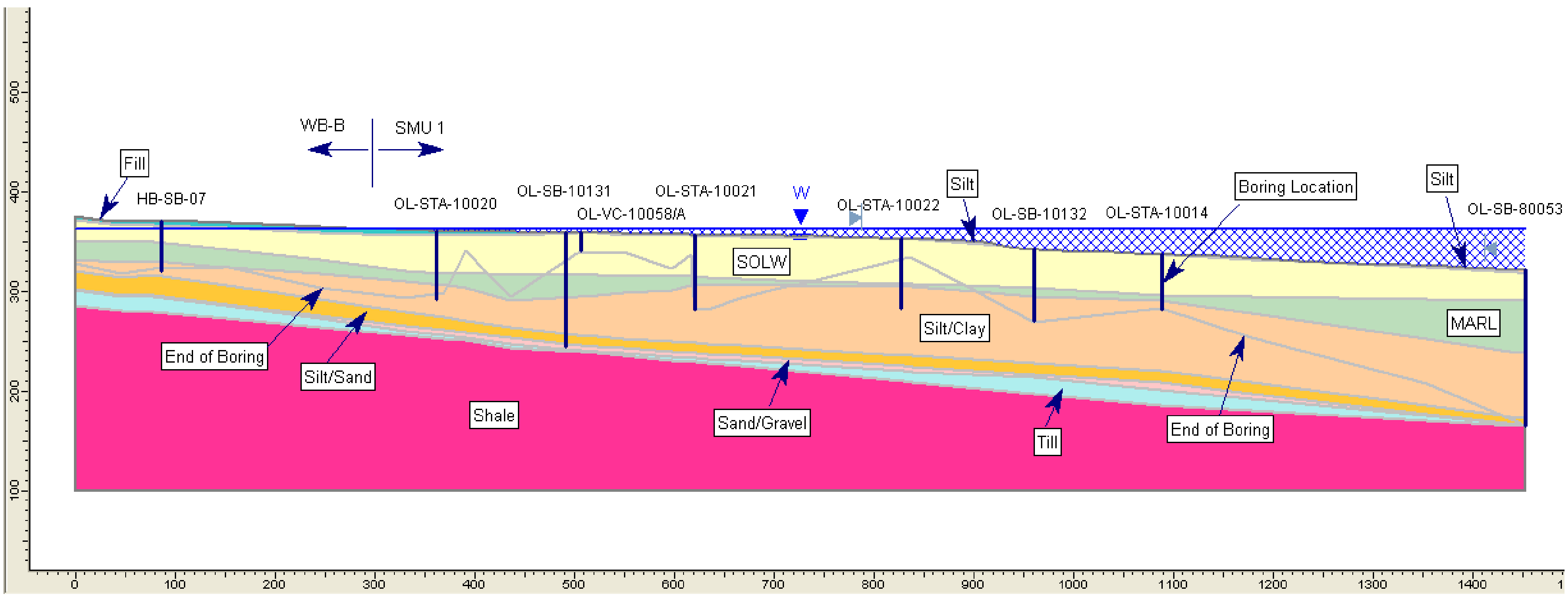

Figure 4. Geometry of cross section 2

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. Borings OL-SB-10131 and OL-STA-10022 are offset from the cross section line. Therefore, the end of the boring shown in the figure does not match the line of end of boring for these two borings.
3. Subsurface layer elevations above the end of boring at the boring locations shown in the figure were checked and found to match well with the available elevations reported in the boring logs.

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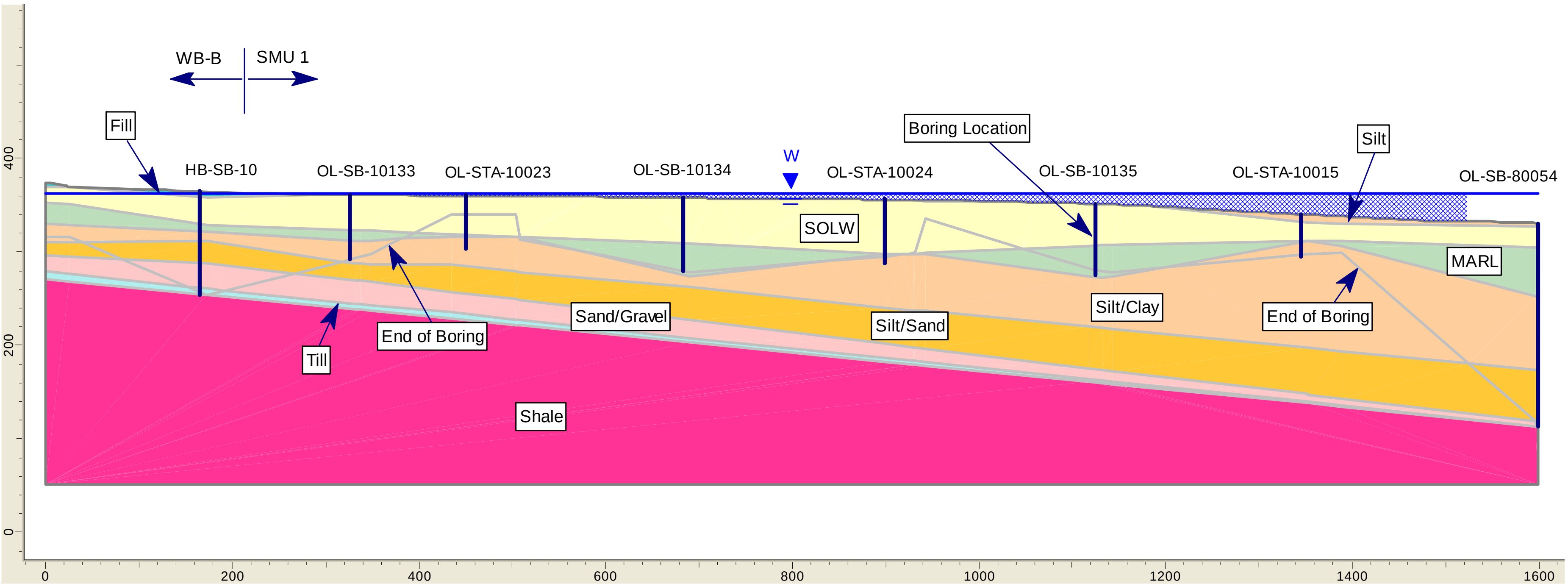

Figure 5. Geometry of cross section 3

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. Boring OL-STA-10023 is offset from the cross section line. Therefore, the end of the boring shown in the figure does not match the line of end of boring for this boring.
3. Subsurface layer elevations above the end of boring at the boring locations shown in the figure were checked and found to match well with the available elevations reported in the boring logs.

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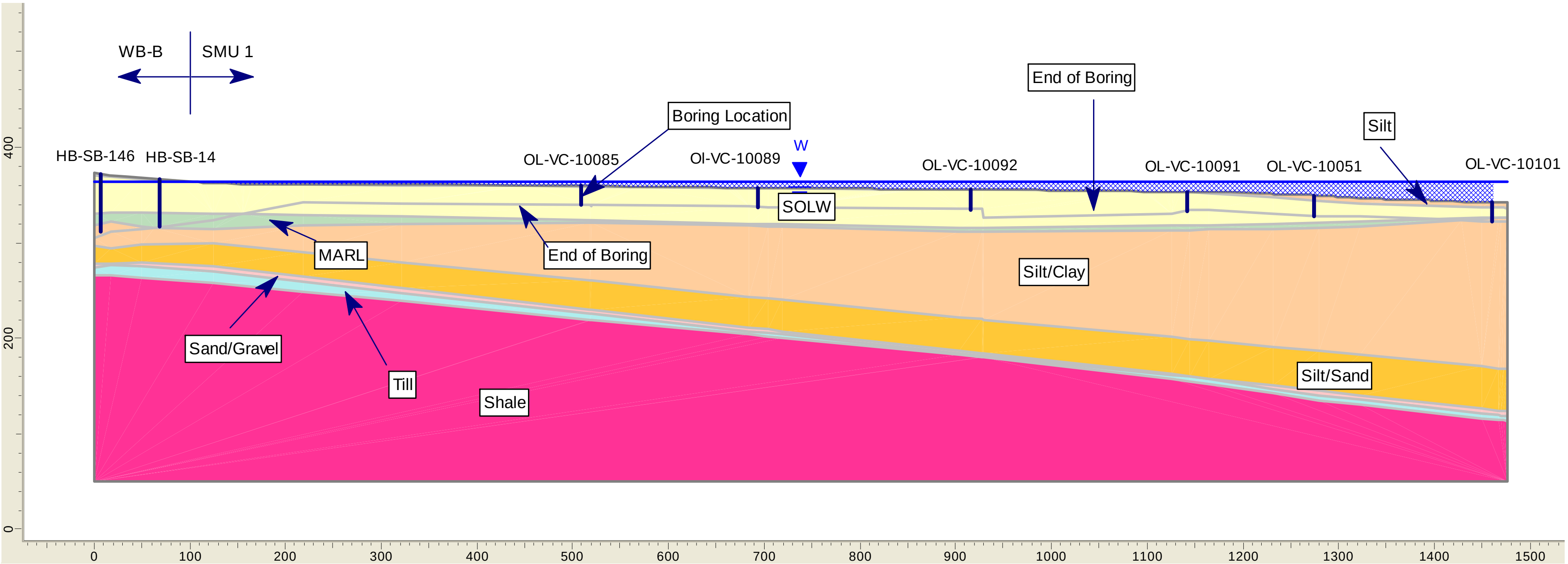

Figure 6. Geometry of cross section 4

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. Subsurface layer elevations above the end of boring at the boring locations shown in the figure were checked and found to match well with the available elevations reported in the boring logs.

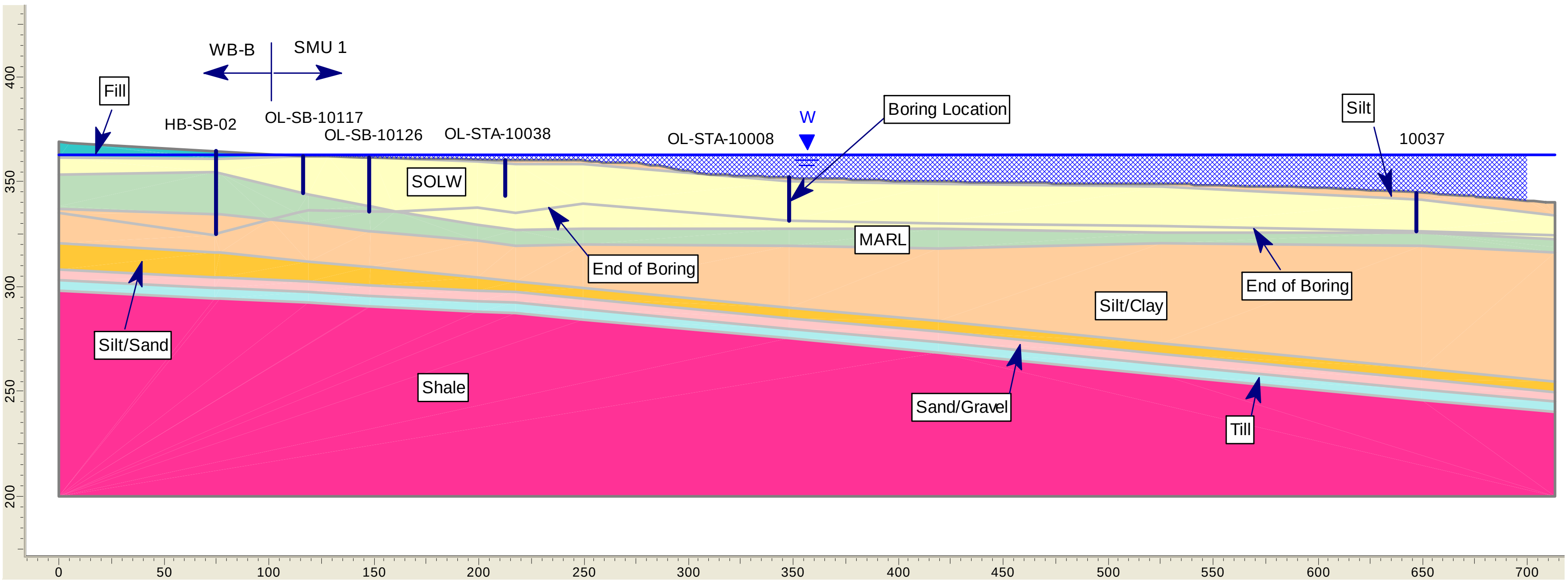

Figure 7. Geometry of cross section 5

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. Borings OL-SB-10117 and OL-STA-10038 are offset from the cross section line. Therefore, the end of the boring shown in the figure does not match the line of end of boring for these two borings.
3. Subsurface layer elevations above the end of boring at the boring locations shown in the figure were checked and found to match well with the available elevations reported in the boring logs.

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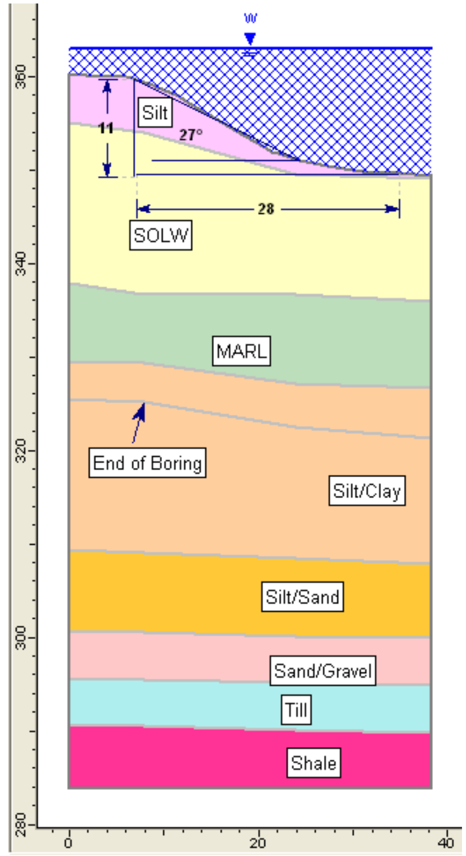

Figure 8. Geometry of cross section 6

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. The average slope is about 27 degrees and the maximum slope is about 32 degrees.

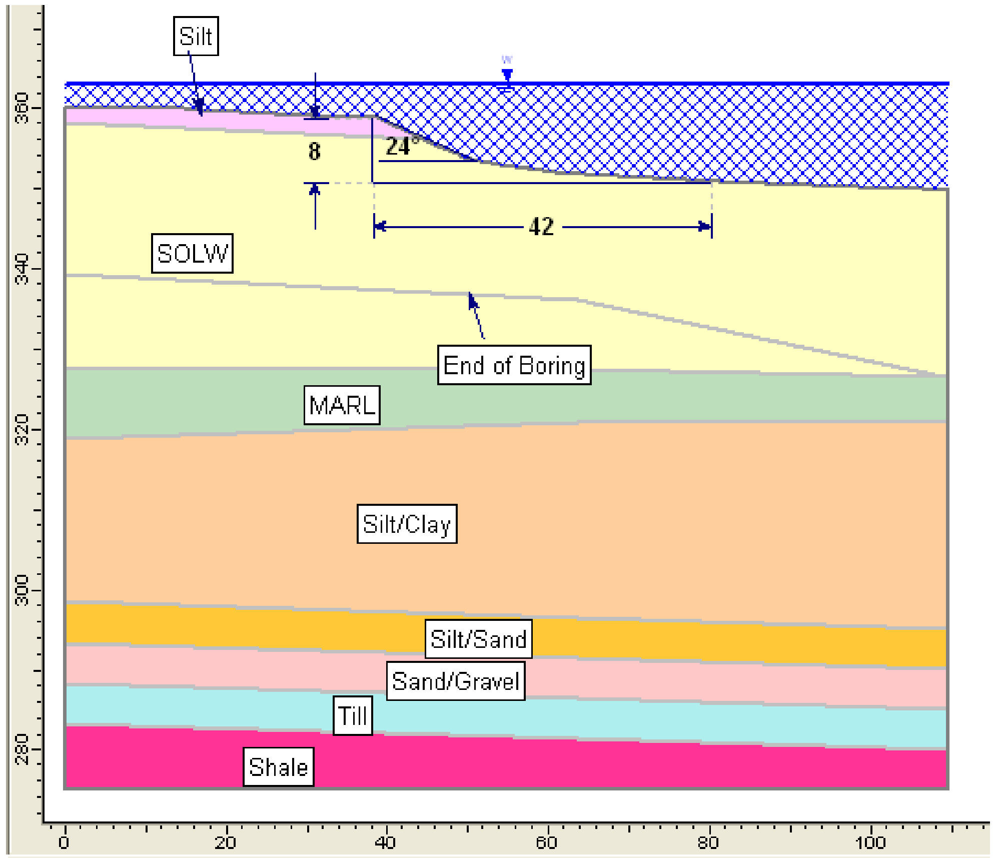

Figure 9. Geometry of cross section 7

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. The average slope is about 24 degrees and the maximum slope is about 28 degrees.

Written by: **Ming Zhu** Date: **08/20/2008** Reviewed by: **R. Kulasingam/J. Beech** Date: **08/20/2008**

Client: **Honeywell** Project: **Onondaga Lake ILWD Stability** Project/ Proposal No.: **GJ4204** Task No.: **01**

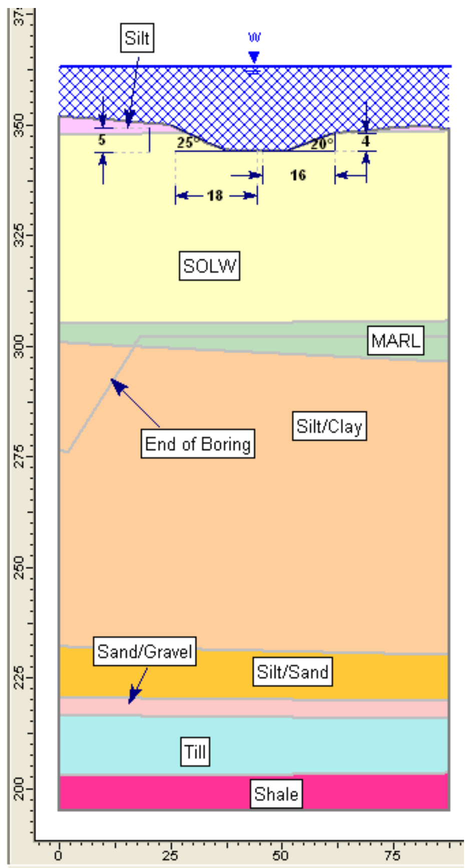

Figure 10. Geometry of cross section 8

Notes:

1. Subsurface profiles below the line of end of boring were estimated based on information from deeper borings and may not represent the true field stratigraphy. See Attachment 1 for details.
2. The average slope is about 25 degrees and the maximum slope is about 28 degrees for the steeper left-side slope.

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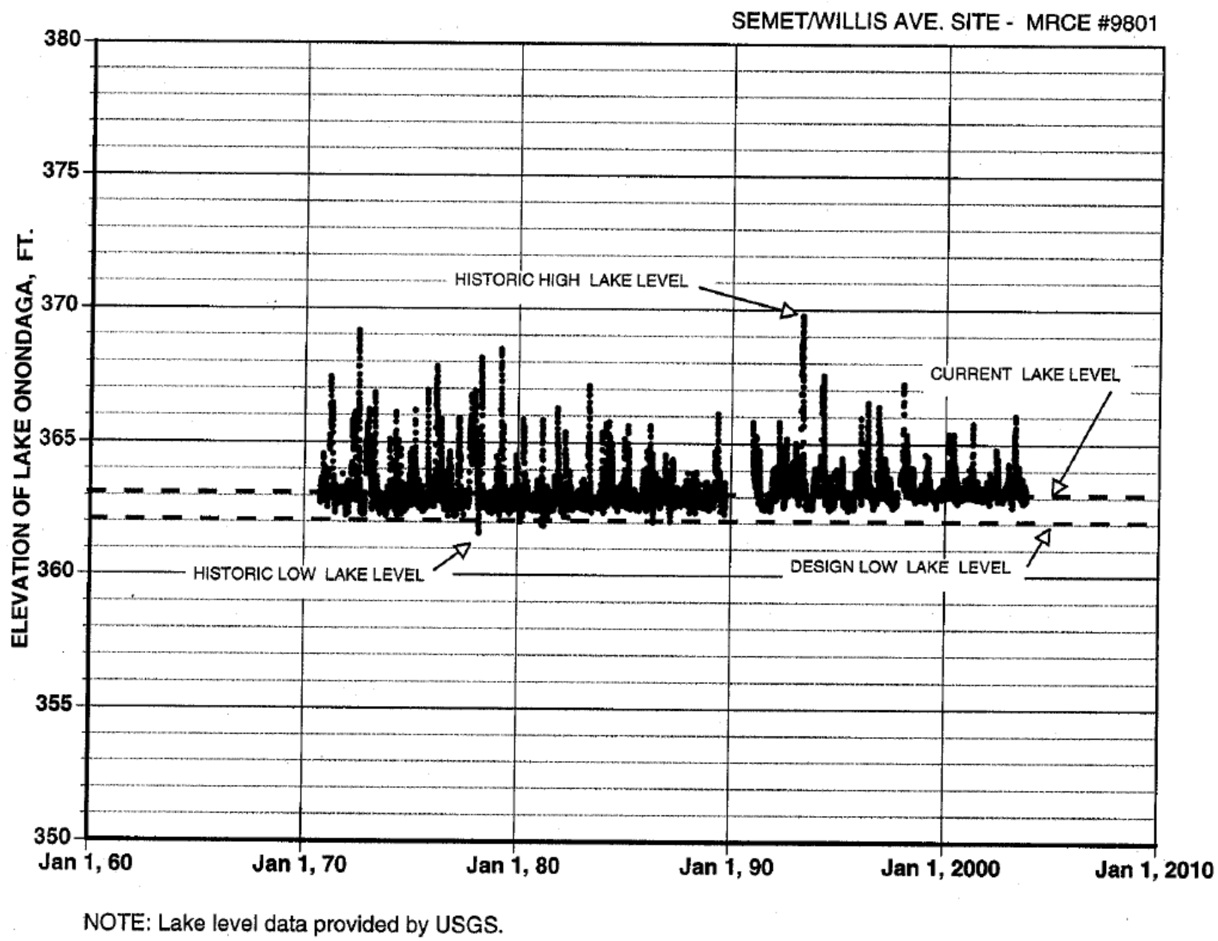

Figure 11. Onondaga Lake water level
(Figure provided to Geosyntec by Parsons)

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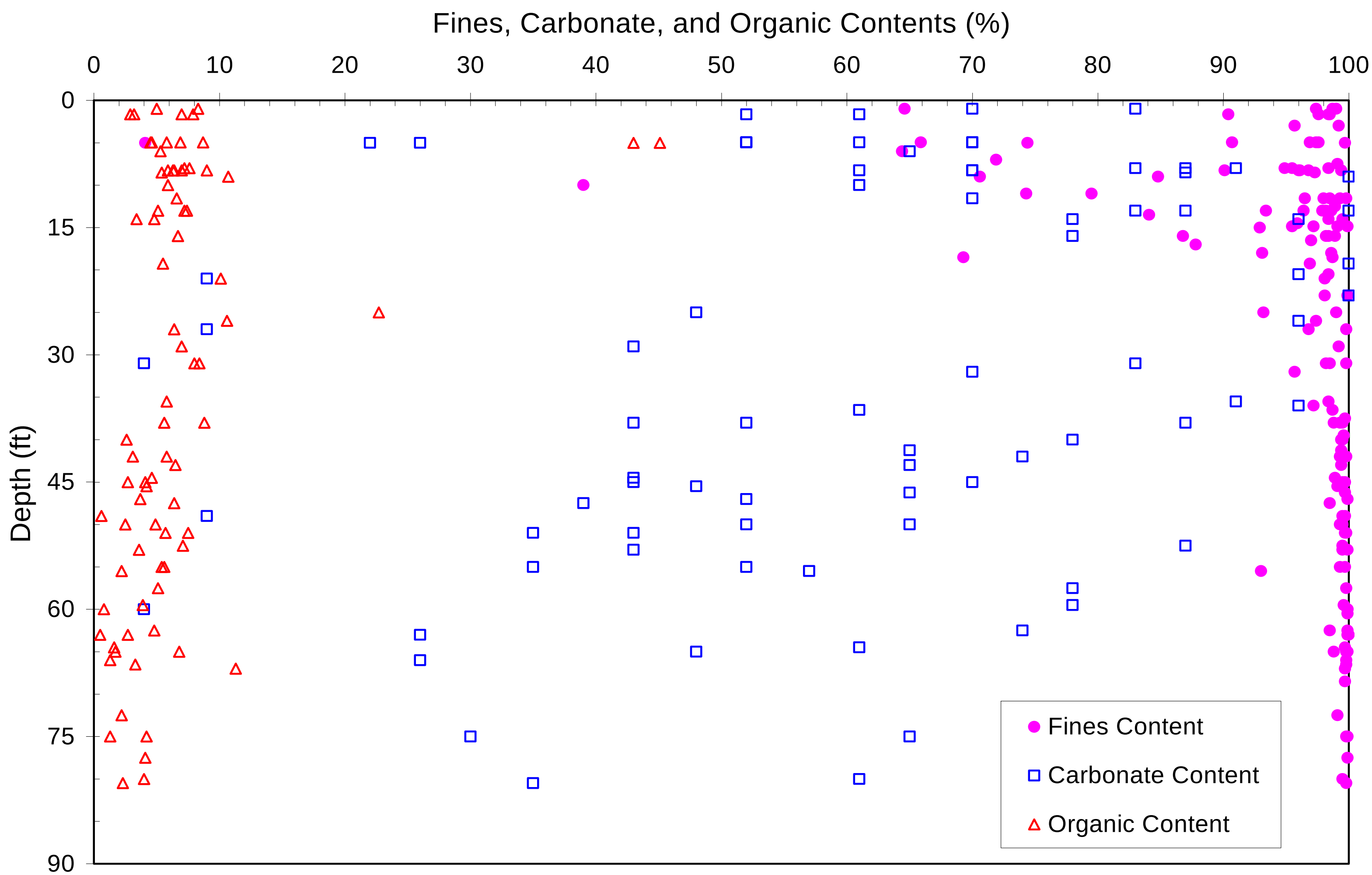

Figure 12. Plot of fines, carbonate, and organic contents versus depth

Written by: **Ming Zhu** Date: **08/20/2008** Reviewed by: **R. Kulasingam/J. Beech** Date: **08/20/2008**

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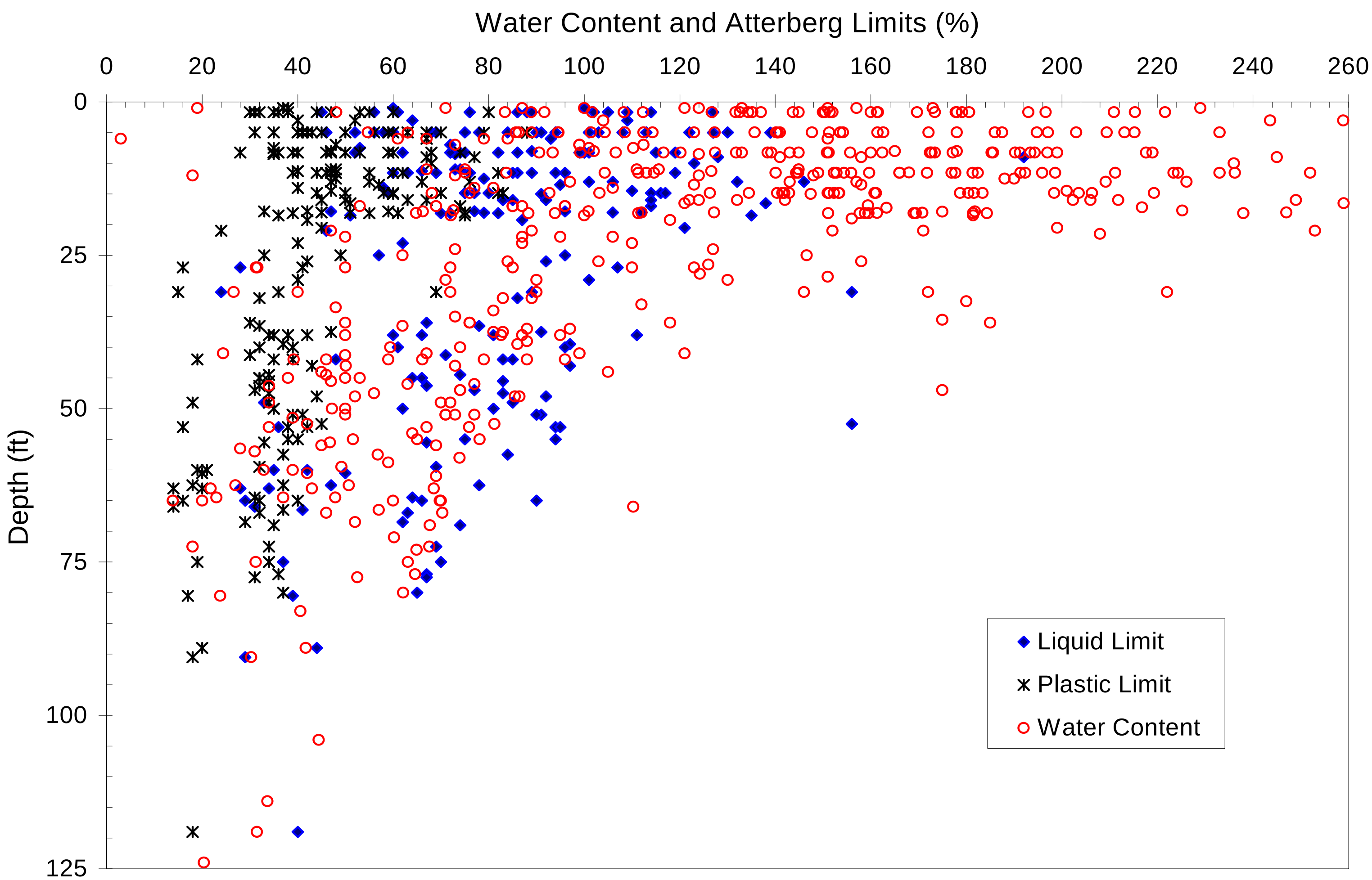

Figure 13. Plot of water content and Atterberg limits versus depth

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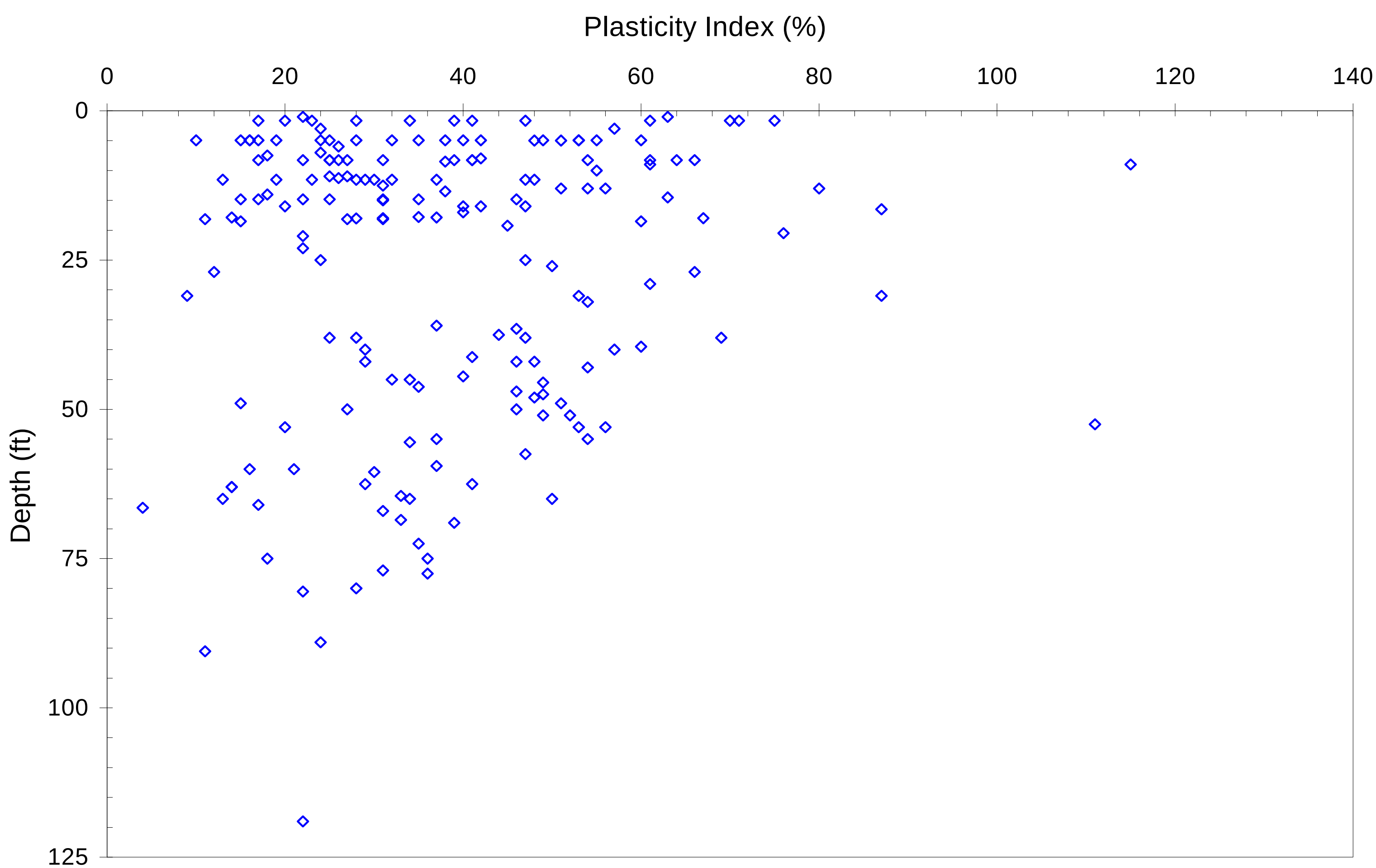

Figure 14. Plot of plasticity index versus depth

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Client:	Honeywell	Project:	Onondaga Lake ILWD Stability	Project/ Proposal No.:	GJ4204	Task No.:	01

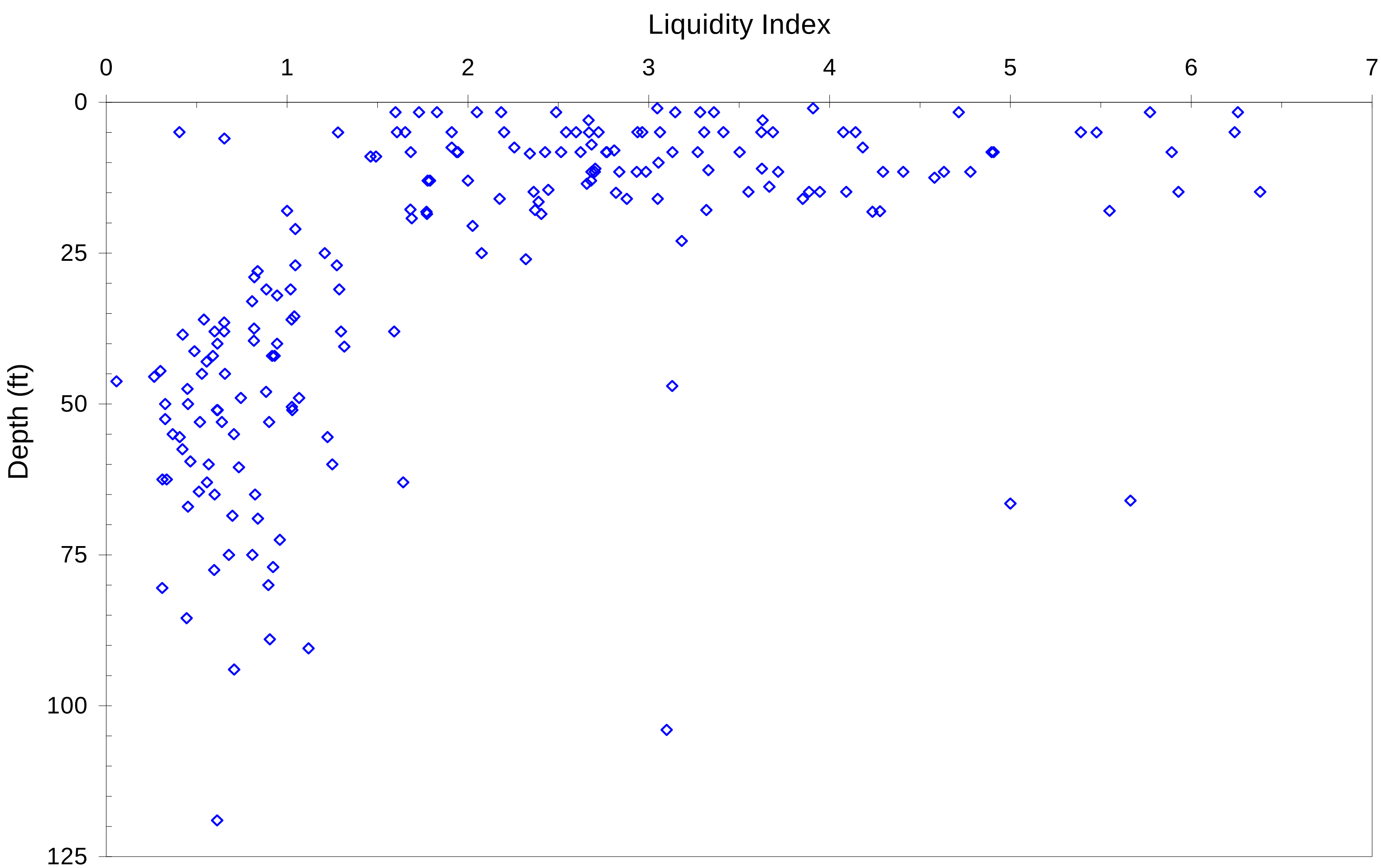

Figure 15. Plot of liquidity index versus depth

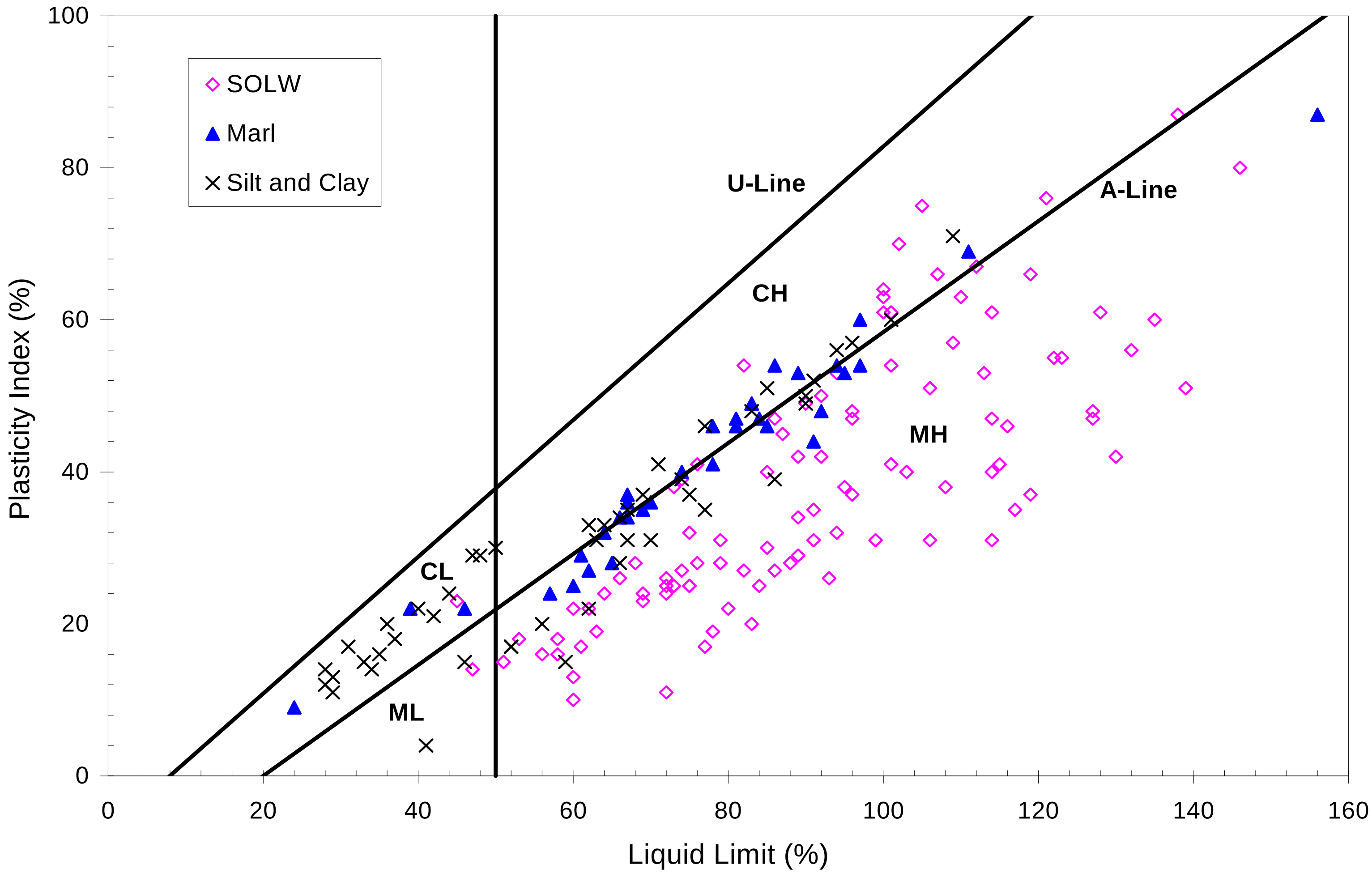

Figure 16. Casagrande's plasticity chart

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Client:	Honeywell	Project:	Onondaga Lake ILWD Stability	Project/ Proposal No.:	GJ4204	Task No.:	01

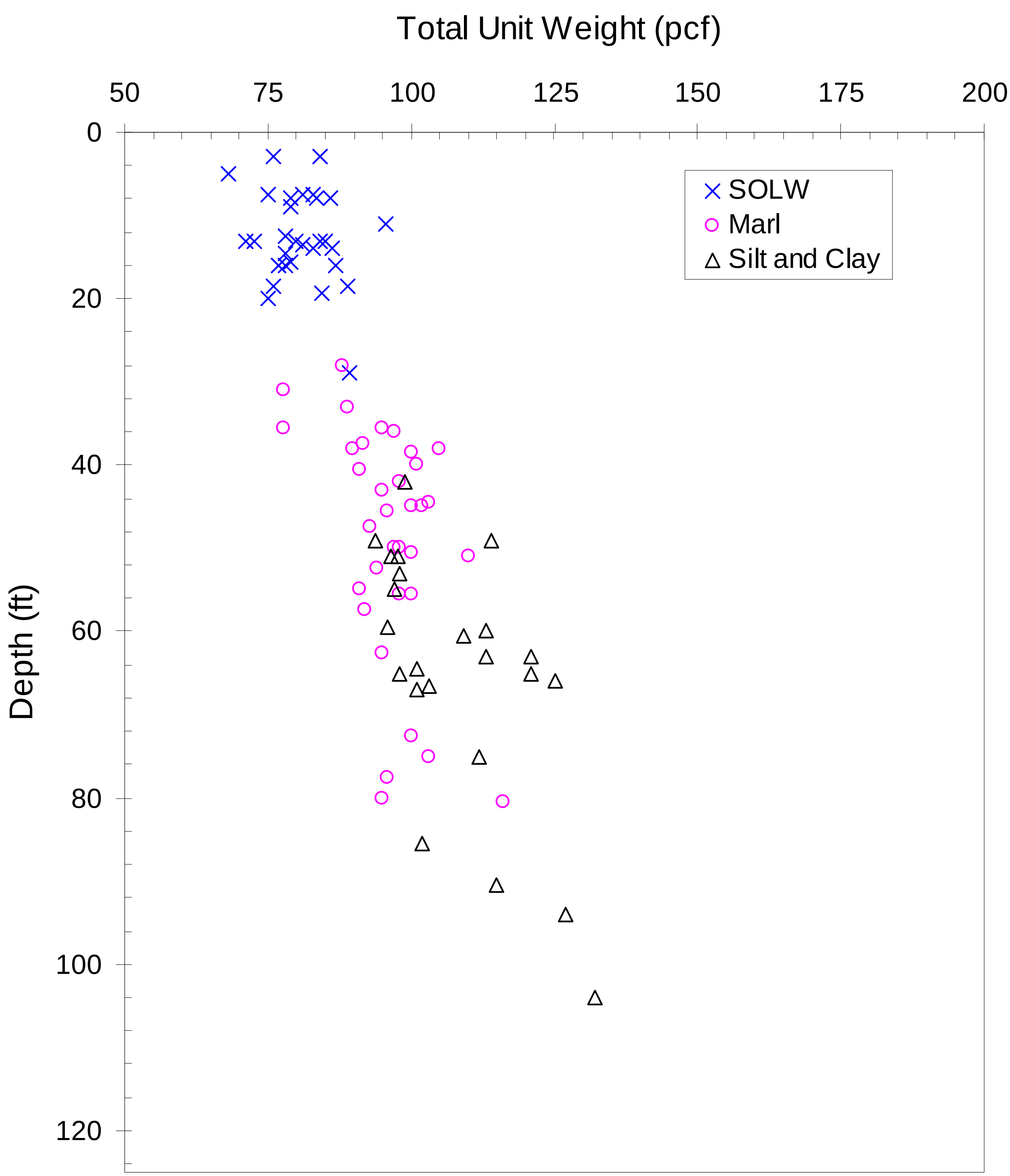

Figure 17. Plot of total unit weight versus depth

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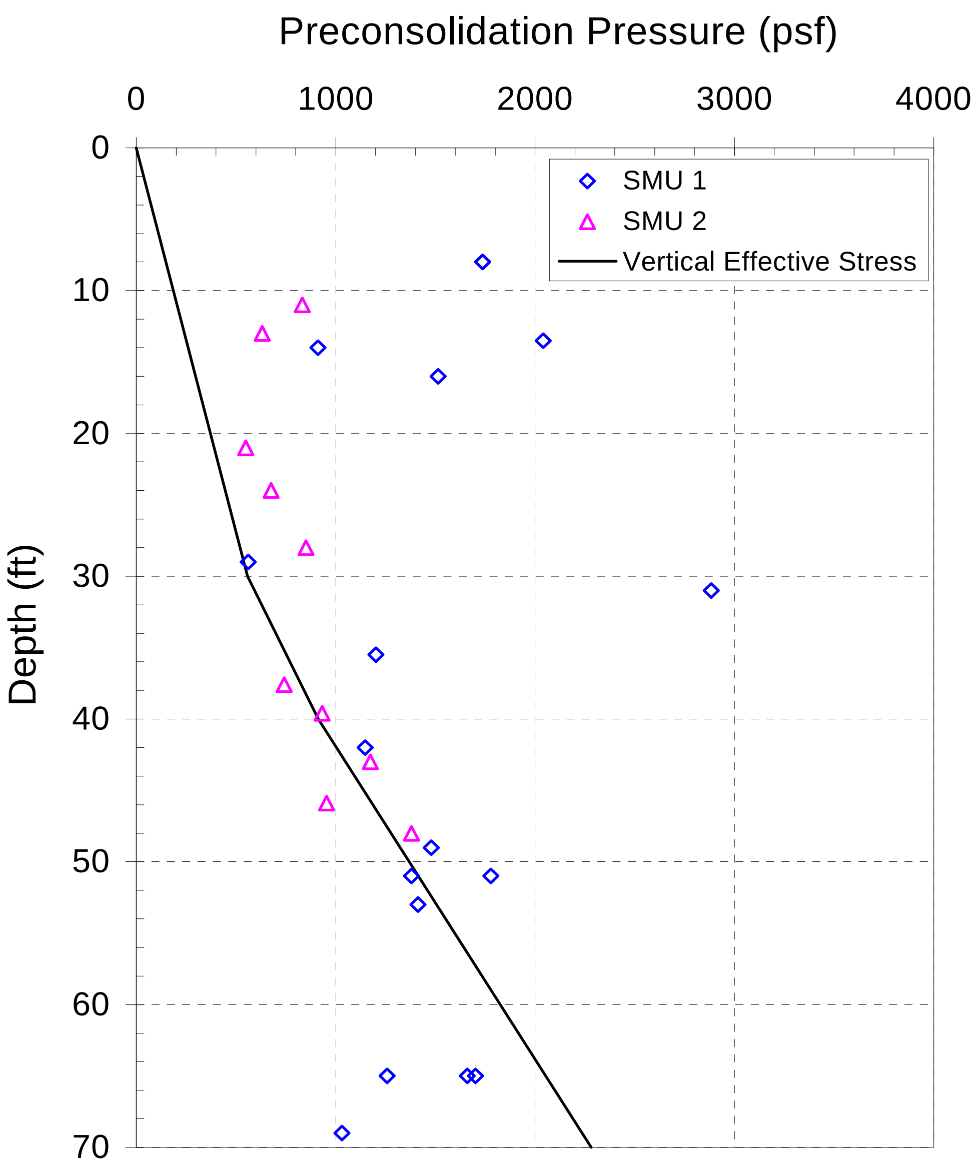

Figure 18. Profile of preconsolidation pressure
(Note: data from SMU 2 were included for comparison)

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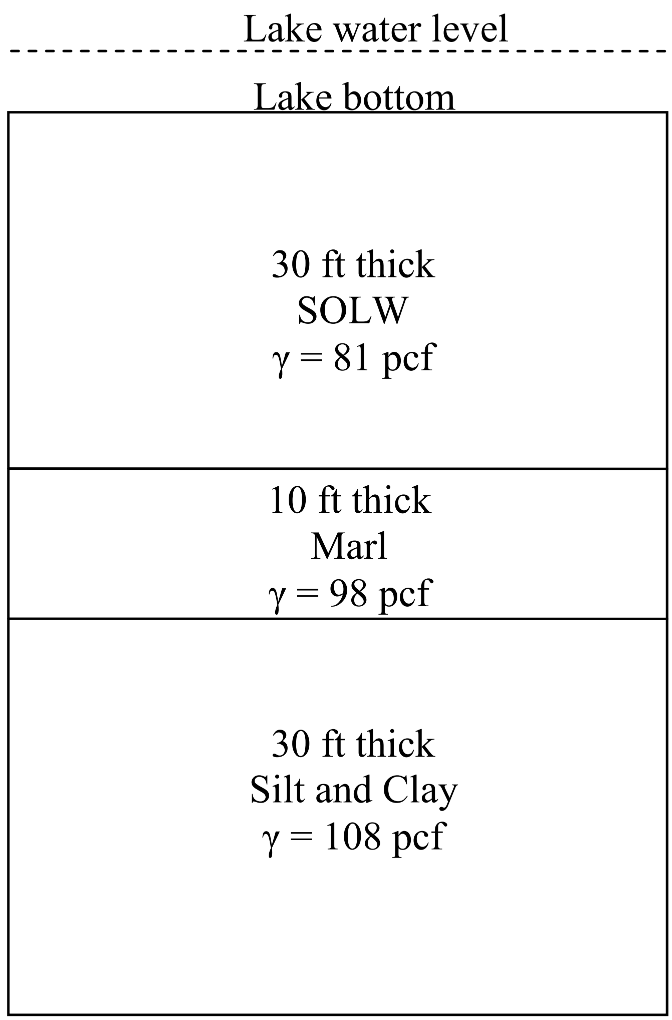

Figure 19. Assumed representative subsurface profile in the ILWD area for in-situ effective overburden stress calculation

Written by: **Ming Zhu** Date: **08/20/2008** Reviewed by: **R. Kulasingam/J. Beech** Date: **08/20/2008**

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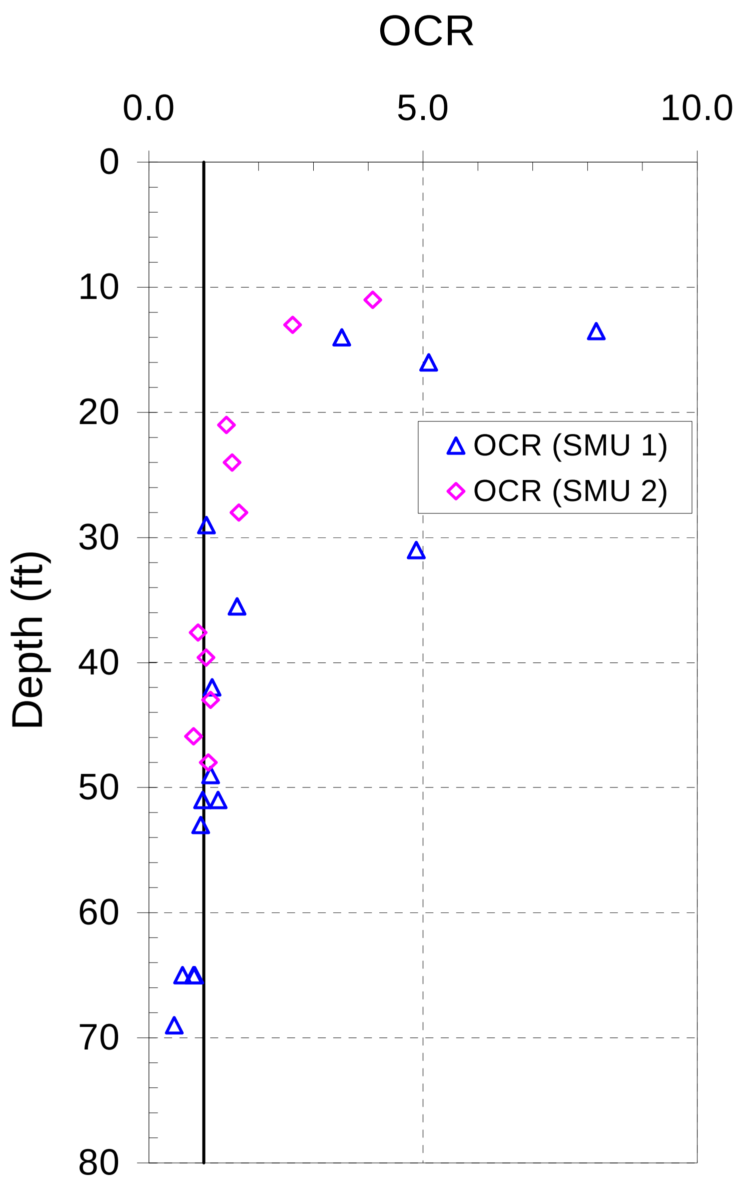

Figure 20. Profile of overconsolidation ratio
(Note: data from SMU 2 were included for comparison)

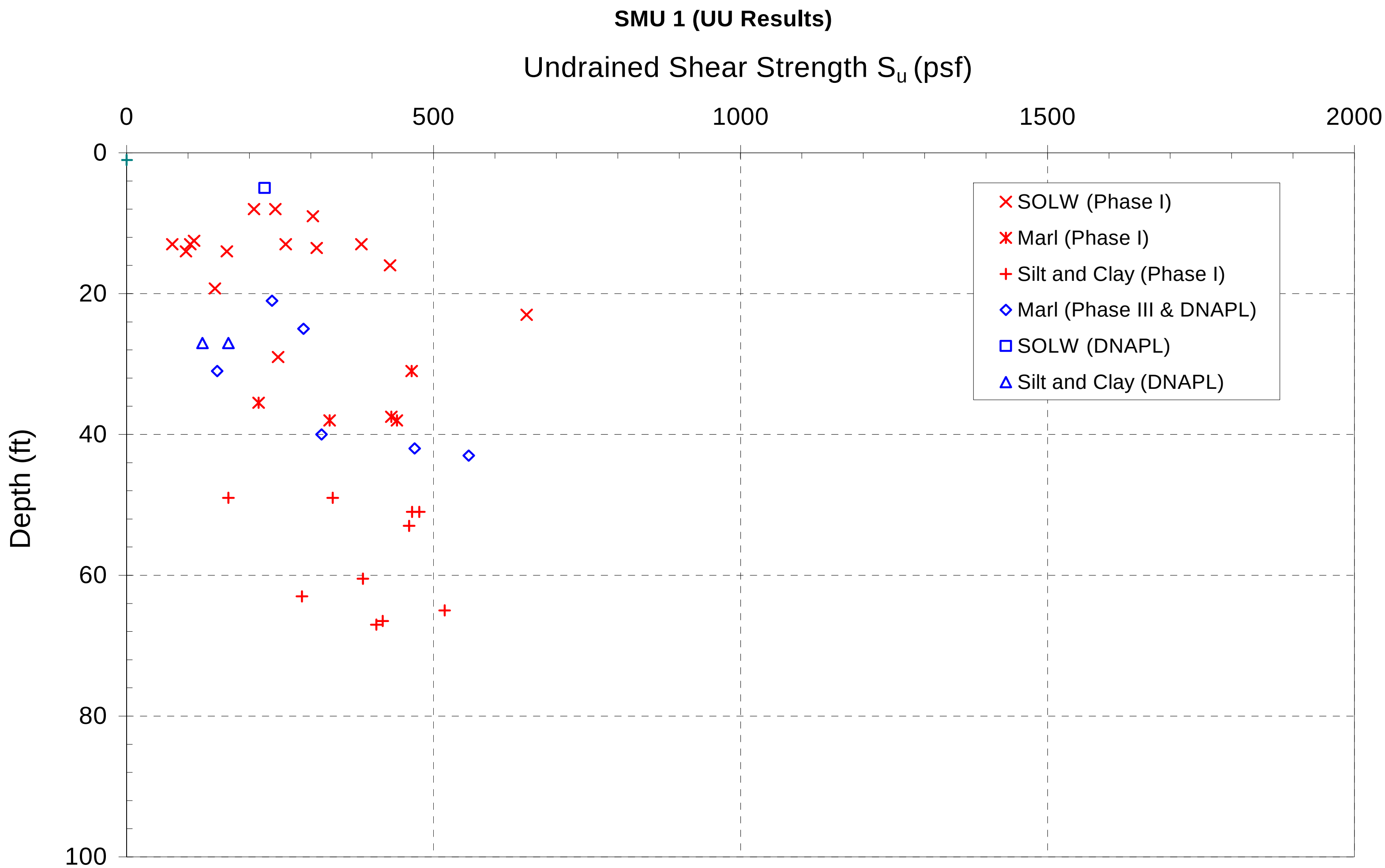

Figure 21. Undrained shear strength from UU tests

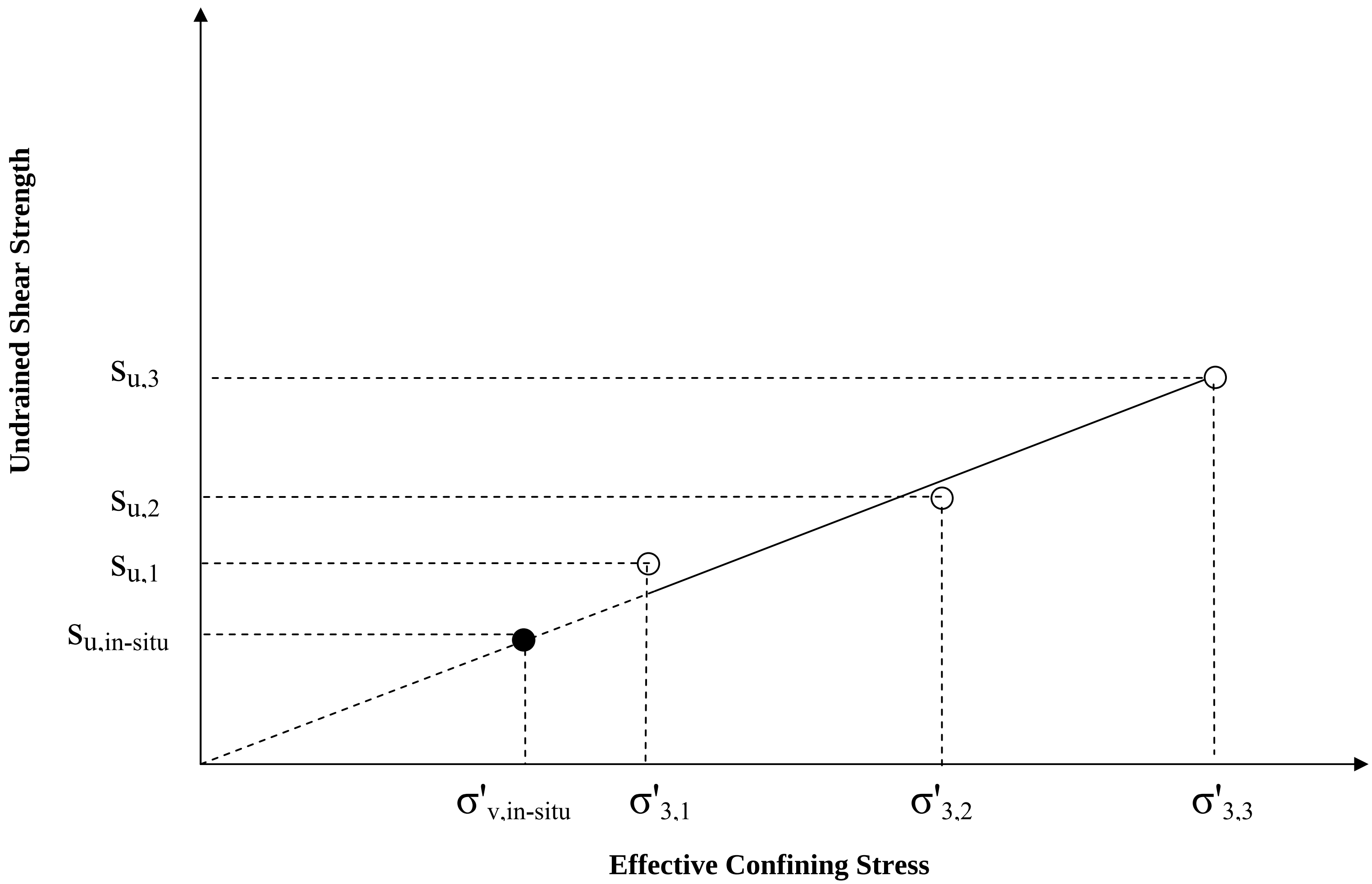

Figure 22. Obtaining S_u corresponding to the in-situ vertical stress from CU tests (Approach 2).

Written by:	Ming Zhu	Date:	08/20/2008	Reviewed by:	R. Kulasingam/J. Beech	Date:	08/20/2008

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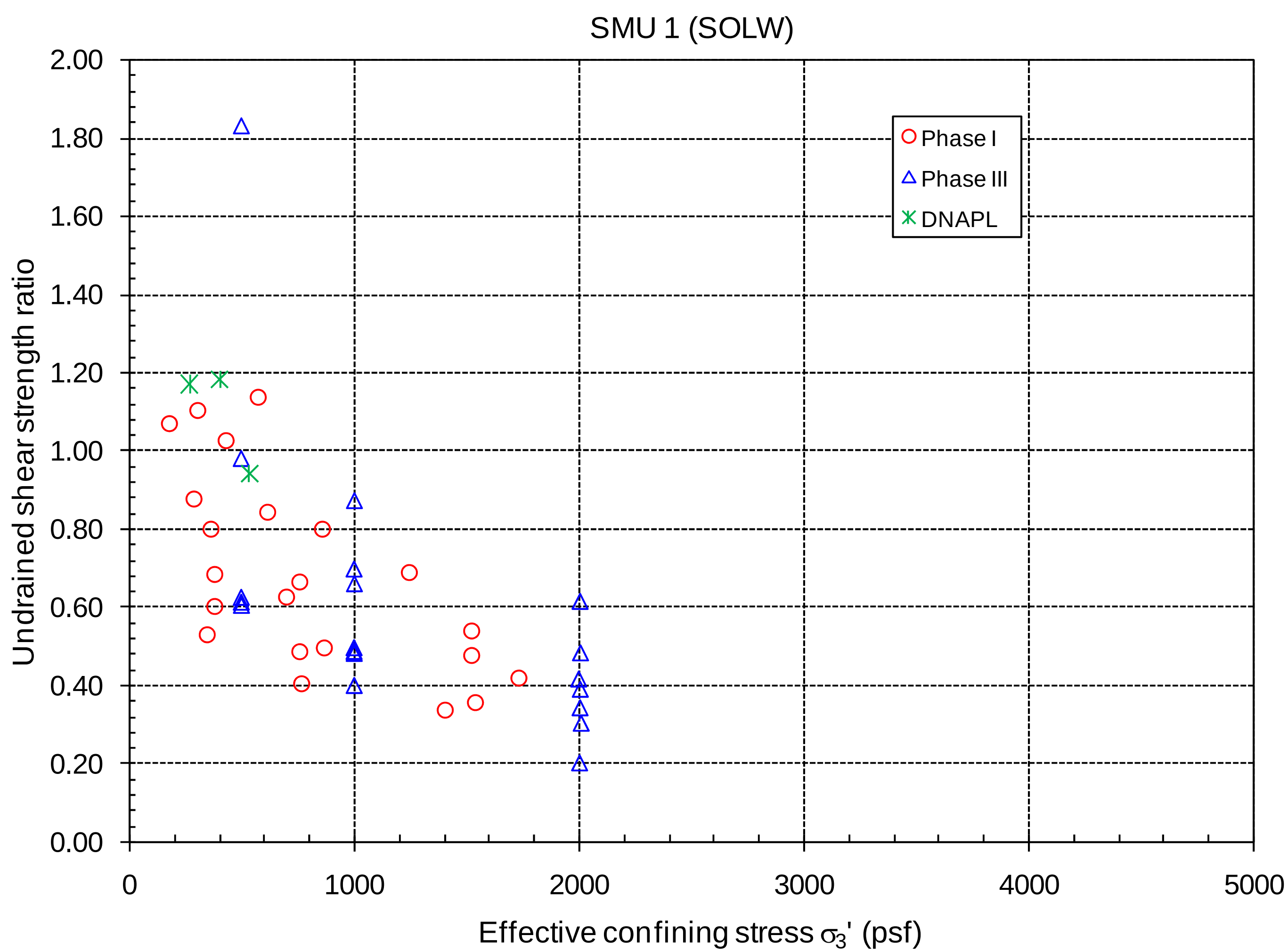

Figure 23. Undrained shear strength ratio for SOLW from CU tests

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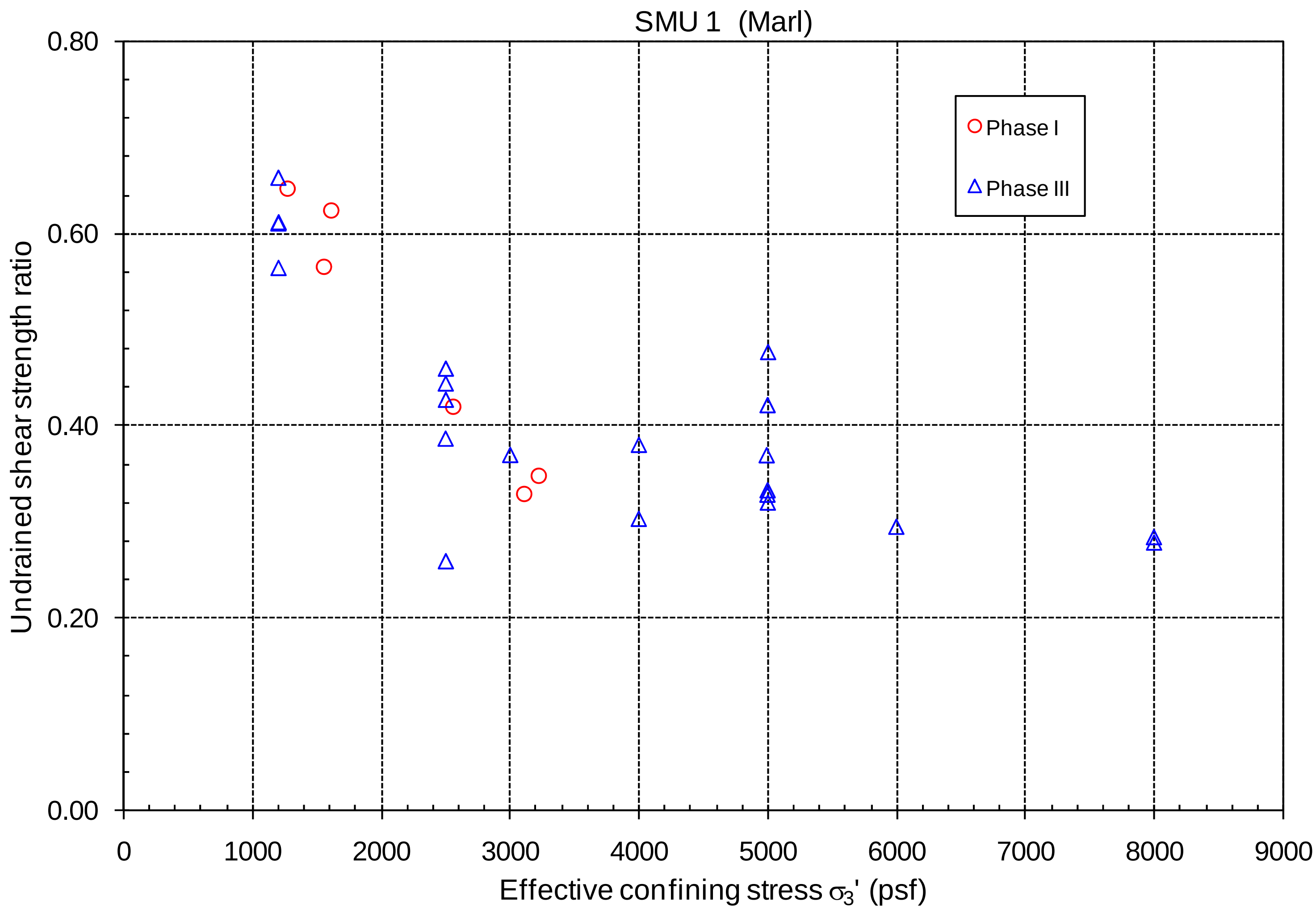

Figure 24. Undrained shear strength ratio for Marl from CU tests

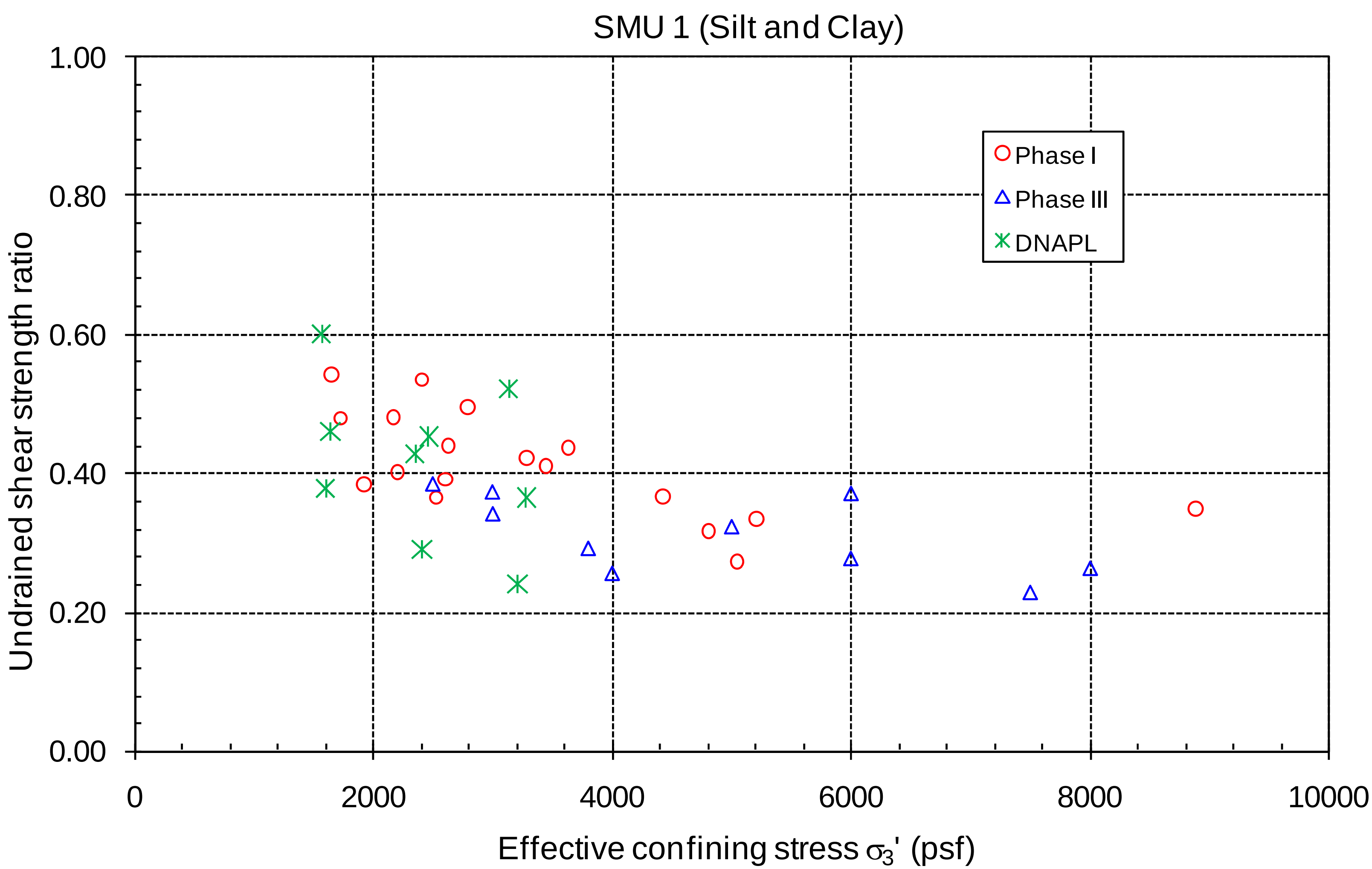

Figure 25. Undrained shear strength ratio for Silt and Clay from CU tests

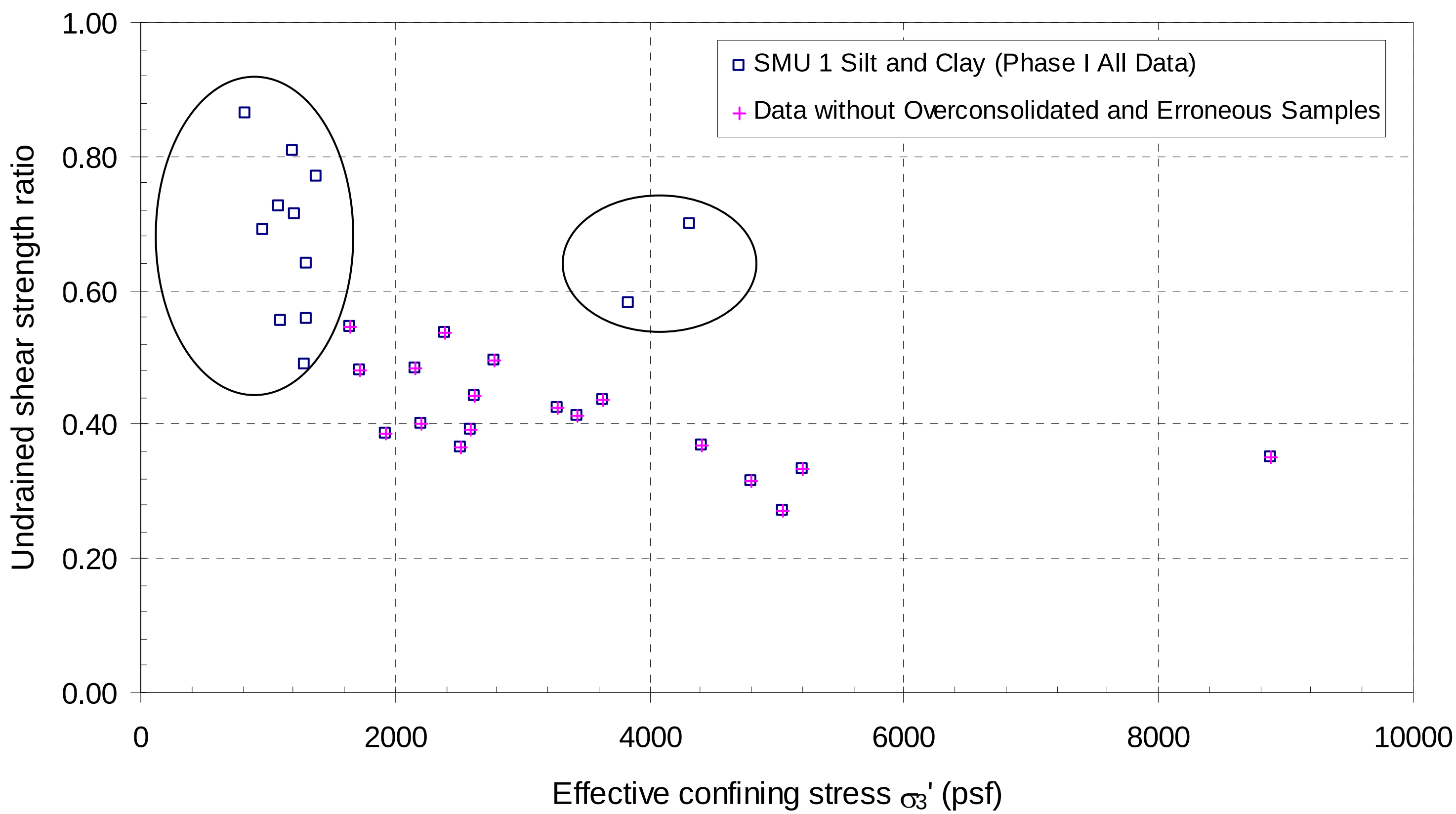

Figure 26. Example of removed samples from CU tests

Notes:
1. Data obtained from a confining stress lower than the in-situ vertical stress were removed.
2. Two data points showing erroneous behavior were removed based on the observation of stress-strain curves.

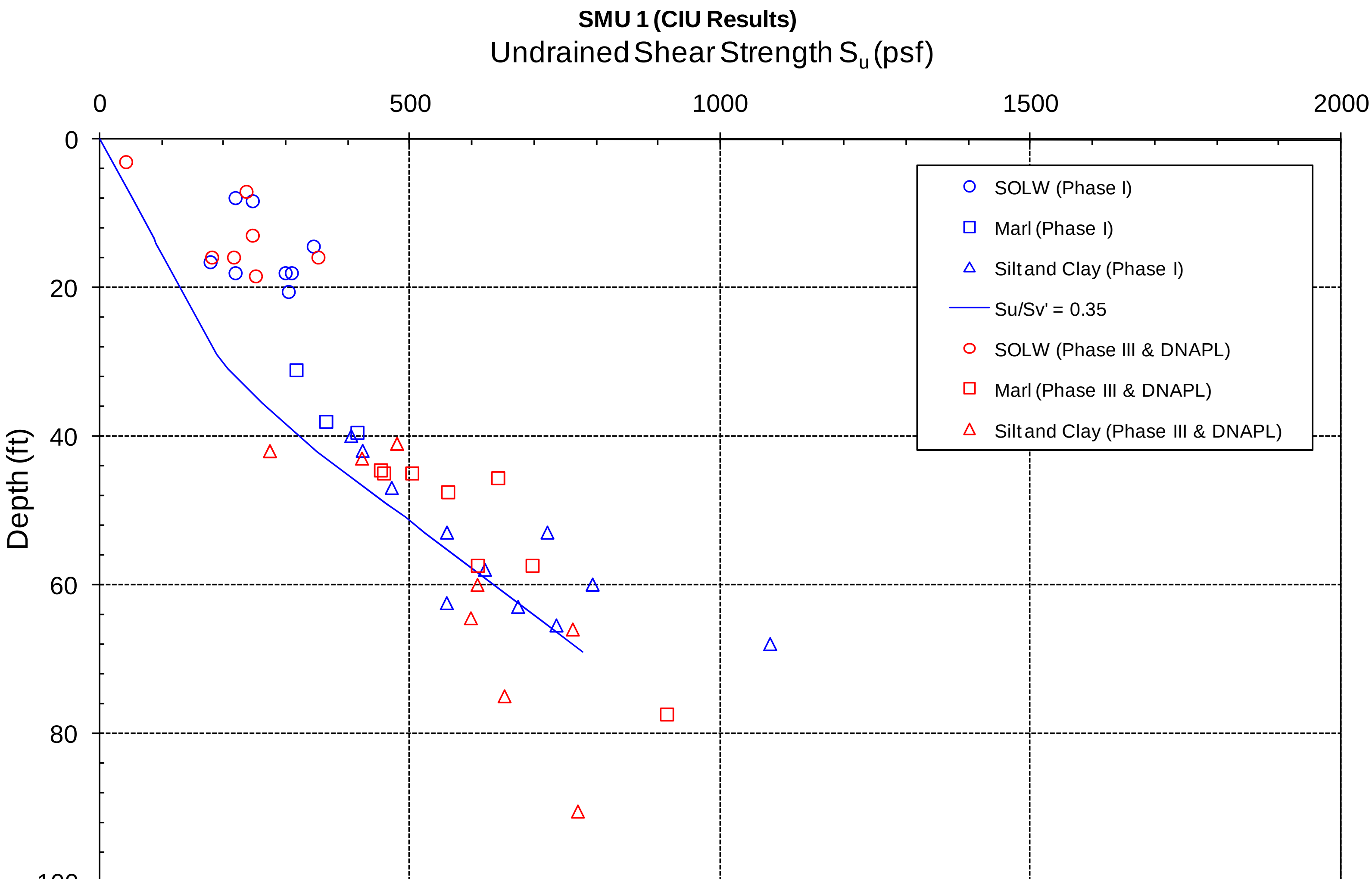

Figure 27. Interpreted undrained shear strength from CU tests

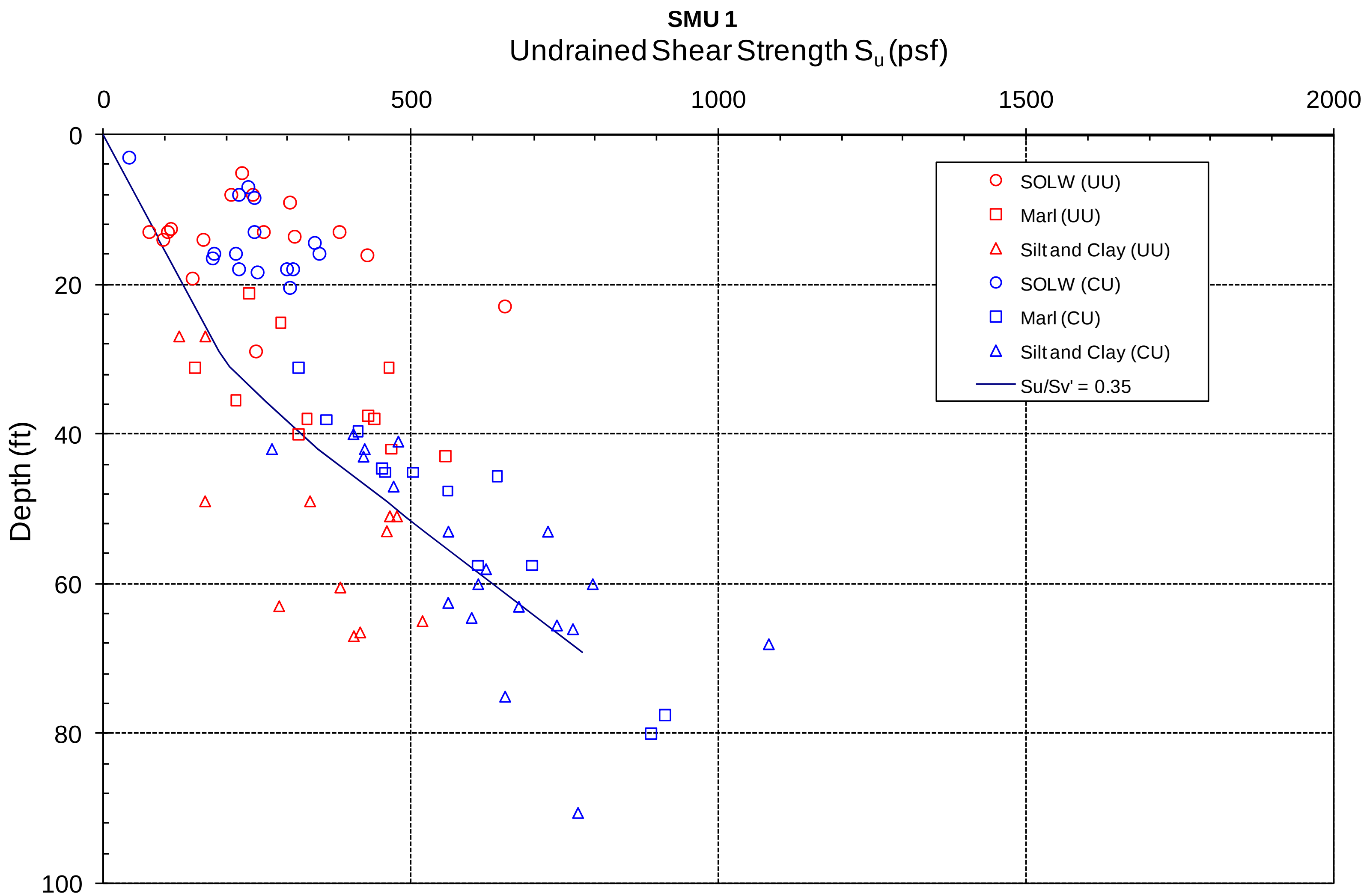

Figure 28. Comparison of undrained shear strength from UU and CU tests

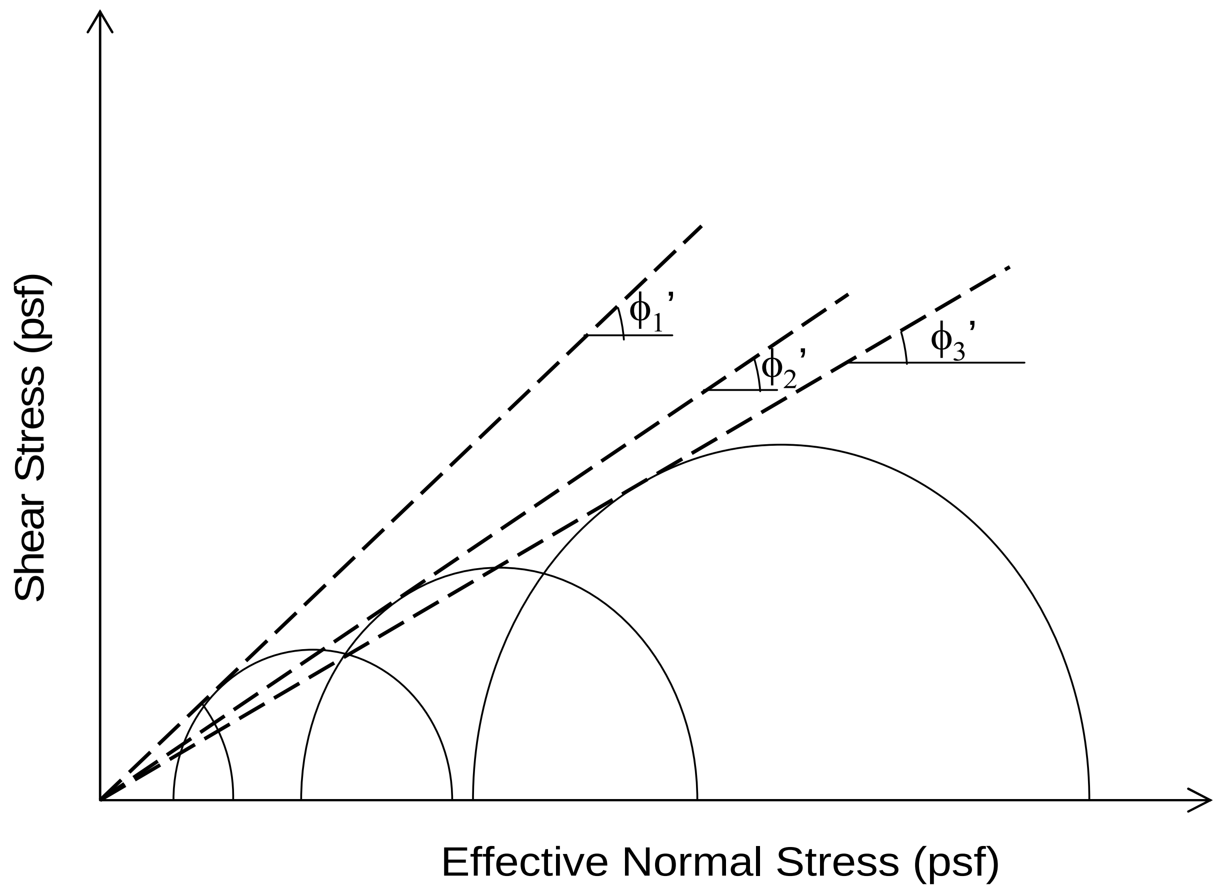

Figure 29. Obtaining effective stress friction angle using effective stress Mohr circles from CU tests

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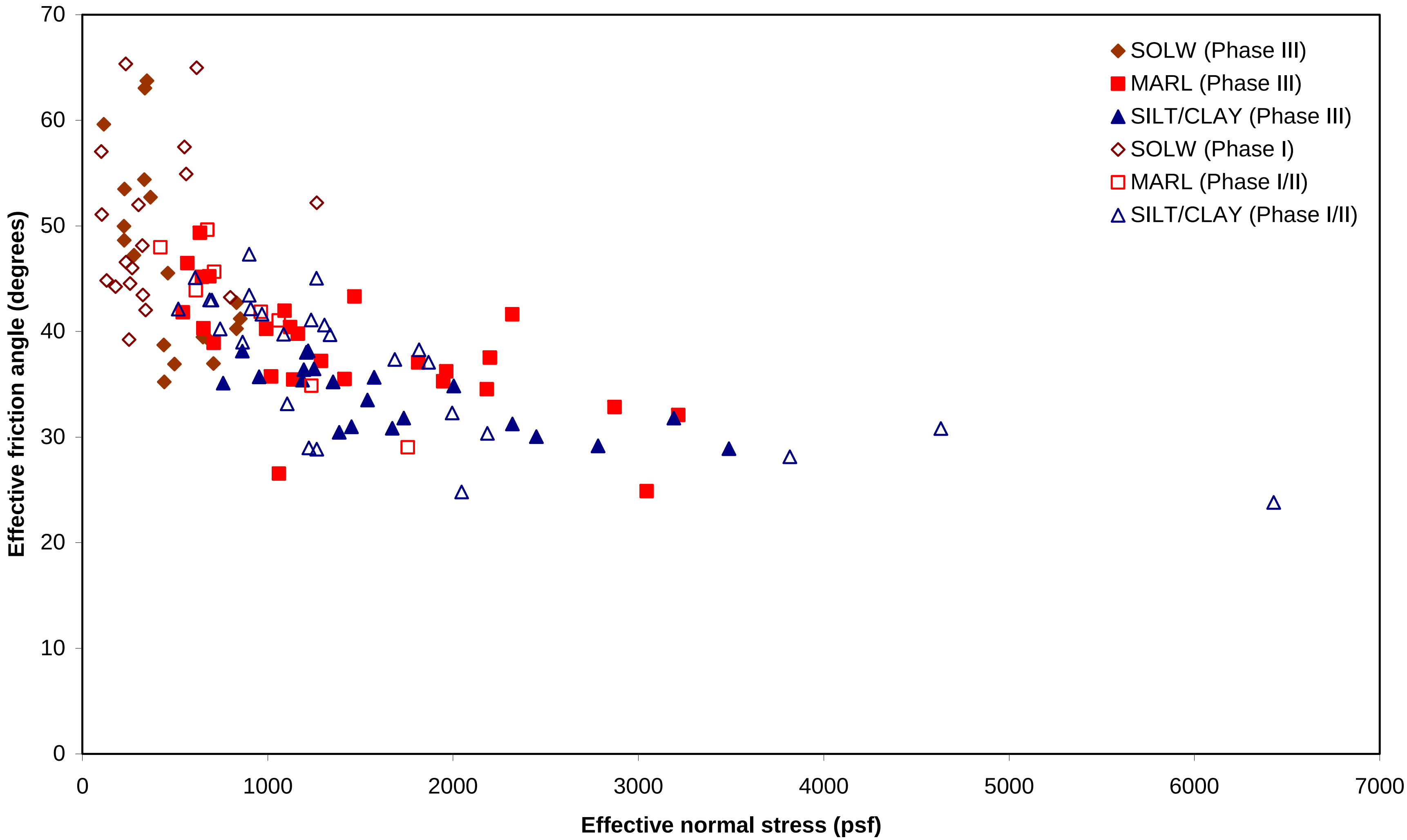

Figure 30. Effective stress friction angle versus effective normal stress for SOLW, Marl, and Silt and Clay

Written by:	**Ming Zhu**	Date:	**08/20/2008**	Reviewed by:	**R. Kulasingam/J. Beech**	Date:	**08/20/2008**

Client:	**Honeywell**	Project:	**Onondaga Lake ILWD Stability**	Project/ Proposal No.:	**GJ4204**	Task No.:	**01**

ATTACHMENT 1

Development of Subsurface Profiles in the ILWD Area
(provided on CD on following page)

ATTACHMENT 2

Summary Tables of Lab Testing Results for ILWD
(provided on CD on following page)